MVD requirements & simulations

TAG Tracking

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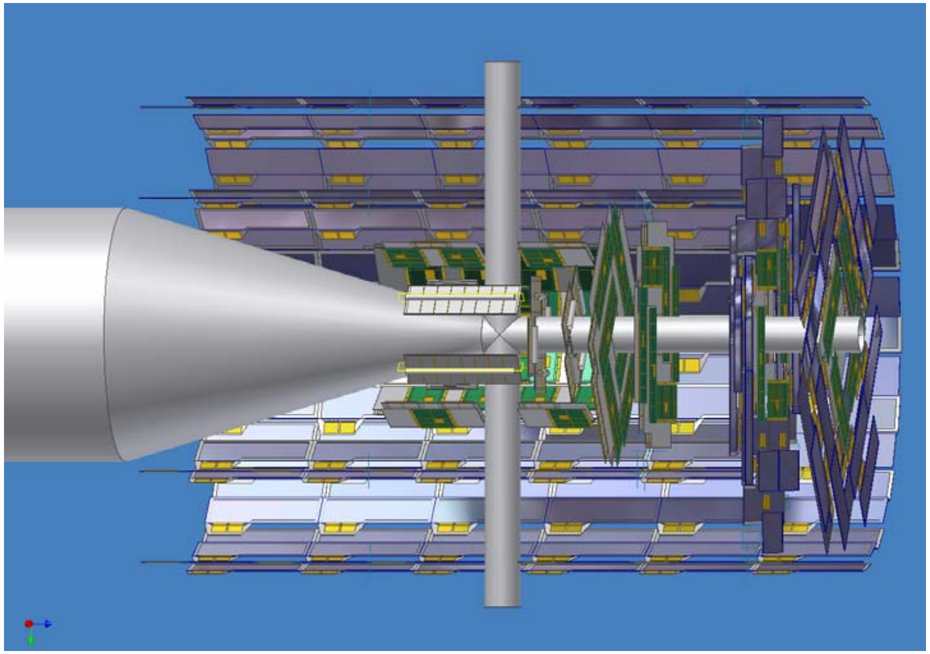
MVD Design: Rev 14b



~540 modules in 4 barrel & 6 disk layers

- Geometry:
  - pixel barrels at R= 27; 50 mm
  - strip barrels at R= 75; 125 mm
  - 2 single sided pixel disks at Z= 20; 40 mm
  - 4 double sided mixed disks at Z =60; 85; 145; 185 mm
  - closest distance to beam-pipe: 2 mm (disks)
  - overall length: 40 cm
- 140 pixel modules
  - 0.15 m^2 active silicon
  - ~6.5 Mio readout channels
- 400 strip modules
  - 0.5 m^2 active silicon
  - ~70,000 readout channels
- 2 kW power dissipation inside the MVD

Basic requirements for MVD: pixel

- spatial resolution in r-phi ➔ < 100µm (for momentum measurement)
- spatial resolution in z ➔ < 100µm (especially for D-tagging)
- time resolution ➔ < 50ns (for separation of 'DC'-beam 10^7 events/s)
- triggerless readout ➔ track rate up to 720 kHz (peak) and 54 kHz (average) per chip of size $7.6\text{x}8.2\text{mm}^2$
- low material ➔ < 1.2 % per layer (for low momentum particle tracking)
- modest radiation hardness ➔ ~$3\text{x}10^{14}$ n_{eq} / cm^2
- moderate occupancy ➔ up to 16 kHz (peak) and 350 Hz (average) for $50\text{x}400\mu\text{m}^2$
- amplitude measurement ➔ dE/dx for particle identification

Basic requirements for MVD: strip

- spatial resolution in r-phi ➔ < 100µm (for momentum measurement), to be confirmed by simulations.
- spatial resolution in z ➔ < 100µm, to be confirmed
- time resolution ➔ at least < 50ns (for separation of 'DC'-beam 10^7 events/s); better < 2ns (for DAQ event de-convolution and ToF)
- triggerless readout ➔ simulations underway
- occupancy ➔ simulations underway
- low material ➔ < 1% per layer (for low momentum particle tracking)
- modest radiation hardness ➔ $\sim 10^{14}\ n_{eq} / cm^2$
- amplitude measurement ➔ dE/dx for particle identification

Simulations: defining FE electronics

- Data loads (strip and pixel part)
  - rates & rate distributions – peak rates, average rates
  - energy deposit - global and locally, peak and average → define dynamic range

Channels: background p̄p & p̄A FoM: track rate, hit rate, data rate, occupancy & dynamic range

- time structure and ordering (strip and pixel part)
  - latency distributions
  - beam fluctuations on various timescales
  - overlapping of events

Channels: background p̄p & p̄A FoM: time resolution, occupancy & dynamic range of timing informations

Note: these simulations need input/interactions with dedicated electronics simulations!

Simulations: geometry optimization (1)

- variation of pixel size and shapes
  - [50x400 μm²]; 100x100 μm²; 50x200 μm²; 200x50 μm²
  - different relative orientations of layers

Channel: $\bar{p}p \rightarrow \bar{D}D$ FoM: position resolution & vertex resolution

- strip optimization
  - modules size and shape

    rectangular vs wedge for the disks
  - pitch sizes

Channel: $\bar{p}p \rightarrow \bar{D}D$ FoM: position resolution & vertex resolution

- positions of forward disks and barrels → 'strangeness layout' vs. 'charm layout'
  - number and position of disks
  - Layout of disks – only pixel, mixture of strips and pixel
  - barrel layer radii

Channels: $\bar{p}p \rightarrow \bar{D}D$, $\bar{p}p \rightarrow \Lambda\Lambda$ FoM: secondary vertex resolution, momentum resolution (?)

Simulations: geometry optimization (2)

- variation of sensor thickness (strips and pixels)
  - 200 µm - 100 µm

Channels: $\bar{p}p \rightarrow \bar{D}D$ FoM: position resolution, signal resolution, dE/dx resolution

- sensor sizes and shapes (to optimize material)
  - size and dead zone ratio (for pixel)
  - arrangement options: overlap layout vs straight layout (for pixel and strip)

Channels: $\bar{p}p \rightarrow \bar{D}^*D^*$ FoM: position resolution, momentum resolution, vertex resolution

- structural support, services (cables, cooling,…)
  - different inhomogeneous distributions
  - identify areas to put things

Channels: $\bar{p}p \rightarrow \bar{D}^*D^*$ FoM: position resolution, momentum resolution, vertex resolution

- other layout option
  - effect of target pipe hole
  - constant radius vs. constant angle for beam pipe

Channels: $\bar{p}p \rightarrow \bar{D}^*D^*$ FoM: position resolution, momentum resolution, vertex resolution

Simulations: optimization of performance goals

- optimize $\bar{D}^*D^*$ ($\bar{D}D$) resolving power
  - input needed: efficiency / purity requirements to be settled!
  - limited amount of variation, strategy:

    → key parameters to be defined after basic geometry optimization!

    → keep a number of constraints that are already "established"

    → respect boundary conditions!

    → optimize $\bar{D}^*D^*$ (or $\bar{D}D$), then check background performance

Channels: $\bar{p}p \rightarrow \bar{D}D$ and $\bar{p}p \rightarrow \bar{D}^*D^*$ FoM: D* and D-tag efficiency and purity, secondary vertex resolution