

The CASCADE Project a multi-layer ^{10}B neutron detection system

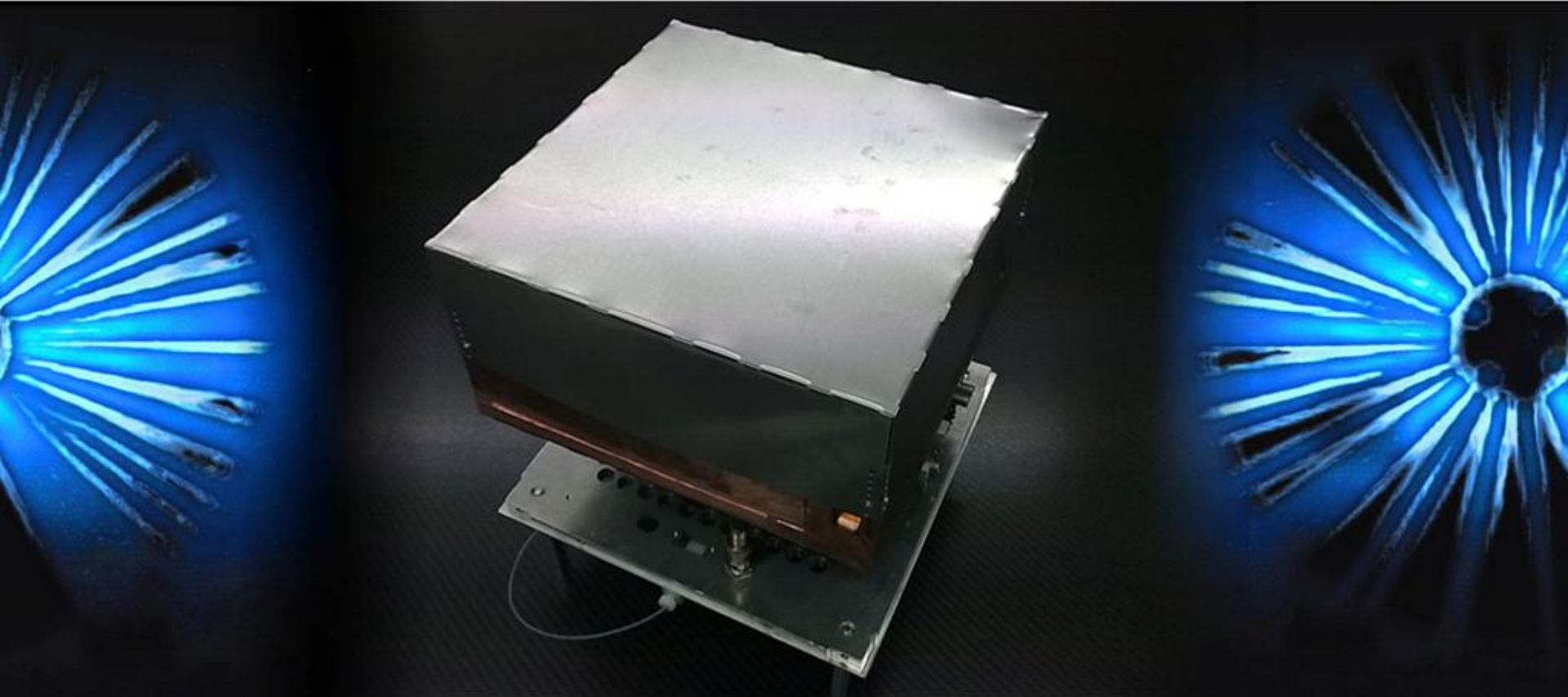


Physikalisches Institut

Ruprecht-Karls-Universität
Heidelberg

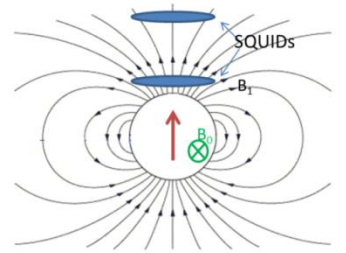
Markus Köhli

M.Klein, U. Schmidt
AG Dubbers

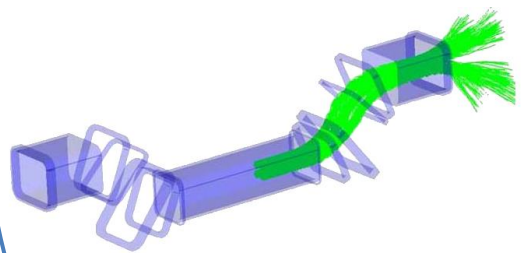


Heidelberg Research Fields

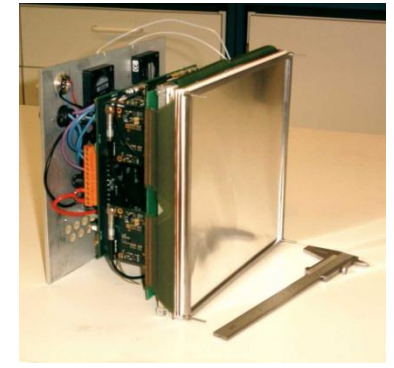
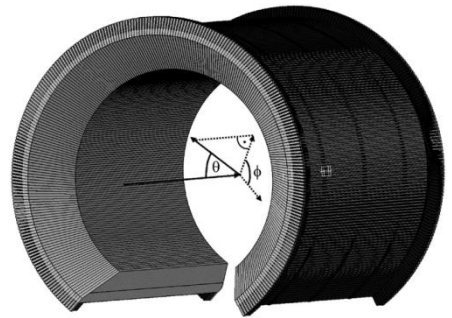
Helium-Xenon EDM
[test of Lorentz invariance]



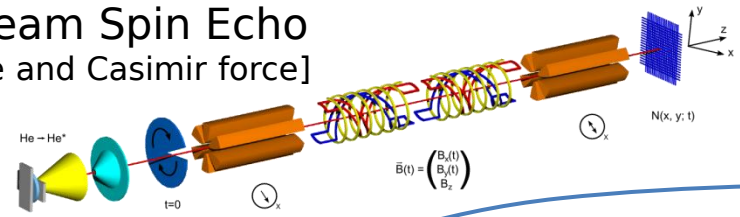
PERC and PERKEO
[v_{ud} via neutron beta decay]



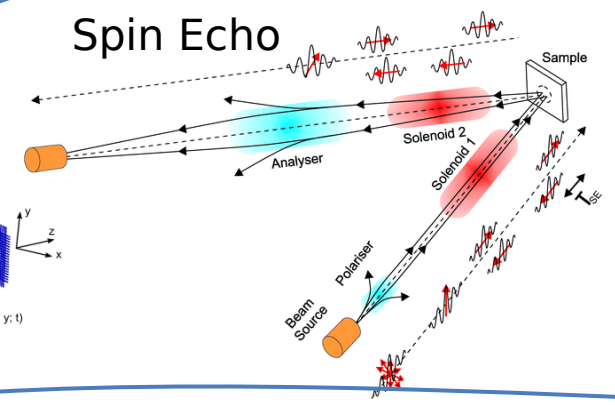
¹⁰B Neutron Detectors
[large area and high time resolution]



Atomic Beam Spin Echo
[Berry phase and Casimir force]



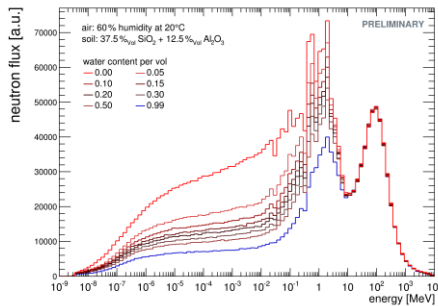
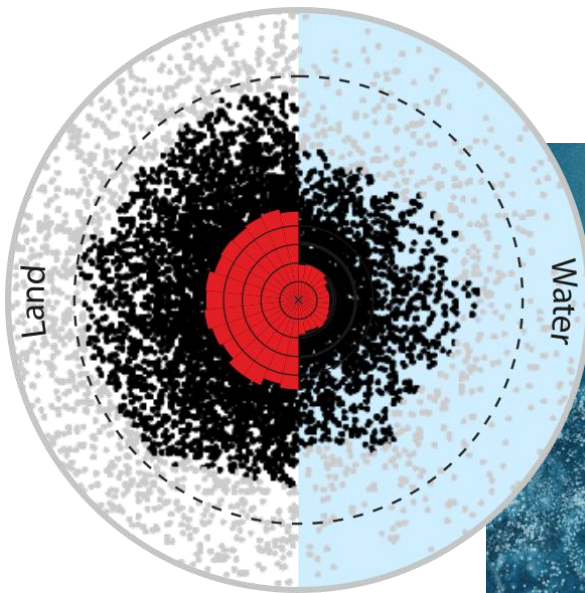
Spin Echo



Heidelberg Research Fields

COSMOS Project, UFZ Leipzig

Ground water sensing by
cosmic ray induced neutron showers



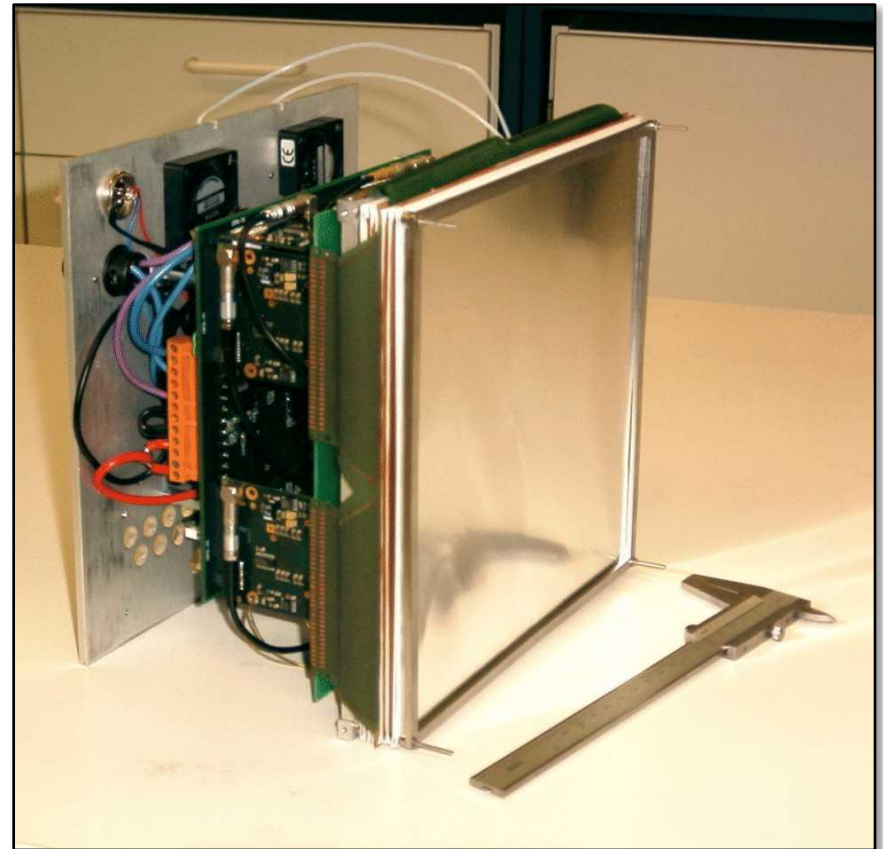
||| CASCADE The Detector



The CASCADE Detector

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CASCADE detector without housing



The CASCADE Detector

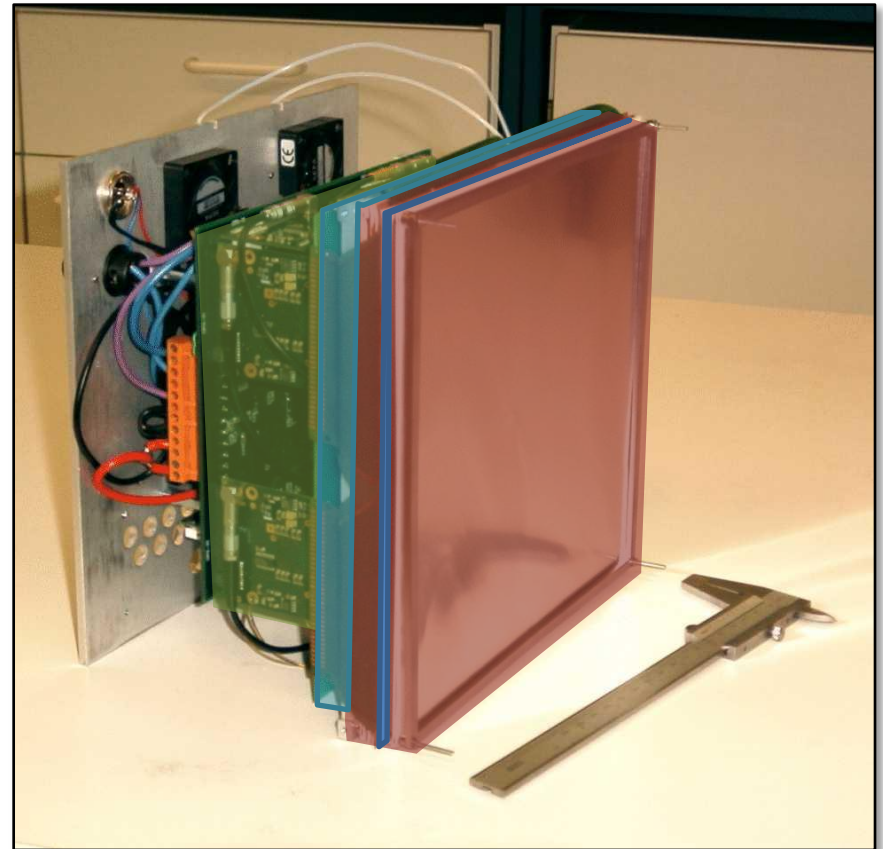
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Active Detection Volume

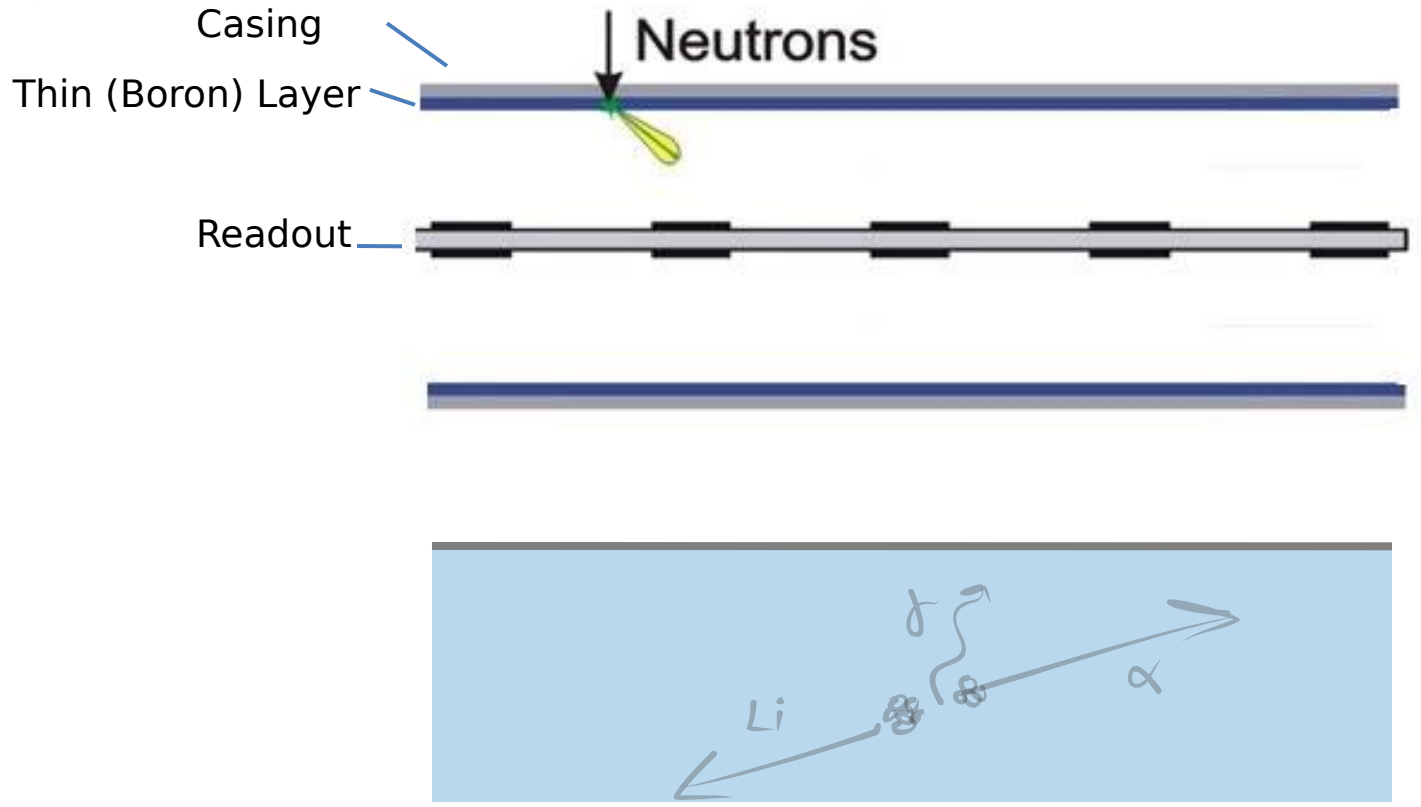
Readout

Electronics

CASCADE detector without housing

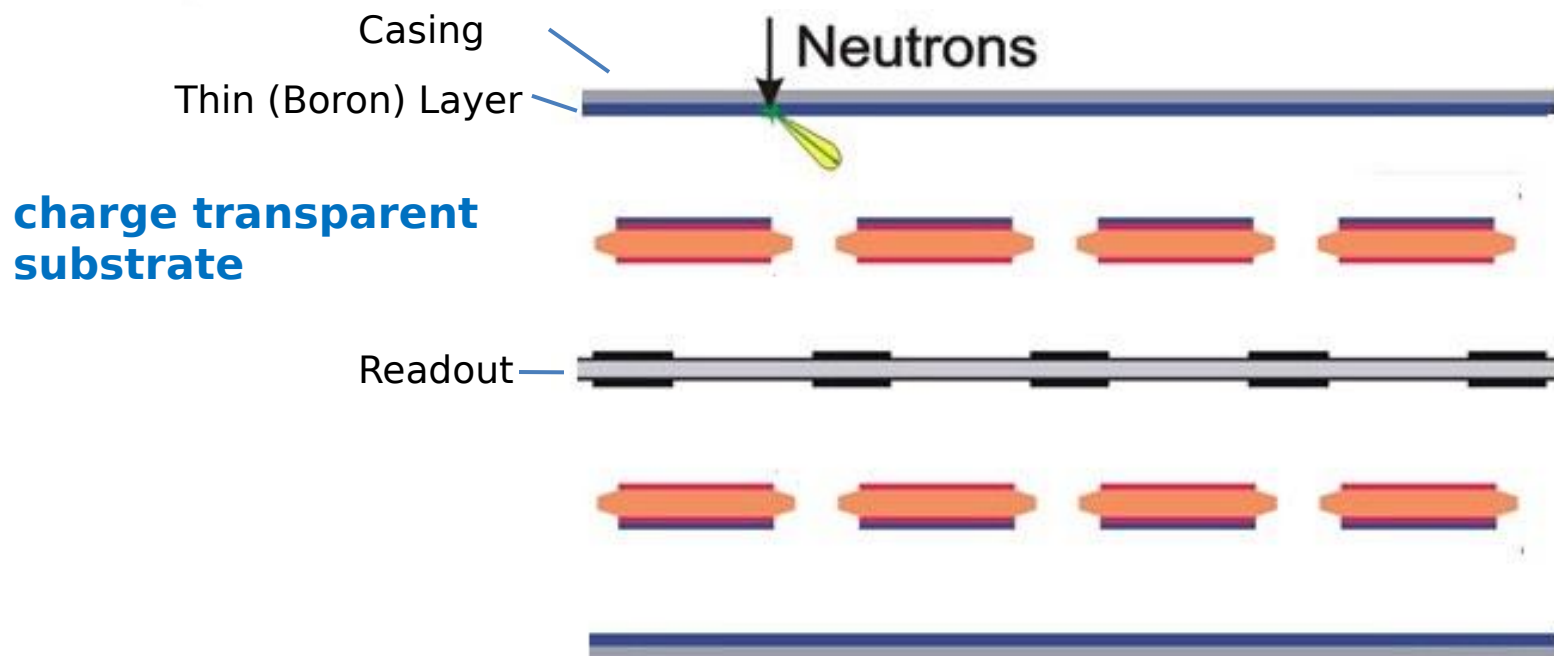


The CASCADE Concept

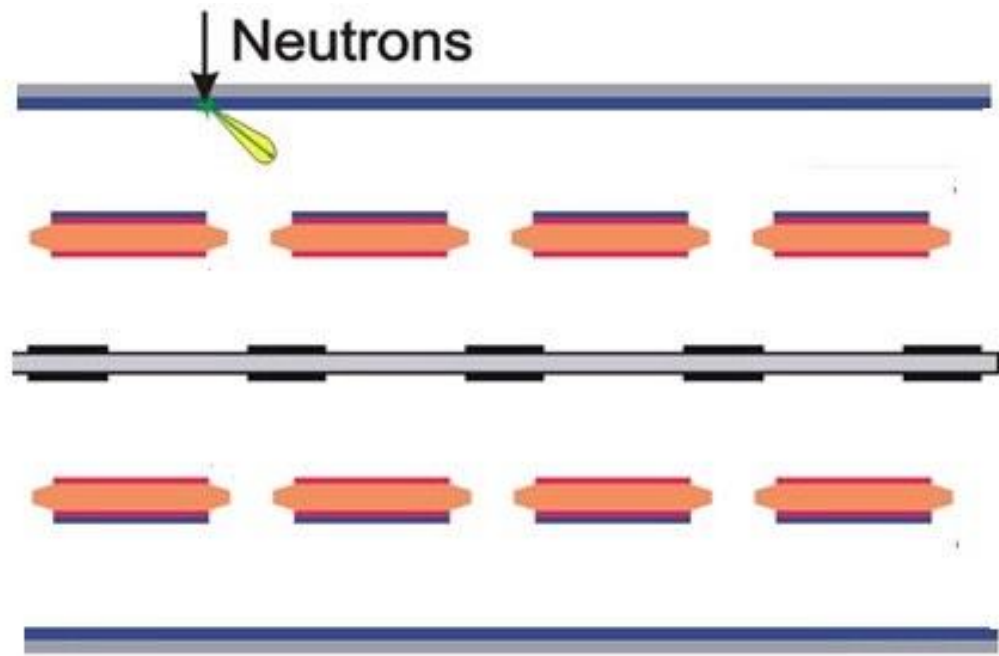
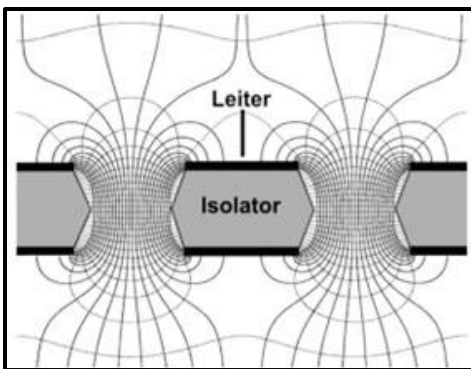
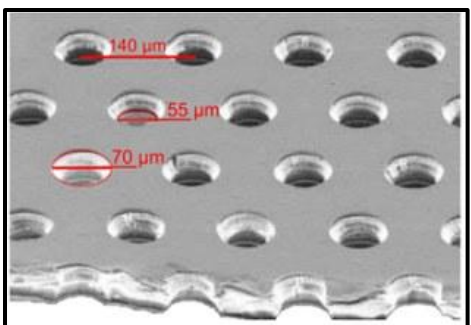


The CASCADE Concept

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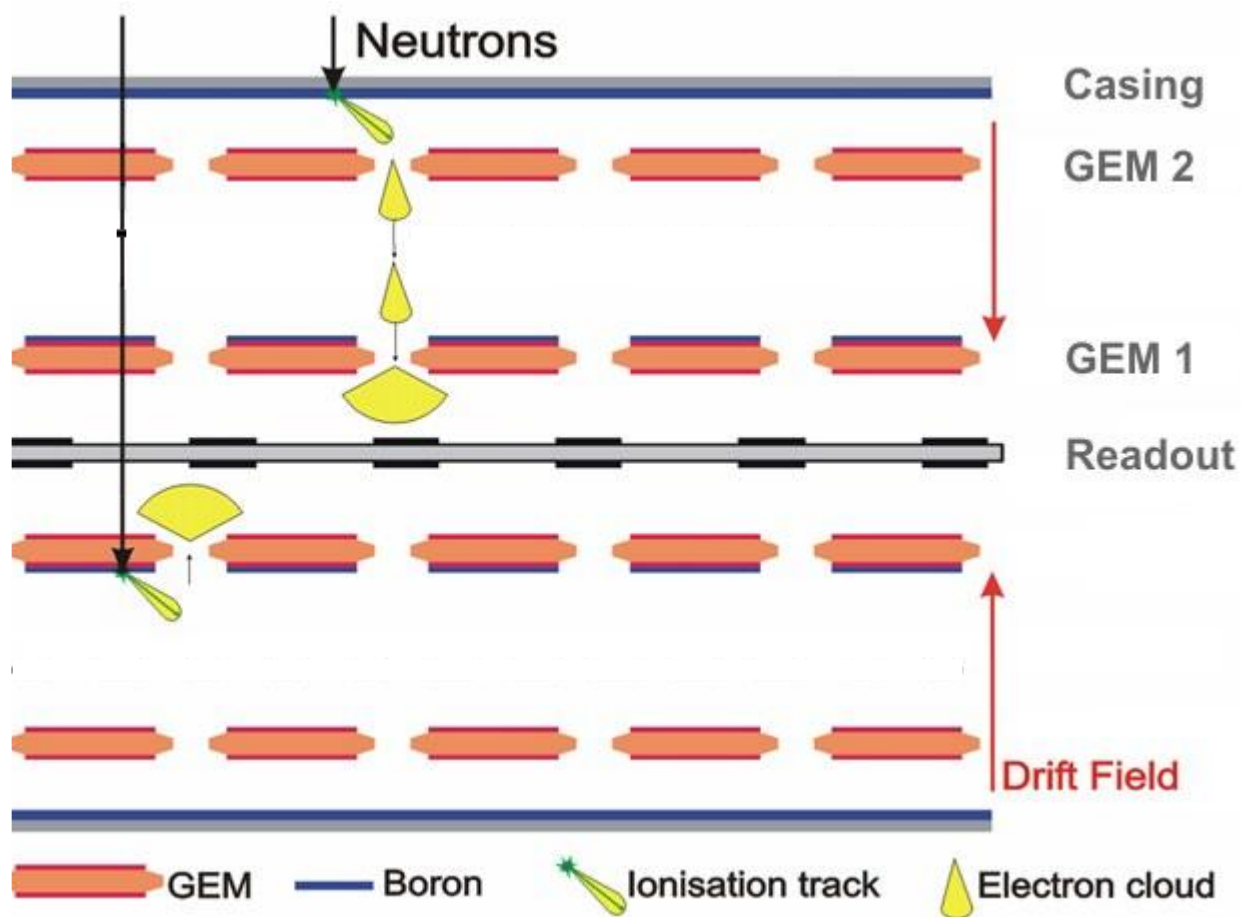
The CASCADE Concept



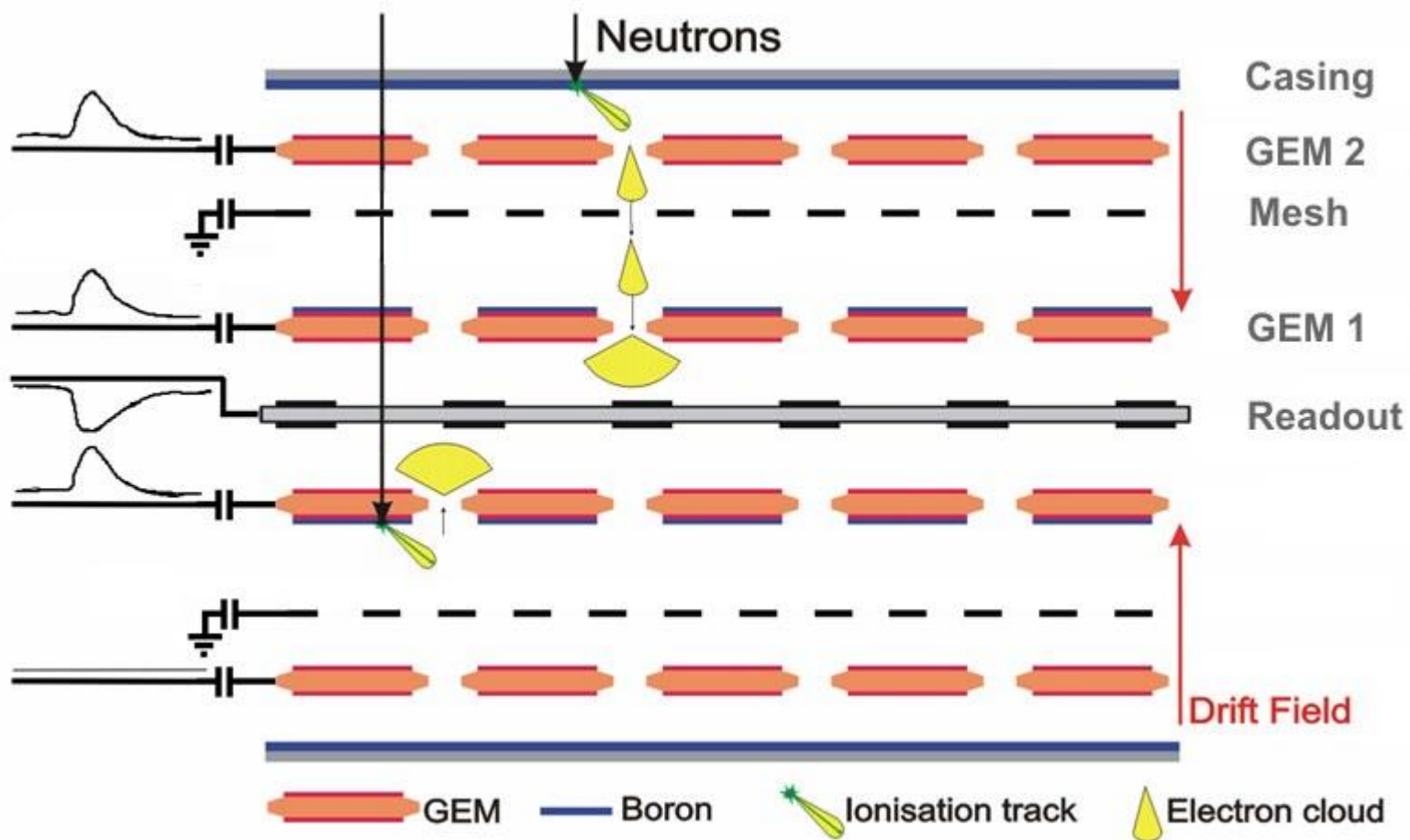
GEM
(Gas Electron Multiplier foil)

The CASCADE Concept

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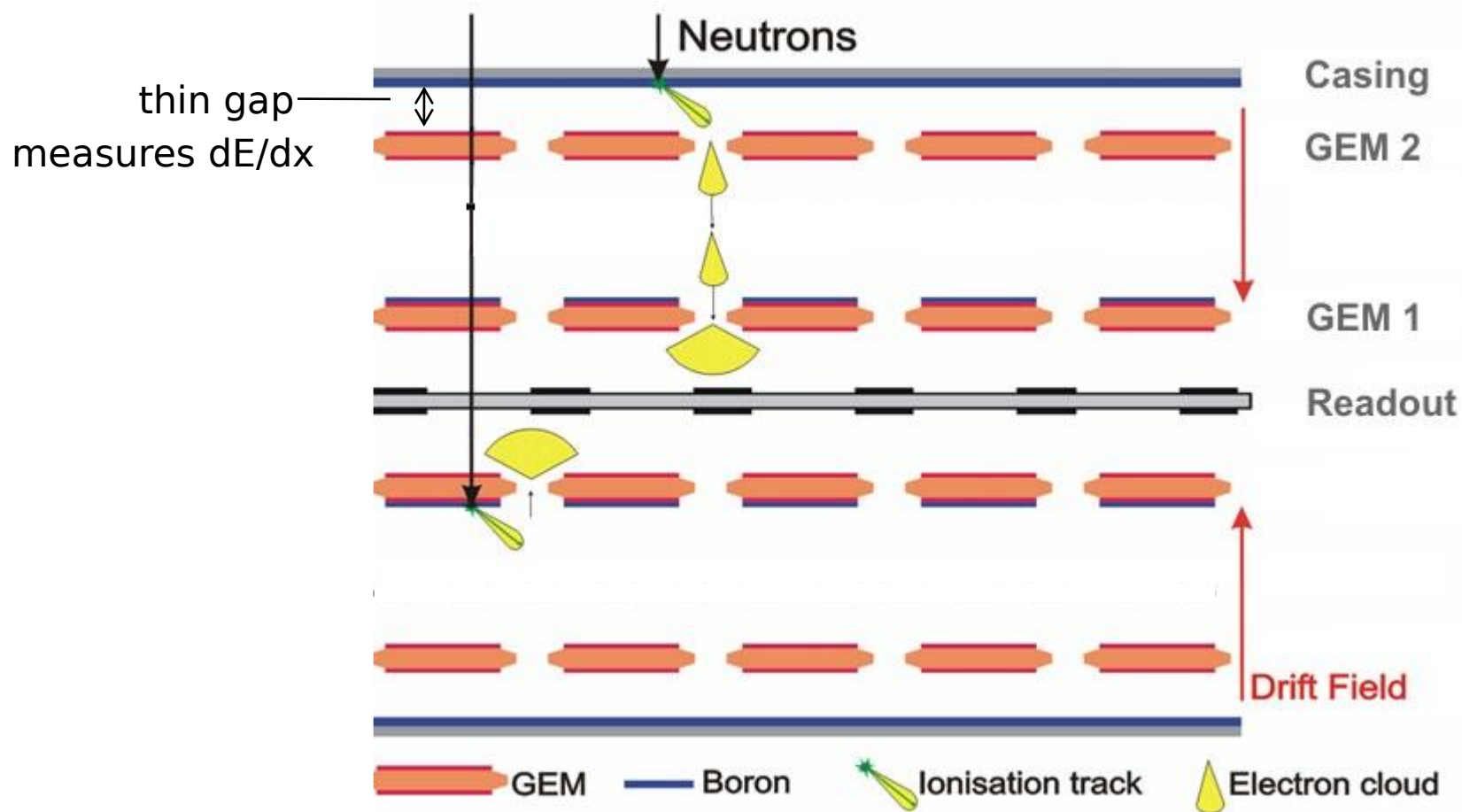


The CASCADE Concept



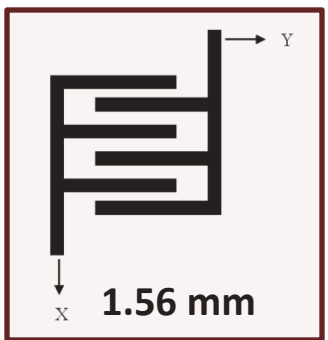
The CASCADE Concept

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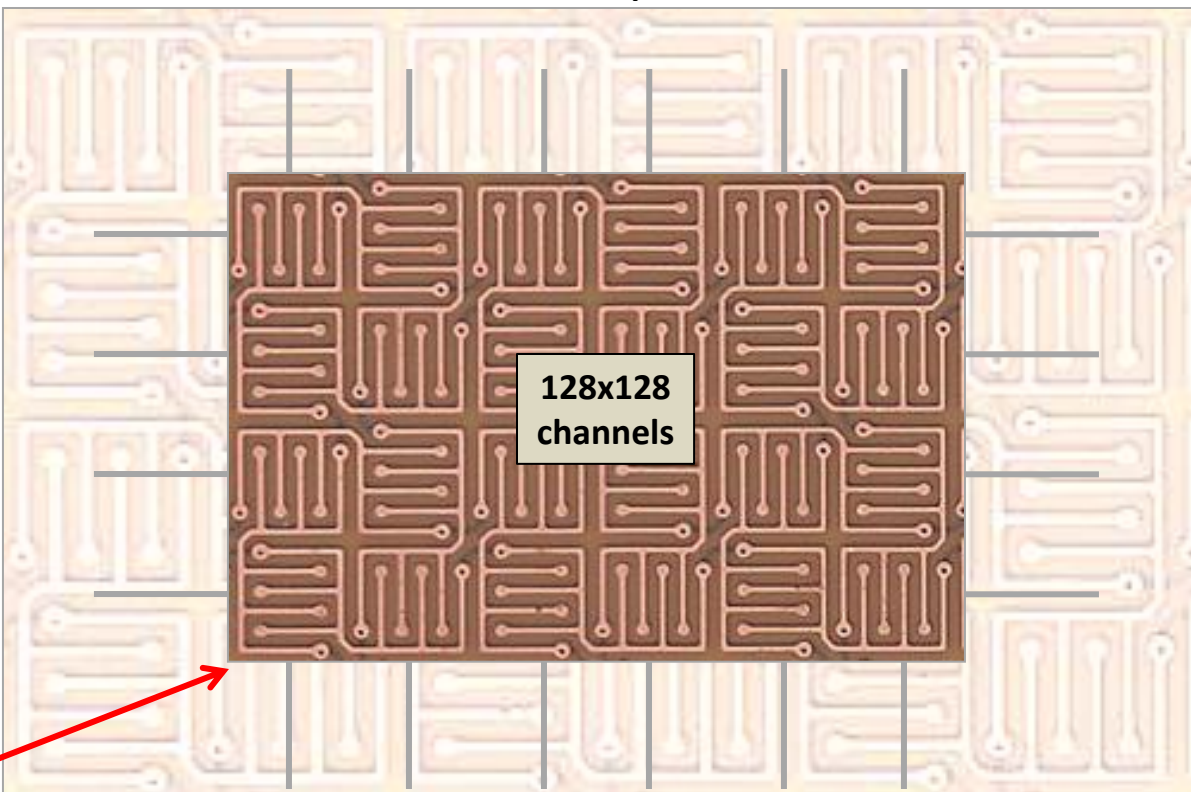


Readout

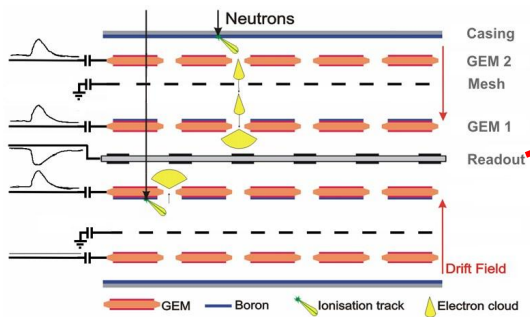
Unit Cell:



Y stripes



X stripes



Crossed stripes: reduces noise correlating x and y

CIPIX Readout ASIC

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- 64 channels
- 10 MHz (40 MHz) readout clock

FELIX chip (RD20, LHC) **[1993]**

HELIX 1.0

HELIX 32 **[1998]**

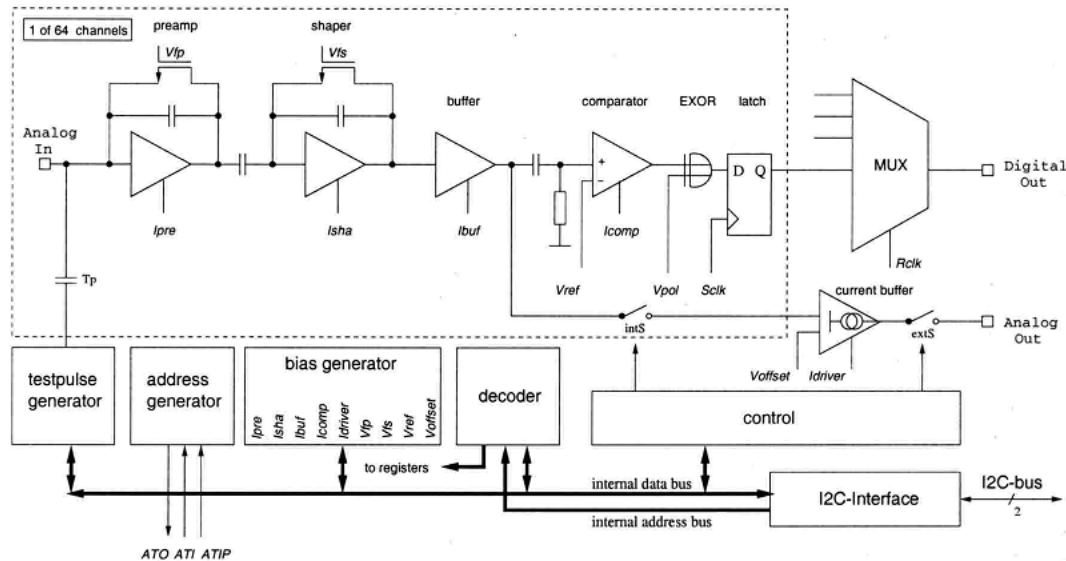
HELIX128-2.2 (HERA-B)

HELIX128-3.0 (Zeus)

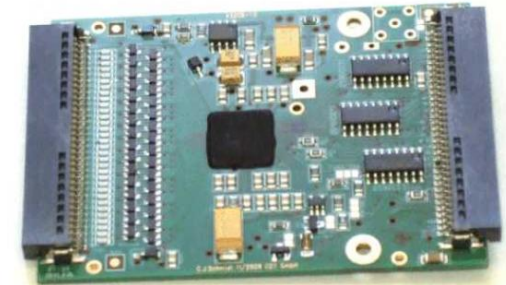
CIPIX (H1)

BEETLE (LHCb)

Timeline

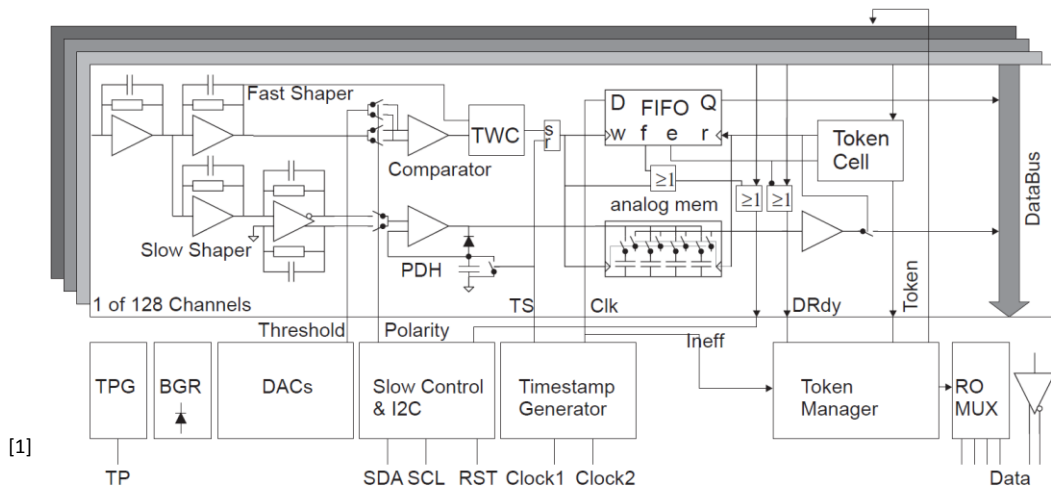


[1]



nXYter ASIC

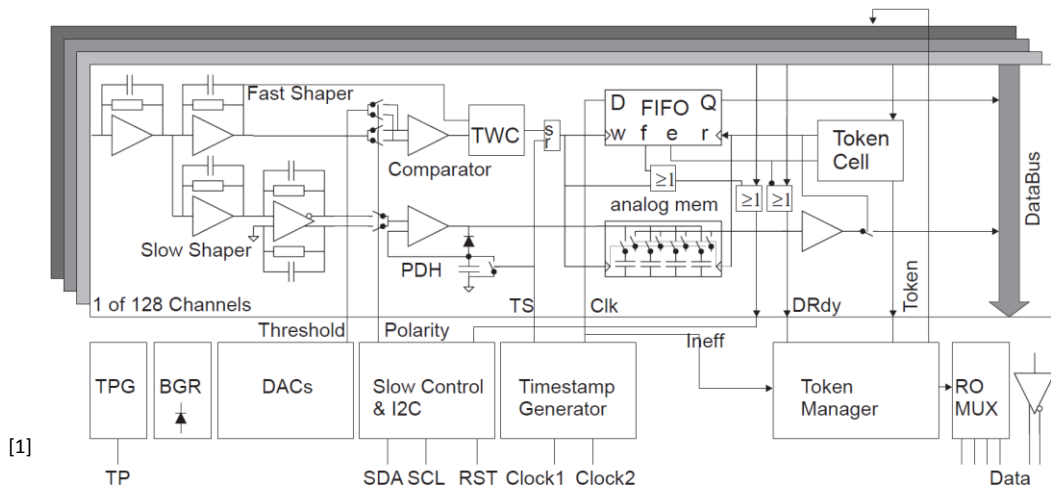
- 128 channels
- 1 ns time resolution
- Token Ring Readout



[1] The n-XYTER Reference Manual 1.50, 2009

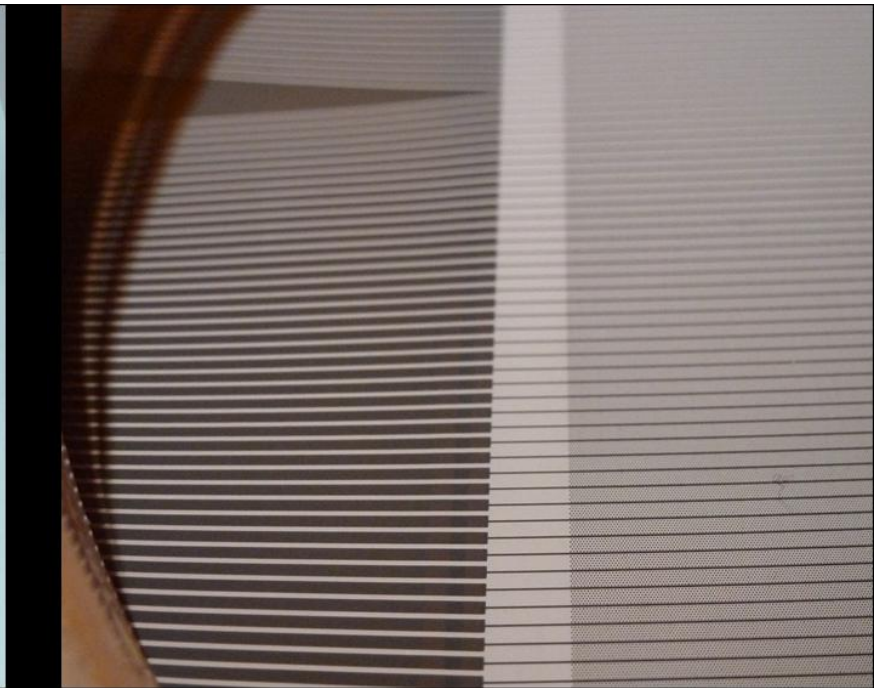
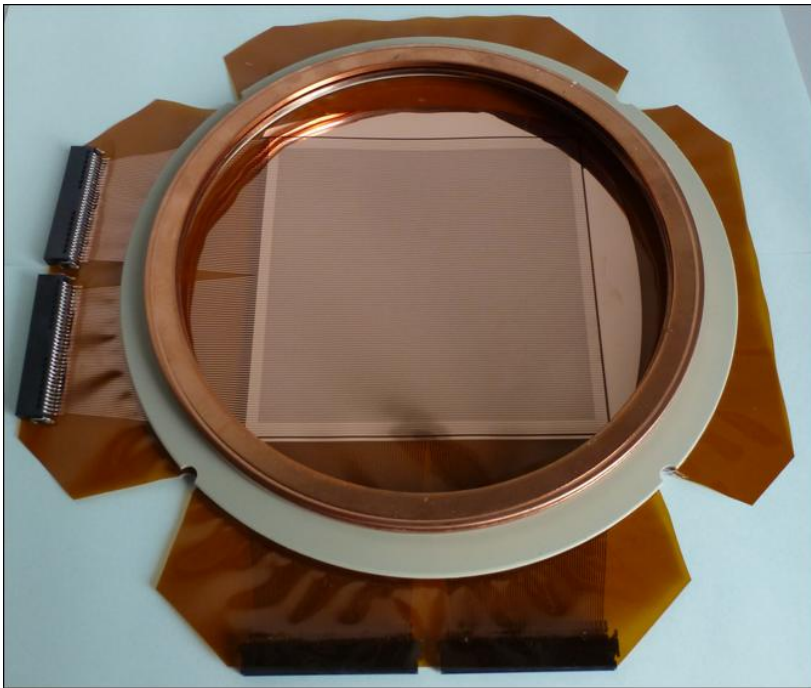
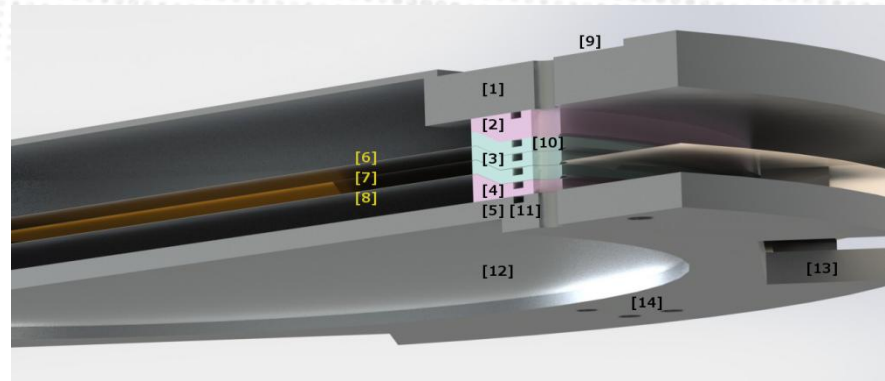
nXYter Prototype

- 128 channels
- 1 ns time resolution
- Token Ring Readout

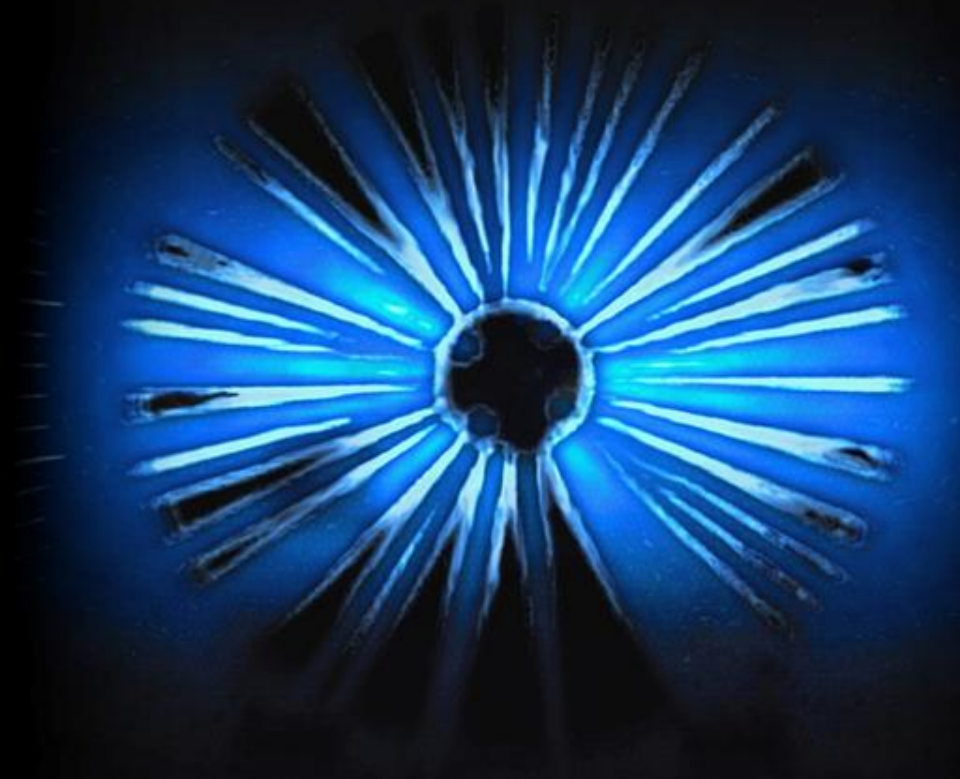


[1] The n-XYTER Reference Manual 1.50, 2009

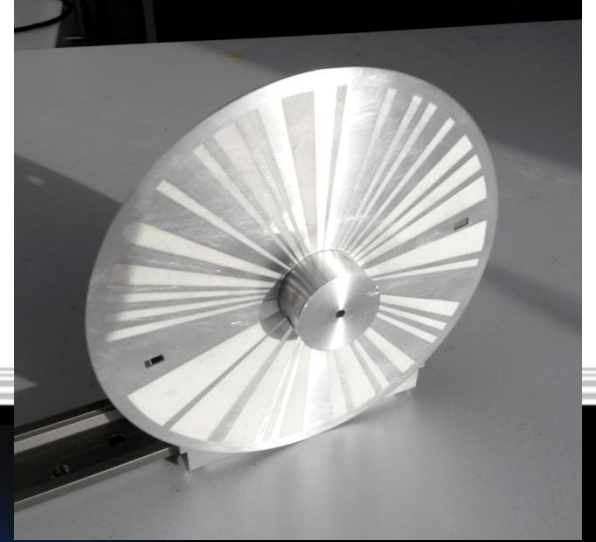
nXYter Prototype



||| CASCADE
Characterization
Measurements

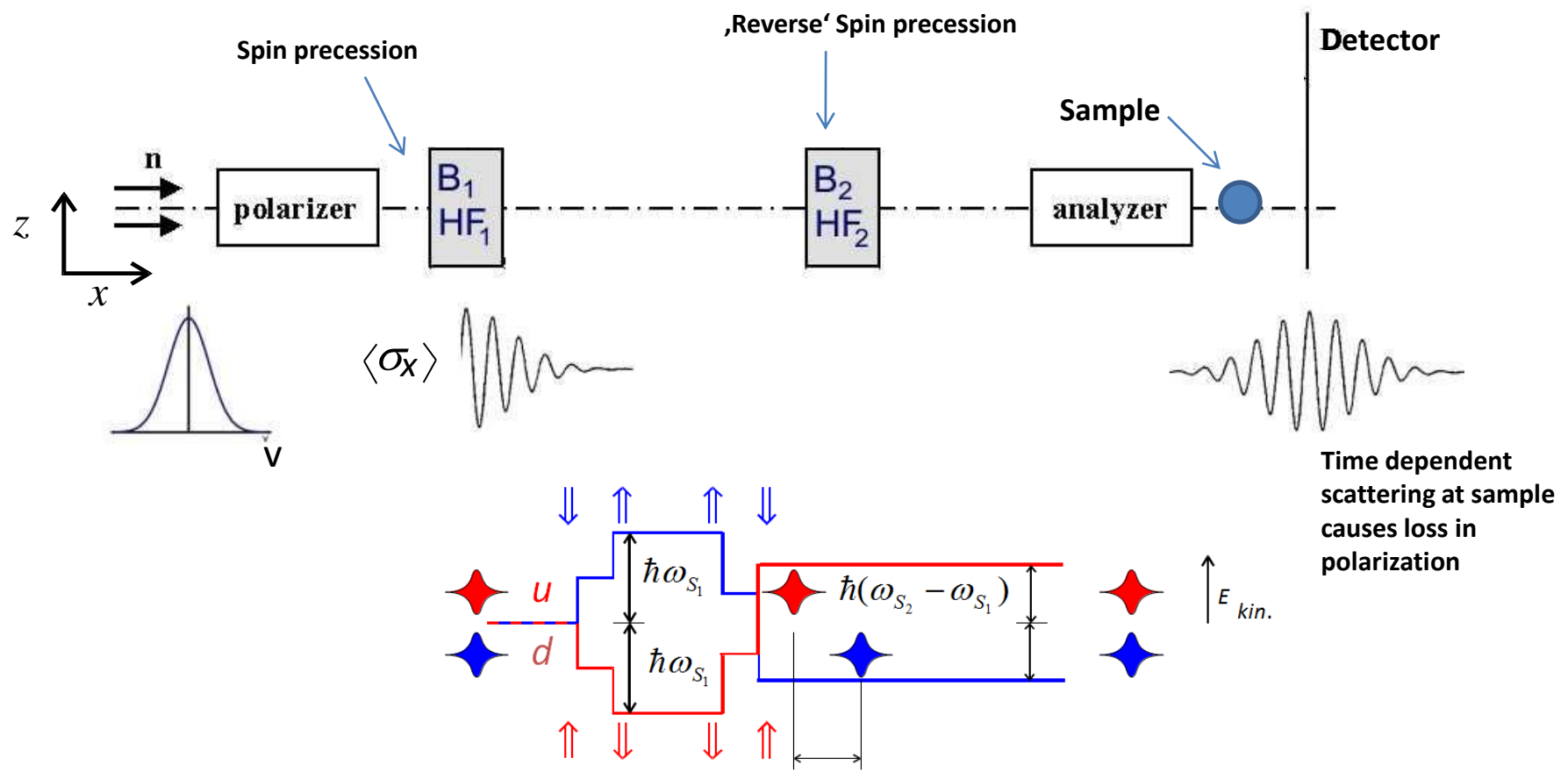


||| CASCADE
Characterization
Measurements

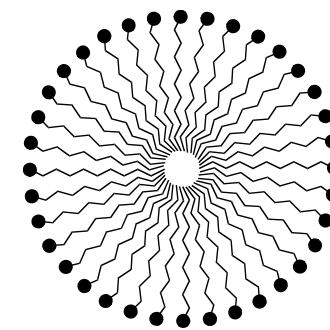
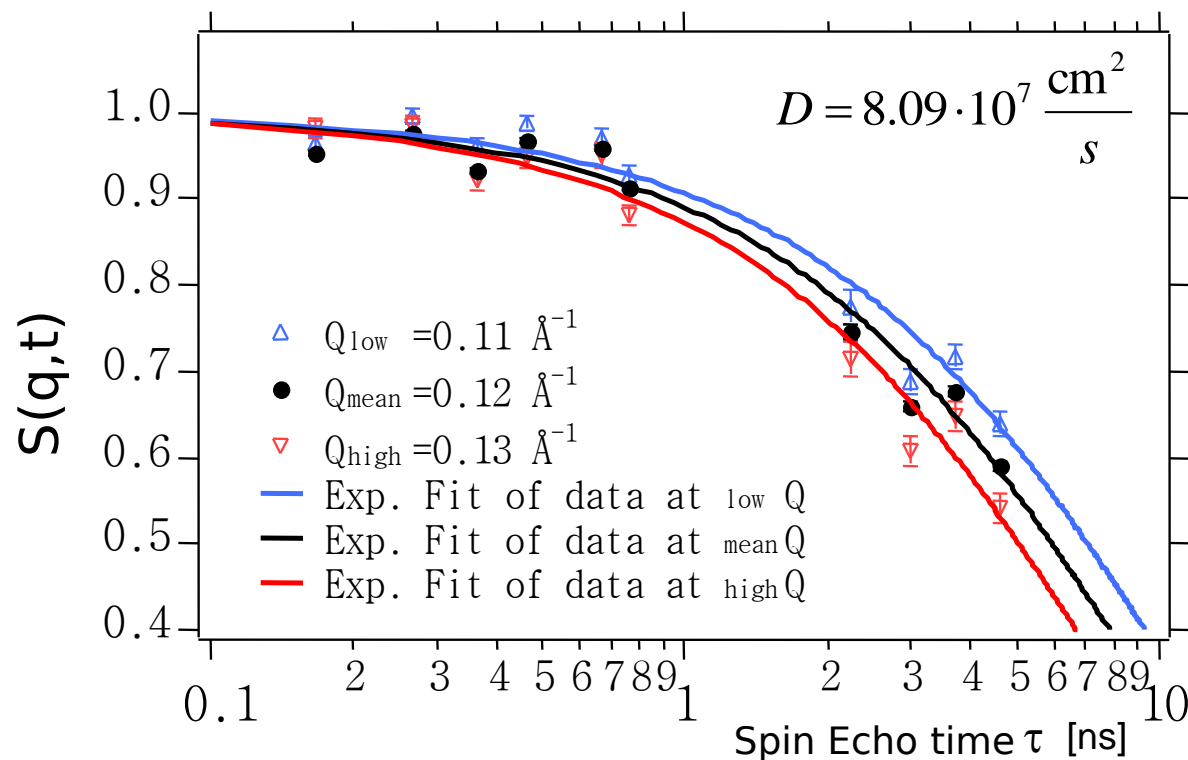


Neutron Resonance Spin Echo - MIEZE

Principle: Use Neutron Spin as Observable in Interference Time Of Flight Experiments



Spin Echo: Diffusion of micelles

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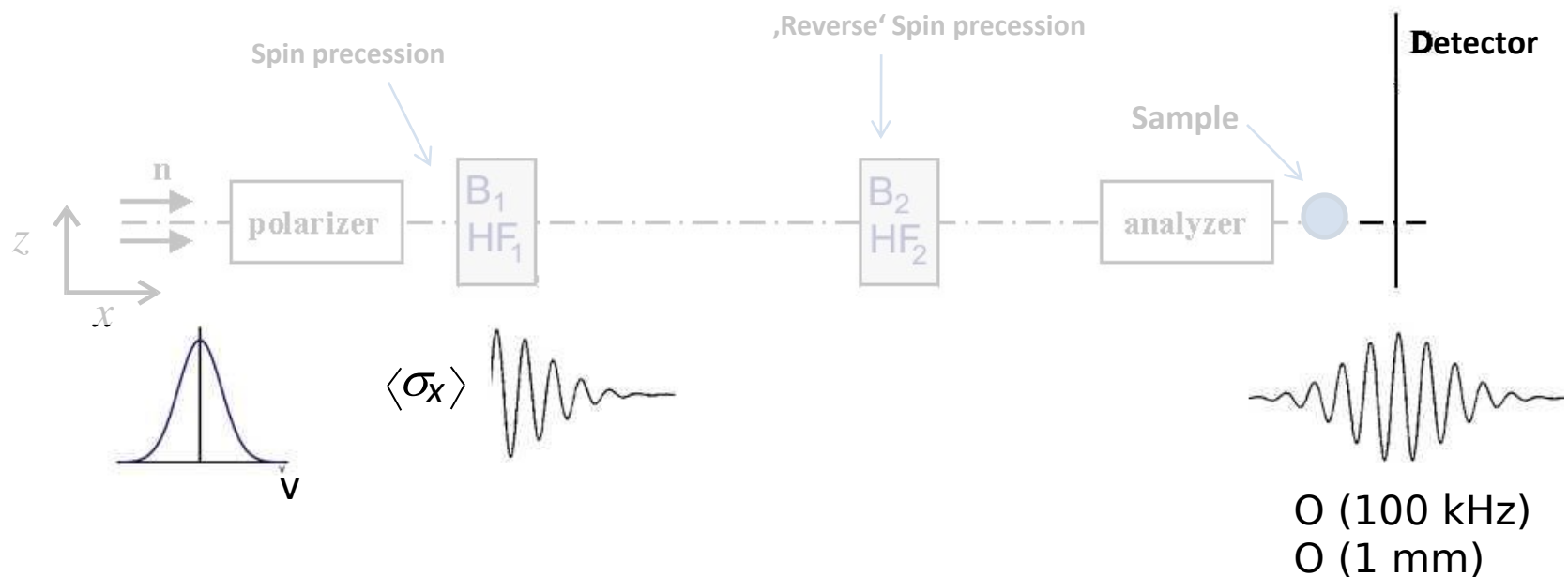
Natriumdodecylsulfat
in D_2O

for classical diffusion :

$$\tilde{S}_{\text{inc}}(\vec{q}, t) \propto e^{-Dq^2 t}$$

Neutron Resonance Spin Echo - MIEZE

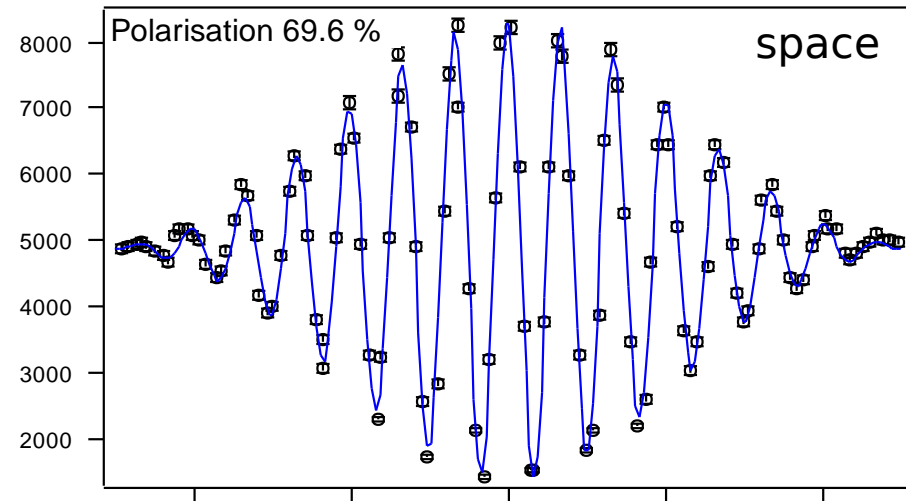
Principle: Use Neutron Spin as Observable in Interference Time Of Flight Experiments



Spin Echo Measurements



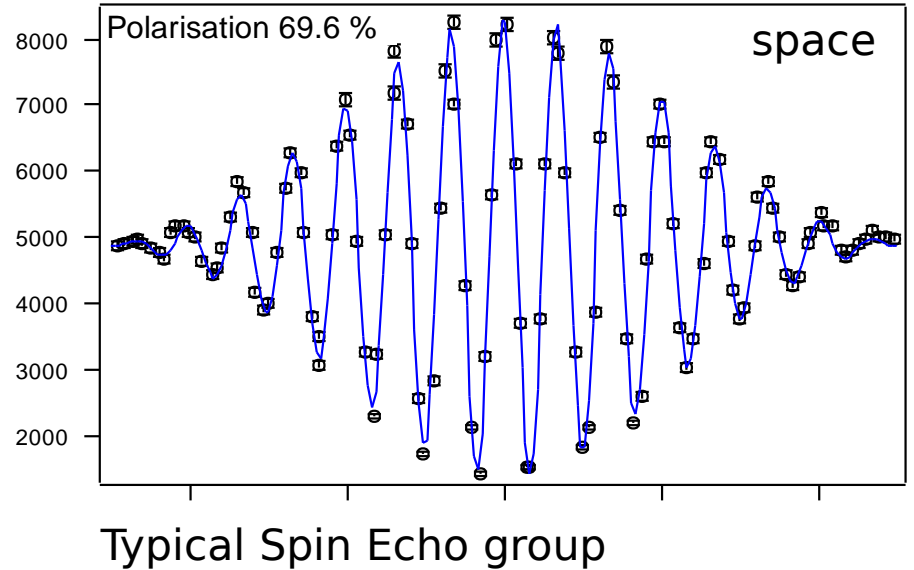
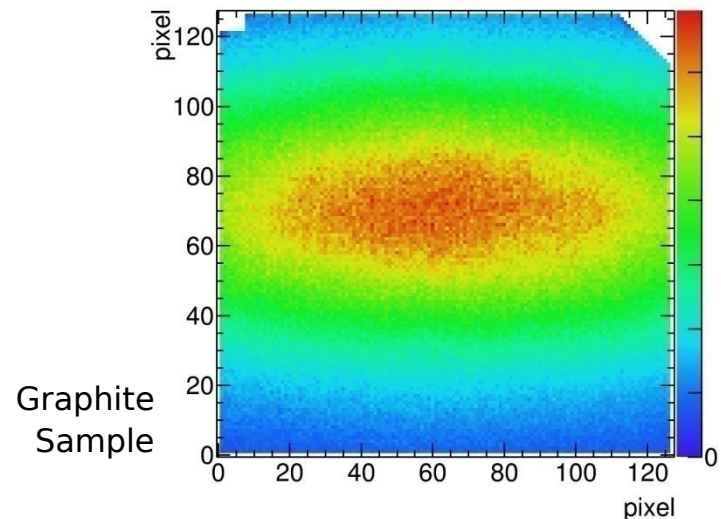
RESEDA, FRMII: spectrometer arms
3 - 15 Å @ 11% FWHM



Typical Spin Echo group

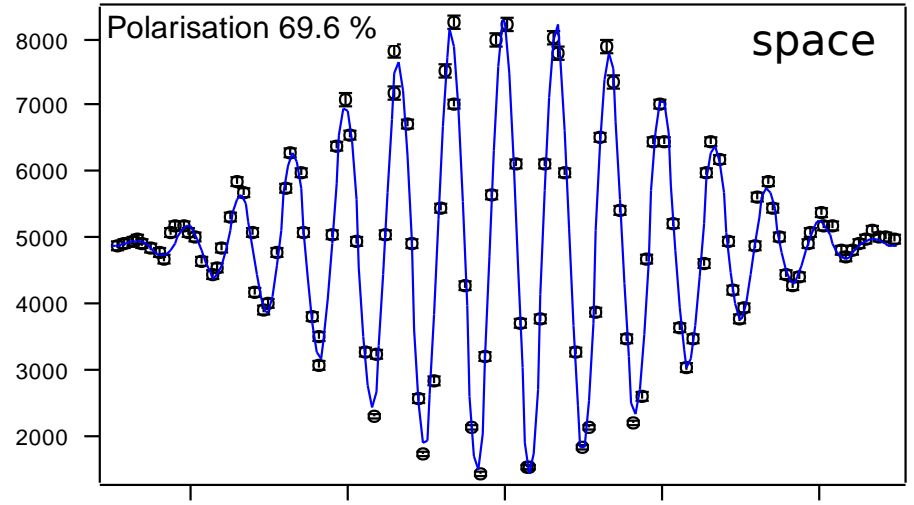
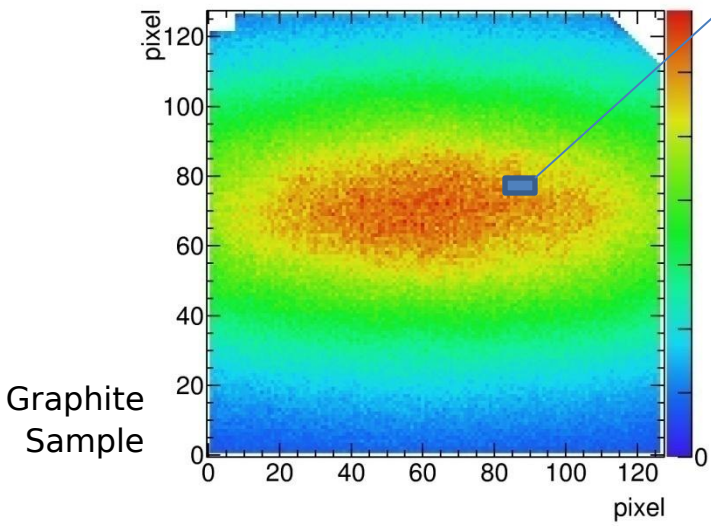
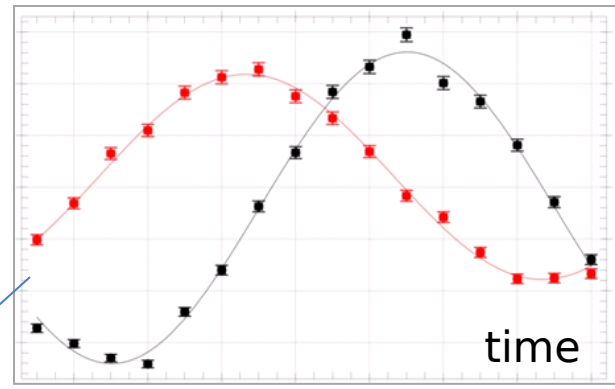
Spin Echo Measurements

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Spin Echo Measurements

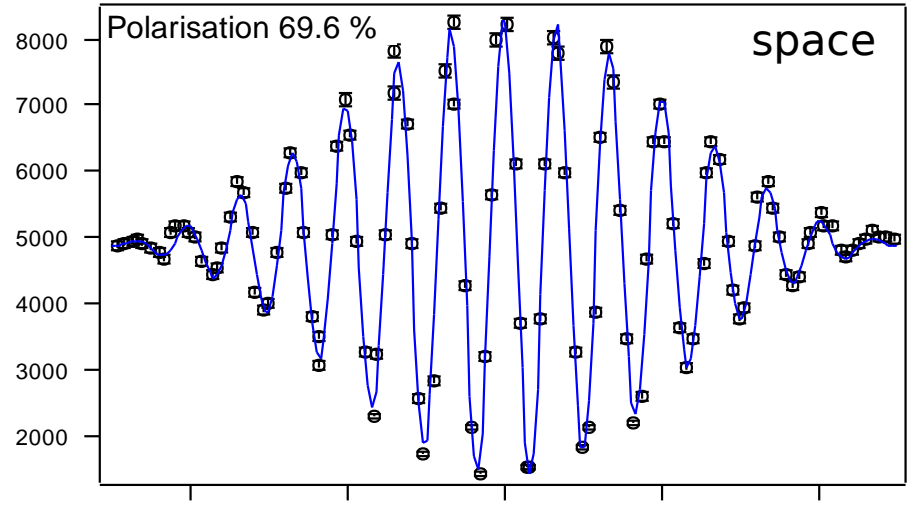
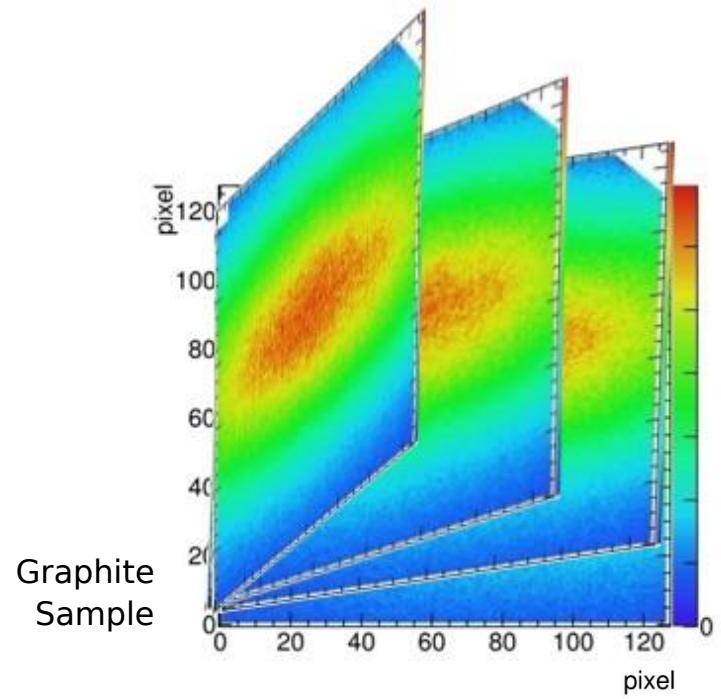
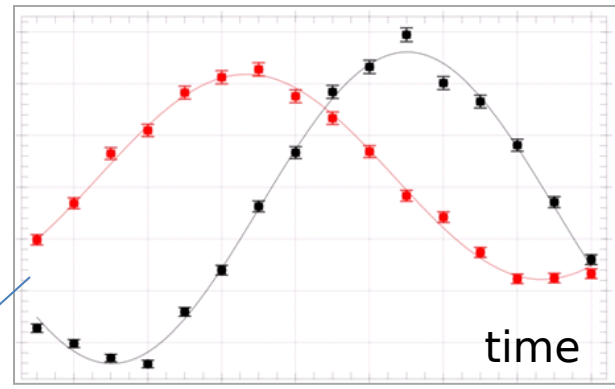
100 kHz x16



Typical Spin Echo group

Spin Echo Measurements

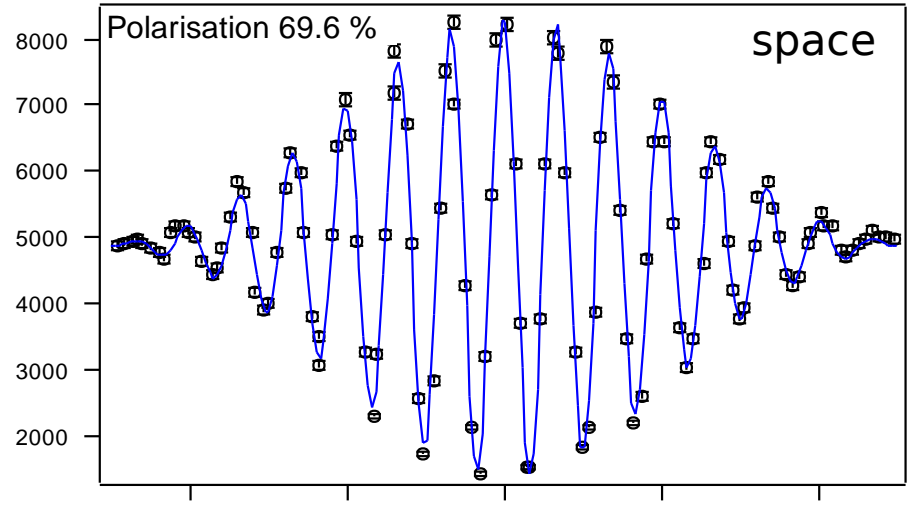
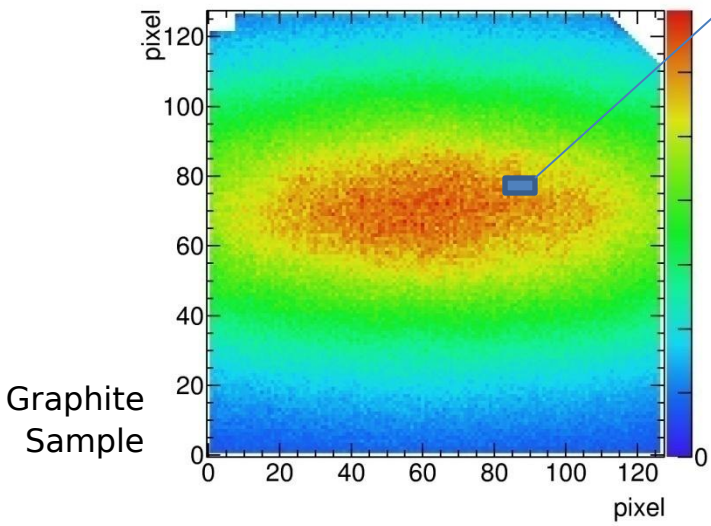
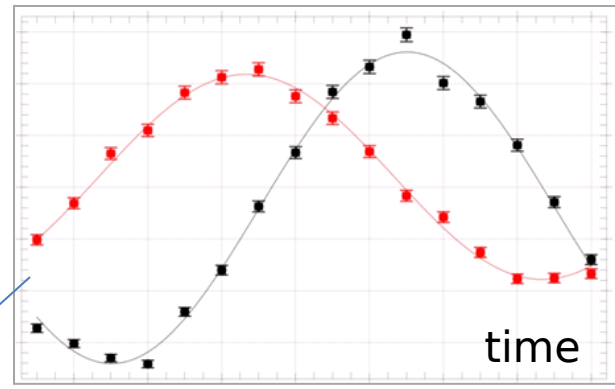
100 kHz x16



Typical Spin Echo group

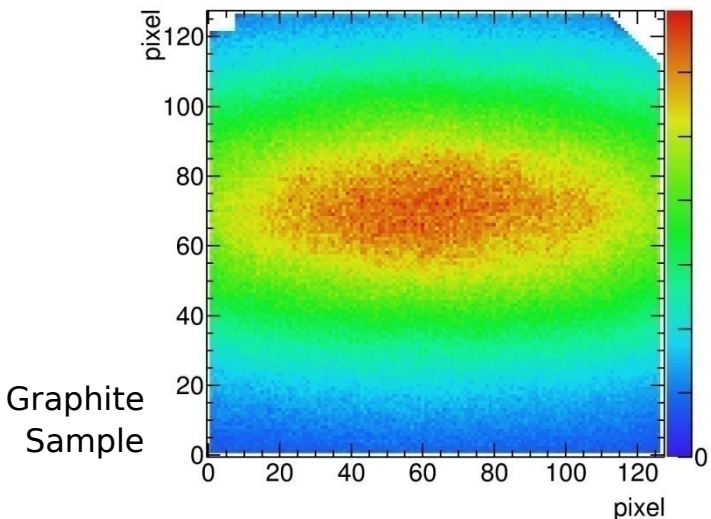
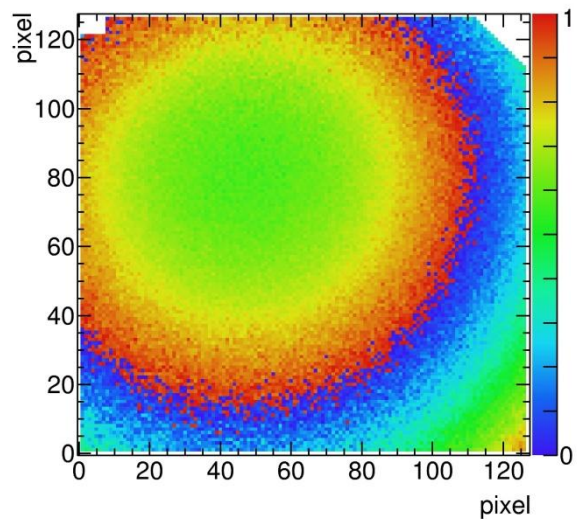
Spin Echo Measurements

100 kHz x16

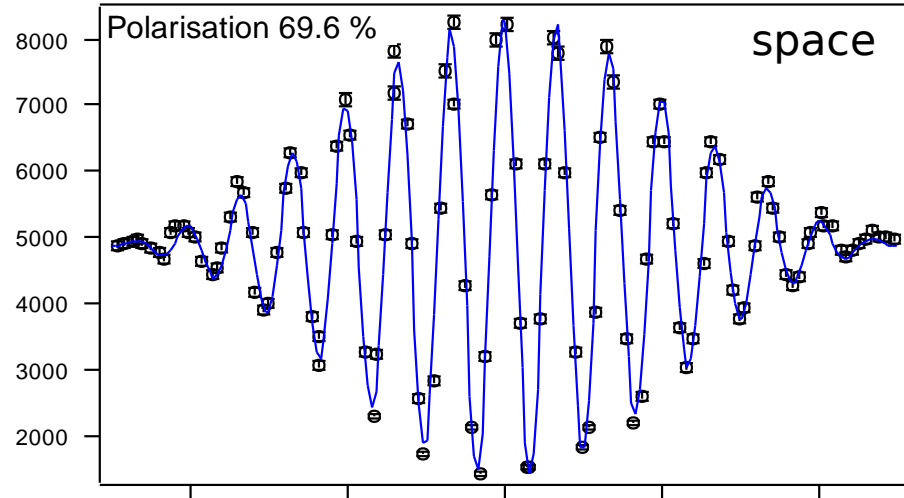
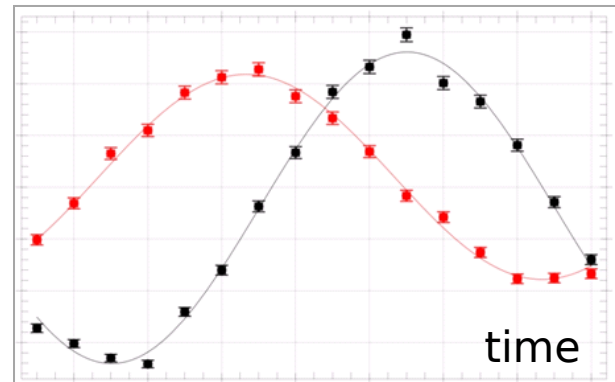


Typical Spin Echo group

Spin Echo Measurements

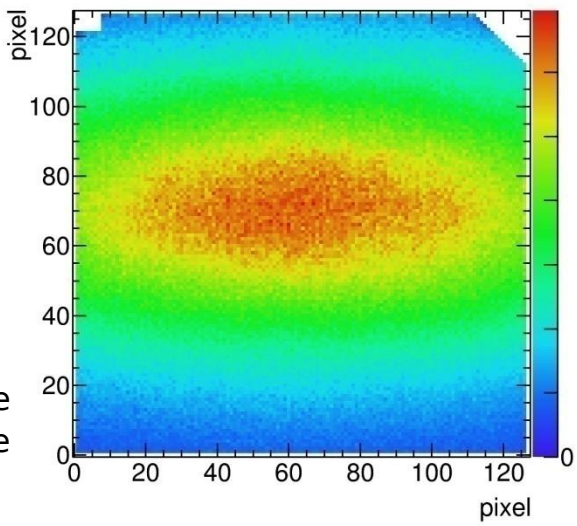
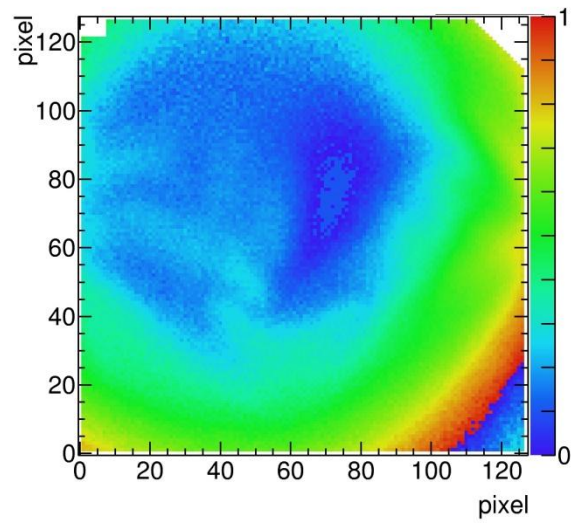


100 kHz x16

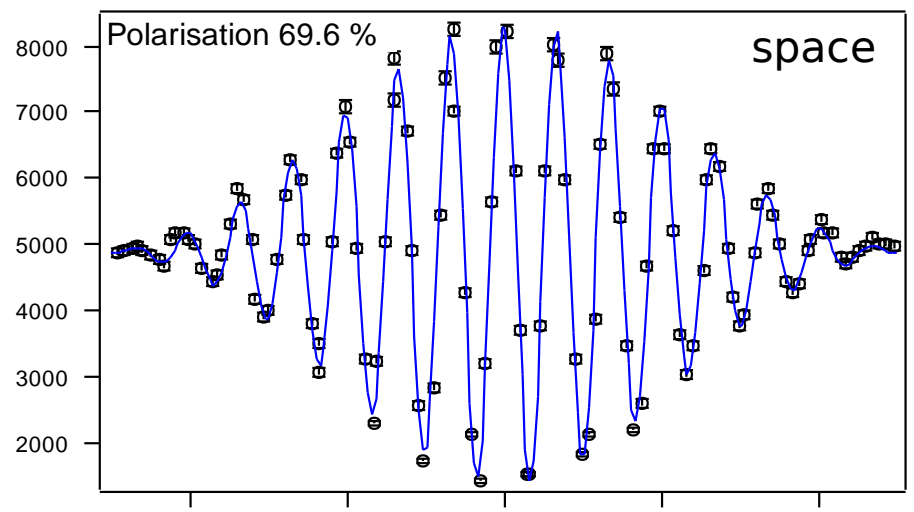


Typical Spin Echo group

Spin Echo Measurements



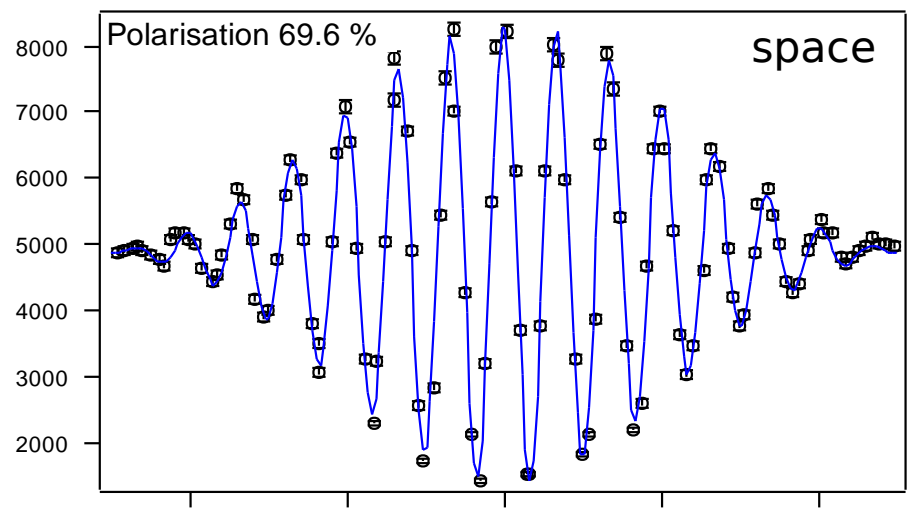
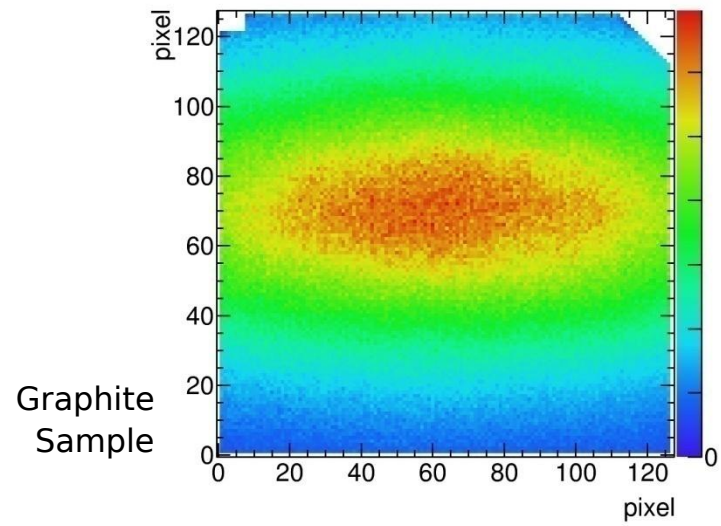
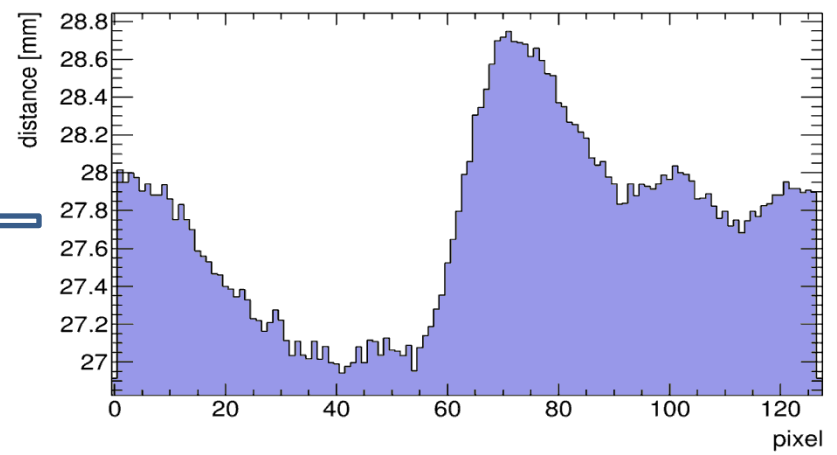
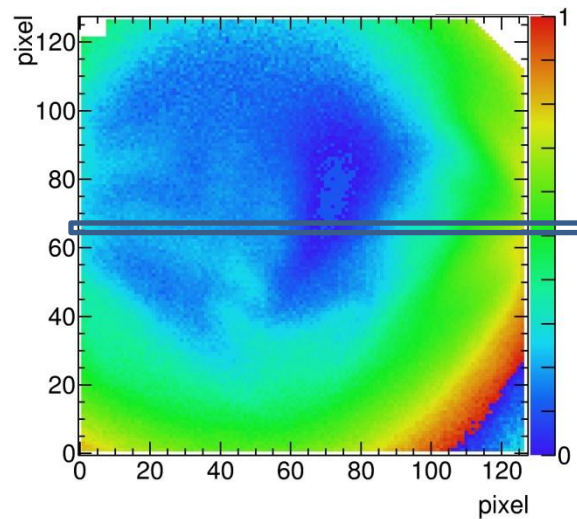
Graphite Sample



Typical Spin Echo group

Spin Echo Measurements

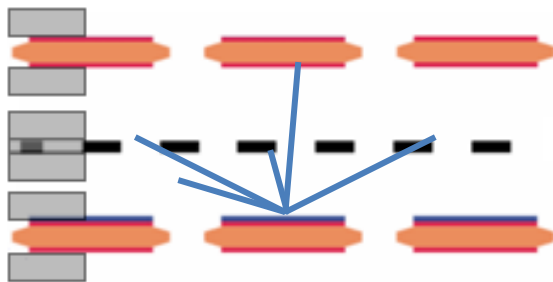
DENIM
2015



Typical Spin Echo group

Spatial Resolution

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2015



Spatial resolution: 2.4 mm FWHM

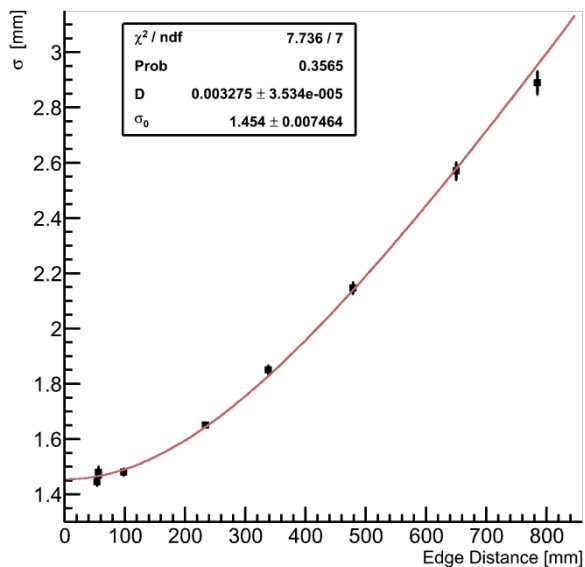
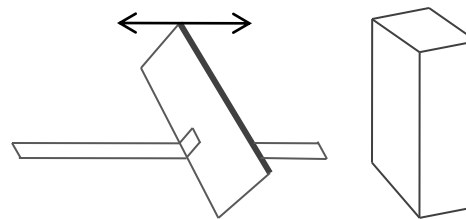
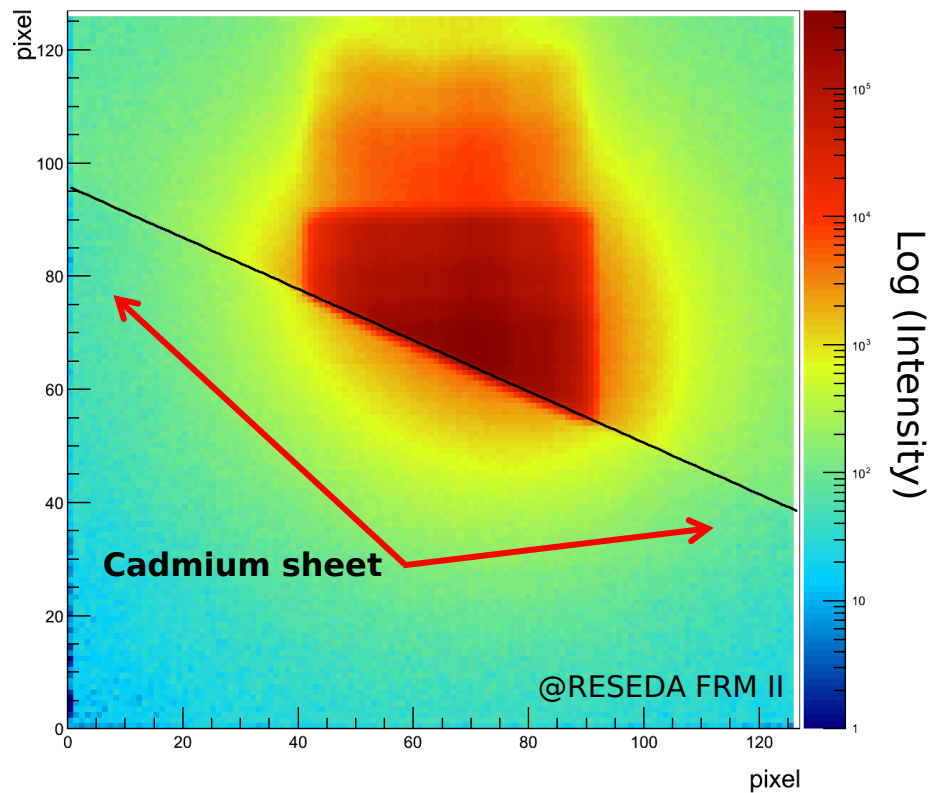
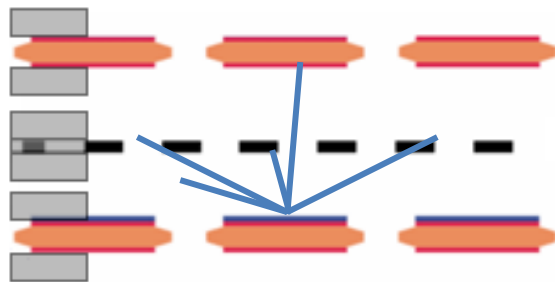


Image of a cold neutron beam (after guide)



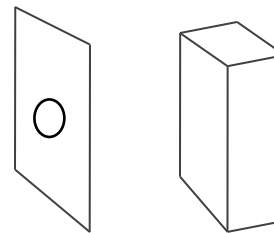
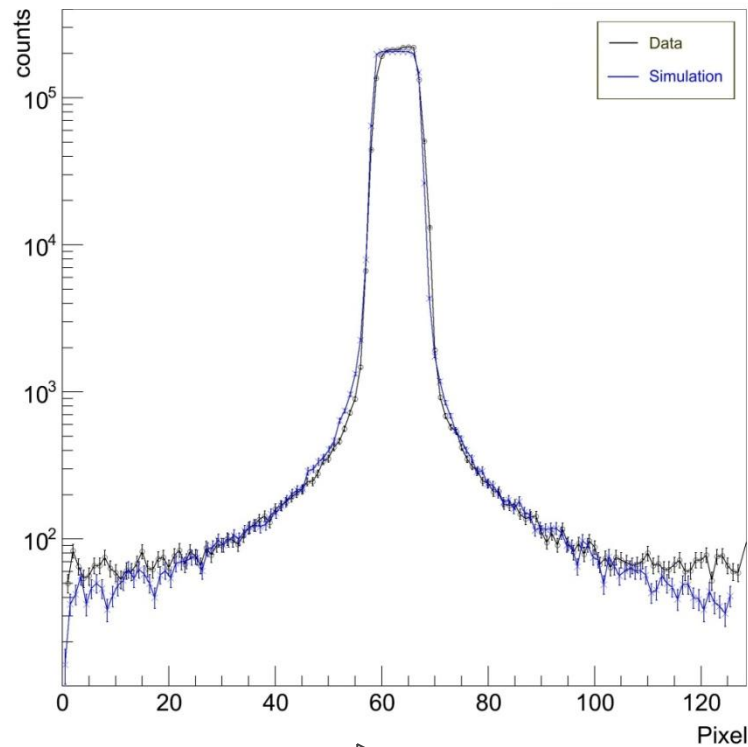
Spatial Resolution

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2015



Spatial resolution: 2.4 mm FWHM

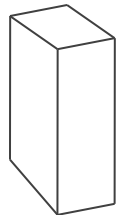
Cross section of a collimated n beam



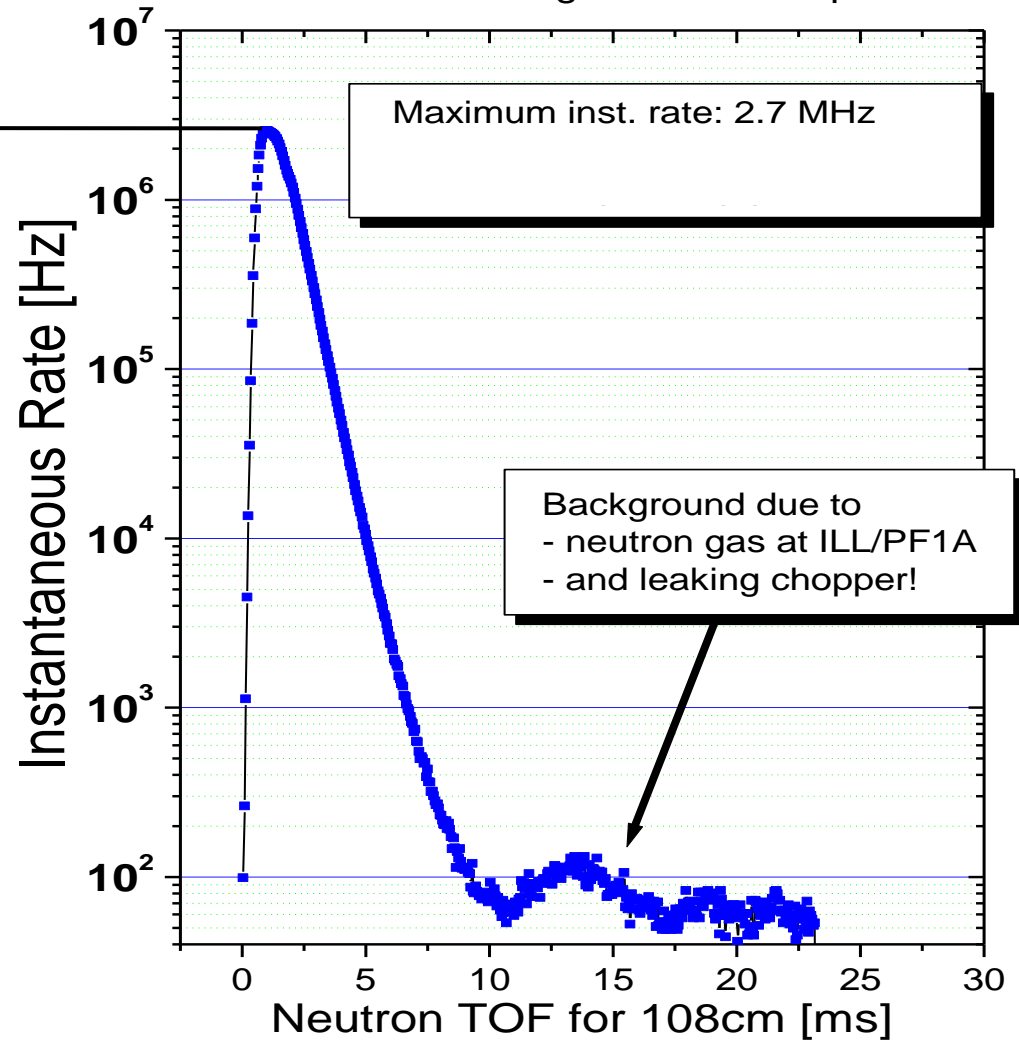
▶ Rate Capability

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count rate
2-3 MHz

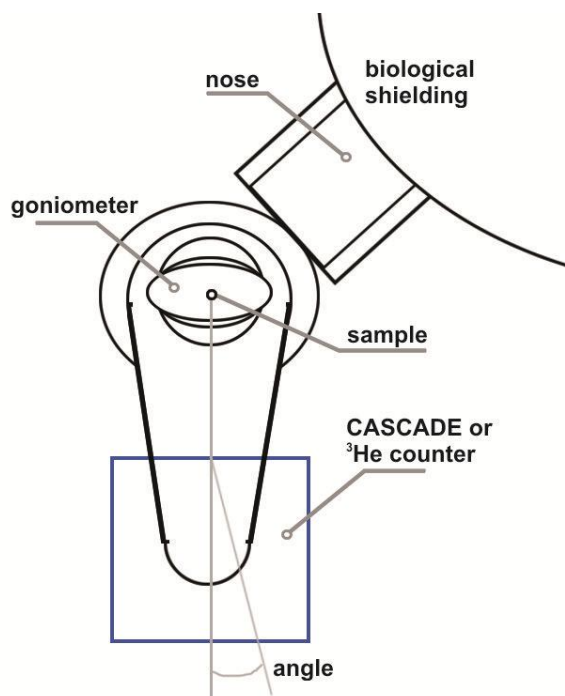


Time of Flight measurements
at ILL/ PF1A on a single readout strip of 1cm^2

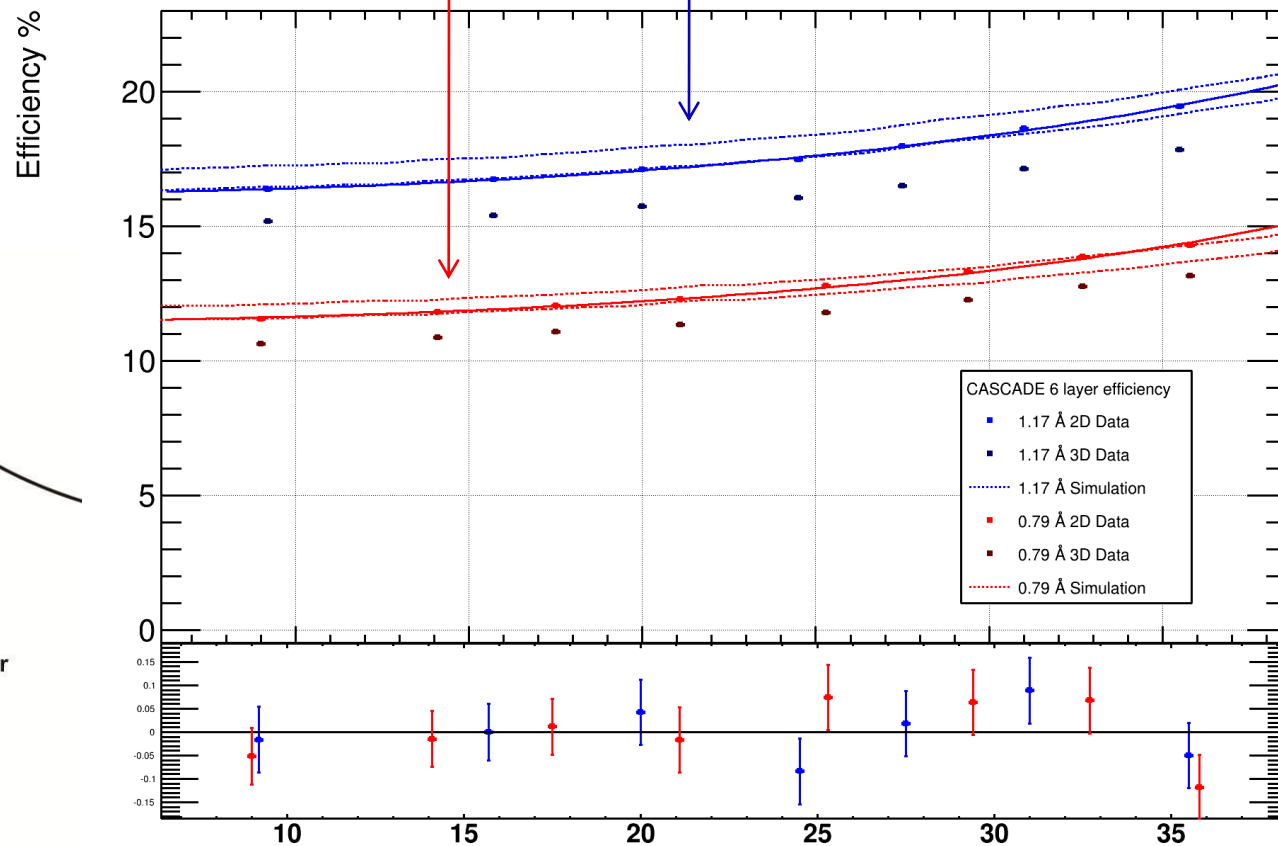


Detection Efficiency

1.5 - 0.8 - 1.0 - 1.0 - 0.8 - 2.0

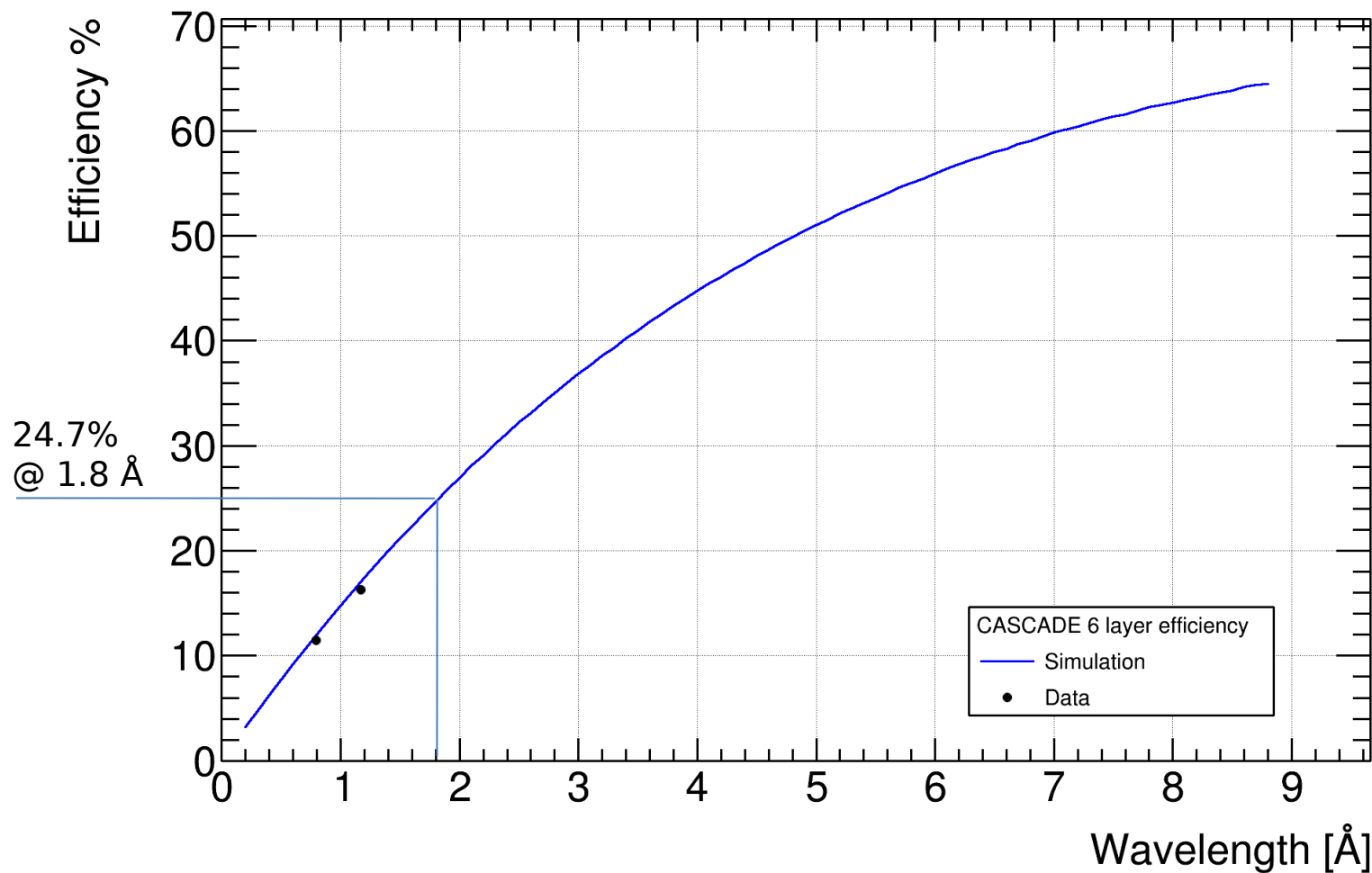
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Efficiency at 0.8 Å and 1.2 Å in 2D and 3D



@HEIDI FRM II

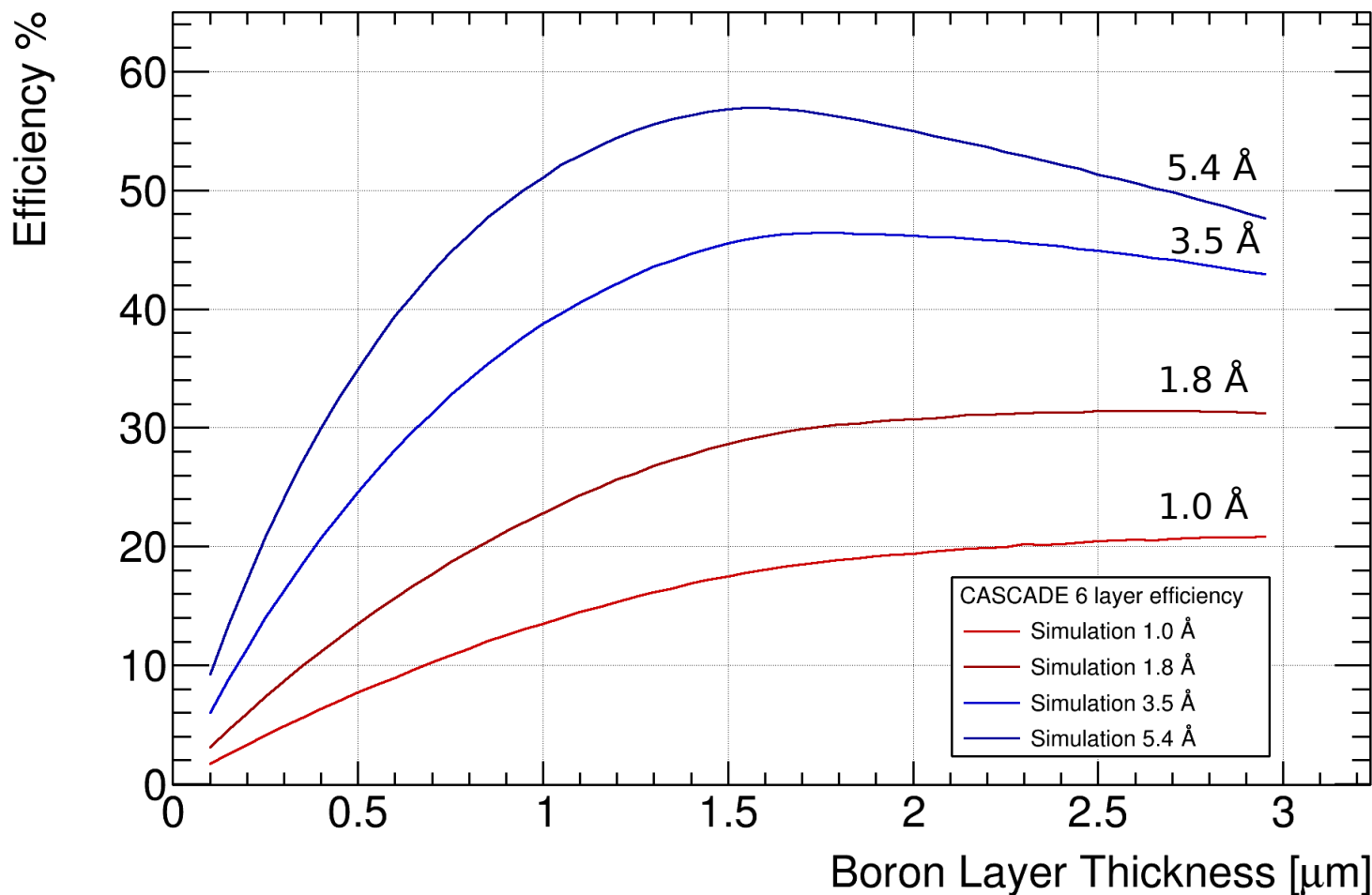
Simulation of the 2D efficiency and data of 0.8 Å and 1.2 Å



Detection Efficiency

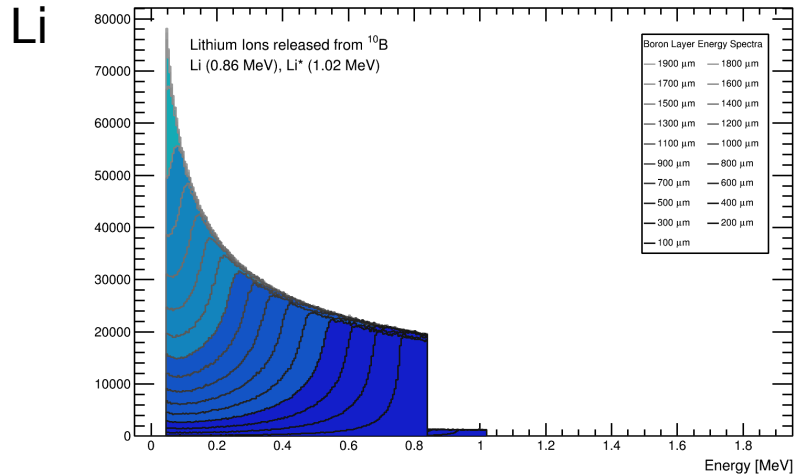
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Simulation of the 2D efficiency with different coating thicknesses

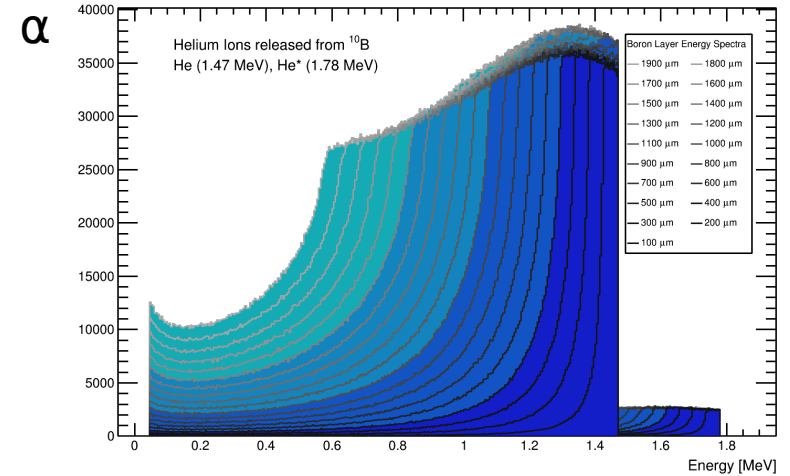


Conversion Products: Energy Spectra

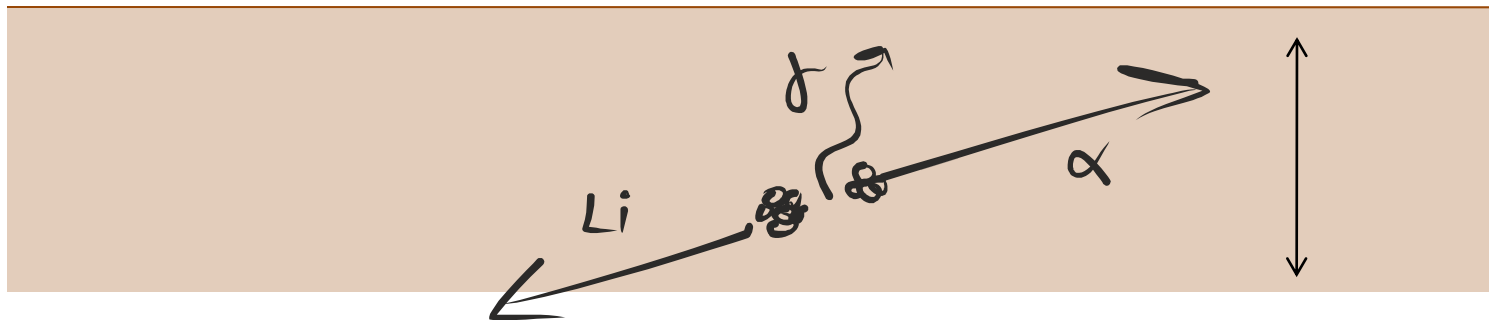
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2015



From 0.1 μm to 2 μm ^{10}B

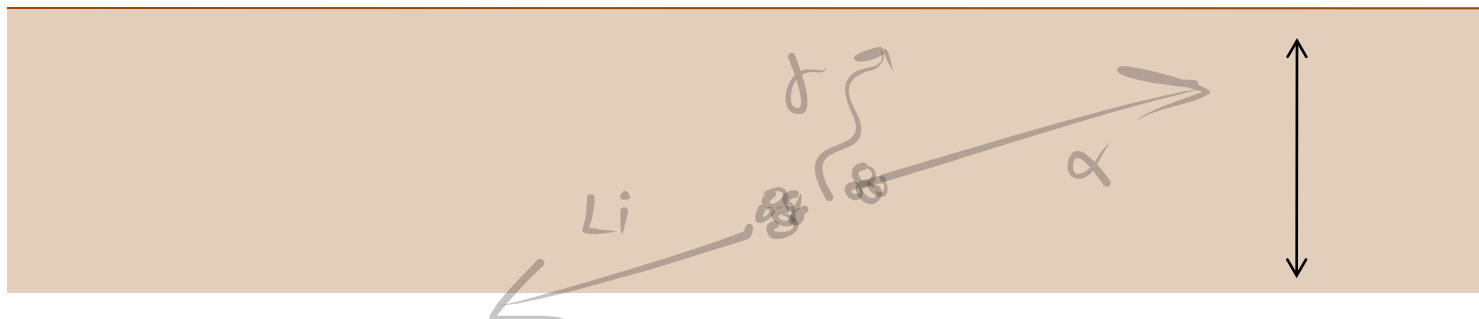
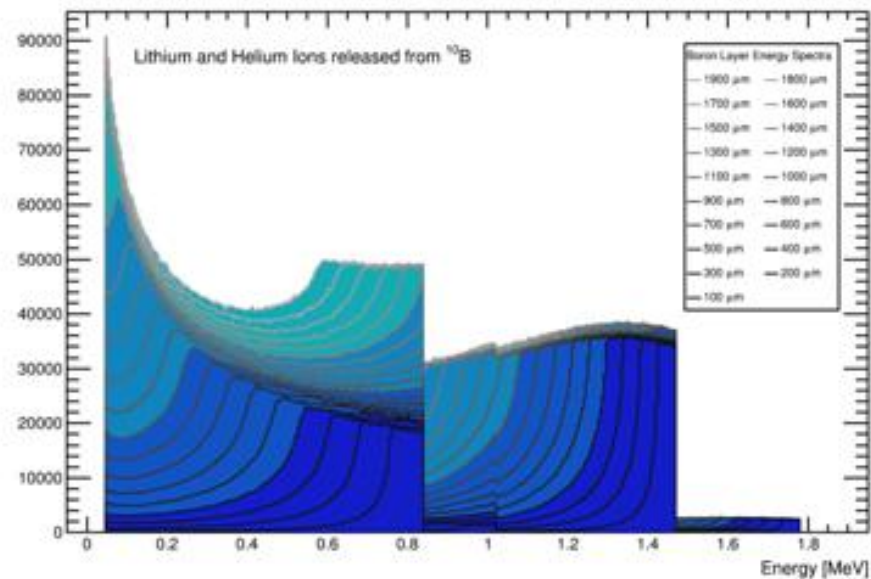


From 0.1 μm to 2 μm ^{10}B



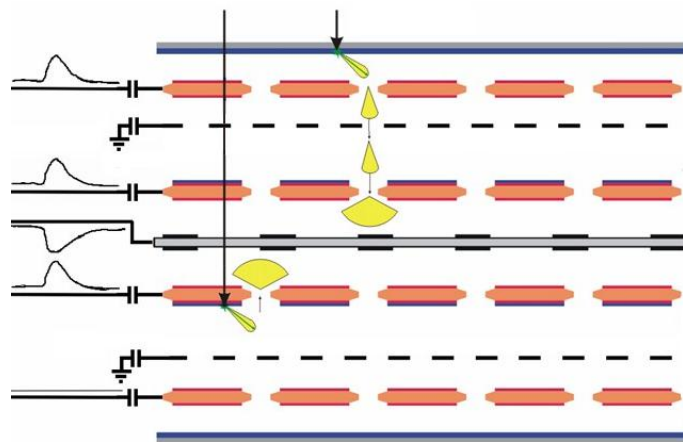
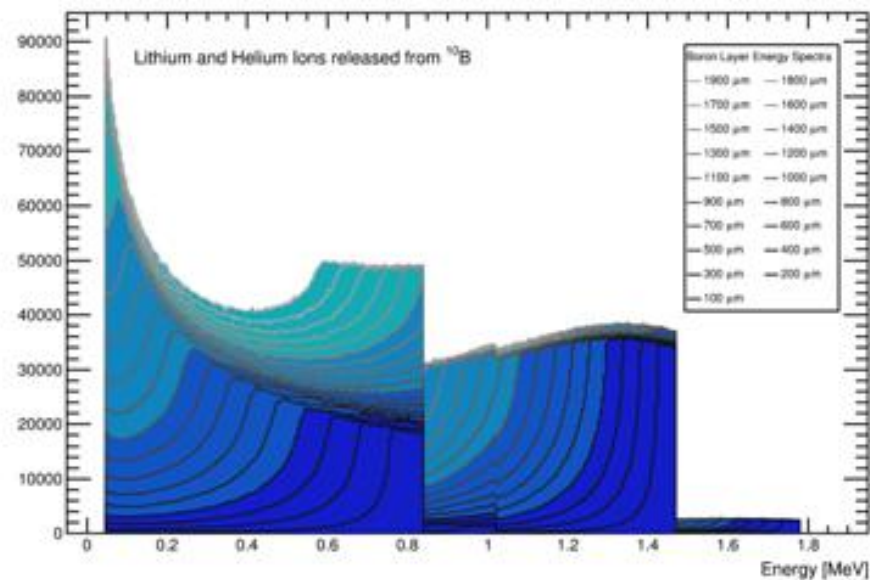
Conversion Products: Energy Spectra

DENIM
2015



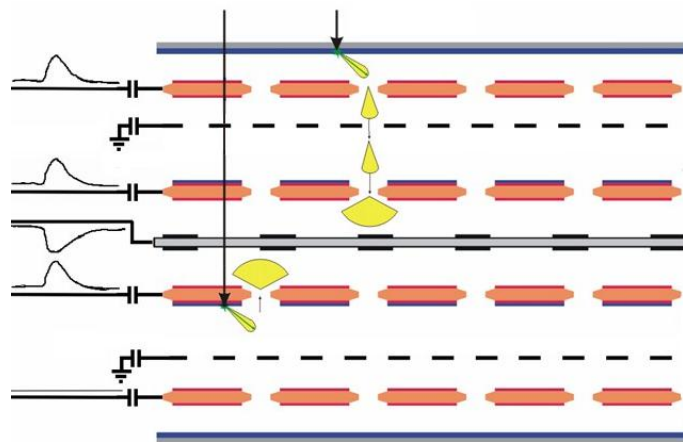
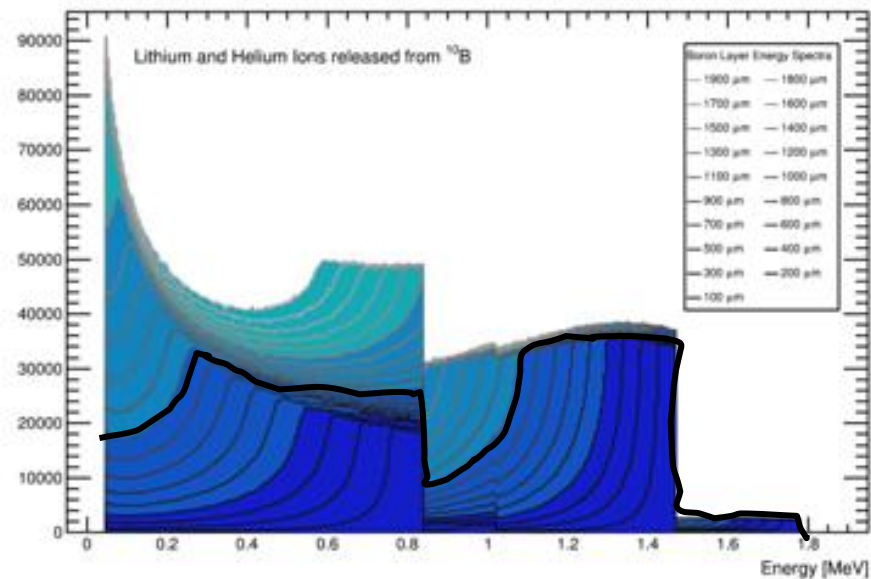
Conversion Products: Energy Spectra

DENIM
2015

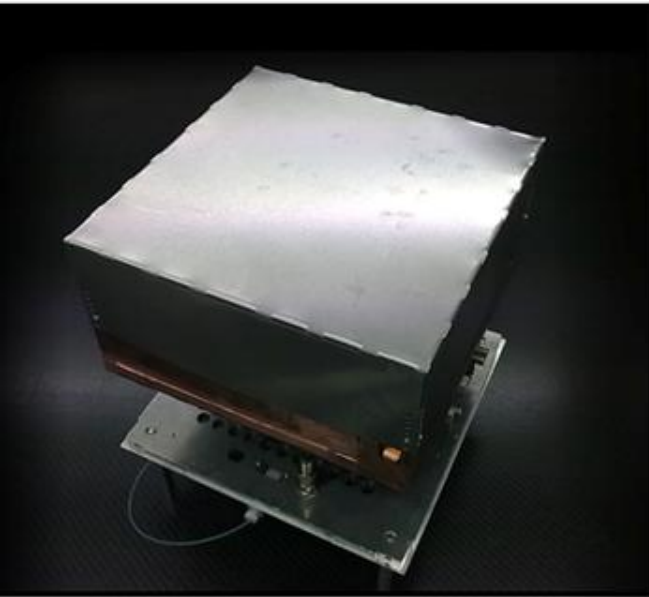


Conversion Products: Energy Spectra

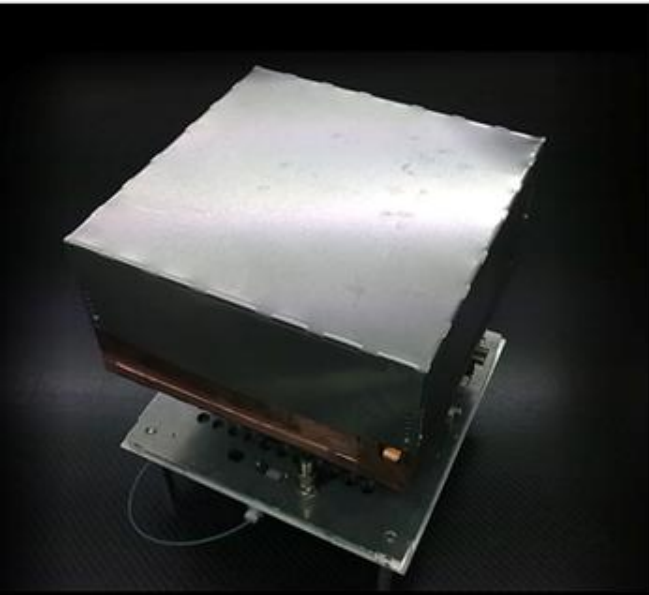
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2015



 CASCADE

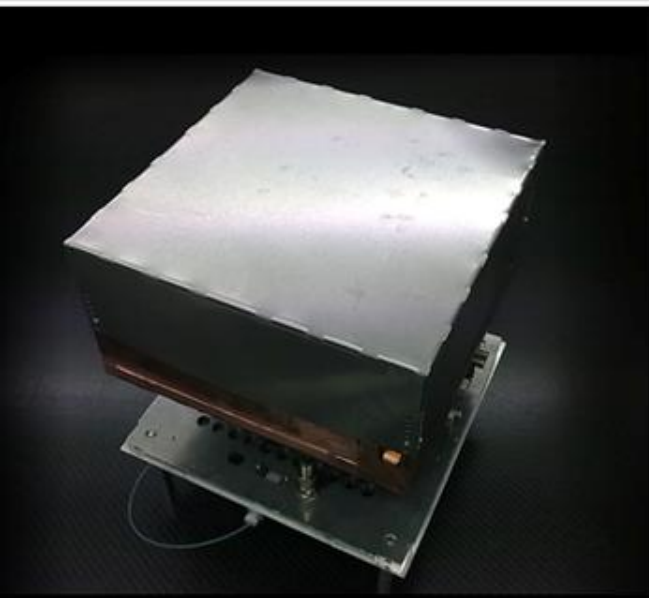


Boron-10 technology



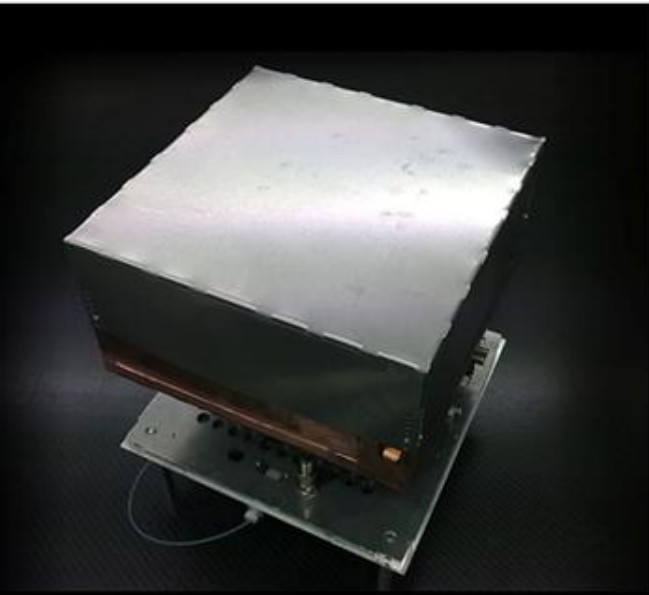
Boron-10 technology

a high rate, spatially and time resolved
detector for Spin Echo applications



Boron-10 technology

a high rate, spatially and time resolved detector for Spin Echo applications

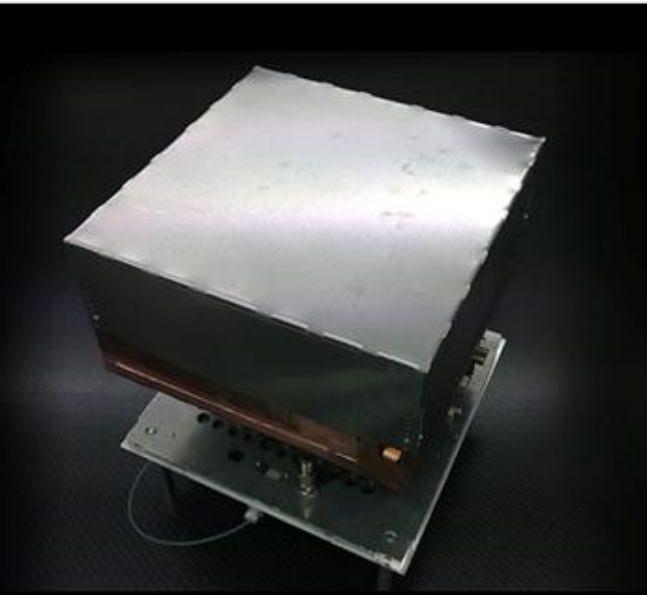


- conversion layer identification
- high TOF resolution (100 ns readout)
- 2.4 mm FWHM spatial resolution
- 2 MHz rate capability
- 25% thermal neutron efficiency @ 6 layers (21% in new configuration)

Boron-10 technology

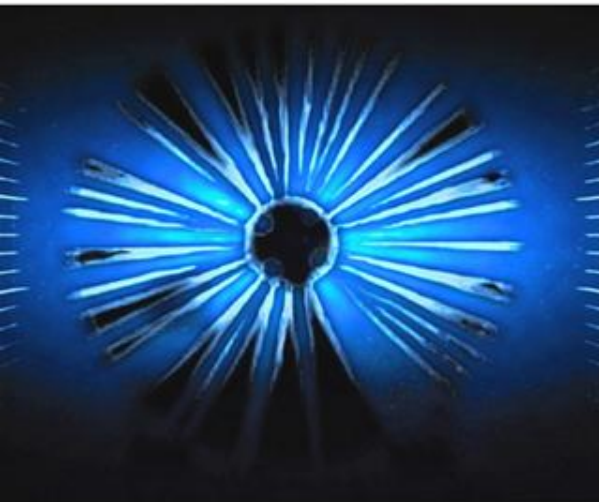


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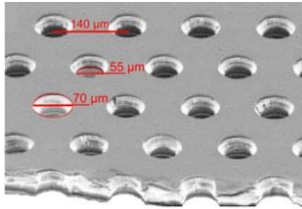
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||| The road to go?

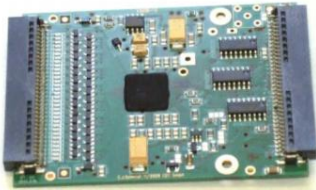


■ ■ ■ ■ The road to go?

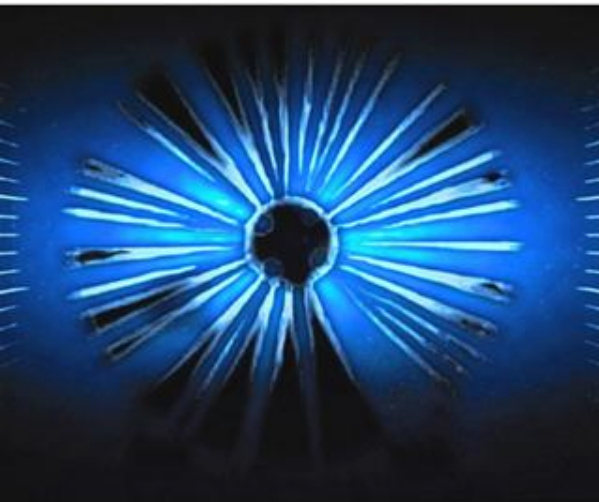
GEM



Multichannel
ASIC

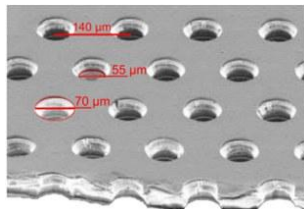


Technology available in 2000

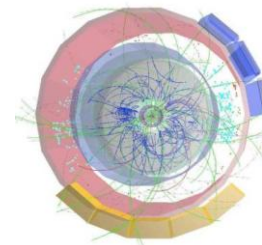
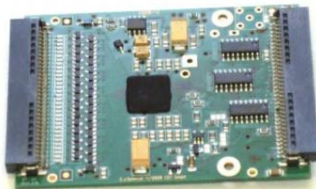


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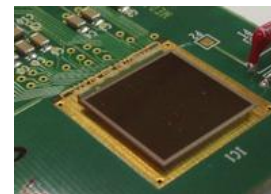
GEM



Multichannel
ASIC



TPC



TimePix

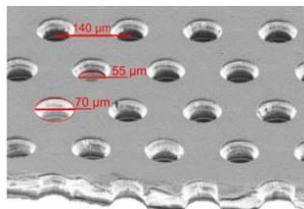
Technology available in 2000

Technology available in 2015

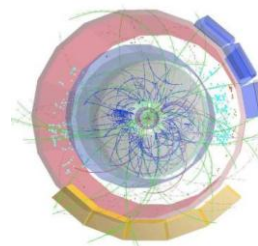
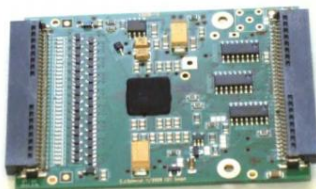


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GEM



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TPC



TimePix

Technology available in 2000

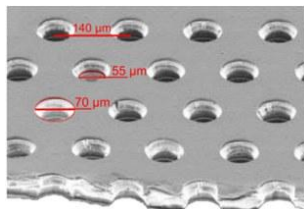
Technology available in 2015



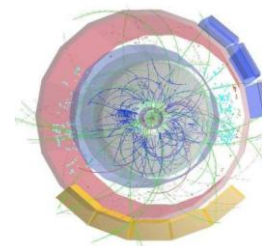
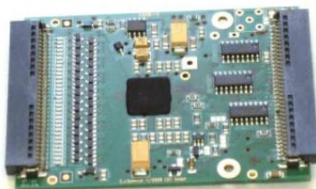
Particle Flow

The road to go?

GEM



Multichannel
ASIC



TPC



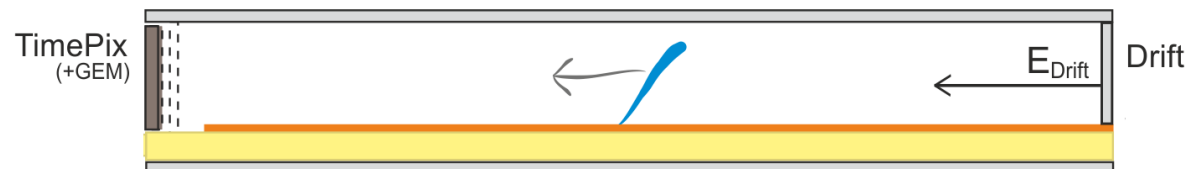
TimePix

Technology available in 2000

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Particle Flow



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