brightness

EUROPEAN SPALLATION SOURCE

GA Meeting

Work Package 4: Innovation of key neutronic technologies: Detectors and Moderators

Richard Hall-Wilton, Work Package Manager

- The goal of BrightnESS was risk reduction for ESS
- The goal of the WP was technological risk reduction for key technologies
- Validating and realising these technologies
- Taking novel technologies selected for ESS from “Technological Readiness Level” 3-5 to 8-9
- Aim: helping a smooth start for ESS scientific output
- Timeline: September 2015 – June 2018

NEUTRONS FOR SCIENCE

CERN

LUND UNIVERSITY

IEAP

CZECH TECHNICAL UNIVERSITY IN PRAGUE

Mittuniversitetet MID SWEDEN UNIVERSITY

WIGNER

ESS bilbao

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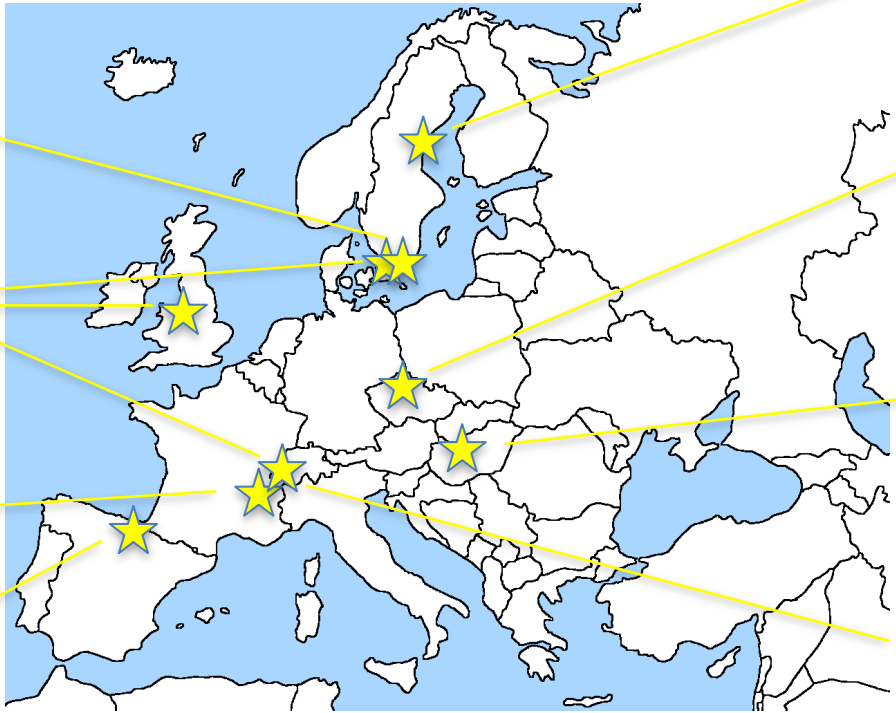
WP4 Partners



- ESS-Bilbao joined WP4 in 2017

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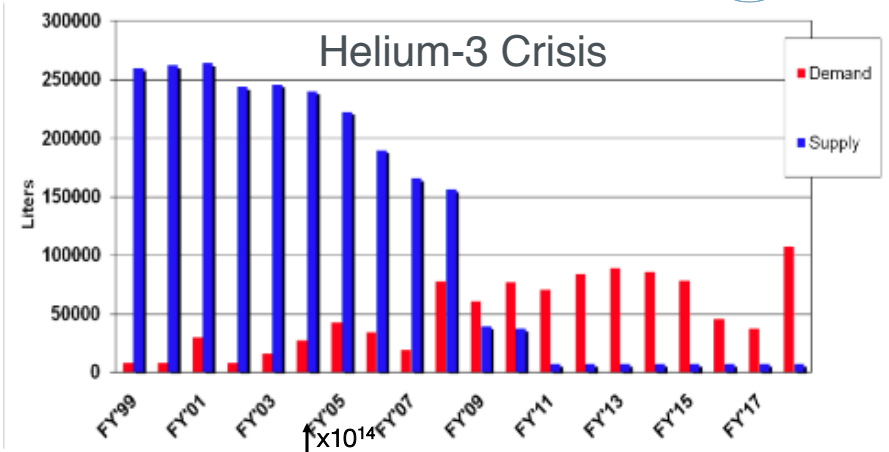
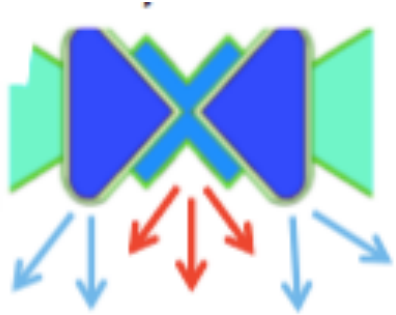
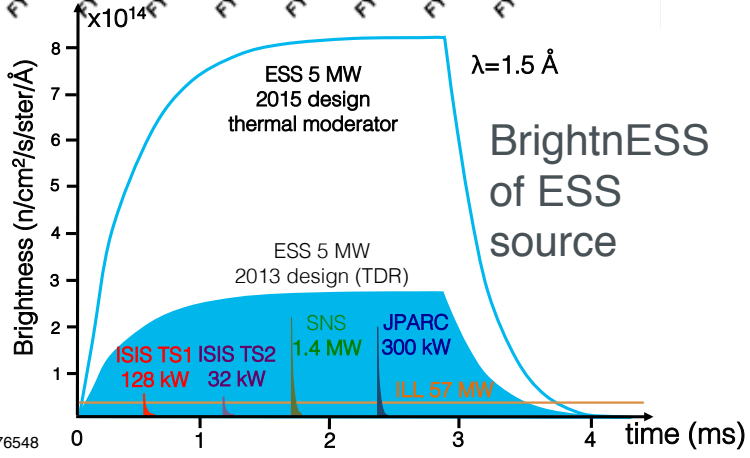
The Technical Challenge





Engineering Low Dimensional Moderators



BrightnESS of ESS source

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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

Task 4.1
"The Resolution Challenge"

Task 4.2:
"The Intensity Frontier"

Task 4.4: "Detector Realisation"

Task 4.3:
"Realising Large Area Detectors"

Developments required for detectors for ESS

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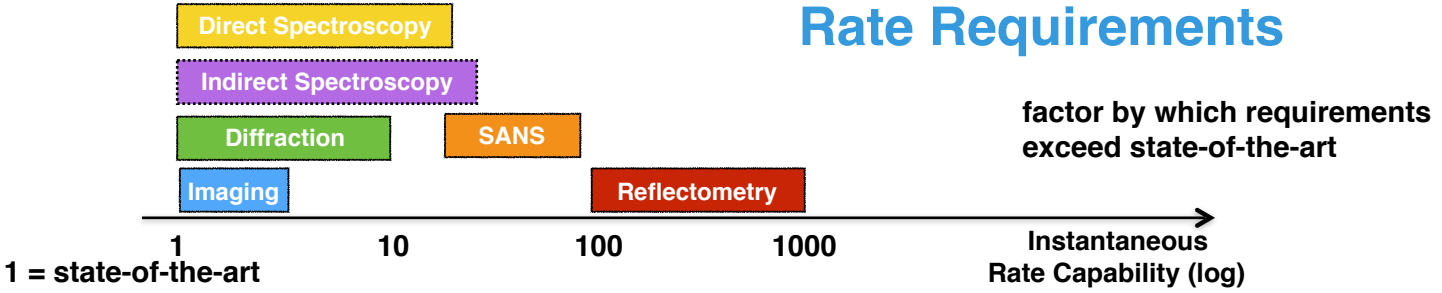
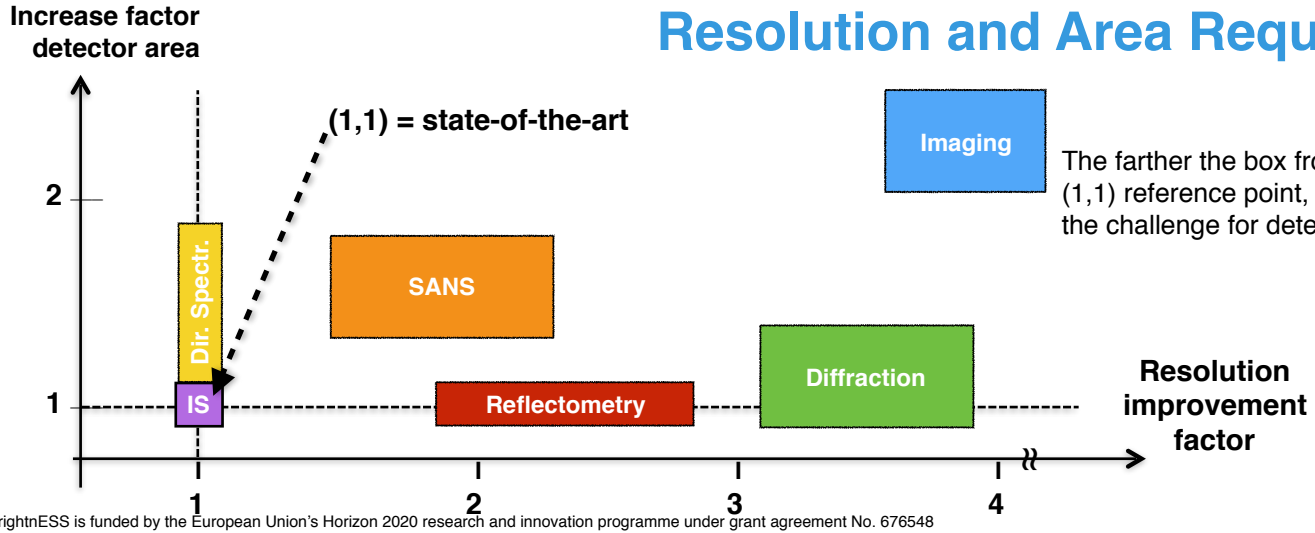
Requirements Challenge for Detectors for ESS: beyond detector present state-of-the art

Rate Requirements



Resolution and Area Requirements



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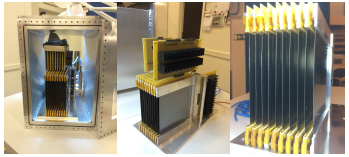
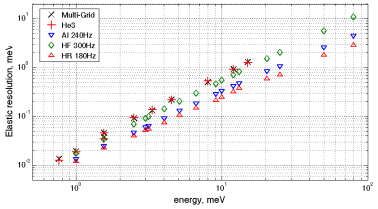
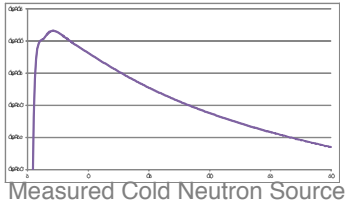
Overview of WP



MB 2015 prototype built and tested in BNC



Instrument energy resolution using MG compared to He3



Measured Cold Neutron Source Brilliance

- WP4 aim for the disruptive innovation in terms of the development and integration of neutron detectors and moderators currently needed directly and indirectly for 9 current and future ESS Instruments.
- Timeline: September 2015 – August 2018
- Purpose of Tasks:
  - Task 4.1: The Resolution Challenge
  - Task 4.2: The Intensity Frontier
  - Task 4.3: Realising Large Area Detectors
  - Task 4.4: Detector Realisation
  - Task 4.5: Moderator Testing and Beamline Development

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WP4: Project Management

- Work Package Manager: Richard Hall-Wilton
- Deputy Work Package Manager: Judith Freita-Ramos
- Purpose of Tasks:
  - Task 4.1: The Resolution Challenge. Task leader: Michael Lupberger (CERN)
  - Task 4.2: The Intensity Frontier. Task leader: Francesco Piscitelli (ESS)
  - Task 4.3: Realising Large Area Detectors. Task Leader: Anton Khaplanov (ESS)
  - Task 4.4: Detector Realisation. Task Leader: Hanno Perrey (Lund U)
  - Task 4.5: Moderator Testing and Beamline Development. Task Leader: Laszlo Rosta (Wigner)

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WP4 Status

- 12 (of 15) deliverables complete
- 18 (out of 20) milestones achieved
- Budget will be spent according to consortium agreement
- On track: expected to complete by 31.8.2018

Status of KPIs from WP4

KPI	Planned number (project)	Actual number (@M32) (Detectors)
Number of publications on neutronic technologies	7	**23 (will be >30 by end of BrightnESS)**
Number of participation in conferences related to neutronic technologies	23 (3 Data + **20** Detectors)	**54**
Number of developed open source software packages	6 (2 Data + **4** Detectors)	**7**
Number of successful simulations	6	**16**

The biggest impact to ESS:

Detectors are now a "normal" risk item

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Activities and results not (yet) achieved

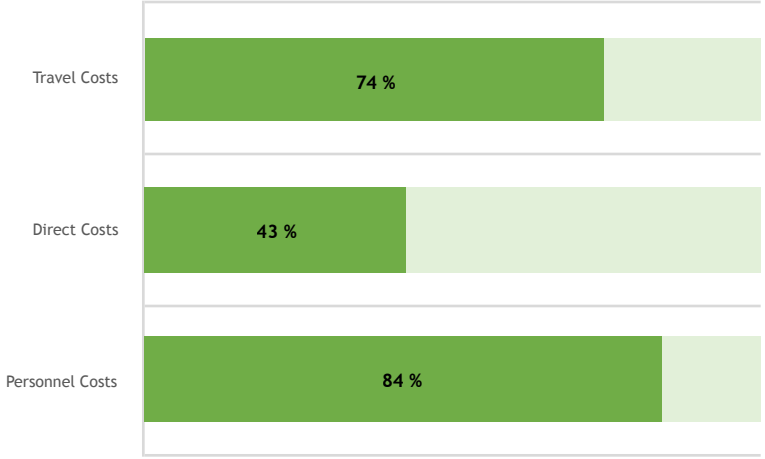
- All activities on track to be completed by 31.8.2018

- Milestones:
- MS28: Task 4.5: Verification of moderator and EPSI components. *Components complete of under fabrication. Expected during July.*
- MS31: Task 4.1: Module of detector ready for deployment. *Expected within 4-6 weeks.*

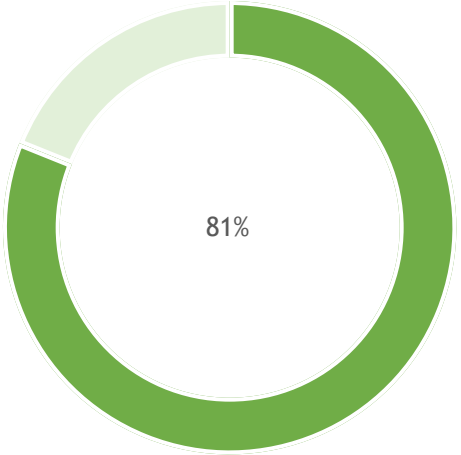
- Deliverables:
- D4.11: Task 4.4: Standardised test procedures for performance of detectors for early ESS instruments. *Work completed. Awaiting writing of report. End July.*
- D4.13: Task 4.1: Module for NMX detector. *Work expected to be complete in 6 weeks. Deliverable in August.*
- D4.14: Task 4.3: Large area detector for spectrometry. *Work complete in <4 weeks. Deliverable end July.*
- D4.15: Task 4.5: Final verification for BRR moderator. *Majority work completed. Final verification in August, deliverable follows.*

Financial Status

- Spent 81% of total at 86% through the project
- On track to spend according to plan
- Will continue to monitor costs towards end of project



Overall spending M1-M31



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Results

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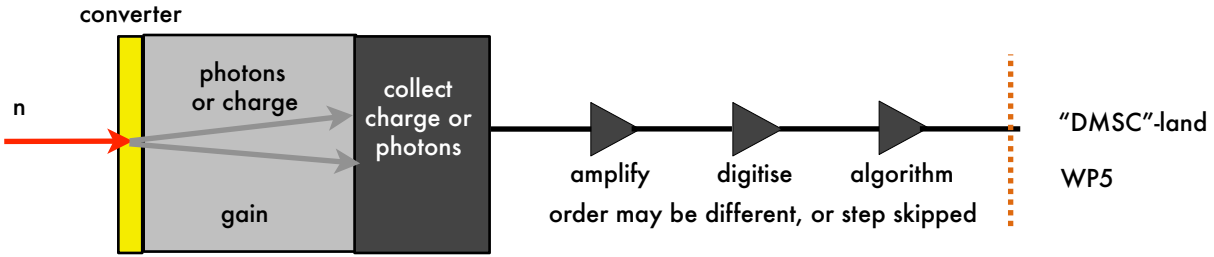
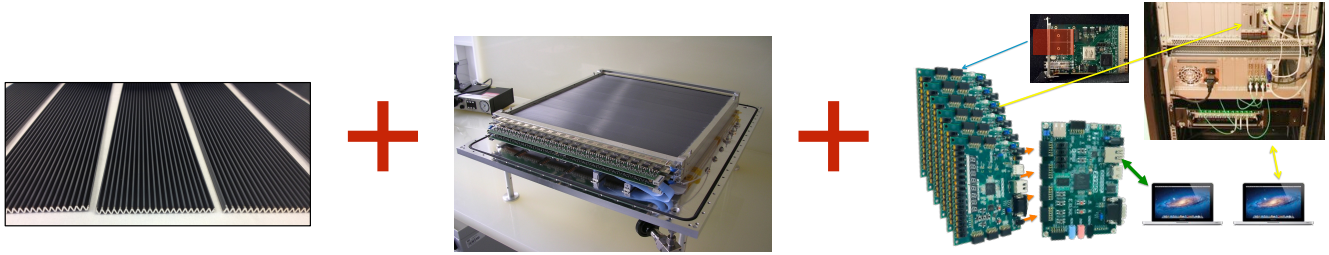
Neutron Detectors

Efficient neutron converters a key component for neutron detectors





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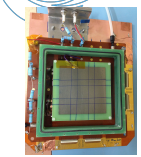
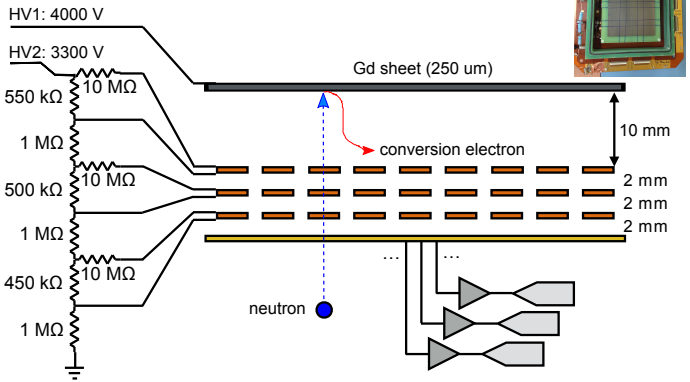
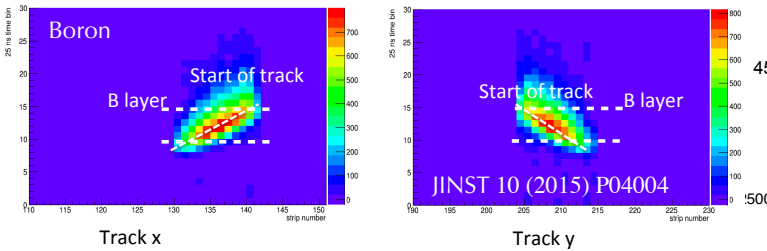
Task4.1: The Resolution Challenge

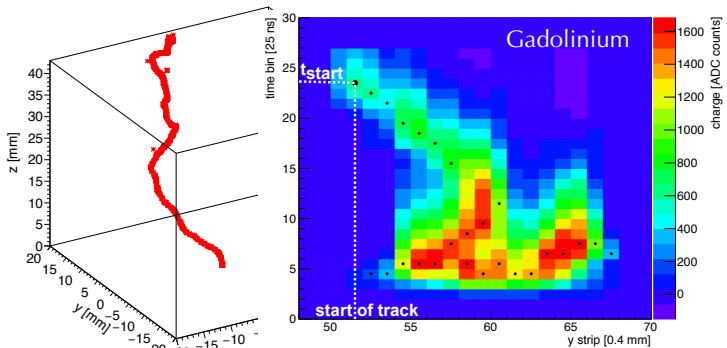
Gd-GEM

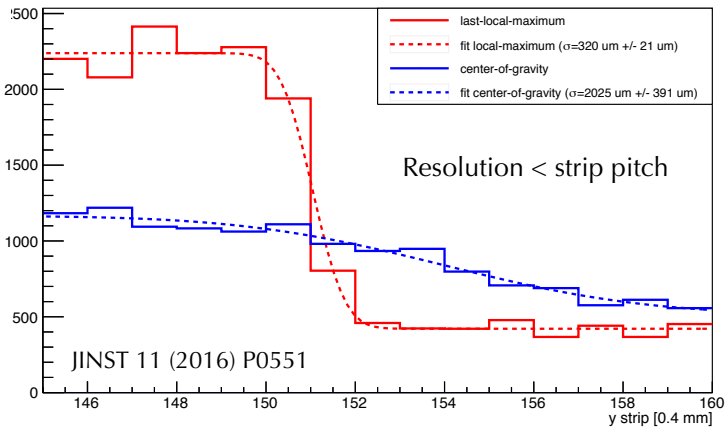
- NMX: <<1mm position resolution requirement, Time Resolved, ca. 1m^2 detector area
- Take Micro Time Projection Chamber concept from CERN ATLAS experiment upgrade
- Resolution: use single layer Gd, look for electrons
- Full-scale demonstrator ready next month











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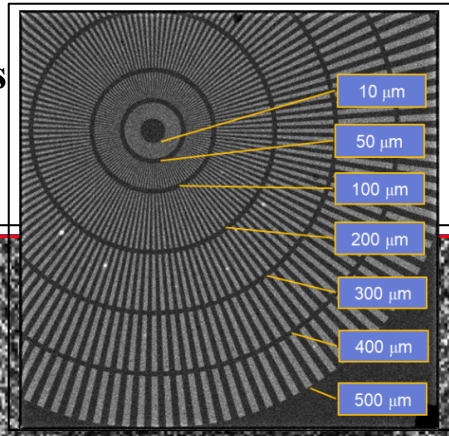
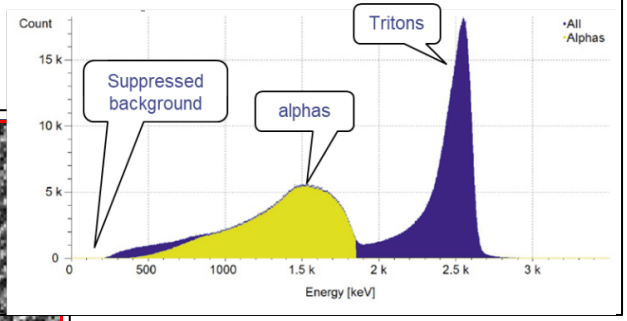
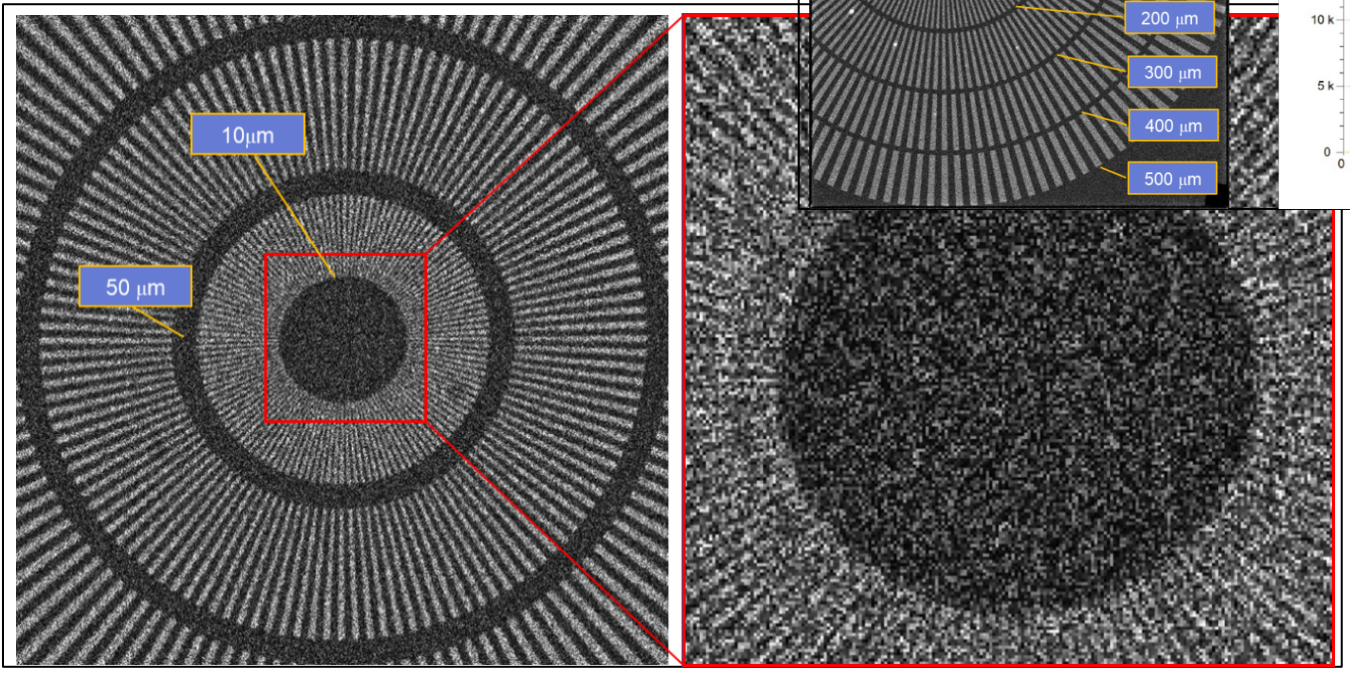
Task4.1: The Resolution Challenge

- Ultra-high position resolution of neutrons
- Particle track analysis
- ^{6}LiF or $^{10}B_4C$ coating







- Even the smallest features of the Siemens star are visible
- 10um

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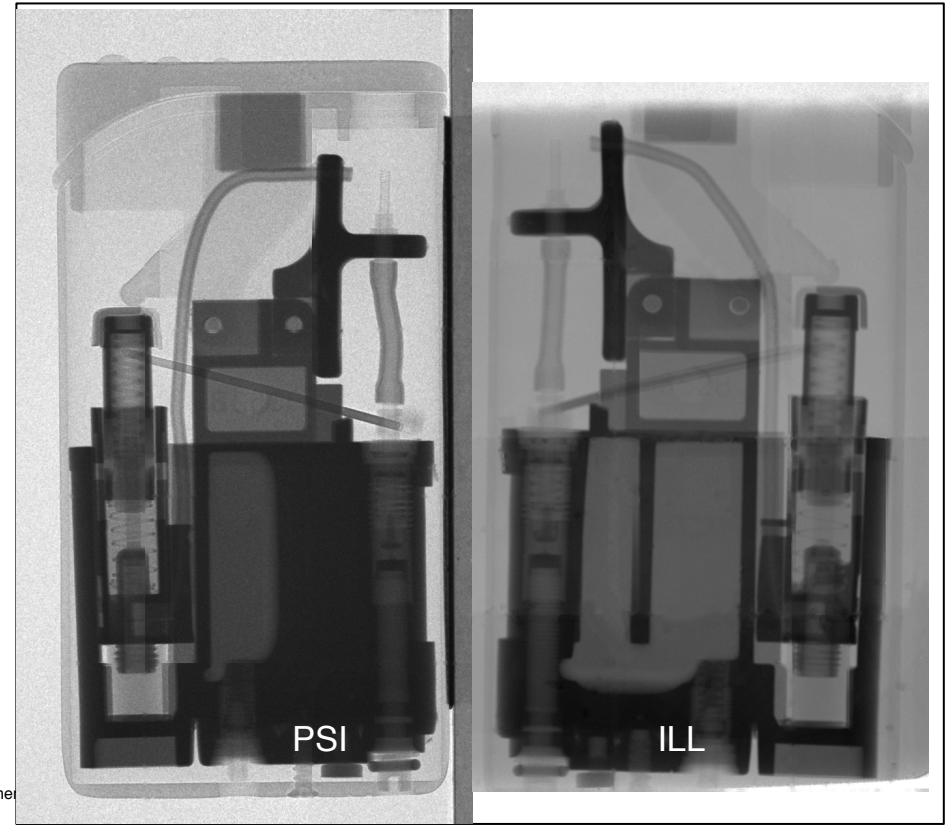
Task4.1: The Resolution Challenge

Large area Timepix detector Widepix4x5 covered with 6LiF

Si-based neutron detectors for ultra-resolution have arrived

Neutron radiography of a lighter



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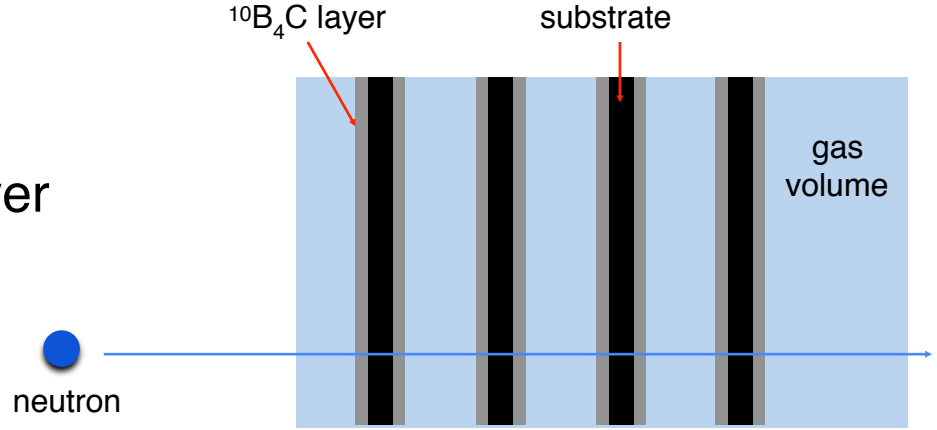
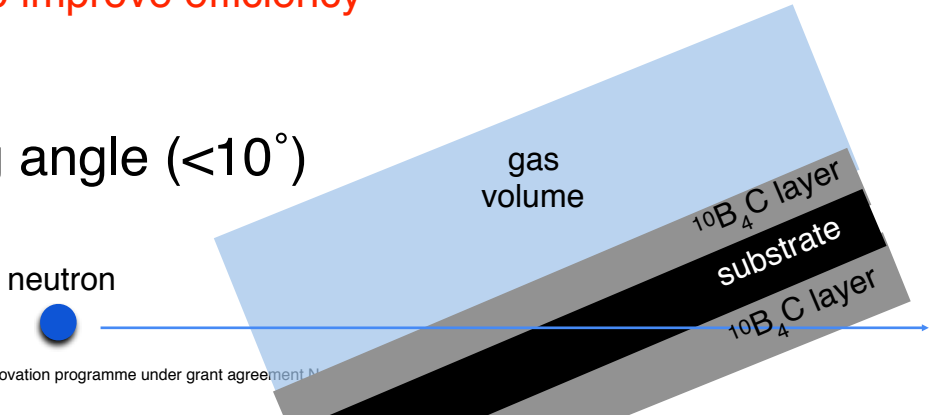
Enhancing the efficiency of ^{10}B-based Neutron Detectors

Task 4.3 **1** Multi layer



Generic approaches to improve efficiency

Task 4.2 **2** Grazing angle (<10˚)



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Task4.2: The Intensity Frontier

The Multi-Blade project

High counting rate capability

High spatial resolution

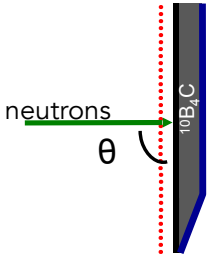
A single Boron layer inclined at 5 degrees

Efficiency <5% at 2.5Å

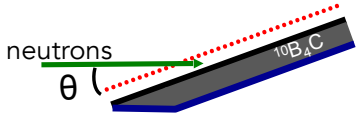
Efficiency 45% at 2.5Å

Multi–Blade

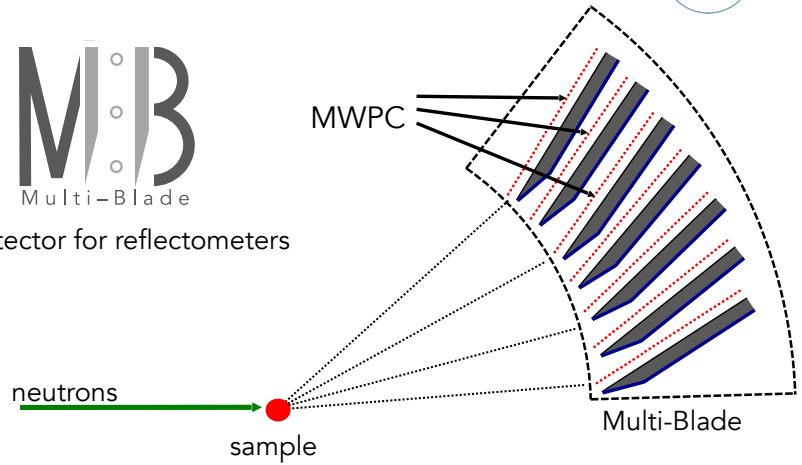
^{10}B-detector for reflectometers

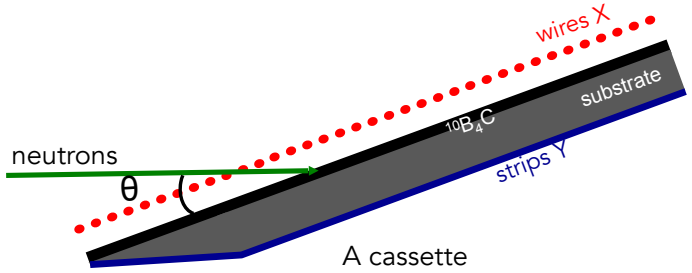


θ = 90 degrees



θ = 5 degrees





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

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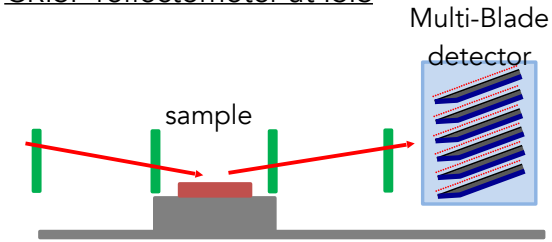
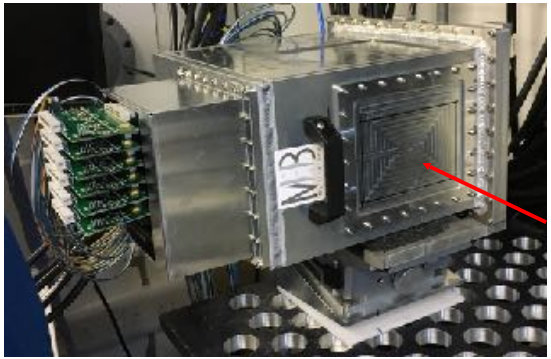
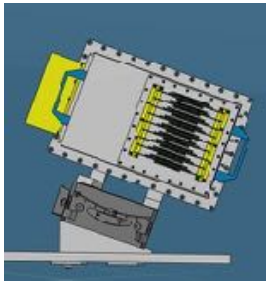
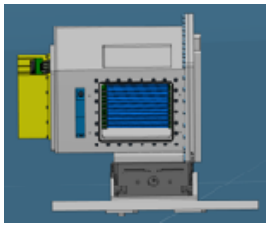
Task4.2: The Intensity Frontier

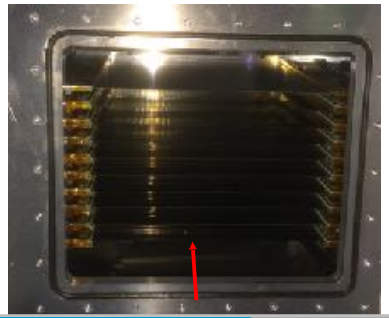
CRISP reflectometer at ISIS

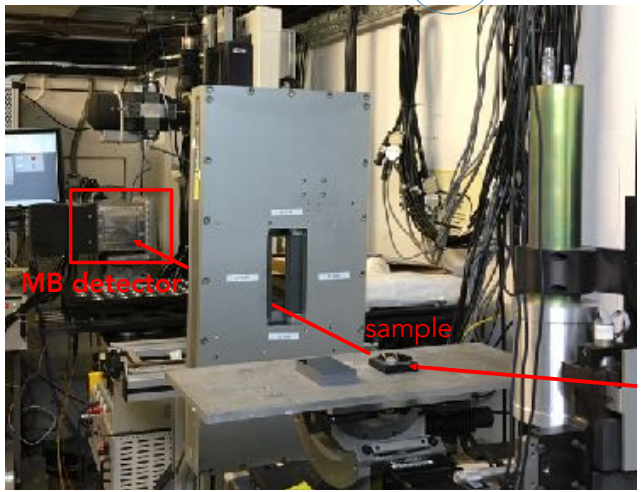


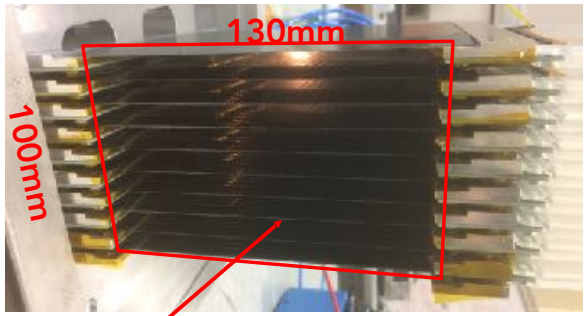












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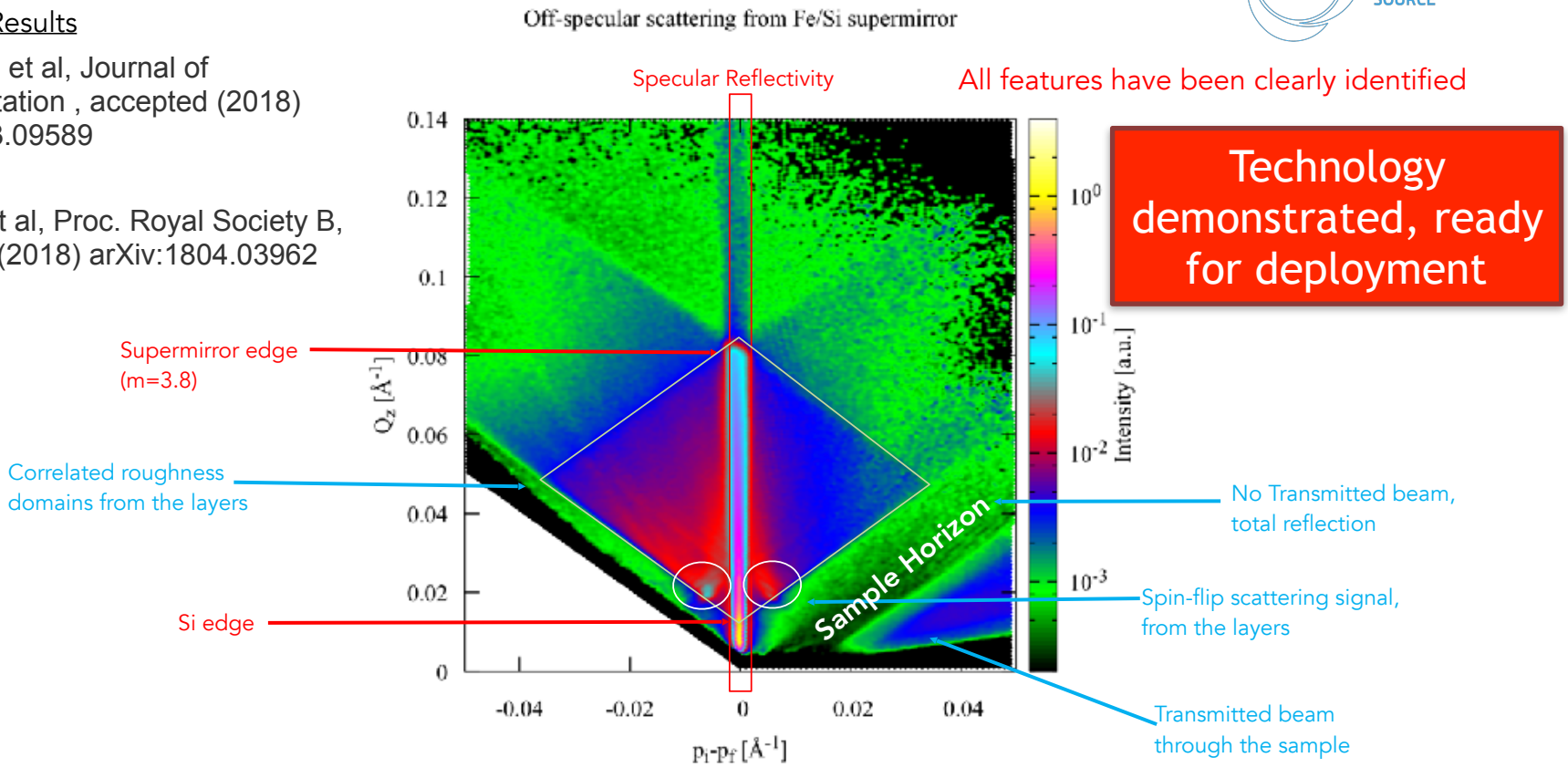
Task4.2: The Intensity Frontier

Results

F. Piscitelli et al, Journal of Instrumentation , accepted (2018) arXiv:1803.09589

G. Mauri et al, Proc. Royal Society B, submitted (2018) arXiv:1804.03962



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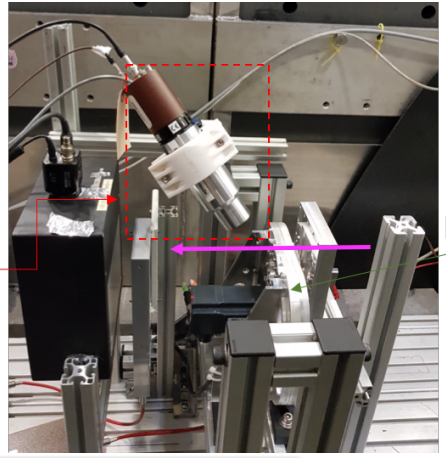
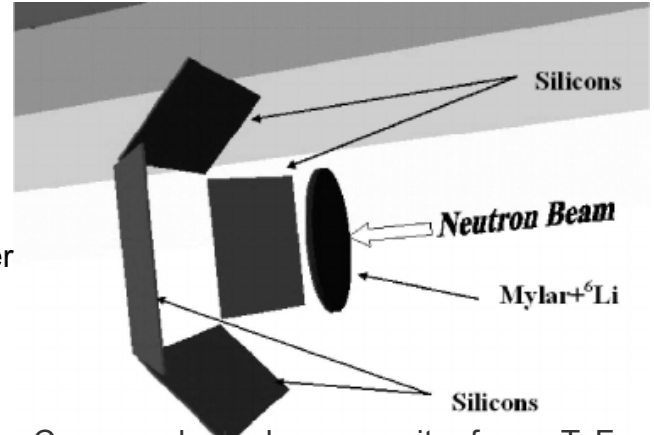
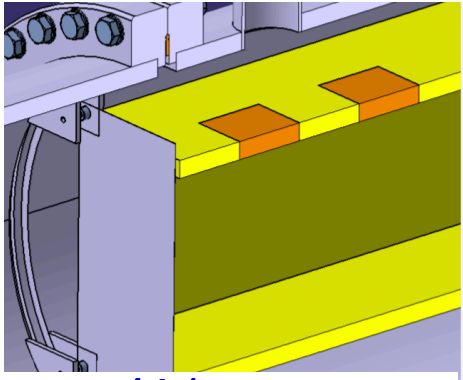
Task4.2: Intensity Frontier: Beam Monitors

V20 Beamline in Berlin

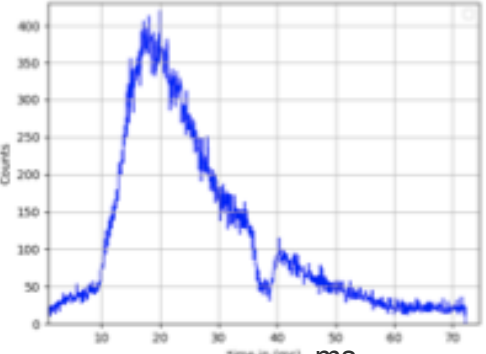




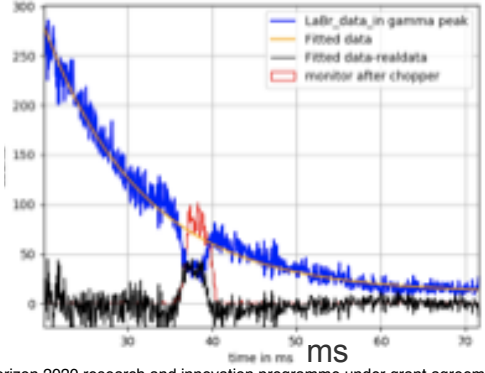


Thicknesses

Can we adapt a beam monitor from nToF at CERN to ESS applications?

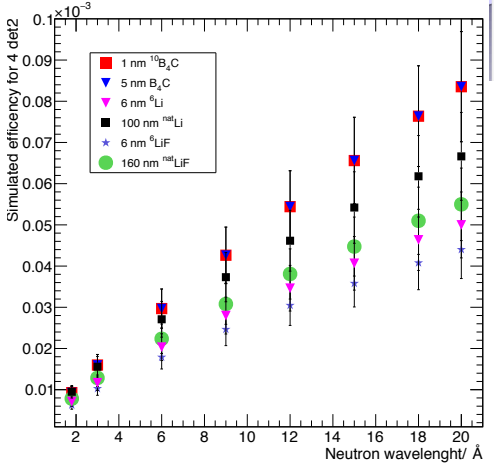


ms



ms

Maybe we can measure chopper phases through parasitic monitoring?



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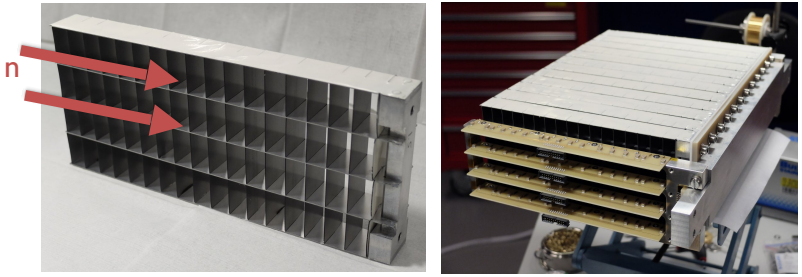
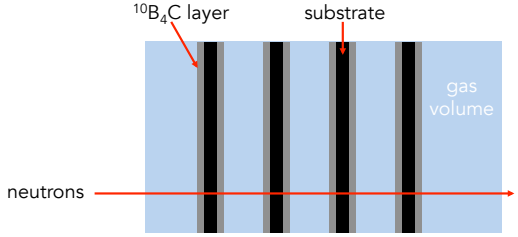
Task4.3: Realising Large Area Detectors

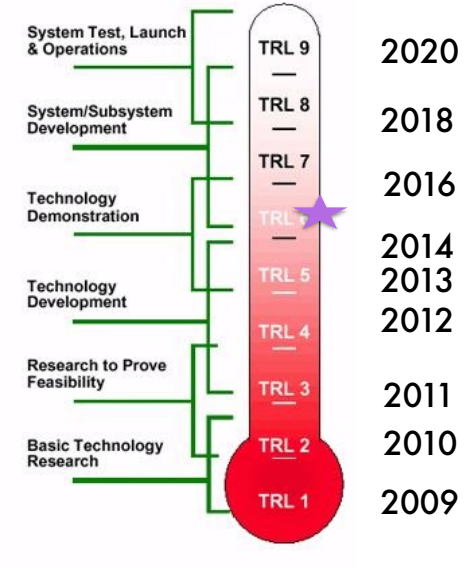




Technology Demonstrators of Scientific Performance planned for:
CNCS@SNS and SEQUOIA@SNS

Multi-Grid Design

Invented by ILL, co-developed ILL-ESS



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brightness Task4.3: Realising Large Area Detectors

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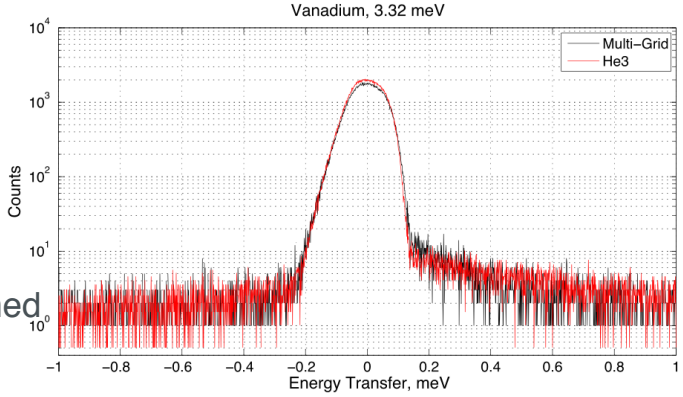
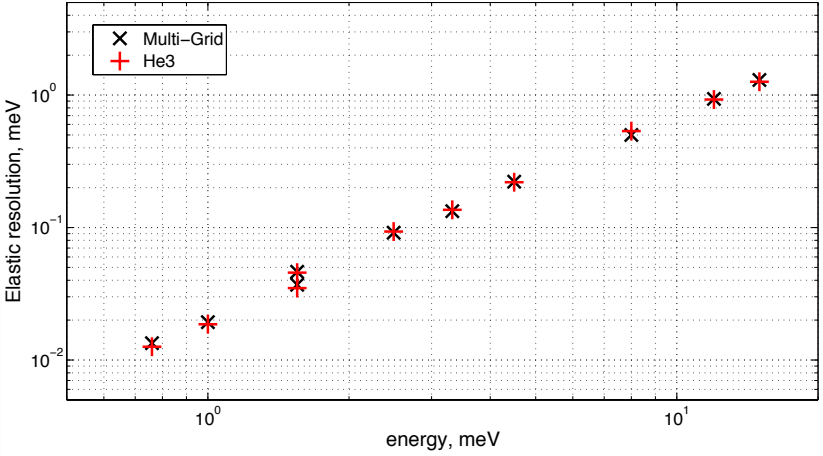
B10 Multi-Grid Detector Performance is equivalent to that of He-3 detectors

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

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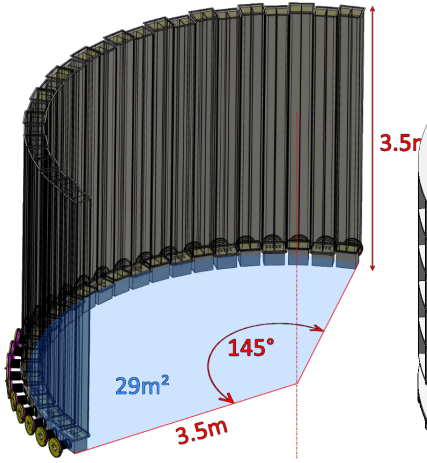

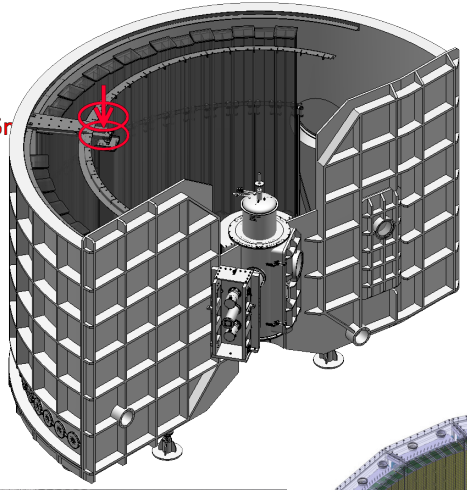

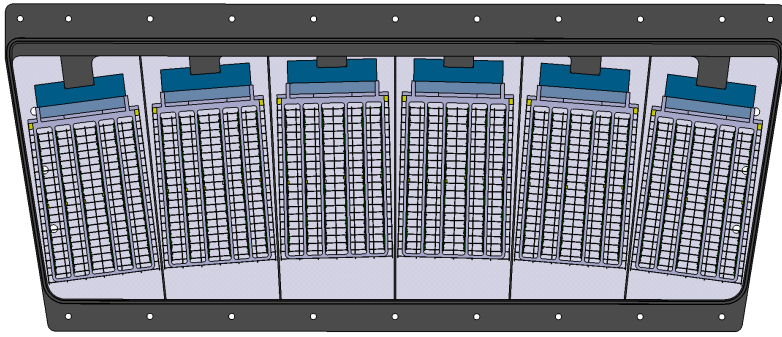

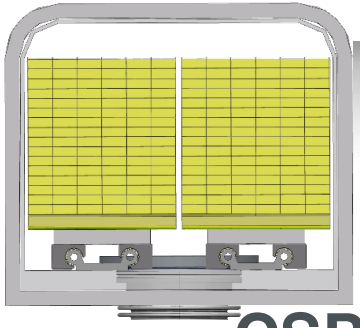

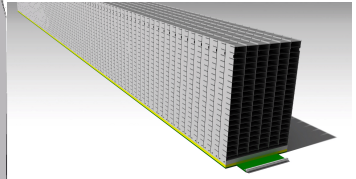

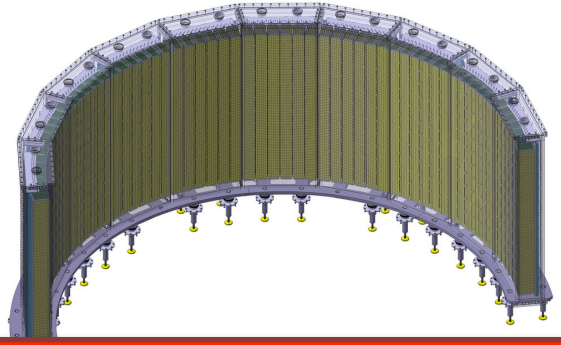

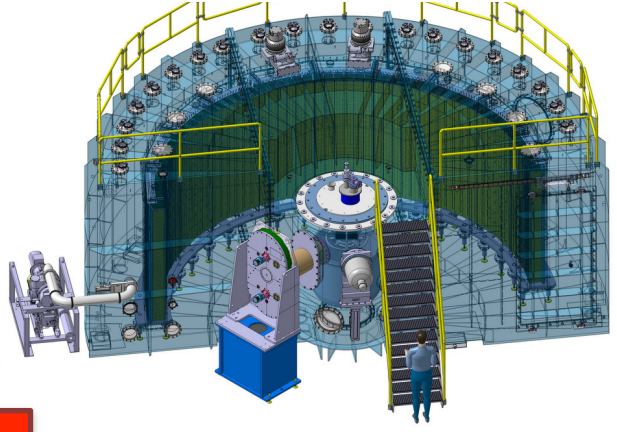

CSPEC

Detailed Engineering Design Started

TREX

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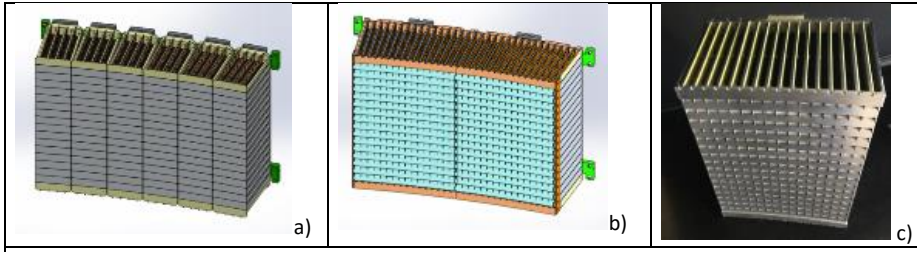
brightness Task4.3: Realising Large Area Detectors



Much engineering work presently ongoing.

Two examples from work carried out at ILL:

- Studies of increasing grid size to reduce dead areas
- Into gas delivery if detector pressure is below atmosphere

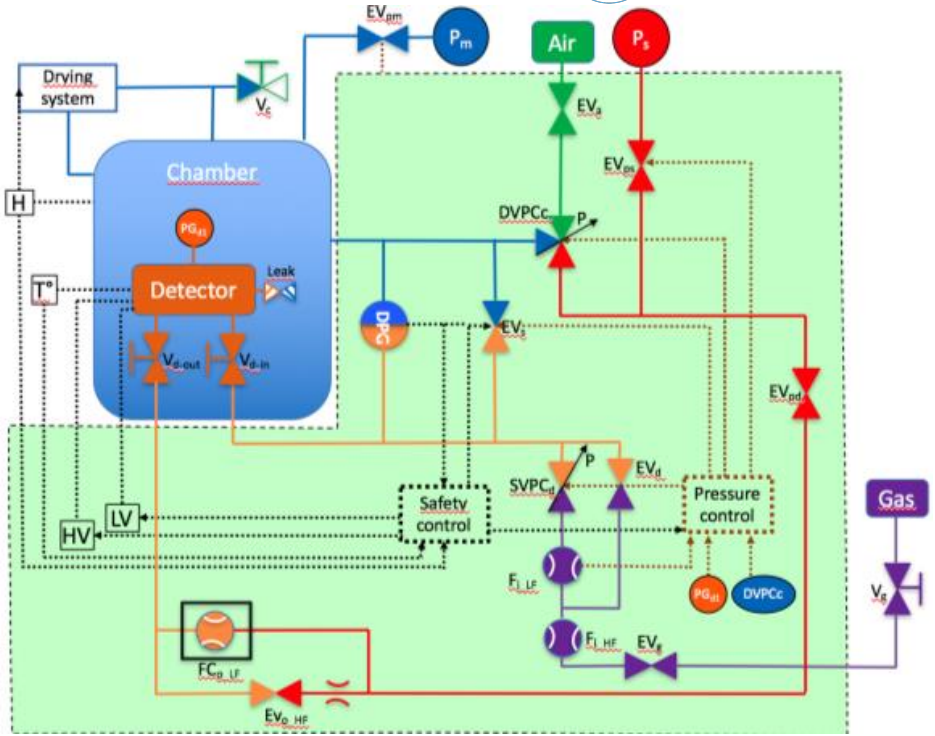


Figure 1: Scheme of the gas delivery system

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Task4.4: Detector Realisation: Simulation

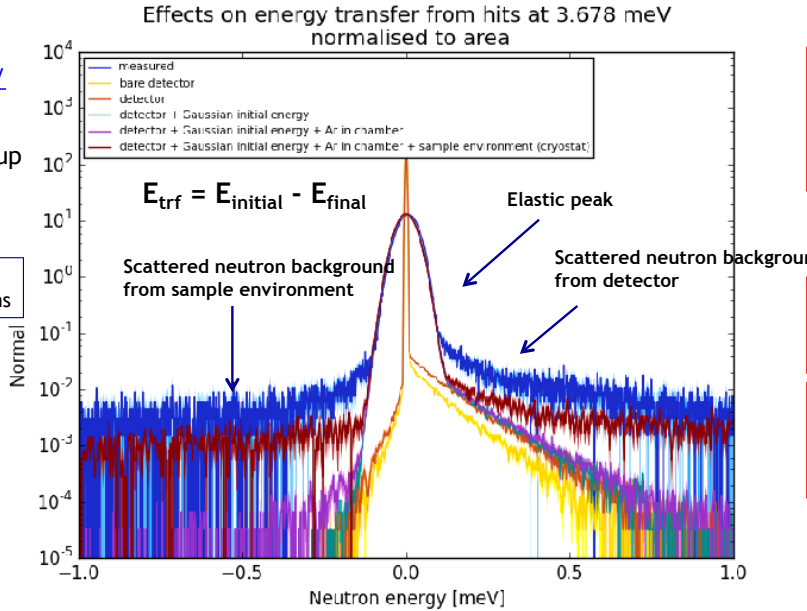
- New tools & utilities are recently developed for neutron studies
  - Physics
    - Coherent scattering
    - Inelastic scattering
    - Single- and poly-crystals…
  - And more
    - Communication
    - Visualisation
    - Ready-to use…

NXSG4
doi:10.1016/j.cpc.2014.11.009
http://nxsg4.web.cern.ch/nxsg4

NCrystal
https://github.com/mctools/ncrystal/

MCPL -
Monte **C**arlo **P**article **L**ist
https://mctools.github.io/mcpl/

ESS Coding Framework -
Geant4 simulation framework Developed by ESS Detector Group
doi:10.1016/S0168-9002(03)01368-8
doi:10.1088/1742-6596/513/2/022017



Becoming possible to model detector and scientific performance …

… and optimise it before building it

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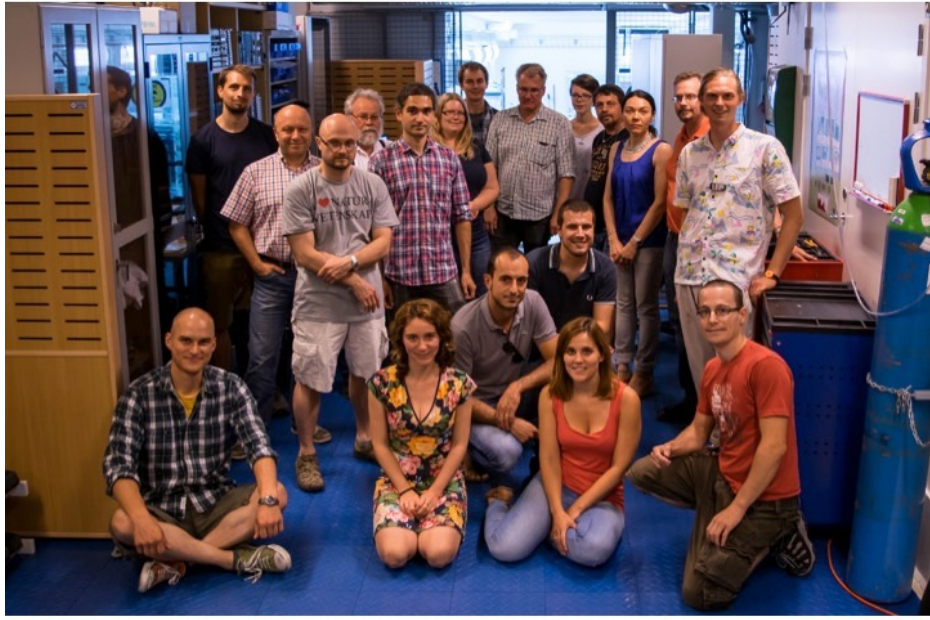
Task4.4. Detector Realisation

- Source Facility available at Lund University
- Detector testing possibility in Lund with (fast and thermal) neutrons, gamma
- Heavily used for all ESS detector activities



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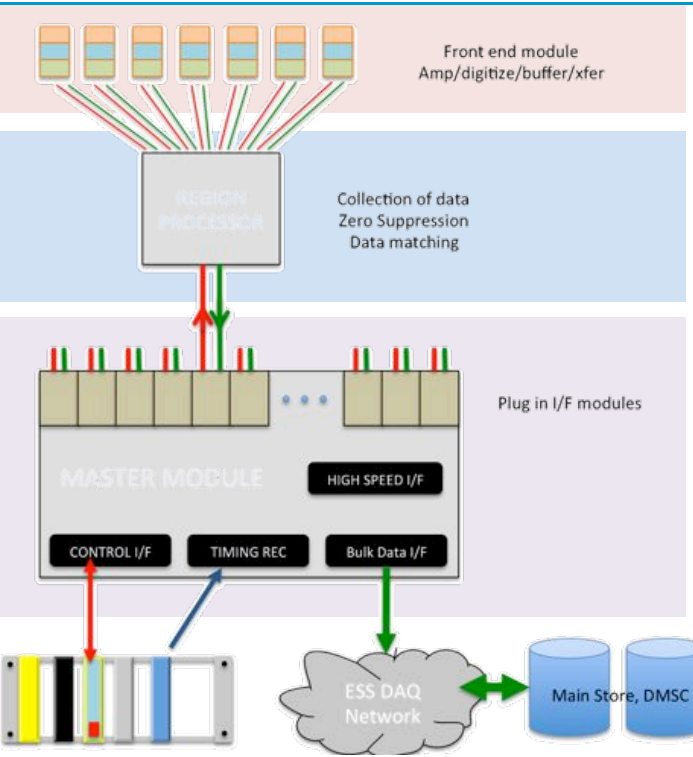
Task4.4: Detector Realisation



- An integrated plan for integrated detector readout
- For all parts of system, prototype hardware exists

- Interface between WP4 and WP5 a key interface for ESS instruments
- The sum of this interface defines the data acquisition path for neutron detector data at ESS

Interface shared, understood, manned and demonstrated

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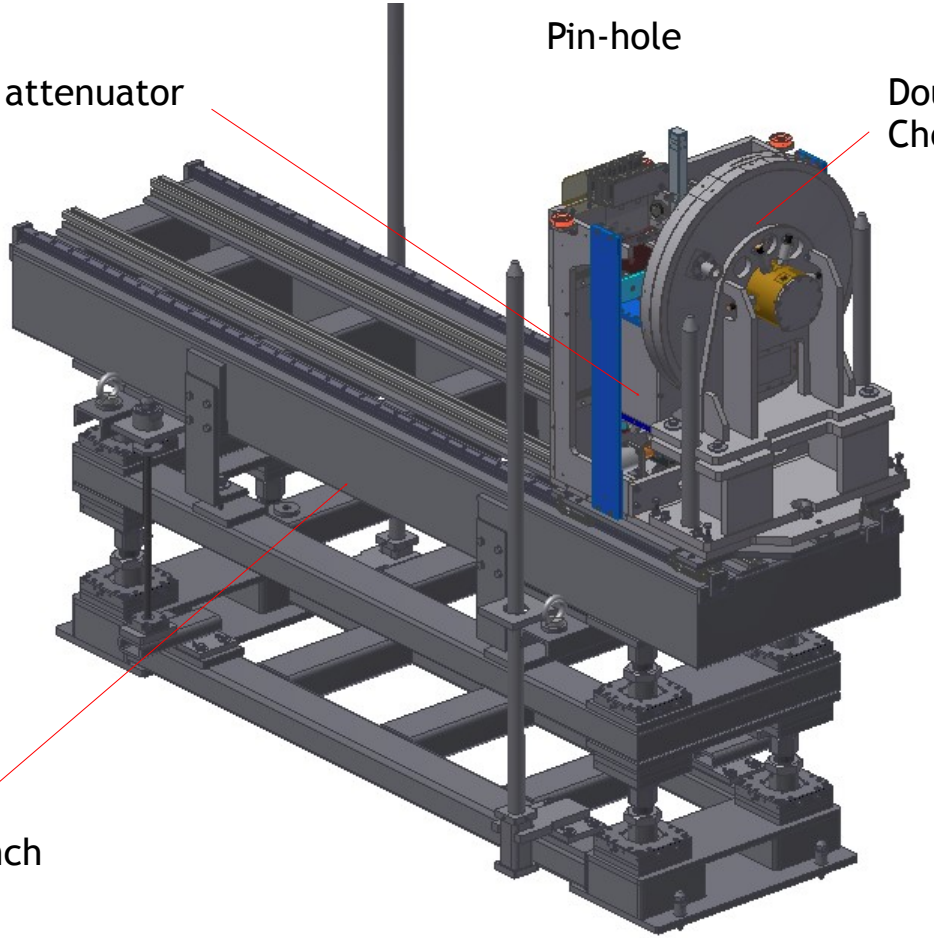
Task4.5: Moderators and Test beamline



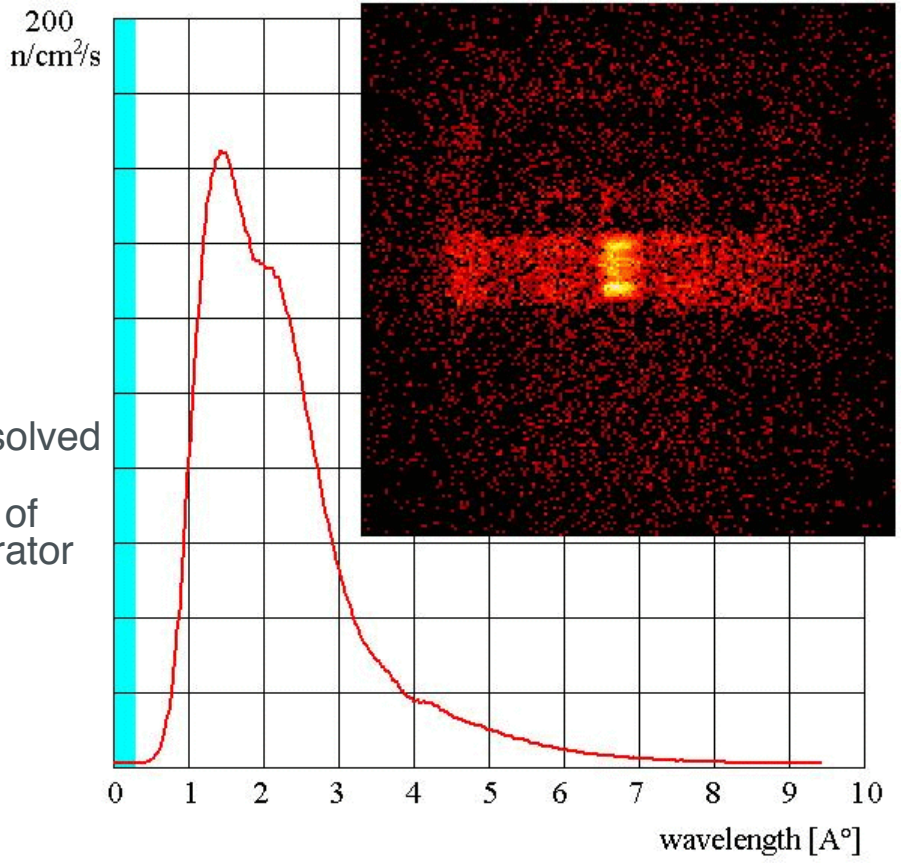
Optical bench – pinhole – chopper assembly of the ESS moderator test beamline

- Beamline for diagnosing moderator performance foreseen as part of BrightnESS
- This beam line has been designed and commissioned from experience at BNC-Wigner (HU)
- Components of this beam line will be moved from BNC to ESS as the ESS tesbeam line to "see" 1st neutrons

Task4.5: Moderators and Test beamline

Solid boron converter neutron detector for source imaging

Wavelength resolved imaging measurements of the BNC moderator brightness



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Next steps

- 4 WP4 deliverables remaining
- 2 WP4 milestones remaining

- Continuing impact of BrightnESS after end of project
- (open dissemination of results, seek opportunities for continuation of collaborations developed, integration into the ESS construction of detectors for instruments)

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In terms of ESS project risk, impact of BrightnESS is to move detectors and novel moderators from being high risk technical items into a normal level of risk

BrightnESS reduces the level of risk for the delivery of the ESS project

A big thank you to all our partners for a successful project

Richard Hall-Wilton

Detector Group Leader

European Spallation Source ERIC

Mobile: +46 72 179 2089

E-mail: richard.hall-wilton@esss.se

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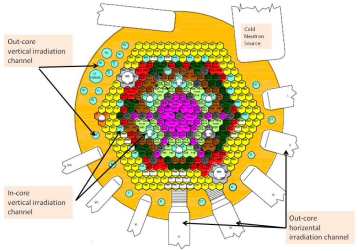
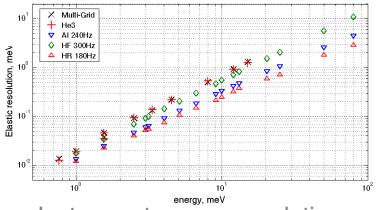
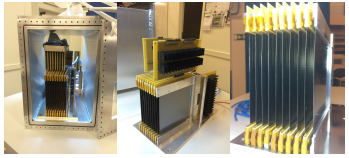
Overview of WP



LEU Core scheme



Instrument energy resolution using MG compared to He3



MB 2015 prototype built and tested in BNC

- WP4 is a technical work package focussed on challenges in neutronic technologies
- WP4 aim for the disruptive innovation in terms of the development and integration of neutron detectors and moderators currently needed directly and indirectly for 9 current and future ESS Instruments.
- Technological risk reduction for the delivery of the ESS project
- By enhancing moderator and detector capability, maximise the early science impact of ESS
- Fundamentally in-kind and collaborative tasks, relying on the expertise of partner institutes involved

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