RAYDOSE®

AutoScanner 600

User Manual

AutoScanner 600 User Manual

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i. Statement

(1) Purpose

- This user manual serves as the exclusive operational specification for the AutoScanner 6000 (AS600) and must be properly stored with the equipment as the sole reference for operation, maintenance, and safety management.
- Operators must strictly adhere to the procedures outlined in this manual. Any unauthorized use of the equipment is strictly prohibited, including but not limited to the disclosure of technical data, unauthorized duplication, or non-compliant applications.

(2) Safety and Liability

① Operational Liability

- Guangzhou Raydose Medical Technology Co., Ltd. (hereinafter referred to as "Raydose") shall not be held legally responsible for any misuse of the equipment, personal injury, or device damage resulting from failure to comply with the safety protocols outlined in this manual, including hazard operation warnings and radiation protection requirements, or from violation of local health and safety regulations.
- Raydose assumes no liability for any direct or indirect losses resulting from the use of unauthorized tools, accessories, or modified electronic files not approved by Raydose.

② Equipment and Environmental Requirements

- Before operation, ensure that the working environment complies with the technical specifications required for device performance (e.g., stable power supply, appropriate temperature and humidity).
- Unauthorized disassembly of any device components is strictly prohibited. All maintenance and repair work must be carried out by technical personnel authorized by Raydose.

(3) Intellectual Property and Document Management

① Copyright Notice

- This manual and all accompanying documents (including electronic and printed versions) are the proprietary property of Guangzhou Raydose Medical Technology Co., Ltd. (hereinafter referred to as "Raydose") and its suppliers, and are protected by intellectual property laws.

- Without written permission from Raydose, modification, translation, or reproduction of this document is prohibited, except for limited internal reference within the same department.
- Raydose retains ultimate ownership of this manual and its accompanying documents. Any infringement will be subject to legal action.

② Revisions and Updates

- Raydose reserves the right to revise the content of this manual. All updated versions will be marked with revision dates and will automatically supersede previous editions.

(4) Compliance Statement

This statement is prepared in accordance with the Regulations on the Supervision and Administration of Medical Devices and the ISO 13485 Quality Management System standard. Guangzhou Raydose Medical Technology Co., Ltd. reserves the right of final interpretation.

ii. Product Information

- **Product Name:** AutoScanner 600
- **Model:** AS600
- **Production Date:** Refer to the product label

iii. Registration Information

- **Manufacturer:** Guangzhou Raydose Medical Technology Co., Ltd.
- **Supplier:** Guangzhou Raydose Medical Technology Co., Ltd.
- **Distributor:** Guangzhou Raydose Medical Technology Co., Ltd.
- **After-sales Service Provider:** Guangzhou Raydose Medical Technology Co., Ltd.
- **Production Address:** Room 506, Building B, No. 19 Nanxiang 3rd Road, Huangpu District, Guangzhou, Guangdong Province, China
- **Postal Code:** 510700
- **Email:** info@raydose.com
- **Website:** https://www.raydose.com/

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1. Introduction

1.1. Product Description

AutoScanner 600 (hereinafter referred to as AS600) is a high-precision integrated system for dosimetric performance testing of radiotherapy equipment, consisting of hardware components and XBeam. The hardware mainly includes an AutoScanner 600, AutoScanner Mover, AutoScanner Core Control Module (CCM), AutoScanner Reservoir, and other supporting accessories.

AS600 is primarily used for quality assurance scenarios such as TPS modeling, commissioning and acceptance testing of LINAC, and annual testing. It can comprehensively evaluate the dosimetric output accuracy and operational stability of radiotherapy equipment, providing reliable data support and quality assurance for radiation therapy.

1.2. Intended Use

The AS600 is mainly intended for quality assurance of various types of LIANC (e.g., C-arm and O-arm linear accelerators). Through precisely measuring radiation output dose, the AS600 can be used for TPS modeling and validation, linear accelerator commissioning and acceptance testing, annual QA, and routine performance testing. The measurement results help evaluate the operational status of the equipment, ensuring its clinical performance is stable, accurate, and safe.

1.3. Intended Users

Personnel operating the AS600 system must possess relevant professional knowledge in the field of radiation therapy and receive appropriate training in accordance with this manual. Intended users include radiation therapy physicists, medical physics technicians, quality control engineers from radiotherapy equipment manufacturers, and technical staff from medical institutions. Operators should be familiar with fundamental radiation physics and system operation procedures, enabling them to operate the system correctly and interpret measurement results accurately, thereby ensuring operational safety and data reliability.

1.4. Contraindications

AS600 is exclusively intended for testing radiotherapy equipment and must not be used directly on patients. Its measurement data shall not serve as the basis for directly controlling radiotherapy equipment. To ensure safe operation and data accuracy, users must strictly comply with the operating procedures. The following actions may cause equipment damage, data distortion, or pose risks to personnel and must be avoided:

- **Unauthorized operation:** Only trained and authorized personnel are permitted to operate this system.
- **Non-compliant environmental conditions:** The operating environment must meet the specified technical requirements, including temperature and humidity, to prevent equipment malfunction.
- **Violation of operating procedures:** Neglecting operational steps or safety warnings in the user manual may cause system failures.
- **Connection of incompatible devices:** The system must not be connected to unverified or incompatible equipment.
- **Software version mismatch:** Only verified software versions compatible with the hardware platform should be used.
- **Continued use during malfunction:** The system must be immediately shut down and technical personnel contacted for maintenance if error messages, hardware abnormalities or calibration failures occur.
- **Unauthorized modification or connection of uncertified components:** Any unauthorized replacement of interfaces or cables, or the connection of accessories or parts not certified by Raydose, is strictly prohibited.

2. Health and Safety Information

2.1. Overview

This chapter outlines potential hazards associated with the device. Before installation, operation, or maintenance, all personnel must carefully read and fully understand the contents of this chapter. It is essential to strictly follow all signs, prompts, and warnings and operate the device correctly according to the instructions in this manual to prevent accidents.

2.2. Symbols and Labels

No.	Name	Graphic	Meaning	Examples
1	Fragile Items		The package contains fragile items; handle with care.	
2	This Side Up		The package must be kept upright, with the arrows pointing upwards.	
3	Keep Dry		Protect the package from rain or exposure to a humid environment.	/
4	Do Not Roll		The package must not be rolled during transportation.	/
5	Do Not Stack		Do not stack packages; no items should be placed on top.	/
6	Temperature Limit		Suitable transportation temperature range: -10°C~50°C.	/
7	Humidity Limit		Suitable transportation humidity range: 10%~90%.	/
8	Warning		Alerts users to important warnings in the user manual to prevent accidents.	/
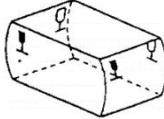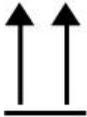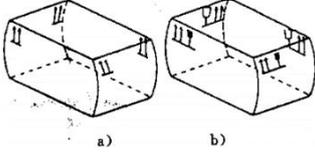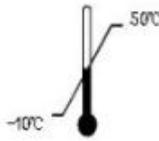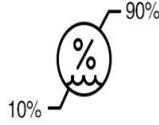
9	AC Power		Indicates alternating current (AC).	
10	Special Disposal		The product must not be disposed of as regular waste and requires special disposal handling.	/
11	Refer to Instructions		Users should refer to the manual for operational guidance and information.	/
12	Serial Number	SN	Identifies the manufacturer's serial number for tracking specific medical devices.	/
13	Manufacturer		Indicates information about the manufacturer.	/
14	Non-Ionizing Radiation		Indicates that the device emits or involves non-ionizing radiation.	/
15	Grounding		Indicates that the device must be connected to protective grounding for safe operation.	/
16	Emergency Shutdown		Immediately cut off the system power supply in emergency situations.	/
17	Weight	XXkg	Weight identifier.	/

2.3. Responsibility

(1) Liability Statement

During the use of the AS600, users must strictly adhere to the relevant operating procedures and safety standards. Guangzhou Raydose Medical Technology Co., Ltd. (hereinafter referred to as "Raydose") shall not be held liable for any direct or indirect damages, data deviations, or consequences arising from the following:

- Improper use or incorrect operation of the device;
- Unauthorized modification, disassembly, or repair of the device;
- Use of unauthorized software or accessories;
- External environmental factors (e.g., temperature or humidity) affecting system performance.

Furthermore, due to the inherent limitations of measurement technology, Raydose does not guarantee absolute accuracy of the measurement data under all usage conditions. Users are responsible for independently evaluating the applicability of the measurement results in specific clinical scenarios.

(2) Operational Restrictions

To ensure the safety of the AS600 and the reliability of its measurement data, the following restrictions must be observed during operation:

- **Qualified personnel:** The system may only be operated by trained technical personnel with relevant professional knowledge and skills.
- **Environmental conditions:** Before operation, ensure that environmental parameters such as temperature, humidity, and power supply comply with the specified operating requirements of the system.
- **Equipment compatibility:** Only Raydose-certified devices and accessories that are compatible with this system may be used. The use of incompatible products is strictly prohibited.

2.4. Assembly, Maintenance, and Accessories

To ensure the quality of system installation and operational safety, please comply with the following regulations.

2.4.1. Assembly and Installation

- The assembly, expansion, modification, and related technical operations of the device must be carried out by Raydose personnel or service engineers authorized by Raydose and equipped with the necessary technical qualifications. Installation or adjustment by unauthorized personnel may result in system malfunctions or pose safety hazards.
- All accessories and components used during assembly must be original parts provided by Raydose or certified by Raydose. The use of unauthorized components may compromise system performance and measurement accuracy, and may also pose risks to operator safety.
- The use of parts or tools not approved by Raydose during the assembly process will be regarded as a violation. Raydose shall not be held responsible for any quality issues or safety incidents arising from such actions.

Warning:

Any modifications not authorized in writing by Raydose, including but not limited to:

- Hardware Tampering: Replacement of non-original mechanical components, motion motors, cables, or control circuit boards.

- Software Tampering: Cracking of software encryption protocols or modification of software configurations.
- Mechanical Structure Alteration: Self-installation of external brackets or extension cables.

Such actions may result in the following immediate risks:

- Electromagnetic compatibility issues, leading to non-compliance with the relevant EMC requirements of YY 9706.102-2021.
- Electrical safety hazards, causing non-compliance with applicable standards.
- Collision between the AutoScanner Mover and the operator.
- Electric shock or short circuits, potentially leading to fire.

2.4.2. Maintenance and Repair

(1) Routine Maintenance
- All components should be protected from dust and moisture, and stored in a dry environment when not in use.
- If scale buildup is found in the water phantom, it should be cleaned promptly.

(2) Troubleshooting
- Water phantom issues: If cracks or leaks are detected, stop using the system immediately and contact after-sales service for repair.
- Sensor failure: Diagnosis, repair, or replacement must be performed by qualified personnel.
- AutoScanner RC malfunction: If button response fails or communication errors occur, check the connection status or replace the system.
- AutoScanner Mover failure: If the wheel set is damaged or movement is abnormal, stop operation and carry out inspection and repair.
- Other system abnormalities: If abnormalities occur in the core controller or detectors, do not attempt to fix the issue yourself. Contact the manufacturer or authorized service personnel for diagnosis and repair.

Note: Unauthorized disassembly or repair by unqualified personnel is strictly prohibited, as it may result in further damage to the equipment.

2.4.3. Accessory Management and Replacement

- It is recommended to use Raydose's original standard accessories to ensure system compatibility, measurement accuracy, and long-term stability.
- All accessory replacements must be performed with the power off and carried out by authorized technical personnel.

2.5. Power Supply and Connections

(1) Standard Power Requirements
- Rated input voltage for the main control box: 24V DC
- The system must be powered via the original power adapter provided by Raydose, connected to a 220V/50Hz power source.

- Directly connecting the main control box to a non-standard power source or using third-party adapters is strictly prohibited, as it may cause equipment damage or electrical failure.

(2) Main Control Box Connection Method

- The output end of the original adapter must be directly inserted into the power interface of the main control box (labeled "P/D") to ensure stable power supply.

(3) Power Supply Requirements for the AutoScanner Mover

- When powering the AutoScanner Mover, a shielded P/D dedicated cable must be used to connect the main control box and the AutoScanner Mover, ensuring synchronized power and signal transmission.
- The use of unshielded cables or unauthorized modifications to the connection method is strictly prohibited, as this may cause electromagnetic interference, resulting in abnormal measurement data or unstable platform operation.
- Note: If power anomalies occur (e.g., voltage fluctuations exceeding ±10%), data acquisition accuracy may be affected, and system malfunctions may occur. It is recommended to use a voltage stabilizer to ensure a stable power supply.

(4) Cable Table and Specifications

No.	Name	Cable Length (m)	Shielded (Yes/No)
1	Power Cable	1.8	No
2	Adapter Cable	1.2	No
3	Ethernet Cable	25	No
4	P/D Cable	0.6	Yes
5	CCM Cable	2.8	Yes
6	Power Adapter Cable	0.3	Yes

Note: Cables include external connection wires (such as power cables, adapter cables, port connection wires, and terminal wires) as well as internal connection wires between components of the product.

2.6. Electromagnetic Compatibility

⚠ **Note:**

- This system complies with the electromagnetic compatibility(EMC) requirements of YY 9706.102-2021.
- Users should install and operate the system in accordance with the EMC information provided in the accompanying documentation.
- Portable and mobile RF communication equipment may affect the performance of this system. Strong electromagnetic interference—such as that from mobile phones or microwave ovens—should be avoided during use.
- For detailed guidance and manufacturer declarations, refer to the Appendix.

⚠ **Warning:**

- Even if other devices comply with national emission standards, they may still interfere with the operation of this system.

- This system should not be used in close proximity to or stacked with other equipment. If such use is necessary, verify that the system operates normally in the intended configuration.
- This is a Class A device intended for use in industrial environments. Due to its conducted and radiated disturbances, it may present EMC difficulties in other environments.
- Use of accessories or cables other than those specified by the manufacturer—or not supplied as internal components—may increase electromagnetic emissions or decrease the system's immunity to interference.

2.6.1. Electromagnetic Emissions

The operator of the device should ensure its use under the following electromagnetic environmental conditions.

Emissions Test	Compliance	Electromagnetic Environment Guidelines
RF Emissions GB4824	Group 1	This device is used only for internal functions and generates minimal RF energy, causing negligible interference to surrounding electronic equipment.
RF Emissions GB4824	Class A	The device is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic Emissions GB17625.1	Not applicable	
Voltage Fluctuations/ Flicker Emissions GB17625.2	Not applicable	

2.6.2. Electromagnetic Immunity

The operator of the device should ensure its use under the following electromagnetic environmental conditions.

Immunity Test	IEC60601 Test Level	Compliance Levels	Electromagnetic Environment
Electrostatic discharge (ESD) GB/T 17626.2	±6kV contact ±8kV air	±6kV contact ±8kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst GB/T 17626.4	±2kV for power supply lines ±1kV for input/output lines	±2kV for power supply lines ±1kV for input/output lines	Mains power should have the quality typically used in commercial or hospital environments.

Surge GB/T 17626.5	±1kV Differential Mode Voltage ±2kV Common Mode Voltage	±1kV Differential Mode Voltage ±2kV Common Mode Voltage	Mains power should have the quality typically used in commercial or hospital environments.
Voltage dips, short interruptions, and voltage variations on the power supply input lines GB/T 17626.11	<5% U_T, for 0.5 cycles (>95% voltage dip on U_T) 40% U_T, for 5 cycles (60% voltage dip on U_T) 70% U_T, for 25 cycles (30% voltage dip on U_T) <5% U_T, for 5 seconds (>95% voltage dip on U_T)	<5% U_T, for 0.5 cycles (>95% voltage dip on U_T) 40% U_T, for 5 cycles (60% voltage dip on U_T) 70% U_T, for 25 cycles (30% voltage dip on U_T) <5% U_T, for 5 seconds (>95% voltage dip on U_T)	Mains power should have the quality typically used in commercial or hospital environments. If continuous operation is required during power interruptions, it is recommended that the device use an uninterruptible power supply (UPS) or battery power.
Power frequency magnetic field (50/60Hz) GB/T 17626.8	3A/m	3A/m	The power frequency magnetic field should at typical levels found in commercial or hospital environments.

Note: U_T refers to the AC mains voltage before applying the test voltage.

Conducted RF GB/T 17625.6	3Vrms 150kHz to 80MHz	3 Vrms	Portable and mobile RF communication devices should not be used closer to any part of the equipment, including cables, than the recommended separation distance. This distance should be calculated using the corresponding formula for the transmitter's frequency. Recommended separation distance: $$d=1.2\sqrt{P}$$ $$d=1.2\sqrt{P}$$ 80MHz - 800MHz $$d=2.3\sqrt{P}$$ 800MHz - 2.5GHz Where P is the maximum output rated power of the transmitter, as provided by the manufacturer, in watts (W), and d is the recommended separation distance, in meters (m). The field strength of fixed RF transmitters is determined by
Radiated RF GB/T 17626.3	3V/m 80MHz to 2.5GHz	3 V/m	

			conducting an electromagnetic site survey.[a] In each frequency range, the field strength should be below the compliance level.[b] Interference may occur near devices marked with the following symbols:

Note 1: For frequencies of 80 MHz and 800 MHz, use the formula for the higher frequency range.

Note 2: These guidelines may not be suitable for all situations, as electromagnetic propagation is influenced by building structures, objects, and the absorption and reflection from the human body.

a. Fixed RF transmitters, such as wireless (cellular/cordless) phones, ground-based mobile radio stations, amateur radio, AM (Amplitude Modulation) and FM (Frequency Modulation) radio broadcasting, and television broadcasting, may have field strengths that cannot be accurately predicted theoretically. To assess the electromagnetic environment of a fixed RF transmitter, an electromagnetic site survey should be considered. If the field strength at the location where the device is used exceeds the RF compliance levels mentioned above, the device should be observed to ensure proper operation. If abnormal performance is observed, additional measures may be necessary, such as realigning or repositioning the device.

b. For the frequency range of 150 kHz to 80 MHz, the field strength should be below 3 V/m.

2.6.3. Recommended Separation Distances

The device is intended for use in the electromagnetic environment where radiated RF disturbances are controlled. Based on the maximum rated output power of communication equipment, the user of the device can prevent electromagnetic interference by maintaining the minimum distance between portable and mobile RF communications equipment (transmitters) and this device, as recommended below.

Maximum Rated Output Power of Transmitter (W)	Corresponding Separation Distance for Different Frequencies		
	150kHz～80MHz $d=1.2\sqrt{P}$	80MHz～800MHz $d=1.2\sqrt{P}$	800MHz～2.5GHz $d=2.3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23

For transmitters with a maximum rated output power not listed in the above table, the recommended separation distance d, in meters (m), can be determined using the formula from the corresponding transmitter frequency section. Here, P is the maximum rated output power provided by the transmitter manufacturer, in watts (W).

Note 1: For frequencies of 80 MHz and 800 MHz, use the formula for the higher frequency range.

Note 2: These guidelines may not be suitable for all situations, as electromagnetic

propagation is influenced by building structures, objects, and the absorption and reflection from the human body.

2.7. Regulatory Compliance Requirements

(1) Certified Manufacturing Qualifications
Guangzhou Raydose Medical Technology Co., Ltd., as a licensed medical device manufacturer, manages the development, production, quality control, and delivery of the AS600 system in full compliance with the quality management system standard YY/T 0287-2017 / ISO 13485:2016 Medical Devices — Quality Management Systems — Requirements for Regulatory Purposes.

(2) Scope of Quality System Control
- Comprehensive Quality Management: From raw material procurement to final product inspection, all processes are strictly integrated into the company's quality management system. All related products comply with the GB/T 42061-2022 standard.
- Regulatory Alignment: The production environment, facility configurations, and documentation control fully comply with regulatory requirements such as the Good Manufacturing Practices for Medical Devices (NMPA Announcement No. 64), ensuring traceability and auditability of the quality management system.

2.8. Safety Precautions

2.8.1. Electrical Safety

- Electrical installations in the system's operating environment must comply with IEC 60601-1: General Requirements for Basic Safety and Essential Performance of Medical Electrical Equipment, and adopt a single-point grounding design.
- **Warning:**
  ①　To avoid the risk of electric shock, the system must be connected to a power supply with a protective earth (ground).
  ②　The grounding resistance must be $\leq 0.1\,\Omega$. The system must not share a power circuit with high-power devices, in order to prevent electromagnetic interference or power supply instability.

2.8.2. Operator Safety

(1) Qualification Requirements
- Operators must hold a valid and legally recognized radiation equipment operation license (e.g., Co-60 or medical linear accelerator safety operation certification).

- Operators should possess basic knowledge of radiation measurement equipment and understand the limitations of measurement.
- Operators must complete professional training on the AS600 system and be familiar with its operational procedures and safety precautions.

(2) Pre-Operation Checks

- Ensure all device connections are secure and correct, including firmly connected data cables, proper port alignment, and confirmation that the 24V power indicator is on and functioning normally.
- Confirm the operating environment meets requirements: temperature and humidity within specified ranges, and absence of strong electromagnetic interference sources nearby, which could affect system performance.

2.8.3. Equipment Operation and Maintenance

(1) Operational Standards

- Mechanical impact is strictly prohibited. Surface pressure must not exceed 25 g/cm².
- Anti-static wrist straps must be worn during operation. Avoid touching the device with wet hands to prevent damage to humidity-sensitive components (tolerance: ±5%).
- If the device has been used in an emergency situation, a comprehensive inspection must be performed before any subsequent use.
- After filling or draining water, residual droplets may remain when disconnecting water hoses. It is recommended to use a bucket to catch the water and prevent liquid damage to surrounding equipment.
- If electronic components such as the power adapter, main control circuit, or controller come into contact with water, immediately disconnect the power supply, wait approximately 1 minute, and then proceed with inspection or handling.

(2) Cleaning and Maintenance

- Annual inspection: Check for loose nuts/screws and any damaged or broken parts.
- The CCM should be tested and calibrated annually in accordance with JJG 912-2010: Verification Regulation of Ionization Chamber Dosimeters for Therapy-Level.
- Approved cleaning agents: Use only 3% hydrogen peroxide or 75% ethanol. Chlorine-based agents are strictly prohibited.
- Cleaning procedure:
  ① After powering off the device, wipe with an approved cleaning agent using a lint-free cloth (unidirectional wiping).
  ② Thoroughly dry the surface with a clean lint-free cloth.
  ③ Ventilate for at least 30 minutes before reactivation.

2.8.4. Transportation and Storage

(1) Transportation Requirements

- Packing materials must be environmentally friendly, non-toxic, and provide shockproof and moisture-proof protection to ensure transport safety.
- Maintain device stability during transit; tumbling, collisions, or violent shaking are strictly prohibited. Loading and unloading must be performed using professional equipment and standardized procedures.
- For long-distance or extreme-environment transport, additional thermal insulation, moisture barriers, or reinforced packaging are required to prevent damage.

(2) Storage Requirements

- Storage in accelerator rooms is strictly prohibited to avoid radiation-induced component aging (annual attenuation rate $\geq$ 15%).
- The device must be kept at least 3 meters away from MRI equipment to avoid exposure to strong magnetic fields.
- Storage areas must be free of corrosive gases and maintain adequate ventilation.
- It is recommended to store the device horizontally in its original IP67-rated shockproof flight case.

(3) Environment Requirements

Transportation and storage conditions must meet the following requirements:

Temperature	0°C ~ 55°C
Pressure	700hPa ~ 1100hPa
Relative Humidity	10% ~ 90%

(4) Warning Notes

- It is strictly prohibited to expose the main control box, AutoScanner CCM, or other core components to radiation fields (dose rate limit: $\leq$ 0.1 mGy/h).
- For long-term storage or non-use, unplug the power supply to prevent standby current from accelerating component aging.

2.8.5. Operating Environment

- Maintain a clean, dry environment at suitable room temperature during operation.
- Avoid exposing equipment to low temperatures, high pressure, excessive moisture, solvents, or reactive vapors.
- After sudden temperature/humidity changes, ensure complete drying before power activation.
- The operating environment must meet the following requirements:

Temperature	+10°C ~ +40°C
Pressure	700hPa ~ 1100hPa
Relative Humidity	20% ~ 80%, with no condensation

2.8.6. Emergency Measures

- When the device experiences external shocks, vibrations, or overload, first check for visible damage on the exterior to ensure there is no internal damage. If severe

damage is found, immediately stop using the device, document its condition, and contact professional personnel for repairs.
- If the device shows signs of overheating, abnormal noise, or other malfunction symptoms during operation, immediately stop using it, disconnect the power, and then contact technical support for troubleshooting.
- When cleaning the device, if any components are loose or detached, immediately stop cleaning and check that all connections are secure. If there are issues, contact technical support for inspection and repair.
- If the device experiences a system failure or operational abnormality, perform a preliminary check to see if the device is affected by moisture or water, or if any parts show signs of obvious wear. For further diagnosis, please contact technical support.

2.9. Environmental Protection & Equipment Disposal Statement

At the end of its service life, this system and its accessories must be disposed of in the following manner:

Device Disposal
- Contact the Raydose After-sales Service Center (service@raydose.com) for professional collection and recycling.
- Do not disassemble, incinerate, or discard the device as general waste to avoid the risk of leakage from radiation-sensitive components.

Consumables and Residue Handling
- Components containing radiation-sensitive materials (e.g., ionization chambers, sealing gaskets) must be classified as chemical waste and disposed of by certified waste management institutions.
- Water from the tank must be drained via the water storage trolley into treatment facilities designated by the medical institution.

Packaging Materials
- Transport packaging materials such as foam and plastic film should be disposed of as recyclable waste.

2.10. User Suggestions and Complaint Handling

Users can provide feedback through the following channels:
- **Email:** service@raydose.com
- **Feedback via Agents:** Users can also directly report device issues or file complaints with Raydose's authorized agents.

We will respond to your feedback as soon as possible and provide you with full support and solutions.

3. Product Description

3.1. Composition

AS600 system consists of the following components:

Category	Name	Model	Quantity
Hardware	AutoScanner 600	AS600	1
	AutoScanner Mover	M-I	1
	AutoScanner CCM	CCM-I	1
	AutoScanner Reservoir	R-I	1
	AutoScanner RC	RC-I	1
Accessories	Detector	-	1
	-	-	1
	-	-	1
	-	-	1
Software	XBeam	-	1

3.2. Terminology Description

Abbreviation	Full Term	Description
QA	Quality Assurance	Ensures that medical devices or software systems meet defined performance standards to guarantee treatment quality and safety.
TPS	Treatment Planning System	A software system used to design radiotherapy treatment plans, including dose calculation and beam optimization.
MLC	Multi-Leaf Collimator	A radiation shielding device consisting of independently movable high-density metal leaves, mounted at the beam output of a linear accelerator for precise conformal irradiation.
IP	Internet Protocol Address	A unique identifier for a device on a network, used for communication and remote access.
AAPM	American Association of Physicists in Medicine	-
IAEA	International Atomic Energy Agency	-
IEC	International Electrotechnical Commission	-
Profile	-	A dose distribution curve measured at a specific depth along a direction perpendicular to the beam's central axis (X/Y direction).
MU	Monitor Unit	A unit used in radiotherapy to control the output of the linear accelerator, corresponding to a defined radiation dose.

PDD	Percentage Depth Dose	The percentage ratio of absorbed dose at a specific depth to the dose at the reference depth along the central axis of the beam.
OAR	Off Axis Ratio	The ratio of the dose at an off-axis point to the dose at a point on the central axis at the same depth.
PD	Point Dose	The radiation dose measured at a specific point in space.
TPR	Tissue-Phantom Ratio	The ratio of the radiation dose (or dose rate) measured at a specific depth within a phantom to the dose at a reference depth, with both measurements taken at the same source-to-detector distance and field size.
TMR	Tissue-Maximum Ratio	The ratio of the dose rate at a given point in a phantom to the dose rate at the same source-to-axis distance (SAD) and the reference depth of maximum dose (dmax).
PDI	Percentage Depth Ionization	The ratio of the ionization charge at a given depth to the maximum ionization charge within a phantom, typically water.
Sp	Phantom Scatter Correction Factor	The ratio of the dose rate at a reference depth in a phantom for a given field size to the dose rate at the same depth for a reference field size (often 10x10 cm²) with the same collimator opening.

3.3. Data Interface Instructions

(1) User Access Control Requirements
- The system must be bound to an authorized certificate file on a designated computer before it can be accessed.
- If the certificate file is lost, please contact Raydose or an authorized service representative immediately to request recovery.

(2) Data and Equipment Communication Mechanism
- The system establishes communication between the control host and embedded devices based on the TCP/IP protocol, ensuring real-time data interaction and stable remote control.

3.4. Network Security Description

3.4.1. Network Architecture

The AS600 system adopts a point-to-point physical direct connection architecture. The XBeam software on the PC connects directly to the AutoScanner CCM via an

Ethernet cable. This communication method does not require access to a local or wide area network and does not rely on any routers, switches, or other network devices. It effectively isolates the system from external network risks and enhances the security and stability of data transmission.

3.4.2. Communication Security Requirements

(1) Physical Connection Security
- Only shielded Ethernet cables provided by the manufacturer (e.g., 25-meter Gigabit Ethernet cables) may be used. Non-standard or damaged cables are strictly prohibited.
- Ensure cable connections are secure during operation to avoid disconnections or communication errors due to loose or poor contact.

(2) Data Security Assurance
- The system uses the TCP protocol to implement end-to-end encrypted communication, with encryption keys dynamically generated from the device certificate, effectively preventing data leakage or tampering.
- All measurement data is stored locally on the computer. It is not transferred via external storage media or cloud services, further ensuring information security.

(3) Access Control
- Each system is bound to a unique authorization certificate. Unauthorized computers cannot establish a connection.
- User accounts can be managed through the local operating system (e.g., Windows User Account Control) to restrict access by unauthorized users.

3.4.3. Abnormal Response and Maintenance

- **Communication failure handling:** If a disconnection occurs (e.g., due to a cable disconnection), network status can be checked via the CCM indicator lights. The AS600 system indicators can also be used to assess the operational status of each module.
- **Firmware updates:** For controller firmware upgrades, please contact Guangzhou Raydose Medical Technology Co., Ltd.

3.5. Operating Environment Requirements

(1) Software Environment
- Operating system: Microsoft Windows 10 or Windows 11 (64-bit versions)

(2) Recommended Computer Hardware Configuration
- CPU: Intel Core i5 (8th Gen or higher), or equivalent AMD processor
- Memory: 8GB DDR4 or above
- Storage: 512GB SSD or HDD

(3) Network Requirements
- Network interface: Wired Ethernet connection supporting 100 Mbps or higher (Gigabit network card recommended)

4. Hardware

4.1. Composition

The hardware components and associated cables of the AS600 system include the following:

Category	Name	Model	Quantity	Remark
Hardware	AutoScanner 600	AS600	1	-
	AutoScanner Mover	M-I	1	-
	AutoScanner CCM	CCM-I	1	-
	AutoScanner RC	RC-I	1	-
	AutoScanner Reservoir	R-I	1	-
Detector	Detector	-	2	0.13cc ionization chamber
Cable Kit	CCM Connection Cable	-	1	2.8 m
	P/D Cable	-	1	0.6 m
	Power Supply and Power Cable	-	1	-
	Power Adapter Cable	-	1	0.3m
	Ethernet Cable	-	1	-

The overall schematic of the system is shown below:

Figure 1. AS600 Overview Diagram

①	②	③	④	⑤	⑥
Main Control Box	Motion Structure	Detector Holder	Box	Water Pipe Interface	Motion Platform

4.2. AutoScanner 600

4.2.1. Introduction

- The AutoScanner 600 serves as the core component of the AS600 system. It primarily comprises a main control box, motion structure, water pipe interface, and other key components.
- During operation, the AS600 must be connected to additional modules such as the AutoScanner CCM, AutoScanner RC, and detectors, and used in conjunction with XBeam software for measurement and data analysis.
- The bottom of the AS600 is equipped with carrying handles to facilitate transport and handling by users. The AS600 can operate independently for measurements under O-arm conditions.
- When used in combination with the AutoScanner Mover, it also supports measurements under C-arm conditions, thereby fulfilling a wide range of clinical measurement requirements.
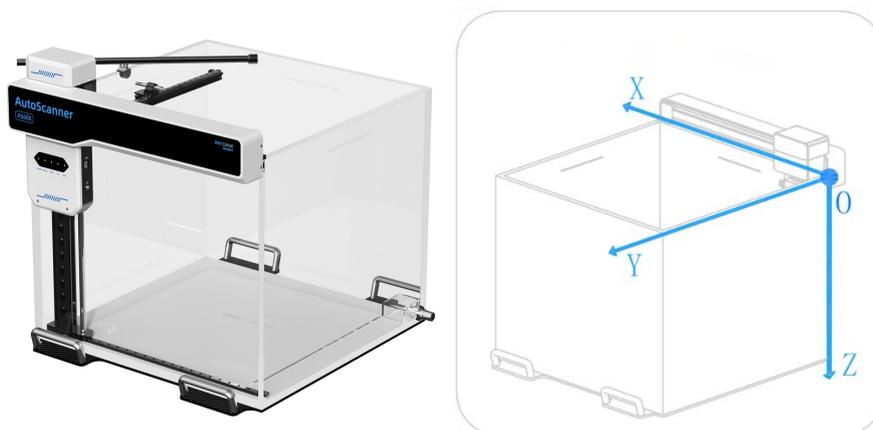
Figure 2. AS600 (left) and mechanical coordinate diagram (right)

4.2.2. Technical Parameters

AutoScanner 600	
External Dimensions (L×W×H)	724 mm × 665 mm × 624 mm
Internal Dimensions (L×W×H)	585 mm × 575 mm × 497 mm
Scanning Range: Without Mover (L×W×H)	470 mm × 470 mm × 400 mm
Scanning Range: With Mover (L×W×H)	580 mm × 580 mm × 400 mm
Wall Thickness	15 mm
Water Volume	151.7±1 L
Weight	38.4±1 kg
Minimum Step Size	0.1 mm
Maximum Scanning Speed	50 mm/s
Repeatability	≤ 0.1 mm
Material	PMMA
Scanning Modes	Continuous Mode and Step Mode

4.2.3. Main Control Box
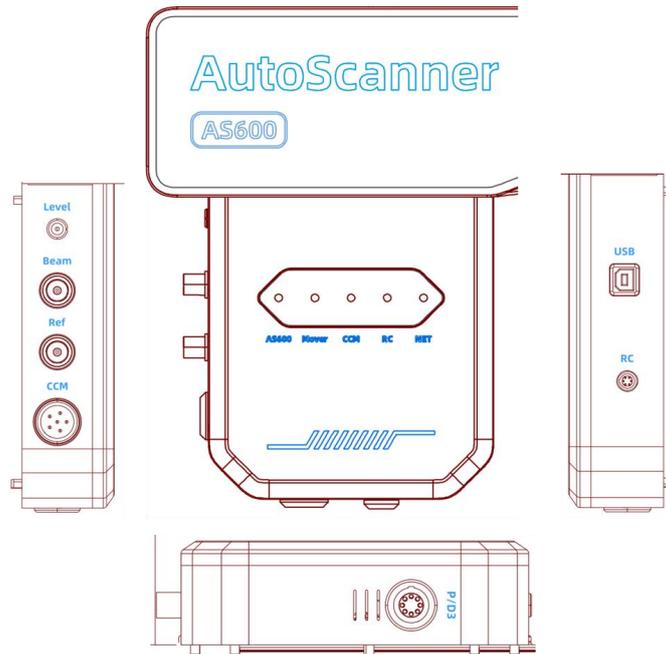
Figure 3. Main Control Box

Category	Label	Description
Cable Interfaces	Level	Water level sensor cable port
	Beam	Field detector cable port
	Ref	Reference detector cable port
	CCM	CCM cable port
	P/D3	Power cable port
	RC	RC cable port
	USB	Programming/debugging cable port
Indicator Lights	AS600	System status indicator
	MOVER	Mover operation status indicator
	CCM	CCM operation status indicator
	RC	RC operation status indicator
	NET	Network status indicator

Note: When the indicator lights are properly connected and functioning normally, they will remain steadily lit.

4.3. AutoScanner Mover

4.3.1. Introduction

The AutoScanner Mover is designed to work in conjunction with the AutoScanner 600 for radiation beam measurements. It enables positional adjustment and movement of the AS600, expanding the measurement range. Its main structure is illustrated below.

Figure 4. AutoScanner Mover Structural Diagram

① **Motion Platform:** Controlled via the remote control or XBeam software, it allows horizontal movement of the system to extend the scanning range.

② **Cable Connection Panel:** Central interface for power and signal cable connections, ensuring stable data transmission and power supply between the platform and system components.

③ **Mechanical Push Rod:** Used to manually push the entire system for horizontal repositioning during setup or adjustment.

④ **Motorized Lifting Column:** Controlled via the remote control or XBeam software, enabling height control during measurement.

⑤ **Retractable Universal Wheels:** Equipped with a self-locking mechanism, the wheels can be extended or retracted via a handle.

4.3.2. Technical Parameters

AutoScanner Mover	
Dimensions (L × W × H)	1100 mm × 920 mm × 710 mm
Weight	96 ± 1 kg
Maximum Scanning Range (X/Y)	± 55 mm

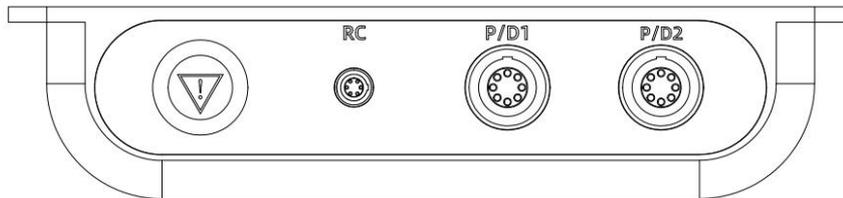| Lifting Range	0 ~ 400 mm
No-Load Lifting Speed	2.8 mm/s
Maximum Scanning Speed (X/Y Direction)	5 mm/s
Maximum Load Capacity	300 kg

4.3.3. Cable Connection Panel

Figure 5. Cable Connection Panel

Label	Description
⚠	Emergency Stop Button: Press to cut off power; rotate the button to restore power.
RC	RC Port: Used to connect to the AutoScanner RC.
P/D1，P/D2	Power Cable Port: Used to connect to the power supply cable.

Note:
- When using the AutoScanner Mover, the P/D cable must be connected at one end to the P/D3 interface on the main control box, and at the other end connected to the power supply via the power adapter cable.
- The AutoScanner RC can be connected to either the RC interface on the main control box or on the Mover, depending on the user's needs.

4.4. AutoScanner Core Control Module(CCM)

4.4.1. Introduction

The AutoScanner CCM converts the charge signals output from the detector into voltage signals. It supports two power supply methods:
- Direct power supply via the power cable.
- Power supply through connection to the main control box using the P/D cable.

The CCM can be used in two modes:
- **Connection to Main Control Box:** The CCM can be connected to the main control box via cable and to the computer via Ethernet cable, working together with the AS600 system to perform measurements.
- **Use as an Electrometer:** The CCM can be connected via cable to other AS series water phantoms, powered by a power adapter, and connected to the computer via Ethernet cable to perform measurements with the AS series water phantom
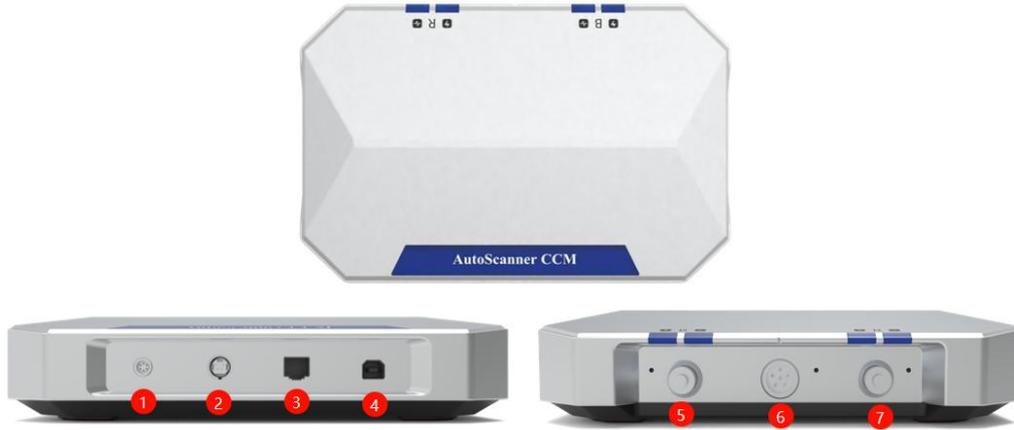
Figure 6. AutoScanner CCM

①	②	③	④	⑤ (B)	⑥	⑦ (R)
Adapter Port	Power Port	Network Port	USB Port	Field Detector Port	P/D Port	Reference Detector Port

4.4.2. Technical Parameters

AutoScanner Core Control Module(CCM)	
Resolution	≥ 10 fA
Voltage	(0 ···±450) V, step size 1 V
Time Constant	≤ 10 ms
Charge	2pC—10C, resolution 10 fC
Current	1 pA-200 nA
Leakage Current	≤ 100.0fA, typical leakage ≤ 10.0 fA
Linearity	≤ ± 0.5%
Long-term Stability	≤ ± 0.5%
Repeatability	≤ ± 0.5%

4.4.3. Indicator Status

Indicator	Description
⚡	High Voltage Indicator Light: Indicates whether the device has detected a high voltage signal. • Steady On: High voltage detected. • Off: No high voltage detected / power not connected. • Breathing Light Effect: Power connected, but no network connection.
⎍	Detector Signal Indicator Light: Indicates whether the detector signal is received. • Steady On: Signal detected. • Off: No signal detected / power not connected. • Breathing Light Effect: Power connected, but no network connection.

	Network Connection Indicator Light: Indicates the network and software connection status of the device.
AutoScanner CCM	• Steady On: Device connected to the network, but not connected to the software. • Breathing Light Effect: Device not connected to the network. • Running Light Effect: Device successfully connected to the network and communicating with the software. • Off: Device power is off.

4.5. AutoScanner RC

4.5.1. Introduction

The AutoScanner RC features a touch screen design, supporting direct control of the detector, AutoScanner Mover, and AutoScanner CCM. Additionally, the AutoScanner RC can be used to perform system settings operations, including starting background measurements and setting isocenter.
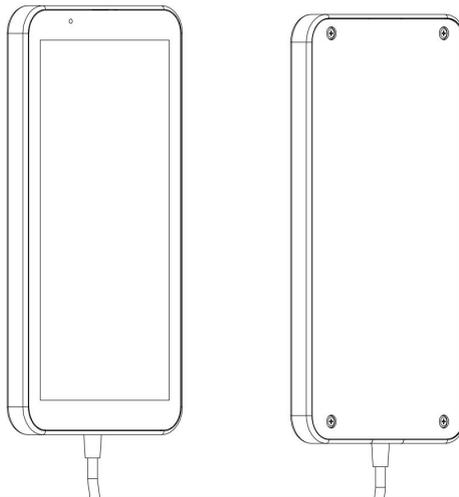

Figure 7. AutoScanner RC Appearance

4.5.2. Technical Parameters

AutoScanner RC	
Dimensions (L × W × H)	147mm × 76mm × 9.8 mm
Display Type	TFT LCD
Display Size	5.45 inch
Display Resolution	720 (RGB) × 1440 (dot)
Display Colors	16.7 M

4.5.3. AutoScanner RC Interface

After powering on the AS600 system, connect the AutoScanner RC to the RC Port on the main control box to activate it. Upon startup, the AutoScanner RC defaults to the "Detector" page, where users can control functions and switch between pages via touch operation. The functions of each page are described as follows.
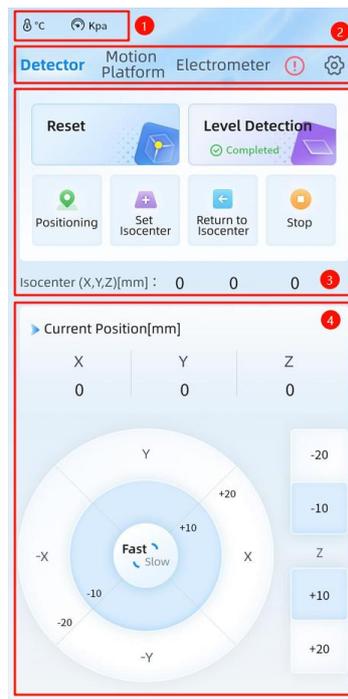
(1) Detector

Figure 8. AutoScanner RC_Detector Page

① Temperature and Air Pressure Display: Automatically measures and displays the internal water temperature of the AS600 and the current atmospheric pressure.
② Page Switching: Allows switching between the "Detector," "Motion Platform," and "Electrometer" pages.
③ Function Buttons: Provides quick access to detector-related operations such as reset, level detection and positioning.
④ Motion Control: Directly controls detector movement along the X, Y, and Z axes, with real-time display of the current position. Speed can be adjusted by tapping button, with speed settings of 0.1, 1, 10, and 20 mm/s. Short press moves the detector stepwise, long press enables continuous movement.

(2) Motion Platform
This page controls the movement of the Mover in the X/Y plane and Z axis. The operation is the same as on the "Detector" page.
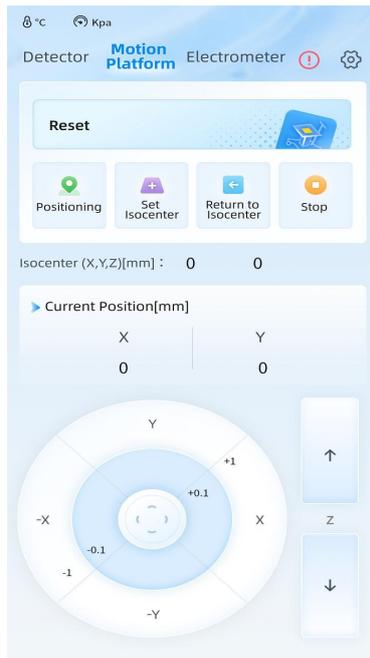
Figure 9.　AutoScanner RC_Motion Platform Page

(3) Electrometer

This page controls the electrometer (i.e., the AutoScanner CCM). Users can set the voltage for the detector, start or stop background measurement, and monitor system status in real time.
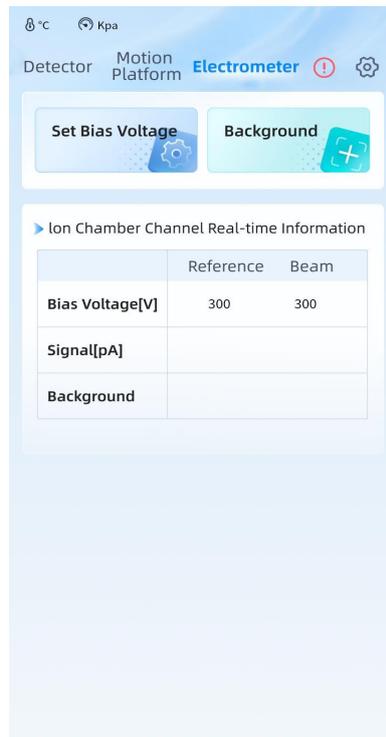

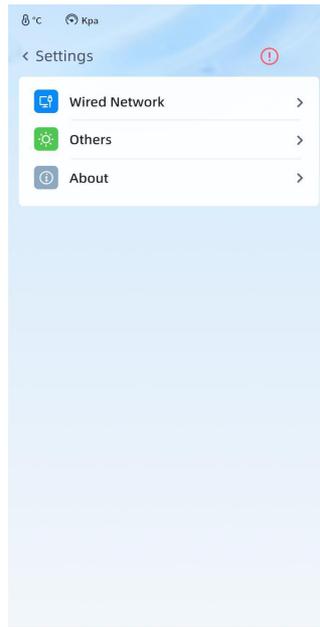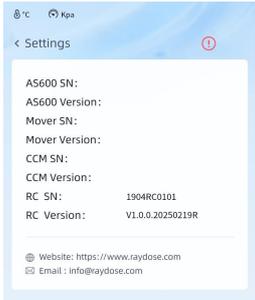Figure 10. AutoScanner RC_Electrometer Page

(4) Settings

Figure 11. AutoScanner RC_Settings Page

Tap ⚙ to enter the settings page. The descriptions of each item are as follows:

Name	Item	Description
Wire Network		View and configure network connection details such as IP address.
Others		Adjust the screen brightness, switch display language, or enter "Transport Mode" (in this mode, moving parts automatically move to positions suitable for packaging and transport).
About		View product-related information.

(5) Warning Information

When the system encounters an abnormal condition, a warning button ⓘ will appear on the interface. Tap ⓘ to enter the warning page and view details information.
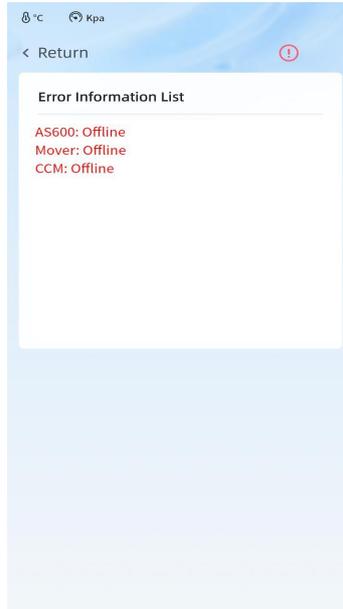

Figure 12. AutoScanner RC_Warning Information

4.6. AutoScanner Reservoir

4.6.1. Introduction

- The AutoScanner reservoir is used for liquid storage and transportation. Equipped with a built-in water pump, it can be connected to the AutoScanner 600 via water pipe to enable automatic water filling and draining. The reservoir features a touchscreen, allowing users to conveniently control the water filling and draining operations.
- The device supports automatic water level detection. When an excessively high or low water level is detected, it will automatically stop filling or draining to ensure system safety.
- If the water level becomes too high, users can initiate draining by tapping the button 🔲 on the touchscreen, or manually release water through the drain outlet located at the bottom of the device.
- Manual water filling procedure:
  ① Open the top cover of the AutoScanner Reservoir.
  ② Remove the internal sealing plug.
  ③ Pour water into the reservoir through the opening.

Figure 13. AutoScanner Reservoir

4.6.2. Technical Parameters

AutoScanner Reservoir	
Dimension (L × W × H)	696mm × 570mm × 1005 mm
Unladen Weight	37 kg
Water Capacity	180 L

4.6.3. Touchscreen Button Description

Figure 14. Touchscreen

Button	Description
	Drain water from the reservoir to the outside.

⏸	Stop the current filling or draining operation.
📥📦	Fill water into the reservoir.

4.7. Water Level Sensor

• The water level sensor is used to detect the water level inside the AutoScanner AS600.

• To ensure measurement accuracy, the sensor must be used in a purified water environment.

• It should be securely mounted on the motion structure of the AS600 and must be positioned in such a way that it does not interfere with or collide with any other components during measurement.
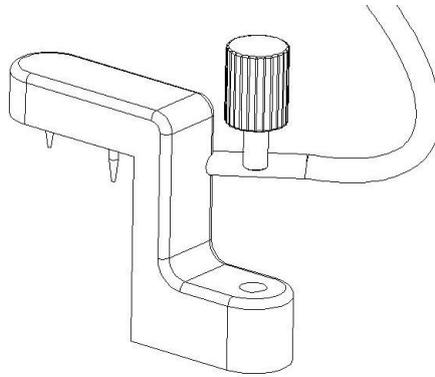

Figure 15. Water Level Sensor

4.8. Cable Kit

Figure 16. Cable Kit

No.	Name	Connection Method
1	CCM Connection Cable	• Length: 2.8 m. This cable supplies power to the CCM and transmits detector signals received by the main control box to the CCM. • Connect one end to the CCM port on the main control box, and the other to the P/D port on the CCM. • To avoid interference from radiation, ensure the CCM is positioned away from the radiation source during use.
2	Water Level Sensor and Cable	• This component detects the water surface height in real-time and transmits the information to the main control box. • Mount the sensor on the motion rod and connect the other end to the Level port on the main control box.
3	P/D Cable	• Length: 0.6 m. This cable provides both power and data transmission between two modules. • Connect one end to the P/D2 port on the Mover, and the other to the P/D3 port on the main control box.
4	Power Adapter (with Conversion Cable)	• Connect one end to the Mover via the power conversion cable (No. 5), and the other end to the power cable (No. 7).
5	Power Conversion Cable	• Converts the output end of the power adapter to a compatible interface for the Mover. • Connect one end to the power adapter (No. 4) and the other to the P/D1 port on the Mover.
6	Ethernet Cable	• Enables data communication between the XBeam software and the AS600 system. • Two connection options: ① Connect directly from the CCM's network port to the computer's Ethernet port. ② Connect from the CCM to a local area network (LAN) switch or port, the computer must also be connected to the same LAN (via Ethernet or Wi-Fi).
7	Power Cable	• Used to supply power to the system. • Connect one end to the power adapter (No. 4), and the other to a standard power outlet.
8	AutoScanner RC and Cable	• Can be connected to the RC port on the main control box or on the Mover.
9	Ionization Chambers and Cables	• The field detector is mounted on the motion rod and connected to the Beam port on the main control box. • The reference detector is mounted on the fixed support and connected to the Ref port on the main control box.

5. XBeam

5.1. Overview

- XBeam is the dedicated control software for the AS series water phantoms. It is used to set measurement conditions, control scanning procedures, view and analyze measurement results, and assist in the commissioning, calibration, and acceptance testing of radiotherapy equipment.
- The XBeam software supports the following measurement conditions and data acquisition functions:

Item	Description
Measurement Types	Supports acquisition and analysis of PDD, OAR, and Point Dose.
Analysis Protocols	Built-in analysis protocols including IEC, IAEA, AAPM, Elekta, and Varian, also supports user-defined settings.
Photon Energies	Compatible with 6X, 6FFF, 10X, 10FFF, 15X photon beams.
Electron Energies	Supports electron beams in the range of 4 to 18 MeV.
Wedges	Wedges Compatible with Varian wedges (W15, W30, W45, W60) and Elekta W60, other compatible models also supported.
Cones	Supports cone measurements with Elekta (A6, A10, A14, A20, A25, SSD = 95 cm) and Varian (Cone6–Cone25, SSD = 100 cm).
Detector Types	Supports various detector types, including Farmer ionization chambers, plane-parallel ionization chambers, and semiconductor detectors.

5.2. Login

Upon launching the XBeam software, the system will display the login page. Users must enter the username and password to proceed to the main interface.
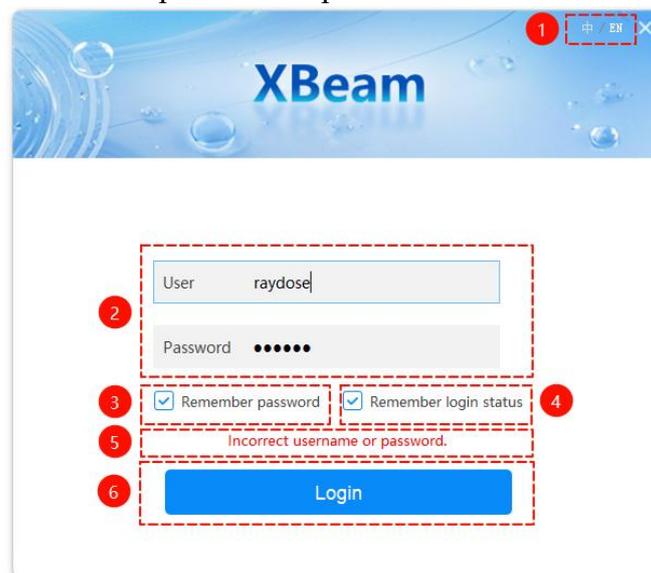

Figure 17. Login Page

① Language Switch. Click here to switch between Simplified Chinese and English interfaces.

② Username and Password Input. The default initial username is "admin". It is recommended to change the password after the first login.

③ Remember Password. When selected, the system will save the current password after a successful login and auto-fill it in future sessions.

④ Remember Login Status. When selected, the system will keep the user logged in for 24 hours after a successful login. During this period, the user can re-enter the main interface even after restarting the software.

⑤ Message Prompt. If login fails, the error reason will be displayed in this area.

⑥ Login Button. Click to execute the login operation.

5.3. Main Interface

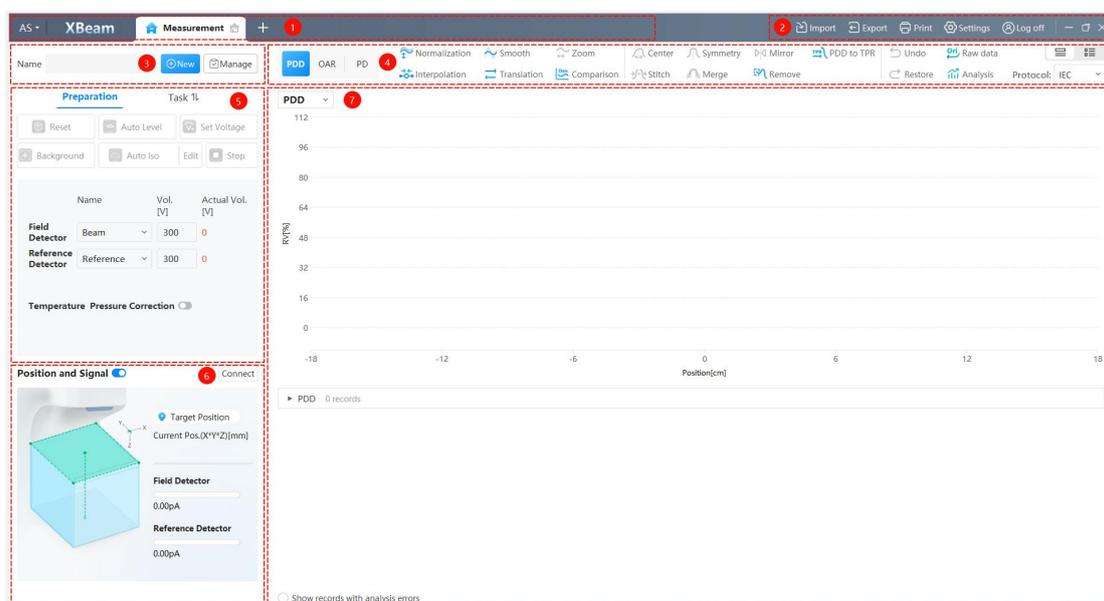After successful login, the system enters the main interface, defaulting to a blank "Measurement Project" page.

Figure 18. Main Interface_Measurement Project Page

① **Tab Bar**

Used to open or switch between different tabs. See section *5.4 Tabs* for details.

② **Top Toolbar**

Provides functions such as importing and exporting the current project. See section *5.6 Top Toolbar* for details.

③ **Project Management Panel**

Used to manage information of the current measurement project. Users can click ⊕New to create a new project or click 🗐Manage to edit tasks under the current project. The project name can be directly edited by clicking the input box, changes will be automatically saved. See section *5.5 Data Management Page* for details.

④ **Data Processing Toolbar**

Used for processing and analyzing measurement curves. For specific functions, see

section *5.8 Project Page*, for algorithm principles, refer to section *6 Algorithms and Formulas*.

⑤ **Measurement Control Area**

Used to control scanning motion, configure measurement parameters, and execute measurement tasks. See section *5.9 Measurement Operation Procedures* for details.

⑥ **Measurement Status Area**

Displays system connection status, real-time detector position coordinates, etc.

⑦ **Display Area**

During measurement, this area displays real-time measurement curves. After measurement, it shows all recorded measurement curves under the current project. See section *5.8 Project Page* for details.

5.4. Tabs

Tabs are located at the top area of the main interface and allow quick switching between different functional modules.
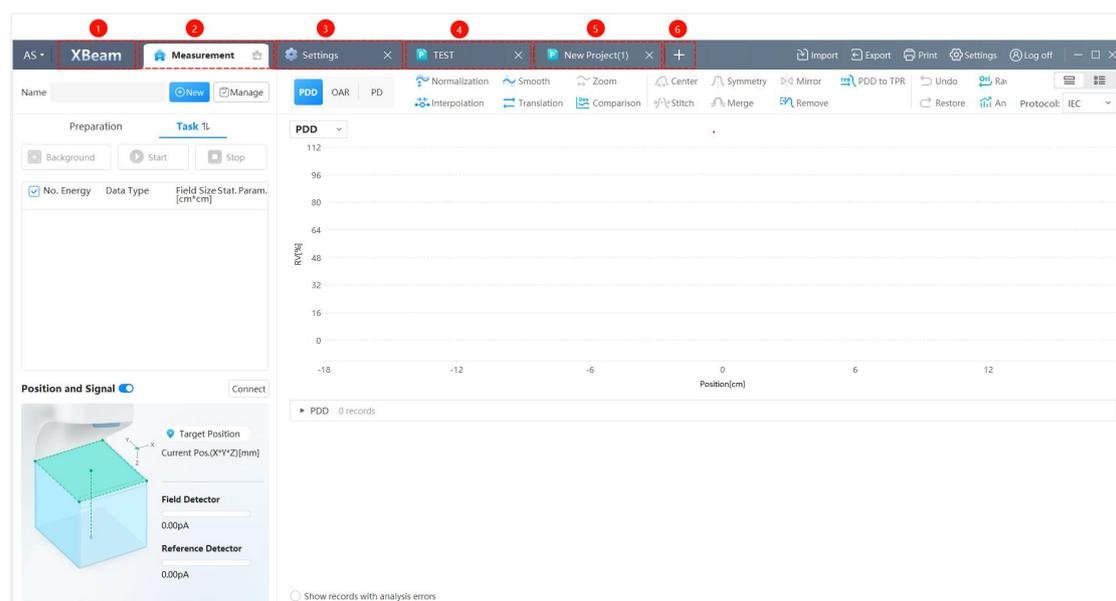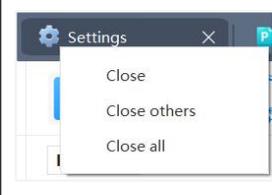

Figure 19. Tabs

① **Data Management:** A Fixed tab. Click XBeam to enter the *Data Management* page.

② **Management Project:** A Fixed tab, click to enter *Management Project* page. To close the currently open project, click 🖼 on the right side of the tab or right-click the tab and select "Close" from the pop-up menu. After closing, the interface will return to a blank *Measurement Project* page.

③ **Settings:** Click the "Settings" button on the top-right corner of the main interface to enter the settings page.
   • Tab Closing Methods: Click ✕ on the right side of the tab to close the page, or right-click the tab to open the following menu.

Menu	Option	Description
	Close	Close only the currently selected page.
	Close others	Close all pages except the current one and the fixed tabs.
	Close all	Close all pages except the fixed tabs.

④ **Historical Project:** When a historical project is opened in the XBeam *Data Management* page, it will appear as a corresponding project tab. Closing behavior is the same as described in item ③.

⑤ **Temporary Project:** Click + to create a temporary project tab. User can copy measurement data from historical project to this temporary project for review or comparison analysis.

• Temporary projects are not saved automatically and will be permanently deleted when closed.

• To save a temporary project, click Save in the *Project Management Panel*. Some functions are only available after the temporary project has been saved (e.g., right-clicking data in the table at the bottom of the page and selecting *Set as Reference* to mark it as the baseline).

• When saving a temporary project, if all measurement data belong to the same institution, the system will automatically assign that institution to the current project. If the institution information is inconsistent, a selection window will pop up after clicking the *Save* button Save . Users can either select an existing institution or double-click the input field to enter a new institution name manually.

• Note: If a user manually enters a new institution name, it will not be automatically added to the list under [Settings > Machine] and will only serve as a filtering condition in the *Data Management* page XBeam .
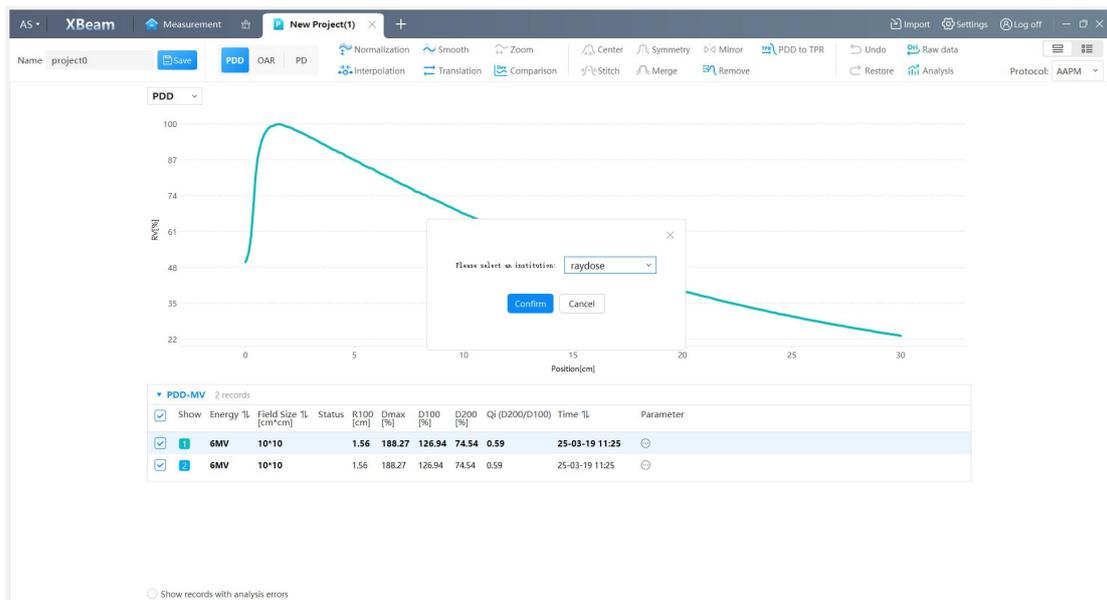

Figure 20. Tabs_Temporary Project

⑥ **New Button:** Click to create a new temporary project.

5.5. Data Management Page

Click the icon ![XBeam] in the upper-left corner of the main interface to enter the *Data Management* page. By default, the page is displayed in Card View.
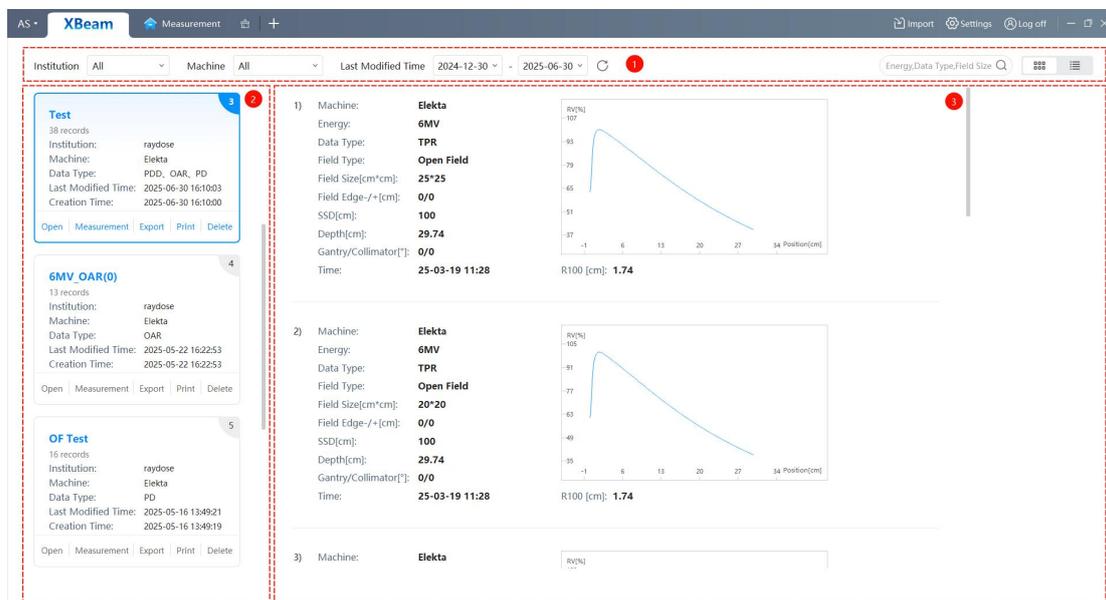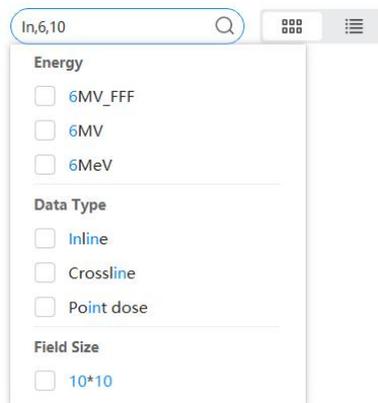

Figure 21. Data Management Page_Card View

① Filter Panel.

• Users can filter projects by Institution, Machine, Last Modified Time, and other criteria.

• Click ↻ to reload the page. This is useful when certain data is not displayed promptly, allowing the content to be updated manually.

• The project search bar (Energy,Data Type,Field Size 🔍) supports fuzzy matching with keywords like "Energy", "Data Type", and "Field Size", enabling quick filtering of relevant projects. After entering a keyword, the page will expand matching results. Users can then check the desired conditions for further filtering. To search with multiple conditions at once, separate the keywords using commas (,). Note: Do not add spaces before or after the commas.

• Click ↻ to refresh the page. Click the view toggle button [⊞] [≡] to switch between **Card View** (⊞) and **List View** (≡).
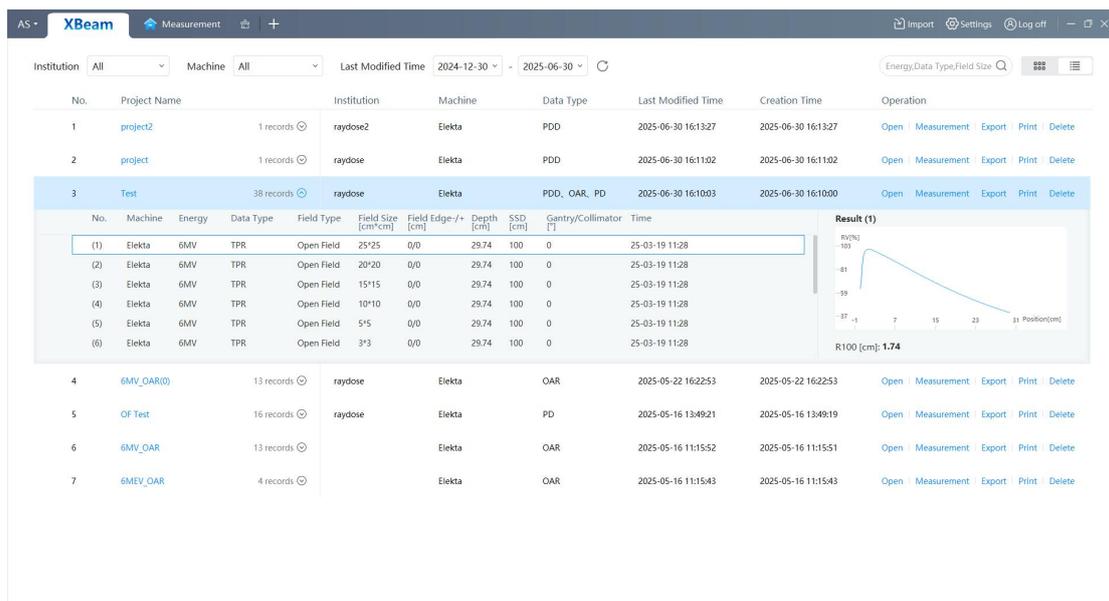
Figure 22. Data Management page_List View

② Project Area.

• A maximum of 12 project cards are displayed per page. Projects are sorted in descending order by last modified time, meaning the most recently edited projects appear first.

• The following operations are supported:

Operation	Description
Open	Open the project in a new tab, or by double-clicking the card. Users can view and operate all data under this project.
Measurement	Load the current project into the Measurement Project page, allowing users to add new measurement data.
Export	Export all data of the current project in .csv format.
Print	Generate a PDF file of the current project for archiving or printing.
Delete	Delete the project and all its associated data.

③ Record Data Area.

• Once a project is selected, this area displays all records under the selected project, sorted by creation time in descending order by default.

• Double-clicking a specific record will open the project in a new tab and automatically highlight the selected record's details.

• Each record consists of two parts, the left side shows basic information, the right side displays analysis images.

➤ For **PDD** and **OAR** types, the right side shows the corresponding measured dose curve.

1)	Machine:	**Elekta**		
	Energy:	**4MeV**		
	Data Type:	**Inline**		
	Field Type:	**Open Field**		
	Field Size[cm*cm]:	**14*14**		
	Field Edge-/+[cm]:	**0/0**		
	SSD[cm]:	**100**		
	Depth[cm]:	**0.6**		
	Gantry/Collimator[°]:	**0/0**		
	Time:	**25-03-19 11:27**		

Penumbra-/+ [cm]: **1.25/1.25**   Flatness [%]: **3.34**   Symmetry [%]: **102.26**

2)	Machine:	**Elekta**		
	Energy:	**4MeV**		
	Data Type:	**Crossline**		
	Field Type:	**Open Field**		
	Field Size[cm*cm]:	**14*14**		
	Field Edge-/+[cm]:	**0/0**		
	SSD[cm]:	**100**		
	Depth[cm]:	**0.6**		
	Gantry/Collimator[°]:	**0/0**		
	Time:	**25-03-19 11:27**		

Penumbra-/+ [cm]: **1.48/1.24**   Flatness [%]: **6.61**   Symmetry [%]: **104.03**
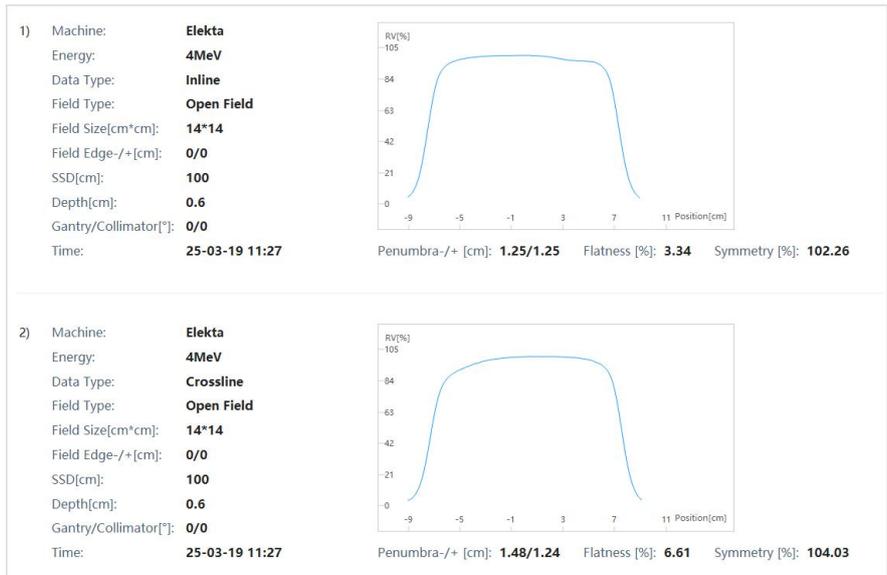
Figure 23. Data Management Page_Record Data Area_PDD and OAR

➢ For **PD** (Point Dose) type records, if the *Generate Curve* operation has not yet been performed, no image will be displayed on the right. To generate the dose curve, go to the Project Page and hold down the Ctrl key to select multiple measurement records. Then, right-click and select *Generate Curve*. This will create point dose curves and corresponding dose values for different fields. (The 🔵 indicates the current record's position.)
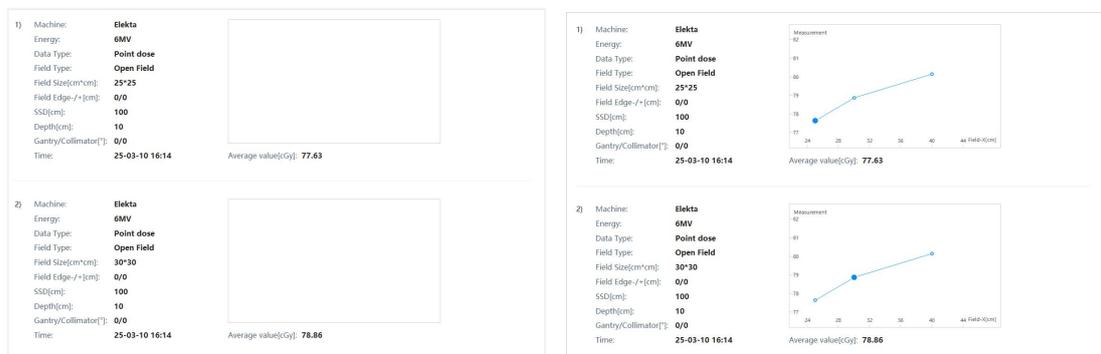

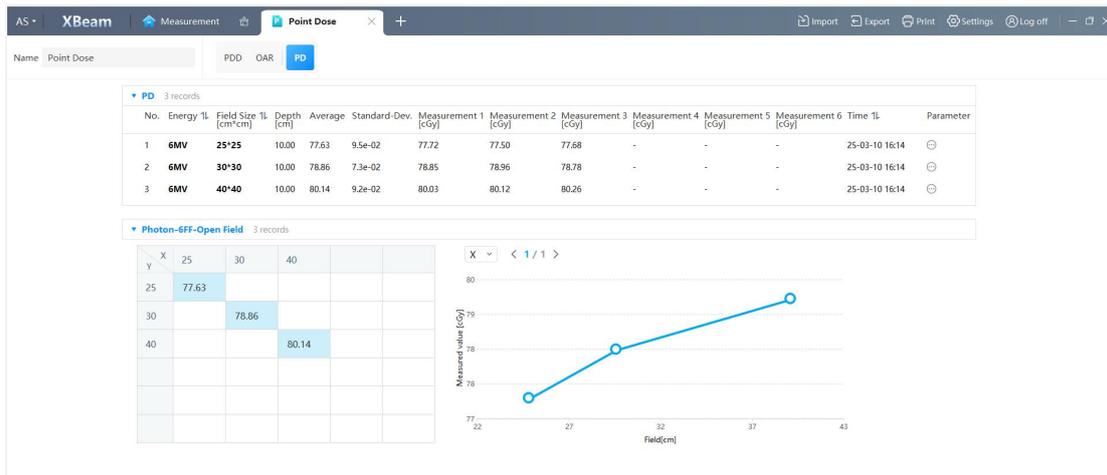Figure 24. Data Management Page_Record Data Area_PD

Figure 25. Data Management Page_Record Data Area_PD Generate Curve Operation

5.6. Top Toolbar

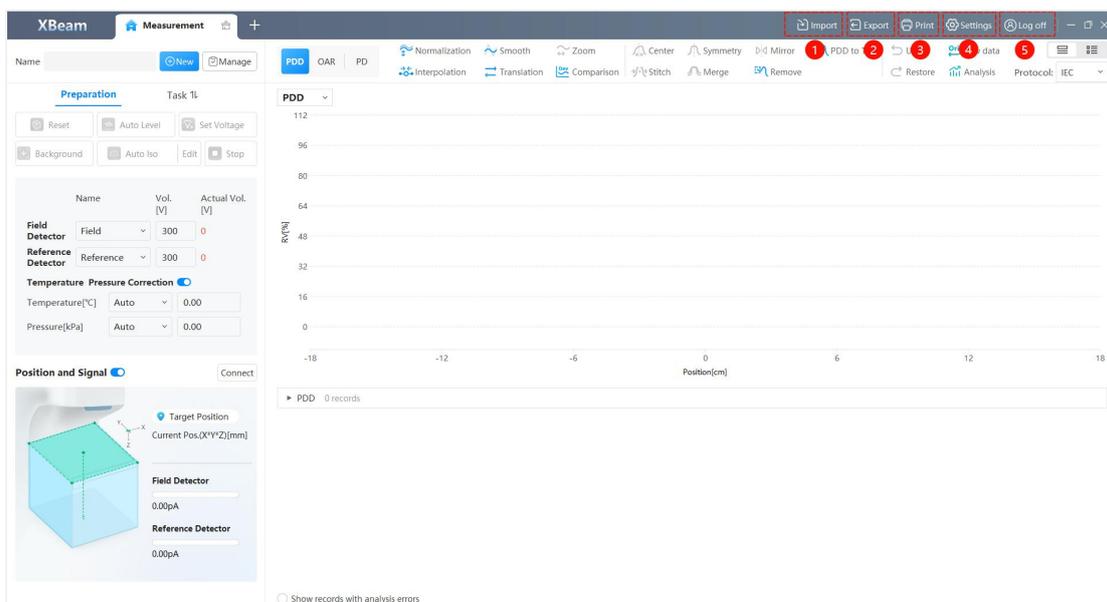The top toolbar is located in the upper-right corner of the main interface.

Figure 26. Top Toolbar

① **Import:** Allow users to import project files from the local computer in .csv format. Only files exported from the XBeam in the standard format are supported, other .csv files will not be recognized.

② **Export:** Available only on the *Measurement Project* and *Historical Project* pages. Used to export measurement data from the current project in .csv format.

③ **Print:** This button is available when the *Measurement Project* page or the *Historical Project* page is open. Clicking 🖶 will open a *Print Preview* window, from which users can export the project report as a PDF file. (For **PD** types, the report includes only the dose curve of the X field.)

Figure 27. Top Toolbar_Print

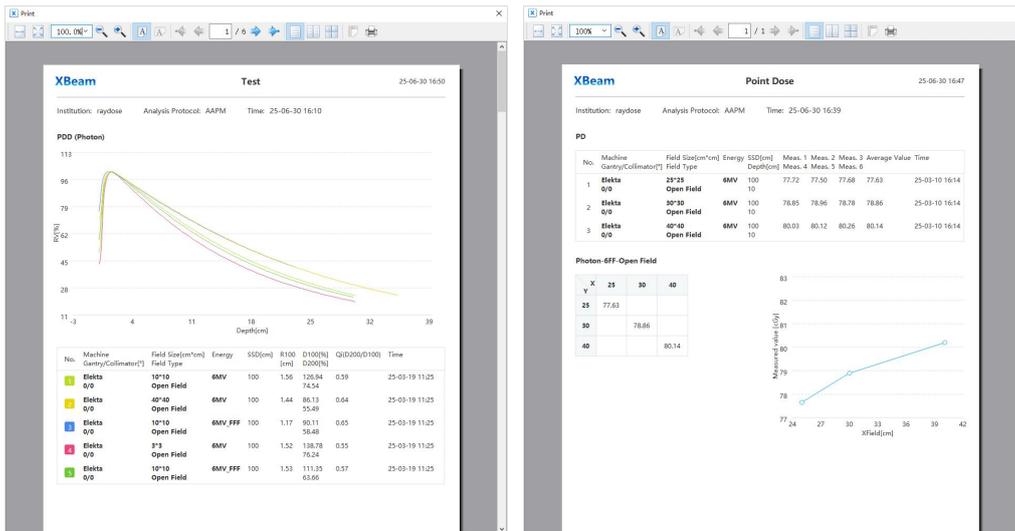④ **Settings:** Open the settings page.

⑤ **Log Off:** Log out the current user and returns to the login screen.

5.7. Settings

Before using XBeam, the relevant system settings must be configured to ensure smooth measurement operations.

5.7.1. Scan

On the *Scan* page, users can configure key parameters of the AutoScanner 600 during the measurement process.
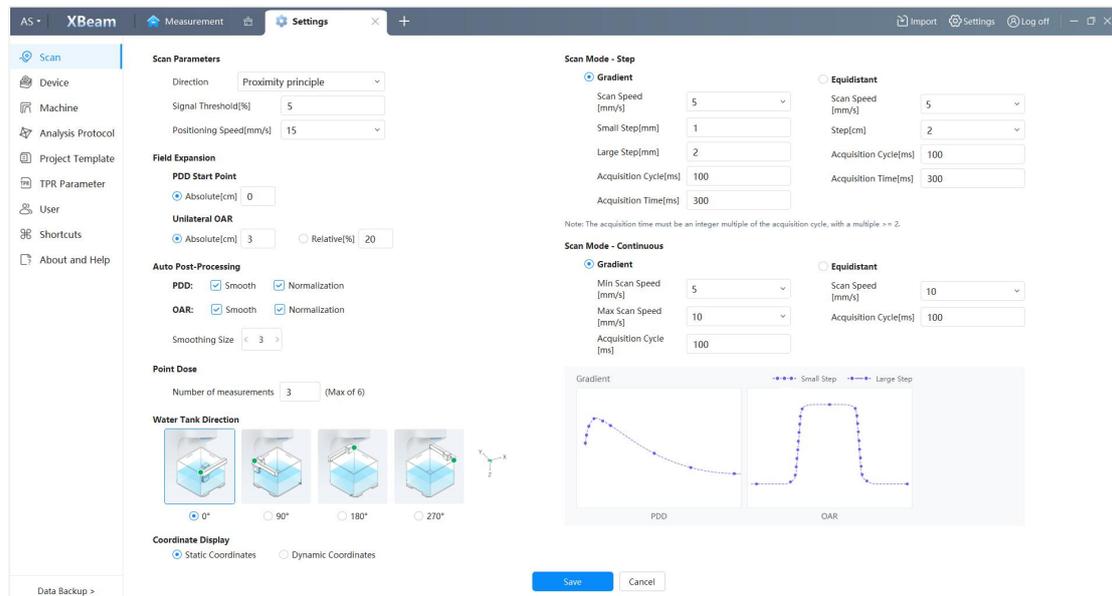

Figure 28. Settings_Scan

5.7.1.1. Scan Parameters

(1) Direction

Used to set the movement direction of the field detector during the measurement process. Two modes are available:

- **Stick to consistent direction:** Measurement always starts from the start point of the task.
- **Proximity principle:** The system automatically identifies the optimal path based on the current position of the field detector and starts measurement from the nearer end (start or end point).

(2) Signal Threshold [%]

- The signal threshold defines when the system initiates data acquisition. The system first calculates a fixed minimum instantaneous current based on a dose rate of 50 MU/min. This value is then multiplied by the user-defined signal threshold **T%** to determine the current threshold I_0 for starting measurement.

$$\text{Threshold current } I_0 = \text{Minimum instantaneous current} \times \text{T\%}$$

- Users can view the real-time current I_B of the reference detector in the lower-left corner of the main interface under *Position and Signal*.
  - ➢ If $I_B < I_0$, the system will remain in standby mode and will not initiate measurement.
  - ➢ If $I_B \geq I_0$, the system will start the measurement.

(3) Positioning Speed [mm/s]

The positioning speed refers to the movement speed of the field detector when it is not performing a measurement. Users can set this speed via a dropdown menu, with selectable values of 5, 15, or 25 mm/s.

5.7.1.2. Field Expansion

To ensure the measured dose profile fully covers the field edges, the system supports field expansion for both PDD and OAR tasks. This allows the scan range to extend beyond the field size.

(1) PDD Start Point

For PDD measurements, the starting point of the scan in the Z-direction can be extended by a user-defined distance (unit: cm).

(2) Unilateral OAR

For OAR measurements, both the start and end points of the scan can be extended beyond the field size in the corresponding directions. The specific expansion direction depends on the data type:

Data Type	Expansion Direction
Crossline	Extended along the X-axis.
Inline	Extended along the Y-axis.
Diagonal 45°/ Diagonal 135°	• Extended along both X and Y axes. • E.g., if the extension distance is d, then for Diagonal 135°, the scan will extend by d in both X and Y directions

Field expansion can be set in two ways:

- Absolute [cm]: Expand the start/end points by a fixed linear distance.
- Relative [%]: Expand the start/end points by a percentage of the field size.

5.7.1.3. Auto Post-Processing

After measurement is completed, the system can automatically perform the following operations on the raw measured data:

(1) Smooth

• The system applies smoothing to the measured curve based on the user-defined smoothing size. Available smoothing sizes: 3, 5, 7, 9, 11.

• Note: The smoothing size must be smaller than the number of data points in the curve. If the smoothing size is too large, the system will prompt that the smoothing has failed and the raw measured data will not be processed.

(2) Normalization

• For PDD, the system normalizes by the maximum value by default.

• For OAR, the system normalizes by the central point value of the field by default.

5.7.1.4. Point Dose

• This setting allows users to define the number of acquisitions for point dose measurements. The minimum is 1 time, and the maximum is 6 times.

• After the measurement is completed, the system automatically calculates the average of all measured values. The displayed point dose represents this average.

5.7.1.5. Water Tank Direction

The AutoScanner 600 supports four different placement orientations. Users must select the correct orientation based on the actual condition setup before starting the measurement.

Figure 29. Settings_Scan_Water Tank Direction

5.7.1.6. Coordinate Display

During the measurement process, the system displays a real-time curve of the current measurement results. This setting defines the display mode of the coordinate view during measurement.

• **Static Coordinates:** The horizontal axis range is preset based on the task's start and end positions. This range remains unchanged during the measurement, meaning the axis does not adjust as additional data points are collected.

• **Dynamic Coordinates:** The horizontal axis range adjusts dynamically in real time as additional data points are collected during the measurement.

5.7.1.7. Scan Mode

This setting configures how the field detector scans during OAR or PDD measurement tasks. The system supports the following two scan modes.

(1) Step Mode

• Definition: In Step mode, the field detector moves at a specified scanning speed and stops at defined intervals (step length). At each acquisition point, the detector pauses for a set acquisition time. During this pause, the system collects multiple sets of data at the configured acquisition interval and averages them to produce the final measurement result for that position.

• Two acquisition methods are available in step mode:

| Parameter	Gradient	Equidistant
Scan Speed [mm/s]	Speed of the detector while moving.	
Step Length [mm]	• Small Step: Suitable for areas with large dose variations (e.g., penumbra). • Large Step: Suitable for areas with small dose variations (e.g., flat region).	The field detector scans from start to end using a fixed step length.
Acquisition Cycle [ms]	Time interval between two successive acquisitions. Minimum: 100 ms.	
Acquisition Time [ms]	• The dwell time at each acquisition point must be an integer multiple of the acquisition period, with a multiplier $\geq$ 2, and a minimum value of 200 ms. • During this dwell time, the system will perform multiple data acquisitions at the set acquisition period and calculate the average of all collected data. The resulting average value will be used as the final measurement result at that position.	

• **OAR Scan_Step Length Explanation**
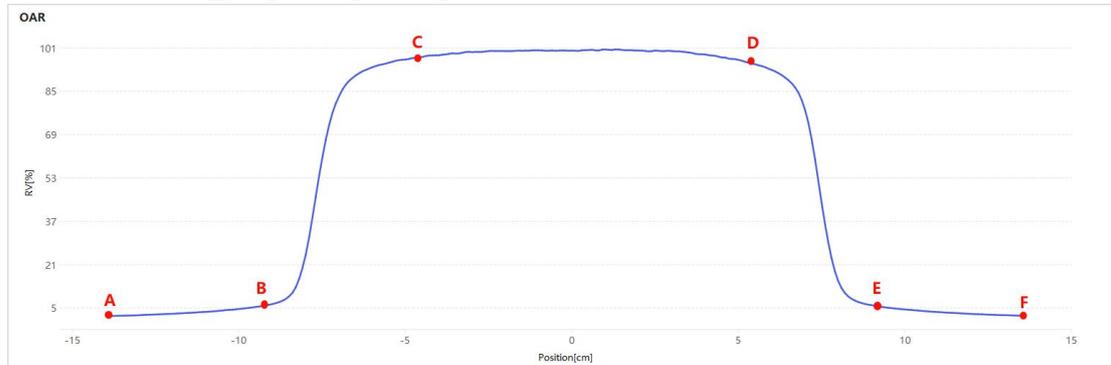
Figure 30. Settings_Scan_Scan Mode (OAR)

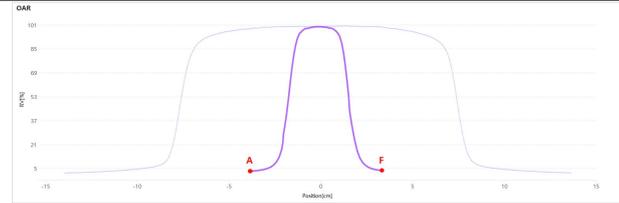| Position	Description	
A	X = Start point	
B	X = Start + Field expansion + Penumbra/2	AB: Large steps
C	X = Start + Field expansion + Penumbra	BC: Small steps
D	X = End － Field expansion － Penumbra	CD: Large steps
E	X = End － Field expansion － Penumbra/2	DE: Small steps
F	X = End point	EF: Large steps
•	In general, the X coordinate relationship follows: A < B < C < D < E < F, and the	

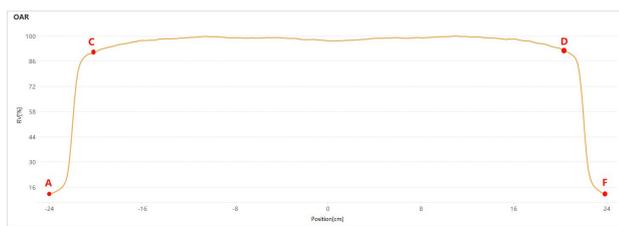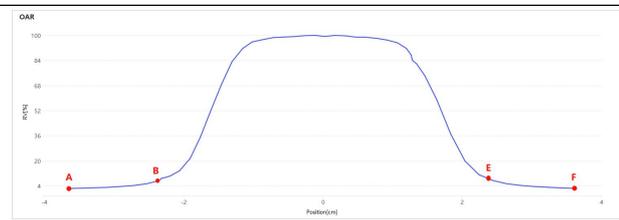|	
step size is set as above. • In special cases, there are three configurations for step size settings. The corresponding instructions are as follows:	
When (A > B, C > D, E > F) or (D < B, C > E): • Remove points B, C, D, and E. • AF: small steps.	
When (A > B, C < D, E > F): • Remove points B and E. • AC and DF: small steps. • CD: large steps.	
When (A < B, C > D, E < F): • Remove points C and D. • AB and EF: large steps. • BE: small steps.	

• **PDD Scan_Step Length Explanation**

During PDD measurement, segment AB uses small steps, while BC uses large steps.
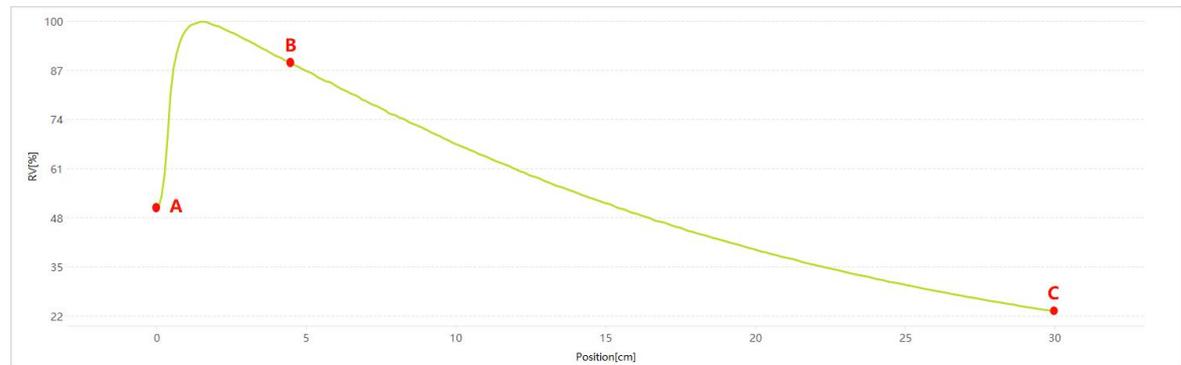
Figure 31. Settings_Scan_Scan Mode (PDD)

(2) Continuous Mode

• .Definition: In continuous mode, the field detector moves continuously at a preset scanning speed. The system performs data acquisition at the configured acquisition interval. Each acquired data is treated as the measurement result at the current position.

• Two acquisition methods are available in continuous mode:

	Gradient	Equidistant
Scan Speed [mm/s]	• Min Scan Speed: Suitable for areas with large dose variations (e.g., penumbra), where the detector moves at a slower speed.	The detector moves at a constant scanning speed throughout the entire scan.

	• Max Scan Speed: Suitable for areas with small dose variations (e.g., flat region), where the detector moves at a faster speed.	
Acquisition Cycle [ms]	Time interval between two successive acquisitions. Minimum: 100 ms.	

• Note: The principle of this mode is similar to the step mode. The key difference is that areas using large step size in step mode correspond to max scan speed in continuous mode, while areas using small step size in step mode correspond to min scan speed in continuous mode.

5.7.2. Device

Before initiating formal measurements, users need to configure the hardware devices and detectors used for measurement on the *Device* page.

Figure 32. Settings_Device

(1)   Water Tank, Motion Platform, Electrometer

Figure 33. Settings_Device_Edit IP

• This section is used to configure the hardware devices required during measurement, including the **Water Tank (AutoScanner 600)**, **Motion Platform**

(Mover), and **Electrometer (CCM)**. Once these devices are properly connected and the correct IP address of the water tank is entered in this page, the system will automatically identify all connected devices and update the corresponding fields (e.g., serial number) in the table.

• Users can add new hardware devices by clicking the IP field in a blank row of the table. In theory, the number of devices that can be added is unlimited. In the current version, only the "Electrometer" column allows IP address entry, which in practice corresponds to the water tank's IP address.

• After adding or editing an IP address, users must click [Save] to save the changes before setting it as the default device. To set a device as default, click the icon ☆ next to the device number. The selected default device will display icon.

• The system will automatically connect to the device. Users can also manually connect devices by clicking [Connect] in the *Position and Signal* on the main interface.

• If the water tank's IP address has been modified via the AutoScanner RC, users must manually update the corresponding IP address in XBeam. Double-click the IP field to edit, and click the button to apply the changes.Double-click the corresponding IP field to edit it, and then click [Save] to apply the changes.

(2) Detector

No.	Name*	Serial Number	Type*	Model*	User Factor*	Sensitivity* [Gy/c]	Default V* [V]	Max V* [V]	Diameter[cm]	Offset[cm]	V Polarity	Remarks
1 ⭐	Reference	SN-18505	FC	IBA CC13	1	2.716e+08	300	350	0.6	-	-	REF-DS02-000
2 ⭐	Field	SN-18505	FC	IBA CC13	1	2.716e+08	300	350	0.6	-	-	REF-DS02-000
3 ☆	Semiconductor		Semiconductor	11	11	1	-	-	-	-	P/+	
4												
5												
6												
7												

[Save] [Cancel]

Figure 34. Settings_Scan_Detector

• This section is used to configure the detectors used during measurement. Click any cell in a blank row to add a new detector. In theory, an unlimited number of detectors can be added.

• After adding a new detector, click [Save] to save the information before setting a default detector. The default detector refers to the one used by default during actual measurements.

• Users can set the default detector by clicking the icon ☆ next to the detector ID. ⭐ indicates the field detector, and ⭐ indicates the reference detector. The system supports only one default field detector and one default reference detector.

• Supported detector types include Farmer ionization chambers, plane-parallel ionization chambers, and semiconductor detectors.

• Fields marked with "*" are mandatory and must be completed before saving.

• For detailed instructions on how to fill in the table, refer to **5.7.11 General Editable Table**.

5.7.3. Machine

Before performing formal measurements, users must configure the institution and associated machine information on the *Machine* page.

- Institutions are responsible for managing machines, while machines manage parameters such as energy, wedge, and applicator.
- For detailed instructions on how to fill in the table, refer to **5.7.11 General Editable Table**.
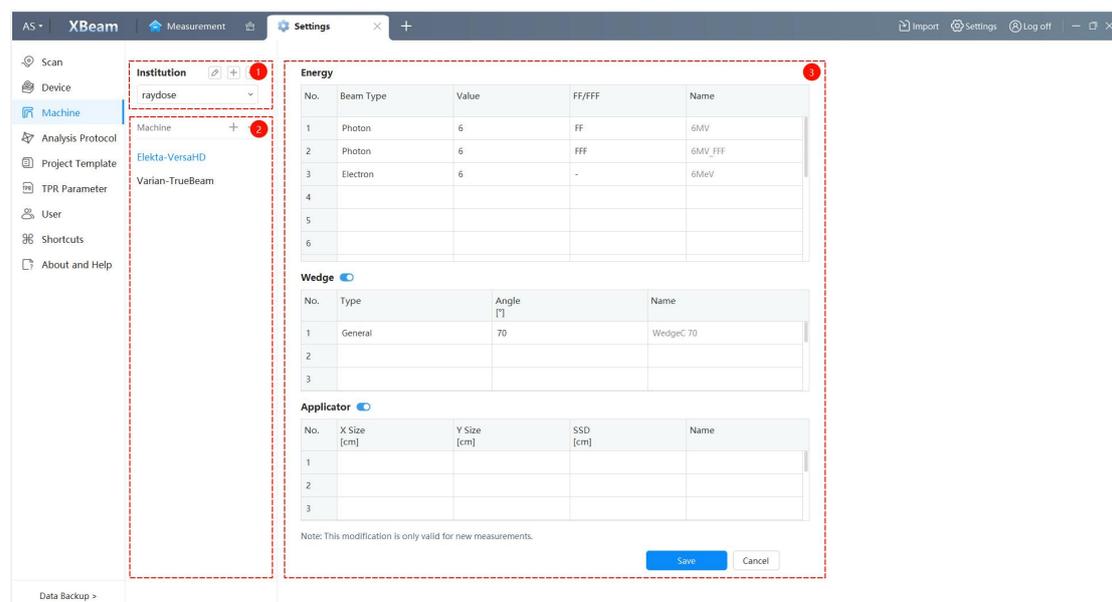
Figure 35. Settings_Machine

① **Institution Management.**
Click ➕ to add a new institution, click ➖ to delete the current institution, click ✎ to edit the name of the selected institution.

② **Machine List**.
- Under the selected institution, users can manage its associated machines: Click ➕ to add a new machine, click ✎ to delete the currently selected machine.
- The software includes basic information on 12 LINACs from four manufacturers:
  - ➢ Elekta: VersaHD, Synergy, Harmony
  - ➢ Varian: TrueBeam, Trilogy, Unique, 2300EX, 600CD, Halcyon, VitalBeam
  - ➢ Siemens: Primus
  - ➢ Neusoft: NMSR600

③ **Machine Management**
After selecting a machine, users can edit the its energy, wedge, and applicator information. These parameters will be recorded as remarks in the measurement results.

5.7.4. Analysis Protocol

On the *Analysis Protocol* page, users can configure the default protocol and corresponding analysis items to be used during measurement analysis.
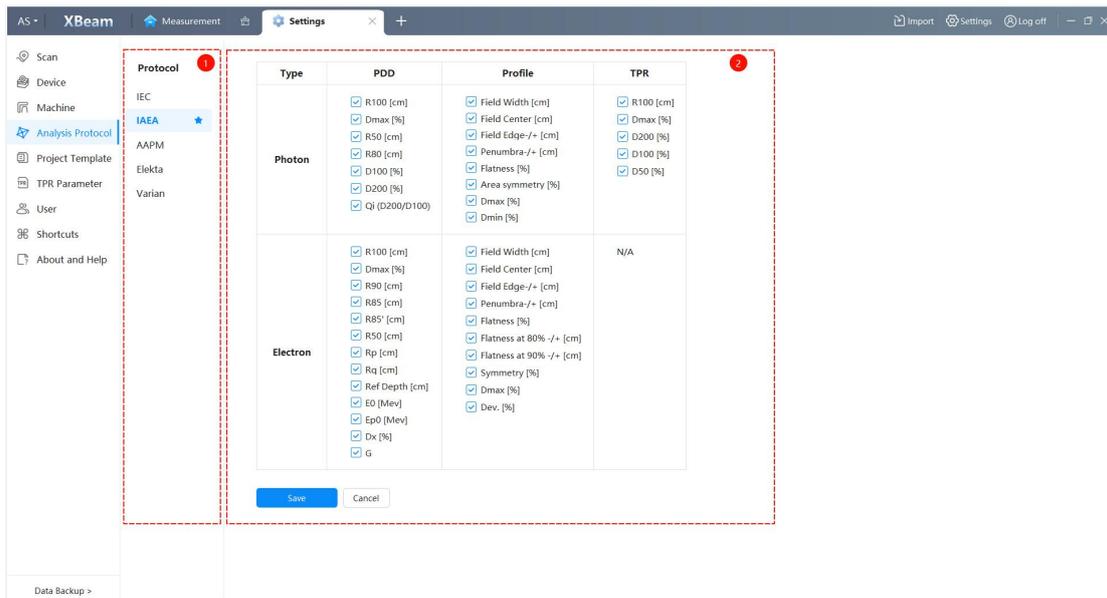
Figure 36. Settings_Analysis Protocol

① **Protocol List**

• The system comes with five built-in analysis protocols: IEC, IAEA, AAPM, Elekta, and Varian.

• Hover over a protocol and click the icon ☆ to set it as the default. Measurement analysis will then use this protocol by default. The default protocol will be marked with the icon ★.

② **Analysis Item List:** The selected (checked) analysis items will be applied during the processing of measurement data.

5.7.5. Project Template

On the *Project Template* page, users can view built-in templates or create custom templates.

Figure 37. Settings_Project Template

① **Template Management.** Templates are divided into two categories: Built-in Templates and Custom Templates.

• Built-in Templates are predefined by the system and cannot be modified.

• In Custom Templates, click ⊞ to create a new template, or click ⊟ to remove the currently selected template. Hover over the template name to reveal the edit button `test        ✎` . Click ✎ to rename the template.

② **Task Editing Area.** Once a template is selected, the task list under that template will be displayed on the right side of the interface.

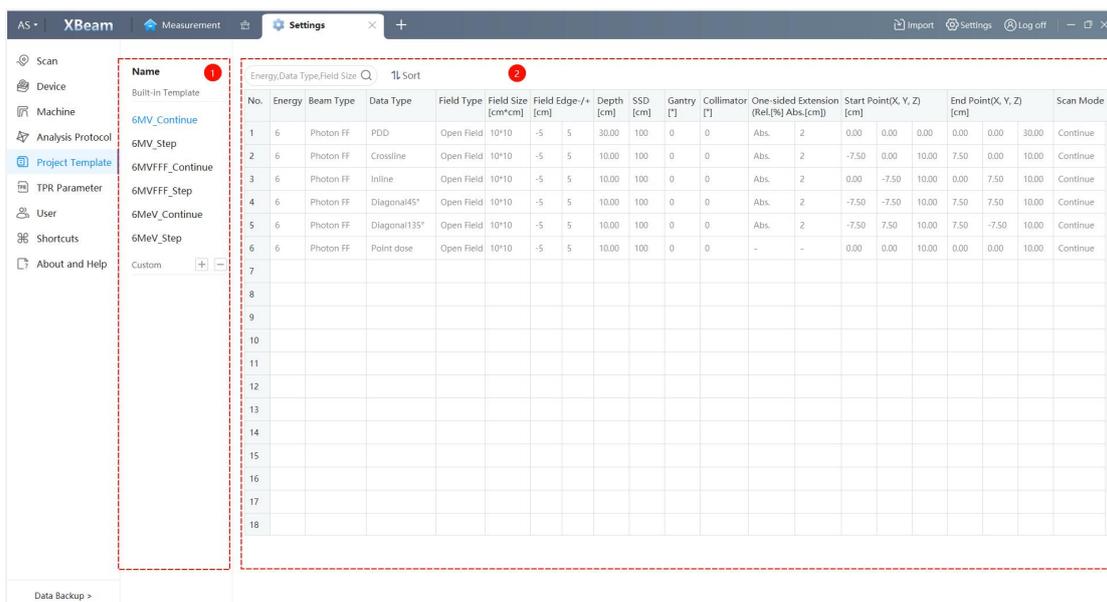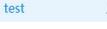• Project Search Bar `Energy,Data Type,Field Size Q` : You can perform fuzzy search using keywords such as "Energy", "Data Type", and "Field Size". The system will expand the list of matching results based on the entered keywords, allowing users to further filter by checking desired conditions. To search with multiple criteria simultaneously, separate keywords using a comma, (Do not add spaces before or after the comma).
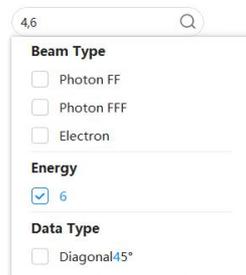
• Table Sorting: Click `⇅ Sort` to sort the table entries in the following priority order: Beam Type > Energy > Data Type > Field Size.

• Table Editing Rules:

> ➤ Double-click any of the following fields in a blank row: Energy, Beam Type, Data Type, or Field Type. Upon entering a value, the system will auto-fill other related fields based on default values, which can then be edited individually.

> ➤ The default value for One-Sided Extension can be set under [Settings > Scan > Field Expansion]. After selecting a Data Type, the default value will auto-populate. If the selected data type is Point Dose, this field is not applicable.

> ➤ After modifying the Data Type or Field Size, the Field Edge will be auto-calculated. If one side of the edge is manually modified, the other side will update automatically based on current parameters.

> ➤ When any of the Depth, Start Point (Z), or End Point (Z) values is changed, the other two will automatically sync. If the Data Type is PDD, the Start Point (Z) will be excluded from auto-sync.

> ➤ When Data Type, Field Size, One-Sided Extension, SSD, Depth, and Field Edge are all filled in, the system will automatically calculate and fill in the Start Point and End Point of the scan.

> ➤ After completing edits, click `Save` to save.

> ➤ For more details about filling in the table, refer to **5.7.11 General Editable Table**.

5.7.6. TPR Parameter

- On the TPR Parameter page, users can customize the conversion model for PDD-to-TPR transformation.
- PDD-to-TPR Transformation Formula (for detailed descriptions, refer to **7.2.9. PDD-to-TPR Calculation**):

$$\text{TPR}_{(d,fs,E)} = \frac{\text{PDD}_{w(d,fs_d,SSD)}}{\text{PDD}_{w(d_{ref},fs_{d_{ref}},SSD)}} \left(\frac{SSD + d}{SSD + d_{ref}}\right)^2 \frac{S_{p(fs_{d_{ref}})}}{S_{p(fs_d)}}$$
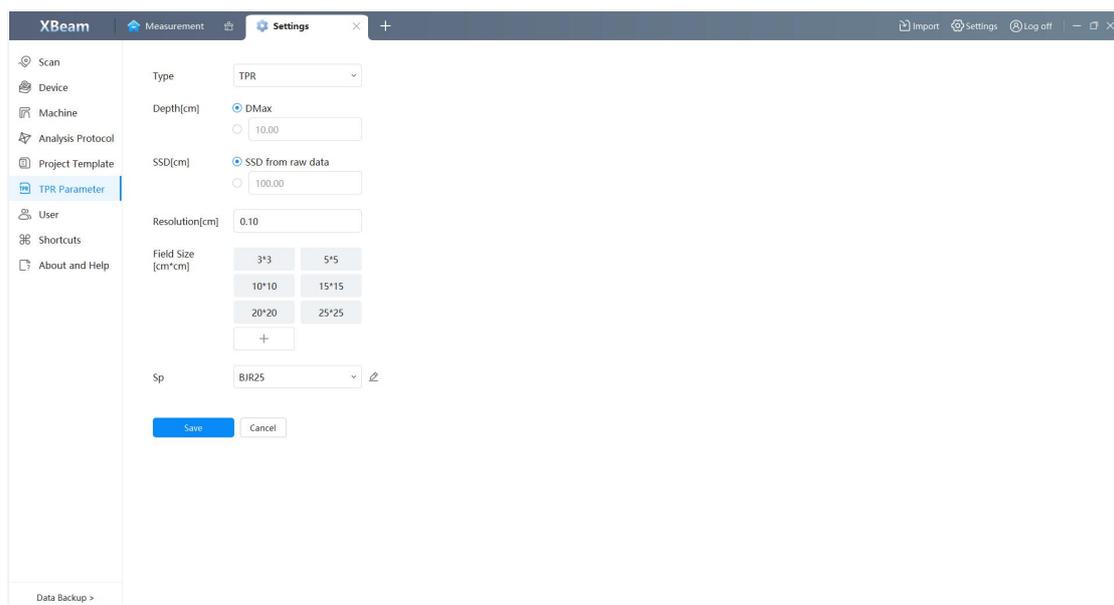
Figure 38. Settings_TPR Parameter

Parameter	Description
Type	You can select TPR or TMR from the dropdown menu.
Depth	• Dmax: The system will use the depth corresponding to the max dose in the PDD. • Custom: Users must manually input the depth value.
SSD	• SSD from original data: The system will extract the SSD value from the PDD data. • Custom: Users must manually input the SSD value.
Resolution	Set the point spacing for TPR conversion (unit: cm).
Field Size	• Define the field size used for generating TPR data. • Click ⊞ to add a new field size. • Hover over a field size to display 3*3 ✕ , click "✕" to remove it.
Sp	• Click ✎ to enter the SP editing page. • On the editing page, click ⊞ to add a new Sp template, and click ⊟ to remove the currently selected Sp template. • BJR25 is a built-in template and cannot be deleted or modified.
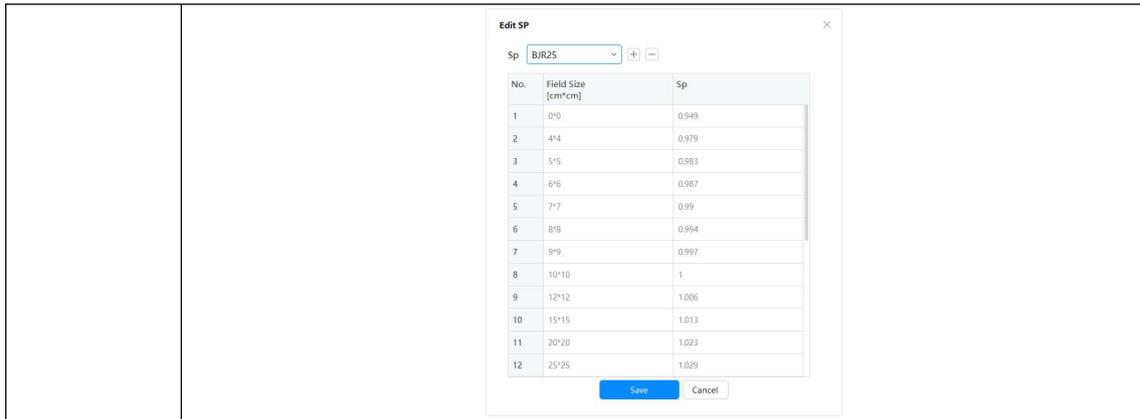
5.7.7. User

On the *User* page, users can manage and edit account information within the system.
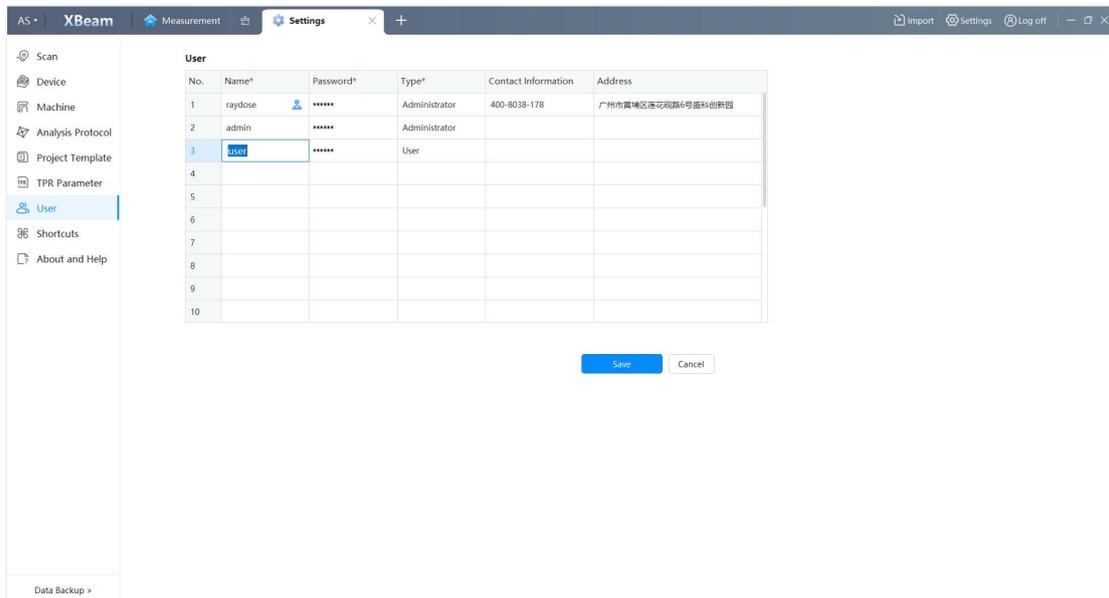
Figure 39. Settings_User

• User types are divided into "Administrator" and "User". Users can only edit their own account information, while administrators can edit all user accounts in the system.

• The ![icon] represents an Administrator, while the ![icon] represents a User.

5.7.8. Shortcuts

On the *Shortcuts* page, users can view keyboard shortcuts related to tables and curves.
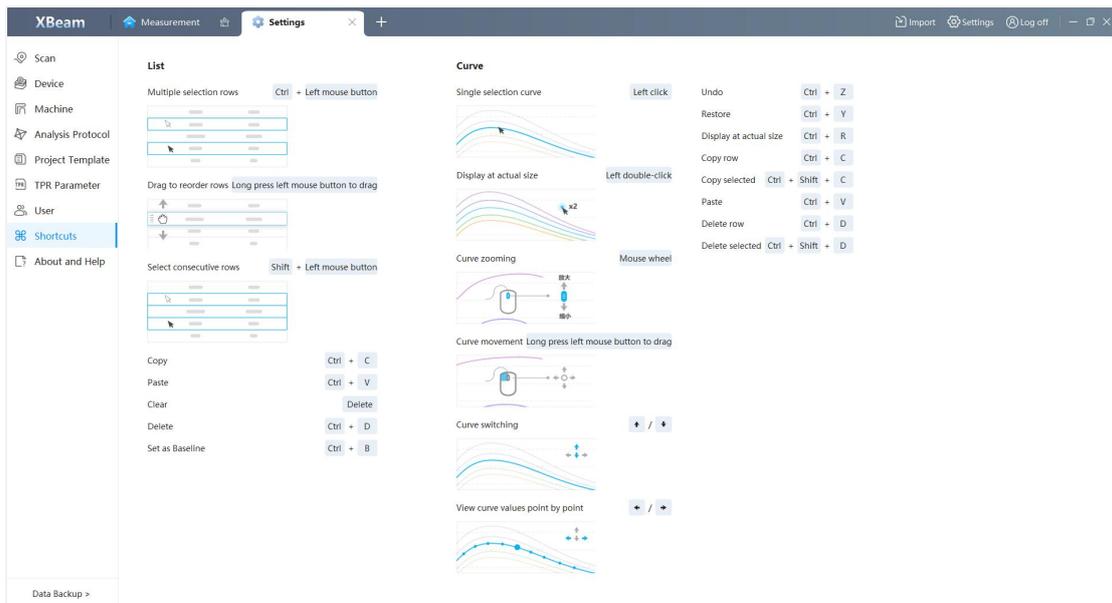
Figure 40. Settings_Shortcuts

(1) Table

➢ There are three main types of tables:

① Task Table
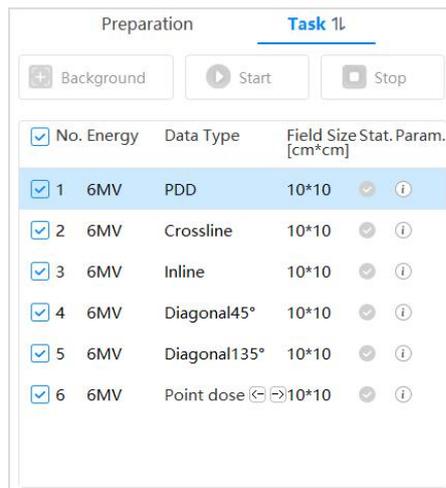
Figure 41. Table_Task Table

② Editable Table

Note: This table type is widely used across multiple pages, such as [Settings > Device] and *New Project*.

Figure 42. Table_Editable Table

③ Record Table

Figure 43. Table_Record Table

➢ The shortcut operations supported by each table type are as follows:

Operation	Shortcut	Table	Description
Multiple selection rows	Ctrl+Left mouse button	①②③	• Supported by all table types. • For ②: Clicking the No. column allows multi-select of entire rows, clicking a cell allows multi-select of cells.
Drag to reorder rows	Long press left mouse button to drag	①②	• Only applicable to table types ① and ②. • For ②: Must operate through the No. column.
Select consecutive rows	Shift+Left mouse button	①②③	• Supported by all table types. • For ②: Clicking the No. column selects consecutive rows, clicking a cell selects consecutive cells.
Copy	Ctrl+C	②③	• For ②: Clicking the No. column copies the entire row, clicking a cell copies the selected cell content. • For ③: Must select a record row before copying.
Paste	Ctrl+V	②③	• For ②: Clicking the No. column pastes the entire row, clicking a cell pastes into the selected cell. • For ③: Must select a record row before pasting.
Clear	Delete	②	• Clicking the No. column clears the entire row. • Clicking a cell clears the content of the selected cell.
Delete	Ctrl+D	②③	• For ②: Must select the row via the No. column, then use the shortcut to delete the row. • For ③: Must select a record row to delete.
Set as Baseline	Ctrl+B	③	• Set the selected record as the baseline.

(2) Curve
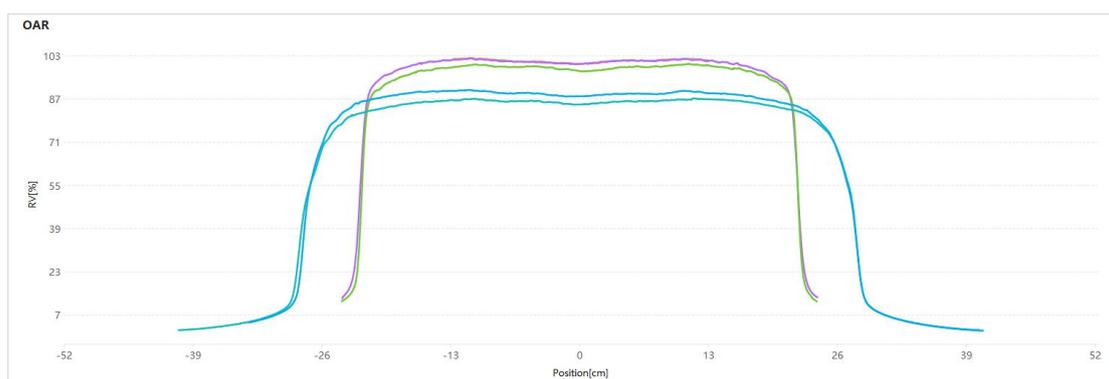
Figure 44. Curve

➢ Before performing shortcut operations on a curve, users must first click to select the target curve. The available shortcut operations are as follows:

Operation	Shortcut	Description
Single selection curve	Left click	Select a single curve to view details or perform operations.
Display at actual size	Left double-click/ Ctrl+R	Restore the curve display to actual size.
Curve zooming	Mouse wheel	Zoom in or out on the curve display.
Curve movement	Long press left mouse button to drag	Drag the curve to move its position on the canvas.
Curve switching	Keyboard ↑ / ↓	Use to switch between currently selected curves.
View curve values point by point	Keyboard ← / →	Use to view point-by-point values on the curve.
Undo	Ctrl+Z	Undo the previous operation, up to 10 steps can be undone consecutively.
Restore	Ctrl+Y	Redo the last undone operation.
Copy row	Ctrl+C	Copy the curve selected by a single click.
Copy selected	Ctrl+Shift+C	Copy the currently checked curves.
Paste	Ctrl+V	Paste the previously copied curve(s).
Delete row	Ctrl+D	Delete the curve selected by a single click.
Delete selected	Ctrl+Shift+D	Delete the currently checked curves.

5.7.9. About and Help

The *About and Help* page provides access to product version information and company details.
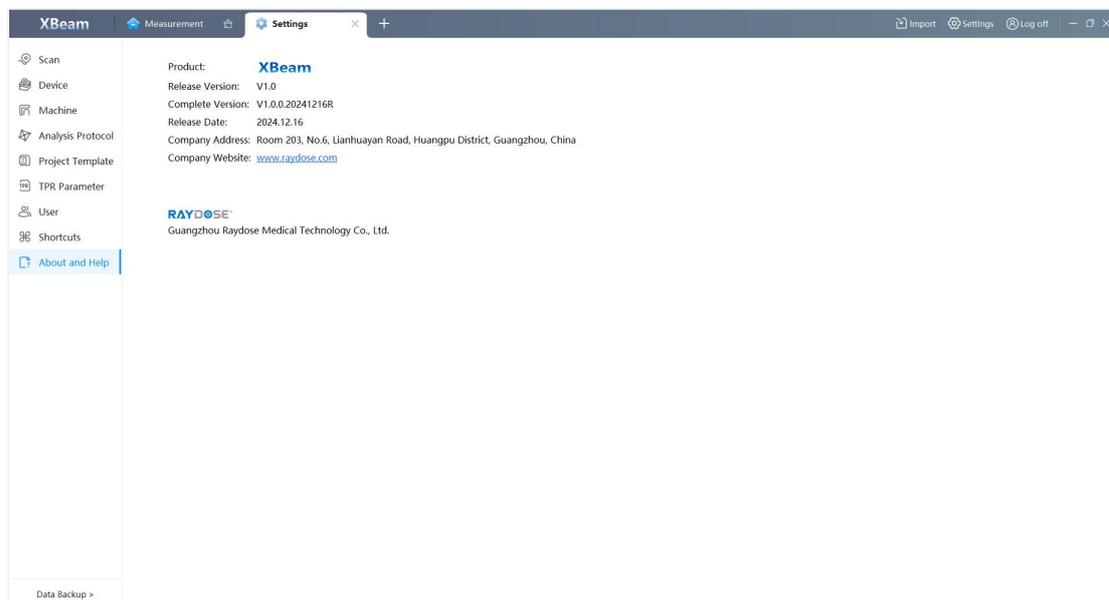
Figure 45. Settings_About and Help

5.7.10. Data Backup

A data backup feature is available at the bottom left corner of the settings page. Users can export a compressed package containing the complete program data for technical support or troubleshooting complex issues. Click Data Backup > to initiate the backup.
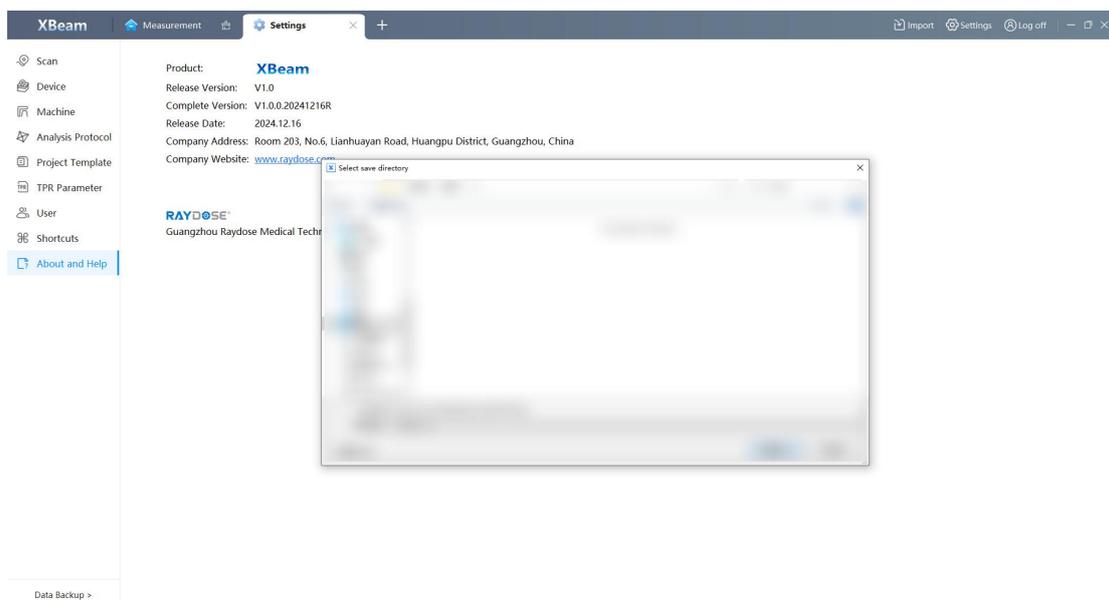
Figure 46. Data Backup

5.7.11. General Editable Table

A general editable table format is used across multiple pages in the XBeam, such as [Settings > Equipment], *New Project*, etc. The following section details the usage rules for this type of table.

Figure 47. General Editable Table

① **No. Column:** Actions on the No. column apply to the entire row, including selection, drag-and-drop, copy, paste, clear content, and delete.

② **Content Column:** Actions on cells in the content column only affect the individual cell, including selection, copy, paste, and clear content.

• Note: Different font and border colors in cells indicate different statuses.

Cell Status	Description
Electron	Normal
Electron	Read-only
-1	Content Error
	Required (Cannot be empty)
–	Invalid Entry

• Editing: Double-click a cell to edit. After editing, click outside the cell to exit edit mode for the changes to take effect.

• Adding Blank Rows: Scroll downward with the mouse wheel to load and display more blank rows.

• Multi-selection and Range Selection: Use **Ctrl + Left-click** to select multiple items, or **Shift + Left-click** to select a continuous range. Rows can be reordered by dragging via the No. column.

• Input format prompt: When clicking on a cell, a format requirement or input range prompt will be displayed, as shown below.

• Shortcuts and Right-click Menu: Refer to [Settings > Shortcuts] or the right-click menu for available shortcut key operations.

• Undo and Redo: The right-click menu includes "Undo" and "Redo" to reverse or reinstate the most recent operation.

• Copy and Paste Rules:

> ➢ If a cell is selected (not in edit mode) and copied, the pasted data must stay within the same column.
> ➢ If a cell is double-clicked and the content copied (in edit mode), the text can be pasted anywhere.
> ➢ When table types are the same, full row copy-paste is supported (e.g., copying an entire built-in template row from [Settings > Project Templates] into a custom template).

5.8. Project Page

Click [XBeam] in the upper left corner of the main interface to enter the Data Management page. After selecting and opening a project, the software will display the corresponding project page, as shown below.

Figure 48. Project Page_Combined Display View

① **Project Name**: Click here to edit the current project's name.

② **Curve Type Switch**:

• Click the curve type tab to view the corresponding curve data.

• The "PDD" type includes both PDD and TPR data.

• The "OAR" type includes Crossline, Inline, Diagonal 45°, and Diagonal 135°.

• The "PD" type refers to Point Dose data.

• PDD and OAR curves can be displayed on the same page, while PD curves are displayed on a separate page.

③ **Data Processing Toolbar**:

• ☑ After selecting records in the table, click the corresponding toolbar button to process the curves.

Operation	Data Type	Description
Normalization	PDD，OAR	Normalize data based on a specified reference point. • PDD: Can be normalized to Dmax (maximum dose) or a specific depth.

		• OAR: Can be normalized to field center, Dmax, or a specified dose.
Smooth		Apply smoothing to the data curve. The smoothing size can be configured under [Settings > Scan > Auto Post-Processing].
Zoom		• Adjust the display scale of the data curve. • Scaling can be based on SSD or SDD.
Interpolation		• Fill in missing points on the curve. • Two interpolation methods are available: coordinate interpolation and dose interpolation.
Translation		Shift the entire curve along the horizontal axis.
Comparison		Compare selected curves with a baseline.
Center	OAR	Center the selected curve.
Symmetry		• Apply axial symmetry to the curve. • Supports three symmetry modes: left, right, and Left-Right Average.
Mirror		• Apply mirroring to the curve. • Supports three mirror modes: left, right, and Left-Right.
Stitch		• Stitch two OAR curves into a complete curve. • Applicable for segmented curve measurements of large field sizes. • The first curve serves as the baseline, while other curves supplement uncovered regions to generate a complete curve.
Merge		• Merge multiple OAR curves into one. • Applicable when multiple curve sets are acquired under the same measurement conditions to improve density and accuracy. • The system uses the first curve as a baseline and performs interpolation averaging on overlapping regions to generate a new curve.
Remove	PDD	Removes PDD data points with depths smaller than a specified value.
PDD to TPR		Convert PDD data to TPR format.
Undo	PDD，OAR	• Undo the last operation. • Up to 10 consecutive steps can be undone.
Restore		Redo the last undone operation.
Raw data		Display raw measurement readings.
Analysis		After modifying the analysis protocol or parameters, click this button to reanalyze the data.

④ **Display View Switching** (Applicable only to PDD and OAR)
• Combined Display View: Click ☰ to display PDD and OAR together.
• Separate Display View: Click ▤ to display PDD and OAR separately.
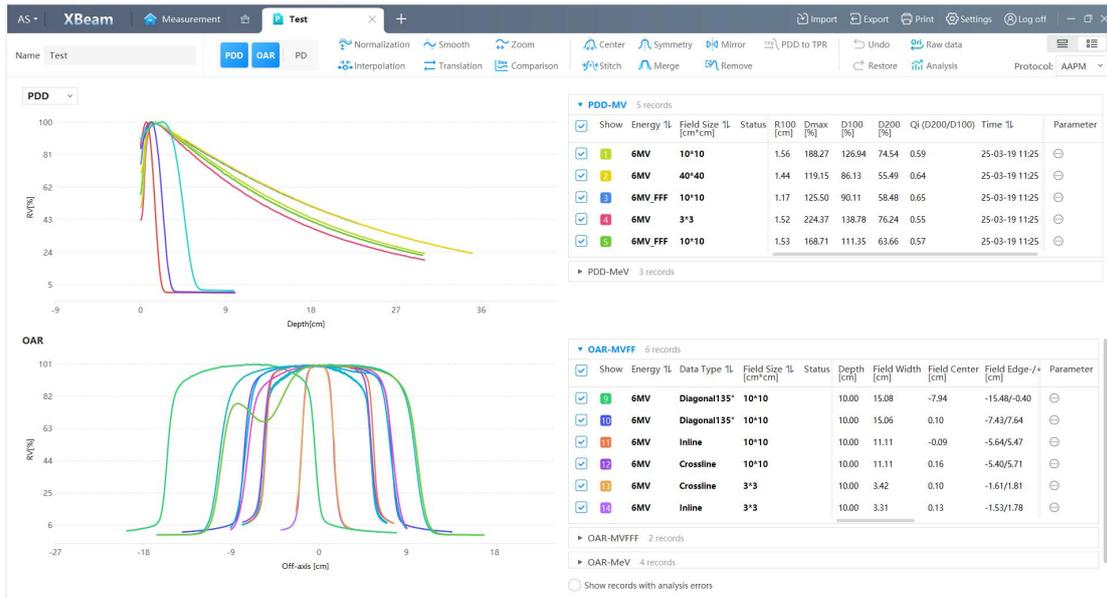
Figure 49. Project Separate Display View

⑤ **Analysis Protocol:** Use the drowdown menu to switch the analysis protocol. After switching, click 📊 Analysis in ③ to reanalyze the data using the current protocol.

⑥ **Curve Display Area**: This area displays only the curves that are checked in the table. Features include:

• Display TPR data: When the data type is PDD, click PDD ∨ in the upper left corner to switch to TPR display TPR ∨ . TPR curves will only appear after converting PDD to TPR via the button 📈 PDD to TPR in ③.

• Default display state: When no curve is selected, all curves are shown with the same transparency and thickness.
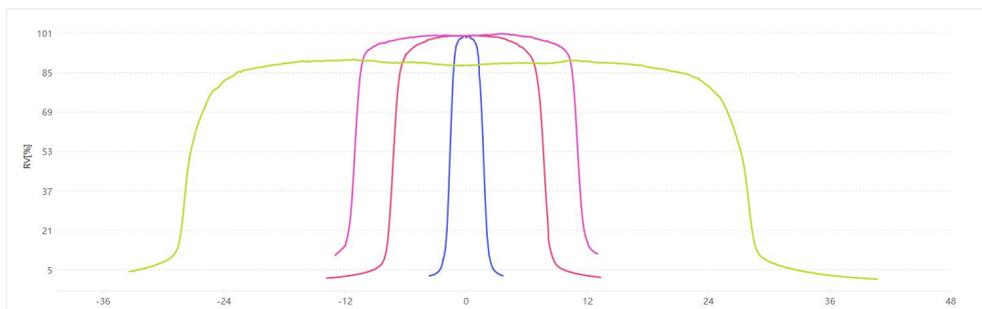
• Highlighted selection: When a record is selected in the table or a curve is clicked in the curve area, the corresponding curve is highlighted (bold). Clicking the already highlighted record again will deselect it and restore the default display.
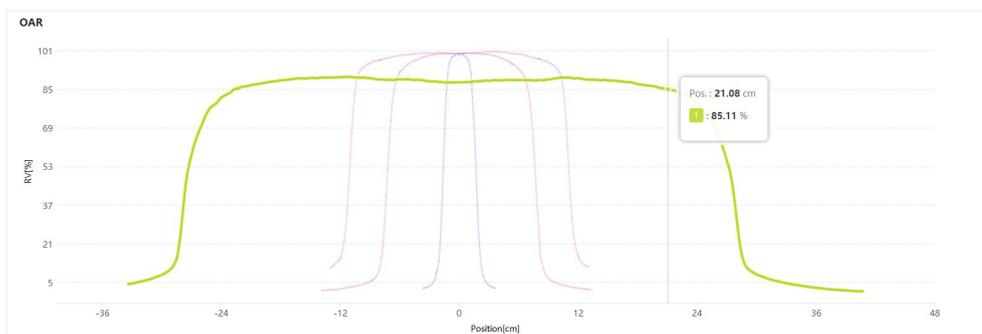
- View curve point values: Hovering the mouse over the curve area shows the Y-values of all curves at the current X-coordinate, sorted in descending order.
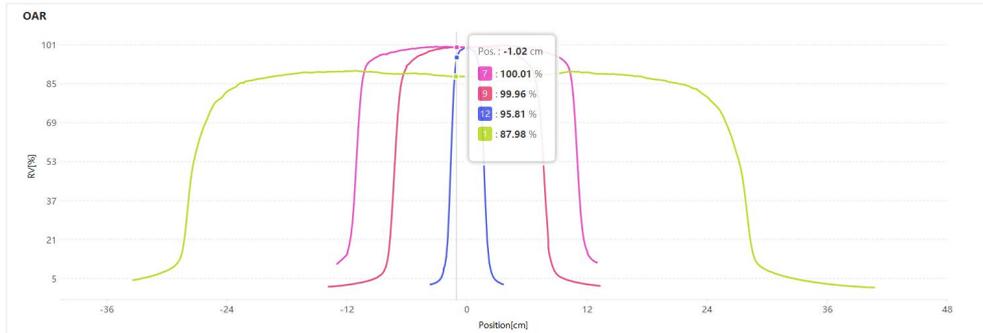
- Shortcut menu: Right-clicking in the curve area opens a shortcut menu.

Operation		Shortcut	Description
	Undo	Ctrl+Z	Undo the last operation, up to 10 steps in succession.
	Resort	Ctrl+Y	Redo the last undone operation.
	Display at actual size	Double-click/ Ctrl+R	Restore the curve to actual size for display.
	Copy	Ctrl+C	Copy the currently selected curve.
	Copy selected	Ctrl+Shift+C	Copy the curves checked in the table.
	Paste	Ctrl+V	Paste the previously copied curve(s).
	Delete	Ctrl+D	Delete the currently selected curve.
	Delete selected	Ctrl+Shift+D	Delete the curves checked in the table.

⑦ **Table Area**
- The table area displays detailed information about the curves in the project.
- When a record is selected in the table, the corresponding curve in the curve area will be highlighted.
- Right-clicking on the table opens a shortcut menu with the following options:

Operation		Shortcut	Description
	Copy Row	Ctrl+C	Copy the currently selected curve.
	Copy Selected	Ctrl+Shift+C	Copy the currently checked curves.
	Paste	Ctrl+V	Paste the copied curve(s).
	Set as Baseline	Ctrl+B	• Set the selected record as the baseline. Once set, the icon for this record will change to ⭐ . • Click 📊 Comparison in ③ to calculate the deviation between other records and the baseline. • Multiple baselines can be set,

			but only the most recently set one will be used for comparison analysis.
	Remove Baseline	Ctrl+B	Cancel the baseline status of the selected record.
	Delete Row	Ctrl+D	Delete the currently selected curve.
	Delete Selected	Ctrl+Shift+D	Delete the currently checked curves.

- The tables are divided into two types based on data type: **PDD and OAR tables**, and **PD tables**.

(1) PDD and OAR Tables

Click the PDD or OAR tabs in the [PDD OAR PD] to switch between corresponding records and table contents.

Figure 50. Project Page_PDD and OAR Tables

① **Automatic Classification:** The software will automatically categorize and display the records based on the measurement curve's data type and energy, including: PDD－MeV(Electron beam), PDD-MV(Photon beam), TPR－MV, OAR－MeV, OAR－MVFF, OAR－MVFFF

② **Curve Markers:** Each record is indicated with an icon in the graph. When a record is set as a baseline, its icon changes to 🟢 .

③ **Sorting:** The table is sorted in reverse chronological order by default. Users can click the sort icon ⇅ to toggle the order. ⇅ indicates ascending order, while ⇅ indicates descending order.

④ **Parameters:** Click ⊙ to expand and view detailed parameter information for the record.

⑤ **Show Records with Analysis Errors:** Check this option to display only records with abnormal analysis results.

⑥ **Analysis Results:** The analysis results shown in the table can be customized. Related parameters can be configured under [Settings > Analysis Protocol].

(2) PD Tables

Click the PD tab in the [PDD OAR PD] to switch and view Point dose type records and their corresponding table.
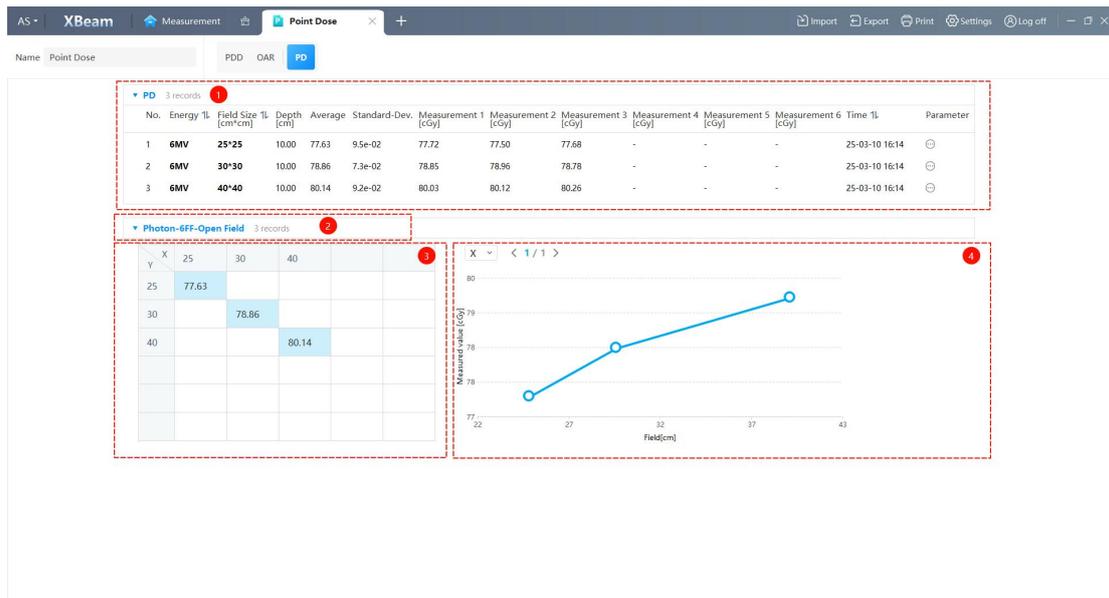
Figure 51. Project Page_PD Tables

① **PD Measurement Records Table**
- This table displays all point dose measurement records within the project.
- After double-clicking the measurement cell to enter edit mode, you can click the button ☒ to delete the value. Deleted values will be excluded from subsequent analysis.

- Right-clicking within the table will open a shortcut menu:

Operation		Shortcut	Description
	Undo	Ctrl+Z	Undo the last operation, up to 10 steps in succession.
	Resort	Ctrl+Y	Redo the last undone operation.
	Copy Row	Ctrl+C	Copy the currently selected curve.
	Paste	Ctrl+V	Paste the copied curve(s).
	Clear Measurement	-	Clears all measurement values in the selected row.
	Delete Row	Ctrl+D	Delete the currently selected curve.

② **PD Analysis Records Table**
- The software categorizes the records based on the field size and energy.

③ **Table Area**
- The system filters PD records within the current project that share the same energy, depth, and field size, and groups them by field size to generate the corresponding tables. Each cell corresponds to a PD record. The system calculates the average of multiple measured values within that record and fills it into the cell.

- If multiple eligible records exist, the system will use the most recent one by default. Users can also manually select a specific record from a drop-down list in the cell.
- Right-click the table will open a menu with the following supported actions:

Operation		Trigger	Description
☆ Set as Baseline A⊘ Delete value	Set as Baseline	Right-click a cell that contains a value.	• After setting the selected cell as the baseline, the values in other cells will be displayed normalized to it. • The baseline cell will display the icon ✱, and its value becomes 1. • Only one baseline can be set per table.
☆✗ Remove Baseline A⊘ Delete value	Remove Baseline	Right-click on the baseline cell.	• Cancel the baseline setting and all cells display the original values.
⋈ Generate Curve A⊘ Delete value	Generate Curve	Hold down Ctrl and left-click to select multiple cells, then right-click to open this menu.	• At least two cells containing values must be selected. After clicking "Generate Curve," the corresponding curves will be plotted on the right. • Multiple curves can be generated, and they will not overlap. Each curve is distinguished by a different color. • ‹ 78.86 › Colored cells indicate which data belong to which curve.
	Delete Value		• Click "Delete Value" to clear the contents of the selected cells. • If a selected cell's value has already been used to generate a curve, deleting the value will also remove the corresponding point from the curve area.
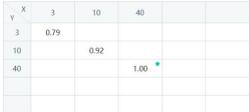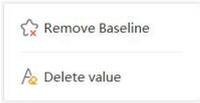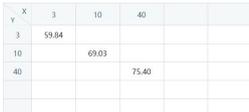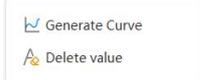
④ **Curve Area**
- Curve area displays the curves generated from the data in ③.
- When a data point is selected in the curve area, the corresponding cell in the table will be highlighted.
- Use the dropdown menu [X ⌄] to switch the curve display mode, viewing the direction along the X-axis or Y-axis as the horizontal coordinate.
- Right-click in this area to open a shortcut menu with the following options:
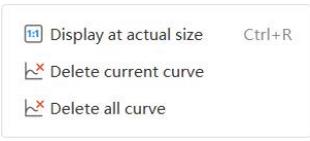
Operation		Shortcut	Description
	Display at actual size	Left double-click / Ctrl+R	Restore the curve view to its original scale and display at actual size.
	Delete current curve	-	Remove the currently selected curve.
	Delete all curves	-	Remove all curves displayed in the curve area.

5.9. Measurement Operation Steps

Before starting the measurement, please ensure that all devices are properly connected and that communication between the device and the computer is functioning correctly. After finish positioning, fill the AutoScanner 600 with clean water to a level above 10 cm, then complete the following steps in sequence.

5.9.1. Configuration

• Turn on the power, connect the CCM to the computer via a Ethernet cable, and configure the AutoScanner 600 IP address on the XBeam [Settings > Device] (see section **5.7.2 Device**).

• On the [Settings > Scan] page, select the appropriate orientation setting based on the actual placement of the AutoScanner 600.
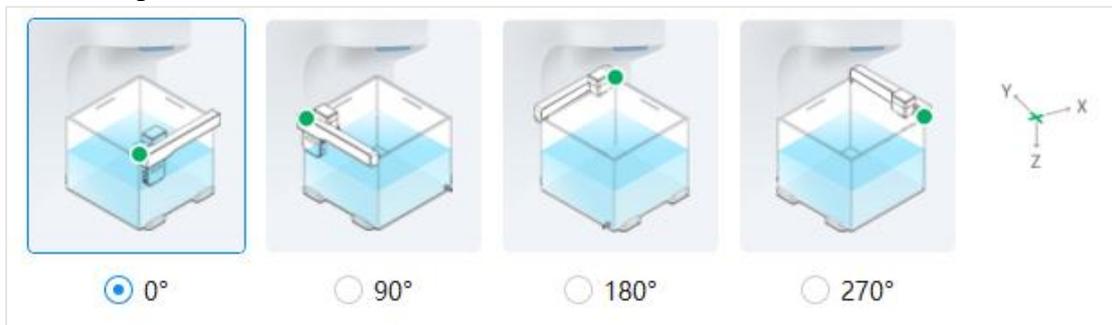
Figure 52. Measurement Operation Steps_Orientation

• After completing the setup, you can check the connection status of the AutoScanner 600 on the main interface.

Not Connected	Connected
Device information is not displayed in this area.	Device model and current status will be displayed once successfully connected.
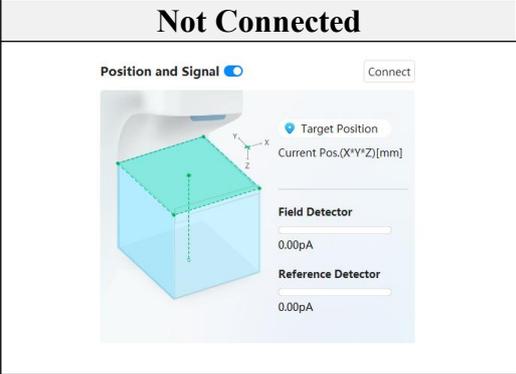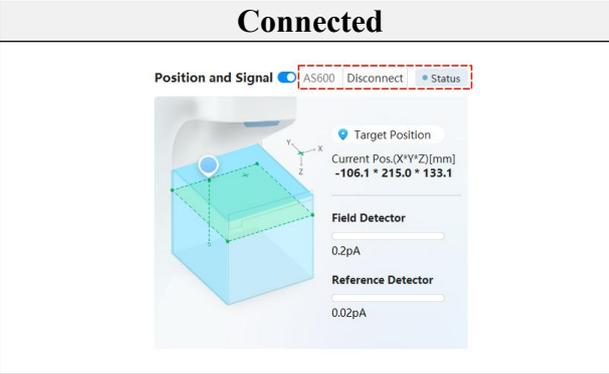
- Click to view the current status of each module.
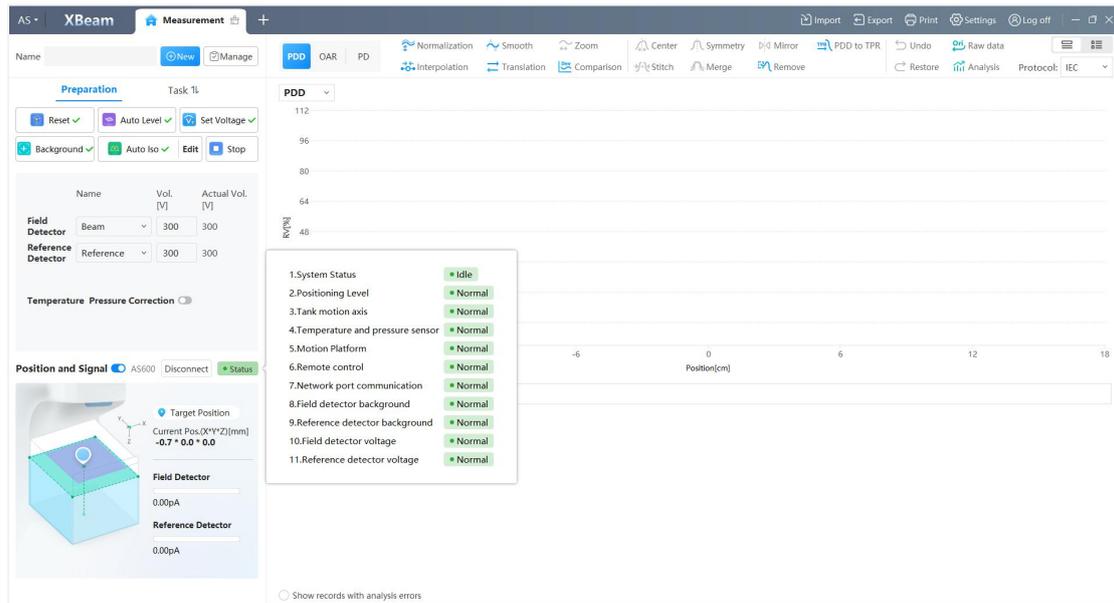
Figure 53. Measurement Operation Steps_Measurement Status

No.	Module	Status	Description
1	System status	Idle/ Resetting/ Leveling/ Background/ Moving	Indicates current system operation state.
2	Positioning level	• Normal: Device connected properly. • Unknown: Device information unavailable; usually does not affect measurement. • Error: This may affect measurement. Please check the device status again.	Verify water level if abnormal.
3	Tank motion axis		Restart if abnormal.
4	Temperature and pressure sensor		
5	Motion platform		
6	Remote control		
7	Network port communication		
8	Field detector background		Re-measure background if abnormal.
9	Reference detector background		
10	Field detector voltage		Re-measure voltage if abnormal.
11	Reference detector voltage		

5.9.2. Preparation
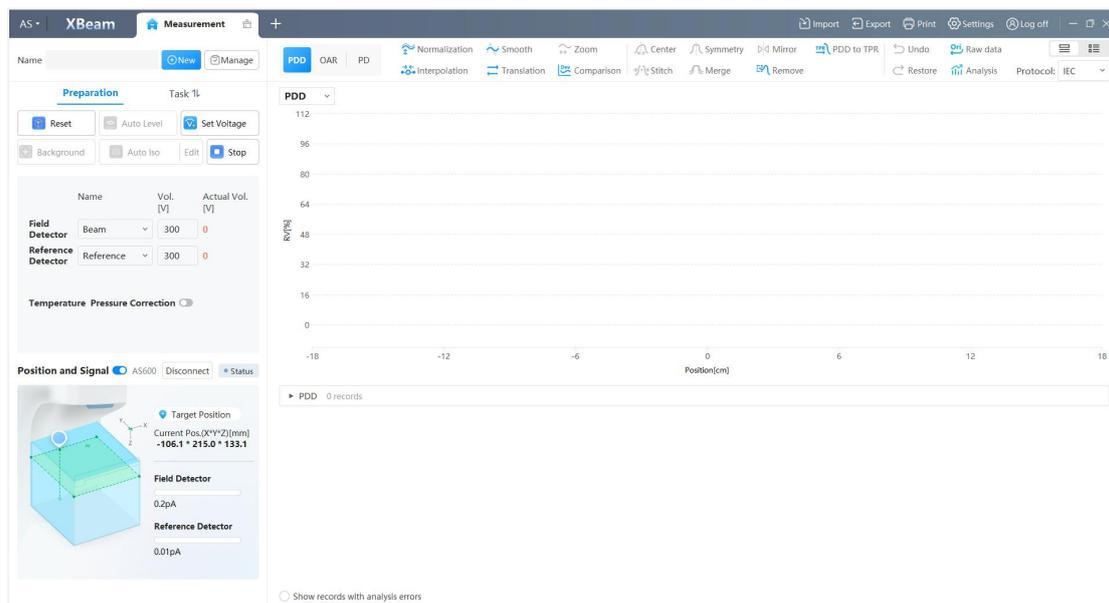
Figure 54. Measurement Operation Steps_Preparation

• After successful device connection, complete the following steps on the main interface in order: Reset → Auto Level → Set Voltage (ionization chamber only) → Background → Automatic Iso.

• Note: If using a semiconductor detector, skip the "Set Voltage" step and proceed directly to background measurement.
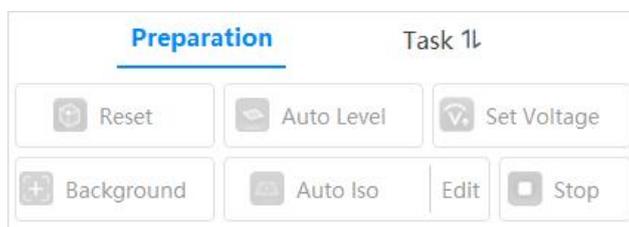
(1) Reset

• Description: The reset operation verifies whether all modules work properly. During reset, the system performs a full motion test. After reset completes, the measurement unit automatically returns to the center position.

• Note: Reset is required before proceeding. Until reset is completed, functions such as "Auto Level," "Set Voltage," "Background," and "Auto Iso" will be disabled.

• Operation: After all connections are complete, click [Reset] to start reset.

Icon	Description
Reset	Device not connected (button disable).
Reset	Device connected (button enabled).
Reset ⊙	Reset in progress.
Reset ✓	Reset completed.

66

(2) Auto Level

• Description: The system automatically detects water surface height at all four corners of the tank to determine levelness and perform algorithmic leveling.

• Operation: After reset completion, click [Auto Level] to initiate auto-leveling.

• Description: The system automatically detects the water surface height at the four corners of the AutoScanner 600, determines whether the surface is level, and performs algorithm-based leveling automatically.

• Operation: After reset is complete, click [Auto Level] to start auto level detection.
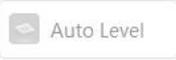
Icon	Description
Auto Level	Device not connected/ Reset incomplete (button disable).
Auto Level	Reset completed (button enabled).
Auto Level ⊙	Auto level in progress.
Auto Level ✓	Auto level completed.

(3) Set Voltage

• Description: Applies high voltage to the ionization chamber detector to activate it.

• Note: Applicable only to ionization chamber detector, not allowed for semiconductor detectors.

Icon	Description
Set Voltage	Device not connected/ Reset incomplete (button disable).
Set Voltage	Reset completed (button enabled).
Set Voltage ⊙	Setting voltage.
Set Voltage ✓	Voltage set complete.

• Operation: Set voltage parameter for the detector in the red-formed area shown in the figure below. After completing the settings, click [Set Voltage] to proceed.

Field Detector	• The field detector is the main detector for data acquisition and must be set before measurement. Please select the desired detector from the dropdown menu. • Only configured detectors appear in the dropdown. To add or modify detectors, go to [Settings > Device > Detector]. • On the [Settings > Device > Detector] page, you can set the detector's default voltage (Default V) and maximum voltage (Max V). On the main interface, you can set the voltage for the current measurement. The system will display the detector's actual voltage for reference. • Note: The set voltage must not exceed the default voltage; otherwise, the system will show a warning. If the set voltage differs from the actual voltage, the voltage value will be highlighted in red to alert the user to check the detector connection status or parameter settings.
Reference Detector	• The reference is used to control the start of measurement: when the field detector's reading exceeds the reference detector's preset acquisition threshold, the system automatically begins data acquisition. • Configuration and voltage settings for the reference detector are the same as for the field detector; see previous instructions. • The reference detector should be placed inside the radiation field without blocking the scanning path of the field detector to avoid affecting the measurement. When switching field or task type, please reconfirm the reference detector's position. • Abnormalities in measurementrecords can help judge whether the reference detector is properly placed. For example, a local dip in the OAR curve often indicates blockage by the reference detector, as shown below: • If a reference detector is not used, select "-" from the dropdown menu. In this case, start beam delivery first, then start acquisition in XBeam. Note that the system cannot detect beam interruptions under this condition, which may result in measurement errors. • When not using a reference detector, it is recommended to reduce the scan speed, increase acquisition cycle, or use step mode in [Settings > Scan] to improve measurement accuracy. • For multi-task measurements with asymmetric fields, you may choose not to use the reference detector to reduce frequent room entry for repositioning, thus improving work efficiency.

(4) Background

- Description: Measure the background when the linac is not delivering the beam.
- Operation: After reset is complete, click [Background] to start background measurement.
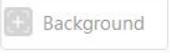
Icon	Description
[Background]	Device not connected/ Reset incomplete (button disable).
[Background]	Reset completed (button enabled).
[Background ⊙]	Background measurement in progress. The measurement duration is 60 seconds.
[Background ✓]	Background measurement completed.

(5) Auto Iso

- Description: The system scans three preset trajectories to determine the isocenter of the radiation field. The default scanning depth is 10 cm below the water surface. Ensure the water depth exceeds 10 cm before measurement.
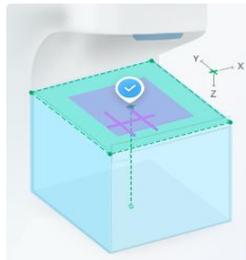
- Operation: After reset is complete, choose the appropriate procedure based on whether a reference detector is connected. (Default beam condition: 6 MV, 15×15 cm, 999 MU)

  ➢ If no reference detector is connected: Click [Auto Iso] to start measurement, then begin beam delivery.
  ➢ If a reference detector is connected: The system automatically starts the measurement based on the scan threshold, so the order of operations does not matter.

Icon	Description
[Auto Iso]	Device not connected/ Reset incomplete (button disable).
[Auto Iso]	Reset completed (button enabled).
[Auto Iso ⊙]	Isocenter positioning in progress.
[Auto Iso ✓]	Isocenter positioning complete.

- Users can customize the isocenter position or set beam conditions using the "Edit" function. After clicking the "Edit" button [Auto Iso Edit], the following two setting options will appear:

Custom Isocenter	Auto Positioning
• Allows users to manually set the isocenter. Click the "Save as Isocenter" button to complete the setting. • Users can also check the current position using AutoScanner RC and tap "Set as Isocenter" to confirm it. • After this operation, **Auto Iso** is no longer required. The system will use the current position as the isocenter for subsequent measurements.	• Customize beam energy and field size. Click "Save" to confirm. • After configuration, re-execute isocenter positioning. Deliver a 999 MU beam under the new energy/field conditions before clicking [Auto Iso] to start acquisition. • Here, users can customize the beam energy and field size. Click the "Save" button to apply the settings. • After saving, **Auto Iso** must be performed again. Users should first deliver 999 MU with the specified energy and field size, then click [Auto Iso] to begin the measurement.

(6) Stop

• Description: Click this button to immediately terminate all ongoing tasks, including reset, auto-level, and any motion operations. This function serves as an emergency stop and can be used at any time to ensure the safety of both the equipment and operators.

Icon	Description
Stop	Device not connected (button disabled).
Stop	Device connected (button enabled).

(7) Temperature & Pressure Correction

- Description: This function controls whether temperature and pressure corrections are applied during measurement. It only affects Point Dose measurements and does not apply to PDD or OAR data types.

Off	On
• No correction is applied during measurement. • The Point Dose measurement value is calculated as follows: $$Dose = V_{Beam} \times f_{Sensitivity}$$ Where: V_{Beam} = charge signal value of the field detector, $f_{Sensitivity}$= detector sensitivity.	• Corrections applied during measurement. • The Point Dose measurement value is calculated as follows: $$Dose = V_{Beam} \times f_{Sensitivity} \times f_{TP}$$ Where: V_{Beam} = charge signal value of the field detector, $f_{Sensitivity}$= detector sensitivity, f_{TP}=temperature&pressure correction factor. • Both automatic and manual input modes are supported. In automatic mode, the system acquires the data automatically; in manual mode, the user inputs the values manually.

5.9.3. Task Creation and Management

Click ⊕New on the main interface to create a new measurement task. Click ⊠Manage to manage existing tasks.
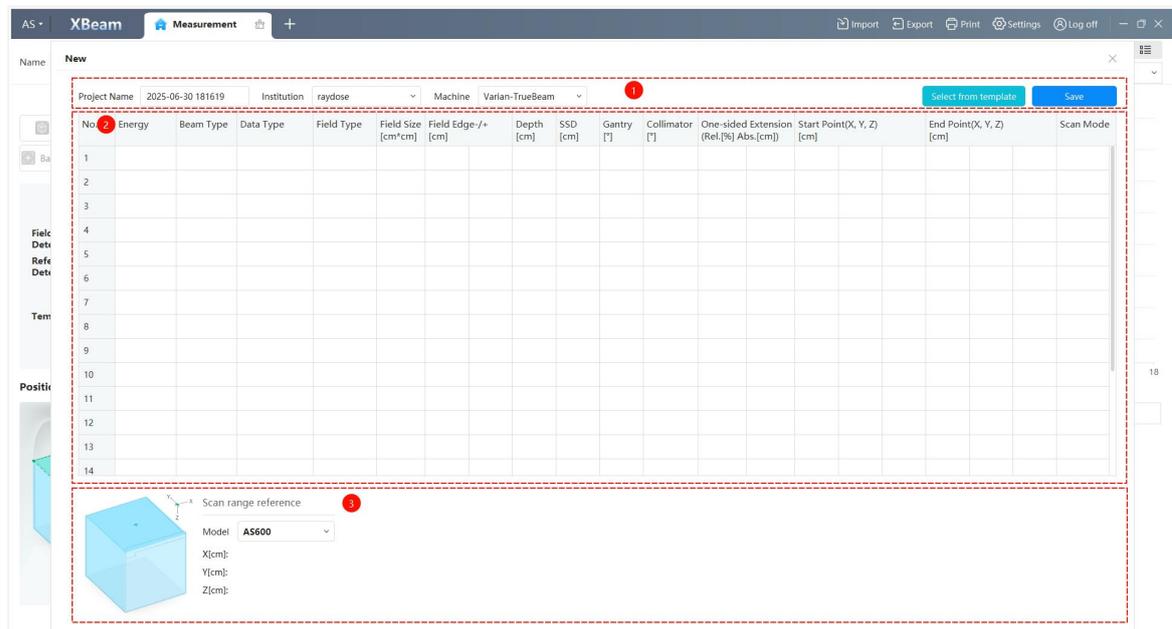
Figure 55. Measurement Operation Steps_Task Creation and Management

① **Top Area**

• Allows editing the project name and selecting the Institution and Machine, which are managed centrally in [Settings > Machine].

• Click Select from template to batch import tasks from templates. After selecting the desired tasks, click Confirm to complete the import.

• After editing the table, click Save to save. Once saved, the task list on the

main interface will update automatically, and measurement can begin.

② **Table Area**

•   Used to fill in and edit measurement task parameters, including beam type, data type, start and end positions, etc.

•   The Energy option updates automatically according to the selected Machine.

•   Table filling guidelines are detailed in sections **5.7.5 Project Template** and **5.7.11 General Editable Table**.

③ **Scan Range Reference Area**

•   When a task row in the table is selected, this area displays the scanning path.

•   Editing the Start or End points will update the displayed scan range in this area.
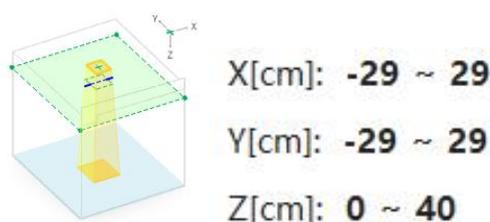
5.9.4. Task Measurement Process
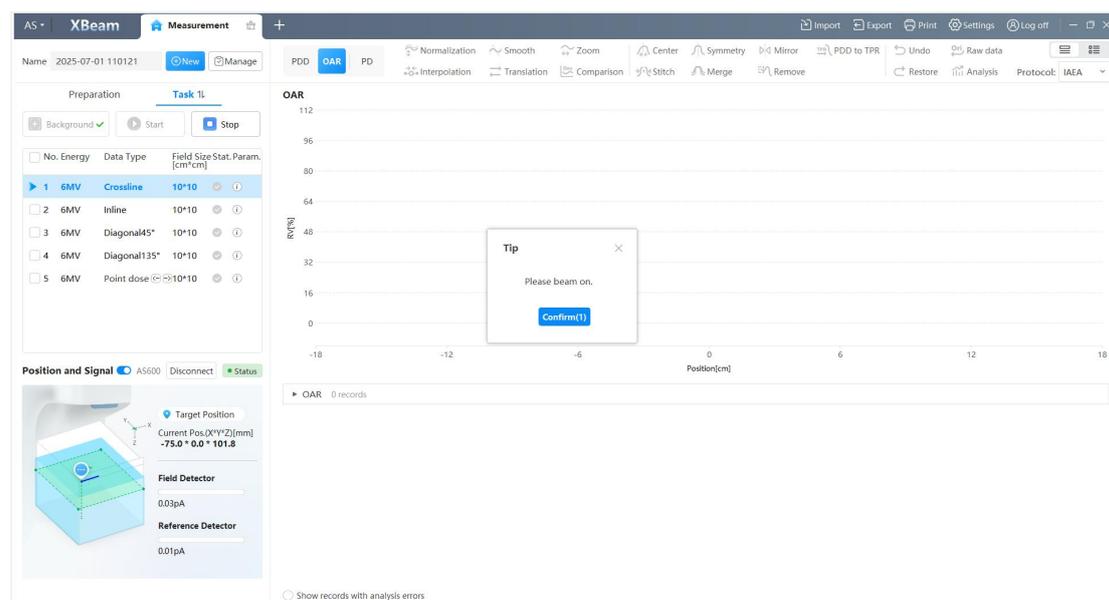
Figure 56. Measurement Operation Steps_Task List

•   After creating tasks, click ⇅ to automatically sort them by parameters such as energy and field size.

•   Select the tasks to be executed, then click ▶ Start to start. The system will perform measurements sequentially. Task status can be viewed in the Status column. If an error occurs, the system will skip the task and continue with the next.

•   At measurement start, the software will prompt "Please beam on." At this time, the linac should deliver the beam according to the current task parameters. For example, if the current task requires ▶ 2 6MV Crossline 10*10 ✓ ⓘ (6 MV, 10 × 10 cm, 300 MU/min, 999 MU), the beam must match the specified energy and field size; the dose rate can be set freely. It is recommended to use a higher step size to ensure

complete data acquisition.

• During measurement, the curve area displays real-time data. The system automatically processes data based on the configuration in [Settings > Scan]. Analysis protocols and parameters can be configured in [Settings > Analysis Protocol].

• After all tasks are completed, the system stops automatically. Users can also manually stop the process at any time by clicking ⬛ Stop .

5.9.5. Display During Measurement

• During task execution, if "Show Measurement" (at the top right of the page) is checked, the system will display only the current measurement curve in real time.
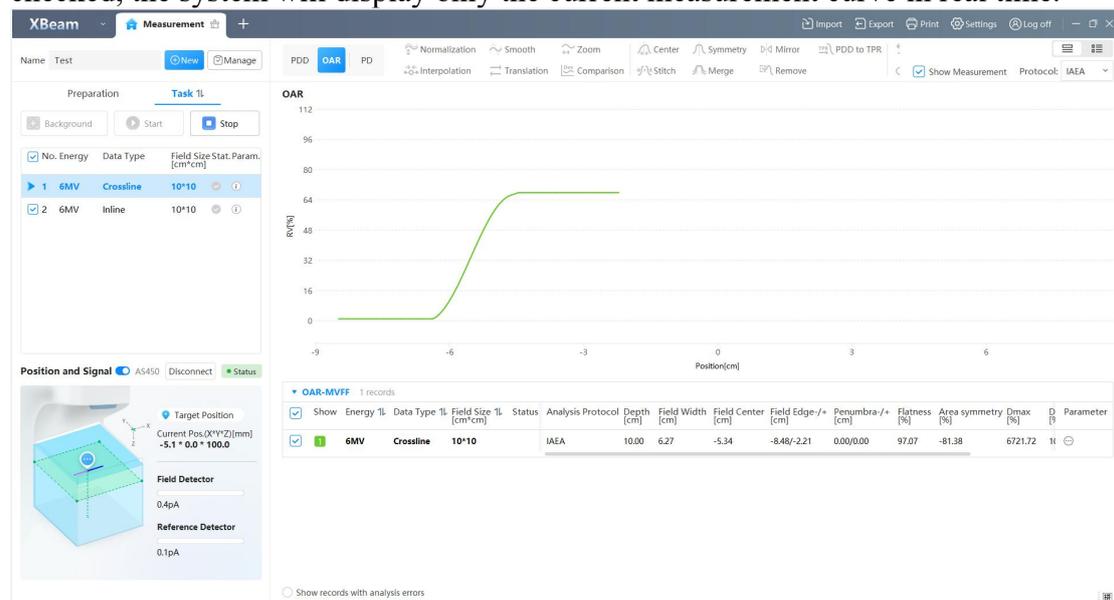
Figure 57. Measurement Operation Steps_Show Measurement Enabled

• If "Show Measurement" is not checked, other curves under the same task can be viewed during measurement, while the current measurement curve is still shown in real time. Note that the interface is still in viewing mode and all operation functions are locked.
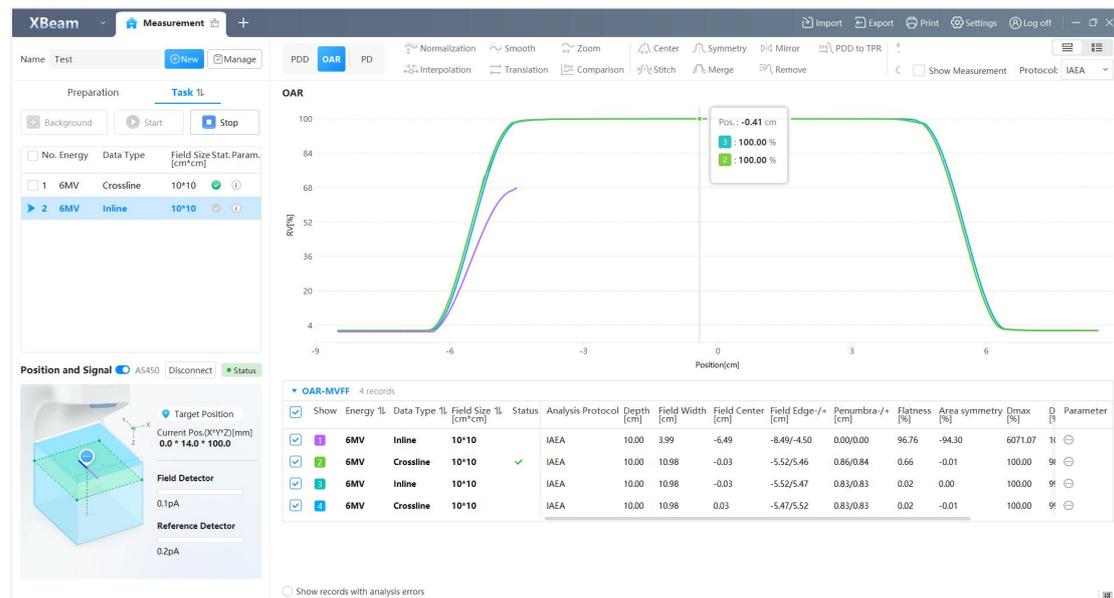
Figure 58. Measurement Operation Steps_Show Measurement Disabled

6. Algorithms and Formulas

6.1. Normalization

6.1.1. PDD Curves

- **Normalized to Dmax**

$$Dose_{normalize}(x) = \frac{Dose(x)}{Dose_{max}}\%$$

- **Normalized to specified depth**

$$Dose_{normalize}(x) = Dose(x) * \frac{100}{Dose(x_i)}\%$$

Where:
- $Dose(x)$ = Dose value at any point on the curve
- $Dose_{max}$ = Maximum dose on the PDD curve
- $Dose(x_i)$ = Dose at the specified depth

6.1.2. OAR Curves

- **Normalized to Dmax**

$$Dose_{normalize}(x) = \frac{Dose(x)}{Dose_{max}}\%$$

- **Normalized to field center**

$$Dose_{normalize}(x) = \frac{Dose(x)}{Dose_{Center}}\%$$

- **Normalized to specified dose**

$$Dose_{normalize}(x) = \frac{Dose(x)}{Dose_{input}}\%$$

Where:
- $Dose(x)$ = Dose value at any point on the curve
- $Dose_{max}$ = Maximum dose on the OAR curve
- $Dose_{Center}$ = Dose at the center of the field
- $Dose_{input}$ = User-defined dose value

6.2. Smooth

The smoothing function is used to eliminate random fluctuations in the measurement. A moving average method is applied, in which the current value is calculated as the average of a total of (2n+1) observed values around the current point.

$$Dose(x) = \frac{\sum_{x-n}^{x=n} Dose(x)}{2n + 1}$$

Where:
- $Dose(x)$ = Dose value at any point on the curve
- Smoothing size = $2n + 1$

6.3. Zoom

6.3.1. Scale by SSD

- The user must first enter the SSD. The algorithm will calculate a scaling factor based on the SSD.

- The scaling factor: $f = SSD_{to}/SSD_{original}$, The scaled value is obtained by multiplying the current value by the scaling factor.

$$Dose(x) = Dose(x) * \frac{SSD_{to}}{SSD_{original}}$$

Where:
- $Dose(x)$ = Dose value at any point on the curve
- SSD_{to} = User-entered SSD
- $SSD_{original}$ = SSD of the original data

6.3.2. Scale by SDD

- The user must first enter the SSD. The algorithm will calculate a scaling factor based on the SSD and Depth.

- The scaling factor: $f = SDD_{to}/(SSD_{original} + Depth)$, The scaled value is obtained by multiplying the current value by the scaling factor.

$$Dose(x) = Dose(x) * \frac{SDD_{to}}{SSD_{original} + Depth}$$

Where:
- $Dose(x)$ = Dose value at any point on the curve
- SDD_{to} = User-entered
- $SSD_{original}$ = SSD of the original data
- $Depth$ = Depth of the original data

6.4. Interpolation

The interpolation function is used to insert new points between adjacent measured data points, enhancing data density and continuity. A two-point linear interpolation method is used.

6.4.1. Coordinate Interpolation

Users must first input the coordinate spacing value gap. The system will perform linear interpolation on all intervals where the horizontal spacing between adjacent points exceeds gap, until all adjacent points meet the spacing requirement.

For each pair of adjacent points (x_i, y_i) and (x_{i+1}, y_{i+1}):

- If $x_{i+1} - x_i > gap$, then insert m equally spaced points within this interval such that the spacing between adjacent points after insertion $\leq gap$. The formula for calculating the number of inserted points is: $m = \frac{(x_{i+1} - x_i)}{gap} - 1$

- The coordinates of newly inserted points are calculated by linear interpolation:
$$x_{new} = x_i + k * \Delta x$$
$$y_{new} = y_i + k * \Delta y$$

Where:

- $\Delta x = \frac{(x_{i+1} - x_i)}{m+1}$

- $\Delta y = \frac{(y_{i+1} - y_i)}{m+1}$

- $k = 1, 2, \ldots, m$

6.4.2. Dose Interpolation

Users must first input the dose spacing value *gap*. The system will perform linear interpolation on all intervals where the point dose difference between adjacent points exceeds *gap*, until all adjacent points meet the spacing requirement.

For each pair of adjacent points (x_i, y_i) and (x_{i+1}, y_{i+1}):
- If $y_{i+1} - y_i > gap$, then insert m equally spaced points within this interval such that the spacing between adjacent points after insertion $\leq gap$. The formula for calculating the number of inserted points is: $m = \frac{(y_{i+1} - y_i)}{gap} - 1$

- •The coordinates of newly inserted points are calculated by linear interpolation:
$$x_{new} = x_i + k * \Delta x$$
$$y_{new} = y_i + k * \Delta y$$

Where:

- $\Delta x = \frac{(x_{i+1} - x_i)}{m+1}$

- $\Delta y = \frac{(y_{i+1} - y_i)}{m+1}$

- $k = 1, 2, \ldots, m$

6.5. Translation

The translation function is used to move the entire curve horizontally by a user-specified value.

A positive input translates the curve to the right (positive X direction); a negative input translates it to the left (negative X direction).
$$x_{new} = x_i + x_0$$
$$y_{new} = y_i$$
Where x_0 refers to input translation value.

6.6. Comparison

The comparison function is used to evaluate deviations between all selected records and a baseline.

Notes:

- One curve must be set as the baseline for comparison. If multiple baseline curves exist, the system will use the most recently set curve as the current baseline by default.
- If the baseline curve is of PDD type, only records of the same PDD type will be compared; other types will be excluded from comparison. The same applies if the baseline curve is of OAR type.

6.7. Center

The center function shifts the curve so that the field center aligns with the coordinate origin, centering the curve along the horizontal axis.

$$x_{new} = x_i - x_{center}$$
$$y_{new} = y_i$$

Where:

- x_{center} = Field center position

6.8. Symmetry

The symmetry function performs symmetry operations on the measured data about the field center. This function includes three modes: left symmetry, right symmetry, and left-right average symmetry.

6.8.1. Left Symmetry

Set the field center as symmetry axis. Preserve original data at the field center and its left side, and generate right-side data through mirror symmetry transformation of left-side data.

$$point_{left} = \{(x_i, y_i) \mid x_i \leq x_{center}\}$$

$$point_{right} = \{(2 * x_{center} - x_i, y_i) \mid x_i > x_{center}\}$$

$$point_{new} = point_{left} \cup point_{right}$$

Where:

- x_{center} = Field center position
- $point_{left}$ = Left-side point of field center
- $point_{right}$ = Right-side point of field center

6.8.2. Right Symmetry

Set the field center as symmetry axis. Preserve original data at the field center and its right side, and generate left-side data through mirror symmetry transformation of right-side data.

$$point_{left} = \{(2 * x_{center} - x_i, y_i) \mid x_i \leq x_{center}\}$$

$$point_{right} = \{(x_i, y_i) \mid x_i > x_{center}\}$$

$$point_{new} = point_{left} \cup point_{right}$$

Where:
- x_{center} = Field center position
- $point_{left}$ = Left-side point of field center
- $point_{right}$ = Right-side point of field center

6.8.3. Left-Right Average Symmetry

Set the field center as symmetry axis. Traverse corresponding points on both left and right sides, calculate the average dose value for each symmetric point pair, and use this average as the dose value at the corresponding position in the new curve.

- If no corresponding data point exists at the symmetric position, the dose value of the symmetric point is obtained through linear interpolation before calculating the average value.

$$point_{left} = \{(x_i, y_{new}) \mid x_i \leq x_{center}\}$$

- If symmetric position: $2 * x_{center} - x_i$ exists data point (x_{sym}, y_{sym}):

$$y_{new} = \frac{y_i + y_{sym}}{2}$$

- If no symmetric data point (x_{sym}, y_{sym}) exists:

$$x_{sym} = 2 * x_{center} - x_i$$

- Adjacent data points around x_{sym} are: (x_j, y_j) and (x_{j+1}, y_{j+1}). Calculate dose value y_{sym} via linear interpolation:

$$y_{sym} = y_j + \frac{x_{sym} - x_j}{x_{j+1} - x_j} * (y_{j+1} - y_j)$$

- If $x_i > x_{center}$ (Right-side point $point_{right}$): Covered by left-side point processing.

$$point_{new} = point_{left} \cup point_{right}$$

6.9. Mirror

The mirror function performs reflection operations on measurement data about the coordinate origin. This function includes three modes: left mirror, right mirror, and left-right mirror.

6.9.1. Left Mirror

• Data on the left side of the coordinate origin remains unchanged.
• Set the coordinate origin as symmetric center. Copies data points from left side of the coordinate origin to their mirror positions on the right side.

$$point_{left} = \{(x_i, y_i) \mid x_i \leq 0\}$$

$$point_{right} = \{(-x_i, y_i) \mid (x_i, y_i) \in point_{left}\}$$

$$point_{new} = point_{left} \cup point_{right}$$

6.9.2. Right Mirror

• Data on the right side of the coordinate origin remains unchanged.
• Set the coordinate origin as symmetric center. Copies data points from right side of the coordinate origin to their mirror positions on the left side.

$$point_{left} = \{(-x_i, y_i) \mid (x_i, y_i) \in point_{right}\}$$

$$point_{right} = \{(x_i, y_i) \mid x_i > 0\}$$

$$point_{new} = point_{left} \cup point_{right}$$

6.9.3. Left-Right Mirror

• With the coordinate origin as symmetric center, mirror the original left data points to the right side, and the original right data points to the left side.

$$point_{left} = \{(-x_i, y_i) \mid x_i \leq 0\}$$

$$point_{right} = \{(-x_i, y_i) \mid x_i > 0\}$$

$$point_{new} = point_{left} \cup point_{right}$$

6.10. Stitch

The stitching function is used to combine two data curves with identical characteristics into a single complete measurement data.

Key Notes:
  • During stitching, one curve must be selected as the baseline. If no baseline curve is specified , the system defaults to the first curve as the baseline.
  • In overlapping data regions, the baseline curve's data takes precedence and is retained.
  • The two curves being stitched must share identical characteristics, including Crossline/Diagonal/Inline type, field size and symmetry, water depth, energy value, etc.

Implementation Method:
  • Sort both measured datasets in ascending order based on the horizontal

(position) coordinates.
- For non-overlapping data points, append the non-baseline curve's data to the baseline curve.
- For overlapping data points, replace them with the corresponding data from the baseline curve.
- The final output is a complete stitched curve for further analysis and processing.

6.11. Merge

The merging function is used to combine two or more measurement data to increase data density.

Key Notes:
- During merging, one curve must be selected as the baseline. If no baseline curve is specified, the system defaults to the first curve as the baseline. The baseline curve's OAR must fully cover the radiation field area.
- All curves participating in the merge must share identical characteristics, including Crossline/Diagonal/Inline type, field size and symmetry, water depth, and energy value.
- Data must undergo normalization processing before merging.

Implementation Method:
- Calculate the overlapping regions between all non-baseline OAR curves and the baseline OAR curve.
- In overlapping regions, interpolate and replace point data from non-baseline OAR curves according to the baseline OAR curve's coordinates.
- Normalized all profiles to the field center; for wedge fields of the Inline type, use maximum value normalization.
- Sequentially merge all curve data. If multiple measurement points exist at the same position, take the average relative dose; non-ovelapping sections are directly appended.

6.12. Remove

This function removes all data points with depths (x-coordinates) below the user-defined threshold from PDD curves.

6.13. PDD to TPR

$$TPR_{(d,fs,E)} = \frac{PDD_{w(d,fs_d,SSD)}}{PDD_{w(d_{ref},fs_{d_{ref}},SSD)}} \left(\frac{SSD + d}{SSD + d_{ref}}\right)^2 \frac{S_{p(fs_{d_{ref}})}}{S_{p(fs_d)}}$$

➢ In $PDD_{w(d,fs_d,SSD)}$, $fs_d = fs \times \frac{f}{f+d}$, where:
- fs_d = Field size scaled at depth d for the currently calculated TPR
- fs = Currently calculated TPR field size (as defined in the TPR calculation model)
- SSD = Corresponding SSD (as defined in the TPR calculation model)
- d = Current TPR depth
- $fs_{d_{ref}}$ = Field size of the currently calculated TPR when scaled to the

reference depth
- d_{ref} = Reference depth (as defined in the TPR calculation model)
➢ According to BJR25 data, the corresponding Sp values for different field sizes are as follows:

Fs (cm²)	Sp
0 × 0	0.949
4 × 4	0.979
5 × 5	0.983
6 × 6	0.987
7 × 7	0.990
8 × 8	0.994
9 × 9	0.997
10 × 10	1.000
12 × 12	1.006
15 × 15	1.013
20 × 20	1.023
25 × 25	1.029
30 × 30	1.033
35 × 35	1.037
40 × 40	1.040

6.14. PDI to PDD

$$PDD_{depth} = \frac{PDI_{depth} \times StoppingPower_{depth,R50} \times P_{repl(depth,R50,Chamber\ Diameter,Rp)}}{StoppingPower_{(depthmaxionization,R50)} \times P_{repl(depthmaxionization,I50,Chamber\ Diameter,Rp)}}$$

➢ P50 can be calculated based on the I50 value:

$$R_{50} = 1.029 I_{50} - 0.06, \quad 2 \le I_{50} \le 10$$
$$R_{50} = 1.059 I_{50} - 0.37, \quad I_{50} > 10$$

➢ $StoppingPower$ can be calculated based on the R50 value:

$$StoppingPower = \frac{a + b(\ln R_{50}) + c(\ln R_{50})^2 + d([Depth]/R_{50})}{1 + e(\ln R_{50}) + f(\ln R_{50})^2 + g(\ln R_{50})^3 + h([Depth]/R_{50})}$$

Where:

a	b	c	d	e	f	g	h
1.0752	-0.50867	0.088670	-0.08402	-0.42806	0.064627	0.003085	-0.12460

➢ Prepl Calculation
- If using a plane parallel chamber, or when "effective point of measurement correction" is enabled for thimble ionization chambers, Prepl shall be set to 1;
- Otherwise, Prel shall be calculated using the following empirical formula based on depth z:

$$\overline{E_0} = 0.818 + 1.935 * I_{50} + 0.040(I_{50})^2$$
$$\overline{E_z} = \overline{E_0}\left(1 - \frac{z}{R_p}\right)$$
$$z = Depth$$

➢ The corresponding Prel value shall be determined from the reference table based

on the calculated $\overline{E_z}$ value:

➢ Refer to the table below to find the corresponding Prepl value based on the calculated result of $\overline{E_z}$:

Internal Diameter						
Ez（MeV）	3mm	4mm	5mm	5.5mm	6mm	7mm
2	0.977	0.970	0.962	0.959	0.956	0.949
3	0.978	0.972	0.966	0.963	0.959	0.952
5	0.982	0.977	0.971	0.968	0.965	0.96
7	0.986	0.982	0.977	0.975	0.972	0.967
10	0.99	0.988	0.985	0.983	0.981	0.978
15	0.995	0.994	0.992	0.992	0.991	0.99
20	0.997	0.997	0.996	0.996	0.995	0.995

6.15. Undo

• Reverts the most recent processing operation performed on the curve data. Dose not apply to reversal of copy operations.
• Supports up to 10 consecutive undo steps.

6.16. Raw Data

• Clear all executed processing steps and restores the currently displayed curve to its original measured data state.

6.17. Restore

• Re-executes the most recently undone processing operation. Does not apply to restoration of copy operations.

6.18. Analysis

• Performs analysis on all selected curves according to the currently selected protocol.
• Analysis protocol and related parameters can be configured and managed in the software's [Settings > Analysis Protocol].

7. Analysis Protocol

- The analysis parameters displayed in XBeam are based on the analysis protocol selected by the user. AutoScanner currently includes built-in protocols such as IEC, IAEA, AAPM, Elekta, and Varian.
- If a protocol does not specify special requirements for Profile (FFF) data (e.g., AAPM, IAEA, IEC), the system will apply the same calculation method used for Profile (FF) data to analyze Profile (FFF) data.

7.1. Parameters

7.1.1. IEC Parameter List

Type	PDD	Profile	TPR
Photon	R100 [cm] Dmax [%] R80 [cm] Ds [%] Qi(D200/D100)	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Symmetry [%] Dmax [%] Dev. [%]	R100 [cm] Dmax [%] R80 [cm] Ds [%]
Electron	R100 [cm] Dmax [%] R80 [cm] Rp [cm] Rq [cm] Ds [%] Dx [%] G	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Flatness at 80%-/+ [cm] Flatness at 90%-/+ [cm] Symmetry [%] Dmax [%] Dev. [%]	N/A

7.1.2. IAEA Parameter List

Type	PDD	Profile	TPR
Photon	R100 [cm] Dmax [%] R50 [cm] R80 [cm] D100 [%] D200 [%] Qi(D200/D100)	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Area Symmetry [%] Dmax [%] Dmin [%]	R100 [cm] Dmax [%] D200 [%] D100 [%] D50 [%]

Type	PDD	Profile	
Electron	R100 [cm] Dmax [%] R90 [cm] R85 [cm] R85' [cm] R50 [cm] Rp [cm] Rq [cm] Ref Depth [cm] E0 [MeV] Ep0 [MeV] Dx [%] G	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Flatness at 80%-/+ [cm] Flatness at 90%-/+ [cm] Symmetry [%] Dmax [%] Dev. [%]	N/A

7.1.3. AAPM Parameter List

Type	PDD	Profile	TPR
Photon	R100 [cm] Dmax [%] D100 [%] D200 [%] Qi(D200/D100)	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Symmetry [%] Dmax [%] Dmin [%] Dev. [%]	R100 [cm] Dmax [%] D100 [%] D200 [%]
Electron	R100 [cm] Dmax [%] R90 [cm] R85 [cm] R50 [cm] Rp [cm] Rq [cm] Rt [cm] Ref depth [cm] Ds [%] Dx [%] E0 [MeV] Ep0 [MeV] G	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Symmetry [%] Dmax [%] Dmin [%]	N/A

7.1.4. Elekta Parameter List

Type	PDD	Profile	Profile (FFF)	TPR
Photon	R100 [cm] Dmax [%] R80 [cm] R50 [cm] D100 [%]	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Symmetry [%] Dmax [%] Dev. [%]	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Dmax [%] Dose at 20% field width (-/+) [%] Dose at 50% field width (-/+) [%] Dose at 60% field width (-/+) [%] (Diagonal) Dose at 80% field width (-/+) [%] (Cross or Inline) Symmetry [%]	R100 [cm] Dmax [%] R80 [cm] R50 [cm] D100 [%]
Electron	R100 [cm] Dmax [%] R85 [cm] R80 [cm] Rq [cm] Ds [%]	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Flatness at 80%-/+ [cm] Flatness at 90%-/+ [cm] Symmetry [%] Dmax [%] Dev. [%]	N/A	N/A

7.1.5. Varian Parameter List

Type	PDD	Profile	Profile (FFF)	TPR
Photon	R100 [cm] Dmax [%] D100 [%]	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Symmetry [%] Dmax [%]	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Symmetry [%] Dmax [%] Dose@2cm(-/+) [%] Dose@4cm(-/+) [%] Dose@6cm(-/+) [%] Dose@18cm(-/+) [%]	R100 [cm] Dmax [%] D100 [%]

Electron	R100 [cm] Dmax [%] R90 [cm] R80 [cm] R50 [cm] R30 [cm] Rq [cm] Ds [%] Dx [%]	Field Width [cm] Field Center [cm] Field Edge-/+ [cm] Penumbra-/+ [cm] Flatness [%] Symmetry [%] Dmax [%]	N/A	N/A

7.2. Formula

The following explains the differences in calculating diagonal field edges for different detector types:

- Farmer Ionization Chamber: Due to its relatively large sensitive volume, only approximately 1/4 of the detector volume is exposed to radiation when positioned at the diagonal field edge. Therefore, for OAR measurements along the diagonal, the field edge is defined at the 25% dose level.
- Plane Parallel Chamber: Similar to the thimble chamber, the radiation coverage ratio remains identical due to comparable geometry. For diagonal OAR measurements, the field edge is likewise set at the 25% dose level.
- Semiconductor Detector: Its extremely small active volume renders volume-averaging effects negligible. The field edge is determined strictly according to the criteria specified in the analysis protocol.

7.2.1. Electron PDD

The following parameters may be calculated for electron PDD: R100, Dmax, R90, R85, R80, R50, R30, Rp, Rq, Rt, Rref, Ds, Dx, E0, Ep0, G

(1) R100: Depth at maximum dose point
(2) Dmax: Maximum dose value
(3) R90: Depth at 90% of maximum dose
(4) R85: Depth at 85% of maximum dose
(5) R80: Depth at 80% of maximum dose
(6) R50: Depth at 50% of maximum dose
(7) R30: Depth at 30% of maximum dose
(8) Rp: Practical range

AAPM	$R_p = 1.271 \times R_{50} - 0.23\ cm$
IAEA	①Calculate first derivative of PDD curve. $$DervD(t) = \frac{[D(t) - D(t-1)]}{[pos(t) - pos(t-1)]}$$ ②Apply smoothing to derivative curve. ③Identify depth at minimum derivative value: the pos(t) corresponding to Min[DervD(t)]. ④Let the minimum derivative value be the slope a; At the position pos(t),

	read the corresponding dose value PDD from the curve. The tangent line equation is derived as: $$Y = aX + b$$ Where, a= Min[DervD(t)], b=intercept ⑤Set $Y = 0$ in the tangent equation and solve for X (defined as Rp).
IEC	The calculation method is identical to the IAEA protocol.

(9) Rq: The depth at the intersection point between the tangent line at the point with minimum derivative and the horizontal line through Dmax.

AAPM	①Refer to the IAEA protocol calculation method of Rp to obtain the tangent line at the steepest point of the PDD curve. ②Draw a horizontal line through Dmax parallel to X-axis and intersect it with the tangent line from step①. ③The X-coordinate (depth) of the intersection point of these two lines is Rq.
IAEA	Same as AAPM.

(10) Rt: Therapeutic depth

AAPM	Uses R90 as Rt, which is the depth of 90% of maximum dose (excluding buildup region).
IAEA	Uses R85 as Rt, which is the depth of 85% of maximum dose (excluding buildup region).

(11) Rref: Reference depth

AAPM	$$R_{ref} = R_{50} \times 0.6 - 1\ mm$$
IAEA	Same as AAPM

(12) Ds: Surface dose

AAPM	The dose at 0.5mm depth underwater is taken as the surface dose.
IEC	The dose at 0.5mm depth underwater is taken as the surface dose.
Varian	The dose at 0.5mm depth underwater is taken as the surface dose.
Elekta	The dose at the water tank surface (i.e., at 0mm depth) is taken as the surface dose.

(13) Dx: X-ray background

AAPM	$$D_x = m \times R_p + \left[Dose\left(R_p + 4\ cm\right) - m \times \left(R_p + 4\ cm\right)\right]$$ Where, $$m = \left[Dose\left(R_p + 4\ cm\right) - Dose\left(R_p + 2\ cm\right)\right]/2$$
IAEA	The dose value at the last measured point is taken as Dx.
IEC	The dose value at depth Rp+100mm is taken as Dx.
Varian	The dose value at depth R10+100mm is taken as Dx.

(14) E0: Mean energy at phantom surface

AAPM	$$E_0 = 0.656 + 2.059 \times R_{50} + 0.022 \times R_{50}{}^2$$ $$E_0 = 0.818 + 1.935 \times I_{50} + 0.04 \times I_{50}{}^2$$
IAEA	$$E_0 = 2.33 \times R_{50}$$
IEC	$$E_0 = 0.818 + 1.935 \times I_{50} + 0.04 \times I_{50}{}^2$$

(15) Ep0: Most probable energy at surface

AAPM	$E_0 = 0.22 + 1.98 \times R_p + 0.0025 \times R_p{}^2$
IAEA	Same as AAPM.

(16) G: Dose gradient

AAPM	$G = \dfrac{R_p}{R_p - R_q}$
IAEA	Same as AAPM.
IEC	$G = \dfrac{R_{80}}{R_p}$

7.2.2. Photon PDD

The following parameters may be calculated for photon PDD: R100, Dmax, R80, R50, Ds, D100, D200, Qi (D200/D100)
(1) **R100:** Depth at maximum dose point
(2) **Dmax:** Maximum dose value
(3) **R80:** Depth at 80% of maximum dose
(4) **R50:** Depth at 50% of maximum dose
(5) **Ds:** Surface dose

IEC	The dose at 0.5mm depth underwater is taken as the surface dose.

(6) **D100:** Dose value at 100mm depth underwater
(7) **D200:** Dose value at 200mm depth underwater
(8) **Qi**: Beam quality index

AAPM	$Q_i = \dfrac{D_{200}}{D_{100}}$
IAEA	Same as AAPM.
IEC	Same as AAPM.

7.2.3. Electron OAR

The following parameters may be calculated for electron OAR: Field Edge, Field Center, Field Width, Penumbra, Flatness, Symmetry, Dmax, Deviation, Flattened Area.
(1) Field Edge
   • Locate the positions with the maximum and minimum slopes on both sides of the OAR curve as the initial rough field edges. The midpoint between these edges is the estimated field center.
   • Calculate the average dose of all points within ± 0.25 cm of the estimated field center to determine the central axis dose.
   • The final field edges are defined as the points where the dose falls to 50% of the central axis dose.
(2) Field Center
   • The field center is the midpoint between the left and right field edges.
(3) Field Width

- The field width is the distance between the left and right field edges.

(4) Penumbra
- Left Penumbra: Distance between the 20% and 80% dose levels on the left side of the field center.
- Right Penumbra: Distance between the 20% and 80% dose levels on the right side of the field center.

(5) Flatness

AAPM	$\text{Flatness} = \dfrac{|D_{max} - D_{min}|}{D_{max} + D_{min}}$
IAEA	① $\text{Flatness} = \dfrac{D_{max}}{D_{CAX}}$ ② Distance between 80% and 50% isodose lines (both sides of central axis) ③ Distance between 90% and 50% isodose lines (both sides of central axis)
IEC	Same as IAEA.
Varian	Same as AAPM.
Elekta	① $\text{Flatness} = \dfrac{D_{max}}{D_{AVG}}$ (where $D_{AVG} = \dfrac{D_{max}+D_{min}}{2}$) ② Distance between 80% and 50% isodose lines (both sides of central axis) ③ Distance between 90% and 50% isodose lines (both sides of central axis)

(6) Symmetry

AAPM	$\text{Symmetry} = 100 * \text{Max}\left[\left|\dfrac{Point_L}{Point_R}\right|, \left|\dfrac{Point_R}{Point_L}\right|\right]$
IAEA	Same as AAPM.
IEC	Same as AAPM.
Varian	$\text{Symmetry} = \dfrac{\text{Max}(|Point_L - Point_R|)}{D_{CAX}}$
Elekta	Same as AAPM.

(7) Dmax: Maximum dose value

(8) Deviation

IAEA	$\text{Deviation} = \dfrac{D_{max}}{D_{CAX}}$
IEC	Same as IAEA.
Elekta	Same as IAEA.

(9) Flattened Area
- Flatness/Symmetry/Deviation calculations must be performed using data acquired within the defined flattened area.

AAPM	0.8 × Field Width
IAEA	Area within 1 cm inside the 90% isodose line.
IEC	Same as IAEA.
Varian	Same as AAPM.
Elekta	① 0.8 × Field Width (for Flatness calculation)

	② Area within 1 cm inside the 90% isodose line (for symmetry calculation).

7.2.4. Photon OAR

The following parameters may be calculated for photon OAR: Field Edge, Field Center, Field Width, Penumbra, Flatness, Symmetry, Dmax, Dmin, Deviation, Flattened Area.

(1) **Field Edge**
- Locate the positions with the maximum and minimum slopes on both sides of the OAR curve as the initial rough field edges. The midpoint between these edges is the estimated field center.
- Calculate the average dose of all points within ± 0.25 cm of the estimated field center to determine the central axis dose.
- The final field edges are defined as the points where the dose falls to 50% of the central axis dose.

(2) **Field Center:** The field center is the midpoint between the left and right field edges.

(3) **Field Width:** The field width is the distance between the left and right field edges

(4) **Penumbra**
- Left Penumbra: Distance between the 20% and 80% dose levels on the left side of the field center.
- Right Penumbra: Distance between the 20% and 80% dose levels on the right side of the field center.

(5) Flatness

AAPM	$\text{Flatness} = \dfrac{|D_{max} - D_{min}|}{D_{max} + D_{min}}$
IAEA	Same as AAPM.
IEC	$\text{Flatness} = \dfrac{D_{max}}{D_{min}}$
Varian	Same as AAPM.
Elekta	Same as IEC.

(6) Symmetry

AAPM	$\text{Symmetry} = 100 * \text{Max}\left[\left|\dfrac{\text{Point}_L}{\text{Point}_R}\right|, \left|\dfrac{\text{Point}_R}{\text{Point}_L}\right|\right]$
IAEA	$\text{Symmetry} = \dfrac{|\text{Area}_L - \text{Area}_R|}{\text{Area}_L + \text{Area}_R}$ Where Area_L refers to the area enclosed between the 50% maximum dose position on the left side of central axis and the central axis curve; and Area_R refers to the area enclosed between the 50% maximum dose position on the right side of central axis and the central axis curve.
IEC	Same as AAPM.
Varian	$\text{Symmetry} = \dfrac{\text{Max}(|\text{Point}_L - \text{Point}_R|)}{D_{CAX}}$

Elekta	Same as AAPM.

(7) Dmax: Maximum dose value
(8) Dmin: Minimum dose value
(9) Deviation

AAPM	$$\text{Deviation} = \frac{\text{Dose(position}_{-FS/3})}{\text{Dose(position}_{FS/3})}$$
IEC	$$\text{Deviation} = \frac{\text{Max}(|D_{min} - D_{CAX}|, |D_{max} - D_{CAX}|)}{D_{CAX}}$$
Elekta	Same as IEC.

(10) Flattened Area

AAPM	$0.8 \times$ Field Width
IEC	• Principle axis For 5cm ≤ Field Width ≤ 10cm: Field Width−2×1 cm; For 10cm < Field Width ≤ 30cm: 0.8 ×Field Width. • Diagonal axis For 5cm ≤ Field Width ≤ 10cm: Field Width− 2 × 2 cm; For 10cm < Field Width ≤ 30cm: Field Width− 2 × (0.2 ×:Field Width).
Varian	Same as AAPM.
Elekta	Same as IEC.

7.2.5. Electron PDI

The following parameters may be calculated for electron PDI: R100 , Imax, I90, I85, I80, I50, I30, Ds, E0

(1) R100: Depth at maximum dose point

(2) Imax: Maximum ionization

(3) I90: Depth at 90% of maximum ionization

(4) I85: Depth at 85% of maximum ionization

(5) I80: Depth at 80% of maximum ionization

(6) I50: Depth at 50% of maximum ionization

(7) I30: Depth at 30% of maximum ionization

(8) Ds: Surface ionization

AAPM	The ionization at 0.5mm depth underwater is taken as the surface ionization.
IEC	The ionization at 0.5mm depth underwater is taken as the surface ionization.
Varian	The ionization at 0.5mm depth underwater is taken as the surface ionization.
Elekta	The ionization at 0.5 mm depth underwater and the ionization at the water phantom surface are both taken as the surface ionization.

(9) E0: Mean energy at phantom surface

7.2.6. Photon TPR

The following parameters may be calculated for photon TPR: R100, Dmax, R80, R50, Ds, D100, D200, D50

(1) R100: Depth at maximum dose point

(2) Dmax: Maximum dose value

(3) R80: Depth at 80% of maximum dose

(4) R50: Depth at 50% of maximum dose

(5) Ds: Surface dose

IEC	The dose at 0.5mm depth underwater is taken as the surface dose.

(6) D100: Dose value at 100mm depth underwater

(7) D200: Dose value at 200mm depth underwater

(8) D50: Dose value at 50mm depth underwater

7.2.7. Photon FFF OAR

The following parameters may be calculated for photon FFF OAR: Field Width, Field Center, Field Edge, Dmax, Dose at 20% field width, Dose at 50% field width, Dose at 60% field width, Dose at 80% field width, Dose at $\pm$2cm, Dose at $\pm$4cm, Dose at $\pm$6cm, Dose at $\pm$18cm, Symmetry.

(1) Field Edge: Points of maximum and minimum slope

(2) Field Center: Midpoint between left and right field edges

(3) Field Width: Distance between left and right field edges

(4) Dmax: Maximum dose value

(5) Dose at 20% field width:

$$\text{Dose@20\%FS} = 100 \times \frac{\text{Dose}_{\text{beamcenter}\pm10\%\text{FS}}}{\text{Dose}_{\text{beamcenter}}}$$

(6) Dose at 50% field width:

$$\text{Dose@50\%FS} = 100 \times \frac{\text{Dose}_{\text{beamcenter}\pm25\%\text{FS}}}{\text{Dose}_{\text{beamcenter}}}$$

(7) Dose at 60% field width (diagonal):

$$\text{Dose@60\%FS} = 100 \times \frac{\text{Dose}_{\text{beamcenter}\pm30\%\text{FS}}}{\text{Dose}_{\text{beamcenter}}}$$

(8) Dose at 80% field width (crossline or inline):

$$\text{Dose@80\%FS} = 100 \times \frac{\text{Dose}_{\text{beamcenter}\pm40\%\text{FS}}}{\text{Dose}_{\text{beamcenter}}}$$

(9) Dose at $\pm$2cm: Dose at $\pm$2 cm from central axis

(10) Dose at $\pm$4cm: Dose at $\pm$4 cm from central axis

(11) Dose at $\pm$6cm: Dose at $\pm$6 cm from central axis

(12) Dose at $\pm$18cm: Dose at $\pm$18 cm from central axis

(13) Symmetry:

Varian	$\text{Symmetry} = 100 \times \dfrac{\text{Max}(\lvert\text{Dose}_{\text{pointL}} - \text{Dose}_{\text{pointR}}\rvert)}{\text{Dose}_{\text{CAX}}}$
Elekta	$\text{Symmetry} = 100 \times \text{Max}\left[\left\lvert\dfrac{\text{Point}_{\text{L}}}{\text{Point}_{\text{R}}}\right\rvert, \left\lvert\dfrac{\text{Point}_{\text{R}}}{\text{Point}_{\text{L}}}\right\rvert\right]$

7.2.8. PDI to PDD

$$\text{PDD}_{\text{depth}} = \frac{\text{PDI}_{\text{depth}} \times \text{StoppingPower}_{\text{depth,R50}} \times \text{P}_{\text{repl(depth,R50,Chamber Diameter,Rp)}}}{\text{StoppingPower}_{\text{depthamxionization,R50}} \times \text{P}_{\text{repl(depthamxionization,I50,Chamber Diameter,Rp)}}}$$

➢ R50 can be calculated based on the I50:

$$R_{50} = 1.029 I_{50} - 0.06, \quad 2 \leq I_{50} \leq 10$$

$$R_{50} = 1.059 I_{50} - 0.37, \quad I_{50} > 10$$

➢ *StoppingPower* can be calculated based on the R50:

$$\text{StoppingPower} = \frac{a + b(\ln R_{50}) + c(\ln R_{50})^2 + d([\text{Depth}]/R_{50})}{1 + e(\ln R_{50}) + f(\ln R_{50})^2 + g(\ln R_{50})^3 + h([\text{Depth}]/R_{50})}$$

Where,

a	b	c	d	e	f	g	h
1.0752	-0.50867	0.088670	-0.08402	-0.42806	0.064627	0.003085	-0.12460

➢ Prepl Calculation
  • If using a plane parallel chamber, or when "effective point of measurement correction" is enabled for thimble ionization chambers, Prepl shall be set to 1;
  • Otherwise, Prel shall be calculated using the following empirical formula based on depth z:

$$\overline{E_0} = 0.818 + 1.935 * I_{50} + 0.040(I_{50})^2$$

$$\overline{E_z} = \overline{E_0}\left(1 - \frac{z}{R_p}\right)$$

$$z = Depth$$

➢ Refer to the table below to find the corresponding Prepl value based on the calculated result of $\overline{E_z}$:

Internal Diameter						
$\overline{E_z}$	3mm	4mm	5mm	5.5mm	6mm	7mm
2	0.977	0.970	0.962	0.959	0.956	0.949
3	0.978	0.972	0.966	0.963	0.959	0.952
5	0.982	0.977	0.971	0.968	0.965	0.96
7	0.986	0.982	0.977	0.975	0.972	0.967
10	0.99	0.988	0.985	0.983	0.981	0.978
15	0.995	0.994	0.992	0.992	0.991	0.99
20	0.997	0.997	0.996	0.996	0.995	0.995

7.2.9. PDD-to-TPR Calculation

$$TPR_{(d,fs,E)} = \frac{PDD_{w(d,fs_d,SSD)}}{PDD_{w(d_{ref},fs_{d_{ref}},SSD)}} \left(\frac{SSD + d}{SSD + d_{ref}}\right)^2 \frac{S_{p(fs_{d_{ref}})}}{S_{p(fs_d)}}$$

➢ According to BJR25 data, the corresponding Sp values for different field sizes are as follows:

Fs (cm²)	Sp
0 × 0	0.949
4 × 4	0.979
5 × 5	0.983
6 × 6	0.987
7 × 7	0.990
8 × 8	0.994
9 × 9	0.997
10 × 10	1.000
12 × 12	1.006
15 × 15	1.013
20 × 20	1.023
25 × 25	1.029
30 × 30	1.033
35 × 35	1.037
40 × 40	1.040

8. Operation Guide

This chapter provides step-by-step instructions for operating the AS600 system in practical use.

8.1. Equipment Setup and Power Connection

(1) Equipment Setup
- Carefully remove the AutoScanner 600 and Mover from the transport case, and detach all transport locking fixtures.
- Move the treatment couch and rotate the accelerator gantry to the 0° position. Retract the EPID panel.
- Push the AutoScanner 600 to the center of the treatment couch, positioning it directly beneath the accelerator.
- Open the light field to an appropriate field size and align the center crosshair with the crosshair area on the bottom of the AutoScanner 600.
- Place the reference ionization chamber inside the radiation field using the provided mounting bracket.
- Note: The reference ion chamber should be placed above the water surface and must not obstruct the scanning path of the field detector to avoid data interference.

(2) Power Connection
- Note: Before powering on or using the equipment, ensure all transport locking fixtures have been removed to prevent damage to mechanical components.
- Main Control Box Power Supply: When AutoScanner 600 used independently, connect the main control box to power using the provided power adapter and cable through the P/D3 port at the bottom. When AutoScanner 600 used together with the Mover, refer to the AutoScanner Mover power supply method below.
- AutoScanner Mover Power Supply:
  ① Use the P/D cable: connect one end to the Mover's P/D1 (or P/D2) port, and the other end to the main control box's P/D3 port.
  ② Alternatively, connect the supplied power adapter directly to an available P/D port on the Mover .

8.2. System Initialization

(1) Reset
- Connect the AutoScanner RC to the RC port on the main control box. Once powered on, AutoScanner RC will start automatically.
- Go to the "Detector" page on the AutoScanner RC and click the "Reset" button.
- The system will automatically perform detector reset and Mover homing.

- Note: Ensure no cables are entangled and no obstacles interfere with the Mover movement during operation.

(2) Water Level Adjustment

- Connect the AutoScanner Reservoir to the AS600 and fill the AutoScanner 600 from the Reservoir.
- You can control the water volume using the Reservoir or adjust the Mover's height via AutoScanner RC to achieve the desired SSD (typically 100 cm).
- Ensure that the water level does not exceed the maximum level mark inside the AutoScanner 600.

8.3. Component Connection and Self-Check

(1) Component Connection

Component	Interface	Notes
Water Level Sensor	Level port (Main Control Box)	Lay the cable along the inner wall of the AutoScanner 600.
Field/Reference Detector	Beam/Ref port (Main Control Box)	Can also connect to B/R port on the CCM.
CCM	CCM port (Main Control Box)	Connect to the PC via Ethernet cable.

Notes: .

- The reference detector should be placed near the center of the radiation field, without obstructing the scanning path of the field detector.
- The CCM should be kept away from radiation sources to avoid damage.
- All cables must be routed to avoid excessive tension, entanglement, or interference with moving parts.
- If the Mover is not used, ensure that the P/D3 port of the main control box is connected to a power supply.

(2) Self-Check

- Verify that the indicator lights on the main control box remain steadily lit, indicating normal operation.
- On the "Detector" or "Motion Platform" page of AutoScanner RC, click the "Reset" button again and observe the movement of the Mover and detector.
- On the "CCM" page of AutoScanner RC, set the detector voltage and check whether the high voltage and background readings are normal.

8.4. Executing a Measurement Task

(1) Connect CCM and Configure Software

- Connect the CCM to the computer using an Ethernet cable.
- Launch the XBeam software. In the Settings page, enter the device IP address and save. Return to the main interface and click Connect to establish communication.
- Use the XBeam to perform water level detection and background

measurements to ensure the system is functioning properly.

- After configuring the measurement tasks in the software, click Start, then initiate beam delivery from the accelerator according to the specified parameters.

(2) Beam Delivery

- The accelerator must deliver the beam according to the energy, field size, MU, and other parameters specified in the current task.
- The system will execute measurements sequentially according to the task list.

(3) Data Analysis

- The measurement curve will be displayed in real time. Post-processing will be performed automatically based on the parameters set in [Settings > Scan].
- Analysis protocol and parameters can be adjusted in [Settings > Analysis Protocol].
- Historical records can be imported for comparison.

8.5. Storage and Packing

(1) Drainage and Disassembly

- Use the AutoScanner Reservoir to drain all liquid from the AutoScanner 600.
- Remove the field and reference detectors, dry them thoroughly, and store them properly.
- It is recommended to perform a system reset via AutoScanner RC before powering off the device.
- Disconnect all cables and accessories, wipe off any remaining water, and ensure no liquid residue remains.

(2) Packing and Storage

- After the AutoScanner 600 is completely dry, place it and its accessories back into the original transport case.
- Store the ionization chambers, CCM, and cables in a dry cabinet.
- Storage conditions: ambient temperature between 15°C and 25°C, relative humidity between 30% and 60%.

9. Service and Support

9.1. Software Updates and Fixes

(1) Obtaining the Installation Package

Raydose regularly maintains the software. When a new version is released, users can contact Raydose's sales or distributors to obtain the update. We will also notify users in a timely manner and inquire whether they need a version update.

(2) Installation Steps

- Download the latest update package.
- Run the installer and follow the installation wizard to complete the update.
- Restart the software for the changes to take effect.

(3) Update Contents

- Feature Enhancements: New or optimized features to improve user experience.
- Bug Fixes: Resolutions for known software issues to enhance system stability.
- Performance Optimization: Faster and more efficient operation.

(4) Precautions

- Ensure a stable power connection during the update process.

It is recommended to back up important data before updating.

9.2. Technical Support

For technical support, please contact your local distributor or sales, or reach out to Raydose's after-sales team through the following channels:

- Website: https://www.raydose.com/
- Email: service@raydose.com