Bulletin
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SPECIAL

# First Neutrons from SNS

## The Commissioning Run

At 7.16 pm on Sunday 16 December 1984 the SNS produced its first neutrons thus achieving the 1980 plan for neutrons in 1984.

Since September when the extraction system was commissioned to put 550 MeV protons into a graphite beam dump in the synchrotron, an immense amount of work has been done to achieve this latest and most important milestone.

Some 60 magnets for the 150 m long extracted proton beam were refurbished, measured, mechanically aligned, wired up and connected to water cooling systems in the shielded tunnel from the synchrotron to the target station. Their power supplies were then to be commissioned. The last power supply was made to work on Sunday morning. The vacuum pipe was installed through the magnets, was progressively tested and joined to the synchrotron vacuum. Diagnostic devices for measuring beam profile and beam intensity were installed along the line and the software for the controlling computers was tested.

The 4.3 m iron and concrete shielding of the target station was completed to a stage where a low intensity proton beam could be used. The 2 m thick shutters were installed with 6 of the 18 in the open position. Neutron collimation was fitted within the corresponding 6 insert shielding boxes. The neutron production target consisting of plates of depleted uranium clad in zircaloy was put in position together with its cooling manifolds and the target cooling channels were filled with heavy water. Below the target were the 2 cryogenic moderators and above were the 2 ambient temperature moderators filled with water. The cold methane moderator had been successfully tested with liquid nitrogen on the previous Wednesday. Sunday morning was the first time that it was possible to test it with liquid methane and it worked, the cool-down to 100K taking many hours. The hydrogen moderator had been made to work in a separate test building on the previous Monday. It then had to be completely stripped down both mechanically and electrically and rebuilt. This was finished on

*Congratulations*

In my Christmas message given in the last copy of the Bulletin I said "we still hope to produce an extracted beam onto a Uranium target and to measure the neutron spectrum from a cold moderator as a last splendid achievement before Christmas". That bulletin appeared on 17 December but it was already out of date. On Sunday 16 December at 7.16 in the evening my "hope" was achieved and exceeded. I found the occasion one of outstanding excitement - an event that I will remember and cherish for years to come.

Congratulations to all who have been concerned in the seven years of hard and dedicated work. You can all be proud of what you have achieved and have earned a truly memorable Christmas. Well done!

Geoff Manning

*The moment of success! Protons hit the target at 7.16 pm.*

Saturday to enable the moderator to be cooled down to 25K over Saturday night. Surrounding the moderators were the reflector tanks containing beryllium rods and heavy water. The target assembly was instrumented with thermocouples, monitored by the target station computer system.

The ventilation plant which provides the insert atmosphere in the target void vessel was installed as was the ventilation system for the target services area.

All of this final installation and commissioning work was going on in parallel with running up the synchrotron. Over Wednesday night the 70 MeV linac injector was run up. During Thursday and Friday other systems were run individually. By Saturday evening the synchrotron run-up could be started and the closure plug at the back of the target shielding wheeled forward together with the train holding the refrigerators and the cooling equipment. Protons were accelerated in the synchrotron and extracted first into the beam dump in the synchrotron. At 02.35 on Sunday the magnets in the extracted proton beam up to the intermediate beam dump 20 m before the neutron target were set to their theoretical currents through the computer control system. The first pulse to be tried went right along the 130 m line to the scintillator on the beam dump. This was a huge success.

By 06.45 on Sunday the beam was adjudged aligned with $5 \times 10^{11}$ protons per pulse hitting the beam dump. During this period the neutron instruments operators were able to check their timing using stray neutrons from the beam dump. The next shift made further improvements to the software of the diagnostics and prepared the settings of the final 6 magnets to the target station. This was being done while the target station people were getting to know the vagaries of the methane moderator system. At 17.00 the methane moderator was stable in temperature and preparations were started to remove the intermediate beam dump.

Then came a call from the Injector "We have a fire alarm". The injector room was filled with smoke from a blown up capacitor. Came the Fire Brigade! By 18.30 all was clear to proceed and at 19.16 Geoff Manning counted down to 'Beam On'. Again the beam was seen first pulse on the scintillator at the entrance to the target station. CHEERS ALL ROUND.

Some tuning was done while the neutron scientists were looking at their initial output. The first results were available within minutes. The MCR log states "the background noise level in the MCR has increased considerably in the last few minutes". We were particularly gratified that the Chairman of the Science Board and university neutron scientists had come to witness this historic occasion.

*The first neutron data being examined at 7.30 pm - 14 minutes after switch-on!*

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The run continued for neutron users until 01.30 hrs on Monday. It was remarkable that so many things had come together to reach a state of operation so soon after their installation. Once again we have achieved a milestone, this one the most important so far, at the first attempt.

## The Neutron Measurements

Six beam lines were open, viewing the three different types of moderator: ambient temperature water, liquid methane at 100K and hydrogen at 25K. Of these six, four had the "day one" assemblies apart from choppers and full shielding (not needed on this occasion). The other two had special apparatus fitted, just for the December run, to give information on the ambient moderator performance. One or two features of the instruments are particularly noteworthy. The two neutron guide tubes (one of 40m and the other of 95m guide which is the longest in the world on a pulsed neutron source), required exceptional care in assembly and alignment. Special scintillator monitor detectors (invented at RAL) were installed to check beam intensities. The counting efficiencies of these were tailored to suit each beam so as to get a good countrate but no saturation, a feat requiring some confidence in predicting what the countrate will be! A last minute adjustment was made to one monitor! A fibre optic coded position sensitive detector, also developed at RAL, was used for the first time. A major component of the instrument set-up, vital to quick assessment of the first data, was the PUNCH computing system using 3 sets of data acquisition electronics 3 VAX 11/730 mini-computers, a VAX 11/750 HUB computer, many terminals, a Cambridge ring local area network and, finally, the all-important software. The neutron experimenters were familiarising themselves with the operating system during the week before the run and all agreed it is an easy system to learn.

Various types of neutron measurement were made with the object of determining the neutron intensity, spectrum and pulse structure from each moderator, the performance of the two neutron guides and that of the neutron instruments and their detection systems. Some of the results obtained are shown in the diagrams which follow. Full analysis of the data will take more time but already it is clear that all aspects of operation of the target station and neutron instrumentation are fully achieving their design specifications.

Because further work still needs to be done on the target station it was necessary to minimise activation by restricting the total number of protons onto the target. The machine was therefore run with between 2 and $5 \times 10^{11}$ protons per pulse and a pulse repetition frequency of 50/128 per second for a total of about 5000 pulses and $1.4 \times 10^{15}$ protons on target. At full intensity the SNS will operate at 50 pulses per second and $2.5 \times 10^{13}$ protons per pulse so that all of the results shown below would have been obtained in $\sim 1$ second of full power operation and 10 seconds at the 10% level expected for initial operation starting in April. As a result of last weekend we now look forward with increasing excitement and confidence to the sustained operation of the world's best spallation source.

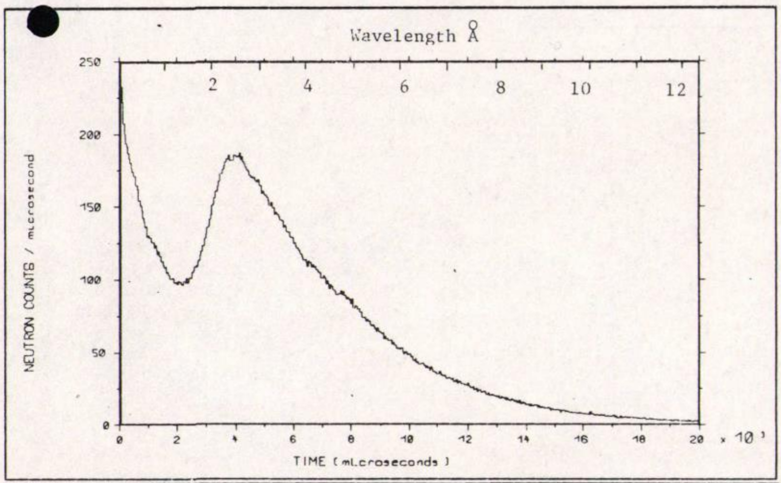


Figure 1

This shows the spectral distribution of neutrons from the 25K liquid hydrogen moderator. Note that there is still a significant flux of neutrons at 12A. Similar data were obtained for the 100K liquid methane and the two faces of the gadolinium poisoned ambient water moderators. The observed intensities, wavelength distribution and neutronic temperatures are in excellent agreement with the design parameters.

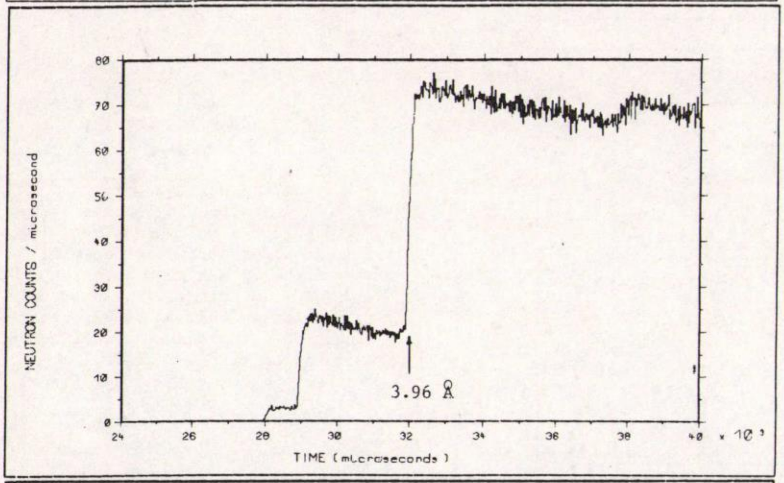


Figure 2

The liquid hydrogen moderator is used to produce long wavelength neutrons. This figure shows the spectrum transmitted through a cooled polycrystalline beryllium filter beyond its Bragg cut off at 3.96A. This edge will be used as part of the Indian high resolution energy analyser for the IRIS spectrometer.

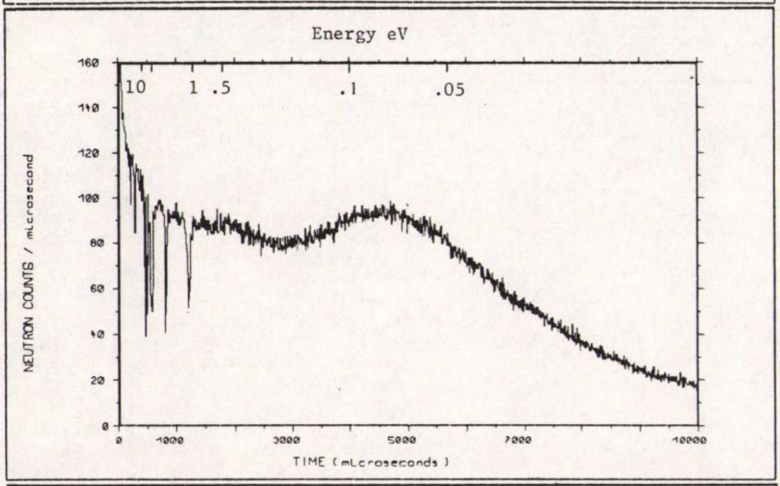


Figure 3

The figure shows a transmission measurement through U and Hf foils on the High Energy Transfer Spectrometer beamline. The moderator spectrum is modified by resonance absorptions in the energy range 1 to 40 eV. These are used for length and time calibrations of the system and highlight the rich epithermal spectra from SNS. On the other side of this moderator (the Single Crystal Diffractometer beamline) a resonance in Sm at 775 eV was observed!

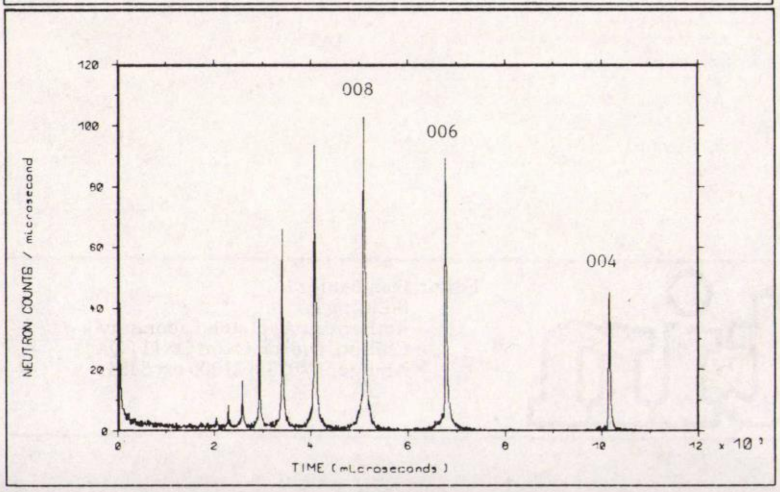


Figure 4

The diffraction pattern from a single crystal of pyrolytic graphite on an ambient beam line is shown in Figure 4. The time structure of the reflections (004 up to 0020 are shown) is used to characterise the moderator pulse shape. Preliminary analysis of these and the methane and hydrogen pulse shapes show them to be in accord with the predicted values.

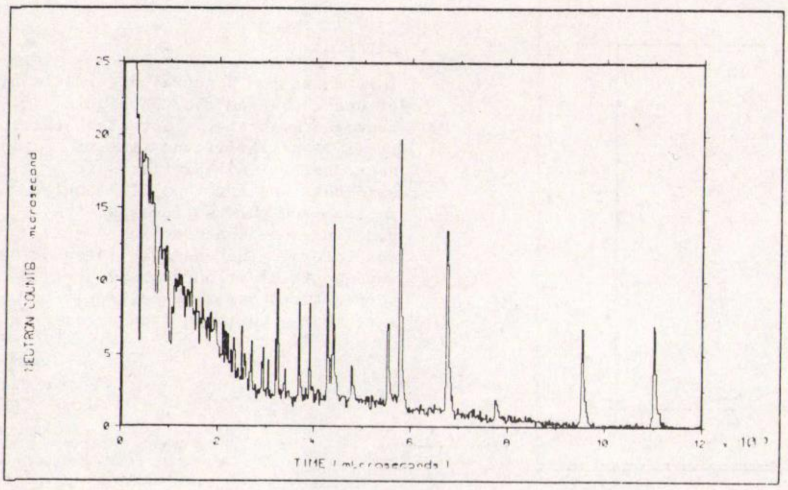


Figure 5

The diffraction pattern of a Ni powder measured at 150° scattering angle on the Liquids and Amorphous Diffractometer. This spectrum would be obtained in ¼ second at full intensity! Calibration resonance absorptions from Ir and Au may also be seen at short times.

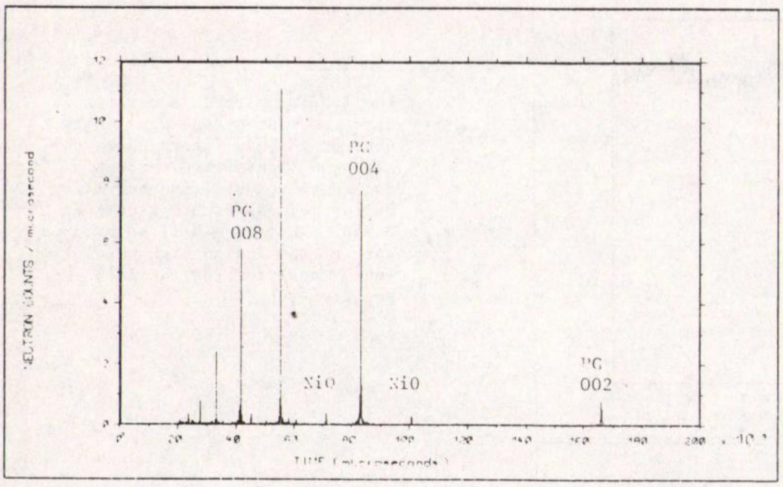


Figure 6

The diffraction patterns of a pyrolytic graphite single crystal and NiO powder simultaneously measured on one of the 40 detector rings of the 96 m High Resolution Powder Diffractometer. The extremely high resolution and low background given by this instrument is evident by comparison with a similar measurement made at 11 m (see Fig 4).

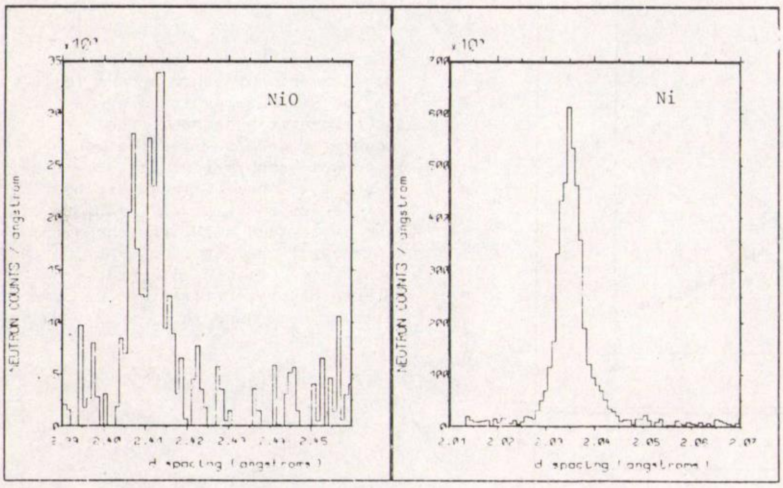


Figure 7

This gives a detailed plot of (a) the 111 and $11\bar{1}$ reflections from NiO compared with (b) a similar plot for the 200 Ni reflection measured on the High Resolution Powder Diffractometer. The two NiO peaks arise because the structure has a slight magnetic lattice distortion from cubic symmetry. The peaks have a relative separation of only $\sim 2 \times 10^{-3}$ and are clearly resolved at the 1 m position on this instrument. To our knowledge this is the first neutron observation of this splitting. The Ni peak at comparable d-spacing has the expected resolution of $1.5 \times 10^{-3}$ and this is consistent with the predicted resolution of $4 \times 10^{-4}$ at the 2 m position.

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Editor: Jean Banford
Building R1
Rutherford Appleton Laboratory
Chilton, Didcot, Oxon OX11 0QX
Abingdon (0235) 21900 ext 5484