

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

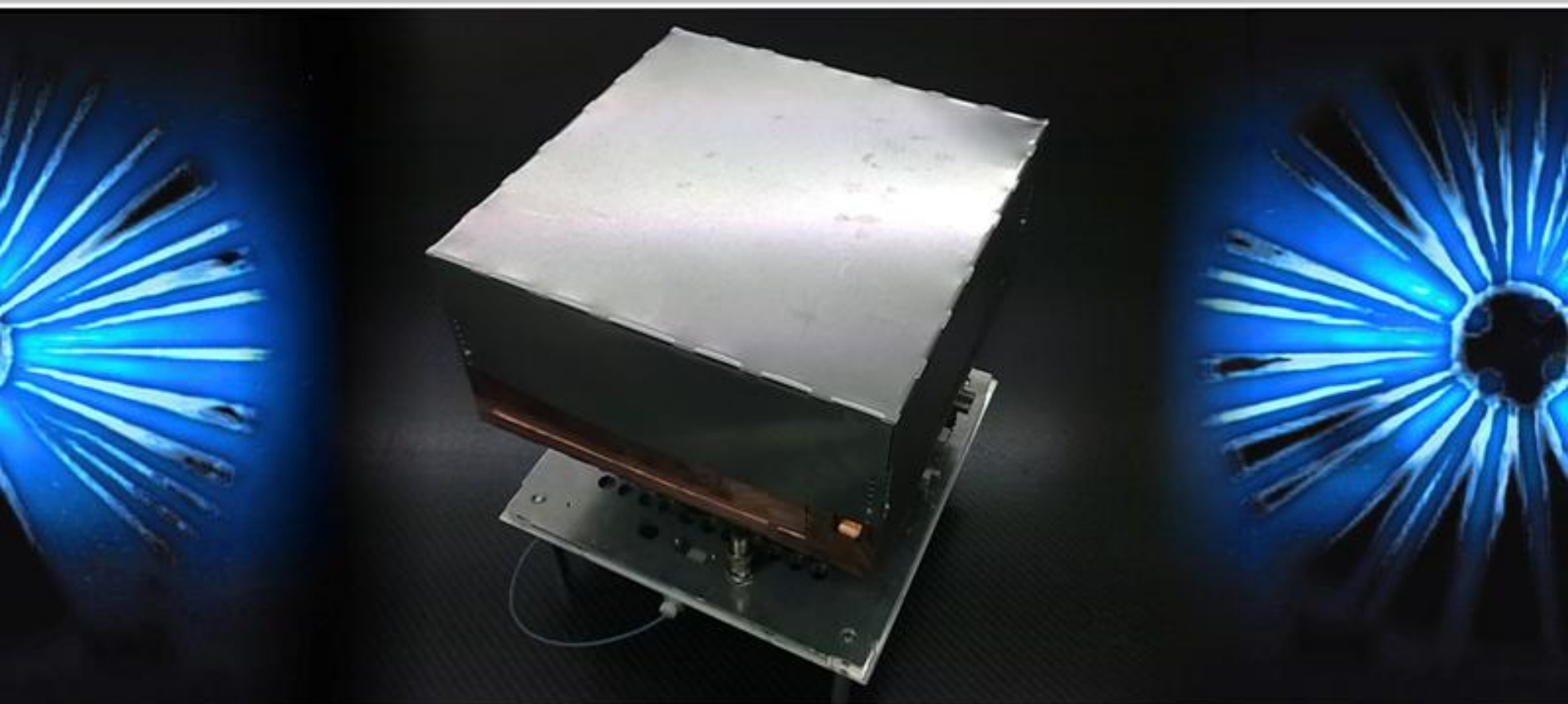


Physikalisches Institut

Ruprecht-Karls-Universität
Heidelberg

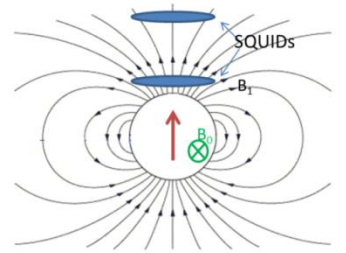
Markus Köhli

M.Klein, U. Schmidt
AG Dubbers

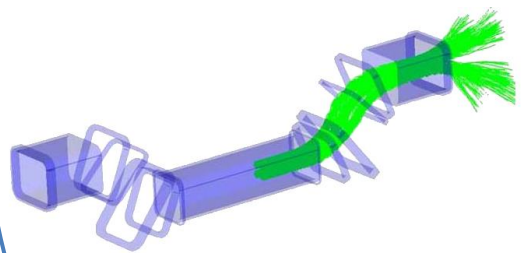


Heidelberg Research Fields

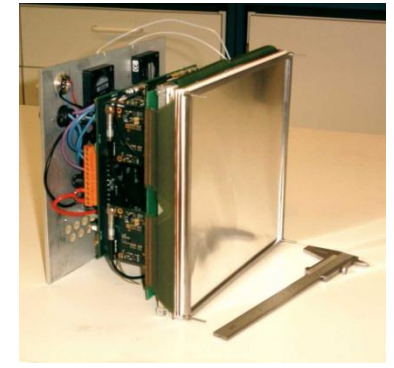
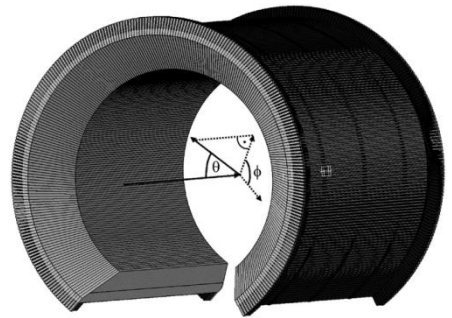
Helium-Xenon EDM [test of Lorentz invariance]



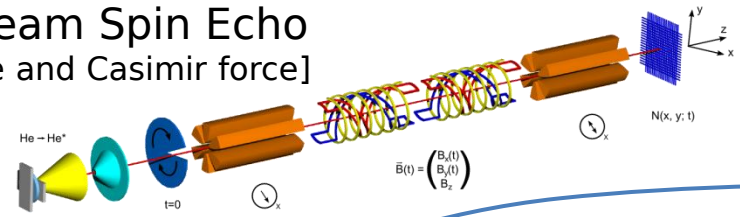
PERC and PERKEO [v_{ud} via neutron beta decay]



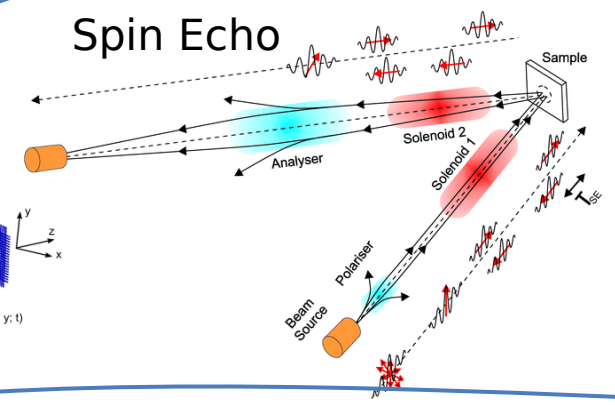
^{10}B Neutron Detectors [large area and high time resolution]



Atomic Beam Spin Echo [Berry phase and Casimir force]



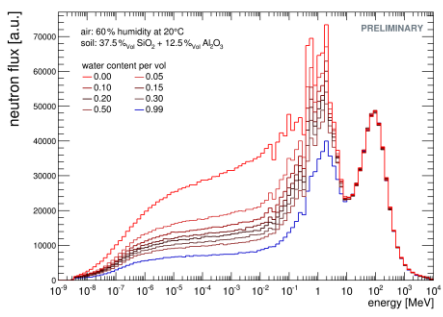
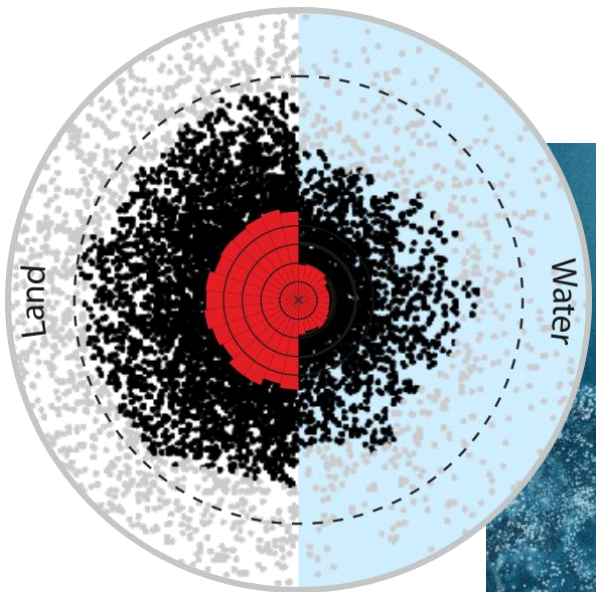
Spin Echo



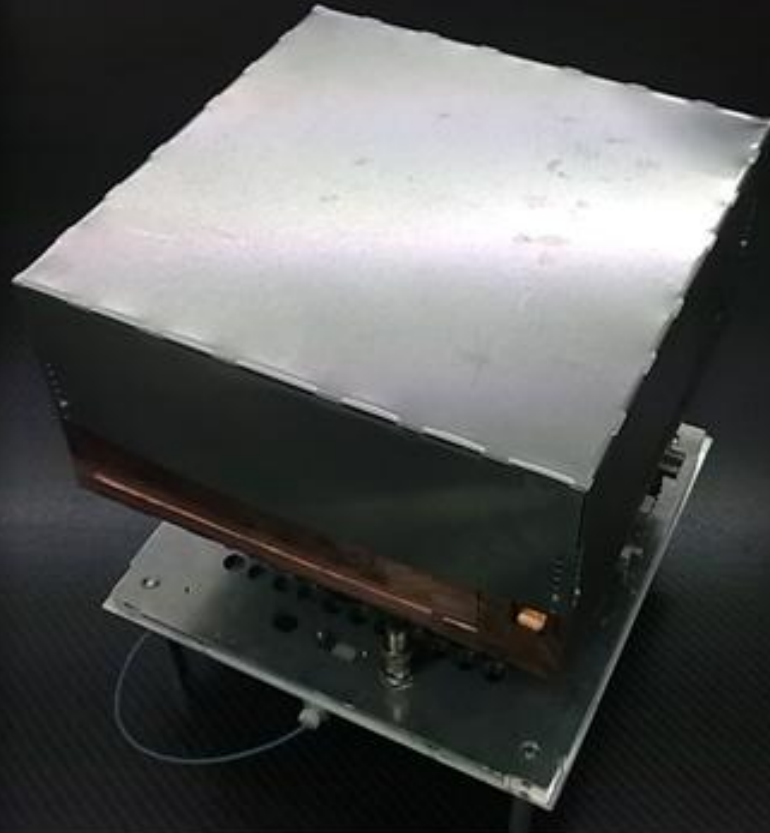
Heidelberg Research Fields

COSMOS Project, UFZ Leipzig

Ground water sensing by cosmic ray induced neutron showers



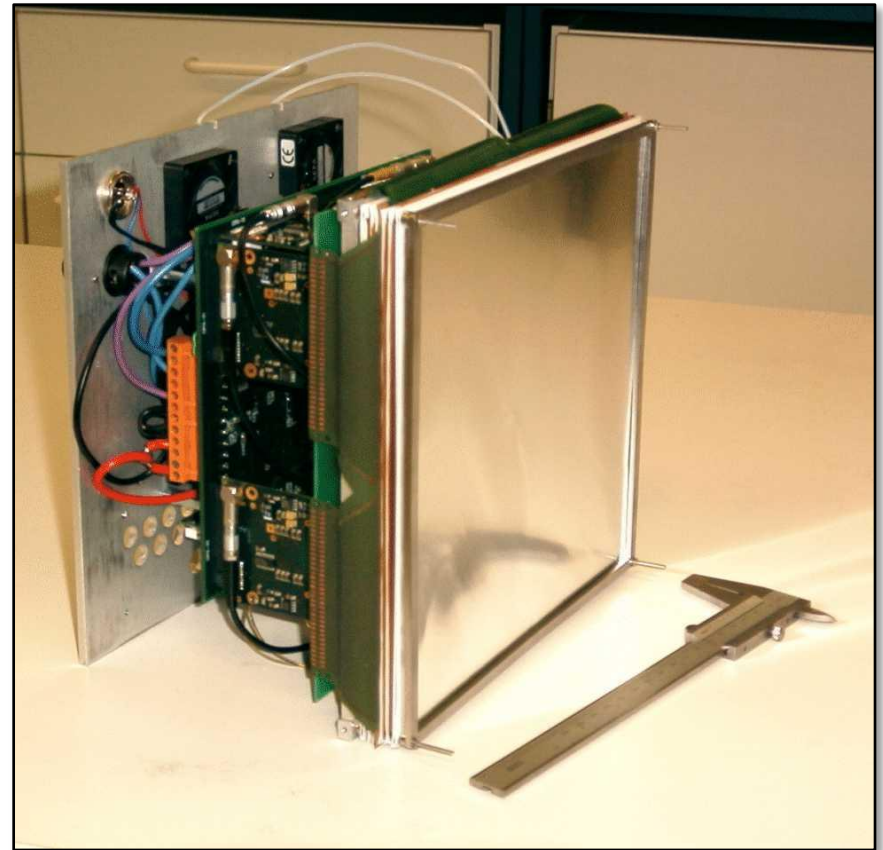
||| CASCADE
The Detector



The CASCADE Detector

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2015

CASCADE detector without housing



The CASCADE Detector

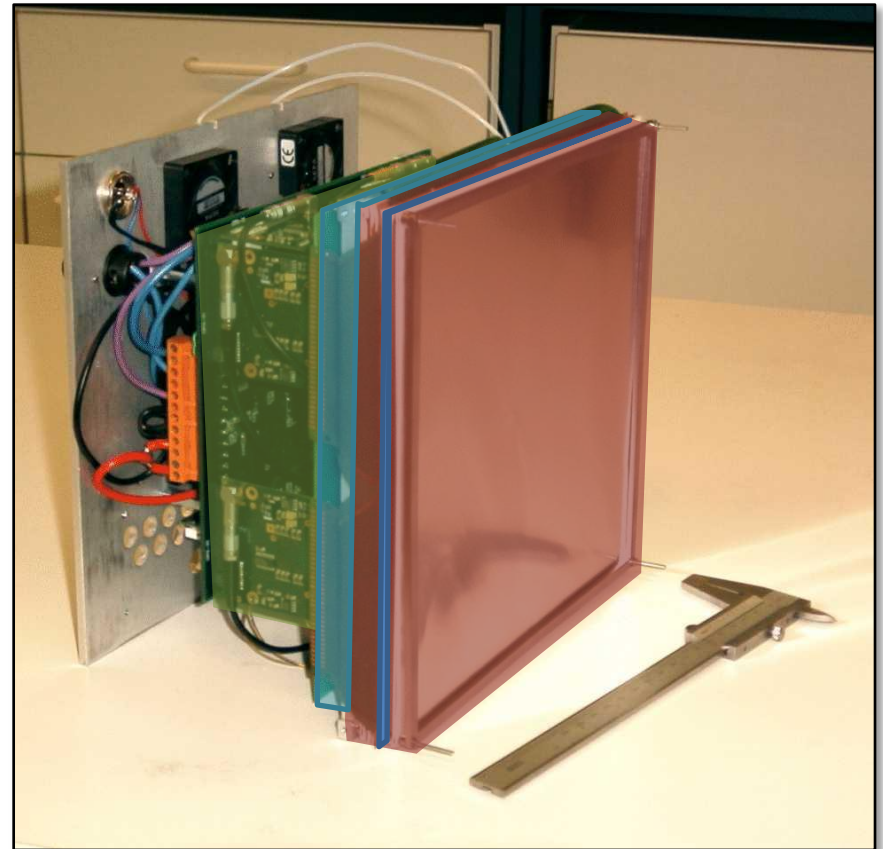
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Active Detection Volume

Readout

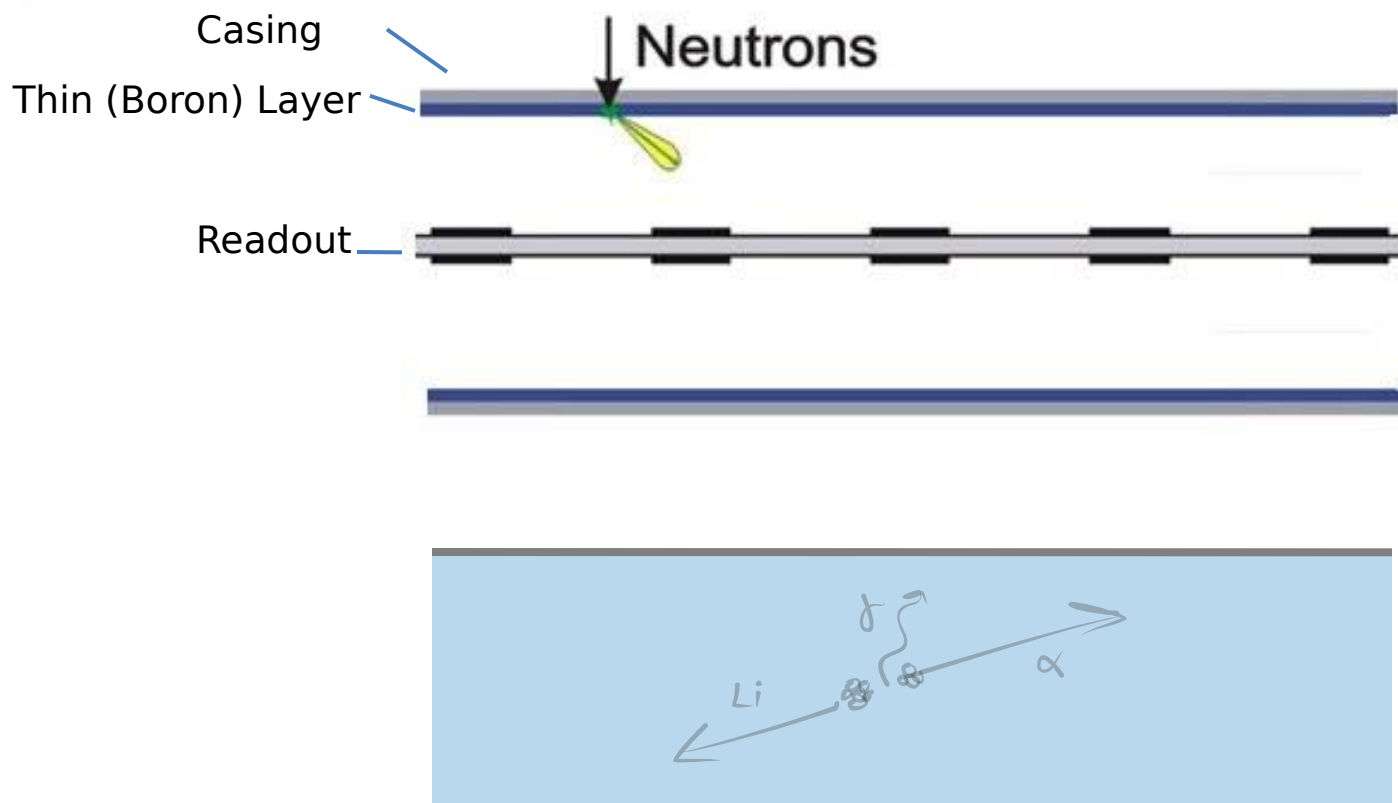
Electronics

CASCADE detector without housing

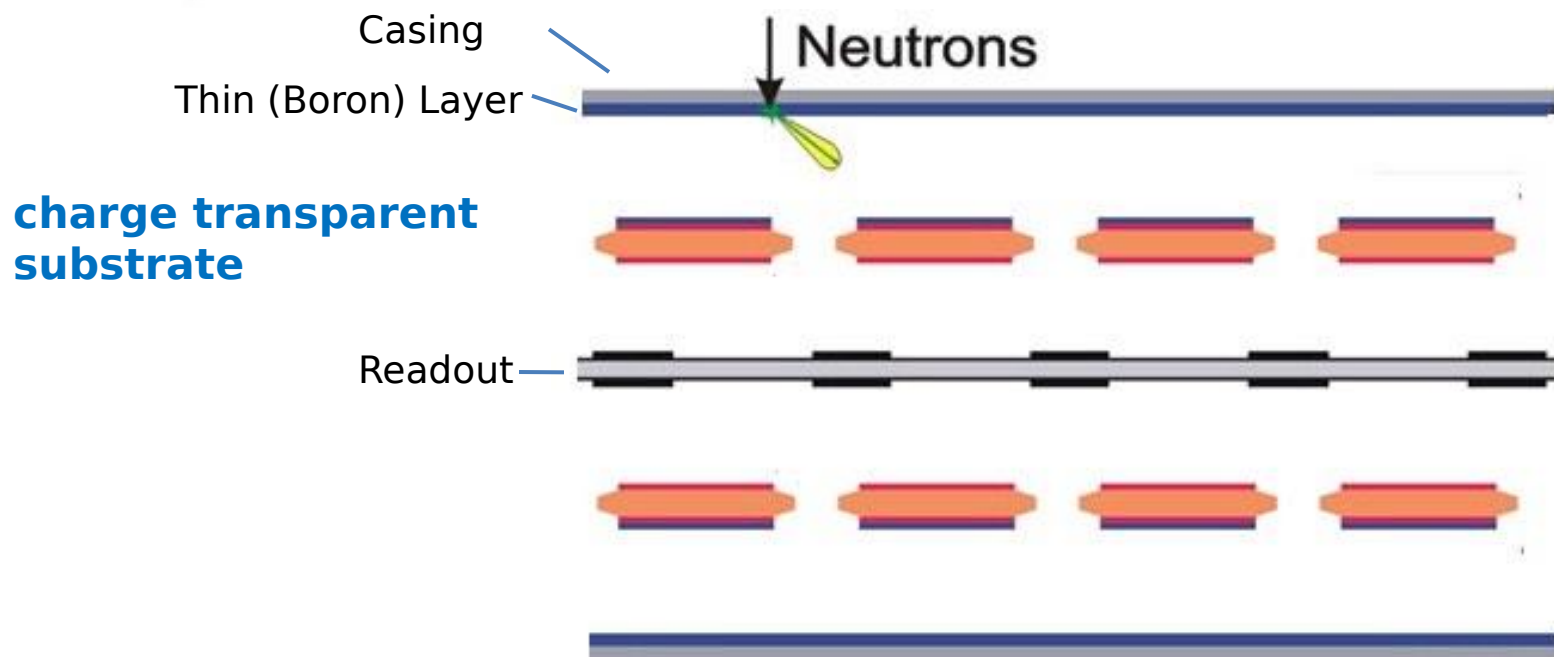


The CASCADE Concept

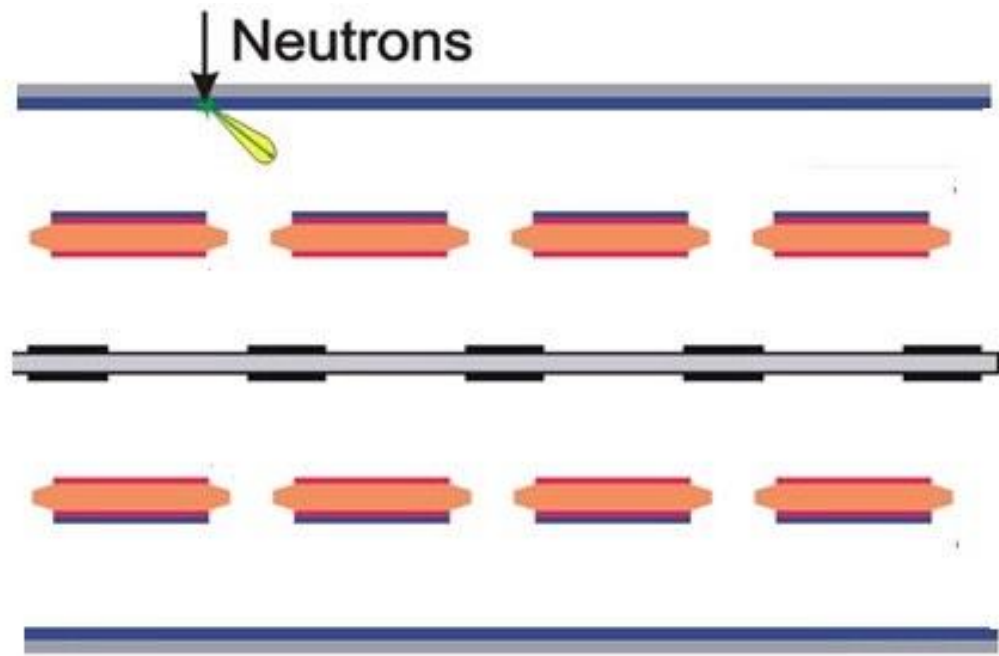
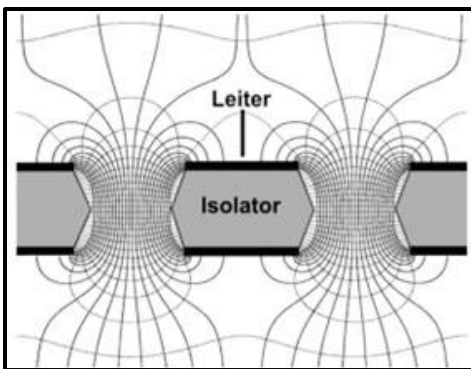
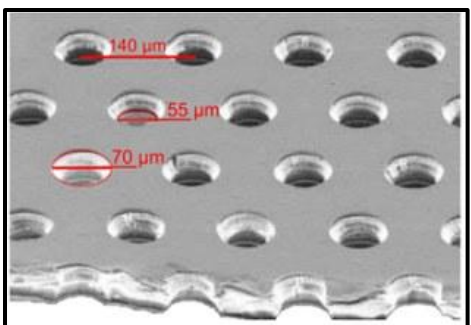
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The CASCADE Concept



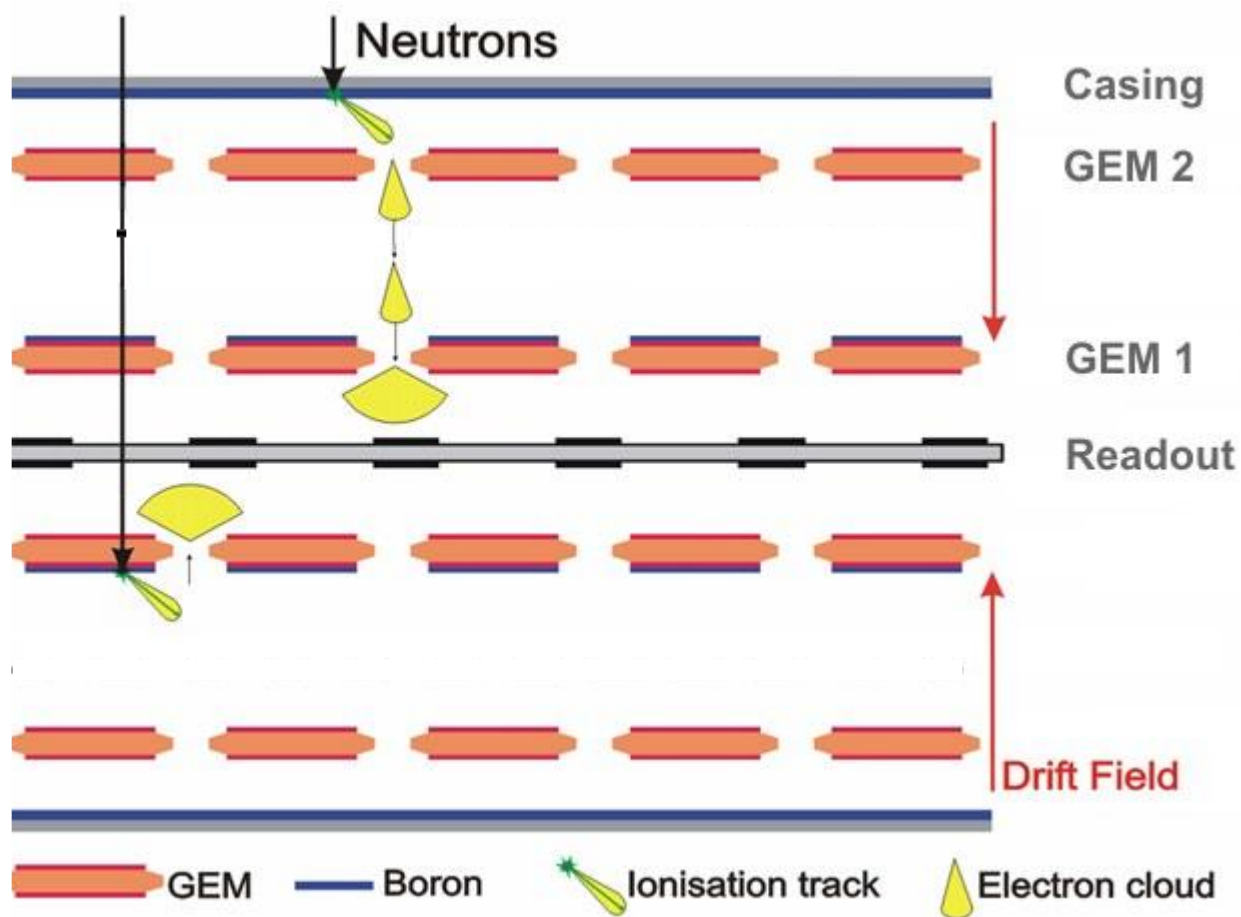
The CASCADE Concept



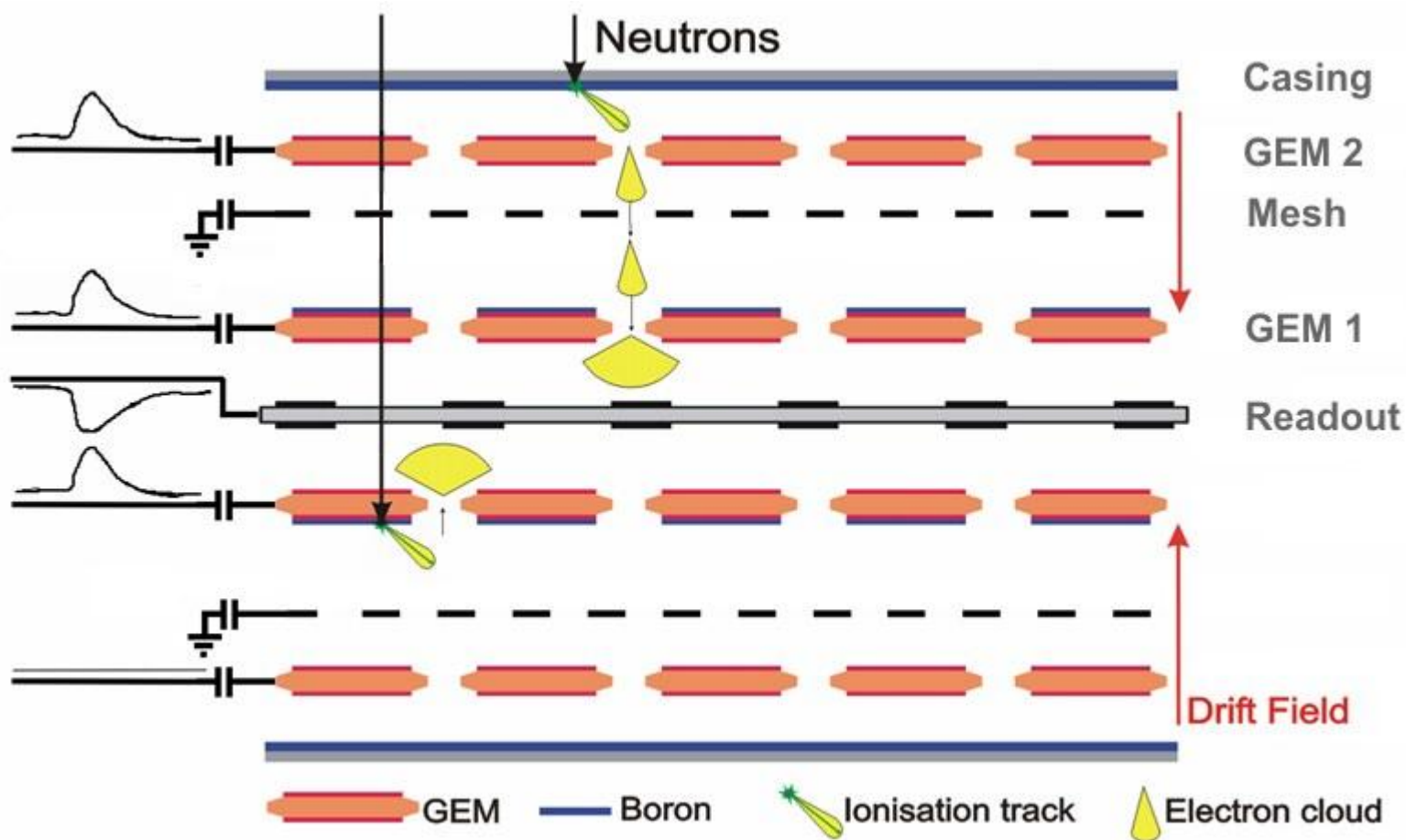
GEM
(Gas Electron Multiplier foil)

The CASCADE Concept

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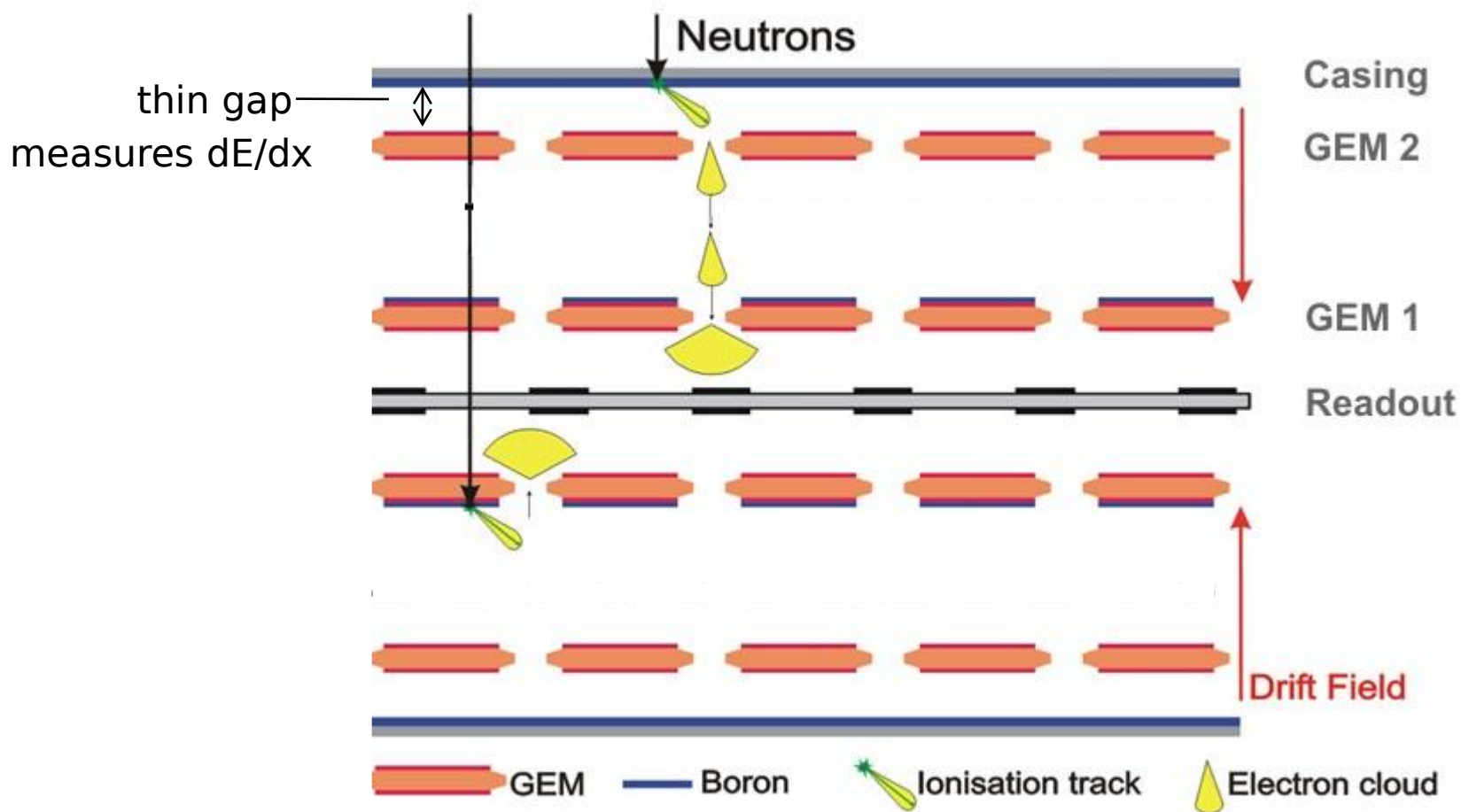


The CASCADE Concept



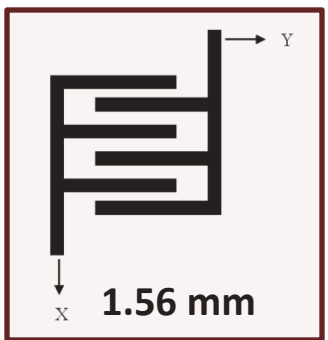
The CASCADE Concept

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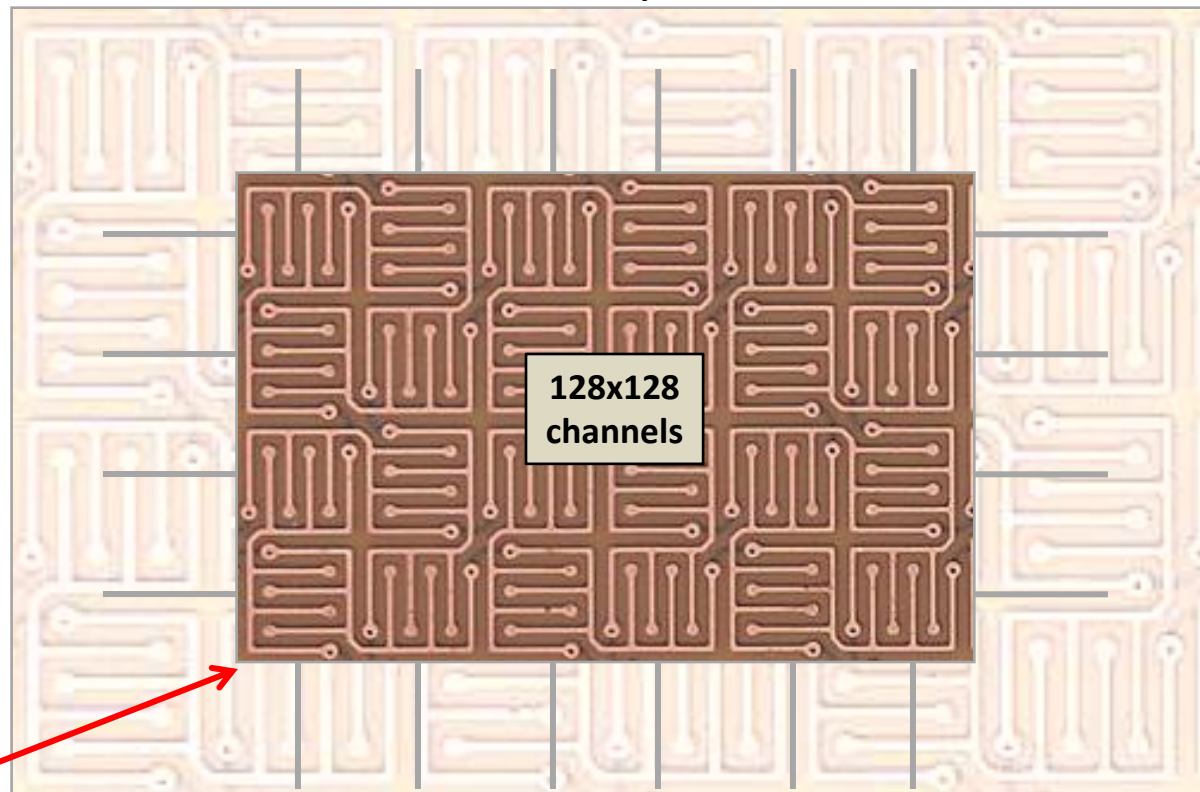
Readout

Unit Cell:

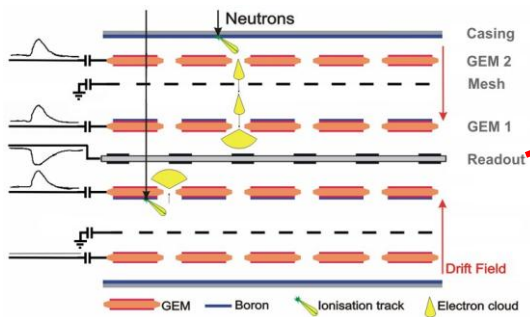


X stripes

Y stripes



Crossed stripes: reduces noise correlating x and y



CIPIX Readout ASIC

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

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

HELIX 1.0

HELIX 32 **[1998]**

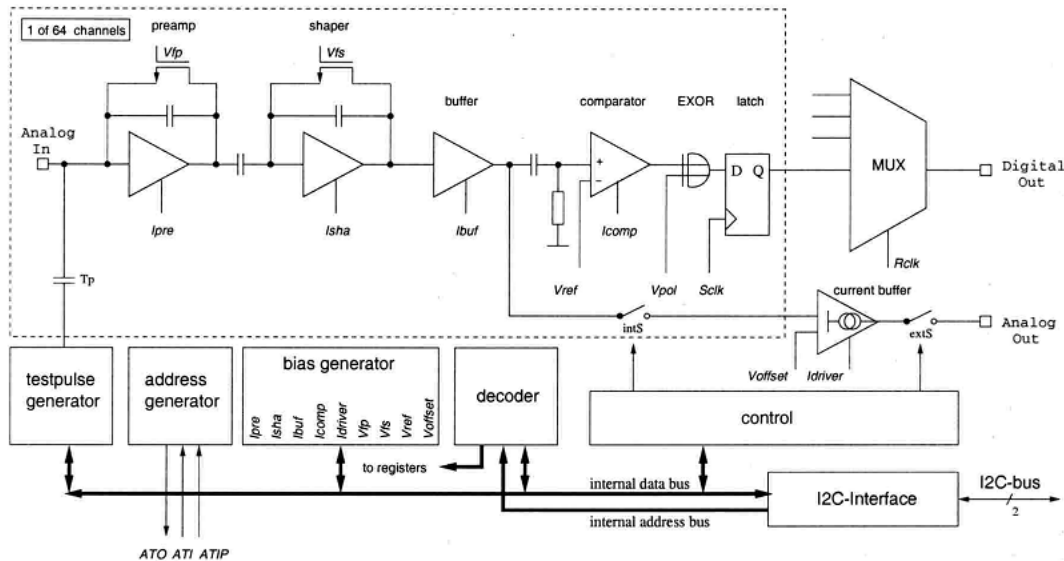
HELIX128-2.2 (HERA-B)

HELIX128-3.0 (Zeus)

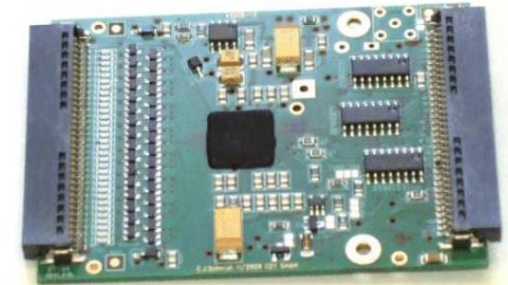
CIPIX (H1)

BEETLE (LHCb)

Timeline

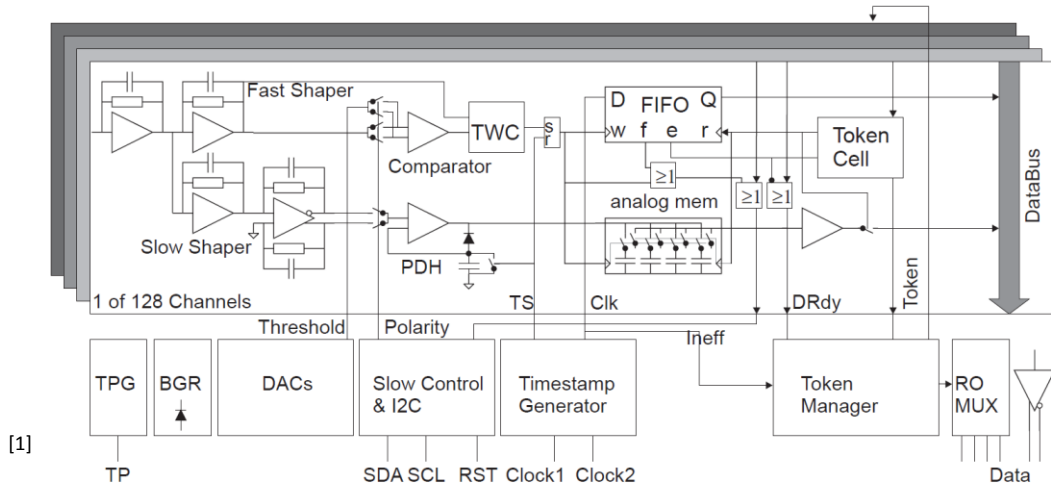


[1]



nXYter ASIC

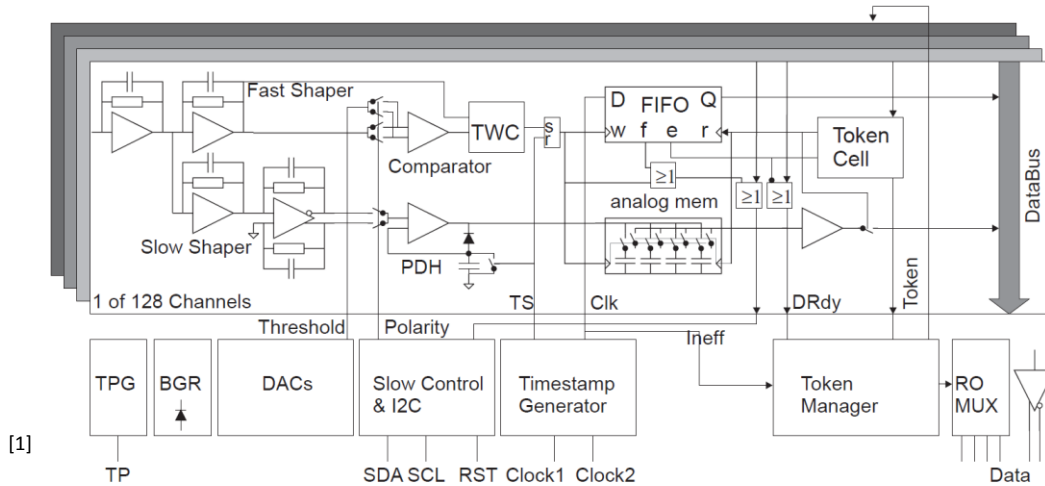
- 128 channels
- 1 ns time resolution
- Token Ring Readout



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

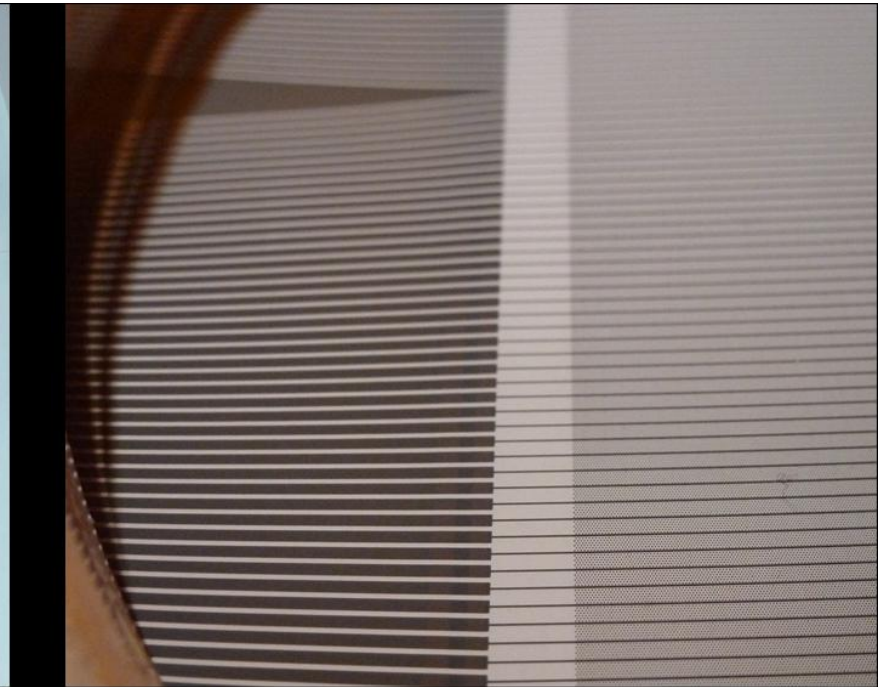
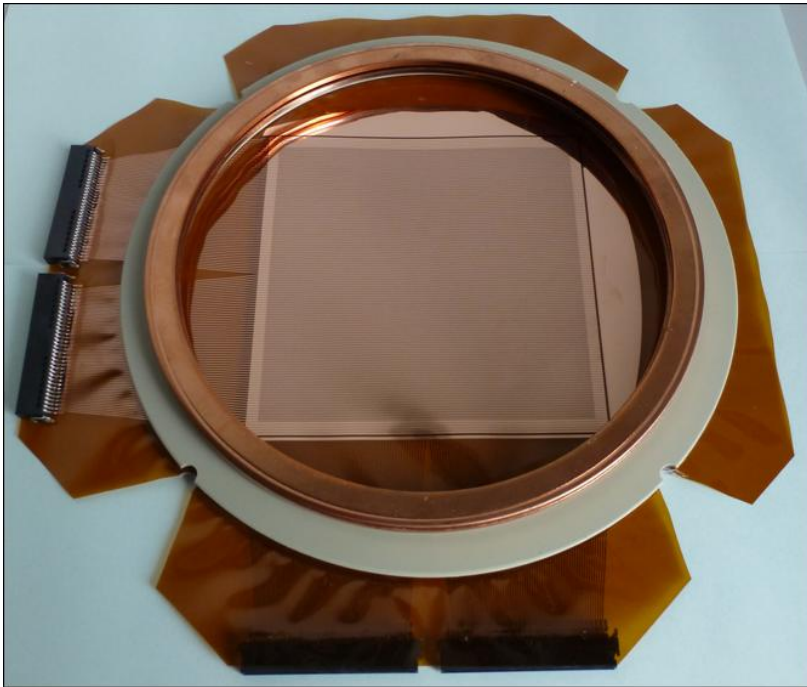
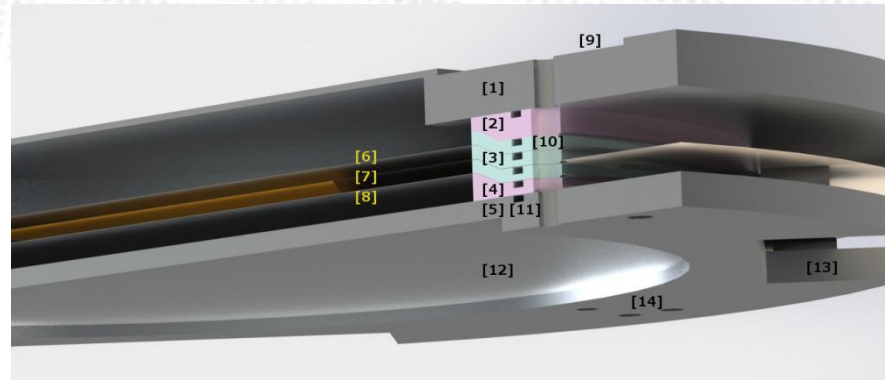
nXYter Prototype

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

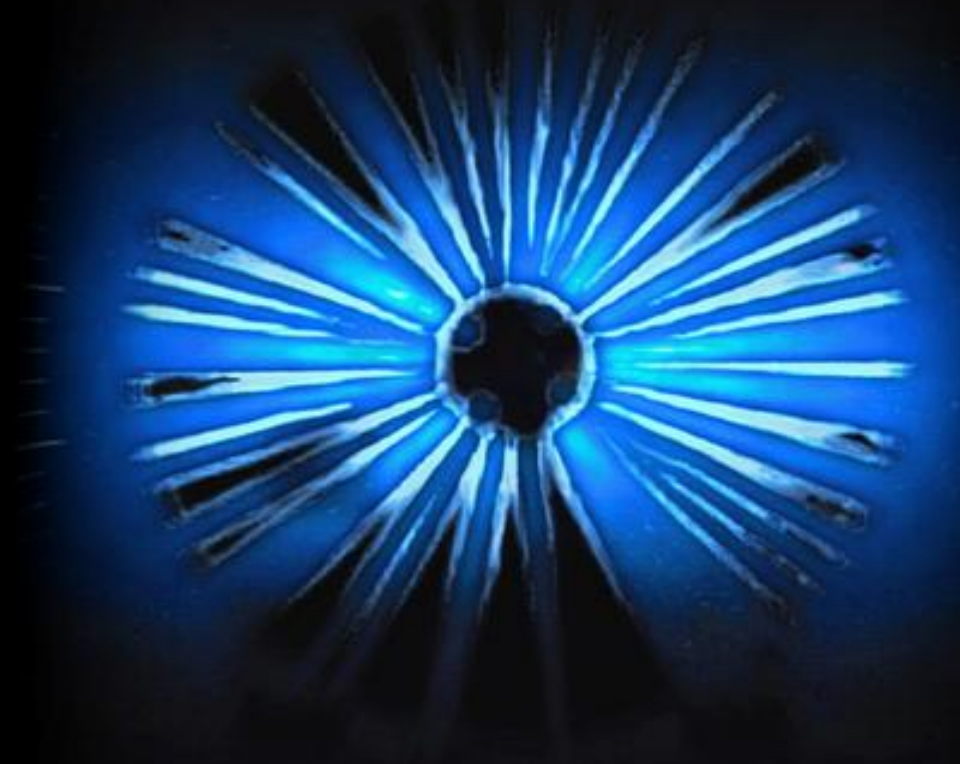


[1] The n-XYTER Reference Manual 1.50, 2009

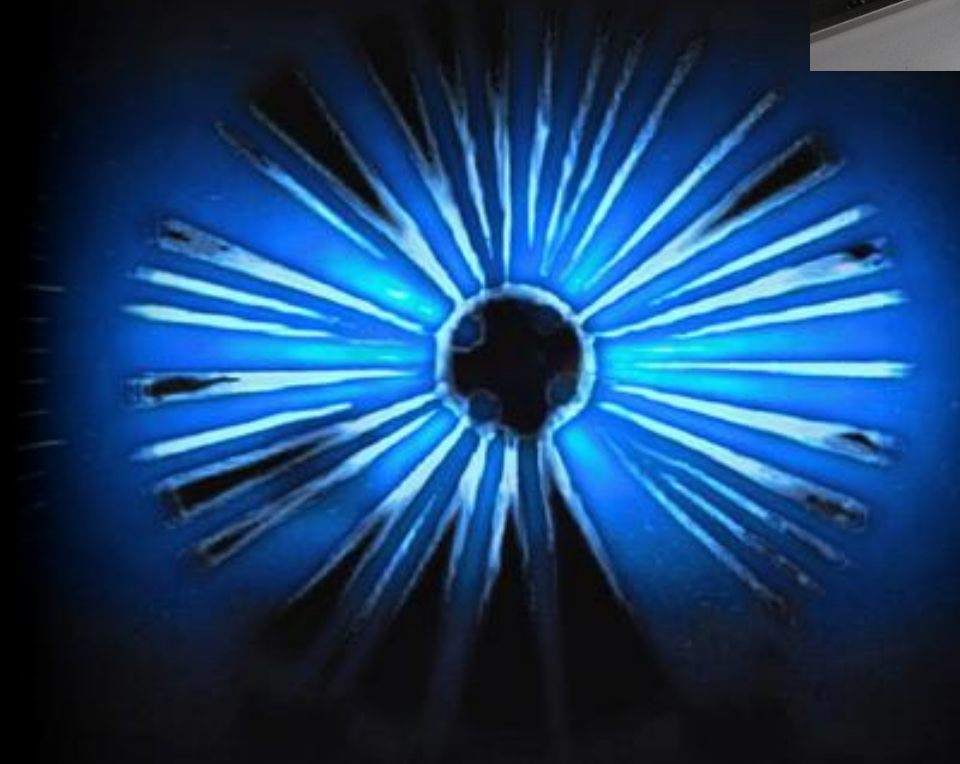
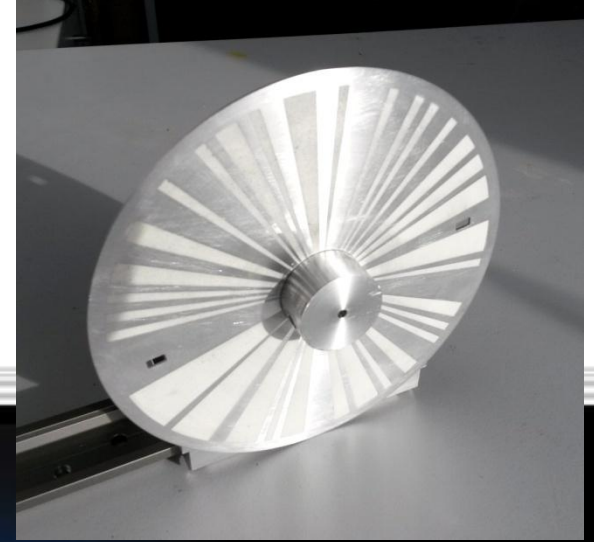
nXYter Prototype



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Characterization
Measurements

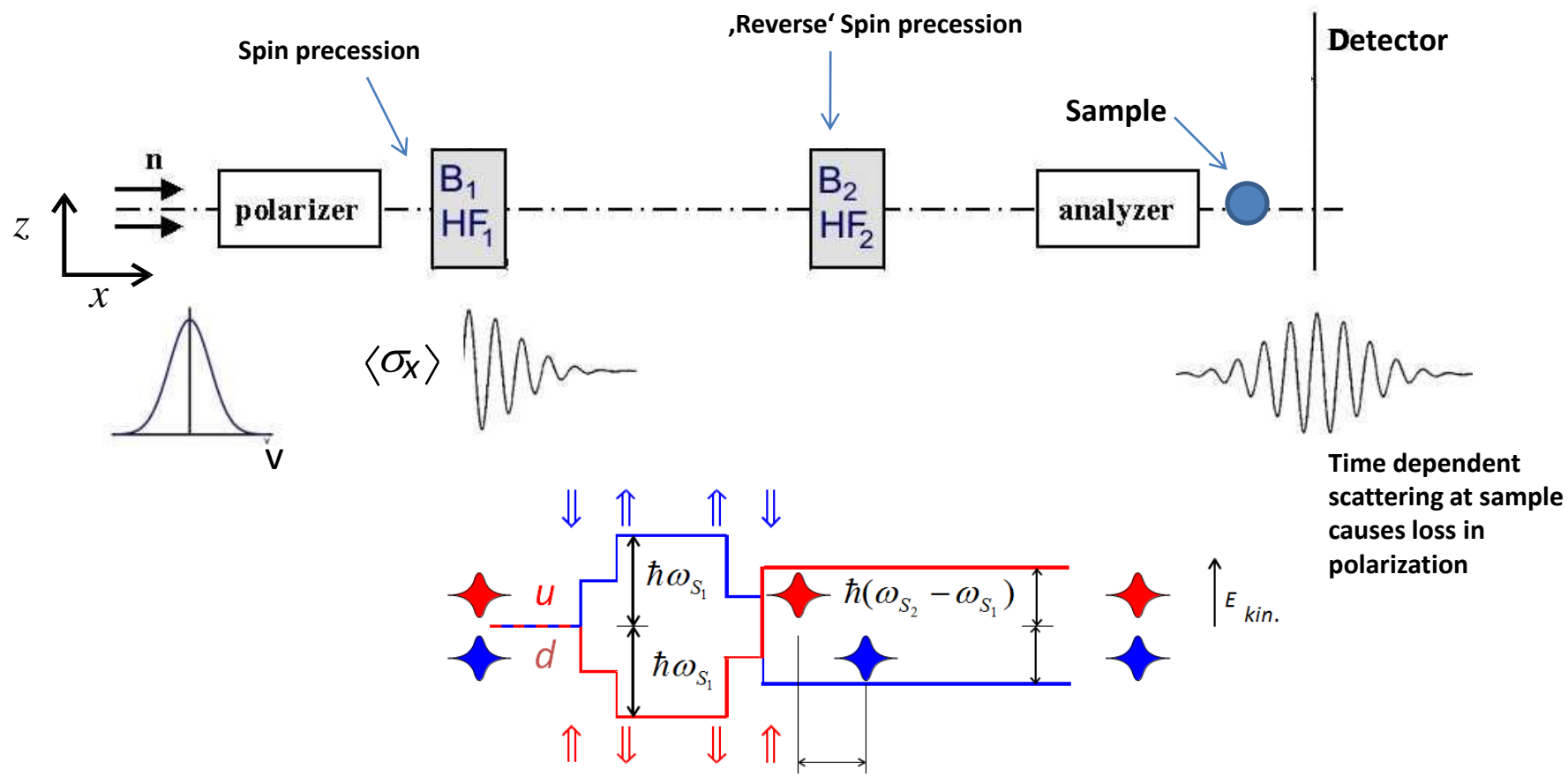


||| CASCADE
Characterization
Measurements

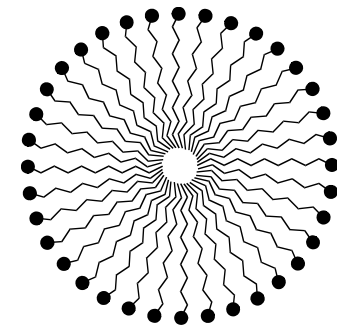
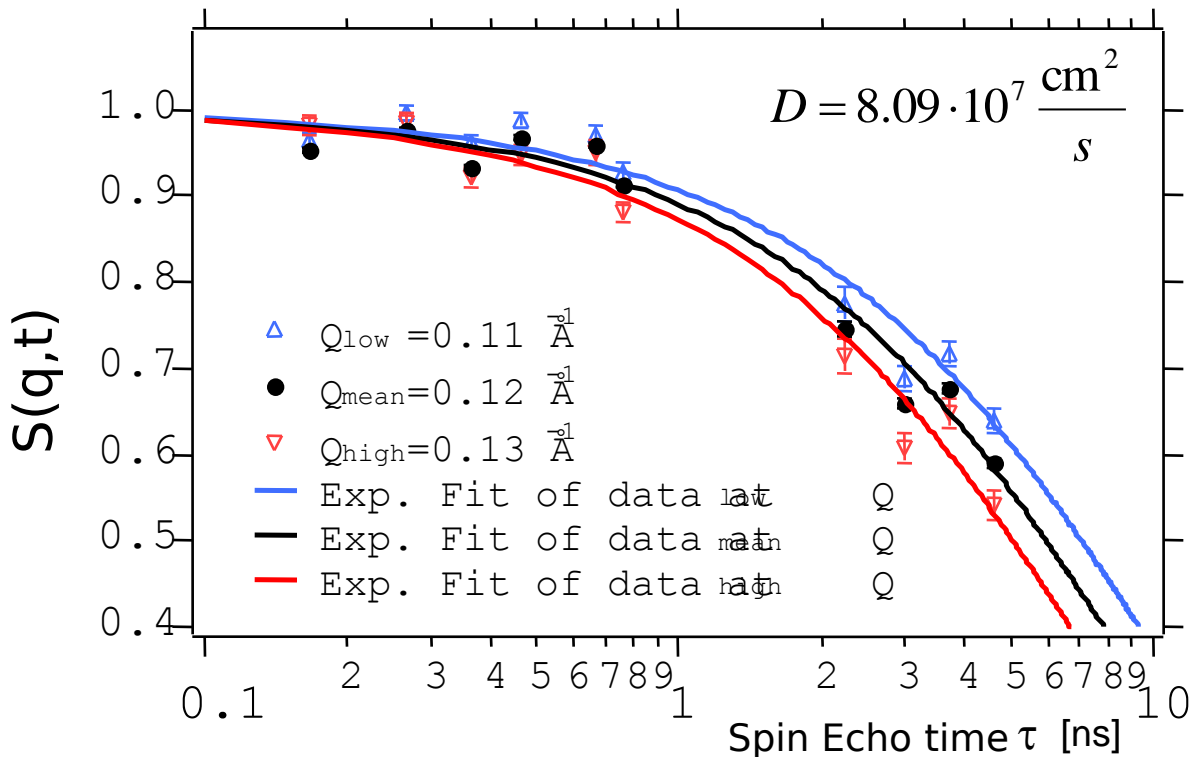


Neutron Resonance Spin Echo - MIEZE

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



Spin Echo: Diffusion of micelles



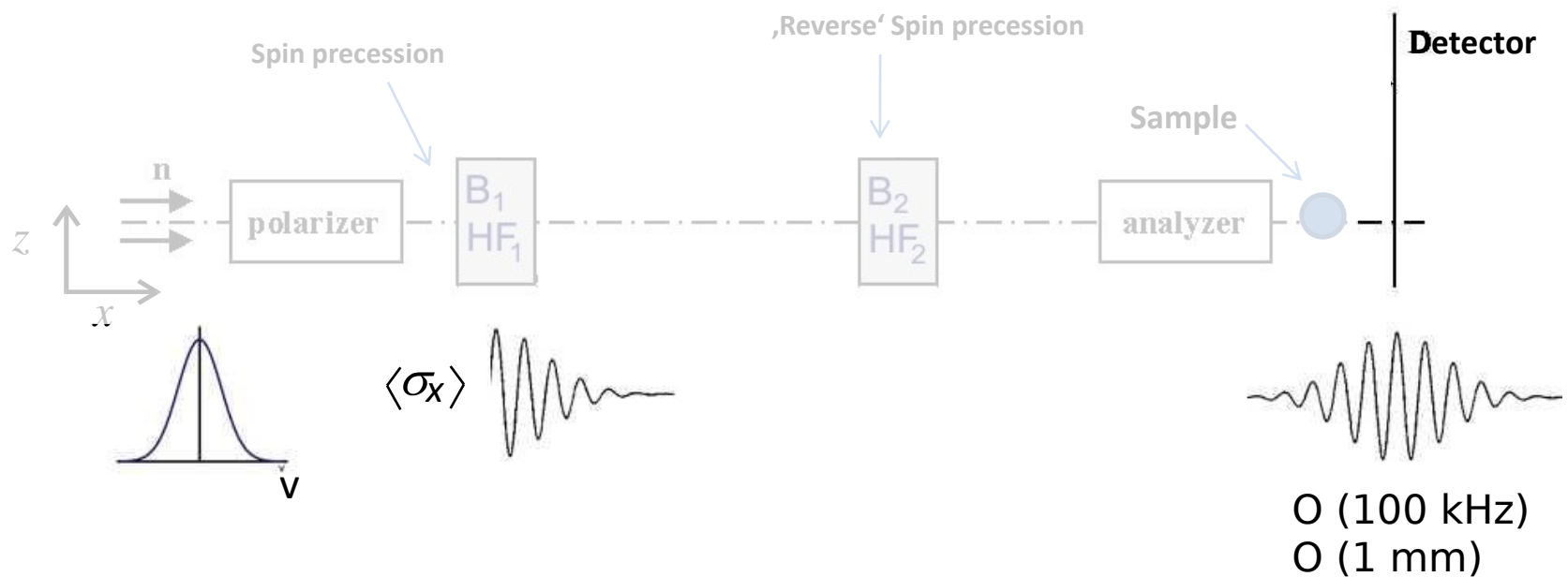
Natriumdodecylsulfat
in D_2O

for classical diffusion :

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

Neutron Resonance Spin Echo - MIEZE

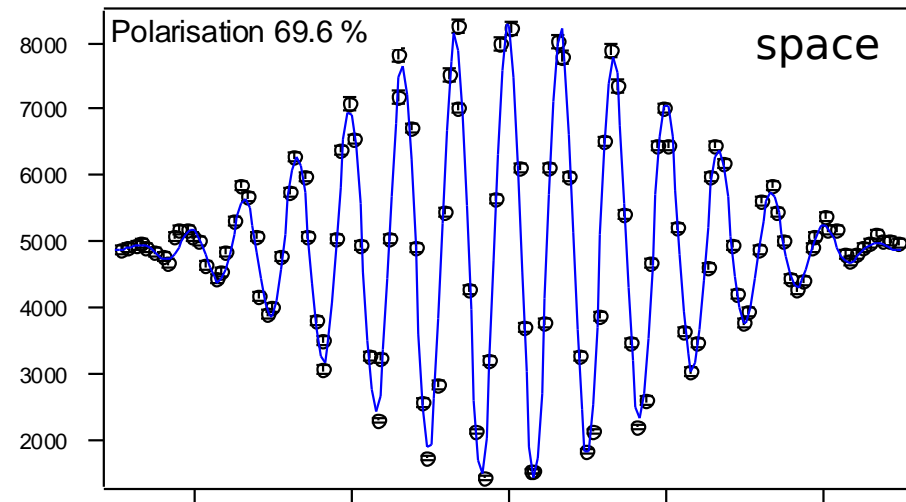
Principle: Use Neutron Spin as Observable in Interference Time Of Flight Experiments



Spin Echo Measurements



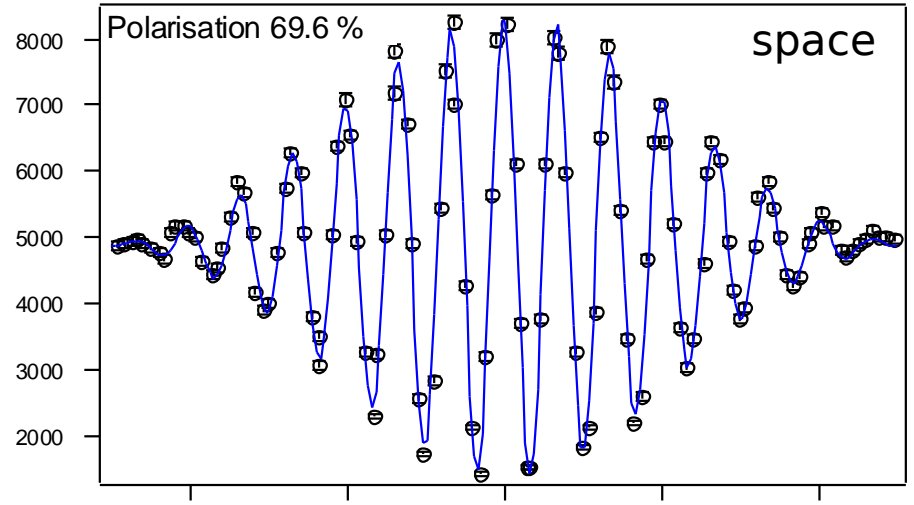
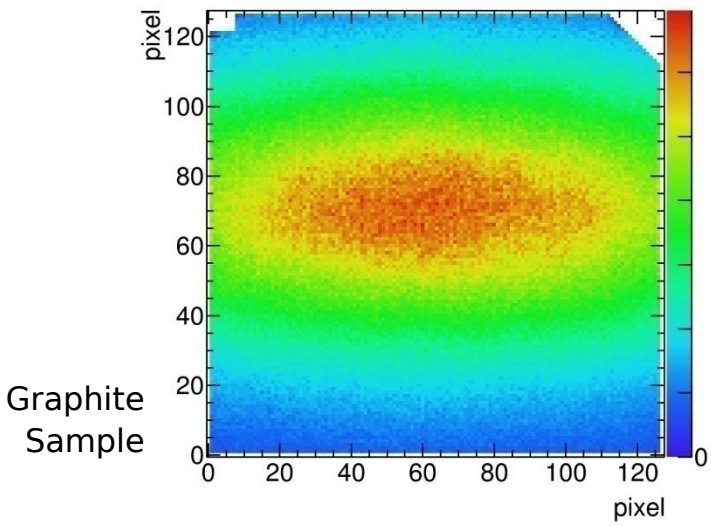
RESEDA, FRMII: spectrometer arms
3 - 15 Å @ 11% FWHM



Typical Spin Echo group

Spin Echo Measurements

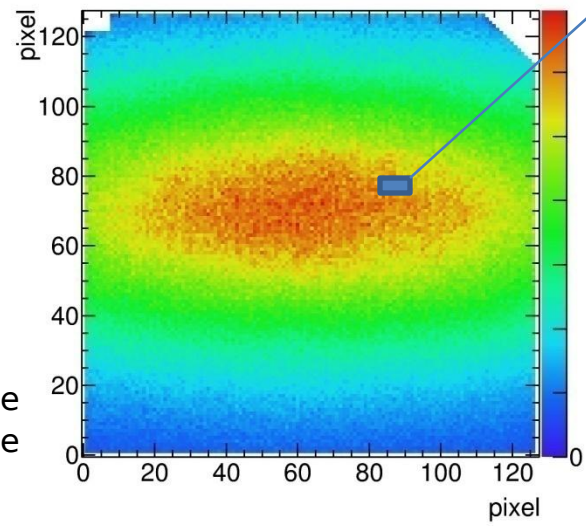
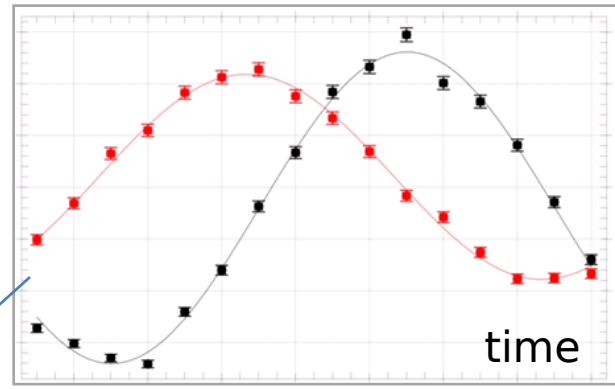
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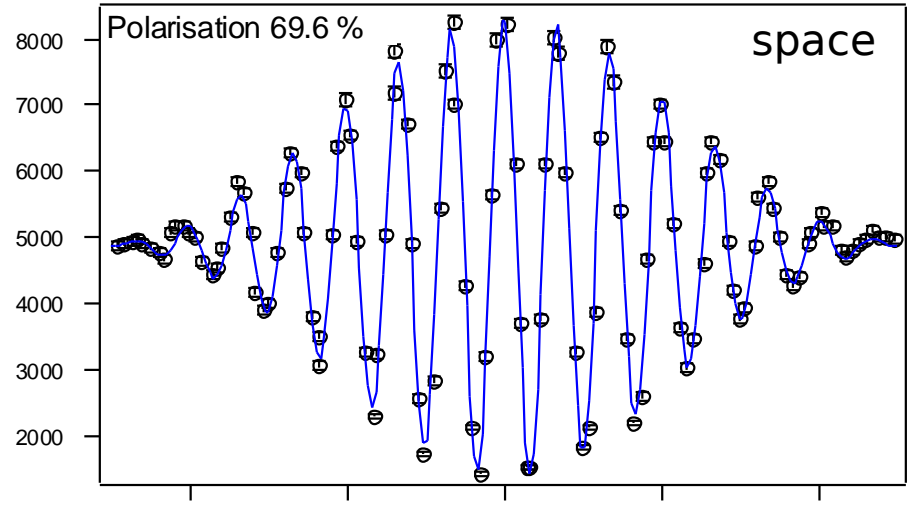
Typical Spin Echo group

Spin Echo Measurements

100 kHz x16

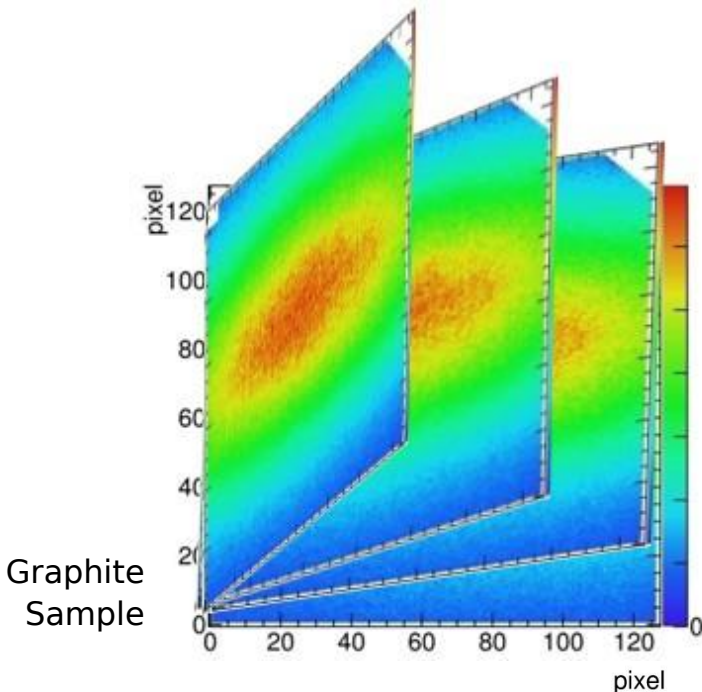


Graphite
Sample

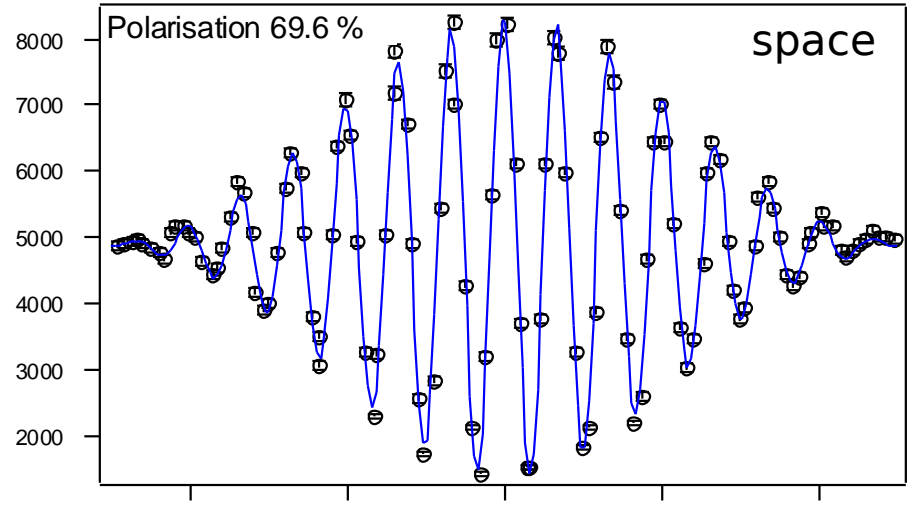
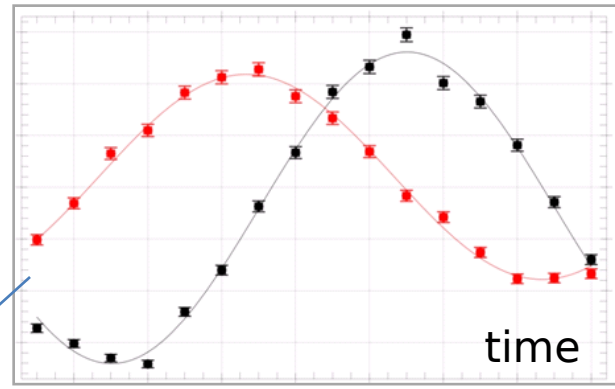


Typical Spin Echo group

Spin Echo Measurements



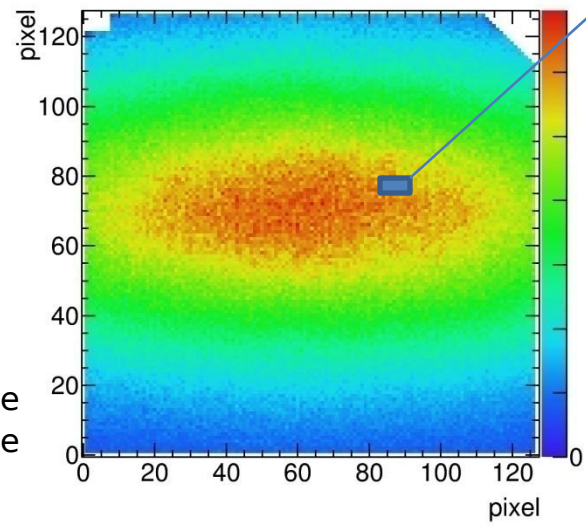
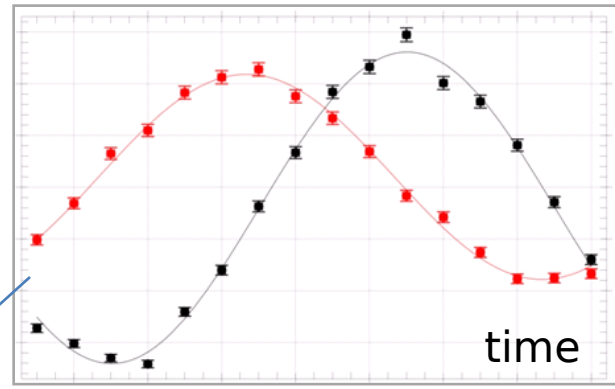
100 kHz x16



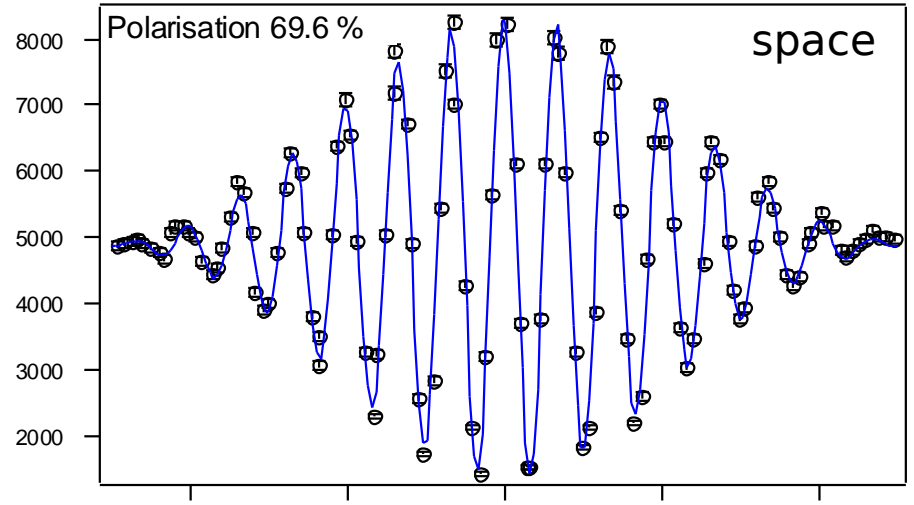
Typical Spin Echo group

Spin Echo Measurements

100 kHz x16

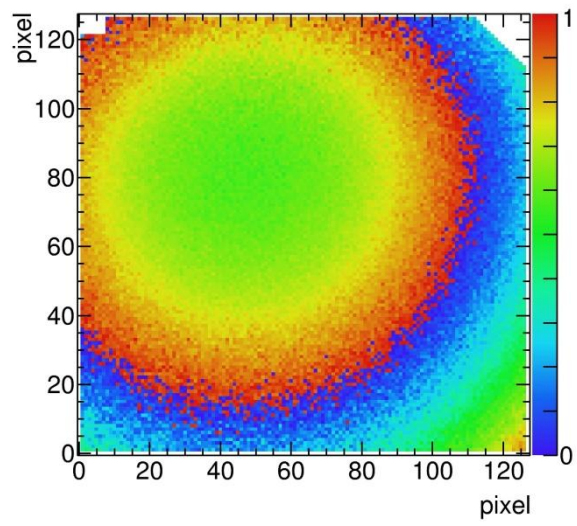


Graphite Sample

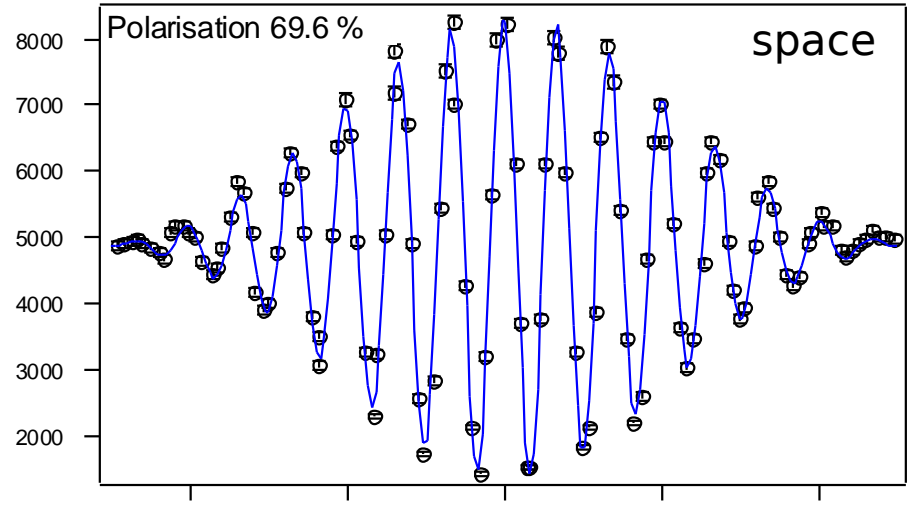
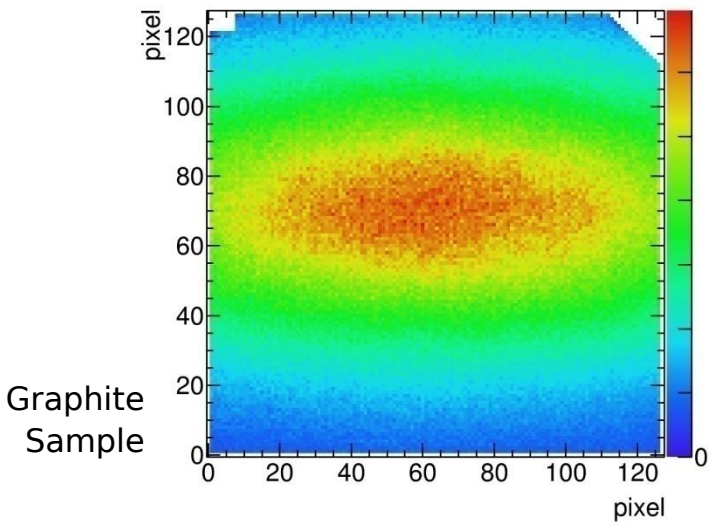
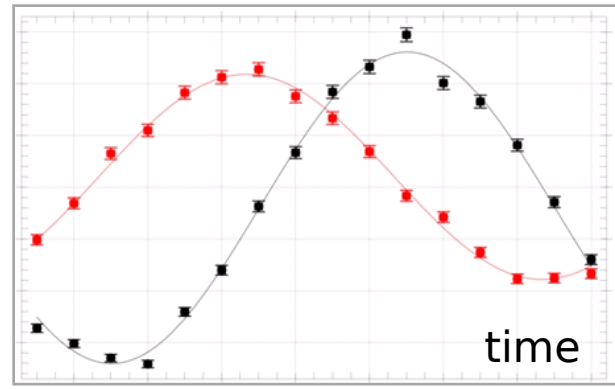


Typical Spin Echo group

Spin Echo Measurements

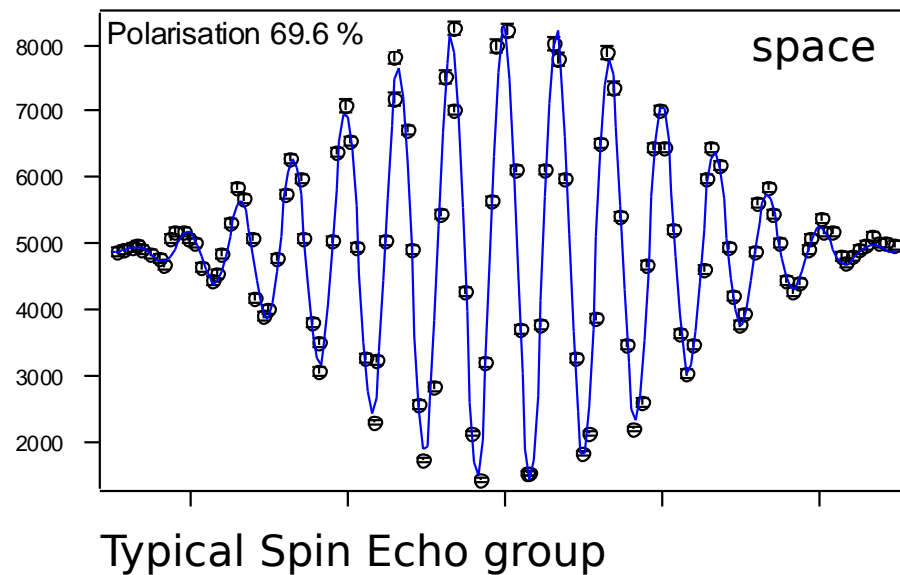
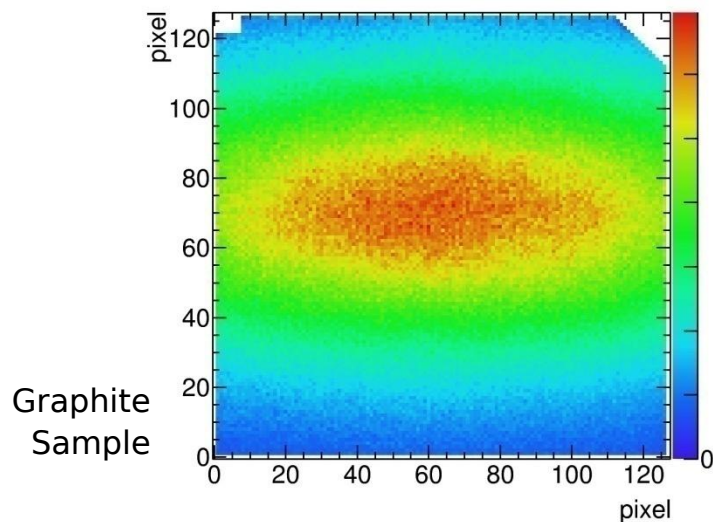
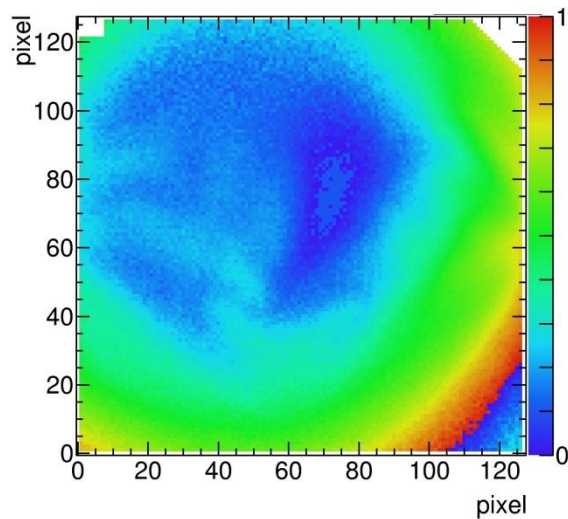


100 kHz x16

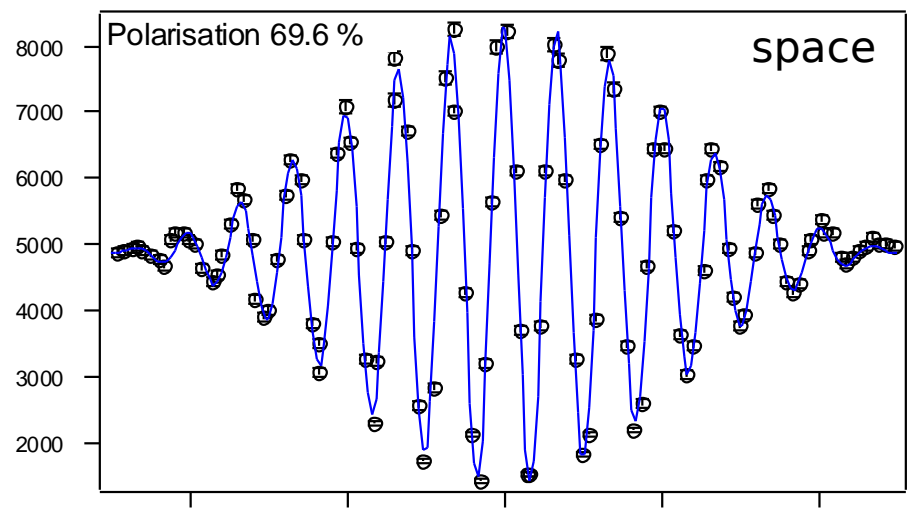
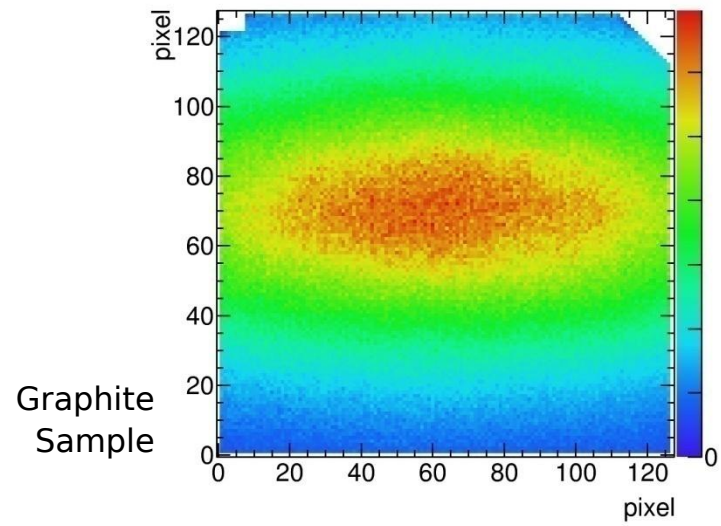
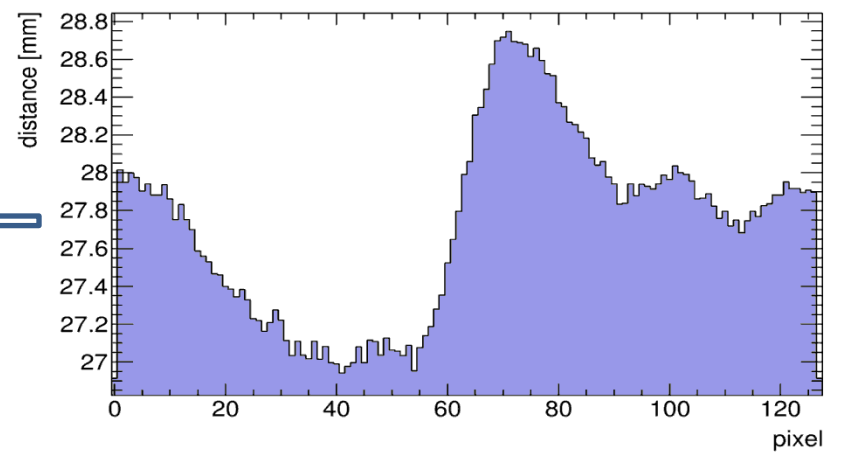
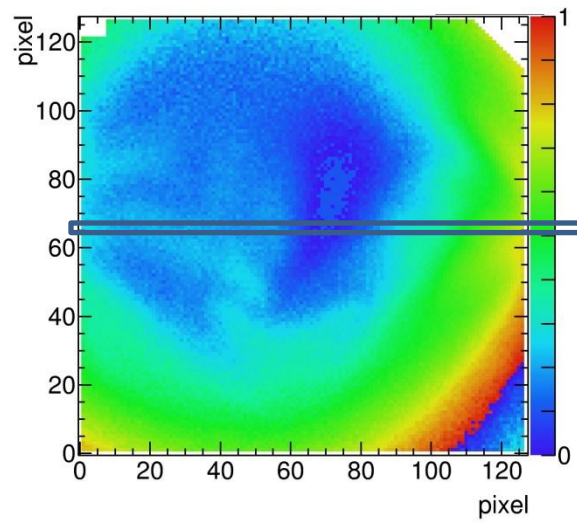


Typical Spin Echo group

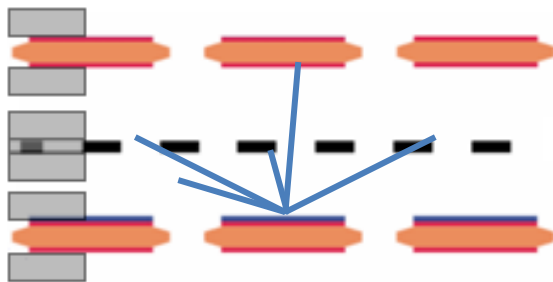
Spin Echo Measurements



Spin Echo Measurements



Spatial Resolution

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Spatial resolution: 2.4 mm FWHM

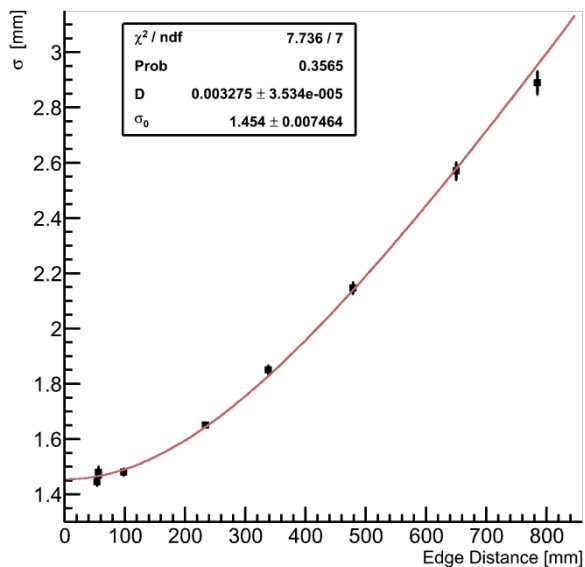
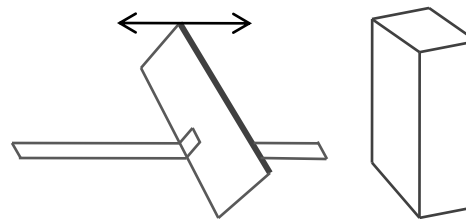
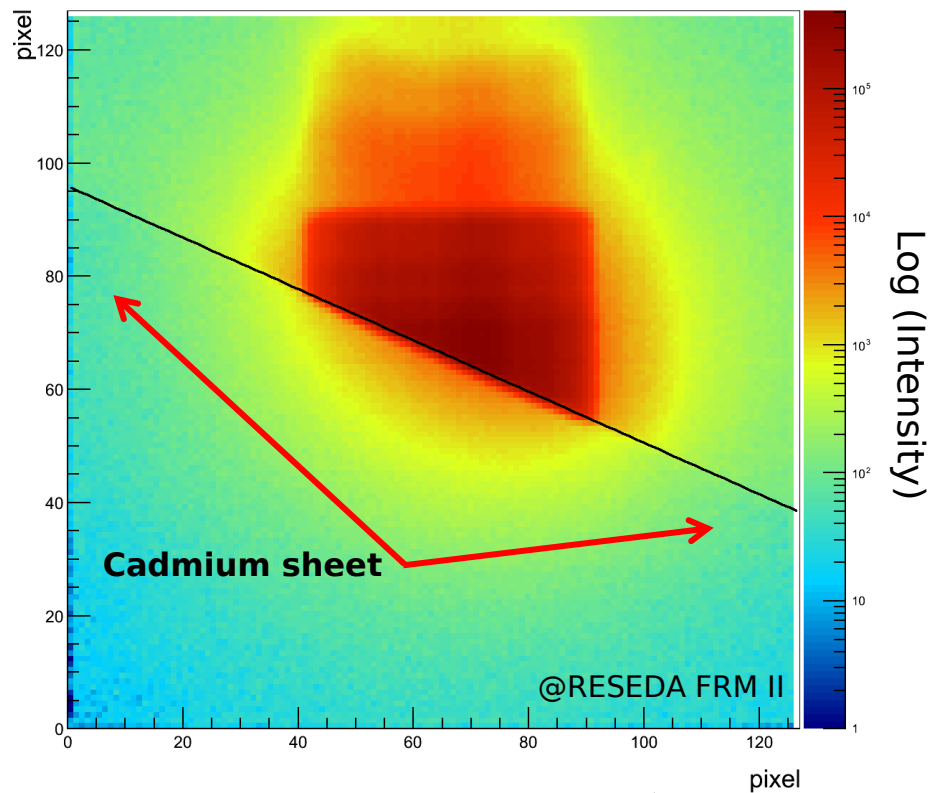
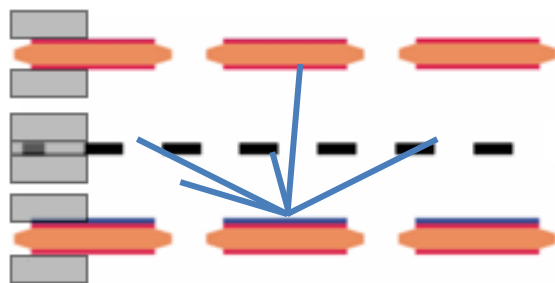


Image of a cold neutron beam (after guide)



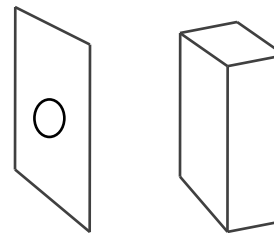
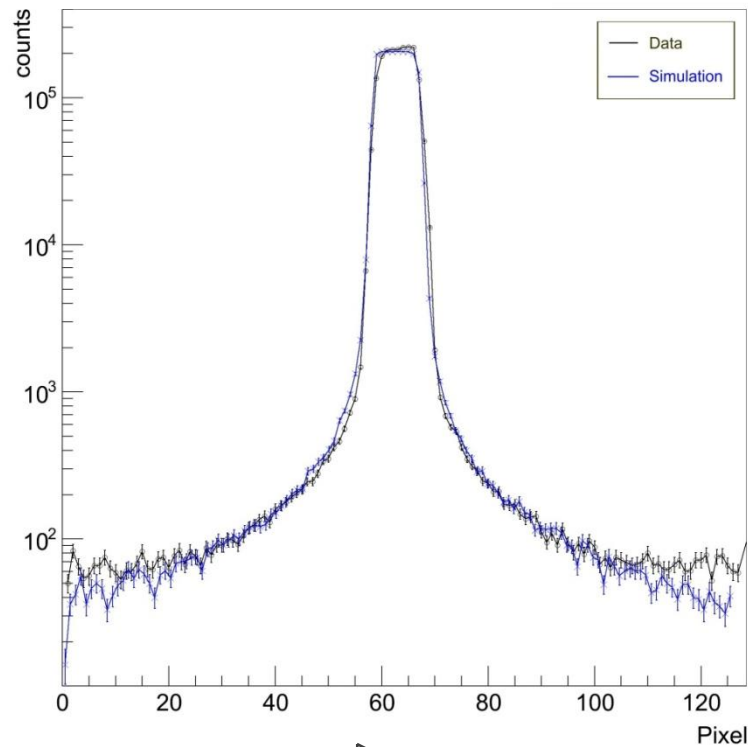
Spatial Resolution

DENIM
2015



Spatial resolution: 2.4 mm FWHM

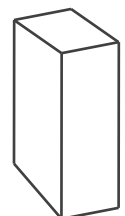
Cross section of a collimated n beam



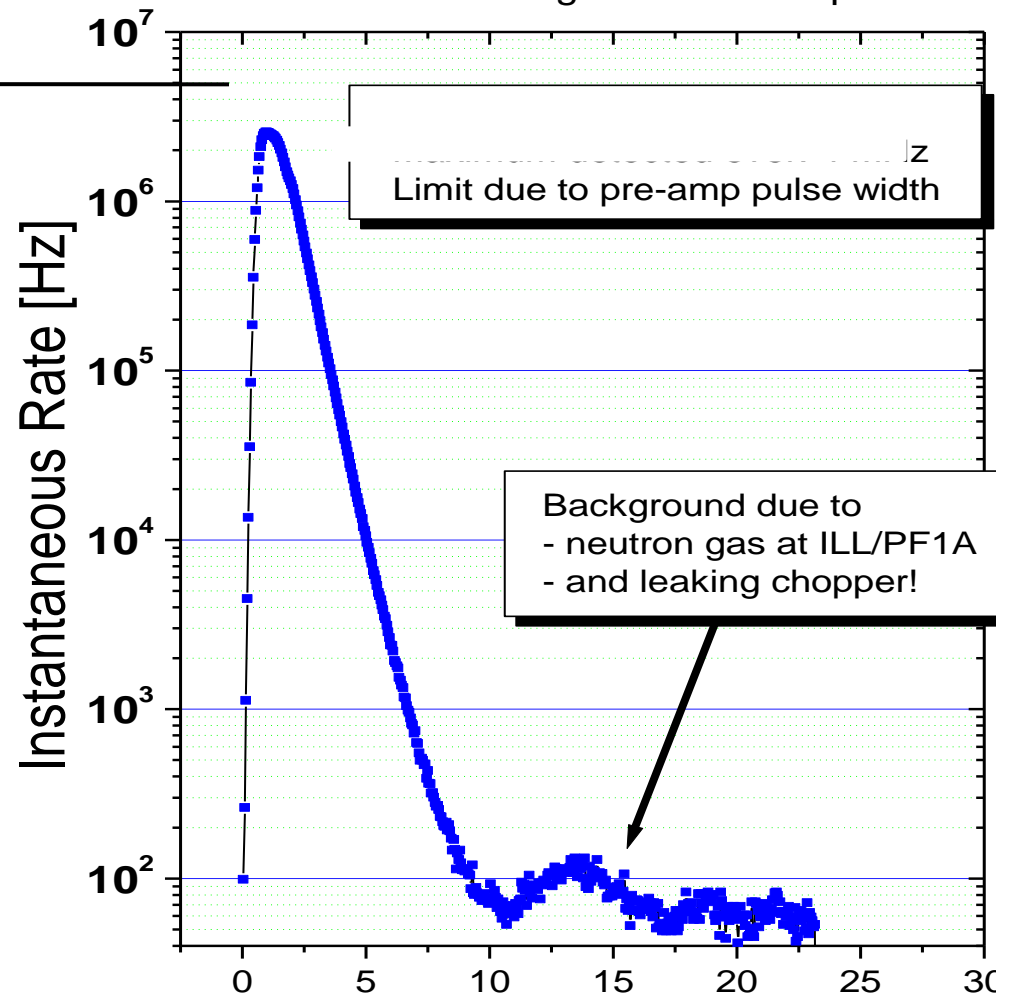
▶ Rate Capability

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2015

count rate
2-3 MHz

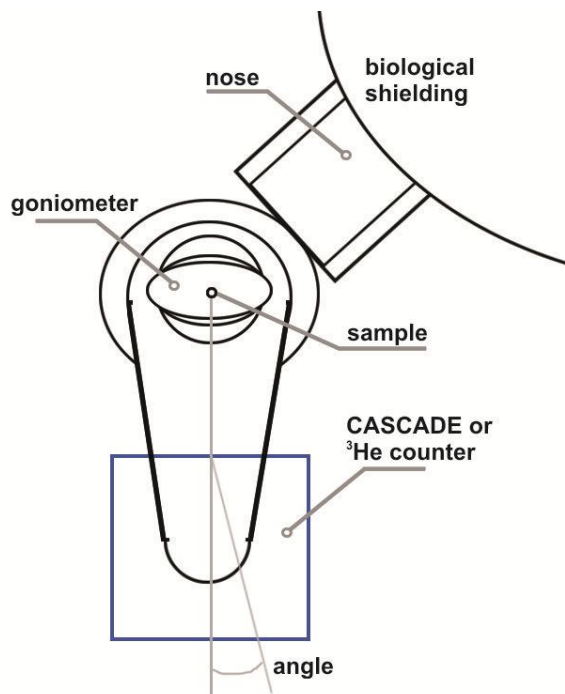


Time of Flight measurements
at ILL/ PF1A on a single readout strip of 1cm²

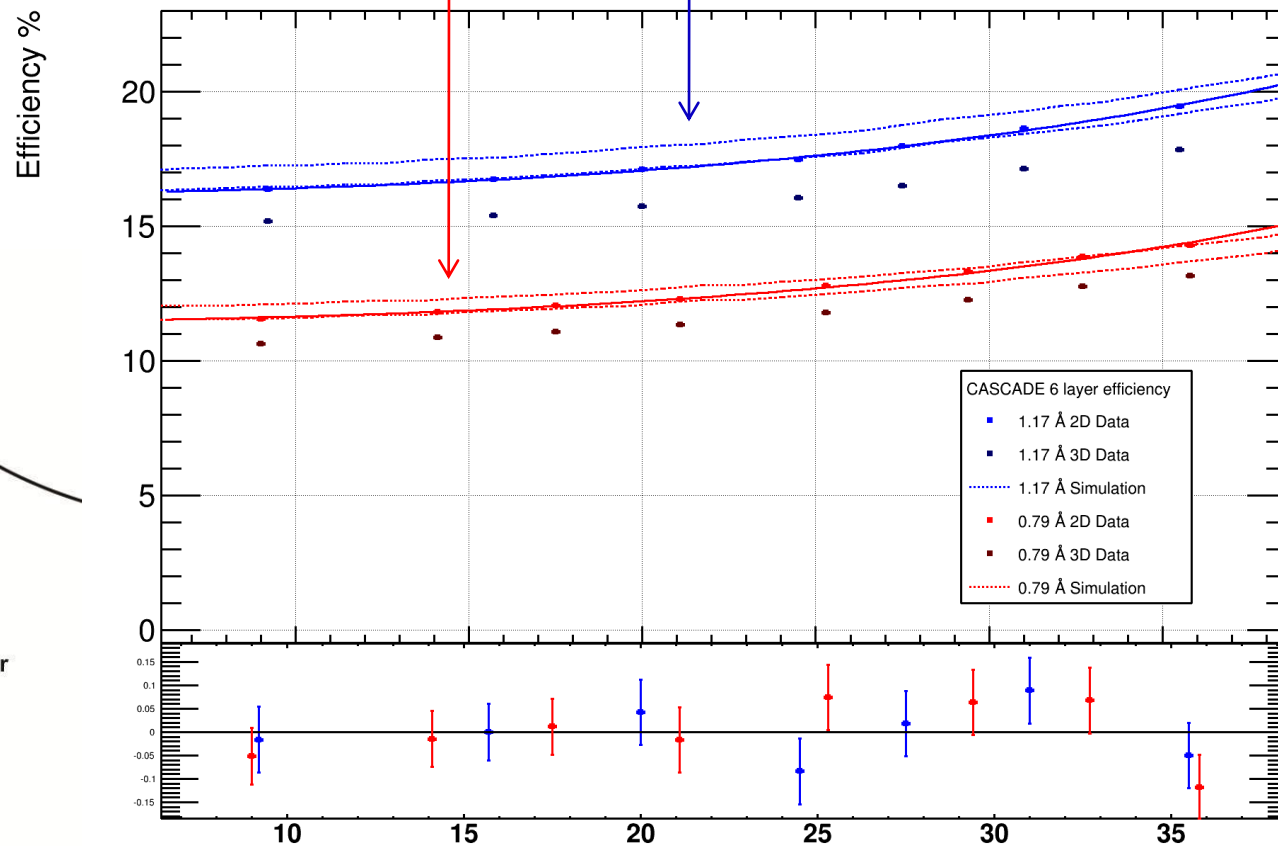


Detection Efficiency

1.5 - 0.8 - 1.0 - 1.0 - 0.8 - 2.0



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

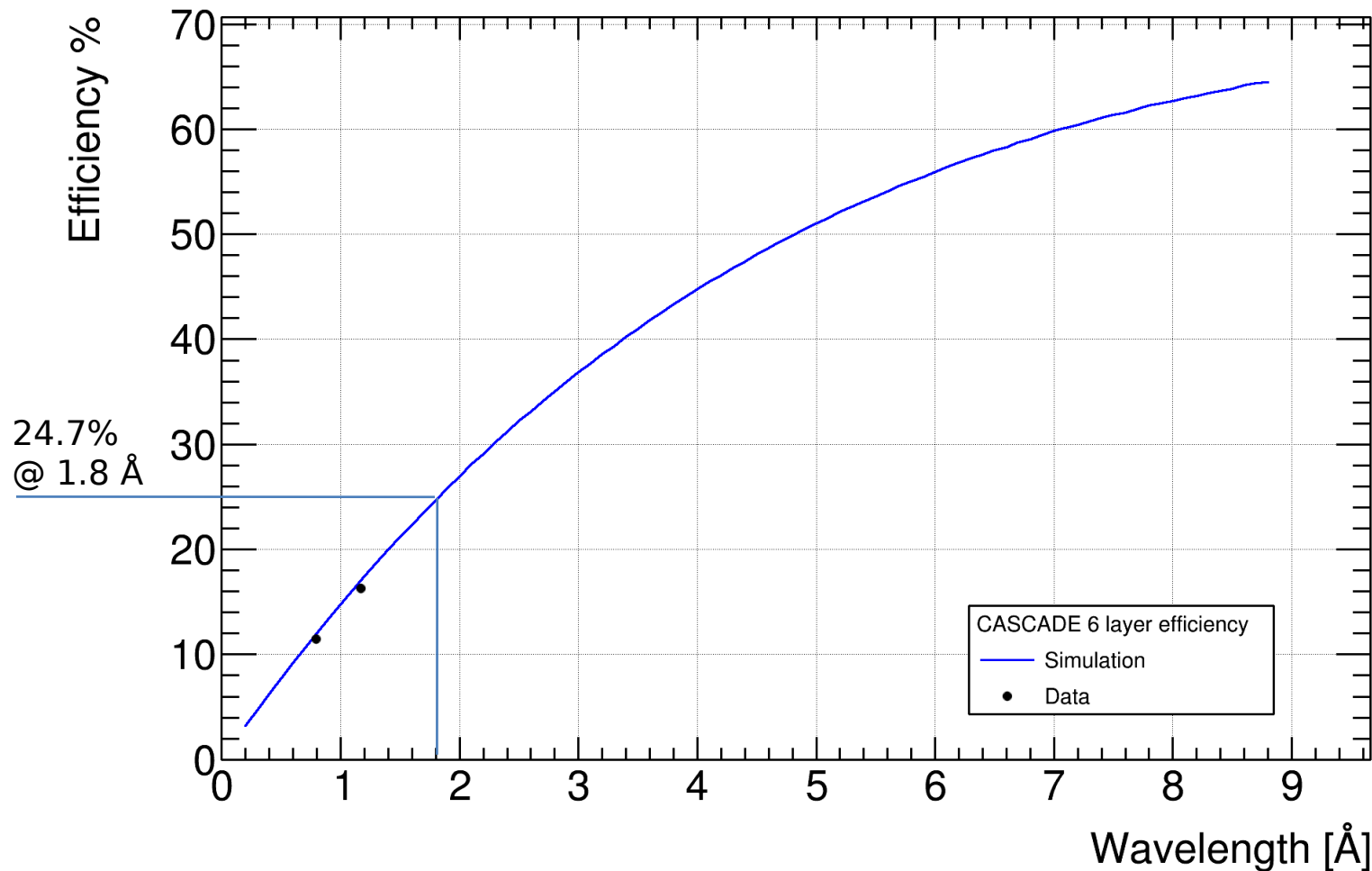


@HEIDI FRM II

Detection Efficiency

1.5 - 0.8 - 1.0 - 1.0 - 0.8 - 2.0

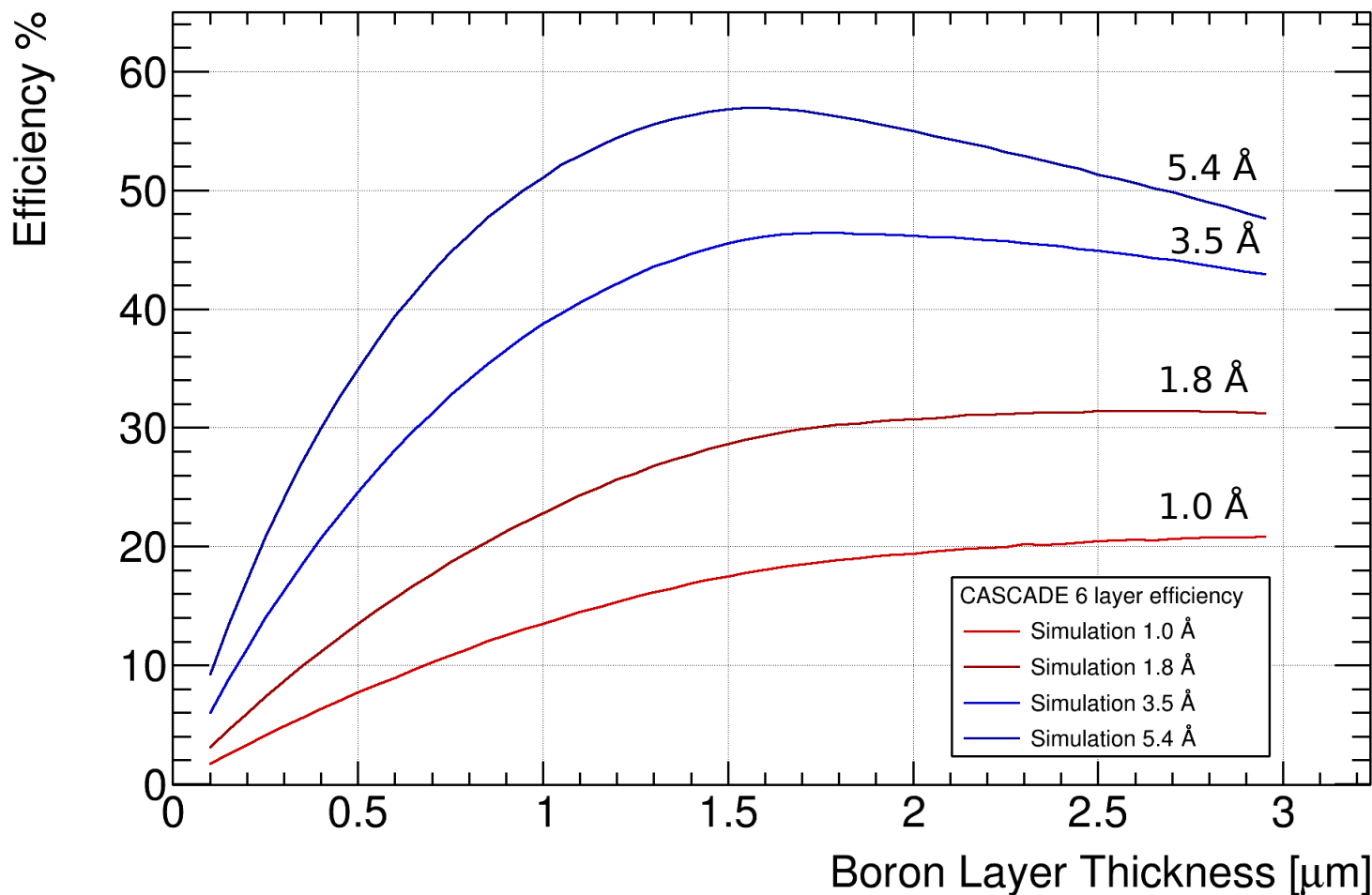
Simulation of the 2D efficiency and data of 0.8 Å and 1.2 Å



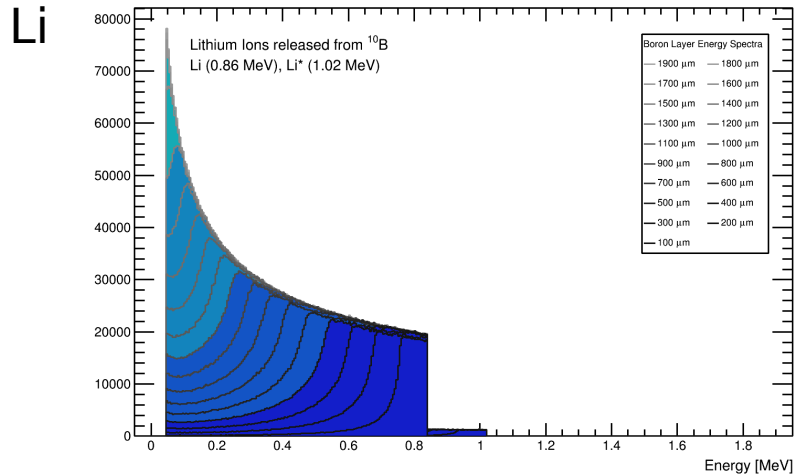
Detection Efficiency

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2015

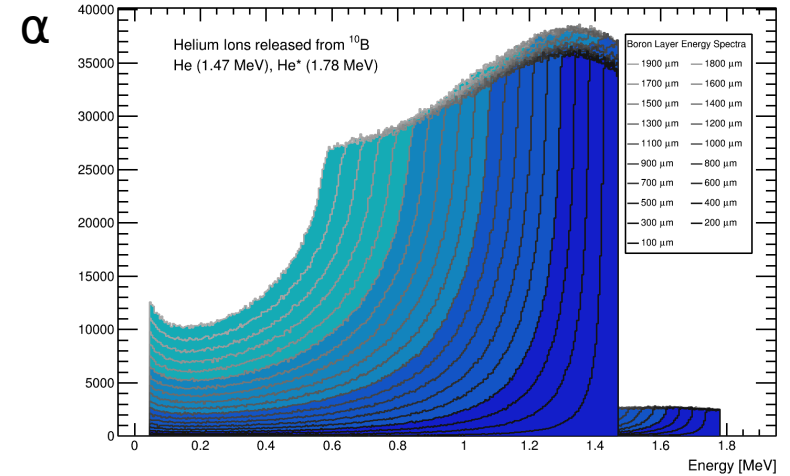
Simulation of the 2D efficiency with different coating thicknesses



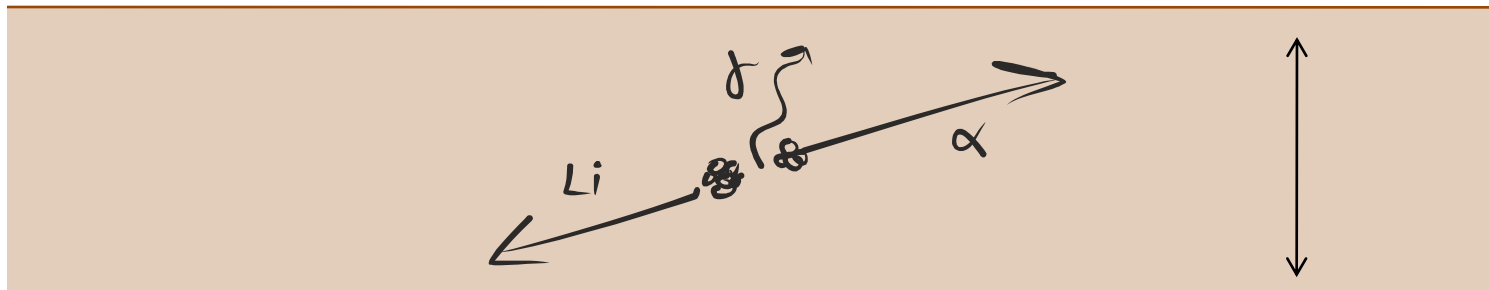
Conversion Products: Energy Spectra



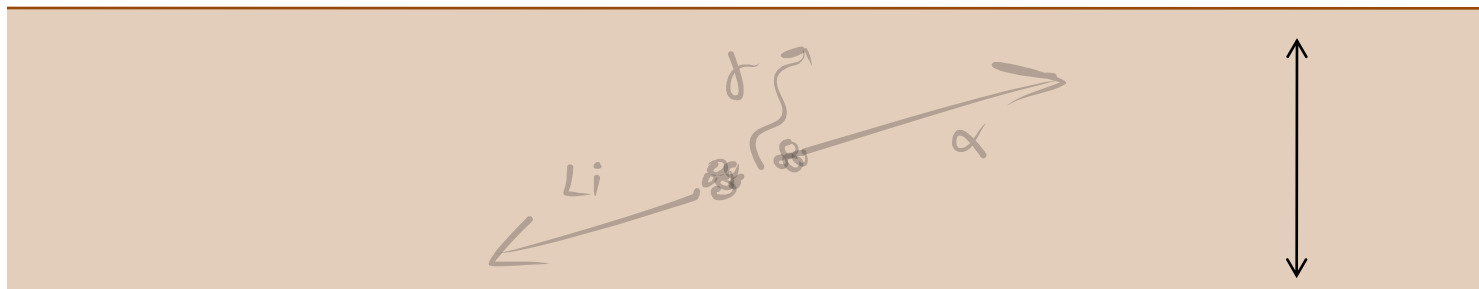
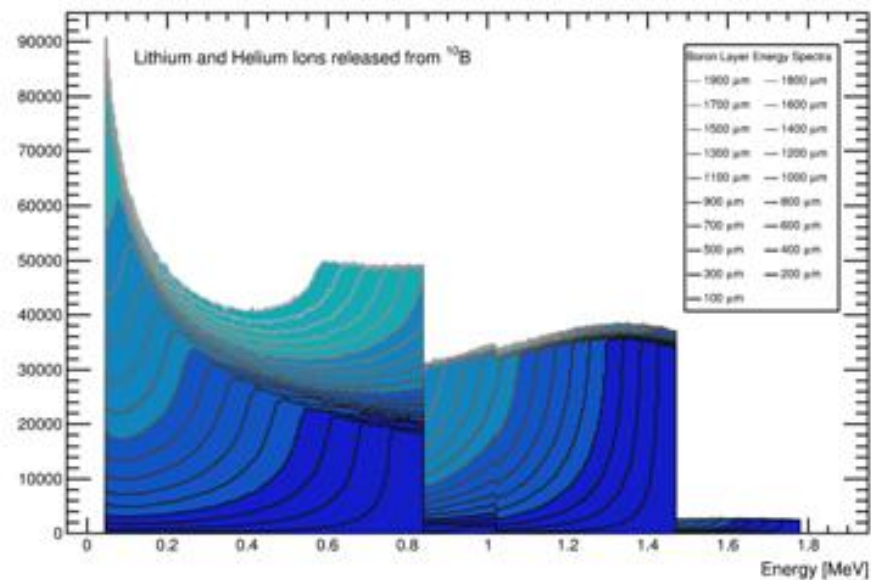
From 0.1 μm to 2 μm ^{10}B



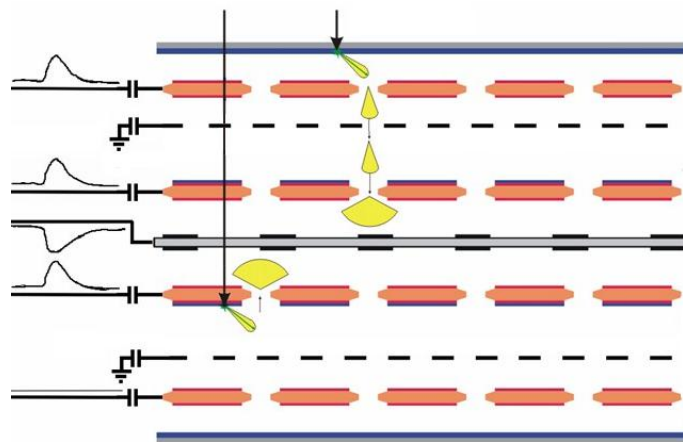
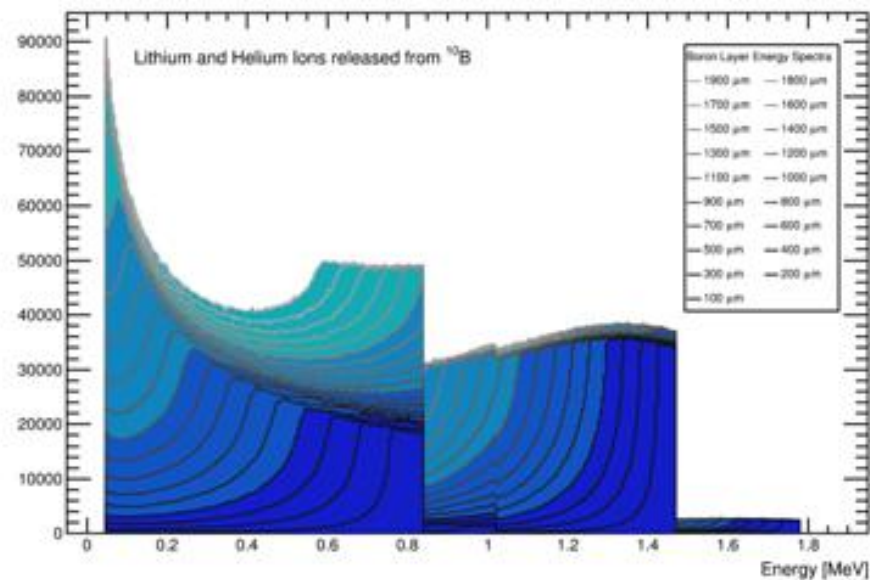
From 0.1 μm to 2 μm ^{10}B



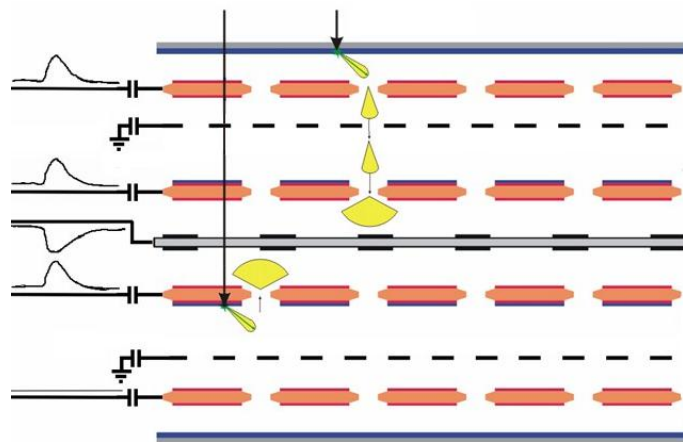
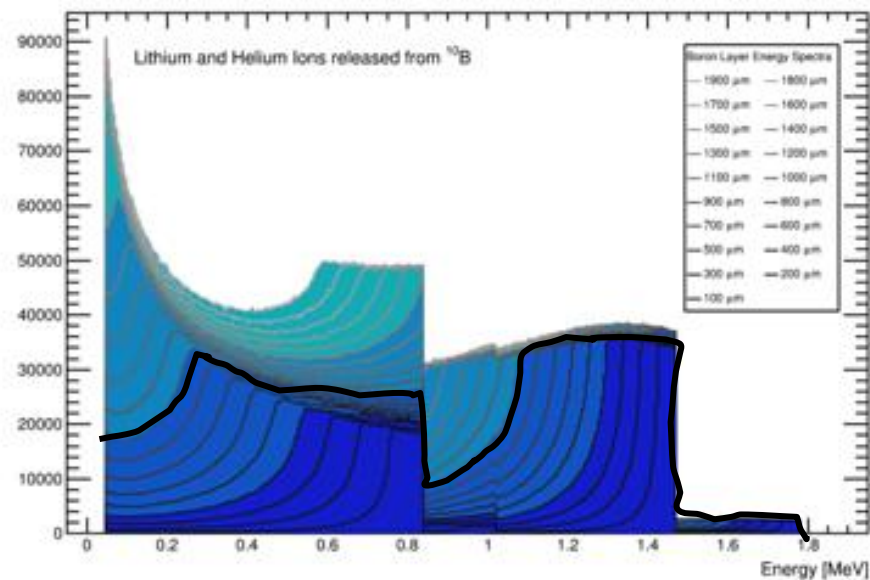
Conversion Products: Energy Spectra



Conversion Products: Energy Spectra



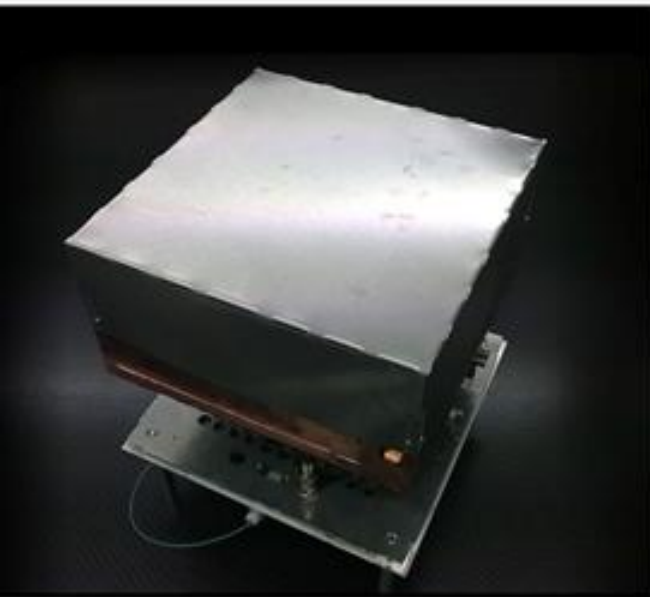
Conversion Products: Energy Spectra



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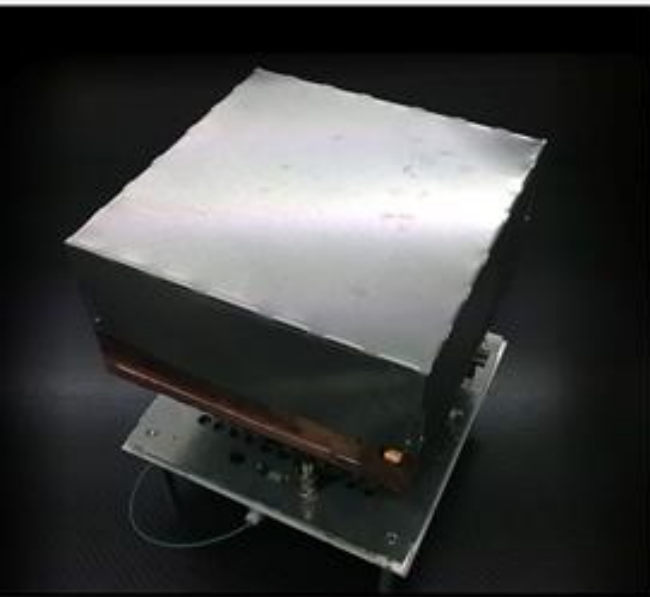


Boron-10 technology



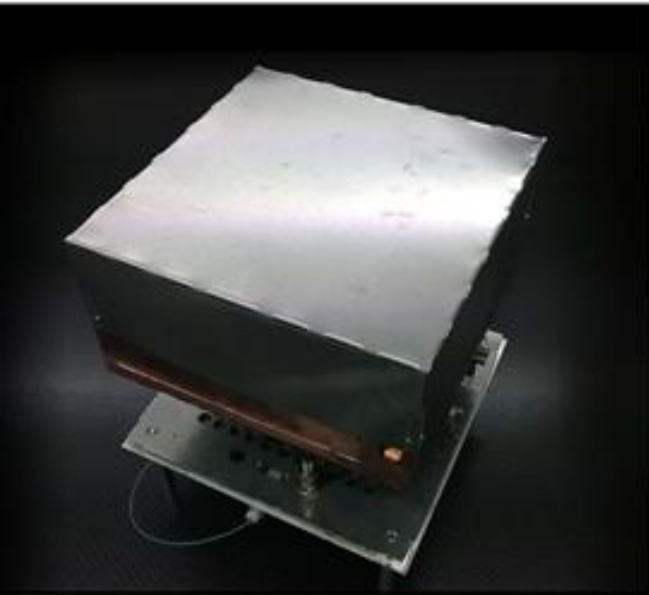
Boron-10 technology

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

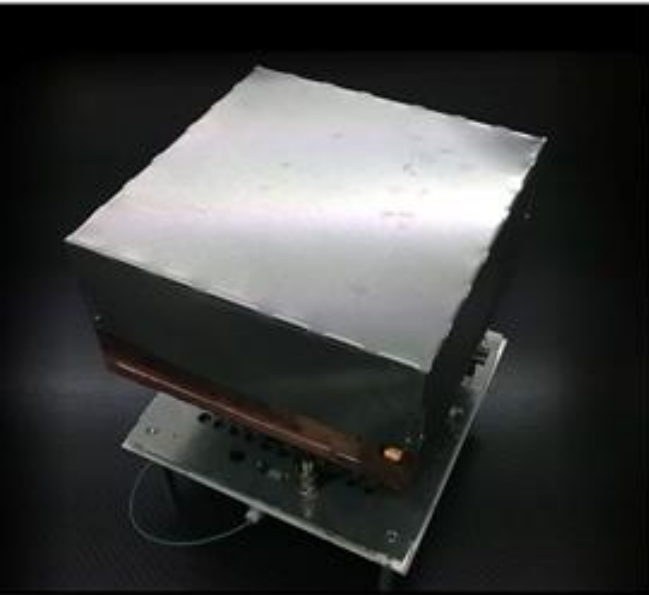


- conversion layer identification
- high TOF resolution (100 ns readout)
- 2.4 mm FWHM spatial resolution
- 2 MHz rate capability
- 25% thermal neutron efficiency @ 6 layers (21% in new configuration)

Boron-10 technology



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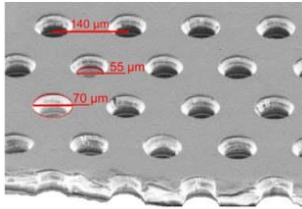
The road to go?



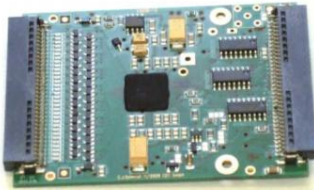


The road to go?

GEM



Multichannel
ASIC



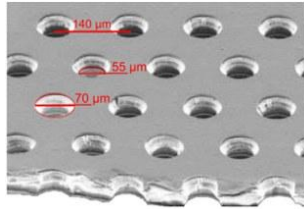
Technology available in 2000



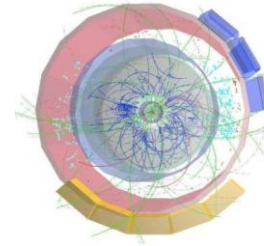
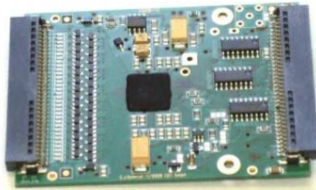


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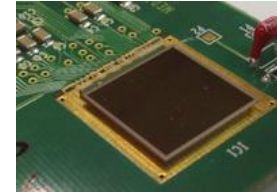
GEM



Multichannel
ASIC



TPC



TimePix

Technology available in 2000

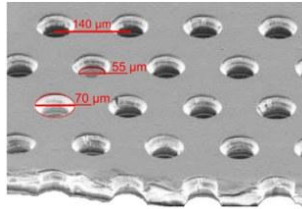
Technology available in 2015



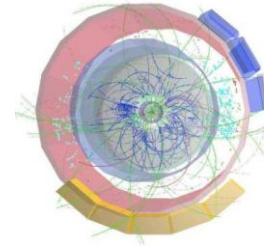
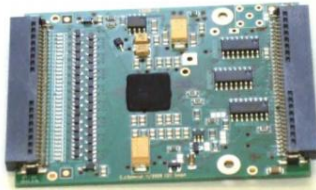


The road to go?

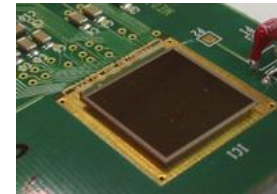
GEM



Multichannel
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TPC



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Technology available in 2000

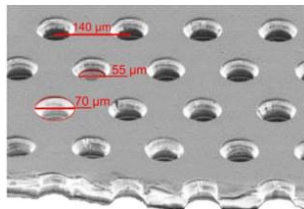
Technology available in 2015



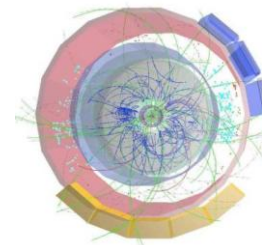
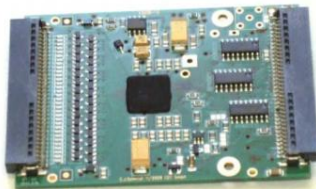
Particle Flow

The road to go?

GEM

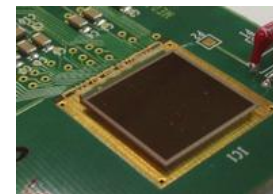


Multichannel
ASIC



TPC

TimePix

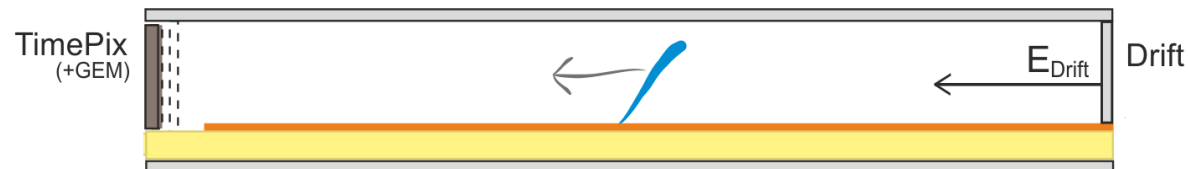


Technology available in 2000

Technology available in 2015

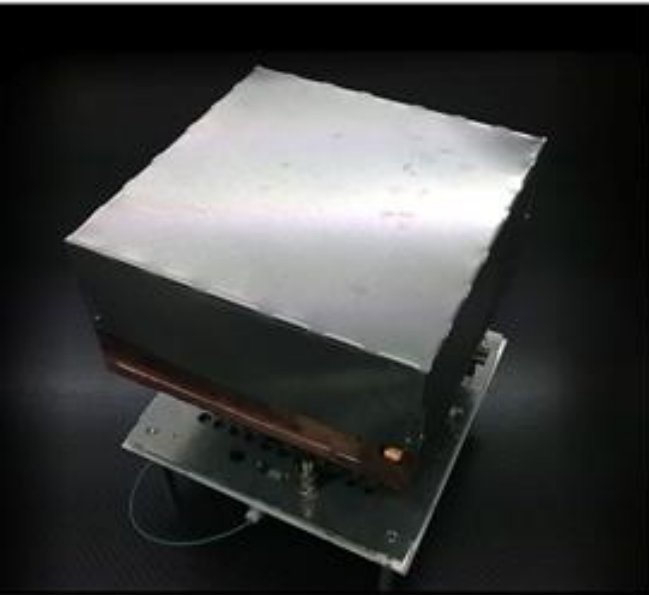


Particle Flow



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CASCADE
Backup

