# STUDY ON DIGITAL REFINED MANAGEMENT OF RADIATION PROTECTION IN NUCLEAR POWER PLANTS BASED ON WIRELESS POSITIONING EPD

Reporter : Yangxing Hu

Time : 2025/10/23

# Contents

# 01

# Why Change

# New Protection Challenges in the Revival of Nuclear Power

China has 58 operational nuclear power units, with a large proportion of the global under-construction capacity. The traditional management model has a lower limit for the ALARA management of collective occupational exposure dose.


### Regulatory Mandate

IAEA lists digitisation as the only credible route to optimise occupational exposure.

### Corporate Efficiency

Drive to reduce costs and improve management efficiency.

### Safety Culture

Evolving employee expectations for the highest safety standards.

# The Three Core Shortcomings of Traditional EPDs

Existing dosimeters are passive devices, unable to meet modern radiation protection needs.

## Invisible

Cannot link dose to real-time location, making radiation risks invisible and leading to misentries.

## Unconnected

Data is stored offline, creating information silos and preventing real-time monitoring.

## Uncontrollable

Lack of real-time intervention makes it difficult to effectively implement the ALARA principle.

Conclusion: Only by synchronously collecting dose and spatiotemporal data can we bridge the last mile of protection.

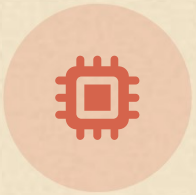
protection.

# 02

## Our Answer

# Wireless Positioning EPD System Blueprint

A four-layer architecture reshapes the radiation protection process.



## Device Layer

Embed UWB & 5G modules for for synchronous data packaging. packaging.

## Network Layer

5G private network & positioning base stations ensure data stability.

## Cloud Layer

Build a radiation digital twin engine for modeling and warning.

## Application Layer

Open APIs for closed-loop management: planning, intervention, review.

# Hardware & Network Upgrade Strategy

## Device-Side Hardware Retrofit Retrofit

Modular Integration: Adds UWB/BLE AoA & 5G modules. modules.

Anti-Interference: Ceramic antenna & shielding.

Low Power: Dynamic power management extends battery life to 10 hours.

## 5G Private Network

High Speed/Low Latency: 150 Mbps uplink.

Security Isolation: Local core, data never leaves the site.

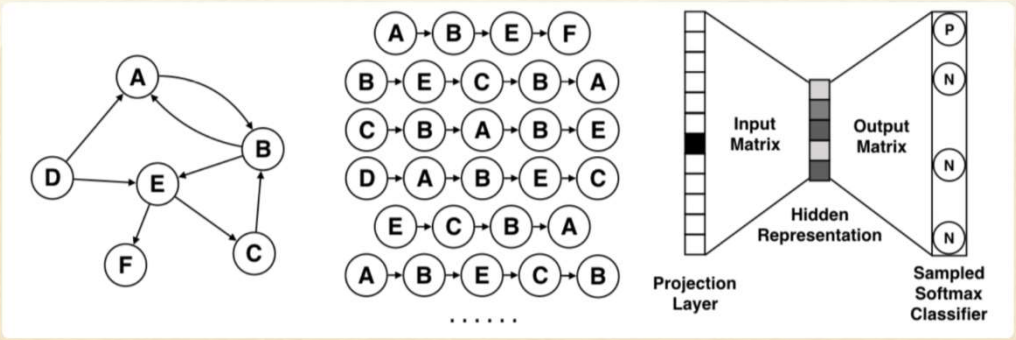
Priority Guarantee: ensures priority for critical alarms in in extreme scenarios.

# 03

# Key Technologies

# Sub-Metre Positioning Engine

Hybrid UWB and Bluetooth-AoA algorithms cancel multi-path echoes typical of steel-rich compartments, ensuring reliable personnel tracking.





## Hybrid Algorithm & Kalman Filtering

Fuses time-of-flight and angle-of-arrival data, holding 2D RMS error below 1 m .

## Auto Time-Synchronisation

Anchors sync over wired backhaul, eliminating the need for impossible GPS reception inside containment.

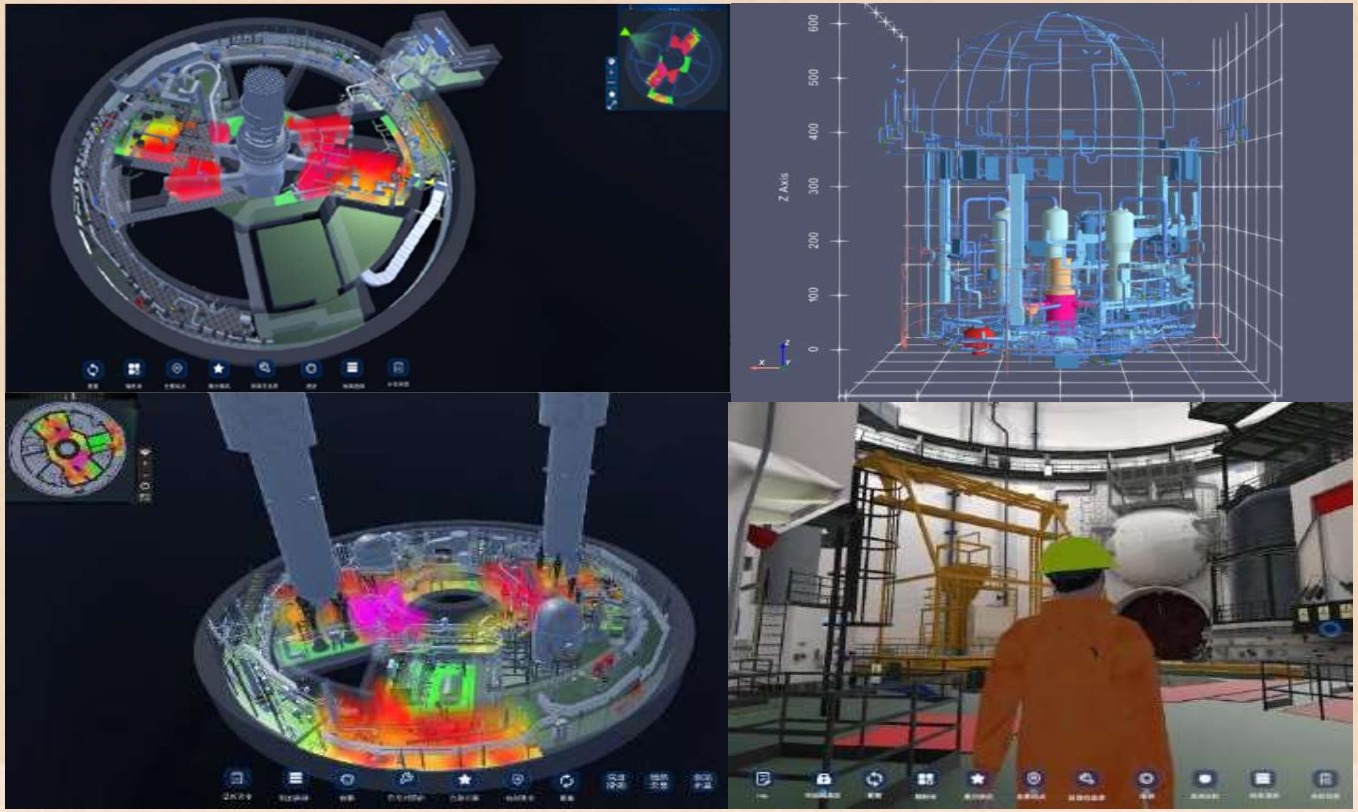
## Redundant Coverage

Ensures continuity in airlocks and cubicles when one anchor is obscured.

# Real-Time Dose Mapping

Edge servers interpolate streaming dose rates into a dynamic 3D field, providing a single authoritative radiation picture.

## 3D Dose Field Visualization

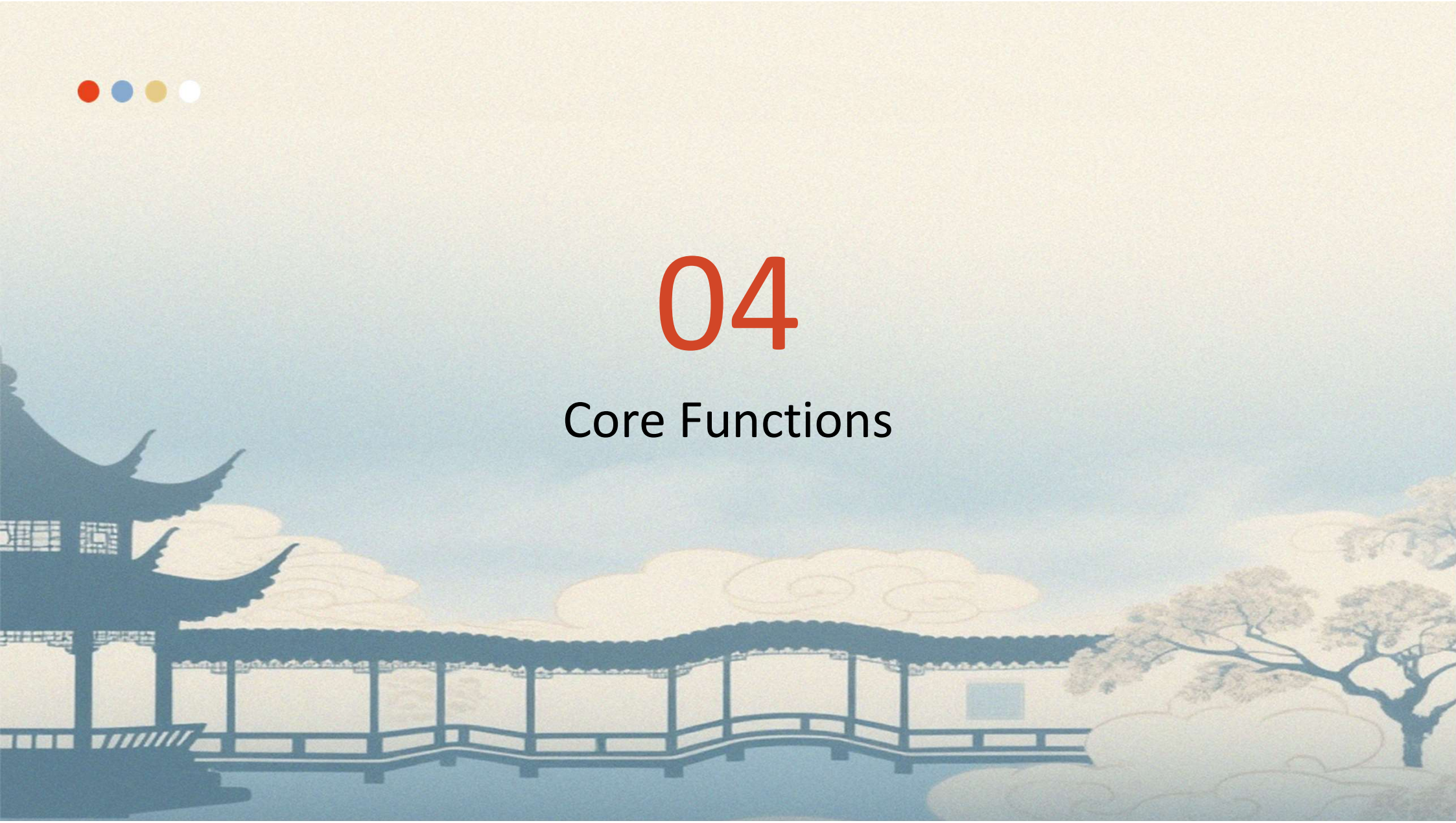



### Color Isopleths

Refresh every 2s, instantly revealing expanding high-dose clouds after valve breaches.

### Interactive Query

Click any voxel to inspect 24-hour rate trends, job counts, and peak individual doses.



# 04

# Core Functions

# Smart Path Planning & Dynamic Warning

## Pre-Job: Intelligent Planning

Input start/end points and dose budget. The engine queries live data and historical trajectories to return three optimized routes in under one second.

- Lowest Dose Route
- Shortest Time Route
- Fewest Zone Crossings Route

## During-Job: Dynamic Intervention

If an operator deviates from the route by more than 2 meters or enters a forbidden zone, the system triggers a triple alarm for immediate corrective action.

- Local Vibration & Flashing on EPD
- Platform Pop-up Alert
- Push Notification to Supervisor & Control Room

# Live Intervention & Post-Job Traceability

The system provides full lifecycle logging and analysis, from real-time intervention to data-driven optimization.

## Live Monitoring

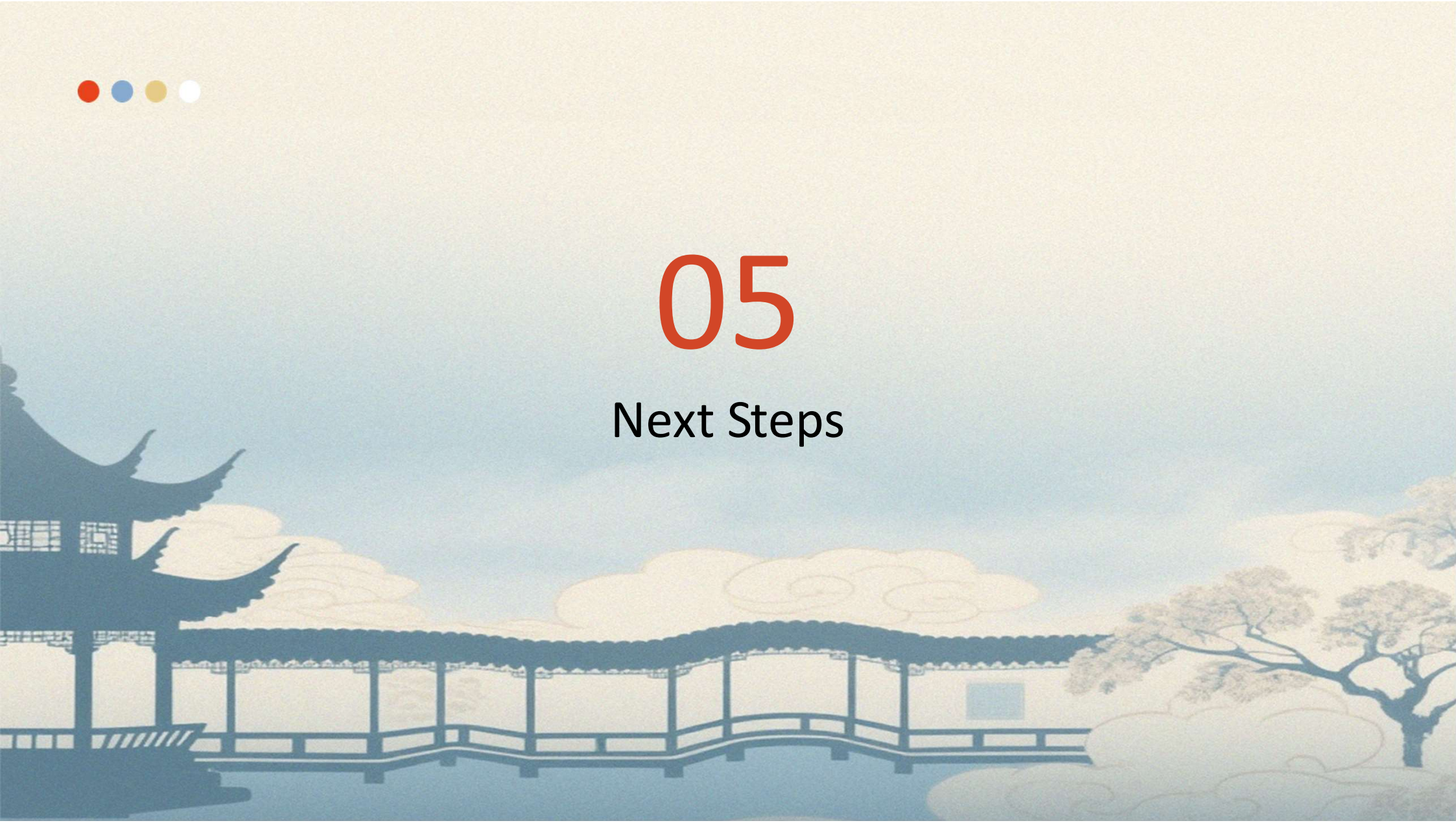
Logs every second of dose and position, flagging flagging rate spikes in real-time.

## Automated Report

One-click PDF generation with 3D track replay, dose stats, and anomaly analysis.

## Long-Term Archive

5-year data archive for regulatory compliance and training future ALARA forecasts.



# 05

## Next Steps

# AI & Robotics: Towards Predictive Control

Next-phase R&D will integrate deep learning and robotics to achieve higher levels of intelligent radiation protection.

## AI-Driven Dose Prediction

Deep learning models forecast local dose rates 1 hour ahead with pan>.

## Smart Work Window

Automatically recommend optimal work windows to minimize collective dose.

## Robotic Inspection

Automatically dispatch robots to high-dose areas, achieving a "No Human, Low Dose" vision.


THANK YOU!