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## Practical Application of Monte Carlo Code in RTP

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## Outline

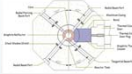
- Overview Of PUSPATI TRIGA Reactor (RTP)
- Research Group
- Neutronics Codes Used
- Familiarized with MCNP
- Results
  - Exercise on k-eff Calculation
  - Exercise on Flux and Power
  - Exercise on Mesh Tally
  - Other Calculation / Application
- Issues & Challenges
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## 3 Overview Of PUSPATI TRIGA Reactor (RTP)

First criticality on 28 June 1982

Functions:

- Irradiations of samples for NAA, beam experiments
- Education and training facilities



**Type:**  
1 MW TRIGA Mark II

**Fuel:**  
19.9% enriched U-ZrH  
\*20 wt% U  
\*12 wt% U  
\*8.5 wt% U

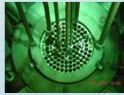
**No. Fuel:**  
111 (Core #15)


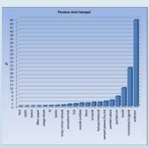
**Coolant:**  
Light Water

**Moderator:**  
Light Water

**Reflector:**  
Graphite

**Control Rod:**  
Boron Carbide  
3 FFCR & 1 AFGR



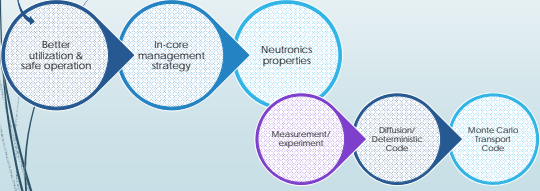



3884 Samples irradiated in 2008, Hairie et al.

## 4 Research Group

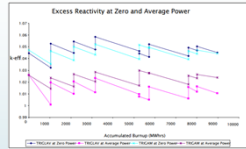
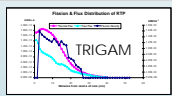
Reactor Technology Center:

- Operation and Maintenance
- Technology Assessment, Engineering and Safety
- **Reactor and Nuclear Physics (RxP)**
- Reactor Electronic, Instrumentation and Control
- Quality Assurance and Integrated Management System


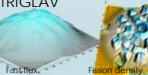



## 5 Neutronics Codes Used

- Codes are used for core management calculation, namely, WIMSD/4, TRIGAM and TRIGLAV.
- TRIGAM and TRIGLAV were developed by Josef Stefan Institute, Ljubljana, Slovenia.
- TRIGAM is a 1-D geometry and two-group approximation
- TRIGLAV based on 2-D and four-group approximation.
- Since 1995 RTP apply TRIGLAV for its core management calculations.
- Lattice cells approximation were still calculated using WIMSD/4.

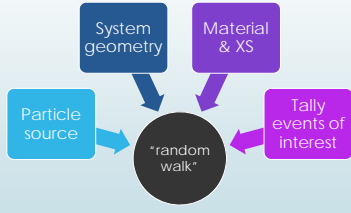
TRIGLAV

Julia et al.

## 6 Familiarized with MCNP

MCNP, is a general purpose Monte Carlo radiation transport code designed to track many particle types over broad ranges of energies



### 7 Familiarized with MCNP

Diagrams illustrating MCNP models for fuel and core geometry. The top left shows a cross-section of a fuel element with various materials and dimensions. The top right shows a quarter-section of a fuel assembly core. The bottom left shows a detailed view of a fuel element. The bottom right shows a grid of fuel elements in a core.

### 8 Exercise on k-eff Calculation

Approach to criticality

	MCNP ( $\pm 0.0001$ )	TRIGLAV	Operational data
Critical core	1.00132	1.00105	1.001
Core-01	1.05677	1.05562	1.053

Water displacement effect on core reactivity

Graph showing the effect of water displacement on core reactivity. The y-axis is  $k_{eff}$  and the x-axis is Distance of cold from center (cm). The graph shows a dip in reactivity as the distance of cold from the center increases.

Criticality safety of spent fuel rack

Diagrams illustrating different configurations of spent fuel racks, showing how they are arranged in a rack to ensure criticality safety.

### 9 Exercise on Flux and Power

Thermal Neutron Flux Core-14

neutron/ cm <sup>2</sup> .s	Central Thimble $\times 10^{12}$	G20 Irradiation hole $\times 10^{12}$	Rotary rack $\times 10^{12}$
MCNP model	1.897 $\pm$ 0.019	5.025 $\pm$ 0.029	2.918 $\pm$ 0.012
Measured	1.777 $\pm$ 0.031	4.813 $\pm$ 2.447	2.33 $\pm$ 0.08

Two graphs showing Power/FEs for Core-01 and Core-14. The x-axis is Fuel Location and the y-axis is Real Power/Fuel Element. Both graphs compare TRIGLAV (blue line) and MCNP (red line) results.

### 10 Exercise on Mesh tally

Mesh tally for Core-15

3D visualizations of mesh tallies for Core-15, showing Thermal flux, Fast flux, and Fission density. A 2D cross-section of the core is also shown.

Neutron spectrum

Graph showing the neutron spectrum, plotting flux vs energy. The spectrum shows a peak in the fast neutron region and a tail extending into the thermal region.

### 11 Other Calculation / Application

MCNPX burnup features

Graphs showing MCNPX burnup features: Fuel burnup rate, Fuel inventory and burnup indication, and Electron-photon dose rate.

Other facilities

Diagram illustrating the skyline effect, showing how the geometry of a facility affects the neutron flux distribution.

### 12 Issues & Challenges

1. Neutronics analysis (calculation & measurement) performed at basic level, lacking in expertise and experience
2. Combine WIMSD + MCNPX code for RTP in-core fuel management
3. Quality assurance program;
  - Y&V of codes and computational approach
  - Management of codes, computational process and documentation

