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SG48 – TSL measurement capabilities at ISIS

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Contents

- ISIS
- Vesuvio
- Tosca
- Recent work
- Planned work

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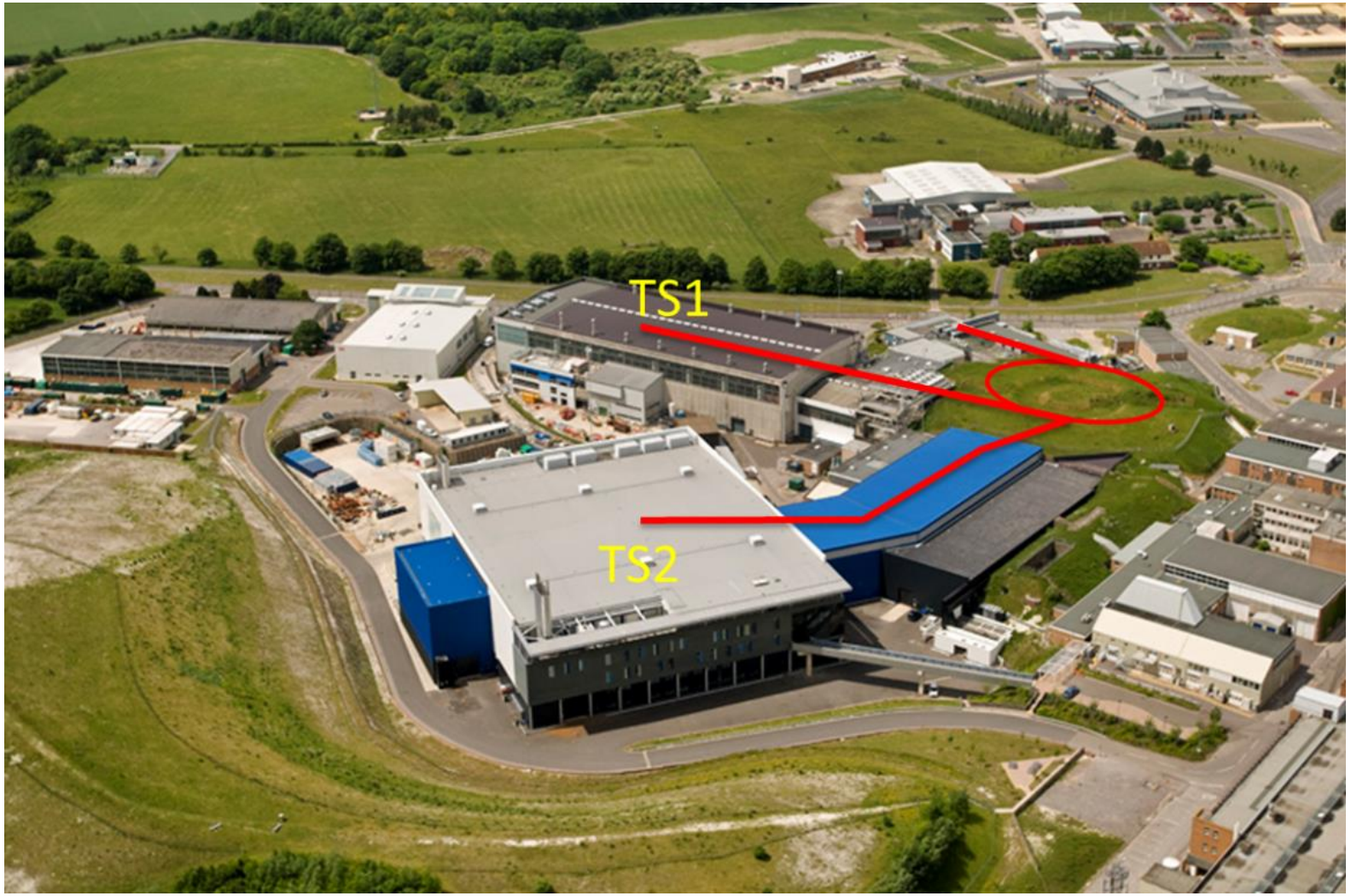
ISIS Neutron and Muon Source

Target Station 1 (TS1) up and running by 1985 and Target Station 2 (TS2) following in 2008



800 MeV protons (50 Hz)

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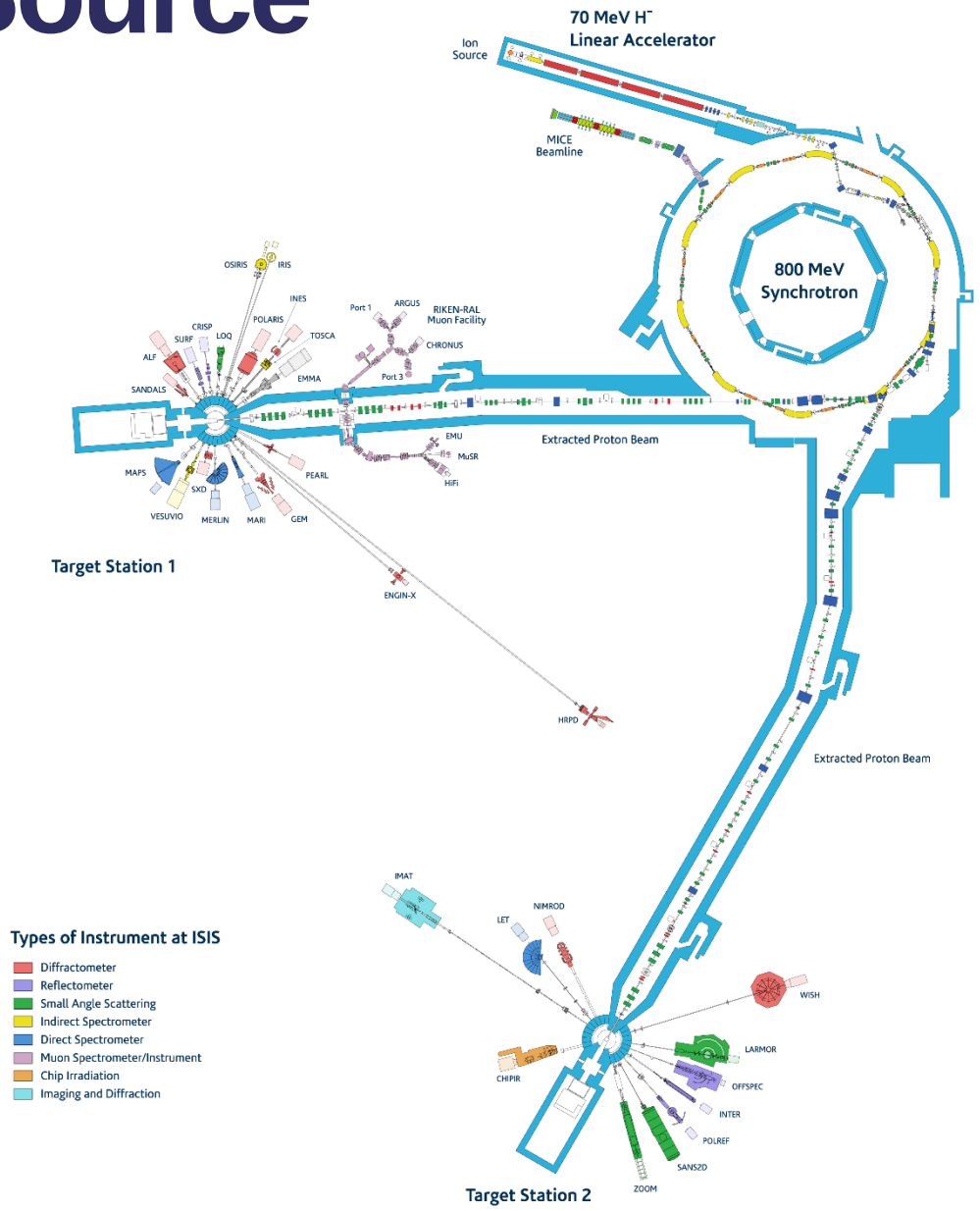
ISIS Neutron and Muon Source

Target station 1 –

- 4 pulse out of 5
- Plate target W clad with Ta
- 160 kW beam power
- 4 moderators – 2 Ambient Water, liquid methane, liquid Hydrogen

Target station 2 –

- 1 pulse out of 5, 10hz
- Solid target, W clad with Ta
- 40 kW beam power
- 2 moderators – Solid methane, liquid Hydrogen



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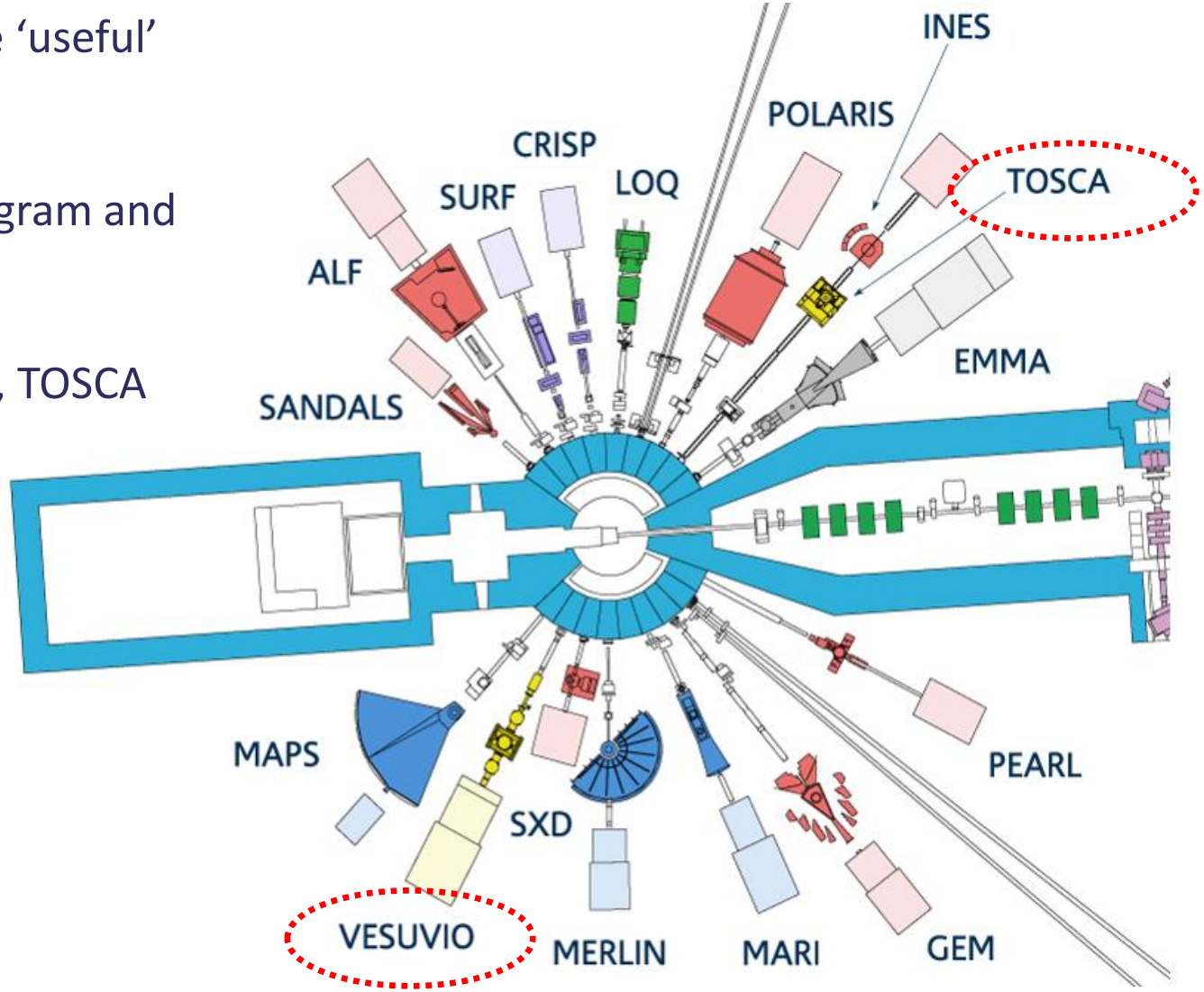
ISIS Neutron and Muon Source

We are interested in moderators to generate more ‘useful’ neutrons to instruments to improve ISIS.

We have an on going moderator development program and TSL work is a major component.

Two instruments are the focus of our TSL research, TOSCA and VESUVIO, both on Target Station 1.

Also we have 30 years of operational moderators data can be useful e.g. historic ethane data and recent methane temperature experiments.



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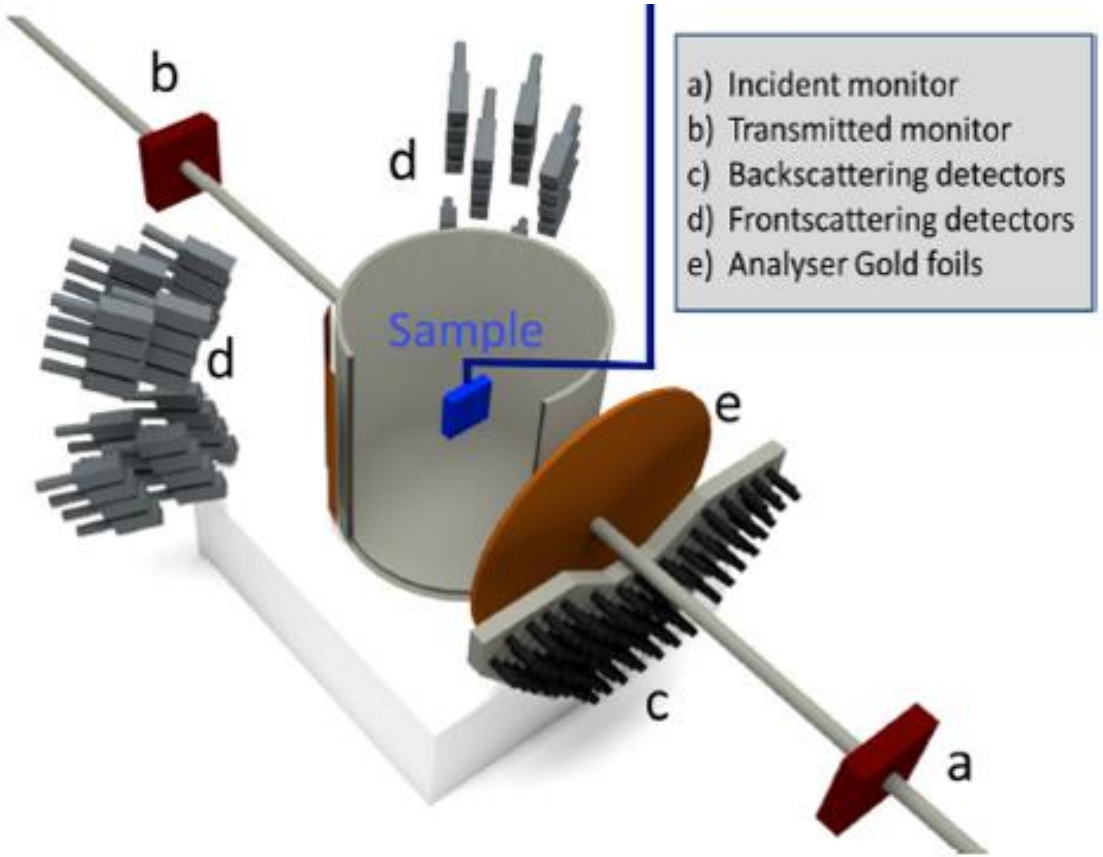
VESUVIO

VESUVIO is an inverted-geometry spectrometer mainly employed for the determination of nuclear quantum effects in materials using Deep Inelastic Neutron Scattering. In recent years, VESUVIO has become an epithermal and thermal analysis station, where samples can be investigated through spectroscopy, neutron diffraction, and neutron transmission (NT) at the same time. The energy range accessible for NT spans 8 orders of magnitude, from a fraction of meV to tens of keV.



Samples are placed at 11 m from the ISIS TS1 water moderator. Incident neutron spectra are recorded using a GS20 6Li-doped scintillator at 8.57 m from the moderator, while the transmitted spectra were recorded using a similar detector at a distance of 13.45 m from the moderator. The neutron beam has a circular shape, with a maximum diameter of 4.5 cm.

VESUVIO

- VESUVIO has also added capability to detect prompt gamma from samples
- Recent focus on reducing backgrounds both neutron and photon
- New capability to cycle Cd and/or W foils into the beam
- 2016 update to the water moderator (CWM) to remove a poison foil gave significant benefits to VESUVIO

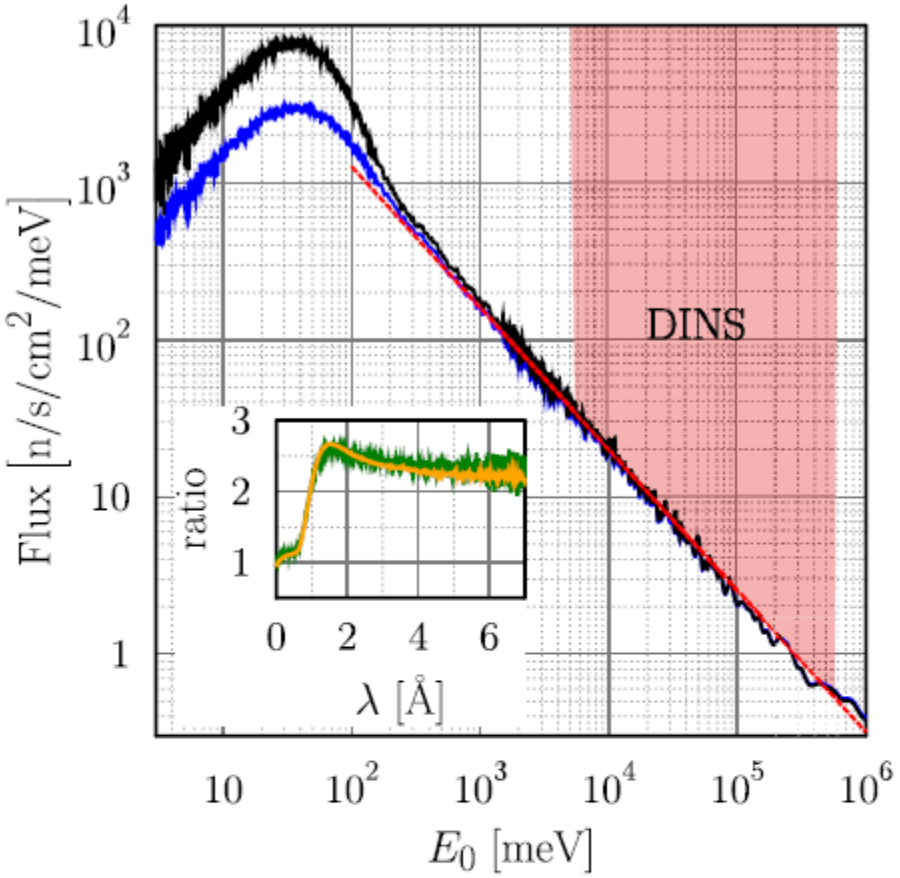


Figure 2. Incident neutron flux at the sample position as measured by the calibrated monitor before the CWM (blue line) and measured by the nGEM after the CWM (black line). The red dashed line is proportional to $E_0^{-0.9}$ and the region shadowed in red represents the energy range used in DINS. The insert shows the spectrum of the incident neutron beam after the CWM normalised to the spectrum before the change. The orange spectrum has been obtained from the VESUVIO incident monitor while the green spectrum from the nGEM detector.

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TOSCA

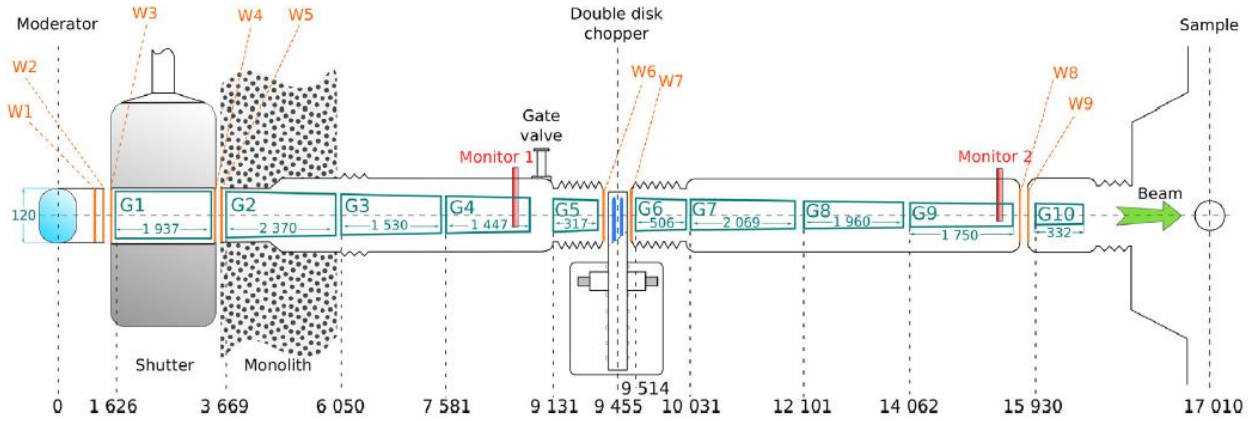
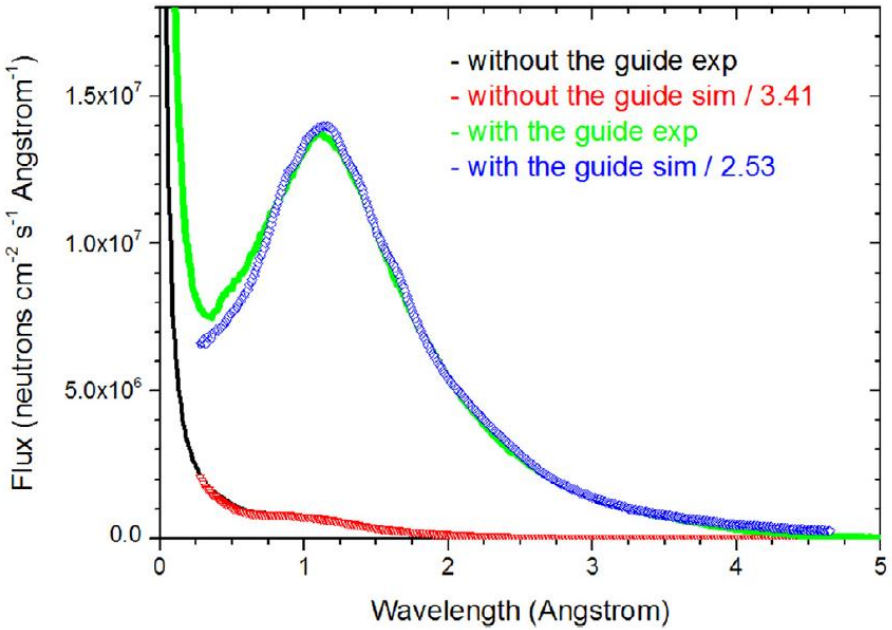


Fig. 1. Schematic representation of the side view of the TOSCA neutron guide as installed on the beamline. The guide sections are numbered in the order in which they appear along the flightpath. The starting position of each section, in relation to the moderator centre, as well as its length are provided (in mm units). Aluminium windows (W) are indicated by the orange vertical lines.

TOSCA is an indirect-geometry inelastic neutron spectrometer optimised for high resolution vibrational spectroscopy in the energy transfer region between −24 and 4000 cm−1. The instrument has been operational for almost two decades and during that time has set the standard for broadband chemical spectroscopy with neutrons.



The primary flightpath of the TOSCA spectrometer has been upgraded recently with a high-m neutron guide in order to boost the neutron flux at the sample position.

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Recent work

- Ethane
- Triphenylmethane – 2018 with CNEA Bariloche
- MgH – October 2019 with CNEA Bariloche

Proposed work

- Mixtures of Ethane/Methane with CNEA Bariloche
- Multiple ring Aromatics – possible moderator additive
- Possibly U238 with Giles – early discussions

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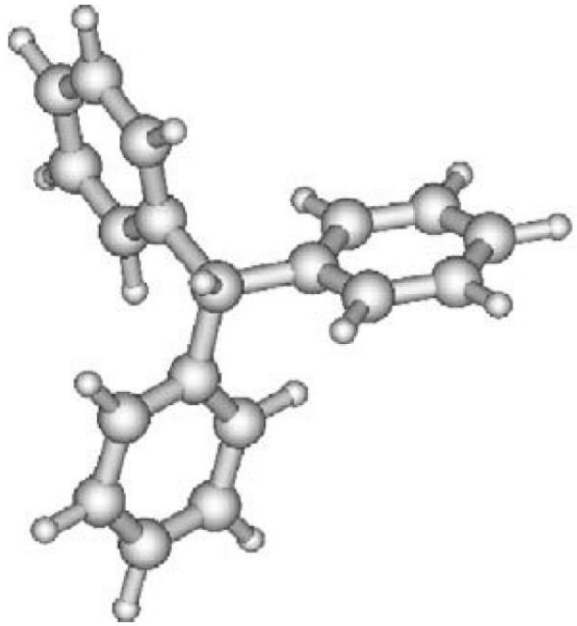
Triphenylmethane:
A very interesting potential moderator material.



Triphenylmethane (TPM),

- Hydrocarbon with the formula $(C_6H_5)_3CH$
- 3 aromatic phenyl groups surrounding a central carbon atom.
- Colorless solid (in powder form) at room temperature
- Melting point around 92 °C
- Boiling point around 359 °C.

TPM has been proposed as a cold neutron moderator because of its relatively high hydrogen content and relatively low neutron absorption cross-section (5.4 barns/molecule for thermal neutrons). In addition to this, TPM is capable of forming relatively stable radicals ("self-repairing" effect, similar to water) so the effects of radiation-induced polymerization, creating damaging operational problems for solid and liquid methane moderators, are significantly reduced.

Characterization (in principle) = measured total cross section and "density of states" (DoS).

+ Theoretical modelling

(Expected) final result: scattering kernel (for neutronics to perform "virtual" experiments).

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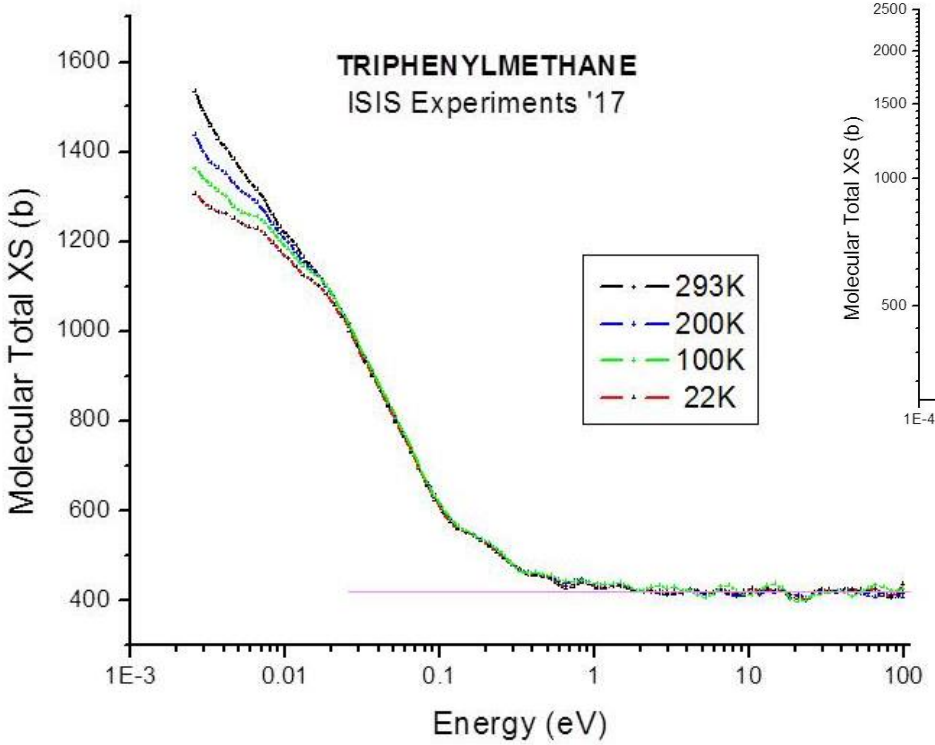
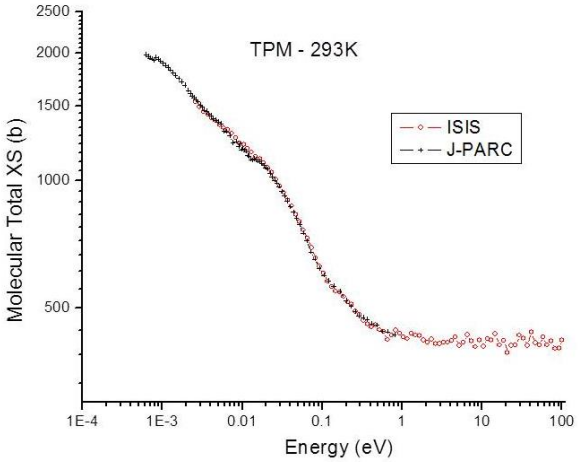
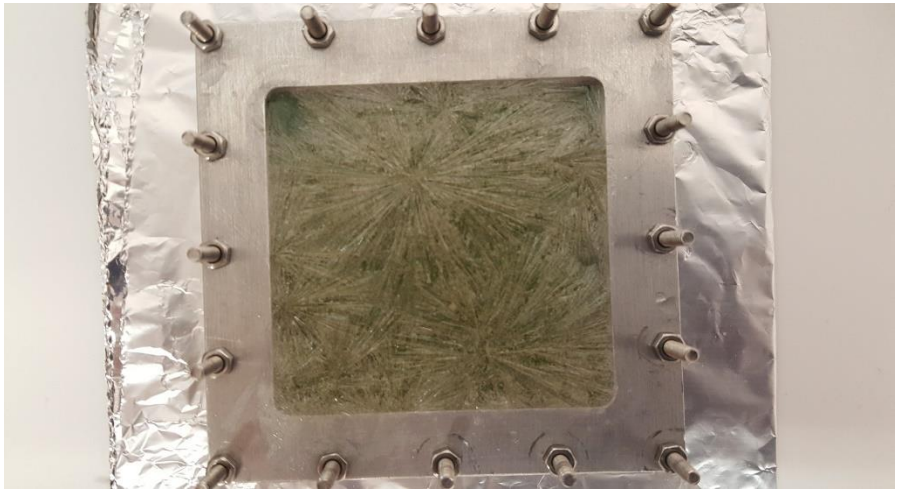
Measurements of triphenylmethane cross-section (VESUVIO)

Measurements in 2018 on VESUVIO with CNEA Bariloche group







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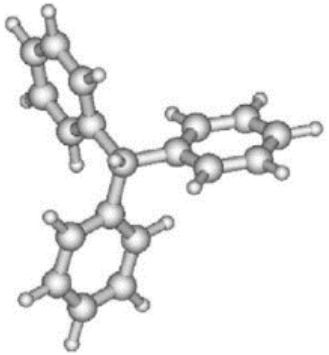
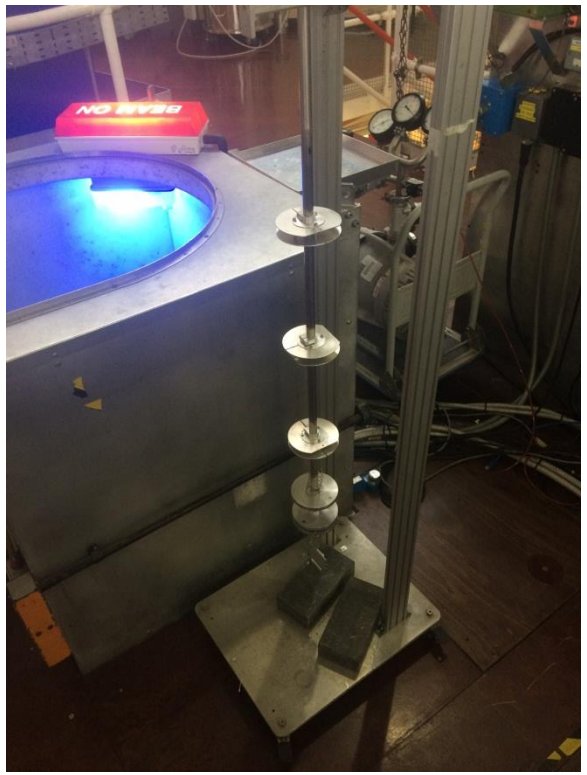
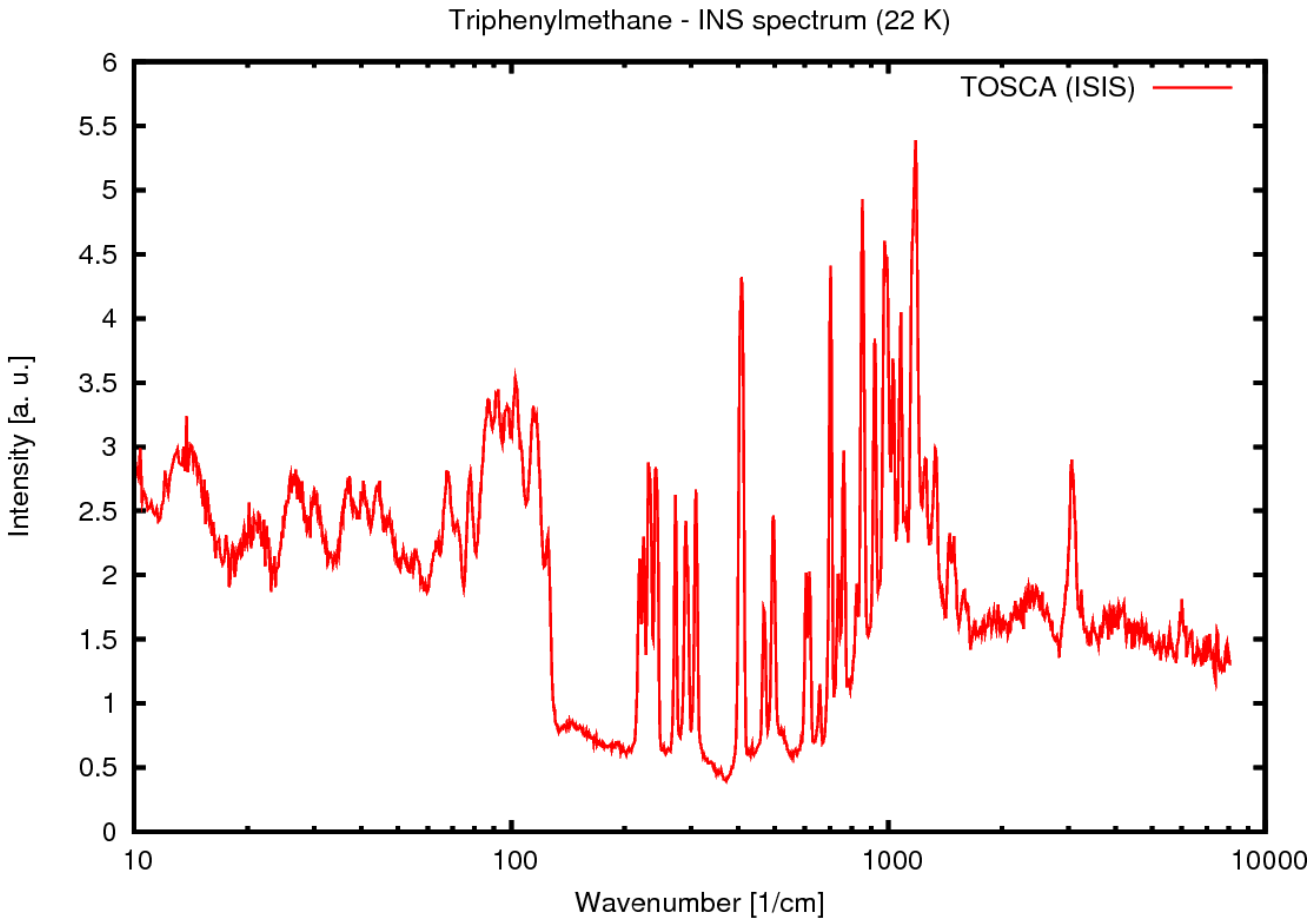
More details: F. Cantargi et al., "Validated scattering kernels for triphenylmethane at cryogenic temperatures", Talk at ND2019.

Measurements of triphenylmethane DoS (TOSCA)

Two temperatures: 22 and 10 K.
Measurement time: ~2 hours per temperature.







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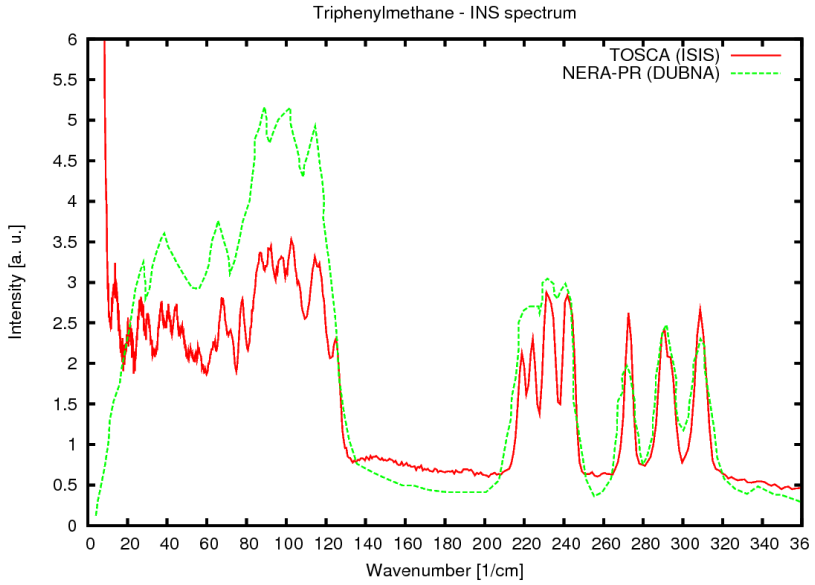
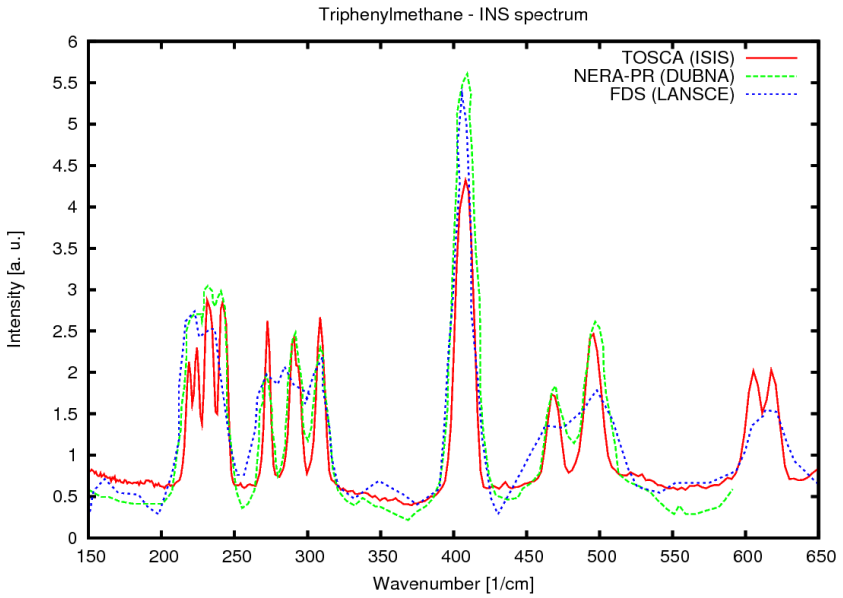
Very high number of excitations. In low frequency range the vibrations of three rings around of central atom appear, ring deformations dominate in the region between 350 and 1300 cm^{-1} and stretch vibrations in the higher frequency region.

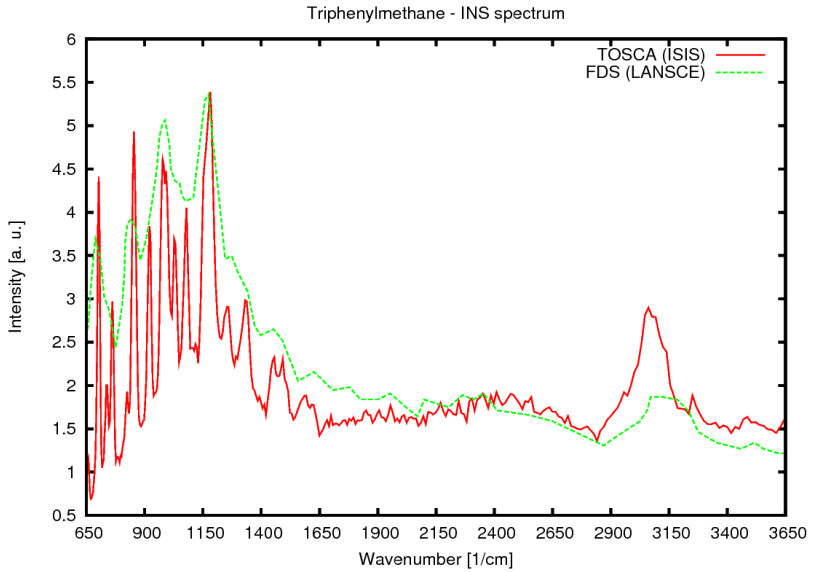
Measurements of triphenylmethane DoS (TOSCA) comparison with other facilities



Wavenumber range: 0 – 360 cm^{-1}.



Wavenumber range: 150 – 650 cm^{-1}.



Wavenumber range: 650 – 3650 cm^{-1}.

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Data for other facilities digitised from plots in:

[1] Th. Hügle et al, Nuclear Instruments and Methods in Physics Research A 738 (2014) 1–5.

[2] I. Majerz and I. Natkaniec, Physica B 350 (2004) e439-e442.

Use of ISIS moderators for validation work

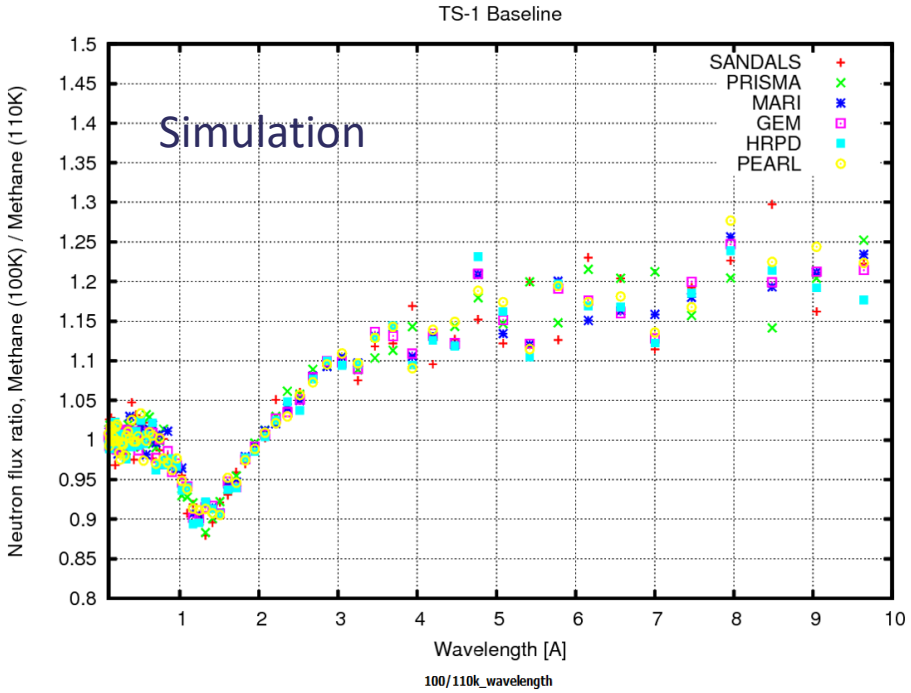
Recently performed a test of the effect of changing the ISIS methane moderator from 110 K to 100 K.

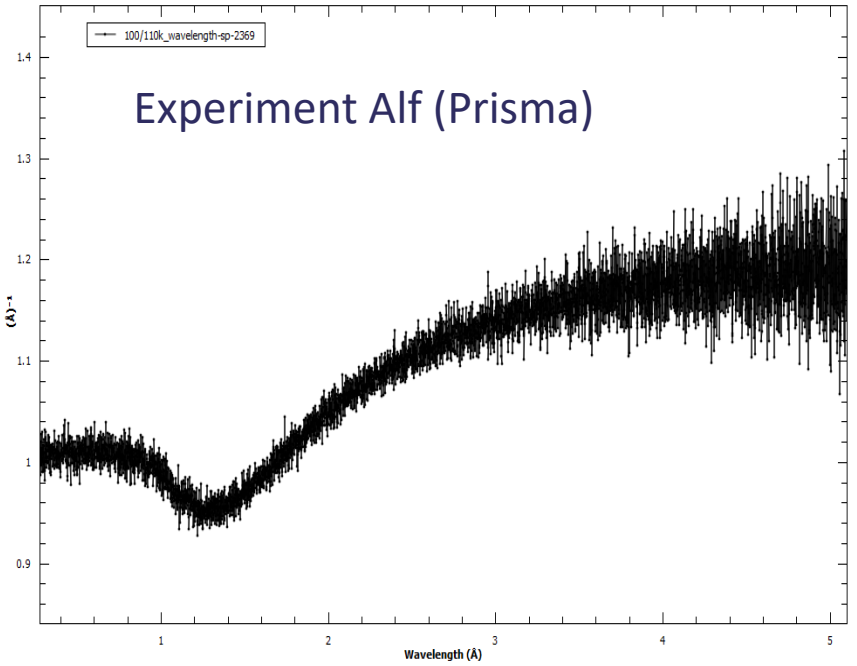
Performed during beam physics time at the end of a user cycle.

MCNP simulations with 2 different scattering kernel temperatures

Experimental results on two instruments, Alf and GEM,
Opposite sides of the moderator,
GEM set up with backscattering detectors to confirm no resolution effect,
ALF for flux measurement.

Results showed good agreement with simulation, we could see the approximate 5-10% dip between 1 and 2 Angstrom.





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Conclusion

The ISIS facility has two instruments – VESUVIO and TOSCA which provide complementary information required for TSL, including transmission, DOS,

We believe the recent upgrades to both instruments mean they are as good(or better!) as any other neutron scattering facility for these type of measurements.

We are happy to discuss any ideas or proposals for experiments and how we can help.

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Thank you

Useful references

VESUVIO

- https://www.isis.stfc.ac.uk/Pages/vesuvio.aspx
- C. Andreani, M. Krzystyniak, G. Romanelli, R. Senesi and F. Fernandez-Alonso, *Electronvolt neutron spectroscopy: beyond fundamental systems*, Advances in Physics, 2017. http://dx.doi.org/10.1080/00018732.2017.1317963
- G. Romanelli et al., Meas. Sci. Technol. **28** 095501(2017). https://doi.org/10.1088/1361-6501/aa7c2a

TOSCA

- https://www.isis.stfc.ac.uk/Pages/tosca.aspx
- R. Pinna et al., Nuclear Inst. and Methods in Physics Research, A **896** 68–74 (2018). https://doi.org/10.1016/j.nima.2018.04.009

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