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PROGRESS REPORT ON THE SNS TARGET STATION

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1. Introduction

This progress report continues the series given in previous ICANS meetings (1). It should be the last in the design and construction phases and inevitably contains much engineering detail. For the next ICANS meeting we look forward to reporting first operational experiences, the schedule for first neutrons being October 1984. Progress is reported under the five broad headings of Target, Target Assembly, Control System, Bulk Shield and Remote Handling. Additional facilities to the target station are also reported.

2. Target

The dimensions and parameters of the target were given at the ICANS-VI meeting. Since that time prototype production of complete target plates, including two with thermocouple wells, has been successfully completed. Good quality bonding has been achieved in all cases. Accordingly a contract was placed for the production of 2 complete target modules, each consisting of 23 plates, with delivery of the first module in October 1983. Further modules will be ordered as dictated by operational experience. The stress calculations and design report for the target vessel and its components have been completed and certified under the ASME III code, and production is underway for delivery complete by December 1983. A back-up target with tantalum plates will also be built.

3. Target Assembly

(a) Ambient

The reflector vessel has been reduced from twelve units to four in a simplifying re-design. Boron laminate ('BORAL') decouplers will be incorporated within the vessels and utilising its coolant, rather than use a separate cooling system. The material of the vessels will be stainless steel. Production of the vessels and final machining of the beryllium rods are underway, for completion in December 1983. The cadmium decoupler for the target will now be attached to the reflector vessel to obtain contact cooling, which is important when considering target cooling under fault conditions (in thermal isolation the cadmium could melt).

The ambient moderators are in the stage of final design: they will be non-pressure vessels operating at less than 0.7 atm, made of Aluminium-Magnesium (5%) alloy. They will be constructed and tested within the spirit of the British standards for pressure vessels.

(b) Cryogenic

Detailed design of the cold moderators has continued and stressing has been carried out using finite element techniques (NASTRAN). A prototype vessel is being manufactured which will be pressure tested to confirm the computer analysis. Production moderators will use Aluminium-Magnesium alloy, as above, even though this is not a classified material under the ASME III code. The hydrogen moderator, which operates with 25K supercritical para-hydrogen at 15 atm, will be triply-contained to satisfy safety requirements. Figure 1 shows a section of the hydrogen moderator.

Both hydrogen and methane refrigerators have been ordered, delivery of the methane one is due in September, and the complete hydrogen machine is due at the beginning of 1984. A tender exercise is underway for the transfer lines. Test areas for the refrigerators and moderators have been set up within the SNS complex to determine satisfactory performance prior to final installation.

Major components of the water services are on order, including heat exchanges, ion-exchange columns, tank and filters. Service trolleys (part of the movable train for operation-to-maintenance locations) are due for delivery in September.

Major simplifications of the water system have been achieved (in particular in providing the totally independent circuits for the target plates and target pressure vessel) as a result of systems reviews in preparation of safety documents (q.v.).

4. Control System and Safety

The software for the extracted proton beam and target station are on schedule for initial completion by June 1984. Routines have been written for the control of the beam line magnets and the final control program will be started soon. On the target station, the microprocessor control system (MCS) has been extended to drive the dynamic interlock interface controlling the permit state of the SNS proton beam. It now incorporates most of the software fault checks and displays each interlock state on an appropriate 48-channel display board. Some MCS routines have been converted to machine language and the number of data channels increased to allow future extensions and flexibility. Data exchange to the minicomputer (GEC 4070) has been running for several months without faults. The minicomputer control system (MINICS) has two separate master programs for target station control and logging. Control programs include software to display the status of all valves and the status of critical plant parameters from the MCS system. Logging routines include all critical parameters and derived parameters, e.g. effective cooling gaps derived from flow rate and pressure drop. Averaging logging runs will indicate long term performances of the plant.

Development of controls hardware is progressing on schedule, however the production of hardware has been limited by demands for resources elsewhere on the SNS. The program calls for completion of hardware in March 1984, to allow commissioning for first neutrons in October 1984. The target station controls room has been completed.

A major effort has been put into the safety assessment and hazard survey of the target station. Under new regulations, soon to become law in the UK, if a quantity of radioactivity exceeds amounts defined in those regulations, a hazard survey must be written. This has been done, plus a large supportive document ("Safety Assessment of the SNS Target Station", August 1983 (2)), which in turn has a number of detailed supportive papers. In one of these, it has been shown that with beam-off and a catastrophic failure of cooling to the target, the maximum temperature reached under decay heating is less than 540°C, i.e. the uranium will not melt. Notwithstanding this statement, a further paper gives calculations of the dose to RAL staff and to the nearest local population if volatile and gaseous radionuclides were able to escape after a meltdown. Iodines, ^{131}I and ^{133}I, are the most significant radiologically, but the doses received are < 1% ERL* for RAL staff evacuating the experimental hall within 3 hours and for the nearest local population < 10^{-3} ERL over 30 days, The documents are now being examined towards seeking approval to operate the SNS in 1984.

5. Bulk Shield

The six modules of the shielding inserts have been installed. Shielding blocks which fit within the inserts are in manufacture for delivery by December 1983.

The shielding wedges have all been delivered and installed to check alignment, and are seen in position in figure 2. They have now been removed pending delivery of the target void vessel. The target void vessel, a pressure vessel designed under the ASME III, category A code, is due for delivery at the end of September. The bridge to be mounted over the void vessel (and therefore also required to be an "ASME designed" structure) and which supports the shielding above, is due for delivery in mid September. The 20 beam shutters are in manufacture, with delivery to be complete by December 1983. Several part-shutters have been delivered and, as can be seen in figure 3, a whole shutter, weighing some 22 tons, has been assembled for test mounting within the shielding wedges also for ventilation tests. The incoming proton beam window has been designed as a double-walled Inconel vessel with light water cooling, based on the LANL design. Access to this window for repair will be obtained by pulling it into the EPB shielding enclosure, an operation requiring shielding from the induced activity within the void vessel (the γ dose rate at centre of the empty void vessel being 1 Sv/hr).

6. Remote Handling

The foundations of the remote handling cell and shielded services area have been laid, incorporating the rail system for the services trolleys and a double drainage system to take split active liquids, see figure 4.

The services area construction itself is due for completion at the end of September. This large area 8 (w) x 22 (l) m^2 has walls 7m high and about 1m thick of concrete. This thickness is required to shield against short lived hard γ-emitters (e.g. ^{16}N) from the target primary coolant, the radiation dose rate 1m from the cooling pipes being 1 Sv/hr. The concrete roof will be initially ½m thick, perhaps increased later to 1m according to operating experience.

Construction of the remote handling cell is about to commence, with completion planned for the end of December 1983. Most of the components have been delivered. The main shielding door has been designed and parts are in manufacture. Design, development and testing of the target removal equipment is about to be restarted (after delays due to other priorities), where considerable simplification is now possible following the calculations of thermal behaviour of the target under decay heating. Cooling will be maintained for 24 hours after shut-down, after which no cooling will be provided, even in the temporary storage wells (prudence however requires that provision for cooling be kept).

7. Other Facilities

Components for the irradiation test facility have been on order, with delivery scheduled to match the installation of major target station components. Some studies have started towards proposals for test rigs to be mounted within the access tube, e.g. a furnace for test samples up to a temperature of about 700°C.

The installation of the EPB will allow the provision of an intermediate target (20 mm graphite) some 20m upstream of the main SNS target. The possible secondary beam facilities from this target were described in the last progress report (ICANS-VI). In particular, a pulsed μSR facility of great flexibility was proposed to the Science Board of the SERC in January 1983. However funds were not available at that time for the installation of this facility. Some simplified μSR facility may still be built for R & D work.

In May 1983 an agreement was signed between the RAL (SERC) and KfK, Karlsruhe to build a large neutrino facility on the south side of the SNS experimental hall. Not only does the SNS target generate large quantities of neutrons, at the same time it produces large numbers of pions which emit neutrinos whilst decaying. In particular π^+ at rest produces ν_μ ($E(\nu_\mu)$ = 29.79 MeV) and μ^+ which in turn decays into ν_e and $\bar{\nu}_\mu$ with an energy spectrum with cut-off at about 53 MeV. For a 200 μA incoming proton beam, equal numbers of neutrinos (10^{14} ν/sec) of each kind are produced. This production rate, combined with the low duty cycle ($\sim 10^{-5}$), makes the SNS a uniquely powerful facility.

Over the initial five year life of the facility five major experiments are proposed in the first instance, including elastic-lepton scattering, neutral current excitation of the nucleus and $\nu_e \leftrightarrow \nu_\mu$ oscillations from inverse β-decay in H and C. The count rates are so low that background counts shound not exceed ∿ 1/day from the SNS source and be "negligible" from cosmic sources. Hence massive shielding around the liquid scintillator detectors is necessary. The walls must be 2.2m thick steel and the roof some 3m

* ERL = Emergency Reference Level ≡ 50% ALI for occupationally exposed personnel

ALI = Permissible annual limit of intake thick: total quantity of steel about 5500 tons. The detector itself will weigh between 50 and 300 tons.

Figure 5 shows (roughly) the layout on the experimental floor and the relation to the target station. This figure is of historic interest in that it formed the basis of the agreement, which was supported by the Science Planning Group of the SNS. Figure 6 shows the shielding bunker together with the neutron beam instrument layout in the hall.

Work on building the foundation for the bunker is due to start in October 1983 and should finish May-June 1984. After this the steel shielding will be installed. Careful planning is required to minimise any conflict with the neutron instrument installation. A large support building built against the outside of the south wall of the experimental hall will form part of the facility. Completion of the RAL part is due by about the beginning of 1985 (depending on steel delivery), ready to receive the detectors for experiments to begin. These will be done by staff from KfK with collaboration from UK Universities. The neutrino facility will be an exciting addition to the SNS as a "universal" source.

8. Acknowledgements

It is a pleasure to acknowledge once again the efforts and enthusiasms of the members of the SNS Target and Utilisation Group. The collaboration of members of Neutron Division is acknowledged, also the efforts of EBW Division in developing the design for the neutrino facility.

9. References

1. A Carne, Report on the SNS Target Station: ICANS Reports, in particular ICANS IV and VI

2. "Safety Assessment of the SNS Target Station", Compiled by A Carne and G H Eaton, SNSMC/P6/82, revision 1

10. Figures

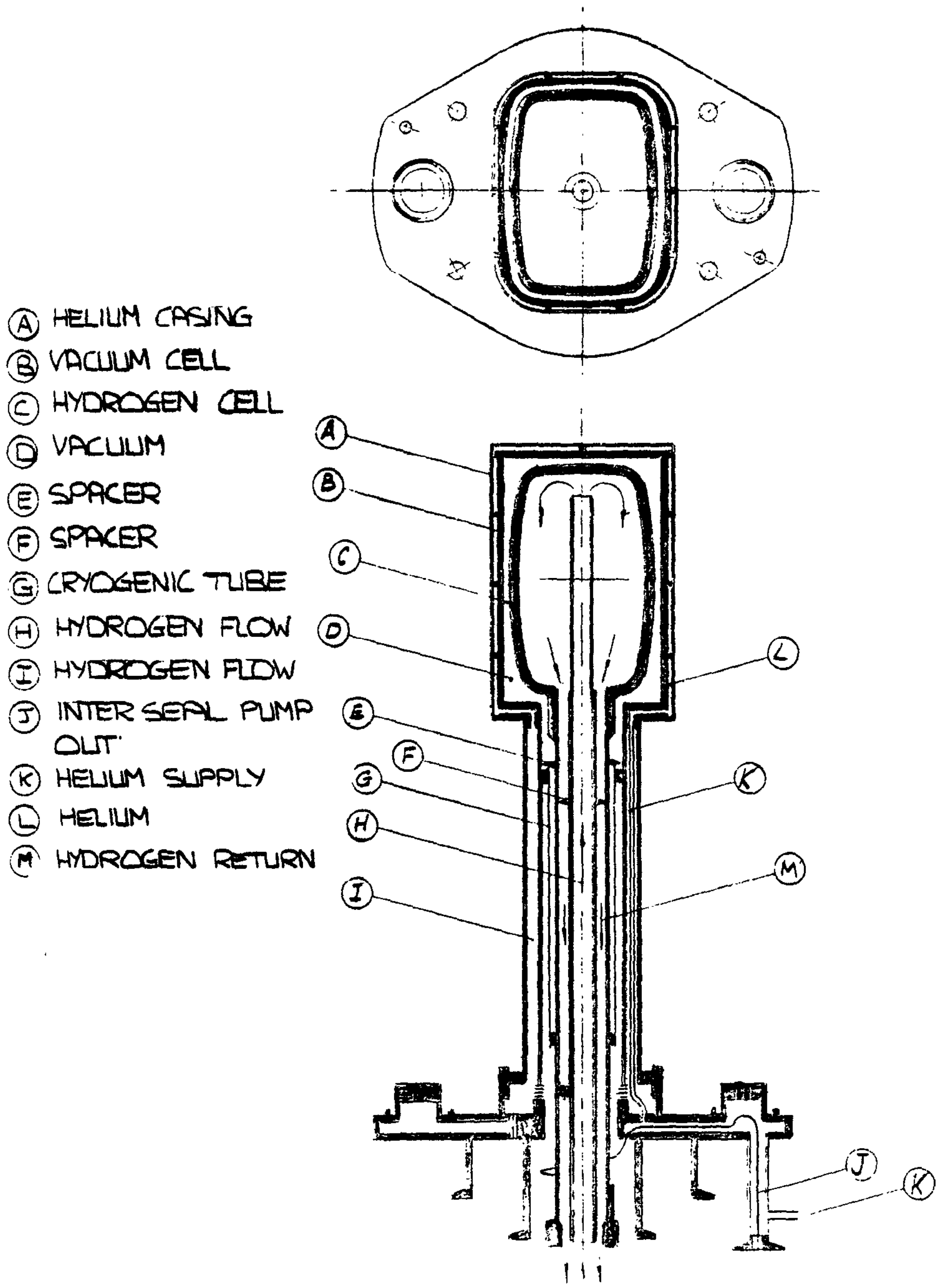


FIGURE:1 HYDROGEN MODERATOR

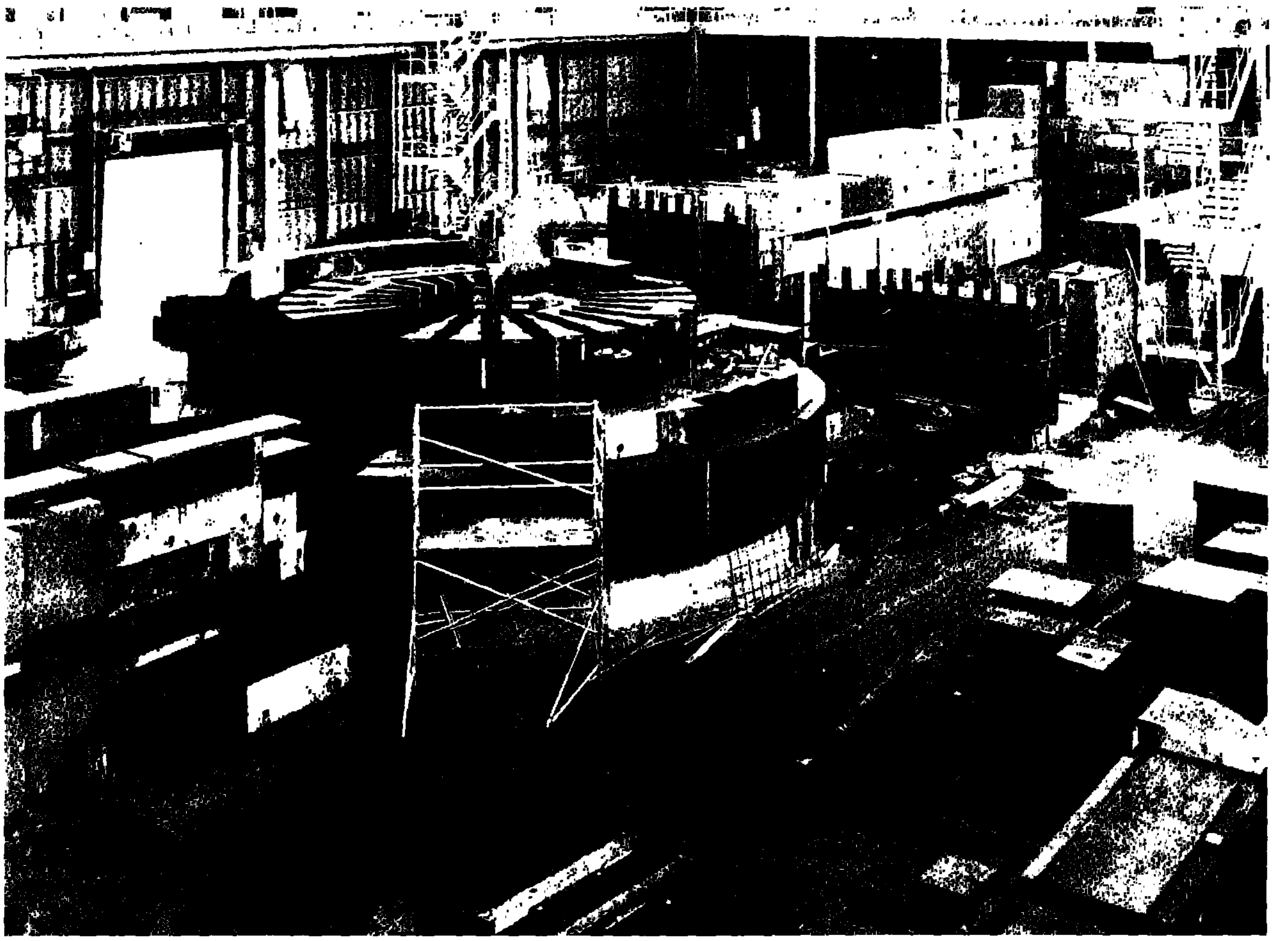


FIGURE 2: View of Target Station Showing Shielding Wedges initially positioned.

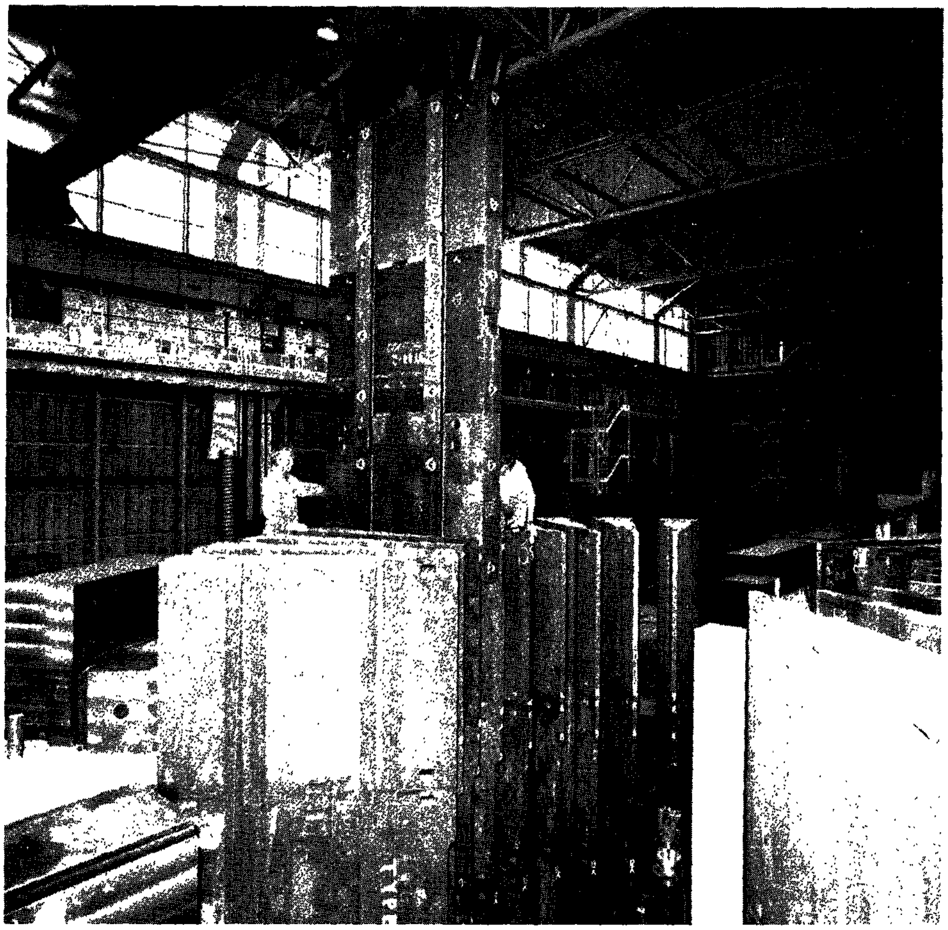


FIGURE 3: Whole Shutter Assembly in Mounting Tests with Target Station Shielding.

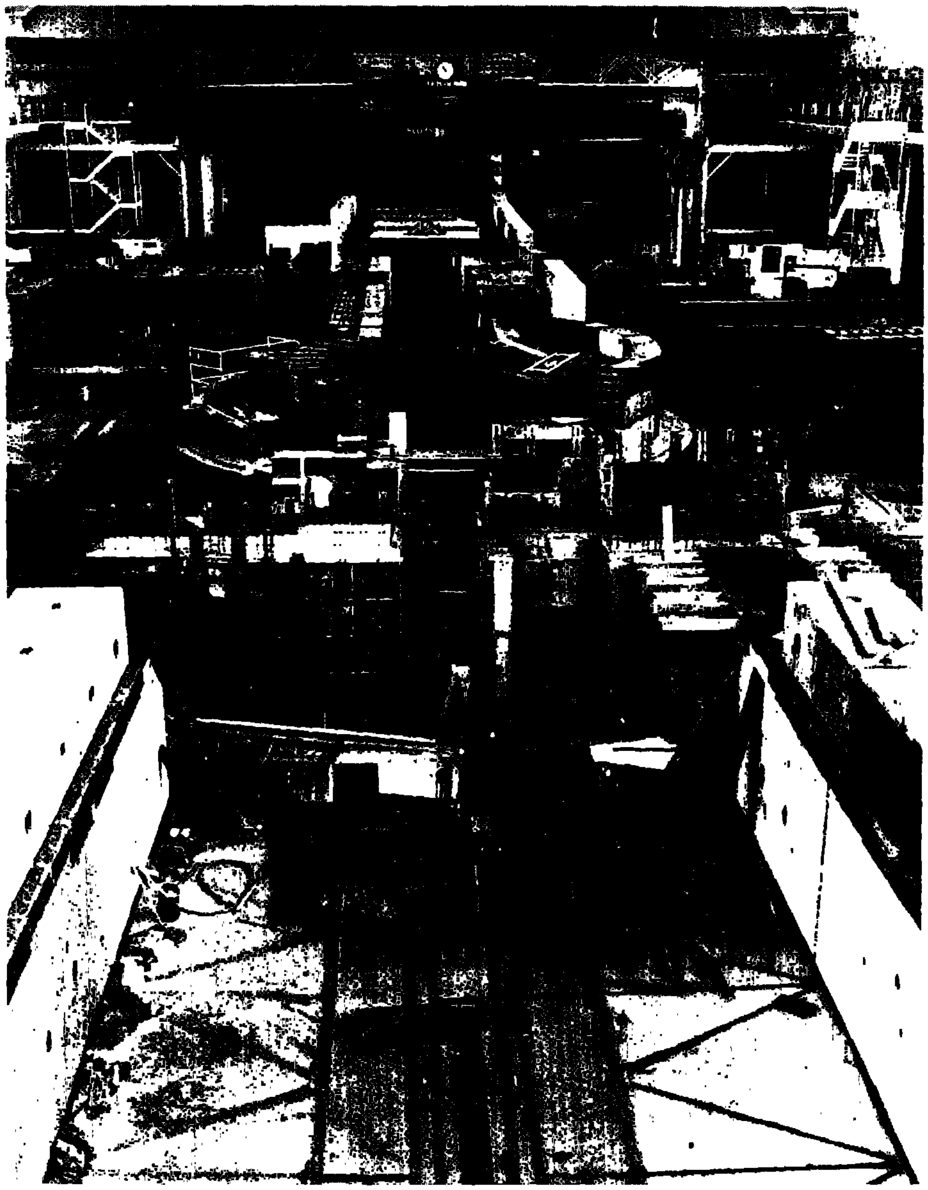
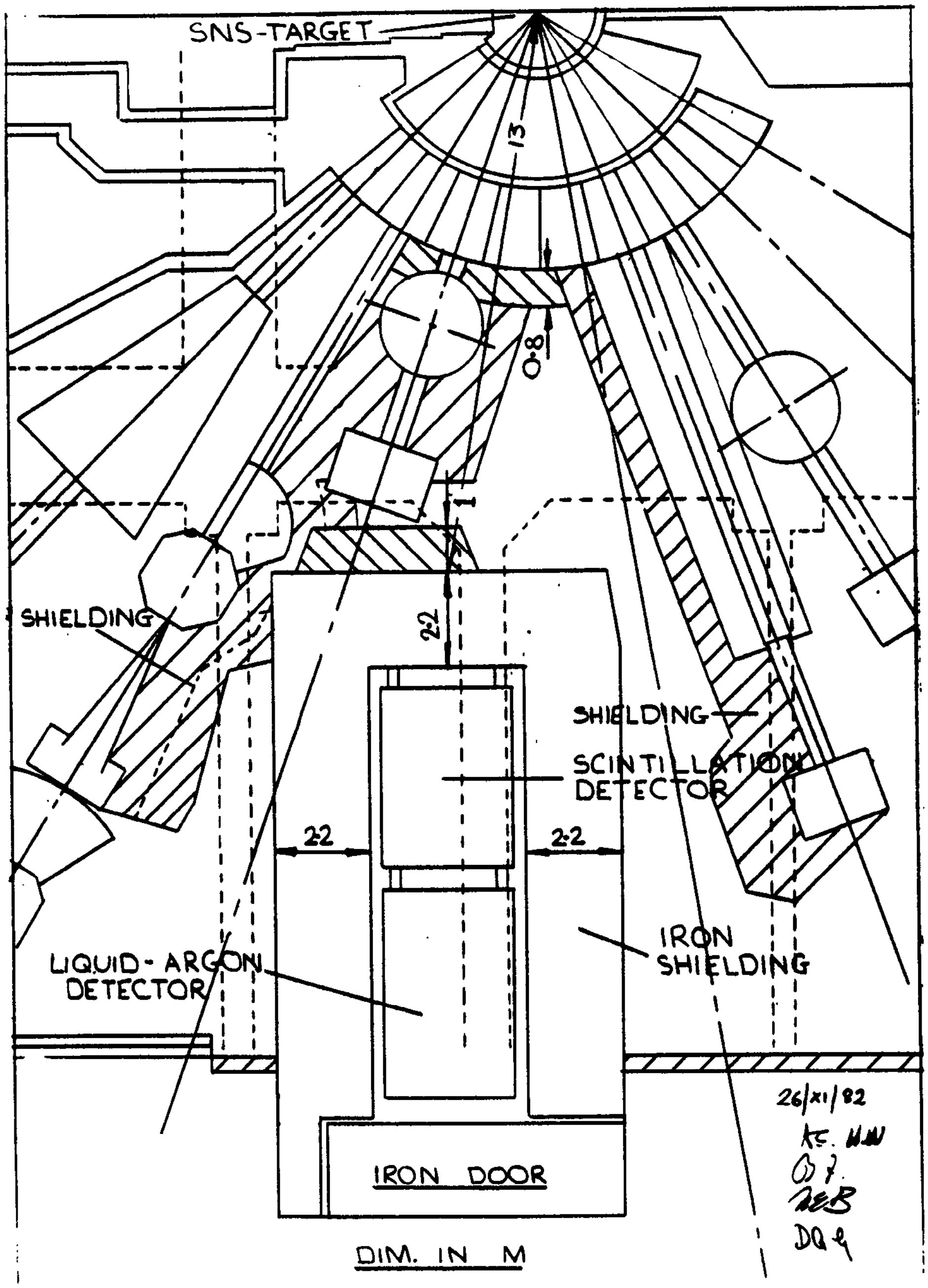


FIGURE 4: Profiled Floor and Services Area Showing Drainage System.



FIG·5 PLAN OF NEUTRINO BUNKER

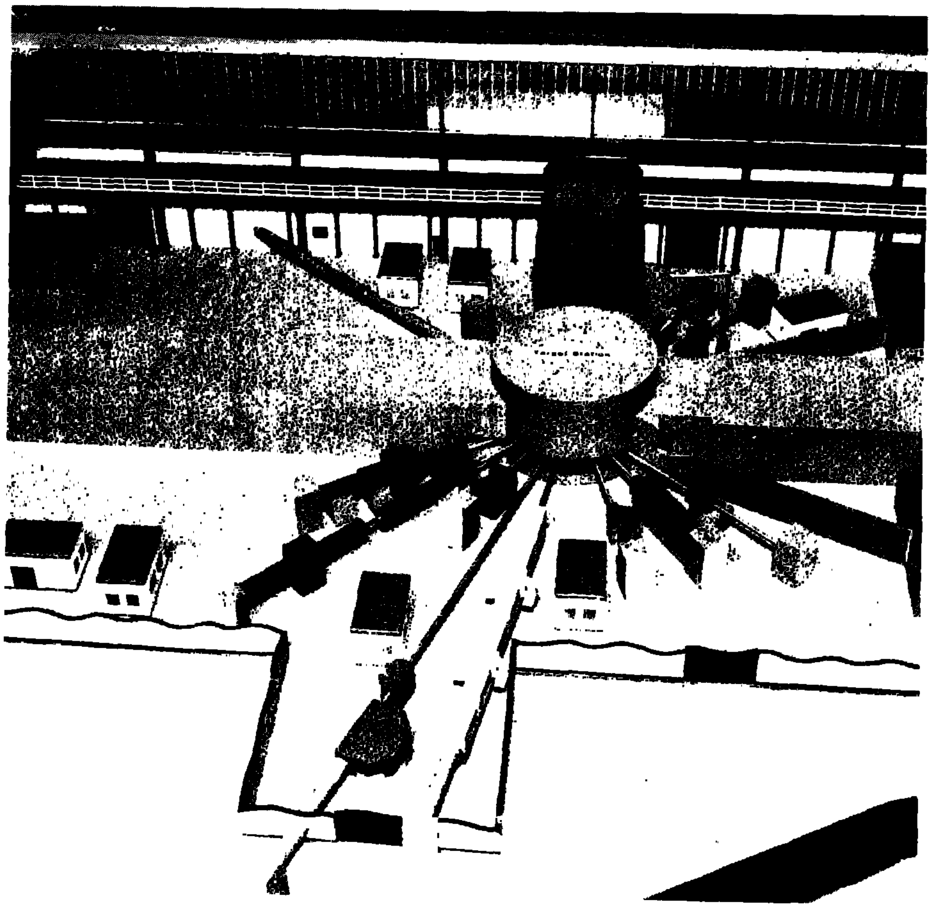


FIGURE 6: Neutrino Bunker Vis-a-vis Neutron Instruments in R55.