Updates on D0 Reconstruction Study

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Vertex Reconstruction

- Ongoing detailed study of algorithms and performance of vertex reconstruction in SpdRoot
- With an ultimate goal to standardize D0 detection analysis at SPD
- In collaboration with Vladimir Andreev
- Regular discussions with Igor Denisenko
- We shall look at PV, SV reconstruction and some properties from reconstructed V0 of (π, K) daughter candidates

Simulation Details

- Subsystems : Beam-pipe, Inner Tracker, Straw Tracker, Magnet
- Magnetic field : Bz = 1 T in box geometry
- Silicon Inner Tracker : MAPS, 4 layers, no end-cap
- Thickness 330 μm (0.35% X_0), radii : 40, 96, 152 and 210 mm
- Event vertex (0,0,0), no smearing applied
- Reconstruction required minimum p_T of 200 MeV
- Minimum bias (except elastic) for background study and opencharm channels for signal (D0 meson)
- $D^0 \to \pi^+ K^-$ channel forced to enhance statistics in simulation (originally branching ratio 3.89%)

Analysis Details

- V0 reconstuction with KFParticle package, constrained to primary vertex
- Require all 4 ITS hits for daughter (π, K) track candidates
- SpdVertexCombiFinder used to reconstruct all possible combinations of (π,K) in minbias event
- Mass window cut (1.75 - 1.98 GeV/c^2) applied for all cases for both signal D0 and random background from MB
- Three cases :
  1. case 1 : beampipe/ITS material 'air', no V0 x_F cut
  2. case 2 : Be beampipe, silicon ITS, no V0 x_F cut
  3. case 3 : Be beampipe, silicon ITS, V0 $|x_F| > 0.2$ (in backup)

Primary Vertex Resolutions : case 1

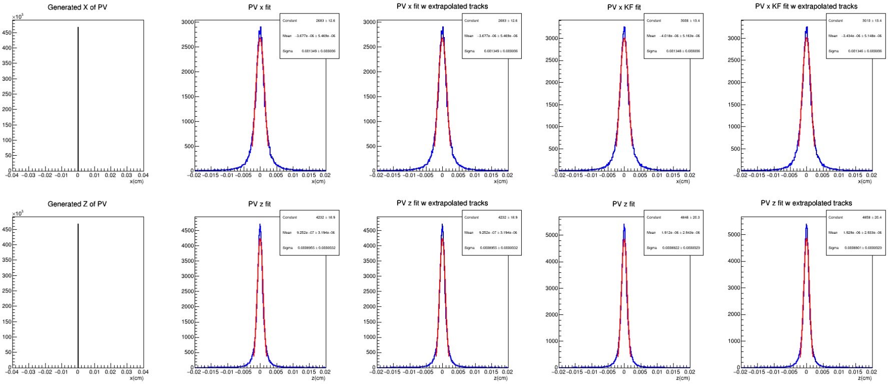


Figure 1: Primary vertex reconstruction, X (upper row) and Z (lower row). Column 1 generated, column 2,3 standard algorithm, column 4,5 KFParticle reconstruction

Primary Vertex Resolutions : case 1

1. std algorithm, std track : $\sigma_x = 13.5\ \mu m, \sigma_z = 8.9\ \mu m$
2. std algorithm, extrapolated track : $\sigma_x = 13.5\ \mu m, \sigma_z = 8.9\ \mu m$
3. KFParticle, std track : $\sigma_x = 13.5\ \mu m, \sigma_z = 8.8\ \mu m$
4. KFParticle, extrapolated track : $\sigma_x = 13.5\ \mu m, \sigma_z = 8.9\ \mu m$

Primary Vertex Resolutions : case 2

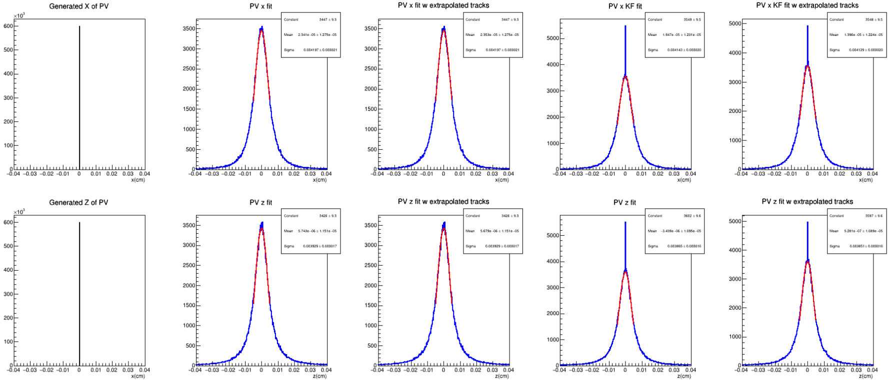


Figure 2: Primary vertex reconstruction, X (upper row) and Z (lower row). Column 1 generated, column 2,3 standard algorithm, column 4,5 KFParticle reconstruction

Primary Vertex Resolutions : case 2

1. std algorithm, std track : $\sigma_x = 42.0\ \mu m, \sigma_z = 39.3\ \mu m$
2. std algorithm, extrapolated track : $\sigma_x = 42.0\ \mu m, \sigma_z = 39.3\ \mu m$
3. KFParticle, std track : $\sigma_x = 41.4\ \mu m, \sigma_z = 38.7\ \mu m$
4. KFParticle, extrapolated track : $\sigma_x = 41.3\ \mu m, \sigma_z = 38.5\ \mu m$

Effect of multiple scattering significant
Failed initial PV reconstructions store default (0,0,0) value that shows up in the KF reconstruction of PV. Need to remove these events manually.

Secondary Vertex Resolutions : case 1

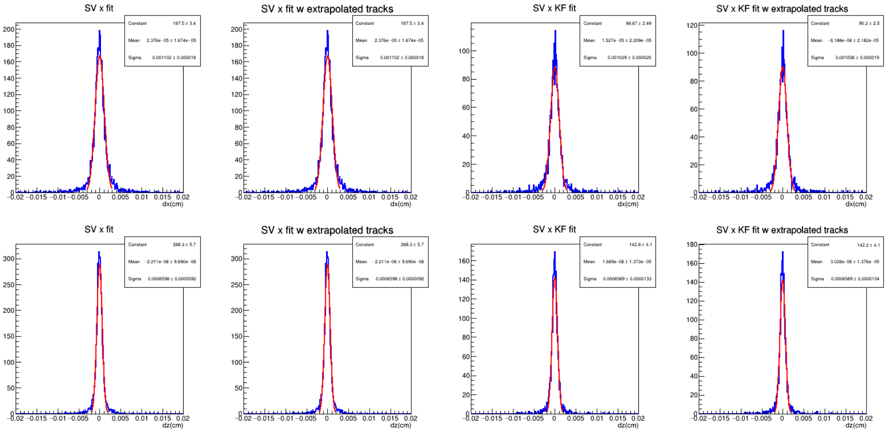


Figure 3: Primary vertex reconstruction, X (upper row) and Z (lower row). Column 1,2 standard algorithm, column 3,4 KFParticle reconstruction

Secondary Vertex Resolutions : case 2

1. std algorithm, std track : $\sigma_x = 11.0\ \mu m, \sigma_z = 6.6\ \mu m$
2. std algorithm, extrapolated track : $\sigma_x = 11.0\ \mu m, \sigma_z = 6.6\ \mu m$
3. KFParticle, std track : $\sigma_x = 10.3\ \mu m, \sigma_z = 6.6\ \mu m$
4. KFParticle, extrapolated track : $\sigma_x = 10.1\ \mu m, \sigma_z = 6.6\ \mu m$

Secondary Vertex Resolutions : case 2

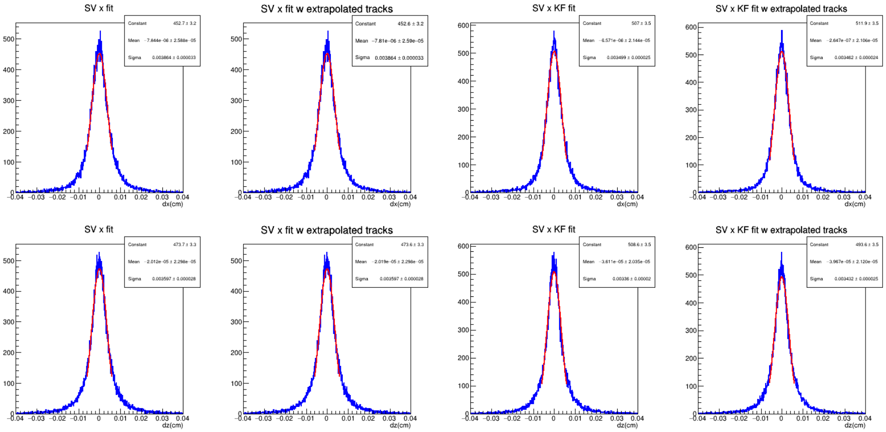


Figure 4: Primary vertex reconstruction, X (upper row) and Z (lower row). Column 1,2 standard algorithm, column 3,4 KFParticle reconstruction

Secondary Vertex Resolutions : case 2

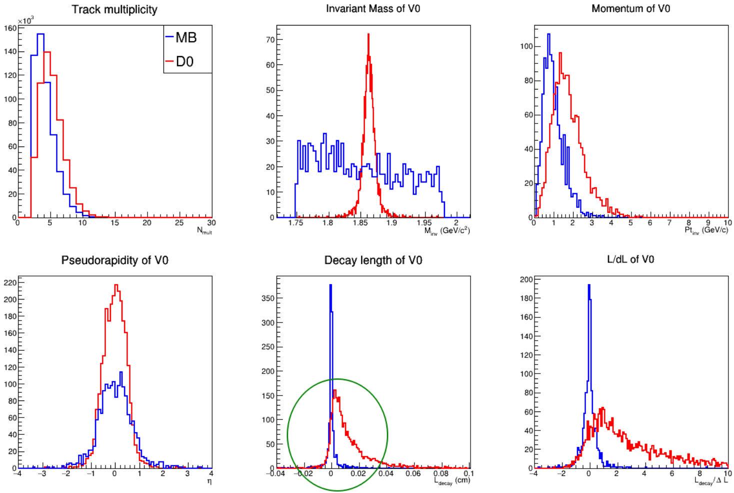
1. std algorithm, std track : $\sigma_x = 38.6\ \mu m, \sigma_z = 36.0\ \mu m$
2. std algorithm, extrapolated track : $\sigma_x = 38.6\ \mu m, \sigma_z = 36.0\ \mu m$
3. KFParticle, std track : $\sigma_x = 35.0\ \mu m, \sigma_z = 33.6\ \mu m$
4. KFParticle, extrapolated track : $\sigma_x = 34.6\ \mu m, \sigma_z = 34.3\ \mu m$

Significant effect of multiple scattering in early material
KFParticle V0 reconstruction slightly better than standard algorithm

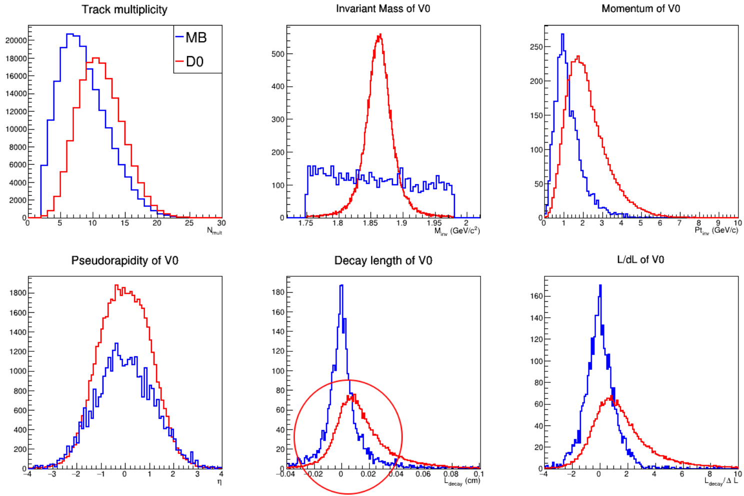
Comparison of Relevant Variables from Signal(D0) and Background(MinBias)

- set 01 : multiplicity, mass, momentum, pseudo-rapidity, decay length, decay length divided by uncertainty
- set 02 : χ^2 and DCA of pi/K tracks to PV, to SV and between pi-K
- set 03 : V0 χ^2 to PV, V0 fit χ^2, 2-D transverse momenta of pi,K, opening angle between pi-K, collinearity angle (between V0 momentum and vector from PV to SV)
- case 1, case 2, case 3 (in backup) as defined before

Comparison S and B 01 : case 1



Comparison S and B 01 : case 2



Issue with Negative Decay Length

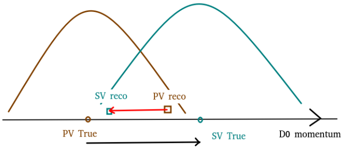
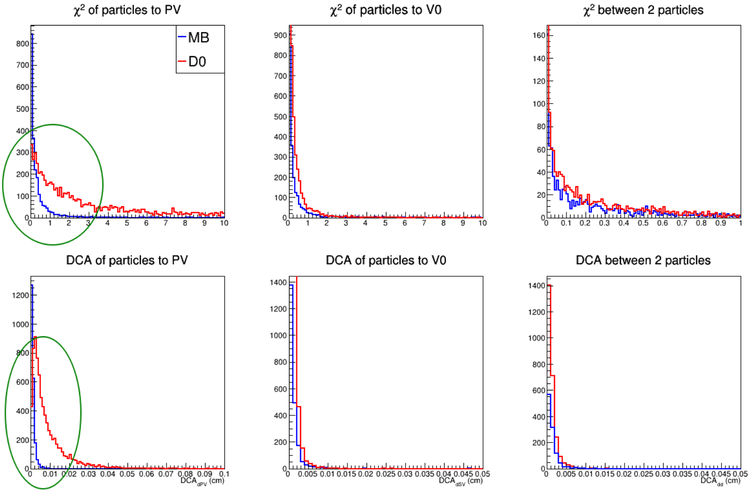


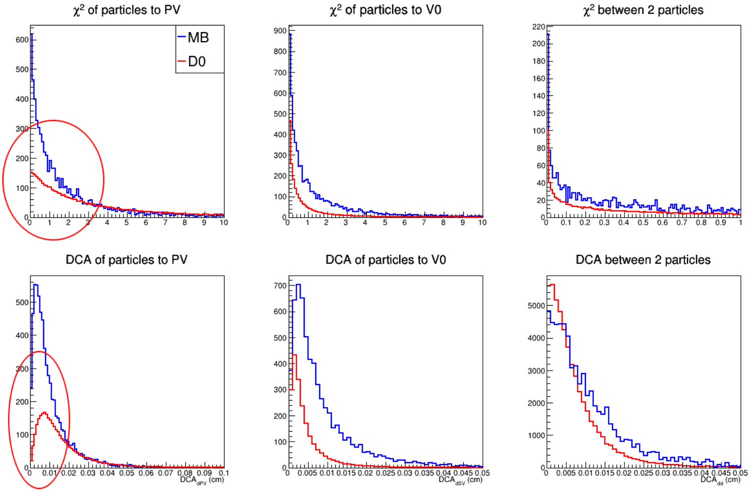
Figure 5: Diagram for negative decay length

- If the vector from reconstructed PV to reconstructed SV is opposite to V0 momentum, the decay length is negative
- It is an artifact of resolution and as such wrong estimations of PV and SV and should be thrown away
- Notice that minbias background is symmetrically distributed around zero as expected for random comb SV very close to PV
- Notice how much the effect is smeared due to multiple scattering in early material

Comparison S and B 02 : case 1



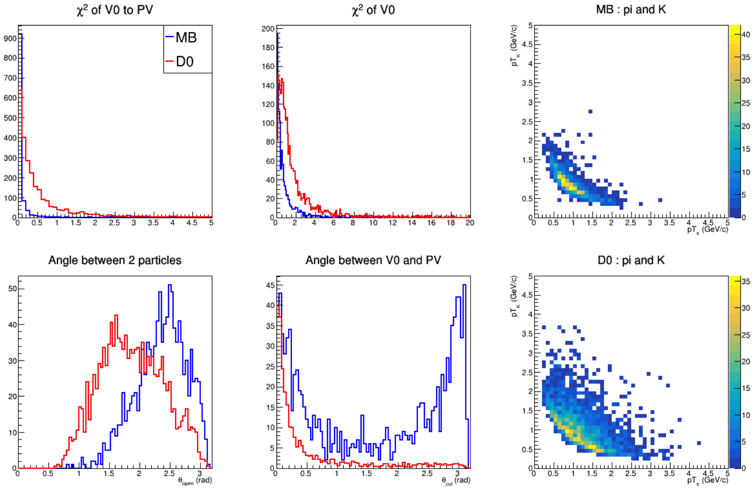
Comparison S and B 02 : case 2



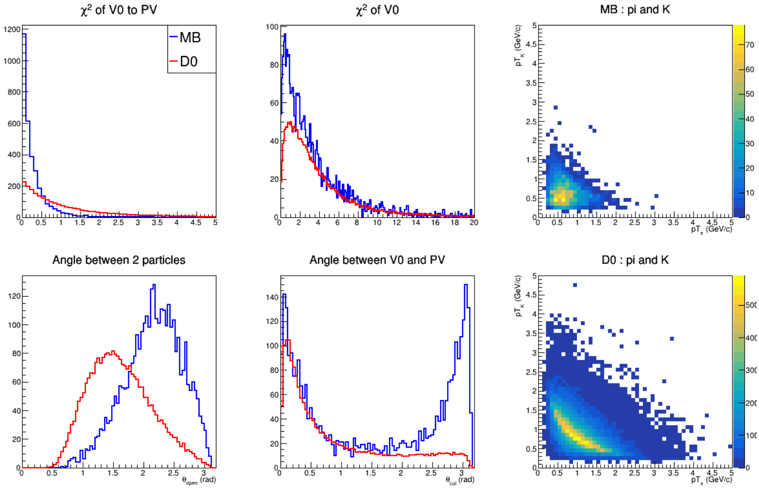
Issue with Impact Parameter

- A powerful variable to separate random combination from real V0
- CBM and MPD both use this variable to great effect (however, theirs being Au+Au systems, their randoms are more 'random' than ours)
- Material stripped version show exactly what we expect (and what I mentioned a few times in my previous talks)
- Narrow distribution for bkg and thick tail for sig : both in χ^2 and DCA/impact parameter
- Notice how these distributions are smeared due to multiple scattering - making it difficult to put a cut effectively to suprpess bkg

Comparison S and B 03 : case 1



Comparison S and B 03 : case 2



Issue with Collinearity Angle

- Another very useful variable for CBM and MPD analyses
- In their cases, pointing/collinearity angle is very narow and small angle for signal and almost uniform over large angles for random background
- Unfortunately again, random combinations in N-N collisions are more random than in p-p collisions
- This variable, is not as useful to us (it will remove about 1/2 the background for us rather than 95%)

Estimates of counts : Halfway 'Realistic'

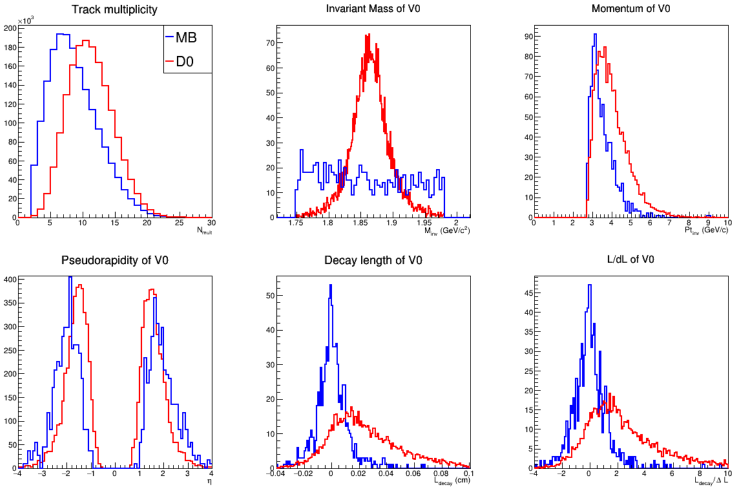
- For cross-sections :
- 1 M open-charm events : 3402 reco D0, no x_F cut
- 1 M minbias events : 12726 reco V0, no x_F cut
- For asymmetries :
- 1 M open-charm events : 440 reco D0, $x_F \geq 0.2$
- 1 M minbias events : 360 reco V0, $x_F \geq 0.2$
- CDR estimates 360 M D^0 'produced'/year, for asymmetry analysis, statistics will depend on 'online selection' of events
- By ratio of cross-sections, $\sim$ 22K more bkg produced
- Also, it makes less than 1% efficiency of D^0 detection (*I may have applied strict ITS hit requirement for all tracks - losing events with missing reco PV*)

Summary

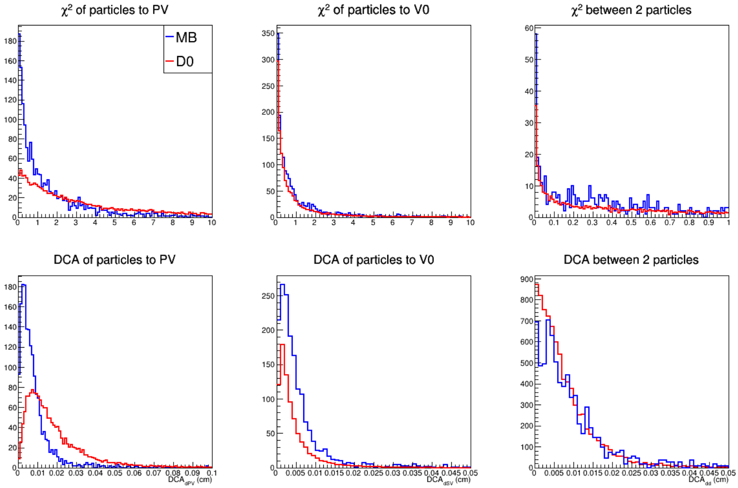
- Do we have too much material in beampipe+inner tracker? We clearly see how they distort some useful variables
- Next steps : apply vertex smearing
- To truly test the effectiveness of analysis cuts (expecteing orders of magnitude reduction), I will require to produce AT LEAST 1000 times more minbias events
- Producing $\sim$ 1 B events is extremely tedious for individuals, especially the hugse disk space required is untenable for single user
- My analysis chain simulates+reconstructs+analyzes and only saves histogram. Throwing away reconstructed data is very inefficient
- Important : We need a repository of large (1-10 B) simu+reco MinBias data as SPD conveninece so I and others can analyze

Backup

Comparison S and B 01 : case 3



Comparison S and B 02 : case 3



Comparison S and B 03 : case 3