DETERMINATION OF SAFARI-1 NEUTRON FLUXES BY MCNPX MODELLING OF FOIL EXPERIMENTS

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Introduction

- SAFARI-1 reactor used for
  - radioisotope production
  - material testing applications
- RRT support through modelling of applications
  - to determine radiation safety safeguards
  - or engineering requirements
- E.g. experiment to test performance of PBMR fuel particles at specified burn-up conditions by irradiating them in SAFARI-1 core

Introduction

- To reach required burn-ups, vital to know neutron fluxes in irradiation rig
- Restrictions in rig design – not possible to measure directly inside the rig
- Modelling – fluxes can be calculated inside & outside rig
  - Outside values compared with measurements
  - Inside values estimated with greater accuracy

Introduction

- OSCAR-3: 3D nodal depletion code
- OSMINT: transfer material data to MCNPX input
- Developed geometrically detailed MCNPX model of SAFARI-1 core

→ **Representing every single moment in reactor cycle in terms of isotopic inventory**

- Great improvement over previous approximations
- Aim: verify applicability of this core model

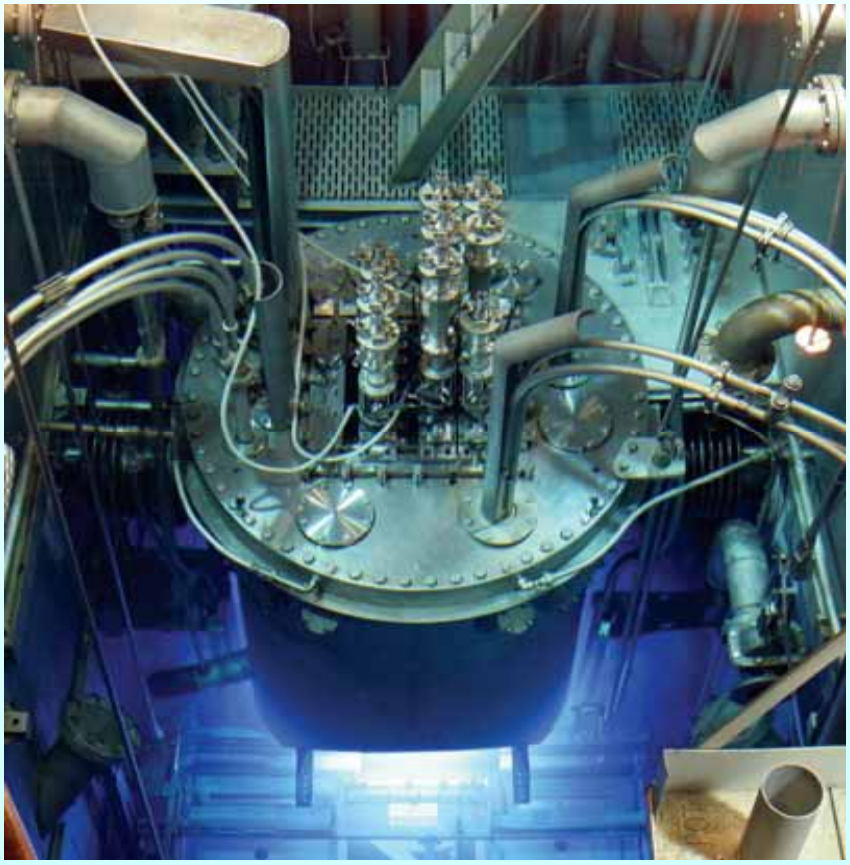
Modelling with MCNPX

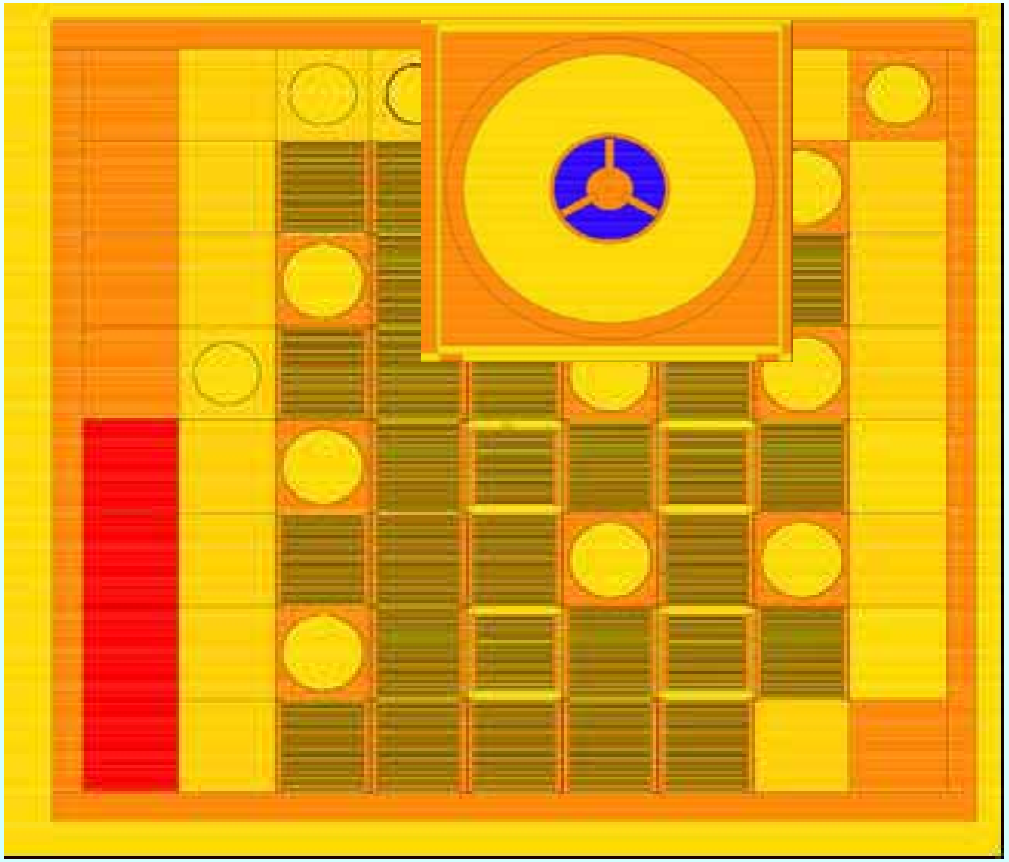
- Model earlier Co & Ni foil irradiation experiment using core model
  - Co high cross section for thermal neutrons
  - Ni high cross section for fast neutrons
  - Combination cover high & low energy regions
- Calculate fluxes & activities
- Compared with experimental measurements

Modelling with MCNPX

- MCNPX input file for reactor at 20 MW
  - OSCAR-3 and OSMINT programs for material
  - Exact geometry of irradiation rig & foils from drawings
- KCODE source problem with 25000 k-eff cycles
- F4 tallies for neutron flux & reaction rate

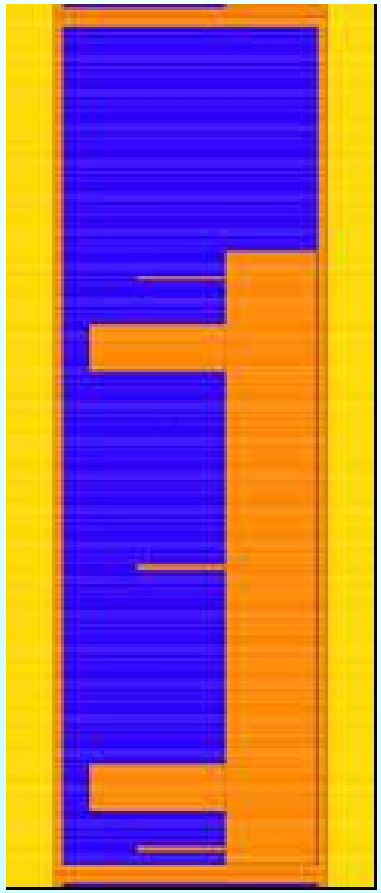
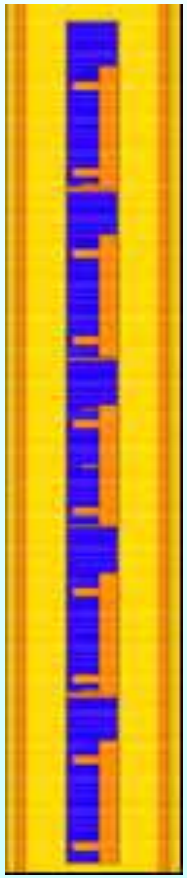
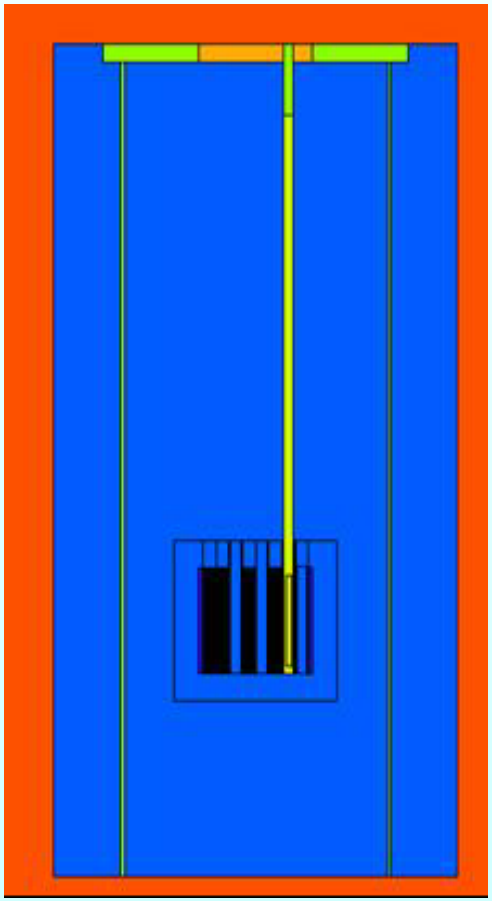
Modelling with MCNPX





Modelling with MCNPX



Results

- Calculation:
  - Flux
  - Reaction Rate

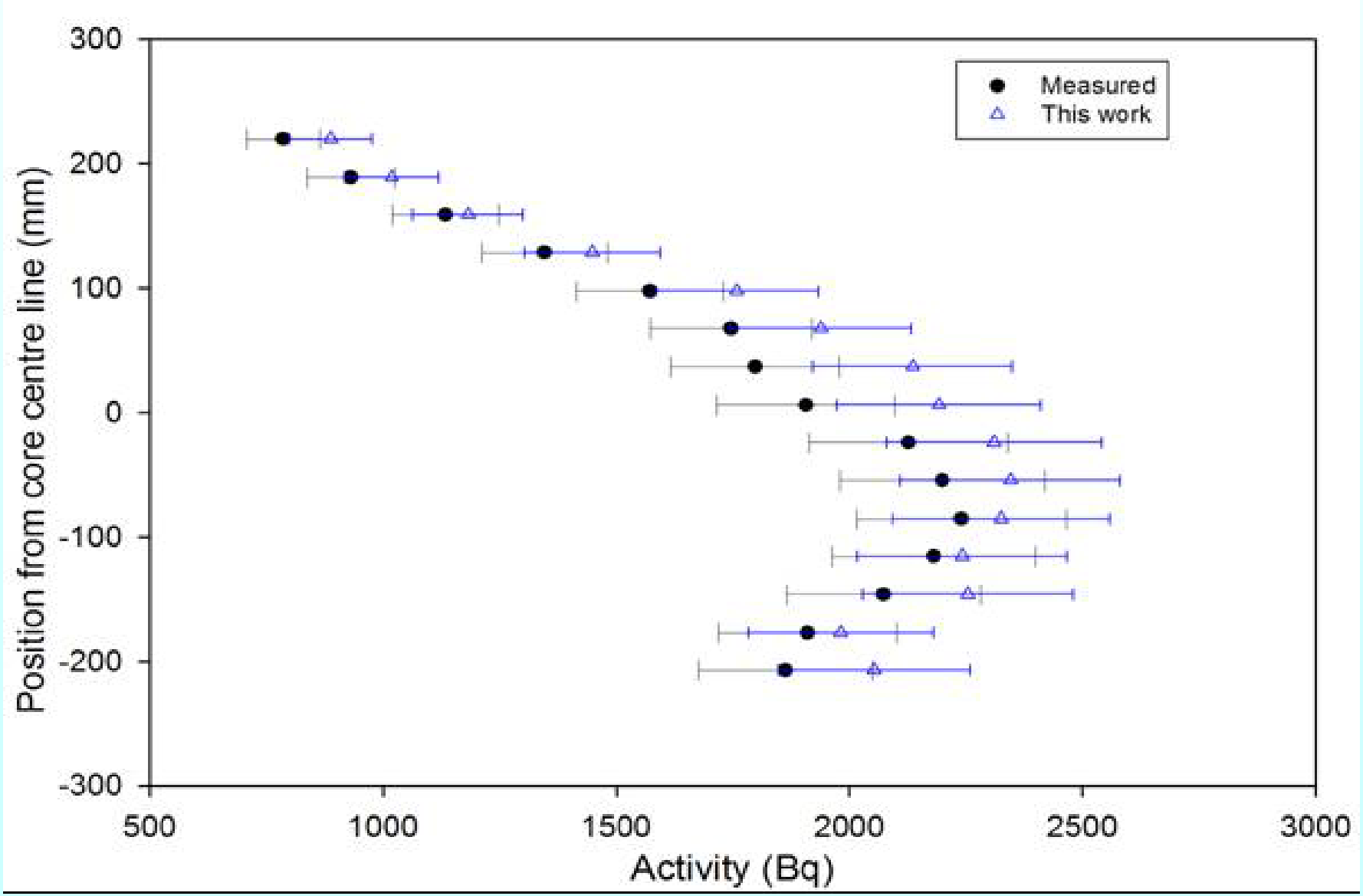
$$A_i^{calc} = n\sigma_i\phi_i\,(1-e^{-\lambda t})$$

comparison

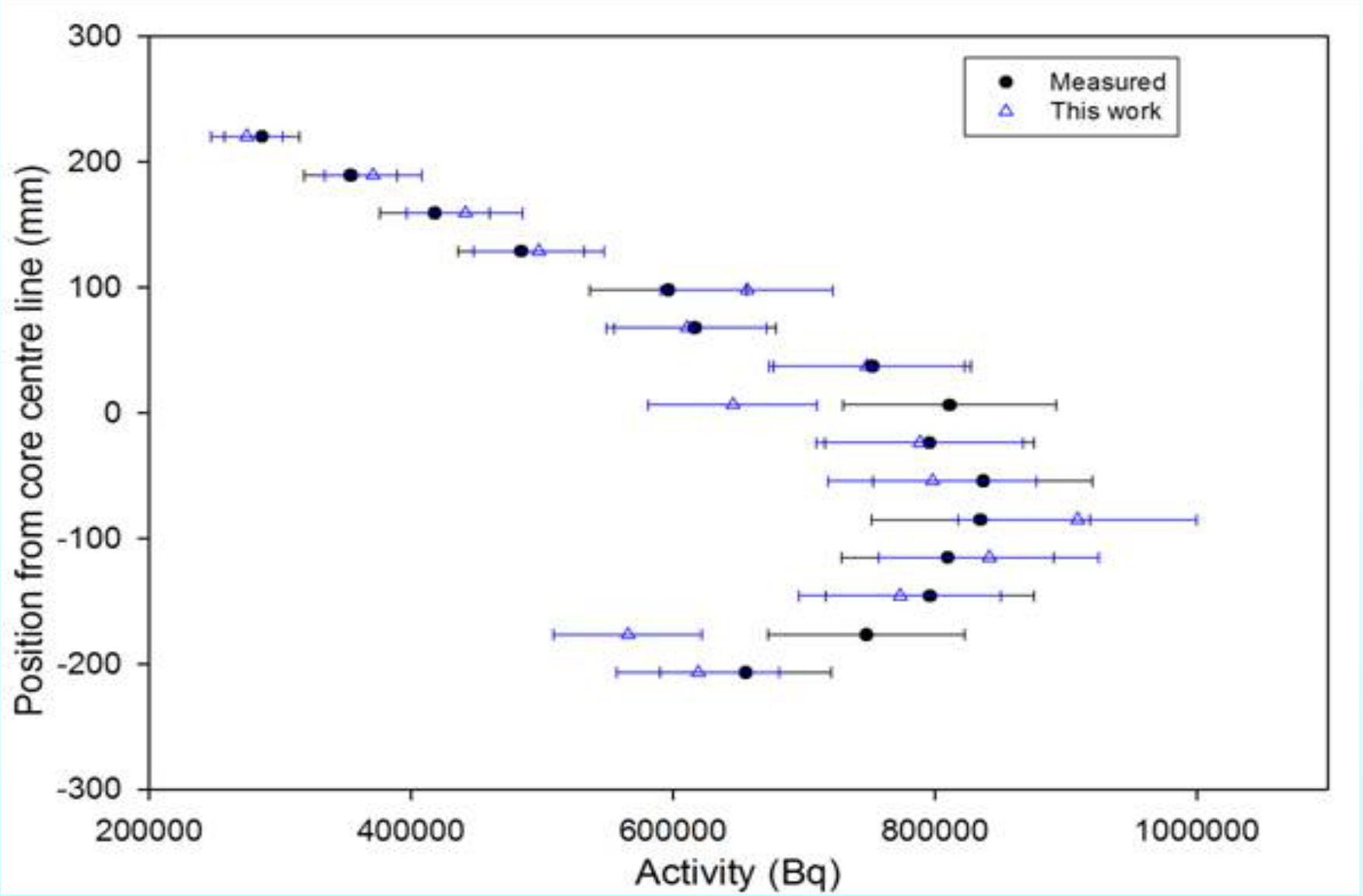
- Measured
  - Activity

$$A_i^{measured}$$

Results: Co – activities



Results: Ni – activities



Conclusion

- Good agreement between calculations & measurements
  - Ni two outliers: unsure whether statistics or modelling
  - MCNPX results only snapshot in time of experiment
  - Core depletion process can have effect on results
- Model show promise as calculational tool
- **Gives assurance that unknown parameters could be calculated with good accuracy**