

Needs and Present Status of the First Multipurpose Nuclear Facilities in Jordan

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Jordan Overview



- Total Area: 89 213 sq. Km
- Sea Port: Aqaba
- Coastline: 26 Km
- Population: 5.96 million
31% (15- 29) 38% (below 15)
- Climate: Mediterranean & Arid Desert



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Jordan's Nuclear Program

- Initiated in 2007
 - Established Nuclear Engineering Department at Jordan University of Science and Technology (JUST)
- In 2008, established Jordan Atomic Energy Commission (JAEC) and Jordan Nuclear Regulatory Commission (JNRC)
 - Two main nuclear facilities are underway
 - Research reactor
 - Subcritical assembly



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Jordan Research and Test Reactor - JRTR

- Objectives:
 - Focal point of a nuclear science and technology center
 - Train the upcoming generations of nuclear technology experts
 - Support the technological infrastructure in various fields including medical, industrial, agricultural etc.



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Jordan Research and Test Reactor - JRTR

- RFP issued in January, 2009
 - Evaluation process until end of 2009
- In early 2010, South Korean KAERI-DAEWOO Consortium (KDC) selected
 - Contract signed on March 30, 2010 between JAEC and KDC
 - JRTR to be established within the campus of the JUST



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JRTR – General Design Features

- 5-MWth power (with ability to upgrade to 10-MW)
- Open pool
- Light water moderated and cooled
- MTR plate type fuel
 - Silicide in an Al matrix
 - 19.75% maximum enrichment
- Heavy water and beryllium reflected
- Capable of in-core thermal neutron fluxes reaching 10^{14} n/cm².s



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JRTR – Primary Applications

- Training in support of establishing Jordan's nuclear program including the pursuit of the nuclear power option
- Initiate neutron science and radiography utilization
- Radioisotope production in support of medical and industrial applications
- Neutron activation analysis
- Neutron transmutation doping



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JRTR – Facilities

- Several beam tubes for utilization in beam experiments
 - Provisions made for the future addition of a cold neutron source
- Thermal column for irradiation and teaching exercises
- Many in pool irradiation locations for isotope production, NAA and potentially NTD
- Fully equipped NAA systems and facilities
- Fully equipped radioisotope production facilities



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JRTR – Project Status

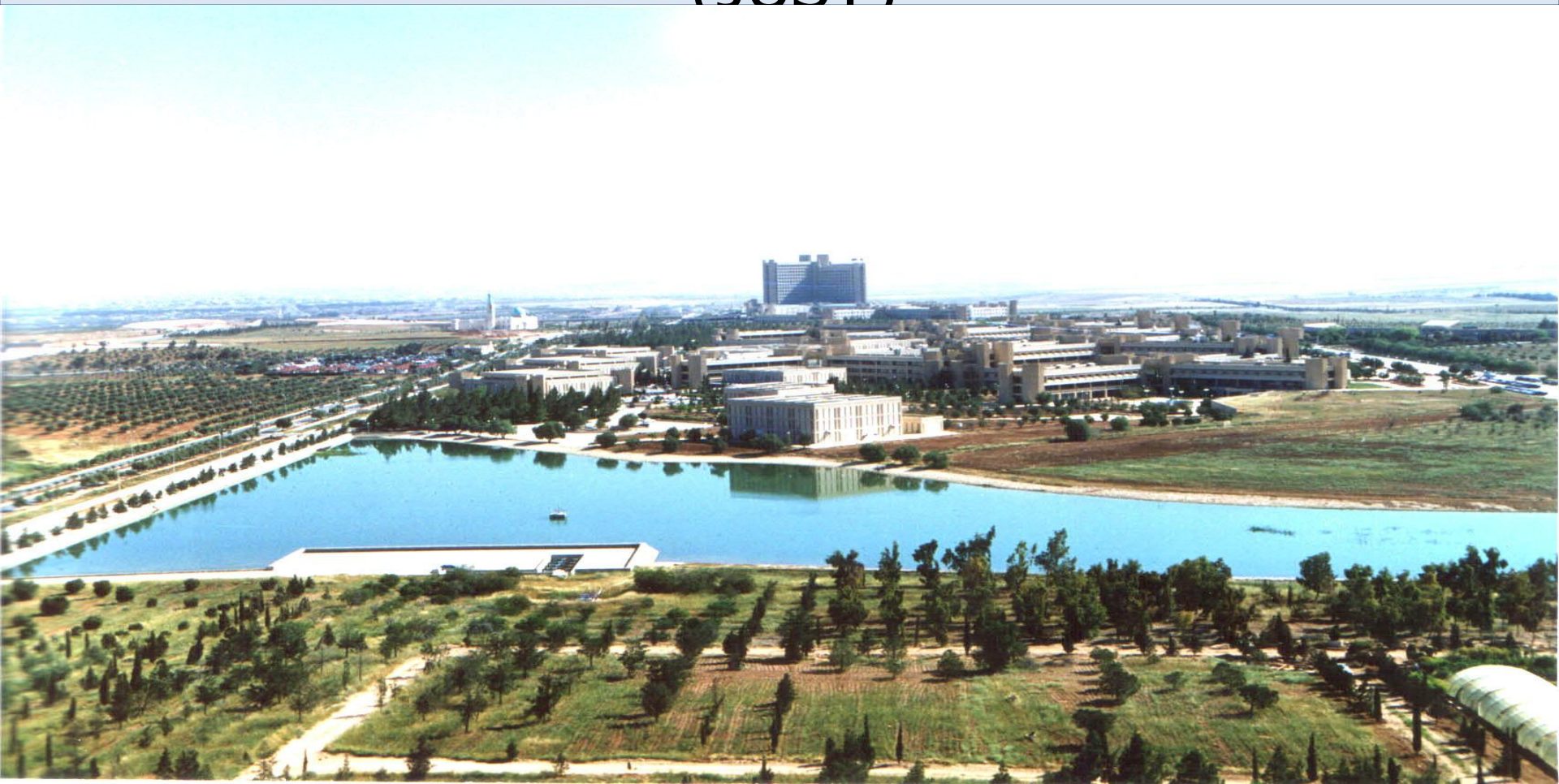
- A two step licensing approach is being implemented
 - Preliminary Safety Analysis Report (PSAR) has been submitted to JNRC
 - Other associated documentation has also been submitted
 - Expect the construction permit (CP) to be issued in 8 months
 - Final SAR to be submitted towards end of the construction period
 - Facility turn over expected in 2015
- An owner's representative that will work with JAEC on the project is being pursued
 - OR applications have been received by JAEC
 - Expect the OR to be in place in the near future



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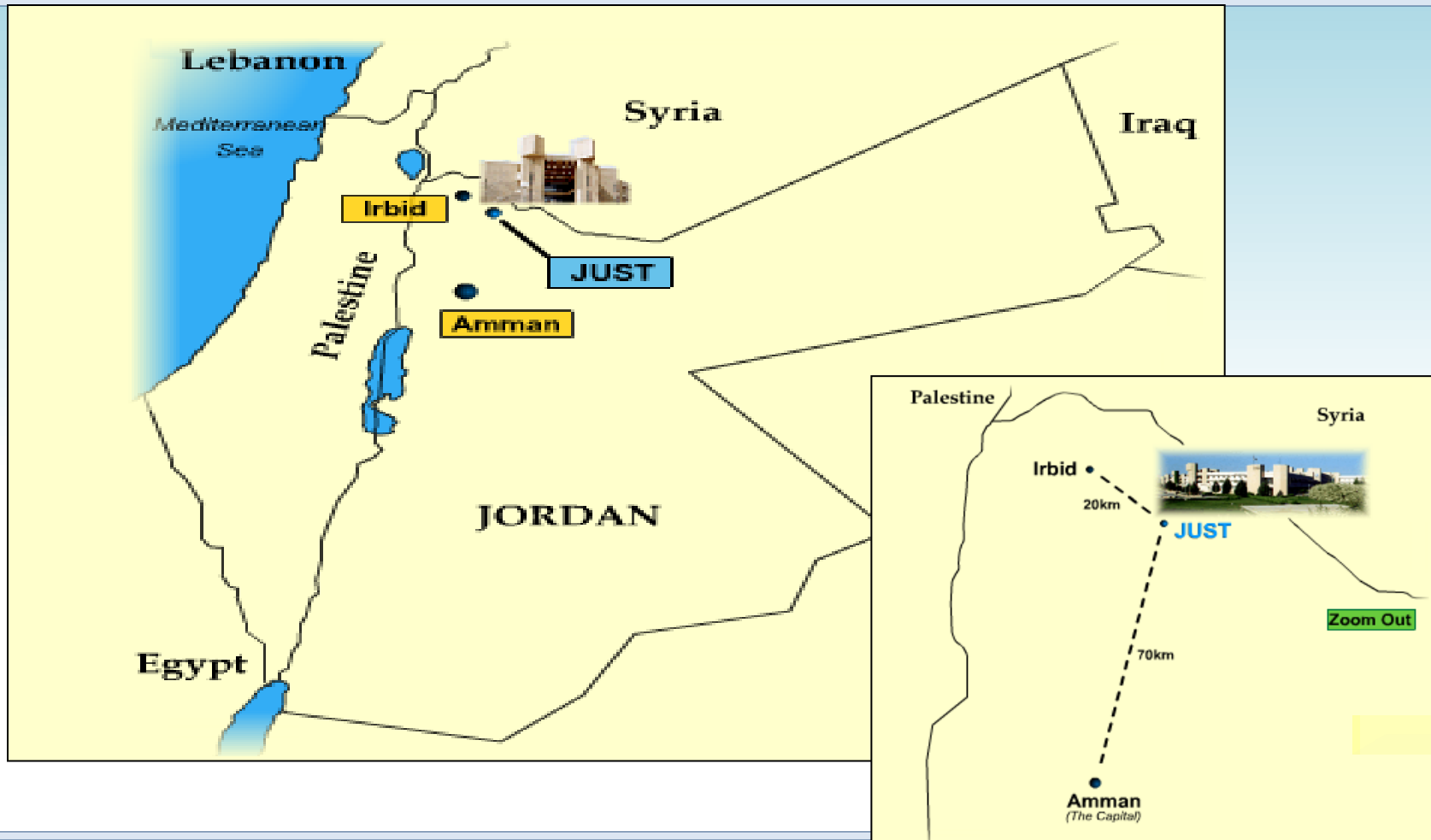
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JUST Location



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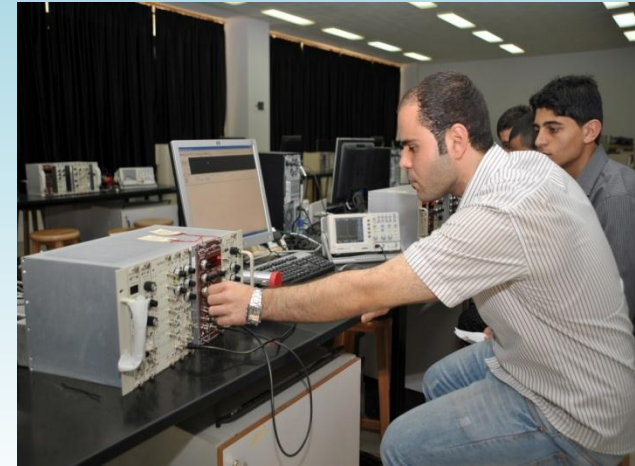
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Nuclear Engineering Department

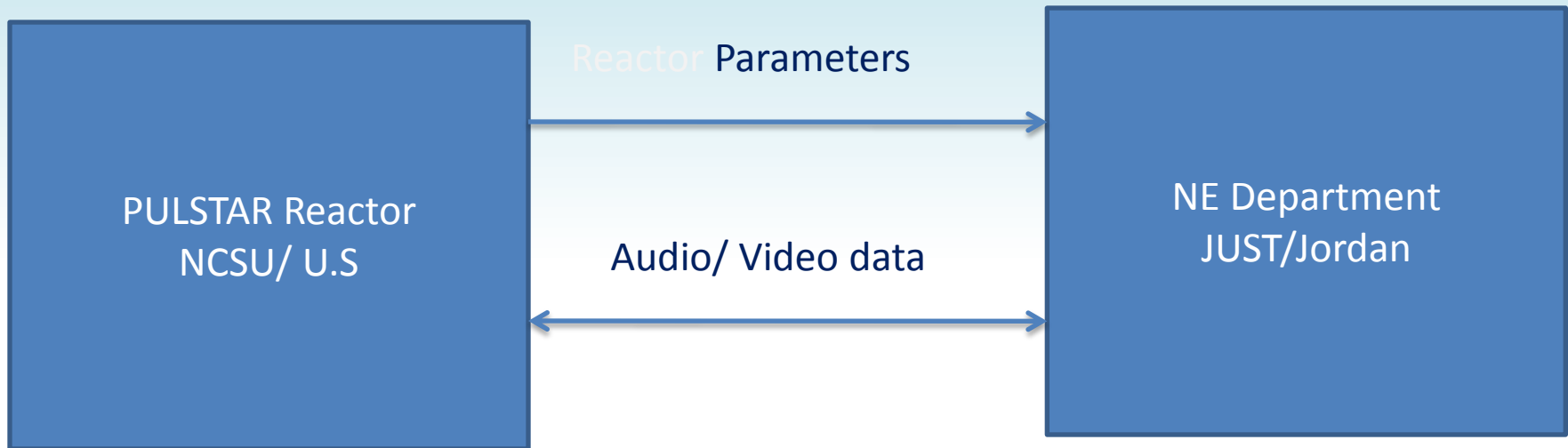
- First and the only nuclear Engineering Program in Jordan.
- Started in 2007
- Students: 132
- Graduated: 19 (2011)
- Faculty Members: 4
- Facilities:
 - High Performance Computing lab.
 - Radiation Detection and Measurement Labs.
 - Internet Reactor Lab. (IRL)
- Jordan Subcritical Assembly (JSA)



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Internet Reactor Lab (IRL)



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Students' Evaluation of the IRL

- **15** students who took the IRL course at JUST (4 of them also attended an IAEA fellowship on RR) were asked to evaluate the course by giving a grade (out of 10) for the following questions:
 - How do you compare this lab to other practical lab courses you took during your study?
 - **Evaluation: 8.3/10 (min: 7, max: 10)**
 - To what extent did this lab give you the feeling that you are in an actual reactor.
 - **Evaluation: 8.4/10 (min: 7, max: 10)**



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Students' Evaluation of the IRL/2

- To what degree did the lab provide the link between the reactor physics you studied and the actual performance of the reactor
 - **Evaluation: 8.5/10 (min: 6, max: 10)**
- Was the language an obstacle in communicating with reactor operators and understanding the course?
 - **Evaluation: No (all answered: No)**



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Overall Evaluation of the IRL

- The IRL was found to be an excellent tool for educational purposes on Reactor Physics, with the following extra advantages:
 - Benefit from an already existing RR with all its accumulative experience.
 - Access can be arranged in no time as compared to the construction of a new RR.
 - Can accommodate larger number of students in one session, as compared to education on the actual reactor.
 - Reduces Safety and security requirements regarding students accessing the RR.



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Jordan Sub-critical Assembly (JSA)

- Jordan's first Nuclear facility.
- Designed and constructed for the purpose of education, training, and experimental research.
- Inherently safe
- Hands on experience for students and trainees:
 - Easily operated
 - Parts are easily accessible for demonstration and inspection purposes.
 - Ability to change core configuration and introduce voids, poisons, etc.



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JSA: Experiments Programme

- Approach to Criticality Experiment:
- Static Experiments
 - a) Axial flux measurement.
 - b) Radial flux measurement.
 - c) Absolute flux measurement.
- Dynamic Experiments
 - a) Rossi- α method
 - b) Feynman- α method
 - c) Source-jerk method
- Void Effect
- Control rod (poison) Effect.



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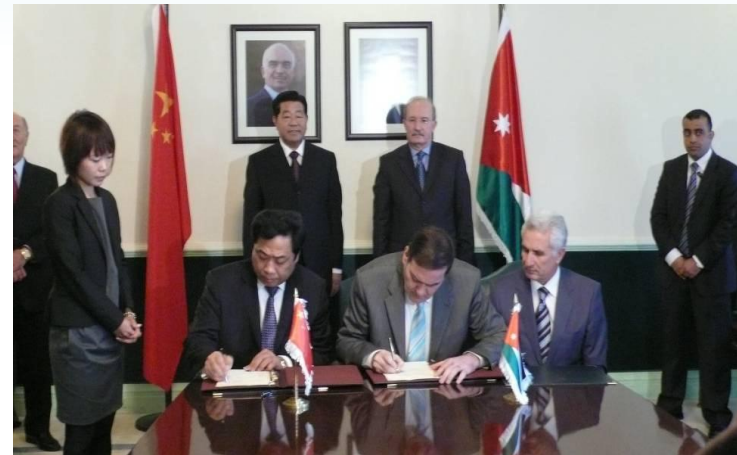
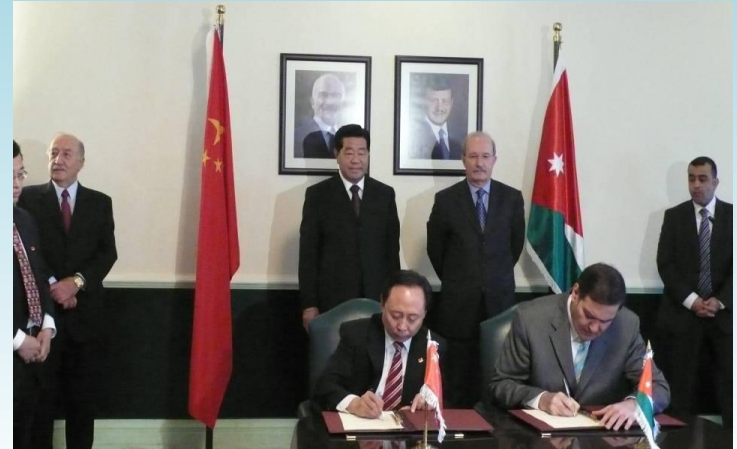
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JSA: Project

- November 24, 2008 Jordan Atomic Energy Commission (JAEC) and Jordan University of Science and Technology (JUST) signed a contract with China Institute of Atomic Energy (CIAE) to design and construct Jordan Subcritical Assembly (JSA).
- February 9, 2009 Chinese government approved the contract and it came into effect officially.



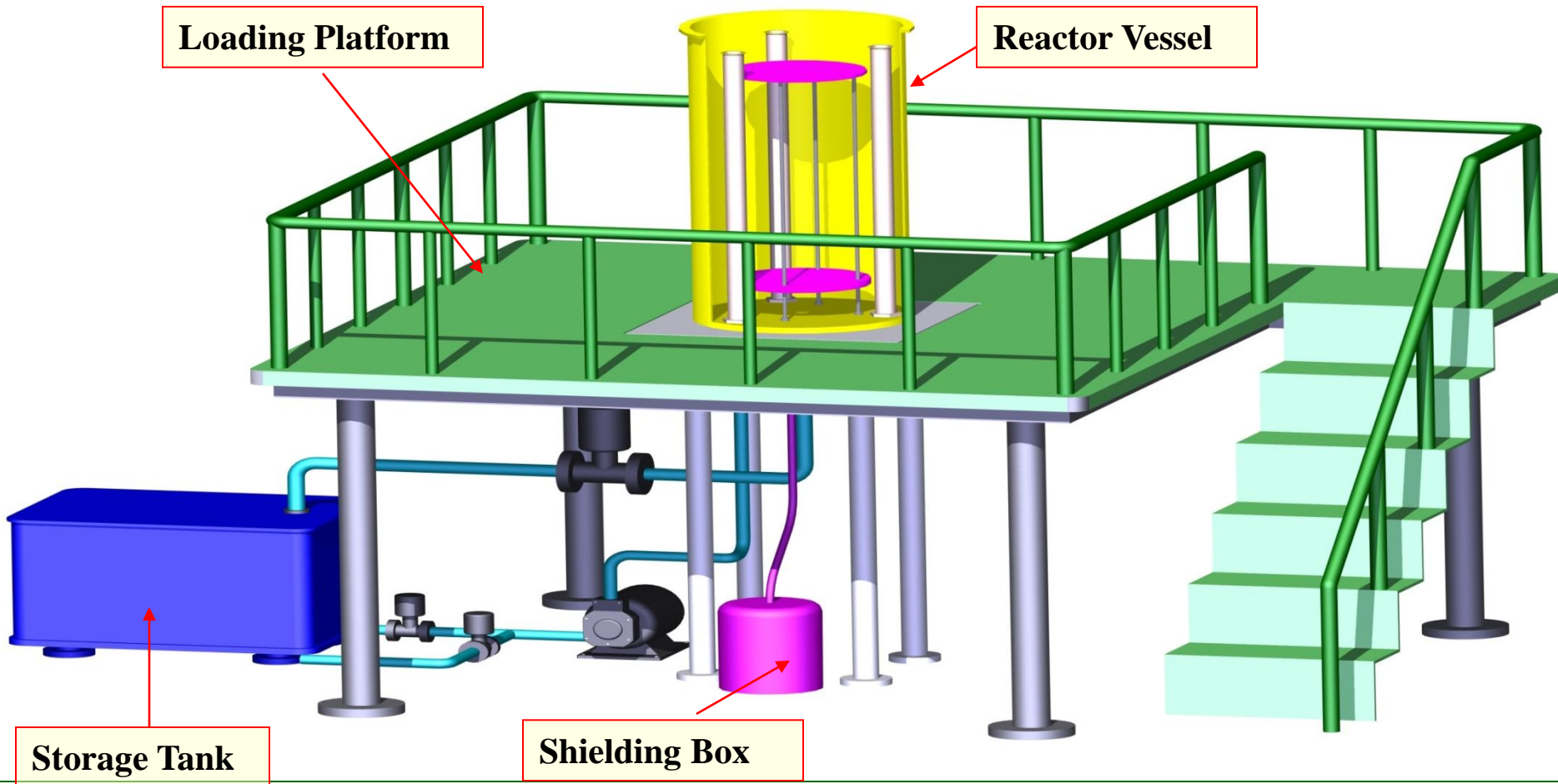
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JSA: Overall Layout



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JSA Construction



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JSA: Control Console



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JSA: Design Principles

- Uranium Fuelled (3.4% U-235)
- Uranium Oxide (UO_2) with Zr-4 cladding
- Light Water Moderated
- No Safety Protection System
- Simple and Reliable Structure
- Sub-critical State ($K_{\text{eff}} \cong 0.95$)



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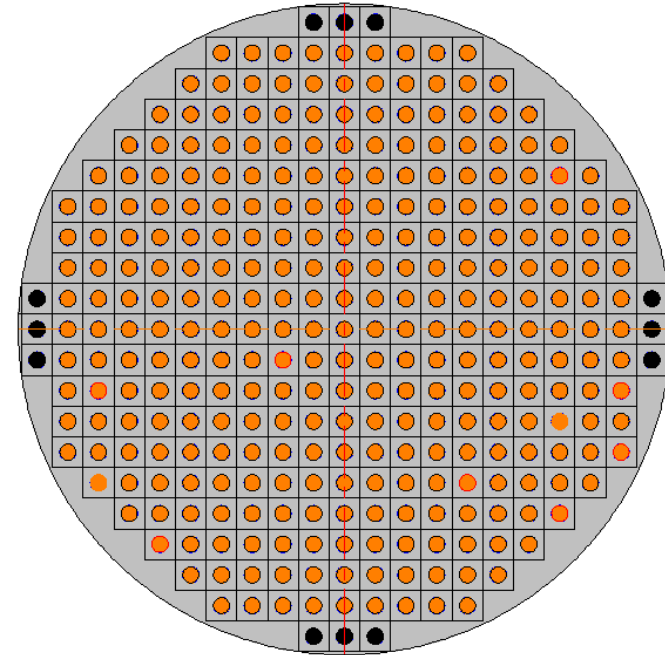
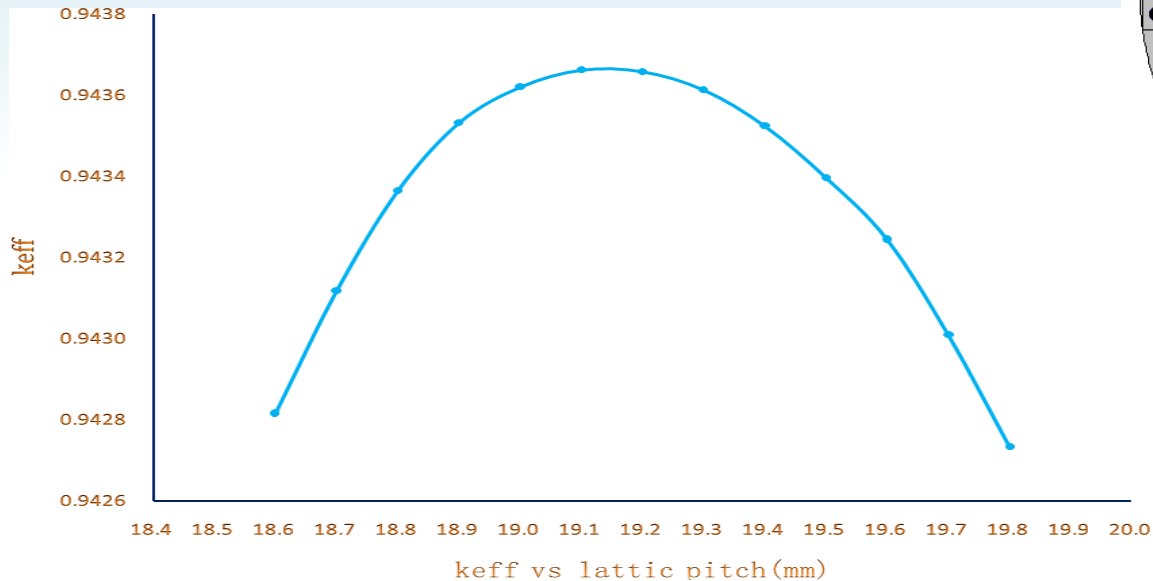
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JSA: Core Design

- Optimal lattice pitch
19.1 mm
- 313 fuel rods



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JSA Project Status

- Environmental Management Plan was submitted to JNRC and approved.
- Site approval was issued on 6 January 2011.
- Modifications of the JSA building to meet the vendor and JNRC requirements was completed.
- Safety Analysis of the JSA was prepared.
- A security system was installed.
- Construction/ Installation permit was granted on 25th August 2011.
- Installation of all JSA equipment has been completed.
- JSA is scheduled to be fully operational before end of 2011



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Centre of Excellence for Energy and Mega Projects

- Prepare qualified manpower for the nuclear and mega projects not covered by other programmes
- Meet the human resources needs of the Jordanian Megaprojects:
- Address as well the needs for training for the Region
- Focus on “virtual centers” harnessing on strengths of existing faculties and resources of all the academic and VT institutions in Jordan
- Proposed Programmes:
 - Master's Programme in Project Management
 - Master's Programme in Nuclear Safety and Regulation
 - Professional Degree for advanced training for technologists



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Thank You



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