Australian Synchrotron Beamline Controls Design and Implementation

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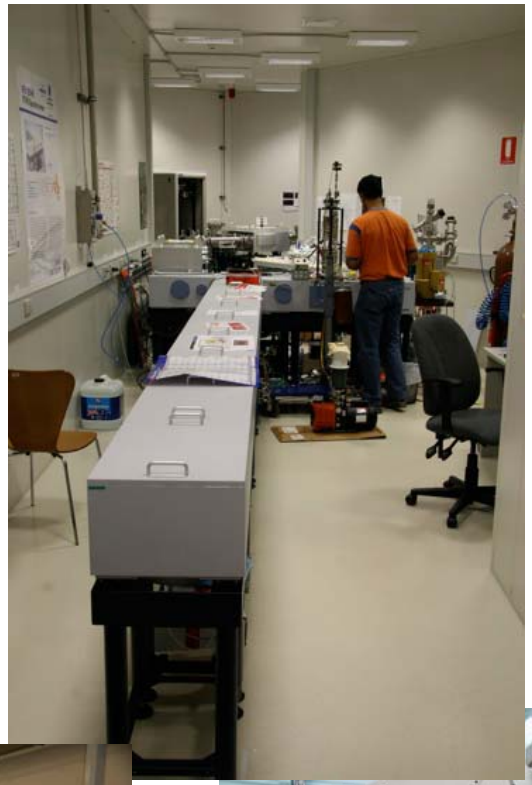
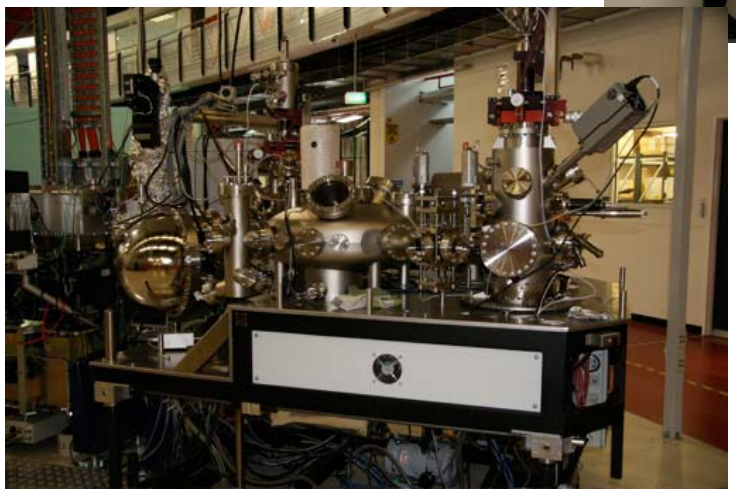
Beamline Controls Design and Implementation

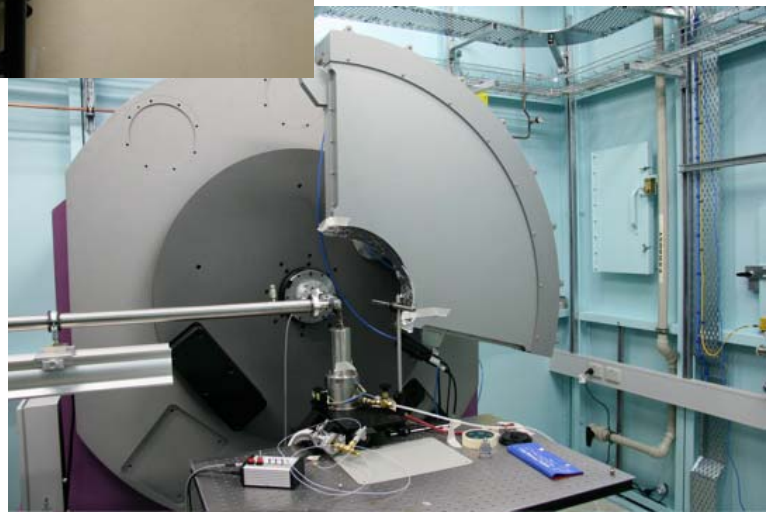
- Beamline summary
- Technology decisions
- Case studies
  - Powder diffraction
  - Protein crystallography
- Motion controls
- Summary of observations

Beamline summary

- Phase 1
  - Infrared Spectroscopy
  - Protein Crystallography
  - Powder Diffraction
  - X-ray Absorption Spectroscopy
  - Soft X-ray Spectroscopy







Beamline summary

- Phase 2
  - X-ray Fluorescence Microscopy
  - Imaging and Medical Therapy
  - Small/Wide Angle Scattering
  - Protein Crystallography 2

Technology decisions - background

Accelerator controls

- EPICS controls throughout
- Standard PC based IOCs
- No use of VME
- GUI implemented in Delphi

Technology decisions - background

Beamline controls

- Desire to use open source software
- Desire to maintain consistency with existing accelerator controls
- Determine approach at comparable facilities and beamlines
- Desire to have single control system for all beamlines
- Contractors implementing photon delivery controls systems - turnkey systems

Beamline control technology decisions

- Off the shelf products
- PC based IOCs
- VME where essential (using PCI/VME bridge)
- In-house motion control
- EPICS as base control system
- No common user interface

Technology decisions

Protection systems

- Personnel protection
- Equipment protection

Operating system

- Avoid vxWorks
- Use standard Linux distributions
- No need for real-time OS

Standards development

- Naming convention
- IP addressing scheme
- User interface standards
- Motion control connectors
- Coordinate system

Infrastructure

Network

- Individual VLAN for each beamline
- EPICS gateway to accelerator

Data storage

- One shared storage server for most beamlines (10 TB)
- Individual storage servers for high volume beamlines (PX - 40TB)

Electronic log

Wiki

Powder diffraction

Experimental requirements

- Single energy experiments
- Multiple sample environments
- Precision sample and detector positioning
- Microstrip detector
- High-resolution detector
- Scanning – step and on-the-fly
- Temperature profiles
- Dual endstations
- Relatively low data volume and rate
- No well defined user interface preference

Powder diffraction

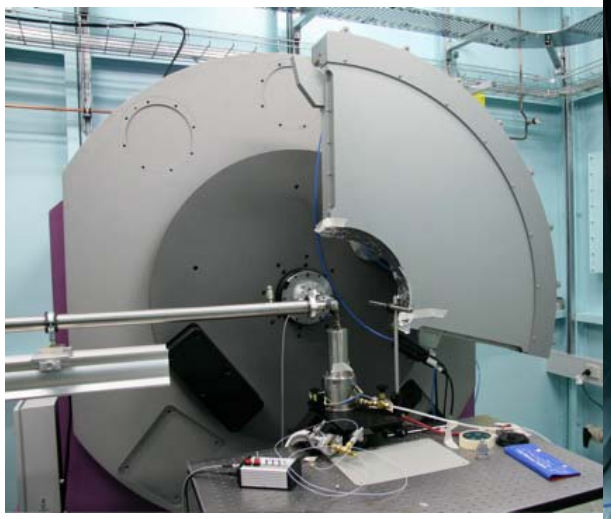
Photon delivery system

- Turnkey contract
- Design, construction and supply of optics
- Basic controls included in scope of supply
- Controls involvement at all stages essential
- Close working relationship with controls vendor
- 40 motors
- 2 cameras, 1 equipment protection PLC
- Beam condition and position monitoring

Powder diffraction

Endstation

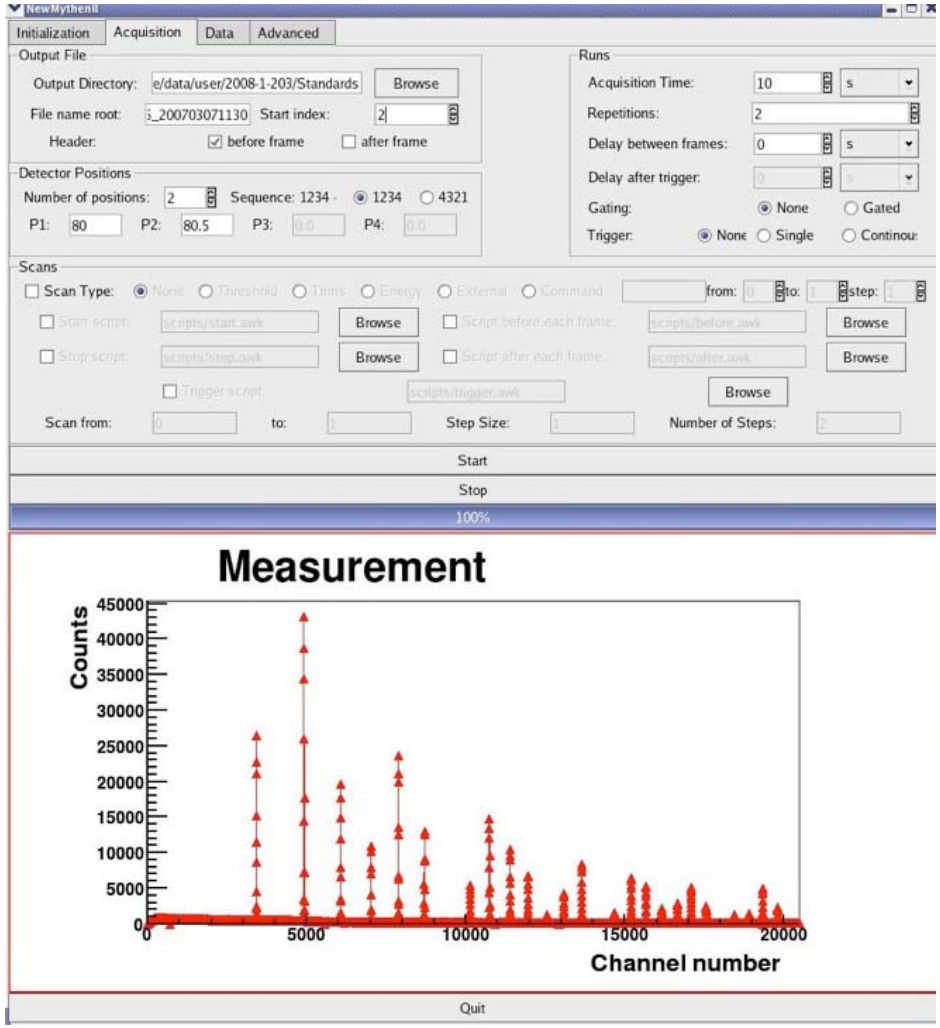
- Individual components purchased separately
- In-house integration
- Close interaction with detector supplier
- Sample environments
- 15 motors
- VME components - PCI/VME bridge, SIS3820 scaler, Digital I/O, detector



Powder diffraction

Endstation software

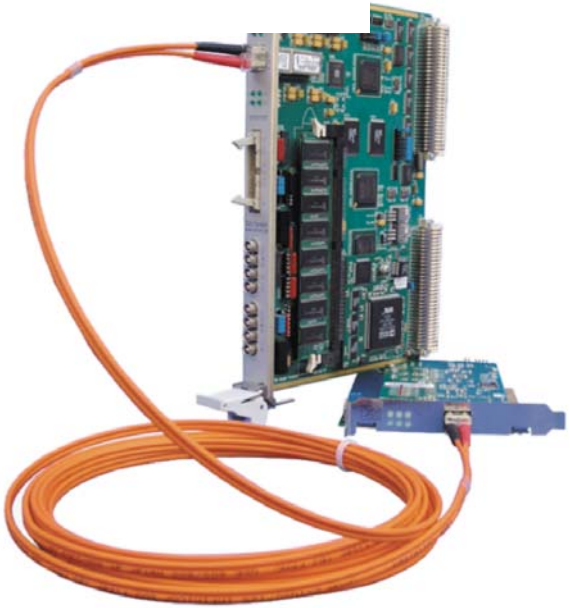
- Using ‘xxx’ application from synApps
- Dedicated GUI for detector
- EPICS ‘sscan’ record to manage data collection
- Detector controls modified to be ‘EPICS-aware’

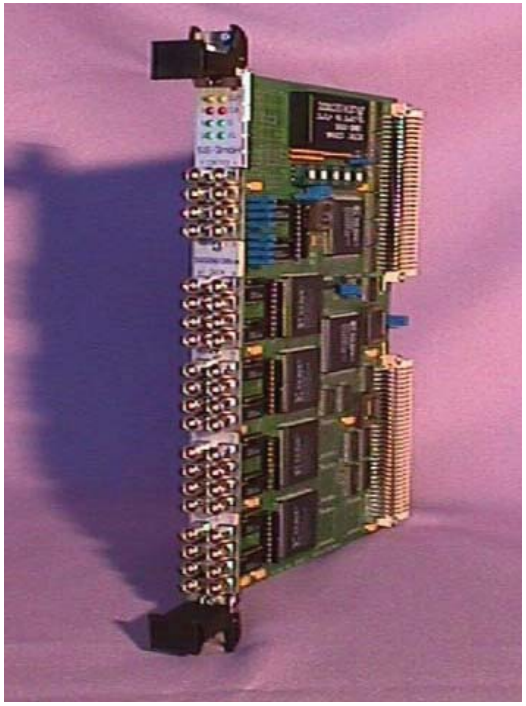


Powder diffraction

New developments

- EPICS support for PCI/ VME bridge
- Development of EPICS support for SIS3820 scaler
- Detector software EPICS integration





Powder diffraction

Current status

- Customised user interfaces (MEDM) providing automation of a range of functions including specific experimental setup
- Implementation of second endstation
- Implementing supporting records to allow experiment customisation by users/beamline staff
- Integration of multiple sample holder

Powder diffraction

Experiences and observations

- Ongoing contact with beamline staff and users to keep up to date with experimental requirements
- Users bringing own sample environments - integration with experimental controls
- Automation of experiment operation high priority
- Transfer of knowledge to beamline staff
- Highly iterative, incremental controls implementation
- Important to understand operation of contractor delivered control systems

Protein crystallography

Experimental requirements

- Two beamlines - BM and ID
- Single energy data acquisition
- Energy scanning
- Single sample environment
- Well defined user interface
- Commissioning endstation followed by final endstation on BM
- Synchronisation of sample rotation and shutter
- High data volume and rate

Protein crystallography

Photon delivery system

- Similar to powder diffraction for BM
- Same vendor
- 30 motors
- 2 cameras
- 2 beam position monitors

Protein crystallography

Endstation

- Commissioning endstation for twelve months
- Full endstation controls integrated in-house
- CCD detector
- Robotic sample loading

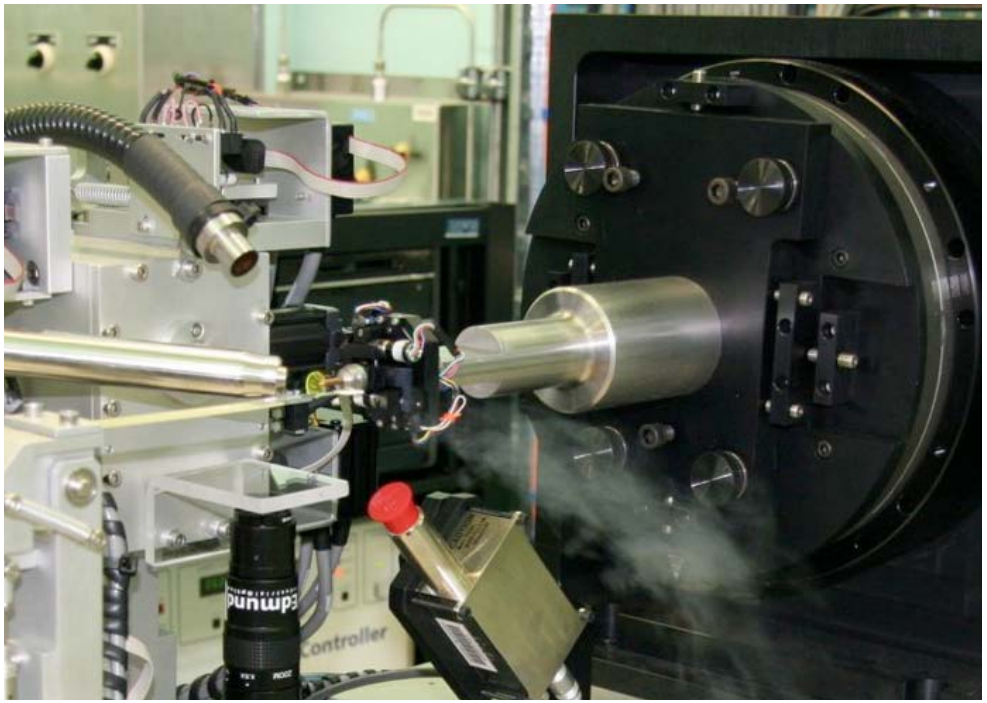
Protein crystallography

Endstation

- High speed shutter
- High precision sample rotation
- Cryogenic sample environment
- Sample monitoring
- Sample alignment
- Sample visualisation
- 22 motors
- PMAC motion controllers
- Fluorescence detector
- Data storage – 40TB

Protein crystallography data acquisition

- High speed shutter
- High precision sample rotation
- PMAC motion controller
- Need to synchronise shutter opening/ closing with sample position

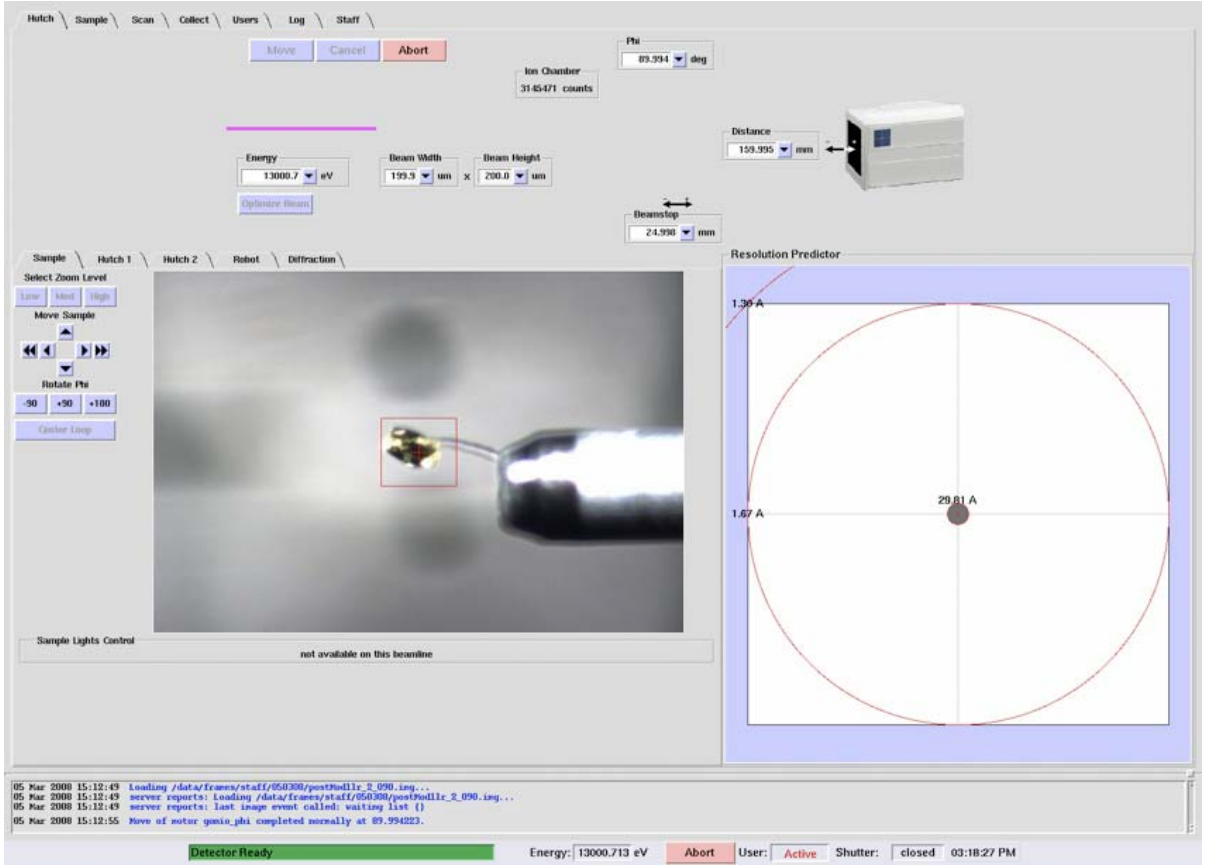


- Rotation parameters set through EPICS
- Motion program developed to synchronise movements

Protein crystallography

Control system

- Mandate for BluIce user interface
- Utilised SSRL system with extensive device support
- Developed interface to EPICS motors

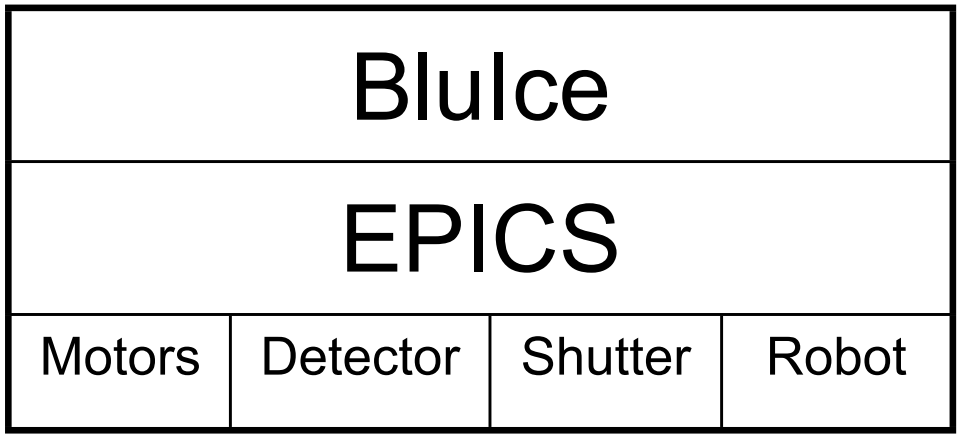


- Energy implemented in EPICS
- Oscillation implemented in motion controller

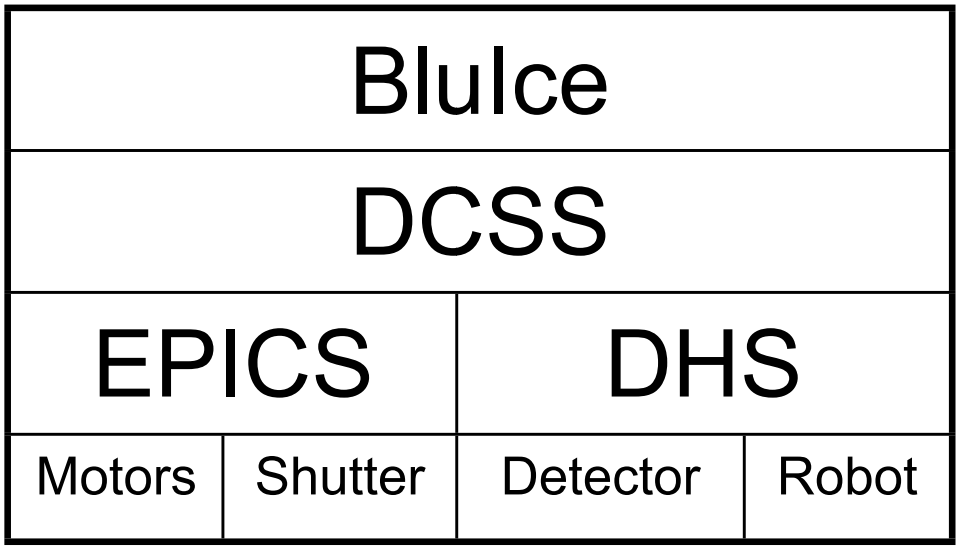
Protein crystallography

Comparison of SSRL and GMCA controls

GMCA



SSRL



Protein crystallography

SSRL vs GMCA

- SSRL benefits
  - Use existing hardware drivers
  - Use existing scripted functions
  - Easier integration of specific hardware
  - Support from SSRL controls people
  - Minimal development work required
  - Can take advantages of updates from SSRL
- GMCA benefits
  - “Simpler” architecture
  - No new control system to learn

Protein crystallography

Experiences and observations

- Substantial learning curve for new control system
- Significant reuse of hardware support
- Many experimental procedures already developed
- Very standardised experimental process
- Successful collaboration with SSRL
- Rapid progress to user experiments
- Synchronisation of undulator and monochromator required for step scanning

Motion controls

Delta Tau PMAC

- Powerful, but complex
- Highly configurable
- PID control at motion loop level
- Difficult to implement both open and closed loop on single axis
- Good for complex motion programs
- Good motion synchronisation capability
- By default, motors never completely stop
- Distributed motor drives possible

Motion controls

Galil

- Relatively simple to configure
- Precalculated motion profile
- Developed for single axis applications
- Basic motion synchronisation capability
- Complex EPICS driver developed in-house

Observations

- Standardise as much as possible, but...
- Standardising user interfaces is difficult
- Automation of experimental processes takes time
- EPICS “user” records are powerful
- In-house hardware development can be time consuming
- Keep hardware drivers simple and generic
- EPICS access to PSS added later

Observations

- Plan ahead as much as possible - early identification of requirements and design constraints
- Will probably have to retrofit scripting capabilities at Australian Synchrotron
- Get archiving going early and record as much as possible
- Decide whether to rely on save-restore for saving configuration changes
- Data processing software managed by beamline staff, not controls

Observations

- Ensure sufficient resources allocated to beamline controls
- Have multiple people familiar with each beamline
- Close interaction with beamline staff essential
- Development process should be incremental
- Reuse existing solutions as much as possible
- Implement controls at lowest level possible
- Motion control commissioning is time consuming
- Don’t underestimate length of time to get control system fully working

Thank you