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**SINQ - A CONTINUOUS SPALLATION NEUTRON SOURCE
 (AN APPROACH TO 1 MWATT OF BEAM POWER)**

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ABSTRACT

In this status report we describe the continuous spallation neutron source at PSI, which will come into operation in fall 1996. We present the present state of the construction work and review the expected performance of the source.

1. The accelerator system

Fig. 1 shows the layout of the experimental facilities at PSI together with its accelerator system. Today it is used for particle/nuclear physics, medical applications and an ever increasing portion of physics of condensed matter and material science. The experimental program using the muon spin resonance technique, by now traditional at PSI, gained significance through its contributions to the investigation of high temperature superconductors and heavy fermion systems. The spallation neutron source which is in construction and should go into operation next year obviously amplifies this trend.

The PSI-accelerator system consists of two isochronous cyclotrons fed by a Cockcroft-Walton preaccelerator with a 860 keV proton beam. The time structure of the accelerated beam from the cyclotrons is determined by the frequency of the acceleration cavities which is 50 Mc. Hence the beam has a pulse microstructure of 20 ns (which is irrelevant for the production of thermal neutrons) and no "macro" time structure. Hence SINQ is a continuous spallation neutron source and has strong similarities with a beam tube research reactor.

Properties of the Proton Beam

extraction energy	590 MeV
energy spread (FWHM)	1.5 ‰
beam emittance	2π mm x mrad
beam current	1.5 mA
time between pulses	19.75 ns
bunch width	1 ns

Table 1:

Keywords: SINQ

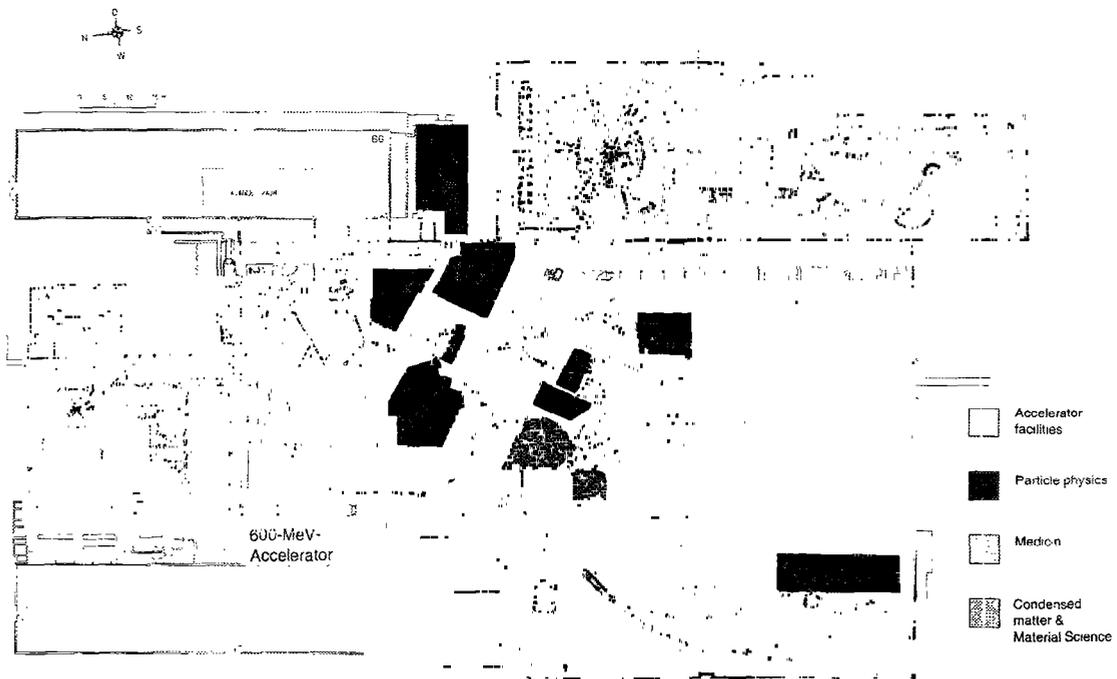


Figure 1: Layout of the experimental facilities of PSI at the accelerator system

2. On the target station

Since SINQ is a steady state neutron source, its concept should be optimized for the highest possible neutron flux that can be generated from the available beam power. Furthermore, with our emphasis on cold neutrons, we aimed at an optimal position for the cold moderator and at maximal possible space for the instruments. Together with a liquid metal spallation target as ultimate concept these are reasons for the choice of an arrangement of the target station with vertical beam injection from below (Fig. 2). The whole circumference of the target station is then accessible for neutron beam extraction. This concept also provides for a multiple containment of all potentially volatile radioactivity produced inside the target block. For this purpose a double-walled steel tank with contained atmospheres will surround the target and the moderator tank (Fig. 3).

The target block will surround a 2 m diameter heavy water tank in whose axis the target with essentially cylindrical geometry is positioned. Fig. 4 shows a cut through this inner region of the target block. The double walled moderator tank with two meter diameter and height is readily visible. This tank has in its axial center a central tube, containing (from below) the collimator for the injected proton beam, the target and a shielding and heat transport zone. A cooled beam tube plug (tangential to the target) and the horizontal part of the installation for the cold D₂-moderator are also shown. A perspective view of the moderator tank is shown in Fig. 5. The manufacture of this tank turned out to be a formidable task of casting and welding - all in aluminum (Fig. 6).

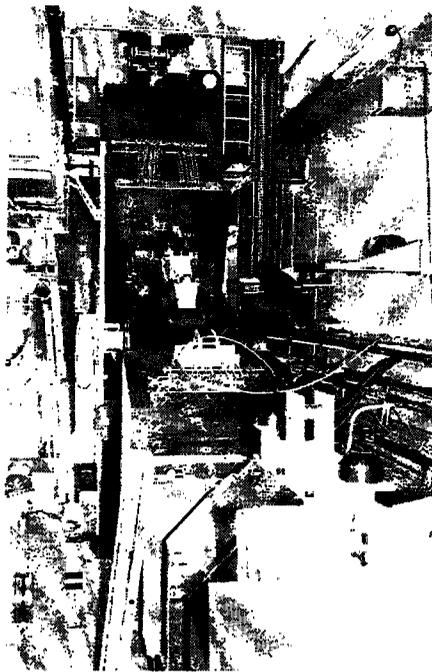


Figure 2: View of the proton beam line in the ditch below the floor of the neutron hall. The bending magnet for vertical injection is visible in the back.



Figure 3: Deposition of the double-walled containment tank in an early phase of construction at the target station. Two - already positioned - boxes for beam tubes are also visible.

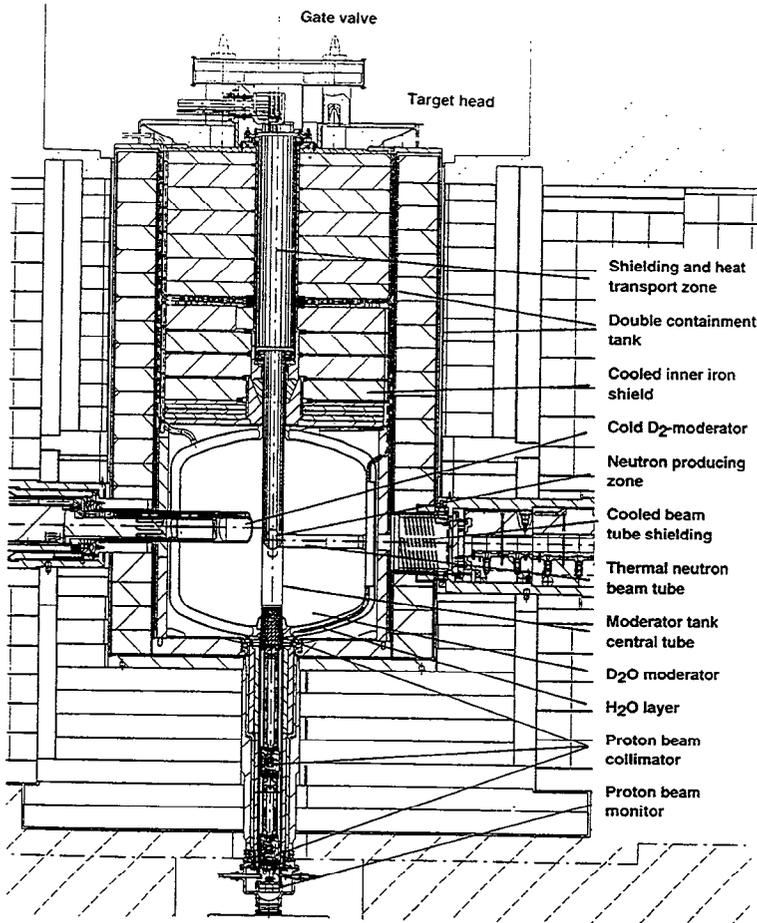


Figure 4: Cut through the inner region of the target block

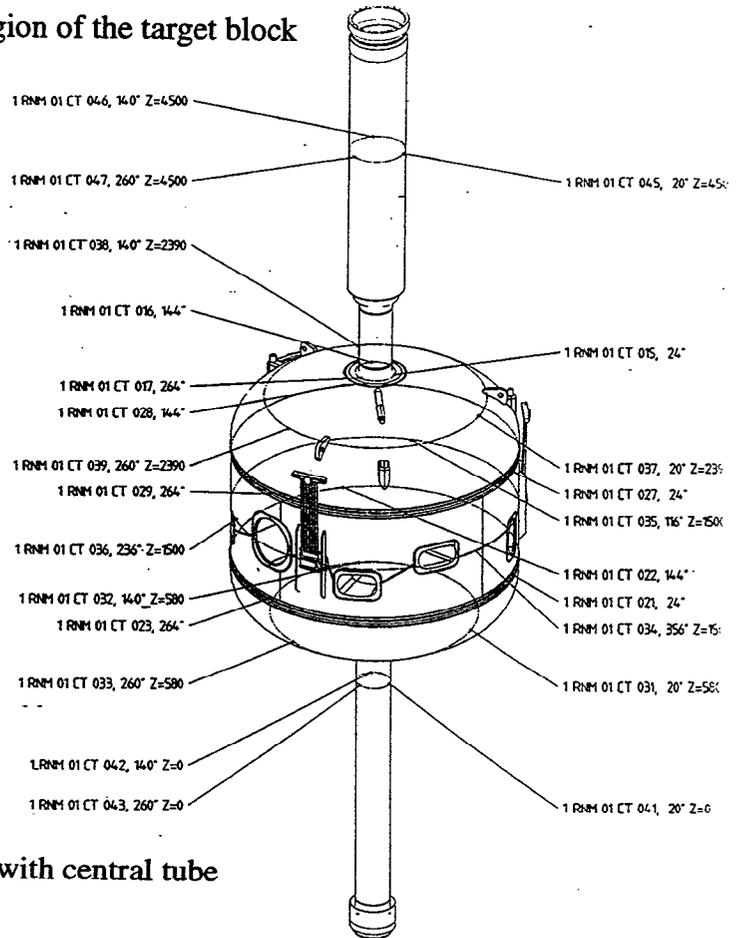


Figure 5: The D₂O-moderator tank with central tube

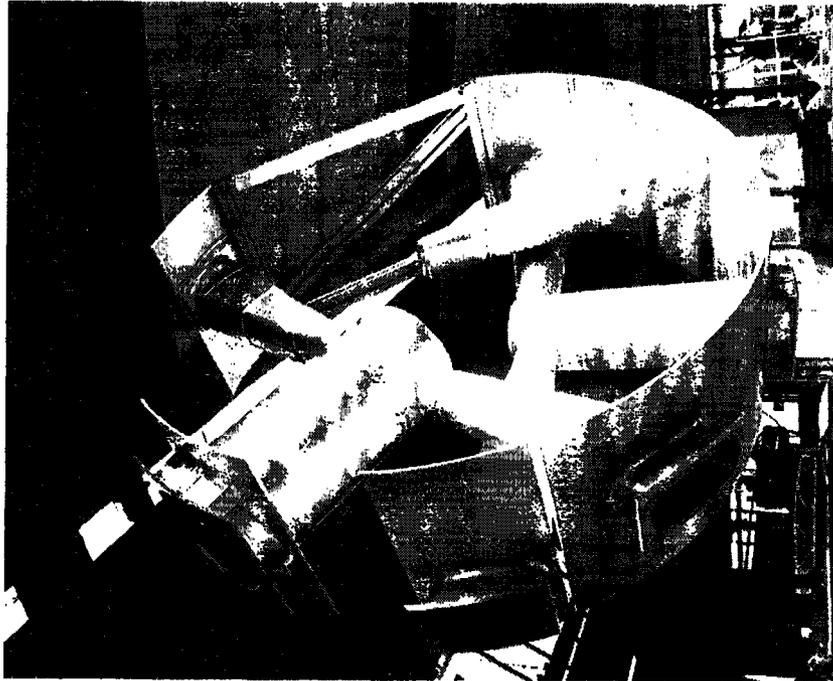


Figure 6: Welded beam tube inserts in the moderator tank. The T-frames for the cold D₂-source and for the scatterer (later second cold source) are already attached.

3. On the target

Safe and reliable operation of a target at the anticipated beam power of 1 MW is a prime concern. The proton current density will be $25 \mu\text{A}/\text{cm}^2$ under normal conditions. In view of the lack of experience world-wide with targets at this power density we shall start with a relatively simple design of a target made up of zircaloy rods, cooled by D₂O. The concept of this target is shown on the right side of Fig. 7. For safety a double walled aluminium container with water cooling will surround the target proper. We hope to proceed to a target with higher neutron yield within a year by replacing the zircaloy rods by lead filled zircaloy- (or aluminium-) tubes. These targets, while producing neutrons for the users of the source, serve as a demonstration of the integrity of the safety hull under real operational conditions.

The concept of the liquid metal target is shown on the left side of Fig. 7. The realization of this concept will remain a focus of the development work for SINQ. Apart from a favourable neutronic performance, this target is self shielding and heat is transported away from the reaction zone of the proton beam by convective motion of the target material. Hence the target cooling water is not intercepted by the proton beam, thus avoiding radiolysis - and part of the activation problems in the secondary circuit.

4. Cold source and neutron guides

The cold source has been built up on a test rig and is essentially ready for first operational tests. The stability of the stationary states and the behaviour of the thermo-syphon during transients have to be tested before moving and integrating the installation to the target station.

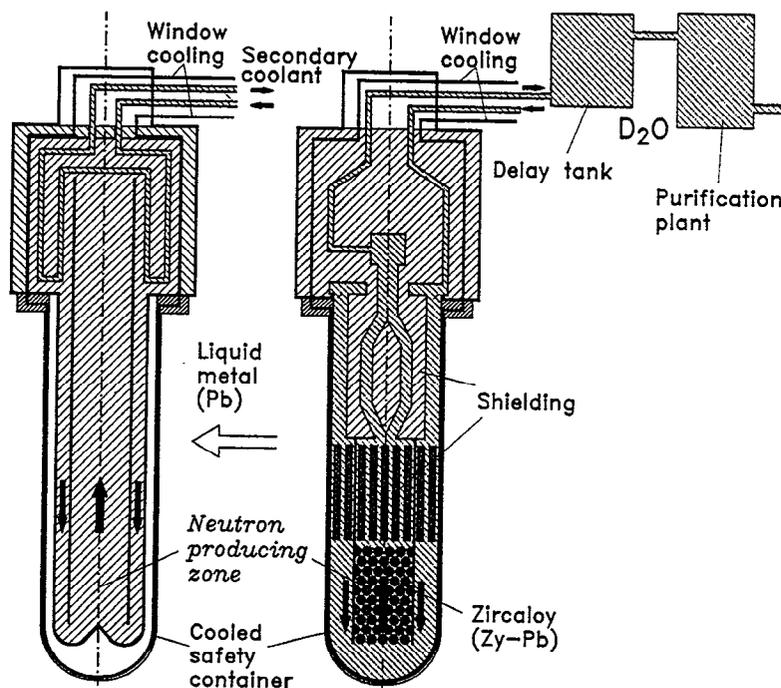


Figure 7: Concepts of the SINQ-target, right: rod target; D₂O-cooled, left: convectively cooled liquid metal target

The mounting of the neutron guide system is near completion. According to the emphasis we give to the production of cold neutrons at SINQ, most of the guides (depending on the kind of instrument attached to them) are of the supermirror type. A supermirror with $m=2$ times the critical angle of bulk Ni-coating consists typically of 40 bilayers of Ni and Ti. The thickness of the single layers varies continuously between 70 Å and 1000 Å. All the pieces have been tested on a test spectrometer at reactor "Saphir" at PSI and later on at "Orphée" in Saclay. A transmission profile for about nine reflections near $m=2$ is shown in Fig. 8. As can be seen in Fig. 9, by means of the transport properties of these guides, the neutron flux can be increased by more than a factor of three and the spectrum of the transmitted neutrons through curved guides can be extended to shorter wave length (e.g. below 2 Å).

5. Performance and Instrumentation

Fig. 9 shows the expected (calculated) performance of SINQ for a primary proton current of 1 mA on the spallation target. The spectral flux data is given at positions of the user, that is either at the monochromator for a thermal beam tube or at the exit of a 50 m long neutron guide. The benefit from use of supermirrors is clearly visible, if the data of "cold beam tube" (3.5 x 12) is compared with "cold guide $m=2$ ".

Table 2 lists the instruments which are under preparation at SINQ. Their location at beam ports or neutron guides can be seen in Fig. 10.

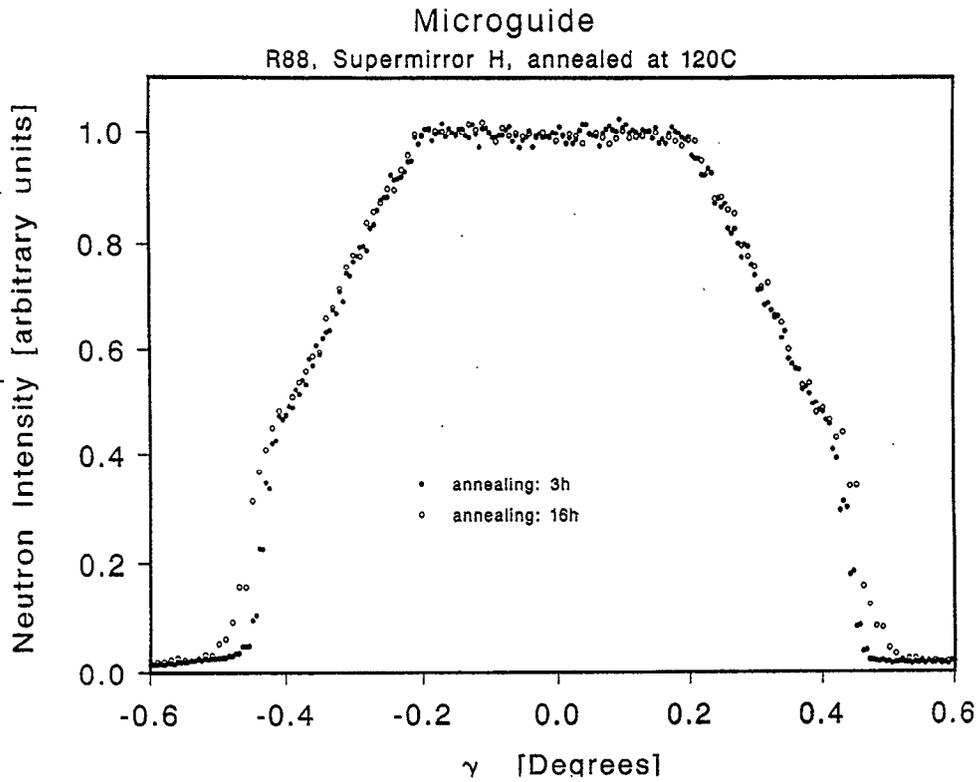


Figure 8: Transmission profile for about nine reflections at a supermirror plate of the neutron guide system.

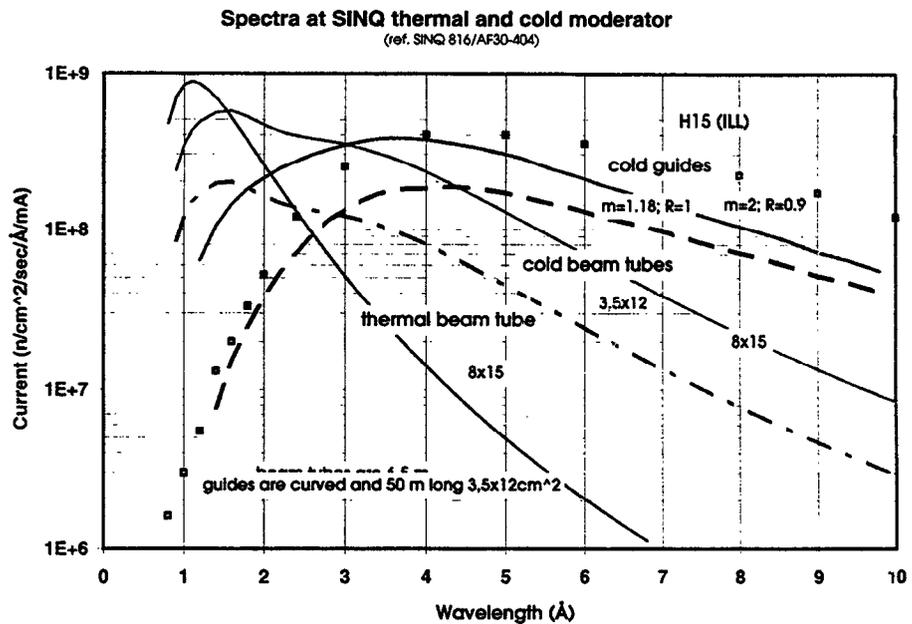


Figure 9: Spectral flux at various user positions for SINQ

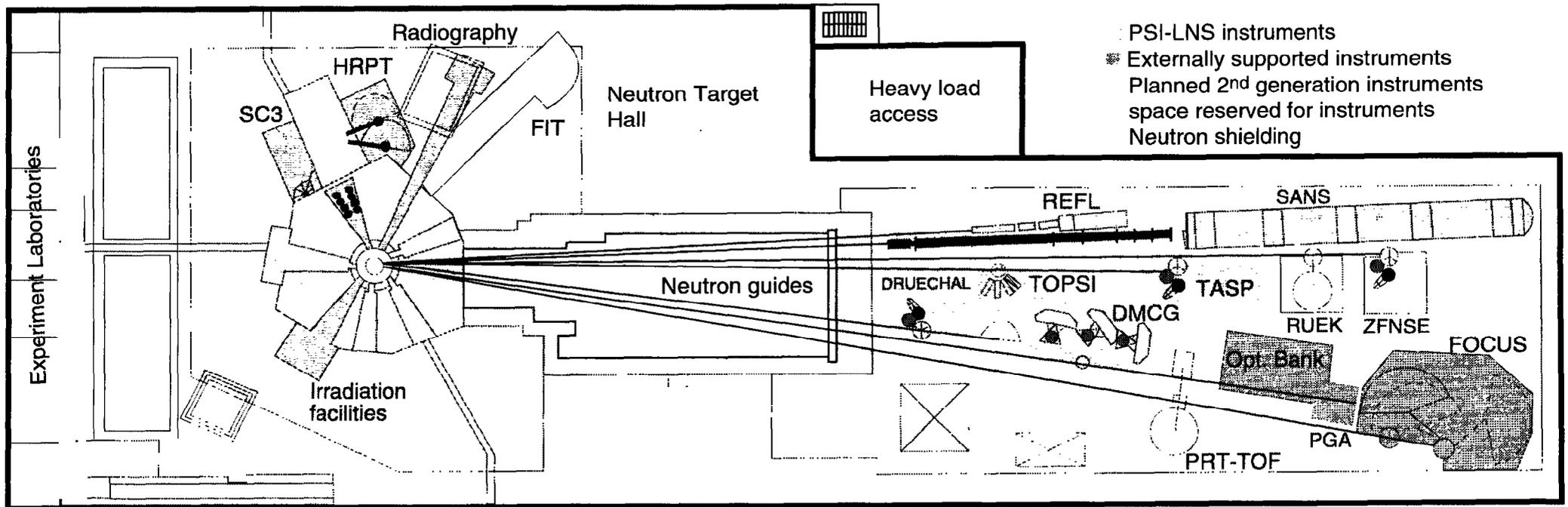


Figure 10: Layout of the instruments and spectrometers at the beam ports and neutron guides of SINQ

Instruments under preparation for SINQ

Gen. Design.		Avail. Suppl.
<u>New PSI-LNS-Instruments</u>		
{1} HRPT	High resolution diffractometer (thermal neutrons)	So 96 ETHZ/UGe
{1} SC3	4-circle diffractometer (thermal neutrons)	So 96 PSI
{1} Drüchald	Three axis spectrometer (cold neutrons)	So 96 ETHZ
{1} TASP	Three axis spectrometer (polarized cold neutrons)	So 96 PSI
{1} SANS	Small angle scattering camera, 40 m (cold n.)	So 96 PSI
{1} (REFL)	Neutron reflectometer (cold neutrons)	Wi 96 PSI
<u>Transfer from SAPHIR (LNS-Instr.)</u>		
{1} DMCG	Powder diffractometer (cold neutrons)	So 96 PSI/ETHZ
{1} TOPSI	Test spectrometer (cold neutrons), NSE-option	So 96 PSI/TUM
{1} NTR	Neutron radiography facility (thermal neutrons)	So 96 PSI
{2} T3AX	Triple axis spectrometer (thermal neutrons)	Wi 96 PSI/ETHZ
<u>Instruments with outside support {Country}</u>		
{1} FOCUS	Time of flight spectrometer (cold neutrons) {D}	Sp 97 BMFT/PSI
{2} ITOF	Inverted time of flight instr. (cold neutrons) {D}	Sp 97 PSI/ETHZ
{1} NOB	Neutron optical bench (cold neutrons) {A}	Wi 96 AI-Wien
{1} PGA	Prompt gamma activation analysis (cold n.) {CH}	Au 96 UfB/PSI
<u>New developments considered</u>		
{2} FTOF	Fourier diffractometer (for radioactive samples)	PSI/ETHZ
{2} PST-TOF	Phase space transformation time-of-flight	PSI
{2} LADI	Laue Diffractometer	PSI/?
{2} (DENS)	Instrument for diffuse-elastic scattering	PSI/?
{2} PTBS	Phase space transformation back scattering	PSI/?
<u>Non-beam facilities</u>		
{1} PNA	Isotope production stringer (2 thimbles)	So 96 PSI
{1} NAA	Neutron activation analysis (2 thimbles)	So 96 PSI
{1} GJA	Fission product gas jet	So 96 UBe/PSI

Table 2:



Instruments, Methods and Components

