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PROGRESS ON THE CONSTRUCTION OF THE SPALLATION NEUTRON SOURCE AT THE RUTHERFORD APPLETON LABORATORY

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ABSTRACT

This paper gives details of progress on the Spallation Neutron Source which is due to produce first neutrons in 1984. It updates similar reports given at ICANS-IV and ICANS-V.

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1. INTRODUCTION

This report is an update of reports given by G Manning at ICANS-IV and by myself at ICANS-V. A recapitulation of the main parameters of the SNS is given in Table 1 and the layout of the facility in Figure 1. A full description of the project is given in Reference 1.

2. FINANCE

The financial approvals for capital are in the process of being updated to £15.04M for the machine and target station and £2.31M for the 7 (out of 15) approved instruments. The update is purely for inflation. This does not include costs for staff nor for design, research and development costs. The allocation to cover all costs for the SNS in the current financial year is £8.53M with similar figures foreseen in Forward Look projections. The money is consistent with providing first neutrons in mid-1984 with 5 instruments available at that time.

Approximately £9M worth of equipment has been ordered for the machine and target station and £0.3M for the instruments.

3. PROGRESS

3.1 Injection

The ion source (Figure 2) and pre-injector were successfully run to produce H^- beam at 665 keV during February. During several runs since then improvements have been made to power supplies for the ion source and to reduce damage to electronic components caused when there is a spark-over in the accelerating column. Computer control of the ion source is now being implemented.

TABLE 1: MAIN PARAMETERS OF THE SNS

Proton design energy	800 MeV
Proton design intensity	200 μA
Nominal repetition frequency	50 Hz
Injection scheme	H^- charge exchange
Injection interval	376 μs
Injection energy (protons)	70.44 MeV
Injected protons/pulse	5×10^{13}
Emittance H^- ions	$25\pi \times 10^{-6}$ rad m
Mean radius of synchrotron	26.0 m
Number of superperiods	10
Dipole field at 70.44 MeV	0.1764 T
Dipole field at 800 MeV	0.6970 T
Betatron tune (Q_h, Q_v)	4.31, 3.83
Beam emittance at 70.44 MeV H	$540\pi \times 10^{-6}$ rad m
V	$430\pi \times 10^{-6}$ rad m
Number of RF cavities	6
Frequency swing (harmonic No. = 2)	1.34 to 3.09 MHz
Vacuum chamber in magnet	Ceramic
Target material	Depleted Uranium
Fast neutron production rate	3×10^{16} n per sec
Neutron current from surface of moderator	$10^{15} - 10^{13}$ s^{-1} $ster^{-1}$ eV^{-1} (.01 eV - 1 eV)

During March 10 MeV beam was accelerated through the first of the 4 linac tanks. Further linac beam will not be run until the whole linac is ready for 70 MeV tests which is programmed for October.

The linac has been aligned and the tanks flattened to produce the required RF field law.

The October 70 MeV beam date is determined by the build and test and the modulators for the RF valves driving the tanks. This work is going to programme.

The 70 MeV beam transport line between the linac and the synchrotron is being installed.

The injection septum magnet which steers the H^- ions on to the stripping foil has been delivered. Its power supply has been installed and it is about to be powered. Components have been delivered for the 4 beam bump magnets which change during injection the circulating proton closed orbit to make it pass through the stripping foil. The first has been assembled. The beam bump magnet power supply will be delivered shortly.

Development work on stripping foils is continuing with good results. Circular foils, 50mm in diameter, of the required thickness, 0.25μ, with a conducting coating of alumina and supported all round are routinely made. These foils have been tested with 70 MeV proton beam at SIN, Zurich, and initial indications are that they last for the equivalent of 10 hours of full SNS intensity as expected. Work is now proceeding on improving techniques for making the required 120 x 30 mm foils with one unsupported edge of which some have already been made.

A rectangular foil supported all round is shown in Figure 3.

3.2 Synchrotron ring magnets

There has been a delay in the delivery of the 10 dipole magnets. The prototype was delivered 14 months late in January. The configuration was determined using computer calculations. The central field and field gradient was as computed within the measurement accuracy ($\Delta B/B \sim 10^{-4}$).

The end fields similarly tied up with calculations. Since the prototype was ordered further refinement of the beam dynamics has changed the required average gradient in the magnet. This will be accommodated by changing the end shapes of the dipoles which have now been determined. Losses in the core and coils have been as the predictions. The inductance is about 10% higher than calculated.

The 10 main quadrupole doublets have been assembled in modules with a trim quadrupole doublet and have been installed in the synchrotron room (Figure 4).

The 10 singlet quadrupole magnets have been delivered, as have the steering magnets for closed orbit correction.

The support frames for all the main magnets have been surveyed into position. In the case of the dipoles, see foreground of Figure 4, this was done using the dipole base with dummy targets.

3.3 Magnet power supplies

All components for the main magnet power supply have been delivered. Part of the capacitor bank has been used to power the dipole prototype.

All 30 of the programmable power supplies needed for the trim quadrupole and correction magnets have been delivered and are being positioned in the centre of the synchrotron room which has sufficient shielding to protect electronic components.

3.4 Main ring vacuum

The ceramic chambers for the quadrupole modules have been installed and the singlet chambers manufactured. The 10 5m long 36° chambers for the dipoles (Figure 5) have been manufactured. Shorter ceramic chambers for straight section modules containing steering magnets are being manufactured.

Components for the roughing line are available and the ion pump controls have been installed.

3.5 RF shields

The design of the RF shields which fit inside the ceramic chambers is complete. The inside dimensions of the doublet ceramic chambers have been measured. The supports for the wires in the shield are individually machined to put the shield accurately around the beam. The first doublet shield is being assembled. Components for the dipole shields are being manufactured.

3.6 Main ring RF system

The prototype RF cavity has been tested successfully to full voltage with the correct frequency swing and swing rate (Figure 6). Two production cavities have been installed in the synchrotron room.

The prototype amplifier chain which powers the cavity has been shown to provide sufficient power. There have been problems with parasitic oscillations at high frequency emanating from either inside the valve or associated with the mounting of the valve which are in the process of resolution. Preliminary work has been done on the parallel chain which compensates for the beam loading of the intense proton pulses. The production amplifiers are being built up.

The DC bias supplies have been installed and the 6 anode power supplies are nearly complete. A new bias regulator using larger transistors has been designed and the prototype is under construction. The low power RF system has been used in the cavity tests.

3.7 Diagnostics

Position monitors, profile monitors, intensity monitors and the Q-measuring system for the synchrotron are being manufactured. The high quality co-axial cables have been installed. Electronics are being manufactured and installed.

3.8 Extraction

The extraction team have been diverted during the year to help with the injector. The extraction work is now continuing and components are being ordered.

3.9 Extracted proton beam

The new components required have been ordered. Stands for the EPB which has to go over and back across the synchrotron will be of concrete and have been designed.

3.10 Target station

A Carne will be dealing with this item in detail at this meeting. Highlights of progress have been the successful production of two uranium target plates encased in Zircaloy and the build-up of target station shielding to include the installation on one side of the 'inserts' which will allow individual collimators for each of the neutron lines. The shutter system has been designed and the lower shielding wedges which go radially between the shutters have been ordered.

The 3.2m diameter target void vessel which contains the target, moderator, reflector assembly and which has been designed to ASME 3 Class A standard, has been ordered. The target, moderator, reflector assembly has been specified following neutronic measurements at Los Alamos.

Development work continues on the remote handling system.

3.11 Controls

One of the 3 satellite computers is being used progressively to control components of the injector (Figure 7). The second satellite, for the synchrotron, has been installed and is being used for development of the diagnostics and other systems. Development of system hardware continues and interface hardware modules are in various stages of manufacture.

3.12 Experimental facilities

Of the 7 approved instruments[2], the Liquids and Amorphous Materials Diffractometer (LAD) has been installed on the Harwell linac and commissioned successfully. The components for the High Throughput Inelastic Spectrometer (HTIS) have been delivered. Installation on the Harwell linac is expected this month. The type of system for the HUB computer has been chosen and the approval procedure is underway to buy the initial components for this system so that software development can be done.

4. OTHER USES OF THE SNS

Other uses of the SNS are being considered. These include facilities for research using the μSR technique, neutrinos, fast neutrons for irradiation studies, pions for radiobiology and charged particles for setting up detectors for particle physics research. These facilities are described in more detail in Alan Carne's paper at this meeting.

References

1. Spallation Neutron Source: Description of Accelerator and Target. B Boardman (Ed). RL-82-006, March 1982.

2. ICANS-V. Proc. of 5th meeting, Jülich 22-26 June 81, p.63. Jül-Conf-45, Oct 81.

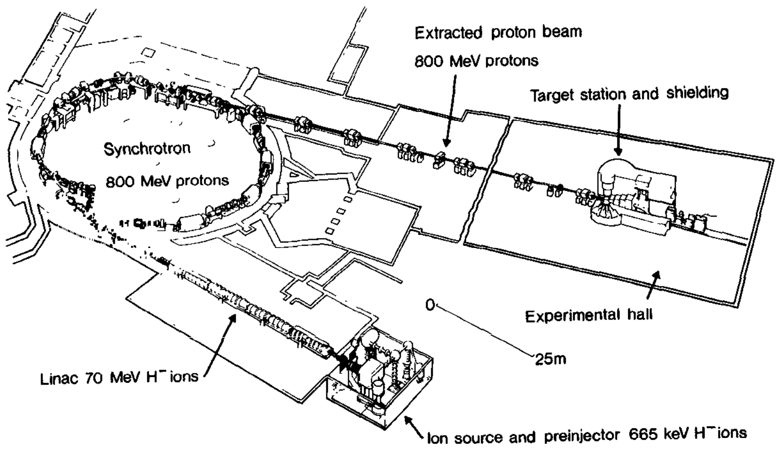

Fig. 1. Layout of the SNS

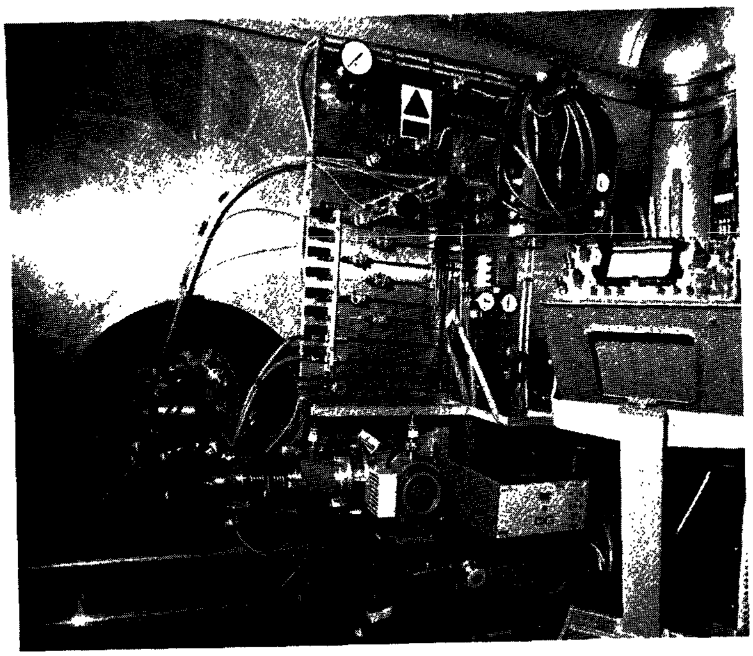

Fig. 2. H^- ion source on EHT platform

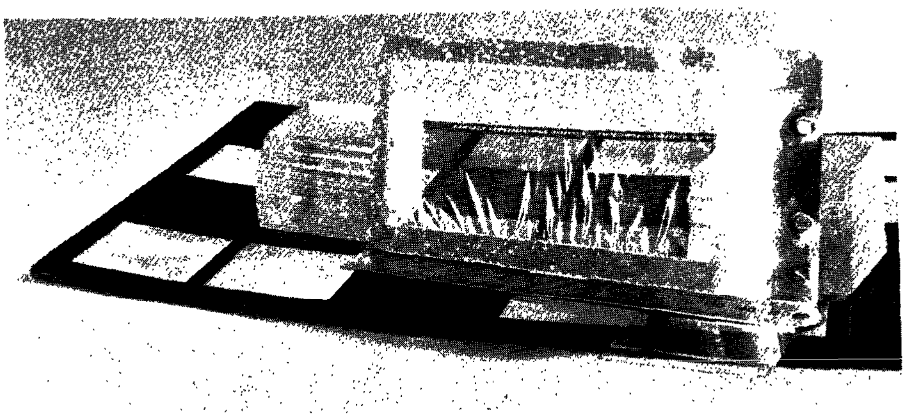

Fig. 3. Experimental stripping foil

Fig. 4. The SNS synchrotron room

Fig. 5

5m long dipole ceramic vacuum chamber

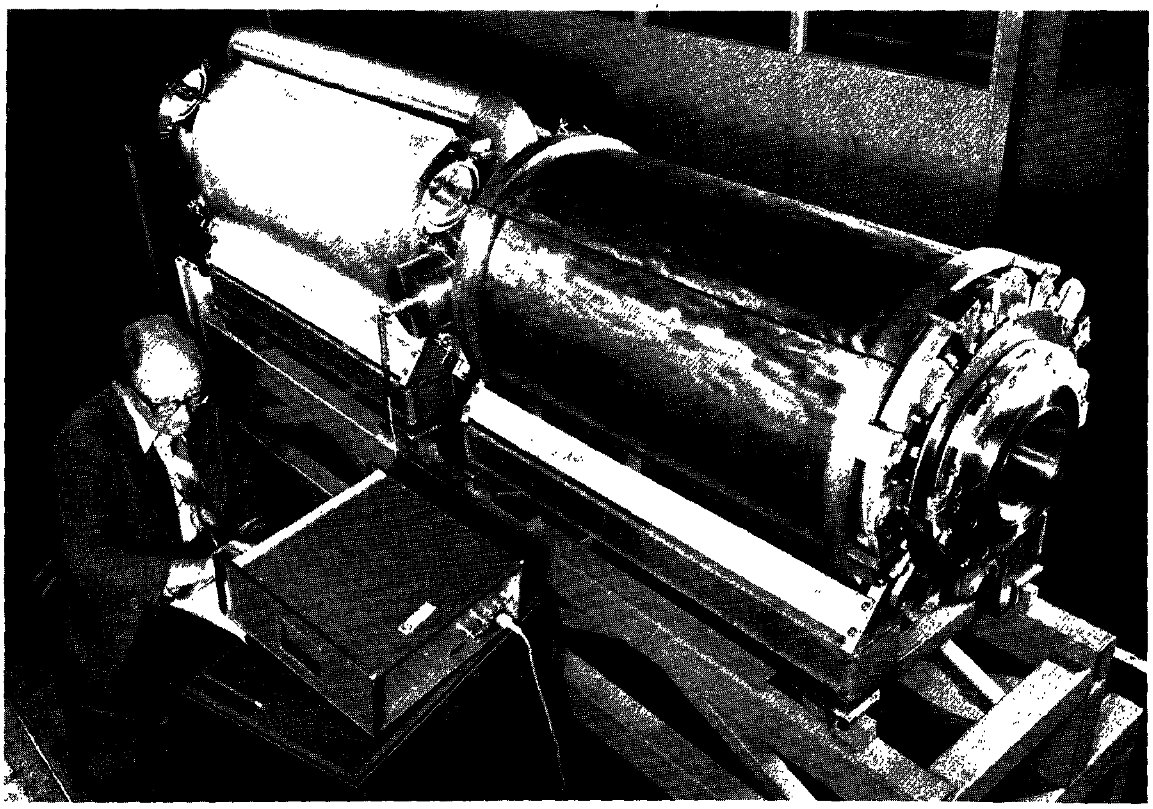

Fig. 6. One of the 6 RF cavities

Fig. 7. Injector Control Centre

<u>SNS</u> - D. A. Gray

J. Meese	Q	What is the maximum Q shift achievable with the trim quads?
D. A. Gray	A	0.25
R. Kustom	Comment	- I'm concerned about the durability of the ceramic vacuum vessel under proton bombardment. What tests had been done on the material?
D. A. Gray	A	Tests had been done using the Harwell cyclotron at beam intensities corresponding to the maximum loss expected in SNS.
R. Kustom	Q	Can you change the vacuum vessels and how long would it take?
D. A. Gray	A	Yes we can change them but the time to do so cannot yet be assessed.
A. D. Taylor	Q	Can you extract a single beam bunch rather than 2, to get shorter neutron pulses?
D. A. Gray	A	We could kick out one pulse in principle and send it to a second target station or a beam dump, but we cannot trap and accelerate a single bunch to 800 MeV with the present RF system.
J. M. Carpenter	Q	What is the present position on glueing the dipole magnet laminations together?
D. A. Gray	A	The problem has now been solved by the manufacturers.
R. Moon	Q	What are the first 5 instruments?
H. Wroe	A	A liquids and amorphous materials diffractometer (LAD now operating initially on the Harwell linac); a high throughput, inelastic spectrometer using the Be filter techniques (HTIS) is being assembled ready for initial operation on the linac; parts are being ordered a high resolution powder diff-ractometer (HRPD) on a 100 m guide tube; designs

are being finalized on a high energy transfer spectrometer (HET) using a fast chopper to monochromate the incident beam and finally the incident flight path for a quasielastic instrument will be built to serve a beryllium-beryllium window spectrometer to be supplied by the Bhaba Institute in Bombay. A polarized neutron spectrometer using filters is also being built as a development project, initially for use on the Harwell linac.

J. Meese	Q	What run time do you expect?

H. Wroe	A	Probably the best feel for that is given by some figures Colin Windsor has produced comparing estimated run times on the SNS with actual times on the linac for the same measurement. The SNS times are a few minutes in some cases. In practice you would do harder experiments say with small samples or at high resolution.