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Overview and Status of Detectors@ESS
ICND2019 in Manchester

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On Behalf of Detector Group and Collaborators

European Spallation Source ERIC
2019-10-27

Outline

- ESS Status
- Closeout of BrightnESS project
- DAQ
- Where we are: Status of Tollgate 3 associated reviews
- What we are doing: Detectors for Baseline Instruments at ESS



ESS Status

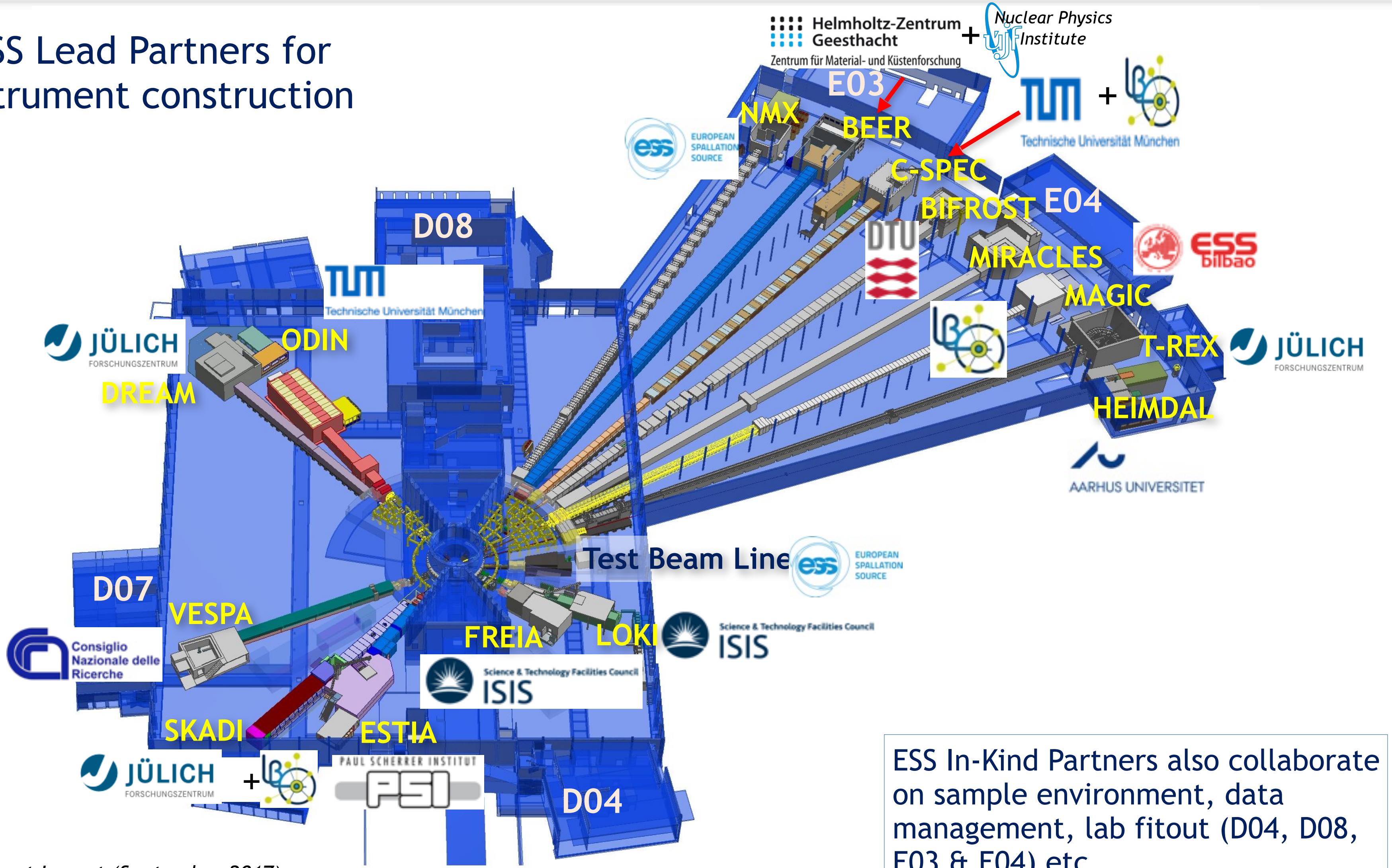
ESS Construction - April 2019

ESS Construction - April 2019


webcam view from this morning

NSS Project scope: *15 neutron instruments + test beamline + support labs*

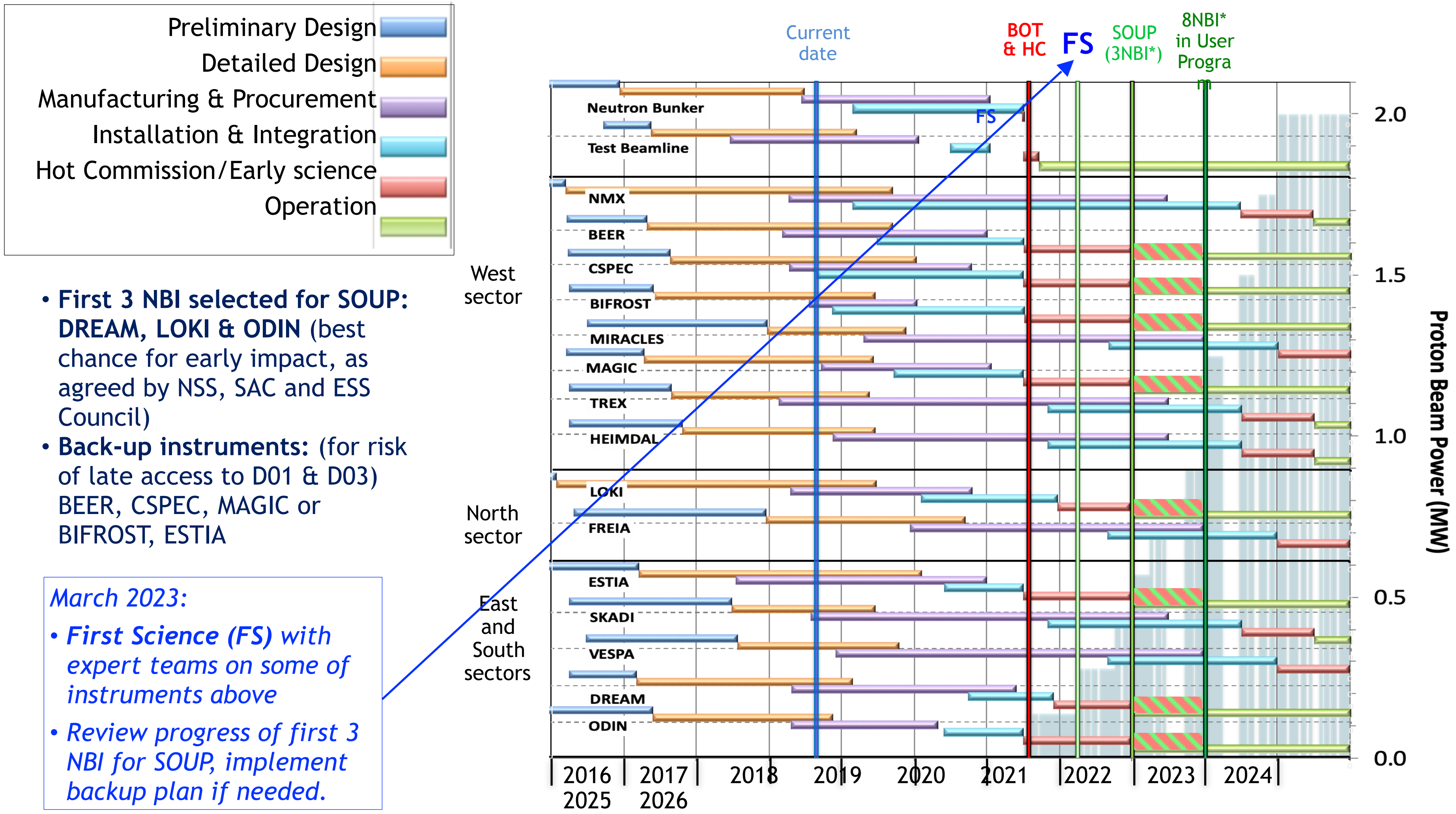
ESS Lead Partners for instrument construction



ESS In-Kind Partners also collaborate on sample environment, data management, lab fitout (D04, D08, E03 & E04) etc.

ESS Instrument Layout (September 2017)

Baseline schedule for Neutron Beam Instruments
(NSS MS V4.2)



- **First 3 NBI selected for SOUP: DREAM, LOKI & ODIN** (best chance for early impact, as agreed by NSS, SAC and ESS Council)
- **Back-up instruments:** (for risk of late access to D01 & D03) BEER, CSPEC, MAGIC or BIFROST, ESTIA

March 2023:

- ***First Science (FS)** with expert teams on some of instruments above*
- *Review progress of first 3 NBI for SOUP, implement backup plan if needed.*

* NBI = Neutron Beam Instrument

Status at Closeout of the BrightnESS project
2018

brightness Technical Challenge for Detectors

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Instrument Design	Implications for Detectors
Smaller samples	Better Resolution (position and time) Channel count
Higher flux, shorter experiments	Rate capability and data volume
More detailed studies	Lower background, lower S:B Larger dynamic range
Multiple methods on 1 instrument Larger solid angle coverage	Larger area coverage Lower cost of detectors

Final status is >40 publications related to detectors from BrightnESS

Task 4.1
"The Resolution Challenge"

NMX, ODIN

Task 4.2:
"The Intensity Frontier"

ESTIA, FREIA,
Beam Monitors

Task 4.4:
"Detector Realisation"

All instruments:
Electronics, testing, simulation, quality

Task 4.3:
"Realising Large Area Detectors"

CSPEC, TREX

The biggest impact to ESS: **Detectors are now a "normal" risk item**

BrightnESS is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 676548

Electronics & DAQ

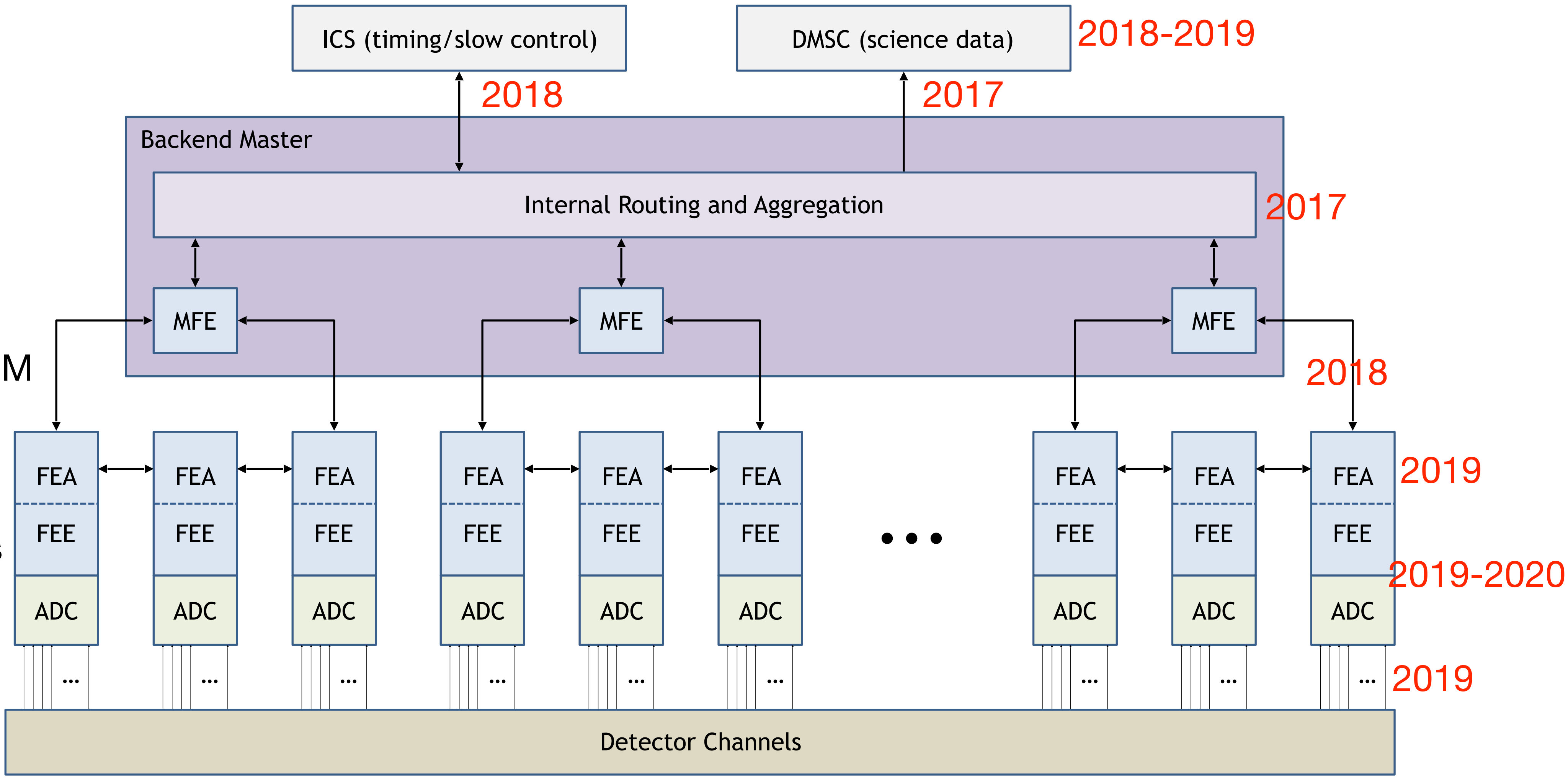
Readout Architecture

1st end-end DAQ demonstration
End of 2019

3 different implementations very close:
LOKI/BCS/CAEN
MG/MB/Gd-GEM/VMM
Jalousie/CDT

Probably readout for 12 (of 15) instruments

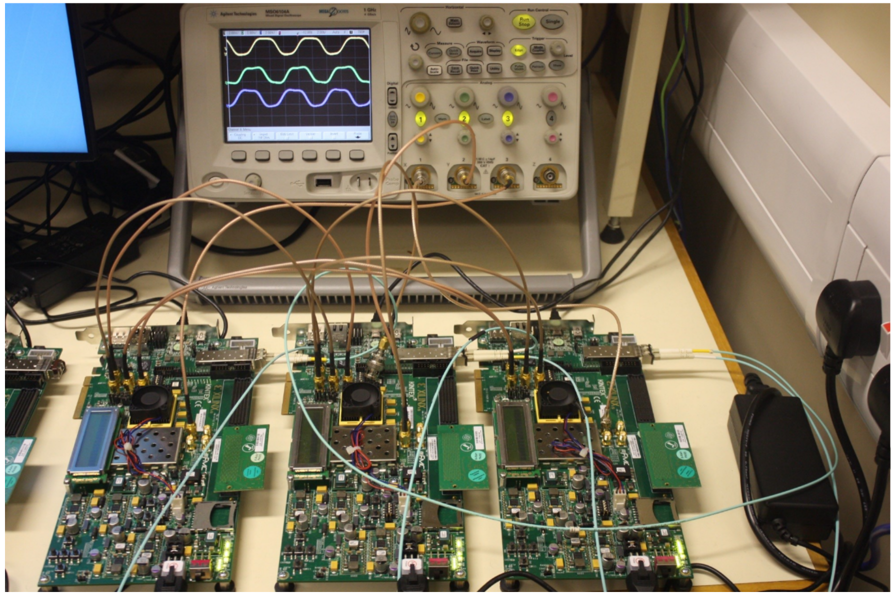
2020/2021: moving this into a production system



Timing Distribution

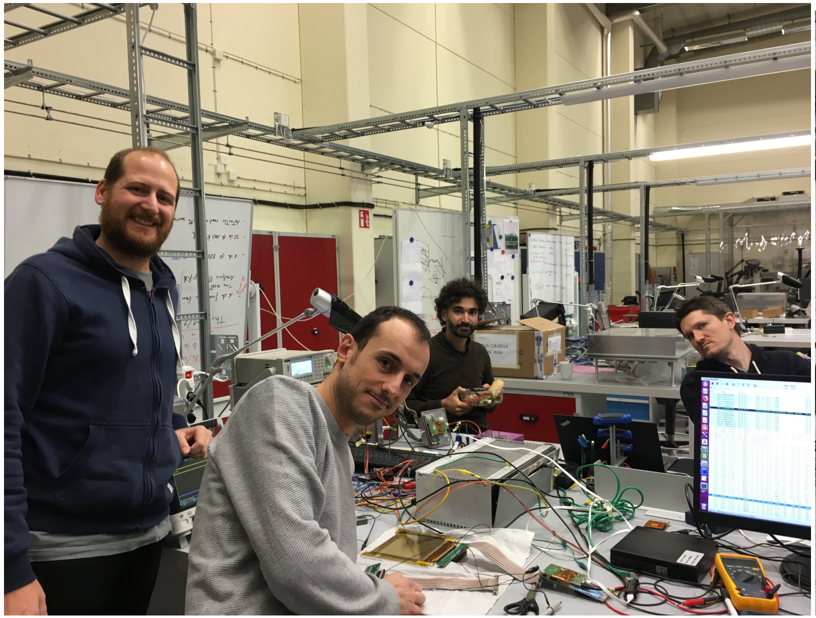
- Front ends connected to Master via 8b/10b encoded SFP+ links.
- ESS clock used to generate these links – can be recovered and forwarded by each front end (similar concept to Synchronous Ethernet).
- The ESS timestamp can therefore be forwarded to all the front ends, forming a single distributed synchronous system.

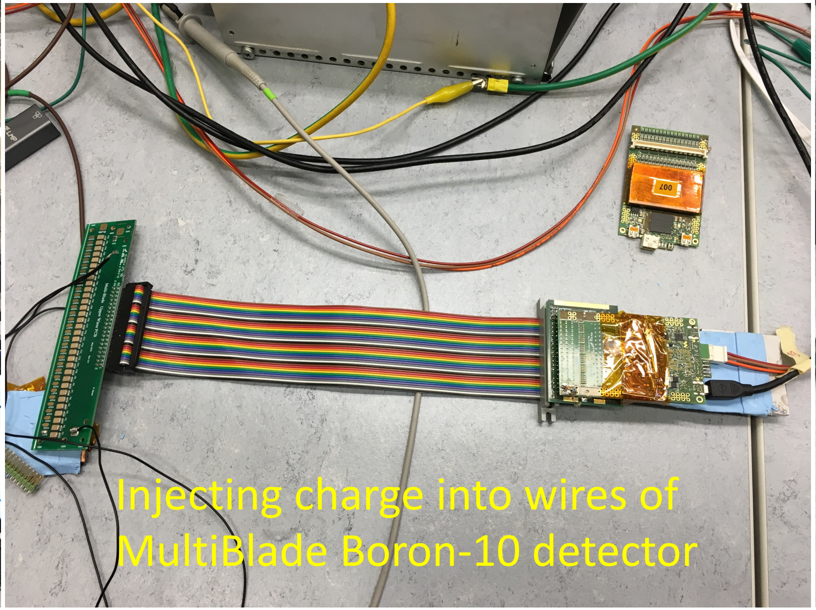
- Assister firmware run on assister hardware
- Next step: demonstrate large rings

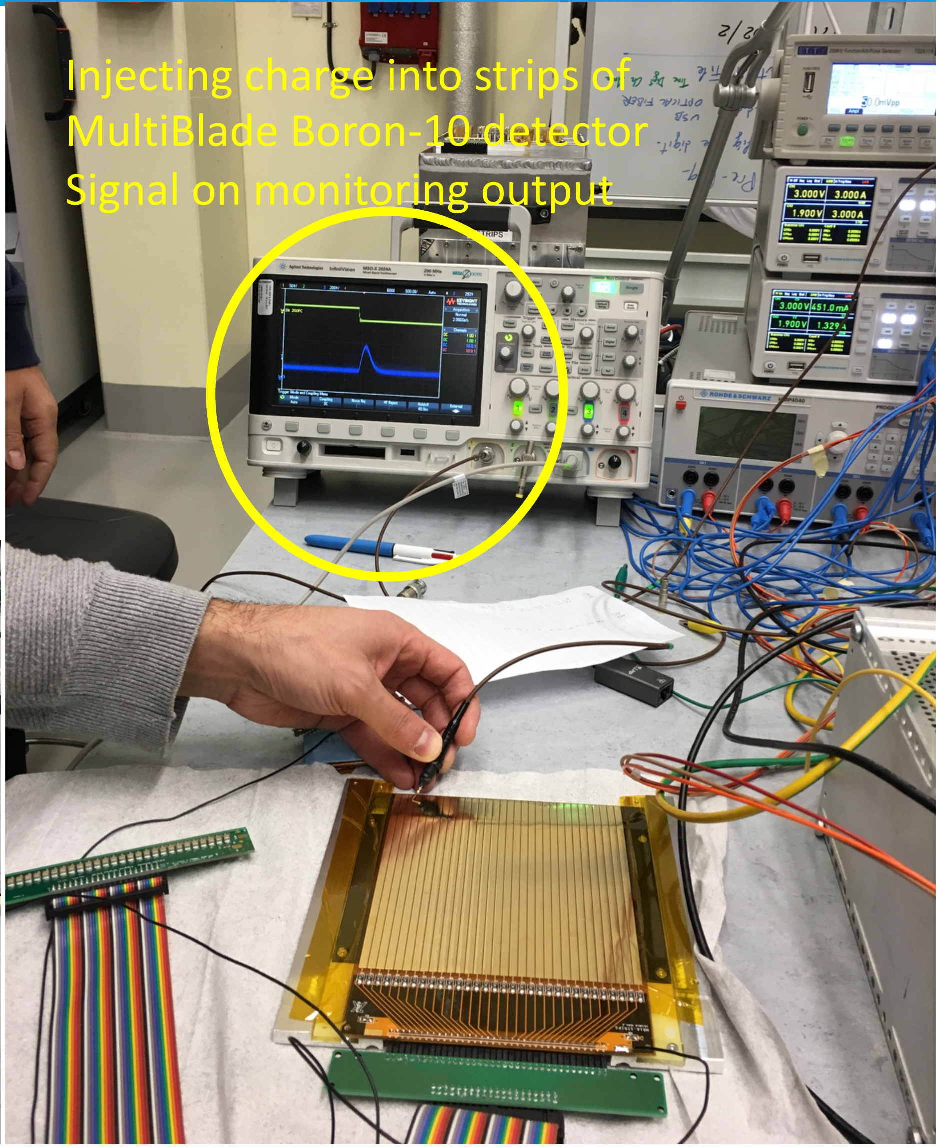


VMM3a
Multiblade test at Utgard December 2018

- Successful test of VMM3a hybrid with MB
- MB: Charge injection into:
  - Wires (negative polarity, AC coupled)
  - strips (positive polarity, DC coupled)
- Successfully read out with VMM3a via analog monitoring output and digital data in continuous mode
- Gain 1 mV/fC , 200 ns shaping time



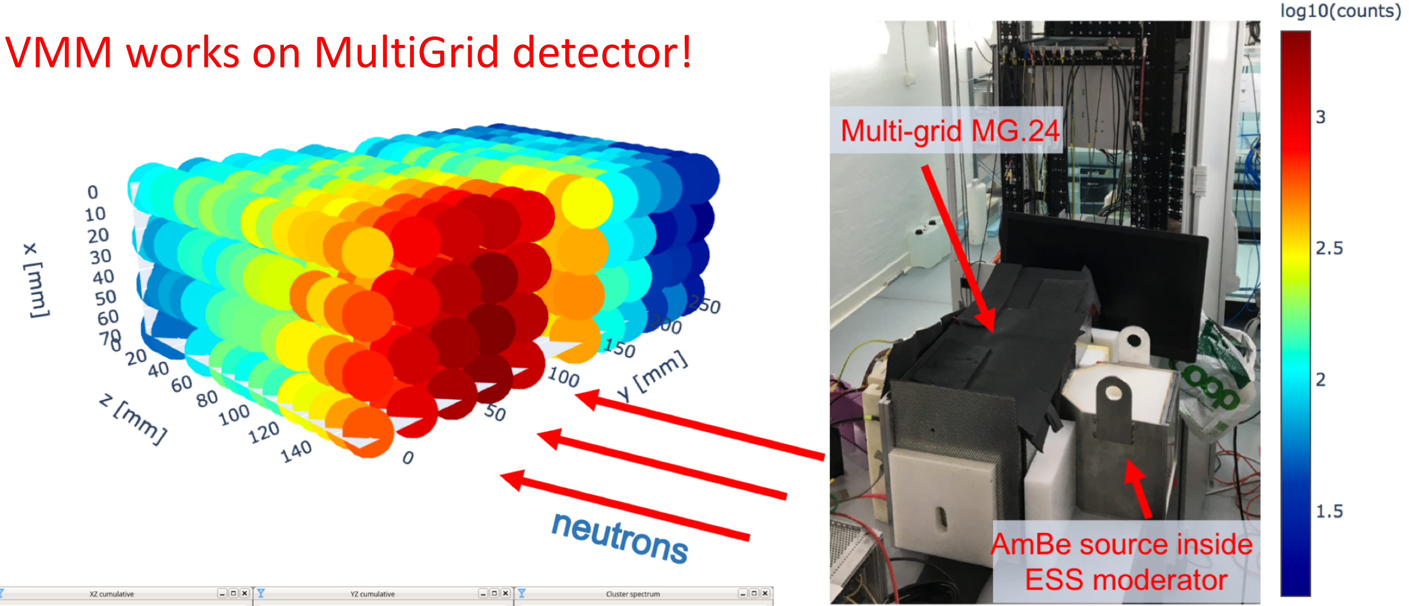


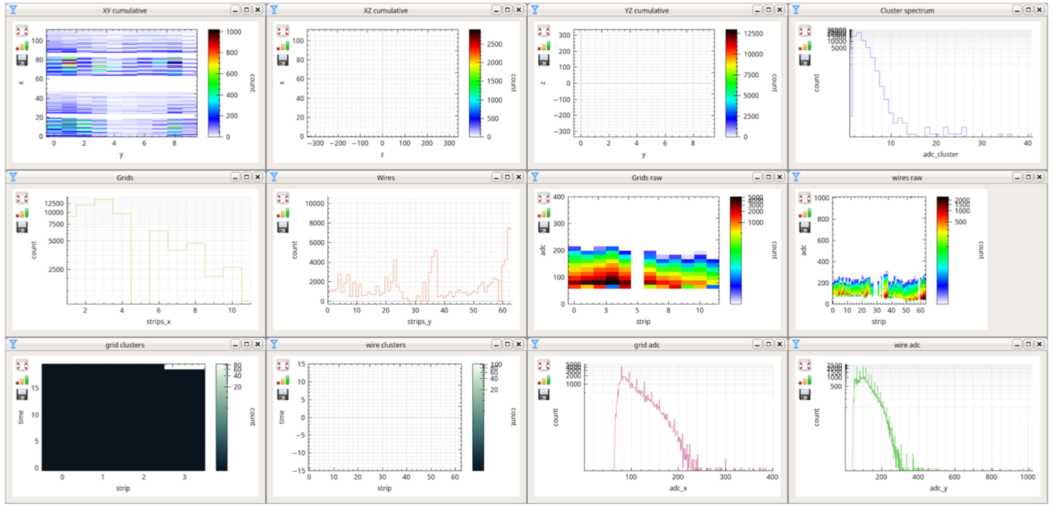


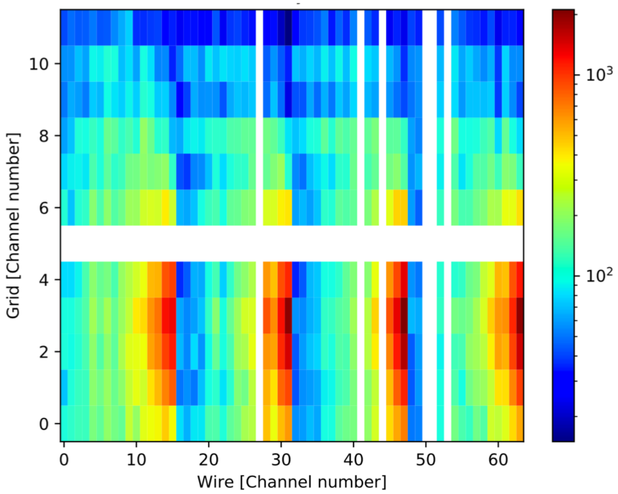
VMM3a
Multigrid test at STF Summer 2019

- Analog matching of VMM to MG succesful
- After solving mapping and noise issue, successful reconstruction of source position
- Wires and grids read out with VMM3a gain of 1mV/fC
- Optimization: Matching of detector gain to VMM3a gain to use full range of 10 bit ADC

VMM works on MultiGrid detector!







Status of Projects: Tollgates and IKON

Status of Tollgate 3 associated reviews

Instrument	CTV Tender Verification	IDR Intermediate Design Review	Sub-TG3 Tollgate Review
DREAM			
LOKI	Vessel: done		
ODIN			Jan20
ESTIA		Mar 20	Aug 20
BIFROST	Vacuum tank: done. Detectors: Dec19	Vacuum tank: done	Detectors: Jun20
CSPEC	Vacuum tank design: done.	Vacuum Tank & Detectors June 20	Vessel&Detectors, May&Sep20
MAGIC			Feb20
BEER		Jan 20	Apr 20

Detector Sessions at IKON Meetings

Dedicated detector sessions (1 day) at each IKON to ensure communication and good collaboration

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Aim is detailed status of detector projects
Rotate between instruments and projects
Collaboration: mixture of instrument, in-kind, internal presenters

eg. Last IKON17: https://indico.esss.lu.se/event/1230/timetable/#20190911.detailed

Session on Beam Monitor Common Project

11:00	**Updates on the Beam Monitor Common Project**	*Kalliopi Kanaki*	*Piratensalen, Grand Hotel*	11:00 - 11:30
	Vanadium-based beam monitor	*Vendula Maulerova*	*Piratensalen, Grand Hotel*	11:30 - 11:50
12:00	**Mechanical integration of beam monitors**	*Ioannis Apostolidis*		
	Beam monitors and detectors: utilities and services	*Anders Lindh Olsson*		

Project Status & Performance

Mechanical Locations & Integration

Services, DAQ, Slow Control

2 detector sessions:

	NCrystal	*Thomas Kittelmann*	*Piratensalen, Grand Hotel*	13:30 - 13:50
14:00	**Simulation of Boron Coated Straws performance and LoKI Rates**	*Milan Klausz*		
	DREAM demonstrator tests: Results from tests on JALOUSIE modules	*Mikhail Feygenson*		
	Simulation of the HEIMDAL detector performance	*Irina Stefanescu*		
	Status of the HZG-Demo detector project	*Gregor Nowak*	*Piratensalen, Grand Hotel*	14:40 - 15:00
15:00	**Coffee Break**		*Piraten Foyer, Grand Hotel*	
	Status of the MultiBlade detector for reflectometry	*Francesco Piscitelli*		
16:00	**Update on MultiGrid design for CSPEC instrument**	*Ramsey Al Jebali*		
	Detector Electronics: Overview and Recent Updates	*Harry Walton*		
	VMM news	*Dorothea Pfeiffer*	*Piratensalen, Grand Hotel*	16:30 - 16:50
17:00	**TG3 for Detectors**	*Richard Hall-Wilton*	*Piratensalen, Grand Hotel*	16:50 - 17:05

And a final morning session in NSS/detector workshops

Technology Choices

Detector Technology Choices for Initial 15 Instruments

Good dialogue and close collaboration needed for successful delivery and integration

arXiv:1411.6194

Instrument class	Instrument sub-class	Instrument	Key requirements for detectors	Preferred detector technology	Ongoing developments (funding source)
Large-scale structures	Small Angle Scattering	SKADI	Pixel size, count-rate, area	Pixellated Scintillator	SonDe (EU SonDe)
		LOKI		10B-based	BandGem
	Reflectometry	FREIA	Pixel size, count-rate	10B-based	MultiBlade (EU BrightnESS)
		ESTIA			MultiBlade (EU BrightnESS)
Diffraction	Powder diffraction	DREAM	Pixel size, count-rate	10B-based	Jalousie
		HEIMDAL		10B-based	Jalousie
	Single-crystal diffraction	MAGIC	Pixel size, count-rate	10B-based	Jalousie
		NMX	Pixel size, large area	Gd-based	GdGEM uTPC(EU BrightnESS)
Engineering	Strain scanning	BEER	Pixel size, count-rate	10B-based	AmCLD, A1CLD (HZG)
	Imaging and tomography	ODIN	Pixel size	Scintillators, Multi Channel Plates (MCP)	Existing technologies
Spectroscopy	Direct geometry	C-SPEC	Large area (^{3}He-gas unaffordable) Count rate, Background	10B-based	MultiGrid (EU BrightnESS)
		T-REX			MultiGrid (EU BrightnESS)
	Indirect geometry	BIFROST	Count-rate	3He-based	He-3 PSD Tubes
		MIRACLES		3He-based	He-3 PSD Tubes
		VESPA	Count-rate	3He-based	He-3 PSD Tubes

Baseline Detector Technologies for Initial Suite

Detectors for ESS will comprise many different technologies

Imaging: 1 instrument
Various

NMX: 1 instrument
Gd-GEM

Indirect Spectroscopy: 3 instruments
He-3 PSD Tubes

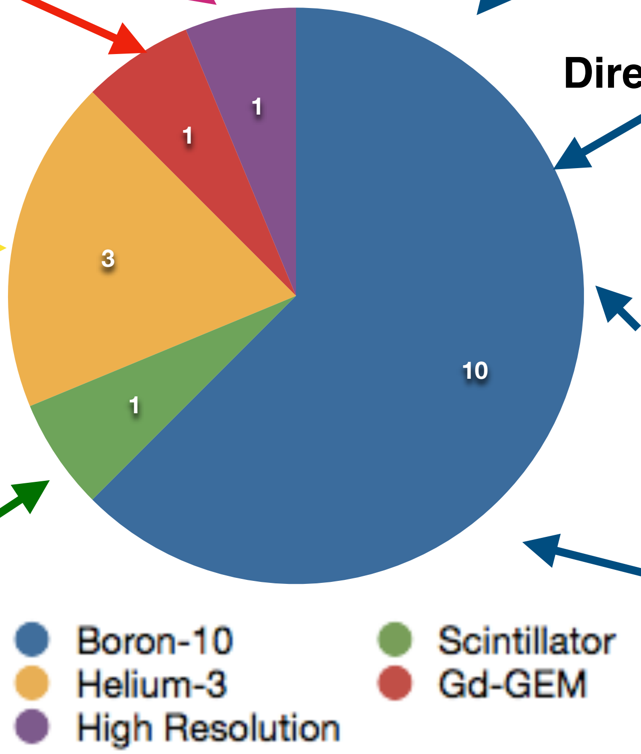
SANS: 1 instruments
SoNDe

Diffraction: 4 instruments
Jalousie (3)
Am-CLD (1): B-10 MWPC

Direct Spectroscopy: 3 instruments
Multi-Grid

Reflectometry: 2 instruments
Multi-Blade

SANS: 1 instrument
Boron Coated Straws



Run through of the instruments for ESS

Will show:

- Diffraction: DREAM, MAGIC, HEIMDAL
    - Jalousie Detector
- Reflectometry: ESTIA, FREIA
    - MultiBlade Detector
- Spectroscopy:
    - MultiGrid for CSPEC, TREX

Will show briefly:

- Engineering: AmCLD for BEER
- NMX: Gd-GEM for NMX

I will not go through:

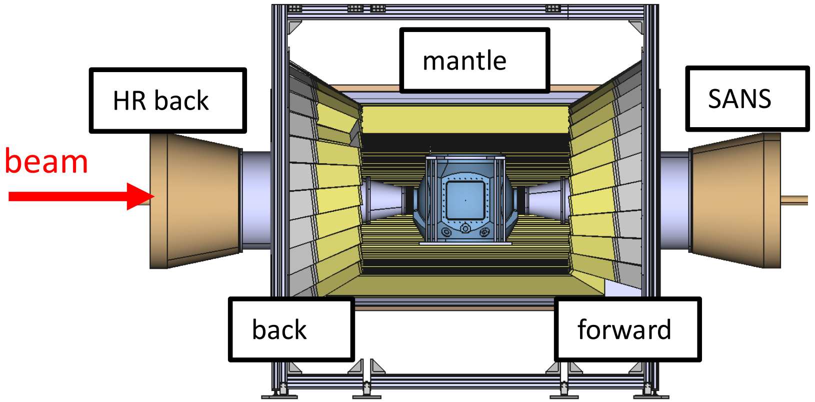
- SANS:
    - Boron Coated Straws for LOKI (Davide shows)
    - SoNDe for SKADI (Ralf shows)

- Spectroscopy: BIFROST (Kelly shows)
- As ODIN (imaging), VESPA, MIRACLES spectroscopy) are standard technologies, no details shown

JALOUSIE Detector Design: DREAM, MAGIC, HEIMDAL

JALOUSIE Detector Design: DREAM, MAGIC, HEIMDAL

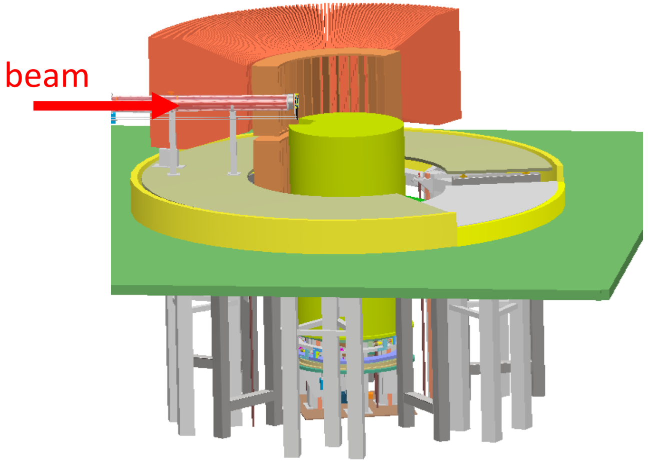
DREAM-Jalousie detector

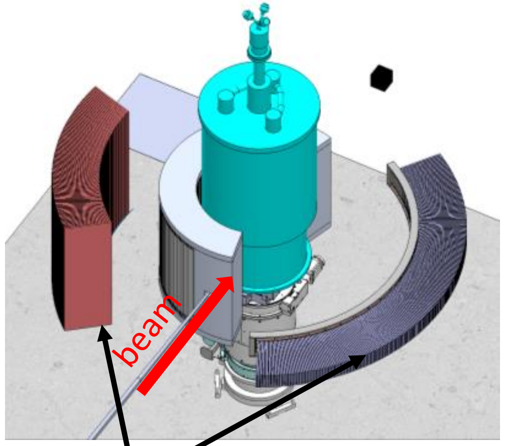


Segments mounted parallel to the beam axis

- Diffraction Instruments use JALOUSIE detector design
- From CDT in Heidelberg
- Originally developed for POWTEX@FRM II
- Barrel like geometry for DREAM
- Cylinder like geometry for MAGIC, HEIMDAL

HEIMDAL-Jalousie detector

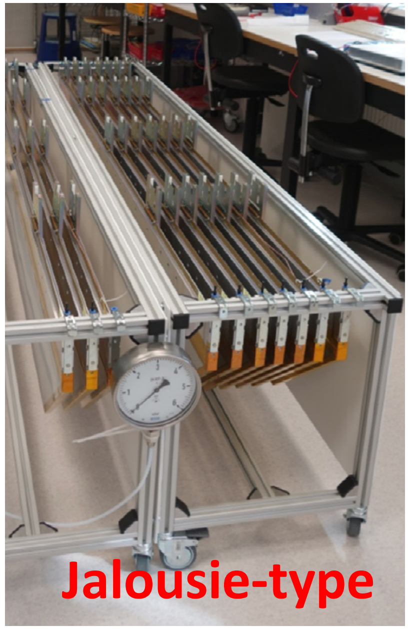




MAGIC-Jalousie detector

Segments mounted perpendicular to the beam axis

6



JALOUSIE Detector Design: DREAM, MAGIC, HEIMDAL

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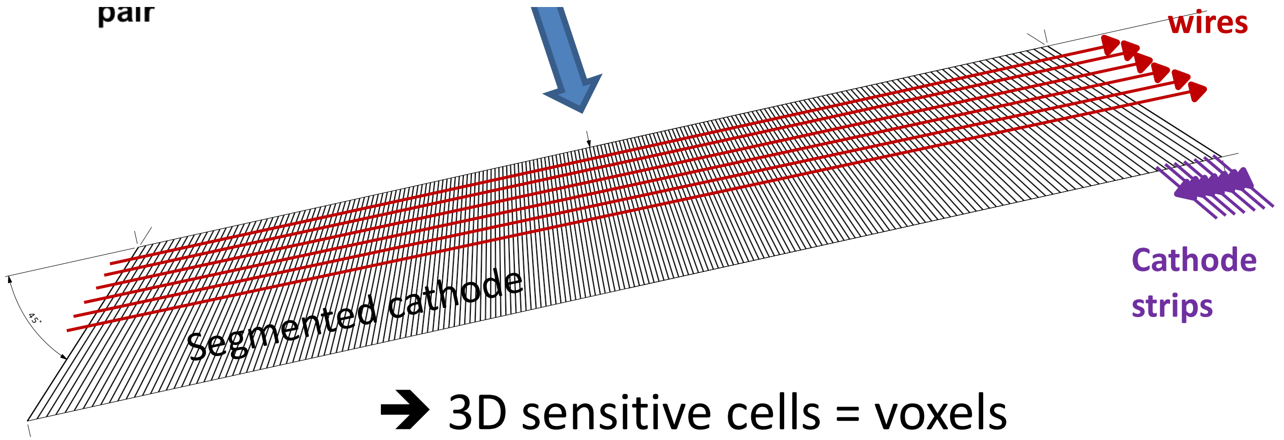
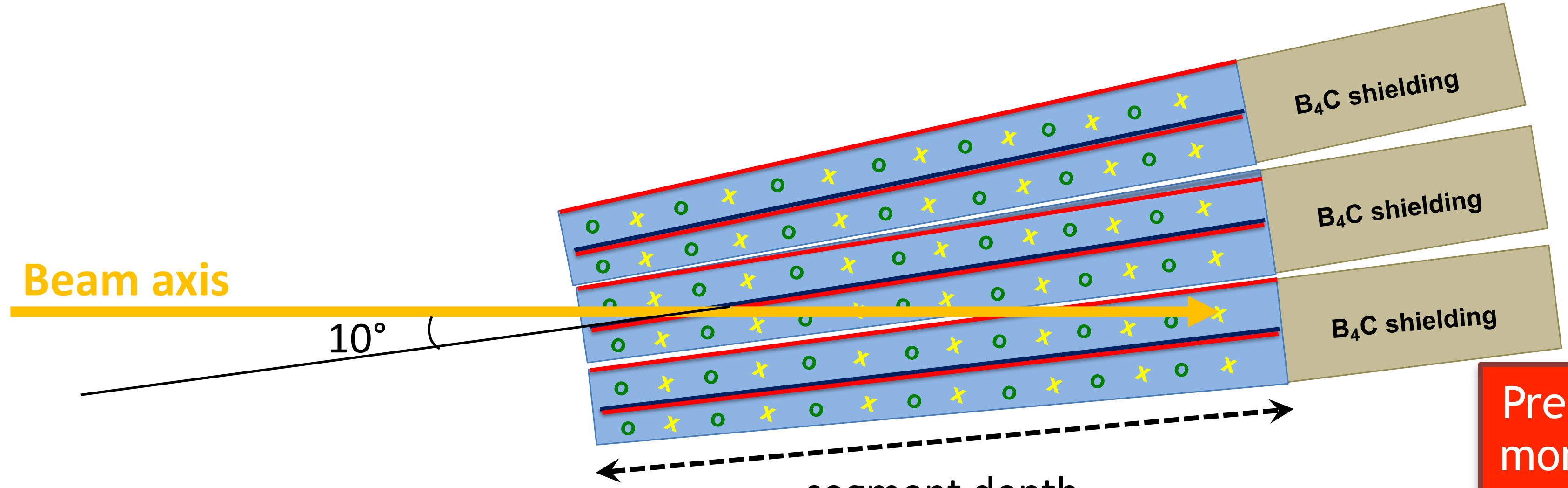


➔ 3D sensitive cells = voxels

Rate capability	10x state-of-the-art (pressurized ^{3}He tubes, scintillator-based detectors) (10^{9} n/cm^{2}/s on sample)	^{10}B – based MWPC in inclined geometry (Jalousie)
Position resolution	2x better than the state-of-the-art (DREAM: 5mm x 10mm, HEIMDAL/MAGIC: 3mm x 6mm)	
Efficiency	≥ state-of-the-art (>50% at 1 Å)	
Large area and availability of neutron converter	unclear availability for the ^{3}He gas	

Detector Requirements and Technology Choices

JINST 12 P01019 (2017)



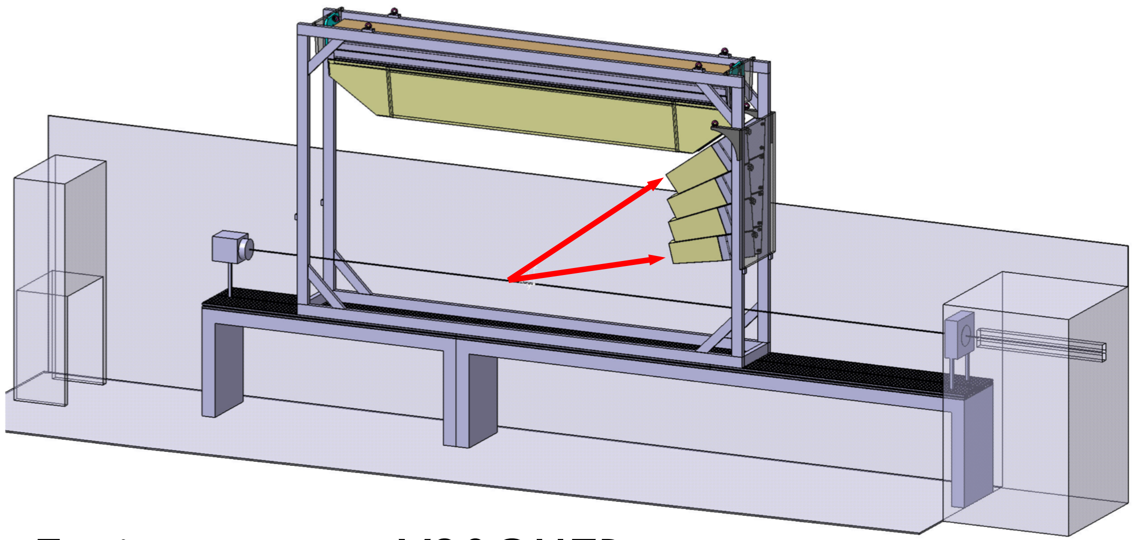
segment depth

Evaluation of simulated performance for HEIMDAL: I. Stefanescu et al., JINST 14 (2019) P10020

10 nominal interactions ➔ ε>50% at 1 Å

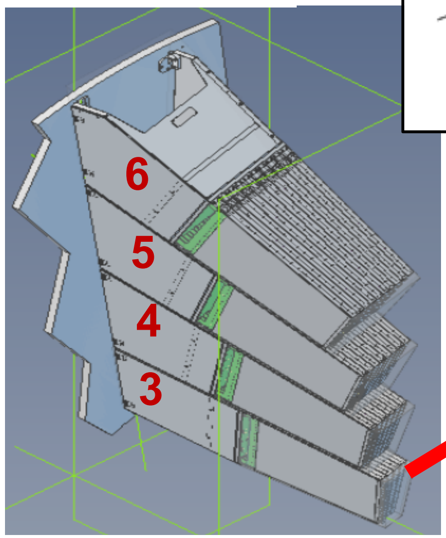
Pre-production contract started ca. 18 months ago for DREAM detector design to expedite schedule and evaluate performance issues

JALOUSIE Detector Design: DREAM, MAGIC, HEIMDAL

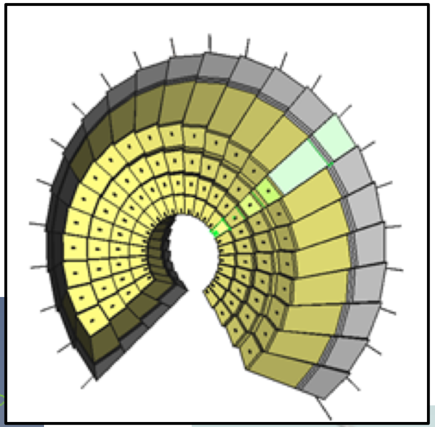


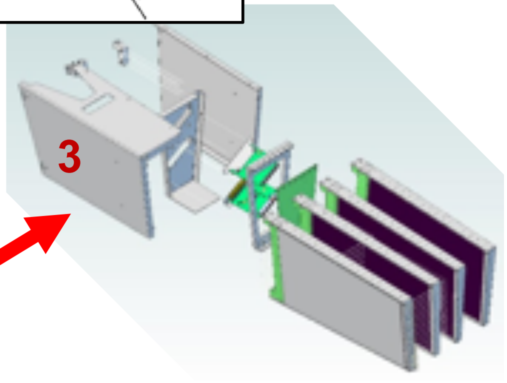
Testing setup on V20@HZB

- DREAM backscattering detectors from pre-production contract tested at V20 beamline in June



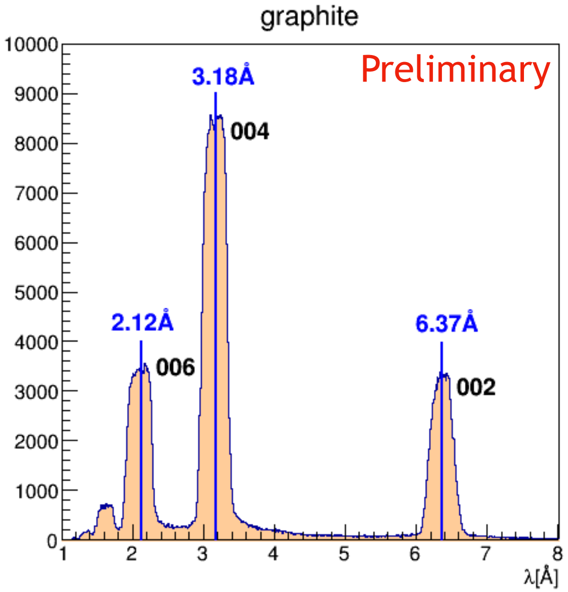
DREAM forward/ backscattering banks

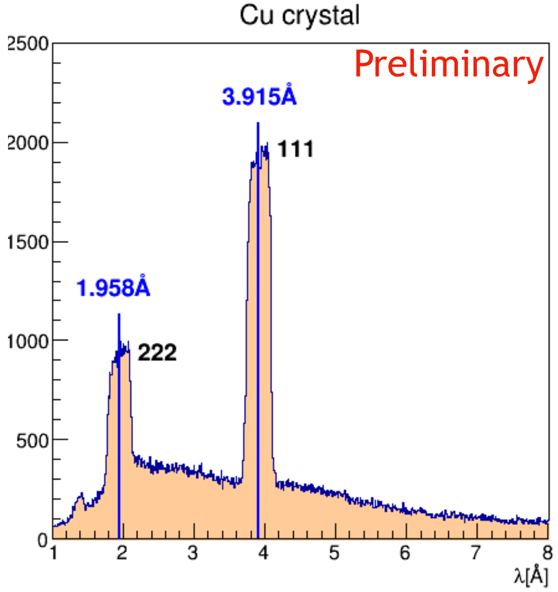




Detector + shielding

JALOUSIE Detector Design: DREAM, MAGIC, HEIMDAL





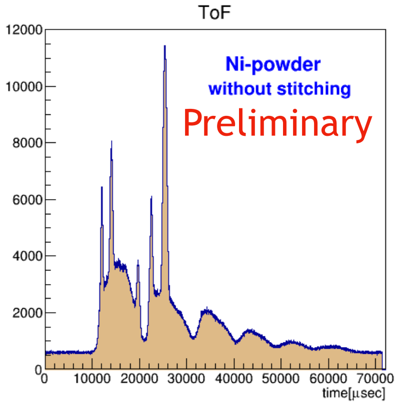
Parameters for L_{tof},chopper timing etc. together with hit times allow for wavelength calculations. Values match well with peak wavelengths of Cu and graphite.

Complex geometry: Further demonstration on diffraction instruments will be needed to be ready for first science

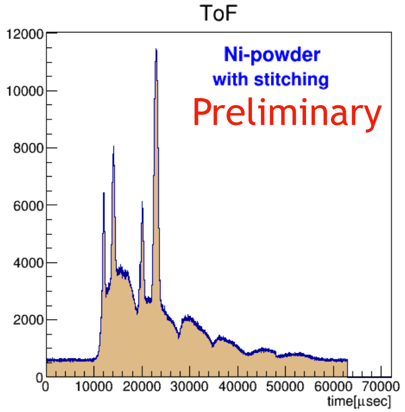
- Data w/ Cu and graphite, broadly as expected
- Geometry can be understood

- Ni-Powder measurements w/ WFM chopper
- Data can be corrected and stitched together

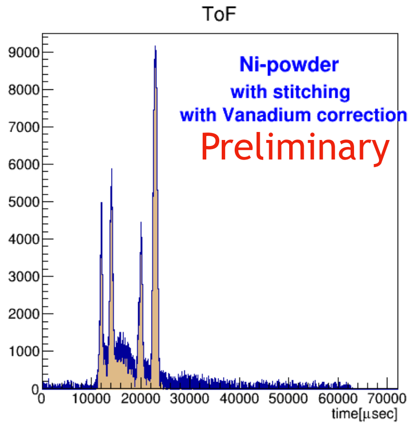
- Data from complex geometry can be understood



Raw ToF-spectrum only with T_0 correction



ToF-spectrum with stitching according to chopper windows time shift delays



ToF-spectrum with empty Vanadium can subtraction

MultiBlade Detector Design for Reflectometry: ESTIA and FREIA

Task4.2: The Intensity Frontier

The Multi-Blade project

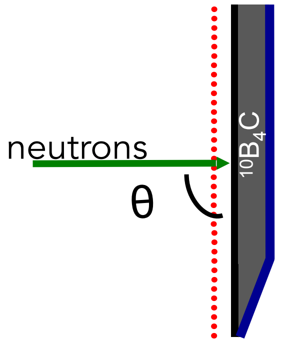
High counting rate capability

High spatial resolution

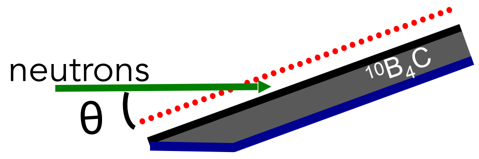
A single Boron layer inclined at 5 degrees

Efficiency <5% at 2.5Å

Efficiency 45% at 2.5Å



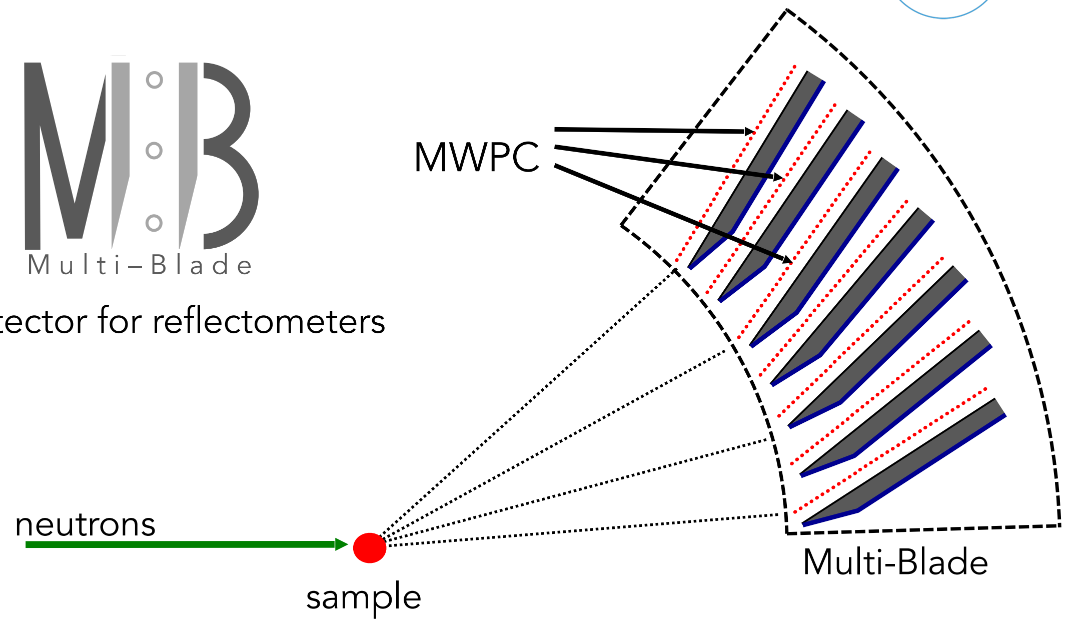
θ = 90 degrees

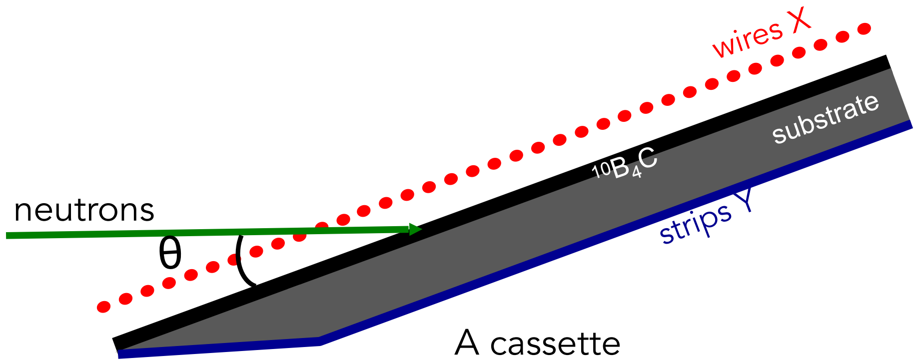


θ = 5 degrees

Multi-Blade

^{10}B-detector for reflectometers



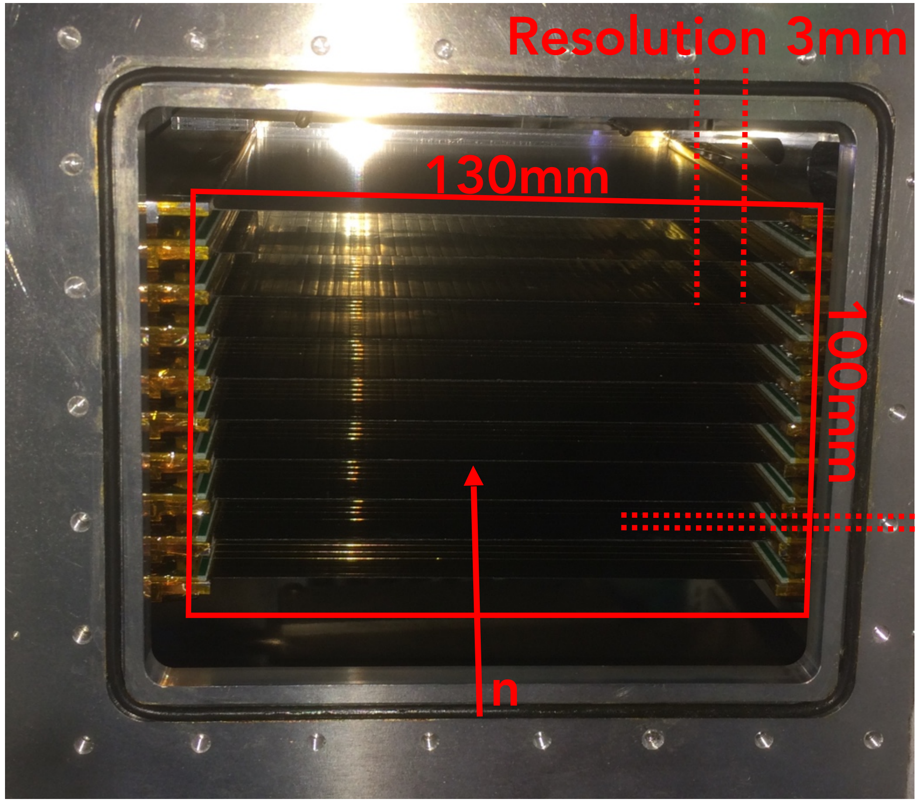


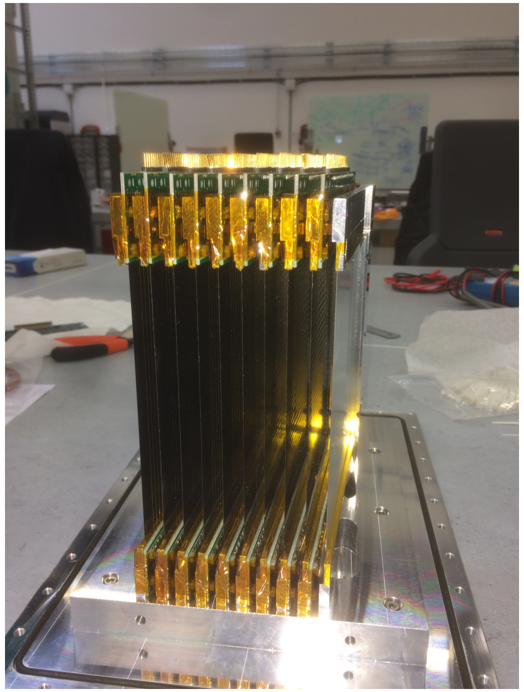
A cassette (unit)

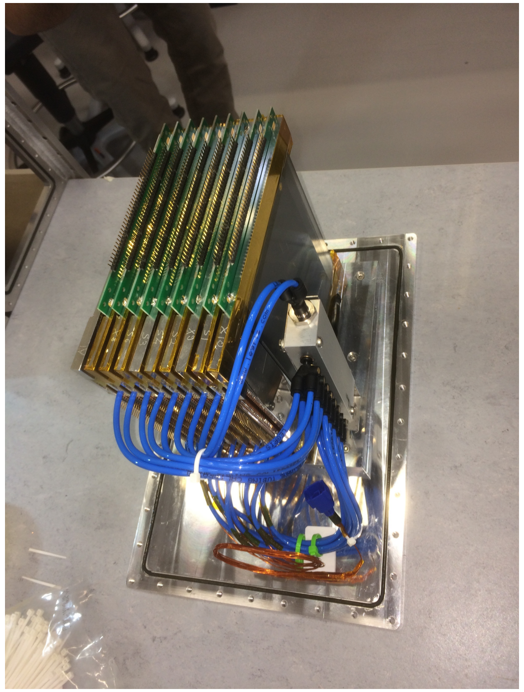
θ = 5 degrees

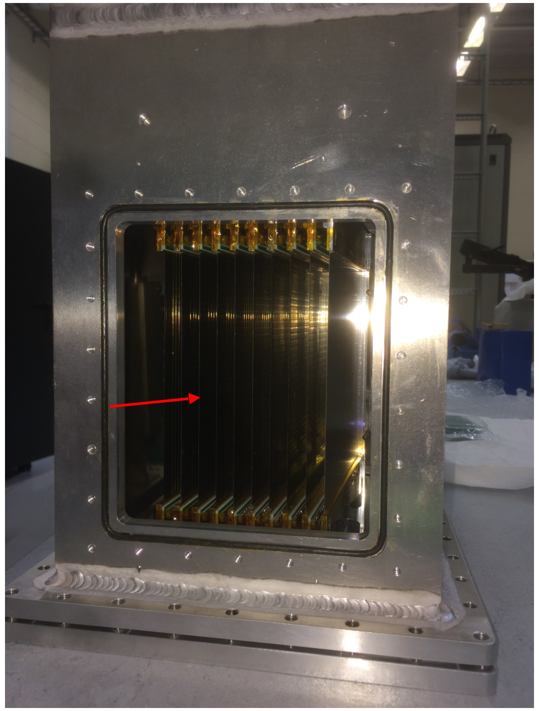
F. Piscitelli et al, Journal of Instrumentation 12, P03013 (2017) - doi: 10.1088/1748-0221/12/03/P03013 , arXiv:1701.07623

BrightnESS is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 676548



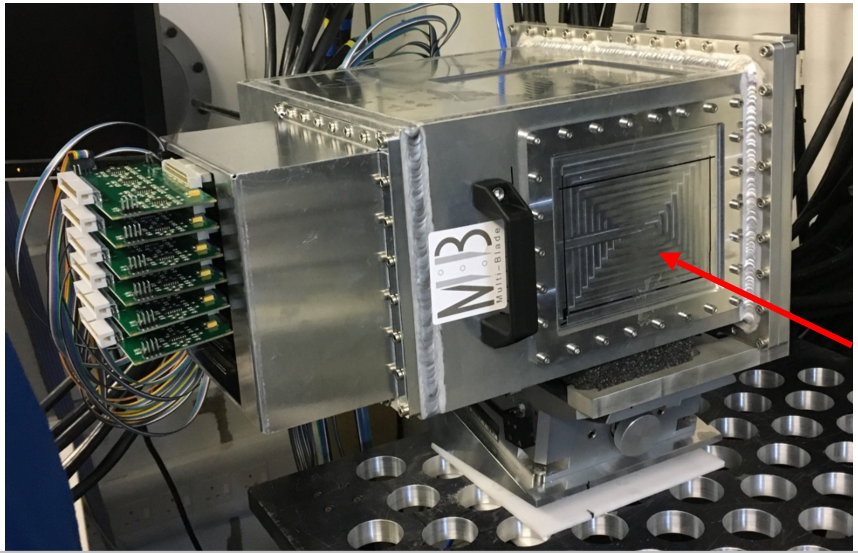


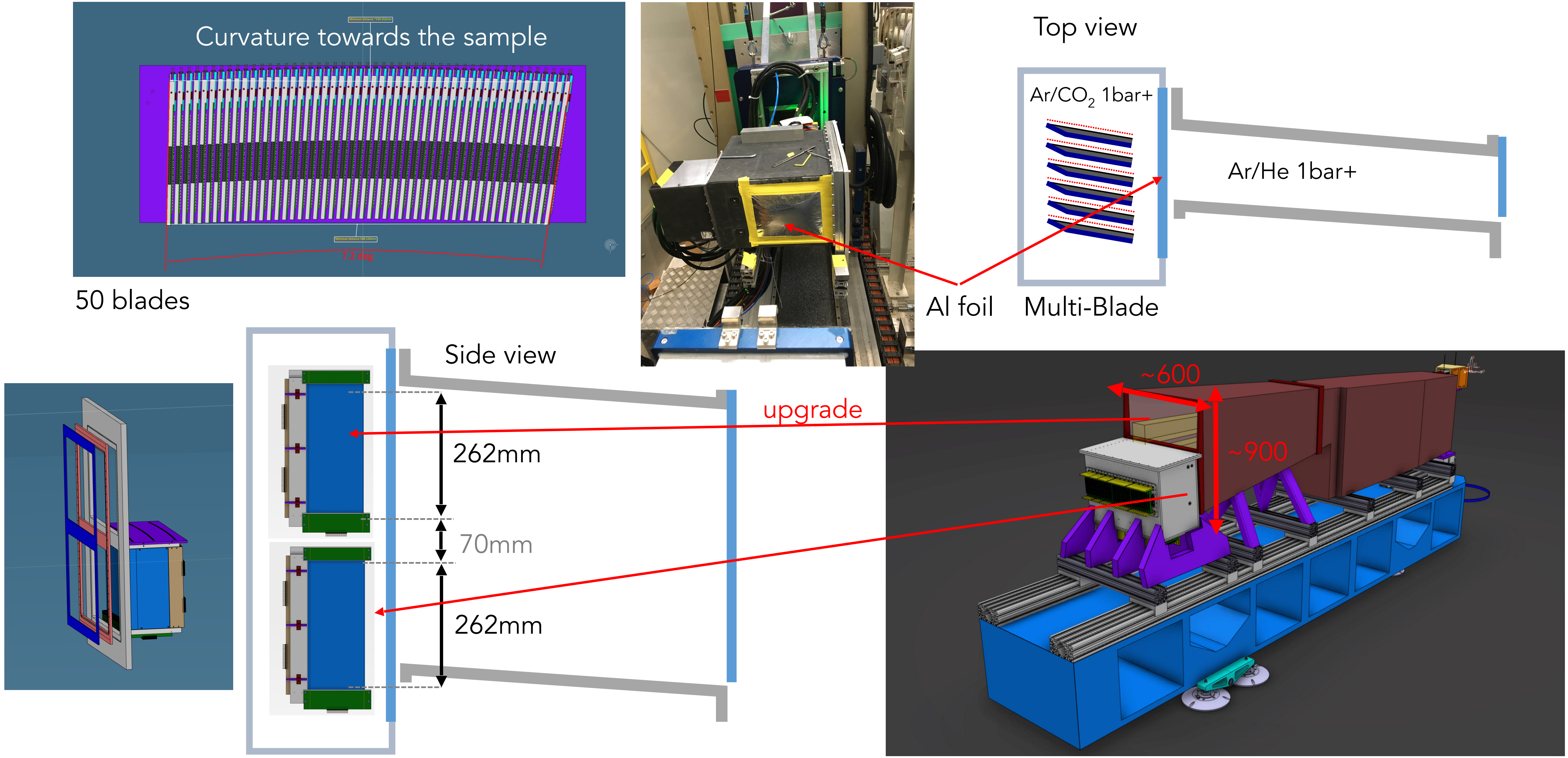




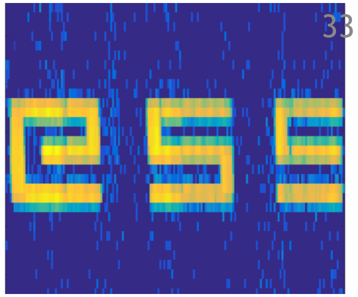
The cassettes (units)
are placed horizontally

Resolution 0.5mm




Curvature towards the sample
7.2 deg
50 blades
Top view
Ar/CO$_2$ 1bar+
Ar/He 1bar+
Al foil
Multi-Blade
Side view
262mm
70mm
262mm
upgrade
~600
~900

Multi-Blade characterization



Multi–Blade

Matching ESS requirements

✓	efficiency	44% @ 2.5 Å 57% @ 4. Å 82% @ 12 Å	
✓	spatial resolution	0.5 x 3.5 mm^2	**x3 better than state-of-the-art**
~	uniformity	±1.5%	**<1% with better precision**
✓	stability	2% (over days)	
✓	counting rate capability (peak rate)	>3.5 kHz/mm^2 (lower limit) >60kHz / 30mm^2 (lower limit)	**x20 better than state-of-the-art**
✓	gamma-ray sensitivity	< 10^{-7} (with 100keV threshold)	**as good as state-of-the-art**
✓	fast neutron sensitivity	< 10^{-5}(with 100keV threshold)	**x100 better than state-of-the-art**
✓	gas gain	60	
✓	overlap	50% eff. drop in 0.5mm gap	

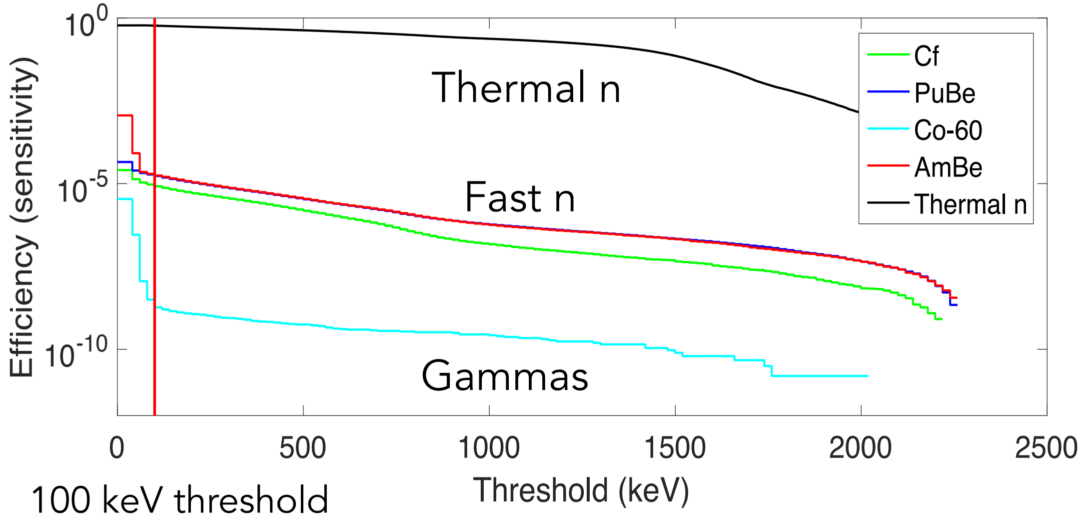
Next tests: D50 and D17 @ ILL Nov19

Performance requirements met

G. Mauri et al., Results of the tests at AMOR (in preparation).
F. Piscitelli et al., Characterization of the Multi-Blade 10B-based detector at the CRISP reflectometer at ISIS, JINST 13 P05009 (2018).
G. Mauri et al., Neutron reflectometry with the Multi-Blade 10B-based detector, Proc. R. Soc. A 474: 20180266 (2018).
G. Mauri et al., Fast neutron sensitivity of neutron detectors based on boron-10 converter layers. JINST 13 P03004 (2018).
F. Piscitelli et al., The Multi-Blade Boron-10-based Neutron Detector for high intensity Neutron Reflectometry at ESS, JINST 12 P03013 (2017).
F. Piscitelli et al. Study of a high spatial resolution ^{10}B-based thermal neutron detector for neutron reflectometry: the Multi-Blade prototype, JINST 9 P03007 (2014).

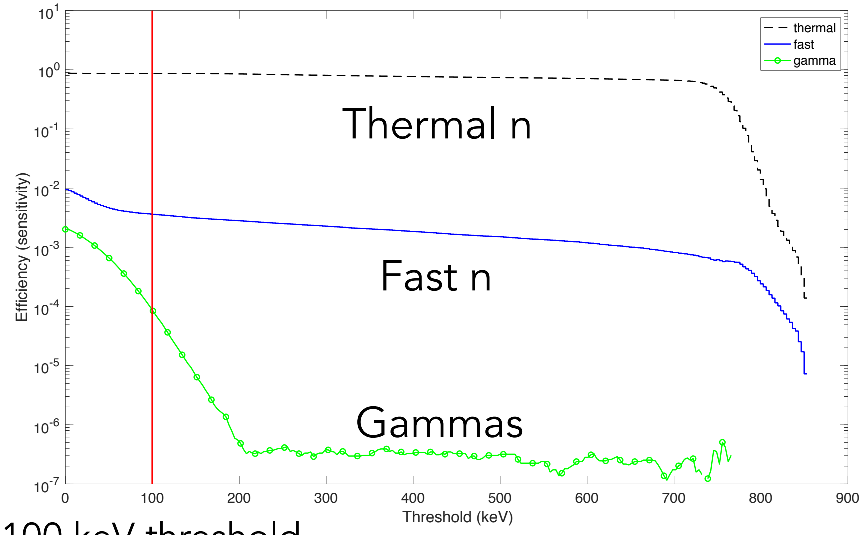
Fast neutron sensitivity (1 – 10MeV)

Multi-Blade measurements



100 keV threshold

Helium-3 measurements



100 keV threshold

Thermal-cold neutron efficiency (2.5Å) ~ 0.44

0.65 ~ Thermal-cold neutron efficiency (2.5Å)

Fast neutron sensitivity ~ 10^{-5}

x100

~ 10^{-3} Fast neutron sensitivity

Gamma sensitivity < 10^{-7}

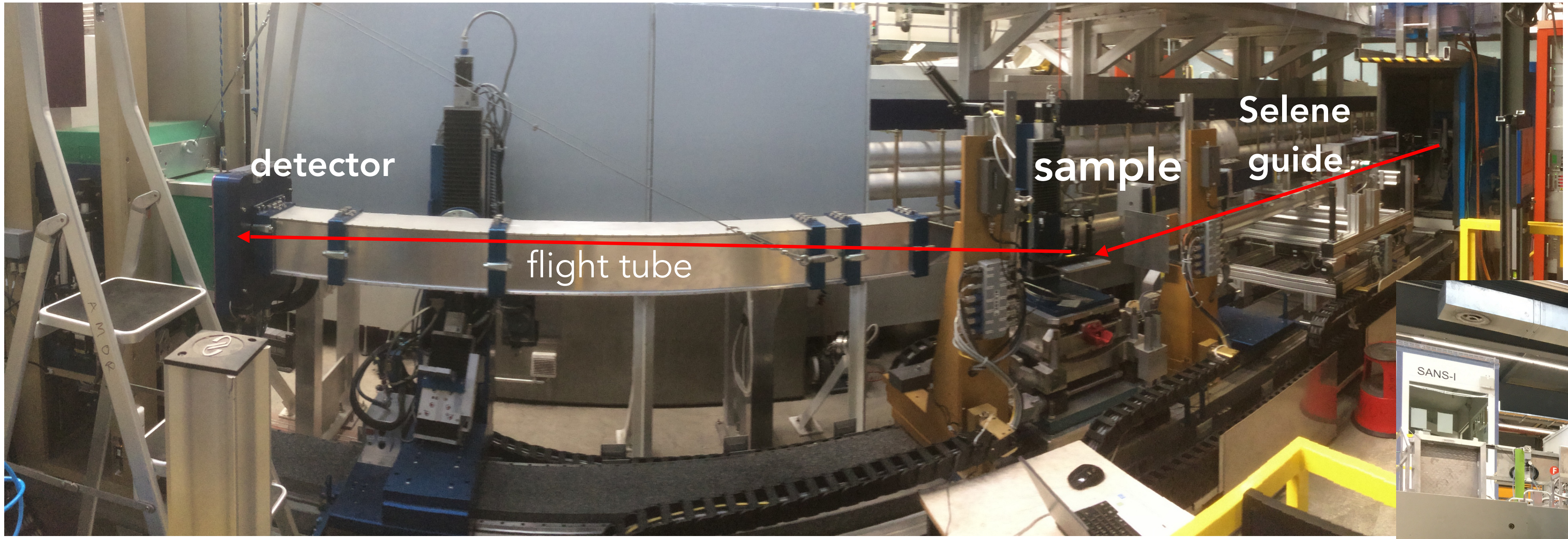
< 10^{-7} Gamma sensitivity

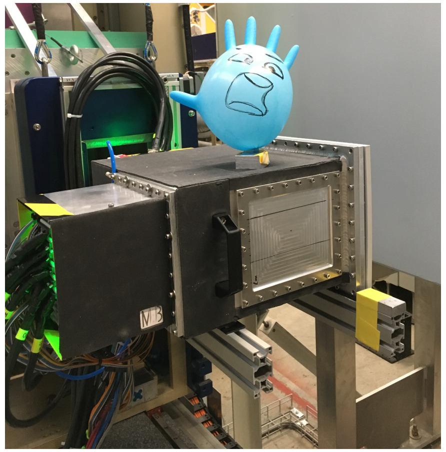
G. Mauri et al., Fast neutron sensitivity of neutron detectors based on boron-10 converter layers. JINST 13 P03004 (2018).

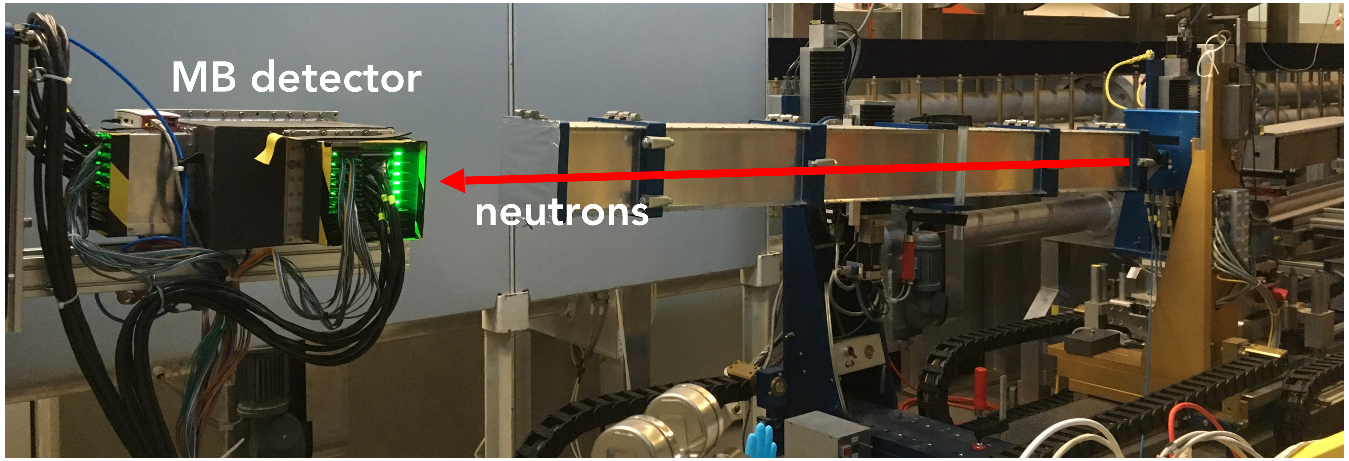
G. Mauri et al., Evidence of fast neutron sensitivity for 3HE detectors and comparison with Boron-10 based neutron detectors. EPJ TI accepted.

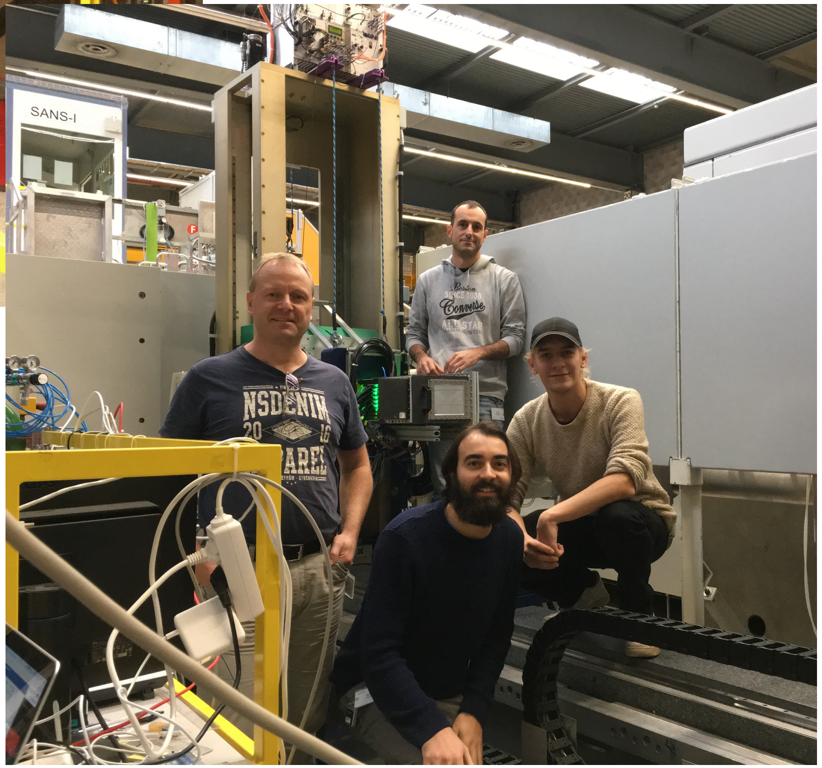
PAUL SCHERRER INSTITUT PSI

November 2018 - AMOR reflectometer @ PSI

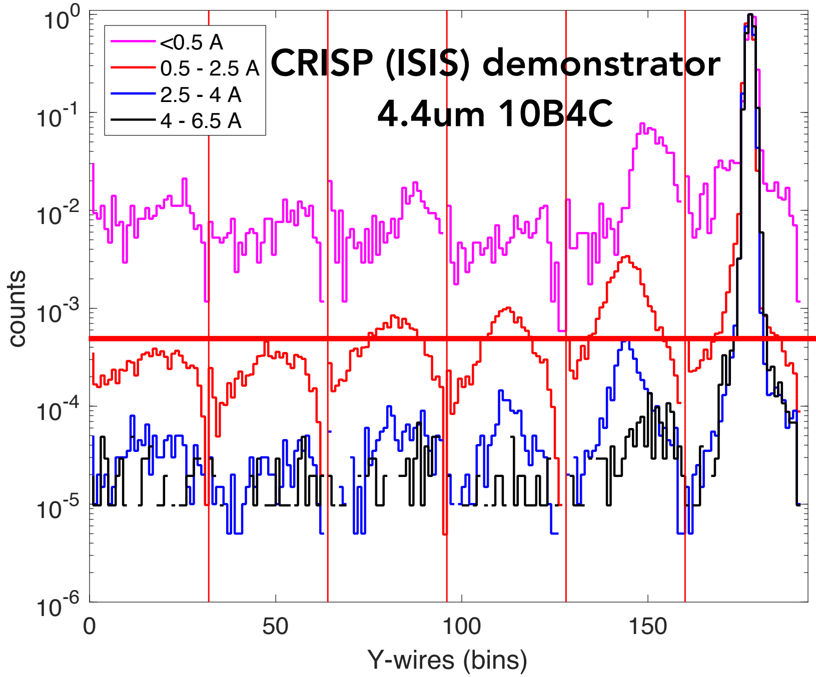




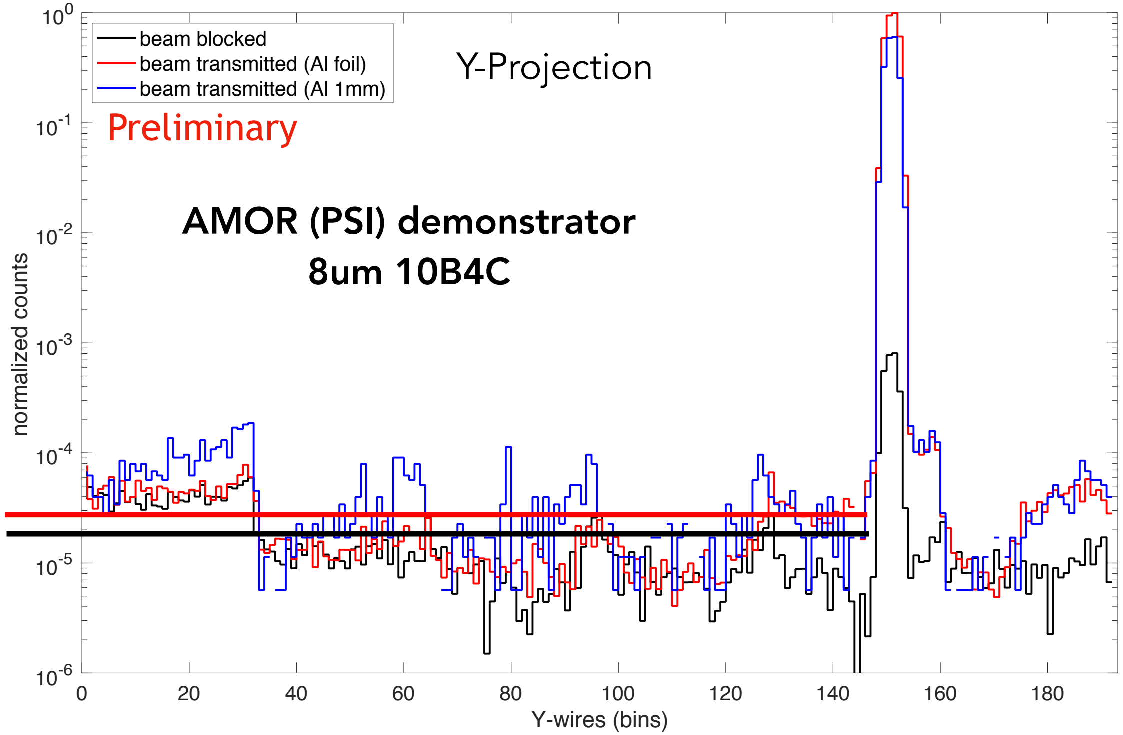




WP5 Data Acquisition software chain has been developed during BrightnESS (WP5 - i.e. DMSC/Data) and tested @ AMOR

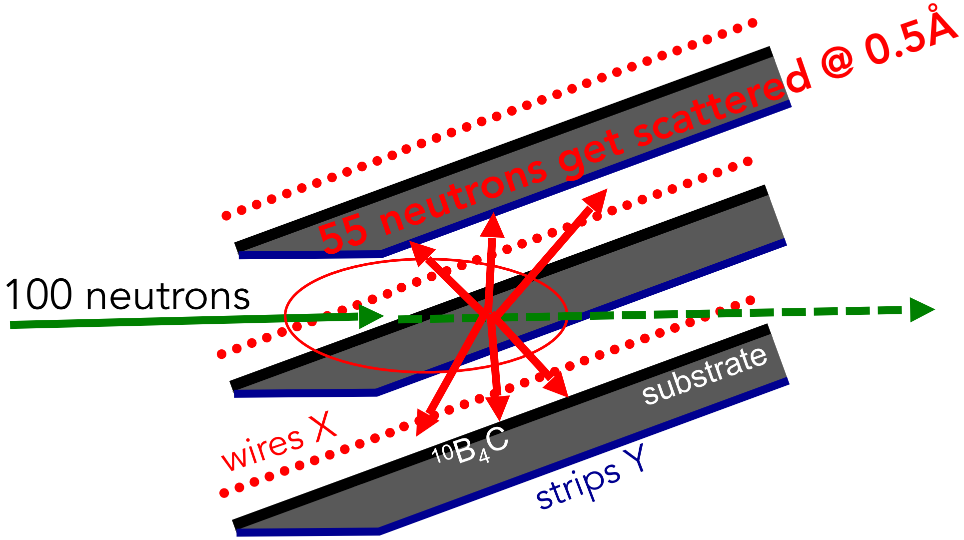


~4·10-3



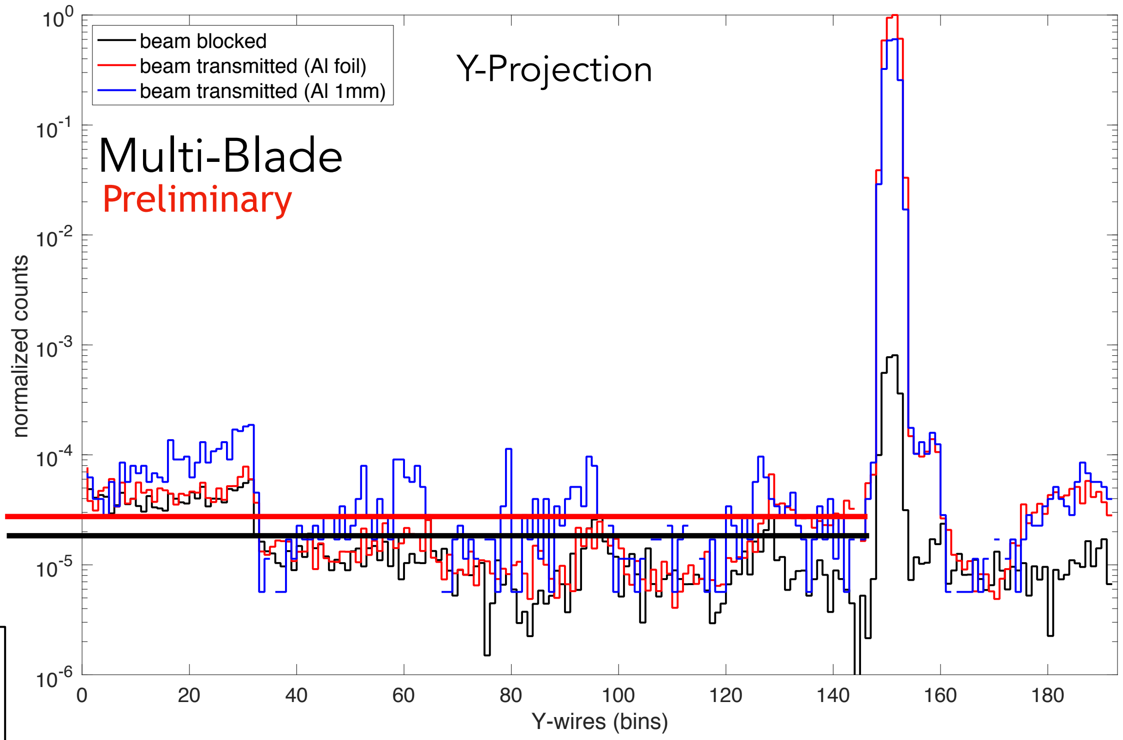
~ 3·10-5

~ 2·10-5



Scattering removed

x100 better than He-3 (from instrument proposal)



Foil window ~ $3 \cdot 10^{-5}$

Instrument background ~ $2 \cdot 10^{-5}$

He-3 detector

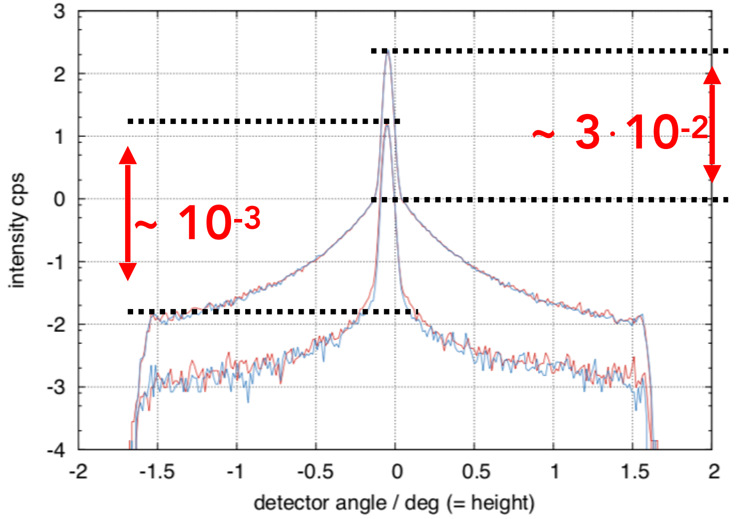


Figure 9.1: Intensity distribution on the Amor area detector integrated horizontally. The detector was illuminated with a vertically collimated beam, corresponding to the sharp peak. For the red curves, the detector slit was completely open, for the blue it was closed to shade the area outside the beam. The upper curves are obtained by integrating λ from 3 Å to 5 Å, the lower curves by integrating from 8 Å to 10 Å.

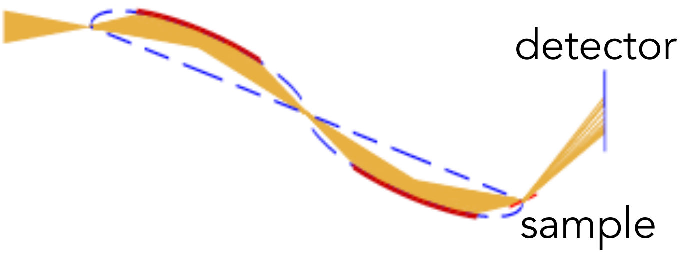
Instrument Proposal ESTIA Instrument Proposal

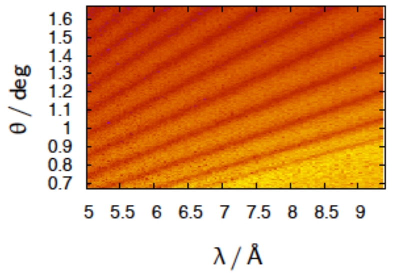
November 2018 - AMOR reflectometer @ PSI

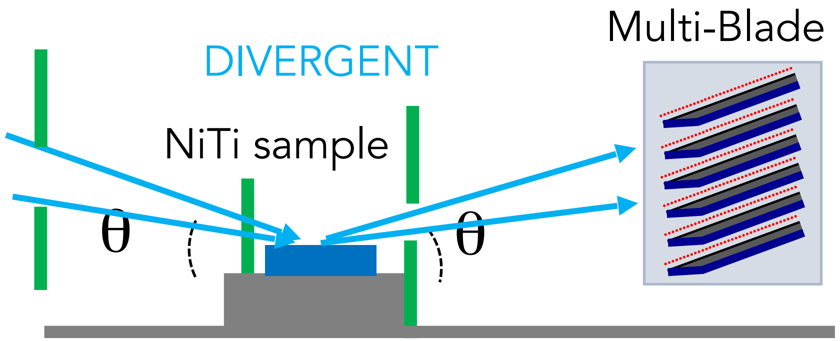
ESTIA Selene guide and High intensity mode

NiTi Multilayer

Selene guide using the ReFocus principle



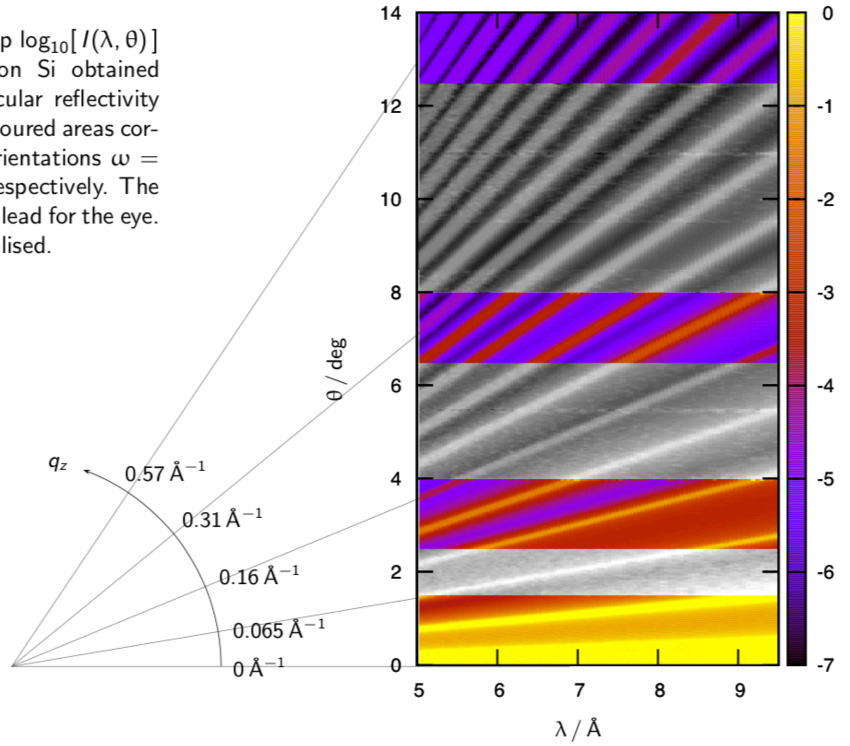




Divergence of the beam : 1.6 degrees

Instrument Proposal ESTIA Instrument Proposal 23

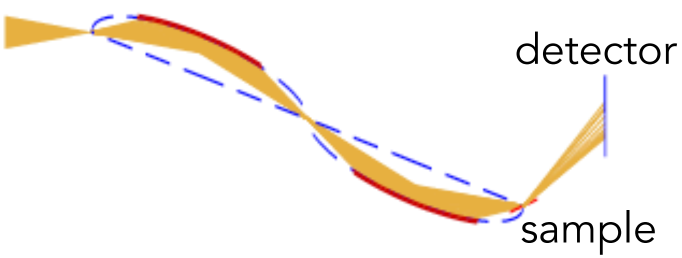
Figure 2.12: Intensity map $\log_{10}[I(\lambda, \theta)]$ for a Ni/Ti multilayer on Si obtained in the high-intensity specular reflectivity mode [→10.4]. The 4 coloured areas correspond to the sample orientations $\omega = -0, 5°, 2°, 6°$, and 12°, respectively. The gray-scale areas are just a lead for the eye. The intensities are normalised.

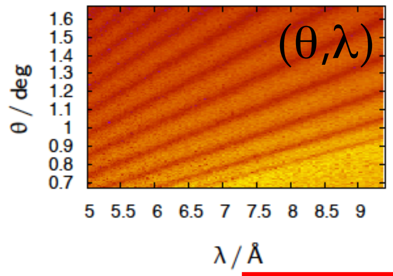


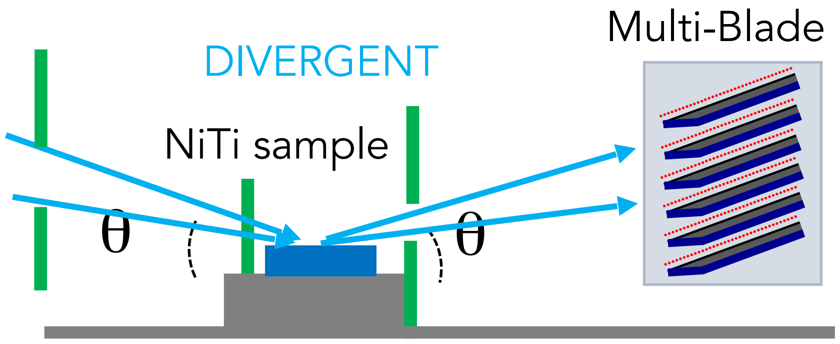
November 2018 - AMOR reflectometer @ PSI

ESTIA Selene guide and High intensity mode

Selene guide using the ReFocus principle





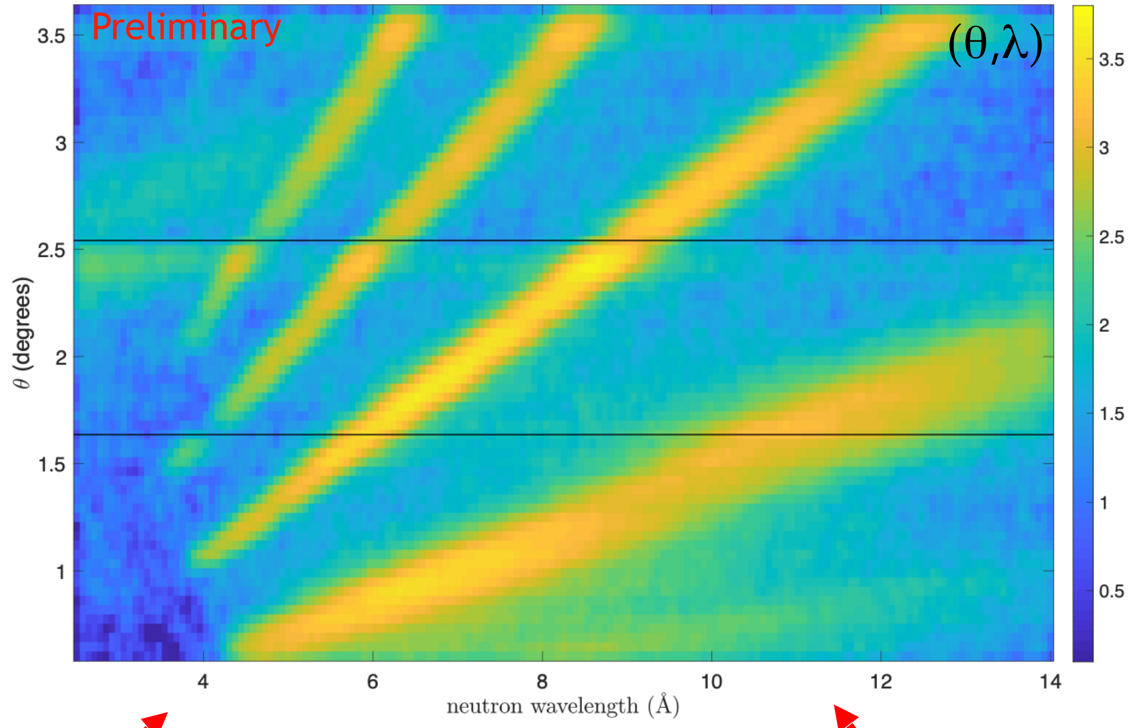


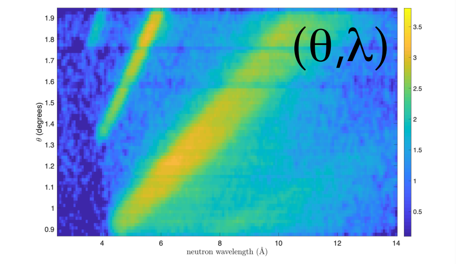
Divergence of the beam : 1.6 degrees

(ToF,y) → (θ,λ)

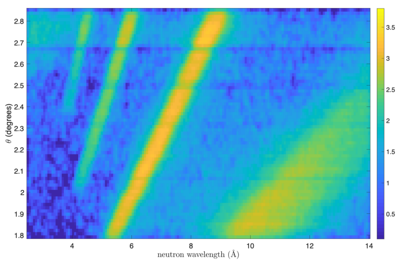
NiTi Multilayer

Combination of 3 angles

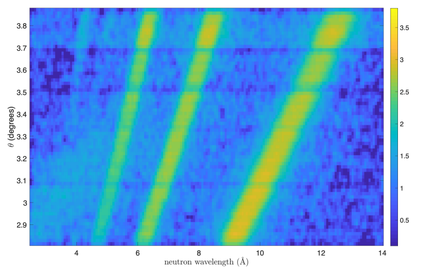




Angle 1: 1.4deg



Angle 2: 2.2 deg

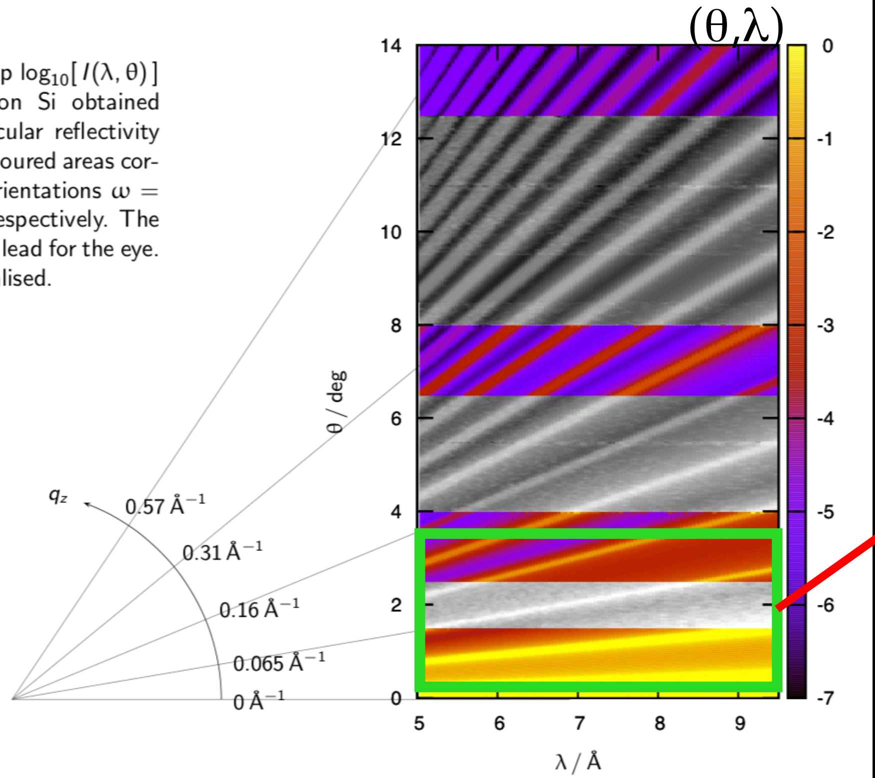


Angle 3: 3.2deg

November 2018 - AMOR reflectometer @ PSI

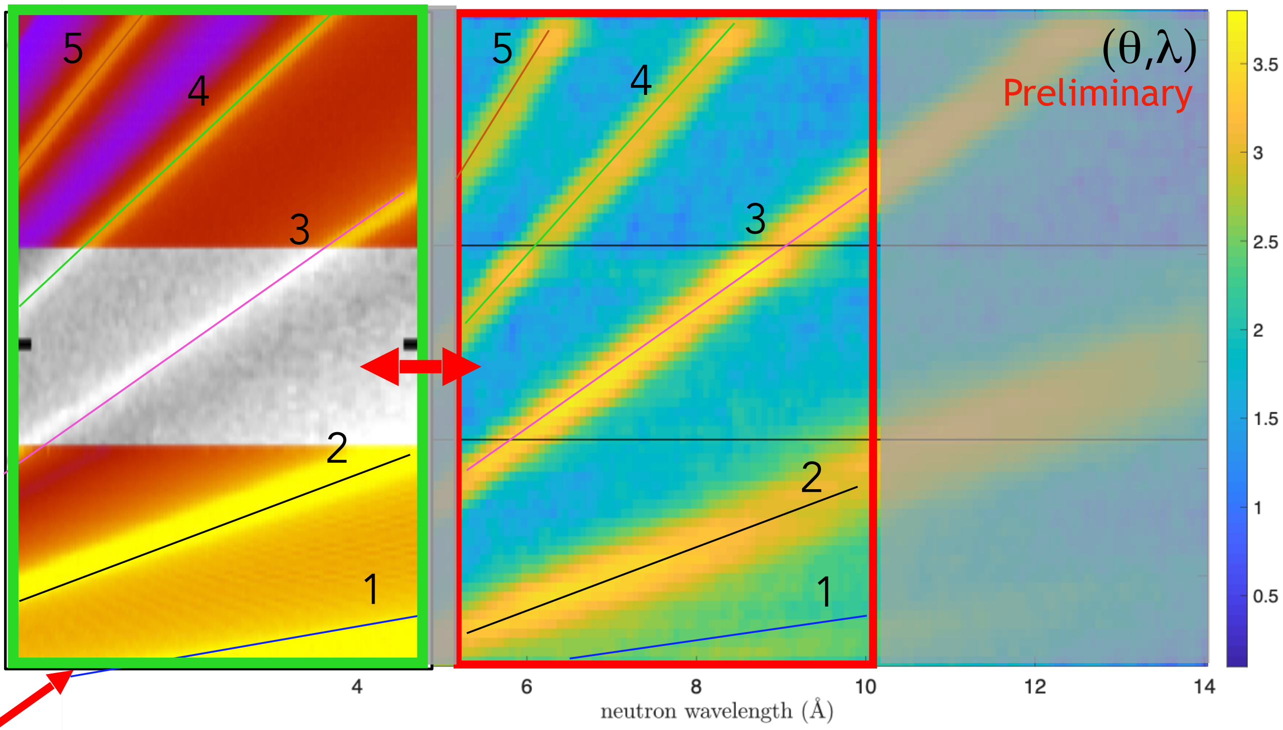
ESTIA Selene guide and High intensity mode

Figure 2.12: Intensity map $\log_{10}[I(\lambda, \theta)]$ for a Ni/Ti multilayer on Si obtained in the high-intensity specular reflectivity mode [→10.4]. The 4 coloured areas correspond to the sample orientations $\omega = -0, 5°, 2°, 6°$, and $12°$, respectively. The gray-scale areas are just a lead for the eye. The intensities are normalised.



NiTi Multilayer

Combination of 3 angles



Simulated

Measured

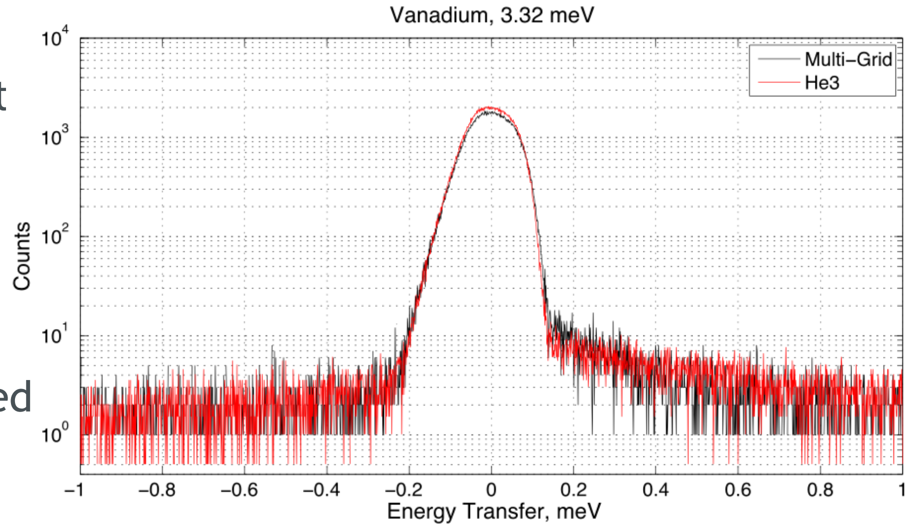
Scientific Performance for all proposed operational modes shown

MultiGrid Detector Design for Direct Spectroscopy: CSPEC and TREX

brightness Task4.3: Realising Large Area Detectors

EUROPEAN SPALLATION SOURCE

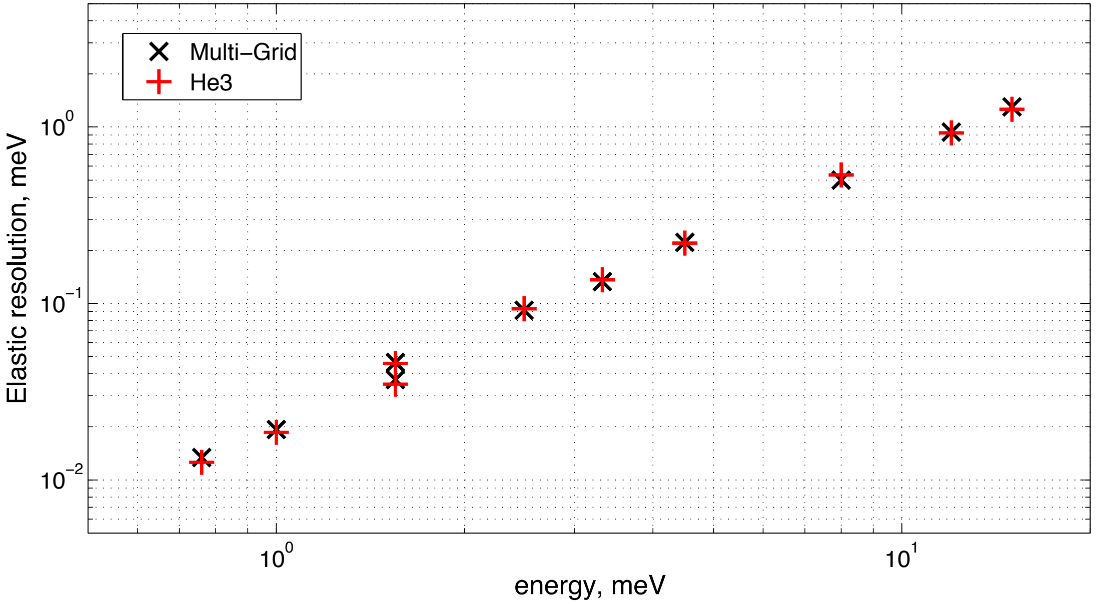
B10 Multi-Grid Detector Performance is equivalent to that of He-3 detectors



Similar test for thermally optimised detector planned for August on SEQUOIA

A.Khaplanov et al. *"Multi-Grid Detector for Neutron Spectroscopy: Results Obtained on Time-of-Flight Spectrometer CNCS"* https://arxiv.org/abs/1703.03626
2017 JINST 12 P04030

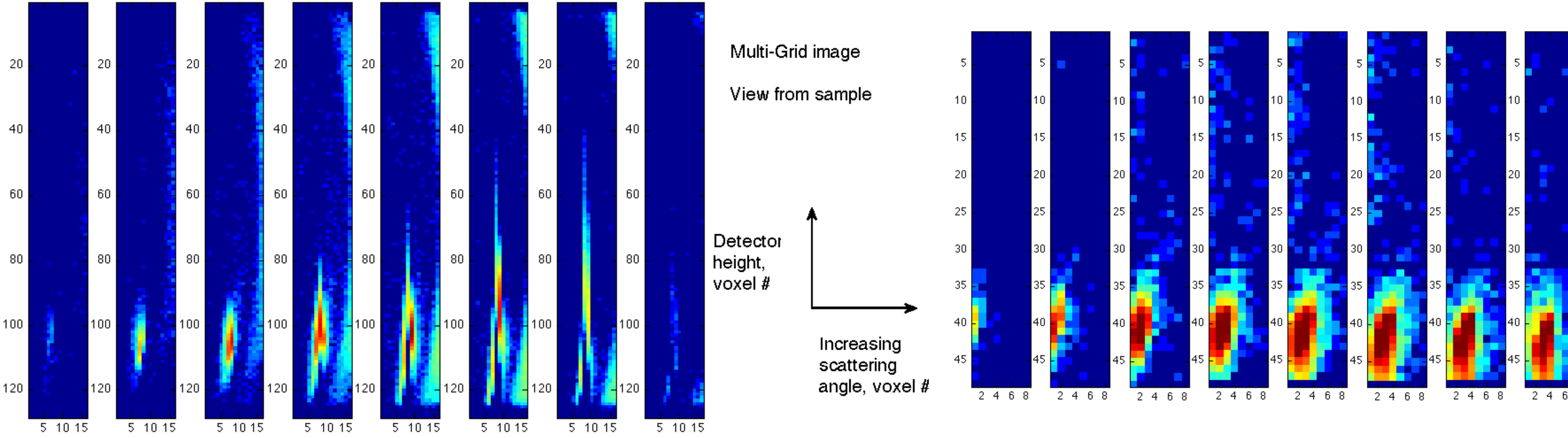
Technology demonstrated, ready for deployment



BrightnESS is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 676548

Rate performance: MultiGrid vs Helium-3 PSD

Results from CNCS demonstrator



- Saturation observed in Helium-3 detectors
- Creates spurious signals
- Best case: tube is inactive during saturation

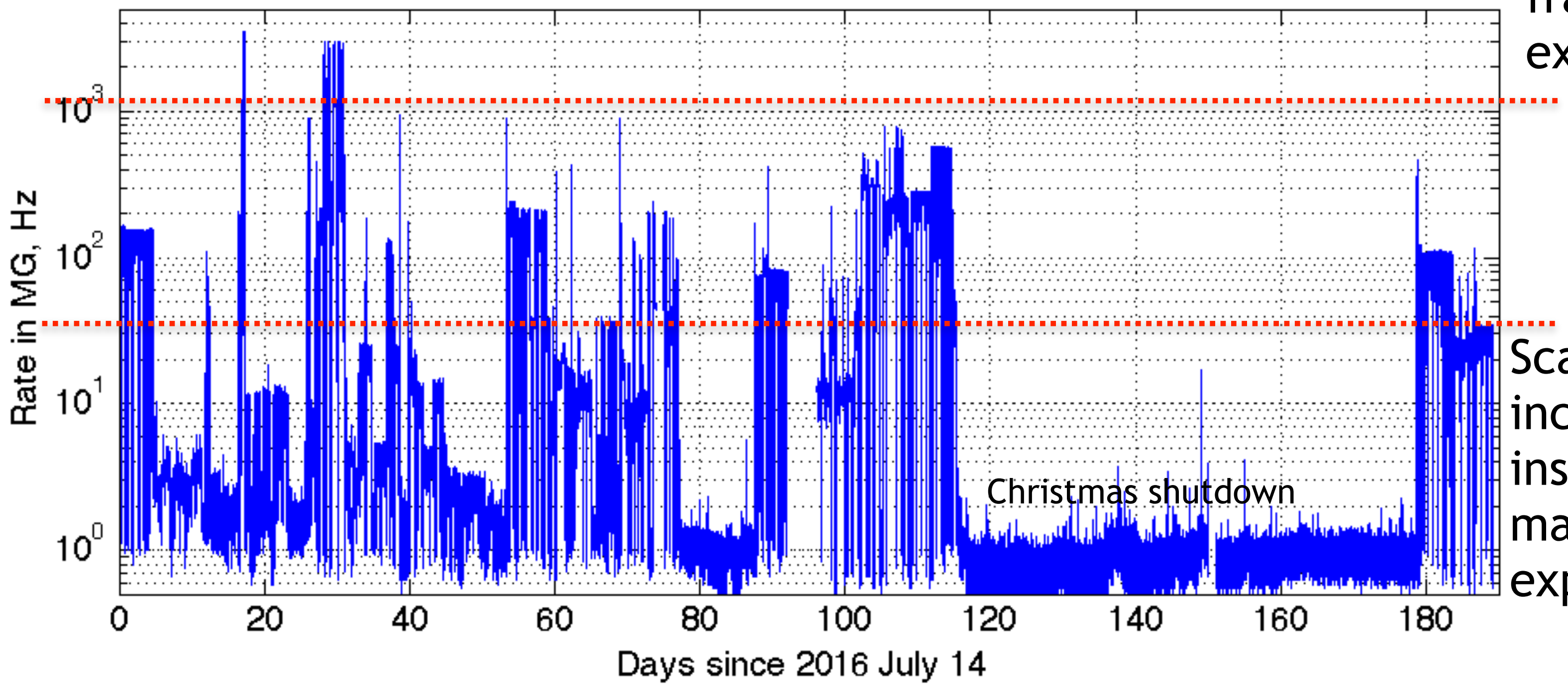
- No saturation observed in MultiGrid detector

A.Khaplanov et al. *"Multi-Grid Detector for Neutron Spectroscopy: Results Obtained on Time-of-Flight Spectrometer CNCS"* https://arxiv.org/abs/1703.03626 2017 JINST 12 P04030

BrightnESS is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 676548

Results from CNCS demonstrator

Caveat: Rate is an average, which is proxy for instantaneous rate



Saturation for small fraction of experiments now

Scale by expected increase in instantaneous rate: majority of experiments affected

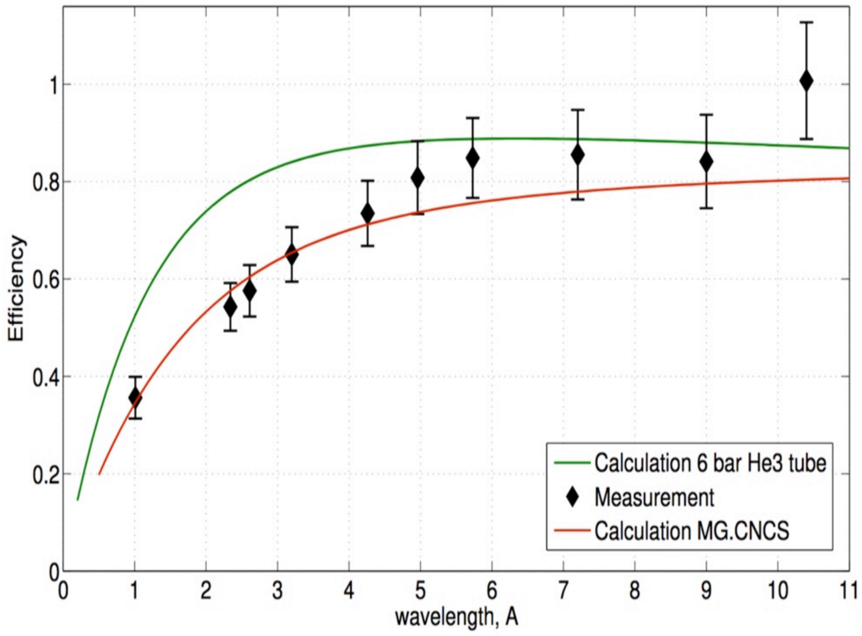
A.Khaplanov et al. *"Multi-Grid Detector for Neutron Spectroscopy: Results Obtained on Time-of-Flight Spectrometer CNCS"* https://arxiv.org/abs/1703.03626 2017 JINST 12 P04030

BrightnESS is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 676548

MG Performance at CNCS

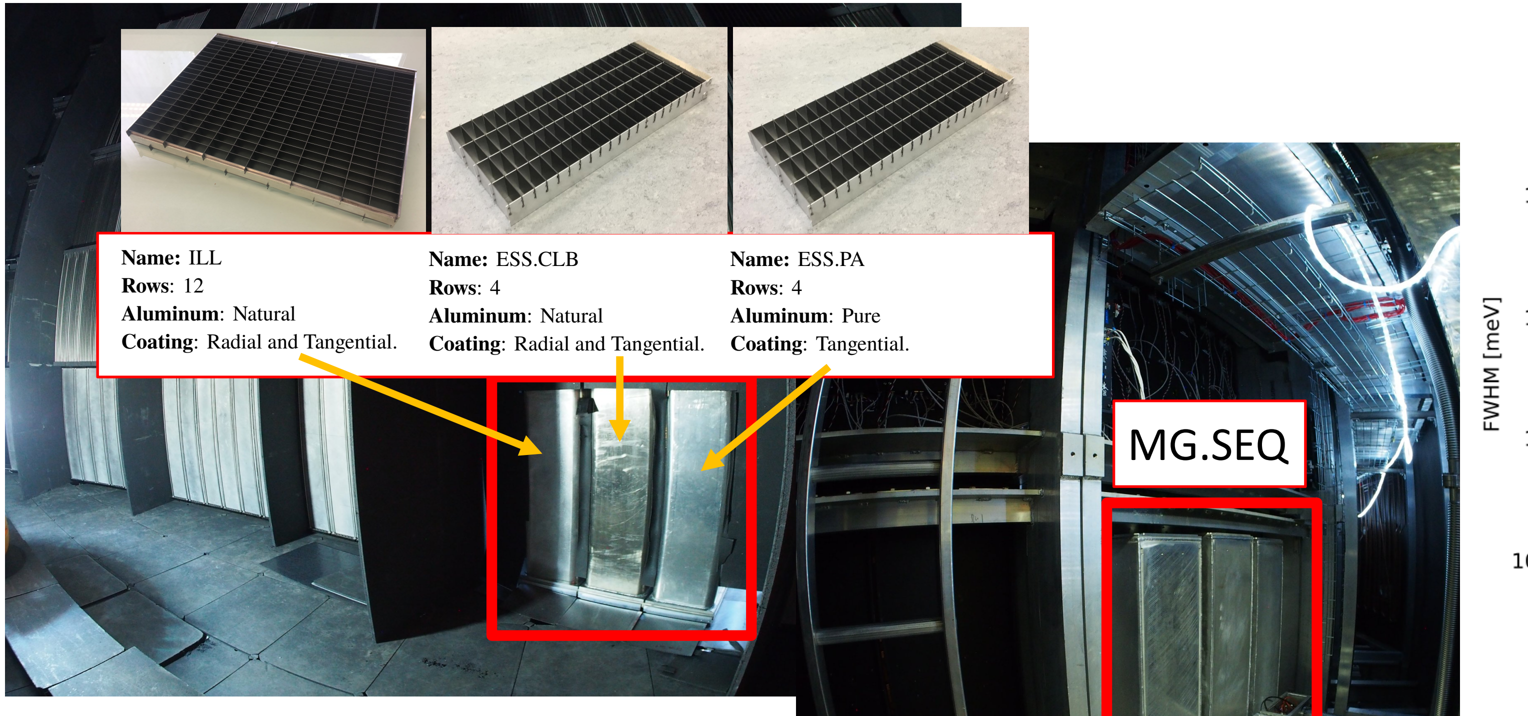
CNCS Demonstrator was designed to be CSPEC demonstrator

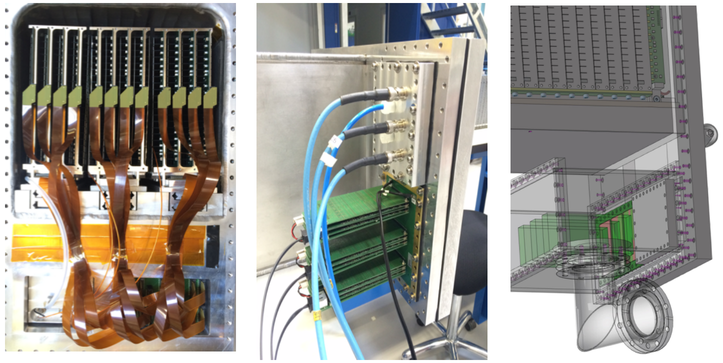
- **Long-term operation**: Continuous operation for over a year with no intervention.
- **Spectra**: ToF and in the energy transfer spectra show comparable features to those obtained with 3He.
- **Energy resolution:** Equivalent energy resolution to 3He.
- **Efficiency:** 70% efficiency for 4 Å neutrons (in excess of the requirement of 60%) and follow the theoretical calculation.
- **Rate:** Much better count rate capability than 3He tubes.
- **Fast Neutrons:** Less than 50% sensitivity to fast neutrons than 3He: lower prompt pulse and background sensitivity. Dedicated measurements determined factor 4 better
- **Background:** Background level was deemed adequate, but improvements would be helpful.



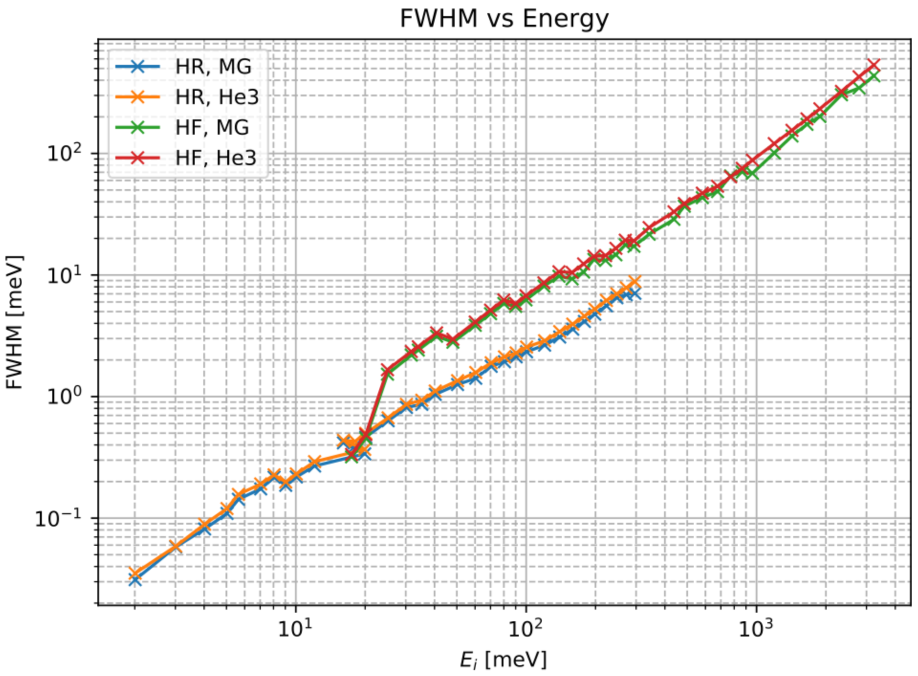
Efficiency vs Energy
The calculated efficiencies for MG.CNCS and the CNCS instrument 6-bar He-3 tubes

MG Performance at SEQ





3 detectors (+ 1 spare)
3 modules per detector
40 grids per module
20 cell layers per grid
1m² Detector Active Area



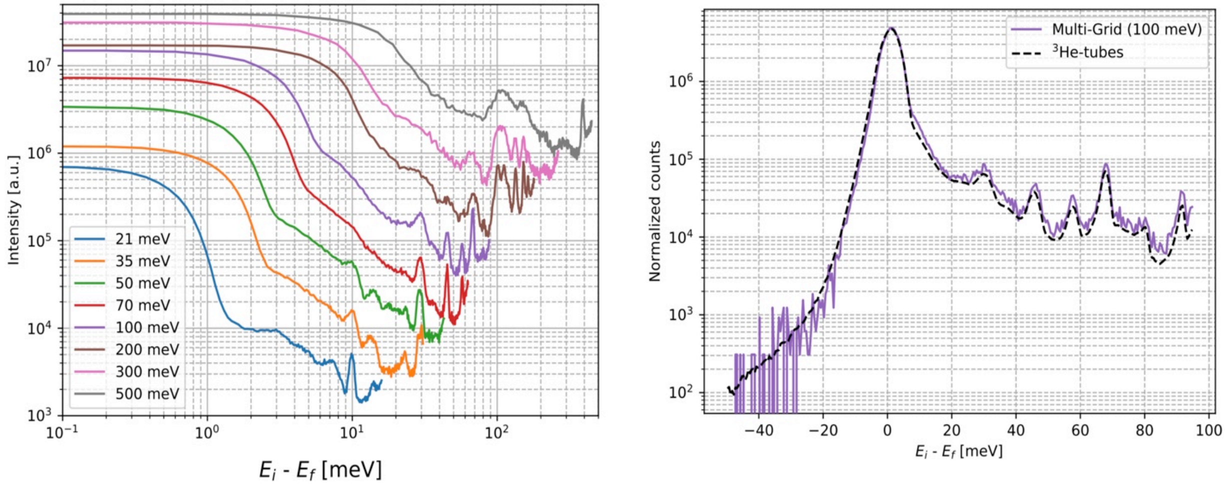
Equivalent Energy resolution for all energies in HR and HF modes

- MG.SEQ demonstrator was primarily to demonstrate vacuum compatibility of technology and to show performance of TREX detector design for thermal neutrons.

MG Performance at SEQ

Additional Key achievements:

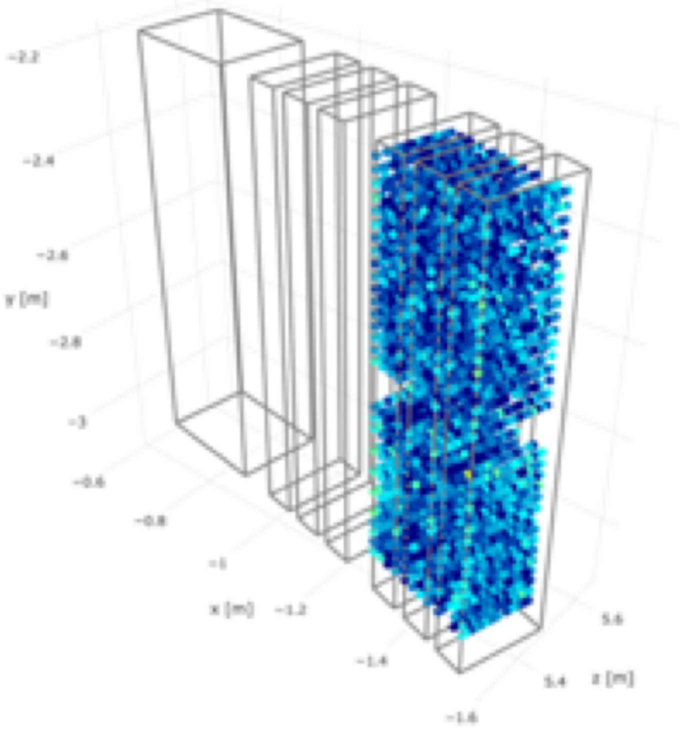
- Vacuum compatibility of the design is shown.
- Capability of MultiGrid detector to function with RRM (repetition rate multiplication mode) demonstrated. It is possible to analyse data.
- Full DMSC Event formation integration demonstrated: DAQ chain demonstrated.

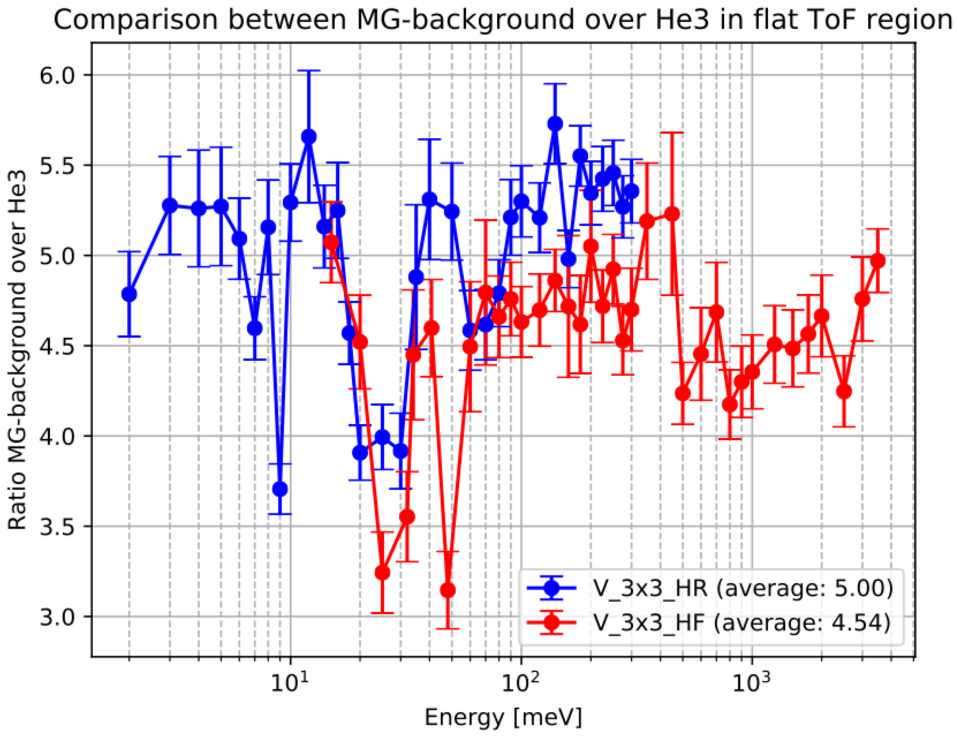


Summary of all measured Energy transfer spectra for $C_4H_2I_2S$ (2,5-diiodothiophene) sample (left) comparing MG data with 3He for 100meV (right).

Background

Subjects of concern to CSPEC: Background

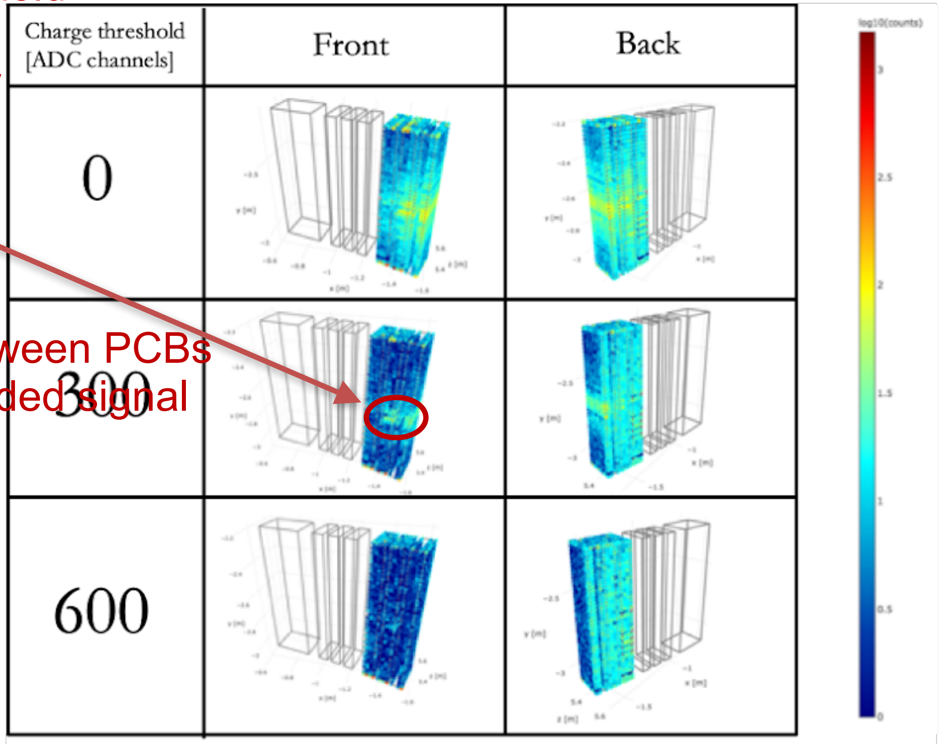




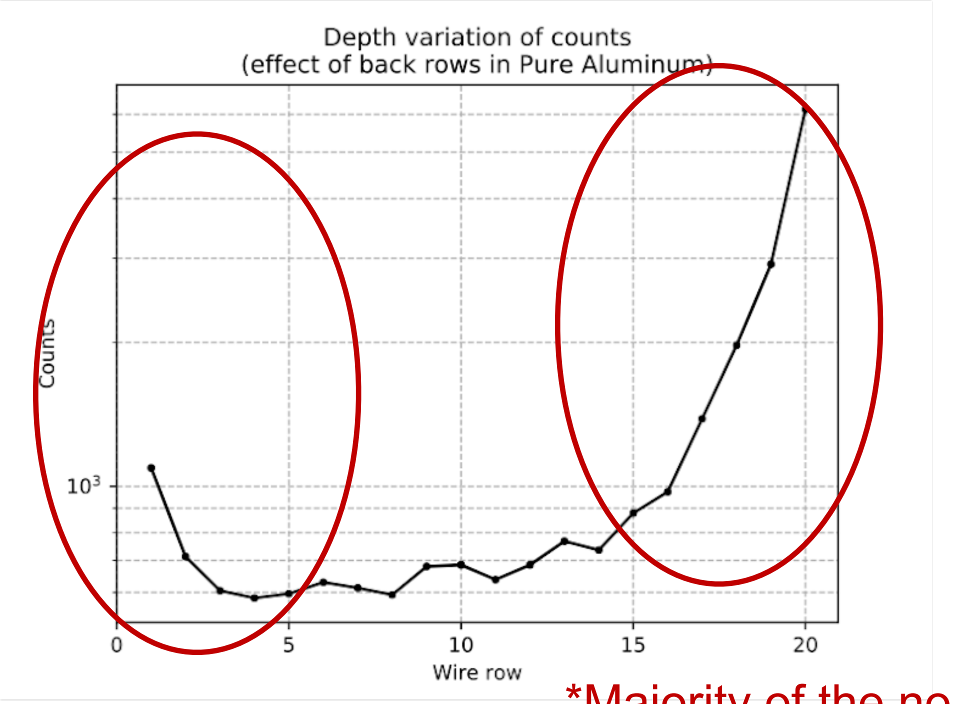
Background rate in the MG.SEQ: 0.63 n/s/m2 about
4.5 to 5 times more than that in SEQUOIA He3 tubes

Subjects of concern to CSPEC: Background

Electronic noise:
Very low amplitude
20% rise in threshold eliminates
(ca. 1% efficiency loss)



Location is join between PCBs in detector: unshielded signal cable connection

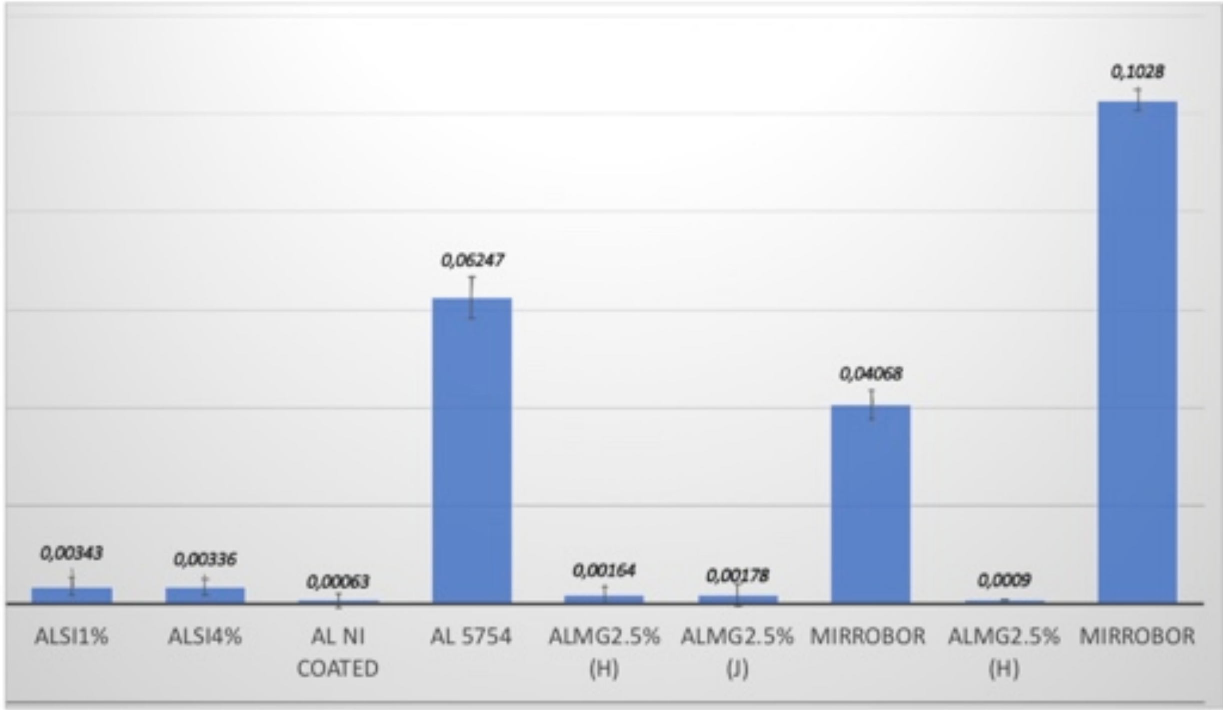


*Majority of the noise

Further investigation indicates the background observed at SEQ is a collective contribution from two different elements, one of which is most likely to be related to low level electronic noises from the detector PCBs. The other element is most likely related to the neutron absorber at the back of the grids (used to to eliminate back reflection).

Subjects of concern to CSPEC: Background

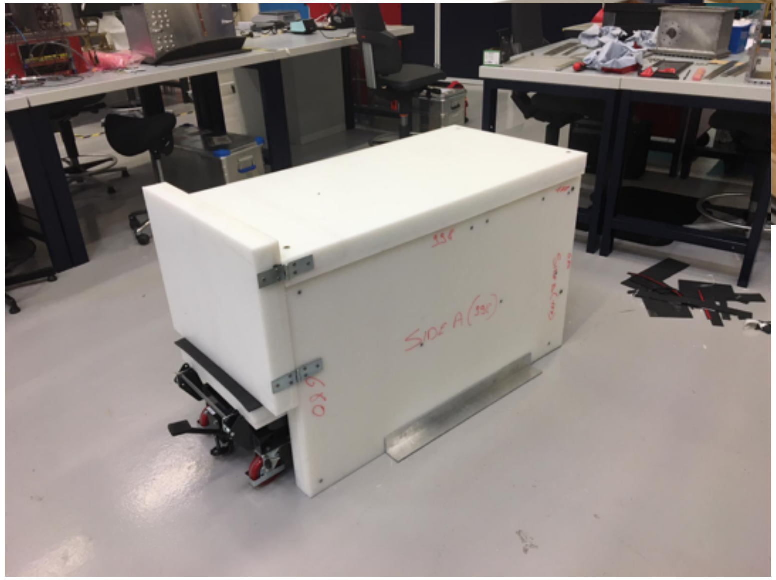
Samples measured at ORDELA, US and IROTECH, Grenoble



Alpha activity results on different Al samples and one Mirrorbor sample (verified by two different labs). This was added to the MG.SEQ demonstrator to improve neutron shielding, however, it should never be used inside detector volume.

Subjects of concern to CSPEC: Background
Intensive investigation during the summer

Detector	Location	Background Rate (Hz/m2)
3He.CNCS	SNS	~0.4
3He.SEQ	SNS	0.148
3He.1M. 3He.2M	Utgard	0.163, 0.167 (PE+B4C) 0.208, 0.256 (B4C) 2.778, 2.613 (PE) 8.437, 8.54 (no Shielding)
MG.IN6 (4.4Hz/96grids)	ILL	30
MG.12 (pure Al) **(fames nickel plated nat Al.)**	ILL	0.6
MG.CNCS (0.11Hz/96 grids) **(fames nickel plated nat Al.)**	SNS	0.55 (No Cuts) (Cd+B4C) 0.25 (with Cuts)
MG.CNCS **(fames nickel plated nat Al.)**	Utgard	0.50 (with Cuts) (B4C)
MG.SEQ (pure Al)	SNS	1.40 (No Cuts) 0.63 (With Cuts)
MG.SEQ (pure Al)	Utgard	**0.3 (Unshielded)** **0.07 (Shielded),** **0.04 Based on Understood regions.**



More details at https://indico.esss.lu.se/event/1258/contributions/9658/attachments/9184/14319/2019_05_29_DG.pptx

Subjects of concern to CSPEC: Background
Intensive investigation during the summer

EUROPEAN SPALLATION SOURCE

Detector	Location	Background Rate (Hz/m2)
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MG.SEQ (pure Al)	Utgard	**0.3 (Unshielded)** **0.07 (Shielded),** **0.04 Based on Understood regions.**

- Helium-3 measurements:
- Numbers not necessarily comparable
- No guarantee that Helium-3 tubes operated exactly the same at CNCS, SEQ and by ESS

- Shielding is only roughly comparable
- CNCS in annex hut, SEQUOIA is deep down, very thick shielding around, very dense region
- Utgard has a thin roof
- 35 vs 55 degrees north …

- He-3 and MG have same sensitivity to thermal neutrons
- Same response to gammas
- MG has 4 times lower response to Fast Neutrons
- Volume/active area ratio between detectors makes scaling unclear

More details at https://indico.esss.lu.se/event/1258/contributions/9658/attachments/9184/14319/2019_05_29_DG.pptx

Subjects of concern to CSPEC: Background
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MG.SEQ (pure Al)	Utgard	**0.3 (Unshielded)** **0.07 (Shielded),** **0.04 Based on Understood regions.**

- CSPEC Requirement (Update: 12 March 2019):
    - 1250 n /hr / m^2
    - 0.34 Hz/m2
- Detectors can meet this requirement

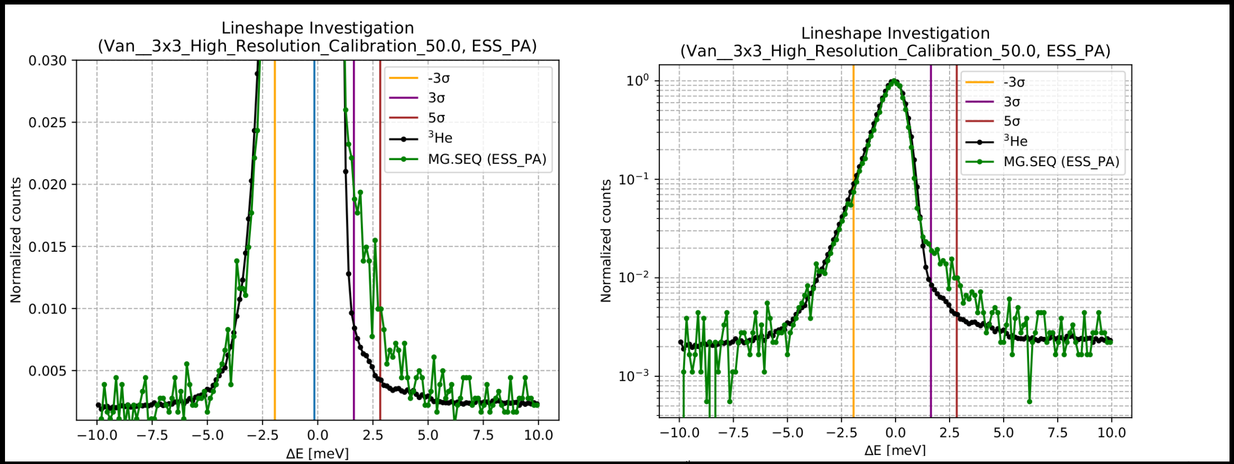
- Aim to be as low as possible
- Shielding environment both locally in detector and in surrounding as important to these measurements as natural noise
- Local shielding of cosmically induced neutrons

- Detector must be shielded effectively in detector
- Effort must also go in to get tank and cave shielding correct

More details at https://indico.esss.lu.se/event/1258/contributions/9658/attachments/9184/14319/2019_05_29_DG.pptx

LineShape

Elastic Line Shape

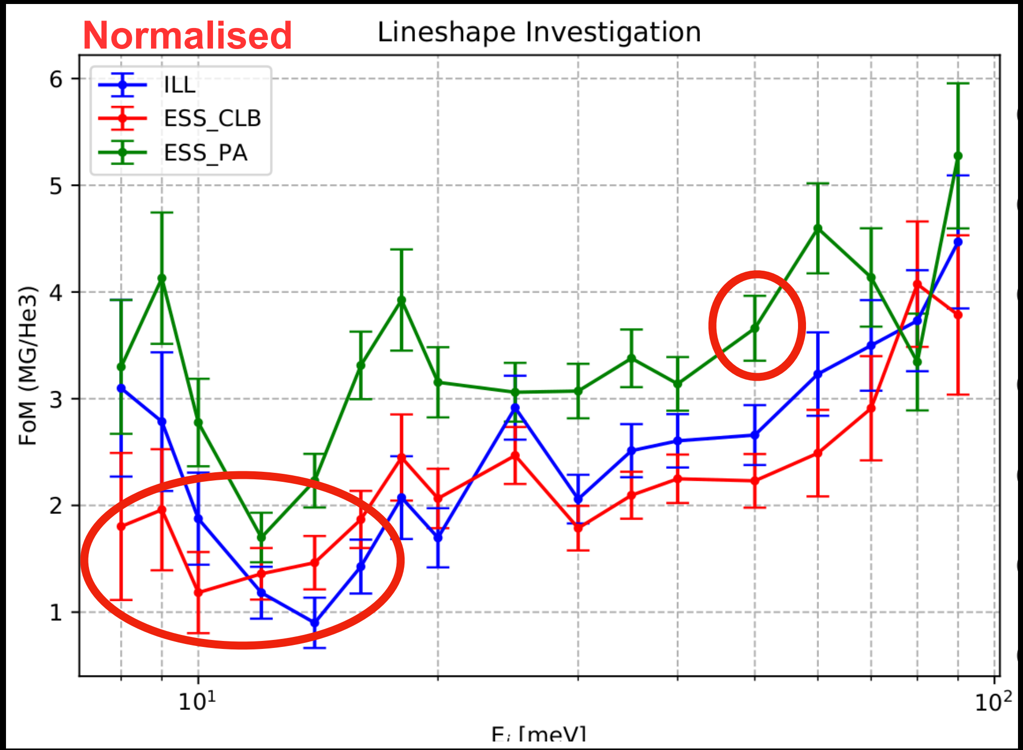


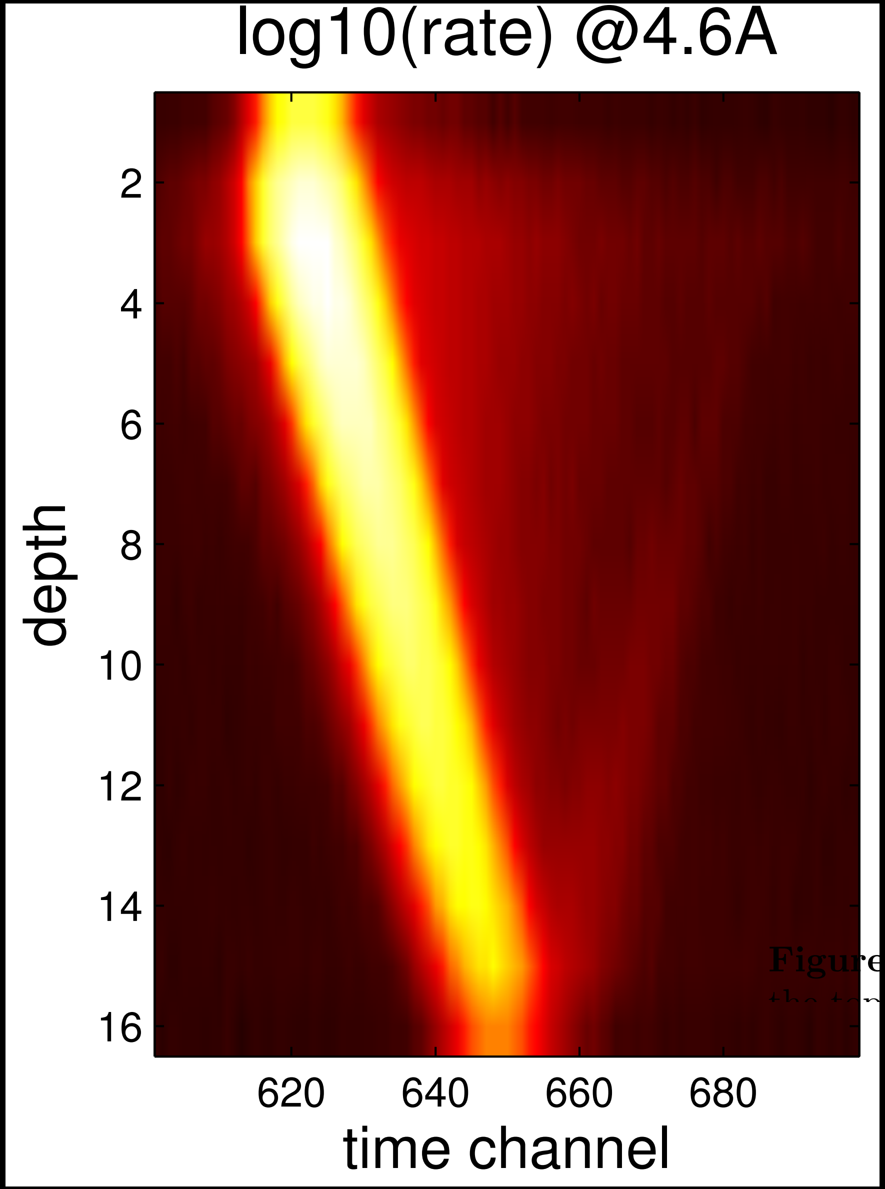
- Worry that tail in elastic line shape may prejudice quasi-elastic science studies on CSPEC

- Improvements from:
  - Coating radial blades
  - Improved shielding as per simulation
  - CSPEC: 25% less Al than MG.SEQ

Table 5: Relative FOMs for the different coating thicknesses of the radial blades.

Configuration	Relative F.O.M. (MG/He3)
No Radial Blade coating (0 μm) (MG.SEQ data)	3 – 4
Radial Blades 1 μm coating (MG.SEQ data)	1.2 – 2.0
Improved shielding (from simulation)	0.8 – 1.3 ref.[7, 8]





- Data from MG demonstrator on IN6@ILL in 2012
- There was (deliberately) no shielding to see the effect of scattering in the detector
- This has been reproduced by simulation

- Therefore line shape effect is a function of geometry and energy (i.e. it is part of the resolution function of the detector)

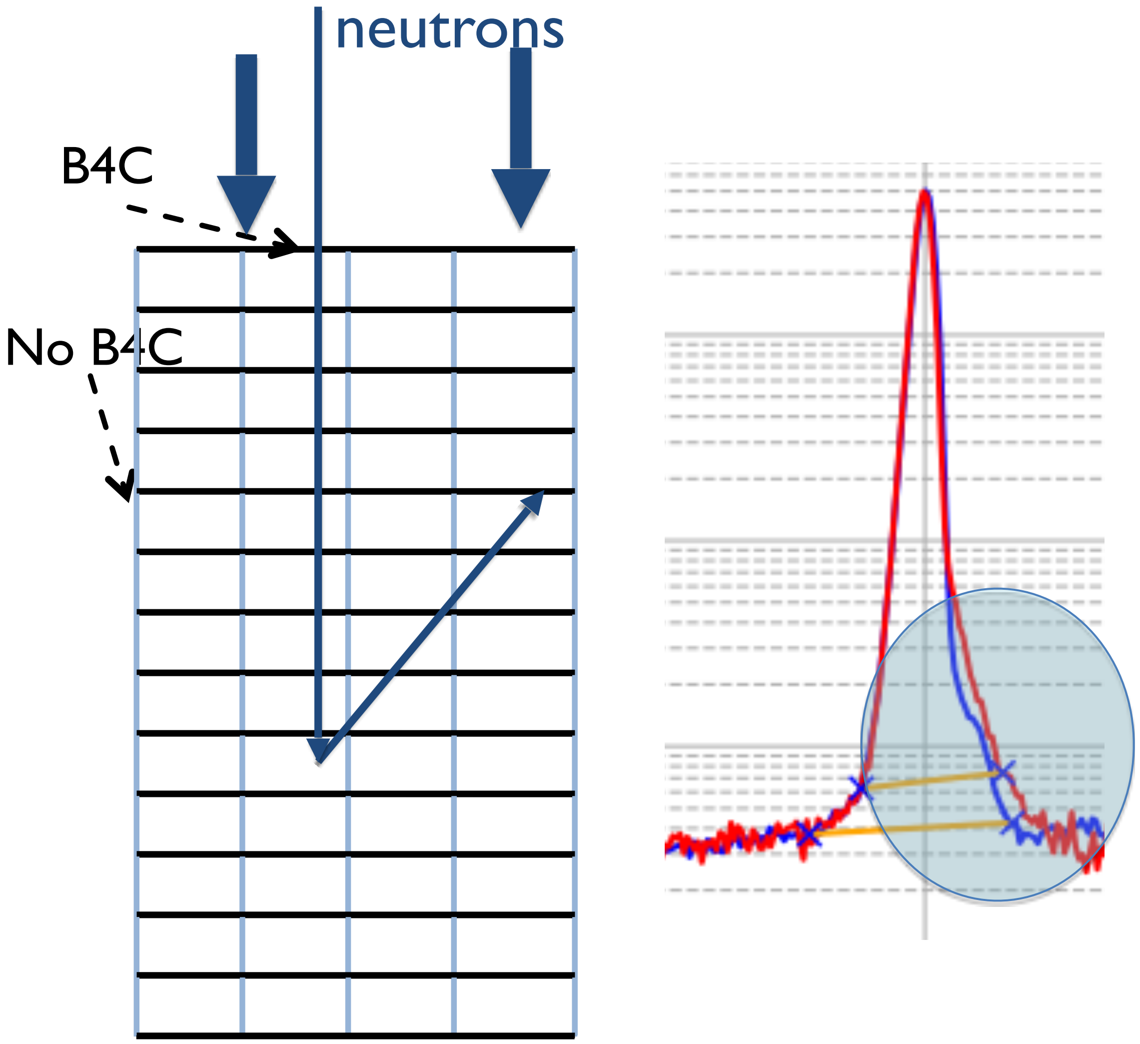
Subjects of concern to CSPEC: Quasi-Elastic Lineshape

To be able to determine how well this is solved, you defined a Figure of Merit (FOM): The integral of counts between 3 and 5 gaussian sigma from the centre of the elastic line, divided by the total integral of the elastic line data.

The relative FOM of MG compared to He-3 can thus be defined as:

$$\mathrm{FOM}_{\mathrm{MG/He\text{-}3}} = \frac{\mathrm{FOM}_{\mathrm{MG}}}{\mathrm{FOM}_{\mathrm{He\text{-}3}}}$$

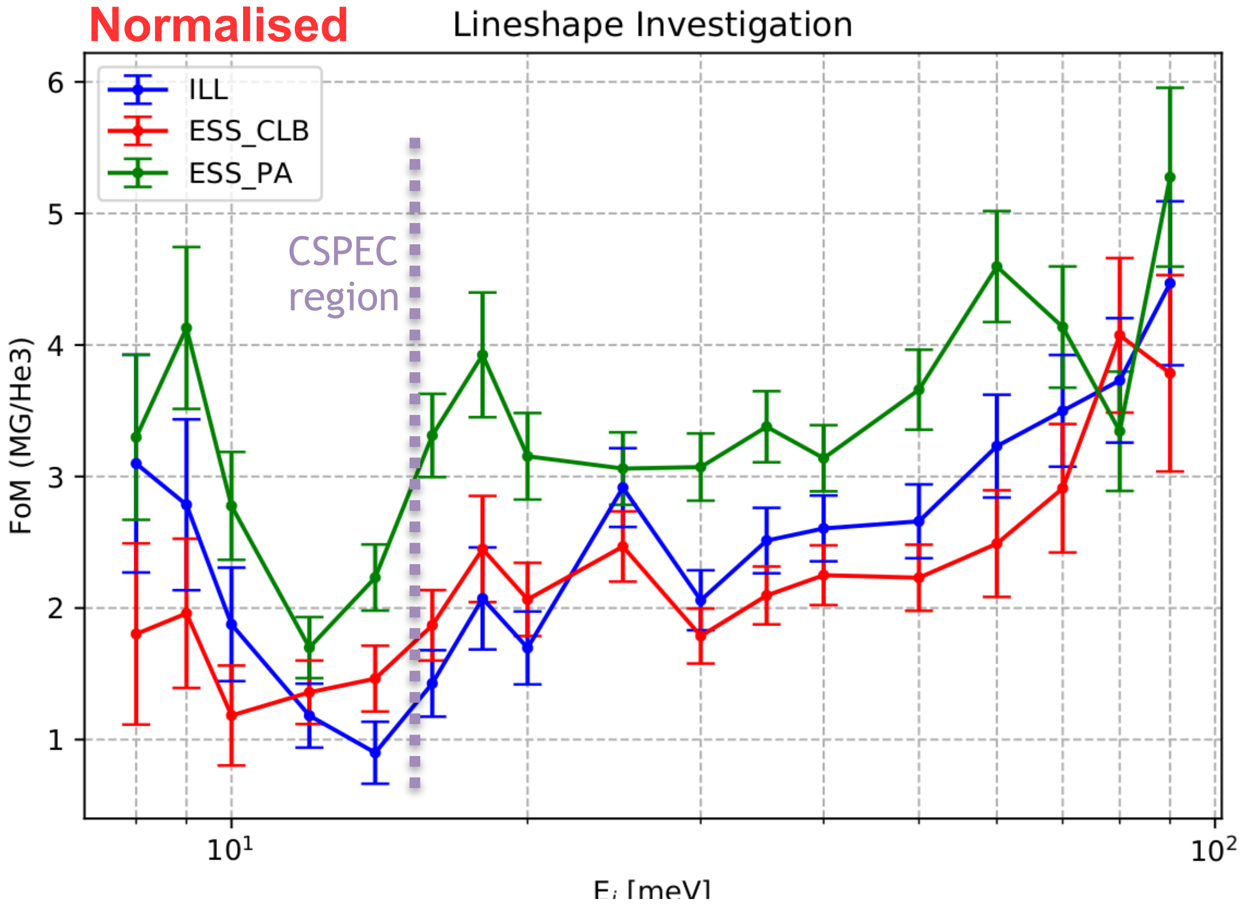
A lower figure of merit is better than a high one. 1.0 means that the performance is equal to Helium 3.

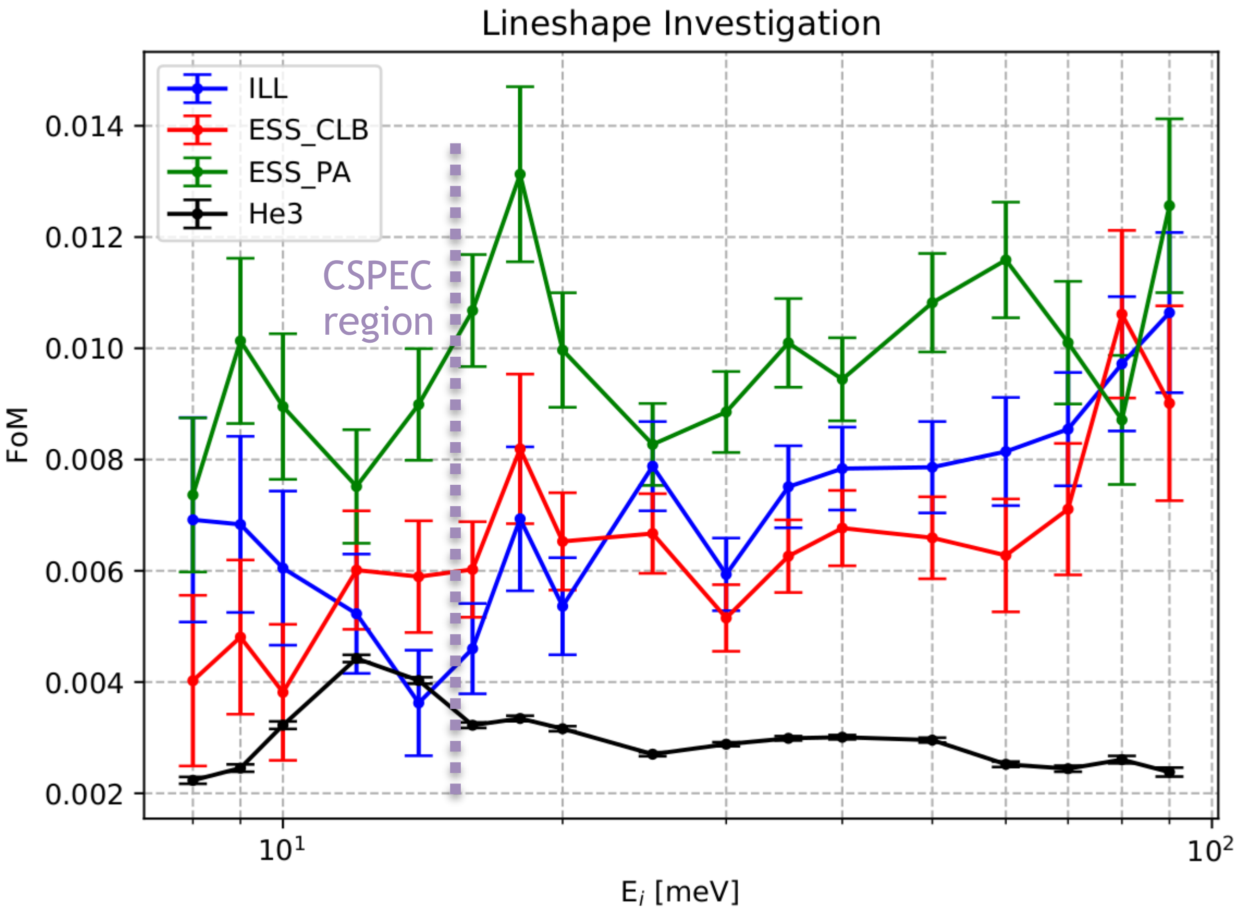


Subjects of concern to CSPEC: Quasi-Elastic Lineshape
FOM: Coated VS non-Coated Radial Blades

EUROPEAN SPALLATION SOURCE

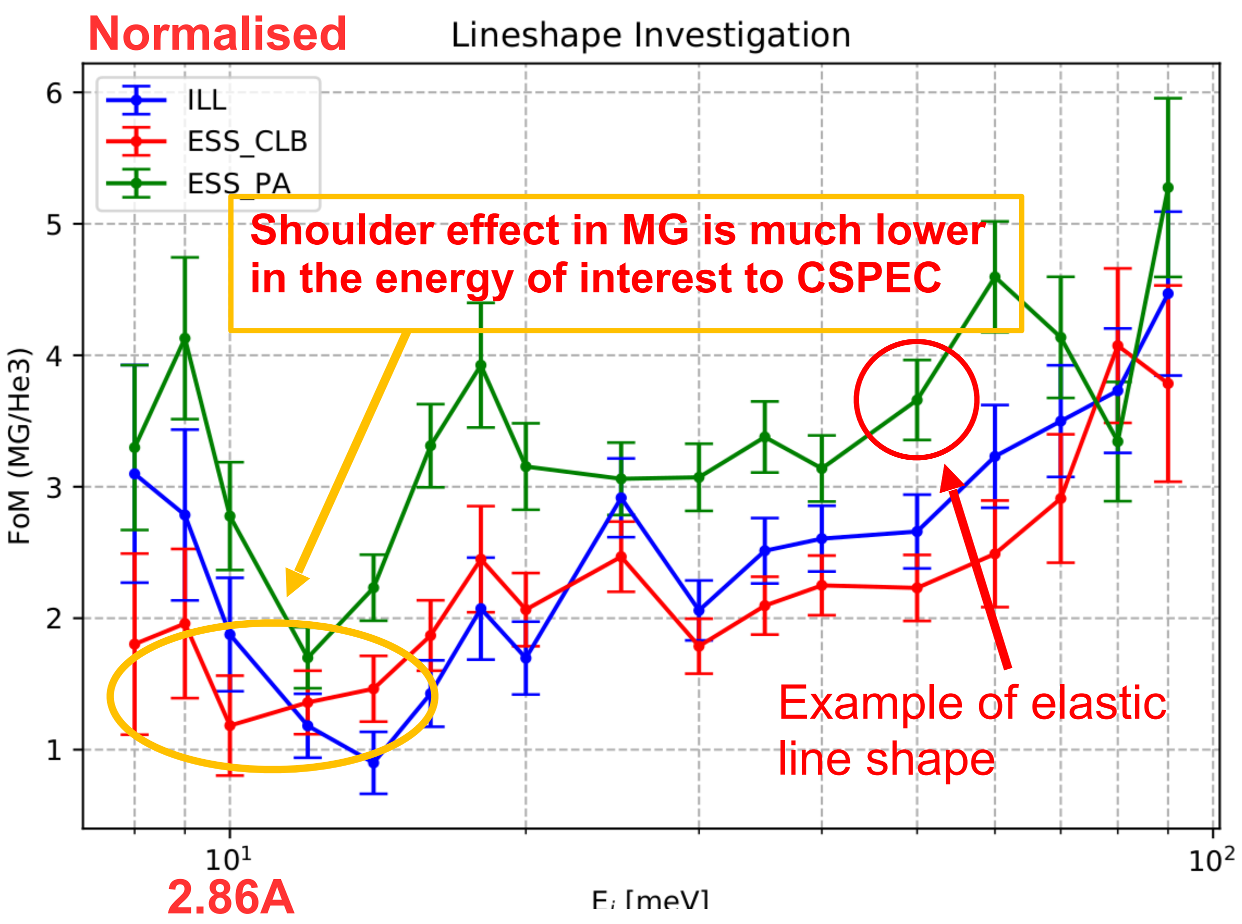
Normalised





- Radial Blades will be coated for CSPEC

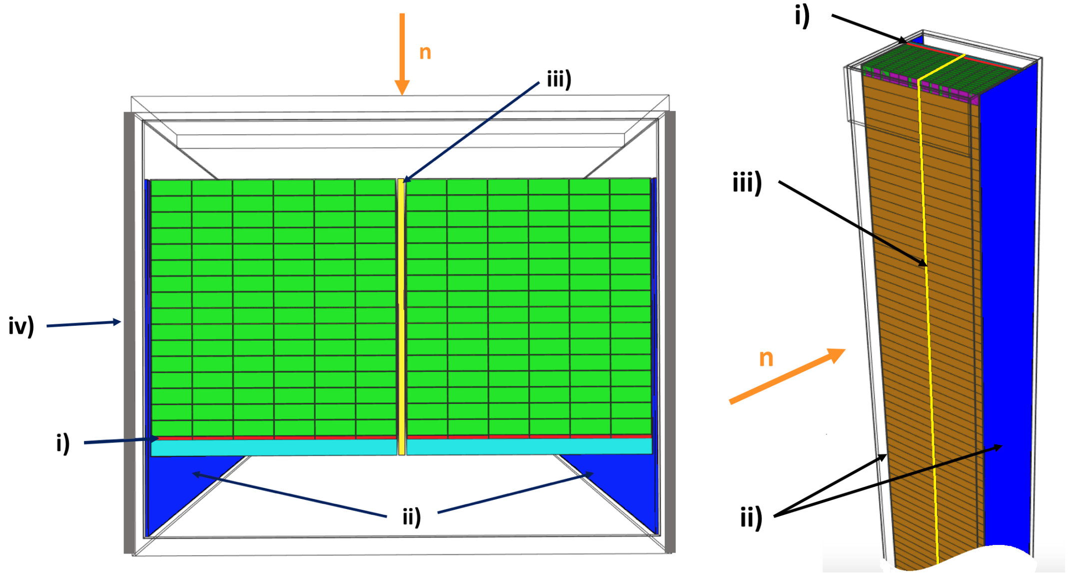
Subjects of concern to CSPEC: Quasi-Elastic Lineshape
FOM: Coated VS non-Coated Radial Blades



Configuration	Relative F.O.M (MG/He3)
No Radial Blade Coating (MG.SEQ data)	3-4
Radial Blades 1um coating (MG.SEQ data)	1.2-2.0
Improved Shielding (Simulations)	0.8-1.3

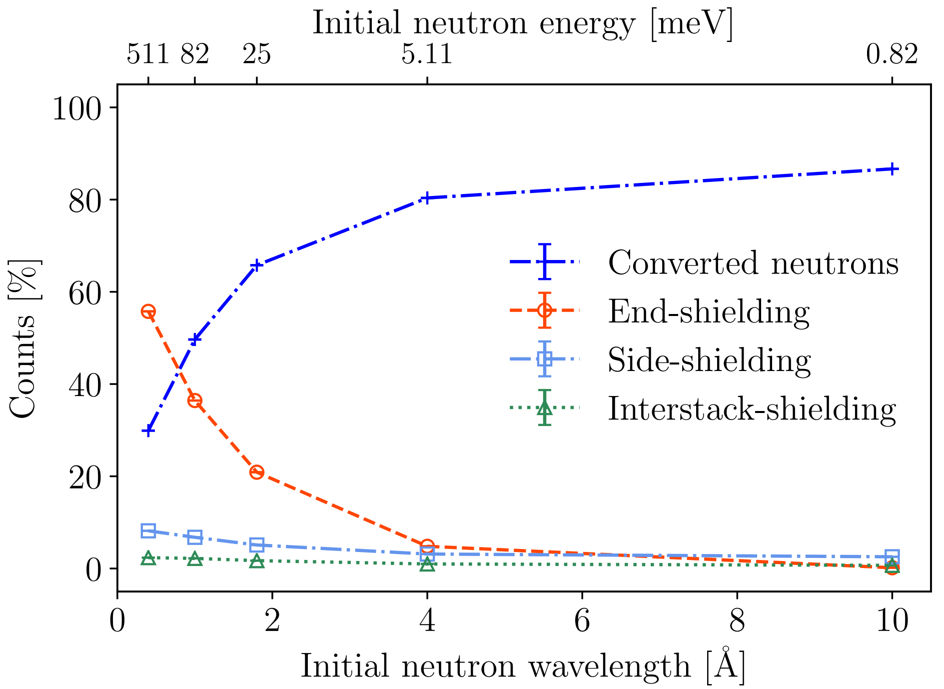
There is 20% less material in the CSPEC design than the SEQ design which means that you would expect 20% less excess from CSPEC wrt the numbers quoted here.

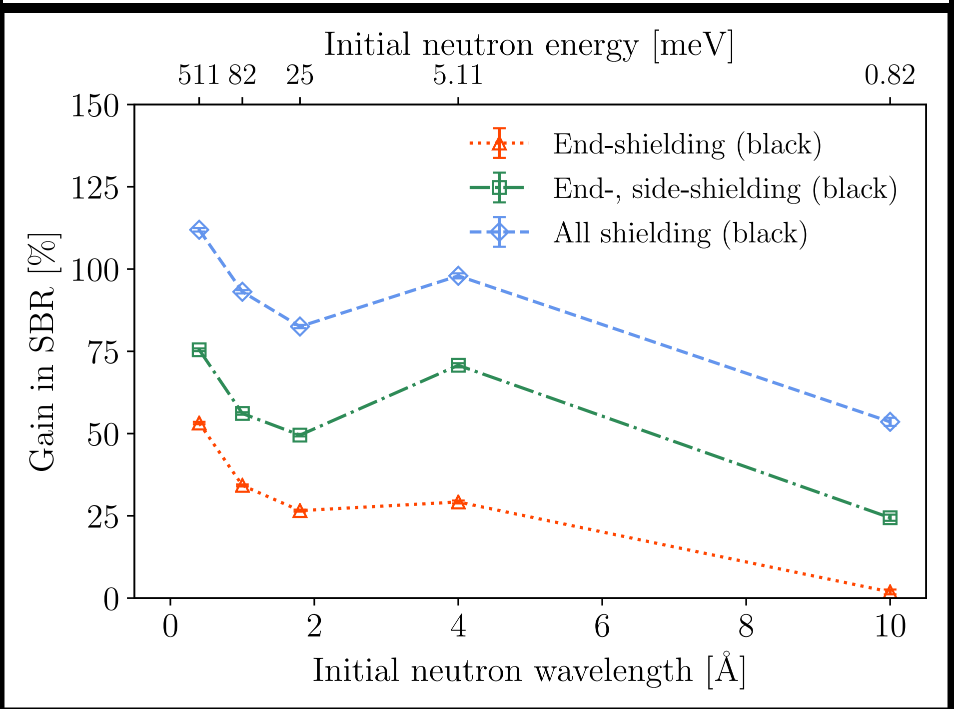
- Radial Blades will be coated for CSPEC



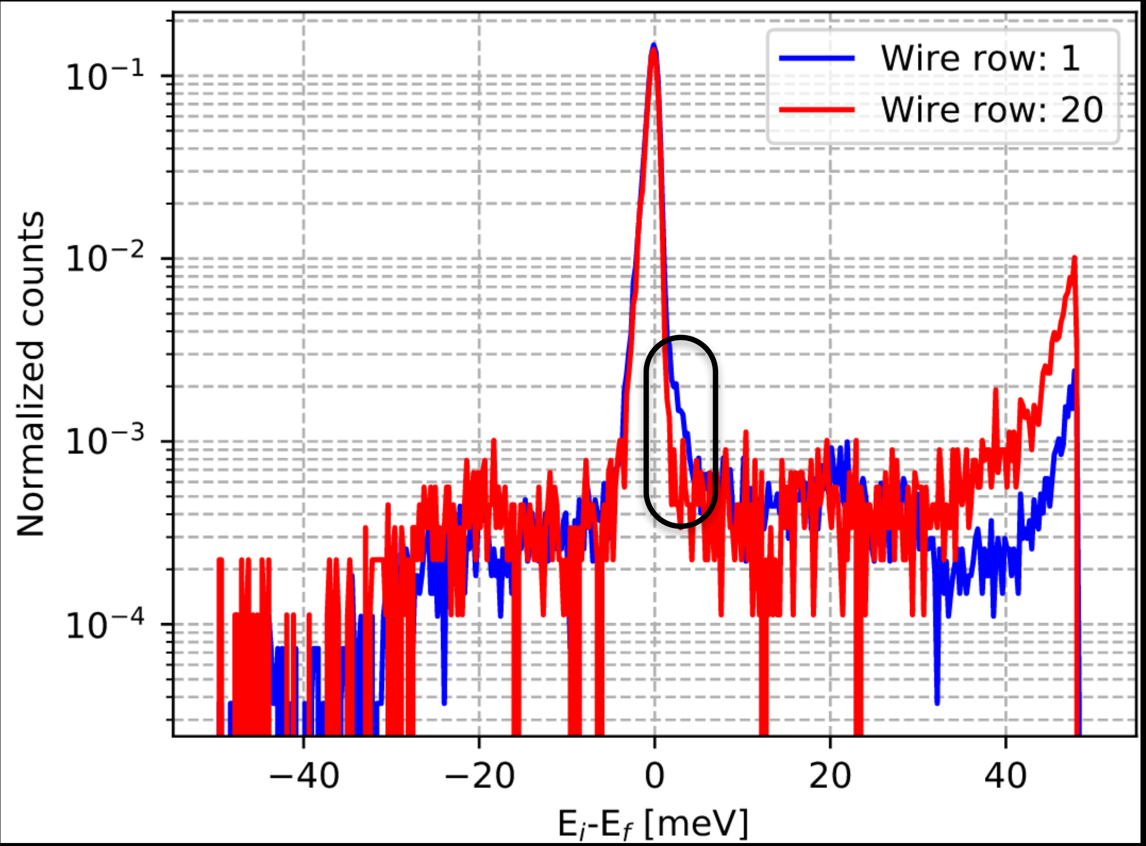
(a) (b)

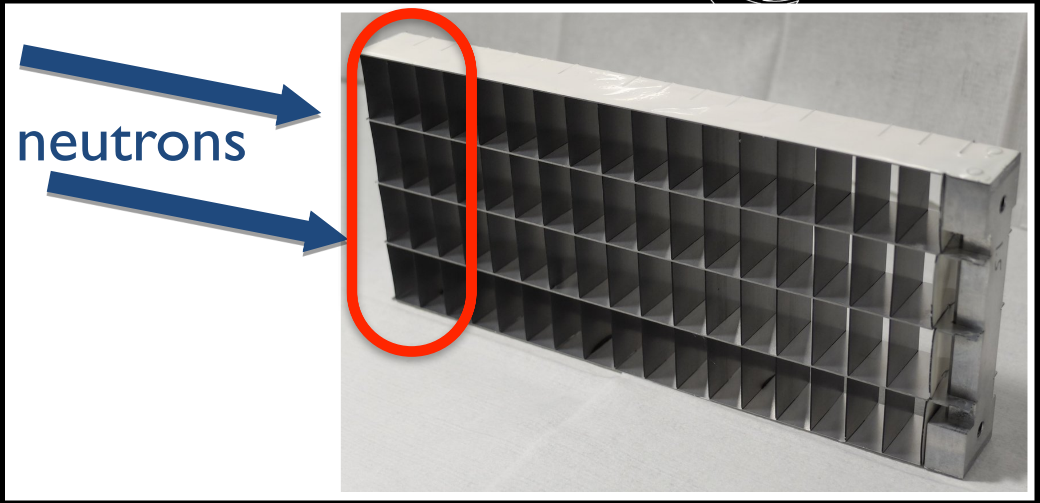
Figure 6.4: Shielding elements in Multi-Grid detector module geometry. Top view (a) and side view (b) with the studied shielding topologies marked with: red for *i)* 'End-shielding', blue for *ii)* 'Side-shielding', yellow for *iii)* 'Interstack-shielding' and grey for *iv)* 'External vessel-shielding'. (Only marked in a for better visibility.) Counting gas is shown in green, the grid is brown with cyan rear blade, and the incident neutron beam is indicated in orange.





Elastic Line Shape: Worst case scenario: mitigation by running mode





- Worst case scenario:
- This line shape excess only occurs in the first couple of wires/cells
- By filtering the data, it can be removed
- Event mode data: all information on cell/voxel is retained
- “A quasielastic studies line shape filter” can be applied seamlessly on the data stored

- Effect: Ca. 10% of events
- Only affects experiments where this is a core part of the investigation
- i.e. 10% effect, on fraction of experiments
- In comparison, He-3 saturation will introduce problematic data into >50% of experiments, and is difficult to filter

AmCLD detector for BEER Instrument

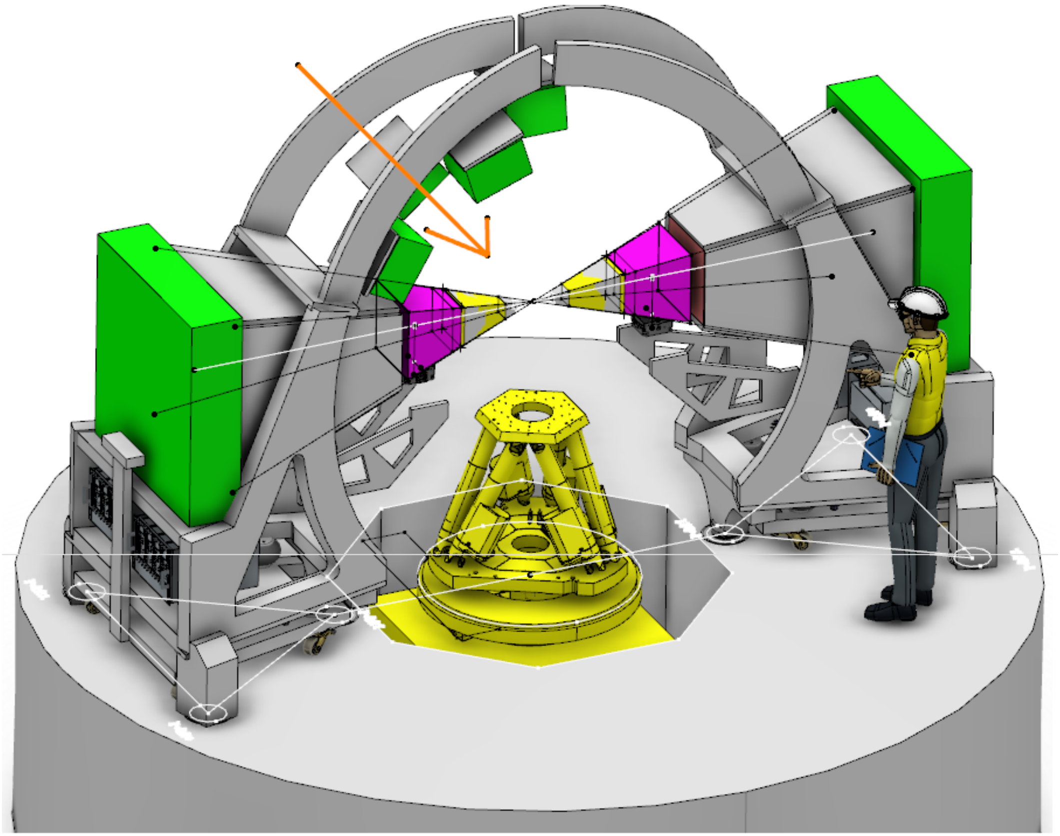
Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

AmCLD detector for BEER Instrument

EUROPEAN SPALLATION SOURCE

Diffraction detector requirements:

- sample-detector distance: 2 m:
- active area: 1 m x 1m
- efficiency: η > 60 % (@ 2 Å)
- position resolution: 2 mm x (5 mm)
- max. countrate:< 10^6 Hz (global)
- mobile design (max. 800 kg)
- price < 3He-technology



Development started 1 year ago after considerable delay due to in-kind administrative problems

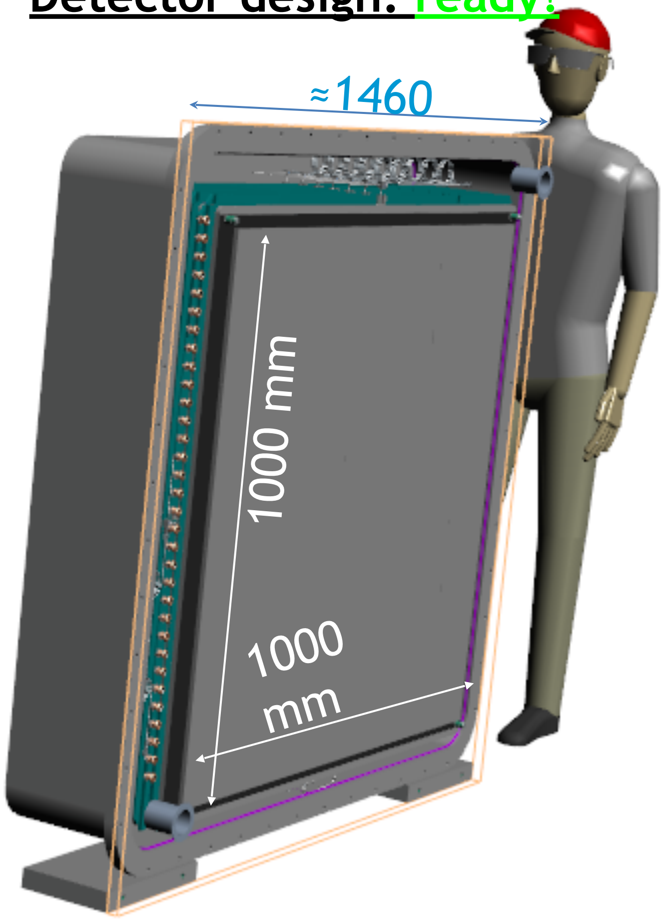
Schedule is tight but feasible for delivery, if development schedule is kept

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

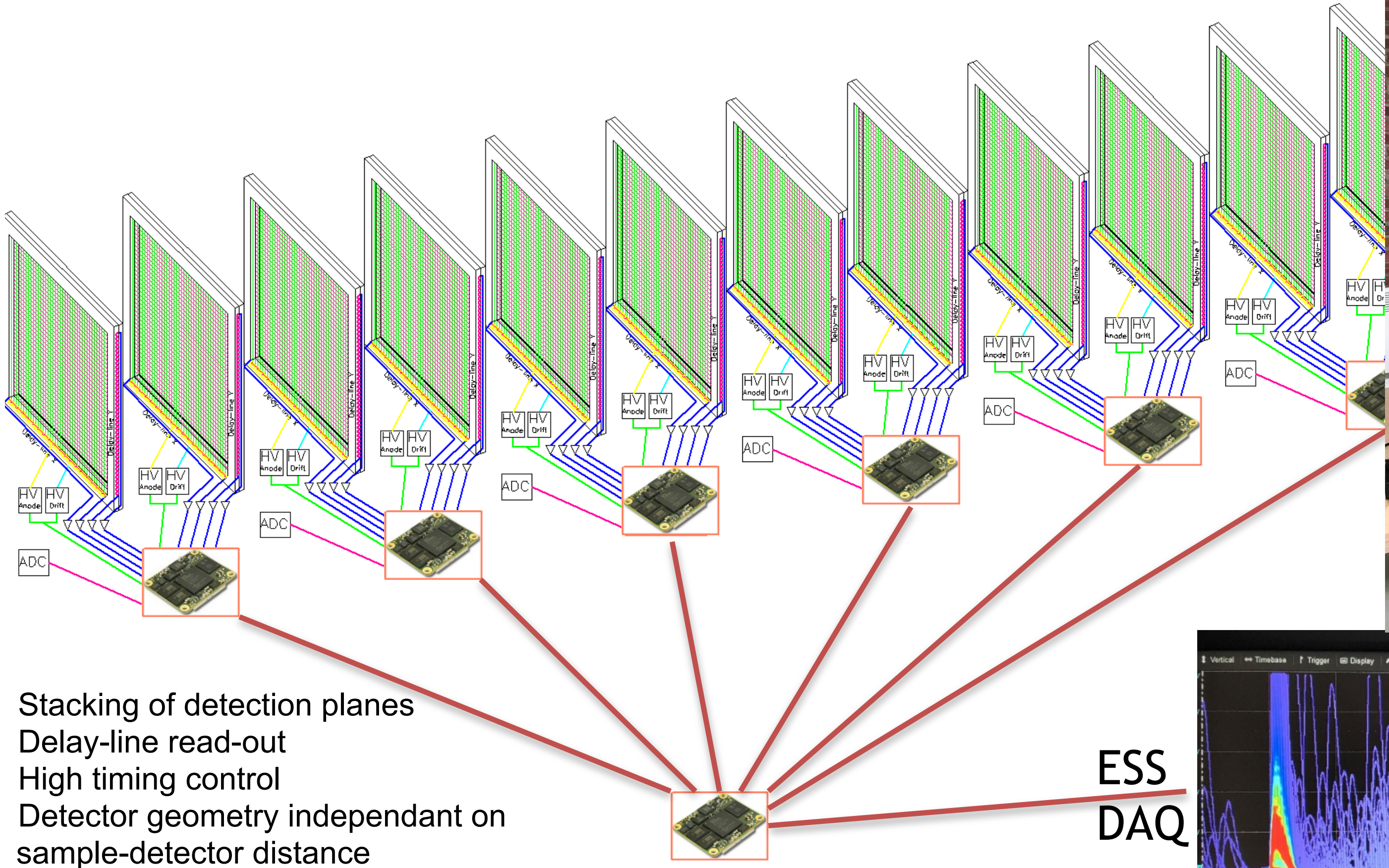
AmCLD detector for BEER Instrument

EUROPEAN SPALLATION SOURCE

Detector design: ready!



-weight: currently 600 kg

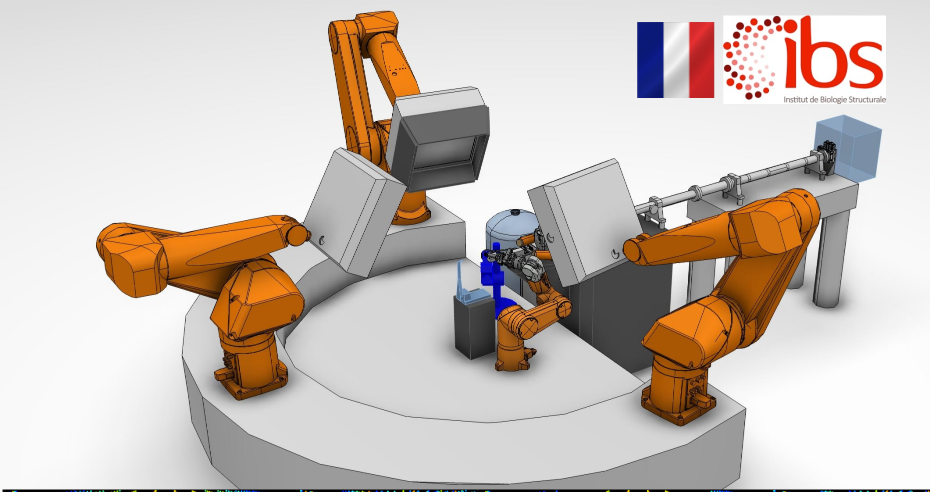


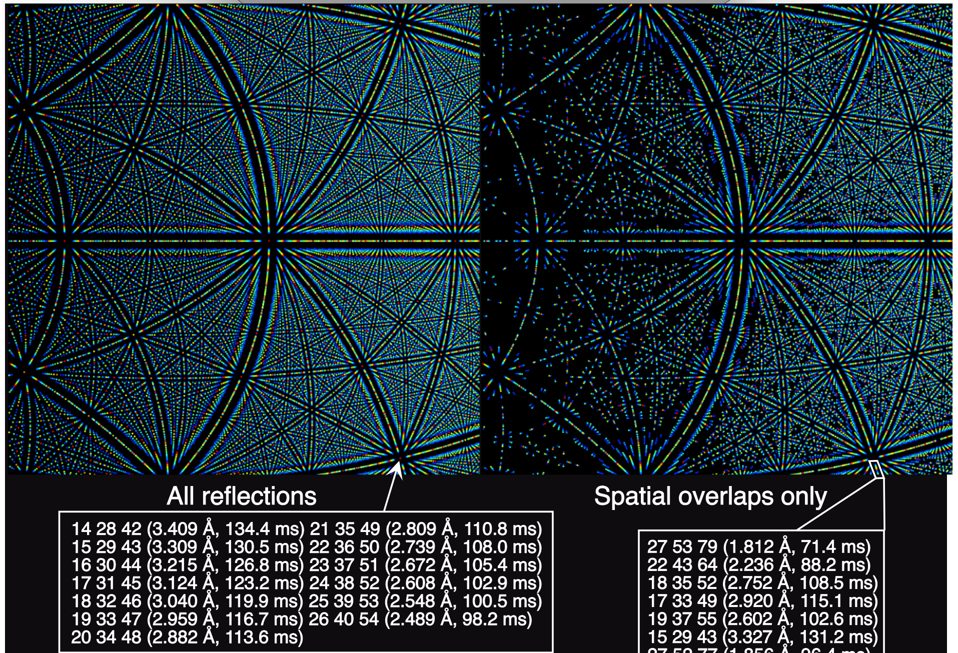
Stacking of detection planes
Delay-line read-out
High timing control
Detector geometry independant on sample-detector distance

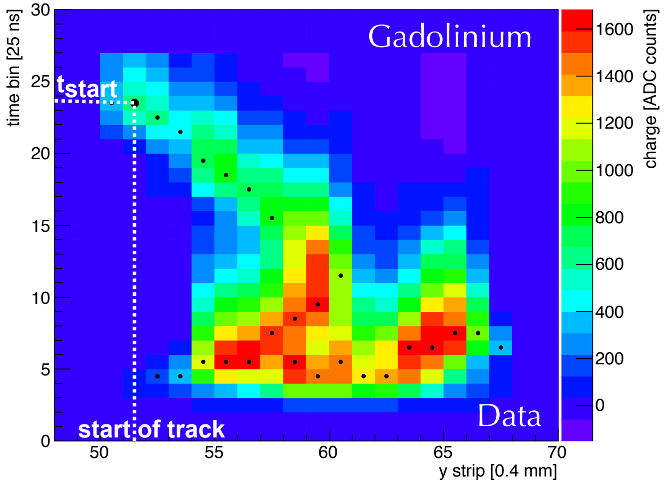
Some development to go
But key engineering risks addressed

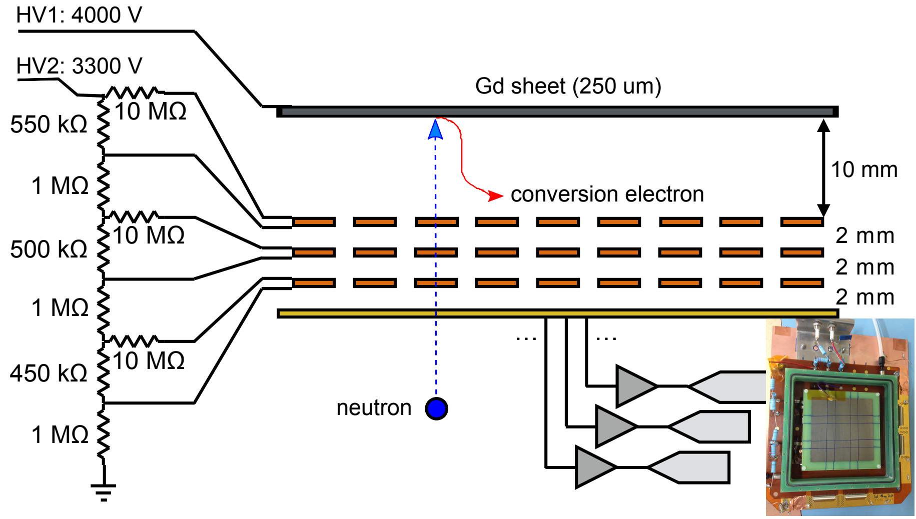
Neutron Macromolecular Crystallography: NMX

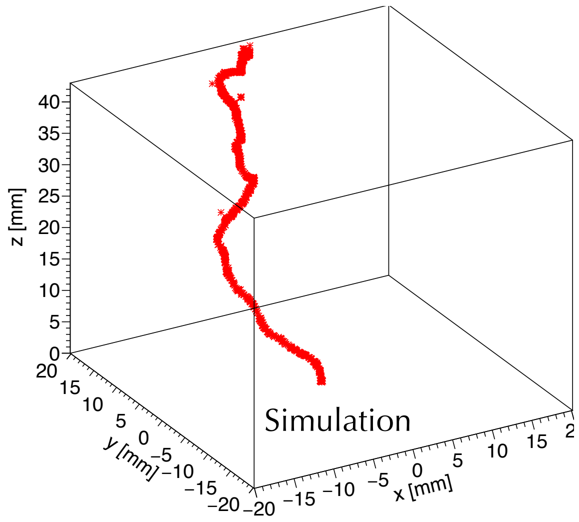
NMX Instrument



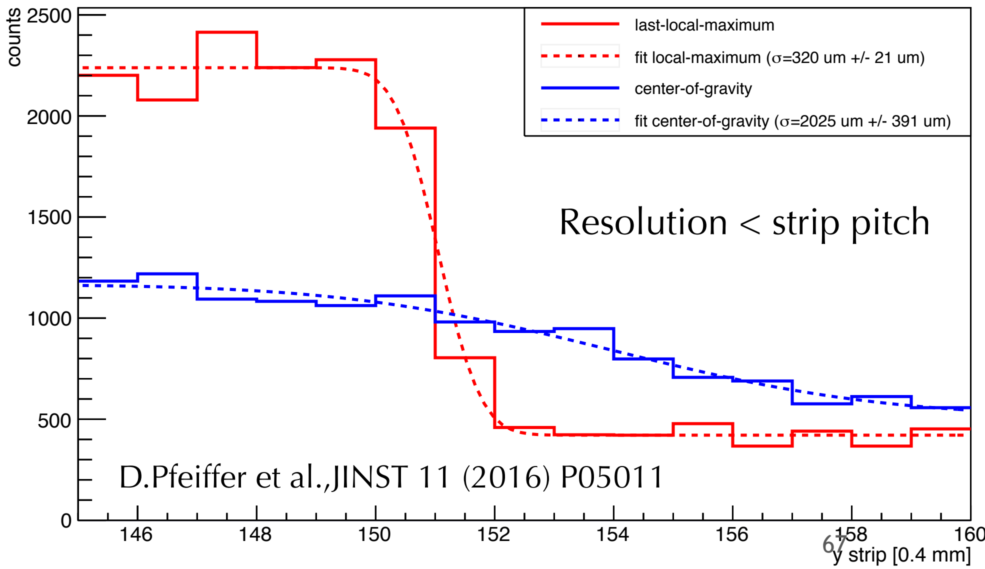




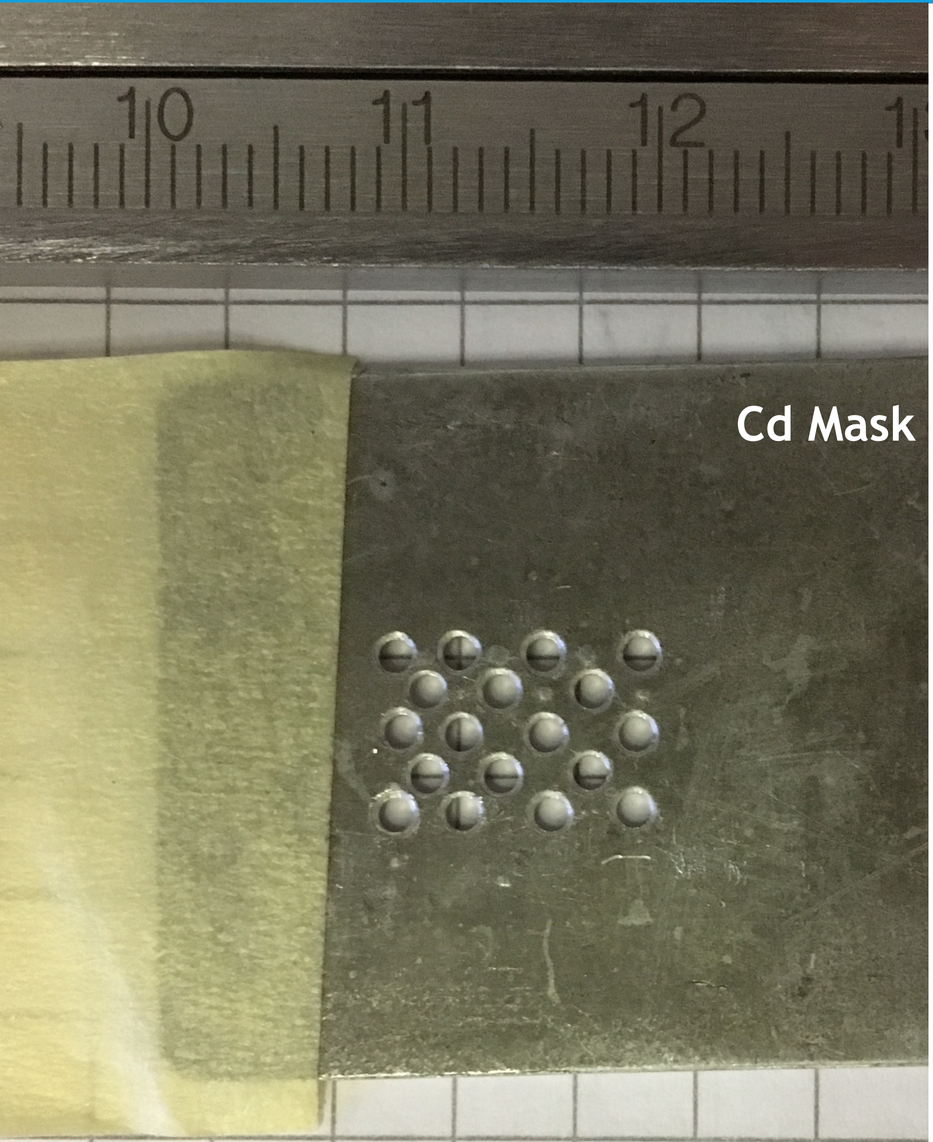




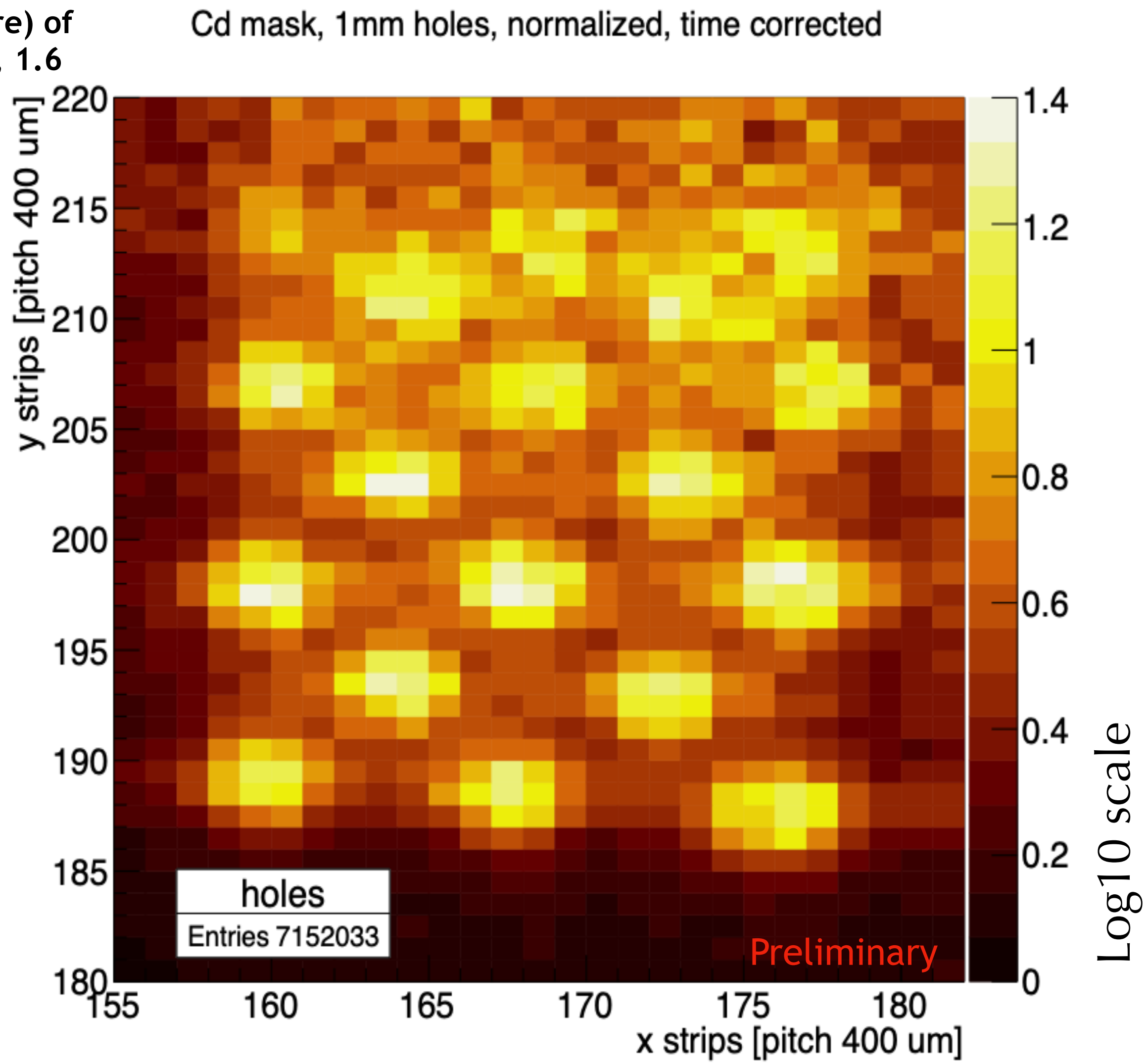
Method: JINST 10 (2015) P04004



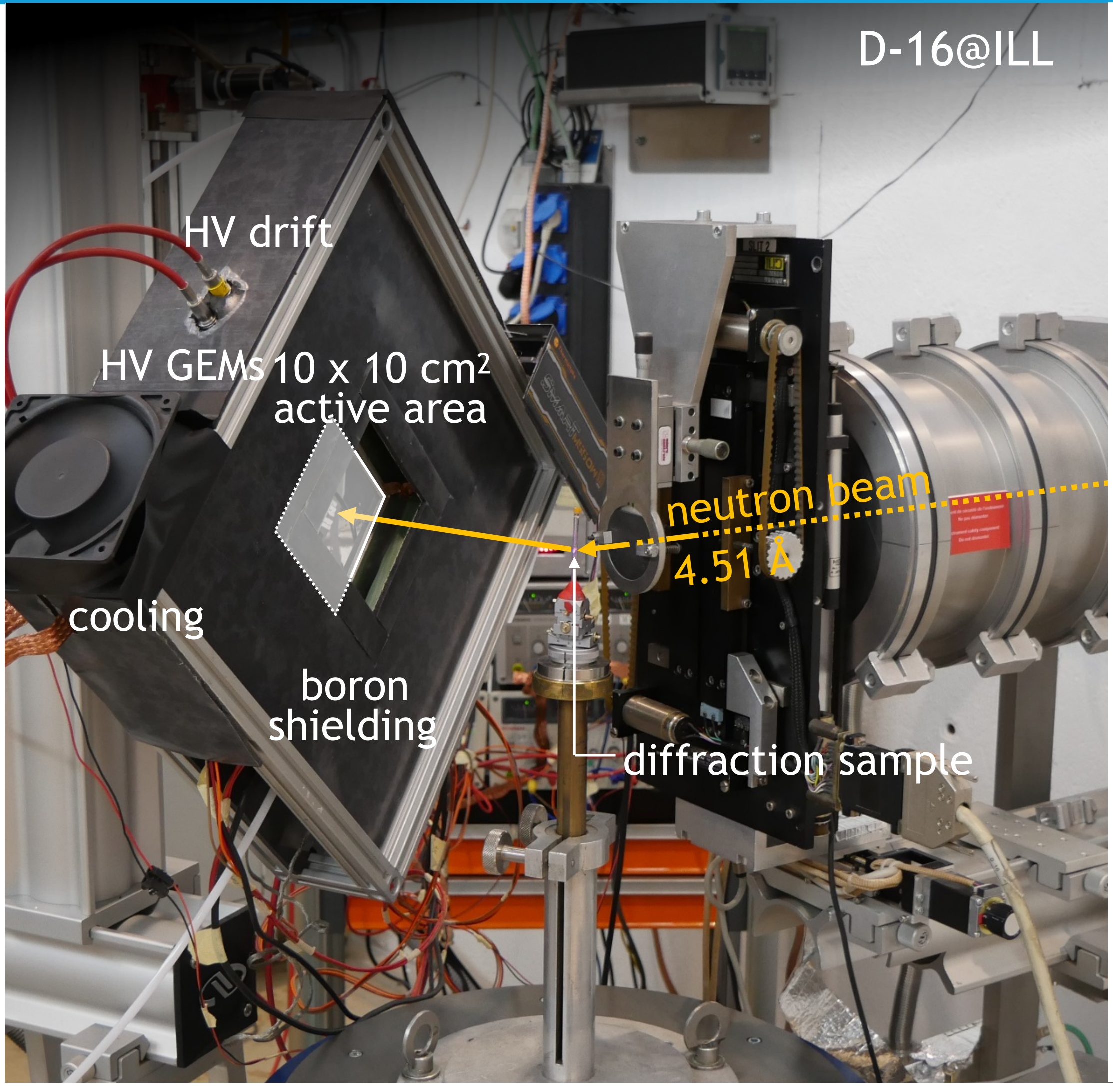
Gd-GEM Detector Demonstrator@BNC

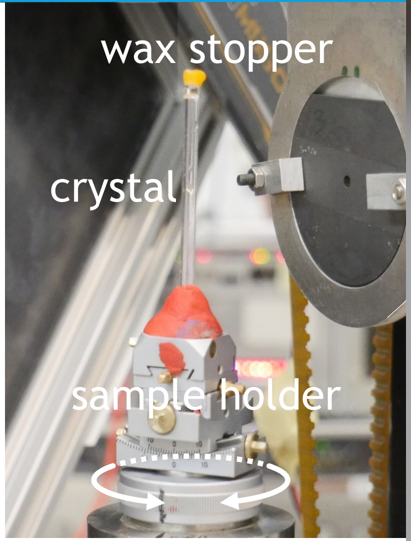


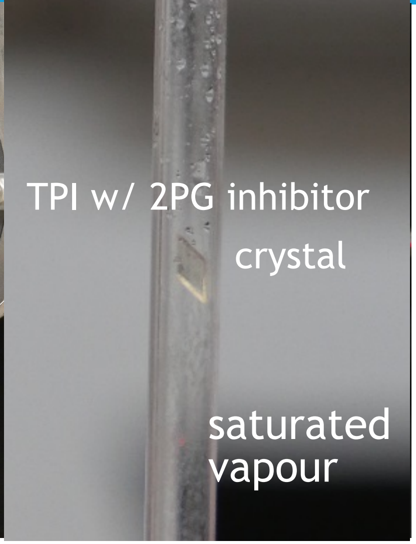
The holes have a minimum separation (centre to centre) of about 2.0 mm horizontally, 1.6 mm vertically, and 1.3 mm diagonally.

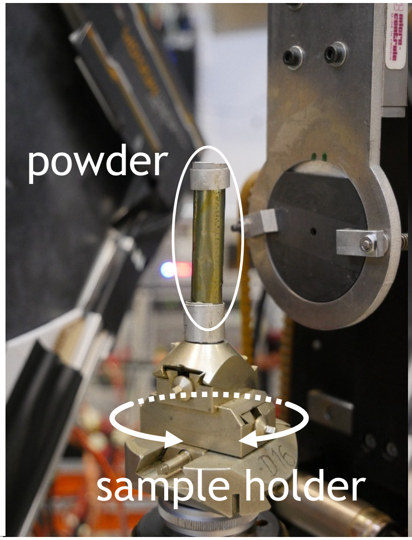


Gd-GEM Detector Demonstrator@ILL

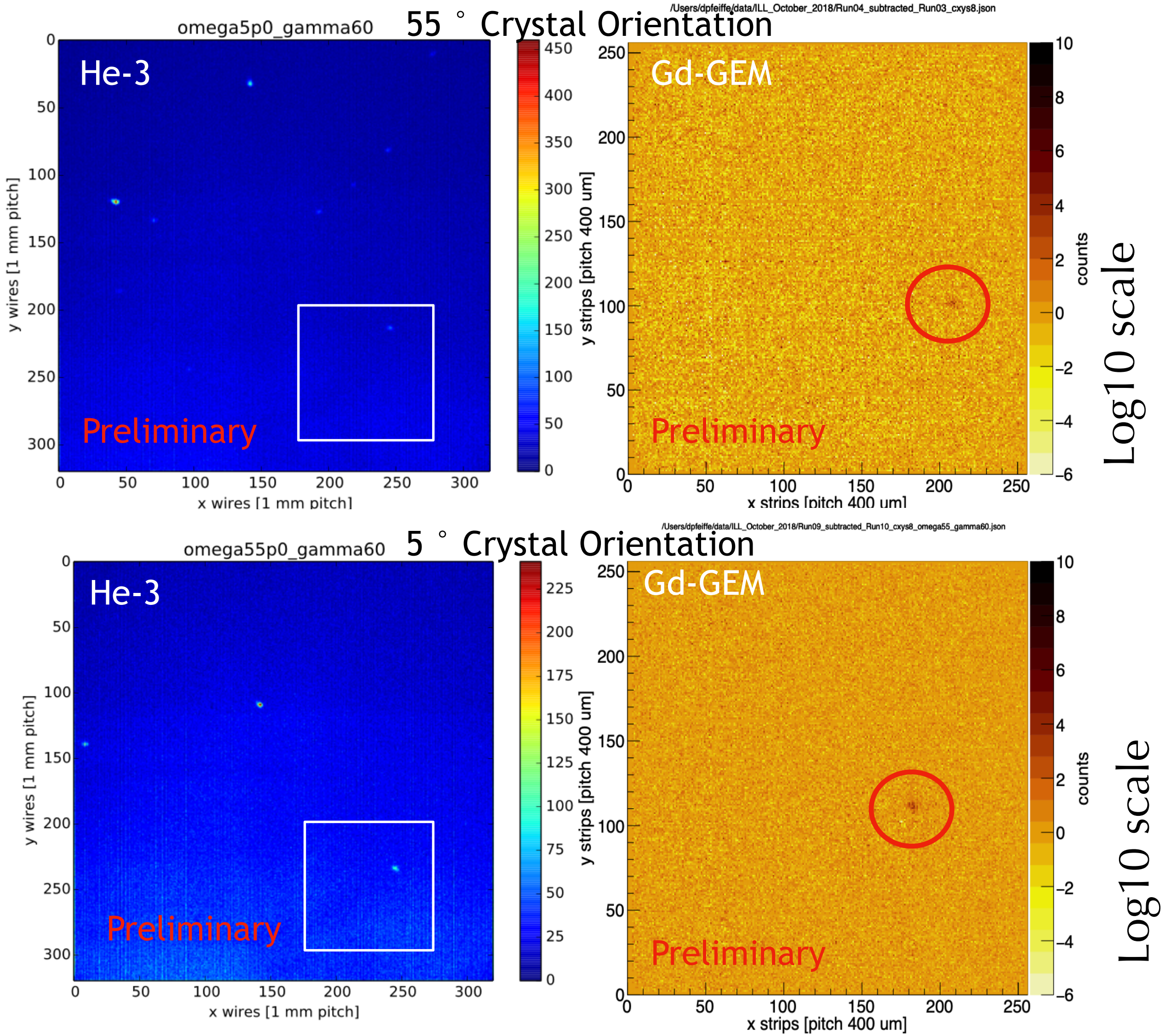








Gd-GEM Detector Demonstrator@ILL



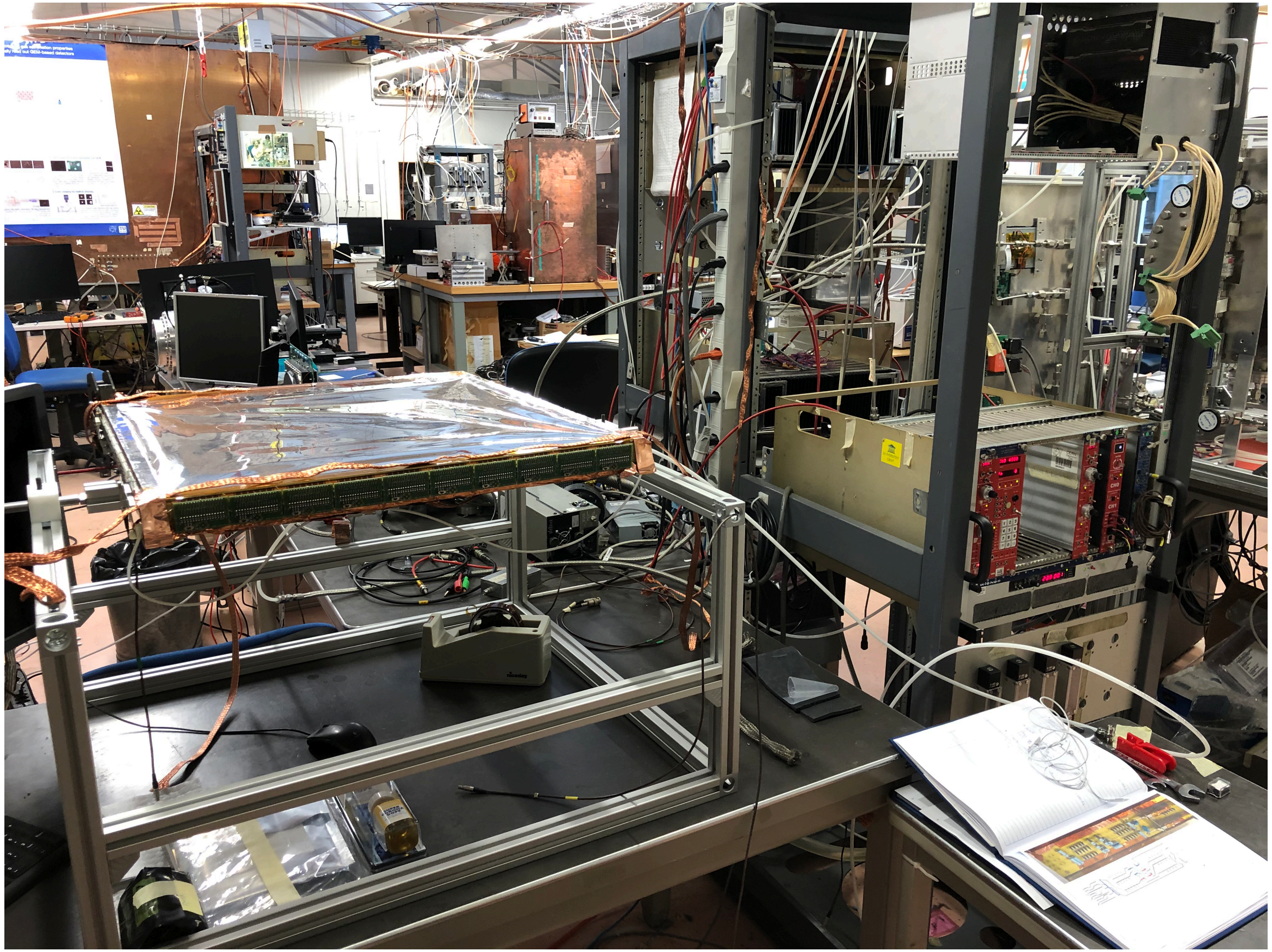
Sample crystal: Triose phosphate isomerase w/ 2 - phosphoglycolate (2PG) inhibitor

- Weak reflections seen
- S:B equivalent to that in He-3 detector

Gd-GEM Detector Demonstrator

- Full-size Demonstrator of 1 panel exists
- Testing started at CERN last week
- Full test on neutron beam line next year

- At that point, detector is ready to be built



Summary

- Overview of status of detectors for instruments
- Detectors are now a regular project risk for instruments rather than an extraordinary risk

- Development is (basically) complete
- Some testing to understand performance and integration still happening in coming year

- Detector build programme starting
- Well-developed designs and project plans
- Schedules will be closely monitored
- Installation and commissioning will be tight