



# Central Tracker Physics Channel Benchmark

$$\bar{p}p \rightarrow \Psi(3770) \rightarrow D^+D^- \rightarrow K^-\pi^+\pi^+ K^+\pi^-\pi^-$$

# Outline

- Figures of merit
- Overview on the simulation procedure
- Overview on the analysis procedure
- STT analysis
- TPC analysis
- Summary of the Results

## Figures of merit

For the exclusive reconstruction of the Channel



the following properties\* are to be determined:

- the channel reconstruction efficiency
  - **Detector Acceptance**: (*events entering within detector acceptance*) / (*generated events*)
  - **Efficiency**: (*reconstructed events*) / (*events entering within detector acceptance*)
- the resolution of the invariant **mass**
- the spatial resolution of the **secondary vertices**

\*see <http://www2.pv.infn.it/~boca/panda/comparisonTPC-STT/list.html>

## Simulation Overview

- Channel:  $\bar{p}p \rightarrow \Psi(3770) \rightarrow D^+D^- \rightarrow K^-\pi^+\pi^+ K^+\pi^-\pi^-$
- Beam momentum: 6.5788 GeV/c
- Simulated data on the PandaGrid
  - *Signal samples for STT*  
(run935oldnocu, PandaRoot 12725)
  - *Signal samples for TPC*  
(run985, PandaRoot tpreco 13305)
- Steps
  - *Simulation*
  - *Digitization*
  - *Reconstruction*
  - *PID*
  - ***Analysis (common for both CT options)***

Software experts, full data sets available on the Grid

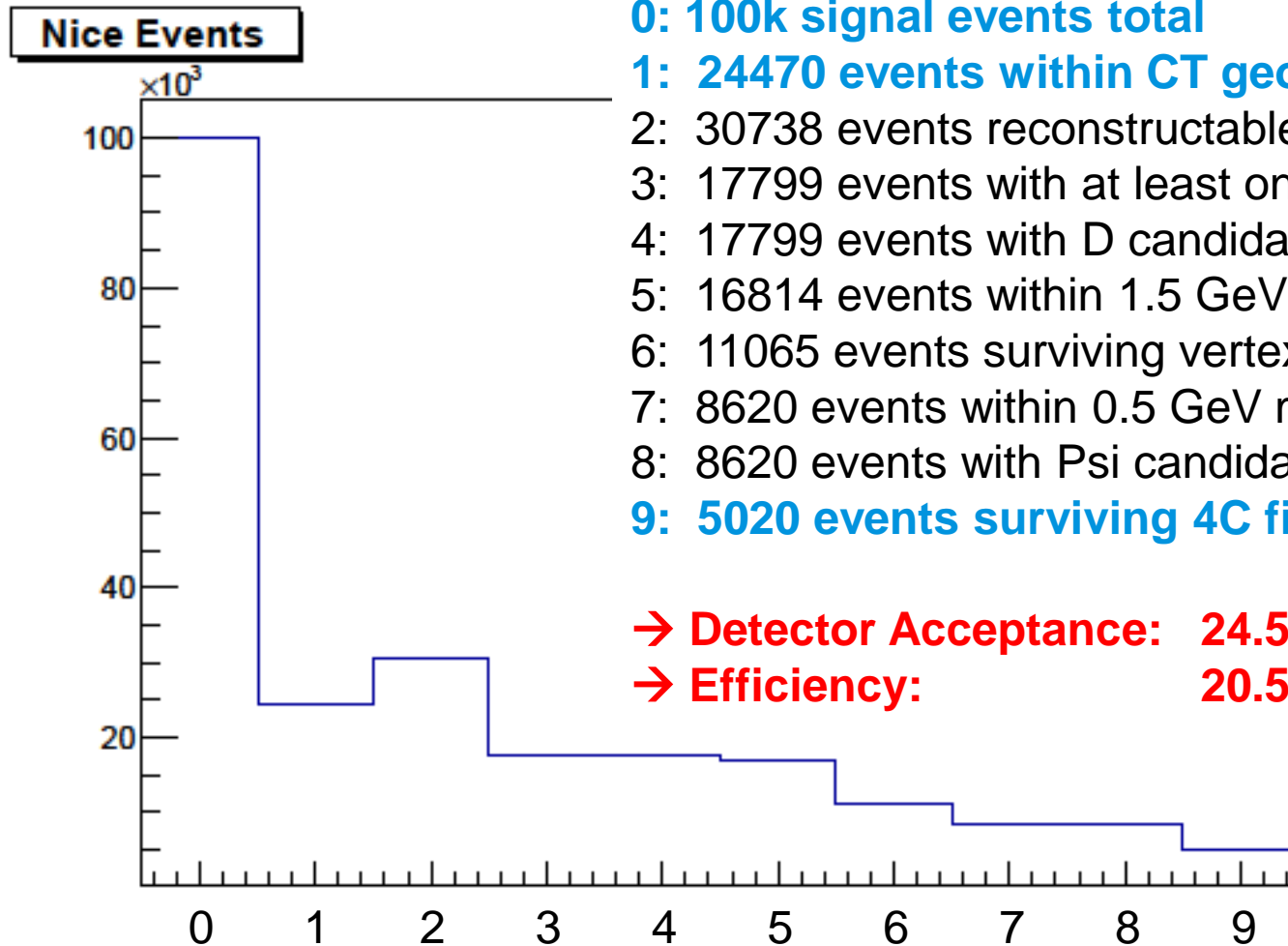
# Analysis Overview

- 0: **Total count** of signal events as input
- 1: Events within **geometric acceptance** of the central tracker. All six MC signal tracks must touch the CT volume. → **Detector acceptance**
- 2: **Reconstructable events**. The reconstructed tracks are cleaned by positive MC PID information. After that they must contain (at least) two oppositely charged Kaons and two oppositely charged pairs of two Pions.
- 3: **Events hitting the CT**. The STT reconstruction code does a global reconstruction MVD+STT+GEM which is not yet ready for the TPC. To allow comparison, all tracks without an STT hit are discarded (Same events as in (2) for TPC). After that they must contain (at least) two oppositely charged Kaons and two oppositely charged pairs of two Pions.
- 4: **Events with D+ and D- candidates**. Same events as in (3)
- 5: **Events with D+ and D- candidates within 1.5 GeV mass window**
- 6: **Events surviving vertex fit**. (Best candidate with GlobalChi2 < 18)  
→ **Secondary vertex resolution**
- 7: **Events with D+ and D- candidates within 0.5 GeV mass window**
- 8: **Events with Psi candidates**. Same events as in (7)
- 9: **Events surviving 4C fit**. (Best candidate with GlobalChi2 < 18)  
→ **Efficiency, mass resolution**

# Event Selection Process (STT)

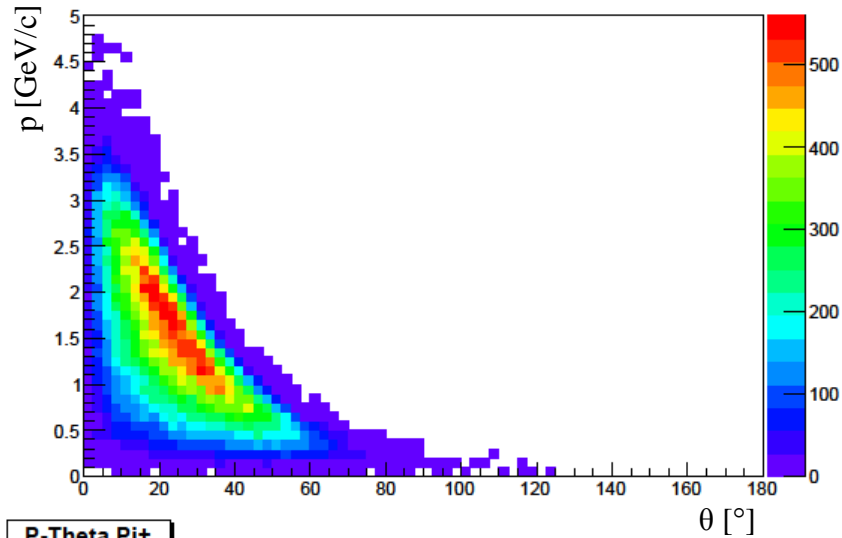
- 0: 100k signal events total**
- 1: 24470 events within CT geometric acceptance**
- 2: 30738 events reconstructable by track finding
- 3: 17799 events with at least one STT hit
- 4: 17799 events with D candidates
- 5: 16814 events within 1.5 GeV mass window
- 6: 11065 events surviving vertex fit
- 7: 8620 events within 0.5 GeV mass window
- 8: 8620 events with Psi candidates
- 9: 5020 events surviving 4C fit**

→ **Detector Acceptance: 24.5 %**  
 → **Efficiency: 20.5 %**

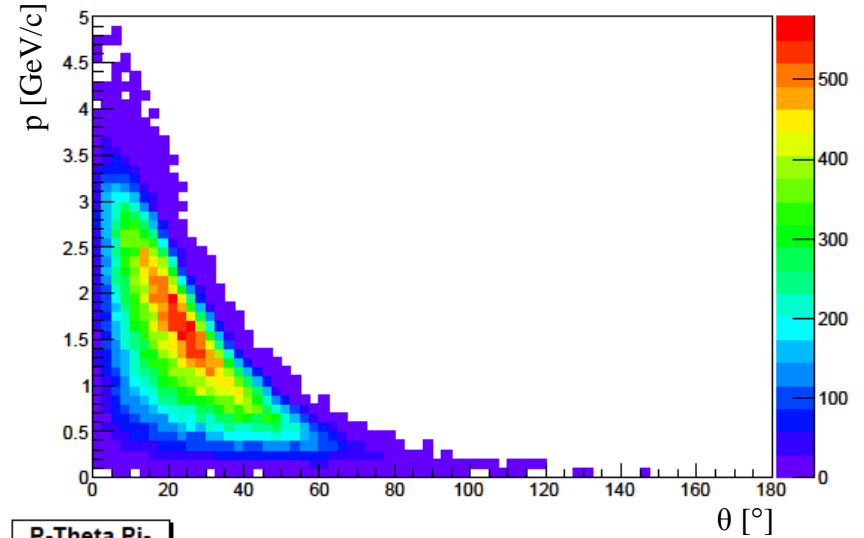


# P- $\theta$ Distribution (Input Events, Analysis Step 0)

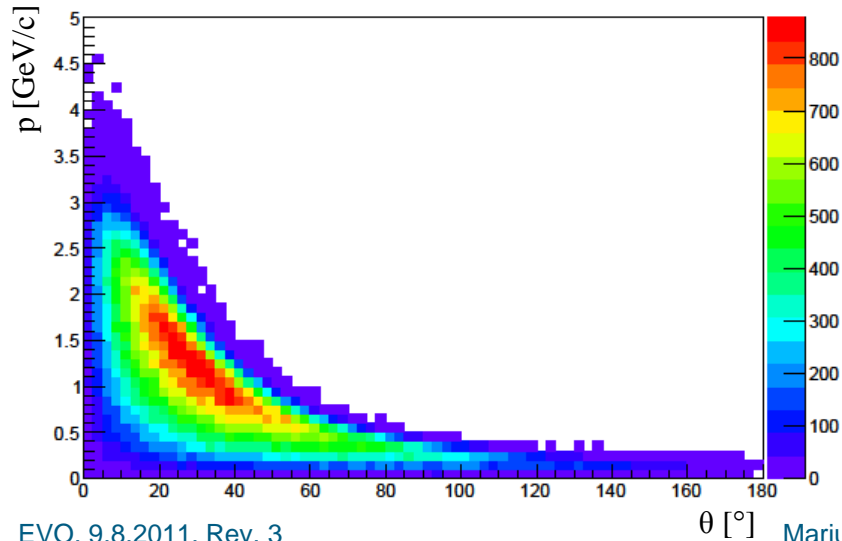
**P-Theta K+**



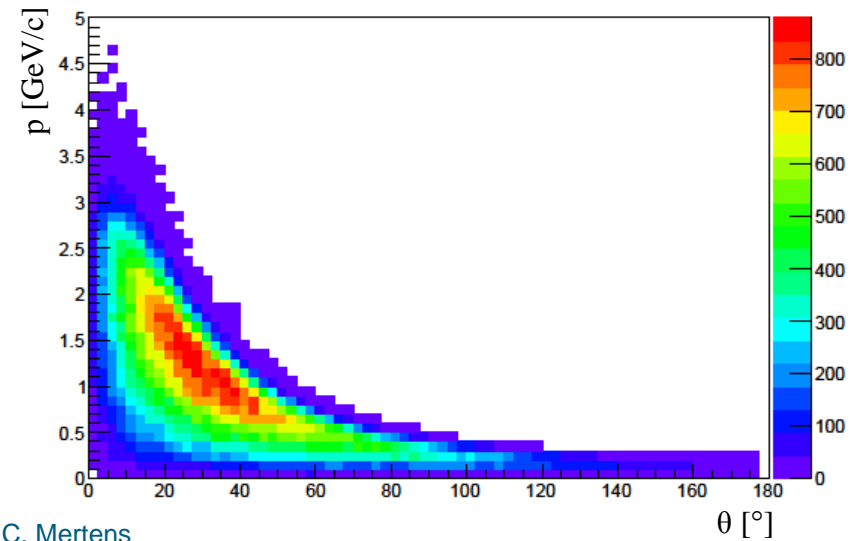
**P-Theta K-**



**P-Theta Pi+**

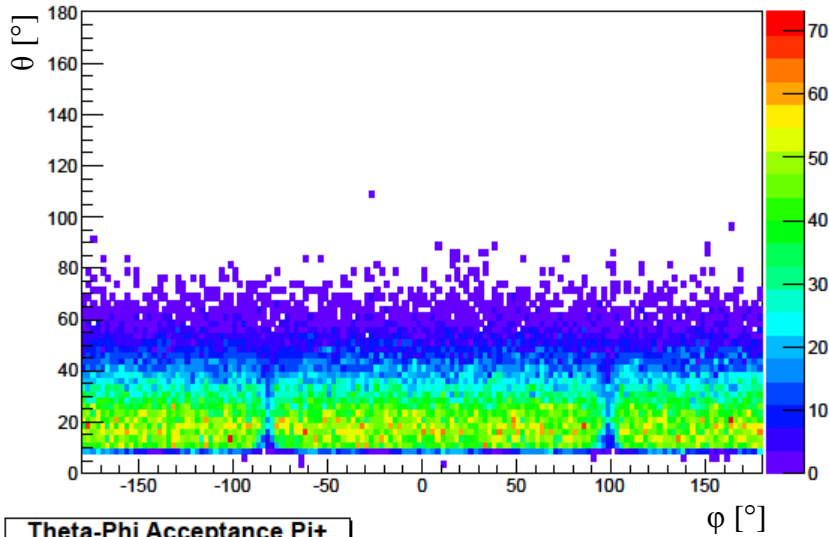


**P-Theta Pi-**

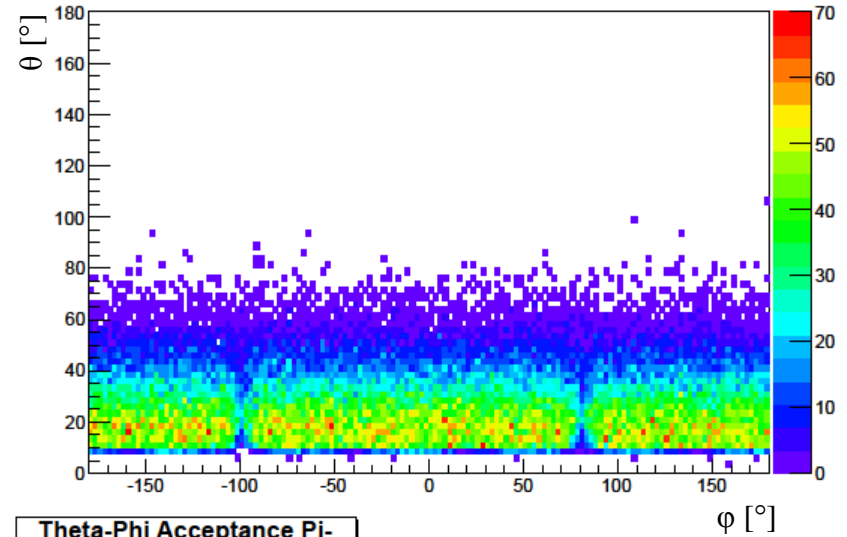


# $\theta$ - $\phi$ Geometrical Acceptance (Analysis Step 1, STT)

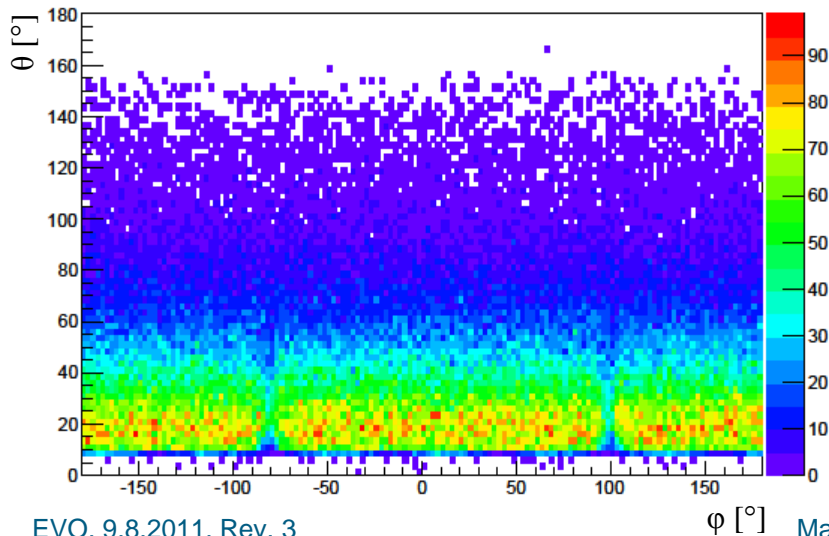
Theta-Phi Acceptance K+



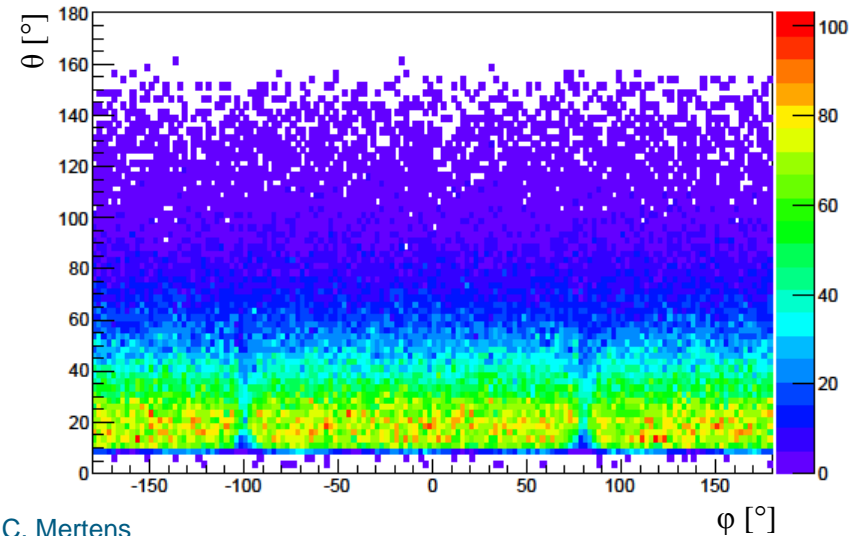
Theta-Phi Acceptance K-



Theta-Phi Acceptance Pi+



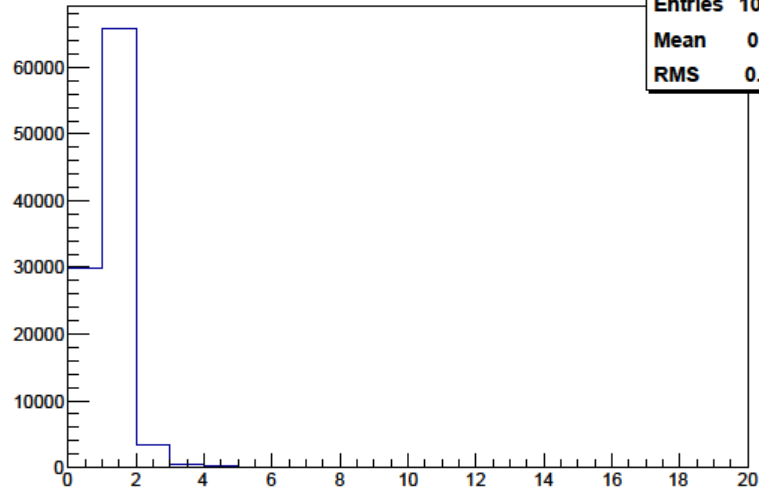
Theta-Phi Acceptance Pi-





# Track Multiplicities (in Analysis Step 3, STT)

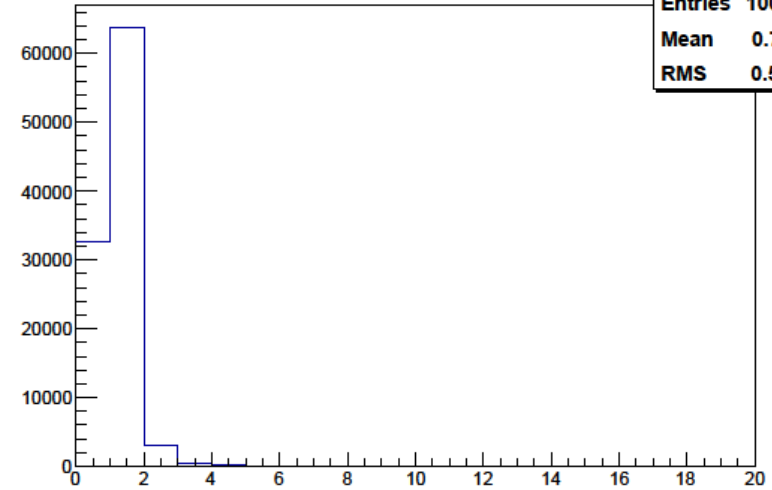
**K+ per Event**



**hkpperevent**

Entries	100000
Mean	0.7551
RMS	0.5813

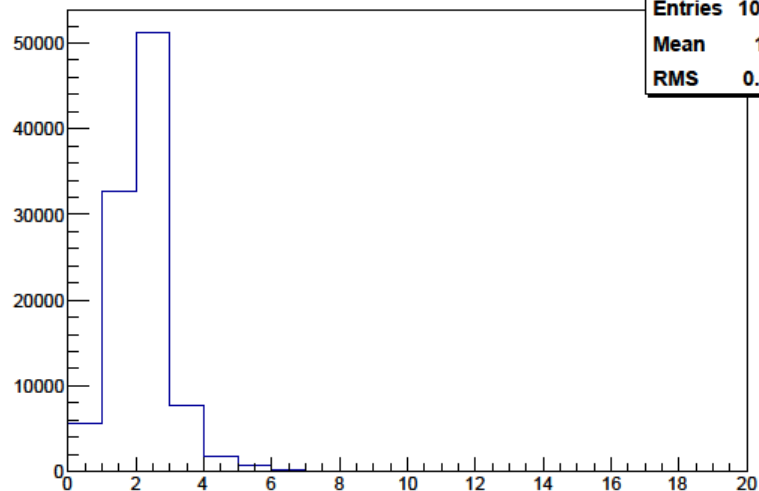
**K- per Event**



**hkmperevent**

Entries	100000
Mean	0.7207
RMS	0.5706

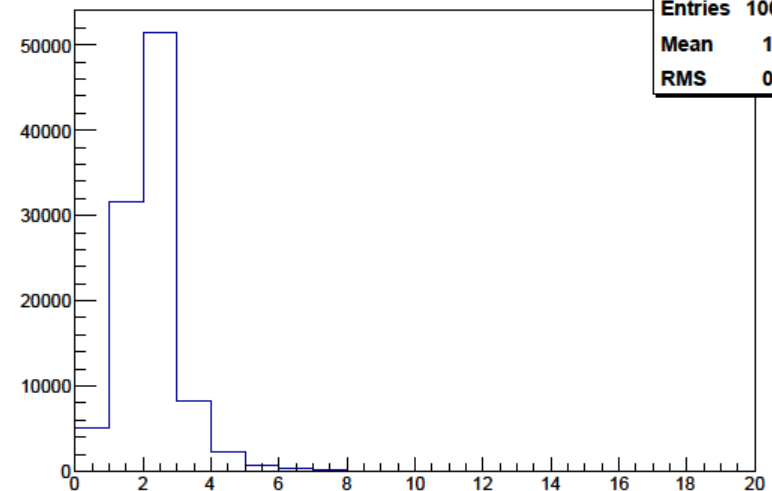
**Pi+ per Event**



**hpipevent**

Entries	100000
Mean	1.715
RMS	0.8884

**Pi- per Event**

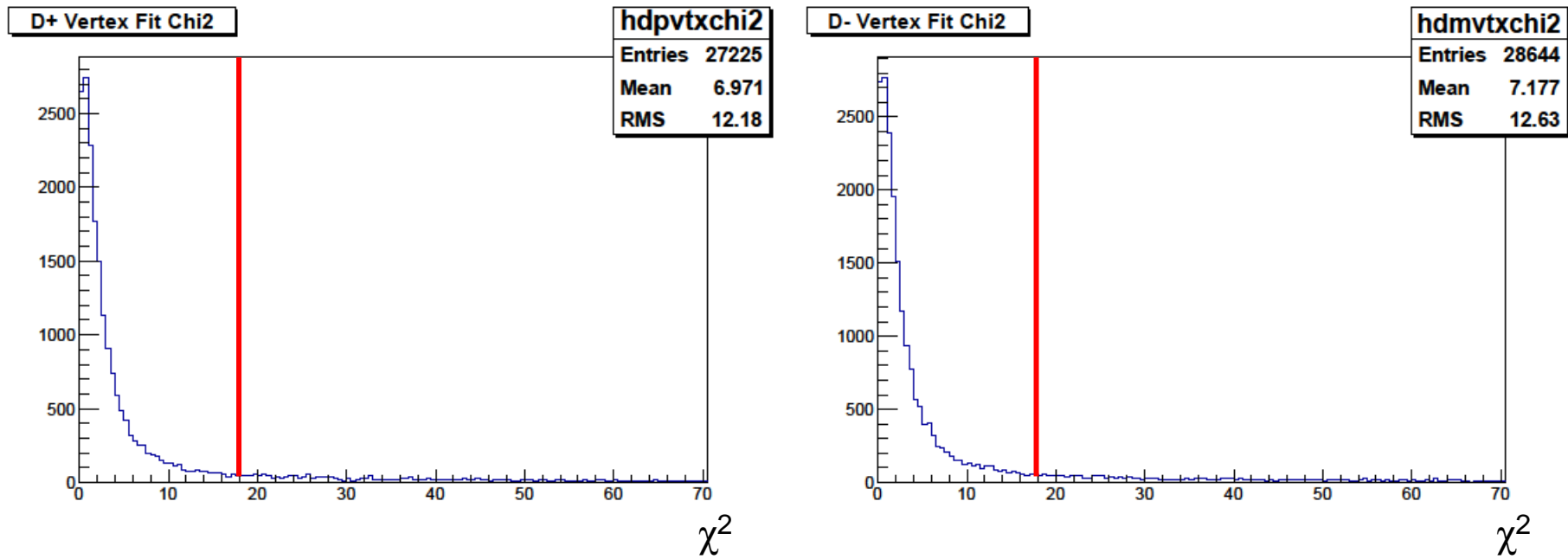


**hpimpevent**

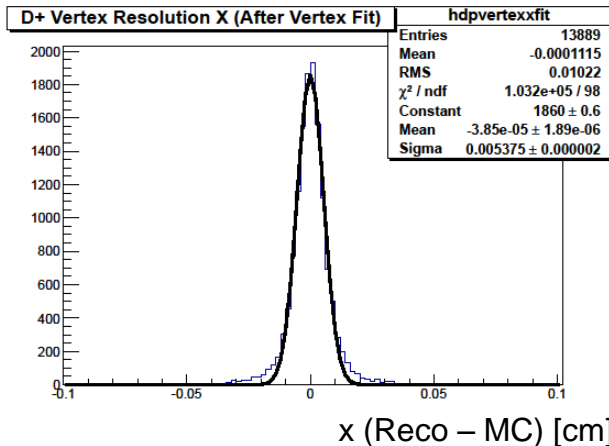
Entries	100000
Mean	1.763
RMS	0.933

# D-Meson Vertex Fit (STT)

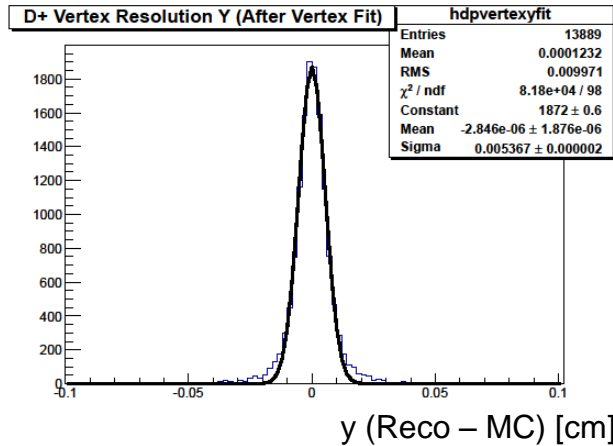
$\chi^2$  distribution of the vertex fits to the D-mesons. For each event, the candidates with the best  $\chi^2 < 18$  are selected (one  $D^+$ , one  $D^-$ )



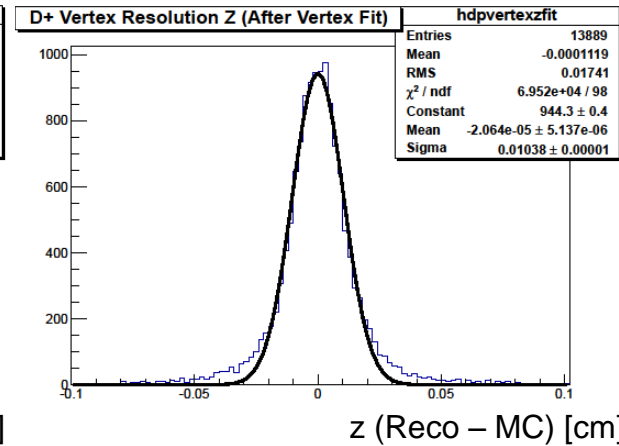
# D-Meson Vertex Resolution (STT, after Vertex Fit)



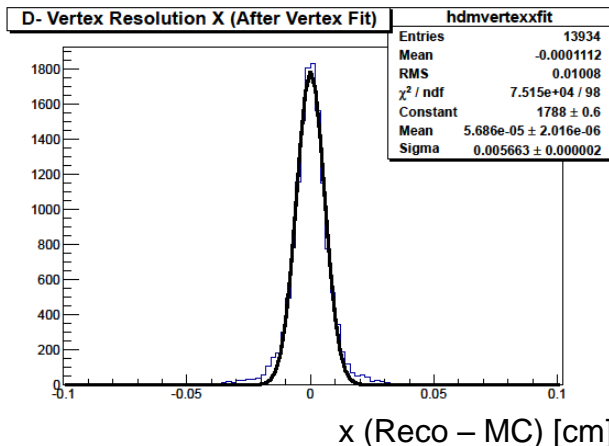
$$\sigma_x = (53.75 \pm 0.02) \mu\text{m}$$



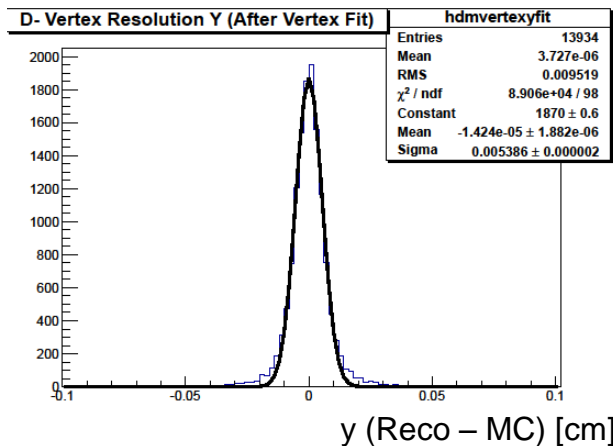
$$\sigma_y = (53.67 \pm 0.02) \mu\text{m}$$



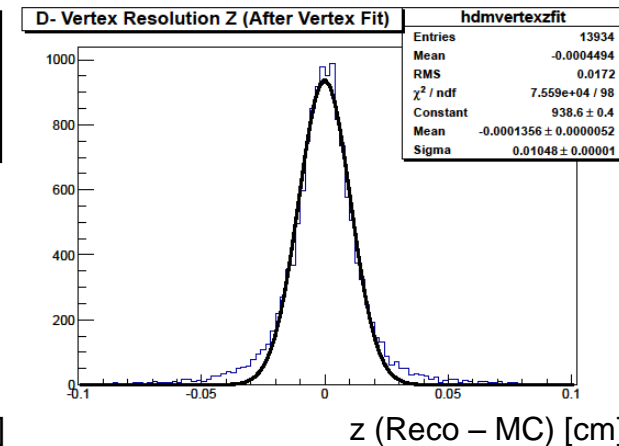
$$\sigma_z = (103.8 \pm 0.1) \mu\text{m}$$



$$\sigma_x = (56.63 \pm 0.02) \mu\text{m}$$

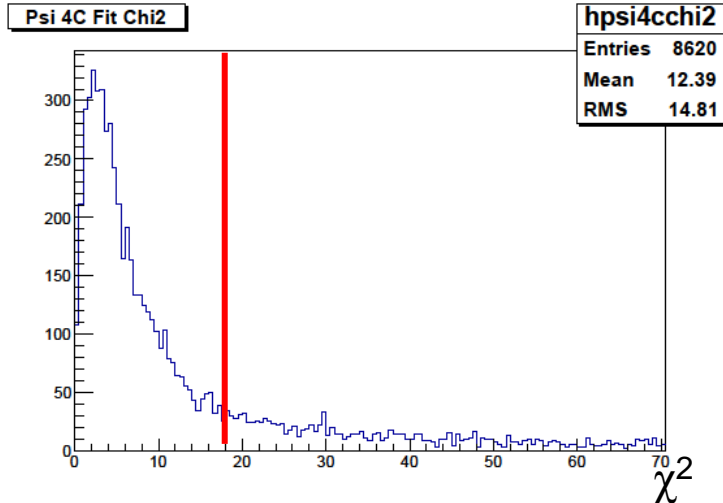


$$\sigma_y = (53.86 \pm 0.02) \mu\text{m}$$



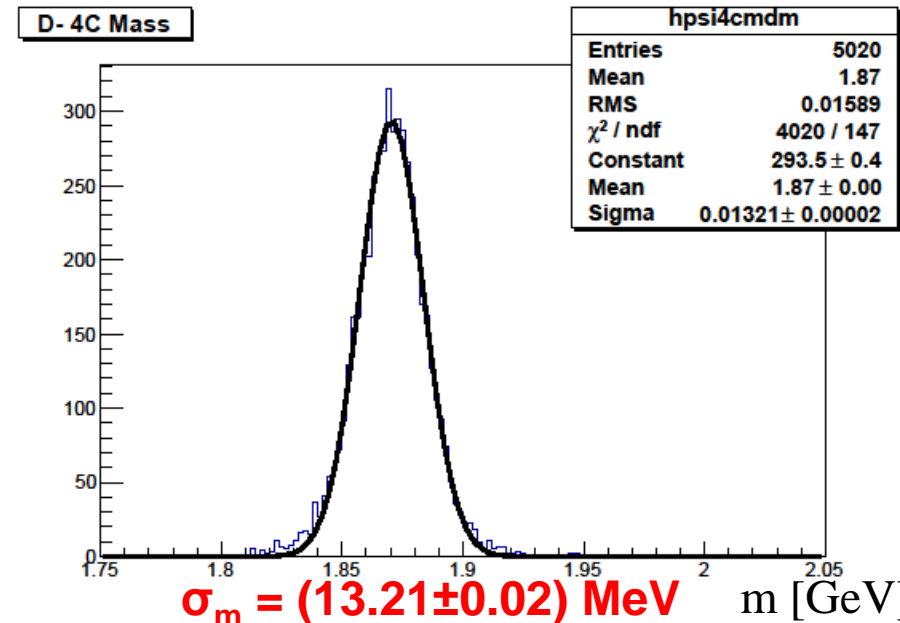
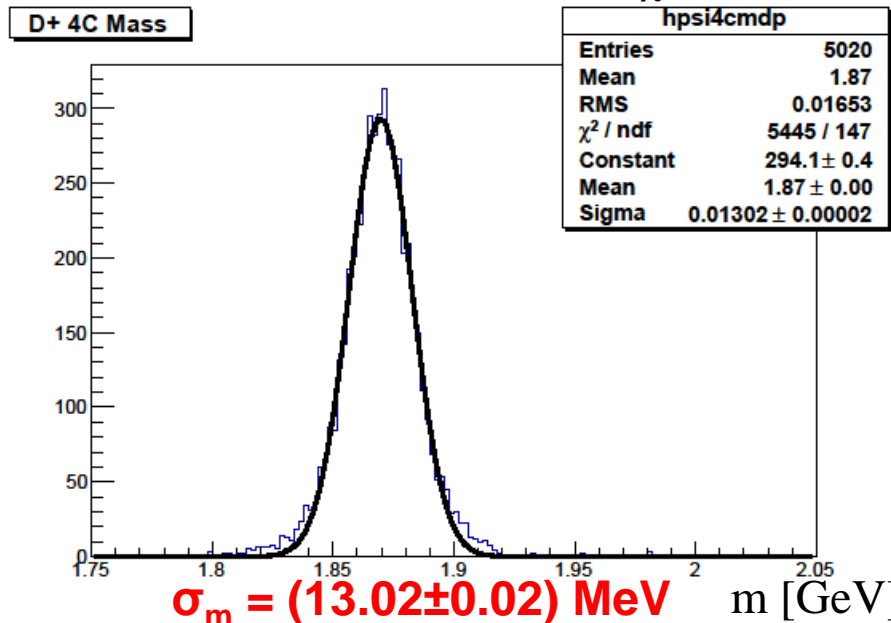
$$\sigma_z = (104.8 \pm 0.1) \mu\text{m}$$

# D-Meson Mass Resolution (STT, after 4C Fit)



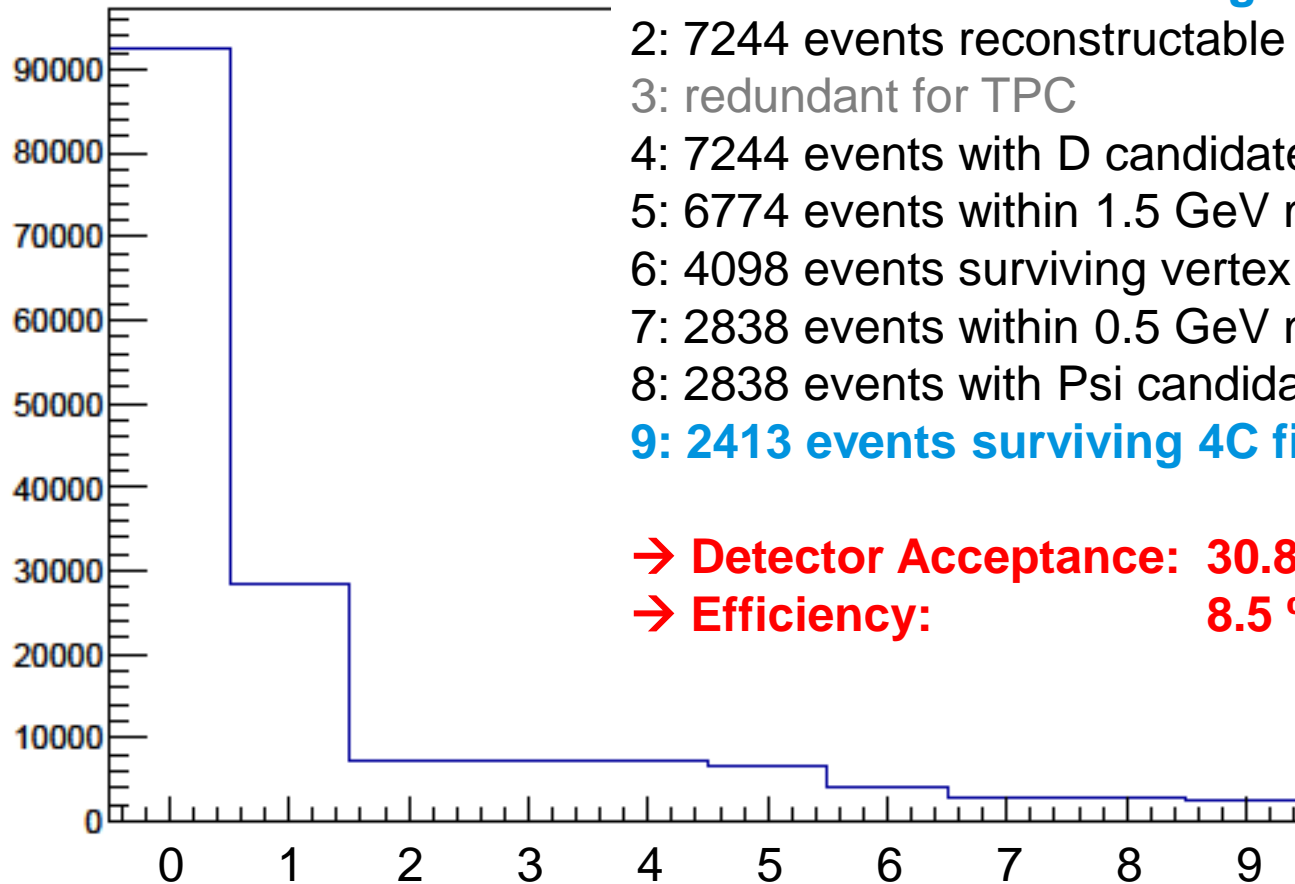
Left:  $\chi^2$  distribution of the 4C fit. For each event, the candidate with the best  $\chi^2 < 18$  is selected (in this analysis, each event already starts with just one Psi candidate)

Below: D-Meson mass resolutions



# Event Selection Process (TPC)

## Nice Events



0: 92.5k signal events total

1: 28541 events within CT geometric acceptance

2: 7244 events reconstructable by track finding

3: redundant for TPC

4: 7244 events with D candidates

5: 6774 events within 1.5 GeV mass window

6: 4098 events surviving vertex fit

7: 2838 events within 0.5 GeV mass window

8: 2838 events with Psi candidates

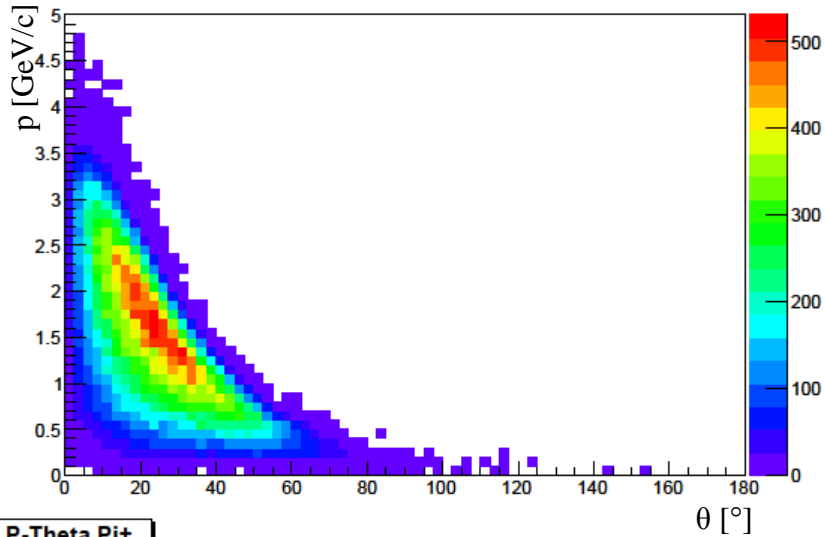
9: 2413 events surviving 4C fit

→ Detector Acceptance: 30.8 %

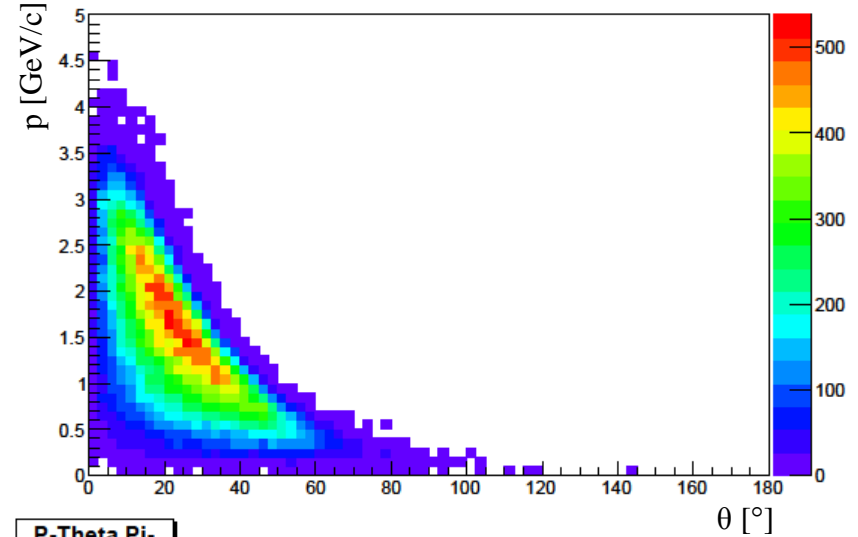
→ Efficiency: 8.5 %

# P- $\theta$ Distribution (Input Events, Analysis Step 0)

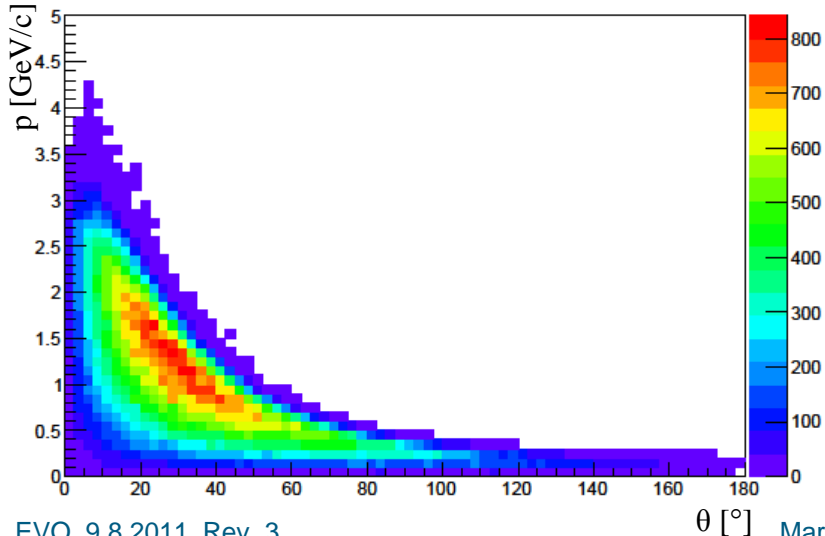
**P-Theta K+**



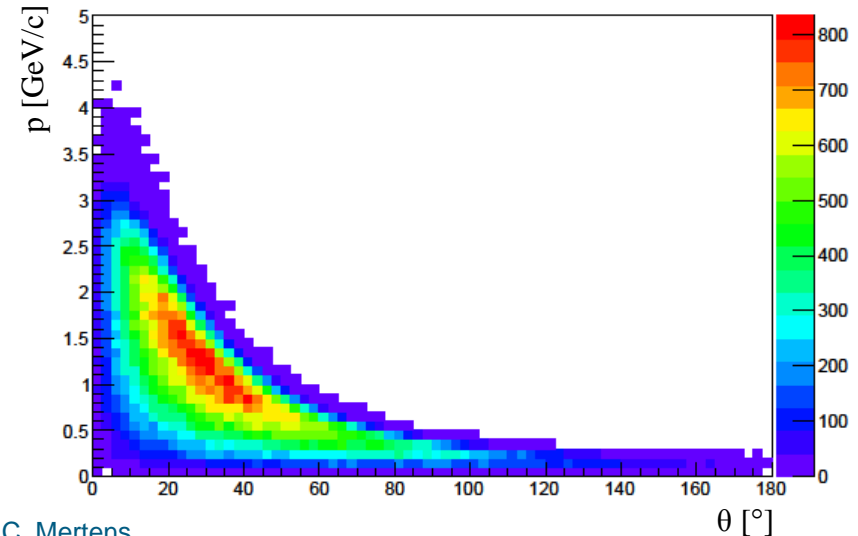
**P-Theta K-**



**P-Theta Pi+**

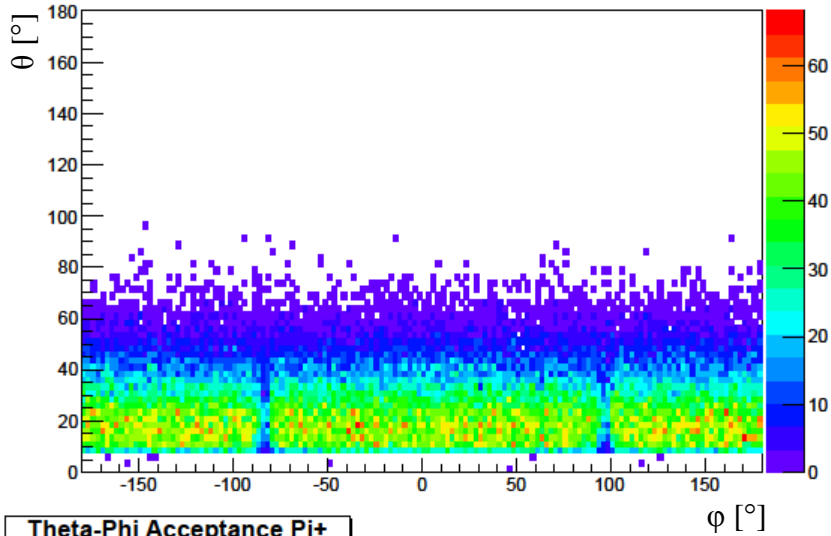


**P-Theta Pi-**

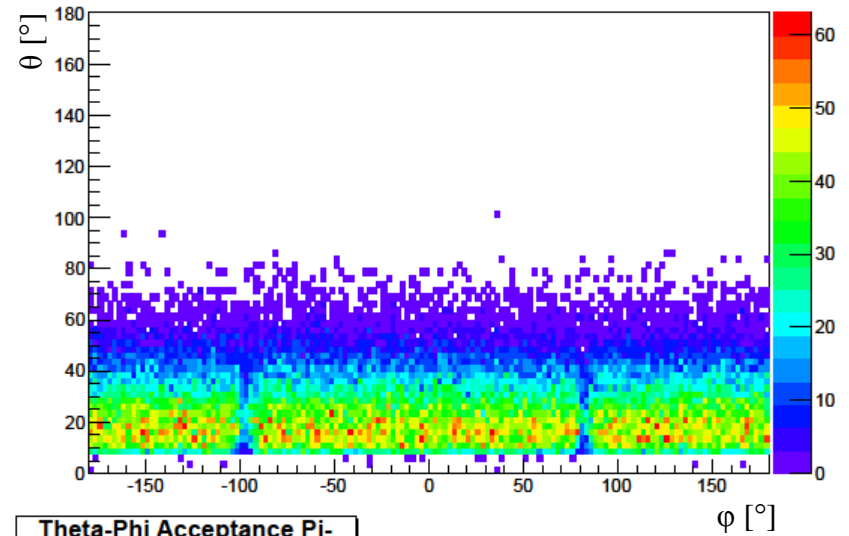


# $\theta$ - $\phi$ Geometrical Acceptance (Analysis Step 1, TPC)

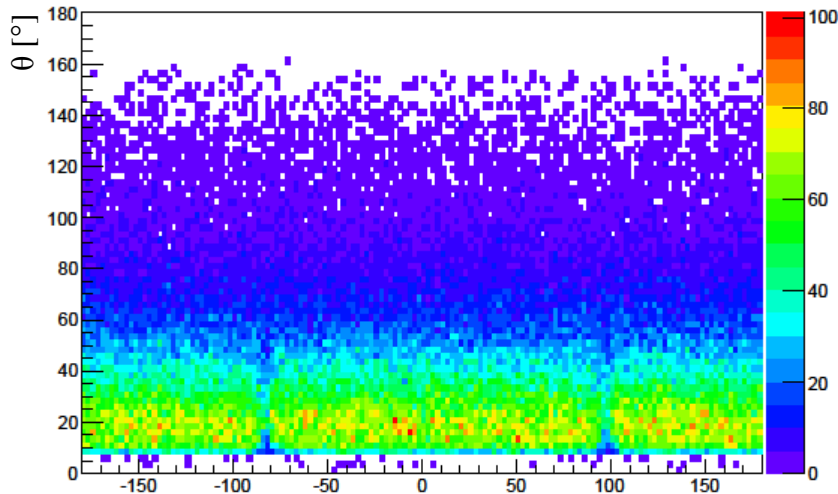
Theta-Phi Acceptance K+



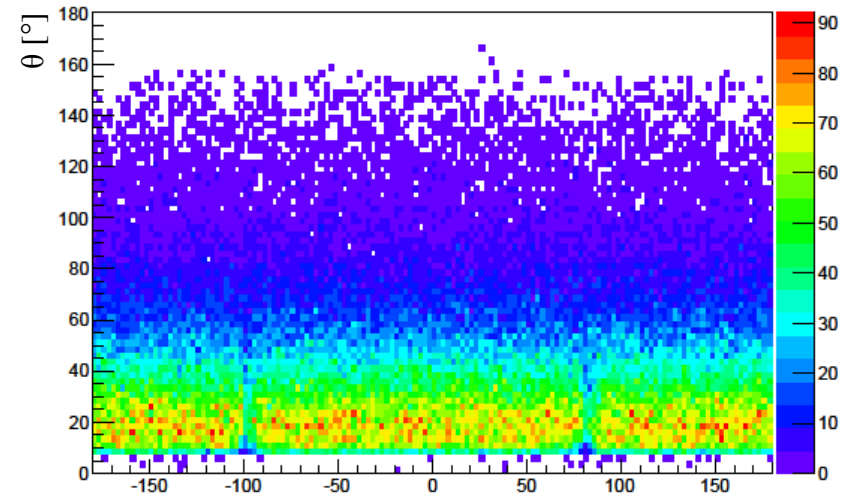
Theta-Phi Acceptance K-



Theta-Phi Acceptance Pi+

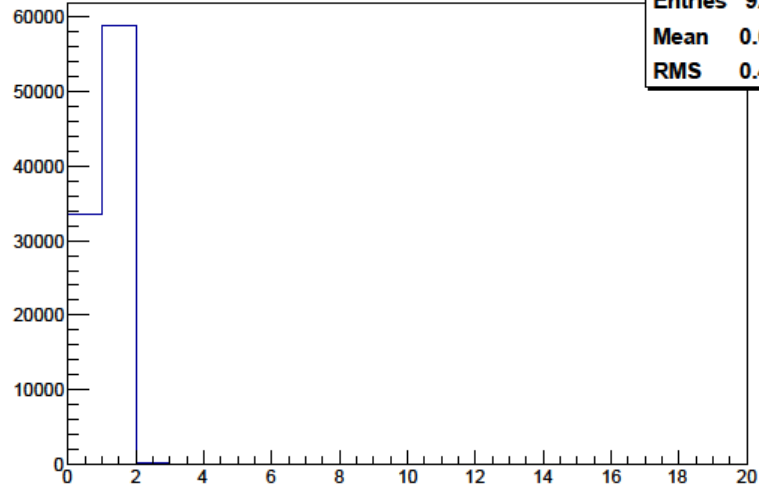


Theta-Phi Acceptance Pi-



# Track Multiplicities (in Analysis Step 3, TPC)

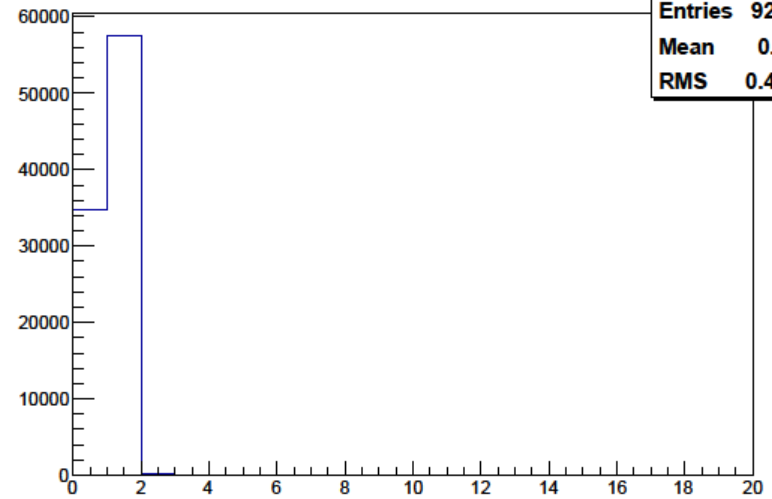
**K+ per Event**



**hkpperevent**

Entries 92500  
Mean 0.6394  
RMS 0.4842

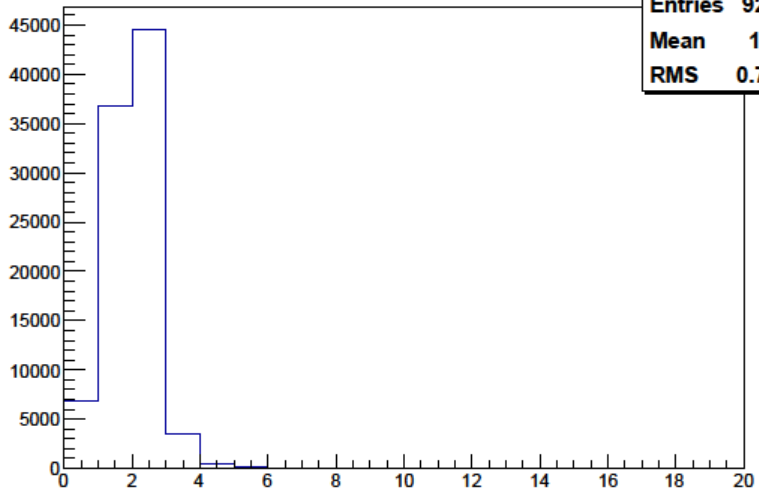
**K- per Event**



**hkmperevent**

Entries 92500  
Mean 0.626  
RMS 0.4883

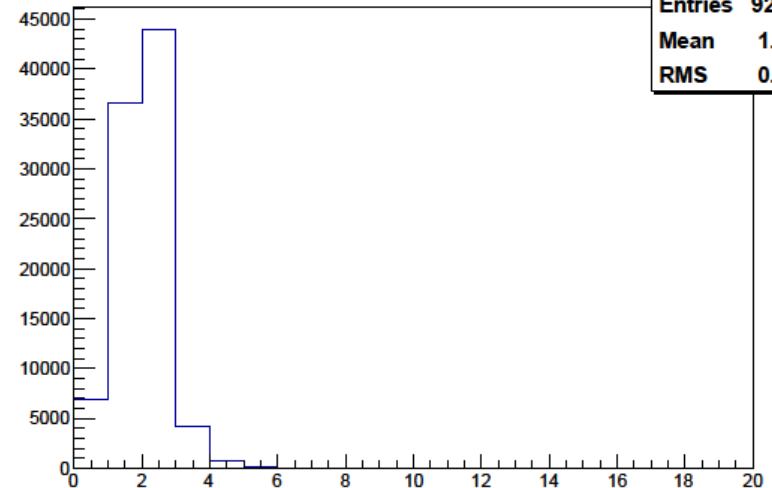
**Pi+ per Event**



**hpi+perevent**

Entries 92500  
Mean 1.509  
RMS 0.7374

**Pi- per Event**



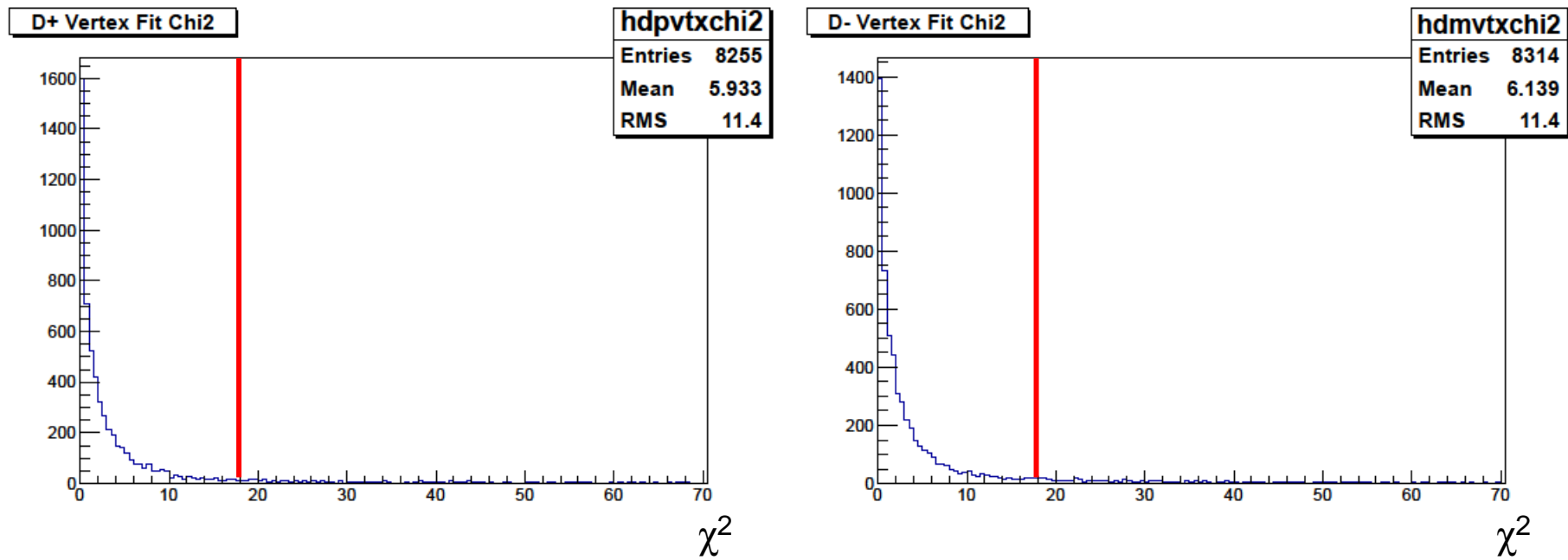
**hpim+perevent**

Entries 92500  
Mean 1.524  
RMS 0.763

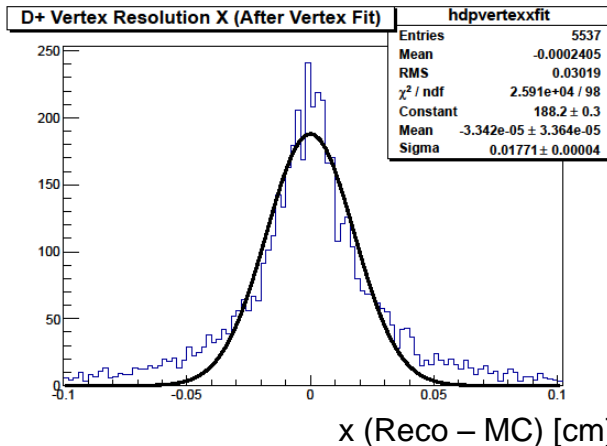


# D-Meson Vertex Fit (TPC)

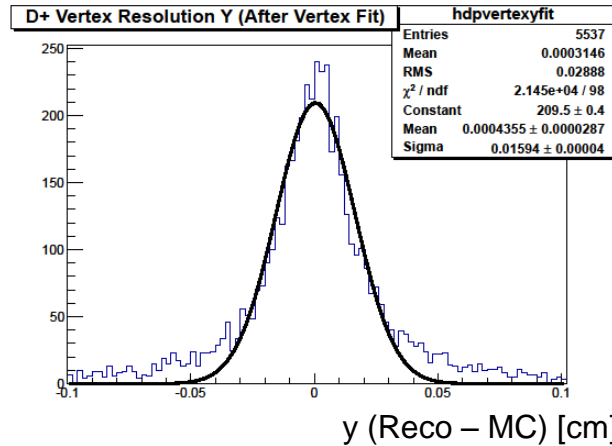
$\chi^2$  distribution of the vertex fits to the D-mesons. For each event, the candidates with the best  $\chi^2 < 18$  are selected (one  $D^+$ , one  $D^-$ )



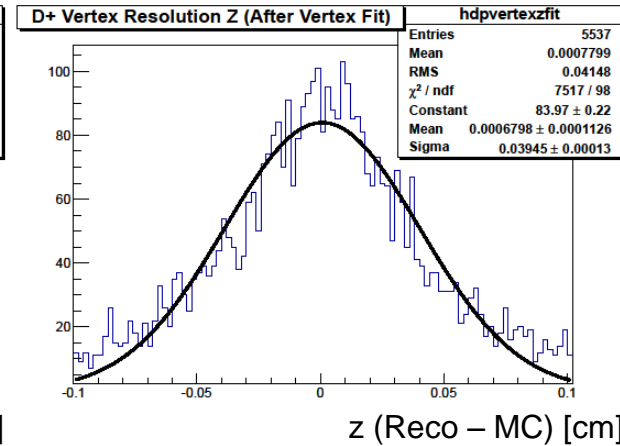
# D-Meson Vertex Resolution (TPC, after Vertex Fit)



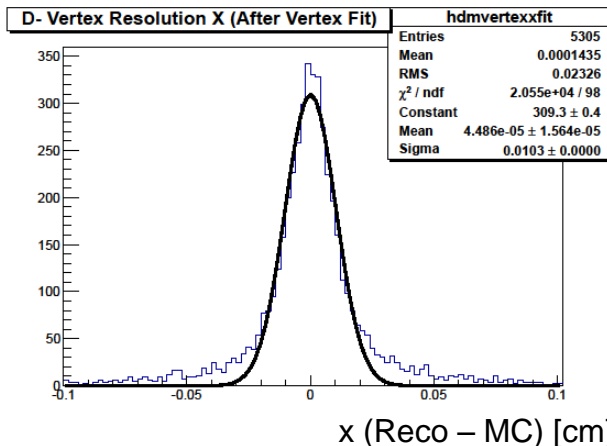
$$\sigma_x = (177.1 \pm 0.4) \mu\text{m}$$



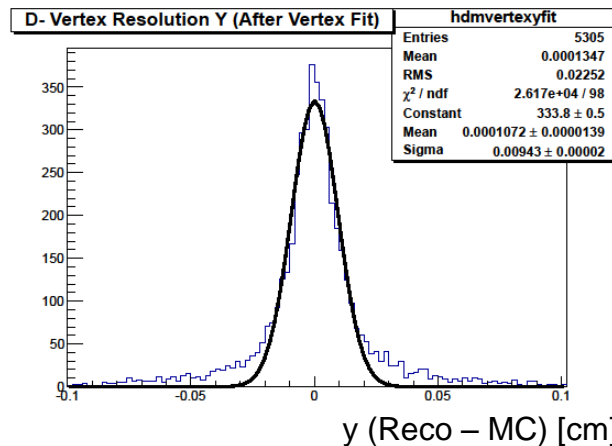
$$\sigma_y = (159.4 \pm 0.4) \mu\text{m}$$



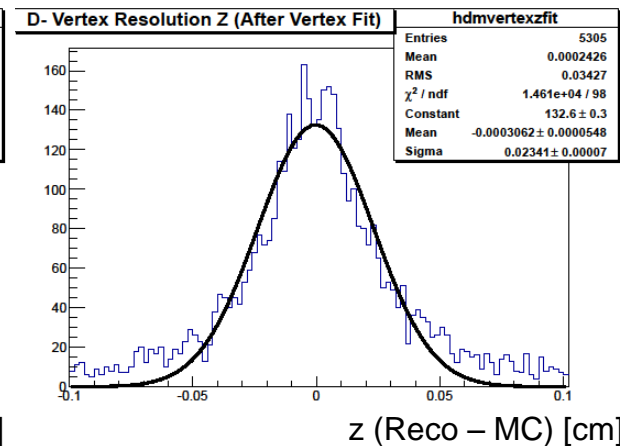
$$\sigma_z = (394.5 \pm 1.3) \mu\text{m}$$



$$\sigma_x = (103.0 \pm 0.4) \mu\text{m}$$

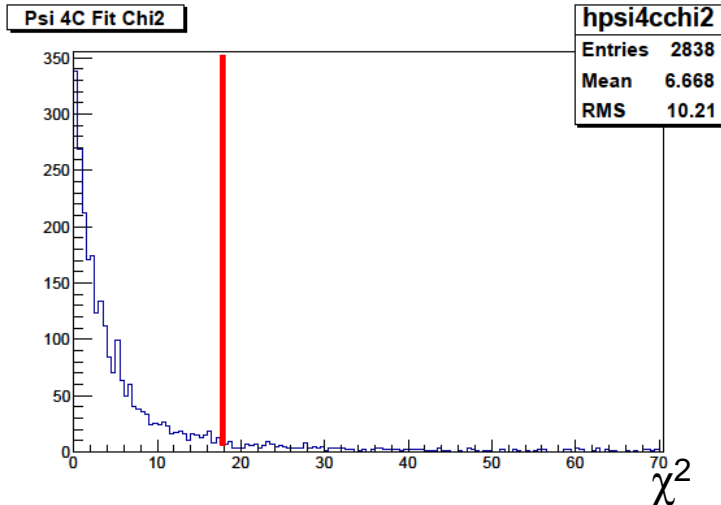


$$\sigma_y = (94.3 \pm 0.4) \mu\text{m}$$



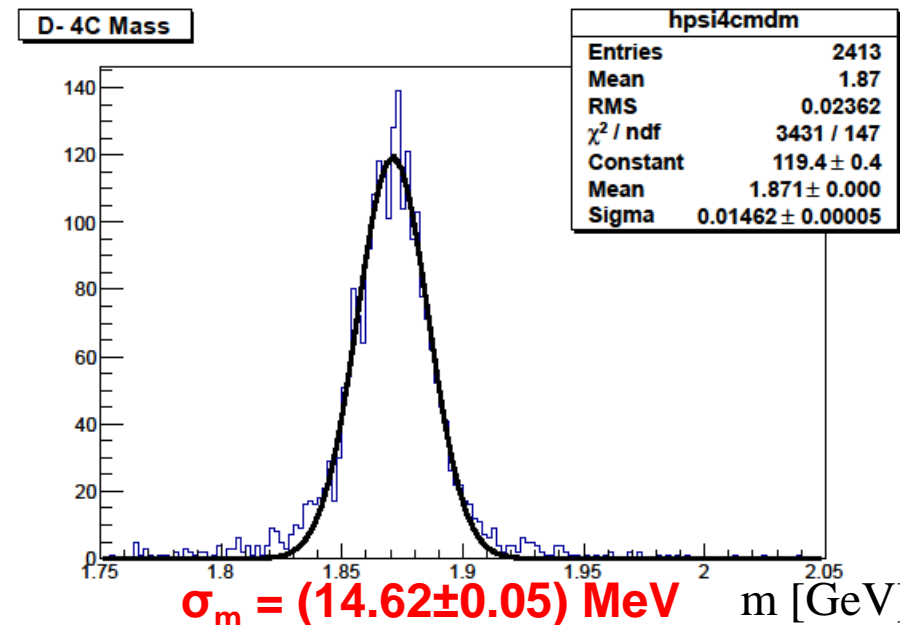
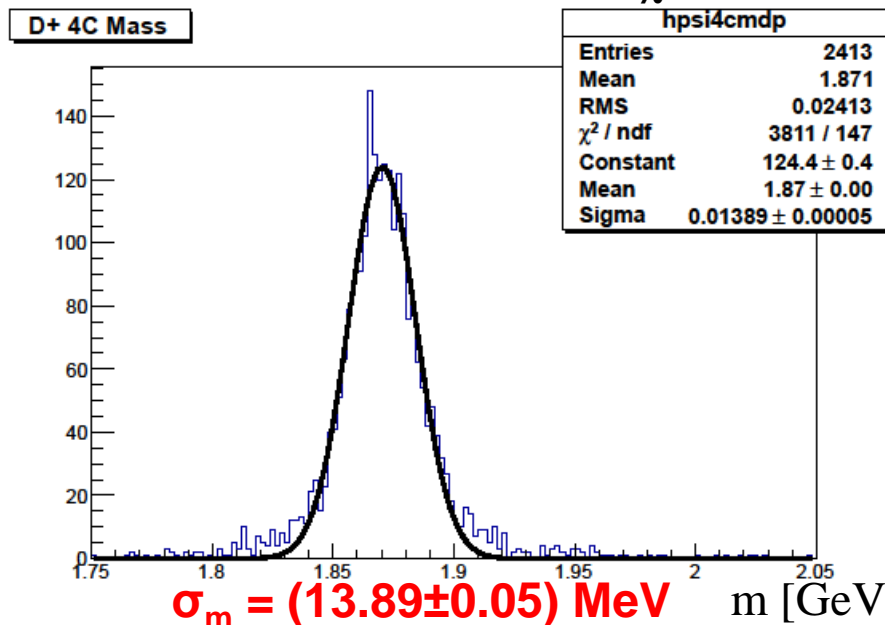
$$\sigma_z = (234.1 \pm 1.3) \mu\text{m}$$

# D-Meson Mass Resolution (TPC, after 4C Fit)



Left:  $\chi^2$  distribution of the 4C fit. For each event, the candidate with the best  $\chi^2 < 18$  is selected (in this analysis, each event already starts with just one Psi candidate)

Below: D-Meson mass resolutions



## Summary of the Results

	STT	TPC
Acceptance	24.5 %	30.8 %
Efficiency	20.5 %	8.5 %
Total Reconstructed	5.0 %	2.6 %
Vertex Resolution (xy)	54.5 $\mu\text{m}$	133.5 $\mu\text{m}$
Vertex Resolution (z)	104.3 $\mu\text{m}$	314.3 $\mu\text{m}$
Mass Resolution	13.1 MeV	14.3 MeV

### Remarks:

- For the studied (clean) channel with the given input, **both CT choices offer a good overall performance** (results reflecting both detector properties and reconstruction software) **within a similar range**
- A tradeoff between efficiency and resolution by fine-tuning the parameters of the analysis seems possible for either CT choice