User Manual

EMU

Cold-neutron Backscattering Spectrometer

Contents

1. Technical description

Cold-neutron backscattering spectroscopy is a neutron scattering technique for investigating molecular and atomic motions at the nanoscale, i.e. 0.1 – 1 nm and 0.1 – 10 ns. It enables the microscopic characterization of a variety of materials from chemistry and physics to bio- and geo-sciences, and associated engineering disciplines. Specifically, the atomic, molecular, or other local diffusive and vibrational phenomena in solid matrices, glasses, liquids, or even heterogeneous media being porous or colloidal, are accessible in suitably devised experiments. This technique is most sensitive to hydrogenous species.

1.1. Principle of backscattering

Cold-neutron backscattering spectroscopy relies on crystal monochromators whereby Bragg diffraction is utilised to tailor the neutron beam energy and energy width. The narrowest energy width is obtained in the backscattering geometry ($\theta_{Bragg} \approx 90°$) from high-quality single crystals such as re adily available from silicon. Figure 1 shows the reflected wavelength as a function of Bragg angle for Si(111) crystals.

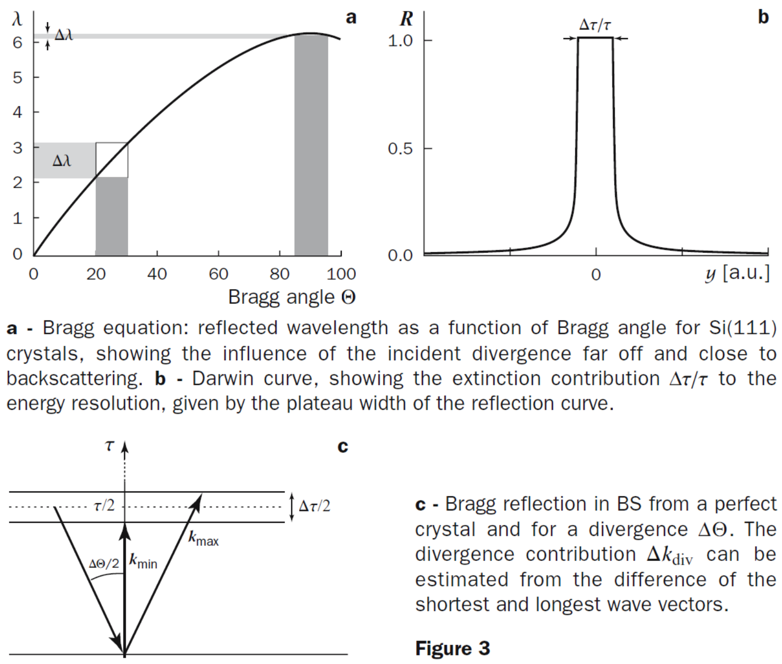


Figure 1. Principles of neutron backscattering spectroscopy (Reproduced from [1][1])

A narrow energy width translates to a high-resolution, i.e. the ability to resolve sample relaxation times as long as several nanoseconds for silicon crystals configured in backscattering. The backscattering condition implies that the backscattered beam travels the same path as the incident beam, which imposes serious constraints on the instrument design and geometry. In order to allow the highest detector count rate, the neutron beam angular divergence is relaxed by use of spherical focusing, resulting in the compact instrument geometry shown in Figure 2 (side view) and Figure 3 (plan view).

[1] *Hippert, Geissler, Hodeau, Lelievre-Berna and Regnard. Neutron and X-ray Spectroscopy. Springer © 2006*

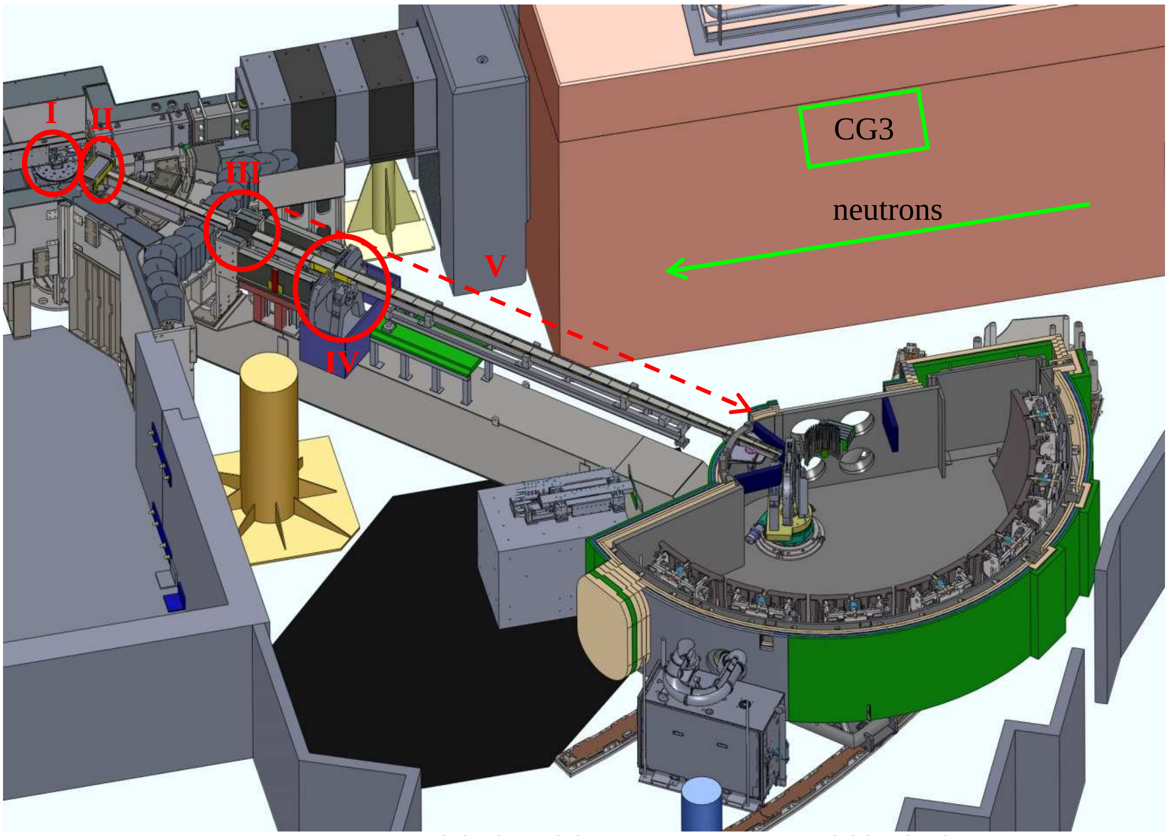


Figure 2: Conceptual design of the EMU spectrometer (side view)

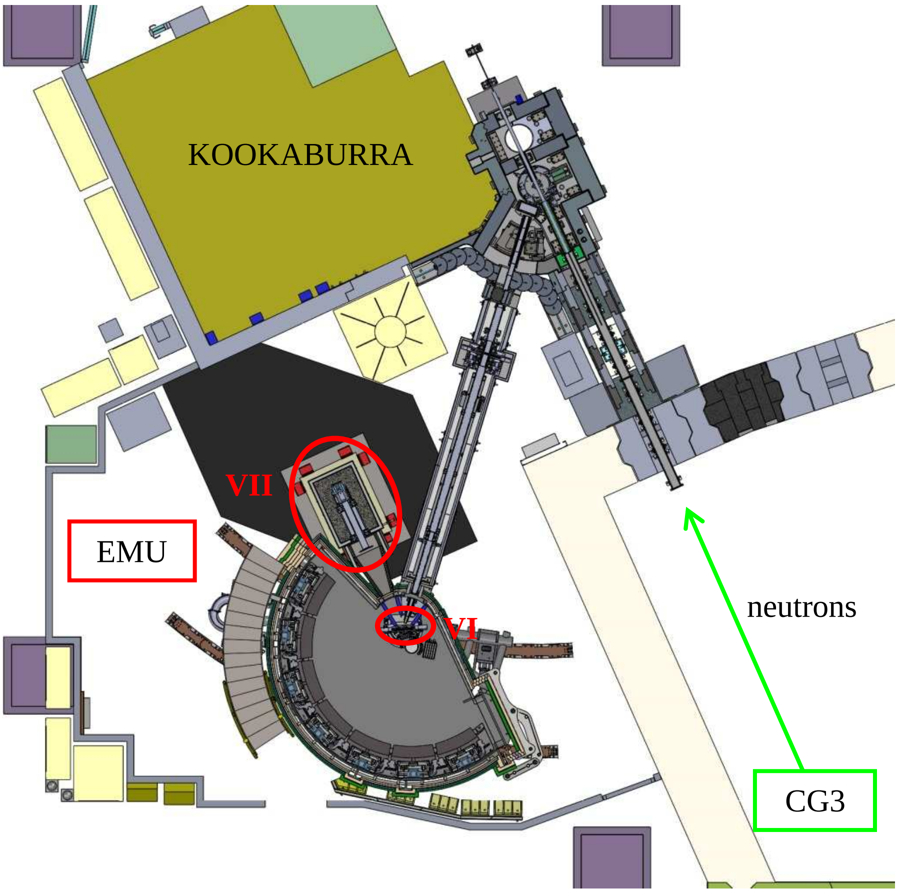


Figure 3: EMU Instrument layout (plan view)

1.2. EMU Instrument Components

1.2.1. Premonochromator

The EMU premonochromator (Figure 2, I) deflects a fraction of the CG3 neutron beam into the EMU focusing guide. The remainder of the neutron beam travels on to KOOKABURRA and PLATYPUS.

The EMU premonochromator is composed of highly-oriented pyrolytic graphite (HOPG) crystal pieces held into a rigid aluminium frame, and installed on a narrow-range motion stage. Rotating the premonochromator about the vertical axis selects the Bragg reflection of choice. In our case this is HOPG (002). Higher order reflections are deflected in the same direction as HOPG (002).

1.2.2. Cooled beryllium filter

The beryllium filter (Figure 2, II) is placed between the premonochromator and the tertiary shutter. It is a block of dimensions 282 (L) x 120 (W) x 170 (H) mm^3, where the width is oriented along the neutron beam. It transmits only the HOPG (002) reflected neutrons, and scatters higher energies away from the transmitted beam. These higher energy neutrons are absorbed into the premonochromator shielding. The beryllium block itself is housed in a vacuum vessel and cooled by a closed-cycle refrigerator to liquid nitrogen temperature to increase its efficiency.

Effectively, the Be-filter acts as a band-pass filter; only allowing neutrons above a certain energy to be transmitted. Figure 4 shows the cut-off wavelengths for cold neutrons by Be at room and liquid nitrogen temperatures.

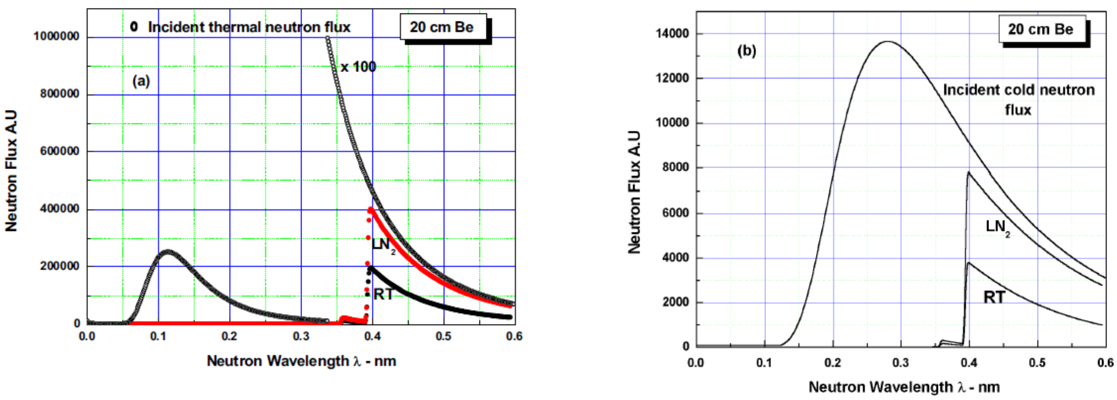


Figure 4. Transmitted neutron flux through polycrystalline beryllium. (Reproduced from [2][2])

1.2.3. Tertiary Shutter

The neutron beam path from CG3 to the EMU instrument is closed by the tertiary shutter (Figure 2, III), so as to allow safe access to the instrument. In the open shutter position, the neutron beam proceeds down the focusing guide and through the background chopper.

1.2.4. Background chopper

The background chopper (Figure 2, IV) is a disc chopper ~ 2500 rpm spinning speed, ~ 700 mm diameter. It is made of two borated-epoxy coated aluminium discs bolted together at the desired sector angle so as to yield the desired ~ 37% transmission duty cycle. In its closed state the top of the chopper disc blocks the neutron beam path. The chopper is spinning inside a vacuum housing and is synchronized with the graphite chopper, as shown in Figure 5.

[2] *N. Habib, J. Nuc. Rad. Phys.* ***1*** *2 (2006) 137-145*

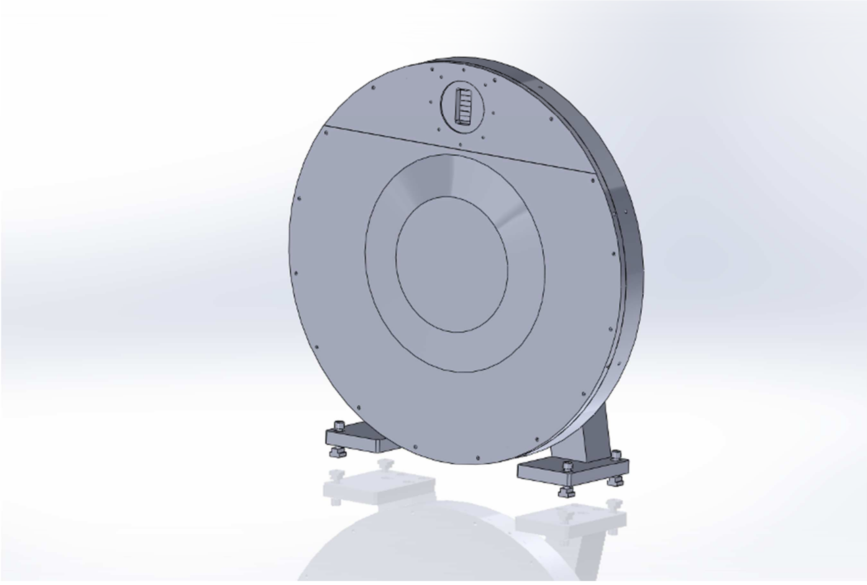


Figure 5: EMU background chopper

1.2.5. Focusing Guide

The focusing guide (Figure 2, V) efficiently transports the neutron beam from the EMU premonochromator to the graphite chopper. The focusing guide consists of precision-assembled glass elements that are coated with NiMo-Ti supermirrors and glued together to form the neutron guide.

In practice it is made of four distinct sections (Figure 6), allowing for the relevant components to be inserted at various locations along the beam path. These components are the EMU tertiary shutter (III), the background chopper (IV), and the focusing guide window of the scattering tank.

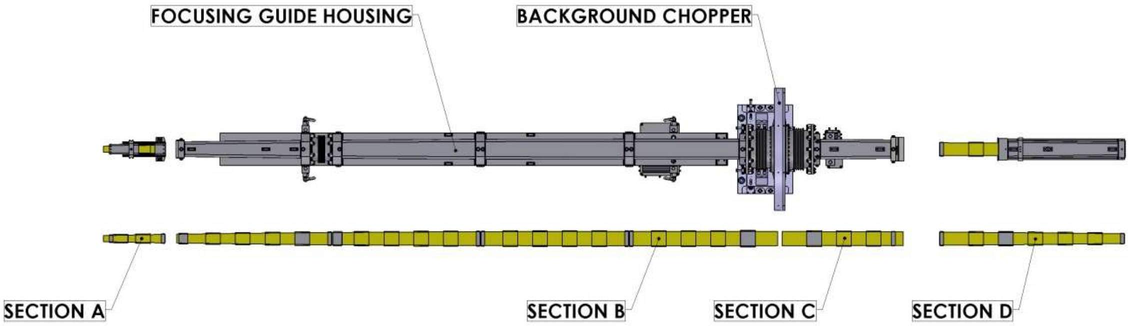


Figure 6: Focusing Guide with housing and the background chopper located between Sections B and C.

The focusing guide provides a roughly rectangular beam profile of 23 x 30 mm as shown in the neutron beam image of Figure 7.

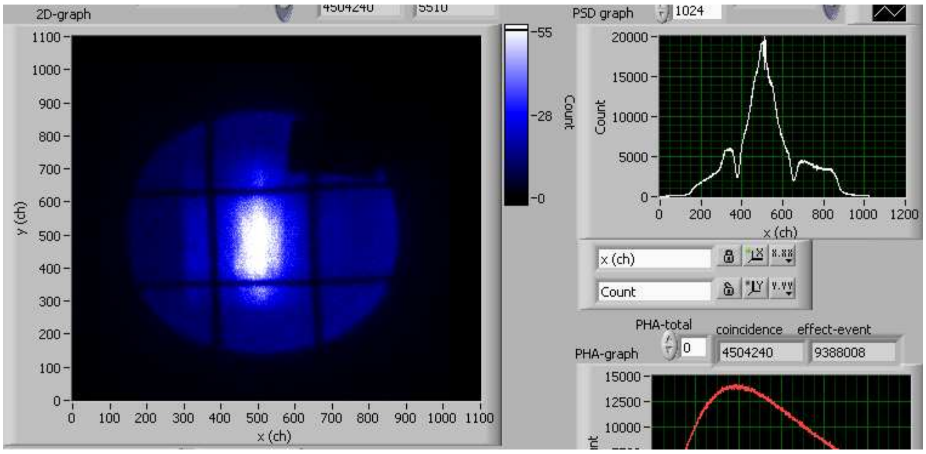


Figure 7. EMU beam profile at exit of focusing guide. Image obtained in air using a neutron camera.

1.2.6. Graphite chopper

The graphite chopper (Figure 3, VI) is a disc chopper ~ 2500 rpm spinning speed, ~ 700 mm diameter. It is made of an aluminium disc bearing HOPG crystal stacks on its periphery. As seen in Figure 8a, the graphite chopper periphery is divided into four sectors, two HOPG stack-bearing sectors and two open sectors. The vacuum necessary for spinning the graphite disc chopper is the scattering tank ambient vacuum. The graphite chopper is located within a housing affording containment of chopper and crystal parts in the unlikely event of a mechanical failure of the assembly (Figure 8b).

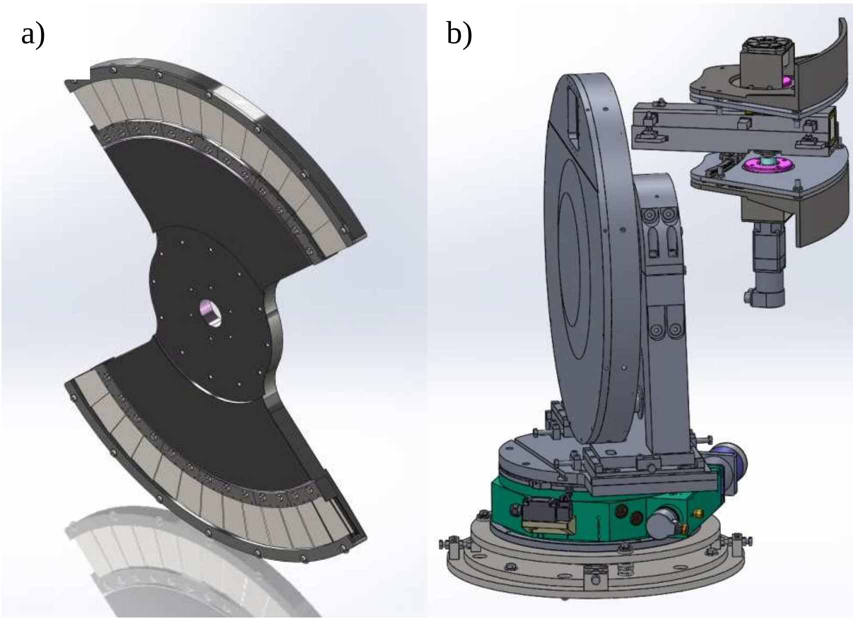


Figure 8: Graphite chopper a) disc (showing mounted crystals) and b) housing

Essentially, the graphite chopper functions as the second premonochromator of the instrument. The purpose of its HOPG stacks is to deflect the primary neutron beam from the focusing guide onto the backscattering monochromator, tuning their HOPG (002) Bragg reflection angle. However, since the backscattering condition implies that the backscattered beam travels the same path as the incident beam, the deflecting elements must intermittently rotate out of the beam path to allow further transport of the backscattered monochromatised beam, onto the scattering sample. Thus the HOPG stacks are mounted on a disc chopper.

The graphite chopper is installed on a narrow-range motion stage bolted to the scattering tank floor. The motion stage serves both for locating the graphite chopper and controlling the deflection of the neutron beam exiting the focusing guide into the backscattering monochromator. The graphite chopper (vertical) rotation axis coincides with the scattering tank rotation axis.

The graphite chopper operates in concert with the background chopper, i.e. the choppers operate at a common rotational frequency and fixed relative phase, for given primary take-off angle, background chopper transmission sector angle, and backscattering monochromator position. The specific values for these parameters are chosen so as to ensure that the primary neutron beam does not normally pass the graphite chopper without being first deflected by its graphite crystal stacks. More precisely, such that:

- no neutrons from the primary neutron beam scatter from the sample;
- no neutrons from the primary neutron beam reach the detector array at the same time as the analysed neutrons;
- no neutrons from the primary neutron beam hit the analyser arrays. This is essential to ensure safe radiation levels outside the instrument enclosure.

Figure # shows the time-distance diagram for the two EMU choppers. When the background chopper is OPEN i.e. neutrons pass through, a short time interval later, the graphite chopper must be CLOSED to reflect the neutrons to the Doppler plate.

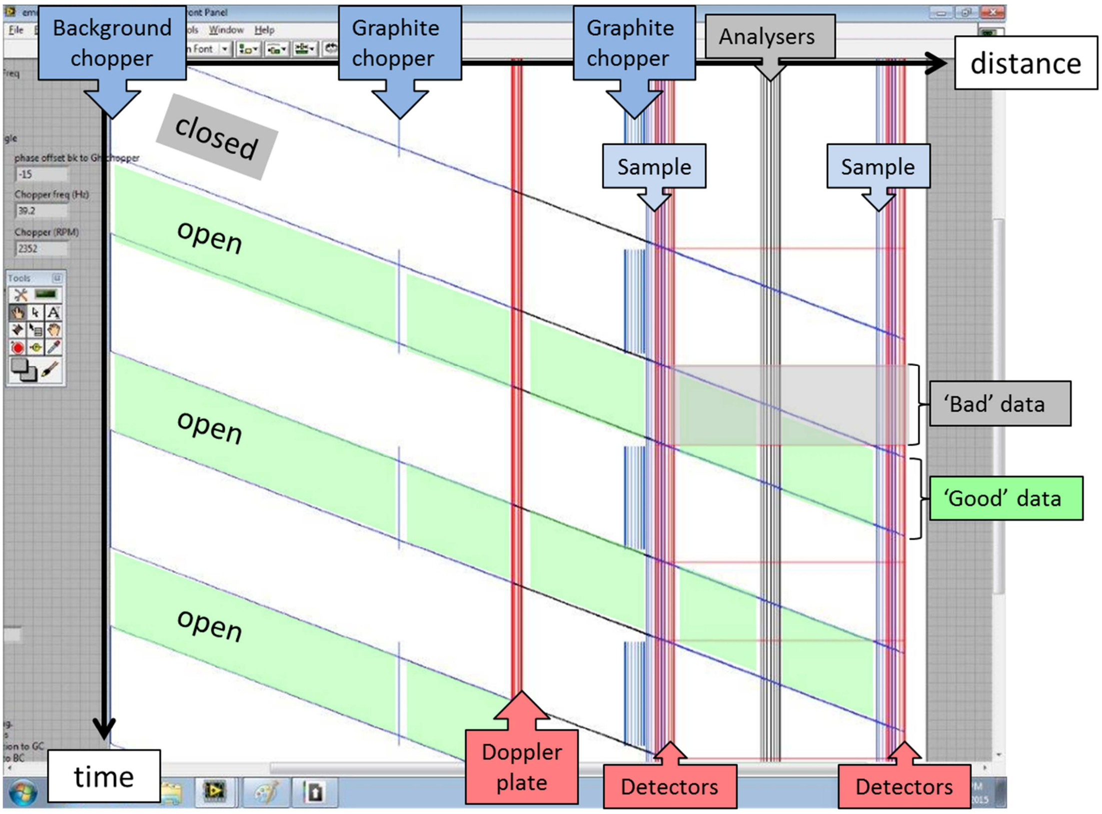


Figure 9. Time-distance diagram for EMU showing all major components of instrument.

1.2.7. Doppler Drive

Doppler backscattering monochromator

The backscattering monochromator (Figure 3, VII) is the final monochromator defining the beam onto the sample. It consists of a ~ 1.8 m radius spherical section fully tiled with hexagonal, 0.87 mm thick silicon crystal wafers, of dimension 240 x 400 mm^2. The backscattering monochromator support itself is made of carbon fibre, and this plate is shown in Figure 10.

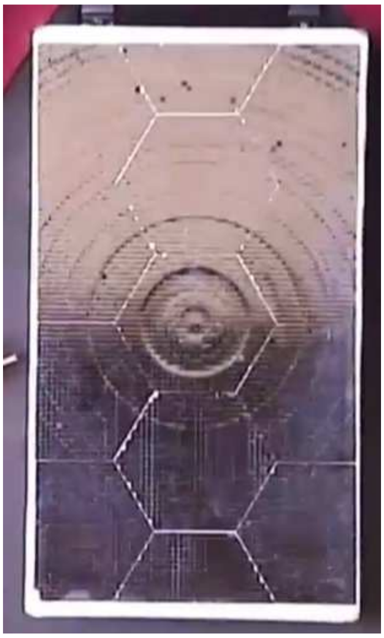


Figure 10. Doppler drive showing monochromator Si (111) crystals mounted on spherical plate.

This monochromator reflects a narrow energy band from the beam deflected by the graphite chopper, using the Si (111) Bragg reflection in backscattering (i.e. at 90 ° Bragg angle) to provide the high-resolution characteristic of EMU. To this end, identically to the analyser arrays, several conditions need to be fulfilled: the backscattering monochromator support is precision machined to a radius ~ 1.8 m and is positioned such that it focuses at a fixed point between the graphite chopper and the scattering sample; the hexagonal crystal wafers were precision cut such that the Si (111) crystal planes are normal to the wafer face; and the wafers were conformally glued into the spherical carbon-fibre support.

Doppler drive unit

Since the backscattering condition must be preserved both for the monochromatised and analysed beams, and the silicon crystal analyser arrays are fixed, the incident neutron energy is modulated by oscillating linearly the backscattering monochromator along the reflection direction (Doppler Effect).

The device performing this oscillation is the Doppler drive unit, which moves the monochromator back and forth over a short distance in a sinusoidal motion (Figure 11).

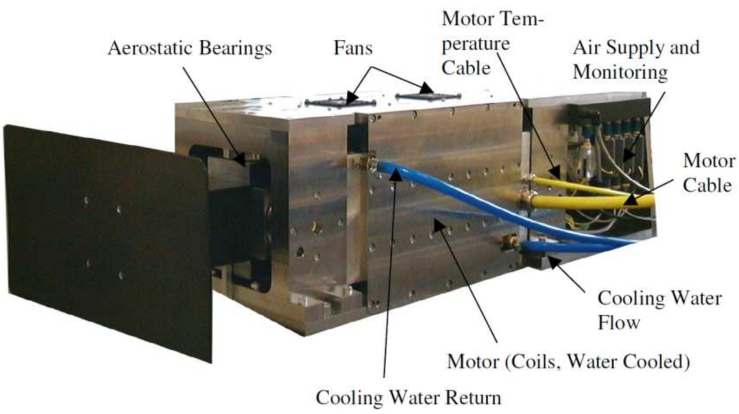


Figure 11: Doppler drive unit with a test backscattering monochromator support

The timing of the background chopper, the graphite chopper and the Doppler driven monochromator is carefully aligned to provide unique scattering at the sample position. Figure 12 shows how data acquisition is achieved with respect to the neutron pulses and movement of the monochromator.

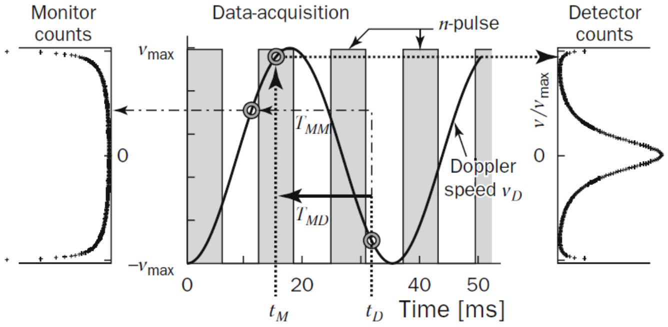


Figure 12. Data acquisition on a reactor-BS instrument with Doppler monochromator. Neutrons which are counted at time t_D have been at the moving monochromator at time $t_M = t_D - T_{MD}$. The flight time T_{MD} is assumed to be constant. (Reproduced from ref [Error! Bookmark not defined.])

The incoming neutrons have a velocity, v_n ~ 630 ms^{-1}

The maximum speed of the Doppler drive, v = 4.7 ms^{-1}

The maximum displacement of the monochromator, a = +/- 75 mm

1 complete cycle of the monochromator = 100 ms (if v = 4.7 ms^{-1} and a = +/-75 mm)

The maximum energy range of the Doppler drive, ΔE = +/- 32 μeV

Doppler drive support

The Doppler drive unit itself is secured onto a granite block to absorb the vibrations of the unit, itself on a rigid concrete and steel support base (Figure 13).

The Doppler drive support allows positioning of the backscattering monochromator and helps to bring its focal point in coincidence with the graphite chopper.

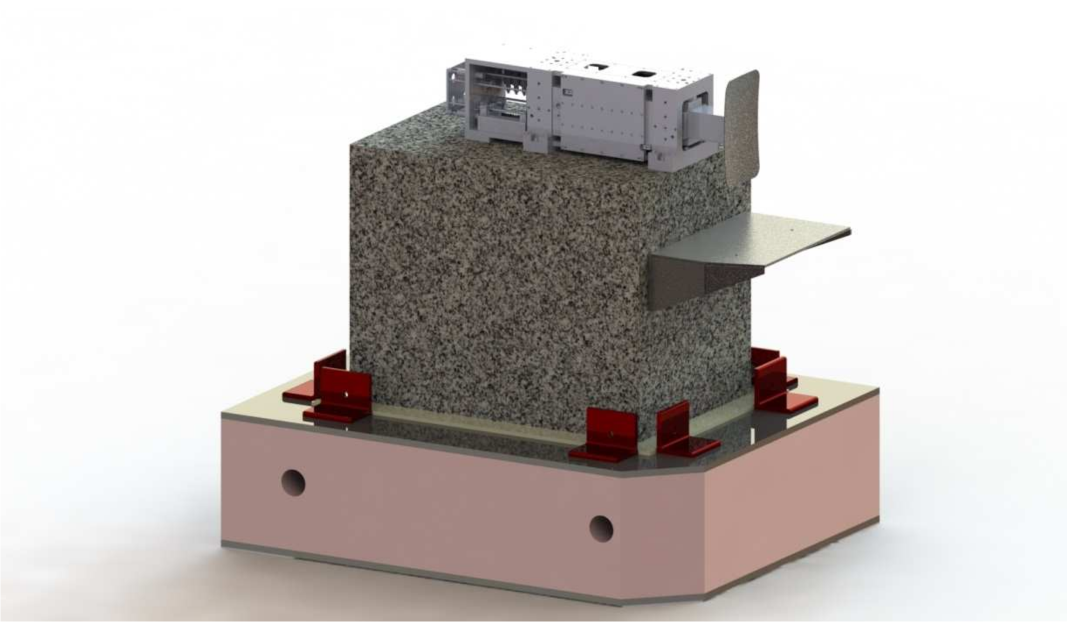


Figure 13: Doppler drive assembly

1.2.8. Analyser arrays

Seven silicon crystal analyser arrays (Figure 3, VIII) are positioned within the scattering tank to analyse the beam scattered from the sample. They consist of cast-aluminium 1.8 m radius spherical sections, fully tiled with 0.87 mm thick hexagonal silicon crystal wafers. The total coverage is in order of 0.9π steradians.

Figure 14: Analyser arrays fitted inside the scattering tank

Energy analysis of the scattered beam is carried out by Si (111) backscattering reflection (i.e. reflection at a 90 °Bragg angle), which provides t he high-resolution characteristic of EMU. To this end, several conditions need to be fulfilled: Each of the seven aluminium sections was precision machined to a 1.8 m radius and is positioned such that they focus exactly onto the scattering sample; the hexagon crystal wafers were precision cut such that the Si (111) crystal planes are normal to the wafer face; and the wafers were conformally glued into the spherical aluminium sections.

1.2.9. Detectors

The detectors count neutrons scattered by the sample before and after energy analysis by the silicon crystal analyser arrays. Since energy analysis of the scattered beam is performed in backscattering reflection from the crystal analyser arrays, the energy-analysed neutrons traverse the sample a second time prior to hitting the (tube) detectors. Efficient detection is achieved by a pressure of 10 bar ^{3}He pressure within the tubes, and charge division of the detector cathode signals delivers linear position sensitivity of the neutron detection event.

Figure 15 shows the configuration of the two detector arrays with respect to the positions of the sample well and the graphite chopper.

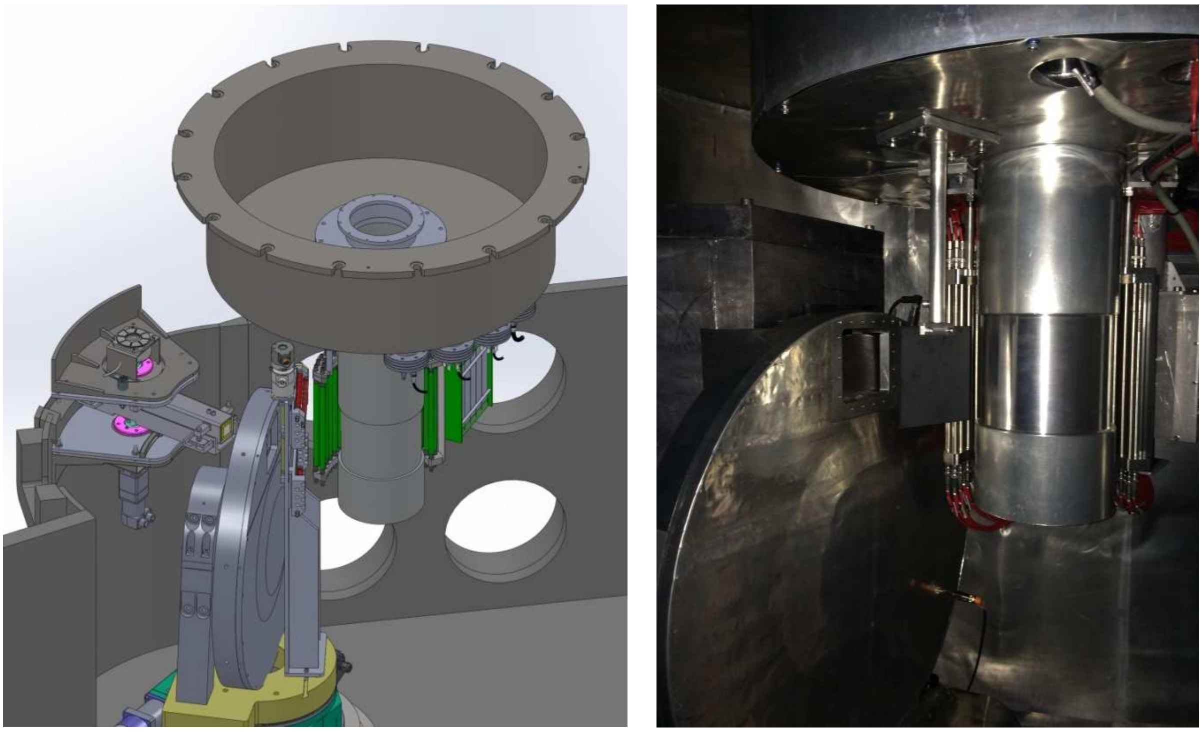


Figure 15: Vertical (green) and horizontal (red) detector arrays in place on the sample well and next to the graphite chopper, respectively.

There are two detector arrays; vertical detectors and horizontal detectors. The vertical tubes are 25 cm long and are configured as a vertical cylindrical assembly of 35 tubes into a static aluminium frame, centred on the scattering sample; this assembly is secured onto the sample well. Figure 16 shows the layout of these tubes with respect to the incoming beam from the Doppler drive.

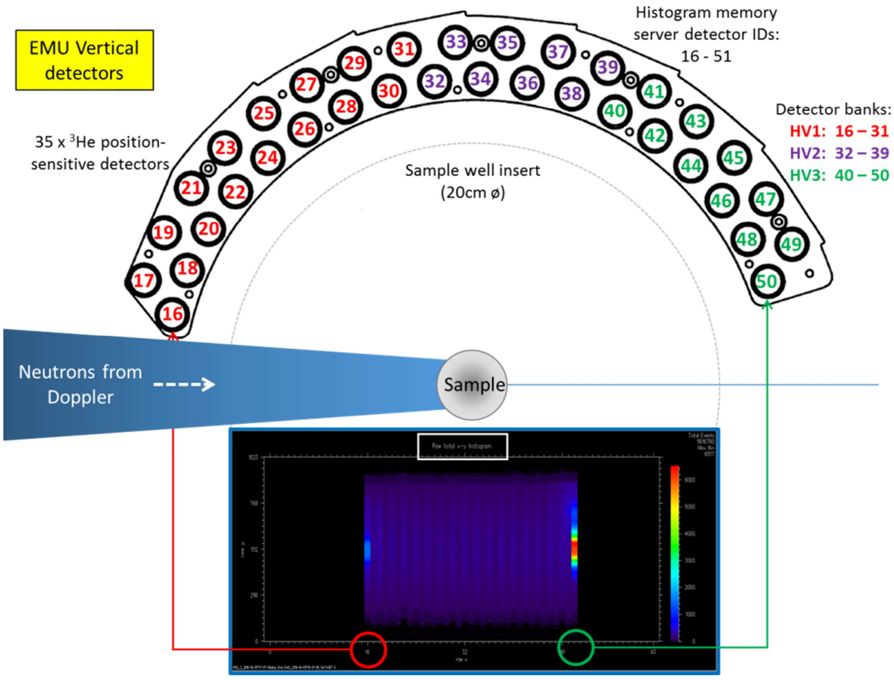


Figure 16: Stepwise configuration of the EMU vertical detectors, their HV connections and histogram memory server ID numbers.

The horizontal tubes are 15 cm long and located between the graphite chopper and scattering sample; there are 16 tubes split into two groups and closing vertically about the beam axis; the horizontal detector array mounts on a post secured onto the graphite chopper motion stage (see Figure 17).

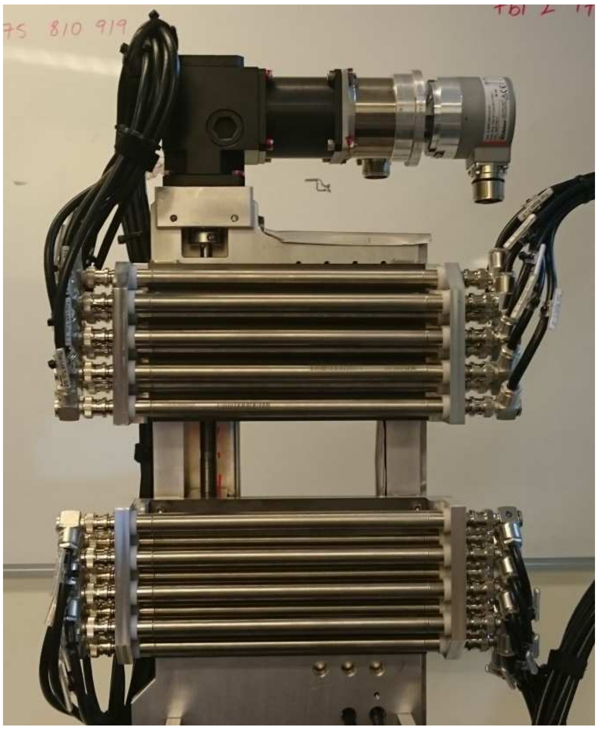


Figure 17: EMU horizontal detectors, mounted upon slits for beam size adjustment

The two detector banks are connected to the data acquisition rack (DAE) as shown in Figure 18.

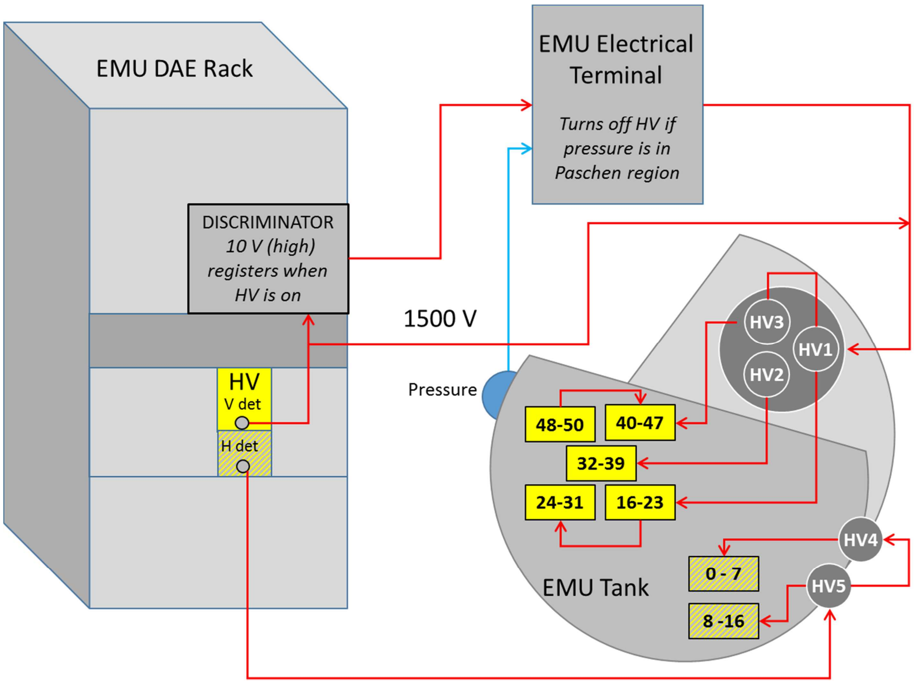


Figure 18: EMU detector connections to HV illustrating detector ID and HV connector.

The two detector arrays provide two separate regions of Q-range coverage. Figure 19 shows the low Q-range provided by the horizontal detectors, and the large Q-range provided by the vertical detectors. For convenience this diagram only shows the elastic case.

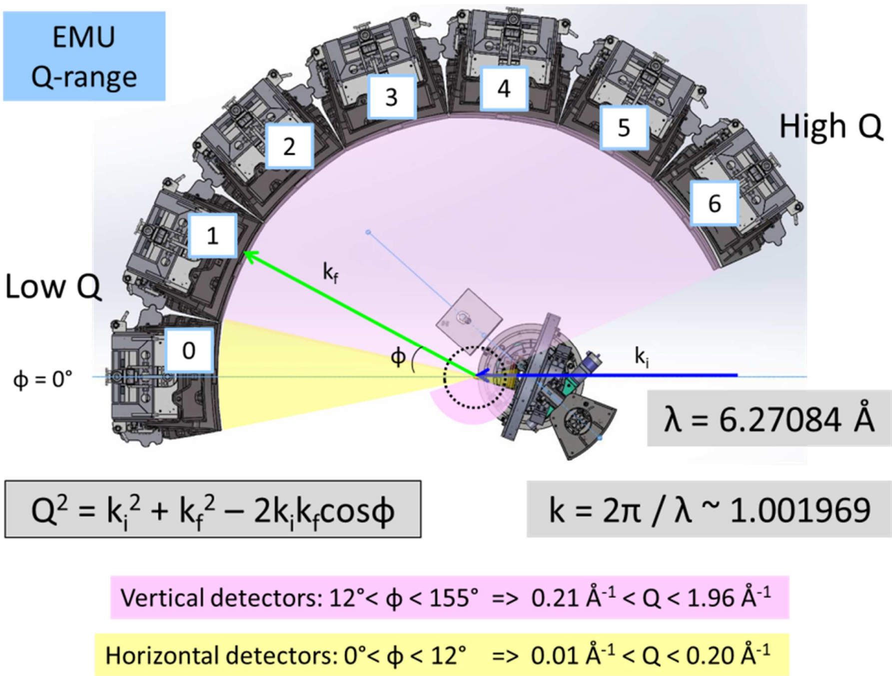


Figure 19. EMU Q-range calculated using $k_i = k_f$.

1.2.10. Operating Platform / Sample preparation table

In order to permit personnel access to the sample well, an aluminium operating platform has been built above the scattering tank. This operating platform is directly secured to the scattering tank and is built on two levels. In addition to the lower level for sample well access proper, an upper level provides equipment storage and sample preparation workbench areas. The platform is accessed through a flight of stairs. Please ensure you keep three points of contact whilst ascending and descending these stairs (which are very steep).

There is a sample preparation table located on the operating platform to enable you to change samples. The sample preparation table is equipped with a heat gun and other sundries to assist with a sample change.

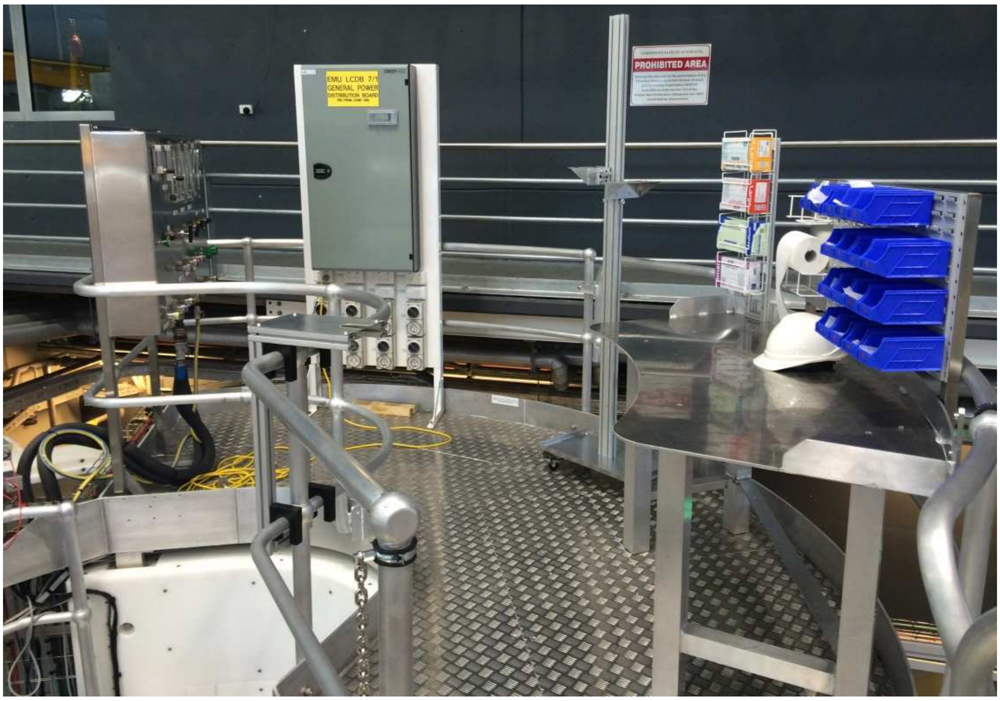


Figure 20. EMU Operating platform, sample preparation table and service panel

To see how EMU works in simulated form, go to the ANSTO YouTube page and search for EMU. There you will find a fully animated simulation of the neutrons passing through all the components of EMU.

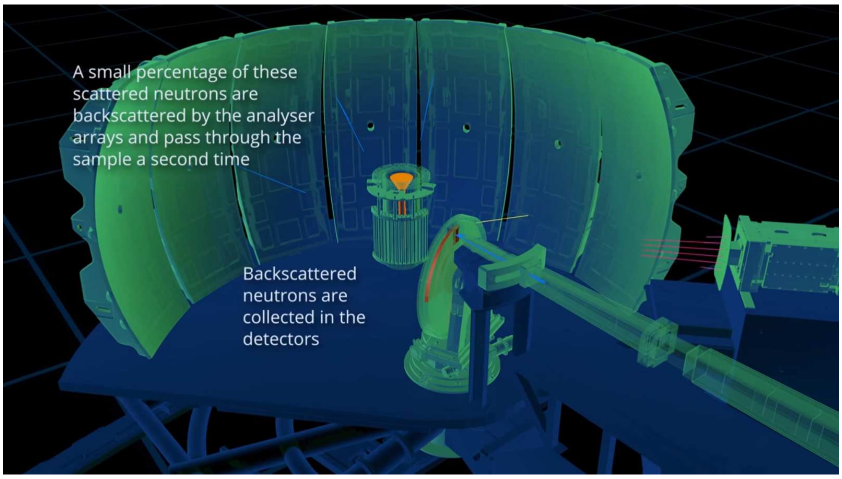


Figure 21. ANSTO YouTube video of EMU – simulating the neutron path through the instrument

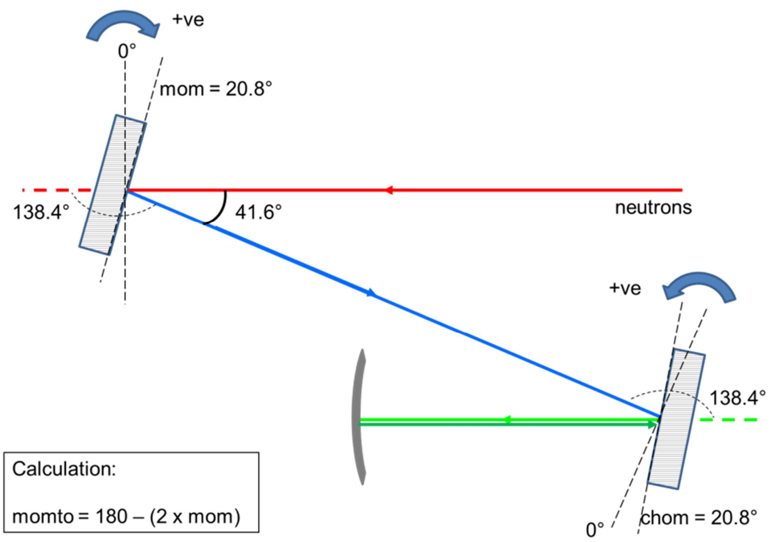
2. Operating the instrument

The purpose of this section is to provide instructions for the use of the backscattering spectrometer EMU. A technical description of the instrument concept, layout, components, and performance is provided in the previous section.

2.1. Wavelength

EMU is operated at a wavelength **λ = 6.27084Å**, obtained from a take-off angle at the HOPG (002) premonochromator of 138.4°.

This is a theoretical wavelength obtained from the EMU geometry:



This is currently the only wavelength offered on EMU. The tracks inside the sample area allow for additional take-off angles to be implemented in the future.

2.2. Sample requirements

EMU is able to measure both single-crystals and powder samples. The accessible elastic Q-range on EMU is **0.01 < Q < 1.95 Å^{-1}**.

For powder samples, calculate a sample thickness which will allow 10% transmission of the neutrons and avoid multiple scattering.

You may only measure samples which have been listed on your experimental data sheet. These samples have been checked by the lab manager and have been cleared for exposure to neutrons. We are regulated by ARPANSA, and have to have documented what is in the neutron beam (and considered the risks) at all times. We can be spot checked at any time, and if a sample is not on the experiment data sheet and being measured, this can have serious implications for you and the Australian Centre for Neutron Scattering. If up to two weeks BEFORE your experiment you wish to add some samples to your proposal, please let your instrument scientist know and they will progress this for you.

2.3. Sample mounting

On EMU we typically use i) annular cans or ii) flat-plate sample holders. Annular cans are available with the following thickness gaps:

- 0.1 mm
- 0.2 mm
- 0.5 mm
- 1.0 mm
- 2.0 mm

Figure 22a shows a schematic diagram of an annular can whilst a flat-plate for reflection measurements are shown in Figure 22b.

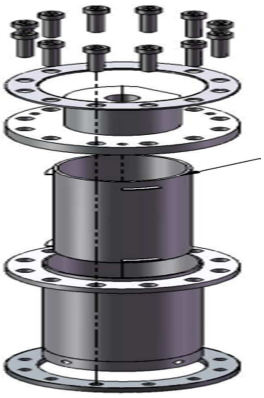


Figure 22: EMU Sample Cans. a) Annular cans b) Flat-plate cans

2.4. Sample Environment

The following cryostats are available for use on EMU:

- CF-1/3
- CF-10 (for dilution temperatures)
- CF-11/12

You can find instructions and additional information on these cryostats in the EMU User Manual (green folder) located in the EMU cabin.

2.4.1. Cryofurnace 1/2/3

CF-1, CF-2 and CF-3 are three identical bottom-loading cryofurnaces. The following temperature ranges are possible:

Configuration	*Lowest Temperature (K)*	*Highest Temperature (K)*	*Sensor*
Cold stage	4	300	Silicon diode
Hot stage	20	750	Thermocouple

For more information use this link:

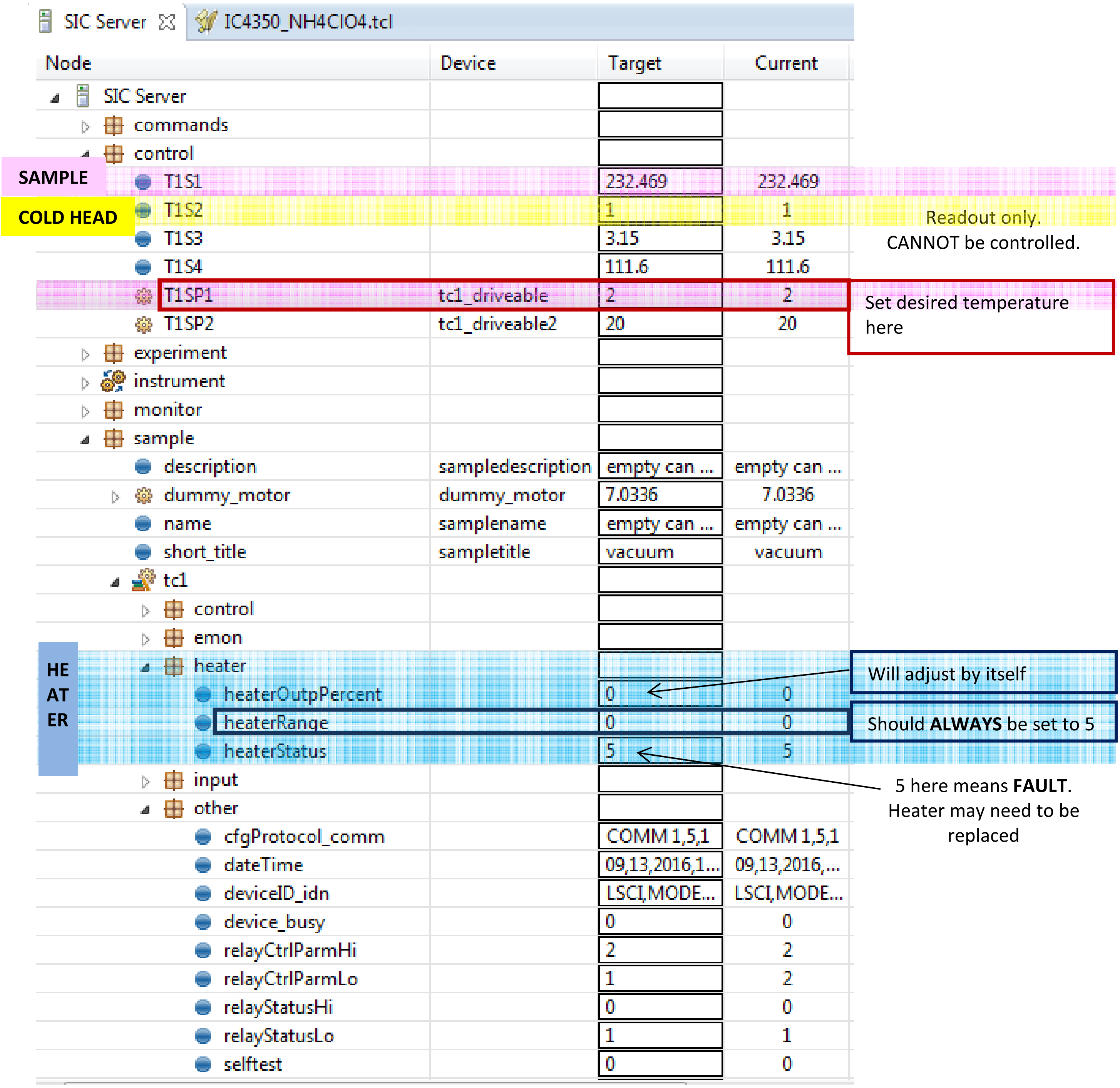
http://www.ansto.gov.au/ResearchHub/Bragg/Facilities/SampleEnvironments/Cryofurnaces/

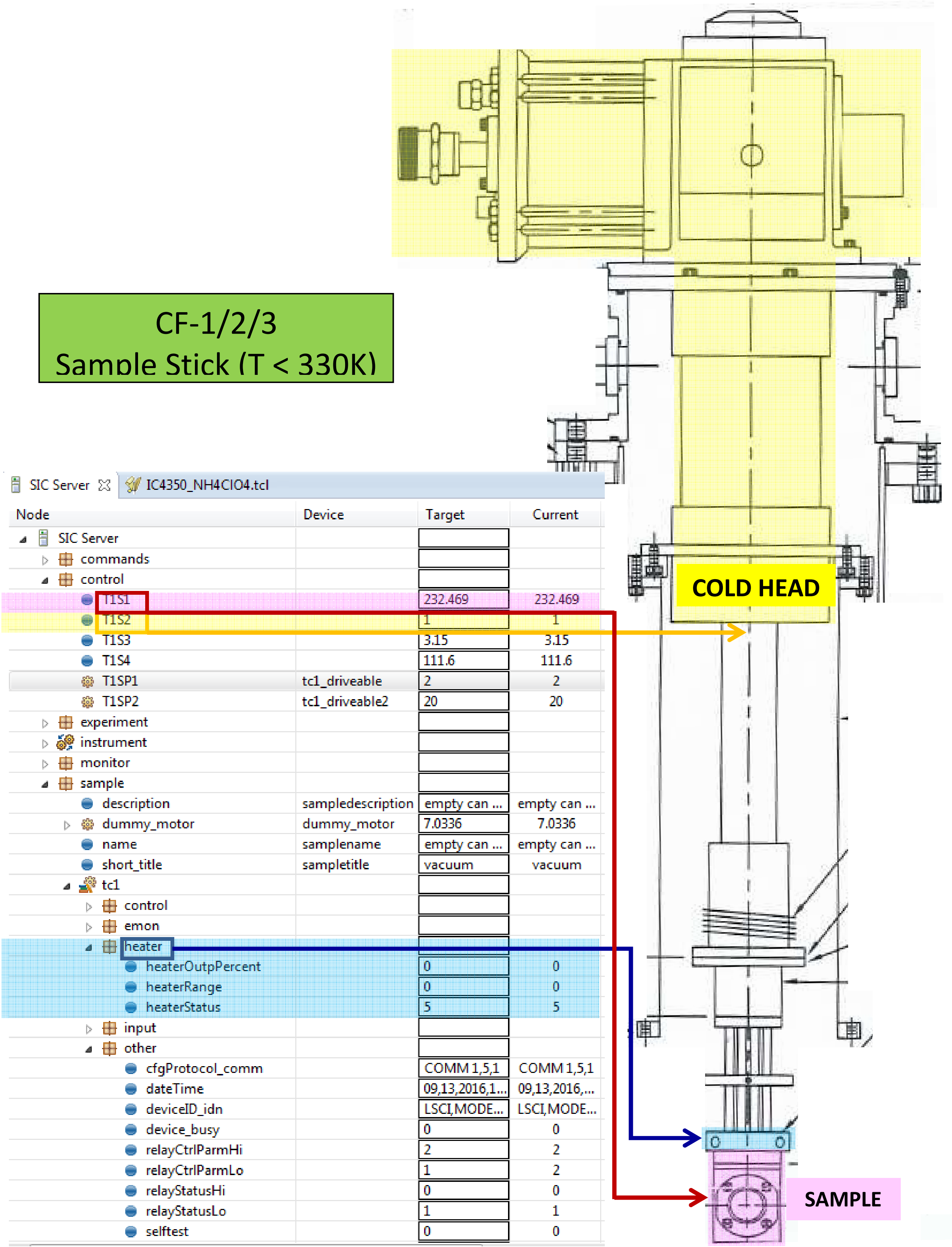
The following procedure can be used as a guide to conduct a sample change on CF-1/2/3:

Turbo Cube • Close pump valve • Turn off pump	 
CF-3 / EMU	Introduce air, four times
CF-3 Rack	Turn off compressor
EMU Service Panel	Turn off water
Wait	~ 1 ½ hours (for cold head to warm up)
Disconnections • Vent space using blue Ball valve • Disconnect vacuum tube • Disconnect green Lakeshore cable • Disconnect grey motor cable • Disconnect 2 x water lines (Supply and Return) • Remove 4 bolts at base	
Crane • No strap necessary with jib crane • Raise up CF-3 • Put plastic cover over hole in sample well	
CF-3 • Remove lower section of radiation shield (looks like a coke can) • Remove upper section of radiation shield – requires Allan key • Use heat gun on cold head and cold finger to remove ice • Mop up all excess water • Reattach upper radiation shield	

New Sample • Ensure the new sample can has a Cd collar around the flange • Screw new sample into M6 thread on CF-3 • Replace lower radiation shield with Cd disc in bottom (DO NOT PUT THIS IN FOR HIGH TEMPERATURES!)	
Crane • Lower CF-3 back into EMU • Remove crane hook	
CF-3 • Reconnect bolts, tubes and cables • Turn blue ball valve to vacuum	
Turbo Cube / Dry Roots Pump • Open the black valve • Turn on pump • Wait for good vacuum • If turbo frequency becomes stuck at ~700 – 800 Hz, use the dry roots pump to extract all moisture • Open GB (Gas Ballast) valve (you will hear a whiney noise) to avoid water build-up in the dry roots pump • When the vacuum reaches ~10-1 mbar, reconnect the turbo cube • Wait for turbo frequency to reach 1500 Hz maximum	

In SICS make sure you have these settings:





Node	Device	Target	Current
SIC Server			
commands			
control			
T1S1		232.469	232.469
T1S2		1	1
T1S3		3.15	3.15
T1S4		111.6	111.6
T1SP1	tc1_driveable	2	2
T1SP2	tc1_driveable2	20	20
experiment			
instrument			
monitor			
sample			
description	sampledescription	empty can ...	empty can ...
dummy_motor	dummy_motor	7.0336	7.0336
name	samplename	empty can ...	empty can ...
short_title	sampletitle	vacuum	vacuum
tc1			
control			
emon			
heater			
heaterOutpPercent		0	0
heaterRange		0	0
heaterStatus		5	5
input			
other			
cfgProtocol_comm		COMM 1,5,1	COMM 1,5,1
dateTime		09,13,2016,1...	09,13,2016,...
deviceID_idn		LSCI,MODE...	LSCI,MODE...
device_busy		0	0
relayCtrlParmHi		2	2
relayCtrlParmLo		1	2
relayStatusHi		0	0
relayStatusLo		1	1
selftest		0	0

2.4.2. Cryofurnace 11/12

CF-11 and CF-12 are two identical top-loading cryofurnaces. The following temperature ranges are possible:

Configuration	Lowest Temperature (K)	Highest Temperature (K)	Sensor
Cold stick	1.5	330	Cernox
Hot stick	1.5	800	Rhodium iron resistive thermometer

For more information use this link:

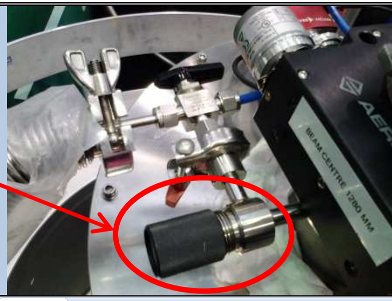
http://www.ansto.gov.au/ResearchHub/Bragg/Facilities/SampleEnvironments/Cryofurnaces/

The following procedure can be used as a guide to conduct a sample change on CF-11/12:

NOTE: This procedure only applies when using the COLD stick i.e. up to a maximum temperature of 300K. For temperatures above 300K, you should use the high-temperature stick.

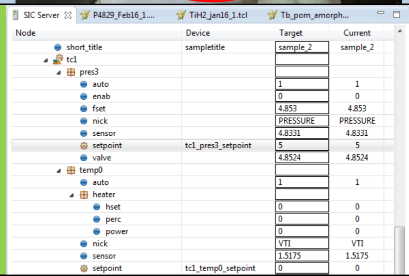
EMU – *Remove sample*

- Turn pump on
- Open over-pressure valve (Not too far)
- Fill cryostat with He(g)
- Remove sample stick - place on rack next to ladder
- Insert cover (fit with collar)
- Put sample space under vacuum



CABIN – *Begin cooling the VTI*

- Set the pressure to 60mbar (Ensure needle valve is at 100%)
- Ensure temp set point is 0K (tc1_temp0)

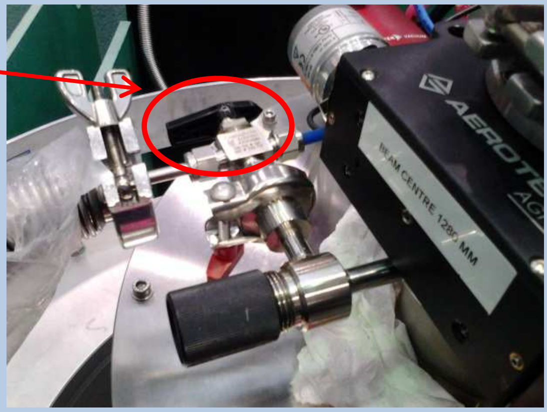


SAMPLE-PREP AREA – *Change samples*

- Defrost and dry the sample stick
- Remove the old sample
  - o Label the sample and put either in the thermoline cabinet (if not active) OR the sample safe in EMU (if active)
- Put the new sample on
- Place Cd collar around top of sample
- Check sample height. Adjust as necessary

EMU – *Load new sample*

- Place sample stick back on the rack by the ladder
- Fill cryo with He(g)
- Remove cover
- Place sample stick in cryo (fix with collar)
- Evacuate sample space to $9x10^{-2}$ mbar
- Fill cryo with He(g)
- Evacuate
- Fill cryo with He(g)
- Evacuate
- Put ~30 mbar of the exchange gas in (He(g))
- Connect temperature sensor
- Close over-pressure valve, turn off pump



OPEN THE BEAM

CABIN

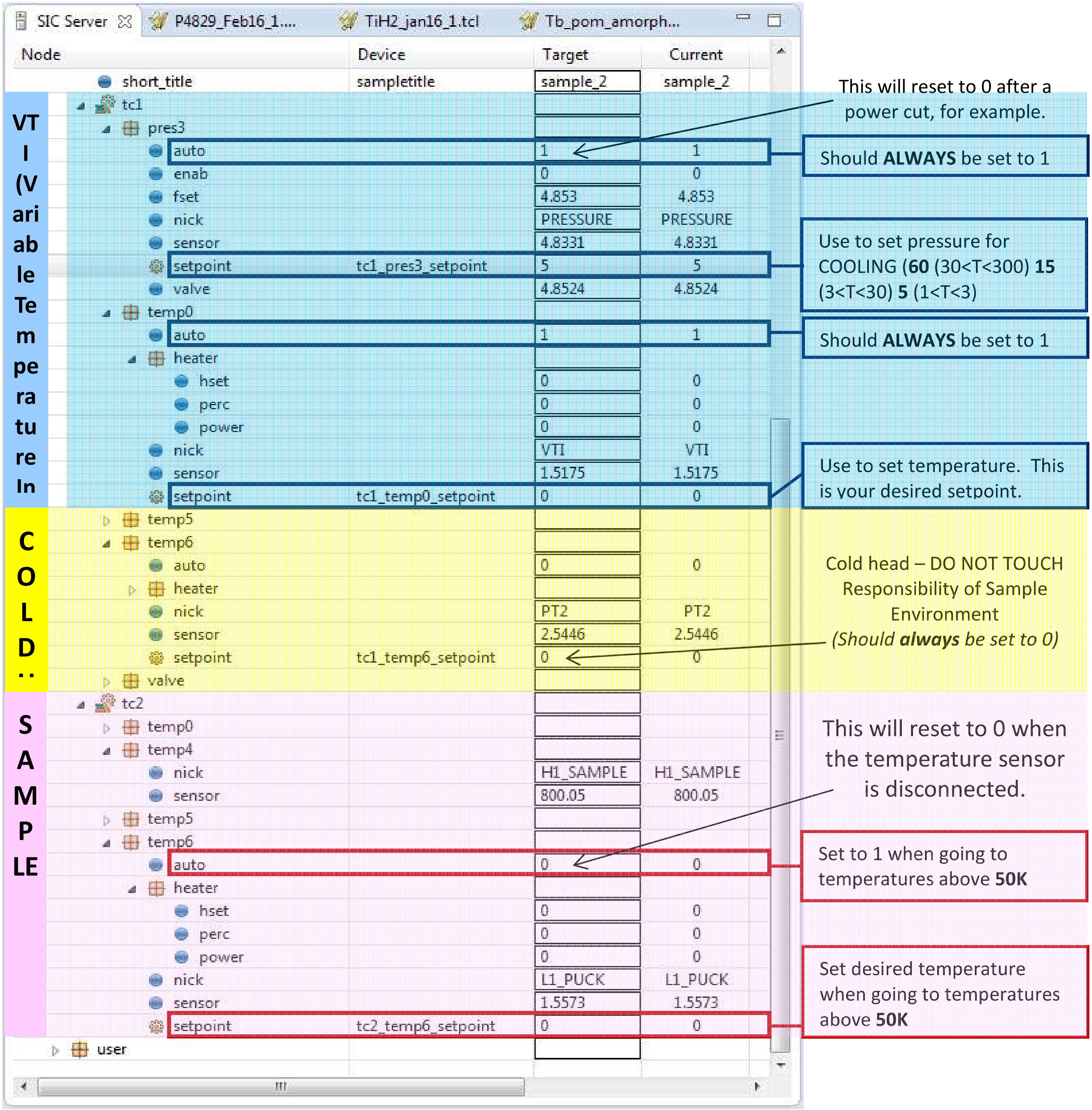
- Start script
- When VTI temp stops decreasing change pressure to 15 mbar
- When VTI temp stops decreasing change pressure to 5 mbar
  - o Sample should reach 1.5K
- Start measurement

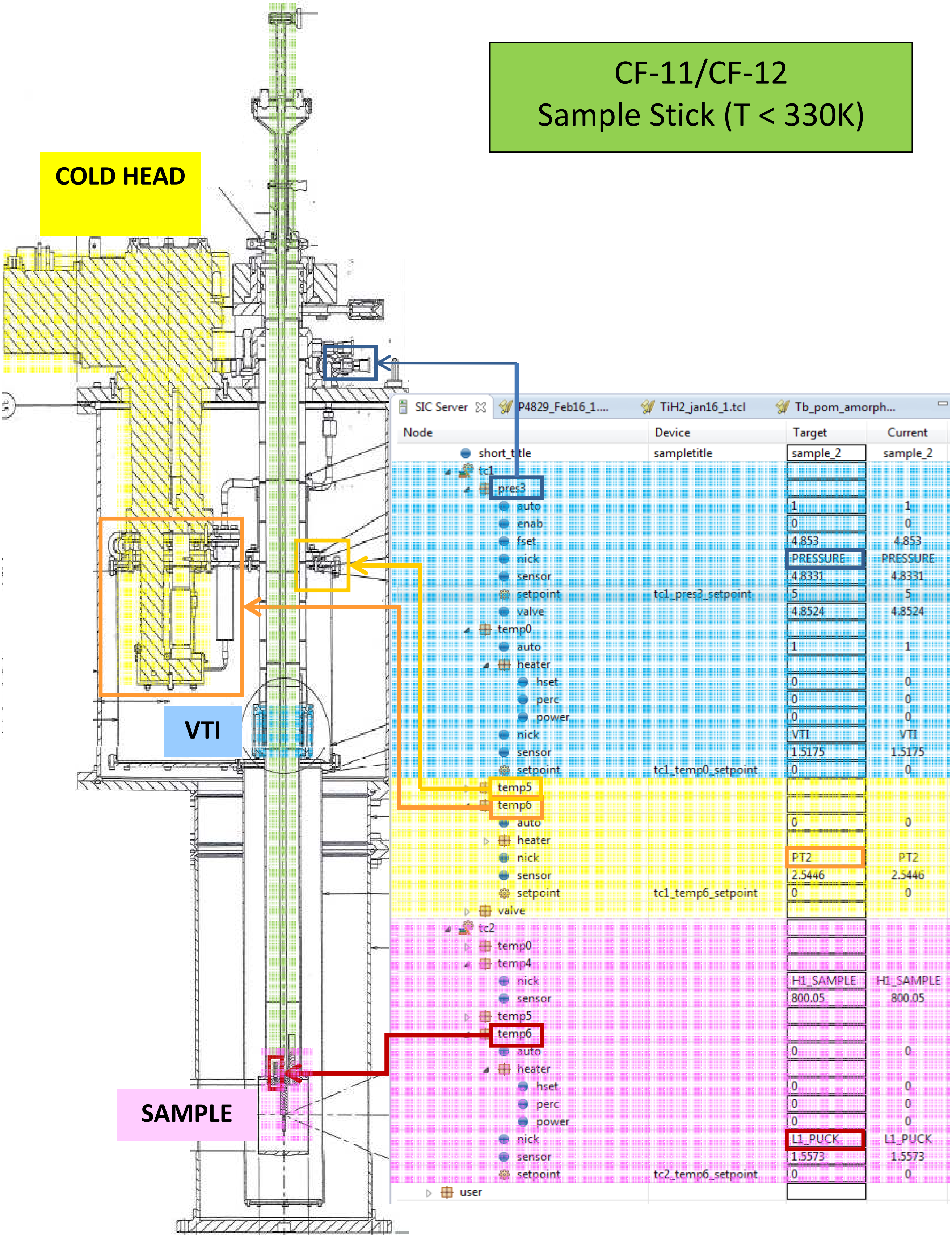
If the VTI is WARM e.g. 250K, cooling will take 5-7 hours

If the VTI is COOL, cooling will take < 2 hours

In SICS, make sure you have these settings:

CF-11/CF-12




CF-11/CF-12
Sample Stick (T < 330K)
COLD HEAD
VTI
SAMPLE
SIC Server
P4829_Feb16_1....
TiH2_jan16_1.tcl
Tb_pom_amorph...
Node
Device
Target
Current
short_title sampletitle sample_2 sample_2
tc1
pres3
auto 1 1
enab 0 0
fset 4.853 4.853
nick PRESSURE PRESSURE
sensor 4.8331 4.8331
setpoint tc1_pres3_setpoint 5 5
valve 4.8524 4.8524
temp0
auto 1 1
heater
hset 0 0
perc 0 0
power 0 0
nick VTI VTI
sensor 1.5175 1.5175
setpoint tc1_temp0_setpoint 0 0
temp5
temp6
auto 0 0
heater
nick PT2 PT2
sensor 2.5446 2.5446
setpoint tc1_temp6_setpoint 0 0
valve
tc2
temp0
temp4
nick H1_SAMPLE H1_SAMPLE
sensor 800.05 800.05
temp5
temp6
auto 0 0
heater
hset 0 0
perc 0 0
power 0 0
nick L1_PUCK L1_PUCK
sensor 1.5573 1.5573
setpoint tc2_temp6_setpoint 0 0
user

2.5. Opening/closing the beam

EMU is on cold guide 3 (CG3). Instruments downstream of EMU on this guide are KOOKABURRA and PLATYPUS. If the emergency stop is pressed and the secondary shutter is closed, all instruments on CG3 will be deprived of neutrons. If this occurs, contact your Instrument Scientist who will arrange for the shutter to be re-opened.

2.5.1. Opening the beam

The sample shutter may only be opened after going through the interlock procedure and ensuring no one is in the instrument enclosure. The interlock procedure is:

1. Search the instrument enclosure, check that no one is working on the instrument.
2. Once you are happy that no one is in the enclosure, activate the interlock by pressing the lockup initiation (exit) button near the door.
3. Visible and audible warnings will indicate the sequence has been initiated.
4. You must move outside the instrument area and within 20 seconds the door must be closed. This is locked by the SIS. Only then will it be possible to open the sample shutter and allow neutron beam onto your sample.

   NB. EMU has two doors. The rear door should remain closed at all times. You only need to close the sliding door. Once this sliding door is closed, slide the bolt into the lock.
5. Emergency stops are in the instrument area or control cabin. Do use in an emergency but be aware that they also close the secondary shutter. In a non-emergency an abort button may be used to stop exit procedure.
6. The sample shutter is then opened using the safety control panel.

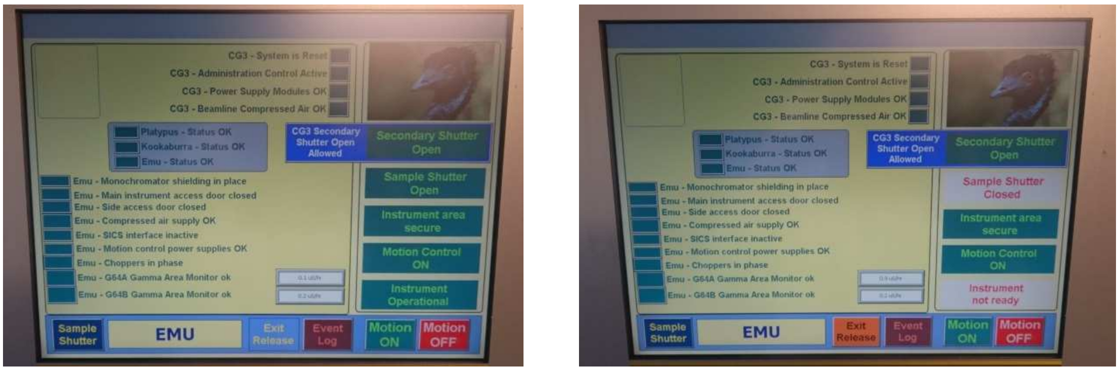


Figure 23: EMU Safety Control Panel. Green boxes indicate shutter is open (left). Orange 'Exit Release' button located bottom of screen (right).

2.5.2. Closing the beam

1. Press the blue Sample Shutter button
2. Press the orange Exit Release button (This releases the door bolt from the locked position)

3. Performing an experiment

Prior to the experiments users will be given an induction including how to use the EMU instrument correctly. This will enable users to independently;

- mount and remove samples on EMU
- leave the experiment area and lock the access door
- open and close the sample shutter
- operate the instrument/control equipment within allowed limits
- run experiments by following the procedure given below:
  - start GUMTREE/SICS
  - input information about user and sample
  - start scans
  - control experiment periodically using GUI
  - repeat scans according to the experiment program
  - stop/pause experiment
  - close sample shutter
  - go to instrument
  - remove or change sample
  - check samples for activation
  - obtain sample clearance certificates

Illustrated step-by-step instructions for running experiments are provided in the next section. At the end of the experiments all users will be provided with a complete data package including a copy of the relevant pages of the EMU logbook (paper and/or electronic).

If you wish to monitor the progress of your experiment whilst off-site, you can use the mobile page on the internet:

www.nbi.ansto.gov.au/emu/status/mobile.html

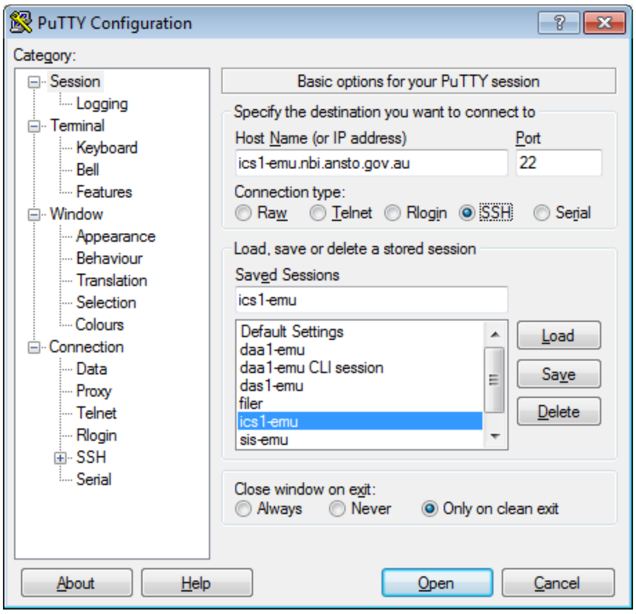
3.1. SICS

[Most of the time you will be running your experiment in Gumtree, a windows interface for SICS that is installed on all the neutron beam instruments.]

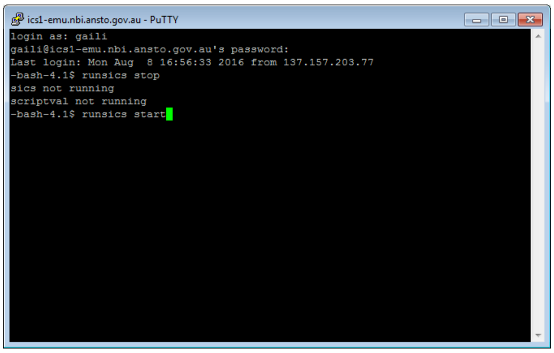
SICS (Swiss Instrument Control Software/System), is a computer program running on Linux. SICS is a command line program that is responsible for keeping track of all motors, moving the motors, starting data acquisitions, etc. There are specific commands that SICS accepts, referred to as SICS commands. SICS is located on the SICS server:

ics1 emu.nbi.ansto.gov.au.

SICS is accessed directly (using putty or similar connection) and through Gumtree.



Upon opening this connection, a command window will open:



The login and password are provided by an instrument scientist. From here, SICS can be started with the following commands:

>> runsics stop

>> runsics start

Next, make sure that your data will be saved under the correct proposal.

In the putty window type the following to verify that your datafiles are mapped to the correct proposal:

```
>> prop-scheduler --status db
```

You should see details of your experiment i.e. Principal Investigator, proposal number etc.

If the proposal is incorrect, type the following command:

```
>> prop-scheduler --start 5947
```

Where the last four digits represent the proposal number. From this point onwards, all datafiles generated after you sent this command will be mapped to your proposal.

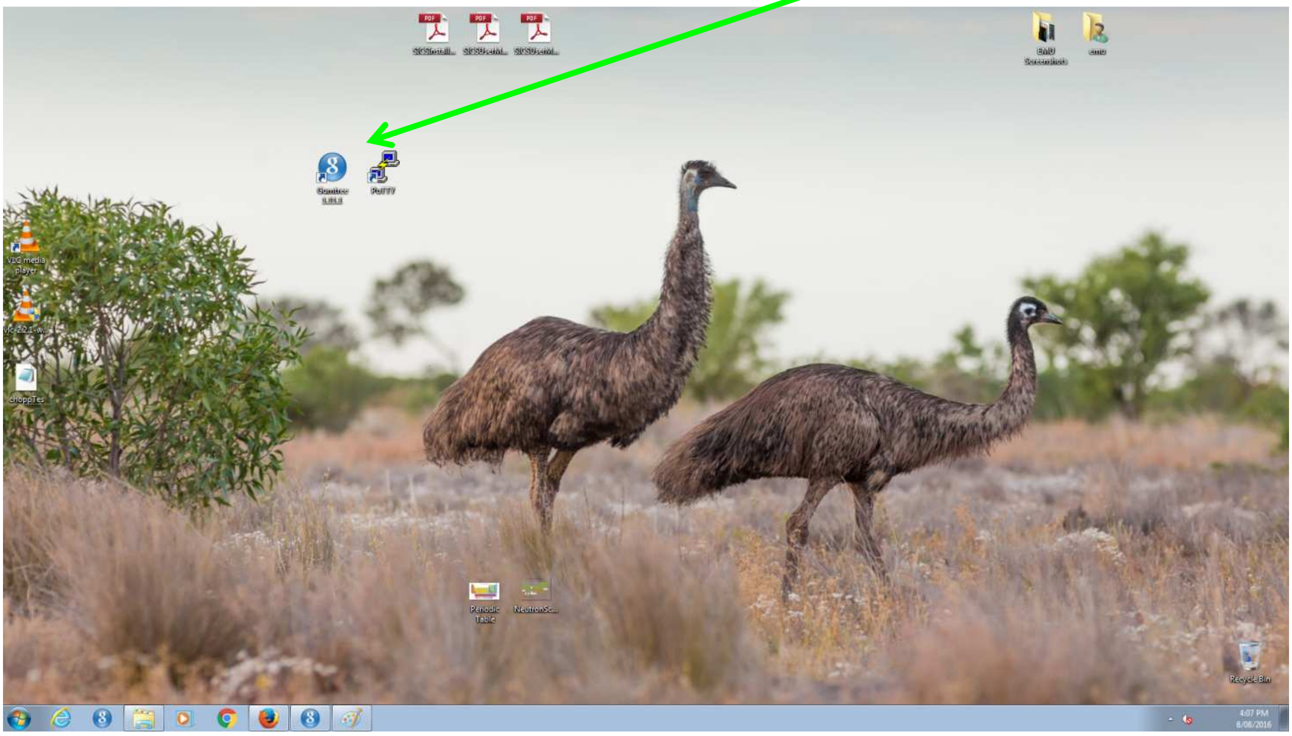
For instructions on the full functionality of prop scheduler, and all manuals related to the EMU instrument, the following link (can only be viewed within NBI network) can be used.

http://cms.nbi.ansto.gov.au

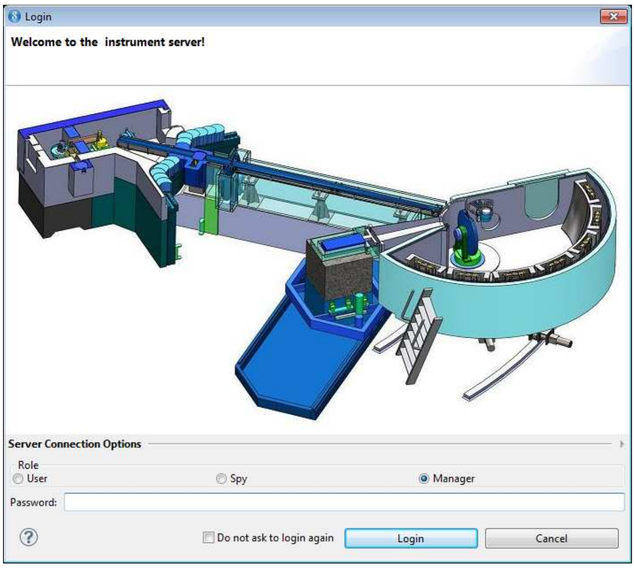
3.2. Gumtree

Gumtree is a combined instrument control and data analysis environment.

On the desktop of the instrument control computer double-click the shortcut labelled "Gumtree 1.12.5" (normally, this would already be open).

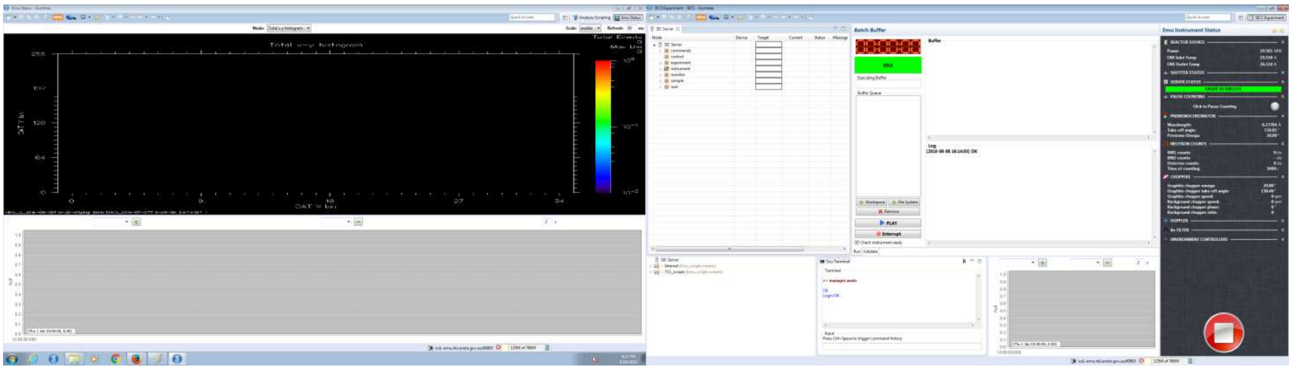


New windows will open on the screen. In the Login window make sure the Role ‘**User’** is selected.

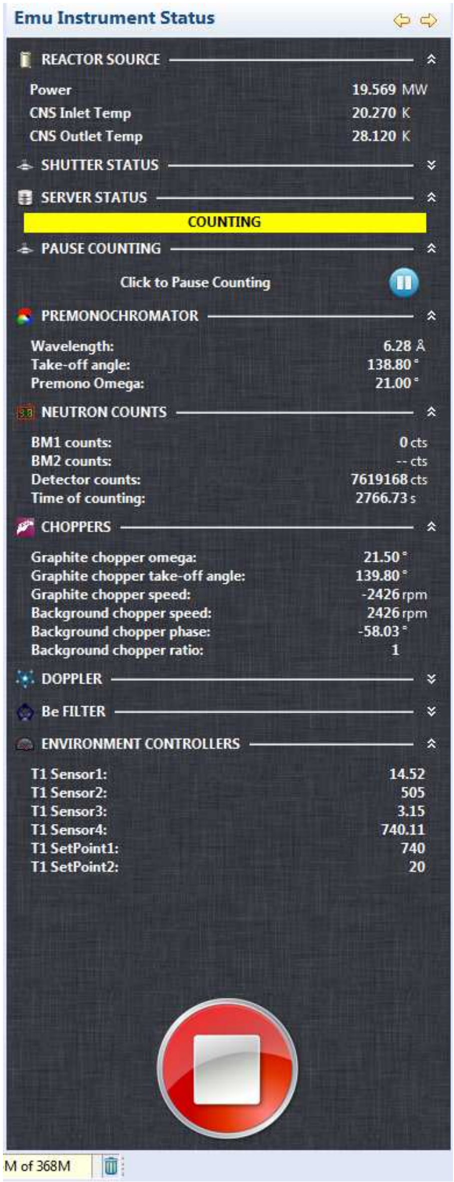


Then type in the password **sydney** (all lowercase letters).

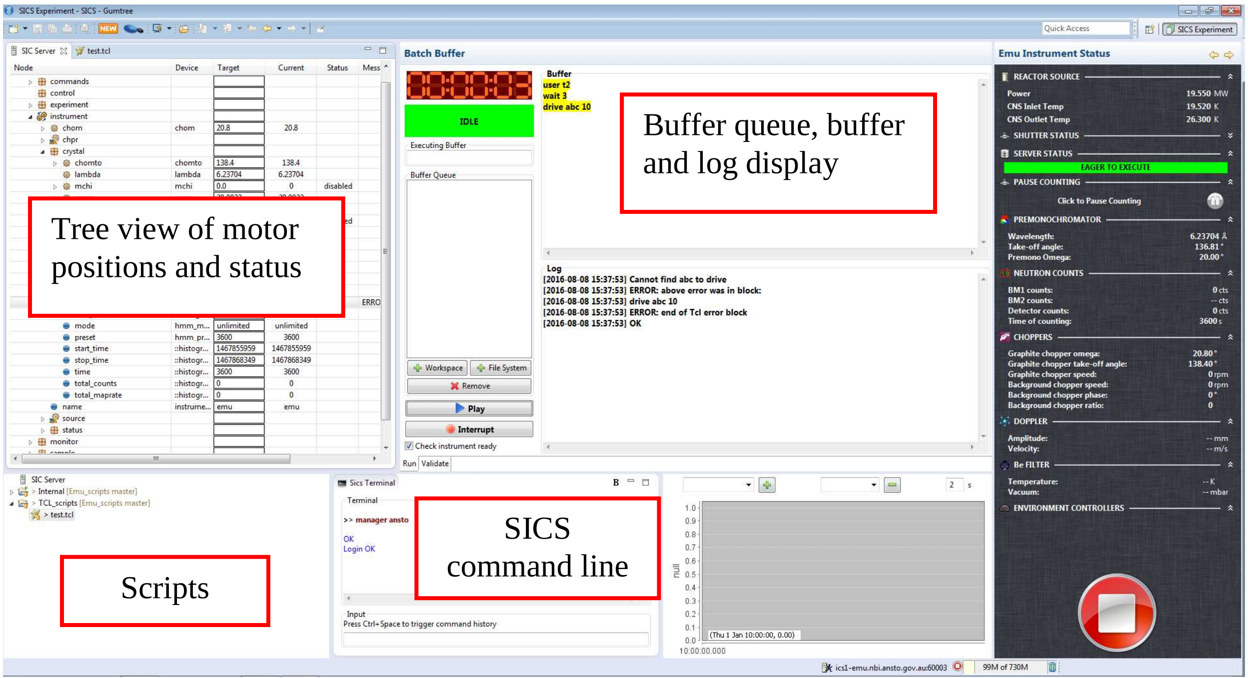
Two new windows should now open: "SICS Experiment - SICS - Gumtree" and "Analysis Scripting - Gumtree".



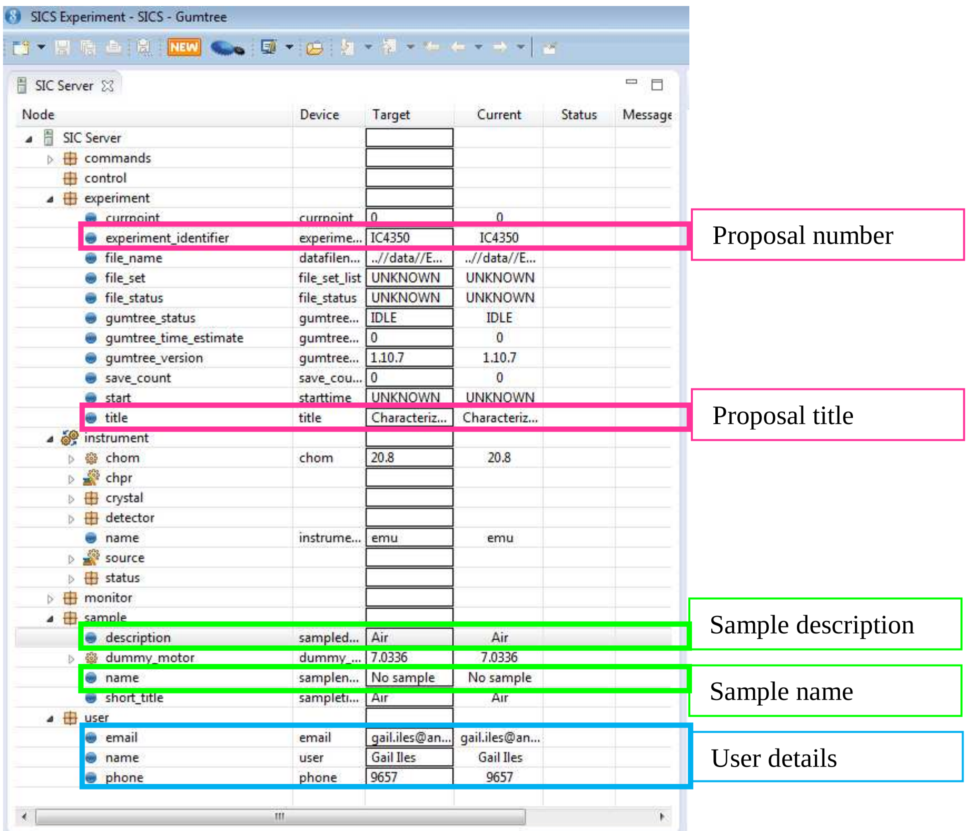
The black panel on the right side of this window is the **Gumtree dashboard** providing an overview of the current status of the reactor source and the current configuration of EMU instrument components (Premonochromator, Graphite chopper, Beam monitors, Doppler Drive, Environment Controllers).



The Gumtree interface has various panels showing different information, as highlighted in the next screenshot.



The first thing you should do is log the details of your experiment using the tree view on the SIC Server tab.



3.2.1. Chopper Settings

EMU Chopper settings should be as follows:

gchs	**-2426 rpm**	Graphite chopper speed
bchs	**+2426 rpm**	Background chopper speed
bchp	**-58°**	Background chopper phase
	1:1	Background chopper ratio

You can find these values in the Gumtree dashboard.

Chopper frequency can be obtained at this url: **daa1-emu.nbi.ansto.gov.au:8080**

The chopper configuration is an essential command. In the Sics Terminal type the following command:

>> set_chopper_config_with_roi 4.244 40.42 1 400 16 51 68 200 0 399

The parameters in the command above correspond to:

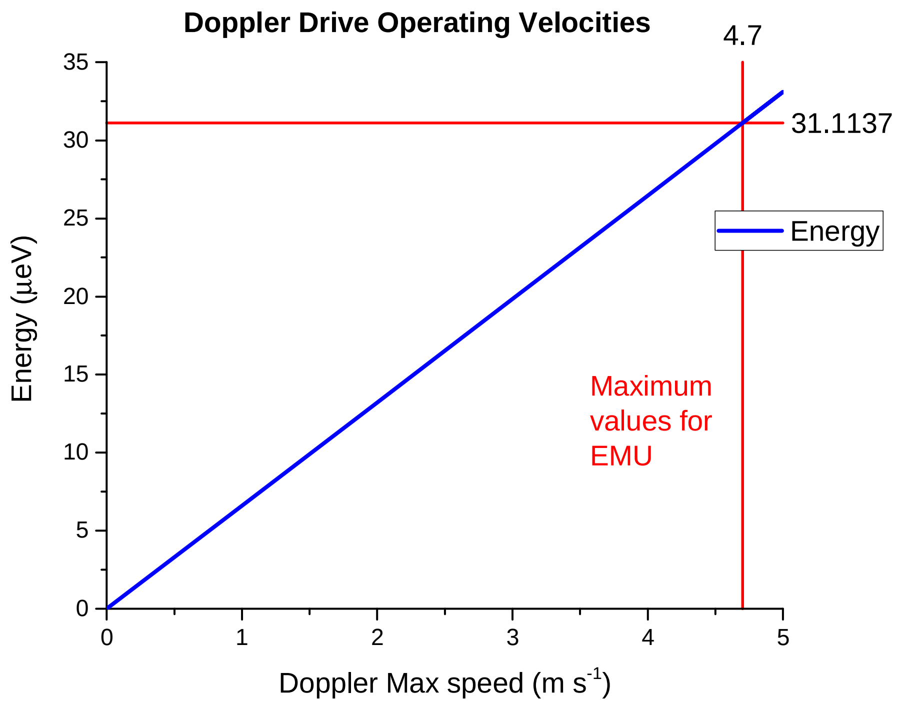
4.244	[Doppler frequency]	Depends upon Doppler velocity
40.42	[Chopper frequency]	Depends upon Chopper speed
1	[Number of frames]	Picks number of frames at a particular chopper time
400	[Chopper time bins]	
16	[Detector channel, minimum]	Vertical detector channels: 16 -> 51
51	[Detector channel, maximum]	
68	[Detector height bin, minimum]	Detector height bins range: 0 < 1023
200	[Detector height bin, maximum]	
0	[Doppler time bins, minimum]	Doppler time bins range: 0 < 400
400	[Doppler time bins, maximum]	

3.2.2. Doppler Settings

We can set two parameters on the EMU Doppler drive:

amplitude	**75 mm**	+/- lateral motion of the monochromator
velocity	**4.7 m/s**	Maximum speed of the monochromator

The velocity of the Doppler drive is directly responsible for the dynamic energy range of the instrument according to the following graph:



3.2.3. Viewing Data

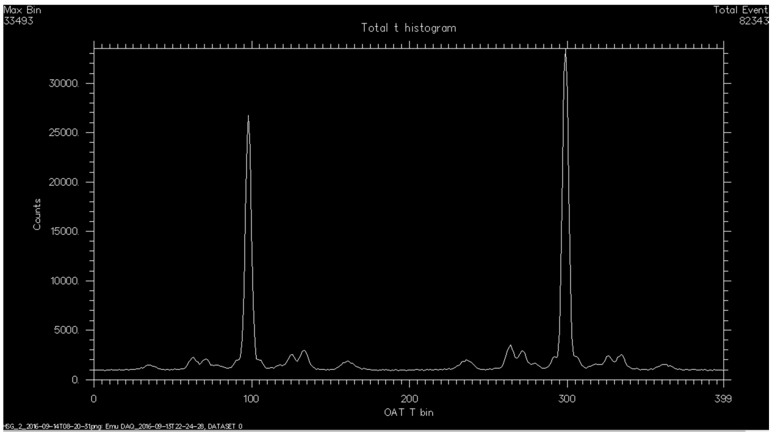
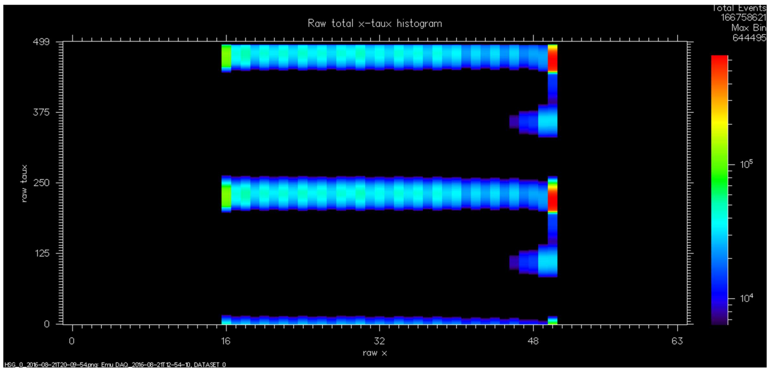
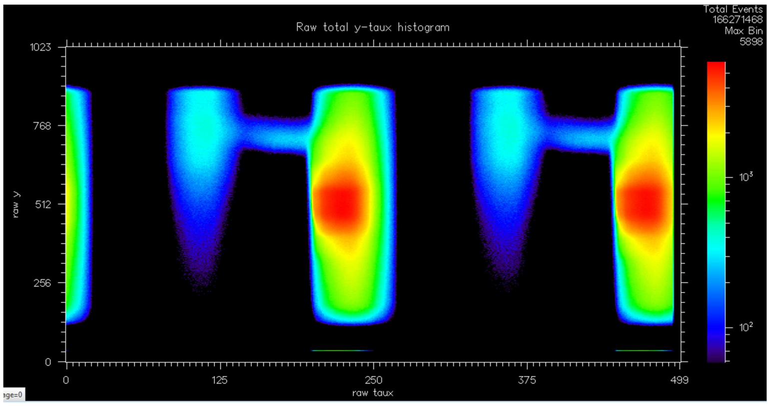
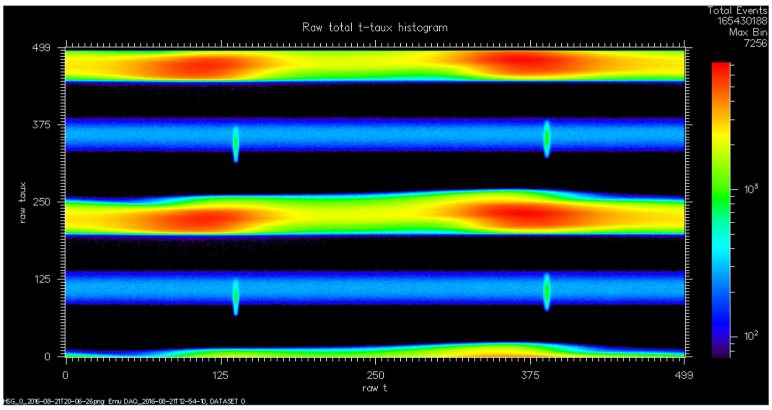
Instantaneous display of data capture is shown in Firefox via the histogram memory server. In Firefox, open the link 'View Data' on the toolbar

(View data takes you to this address: **das1-emu.nbi.ansto.gov.au:8081/admin/viewdata.egi**)

To begin counting, in the SICS terminal, type

>> histmem start

In firefox, change the view by clicking 'Disable auto-refresh' and selecting one of the following graphs:

<table>
<tr><td>Total t histogram
x-axis: Doppler time channels
y-axis: Neutron counts</td><td>
</td></tr>
<tr><td>Raw total x-taux histogram
x-axis: Detectors (16-51, Vertical detectors; 0-15, Horizontal dectectors)
y-axis: Chopper time channels</td><td>
</td></tr>
<tr><td>Raw total y-taux histogram
x-axis: Chopper time channels
y-axis: Detector height bins</td><td>
</td></tr>
<tr><td>Raw total t-taux histogram
x-axis: Doppler time channels
y-axis: Chopper time channels</td><td>
</td></tr>
</table>

If you want to preallocate a particular counting time, say 10 minutes, then use these commands:

>> histmem mode time

>> histem preset 600

Here, the preset number is the time in seconds.

Once the server has finished collecting data, to save your data, in the SICS terminal, type:

>> newfile TOTAL_HISTOGRAM_XT TOTAL_HISTOGRAM_T RAW_TOTAL_HISTOGRAM_XTAUX RAW_TOTAL_HISTOGRAM_YTAUX

>> save

This will create a file with filename similar to: **EMU0000127.nx.hdf** and is stored in the folder:

emu (\\storage\nbi_experiment_data) (U:) \data\current

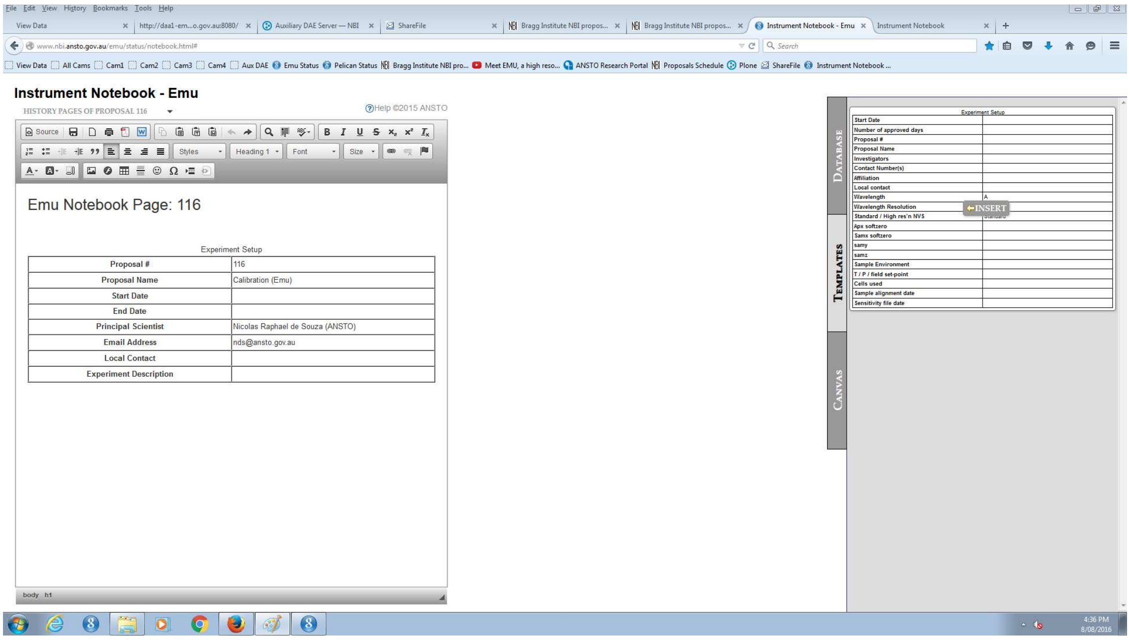
3.3. Electronic Notebook

EMU uses both a paper lab book and an electronic notebook for tracking experimental details. Please complete at least one of these methods throughout your experiment. Pages from the electronic notebook can be printed off and stuck into the paper notebook.

Access to the electronic notebook is at this link:

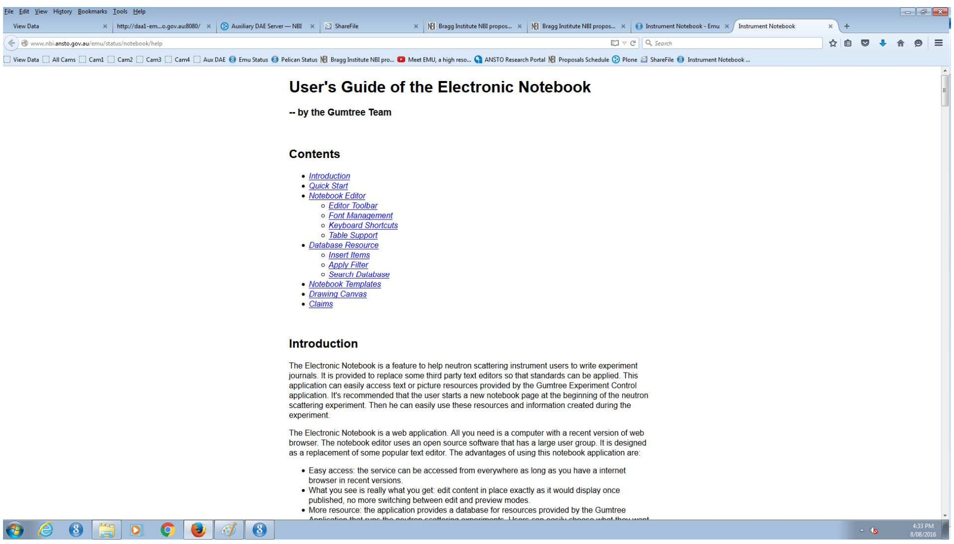
www.nbi.ansto.gov.au/emu/status/notebook.html

The page appears like so:



Your local contact or an EMU instrument scientist will create a page for your experiment with the correct proposal number.

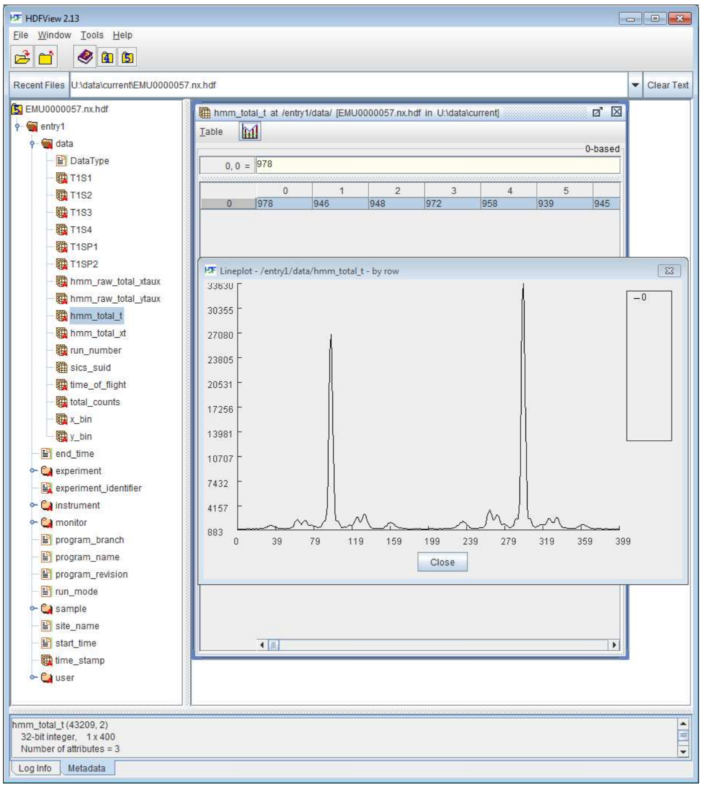
For help filling in the notebook, refer to the help page linked at the top of the page:



4. Data Reduction

4.1. Data format

The raw instrument files from EMU are output in **nx.HDF** format into **U:/data/current**. In addition to your spectroscopy data this file contains important metadata – the position of all motors for the instrument (so we can always determine approximate wavelength and resolution functions), timing signals from the choppers and Doppler drive (so we can determine the scattered neutrons with the correct time-stamp) and output from any configured sample environments.



You can open these files in HDFview (freeware and does not need installation) that HDF Group produces, but you need to know where to look in the file for the details.

https://www.hdfgroup.org/products/java/hdfview/

4.2. Accessing the datafiles

The Australian Centre for Neutron Scattering promotes access to data collected during scientific experiments. Access to a secure copy of your data is available at ANSTO during the 3 year embargo period via

scp.nbi.ansto.gov.au using a client such as

a. **FileZilla** http://filezilla-project.org/download.php

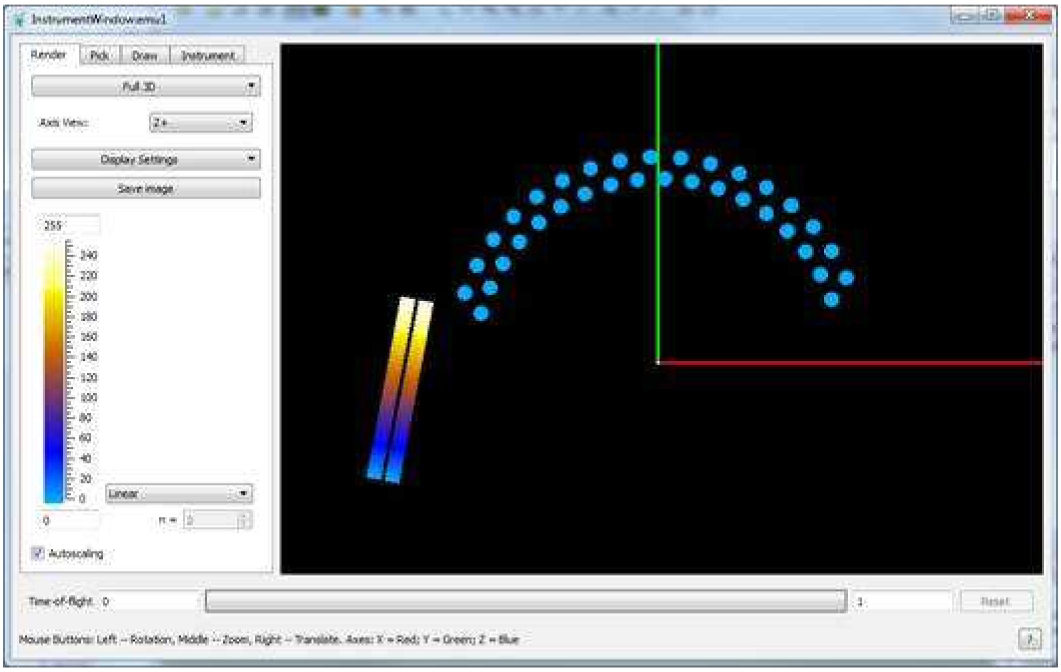
b. **WinSCP** http://winscp.net/eng/download.php

If you are unable to login, contact the ANSTO User Office Bragg-User-Office_@ansto.gov.au

It is ANSTO policy that after a 3 year embargo period, data becomes publicly accessible.

4.3. Data processing

On EMU we use Gumtree for basic data reduction and MANTID to perform further data processing.



5. Troubleshooting

5.1. Gumtree has crashed

Restart Gumtree by following the instructions in section 5.2. If you are unable to login to Gumtree then SICS may have crashed.

5.2. SICS has crashed

Please inform your local contact or any of the EMU instrument scientists. They will need to use their login to restart SICS. This can be done remotely.

5.3. Power Cut

The Lucas Heights area often experiences extreme weather conditions and this sometimes results in power failure. Although many systems have power protection and back-up power, some components may need to be restarted.

As a user of EMU you may restart the PC. Login and password for the PC are located on stickers on the PC monitor.

You should then call an instrument scientist who will be able to make a remote connection to the PC and restart SICS.

5.4. Unable to operate Doppler drive

If SICS was started BEFORE the Doppler drive was powered up, it will be impossible to send commands to the Doppler drive remotely. In order to operate the Doppler drive, power must first be established at the Doppler drive and only AFTERWARDS start SICS.

6. Index

End of document