Australian Government

ansto

Nuclear-based science benefiting all Australians

Optimising instrument designs for ease of use, maintenance and future upgrades.

Scott Olsen (Bragg Institute, ANSTO, Australia)

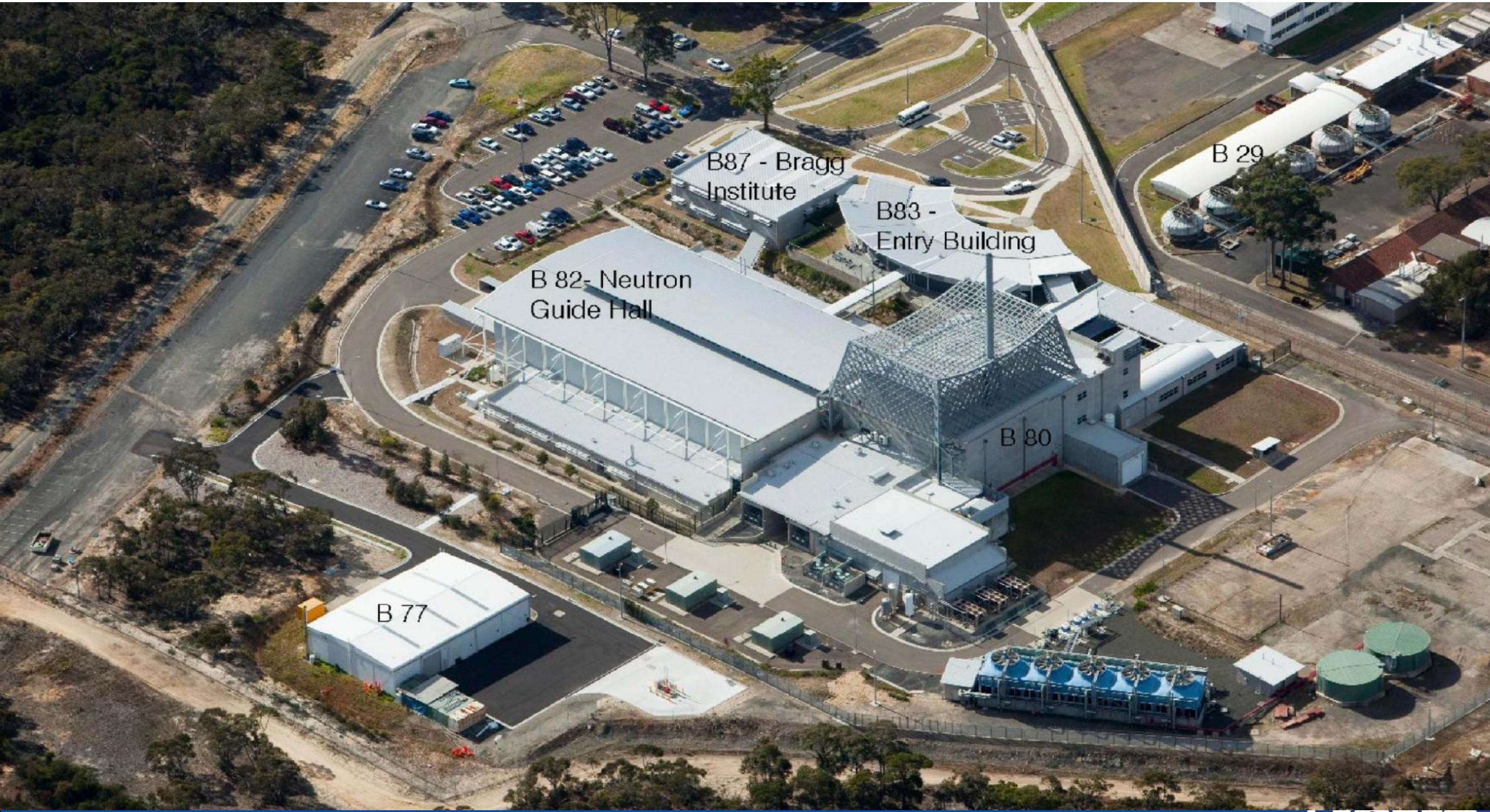
DENIM 2015, Budapest Hungary Sep 7-9 2015.

OPAL – 20 MW Reactor, Sydney AUS

- A variety of projects are underway to improve the initial 7 instruments by.
  - a) reducing maintenance time
  - b) improved flux on the sample
  - c) improving detector efficiencies and
  - d) reducing the set up and change over time between experiments.

- Automated sample changers for the diffractometers.
- Neutron optics upgrades for the strain scanner.
- Two new detectors on order for the SANS and the Reflectometer
- A series of upgrades to the thermal triple axis instrument.

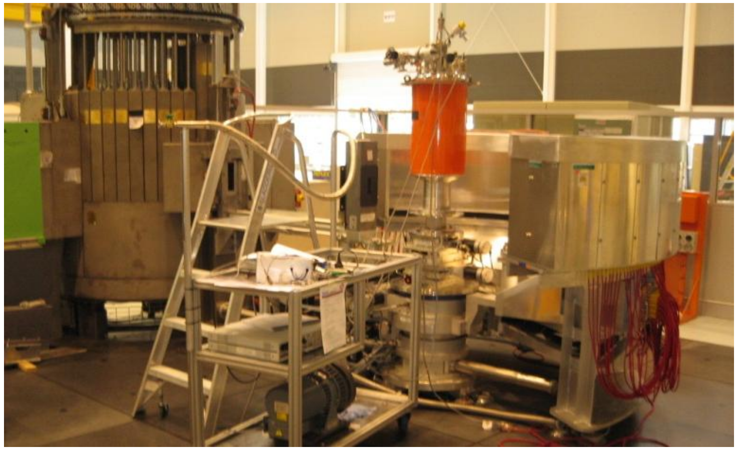
OPAL Research Reactor (2008 image).



Diffractometers

- All came on line in 2006/7.
- Named after Australian animals.

Echidna (HRPD)
High Resolution Powder Diffractometer



Wombat(HIPD)
High Intensity Powder Diffractometer

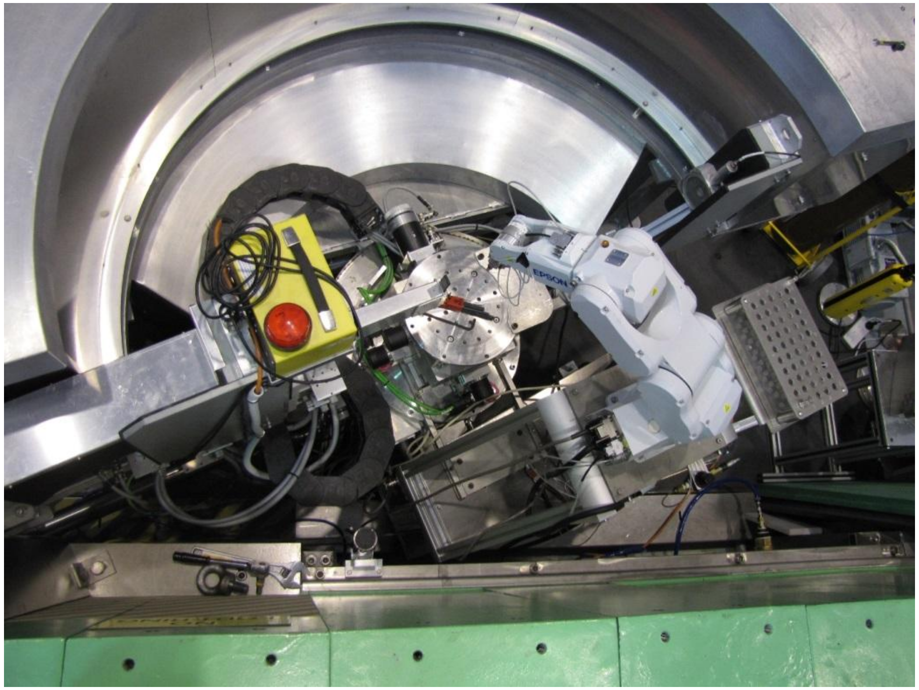
KOALA
Quasi-Laue Diffractometer

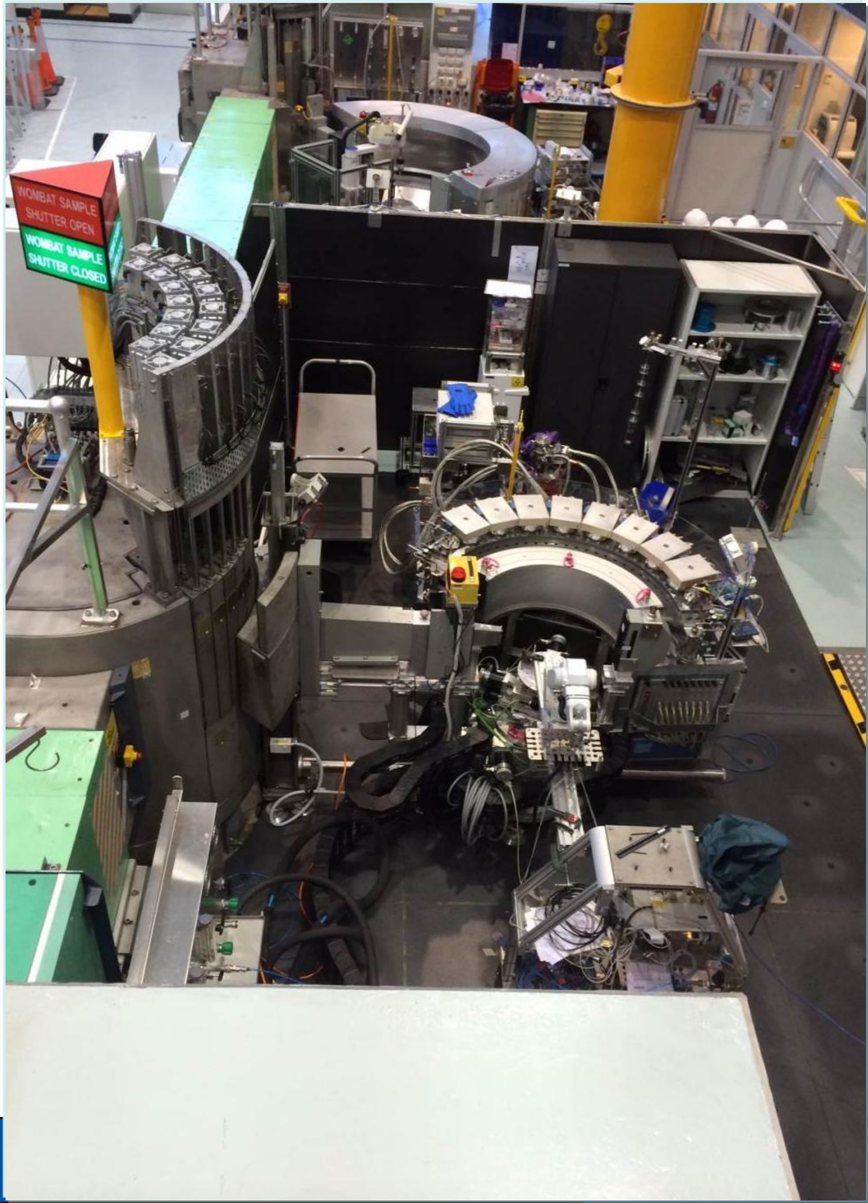
Echidna – HRPD - Automation and higher take off angles

- 4 axis pick and place robot installed 2009.
- 100 sample positions available.
- Mail-in sample system in place.
- Load Friday unload Monday.
- However – restricted available angle for the instrument.

A 100-position robotic sample changer for powder diffraction with low-background vacuum chamber
SR Olsen, SA Pullen, M Avdeev - Journal of Applied Crystallography 43 (2), 377-379

General purpose 6 axis robot with small footprint.





- No space for physical barrier.
- Robot interlocked to instrument Safety Interlock system.
- Robot has a loss of power if a door opens or light curtain broken.
- Cage and dead man switch for off line testing
- 6 axis robot also available for texture measurements on the strain scanner and HIPD.

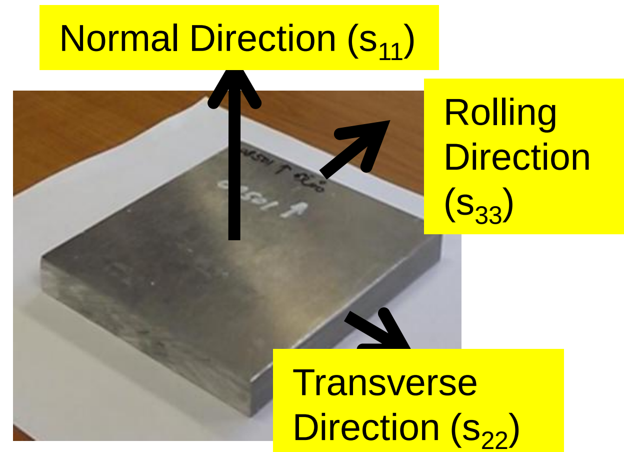
Kowari

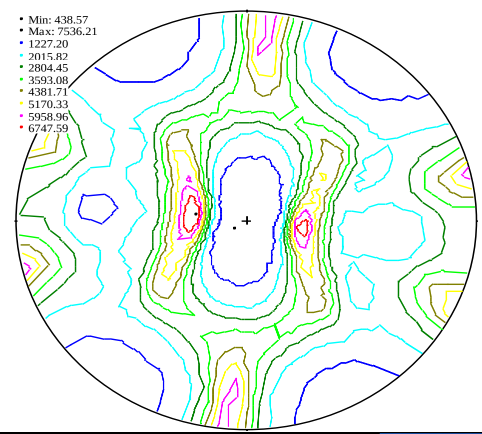
Residual Stress Diffractometer

APPLICATIONS

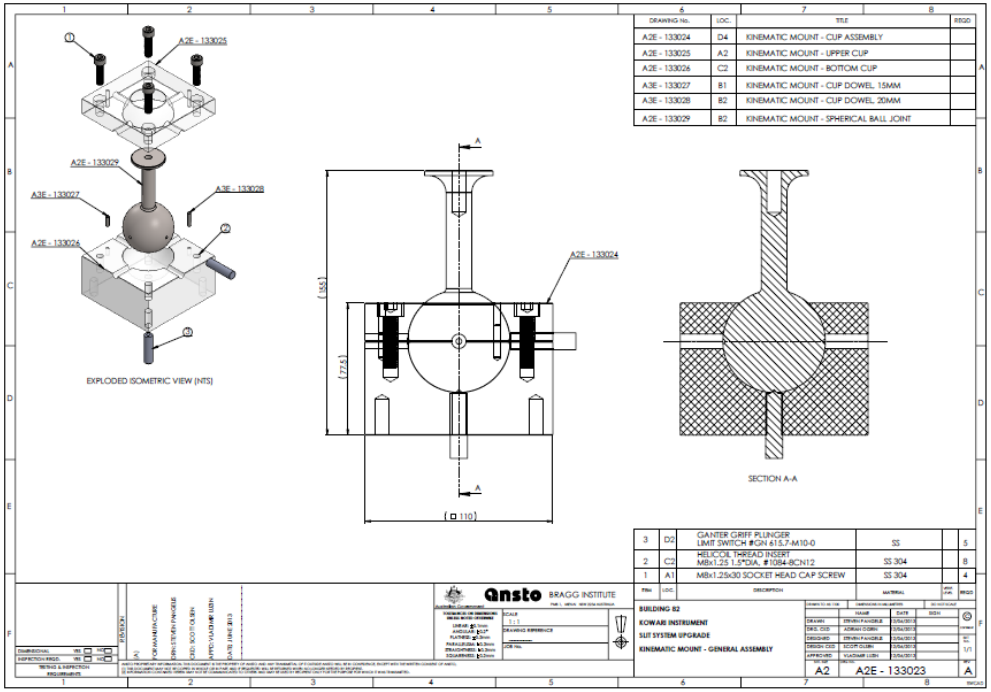
Internal and residual stresses:

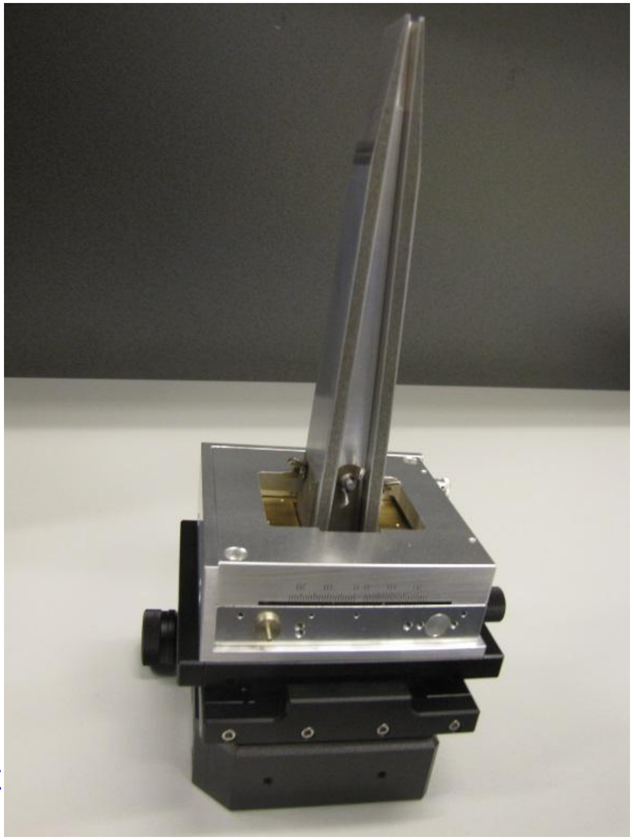
- Effect on material properties including fatigue resistance, creep resistance, fracture toughness and strength.





KOWARI Strain Scanner Optics Upgrades



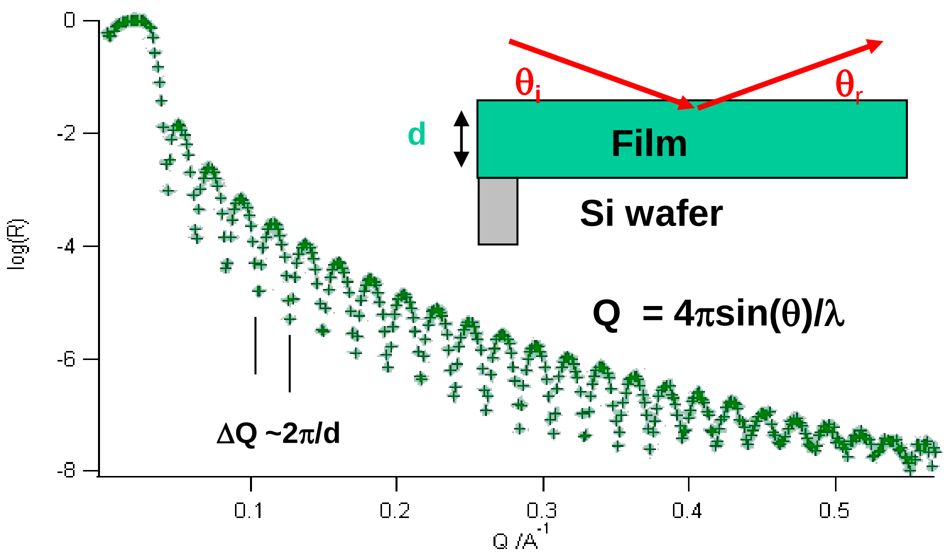


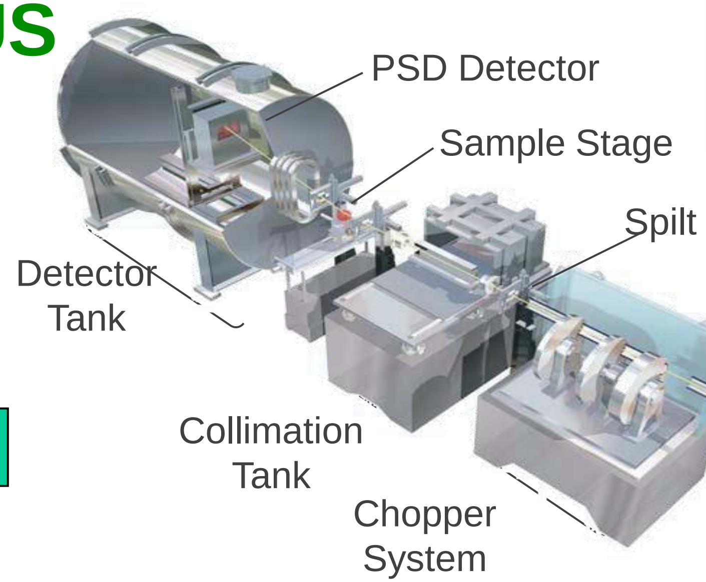
- Issue – Changing slits was a slow difficult manual process, easy to ruin alignment
- Step 1 – Design rotation stage that can swing 360 degrees and lock into position
- Step 2 – Prevent damage to slits and aid alignment with spherical ball & lock pins
- Step 3 – Design new slits with narrow footprint but easily adjustable in size and direction & still neutron absorbing.
- Step 4 – Test collimators from JRR-3 (Japan) –based on calcuation of flux and strain error a set of 4 collimators was ordered 2013 and installed in 2014.
- Lessons learnt – Need agreement from all relevant instrument scientists ☺

- Collimators under optical testing in Japan.
- As installed on Kowari.
- Image of Kowari showing the rotation arm, slits and ball and socket to aid alignment.

Reflectometer - PLATYPUS

Neutrons are reflected off a surface or interface to characterize the structure of surfaces and thin layers.





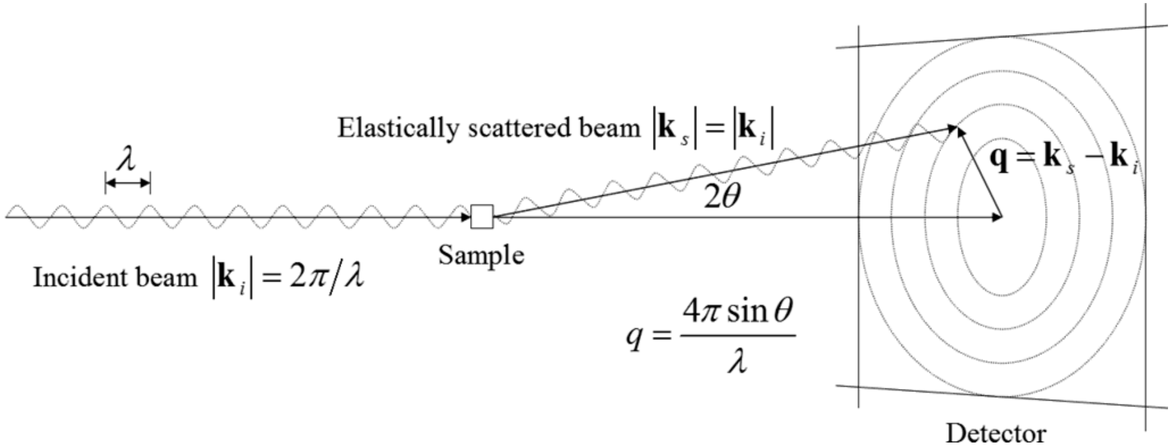
Non-volatile Magnetic Memory

New Generation Computer Hard Drives

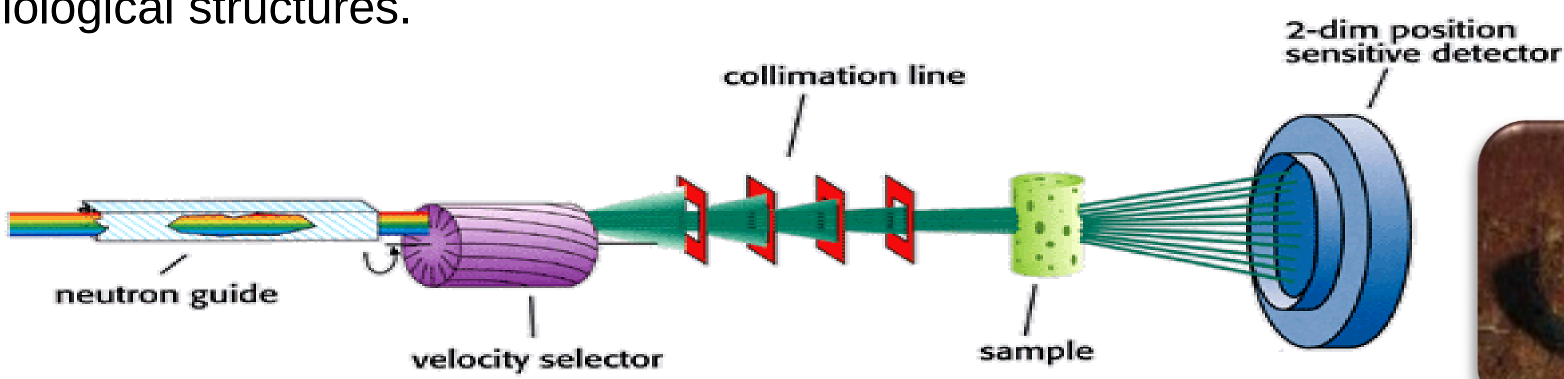
Applications

- Free-liquid surfaces
- Solid thin films
- Solid-liquid interactions
- Magnetic multilayers

Small Angle Neutron Scattering - QUOKKA



Measurement of neutron scattering at small angles used to investigate structures with large interatomic distances (atoms far apart) such as polymers or biological structures.

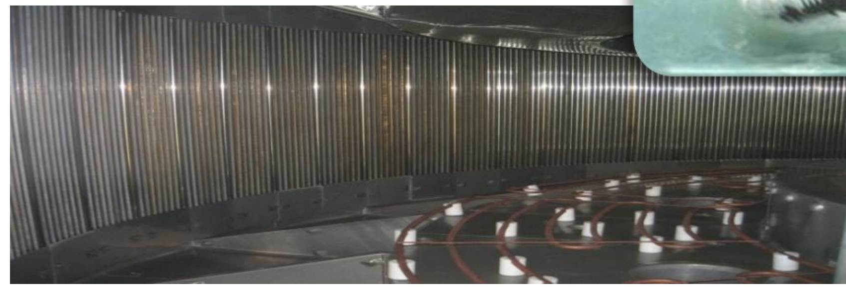


Detector upgrades for Platypus (Reflectometer) and Quokka (SANS)

- New Quokka 1m^2 pad detector, USD $2.2M, BNL. Due end 2016
- Similar resolution, Count rate up to 10k/pixel, 200x200 pixels. Expected 20x increase in count rate.

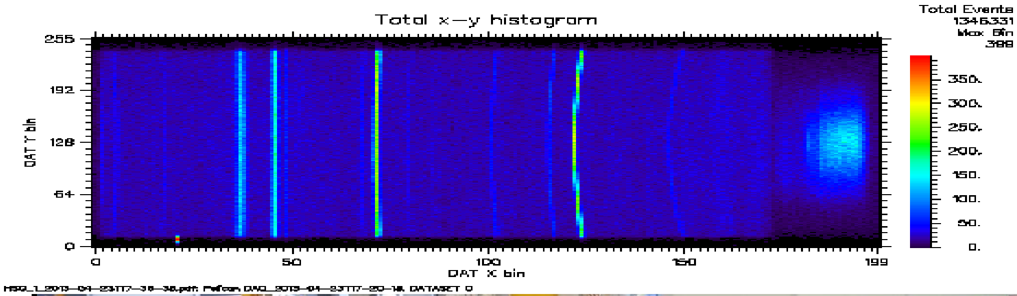
- New Platypus detector USD$0.9M due 2017.
- Current detector has dead time (single wire), max count rate is specified at 1MHz, reality 0.1MHz.
- Less parallax due to thinner window, higher gas pressure, thus higher efficiency, no cross talk. 10kHz / wire.
- Both purchased to stay at the forefront of technology.
- Lessons learnt: IP issues surrounding new technology designs!!

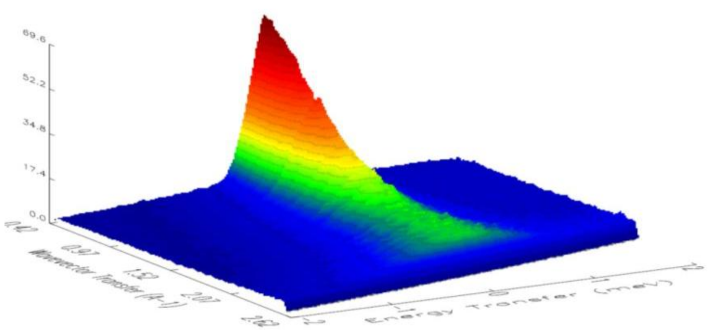
Time-Of-Flight Spectrometer – PELICAN

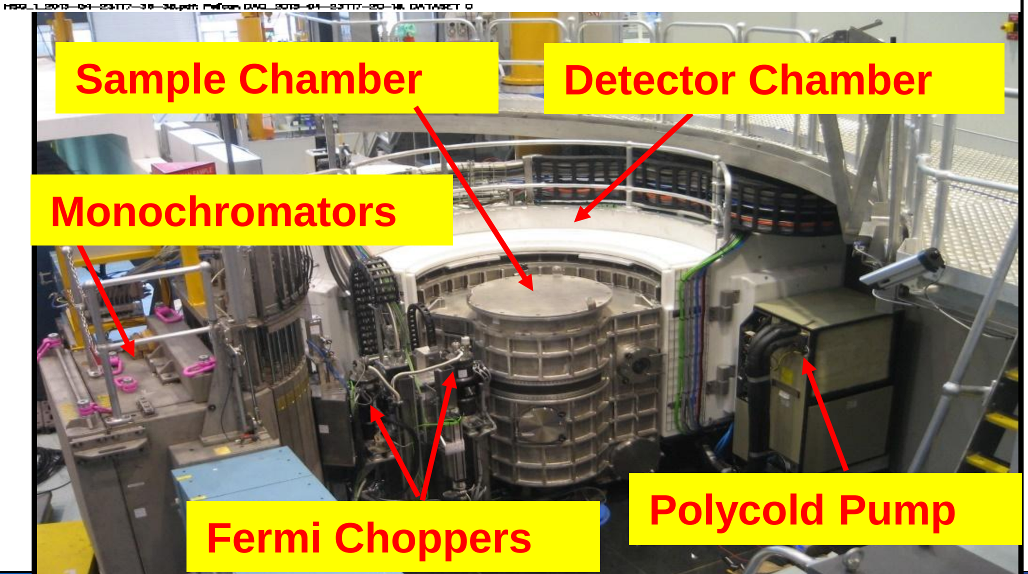


Issue

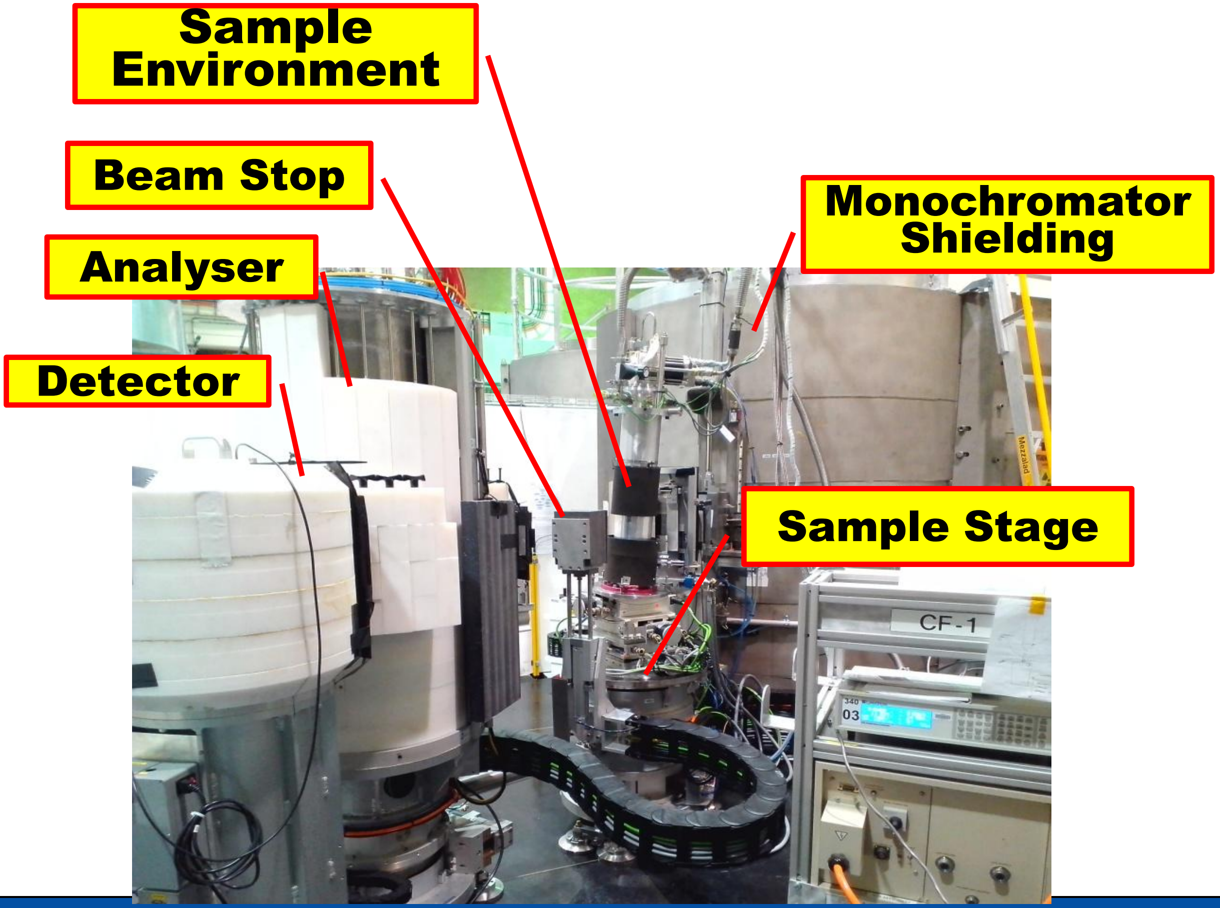
- **SNR ratio critical.**
- **On going process of shielding upgrades.**
- **Watch the effects of loading of optical rails and air pad systems.**
- **Pin pointing sources of Neutrons is hard, watch for secondary neutrons.**
- **Key lesson learnt – late change to fermi choppers (Cd to Gd) caused shielding issues – not feedback into simulations.**

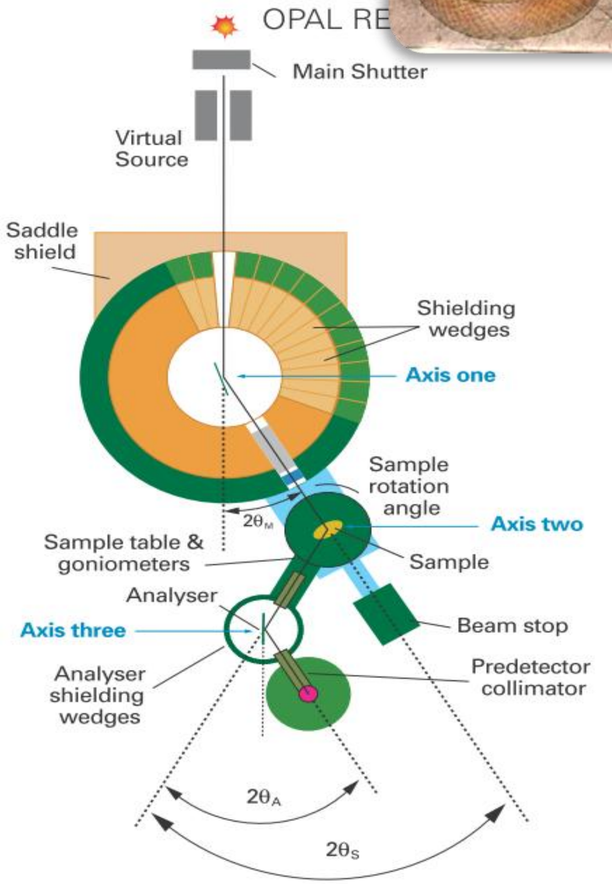




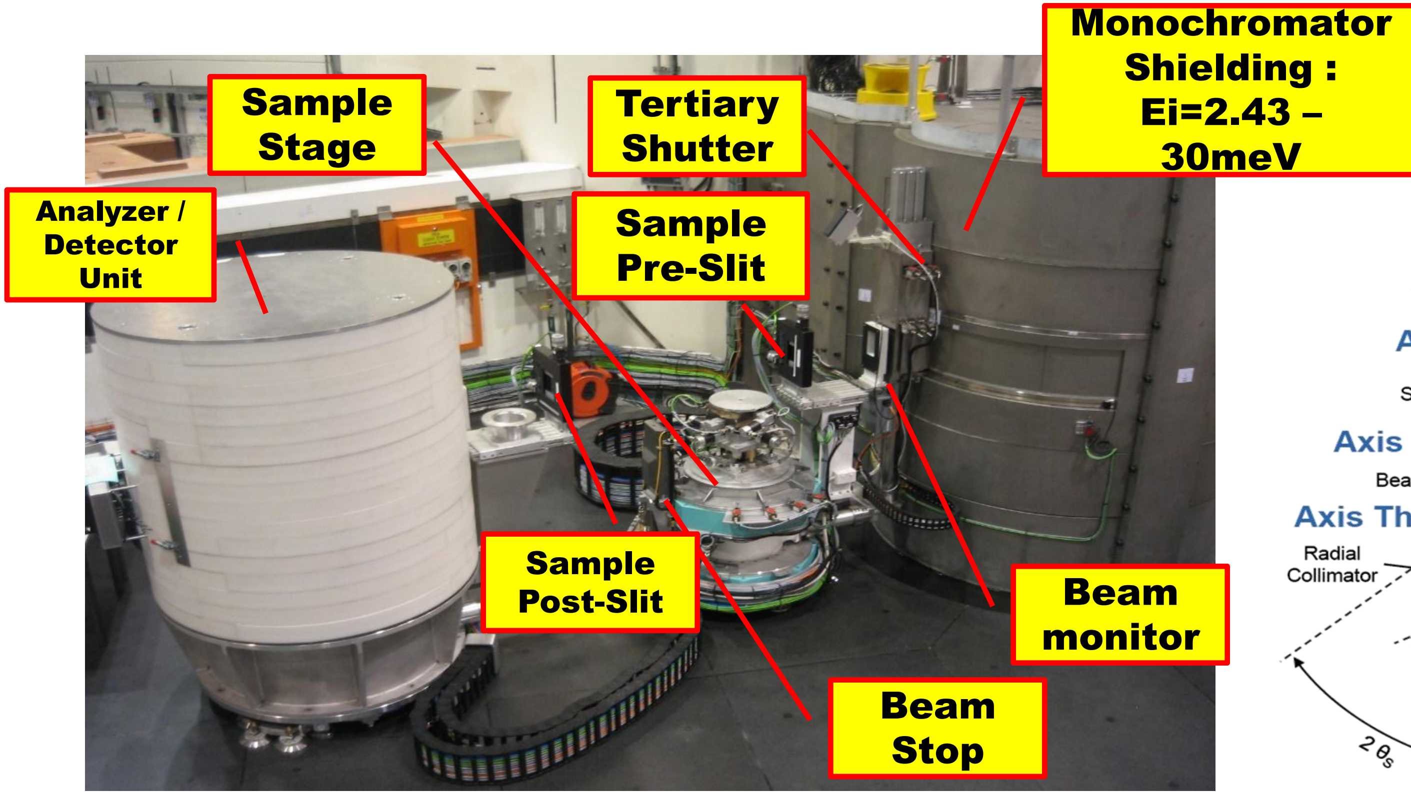


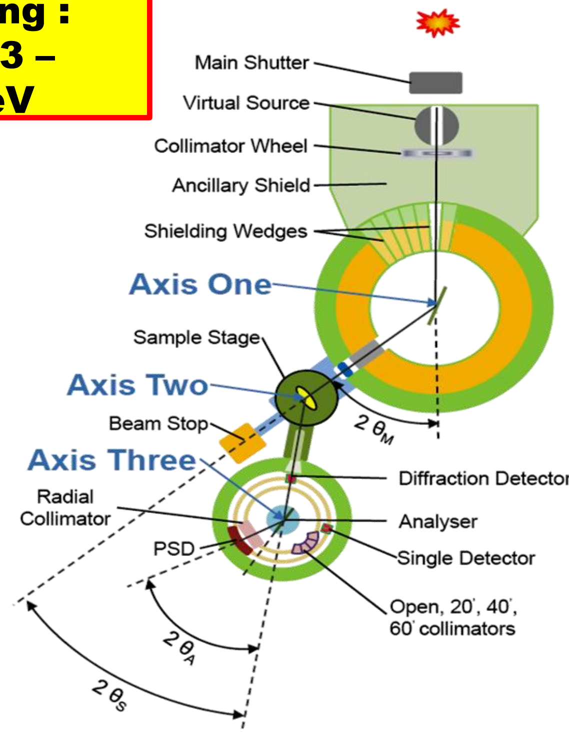
Thermal Triple Axis Spectrometer - Taipan



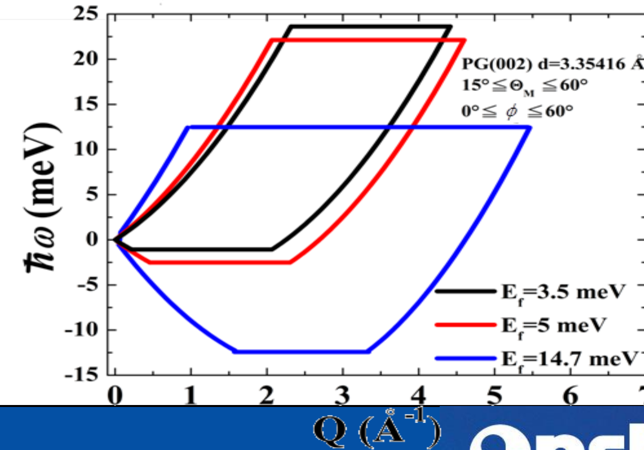


Cold Triple Axis Spectrometer – SIKA

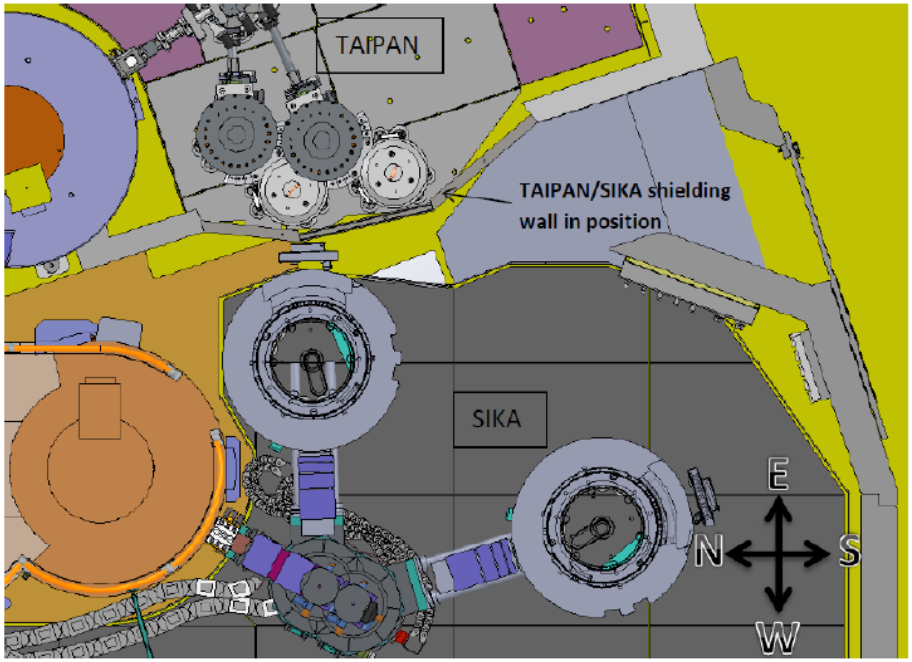




- Built and operated by Taiwan.



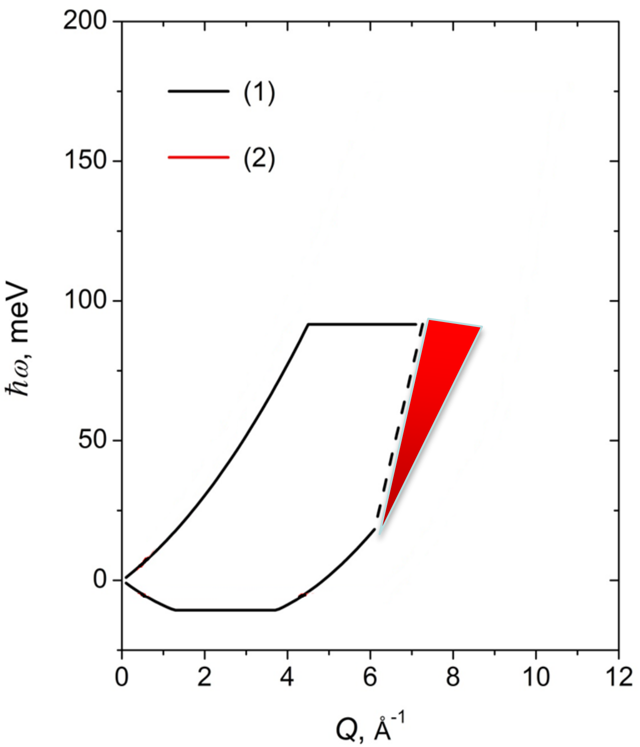
Issue – Restriction in 2Θa and 2Θs for Taipan



- Issue – Enclosure Wall - limitation in momentum transfer at higher incident Energies
- Step 1 – Remove concrete wall. Design more compact Steel/Pb/Steel wall
- Step 2 – Seismic calculations as the load on a suspended floor increased
- Step 3 – Additional dance floor. Keeping slope < 50um/m and steps below 50um.
- Lessons learnt – Neutron detection – insensitive to low energy neutrons.
- Outcome – reasonable increase (in red, see over)

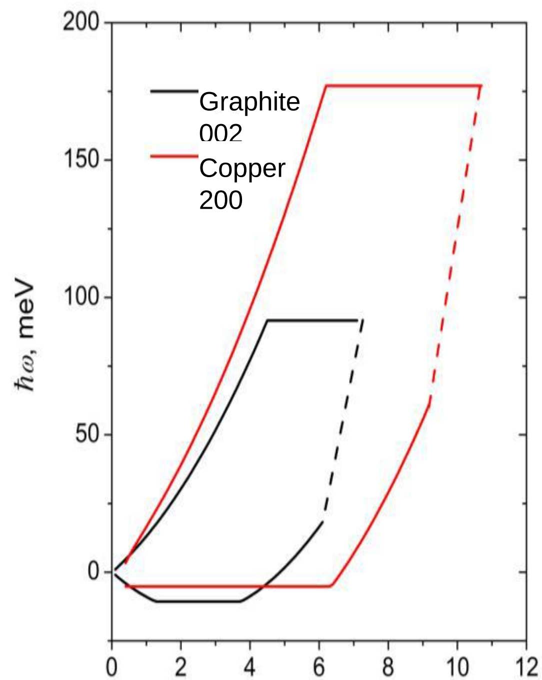
Increase in Incident Energy & Momentum Transfer

1. **Approval in 2014 for a new Copper monochromator.**
2. **Requires the design of a double mono stage and removal of a sapphire (high energy filter)**
3. **Existing area has high dose rates (>1mSv/hr)**
4. **Installation due mid 2016**

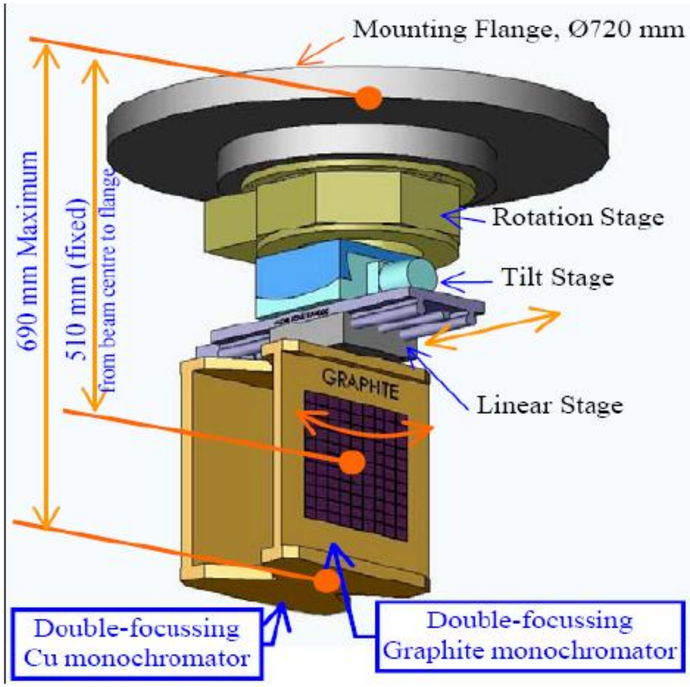


Additional transfer range

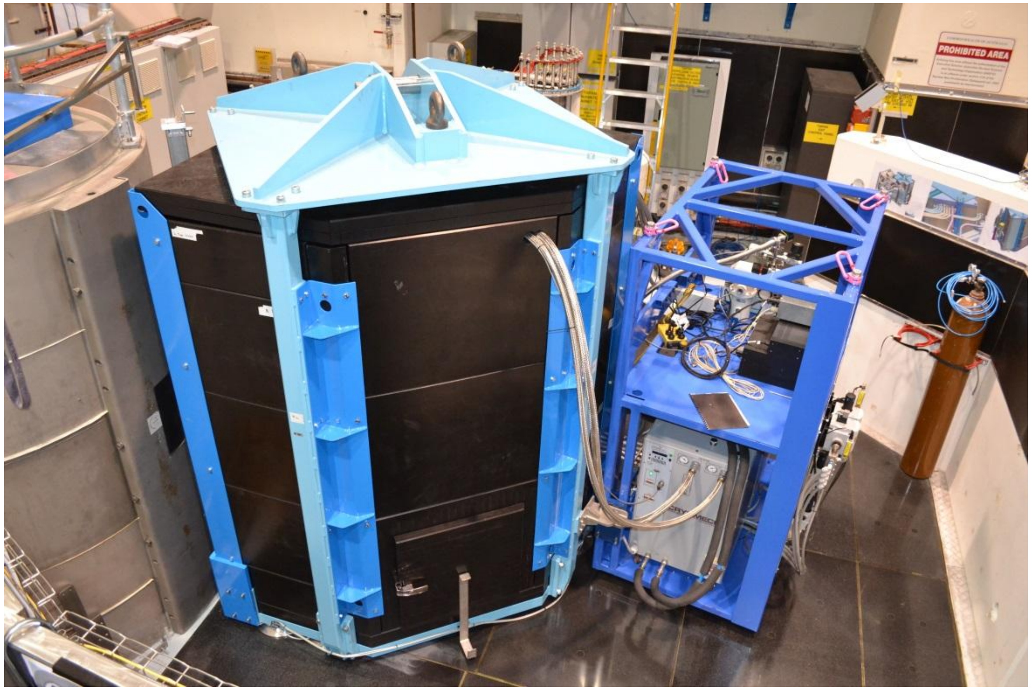
Energy transfer



Momentum transfer



Installation of a dedicated BE Filter option for Taipan



- A US$3M project was approved in 2009.
- Hot commissioning in 2014 – first users July 2015
- The Triple axis spectrometer is moved out of the way when the Be Filter is installed.
- The Be Filter uses a large assembly of cooled polycrystalline beryllium transmission filters along with graphite and bismuth.
- Only very low-energy neutrons are transmitted.

- Issue – Size and weight of the Filter/
- Step 1 – Filter design, significant trade off between shielding and accessible angles.
- Step 2 – Required very $$$ air pads, (50um lift on 2000kg per aid pad).
- Step 3 – Vastly larger detector means stray neutrons caused SNR issues, challenge to pin point source.
- Lessons learnt – Integration to existing instrument a challenge, requires project team and instrument operation team to work closely. Original time frame and budget significantly underestimated integration costs.
- Outcome – First happy users 6 weeks ago.

Asset Management Planning…

- **Currently required tool for money for upgrades.**
- **Important in considering the 20-40 year life of an instrument.**
- **Condition monitoring (oil/water etc) now used as a preventative maintenance strategy.**
- **In certain cases run-to-fail is valid – eg the operating cost of replacement parts & labour per year is high**

5S Organisation System being implemented

Before (Oct09)

After (Sep13)

Area – the same. Instruments & Equipment doubled.
Therefore 5S was introduced to optimise operations.

5S methodology

- **From the Japanese words for Sort, Shine Standardise, Straighten, Sustain**
- **Slowly being implemented in the Neutron Guide Hall.**
- **Saves time in hunting around for parts.**
- **Everything has a home!**

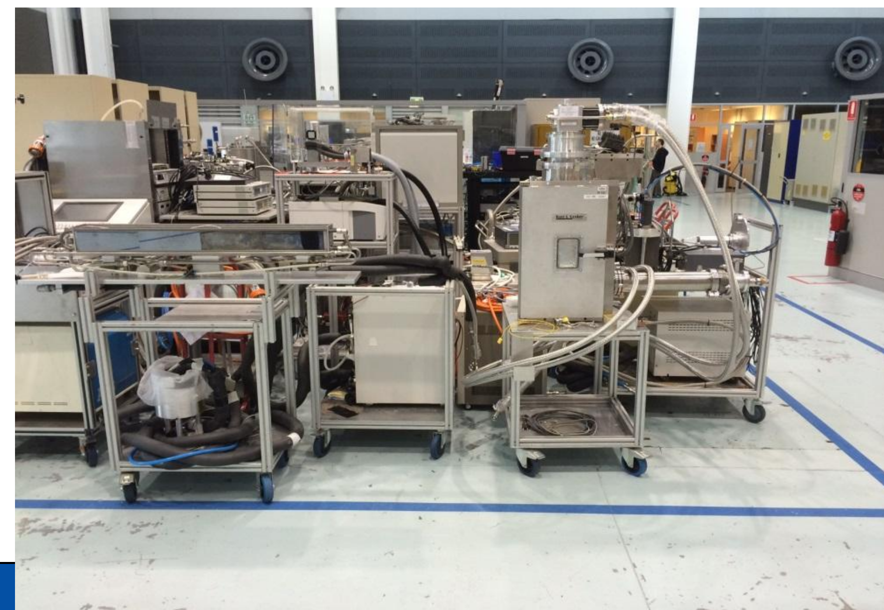
Mechanical Engineering Work Area

New Xray Reflectometry Lab

Areas upgraded July – Dec 2014

New Electrical Engineering Lab

Sample Environment Storage



Neutron Guide Hall labelled storage

Conclusion

- **Talk with the user community – before and after the design.**
- **Consider the ergonomics of operating and servicing instruments.**
- **Asset management plans required for spares & upgrades.**
- **5S methodology is a useful operational tool.**
- **Strong science case and user community input for improvements.**
- **Compare radiation calculations with actual dose rates. Feedback**
- **Budapest is a very pretty city.**
- **Thanks for listening!**

Nuclear-based science benefiting all Australians

Key learnings from our recent upgrade work

- Flexibility in instrument design for later upgrades requires good communication with the widest possible user base.
- The ability to easily maintain instruments requires consideration of access for personal to all pumps, gauges, valves, feedthroughs etc.
- The ability to rapidly change in between experiments requires consider of the easy of reconfiguration, ergonomics and method of realignment
- More focus on automation, particularly sample changers on high throughput instruments – which also removes the hazard of the user from the radiation.
- Incorporating ongoing user feedback into design and maintenance plans going forward.
- Minimising the hot commissioning time. Ensuring the regulatory framework is considered early in the design stage.
- Feeding back actual dose rate surveys into computer simulations – so simulations can be reviewed to see if they were accurate or not. This also builds confidence in the modelling and can save much time on expensive shielding upgrades.
- Though there is an initial cost by having more sophisticated monitoring of systems of vital services (air, helium, vacuum, exhaust, nitrogen, chilled water, oil) we can catch potential issues before a failure occurs and beam time is lost.
- Need to allow for new instruments in the design of current ones. Include disassembly for shutter upgrades!