Mu3e Experiment and the Vertex Detector

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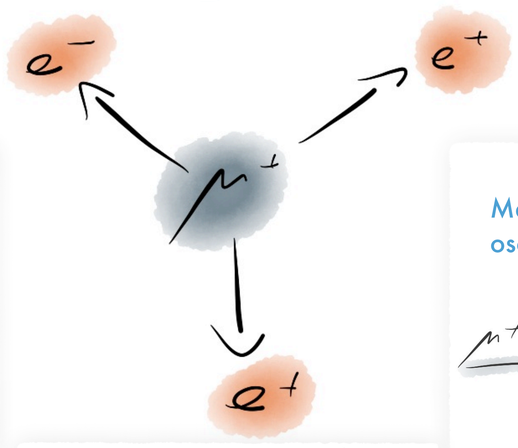
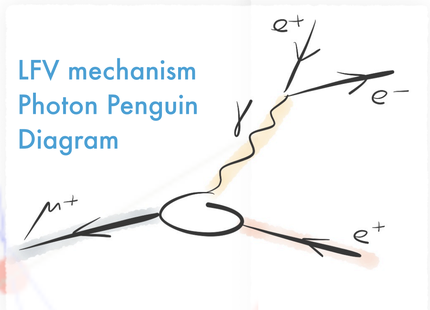
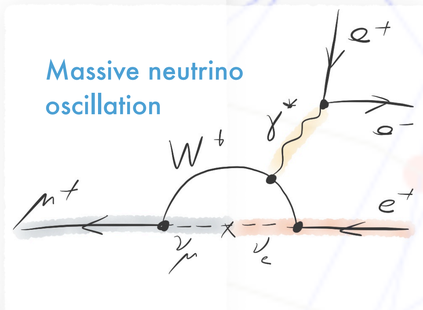
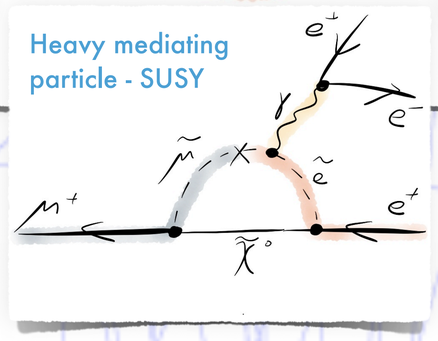
Can a muon decay into 3 electrons*?

The decay dynamics for $\mu \rightarrow eee$ signal are dependant on the unknown lepton flavour violating (LFV) mechanism









The signature has no physics background and the sensitivity depends only on distinguish overlays process producing three resembling tracks and radiative decays with internal conversion $\mu \rightarrow eee\nu\nu$

The predicted SM branching fraction for this process is 2.9×10^{-55}

Currently the SINDRUM-1 experiment posses the best branching fraction of the process with a upper limit of 1.0×10^{-12}

If the decay exists the model can be explain by different process beyond SM

Mu3e Experiment

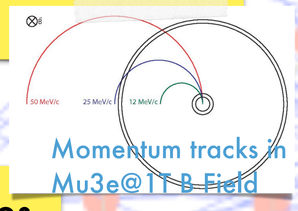
Goal: Observe branching fraction of $\mu \rightarrow eee$ process and set new limit 10^{-16}.

Key factors

- High **momentum resolution** ~ 1 MeV
- High **vertex position resolution**, thus low material budget to minimise multiple scattering.
- Good time resolution to reduce combinatorial background ~ 500ps

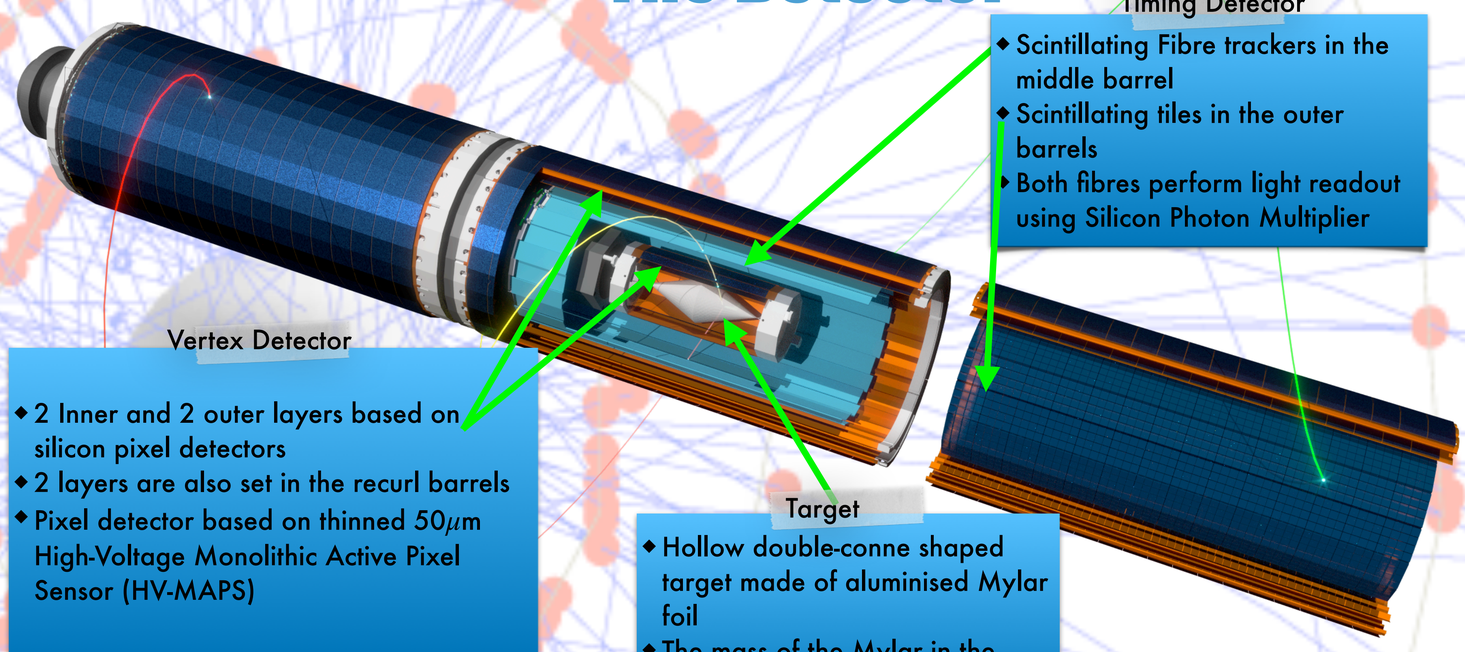
The beam

- Experiment utilises the muon beam lines from PSI facility
- The $\pi E5$ beam provides muon rates up to 1×10^8 Hz and with 1.2×10^7s (290 days) the experiment can reach the expected sensitivity



Momentum tracks in Mu3e@1T B-Field

The Detector



Timing Detector

- Scintillating Fibre trackers in the middle barrel
- Scintillating tiles in the outer barrels
- Both fibres perform light readout using Silicon Photon Multiplier

Vertex Detector

- 2 Inner and 2 outer layers based on silicon pixel detectors
- 2 layers are also set in the recurl barrels
- Pixel detector based on thinned 50μm High-Voltage Monolithic Active Pixel Sensor (HV-MAPS)

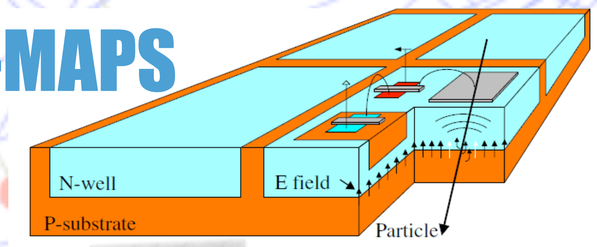
Target

- Hollow double-conne shaped target made of aluminised Mylar foil
- The mass of the Mylar in the target is 0.671 g.

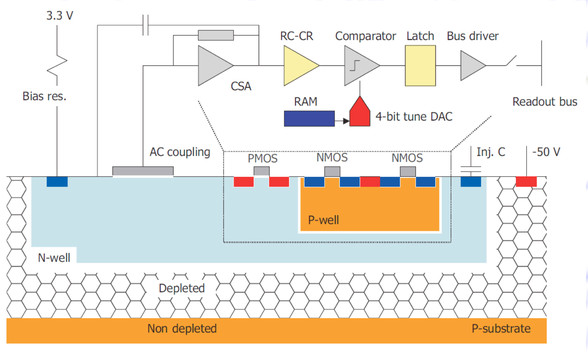
Vertex Detector

UZH Contribution: Building and Commissioning of Inner Vertex layers with 108 MuPix11 chips.

HV-MAPS

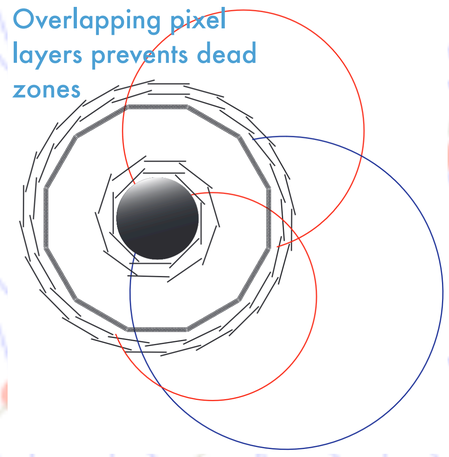


- MuPix11 used the commercial 180nm technology
- High Voltage can stand up to 100V
- Charge collection is via drift in a very small region, thus fast reaction.
- Monolithic design: Detection and Readout combined in one chip



Inner Vertex Layers

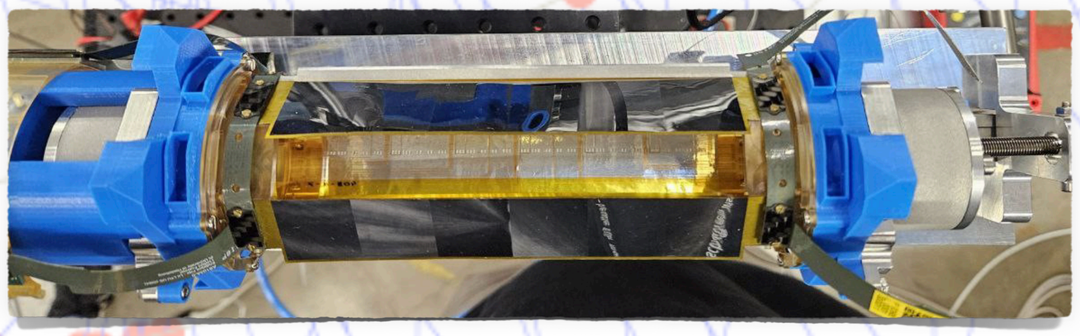
- First layer consists of 8 array of 6 (ladder) MuPix11 chip to form an octagon
- Second layer consists of 10 ladders with 6 MuPix11 to cover all possible dead zones.
- Each MuPix11 have 256x250 pixels
- All pixels have independent threshold and masking capabilities
- Efficiency expected of >99% with a time resolution of <20ns
- 3 configurable data lines per chip with a data rate of 1.25 Gb/s



Overlapping pixel layers prevents dead zones

UZH contribution

- QC Tests and validation of all MuPix11 for the two inner layer of Vertex Detector
- 18 Ladder construction
- Full readout validation chain for inner layers
- Build and Commissioning Inner vertex detector



Two ladders setup in latest test beam at PSI

Wants to know more?

SINDRUM-1 Measurement

More about HV-MAPS

Mu3e Experiment@PSI

Info about our group@UZH