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# Instruments on the ISIS second target station

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ABSTRACT

The second target station at ISIS is now nearing completion. This paper briefly describes the design of the target station and outlines the 13 instruments that are currently being built or are have funding and are in the design stage. The first seven instruments will be ready by the end of 2008 and the second six are due for completion by the end of 2012. All are designed to make optimum use of the high flux of cold neutrons that we expect from this highly compact and efficient target station.



## 1. Introduction

The ISIS second target station saw its first protons on 14th of December 2007, 23 years almost to the day that ISIS as a whole saw its first neutrons. The commissioning of the target and moderators will start in the summer of 2008 followed by the commissioning of the seven phase one instruments, all of which are due to be completed and delivered to the user programme by early 2009. Funding has also been made available for six-phase two instruments, the construction of which will be staged, but will start in 2009.

In this paper, I will describe the 13 instruments in phases one and two and outline their capabilities. More detail can be found at the ISIS web site [1].

The first target station at ISIS was designed to provide narrow pulse shapes over a wide range of neutron wavelengths, whereas the second was designed to be complementary; providing a high flux of cold neutrons, but with much longer pulse widths. It will take one pulse in five from the synchrotron; running at 10 Hz with a power of 48 kW. Improvements in computing have made it possible to design the instruments and moderators in parallel to optimise the overall performance in a way that was not possible 25 years ago when ISIS was first built.

The first seven instruments were designed to be world-class, work-horse machines, providing the freedom for more adventurous second phase machines, all of which will employ newer and more complex technologies. All the instruments have been chosen to align the facility to the changing needs of our user base, in particular increasing our capabilities in: biology, soft matter and advanced materials.

## 2. The ISIS second target station

The second target station is compact and highly efficient. It uses a surface cooled cylindrical tungsten target that is sufficiently small to enable us to position the two wing-geometry moderators very close to the source of neutrons. Both moderators will operate in the 25–30 K range, but one is coupled to produce high-flux and long-pulses and the other uses decoupling to produce narrower pulse shapes. The low power of the target station makes it possible to use solid-methane as well as hydrogen [2] producing a cold spectrum (Table 1).

The coupled moderator has two viewed surfaces, one is hydrogen and the other is solid-methane with a single groove to produce a small bright surface for those instruments that only need to view a small moderator area. The decoupled moderator also has two surfaces. It is based on solid-methane and has the provision to be poisoned asymmetrically. In total there is space for 18 shutters, but since instruments on long guides can share a beam port there is a potential to have many more than 18 instruments in total.

## 3. Phase one instruments

Reflectometers and SANS machines only view a restricted area on the surface of the moderator; and so the grooved solid-methane moderator was designed exclusively for their use. The hydrogen face of the coupled moderator has a similar peak flux but a slightly warmer spectrum, and will be viewed by the low-energy spectrometer LET and the liquids diffractometer NIMROD, both of which require a high-flux of cold neutrons but do not require a narrow pulse width. Currently the only instrument that

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**Table 1**
A list of 13 instruments that are planned for the ISIS second target station.

| | |
|---|---|
| Reflection | |
| Inter | Wet interfaces |
| PolRef | Magnetic multi-layers |
| OffSpec | Off-specular scattering |
| *Larmor* | *Development of spin echo techniques* |
| Small-angle scattering | |
| SANS2D | General purpose SANS |
| *ZOOM* | *Focusing SANS* |
| Diffraction | |
| WISH | Magnetic and high *d*-spacing |
| NIMROD | Liquids diffractometer |
| *LMX* | *Large d-spacing single-crystal measurements* |
| *eXeed* | *High-pressure diffraction* |
| *IMAT* | *Imaging beam line* |
| Inelastic | |
| LET | High-resolution wide *Q* and *E* range |
| Other | |
| *ChipIR* | *Electronics irradiation* |

The phase 1 instruments are in regular font and the phase 2 instruments are in italic.

requires shorter pulse widths is the diffractometer WISH which will view the decoupled moderator.

### 3.1. *OffSpec*

OffSpec, as the name implies, is a reflectometer optimised for the measurement of off-specular scattering. Running at 10 Hz means that it will have a much wider wavelength range than the two target station one machines CRISP and SURF. Ultimately it will use the SEASANS concept, which will enable the accurate measurement of the scattering angle of even highly divergent beams using spin-echo techniques, making it possible to achieve the same resolution laterally as is more normally possible perpendicular to the scattering plane.

Not only will it have more than 20 times the flux of any of the first target station reflectometers, it is designed to do something very different from either CRISP or SURF, in that it will be used for measuring in-plane structures in materials such as: patterned storage media, polymers and biological membranes. It will also be able to use the grazing incidence diffraction to reveal surface crystalline and magnetic structures.

### 3.2. *Inter*

Inter is designed for the study of chemical interfaces, in particular the air–water interface. It will have 20 times the flux of SURF (Fig. 1), higher resolution, and because it will run with a 100 ms time frame, a much larger dynamic range in a single measurement. It will be used for work on biological systems and polymers.

### 3.3. *PolRef*

PolRef is the successor instrument to CRISP; it will use polarized neutrons to study the magnetic ordering in thin films

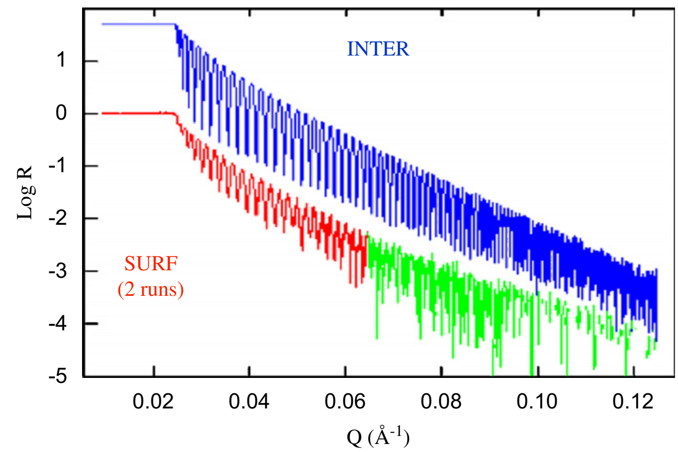


**Fig. 1.** Simulated data sets from Inter (top) and SURF (bottom). SURF requires two runs to achieve the same dynamic range as Inter, with lower flux and poorer resolution. Similar performance improvements are expected from PolRef and OffSpec over their target station one, precedents.

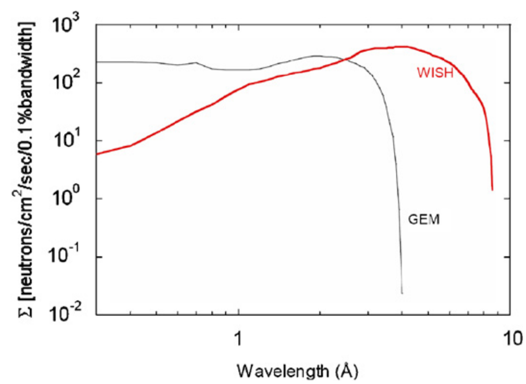


**Fig. 2.** A flux comparison between WISH and GEM with the same divergence.

and surfaces. Like Inter it will have an incident flux approaching $10^7$ n/cm$^2$/s, more than 20 times CRISP, with higher resolution and a huge dynamic range.

### 3.4. *SANS2D*

This is designed as a flexible high-flux small-angle scattering instrument. It will have an incident flux close to 30 times that of LOQ, but will have two 1 m square multi-wire detectors in its large 3.2 m diameter vacuum vessel, each of which will be able to move independently to give a highly flexible instrument able to measure a very wide simultaneous *Q* range. The secondary flight path will be between 2 and 12 m giving minimum momentum transfer of $Q \sim 0.002$ Å$^{-1}$, and a maximum *Q* of 3 Å$^{-1}$, enabling it to be able to cross-over from small-to-wide angle diffraction.

In the primary beam three sections of shielding are mounted on precision slides to make it possible to switch between collimation and guide sections so that resolution can be traded for flux. The high flux will make it possible to study smaller or more dilute samples, or to do parametric studies.

### 3.5. *LET*

LET will be a high-flux multi-chopper spectrometer that will be able to utilise a wide range of incident energies (0.5–80 meV). Its novel arrangement of seven-disc choppers will give it huge flexibility, with an ability to trade flux for resolution and work

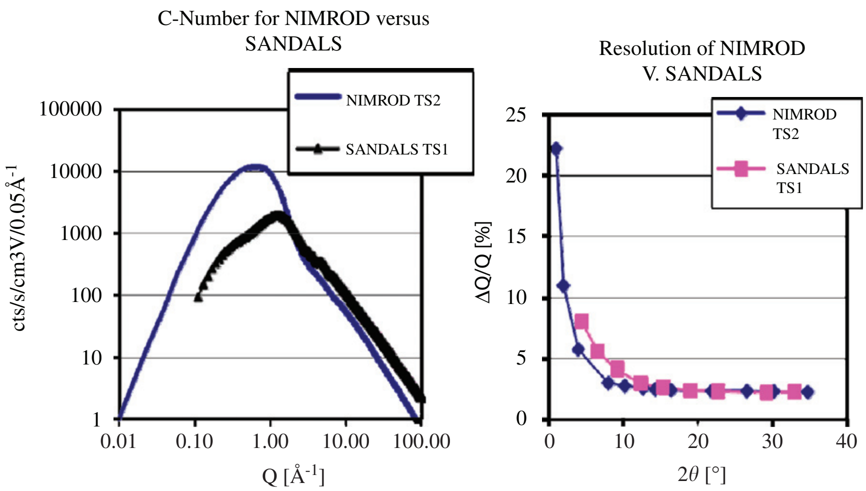


**Fig. 3.** A comparison between the flux and resolution of SANDALS and NIMROD.

in a multiple repetition rate mode where several incident energies can be collected simultaneously.

The secondary spectrometer will have a 3.5 m secondary flight path with a huge array of 4 m position-sensitive detectors covering +45° to 135° in the horizontal plane and $\pm 30°$ in the vertical, a total of 50,000 pixels.

LET will be able to measure quasi-elastic and inelastic measurements with a high resolution (5 μeV with and incident energy of 1 meV, or 260 μeV at 20 meV incident) and will be able to measure over a wide range of scientific fields: from dispersive excitation in strongly correlated electron systems to the diffusion of hydrogen in fuel cell materials.

### 3.6. *WISH*

WISH will be a high-flux long-wavelength diffractometer for strongly correlated systems and functional materials. It will view the poisoned solid-methane moderator and will have an elliptical guide system with a series of jaws that can be used to alter the resolution; highly divergent neutrons spend more time close to the neutron guide walls and the jaws will be able to filter these out. When set up to have the same divergence as GEM it will have 20 times its cold neutron flux (Fig. 2), but when in high-divergence mode it will have more than two orders of magnitude the cold neutron flux of GEM.

### 3.7. *NIMROD*

NIMROD will be a diffractometer tuned for the study of the structure of liquids and disordered matter. It will have a *Q*-range of between 0.2 and 100 $Å^{-1}$, enabling it to probe length scales ranging from the interatomic to the mesoscopic (<300 Å). It will have more flux and a wider *Q*-range and similar or better resolution then SANDALS (Fig. 3).

## 4. Phase two instruments

The outline designs of the phase two instruments rely on the extensive use of optics, polarization technologies and highly pixilated detectors, and will require much more development work then the previous seven. They are ambitious and will be challenging to build, but will provide ISIS with an exciting long-term future and further develop neutron scattering as a technique.

*LMX* will be a long-wavelength single-crystal diffractometer able to measure systems with unit cells of between 20 and 30,000 $Å^3$ with a resolution of 1 Å. It will have gains of the order of 40 over SXD and be able to study sub-1 $mm^3$ crystals.

*eXeed* will be a diffractometer aimed at high-pressure and other extreme sample environment work. It will have a gain of two orders of magnitude over PEARL at long wavelengths and able to measure at pressures up to 50 GPa with gem anvil cells. ZOOM will be a flexible high-count rate SANS machine that will use focusing to access *Q*'s down to 0.0003 $Å^{-1}$.

*Larmor* This will be a test bed for developing spin-echo techniques on a time-of-flight source, including: SESANS, MIEZE, MISANS and Larmor diffraction and NRSE.

*IMAT* will be a cold neutron imaging instrument that will combine Imaging, with Bragg edge tomography and spatially resolved diffraction.

*ChipeIR* will be a facility that will use the high flux of epi-thermal neutrons to measure single event effects in critical electronic and computer equipment, such as those used by the avionics industry.

## 5. Conclusions

The instruments being built and planned on the ISIS second target stations will all be world-class. They are a balance of instruments to service the user programme for the short to medium term, and instruments that will develop and extend neutron scattering for longer term. All are designed to exploit the cold neutron flux on the second target station and to align the ISIS facility with the changing needs of our user community.

## References

[1] 〈http://ts-2.isis.rl.ac.uk/〉.
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