



# 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 (run934oldnocu, PandaRoot 12725)*
  - *Signal samples for TPC (run984, PandaRoot 12933)*
- Steps
  - *Simulation*
  - *Digitization*
  - *Reconstruction*
  - *PID*
  - ***Analysis (common for both CT options)***

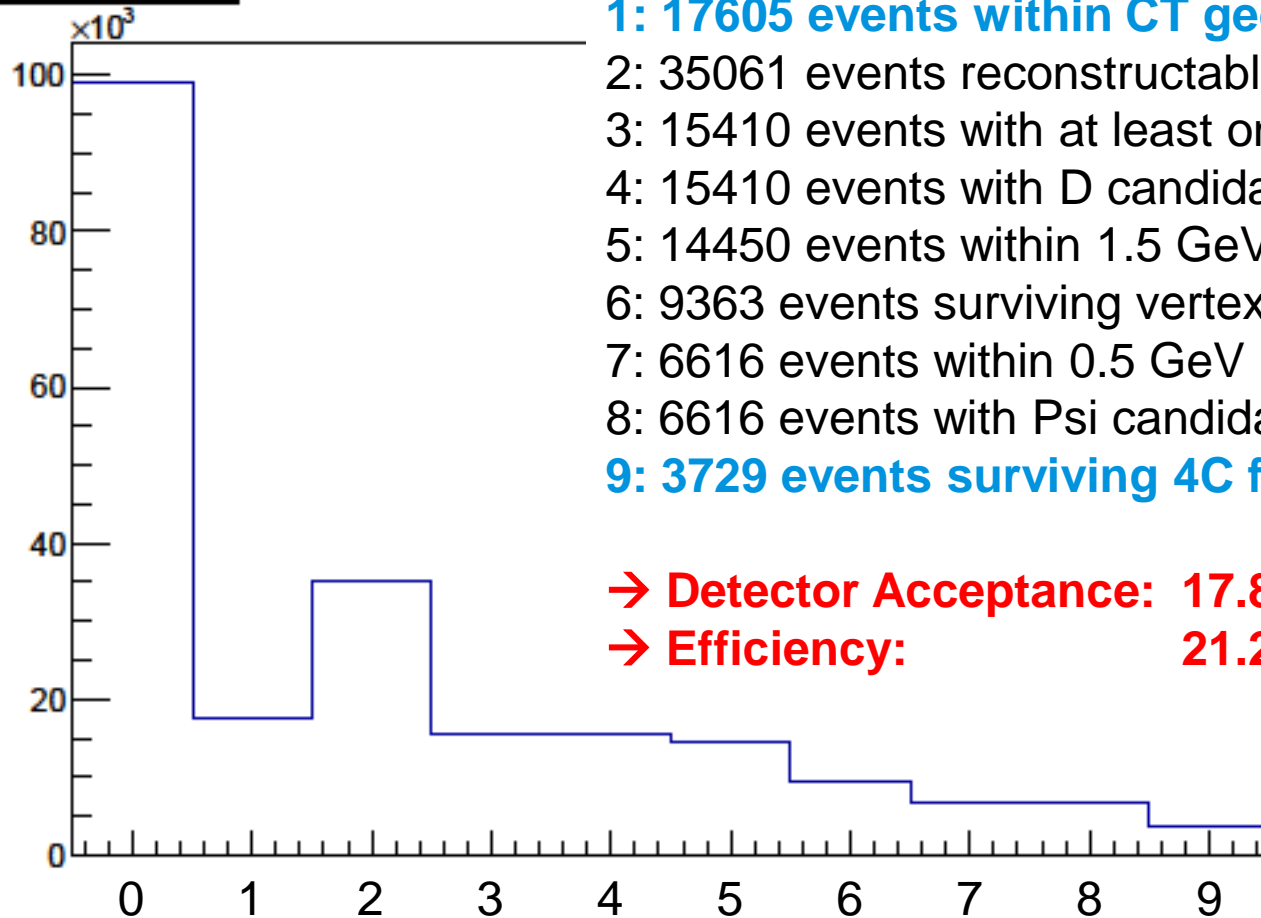
Software experts, full data sets available on the Grid

# 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)

**Nice Events**



**0: 99k signal events total**

**1: 17605 events within CT geometric acceptance**

2: 35061 events reconstructable by track finding

3: 15410 events with at least one STT hit

4: 15410 events with D candidates

5: 14450 events within 1.5 GeV mass window

6: 9363 events surviving vertex fit

7: 6616 events within 0.5 GeV mass window

8: 6616 events with Psi candidates

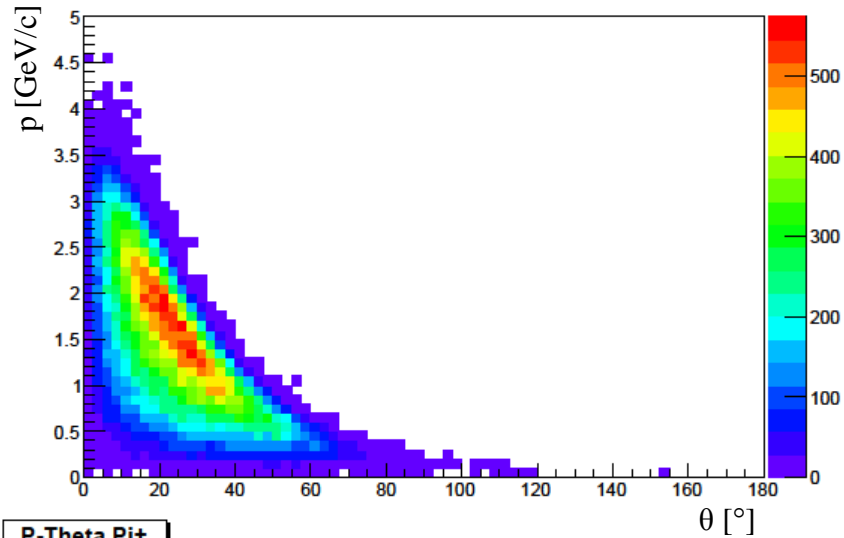
**9: 3729 events surviving 4C fit**

**→ Detector Acceptance: 17.8 %**

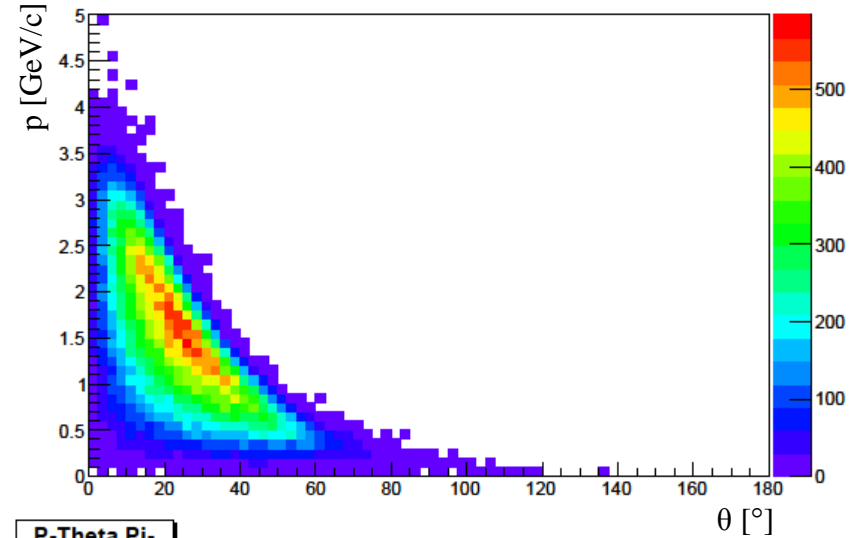
**→ Efficiency: 21.2 %**

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

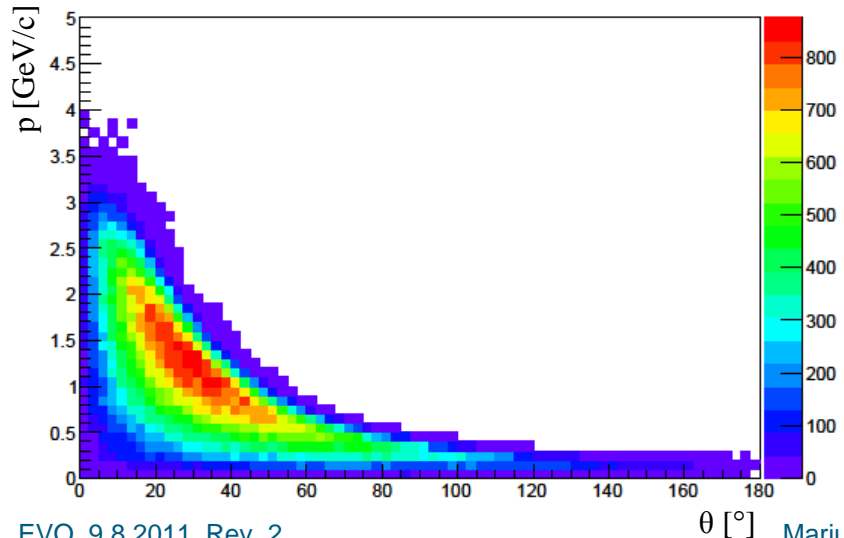
**P-Theta K+**



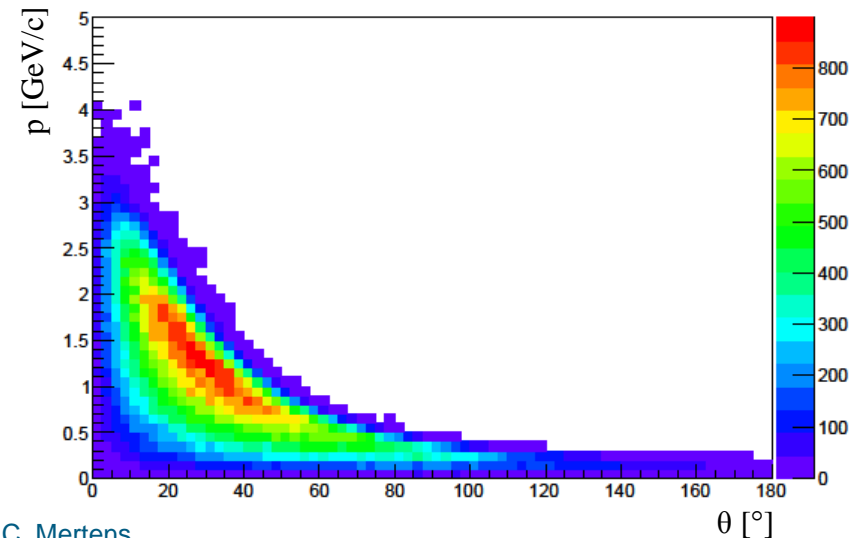
**P-Theta K-**



**P-Theta Pi+**

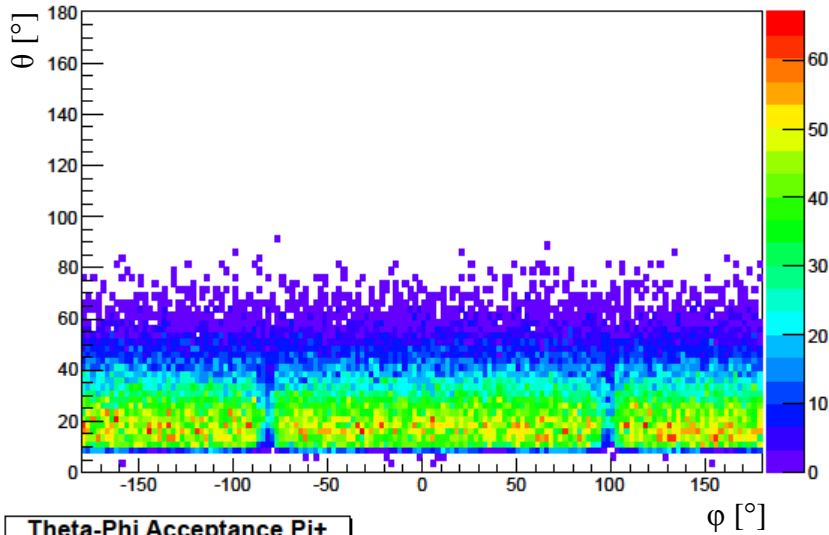


**P-Theta Pi-**

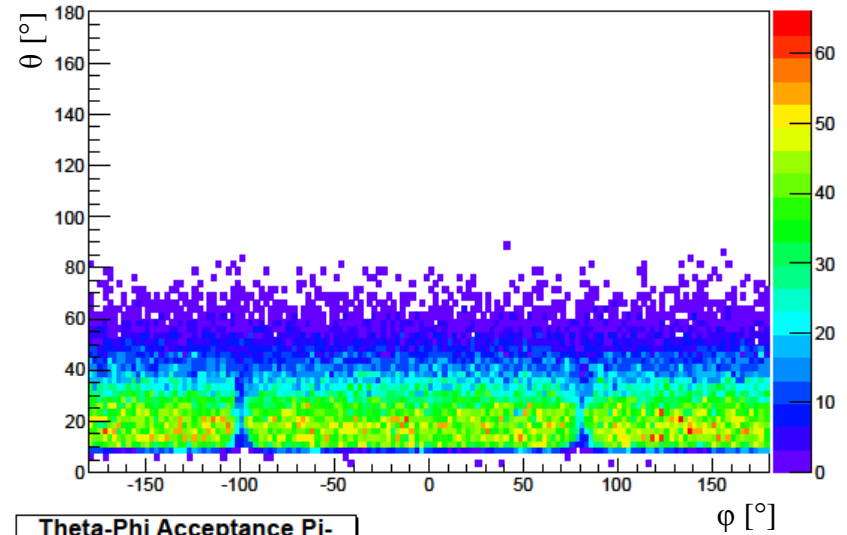


# $\theta$ - $\phi$ Geometrical Acceptance (Analysis Step 1, STT)

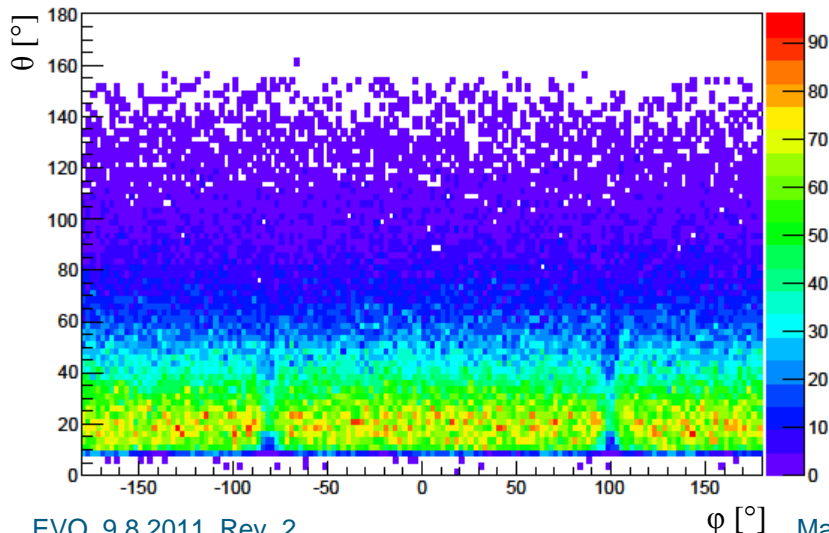
Theta-Phi Acceptance K+



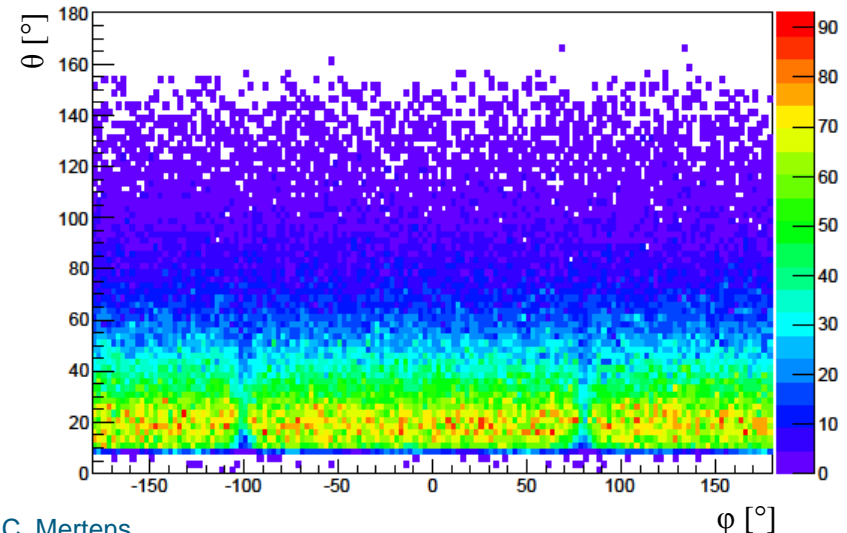
Theta-Phi Acceptance K-



Theta-Phi Acceptance Pi+



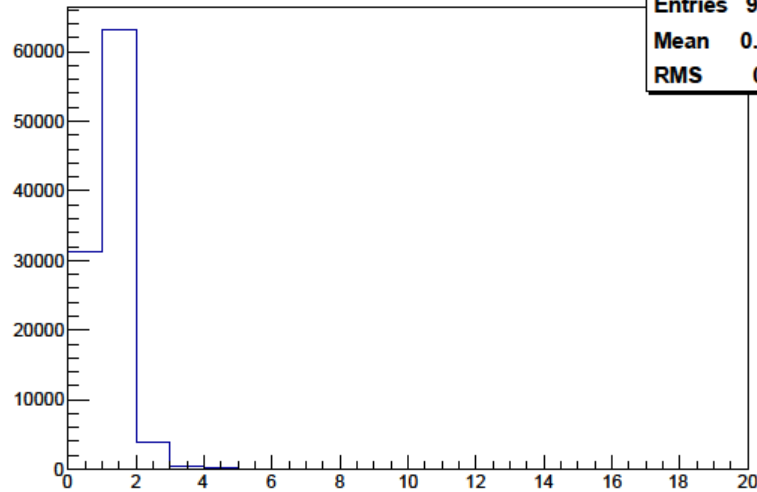
Theta-Phi Acceptance Pi-





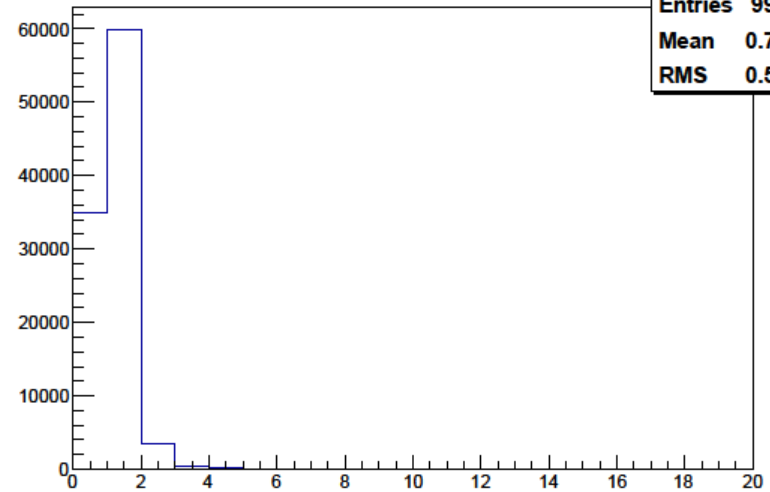
# Track Multiplicities (in Analysis Step 3, STT)

**K+ per Event**



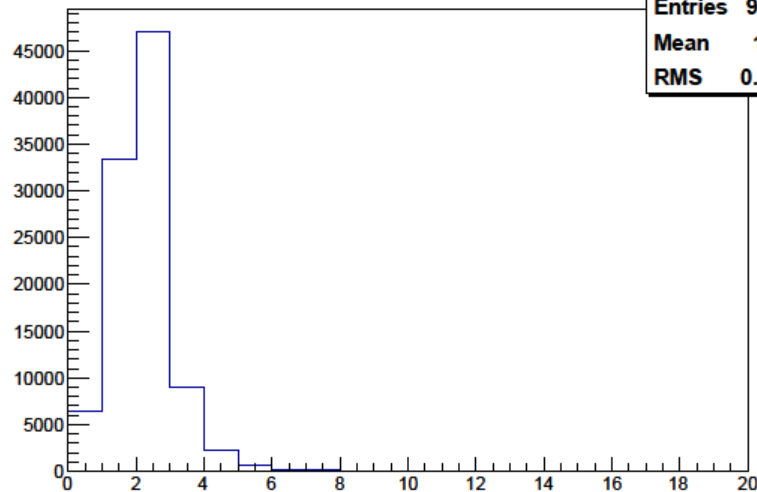
<b>hkpperevent</b>
Entries 99000
Mean 0.7464
RMS 0.598

**K- per Event**



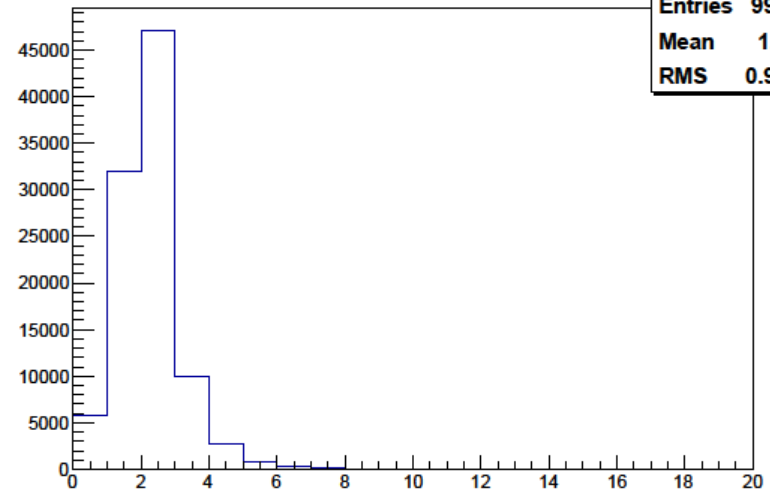
<b>hkmperevent</b>
Entries 99000
Mean 0.7009
RMS 0.5939

**Pi+ per Event**



<b>hpippurevent</b>
Entries 99000
Mean 1.709
RMS 0.9233

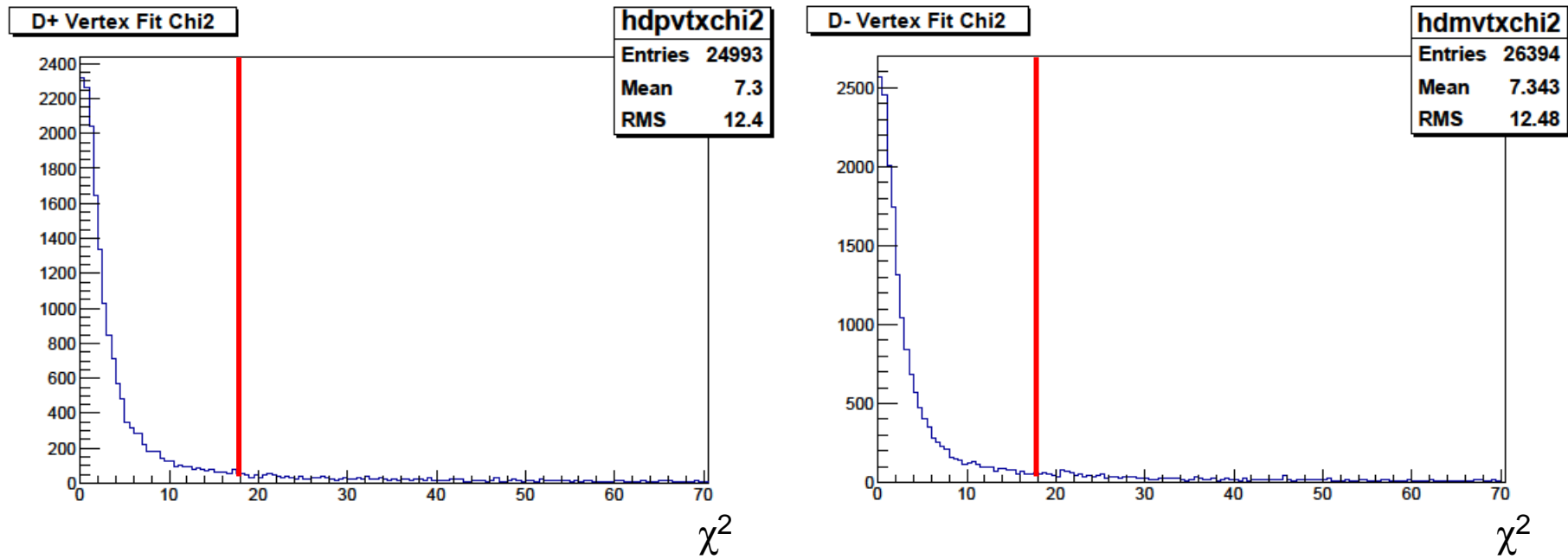
**Pi- per Event**



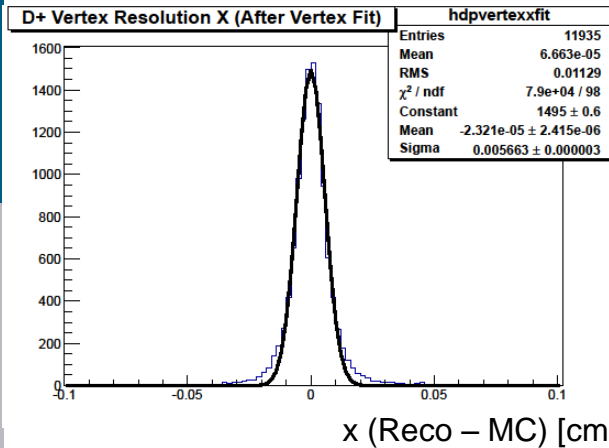
<b>hpimperevent</b>
Entries 99000
Mean 1.768
RMS 0.9758

# D-Meson Vertex Fit (STT)

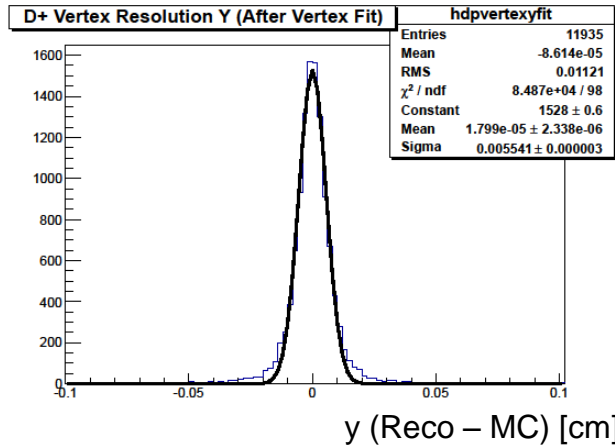
$\chi^2$  distribution of the vertex fits to the D-mesons. For each event, the candidates with the best  $\chi^2 < 18$  are selected (one  $D^+$ , one  $D^-$ )



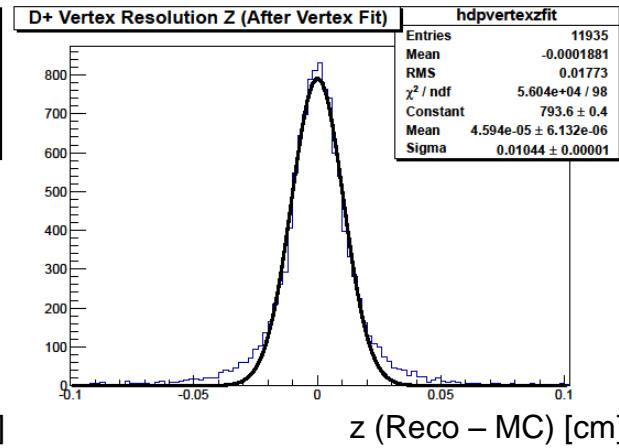
# D-Meson Vertex Resolution (STT, after Vertex Fit)



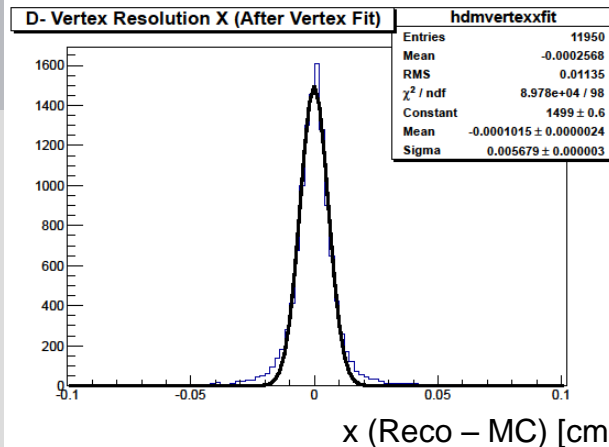
$$\sigma_x = (56.63 \pm 0.03) \mu\text{m}$$



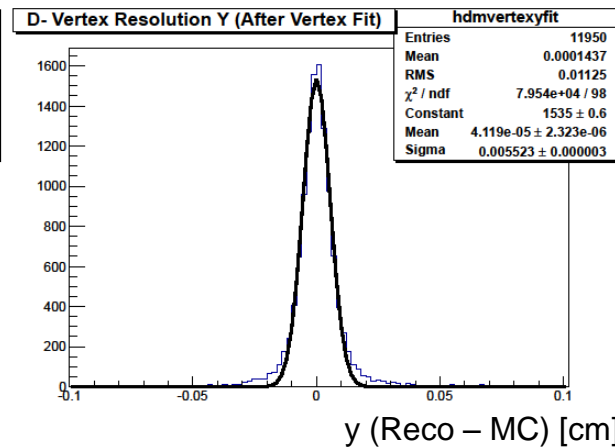
$$\sigma_y = (55.41 \pm 0.03) \mu\text{m}$$



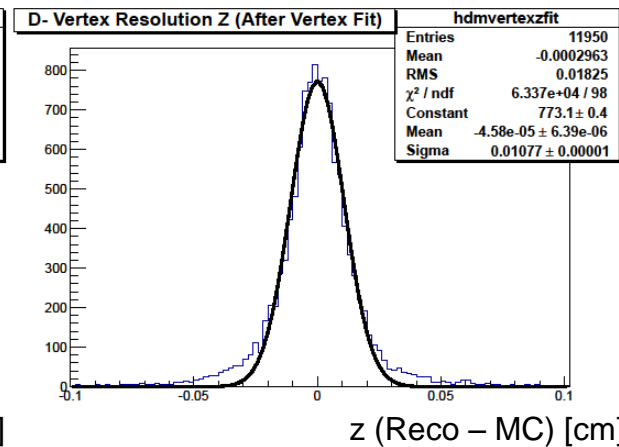
$$\sigma_z = (104.4 \pm 0.1) \mu\text{m}$$



$$\sigma_x = (56.79 \pm 0.03) \mu\text{m}$$

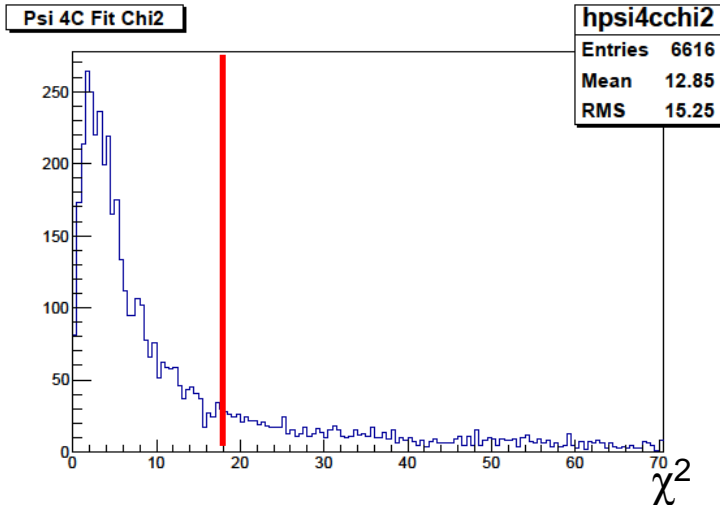


$$\sigma_y = (55.23 \pm 0.03) \mu\text{m}$$



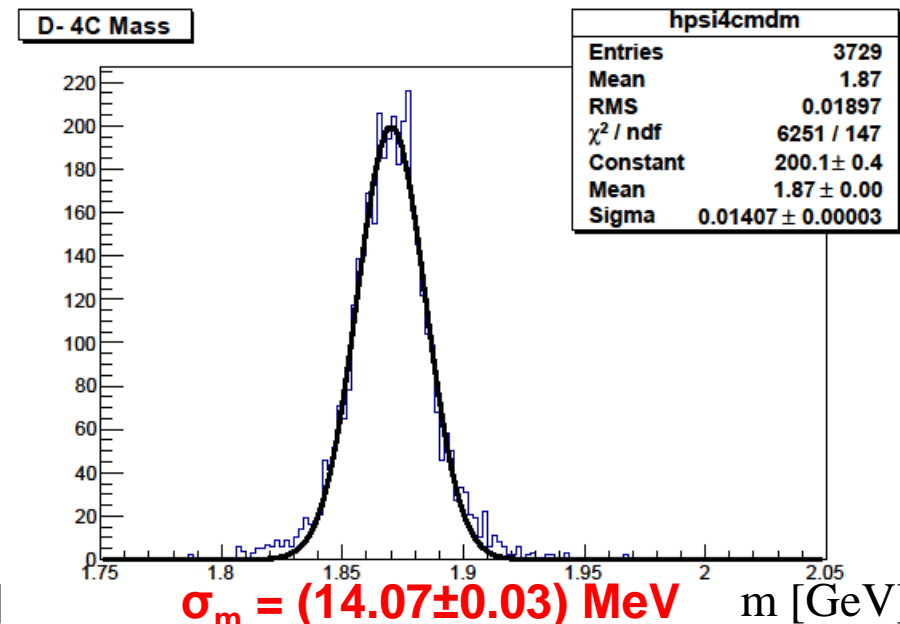
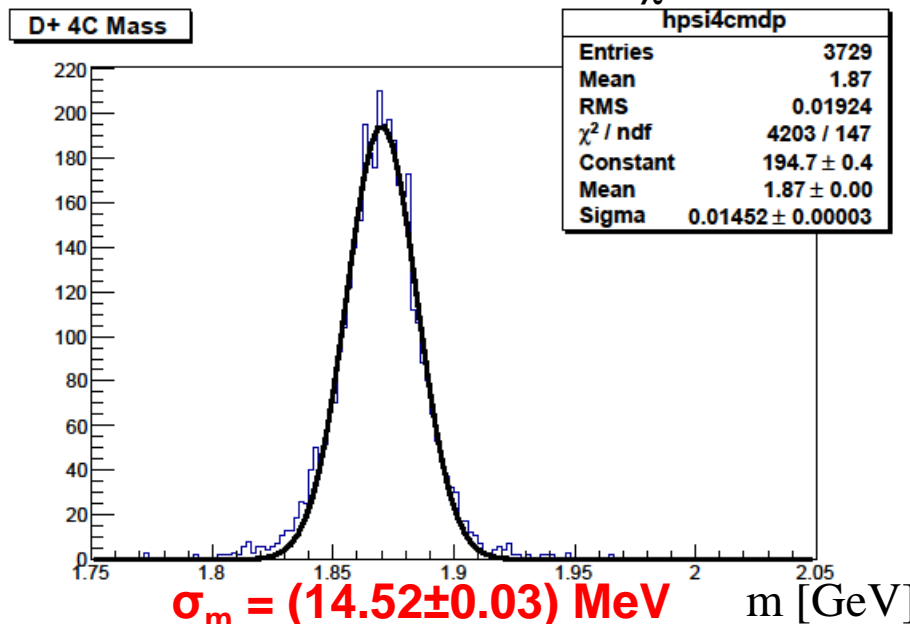
$$\sigma_z = (107.7 \pm 0.1) \mu\text{m}$$

# 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)

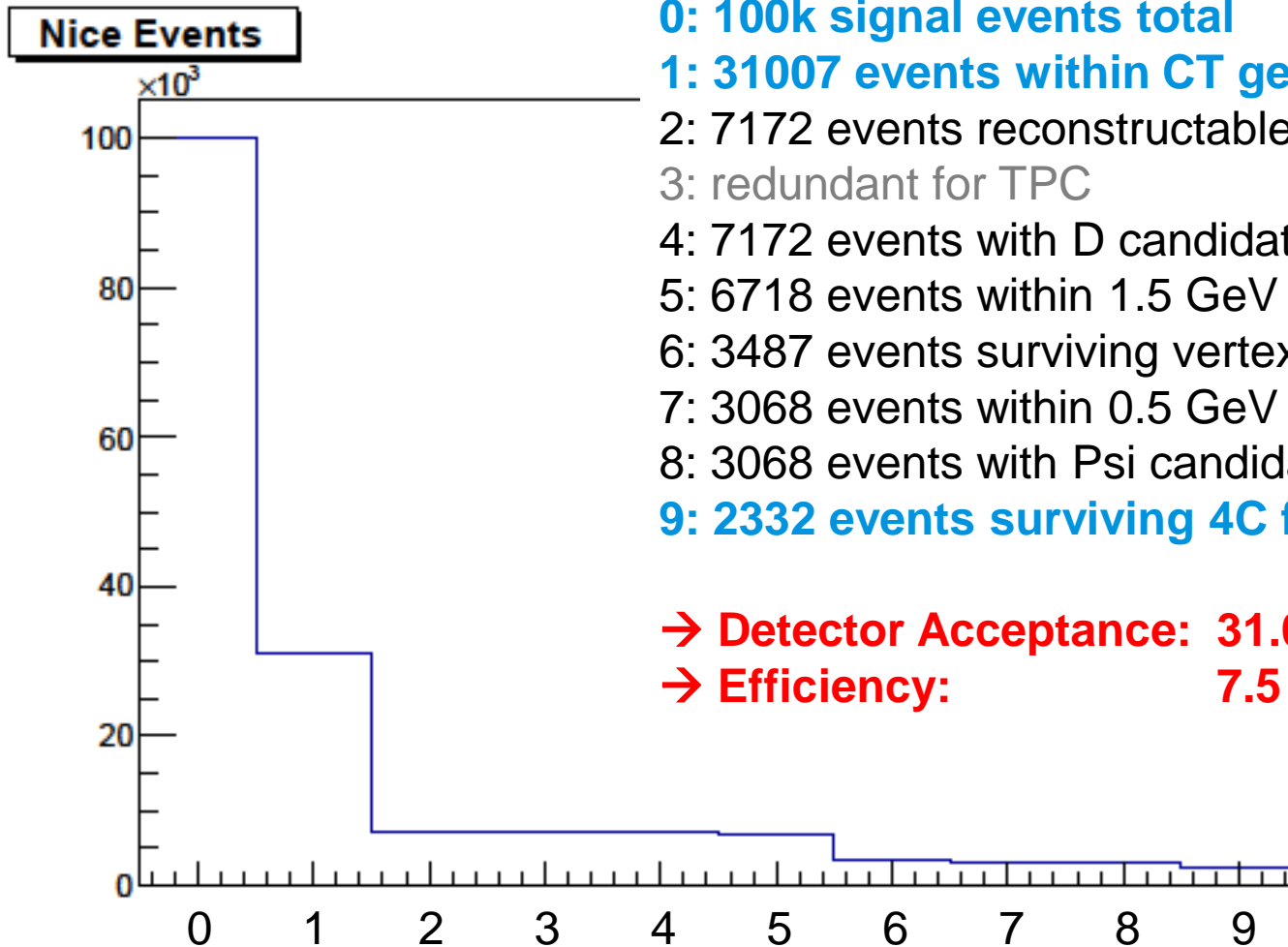
Below: D-Meson mass resolutions



# Event Selection Process (TPC)

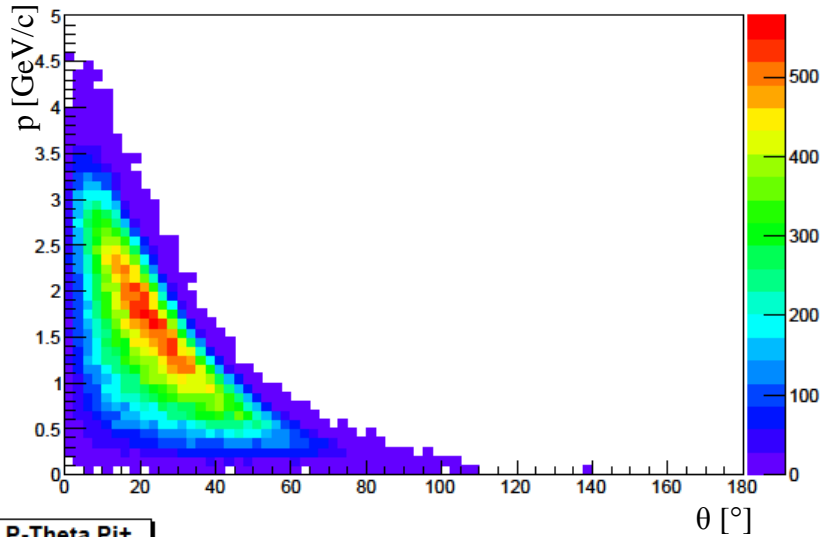
- 0: 100k signal events total**
- 1: 31007 events within CT geometric acceptance**
- 2: 7172 events reconstructable by track finding
- 3: redundant for TPC
- 4: 7172 events with D candidates
- 5: 6718 events within 1.5 GeV mass window
- 6: 3487 events surviving vertex fit
- 7: 3068 events within 0.5 GeV mass window
- 8: 3068 events with Psi candidates
- 9: 2332 events surviving 4C fit**

→ **Detector Acceptance: 31.0 %**  
 → **Efficiency: 7.5 %**

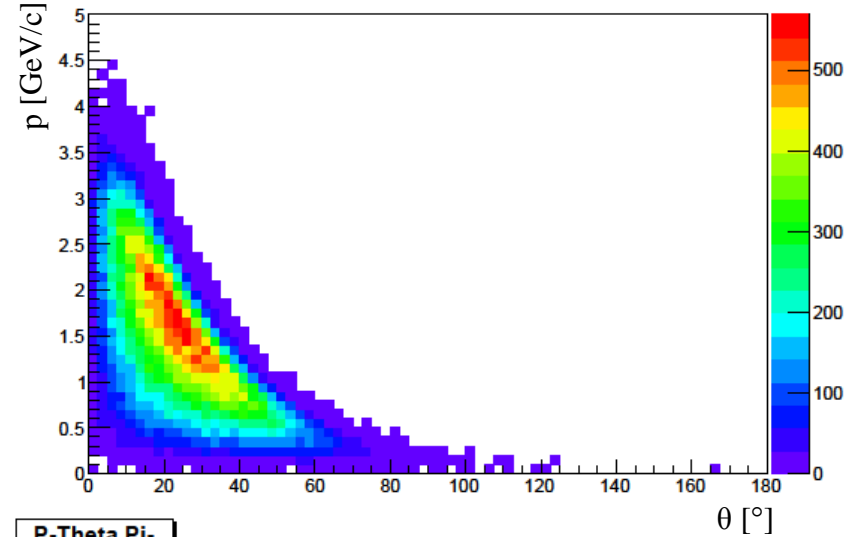


# P- $\theta$ Distribution (Input Events, Analysis Step 0)

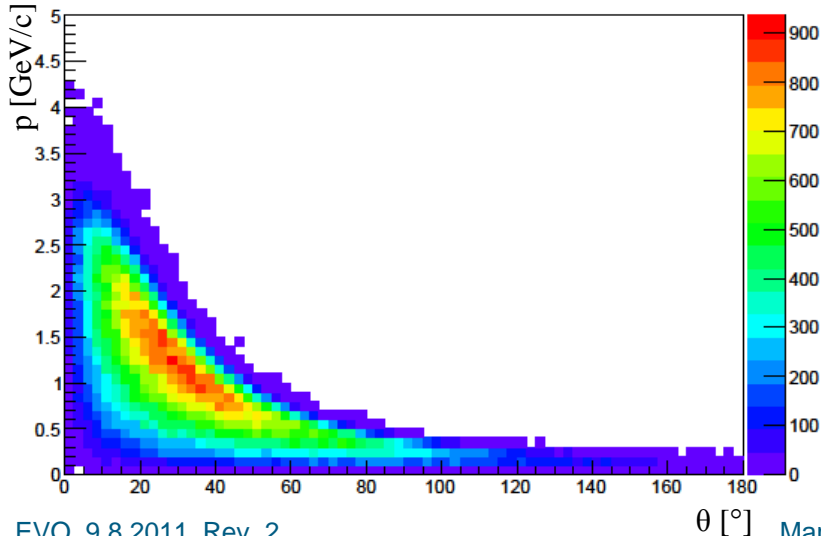
**P-Theta K+**



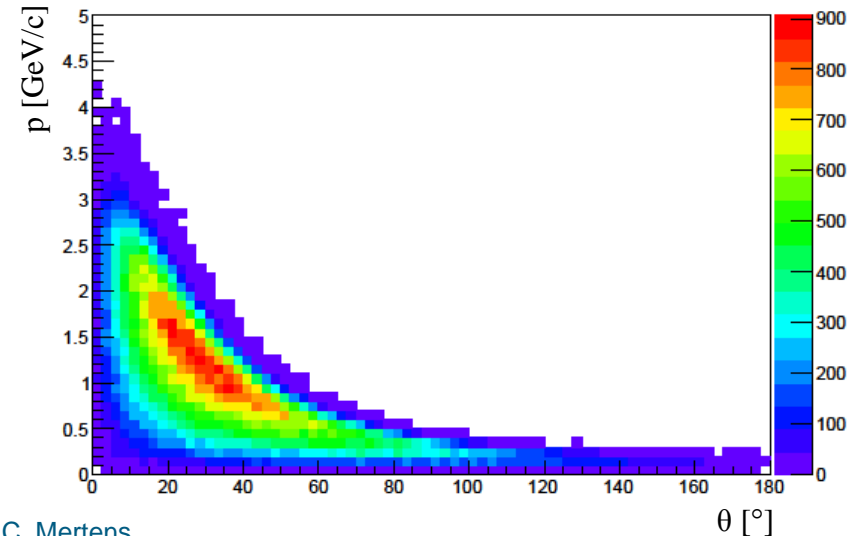
**P-Theta K-**



**P-Theta Pi+**

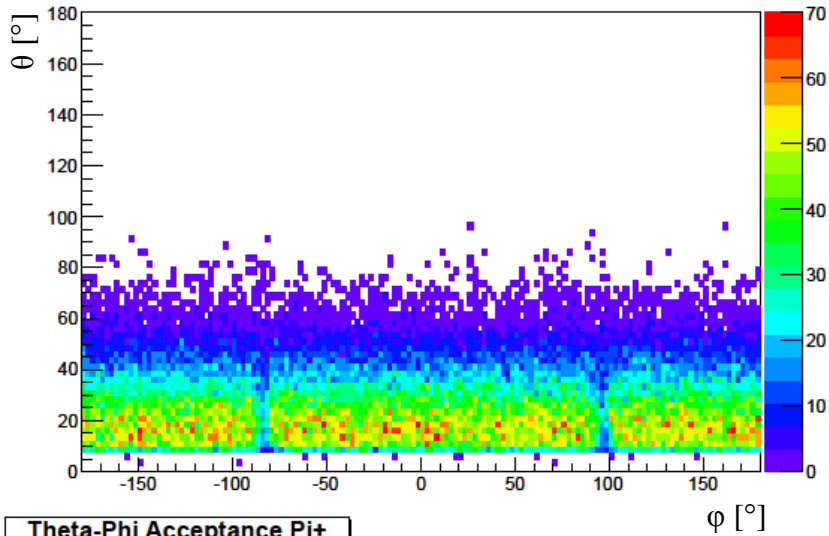


**P-Theta Pi-**

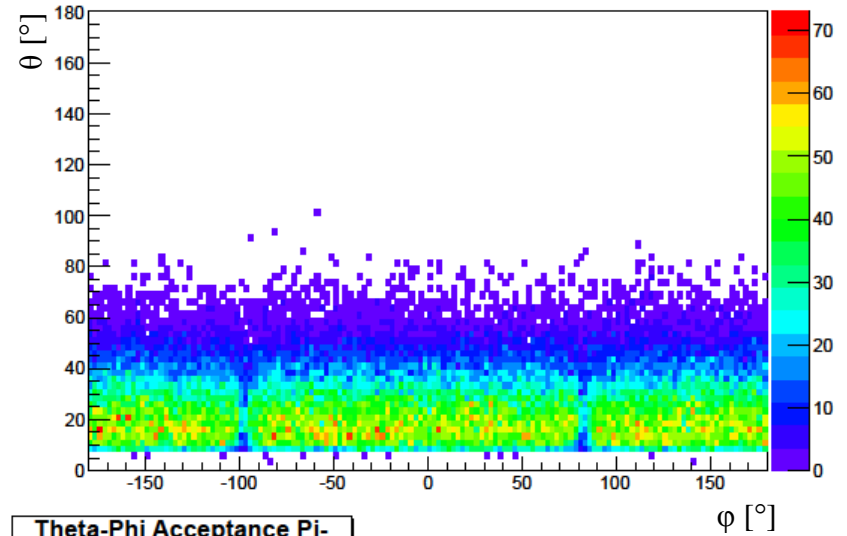


# $\theta$ - $\phi$ Geometrical Acceptance (Analysis Step 1, TPC)

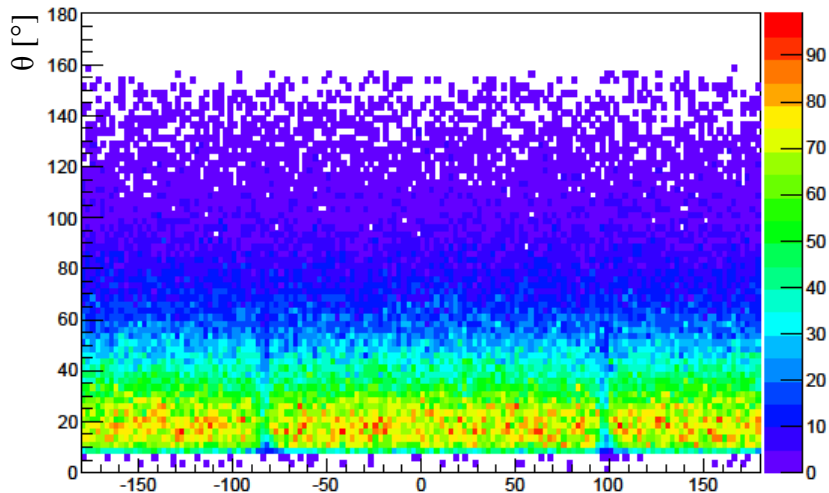
Theta-Phi Acceptance K+



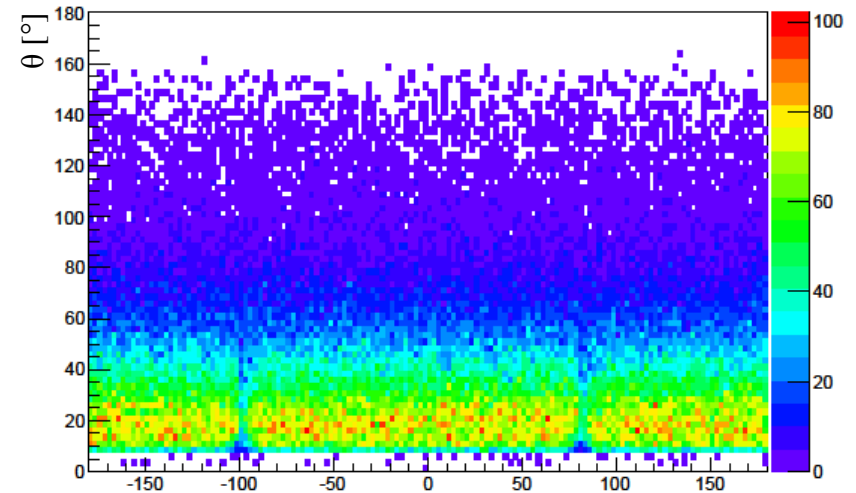
Theta-Phi Acceptance K-



Theta-Phi Acceptance Pi+

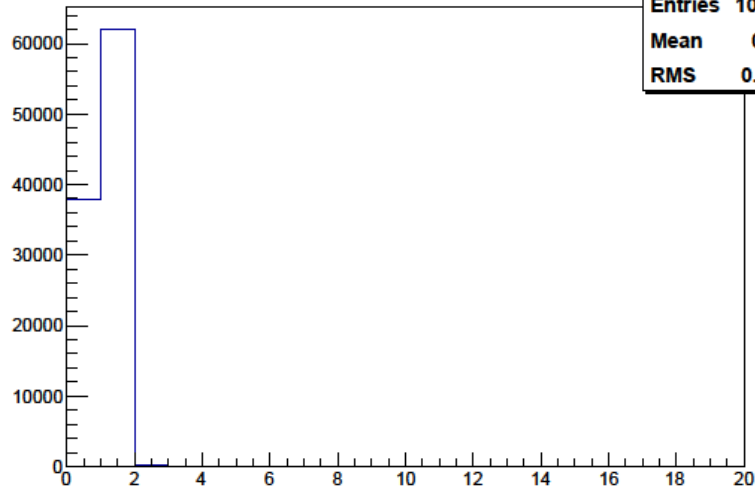


Theta-Phi Acceptance Pi-



# Track Multiplicities (in Analysis Step 3, TPC)

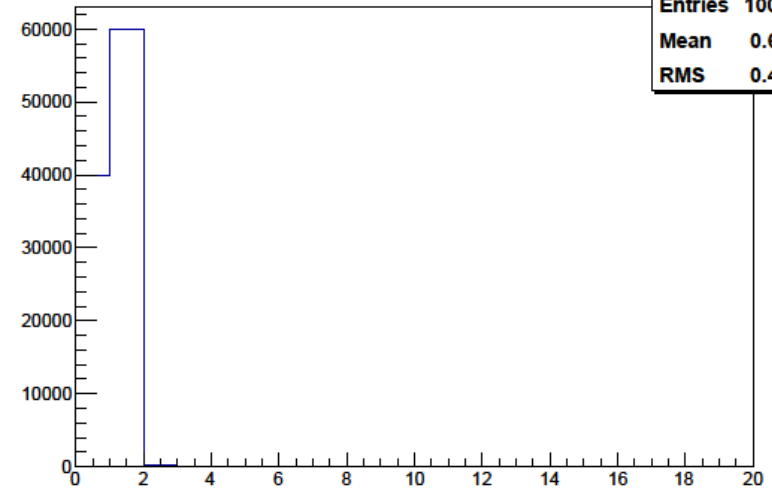
**K+ per Event**



**hkpperevent**

Entries	100000
Mean	0.624
RMS	0.4887

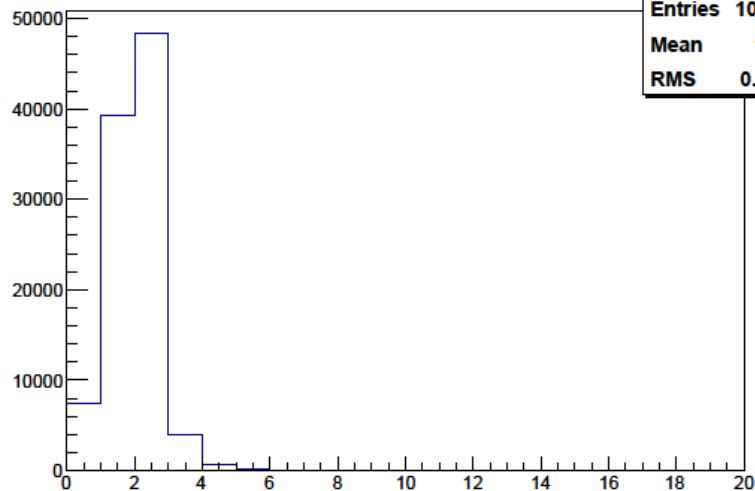
**K- per Event**



**hkmperevent**

Entries	100000
Mean	0.6027
RMS	0.4929

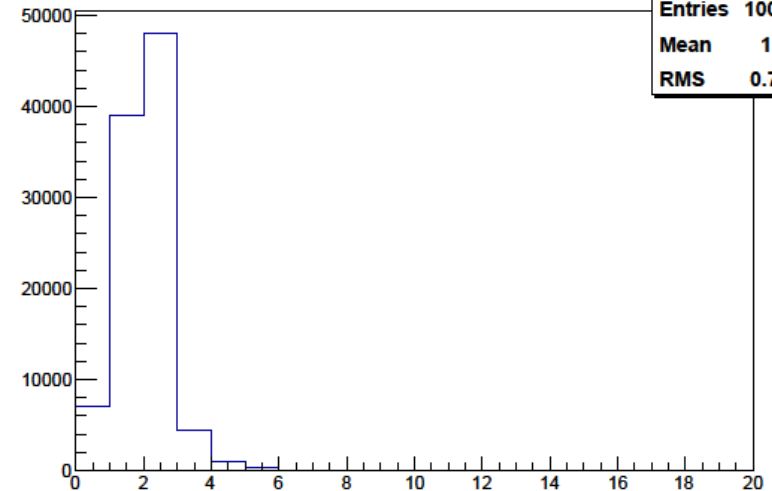
**Pi+ per Event**



**hpippurevent**

Entries	100000
Mean	1.521
RMS	0.7516

**Pi- per Event**



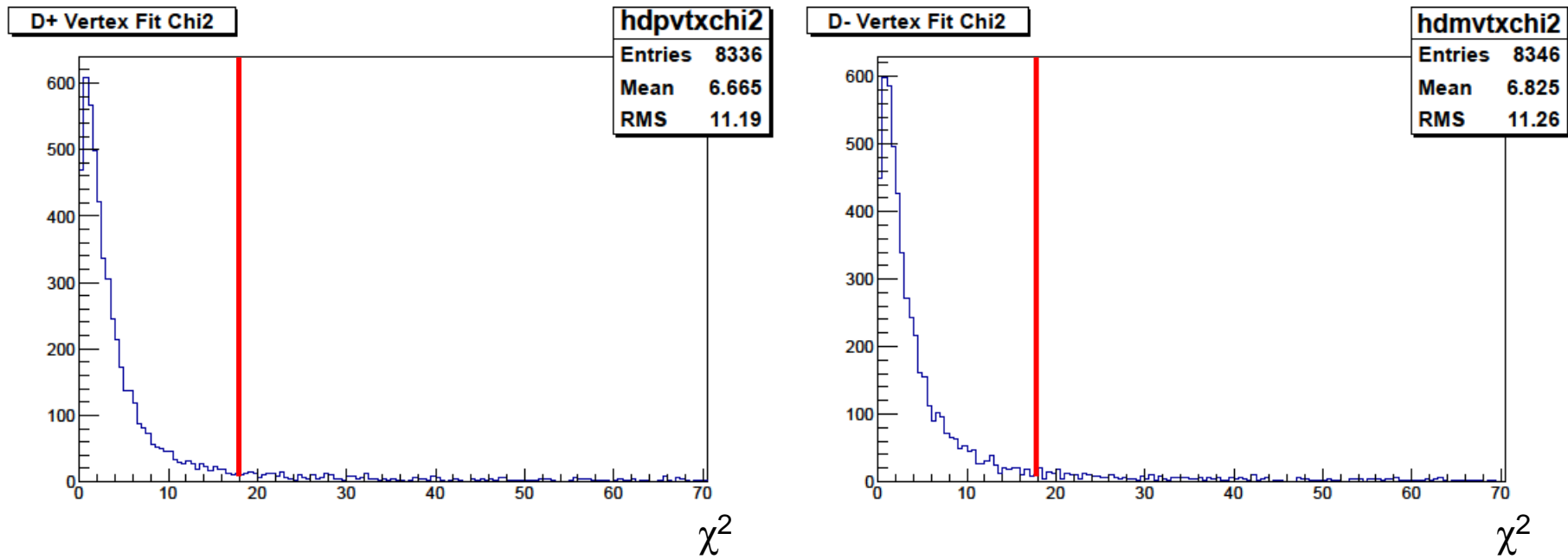
**hpimpevent**

Entries	100000
Mean	1.546
RMS	0.7798

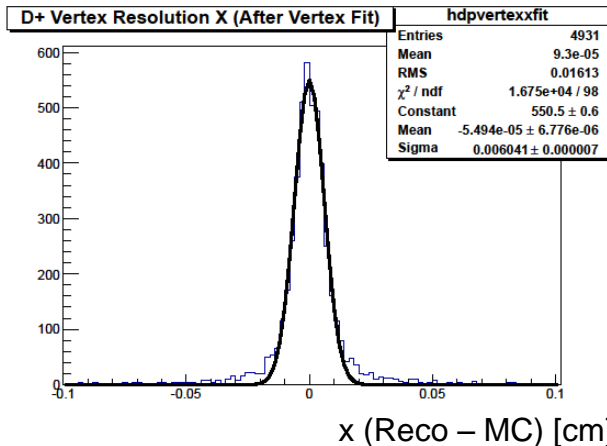


# D-Meson Vertex Fit (TPC)

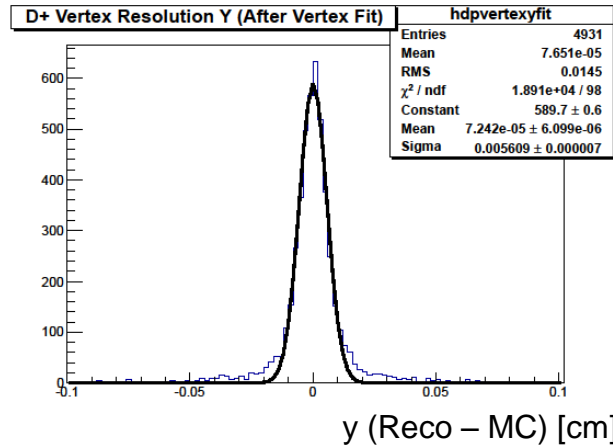
$\chi^2$  distribution of the vertex fits to the D-mesons. For each event, the candidates with the best  $\chi^2 < 18$  are selected (one  $D^+$ , one  $D^-$ )



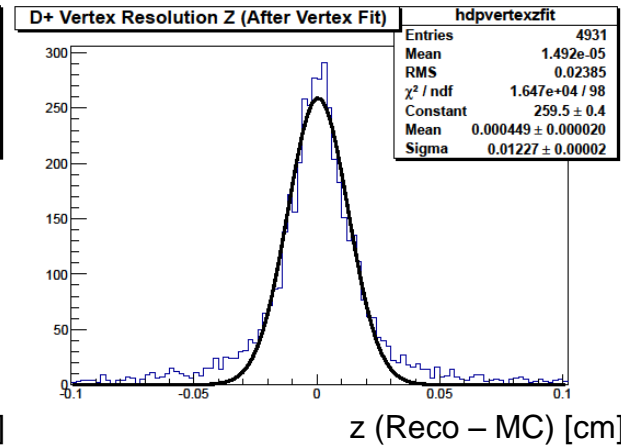
# D-Meson Vertex Resolution (TPC, after Vertex Fit)



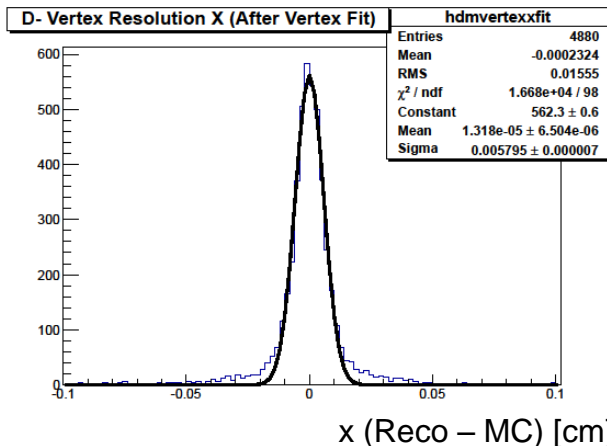
$$\sigma_x = (60.41 \pm 0.07) \mu\text{m}$$



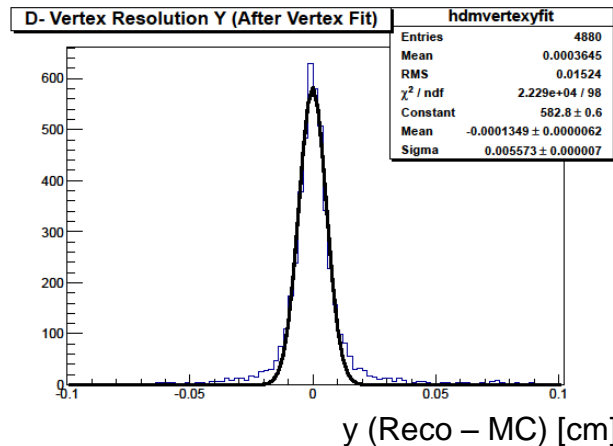
$$\sigma_y = (56.09 \pm 0.07) \mu\text{m}$$



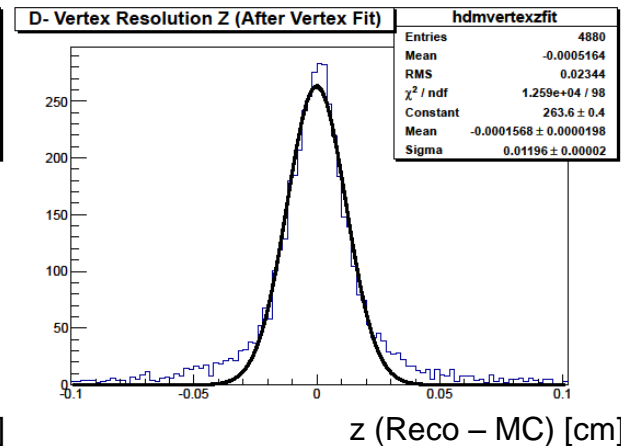
$$\sigma_z = (122.7 \pm 0.2) \mu\text{m}$$



$$\sigma_x = (57.95 \pm 0.07) \mu\text{m}$$

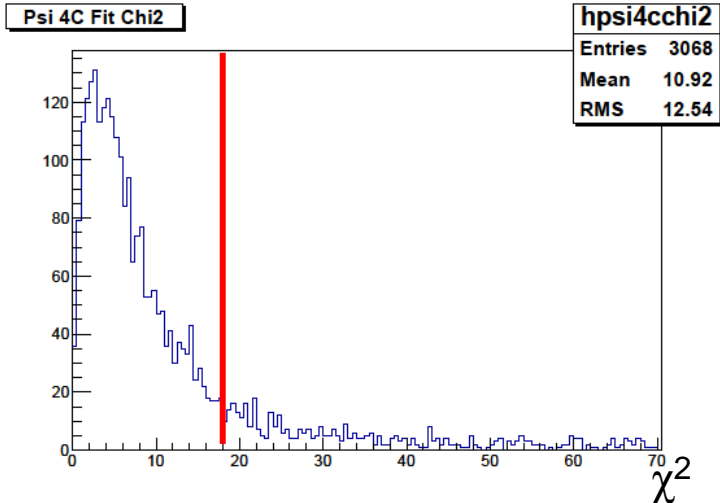


$$\sigma_y = (55.73 \pm 0.07) \mu\text{m}$$



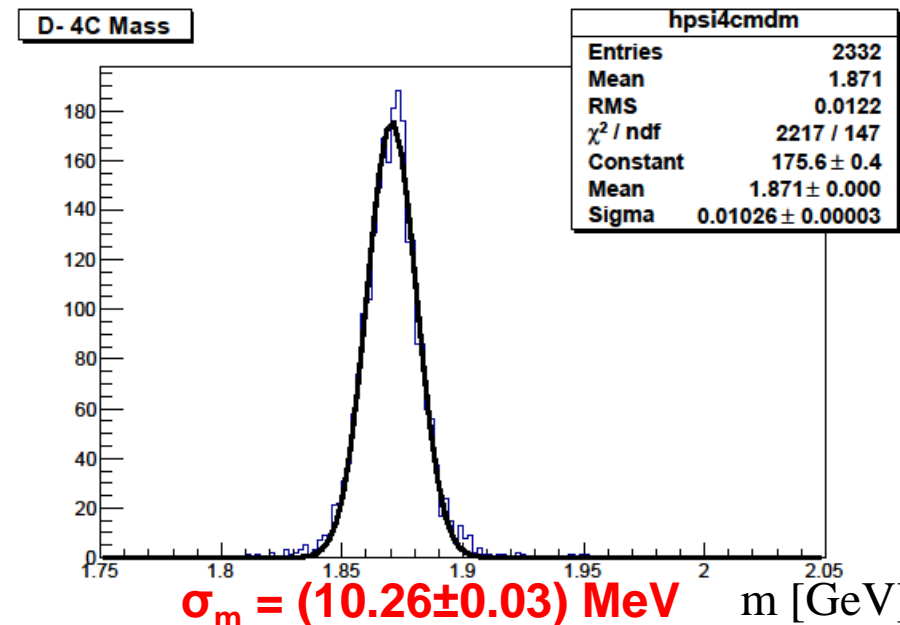
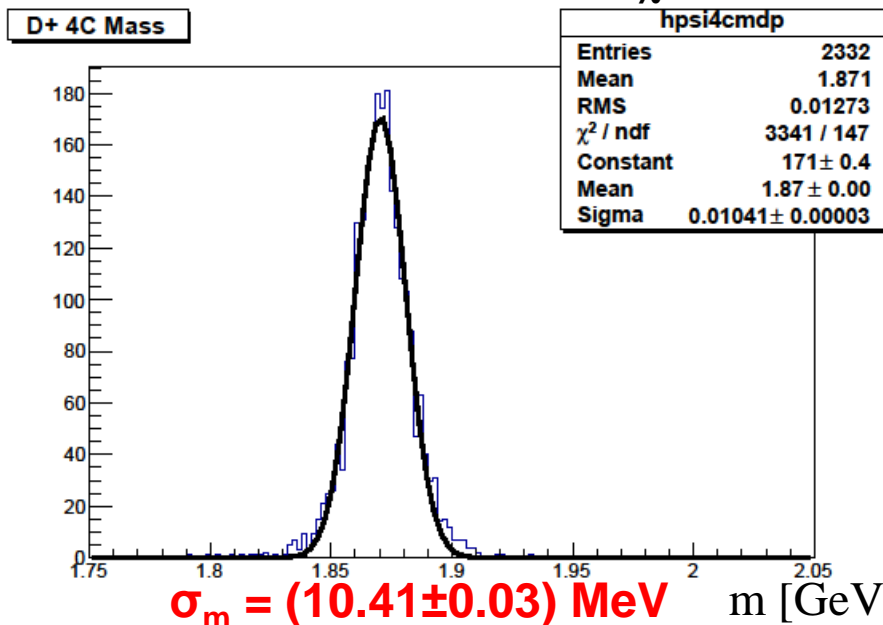
$$\sigma_z = (119.6 \pm 0.2) \mu\text{m}$$

# 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	17.8 %	31.0 %
Efficiency	21.2 %	7.5 %
Total Reconstructed	3.8 %	2.3 %
Vertex Resolution (xy)	56.0 $\mu\text{m}$	57.5 $\mu\text{m}$
Vertex Resolution (z)	106.1 $\mu\text{m}$	121.1 $\mu\text{m}$
Mass Resolution	14.3 MeV	10.3 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