Vertex Detector Discussion

Amaresh Datta (amaresh@jinr.ru)

DLNP
Dubna, Russia

Dec 20, 2023

Vertex Detector Resolutions and other things ...

- Repeat presentation from Nov 28 Weekly Physics Meeting
- We looked at different configurations for silicon vertex detector for TDR update
- Comparisons between :
  1. MAPS configurations from TDR and MAPS configuration used for D meson study ('wishlist')
  2. TDR configurations of three options for VD : DSSD, MAPS, MicroMegas (one superlayer)

Vertex Detector Configurations

- MicroMegas TDR config : 1 (super)layer barrel, barrel z-length = 90 cm, layer thickness $\sim$ 1120 μm ($3 \times 0.4\%\ X_0$)
- DSSD TDR config : 3 layers barrel + 3 layers endcap, barrel z-length 74 cm, layer thickness 500 μm ($\sim 0.53\%\ X_0$ in Si, $X_0 = 9.37$ cm)
- MAPS TDR config : 4 layers in barrel only, z-length 150 cm, layer thickness 750 μm ($\sim 0.8\%\ X_0$)
- MAPS 'wishlist' config : 4 layers barrel + 4 layers endcap, barrel z-length 74 cm, layer thickness 330 μm ($\sim 0.35\%\ X_0$)

Possible Inner Tracker Configurations

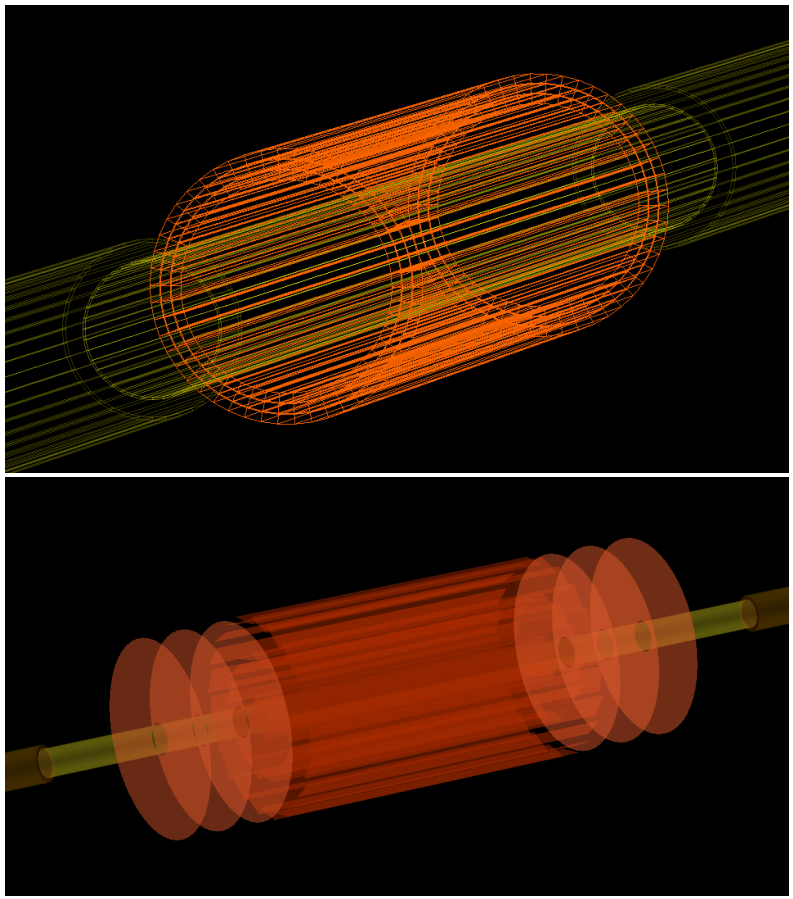


Figure 1: MicroMegas (above) and DSSD (below) TDR versions

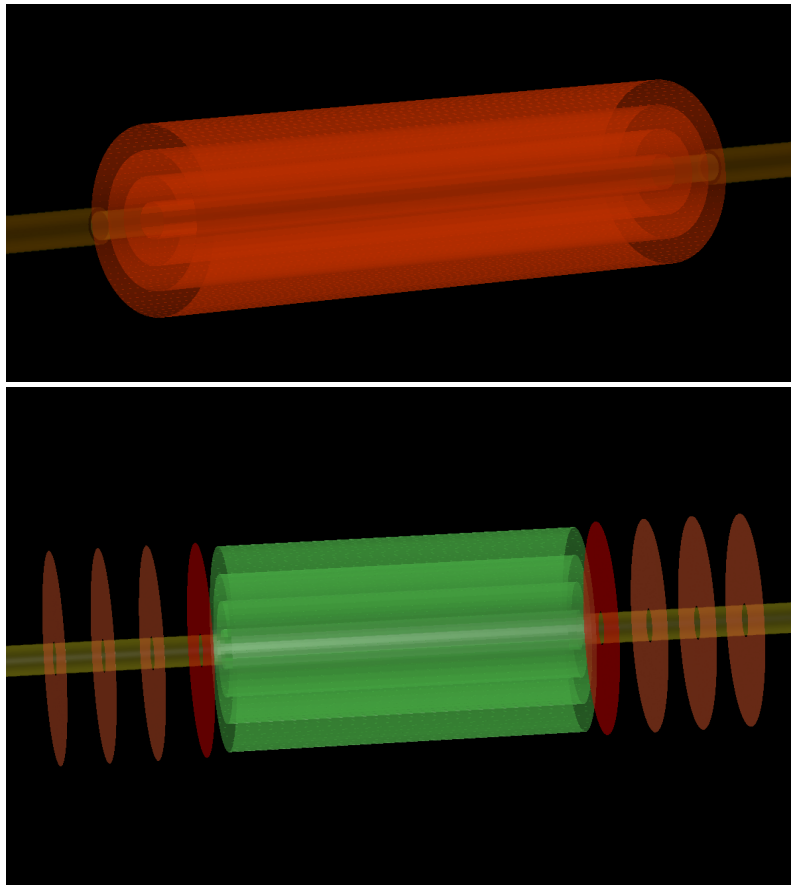


Figure 2: MAPS : TDR (above) and 'wishlist' (below) configurations

Simulation Details

- Pythia8 + SpdRoot
- Open-charm process, $D^0 \rightarrow \pi^+ K^-$ forced
- Event vertex Z : Gaussian profile with $\sigma_z = 30$ cm
- KFParticle to reconstruct secondary vertex (D^0)
- Resolution obtained from the distribution of (Reconstructed - MonteCarlo True) positions

Sec Vtx Resolutions : Closer Look : DSSD TDR

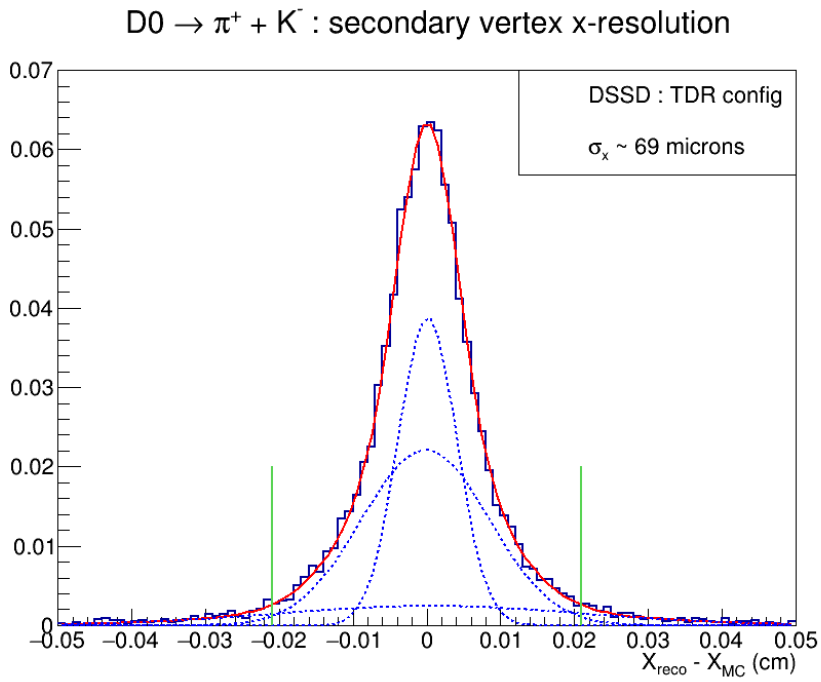


Figure 3: DSSD TDR config : x-direction

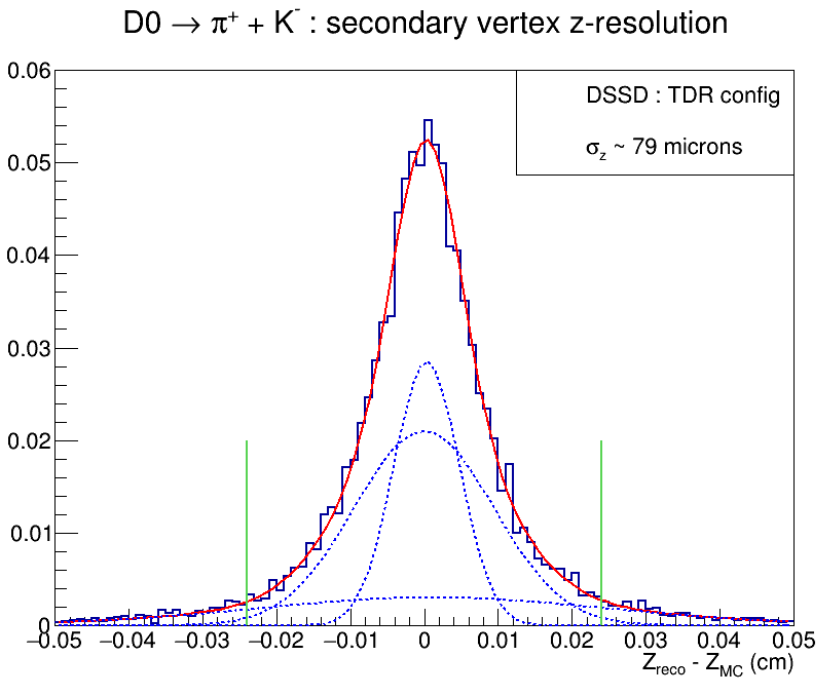


Figure 4: DSSD TDR config : z-direction

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 background.

Sec Vtx Resolutions : Closer Look : MAPS TDR

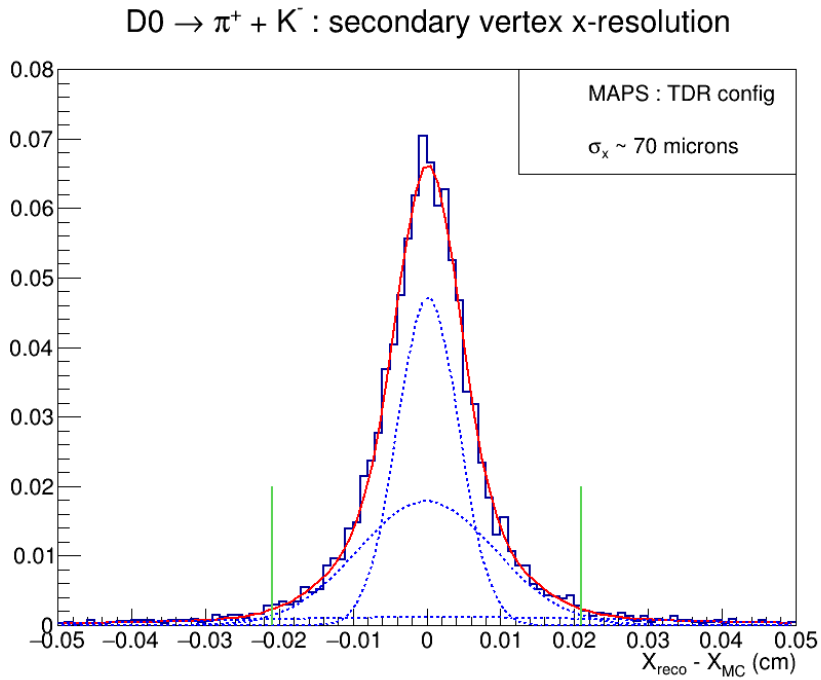


Figure 5: MAPS TDR config : x-direction

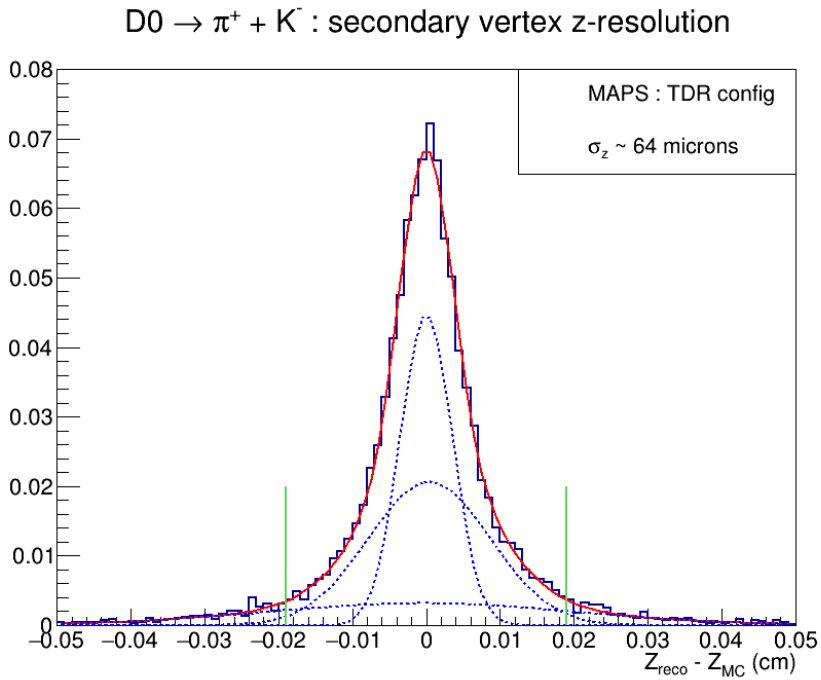


Figure 6: MAPS TDR config : z-direction

Fitted with two Gaussians, quoted σ is weighted average

Sec Vtx Resolutions : Closer Look : MAPS 'Wishlist'

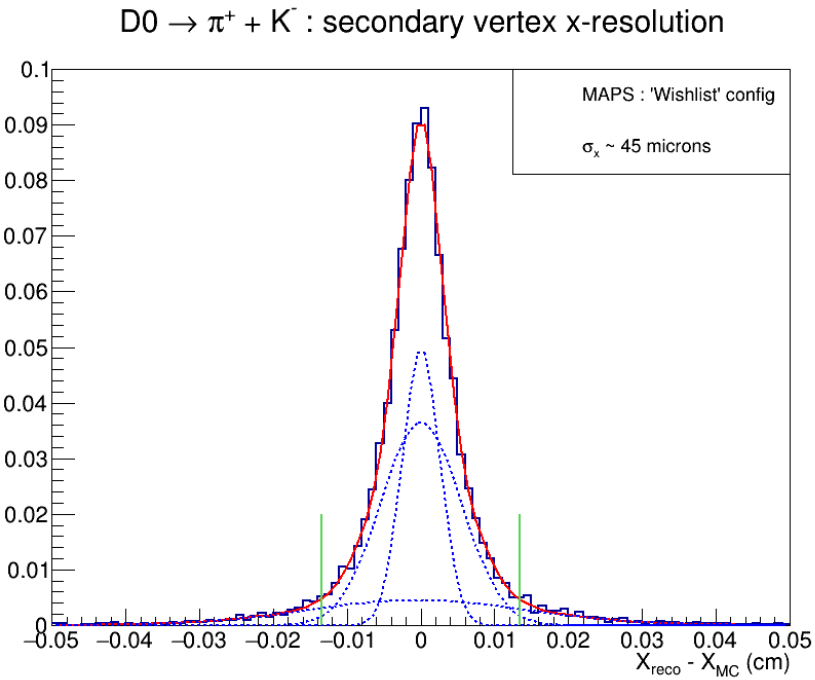


Figure 7: MAPS 'Wishlist' config : x-direction

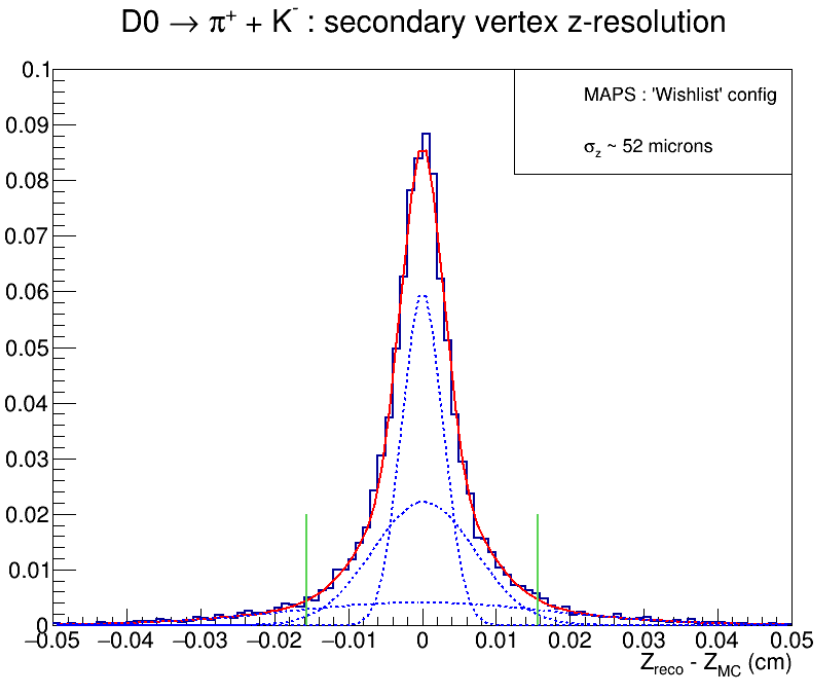


Figure 8: MAPS 'Wishlist' config : z-direction

Fitted with two Gaussians, quoted σ is weighted average

Sec Vtx Res Comparison : MAPS Configs

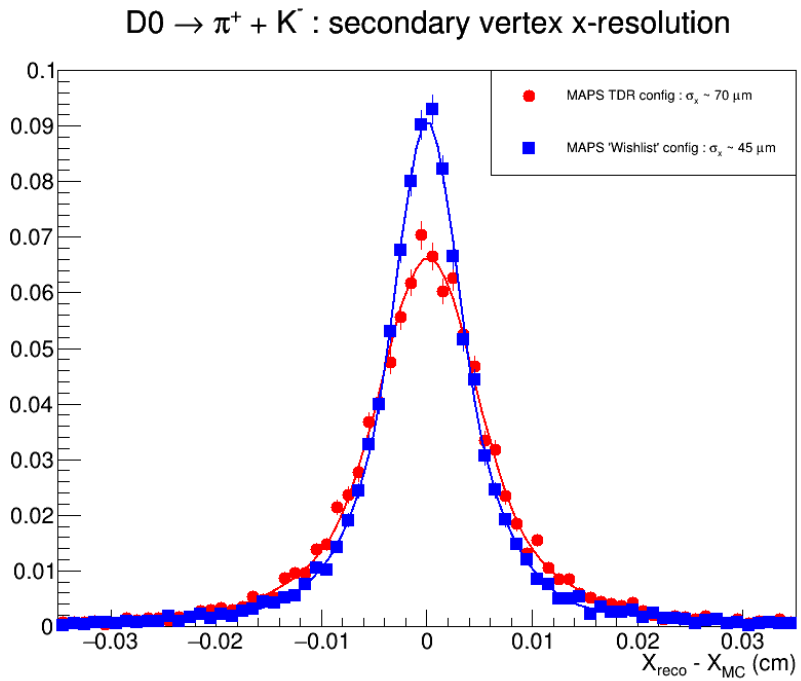


Figure 9: Different MAPS config. resolutions : x-direction

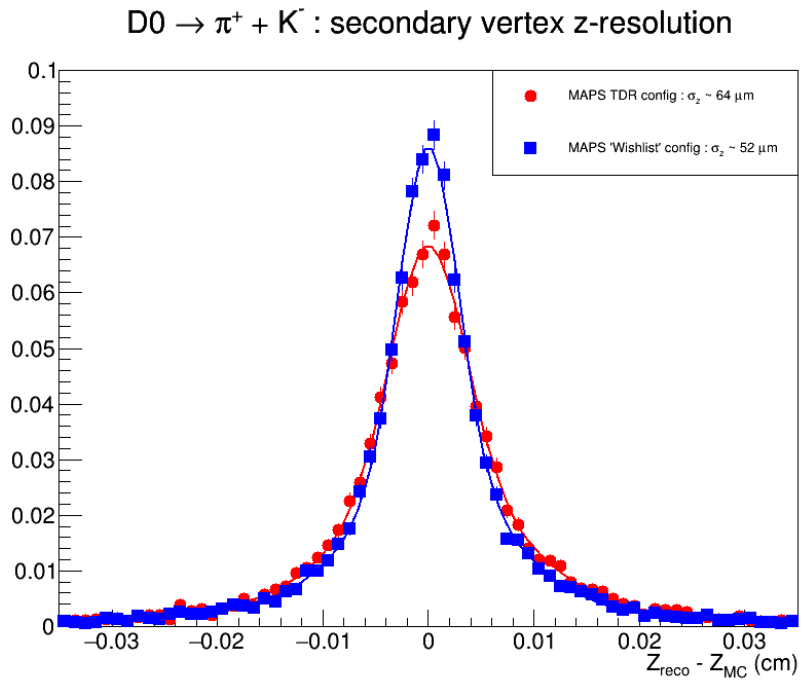
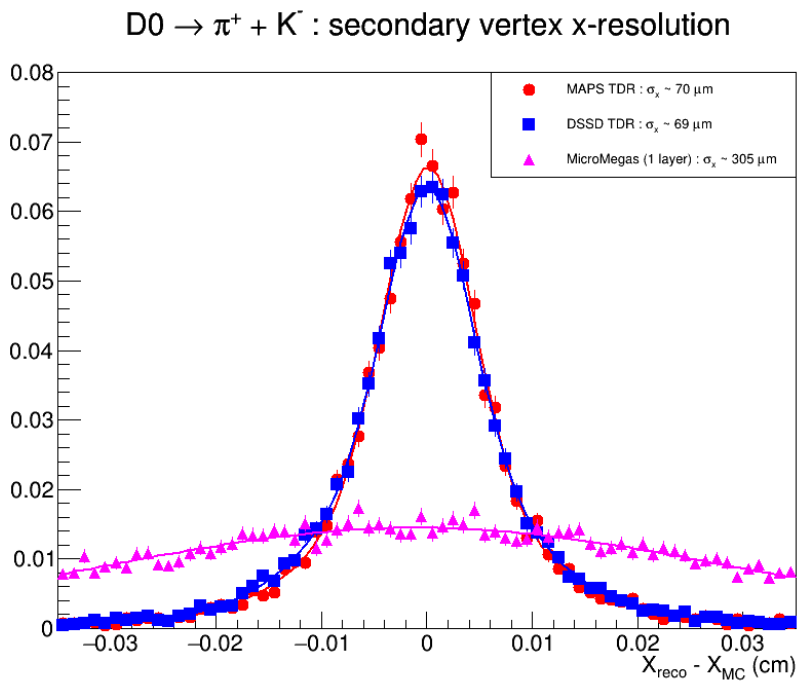


Figure 10: Different MAPS config. resolutions : z-direction

20% better Z-resolution with 'wishlist' configuration : less material budget, endcap included

Sec Vtx Res Comparison : TDR Options for VD



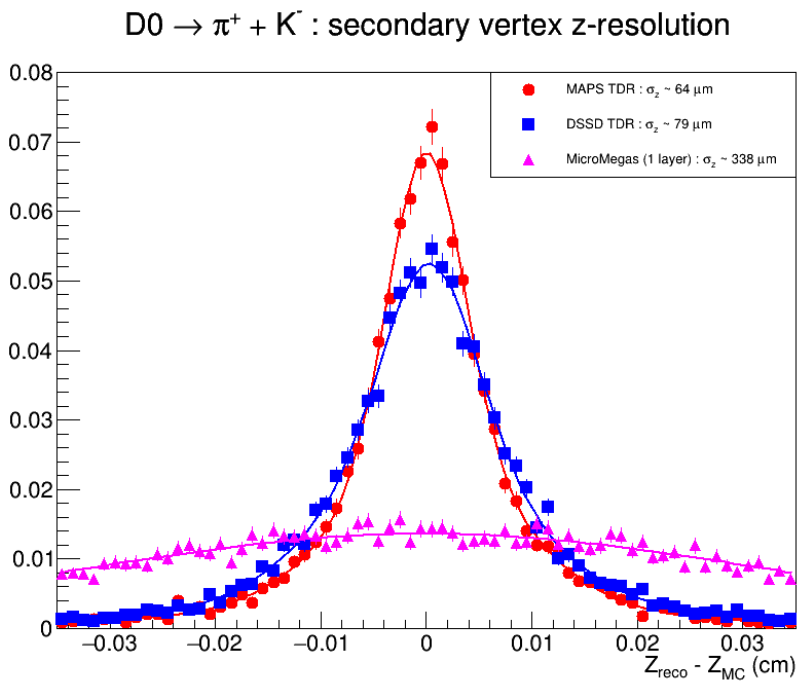


Figure 11: VD resolutions : x-direction

Figure 12: VD resolutions : z-direction

$\sim$ 20% better Z-resolution for MAPS compared to DSSD, both TDR configurations. MicroMegas is of no use for Stage II physics

Vertex Detector : Importance of EndCaps

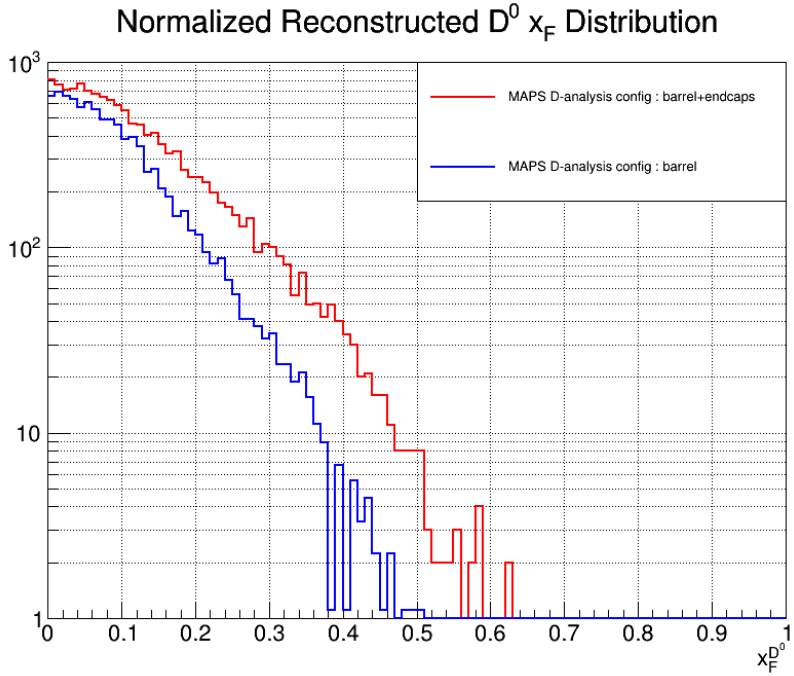


Figure 13: Reconstructed $x_F^{D^0}$ with and without Endcaps

- 'Wishlist' MAPS configuration : 4 barrel layers, 4 endcap layers, barrel layer z-length 74 cm, layer thickness 330 μm
- x_F distribution of reconstructed D^0 shows more counts with endcaps
- Factor of 2-3 gain at $x_F = 0.2, 0.3, 0.4$
- Further reach in x_F as well

Ideas from a Neighbour

Nuclear Inst. and Methods in Physics Research, A 985 (2021) 164668

Contents lists available at ScienceDirect

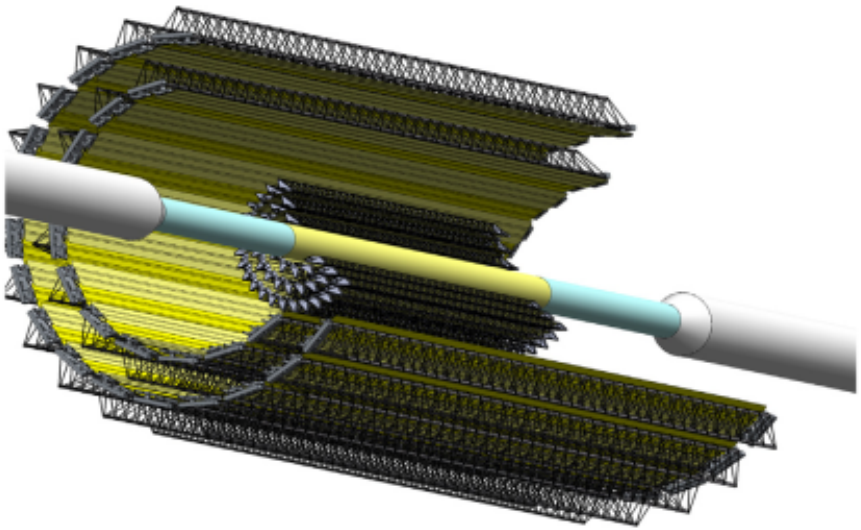
Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

The concept of the MPD vertex detector for the detection of rare events in Au+Au collisions at the NICA collider

V.I. Zherebchevsky*, V.P. Kondratiev, V.V. Vechernin, S.N. Igolkin

St.Petersburg State University, 7-9, Universitetskaya nab., St.Petersburg, 199034, Russia



succeeding layer. The characteristics of the vertex detector layout used in the calculations, assuming an average radius: $(R_{min} + R_{max})/2$, an intrinsic resolution of 4 μm both in transverse ($r\varphi$) and longitudinal (z) planes, and a material budget (detectors + cables) of 0.3% of X_0 for each layer, are shown in Table 2. A beryllium beam pipe with a wall

- NIM article from V.I. Zherebchevsky (also SPD member) et al. gives a posisble MAPS SVD for MPD
- Three layers of length 75 cm and two of 150 cm
- It quotes material budget per layer as 0.3% X_0, which sounds very hopeful for us

Summary

- Speaking about Stage II physics :
- MAPS (even as described in TDR, which is not ideal) is better that DSSD ($\sim 20\%$ better resolution in beam direction)
- A 'wishlist' configuration would be $\sim 20\%$ better than the current TDR version of MAPS (or $\sim 34\%$ better than DSSD)
- That 'wishlist' configuration particularly includes Endcaps which is *very* important for decent D-meosn A_N measurements (above $x_F = 0.2$)
- As Alexey Guskov put it, it's a multi-million dollar question exactly how essential is SVD for stage II physics analysis - running simulations without SVD - hopefully shall present after the Holidays to show it is necessary for D-meson analysis