



# Jordan Research & Training Reactor

# Utilization Facilities

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**Commissioner, Jordan Atomic Energy Commission**

الدكتور نضال الزعبي  
مدير مشروع مفاعل البحوث والتجارب النووية

**IAEA Technical Meeting on**  
**Commercial Products and Services of Research Reactors**

**International Atomic Energy Agency**

**Vienna, Austria**

**28 June – 2 July , 2010**



**IAEA**

International Atomic Energy Agency

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# Jordan Facts & Figures

- Population 6.4 million<sub>(2010 est.)</sub>
  - Area 89,000 square km
  - GDP \$22.82 billion<sub>(2009 est.)</sub>
  - Budget \$8.223 billion
  - Oil imports 108,200 bbl/day<sub>(2007 est.)</sub>
  - 2.72 billion cu m<sub>(2008 est.)</sub>
- **Lack of indigenes resources**
  - Dependence on imports
  - High Cost ... 19.5% of GDP and 23.1% of imports<sub>2008</sub>





# Milestones on the Road to Nuclear



**Program is Announced**

**Nuclear Law Establish**



**JAEC & JNRC**

**NCA Exploration Agreement**



**Reactor EPC Contract**




**Site & Technology Selection**




**Uranium Mining**




**Nuclear Engineering Department Established**



**NFC Laboratory Established**



**CSF Facility Built**

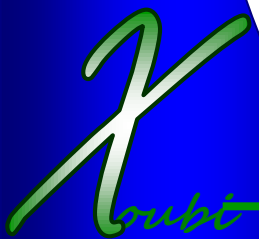


**Subcritical Assembly Built**



**Nuclear Research Reactor Start Operation**

**Nuclear Power Plant**

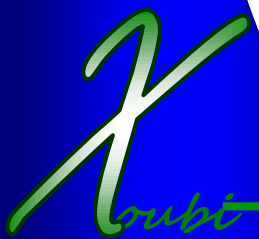




# Research Reactor



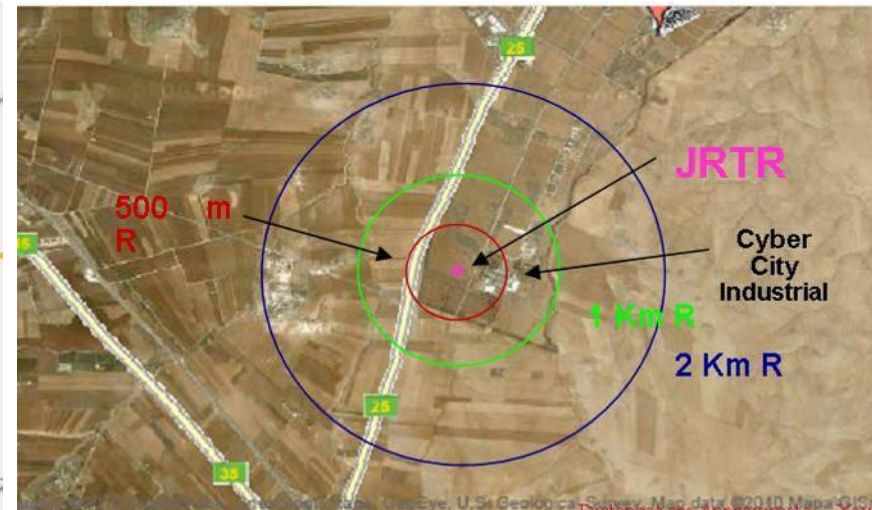
- January 15<sup>th</sup> 2009, RFP was issued for MPR
- 4 International Bids received
  - Russia, ATOMSTROYEXPORT
  - China, ZHONGYUAN Co (CNNC)
  - Korea, KAERI / Daewoo
  - Argentina, INVAP
- December 4<sup>th</sup>, 2009 K/D was selected as the Preferred Bidder
- March 31, 2010 EPC Contract is Signed for Jordan Research & Training Reactor (JRTR)





# JRTR Location

- JRTR is Jordan's first nuclear reactor
- Focal point for Jordan national nuclear centre
- Built within JUST University campus
- Modern Engineering and Medical infrastructure
- Located in Ramtha city 65 Km north of Amman





# Jordan National Nuclear Center

- State of the art Nuclear Center for Jordan & the Region
- Complete center that includes
  - JRTR Reactor
  - Radioisotope production facility
  - Education and training building
  - Fuel fabrication plant (phase-2)
  - Radioactive waste facility (phase-2)
  - Cold neutron facility (phase-3)





# JRTR Main Functions

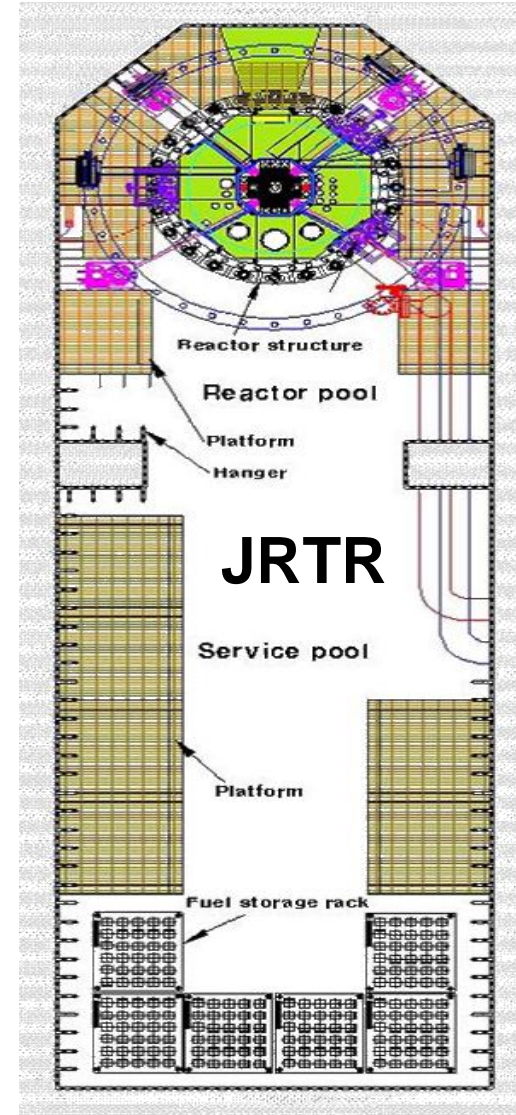
- would serve as an integral part of Jordan nuclear infrastructure
- Educating upcoming generations of nuclear engineers
- Training of nuclear operators, technicians
- Provide irradiation services in support of the Jordan industrial, agricultural and health/medical infrastructure
- National research facility of nuclear science and technology





# JRTR Nuclear Specifications

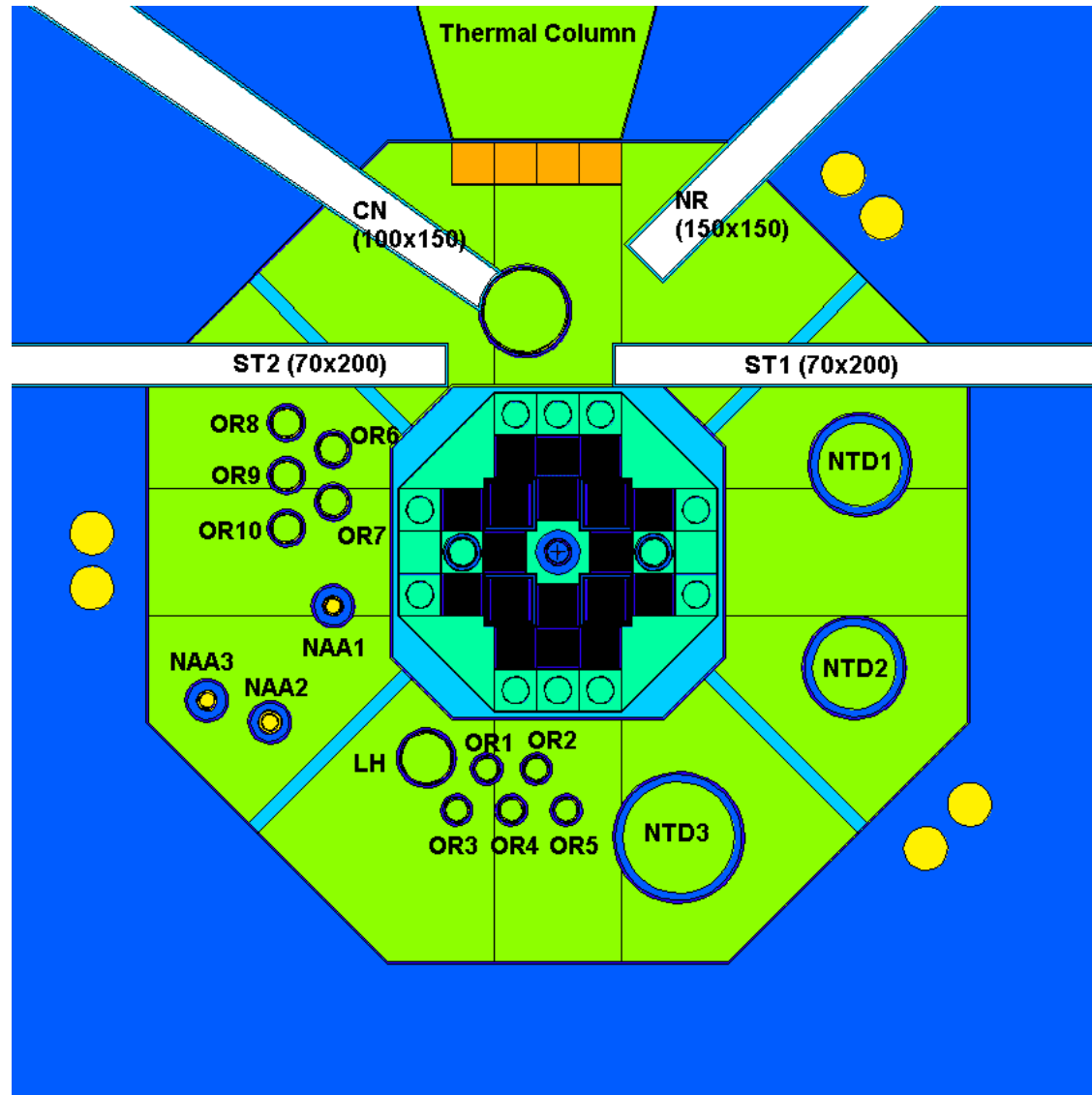
- 5 MW upgradeable to 10 MW
- Open Pool, water cooled and moderated
- Maximum Flux  $1.45 \times 10^{14}$
- MTR plate type fuel 18FA Core
- $U_3Si_2$  in Aluminum matrix; 19.75% enriched, Al Clad
- Reflector is Beryllium & Graphite
- Average Discharge Burnup 70%
- Cycle Length 50 days 1 FA
- Control rods Material Hafnium (control),  $B_4C$  (2<sup>nd</sup> shutdown syst)







# Irradiation Facilities Layout

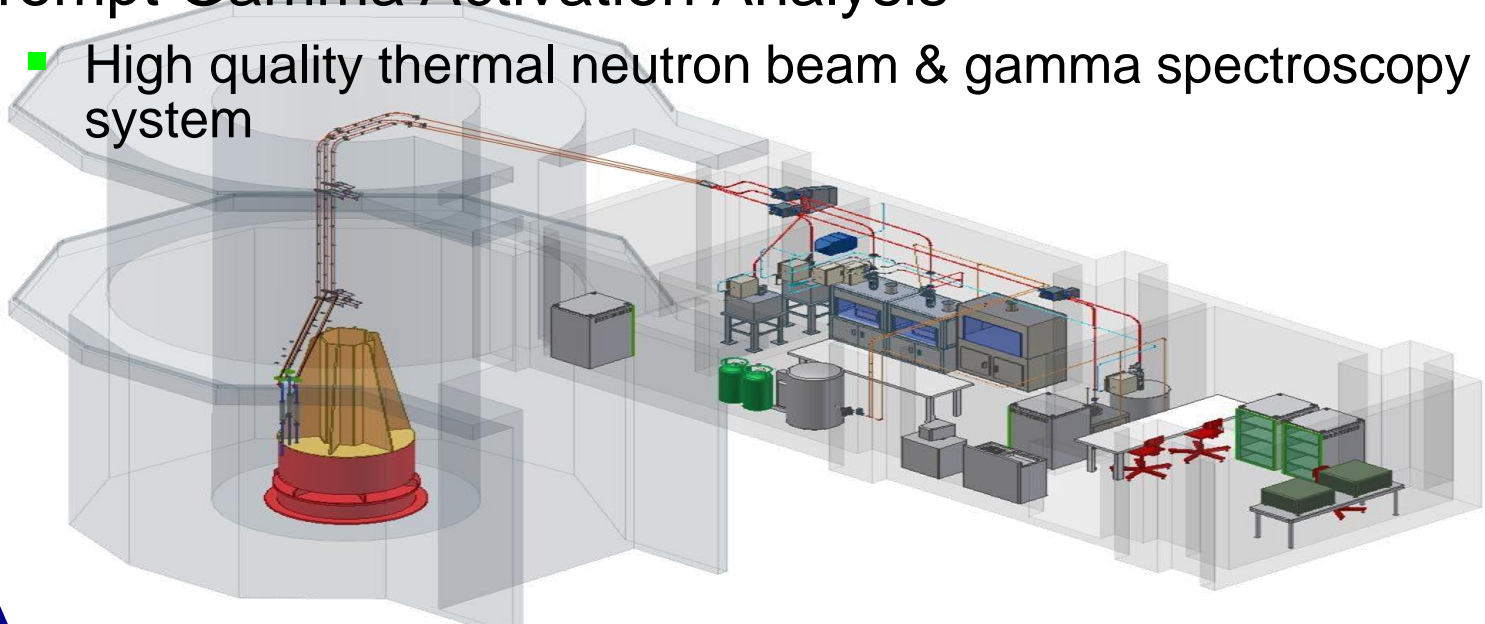


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# JRTR NAA Facilities

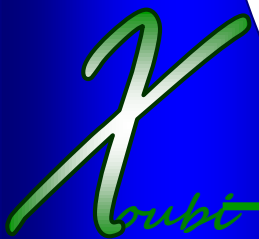
- JRTR have 3 VXF dedicated for NAA with 3 Pneumatic Transfer Systems (1 PTS for each VXF)
- NAA Labs for specimen preparation, irradiation control, measurement, and storage
- INAA, DNAA, Epithermal NAA
  - Gamma spectroscopy/neutron detection system
- Prompt Gamma Activation Analysis
  - High quality thermal neutron beam & gamma spectroscopy system





# NAA Applications

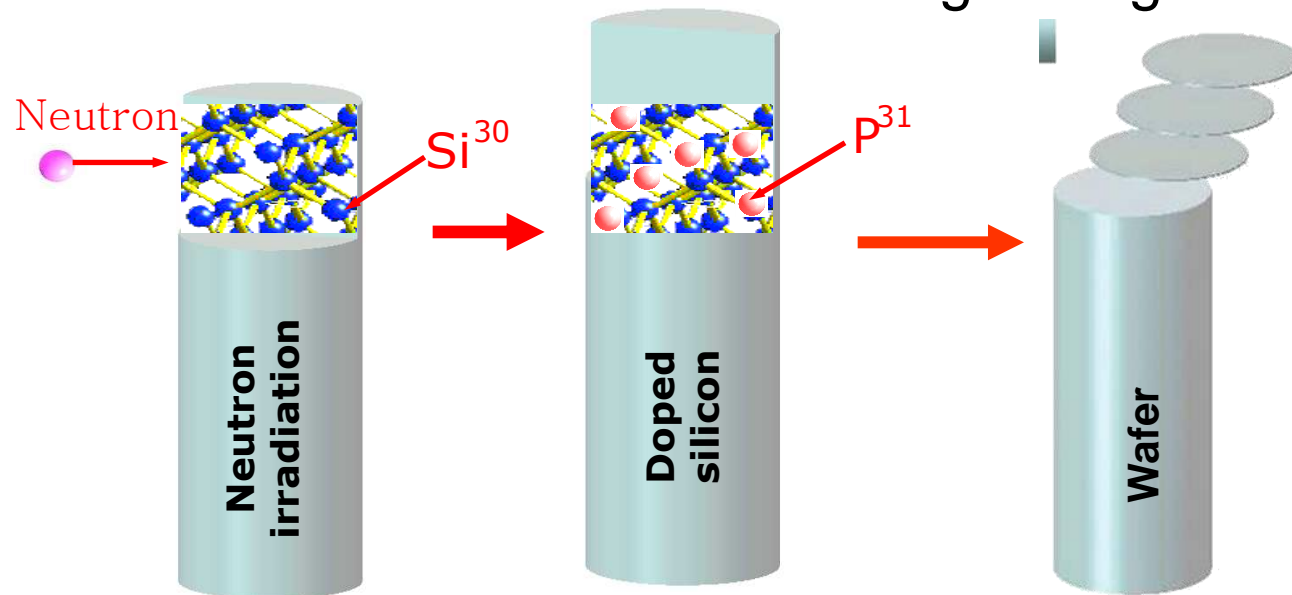
JRTR NAA Applications : Research & development, Analytical service





# Neutron Transmutation Doping

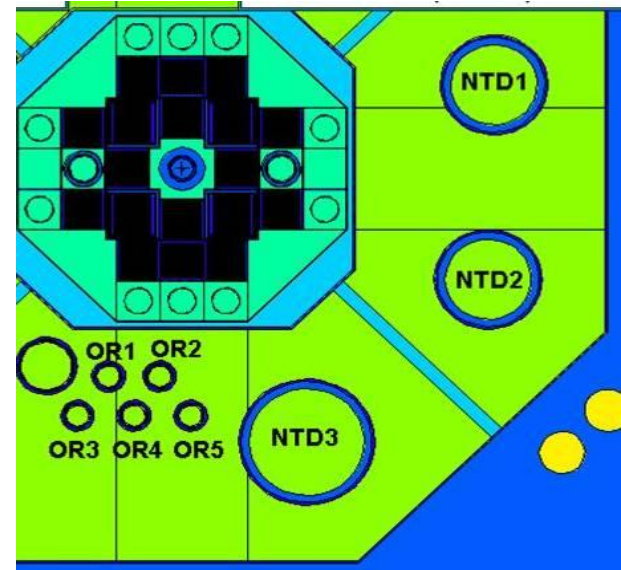
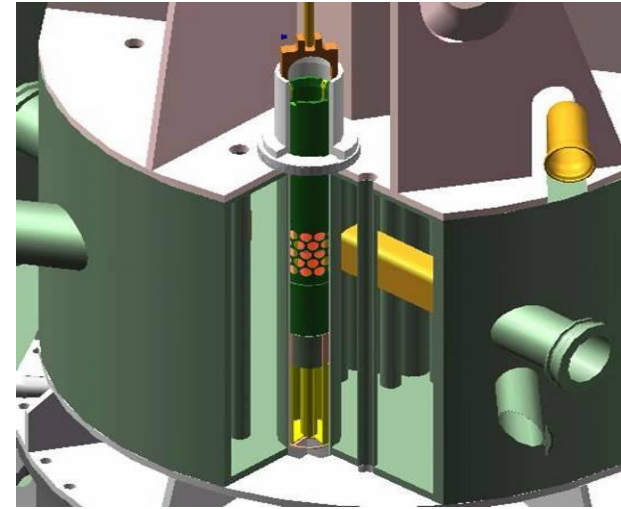
- JRTR have 3 VXF dedicated for NTD
  - NTD1&2 : Commercial service for 5, 6 inch silicon ingots
  - NTD3 : Commercial service for 8 inch silicon ingots
  - Ingot length: 50 cm
- Average thermal flux  $1.4 \times 10^{13}$  n/cm<sup>2</sup>s
- Uniform Irradiation: Rotation and Reciprocating motion
- Accurate neutron fluence corresponding to target resistivity





# JRTR Estimated Revenue from NTD

- Assumptions
  - JRTR operation of 200 days/year
  - Average target resistivity:  $50 \Omega \cdot \text{cm}$
- JRTR maximum capacity
  - Average irradiation time for a batch: ~ 10 h
  - About 35 tons/y: ~ \$4M/y
- Advantages
  - Lower investment & operation cost than other services
  - Almost no waste
  - Possibility of rapid increase in demand

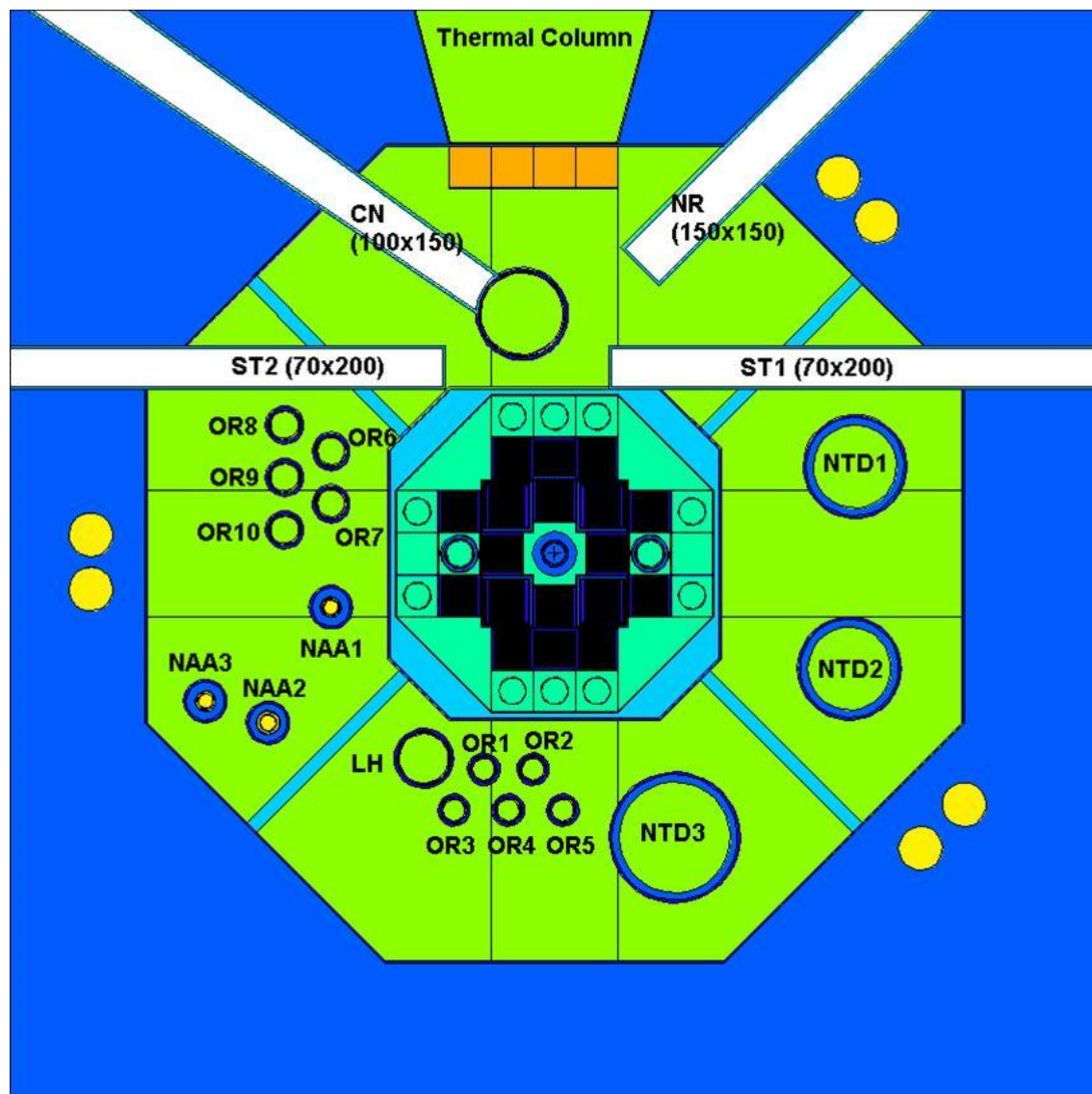


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# Radioisotope Production Facility

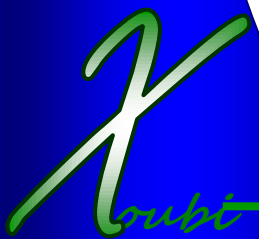
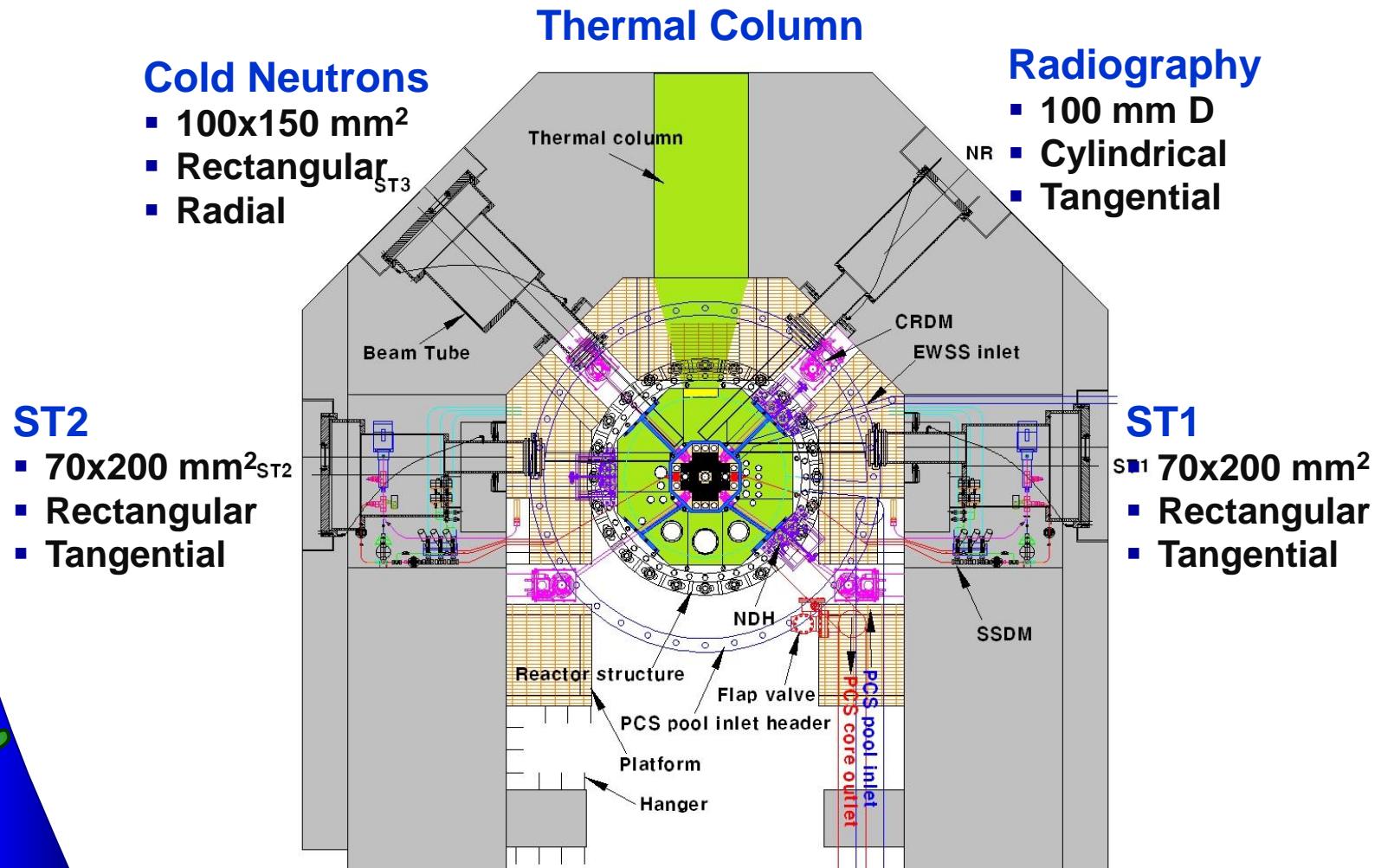
- RIP Building
  - 3 Banks
  - 8 Hot Cells
  - $I^{125}$
  - $Ir^{192}$
  - $Mo^{99}$



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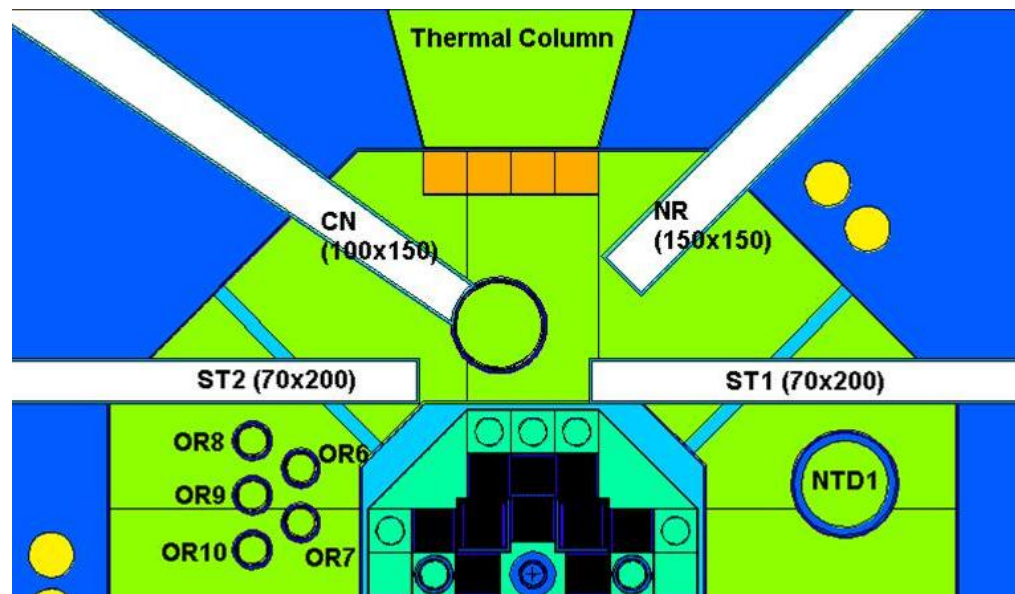
# JRTR Neutron Beam Ports





# JRTR Neutron Beam Ports

	Maximum Thermal Flux	Maximum Fast Flux
<b>ST1</b>	<b>3.63 E+13</b>	<b>3.73 E+12</b>
<b>ST2</b>	<b>2.94 E+13</b>	<b>1.98 E+12</b>
<b>CNS</b>	<b>2.98 E+13</b>	<b>1.92 E+12</b>
<b>NR</b>	<b>4.16 E+13</b>	<b>3.29 E+12</b>
<b>TC</b>	<b>6.27 E+12</b>	<b>2.64E+10</b>

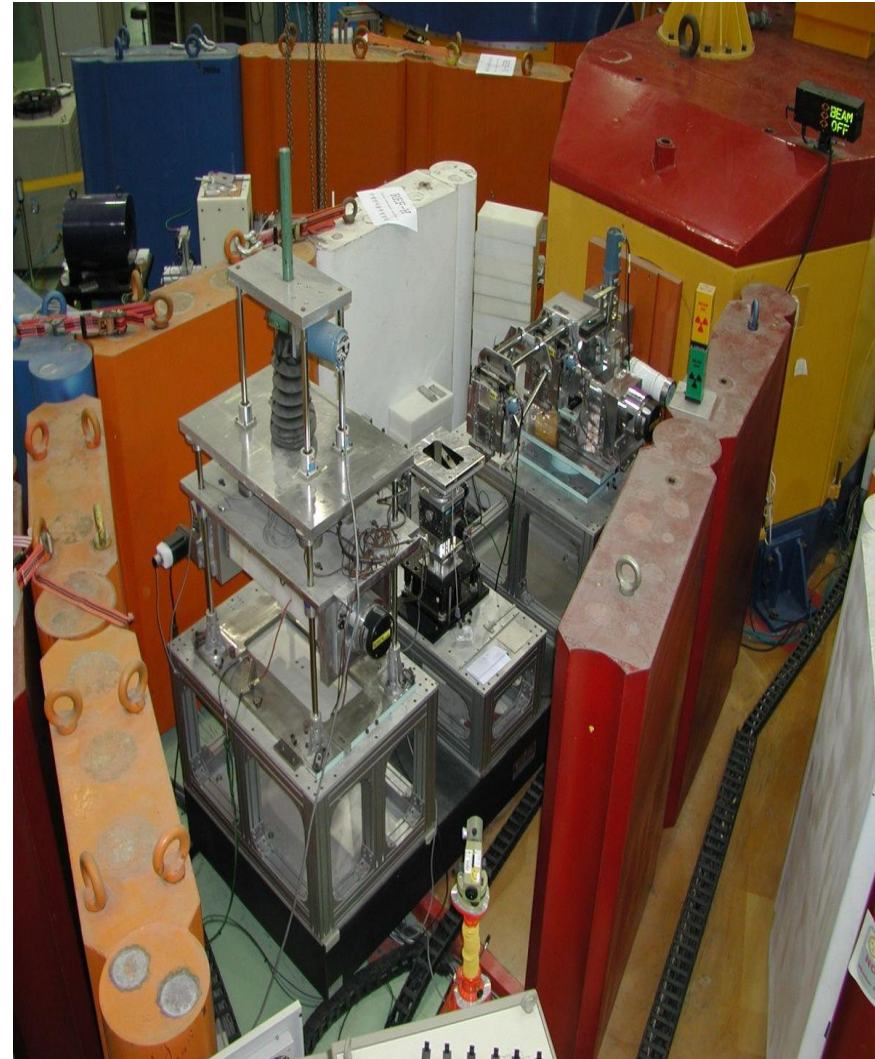






# Neutron Reflectometer (REF-H)

- Neutron reflectometer with horizontal sample geometry, (REF-H)
- For surface and interface studies
- Has a specialized capability for studies of those surface and interface with liquid from the horizontal sample geometry
- Can be used for bio-interfaces such as mimetic membranes



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# Technology Transfer

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# Moving Jordan into a New-Clear Future



JAEC

JRTR

*Thank You*

