SPD meeting,
7 October 2020

Reconstruction of short-lived particles in SPD experiment (update)

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Ideal V^0 finder (selection)

Selection criterion in KF Particle package:

1. select tracks (primary and secondary) on the base of chi2 of track and primary vertex (rec and sim)

$$\chi^2_{prim} = \Delta\mathbf{r}^T (C_{track} + C_{PV})^{-1} \Delta\mathbf{r},$$

where Δr – distance between track and the primary vertex position, C_{track} is covariance matrix of a track and C_{PV} is a covariance matrix of primary vertex

2. consider only combination of 2 particles with different charge (q1*q2 < 0) for 2 particles decay case

3. check the distance between 2 daughter particles

4. check L / dL - decay length normalized on the error

5. check χ^2_{topo} - of mother particle to primary vertex

6. check some kinematic variables (θ of mother particle, P_T mother or daughter particles)

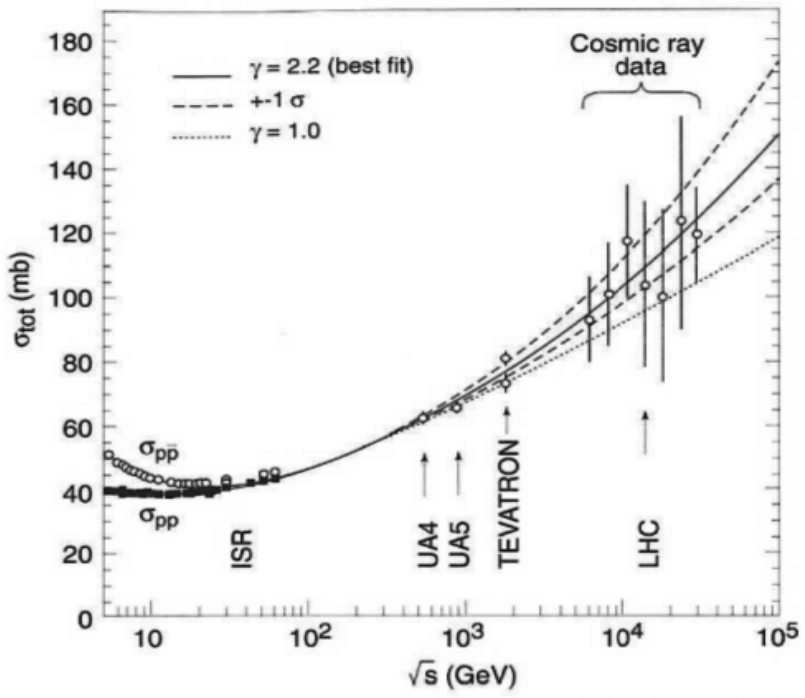
Ideal D^0 finder (M=1864,84 MeV/c²)

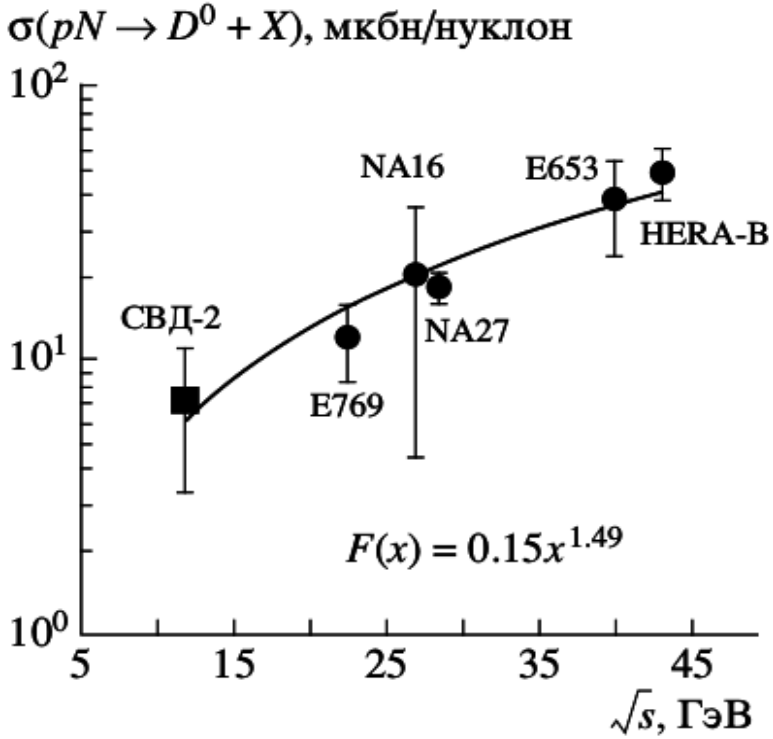
1. consider $D^0 \to K^- \pi^+$ decay (BR 3.9 %) => cτ = 122.9 μm, M=1864,84 MeV/c²

2. simulate 100000 Minimum Bias (MB) events with Pythia6, √s = 27 GeV

3. additionally simulate 20000 D^0 events, uniform θ and φ (~15240 reconstructed, ~76%)

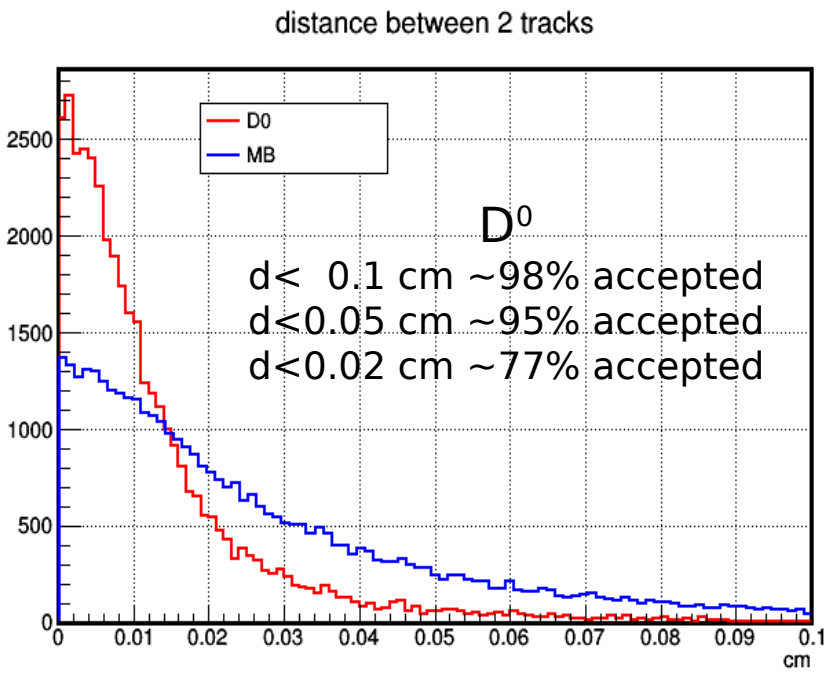
4. consider $K^- \pi^+$ ombination with different charge (q1*q2 < 0) in each event

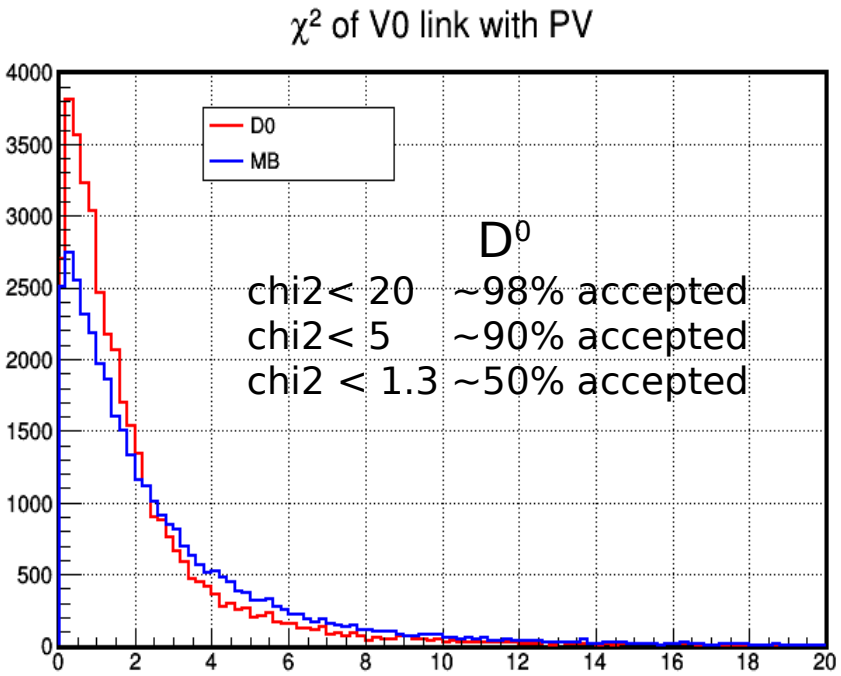


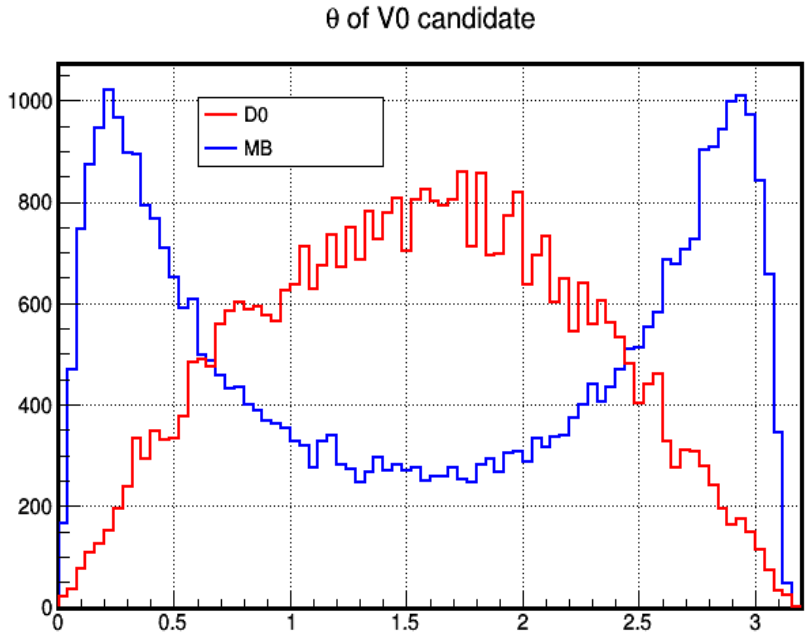


5. need to suppress MB background:
   a) S/B ~ 1 => ~10^{-5} times (with ~50% D^0 reconstruction and selection efficiency)
   b) S/B ~0.1 => ~10^{-4} times (with ~50% D^0 reconstruction and selection efficiency)

Ideal D^0 finder

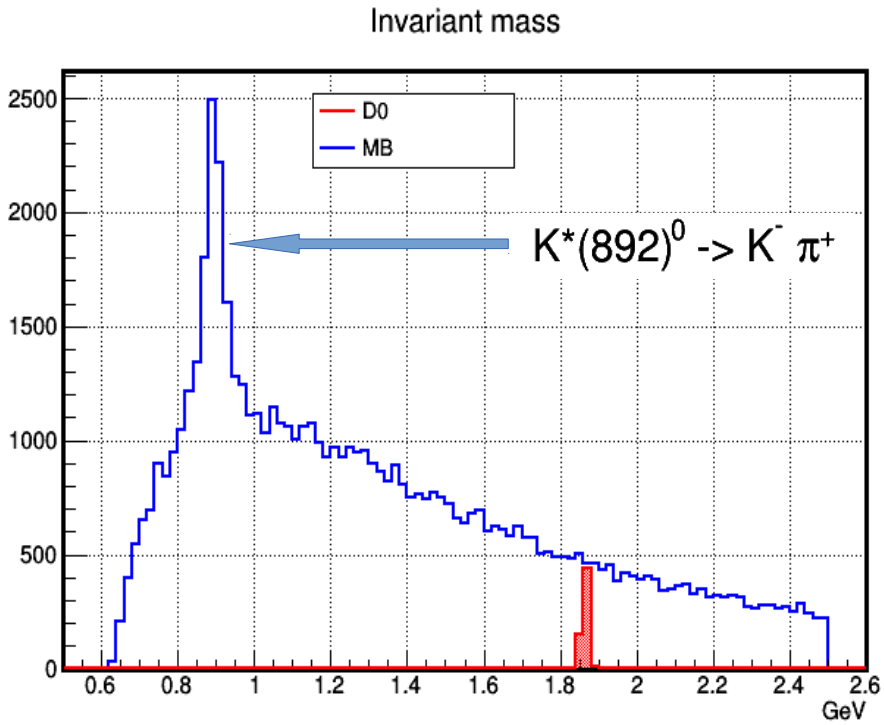






$0.57 < \theta < 2.57$ => ~85% of D^0 accepted

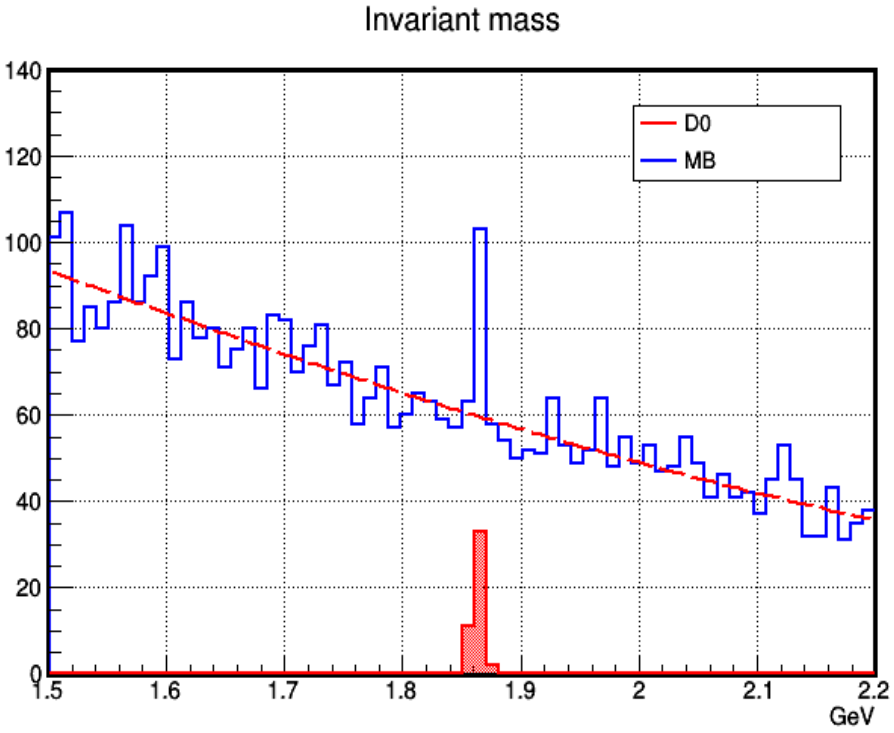
Ideal D^0 finder



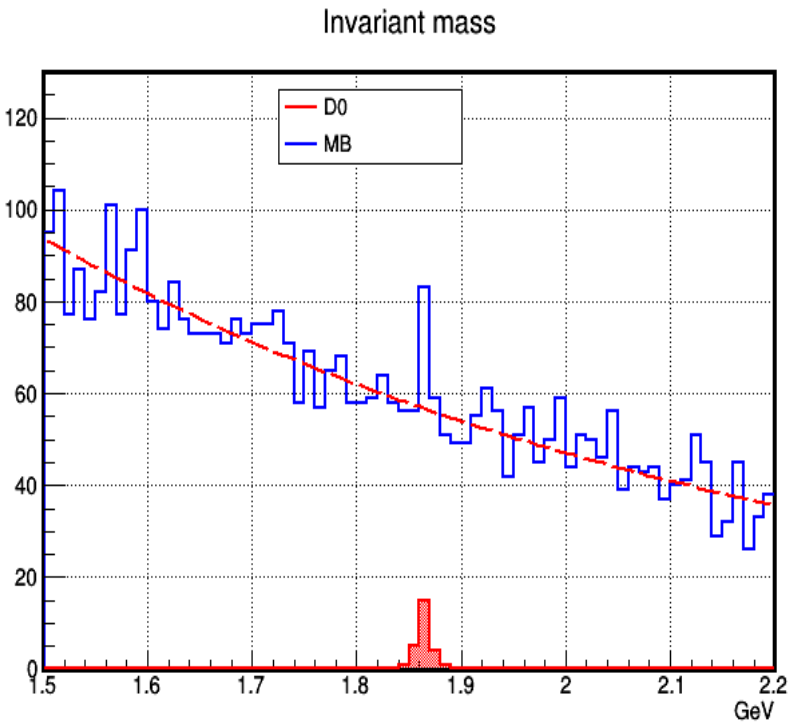
100000 MB events + 100 D^0 events
S/B ~10^{-3} - no selection
S/B ~$5*10^{-4}$ - with selection

Selection efficiency (~50%):
a) dist<0.02 cm
b) chi2 link D^0 to PV<5
c) $\Delta\theta < 1.0$

S/B ~0.19 inside 3*σ
around signal



Ideal D^0 finder



100000 MB events + 50 D^0 events
S/B ~$5*10^{-4}$ - no selection
S/B ~$2.5*10^{-4}$ - with selection

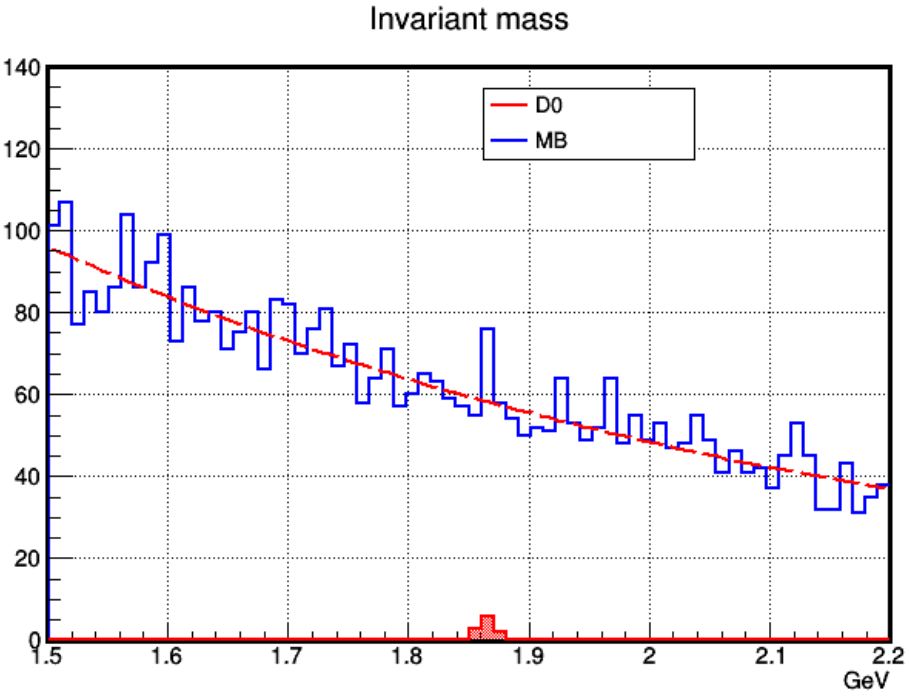
Selection efficiency (~50%):
a) dist<0.02 cm
b) chi2 link D^0 to PV<5
c) $\Delta\theta < 1.0$

S/B ~0.10 inside 3*σ around signal

100000 MB events + 20 D^0 events
S/B ~ $2*10^{-4}$ - no selection
S/B ~ 10^{-4} – with selection

Selection efficiency (~50%):
a) dist<0.02 cm
b) chi2 link D^0 to PV<5
c) $\Delta\theta < 1.0$

S/B ~0.05 inside 3*σ around signal



Ideal D^{*+} finder ($M=2010.27$ GeV/c^2)

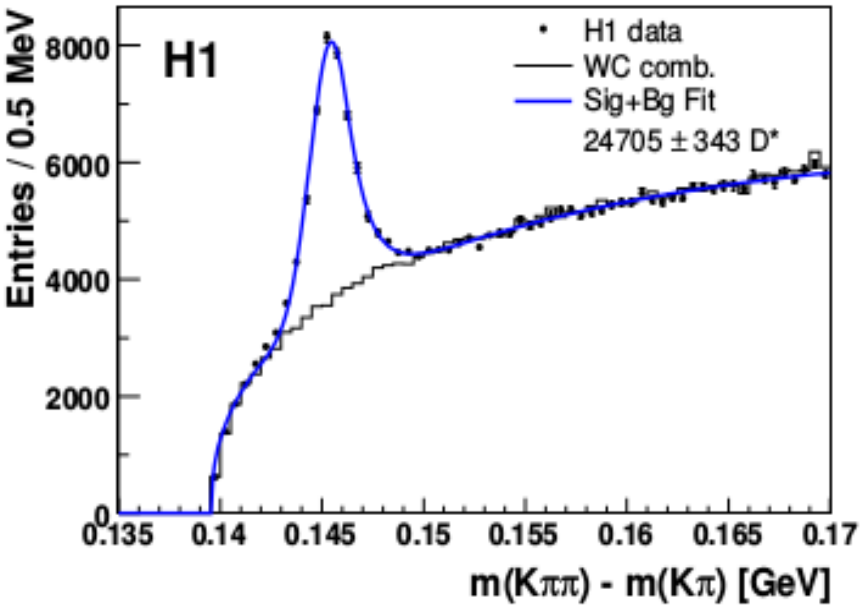
1. consider $D^{*+} \to D^0 + \pi^+_{slow}$ decay (BR ~67.7 %) with $D^0 \to K^- \pi^+$ (BR ~3.9%)

2. main advantage of this channel – 3 particles decay and very narrow mass difference $\Delta M = M(D^{*+}) - M(D^0)$ (~145 MeV) => good background suppression

3. simulate 100000 Minimum Bias (MB) events with Pythia6, √s = 27 GeV

4. additionally simulate 20000 D^{*+} events, uniform θ and φ (~2880 reconstructed, ~14.4%)

5. reconstruct D^0 using $K^- \pi^+$ combination => apply some mass window, then add slow positive pion in some momentum range => 0.10-0.20 GeV/c and reconstruct invariant mass of $K^- \pi^+ \pi^+_{slow}$ particles combination and finally apply also some ΔM window

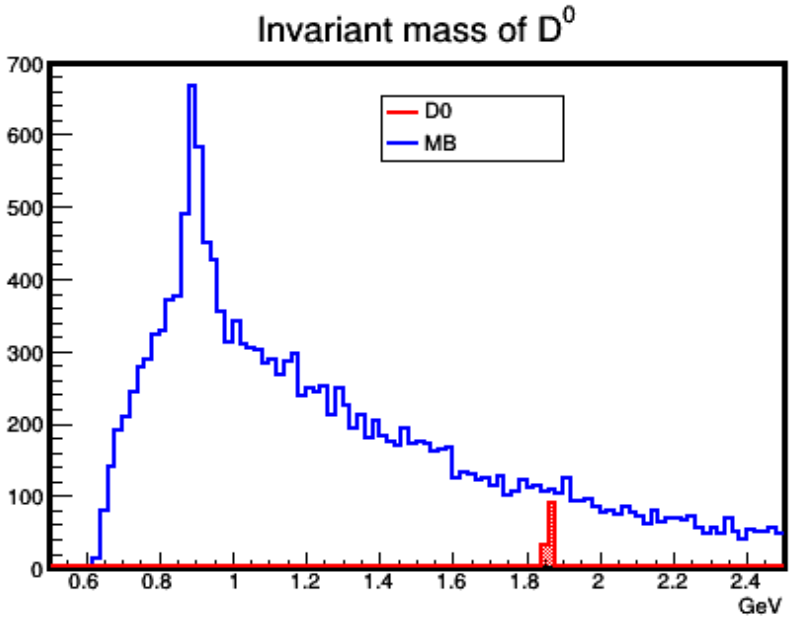


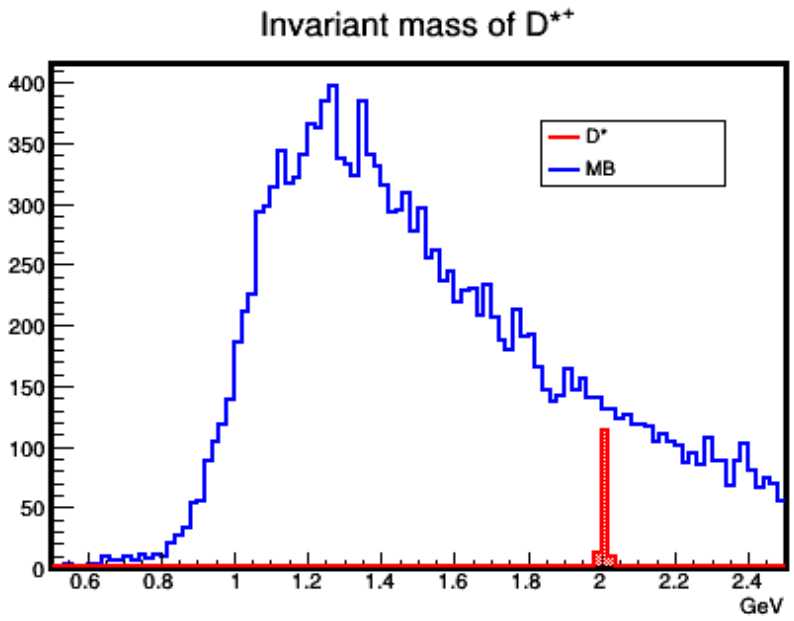
Used selection (~12% accepted D^{*+}):

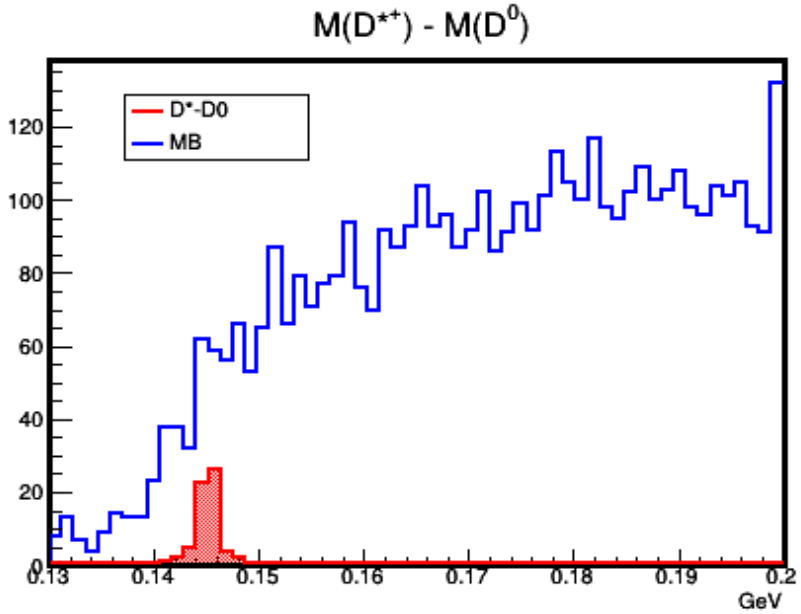
1) 0.100 Mev/c $< P^+_{slow} <$ 0.165 MeV/c
2) 1.840 MeV/c^2 < $M(D^0)$ < 1.890 MeV/c^2
3) 1.980 MeV/c^2 < $M(D^{*+})$ < 2.04 MeV/c^2
4) 0.138 MeV/c^2 < $\Delta M(D^{*+}\text{-}D^0)$ < 0.152 MeV/c^2

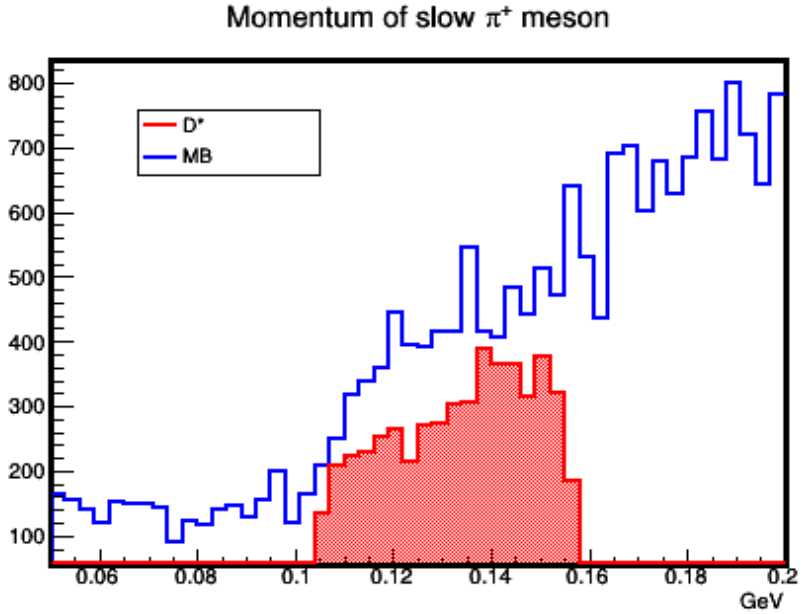
Need to suppress MB background:
a) S/B ~ 1 => ~10^{-6} times
b) S/B ~0.1 => ~10^{-5} times

Ideal D*+ finder (M=2010.27 GeV/c²)

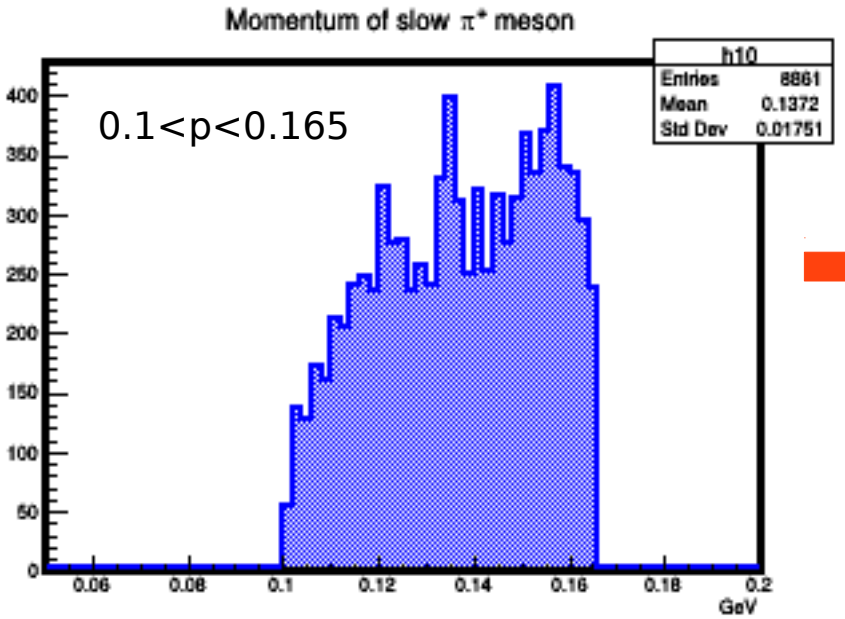


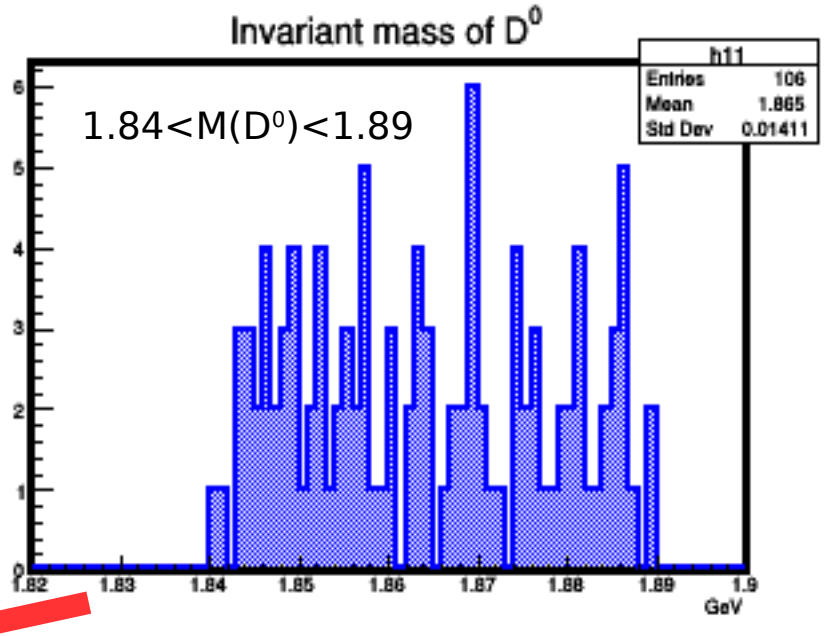


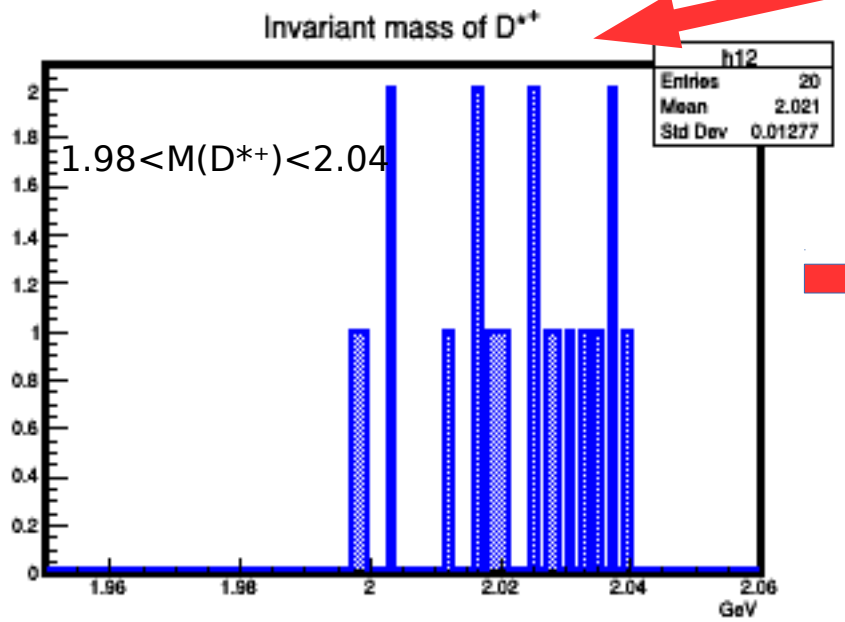


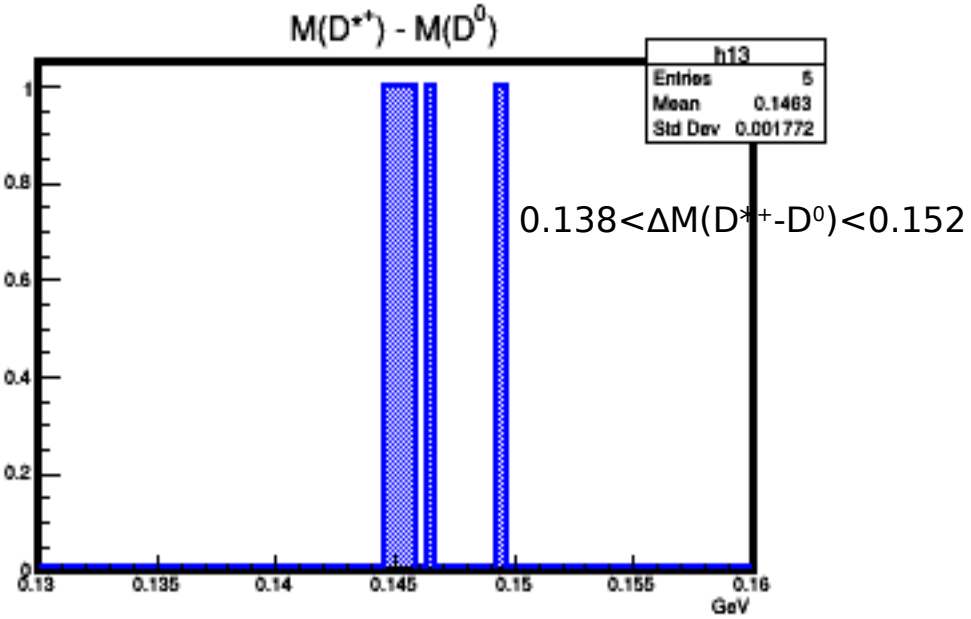


Ideal D^{*+} finder (Minimum Bias)

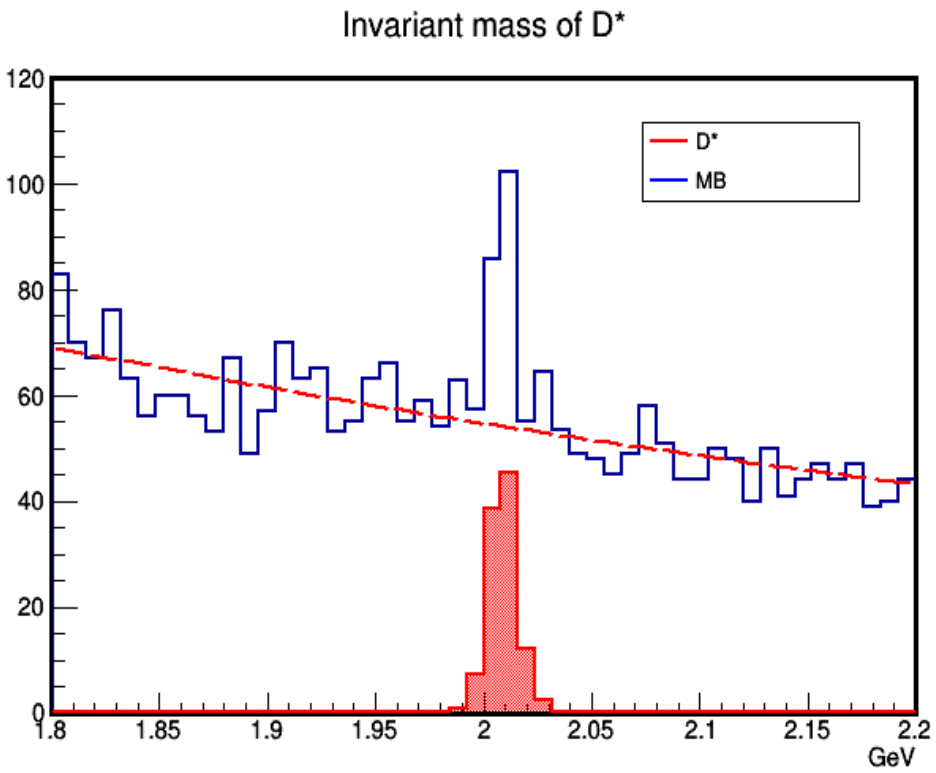








Ideal D^{*+} finder (Minimum Bias)



10^7 MB events + 100 D^{*+} events
S/B ~10^{-5} - with selection

S/B ~0.2 inside 3*σ around signal

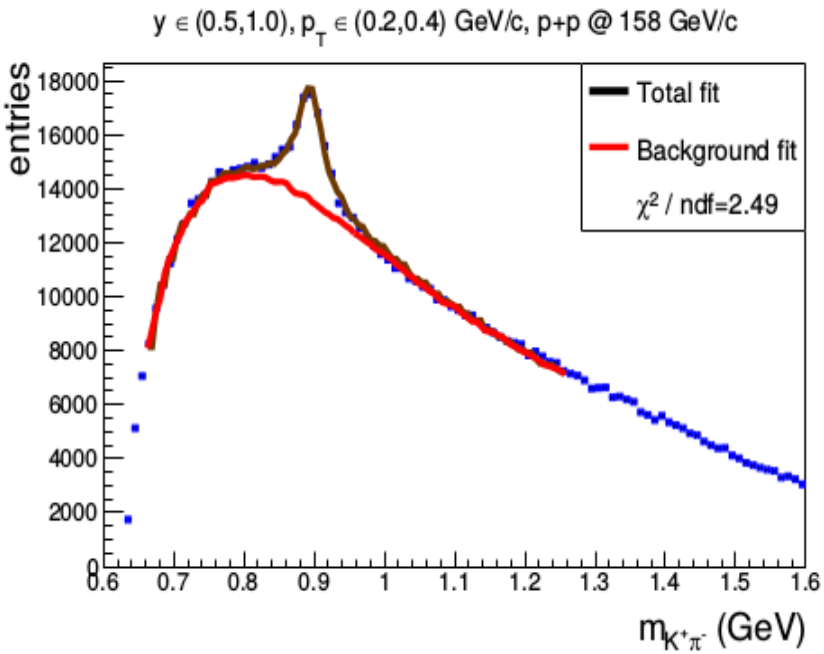
Summary

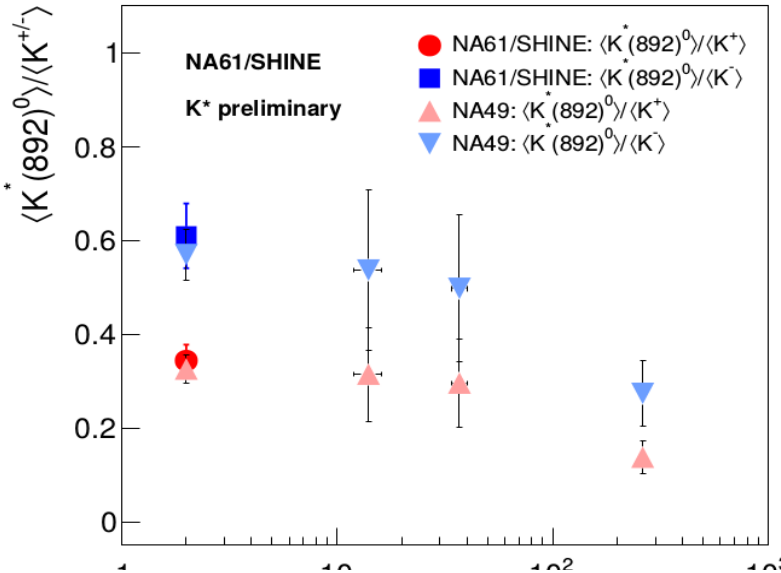
1) KF Particle package for finding and reconstruction of short-lived particles is available in SPDroot

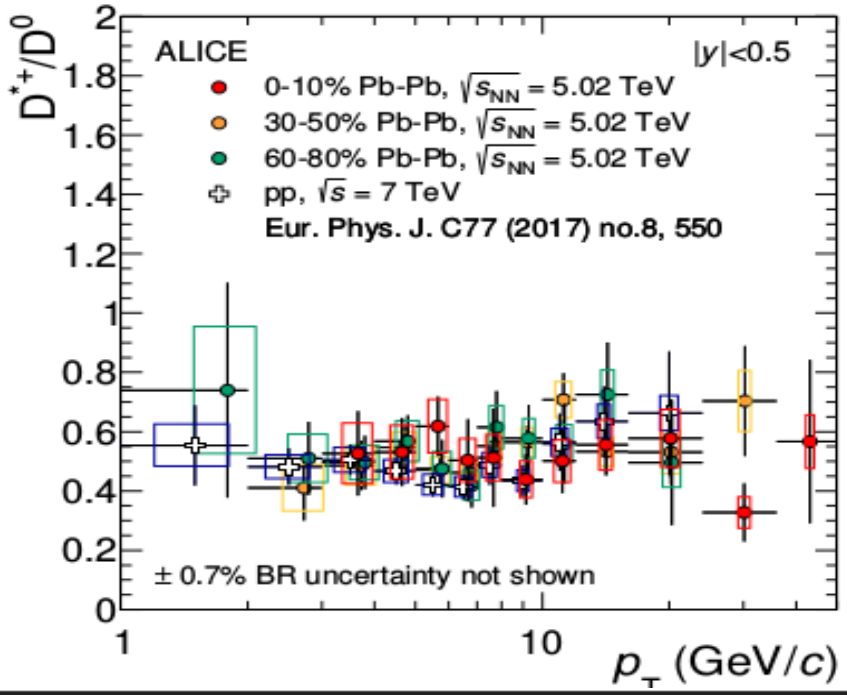
2) separation of D^0 candidate is possible with more complicated selection cuts

3) registration of $D^{*+} \rightarrow D^0 + \pi^+_{slow}$ is possible with standard cuts

Backup slides

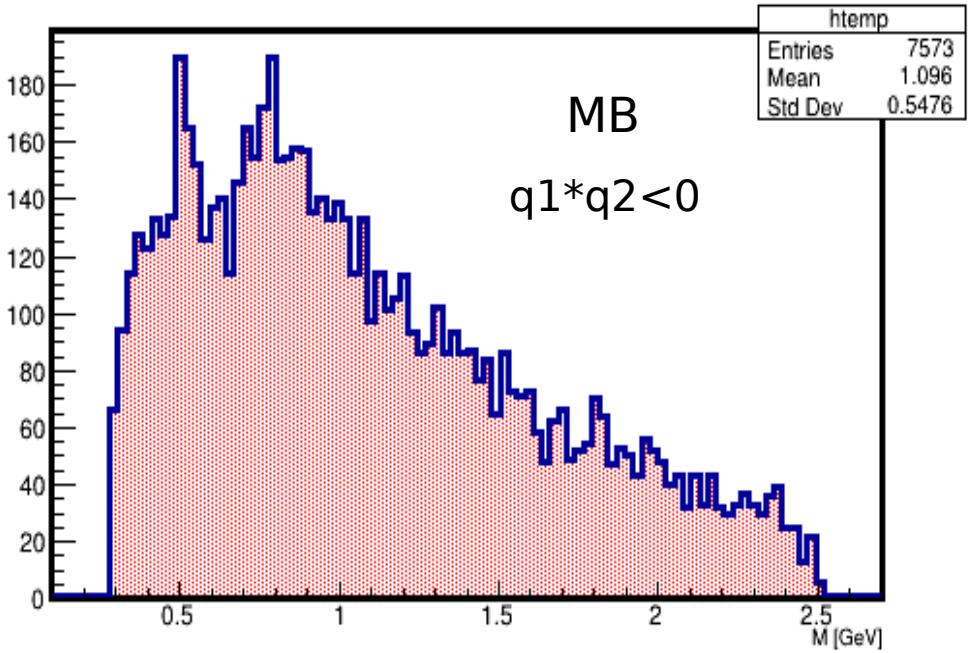


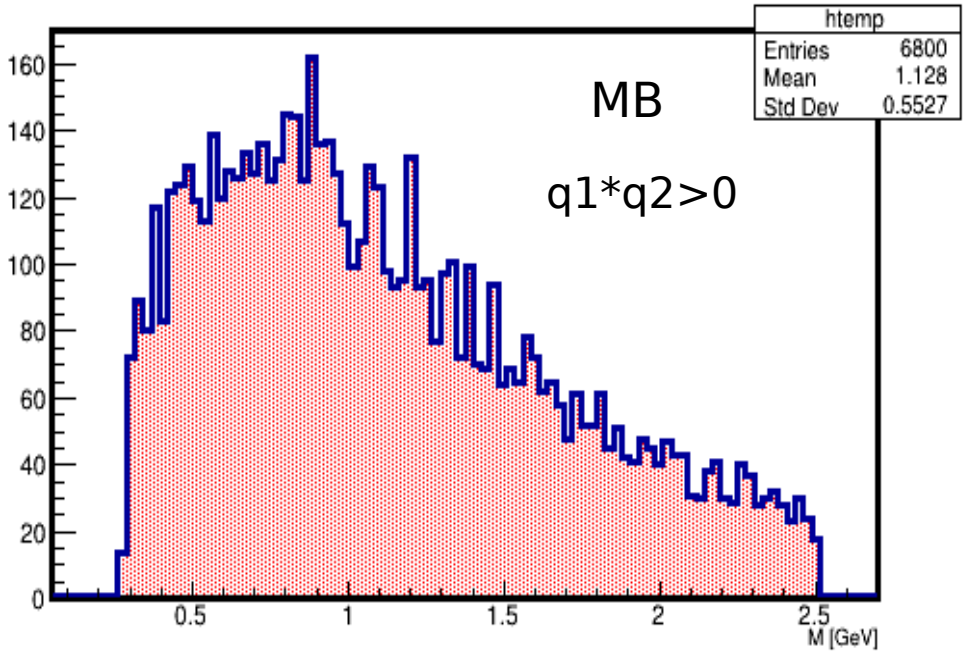




Ideal V^0 finder (K^0_s)

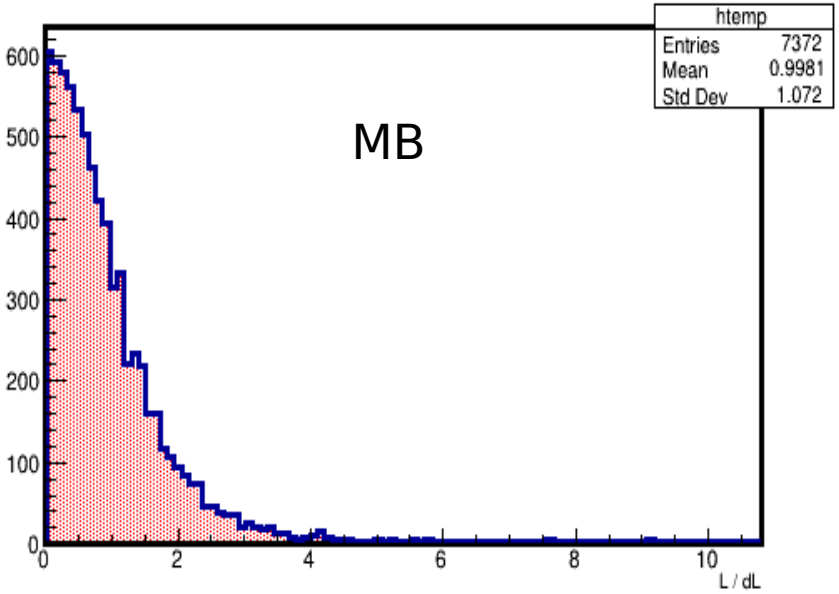
1. consider $K^0_s \to \pi^+ \pi^-$ decay (68,6 %) and $\tau = 0.895*10^{-10}$ => $c\tau = 2.7$ cm
2. simulate Minimum Bias (MB) events with Pythia6 and $\sqrt{s} = 27$ GeV
3. additionally simulate 5000 K^0_s events, uniform θ and φ (~1800 reconstructed)
4. consider 2 pions combination with different charge (q1*q2 < 0) in each event

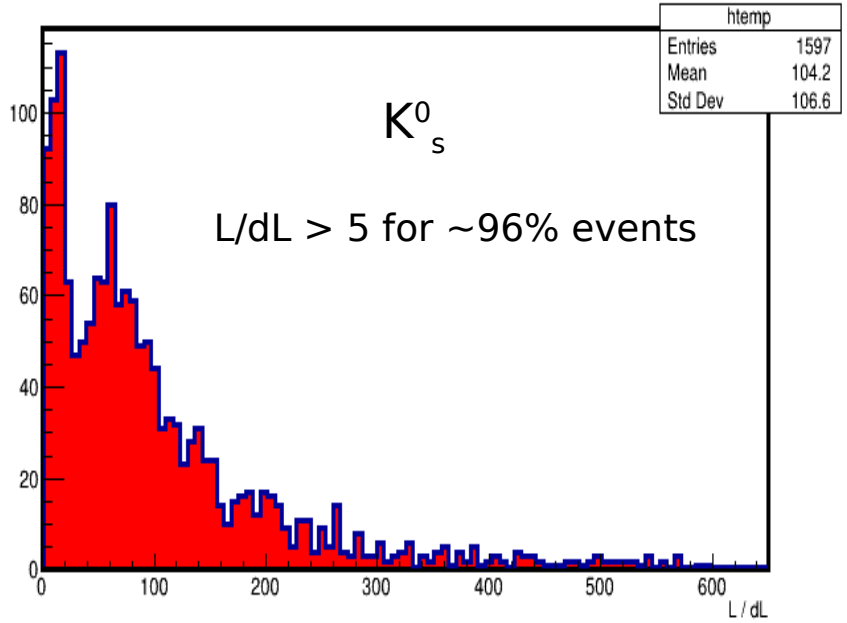




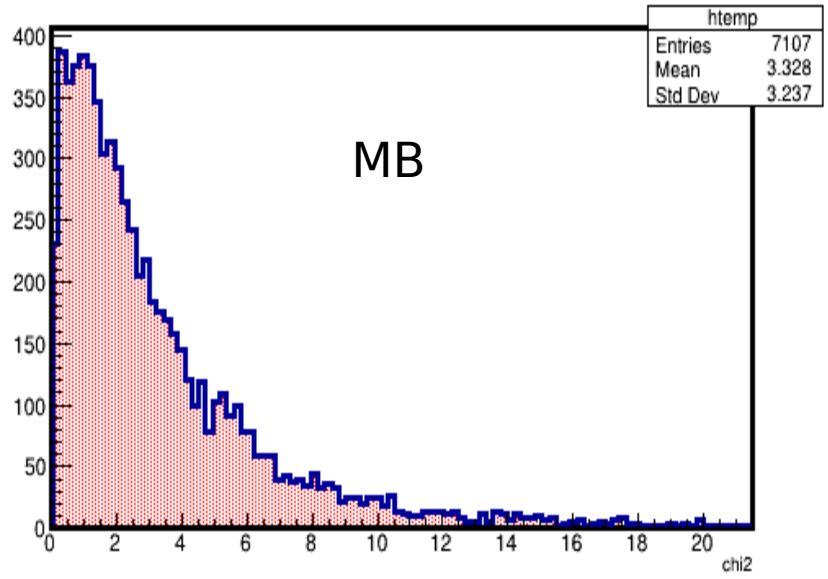
Ideal V^0 finder (K^0_s)

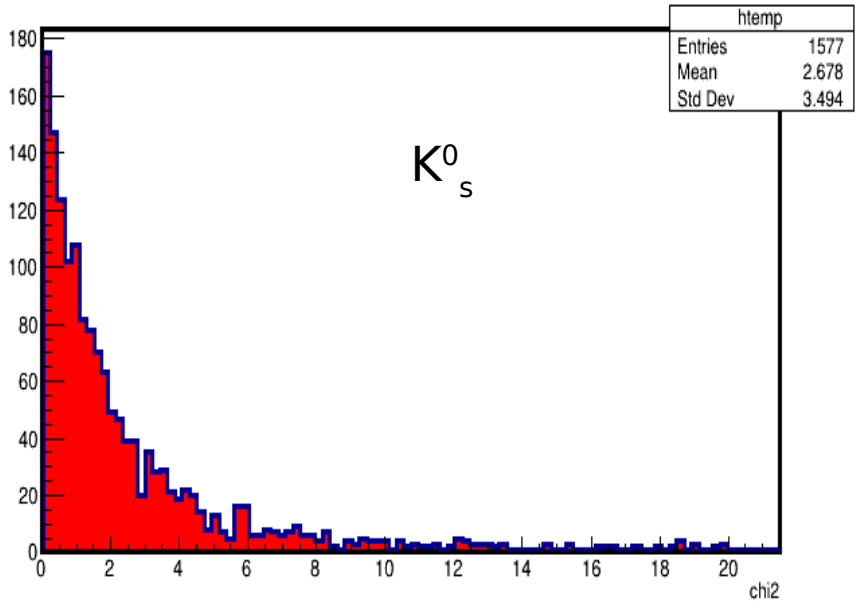
Normalize distance L/dL of V^0 particle to PV





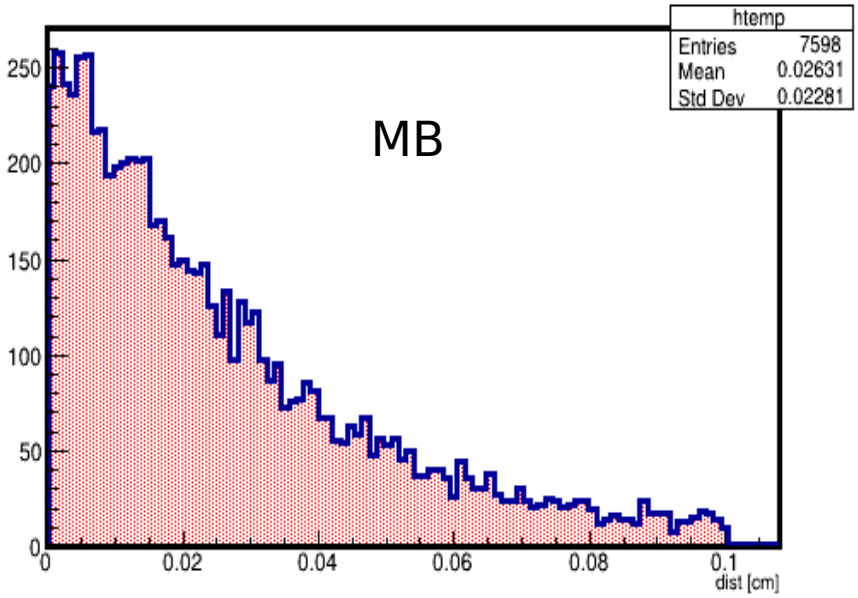
chi2 link V^0 particle with PV

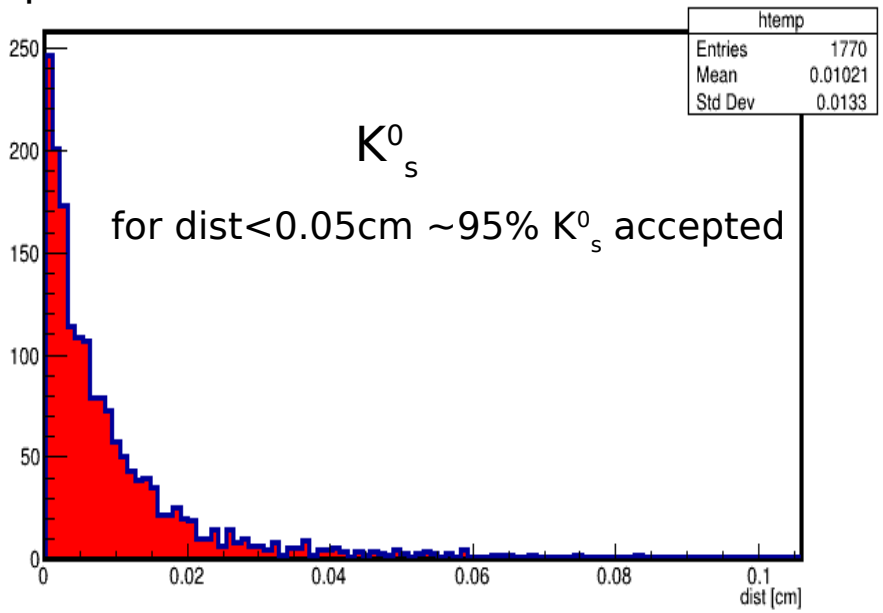




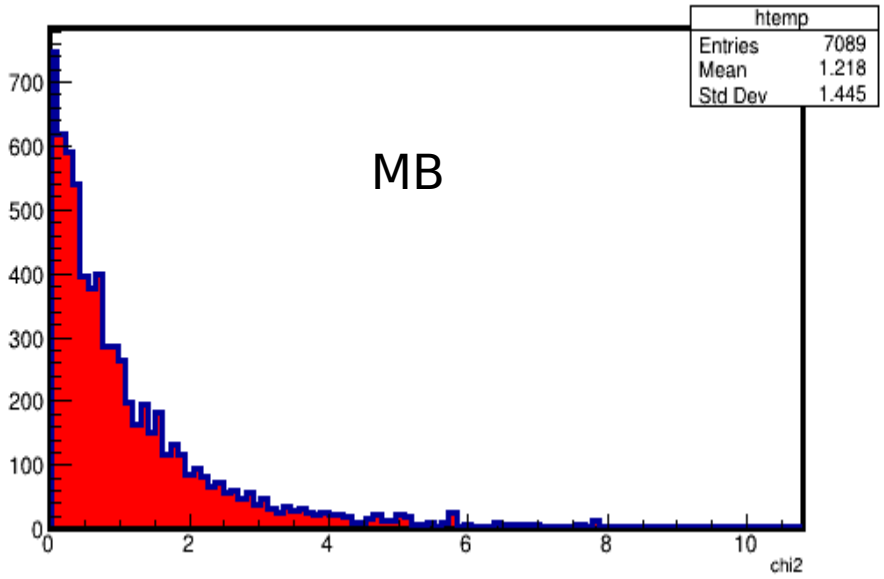
Ideal V^0 finder (K^0_s)

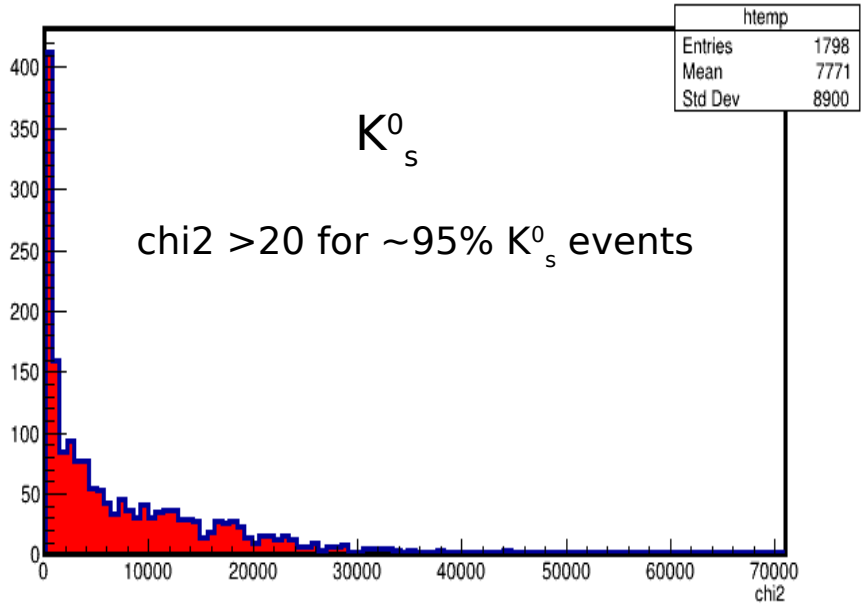
Distance between 2 particles



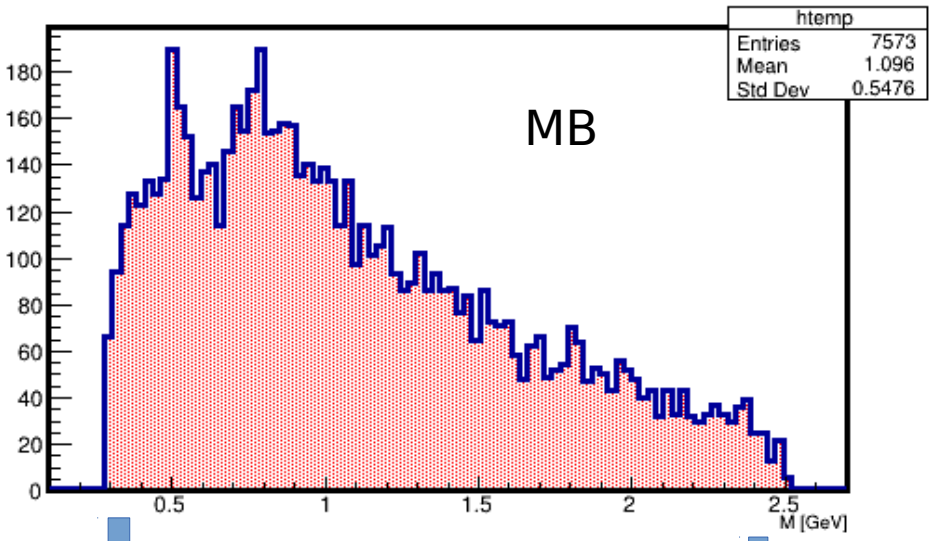


chi2 of track to PV

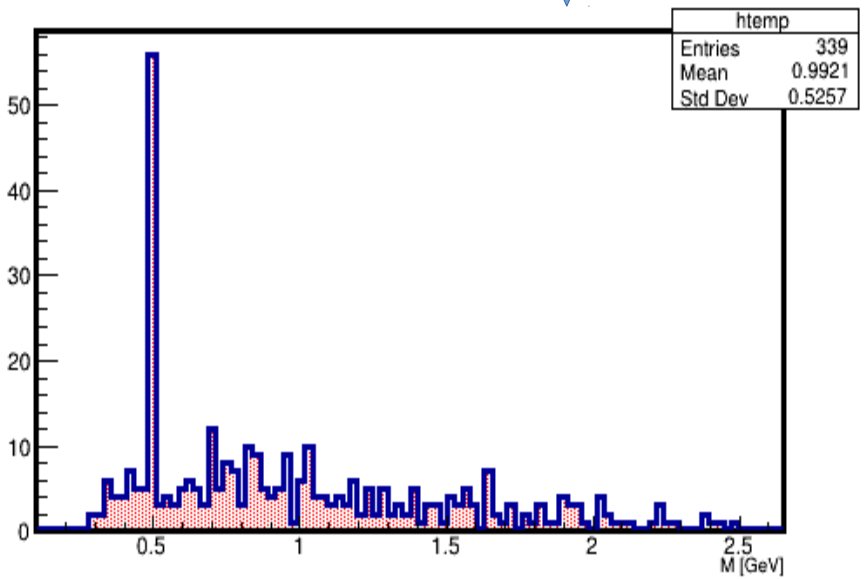




Ideal V⁰ finder (K^0_s)



chi2 > 20



L/dL > 10