Status of the $B^0_s \to D^{\pm}_s K^{\mp}$ benchmark analysis

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IDEA Physics and Software Meeting

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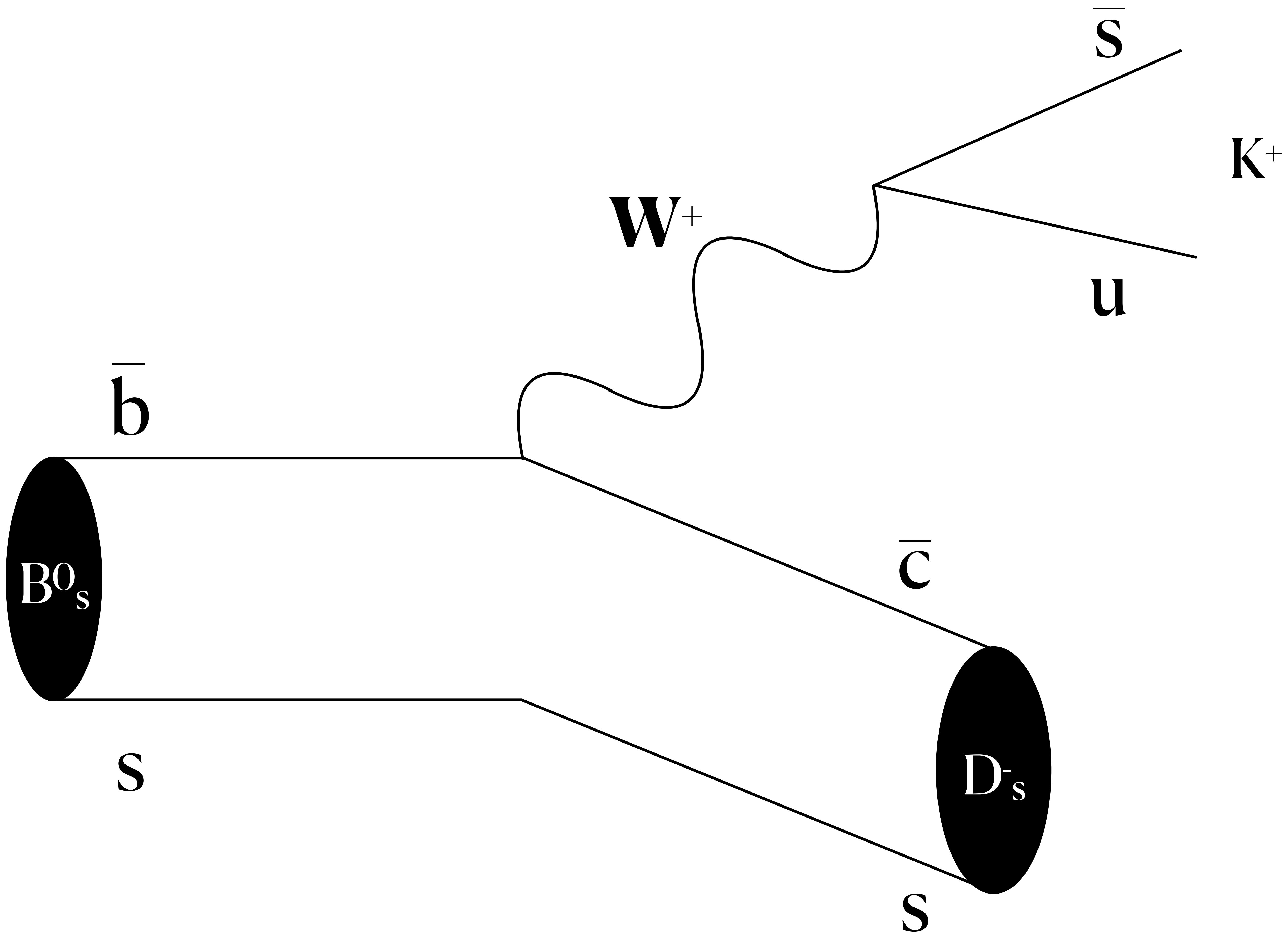
$B^0_s \to D^\pm_s K^\mp \to (KK\pi^\pm)\, K^\mp$



Signal MC samples

$B^0_s \to D^\pm_s K^\mp \to (KK\pi^\pm)\, K^\mp$

Exclusive $Z \to b\bar{b}$ with
10k events @ $\sqrt{s}$ = 91.188 GeV

```
#
Decay B_s0
  1.000 MyD_s- K+ PHSP;
Enddecay
CDecay anti-B_s0
#
Decay MyD_s-
  1.000 Myphi pi- PHSP;
Enddecay
CDecay MyD_s+
#
Decay Myphi
      1.000  K+ K-  VSS;
Enddecay
#
End
```

Inclusive $Z \to b\bar{b}$
10k events @ $\sqrt{s}$ = 91.188 GeV

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SigMC
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IncMC
Inclusive $Z \to b\bar{b}$
10k events @ $\sqrt{s} = 91.188$ GeV

SigMC

Status

$B^0_s \rightarrow D^{\pm}_s K^{\mp} \rightarrow (KK\pi^{\pm}) K^{\mp}$

Identified the $D^{\pm}_s$ final state

Simple selection

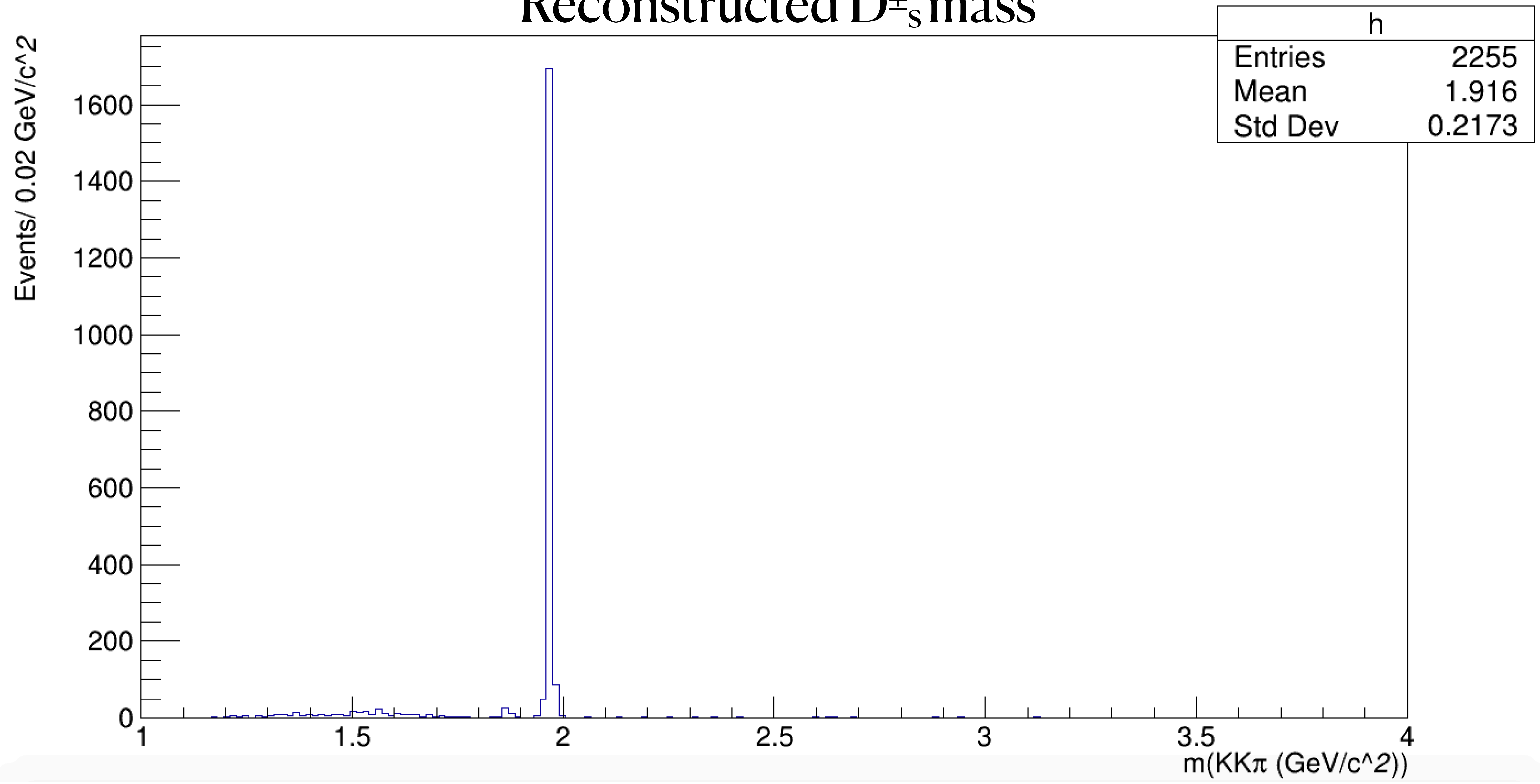
$n_K = 2$

$n_\pi = 1$

$|Q_{Tot}| = 1$

$Q_{KK} = 0$

Reconstructed $D^{\pm}_s$ mass



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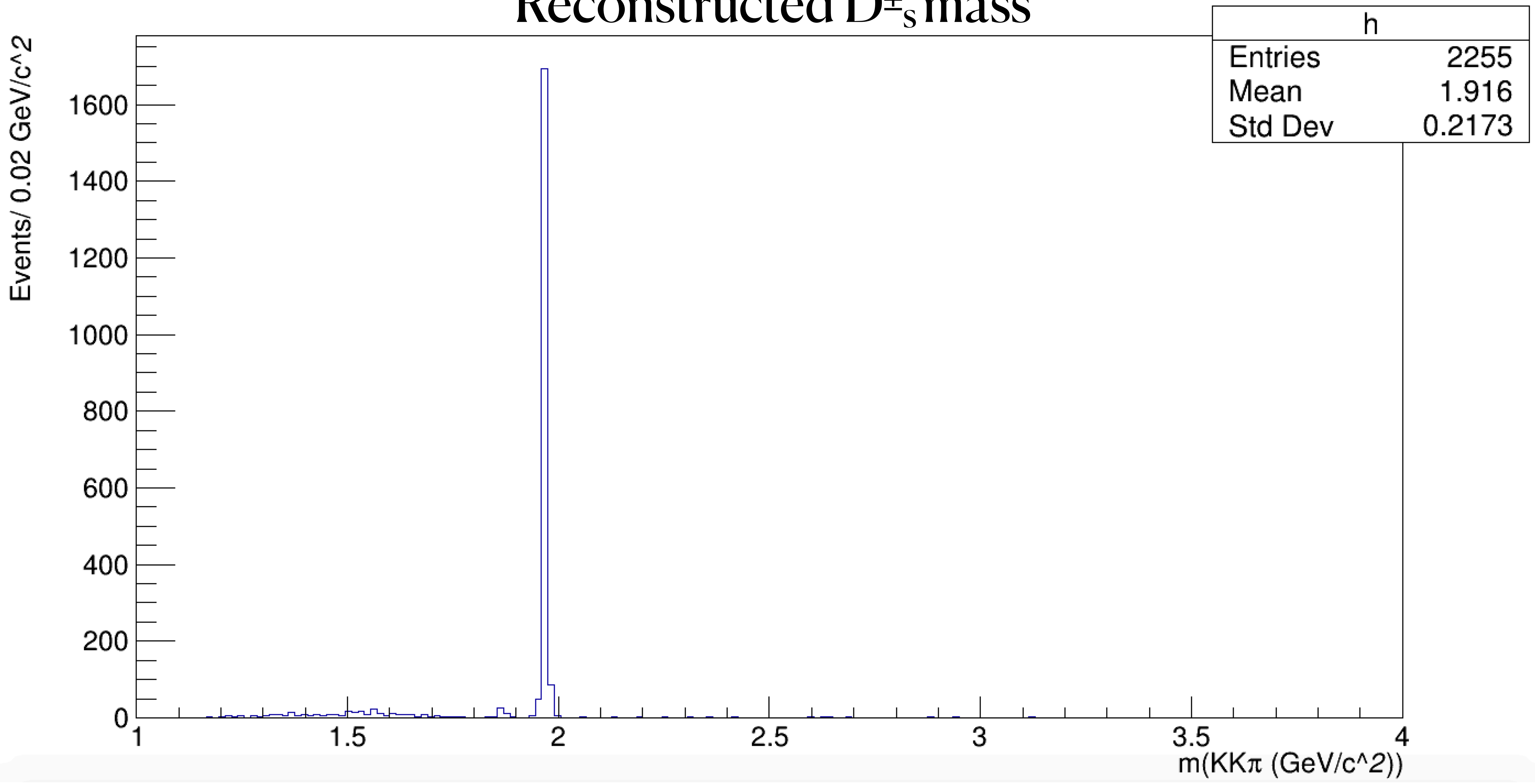

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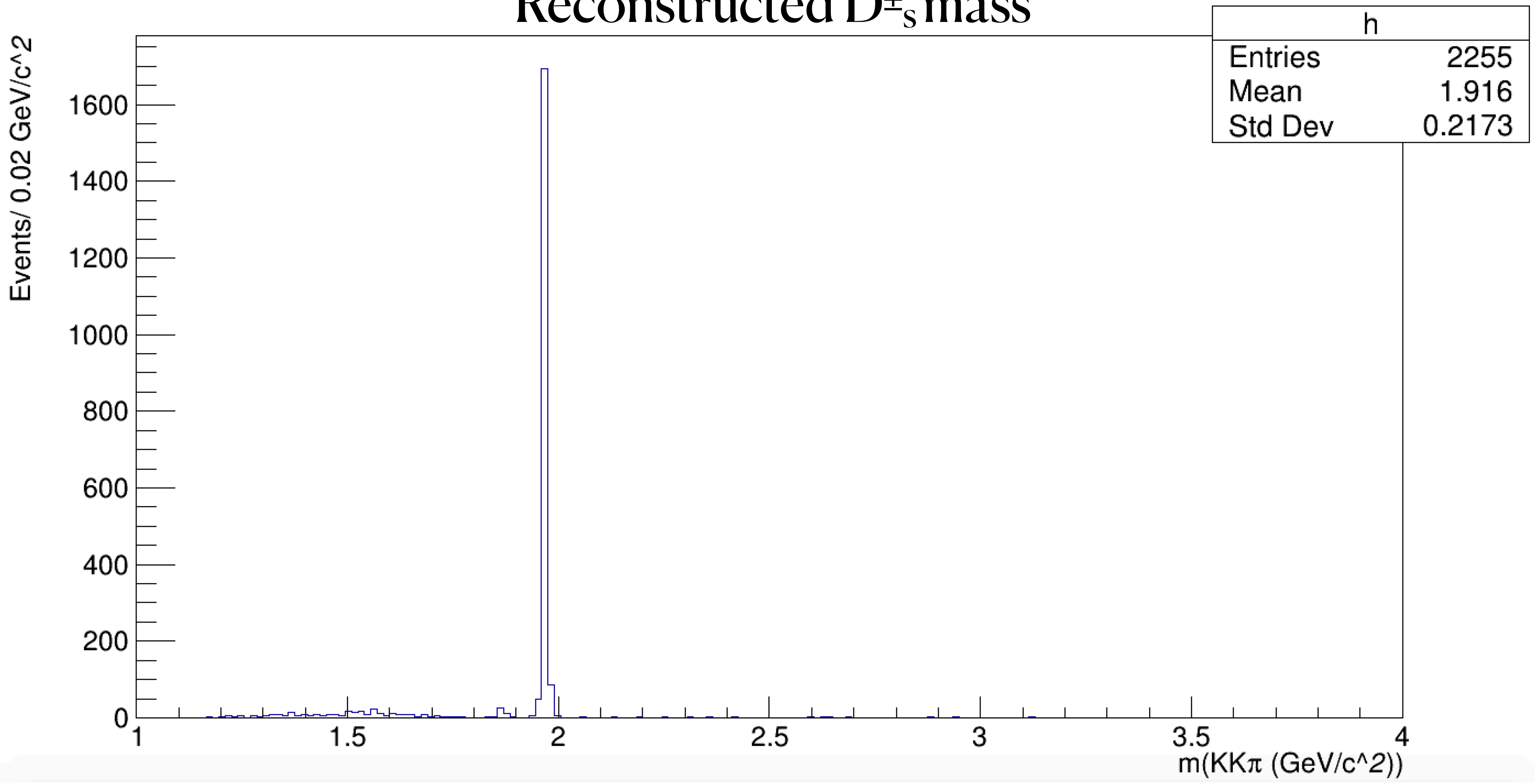
PID is 100%
(i.e. made via PDGid)

Reconstructed $D^{\pm}_s$ mass



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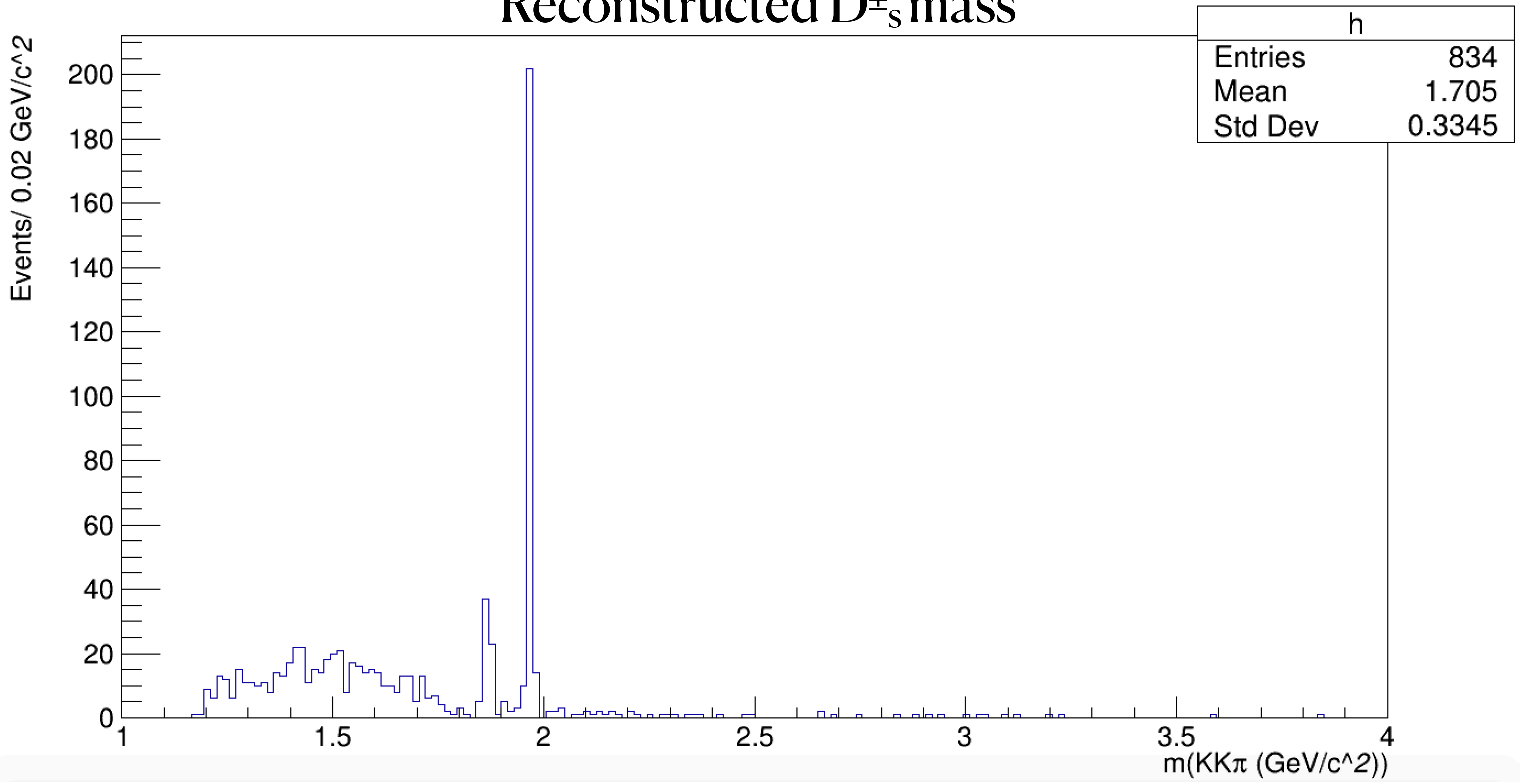


SigMC

Status

$B^0_s \to D^{\pm}_s K^{\mp} \to (KK\pi^{\pm})\, K^{\mp}$

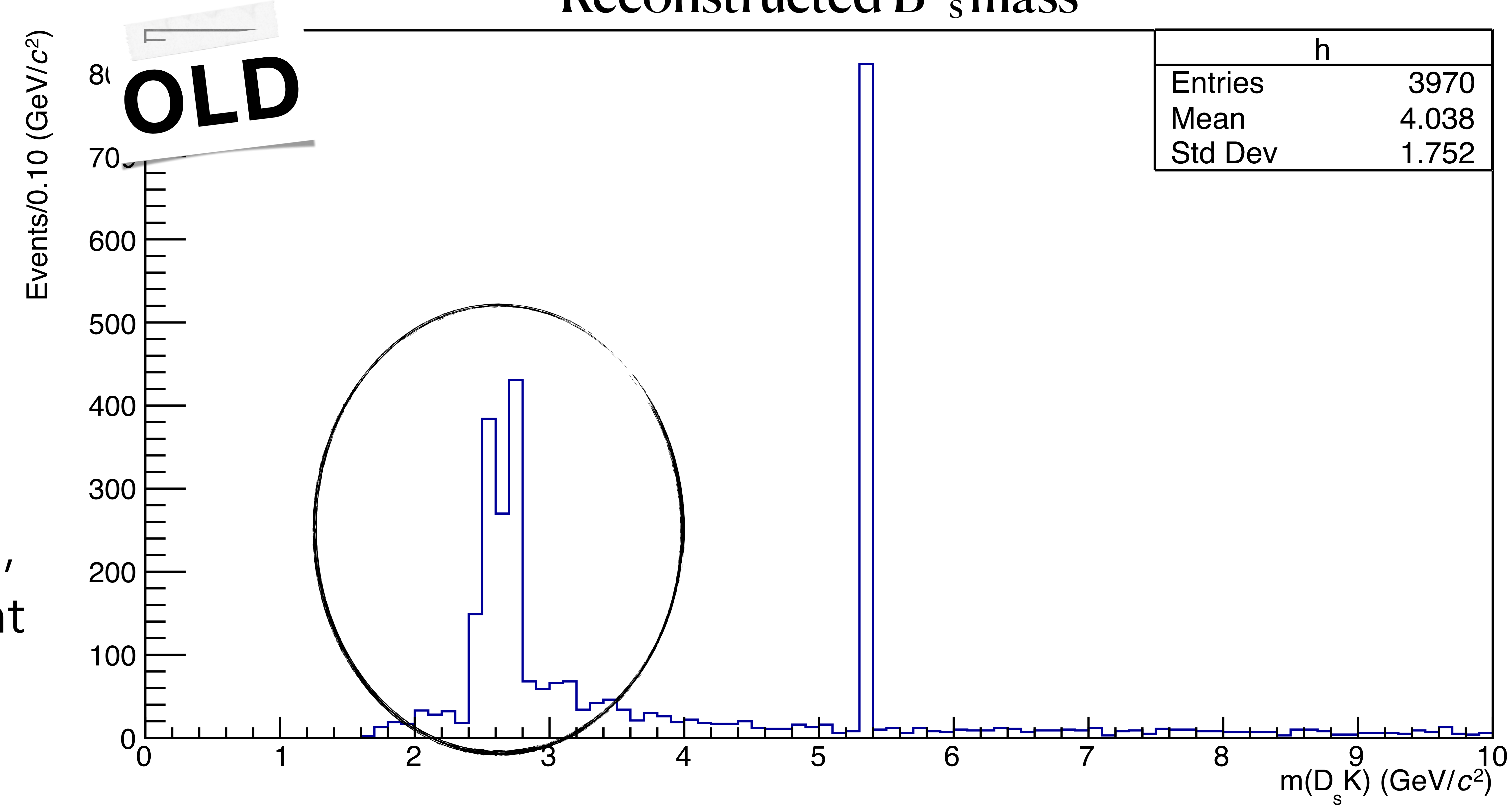
Purely combinatorial

Combine the $\mathbf{D^{\pm}_s}$ candidates with the $\mathbf{K^{\mp}}$ requesting

$|Q_{Tot}| = 1$

Despite main peak clearly visible, there is a heap in the low invariant mass region

Reconstructed B^0_s mass



Status

SigMC

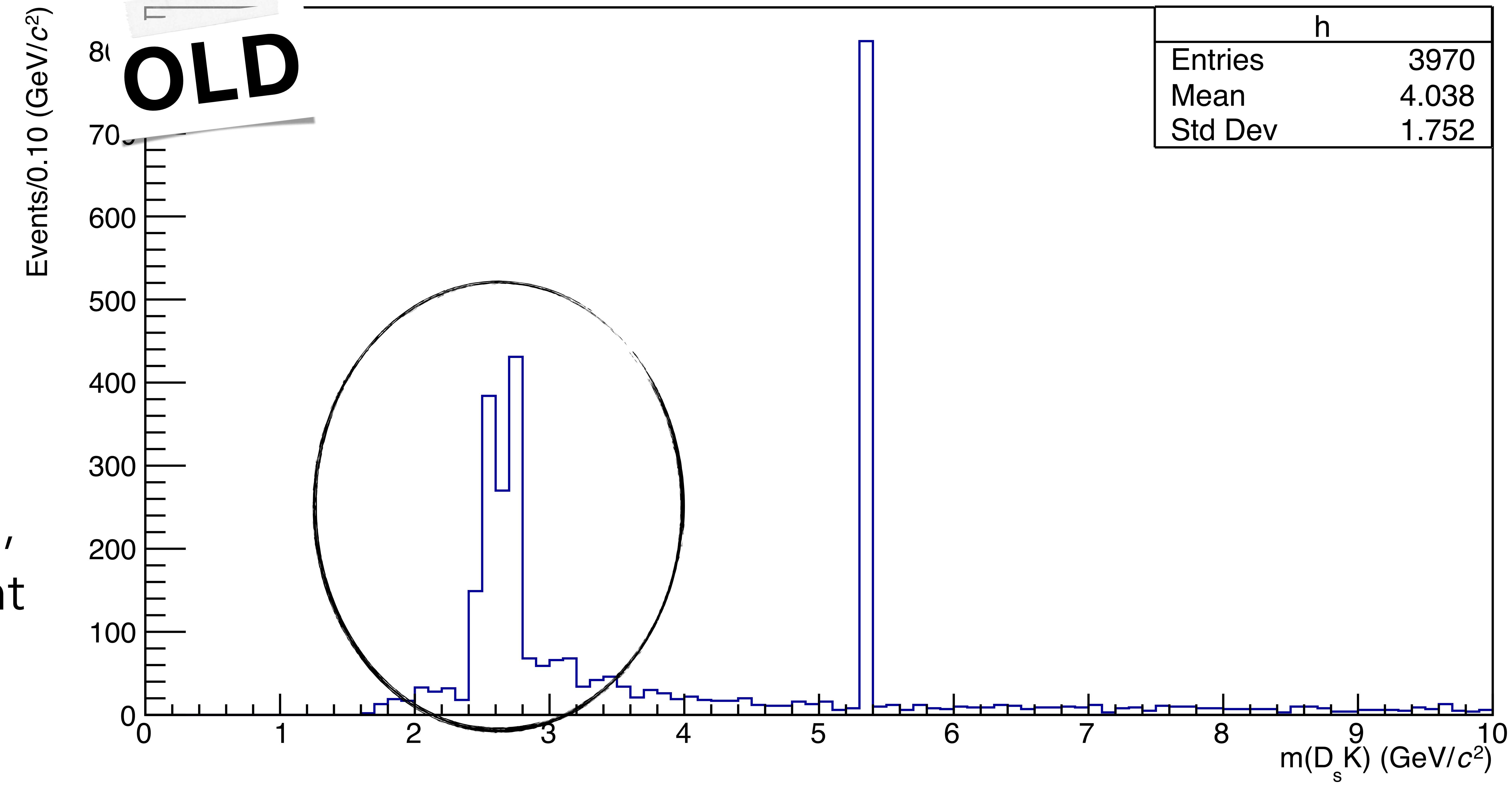
$B^0_s \rightarrow D^{\pm}_s K^{\mp} \rightarrow (KK\pi^{\pm})\ K^{\mp}$

Many possible reasons:

D_s not correctly identified
Kaons mixed
The two hemispheres confused
… 🐛

Despite main peak clearly visible, there is a heap in the low invariant mass region

Reconstructed B^0_s mass



Status

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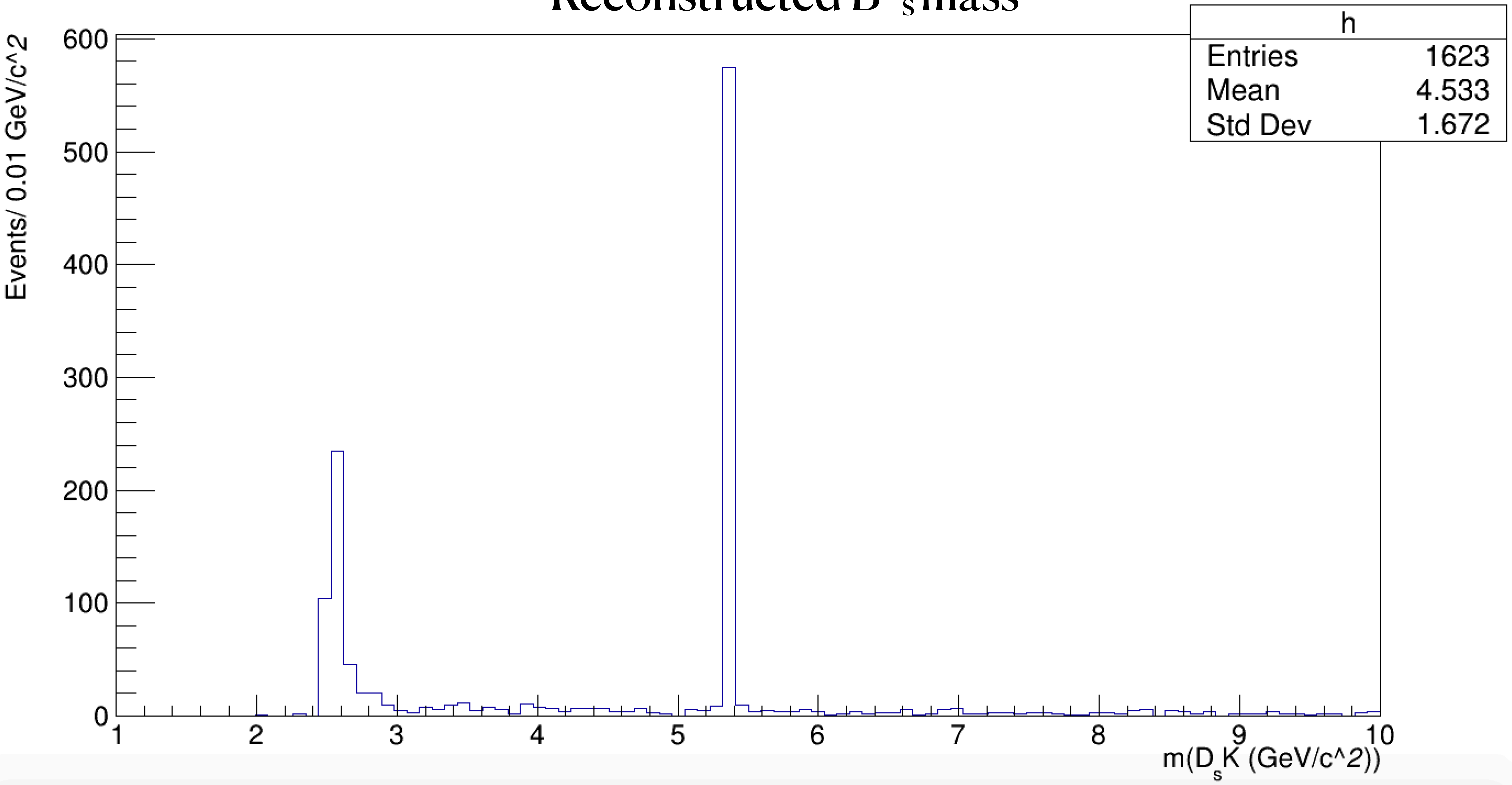
$B^0_s \to D^{\pm}_s K^{\mp} \to (KK\pi^{\pm}) K^{\mp}$

If D_s get truth-matched, the low mass heap decreases

Though a small contribution is still present

Reconstructed B^0_s mass



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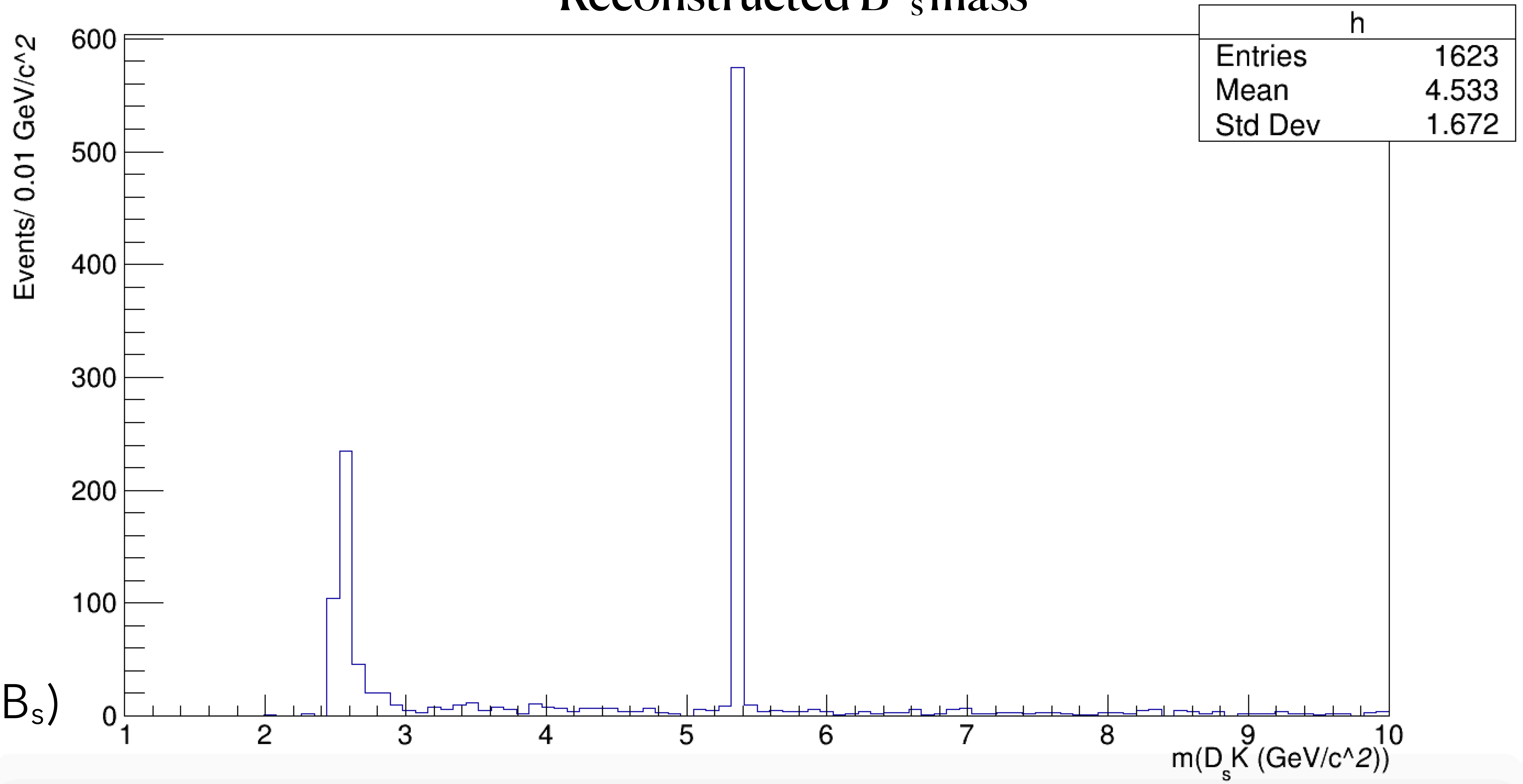
Thought of dividing the K into 2 sub-groups

D_s - Kaons

"prompt-" Kaons (i.e. coming from B_s)

Reconstructed B^0_s mass



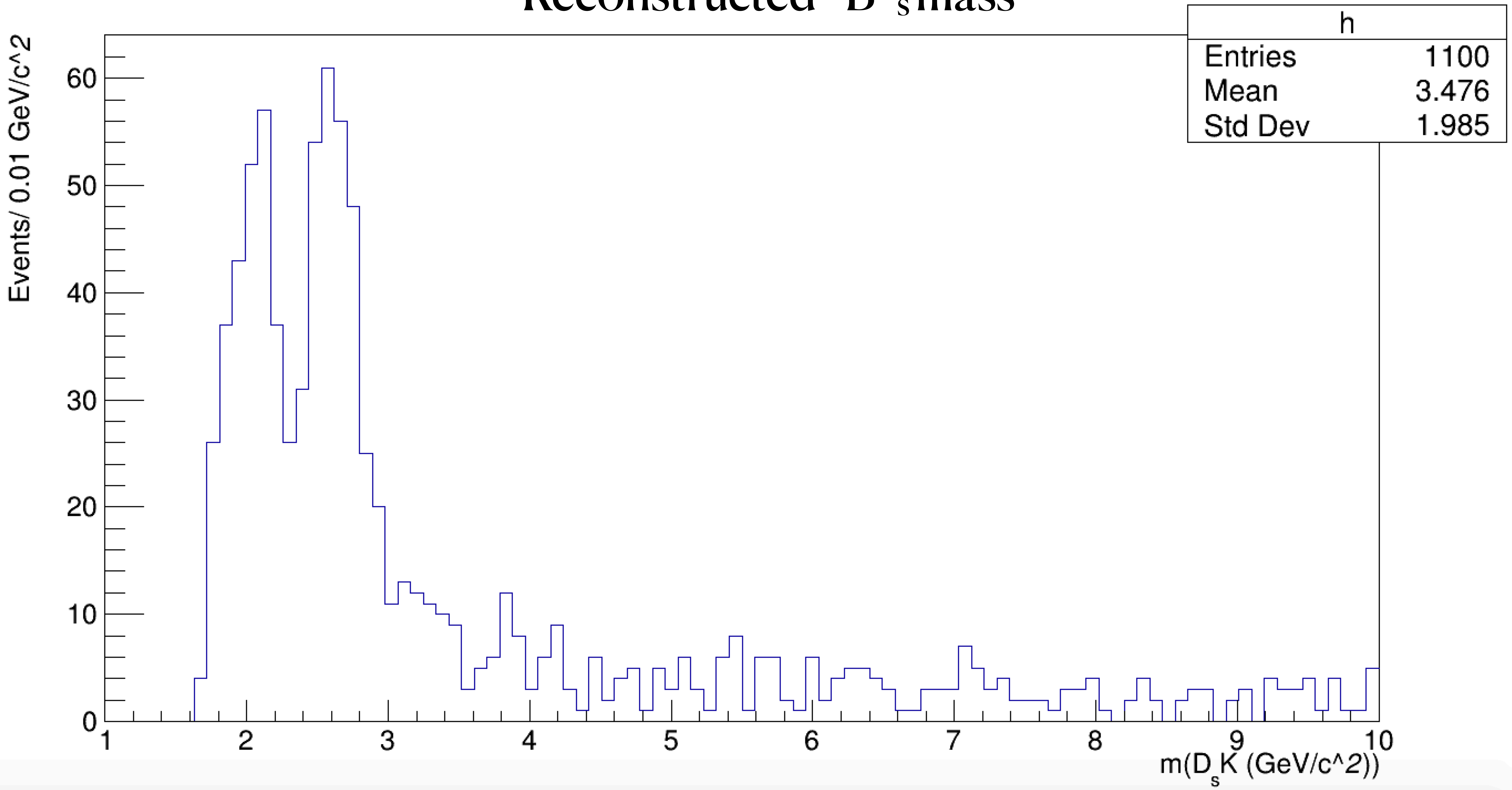
Status

IncMC

$B^0_s \rightarrow \mathbf{D^{\pm}_s}K^{\mp} \rightarrow \mathbf{(KK\pi^{\pm})}\ K^{\mp}$

In any case…
the **heap** seems to be
coming from **combinatorial**
combinations of K + KKπ

Reconstructed "B^0_s mass"



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"prompt-" Kaons (i.e. coming from B_s)

To do so, use φ mass as
discriminating values

Status

SigMC

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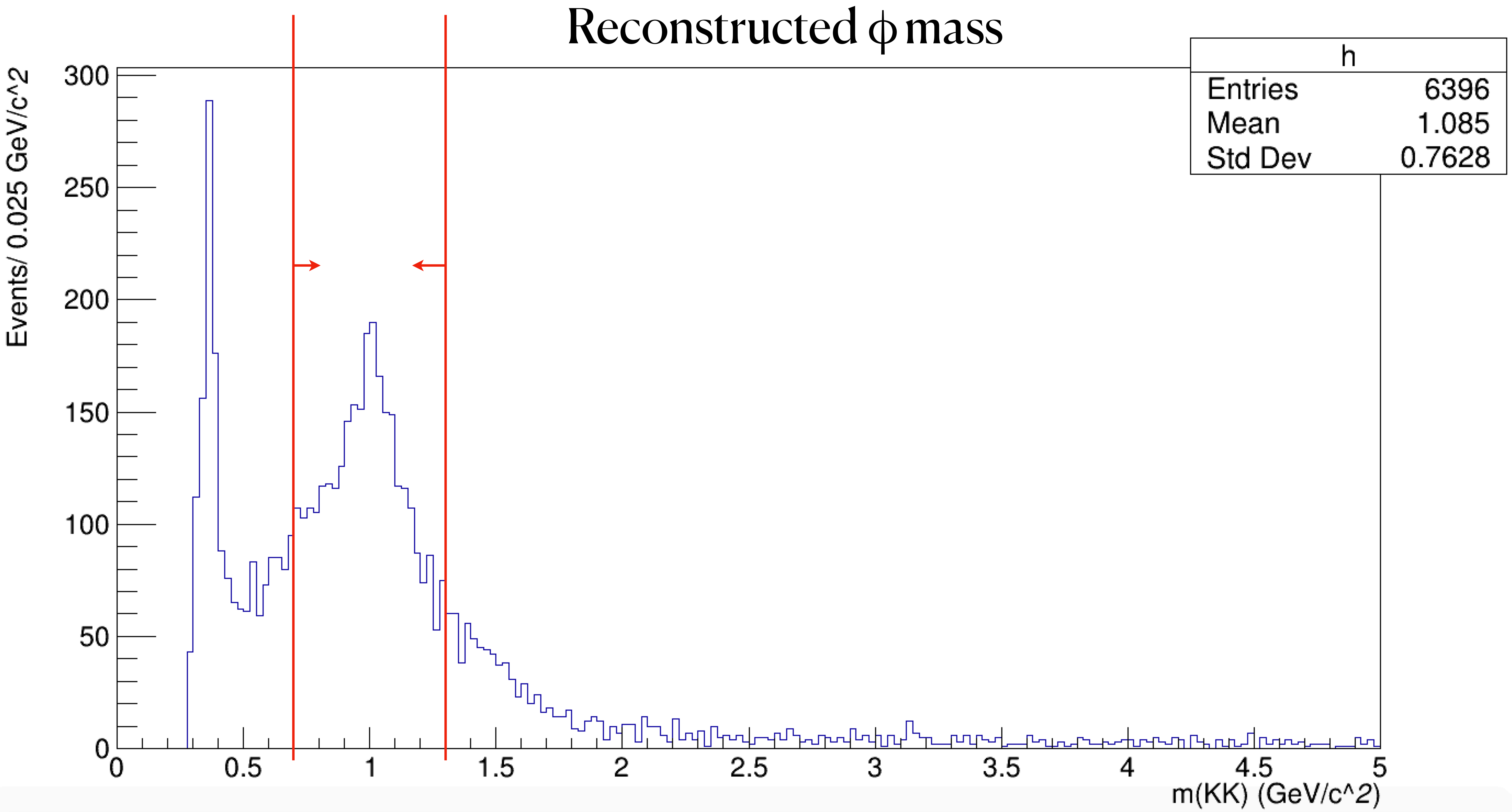

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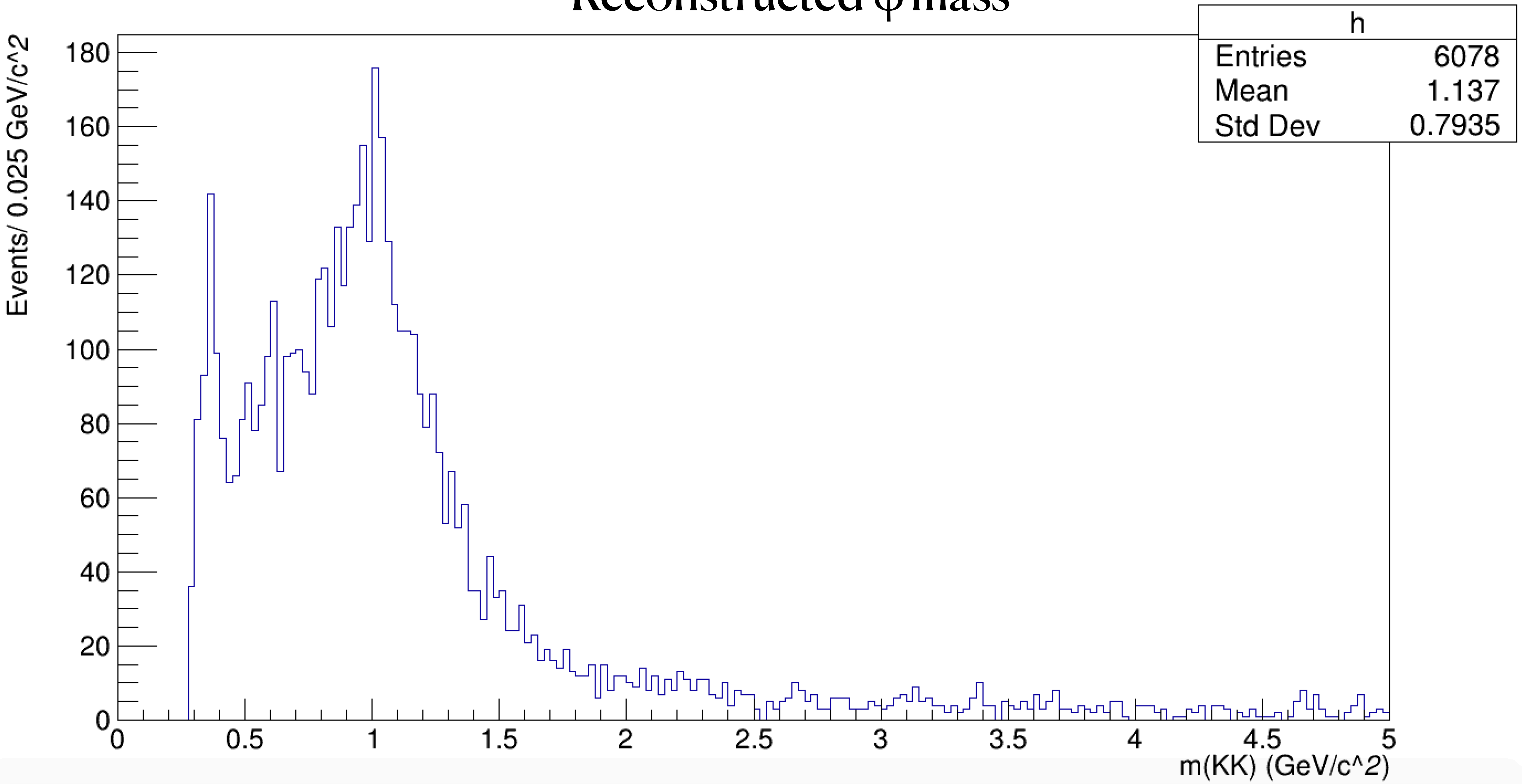
$B^0_s \rightarrow D^{\pm}_s K^{\mp} \rightarrow (KK\pi^{\pm})\, K^{\mp}$

Reconstructed ϕ mass



NB

The "best" φ mass is always selected

Status

PID

REMINDER
We did not have all the necessary ingredients:

1. dE/dx in Delphes
2. dN/dx in EDM4HEP (recently added by Clements)
3. dN/dx in key4SimDelphes

Regarding the first item

A function which gives the energy loss by a track at different βγ was inserted in TrackUtil method
A method to evaluate the energy loss cell per cell is being tested
A method to evaluate the truncated mean for the particle identification was added

NEW
dE/dx is in Delphes… some checks to do, but we’re almost there

Status

Full MC

$B^0_s \rightarrow D^{\pm}_s K^{\mp} \rightarrow (KK\pi^{\pm}) K^{\mp}$

http://fcc-physics-events.web.cern.ch/fcc-physics-events/Delphesevents_dev_IDEA.php

NB

These data sets
can be good for 100% PID

Will be re-run once
FC's PID is there

Main mode	Decay chain	Background mode	Decay chain
$\boldsymbol{B_s \rightarrow D_s^{\pm} K^{\mp}}$	$D_s^{\pm} \rightarrow \phi\pi^{\pm}, \phi \rightarrow K^+K^-$	$\boldsymbol{B_s \rightarrow D_s^{*\pm} K^{\mp}}$	$D_s^{*\pm} \rightarrow \gamma\phi\pi^{\pm}, \phi \rightarrow K^+K^-$
"	$D_s^{\pm} \rightarrow \phi\rho^{\pm}, \phi \rightarrow K^+K^-$	"	$D_s^{*\pm} \rightarrow \gamma\phi\rho^{\pm}, \phi \rightarrow K^+K^-, \rho^{\pm} \rightarrow \pi^{\pm}\pi^0$
		$\boldsymbol{B_s \rightarrow D_s^{\pm} K^{*\mp}}$	$D_s^{\pm} \rightarrow \phi\pi^{\pm}, \phi \rightarrow K^+K^-, K^{*\mp} \rightarrow K^{\mp}\pi^0$
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		$\boldsymbol{B_s \rightarrow D_s^{\pm} \pi^{\mp}}$	$D_s^{\pm} \rightarrow \phi\pi^{\pm}, \phi \rightarrow K^+K^-$
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		$\boldsymbol{\Lambda_b^0 \rightarrow D_s^{-} p^{+}}$	$D_s^{\pm} \rightarrow \phi\pi^{\pm}, \phi \rightarrow K^+K^-$
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Conclusion and Outlook

Deep into the **analysis**, added some functions the FCCSW classes… might *push* them at some point

Despite PID is 100% correct, **B^0_s & $D^\pm_s$** mass have been **reconstructed**

Some few **refinements** need to be put **into the B^0_s** (and the **φ**) **mass**

Next Steps

Add the PID
(cannot give a time on this, will interface with FC)

Implement(ing) vertex reconstruction at the B^0_s level (*few weeks*)

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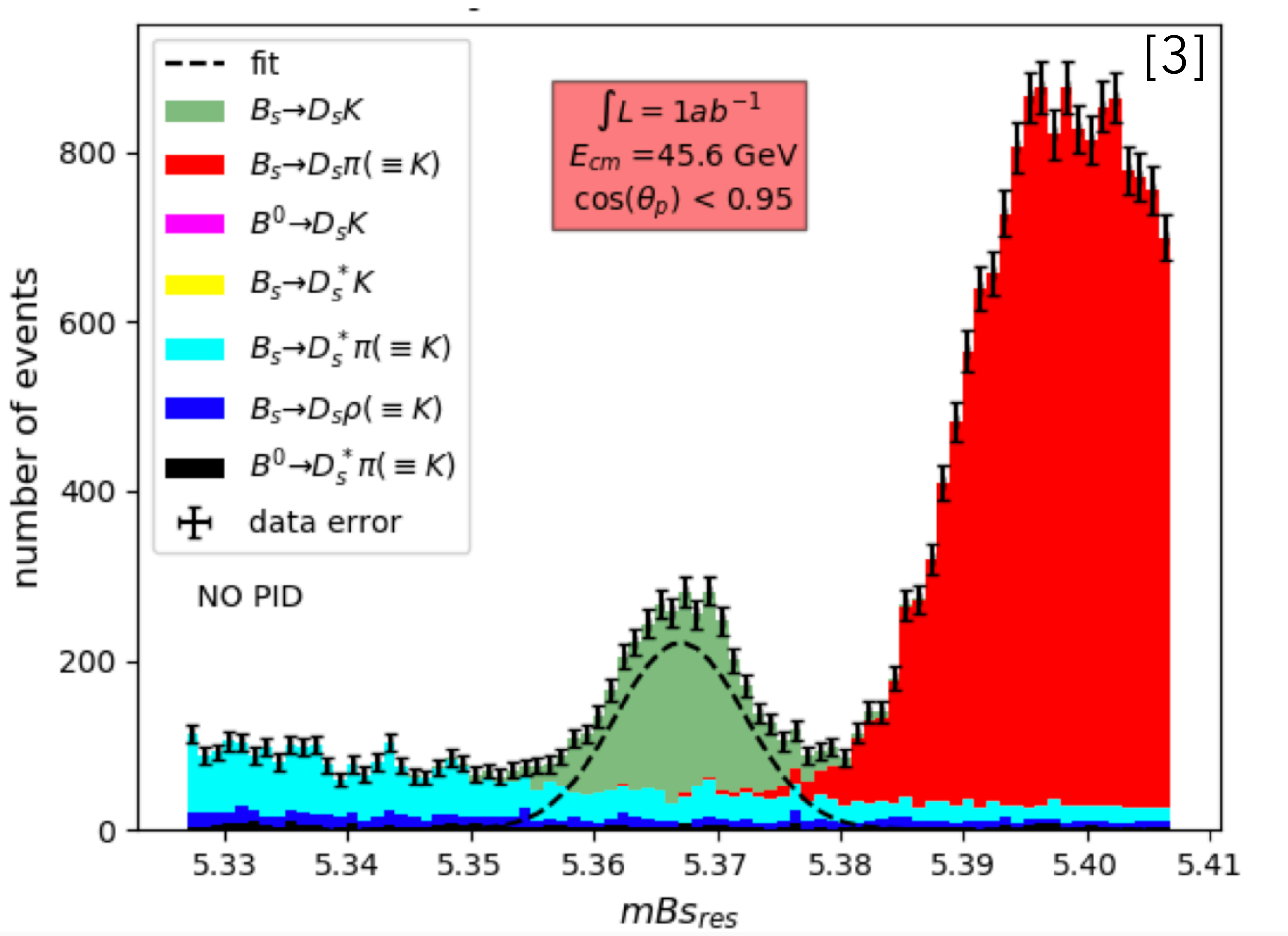
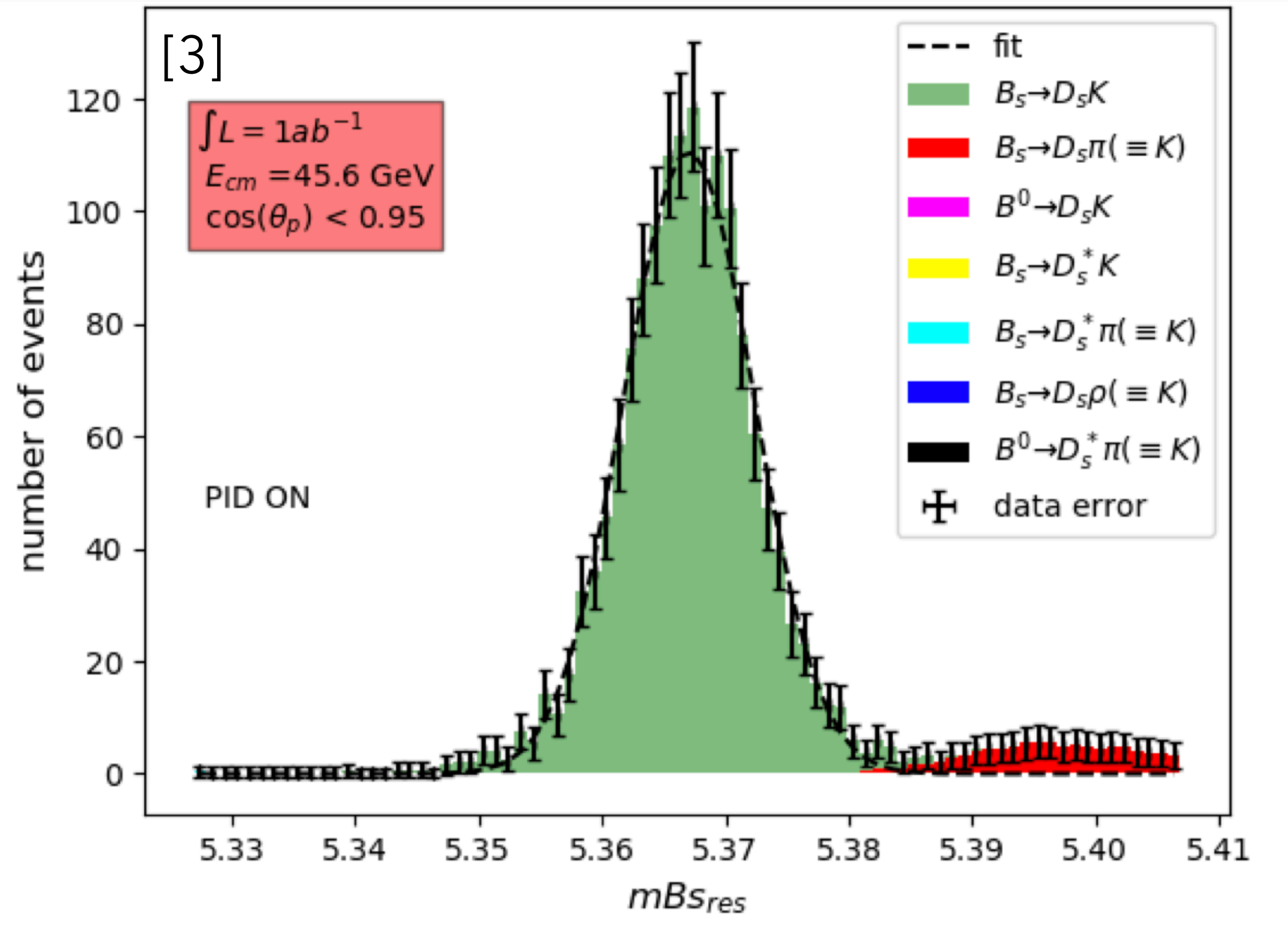
Reproduce the plots of the **B^0_s reconstructed mass** on the right[3]

Ref. [3] describes a generic FCC scenario, so it would be useful to see them within EDM4hep





[3] R. Aleksan, L. Oliver, and E. Perez, arXiv:2107.02002

Thank you for the attention!