Recent measurements using monoenergetic and thermal neutrons at the National Physical Laboratory

Nigel Hawkes, Catalin Matei, Neil Roberts, Graeme Taylor, David Thomas

Bushy House

NPL
National Physical Laboratory

NPL was founded in 1900 in a former royal residence

New laboratories

Completed 2010

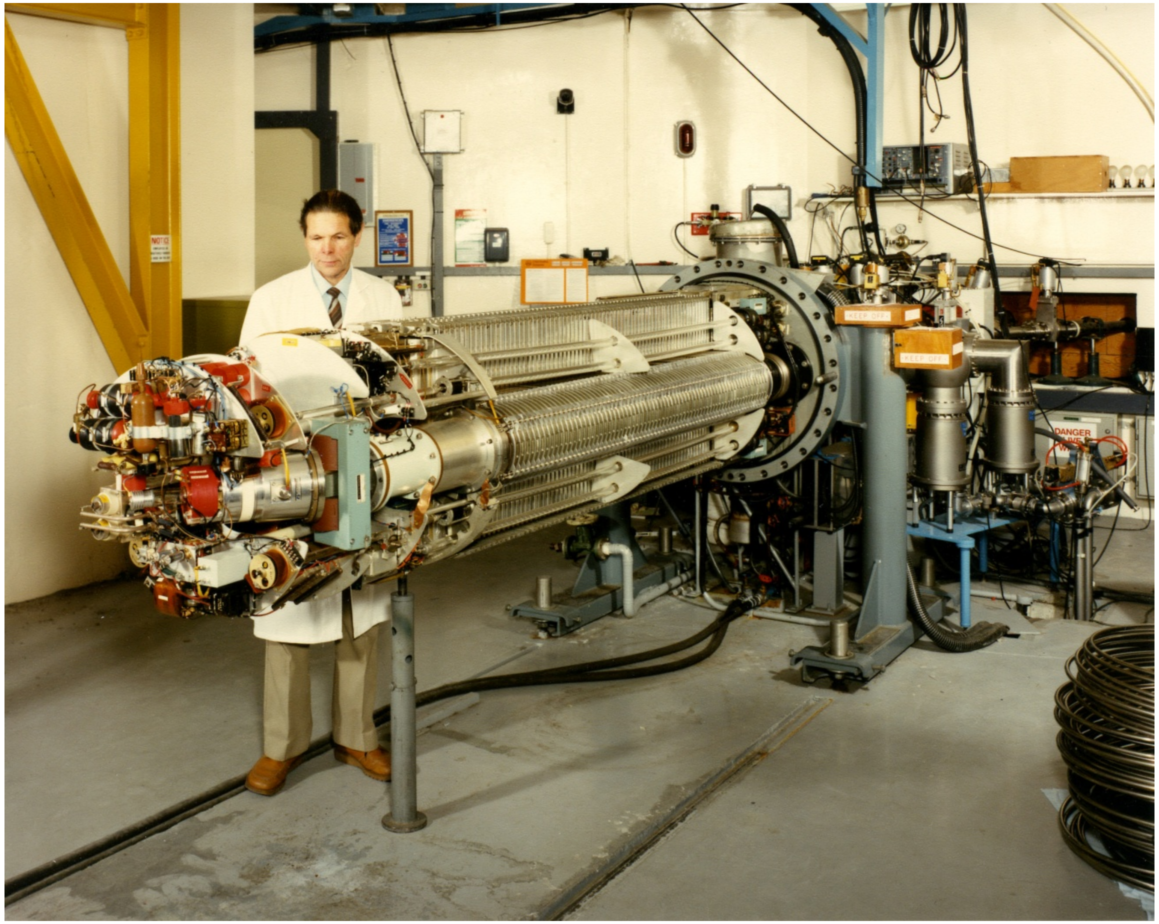
Neutron facility

National Physical Laboratory

Chadwick Building

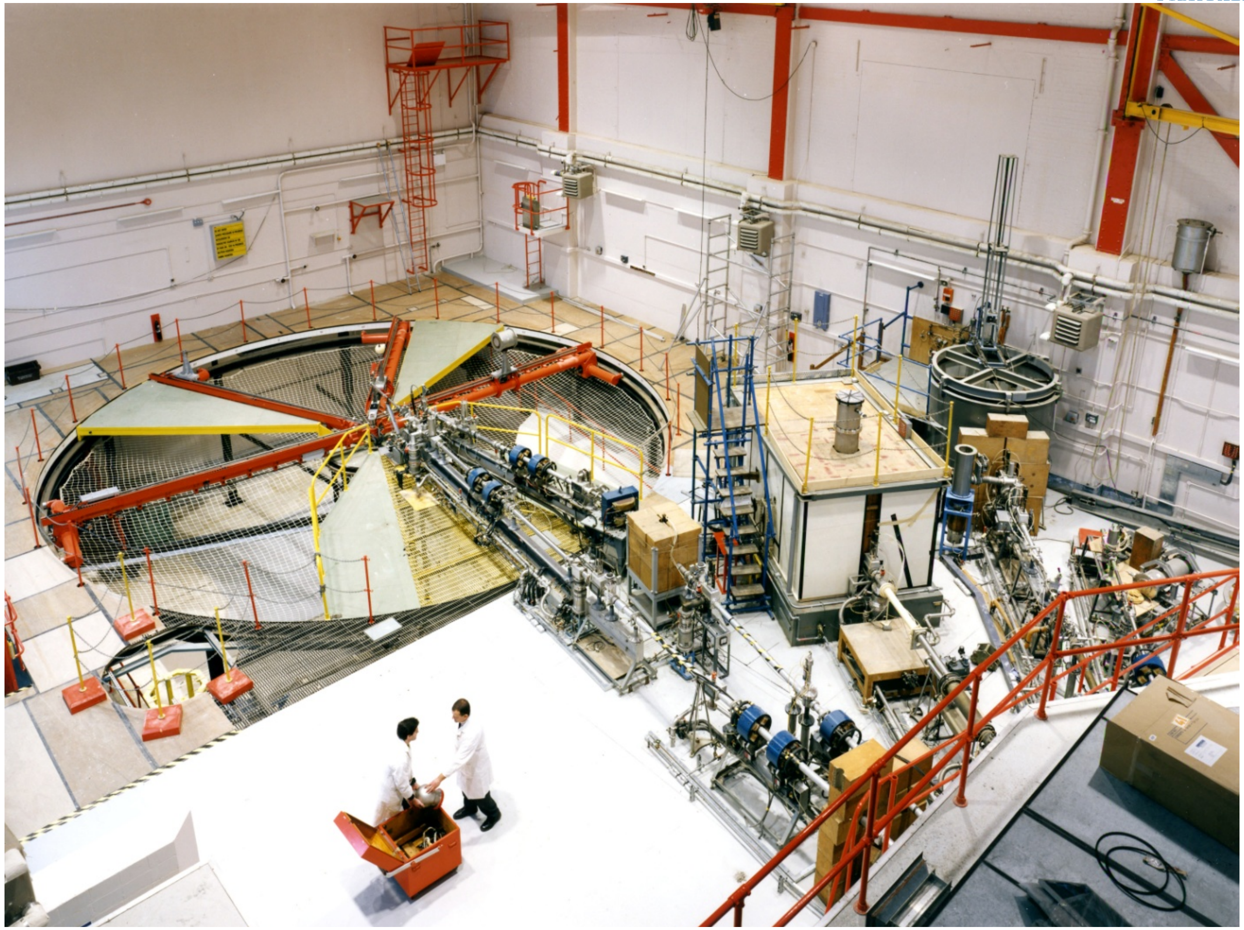
3.5 MV Van de Graaff accelerator

National Physical Laboratory



Showing ion source, pulser and accelerator tube

Experimental area



Showing low scatter area for monoenergetic & radioisotope neutrons (left side) and thermal pile (right)

Low-scatter area

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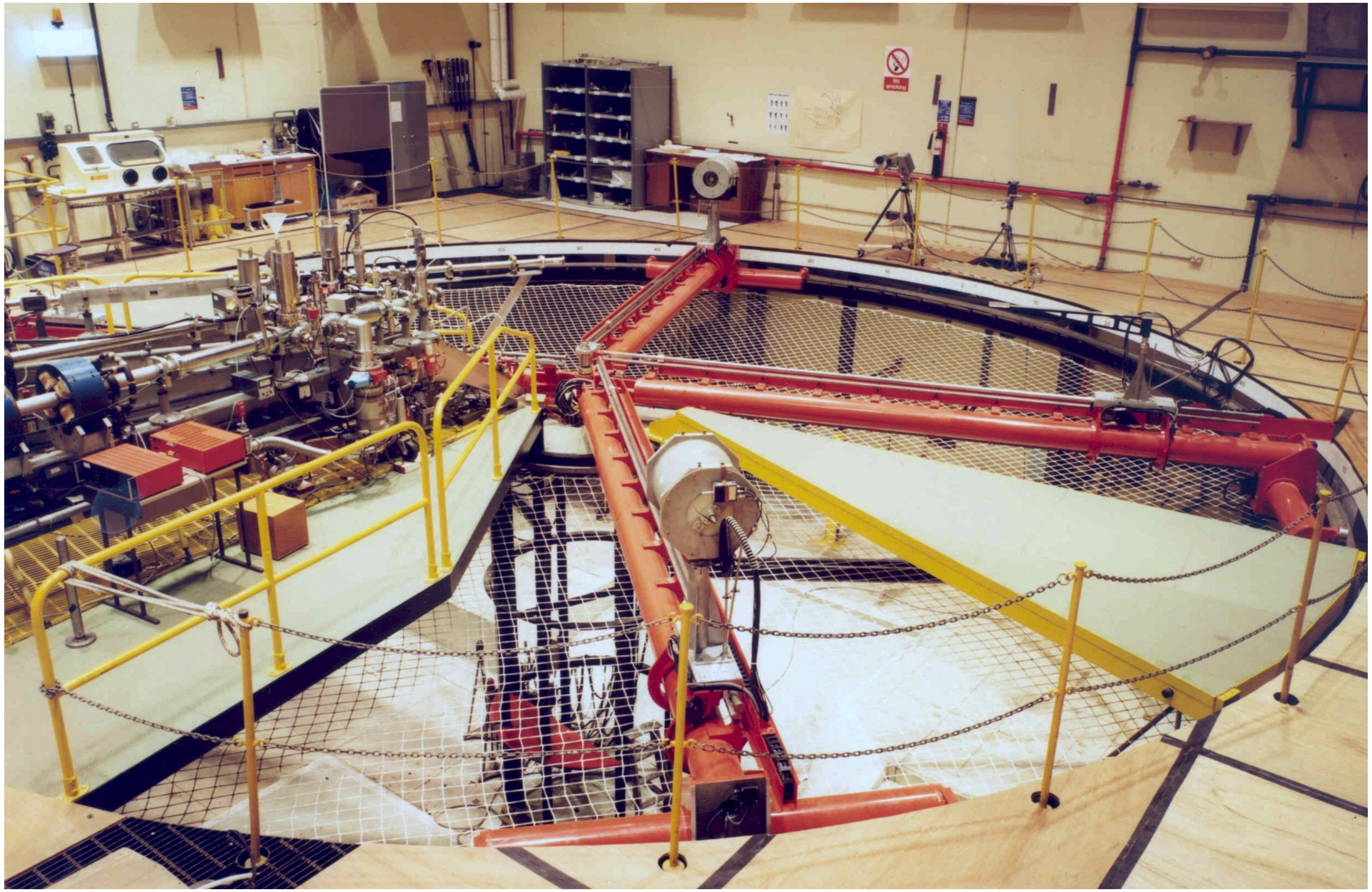
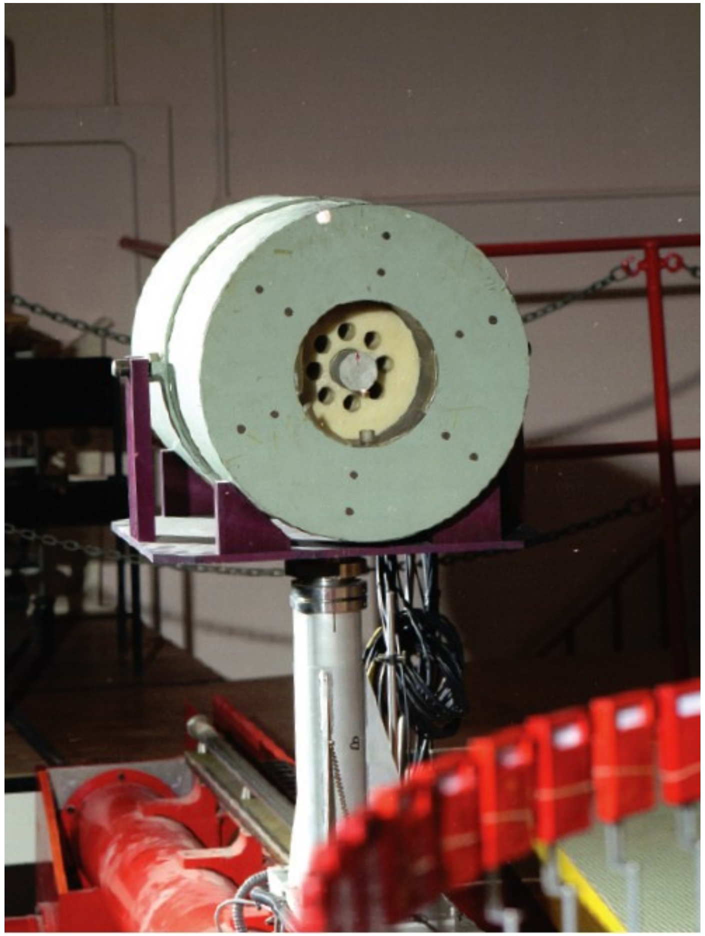


At least 6 m from the neutron source to the shield walls & real floor. Low-mass detector supports & walkways.

Neutron fluence

- Measured using a Long Counter (BF_3 counter inside a cylindrical moderator)
- The efficiency, about 11 counts per (neutron per cm^2), varies relatively little with energy
- Efficiency established by (e.g.) using neutron sources with accurately known output (measured in NPL Mn bath)



Monoenergetic neutrons

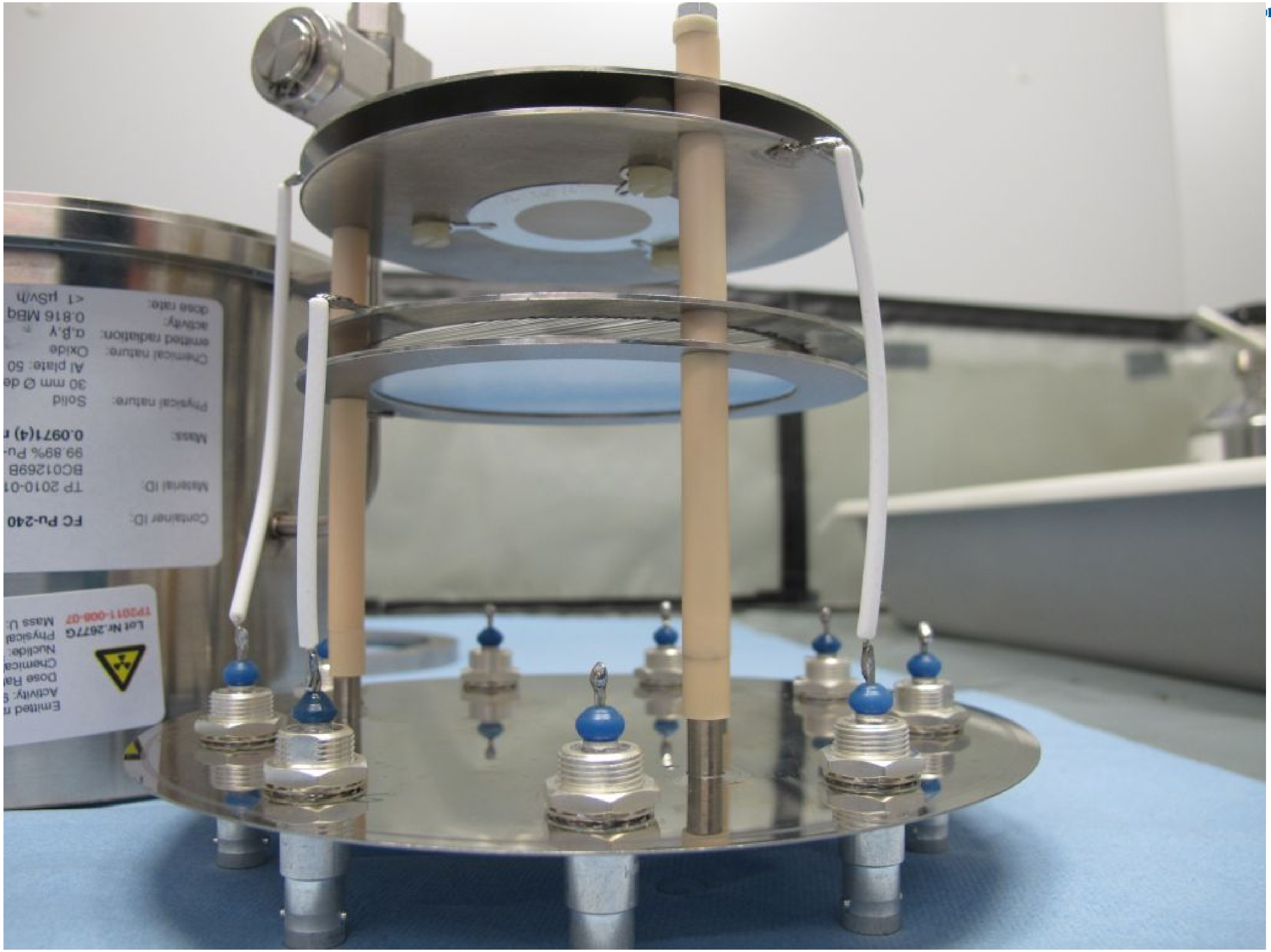
Typically used for:

- Calibrating external neutron standards
- Testing and characterising novel detectors
- Nuclear data

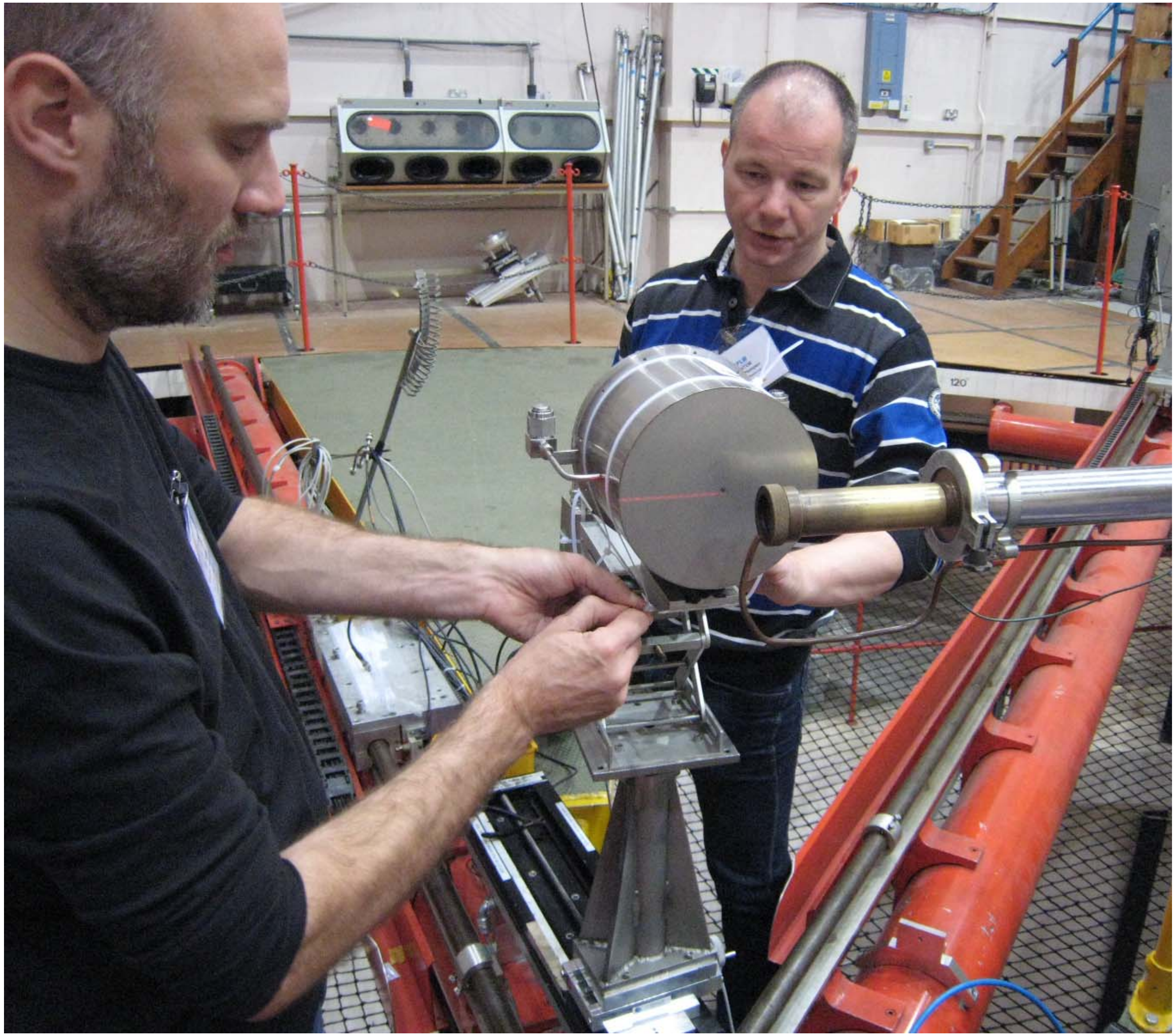
Specific example:

- Nuclear modelling relies on accurate and precise data.
- Calculations for Generation IV nuclear reactors require ^{242}Pu fission cross section to 3 – 5 percent.
- But currently the uncertainty is 19 – 21 percent.
- This is currently being addressed in an IRMM / NPL / PTB collaboration as part of the EMRP Metrofission project

^{242}Pu target in ionization chamber



Experimental setup



^{242}Pu (n,f) cross section

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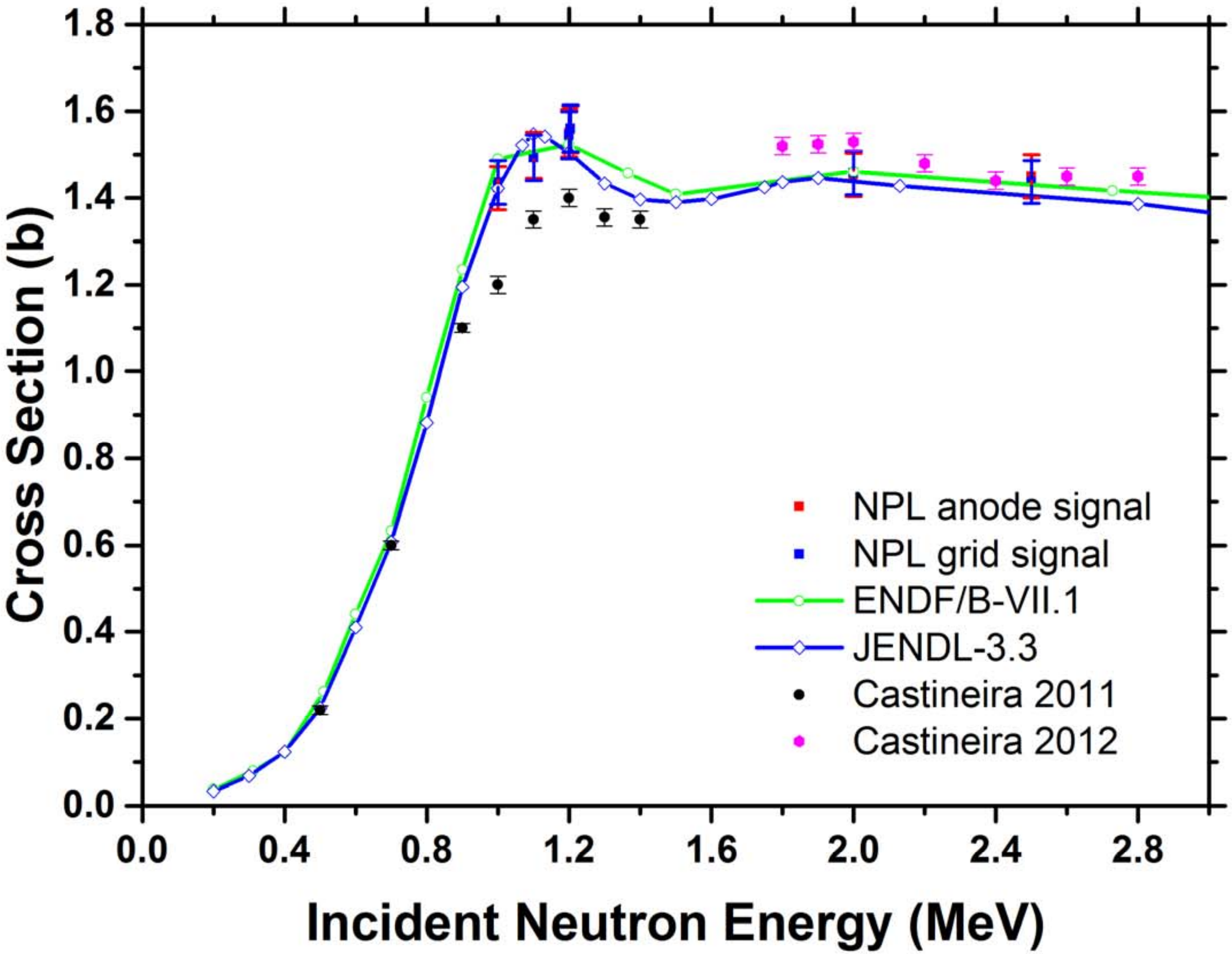
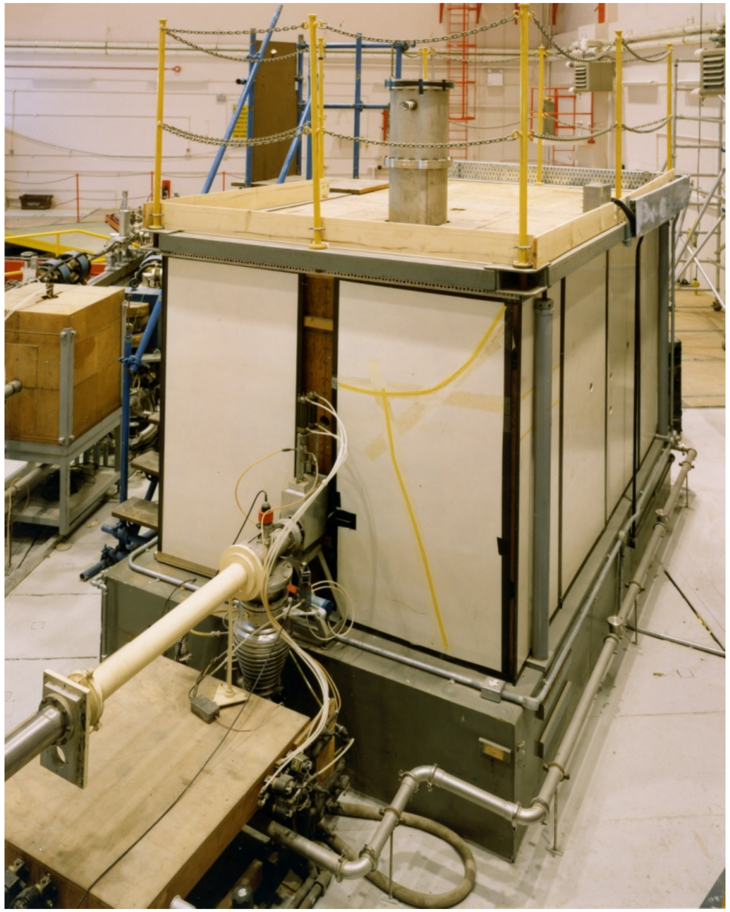
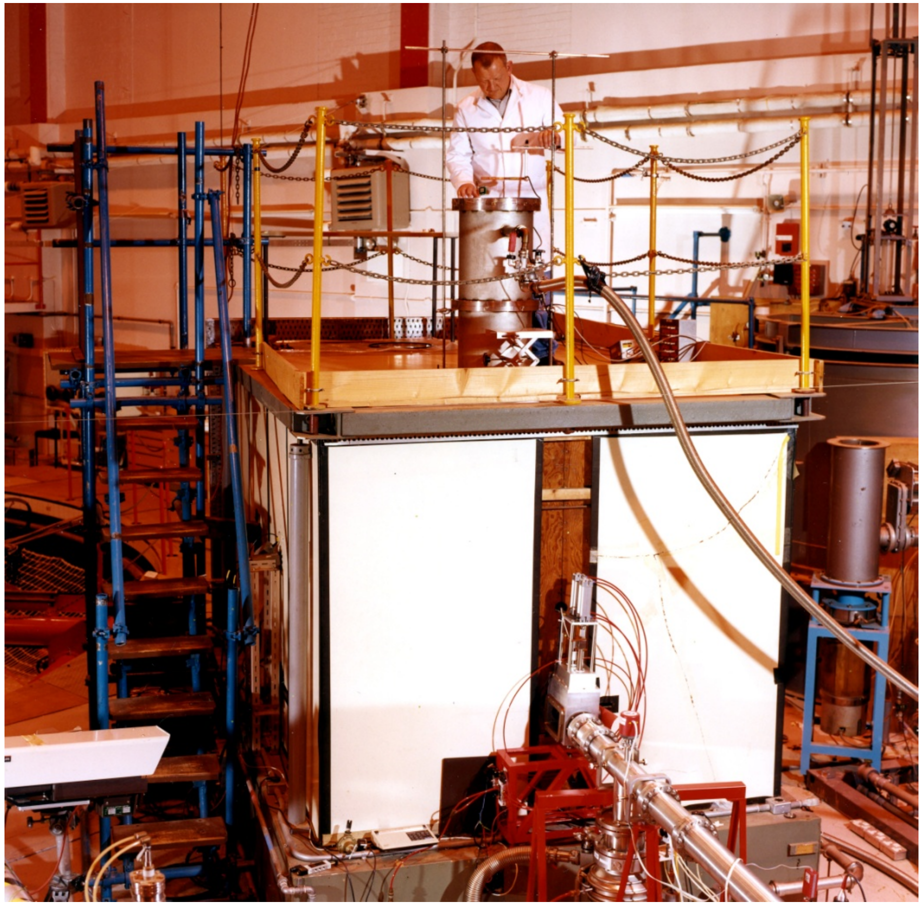


Thermal Pile





Graphite block about 2.8 m long by 1.4 m wide by 1.6 m high

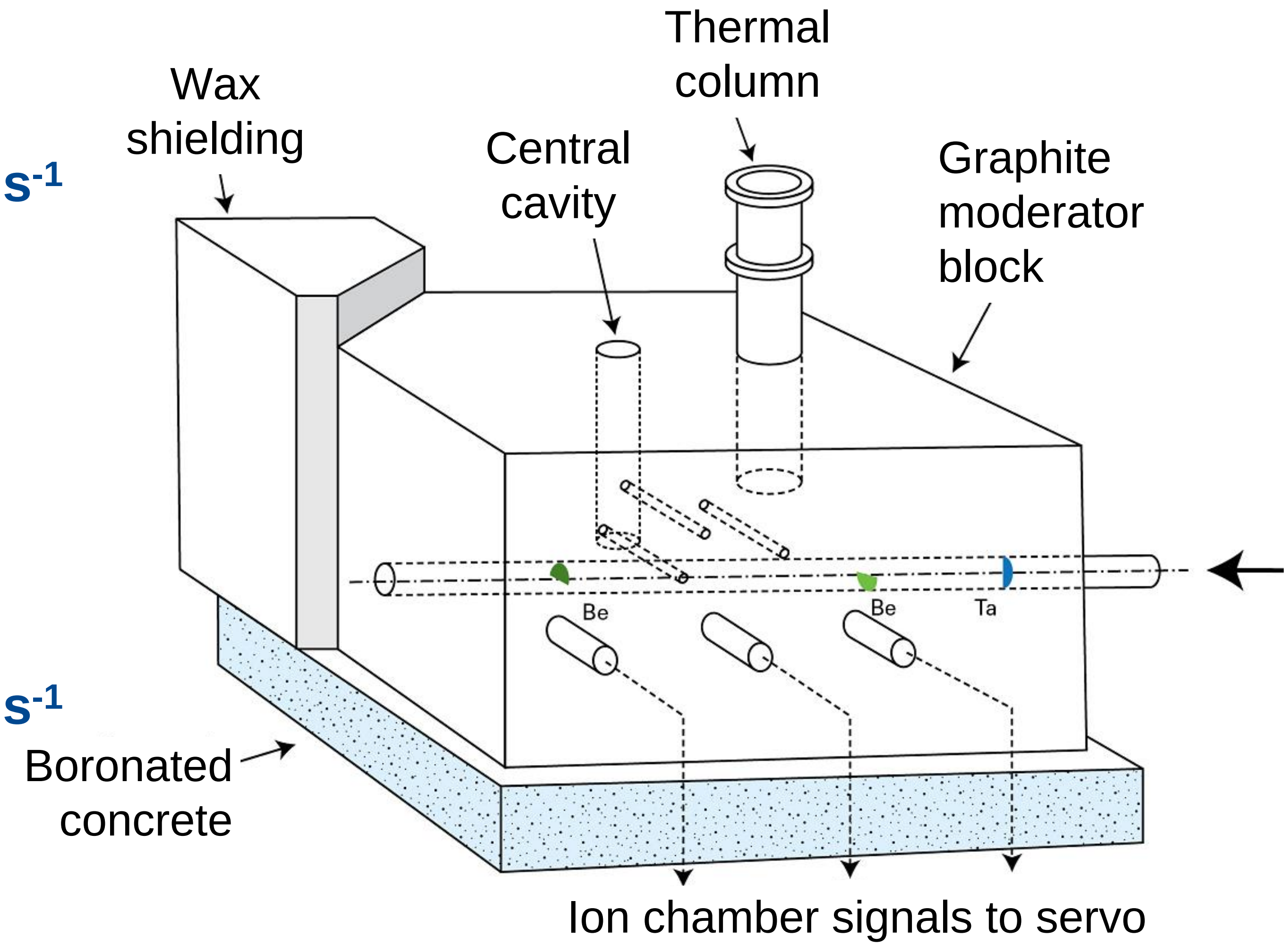
Thermal Pile

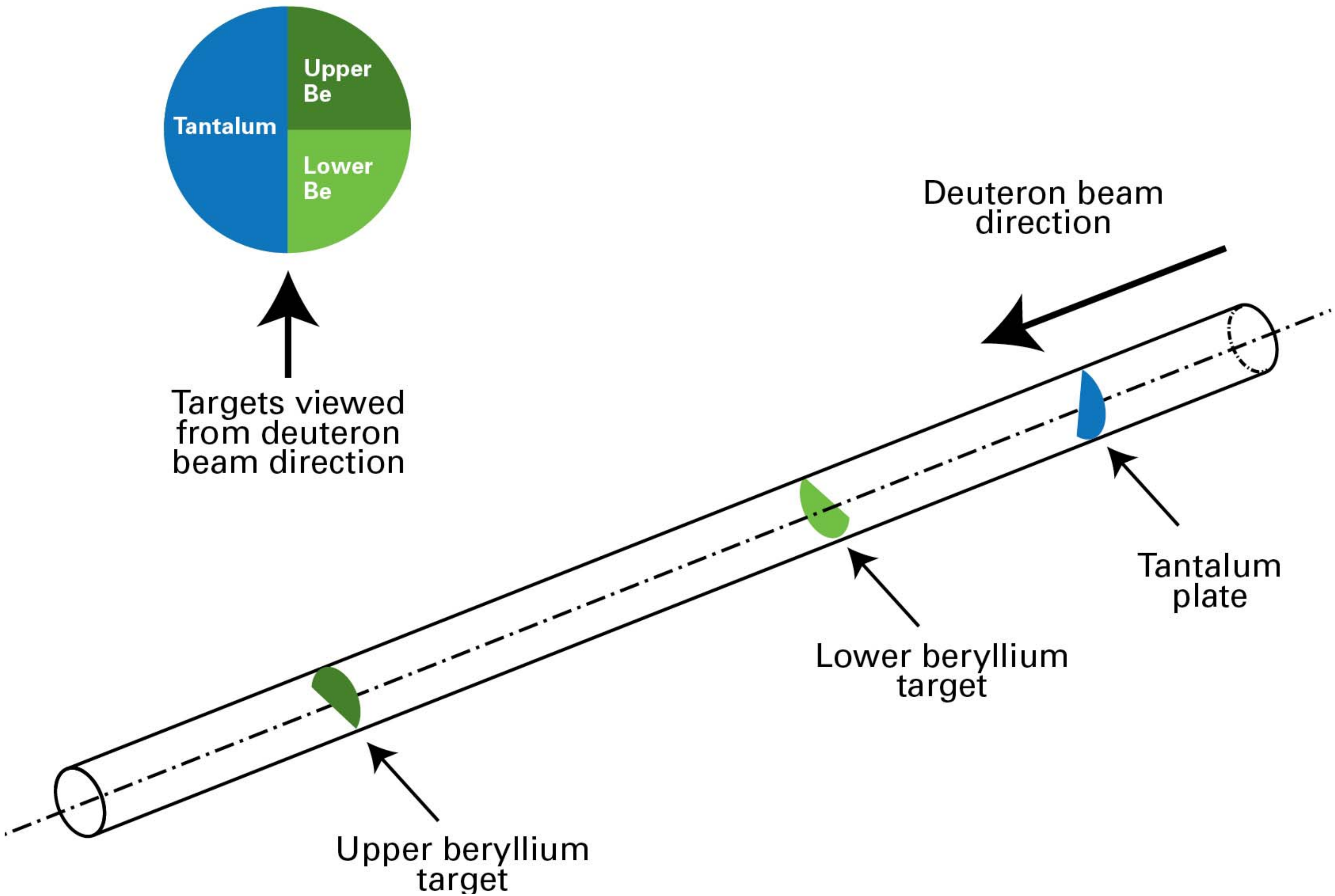
Central cavity:

- **Isotropic field**
- **Up to 2×10^7 cm^{-2} s^{-1}**
- **Diameter ~12 cm**
- **Cd ratio ~33**

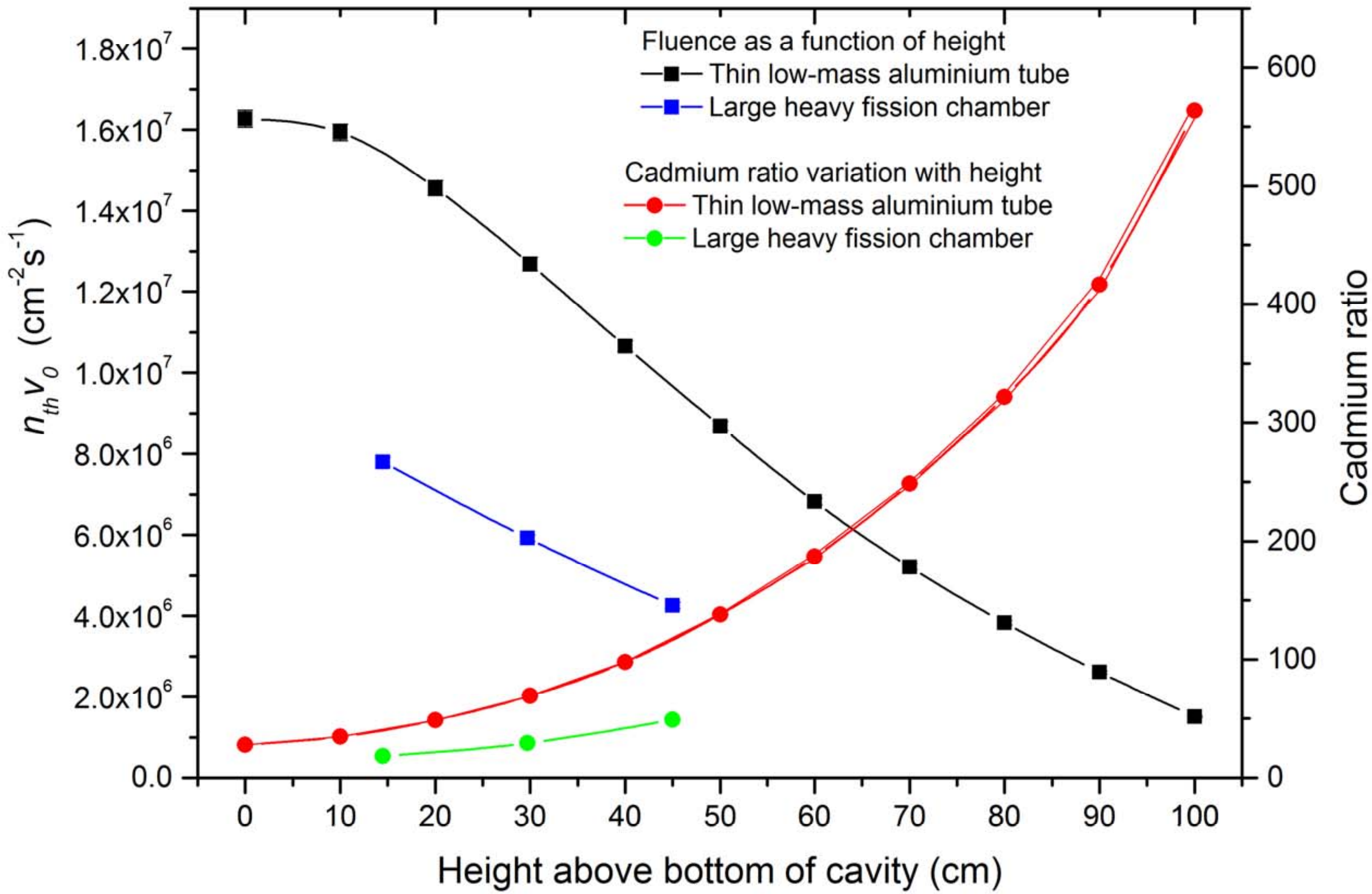
Thermal column:

- **Beam geometry**
- **Up to 4×10^4 cm^{-2} s^{-1}**
- **Diameter ~30 cm**
- **Cd ratio ~6.5**



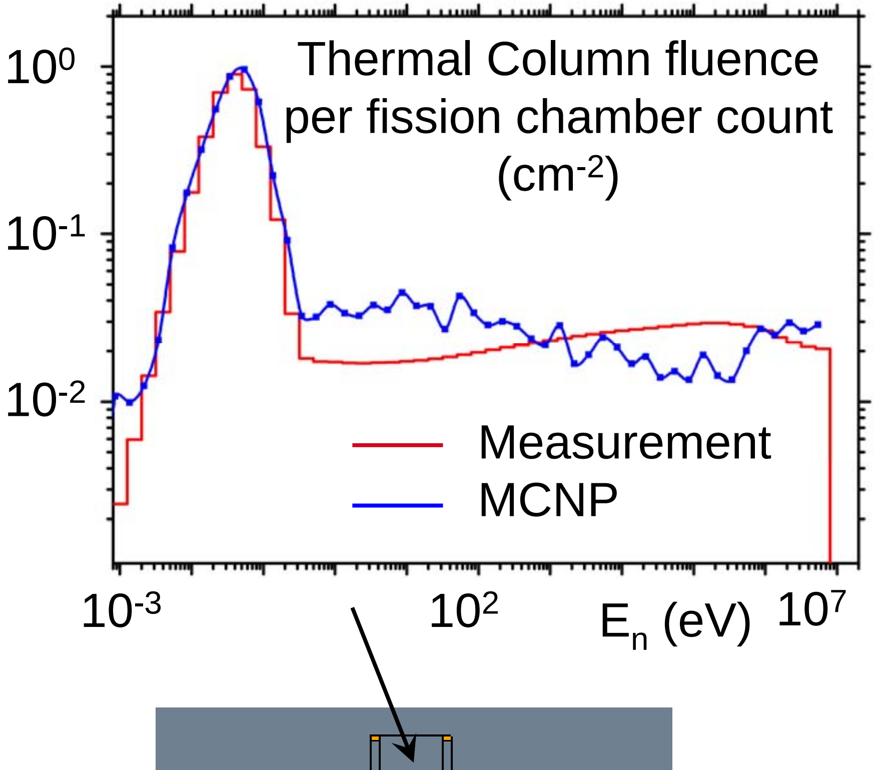

Upper Be
Tantalum
Lower Be
Targets viewed from deuteron beam direction
Deuteron beam direction
Tantalum plate
Lower beryllium target
Upper beryllium target

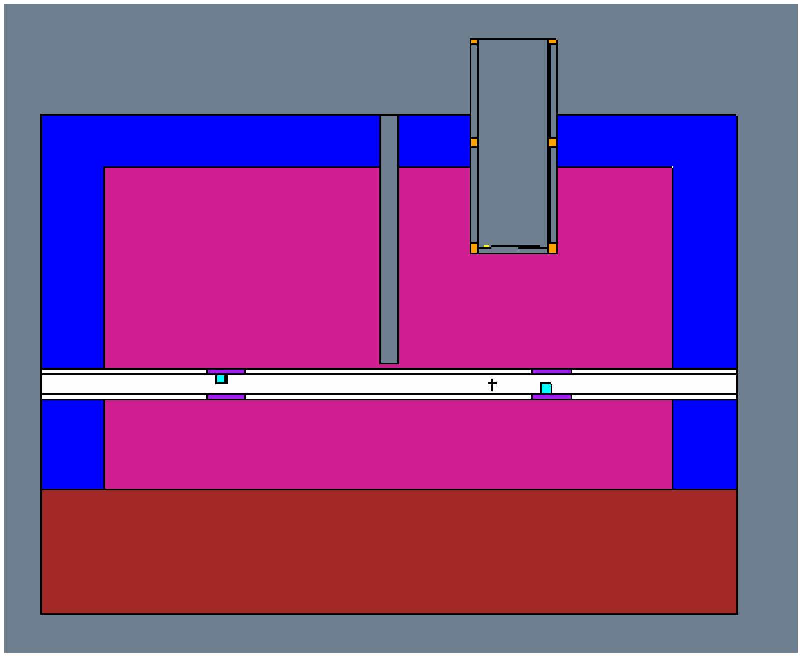
Central cavity – fluence rate (at max setting) & Cd ratio

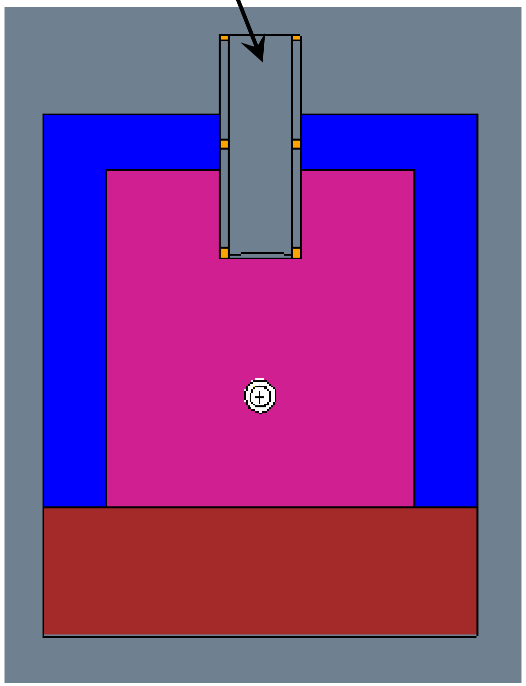


MCNP simulation

- Behaviour of Thermal Pile modelled using MCNP
- Neutrons that enter the central cavity commonly do so multiple times (2.3 on average)

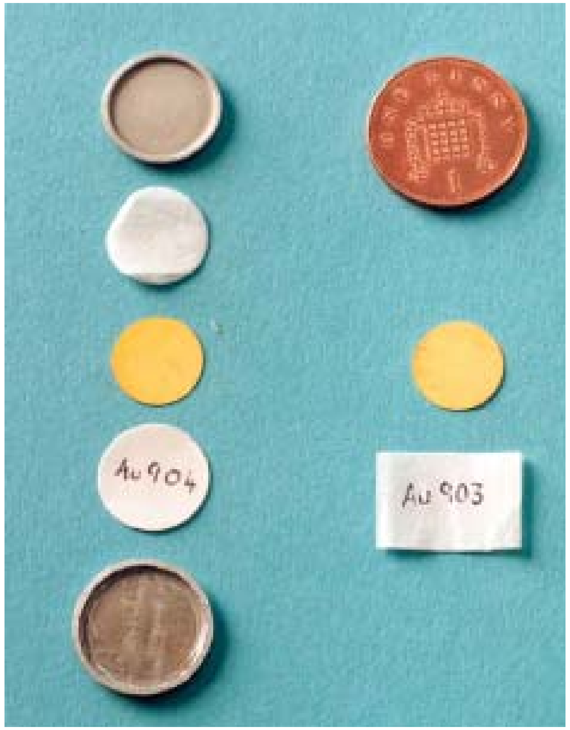


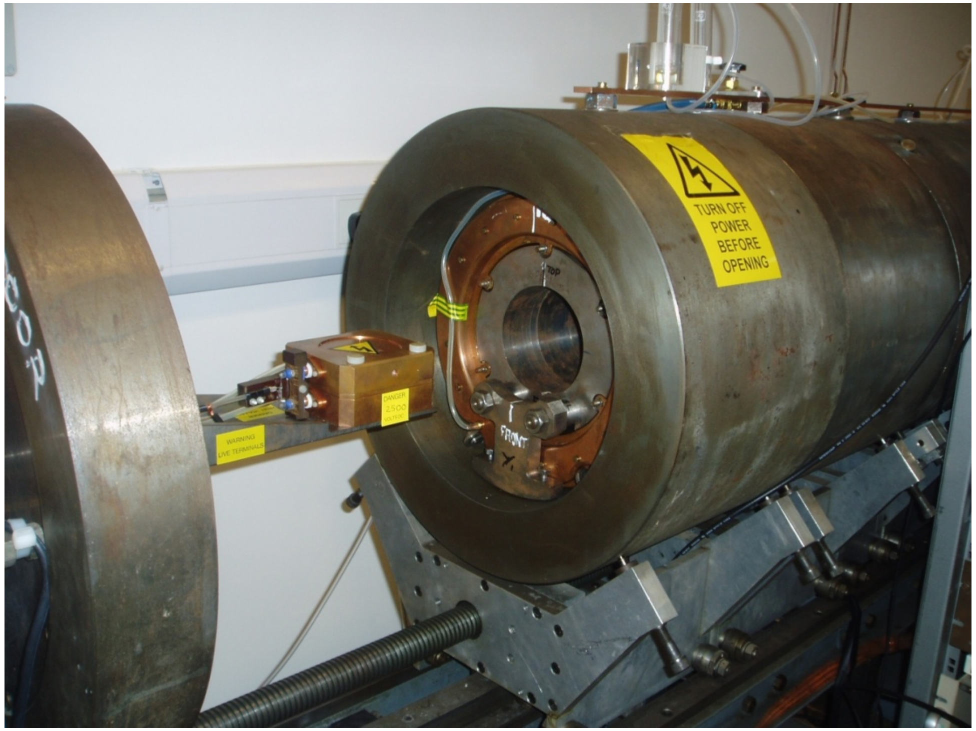




Measuring the fluence delivered

Gold foil activation followed by off-line β–counting in a 4π low background β–counter (or β–γ counter).





Conclusions

- The NPL Neutron Metrology Group has a 3.5 MV Van de Graaff accelerator and a range of experimental facilities.
- Well-characterised neutron fields can be produced in the fast and thermal energy regions.
- These can be used for calibrations, activations, reactor instrument testing, and cross section measurements.