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

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* Work supported by BMBF and EU FP6
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

\[ D^\pm \rightarrow \bar{K}^0 x + K^0 y \]
\[ c\tau = 312 \mu m \]
\[ D^{\pm}_S \rightarrow \bar{K}^0 x + K^0 y \]
\[ c\tau = 147 \mu m \]
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
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
       - 1st 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
  - $d_{\text{eff}}$ (sensor thickness, incident angle of track)
  - Signal-to-Noise as function of $d_{\text{eff}}$ …
Design parameters

Basic Parameters

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

Physics Results

- Count rate studies
- Single hit resolution

... ...

- Track resolution
- Vertex resolution
- Simulation of physics channels
  ($R. \text{ Jäkel}, \text{ HK 25.7}$)
Design parameters

Basic Parameters

- Number of hit points / track ($N_{trk-pt}$)
- Spatial distribution of ($N_{trk-pt}$ / track)
- Spatial distribution of material load
- Mapping of scattering effects
- Count rate studies
- Single hit resolution
- Track resolution
- Vertex resolution
- Simulation of physics channels

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

... no parameter can be studied independently ... !

Physics Results

(R. Jäkel, HK 25.7)
Track-point studies

- Comparison for different particles and excess energy

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

![Graph showing average number of MVD hit points per track for different particles.](image)

Average number of MVD hit points / track (N = 500,000)

- All tracks
- Barrel part (θ < 45°)
- Forward part (θ > 45°)

Mean = 3.75
Mean = 3.65
Mean = 4.03
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 diagram](image)
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: $\pi^+$, 0.5 GeV / c
    - Barrel layer
  - Plotting the deviation due to scattering ($\Delta$)

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

- Single track vertex resolution for different readout structures (pixel cell size/ strip pitch)
  - Example: $\pi^-$, (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 $\mu$m 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