International Conference on Human Resource Development
For
Introducing and Expanding Nuclear Power Programmes
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Knowledge Transfer via Remote Learning: The Jordan-North Carolina Example

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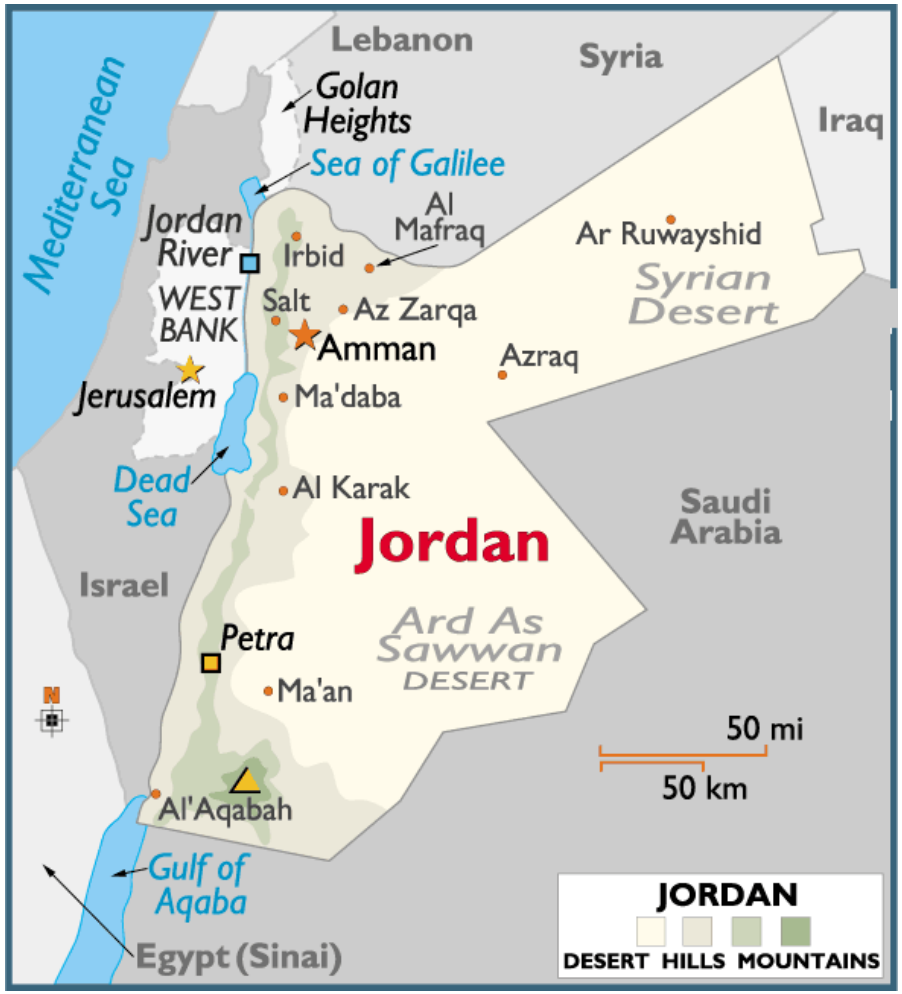
Jordan Overview



- Population ~ 5.7 million
- Area ~ 34,445 square miles
- Capital – Amman (~ 40% of population)
- GDP ~ $9.0 billion
  - Growth ~ 6.8% per year
- 25% of national budget is spent on energy imports

Nuclear Power in Jordan

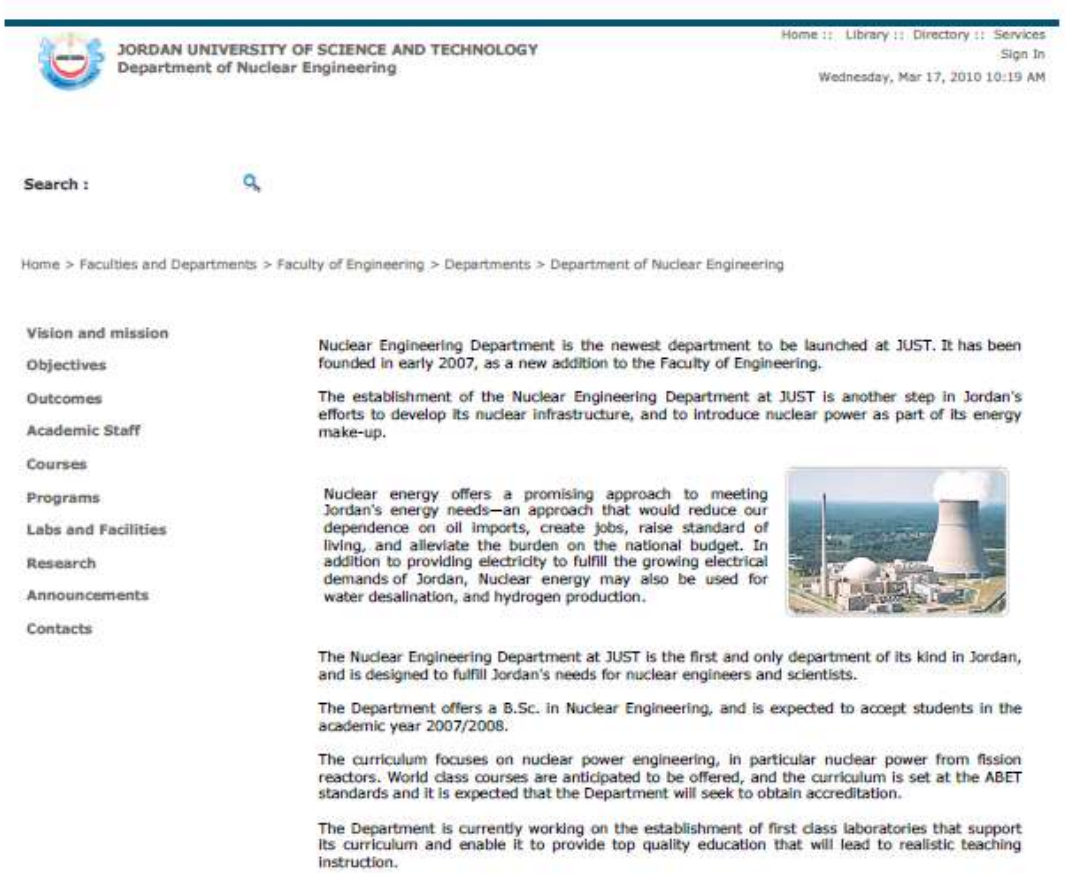
- Commitment to Nuclear Power was officially made in January 2007

- Basic forces drive the development of Nuclear power
  - Lack of indigenous resources
  - Desire to reduce dependence upon imported energy
  - Need to diversify the supplies (to enhance national security)
  - Need to protect the environment

Human Resource Development

- **Jordan University of Science and Technology (JUST)**- established a nuclear engineering dept. to graduate future reactor operators holding BSc degrees in nuclear engineering
- JU, YU, BAU have started MSc programs in nuclear physics & students are trained on the Van de Graaf & SESAME
- An active training TC programme with IAEA in nuclear safety, security, and safeguards
- Recent Jordan-France agreements on training in the Nuclear field

Nuclear Engineering at JUST



JORDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
Department of Nuclear Engineering

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Vision and mission
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Nuclear Engineering Department is the newest department to be launched at JUST. It has been founded in early 2007, as a new addition to the Faculty of Engineering.

The establishment of the Nuclear Engineering Department at JUST is another step in Jordan's efforts to develop its nuclear infrastructure, and to introduce nuclear power as part of its energy make-up.

Nuclear energy offers a promising approach to meeting Jordan's energy needs—an approach that would reduce our dependence on oil imports, create jobs, raise standard of living, and alleviate the burden on the national budget. In addition to providing electricity to fulfill the growing electrical demands of Jordan, Nuclear energy may also be used for water desalination, and hydrogen production.

The Nuclear Engineering Department at JUST is the first and only department of its kind in Jordan, and is designed to fulfill Jordan's needs for nuclear engineers and scientists.

The Department offers a B.Sc. in Nuclear Engineering, and is expected to accept students in the academic year 2007/2008.

The curriculum focuses on nuclear power engineering, in particular nuclear power from fission reactors. World class courses are anticipated to be offered, and the curriculum is set at the ABET standards and it is expected that the Department will seek to obtain accreditation.

The Department is currently working on the establishment of first class laboratories that support its curriculum and enable it to provide top quality education that will lead to realistic teaching instruction.

- Initiated in 2007
- Established MOU with US universities including NCSU
- 5 year programme
- 50 undergraduate students.
- First BSNE in 2011

Research/Training Reactor?

- A university nuclear reactor is “typically” a source of radiation.
  - It primarily produces neutrons and gamma-rays.
  - The produced radiation can be used for performing studies either in the core of the reactor or can be guided to be used in ex-core experiments.
- While the reactor does not usually produce electricity, it can be used to understand the fundamental concepts that are relevant to the safe operation and control of electricity producing reactors.

Mission of Research/Training Reactors

- Education
  - Provide a hands-on understanding of the physics and operations of nuclear reactors to the next generation of nuclear engineers
  - Serve as a multi-disciplinary education center for all members of the university community in the area of radiation physics applications
  - Provide training in support of nuclear power development
- Scientific research (another form of education)
  - Develop state-of-the-art facilities for understanding and applying the principles of radiation interaction with matter
    - Includes in-core and ex-core studies
- National service
  - Support the national infrastructure Use of nuclear methods in various aspects including medical and industrial

History of Reactors -1

- It can be claimed that the first reactor on a university campus is the CP-1 experiment at the University of Chicago in 1942.

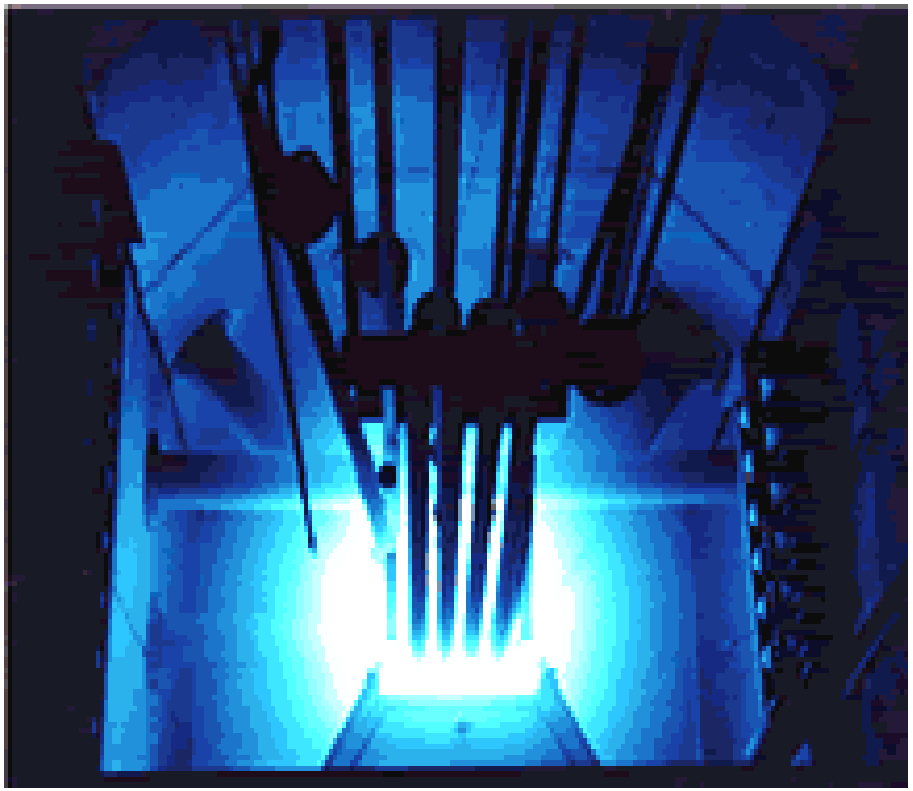
- The first university reactor constructed specifically to meet the institutional mission defined earlier is the R-1 reactor at NC State University

Achieved criticality

September 5, 1953

PULSTAR Reactor

- 1-MW power
- Open tank
- Light water moderated and cooled
- 5 x 5 array of fuel assemblies
- 5 x 5 array of pins
- Sintered UO_2 pellets
- 4% enriched



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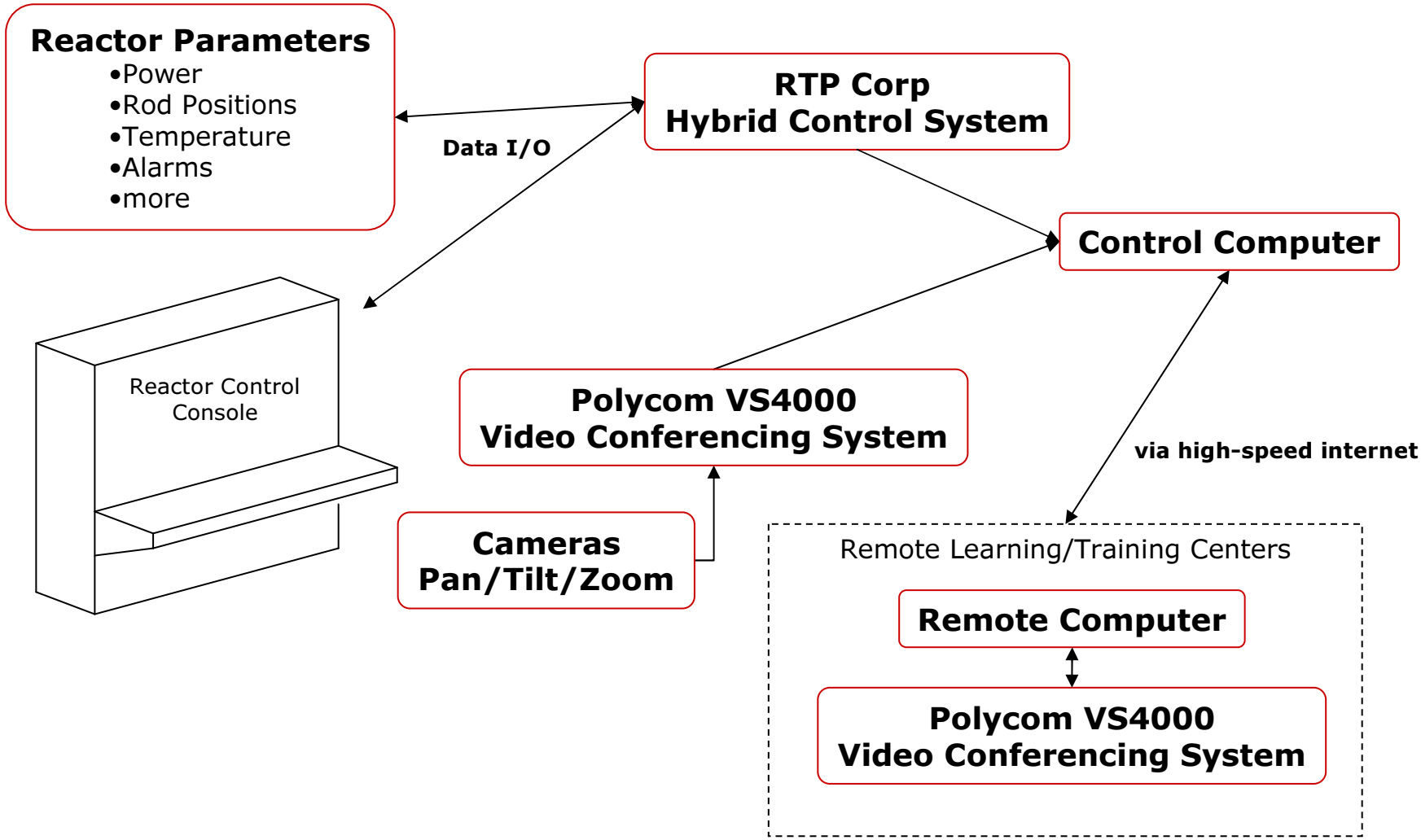
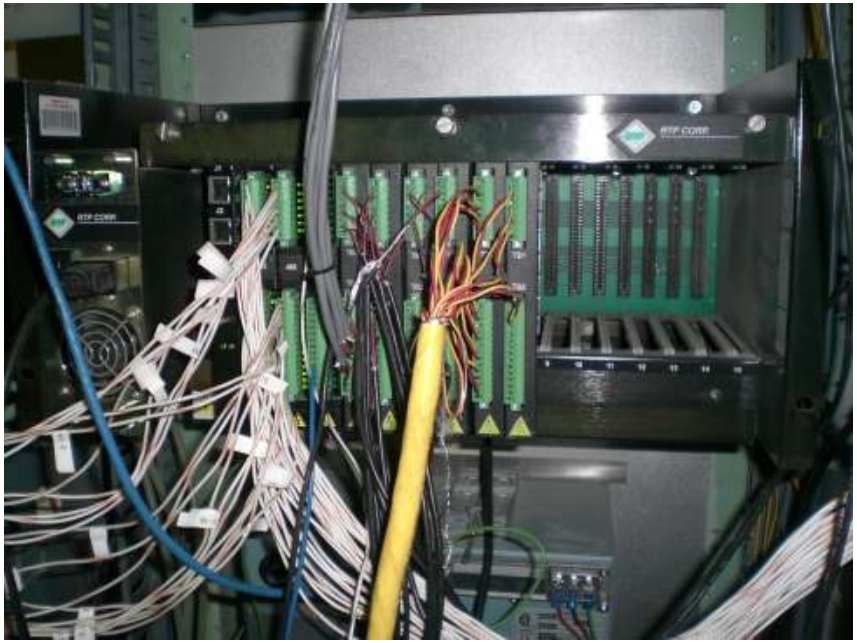
- Several undergraduate and graduate students help in operations and perform their studies at the PULSTR reactor

PULSTAR Internet A/V Data Link



RTP corp micro 2000 data acquisition system

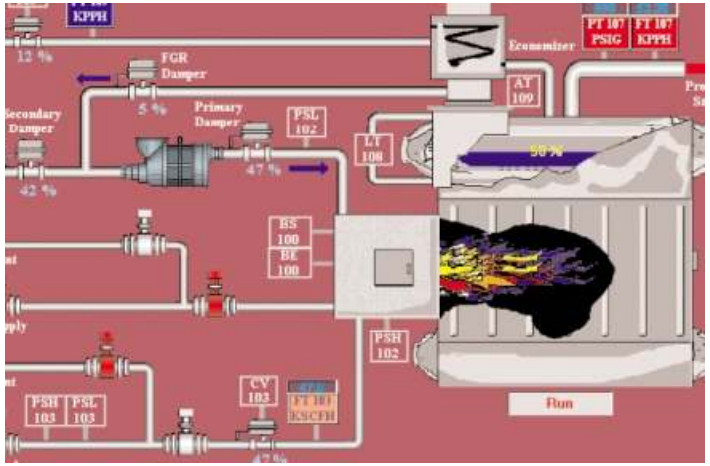


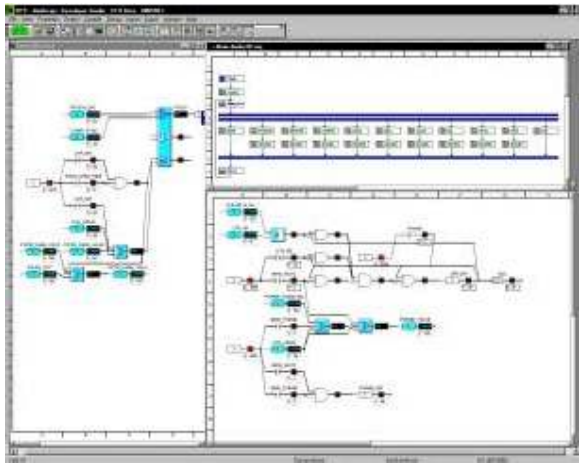
System installed
At
NCSU PULSTAR reactor

RTP Corp - Hybrid Control System

Software

- Fully Integrated
- Open Architecture
- Graphical Object-oriented
- Fast PID Algorithms
- Rapid Development and Deployment
- No license required, free updates





Polycom – Video Conferencing

Polycom VS4000

- High-Performance audio, video, and data
- Standard internet connectivity
- Encryption available
- Pan/Tilt/Zoom Remotely Controlled Cameras

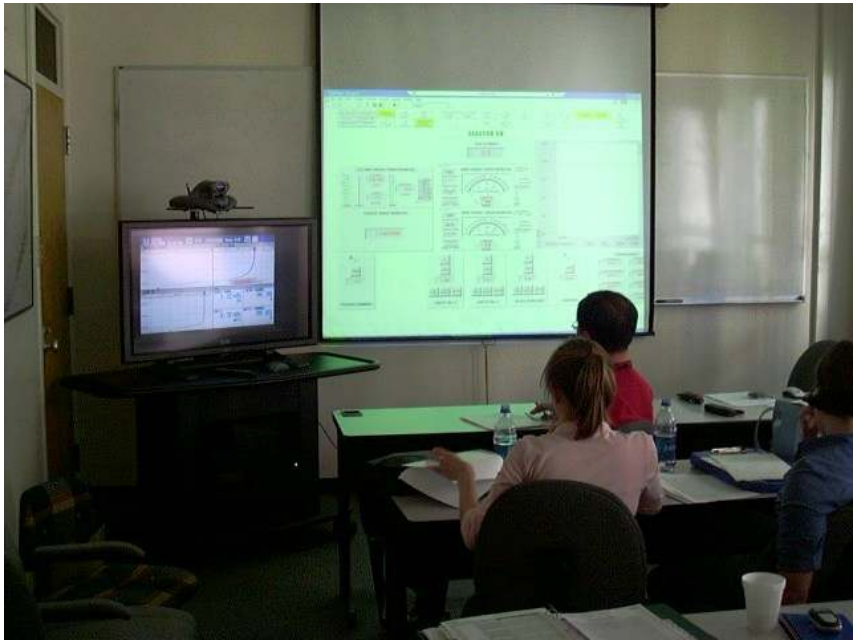
Typical Experiments

- Reactor startup exercise
  - Present ideas about procedures, tech specs, regulations etc.
- Control rod worth measurement
  - Demonstrate the concepts of reactivity, period etc.
  - Application of theoretical ideas such the inhour equation
- Power coefficient measurement
  - Demonstrate the concept of reactor feedback
  - Advanced rector theory – inverse kinetics
- Approach to critical
  - 1/M approach
  - Demonstrate the concepts of criticality

Implementation within USA

- Safety and Security concerns
- Both aspects are evaluated within the framework of the facility's technical specifications, operational procedures and safeguards plans
  - As approved by the US NRC
- Internal evaluations were performed and found that the proposed modality does not affect any of the above aspects
- The outcome of the internal findings is documents and periodically inspected by the US NRC

The PULSTAR control room as Viewed By students at University of Tennessee



Students Collecting and analyzing PULSTAR data during a lab session at Georgia Institute of Technology

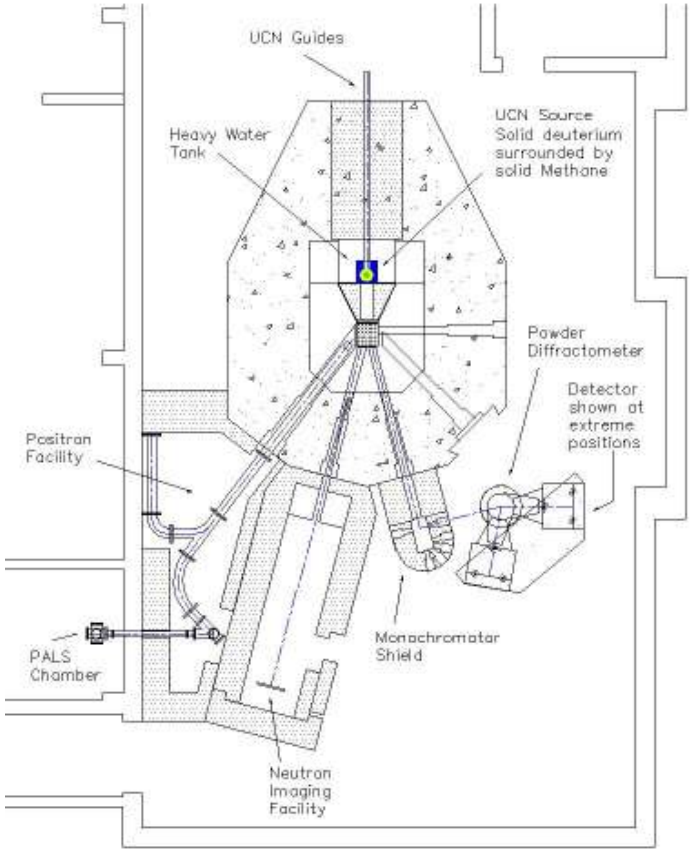
Implementation Across International Borders
USA-JORDAN

- Safety and Security concerns - NRC
  - Treated as before
- However, Export Control issues, are introduced
  - NNSA concerns and criteria must be satisfied
  - Part 810 evaluation

    "*Part 810-refers to the process set forth in 10 Code of Federal Regulations Part 810. Under the authority of section 57.b of the Atomic Energy Act of 1954, as amended, and in accordance with established procedures, only the Secretary of Energy may authorize, through the Part 810 process, persons to engage, directly or indirectly, in the production of special nuclear material outside the United States. This provision applies to technology transfers and technical assistance to all activities of the nuclear fuel-cycle, including non-power reactors.*"
- Outcome of both of the above examination steps was favorable and the project with JUST is moving forward
  - Under the supervision of the IAEA and financial support of the US DOS

PULSTAR Projects

- Ultra-Cold Neutron Source
- Intense Slow Positron Beam
- Neutron Powder Diffractometer
- Thermal Neutron Imaging



Summary

- Current communications technology allows for establishing new modalities of education in the nuclear field
  - Using university based nuclear reactors
- These technologies can be successfully implemented within a given nation or internationally
- In both cases the use of the research reactors within such a model requires meeting safety and security concerns
- The international implementation requires meeting potential existing export control concerns