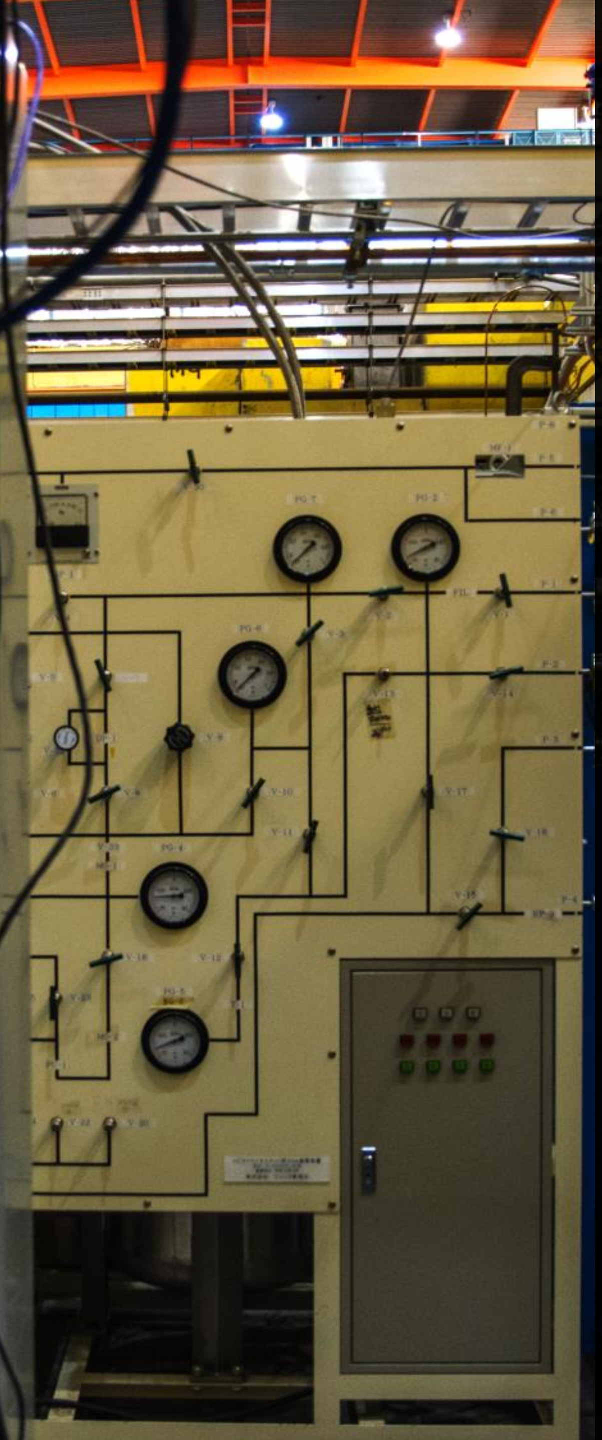
TRIUMF

TUCAN

TRIUMF Ultra Cold Advanced Neutron source

Progress towards the TRIUMF UCN facility and nEDM experiment



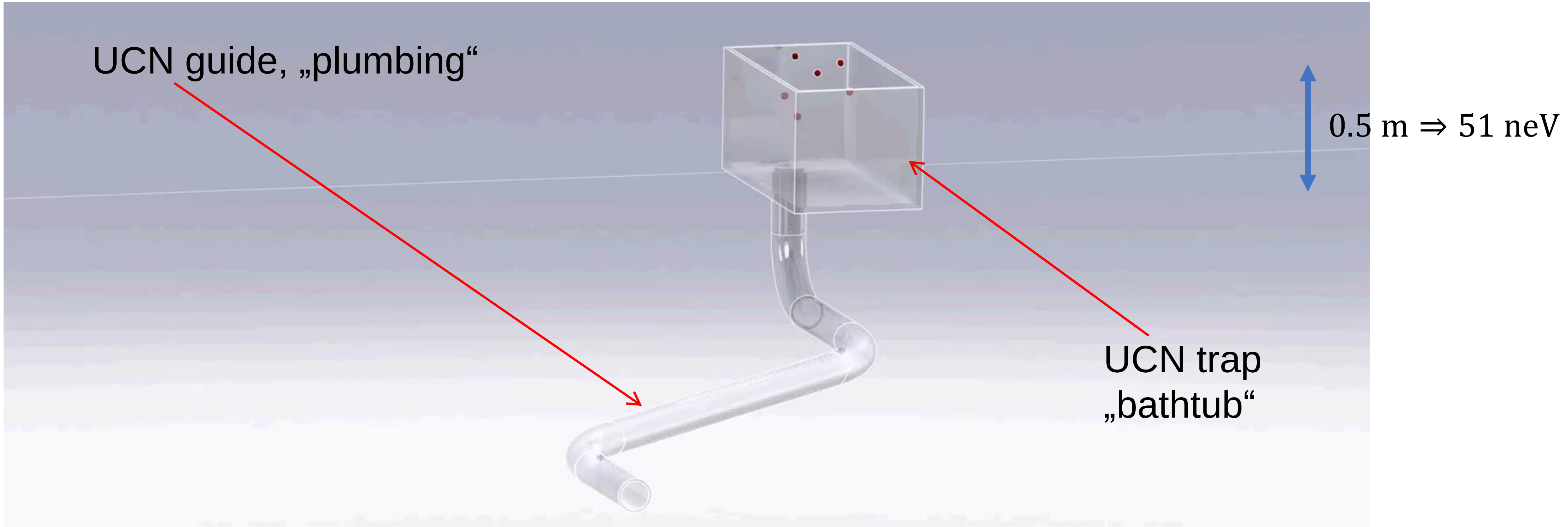
Ruediger Picker

2022-08-29

Discovery, accelerated

UltraCold Neutrons are conceptually very simple

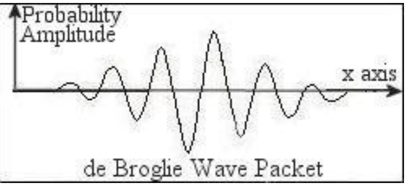
- non-relativistic
- very classical trajectories
- gravitation has significant influence
- easy to transport and store



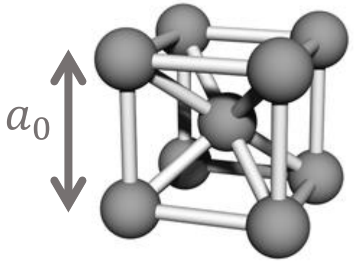
Solidworks simulation, hard spheres, no energy loss on impact

How do UCN bounce?

- **U**ltra**C**old **N**eutrons are so slow, their wavelength is longer than solid matter lattice constants



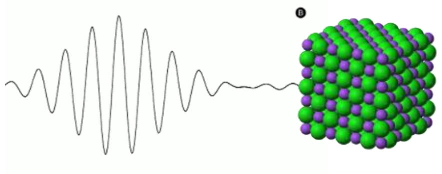
$$\lambda = \frac{h}{p} = \frac{h}{m_n v} \qquad v = 5\ \mathrm{m/s} \qquad \lambda = ??? \qquad a_0 = ???$$



iron lattice
BCC

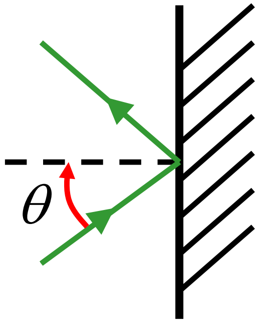
- UCN wave averages over many nuclear potentials

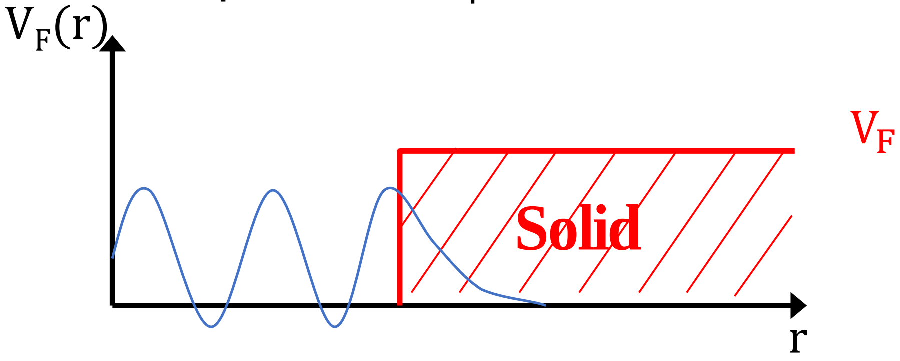
$$V(\vec{r}) = \frac{4\pi\hbar^2}{2m} \sum_i a_i \delta(\vec{r} - \vec{r}_i\,')$$



- effective step potential called Fermi potential V_F

$$E_{kin} < V_F :$$

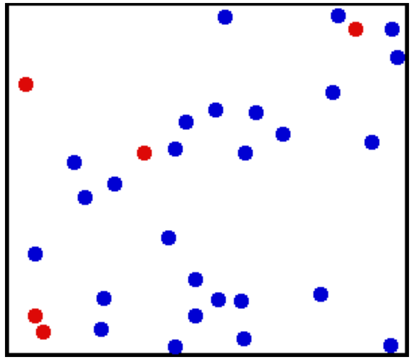




- typical values of V_F

Material	V_F (neV)	v (m/s)
Al	54	3.2
^{58}Ni	350	8.2
Ti	- 48	
Stainless Steel	**188**	**6**

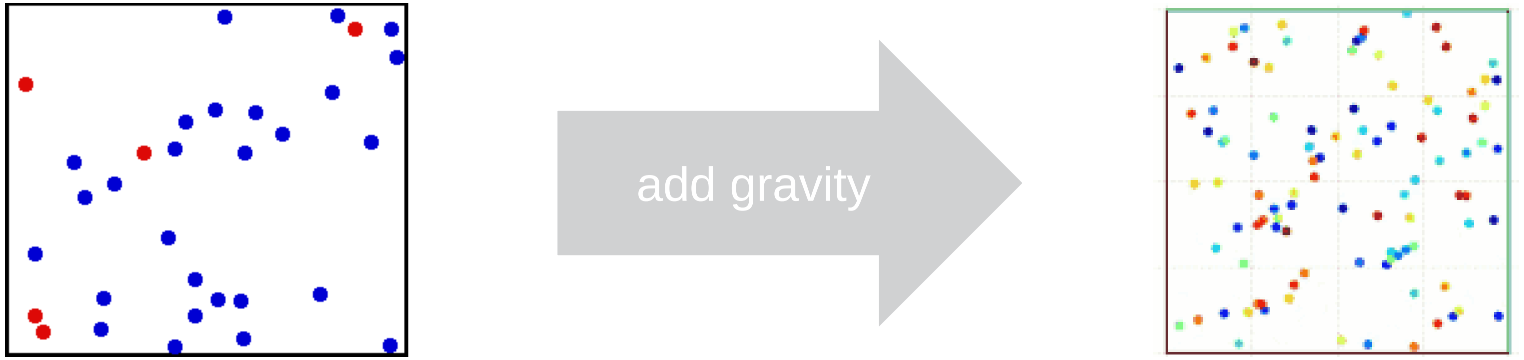
Neutrons in a box



- Reflection is mostly specular on smooth surfaces

Neutrons in a box

Neutrons in a box with gravity



- Reflection is mostly specular on smooth surfaces

- Gravitational potential: 102 neV/m
  - 102 neV corresponds to 4.4 m/s

What is wrong here?

UCN’s (basically) don’t interact since densities are too low.
Collission (basically) do not happen…

Why does it help to put neutrons in a box?

Precision measurements

- Heisenberg: $\Delta E \Delta t \geq \frac{\hbar}{2}$

$\Rightarrow$ longer observation time

$\Rightarrow$ more precise measurement

- long neutron β-decay lifetime (880 s)

+

storage in “simple” containers

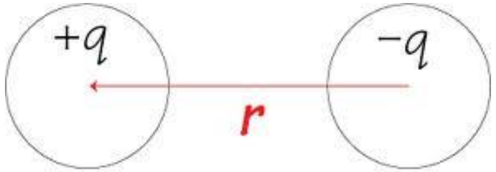
$\Rightarrow$ UCN observation times > 100 s

$\Rightarrow$ **Very good for an EDM search**

EDM, what the heck?

electric dipole moment (EDM)

charge separation



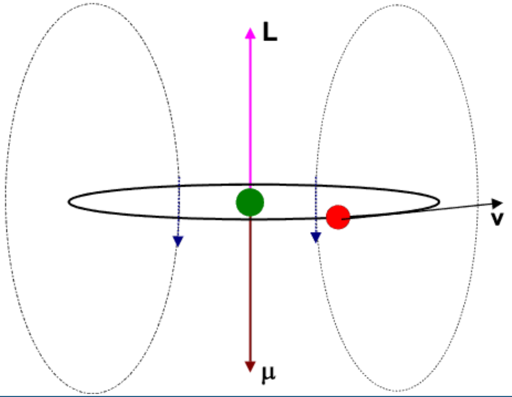
$$\mu = qr \text{ [e·cm]}$$

Experimental limit today:

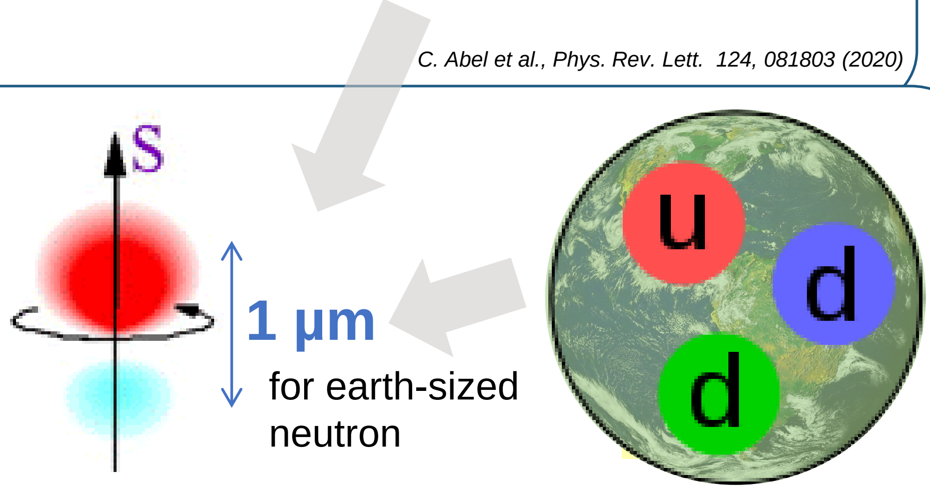
$d_n < 1.8 \cdot 10^{-26}$ e·cm (PDG 90% conf.).

C. Abel et al., Phys. Rev. Lett. 124, 081803 (2020)

neutron case



slight separation of the positive and negative **charge cloud** along the axis of the magnetic moment (spin)

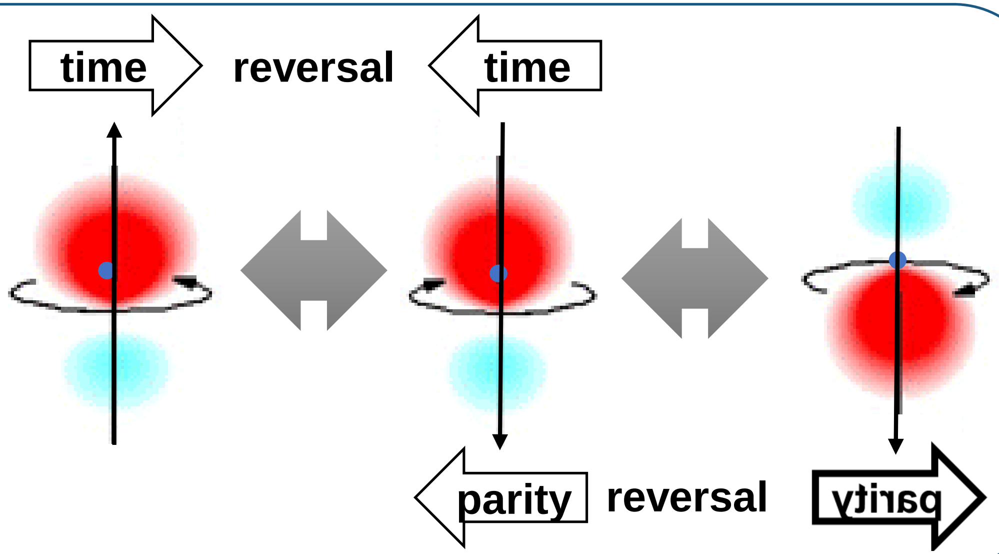


Why is it special?

Time and parity reversal violation

⇒ **CP violation** (if CPT holds)

⇒ More CP violation needed to explain matter-antimatter asymmetry in the universe



Electroweak baryogenesis (matter creation)

Possible recipe:

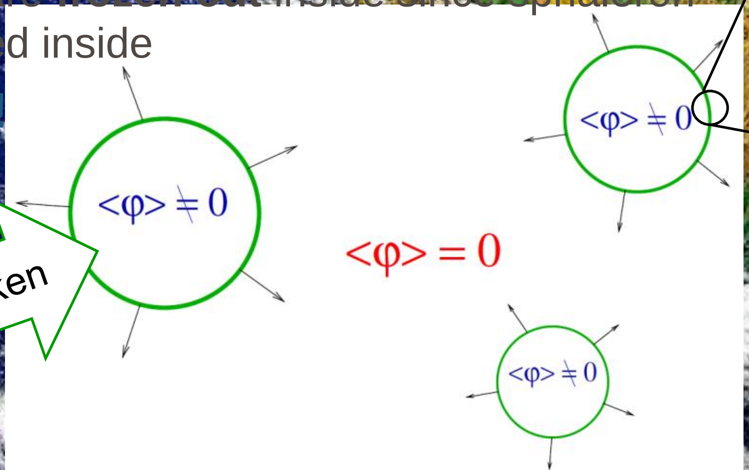
(D.E. Morrissey and M.J. Ramsey-Musolf, New J. Phys. 14, 125003 (2012))

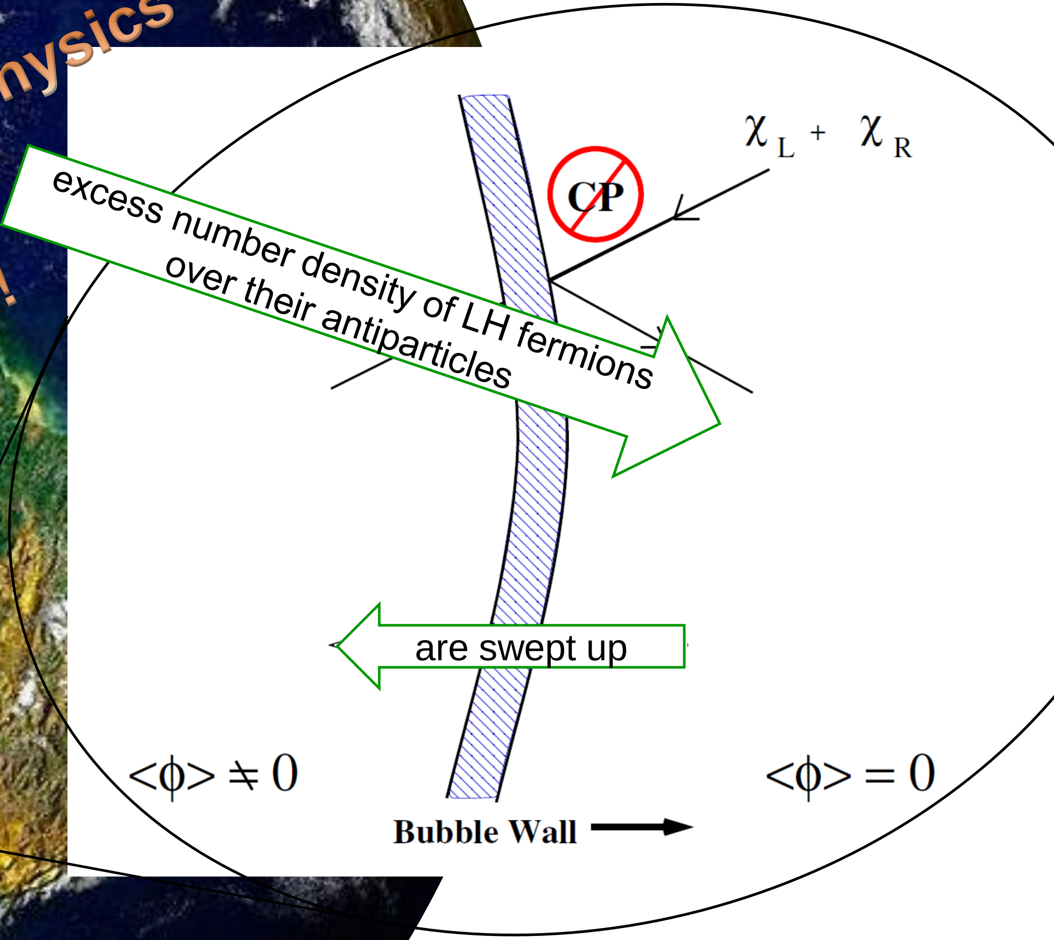
1. Start with a radiation dominated universe of net zero baryon number (no matter only quantum fluctuations)
2. $T \lesssim 100$ GeV: Higgs field breaks electroweak symmetry (phase transition (1st order?))
3. Bubbles of these regions nucleate
4. At the bubble walls baryogenesis happens
   1. Particles scatter across the bubble walls, where **CP is broken**
   2. These asymmetries bias **electroweak sphaleron transitions** to produce **more baryons than antibaryons**
   3. Some of the **baryons** created outside are swept up by the expanding bubbles and are **frozen out** inside since sphaleron transitions are suppressed inside
5. **We live inside a bubble!**

new physics

need more!

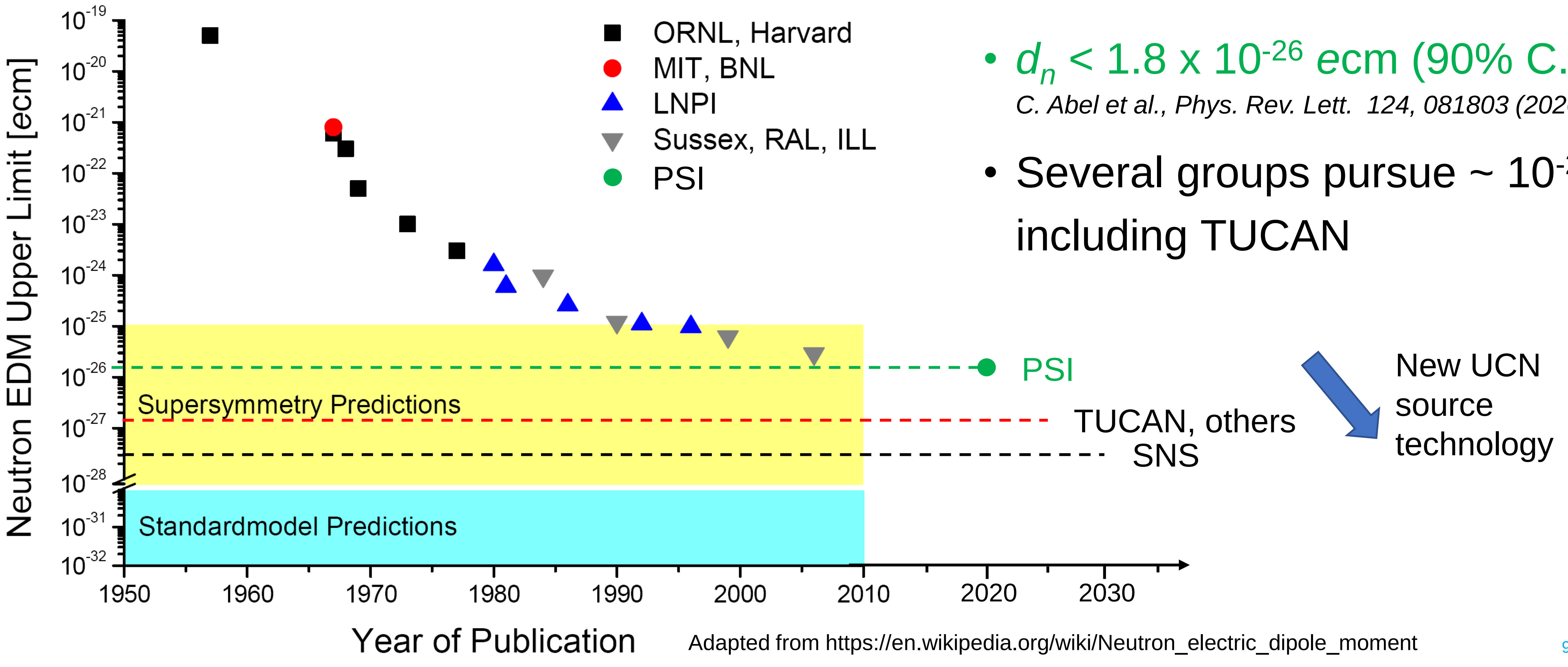
okay





EDM motivation and history

- EDM experiments essentially search for sources of CP violation beyond the standard model.
- Lowering EDM limits seriously restricts BSM theories.



- $d_n < 1.8 \times 10^{-26}$ ecm (90% C.L.)

  C. Abel et al., Phys. Rev. Lett. 124, 081803 (2020)

- Several groups pursue ~ 10^{-27} ecm, including TUCAN

Adapted from https://en.wikipedia.org/wiki/Neutron_electric_dipole_moment

Sensitivity of an EDM measurement

Sensitivity of nEDM experiment $\sigma(d_n) \propto \frac{1}{E\tau\sqrt{N}}$

E : strength of applied electric field
τ : interaction time
N : neutron counts

Sensitivity of an EDM measurement

Sensitivity of nEDM experiment $\sigma(d_n) \propto \dfrac{1}{E\tau\sqrt{N}}$

E : strength of applied electric field
τ : interaction time
N : neutron counts

	Free flight method	Crystal diffraction method	UCN method	
interaction tome τ [s]	$\sim 10^{-1}$	$\sim 10^{-3}$	$\sim 10^{2}$	
electric field E [V/cm]	$\sim 10^{4}$	$\sim 10^{8}$	$\sim 10^{4}$	
neutron counts n [n/s]	$\sim 10^{8}$	$\sim 10^{4}$	$\sim 10^{2}$	$\Rightarrow 10^3$
sensitivity σ(d_n)	$\sim 10^{-25}/\sqrt{\text{Day}}$	$\sim 10^{-25}/\sqrt{\text{Day}}$	$\sim 10^{-25}/\sqrt{\text{Day}}$	$\Rightarrow 2\text{x}10^{-26}/\sqrt{Day}$

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Each value is regulated to be same sensitvity for the purpose of making characteristc of each method clear

All methods have the possibility to get the sensitivity at the same level.

Slide by Shigeyasu Itoh

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TUCAN collaboration and goals

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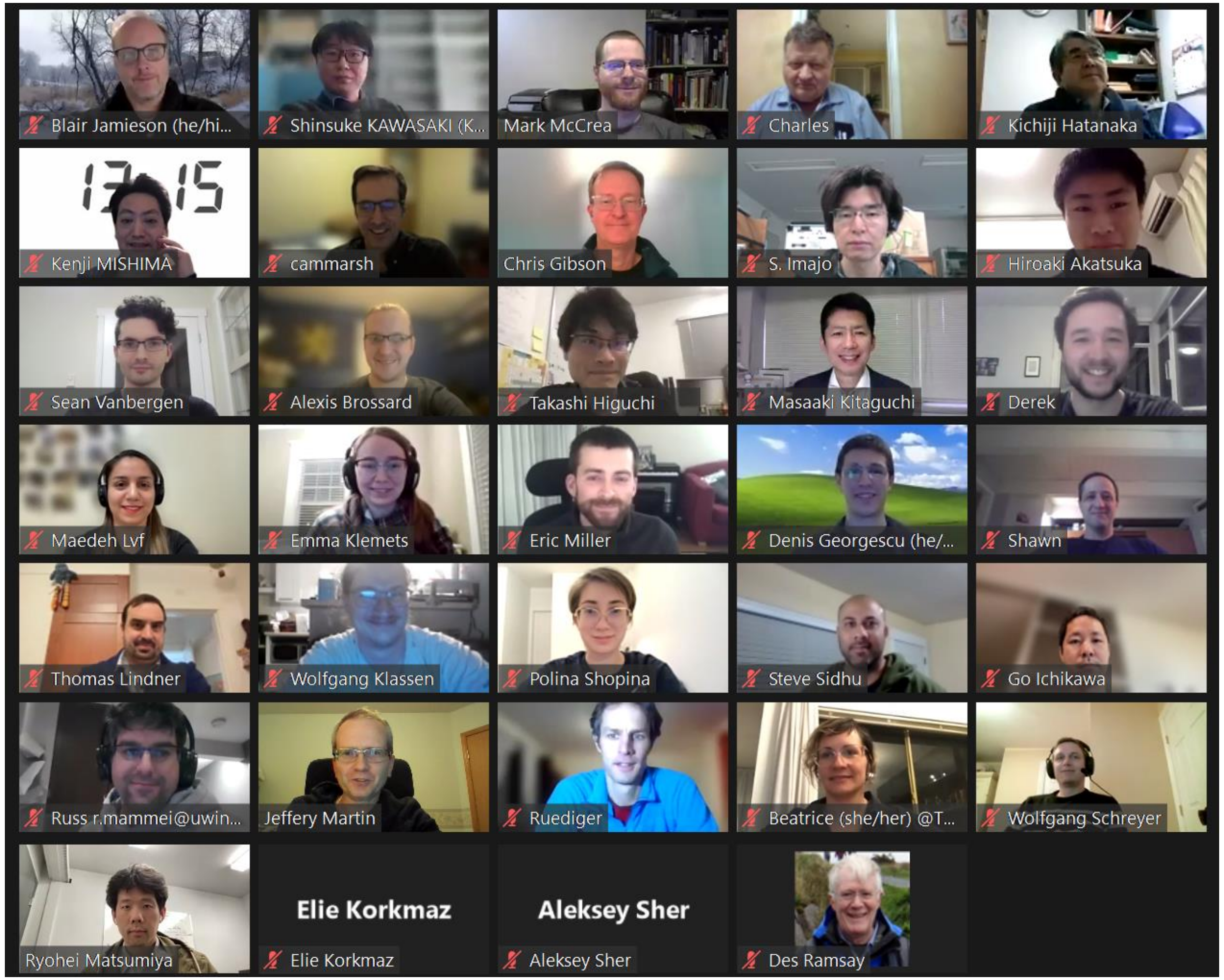
TRIUMF UltraCold Advanced Neutron Collaboration



Jan. 2022 virtual collaboration meeting

TUCAN collaboration goals:

1. Create the world's **strongest ultracold neutron source using the TRIUMF cyclotron**.
2. **Search for a neutron electric dipole moment** with a **sensitivity of 10-27 e cm (1-σ) in 400 beam days.**
3. Create an **international user facility** for fundamental research using ultracold neutrons.

H. Akatsuka[1], C. Bidinosti[2], A. Brossard[3], C. Davis[3], B. Franke[3,4], D. Fujimoto[3], M. Gericke[5], P. Giampa[6], R. Golub[7], S. Hansen-Romu[5,2], K. Hatanaka[8,*], T. Higuchi[8], G. Ichikawa[9], S. Imajo[8], B. Jamieson[2], S. Kawasaki[9], M. Kitaguchi[1], W. Klassen[4,5,2], E. Klemets[4], A. Konaka[3,10], E. Korkmaz[11], E. Korobkina[7], F. Kuchler[3], M. Lavvaf[5,2], T. Lindner[3,2], K. Madison[4], Y. Makida[9], J. Mammei[5], R. Mammei[2,3], J. Martin[2,*], R. Matsumiya[3], M. McCrea[2], E. Miller[4], K. Mishima[9], T. Momose[4], T. Okamura[9], H.J. Ong[8], R. Picker[3,12], W.D. Ramsay[3],W. Schreyer[3], A. Sher[3], H. Shimizu[1], S. Sidhu[12], S. Stargardter[5,2], I. Tanihata[7], S. Vanbergen[4], W.T.H. van Oers[5,3], Y. Watanabe[9]

[1]Nagoya University, [2]The University of Winnipeg, [3]TRIUMF, [4]The University of British Columbia, [5]University of Manitoba, [6]SNOLAB, [7]North Carolina State University, [8]RCNP Osaka, [9]KEK, [10]Osaka University, [11]University of Northern BC,[12]Simon Fraser University

*co-spokespersons (K. Hatanaka and J. Martin)

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TRIUMF Ultra Cold Advanced Neutron source

Several ways of freeing n and making UCN

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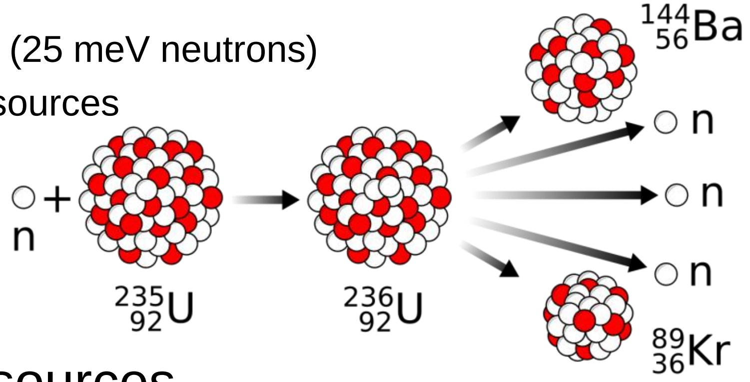
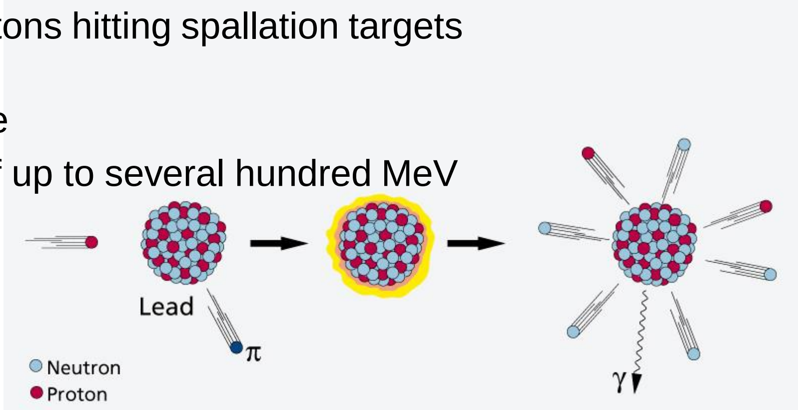
Neutron sources

- Fission reactor neutron sources
  - ILL, NIST, PNPI, FRM2, Mainz, NCState
  - **Usually compact fuel element**, high enrichment
  - Constant neutron flux
  - **Thermal moderators** (25 meV neutrons)
  - Often have LD2 cold sources



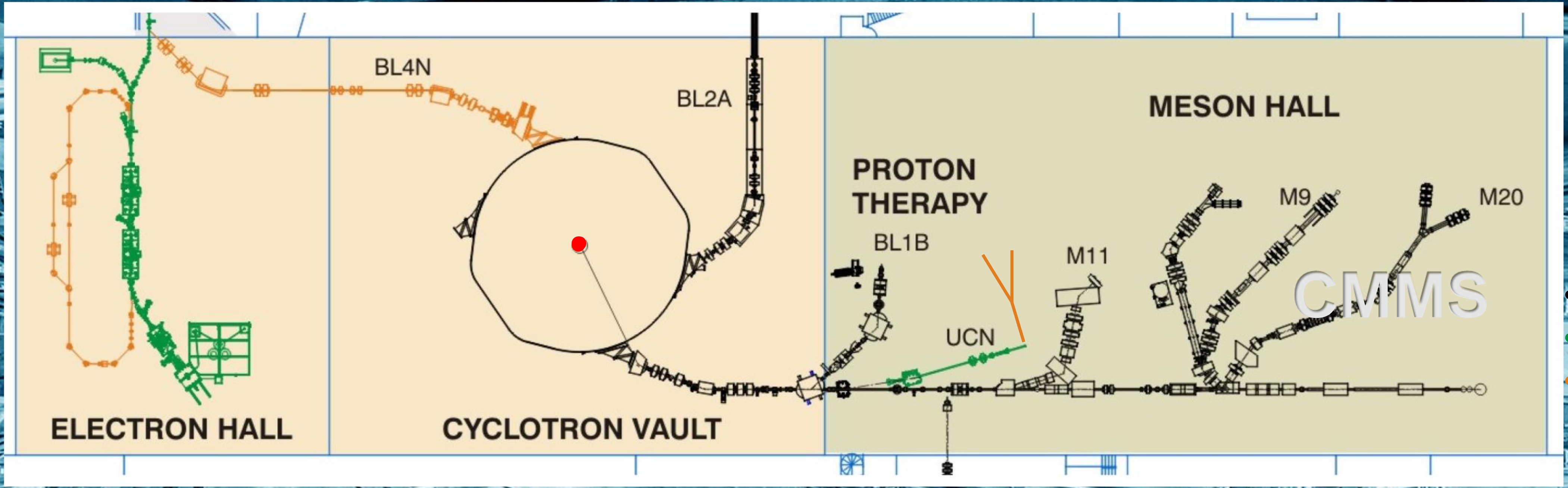
- Spallation neutron sources
  - J-PARC, LANSCE, PSI, ESS, SNS, RCNP, TRIUMF
  - 500 – 800 MeV protons hitting spallation targets (W,Pb)
  - Some time structure
  - Neutron energies of up to several hundred MeV



UCN source

- Phase space shifters
  - ILL turbine, J-PARC doppler shifter
  - UCN bounce off **retracting neutron reflectors**
  - Respect Liouville's theorem of **constant phase space density**
- Solid deuterium sources
  - LANSCE, PSI, FRM2
  - cold neutrons create phonons in solid deuterium and become UCN
  - Reverse process suppressed at **5 K**
  - UCN lifetime: micro seconds
  - UCN production: thousands/s/cm^3
- Superfluid liquid helium sources
  - RCNP, ILL, TRIUMF
  - Cold neutrons create phonons and rotons in superfluid isopure ^{4}He
  - Upscattering largely suppressed around 1 K
  - UCN lifetime: tens to hundreds of seconds
  - UCN production: few to hundreds/s/cm^3

The TRIUMF beam delivery system



- Existing
- New
- Planned

- **H⁻ ions** are accelerated by TRIUMF's main cyclotron (up to 520 MeV).
- Foils strip electrons and **p^+ can be extracted** at selectable radii (and energies).
- **Three beamlines** can be fed with up to 120 μA simultaneously.

- Simultaneous operation of different facilities
  - Nuclear Physics, Particle Physics, Life Sciences, Material and Molecular Science, Material Irradiation with Protons and Neutrons
- **UCN shares the beam with CMMS via** (Center for Material and Molecular Science) **via kicker magnet**

Inside the TRIUMF cyclotron

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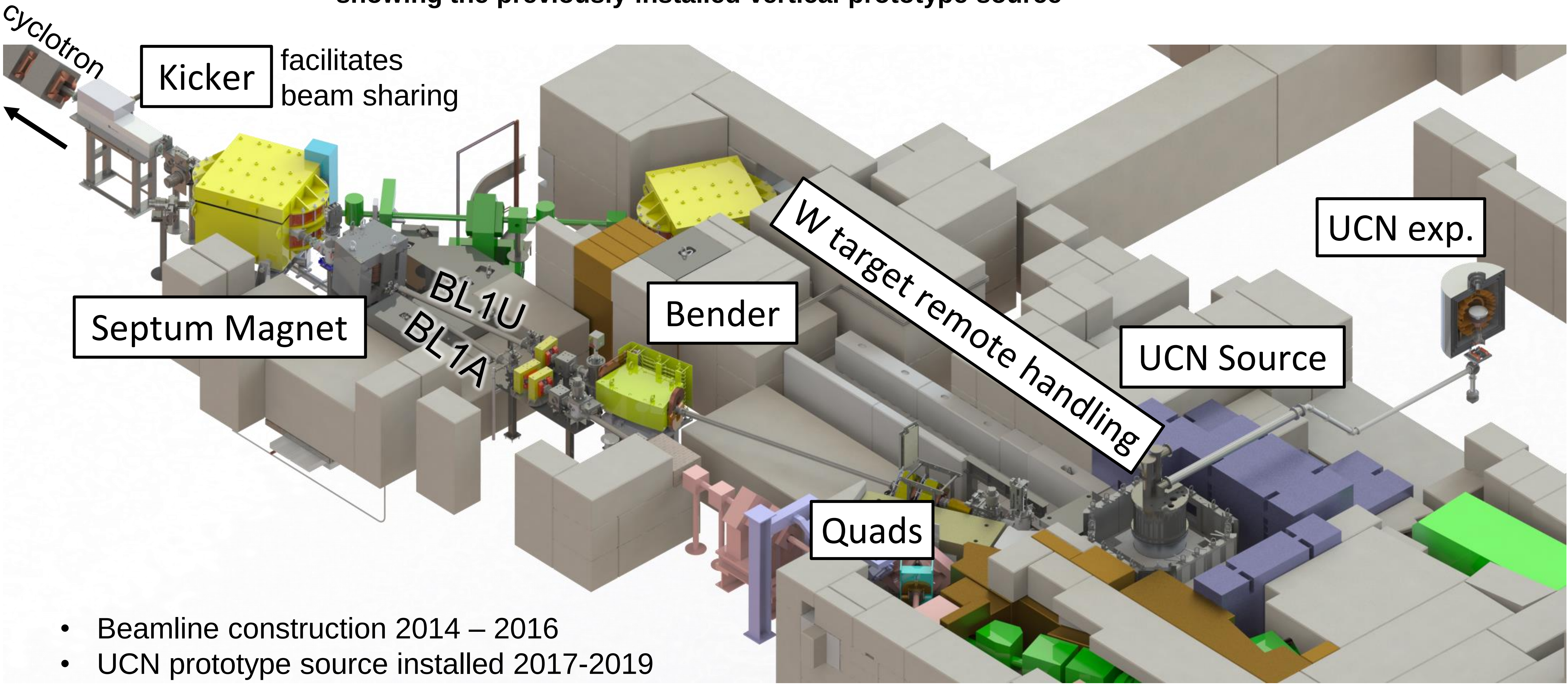
New beamline at TRIUMF for the UCN source

TRIUMF

showing the previously installed vertical prototype source



- Beamline construction 2014 – 2016
- UCN prototype source installed 2017-2019

S. Ahmed, et al, NIM A, Volume 927, 2019, pp 101.

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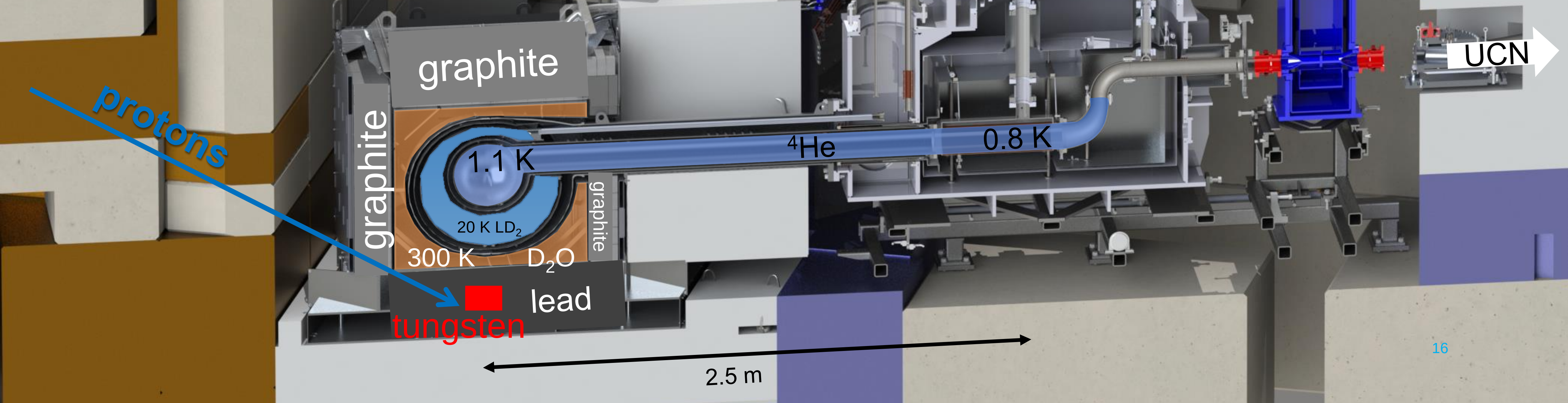
Advanced Neutron source

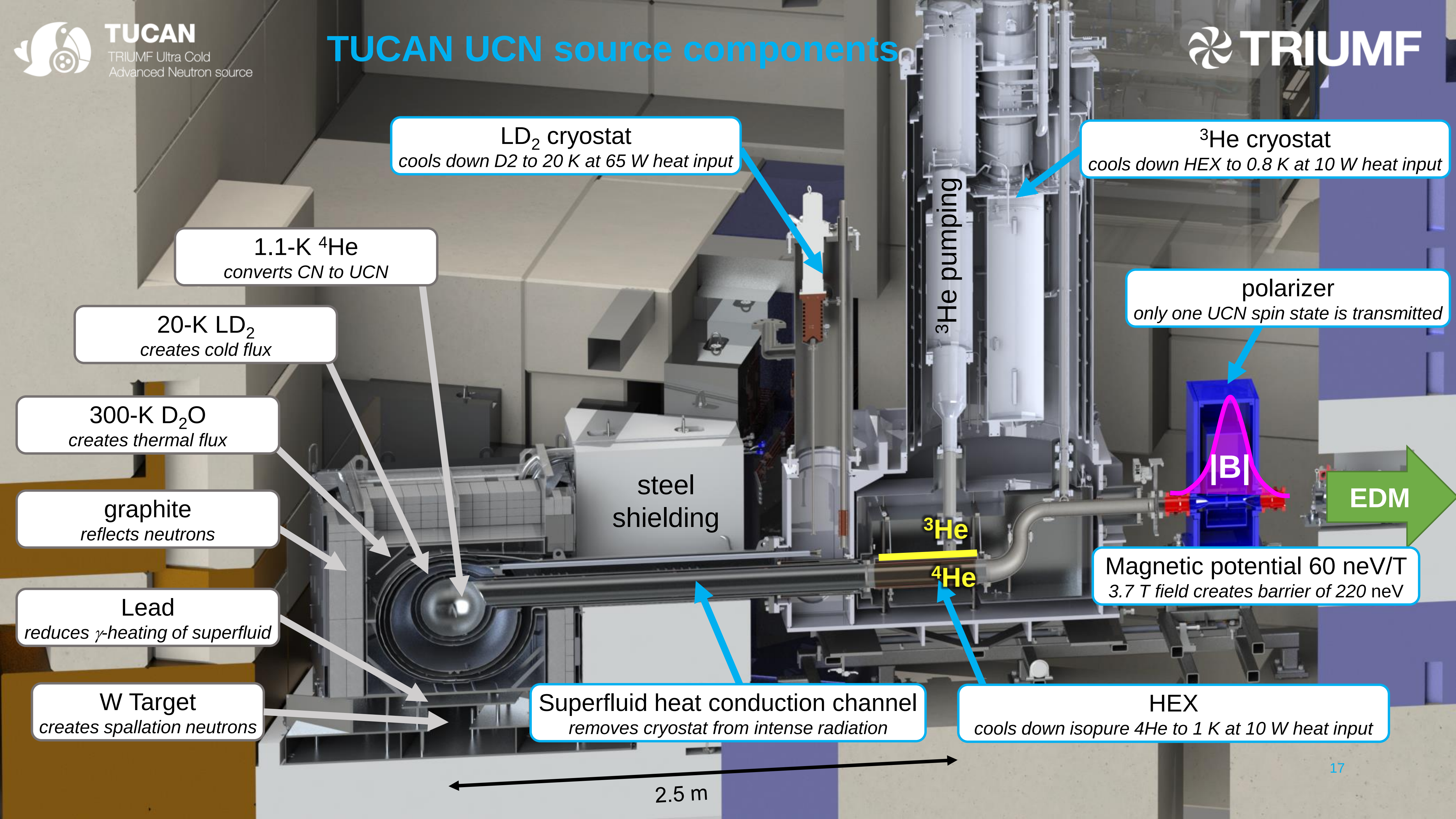
TUCAN UCN source recipe

TRIUMF

1. 480 MeV protons on tungsten create **spallation neutrons**
2. lead, graphite and heavy water **moderate** fast neutrons (MeV) to thermal neutrons (25 meV)
3. liquid deuterium at 20 K moderates further to create a large cold flux (1 meV)
4. **^{4}He** at around 1 K **converts** 1 meV (9Å) neutrons **to UCN** (< 215 neV)
5. **Extraction** to experiments via material guides



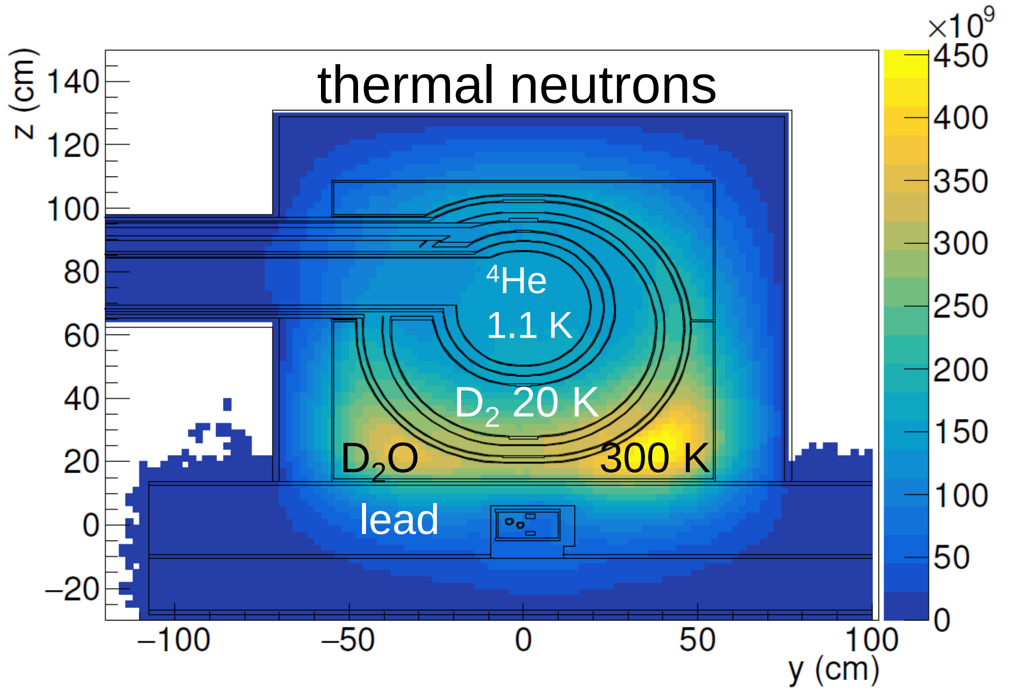
TUCAN UCN source components

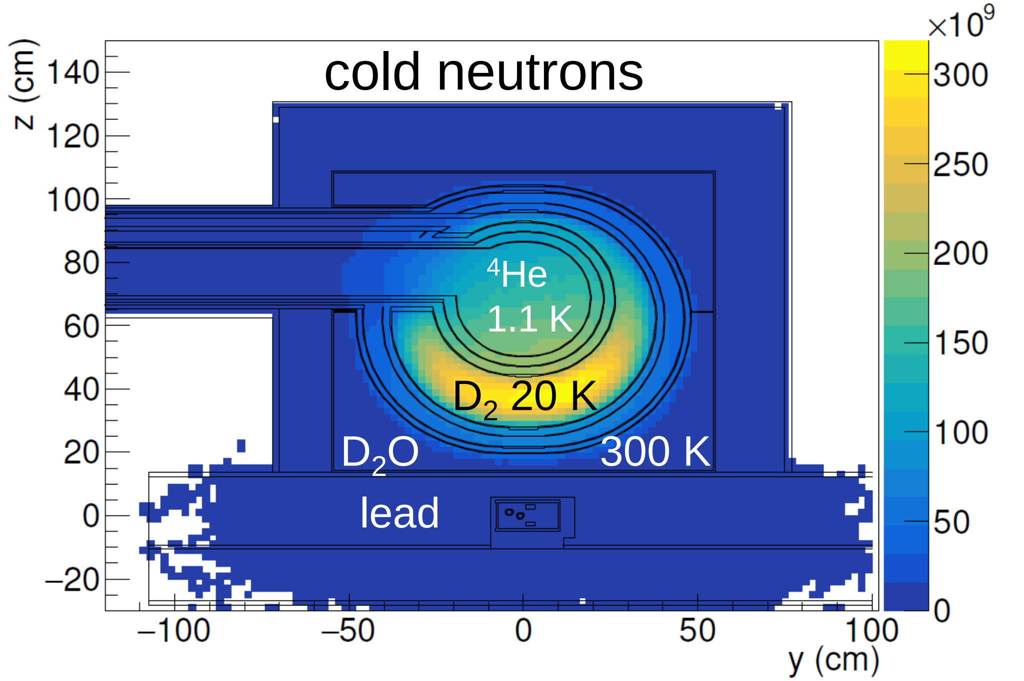


TUCAN source numbers

- 40 µA of 483 MeV protons on W target
- Production 1.4 x 10^7 UCN/s
- Source helium temp 1.03 K to 1.13 K
- Cooling power 10 W (3He fridge)
- Source storage lifetime 28 s
- Figure of merit $P\tau = 4.5 \times 10^8$
- Density in the source 3 x 10^3 UCN/cc
- Total number in the source 3 x 10^8 UCN
- Initial density in 70 l EDM experiment 200 UCN/cc
- Counted at the end of EDM cycle 1.6 x 10^6

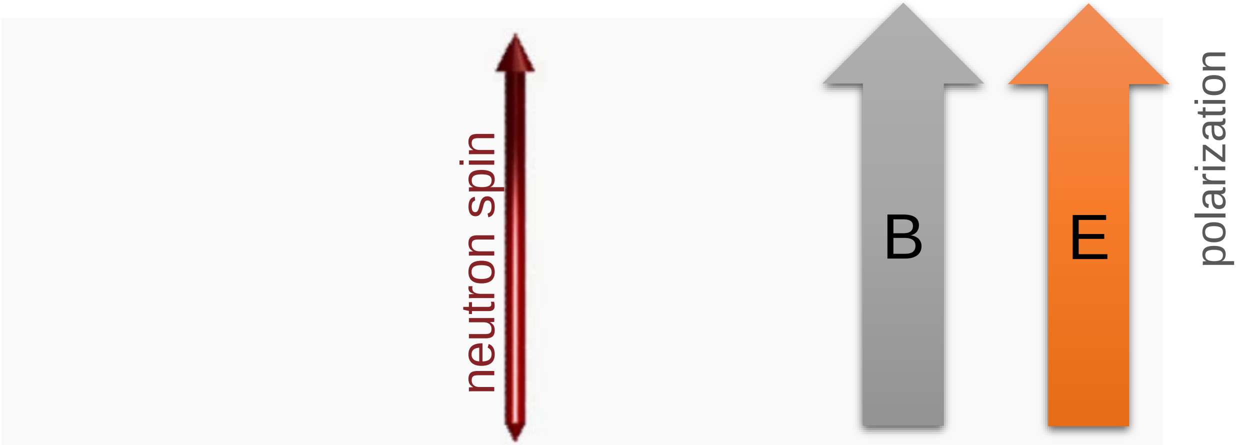
Once we have lots of UCN how do we measure the EDM?





Ramsey method

N. F. Ramsey, Phys.Rev.**76** 996 (1949) $\Rightarrow$ **Nobel Prize 1989**



Ramsey method facilitates frequency determination through polarization measurement.

1. prepare a sample of **polarized neutrons**
2. make a $90°$spin flip(“**start clock**”)
3. allow **free spin precession** in static, parallel ***B*** and ***E*** fields
4. make another $90°$spin flip (“**stop clock**”)
5. Projection of neutron spin on B field vector $\Rightarrow$ polarization

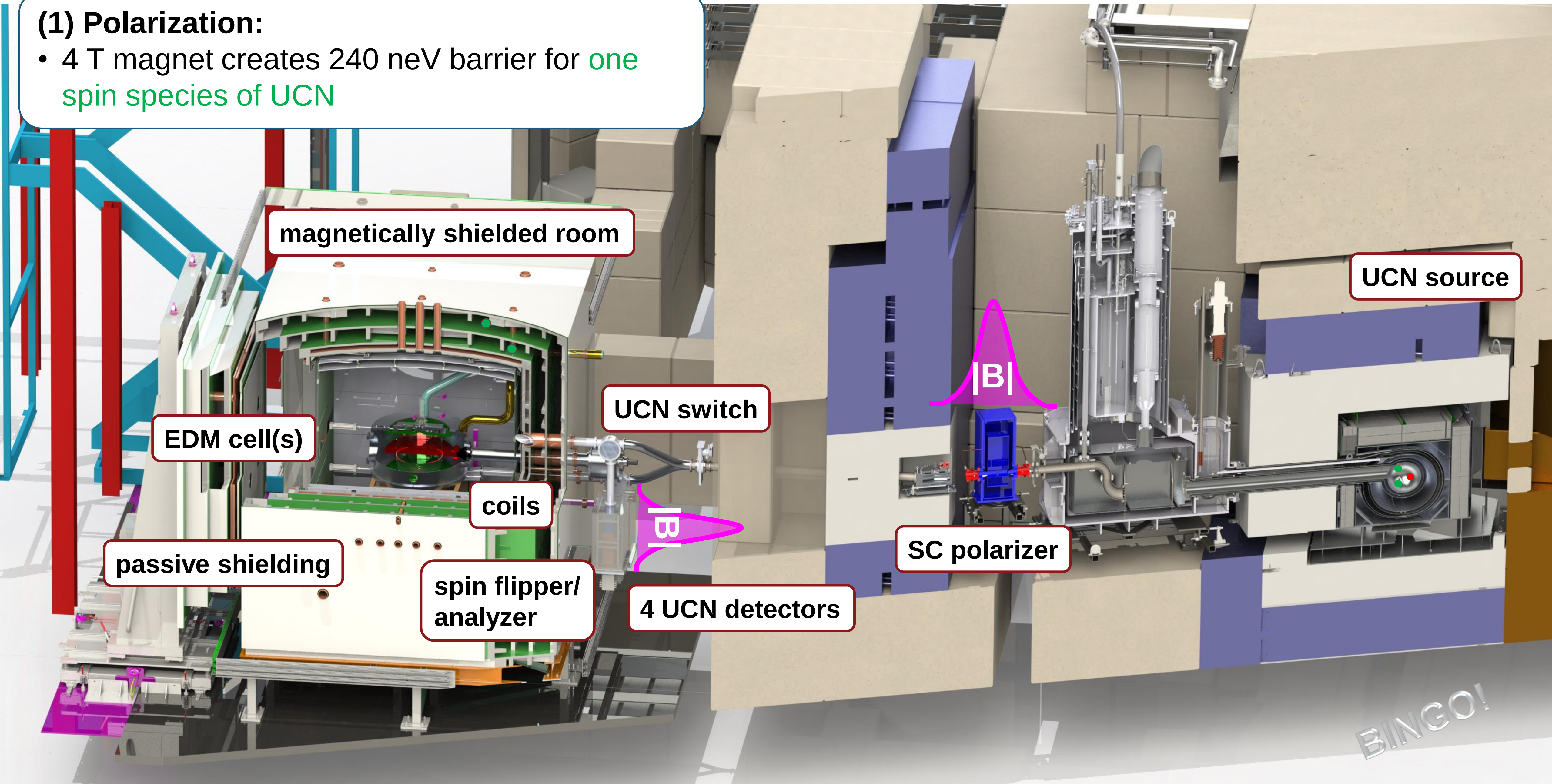
$$P = \frac{N_\downarrow - N_\uparrow}{N_\downarrow + N_\uparrow}$$

6. **Flip E field and repeat**

$$\Delta\varepsilon = h\,|\Delta\nu| = 4Ed_n$$

UCN room temperature EDM experiment

(1) Polarization:
- 4 T magnet creates 240 neV barrier for one spin species of UCN



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UCN room temperature EDM experiment

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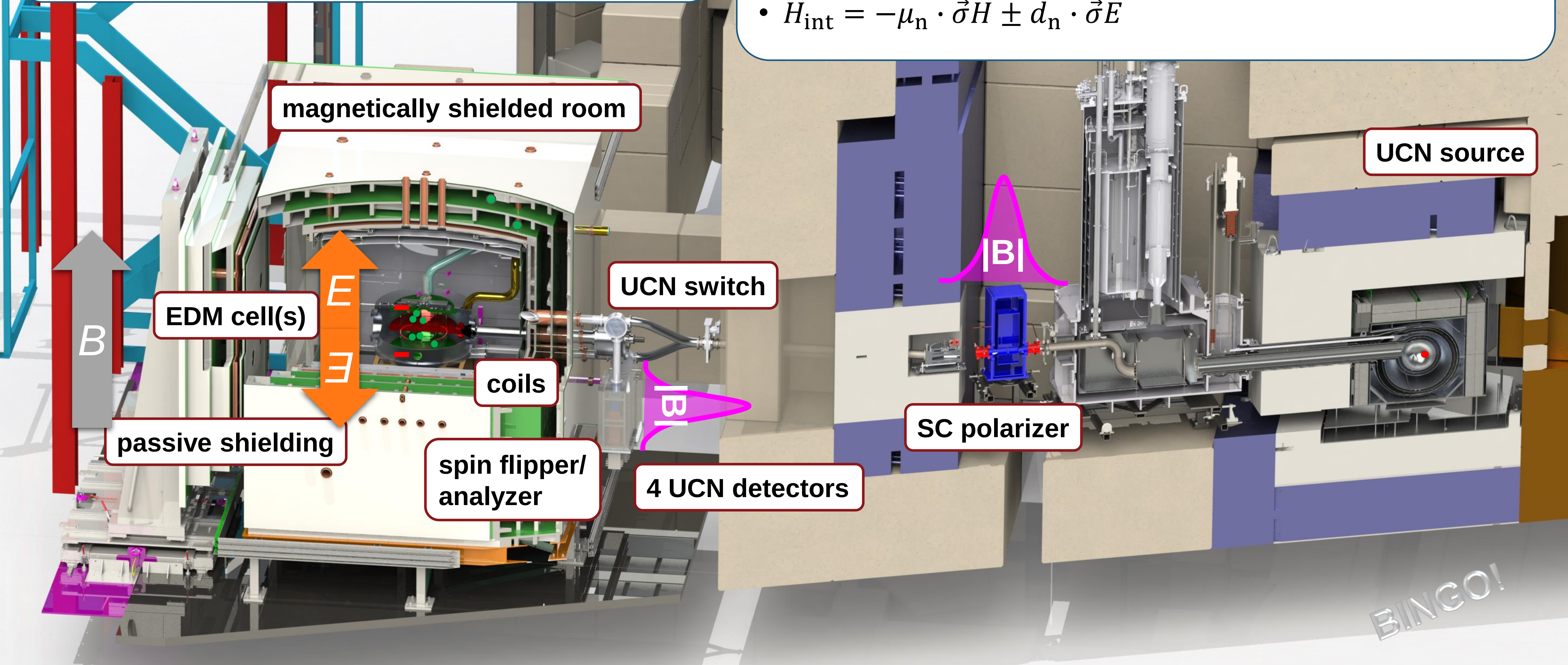
(1) Polarization:

- 4 T magnet creates 240 neV barrier for one spin species of UCN

(2) Ramsey cycle:

- two π/2 spin flips turn a Larmor precession change into a polarization change
- $H_{\text{int}} = -\mu_{\text{n}} \cdot \vec{\sigma}\vec{H} \pm d_{\text{n}} \cdot \vec{\sigma}\vec{E}$



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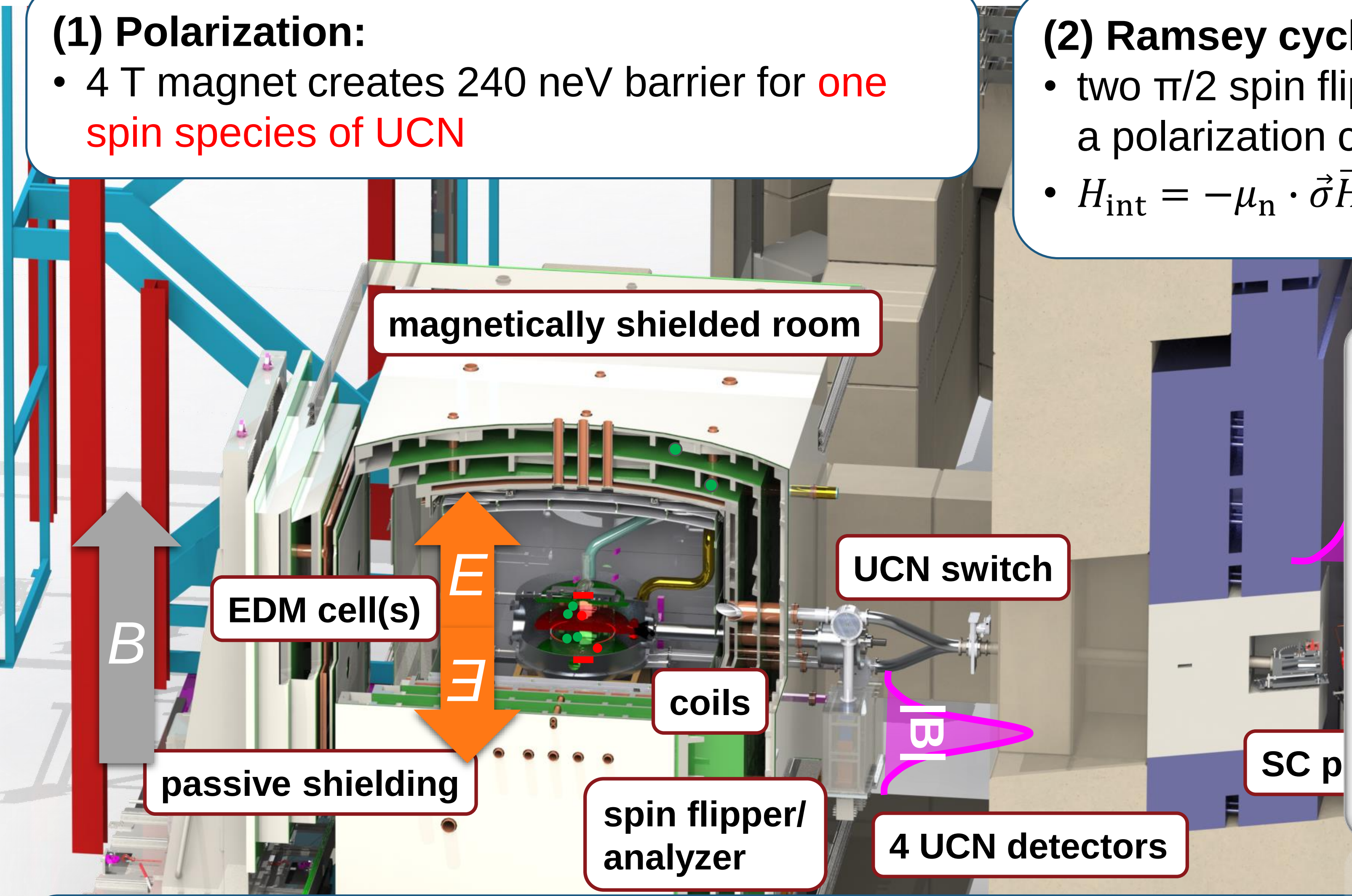
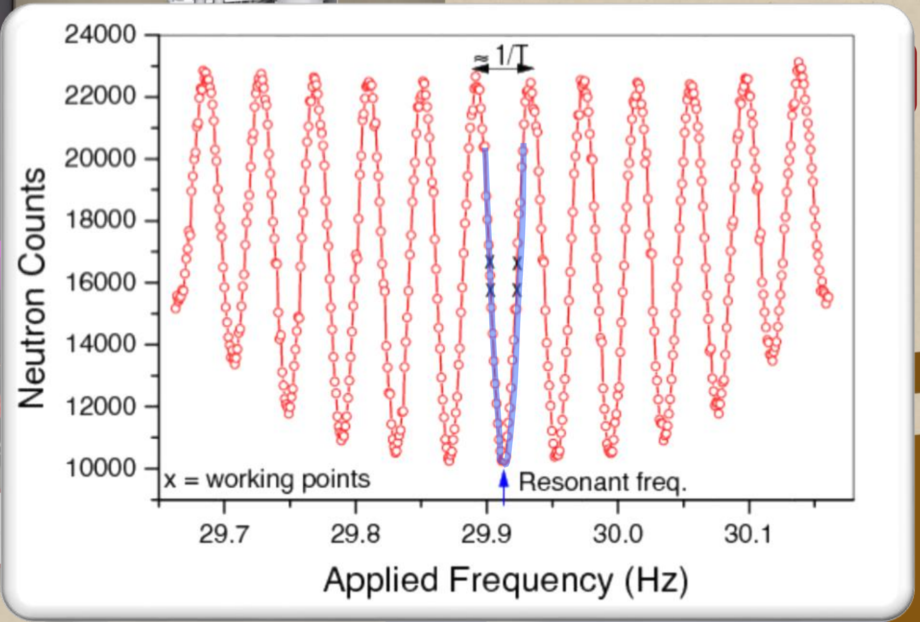




(3) Analysis:
- spin sensitive neutron counting

⇒polarization measurement

- fit the Ramsay curve to determine Larmor frequency
- change in frequency under field reversal?

$$\Delta\epsilon = \hbar|\Delta\nu| = 4Ed_n$$

Why could we be very competitive?

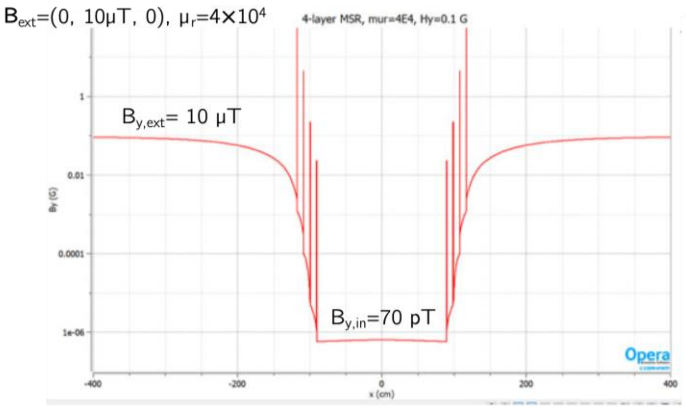
UCN Density!

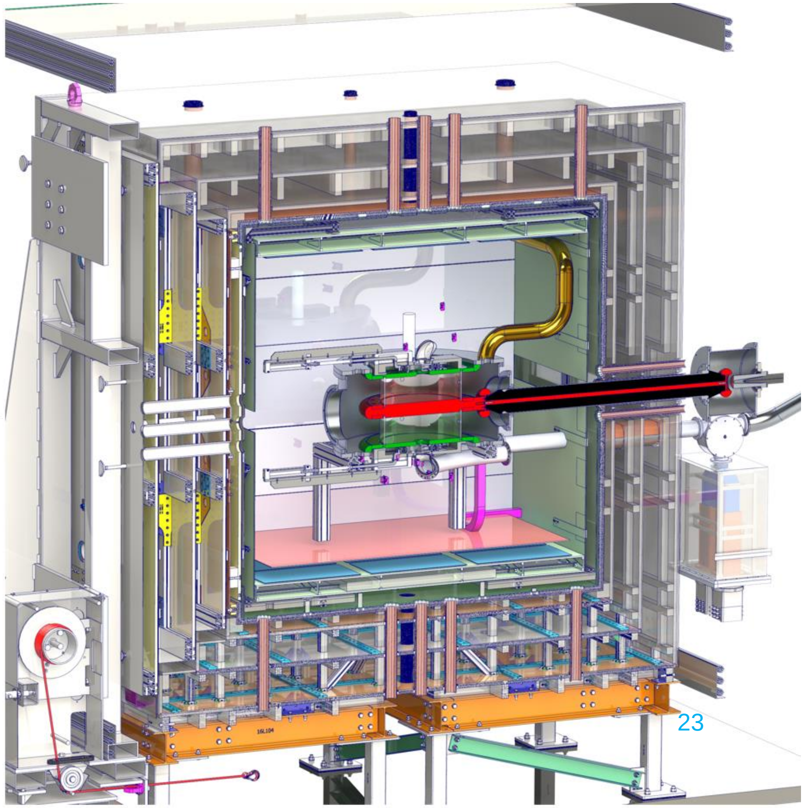
	published		future		
EDM Experiment	ILL	PSI nEDM	PSI n2EDM*	LANL EDM**	**TUCAN*** **
UCN detected per cycle	14 000	15 000	121 000	78 000	**1 600 000**
Size	20 l	20 l	116 l	40 l	**63 l**
Density detected	0.7	0.75	1	2	**26**

* expected, based on PSI nEDM.
** expected, based on storage expts.
*** expected, extensive MC.

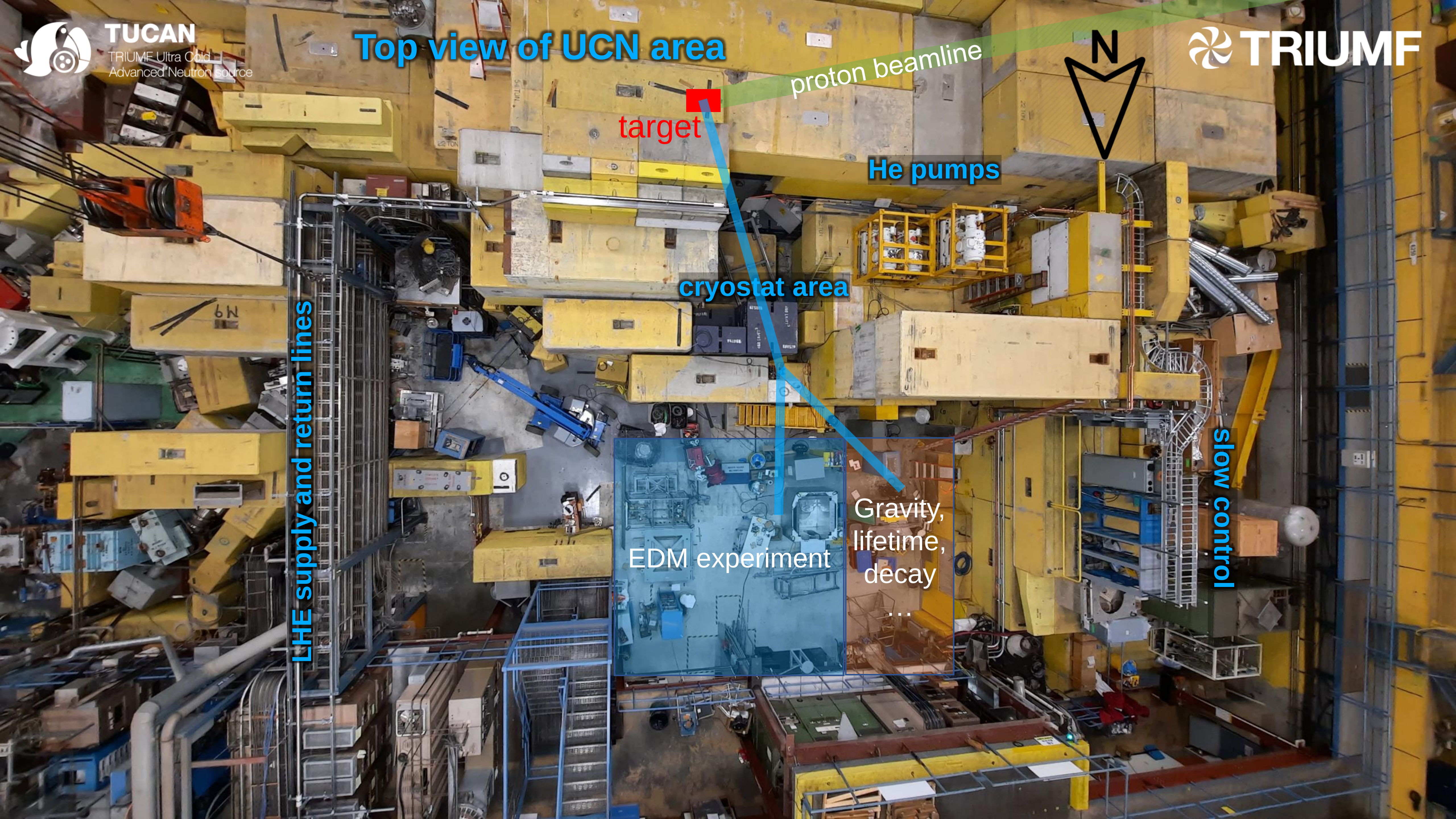
Magnetic field control!

State-of-the-art, 4-layer, magnetically shielded room combined with a self shielded main holding **B_0** field coil.

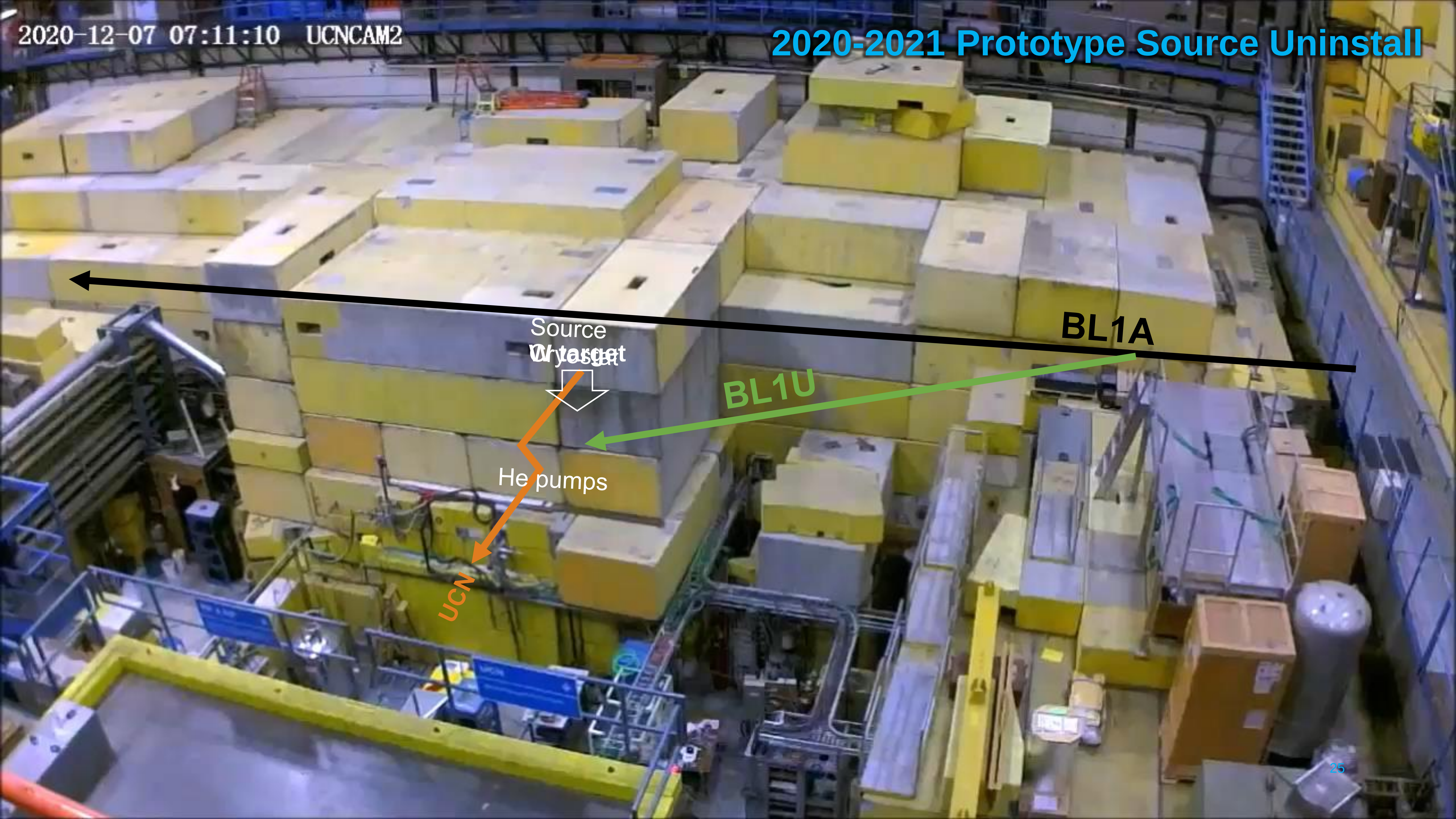




Top view of UCN area

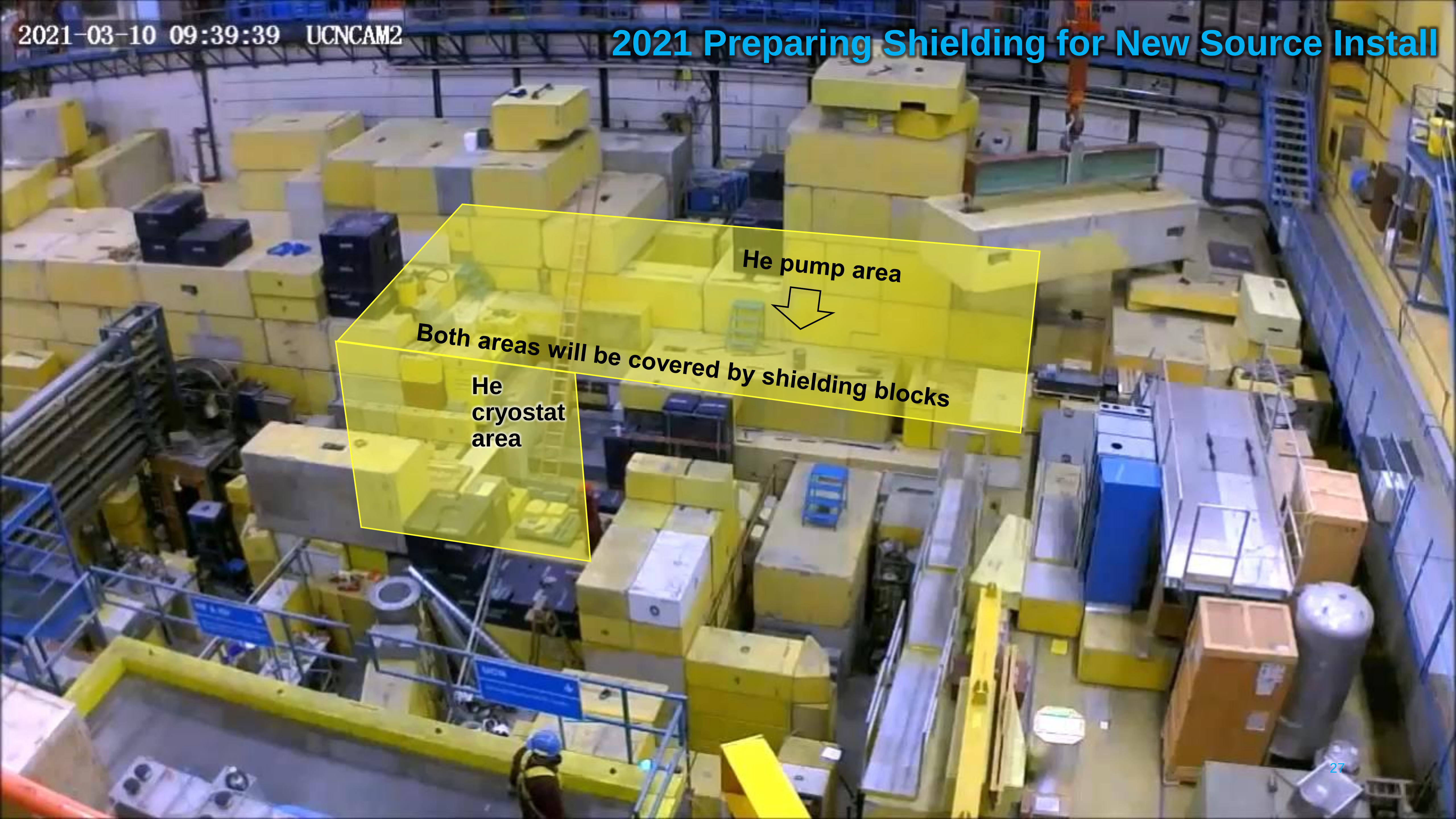


2020-2021 Prototype Source Uninstall



2021 Shutdown: Reconfiguring Target and Moderator Service Area

2021 Preparing Shielding for New Source Install



2021-2022 Electrical and Controls Installation

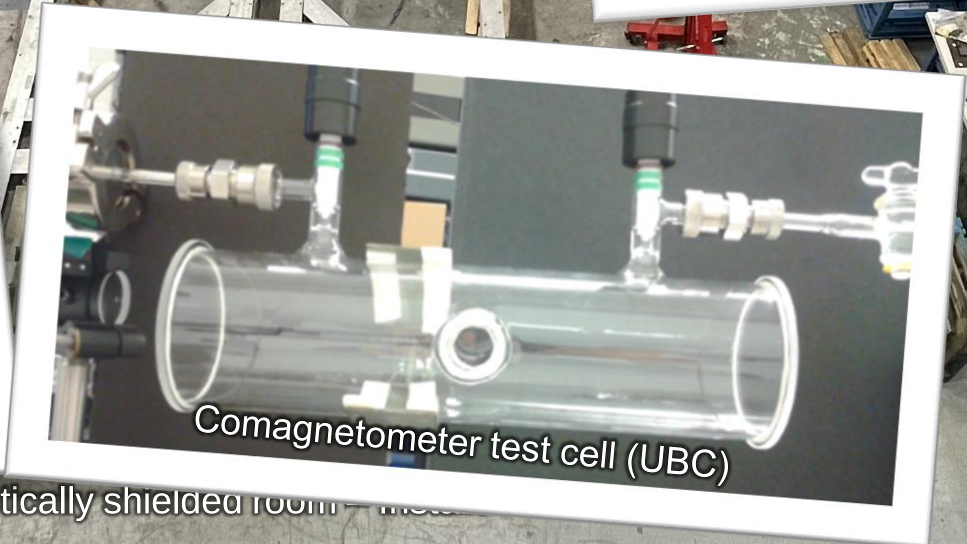
2022 Installing LHe Cryo Line

Some highlights

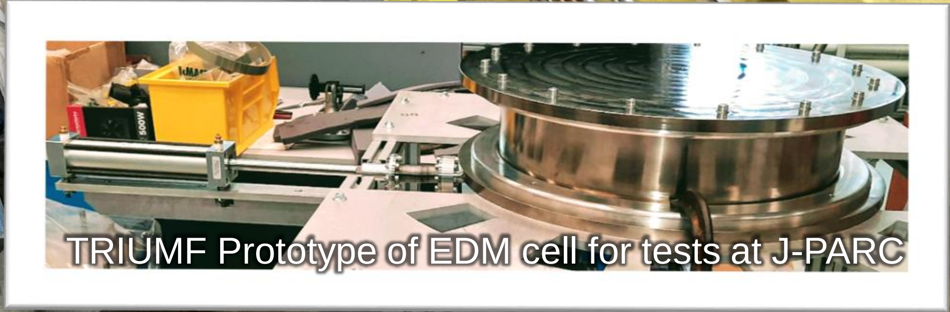
UCN production volume tests at LANL (2021)

Machined remaining tail section domes

^{3}He cryostat (KEK)



Comagnetometer test cell (UBC)



TRIUMF Prototype of EDM cell for tests at J-PARC

TRIUMF

- TRIUMF's cyclotron enables a world-leading ultracold neutron source
- Combination of a spallation neutron source and a superfluid helium ultracold neutron converter very promising.
- Stay tuned for first UCN from new source and EDM magnetics commissioning in the next 24 months

Questions?

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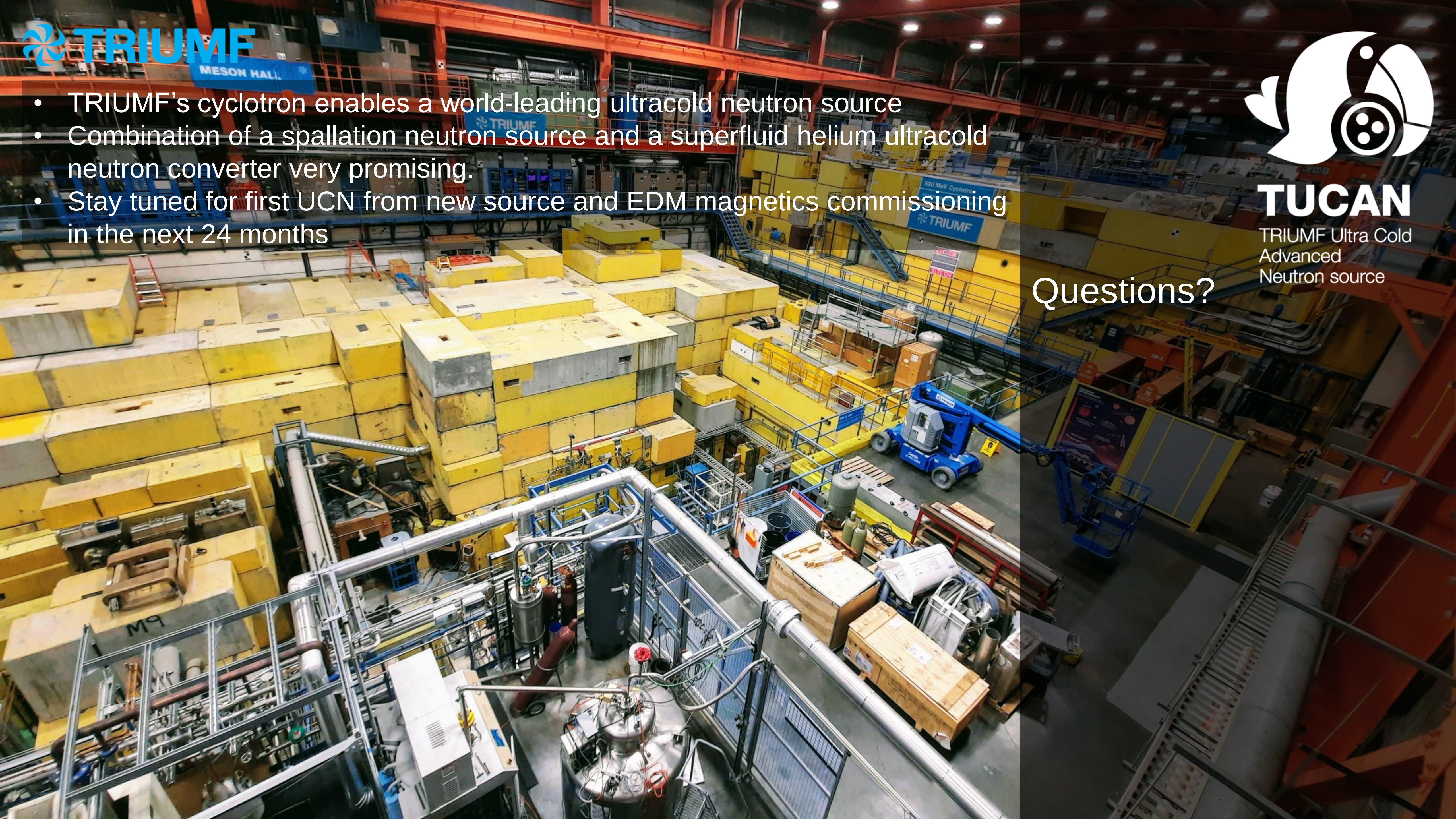


Backup slides

UCN in magnetic fields

(3) magnetic interaction

neutron magnetic moment $\mu_n = -60.3 \frac{\text{neV}}{\text{T}}$

Stern-Gerlach force $\vec{F} = \nabla(\vec{\mu}_n \vec{B})$

potential for one spin state in 2 T field $U = -\mu_n \cdot \text{B} \approx 120\text{neV}$

POLARISATION

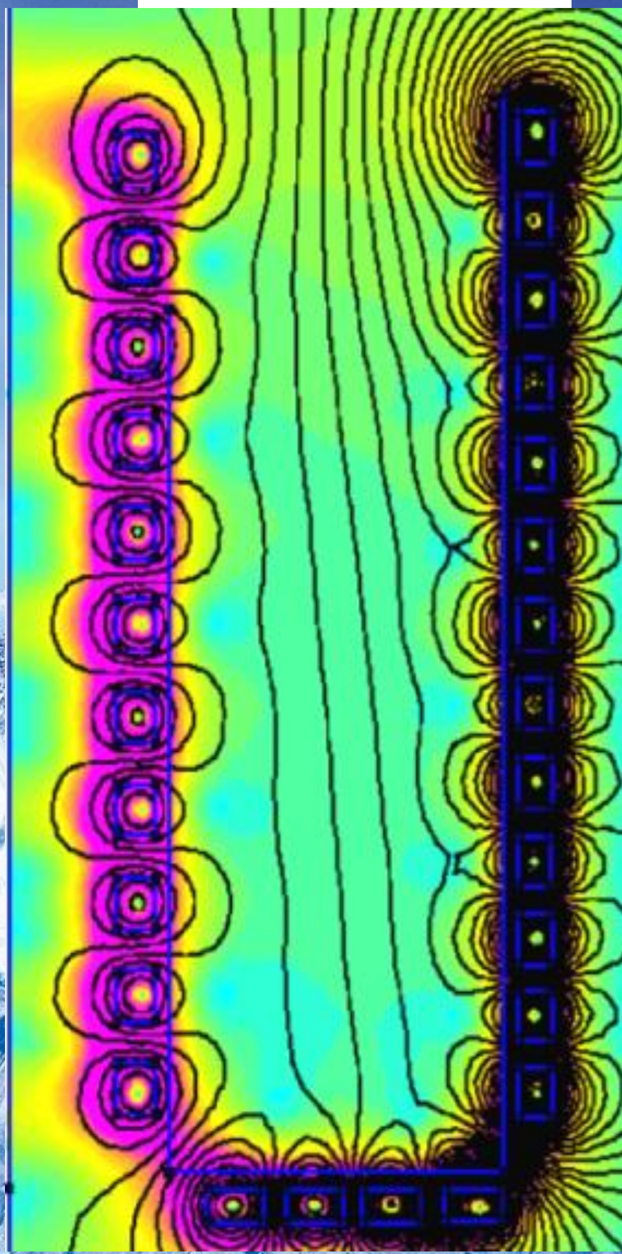
STORAGE

polarising magnet

UCN source

← experiment

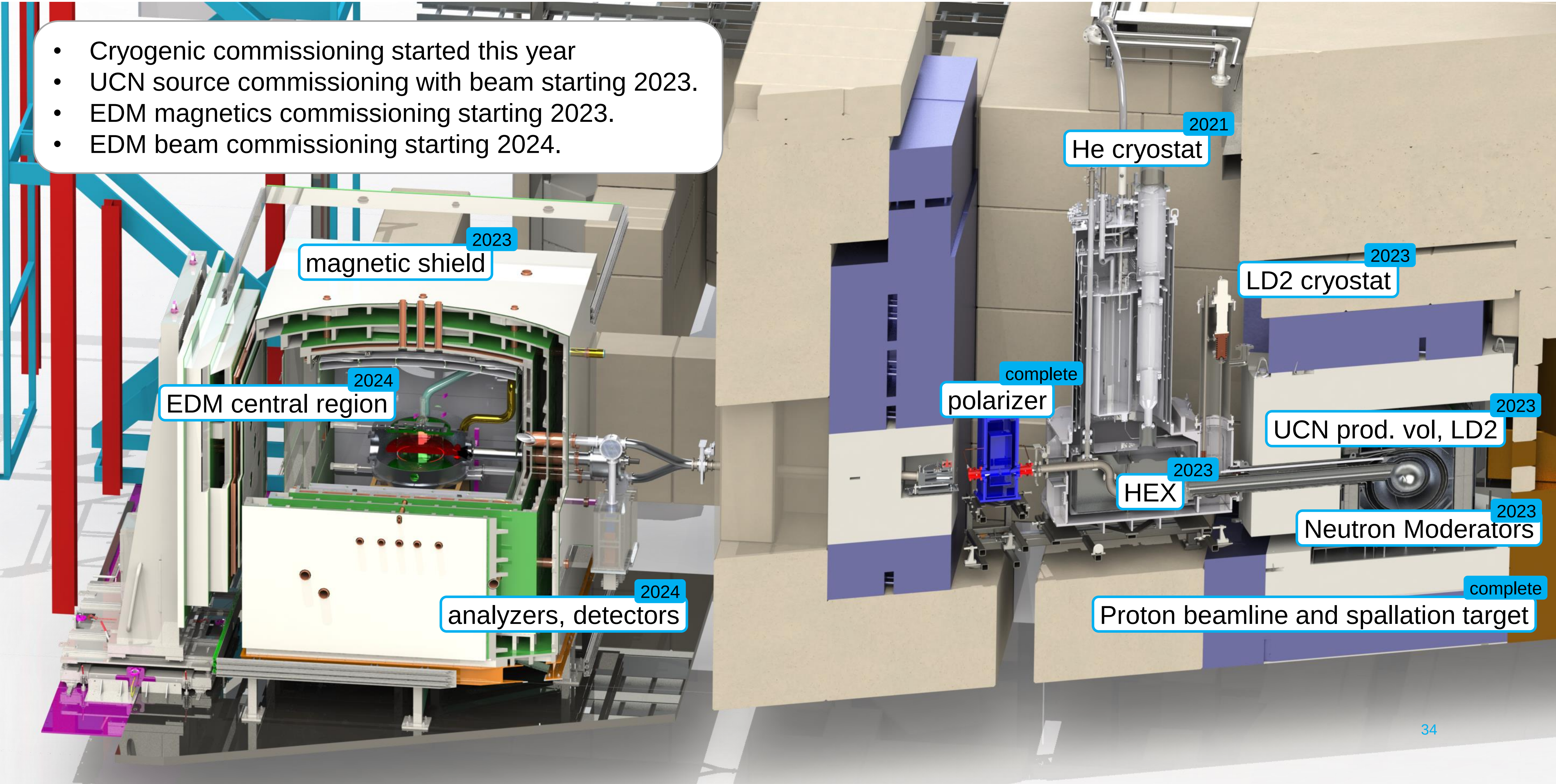
|B|



Neutron lifetime experiment PENeLOPE

Main ingredients and status

- Cryogenic commissioning started this year
- UCN source commissioning with beam starting 2023.
- EDM magnetics commissioning starting 2023.
- EDM beam commissioning starting 2024.



TUCAN
TRIUMF Ultra Cold Advanced Neutron source

TUCAN update Summer 2022

TRIUMF

1 33-m-long **liquid helium transfer line** successfully tested (W. Schreyer)

- from room temp. to LHe transfer in around 6 hours
- transfer efficiency around 90% ☺
- low losses as advertised

2 **EDM storage cell** tests at J-Parc completed (S. Vanbergen)

- good deuterated polystyrene-coated insulator and EDM-cell-valve performance ⇒ ready for EDM implementation
- NiP coating of electrodes showed higher losses than expected ⇒ investigating but EDM baseline foresees DLC coating anyways

3 Large **helium pump** tests (A. Brossard)

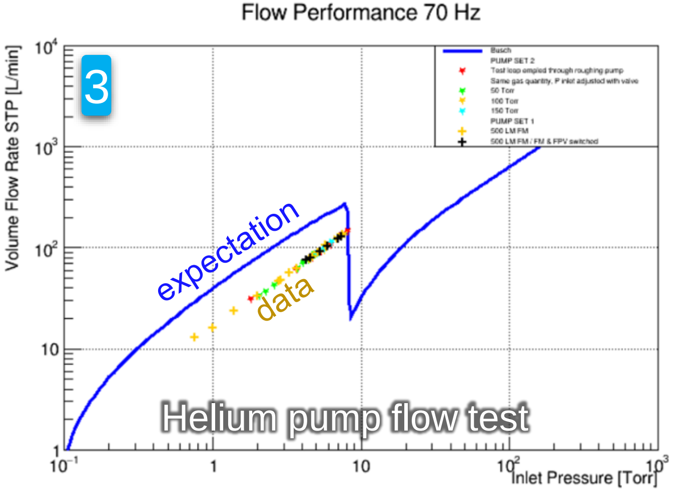
- VFDs and pump operation via PLC work well
- Cause for lower than expected performance was found to be in test setup ⇒ after small change, test will be repeated

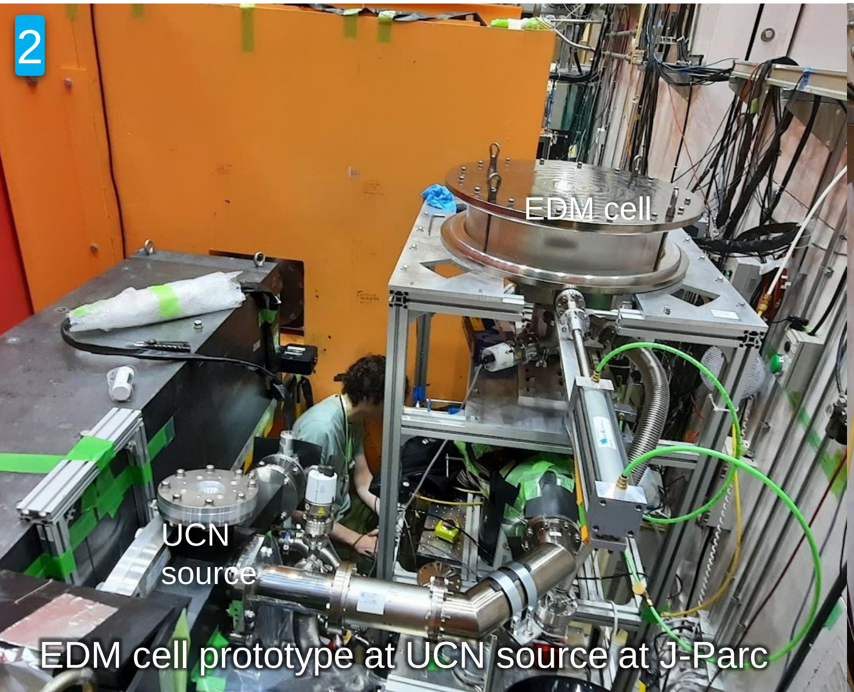
4 **Construction progress**

- all tail section domes are machined
- 3 months delay in delivery of cryo connection box

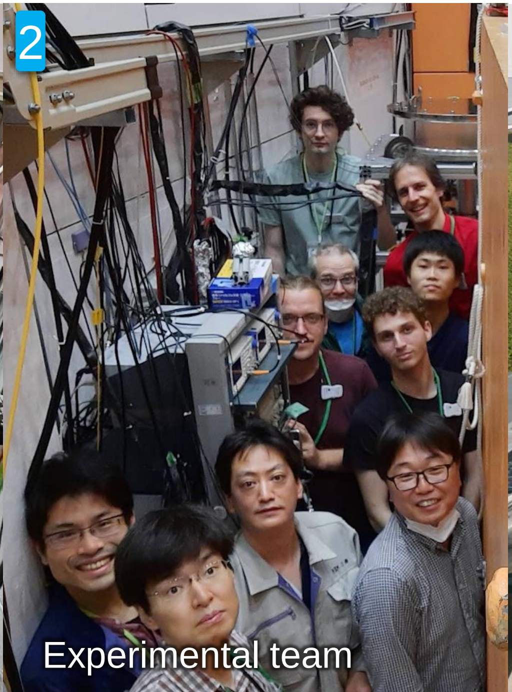
5 **EAC review** of project

- scientific importance of EDM experiment was confirmed
- our strategy moving forward was endorsed
- working on scope adjustments as planned





EDM cell prototype at UCN source at J-Parc



Experimental team

Machined tail section domes

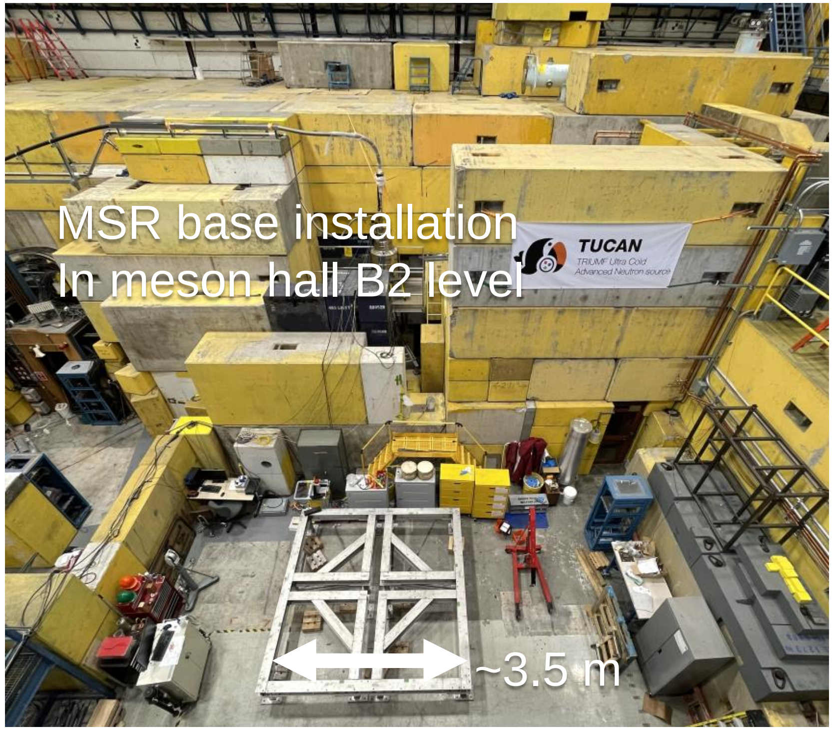
Cryo connection box top flange

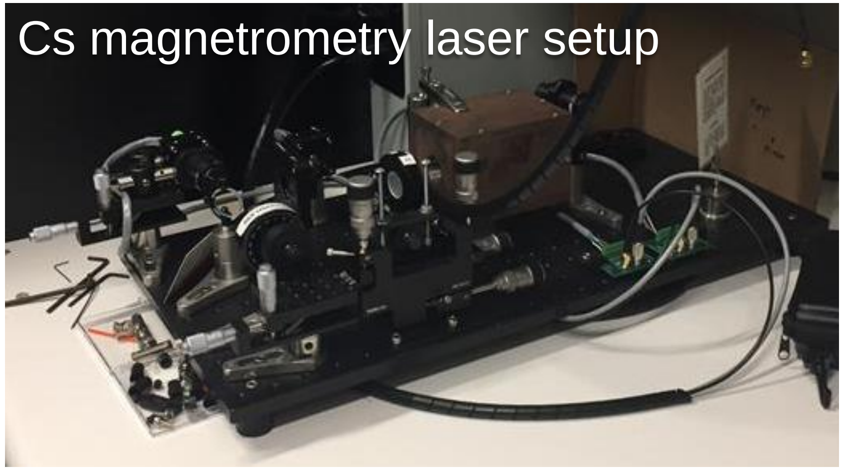
A happy Colin after successfully inserting the stinger

TUCAN
TRIUMF Ultra Cold
Advanced Neutron source

TUCAN update Summer 2022 – nEDM PRJ_555

TRIUMF





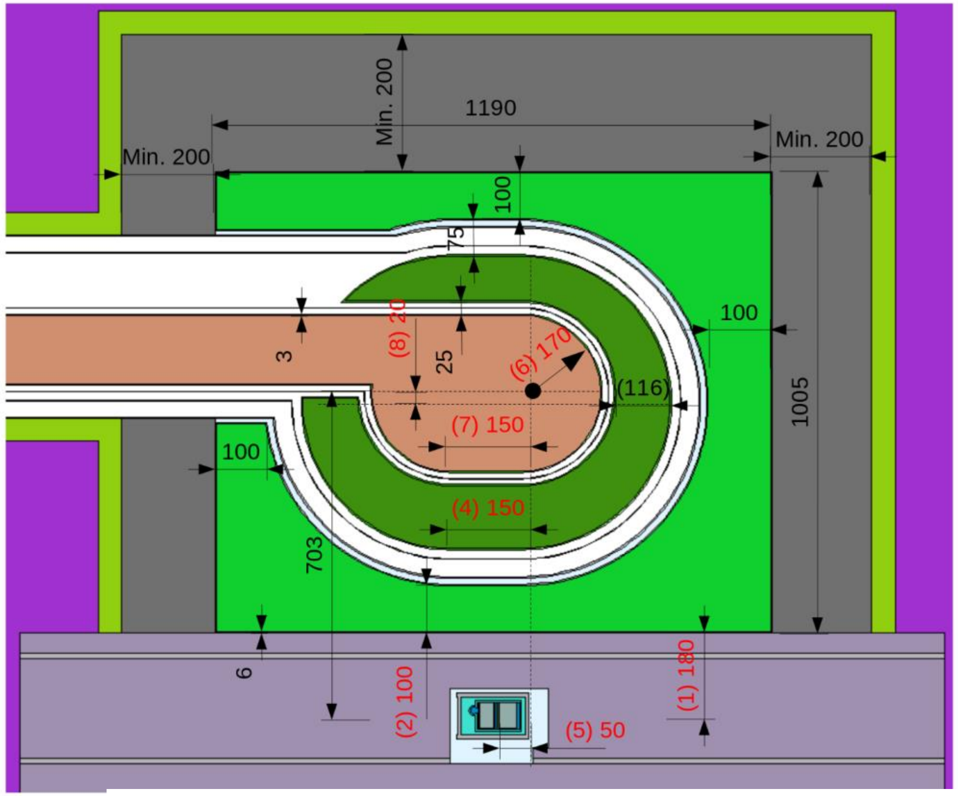
- Preparation ongoing for visit of UK company Magnetic Shields Limited (MSL): arrival on-site October 3rd for 10-12 months, assembly & installtion of TUCAN nEDM magnetically shielded room (MSR) in meson hall B2 level; Progress with visa, training plan, safety regulations for contractor work, etc
- Assembly and tests with perturbation coil which will be used to confirm shielding factor of TUCAN MSR
- TUCAN magnetics lab (MOB149): installation of laser setup for Cs magnetometry, including FSAR which is about to be routed in Docushare

TUCAN
TRIUMF Ultra Cold
Advanced Neutron source

TRIUMF moderator design

Volume (L)	
UCN converter (w/o guide)	**34.2**
Liquid deuterium	**125**
Heavy water	804
UCN production (s^{-1})	$\mathbf{21.5 \cdot 10^6}$
Max. heat load (W)	
UCN converter	4.4
Converter vessel	5.2
Converter total	**9.6**
Liquid deuterium	21
Deuterium vessel	17
Deuterium total	**38**
Heavy water	320
Heavy-water vessel	36
Vacuum separator	7.8
Thermal shield	13
Vacuum vessel	14
Heat exchanger	0.072
^{3}He	0.024
Tritium production (MBq/d)	
Liquid deuterium	330
Heavy water	828
^{3}He	29

Unit: mm



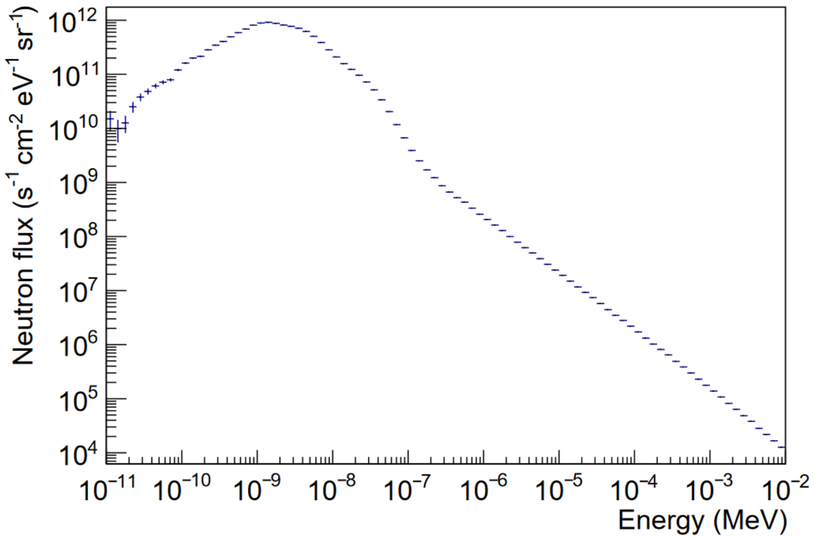
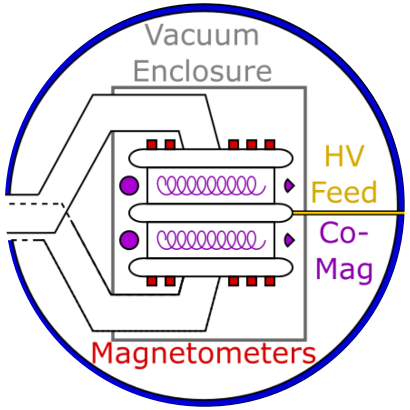


Figure 9: Neutron flux exiting the liquid-deuterium vessel.

TUCAN EDM general idea

- Double cell EDM spectrometer at room temperature
- Central HV electrode
- Hg comagnetometer (Xe to follow later)
- Alkali magnetometers surrounding EDM cells

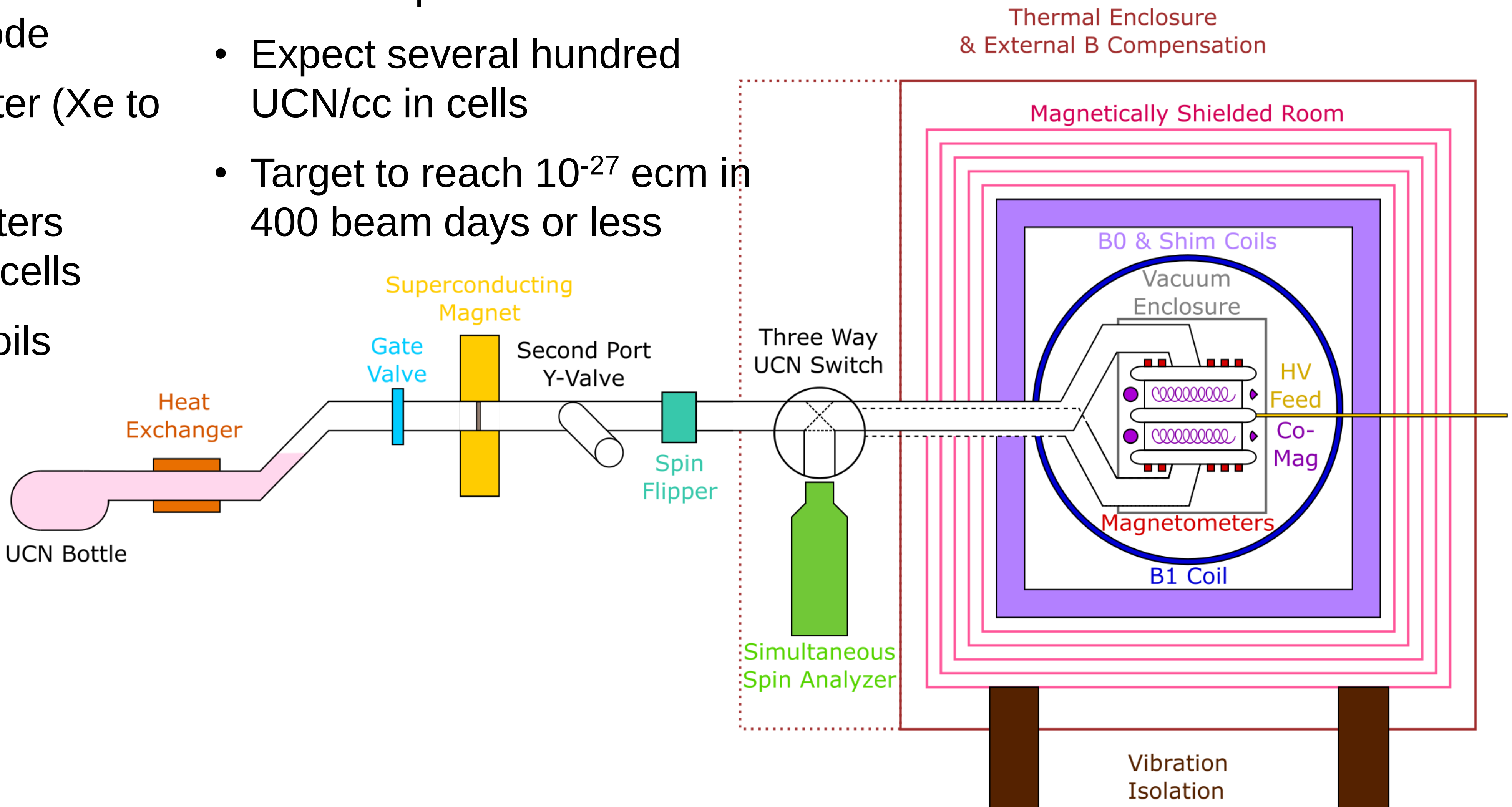


TUCAN EDM experiment layout

TUCAN
TRIUMF Ultra Cold Advanced Neutron source

TRIUMF

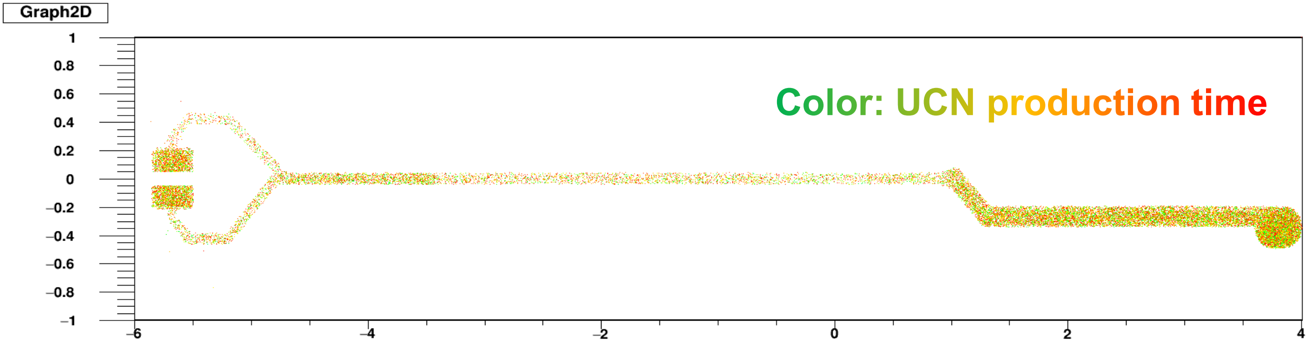
- Double cell EDM spectrometer at room temperature
- Central HV electrode
- Hg comagnetometer (Xe to follow later)
- Alkali magnetometers surrounding EDM cells
- Self shielded B_0 coils
- Magnetically shielded room
- Thermal enclosure and mag field compensation
- Expect several hundred UCN/cc in cells
- Target to reach 10^{-27} ecm in 400 beam days or less



Two highlights of EDM developments

nEDM statistical analysis

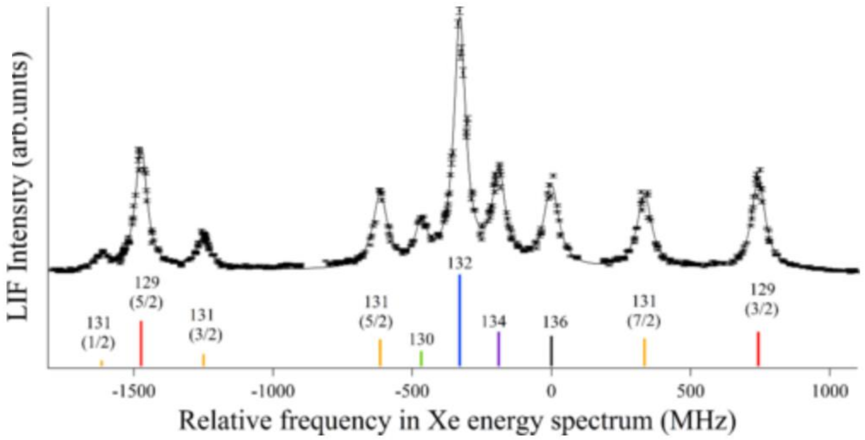
- UCN transport Monte Carlo used to evaluate statistical reach at TRIUMF



- Includes
  - Detailed source model
  - Superconducting polarizer
  - Switches, detector etc
- Used to optimize source and EDM guide layout

Xe comagnetometer

- High-resolution two-photon spectroscopy of a $5p^5 6p \leftarrow 5p^6$ transition of xenon



- This transition will be used for the comagnetometer

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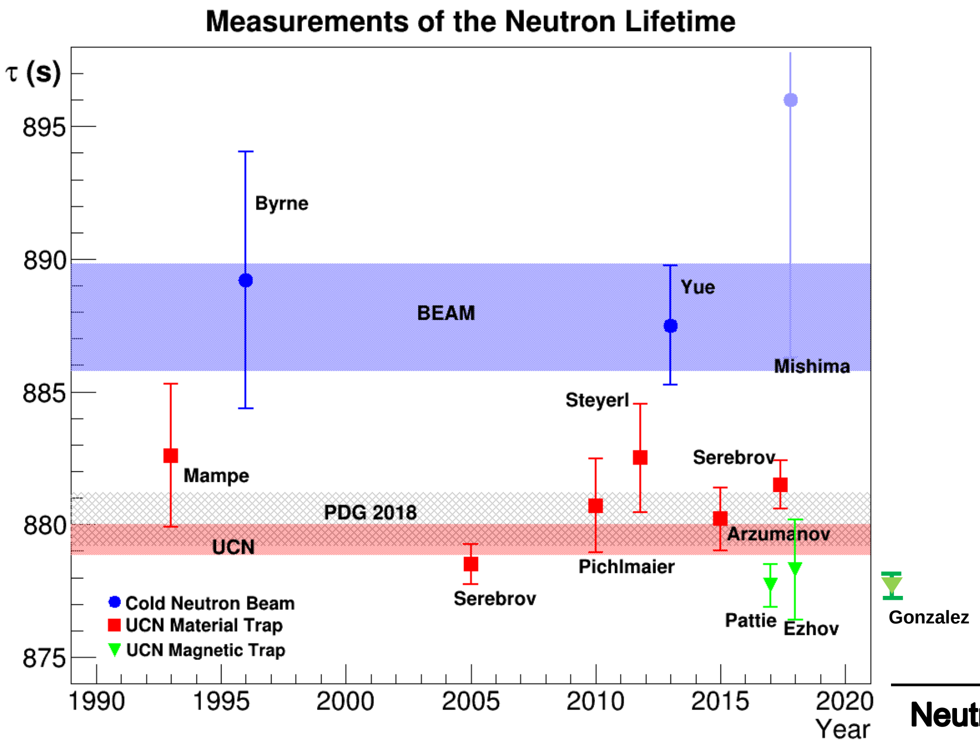
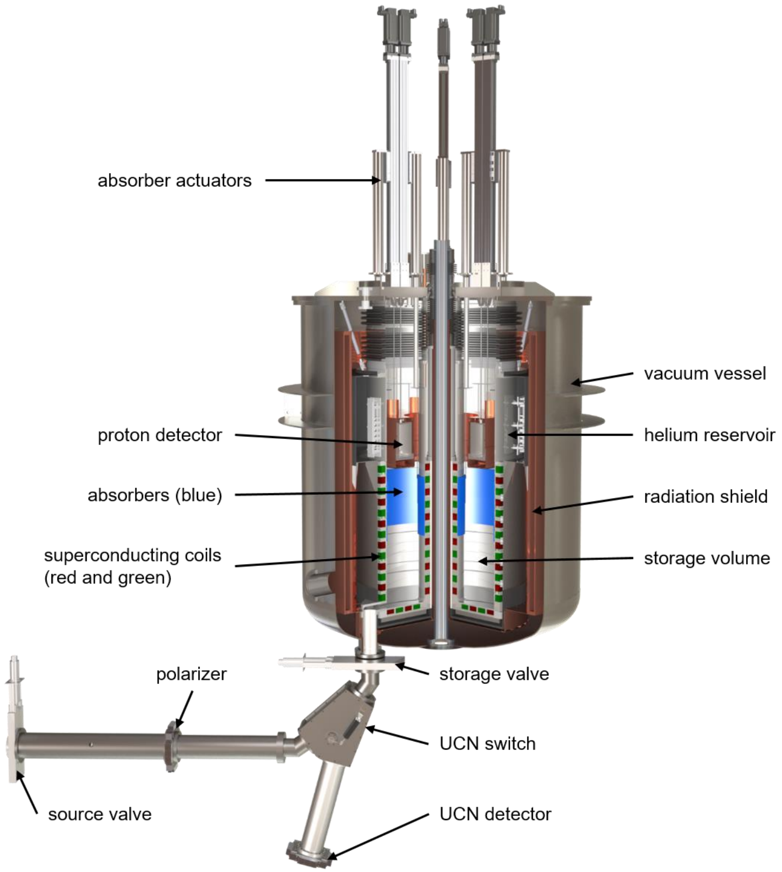
UCN experiments for 2nd port

- At first: 2nd port will be used for source characterization and component testing for EDM
- neutron lifetime experiment
  - large discrepancy between beam and bottle measurements
  - discussion about possible addition dark decay channel largely resolved => systematic effect?
  - collaboration with PENeLOPE exists, could move to TRIUMF



Neutron lifetime puzzle



PENeLOPE neutron lifetime experiment

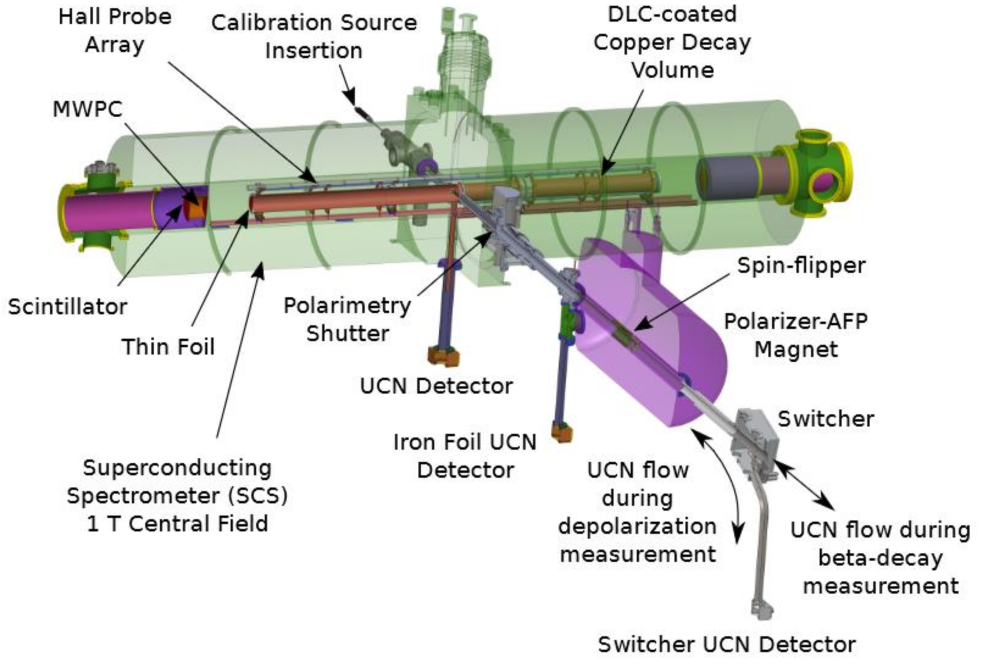
UCN experiments for 2nd port

- At first: 2nd port will be used for source characterization and component testing for EDM
- neutron lifetime experiment
  - large discrepancy between beam and bottle measurements
  - discussion about possible addition decay channel (dark matter?)
  - collaboration with PENeLOPE exists, could move to TRIUMF
- neutron decay expts.
  - e.g. A, the correlation between the electron momentum and the initial spin of the n
    tron in neutron β-decay

$$A_0 = \frac{-2(\lambda^2 - |\lambda|)}{1 + 3\lambda^2}. \qquad \lambda \equiv \frac{g_A}{g_V}$$

  - together with neutron lifetime can obtain V_{ud}, the first CKM matrix element

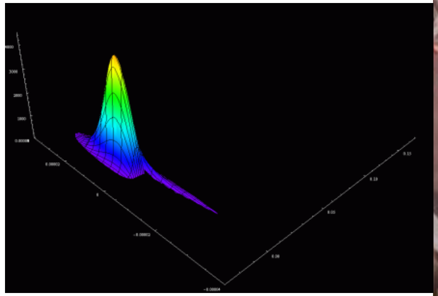
$$|V_{\rm ud}|^2 \tau_n (1 + 3g_A^2) = 4908.6(1.9)\ \text{s},$$



UCNA experiment to measure A with UCN

UCN experiments for 2^{nd} port

- At first: 2^{nd} port will be used for source characterization and component testing for EDM
- neutron lifetime experiment
  - large discrepancy between beam and bottle measurements
  - discussion about possible addition decay channel (dark matter?)
  - collaboration with PENeLOPE exists, could move to TRIUMF



- neutron decay expts.
  - e.g. A, the correlation between the electron momentum and the initial spin of the neutron in neutron β-decay

$$A_0 = \frac{-2(\lambda^2 - |\lambda|)}{1+3\lambda^2}. \quad \lambda \equiv \frac{g_A}{g_V}$$

  - together with neutron lifetime can obtain V_{ud}, the first CKM matrix element

$$|V_{\mathrm{ud}}|^2 \tau_n (1 + 3 g_A^2) = 4908.6(1.9)\ \mathrm{s},$$

- gravitational experiments with UCN
  - can determine the wavefunction of the neutron in the gravitational potential very precisely
  - allow putting constraints on non-Newtonian gravity distances of µm, and thus Axions or Chameleons

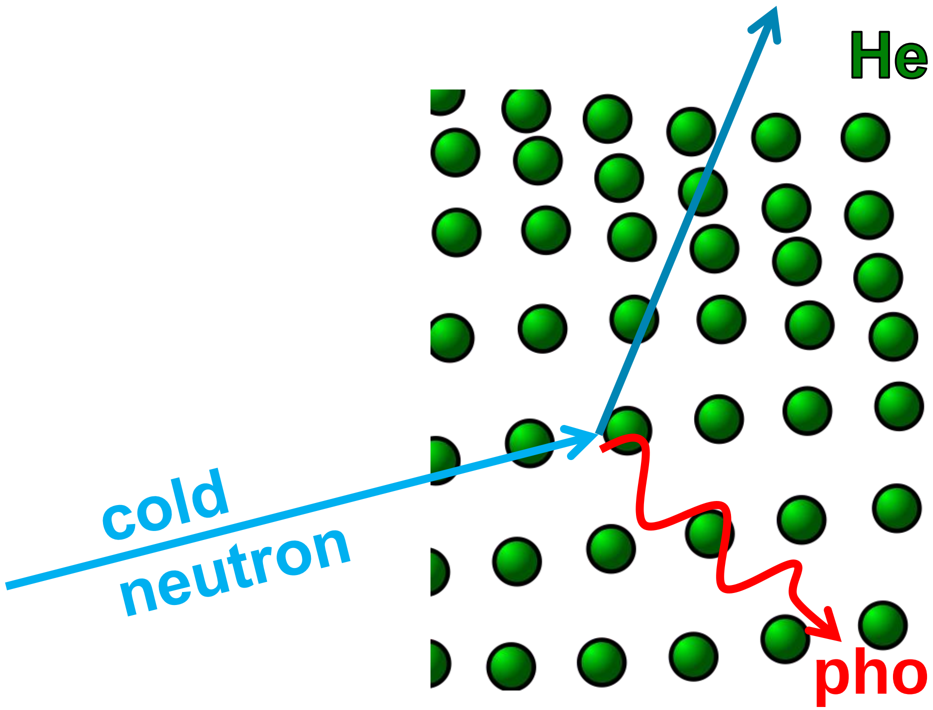
- These are mostly **statistics limited**, so higher UCN densities will boost the sensitivity reaches but also allow to explore new experimental ideas.

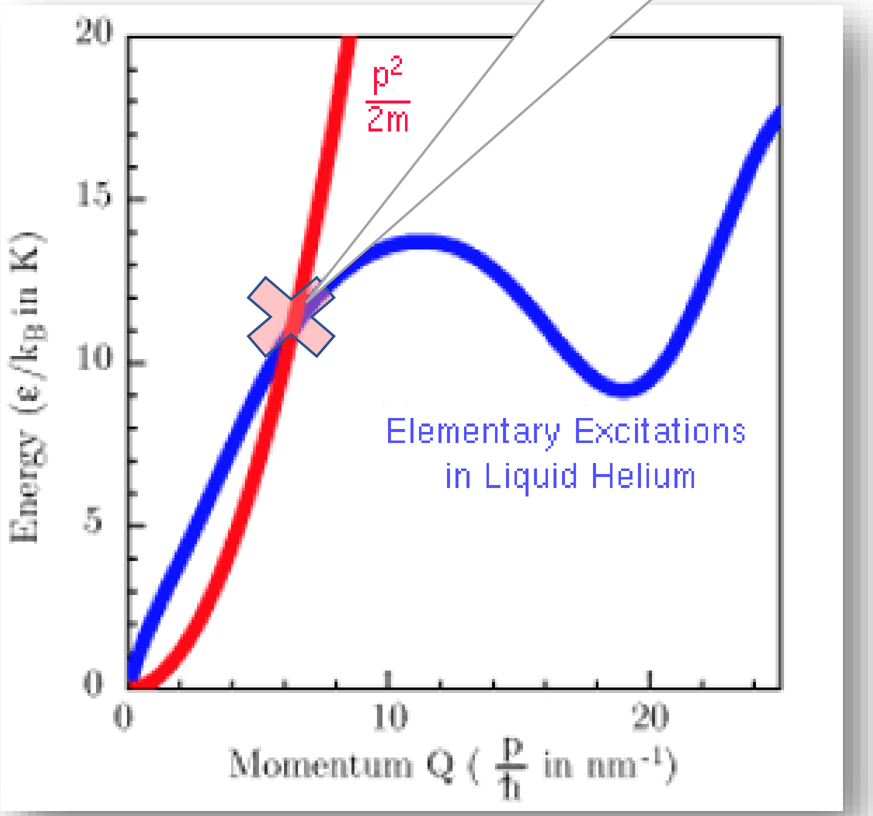
Qbounce @ ILL

How to loose all your energy!

5. ^{4}**He** at 1 K **converts** 1 meV (9Å) neutrons **to UCN (100 neV)**

A neutron with this momentum can create a phonon and loose basically all its energy.

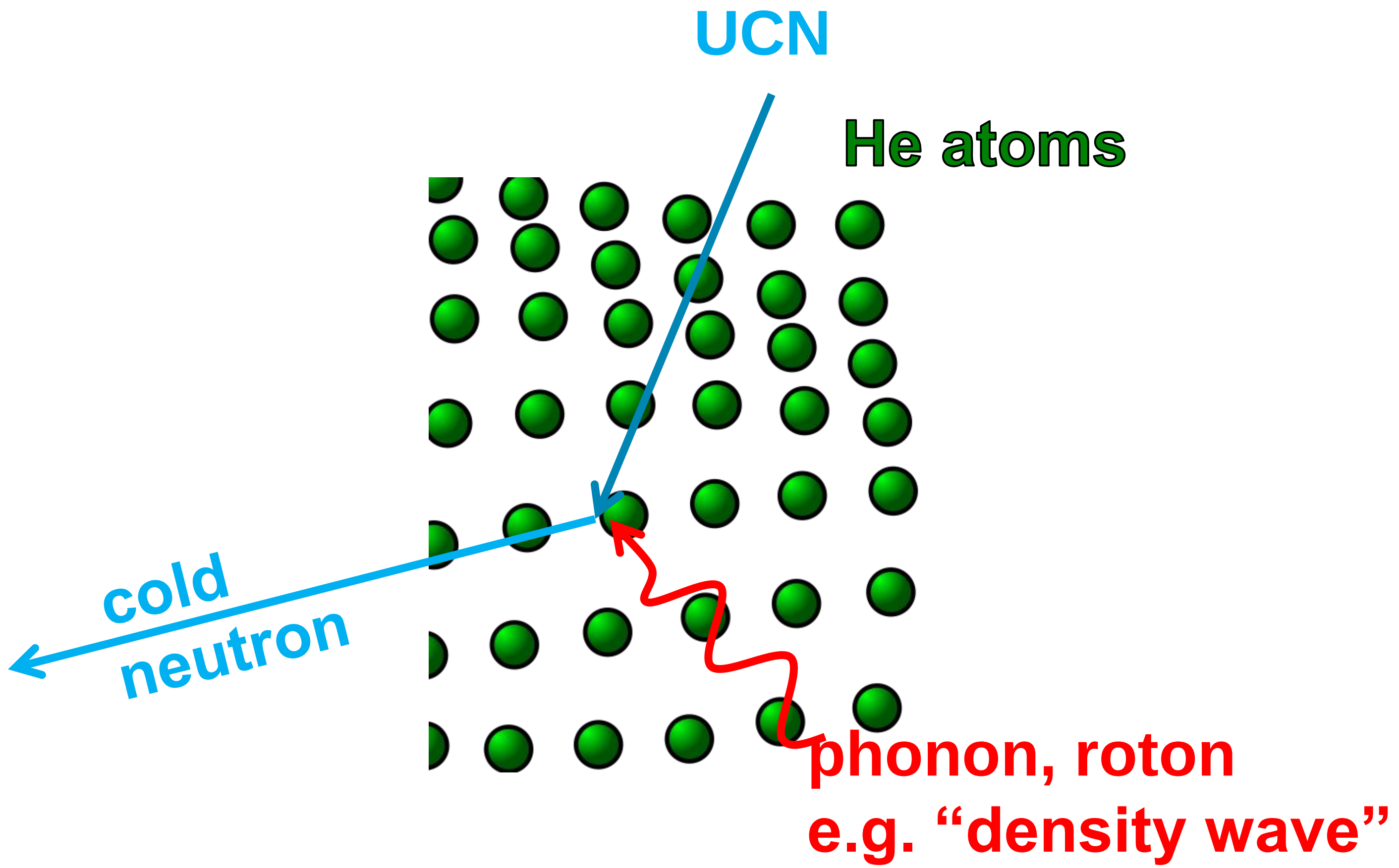


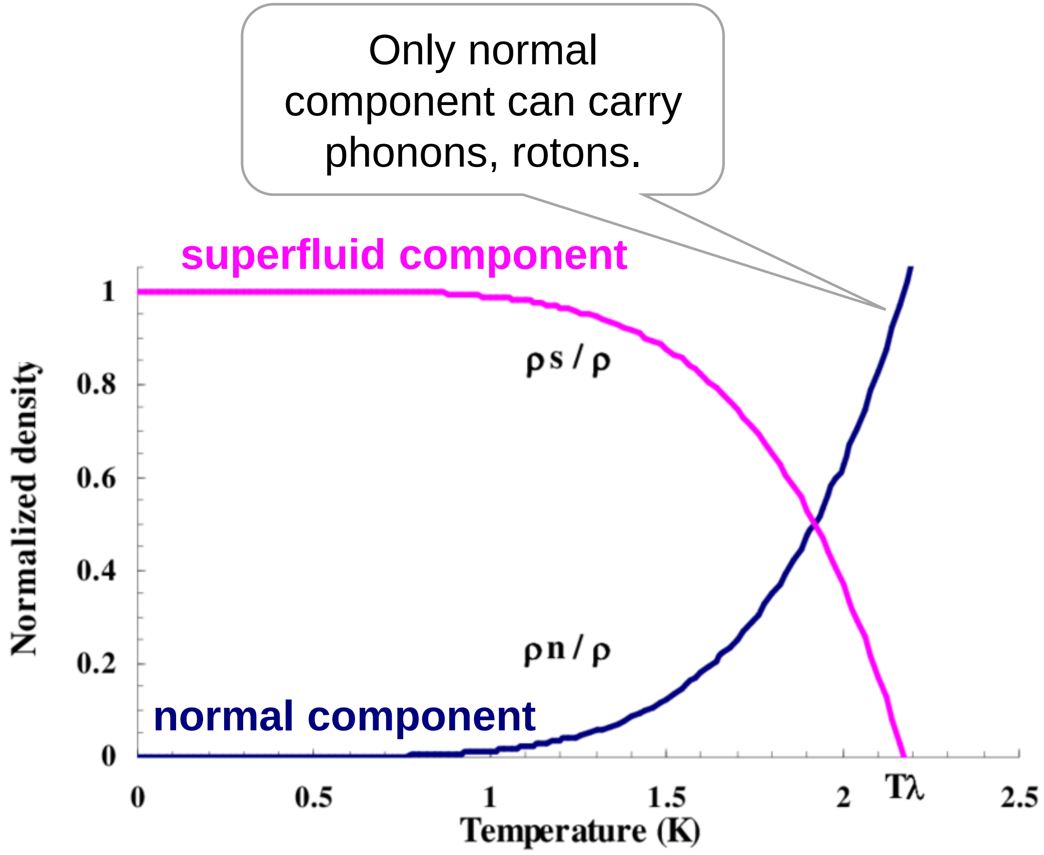


Neutron is downscattered, almost all energy taken away by phonon, roton.

How to avoid the yoyo effect?

Reverse process is bad, since UCN gains enough energy to leave the system.





Cooling reduces phonon, roton density, increases UCN lifetime.

Timescale: up to 100 s

Bold means achieved!	RAL SUSSEX ILL (Grenoble, FR)	PSI (Villigen, CH)		PanEDM TUM ILL (Grenoble, FR ⇒ Munich, DE)		LANL EDM (Los Alamos, US)	SNS EDM (Oakridge, US)	PNPI ILL (Grenoble, FR ⇒ Gatchina, RU)		TUCAN TRIUMF (Vancouver, CA)
temperature	**RT**	**RT**		RT	RT (cryo)	RT	0.7 K	**RT**		RT
comag	**Hg**	**Hg**		none			^{3}He	**none**		Hg
source	**reactor, turbine**	**spall., sD$_2$**		reactor, cold neutrons, ^{4}He		D2	spall, internal ^{4}He	reactor, turbine, ^{4}He		spall., ^{4}He
nr of cells	**1**	**1**	2	2			2	2	>2	2
Cell size [l]	**20**	**20**	2 x 75	2 x 17		2 x 20	2 x 3.2	**2 x 20?**		2 x 31
[UCN/cc] at T=0	**2**	**3**	5	4	40	40	125	**4**	10^4	233
UCN detected	**14000**	**15000**	121000			78000				1 600 000
goal [e·cm]	**$3\cdot10^{-26}$**	**$1.8\cdot10^{-26}$**	$1\cdot10^{-27}$	$4\cdot10^{-27}$	$8\cdot10^{-28}$	$2.1\cdot10^{-27}$	$2\text{-}5\cdot10^{-28}$	**$5\cdot10^{-26}$**	$5\cdot10^{-28}$	$1.7\cdot10^{-27}$
date	**2006**	**2020**	2020	2019	?	2023	2023	**2015**	202?	2024
status	**done!**	**done!**	Big infrastructure installed.	modifications for Munich ⇒ ILL, D$_2$ ⇒ He		Magnetic shield installed, UCN storage tested.	Critical Component Demonstration passed	PNPI source components ready, reactor offline.		Component development phase
comment	**Best limit so far!**	More UCN density expected from source, compensating with cell size.		regulatory issues for UCN source in Munich ⇒ ILL for now			great new concept, high risk, high gain	Very promising UCN source design.		Best nEDM experiment in Canada!