



Central Tracker Physics Channel Benchmark

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

EVO, 9.9.2011 Marius C. Mertens

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
 - **Efficiency**: *(reconstructed events) / (events entering within detector acceptance)*
 - **Detector Acceptance**: *(events entering within detector acceptance) / (generated events)*
- 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 (run 931, PandaRoot 12725)*
 - *Signal samples for TPC (run 983, PandaRoot 12933)*
- Steps
 - *Simulation*
 - *Digitization*
 - *Reconstruction*
 - *PID*
 - ***Analysis (common for both CT options)***

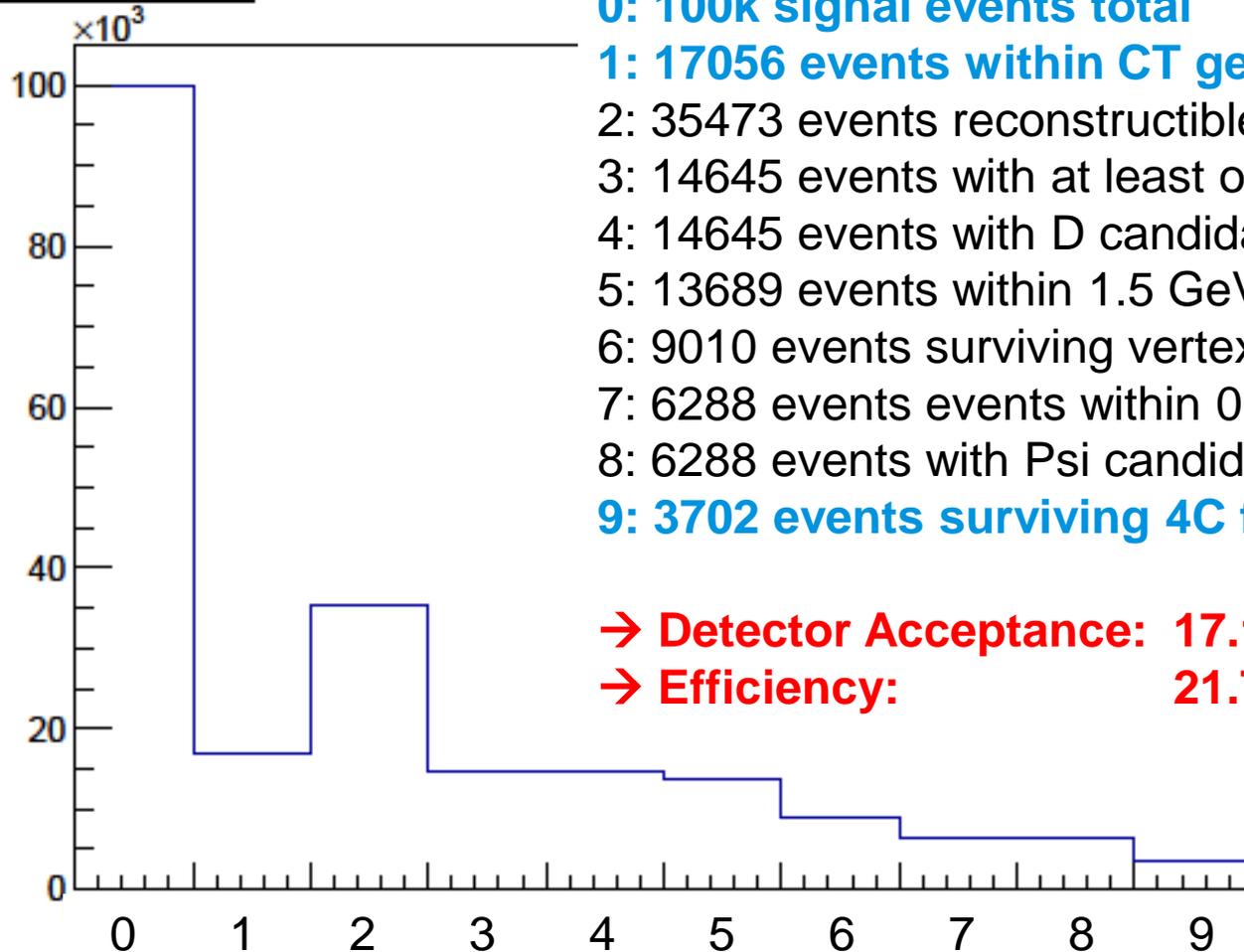
} Software experts, full data sets available on the Grid

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: **Reconstructible 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: 100k signal events total

1: 17056 events within CT geometric acceptance

2: 35473 events reconstructible by track finding

3: 14645 events with at least one STT hit

4: 14645 events with D candidates

5: 13689 events within 1.5 GeV mass window

6: 9010 events surviving vertex fit

7: 6288 events events within 0.5 GeV mass window

8: 6288 events with Psi candidates

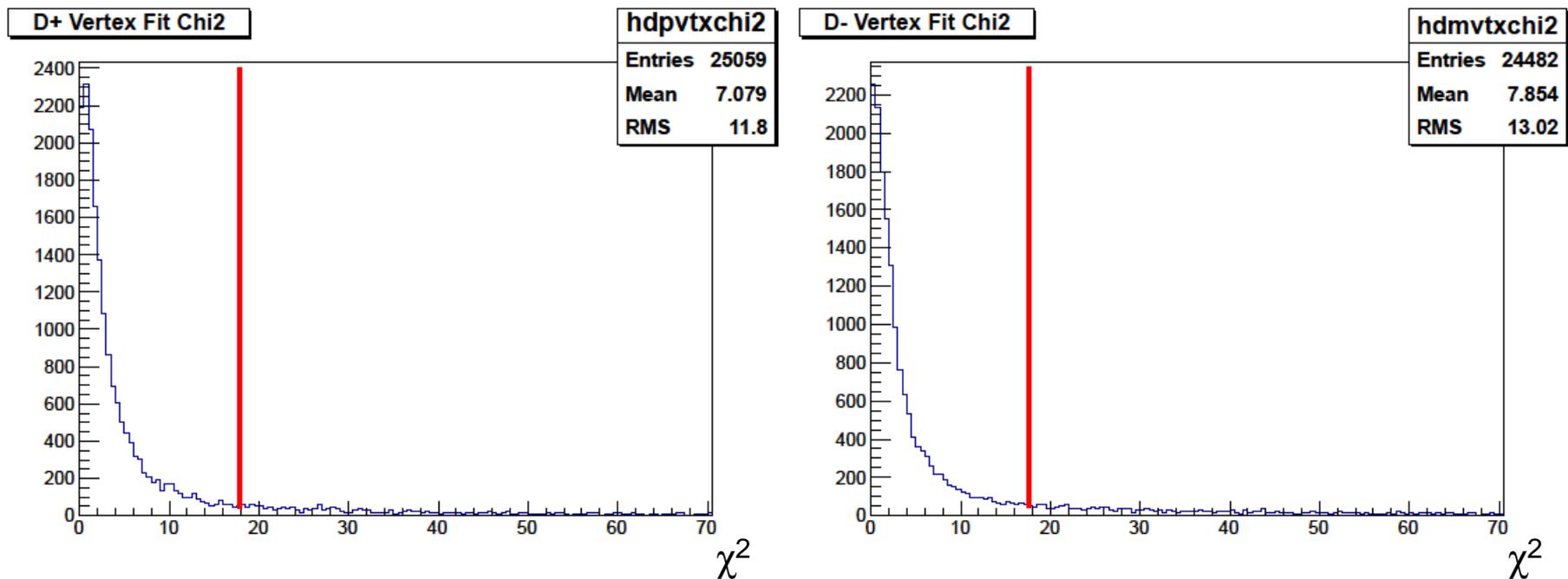
9: 3702 events surviving 4C fit

→ Detector Acceptance: 17.1%

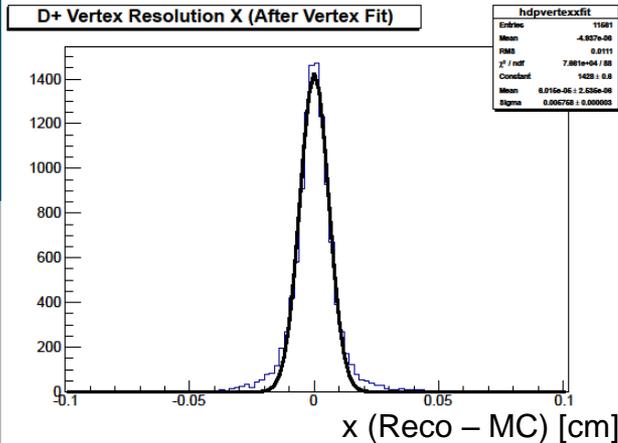
→ Efficiency: 21.7%

D-Meson Vertex Fit (STT)

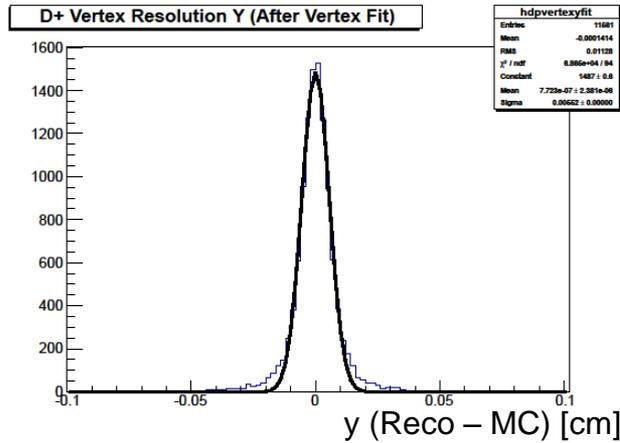
χ^2 distribution of the vertex fits to the D-mesons. For each event, the candidates with the best $\chi^2 < 18$ are selected (one D^+ , one D^-)



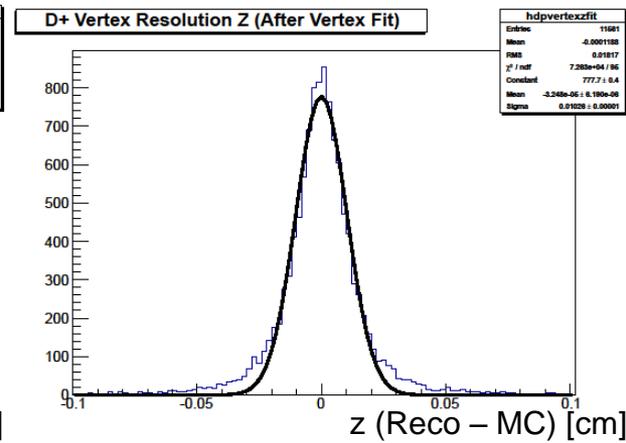
D-Meson Vertex Resolution (STT, after Vertex Fit)



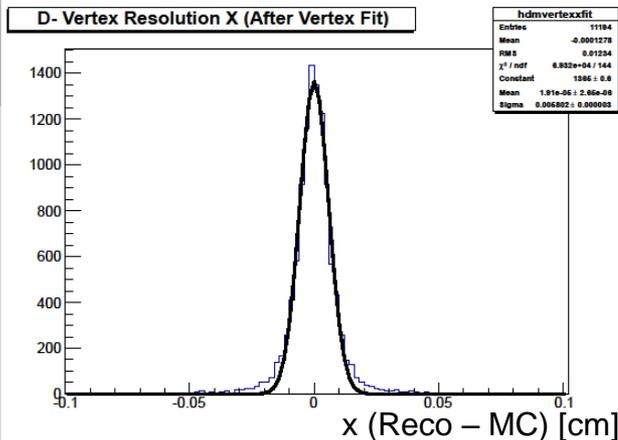
$$\sigma_x = (57.58 \pm 0.03) \mu\text{m}$$



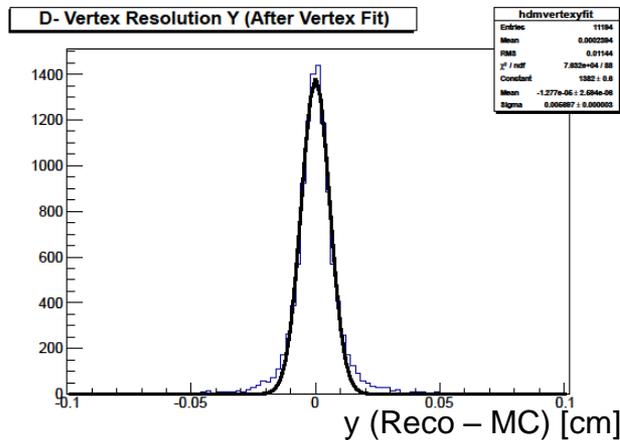
$$\sigma_y = (55.20 \pm 0.03) \mu\text{m}$$



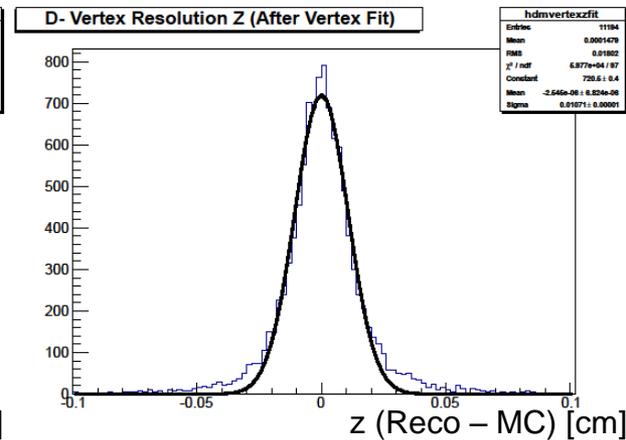
$$\sigma_z = (102.6 \pm 0.1) \mu\text{m}$$



$$\sigma_x = (58.02 \pm 0.03) \mu\text{m}$$

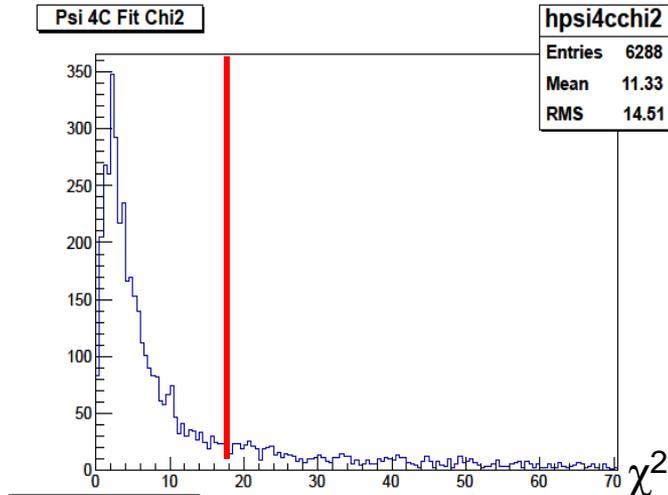


$$\sigma_y = (56.79 \pm 0.03) \mu\text{m}$$



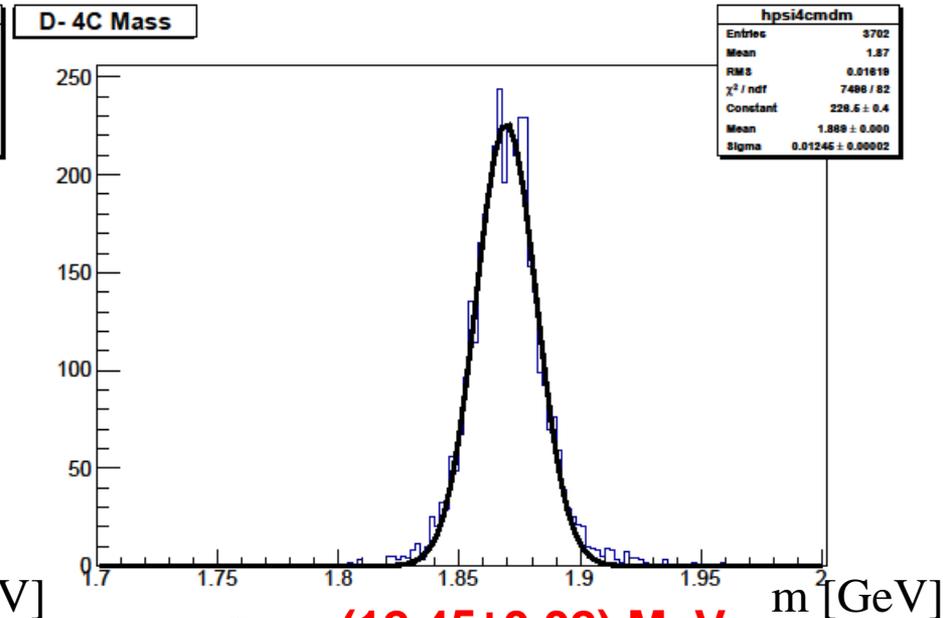
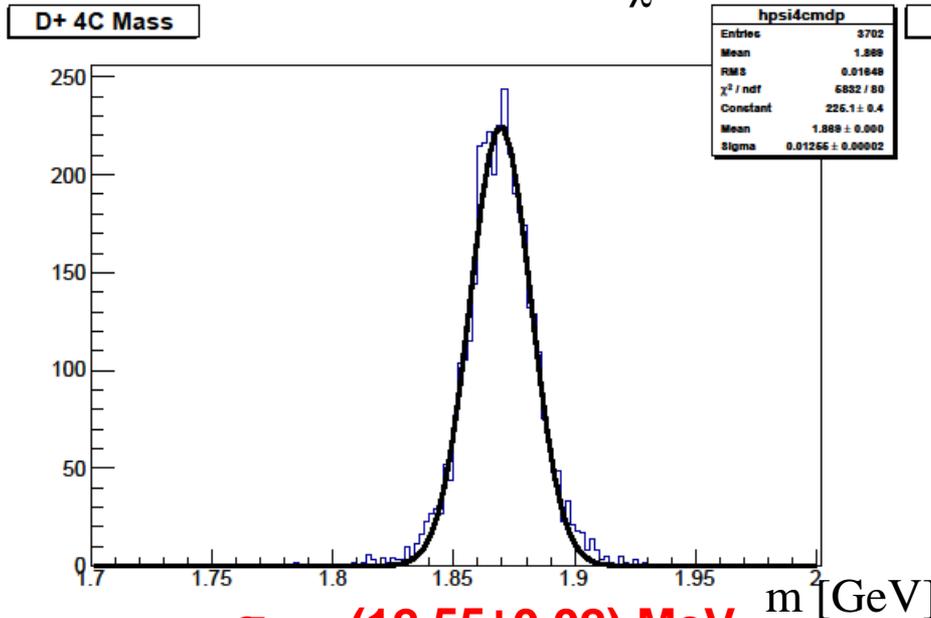
$$\sigma_z = (107.1 \pm 0.1) \mu\text{m}$$

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



Left: χ^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

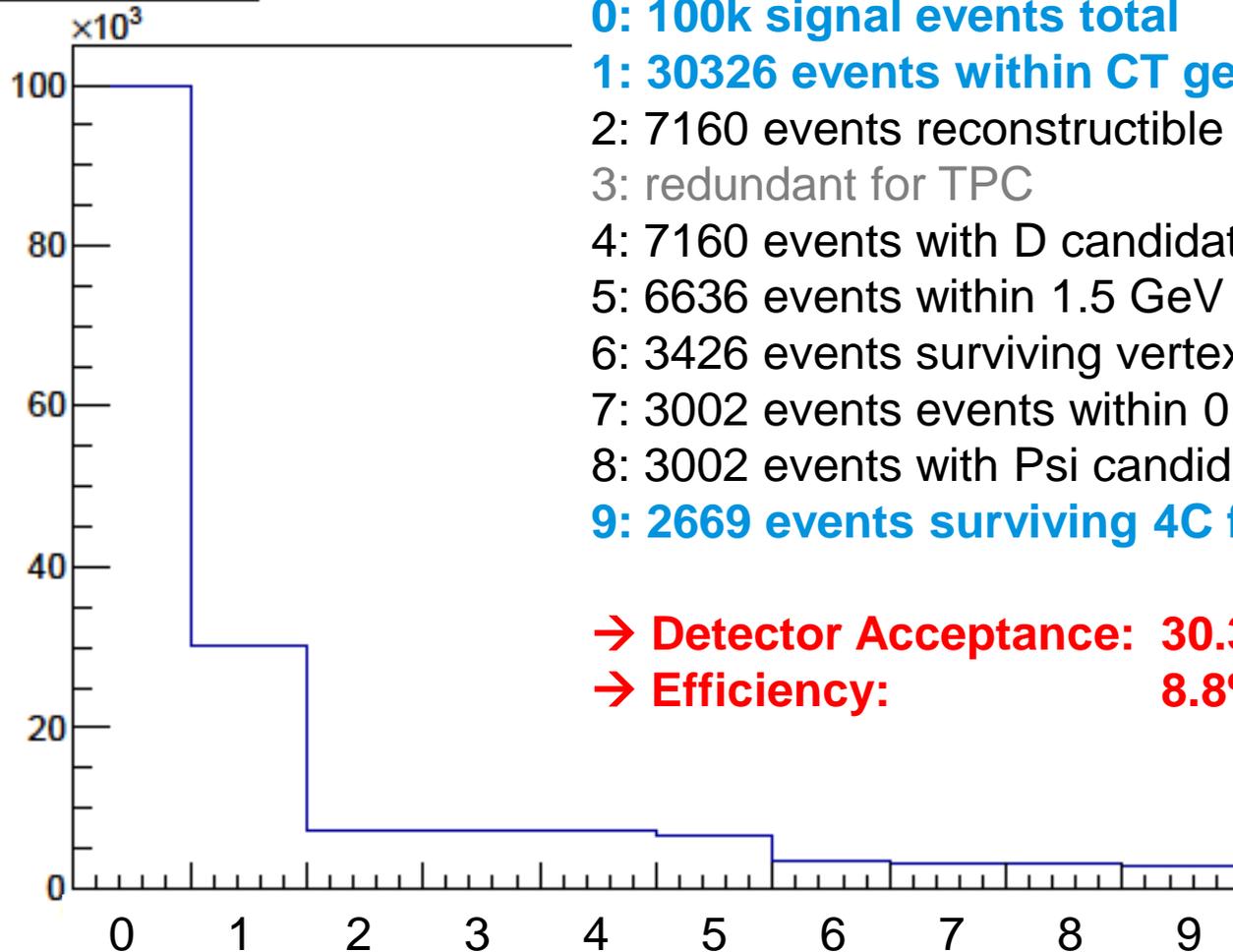


$\sigma_m = (12.55 \pm 0.02) \text{ MeV}$

$\sigma_m = (12.45 \pm 0.02) \text{ MeV}$

Event Selection Process (TPC)

Nice Events



0: 100k signal events total

1: 30326 events within CT geometric acceptance

2: 7160 events reconstructible by track finding

3: redundant for TPC

4: 7160 events with D candidates

5: 6636 events within 1.5 GeV mass window

6: 3426 events surviving vertex fit

7: 3002 events events within 0.5 GeV mass window

8: 3002 events with Psi candidates

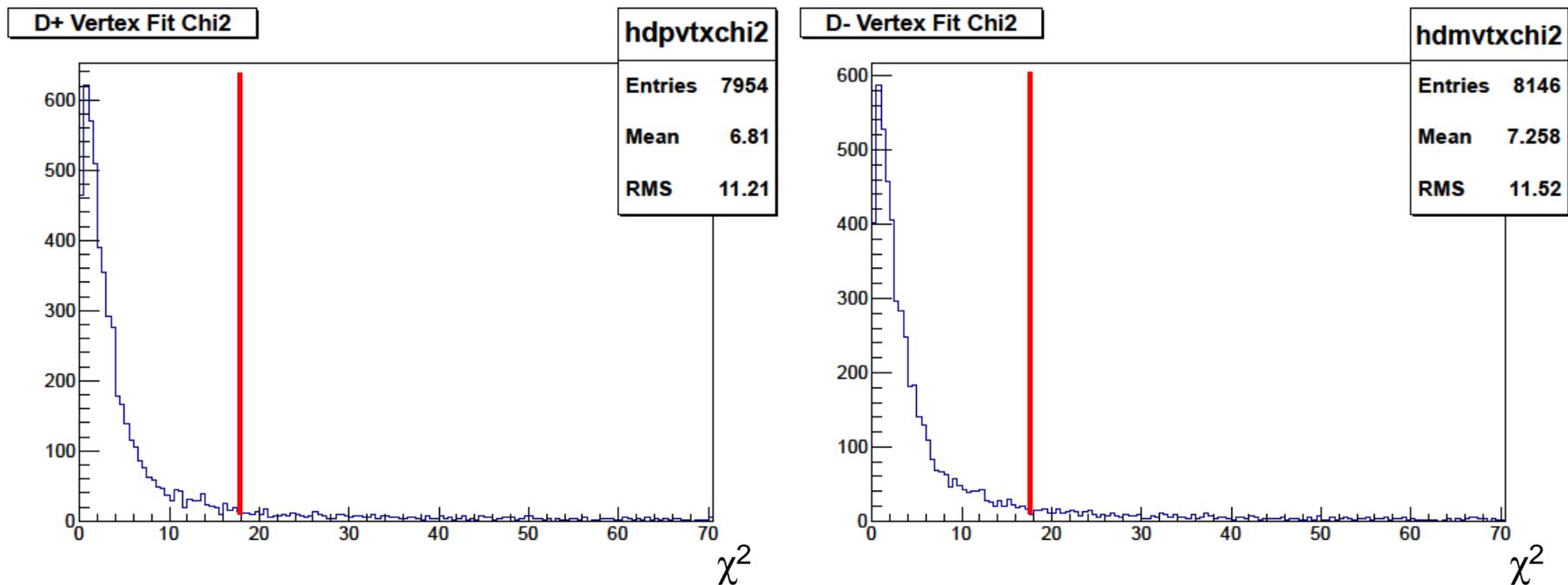
9: 2669 events surviving 4C fit

→ Detector Acceptance: 30.3%

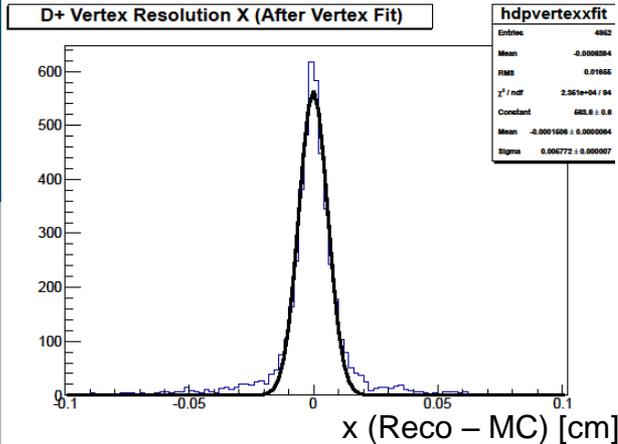
→ Efficiency: 8.8%

D-Meson Vertex Fit (TPC)

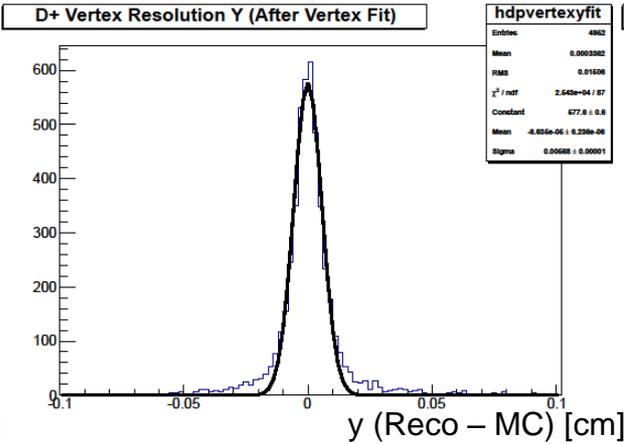
χ^2 distribution of the vertex fits to the D-mesons. For each event, the candidates with the best $\chi^2 < 18$ are selected (one D^+ , one D^-)



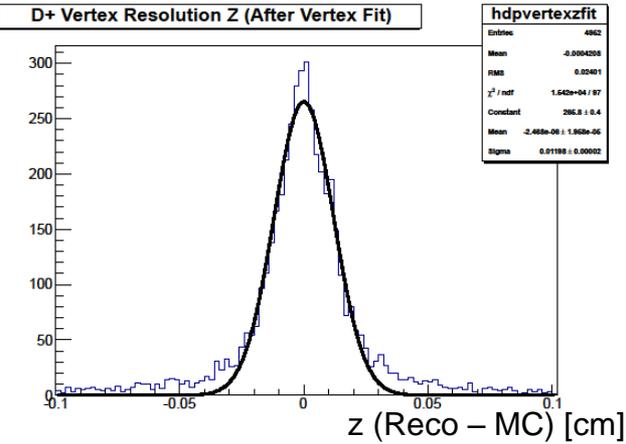
D-Meson Vertex Resolution (TPC, after Vertex Fit)



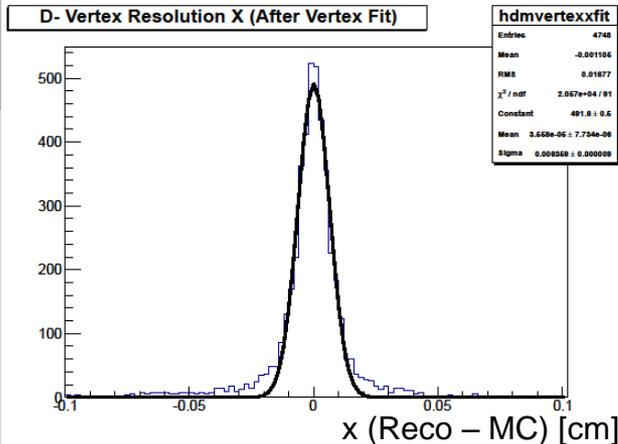
$$\sigma_x = (57.72 \pm 0.07) \mu\text{m}$$



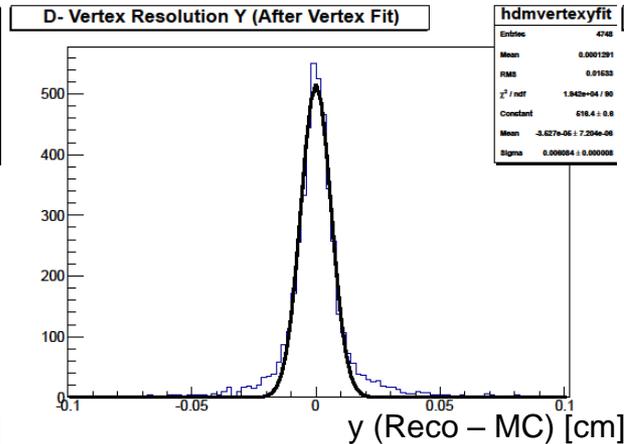
$$\sigma_y = (56.8 \pm 0.1) \mu\text{m}$$



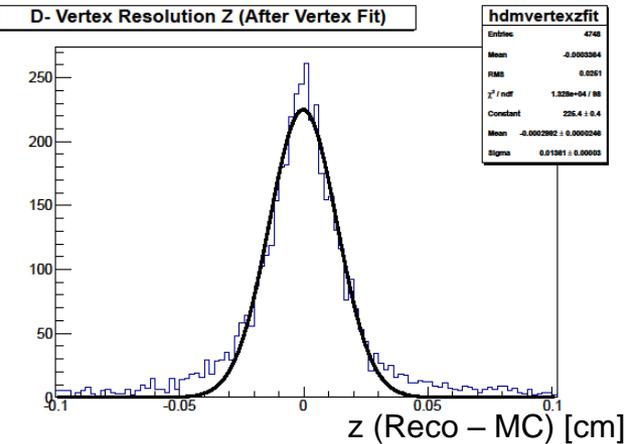
$$\sigma_z = (119.8 \pm 0.2) \mu\text{m}$$



$$\sigma_x = (63.59 \pm 0.09) \mu\text{m}$$



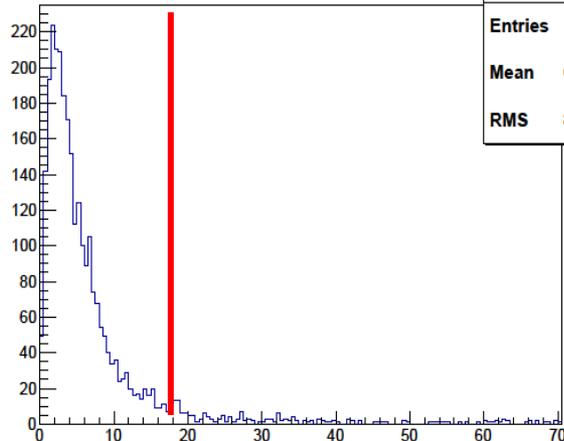
$$\sigma_y = (60.84 \pm 0.08) \mu\text{m}$$



$$\sigma_z = (136.1 \pm 0.3) \mu\text{m}$$

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

Psi 4C Fit Chi2

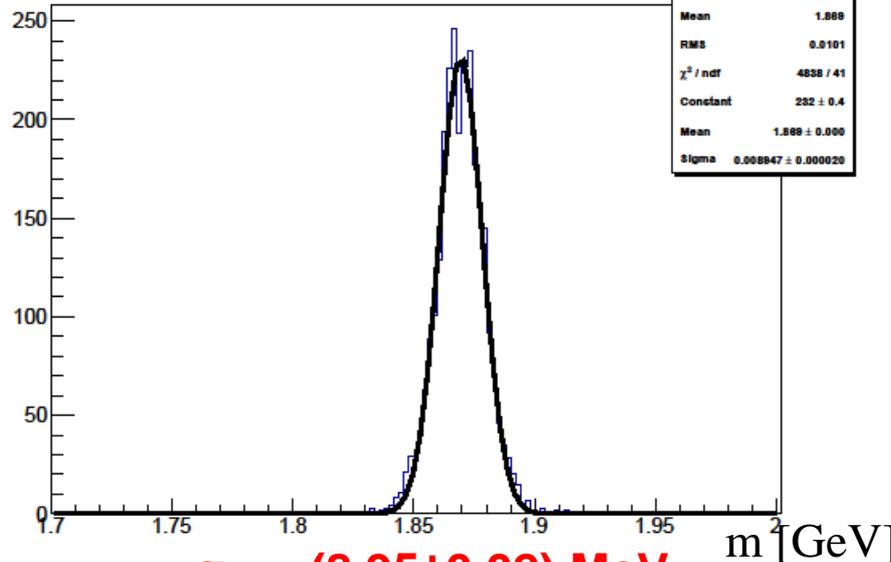


hpsi4cchi2	
Entries	3002
Mean	6.753
RMS	8.758

Left: χ^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)

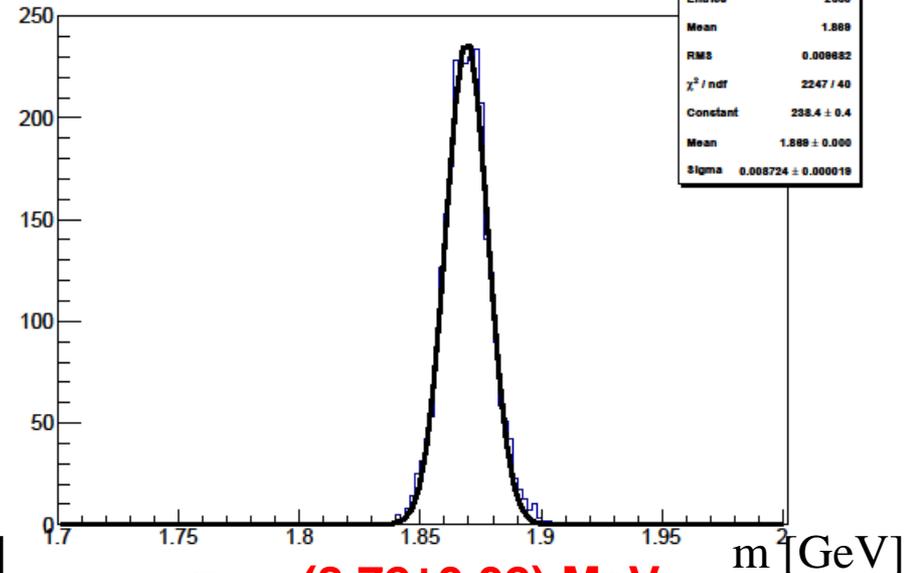
Below: D-Meson mass resolutions

D+ 4C Mass



hpsi4cmdp	
Entries	2888
Mean	1.888
RMS	0.0101
χ^2 / ndf	4838 / 41
Constant	232 ± 0.4
Mean	1.888 ± 0.000
Sigma	0.008847 ± 0.000020

D- 4C Mass



hpsi4cmdm	
Entries	2888
Mean	1.888
RMS	0.008682
χ^2 / ndf	2247 / 40
Constant	238.4 ± 0.4
Mean	1.888 ± 0.000
Sigma	0.008724 ± 0.000018

Summary of the Results

	STT	TPC
Efficiency	21.7 %	8.8 %
Acceptance	17.1 %	30.3 %
Total Reconstructed	3.7 %	2.7 %
Vertex Resolution (xy)	56.9 μm	59.7 μm
Vertex Resolution (z)	104.9 μm	128.0 μm
Mass Resolution	12.5 MeV	8.8 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

Raw Data

STT hniceevents contents

```
root [2] hniceevents->GetBinContent(0)
(const Double_t)0.0000000000000000e+00
root [3] hniceevents->GetBinContent(1)
(const Double_t)1.0000000000000000e+05
root [4] hniceevents->GetBinContent(2)
(const Double_t)1.7056000000000000e+04
root [5] hniceevents->GetBinContent(3)
(const Double_t)3.5473000000000000e+04
root [6] hniceevents->GetBinContent(4)
(const Double_t)1.4645000000000000e+04
root [7] hniceevents->GetBinContent(5)
(const Double_t)1.4645000000000000e+04
root [8] hniceevents->GetBinContent(6)
(const Double_t)1.3689000000000000e+04
root [9] hniceevents->GetBinContent(7)
(const Double_t)9.0100000000000000e+03
root [10] hniceevents->GetBinContent(8)
(const Double_t)6.2880000000000000e+03
root [11] hniceevents->GetBinContent(9)
(const Double_t)6.2880000000000000e+03
root [12] hniceevents->GetBinContent(10)
(const Double_t)3.7020000000000000e+03
```

TPC hniceevents contents

```
root [2] hniceevents->GetBinContent(0)
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root [3] hniceevents->GetBinContent(1)
(const Double_t)1.0000000000000000e+05
root [4] hniceevents->GetBinContent(2)
(const Double_t)3.0326000000000000e+04
root [5] hniceevents->GetBinContent(3)
(const Double_t)7.1600000000000000e+03
root [6] hniceevents->GetBinContent(4)
(const Double_t)7.1600000000000000e+03
root [7] hniceevents->GetBinContent(5)
(const Double_t)7.1600000000000000e+03
root [8] hniceevents->GetBinContent(6)
(const Double_t)6.6360000000000000e+03
root [9] hniceevents->GetBinContent(7)
(const Double_t)3.4260000000000000e+03
root [10] hniceevents->GetBinContent(8)
(const Double_t)3.0020000000000000e+03
root [11] hniceevents->GetBinContent(9)
(const Double_t)3.0020000000000000e+03
root [12] hniceevents->GetBinContent(10)
(const Double_t)2.6690000000000000e+03
```