The CASCADE Detector

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Innovative Neutron Detection

A novel detector concept featuring:

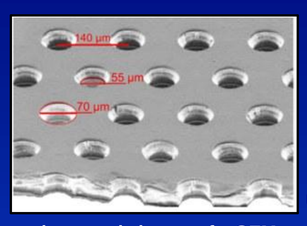
- **high rate capability**
- **X-Y spatial resolution**
- **high time-of-flight resolution**

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]

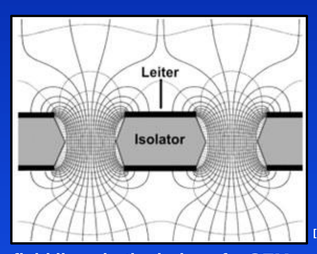
microscopic image of a GEM

Design:

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

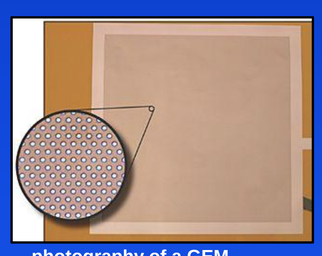
Features:

- 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



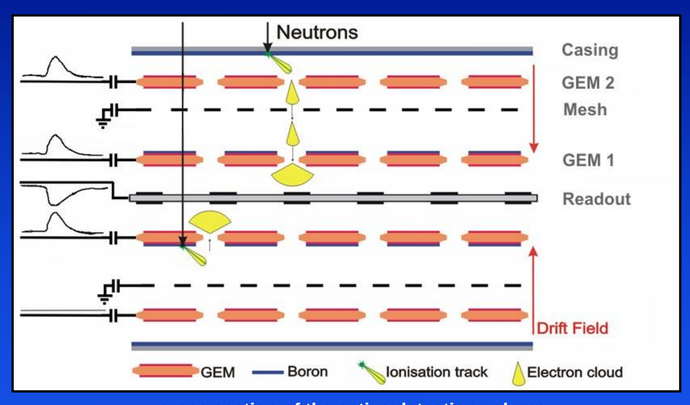
photography of a GEM in (10x10) cm^2

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%)

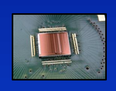
+ Charge amplification with GEMs in Standard Gas



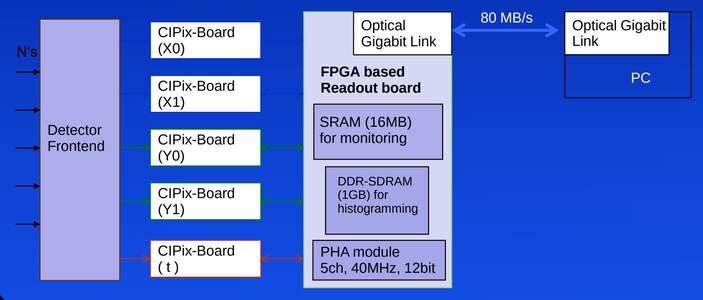
cross section of the active detection volume

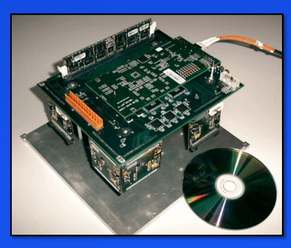
Readout

- **4 CIPix ASIC** (Application-Specific Instruction-Set Processor) 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

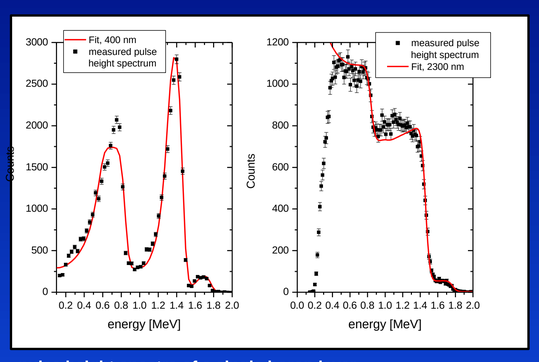




Back PCB of the detector with

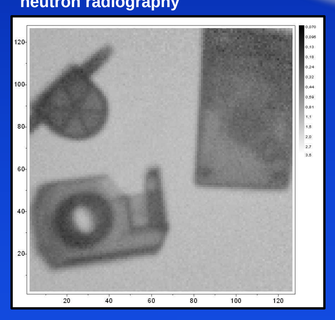
- CIPix ASICs (bottom)
- FPGA board + RAM (middle)
- Optical Interface (top)

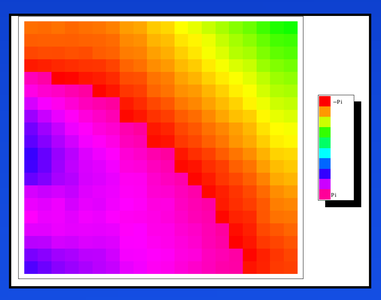
Data Taking Showcase



pulse height spectra of a single boron layer

neutron radiography

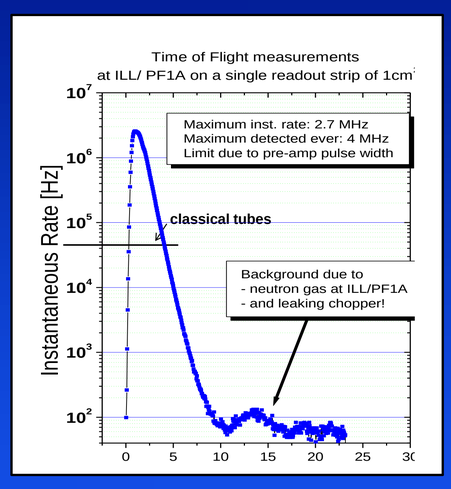




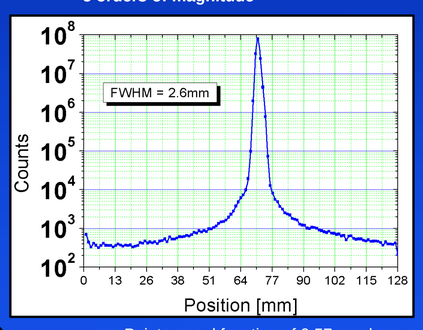
phase front of a neutron beam

Rate Capability

count rate > 1 MHz



dynamic range 5 orders of magnitude



Ppint spread function of 0.57 mm beam

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

Bachelor- and Master – Theses available

Detector development & Neutron physics

- (Re-)Construction / modification of an existing test detector to carry out experiments in order to:
  - I. investigate charge transmission using newly implemented absorbing grid technology
  - II. set up and realize a precise energy calibration of the detector system
- Analysis of your experimental data
- For interest in detector simulation: Modelling the full particle interactions using Monte Carlo Methos, e.g. Geant4

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