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A Comparative Analysis of the Use of Internet Reactor Laboratory and Subcritical Assembly for Nuclear Engineering Education

Salaheddin Malkawi

Department of Nuclear Engineering
Jordan University of Science and Technology (JUST), Jordan
E-mail: salahm@just.edu.jo

Outline

- Introduction
- Nuclear Engineering Education at JUST
- Internet Reactor Laboratory (IRL)
- Jordan Subcritical Assembly (JSA)
- Summary

Research Reactors' Utilization

- Neutron Activation Analysis
- Radioisotope Production
- Transmutation Effects
- Fuel and Material Testing
- Neutron Imaging
- Neutron Capture Therapy
- Geochronology
- **Education and Training**

Education and Training in RRs

- **Mission**:
  - **Community Service:** Provide support and quality usage of the RR facility through the implementation of public tours and visits for public, students, instructors and interested groups.
  - **Basic and Applied Science**: Provide hands on training in support of educational programs in the areas of nuclear science, radiation protection, nuclear instrumentation, and reactor physics.
  - **Reactor Design and Operation**: Provides training in support of the design and operation of nuclear power plants
  - **Radiation Protection**: Versatile tools for education and training in operational radiation protection

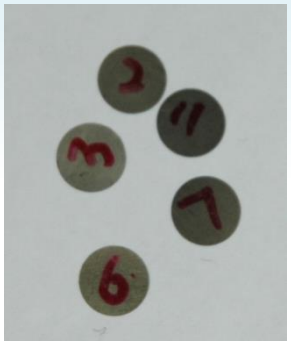
- *Every research reactor, regardless of its power, can be utilized for education and training.*

Utilization of RRs in Nuclear Eng. Education

- **Reactor Physics Laboratory Education**
  - **Static reactor parameters**
  - **Kinetic reactor parameters**
  - **Facility characterization**
- Experiments on Neutron Activation Analysis
- Experiments on Isotope production
- Experiments on extracted neutron beam applications
- Operator training for nuclear Engineering students
- Training of future reactor operators

Measurement Systems

- **Static Experiments:**
  - Online measurement system: miniaturized neutron detector
  - Offline measurement system: activation foils

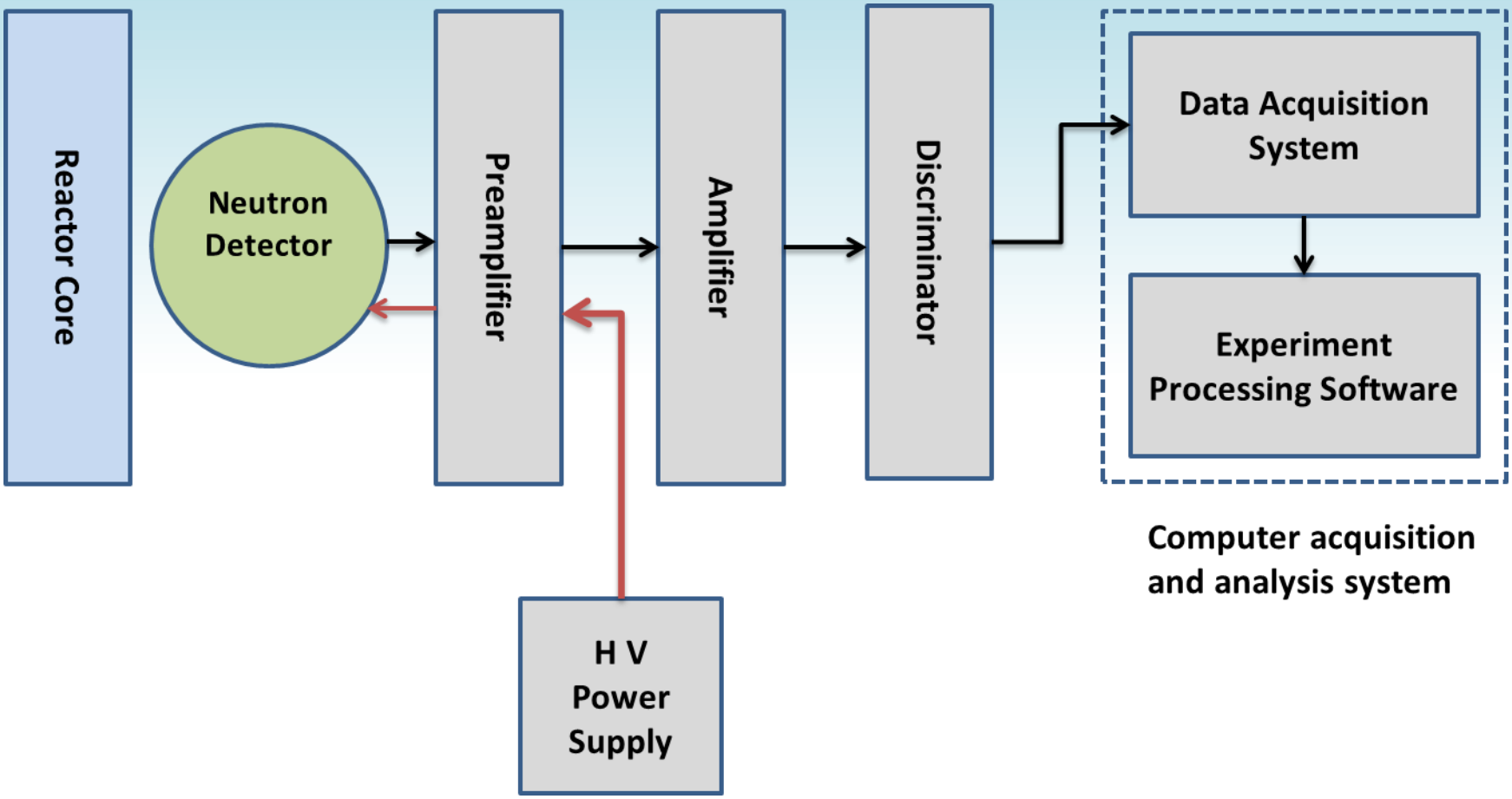


- **Dynamic experiments**:
  - Based on the solution of the point reactor kinetics equations under different conditions

$$\frac{dn(t)}{dt} = \frac{\rho(t)-\beta}{\Lambda} n(t) + \sum_{i=1}^{6} \lambda_i C_i(t) + S \ldots\ldots\ldots\ldots (1)$$

$$\frac{dC_i(t)}{dt} = \frac{\beta_i}{\Lambda} n(t) - \lambda_i C_i(t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Dynamic Reactor Parameters' Measurements



Nuclear Engineering Education at JUST

- B. Sc. Program started at JUST in 2007
- Graduates: 115
- Students: 100
- Faculty Members: 8
- Facilities:
  - High Performance Computing lab.
  - Radiation Detection and Measurement Labs.
  - **Internet Reactor Lab. (IRL)**
  - **Jordan Subcritical Assembly (JSA)**
  - Jordan Research and Training Reactor (JRTR). *Expected to be operational in mid 2016.*

Internet Reactor Lab (IRL)

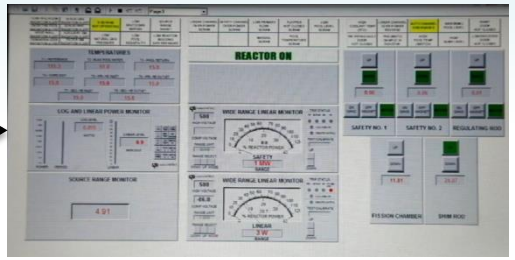
(Host Reactor)
PULSTAR Reactor
NCSU/ U.S

Reactor Parameters

Audio/ Video data

(Guest Institution)
NE Department
JUST/Jordan

Data Link



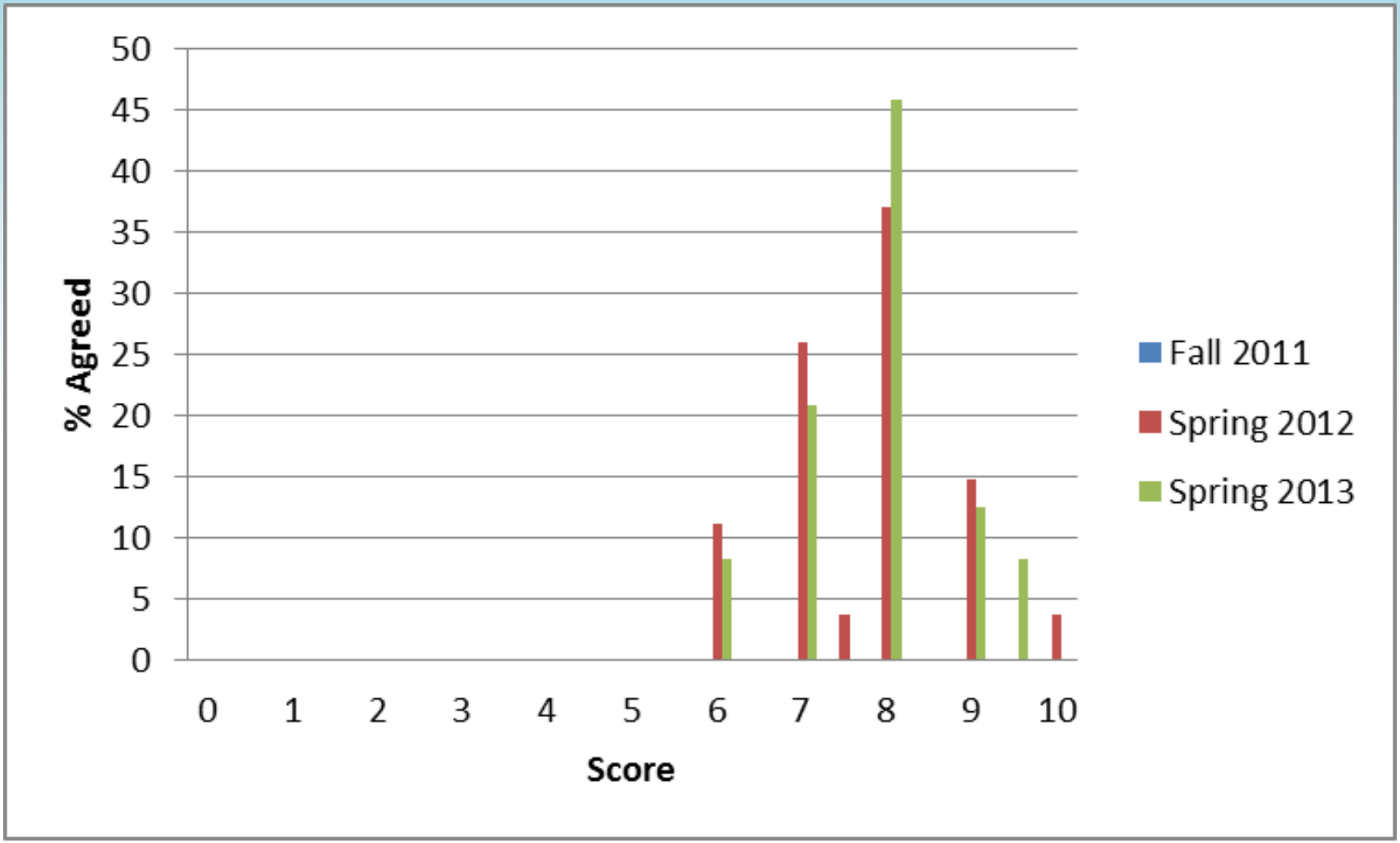
Audio/video data

https://www.iaea.org/OurWork/ST/NE/NEFW/Videos/repository/2014-03-03-RRS-Bradley-2.html

IRL: Utilization at JUST

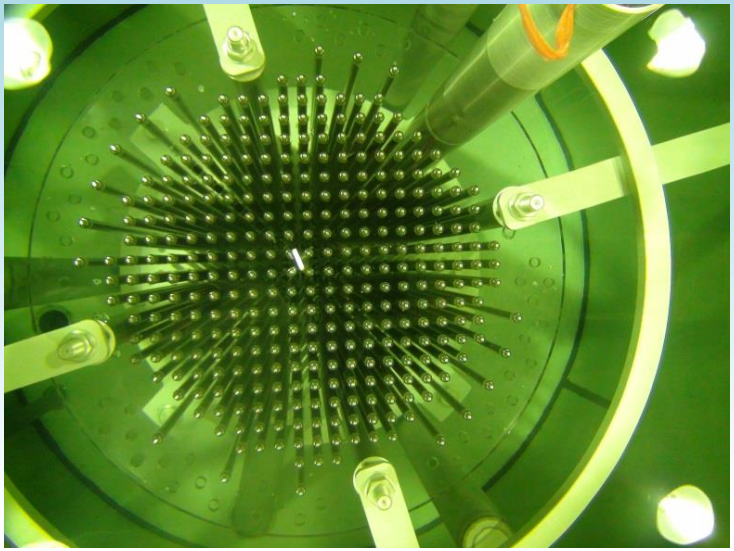
- NE 448 Nuclear Reactor Laboratory course (2010 – 2013)
- Typical Experiments
  - Reactor startup exercise
  - Approach to criticality: 1/M approach
  - Control rod worth measurement
  - Flux mapping
  - Power coefficient measurement
- Course Assessment
  - Pre-Lab assignment
  - In-class experiment
  - Post-Lab report and discussion of results
  - Mid term and final exams
  - Students' Evaluation

IRL: Students' Overall Evaluation



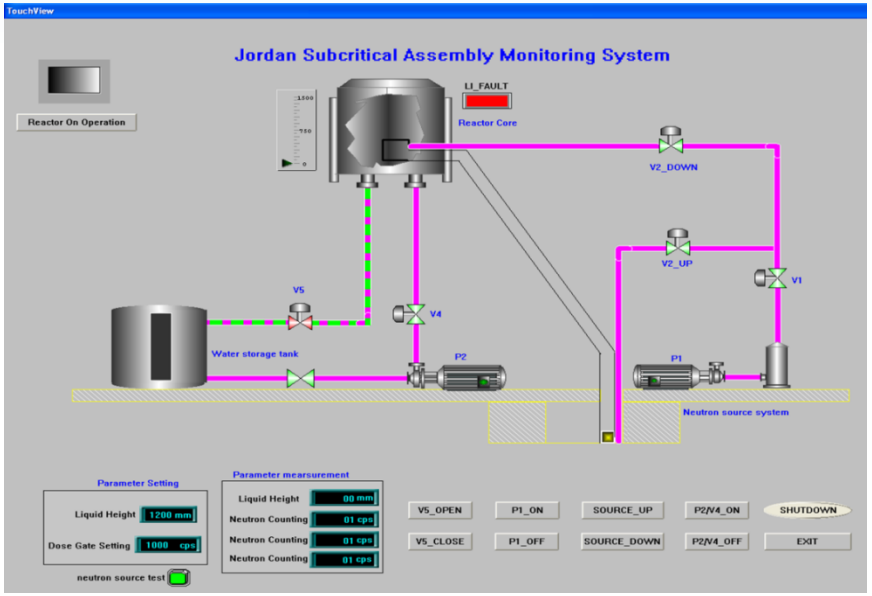
Jordan Subcritical Assembly (JSA)

- Jordan's first Nuclear facility.
- Designed and constructed for the purpose of education, training, and experimental research.
- Inherently safe
- Design Specifications:
  - Uranium Fuelled (3.4% U-235)
  - Uranium Oxide (UO_2) with Zr-4 cladding
  - Light Water Moderated
  - Sub-critical State ($k_{eff} \cong 0.95$)
- Commissioned in June 2013

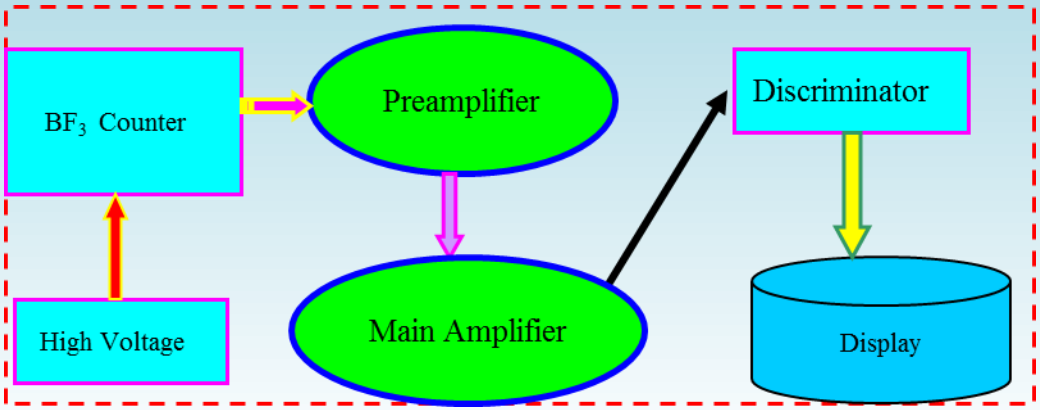


JSA: Control and Monitoring System

Employs modern digital Instrumentation and Control

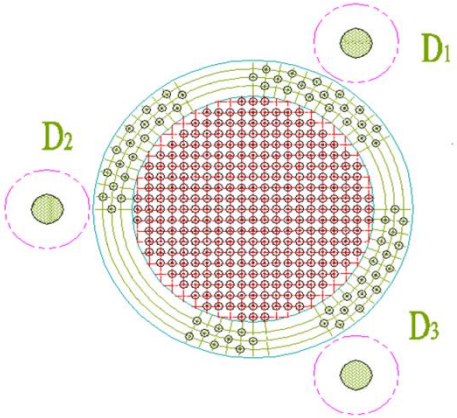


JSA: Measurement System



Measurement System

Control Console

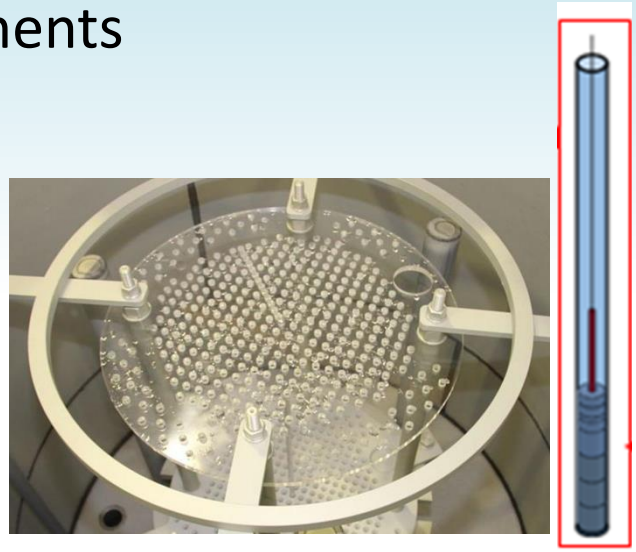


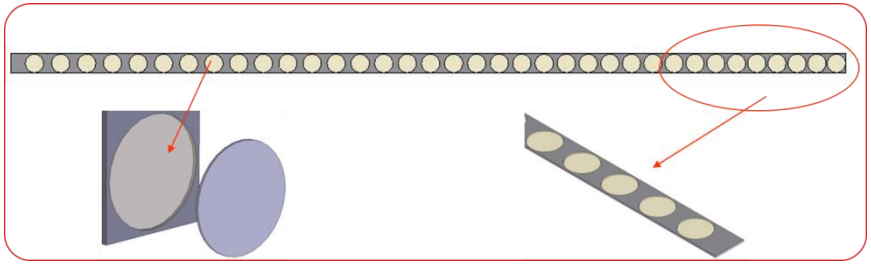
Three BF_3 Detectors

Three startup counters

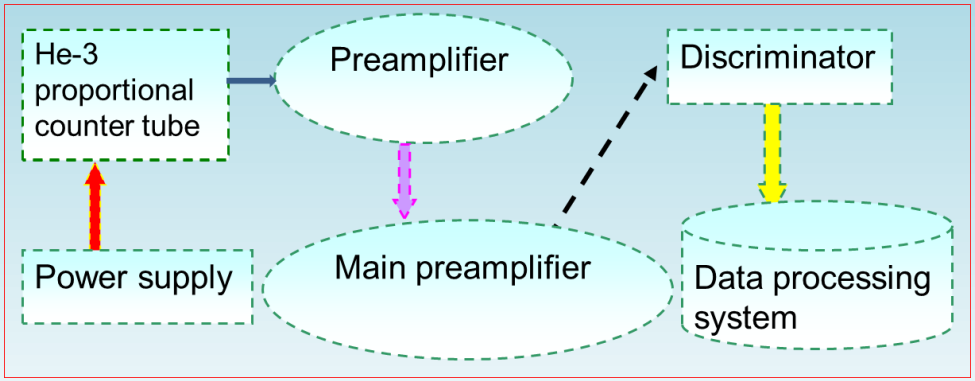
JSA: Utilization for Education

- NE 448 Nuclear Reactor Laboratory course (2014 – present)
- Typical Experiments
  - Start up and approach to critical experiments
  - Static experiments
    - Axial neutron flux distribution measurement
    - Radial neutron flux distribution measurement
    - Absolute neutron flux distribution measurement
  - Dynamic experiments
    - Source-jerk method
    - Rossi- α method
    - Feynman- α method

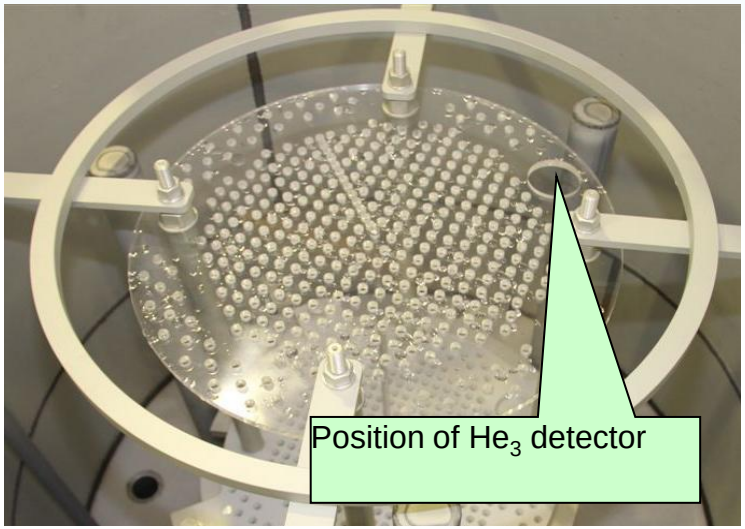


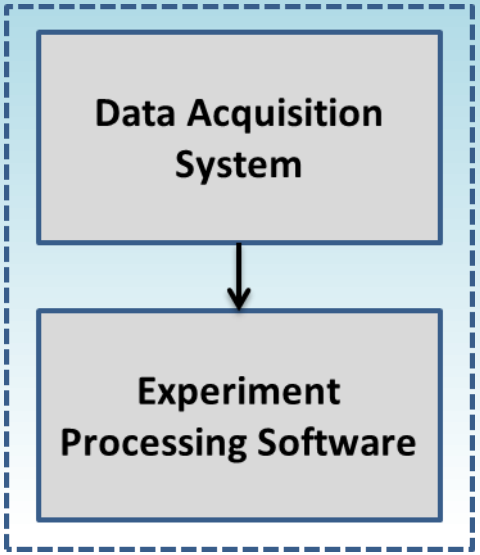


JSA: Setup for Dynamic Experiments

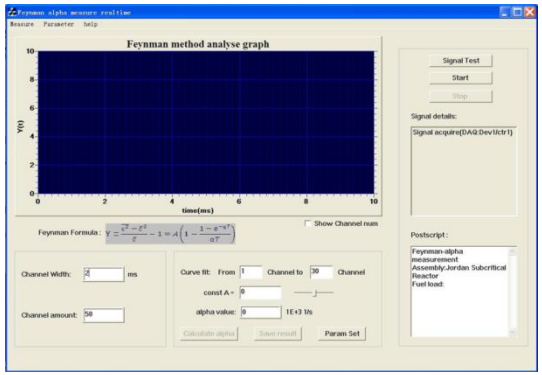


Online Measurement system





Computer acquisition and analysis system



JSA: Course Assessment

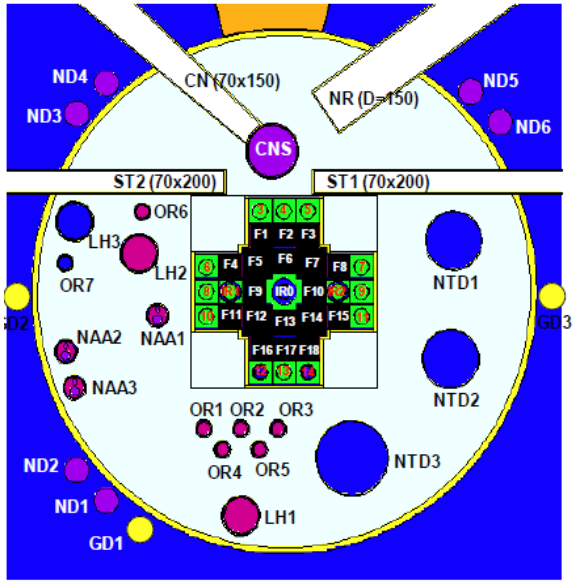
- NE 448 Nuclear Reactor Laboratory course (2014 – present)

- Course Assessment
  - Pre-Lab assignment
  - In-class experiment
  - Post-Lab report and discussion of results
  - Mid term and final exams
  - Students' Evaluation

- Course objectives and learning outcomes are attainable.

Jordan Research and Training Reactor (JRTR)

- **Overview**:
  - 5-MW upgradeable to 10-MW
  - Open pool
  - MTR, plate type fuel (<20% U^{235})
  - H_2O cooled
  - D_2O + Be reflected
- **Applications**
  - Neutron Beam Applications
  - Radioisotope Production
  - Neutron Transmutation Doping
  - Neutron Activation Analysis
  - **Plays the primary role in educating and training the upcoming generations of nuclear engineers and scientists**
  - Irradiation in support of industrial, agricultural and health/medical infrastructure
- **Expected to be operational by mid 2016**



Summary

- Every research reactor facility, regardless of its power, can be utilized for education and training.
- The IRL approach benefits from an already existing RR facility in another location by utilizing it as a remote reactor laboratory.
- An on campus reactor facility provides education, training, experimental research and hands on experience for students and trainees.
- Nuclear Reactor Laboratory course objectives and learning outcomes are attainable by both approaches.
- ***For Nuclear Engineering Education, the need is to have an access to a research reactor facility***.

Thank you…

…for your attention