SHARP: a cold ToF spectrometer at ILL

S. Rodrigues[1], P. Lavie[1], B. Homatter[1], S. Petit[1], Q. Berrod[2], J.-M. Zanotti[1]

RAMSES: a super SHARP

??? M. Koza[3], J.-M. Zanotti[1], B. Homatter[1], Q. Berrod[2]

C-Spec: A cold chopper spectrometer at the ESS

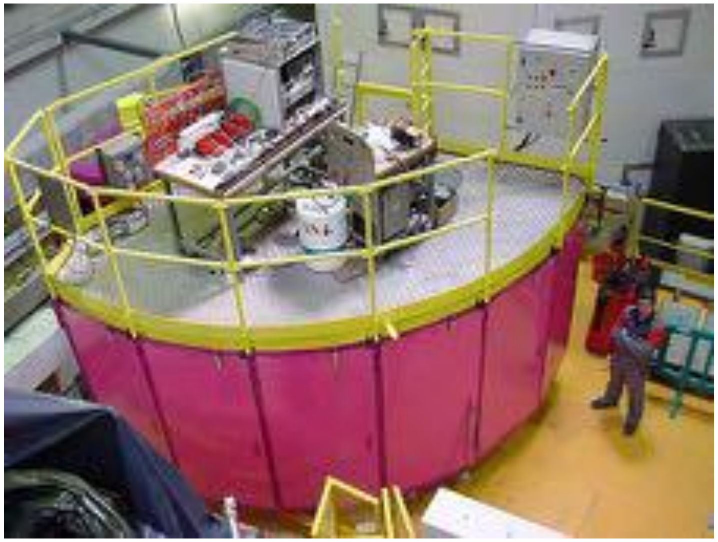
P. P. Deen[4], J. Guyon le Bouffy[1], W. Lohstroh[4], J. Neuhaus[4], W. Petry[4],
S. Longeville[1], J.-M. Zanotti[1] and C. Alba-Simionesco[1]

[1] Laboratoire Léon Brillouin, CEA-CNRS Saclay
[2] CNRS, INAC, SYMMES, CEA Grenoble
[3] ILL, Grenoble
[4] TUM, Munich

18 / 12 / 2018

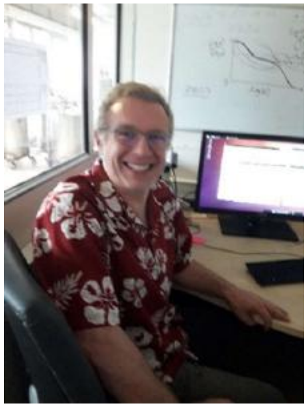
IN6: a French CRG @ ILL

Contract signed on October 29 2017: 50% + 50% ILL beam time



Replacement of IN6 by SHARP

Mars 2020 during ILL long shutdown



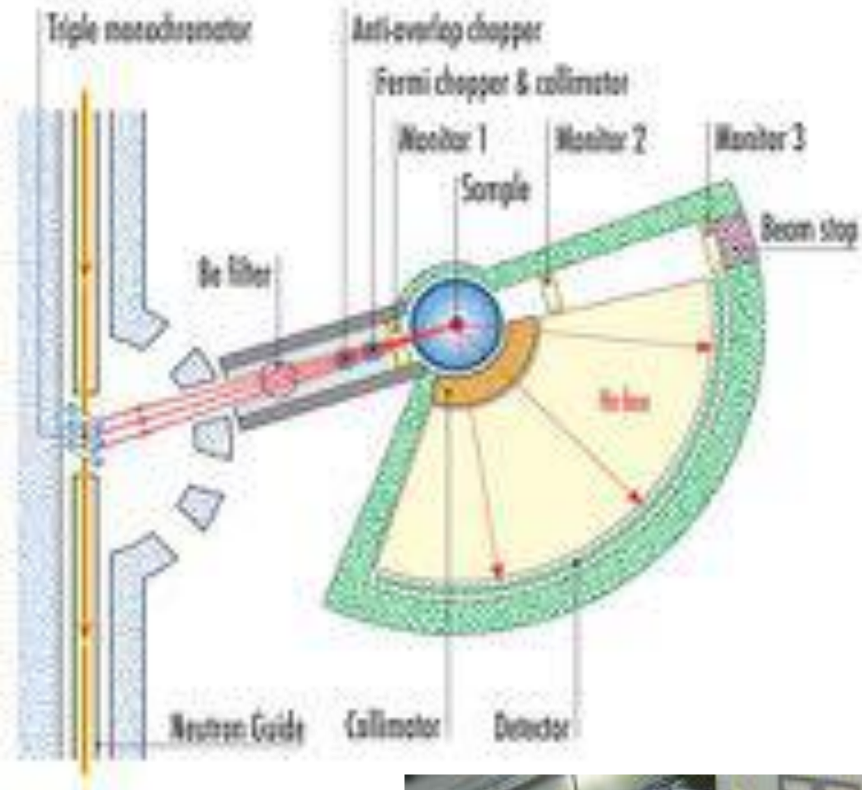
The IN6 Group:

Responsible:	JMarc Zanotti*
Co-responsible:	Quentin Berrod
	Sylvain Petit
Technical responsible:	Benoit Homatter *

*: LLB personnel on site at ILL.

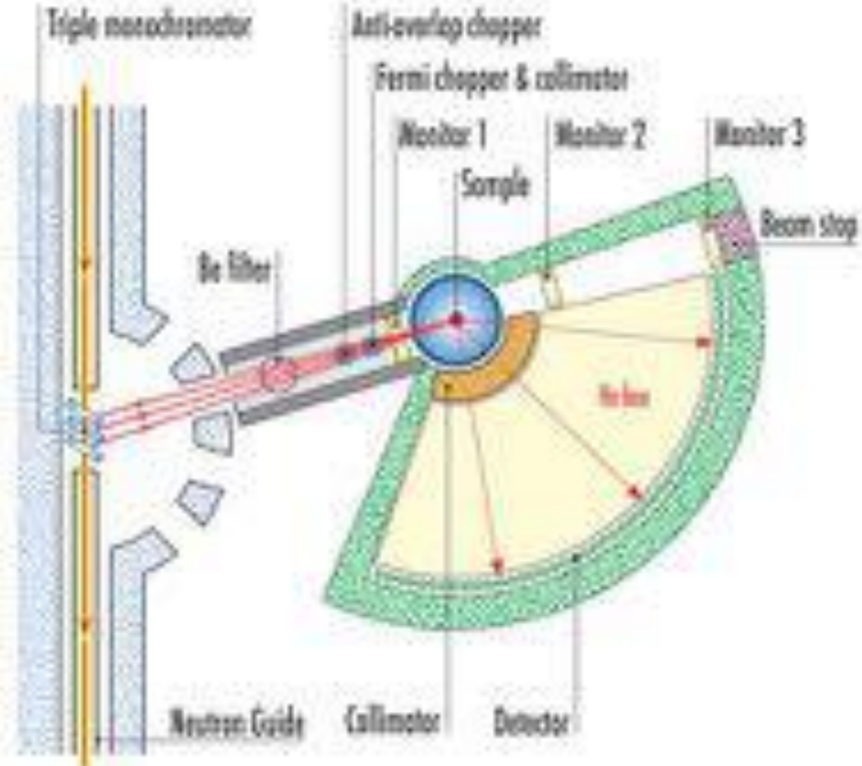
IN6: a cold time-of-flight inelastic spectrometer
High Flux by "time focusing"

A 3 PG monochromator array
with horizontal focusing



https://www.ill.eu/instruments-support/instruments-groups/instruments/in6

IN6: a cold time-of-flight inelastic spectrometer
High Flux by "time focusing"

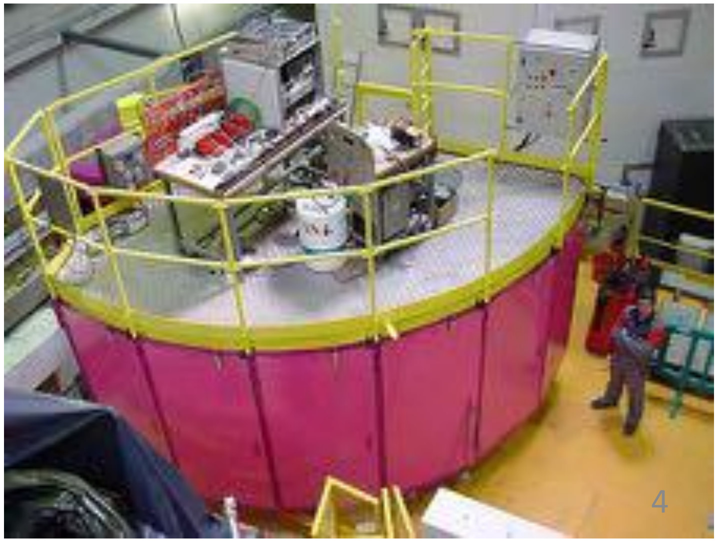


Dynamical structure factor:

$S(\vec{Q},\omega)$: time (ω) and space (Q) depence of motions

→ Energy transfer

→ Momentum transfer



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IN6: a cold time-of-flight inelastic spectrometer
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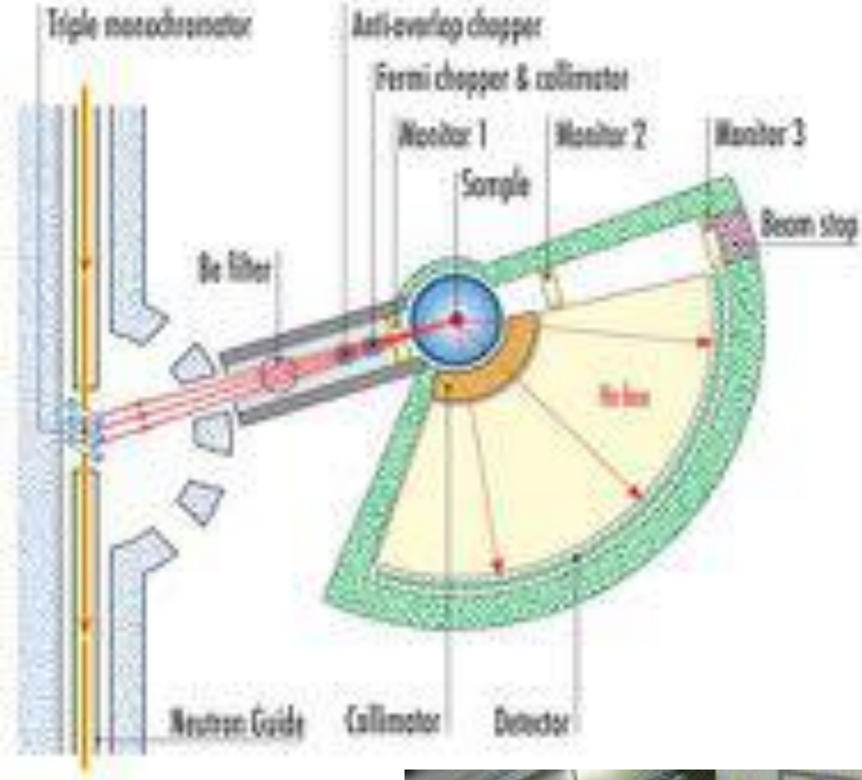

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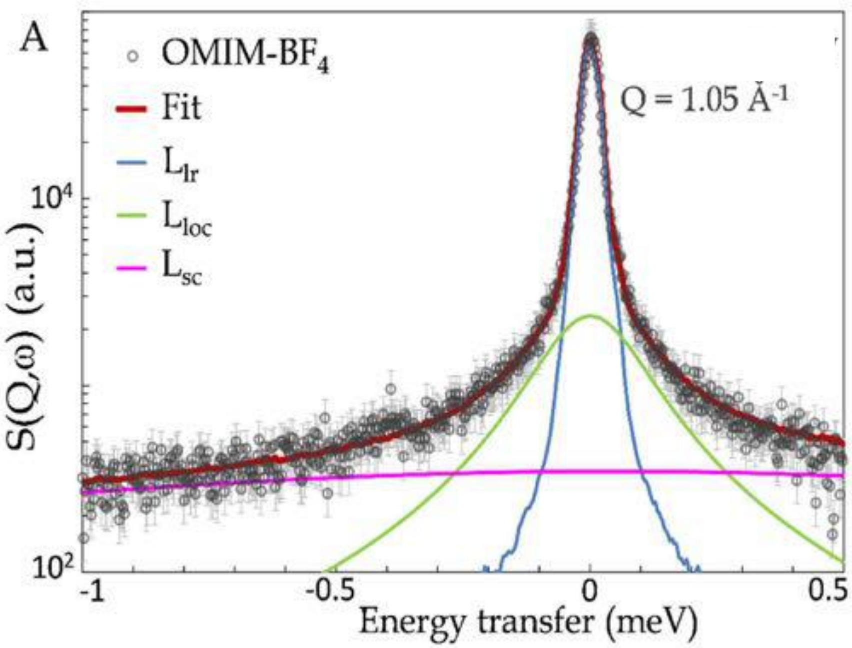
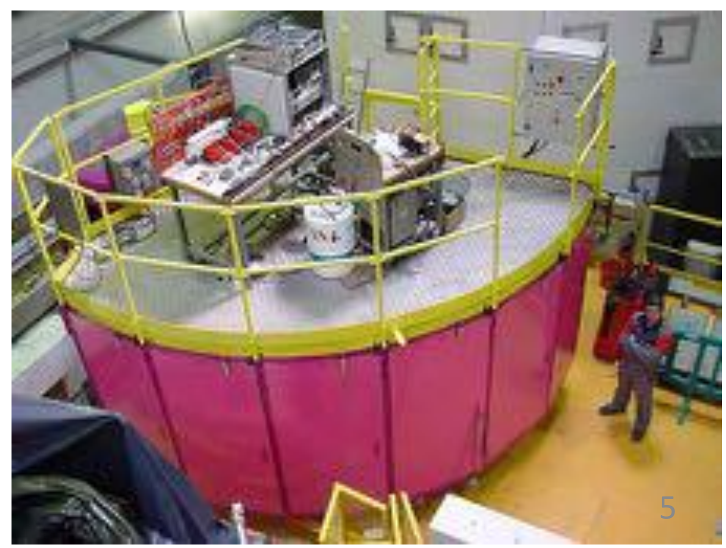
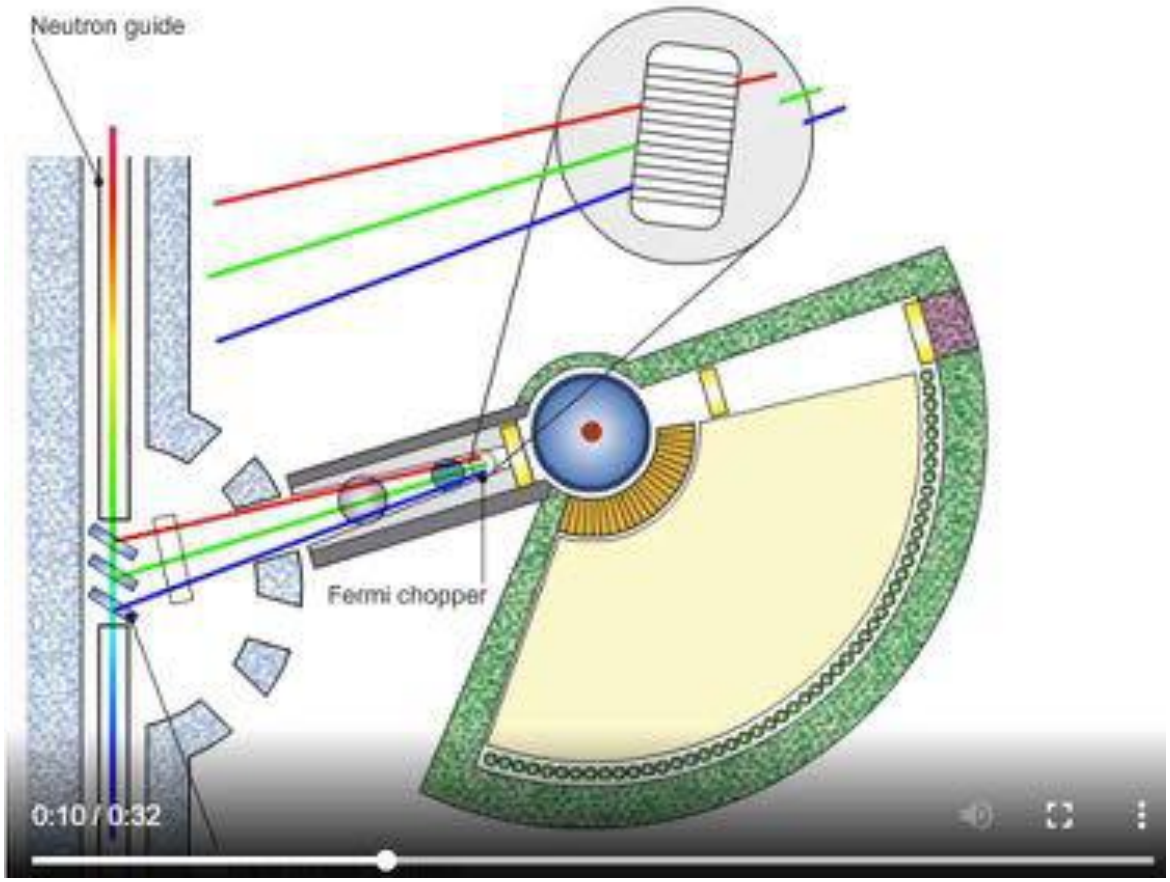




https://www.ill.eu/instruments-support/instruments-groups/instruments/in6

IN6: a cold time-of-flight inelastic spectrometer
High Flux by "time focusing"

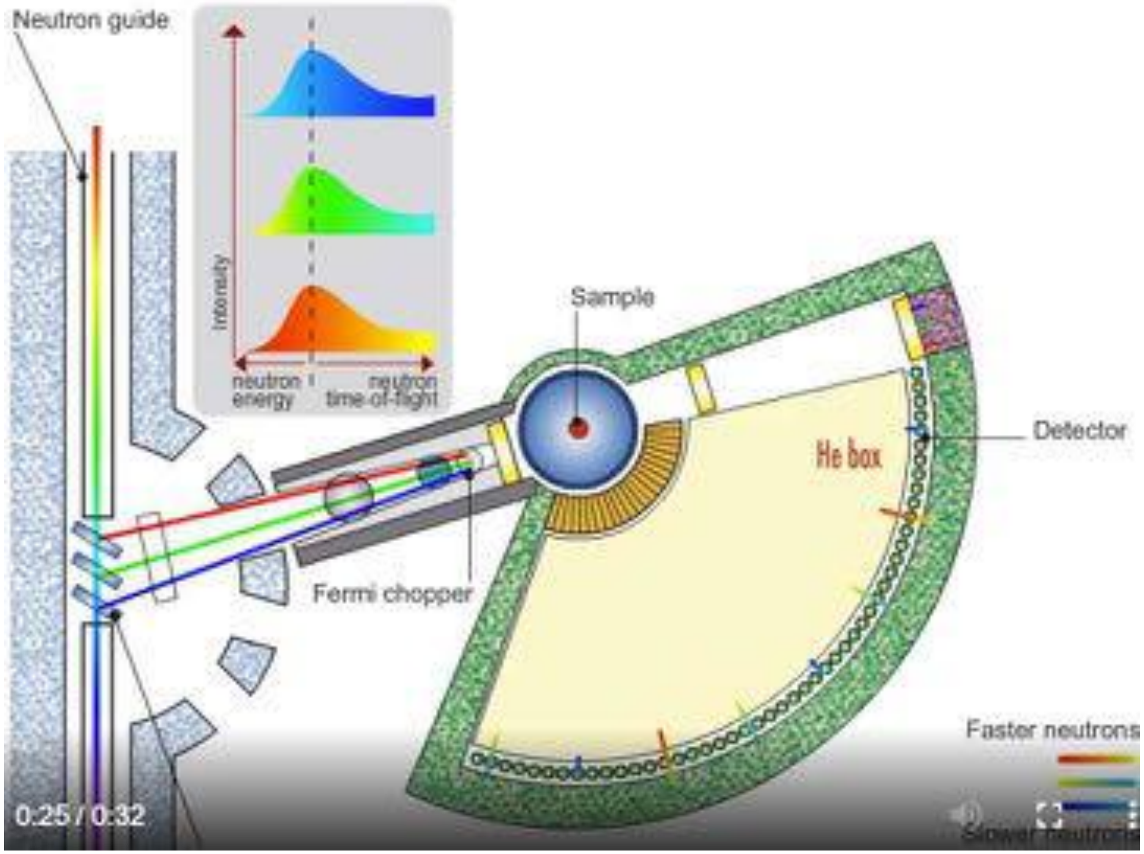


Each monochromator delivers a beam of distinct energy and, thus, of distinct velocity

The slowest (blue) neutrons pass through first and the fastest (red) neutrons to pass through last

https://www.ill.eu/instruments-support/instruments-groups/instruments/in6

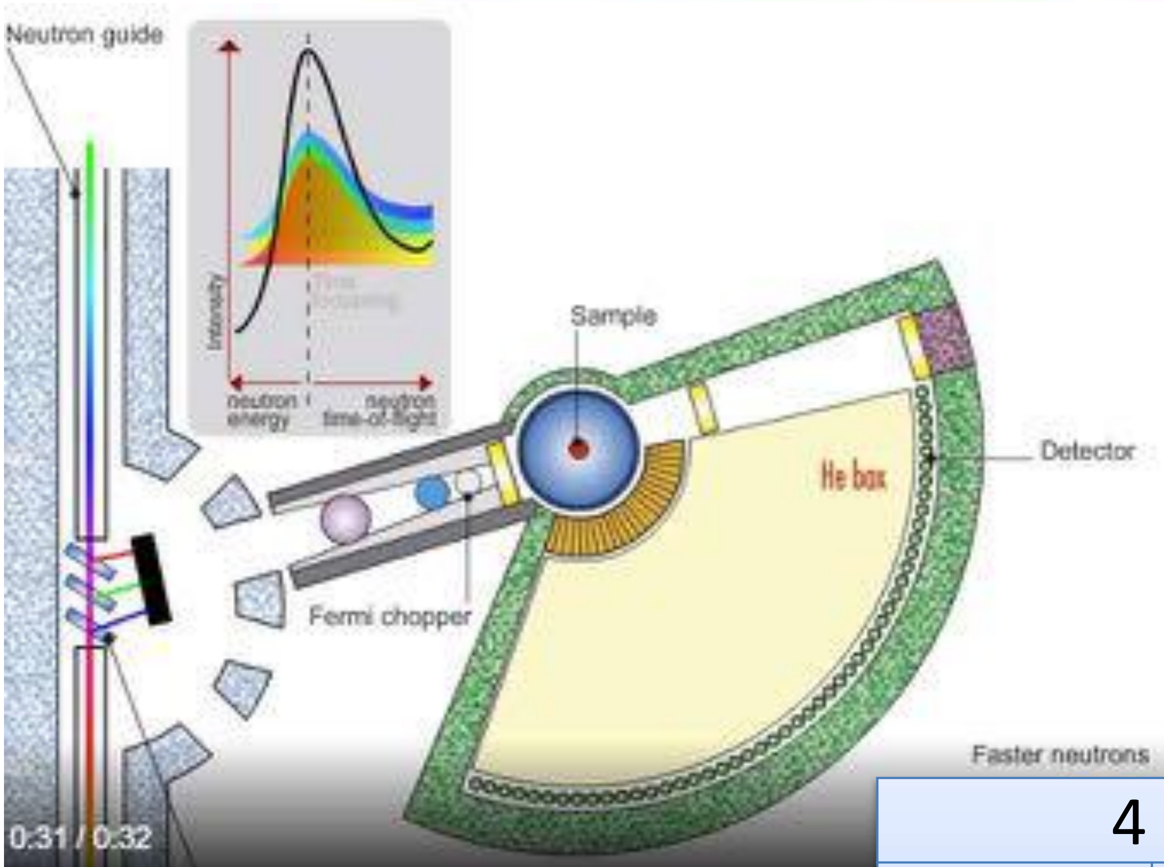
IN6: a cold time-of-flight inelastic spectrometer
High Flux by "time focusing"



The chopper speed can be adjusted in such a way that all three pulses of different energy arrive at the same time in the detectors

https://www.ill.eu/instruments-support/instruments-groups/instruments/in6

IN6: a cold time-of-flight inelastic spectrometer
High Flux by "time focusing"

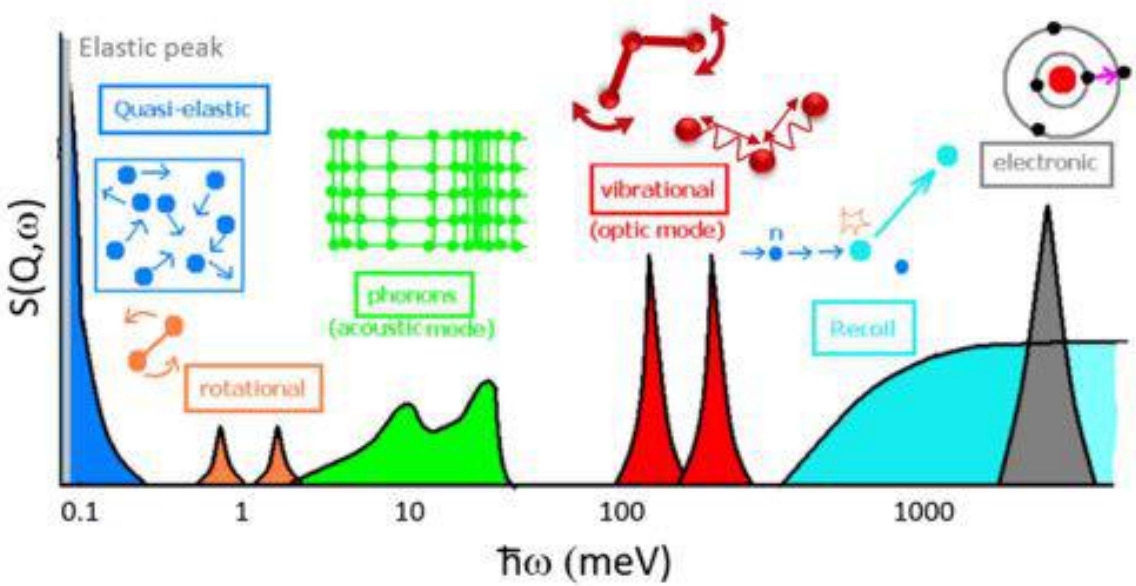


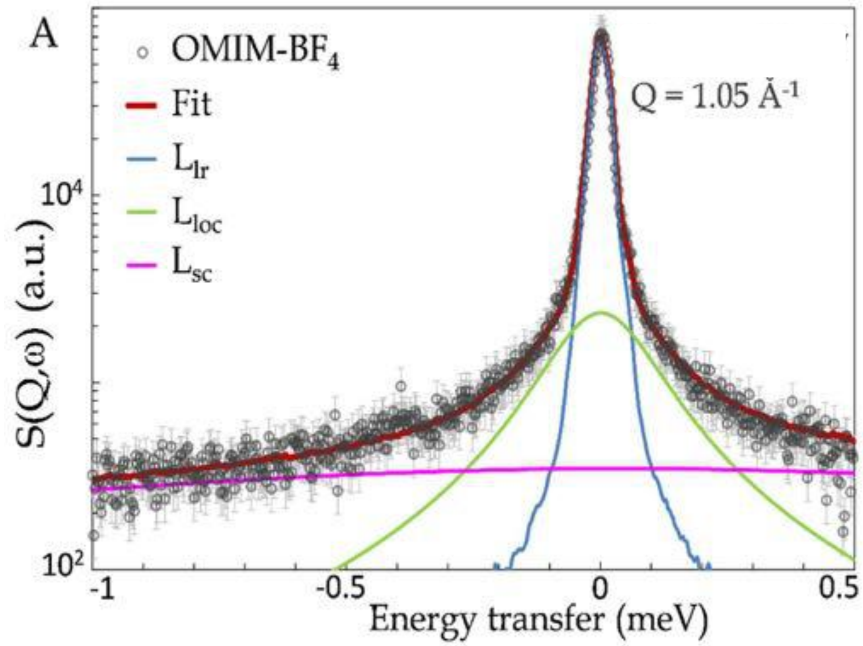
Increase of intensity by a factor of three

4 incident wavelengths			
Inc. wavelenght	Inc. Energy	Energy Resolution	Characteristic Time (ps)
4.1 Å	4.9 meV	170 µeV	0.01 - 4
4.6 Å	3.9 meV	120 µeV	0.01 - 5
5.1 Å	3.1 meV	70 µeV	0.01 - 10
5.9 Å	2.3 meV	50 µeV	0.01 - 15

https://www.ill.eu/instruments-support/instruments-groups/instruments/in6

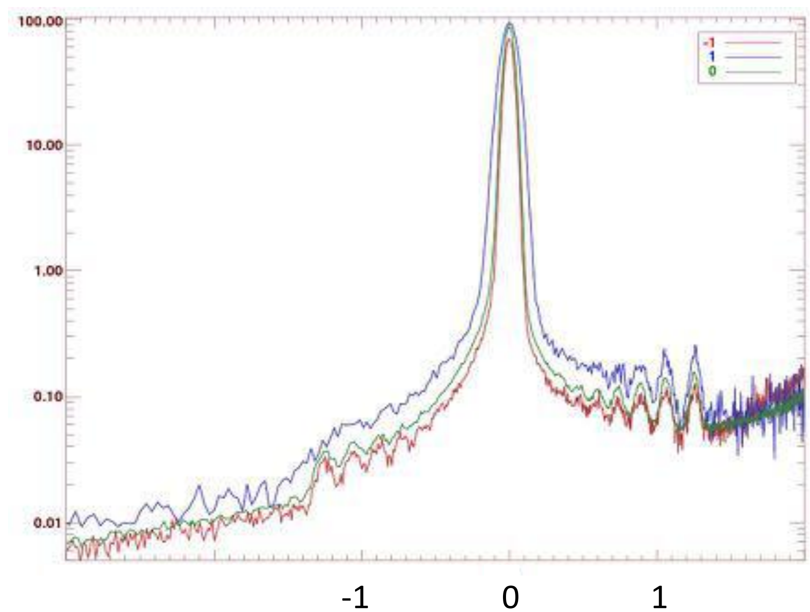
IN6 / Sharp: Scientific Fields





Study of dynamics and relaxation properties in condensed matter. Nuclear and Magnetic scattering

- Vibrational density of states of crystalline and amorphous solids
- Dynamics of soft condensed matter: polymers, proteins, biological membranes and gels
- Diffusion of liquids, and confined systems
- Properties of quantum liquids, Fermi and non-Fermi systems
- Phase transitions and quantum critical phenomena in polycrystals and single crystals
- Spin dynamics in high-T_c superconductors
- Properties of crystal field splittings



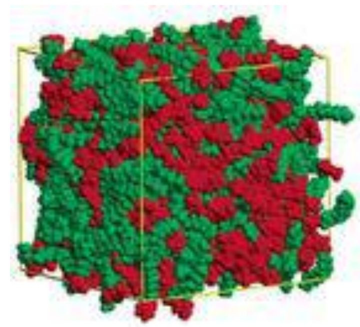
IN6 / Sharp: Exemple

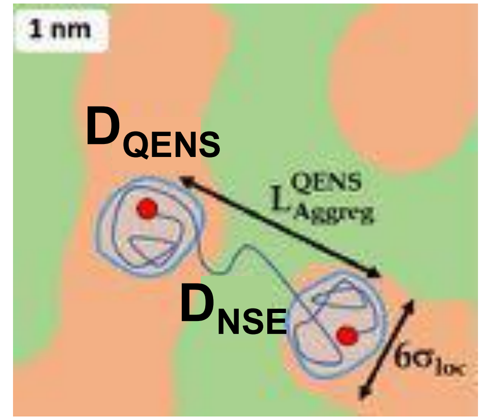
Ionic Liquids dynamics probed by neutron scattering

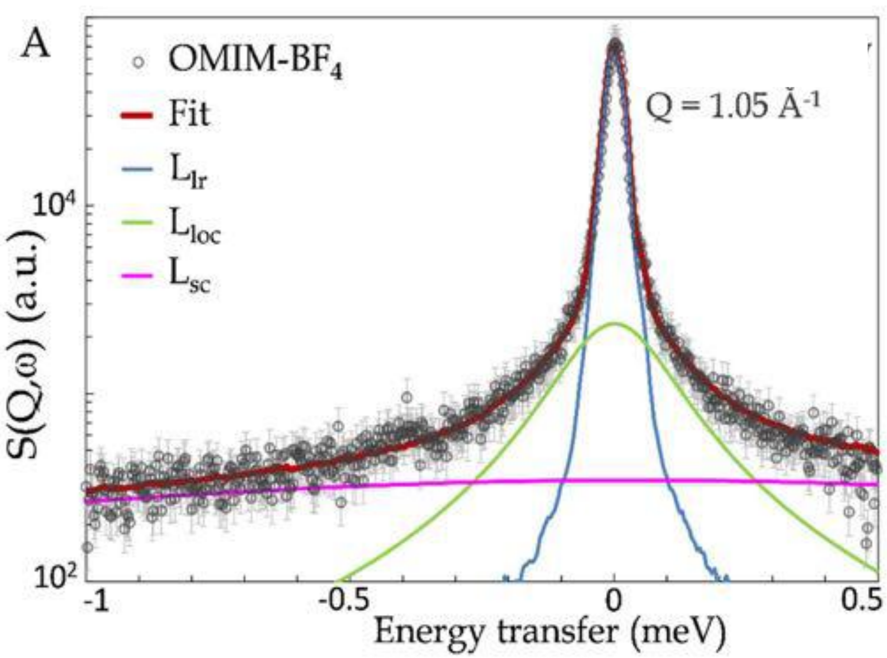
$S(\vec{Q},\omega)$: time (ω) and space (Q) depence of motions

Hydrogen sensitive technique

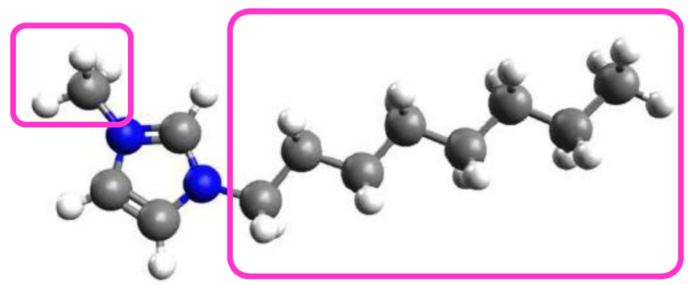
- ω → Energy transfer
- $\vec{Q}$ → Momentum transfer



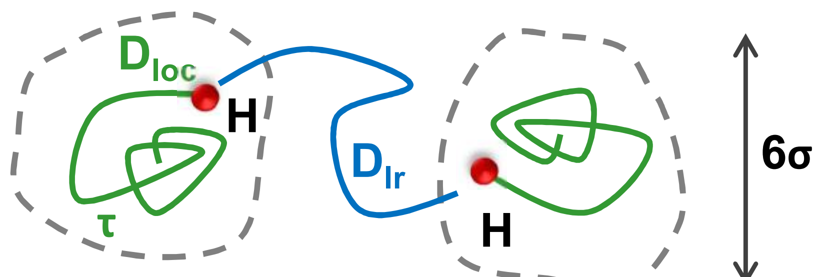




- Reorientation of the side-chains



- Translation of the cation



F. Ferdeghini *et al.*, Nanoscale, 2017 Volino et al., JPC, 2006

IN6 / Sharp: Exemple

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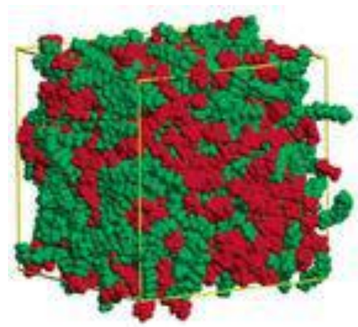
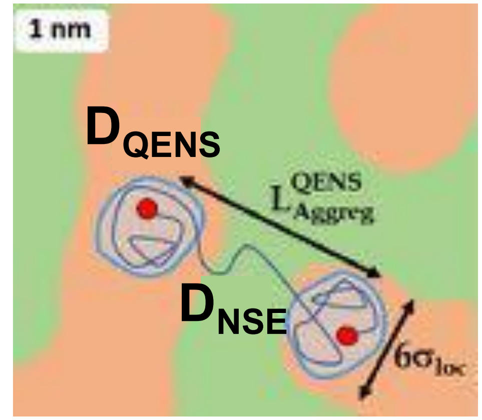
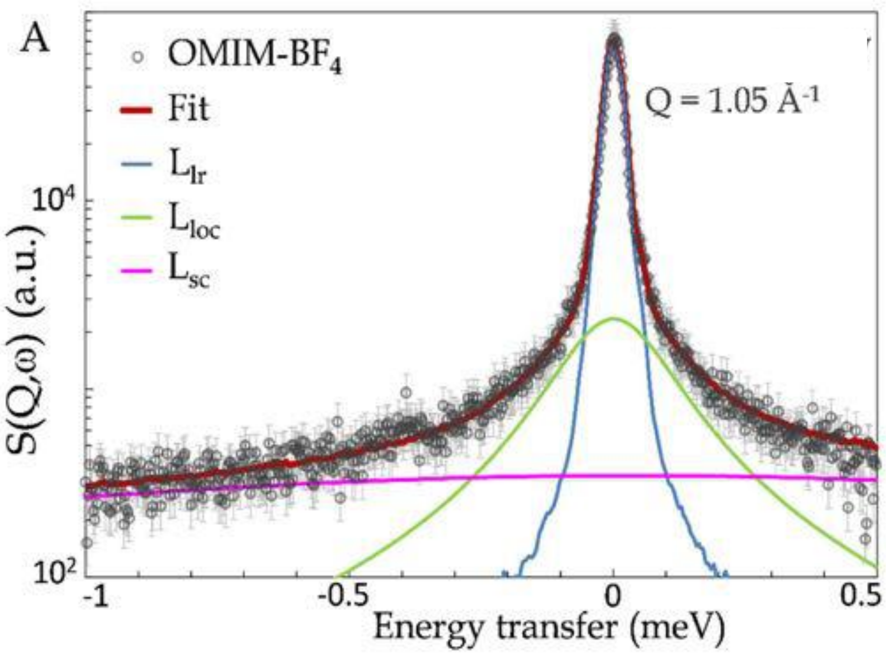
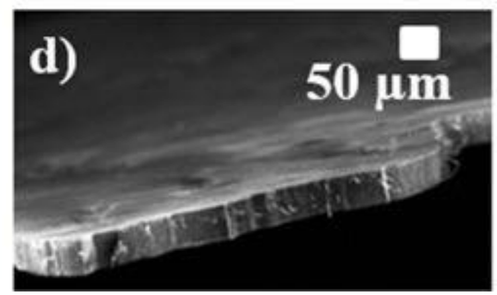








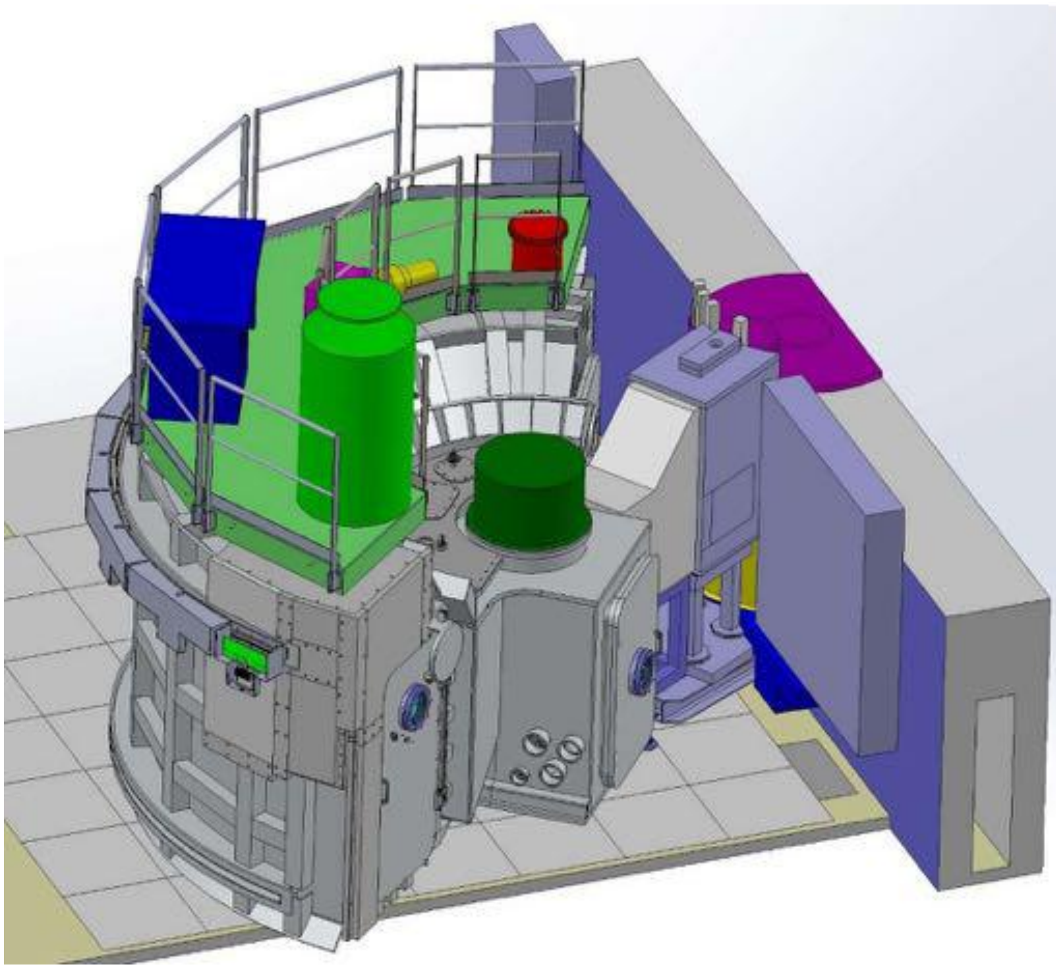
F. Ferdeghini *et al.*, Nanoscale, 2017

Volino et al., JPC, 2006

Q. Berrod *et al.*, Nanoscale, 2016

SHARP: a French CRG @ ILL

Contract signed on October 29 2017: 50% 2FDN + 50% ILL beam time
New ToF chamber: march 2020



The Sharp LLB Group:

Responsible:	JMarc Zanotti*
Co-responsible:	Quentin Berrod
	Sylvain Petit
Engineer:	Sylvain Rodrigues
Engineering support:	Pascal Lavie
Technical responsible:	Benoit Homatter *
Technical Support:	Frédéric Legendre
	Fabien Prunes

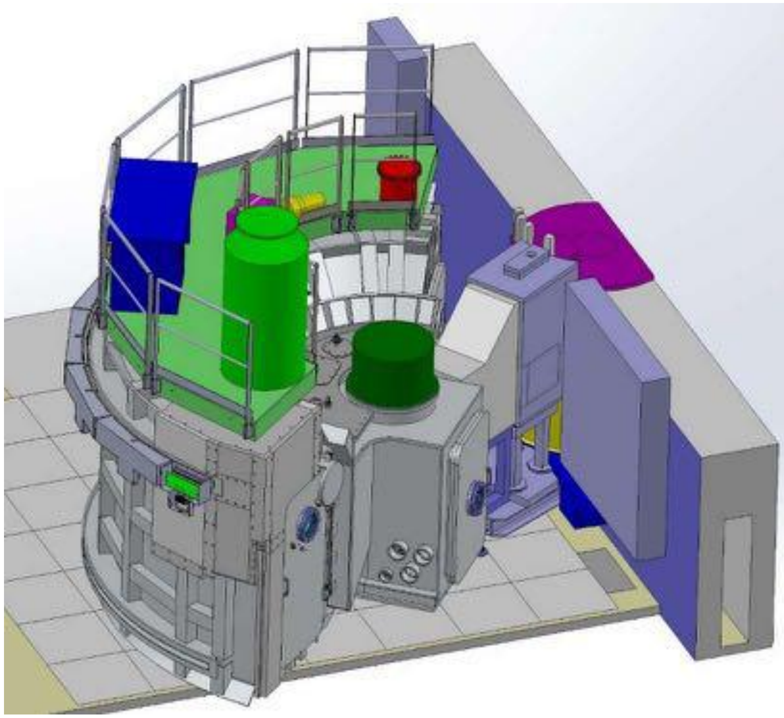
and the LLB technical teams

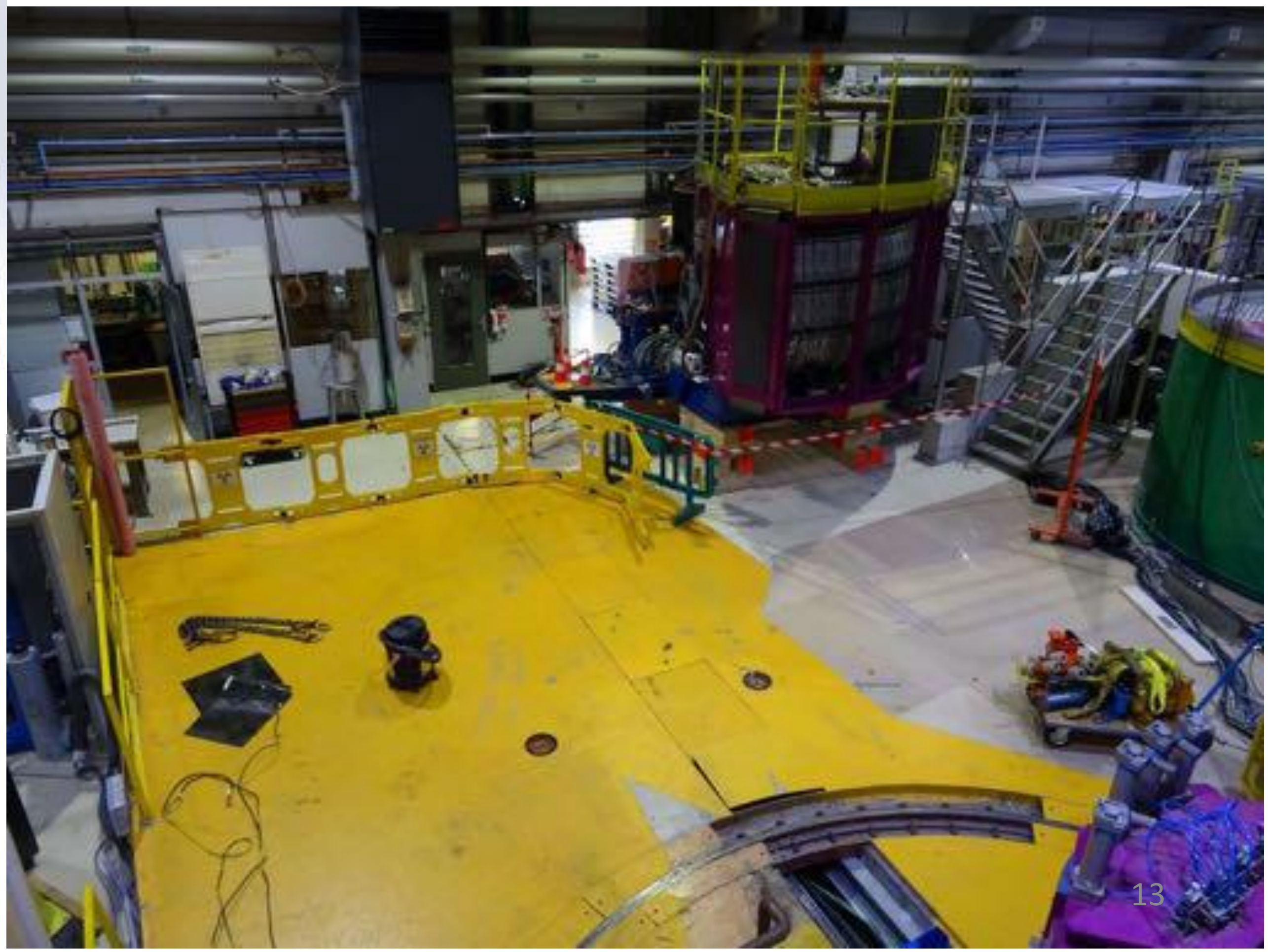
*: LLB personnel on site at ILL.

From IN6 to a Spectromètre Hybride Alpes Région Parisienne SHARP

French CRG from Octobre 29 2017-

A brand new secondary spectrometer:





From IN6 to a Spectromètre Hybride Alpes Région Parisienne
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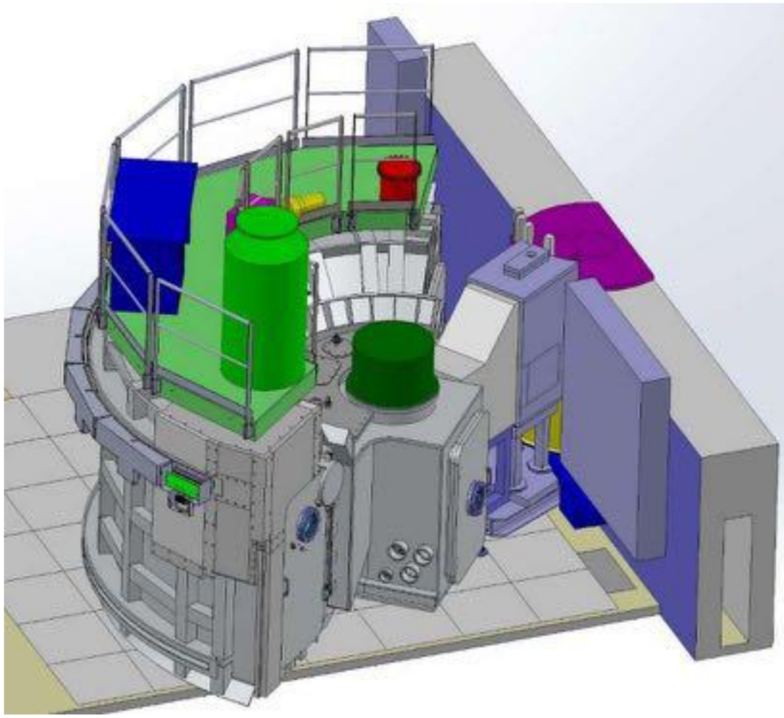

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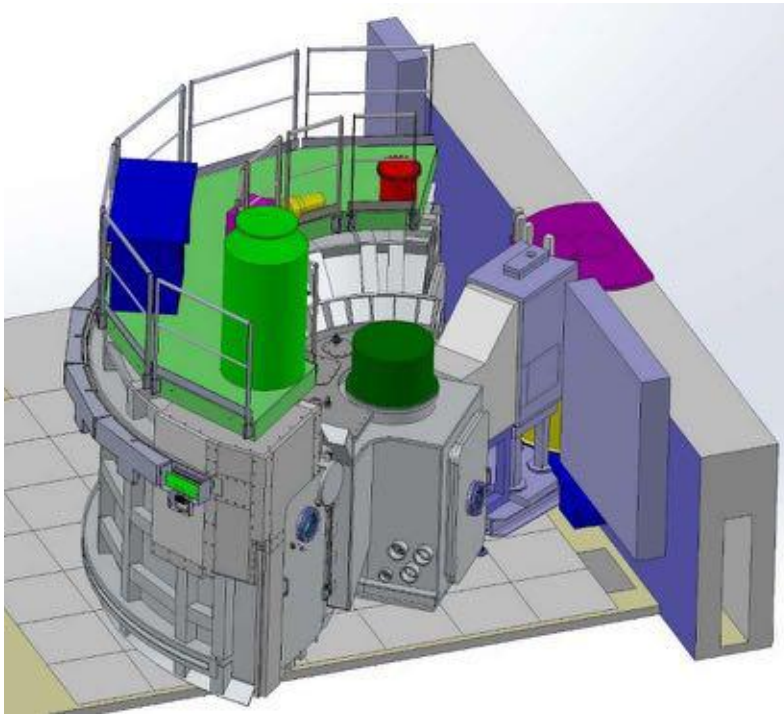

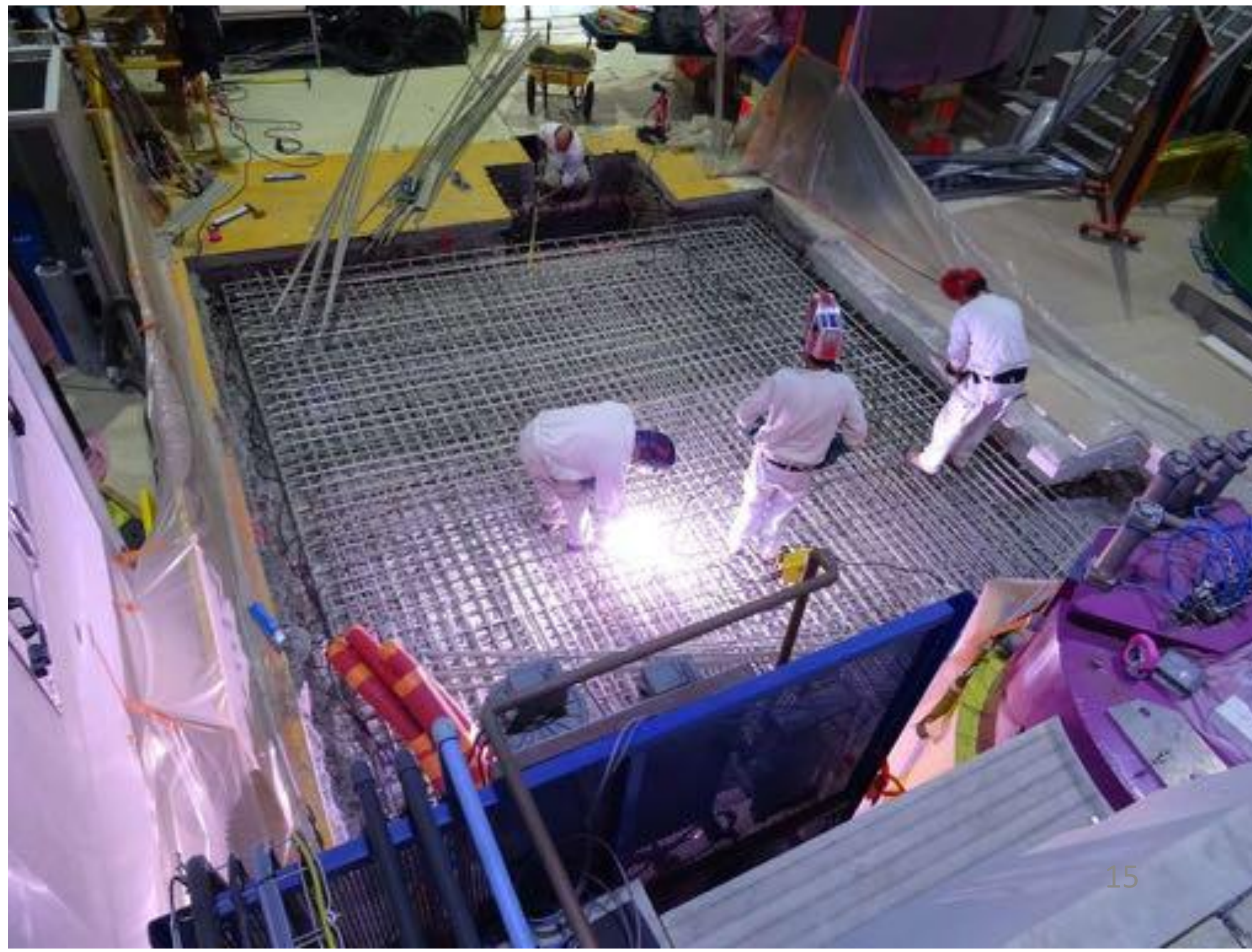

From IN6 to a Spectromètre Hybride Alpes Région Parisienne SHARP

French CRG from Octobre 29 2017-

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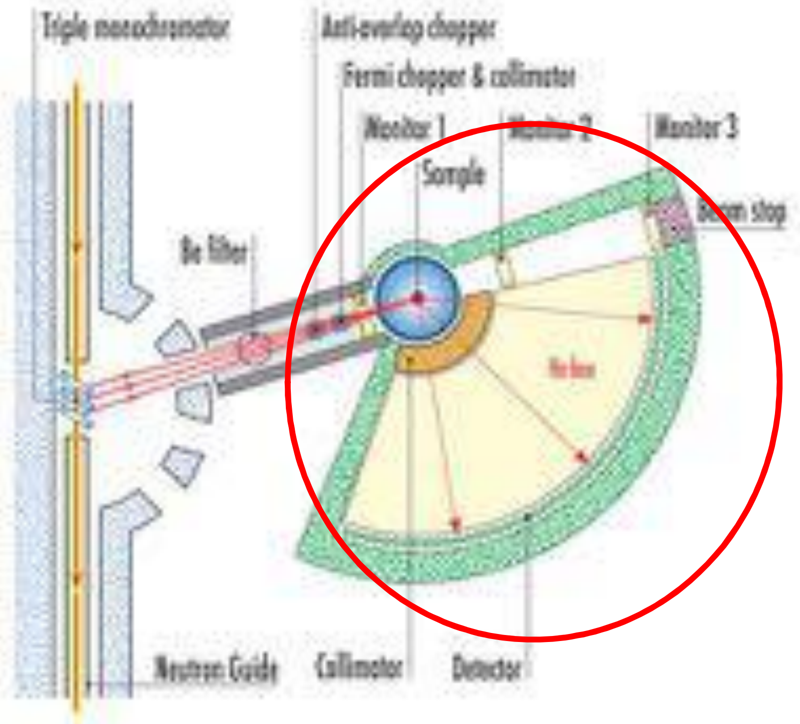
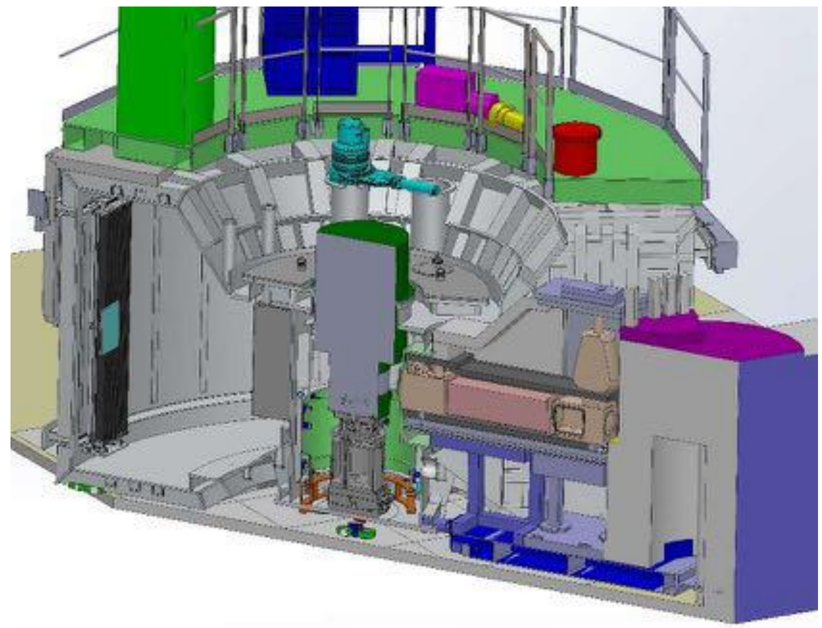
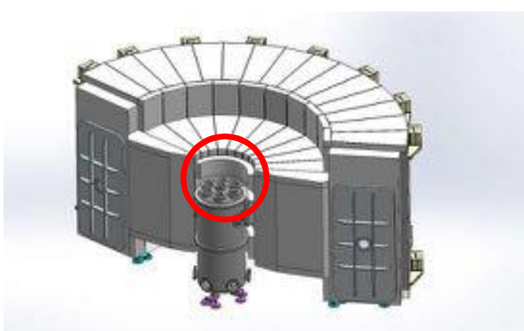


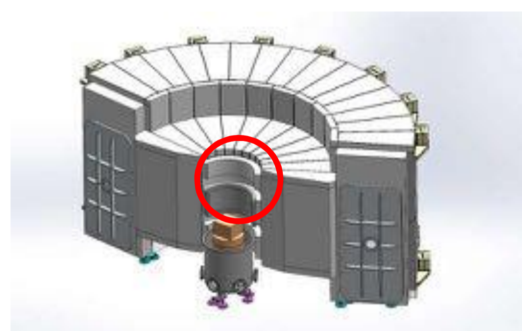
- ToF chamber (2.5 m) under vacuum
- Full Sample environment with
  2 modes: atmospheric *vs* under vacuum mode



- Under vacuum mode



- Atmospheric mode

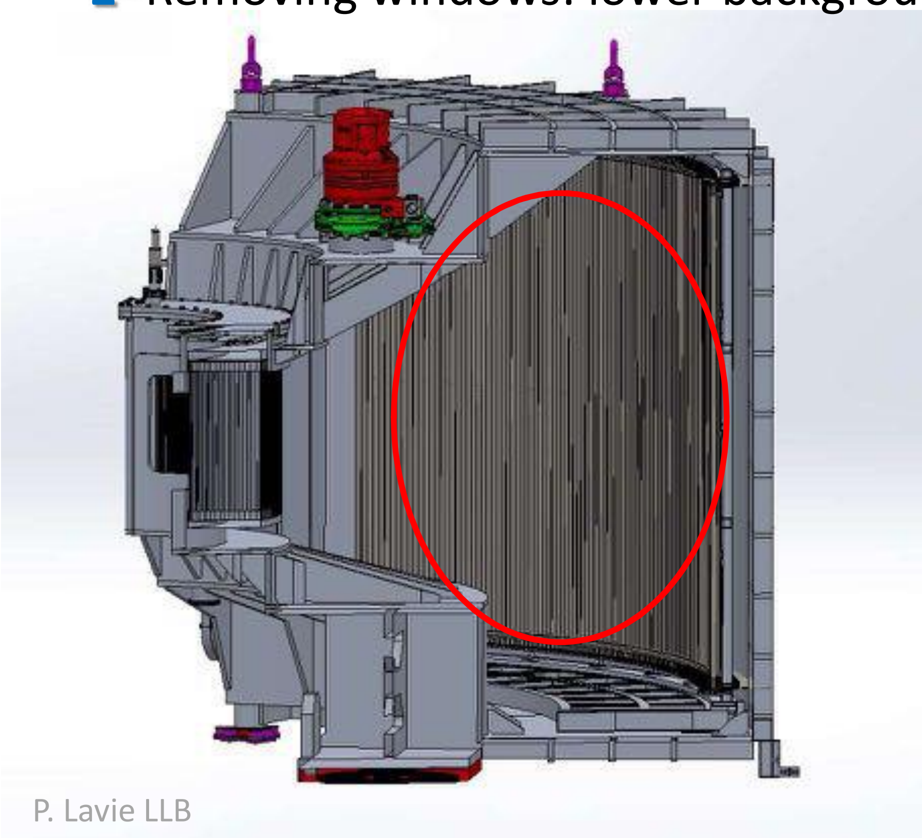


SHARP
a major improvement: 240 ^{3}He PSD detectors (5 bars)

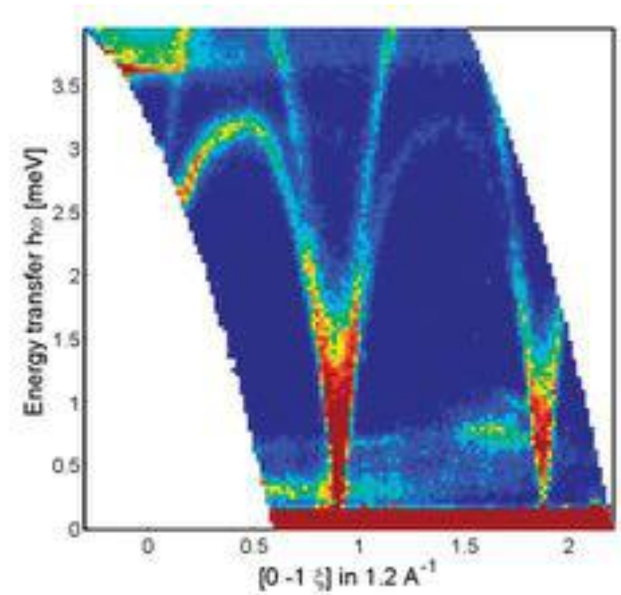
PSD: Position Sensitive Detectors

1- Detection coverage / counting rate:
Gain of a factor 2 compared to IN6.

2- Removing windows: lower background.



3- State of the art PSDs +electronics assembly: breathtaking joint Q definition and resolution performances.



Magnon dispersion curves of BNFS at T = 2 K [1]. This experimental curve as been measured on IN5C (ILL, France).

4- Extended *Q* range (up to 2.9 Å^{-1}).

[1] M. Loire, V. Simonet, S. Petit, K. Marty, P. Bordet, P. Lejay, J. Ollivier, M. Enderle, P. Steffens, E. Ressouche, A. Zorko, and R. Ballou, Parity-Broken Chiral Spin Dynamics in $Ba_3NbFe_3Si_2O_{14}$, PRL 106, 207201 (2011).

Schedule
Octobre 29 2017- August 31 2023

- March 8 2018 - October 2019:

"Normal" IN6 operation
Operated by LLB personnel (2 Scientists, 1 Technician)
50% French time + 50% ILL time

- November 2019 – August 2020 (ILL long shutdown):

Deconstruction of the IN6 secondary spectrometer + Infrastructure Work
Delivery and furbishing (Cd coverage, PE protections, electronics) of the new detector box

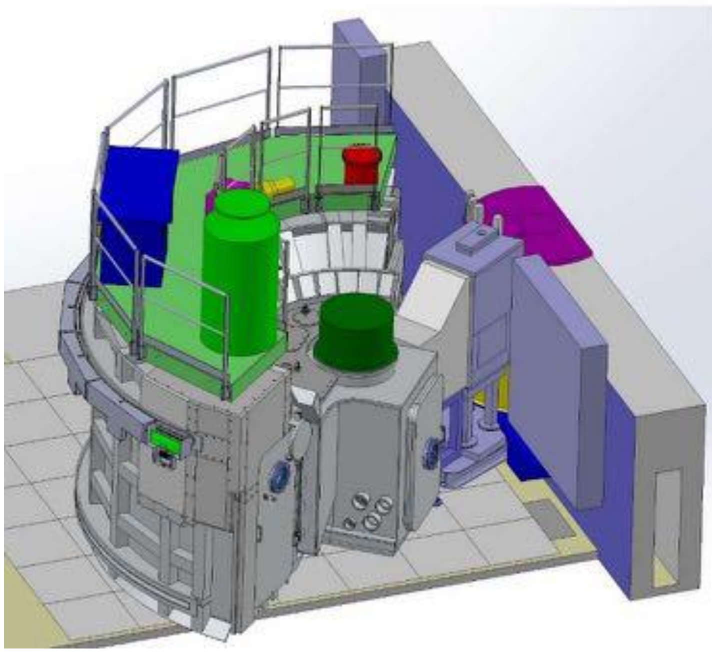
- September 2020 – August 31 2023:

Back to normal operation with a brand new secondary spectrometer.

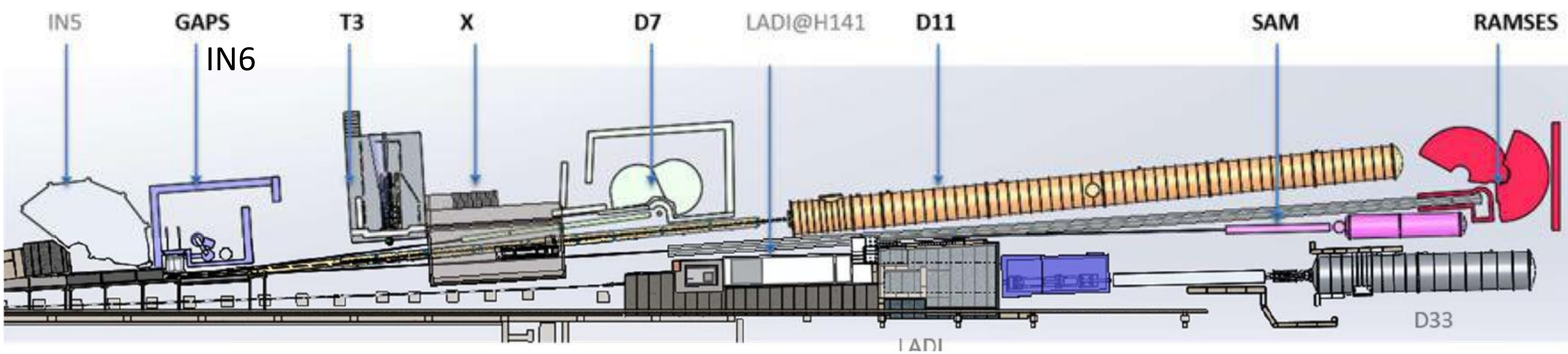
After September 1st 2023, how about a Super-SHARP (RAMSES) ?

Depending on the funding success of the phase 2 of the ILL Endurance program,
SHARP moved to a new position with dedicated guide.
Then extended wavelength (2.0 - 12 Å) coverage can be offered.

RAMSES: a super SHARP ?



SHARP: contract ends in 2023
Relocation: end of guide position
CRG ?
Benefits: - Extended inc. wavelength (2.0 -12 Å)
- High flux: brand new dedicated guide
- Monochromatic focusing



CSpec: The cold chopper spectrometer of the ESS

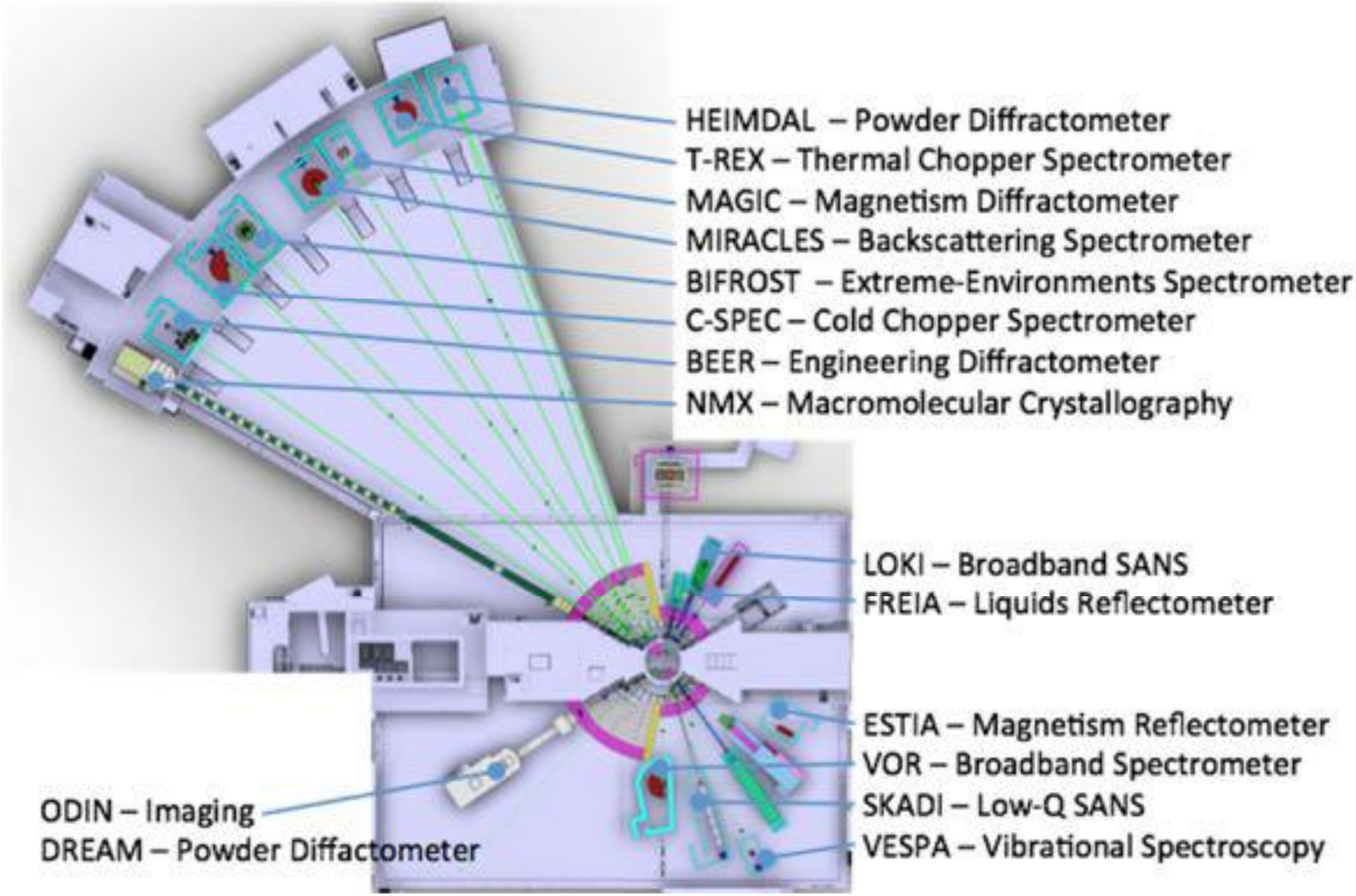
Lead Scientist: P.P.Deen (TUM)
Lead Engineer: Joseph Guyon-le-Bouffy (LLB)

TUM (50%): W. Lohstroh, J. Neuhaus, W. Petry
LLB (50%): S. Longeville, C. Alba-Simionesco

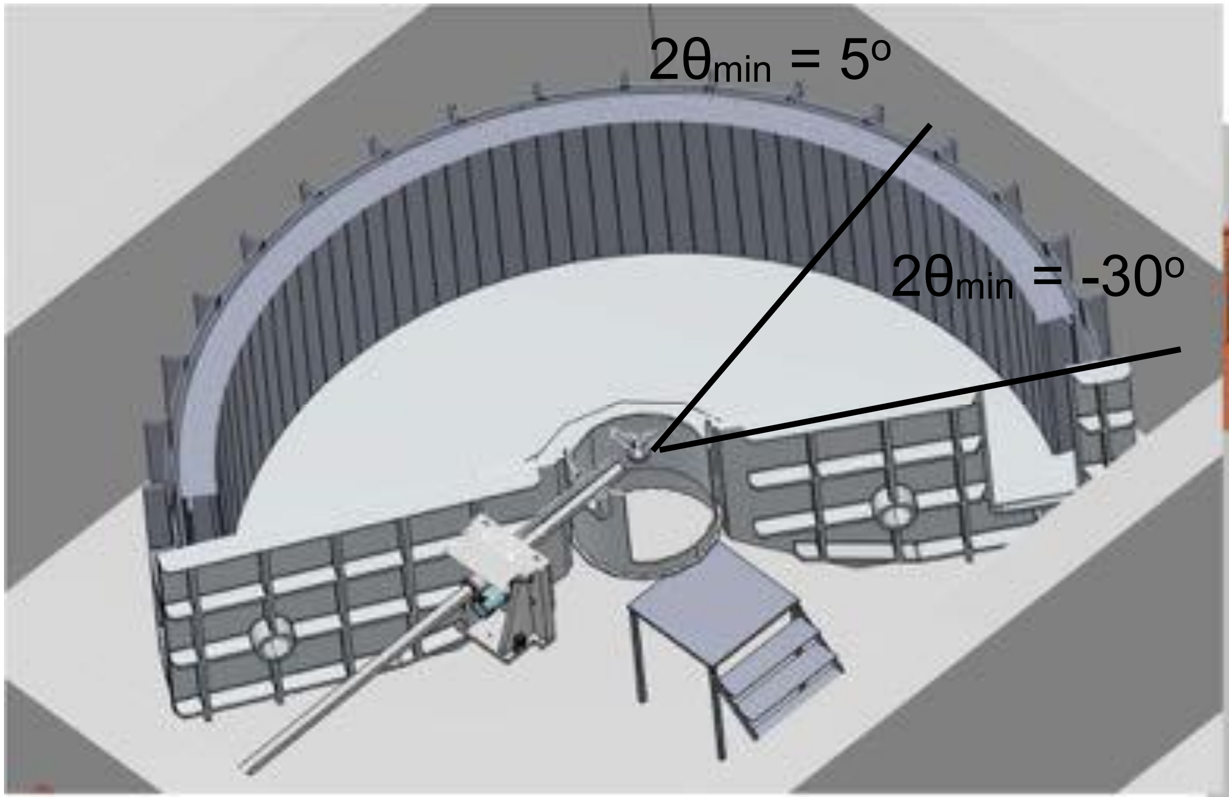
& N. Tsapatsaris (ESS), D. DiJulio (ESS), D. Rodriguez(ESS), H. Schneider(ESS), A. Sandstrom(ESS), M. Anastasopoulos (ESS),G. Laszlo (ESS), C. Lopez, P. Link(TUM)
H. Meier(TUM), J. Huber (TUM), A. Cazenave (LLB), S. Desert(LLB).

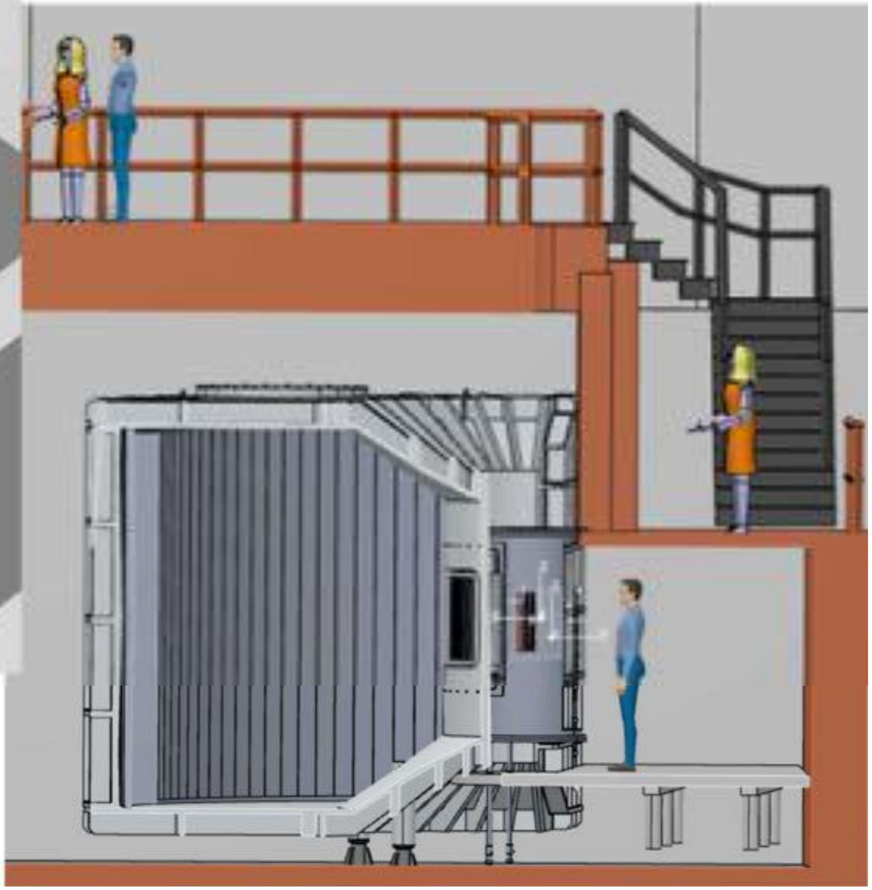
European Spallation Source
(ESS)
Lund, Sweden
5MW

CSpec

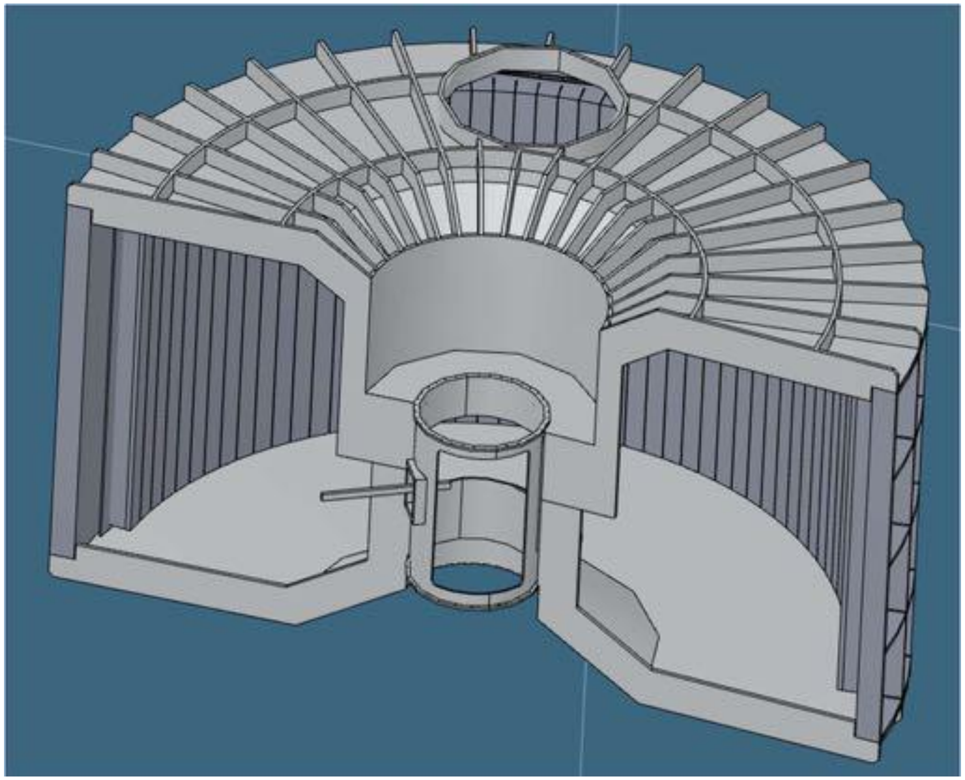

HEIMDAL – Powder Diffractometer
T-REX – Thermal Chopper Spectrometer
MAGIC – Magnetism Diffractometer
MIRACLES – Backscattering Spectrometer
BIFROST – Extreme-Environments Spectrometer
C-SPEC – Cold Chopper Spectrometer
BEER – Engineering Diffractometer
NMX – Macromolecular Crystallography
LOKI – Broadband SANS
FREIA – Liquids Reflectometer
ESTIA – Magnetism Reflectometer
VOR – Broadband Spectrometer
SKADI – Low-Q SANS
VESPA – Vibrational Spectroscopy
ODIN – Imaging
DREAM – Powder Diffactometer

Detector tank & sample environment pot





Detector tank



Sample - Detector = 3.5 m, +/- 26.5°

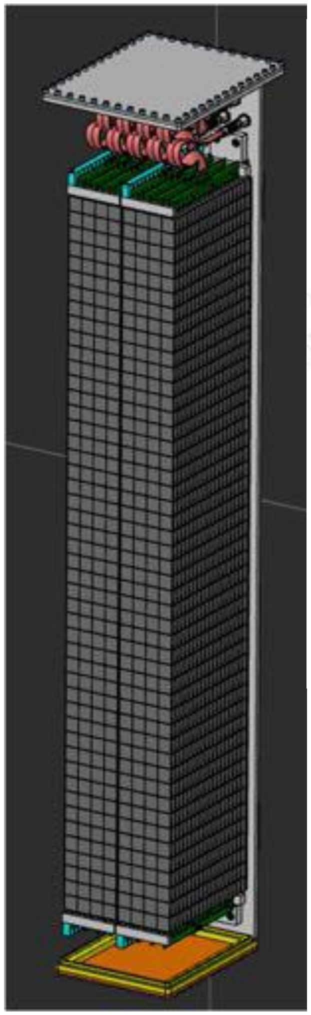
Angle coverage -30° to 140°

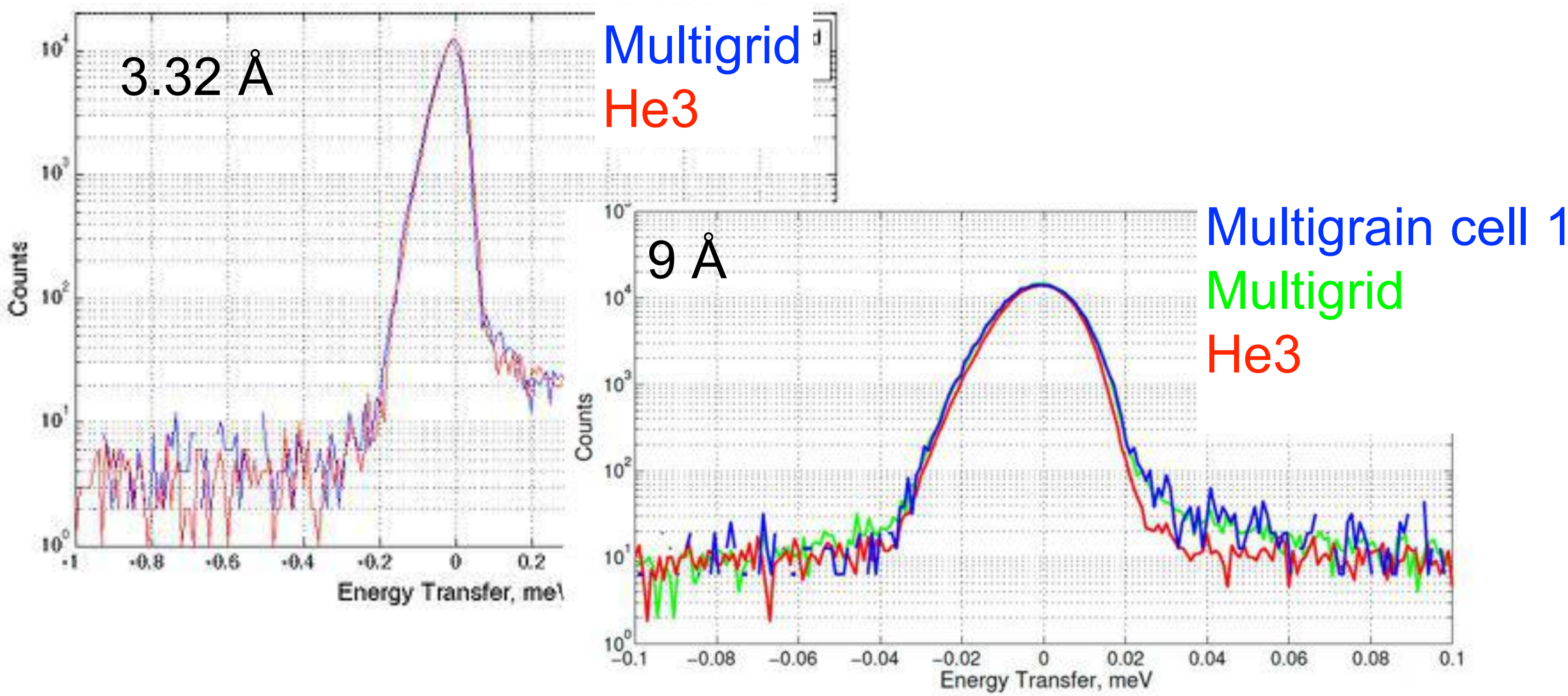
Detector height = 3.5 m

Pressure = 10^{-6} mbar

Sample environment:
accessible from top/side
optimised for in-situ studies

^{10}B multigrid detector technology for CSPEC.





CNCS test: 1.1 m high

Courtesy of M .Anastasopoulos

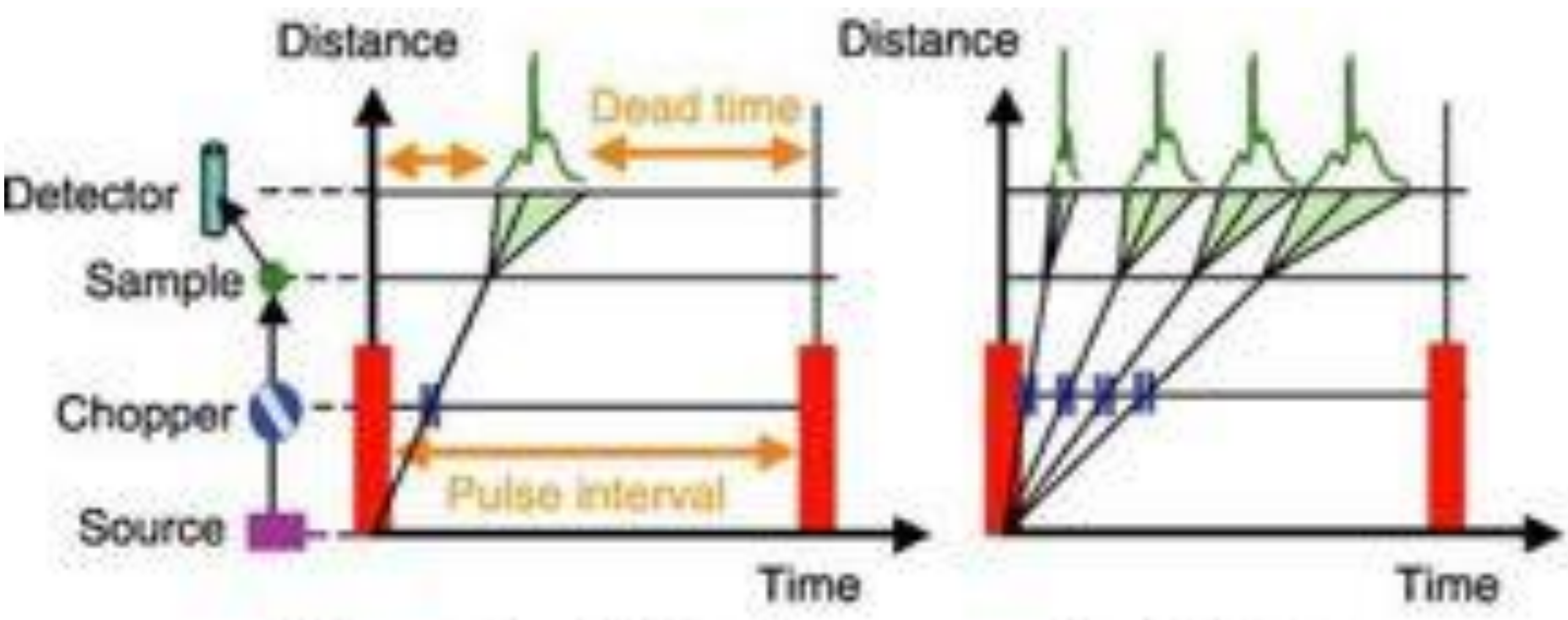
B10 multigrid at CNCS (SNS) (comparison with 6 bar He3)
Successful with further detailed tests underway

Larger scale test model on TOFTOF foreseen

C-Spec

14 Hz (source) versus 50-150 Hz (TOF spectroscopy)

Repetition Rate Multiplication (RRM) = Multi wavelength mode

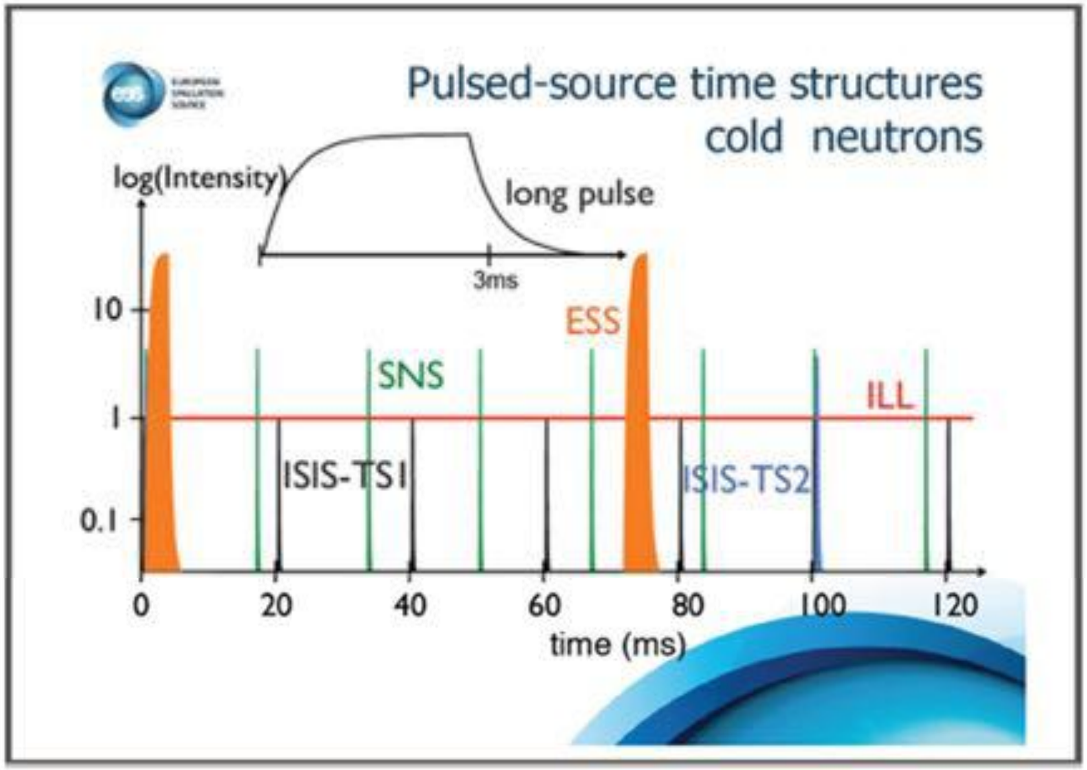


Conventional ToF

RRM

Direct chopper spectrometer at LPSS

ESS a 5MW spallation source with 14 Hz and a PW=2.86 ms



K. Anderson (2011), ESS

ESS vs ILL

Intensity: ESS = 24 × ILL
10 RRM ESS = 240 × ILL

ILL: 1 pulse / 10 ms (80 Hz)
ESS: 1 pulse / 70 ms (14 Hz)

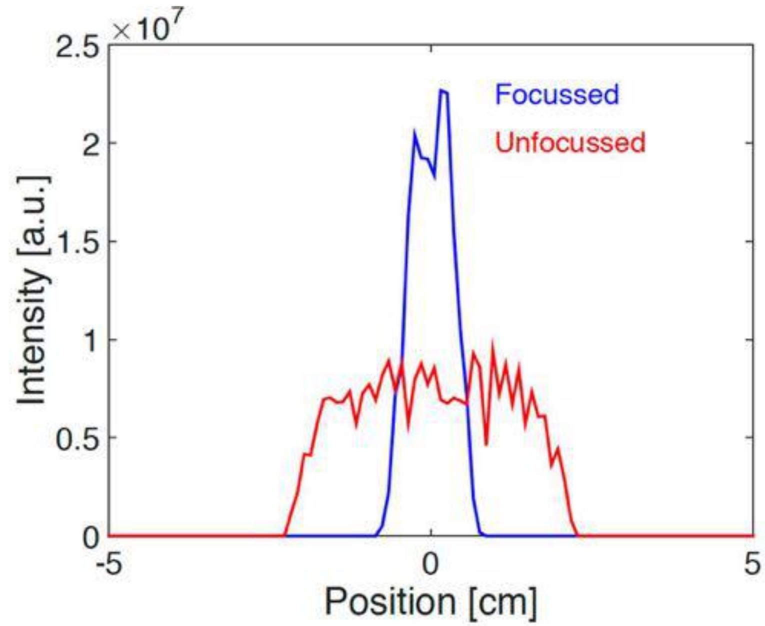
Intensity Theoretical gain:
ESS ~ 40 × ILL

C-Spec

- High flux instrument
- Incident wavelength: 2 – 20 Å
- Energy resolution: 7 – 150 μeV ΔE/E = 1 - 3 %
- 0.5 < Q < 6 $Å^{-1}$
- Excellent signal to noise:

⇒ noise ∝ $1/distance^2$

- In-situ measurements, smaller samples
- Sample Changer inside the cryostat



ESS favorable for ToF but not for all techniques

Specific attention is devoted to:

- Data storage ?
- RRM: how to manage the data analysis ?

Running cost ?

What about the users community ? A technique for highly trained users ..

TECHNISCHE UNIVERSITÄT MÜNCHEN

Orphée Laboratoire Léon Brillouin

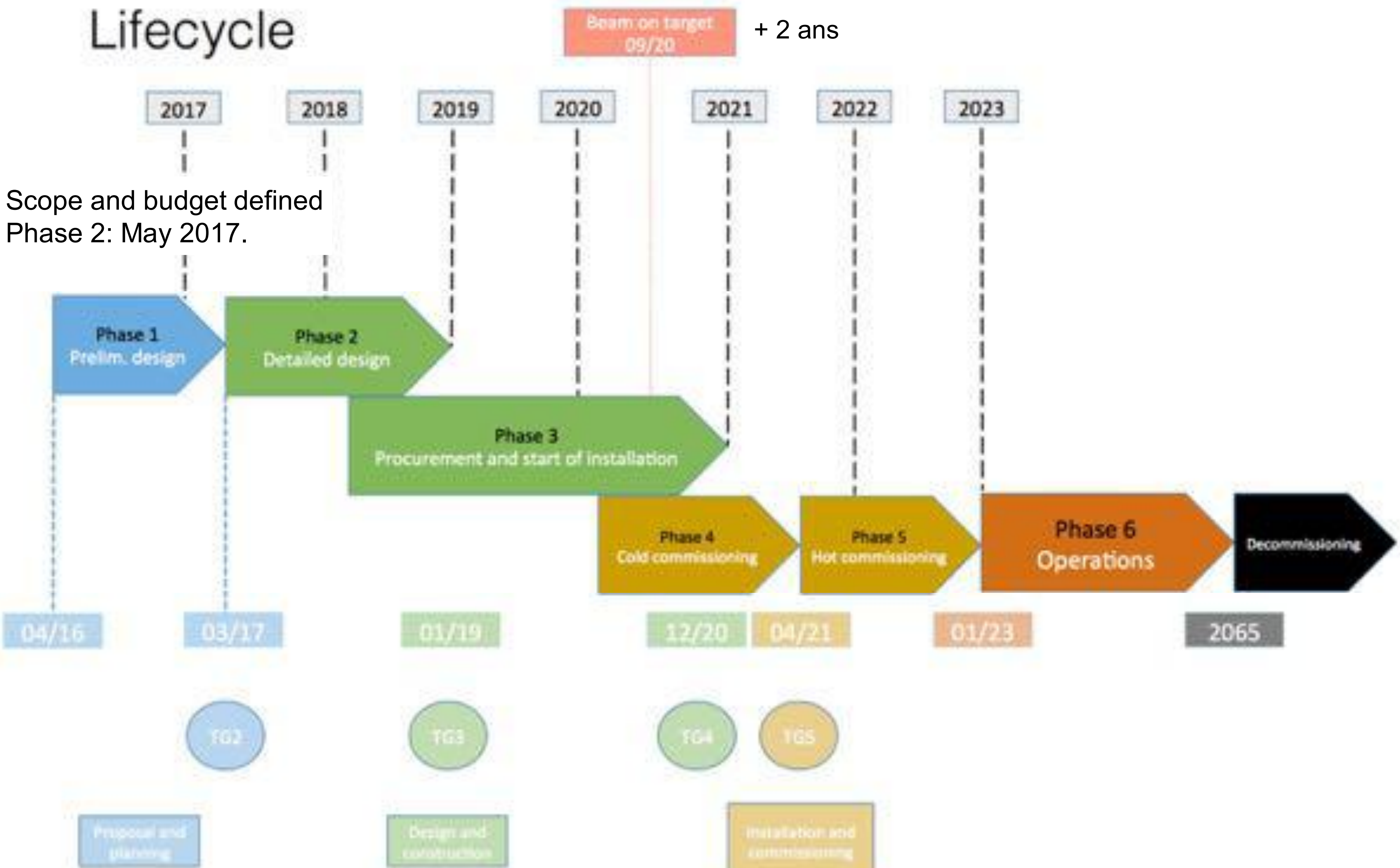
CSpec

EUROPEAN SPALLATION SOURCE

Lifecycle

+ 2 ans

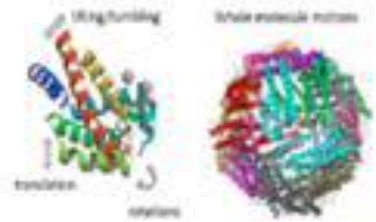
Scope and budget defined Phase 2: May 2017.



C-Spec

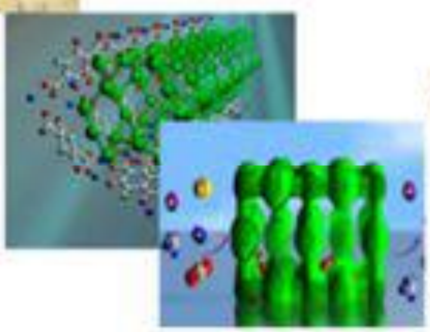
Science case

Soft matter : Multi-scale ξ ~ 10 - 1000 Å, 10^{-12} up 10^4 s, low energy lattice modes.

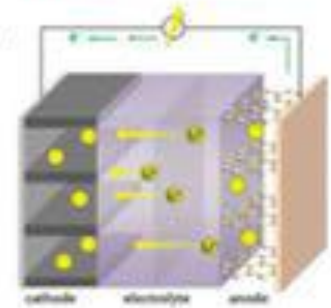


V. García Sakai, A. Arbe
Current Opinion in Colloid & Interface Science 14 (2009) 381–390

CO_2, H-storage: diffusion, range of lattice modes.



Gas storage and catalysis. Few Studies (flux limited)
In-operando kinetics: second - hour timeframe
Requires two orders of magnitude in flux.
S. Yand, et al. Nature Chemistry, 2012, 4, 887-894



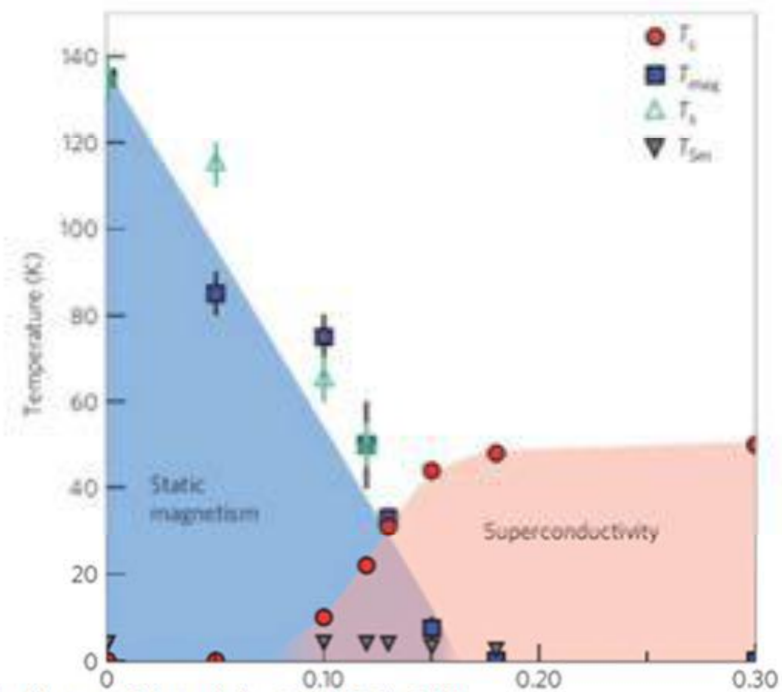
Battery materials: very few in-situ studies

Magnetism: High pressure, high magnetic field and low temperature simultaneously. Out of equilibrium physics

Most importantly:

Current: Fe-arsenide single crystals

Small single crystals: high quality, few imperfections.
High pressure synthesis:global behaviour.
Study many stochiometries
Study high absorption isotopes.
Magnetic multilayers.



AJ Drew et al., Nature Materials 8 (2009) 310

TECHNISCHE UNIVERSITÄT MÜNCHEN

Orphée Laboratoire Léon Brillouin

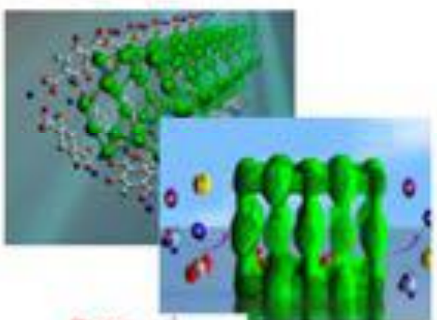
C-Spec

EUROPEAN SPALLATION SOURCE

Perform in-operando studies on the second timeframe. Probe time dependent phenomena

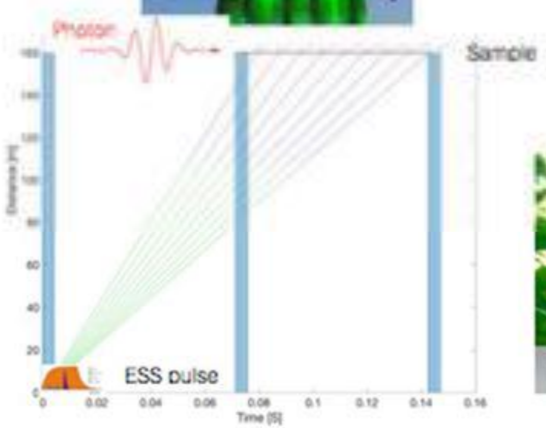
Currently flux limited, requires 1 - 2 orders of magnitude in flux ⇒ CSPEC.

Ionic transport: determines the efficiency of fuel cells & batteries. Improvement of ion conductivity imperative to improve efficiencies:



Batteries & fuel cells Ionic transport under real conditions
Next generation energy supplies.

Gas storage & catalysis Transient stages during hydrogen uptake and release, in a gas atmosphere, are difficult to address. In-operando kinetics:second - hour.
S. Yand, et al. Nature Chemistry, 2012, 4, 887-894



Life science & pump probe measurements:

Correlations between the light harvesting processes of a pigment/protein complex involved in photosynthesis and its internal dynamics.