ESS Detector Group

Multi-Blade

the ^{10}B-based neutron detector for reflectometry at ESS

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Highlights:

Multi-Blade:
- a ^{10}B-based neutron detector conceived to face the arising challenge in neutron reflectometry at the European Spallation Source (ESS).
  - high counting rate
  - sub-millimetre spatial resolution

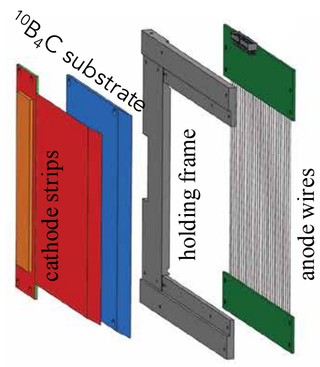
- a stack of Multi Wire Proportional Chambers
  - operated at atmospheric pressure with continuous gas flow (Ar/Co_2 80/20)
  - with a $^{10}B_4C$ neutron converter and a 2D read-out system
  - inclined by 5 degrees with respect to the incoming neutron beam

ESS: unprecedented requirements for neutron reflectometry:

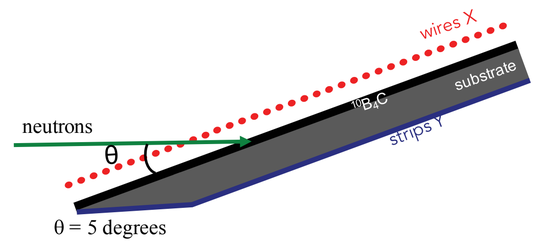
ESS requirements:	Estia	Freia	state-of-art	Multi-Blade (MB16)	
wavelength range (Å)	4 – 10	2.5 – 12	1 – 30	2.5 – 30	✓
detection efficiency	> 45% @4Å	> 40% @2.5Å	80% @2.5Å	~ 44% @2.5Å	✓
sample-detector distance (m)	4	3	-	4	✓
local instantaneous rate @detector (n / mm^2 / s)	10^5	10^5	~ 10^2	1.6 x 10^3	limited by Read-Out Electronics
Spatial resolution wire Spatial resolution strip (mm)	0.5 4	0.5 2.5	2 8	0.6 2.5	✓
Uniformity (%)	5	5	5		
window scattering	< 10^{-4}	< 10^{-4}	- ~5mm thick	< 1mm thick	✓
gamma-sensitivity	< 10^{-6}	< 10^{-6}	10^{-7}	< 10^{-7}	✓
fast-neutron sensitivity	-	-	10^{-3}	< 10^{-5}	✓
number of channels	4800	2880	~ 128	~ 400	✓

A new detector design:

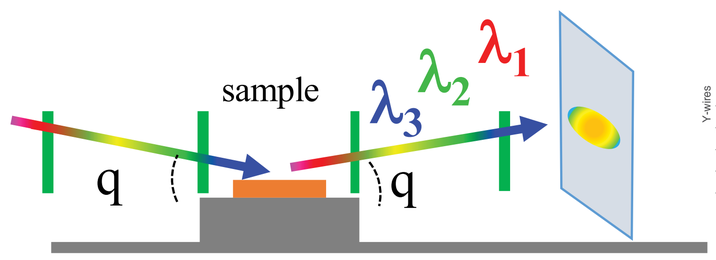
modular design: a *cassette*

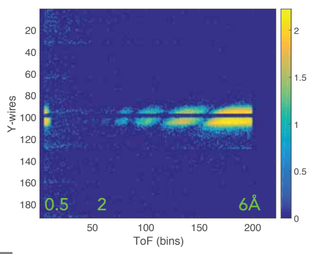


inclined geometry

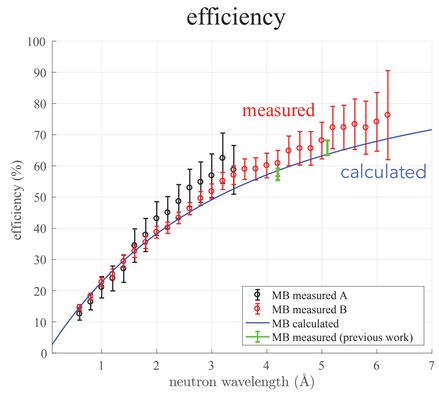


Time-of-Flight reflectometer

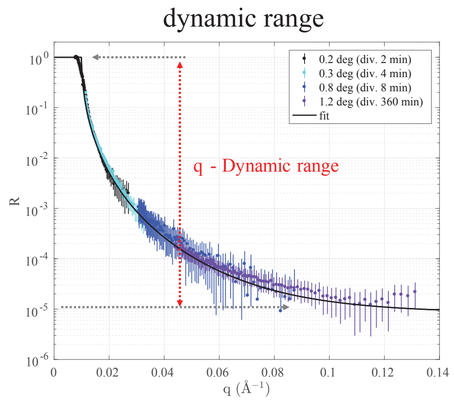




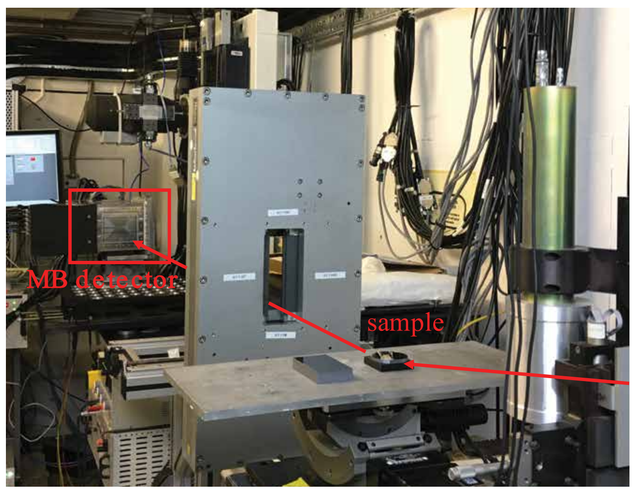
efficiency



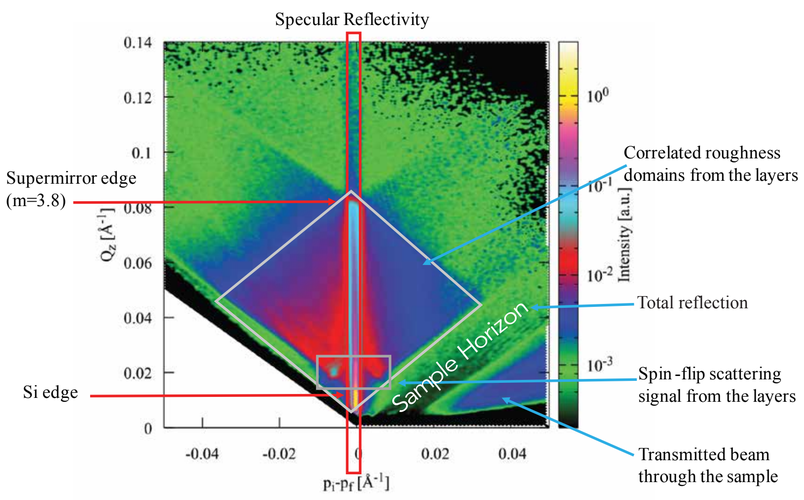
dynamic range



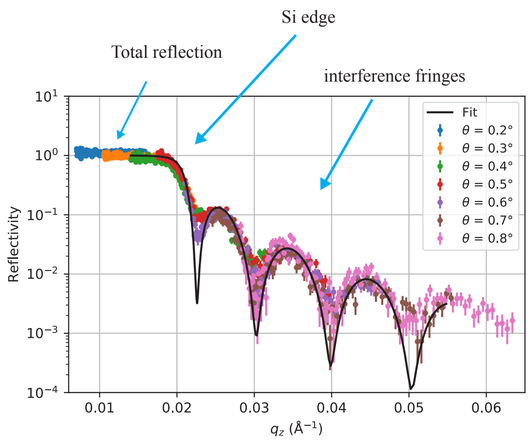
Test at CRISP - ISIS, UK Oct 2017:



off-specular scattering from a Fe/Si neutron supermirror

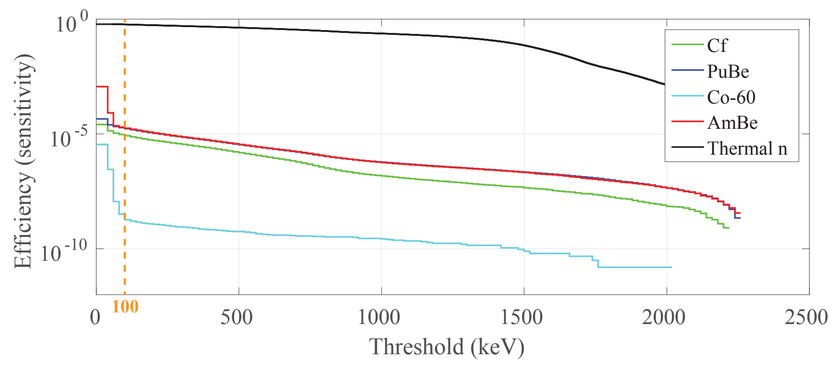


conventional reflectometry from an Ir sample



Test at STF - Lund University, Sweden Dec 2016 & May 2017:

gamma- and fast-neutron sensitivity



all plots are from the bibliography

brightness
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F. Piscitelli et al., "Study of a high spatial resolution 10 B -based thermal neutron detector for application in neutron reflectometry: the Multi-Blade prototype," Journal of Instrumentation, vol. 9, no. 03, p. P03007, 2014. DOI:10.1088/1748-0221/9/03/P03007
F. Piscitelli, F. Messi et al., "The Multi-Blade Boron-10-based neutron detector for high intensity neutron reflectometry at ESS," Journal of Instrumentation, vol. 12, no. 03, p. P03013, 2017. DOI: 10.1088/1748-0221/12/03/P03013
G. Mauri, F. Messi et al., "Fast neutron sensitivity of neutron detectors based on boron-10 converter layers," Journal of Instrumentation, vol. 13, no. 03, p. P03004, 2018. DOI: 10.1088/1748-0221/13/03/P03004
F. Piscitelli, G. Mauri, F. Messi et al, "Characterization of the Multi-Blade 10B-based detector at the CRISP reflectometer at ISIS for neutron reflectometry at ESS," Journal of Instrumentation, accepted 2018. arXiv:1803.09589
G. Mauri, F. Messi et al., "Neutron reflectometry with the Multi-Blade 10B-based detector", Proceeding of the Royal Society A, submitted 2018. arXiv:1804.03962

T. Ilves, "2D Imaging with 10B-Based Multi-Blade Neutron Detector" , Master thesis Lund University, 2018
A. Backis, "Neutron Reflectometry Analysis on Iridium using the Multi-Blade Detector", Master thesis Lund University, foreseen 2018
G. Mauri, "Development and characterization of detectors for large area application in neutron scattering and small area application in neutron reflectometry", PhD thesis University of Perugia, foreseen 2019

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