DPG 2012

Das CASCADE-Projekt

–

Neutronendetektion mittels ^{10}Bor

22. März 2012

Markus Köhli

M. Klein, U. Schmidt
AG Dubbers

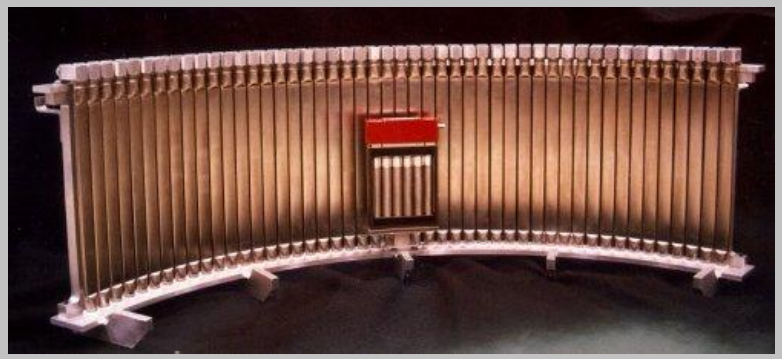
Ruprecht-Karls-Universität
Heidelberg

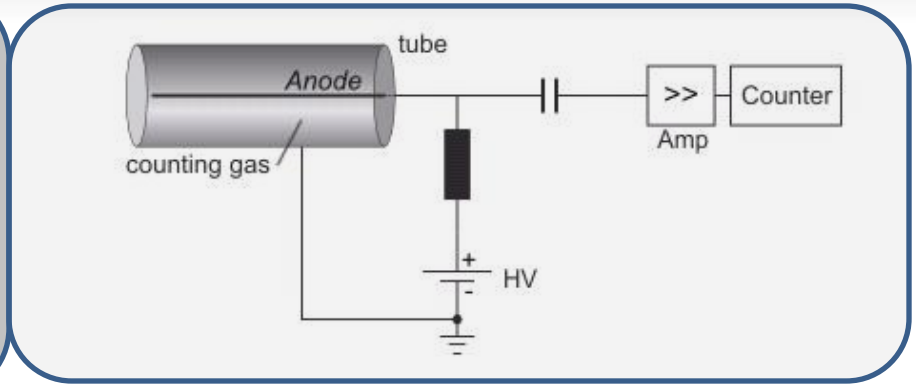
Bundesministerium
für Bildung
und Forschung

CASCADE

The Helium-3 crisis

[1]





[3]

[1] NIST http://www.ncnr.nist.gov/instruments/fans
[2] AAAS, Overview of Helium-3 Supply and Demand
[3] LP Uni Göttingen

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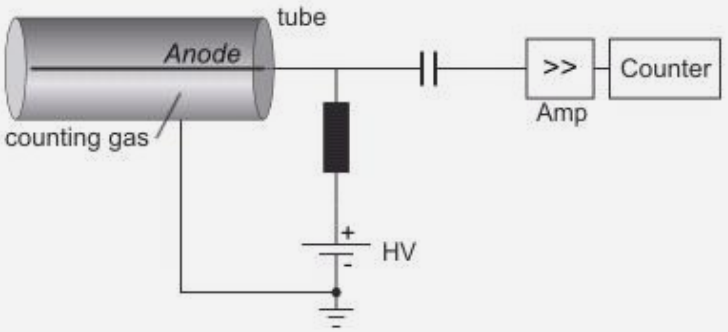

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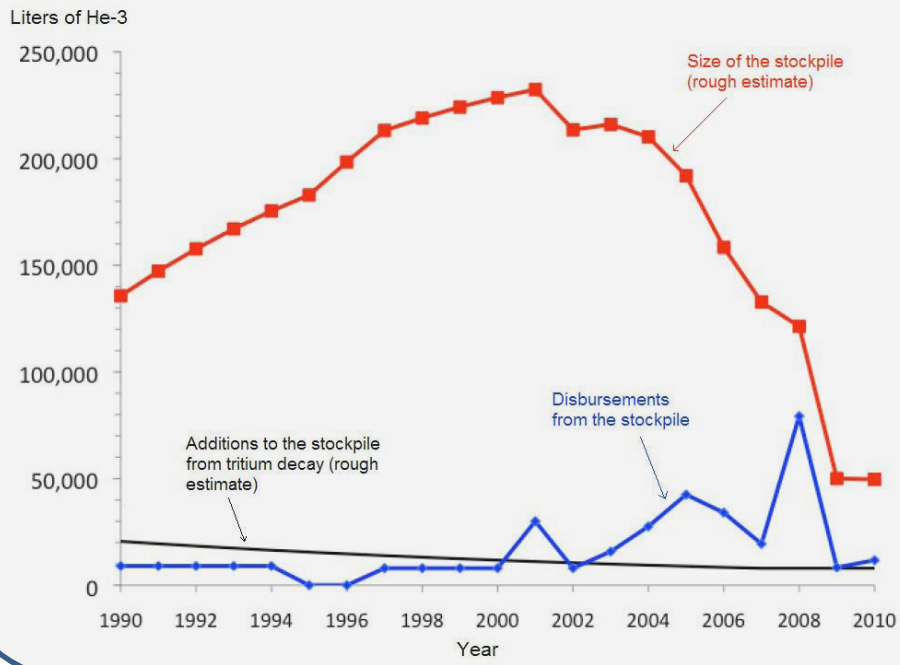
[2]



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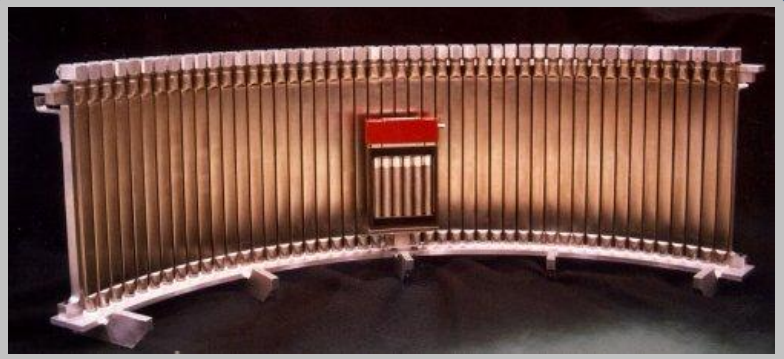

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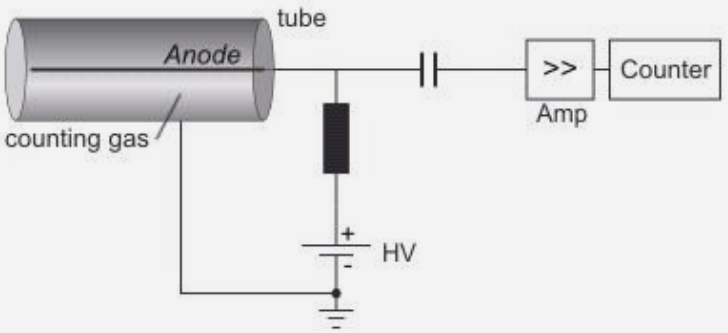

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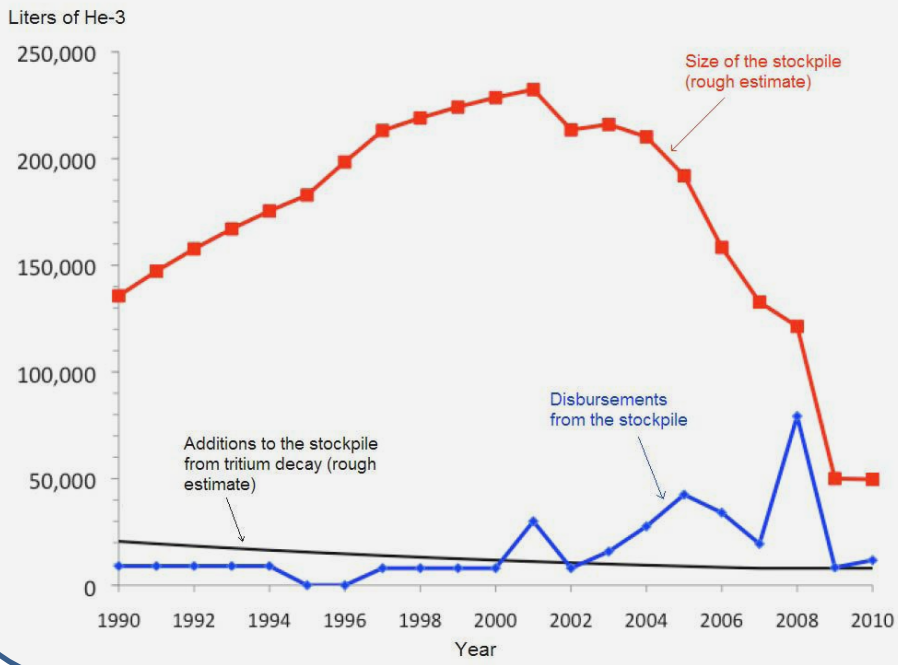

[2]

USA: est. 40k l for neutron detection

[1] NIST http://www.ncnr.nist.gov/instruments/fans
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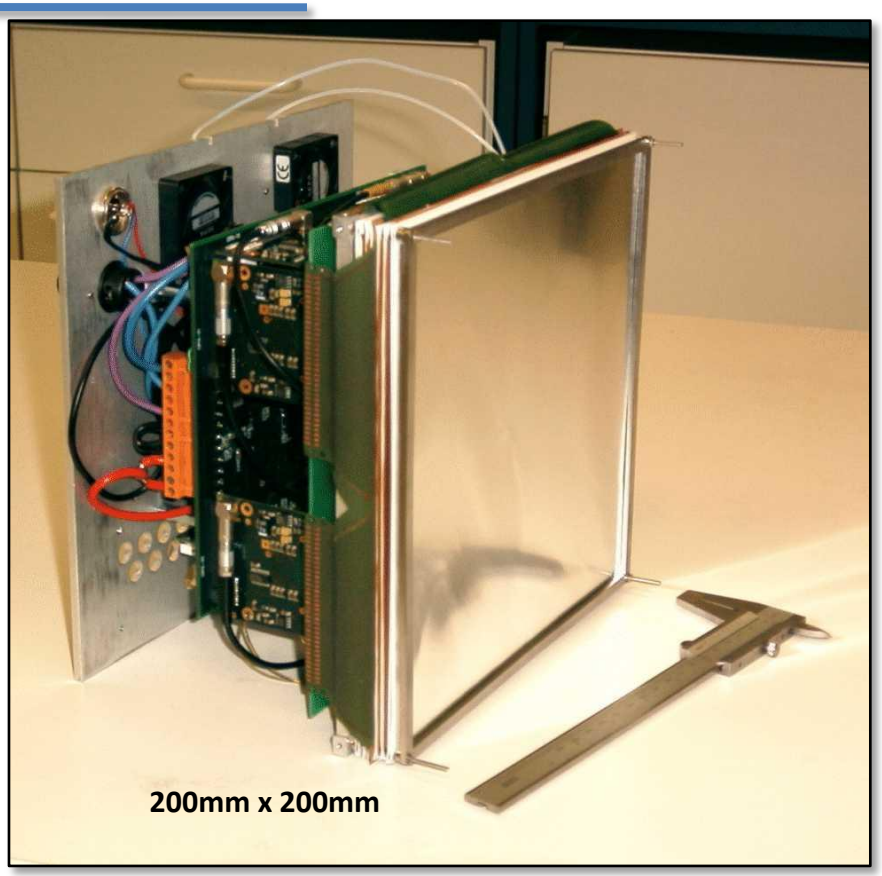
CASCADE – an overview

CASCADE detector without housing



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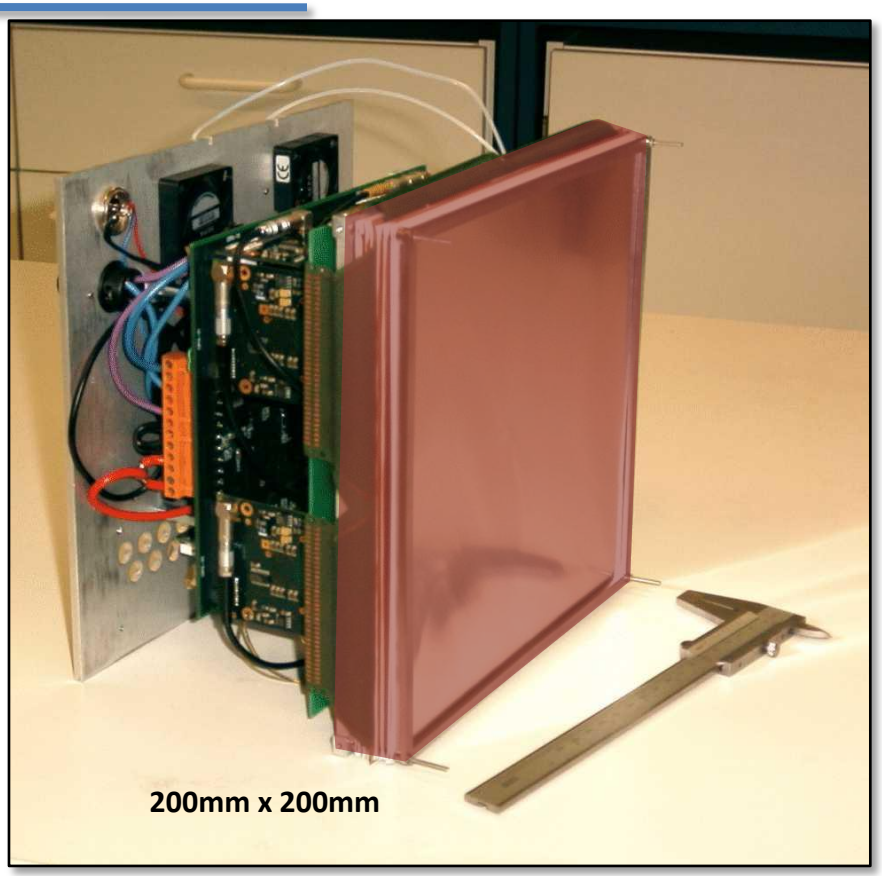


Active Detection Volume

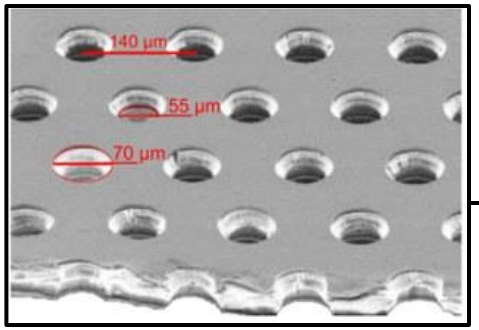
- Neutron conversion with Boron-10

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

- Charge amplification with GEMs in Standard Gas

How to: neutron detection

Cross section: active detection volume



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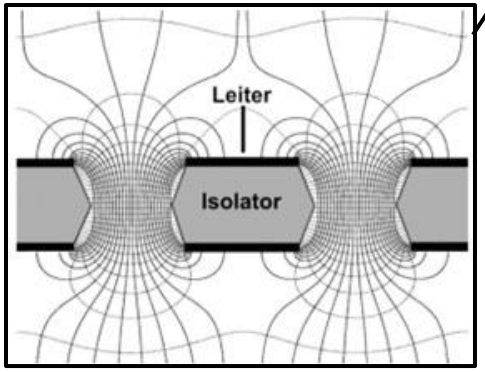

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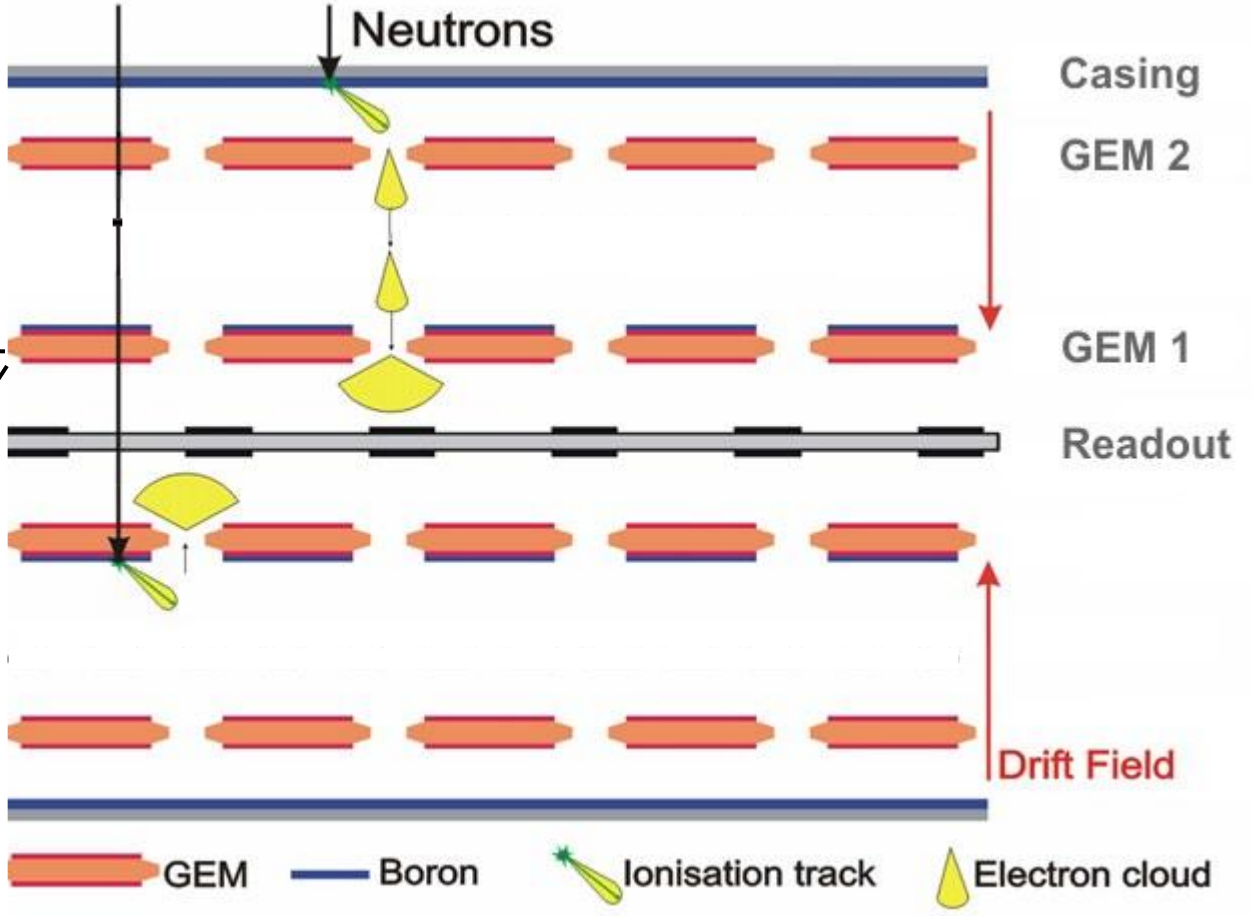

[1] Sauli, F. ; Sharma, A.: Micropattern Gaseous Detectors. In: Annual Review of Nuclear and Particle Science 49 (1999)

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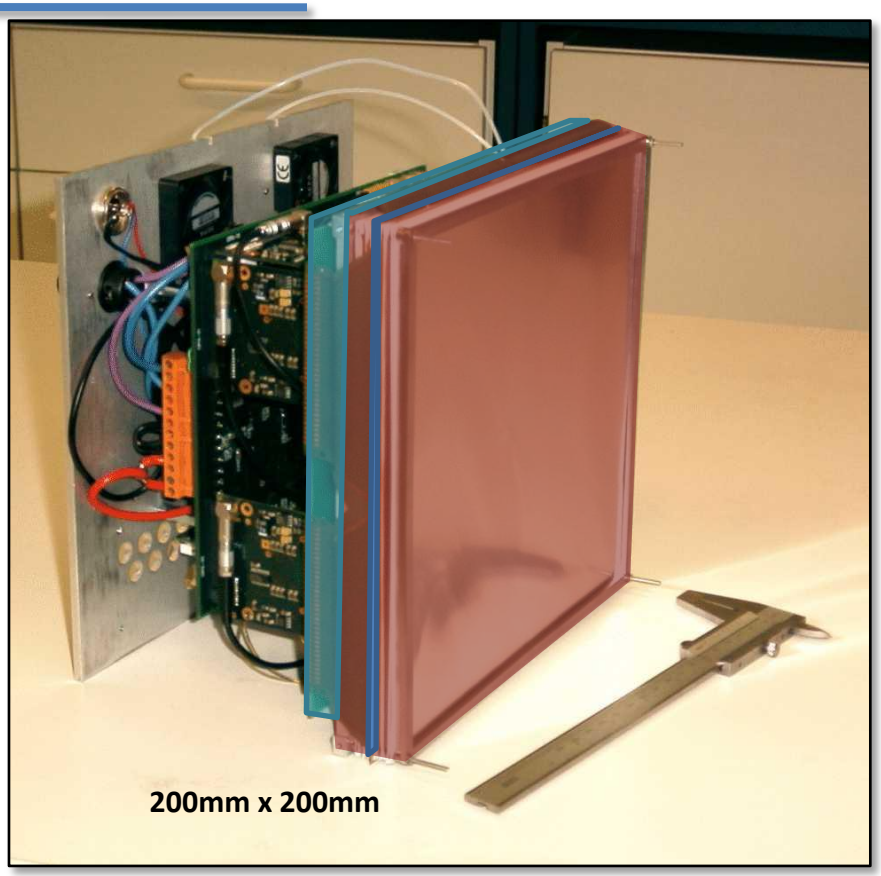

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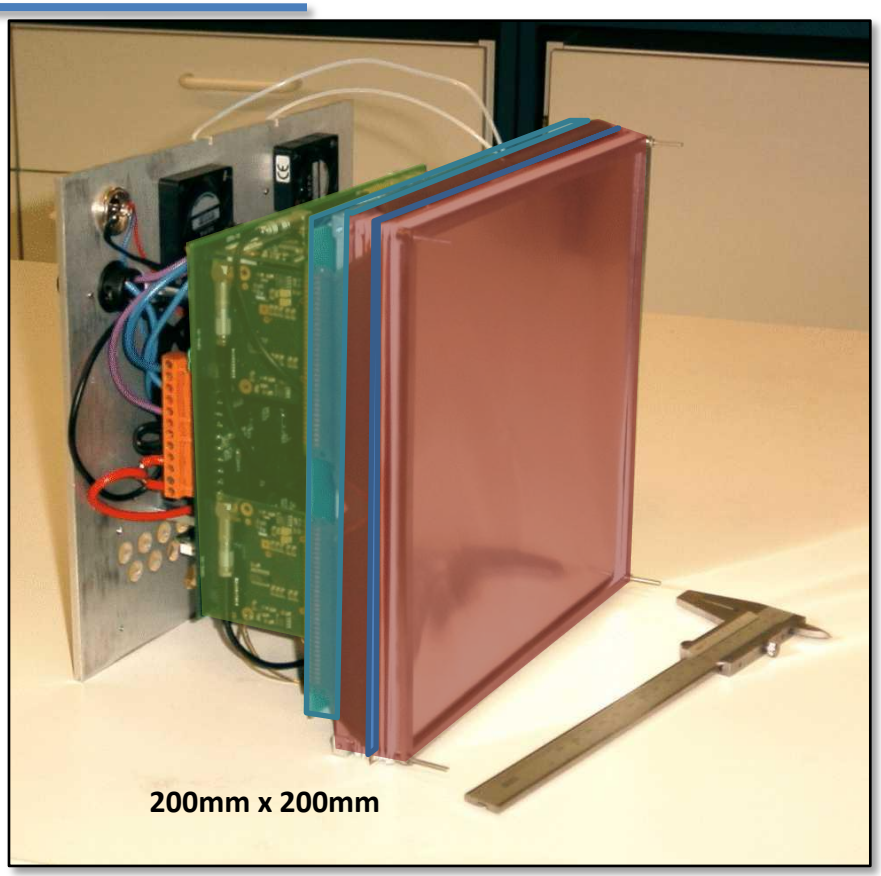
Readout

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

CASCADE – an overview

CASCADE detector without housing



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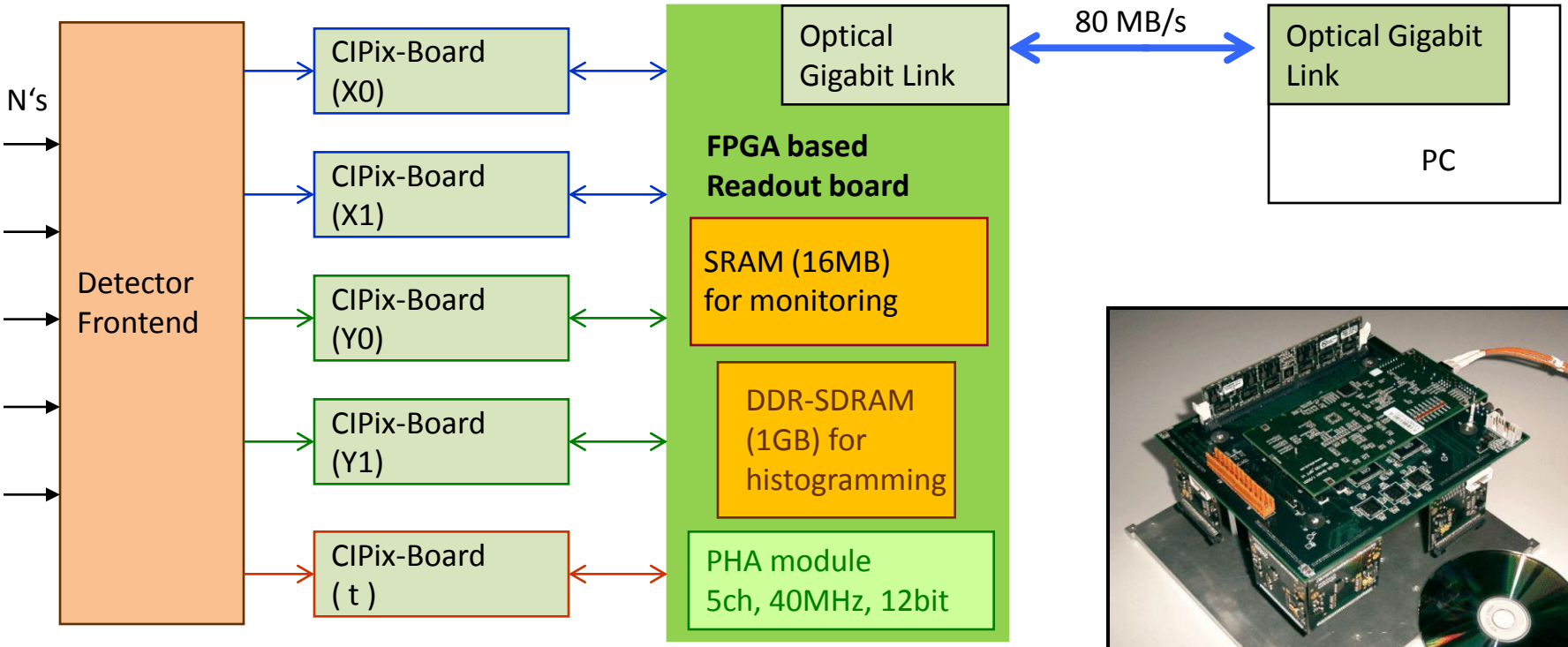
Electronics

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

System electronics



Specs:

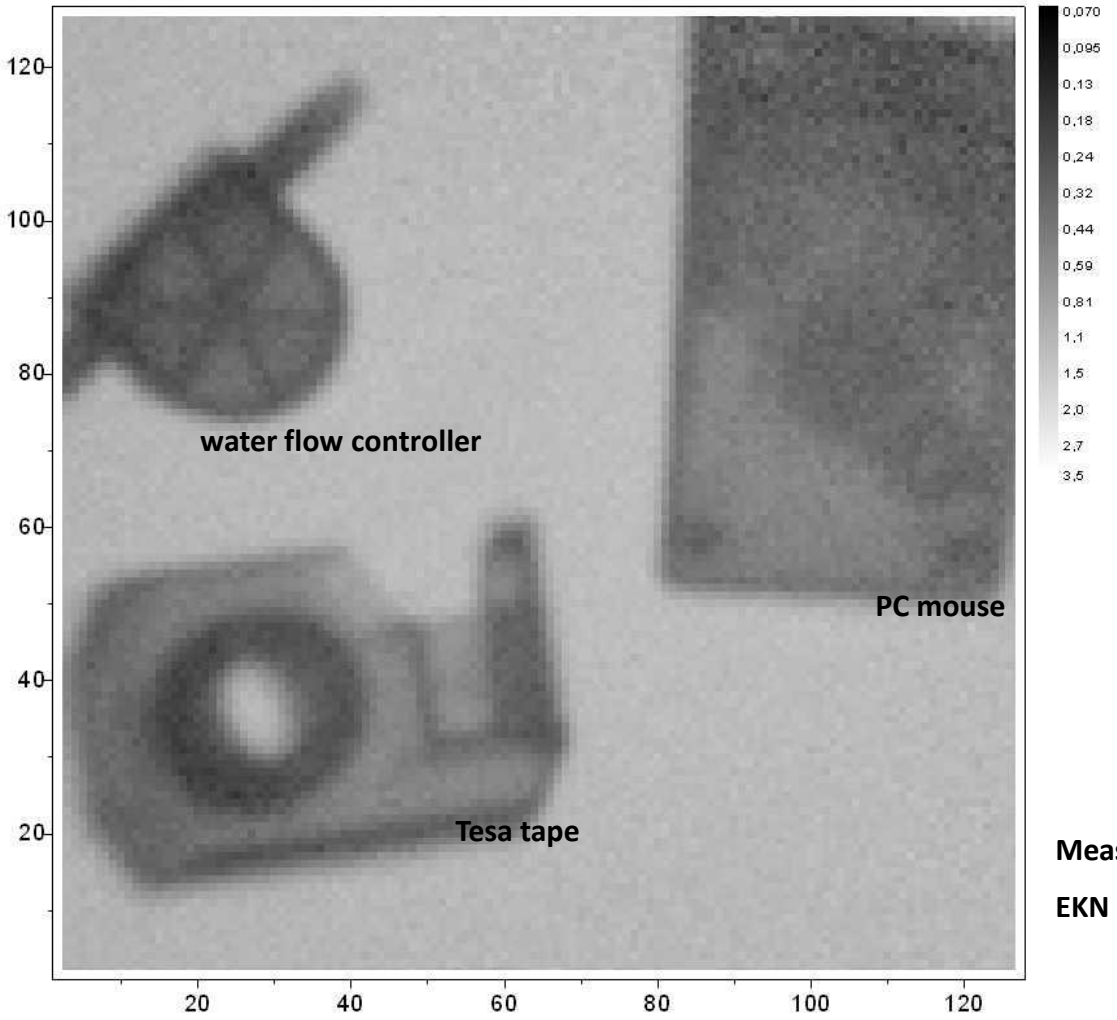
- **4 CIPix ASICs reading 128x128 channels**
- **1 CIPix ASIC for TOF-resolution down to 100ns**
- **FPGA based readout, control of CIPix, data-preprocessing and compression**
- **electrically decoupled from host computer**

Next: Replaced by nXYter

Imaging

1st: Radiography

Neutron Imaging with H containing samples, pixel size: 1.56 mm



Measured at

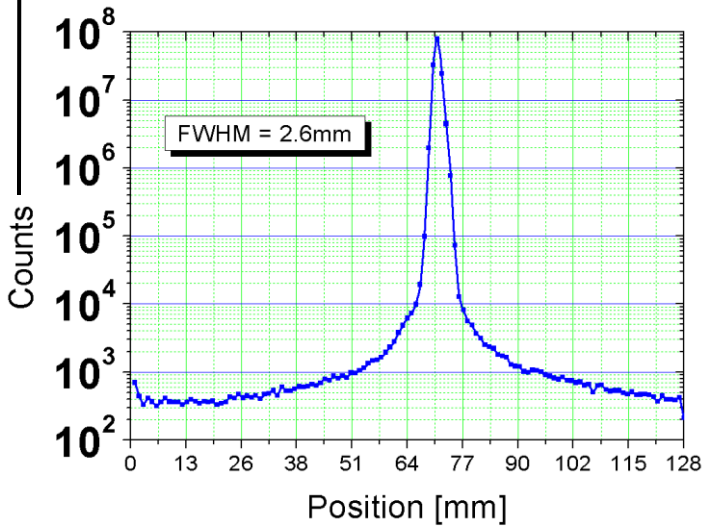
EKN at FZ Jülich

Dynamic range & rate

2nd: Rate capability

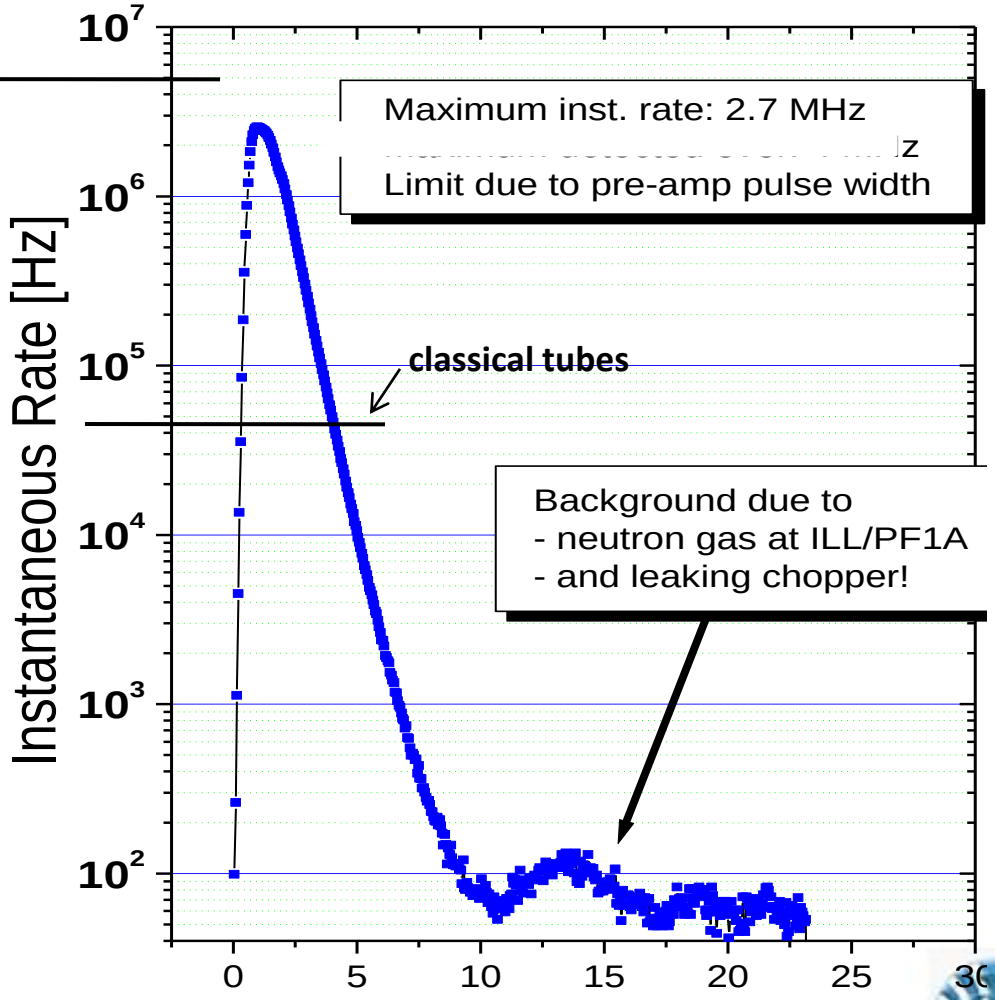
Count rate
> 1 MHz

Dynamic range
5 orders of magnitude



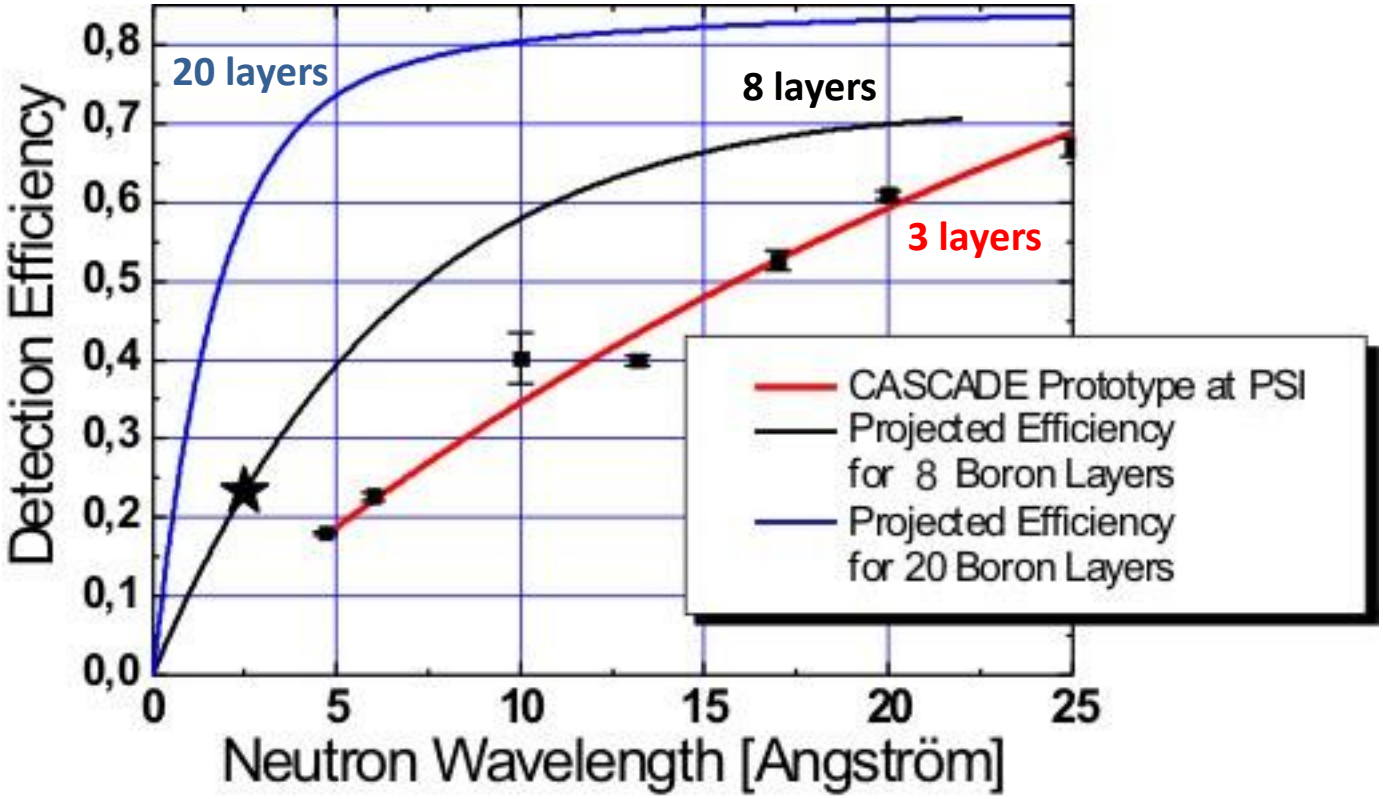
Point spread function of 0.57mm beam

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



Detection Efficiency

Efficiency depends on the number of Boron layers



Summary

- The CASCADE detector offers an alternative to classical ^{3}He based systems with
  - high spacial resolution (about 2.6 mm)
  - high count rate capability (about 2 MHz)

- Efficiency depends on number of layers:

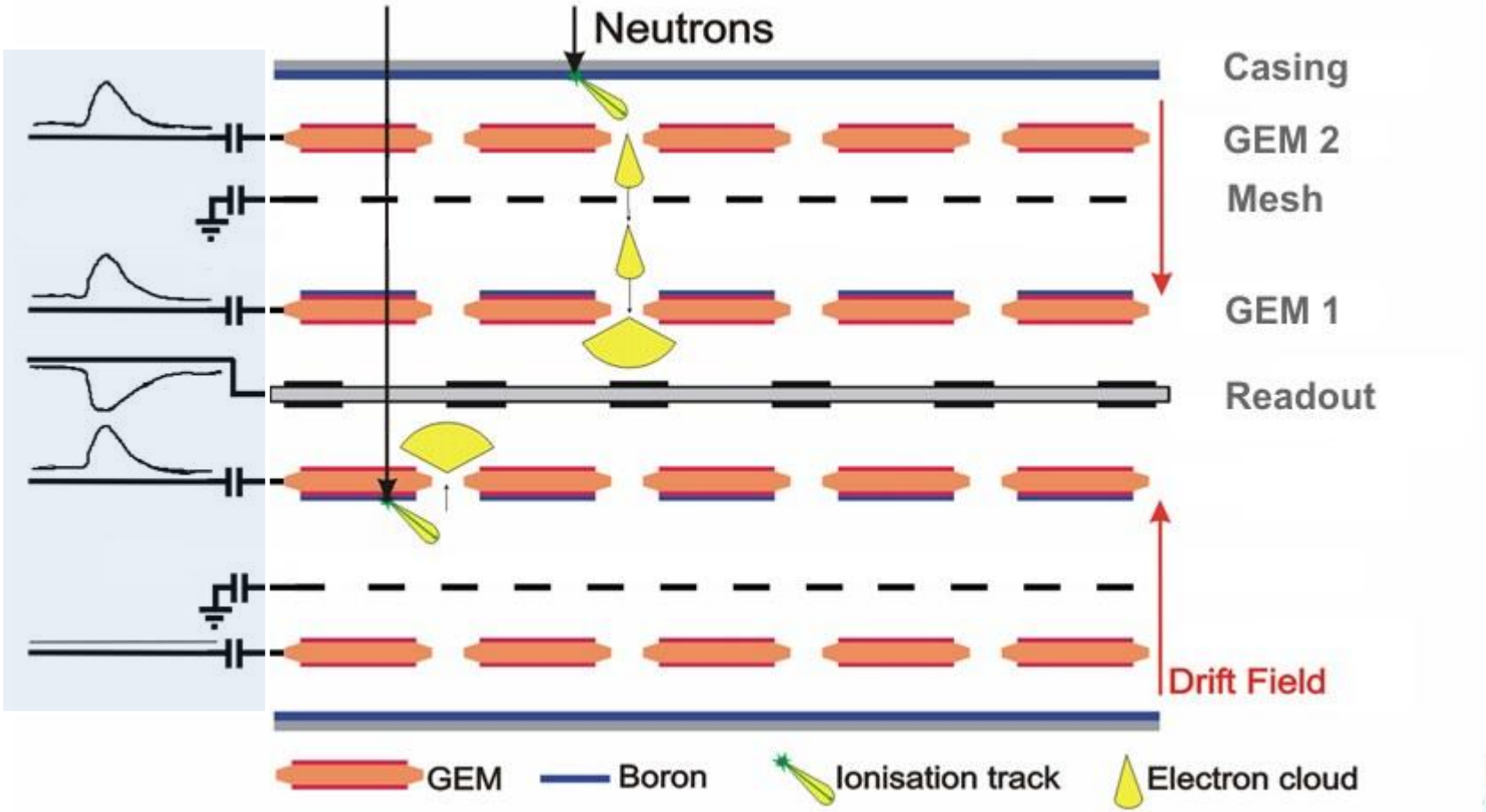
  2x3 layers in operation (18%-40% depending on wavelenght)

Neutron detection in stack

Read charge signals at GEMs

→ **Identify conversion layer**

→ **High resolution in time of flight (position of conversion layer!)**



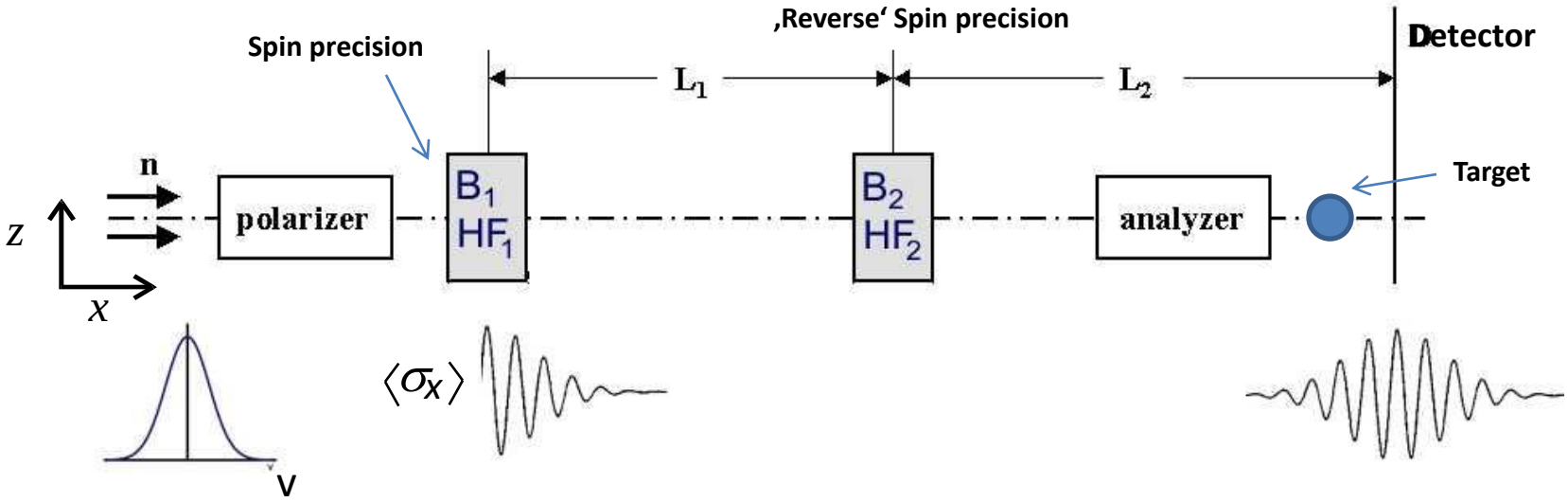
High Res. Neutron scattering

Application: High resolution neutron scattering:

Neutron Resonance Spin Echo Methods

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

e.g. Mach-Zehnder Interferometer in time



Schematic: MIEZE I setup

Time dependent scattering
at sample causes loss in polarization

Polarization is proportional to Fourier Transform of Energy Transfer Spectrum

Example:

Frequency 654kHz,

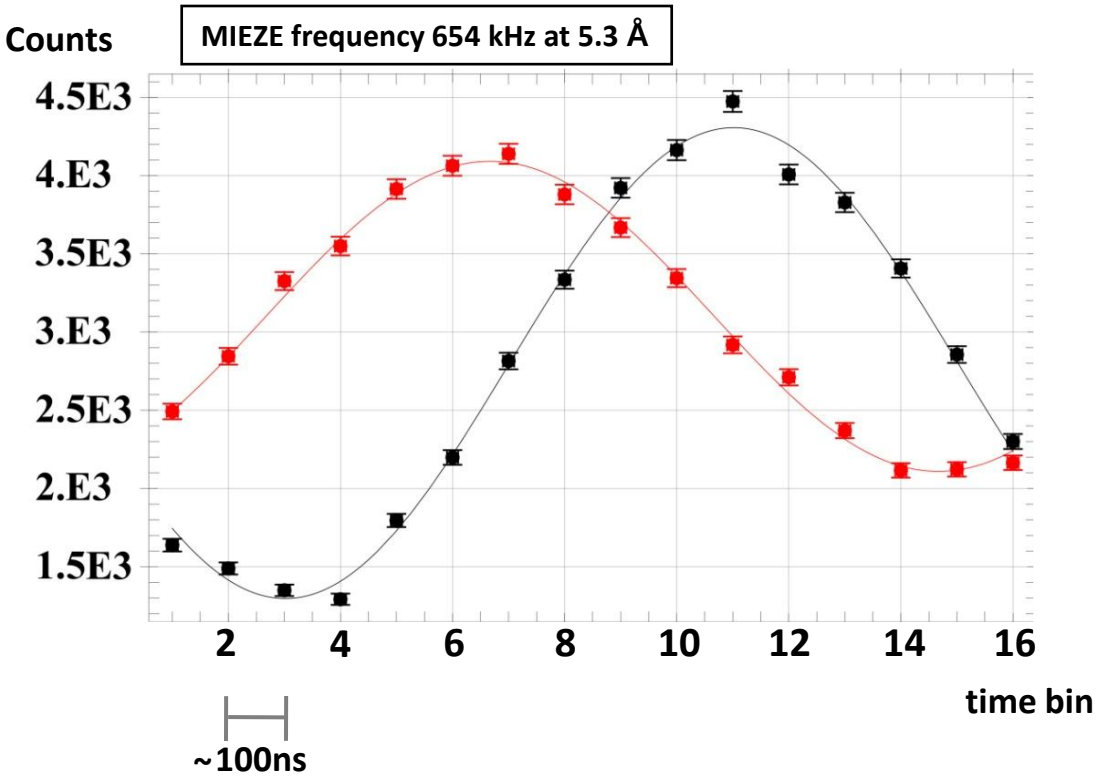
λ_n= 5Å ,v = 800m/s;

Spin-Wavelength of signal: 1.2 mm

Polarization

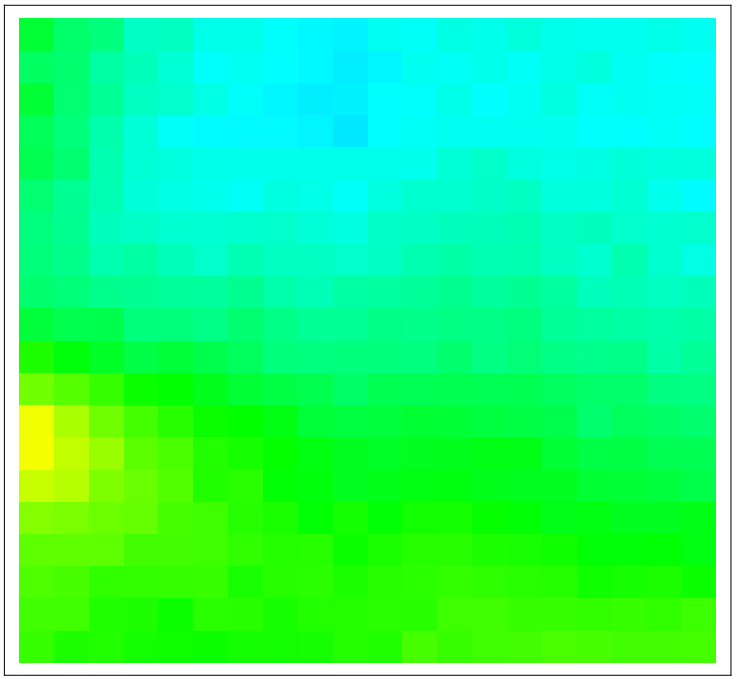
Signal can be obtained in every single pixel and layer

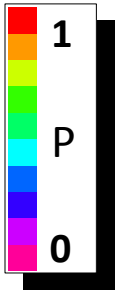
Polarization in two pixels:

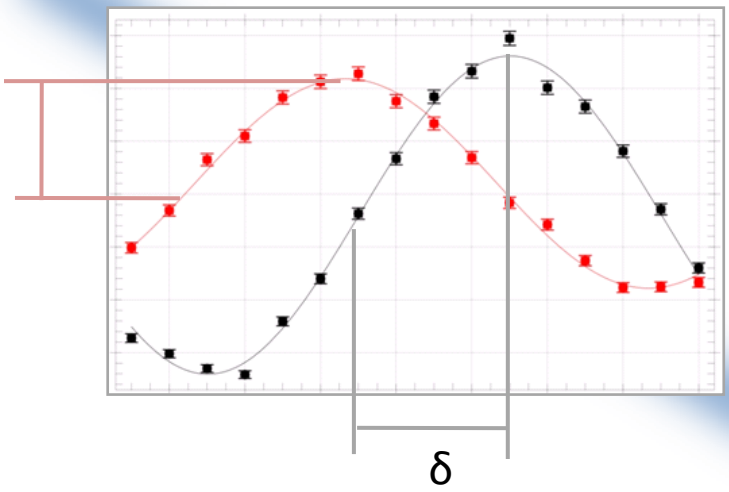


From: FRM II, Reseda

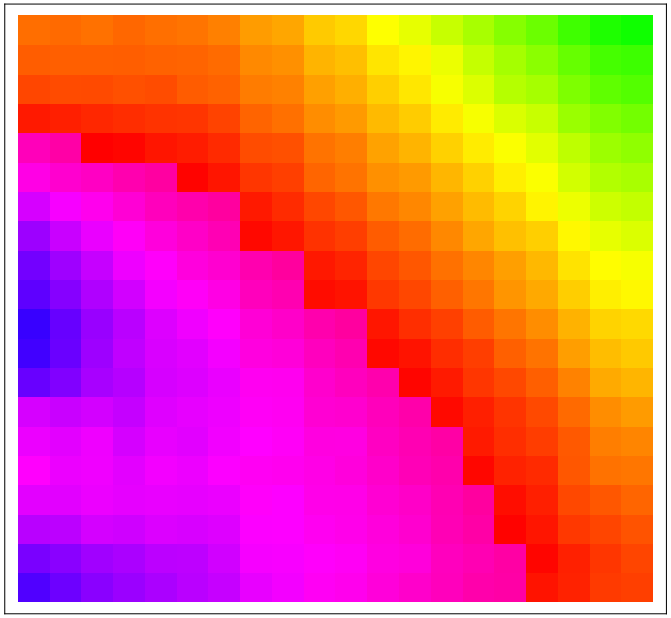
Examples (MIEZE II)







polarization map



phase front map

From: FRM II, Reseda

Summary

- The CASCADE detector offers an alternative to classical ^{3}He based systems with
  - high spacial resolution (about 2.6 mm)
  - high count rate capability (about 2 MHz)
  - high time of flight resolution (about 1 ns spin echo time)

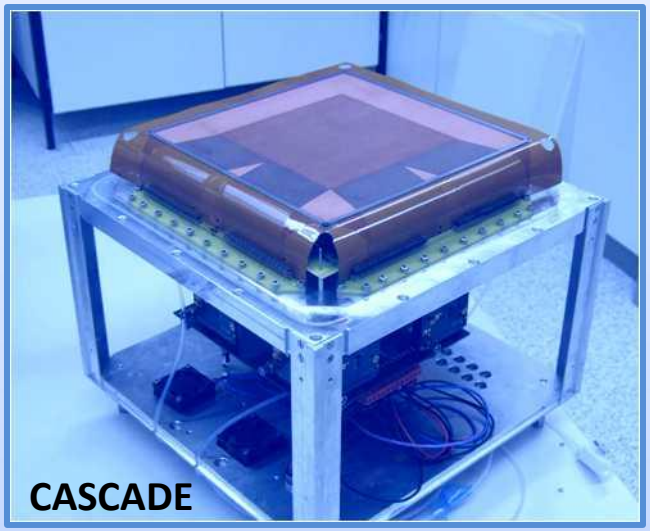
  ⟶ reach new domains in scattering
- Efficiency depends on number of layers:

  2x3 layers in operation (18%-40% depending on wavelenght)

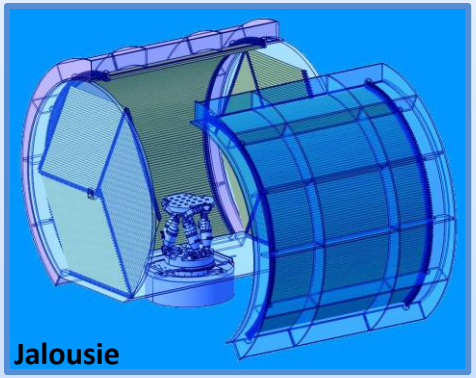
Ongoing Improvements:

- redesign for better ASIC (CiPix → nXYter)
- more compact structures & improved field configuration
- scale up to 10 layers and more

Applications



large area instrumentation



high count rates

special purpose