TS1 Project with-beam commissioning

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An ariel photograph of the ISIS facility

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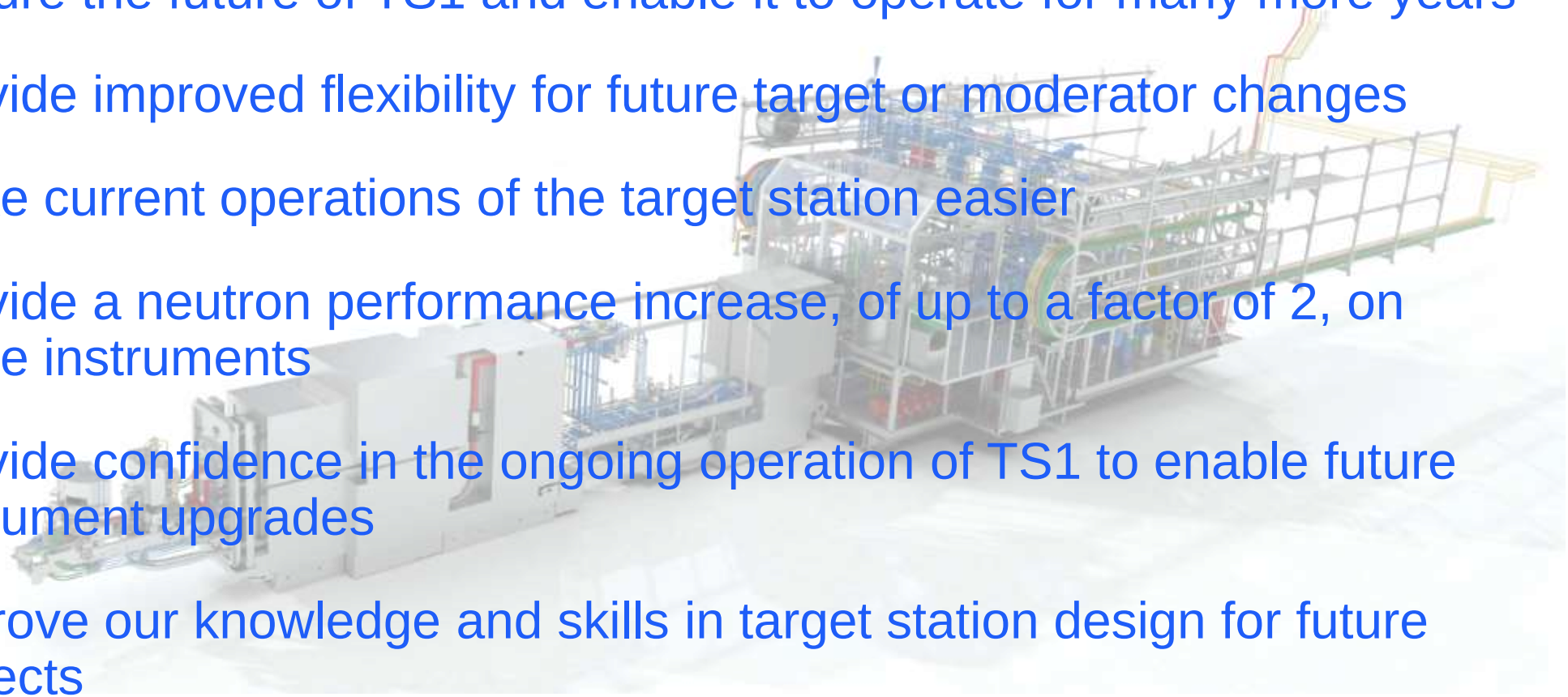
A CAD image of the full TS1 target trolley

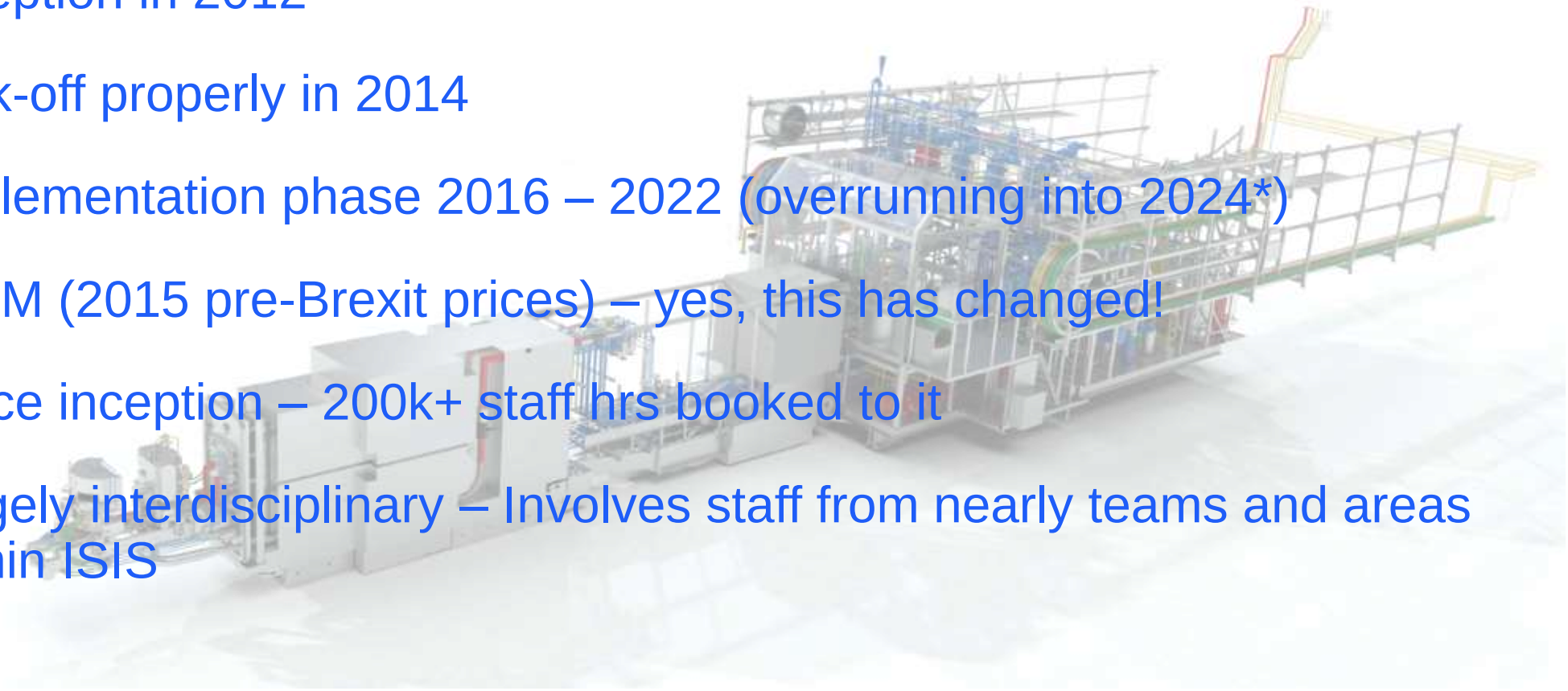
An Introduction to the Project



- Secure the future of TS1 and enable it to operate for many more years
- Provide improved flexibility for future target or moderator changes
- Make current operations of the target station easier
- Provide a neutron performance increase, of up to a factor of 2, on some instruments
- Provide confidence in the ongoing operation of TS1 to enable future instrument upgrades
- Improve our knowledge and skills in target station design for future projects

An Introduction to the Project

- Inception in 2012
- Kick-off properly in 2014
- Implementation phase 2016 – 2022 (overrunning into 2024*)
- £15M (2015 pre-Brexit prices) – yes, this has changed!
- Since inception – 200k+ staff hrs booked to it
- Hugely interdisciplinary – Involves staff from nearly teams and areas within ISIS

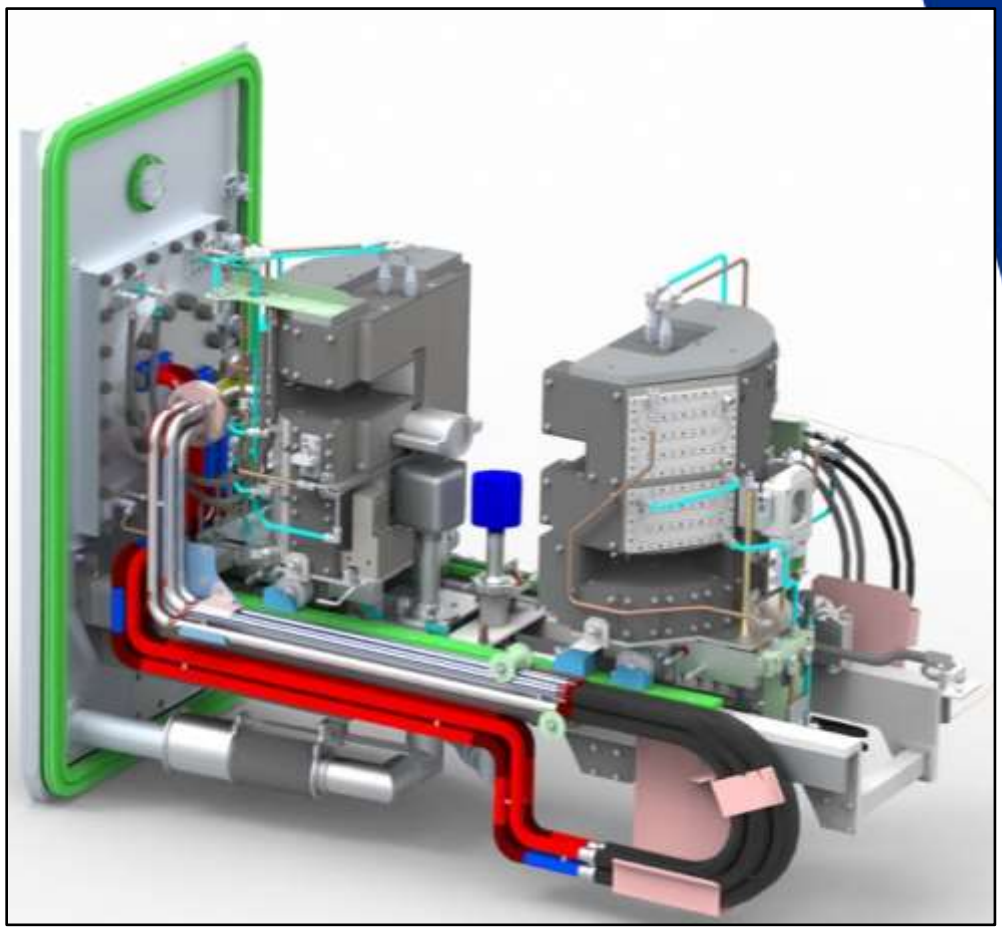


* More on that later

Overview of the TRaM

Target, Reflector and Moderators

- Target – Tantalum-clad tungsten plates housed in a stainless vessel, cooled by D_2O
- Reflector – Solid beryllium blocks externally cooled (H_2O) by aluminium cooling pads
- Moderators – Aluminium alloy vessels containing either ambient water (H_2O), liquid methane (at 110k) or liquid hydrogen (at 20K)
- Pre-moderators for both H_2 & CH_4 moderators
- Halo and profile monitors sit in front of assembly



A CAD image of the TS1 TRaM assembly

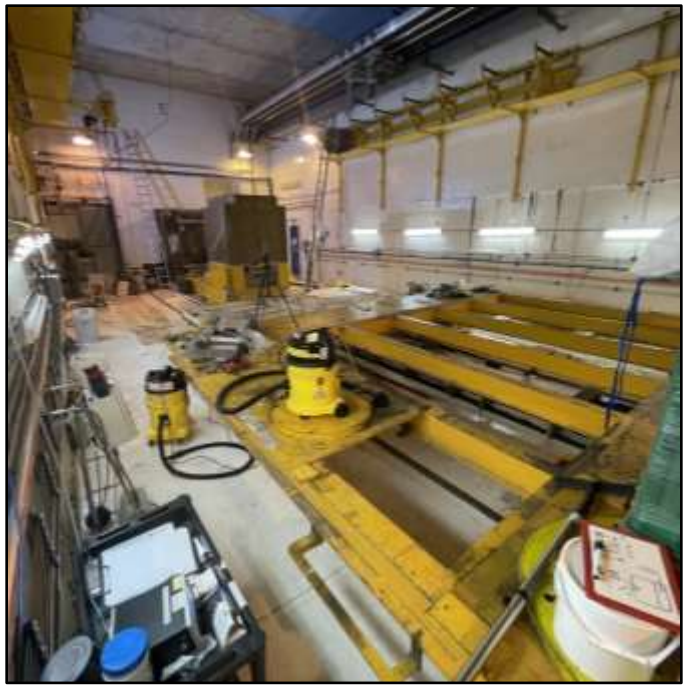
The long shutdown

Started 21st June 2021

Photographs from inside the target services area during the initial weeks of the strip-out phase of the shutdown

The long shutdown

Progress through the shutdown



Photographs of the final stages of the strip-out phase and the beginning of the installation phase

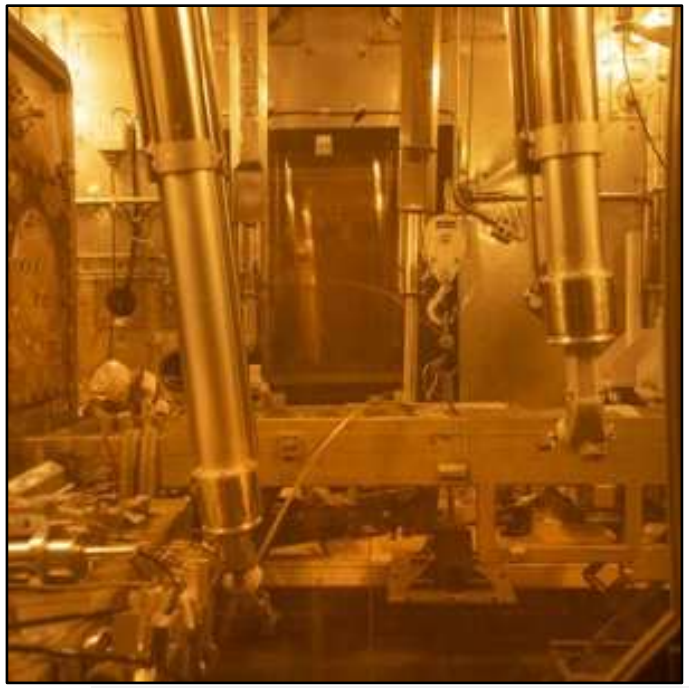
The long shutdown

Progress through the shutdown

Connection of the modular services ‘skids’ and installation of the cryogenic cold boxes. Right hand image is the completed services trolley

The long shutdown

Progress through the shutdown – remote handling work



Images of the remote handling work in the cell to strip out old TRaM assembly

The long shutdown

Progress through the shutdown – remote handling work

Installation images for the new TRaM installation and connection in the RHC

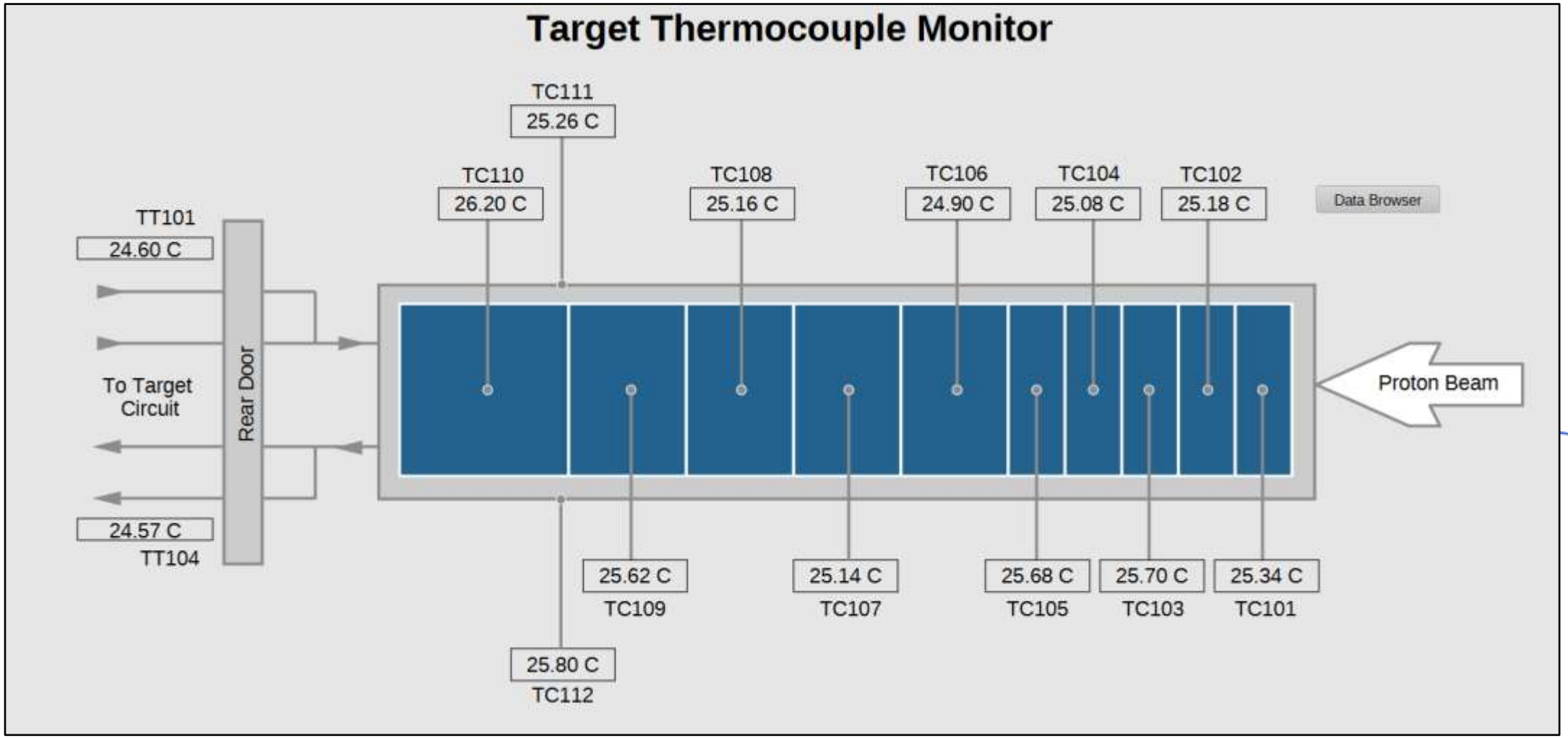
The long shutdown

Progress through the shutdown – dealing with the waste

A series of photos showing aspects of the waste handling and management

The Target

Focussing on challenges encountered during the commissioning of the target

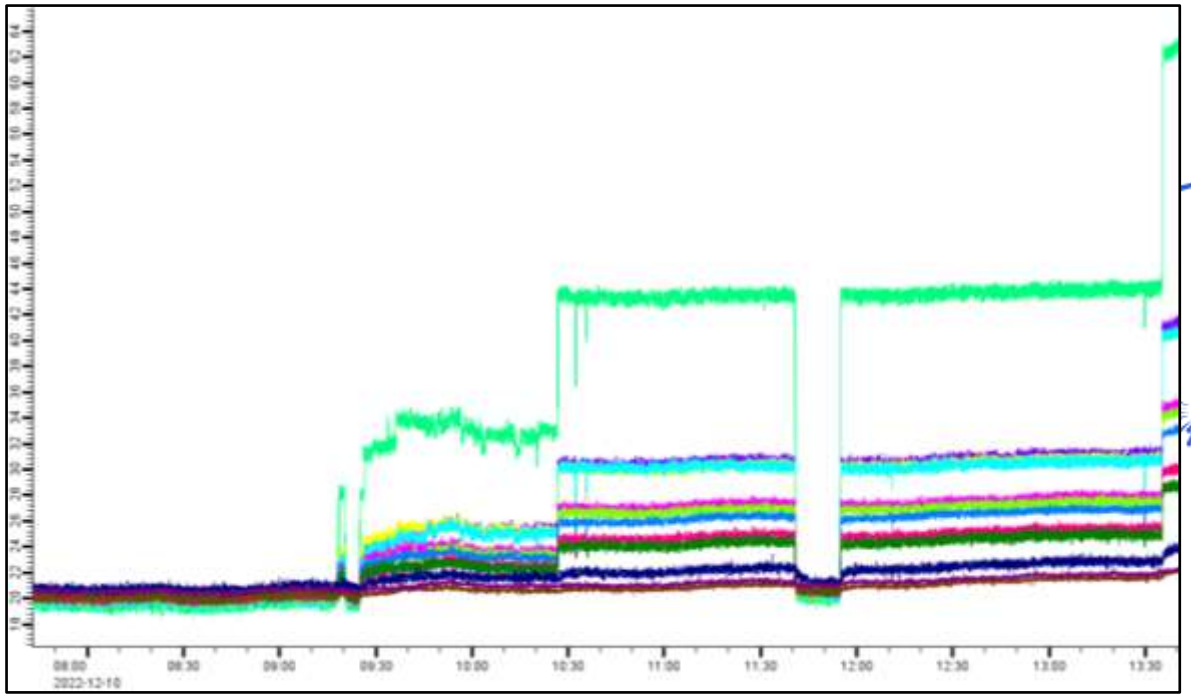


A Schematic layout of the thermocouples on the target

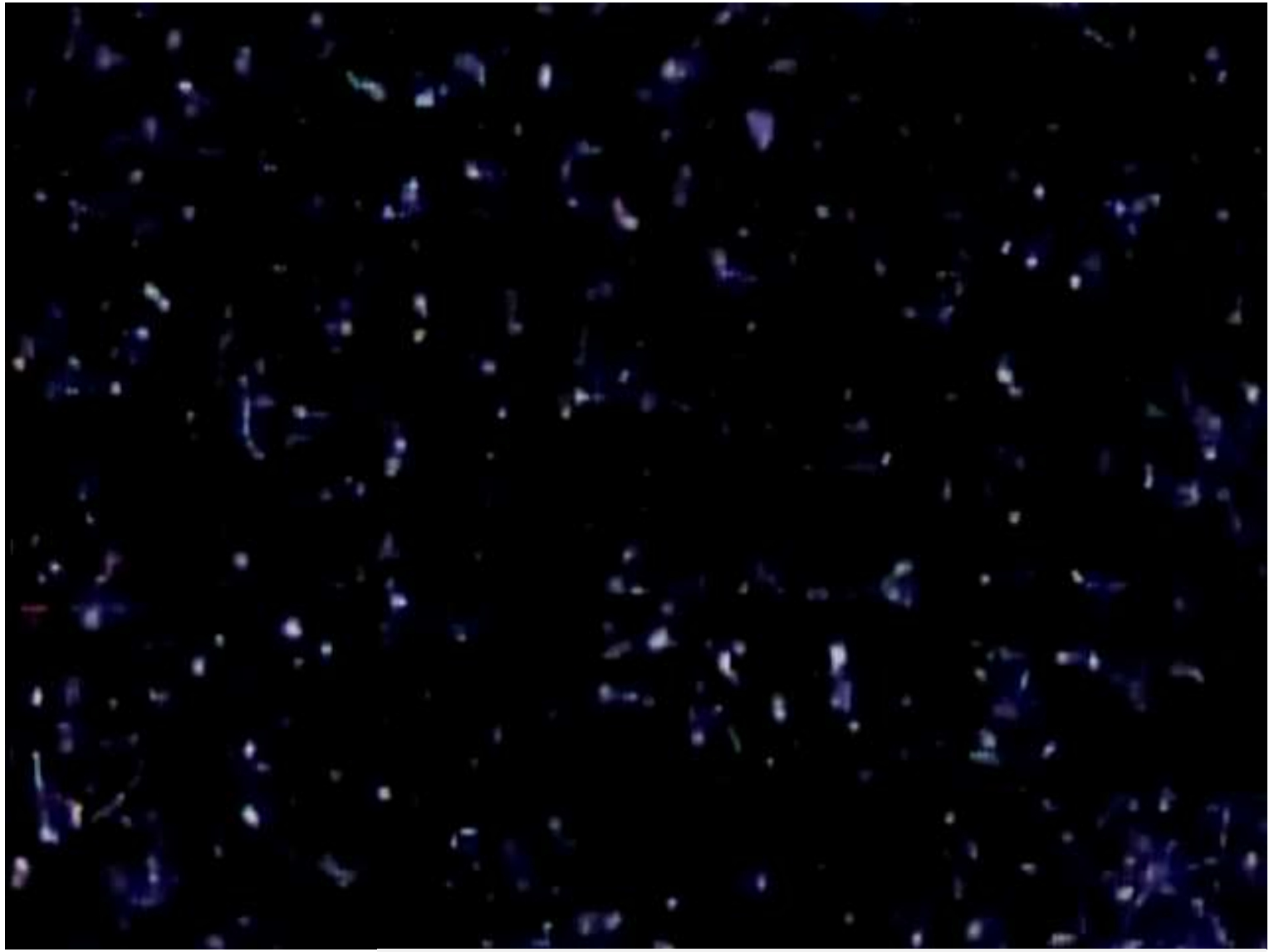
A video from the ISIS control of first pulses of full power beam

The Target

- Initial beam pulses on target showed front target plate running hotter than expected and simulated
- Limited beam to ¼ rep rate while investigated
- Carried out a root cause analysis
- Physical investigations & visual assessment
- Simulations



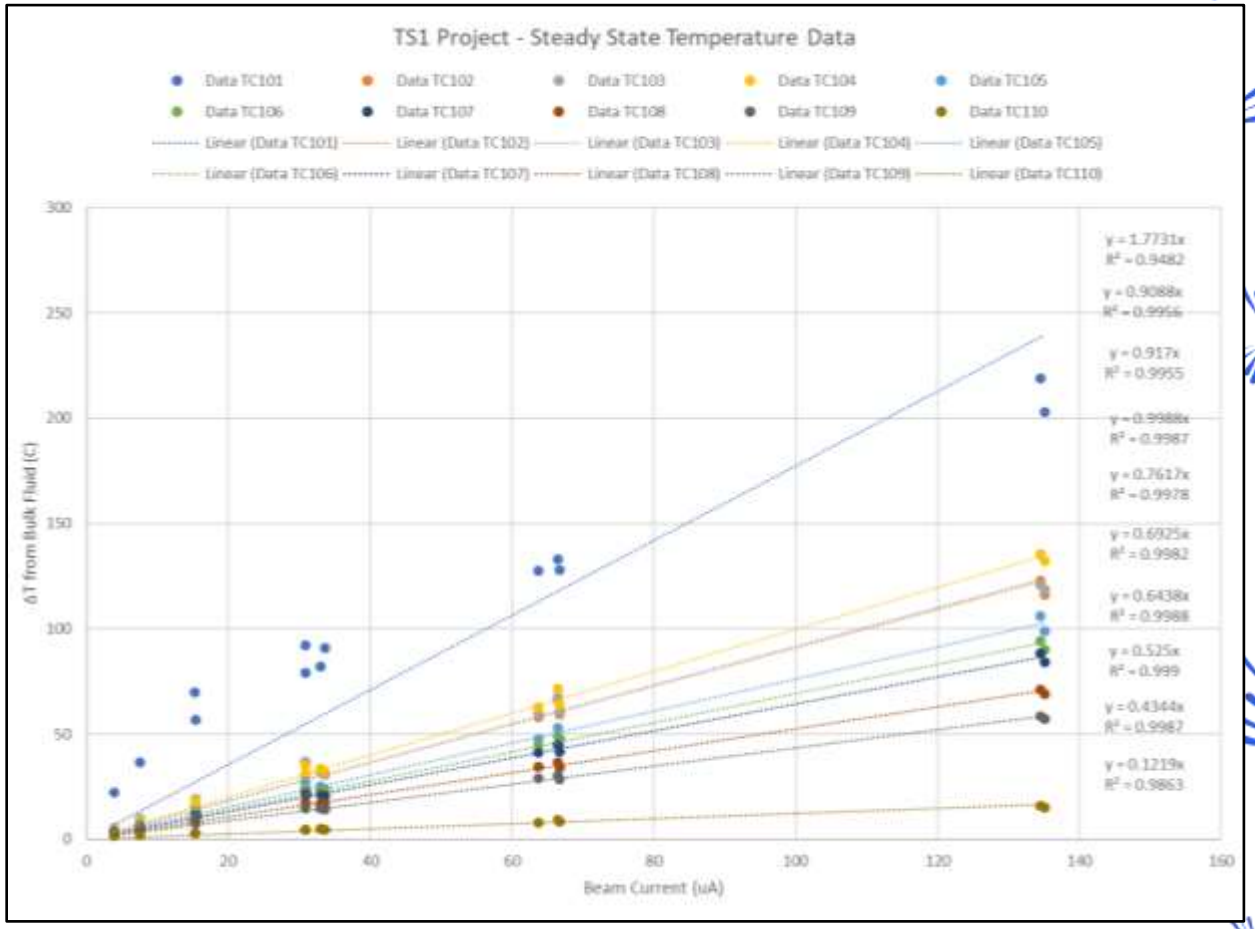
A screengrab from a control screen showing the target thermocouple readings



Video footage from the borescope inserted into the target to look for potentially blockages or other signs of damage

The Target

- Worked through the list of possible causes and mitigation for them
- Beam scan H & V across target
- Change of focus
- Went to full power
- Current ‘best guess’ poor thermal contact(s) – link to Dan W’s talk -
  Simulated and Measured Performance of ISIS TS1 Project Target – on Wednesday 1st Nov



A graph showing the differing temperature behaviour of plate one compared to other plates and predictions

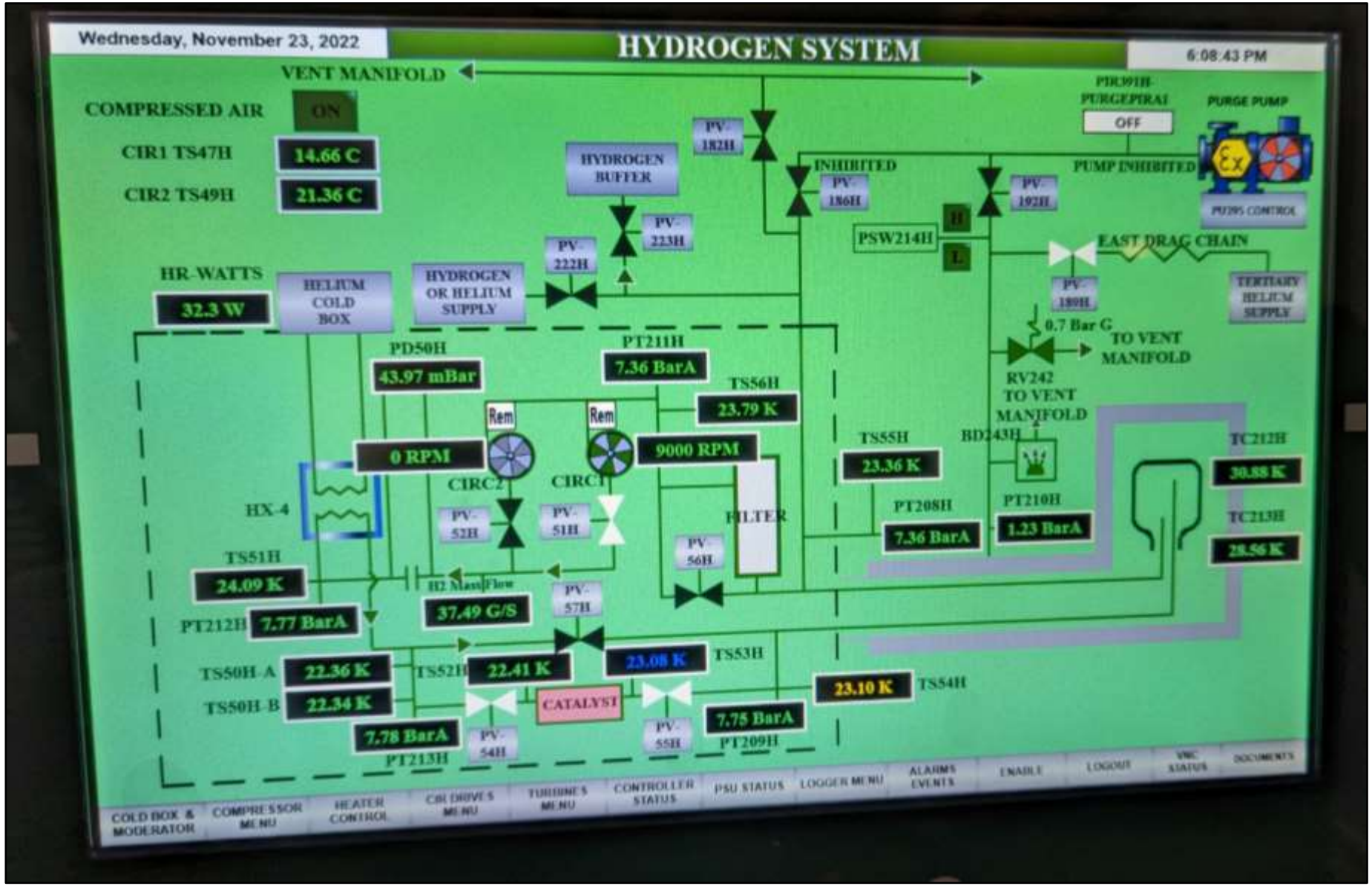
The Target – Status and Outlook

- Continuing to run & monitor
- Repeating beam scan tests
- Repeating decay heat tests carried out on previous target
- Feel we have more margin on plate 1 temperature to increase intensity further
- Extra QA for spare target and future ones

Image from in-cell cameras of the target front face

The H_2 Moderator and cold boxes

Focussing on challenges encountered during the commissioning of the moderator & connected cryo system



An image of the control screen showing an overview of the cryogenic hydrogen system

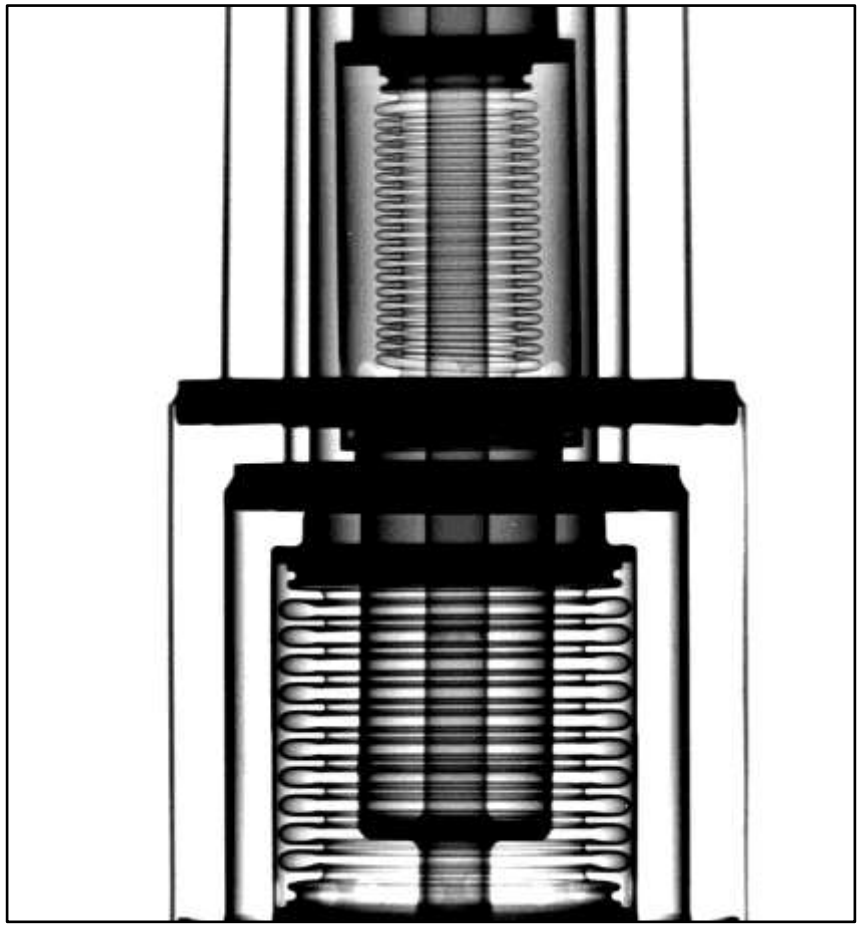
The H_2 Moderator and cold boxes

- Initial operation impacted by some issues connected to the compressor:
  - Heat exchanger scaled-up – insufficient cooling caused trips on oil temp
  - Oil leak due to O-ring installation error
- Cold box contamination due to pressure inspection
  - Ran using N_2 cold trap which took extra time
- Once these were overcome, moderator ran well

A leak on the compressor heat exchanger

The H_2 Moderator and cold boxes

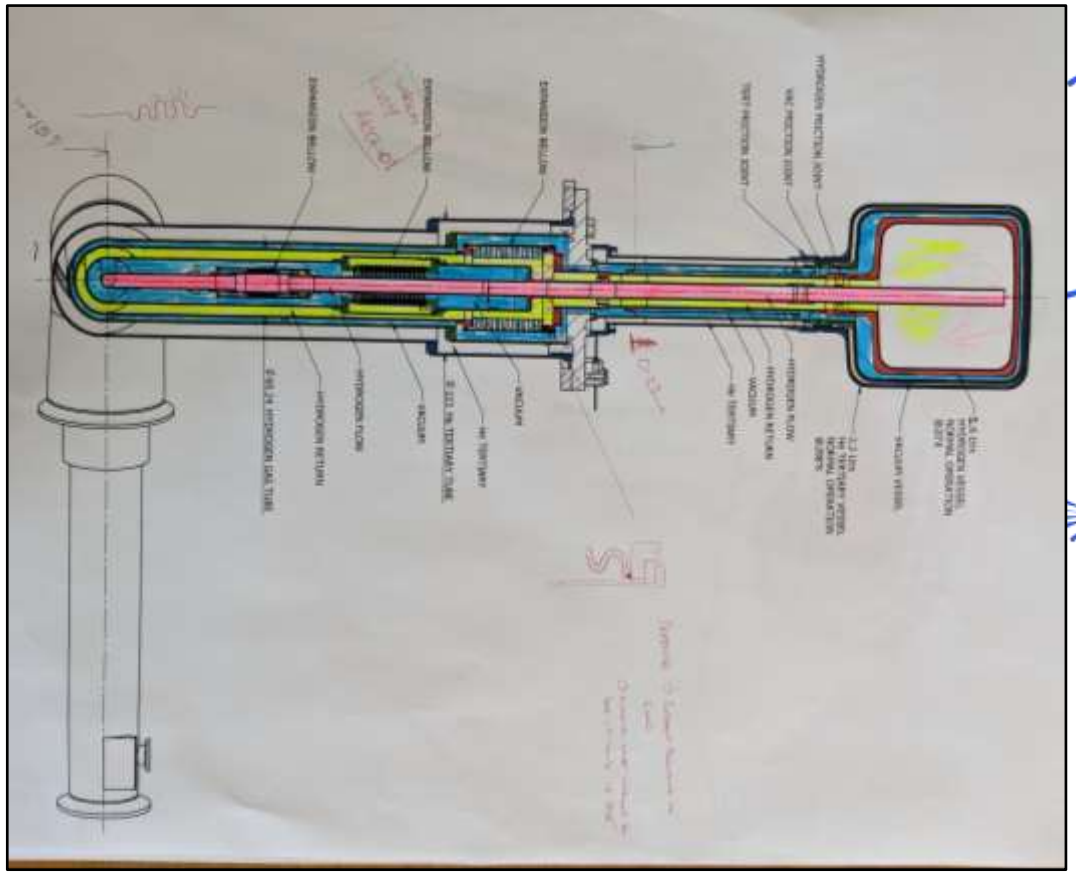
- LH2 moderator vacuum issue meant could not maintain operational temperature
- Leak progressively isolated
- Investigation into cause & IMAT imaging
- Cycle testing of spare moderator
- Concern potential for common design fault
- Re-designed moderator ‘neck’



An image of the moderator’s bellows from the IMAT beamline

The H_2 Moderator and cold boxes – Status and Outlook

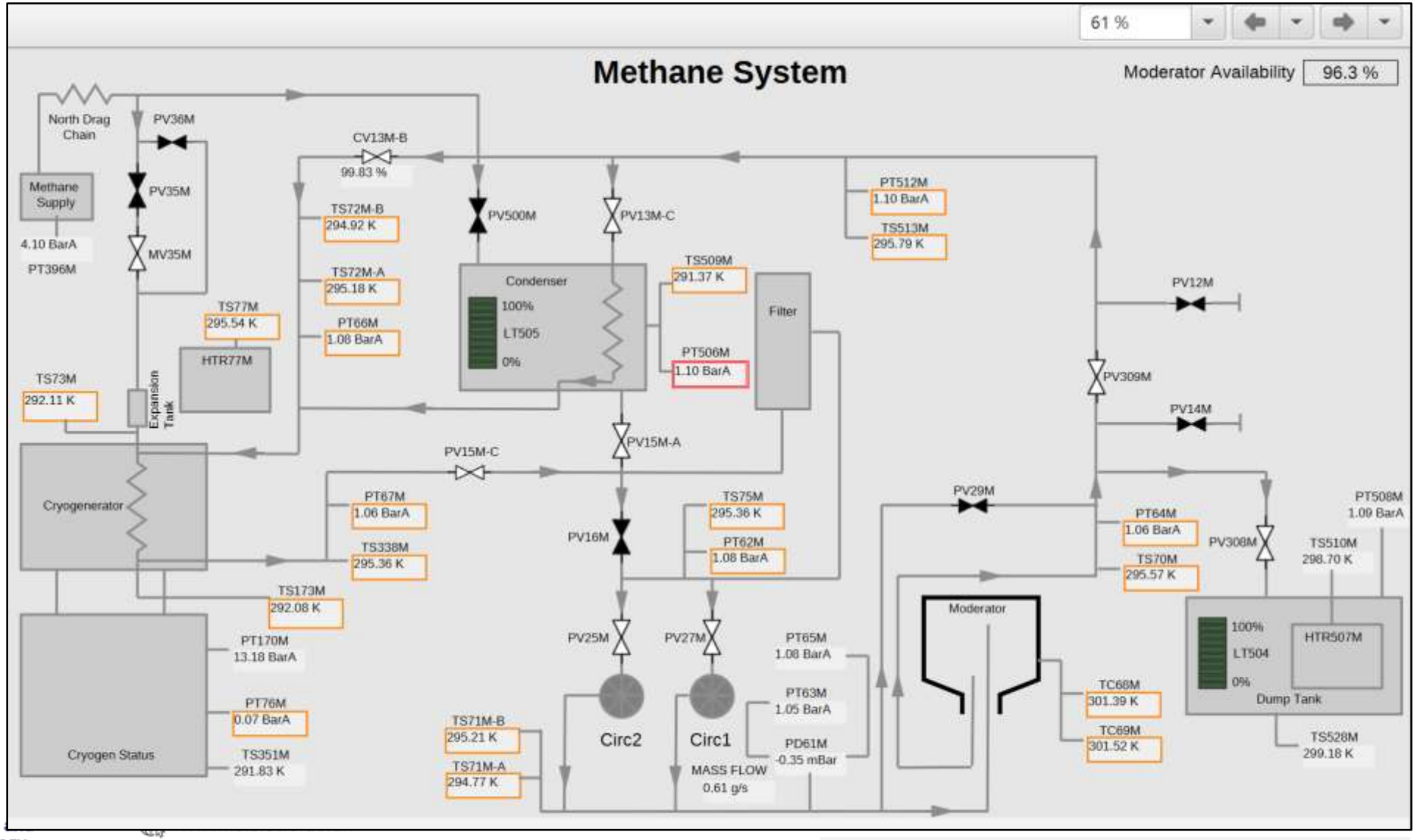
- New moderator now in manufacture
- Due to be delivered and fitted in Jan 24 shutdown
- Will image this on IMAT under loaded conditions before installation
- Still need to fully commission system
- Initial early running of previous moderator showed positive neutronic performance



A marked-up drawing of the moderator as part of a review of the design

The CH_4 Moderator and cold boxes

Focussing on challenges encountered during the commissioning of the moderator & connected cryo system



A schematic of the methane cryogenic system

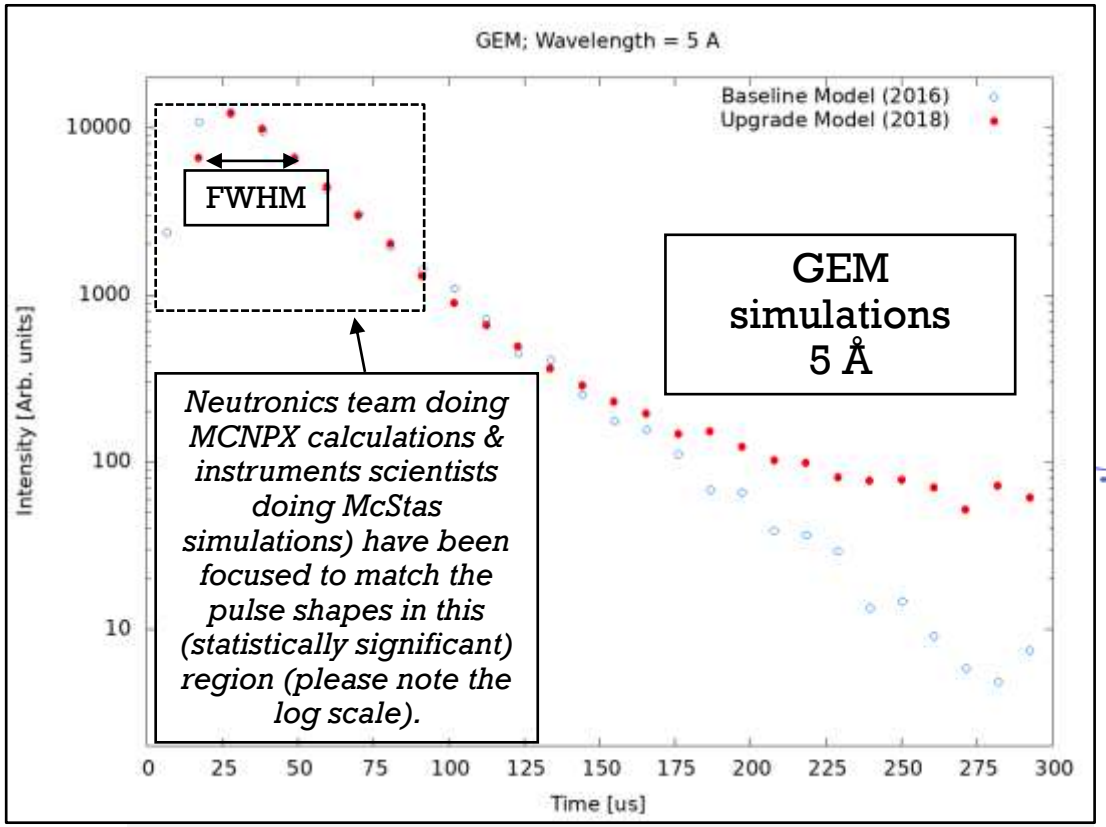
The CH_4 Moderator and cold boxes

- Initial struggles to get system into liquid – topography
- VSD & vibration leading to bellows leak
- Filter pressure drop and pressure instabilities
- Cryogenerator issues
- Circulator flange temp trips
- Circulator speed adjustments

A photo of the methane system filter unit

The CH_4 Moderator and cold boxes

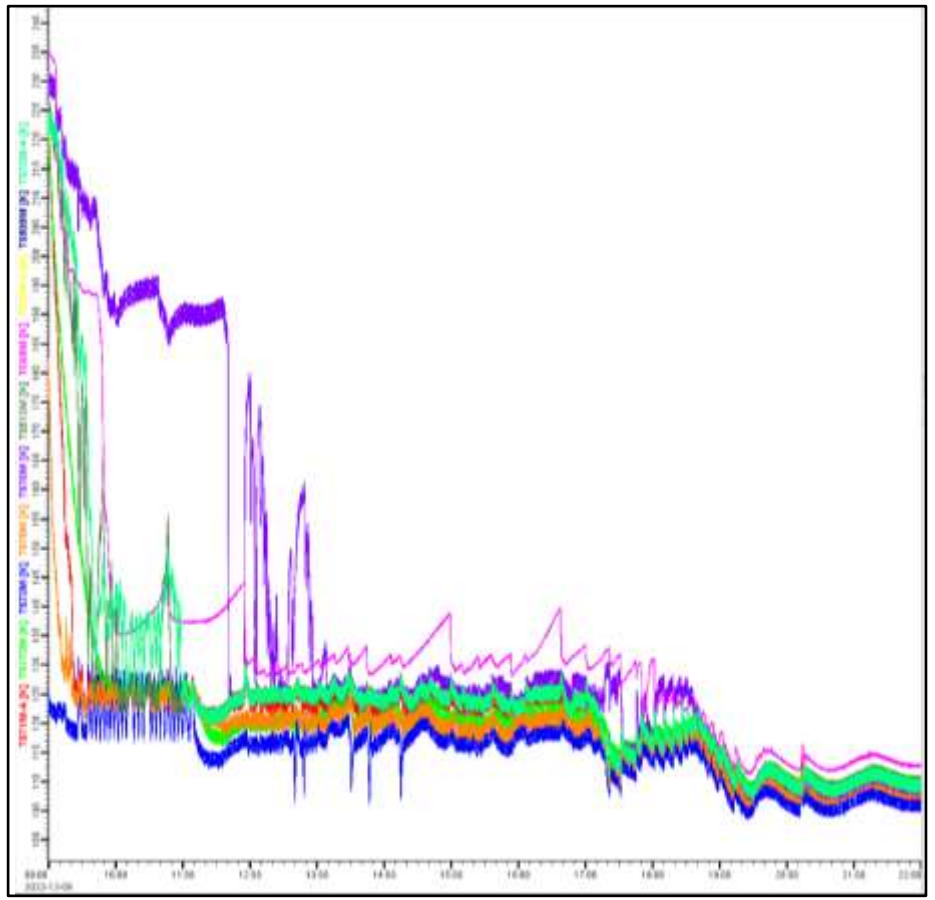
- Build-up to steady ops
- Methane system parameters took several months to optimise
- Unexpected ‘tails’ on methane pulse:
  - Cd ‘beanie hat’
  - Investigated draining pre-mod



A plot of simulations for GEM beamline showing the ‘tail’

The CH_4 Moderator and cold boxes – Status and Outlook

- Have run 2 successful cycles on the moderator
- Have a reduced ‘veto-window’ during the charge change
- Have an improved understanding of moderator deterioration
- Continue to monitor
- New Cd ‘deerstalker hat’ to be fitted
- Several system design improvements underway



A control screen image for the temperature measurements during a CH4 system cooldown

General outlook and plans for the future

A quick look at where we are currently and future work & plans

General outlook and plans for the future

- Continue to run on with current target and increase intensity
- Change methane moderator in winter shutdown
- Install new hydrogen moderator in winter shutdown
- Will re-run absolute flux and time-structure measurements on all TS1 instruments
- Continue to work through long list of follow-on work
- Longer-term look at repeating more of the baselining activities carried out, for instance radiation levels inside TSA when running

General outlook and plans for the future

- Well on our way to meeting the aims of the project
- Staff retention will be key – want to use skills and experience for future projects
- Beginning to regain confidence of science community, which did take a knock
- ISIS Endeavour and post-Endeavour programmes will look to develop instruments with greater confidence and with flexibility to possibly change TRaM to support

Acknowledgement

I want to recognise, acknowledge and offer my gratitude to all of the (mainly) ISIS staff whom have contributed to the project, in whatever form. There has been a tremendous amount of hard work, effort and input, without which, what we have already achieved would not have been possible.

Thank you for your attention.

Any questions?

Back-up Slides

Support for potential questions & further info

The ISIS Pulsed Neutron and Muon Source

- 800 MeV Proton Synchrotron
- Two Target Stations
- 30 Neutron Instruments
- 5 Muon Instruments

In a typical year...

1200 experiments *by* **3000** users *from* **30** countries *generating* **600** publications

Science and Technology Facilities Council

ISIS Neutron and Muon Source

The Target – physical investigations

Ran water in reverse

Filtered water with finer mesh filter

Inspected filter

Endoscope inside target

Heated up water (using pumps) to check TC responses

Validated TC cabling and monitoring system

Control System

- Moved control system over to EPICS
  - Allowed for much better visualisation, capture and communication of data
- Essential part of commissioning
  - Adjusting parameters
  - Polishing code
  - Understanding some system errors

TS1 Target control room computer screens

General Systems

- Ventilation – challenges with air changes vs pressure differentials
- Water
- Flammable gas alarms
- Void vessel – He leak