Sample Environment at the Swiss Spallation Neutron Source SINQ:

the Strength of Combination

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SINQ, the Swiss Spallation Neutron Source

- SINQ is a spallation neutron source at the Paul Scherrer Institute in Switzerland
- Built in 1990 as a replacement of the beam dump of an already existing proton accelerator
- SINQ has a continuous source instrumentation as on a reactor
- The flux is about 10^{14} n/cm^2/s, this is not a lot, compared to larger sources (1/15 of ILL)
- But:
  - A sophisticated guide system and instrumentation increases the flux at the sample substantially
  - Reliable sample environment and especially the combination of different devices makes SINQ competitive

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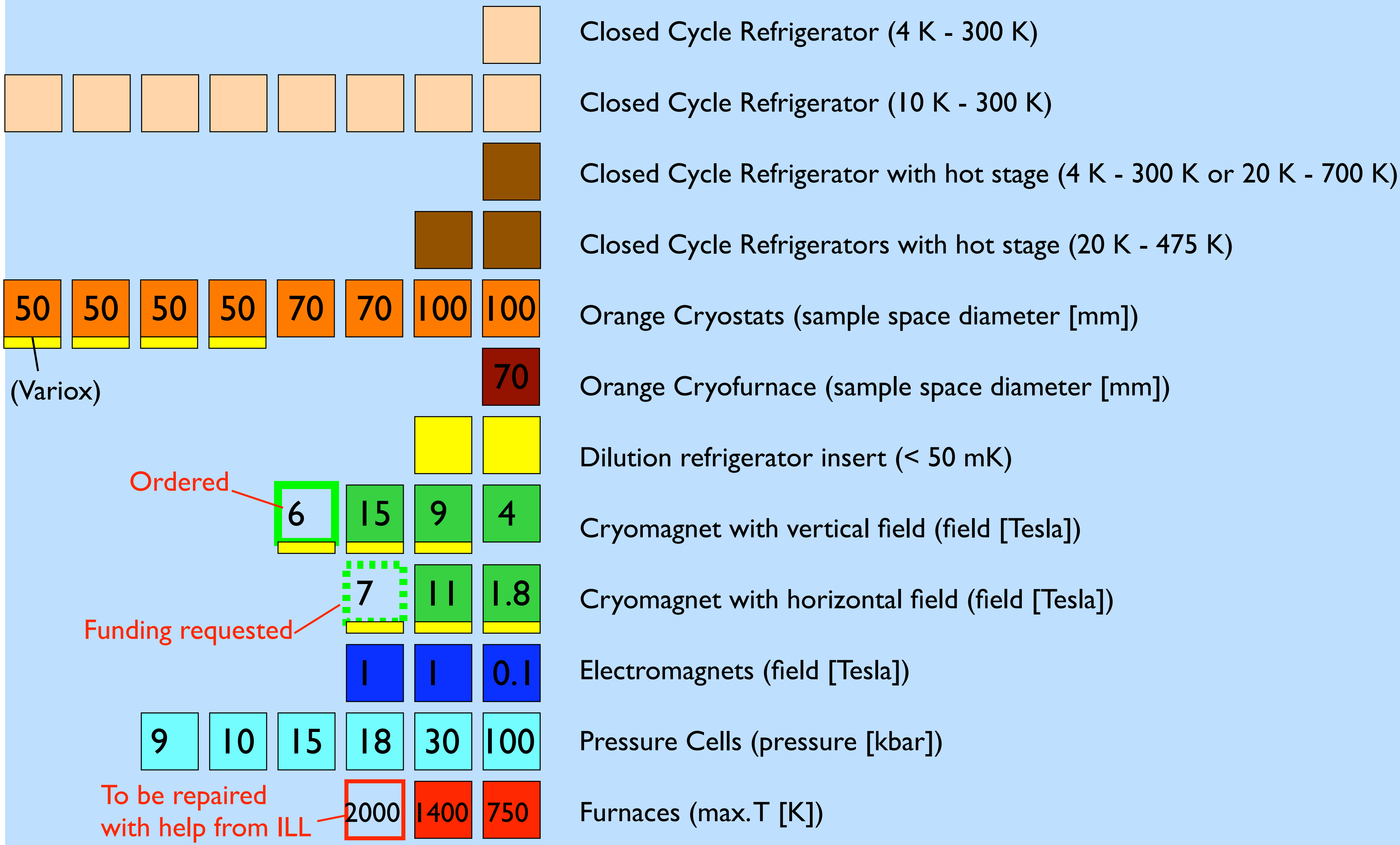
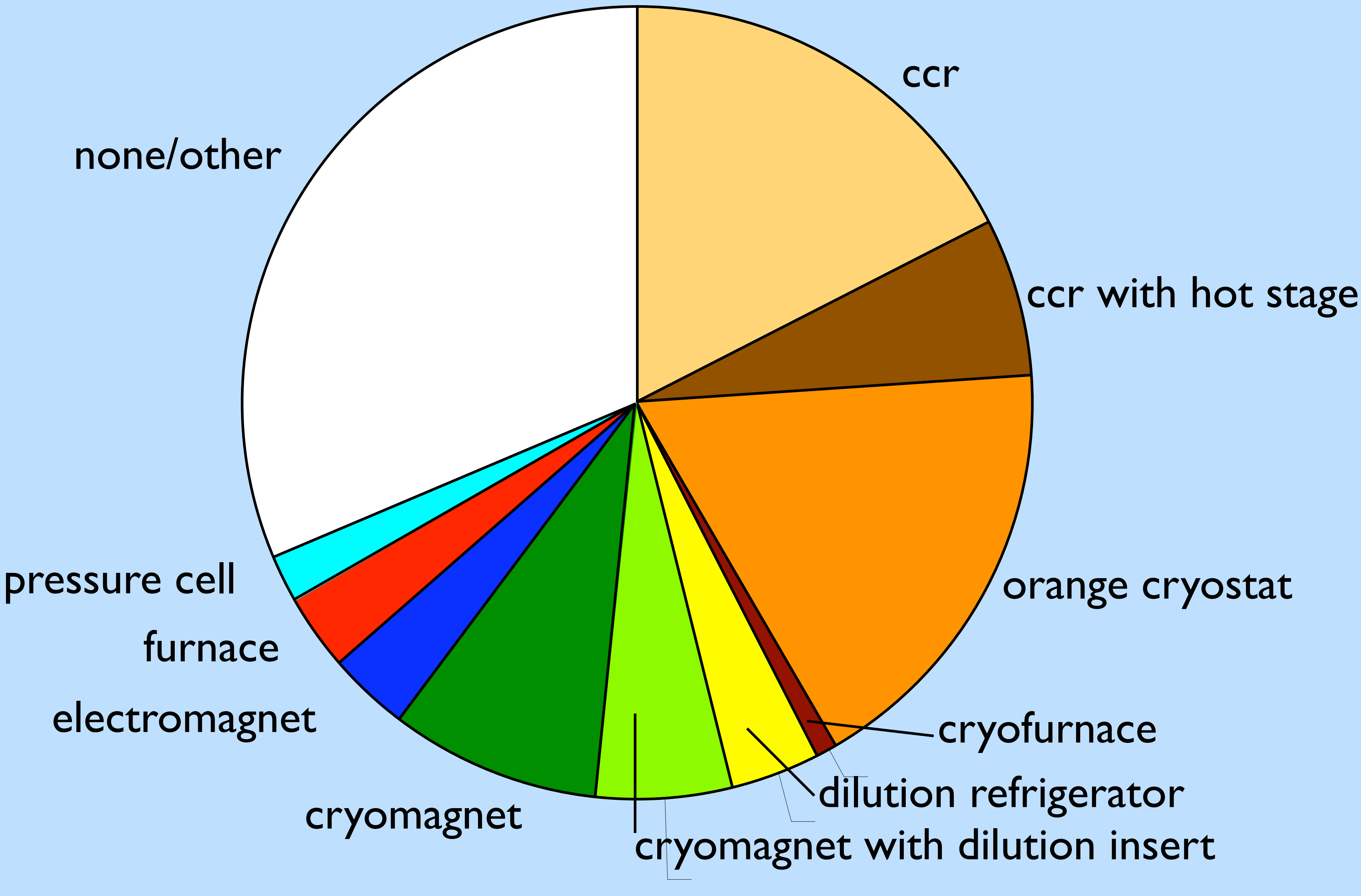
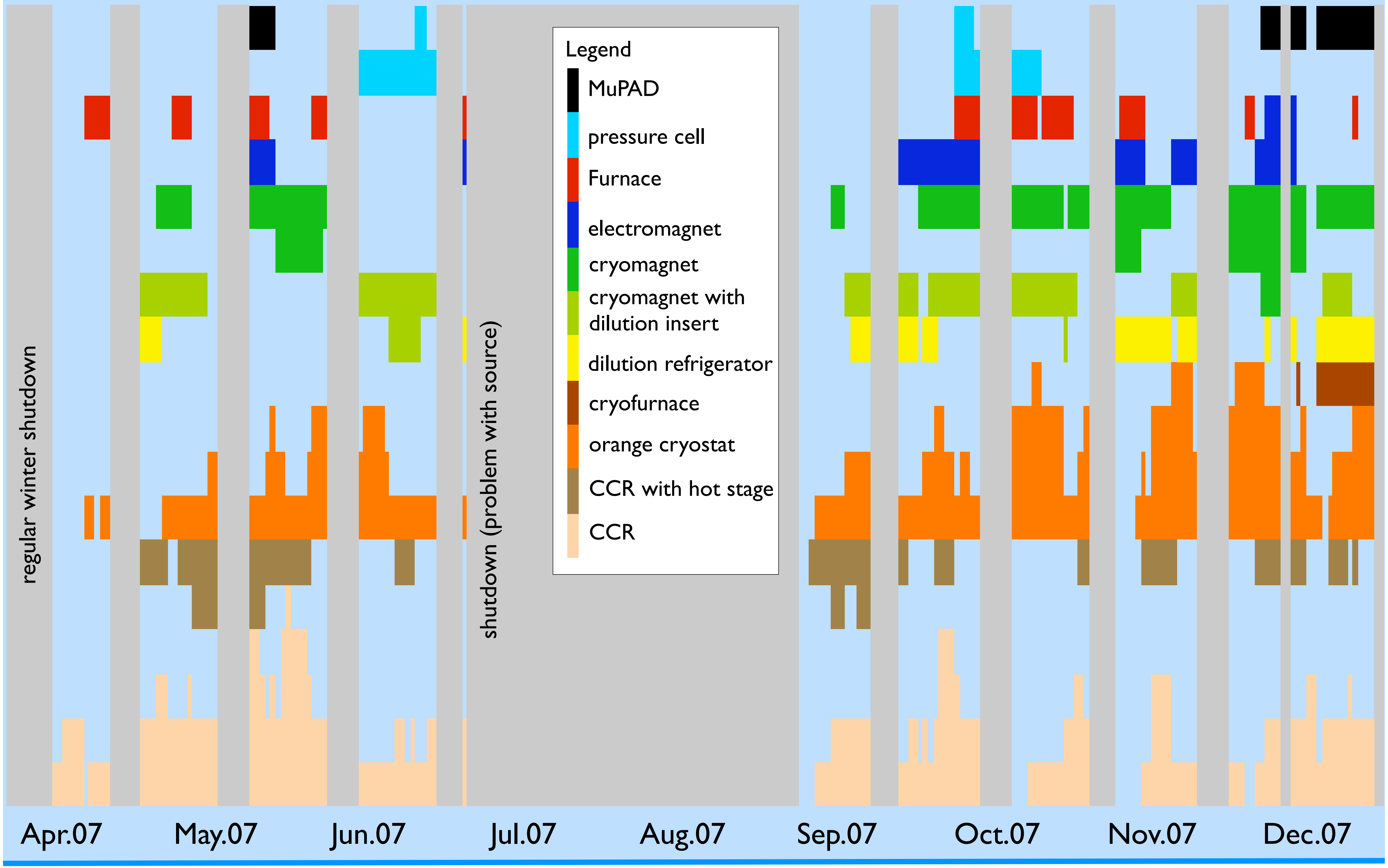
Sample Environment Equipment at SINQ



Sample Environment Usage in 2007



Sample Environment Usage in 2007



SE Combinations at SINQ

- Very low T (<50 mK) and high field
  - 14.9 Tesla vertical (as at HMI, ILL, FRM ...)
  - 11 Tesla horizontal → see talk of Michel Kenzelmann tomorrow
- High electric field and low/high T (20 K ... 475 K)
- Furnace with controlled atmosphere
- Dilution refrigerator in MuPAD
- High pressure (>50 kbar) at low T (20 K)

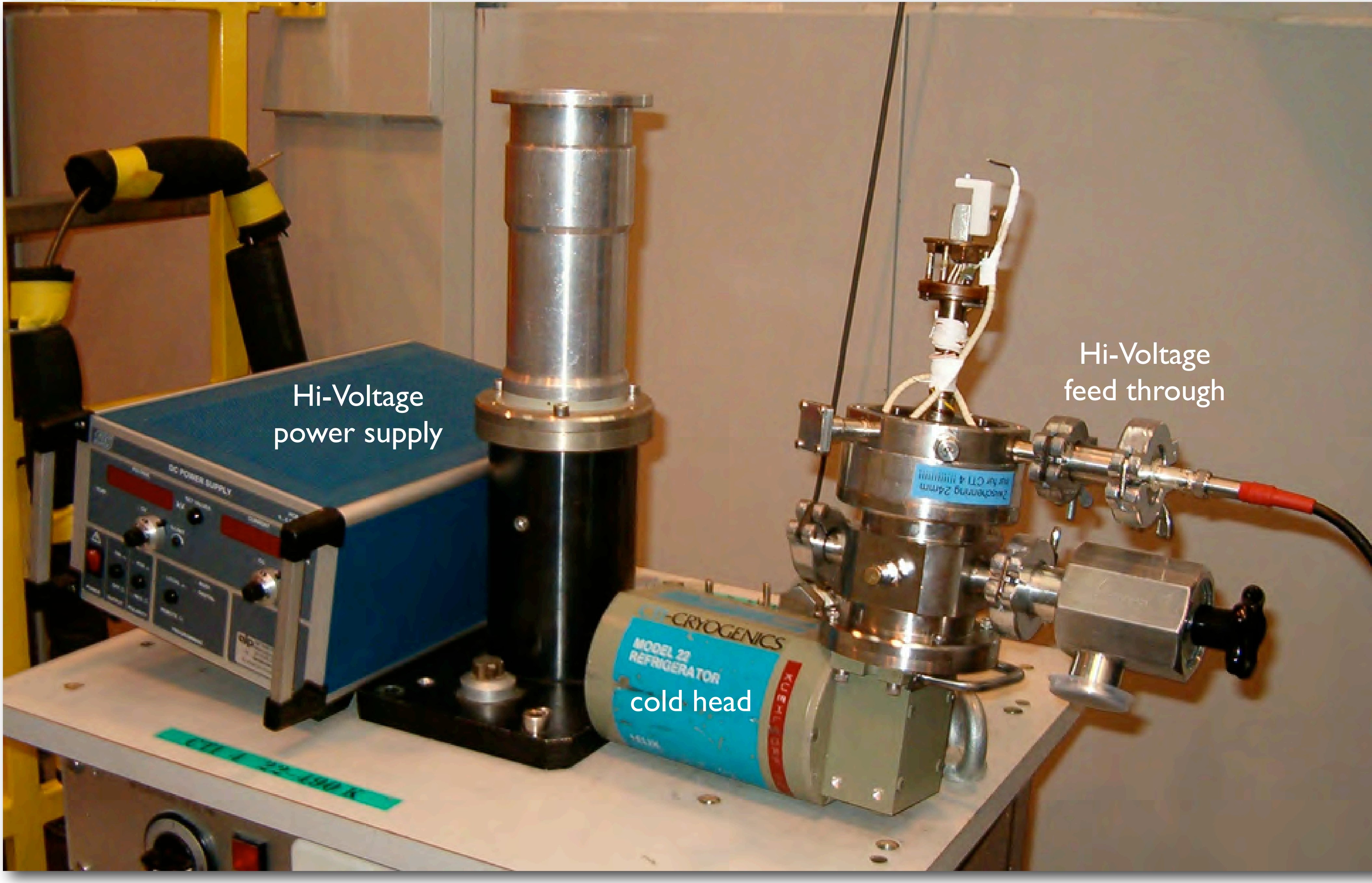
Hi Electric Field at Low and High T

Jochen Stahn, LNS, PSI Villigen

High Electric Field at Low/High Temperature

- High voltage feed through into CCR with hot stage
- 6 kV, < 2 μA
- An other setting with much lower electrical field was even combined with a magnetic field (1 Tesla, electromagnet)

High Electric Field at Low/High Temperature



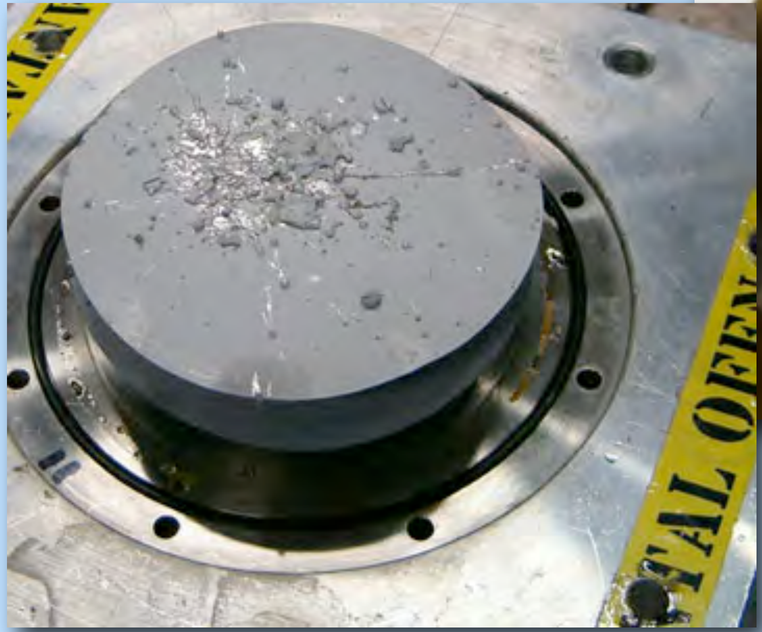
Controlled Atmosphere at High T

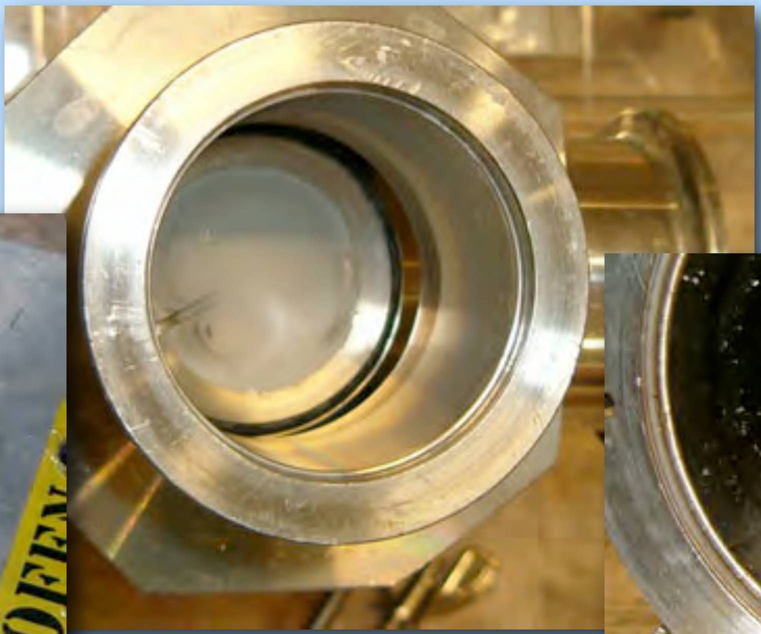
Furnace with Controlled Atmosphere

- Furnaces break very often, due to improper usage:
    - sample reacts with sample container

Furnace with Controlled Atmosphere

- Furnaces break very often, due to improper usage:
  - sample reacts with sample container
  - pieces on the sample container melt





Cadmium
molten and frozen

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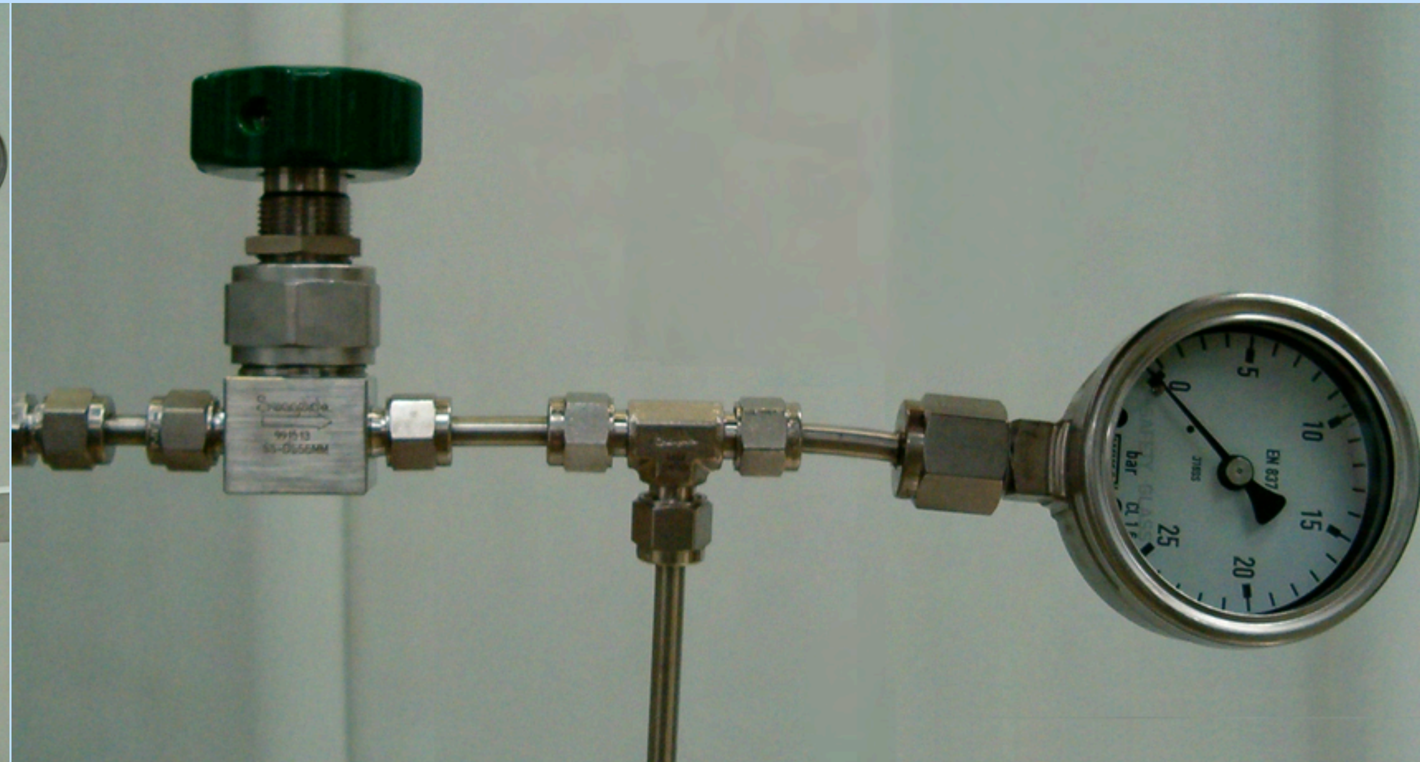
Furnace with Controlled Atmosphere

- Furnaces break very often, due to improper usage:
    - sample reacts with sample container
    - pieces on the sample container melt
    - sample in a hermetically sealed container explodes due to outgasing powder sample
        - → why not put the sample in an open container in vacuum?
        - some samples change its composition due to outgasing
        - Solution: hermetically sealed container, but with a connection to the outside of the furnace

Furnace with Controlled Atmosphere



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Spherical Spin Polarisation Analysis at Very Low T

Bertrand Roessli, Oksana Zaharko

Laboratory for Neutron Scattering, PSI Villigen

Marc Janoschek

Laboratory for Neutron Scattering, PSI Villigen & TU München

Serguei Klimko

Laboratory for Neutron Scattering, PSI Villigen & TU München & ILL Grenoble

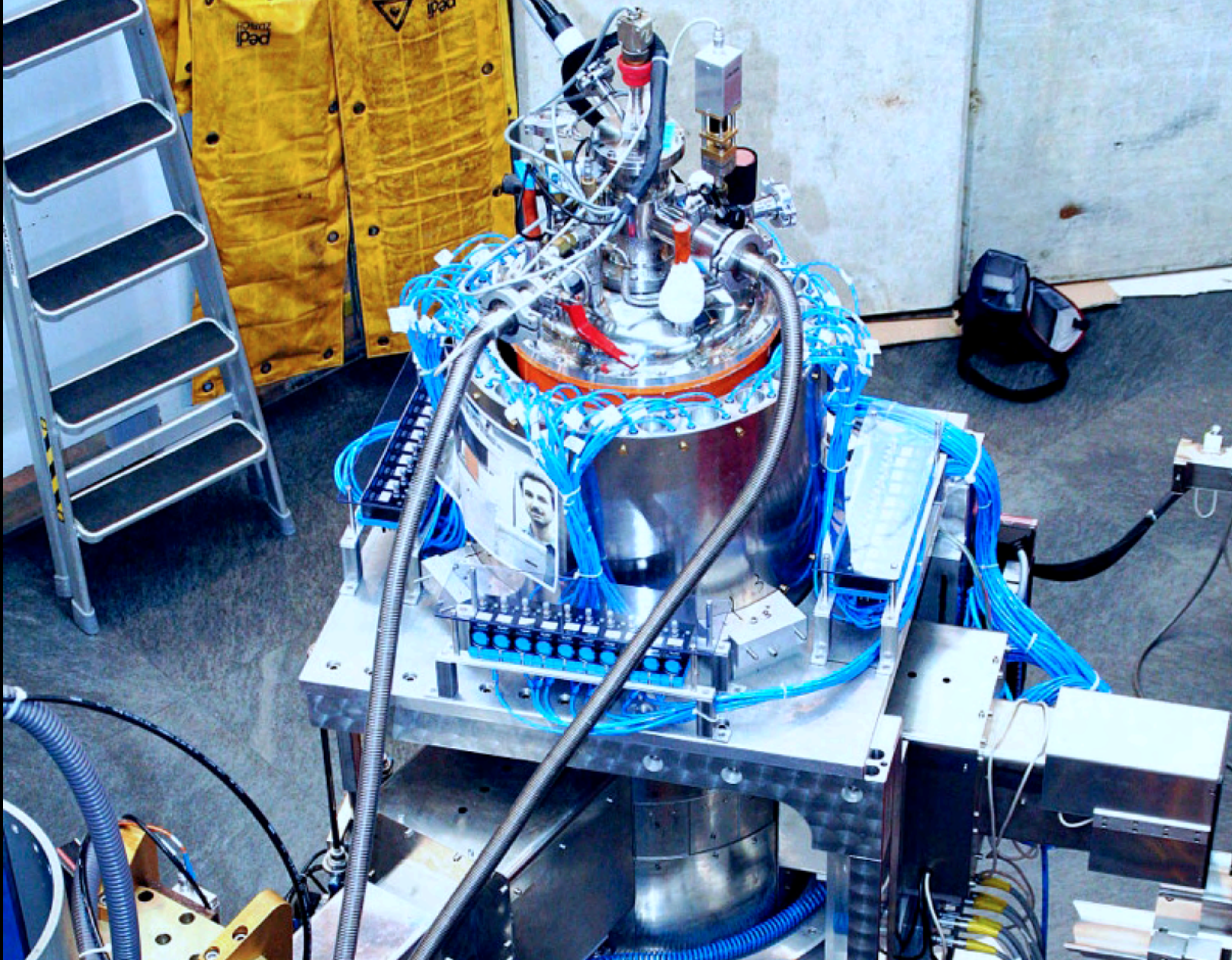
Spherical Spin Polarimetry

- Spherical neutron spin polarimetry exists since 1989 at ILL (CRYOPAD)

  F. Tasset, *Physica B*, **156-157**:627, 1989.

- Another device (MuPAD) was developed by TU München & PSI and is installed at TASP (SINQ)

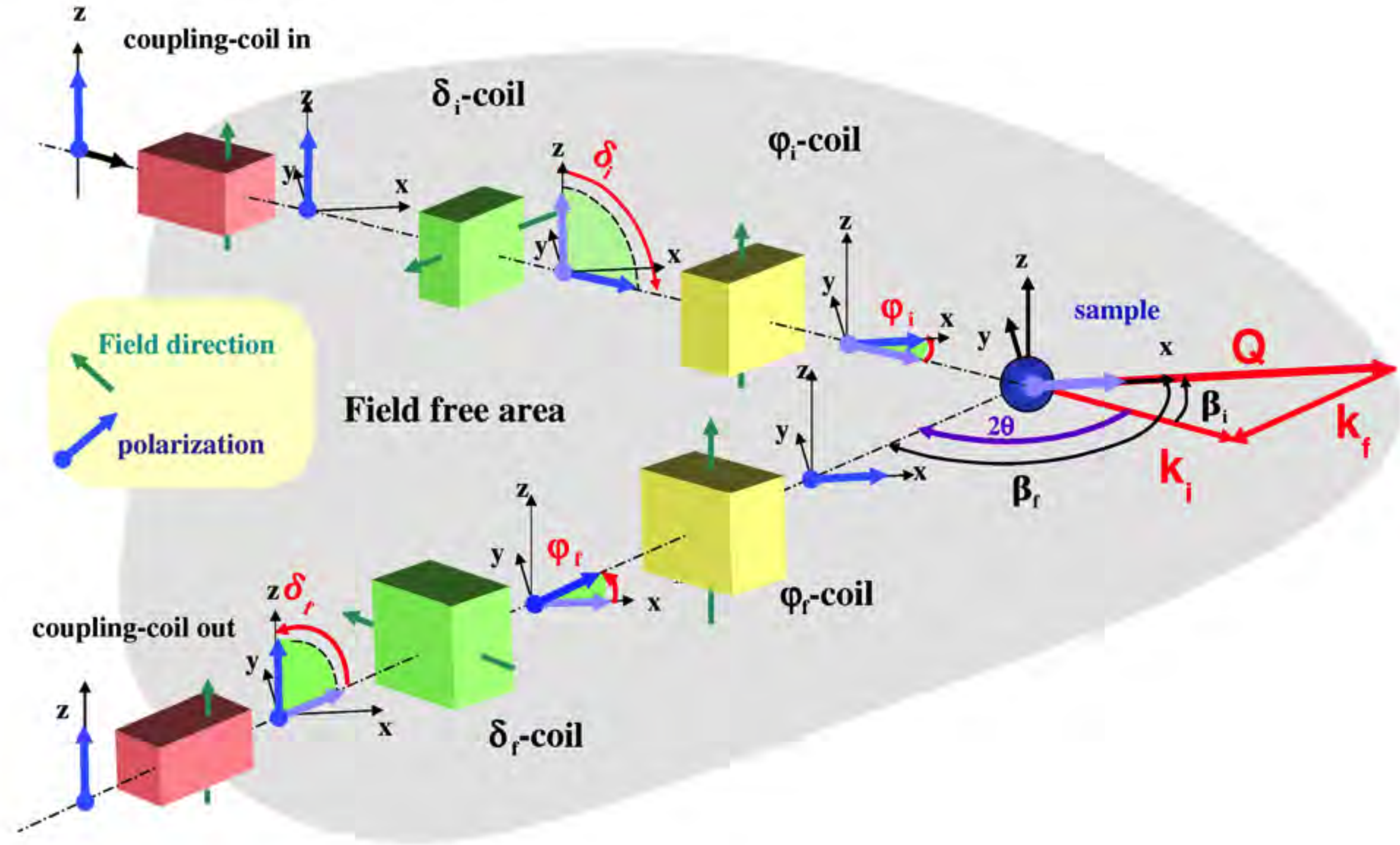
  M. Janoschek & al., *Physica B*, **397**:125, 2007.



Spherical Spin Polarimetry

- polarisation e.g. $P_{xx} = (I_{xx}-I_{x-x})/(I_{xx}+I_{x-x})$
  - longitudinal polarimetry
    - guide field along the whole beam path
    - → we can only measure P_{xx}, P_{yy}, P_{zz}
  - spherical spin polarimetry:
    - we can also measure the off diagonal elements
      P_{xx}, P_{xy}, P_{xz}
      P_{yx}, P_{yy}, P_{yz},
      P_{zx}, P_{zy}, P_{zz}
    - only with a field free area around the sample

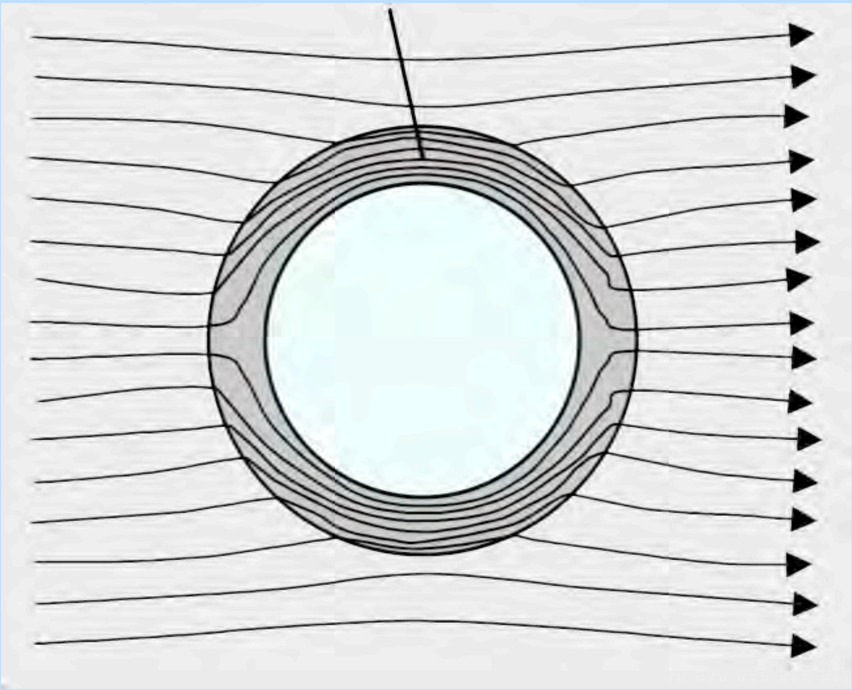
MuPAD



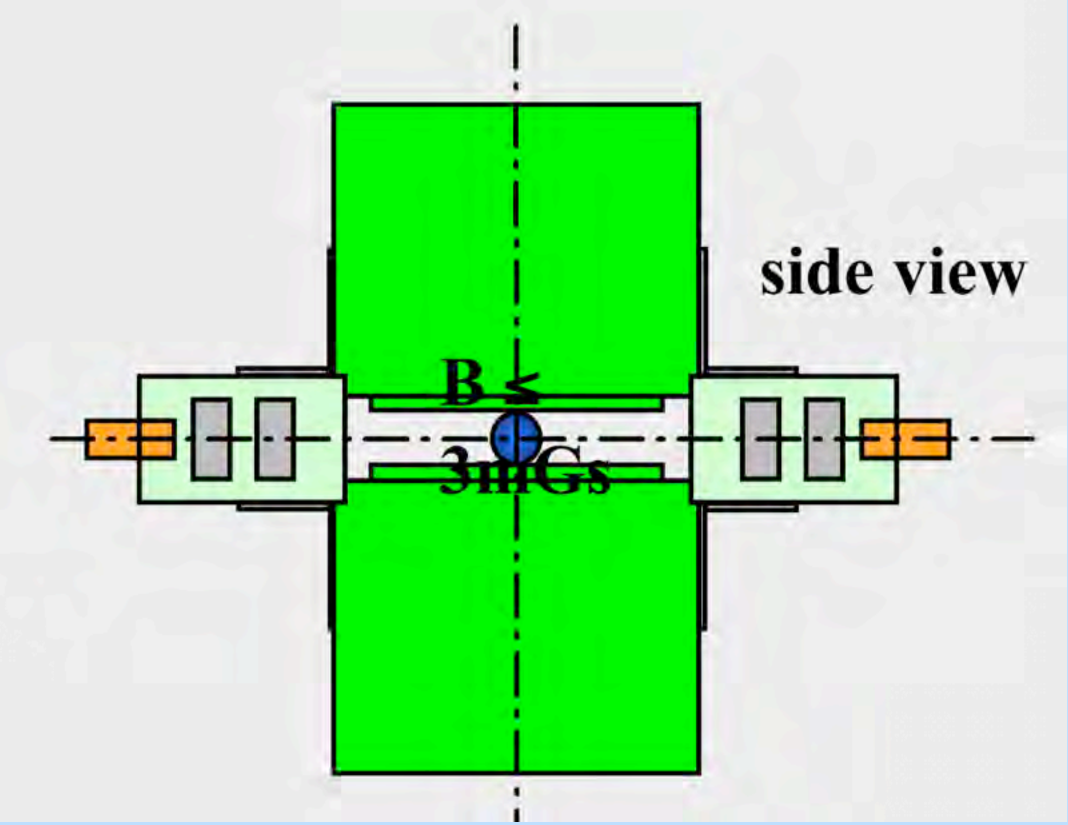
coupling-coil in
δ_i-coil
φ_i-coil
δ_i
φ_i
sample
Q
β_i
k_f
2θ
k_i
β_f
Field direction
polarization
Field free area
φ_f
δ_f
φ_f-coil
coupling-coil out
δ_f-coil

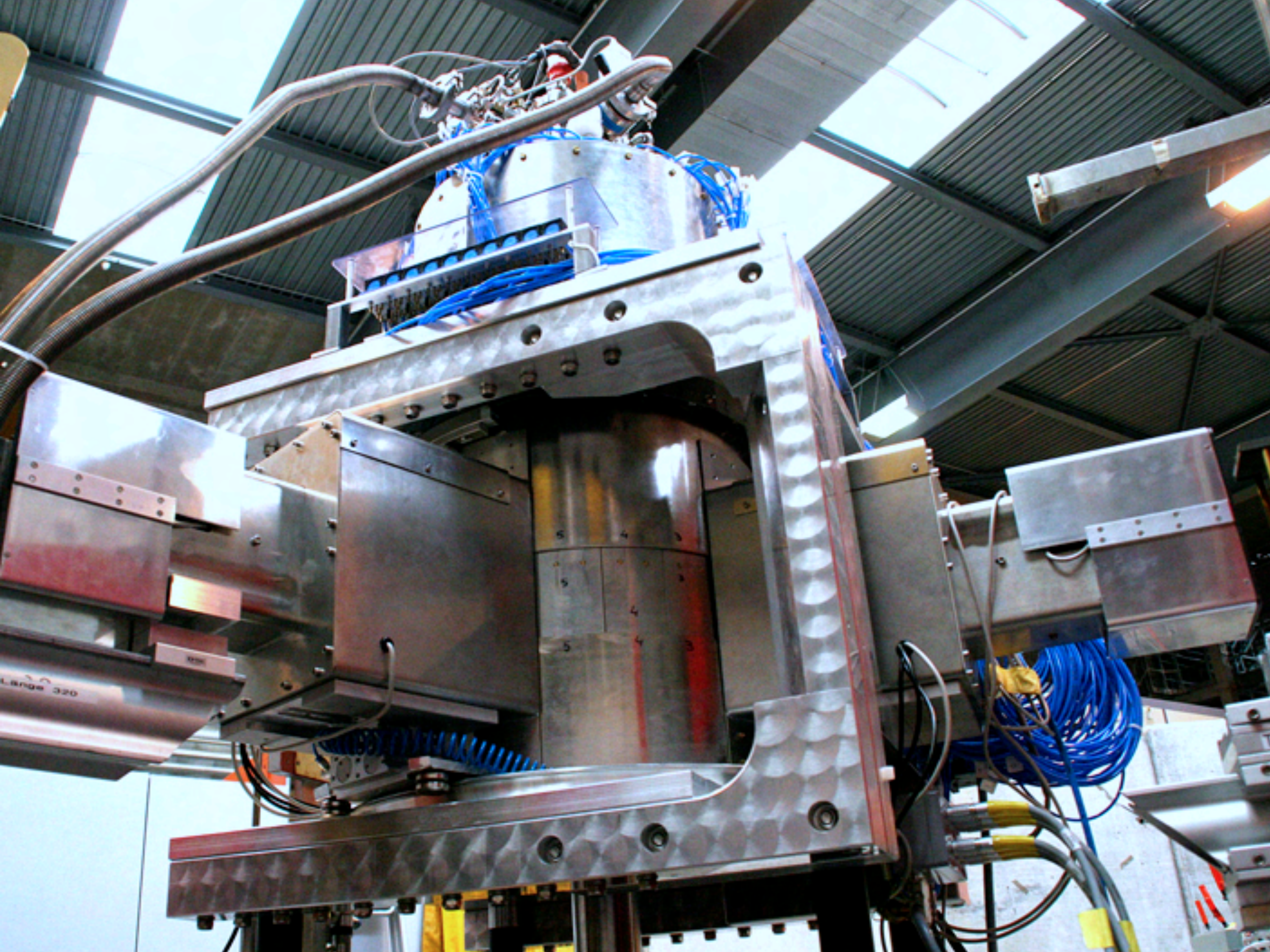
MuPAD

mu-metal pushs the field out

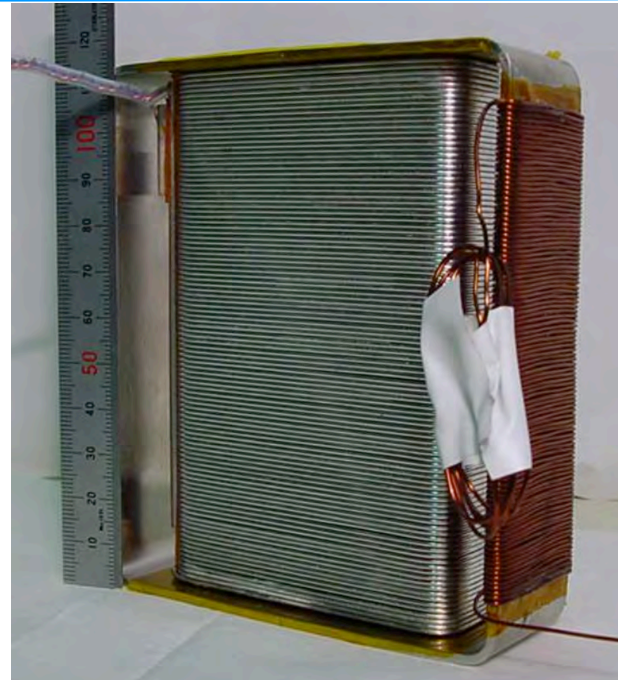


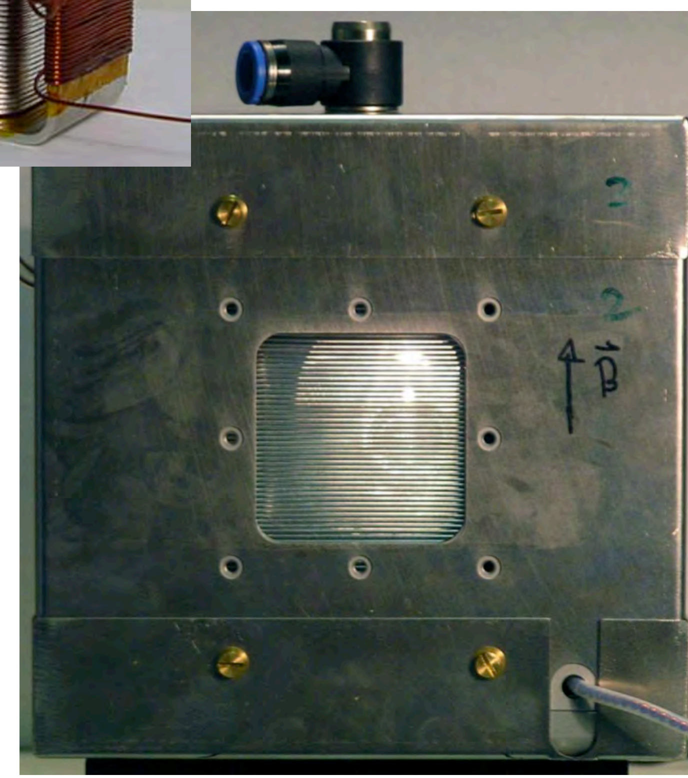
double wall mu-metal shield:
field 60 times smaller than
earth magnetic field




Länge 320

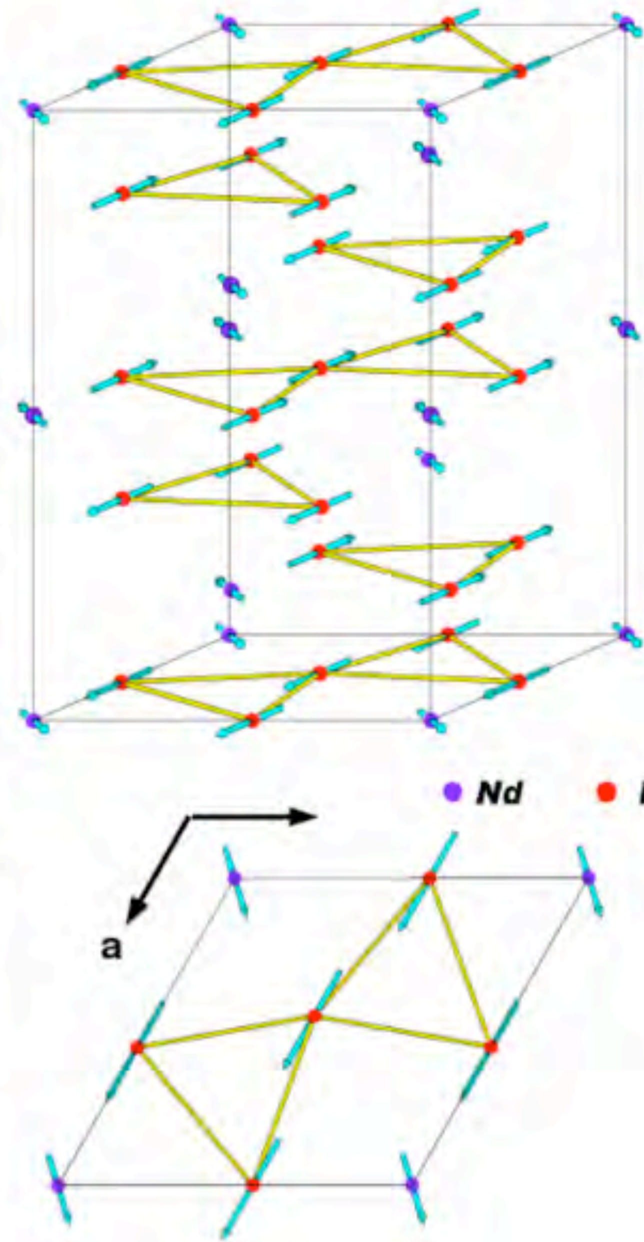
MuPAD precession coil





Example: $NdFe_3(BO_3)_4$ (May 2007)

H	K	L	P_i			$P_{meas.}$			$P_{calc.}$		
0.000	2.000	-0.500	+1			-0.88	+0.03	+0.03	-0.85	+0.00	-0.00
				+1		-0.03	-0.66	-0.06	+0.00	-0.66	+0.00
					+1	+0.08	+0.04	+0.66	+0.00	+0.00	+0.66
			-1			+0.86	-0.07	-0.04	+0.85	-0.00	+0.00
				-1		+0.06	+0.66	+0.05	+0.00	+0.66	-0.00
					-1	-0.04	+0.05	-0.65	+0.00	-0.00	-0.66
0.000	0.000	-1.500	+1			-0.88	+0.05	+0.12	-0.85	+0.00	+0.00
						+0.04	+0.01	+0.01	+0.00	-0.03	+0.03
				+1	+1	+0.02	+0.03	-0.02	-0.00	+0.03	+0.03
			-1			+0.87	-0.06	-0.11	+0.85	+0.00	+0.00
				-1		+0.01	-0.01	-0.02	+0.00	+0.03	-0.03
					-1	+0.03	-0.02	-0.00	-0.00	-0.03	-0.03
0.000	1.000	0.500	+1			-0.88	+0.00	+0.04	-0.85	-0.00	+0.00
				+1		-0.01	-0.49	-0.08	-0.00	-0.40	-0.04
					+1	+0.10	-0.07	+0.48	-0.00	-0.04	+0.40
			-1			+0.86	-0.04	-0.08	+0.85	+0.00	-0.00
				-1		+0.08	+0.49	+0.08	-0.00	+0.40	+0.04
					-1	-0.07	+0.06	-0.48	-0.00	+0.04	-0.40
0.000	4.000	0.500	+1			-0.86	-0.02	-0.03	-0.85	-0.00	-0.00
				+1		+0.01	-0.82	-0.08	-0.00	-0.79	+0.00
					+1	+0.08	-0.08	+0.86	-0.00	+0.00	+0.79
			-1			+0.86	-0.06	-0.01	+0.85	+0.00	+0.00
				-1		+0.05	+0.85	+0.05	-0.00	+0.79	-0.00
					-1	-0.03	-0.02	-0.83	-0.00	-0.00	-0.79
0.000	1.000	-2.500	+1			-0.86	+0.07	+0.10	-0.85	+0.00	+0.00
				+1		+0.02	-0.10	-0.02	+0.00	-0.06	+0.03
					+1	+0.03	-0.02	+0.05	+0.00	+0.03	+0.06
			-1			+0.87	-0.07	-0.10	+0.85	+0.00	+0.00
				-1		+0.04	+0.08	-0.01	+0.00	+0.06	-0.03
					-1	+0.04	+0.01	-0.11	+0.00	-0.03	-0.06



Spherical Spin Polarimetry below 100 mK

- Worked well at 20 K, why not at 100 mK?
- Inner diameter of MuPAD designed for a standard orange cryostat
- Oxford Instruments dilution insert runs best within Variox
    - BUT: The Variox cryostat has a slighly larger diameter (10 mm more) → does not fit
- Test dilution refrigerator in orange cryostat: works, with a higher LHe consumption
    - → First experiment done in December 2007 (O. Zaharko & al.)

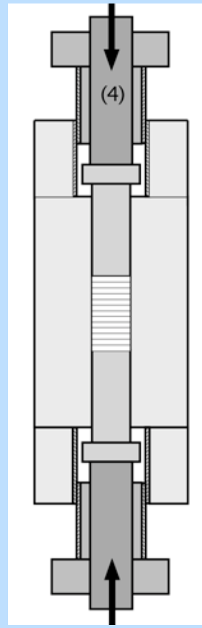
High pressure at low T

Thierry Strässle, Balasubramanian Padmanabhan
Laboratory for Neutron Scattering, PSI Villigen

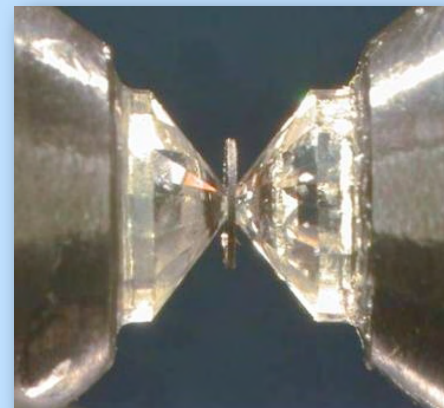
S. Klotz, G. Hamel
Université Pierre et Marie Curie, Paris

High pressure (>50 kbar) at low T (4 K)

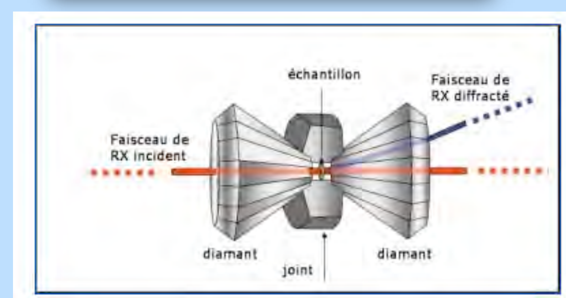
cylindrical geometry *vs* opposed-anvils geometry



available since many years at SINQ 1.5 K < T < 300 K



Ph.Gillet



cylindrical geometry

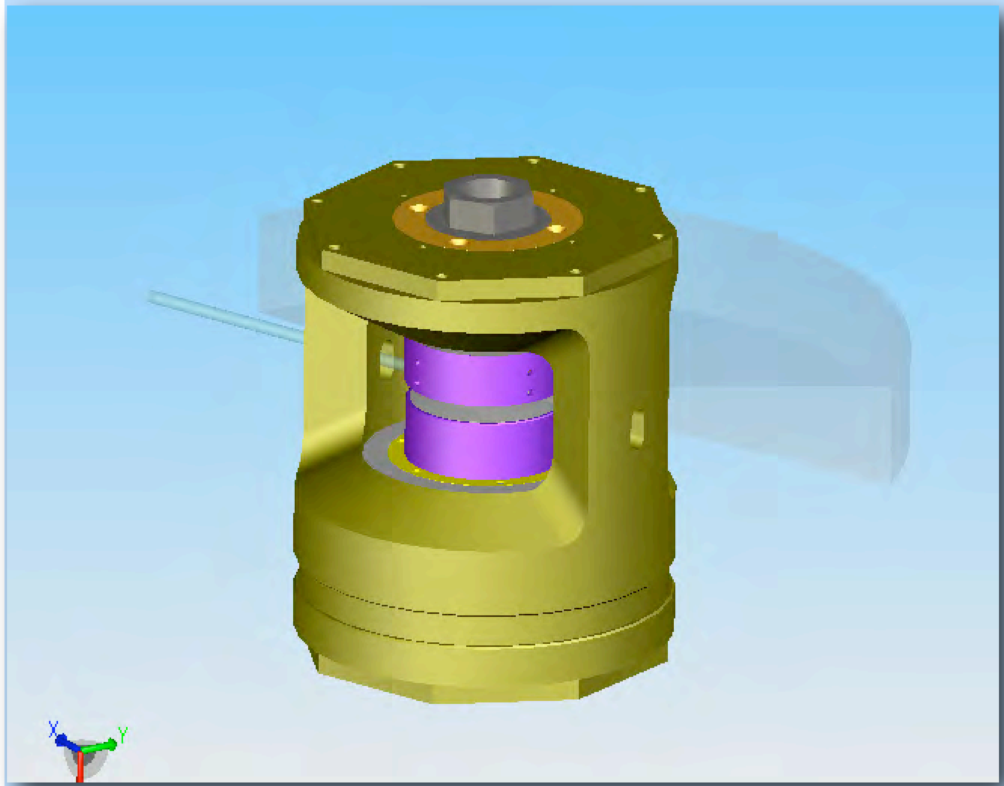
opposed anvil geometry

few cm^3 — few µm^3

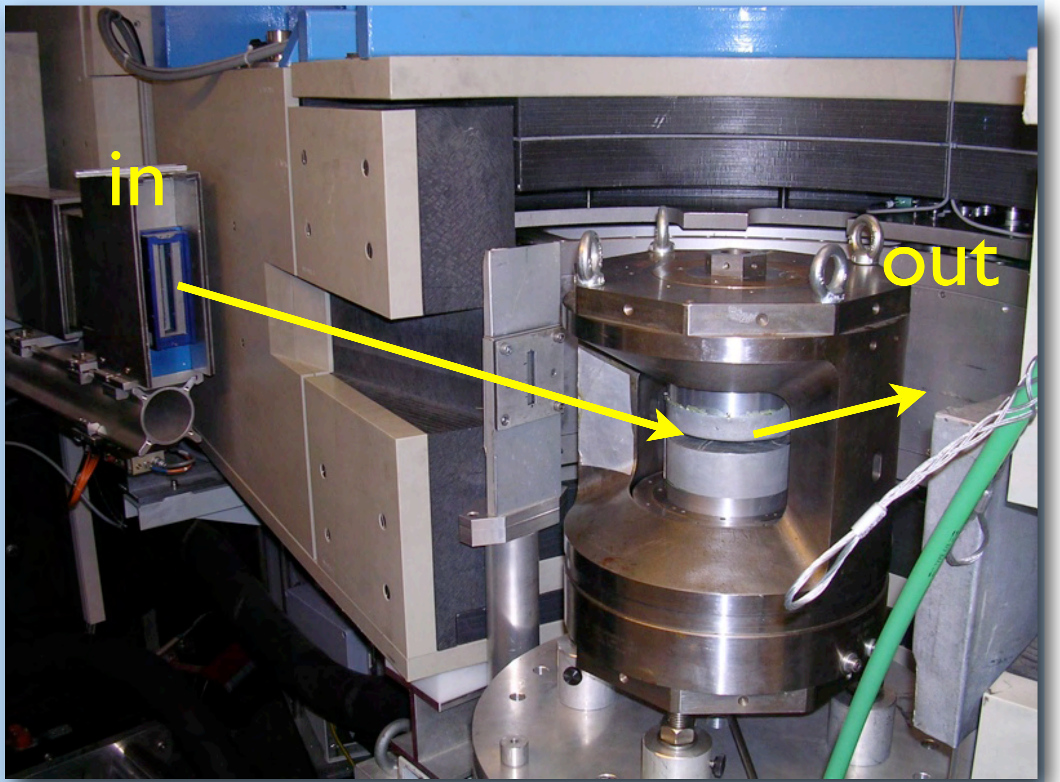
1 GPa/10 kbar | 10 GPa/100 kbar | few 100 GPa/Mbar

High pressure (>50 kbar) at low T (4 K)

- "Junior version" of conventional Paris-Edinburgh cell for cooling with a CCR, ~ 100 kbar
- several successful experiments at RT in 2007



from G.Hamel, IMPMC, Paris



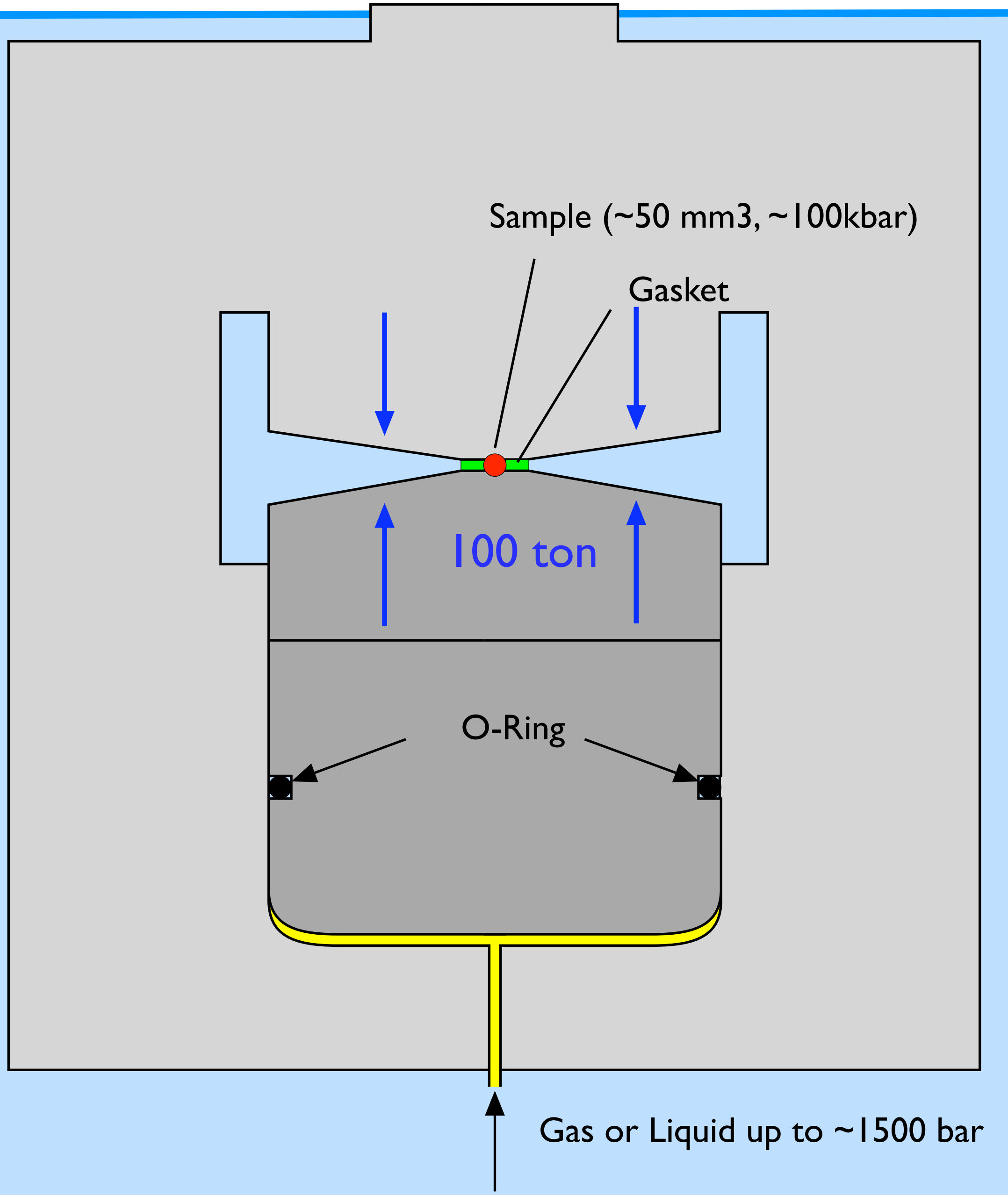
HRPT/SINQ, PSI

High pressure (>50 kbar) at low T (4 K)

- ILL developed a special cryostat for this cell with 4 K CCR (Sumitomo)
- PSI bought one, our technician participated the assembling at ILL.

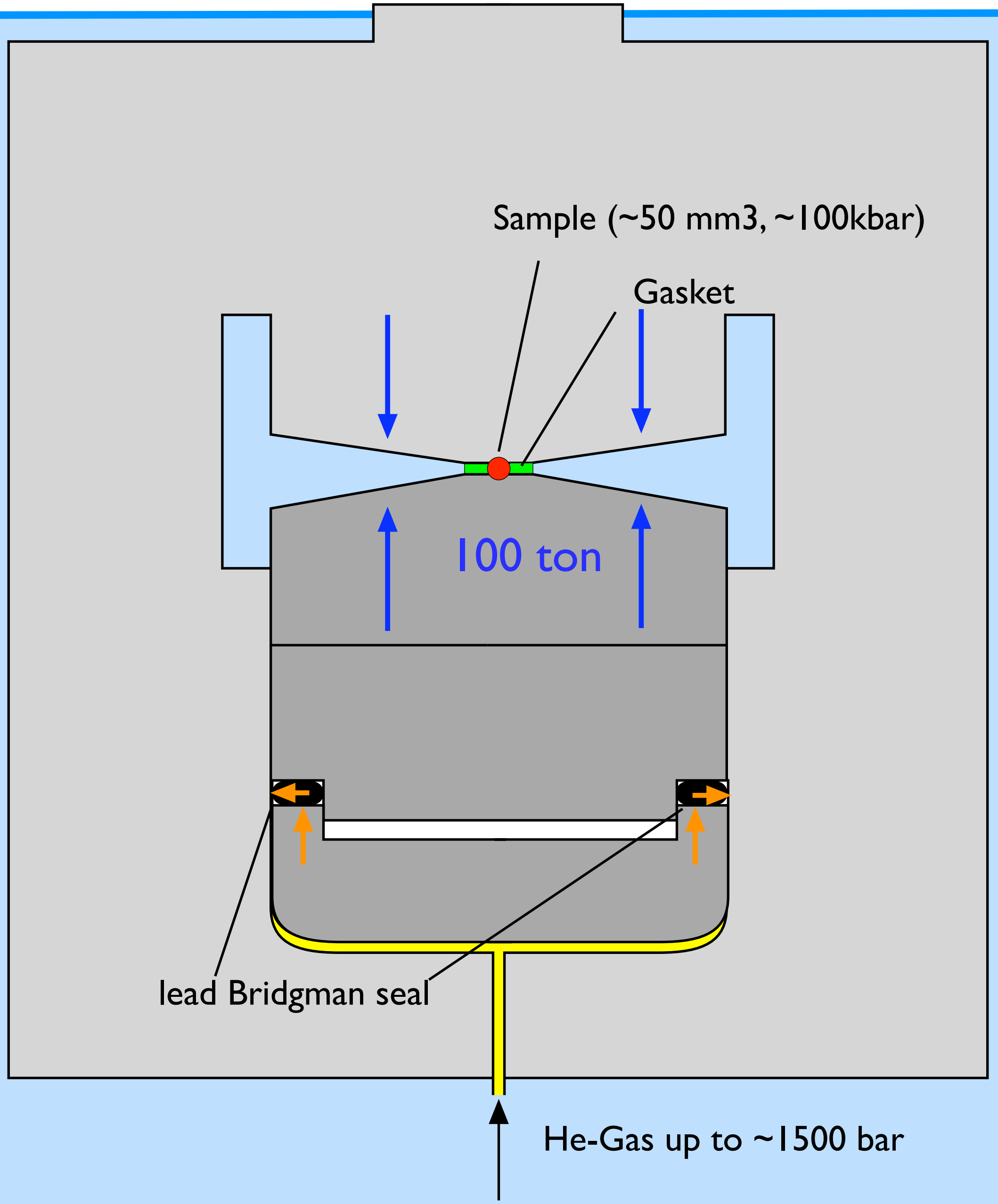
Paris-Edinburgh Anvil Pressure Cell

at RT

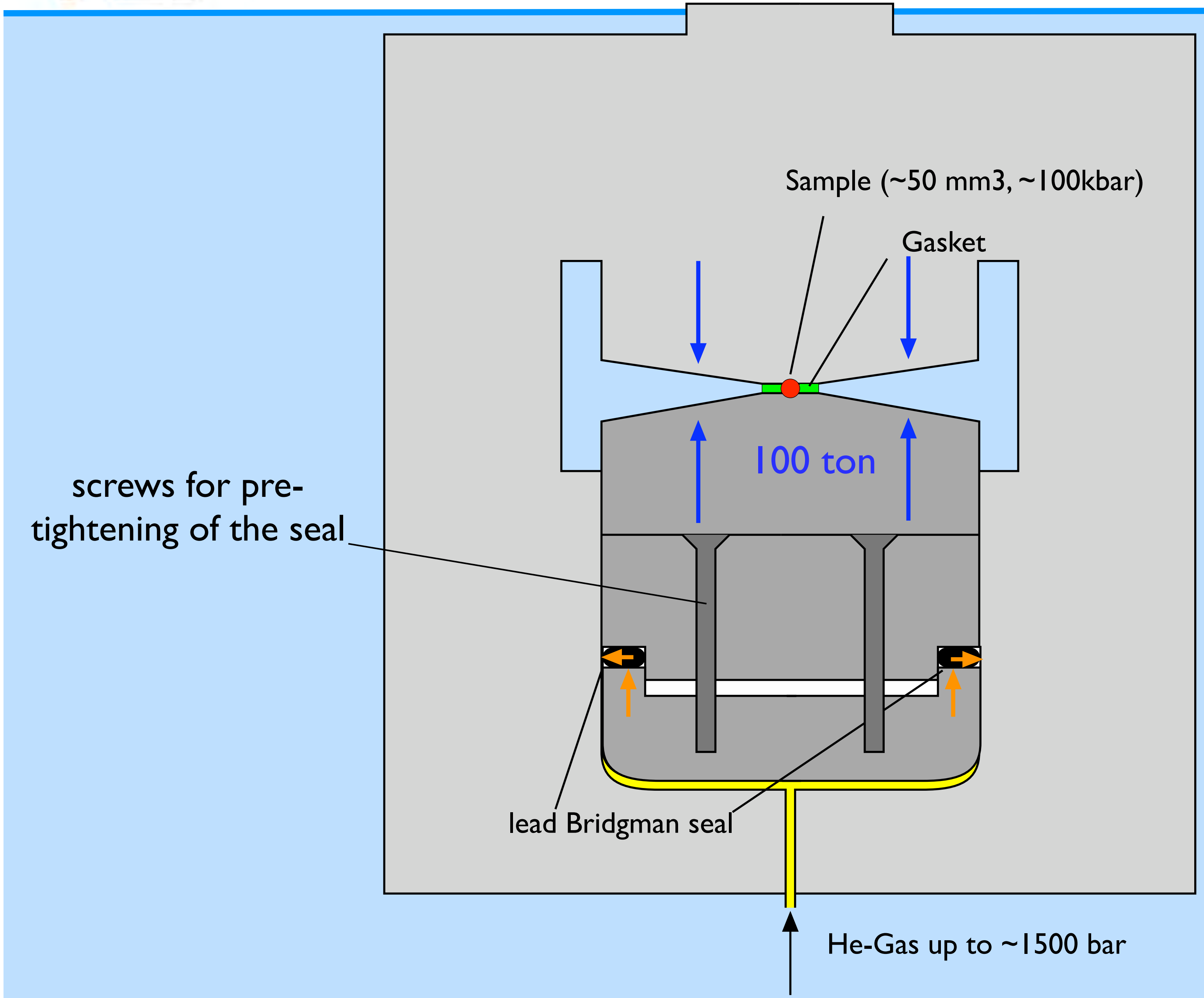


Paris-Edinburgh Anvil Pressure Cell

at low T
(20 K)

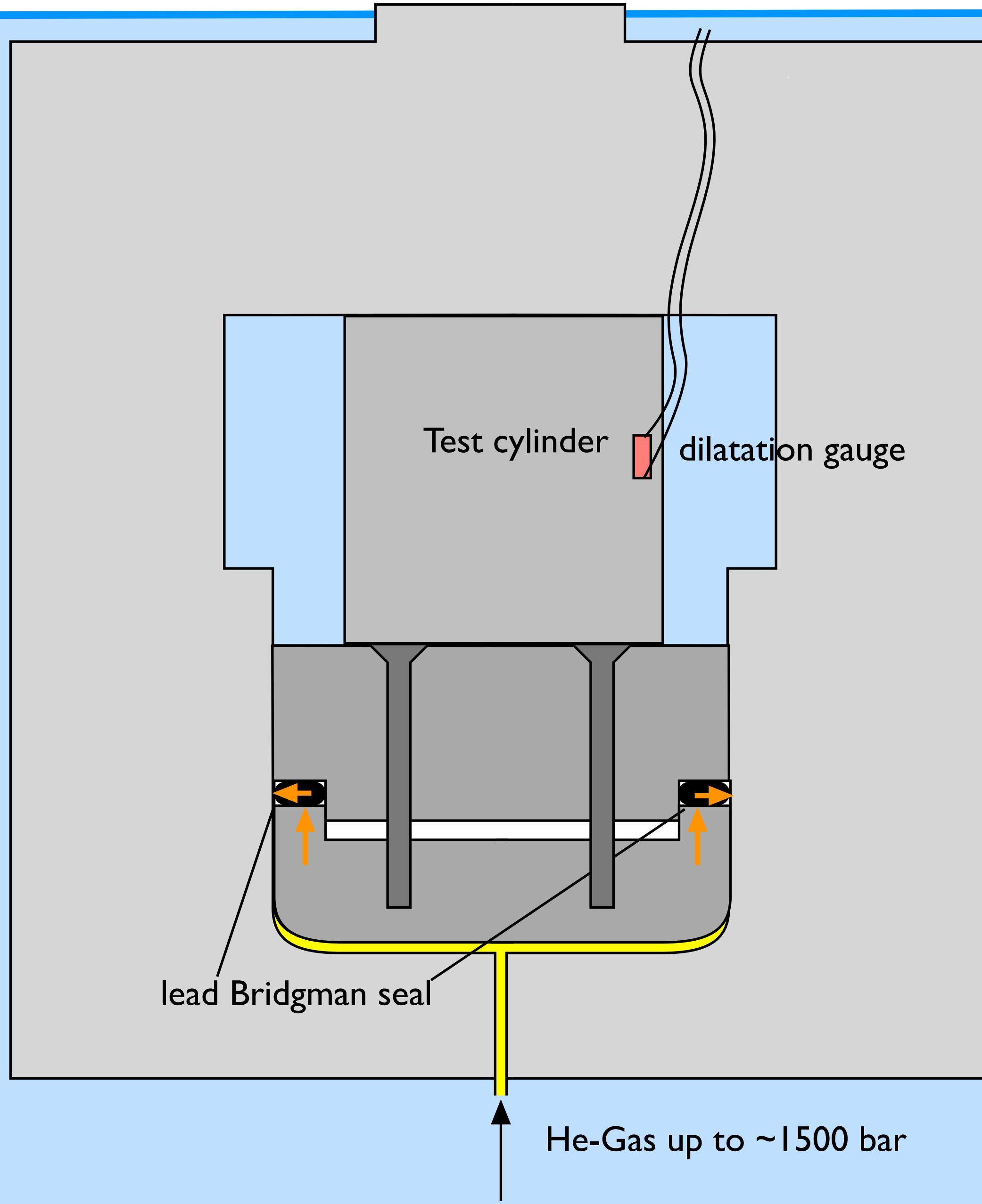


Paris-Edinburgh Anvil Pressure Cell

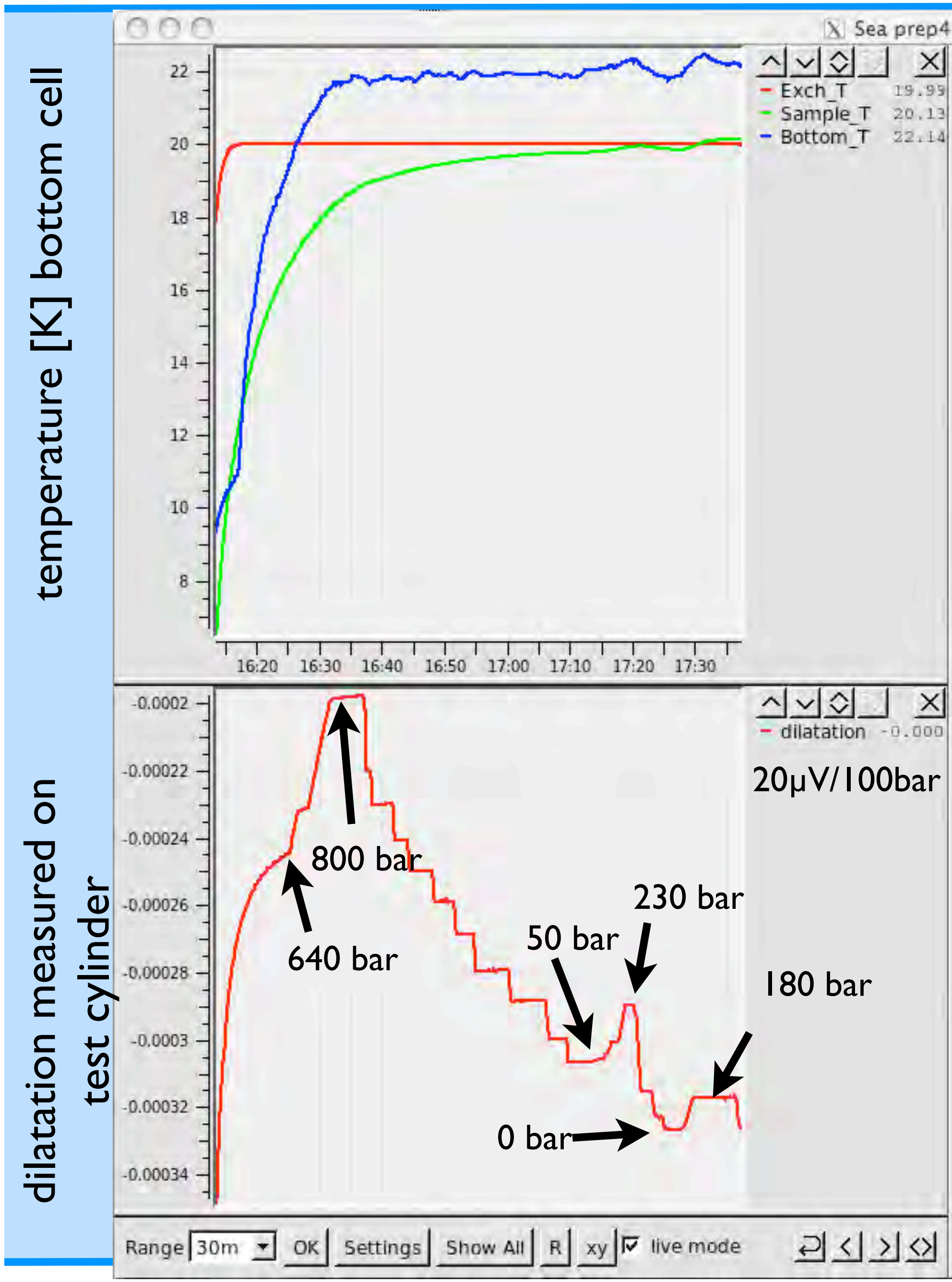


Paris-Edinburgh Anvil Pressure Cell

Testing the Bridgman seal



PE low-T test with Pb Bridgman piston



cooled from RT at 600 bar
(resulted in 520 bar at 4K)

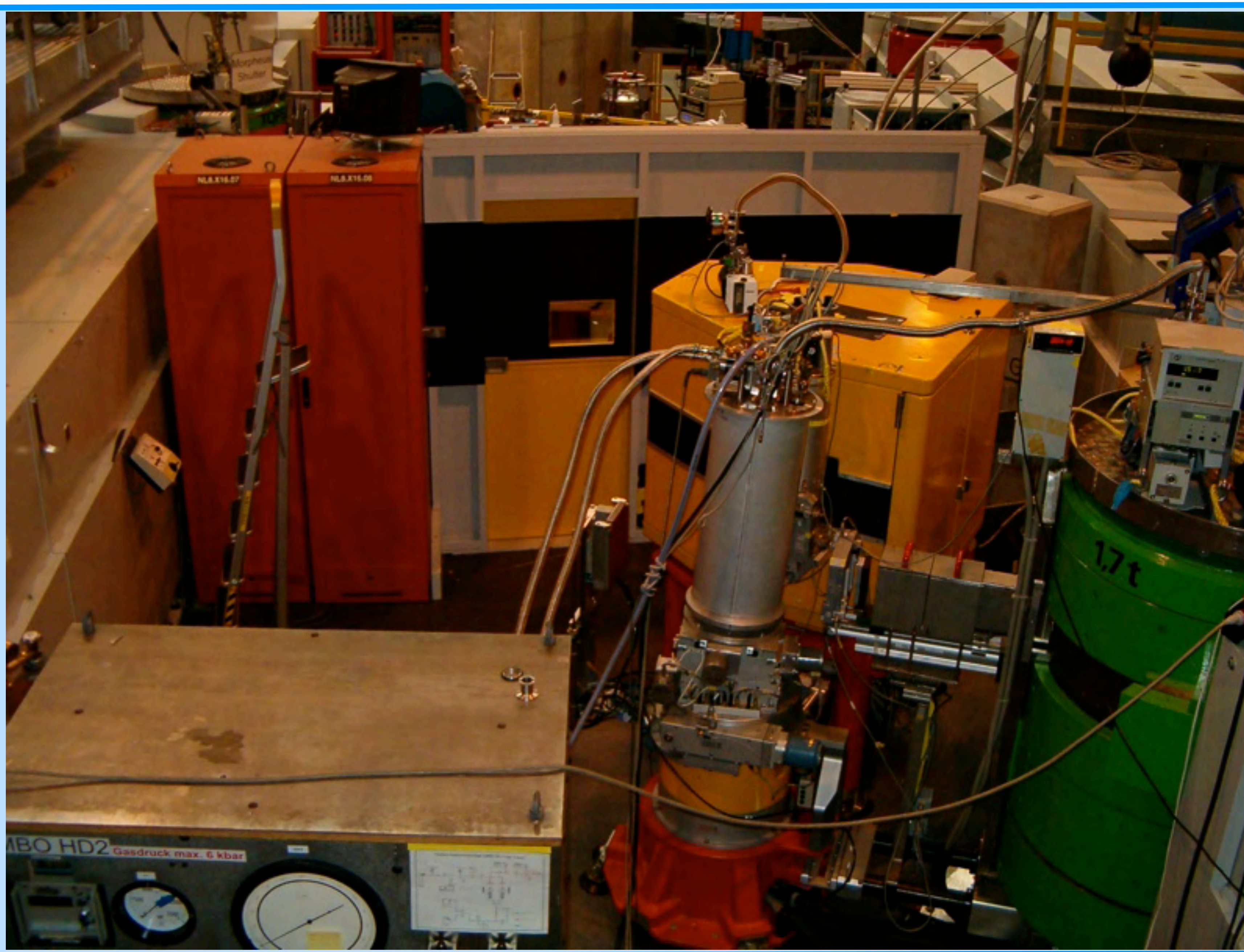
then at 20K
- increase to 800 bar
- decrease in steps of 50 bar
- increase from 50 bar to 230 bar
- complete release to 0 bar
- increase to 180 possible again

dilatation of test cylinder
could be measured for all changes
of the gas pressure
→ piston completely movable at 20K

BP,TS 7/02/08

High pressure at low T (4 K)

first experiment last week at SINQ, RITA-2: 30 kbar



Conclusion

An innovative and reliable sample environment helps to make a neutron scattering facilities competitive