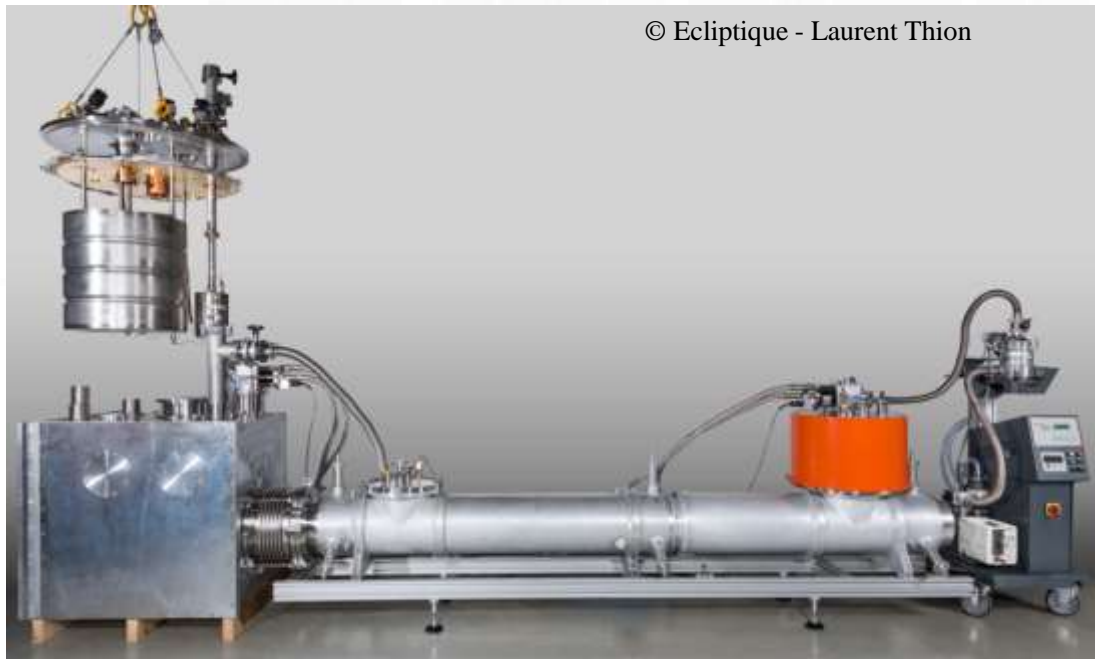




SuperSUN a new ultra-cold neutron converter: concept and strategy



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Moderation vs. conversion sources

Moderation principle

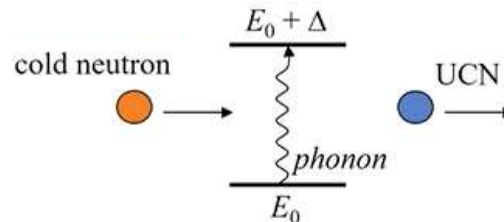
- Multiple scatterings
- Thermal equilibrium

$$\rho_{UCN} = \frac{2}{3} \frac{\phi_0}{\alpha} \left(\frac{V}{k_B T} \right)^{3/2}; \quad \alpha = \sqrt{\frac{2k_B T}{m}}$$

Conversion principle

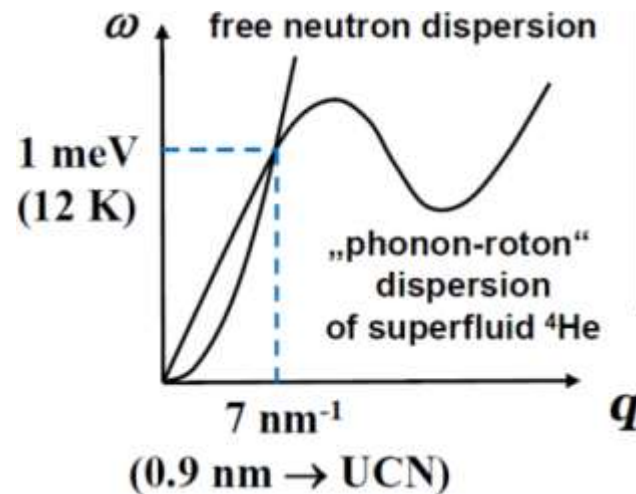
- Single scattering
- Cross-section resonance
- No thermal equilibrium

Down scattering



Up-scattering

$$\tau_{\text{up}}^{-1} \sim \frac{(T[\text{K}])^7}{100 \text{ s}}$$



Neutron delivery at ILL

SuperSUN's converter vessel

End of guide H523:

- $\Phi \sim 2 \times 10^{10}$ n/(cm² s)

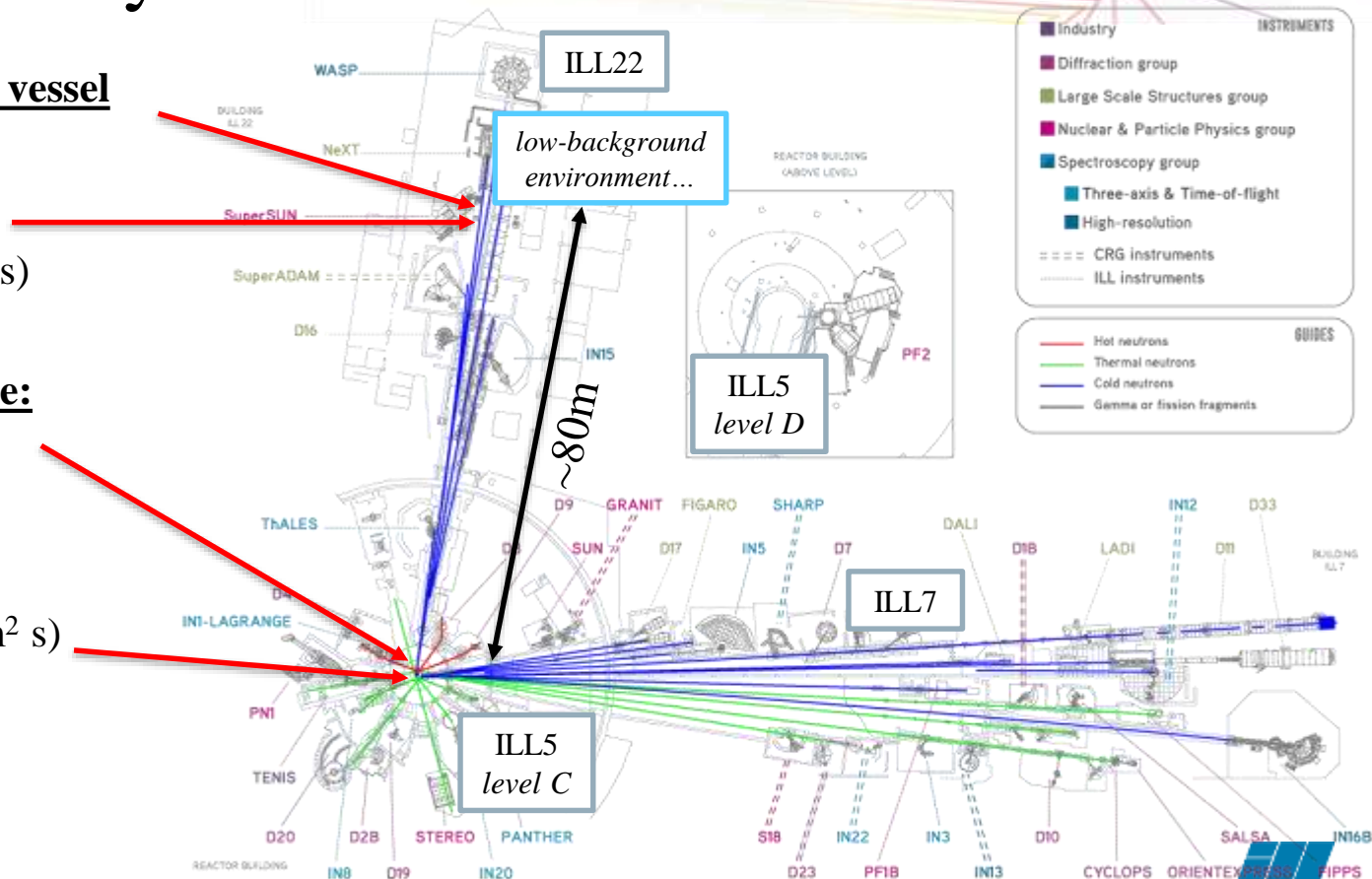
Horizontal Cold Source:

- $\Phi \sim 10^{14}$ n/(cm² s)

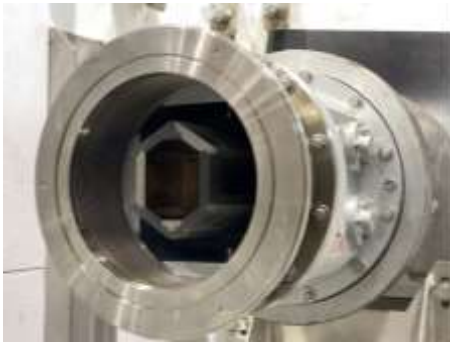
In pile:

- $\Phi \sim 1.5 \times 10^{15}$ n/(cm² s)

Slide adapted from S. Degenkolb

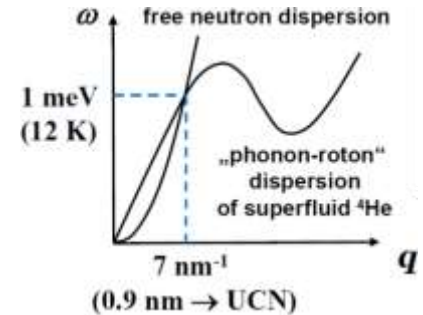
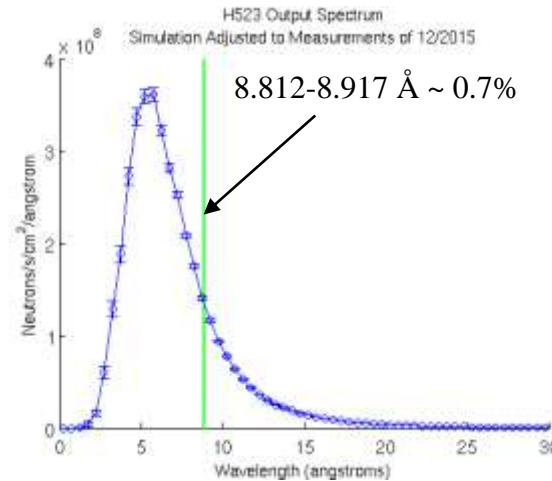
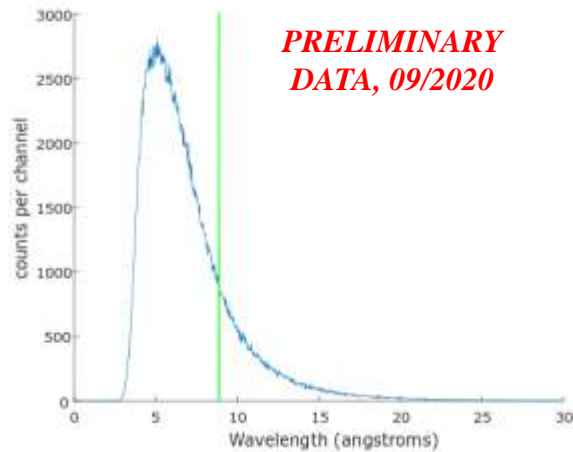


The H523 beamline at ILL

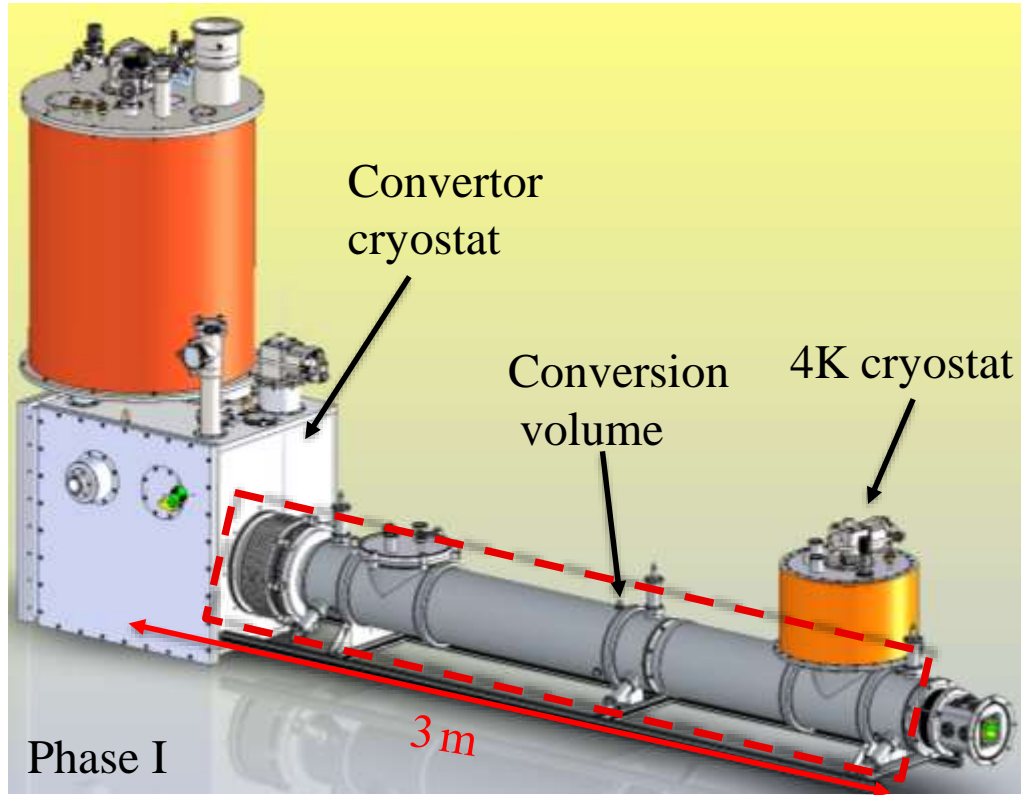


Existing cold neutron beam

- $m=1.2$ and $m=2.5$
- Guide XS: $60 \times 120 \text{ nm}^2$
- Flux (03/2020): $2 \times 10^{10} \text{ n}/(\text{cm}^2 \text{ s})$

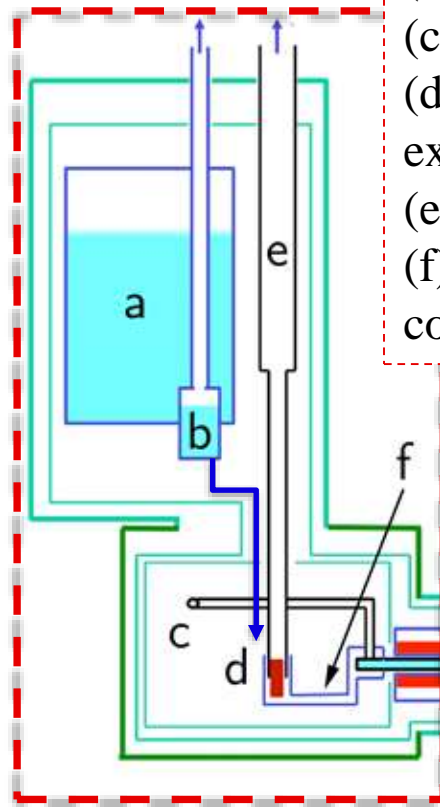
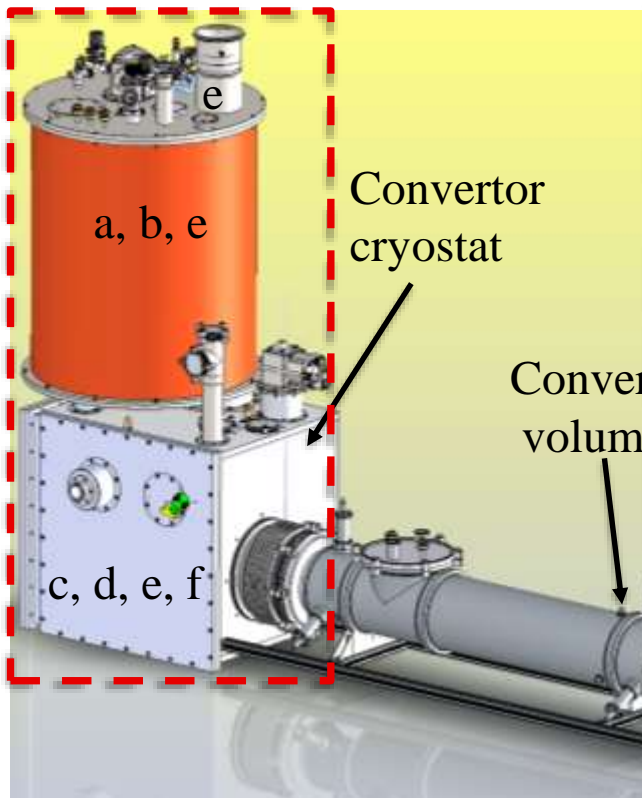


SuperSUN concept- two phases



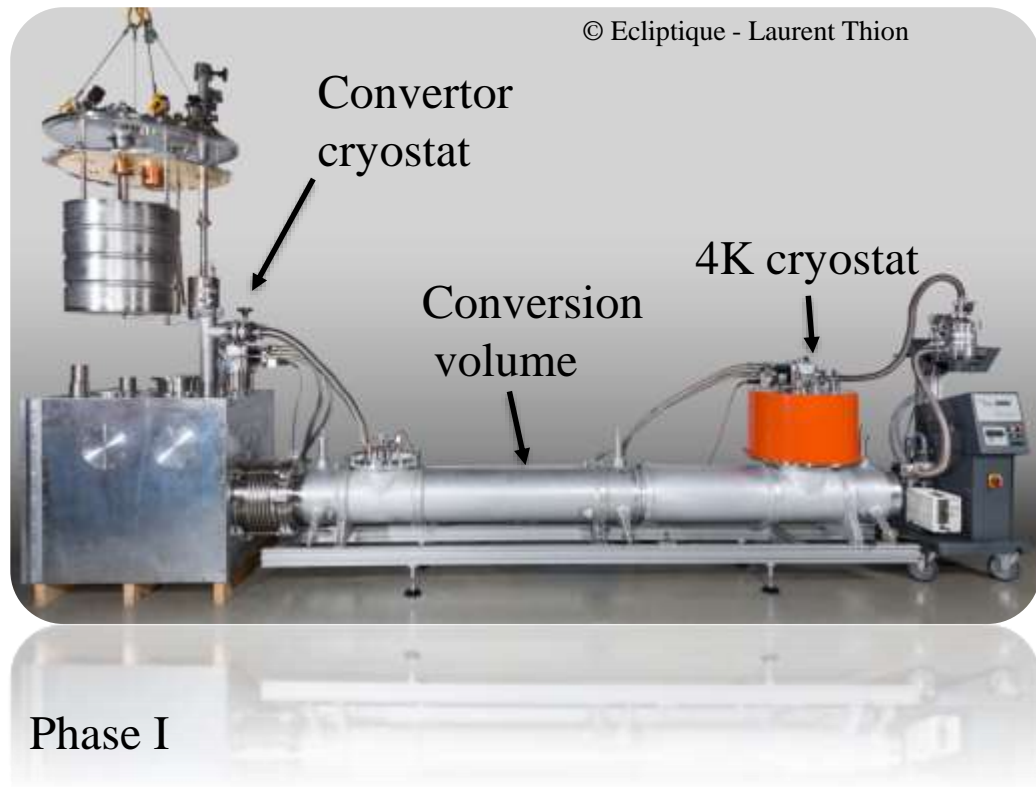
- Full spectrum irradiation
 - 30% increase in the UCN yield
- Superfluid ^4He
 - $V=12\text{ L}$
 - $T=0.6\text{ K}$
- Combination of materials:
 - Replica – Ni (UCN)
 - $m=3$ super mirror coating (CN)
 - Cytop coating (UCN)
- Phase II- Magnet

SuperSUN concept



- (a) 100 L He bath,
- (b) '1K pot',
- (c) UCN extraction,
- (d) $^3\text{He}/^4\text{He}$ heat exchanger,
- (e) ^3He column
- (f) Superfluid ^4He column

SuperSUN concept- two phases

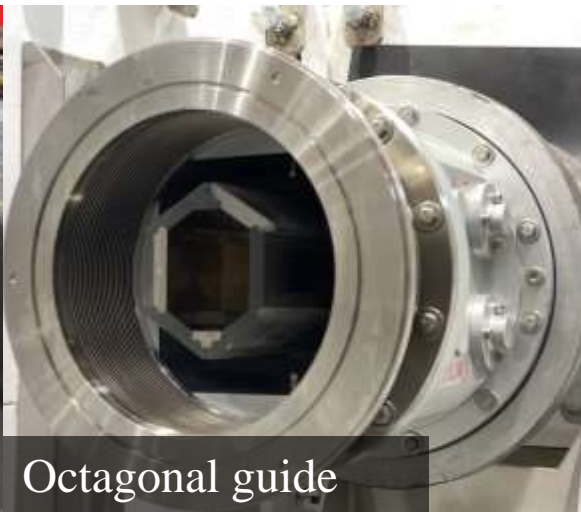


- Full spectrum irradiation
 - 30% increase in the UCN rate
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- Combination of materials:
 - Replica – Ni (UCN)
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- Phase II- Magnet

Components



4K cryostat



Octagonal guide

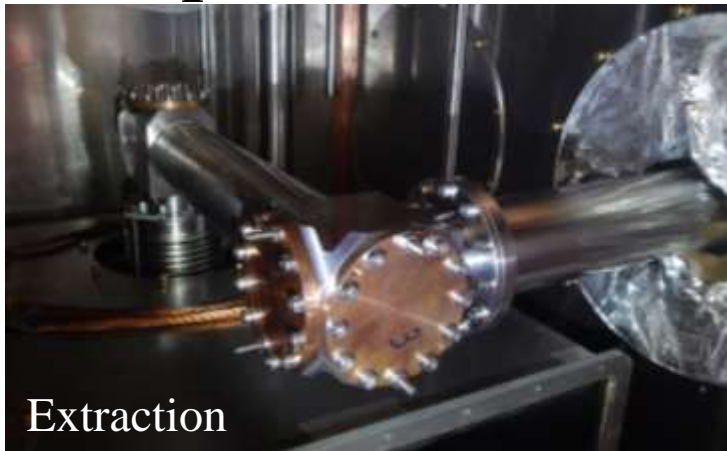


Replica



Convertor volume

Components



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Phase II magnet

- Octupole superconductive magnet
 $\Delta B=2.1\text{ T}$
- Under construction in Spain
- Training in CERN
- Same materials phase I and II
 - non (magnetic or para-magnetic) materials
 - quenches and eddy currents anticipated



SuperSUN status



- Achieve 0.5K without convertor
- Phase I fully setup in 08/2021
- Cooled down to 0.97K with
 - UCN extraction unit
 - 3m convertor
 - 20 mm diameter neutron beam
 - Non-optimized ^3He impedance
- Incident:
 - Purchased replacement components
 - Additional safety components

PanEDM



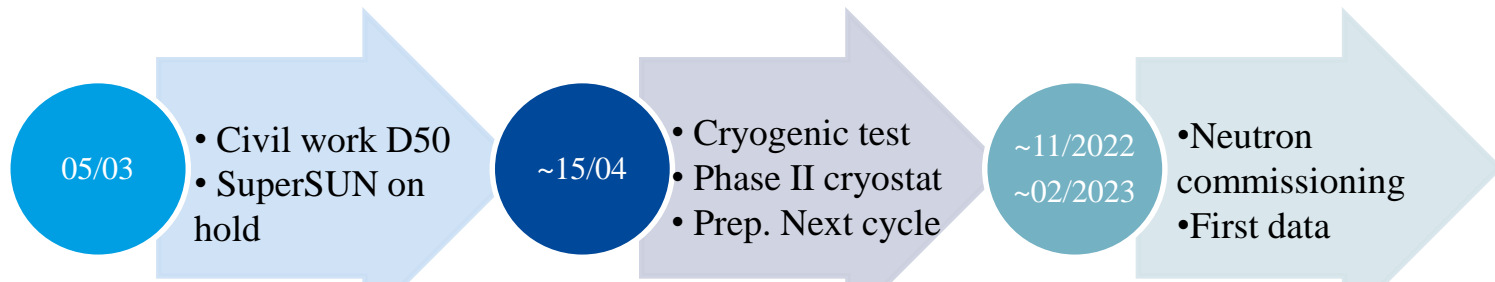
02/02/2022

Workshop on Very Cold and Ultra Cold
Neutron Sources for the ESS – Estelle Chanel

THE EUROPEAN NEUTRON SOURCE



Current planning

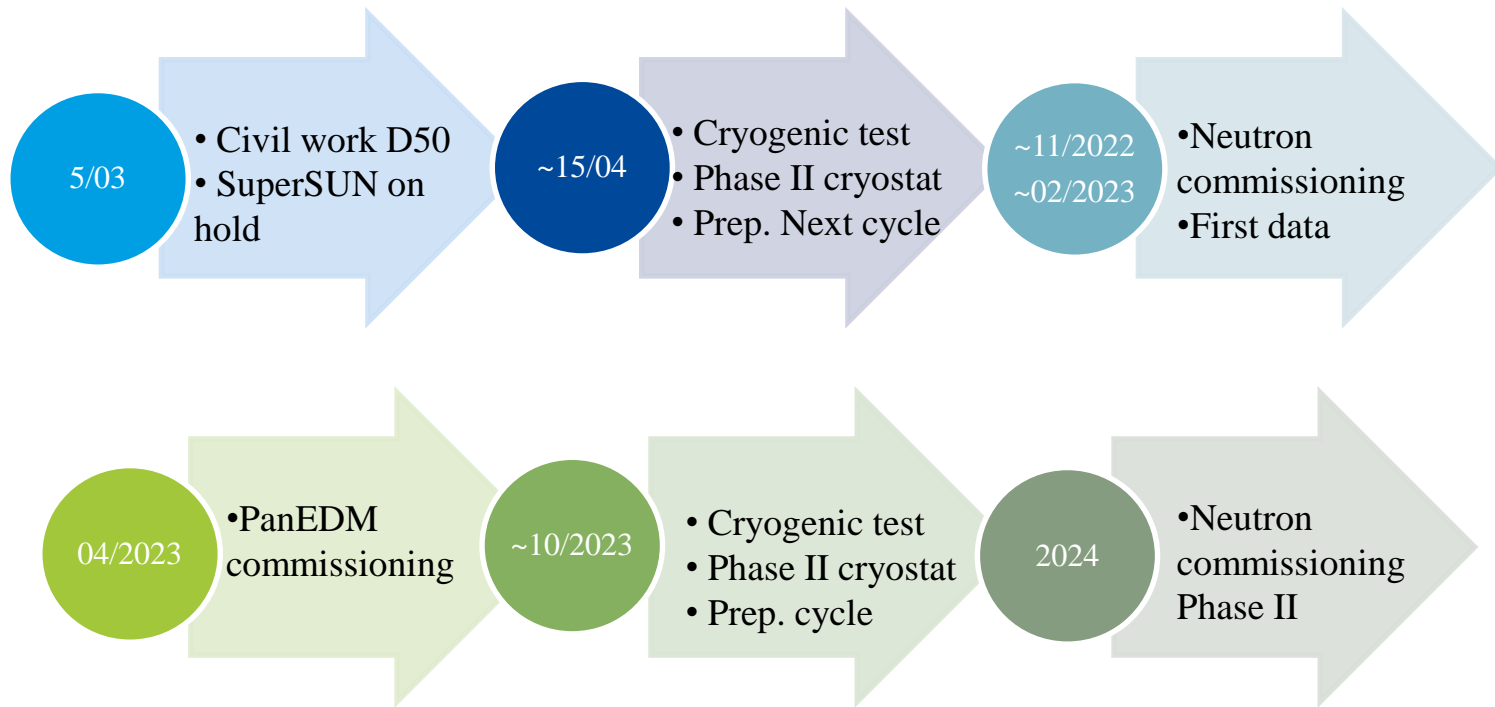


02/02/2022

Workshop on Very Cold and Ultra Cold
Neutron Sources for the ESS – Estelle Chanel

THE EUROPEAN NEUTRON SOURCE

Current planning



ACKNOWLEDGEMENTS

All what will be shown would not have been possible without huge engagement of people:

THANK YOU!!!

SANE: S. Baudoin, N. Belhier, E. Bourgeat-Lami, E. Lelièvre-Berna, V. Joyet, X. Tonon ...

DPT: J. Bonnevaux, P. Cogo, R. Gandelli, Y. Gibert, M. Kreuz, P. Lachaume, T. Mazili, C. Monon, C. Mounier, A. Robert, M. Thomas...

NPP: D. Berruyier, S. Degenkolb, M. Jentschel, T. Neulinger, P. Nordin, V. Popescu, A. Quirk, O. Zimmer ...

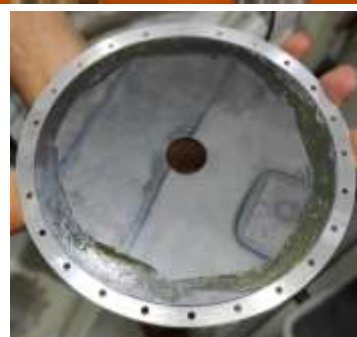
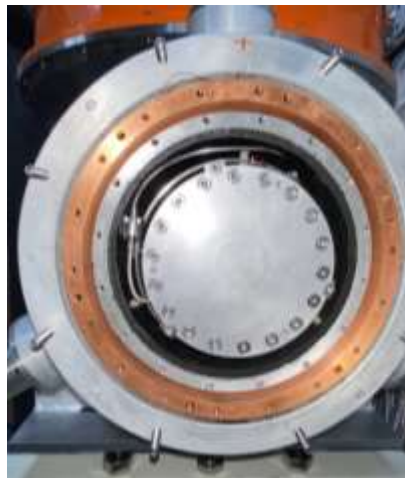
PanEDM: D. Beck, T. Chupp, R. Combe-Colas, S. Degenkolb, P. Fierlinger, H. Filter, L. Hopf, F. Kuchler, M. Rosner, P. Rößner, M. van der Grinten, M. Wojke, D. Wurm ...

Radioprotection, DRE,...and many, many others.



INSTITUT LAUE LANGEVIN

More components



Cryo-system

- Until beginning 2021 ongoing cryotest @ SANE:
 - System cooled down $<0.5\text{K}$
 - First production of liquid ^4He was successful in small vessel
 - Several cool down cycles tested, long term (2 weeks) stability tested

SuperSUN during Tests @ SANE



SuperSUN dismantled @ SANE

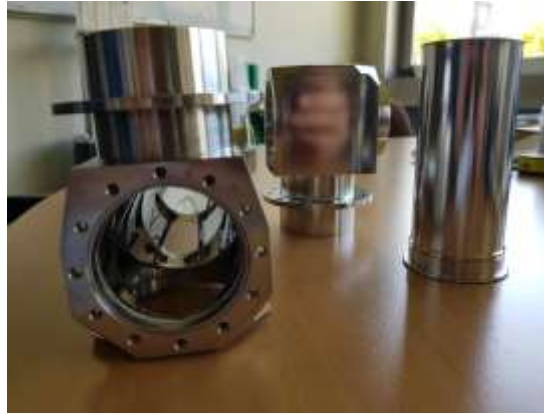


Slide from M. Jentschel

02/02/2022

Workshop on Very Cold and Ultra Cold
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UCN extraction



Assembly of extraction mechanism, standby for welding @ SANE
(D. Berruyer, X. Tonon)
Machining from TUM mechanical workshop

Replica – more pictures



1 m prototype replica tube with ^{10}B foil inserted into cryostat mockup

1 m prototype replica tube after welding

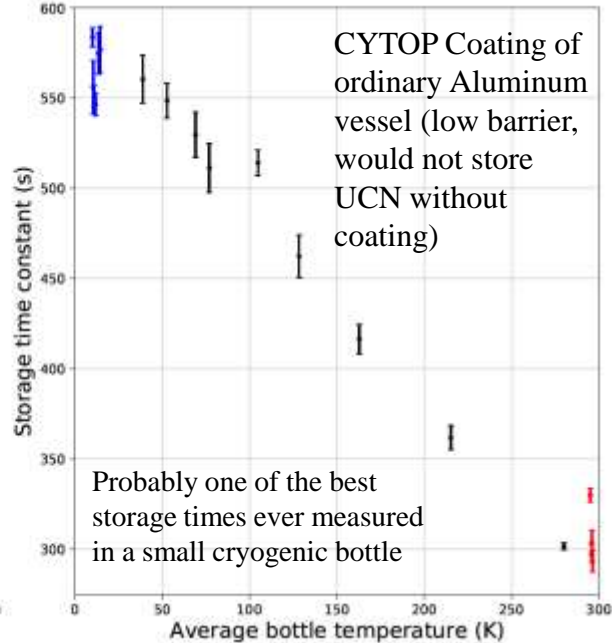
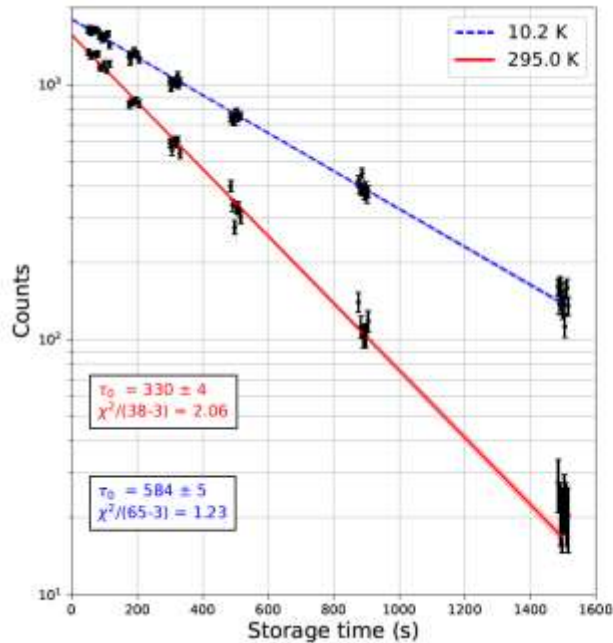


3 m prototype in 0.5K volume (cryostat mockup)

Working on UCN coating

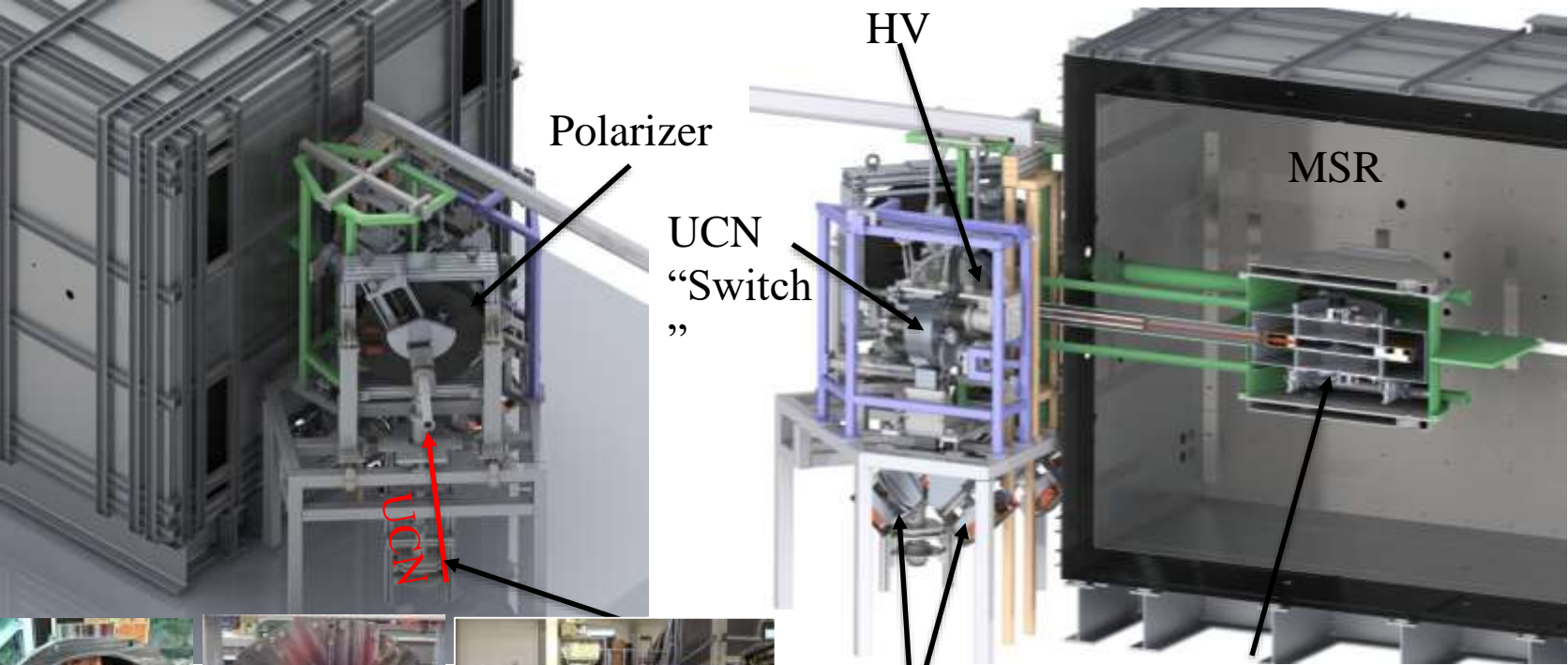
Using SUN2 as R&D facility since superthermal neutron spectrum is special

Work of T. Neulinger 2020/21 -> preliminary results



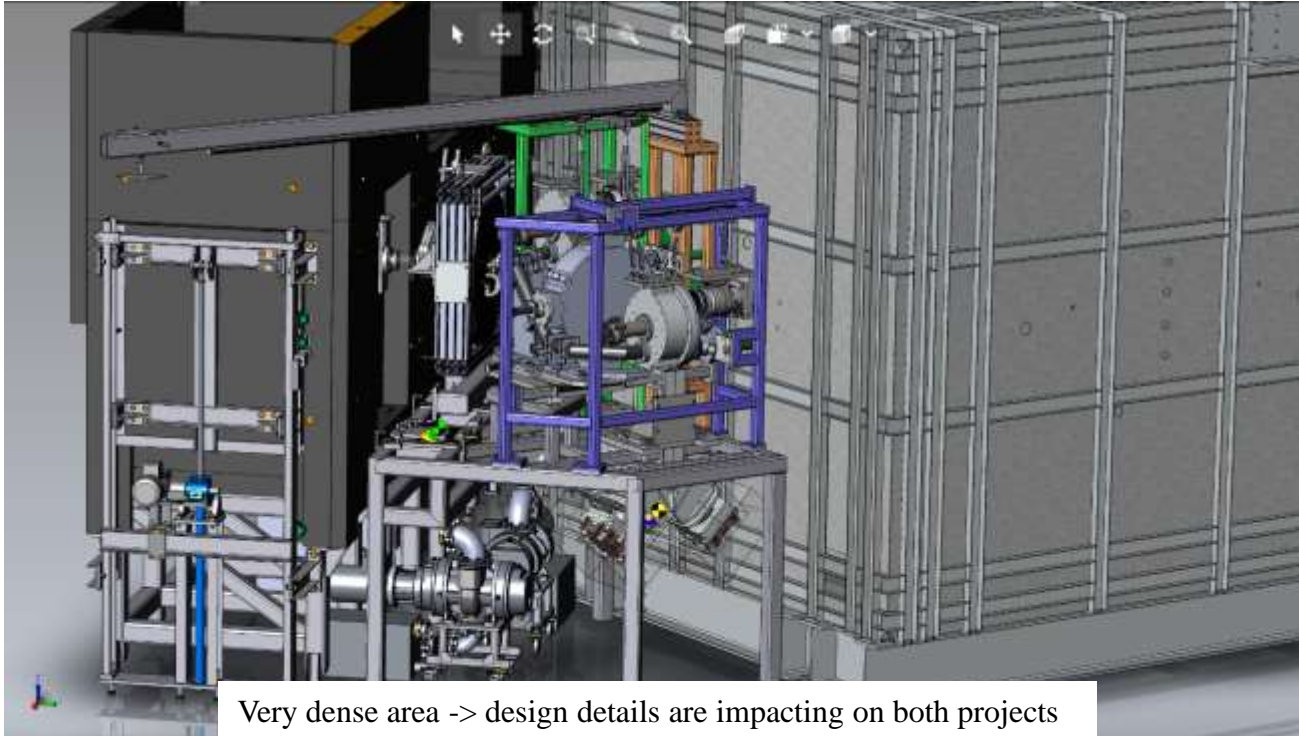
- Superthermal source deliver specific neutron spectrum
- Enables long storage times -> important for EDM
- R&D needs to be done with such neutron spectrum
- Shows the importance to have a R&D device SUN2

SuperSUN/PanEDM interface



UCN-detectors

Interface SUPERSUN/PanEDM



Very dense area -> design details are impacting on both projects

