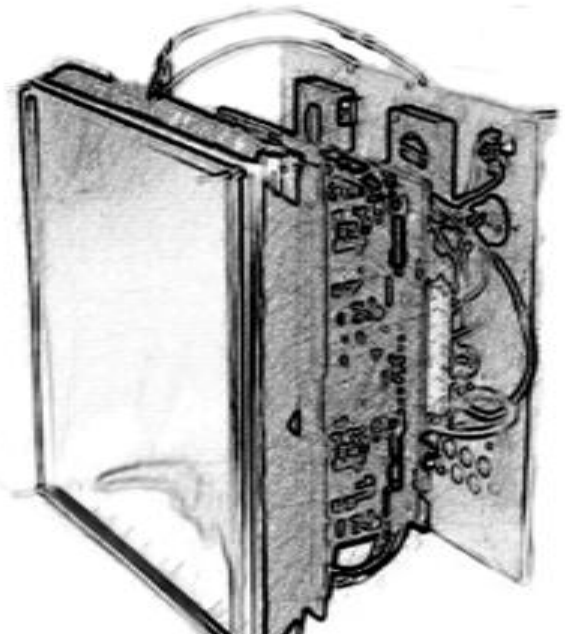
Bundesministerium
für Bildung
und Forschung

SNI 2014

Das CASCADE Projekt

eine alternative Perspektive für Festkörper-Neutronendetektoren



Markus Köhli

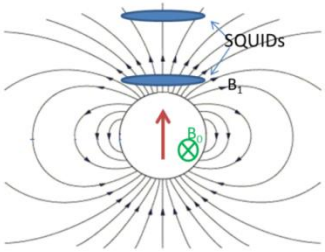
M. Klein, U. Schmidt
AG Dubbers

Physikalisches Institut
Ruprecht-Karls-Universität
Heidelberg

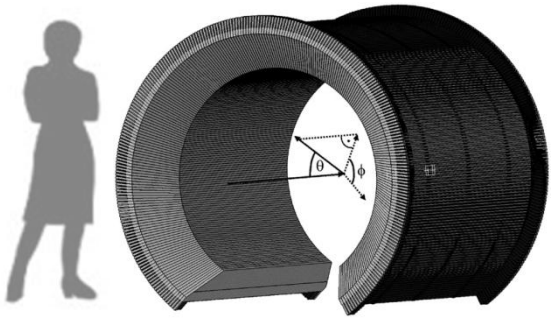
21.09.2014

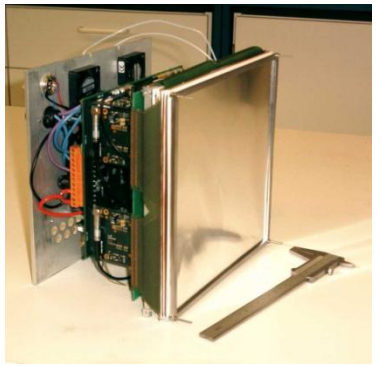
Heidelberg Research Fields

Helium-Xenon EDM
[test of Lorentz invariance]

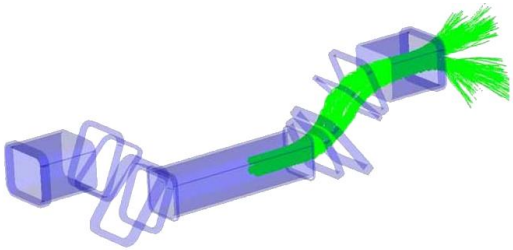


Neutron Detectors
[large area and **high time resolution]**

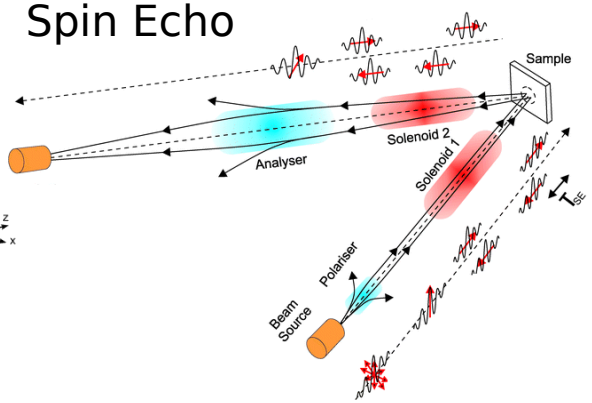




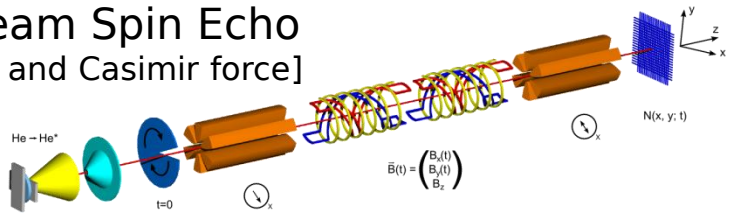
PERC and PERKEO
[v_{ud} via neutron beta decay]



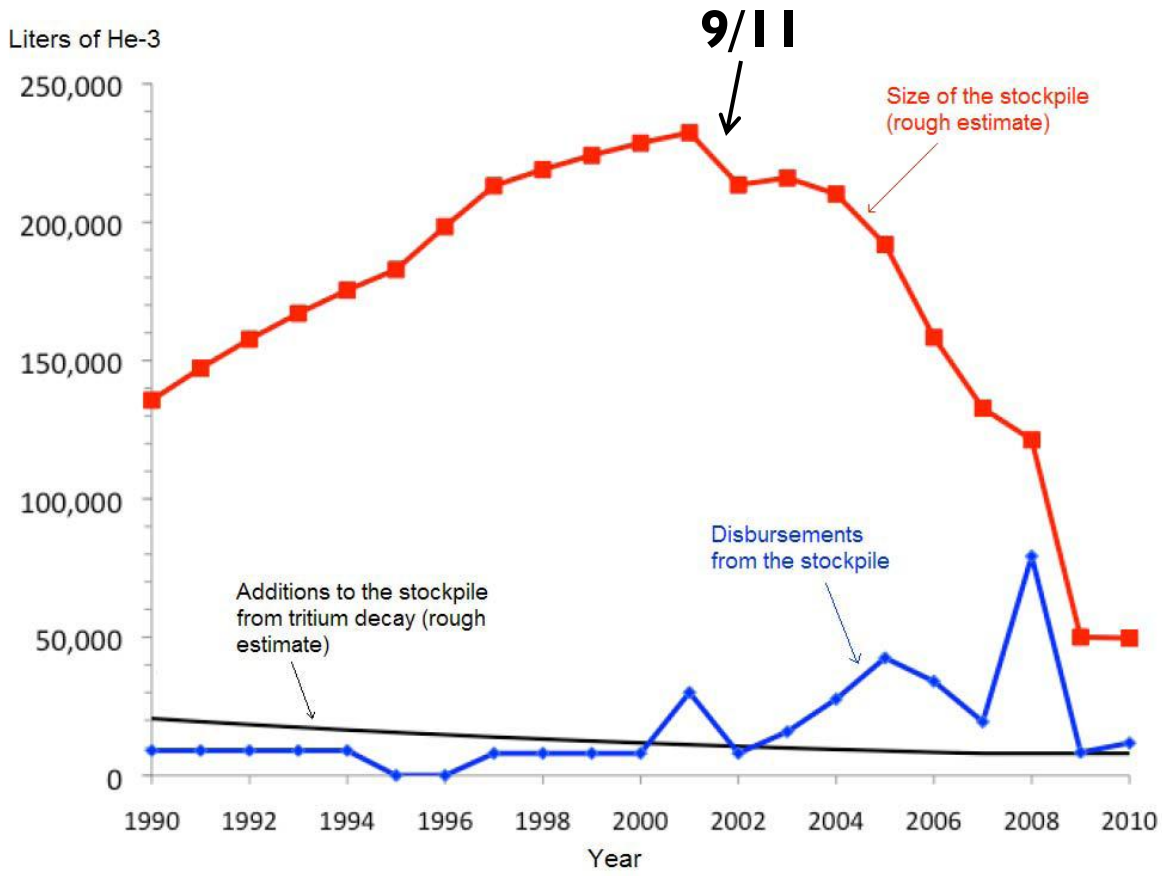
Spin Echo



Atomic Beam Spin Echo
[Berry phase and Casimir force]



The He-3 crisis

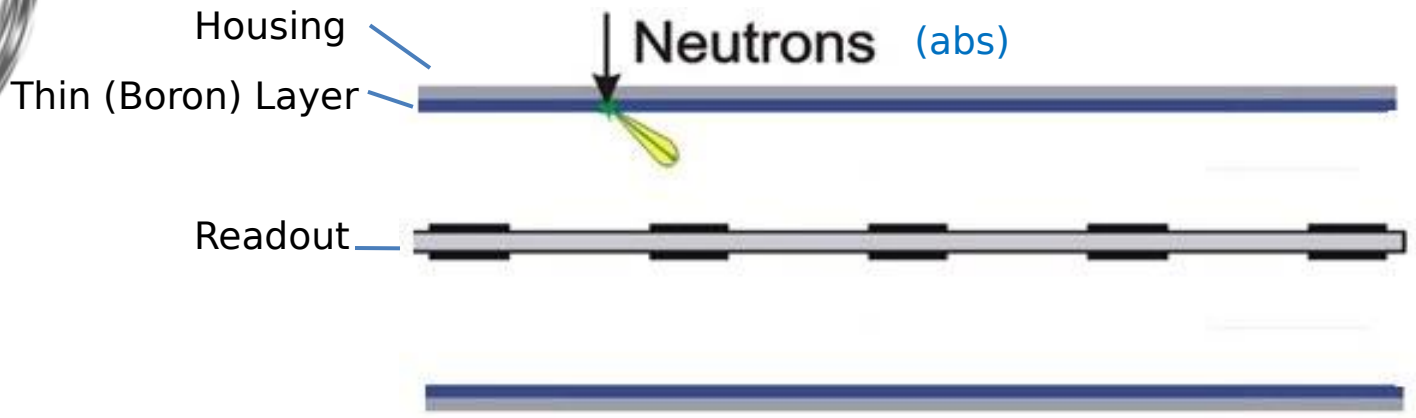


Size of the Helium-3 Stockpile, 1990-2010 [1]

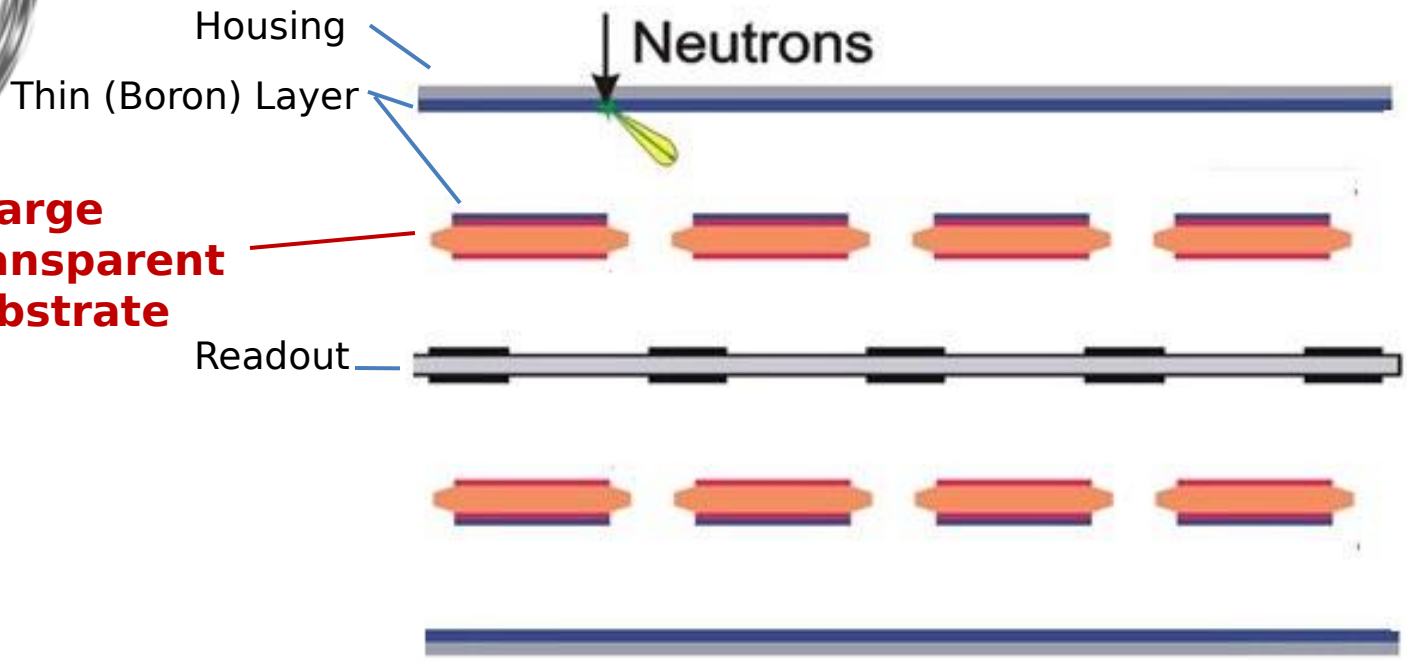
Costs:
2000-3000 €/L
…If you can get it

[1] AAAS, Overview of Helium-3 Supply and Demand

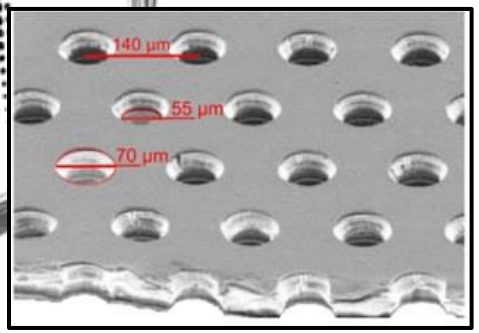
The CASCADE Concept

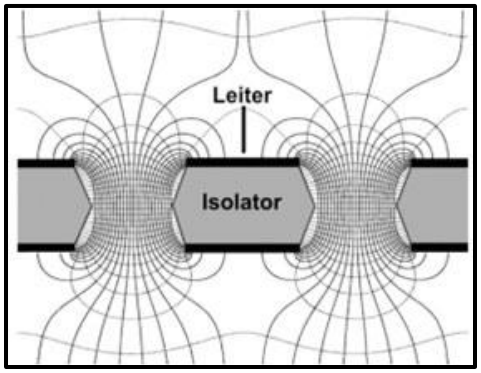


The CASCADE Concept



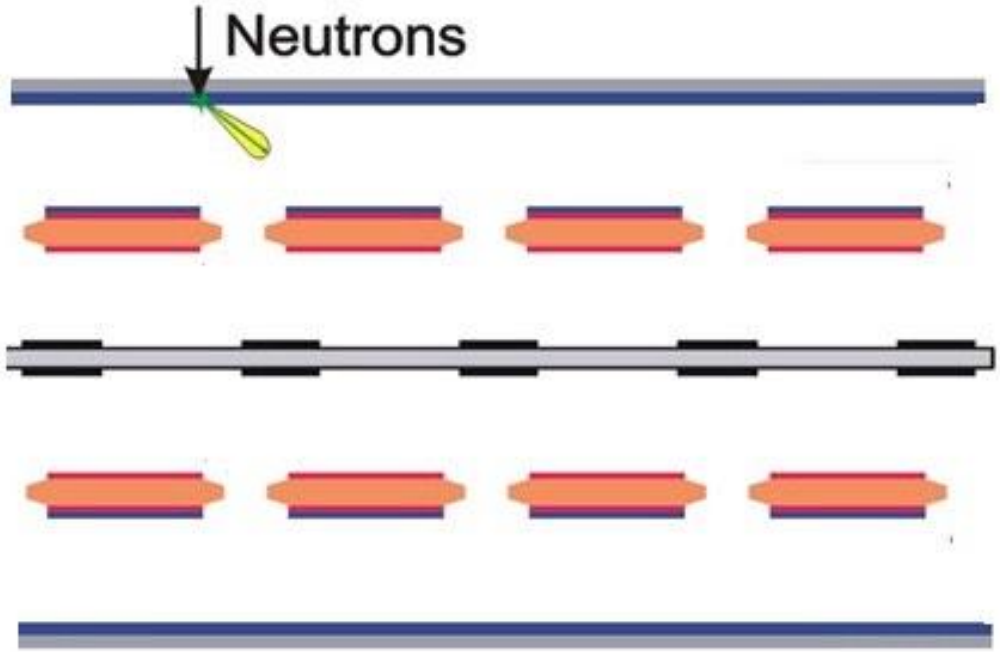
The CASCADE Concept





GEM
(Gas Electron Multiplier foil)

[1]



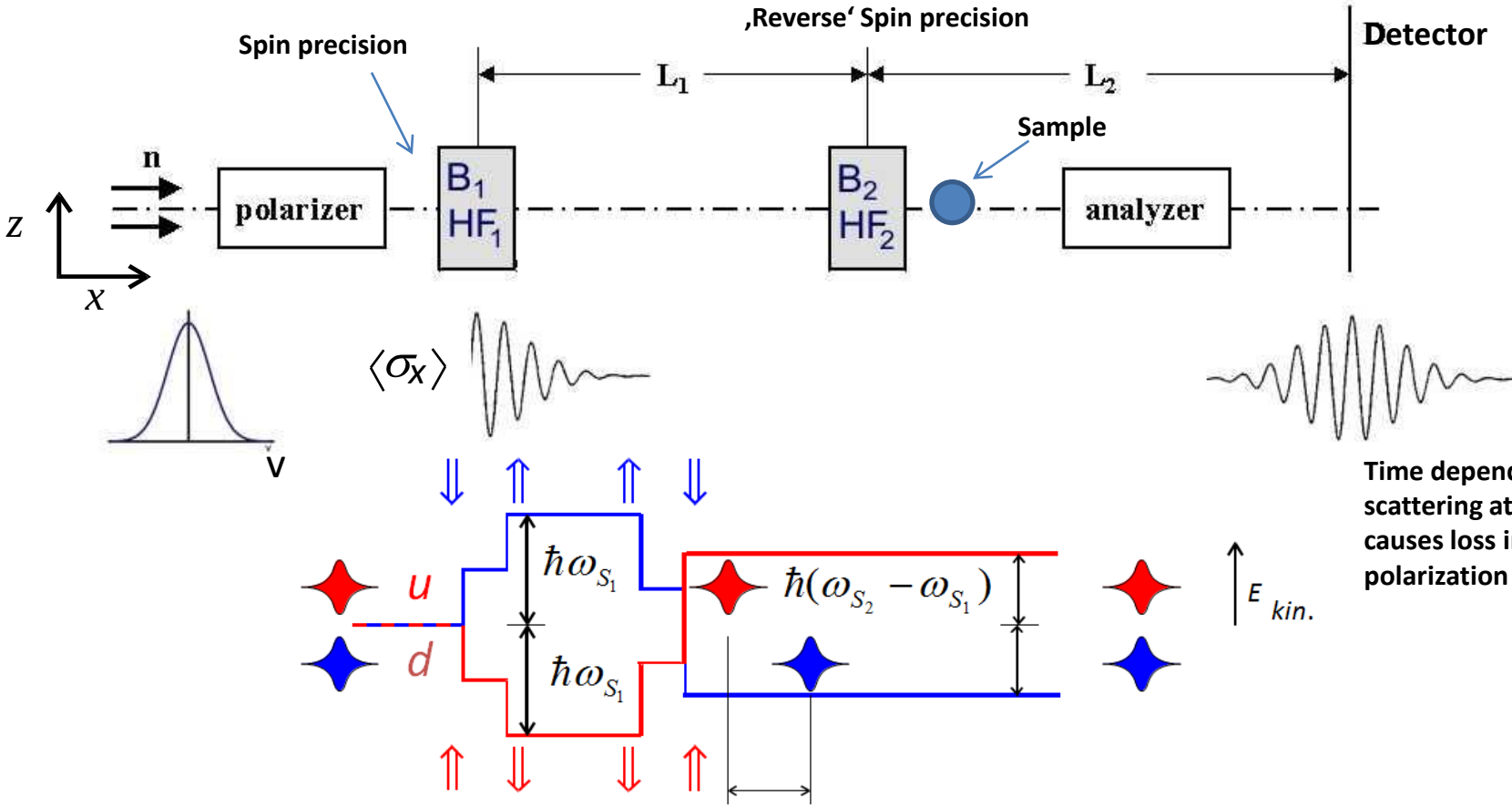
[1] Sauli, F. ; Sharma, A.: Micropattern Gaseous Detectors. In: Annual Review of Nuclear and Particle Science 49 (1999)

Neutron Resonance Spin Echo Methods

The MIEZE setup

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

e.g. Ramsey Interferometer



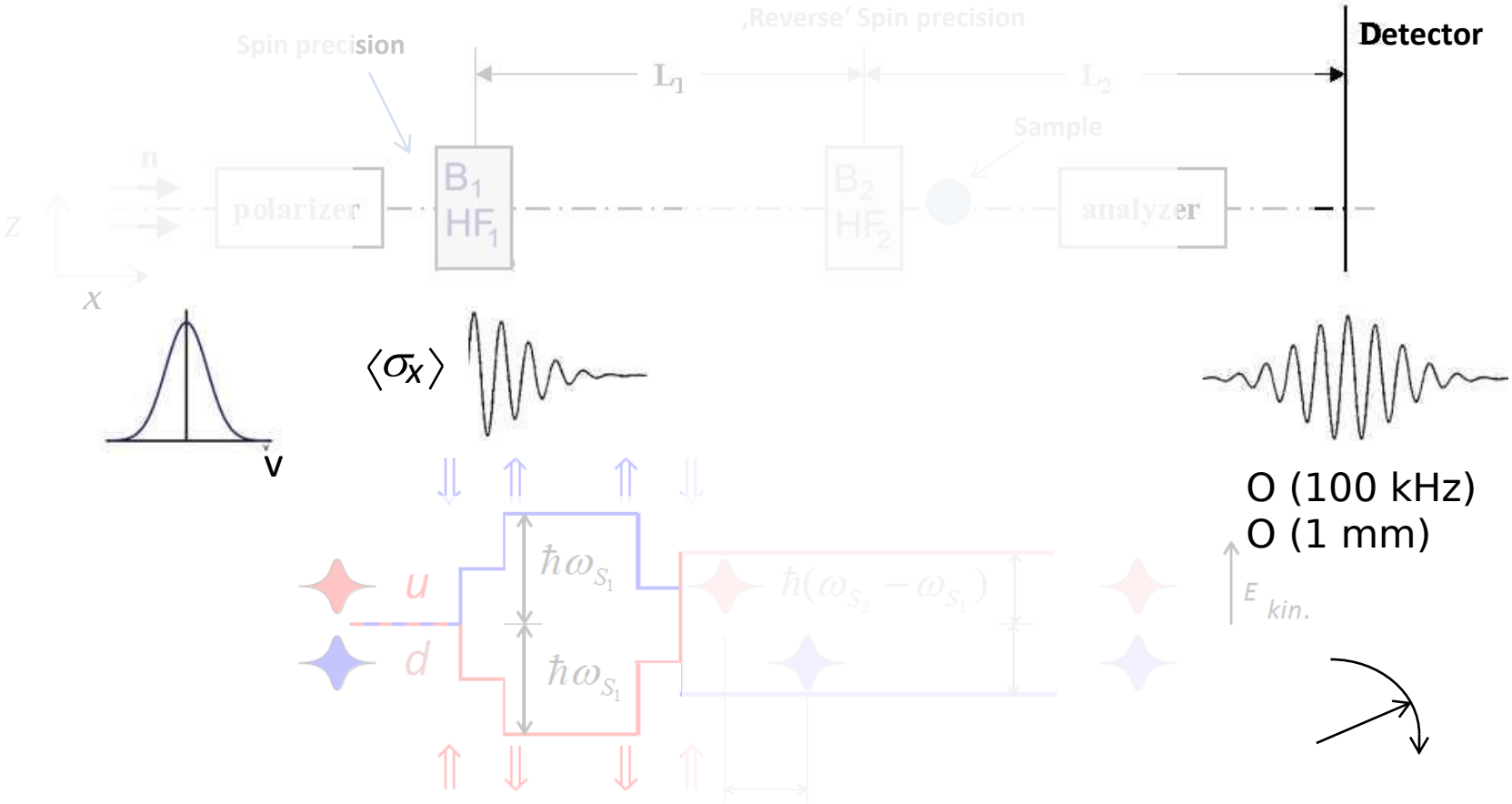
Time dependent scattering at sample causes loss in polarization

Neutron Resonance Spin Echo Methods

The MIEZE setup

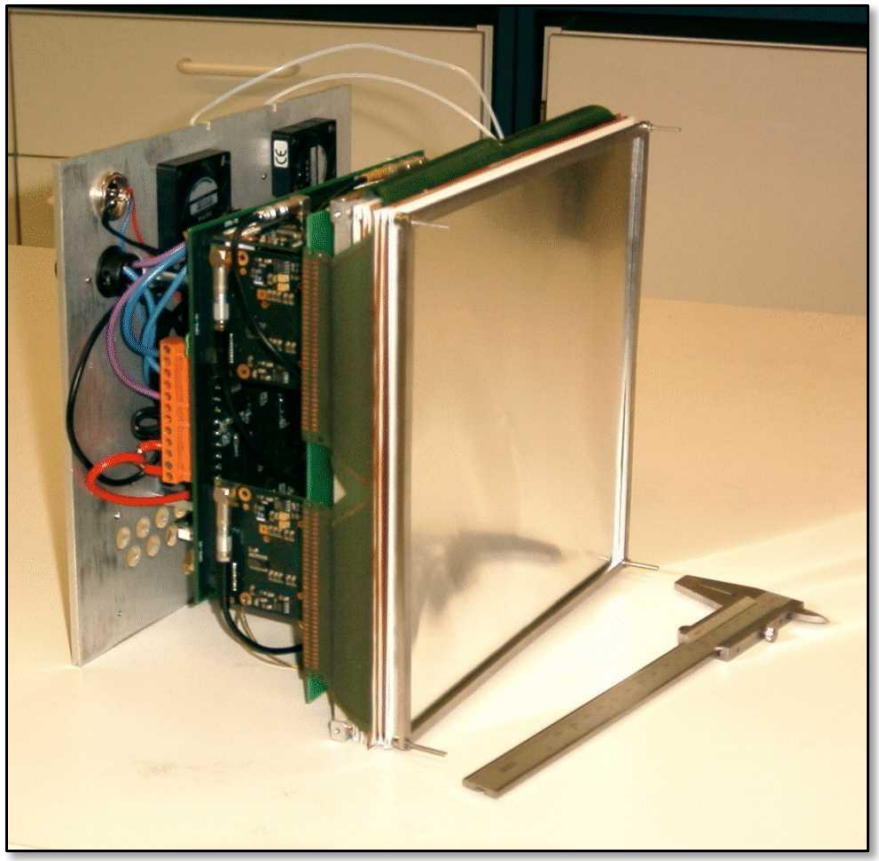
Principle: **Use Neutron Spin as Obervable in Interference Time Of Flight Experiments**

e.g. Ramsey Interferometer



The CASCADE Detector

CASCADE detector without housing



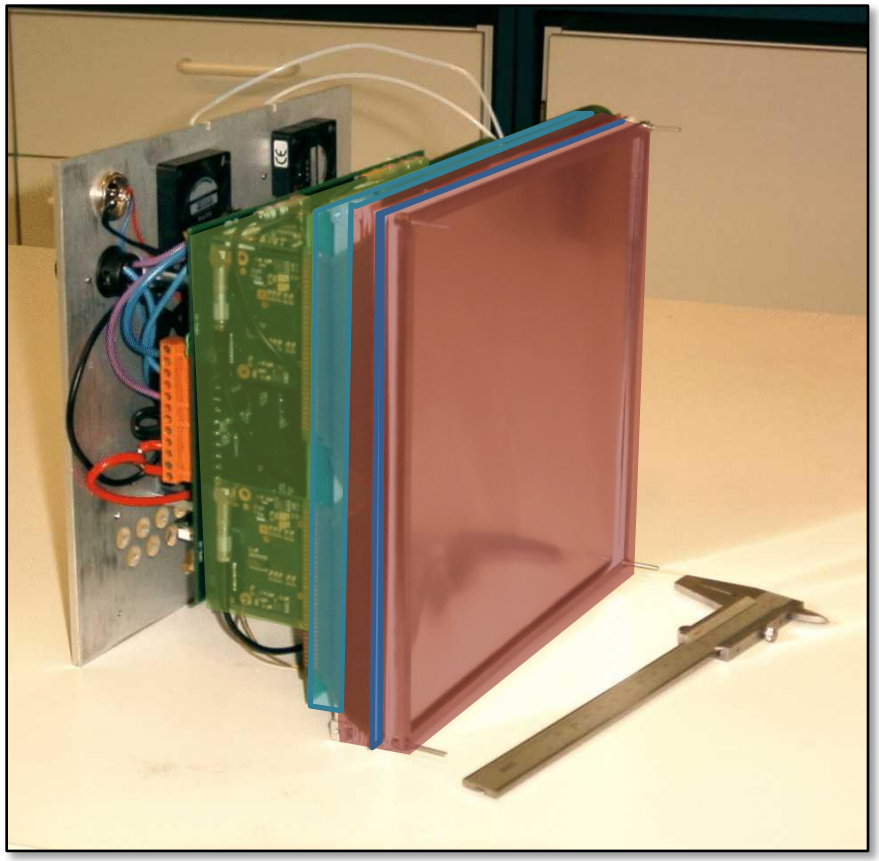
The CASCADE Detector

Active Detection Volume

Readout

Electronics

CASCADE detector without housing



The CASCADE Detector

Active Detection Volume

- Neutron conversion, pure Boron-10

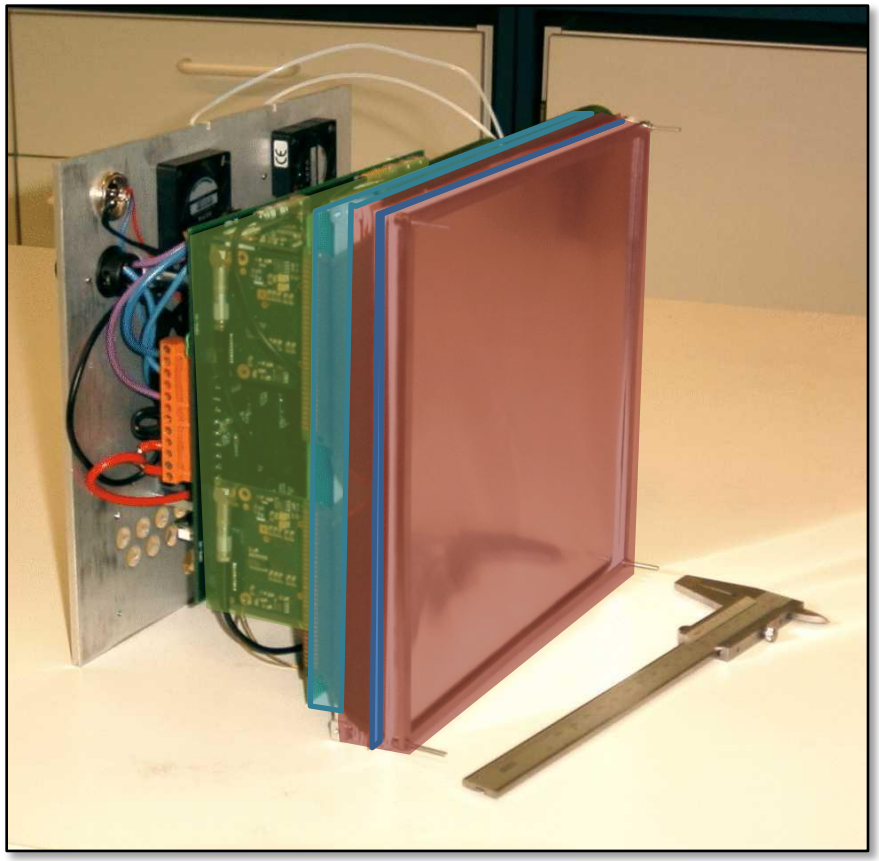
$^{10}B + n \rightarrow {}^{7}Li + \alpha + 2.79\ MeV$ (6%)
$\rightarrow {}^{7}Li^{*} + \alpha + 2.31\ MeV$ (94%)

- Charge amplification with GEMs in Standard Gas

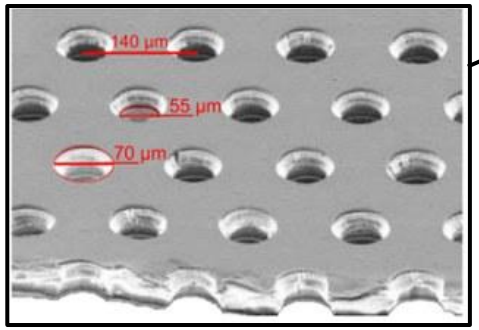
Readout

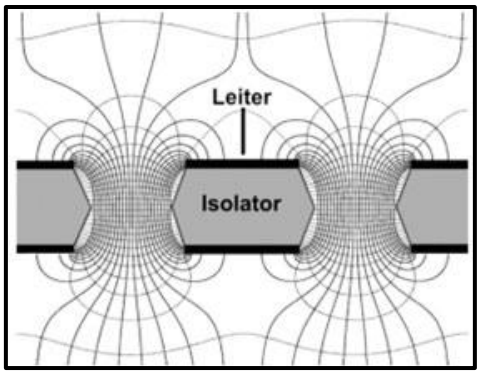
Electronics

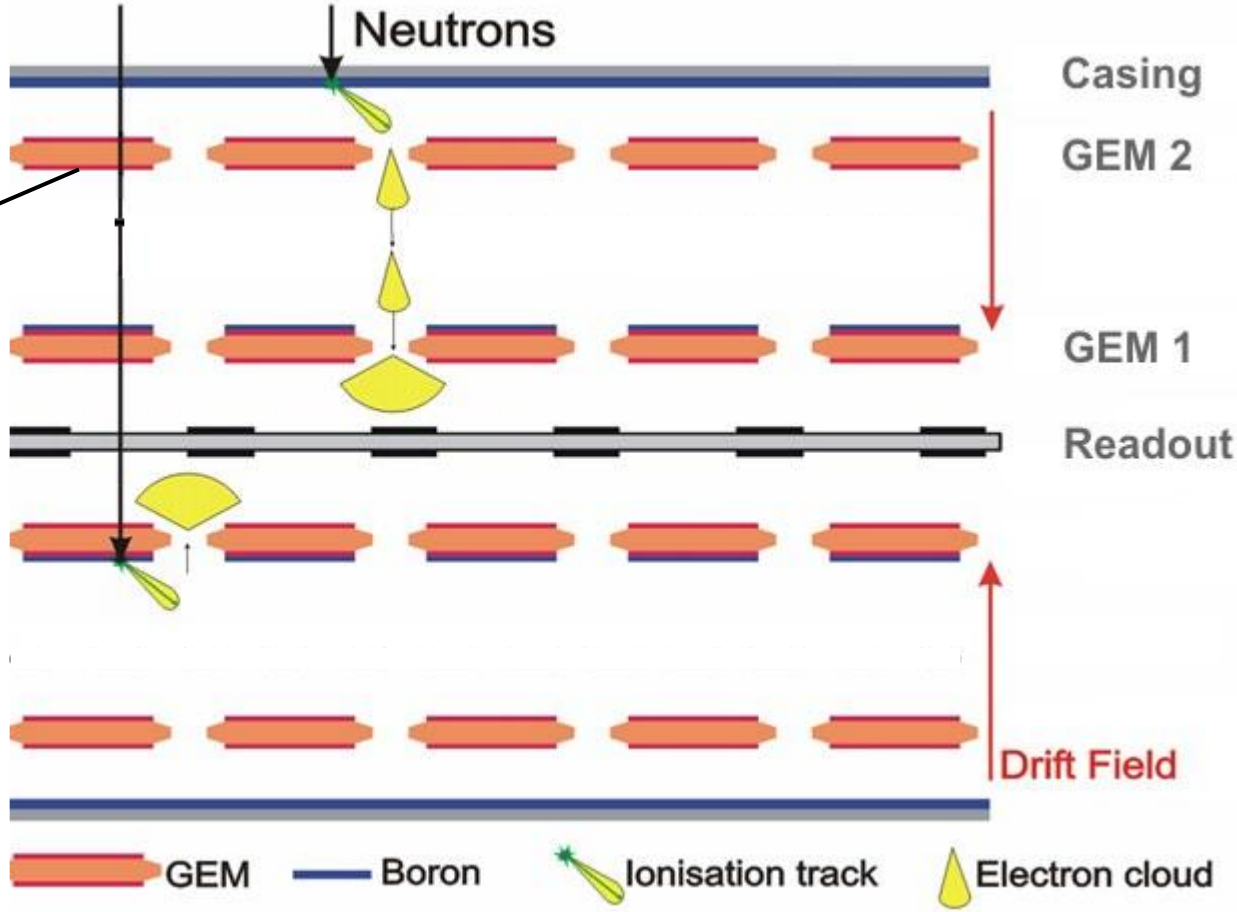
CASCADE detector without housing



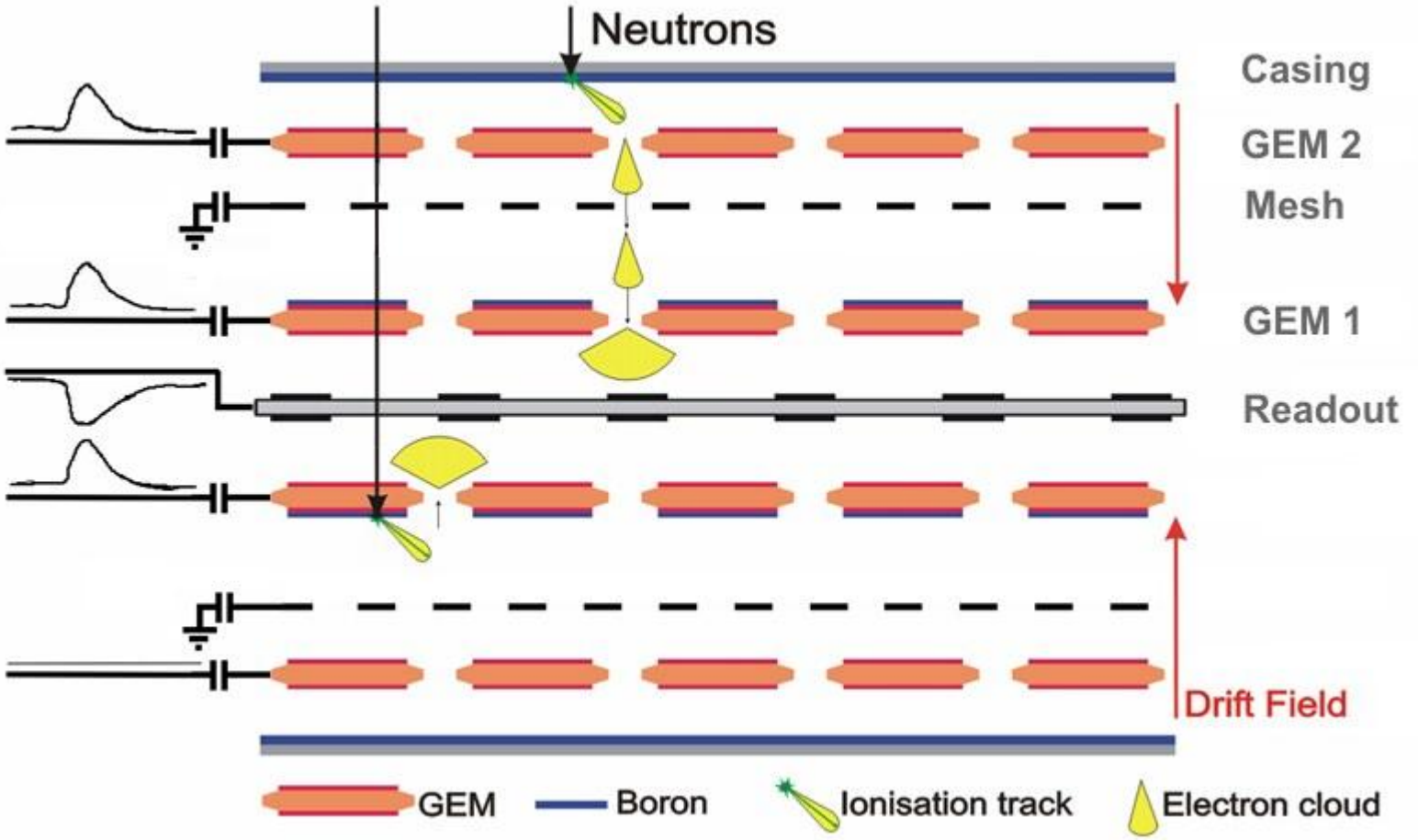
Active Detection Volume



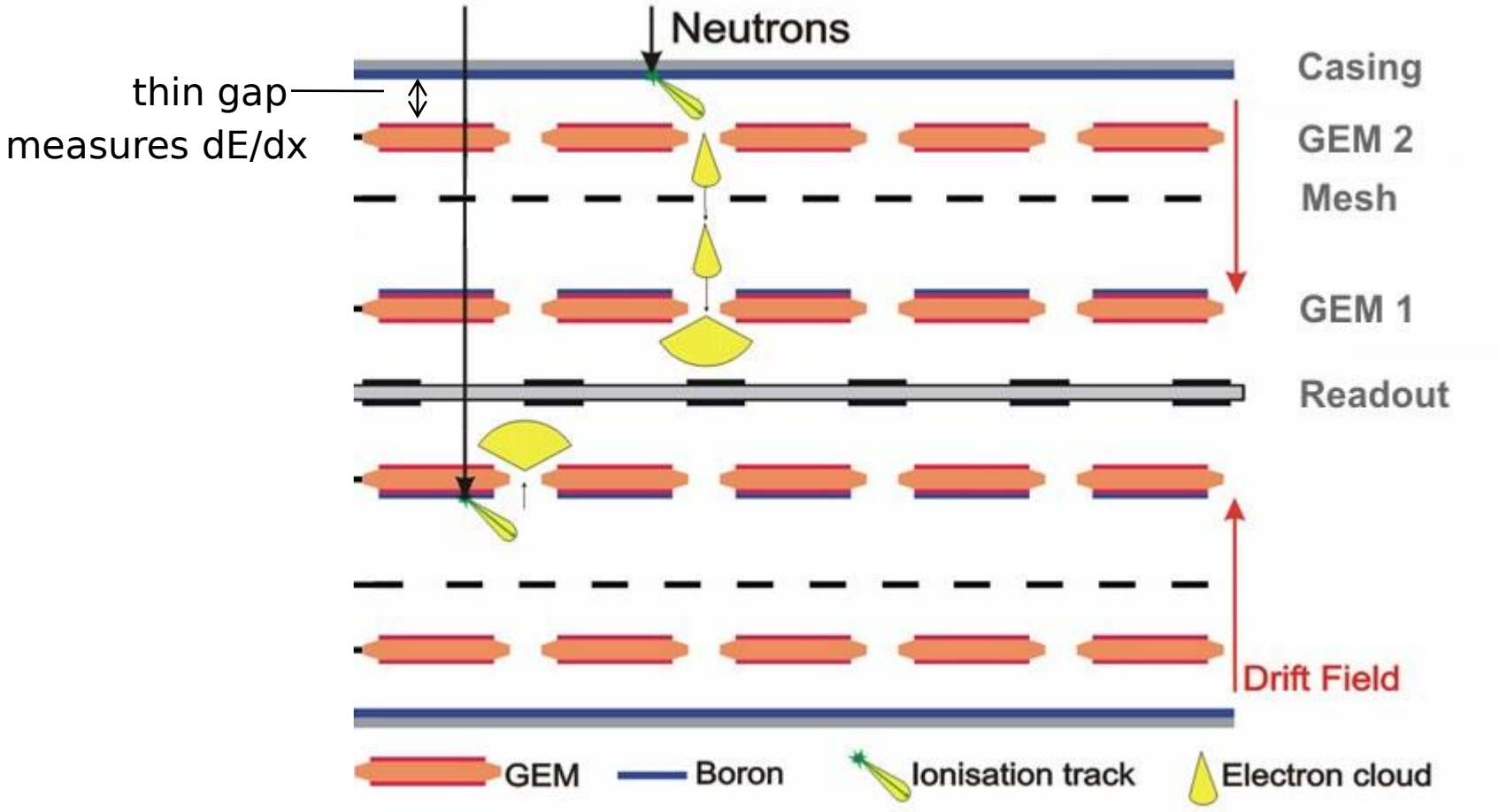




Active Detection Volume



Active Detection Volume



The CASCADE Detector

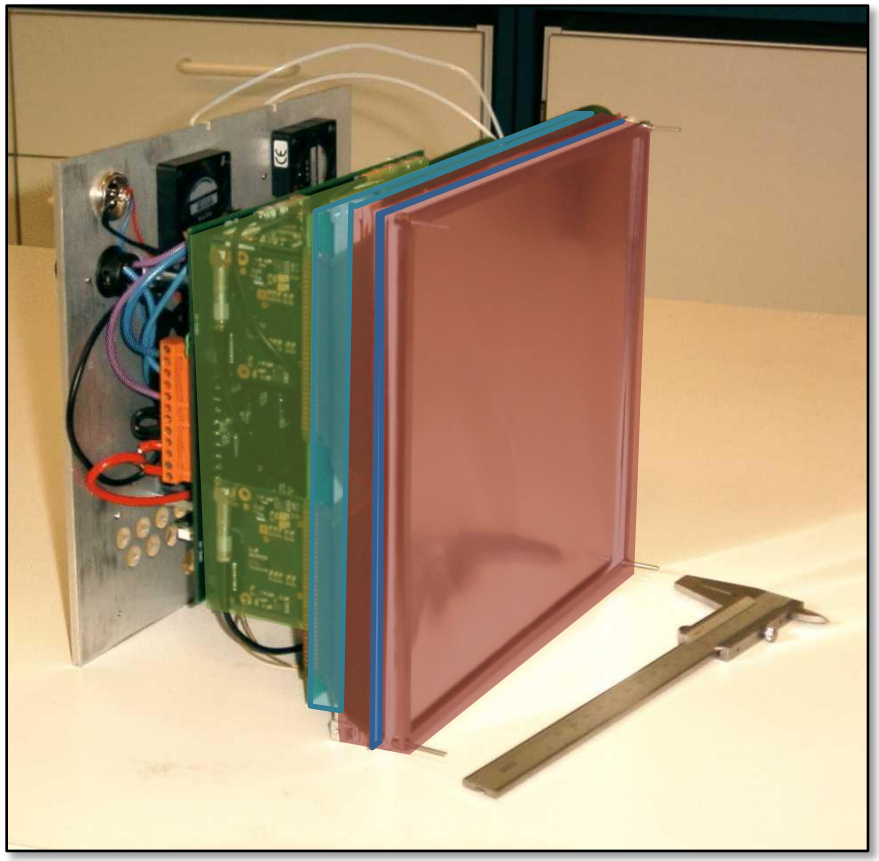
Active Detection Volume

Readout

- readout stripes: 128 x | 128 y @ 1.56mm
- double sided

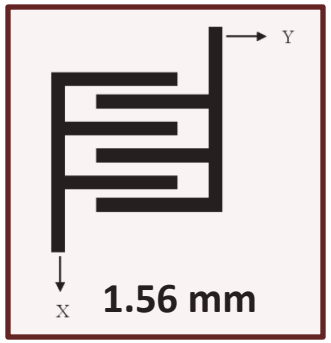
Electronics

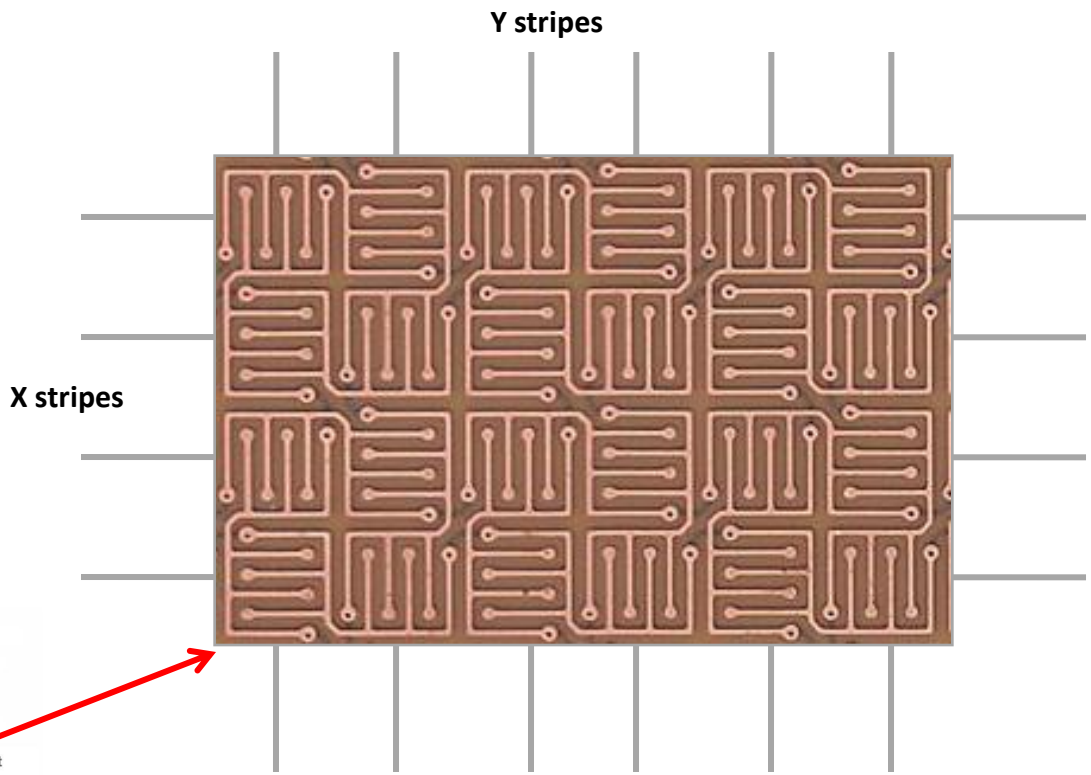
CASCADE detector without housing

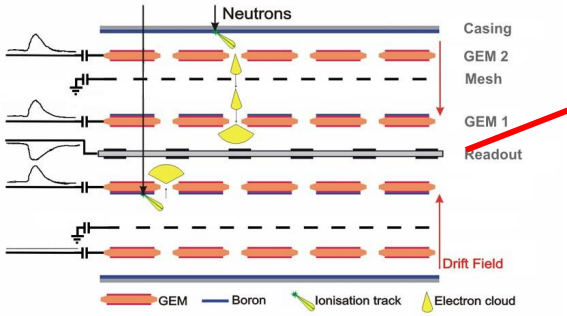


Double Sided Readout

Unit Cell:







Crossed stripes: reduces noise by correlating x and y

The CASCADE Detector

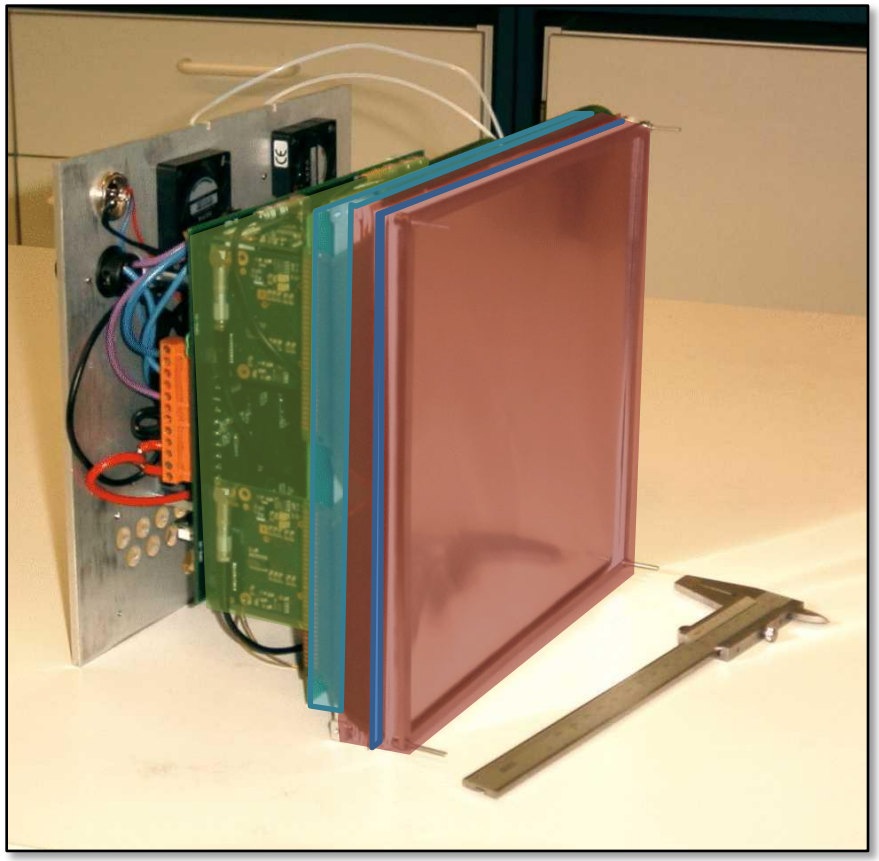
Active Detection Volume

Readout

Electronics

- -A/D: CiPix –Chip (ASIC) with 10 MHz
- -FPGA based data preprocessing
  - o histogram (on the fly)
- - Optical GBit Interface

CASCADE detector without housing

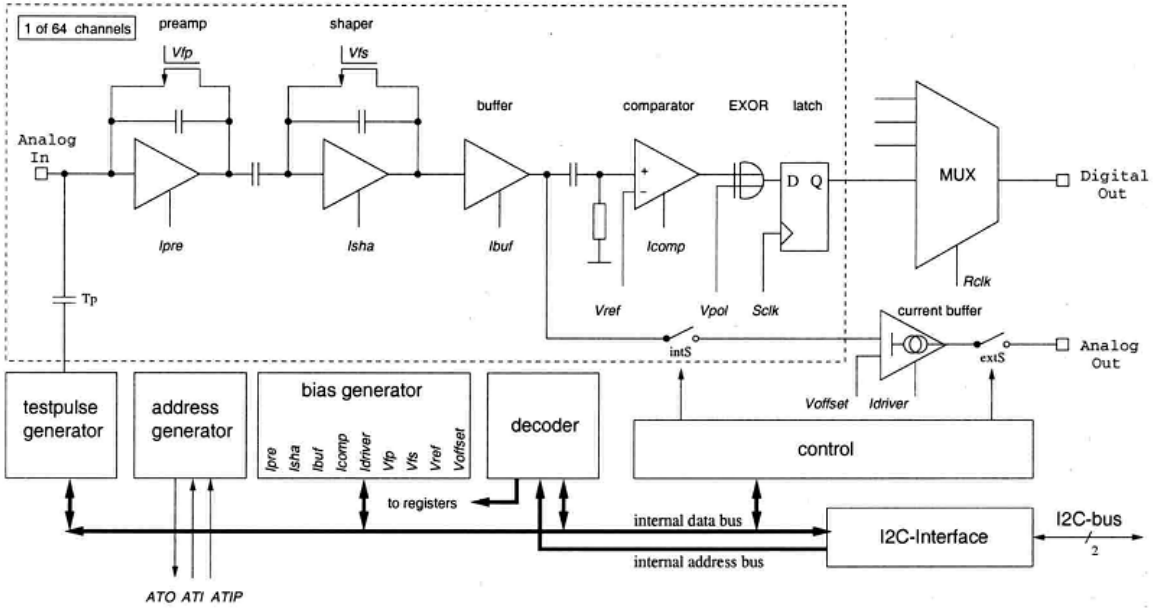


CIPix Preamplifier

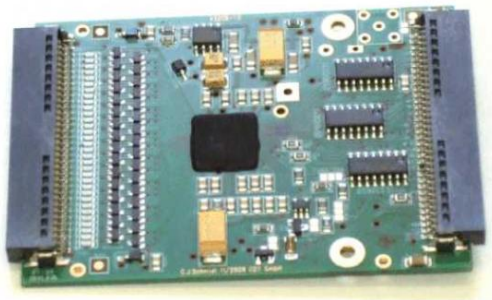
- 64 channels
- 10 MHz (40 MHz) readout clock

Timeline

FElix chip (RD20, LHC) 1993
HELIX 1.0
HELIX 32 1998
HELIX128-2.2 (HERA-B)
HELIX128-3.0 (Zeus)
CIPix (H1)
BEETLE (LHCb)

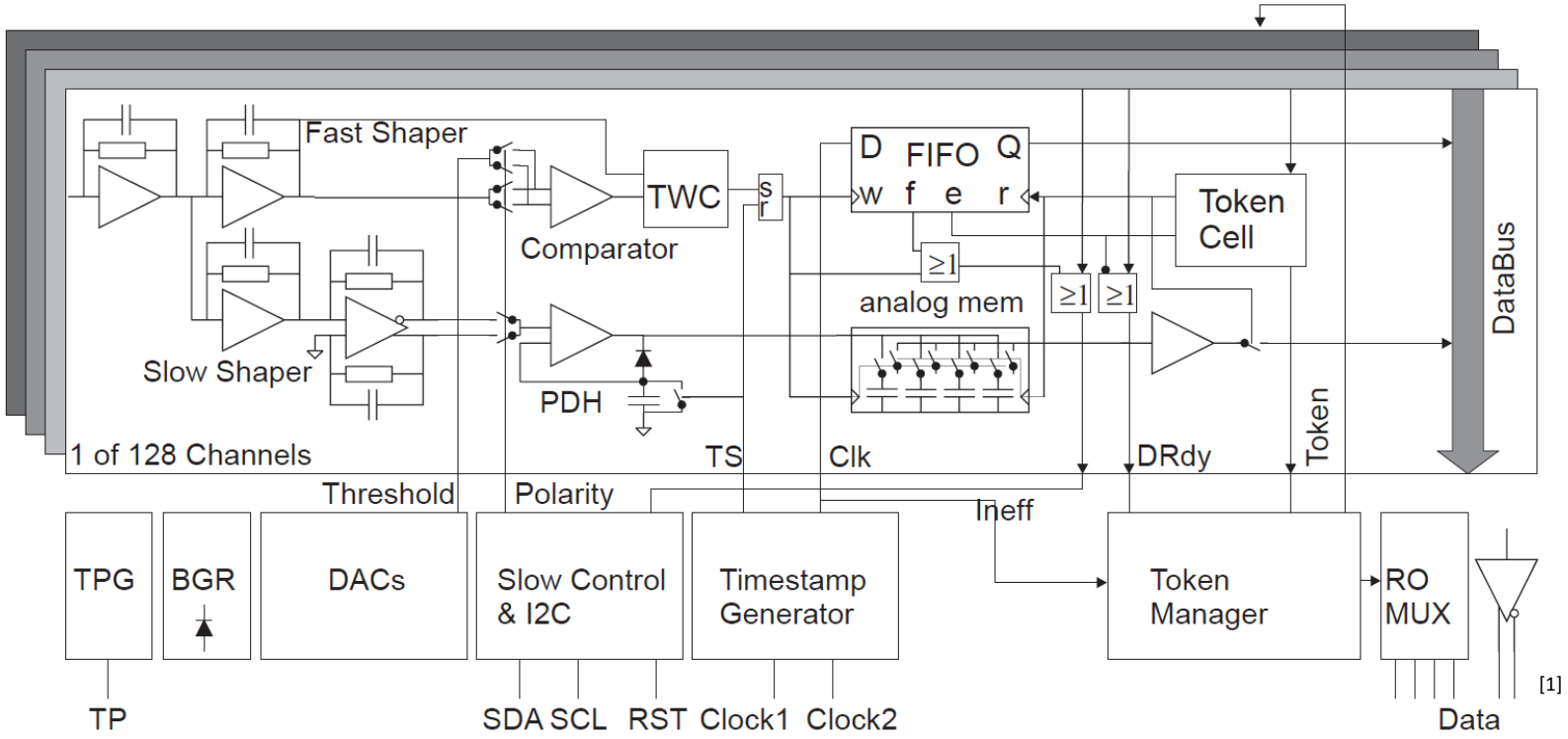


[1]



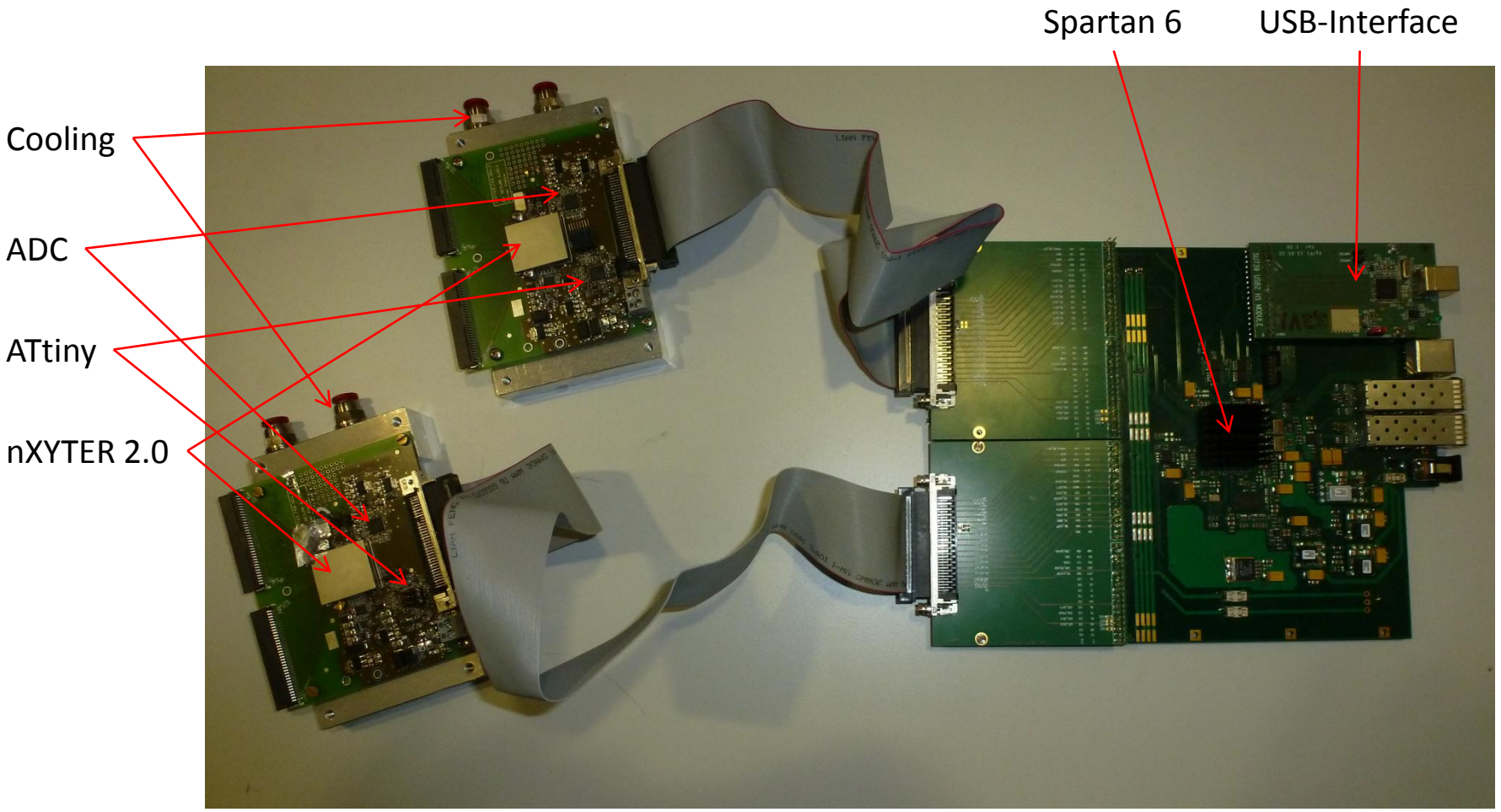
Outlook: nXYTER

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



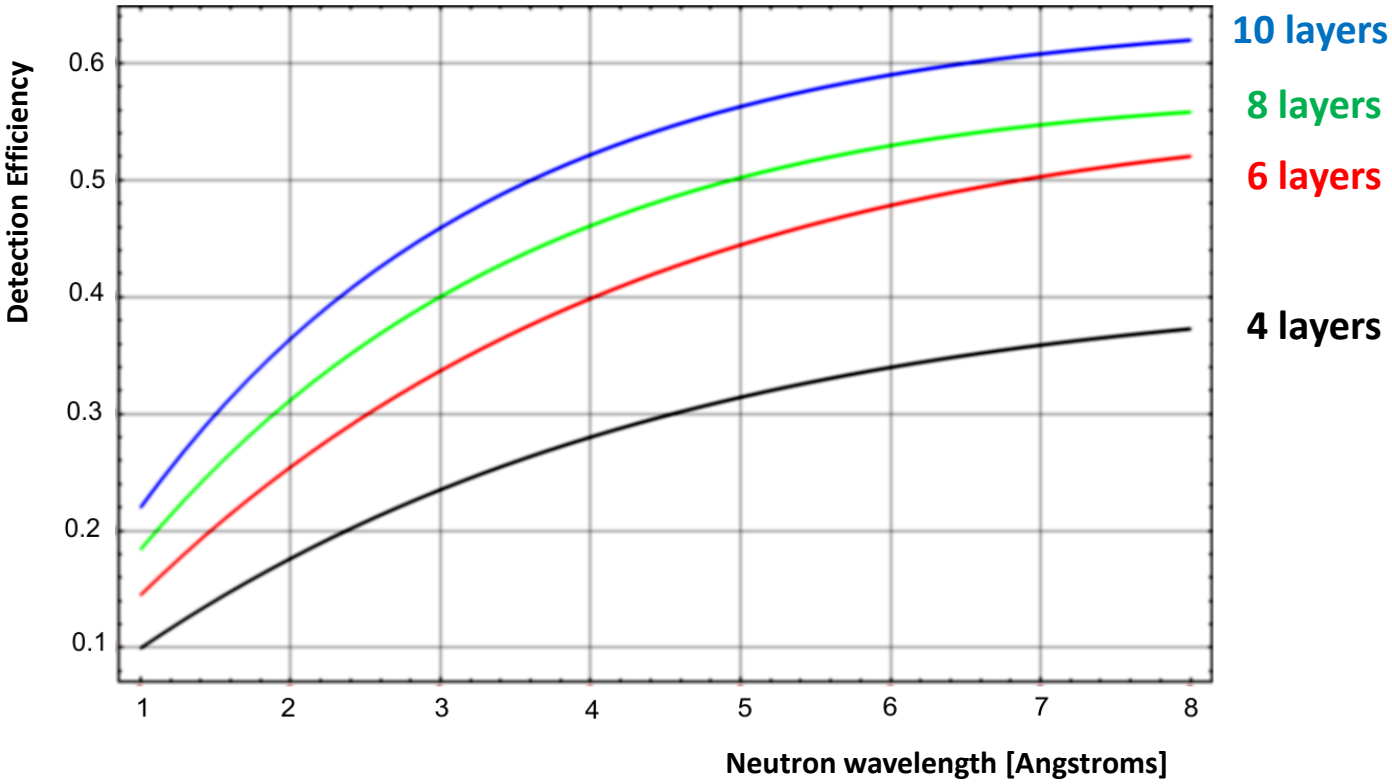
[1] The n-XYTER Reference Manual 1.50, 2009

nXYTER Readout Electronics



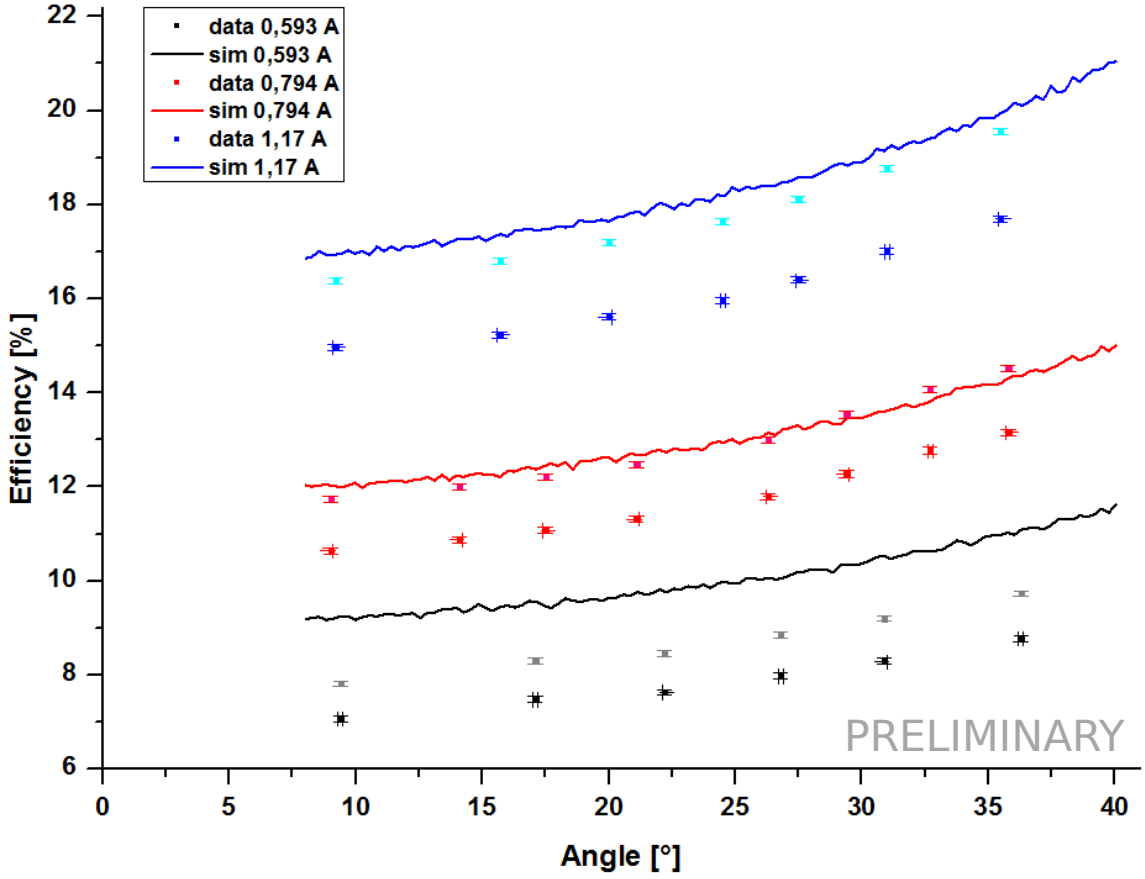
CASCADE Features

Theoretical efficiency



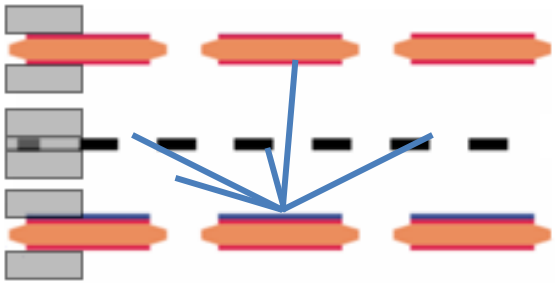
Efficiency measured at HEIDI

Efficiencies of the detector at different wavelengths



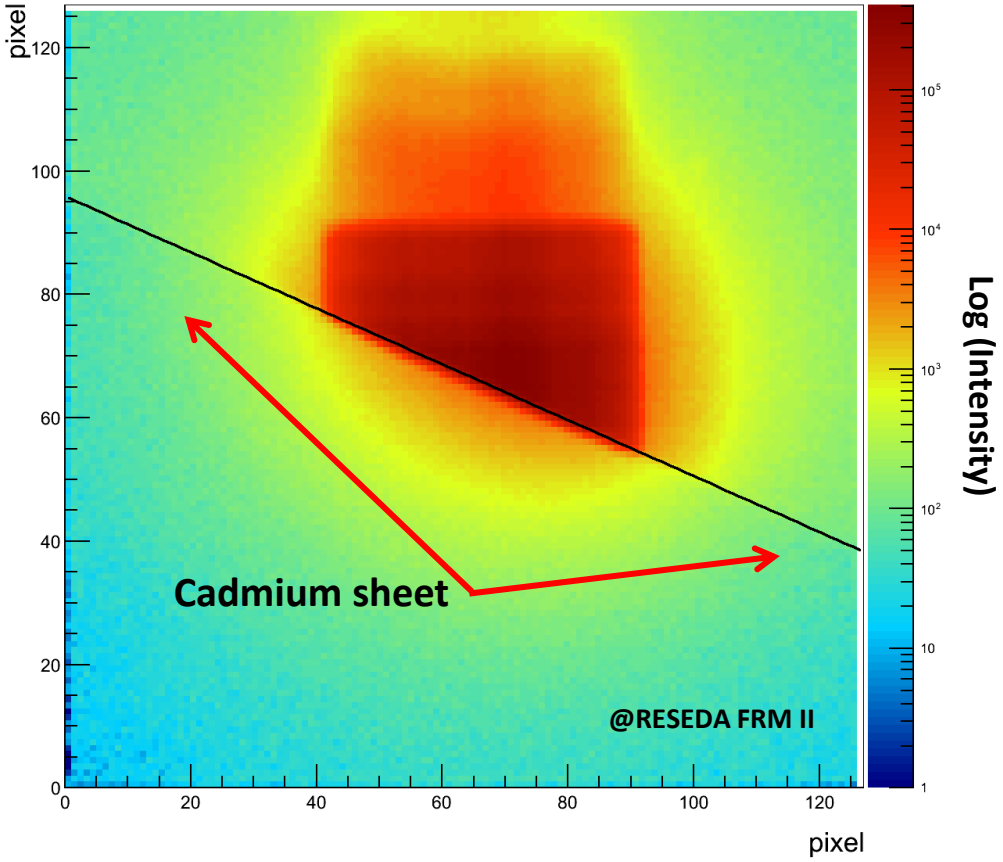
- Simulation
- Data
- Ghost event corrected data

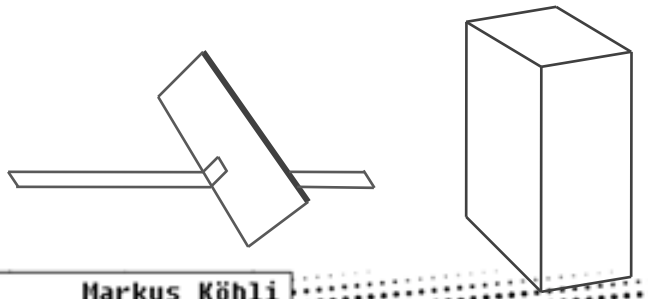
Spatial Resolution



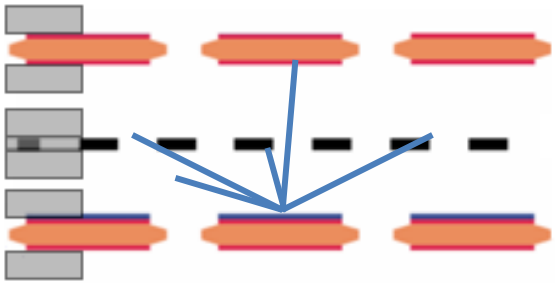
Spatial resolution: 2.4 mm

Image of a thermal neutron beam (after guide)



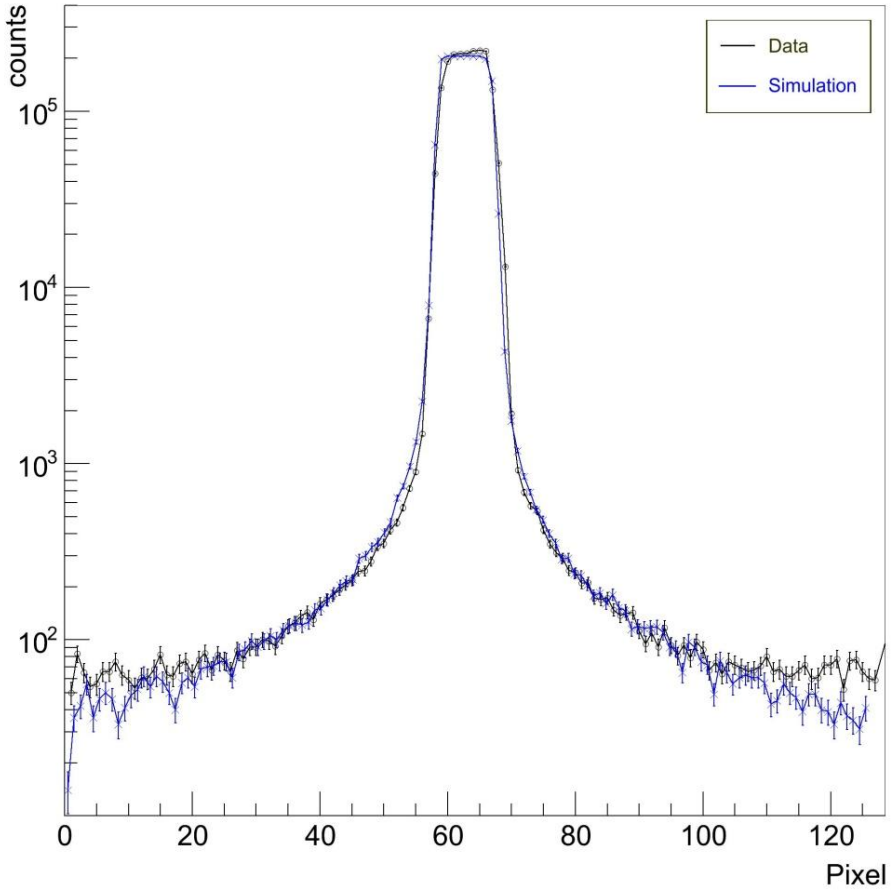


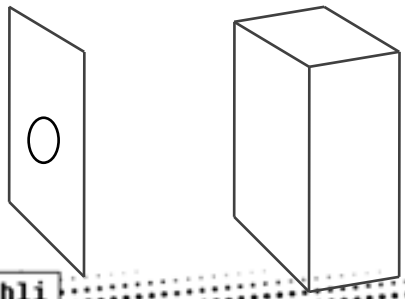
Spatial Resolution



Spatial resolution: 2.4 mm

Cross section of a collimated n-beam

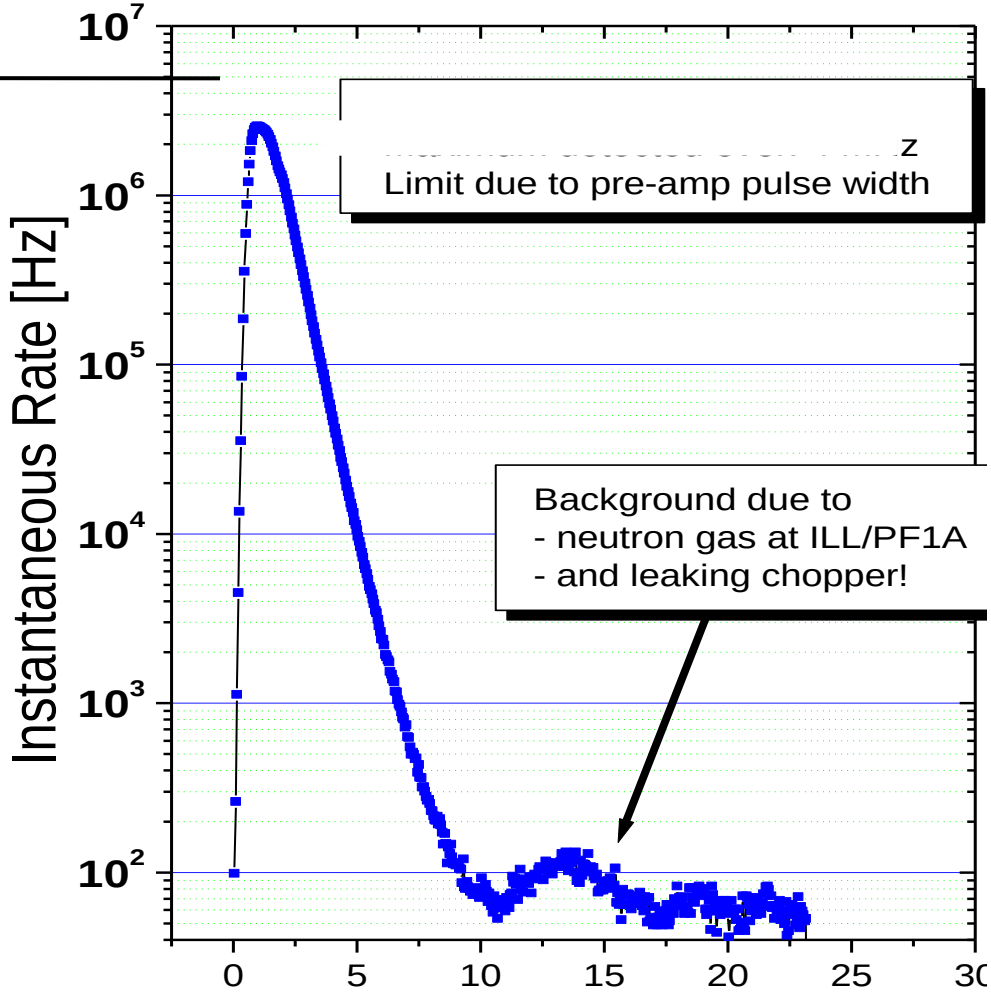




Count rate measurements

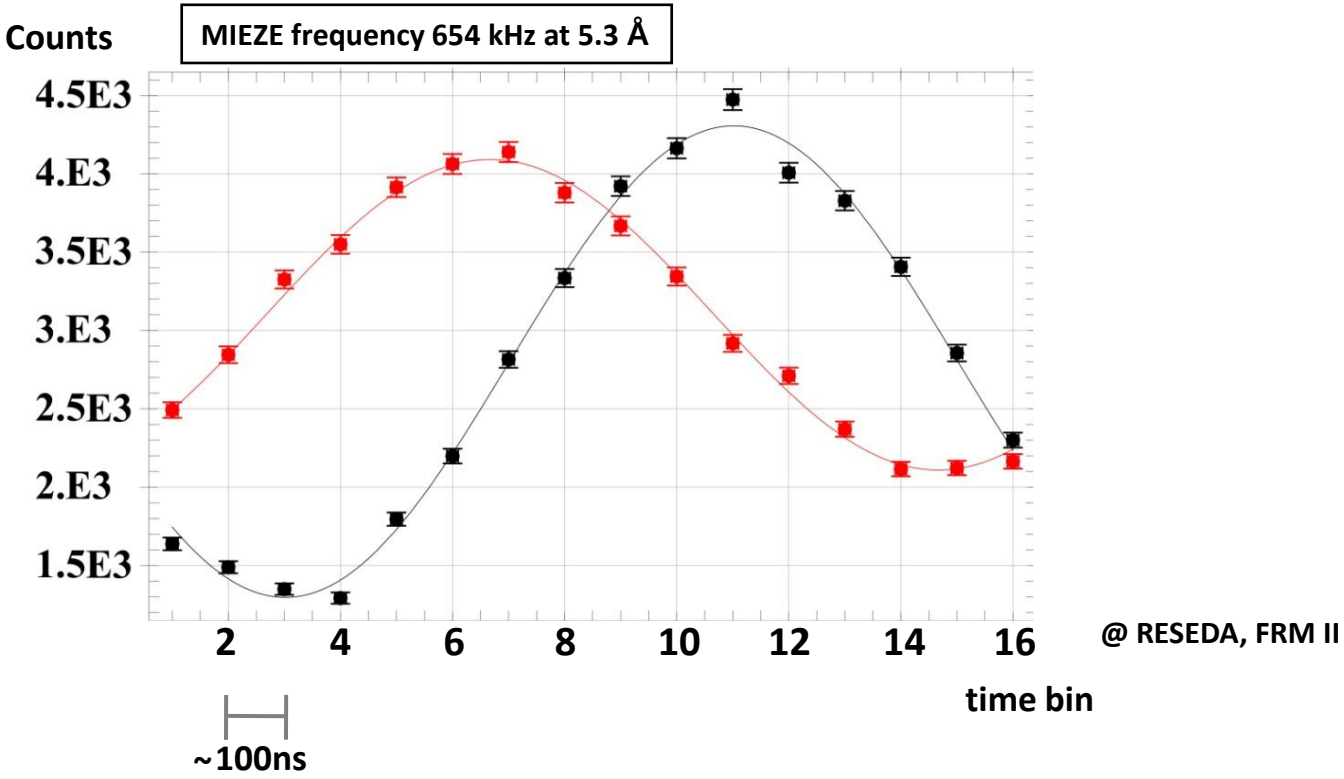
Time of Flight measurements
at ILL/ PF1A on a single readout strip of 1cm

count rate
2-3 MHz



A Spin Echo Signal

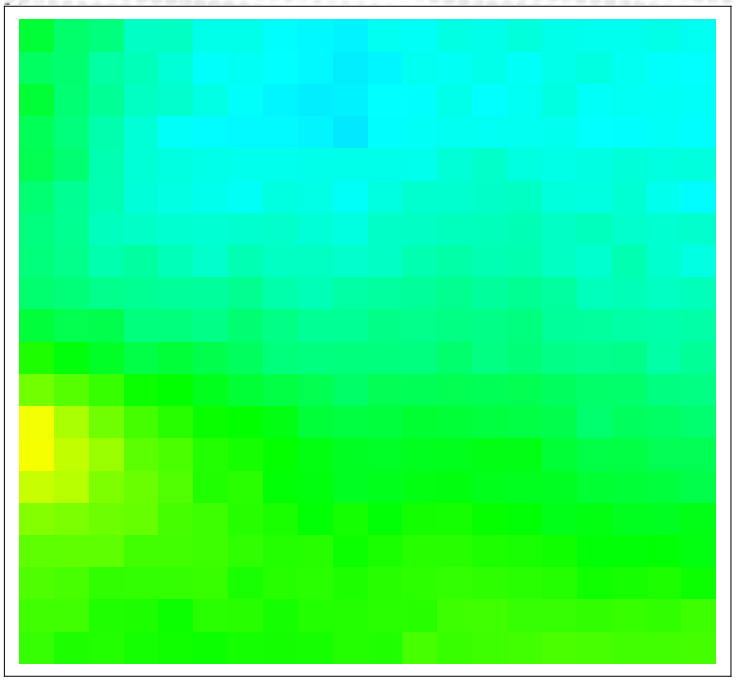
Polarization in two pixels:



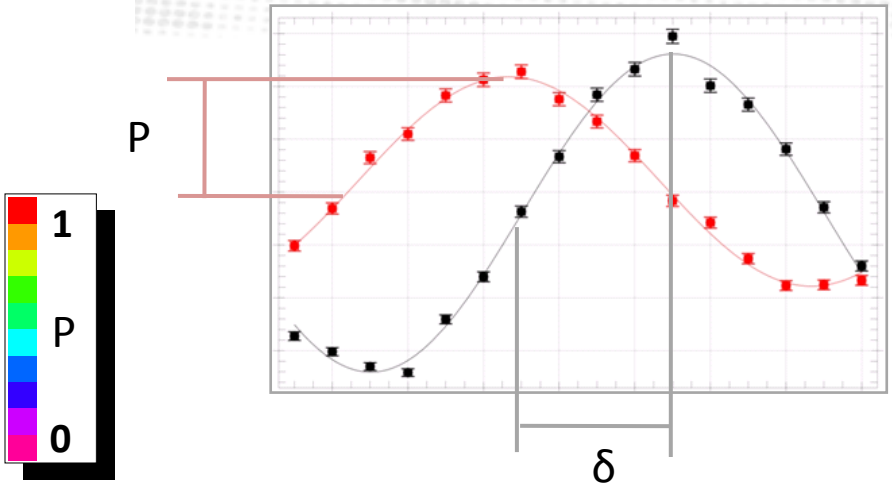
@ RESEDA, FRM II

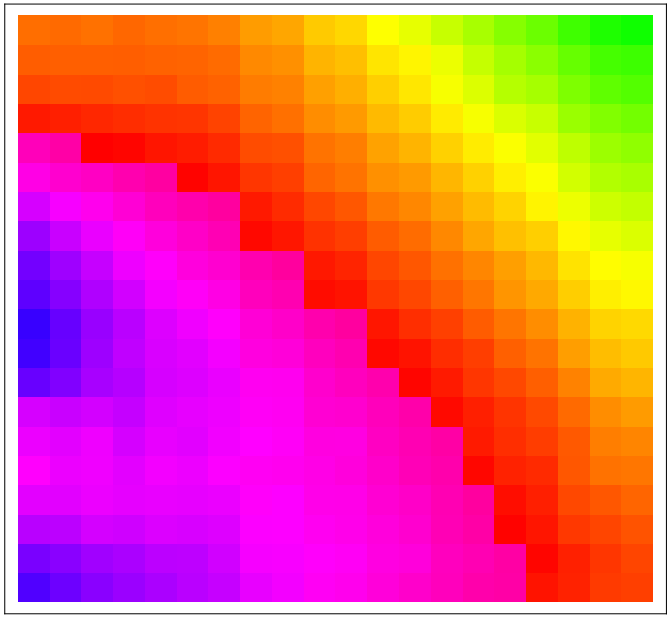
Signal can be obtained in every single pixel and layer

Spin Echo @ CASCADE



polarization map



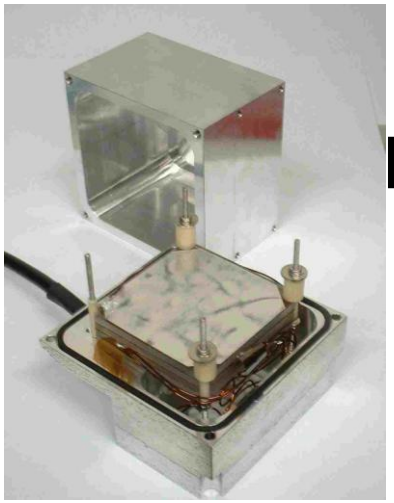


phase front map

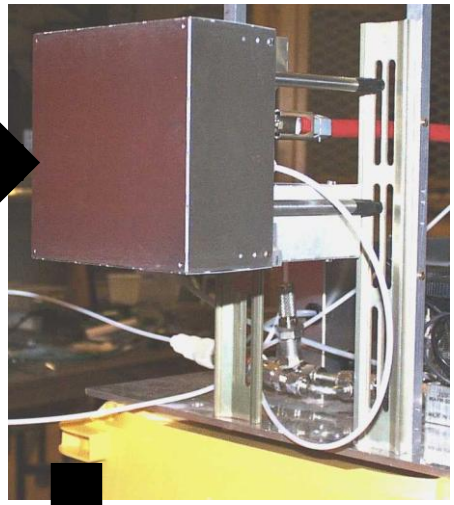
@ RESEDA, FRM II

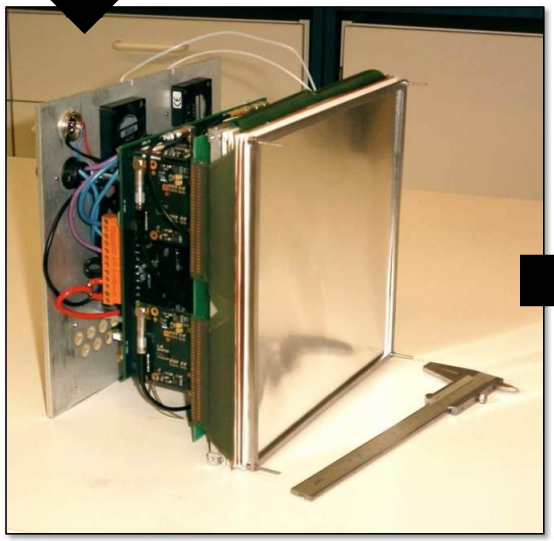
Prototypes

50 X 50



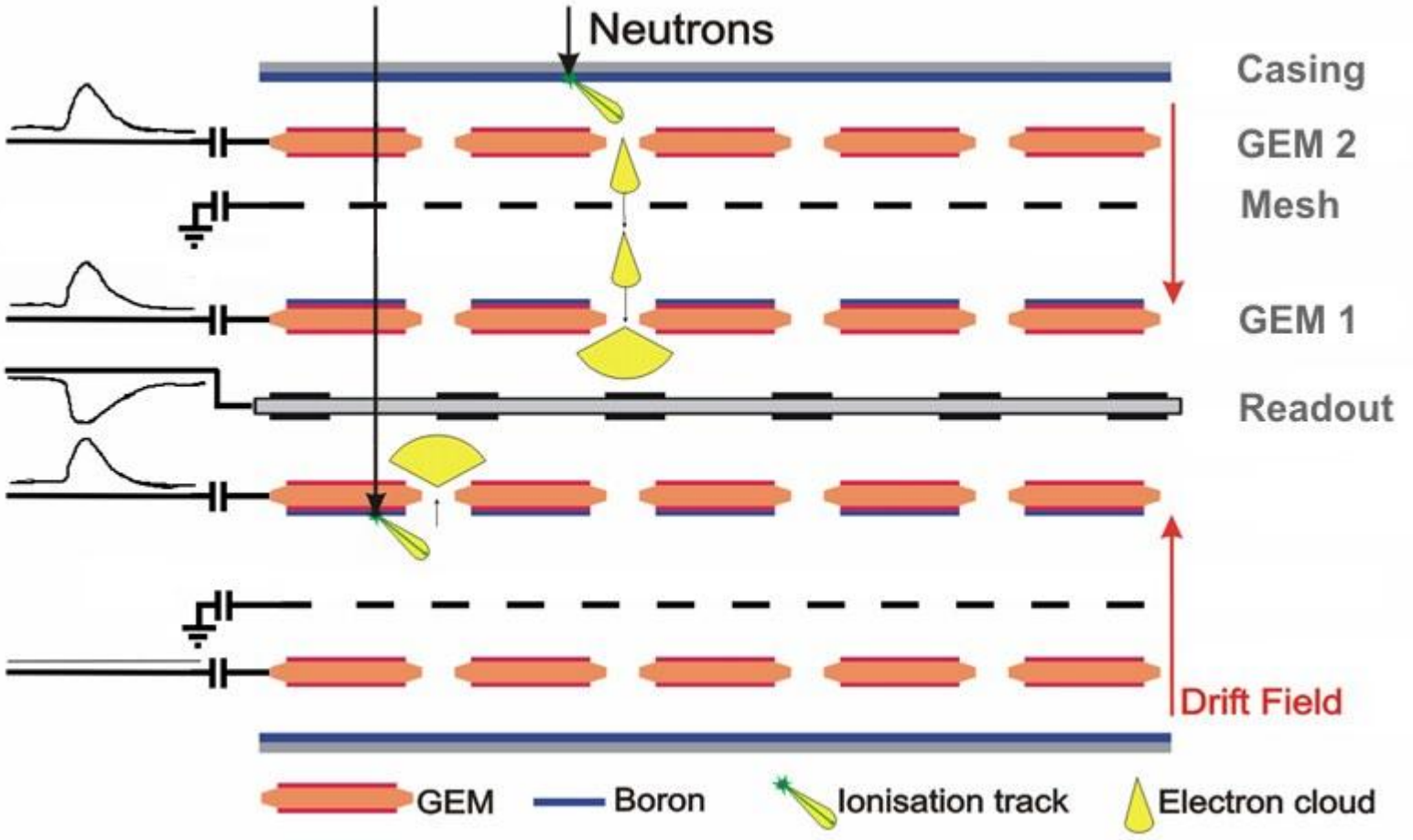
100 X 100





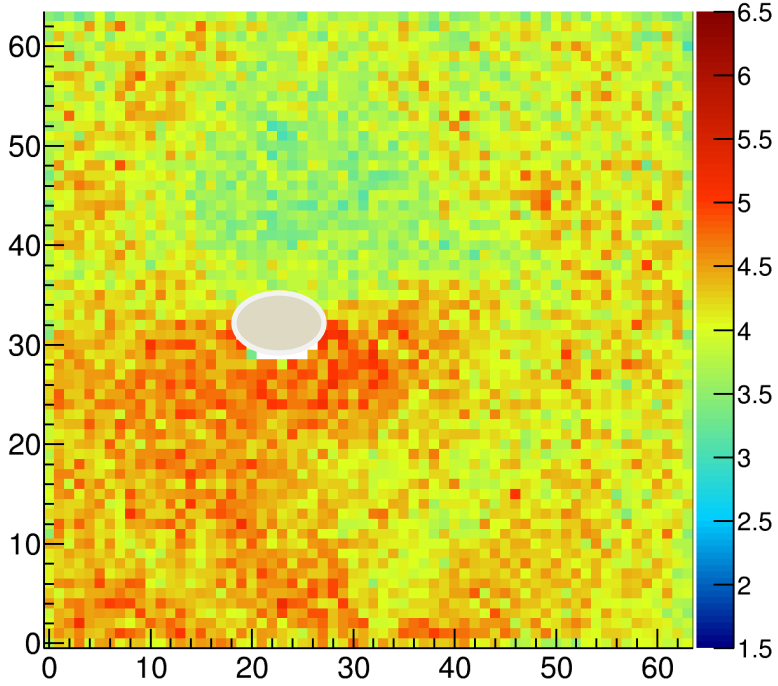
200 X 200

Active Detection Volume

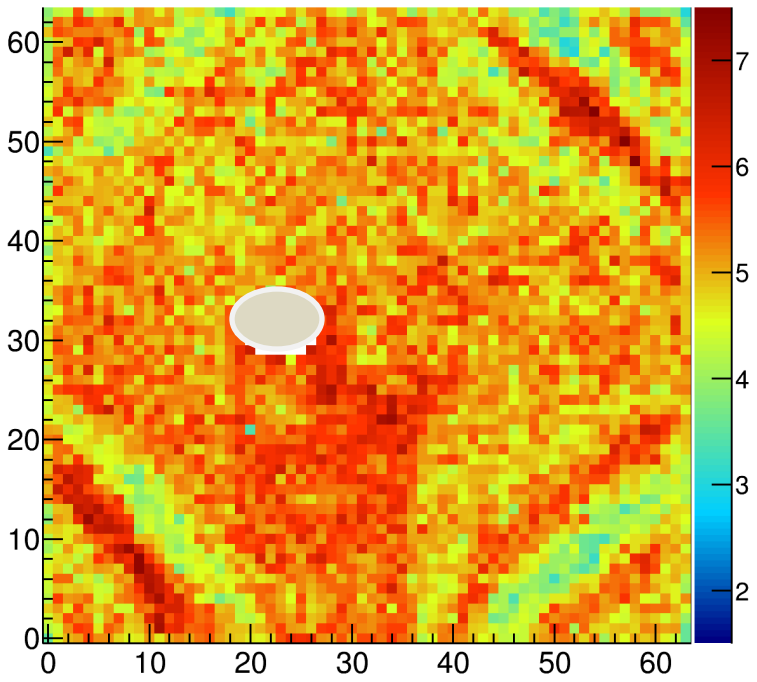


Mean local gas gain

Example: 2 of 6 layers

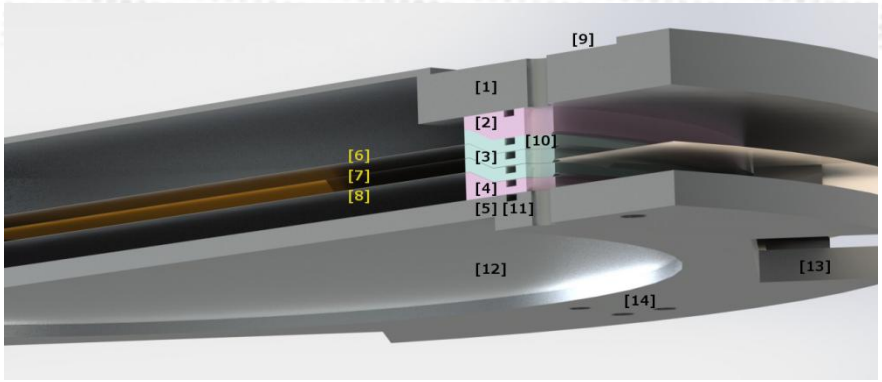


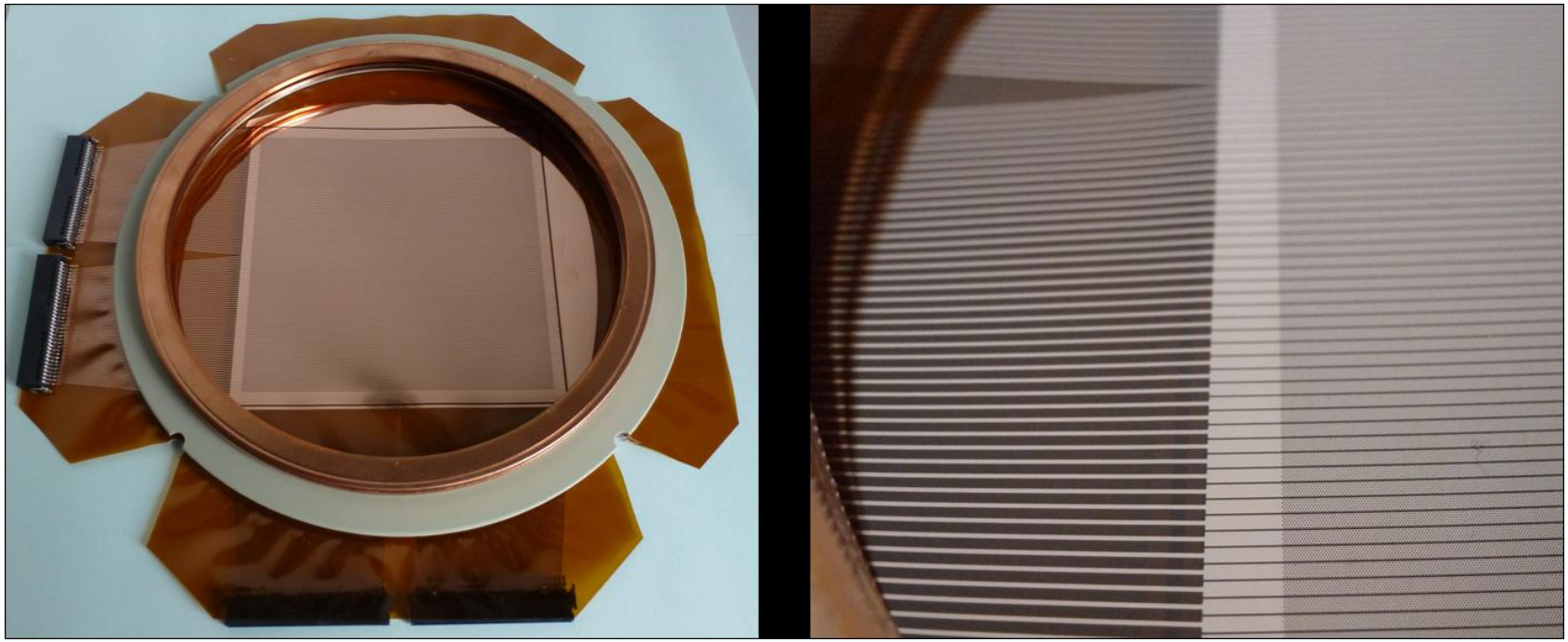
Drift cathode with bump



GEM strained

Outlook





Summary

Summary

GEMs plus standard gas detectors
are a promising alternative technology

Summary

GEMs plus standard gas detectors
are a promising alternative technology

a broad range of technologies
is available from particle physics

Summary

GEMs plus standard gas detectors
are a promising alternative technology

a broad range of technologies
is available from particle physics

CASCADE ____features

- conversion layer identification
  ⟶ high TOF resolution (Spin Echo)
- 2.4 mm spatial resolution
- 2 MHz rate capability
- 20% efficiency at thermal @ 6 layers
- 50% efficiency for 5 A @ 8 layers

Das CASCADE Projekt

eine alternative Perspektive für Festkörper-Neutronendetektoren

fin

SNI 2014

Markus Köhli

M. Klein, U. Schmidt
AG Dubbers

Physikalisches Institut
Ruprecht-Karls-Universität
Heidelberg

21.09.2014

Backup