Updates on the beam monitor common project

Kalliopi Kanaki

Steven Alcock, Ioannis Apostolidis, Vendula Maulerová

IKON18, 25 February 2020

Overview of beam monitor session

- Status of common project (Kalliopi Kanaki, ESS)
- Status of V-monitor (Vendula Maulerova, ESS)
- Mechanical interfaces and integration (Ioannis Apostolidis, ESS)
- DMSC interfaces (Jonas Nilsson, ESS)
- Beam monitors at ILL (Fabien Lafont, ILL/ESS)
- NitroGEM beam monitor updates (Davide Raspino, ISIS)

Purpose of the project

- Ensure provision of monitors to enable science case of instruments and in particular early science success
- Allow efficient commissioning and long term facility monitoring
- Design, procurement, installation and cold commissioning of ~55 beam monitors for the ESS instruments from a few kW to 2 MW
- People involved:
  - Steven Alcock – electronics engineer (15%-20%)
  - Ioannis Apostolidis – mechanical engineer (50%)
  - Kalliopi Kanaki – neutron scientist (50%)
  - Vendula Maulerová – workshop assistant (50%)
- Related documents:
  - https://confluence.esss.lu.se/display/DG/Beam+monitors+common+project
  - Beam Monitors Common Project description (ESS-0502620)
  - Neutron Beam Monitor Use Cases for commissioning and operation of neutron instruments and processing of neutron data (ESS-0419542)





Anders left in Dec 2019.

Participation status

#	Instrument / BM partner	Spatial envelope status	Status of McStas/Vitess model	Indicative participation status
1	**ESTIA / PSI**	Reservations in CAD	Up-to-date	Interested in utilities and services (V-monitor)
2	**ODIN / PSI**	Reservations in CAD	Up-to-date	YES
3	**DREAM / FZJ**	Reservations in CAD	Up-to-date	NO (CDT monitors)
4	**BEER / HZG**	Reservations in CAD	Up-to-date	YES (in-bunker BMs), MWPC by HZG (pre-sample)
5	**CSPEC / TUM**	Reservations in CAD	Up-to-date	Under consideration
6	**BIFROST / LLB**	Reservations in CAD	Up-to-date	YES
7	**MAGIC / FZJ**	Reservations in CAD	Update on the way	Undecided at the moment
8	**LoKI / ISIS**	Reservations in CAD	Up-to-date	NO (NitroGEM monitors from ISIS)
9	SKADI / JCNS	Reservations in CAD	Up-to-date	YES
10	VESPA / CNR, ISIS	Reservations in CAD	Up-to-date	NO (B-GEM monitors from University of Milano-Bicocca)
11	NMX / ESS	Reservations in CAD	Up-to-date	YES
12	MIRACLES / ESS Bilbao	Reservations in CAD	Up-to-date	YES
13	T-REX / CNR	Contact initiated	2018-09-17	Discussion ongoing
14	HEIMDAL / AU	Reservations in CAD	Up-to-date	Undecided at the moment
15	FREIA / ISIS	Reservations in CAD	Up-to-date	YES?

Beam monitors per location and function

Location	BM	Desired functionality
Bunker	Fission chamber (flux × eff ≤ 10^{12} n/cm^2/s)	•Flux •Timing •Discrimination of thermal n vs. fast n vs. γ
	Ionisation chamber (flux × eff ≤ 10^{12} n/cm^2/s)	
	GEM (flux × eff ≤ 10^8 n/cm^2/s)	
Guides/choppers	Quasi-parasitic V-monitor (10^9 n/cm^2/s)	•Flux •Timing (to be investigated further for V-monitor)
	GEM (flux × eff ≤ 10^8 n/cm^2/s)	
Pre- and post-sample	MWPC (flux × eff ≤ 10^5 n/cm^2/s) GEM (flux × eff ≤ 10^8 n/cm^2/s)	•Flux •Timing

Meeting the flux challenge

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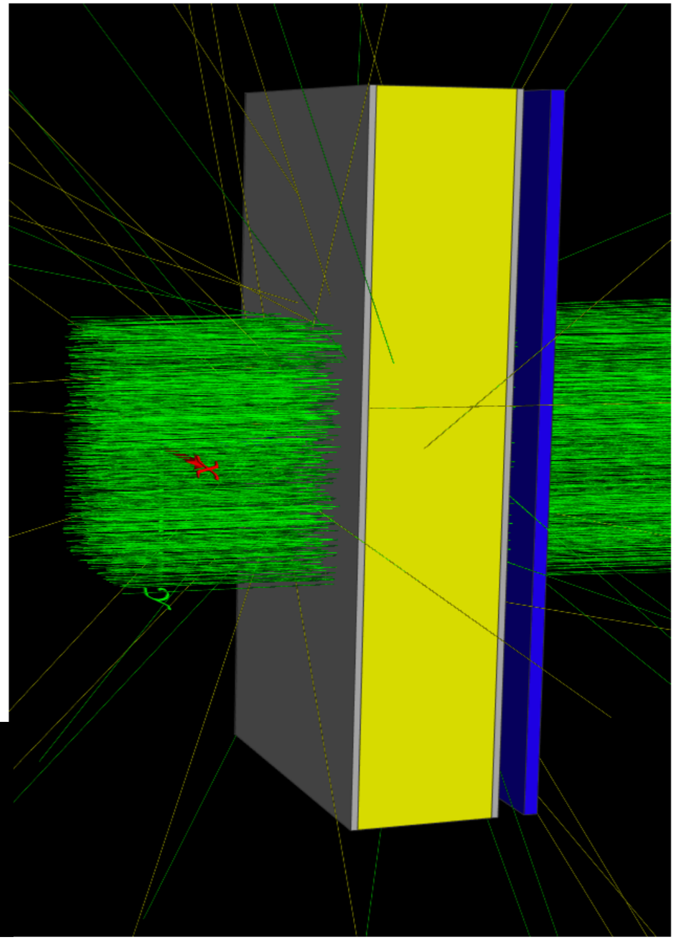
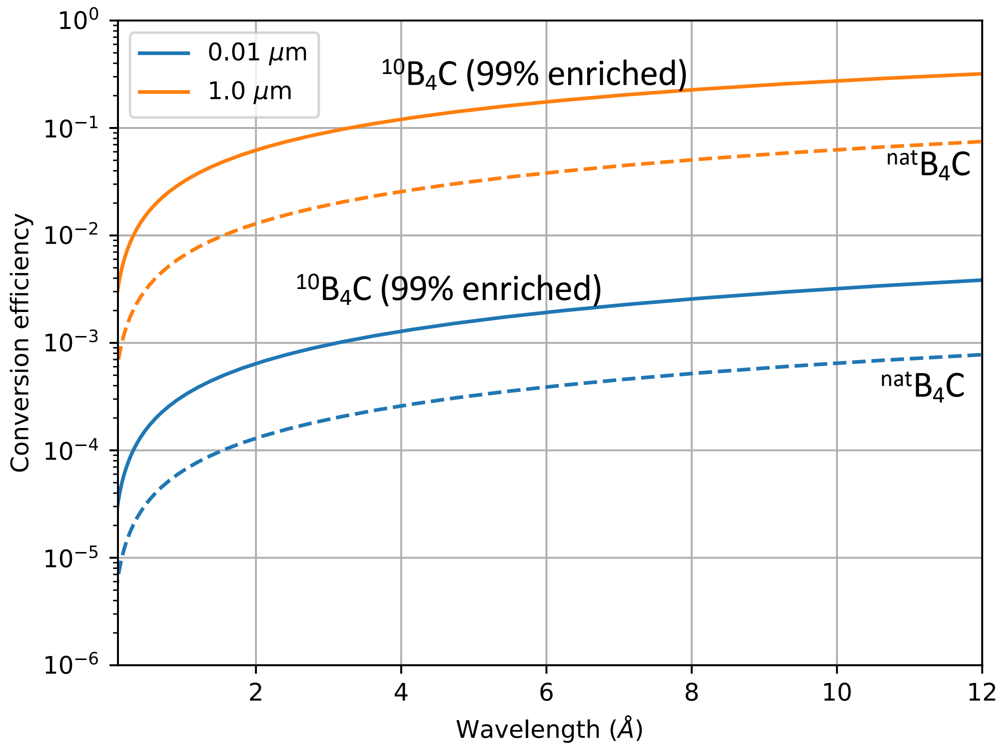
- Optimisation parameters for standard BMs
  - Choice of converter ($^{10}B_4C$, $^{235}UO_2$, N_2, ^3He)
  - Solid converter thickness
  - Enrichment
  - Gaseous converter partial pressure
  - Active gas depth
- Optimisation parameters for V-monitor
  - Foil size
  - Foil thickness
  - Active detector area
  - Detector distance from foil



Green: neutrons
Gray: BM windows
Yellow: gas
Blue: collector volume for analysis

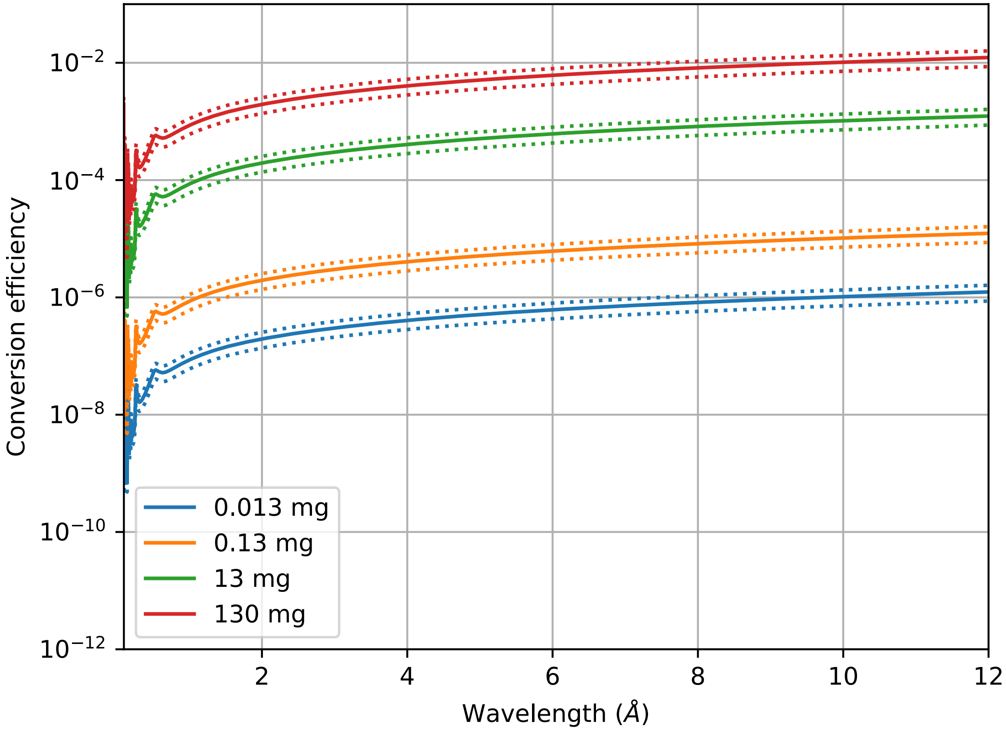
B_4C conversion efficiency



Efficiency is primarily defined by:

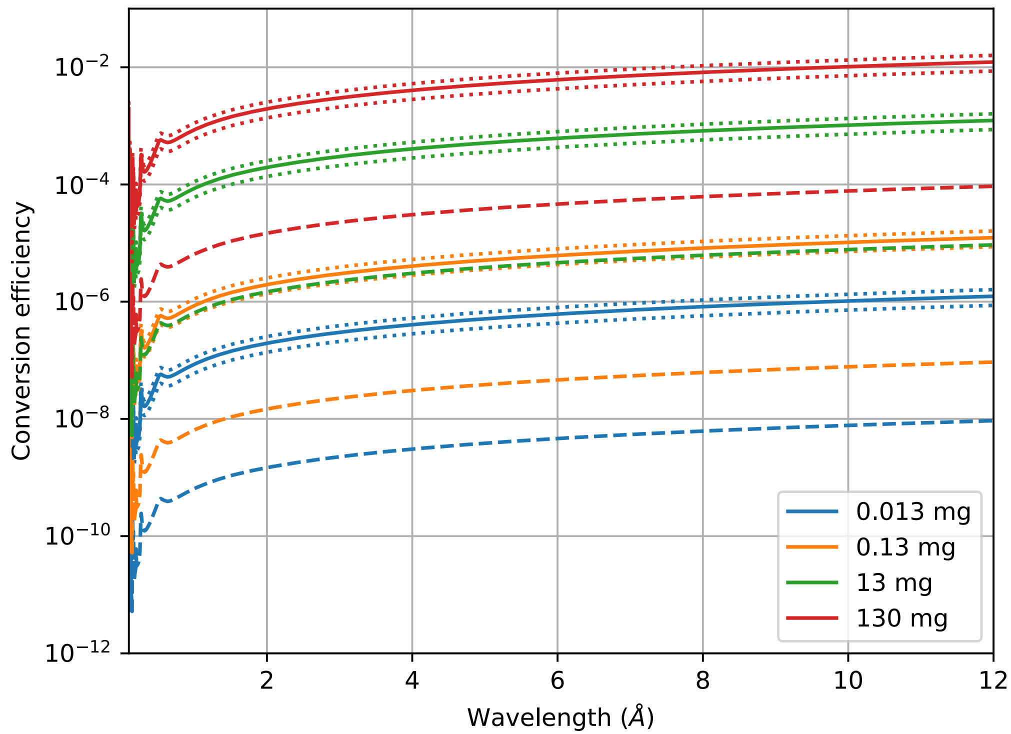
- Enrichment
- Coating thickness

UO_2 conversion efficiency



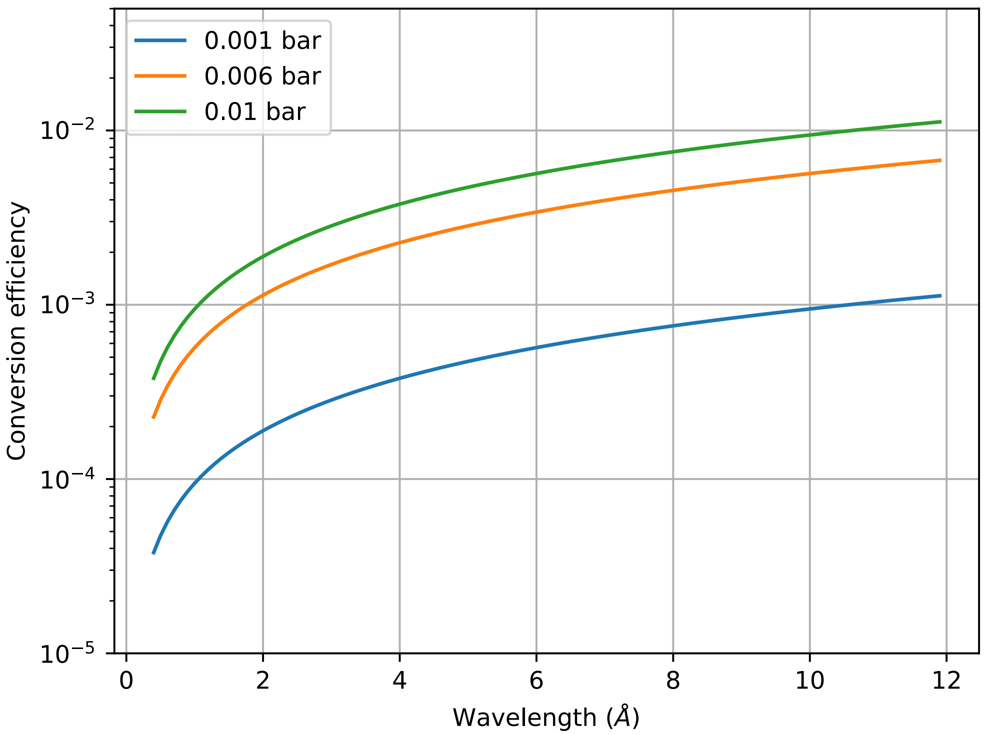
- Solid line: $^{235}UO_2$ (93% enriched)
- Dotted line: ± 30% effective thickness variation

UO_2 conversion efficiency



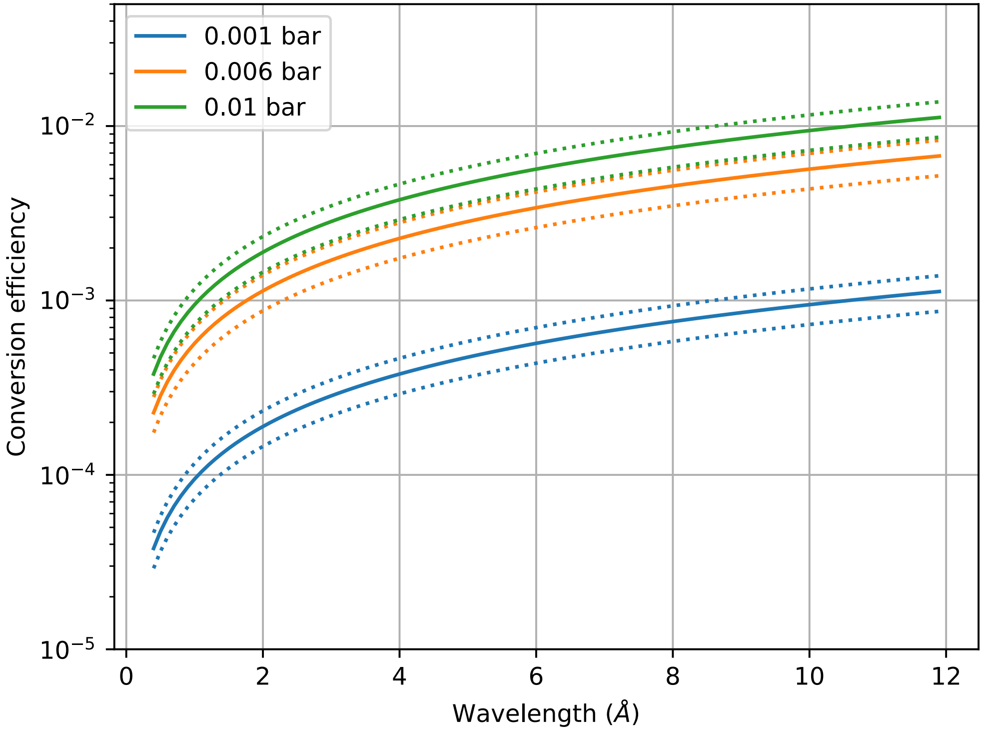
- Solid line: $^{235}UO_2$ (93% enriched)
- Dotted line: ± 30% effective thickness variation
- Dashed line: $^{nat}UO_2$

^{3}He conversion efficiency



BM (gas) thickness = 1.3 cm

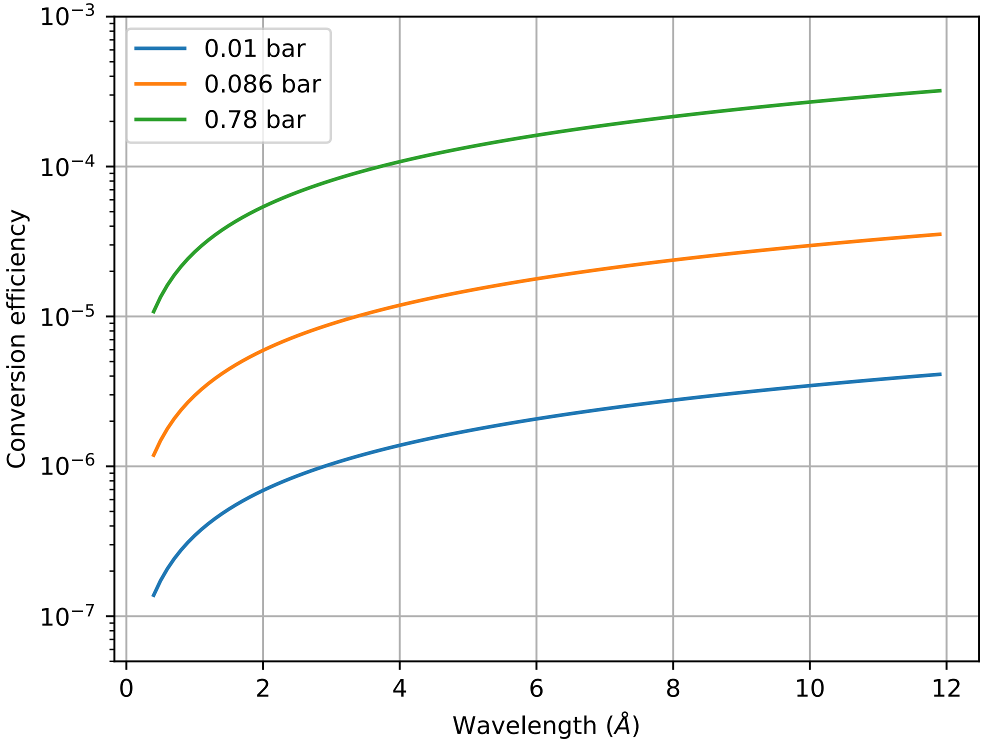
^{3}He conversion efficiency



BM (gas) thickness = 1.3 cm

Dotted line: 1.0 cm < thickness < 1.6 cm

N_2 conversion efficiency



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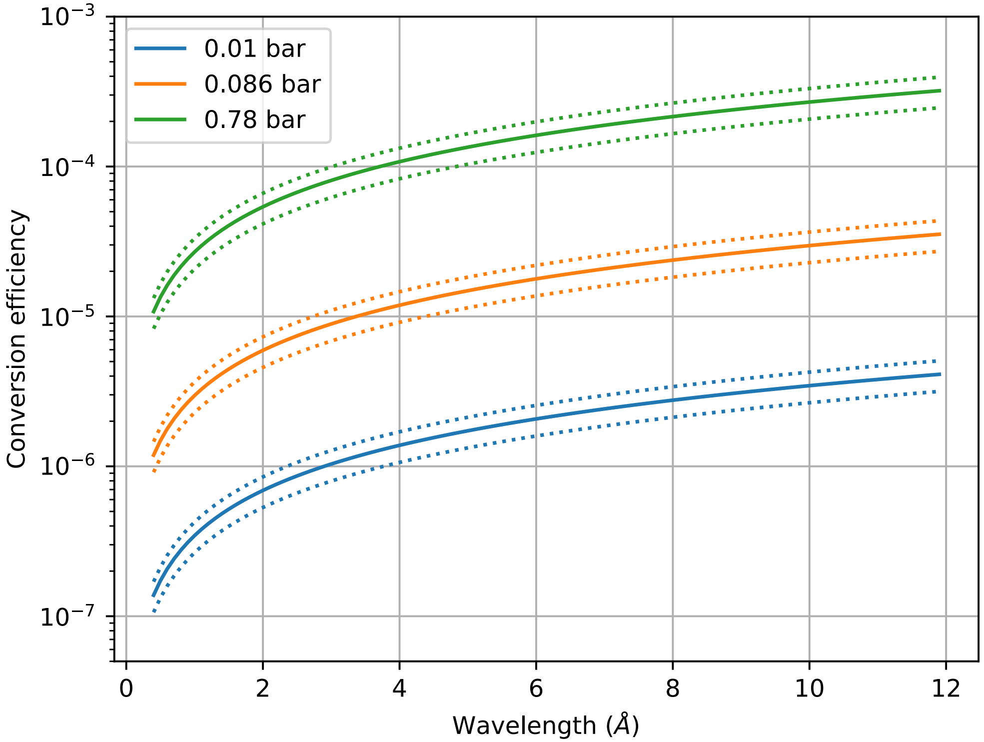

BM (gas) thickness = 1.3 cm

Dotted line: 1.0 cm < thickness < 1.6 cm

BM efficiency calibration

Flux measurement on a monochromatic neutron beam with an absorption profile method

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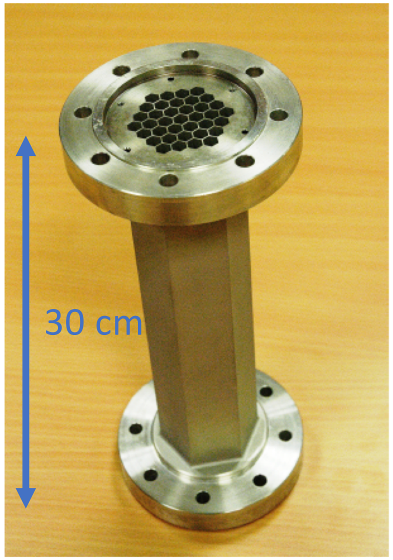
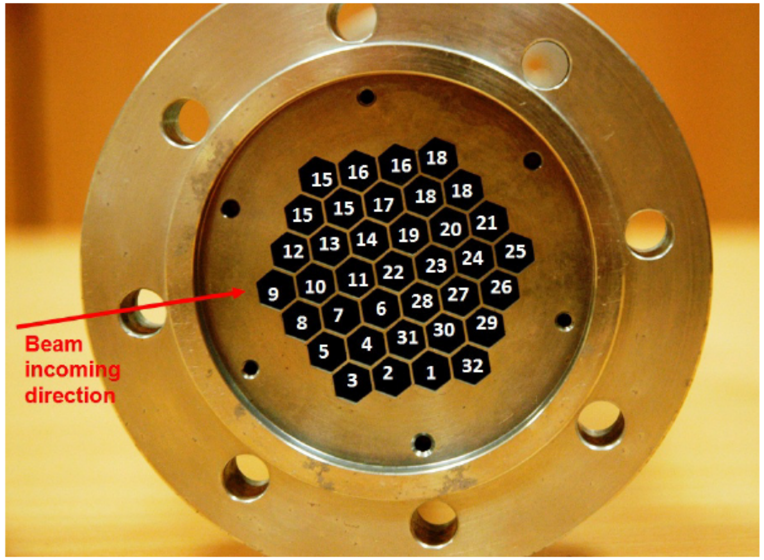
ABSTRACT: The Institut Laue-Langevin (ILL) and the European Spallation Source (ESS), as other neutron facilities in the world, are currently looking for alternative technologies to detect thermal neutrons. Many are the features that a new detector must have to fulfill the new requirements of neutron scattering science. The absolute efficiency is one of the key feature that must be determined to validate the new detector technologies.
We describe a Helium-3-based detector, developed at ILL, and a reliable experimental method to calibrate beam monitors. This detector also allows to determine the neutron flux of a given thermal or cold neutron beam and the absolute efficiency of a prototype under test. The presented method also provide information on the higher order harmonics present in the beam.
A calibrated beam monitor can be easily used to calibrate further monitors or detectors even in other locations.

Draft from 2011!

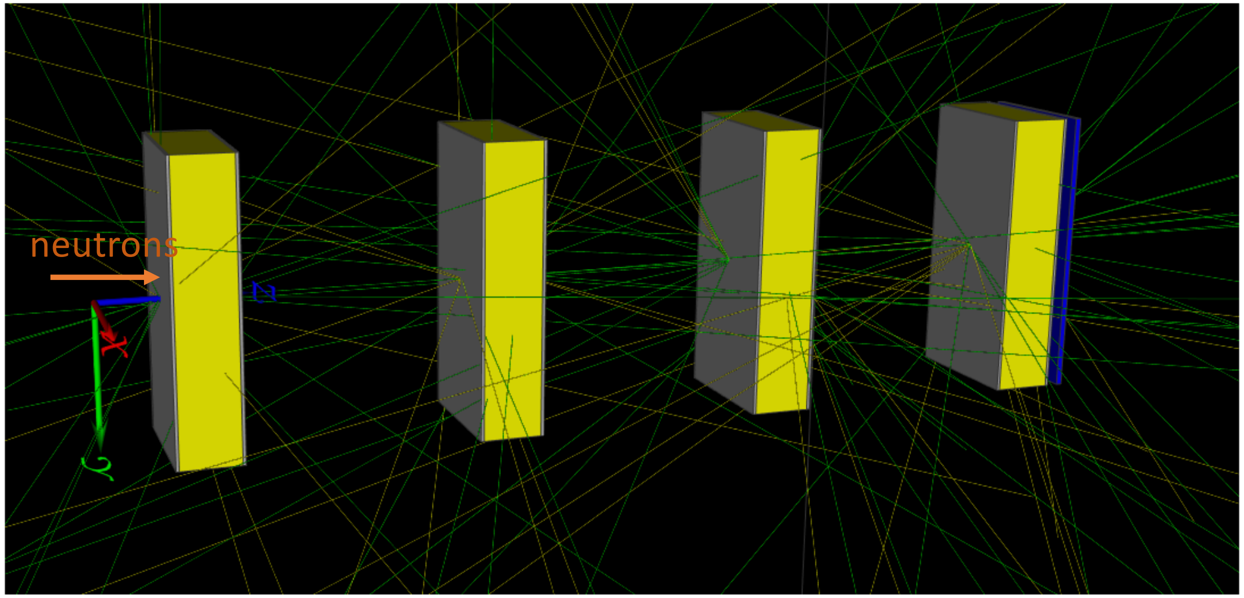
Honeycomb (hexacomb) detector
Allows absolute flux determination of ~ 1%!
Used for MultiGrid and MultiBlade efficiency characterisation





Impact of multiple BM windows

- BM placed at 10 cm distance from each other
- NO converters or gas
- Only windows and/or GEM foil
- Monochromatic beam



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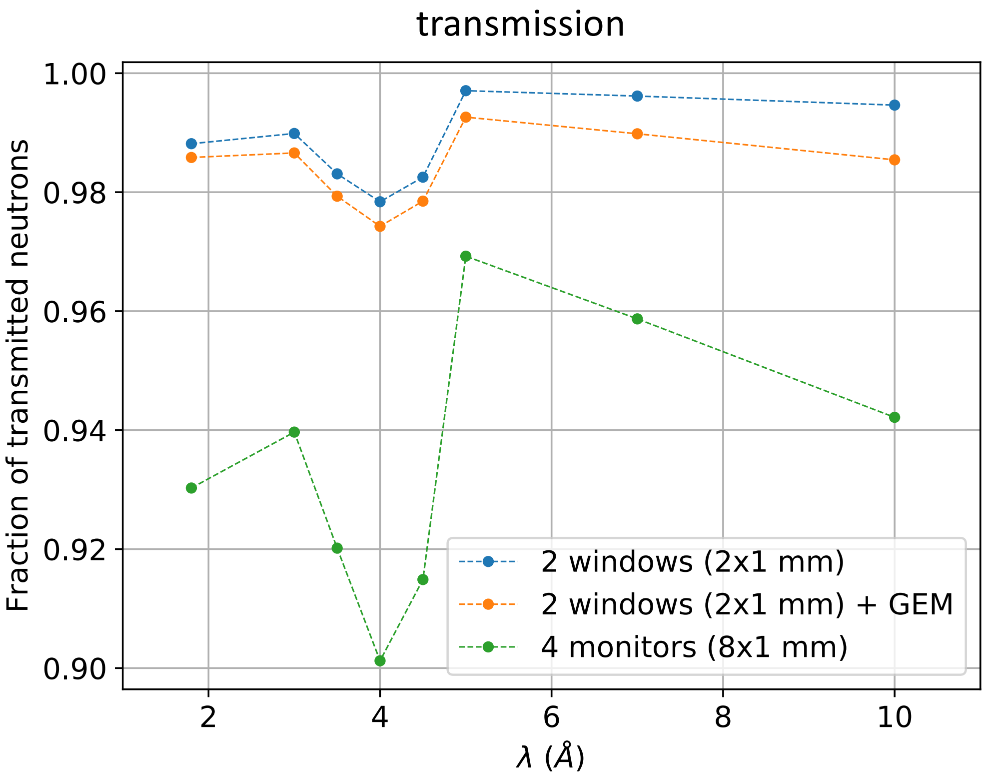
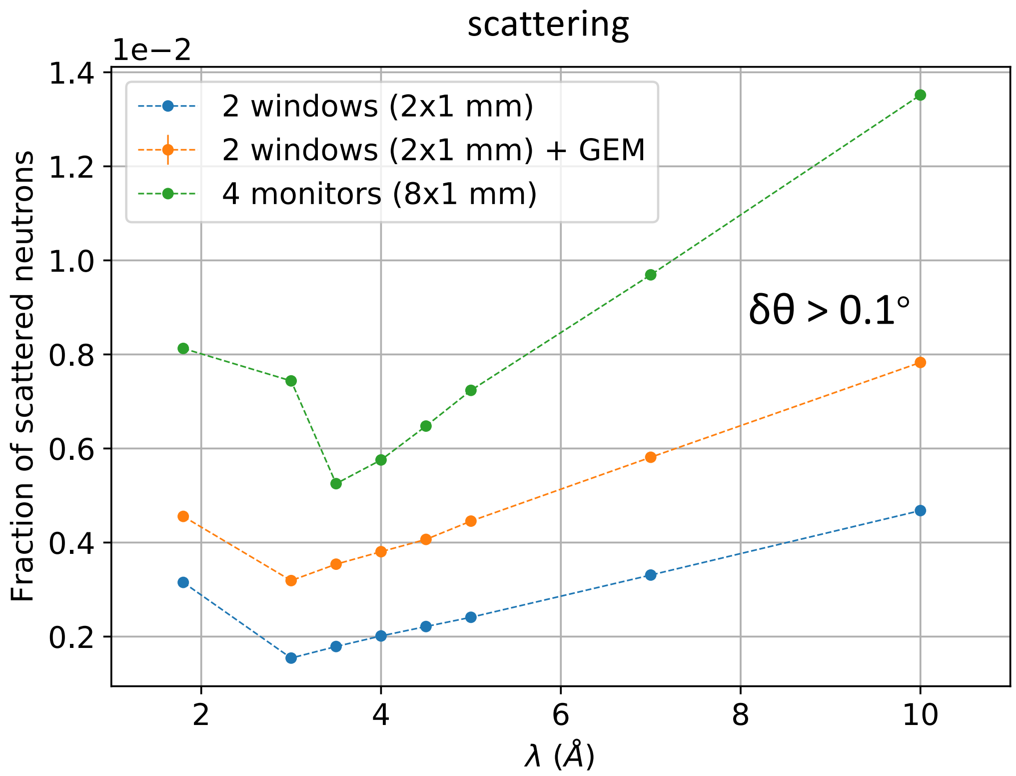
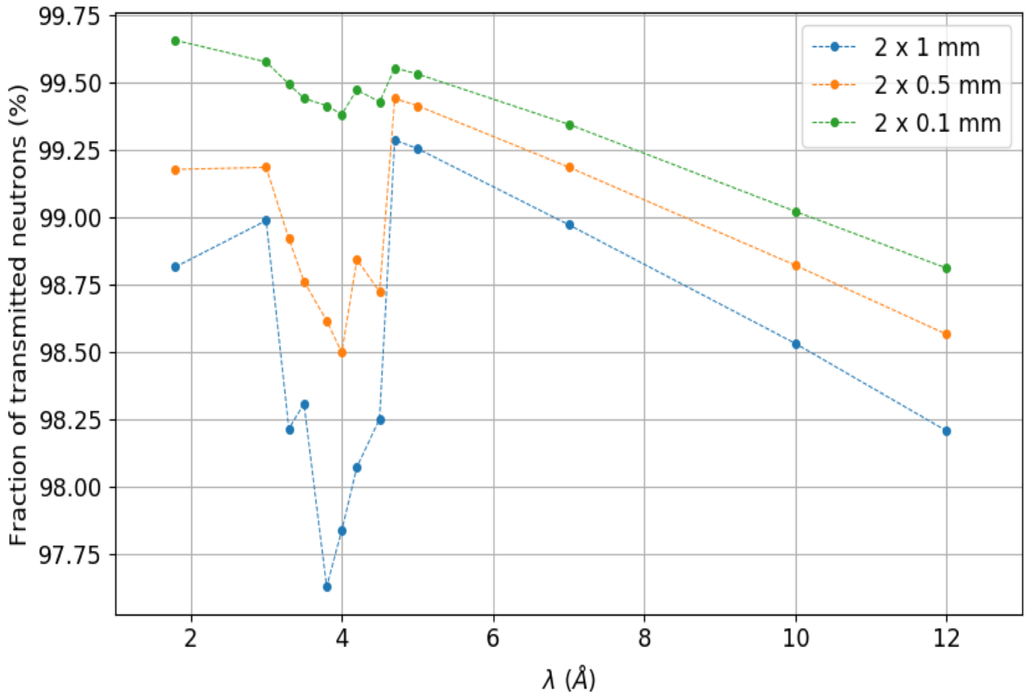




Need a definition for scattering that serves instrument purposes.

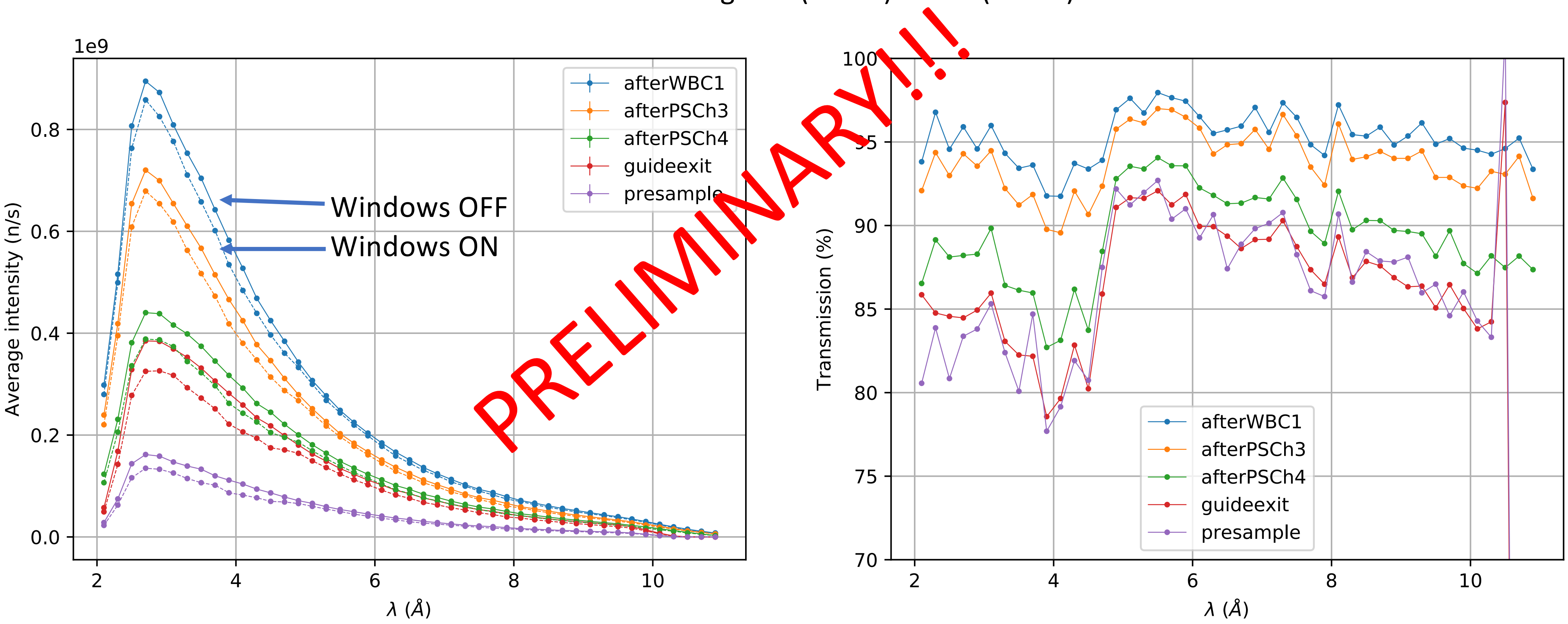
Transmission of single BM monitor



- 2% loss at 4 Å per 2 mm of Al
- Transmission > 99% at 10 Å for thin foil BM windows (100 µm) in air placement (1 atm inner pressure)

Transmission studies with FREIA model

Transmission when all windows – guide (1 mm) & BM (**1 mm**) – are enabled.



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EUROPEAN SPALLATION SOURCE

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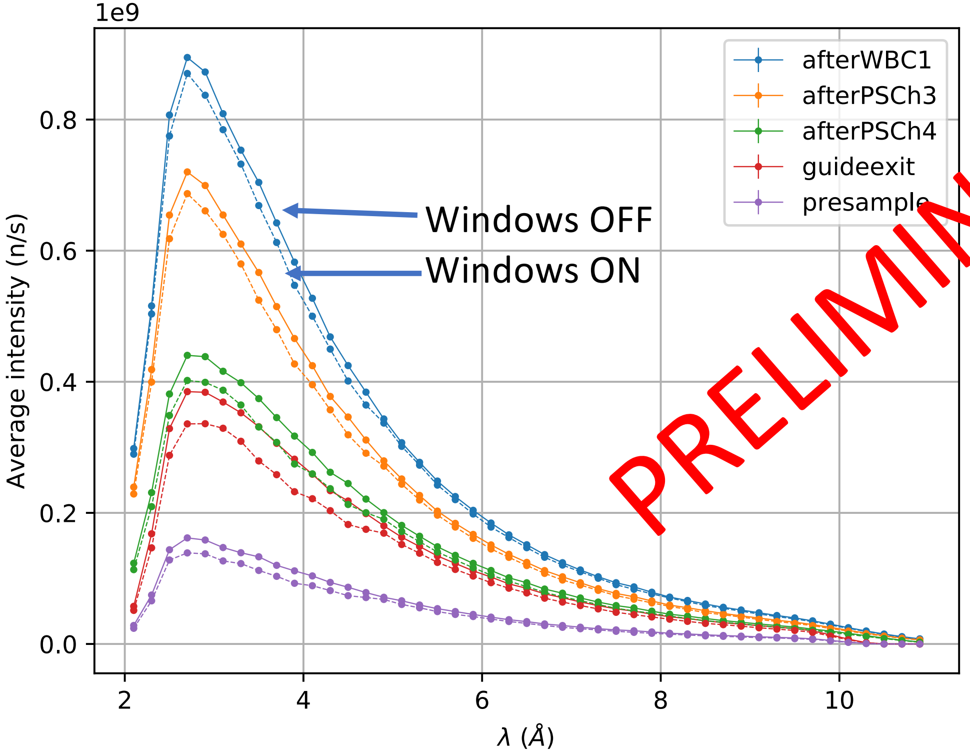
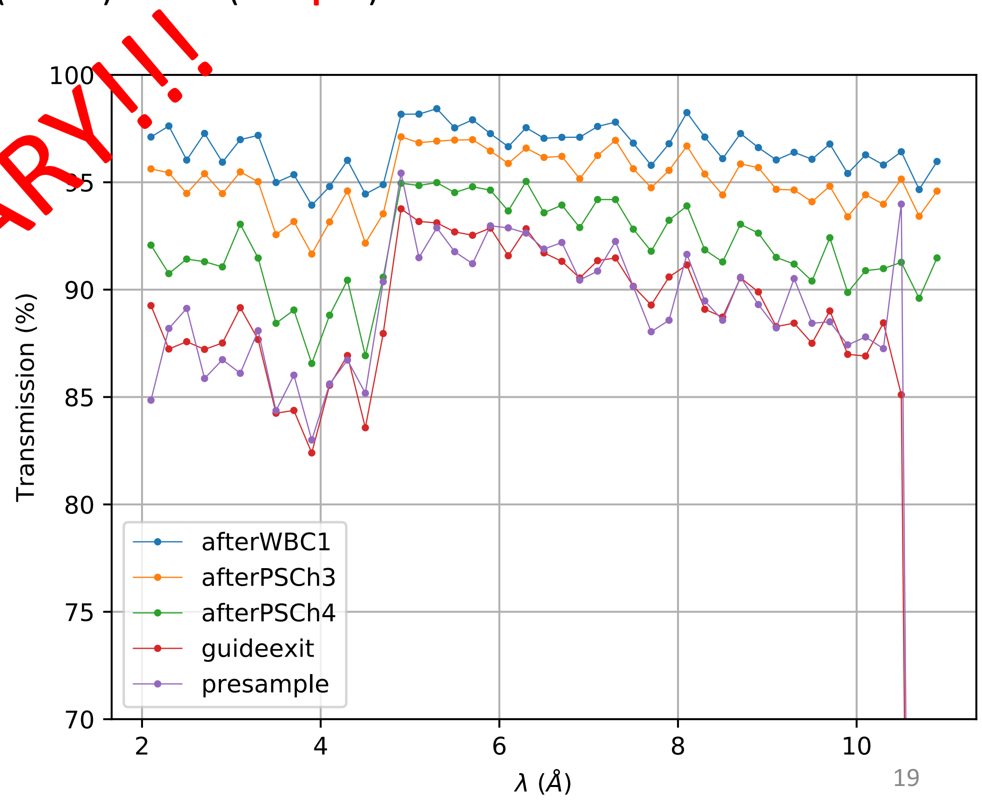
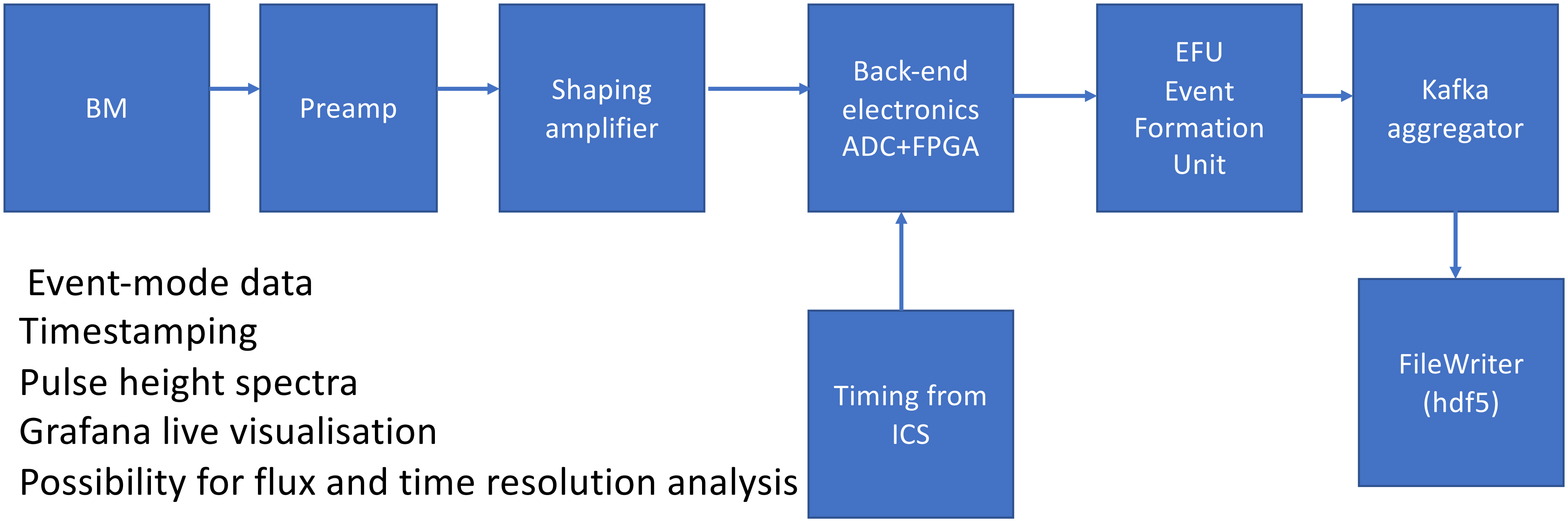




Setup with official ESS DAQ readout



- Event-mode data
- Timestamping
- Pulse height spectra
- Grafana live visualisation
- Possibility for flux and time resolution analysis

V. Maulerová et al., EPL 128 (2020) 52001

Setup with

V20 setup

BM → Preamp

EFU
Event
Formation
Unit

→ Kafka aggregator → FileWriter (hdf5)

- Event-mode data
- Timestamping
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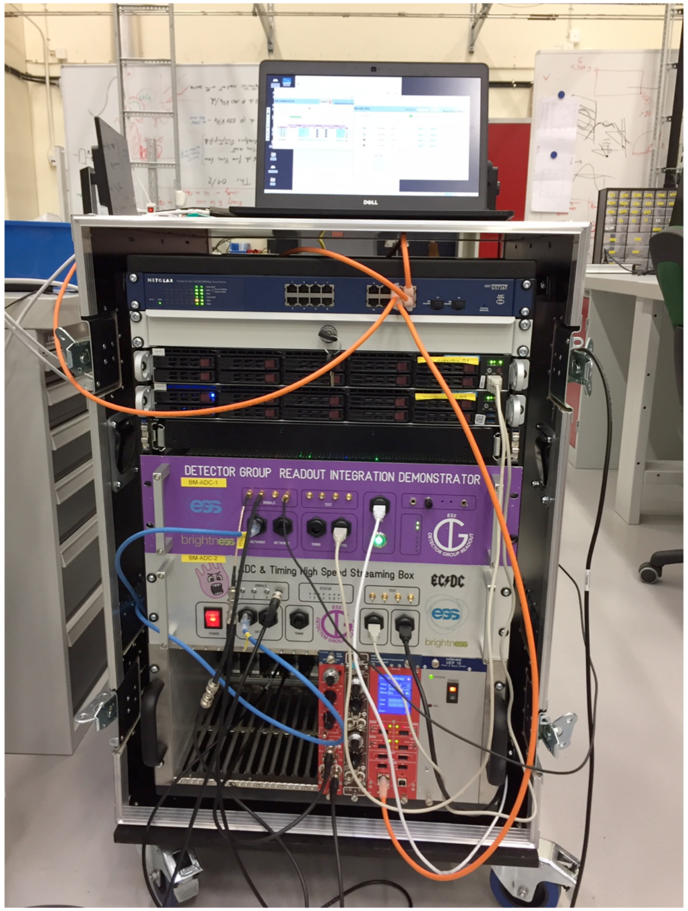
BM data acquisition in Utgård (DG, ICS, ECDC)



- 8 channels in 2 ADC boxes
- EPICS control for HV power supply and back-end readout
- Event Formation Unit (EFU)/Kafka
- Grafana for EFU/BM monitoring
- File writer
- Software ADC scope for pulse monitoring
- Tests with cosmics on-going

Next steps

- Close out phase 1 (after IKON18)
- Write Critical Design Report (March-April)
  - Distribute monitor technologies in each reserved location
  - Document summary of activities so far
- Complete detailed engineering design
  - Initial focus on: ODIN, BIFROST, NMX, ESTIA
- Write offer documents for common project participants
- Write publications
- Experimental tests planned (Dubna, J-PARC)

Check-list for the non-participants of common project

Post TG5 the BMs are delivered to ESS for operation and maintenance.

- Use cases satisfaction
- Documentation of BM requirements and specs (peak and average flux, timing where relevant, stability, time resolution, attenuation, scattering etc.)
- Describe method for absolute flux derivation
- Describe BM calibration methods before installation and regularly during operations (efficiency and TOF)
- Maintain up-to-date McStas model wrt to engineering model
- Shielding and insulation (radiation, electrical, mechanical)

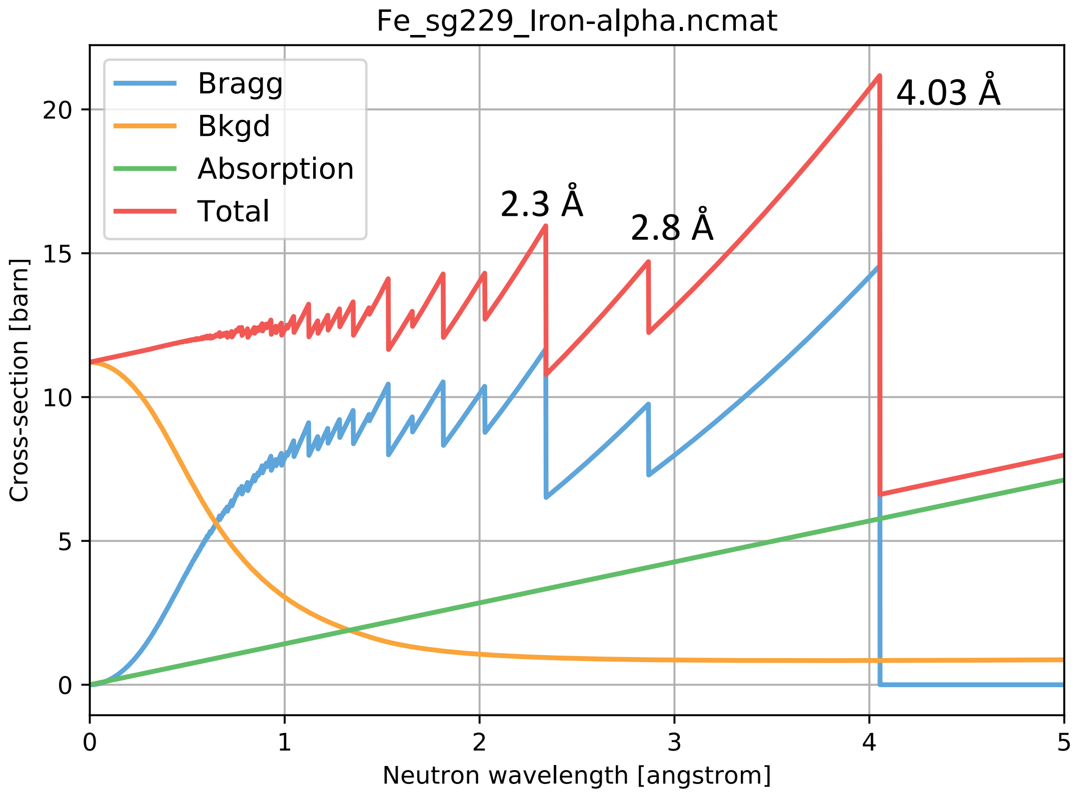
- Mechanical & electrical integration (grounding, cable routes, in-vacuum specifics, remote handling modules, etc.)
- Clear definition of interfaces between instrument and DG/ICS/DMSC
- Front-end electronics
- Back-end electronics readout, ICS and DMSC integration (time-stamping and Mantid integration)
- EPICS controls, adoption of ESS operation modes, logging parameters
- Rack scheme, server characteristics
- Software installation

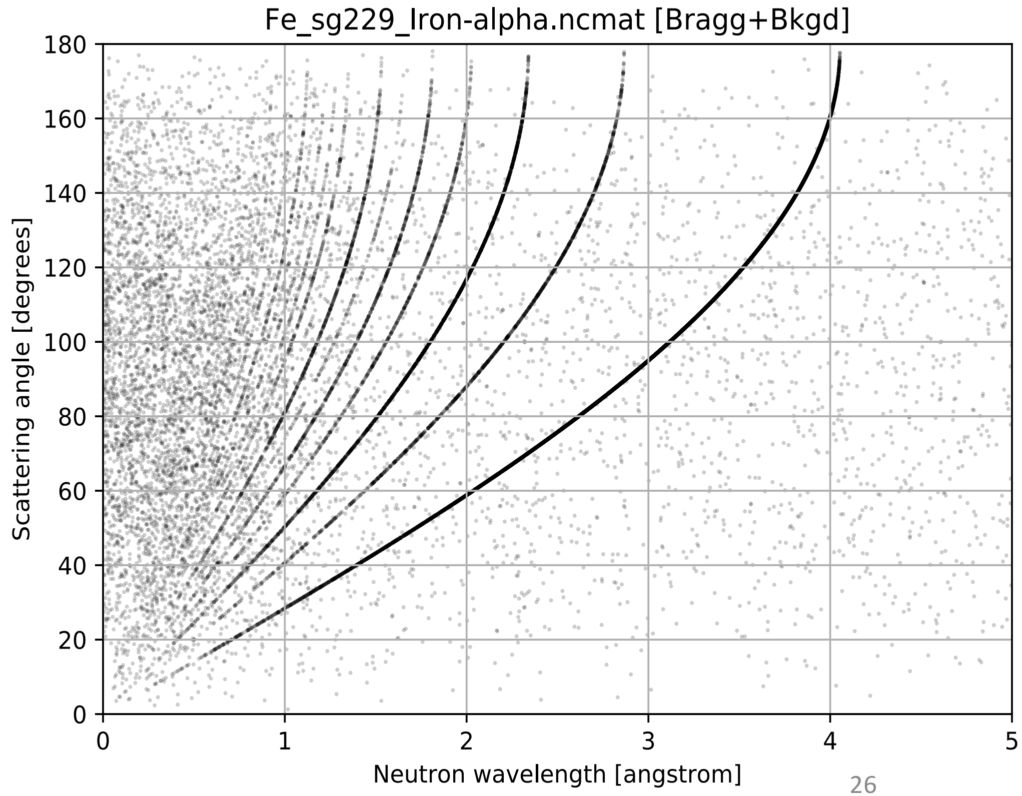
- Cost estimate (hardware, labour)
- Schedule match
- Spares strategy and 10-year maintenance plan

Backup slides

TOF and λ calibration

Steel cross sections and scattering angles (α-Fe)





TOF and λ calibration