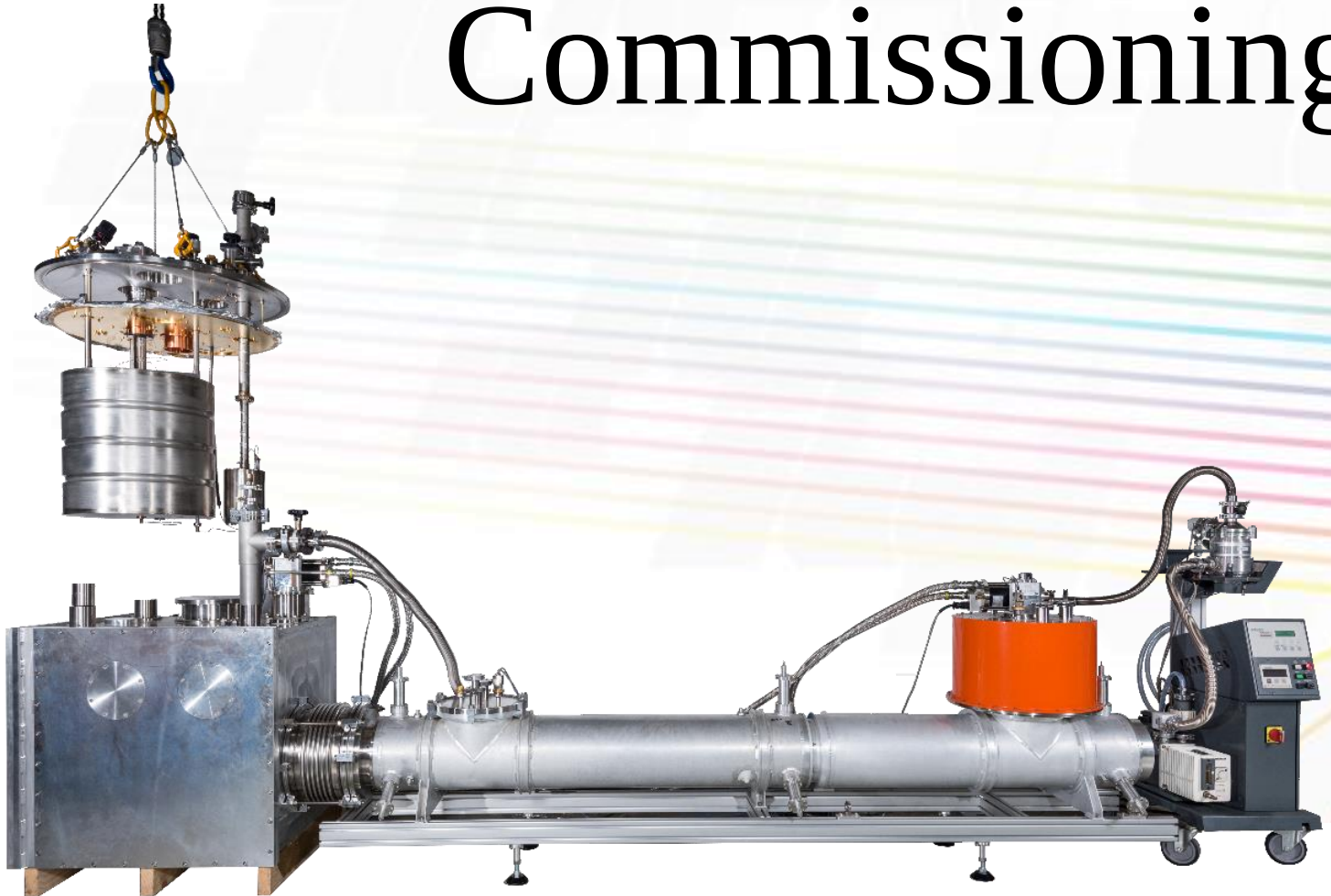
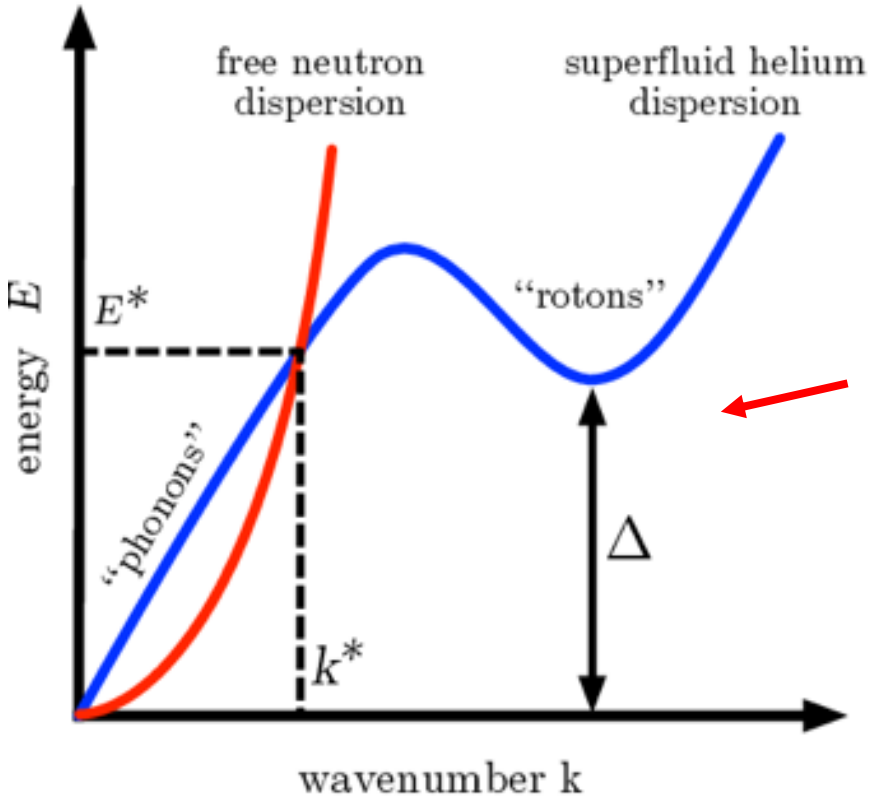
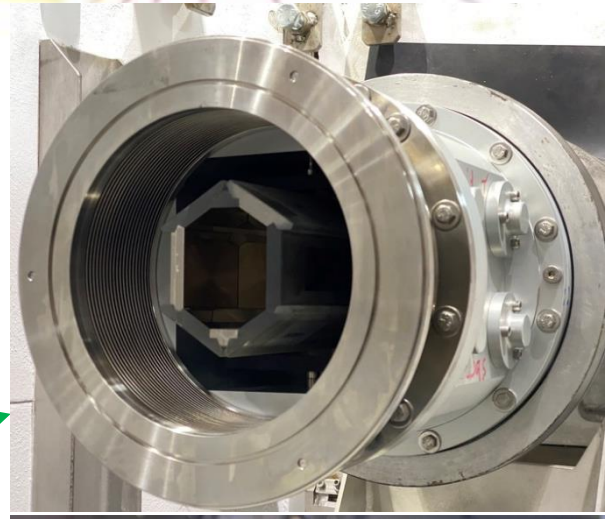
SuperSUN
Commissioning time



A helium based superthermal source for high density



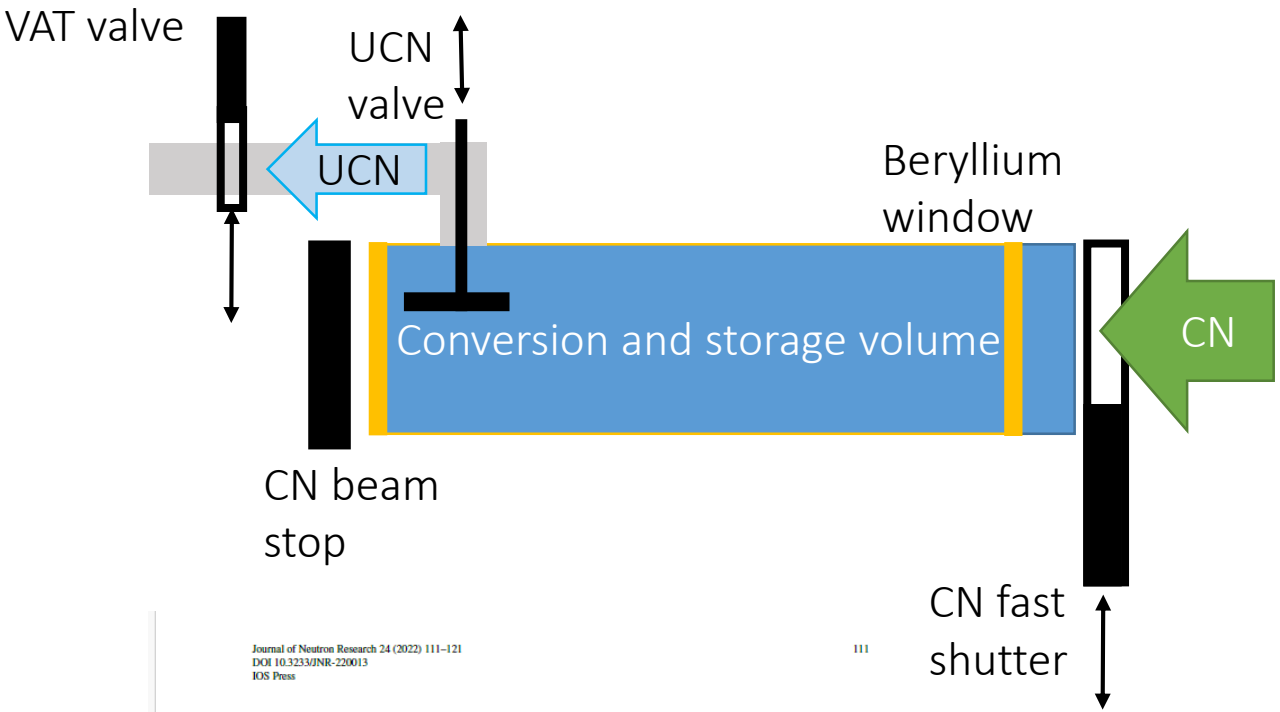
Conversion of cold neutrons into UCN via phonon production in isotopically pure superfluid 4He at 0.6K



$$\tau^{-1} = \tau_{abs\ ^3He}^{-1} + \tau_{up}^{-1} + \tau_{wall}^{-1} + \tau_{\beta}^{-1} + \tau_{gap}^{-1} \dots$$

Eur. Phys. J. A **58**, 141 (2022).
DOI: 10.1140/epja/s10050-022-00791-x
Journal of Neutron Research, vol. 20, no. 4, pp. 117-122, 2018,
DOI 10.3233/JNR-180100

Concept



Journal of Neutron Research 24 (2022) 111–121
DOI 10.3233/JNR-220013
IOS Press

Concept and strategy of SuperSUN: A new ultracold neutron converter

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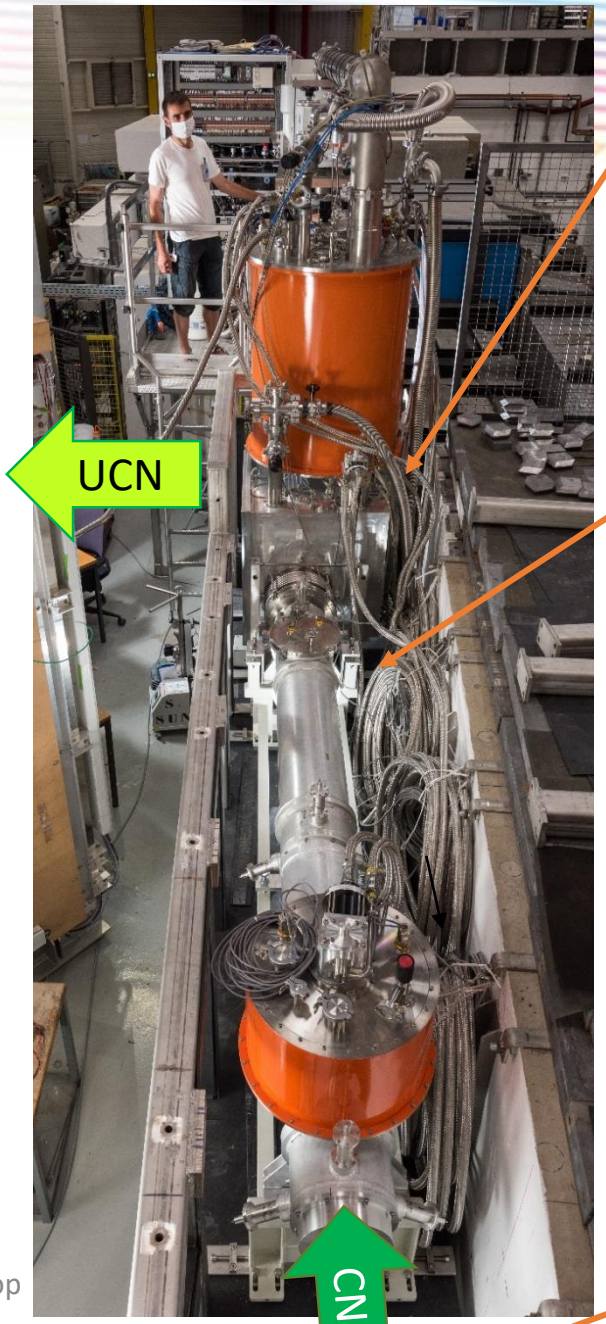
Abstract. A new source of ultracold neutrons (UCNs), developed at the Institut Laue-Langevin (ILL) and named SuperSUN, is currently being commissioned. Its operational principle is the conversion of cold neutrons, delivered by ILL's existing beam H523, to UCNs in a vessel filled with superfluid helium-4, wherein the neutron's energy and momentum are transferred by inelastic scattering to phonons in the superfluid. The inverse Boltzmann-suppressed process is negligible at temperatures below 0.6 K, enabling long storage times and high *in-situ* UCN densities as demonstrated at the ILL for two prototype sources. These two prototypes are installed at secondary beams behind crystal monochromators, whereas a primary beam with a white cold spectrum illuminates the SuperSUN conversion volume. This provides not only higher intensity around the wavelength 0.89 nm where the dominant single-phonon process for UCN production takes place, but also a contribution to UCN

Journal of Neutron Research 24 (2022) 111–121 111
DOI 10.3233/JNR-220013

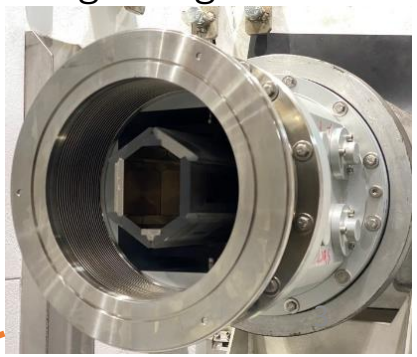
Phase I



Convertor cryostat

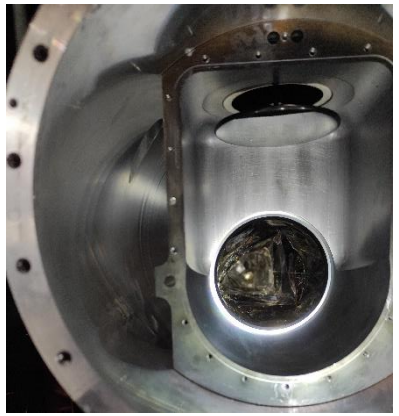
Conversion volume

Octagonal guide

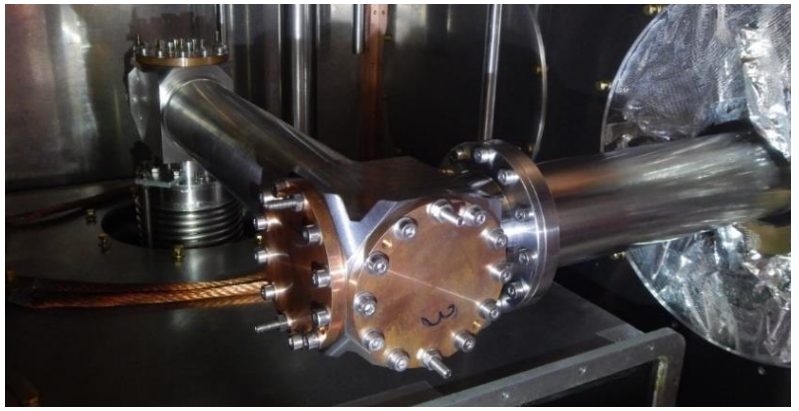


Commissioning in 2023 cycle 1

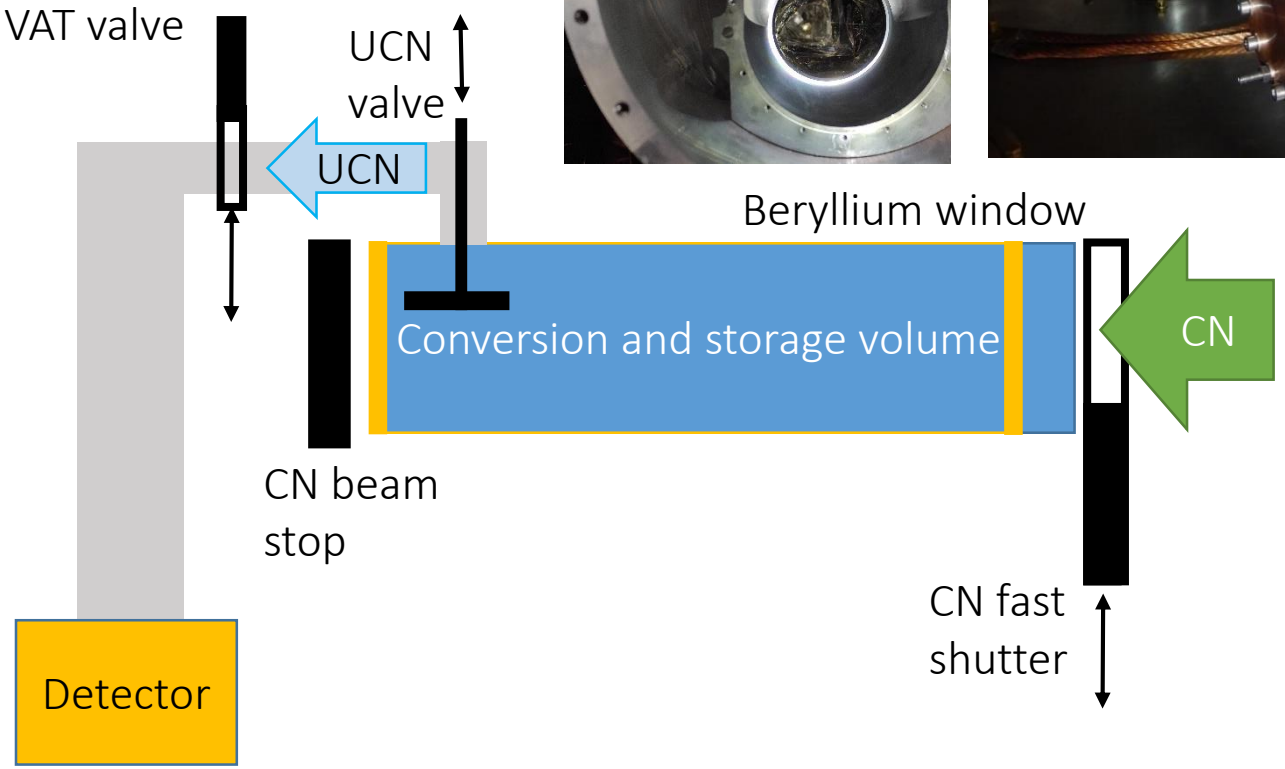
UCN valve



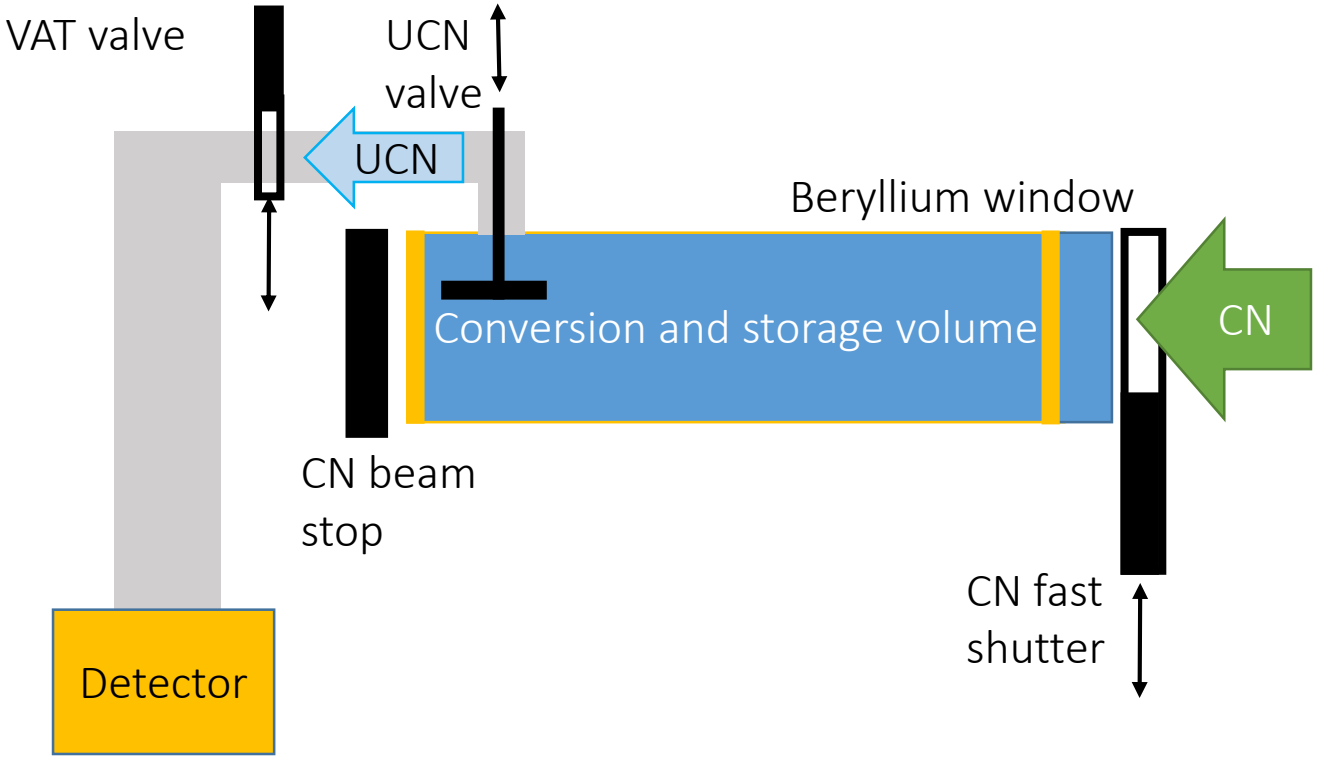
UCN extraction



Setup with detector

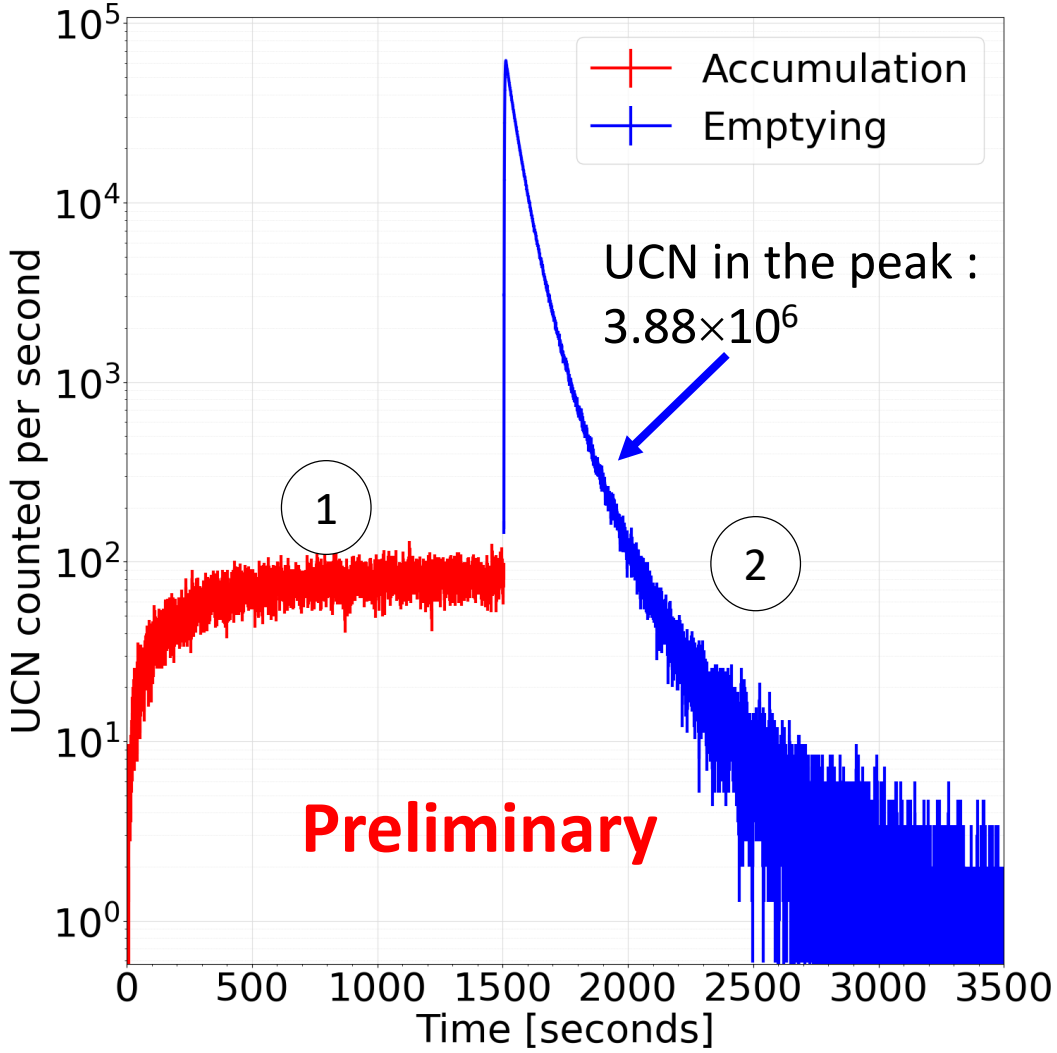


Accumulation measurement– Fill and Empty



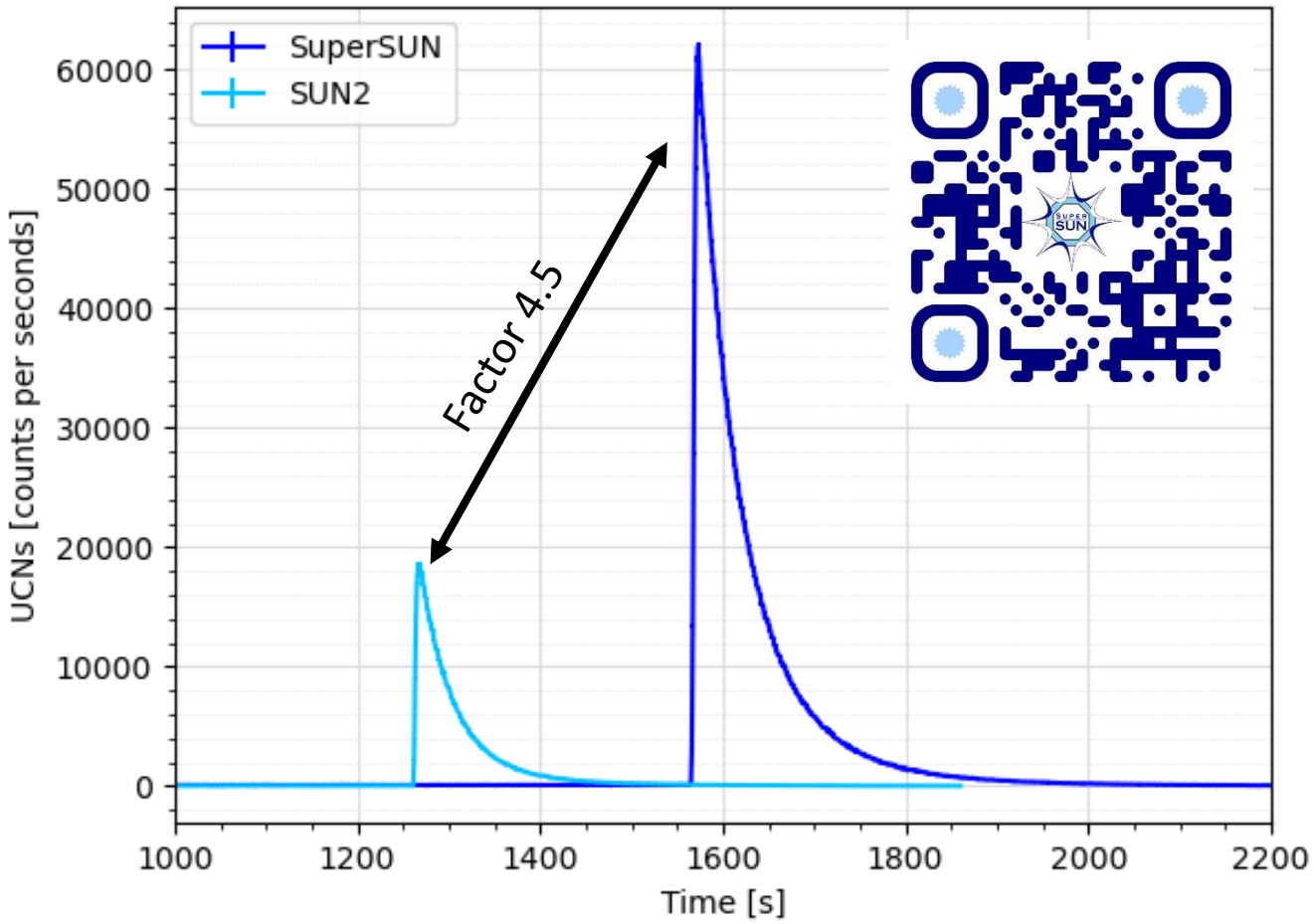
Accumulation mode:

0. Empty converter
1. Fast shutter open, UCN valve close
2. Fast shutter close, UCN valve open

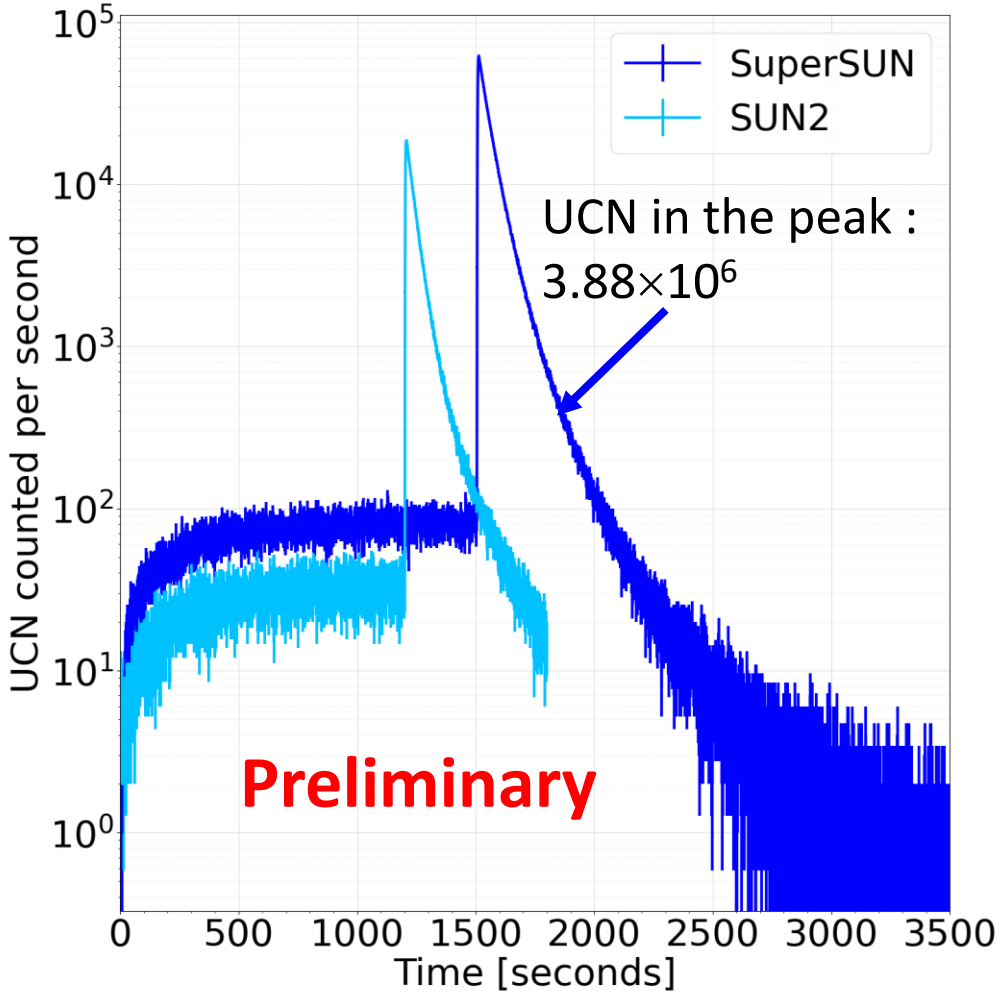


Accumulation measurement– Fill and Empty

Lin scale

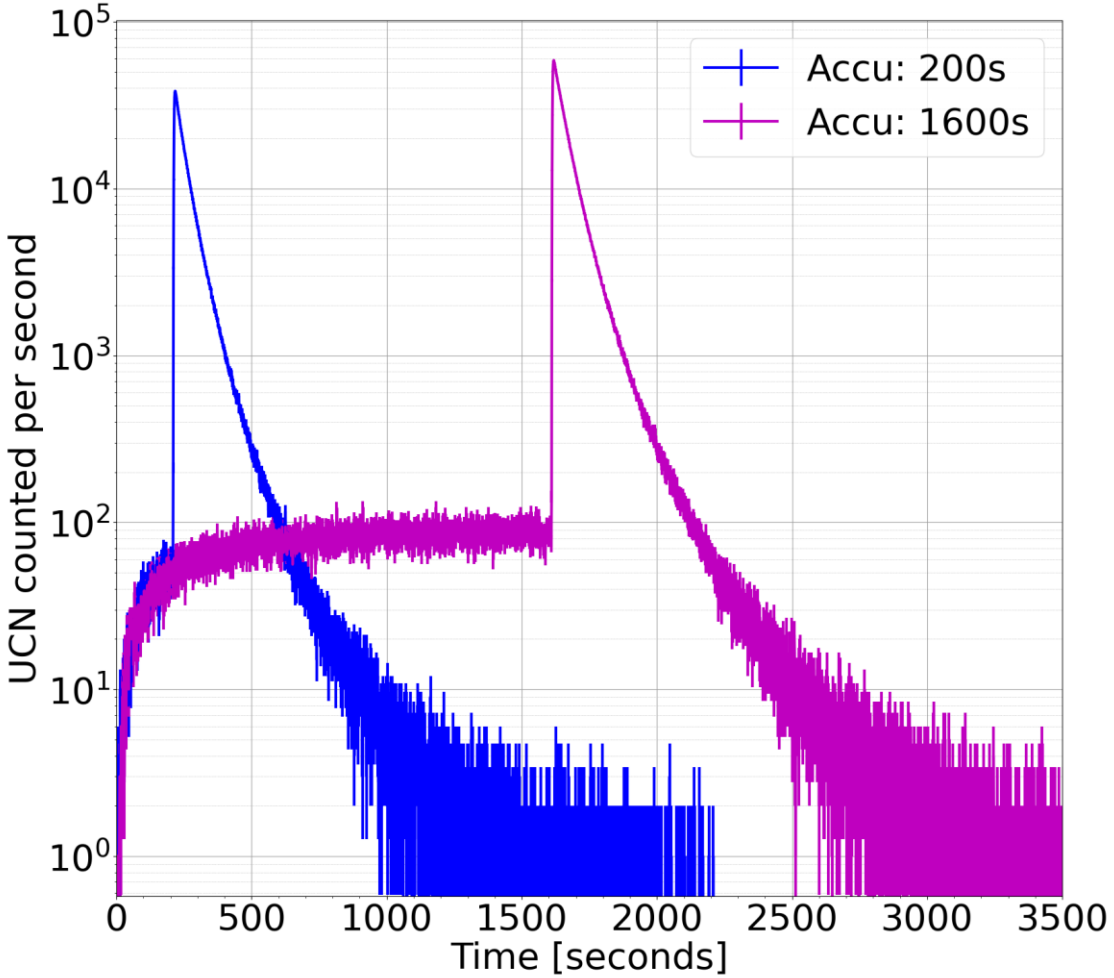


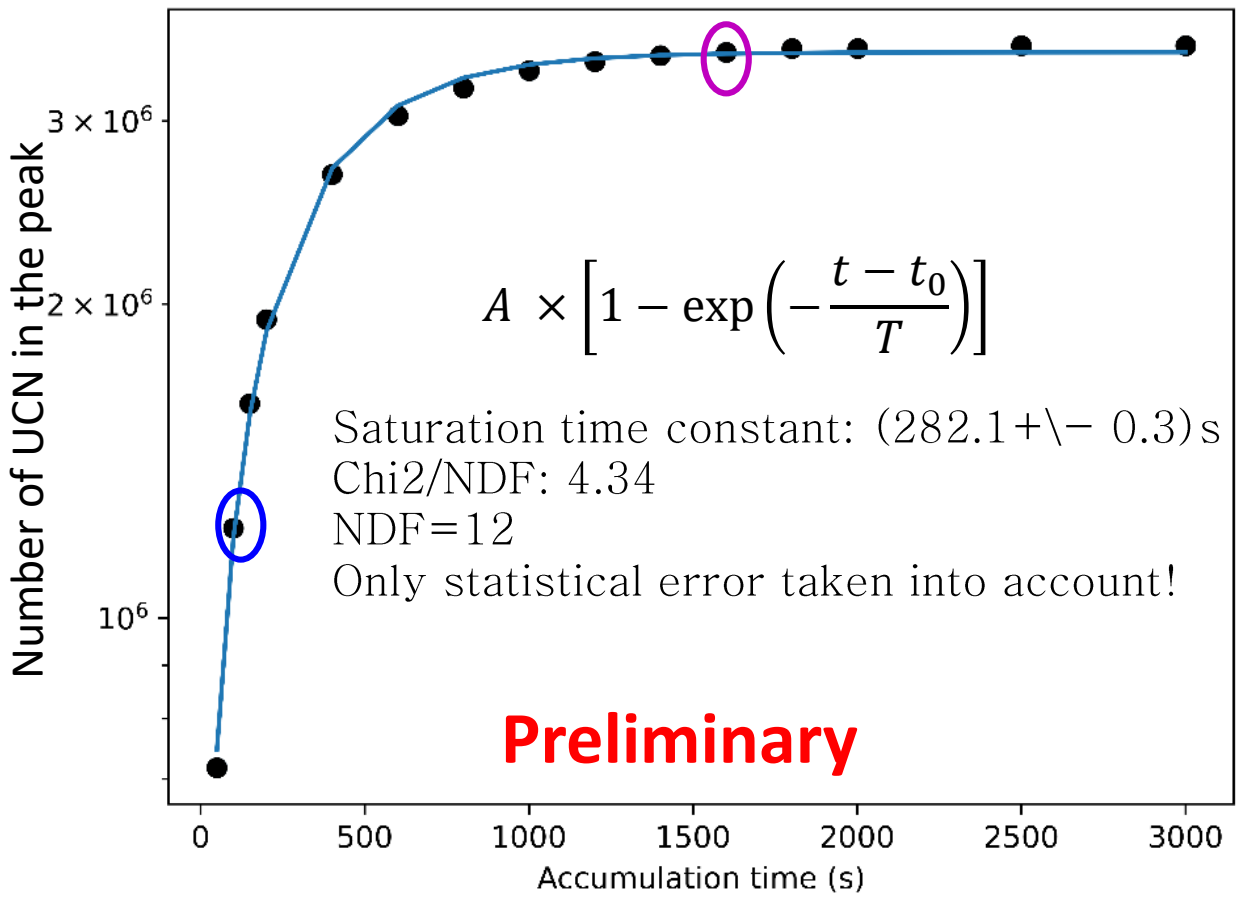
Zoomed log scale



https://arxiv.org/abs/1911.09161

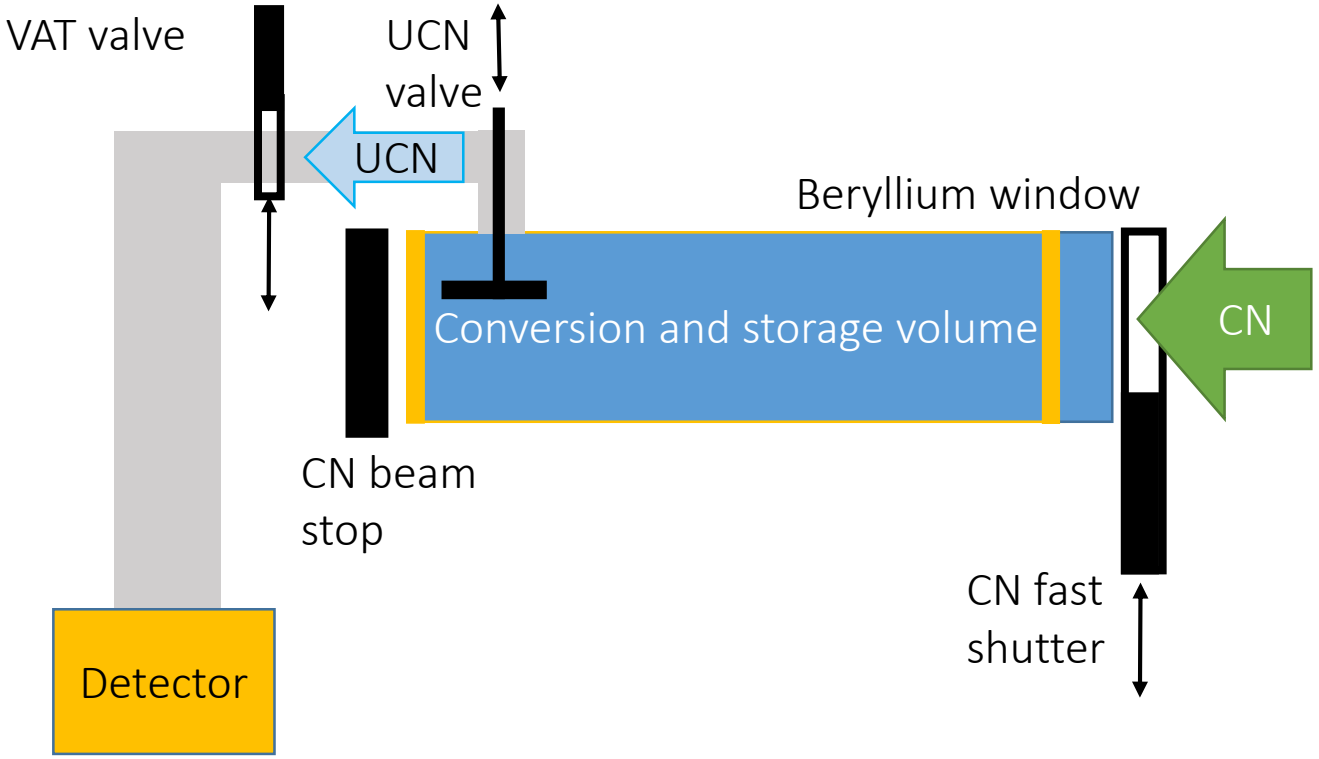
Saturation time of the source

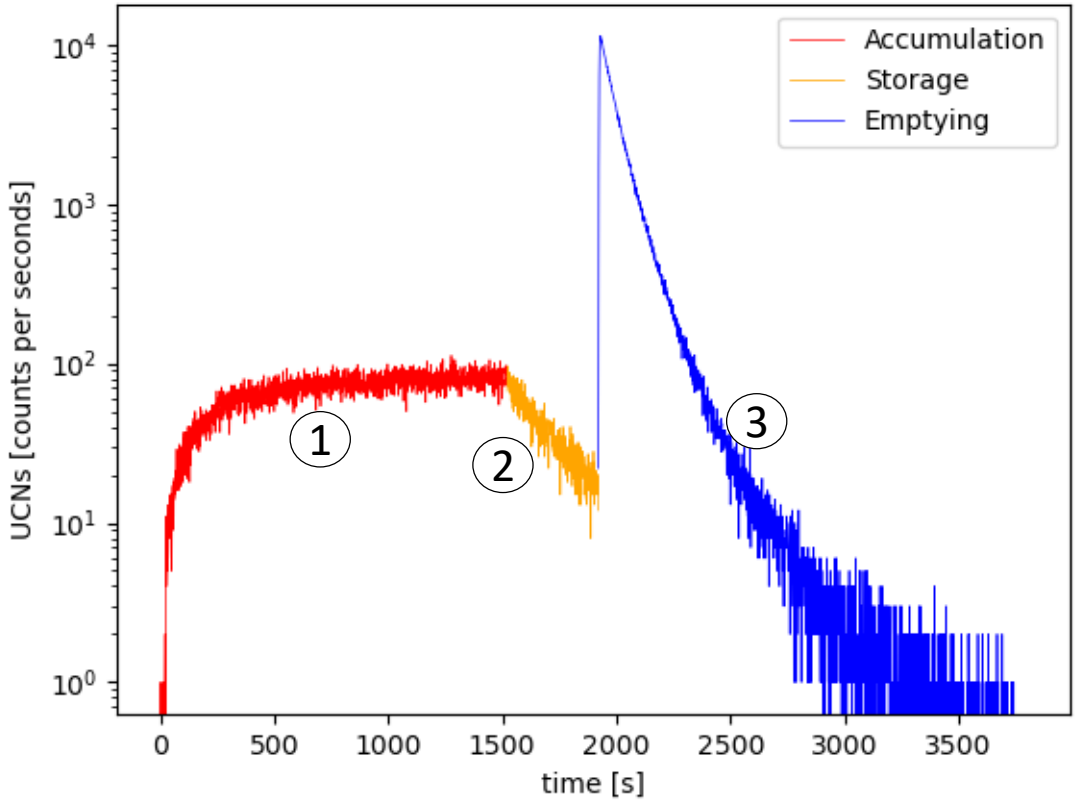




Master student : Juliette Blé

Delayed extraction – Fill, Store, and Empty



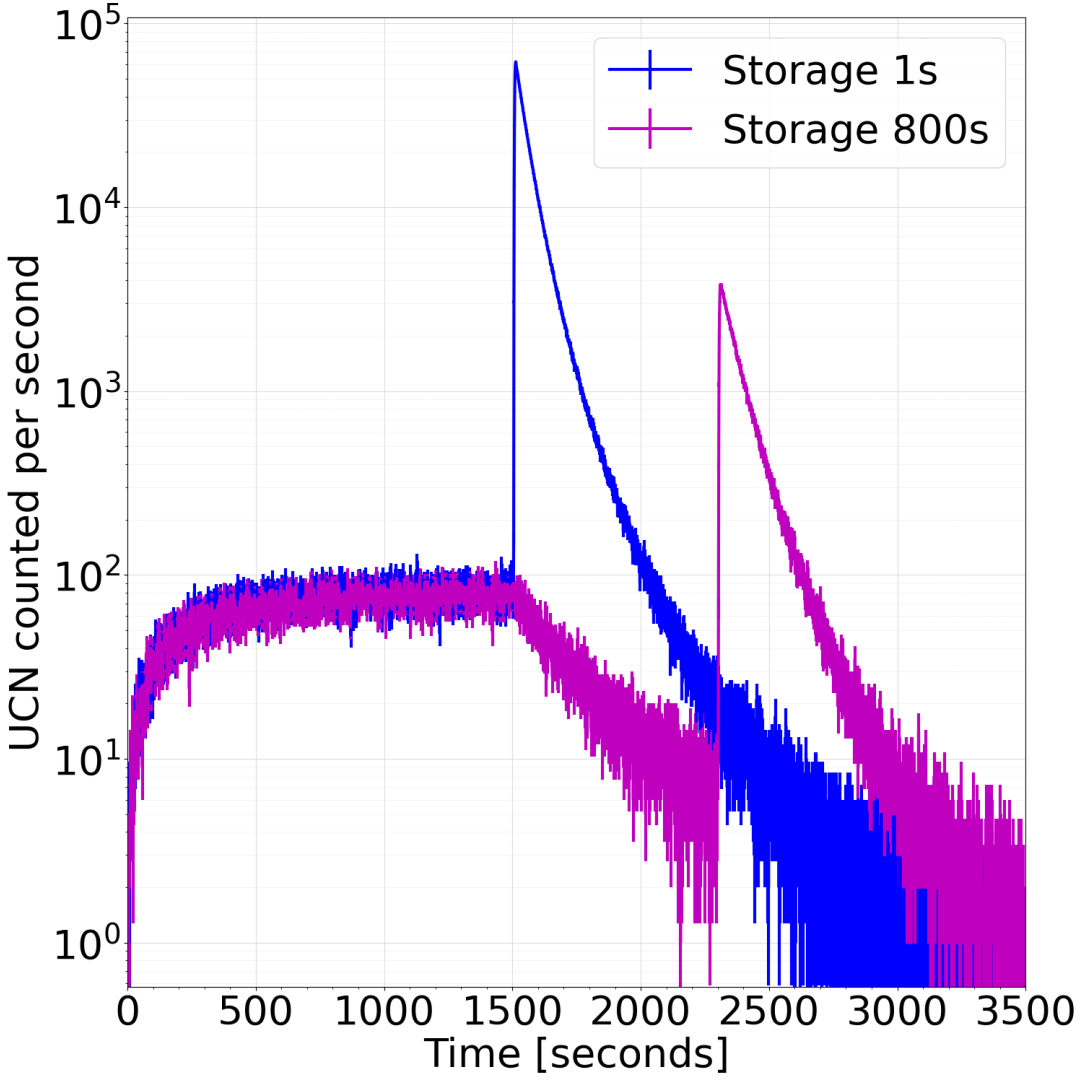


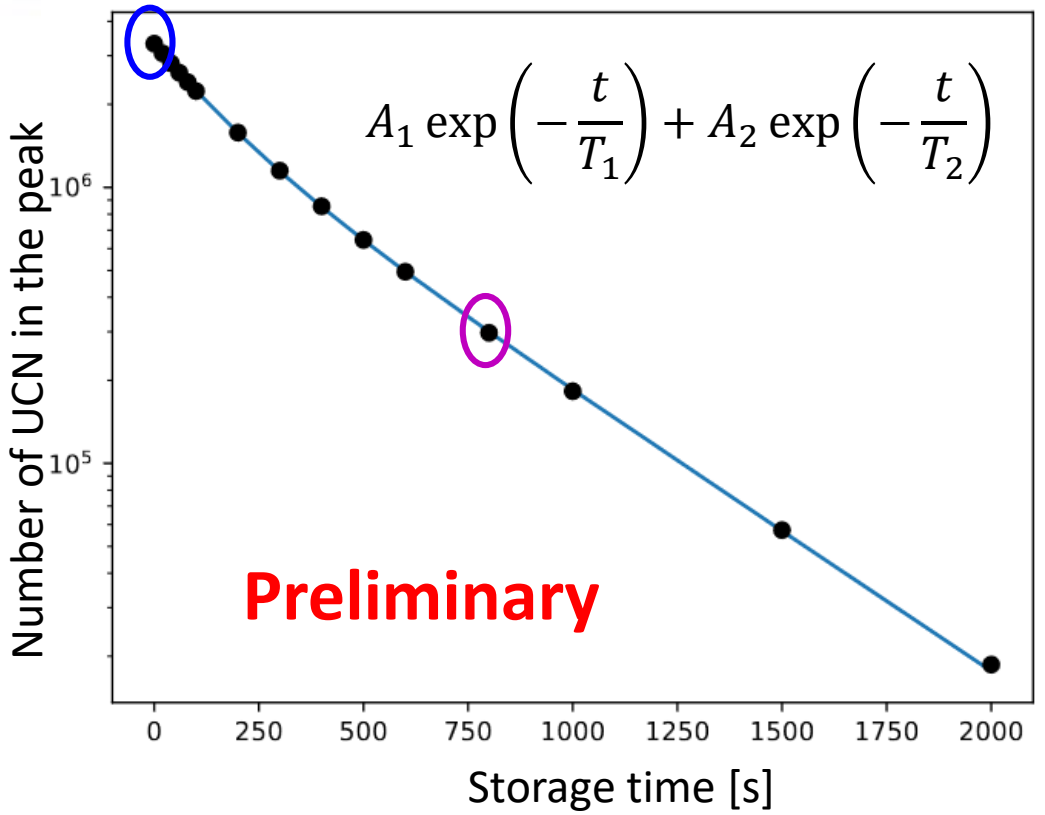
Accumulation mode:

0. Empty converter
1. Fast shutter open, UCN valve close
2. Fast shutter close, UCN valve close
3. Fast shutter close, UCN valve open

Master student : Juliette Blé

Delayed extraction – Fill, Store, and Empty





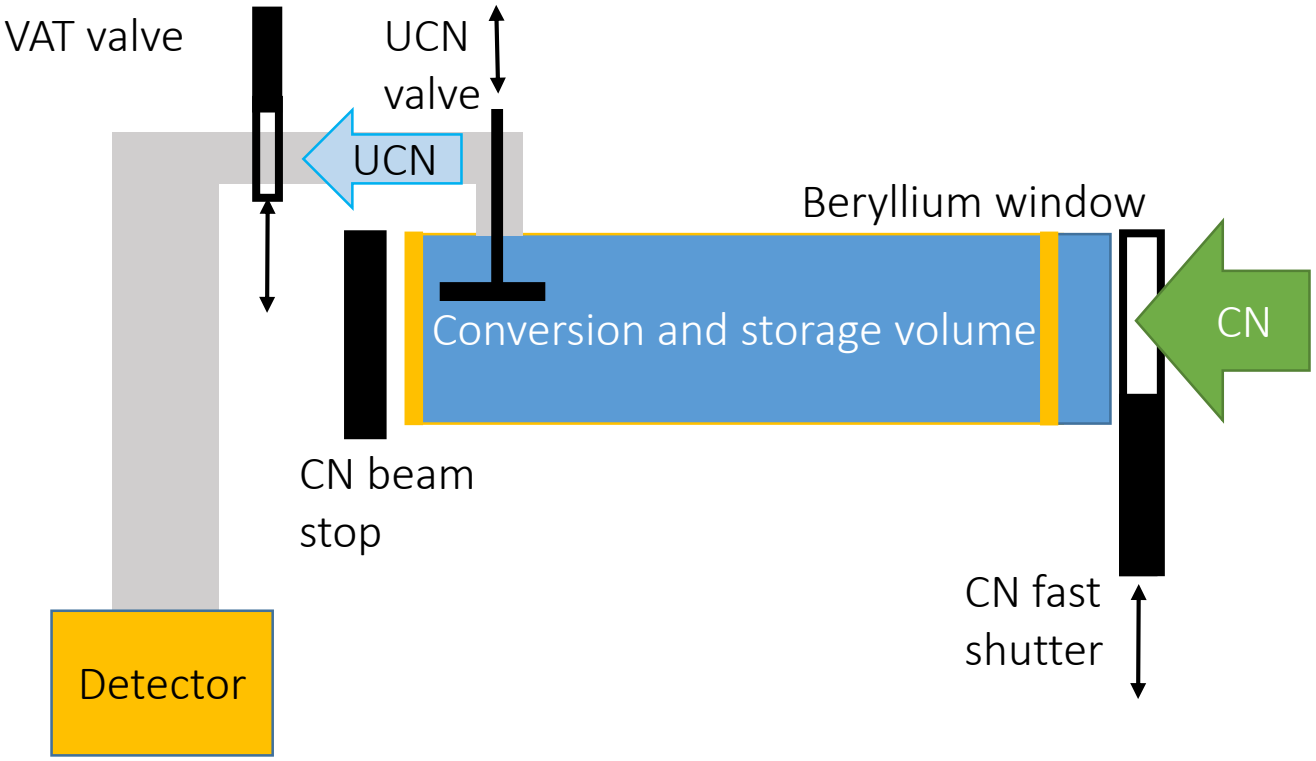
$T_1 = (427.8 +/- 0.8)\,s$
$A_1 = 1.89 \times 10^6$
$T_2 = (154.9 +/- 0.8)\,s$
$A_2 = 1.41 \times 10^6$

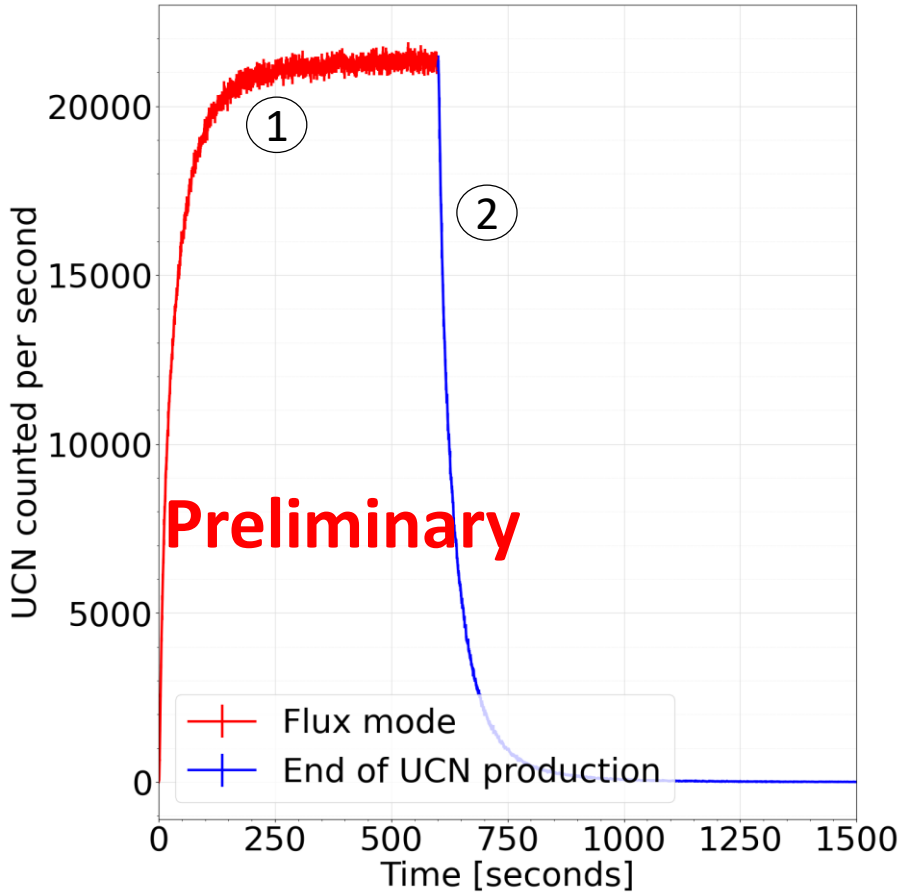
Chi2/NDF= 1.07
NDF=11

Only statistical error taken into account!

Master student : Juliette Blé

Continuous mode measurement – All open





Continuous mode:

0. Empty converter
1. Fast shutter open, UCN valve open
2. Fast shutter close, UCN valve open

Integrated counts over 300s :
6.4×10^{6} UCN

Conclusion

- Source output in continuous mode: 6.4×10^6 UCN/300s (=21×10^3 UCN/s)
- Source output in storage mode: 3.88×10^6 UCN/ batch (density)
- Source saturation time: 282 s
- Source life time: 427.8 s (55%) and 154.9 s (45%)
- Reliability: work for several weeks in a row with standard maintenance

Outlook

Data analysis is not over !

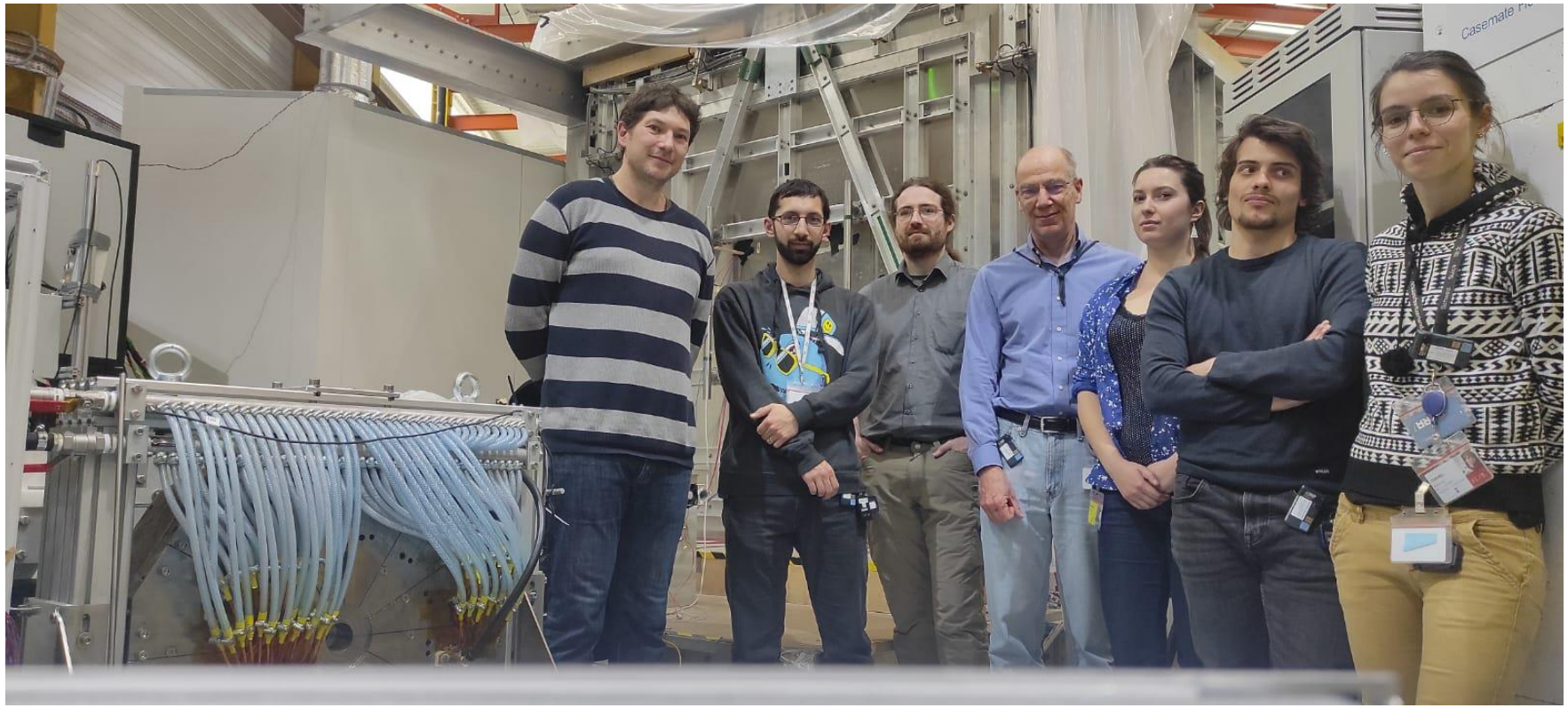
- Analysis of the different constant and careful handling of errors
- One cycle done with a storage cell, the data needs to be analyzed

Additional measurements:

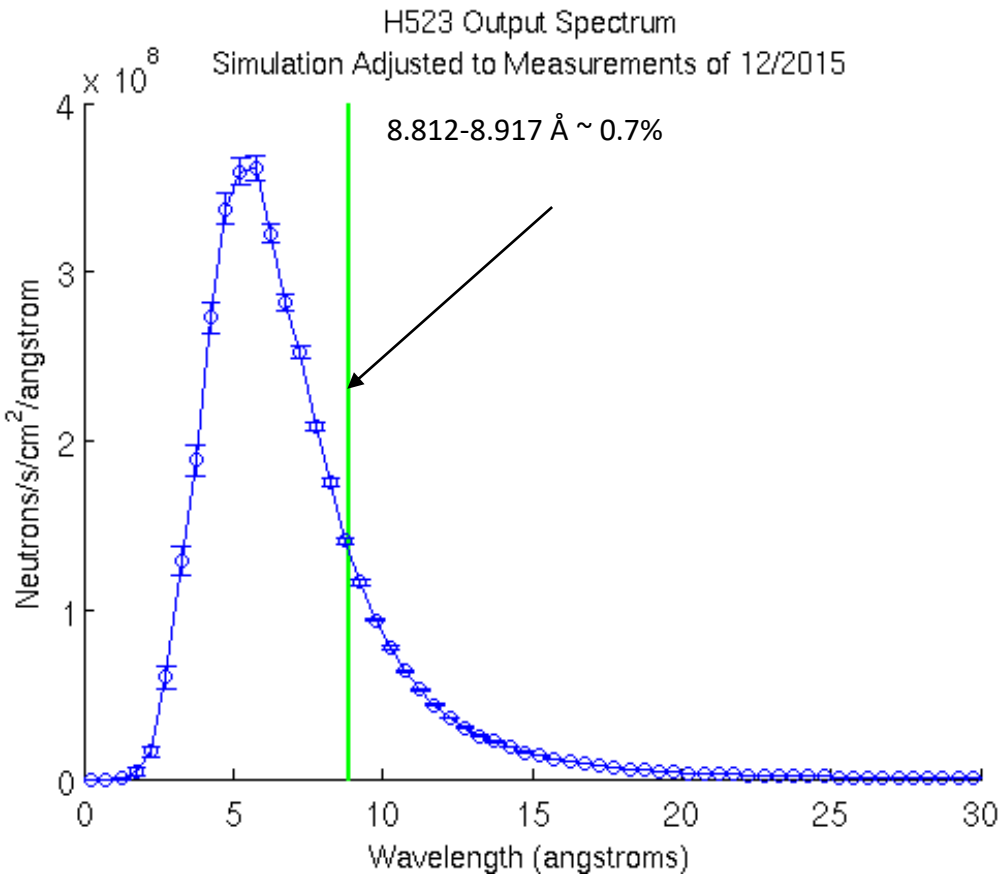
- External storage measurement
- Spectrum information
- Degradation of the source (continuation)

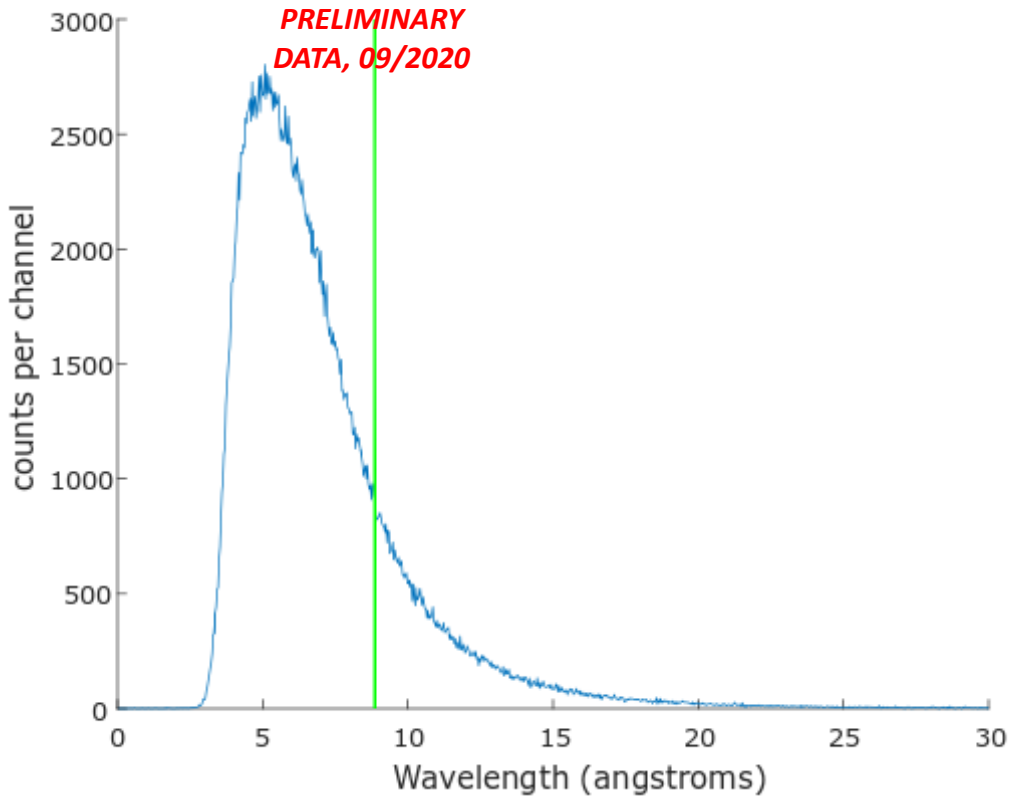
Acknowledgment

PROJET FINANCÉ PAR L'ANR - PROJECT FUNDED BY THE ANR
ANR
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN
UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386
NEUTRONS FOR SCIENCE



Cold neutron spectrum

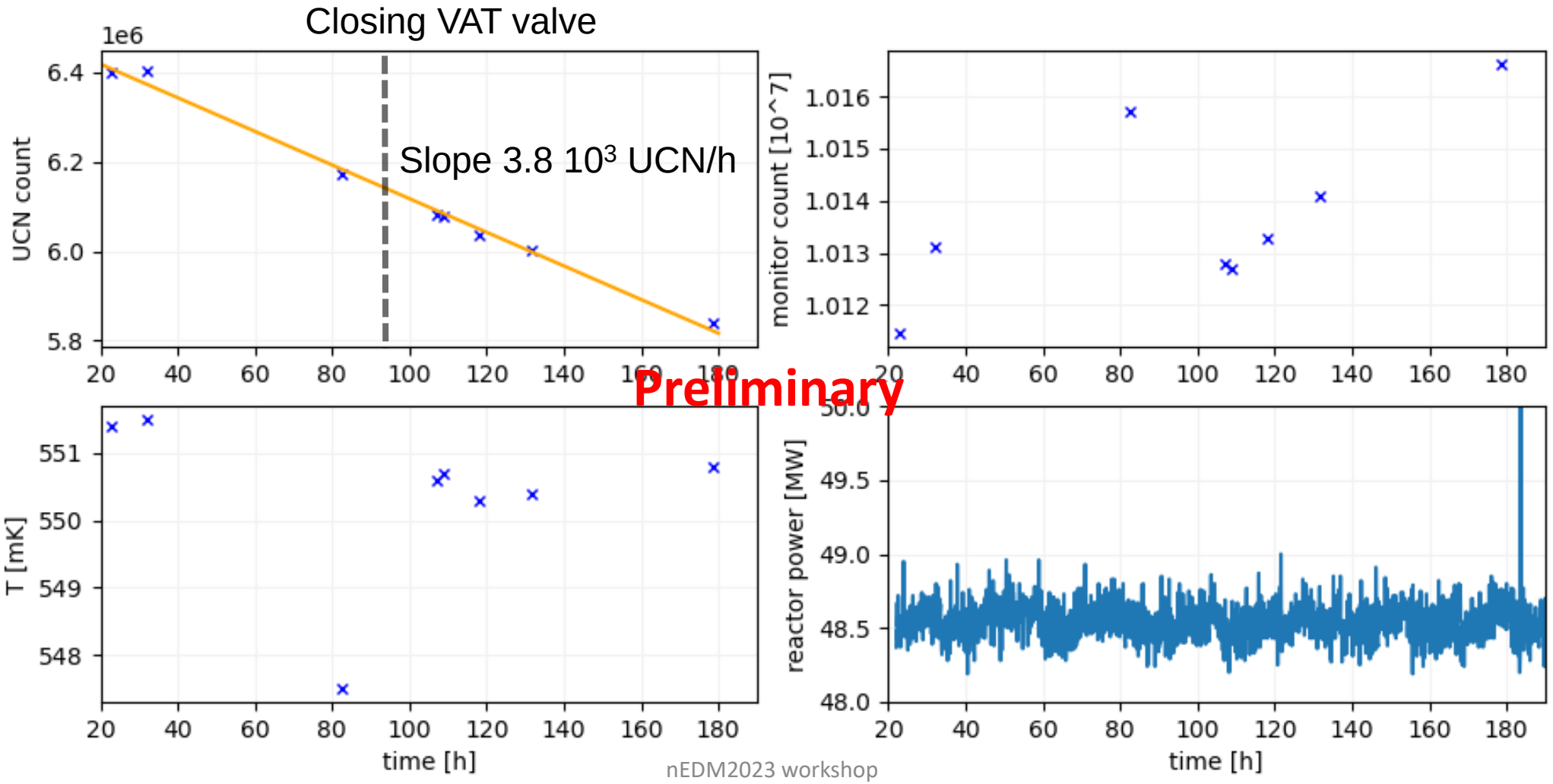




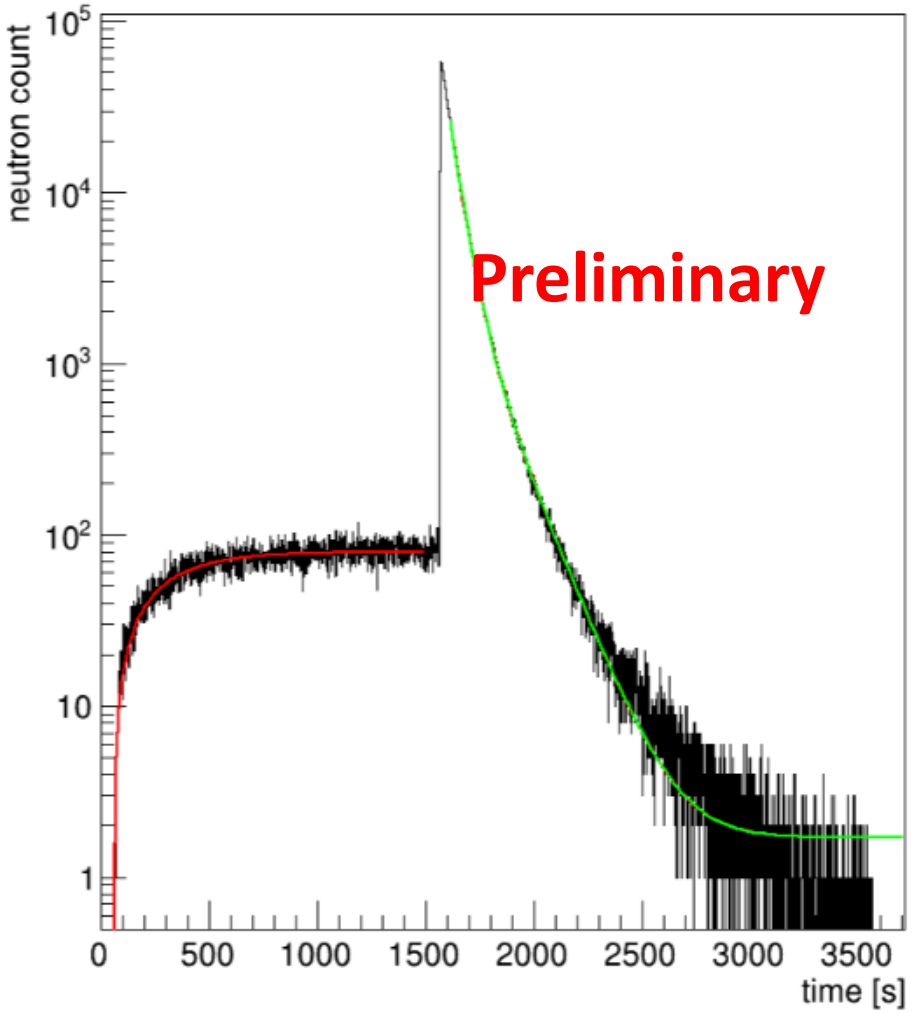
Journal of Neutron Research, vol. 20, no. 4, pp. 117-122, 2018,

DOI 10.3233/JNR-180100

Degradation of the source



Online analysis of single measurements



Saturation time constant

$$A \times \left[1 - \exp\left(-\frac{t - t_0}{T}\right)\right]$$

T=231 +\- 4 s

Chi2/NDF: 1580/1434

ROI [60 -1500[

Emptying time constant

$$A_1 \exp\left(-\frac{t - t_0}{T_1}\right) + A_2 \exp\left(-\frac{t - t_0}{T_2}\right) + B$$

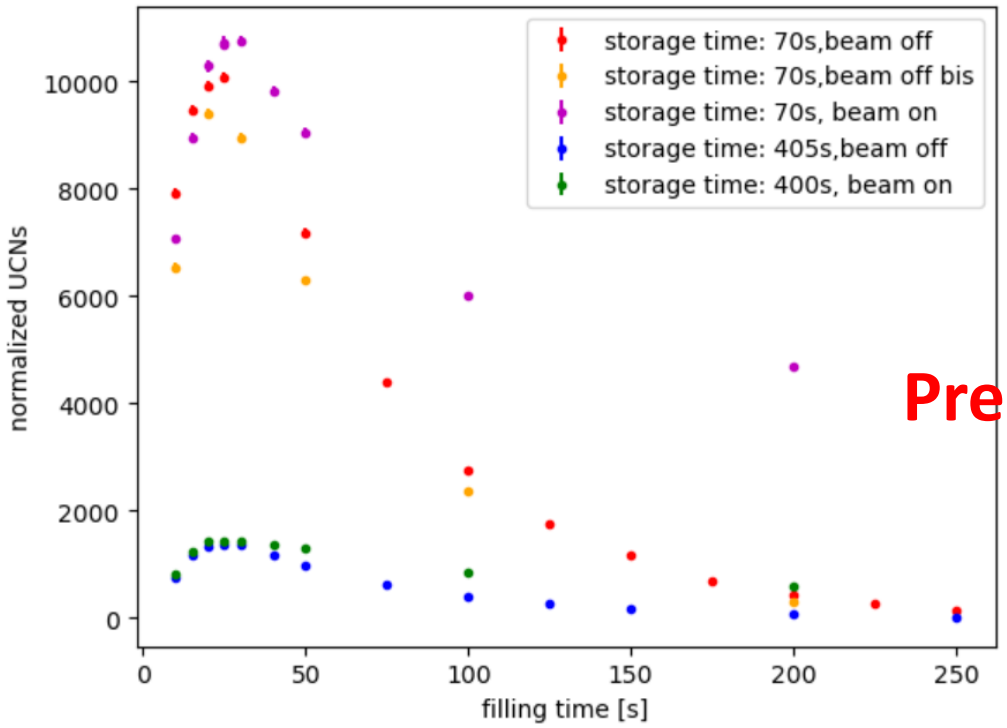
T_1=51.9+/-0.2s

T_2= 140.1+/-0.9s

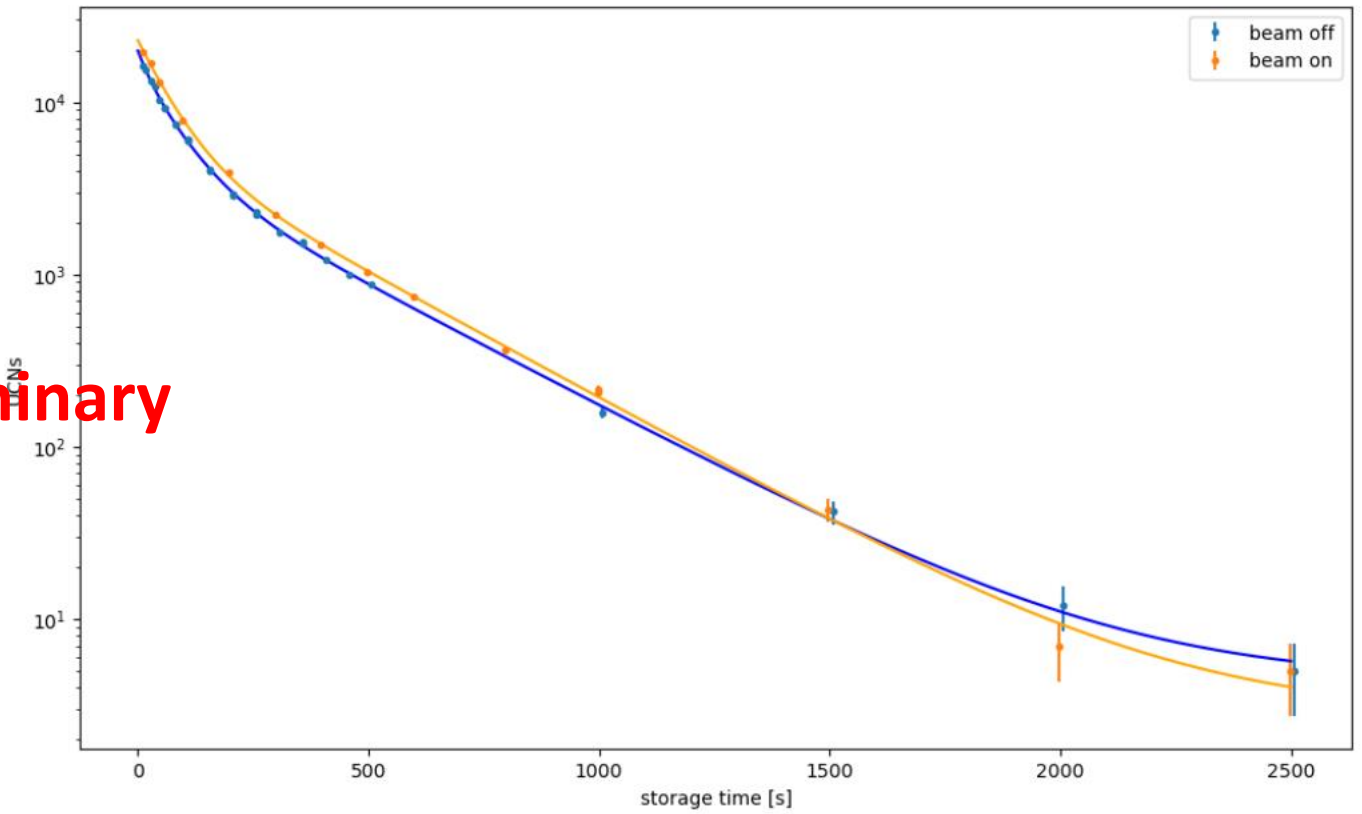
Chi2/NDF: 2049/1664

ROI [1670 -3500]

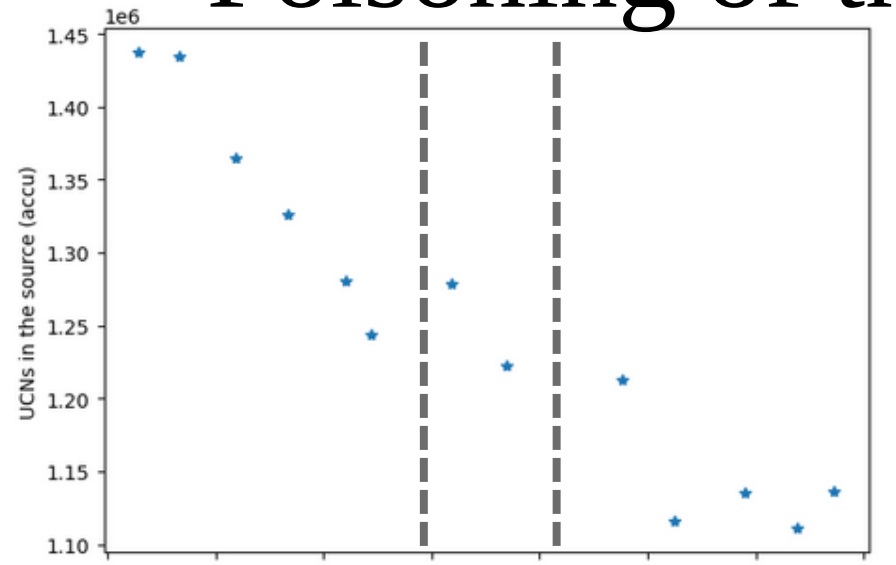
Cycle II 2023

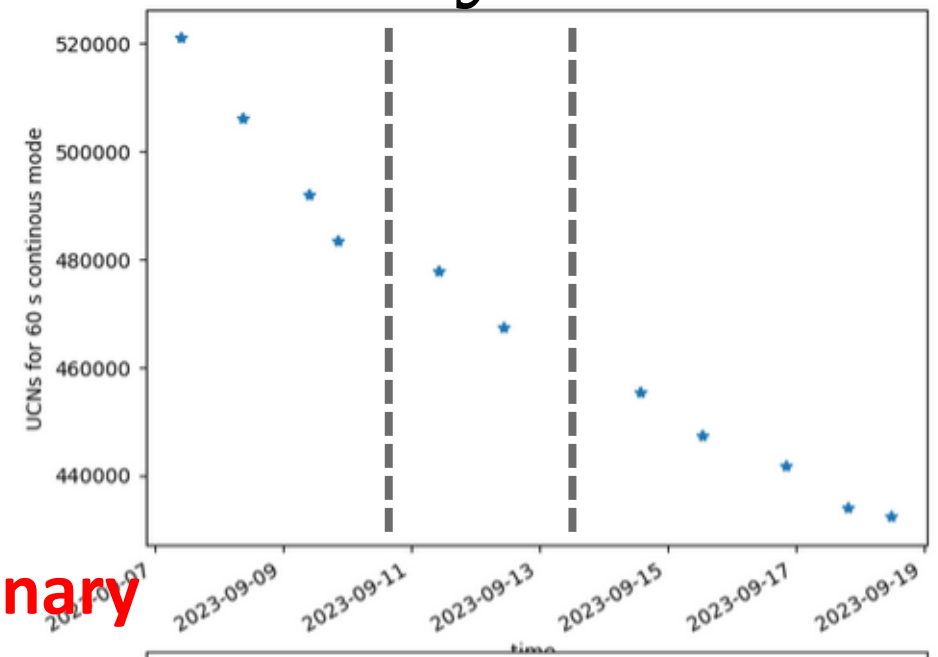


Preliminary

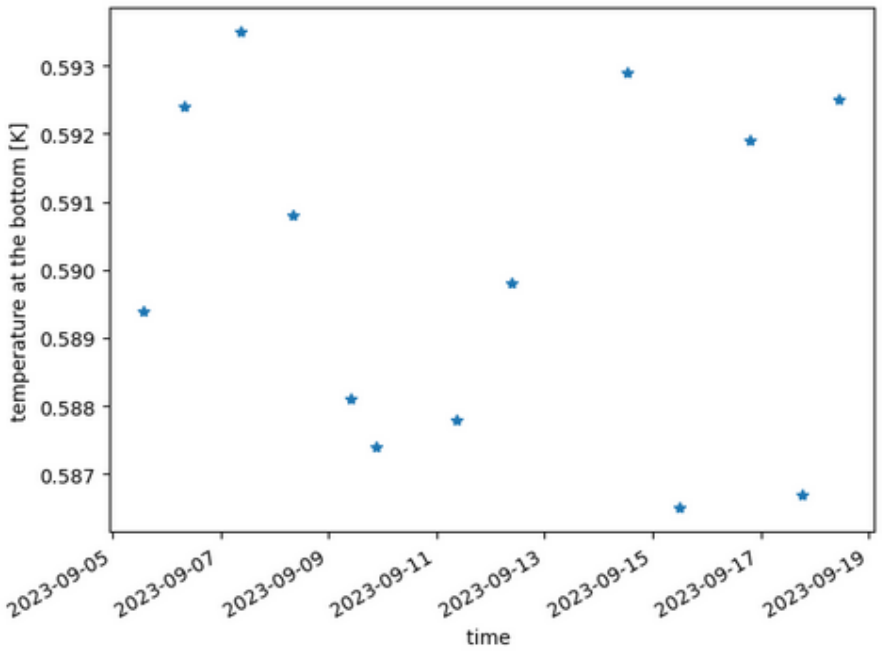


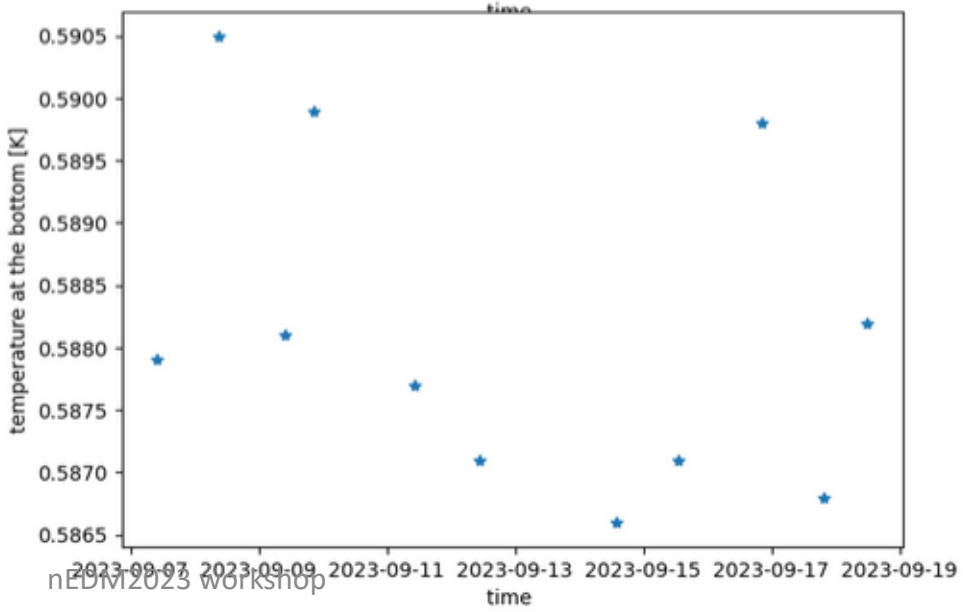
Poisoning of the source Cycle II



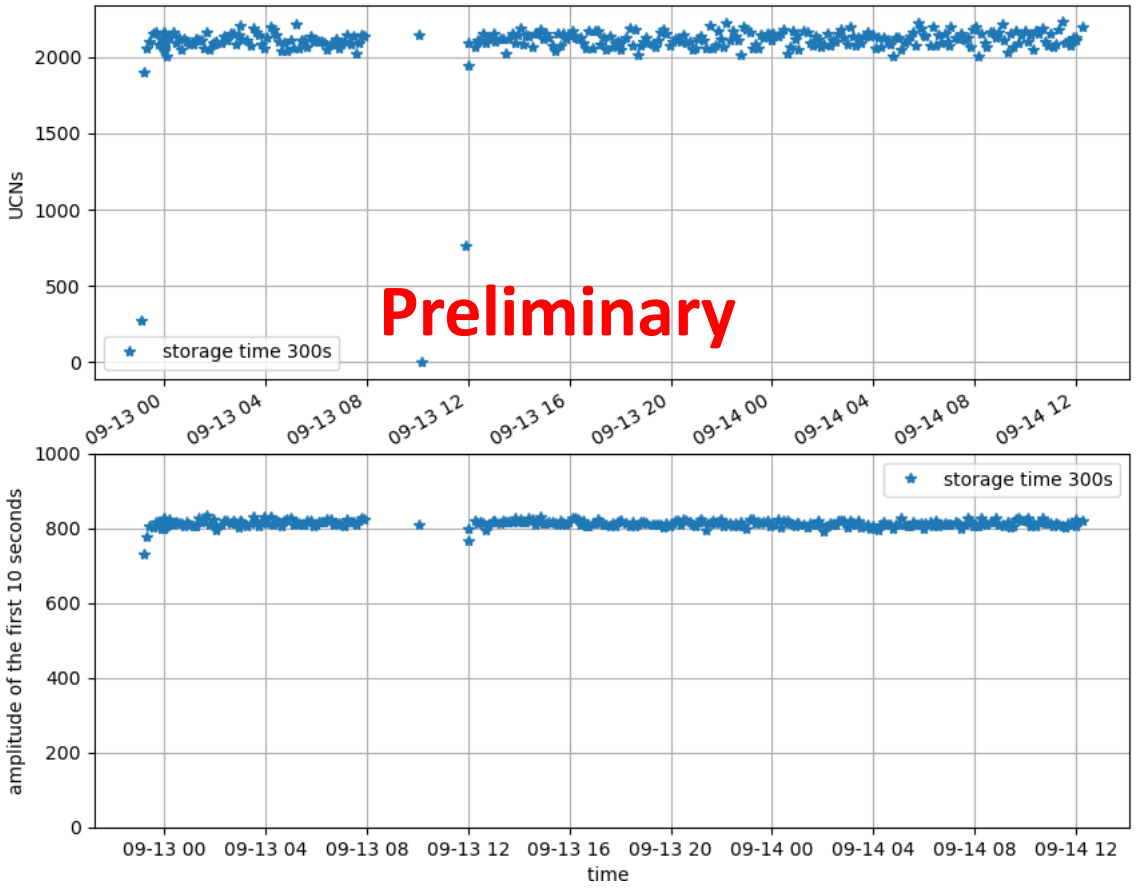


Beam OFF Beam ON **Preliminary**

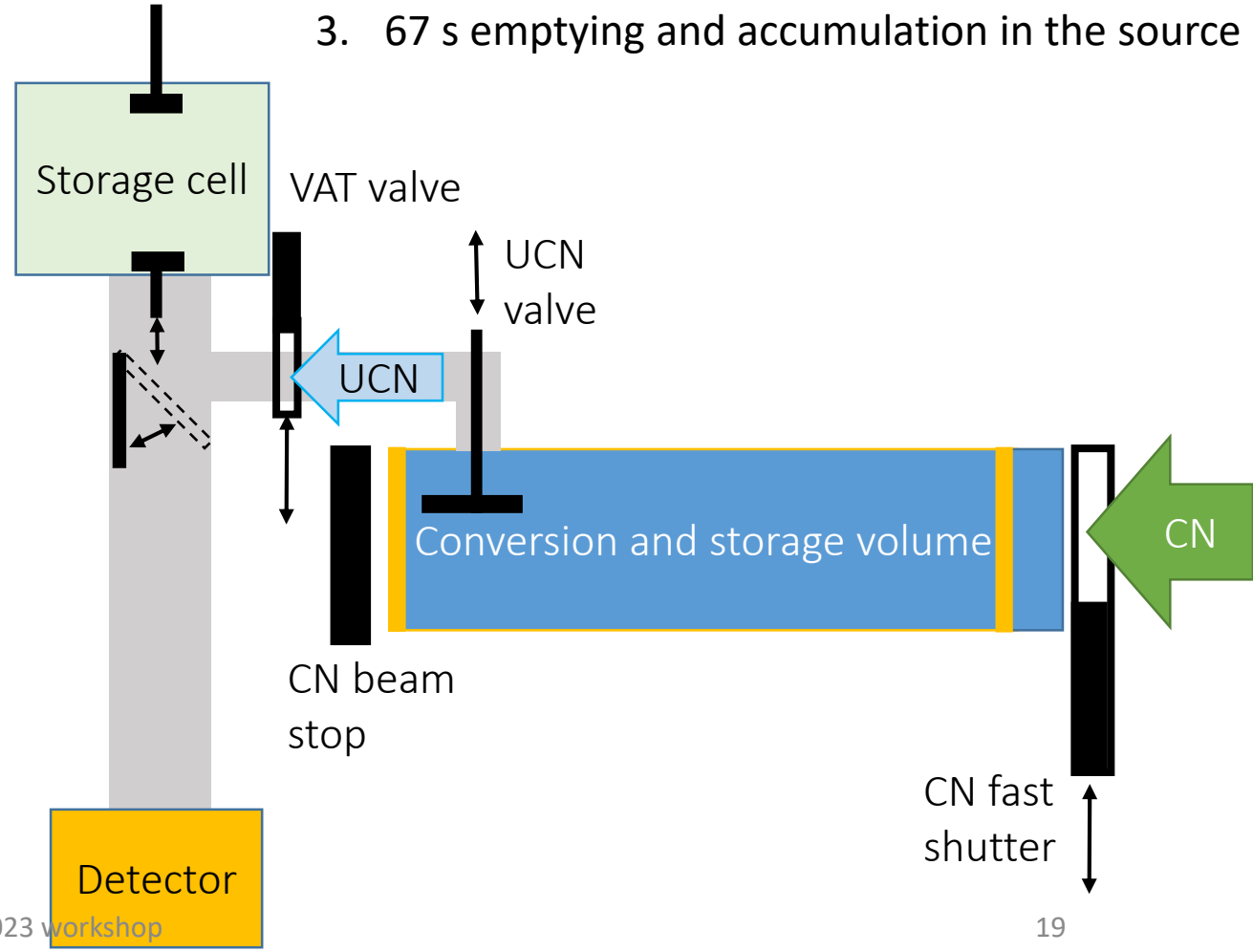




PanEDM cycle- reproducibility

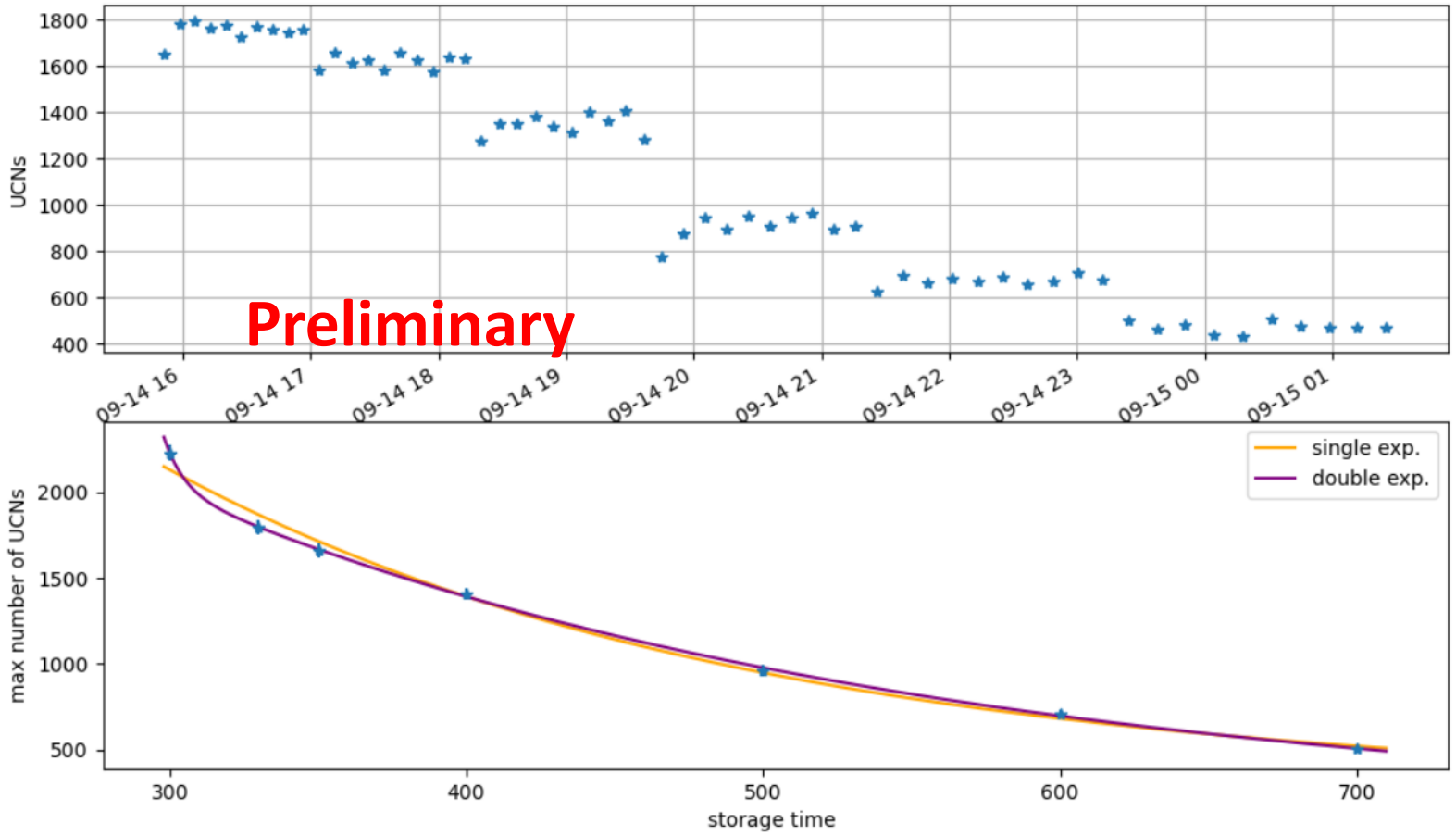


1. 30 s filling the cell, beam still on
2. 300 storing and accumulation in the source
3. 67 s emptying and accumulation in the source

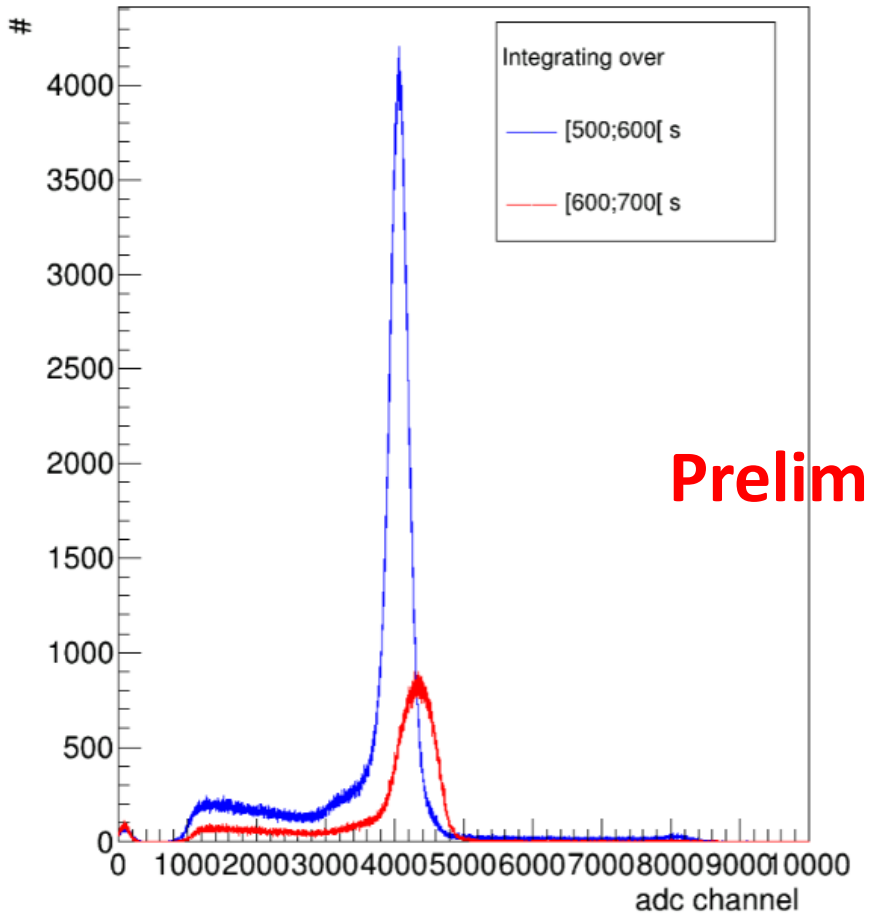


Towards sensitivity assessment

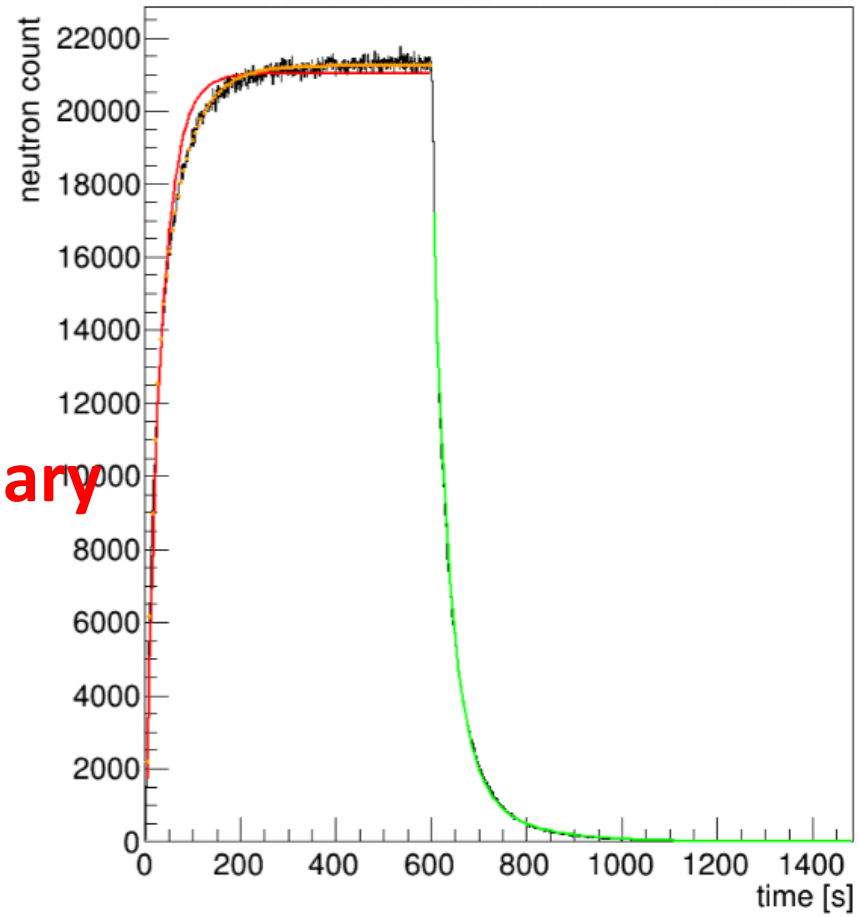
Storage time: 330 350 400 500 600 700



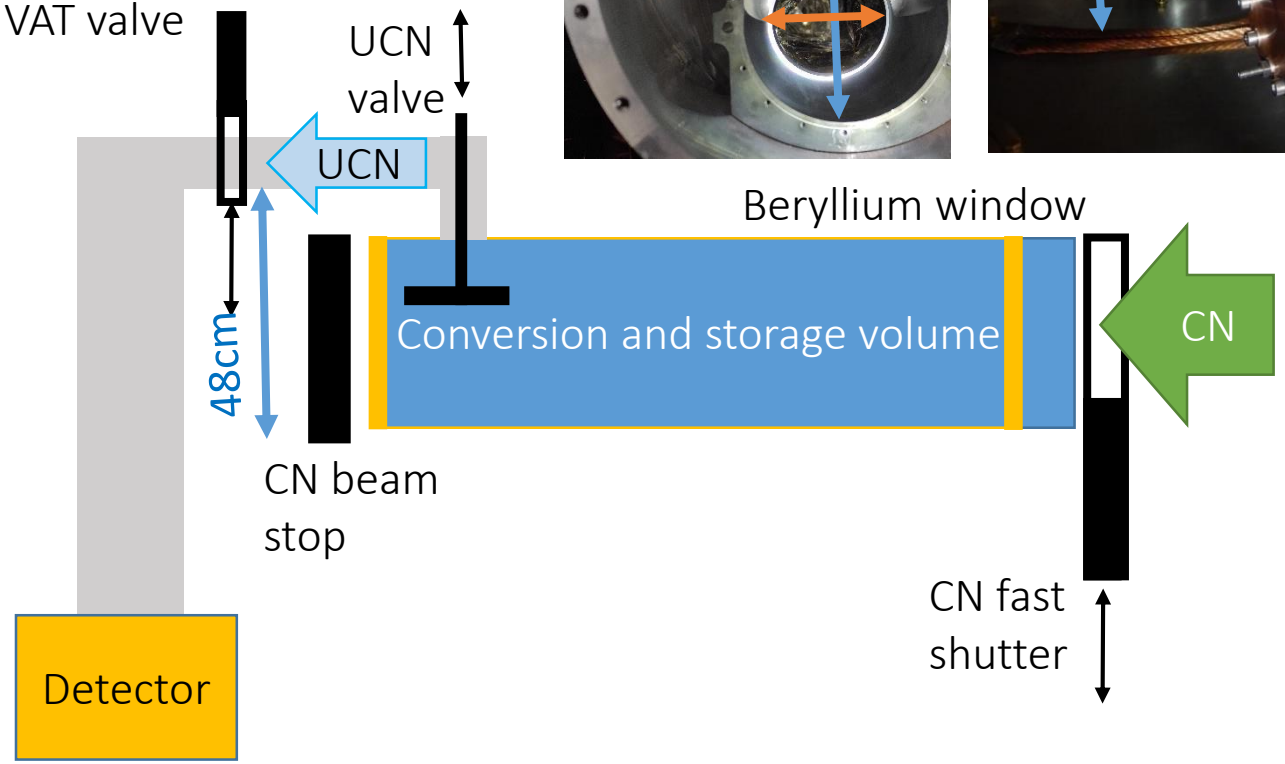
Dunjia detector – Rate effect



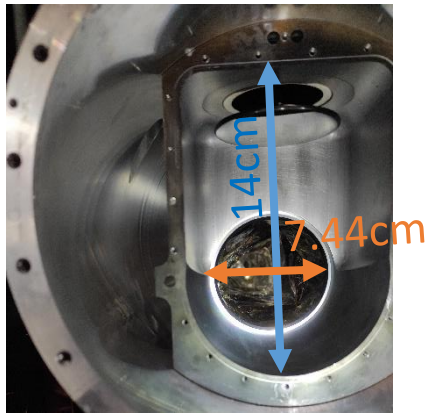
Preliminary



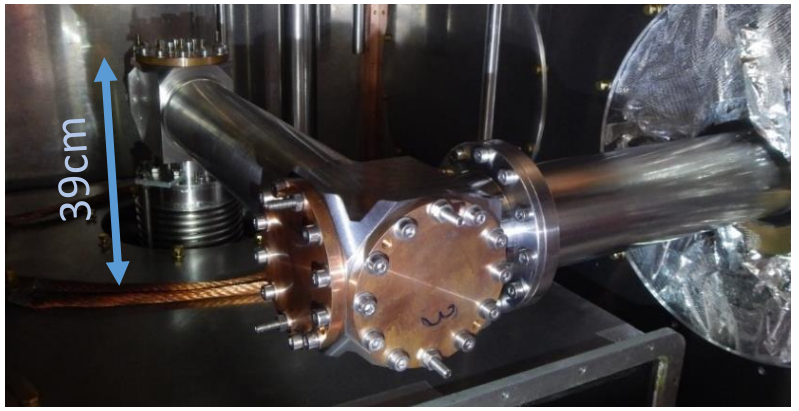
Commissioning in 2023 cycle 1



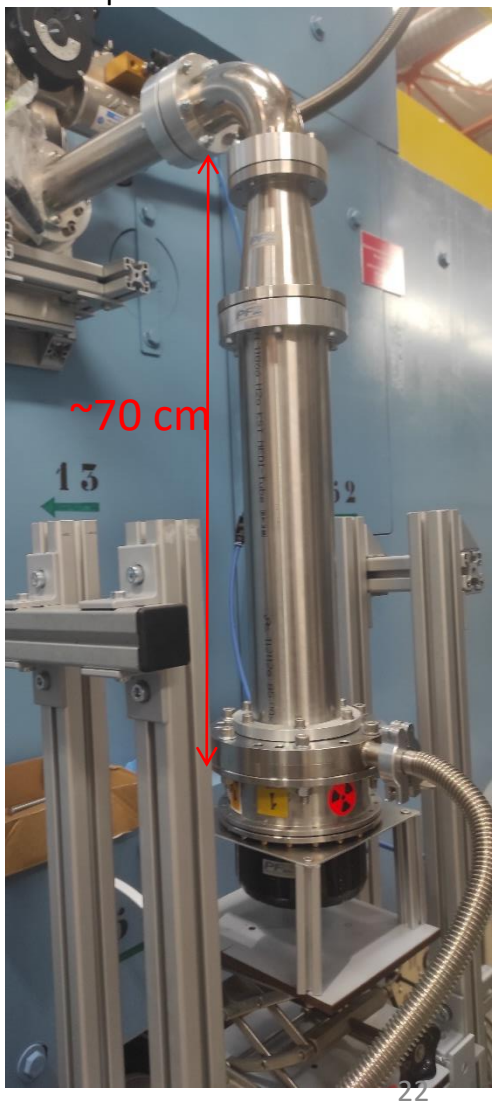
UCN valve



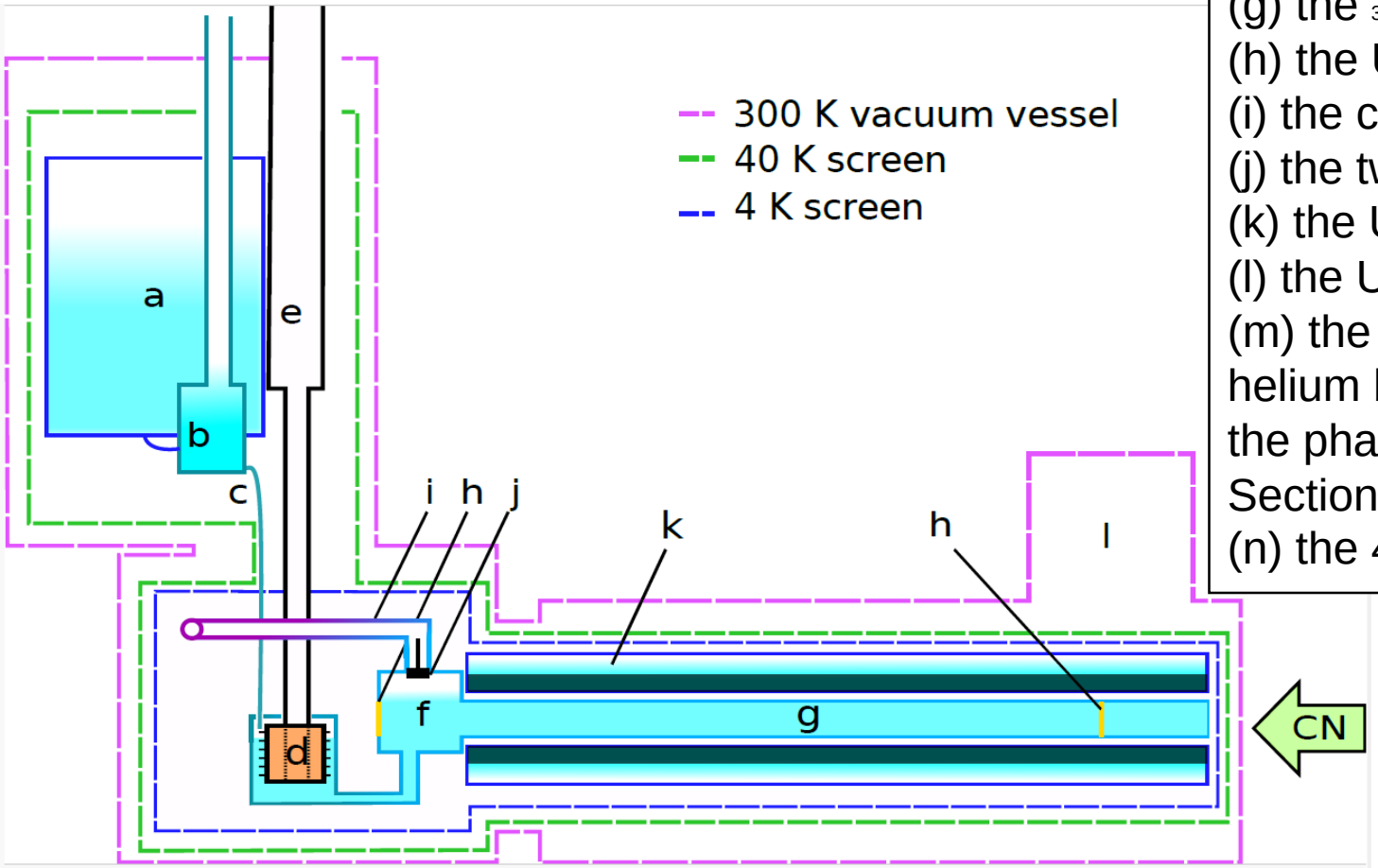
UCN extraction



Setup with detector

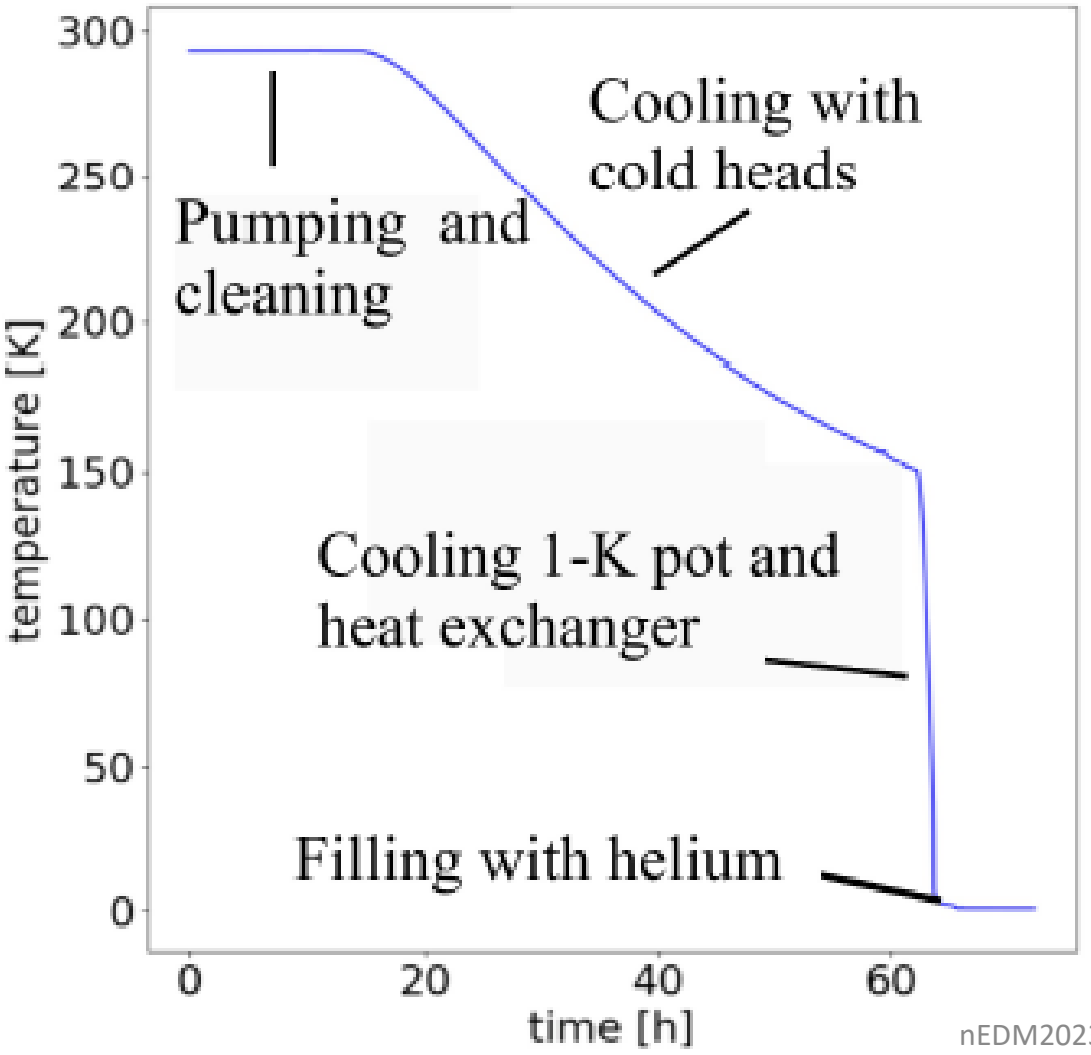


Cryogenic system



(a) the 100-L liquid helium bath,
(b) the needle valve,
(c) the 1-K pot,
(d) the ^{4}He superleak,
(e) the ^{3}He pumping column,
(f) the ^{3}He impedance,
(g) the ^{3}He/^{4}He heat exchanger,
(h) the UCN box,
(i) the conversion volume at 0.6 K,
(j) the two beryllium windows,
(k) the UCN extraction system,
(l) the UCN valve,
(m) the superconducting magnet in a separate liquid helium bath: for SuperSUN phase II this replaces part of the phase I 4-K screen, see description at the end of Section 3,
(n) the 4-K cryostat.

Temperature curve



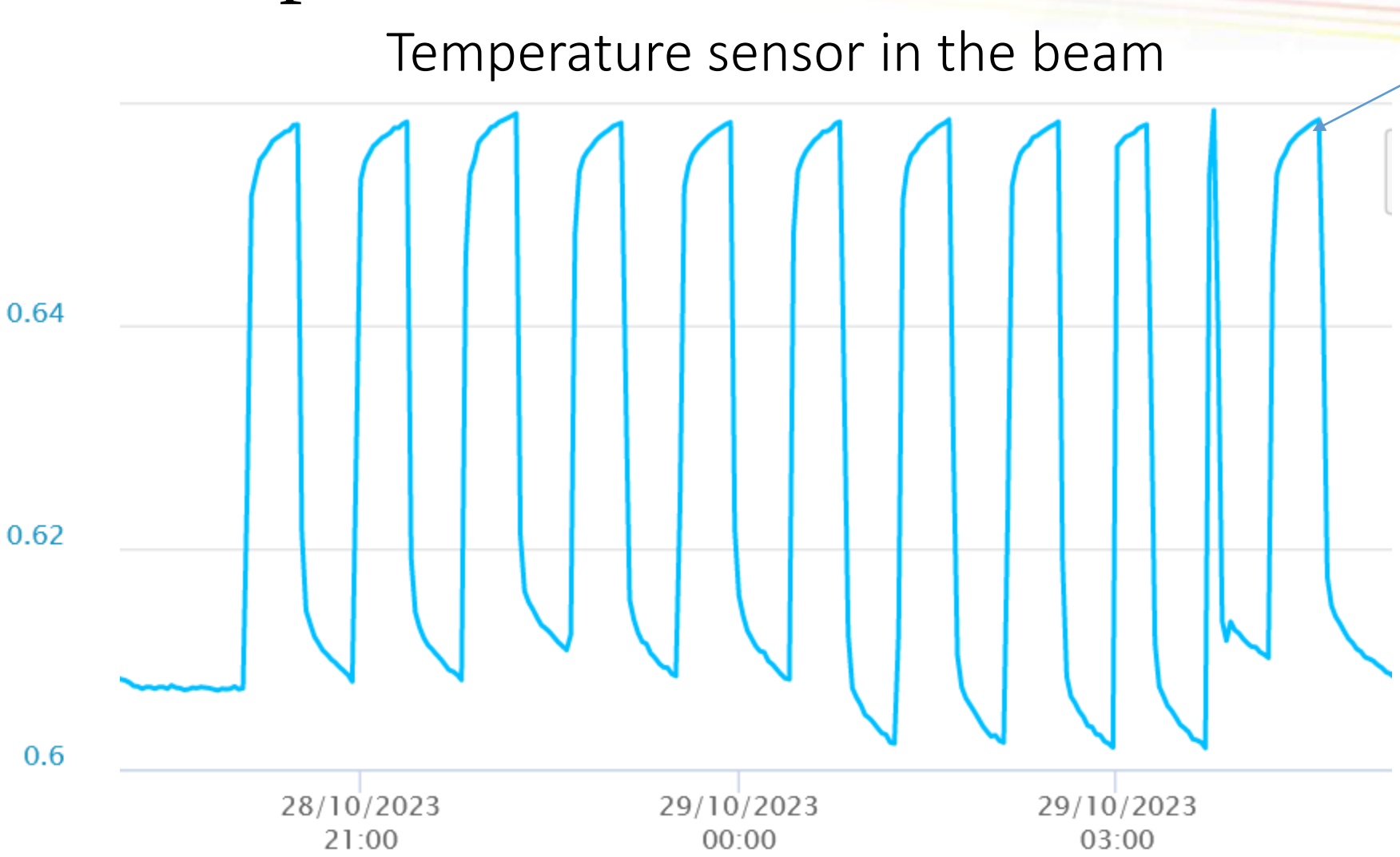
Cool-down cycle

≥48h	Pumping insulation vacuum and cleaning circuits
24-72h	Cooling with cold heads
3-4h	Cooling 1-K pot and heat exchanger
8-16h	Filling with helium
Total	1 week

Warm-up cycle

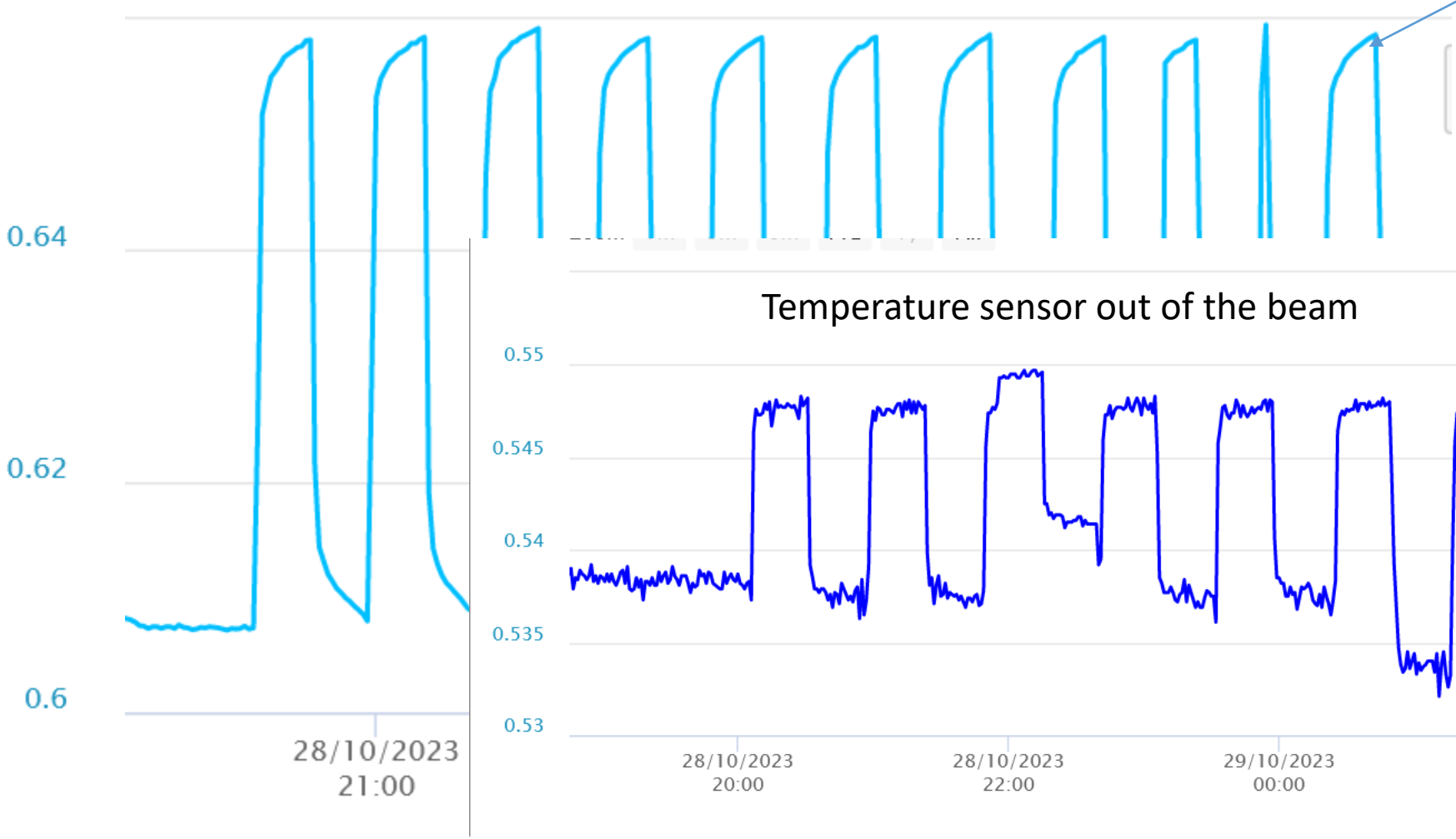
1 day	Emptying
24 h	Pumping
72 h	Warming up at atmosphere
Total	4 days

Temperature

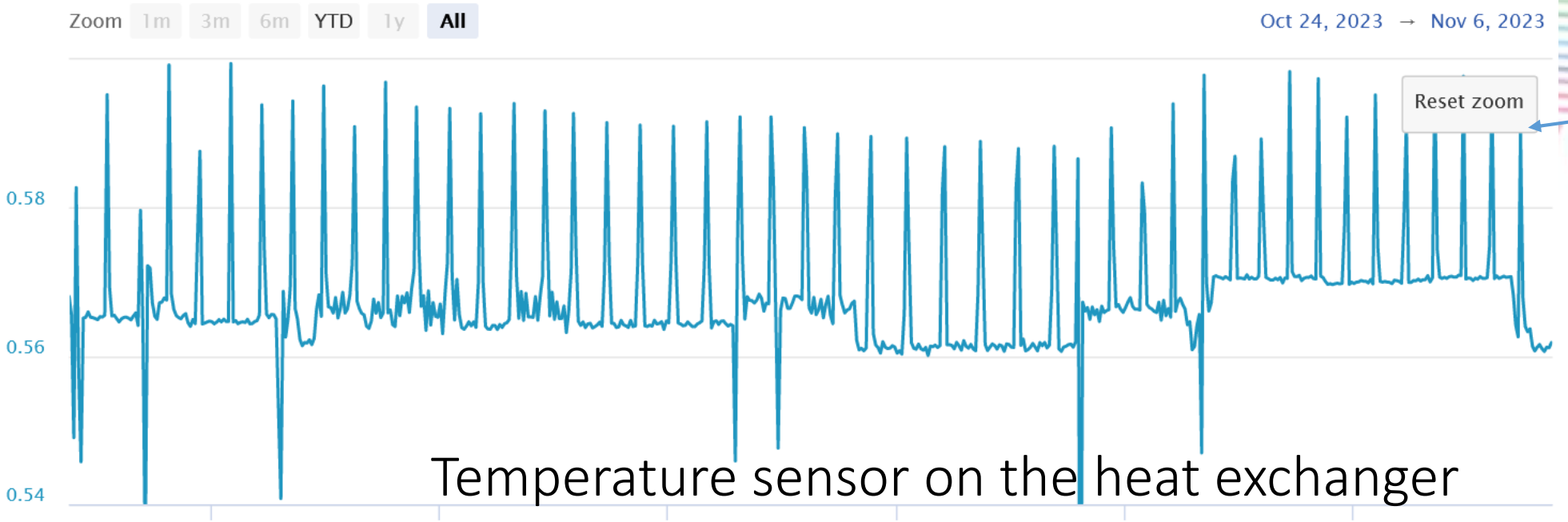


Temperature

Temperature sensor in the beam

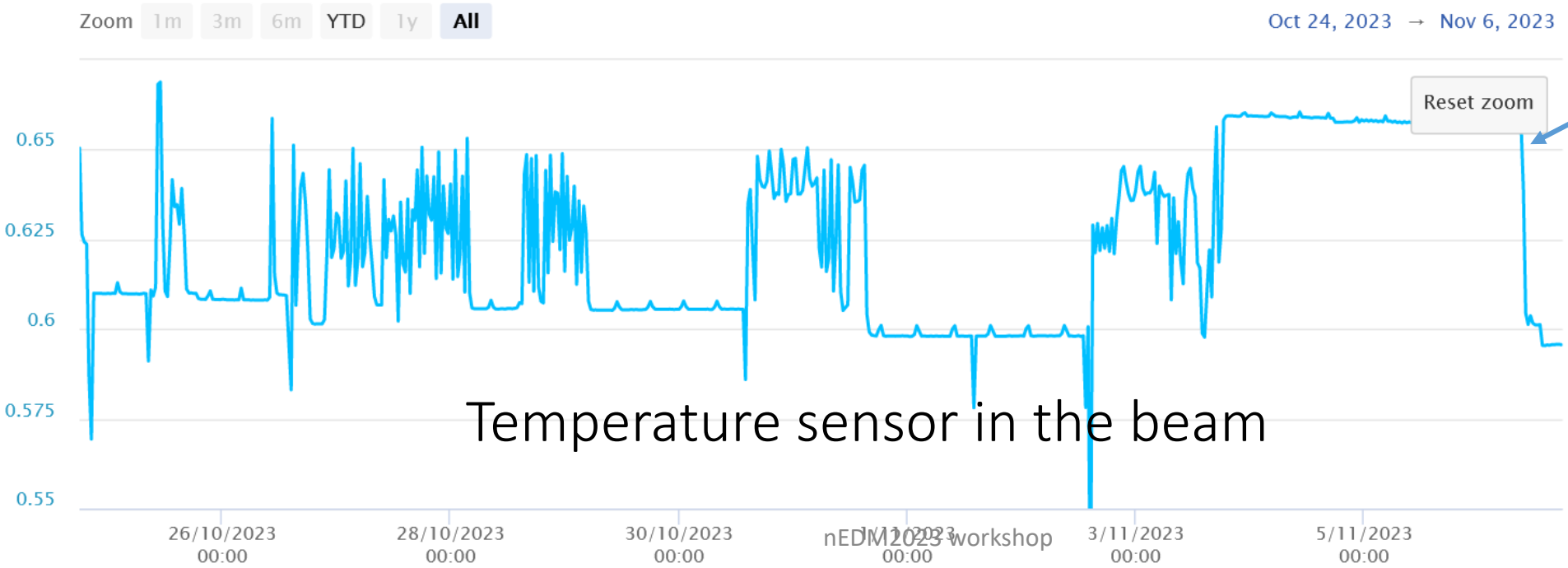


Temperature sensor out of the beam



Filling 1K pot

Temperature sensor on the heat exchanger



Beam On

Beam Off

Temperature sensor in the beam