2022 ATOMEXPO

Research and Preliminary Application of Digital Radiation Protection Technology for Nuclear Facilities

Qinjian Cao

Department of Health Physics

China Institute for Radiation Protection

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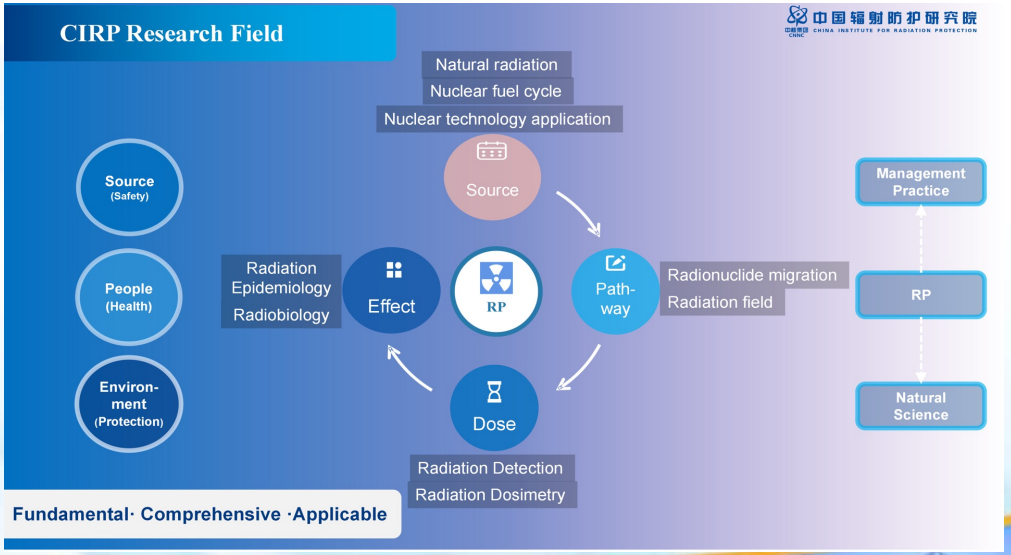
Protect the Safety
Environment and Health
CIRP
60 years

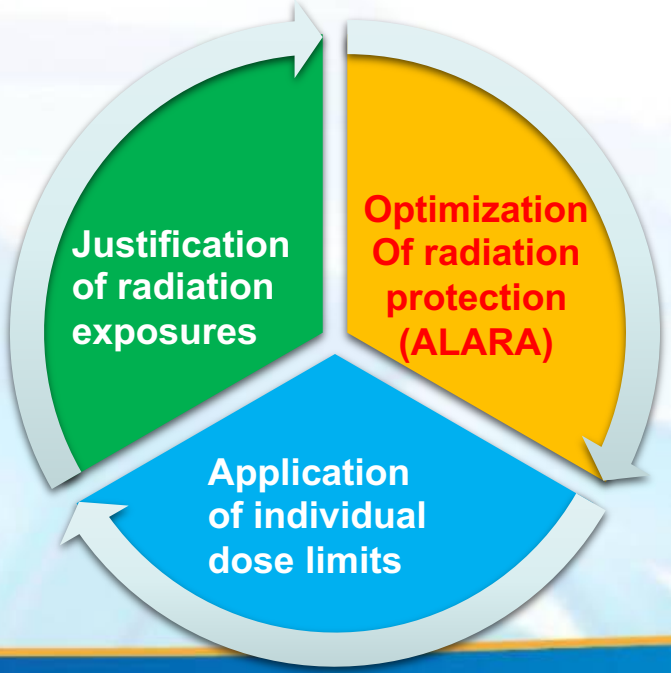

CIRP Research Field
中国辐射防护研究院
CHINA INSTITUTE FOR RADIATION PROTECTION
Natural radiation
Nuclear fuel cycle
Nuclear technology application
Source
(Safety)
People
(Health)
Environ-
ment
(Protection)
Source
Radiation
Epidemiology
Radiobiology
Effect
RP
Path-
way
Radionuclide migration
Radiation field
Dose
Radiation Detection
Radiation Dosimetry
Management
Practice
RP
Natural
Science
Fundamental· Comprehensive ·Applicable

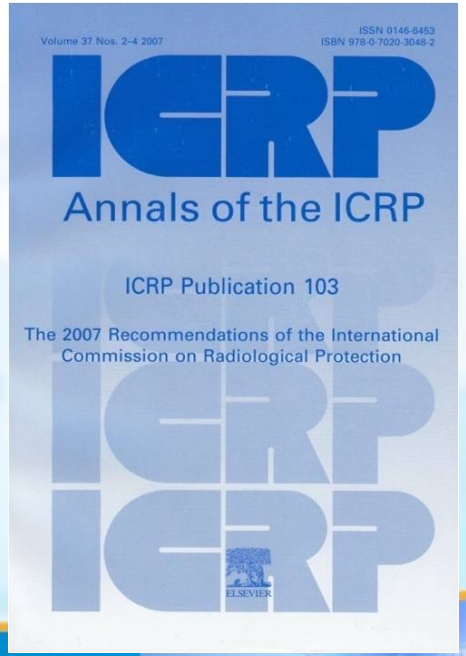
- Introduction
- Digital ALARA System
- CIRPDose: 3D ALARA planning tool
- Conclusion

Introduction

General

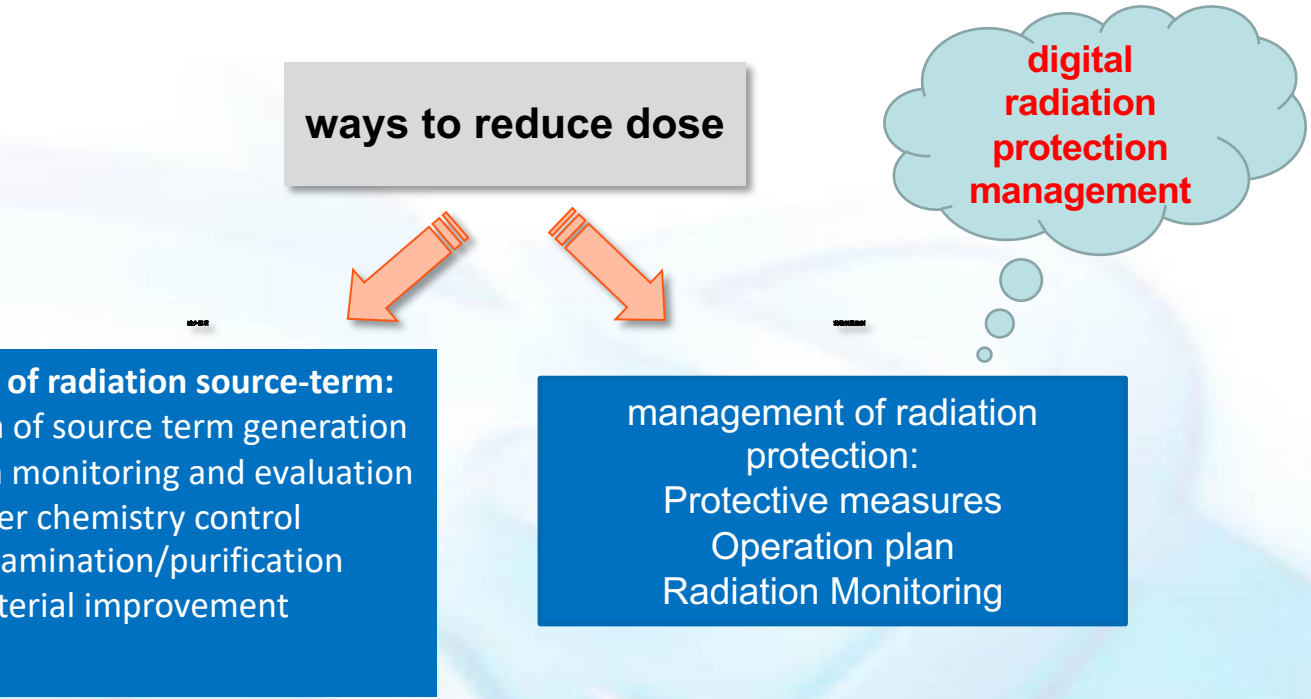
- The system for radiological protection recommended by the ICRP is based on three principles.





Introduction

- two ways to reduce occupational exposure



Digital ALARA System

Background

- Core work of radiation protection for nuclear facilities: Assuring that Occupational Radiation Exposures Are **As-Low-As-Reasonably Achievable (ALARA).**
- **New requirements** are put forward for radiation protection control of nuclear facilities.
- To further reduce the dose and improve radiation protection level, **new and efficient technical means** must be used.
- The nuclear industry has gradually moved towards the mode of **digital operation and management**. The main features include:
  - ✓ 3D visualization
  - ✓ virtual simulation
  - ✓ etc.

Digital ALARA System

Background

- Radiation protection management based on **visualization technology** is one of the important development directions of ALARA.
  - ✓ Rely on 3D virtual reality technology.
  - ✓ The spatial radiation data information can be visually displayed by colour and transparency in a three-dimensional way.
  - ✓ Can mine comprehensive field radiation information, such as dose assessment and shielding calculation for high radiation risk operations.
  - ✓ And to train and simulate operators, to improve the radiation protection management efficiency, promote on-site radiation protection optimization, and provide schemes for radiation protection decisions.

CIRPDose: 3D ALARA planning tool

Geometric Data

Radiometric Data

Data Acquisition

Monitoring and Simulation

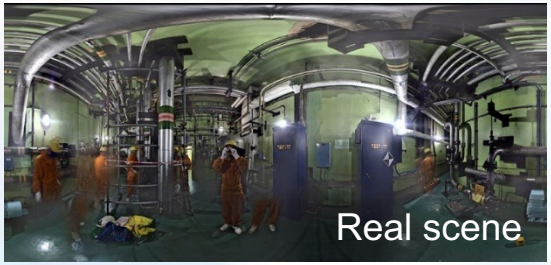
Information Management

Decision Support

CIRPDose: 3D ALARA planning tool

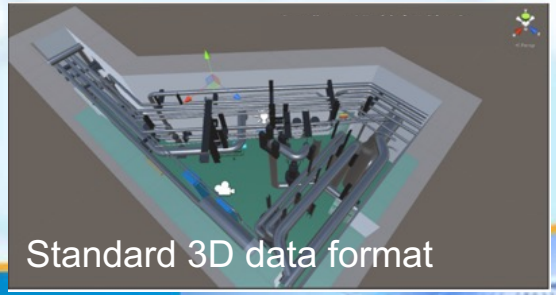
Modelling

- The point cloud model from laser scanning is used to obtain the standard format by algorithms of feature point extraction, parameter identification, and mapping. Then it is rendered into the display model considering texture mapping, lighting, baking, etc.



3D laser scanning

Parameter identification

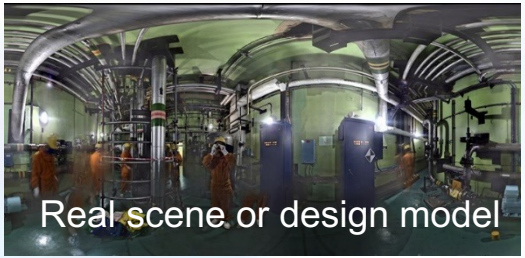


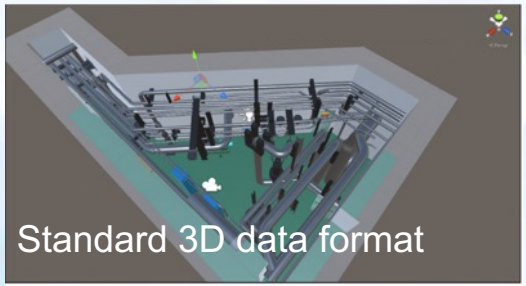
Texture mapping, lighting, baking, etc

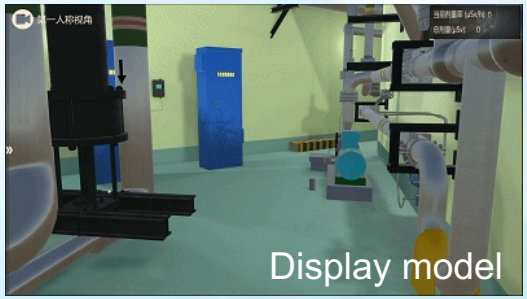
CIRPDose: 3D ALARA planning tool

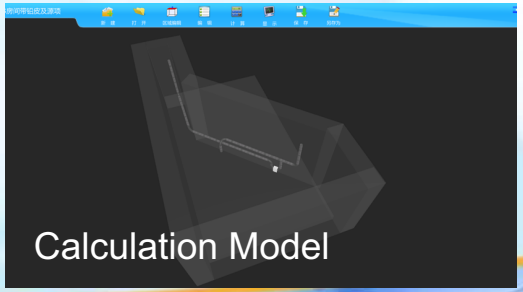
Modelling

- According to the purpose, the models can be divided into four types: design model, scanning model, display model and calculation model. A standard model needs to be established to realize unified transformation.









CIRPDose: 3D ALARA planning tool

3D radiation field Reconstruction

- **Data source**: radiation source item and On-site dose rate measurement.

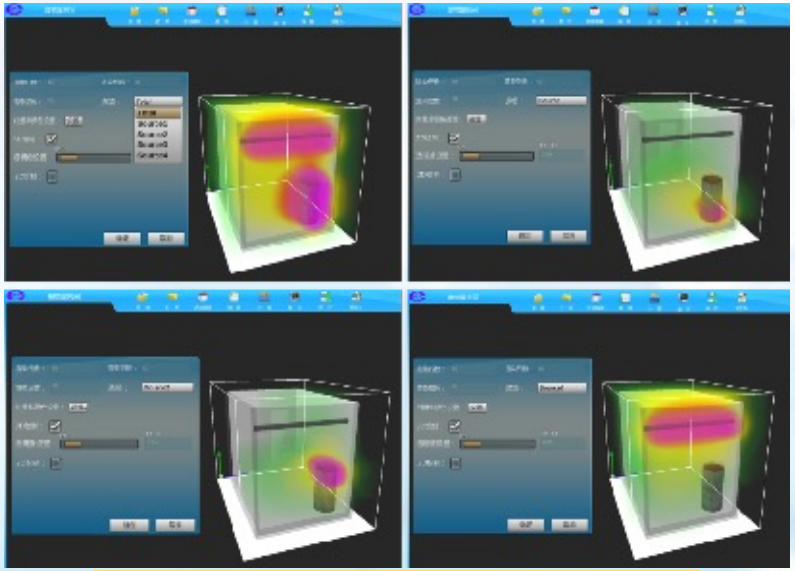
HPGe detector-based γ radiation source term measurement system

Total station for coordinate measurement

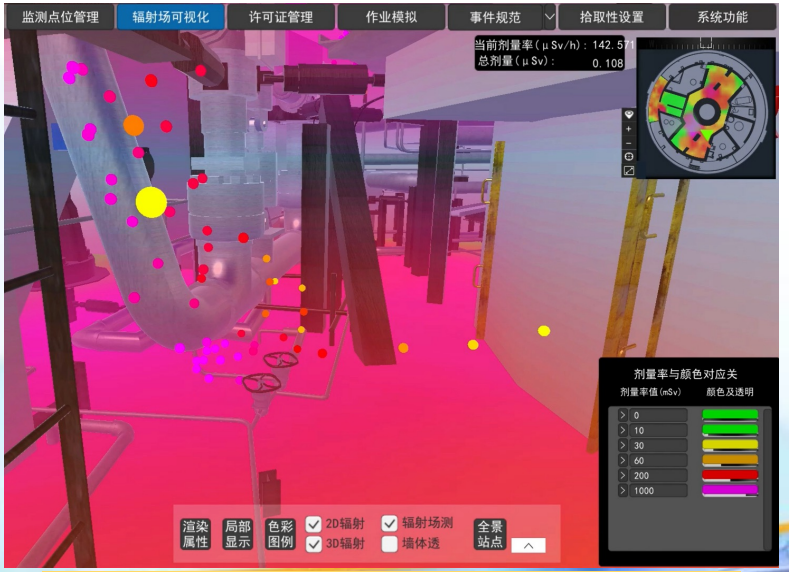
CIRPDose: 3D ALARA planning tool

3D radiation field Reconstruction

- **Reconstruction method**: source term inversion algorithm and improved point-kernel integration technology.
- A mapping relationship between dose rate and colour is established, and the dose rate intensity is displayed using colour in a semitranslucent manner on the spatial grids.



Radiation field calculation module



Radiation field 3D visualization module

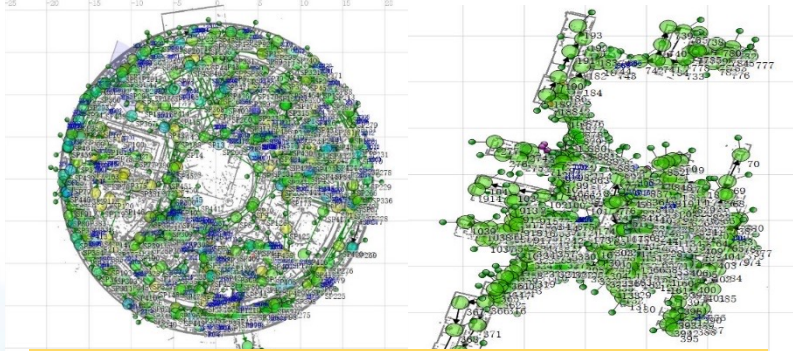
CIRPDose: 3D ALARA planning tool

- **Application: Visualization of 3D radiation field**

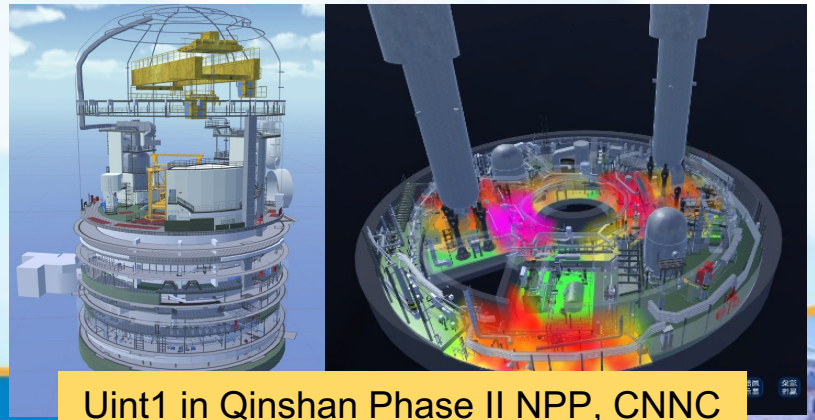
➢ **CIRPDose has been applied to the Uint1 in Qinshan Phase II NPP (CNNC) since December 2020.**

➢ 3D virtual model of the NPP was contructed based on the 3D laser scanning.

➢ 3D visualisation of radiation field.



More than 1700 effective scanning points

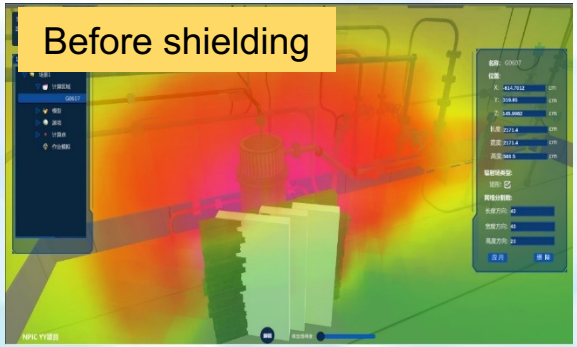


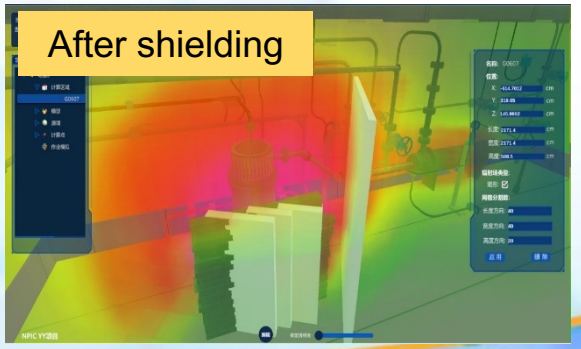
Uint1 in Qinshan Phase II NPP, CNNC

CIRPDose: 3D ALARA planning tool

Application: Operational plan simulation and personnel dose assessment

- Preset operation plans for typical operation processes, especially for high radiation-risk operations.
- Based on the simulated radiation field, the accumulated dose was assessed.
- Shielding settings, path avoidance, and operation plan optimization.

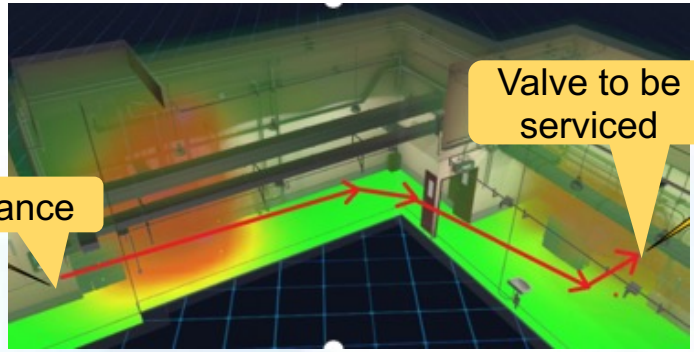




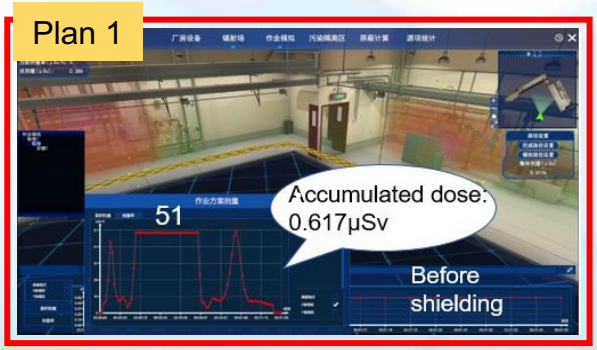
CIRPDose: 3D ALARA planning tool

Application: Operational plan simulation and personnel dose assessment

- Dose assessment of two operation plans for a valve repair case.



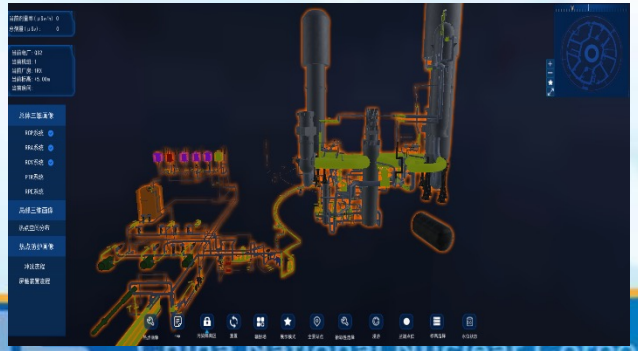
Comparison		Personal accumulated dose / μSv	Collective dose / μSv
Plan 1	Without shielding	0.617	0.617
Plan 2	Set shield	0.302	0.554 (↓10.2%)
	Then repair	0.252	

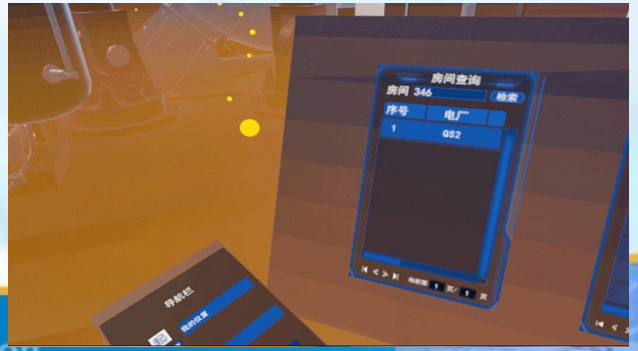


CIRPDose: 3D ALARA planning tool

Application: Digital management

- Information correlation of plant, equipment, radiation field, radiation work permit (RWP), etc.
- VR scene roaming and virtual training





CIRPDose: 3D ALARA planning tool

Application: Digital management

- Radiation safety sign management

- Radiation work permit (RWP) association

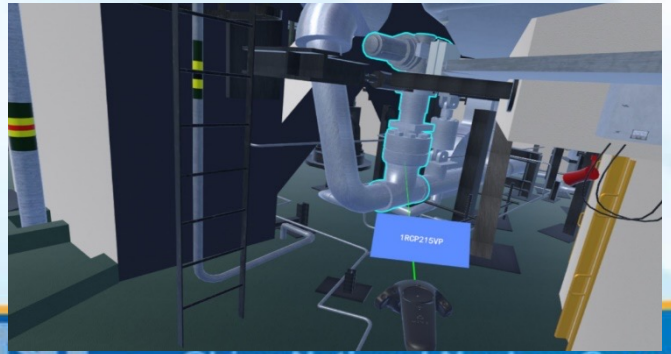
RWP分类统计

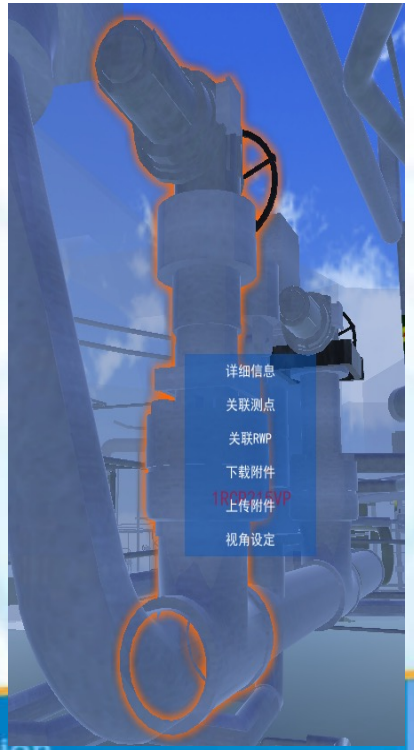
状态	今日RWP	本周RWP
通用	0	0
待分配	0	0
待签发	0	0
待开工	0	0
进行中	0	0
未关闭	0	0
已关闭	0	0
已取消	0	0

CIRPDose: 3D ALARA planning tool

Application: Digital management

- Inquiry, positioning and navigation of plant and equipment (digital management of plant and equipment information)



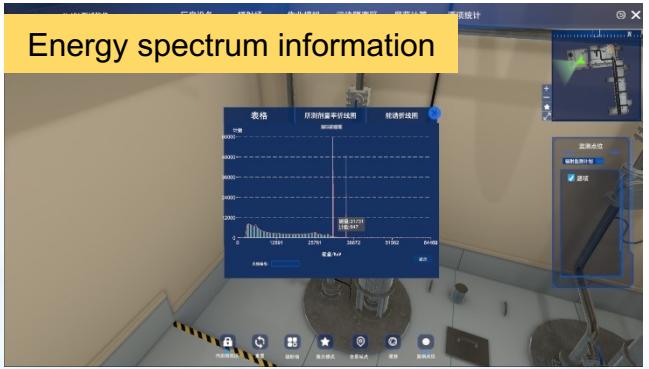


CIRPDose: 3D ALARA planning tool

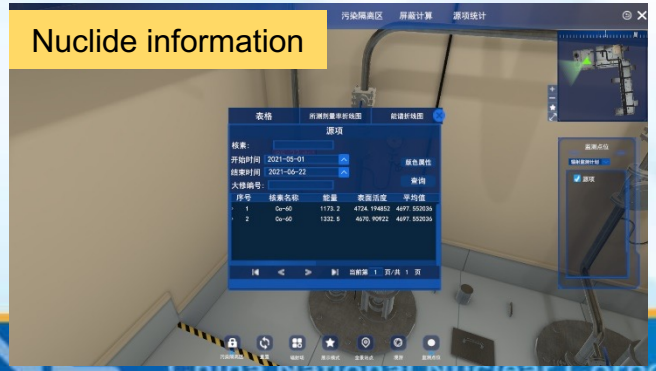
- **Application: Digital management**
  - ➢ Source term and radiation field data management

Measurement information

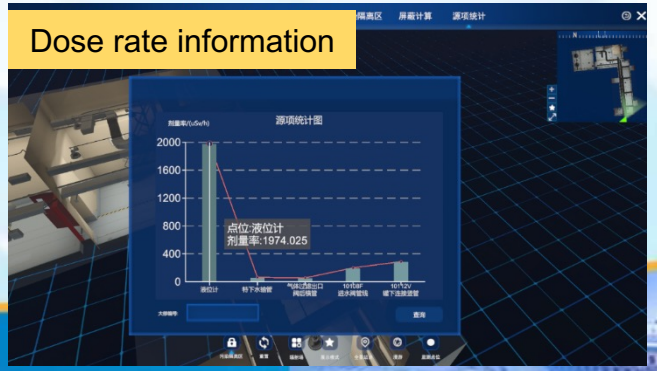
Energy spectrum information



Nuclide information



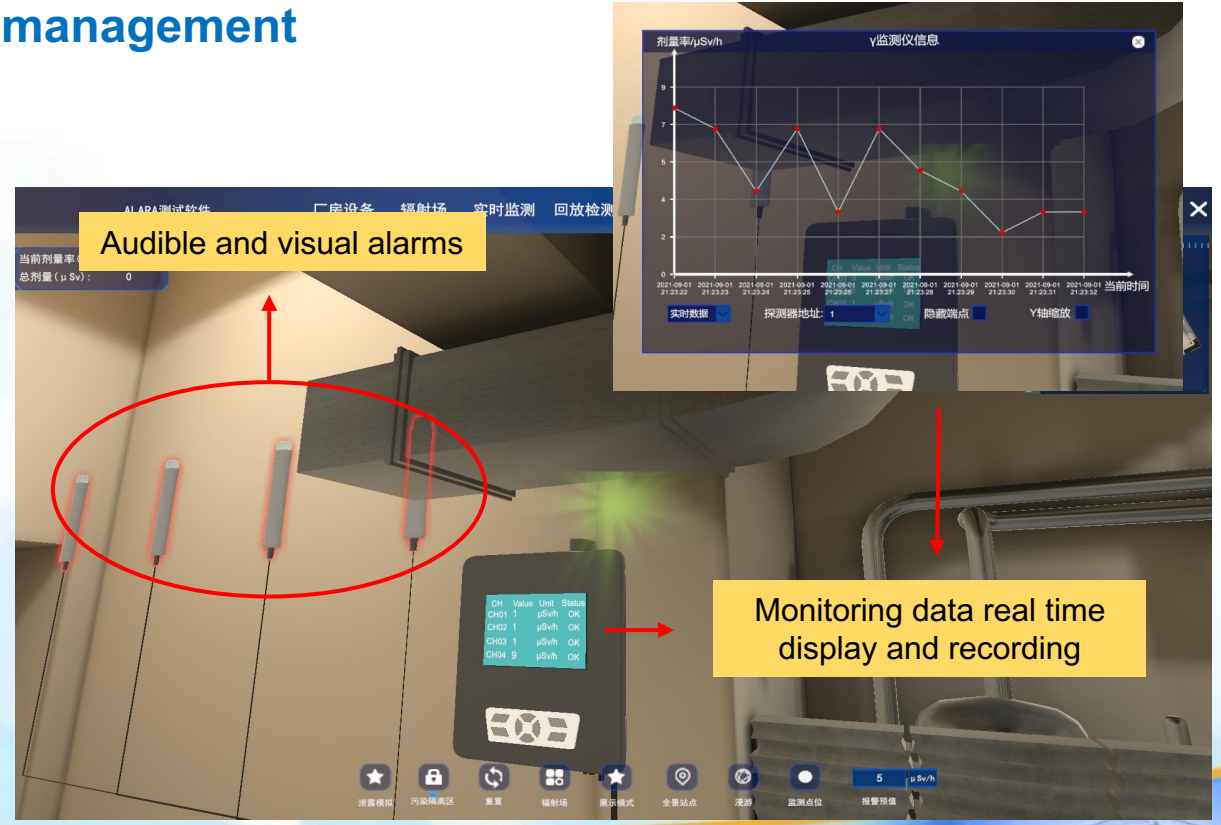
Dose rate information



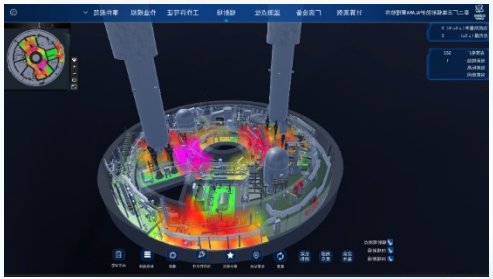
CIRPDose: 3D ALARA planning tool

- **Application: Digital management**

➢ Construction of radiation monitoring database and automatic anomaly warning



Conclusion

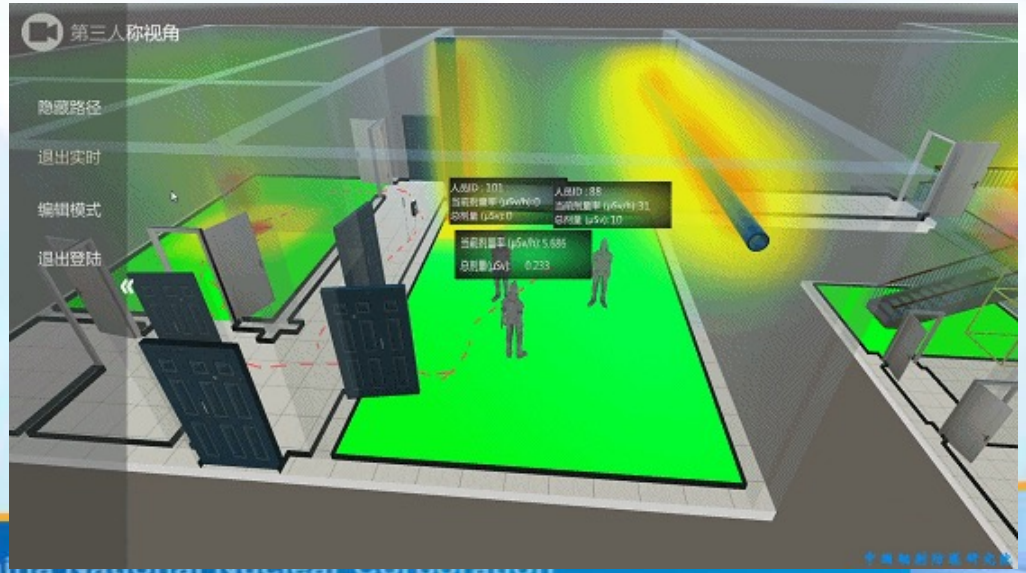


Tools and Services:

- Information management
- Job planning
- Mixed reality training
- Safety evaluation and demonstration
- ……

Conclusion

- More convenient radiation field measurement technology.
- Mine the massive monitoring data accumulated during the operation and maintenance of nuclear installations.
- Remote personal radiation monitoring.
  - ✓ Using Wireless Indoor Locating Electronic Personal Dosimeter (WIL-EPD).
  - ✓ The position, local dose rate and accumulated dose are monitored.



谢谢！

THANKS FOR YOUR ATTENTION!