ICANS IX

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STATUS REPORT ON SINQ, THE SIN NEUTRON SOURCE

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INTRODUCTION

The main emphasis of the present work on SINQ is the production of a full engineering design for the source. The basic concept has not been changed but there has been (and will continue to be!) many modifications of details as we try to accommodate the necessary requirement that will make a system which can be built, operated and maintained. There is a continuing experimental program which includes materials testing (corrosion and radiation damage), thermofluid dynamics investigations and neutronic performance examinations of the cold source.

I. BUILDING WORK

The SINQ project includes the construction of two new buildings; the neutron hall, to house the spallation source and spectrometers located at beam tubes, and the guide hall. The floor areas are 34 x 51.5 m^2 and 24 x 50 m^2 respectively. Both buildings are to be equiped with cranes of capacity and hook clearance 60 t and 18 m for the neutron hall and 10 t and 6 m for the guide hall. An artists impression of the SIN site with these new buildings is shown in Fig. 1.

Figure 2 shows a plan of the SINQ area, the trench for the proton beam, an outline of the source and a tentative storage facility for irradiated targets are shown in the neutron hall, a cellar in the guide hall, containing active liquid storage tanks (again part of the upgrading of general SIN-facilities for high current operation) is shown with broken lines.

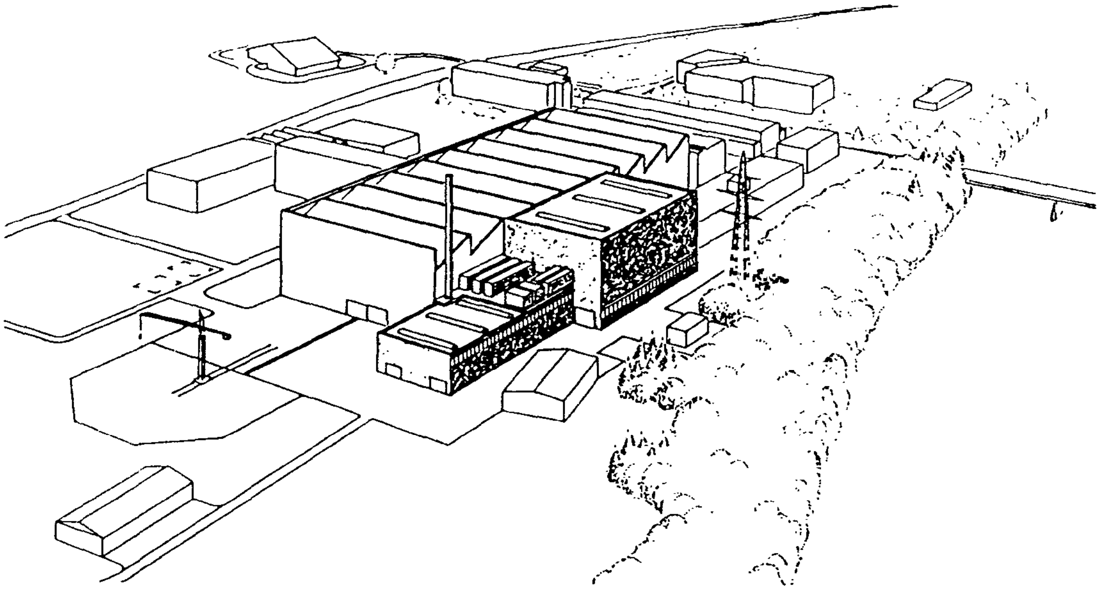


Fig. 1 Artists impression of the SIN-site with the new buildings for SINQ. The equipment on the roof of the guide hall is for the upgraded general SIN experimental ventilator system.

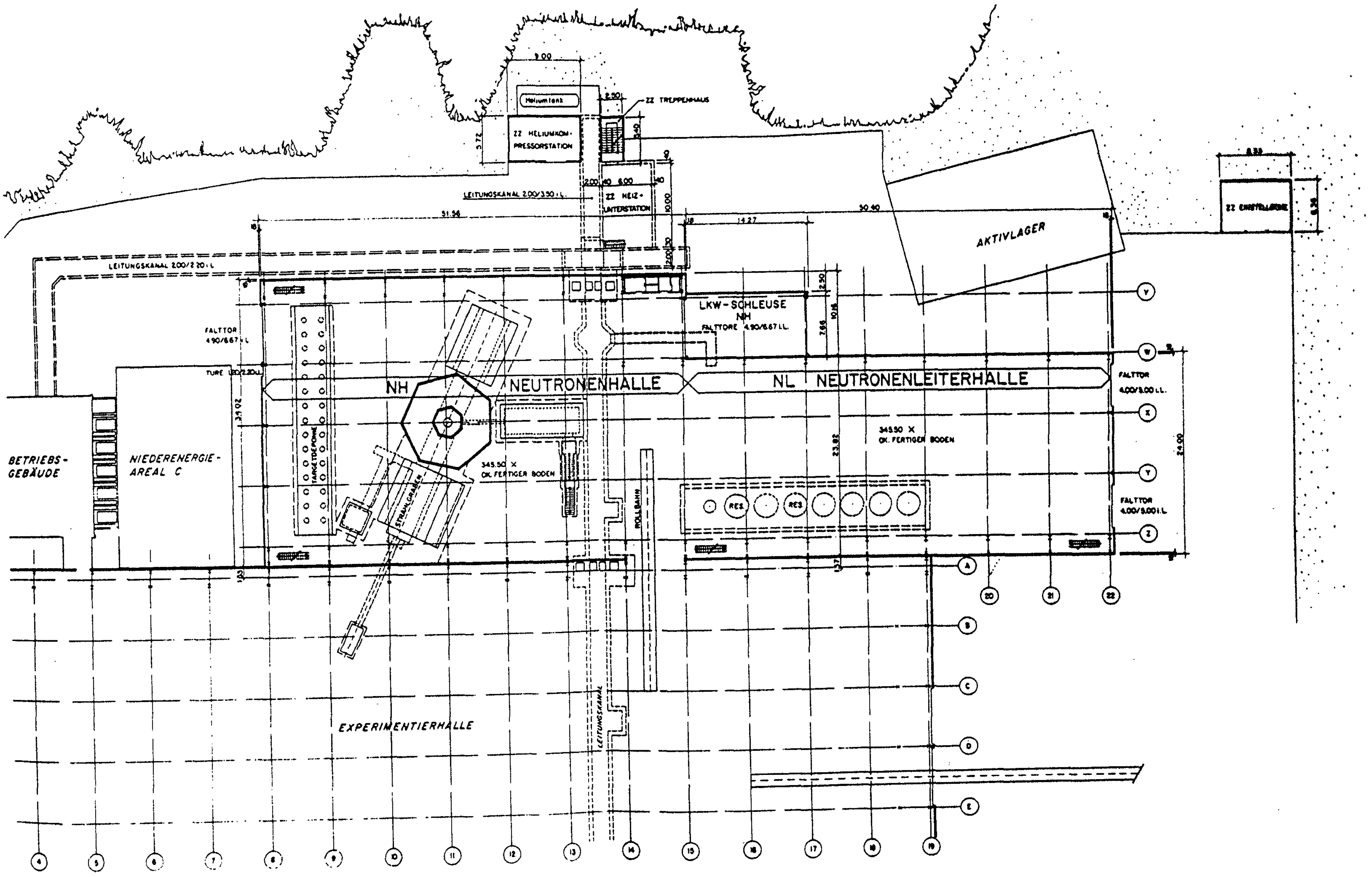


Fig. 2 Layout of the neutron hall and the guide hall. Contours of the trench for the proton beam and the shielding of the neutron source.

II. THE SPALLATION SOURCE - SINQ

i) Principle

As a reminder, we will briefly describe the principal features of SINQ. A vertical section through the central region of the source is shown in Fig. 3. The proton beam is deflected downwards to pass under the beam tube area, thence to the centre of the source, and finally pitched vertically upwards to the spallation target. The proton energy at the spallation target will range from 560 to 590 MeV with an initial intensity of 1 mA. The target consists of a "pot" of Pb/Bi eutectic mixture (molten) of inner diameter about 15 cm and 3 m high. Most of the beam power is deposited in the bottom 30 cm and natural convection is to be used to transport this heat to an exchanger mounted at the top and hence away from the source [1]. The active region of the target (the bottom 30 cm) is located at the centre of the D_2O moderator which has a diameter and height of about 2 m.

Figure 4 shows a plan of the "fixed" part of the source (note; the beam tubes are on two different levels with a vertical centre-line displacement of 230 mm). The beam tubes pass through the bulk shield in boxes. This allows the beam tubes (shielding, collimator, introduction of special equipment etc.) to be custom-built to the requirements of the individual instruments. It also makes it easier to make modifications as the source develops. Every beam tube will also have extra shielding outside the limit of the bulk shield which is most easily constructed onto flat faces; this extra shielding will normally contain the monochromator.

ii) Proton Beam Injection and the Window Problem

The optics of the primary-proton beam was discussed in some detail at the last ICANS-meeting [2]. An important feature of the design is the collimator close to the target window.

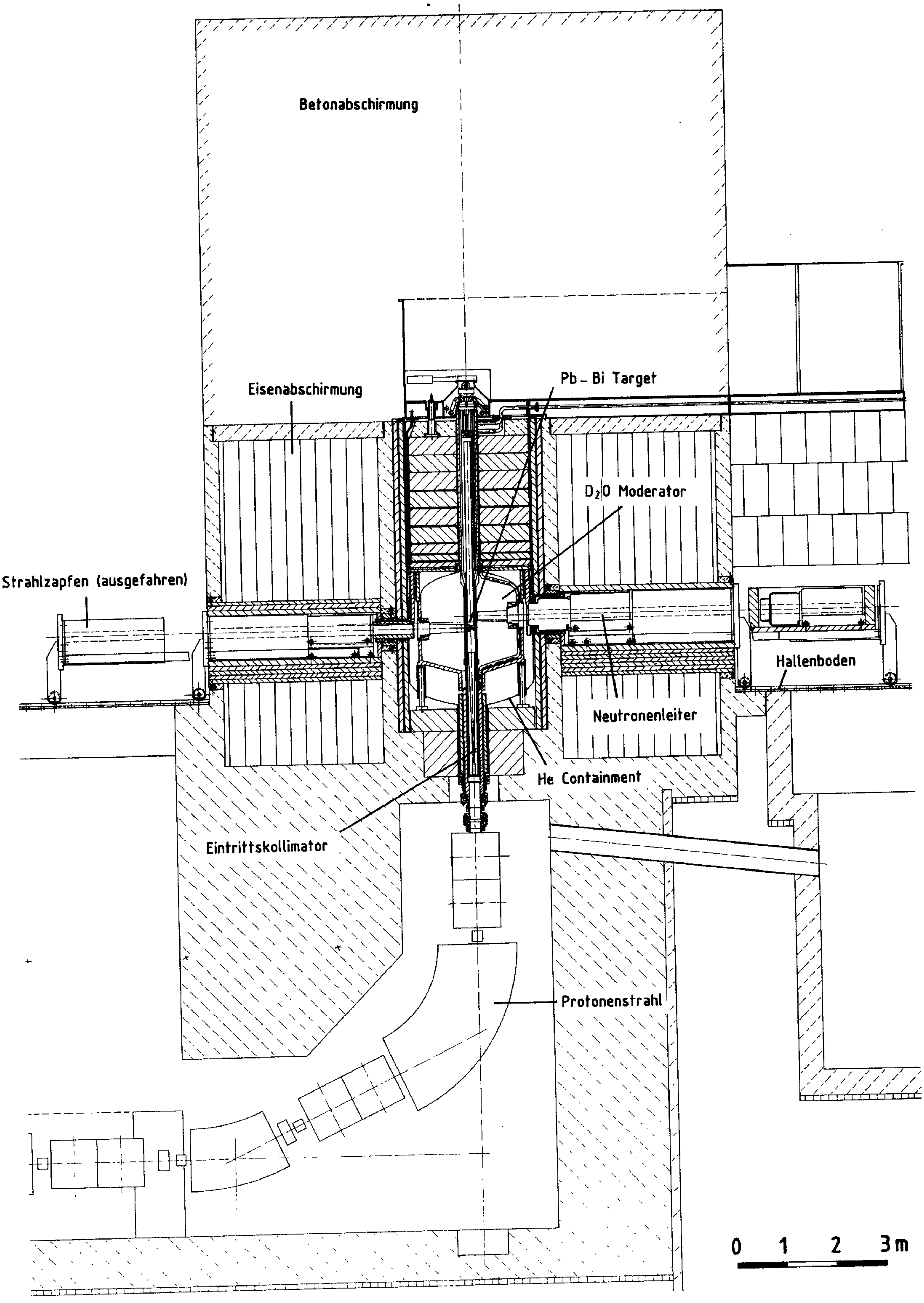
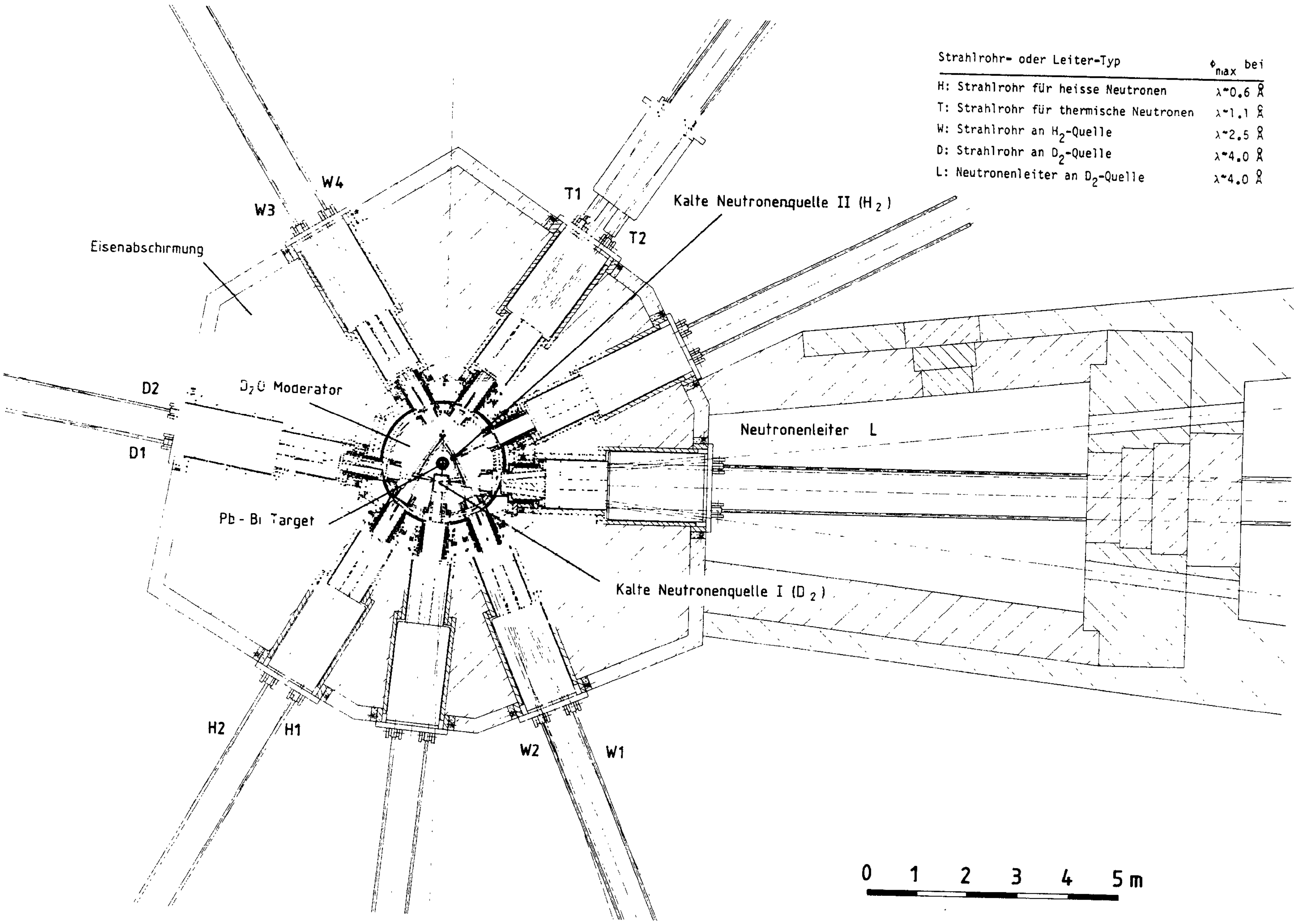


Fig. 3 Vertical section through the central region of the source showing the vertical beam injection into the spallation target.



Strahlrohr- oder Leiter-Typ	ϕ_{max} bei
H: Strahlrohr für heisse Neutronen	$\lambda \approx 0.6$ Å
T: Strahlrohr für thermische Neutronen	$\lambda \approx 1.1$ Å
W: Strahlrohr an H_2-Quelle	$\lambda \approx 2.5$ Å
D: Strahlrohr an D_2-Quelle	$\lambda \approx 4.0$ Å
L: Neutronenleiter an D_2-Quelle	$\lambda \approx 4.0$ Å

Fig. 4 Layout of the beam tube plugs and the insertions for the two cold sources.

This collimator enforces a double focus of the proton beam at a well defined position, presently 1.5 m in front of the target window (Fig. 3). With the given emittance of the beam, this produces a beam diameter at the target window which cannot be smaller than 6 cm. This is a necessary precaution in order to guarantee that the power density in the window material does not exceed ~130 w/grm.

Nevertheless, it is most likely that the beam window will be the limiting component on the target lifetime; we aim for this to be at least 1 year. In an experiment at the Los Alamos beam dump [3], the mechanical properties of various types of steel under proton irradiation were examined. The samples were also irradiated in contact with Pb/Bi to make a first attempt at seeing if there are any radiation induced corrosion effects.

Figures 5 and 6 show the strain-stress behaviour of pure iron and a 12 %Cr-1 %Mo (alloyed) steel, unirradiated and after being irradiated to fluences of 4.8×10^{19} and 5.4×10^{20} protons/cm^2. All the irradiations were made at a sample temperature of 400° C. The expected embrittlement of the pure iron was observed. The steel, however, retained its ductility up to the higher fluence. Although this steel seems a suitable candidate for the window material, the fluence used in the test is a factor of 6 to 7 below the expected operational value. Hence further tests are in progress.

The microscopic analysis of the samples for corrosion effects has not yet been made although macroscopically no signs of Pb/Bi induced corrosion have been observed.

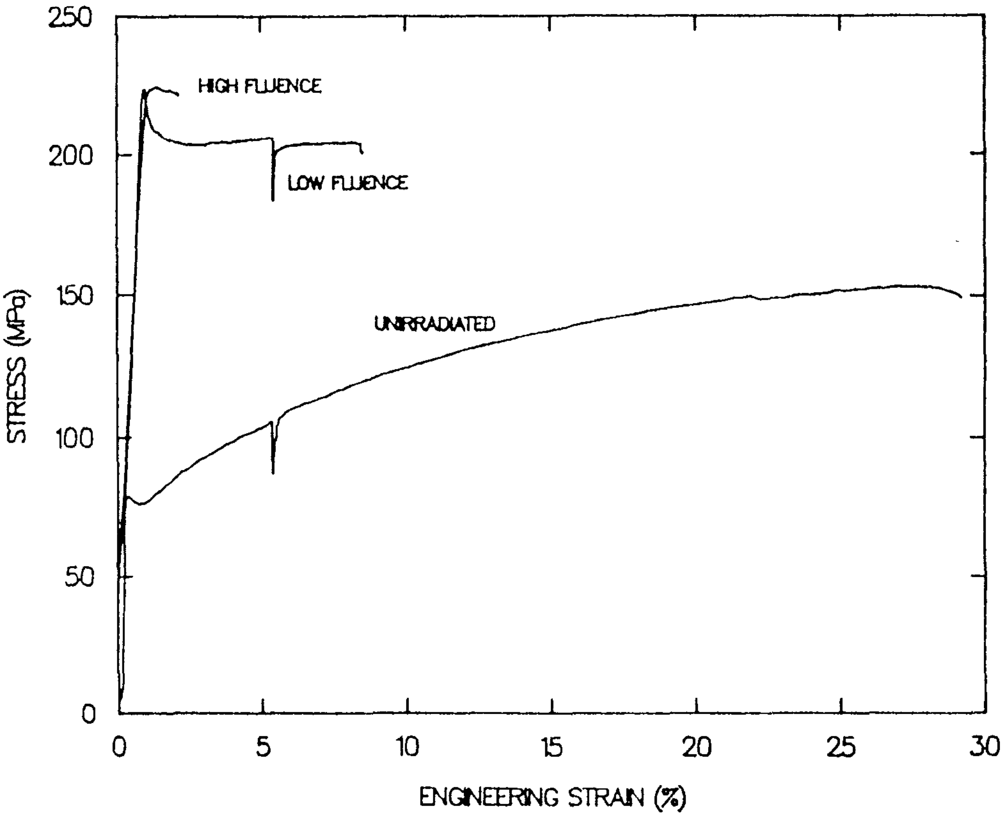


Fig. 5 Stress-strain behaviour of pure iron after irradiation with 500 MeV protons
Low fluence : 4.8 10 P/cm
High fluence: 5.4 10 P/cm
Sample temperature was 400 C

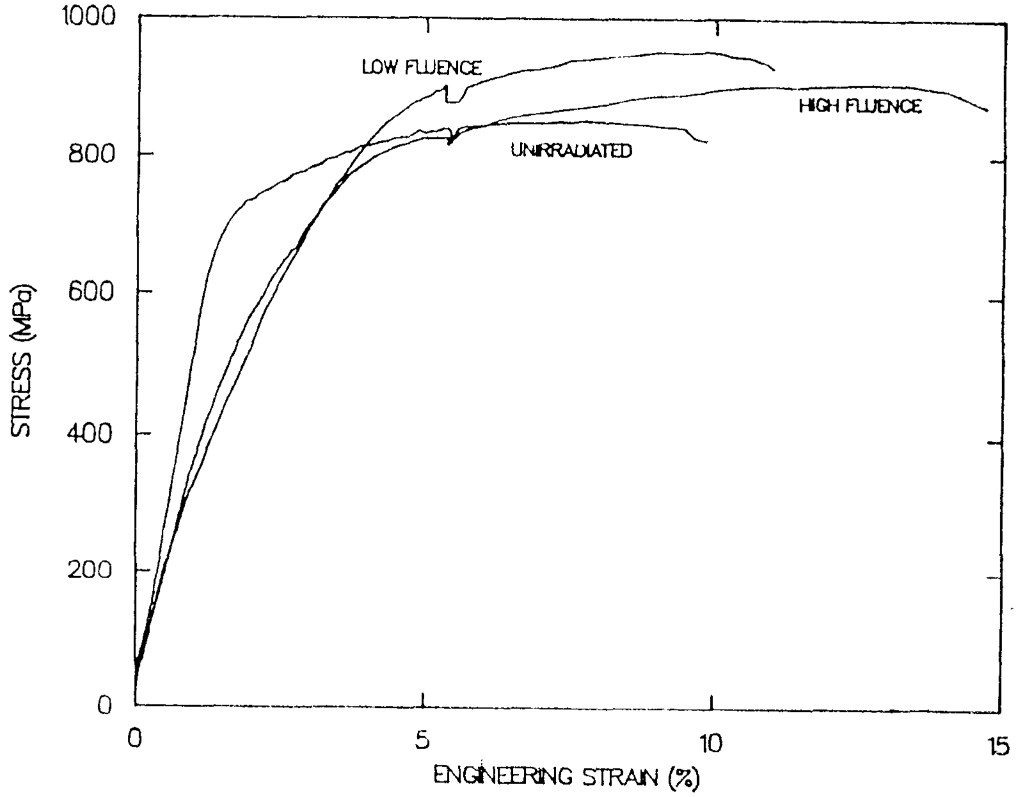


Fig. 6 Stress-strain behaviour of Fe-12Cr-1Mo steel after irradiation with 800 MeV protons
Low fluence : 4.8 10 P/cm
High fluence: 5.4 10 P/cm
Sample temperature was 400 C

iii) Cold Sources and Beam Layout

In order to optimize the performance of SINQ at longer wavelengths we plan to install two cold sources; a small H_2-source and a large (20 l) D_2-source. A vertical insert for the cryogenic thermosyphon-systems of these sources would interfere severly with the infrastructure of the spallation (target heat exchanger, secondary cooling circuits, and (possibly) a gas extraction system). Due to this we have decided on a solution with horizontal plugs inserted through the bulk shield. The height difference to the liquifiers needed to make the thermosyphon principle work (3 to 4 m for the D_2 source) can be obtained in a vertical shaft at the periphery of the bulk shield. According to the investigation for the second cold source at ILL [4] and the expected power deposition in the cold source and its container [5], this solution should be feasible.

The beam tube layout may be seen in Fig. 4. There are five neutron beam tubes, each of which provides two independant beam ports. Two of the equipment boxes are for the cryogenic infrastructure of the cold sources and there is a tube and box for the first sections of a guide system. The beam tubes are on two different levels; the two thermal neutron beams are not a "through tube" and so one of these can be used to provide a hot source.

There are four beam parts viewing the H_2-source which should provide a neutron spectrum in the region 80 to 100 K. The D_2 source will produce a neutron spectrum in the 20 to 30 K region and is viewed by two beam ports and the guide system.

Two guides are planned for the initial operation of SINQ; the option of installing a third is being built into the design. Guides of cross section 30x100 mm^2 are to be used and one will be split to provide two branches of 30x45 mm^2 cross section. Because of the high-energy neutron background we prefer to localise the beam loss in a single strongly shielded region and plan to include beam benders into all guides as the means of obtaining a good sproad and hence sufficient room for the instruments in the guide hall. These benders and the splitter are to be mounted in a beam switch-yard at the laternal face of the bulk shield. The benders would consist of 12 guidlets with a wall thickness of 0.5 mm and a gap of 2 mm. The parameters for bending angles of 2^{0} and 4^{0} are given in Table I. Since this ystem is rather similar to the concept of the new guide laboratory at KFA-Julich, our decision will depend on their operational experience.

Table I

Bending angle	2^{0}	4^{0}
Length (m)	3.5	4.0
Critical wave length (Å)	3.1	4.1
Bending radius (m)	107.0	57.2

The guides are assumed to be coated with ^{58}Ni, that is k = 2.04 x 10^{-4} rad $Å^{-1}$.

iv) SINQ-Performance

The design and performance of SINQ are based on results from an experimental program for the investigation of the neutronics. This program has been realized by a Jülich-SIN collaboration on a secondary proton beam at SIN with a one-to-one mock-up model of the source [6]. In later runs [7] several configurations of cold hydrogen sources and their spectra were examined. From these data we can estimate the spectral fluxes at monochromator (or velocity selector) positions of beam tubes and neutron guides. The spectral fluxes from the D_2-source have, however, not yet been measured at the mock-up and the fluxes presented here are based on the measurements made by Ageron et al. [8] for the development of the cold source at ILL.

The spectral fluxes are shown in Fig. 7. They are based on a primary beam current of 1.5 mA (1 Mw beam power) and beam tube tips of height

10 cm and width 5 cm. Fluxes for the three different guide arrangements as listed below, are also included:

a) a straight guide plated with Ni^{58}

b) the same guide as in a), but also including a Be-filter of 50 cm length at a temperature of 100^0 K

c) a guide which is plated with natural nickel and a 4^0-bender.

All three systems are assumed to have a length of 40 m.

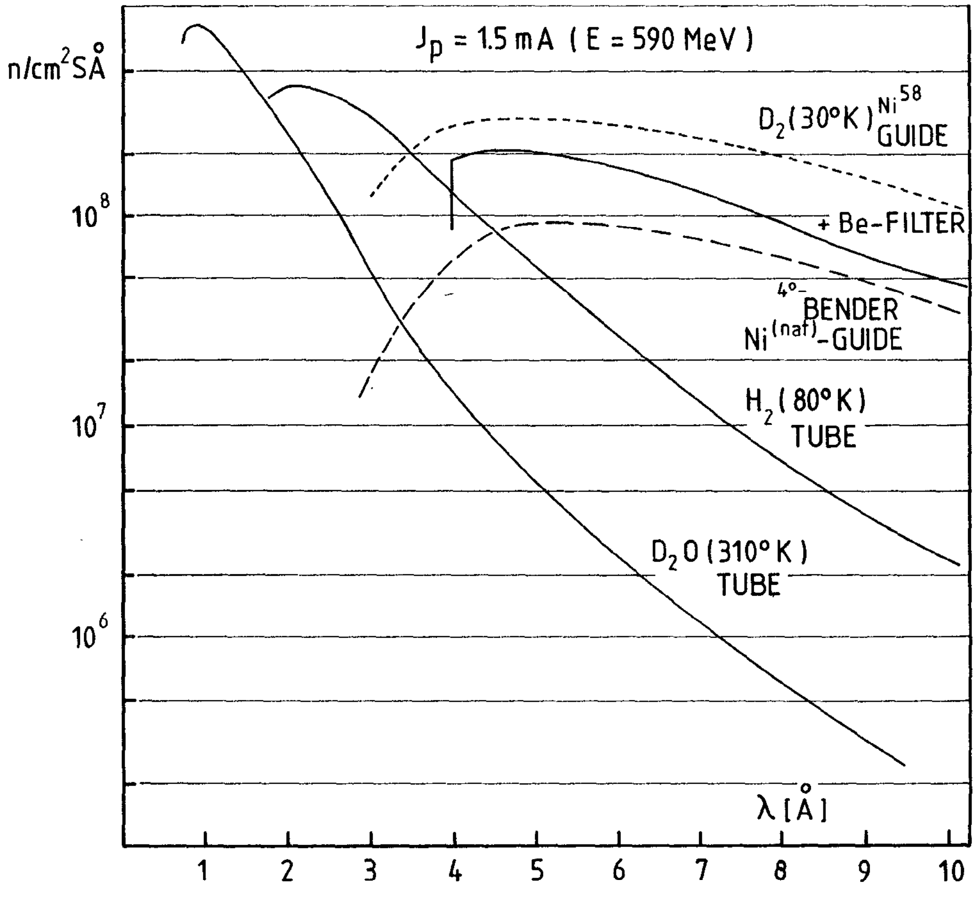


Fig. 7 Spectral fluxes at monochromator (or velocity-selector) positions at thermal beam tubes, cold tubes and neutron guides.

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