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Design Optimisation for (the Silicon Micro-Strip Part of) the PANDA Micro-Vertex-Detector *

Thomas Würschig
on behalf of the PANDA MVD group

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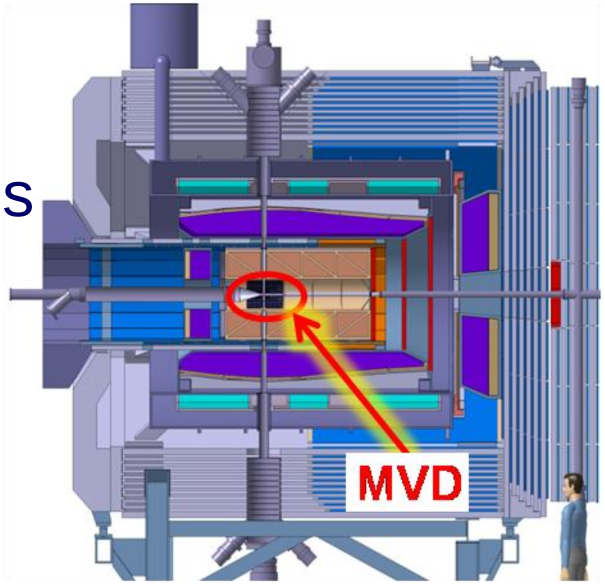
Introduction

- Micro-Vertex-Detector (MVD)
  - **Tracking detector** for charged particles
  - **Innermost** detector in PANDA
  - ***Main tasks***

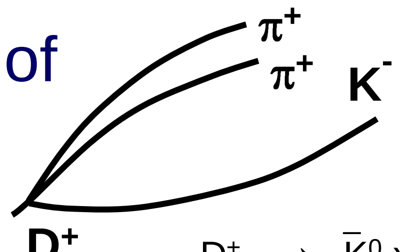
(1) Improvement of momentum resolution

(2) High vertex resolution for primary interaction vertex and secondary vertices of short lived particles and delayed decays

(3) Additional input for particle-ID



Target spectrometer



$D^{\pm} \rightarrow \bar{K}^0\, x + K^0\, y$

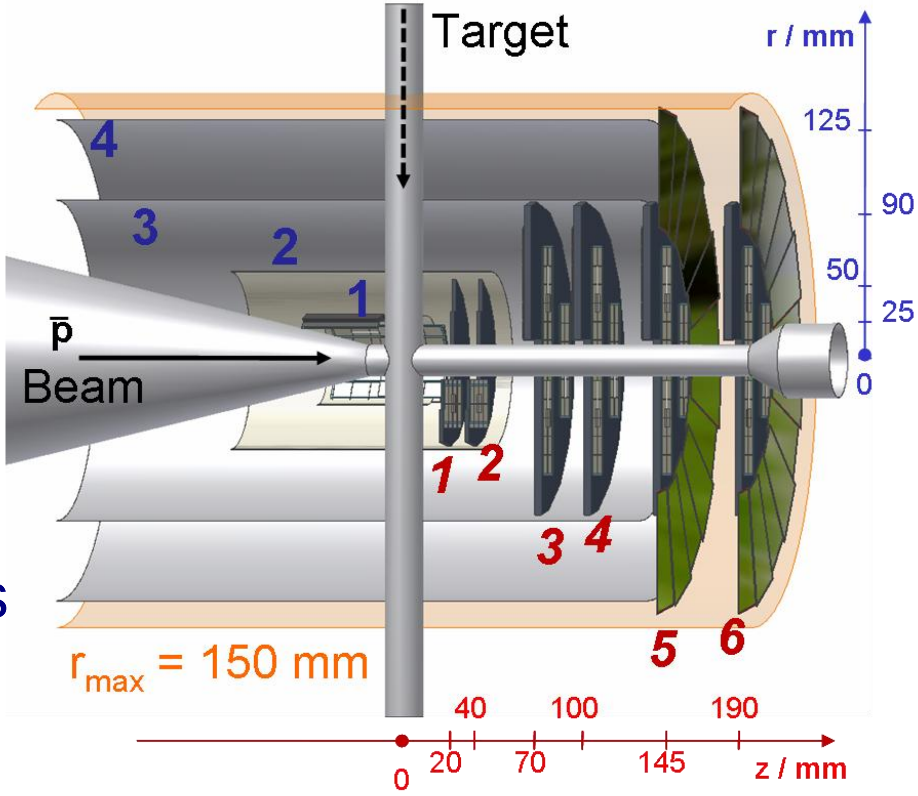
$c\tau$ = 312 µm

$D^{\pm}_S \rightarrow \bar{K}^0\, x + K^0\, y$

$c\tau$ = 147 µm

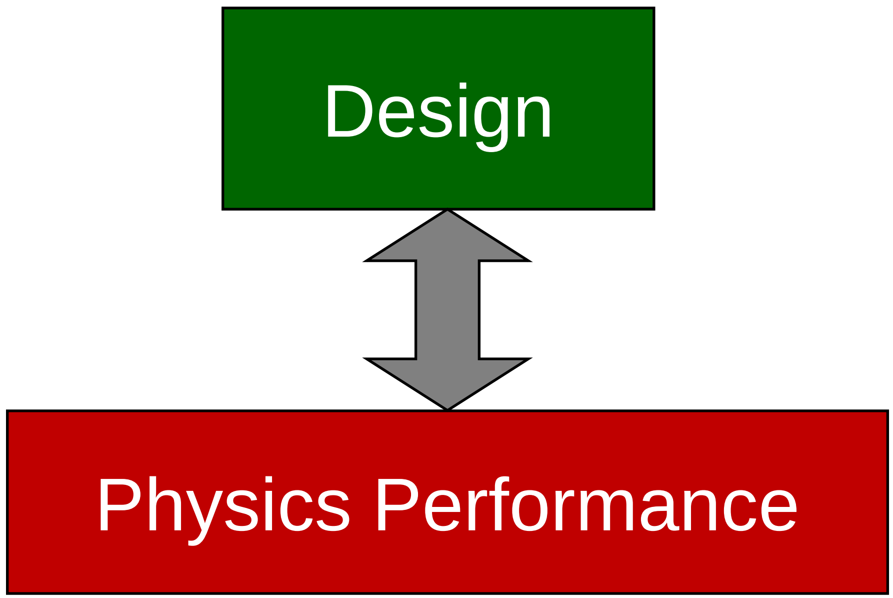
Motivation

- General MVD layout fixed
  - Number of layers
  - Detector type
  - Overall geometry
- Detailed implementation
  - Detector: shape, dimensions
  - Hybridisation
  - Support structure
  - Cooling, cabling and routing concept
  - Alignment … integration / interplay with other subsystems



Motivation

Extraction of **design parameters** in order to **qualify** dedicated concepts in terms of **physics performance**



Design parameters enable **optimisation** of the detector

Design parameters

a **Innermost detector** in PANDA:

- Low material budget, notably in forward direction
  - → Material mapping
  - → Radiation lengths
  - → Scattering effects

b **Tracking** detector:

- Maximum spatial coverage
- Sufficient number of hit points
  - → Number of hit points / track
    - Design goal: 4 points per track
    - 1^{st} point close to vertex
    - Last point close to outer tracker

Design parameters

c Vertex resolution:

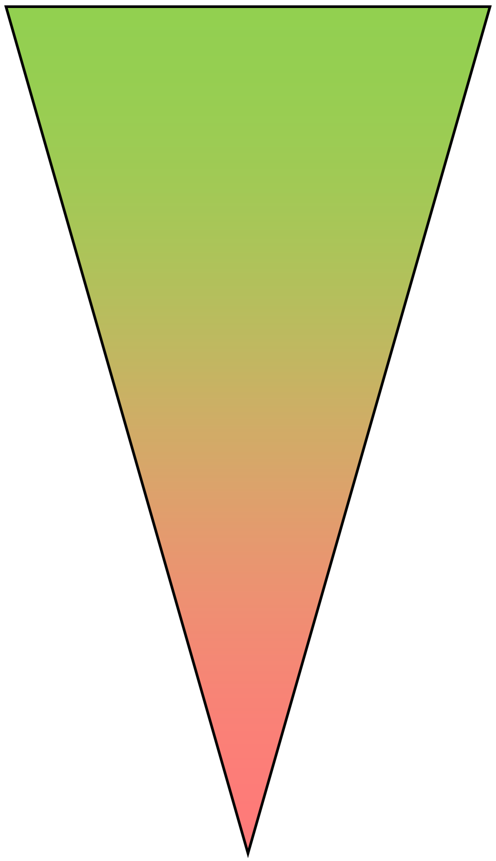
- Number and position of track points (w.r.t. vertex)
- Spatial resolution of single track points
  → Size of readout structure
  → Sensor arrangement …

d Additional input for PID:

- Analogue information for single hit points
  → Energy deposition
  (→ Calculation of hit position … see above)
  → Resolution
  → d_{eff} (sensor thickness, incident angle of track)
  → Signal-to-Noise as function of d_{eff} …

Design parameters

Basic Parameters



Physics Results

- → Number of hit points / track ($N_{trk\text{-}pt}$)
- → Spatial distribution of ($N_{trk\text{-}pt}$ / track)
- → Spatial distribution of material load
- → Mapping of scattering effects

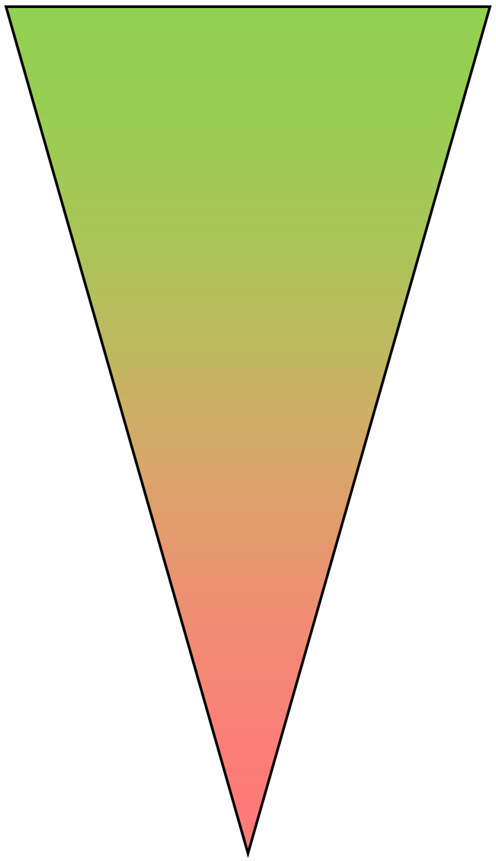
- → Count rate studies
- → Single hit resolution

… …

- → Track resolution
- → Vertex resolution
- → Simulation of physics channels (*R. Jäkel*, HK 25.7)

Design parameters

Basic Parameters



Physics Results

→ Nu ber of hit points / track (N_{trk-pt})

→ S tial distribution of (N_{trk-} / track)

→ oad

→

→

→ Ve tex resolution

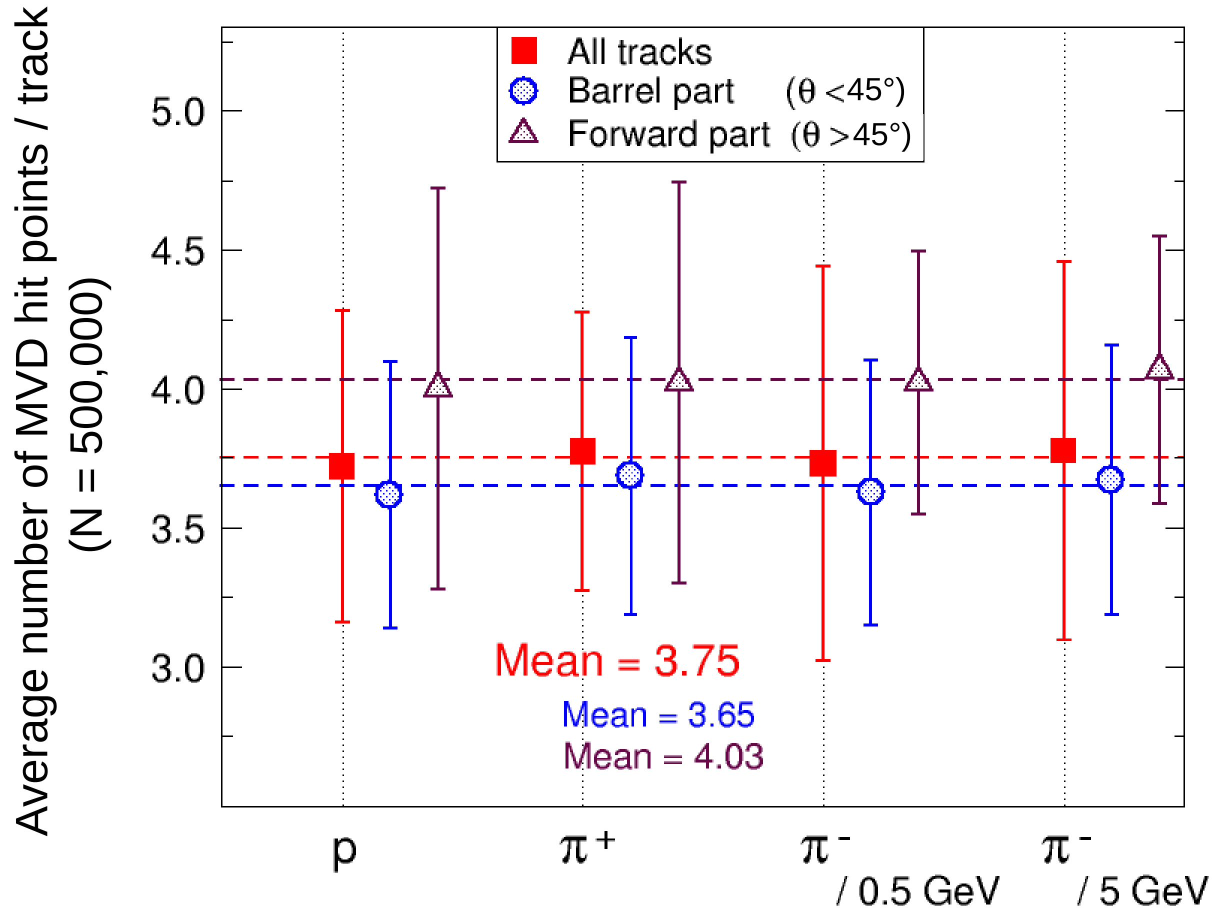
→ Simulation of physics channels
(R. Jäkel, HK 25.7)

Set of complementary parameters, interdependent w.r.t. optimisation

… no parameter can be studied independently … !

Track-point studies

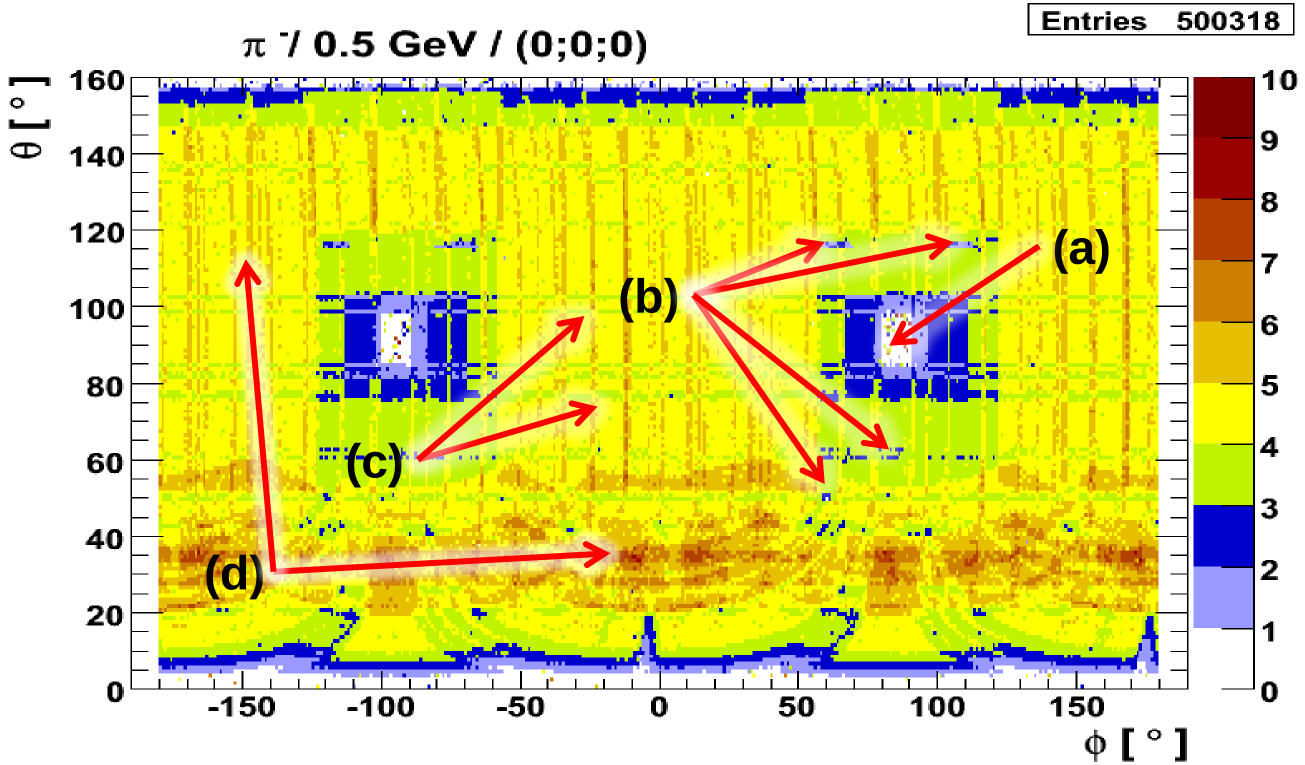
- Comparison for different particles and excess energy



- Implementation of realistic CAD model
- Simulation includes:
  - ✓ Full material budget
  - ✓ Magnetic field

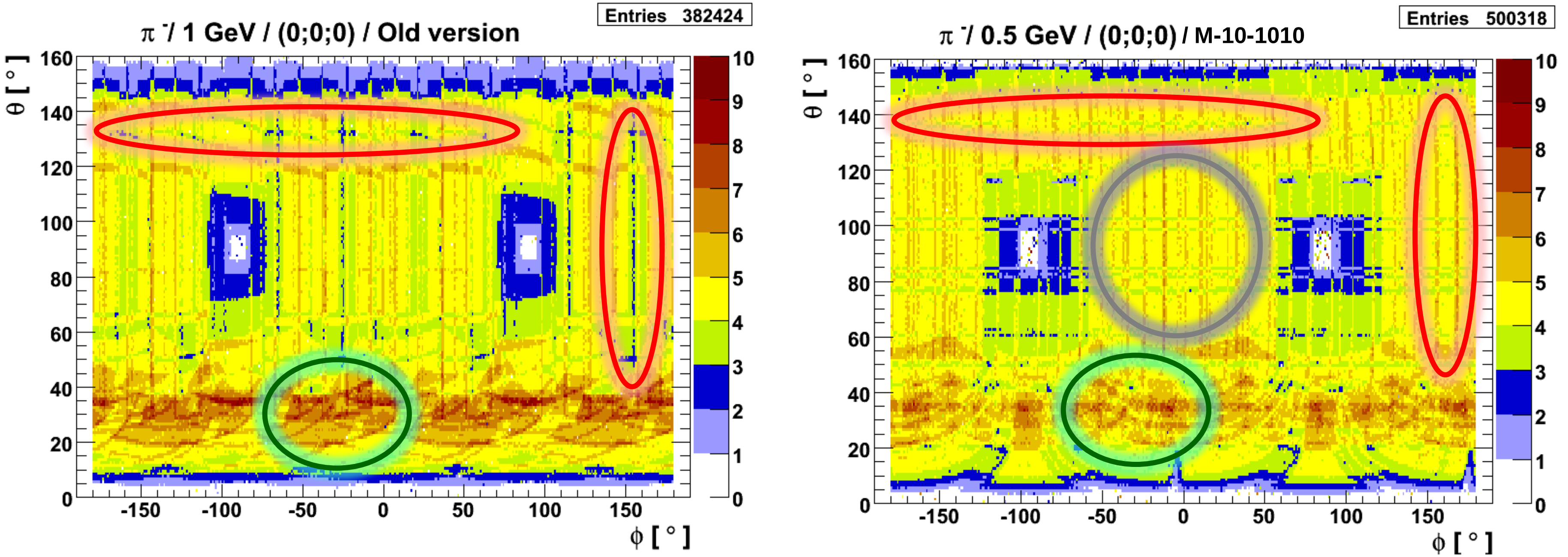
Track-point studies

- Spatial distribution of MVD points / track
  - Inhomogeneities: (a) Target pipe, (b) module positioning, (c) strip-sensor gap in barrel layers, (d) sensor overlap, ...



Track-point studies

- Detector optimisation:
  Comparison of different implementations

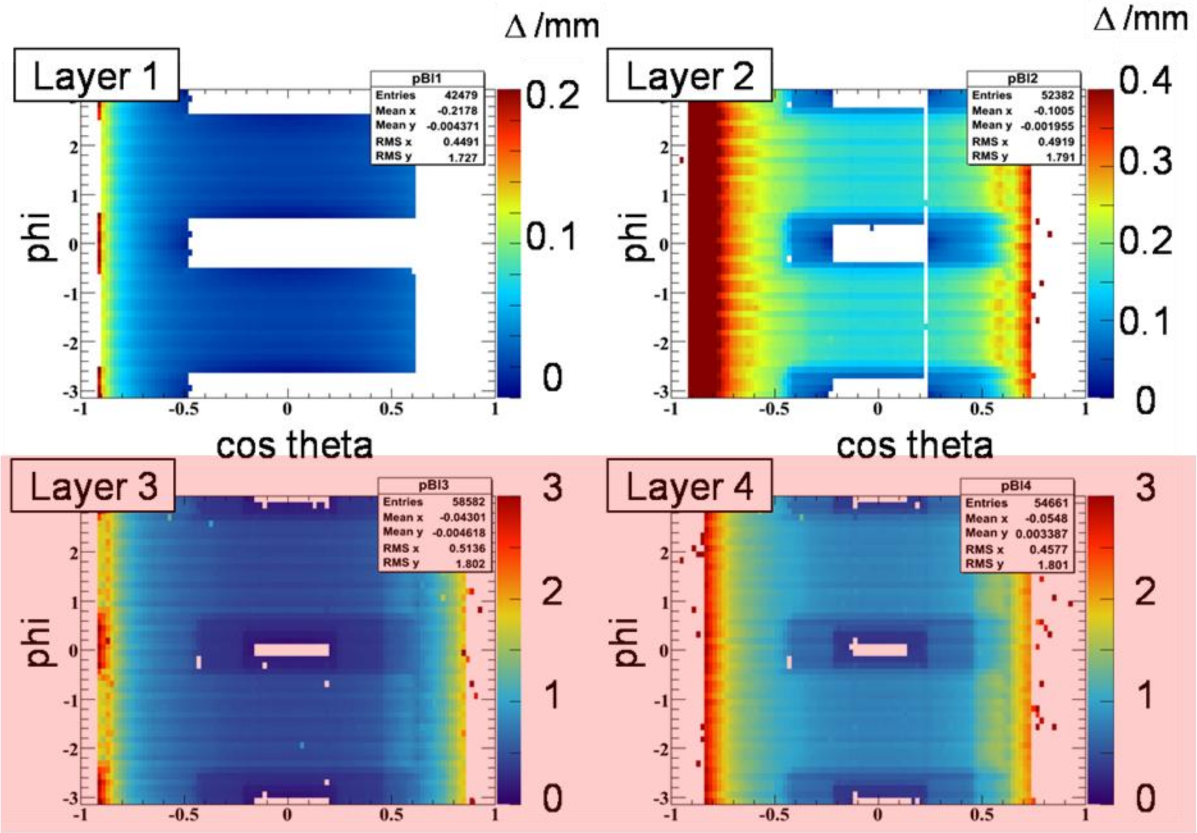


  - Visualisation and correction of gaps
  - Reduction of material: Limitation of track points
  - Homogenous distribution in the barrel part

MVD layer: Point resolution

- Study of multiple scattering with particle propagator
  - *Geane* (based on *Geant3*)
  - Example:
    π^+, 0.5 GeV / c
    → Barrel layer
  - Plotting the deviation due to scattering (Δ)

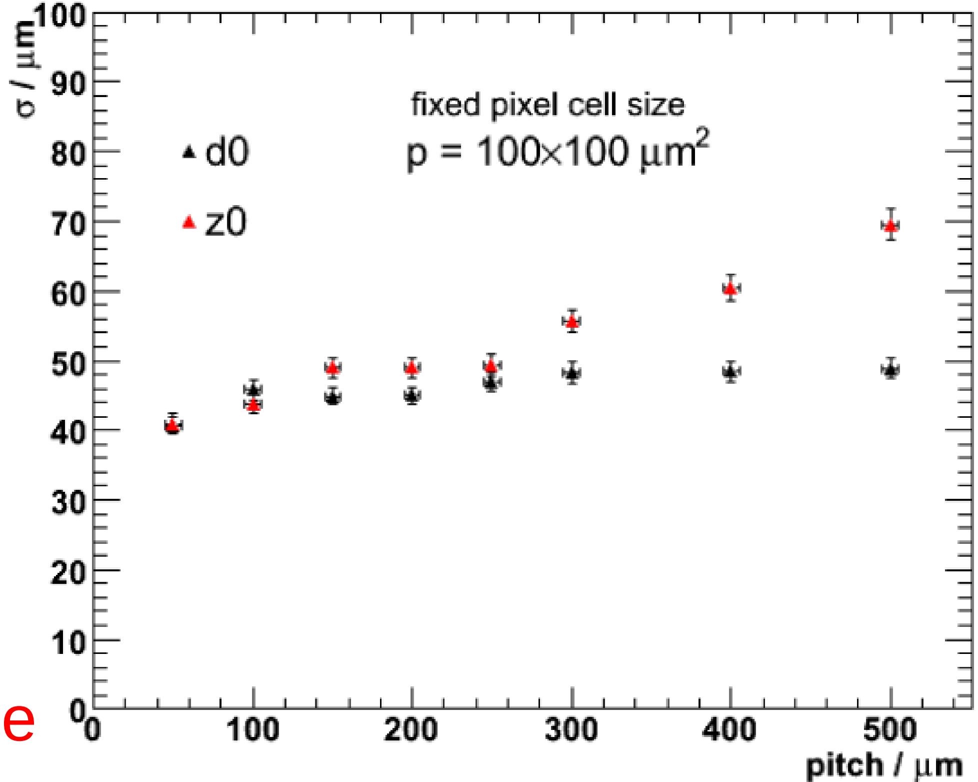
$$\Delta = |\vec{r}_{SIM} - \vec{r}_{IDEAL}|$$



Vertex resolution studies

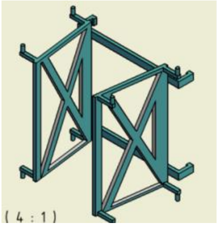
- Single track vertex resolution for different readout structures (pixel cell size/ strip pitch)
  - Example:
    π^-, (0.2 … 3) GeV / c
    → Fixed pixel cell size
    → Variation of strip pitch
  - Analysis:
    → Vertex resolution parameters (d_0, z_0)

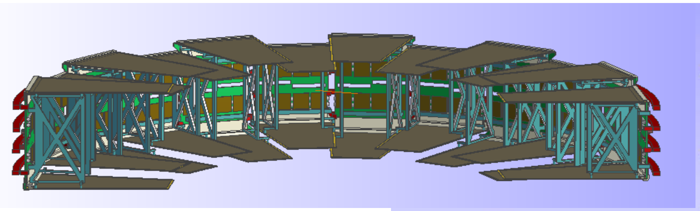
No significant improvement below 250 μm strip pitch due to scattering in precedent layers

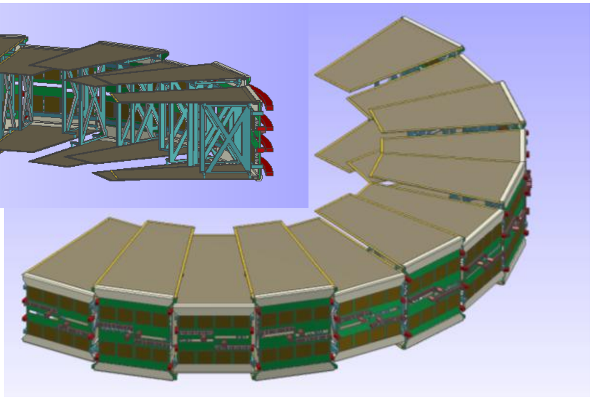


Impact on MVD strip part

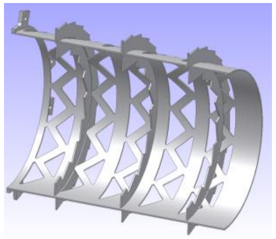
- Validation of sensor size and readout pitch
  - Barrel part:
    - ✓ Rectangular shape, stereo angle 90°, pitch: 130 μm
  - Forward part:
    - ✓ Trapezoidal shape, stereo angle 15°, pitch: 70 μm
- Disk concept

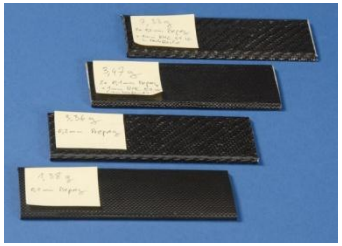


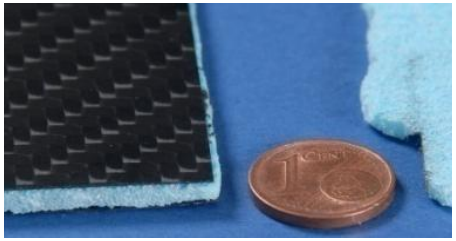




- Barrel support







Summary

- Overall MVD layout fixed
- Work on detailed implementation started
- Design parameters to verify physics performance of detector → Detector optimisation
- Tools for studies and analysis available (Physics and engineering simulations)
  → Set of input parameters must be chosen carefully

Physics guidance of engineering implementation ensure an optimised detector development