The CASCADE Detector

Ulrich Schmidt, Martin Klein and Markus Köhli

Physikalisches Institut
Universität Heidelberg

a high resolution ^{3}He alternative

Innovative Neutron Detection

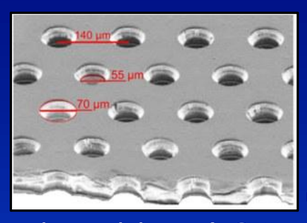
- high rate capability
- X-Y spatial resolution
- high time-of-flight resolution

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 large areas. The detector concept is based on using a solid neutron converter layer in a common gas detector system, which guarantees sub microsecond absolute time resolution and insensitivity to gamma-rays. One GEM-foil is used as gas amplification structure inside the detector. Thus, the position information can undistortedly be imaged through the GEM onto a readout structure. The detector works with ordinary counting gases under normal pressure. Equally large area detectors can be constructed. Cleaning by constant throughput of fresh counting gas avoids ageing effects, which guarantees long term stability and long lifetime of the detector. The use of GEM-foils provides a high dynamic range from single neutron counting up to high count rates of 10^7 n/cm^2 s.

Gas Electron Multiplier

Principle:

Charge amplification by strong electric fields in holes



[1]

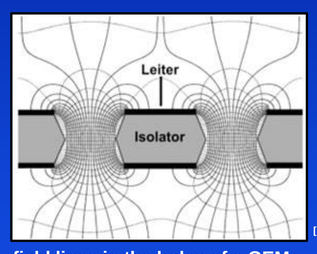
microscopic image of a GEM

Design:

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

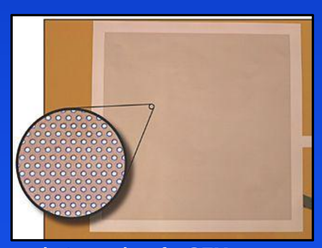
Features:

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



[1]

field lines in the holes of a GEM



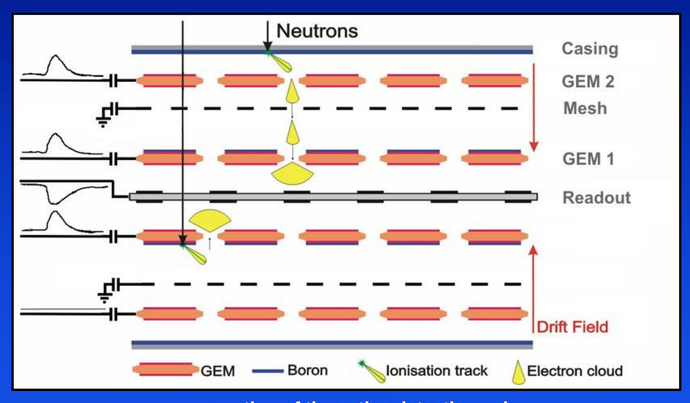
photography of a GEM in (10x10) cm^2

The Detection Concept

- Neutron conversion with Boron-10

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

+ Charge amplification with GEMs in Standard Gas

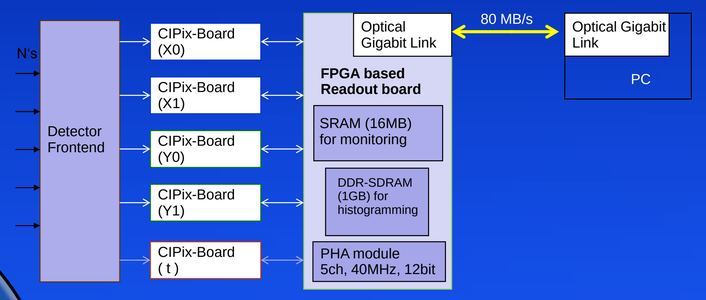


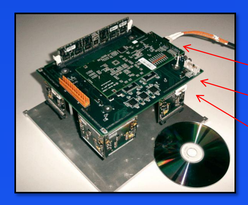
cross section of the active detection volume

Readout

- **4 CIPix ASIC** (Application-Specific Integrated Circuit) reading **128x128** channels in **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 nXYTer

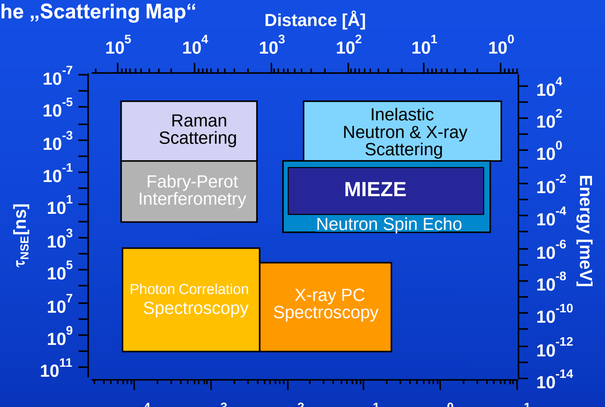




Back PCB of the detector with
- Optical Interface (top)
- FPGA board + RAM (middle)
- CIPix ASICs (bottom)

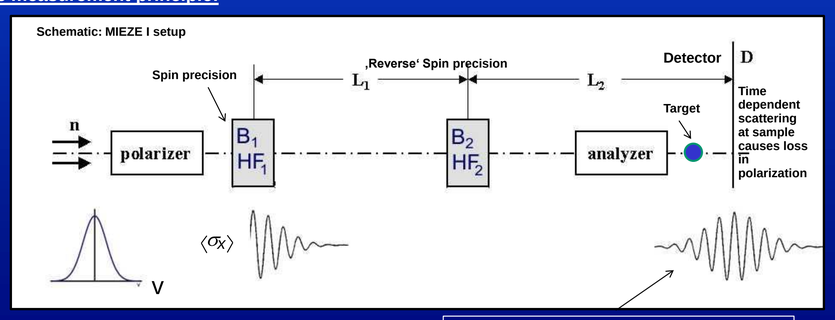
Why Neutron SpinEcho?

The „Scattering Map“



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

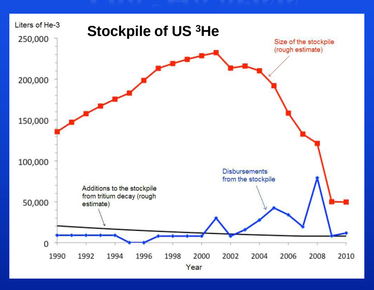
The measurement principle:



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

Polarization is proportional to Fourier transformation of energy transfer spectrum

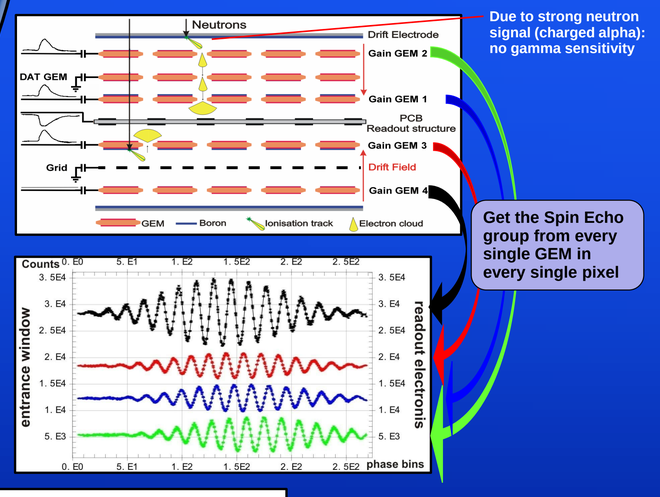
The ^{3}He crisis



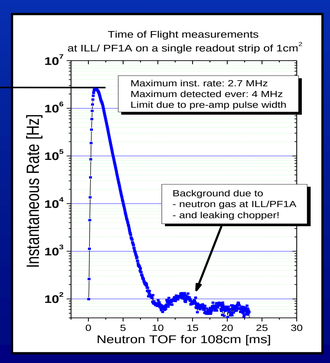
- ^{3}He is a product of the nuclear weapons industry
- due to global nuclear disarmament and increase of ^{3}He based detectors

⟶ not much Helium left and alternative technologies needed

Measurement



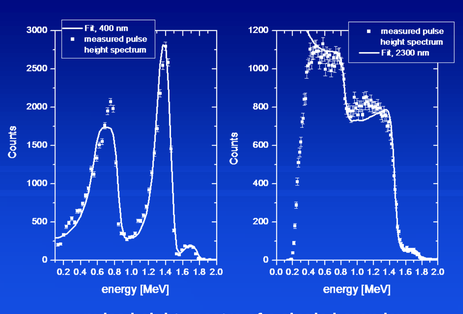
count rate > 1 MHz



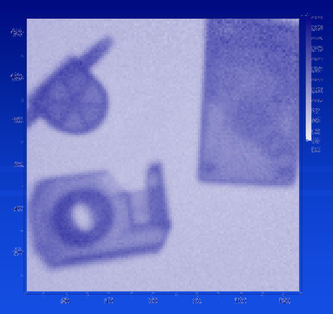
To have a device capable of measuring beyond the NRSE limits, a high spatial resolution, a high time of flight resolution and a high count rate capability are necessary.

Detection Efficiency:

At 5.4 Å with six boron layers ~ 50%



pulse height spectra of a single boron layer



neutron radiography

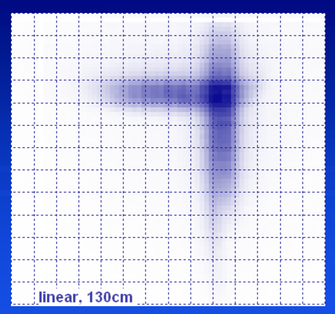
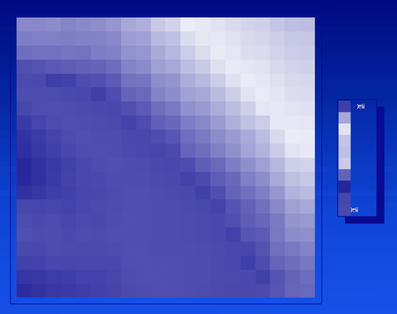
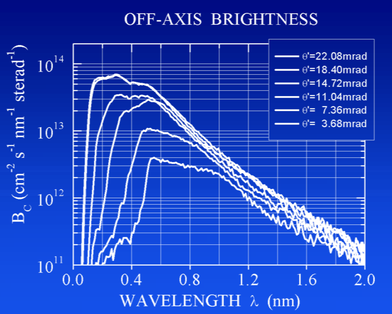


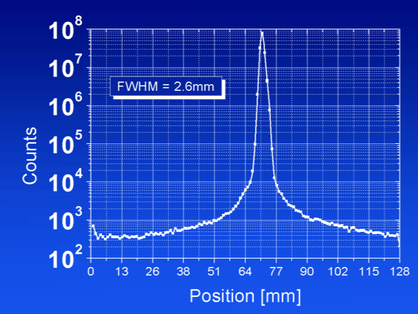
image of a diverging thermal beam



phase front of a neutron beam



Time-of-Flight neutron spectra



point spread function of 0.57 mm beam

Data Taking Showcase

[1] Sauli, F. ; Sharma, A.: Micropattern Gaseous Detectors. In: Annual Review of Nuclear and Particle Science 49 (1999)
[2] AAAS, Overview of Helium-3 Supply and Demand

Ulrich Schmidt (ulrich.schmidt@physi.uni-heidelberg.de
Physikalisches Institut, Universität Heidelberg
Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Bundesministerium für Bildung und Forschung