High rate electron beam tests with MuPix8 sensors at MAMI

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Outline

- Mainz Microtron (MAMI) accelerator
- MAMI testbeam locations
- MuPix8 high rate testbeam 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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- 3 stage racetrack microtrons
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Accelerator stage 4 - MAMI-C

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

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

- A2 hall: tagger magnet
- X1: behind RTM 3
Glasgow photon tagging spectrometer

tagged photon beam (5 - 93% of beam energy)
Testbeam locations - X1
HV-MAPS - MuPix sensor prototype

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

- MuPix8
- Pixel size: 80×81 µm²
- Sensor size: 2×1 cm²
- Used in Mu3e, P2
X1 high rate electron testbeam

- 8 layer MuPix8 telescope (compare L.Huth: The MuPix8 telescope)
- Mu3e front-end readout board
- max. 10 MHz electron beam at 855 MeV
X1 high rate electron testbeam - observations

hitmap during testbeam run

hitmap after the testbeam
X1 high rate electron testbeam - efficiency analysis

- difference of per pixel efficiencies
- dependence on accumulated hits
- Efficiency loss measured with Sr90 source
- Sensor after 48h at 80°C
- No further improvement (72h at 90°C)
Summary

- MAMI provides polarized electron beam up to 1.6 GeV
- successful MuPix8 telescope operation at high rates
- high local rates create degradation of MuPix8
- further testbeams and lab measurements planned
Backup - A1

- Electron scattering
- 3 rotatable spectrometers
Backup - A2

- Photoproduction by Bremsstrahlung
- Beam electrons deflected and tagged by spectrometer
- Meson radiation of target nucleons
Elastic electron scattering
Longitudinally polarized electrons
Unpolarized $H_2$ target
Measure parity violating asymmetry
Mainz Energy Recovering Superconducting Accelerator (MESA)

- 2 modes, up to 155 MeV, 85% polarization
Backup - P2 experiment

- Solenoid Magnet
- Photomultipliers
- Fused Silica Detectors
- Barrel Shield
- Support Frames
- Liquid Hydrogen Target
- Vacuum
- Tracking Detectors
- Helium
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