ICANS IX

INTERNATIONAL COLLABORATION ON ADVANCED NEUTRON SOURCES

22-26 September, 1986

STATUS REPORT ON ISIS, THE SPALLATION NEUTRON SOURCE AT RAL

D A Gray (presented by I S K Gardner)

1. INTRODUCTION

It was reported at the last ICANS meting (July 1985)[1] that the Spallation Neutron Source was being used at 50/16 Hz with 1.8×10^{12} protons per pulse on to target. Since that time the SNS has been renamed ISIS by the Prime Minister at an inauguration on 1 October 1985 and ISIS has been used for neutron production at 50 Hz with 3×10^{12} protons per pulse on target, a mean current of ·24 μA. Details are given of running conditions and problems encountered during the period.

2. PROGRESS SINCE JULY 1985

A detailed report on ISIS and its experimental programme for the period 1 April 1985 to 31 March 1986 is available as a report RAL-86-061[2].

Covering the period until March 1986, all machine systems were run up to 50 Hz with the synchrotron energy at 550 MeV.

3. 70 MeV H^- INJECTOR

There were two main problems in achieving reliable running at 20 μA (10% of design performance). Firstly, the 665 kV pre-injector column sparked over at a rate dependent on the mean current passing through it. This caused electromagnetic pick-up on low level control electronics and subsequent damage to power supplies notably the pulsed quadrupoles for Tank 1 of the linac and to the supplies for the transfer line between the pre-injector and Tank 1. The second problem was one of unreliability of the hard-tube modulators for the linac RF system.

During the long shutdown which started in April 1986, the pre-injector column voltage gradient was modified so that instead of a breakdown every half-hour at 20 μA synchrotron current, there is now a breakdown every few hours at currents which would give about 100 μA in the synchrotron. The cause of the breakdown is believed to be due to electrons, stripped from the H^- beam in the column, being deflected transversely by the stray magnetic field from the ion source magnet. The deflected electrons are multiplied and charge the column insulators which then spark over. The provision of magnetic shielding is planned. The resultant trip puts the beam off for about a minute. Extra electromagnetic shielding and redesign of the power supplies has eliminated the problem.

Also during the long shutdown, a large amount of work has been done on the modulators for the linac RF system to improve reliability. The modulators now run to give a servo-controlled voltage waveform to the main RF valve (TH116) and the RF-level servo to the tanks has been improved. Major changes to the modulators include the changing of the modulator valve from a Maclett 8786 to two EE1600 valves in parallel, minimising the number of pulsed power supplies, reducing the number of interlocks and improvement of heater regulator units. Parasitics in the EE1600 system were cured using isolated carbon resistors near to the valve bases. The modulators now run much more reliably.

The main power supply reservoir capacitors which have frequently failed will be changed sequentially over the next months.

Cooling of the TH 116 valves has been improved to the stage where they have operated consistently with a 140 μs long beam pulse. Further improvement is needed to get to the design pulse length of 400-500 μs, especially in the cooling of the grid structure.

The ion source has run well. With an arc pulse length of 400 μs and 15 mA to 10 mA of H^- ions extracted (at least enough to give 10^{13} protons per pulse from the synchrotron) the source lasts several weeks. The beam pulse length is controlled by the ion source extraction voltage pulse length.

3.1 800 MeV Proton Synchrotron

The synchrotron has continued to run at 550 MeV using 4 of the eventual 6 RF cavities. The match of the beam from the transfer line to the synchrotron whilst not using theoretical beam sizes has produced an injection efficiency of 96% (maximum is 98% since 2% of H^- are not stripped to protons). There is a known protrubrance into the synchrotron aperture in one of the injection bump magnet boxes which will be cured at the next shutdown. It is anticipated that theoretical settings will then be used.

A watch is kept on the injected beam shape using a scintillator to look at the partially stripped H^0 particles.

The 0.25 micron alumina stripping foils are currently fitted individually through a vacuum trap. The most recent foils have operated to give about 1600 μA/hr of synchrotron current ie about 8 hours for a full intensity beam. An automatic foil change mechanism is being developed for fitting in the next shutdown.

The trapping efficiency with about 3×10^{12} protons per pulse injected is about 86% (design is for 50% at 2.5×10^{13} ppp trapped). Extraction efficiencies are 99% thus giving more than 80% of beam from the linac transfer line hitting the neutron producing target at the 3×10^{12} ppp level (24 μA). (See Fig 1). At this level the beam loss monitors (ionisation chambers along the linac and 70 MeV transfer line) operate a beam trip if on one pulse there is a beam loss of >0.05 μ coulomb at 70 MeV. Likewise for the synchrotron and 550 MeV transfer line to the target, the beam current toroid system trips the beam if the losses are greater than certain preset values on any one pulse. This beam trip system is being refined.

The limitation on accelerated beam is currently the voltage induced in the RF cavities by the two proton bunches in the synchrotron. At about 2×10^{12} protons trapped the induced voltage is comparable with the voltage on the cavity during the trapping programme. A feed-forward system which looks at the fundamental frequency component of the bunch amplitude and feeds this to the cavity to overcome the fundamental induced voltage is in routine use. For a short period 5×10^{12} ppp were accelerated to 550 MeV. A laboratory trial has been completed to reduce the impedance of the cavity at the trapping frequency by resistive loading and has shown that the induced voltage can be reduced by a factor 5. This should allow the full beam intensity 2.5×10^{13} ppp to be accelerated without producing too large an induced voltage. Installation has started on a system for circulating copper sulphate solution to provide the resistive loading.

The RF phase loop is operated from trapping until 9.5 ms into operation. The radial beam position is controlled at the moment by programmed function generators to give reasonable stability. A radial beam loop is being developed.

With an untrimmed magnetic field configuration it was found that a coupling resonance was crossed which led to some blow-up in beam size. The computer-controlled trim quadrupole system has been used and betatron frequencies measured to find several satisfactory working points. One of these is used for operation. (See Fig 2).

With horizontal closed orbit positions corrected to about 2 mm using programmed horizontal steering magnets the lost 70-100 MeV beam collection system has worked well.

For extraction, a vertical beam bump puts the beam as near as possible to the vertically bending septum magnet for extraction.

Tuning of injection and extraction conditions is done using the beam loss monitors installed from linac, round the synchrotron and to within 20 m of the neutron target. Extraction from the synchrotron is triggered from the energy resolving chopper in the HET spectrometer neutron line.

Alignment of the extraction line is done by measuring the beam position using wire profile monitors. A segmented halo monitor of which the temperature is monitored is used as a final control of alignment of protons on to the neutron target.

3.2 Target Station

The target station has been run with facilities available to operate with at least 10% final beam levels. Installation of the helium ventilation system for the target void vessel and the ventilation system for the cooling of the shutter void vessel is under way. With the planned provision of the shielding at the top of the target station and in the forward direction, this will complete the target station to cope with full power levels. A system for transporting used targets is being developed. The shutter system which cuts off neutrons to each line is still controlled from the target station control room. The modifications are in hand to provide control from the beam line control rooms.

More details of the target station operation will be given at this conference.

4. SHUTDOWN APRIL-AUGUST 1986

In addition to the work already mentioned the following major items were covered:

i) The remaining two synchrotron RF cavities were installed and run up to full power. The final phasing up is to be completed.

ii) The installation of the first stage of the low energy muon beam for μSR work was installed. This included the extracted proton beam components to make a waist in the beam at the muon producing target position, the target vacuum vessel, the necessary shielding modifications and trial installation of the muon collecting quadrupoles.

iii) The front end shielding for 3 new neutron lines was installed.

5. OPERATIONS

Reliability of operation has not been as good as hoped for at this stage but is improving. As shown in more detail in Reference 2, some 4300 μA hours was achieved up to March 1986.

Since the start of running in August 1986 about 2700 μA hours has been achieved with an average of 176 μA hours per day during the last 2 weeks of the run just completed. (See Fig 3).

It is planned to run until Christmas with 11 weeks scheduled for neutron production. The aim is to produce an average of 400 μA hr/day during this period.

Induced activity levels are high, about 50,000 μGy/hr in the injection straight caused by the need to steer around the protrubrance and 20,000 μGy/hr in straight No.5 caused by operation for a period with the beam collector system not being properly aligned. These levels are consistent with expectations for better operating routines at higher currents.

6. INTERNATIONAL ISIS PROJECT TEAM

As a result of a Memorandum of Understanding signed by Ministers from France, Italy, Sweden and the UK with interest shown from other countries, a project team has been set up to investigate possible development of ISIS beyond its present full specification. Three international working parties have been set up to cover machine, target station and utilisation. A one-week meeting has been held, the second will be in November. A report is planned for early next year.

7. The report produced here is the result of the efforts of many people especially in ISIS Division of RAL to whom the author is grateful for their dedication.

REFERENCES

(1) D A Gray. ICANS-VIII. RAL-85-110, Vol 1, p65.

(2) ISIS 1986. RAL-86-061.

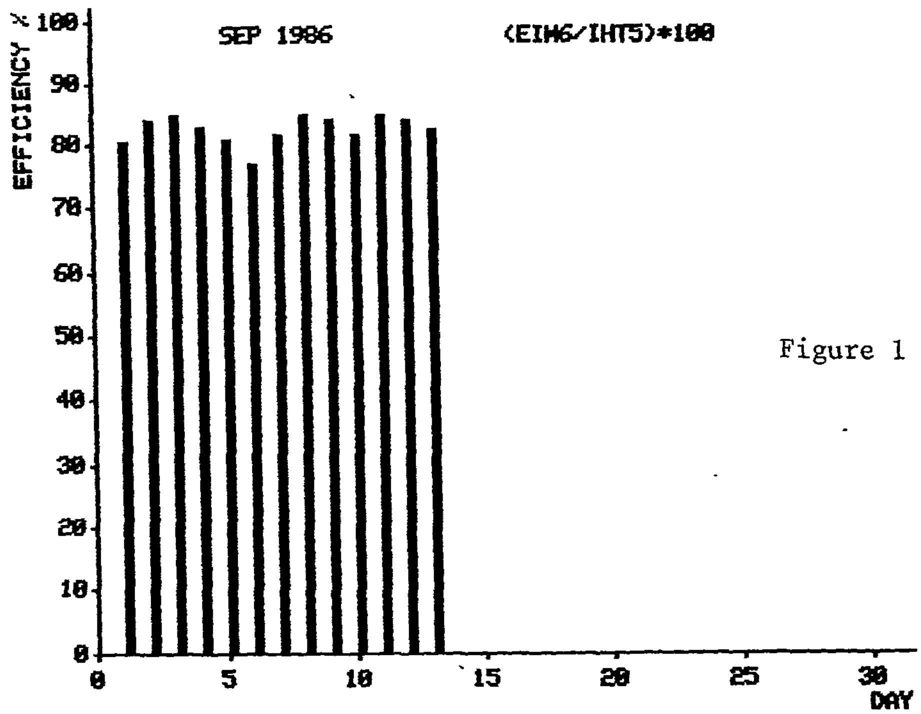

Figure 1

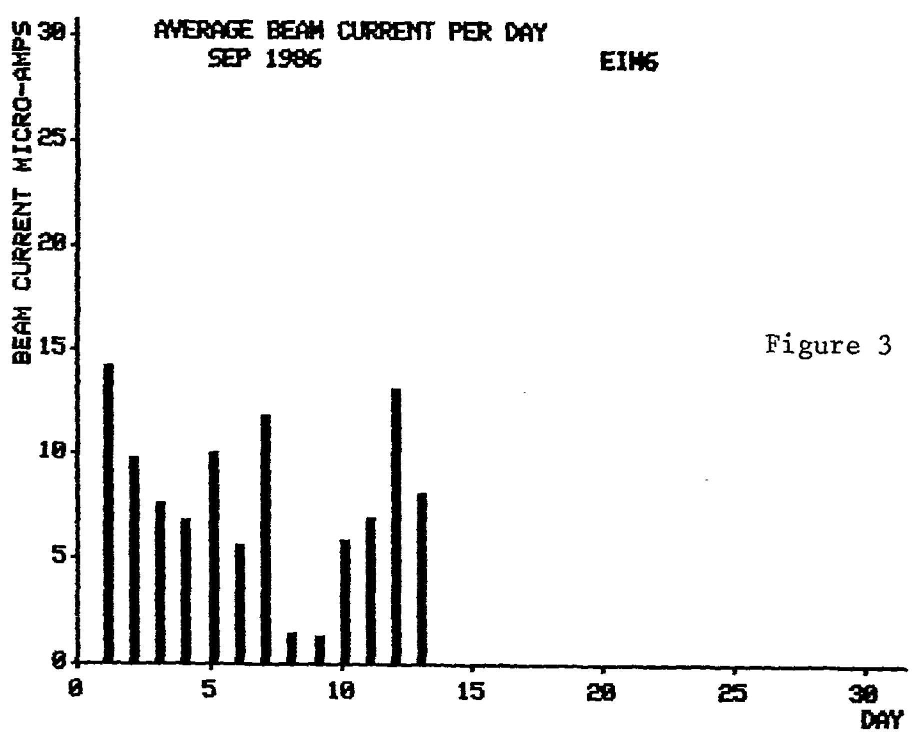

Figure 3

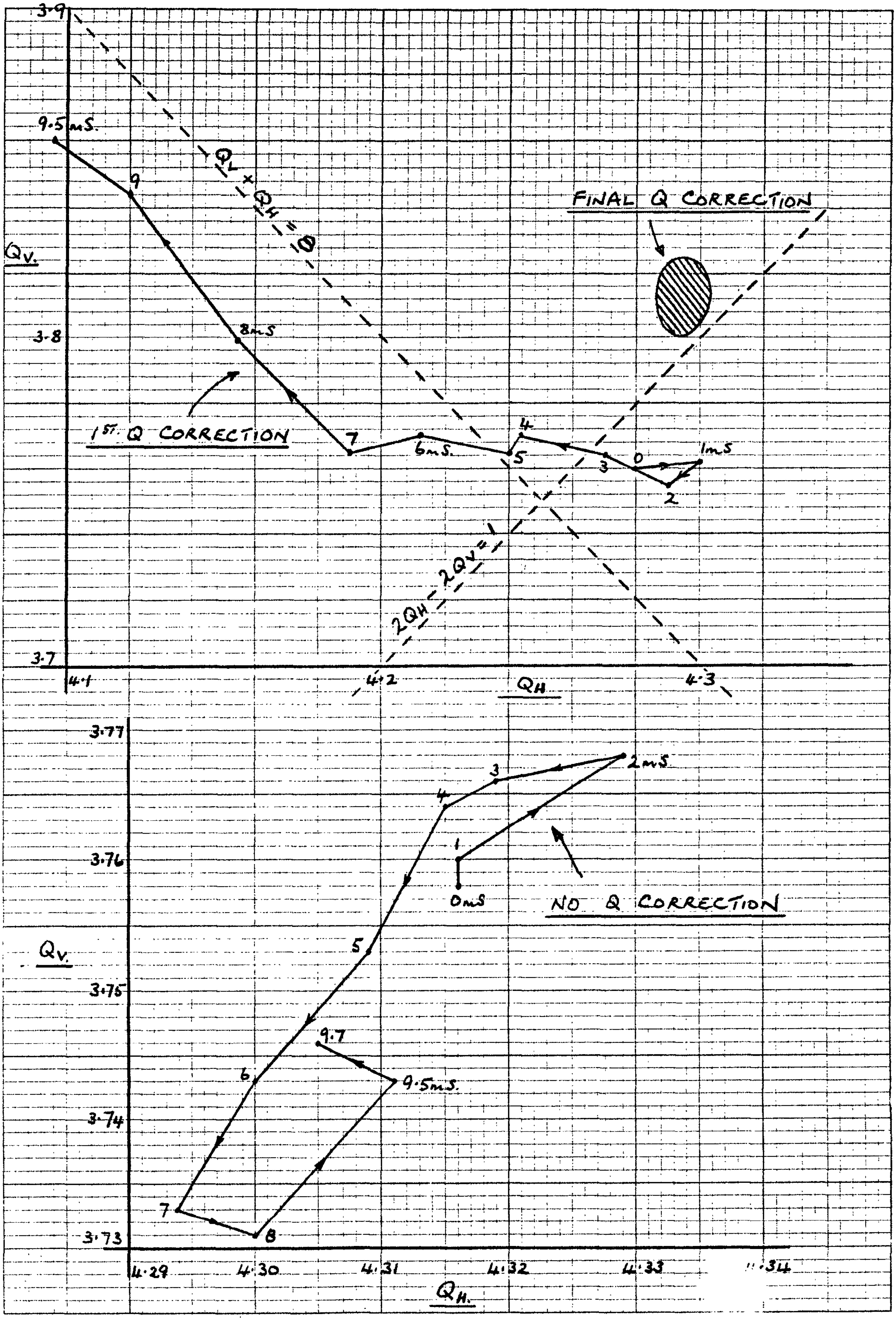

FIG. 2 : Q VALUES DURING ACCELERATION