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Realistic simulation of the MAPS response

Motivation and test results
Simple model of the charge diffusion
Implementation in ILC Software
First results

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Introduction

- Measurements with 6 GeV electrons for different particles incident angles θ ∈ (0°,80°) (DESY test beam facility)
- Tested detectors (MAPS):
 - MIMOSA-5 17 μm pixel pitch
 - MIMOSA-18 10 μm pixel pitch
- Studies of
 - Cluster shapes
 - Single point resolution
 - Occupancy





Mean cluster shapes - measurements



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Deterioration of the single point resolution

- With our setup at DESY 6 GeV electron beam it was very difficult to determine the single point resolution
- Obtained results are dominated by the MVD silicon strip telescope
 - σ_{MIMOSA-5} ~ 1.5 μm (CERN)
 - σ_{MVD} ~ 9.0 μm
- Single point resolution deteriorates with the increasing θ – need to be taken into account in simulations

MIMOSA-5



Position reconstructed for **3x3** cluster using cluster centre of gravity

Number of pixels involved in the charge collection

- The number of signal pixels (S/N > 3) increases with the incident angle θ
- This has to be taken into account in clustering to preserve resolution
- Also important for estimates of the detector occupancy
- Detailed modelling of the pixel detector response is crucial for VXD performances studies



MIMOSA-5

A simple model of charge diffusion



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A simple model of charge diffusion

- Charge distribution depends on attenuation parameter λ
- Model also includes:
 - Noise



• α and λ to be determined from comparison Monte Carlo to data

Fitting λ for $\theta = 0^{\circ}$ and $\theta = 75^{\circ}$



Very good agreement of the Monte Carlo and the Data

Fitting λ **for** $\theta = 0^{\circ}$ **and** $\theta = 75^{\circ}$



Very good agreement of the Monte Carlo and the Data

Particles crossing at large angles can scatter inside the sensor

This is modelled in Geant



Particles crossing at large angles can scatter inside the sensor This is modelled in Geant



However, Mokka used to **add** all Geant steps and store only single hit per particle, with total energy deposit! (only additional hits due to secondary particles stored separately)

This makes realistic simulation impossible !

Particles crossing at large angles can scatter inside the sensor



Dedicated option implemented in new Mokka release forces it to store separate Geant steps:

/Mokka/init/detailedHitsStoring VXD

currently implemented for VXD only, but can be extended to other detectors

New option increases average number of hits per particle by about 25% (for high energy particles from IP)



Average number of hits in VXD for 100 GeV muon VXD03 setup (5 layers), muon at random angle from IP

New option increases average number of hits per particle by about 25% (for high energy particles from IP)

Significantly suppresses hits with very large deposits (>10mip)



Energy deposit in single Geant step for 100 GeV muon VXD03 setup, muon at random angle from IP

New class for charge distribution calculations TDSPixelsChargeMap

Deposit of Geant/Mokka hit is distributed in many steps along particle path.

Charge collected in each pixel is calculated by numerical integration of charge diffusion formula.

Integration results stored in a grid, so simulation is _____ very fast (except for first ~100 hits)



First results

Simulated cluster shape for particle crossing at $\theta \sim 89^{\circ}$



All results very preliminary, for qualitative comparison only

Model parameters still to be tuned to the test data results

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Mean cluster multiplicity, as a function of the incident angle



Position resolution from 3x3 CoG as a function of angle



Comments on geometry description

Results obtained within EUDET telescope software framework ≁EUTelescope driver in Mokka ≁EUTelMAPSdigi processor for Marlin Only epitaxial layer (14µm) defined as sensitive volume. Parameter crucial for detailed simulation!

In VXD detector model in Mokka whole sensor depth (50 μ m) is defined as sensitive volume.

-can be corrected for in digitization processor

-should be corrected in the Mokka driver/database

What is the proper sensitive volume thickness to be used?

Summary

- Measurements at different incident angles show significant cluster elongation. For realistic VXD performance studies detailed description of the detector response is required.
- Simple model parametrising MAPS detector response gives good agreement with beam test data
- New option in Mokka available for storing detailed particle trajectory in sensitive volume
- New class for Track Detailed Simulation (TDS) under development
- First version implemented in the EUTelescope software framework, tests ongoing