The CASCADE Detector

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a high resolution
^{3}He alternative

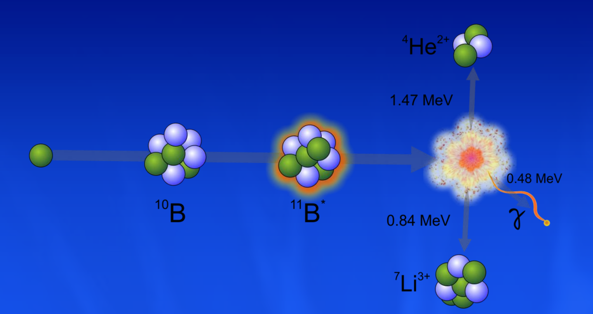
Innovative Neutron Detection

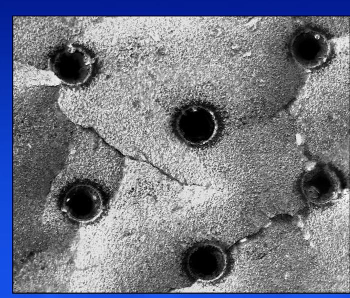
- high rate capability
- X-Y spatial resolution
- high time-of-flight resolution

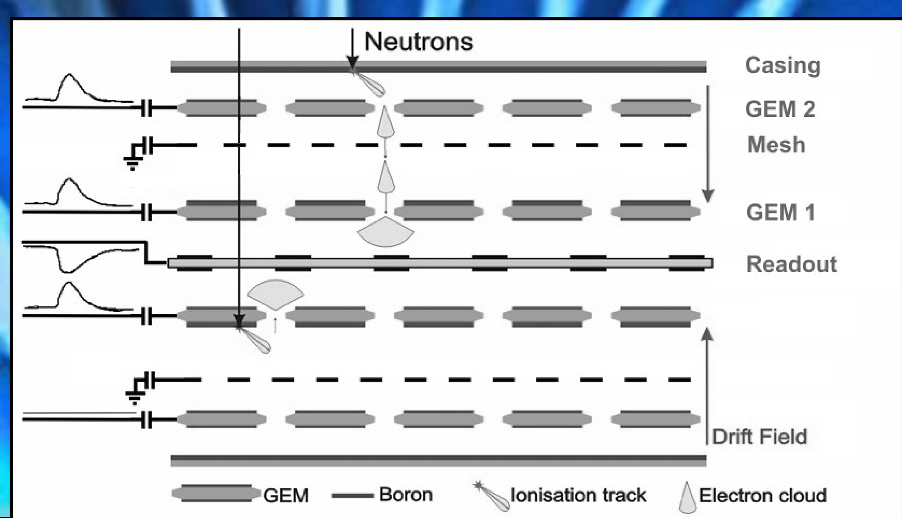
The CASCADE detector is a GEM-based hybrid solid converter gas detector for efficient and position sensitive detection of thermal, cold and ultracold neutrons on medium sized areas. The detector concept is based on using a solid neutron converter layer in a gas detector system, which guarantees sub microsecond detection time resolution and insensitivity to gamma-radiation. GEM foils are used as gas amplification stages inside the detector. Thus, the track can undistortedly be projected through the GEM onto a common readout structure. The detector works with ordinary counting gases at normal pressure. Equally large area detectors can be constructed. The use of GEM foils provides a high dynamic range from single neutron counting up to high count rates of 10^6 n/cm² s. It has successfully been used in a variety of Neutron (Resonance) Spin Echo experiments at RESEDA and MIRA at the FRM II.

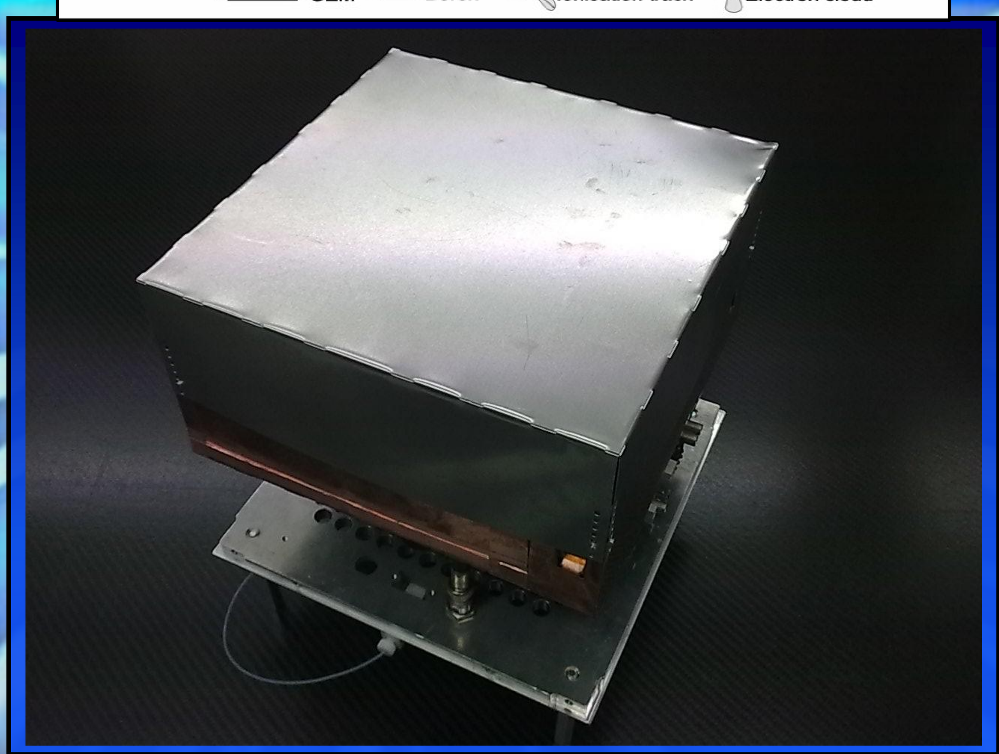
The Detection Concept

Neutron conversion by Boron-10 + Charge amplification with GEMs in Standard Gas

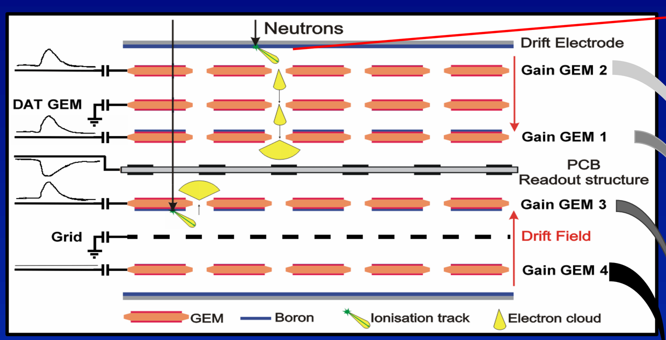






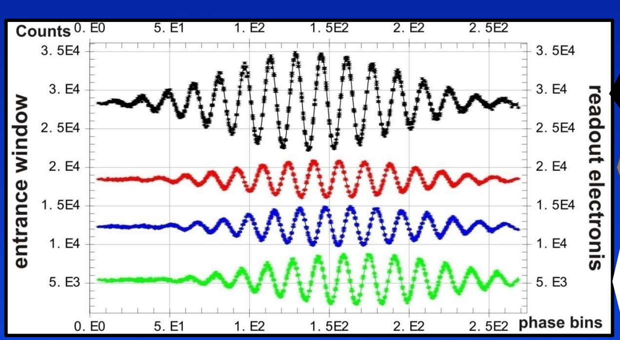


ToF-Measurement

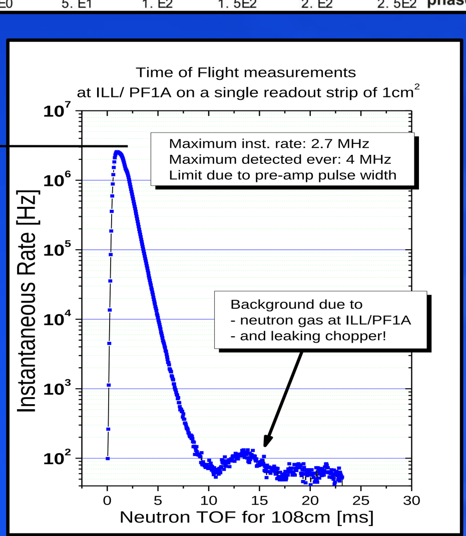


Due to thin gap and strong ionization (charged ion): no gamma sensitivity

Get the Spin Echo group from every single GEM in every single pixel



count rate > 1 MHz



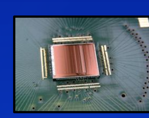
A device capable of measuring at the NRSE limits by: a high spatial resolution, a high time of flight resolution and a high count rate capability

Detection Efficiency:

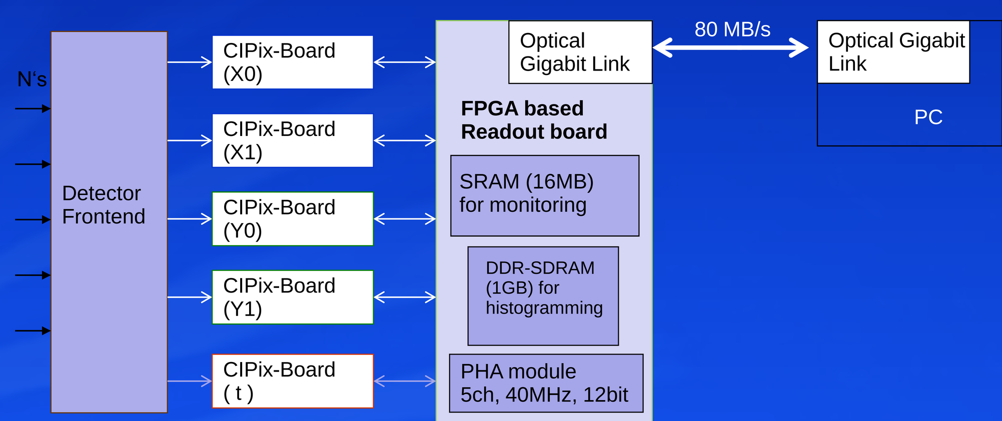
At 5.4 Å with six boron layers ~ 50%

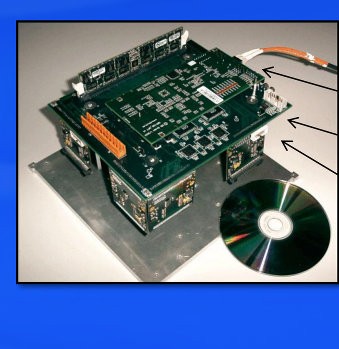
Readout

- **4 CIPix ASIC** (Application-Specific Integrated Circuit) reading **128x128** channels at **10 MHz**
- **FPGA based data acquisition:** control of CIPix, data-preprocessing and compression into on board RAM for up to 256 Mio.Counters (32 bit), giving:
  - 16 k pixels with
  - 16 k time bins **each**
- **Fast On-Line Monitoring:** 1 Mio. counters (32 bit) freely configurable: e.g.
  - 16 k pixels time integrated
  - 16 k pixels each realizing TOF in a window from e.g. 10ms to 11ms
- **Programmable Pulse Height Analysis (PHA) on selected channels**
- **Fiber optical link** (1GBit/sec) decouples the system galvanically from host computer



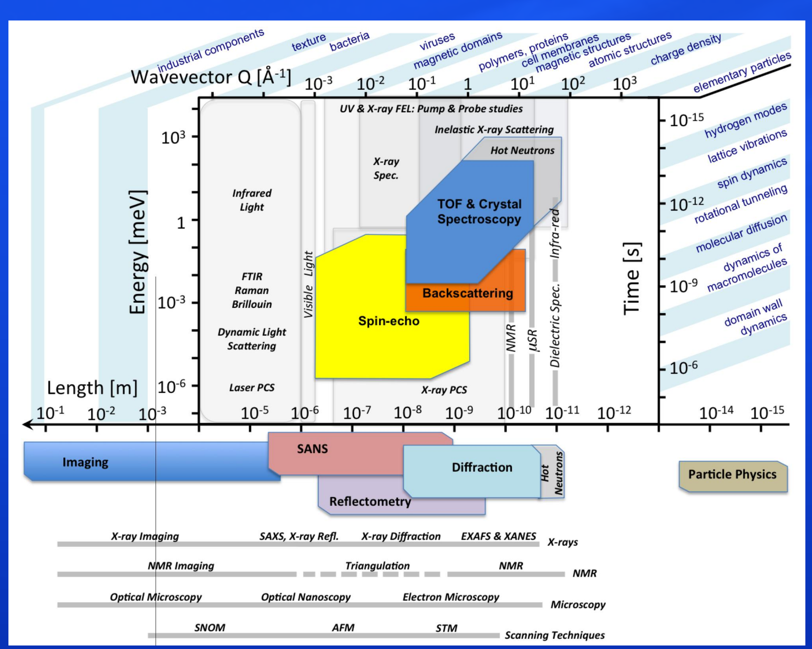
Next Generation:
Replace CIPix by VMM3





Backside PCB of the detector with
- Optical Interface (top)
- FPGA board + RAM (middle)
- CIPix ASICs (bottom)

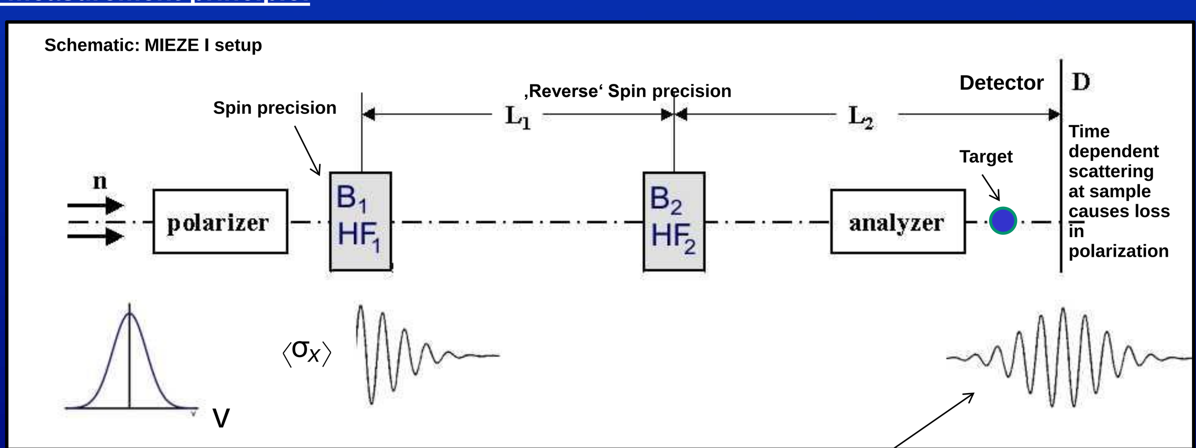
Neutron (Resonance) Spin Echo



[2]

In order to cover high q ranges and large interaction times a fast detector is needed for the MIEZE technique

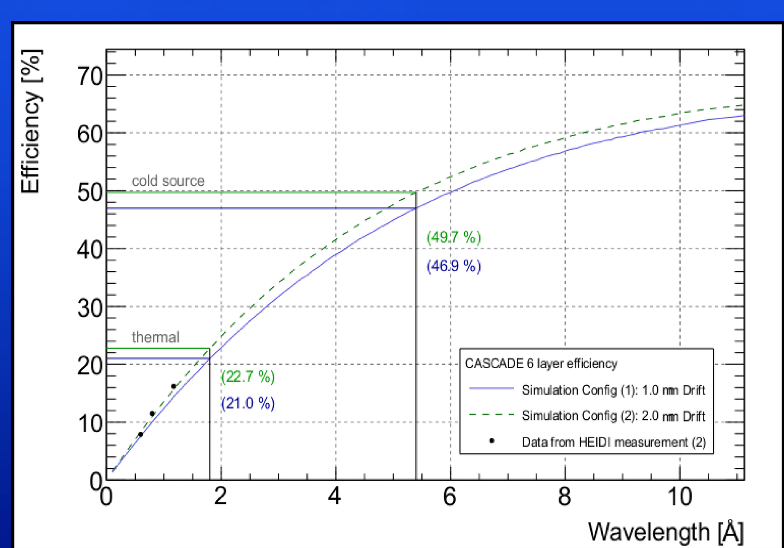
The measurement principle:



Example: Frequency 654kHz, λ_0=5Å ,v = 800m/s; Spin-Wavelength of signal: 1.2 mm

Polarization is proportional to Fourier transformation of energy transfer spectrum

Efficiency

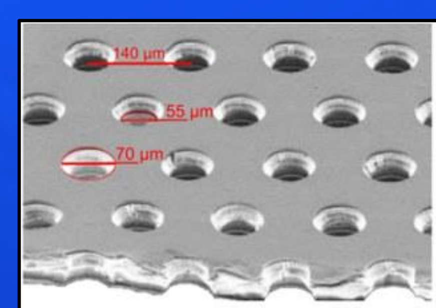


⟶ 21 % for thermal neutrons 47% for cold source at 6 layers

Gas Electron Multiplier

Principle:

Charge amplification by strong electric fields in holes



[1]

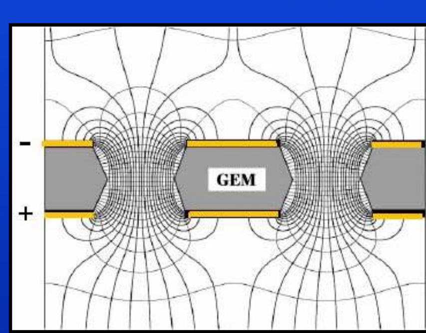
microscopic image of a GEM

Design:

- 50 µm thick foil made of Kapton (insulator) coated with copper
- conical etched holes with 55 µm diameter

Features:

- gas amplification at (60-80) kV/cm
- gas gain O(100)
- positive ion backdrift to drift volume minimal



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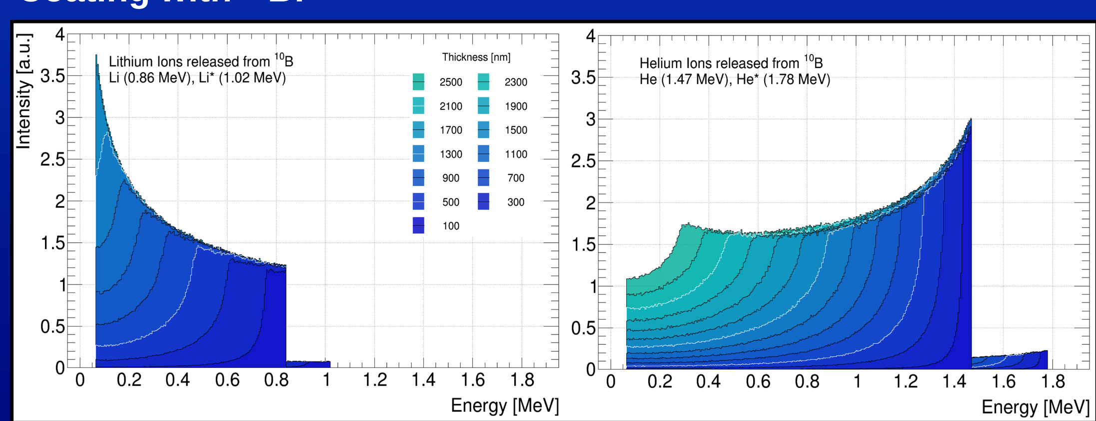
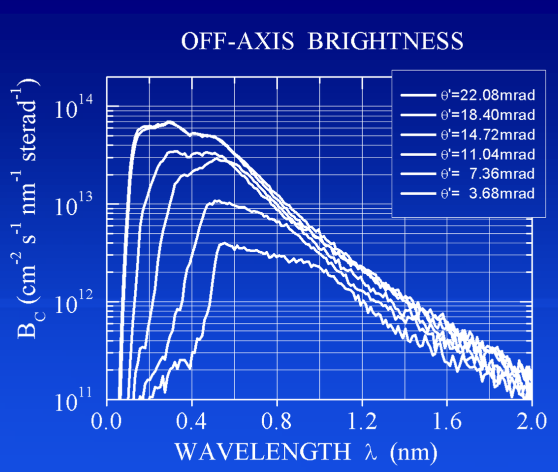
field lines in the holes of a GEM

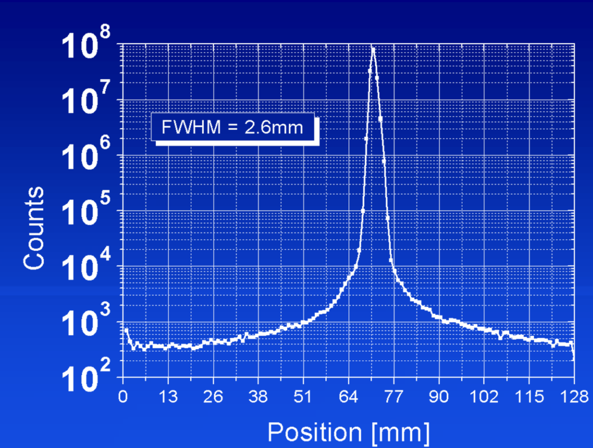
Coating with ^{10}B:



Spectra of conversion products, Lithium and Helium, for different coating thicknesses

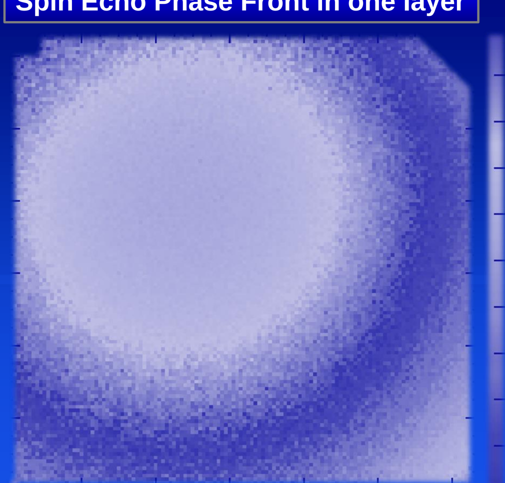


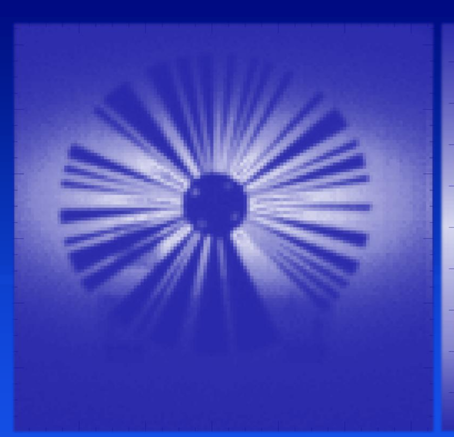
Time-of-Flight spectra



point spread function of 0.57 mm beam

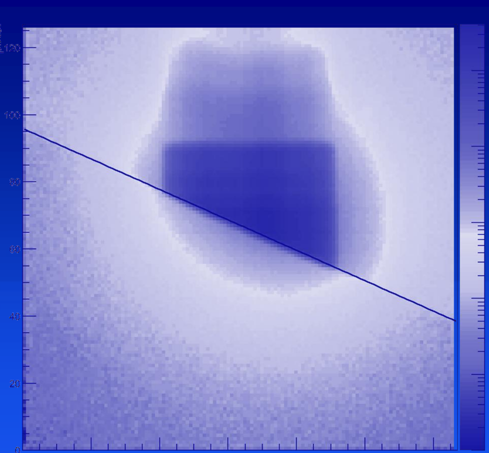
Spin Echo Phase Front in one layer





radiography of a pseudo random chopper

radiography of a cordless screwdriver



cadmium aperture in front of a thermal beam

Data Taking Showcase

[1] Sauli, F. ; Sharma, A.: Micropattern Gaseous Detectors. In: Annual Review of Nuclear and Particle Science 49 (1999)
[2] Peggs, S. et al.: European Spallation Source Technical Design Report. Lund: ESS (2013)

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