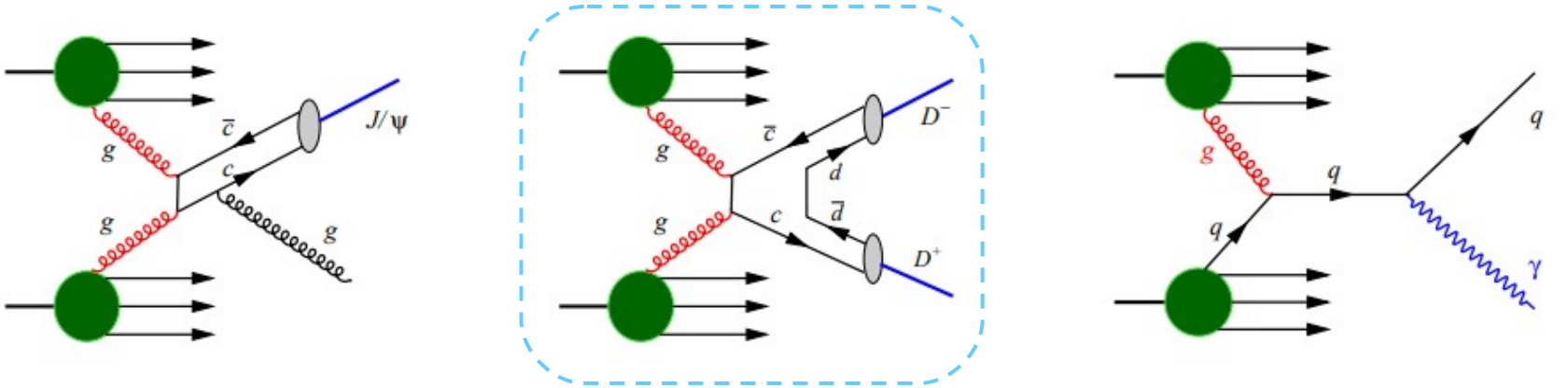
Inner tracker performance

Vasyukov Artem
Email: avasyukov@jinr.ru

Introduction

- **Vertex detector** is responsible for precise determination of the primary interaction point and measurement of the secondary vertices from the decays of short-lived particles.



- On 1st stage Micromegas-based Central tracker will be installed;
- On 2d stage SVD (DSSD or MAPS) is planned to be installed;
- D^0 decay length 123 μm => secondary vertex resolution ~50-80μm is required;
- Previous studies by Amaresh Datta:
  - https://indico.jinr.ru/event/4256/#6-vertex-detector-discussion (PMC#36 20/12/2023)
  - https://indico.jinr.ru/event/4317/#1-prospects-of-d0-tssa-measure (PMC#37 24/01/2024)

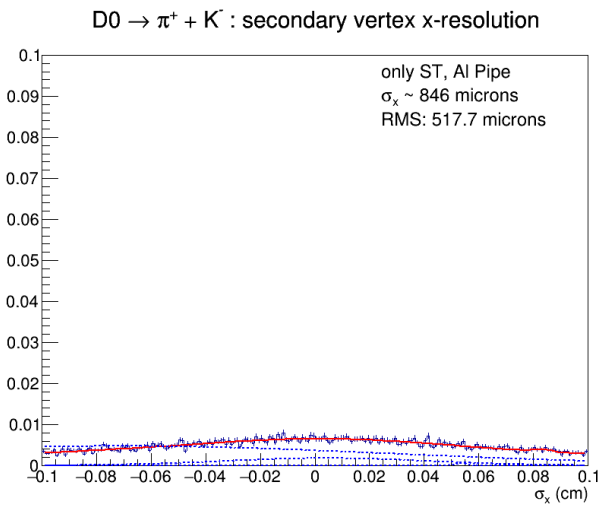
Test description

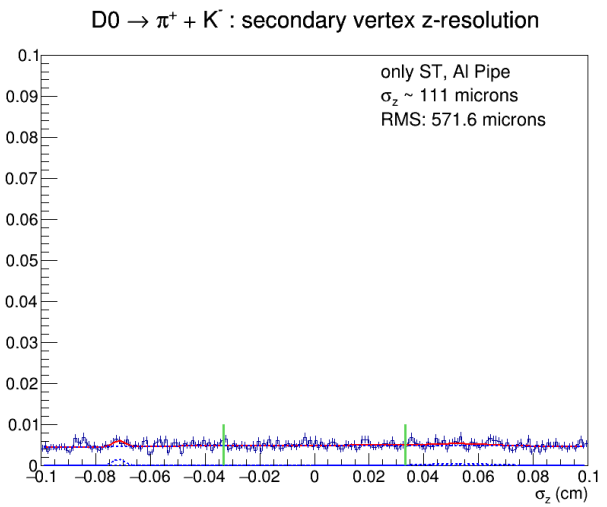
- Pythia 8 + SpdRoot (SpdD0Generator)
- Open-charm process, $D^0 \to \pi^+ K^-$ forced;
- Event vertex Z: Gaussian profile with σ_Z = 30 cm;
- Event vertex X, Y: Gaussian profile with $\sigma_{X,Y}$ = 0.1 cm;
- KFParticle to reconstruct secondary vertex (D^0);
- Resolution obtained from the distribution of (Reco — MC True) secondary vertex positions;
- Detector setup:
  - Aluminium pipe — for stage1 VD;
  - Berrylium pipe — for stage2 VD;
  - Magnetic field;
  - Vertex detector + Straw tracker;

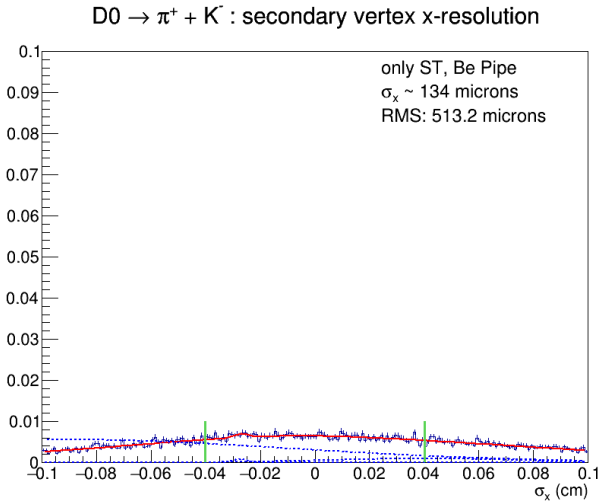
Overview of VD options

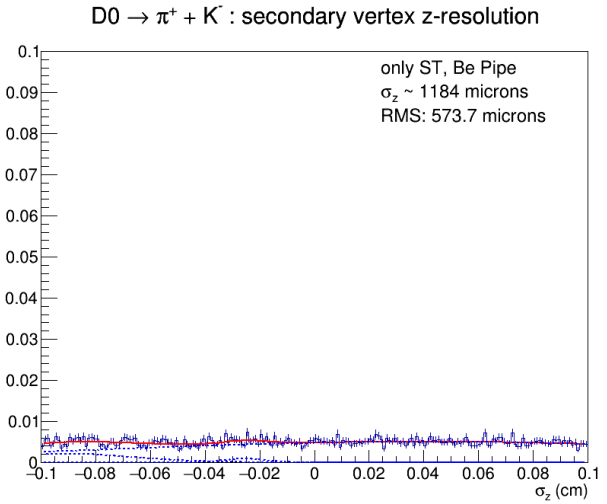
- Only Straw Tracker, no VD – as a starting point;
- MicroMegas-based vertex detector: 1 barrel (super)layer (TDR config.);
  - With electronic modules (types#1,#2);
  - Without electronic modules;
- DSSD TDR config: 3 barrel layers (~0.53%X_0 per layer) + 3 EC layers;
- MAPS-based detector with following configs:
  - **#1** 4 layers in barrel only (~0.8%X_0 per layer), z-length 150 cm;
  - **#2** 2+2 layers in barrel only:
    - (~0.35%X_0 per layer), z-length 74 cm;
    - (~0.8%X_0 per layer), z-length 150 cm;
  - **#3** 4 layers in barrel (~0.35%X_0 per layer), z-length 74 cm + 4 EC layers (~0.3%X_0 per layer);

D^0 vec. resolution | Only straw tracker









Aluminium pipe

- Each normalized distribution is fitted with three gaussians;
- σ is weighted average of two narrow ones within ~3σ range;
- Range shown with **green** lines;
- Third one ignored as it`s almost flat in most cases;

- Only ST shows unsatisfactory performance in the recoconstruction of position of secondary vertex;

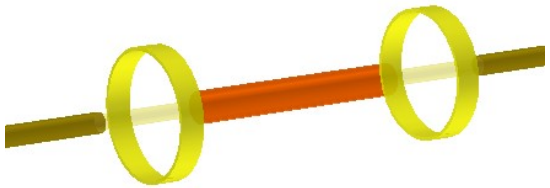
Berrylium pipe

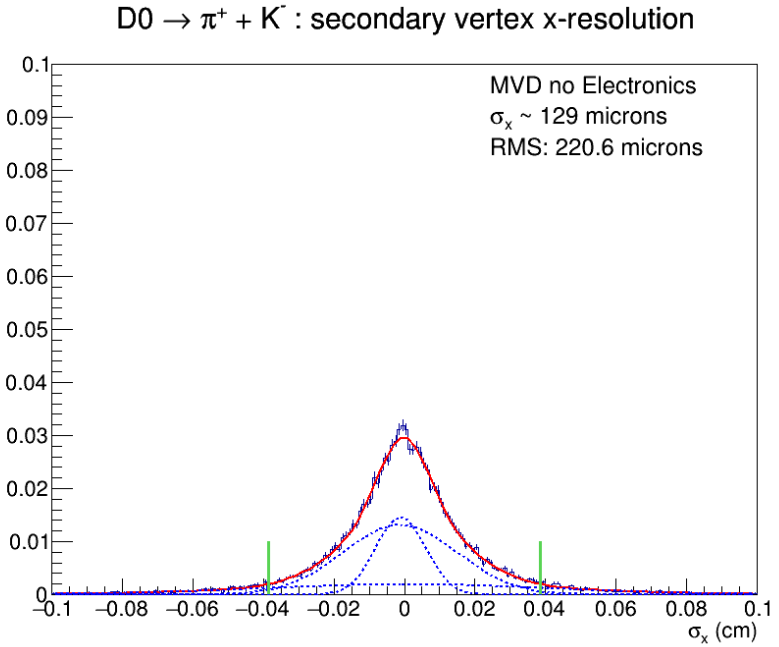
D^0 vec. resolution | MVD w/wo electrics

MVD + no Electronics

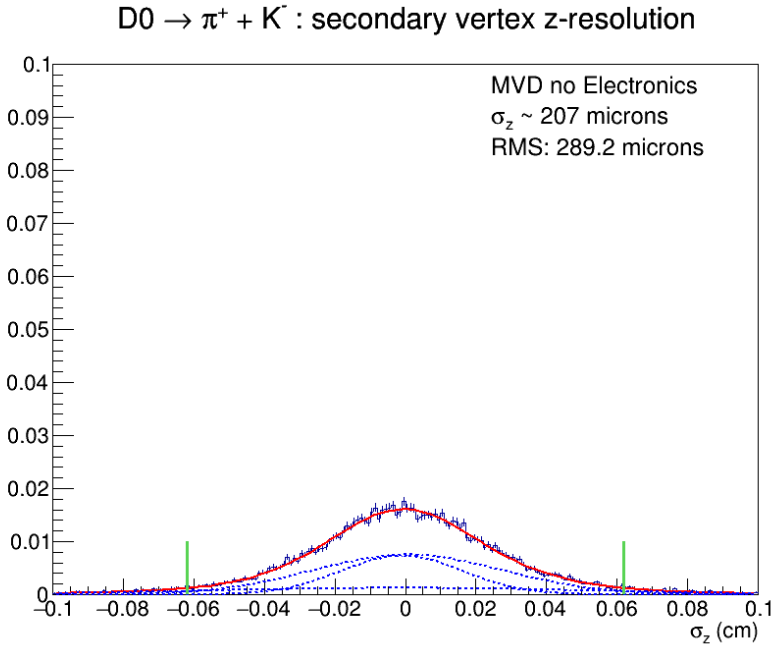
MVD + Electronics#1

MVD + Electronics#2



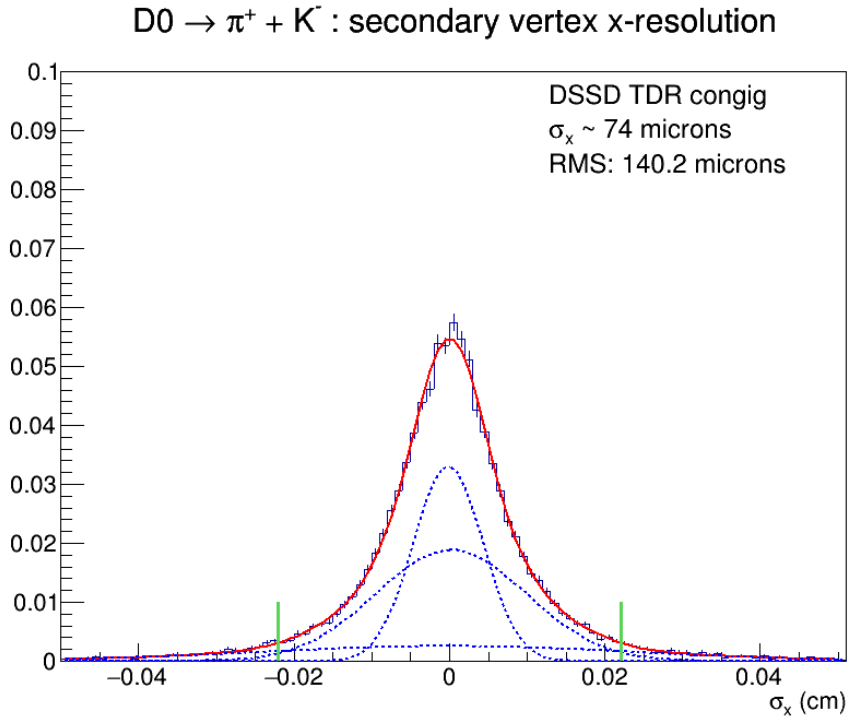


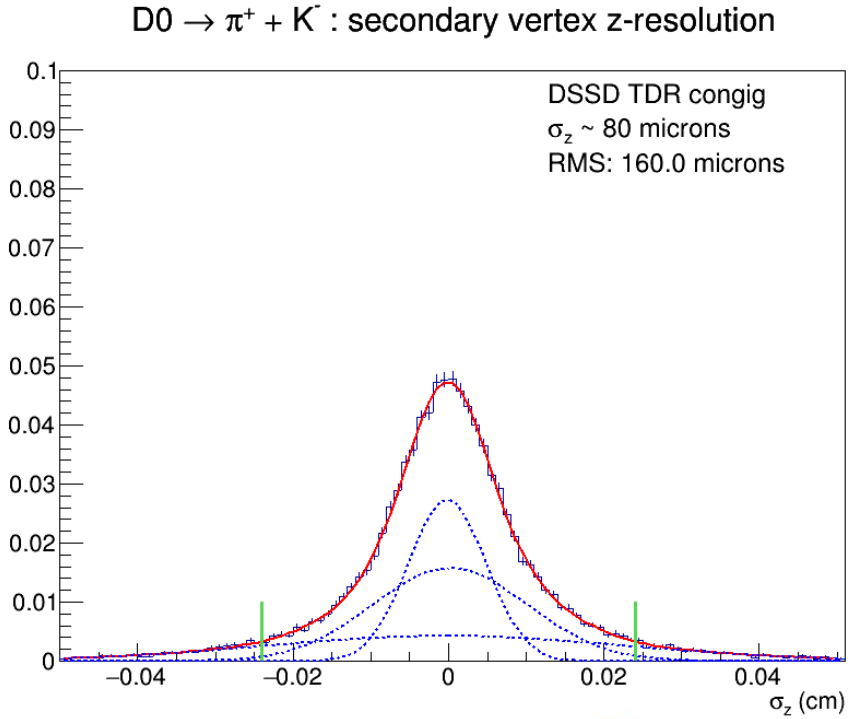
- Electronics#1 (ap.0):
  - σ_X = 153 μm;
  - RMS_X = 223.3 μm;
  - σ_Z = 188 μm;
  - RMS_Z = 291.3 μm;



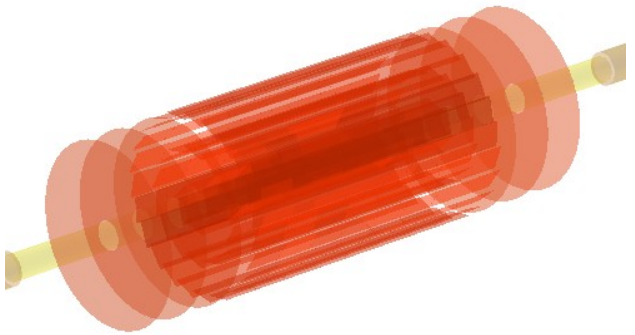
- Electronics#2 (ap.1):
  - σ_X = 119 μm;
  - RMS_X = 221.6 μm;
  - σ_Z = 297 μm;
  - RMS_Z = 291.0 μm;

D^0 vec. resolution | DSSD configuration TDR

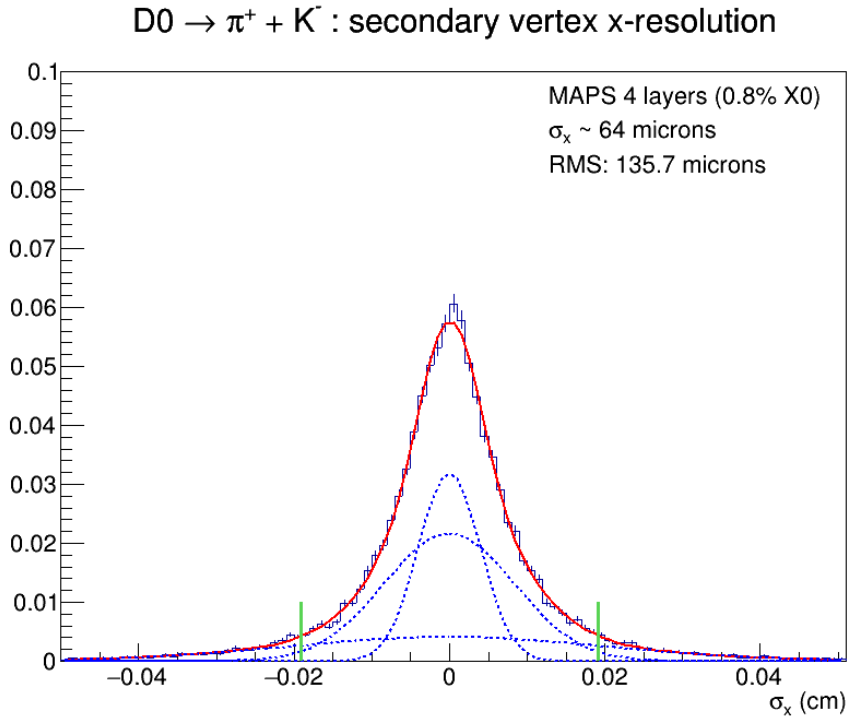


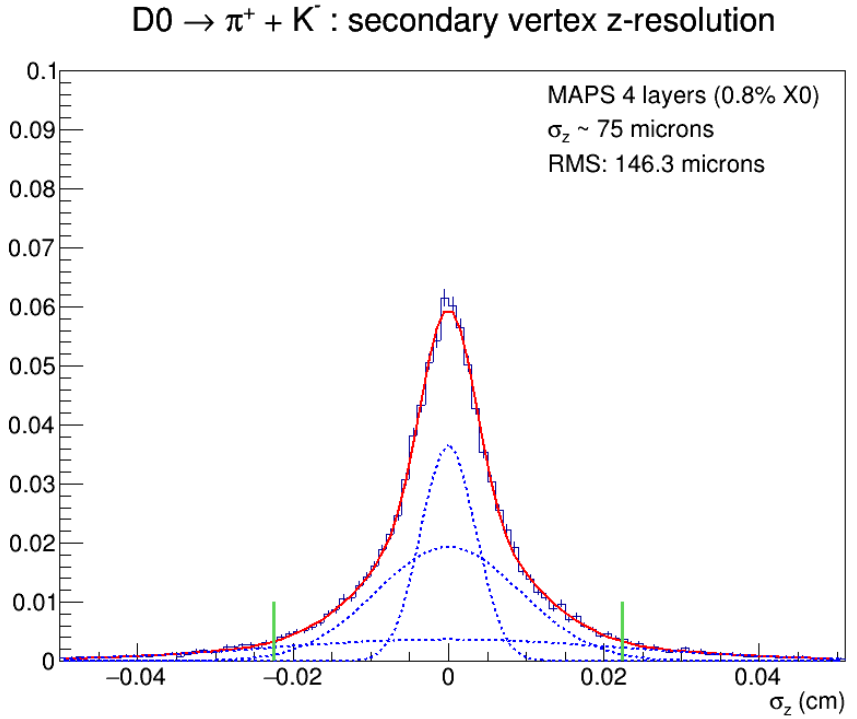


- 3 barrel layers;
- Barrel layer length: 74 cm;
- Barrel layer thickness: 500 μm (0.53% X_0);
- 3 End-Cap disks: width — 300μm, Rmin: 3.5 mm, Rmax: 22 cm;
- Positions of DSSD end-caps:
  - ± 41.45 cm; (TDR)
  - ± 51.45 cm; (TDR)
  - ± 61.45 cm; (TDR)

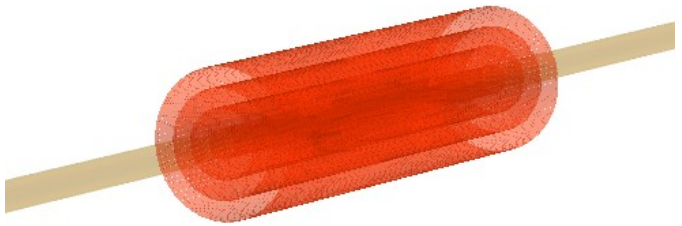


D^0 vec. resolution | MAPS configuration #1

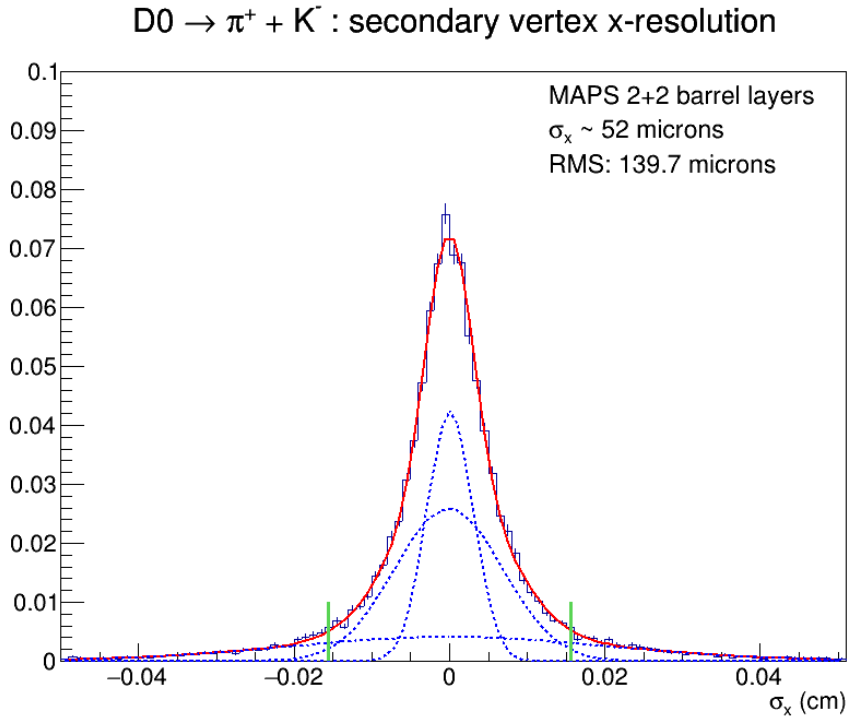


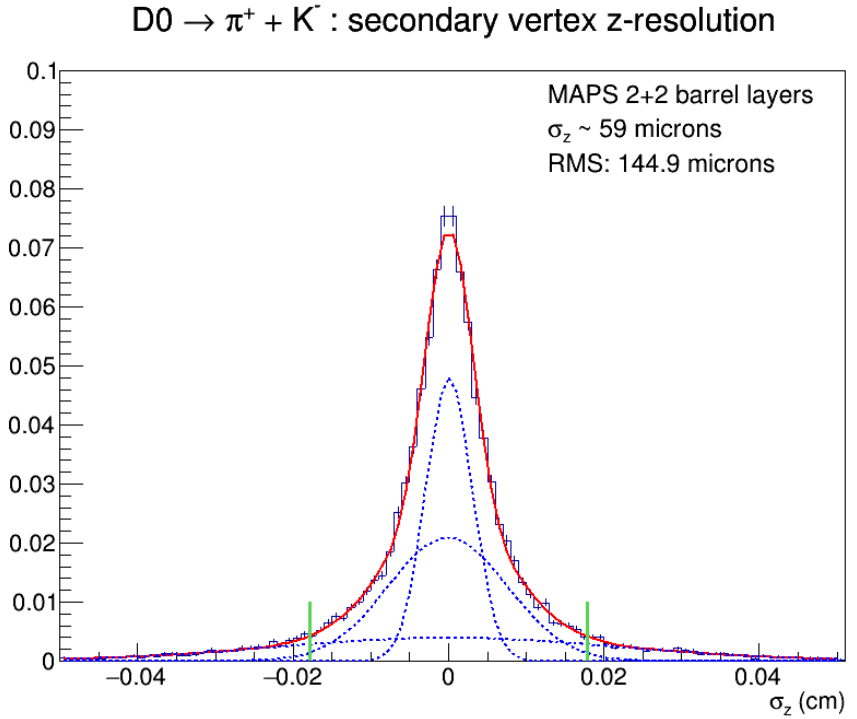


- 4 barrel layers;
- Barrel layer length: 150 cm;
- Barrel layer thickness: 750 μm (0.80% X_0);
- No End-Cap disks;



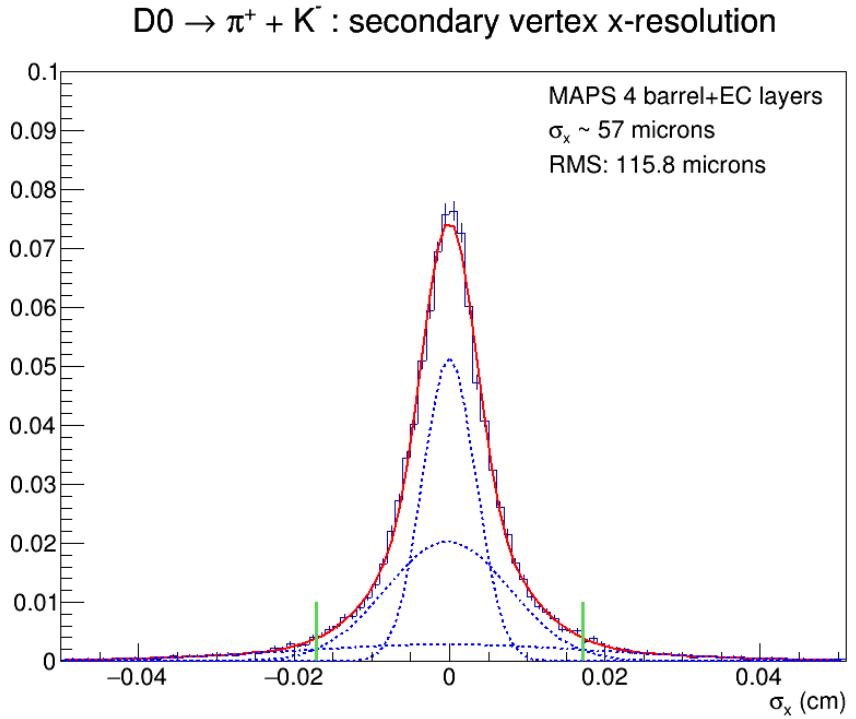
D^0 vec. resolution | MAPS configuration #2

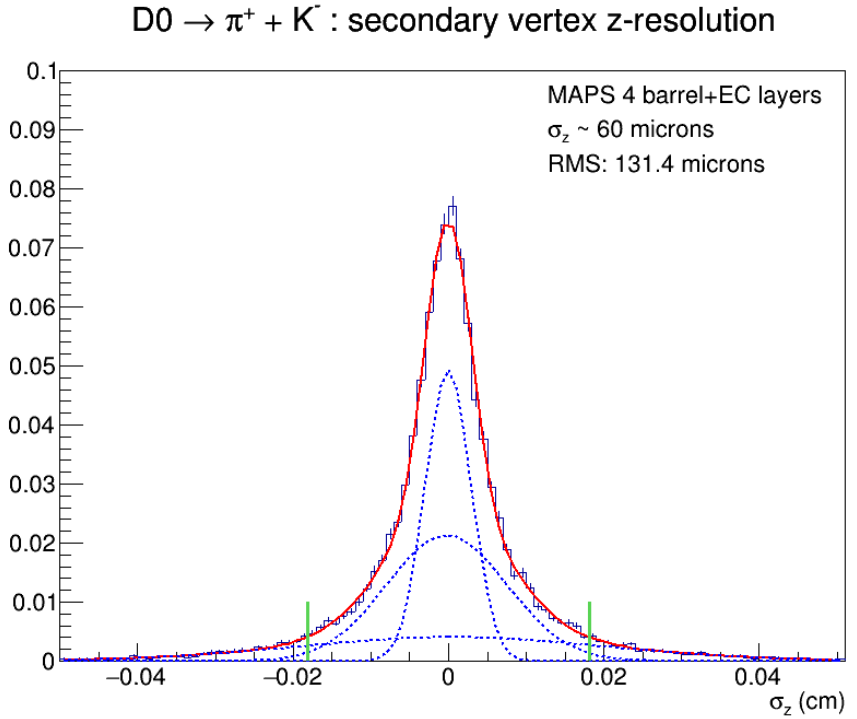




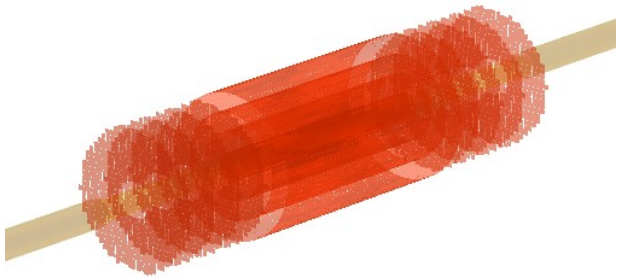
- 4 barrel layers;
- #1, #2 barrel layers length: 74 cm;
- #3, #4 barrel layers length: 150 cm;
- #1, #2 barrel layers thickness: 330 μm (0.35% X_0);
- #3, #4 barrel layers thickness: 750 μm (0.80% X_0);
- No End-Caps;

D^0 vec. resolution | MAPS configuration #3

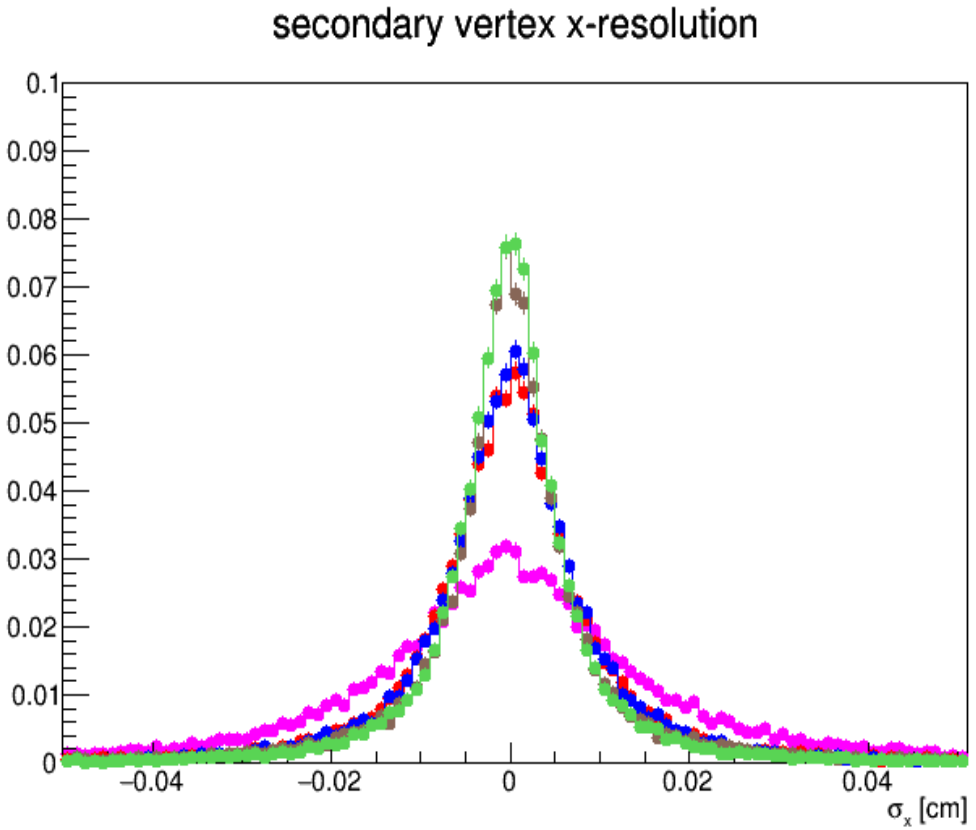


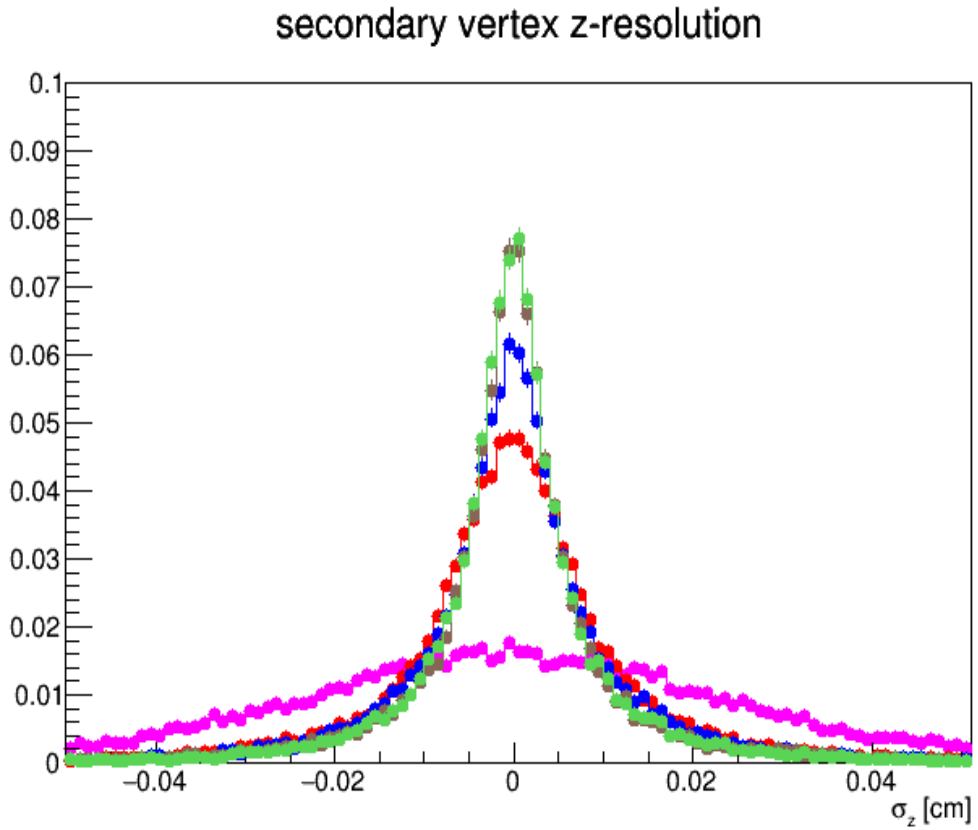


- 4 barrel layers;
- Barrel layers length: 74 cm;
- Barrel layers thickness: 330 μm (0.35% X_0);
- 4 End-Cap disks:
  - ➔ $|Z_{pos}|$ = 45, 55, 65, 75 cm;
- EC disks thickness: 290 μm (0.3% X_0)



D^0 vec. resolution | Different options for VD





MVD **MAPS#1** **MAPS#3**
DSSD **MAPS#2**

Conclusion

- SVD is needed to achieve the required secondary vertex position resolution resolution;
- MAPS is still better than DSSD:
  - At least ~10% (σ_z & RMS) better resolution in beam direction for MAPS#1;
  - ~30% σ_z & ~25% RMS better resolution in beam direction for MAPS#3;

ToDo

- Reconstruction efficiency depending vertex position study;
- Realistic description of DSSD End-caps;
- Re-checking the need for subsystems to reconstruct events with large x_F^{D0} values;