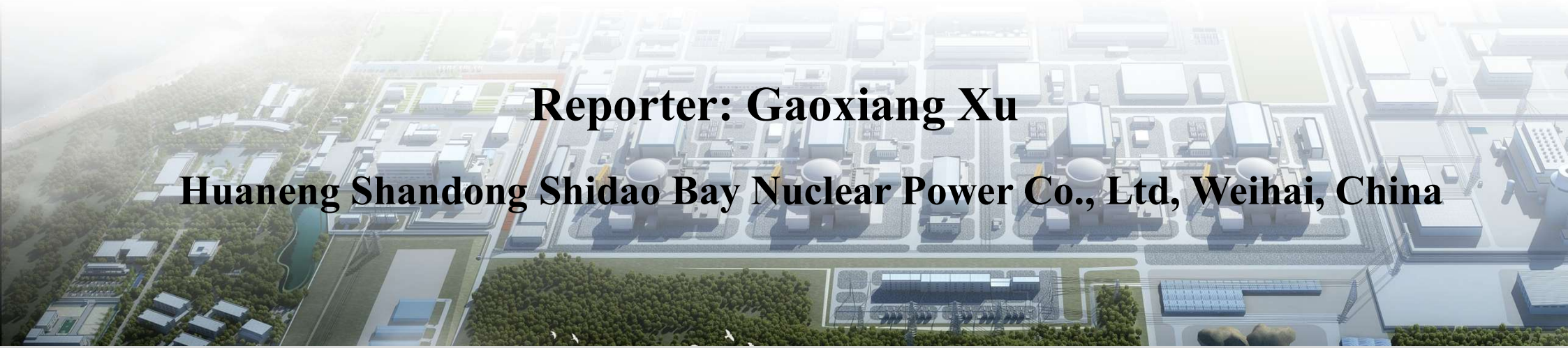
An engineering approach of building effective 3D radiation map with low cost



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1. Background

Unique feature of NPP

control of the reactivity

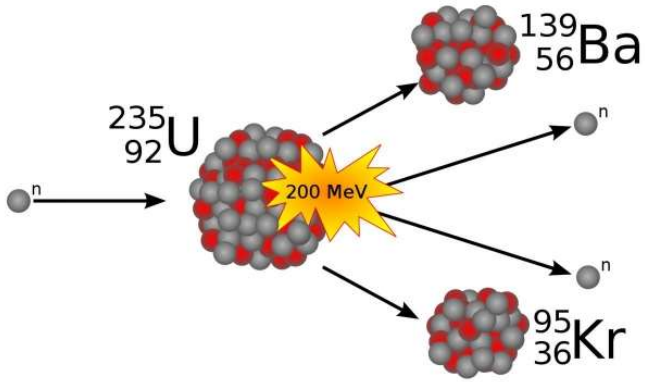
- If reactivity is out of control,the power rate of the reactor will increase too rapid to control,resulting in explosion

contineous cooling of the core

- even shut down,the core will contineously produce heat which needs to be cooled contineously.If not so,the core will be ruined ,resulting in the leakage of radiation

Inclusion of radioactive products

- the reactor will contineously produce radioactive products which need to be included within the reactor boundary.If not so,those products will do harm to the environment and the public



1. Background

The harm of radiation in NPP and conventional practice of radiation protection

1.the harm of radiation in NPP

satage of NPP	point of risk	Representative dose
operation at high power	some specific area in the reactor	1-10Sv/h
shut down	some area within the boundry of the core	0.1-1Sv/h
outage	some area within the boundry of the core	0.05-1Sv/h

2.Conventional practice of radiation protection

working staff use portable radiation detection device to measure the radiation level of the working place.And according to the radiation level,they choose different protection measures.
Disadvantage:low efficiency and may do harm to the measuring person.

2. Discovering problems

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New exploration On the measure of the radiation level

Since the ionic ray is invisable,some nuclear power institute have developed radiation monitoring robot which can automatically detect the radiation level according to the inspection routes.

Disadvantages:

1、relatively low efficiency

2、need plenty of robots

3、need periodic maintenance

4、working staff can’t get the real time radiation level

2. Discovering problems

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- **the possibility of the use of IT method**

  - Since the signal of radiation level is electronic form,some radiation protection institutes have decided to adopt IT method to develop a real time radiation level detecting system.
  - some institutes have developed gamma camera to form the radiation level images.And with the wode spread use of 5G internal Internet in the NPP,there is the possibility of the use of IT method to develop a real time radiation level detecting system.

3. Solution to the problem

➢ the main strcture of the system

（1） the construction of a three-dimensional digital model of the plant,

（2） the visualisation of radiation data embedded in the three-dimensional model of the plant to form a data processing centre,

（3） the use of the 5G Internet highway to ensure that the personnel are connected from time to time, （4） the use of intelligent robots to assist in the completion of the collection of radiation data from the key areas

Fig1. the main priciple of the system

Fig2.the main structure of the system

3. Solution to the problem

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Constructing a three-dimensional digital model of the power plant

with the help of the Smart 3D software,personnel complete the spatial 3D conversion by entering the construction drawing data of each area of each plant into the editing interface of the software,carrying out the supplementation of the details of each structures and equipments to generate a refined 3D power plant digital model of the power plant.And there is a need to update the 3D model to ensure that the model of the authenticity of the data.

Note: the model will be built into the Data Processing Centre described in the next section.

3. Solution to the problem

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Data Processing Centre

The centre is actually a visual data processing and monitoring centre,where the environmental dose data and surface contamination dose data obtained from various sources are converted into data according to the units of radiation zoning limits,and the colour rendering function of the software is used to convert different regions into white, green, yellow, orange, and yellow in accordance with the radiation zoning indications that have been formed after the conversion.

While receiving the transmitted radiation data, the Data Processing Centre automatically obtains the 3D coordinates of the detector and the 3D coordinates of the detected area, and then embeds the coordinate information and the rendered zone colours into the 3D digital model of the power plant in the previous section.

So the users can easily get the real time dose information of the area he is concerning.Also the centre is connected to the plant staff at all times via the 5G Internet highway. The internet highway is described in the next section.

3. Solution to the problem

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5G Internet Highway

- The centre is connected to the 5G private network highway.
- The method of implementation is as follows: the data processing centre swallows dose data obtained by various means from time to time, and generates a visual radiation three-dimensional map through the server computing platform. The three-dimensional map is output through the 5G Internet, and the personnel holding the networked PDA (personal data terminal) can consult the three-dimensional radiation field data information transmitted by the Data Processing Centre in the area of concern to the personnel, and take good personal protection measures with the help of the protective measures suggested by the system.
- This 5G Internet highway receives radiation data uploaded by networked fixed radiation detectors and radiation protection personnel's mobile radiation patrol instruments (including gamma cameras), and the above radiation data are processed in the Data Processing Centre in order to generate real-time updated visualised three-dimensional radiation field maps.

3. Solution to the problem

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Intelligent Robots

- Intelligent robots can master basic walking routes and detection work steps through deep learning.
- The method proposes to use intelligent robots to realise radiation detection in areas inaccessible to personnel and routine regional radiation dose patrol, surface contamination sampling and detection.
- The intelligent robot adopts a highly reliable multifunctional radiation detection sensor networked with the data platform to measure multiple radiation parameters, and the robot has a built-in data discrimination function that automatically rejects invalid data and transmits the detection data to the data processing centre.

3. Solution to the problem

Wireless Positioning Electronic Dosimeter

- We should make use of infrastructure such as the 5g private network covering the plant and epd with wireless transmission and remote positioning function to measure the cumulative irradiated dose of the staff in real time and the ambient dose rate of their location, and transmit the information of personal irradiated dose, ambient dose rate of the location and location information in real time to the backstage terminals and transfer the ambient dose data of each location in the plant to the data processing centre for transformation and data display.
- The environmental dose data of each location of the plant is transferred to the data processing centre for transformation and data display, thus realizing the dynamic update of the three-dimensional radiation field map.
- the scheme is proposed to adopt NB-iot (narrowband IoT based on cellular network), the construction of NB network is based on the existing cellular data base station. Its advantages are low power consumption, wide coverage and small bandwidth occupation. By embedding the wireless transmission and remote positioning chip in the conventional epd equipment, it is connected to the 5g dedicated network of the plant and interconnected with the personal dose control system in the radiation control area on the backend server.

Fig3. The wide use of NB-iot network

4. Results and Discussion

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Conclusion and Engineering Application

1. The method of constructing three-dimensional radiation field maps of nuclear power plants fully adopts mature engineering practices,with high construction efficiency, high reliability, accurate real-time data updating, easy-to-read and easy-to-operate interfaces, and low engineering costs.

2. And the three-dimensional radiation maps can better safeguard the staff of the power plants from excessive radiation exposure, which is of practical significance in eliminating the fear of radiation hazards.

3. This method has the value of popularisation and application.

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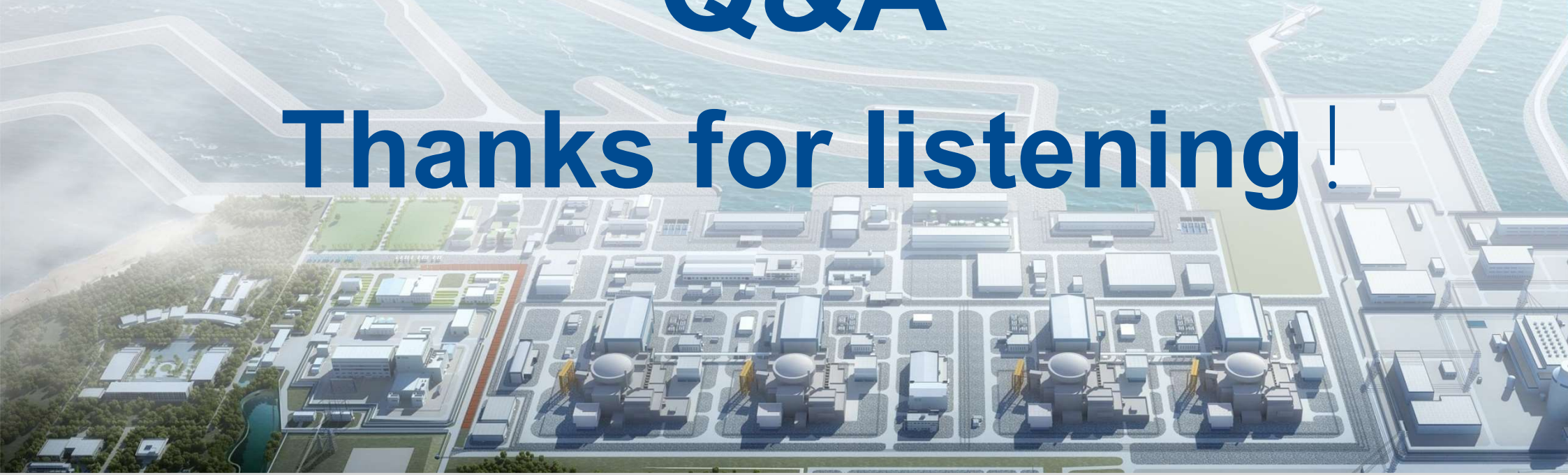
Q&A

Thanks for listening!



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