中国原子能科学研究院

Design and Construct of In-Hospital Neutron Irradiator

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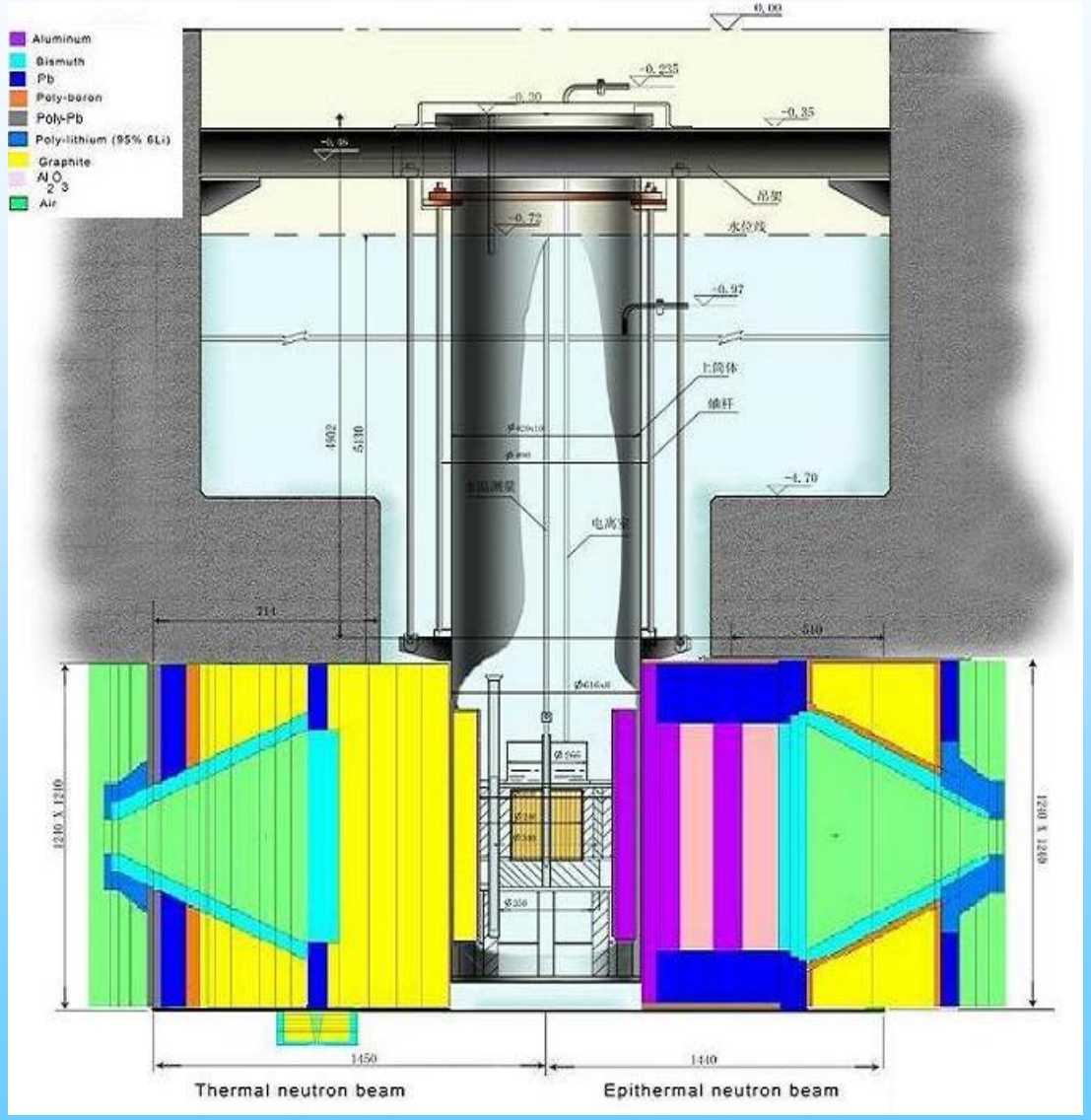
Content

- IHNI and its systems
- Construct
- Startup

IHNI and its systems



- **Use**
  - **Boron Neutron Capture Therpay**
  - **Neutron Activation Analysis (NAA, PGNAA)**
  - **Research**
  - **Education and training**
- **Inherent Safe Feature**
  - **Negative temperature coefficient**
  - **Limited excess reactivity(4-4.5mk)**

➢ Reactor and its systems

IHNI is a pool-tank type reactor.

- ➢ UO_2 as fuel meat (12.5%)
- ➢ Zr-4 as fuel cladding
- ➢ Light water as moderator and coolant,
- ➢ Metal beryllium as reflector.

The fission heat produced by the reactor is removed by the natural convection.

- **IHNI Systems**
  - **Reactor Pool**
  - **Reactor Unit**
  - **Reactor Control System**
  - **Gamma radiation monitoring system**
  - **Thermodynamic measuring system**
  - **Reactor Water purification System**
  - **Reactor Pool Water purification System**
  - **Reactor gas purge System**

- **Reactor pool** **The reactor pool is located at the center of the reactor hall.**

Up Part: 4000×2300 ×4700mm

Lower Part： 2600×1100 ×1800mm

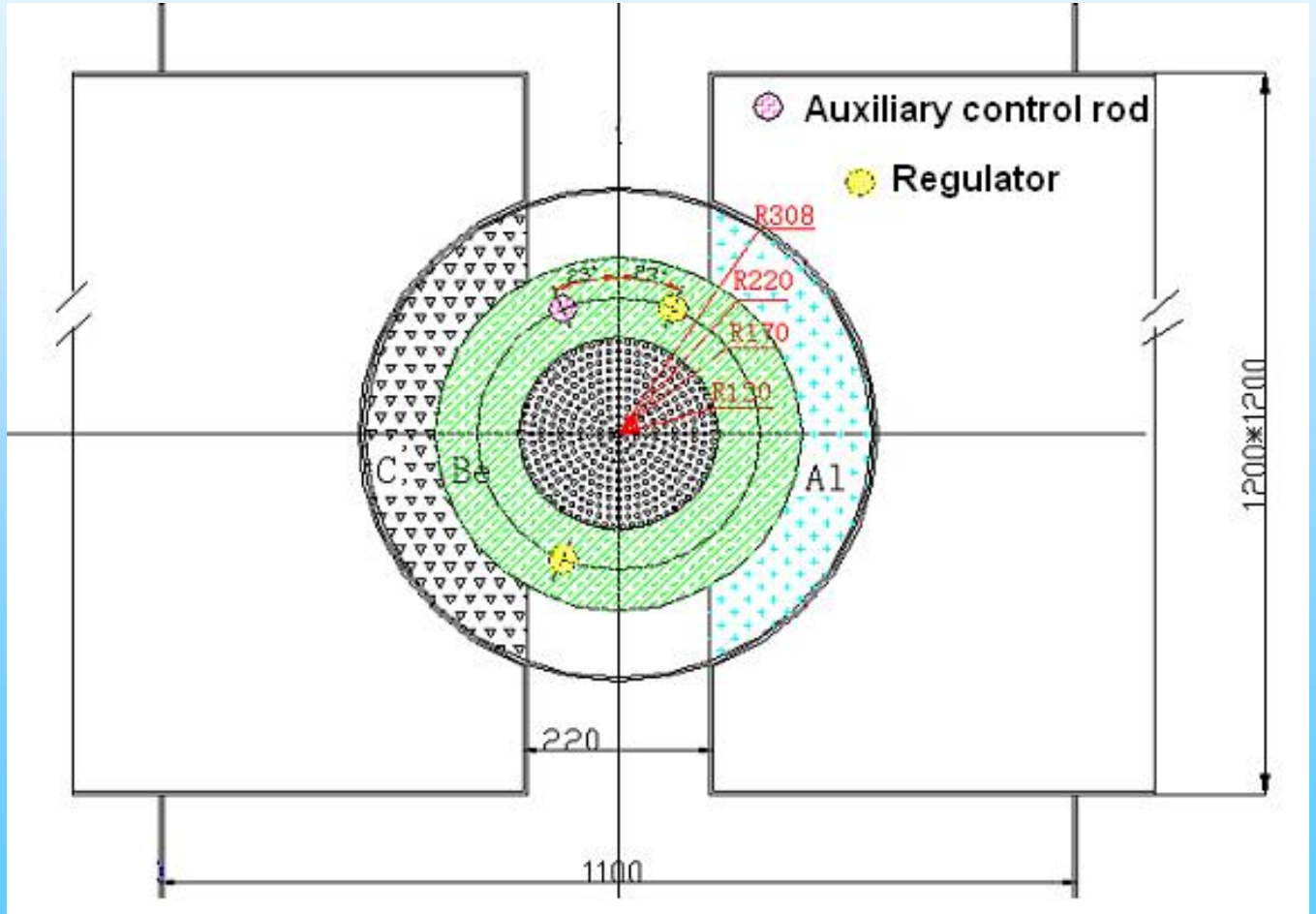
Depth：6500mm

- **Reactor vessel (tank)**
  - **6.0m in height;**
  - **Inner diameter 0.6m;**
  - **thickness 10 cm.**
  - **Up 4.88m;**
  - **Lower part 1.21m**

Link by 16 tie Rods

Reactor core

Two reactivity regulators
One central control rod
One auxiliary control rod
Two fission chambers.



Central Control Rod

Meat：Cd tube outer dia. 4.0mm，inner dia. 2.0mm,
length 280mm;
Inside Cd tube：Al rod φ2.0×280（mm）;

Outside Cd tube : S.S tube outer dia. 5mm
wall thickness：0.5mm

total length：450mm。

Auxiliary Control Rod

Outer dia. 29mm Inner dia. 25mm Al
Total Height 530mm

Lower height 250mm Be
Middle height 30mm Al
Up height 250mm Cd Dia. 25mm wall thickness 1mm
Inside Cd
AL rod: dia. 23mm, height 250mm

Reactivity Regulator

Cd tube outer dia.30.0mm，inner dia.28.0mm;

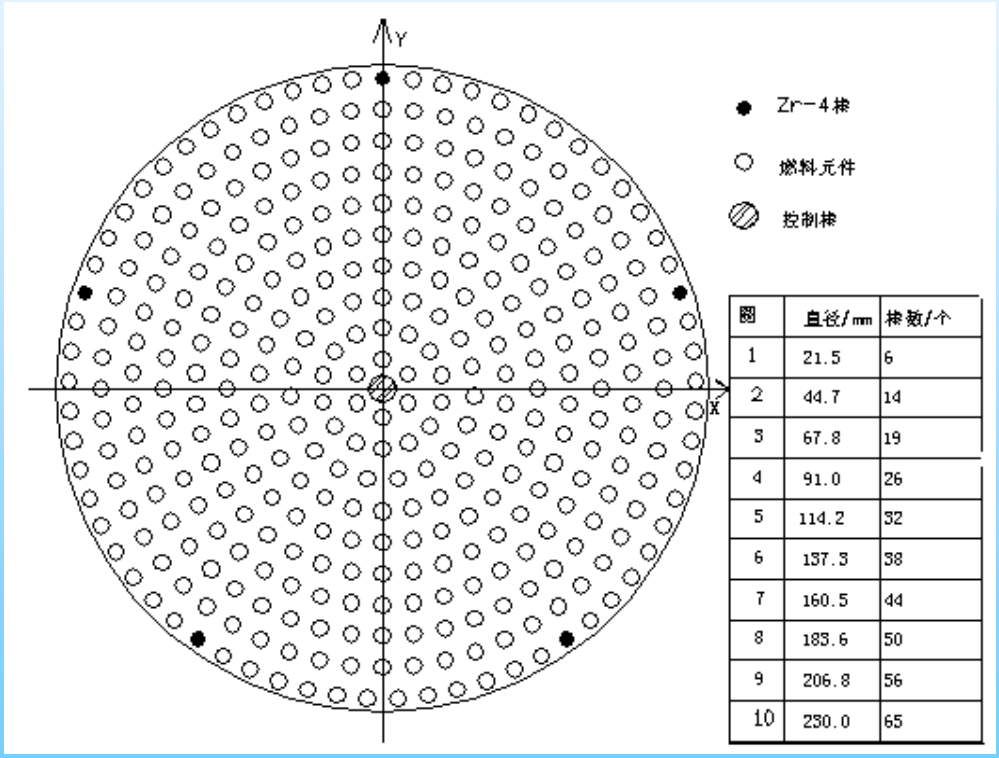
Inside Cd tube: Al rod φ28.0×250（mm）;

Outside Cd tube: Al tubeφ34.0×260（mm）.

Reactor core-fuel

Final Loading:

302 fuel elements.



圈	直径/mm	棒数/个
1	21.5	6
2	44.7	14
3	67.8	19
4	91.0	26
5	114.2	32
6	137.3	38
7	160.5	44
8	183.6	50
9	206.8	56
10	230.0	65

Reactor core-fuel

Fuel element:

Clading： Zr-4

Outer dia. 5.1mm

Inner：4.3mm

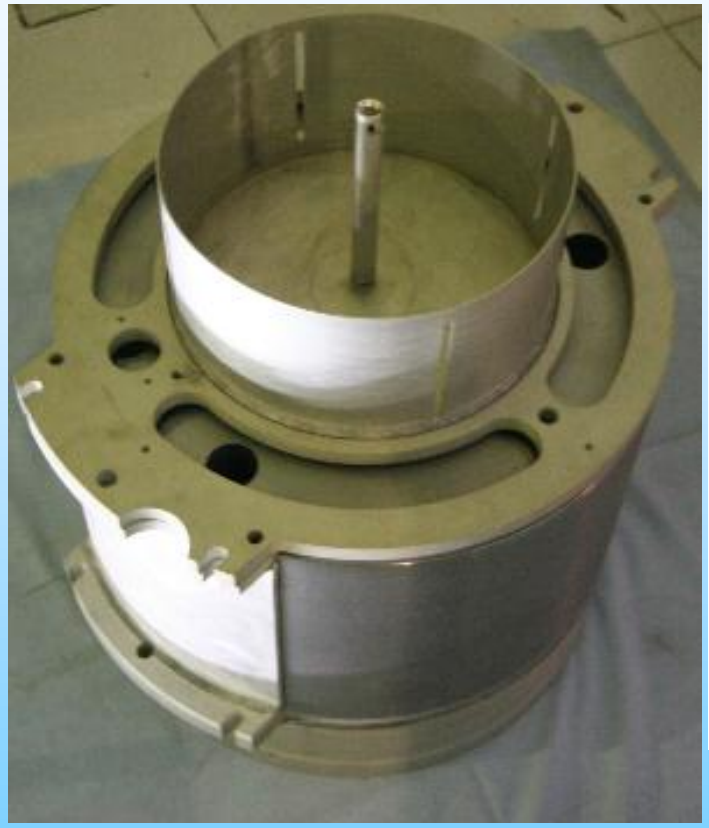
Height：256mm

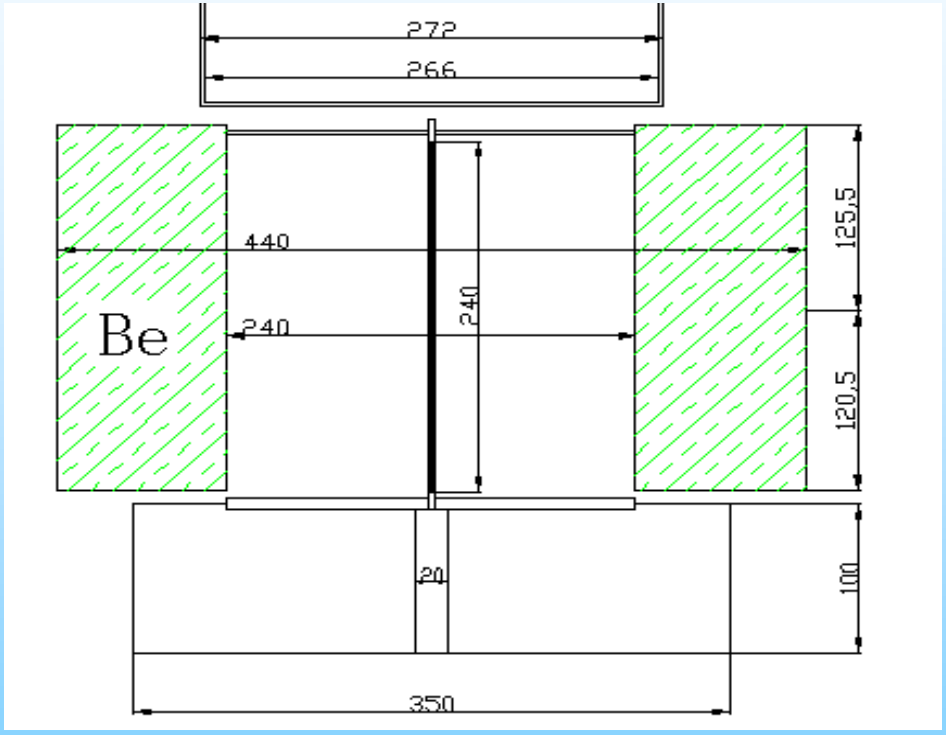
Fuel meat： UO2

Dia. ：4.2mm

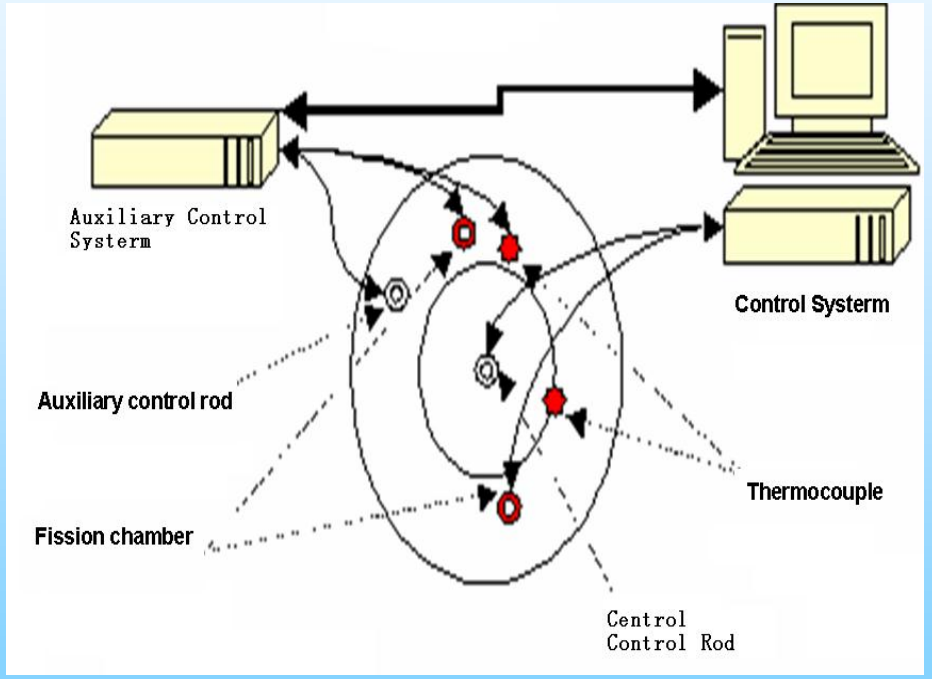
Height：240mm

Reactor core-Be reflector





Reactor control system



Reactor water purification system

Flow: 0.5m³／h

PH:6.0±0.5 （25℃）

Conduct：

＜1μs／cm （25℃）

Reactor pool water purification system

Flow ：2m³/h

Conduct：

≤3μs／cm（25℃）

PH: 6.0±0.5（25℃）

Reactor gas purge system

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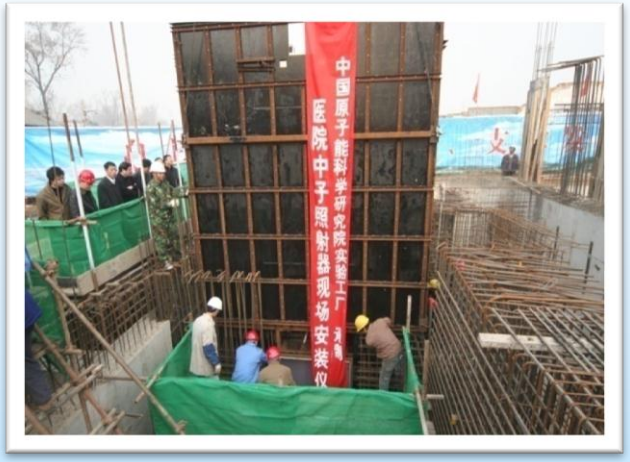
Construct

Site was approved by NNSA in 2007.10

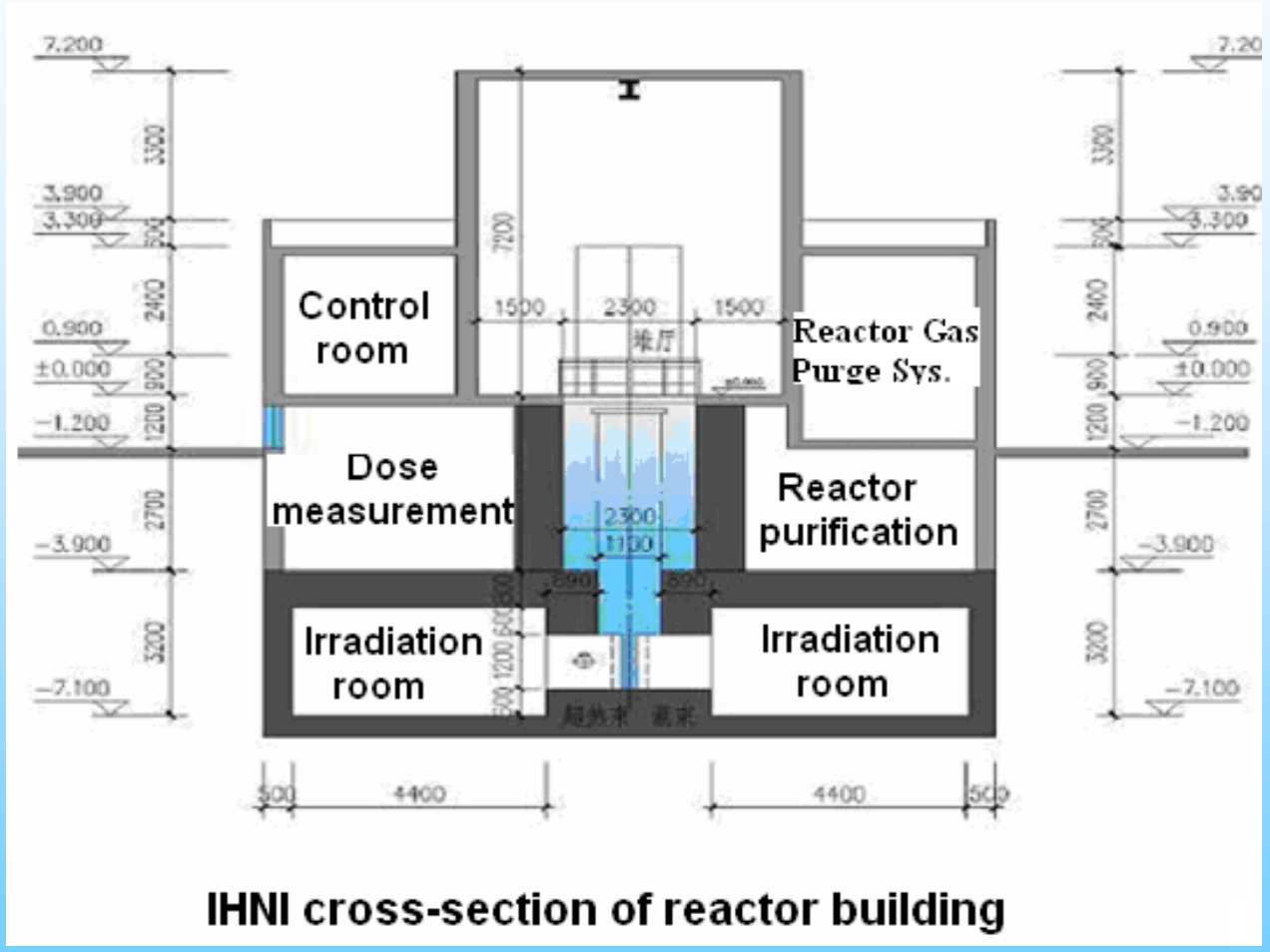


Construct

Total: 1145m²

- **Reactor：477m²**
- **Office：668m²**

Construct



IHNI cross-section of reactor building

Construct

Equipment installation from 2008.11 to 2009.2

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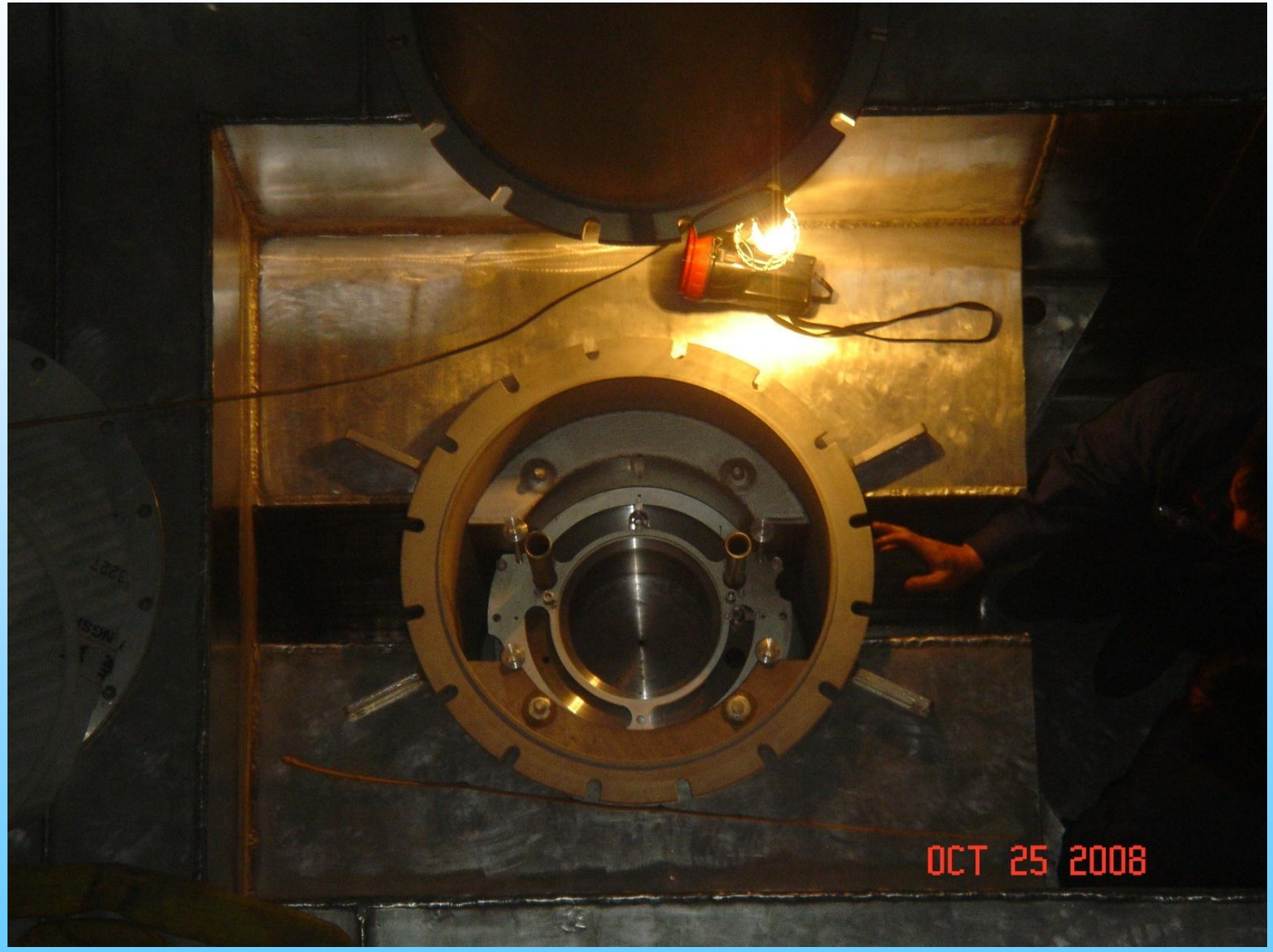


Startup

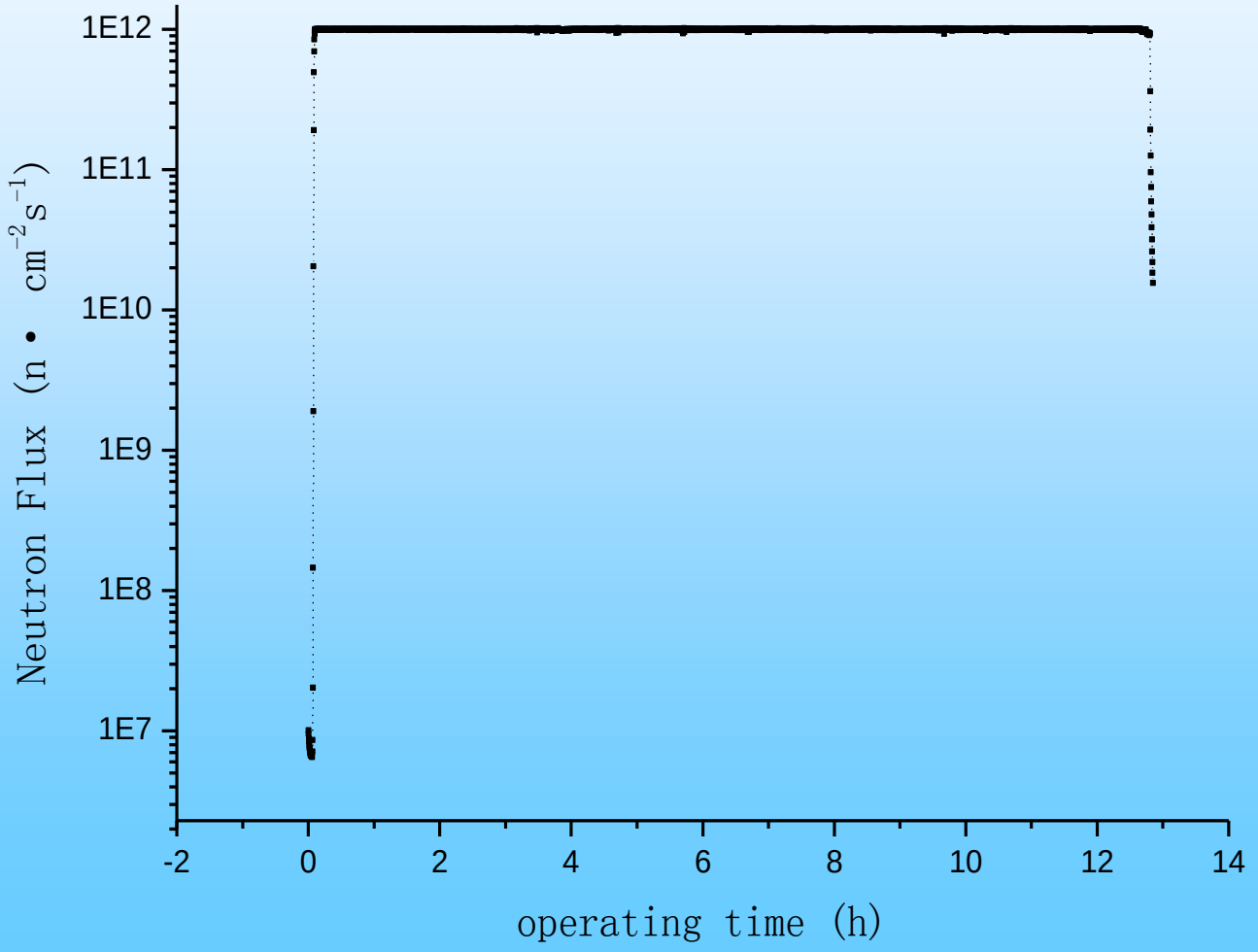
Loading approved by NNSA in 2009.8
Fuel Loading in Dec. 2009

First Critical experiment 2009-12-7

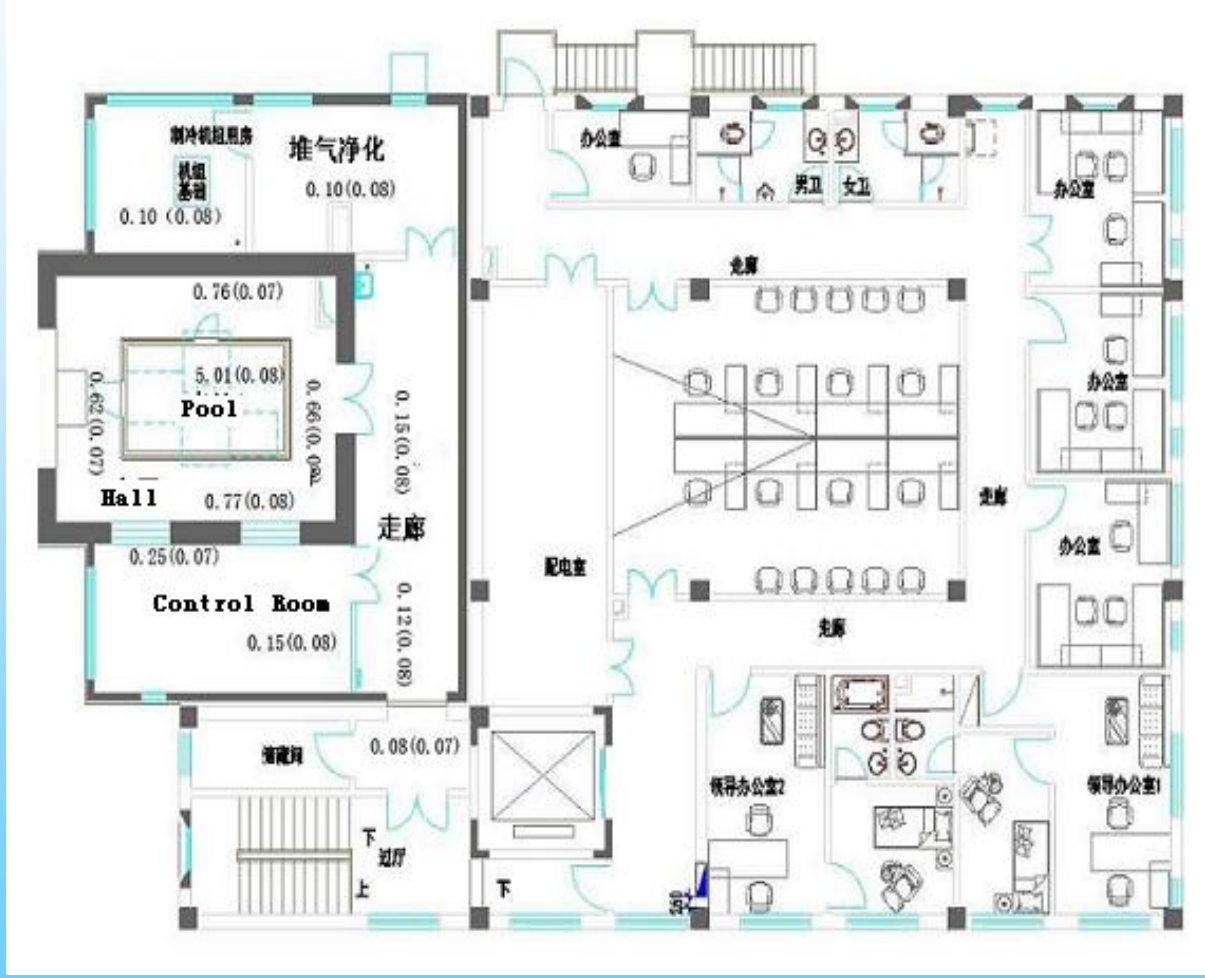
Startup

Excess reactivity: 4.2mk

Max. operation time at 30kW: 12 Hours
Error: less then 3‰



- **Less then 1 μGy/h. Dose rate at 30kW**



Startup

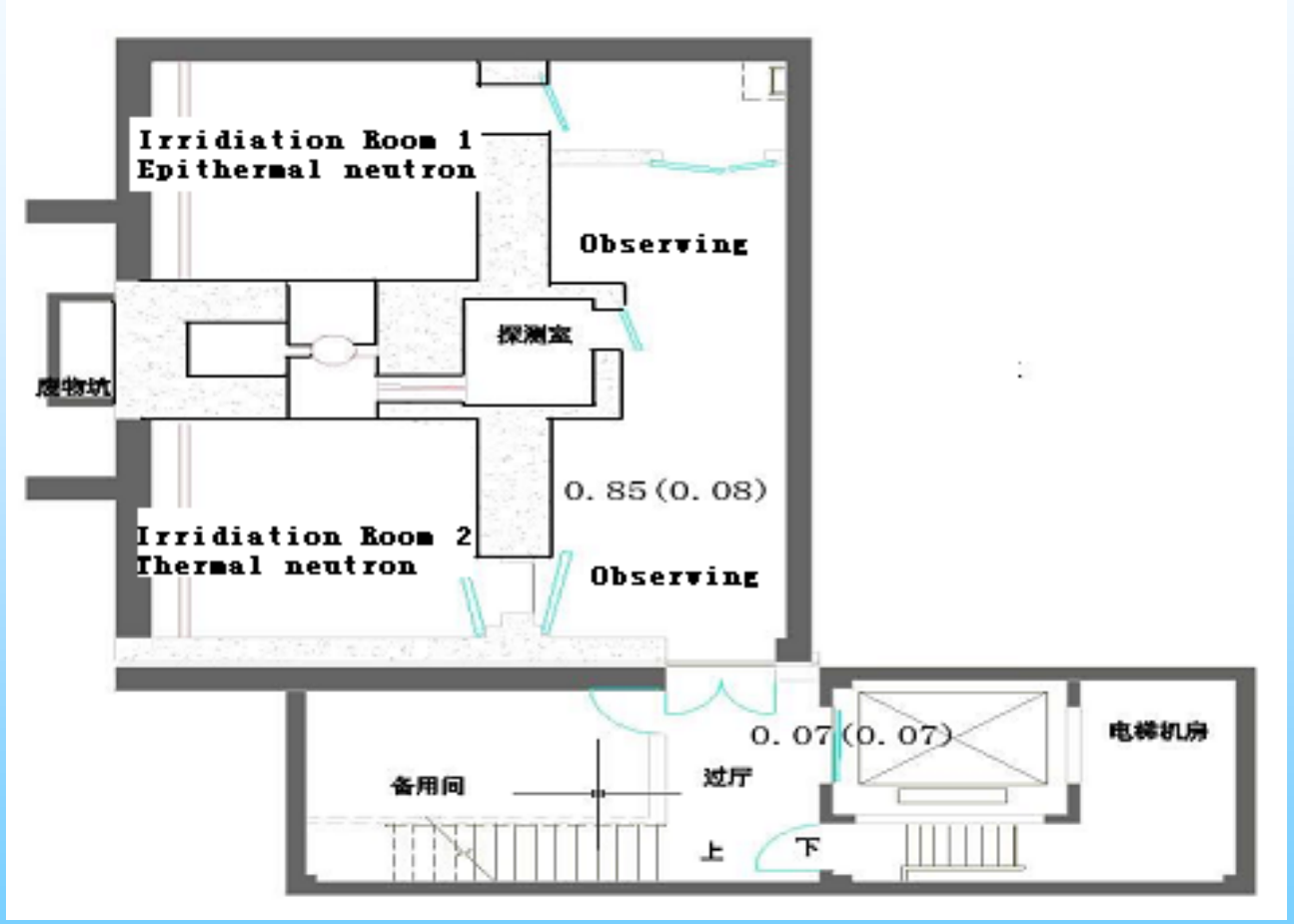
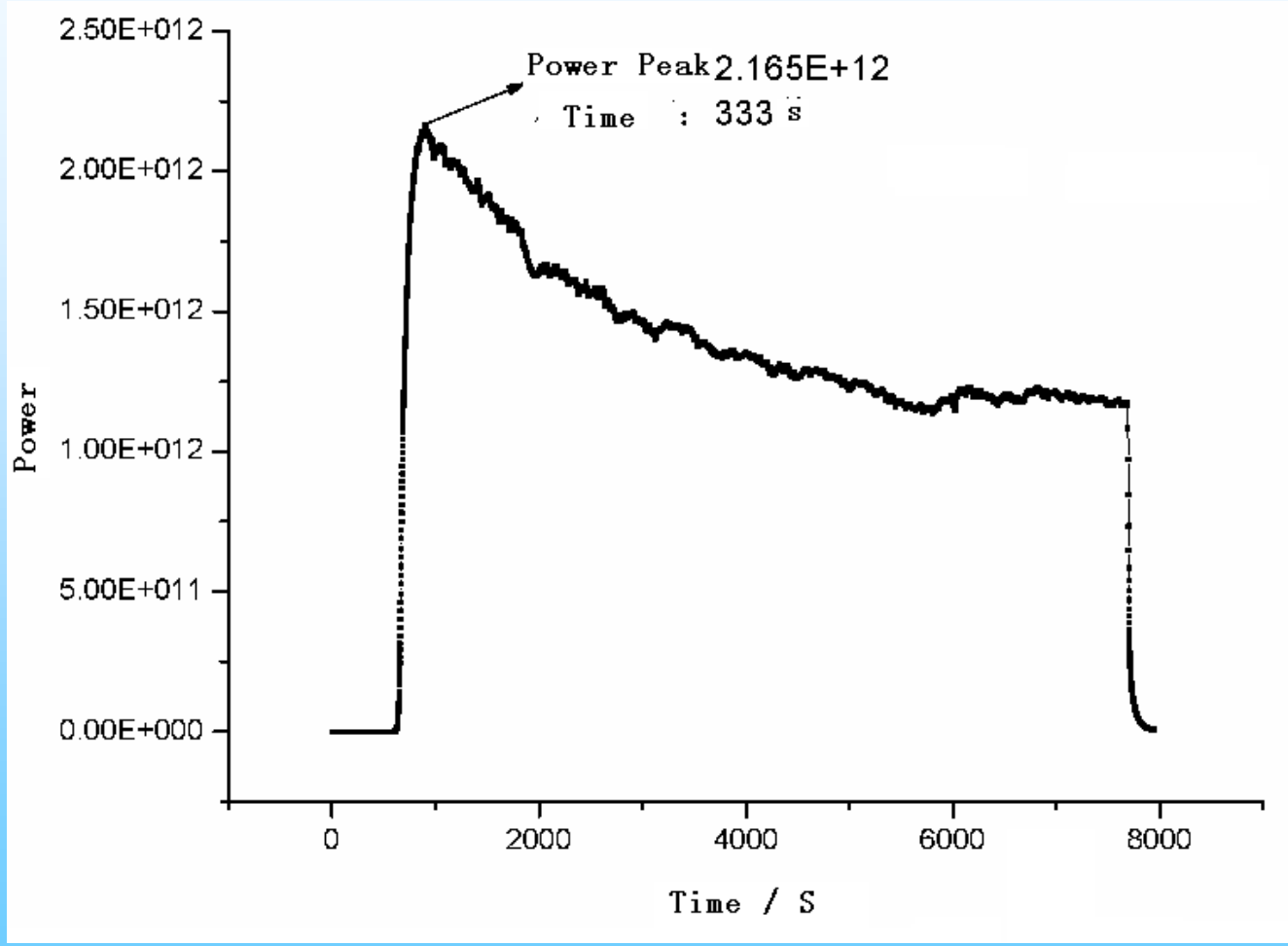

Irridiation Room 1
Epithermal neutron
Observing
探测室
废物坑
0.85(0.08)
Irridiation Room 2
Thermal neutron
Observing
0.07(0.07)
电梯机房
备用间
过厅
上
下

Fig. Power Transient Following 3.4mk Step Increase in Reactivity



- **Peak power: 85kW**

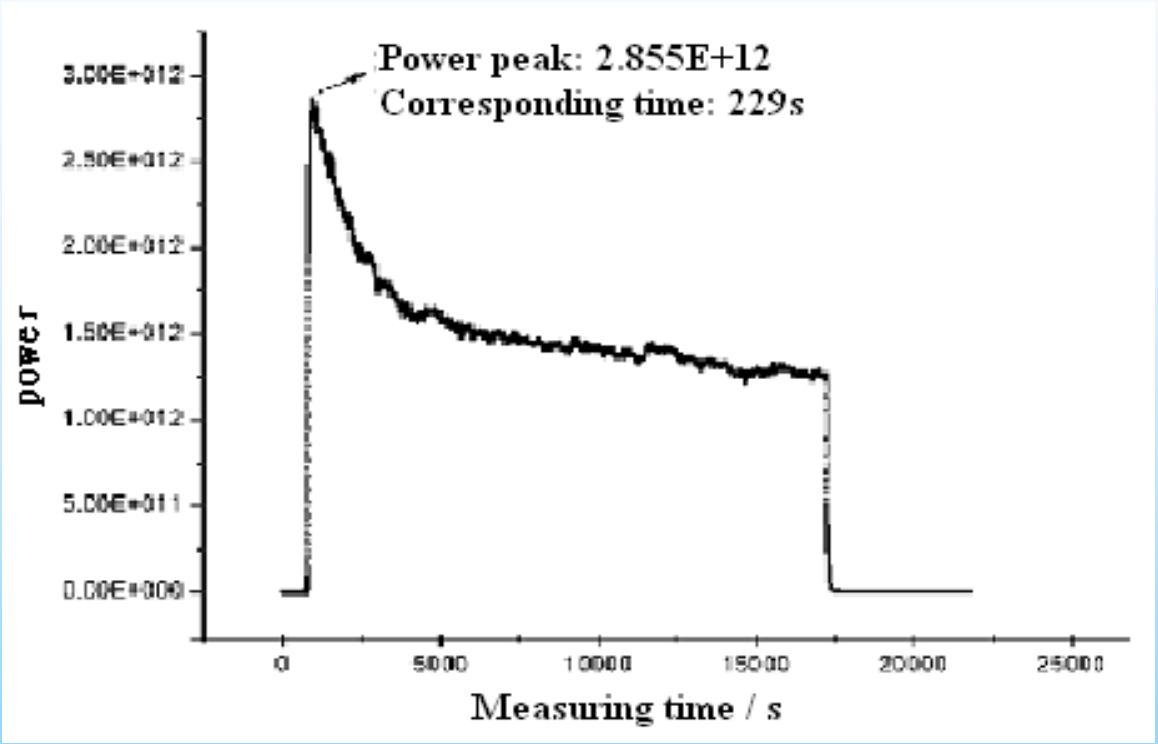


Fig. Power Transient Following 4.2mk Step Increase in Reactivity

Main Technical Data

- ✓ Thermal power : 30kW
- ✓ The central control rod worth : -6.8mk
- ✓ The auxiliary control rod worth : -5.8mk
- ✓ Total top beryllium worth: -17mk
- ✓ Critical mass: 296 fuel elements
- ✓ Excess reactivity(at cold, initial state): 4.5mk
- ✓ Temperature coefficient: -0.1mk/℃(40-20℃)

- **Main Technical Data**

Table 1 Calculated results at thermal neutron port

ϕ_{th} /n.cm^{-2}.s^{-1}	$(\dot{D}_f+\dot{D}_{epi})/\phi_{th}$ / Gy.cm^2	$\dot{D}_\gamma/\phi_{th}$ / Gy.cm^2	$\dot{D}_f/\phi_{th}$ /cGy.s^{-1}	ϕ_{th}/ϕ_f	J_n^+/ϕ_n
2.14×10^9	1.70×10^{-13}	9.73×10^{-14}			0.798
#2.90×10^6		#1.89×10^{-13}	#7.39×10^{-14}	#42.53	#0.984

#: Small thermal neutron beam parameters at the port.

Table 2 Calculated results at epithermal neutron beam port

ϕ_{epi} /n.cm^{-2}.s^{-1}	$\dot{D}_f/\phi_{epi}$ /cGy.s^{-1}	$\dot{D}_\gamma/\phi_{epi}$ /Gy.cm^2	ϕ_{th}/ϕ_{epi}	J_n^+/ϕ_n
4.31×10^9	5.84×10^{-13}	2.07×10^{-13}	0.041	0.812

Thanks