EURISOL DS
PSI Task 2-4

F. Groeschel

Kick-off Meeting
CERN, 10.-11.3.2005

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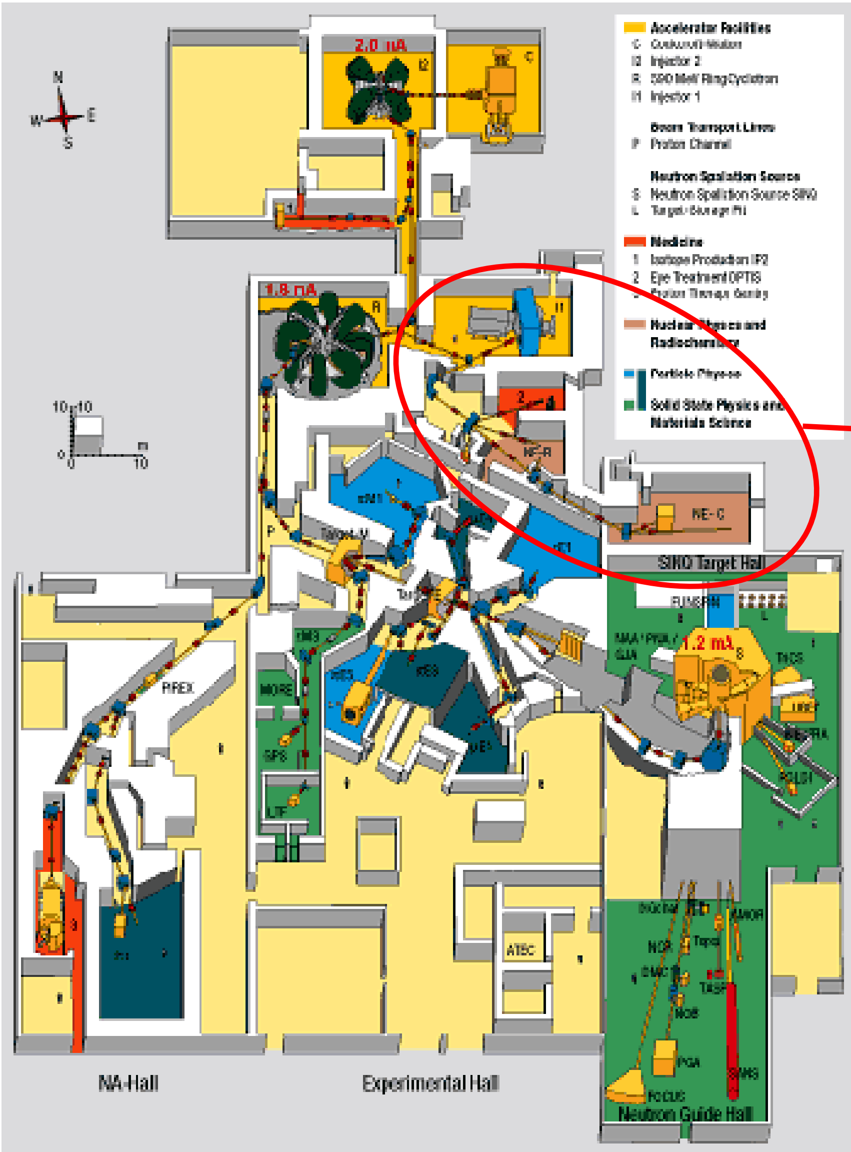
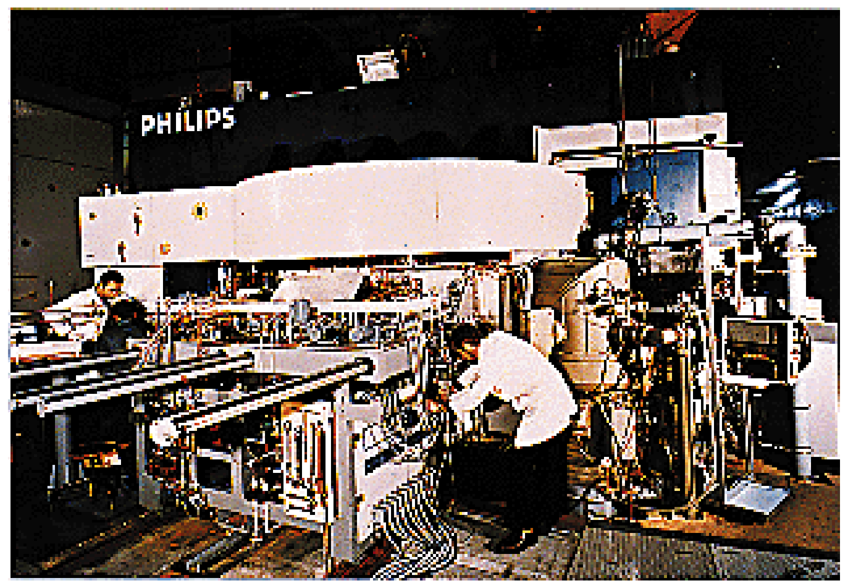
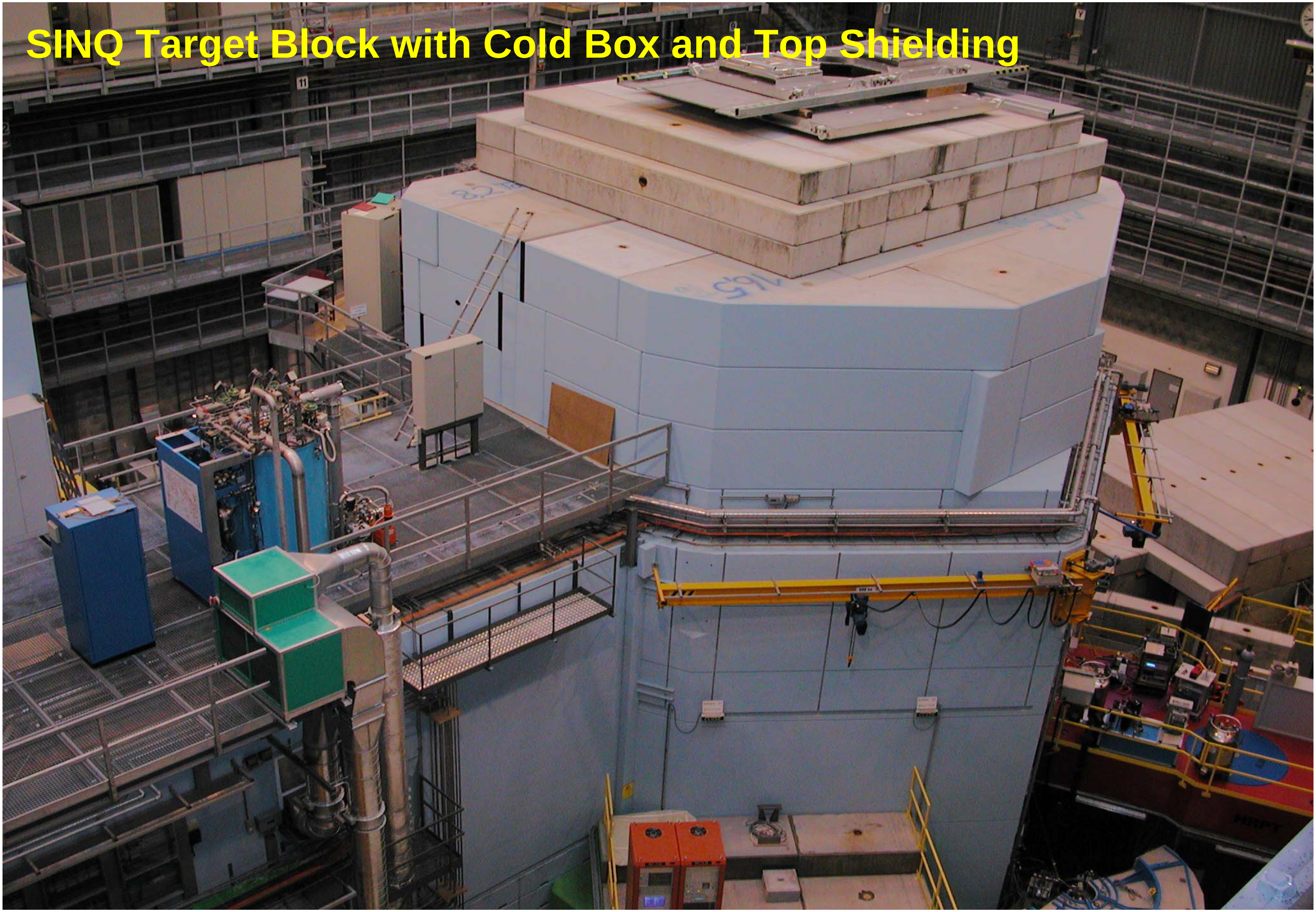
PSI Accelerator Facility



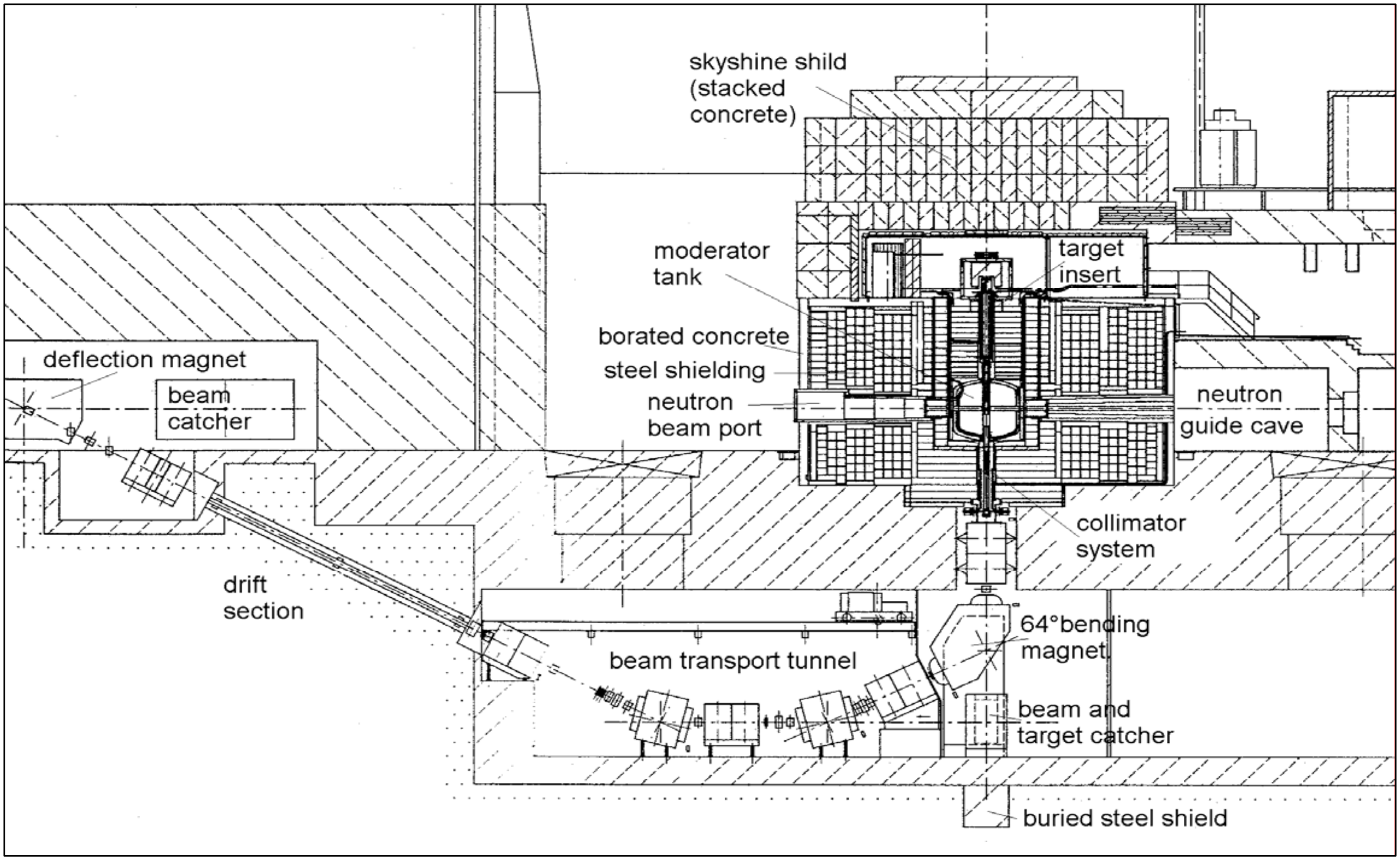
Injector 1



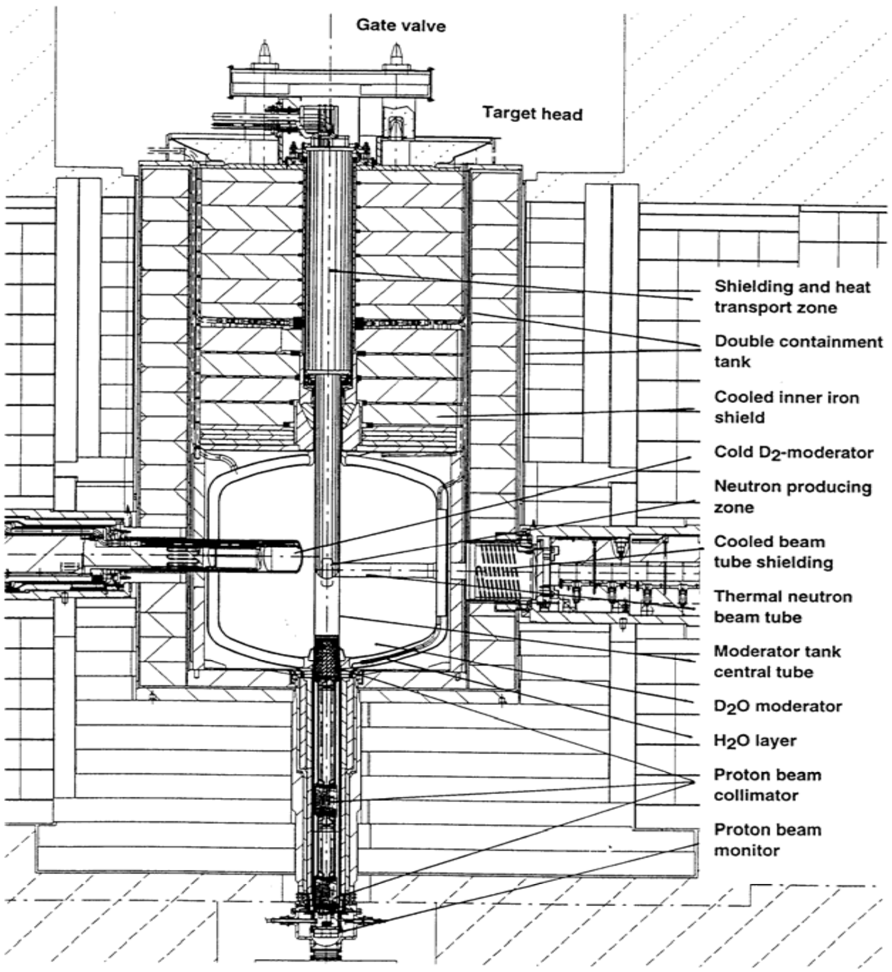
SINQ Target Block with Cold Box and Top Shielding



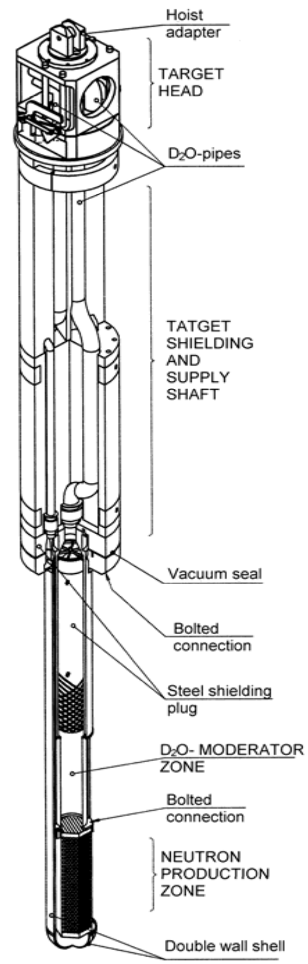
SINQ Spallation Neutron Source

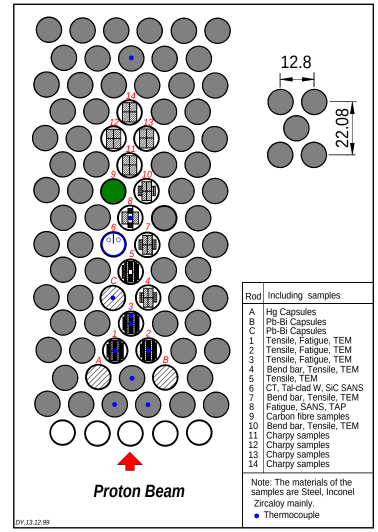


SINQ and Target

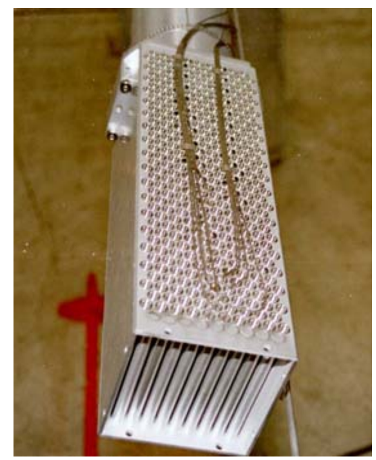


SINQ Target Block

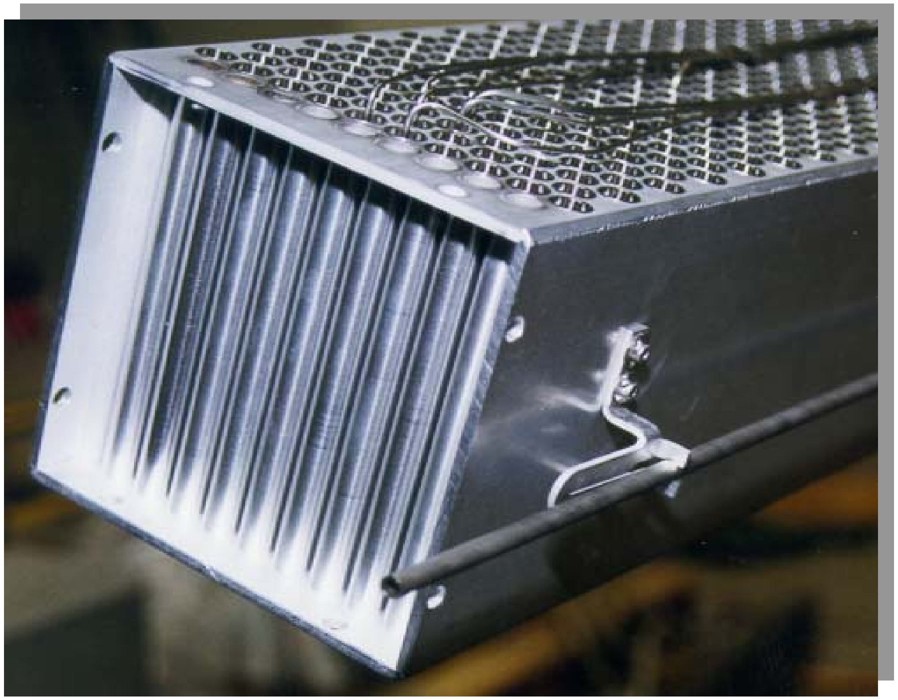




Rod	Including samples
A	Hg Capsules
B	Pb-Bi Capsules
C	Pb-Bi Capsules
1	Tensile, Fatigue, TEM
2	Tensile, Fatigue, TEM
3	Tensile, Fatigue, TEM
4	Bend bar, Tensile, TEM
5	Tensile, TEM
6	CT, Tal-clad W, SiC SANS
7	Bend bar, Tensile, TEM
8	Fatigue, SANS, TAP
9	Carbon fibre samples
10	Bend bar, Tensile, TEM
11	Charpy samples
12	Charpy samples
13	Charpy samples
14	Charpy samples



Solid Target

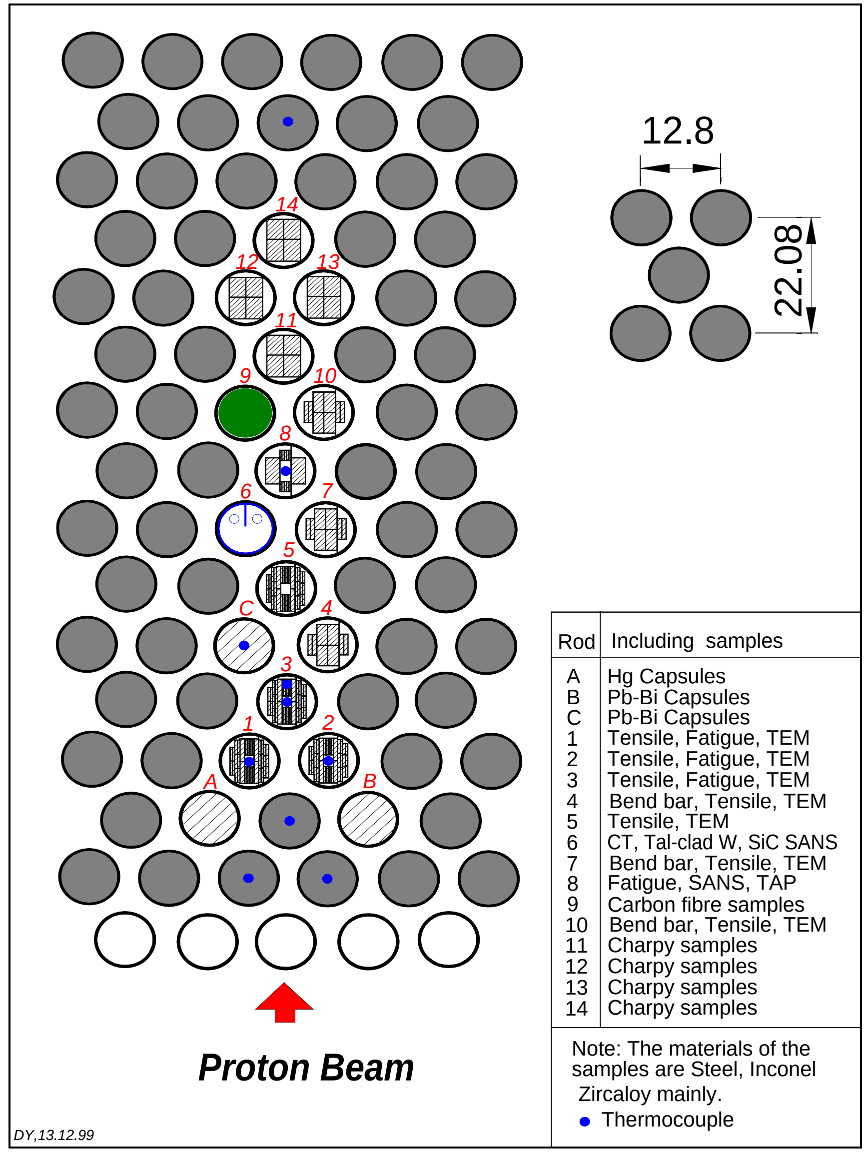


SINQ Target Irradiation Program

Spallation Targets

Fusion Materials

Generation IV reactors



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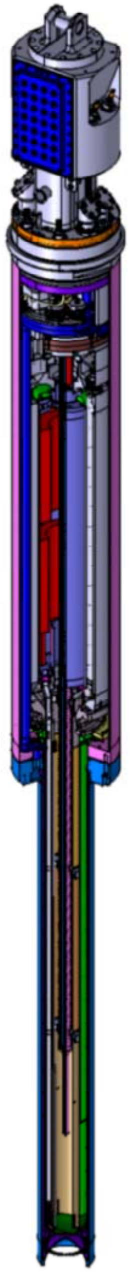
8	Fatigue, SANS, TAP
9	Carbon fibre samples
10	Bend bar, Tensile, TEM
11	Charpy samples
12	Charpy samples
13	Charpy samples
14	Charpy samples

Note: The materials of the samples are Steel, Inconel Zircaloy mainly.

● Thermocouple



MEGAPIE Target

Dimensions

Length:	5.35.m	Weight:	1.5 t
LBE volume:	82 l	Gas Volume:	2 l
Design pressure:	16 bar	Operating pressure:	0-3.2 bar
Design Temperature:	400ºC	Insulation Gas:	0.5 bar He

Materials

Lower Liquid Metal Container:	T91
Upper Container:	316L
Lower Target Enclosure:	AlMg3

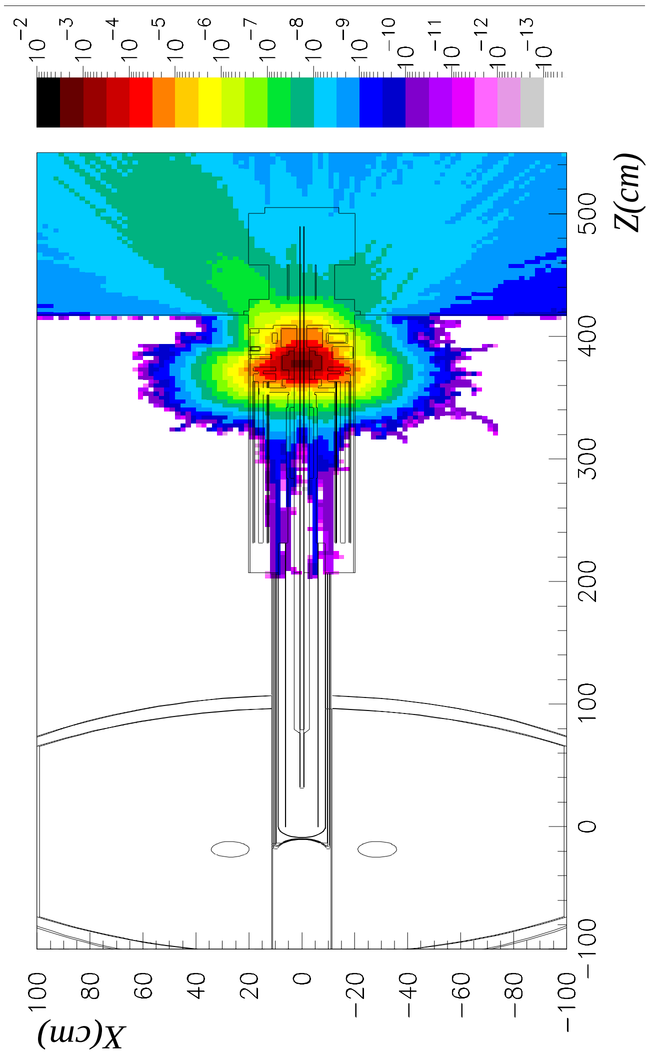
Heat Removal and Beam Window Cooling

Deposited Heat: 650 kW

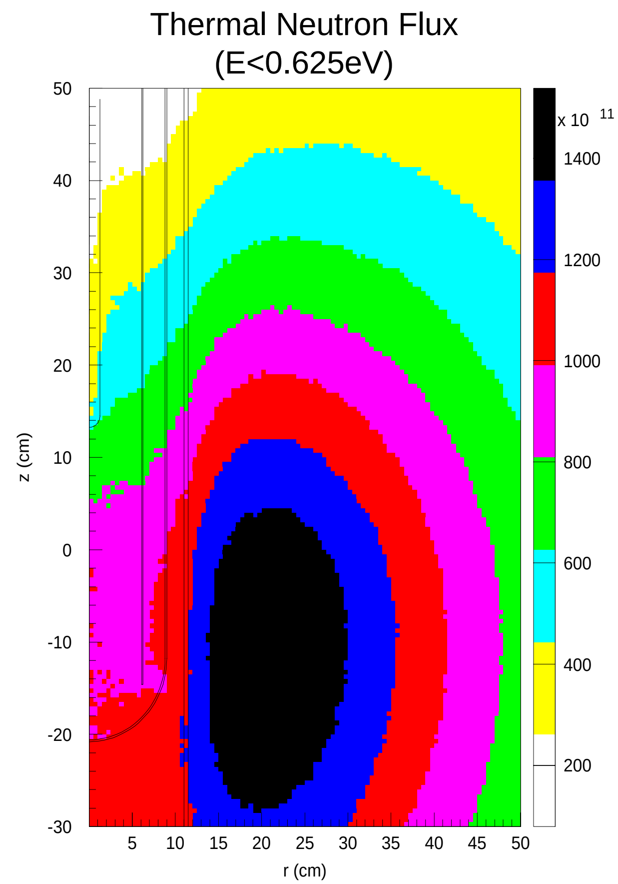
Forced convection assisted by buoyancy

Main pump:	EM in-line pump (4l/sec)
Bypass pump:	EM in-line pump (0.35l/sec)

Nuclear calculations

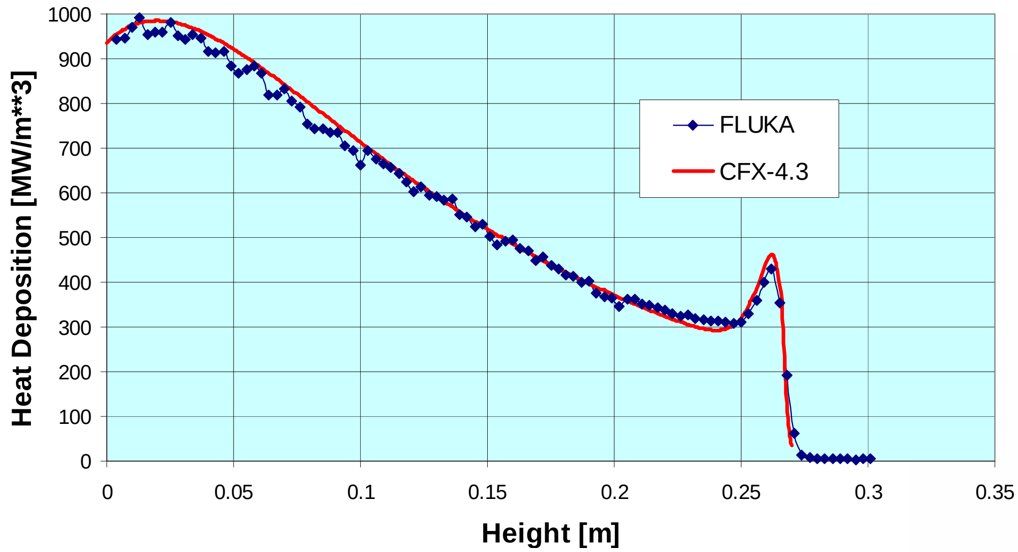


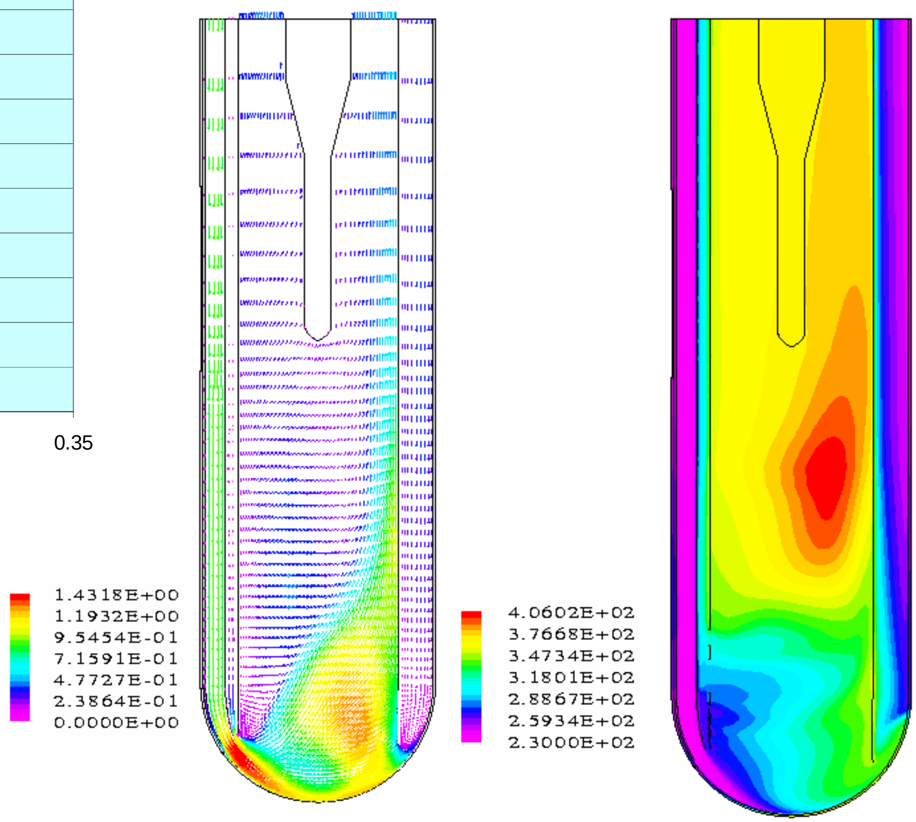
FLUKA



MCNPX

Fluid dynamics - CFD

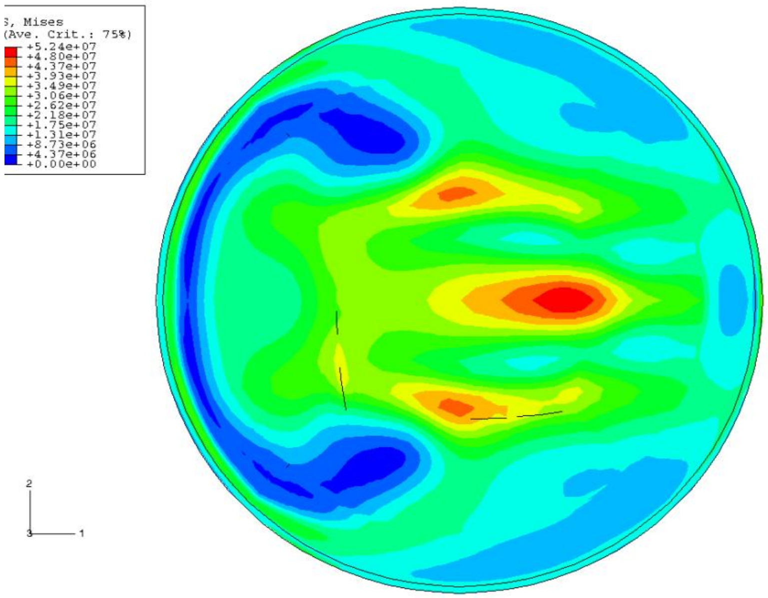




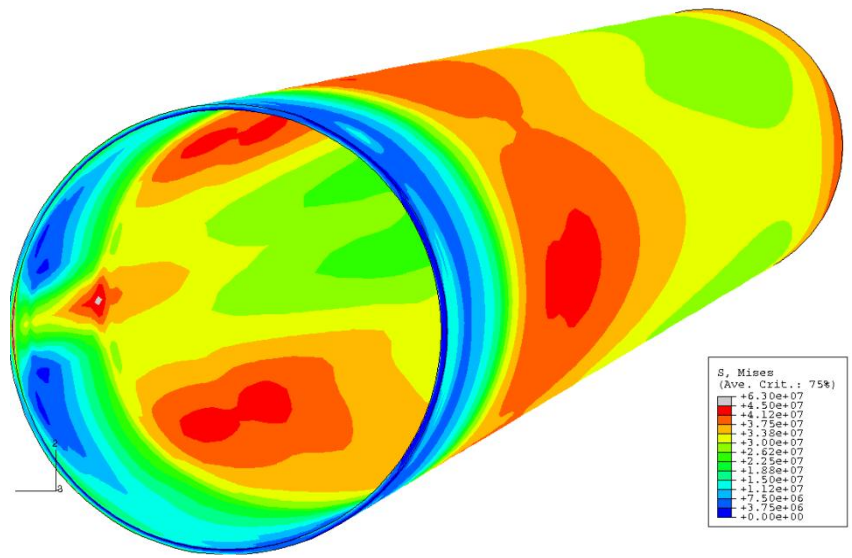
CFX4 – CFX5

with special free surface capabilities

Stress analysis



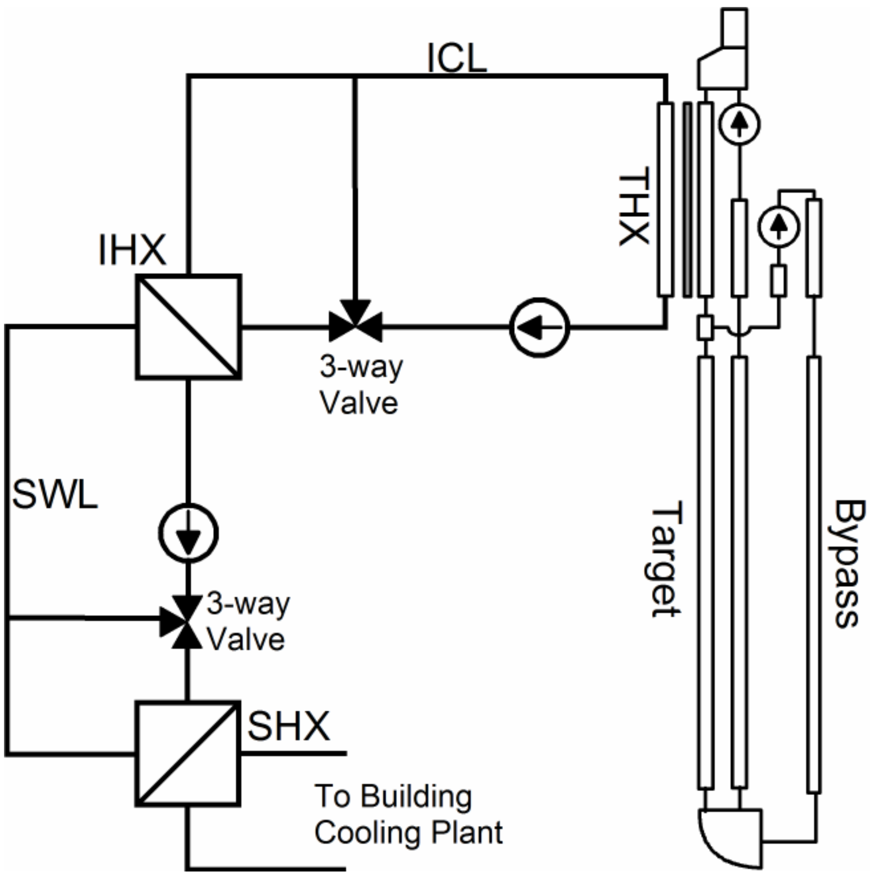
Beam window
Peak stress 55 MPa



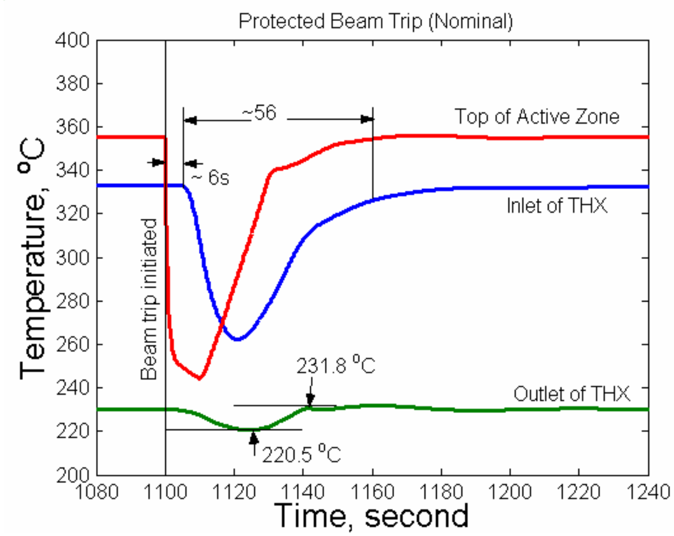
Guide tube
Peak stress 63 MPa

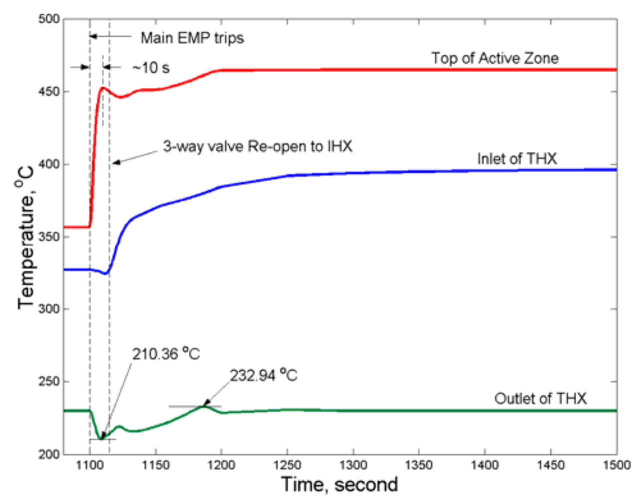
ANSYS FEM code

System Analysis

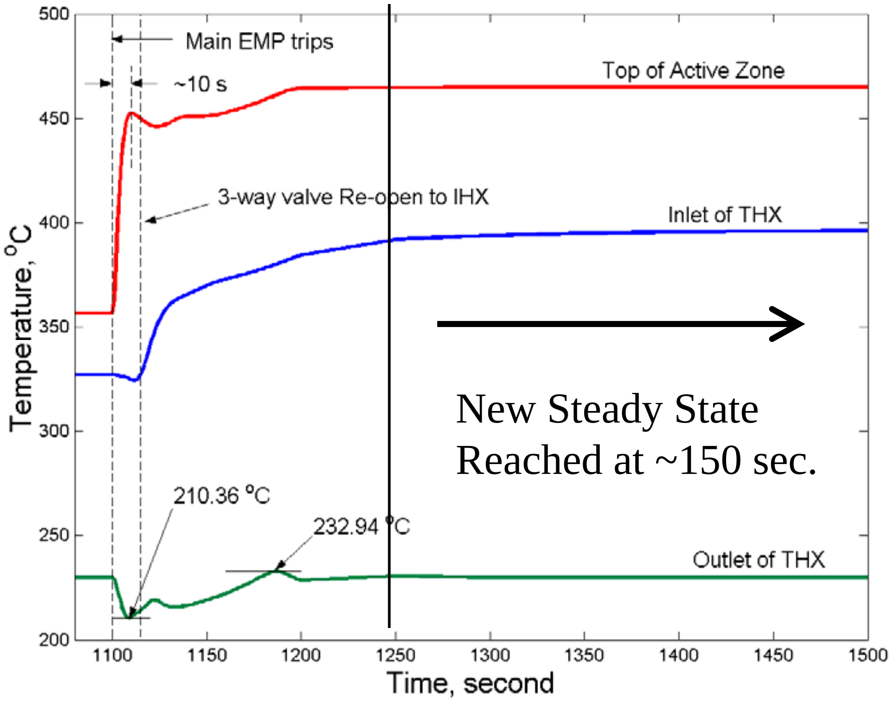


RELAP5 HLM





Simulation of Main-Pump Trip



Equilibrium Conditions after Transient:

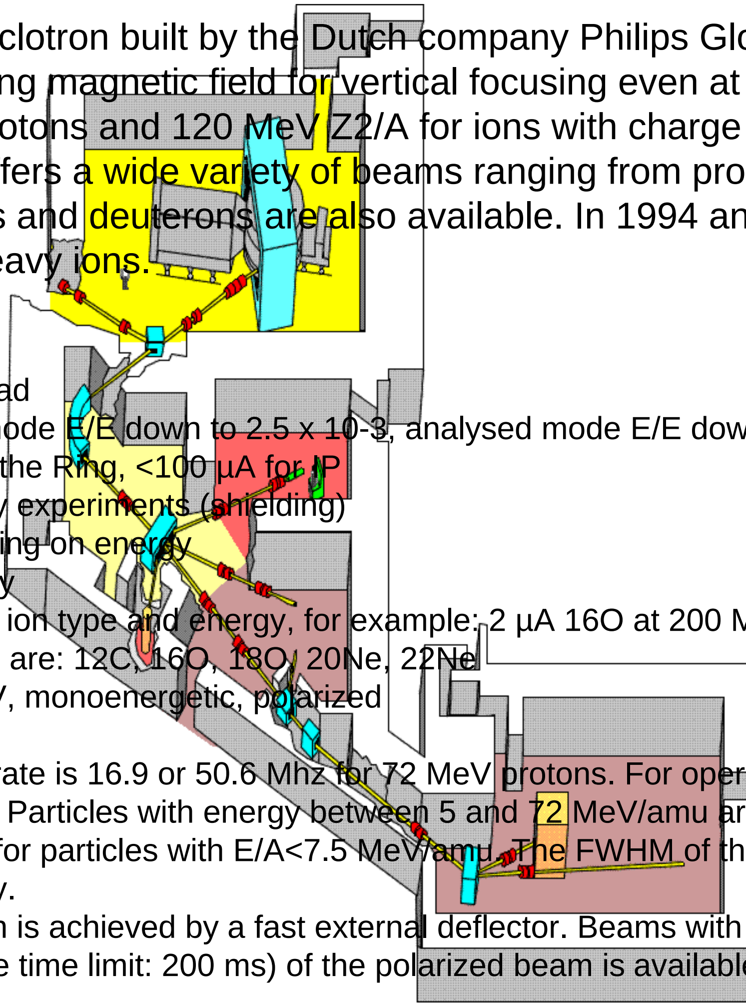
	THX		IHX		SHX	
	Hot	**Cold**	**Hot**	**Cold**	**Hot**	**Cold**
Coolant	**LBE**	**DTHT**	**DTHT**	**Water**	**Water**	**Water**
T_{Inlet}, °C	397.	161.	197.	49.5	67.5	30.0
T_{Outlet}, °C	230.	197.	113.	67.1	46.0	47.7

	Main Flow	Bypass EMP	Oil Pump	Water Pump
Coolant	**LBE**	**LBE**	**DTHT**	**Water**
Flow rate, kg/s	23.2	2.43	8.0	8.0

W. Leung, PSI

Injector 1

Injector 1 is a variable energy cyclotron built by the Dutch company Philips Gloeilampen-fabrieken. Its one-piece magnet has an azimuthally varying magnetic field for vertical focusing even at relativistic energies. The beam energy goes up to 72 MeV for protons and 120 MeV Z2/A for ions with charge Z and mass number A. Equipped with several ion sources, Injector 1 offers a wide variety of beams ranging from protons and deuterons to light and heavy ions. Polarized beams of protons and deuterons are also available. In 1994 an ECR ion source was installed to extend its ability to accelerate heavy ions.



Typical Beam Properties

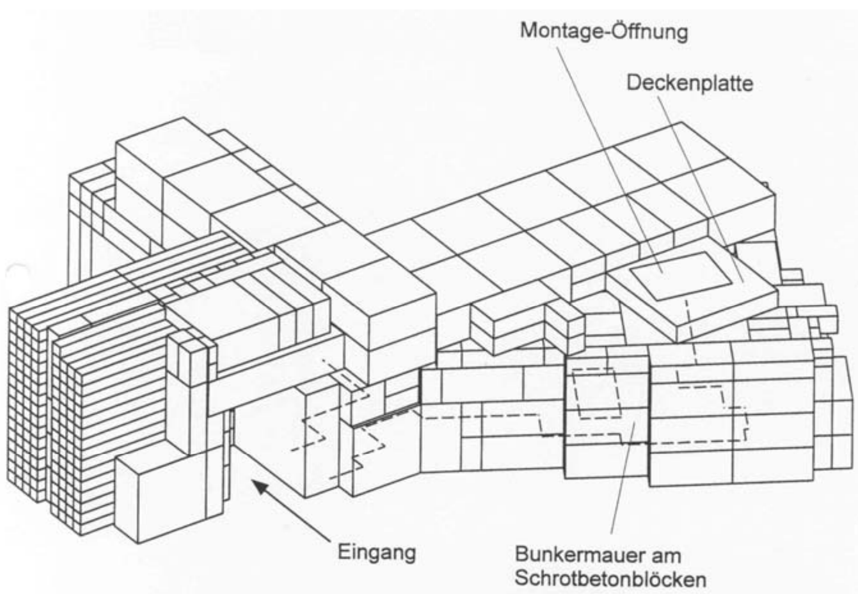
- Emittance: for all beams 30 mm mrad
- Energy resolution: dispersionless mode E/E down to 2.5 x 10-3, analysed mode E/E down to 2 x 10-4
- Intensities: p 150 µA as injector for the Ring, <100 µA for IP
  p, d limited to 10 µA for low energy experiments (shielding)
  Polarized p, d up to 13 µA depending on energy
  a up to 15 µA depending on energy
  Heavy Ions strongly depending on ion type and energy, for example: 2 µA 16O at 200 MeV; 10 nA 208Pb at 600 MeV (design values). Routinely produced species are: 12C, 16O, 18O, 20Ne, 22Ne
  n up to 5 x 105 s-1 cm-2, <70 MeV, monoenergetic, polarized

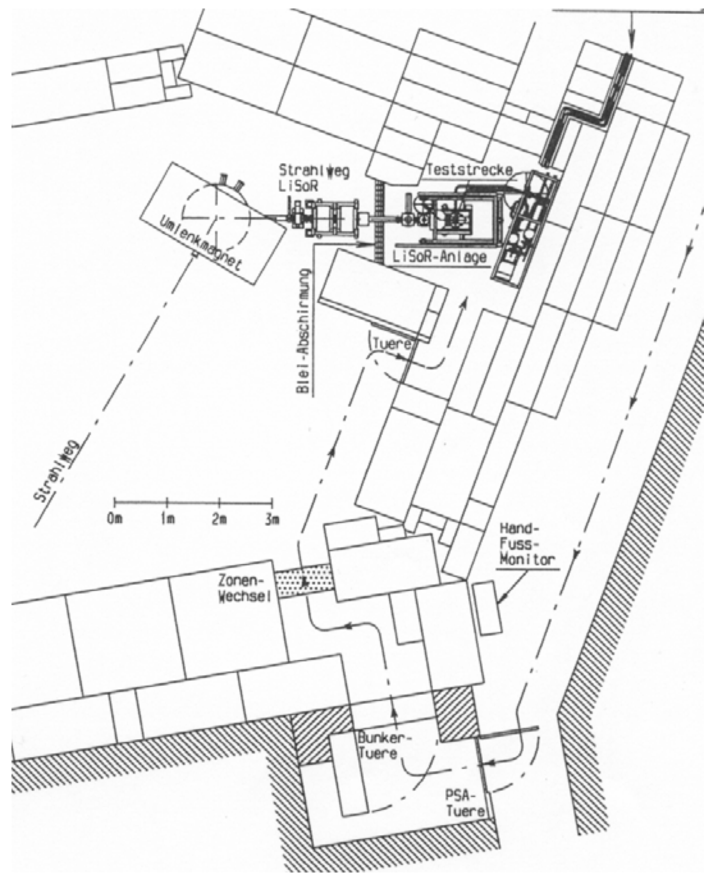
Special features

Time structure: The pulse repetition rate is 16.9 or 50.6 Mhz for 72 MeV protons. For operation at variable energy frequencies between 4.7 and 16.9 Mhz are used. Particles with energy between 5 and 72 MeV/amu are accelerated in the first harmonic mode. The third harmonic mode is suitable for particles with E/A<7.5 MeV/amu. The FWHM of the pulse is about 200 HF. It can be reduced down to 60 at the cost of the intensity.

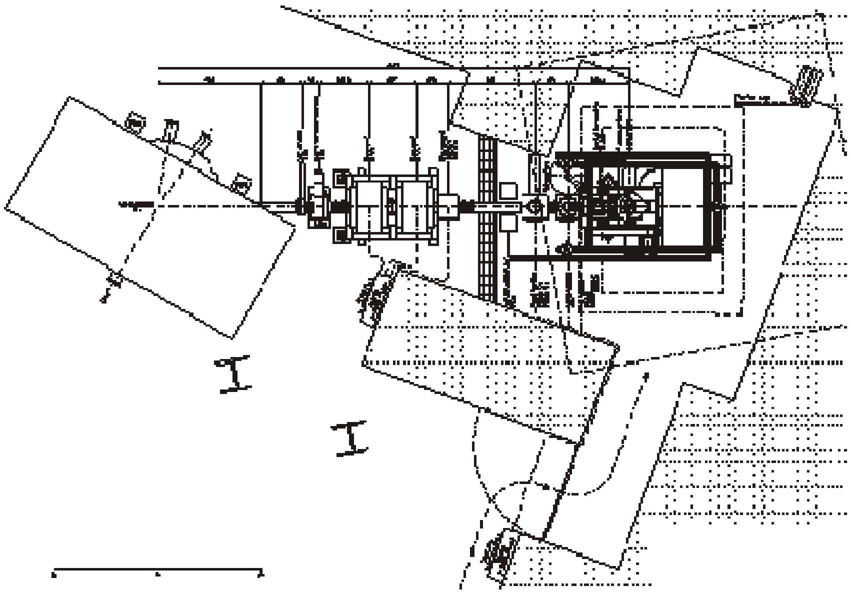
Pulsed beams: Single pulse selection is achieved by a fast external deflector. Beams with selection factors of 1/2 to 1/20 have been routinely produced. Slow pulsing (rise time limit: 200 ms) of the polarized beam is available also. Further schemes might become available on request.

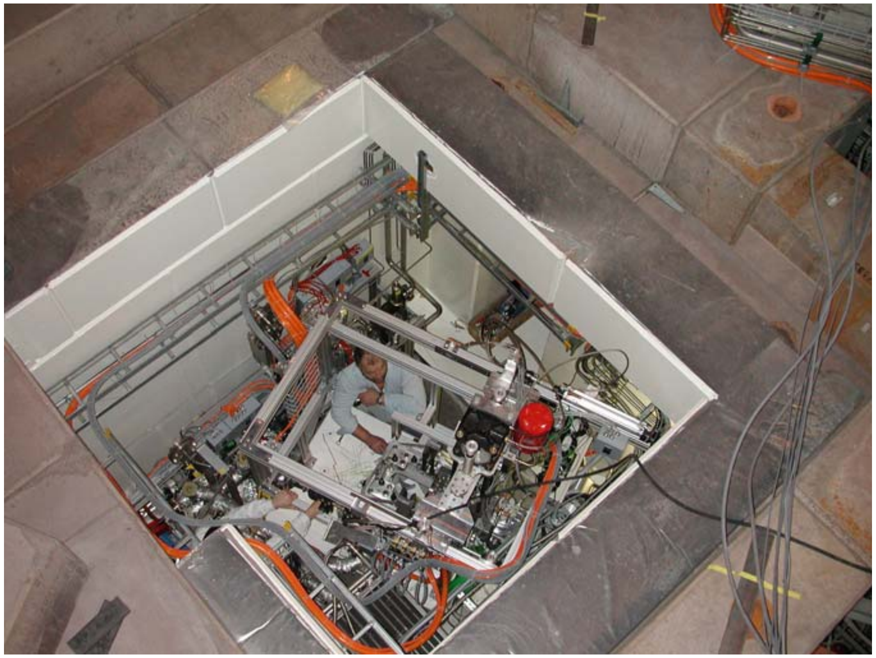
LISOR facility





LISOR facility





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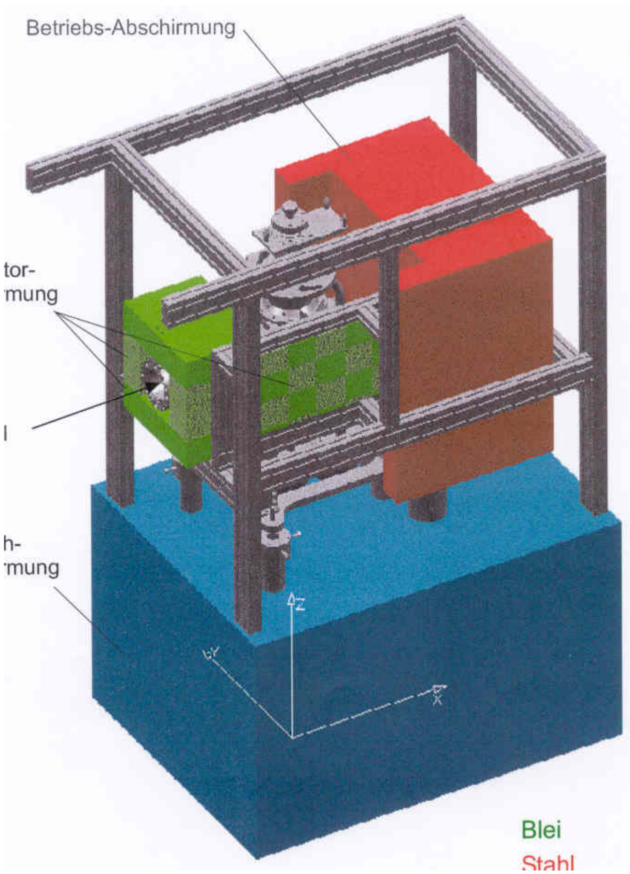

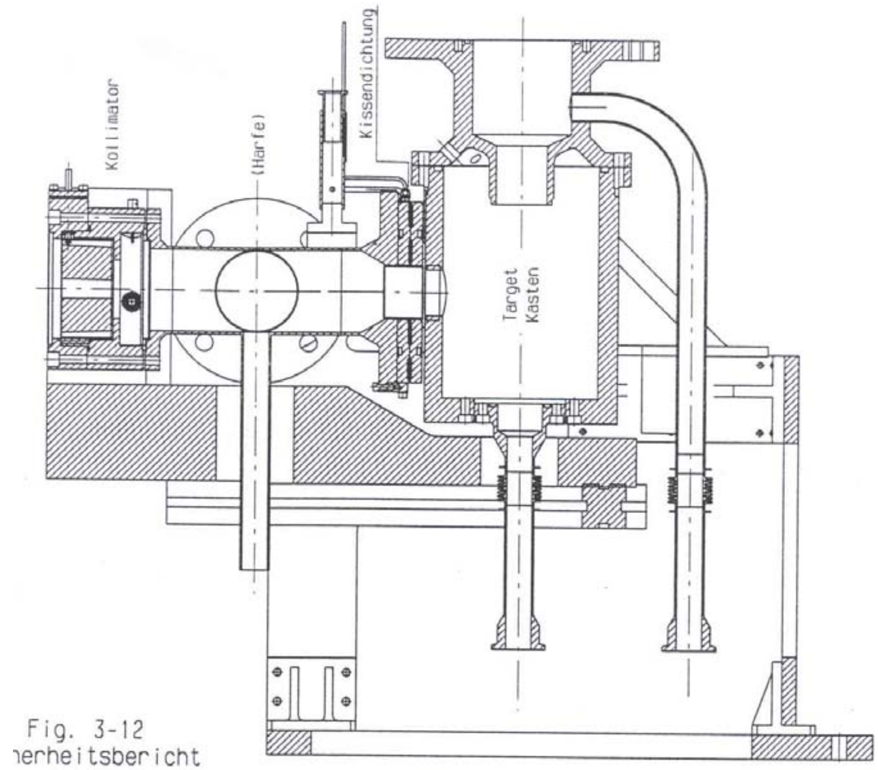

1st year planning

- CFD modelling of the reference design using CFX4 with special free surface capabilities developed at PSI. Results on flow field and temperature distribution in the mercury as well as the bounding structure.
- Parameter studies
- Integration of the design geometry and the CFD results into ANSYS. Modelling of the thermo-mechanical behaviour of the bounding structures for normal operating conditions. Optimisation of design.
- If resources and time available, first attempts of modelling of transients (if not → next period).

Work completed by 12/2005, report by 3/2006.

1st year planning

- Definition of reference design (window, windowless) and reference boundary conditions for the target
- Modelling of the target reference design and nuclear calculations using FLUKA or MCNPX. Main issues are energy deposition, n-flux distribution, spallation products production. The results serve as input for CFD and FEM analysis.
- Parameter studies

Capabilities and Experience

→ Nuclear calculations
→ CFD and FEM modelling
→ Target design and operation
→ Analysis of irradiated materials

LISOR experiment
MEGAPIE target design
SINQ operation

Planning 1st Year

• Nuclear calculation for the design given by CERN in view of energy deposition, activation and dose rates.

• Definition of the necessary modifications of the infrastructure to allow the irradiation in the LISOR facility

• Establishment of a safety, handling procedures and transfer to hotlab specifications for the experiments and start licensing activities.

Work completed by 12/2005, report by 3/2006.

Start of work 1.4.2005

Capabilities and Experience

→ Nuclear calculations
→ CFD and FEM modelling
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LISOR experiment
MEGAPIE target design
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