2025.10.23
Advancing Neutron Facilities
Together 2025

SHOWCASES OF OUR ONGOING COLLABORATIONS ON NEUTRON OPTICS

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Outline

I . High-S/N setup for a Paris-Edinburgh pressure-cell experiments at DMC, SINQ

II . Optical Component developments for BL16, SOFIA

III . Fast neutron/gamma field study of BL16, SOFIA

IV . Material study of 3D-printed neutron optical components using SOFIA

I . High-S/N setup for a Paris-Edinburgh pressure-cell experiments at DMC, SINQ

Key optics components

-- Adaptive Optics: Adjustable focusing mirror with metal substrate

-- Bill-shaped aperture: 3D-printed sample aperture fitting in Paris-Edinburgh Pressure Cells






Gediminas Simutris

PSI
- Uwe Filges
- Peter Keller
- Sascha Thürsum
- Gediminas Simutis
- Paul Filges
- Andrea
- Alex Bolhalder

RIKEN
- Yutaka Yamagata
- Takuya Hosobata

Kyoto Univ.
- Masahiro Hino

KEK
- Sara Yamauchi

Neutron Optics

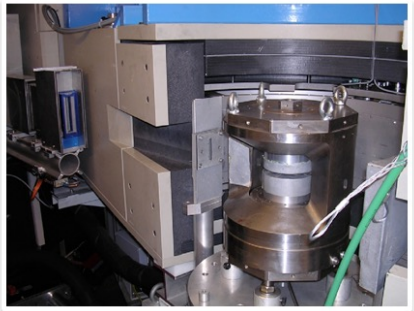
Sample environment

Small samples under extreme conditions are challenging

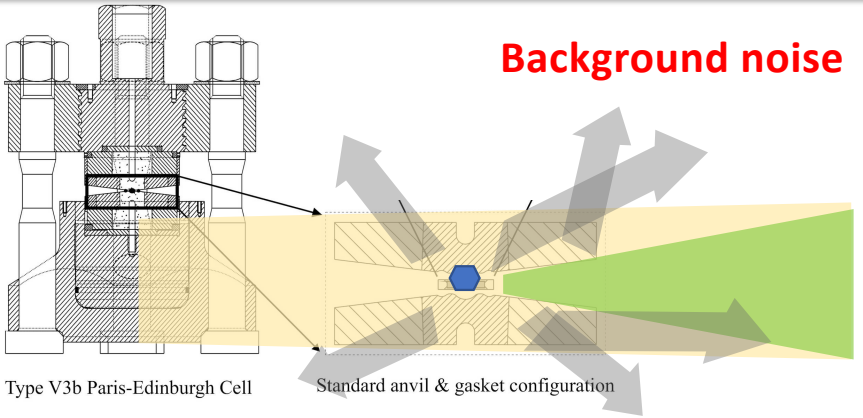
Sample environments

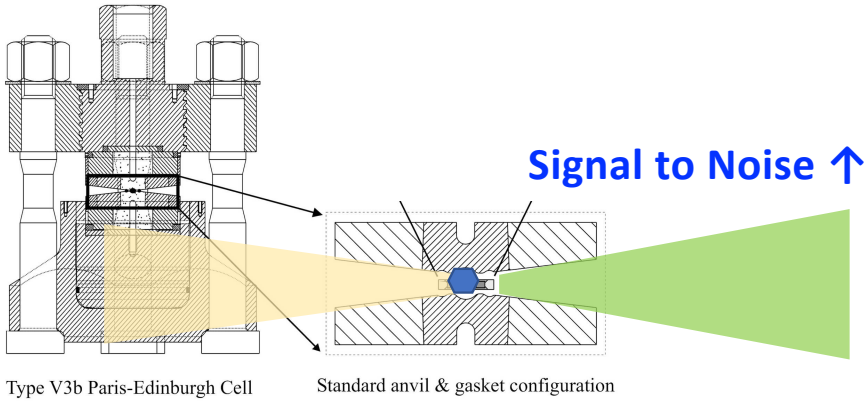
- cryostats
- pressure cells
- magnets
- etc.

  + combinations of all



Room temperature mode @ HRPT





J. Appl. Cryst. (2002). **35**, 122-125

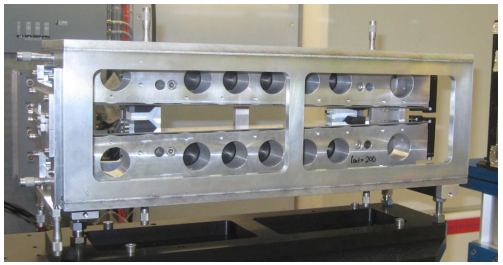
Target: A small sample in a pressure cell

Adjustable focusing mirror: Adaptive Optics

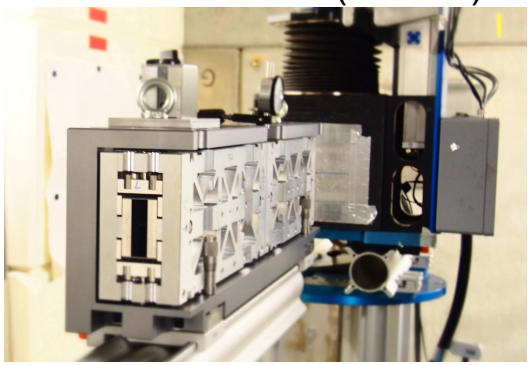
Key development

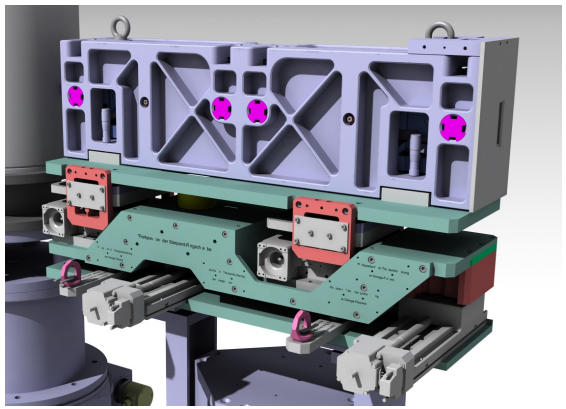
- ✓ metal substrate
- ✓ vertical and horizontal focusing in one unit (1D x 2 direction)
- ✓ Modular structure (no limitation in length)
- ✓ Fully motorized control for the on-site alignment

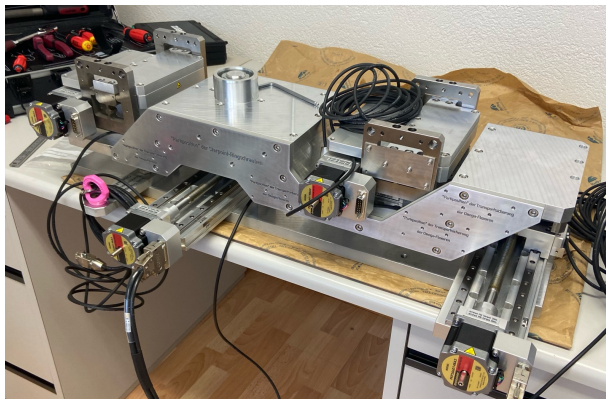
former model (1D)



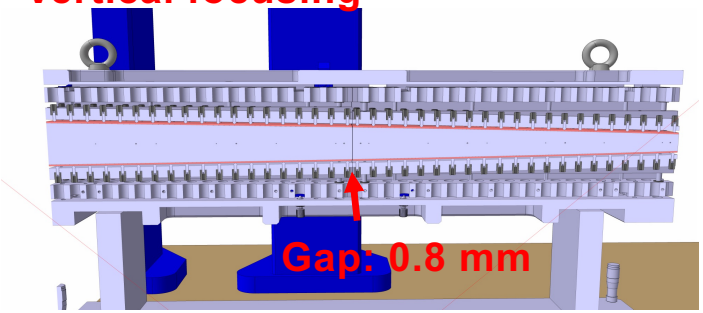
Present model (1D x 2)



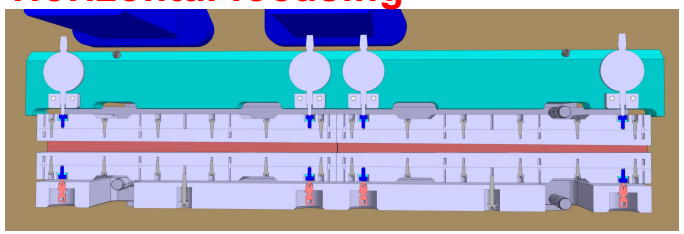




Vertical focusing



Horizontal focusing

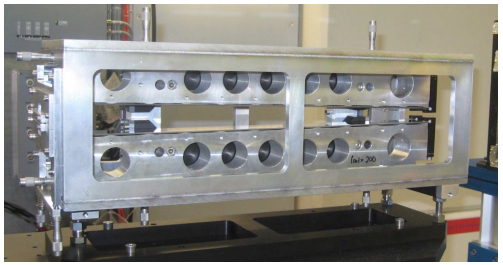


Adjustable focusing mirror: Adaptive Optics

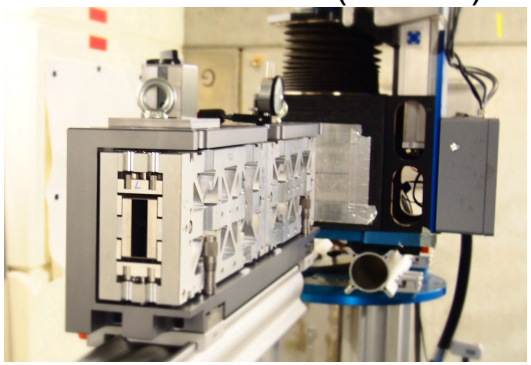
Key development

- ✓ **metal substrate**
- ✓ **vertical and horizontal focusing in one unit (1D x 2 direction)**
- ✓ **Modular structure (no limitation in length)**
- ✓ **Fully r**

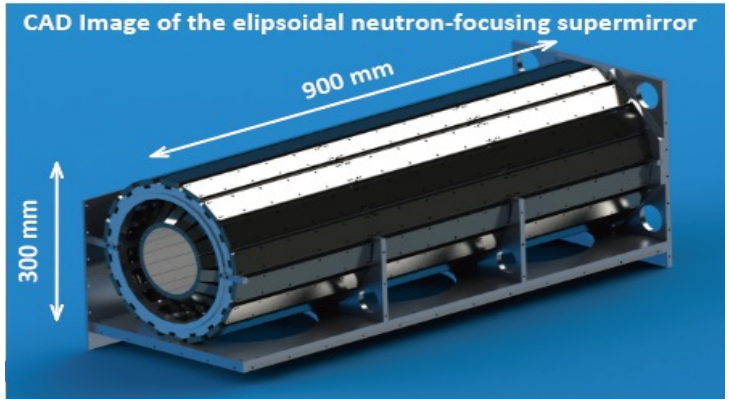
former model (1D)

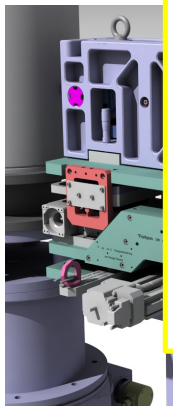


Present model (1D x 2)

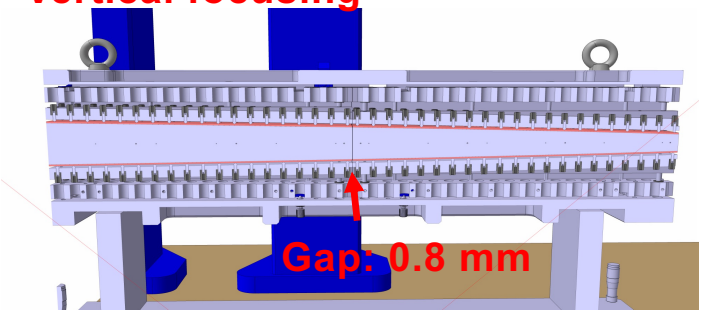


☆ We got inspired by the ellipsoidal focusing optics in a full figure of revolution of BL06-VIN-ROSE, MLF

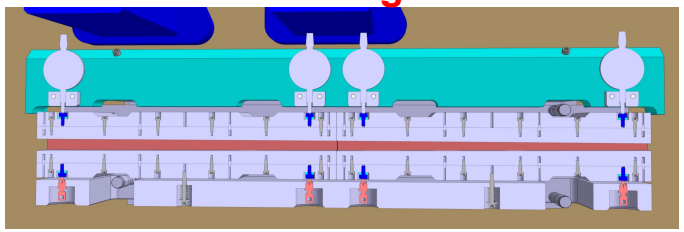




Vertical focusing

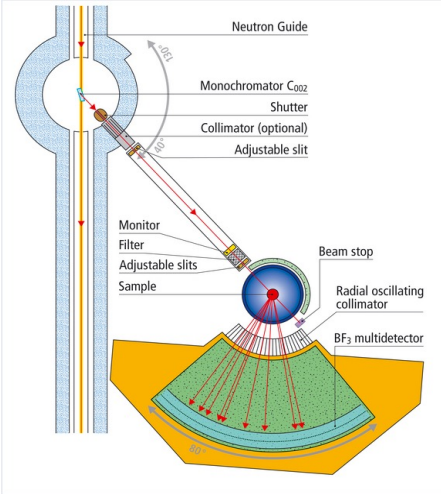


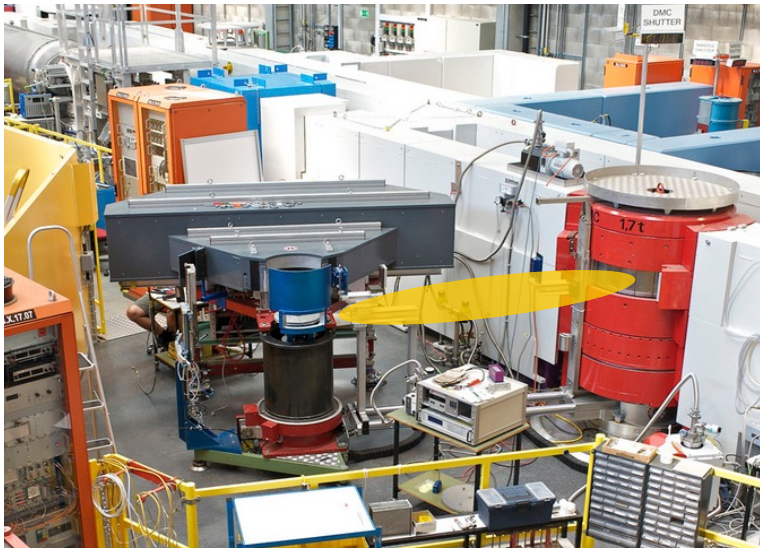
Horizontal focusing



High–S/N setup for ***DMC***, the cold diffractometer in SINQ

- DMC's guide system (SINQ upgrade) and the detector bank was upgraded. => The detector signal x~20
- Still small sample combined with sample environments, especially PE-PC remained challenging.





Requirement

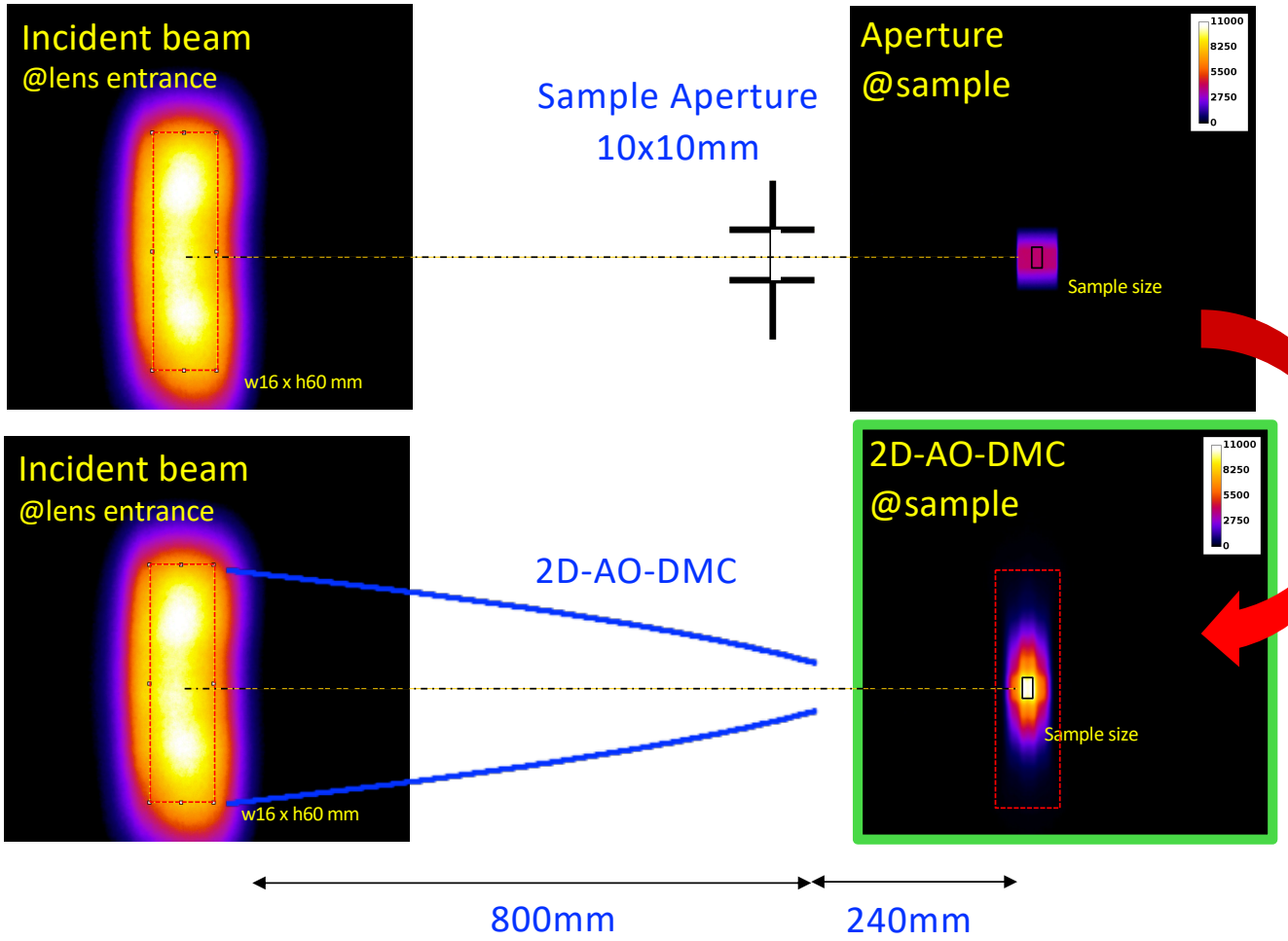
- 2.46Å and 4.6Å
- target beam size: 3x6 (mm2)
- Mono – Sample: 2.2m
- Space for Sample environment
  - Magnet
  - Pressure cell (Paris-Edinburgh)
  - etc.

- Vertical & horizontal focusing
  ⇄ only vertical focusing

Design of 2D-AO-DMC (using McStas)

- Focusing shape: Ellipse
- Total length: 0.8m
  (0.4m x 2 segments)
- Entrance cross section: w16 x h60mm
- Monochromator – Entrance: 1.16m
- Exit – sample: 0.24m
- Ver./hor. focal lengths: 0.156m/0.310m
- Ver./hor. m-value: m=6/m=1.5

Flux gain by only AO (2.46Å)

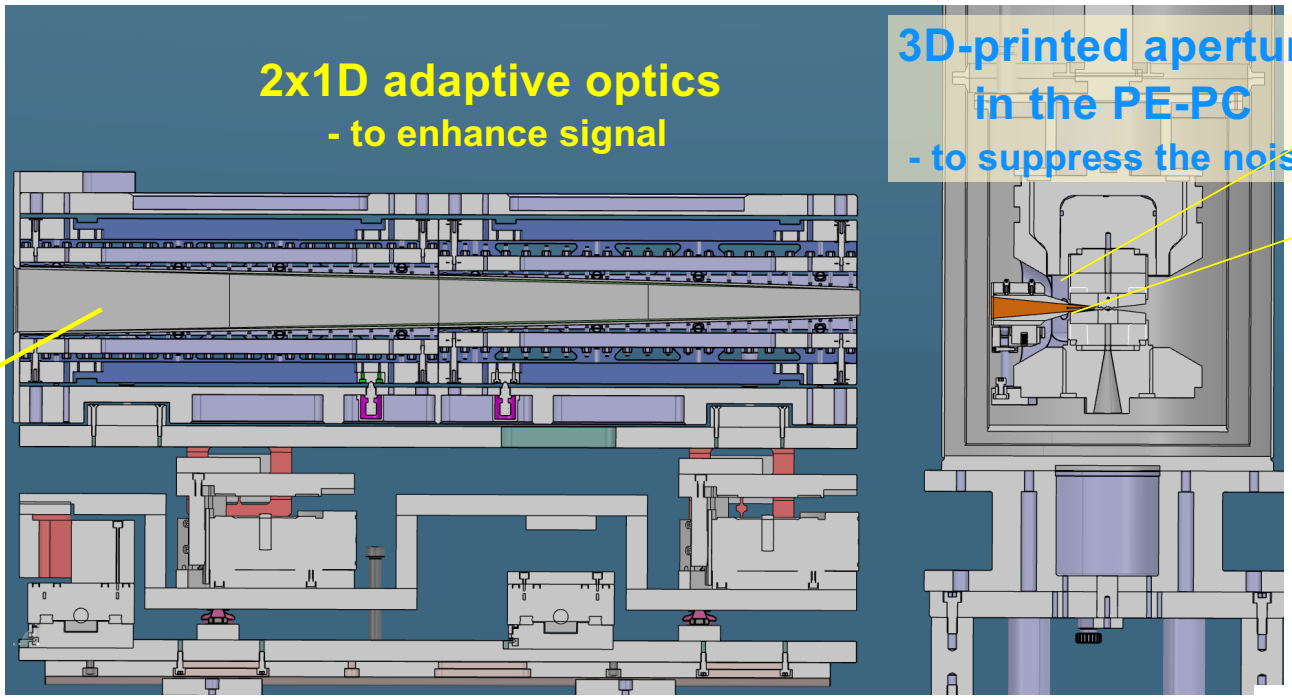


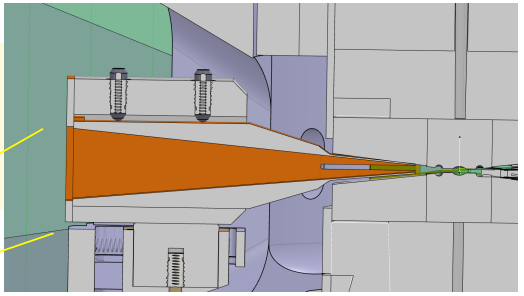
Flux gain	w6xh3mm	w6xh6mm
Measured	2.4	2.4
Simulation	2.6	2.5

Beam flux gain x2.4!

- Beam flux gain of 2.4 was achieved but there is the significant “flair” around the sample region due to the pre-focusing from the focusing monochromator.

High–S/N setup: AO & sample ap. in PC



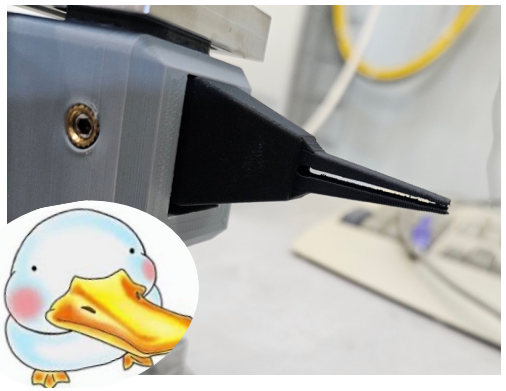


- Tapered in both direction
- 5mm away from the gasket
- Material : PLA + B4C(25wt%)
- works at the cryogenic temperature
- side slit (t0.5mm) allows further compression

3D-printed wall cover (t0.3mm)
- to switch between 1D and 2D focusing

Sara Yamauchi

Gediminas Simutris



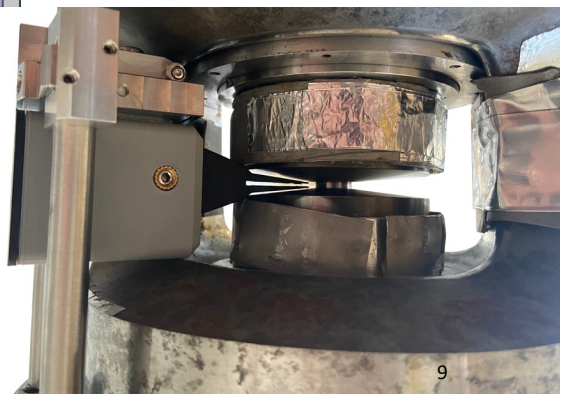
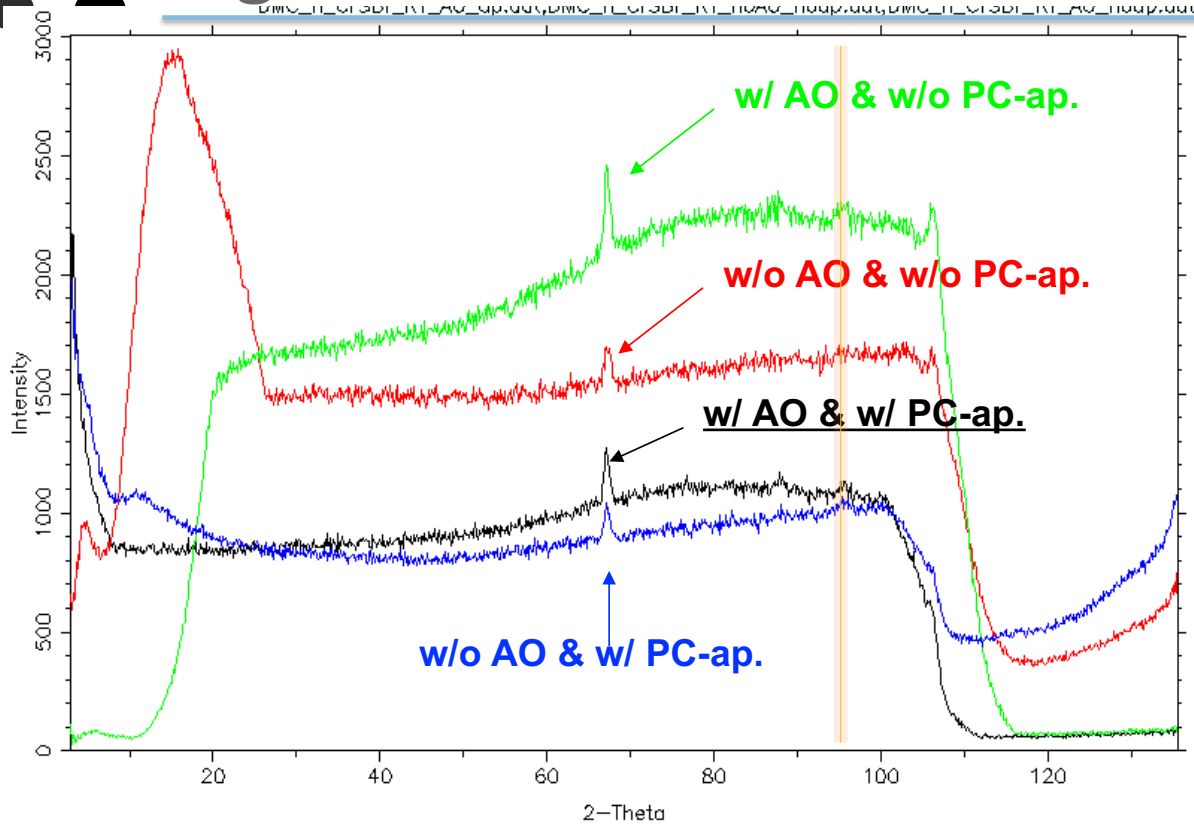


Figure of merit

Sample:Cr-based van der Waals layered materials (2D)



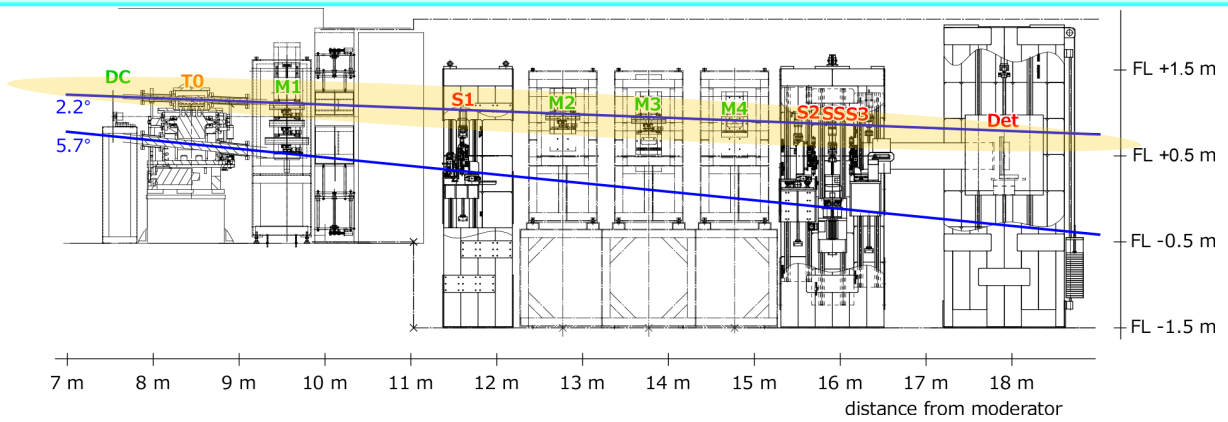
AO	IN	IN	OUT	OUT
PC-ap.	IN	OUT	IN	OUT
peak	214.2	359.8	130.17	151.77
BG	1044.5	2083.9	889.8	1541.9
Int. intensity	179.2	325	114.9	147.7
S/N	0.21	0.17	0.15	0.10

- The ap. reduced the background significantly.
- AO enhanced the signal.
- **The combination (AO+PC-ap.) gives the best S/N**.
- There is the room to improve the intensity with this setup by installing x-/y- sample stages.
- **The salt peak became visible with optics!**

Next: We would like to perform the validation test on **a single crystal** sample in a pressure cell for peak hunting.

II . Optical Component installed for BL16 SOFIA at MLF

SOFT MATTER



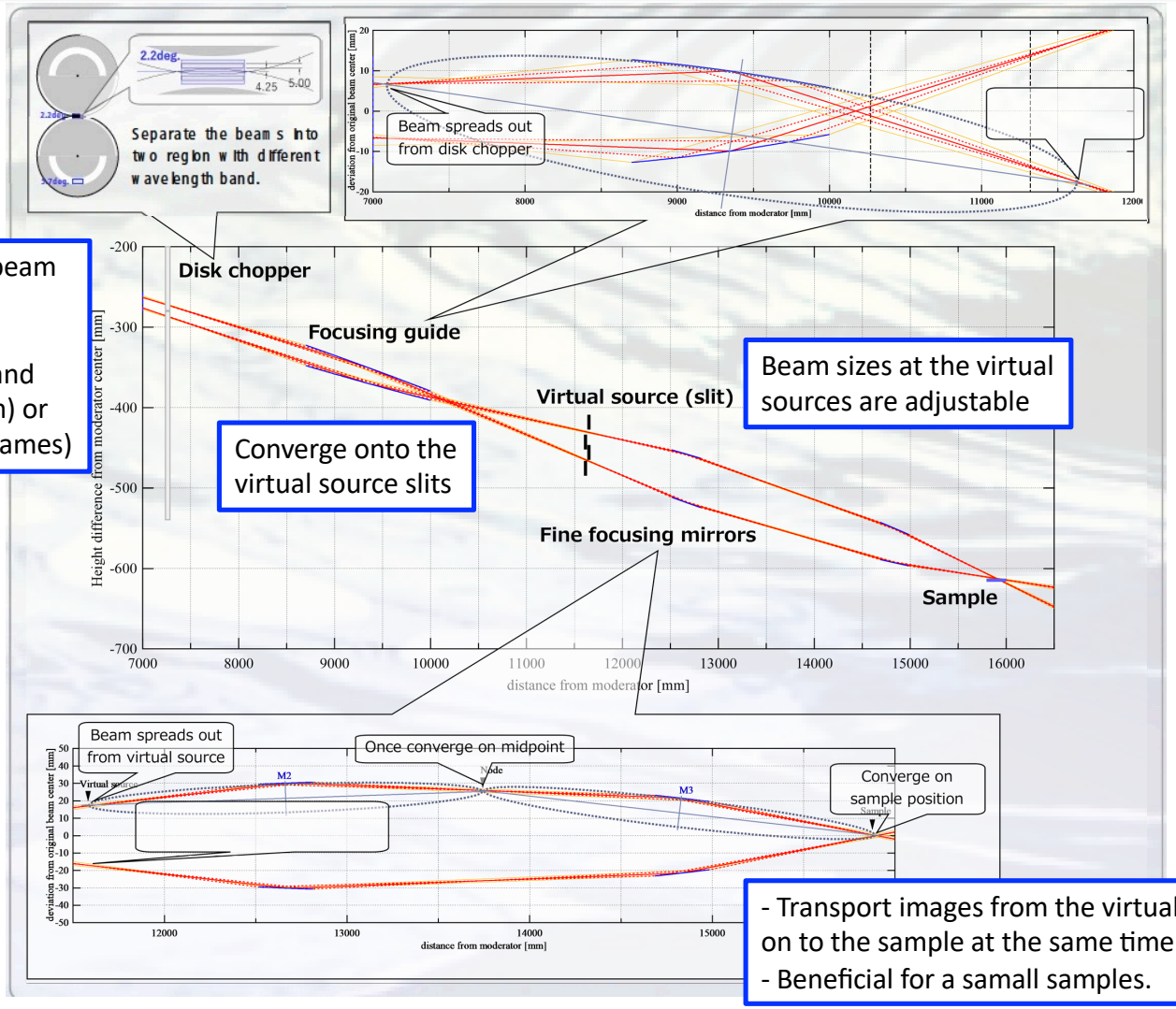
- **Horizontal sample configuration**
- **conventional double slit collimation**
- **non-polarized**
- **TOF (wavelength-dispersive)**
- **coupled moderator ->high intensity**
- **2D detector for high diverging beam**
- **double-frame option**
- **low BG** ~ 10^{-6} -10^{-7}

Upgrade program

Multi-incident-Angle Neutron Reflectometry (MI-NR)

to measure a whole wide q-range in one-go for time-resolved measurement

Design of optics to realize MI-NR at SOFIA



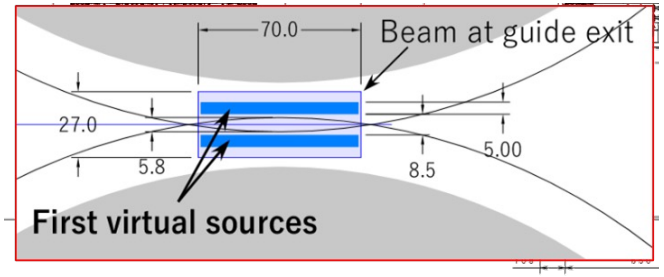
Separate the beam into two with different wavelength band (Single(bottom) or Double(top) frames)

Converge onto the virtual source slits

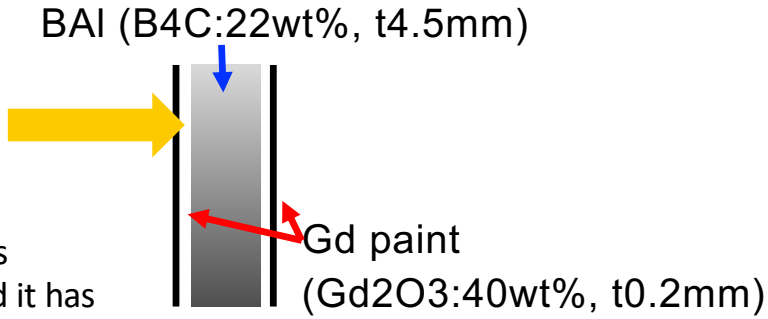
Beam sizes at the virtual sources are adjustable

- Transport images from the virtual source on to the sample at the same time.
- Beneficial for a samall samples.

①Double disc chopper discs

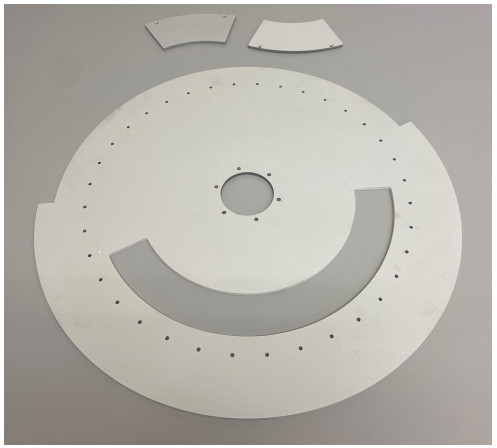


- Neutron transmission
- Stability of the paint

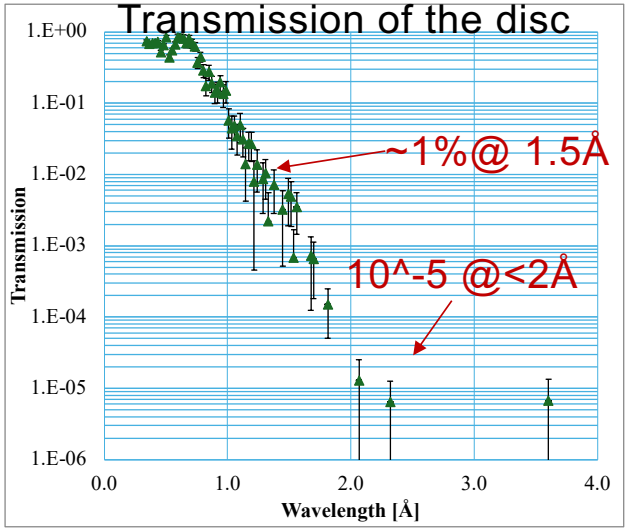


- **Since Nov. 2023**

In collaboration with the Neutron Optics Group at PSI, the disk was remade using BAl with gadolinium paint applied on both sides, and it has been in use for the double-frame since early November 2023.



Opening angle : 180° ➔ 155°



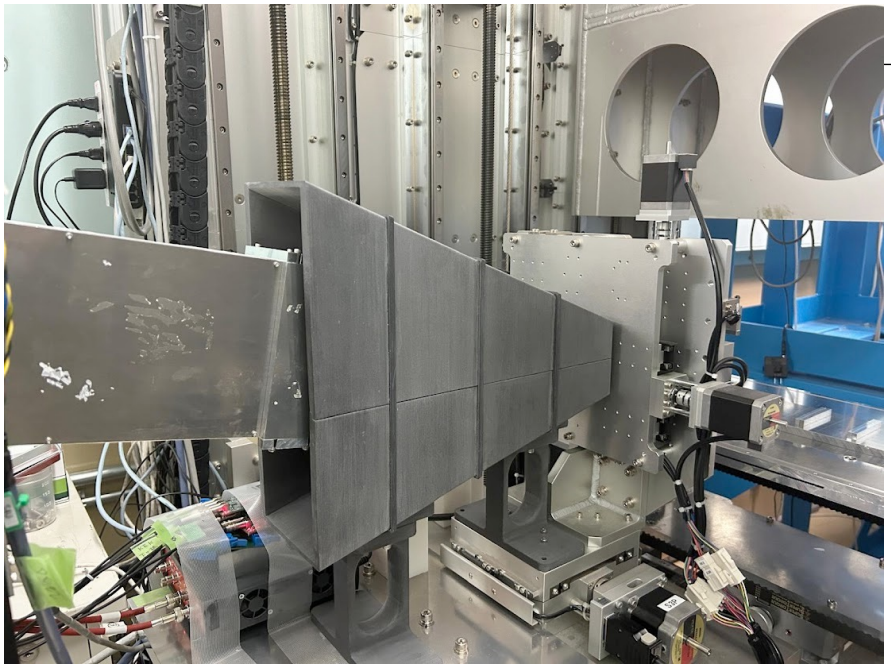
stability test of the paint

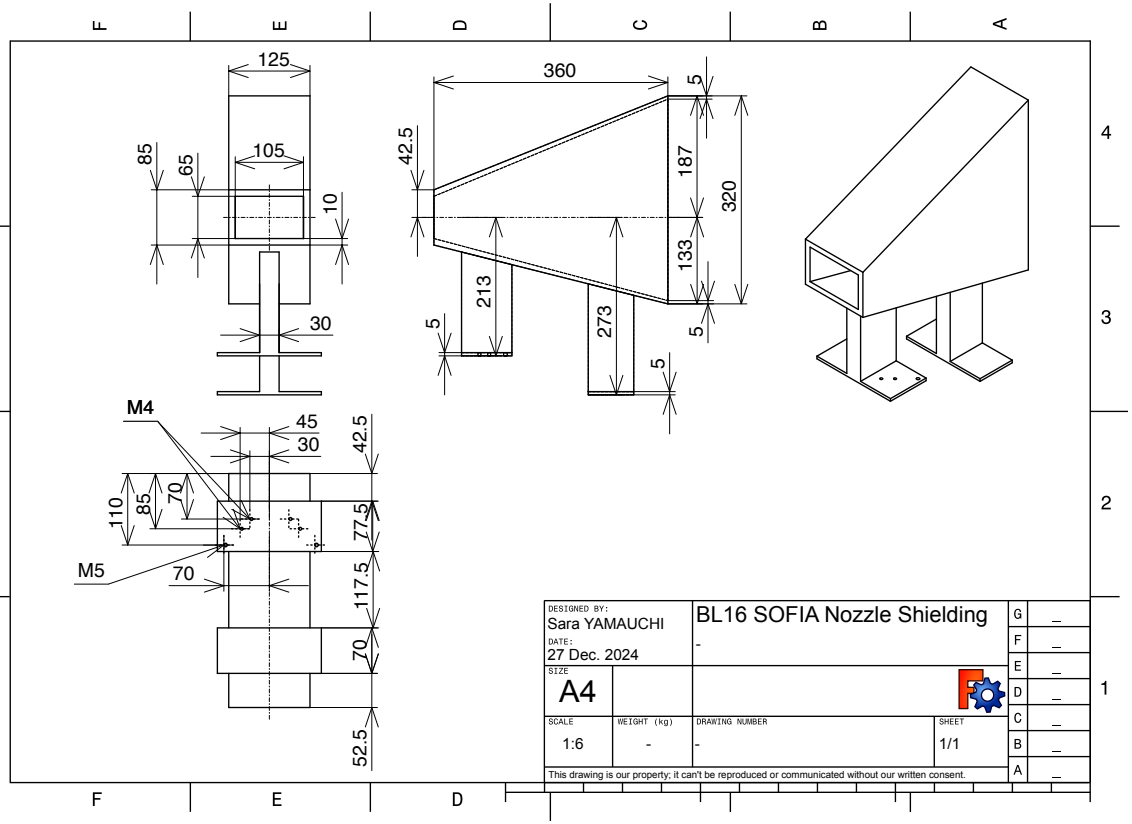
after 24h rotation@25Hz

②3D-printed wide-angle neutron shielding duct

➢ **May. 2025**

"In collaboration with Ms. Sara Yamauchi (technical staff) and the Neutron Optics Group at the Paul Scherrer Institute, we manufactured a tapered beam-duct using a B_4C-loaded filament. From the 2025B period onward, performance testing using a neutron beam will be conducted. (Because it is lightweight and retrofit-installed, there are many constraints on its geometry.)





⇨ The effect of the nose will be tested.

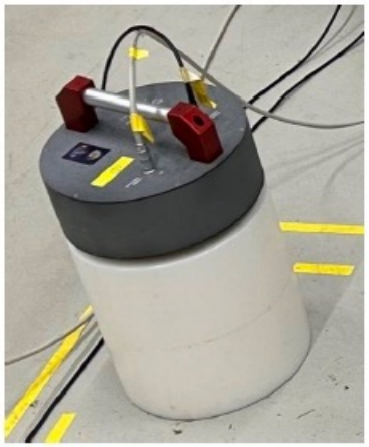
III. Fast neutron/gamma field study at BL16 SOFIA

- **APRIL. 2025**

Gamma and neutron detectors

ELSE BRAD is a gamma spectrometer with an energy range from 10 keV to 2.5 MeV Tested in high gamma environment.

ELSE SP2 enables neutron spectrometry across a broad energy range, from thermal to GeV, in homogeneous fields.



ELSE LUPIN is a calibrated neutron dosimeter for neutrons from thermal to 10 GeV.

Daniel Zeitz

Dr. Kosuke Ishii

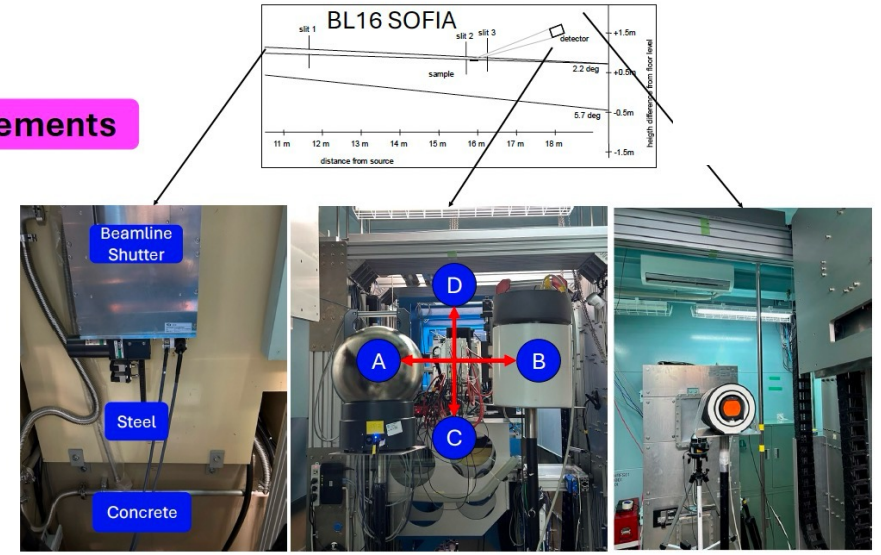
Fast neutron/gamma field study at BL16 SOFIA

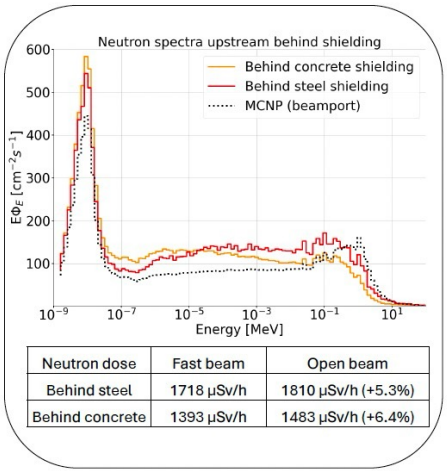
3 Neutron background measurements

Neutron spectra were measured with the open beam and with a closed B_4C aperture to determine the contribution of the thermal beam to the background :

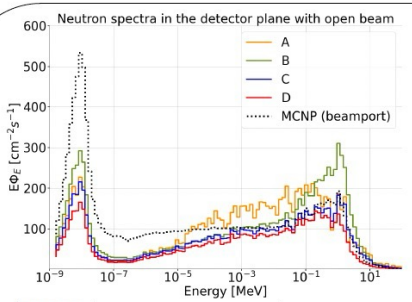
- in the detector plane at 4 positions at 26 cm distance from the detector,
- upstream at a lower position behind concrete shielding and at a higher position behind steel shielding.

The position of the fast beam was determined with a dosimeter with a peak dose of 28.5 mSv and the 3D-PADC-Detector was irradiated with the closed aperture in the beam for 4 different runs from 2 min to 2 hours.

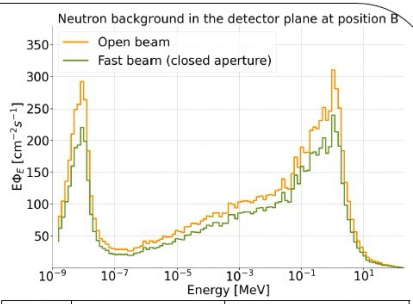




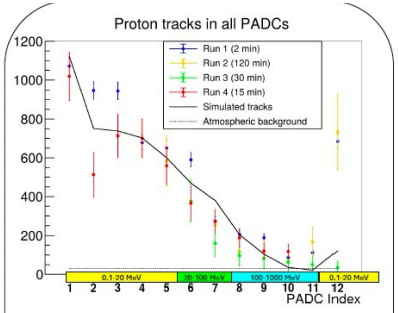
Neutron dose	Fast beam	Open beam
Behind steel	1718 µSv/h	1810 µSv/h (+5.3%)
Behind concrete	1393 µSv/h	1483 µSv/h (+6.4%)

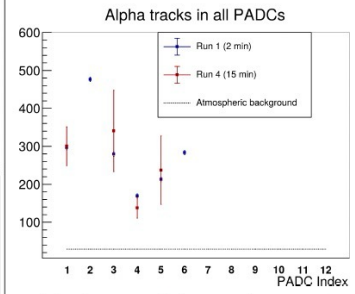


Neutron dose	Fast beam	Open beam
A	1830 µSv/h	2075 µSv/h (+13.3%)
B	1813 µSv/h	2024 µSv/h (+11.6%)
C	1926 µSv/h	2177 µSv/h (+13.0%)
D	1409 µSv/h	1587 µSv/h (+12.6%)



Gamma dose	Fast beam	Open beam
A	112 µSv/h	130 µSv/h (+16%)
B	73 µSv/h	83 µSv/h (+13.7%)
C	95 µSv/h	100 µSv/h (+5.2%)
D	72 µSv/h	74 µSv/h (+2.7%)





- Tracks per PADC up to the tungsten layer are qualitatively in line with simulations.
- Tracks in the last PADC are underestimated due to backscattered neutrons between 0.1 and 20 MeV.
- Lack of alphas in this PADC excludes thermal neutron backscattering.
- Unfolding the measured tracks to a spectrum is the next step.

Summary

I . High-S/N setup for a Paris-Edinburgh pressure-cell experiments at DMC, SINQ

II . Optical Component developments for BL16, SOFIA

III . Fast neutron/gamma field study of BL16, SOFIA

IV . Material study using SOFIA for 3D-printed neutron optical components


Thank you for your attention!
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