Background sources in Advanced High-Pressure Neutron Scattering Experiments

Zhanwen Ma

D. Mazzone, J. Lass, G. Simutis, S. Thürsam, M. Bartkowiak, S. Nikitin, T. Fennell, E. Pomjakushina, M. Bertelsen, P. Willendrup, U. Filges, C. Klauser
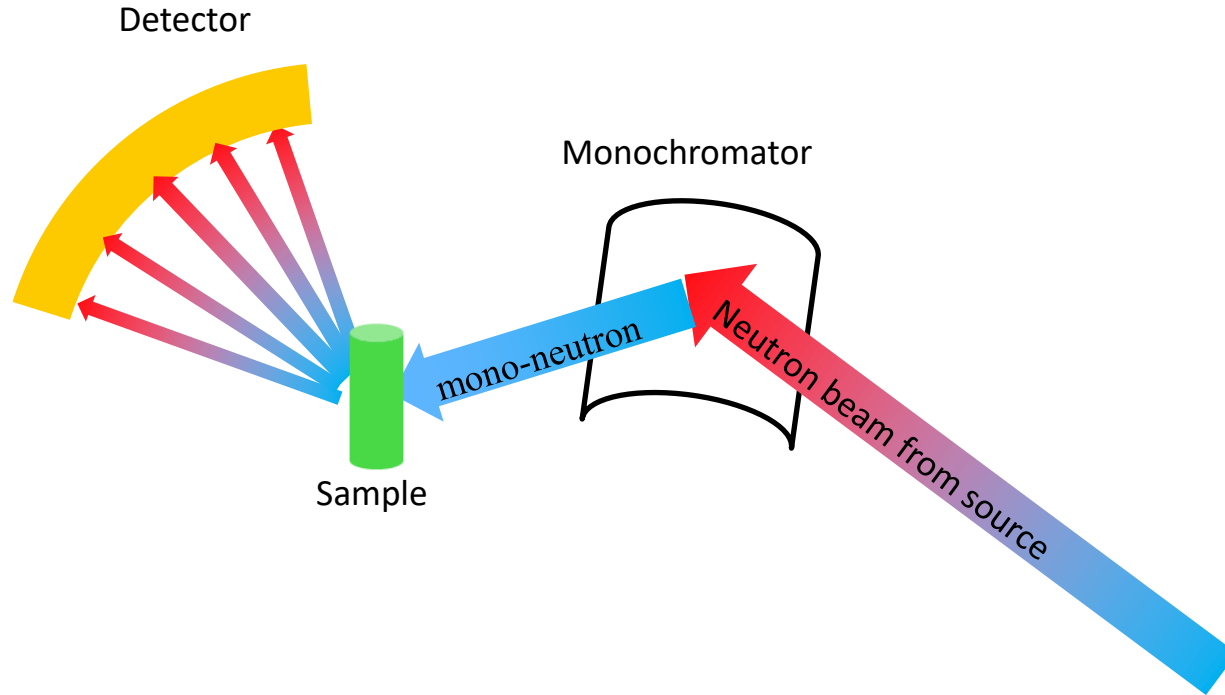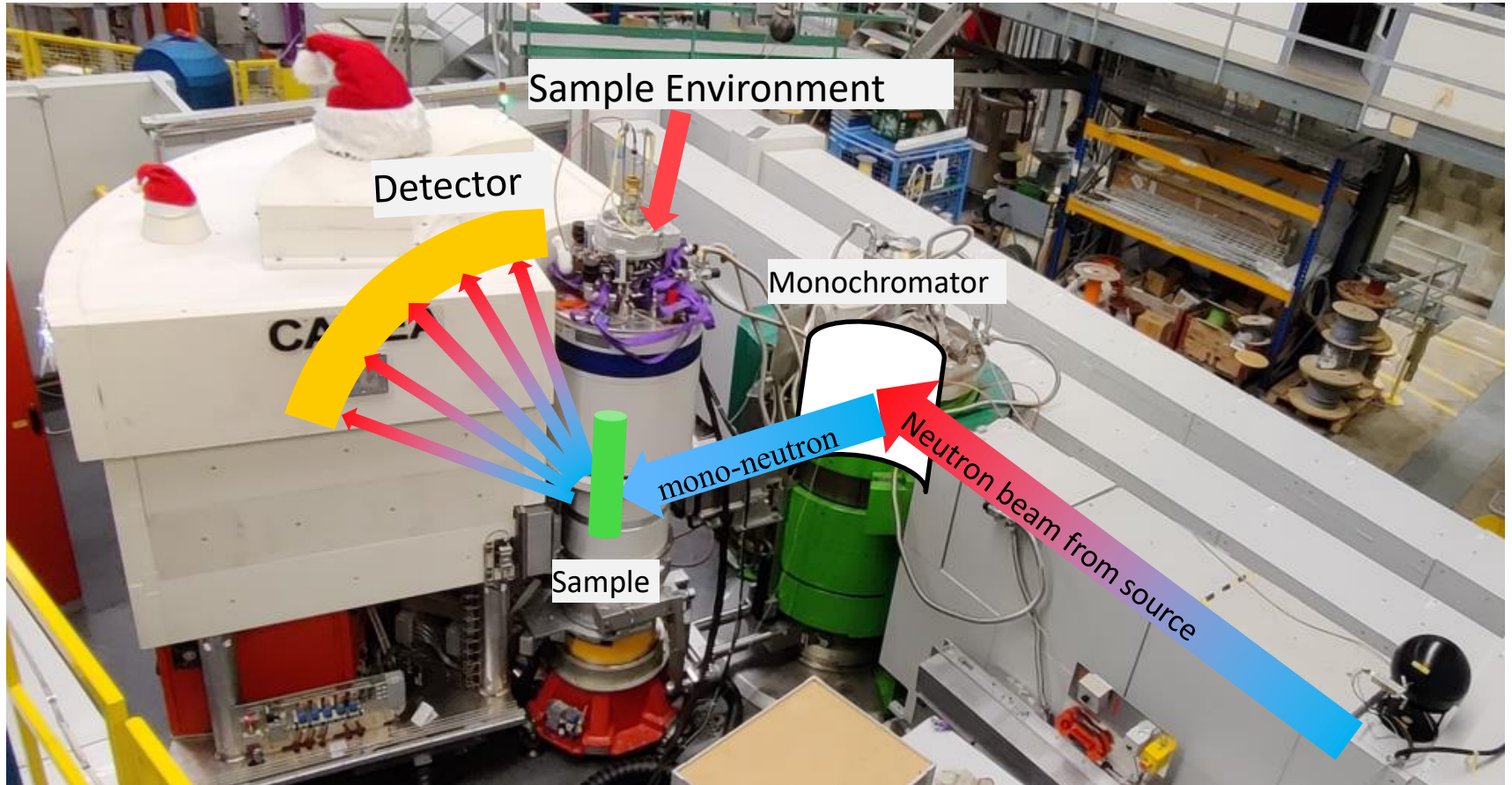
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PAUL SCHERRER INSTITUT

PSI

ess EUROPEAN SPALLATION SOURCE

DTU

McStas
v. 1.0 1998
v. 3.4 2023
25th ANNIVERSARY

MJOLNIR

Outline

- Motivation

- Experimental test of 3D printed collimator

- Simulation

- Summary and Outlook

Detector

Monochromator

mono-neutron

Neutron beam from source

Sample

Sample Environment

Detector

Monochromator

mono-neutron

Neutron beam from source

Sample

Orange cryostats

Magnet

Room temperature mode @ HRPT

Pressure devices

http://lns00.psi.ch/sinqwiki/Wiki.jsp?page=Main
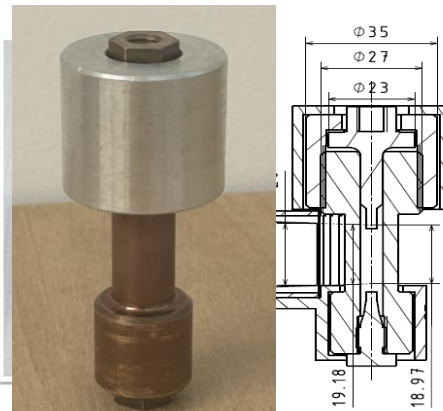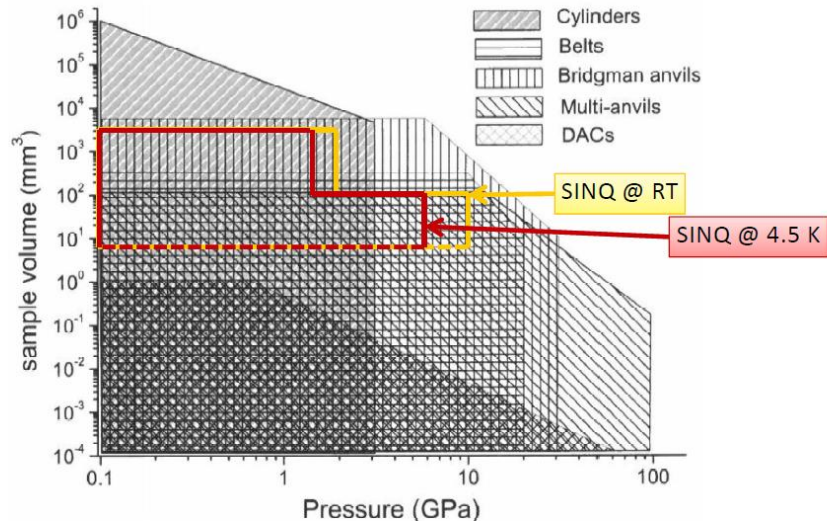
Available sample volume as a function of pressure.
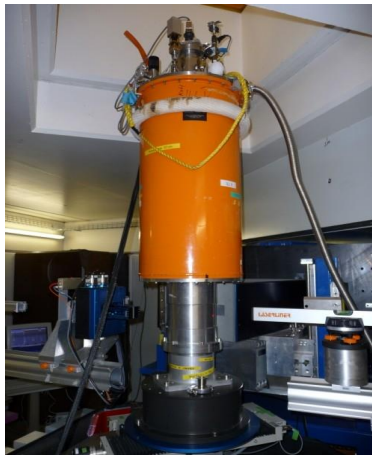
Orange cryostats

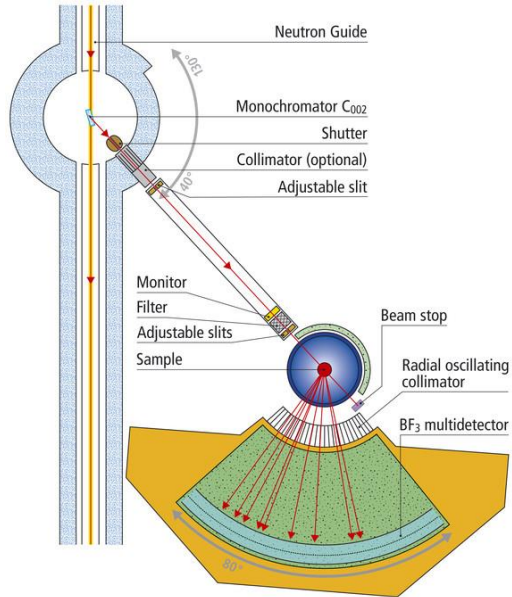
Room temperature mode @ HRPT

Pressure devices

Challenges:
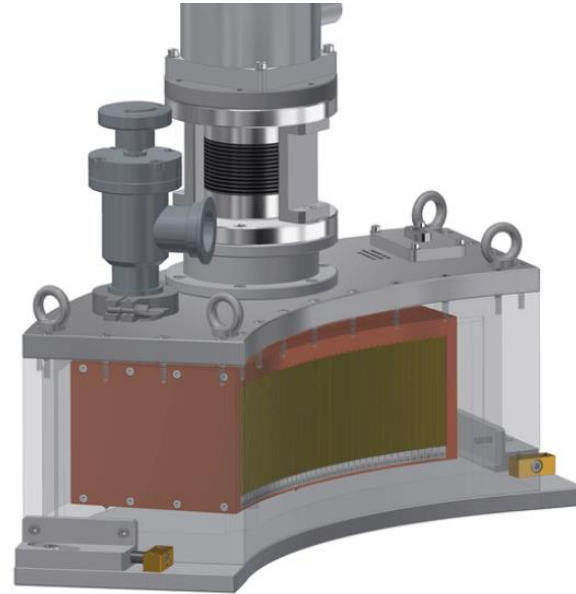- limited sample volume
- high background noise from the sample environment

S. Klotz, "*Techniques in high pressure neutron scattering*", 1st Ed., CRC Press, (2013)

http://lns00.psi.ch/sinqwiki/Wiki.jsp?page=Main

Collimator

- Collimator outside the sample environment

Neutron Guide

Monochromator C$_{002}$
Shutter
Collimator (optional)
Adjustable slit

Monitor
Filter
Adjustable slits
Sample

Beam stop

Radial oscillating
collimator

BF$_3$ multidetector

https://www.psi.ch/en/sinq/dmc


https://www.jjxray.dk/p/collimator-with-cryocooler/

3D printed collimators for pressure cell

- 3D printed B4C collimator (inside the cryostats)
- Minimum thickness 0.4 mm

$$b_0 \approx \frac{2\alpha r_1 r_2}{r_2 - r_1}.$$

r1 – inner radius of the collimator (given by pressure cell size)
r2 – outer radius of the collimator (given by sample volume in the cryostat)
alpha – angular distance between the blades (to be fitted)
b0 - Acceptance radius (maximum impact parameter), given by the sample volume in the pressure cell

Radio-collimator

CAMEA
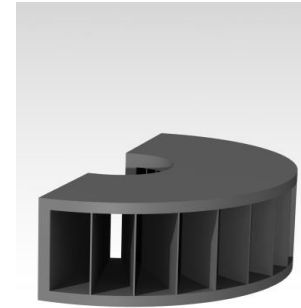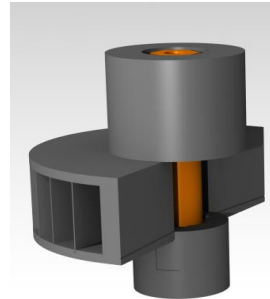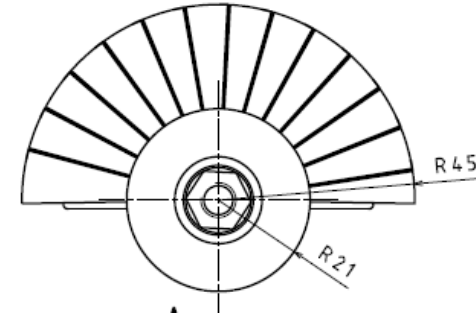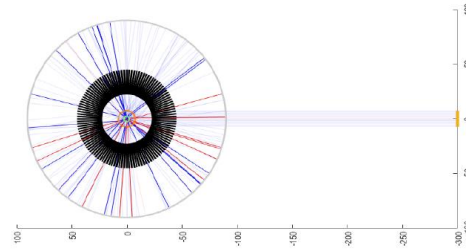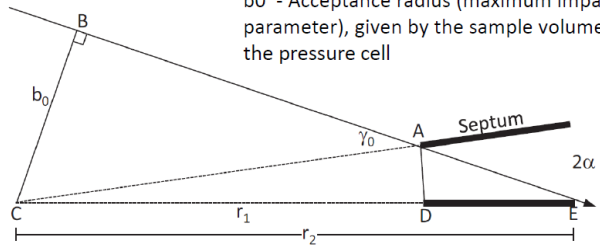
Continuous **A**ngle **M**ultiple **E**nergy **A**nalysis Instrument at cold neutron guide
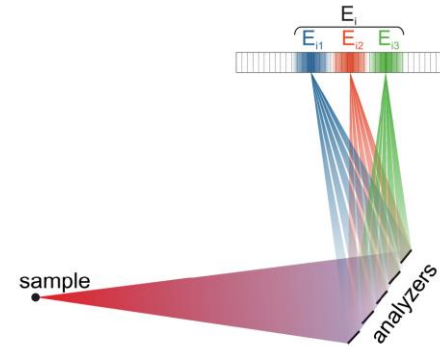In-plane neutrons scattered by 8x8 analyzers (E_f = 3.2-5 meV, 60˙ angular coverage) on 104 PSD.
-Energy resolution tuneable through prismatic concept.
-Large accessible Q-range through A3 scan
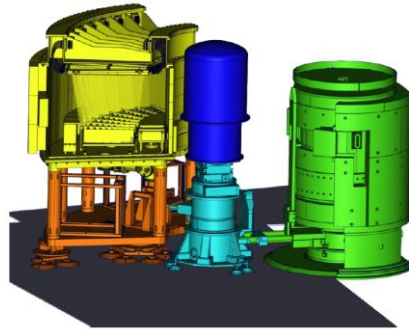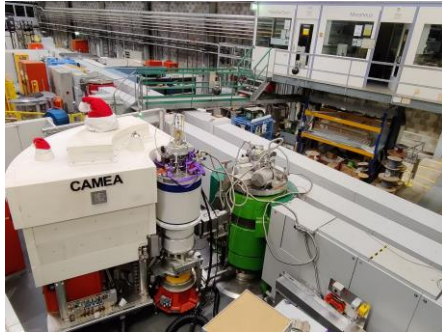
F. Groitl *et al. RSI* **87**, 035109 (2016)
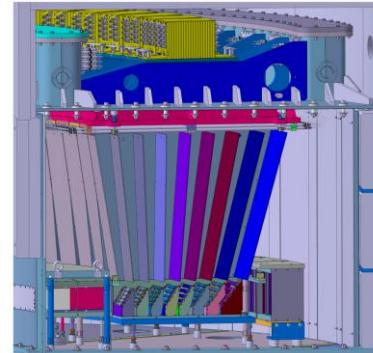
J. Lass *et al. Rev. Sci. Instrum. 94, 023302 (2023)*

F. Groitl *et al. RSI* **87**, 035109 (2016)

CAMEA: **C**ontinuous **A**ngle **M**ultiple **E**nergy **A**nalysis Instrument

neutrons scattered by 8x8 analyzers (E_f = 3.2-5 meV, 60˙ angular coverage) on 104 PSD.

- $Ho_2Ti_2O_7$ powder sample (HTO), 150 k;
- Sample environment: cryostats, pressure cell
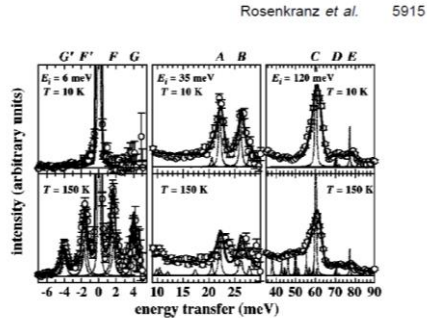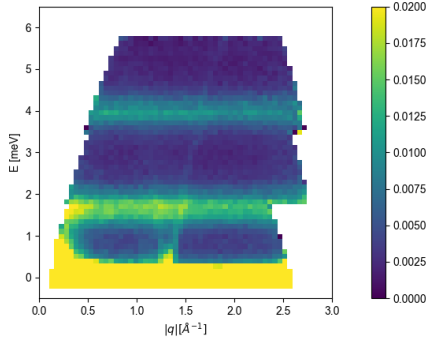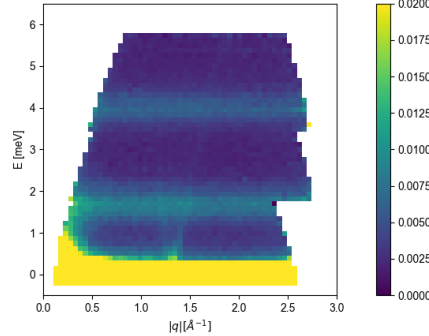- Optics: 3D printed collimator, 3D printed Get_lost (neutron trap)

Rosenkranz *et al.*   5915

FIG. 2. Energy spectra for $Ho_2Ti_2O_7$ measured on LRMECS. The solid line denotes the calculated spectra using the best fitted CF parameters, including an intrinsic Lorentzian broadening of the transitions as well as the instrumental resolution. The dotted lines denote the individual, Lorentzian broadened CF transitions.
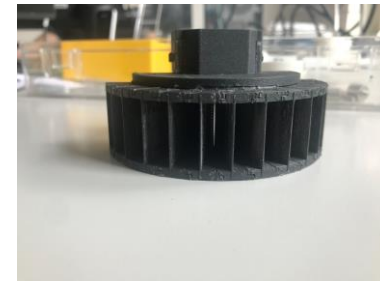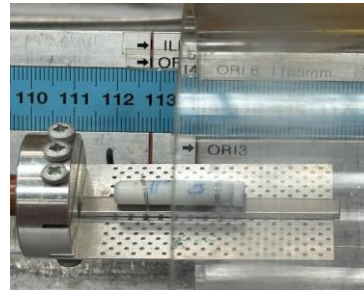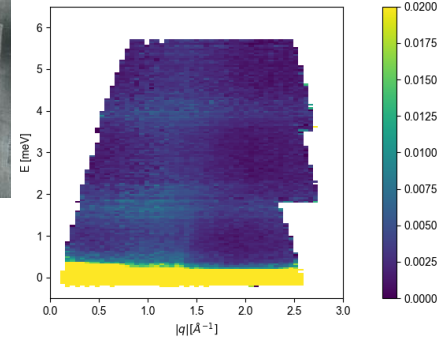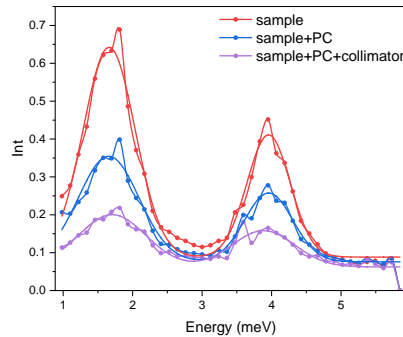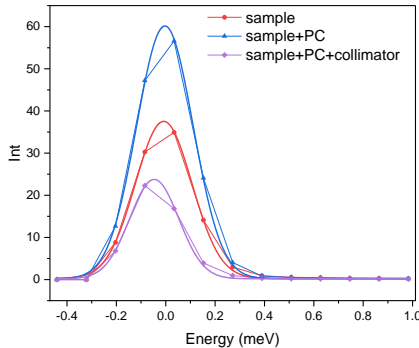
Experimental test with CAMEA at SINQ

Sample

Sample+PC

Sample+PC+Radio_collimator

Integration over entire Q-range

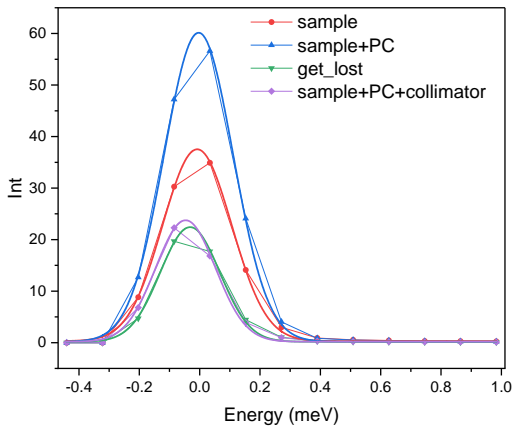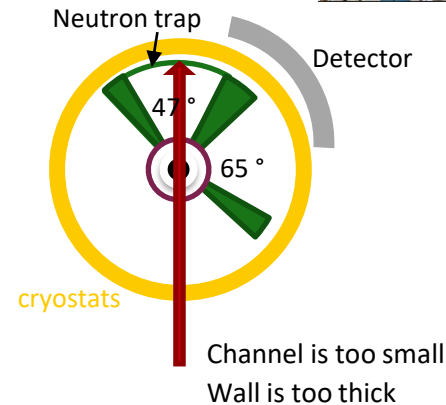|	Elastic peak	Inelastic peak	Inelastic peak / Elastic peak
sample	1	1	1
Sample+PC	1.57	0.63	0.41
Sample+PC+Collimator	0.57	0.41	0.71

3D printed get lost for pressure cell

- 3D printed B4C get lost (neutron trap)

Neutron trap

Detector

47°

65 °

cryostats

Channel is too small
Wall is too thick
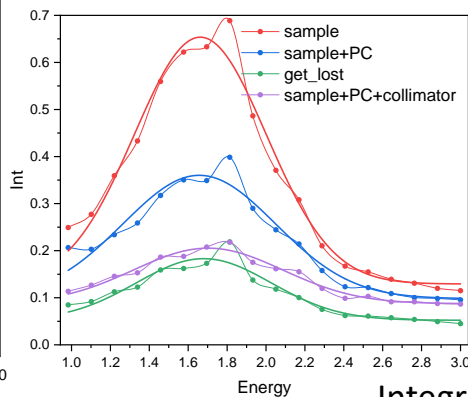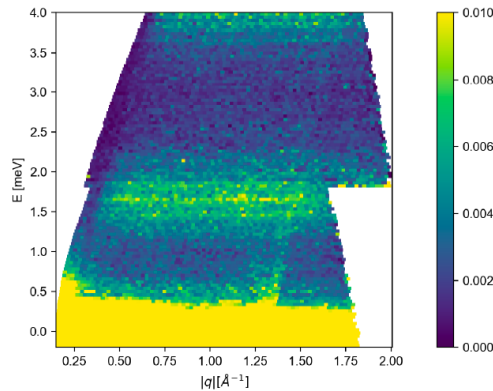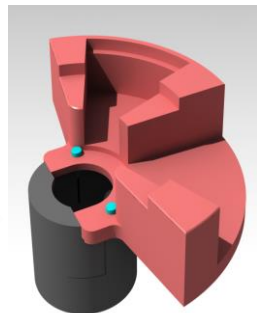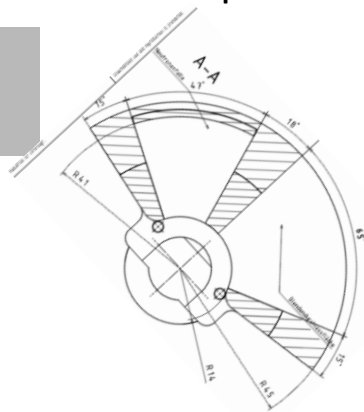
	Elastic peak	Inelastic peak	Inelastic peak / Elastic peak
sample	1.00	1.00	1.00
Sample+PC	1.57	0.64	0.41
Sample+PC+Collimator	0.57	0.41	0.71
Sample+PC+Get_lost	0.51	0.31	0.60

Integration over entire Q-range

McStas - A neutron ray-trace simulation package
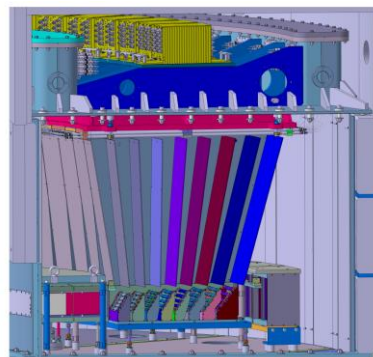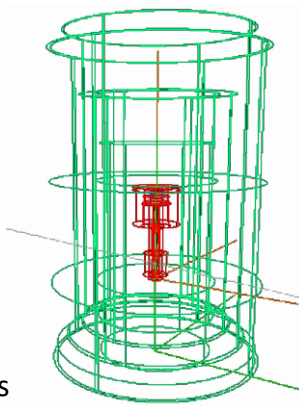25 year anniversary 1998 - 2023

- McStas with Union component (M. Bertelsen)

- CAMEA: 8x8 analyzers and 104 PSD.

- Sample Environment
    - Orange cryostats
    - Pressure cell
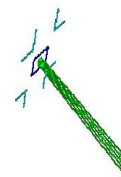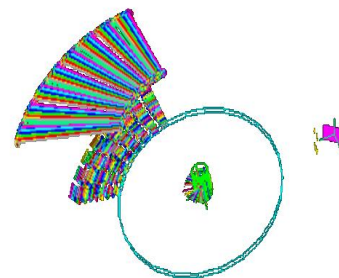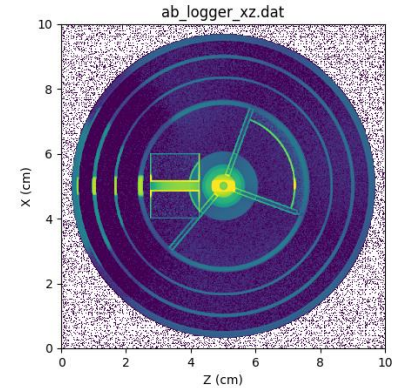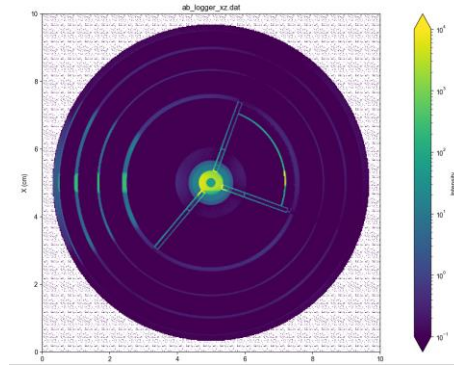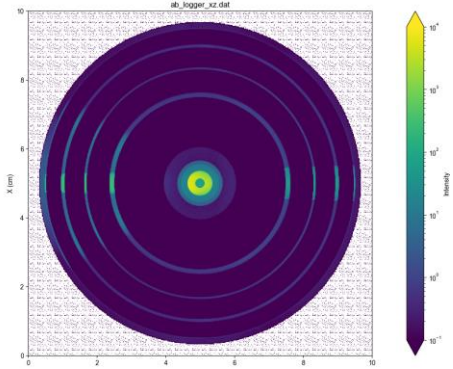

Orange cryostats

Pressure devices

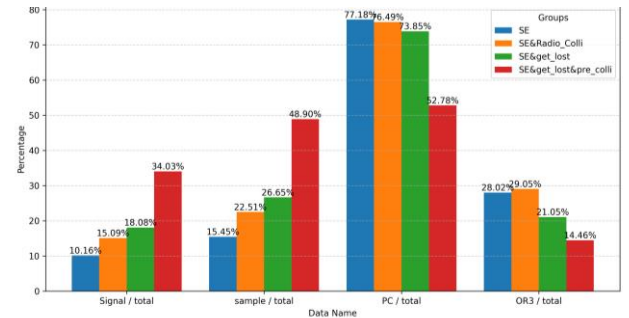J. Lass *et al.* Rev. Sci. Instrum. 94, 023302 (2023)

Top view

Side view

Sample
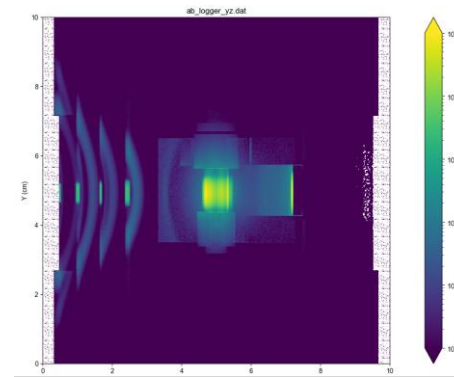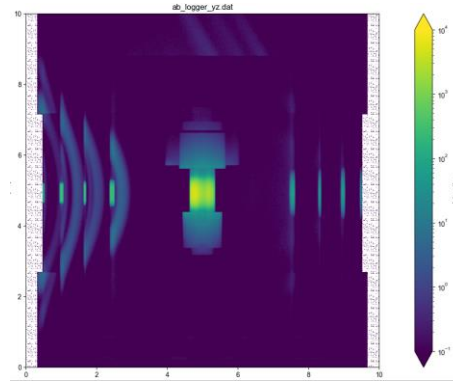
Sample +Get-lost (new)

Customized to the sample & environment

Summary

- Summary

  - ➢ 3D printed optics for sample environment has been tested;

  - ➢ Collimators effectively decrease the background originating from elastic scattering;

  - ➢ Collimator and get_lost remain stable in their structure and can be reused for future test.

- Outlook

  - ➢ Optimization design

  - ➢ 3D printed optics with BN

Thank you for your attention!