Discussion on the simulation $\bar{p}p \rightarrow D_{s0}^{*}(2317)^{+}D_{s}^{-}$

In preparation of the analysis note v3 - E. Prencipe

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Outline

- Analysis strategy
- Background characterization

My original plan:
- to work on $D_{s1}(2460)$ and $D_s(2536)$
- check the analysis strategy on $D_{s0}^*(2317)$, for consistency

Since 1.5 year I have been working on the $D_{s0}^*(2317)$
- progress in tracking
- progress with PID tools
- progress with analysis tools

This is the <u>first full simulation</u> performed with pandaroot on $D_{s0}^*(2317)$

MC simulation – EvtGen model

noPhotos

Decay pbarpSystem
D_s0*+ D_s- PHSP;

Decay D_s+
K- K+ pi+ DS_DALITZ;

Decay D_s0*+
D_s+ pi0 PHSP;

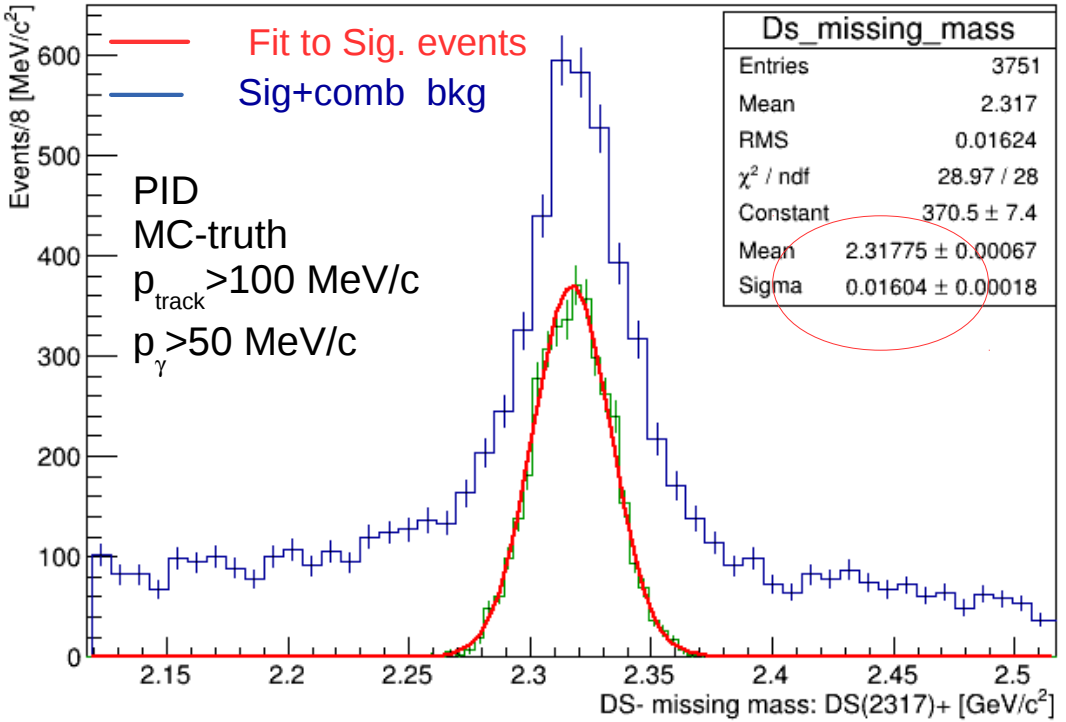
- MC simulations: $D_s(2317)^+$ decays 100% to $D_s^+ \pi^0$
- Approach: D_s^- is reconstructed;
  $D_s(2317)^+$ is obtained as <u>recoil</u> of D_s^-
  because of the higher rate

$$m_{recoil} = \sqrt{(M_{tot} - E^*_{D_s})^2 - p^{*2}_{D_s}}$$

- MC simulation: the approach works by definition....
- DATA: everything allowed, on the D_s^- recoil;
  need to fix selection criteria to identify $D_s(2317)^+$

MC simulation – EvtGen model

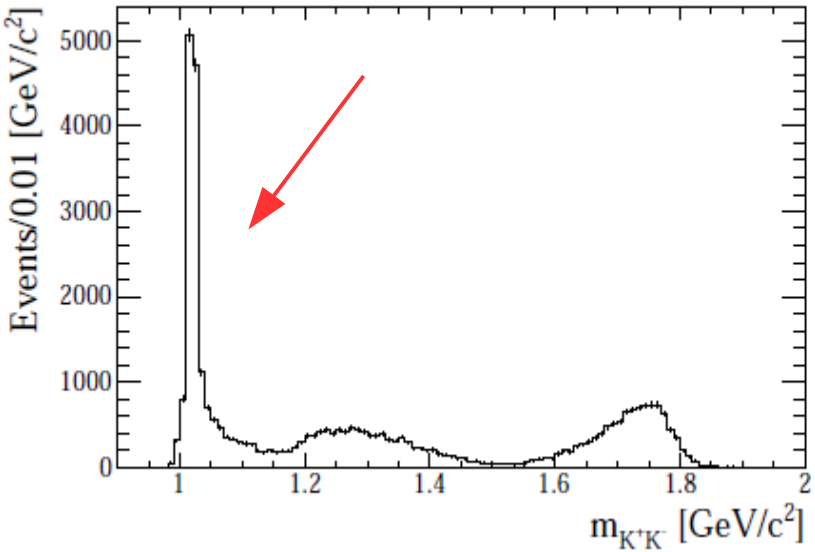
- Pre-selection skim:
  - PID
  - MC-truth matched candidates
  - p_{track}>100 MeV/c
  - p_{γ}>50 MeV/c
  - PndVtxFitter: Probχ^2>0.01
  - POCAxyz <1 mm^3

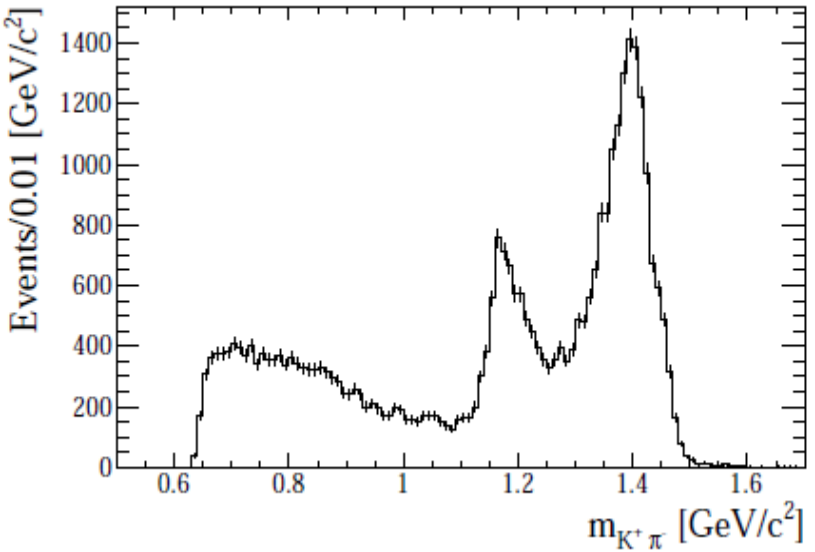


- Hypothesis: σ = [1-100] nb (signal)
  Background $\bar{p}p \rightarrow q\bar{q}$:
  σ = 53 mb (el. + inel.)
- No selection:
  S/B = [2 – 189]10^{-5}
- Pre-selection: S/B = [8-800]10^{-2}

to apply mass constraint fit is not a good idea

D_s recontruction: Dalitz model

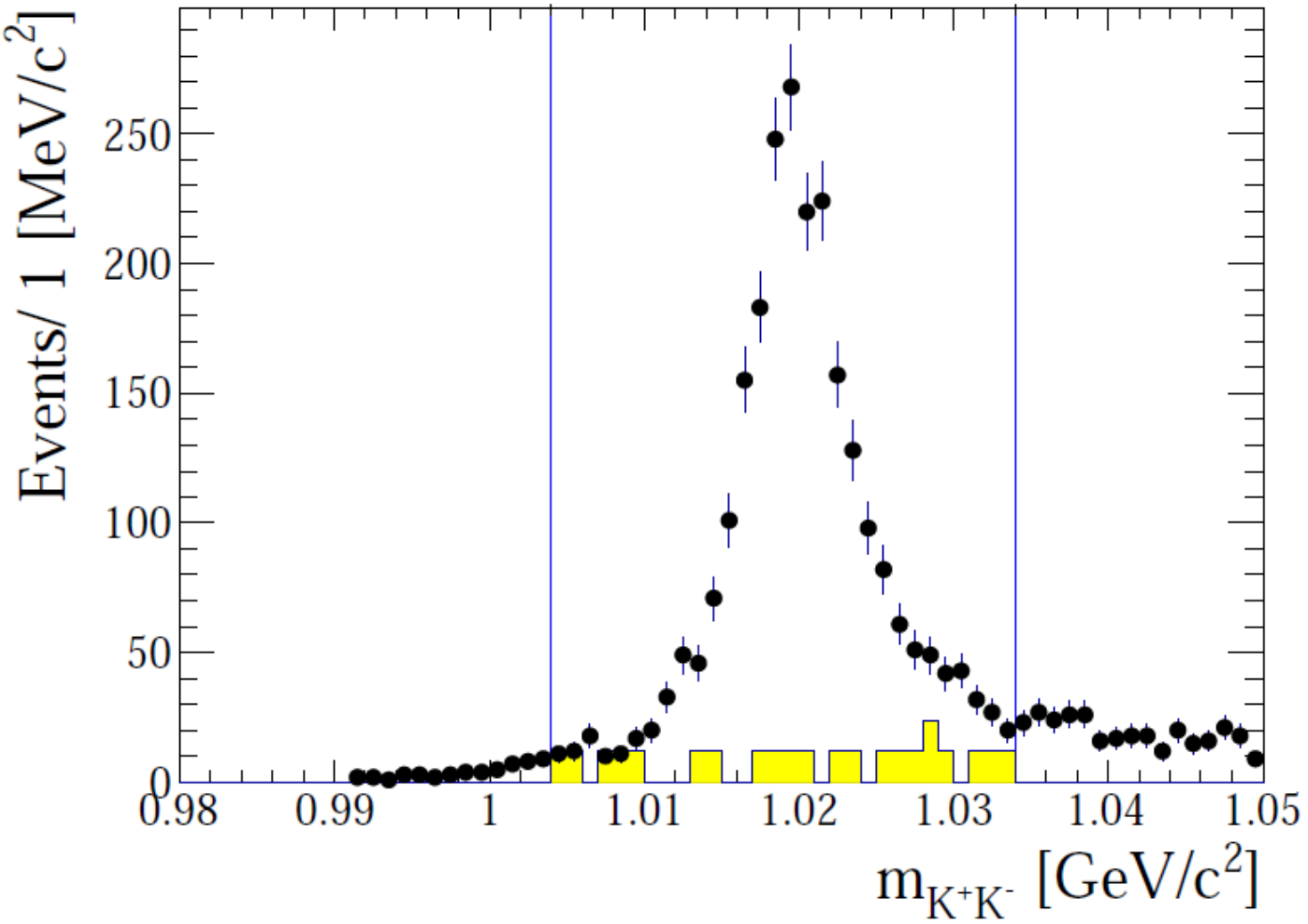




- $D_s^- \rightarrow K^+K^-\pi^-$
- Several structures inside the Dalitz plot: this is not smooth PHSP!
- K^+K^- invariant mass will be restricted to the ϕ signal area

→ consequence: efficiency decreases ~ 3 times; but bkg drastically reduced

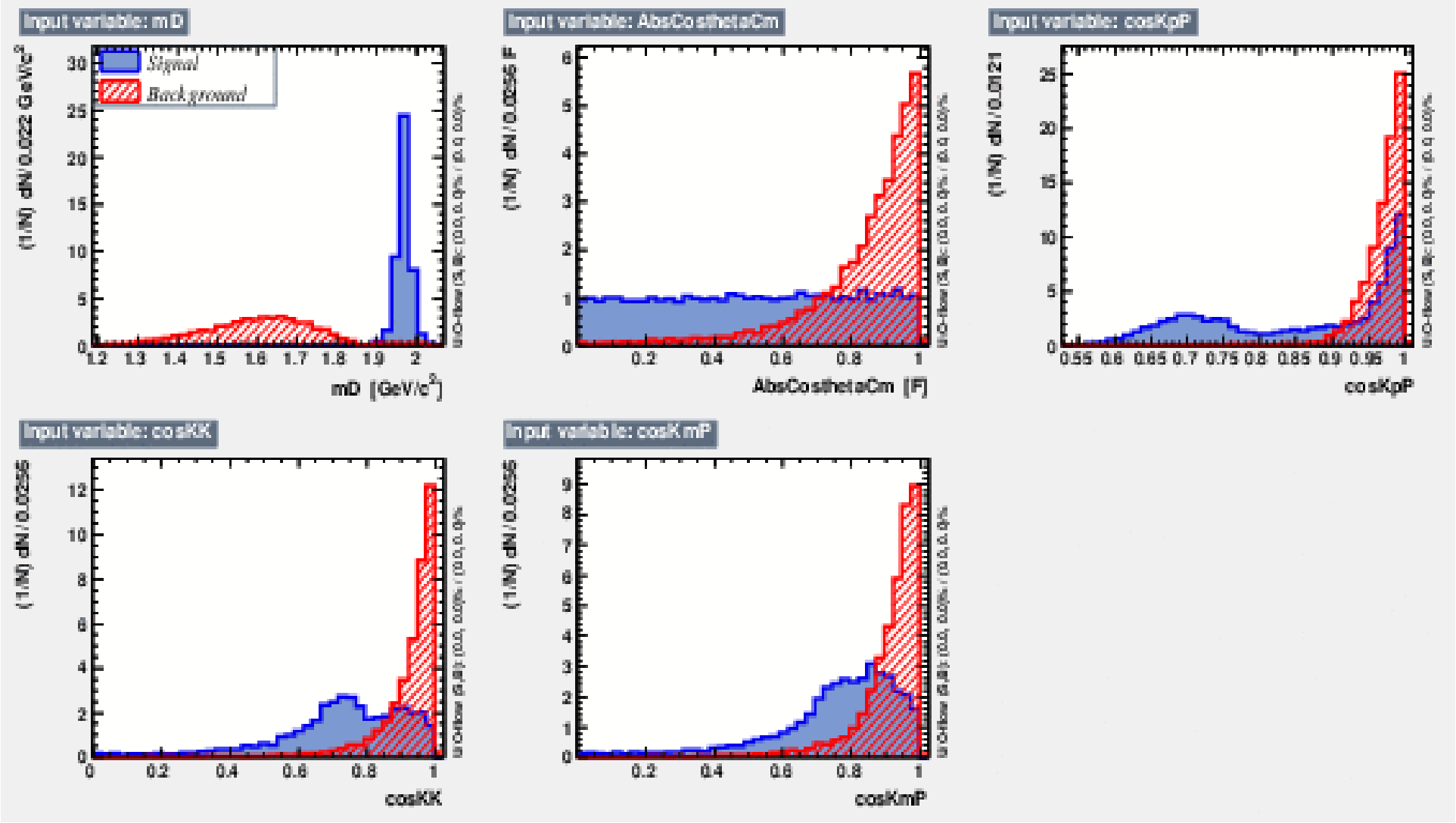
ϕ signal area



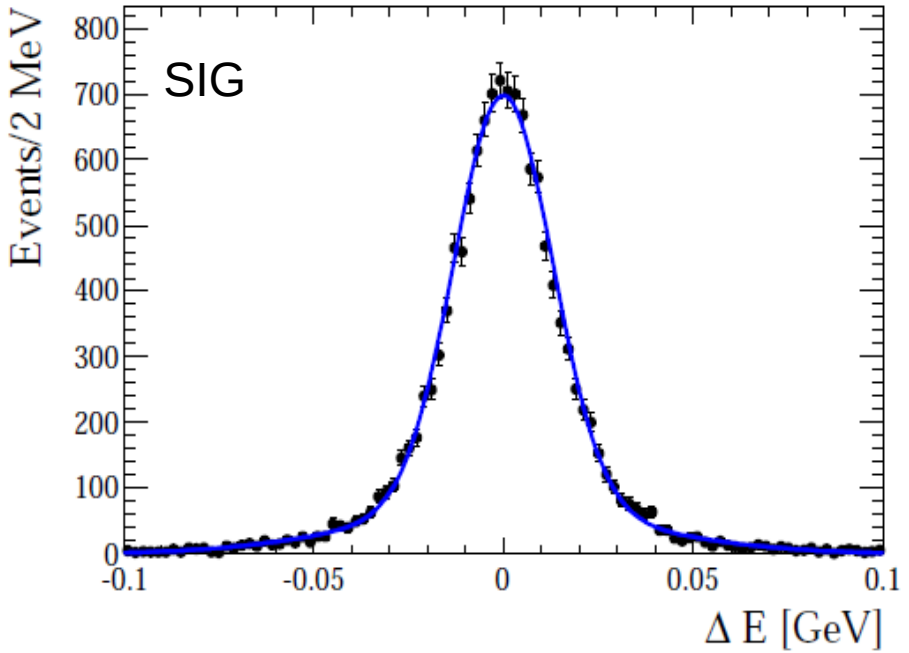
Zoomed figure

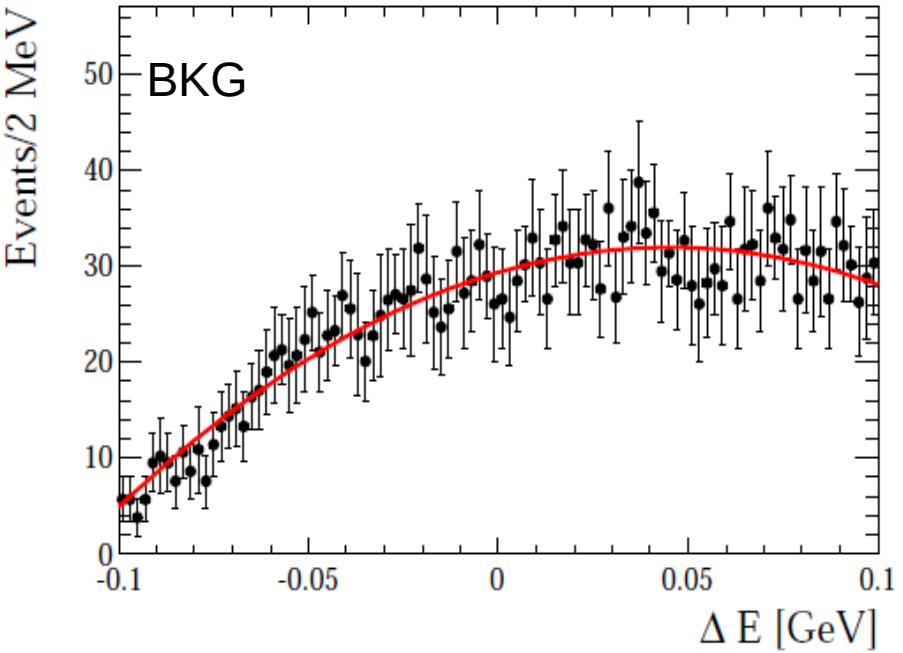
DPM bkg scaled to arbitrary number: it is linear (no $\bar{s}s$ structure in DPM)

Sig/Bkg discriminant: variables



ΔE variable





- Difference between the energy of the D_s in the c.m. and its nominal value
- Expected a distribution centered in 0.
- Double gaussian parametrization for signal; polynomial for bkg

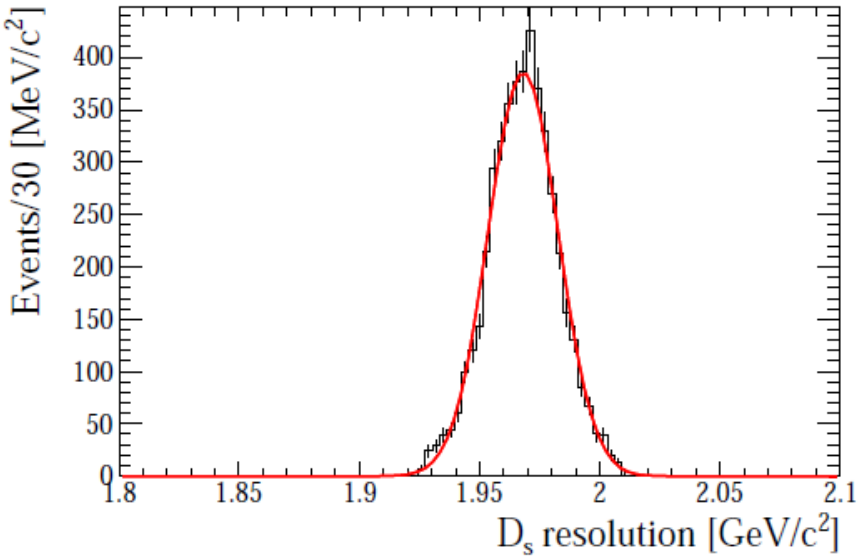
Selection variables

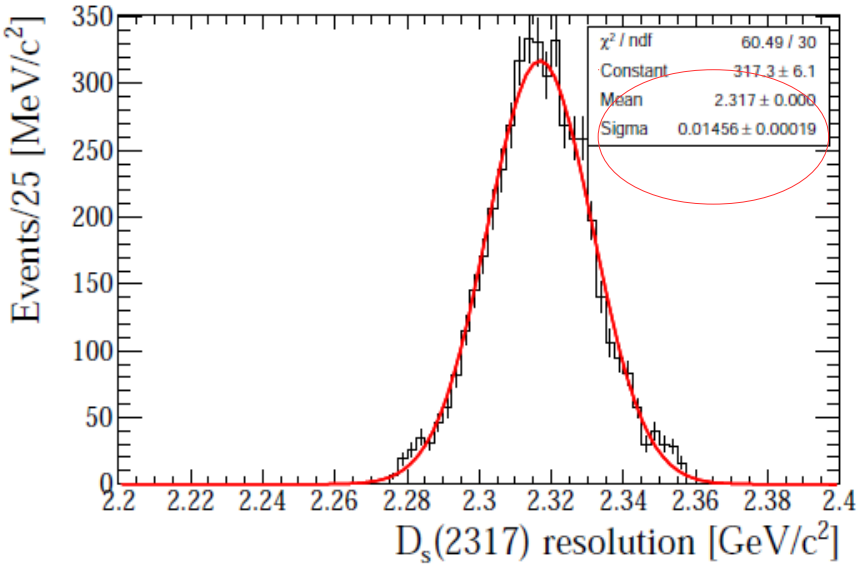
Selection cut
pre-selection
|POCA radius| < 100 μm
|POCA z| < 200 μm
$m_{Ds\ Ds(2317)} > 4.25$
$\mathcal{F} > -0.038$
$\|\Delta E\| < 0.04$
$\|p_z^*\| < 0.1$
$1.92 < m_{Ds} < 2.01$
$p_t\ (D_s) < 0.2$
$1.004 < m_{K^+K^-} < 1.04$

It will be replaced by BDT discr.

$D_{s0}^{*}(2317)^{+}$ as recoil of D_s^{-}

$$m_{recoil} = \sqrt{(M_{tot} - E^{*}_{D_s})^2 - p^{*2}_{D_s}}$$





$D_s^- \to K^+K^-\pi^-$

- KK invariant mass cut: [1.004;1.04] GeV/c^2
- Mass resolution: 14.56 MeV/c^2
- P_{beam} is fixed. No smearing in pandaroot:
  some studies presented at Coll meeting Mar2014 when applying smearing
  $\Delta p/p \sim 10^{-4}$

Background sources

Channel:

$$\begin{aligned} \bar{p}p &\rightarrow D_s^{\pm} D_{s0}^{*}(2317)^{\mp} \\ D_s^{\pm} &\rightarrow \phi\pi^{\pm}, \quad \phi \rightarrow K^{+}K^{-} \\ D_{s0}^{*}(2317)^{\mp} &\rightarrow \text{anything} \end{aligned}$$

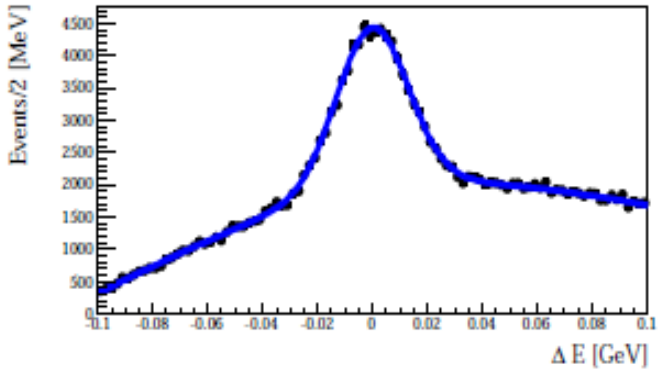
Channel		
$\bar{p}p \rightarrow KK\pi$ + anything	80M	σ = 53 mb /3 = 17.67 mb
$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} \pi^0$	100k	σ same as signal
$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} 2\pi^0$		
$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} \pi^+\pi^-$		
$\bar{p}p \rightarrow D_s^{\pm} D_s^{*\mp}$		
$\bar{p}p \rightarrow D_s^{\pm} D_s^{*\mp} \pi^0$		
$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} \gamma$		
$\bar{p}p \rightarrow D_s^{\pm} D_s^{*\mp} \gamma$		

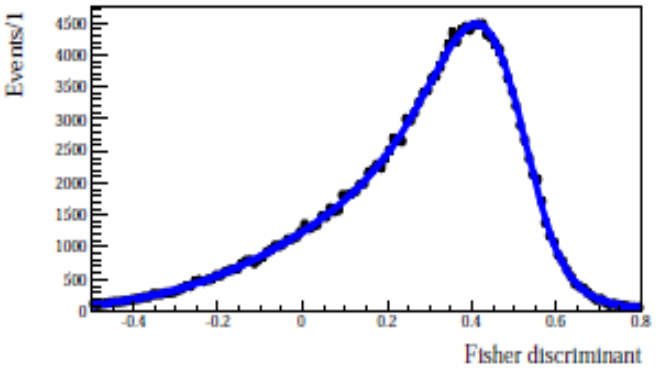
Why a multi-dimensional fit?

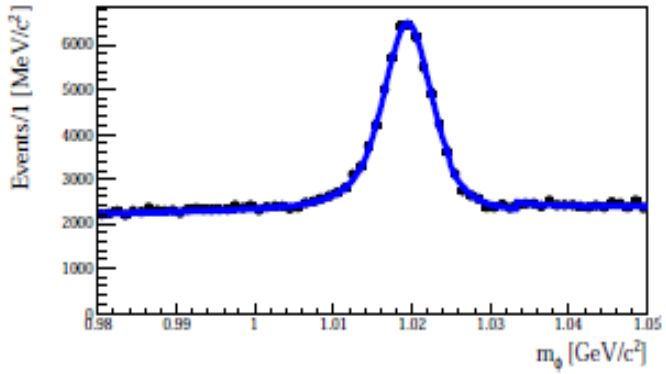
ToyMC study

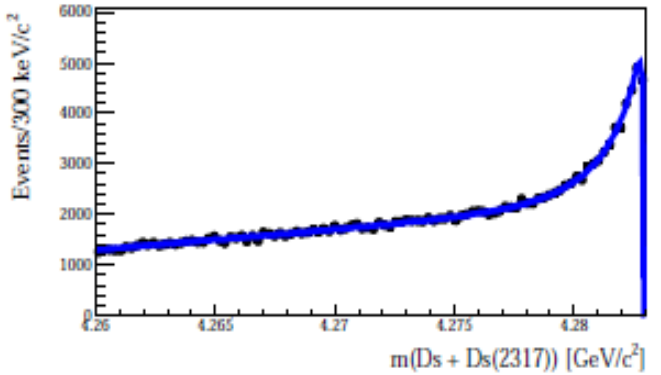
- Multi-dimensional fit are sensitive to measure observable with a resolution < than detector resolution

- When bkg level is high, better chance to get the measurement









S/B = 1/3

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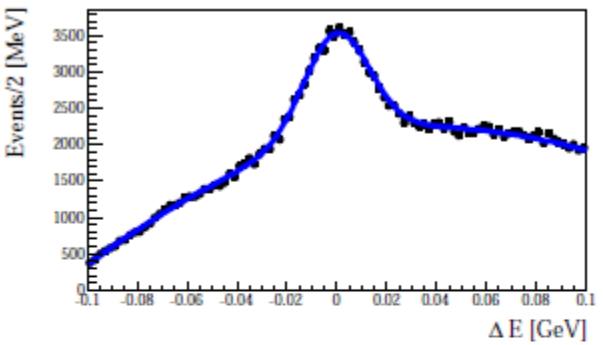

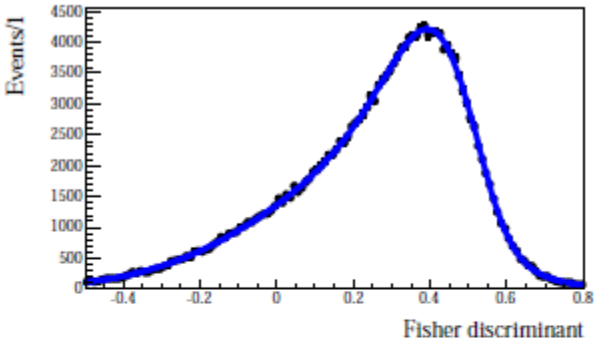

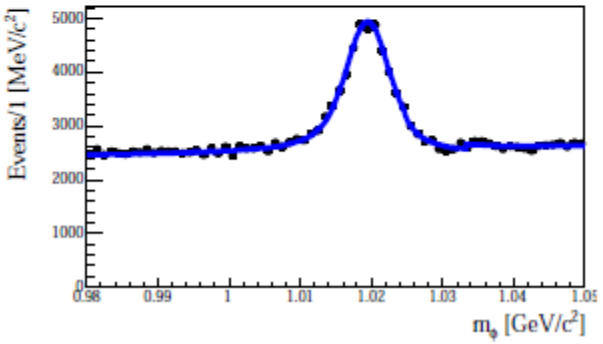

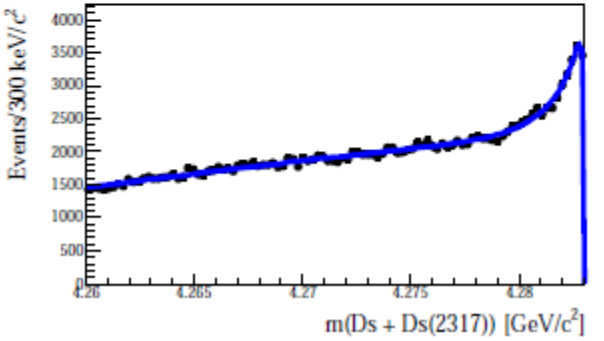

S/B = 1/6

Why a multi-dimensional fit?

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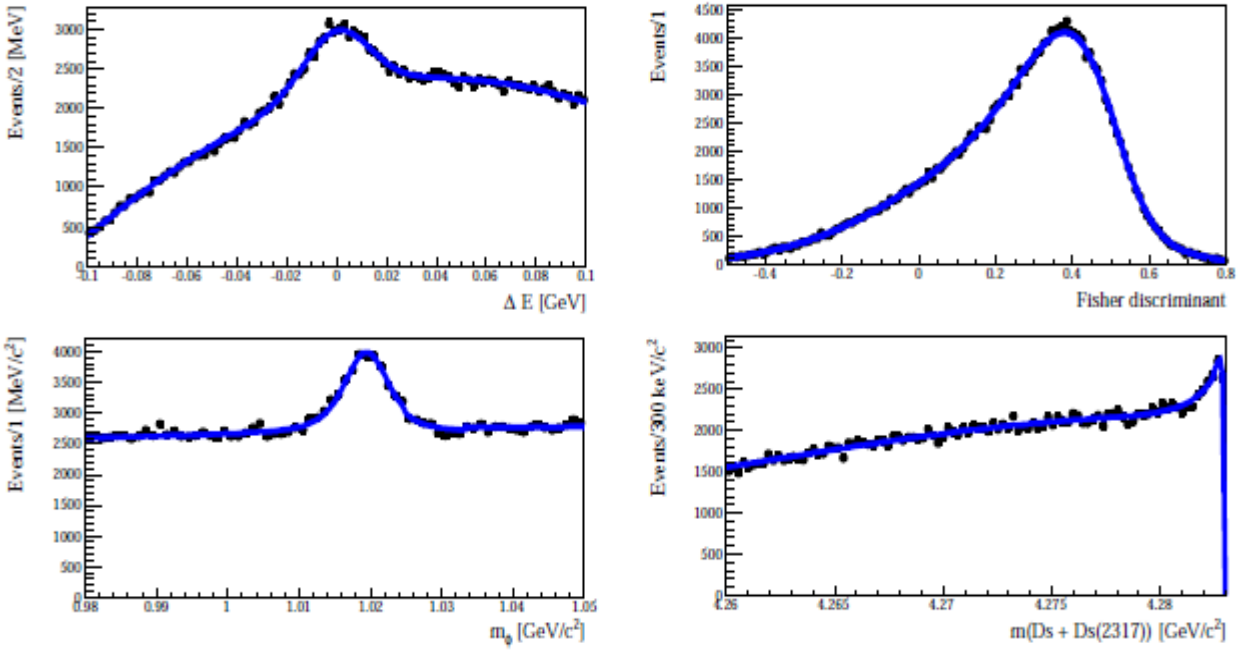

S/B = 1/12

Why a multi-dimensional fit?

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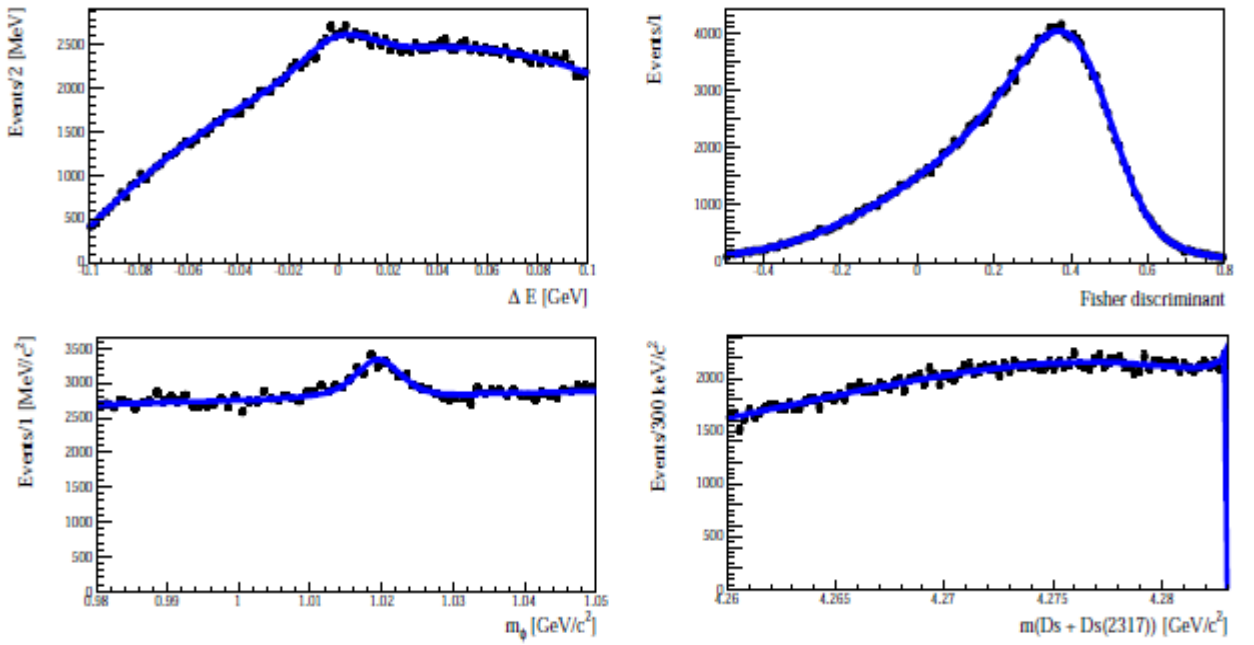

S/B = 1/30

Not feasible with F-discr.

Why a multi-dimensional fit?

ToyMC study

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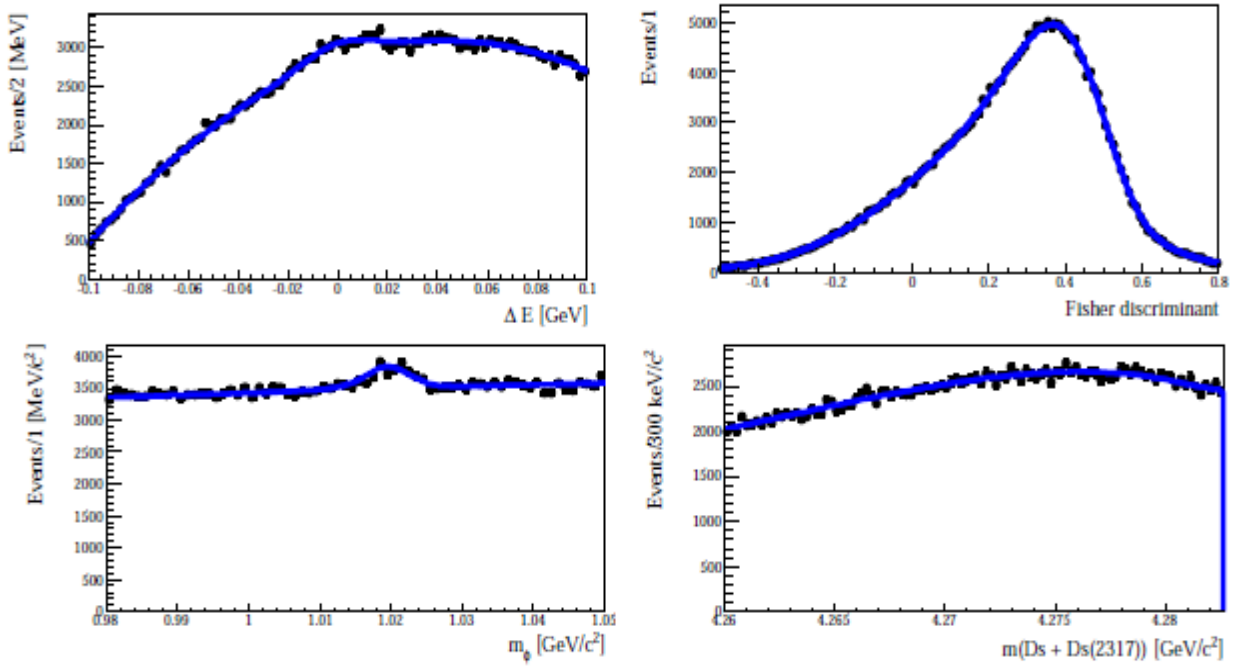

S/B = 1/60

Not feasible with F-discr.

Master formula

$$\sigma(s) = \frac{|M|^2}{64\pi p_1^* s}\,\Phi(E)$$

with $$\Phi(E) = \frac{1}{\pi}\sqrt{\frac{MM^*\Gamma^*}{M+M^*}}\int_{-\infty}^{\hat{E}} d\delta \sqrt{\hat{E}-\delta}\,\frac{1}{\delta^2+1}$$

Critical points: statistic and systematic errors!