The CASCADE Project

a perspective for Solid State Detectors

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Heidelberg Research Fields

Helium-Xenon EDM
[test of Lorentz invariance]

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

Neutron Detectors
[large area and high time resolution]

Atomic Beam Spin Echo
[Berry phase and Casimir force]
The CASCADE Concept

Housing

Thin (Boron) Layer

Readout

Neutrons

(abs. prob.)
The CASCADE Concept

- Housing
- Thin (Boron) Layer
- Charge transparent substrate
- Readout
The CASCADE Concept

GEM
(Gas Electron Multiplier foil)
Neutron Resonance Spin Echo Methods

The MIEZE setup

Principle: Use Neutron Spin as Observable in Interference Time Of Flight Experiments
e.g. Ramsey Interferometer

\[ \langle \sigma_x \rangle \]

Time dependent scattering at sample causes loss in polarization
Neutron Resonance Spin Echo Methods

The MIEZE setup

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

e.g. Ramsey Interferometer
The CASCADE Detector

CASCADE detector without housing
The CASCADE Detector

CASCADE detector without housing

Active Detection Volume

Readout

Electronics
The CASCADE Detector

**Active Detection Volume**
- Neutron conversion, pure Boron-10

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

- Charge amplification with GEMs in Standard Gas

**Readout**

**Electronics**

CASCADE detector without housing
Active Detection Volume

- Neutrons
- Casing
- GEM 2
- GEM 1
- Readout
- Drift Field
- GEM
- Boron
- Ionisation track
- Electron cloud
Active Detection Volume
Active Detection Volume

thin gap measures dE/dx
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:

1.56 mm

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
  - 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)
Outlook: nXYTER

- 128 channels
- 1 ns time resolution
- Token Ring Readout
Efficiency and internal scattering

Efficiencies at 5.4 A

- 8 Layer All Neutrons
- 8 Layer Scattered Subtracted
- 6 Layer All Neutrons
- 8 Layer Scattered Subtracted
- PVC Grid
- 6 Layer Scattered Subtracted
- Zirconium Grid

8 layers
6 layers

Boron Layer Thickness (µm)
Efficiency measured at HEIDI FRM II

Efficiencies of the detector at different wavelengths

- Simulation
- Data
- Ghost event corrected data
Spatial Resolution

Image of a thermal neutron beam (after guide)

Spatial resolution: 2.4 mm

Log (Intensity)

Cadmium sheet

@RESEDA FRM II
Spatial Resolution

Spatial resolution: 2.4 mm

Cross section of a collimated n-beam

- **Data**
- **Simulation**

Counts vs. Pixel

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Count rate measurements

- Count rate measurements
- Maximum inst. rate: 2.7 MHz
- Maximum detected ever: 4 MHz
- Limit due to pre-amp pulse width

Time of Flight measurements
at ILL/ PF1A on a single readout strip of 1cm²

Instantaneous Rate [Hz]
Neutron TOF for 10^8 cm [ms]

- Background due to neutron gas at ILL/PF1A
- Background due to and leaking chopper!
A Spin Echo Signal

Polarization in two pixels:

Counts

MIEZE frequency 654 kHz at 5.3 Å

~100ns

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
A Spin Echo Signal

Mean local gas gain

Drift cathode with bump

GEM strained
Outlook
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% thermal neutron efficiency @ 6 layers
• 50% efficiency for 5 Angstroms @ 8 layers
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