

SuperSUN

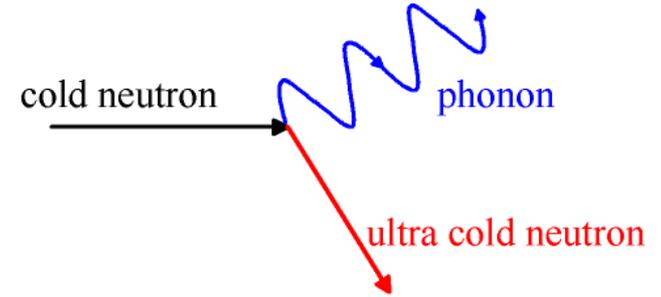
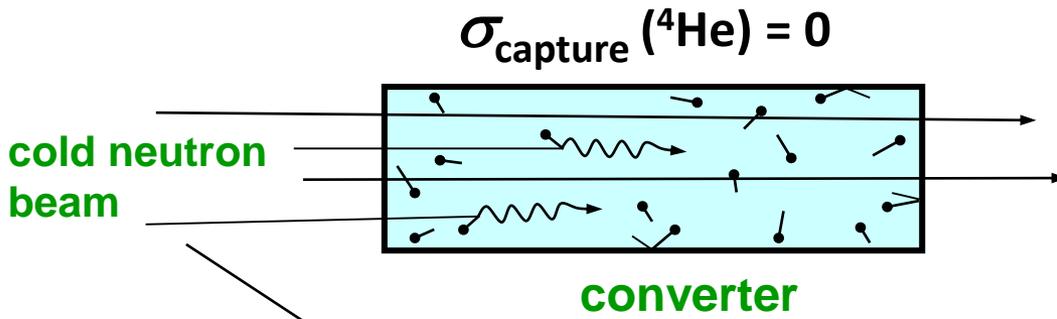
new infrastructure for experiments
with ultracold neutrons

Oliver Zimmer



PSI2016, 17 October 2016

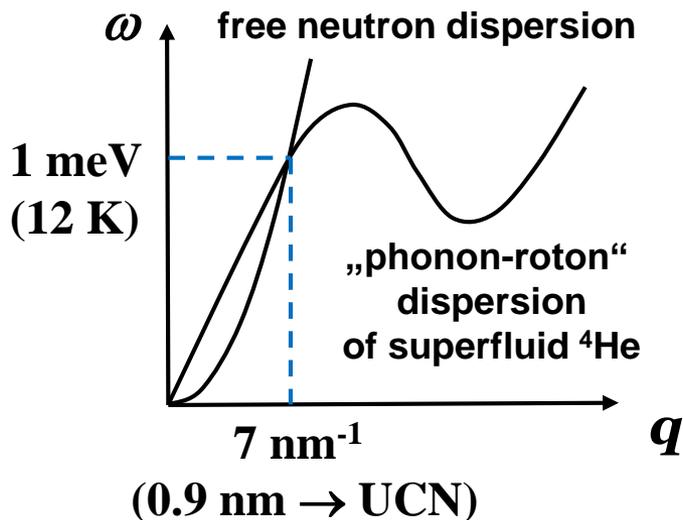
UCN production in He-II



$$\rho_{\text{UCN}} = P\tau$$

$$\tau^{-1} = \tau^{-1}_{\text{decay}} + \tau^{-1}_{\text{upscattering}} + \tau^{-1}_{\text{capture}} + \tau^{-1}_{\text{wall losses}}$$

T [K]	τ_{max} [s]
1	100
0.8	310
0.7	510
0.5	820
0	880



\rightarrow need $T < 0.5 - 0.6 \text{ K}$
and low-loss walls

Source prototypes “SUN-1” & “SUN-2” (≥ 2004)

window- and gap-less vertical UCN extraction

Schmidt-Wellenburg & Zimmer, *Cryogenics* **46** (2006) 799

Zimmer et al., *Phys. Rev. Lett* **99** (2007) 104801

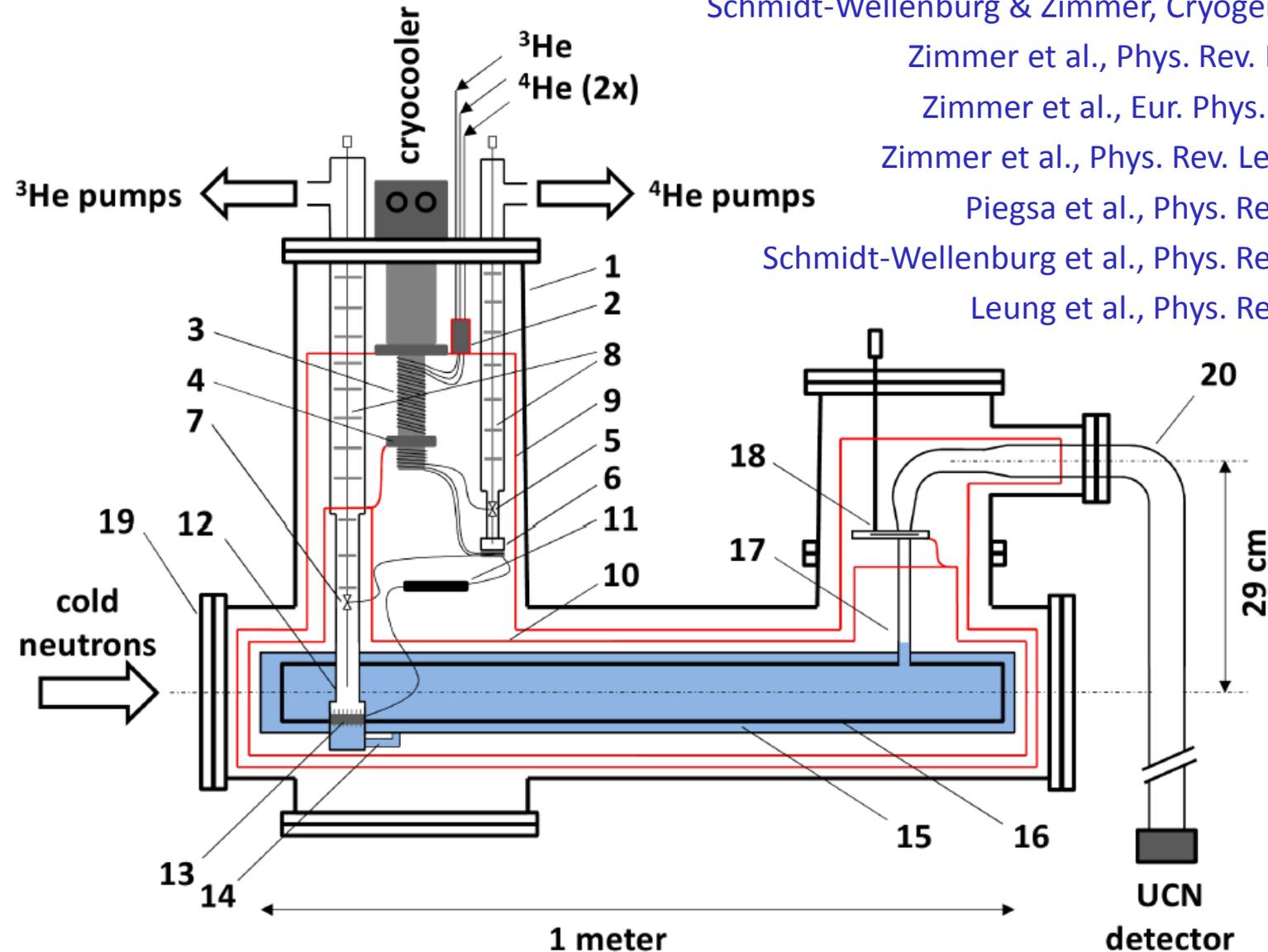
Zimmer et al., *Eur. Phys. J. C* **67** (2010) 589

Zimmer et al., *Phys. Rev. Lett.* **107** (2011) 134801

Piegsa et al., *Phys. Rev. C* **90** (2014) 015501

Schmidt-Wellenburg et al., *Phys. Rev. C* **92** (2015) 024004

Leung et al., *Phys. Rev. C* **93** (2016) 025501



Performances of **SUN-2** (fomblin-coated converter vessel)

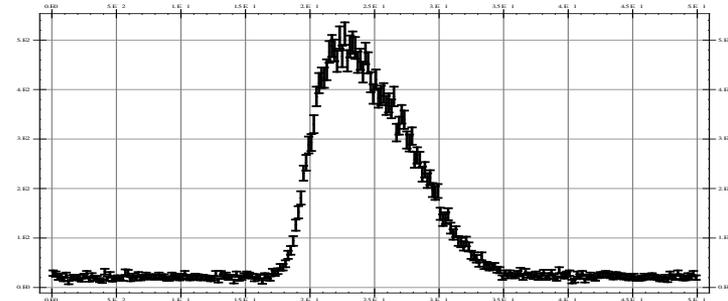
882000 accumulated UCN from 4 litres He-II (0.61 K) $\sim 220/\text{cm}^3$



UCN ToF spectra:

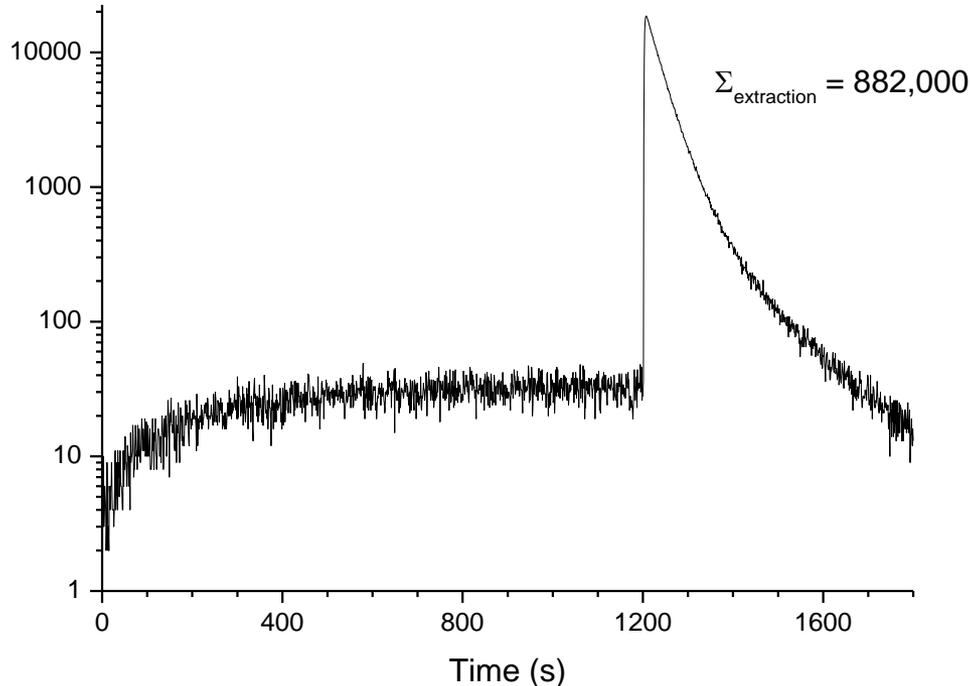
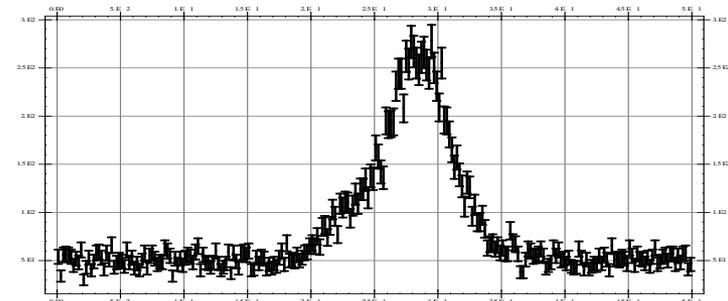
Open converter

$v(\text{max}) = 5.1 \text{ m/s}$, $E_{\parallel} = 144 \text{ neV}$



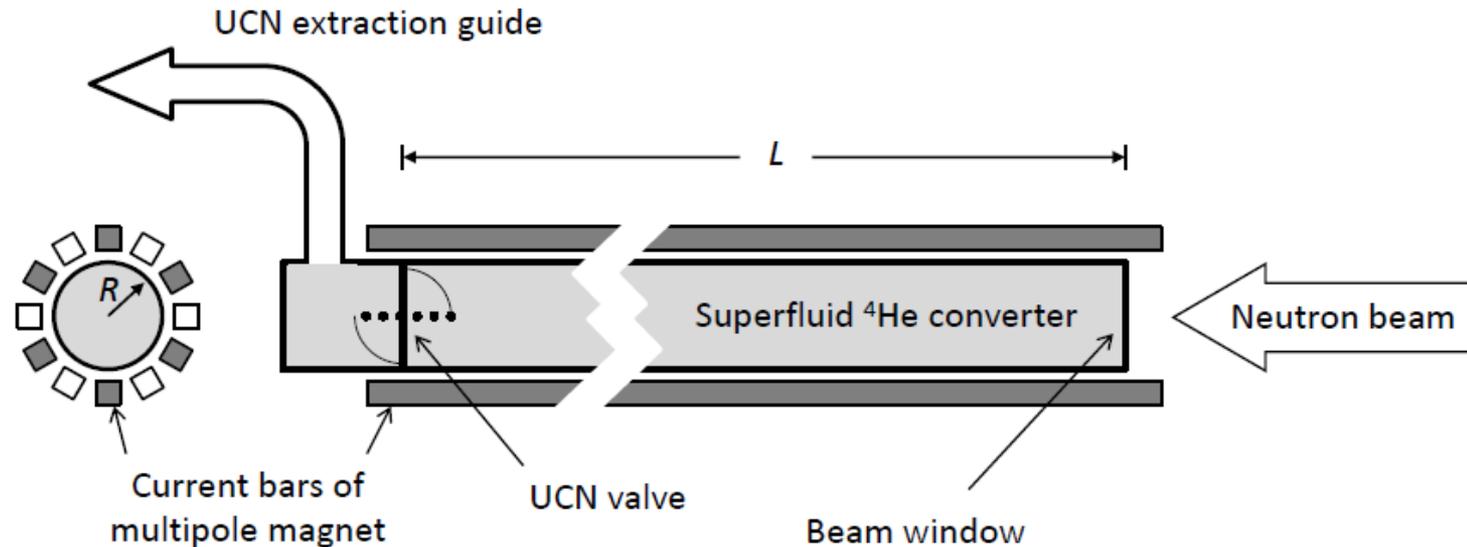
200 s accumulation

$v(\text{max}) = 3.9 \text{ m/s}$, $E_{\parallel} = 81 \text{ neV}$



He-II converter with magnetic UCN reflector: **SuperSUN**

E. Lelievre-Berna, **S. Degenkolb**, Y. Gibert, M. Kreuz, J. Perez-Rios, X. Tonon, O. Zimmer



Advantages:

- **in-situ UCN polarizer**
- **long storage lifetime \rightarrow high saturation UCN density**
- **weak dependence of ρ_{UCN} on wall quality**

Converter volume: **12 litres**

UCN production rate: **10^5 s^{-1} ($E < 230 \text{ neV}$)**

UCN saturation number: **4×10^6 (2018, fomblin spectrum)**

2×10^7 (≥ 2019 , polarised, $E < 230 \text{ neV}$)

Ultracold neutron accumulation in a superfluid-helium converter with magnetic multipole reflector

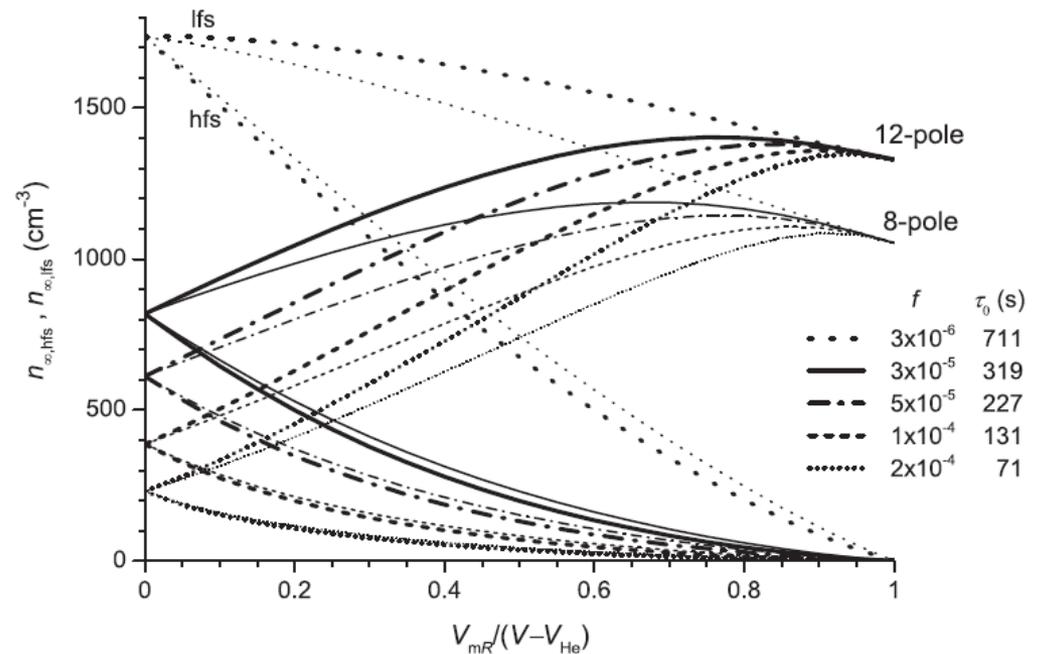
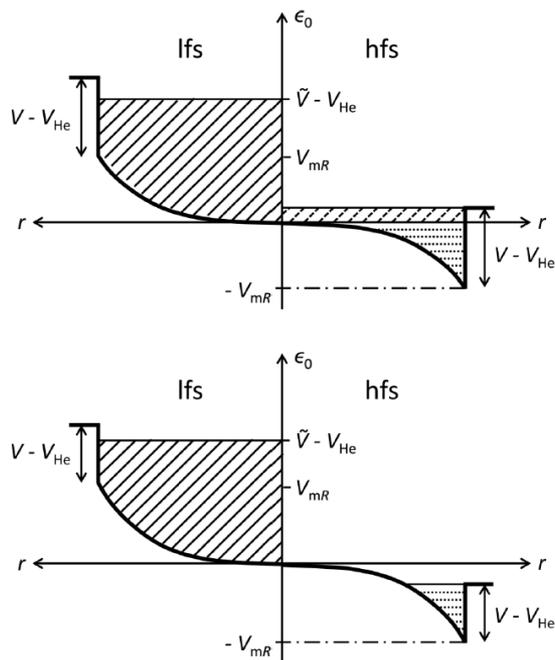
O. Zimmer¹ and R. Golub²

¹*Institut Laue Langevin, 38042 Grenoble, France*

²*Department of Physics, North Carolina State University, Raleigh, North Carolina 27695, USA*

(Received 7 July 2014; revised manuscript received 10 March 2015; published 2 July 2015)

We analyze the accumulation of ultracold neutrons (UCNs) in a superfluid-helium converter vessel surrounded by a magnetic multipole reflector. We solved the spin-dependent rate equation, employing formulas valid for adiabatic spin transport of trapped UCNs in mechanical equilibrium. Results for saturation UCN densities are obtained in dependence of order and strength of the multipolar field. The addition of magnetic storage to neutron optical potentials can increase the density and energy of the low-field-seeking UCNs produced and serves to mitigate the effects of wall losses on the source performance. It also can provide a highly polarized sample of UCNs without need to polarize the neutron beam incident on the converter. This work was performed in preparation of the UCN source project SuperSUN at the Institut Laue–Langevin.



SuperSUN apparatus

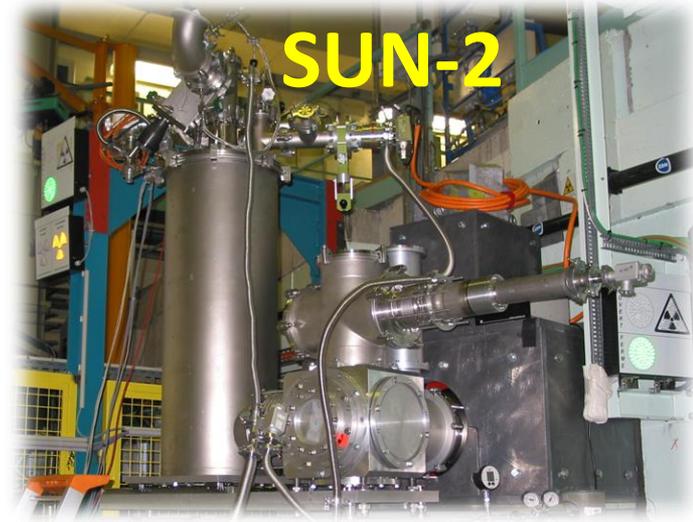


“converter cryostat”

“ ^3He cryostat”



“magnetic trap cryostat”



SuperSUN apparatus



“ ^3He cryostat”

100 l ^4He reservoir

1-K pot with superleaks

^3He circuit...

“converter cryostat”

He-II converter

UCN extraction guide...

“magnetic trap cryostat”

superconducting multipole

^4He reservoir...

SuperSUN apparatus

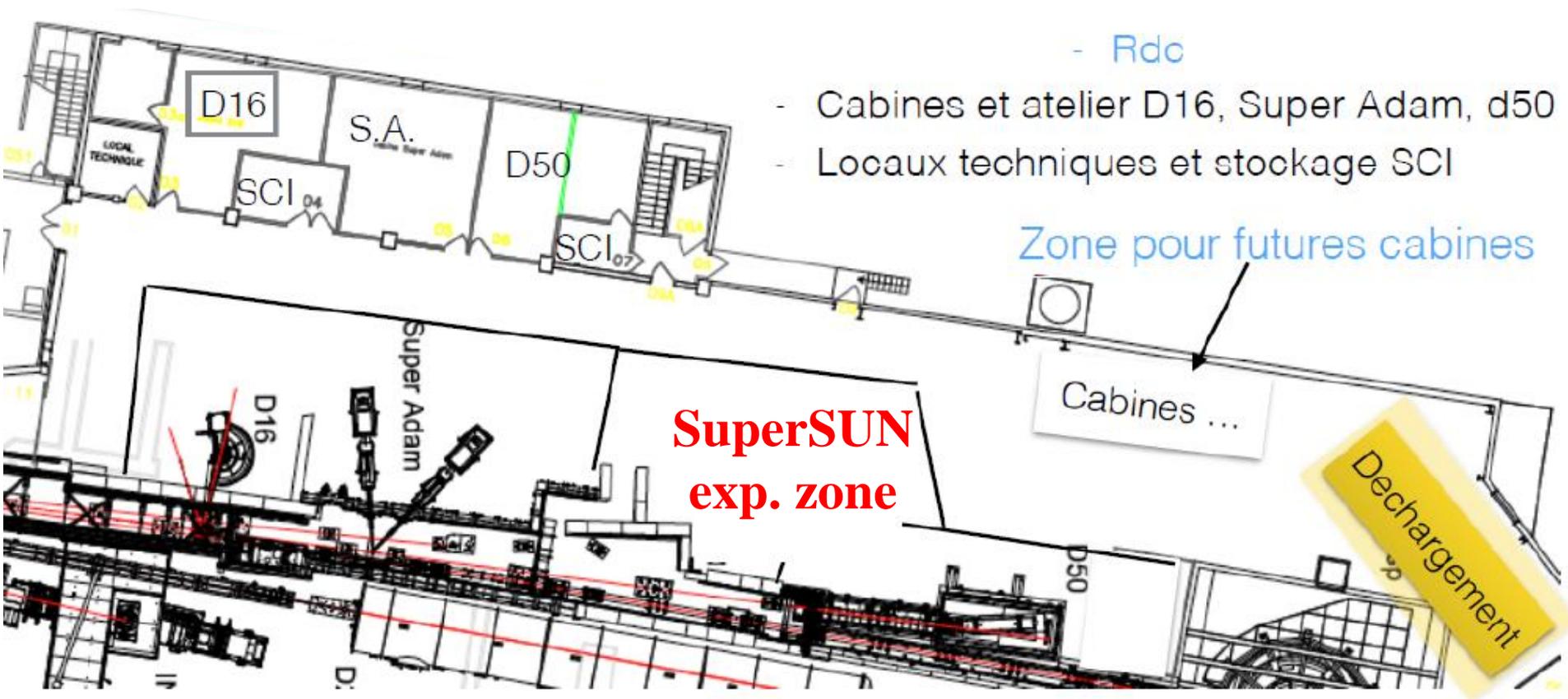


“³He cryostat”
in production

“converter cryostat”
design drawings finished

“magnetic trap cryostat”
call for tender issued

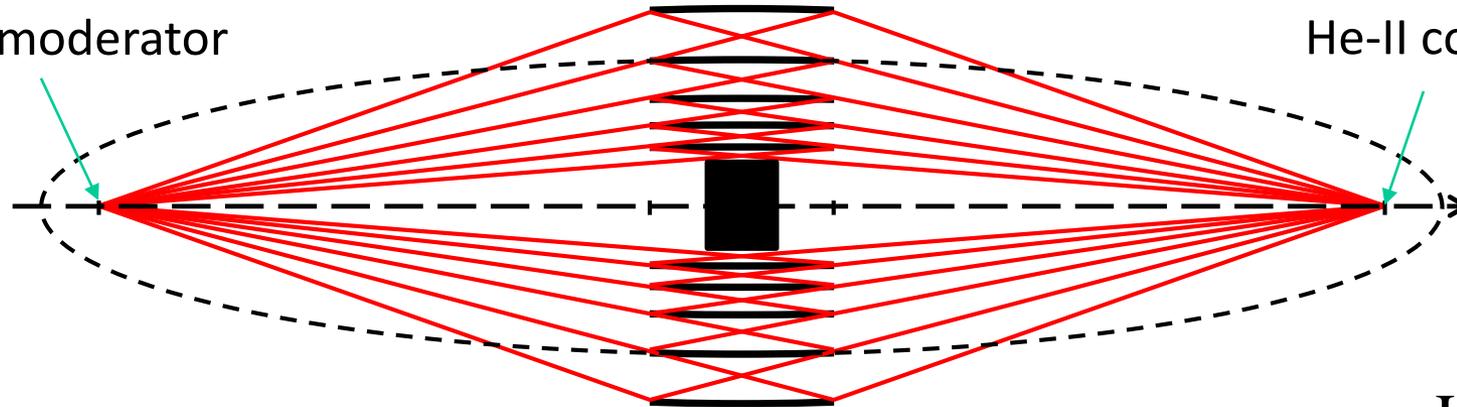
Implementation on beam H523 at ILL



2015	2016	2017	2018	2019
<p>Feasibility design studies</p> <p>Call for expressions of interest for flagship experiments</p>	<p>Launch Execution phase</p> <p>Detailed design study of He-3 cryostat</p> <p>Order of He-3 cryostat</p> <p>Launch design of neutron guide and exp. Zone</p> <p>Detailed design study of converter cryostat</p> <p>Design study of magnetic trap cryostat</p>	<p>Detailed design study of neutron guide and exp. Zone</p> <p>Order of neutron guide</p> <p>Order of converter cryostat and magnetic trap cryostat</p> <p>Order of multipole magnet</p> <p>Modification of H5 casemate</p> <p>Installation of exp. zone for SuperSUN</p> <p>Delivery of He-3 and converter cryostat</p>	<p>Install neutron guide</p> <p>Install He-3 and converter cryostats in exp. Zone</p> <p>Commissioning without magnetic trapping</p> <p>Production of UCN on white neutron beam</p> <p>Delivery of magnetic trap cryostat and multipole magnet</p>	<p>Install multipole magnet and magnetic trap cryostat</p> <p>Commissioning of the complete SuperSUN source</p> <p>Launch of user operation</p>

SuperSUN as precursor for a UCN source at ESS

ESS moderator



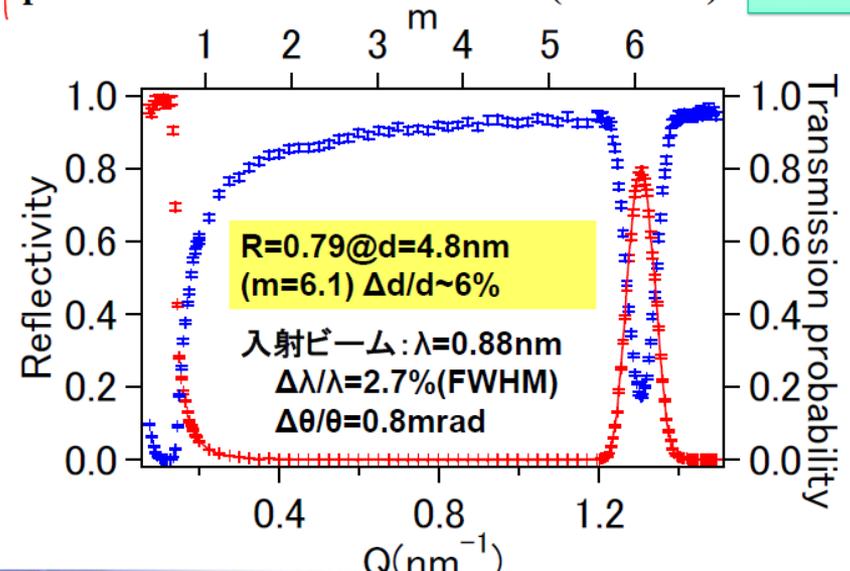
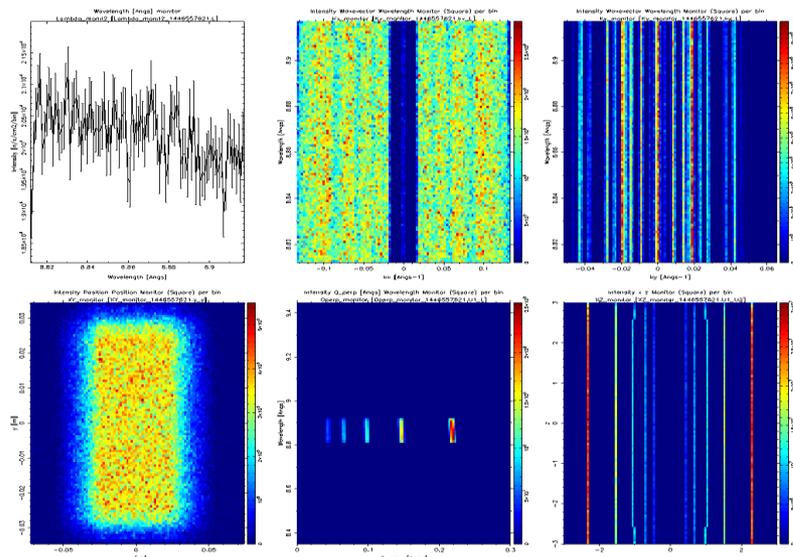
He-II converter

Hino et al.:

NiC/Ti multilayer monochromator (4664 layers)
deposited on thin silicon substrates ($t=0.3\text{mm}$)

$\alpha=1$
 $\sigma=0.7\text{nm}$

D. Kepka et al.:



People having contributed

Ken Andersen

Loris Babin

Karsten Baumann

Ben van den Brandt

Pierre Courtois

Martin Fertl

Beatrice Franke

Peter Geltenbort

Yves Gibert

Sergey Mironov

Sergey Ivanov

Dagmara Kepka

Jens Klenke

Michael Kreuz

Fabien Lafont

Thorsten Lauer

Eddy Lelievre-Berna

Kent Leung

Florian Martin

Florian Piegsa

Jose Perez-Rios

Christian Plonka

Dennis Rich

Felix Rosenau

Philipp Schmidt-Wellenburg

Martin Simson

Torsten Soldner

Xavier Tonon

Hans-Friedrich Wirth

GRANIT team (using and upgrading SUN-1)