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STATUS OF THE SNQ PROJECT AT KFA JÜLICH

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ABSTRACT

The study for a high power spallation neutron source carried out jointly by the Kernforschungszentrum Karlsruhe and the Kernforschungsanlage Jülich has been completed in May 1981. In Feb. 1982 the KFA Jülich was selected as the site for a future spallation neutron source in Germany. A final decision about it construction does, however, require more planning work which will be carried out by KFA until the end of 1983. A formal project SNQ has been established at KFA, starting July 1, 1982. A staged concept for the realization of the facility will be studied.

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In March 1979, a special advisory panel to the German Ministry for Research and Technology recommended to study the possibility of building a high power spallation neutron source as a new central neutron research facility in the Federal Republic of Germany. The chairman of this panel was G. zu Putlitz. About two months later, in May 1979 the two major German laboratories for nuclear research, the Kernforschungszentrum Karlsruhe and the Kernforschungsanlage Jülich established a collaboration to carry out such a study. The goal was to finish the study work within two years. About half way through, in May 1980, an intermediate report was prepared for a panel (Pinkau-panel) appointed to evaluate major proposed projects for foundamental research in Germany. Based on this intermediate report, this panel concluded in February 1981 that a new neutron source should be built in Germany and that, if feasible, this should be a spallation neutron source. A further 3 to 4 year study period was recommended to prove the technical feasibility of components which were considered as being critical to the success of the facility. The SNQ-study was completed in June 1982, with the result that a spallation neutron source which could be competitive with a high flux reactor in terms of time average neutron flux and which would allow the users to benefit greatly from its time structure was feasible with present-day technology. This conclusion was based on numerous experimental and theoretical investigations and had been essentially confirmed by an international group of experts to whom the results had been presented at Heidelberg. It was, however, clear that prototypes should be built for certain components. The complete study report, which consists of three parts in 16 volumes was handed over to the Ministry of Research and Technology in September 1981.

The general plan of the facility is shown in Fig. 1 and the main data of the reference concept as worked out in the SNQ-study are summarized in Table 1.

The estimated cost of the facility was about 540 million DM for the accelerator and proton experimental areas, 140 million DM for the target station and 130 million DM for the proton pulse compressor ring.

Accelerator type:	Linac
Type of particles:	Protons (H^-)
Mean proton current:	5 mA
Peak proton current:	100 mA
Pulse repetition rate:	100 Hz
Injection an preacceleration:	450 keV dc
Low energy accelerating structure:	Alvarez, 108 MHz, 450 keV-105 MeV
High energy accelerating stucture:	Disk and washer, 324 MHz, 105-1100 MeV
Total length of accelerator:	650 m
Total power consumption:	50 MW (whole facility)
Target type:	Rotating target, H_2O cooled
Target material:	Pb, Al-clad
Power dissipated in target:	2,9 MW
Moderators:	H_2O, D_2O, Cold Source
Time average thermal neutron flux:	$7 \cdot 10^{14}$ $cm^{-2}s^{-1}$
Peak thermal neutron flux:	$1.3 \cdot 10^{16}$ $cm^{-2}s^{-1}$
Thermal neutron pulse width:	510 µs
Number of thermal neutron beam tubes:	12
Number of cold neutron beam tubes:	2
Number of neutron guides:	12
Experimental areas:	350 MeV proton hall 1100 MeV proton hall Target hall (thermal neutrons) Neutron guide hall Neutrino cavern Target top hall (irradiation stations)
Options:	U-238 target (flux doubling) 10 mA proton beam (1 ms pulses) Proton pulse compressor (0.5 µs pulses) Target station with pulsed source

Table 1: Main parameters of the SNQ reference concept

Two possibilities were considered, to build the facility in a staged way such as to be able to produce neutrons already well before the full sum has been spent.

One possibility would be to build the target station as conceived and the linac tunnel, but to equip the linac with accelerating structure only up to a fraction of the final energy. It has been estimated that this energy could be of the order of 350 MeV if about half of the total cost was to be spent on stage 1. This would make it possible to serve the 350 MeV experimental area and to produce neutrons in the target. The neutron flux levels achievable in this way would be about 25% of those of the reference concept, but with the early use of depleted uranium it could be brought up to $\bar{\Phi}_{th} = 3 \cdot 10^{14}$ cm^{-2}s^{-1} and $\hat{\Phi} = 6 \cdot 10^{15}$ cm^{-2}s^{-1}. The pulse length would be 510 μs. Further accelerating structures could be added as funding becomes available, each time increasing the neutron flux in the target. With growing operating experience with the U-238 target, this might allow to achieve a time average thermal neutron flux of $1.4 \cdot 10^{15}$ cm^{-2}s^{-1} and a peak flux of $2.6 \cdot 10^{16}$ cm^{-2}s^{-1} when the 1.1 GeV beam is available and the target of depleted uranium is retained. As a last step the proton pulse compressor would be built to provide a time structure suitable for work with epithermal neutrons.

Another possibility for a staged realization would be to partly invert the sequence of construction and to build the target station and the ring first. The ring would than be laid out as a synchrotron initially, but its design would take into account its later conversion into a proton pulse compressor. Desirable specifications for such a synchrotron would be a proton energy of 1.1 GeV, a repetition rate of 50 Hz and a time average proton current of 0.5 mA with proton pulses of no more than 200 ns duration. This last requirement comes from the desire to provide a good time structure for neutrino research and certain applications of mesons right from the beginning. It would be tolerable if two or three such pulses would be extracted from the ring at 10 μs separation. For the thermal neutron pulse in the non-decoupled and unpoisonned moderator this would hardly affect the pulse width, which is of the order of 150 μs. On the other hand, for work with neutrons in the epithermal regime those subpulses should be joined together to give one pulse of less than 1 μs duration. A synchrotron of these ratings may be close to the limits of feasibility, but is still within reasonable extrapolation from existing concepts.

With a target of depleted uranium, a time average thermal neutron flux of $1.5 \cdot 10^{14}$ cm^{-2}s^{-1} and a peak flux of $1.6 \cdot 10^{16}$ cm^{-2}s^{-1} would be anticipated. The high peak-to-average flux ratio results from (a) the reduction in pulse frequency by a factor of two and (b) the shortening of the proton pulses which gives a factor of about 3 in thermal neutron peak flux. While this peak flux is higher than achieved in any neutron source so far, the time average flux of this first stage would still be on the same level as that of the most powerful research reactor presently operating in Germany (the FRJ-2, DIDO, in Jülich). It is a particularly attractive feature of this first stage that all the essential design characteristics of the final concept are already realized, although at only 10% of the intensity. Besides providing very good working conditions for those disciplines which need short proton pulses, it would allow to gain all the necessary experience e.g. in shielding requirements, target operation and instrument design at the correct energy and time structure. The linear accelerator needed for the injection into this synchrotron could be similar in design to the high current linac to be built in stage II. It would, however, operate at reduced load levels and thus allow to collect valuable experience. Also, its final energy would be likely to be of the order of 100-120 MeV and it would thus make an ideal test bed for the high energy accelerating structure of the linac which is yet to be examined under practical beam-load conditions. Based on the experience from the injector, the high power linac would be built in stage II. The goal should be to achieve a peak current of 200 mA, while retaining the 5 mA time average value. Due to the shorter proton pulses and with a target of depleted uranium, the flux levels in the moderators would then be $\bar{\Phi} = 1.4 \cdot 10^{15}$ cm^{-2}s^{-1} and $\hat{\Phi} = 5.2 \cdot 10^{16}$ cm^{-2}s^{-1}. In stage III the synchrotron would finally be converted into a proton pulse compressor with similar pulse characteristics as before but with 10-fold higher intensity (i.e. accommodating the full linac beam). Since the implementation of stage II and III in this concept would not interfere with the operation of stage I respectively II, transition from one stage to the other could be done with only minor shut down periods. Also, since the operation of the linac with H^--ions, which is required for the injection into the synchrotron may be quite difficult to achieve, it would be conceivable that the synchrotron and the linac could be working in alternating periods and thus ensure good time structure or high flux values as dictated by the experimental program.

Table 2 gives a comparison of the two stages of the target station DIANE according to this scheme (with synchrotron and with 200 mA linac) to other leading neutron sources in the world.

In February 1982 a decision was taken by the Federal Ministry of Research and Technology in Germany that, if a spallation neutron source was to be built, it would be located at KFA Jülich. KFA was asked to work out a detailed concept for a staged realization of the facility and to establish a project plan.

Following this decision, the spallation neutron source was made one of the prime research goals at KFA and the process of formal establishing the SNQ project was initiated. On June 9 the supervisory board of the laboratory gave its agreement to the foundation of the project. Fig. 2 gives a scheme of the planned organization.

Following the Ministry's request, KFA will carry out studies for both of the above staging concepts to a sufficient degree of detail that a decision, which one to pursue further, can be made. Such a decision is envisaged for early 1983. For the concept selected, a more detailed plan and cost estimate together with a general project plan will be worked out and submitted to the ministry to serve as a basis for the decision, whether or not the source should be built.

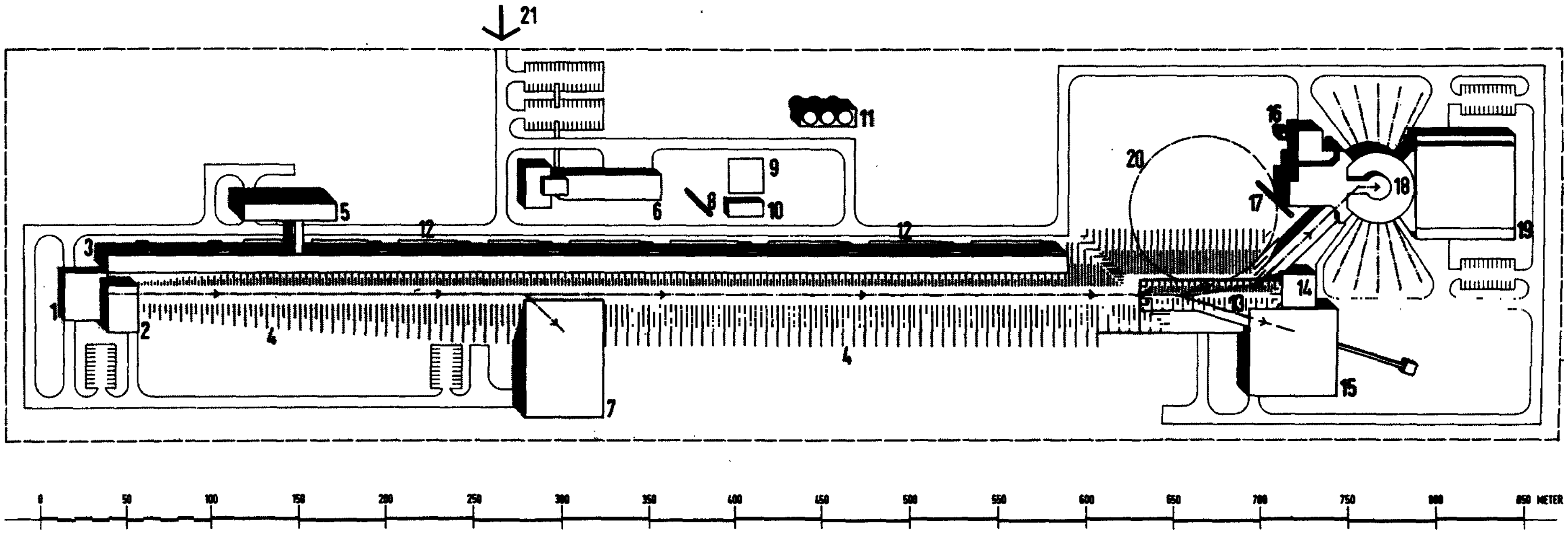
	HFR (ILL)	IBR II	DIANE*	DIANE I	DIANE II	SNS
Peak thermal flux $\hat{\Phi}$ ($cm^{-2}s^{-1}$)	10^{15}	$2 \cdot 10^{16}$	$1.3 \cdot 10^{16}$	$1.7 \cdot 10^{16}$	$5.2 \cdot 10^{16}$	$4.5 \cdot 10^{15}$
Average thermal flux $\bar{\Phi}$ ($cm^{-2}s^{-1}$)	10^{15}	$2 \cdot 10^{13}$	$7 \cdot 10^{14}$	$1.5 \cdot 10^{14}$	$1.4 \cdot 10^{15}$	$7 \cdot 10^{12}$
Pulse repetition rate ν (s^{-1})	-	5	100	50	100	50
Pulse width τ (μs)	-	150	510	150	270	30
Fuel or target	U-235 (HEU)	Pu	Pb	U-238	U-238	U-238
Mode of operation	critical	periodically super critical	non-critical	non-critical	non-critical	non-critical
Coolant	D_2O	Na	H_2O	H_2O	H_2O	D_2O
Average thermal power (MW)	57	4	2.9	1	10	0.25
Moving parts	-	Reflector (5u.25Hz)	Target (0.5Hz)	Target (0.25Hz)	Target (0.5 Hz)	-
Options and extensions	-	Electron Induction Linac Source-pulse 7μs	U-Target, Compressor-ring Source-pulse 0.7μs	multiplying target	Compressor-ring (?)	

* as studied in SNQ-report, $I_{max} = 100$ mA, $I_{av} = 5$ mA, Pb Target

DIANE I: $I_{av} = 0.5$ mA, U-238 Target

DIANE II: $I_{av} = 5$ mA, $I_{max} = 200$ mA, U-238 Target

Table 2: Comparison of modern neutron sources



1 Injector building
2 Assembly hall
3 RF-galery
4 Dirt shielding
5 Test and assembly building
6 Operations building
7 350 MeV experimental hall

8 Air stack
9 Switchyard
10 20 kV power distribution
11 Cooling towers
12 RF power supplies
13 High energy beam switchyard
14 Assembly hall

15 1100 MeV experimental area
16 Cooling towers
17 Airstack
18 Target building
19 Neutron guide hall
20 Proton pulse compressor
21 Site entrance

Fig. 1: Site Planning of the SNQ reference concept

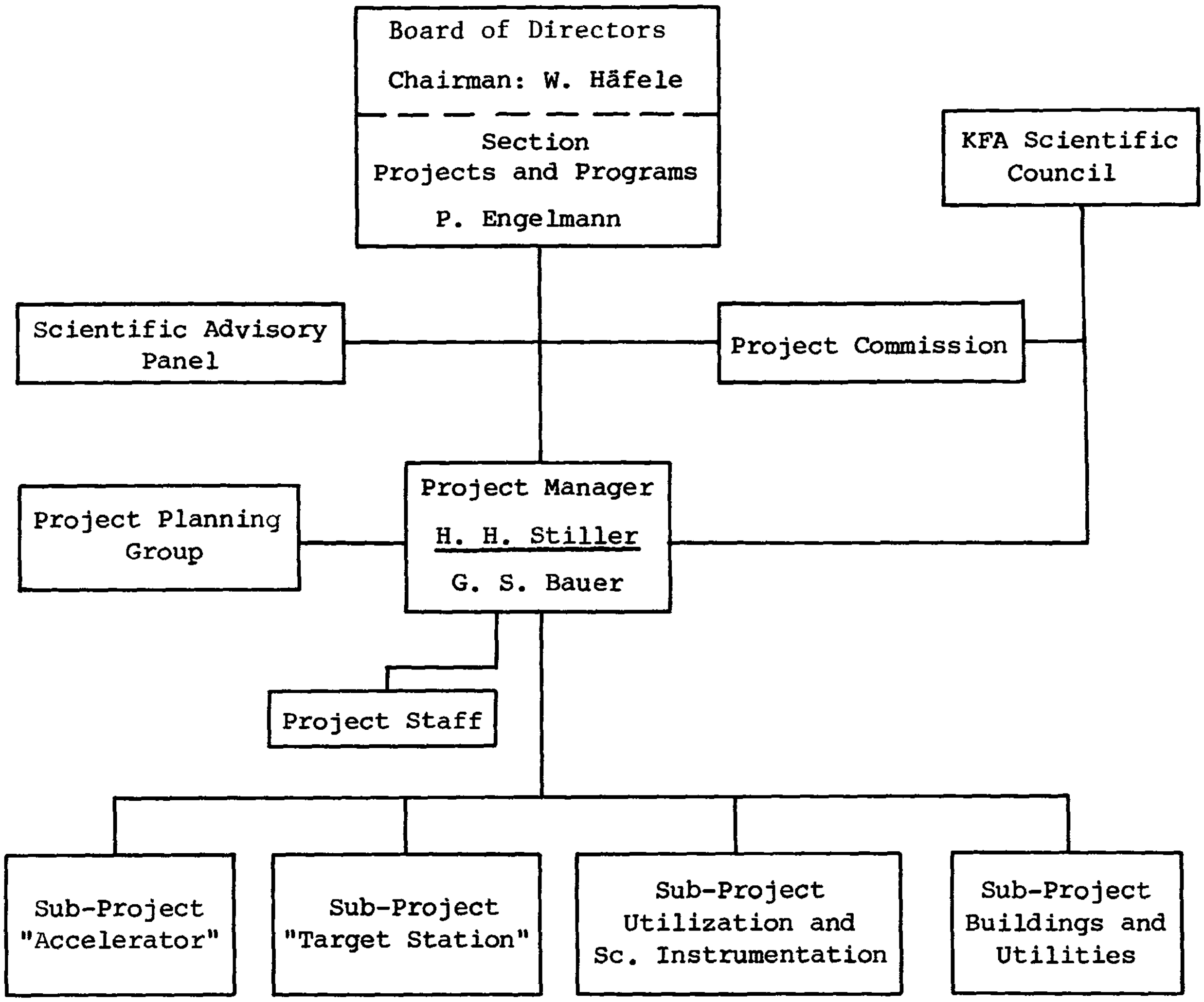


Fig. 2: Preliminary Organizational Diagram of the Project Spallations-Neutronenquelle at KFA Jülich

SNQ - G. Bauer

R. Silver	Q	What is the cost of stage 1 of SNQ?
G. Bauer	A	400 M DM.
W. E. Fischer	Q	What is the neutron flux produced by stage 1?
G. Bauer	A	At 350 MeV with a U target $\bar{\phi} = 3 \times 10^{14}$ and $\hat{\phi}$ is 20 times higher.
F. Mezei	Comment -	It is not correct that all instruments will use the mean flux. Spin echo would have velocity selectors using ~ 20% of the wavelength range so the relevant flux is the peak.
B. Brown	Q	What is the status of the radiation effects facility?
G. Bauer	A	There is nothing very special in mind. We are thinking of a low temperature facility which could be put into the reflector tank or target area when needed.