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Radiological Shielding Design for the Neutron Backscattering Spectrometer EMU at the OPAL Reactor

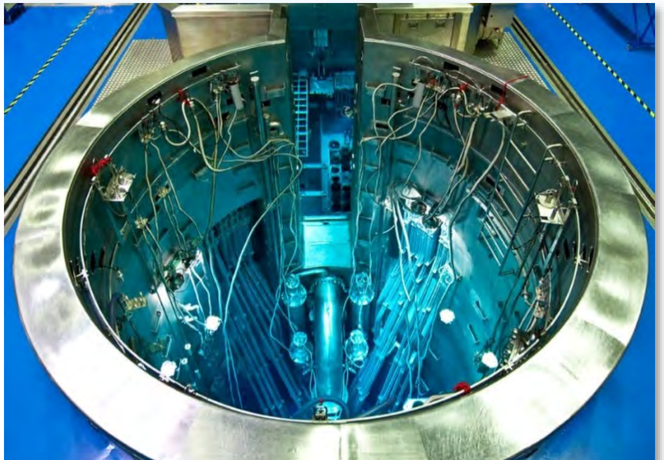
Tunay Ersez, Mark Ho, Fernando Esposto and Nicolas R. De. Souza
Australian Nuclear Science and Technology Organisation
Email: tez@ansto.gov.au


Sydney

ANSTO

- Centre of Australian nuclear expertise
- Home of Australia's only nuclear reactors
- Australian government science and technology organisation
- Around 1200 employees
- Nuclear Science, ACNS (Neutron & X -ray Scattering), Accelerator Sciences, Environmental Research, Radiopharmaceutical Research, Materials Engineering Research

Landmark Infrastructure for Australian Science


OPAL Research Reactor

Australian Synchrotron


EM facility

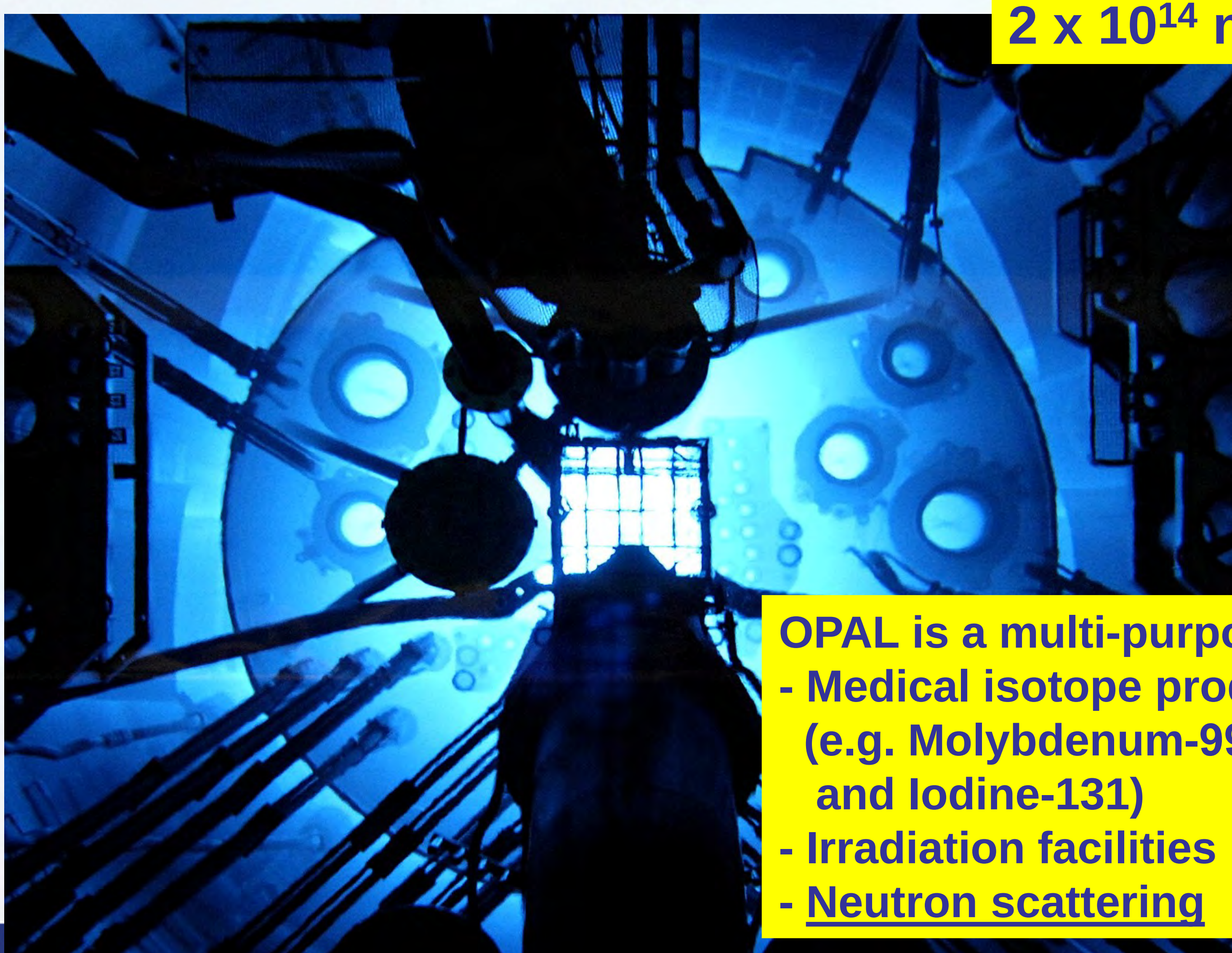

Neutron Scattering


Centre for Accelerator Science


Nuclear Material

OPAL at 20 MW

neutron flux:
2 x 10^{14} neutron/cm^2/sec

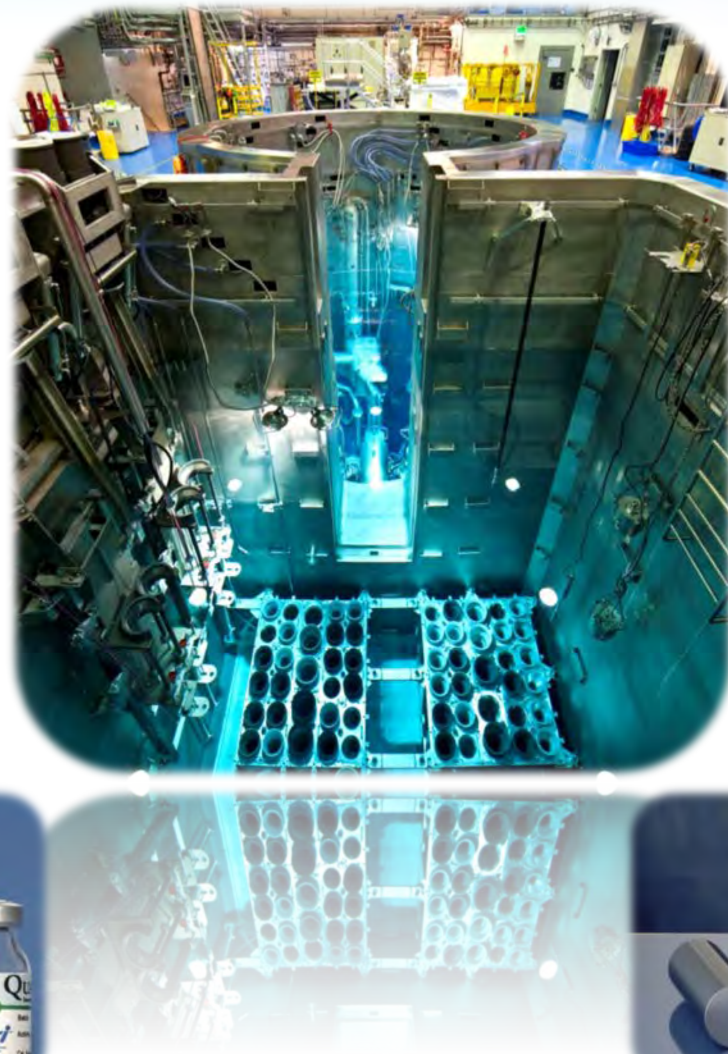


OPAL is a multi-purpose facility:
- **Medical isotope production:**
  (e.g. Molybdenum-99 → Technetium-99m and Iodine-131)
- **Irradiation facilities**
- **<u>Neutron scattering</u>**

OPAL multi-purpose reactor

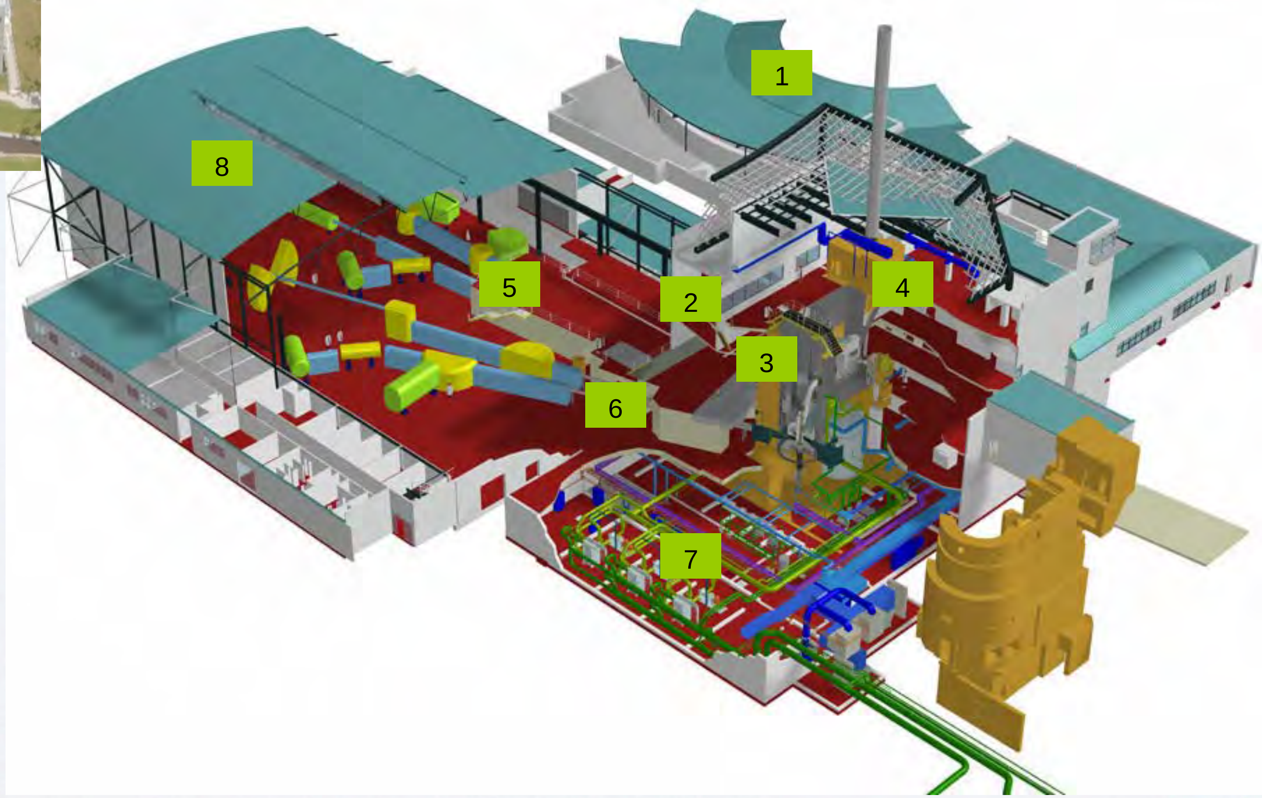
Neutron Activation

Neutron Beams: scientific research



Medical Radioisotopes

Silicon irradiation

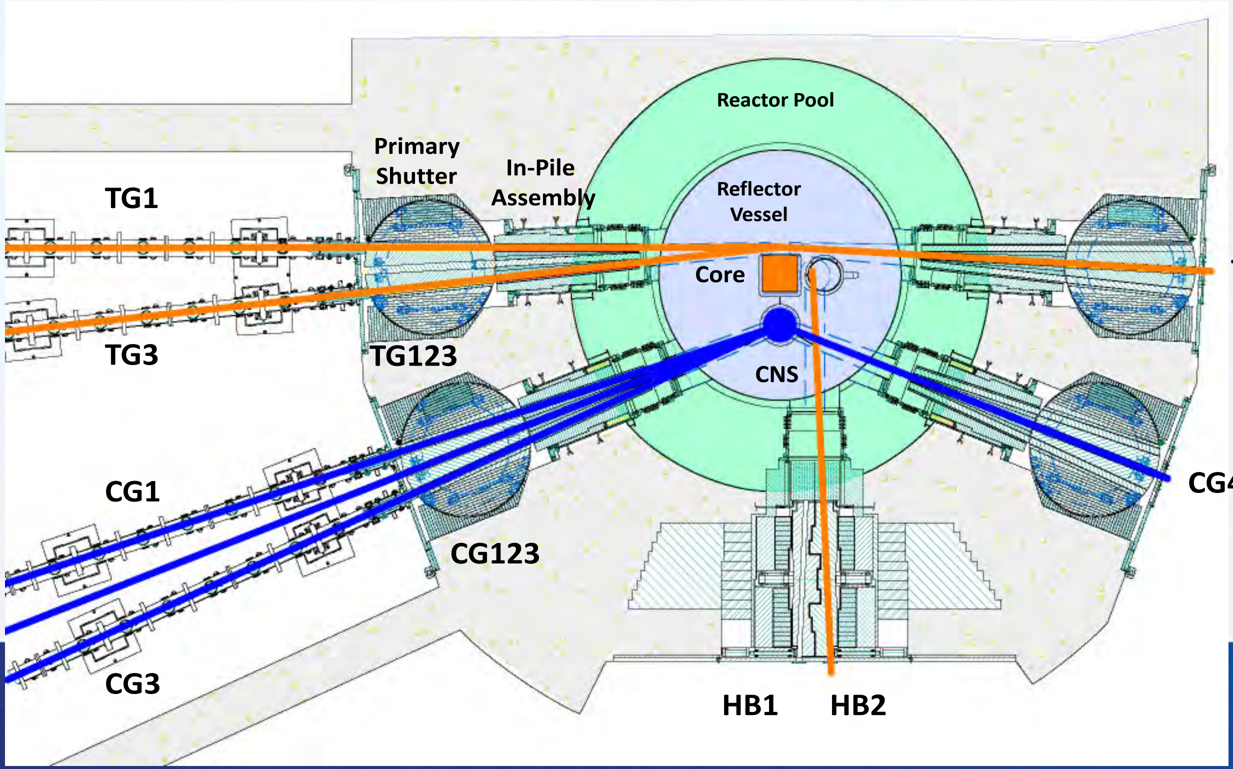


Reactor Plant Key

1. Visitors Centre
2. Control Room
3. Reactor Pool
4. Transfer Hot Cell Complex
5. Thermal Neutron Beam Guides
6. Cold Neutron Beam Guides
7. Primary Cooling System
8. Neutron Guide Hall

Neutron Guide In-Pile Assemblies

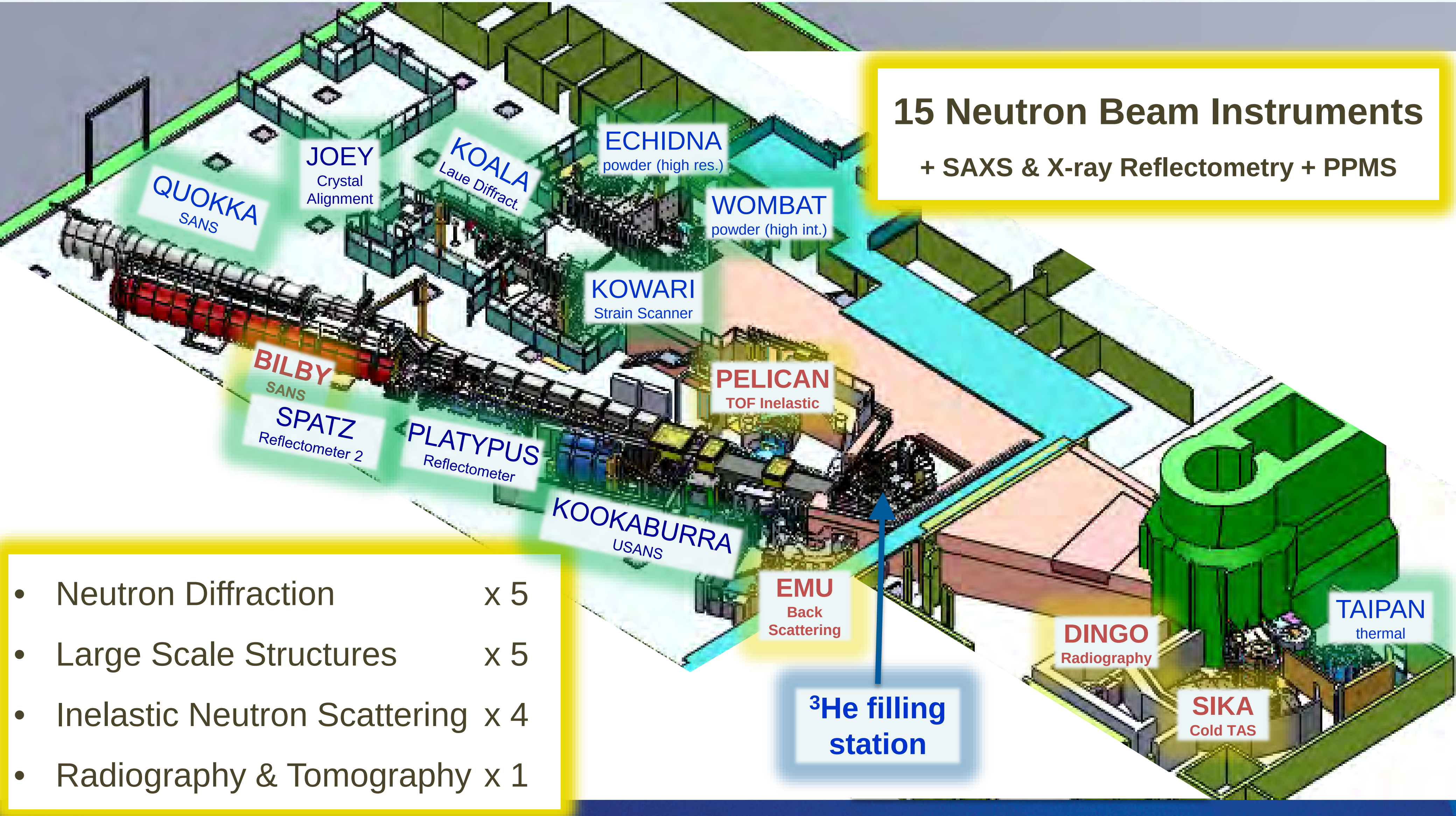
- TG 1-3
- CG1-3
- TG 4 and CG 4
- HB 1 and 2



Australian Centre for Neutron Scattering

15 Neutron Beam Instruments

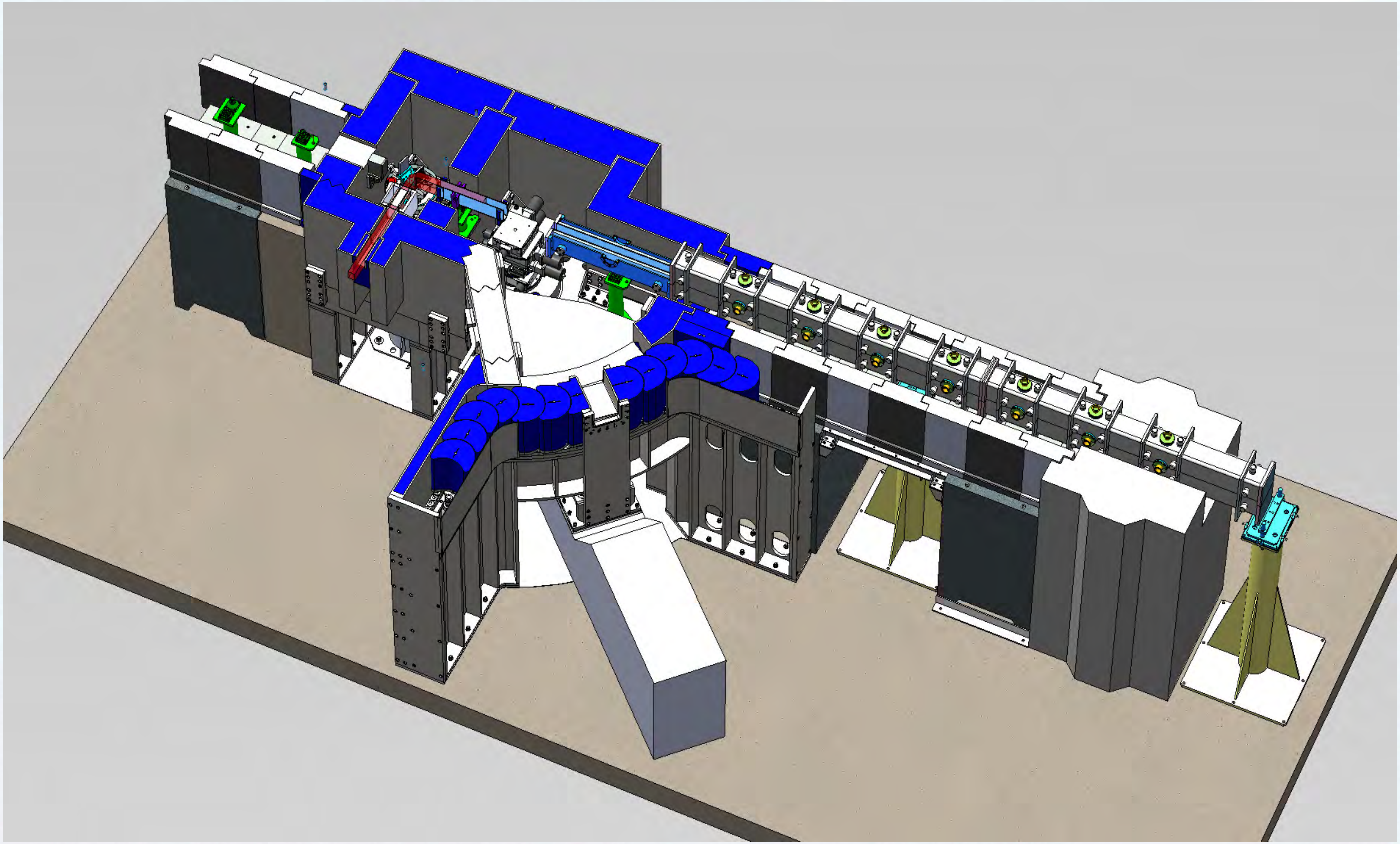
+ SAXS & X-ray Reflectometry + PPMS

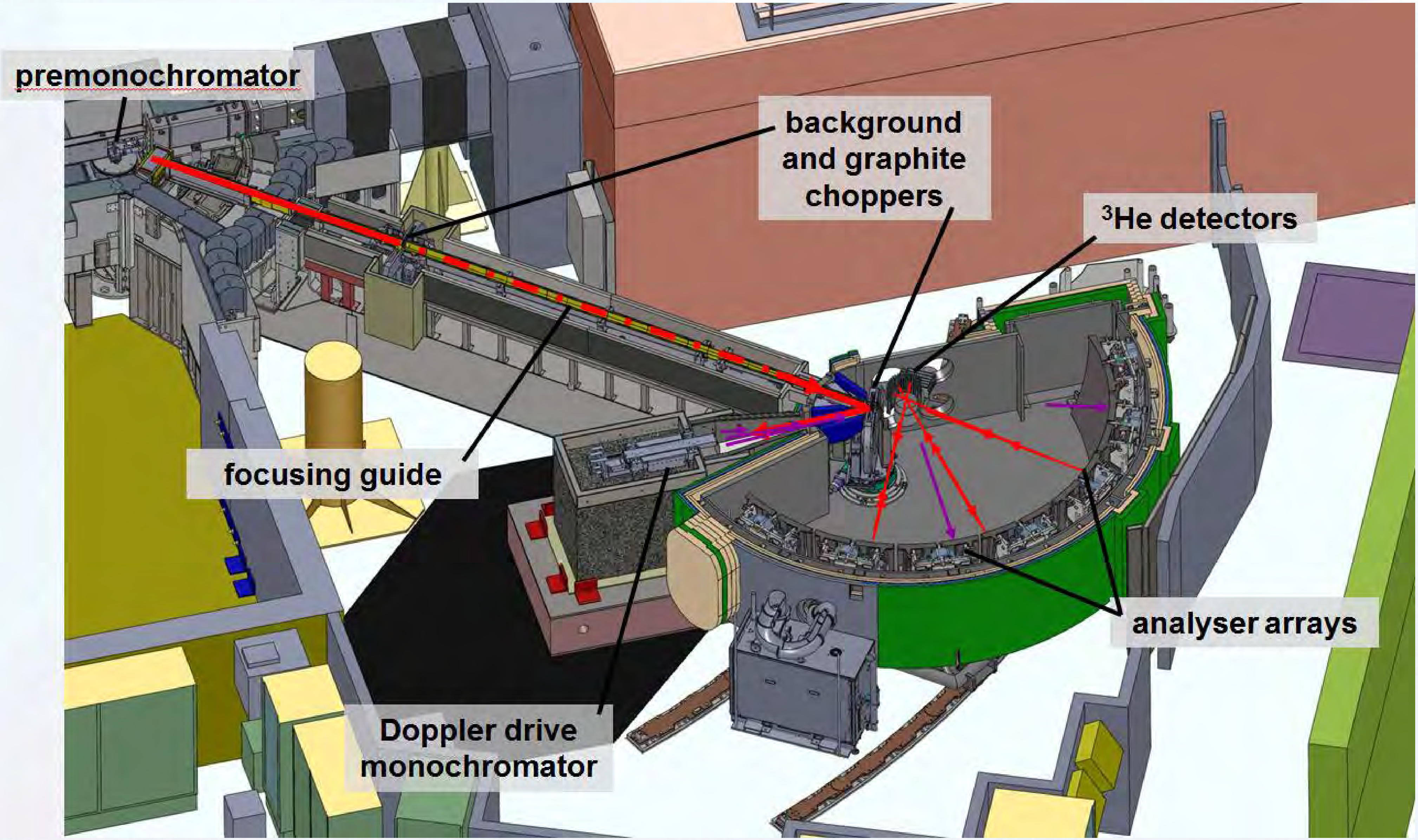


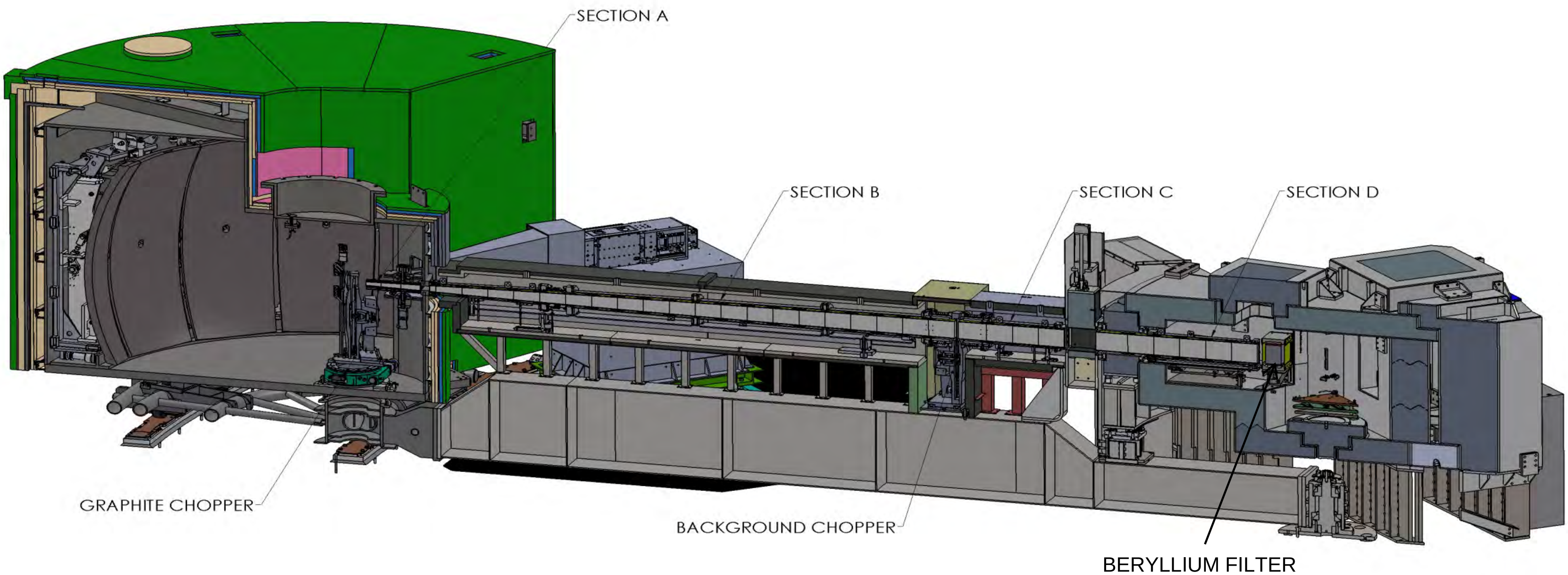
- Neutron Diffraction x 5
- Large Scale Structures x 5
- Inelastic Neutron Scattering x 4
- Radiography & Tomography x 1

Neutron Beam Instruments

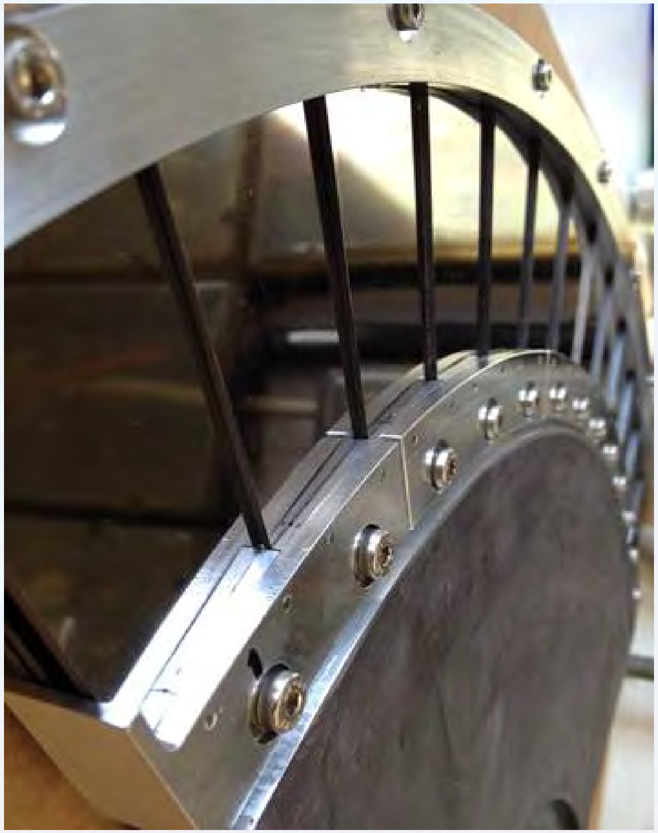
15 world-class neutron scattering instruments
(~$100 million capital investment)

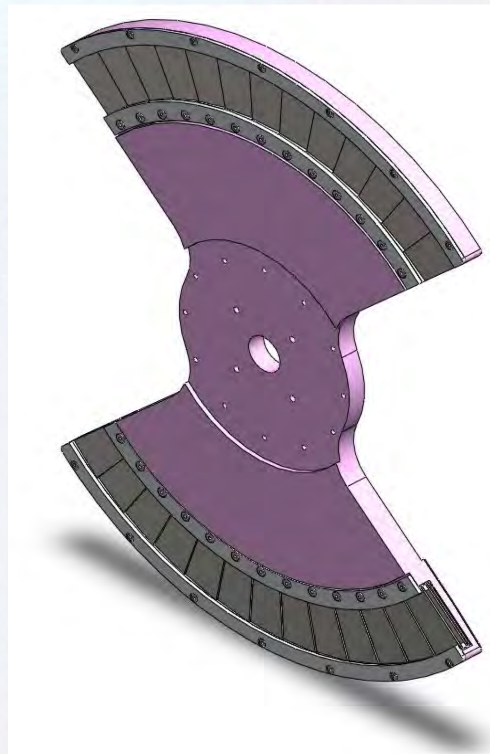


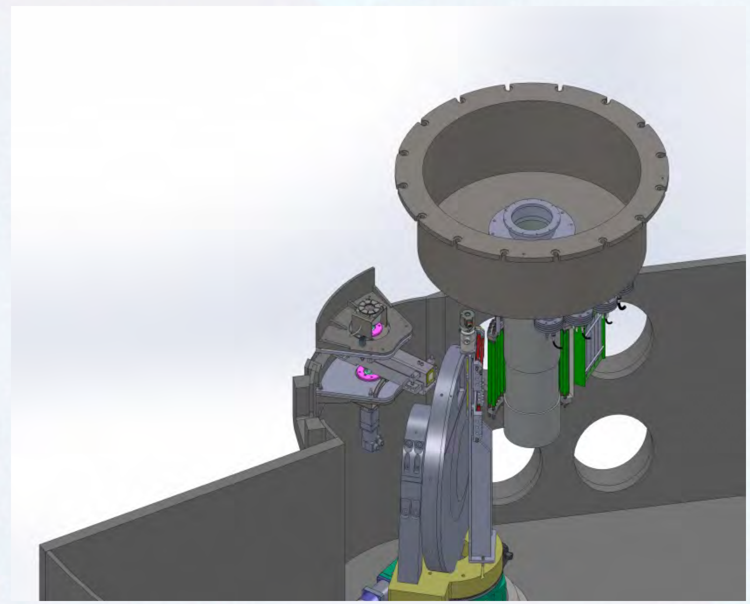

premonochromator
background and graphite choppers
^{3}He detectors
focusing guide
analyser arrays
Doppler drive monochromator


SECTION A
SECTION B
SECTION C
SECTION D
GRAPHITE CHOPPER
BACKGROUND CHOPPER
BERYLLIUM FILTER

Graphite Chopper with HOPG crystals at its periphery and cylindrical sample well insert locating the sample







Inside the Scattering-Tank: Si (111) crystal analyser arrays and cylindrical sample well insert installed

BM and its Doppler drive (left) and with shielding (right)

Acceptance Criteria

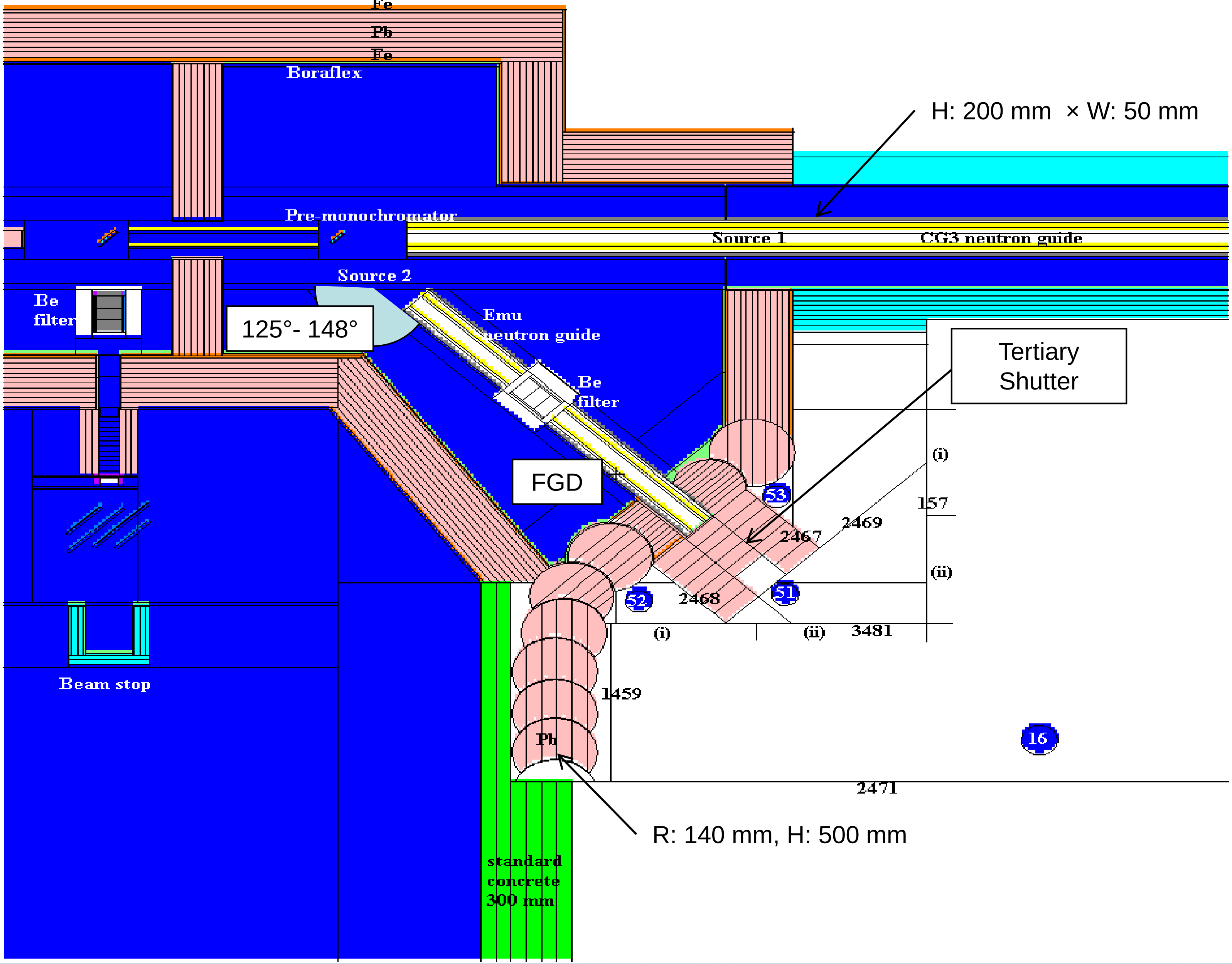
- Radiological safety – dose rate ≤ 3 μSv/h at external surfaces of shielding assembly (blue area)
- Floor load limit – < 20 tonnes/m^2
- Low cost
- For maintenance purposes "easy access" to components of the instruments

Monte Carlo method

- MCNP6 1.0
- explicit 3D representation of neutron beam instruments
- continuous energy representation
- comprehensive treatment of many physical interactions
- results limited by statistical fluctuations
- large set of powerful variance reduction techniques

Neutron Sources

1. Maxwellian (T=20 K) – mono-directional along guide axis (1×10^{12} $n.s^{-1}$)
2. Energy spectrum from pre-monochromator (1×10^{10} $n.s^{-1}$)
3. Two downstream mono-directional beams (2.08 meV and 2.67×10^{9} $n.s^{-1}$; 1.52×10^{9} $n.s^{-1}$)
4. Neutrons directed towards BM (2.08 meV and 7.66×10^{8} $n.s^{-1}$)
5. Mono-directional beam (sample) – radius 0 to 5 mm (2.08 meV and 1.09×10^{7} $n.s^{-1}$)



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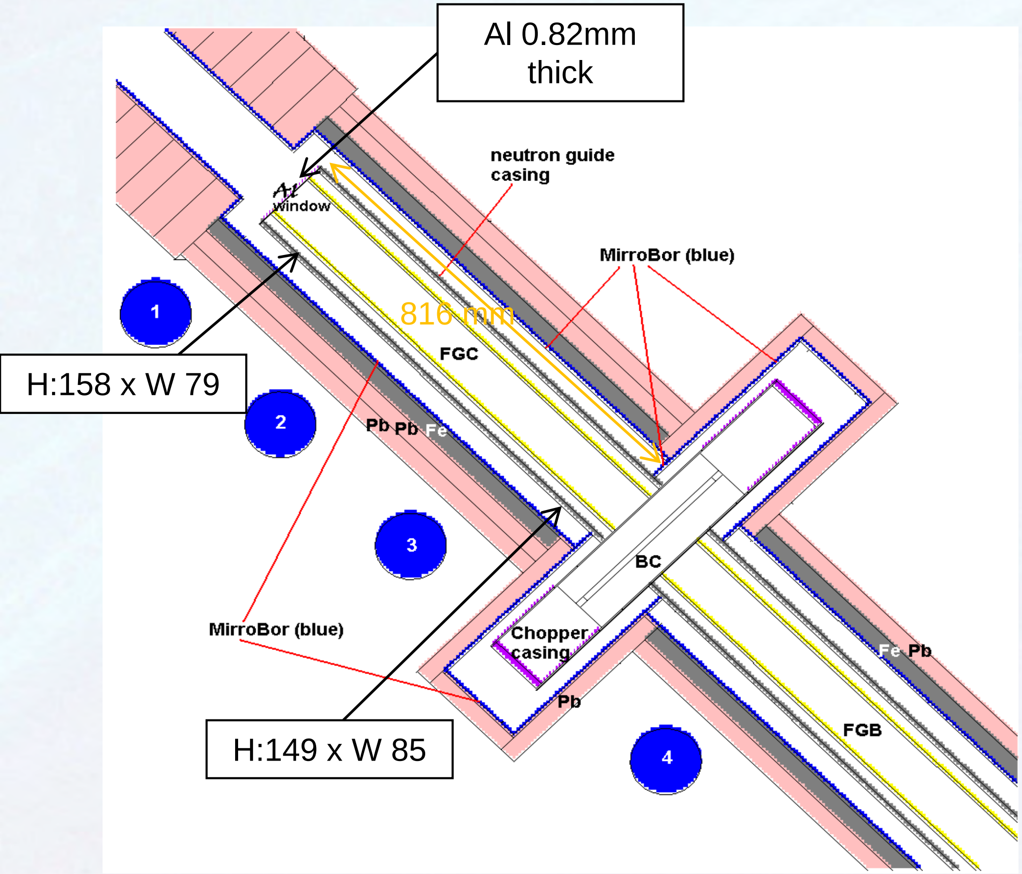
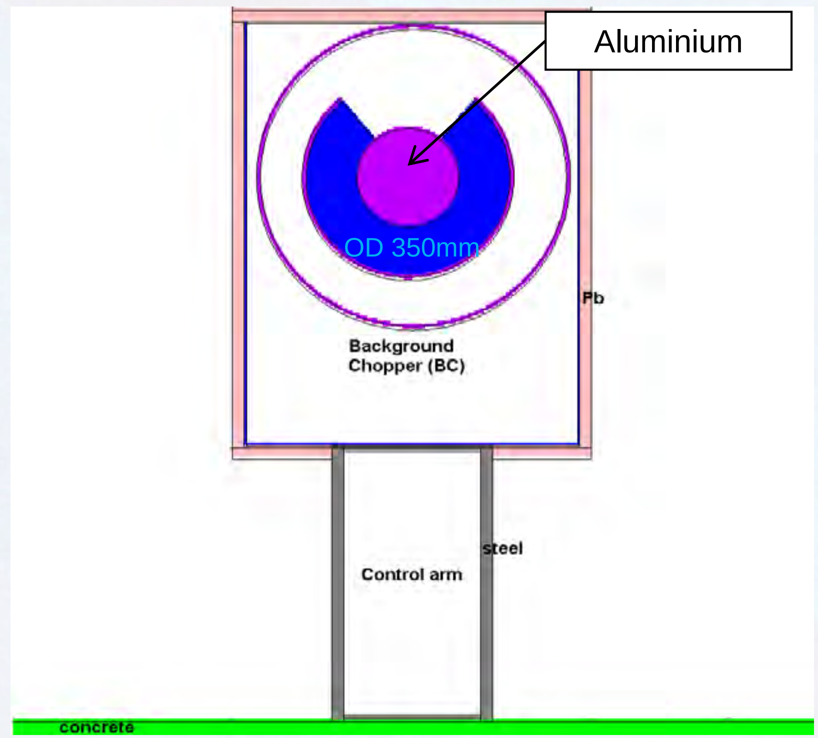
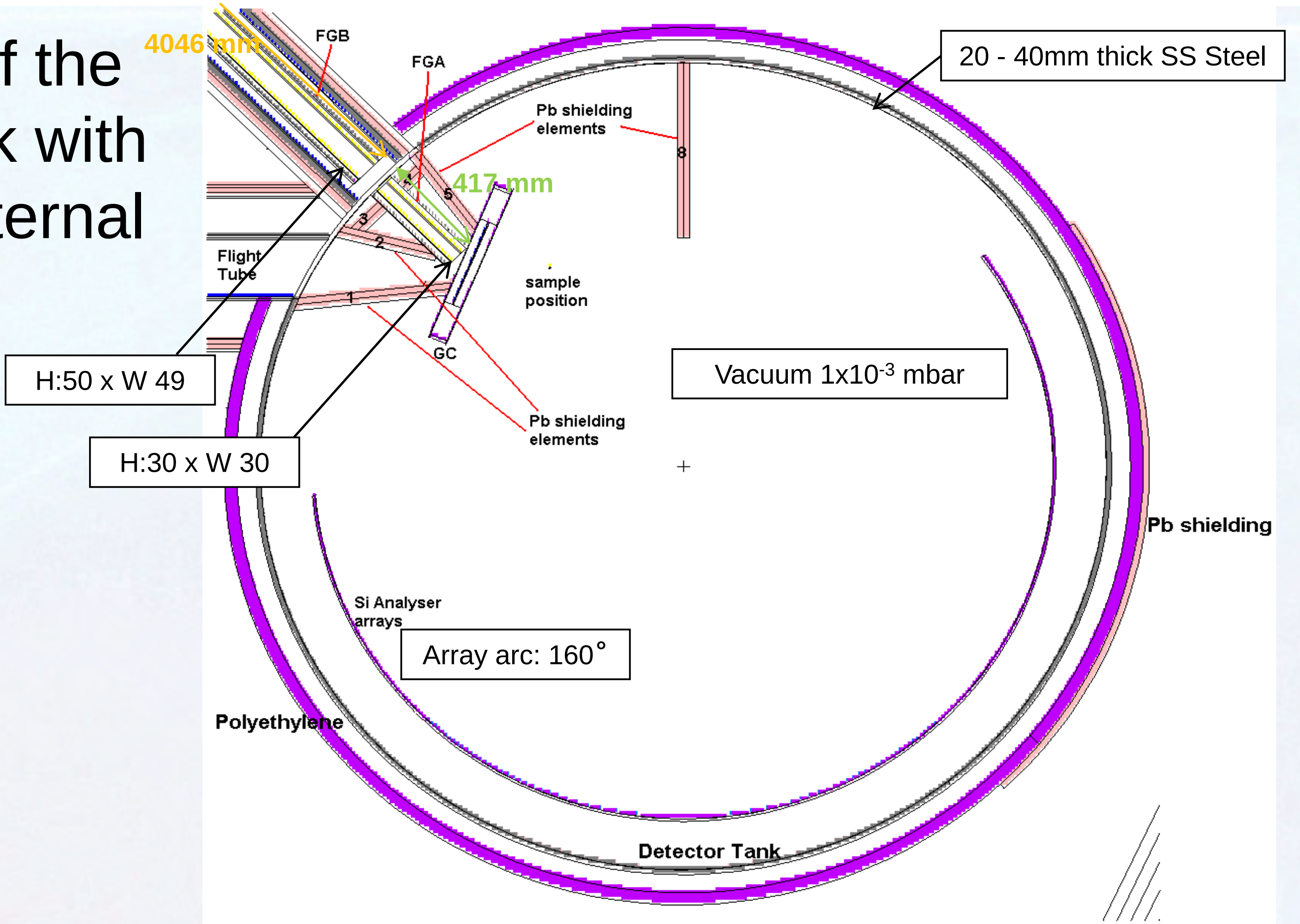
MCNP model of the FGB, FGC and BC surrounded by MirroBor™, Fe and Pb shielding

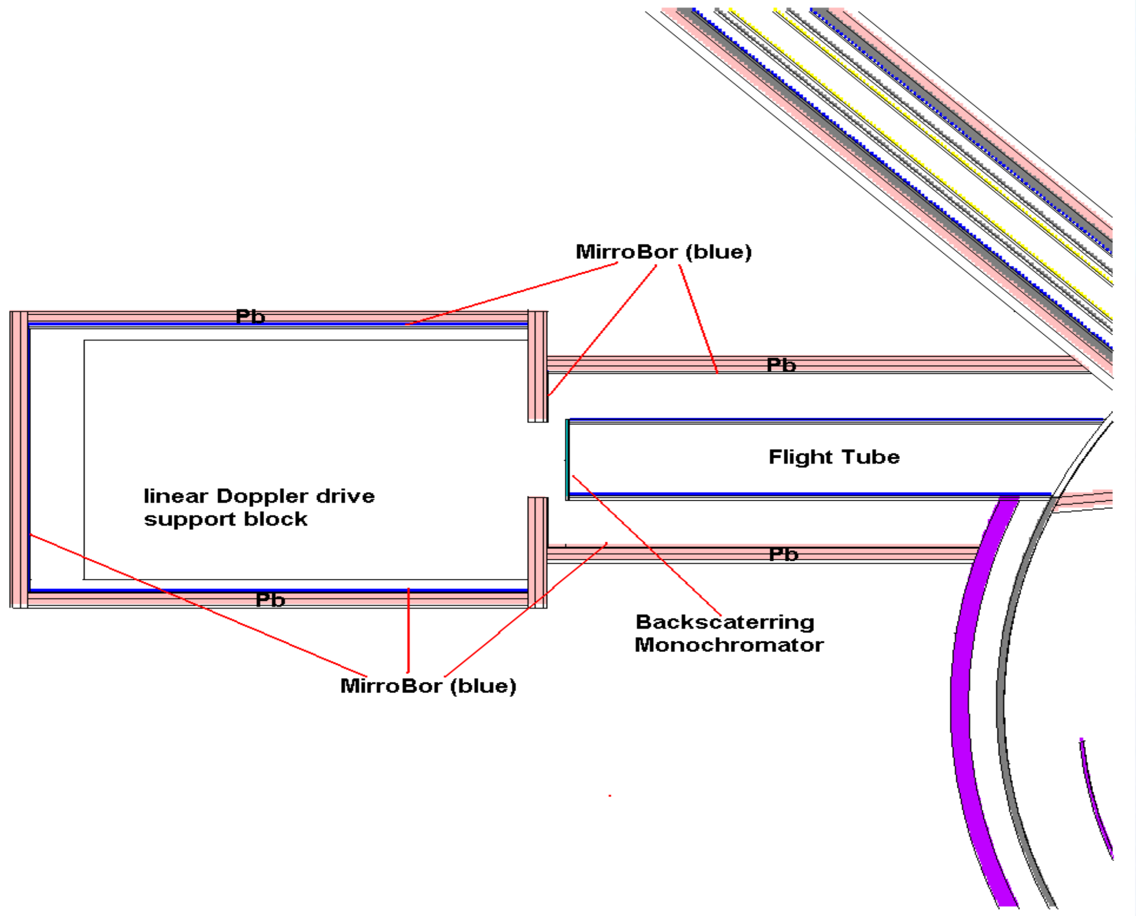


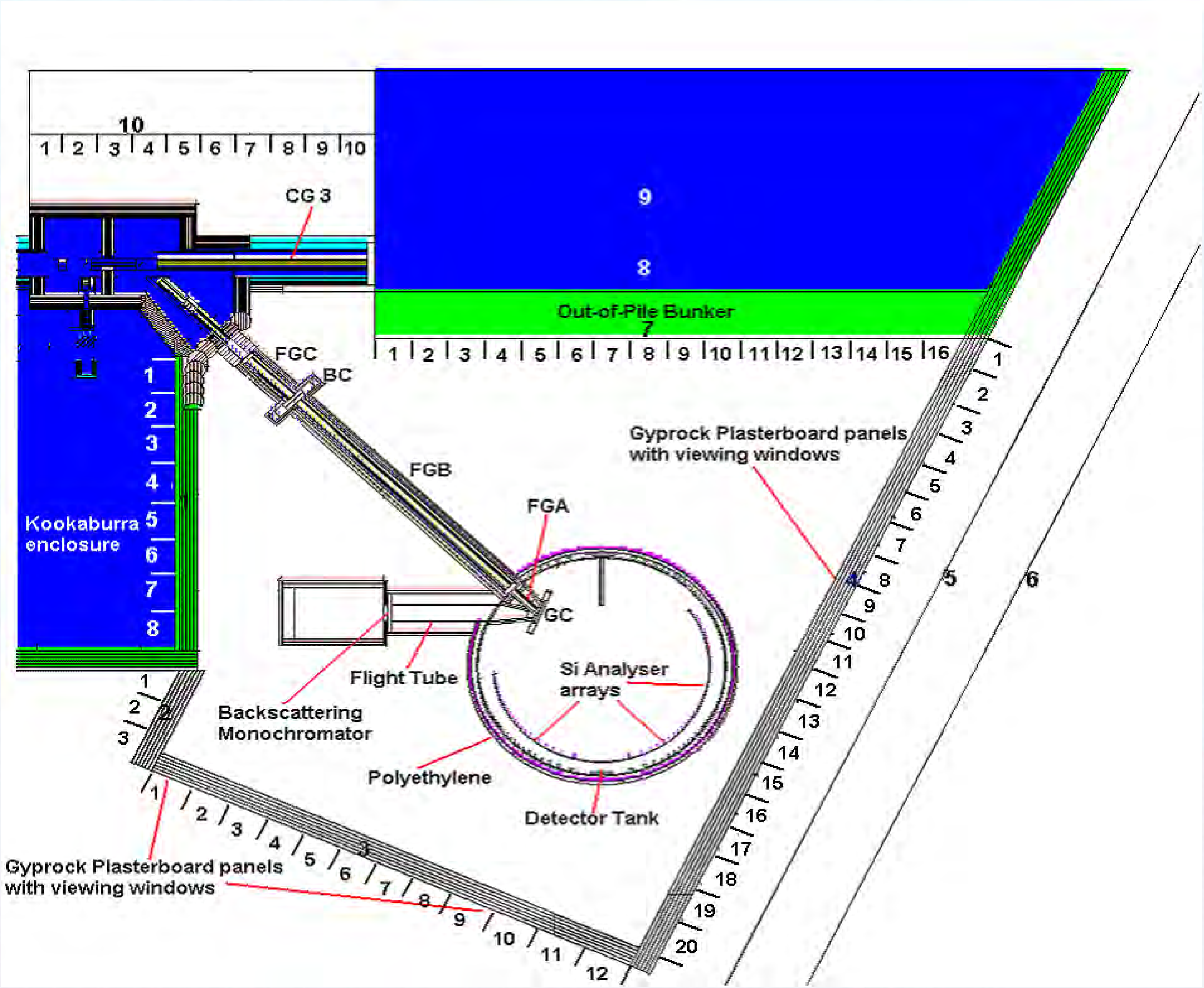


MCNP model of the Scattering-Tank with external and internal shielding

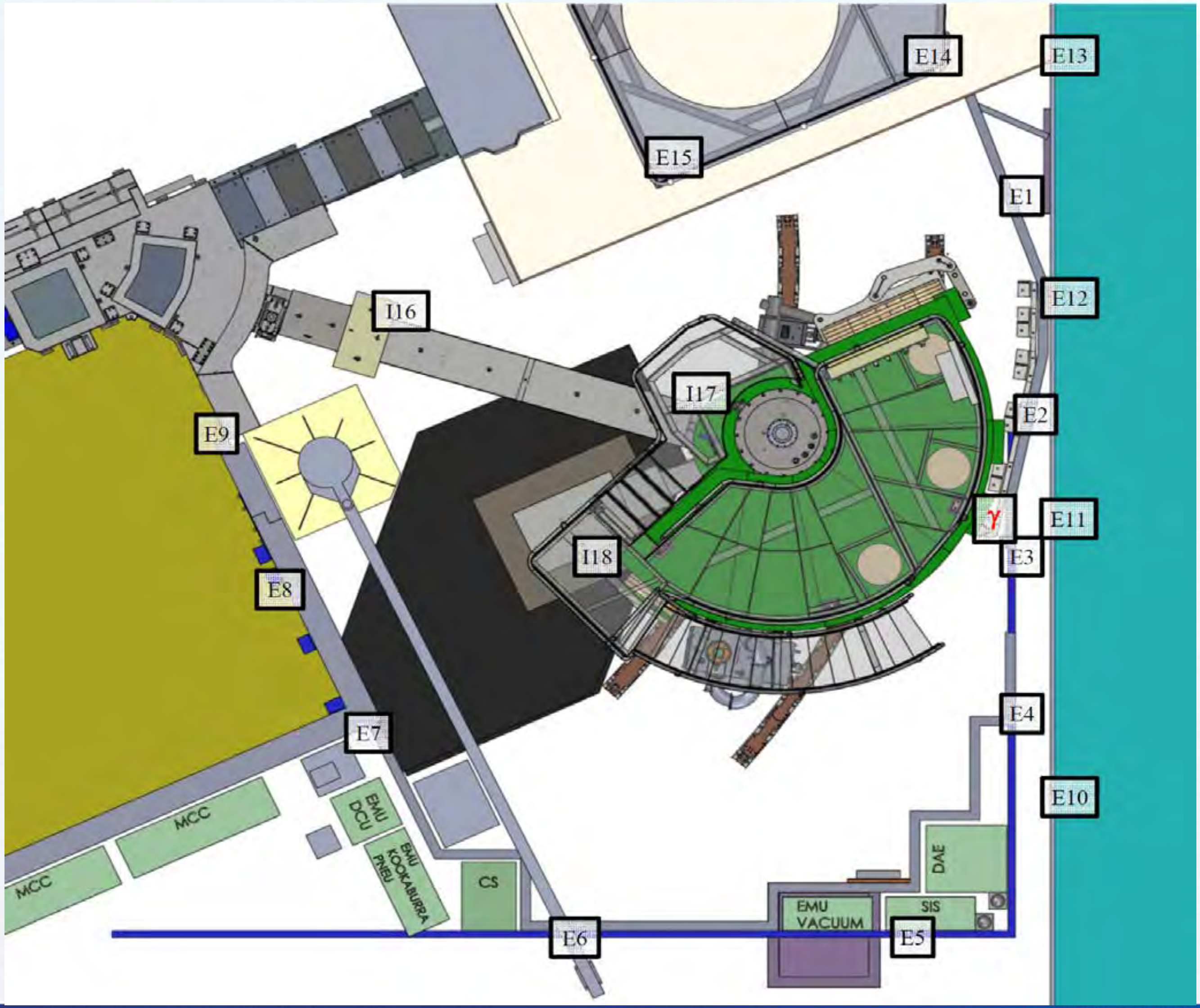


MCNP model of the BM and its Doppler drive with external and internal shielding




CG 3
Out-of-Pile Bunker
FGC
BC
FGB
FGA
GC
Kookaburra enclosure
Gyprock Plasterboard panels with viewing windows
Si Analyser arrays
Flight Tube
Backscattering Monochromator
Polyethylene
Detector Tank
Gyprock Plasterboard panels with viewing windows

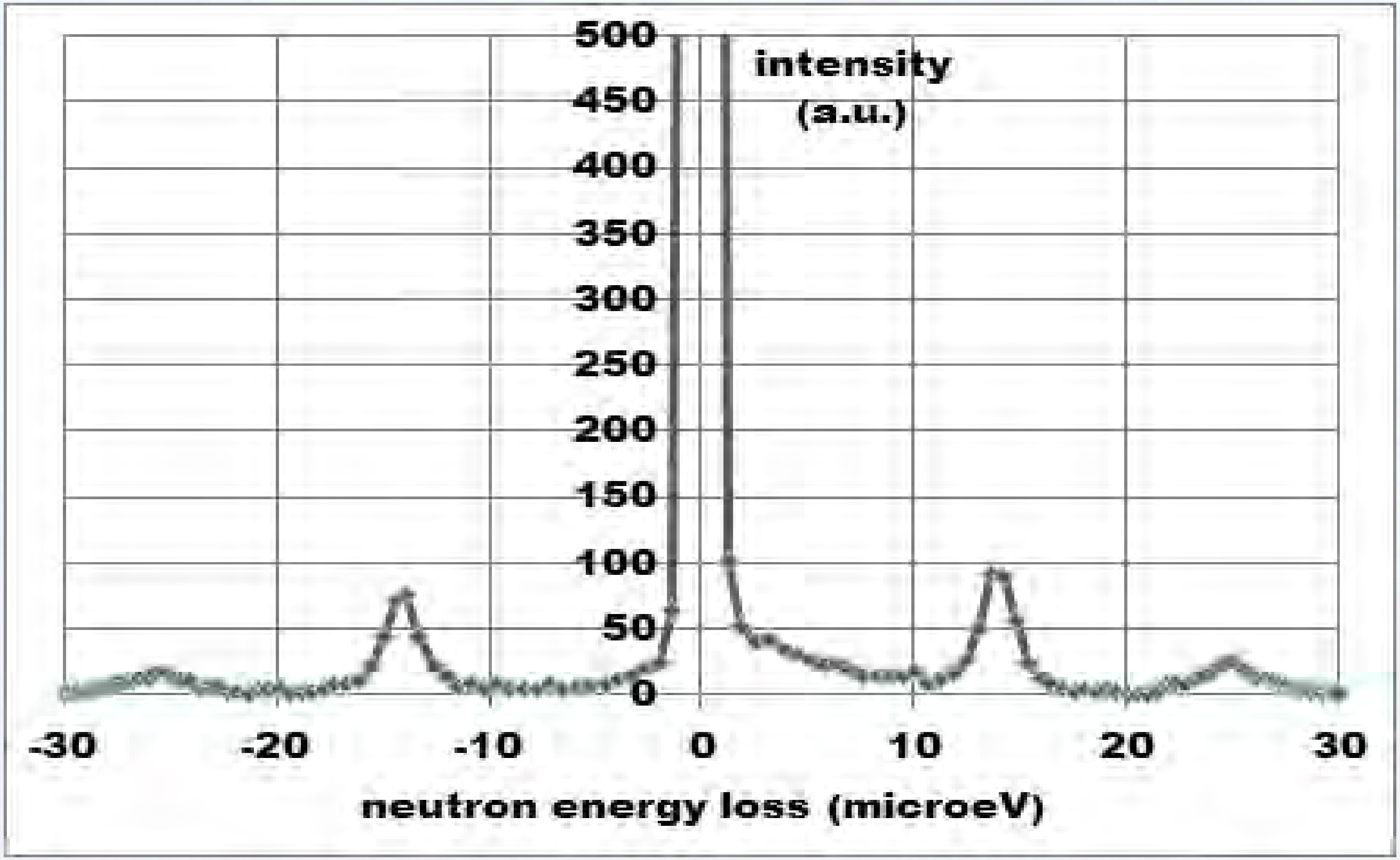
Radiation Base Points and Dose Surveys



Primary and secondary shutters open, tertiary shutter closed, maintenance beam stop in place, chopper system stopped (BC and GC fully open)

RBP	neutron	photon
E1	0.0	3.1
E2	0.0	0.3
E3	0.0	0.2
E4	0.0	0.2
E5	0.0	0.2
E6	0.0	0.1
E7	0.0	0.1
E8	0.0	0.2
E9	0.0	0.3
E10	0.0	0.5
E11	0.0	0.7
E12	0.0	0.6
E13	0.0	2.3
E14	0.0	2.0
E15	0.0	1.7
I16	0.0	0.6
I17	0.0	0.8
I18	0.0	0.2
GRM-1		0.6
GRM-2		0.5

First quantum rotational tunnelling spectra from EMU of m-xylene measured at 3 K



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Thank you

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