High rate electron beam tests with MuPix sensors at MAMI

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Outline

- Mainz Microtron (MAMI) accelerator
- MAMI testbeam locations
- MuPix sensor
- MuPix testbeams at MAMI
The MAMI accelerator

- 4 stage electron accelerator
- 1.6 GeV at 100 µA
- 82% polarization (max. 20 µA)
Accelerator stages 1-3 - MAMI-B

- Linear injector
- 3 stage racetrack microtrons
- Energies[MeV]: 14, 180, 855
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- Linear injector
- 3 stage racetrack microtrons
- Energies [MeV]: 14, 180, 855
Accelerator stage 4 - MAMI-C

- Harmonic double-sided microtron
- Output energy: 1.6 GeV
MAMI operation

- Up to 70% duty cycle
- December 2017 missing ($\approx 150$ h unpolarized)
Testbeam locations

- X1: behind RTM 3
- A2 hall: tagger magnet
HV-MAPS - MuPix sensor prototypes

- 180 nm HV-CMOS technology
- Reverse biased up to 90 V
- Readout logic on chip
- Thinnable down to 50 µm

- MuPix7
- Pixel size: 80×103 µm²
- Sensor size: 3×3 mm²
- Used in Mu3e, P2
Testbeam locations

- X1: behind RTM 3
- A2 hall: tagger magnet
X1 - high rate electron testbeam
X1 - high rate electron testbeam

Efficiency vs rate

χ²/ndf = 14.63 / 63
p0 = 0.9975 ± 0.0001364
p1 = −1.204e−09 ± 8.574e−11
A2-Glasgow-Mainz tagger - photon testbeam

MAMI-C Beam 
\[ E_0 = 450 \text{ MeV} \]

Radiator

Focal Plane Detector

Focal Plane

Primary Beam

Tagging Spectrometer

Dipole

Permanent Magnet

MuPix Sensor

Vacuum Window (Mylar)
A2-Glasgow-Mainz tagger - photon testbeam

![Image of a circuit board with wires and connections]

![Graph showing photon energy vs. detection angle with MC prediction, corrected data with statistical error, and systematic error markers]
A2-Glasgow-Mainz tagger - electron testbeam
A2 electron beamline extension - new 2017

- A2 hall: beamline extended through Crystal Ball
- No radiator, tagger magnet off
- $E_{\text{beam}} = 700 \text{ MeV}$
TPC testbeam - setup in A2 hall

- MuPix telescope
- High pressure helium TPC
TPC testbeam - observations

Beamspot

Background after 2 MHz hit rate
TPC testbeam - results

- MuPix telescope operation
- Beam monitoring
- Provide reference tracks
Summary

- MAMI provides polarized electron beam up to 1.6 GeV
- Electron & photon testbeams possible
- MuPix high rate capabilities tested
- MuPix telescope provides reference tracks up to 2 MHz
- MuPix8 to be tested in March
Backup - A1

- Electron scattering
- 3 rotatable spectrometers
Backup - A2

- Photoproduction by Bremsstrahlung
- Beam electrons deflected and tagged by spectrometer
- Meson radiation of target nucleons
Backup - A4

- Elastic electron scattering
- Longitudinally polarized electrons
- Unpolarized $H_2$ target
- Measure parity violating asymmetry
Backup - MESA

- Mainz Energy Recovering Superconducting Accelerator (MESA)
- 2 modes, up to 155 MeV, 85% polarization
Backup - P2 spectrometer and tracking system

- 0.6 T solenoid magnet
- Inhomogenous field in tracking system
- Measure the average $Q^2$
- Validate acceptance, alignment
- Monitor beam and target conditions
Backup - P2 tracking detector

- Pixel sensors, electronics, gaseous helium cooling, mechanical support
- Low material budget
- $2 \times 4$ modules, double layers, 300 sensors per layer