

# Introduction to the online monitoring system for nuclear power plants' radioactive sources in 5G environment

Liaoning Hongyanhe Nuclear Power Co., Ltd



# CONTENTS

01

Background

02

The overall idea of system design

03

System introduction

04

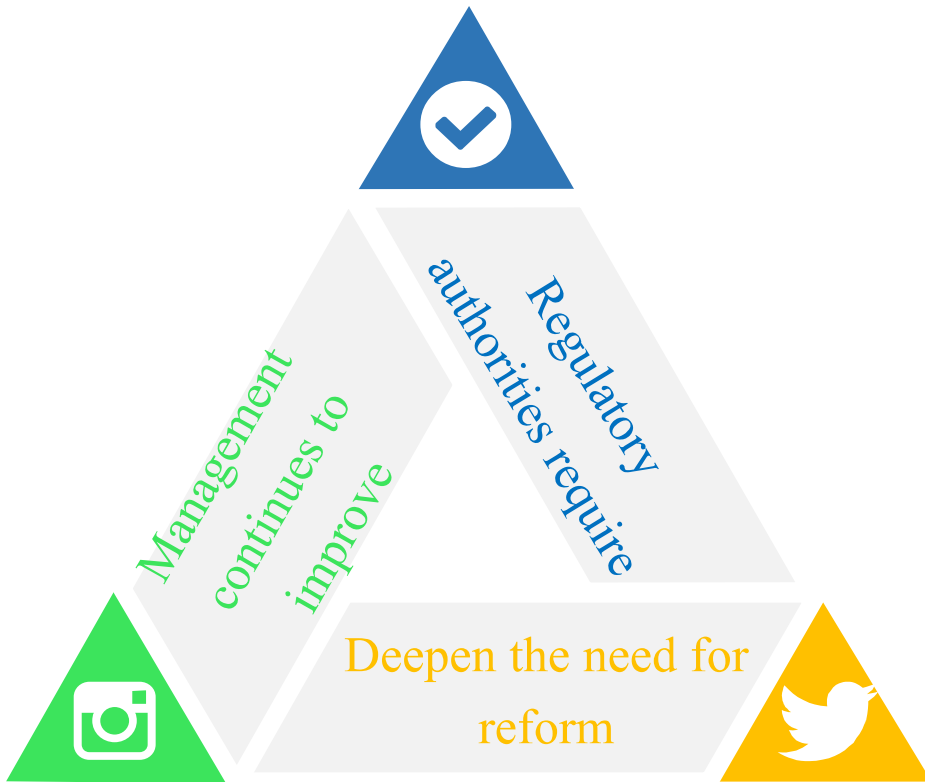
Highlights

05

Areas for improvement

# 1. Background

---



## **Regulatory authorities require**

Implement the spirit of President Xi Jinping's speech at the Nuclear Safety Summit: China will implement an action plan to strengthen radioactive source safety. Focus on real-time monitoring of high-risk mobile radioactive sources;

## **Management continues to improve**

In the process of switching back and forth between storage, transportation and use, the radioactive source is controlled by combining human defense and technical defense, so as to improve the safety and timeliness of radioactive source control.

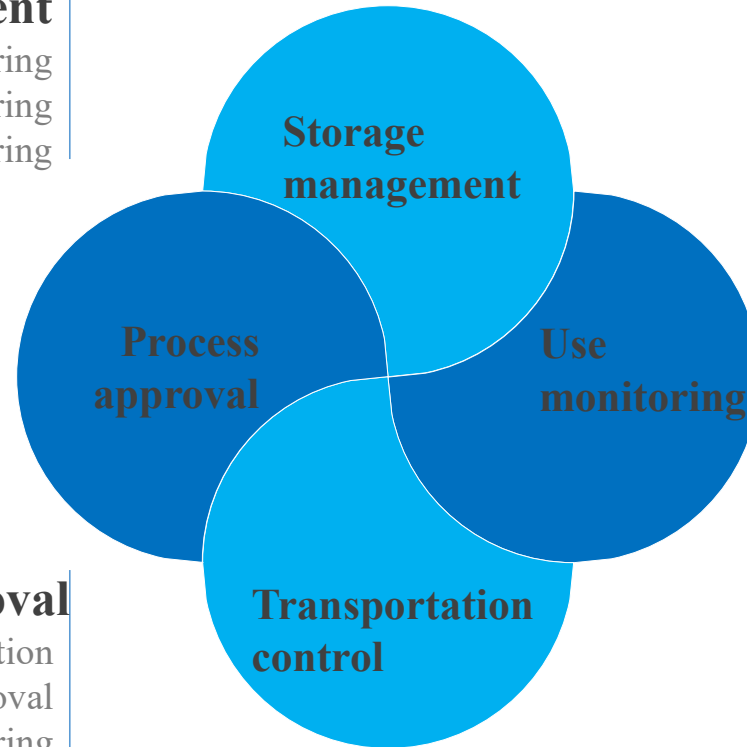
## **Deepen the need for reform**

"Focus on strengthening nuclear power safety and security, do everything possible to ensure nuclear safety" and "Strengthen innovative research and digital transformation to help the company's high-quality development".

## 2. The overall idea of system design

---

**Storage management**  
Location monitoring  
Dose rate monitoring  
Storage and cross-border monitoring



### Use monitoring

Use out-of-bounds monitoring  
Use timeout monitoring  
Radioactive source recovery status monitoring

**Process approval**  
Personnel authorization verification  
Process review and approval  
Outbound/inbound status monitoring

### Transportation control

Trajectory monitoring  
speeding, overtime monitoring  
Monitoring of abnormal dose rate during transportation

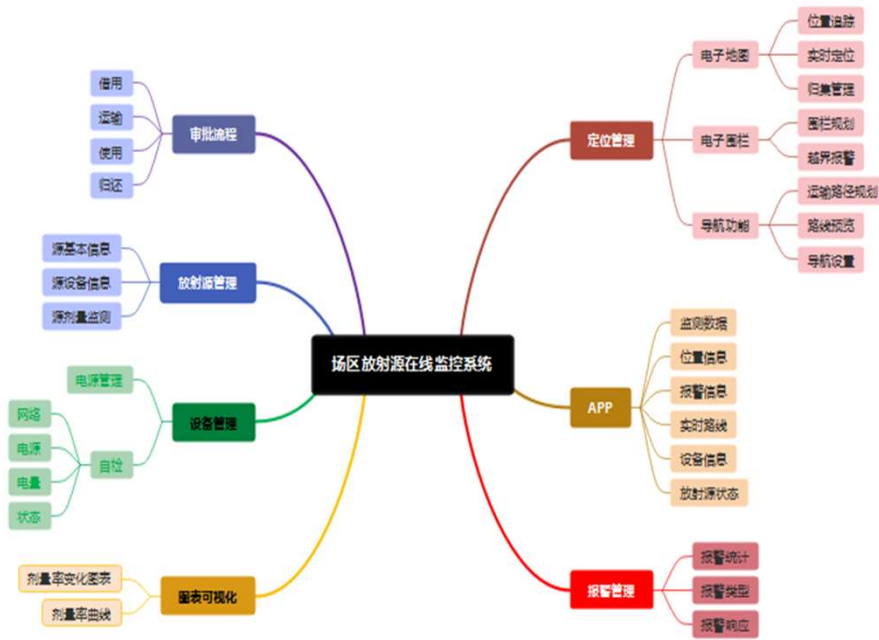
### 3. System introduction

The system integrates Ultra Wide Band (UWB) technology and Beidou Navigation Satellite System (BDS) with indoor and outdoor positioning technology to locate radioactive sources accurately. It also uses the company's 5G intranet to arrange a special channel for radioactive source-related data, and ensures high-speed transmission of data to the radioactive source online monitoring system. The system realizes the status control of radioactive source storage, transportation and use in the plant and also real-time status tracking during the transportation of radioactive materials.



### 3. System introduction

The system is composed of positioning management system, positioning dose rate monitor, power management system, APPs for mobile client, positioning base station, positioning navigation engine, servers, and workstations. The system can realize one-stop approval on mobile APPs, real-time positioning of radioactive sources, dose rate monitoring, transportation route planning and controlling, terminal abnormal reminding and information searching functions.



### 3. System introduction

Radioactive source storage management



Real-time monitoring of the location, dose rate, and status information of radioactive sources in the temporary storage compartment of radioactive sources to ensure that radioactive sources are safe and controllable in the storage buildings.

### 3. System introduction

Radioactive source transportation management



The system can track the transportation trajectory of radioactive sources in real time, grasp the dynamic information of radioactive source transportation, and when the actual transportation route deviates from the scheduled route, the system will have a route deviation alarm.

### 3. System introduction

Radioactive  
material  
Transportation  
management



The system can track the real-time location of radioactive materials, grasp the dynamic information of radioactive material transportation, and when the actual transportation route deviates from the scheduled route, the system will have a route deviation alarm.

### 3. System introduction

Transport trajectory review



The system can review historical transportation tracks, display actual transportation routes, and mark deviated routes。

### 3. System introduction

Radioactive  
source  
use  
management



Real-time monitoring of radioactive source usage, when the radioactive source exceeds the scope of use, an alarm is generated.

# 3. System introduction

- Fault alarm
- Low battery alarm
- Transport yaw alarm
- Transport speeding alarm
- Transportation overtime alarm
- Low dose rate alarm
- High dose rate alarm
- use in wrong building alarm
- Use timeout alarm



## 3. System introduction



### Mobile clients monitoring

The system can manage the online monitoring of radioactive sources by mobile APPs, realize the digitize and intelligent construction of the online monitoring system of radioactive sources in the plant, and improve work efficiency.



Process approval

Status monitoring

Transportation management

Alarm response

### 3. System introduction

Monitoring surface dose rates of radioactive source containers

**Before the inspection**

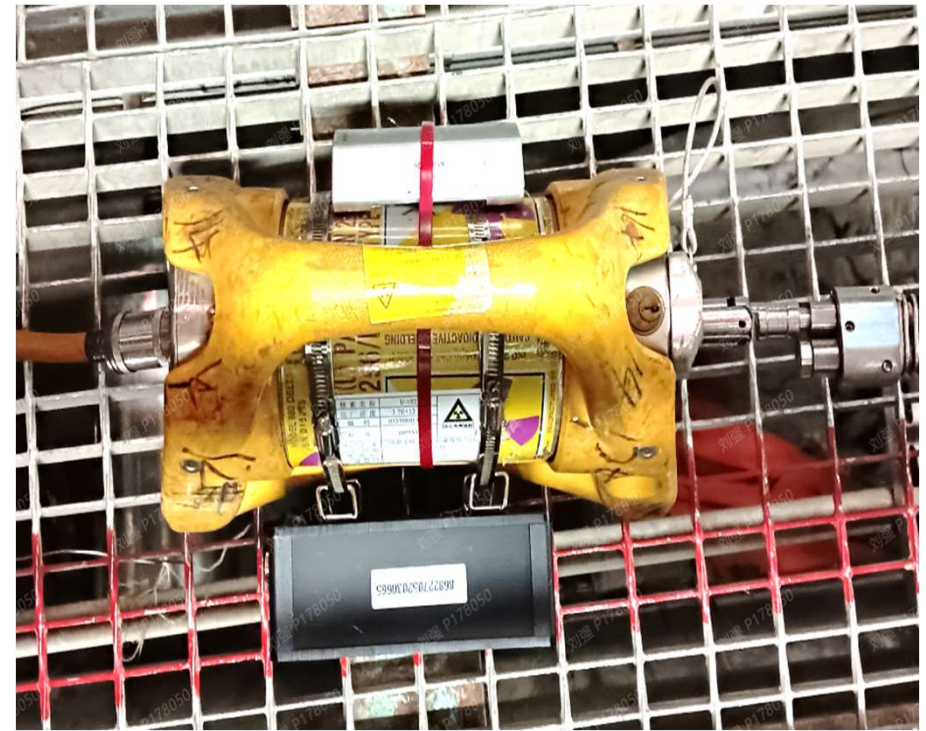
源名称	剂量uSv/h	电量	使用地点	更新时间
4289YGllr-192	65.65	88	9PX	2024-03-01 23:57:21

**During the inspection**

源名称	剂量uSv/h	电量	使用地点	更新时间
4289YGllr-192	158.64	87	9PX	2024-03-02 00:12:57

**After the inspection**

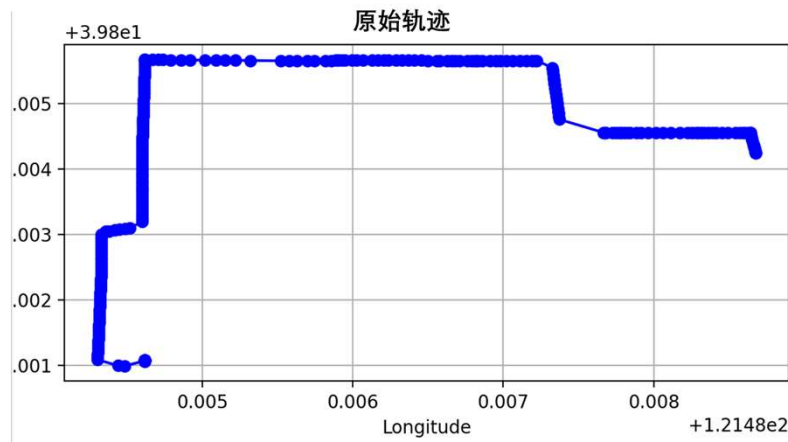
源名称	剂量uSv/h	电量	使用地点	更新时间
4289YGllr-192	70.86	86	9PX	2024-03-02 00:18:09



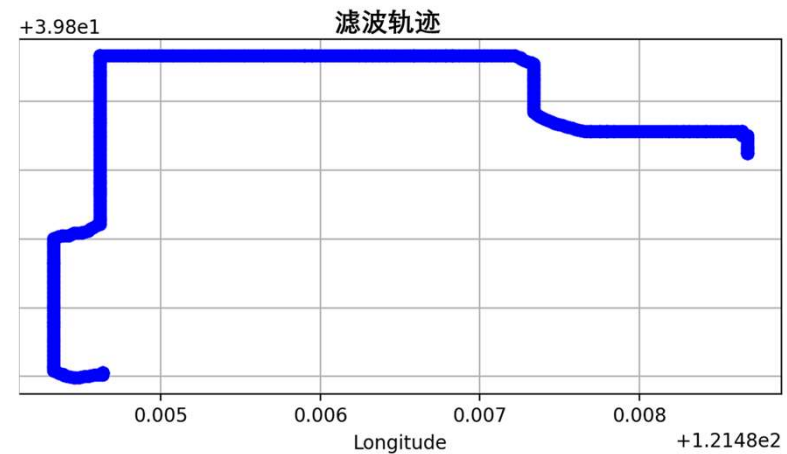
It can monitor the surface dose rates of radioactive source containers in real time, and assist in determining the status of the inspection source by analyzing the trend of dose rate changes, so as to avoid unplanned exposure when the inspection source is stuck.

### 3. System introduction

In the test stage of the radioactive source positioning system, it is found that buildings too close or bad weather would affect the outdoor positioning accuracy of the radioactive source. So Kalman filtering is added to complete the correction of the positioning results of the radioactive source by predicting the direction of the radioactive source in the Beidou system. The actual trajectory is effectively fitted using the past position, velocity and acceleration information of the radioactive source.



Original trajectory

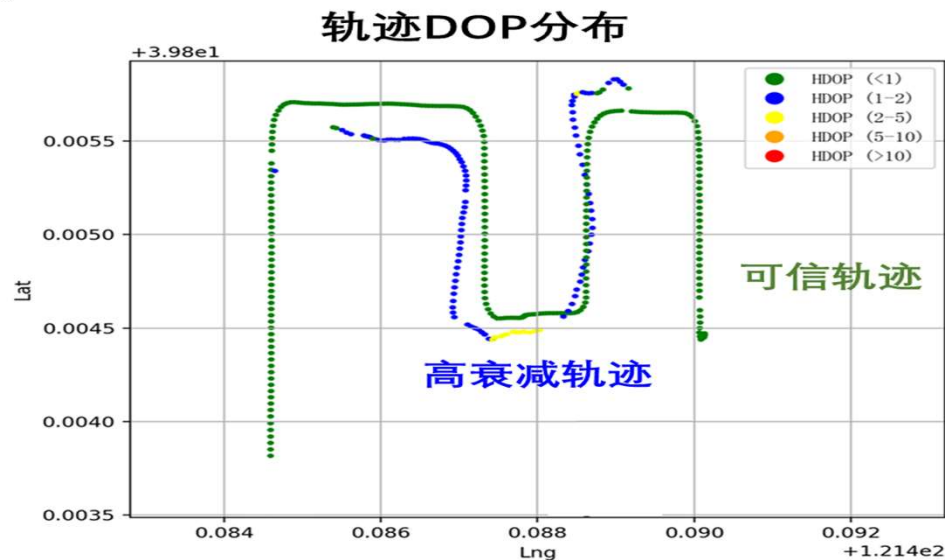


KF smoothed trajectories

### 3. System introduction

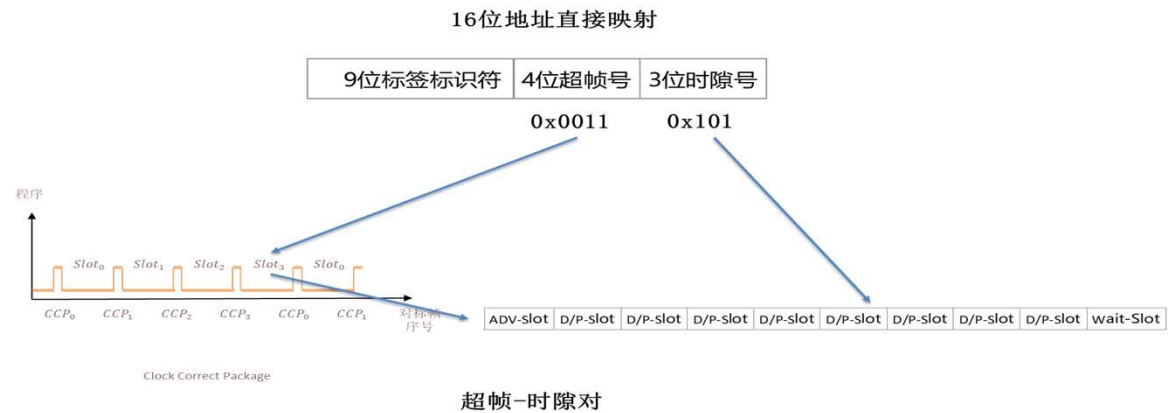
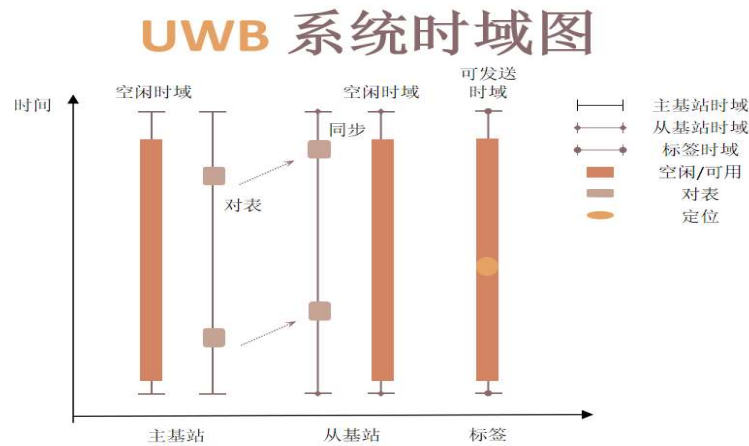
In order to increase the credibility of Beidou positioning data, 3 levels of Dilution of Precision (DOP) threshold are set in the system to determine whether the current accuracy is trustworthy:

- 1) When  $DOP \leq 1$ , the positioning results are considered very credible.
- 2)  $1 < DOP \leq 2$ , the positioning results are considered to be basically credible and acceptable for most applications.
- 3) When  $DOP > 2$ , the localization accuracy is significantly reduced and the monitoring data will be discarded.



# 3. System introduction

The time-division multiplexing access (TDMA) method of mapping is innovatively proposed and applied, and the Time Difference of Arrival (TDOA) algorithm of UWB is used to increase the credibility of the monitoring data, so as to achieve high-precision positioning of  $\pm 10\text{cm}$ . It meets the need for precise monitoring of small movements of radioactive sources (mainly indoor) .



## 4. Highlights

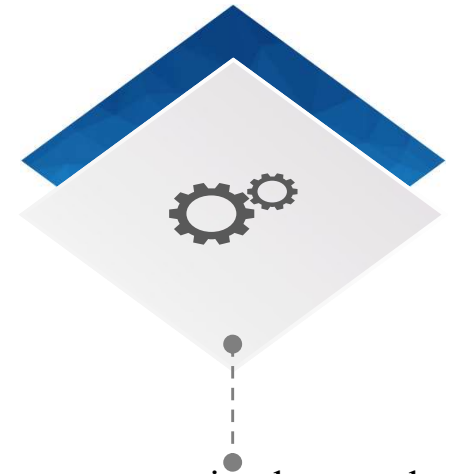
---



For the first time, the company's 5G intranet and Beidou positioning mode are used together to ensure the company's network information security.



Realize a variety of positioning methods of Beidou and UWB, fully distinguish the positioning boundary, and can automatically convert according to specific environmental requirements.



The system can simultaneously realize functions such as location monitoring, dose rate monitoring, transportation monitoring and route planning, mobile terminal control, and power management to achieve full-process control.

## 5. Areas for improvement

### Difficulties

- 1、 The size of the positioning device is limited, and the continuous use time cannot be over 24 hours;
2. Some areas have dense buildings and make positioning signals weak;



### Measures

- 1、 Power banks are going to be added to charge anytime, anywhere
- 2、 Set up more UWB auxiliary positioning devices

**Thank you !**