ASEAN NPSR Singapore Presentation

ASEAN NPSR 4th Annual Meeting

By Tang Jia Hao

NUS National University of Singapore | Singapore Nuclear Research and Safety Initiative

Singapore

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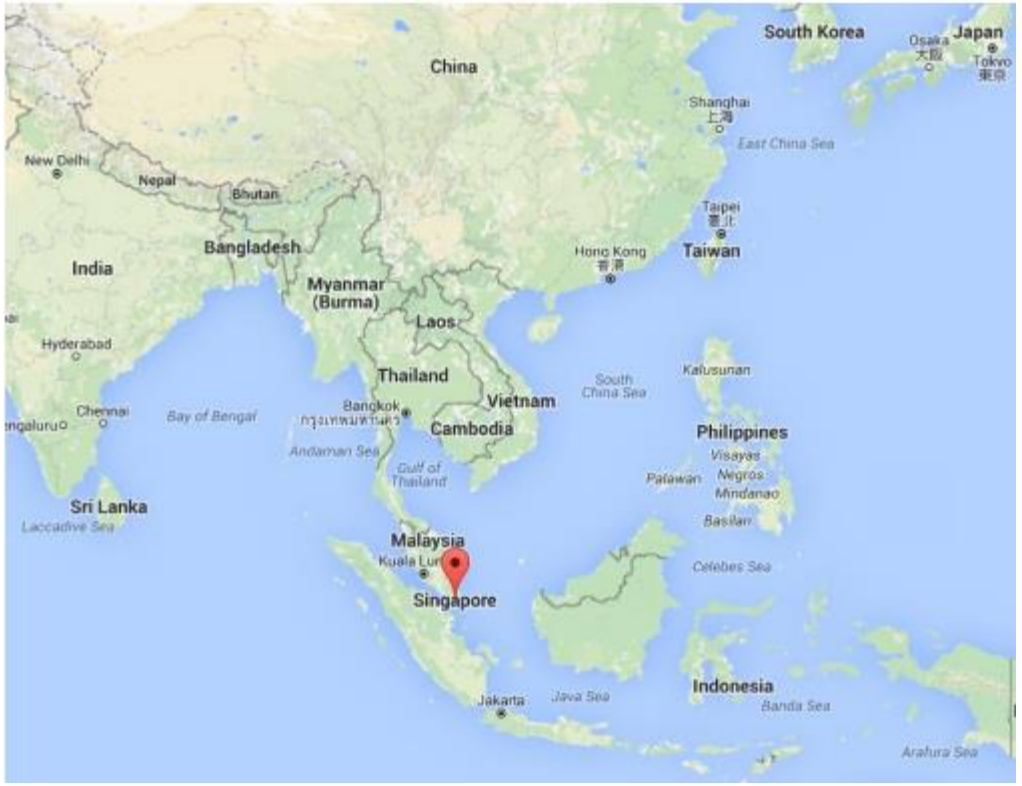
- Population: 5.704 million
- Population density: 7,804 per km2
- Land area: 728.3 km2
- Located on the southern tip of the Malay Peninsula in Southeast Asia, between the Indian Ocean and the South China Sea
- No natural resources
- High demand for energy



NSREP & SNRSI

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- In October 2013, the National Research Foundation (NRF) approved a five-year budget of S$62.9M to develop a **Nuclear Safety Research and Education Programme** (NSREP).

- **Singapore Nuclear Research and Safety Initiative** (SNRSI) was set up in 2014
  - Technical arm of the NSREP to execute its R&D and educational programmes.
  - Hosted by the National University of Singapore as a university-level research institute.
  - SNRSI serves to concentrate nuclear expertise and knowledge in a single institute and sustain a critical mass of manpower.

Manpower Development

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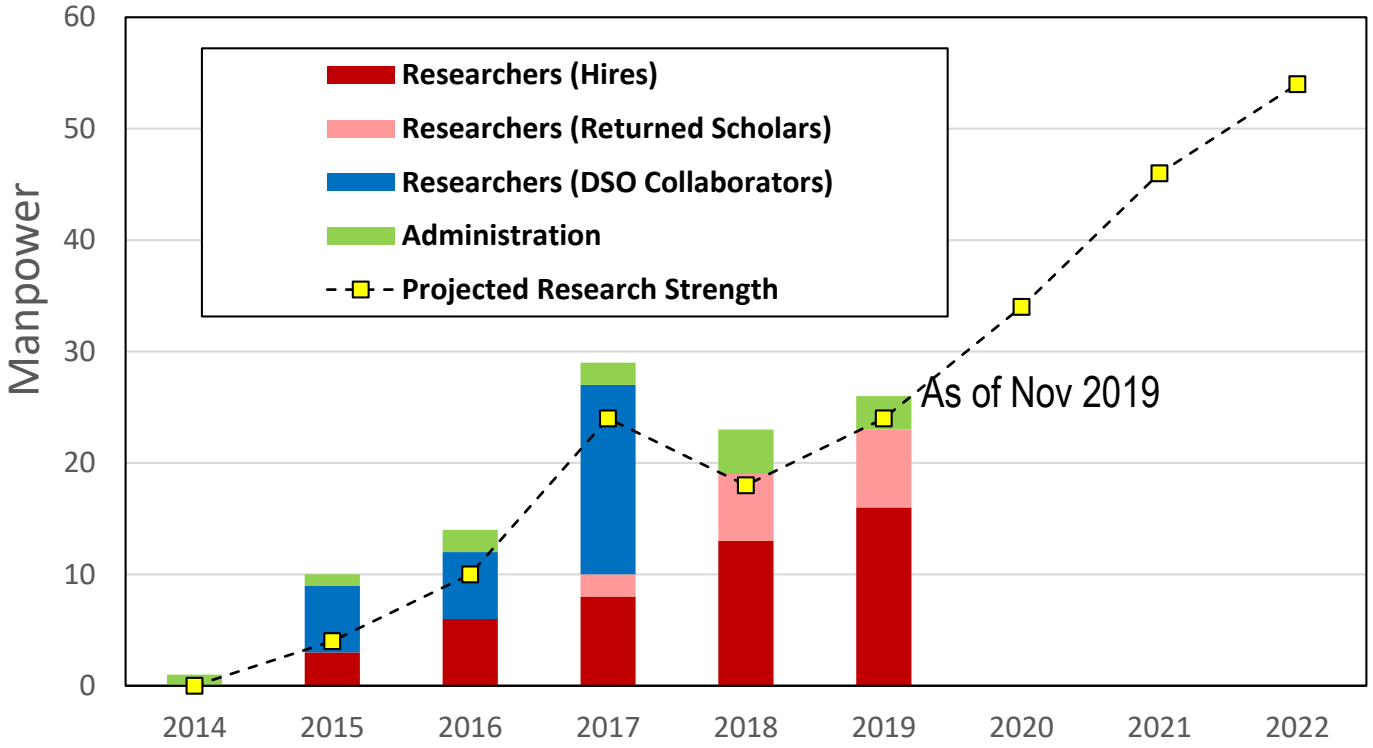
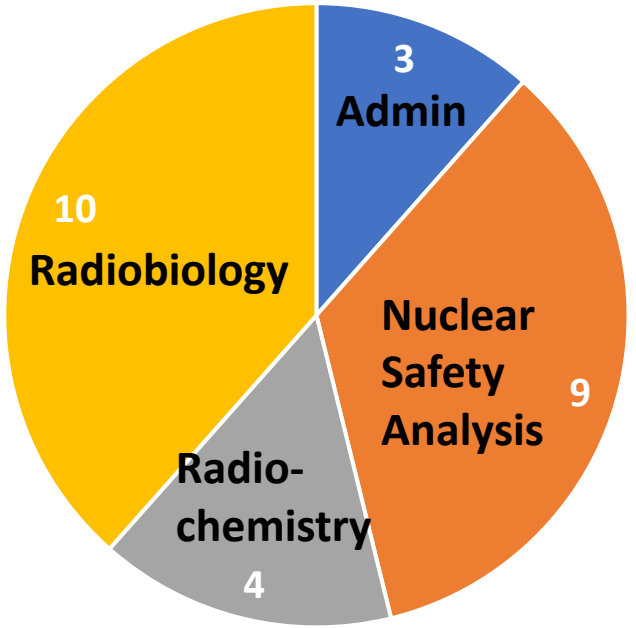
- **Target**: About **30** researchers in **each** of the three research focus areas (Nuclear Safety Analysis, Radiochemistry and Radiobiology) supported by a small team of technical and admin support by 2025 - 30. Growth by direct hires and SNRSI Scholarships.

Projection of Growth of SNRSI



Note: The secondment of the DSO researchers to SNRSI meant to kick start the R&D projects had concluded in Oct 2018.



Current composition of SNRSI

SNRSI Building – Recap

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- **Location** Kent Ridge Campus – Along Prince George's Park
- **Site Area** 5,100 m^2
- **Building Height** 5 storeys + 1 basement
- **Estimated GFA** 13,000 m^2
- **Budget** $69.7M

Key Project Features

- 'Lab in a Forest', 'Forest in a Lab'
- Public access with Teaching Facilities at Ground Level.
- Nuclear Research Wet and Dry Laboratories with Supporting Research Facilities and Office spaces.
- Typical Floor Plate ≈ 2,100 m^2
- Future Expansion Space ≈ 1,000 m^2 (Core and Shell only)

International Engagement

- Engage the international nuclear scientific community through research partnerships and will explore additional research collaboration with suitable countries were appropriate.

- Cooperate and participate in regional and international nuclear fora, e.g.,
  - Asia-Europe Meeting (ASEM) Seminar on Nuclear Safety
  - ASEAN Network for Nuclear Power Safety Research
  - International Atomic Energy Agency (IAEA)

- Collaboration with overseas partners
  - Institute for Radiological Protection and Nuclear Safety
  - US Nuclear Regulatory Commission
  - Ukraine National Research Center for Radiation Medicine

Research Focus of SNRSI

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RADIOBIOLOGY

- Effects of radiation on biological systems ranging from DNA damage, to macroscopic changes in organisms. Focuses on chronic low dose and **novel techniques**.

RADIOCHEMISTRY

- **Developing techniques** for detection of hazardous nuclides that are not trivial to analyze.
- **Remediation methods** focused on urban environments

ATMOSPHERIC DISPERSION

- **Long range dispersion modelling** will be used to model plausible accident scenarios in the region.
- Models to study dispersion and disposition of radionuclides in Singapore's **urban settings**

SAFETY ANALYSIS

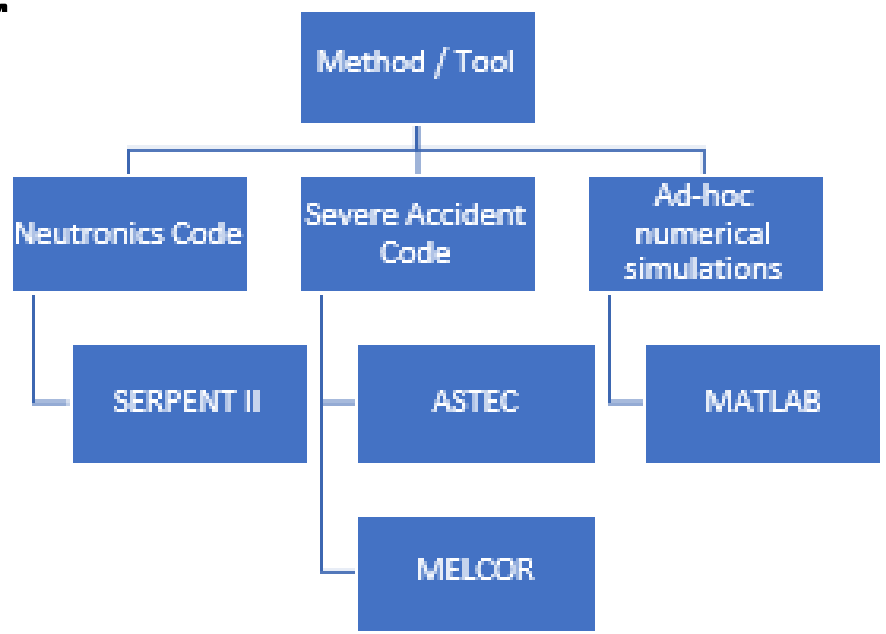
- Using modelling & simulation platforms to understand the operation and safety considerations of **current** as well as **advanced and safer reactor** designs.

SAFETY ANALYSIS

Using modelling & simulation platforms to understand the operation and safety considerations of **current** as well as **advanced and safer reactor** designs

Includes:

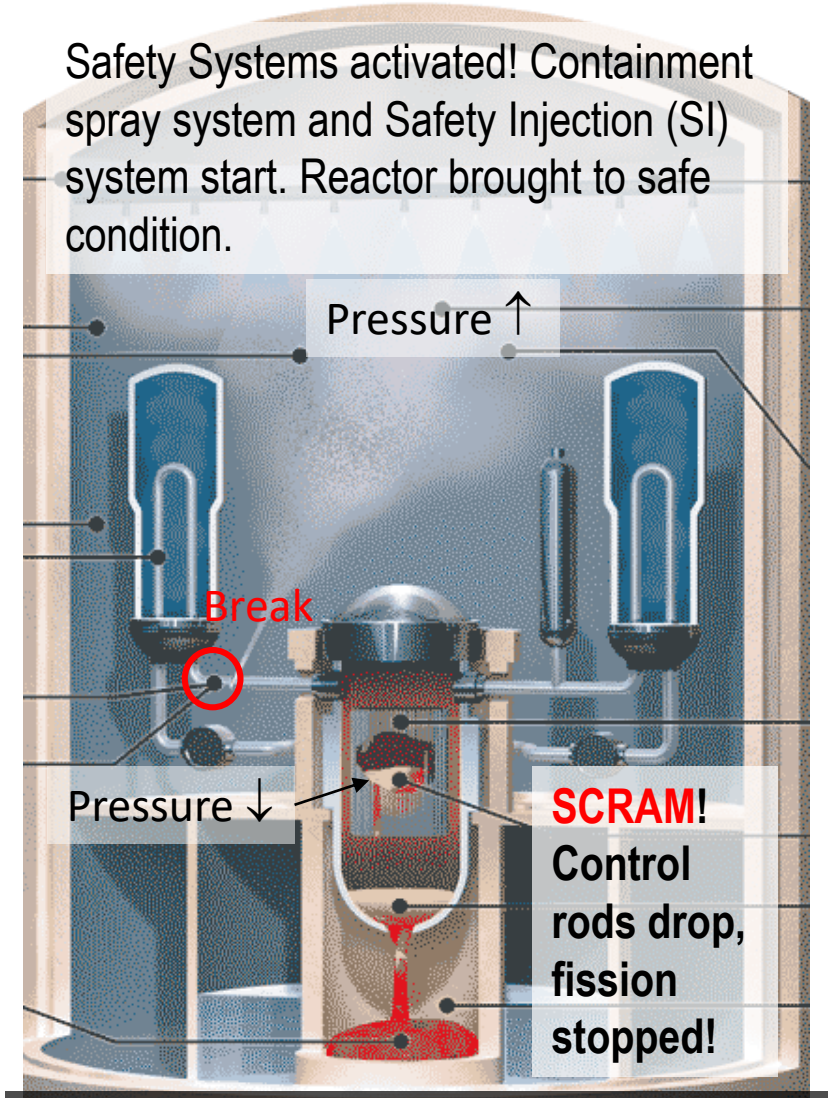
- Pressurized Water Reactors E.g. PWR-900
- Small Modular Reactors E.g. KLT-40s, ACP100, Nuscale & ACPR50S
- High Temperature Gas cooled Reactors E.g. HTR-PM
- Fusion



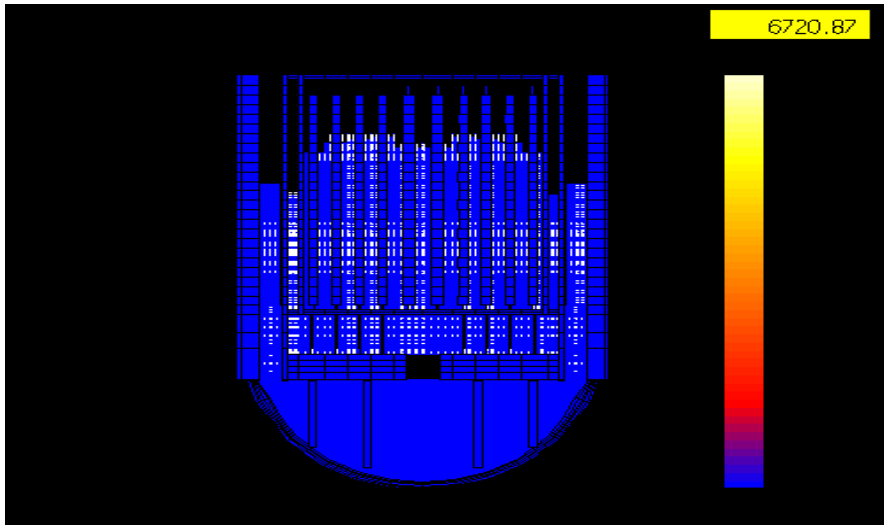
Method/Tool

- SERPENT II
- ASTEC
- MELCOR

Safety Analysis: Severe Accident Simulations



- ASTEC – Simulator on severe accidents in NPP from IRSN, France, has been used to study the phenomena and estimate amount of radioactive release for various possible accident scenarios.



SAFETY ANALYSIS

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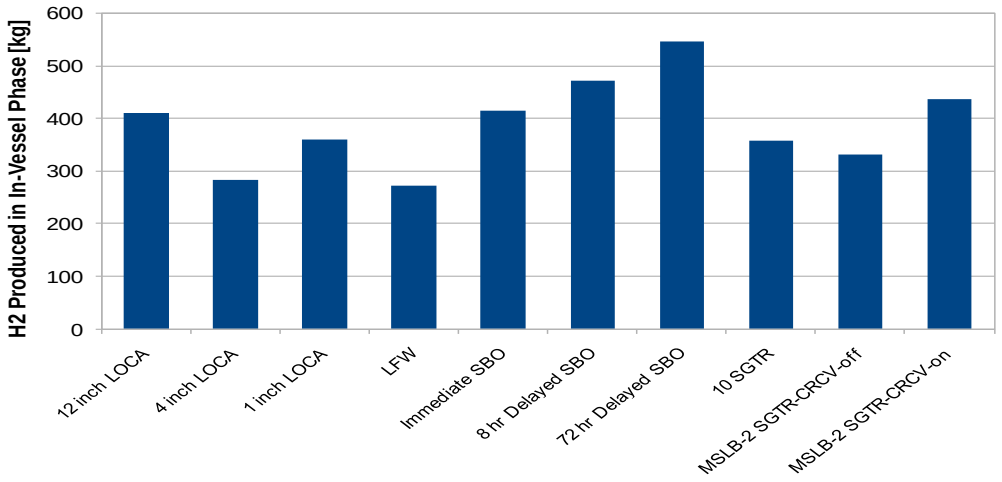
Accident Scenarios

- Loss Of Coolant Accident
- Steam Generator Rupture
- Extended Loss of Power

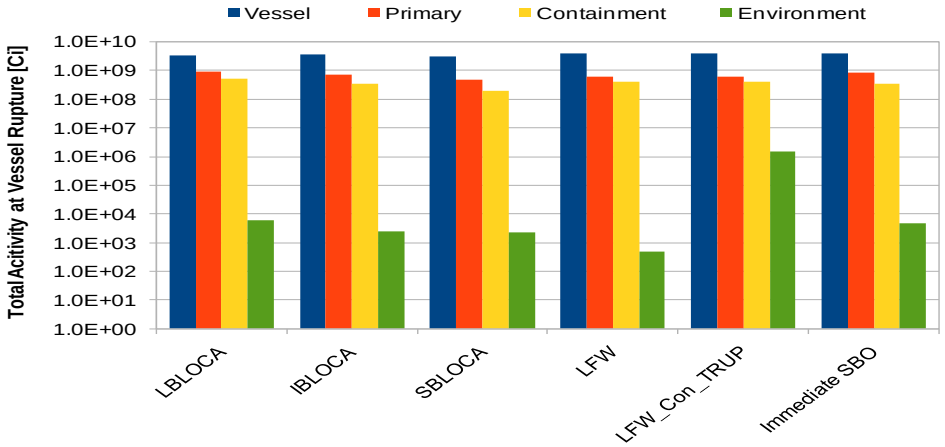


- LOCA = Loss of Coolant Accident
- LFW = Loss of Feedwater
- SBO = Station Blackout
- STGR = Steam Generator Tube Rupture
- MSLB = Main steam line break

Mass of Hydrogen produced during the melting of the core in the Vessel.

Endpoints/results

- Accident Progression
- Fission Products released to the environment



- LOCA = Loss of Coolant Accident
- LFW = Loss of Feedwater
- SBO = Station Blackout

Activity at various part of systems and environment after the vessel ruptures
(Except for LWF_Con_TRUP, we assume that containment remains intact.)

SAFETY ANALYSIS

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Further studies on different aspect of nuclear power safety:

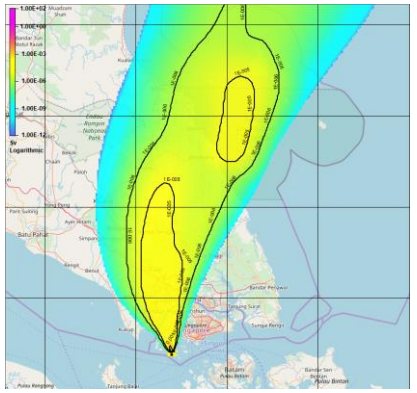
- Assembly design of a fluoride salt-cooled high temperature commercial-scale reactor: Neutronics evaluation and parametric analysis
- Long-term reactivity control of accident tolerant fuel loaded marine small modular reactor using particle-type burnable poisons
- Numerical stability analysis of lp-CMFD acceleration for the discrete ordinates neutron transport calculation discretized with discontinuous Galerkin Finite Element Method

Atmospheric Dispersion of Radionuclides

Long range dispersion modelling will be used to model plausible accident scenarios in the region.

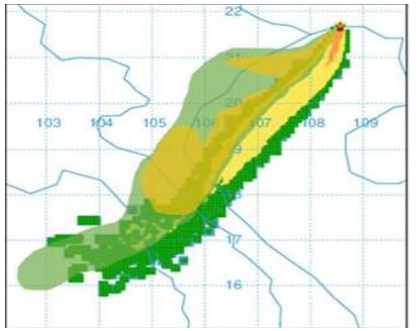
Includes:

- risk map analysis of long-range dispersion
- Evaluation of short-term Numerical Weather Prediction model



Dose Assessment(Future goal)

- Preliminary investigation of Dose Assessment software(RESRAD, MACCS)
- Identification of factors unique to Singapore



Radiochemistry

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Developing techniques for detection of hazardous nuclides that are not trivial to analyze.

Includes:

- Removal of interferences to ensure accuracy of mass spectrometric techniques
- Challenges in electrodeposition and co-precipitation techniques
- Improved capability in detection of radionuclides

Journal of Radioanalytical and Nuclear Chemistry (2019) 322:399–406
https://doi.org/10.1007/s10967-019-06695-3

Check for updates

In situ determination of ^{238}Pu in the presence of uranium by triple quadrupole ICP-MS (ICP-QQQ-MS)

Ling Ying Diane Tiong[1] · Shimin Tan[1]

Received: 25 April 2019 / Published online: 17 August 2019
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Abstract
In this work, a direct determination of ^{238}Pu determination using reactive gases, CO_2 and H_2 in triple quadrupole ICP-MS without prior radiochemical separation resins has been established. Quantification of 0.25 pg/mL ^{238}Pu sample mixture (1.18 pg of ^{238}Pu) yielded satisfactory results (> 95% accuracy), uncertainties of less than 15% and in the presence of spiked natural U (0.5 ng/mL). Additional verification of this method was performed using certified ratio materials (IRMM-086, Belgium) and experimental $^{238}Pu/^{239}Pu$ and $^{240}Pu/^{239}Pu$ values are analogous to the certified values provided.

Keywords Triple quadrupole inductively coupled plasma-mass spectrometry · Plutonium · Uranium · Isobaric interferences · Nuclear forensics

Alpha spectrometry

Gamma spectroscopy : 2 HPGE

- 50 % efficiency
- 100 % efficiency

ICP-MS/MS

Liquid Scintillation Counter

Radiobiology

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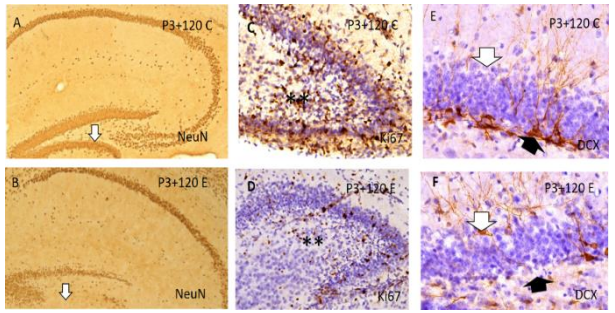
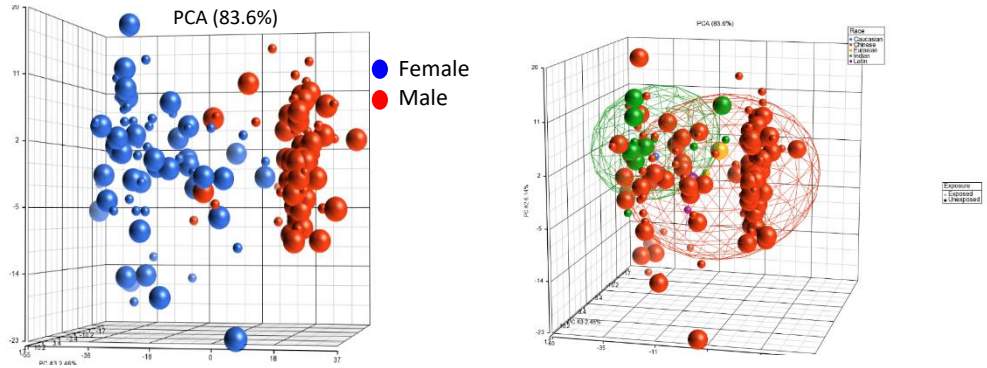
Effects of radiation on biological systems ranging from DNA damage, to macroscopic changes in organisms. Focuses on **chronic low dose** and novel techniques.

Includes:

- Impact on brain development in postnatal mice
- Real-time sensing of damage in zebrafish model
- Molecular changes in blood after low doses
- Understanding non-targeted effects





Thank You!