Measurement of the absolute BRs of $D_{s1}(2536)$ and $D_{s2}(2573)$

Wang Hongpeng ,Yuan Changzheng

B410,IHEP

Outline

- Motivation
- Data Set
- Study in $e^{-}e^{+} \rightarrow D_s D_{s1}\ (2536)/D_{s2}(2573)$
- Study in $e^{-}e^{+} \rightarrow DsD_{s1}/D_{s2}\ \ ,D_{s1}/D_{s2} \rightarrow DK$

Motivation

- In the D_s spectrum ,$D_{s1}(2536)$ and $D_{s2}(2573)$, are the 1st and 2nd particle above the DK threshold . Their absolute branching fractions have not been reported up to now.
- The datasets in BESIII,4.6GeV ($587pb^{-1}$) , make it possible to measure the inclusive decay $e^-e^+ \to D_sD_{s1}$ $(2536)/D_{s2}(2573)$. And The exclusive decay $e^-e^+ \to DsD_{s1}/D_{s2}$,$D_{s1}/D_{s2} \to DK$ has been reported recently.
- The inclusive cross sections also can help us to study the $c\bar{c}$ even find new states when we get higher Energy Data in future .

$D_{s1}(2536)^{\pm}$

$I(J^P) = 0(1^+)$
J, P need confirmation.

Mass $m = 2535.10 \pm 0.06$ MeV
Full width $\Gamma = 0.92 \pm 0.05$ MeV

$D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

$D_{s1}(2536)^+$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$D^*(2010)^+K^0$	0.85 ± 0.12		149
$(D^*(2010)^+K^0)_{S-wave}$	0.61 ± 0.09		149
$D^+\pi^-K^+$	0.028 ± 0.005		176
$D^*(2007)^0K^+$	**DEFINED AS 1**		167
D^+K^0	<0.34	90%	381
D^0K^+	<0.12	90%	391
$D_s^{*+}\gamma$	possibly seen		388
$D_s^+\pi^+\pi^-$	seen		437

$D_{s2}^*(2573)$

$I(J^P) = 0(2^+)$

J^P is natural, width and decay modes consistent with 2^+.

Mass $m = 2569.1 \pm 0.8$ MeV (S = 2.4)
Full width $\Gamma = 16.9 \pm 0.8$ MeV

$D_{s2}^*(2573)^-$ modes are charge conjugates of the modes below.

$D_{s2}^*(2573)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
D^0K^+	seen	431
$D^*(2007)^0K^+$	not seen	238

Data set

- BOSS 7.0.3
- 4.6 GeV 586.9 pb^{-1}
- MC sample :

20,0000 $e^{-}e^{+} \rightarrow D_s + D_{s1}(2536)/D_{s2}(2573)$

10,0000 $e^{-}e^{+} \rightarrow D_s + D_{s1}/D_{s2}$

$D_{s1}/D_{s2} \rightarrow D^{*}0K/D^{0}K$

$D_s \rightarrow KK\pi$ D_DALITZ

Selection

- $|dVz| < 10cm$, $\left|\mathrm{dV_{xy}}\right| < 1cm$
- $|cos\theta_{track}| < 0.93$
- PID: Using the dE/dx, and the TOF

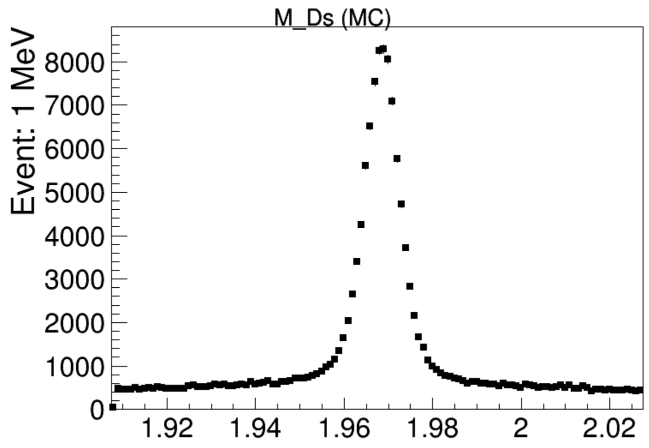
  π: $prob\ (\pi)$ >0 & $prob\ (\pi)\ > prob\ (K)$

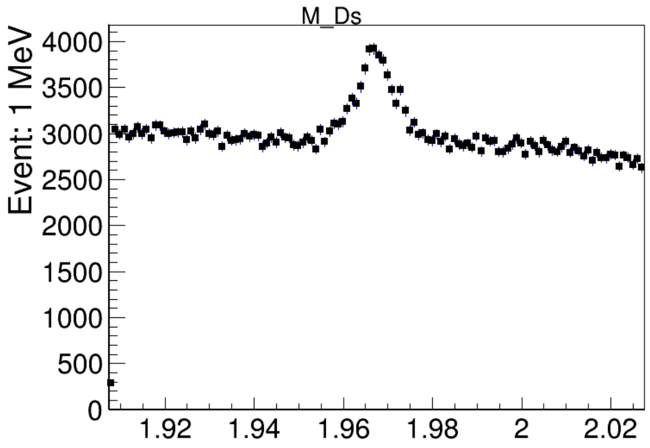
  K: $prob\ (K)$ >0 & $prob\ (K)\ > prob\ (\pi)$

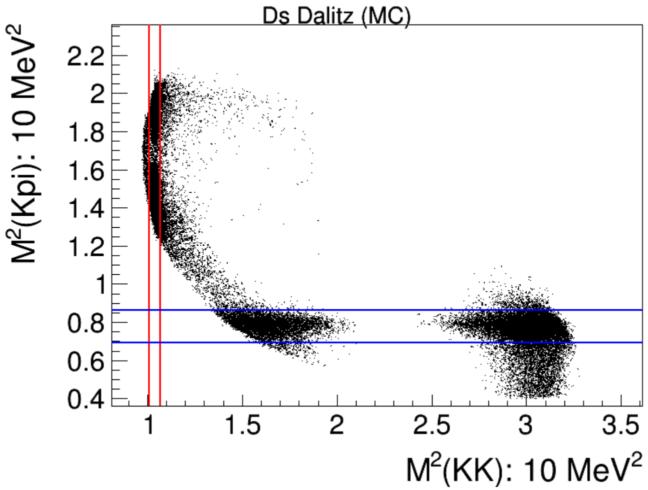
- D_s : $K\ K\ \pi \rightarrow 1C\ \ to\ \ D_s\ \ mass$

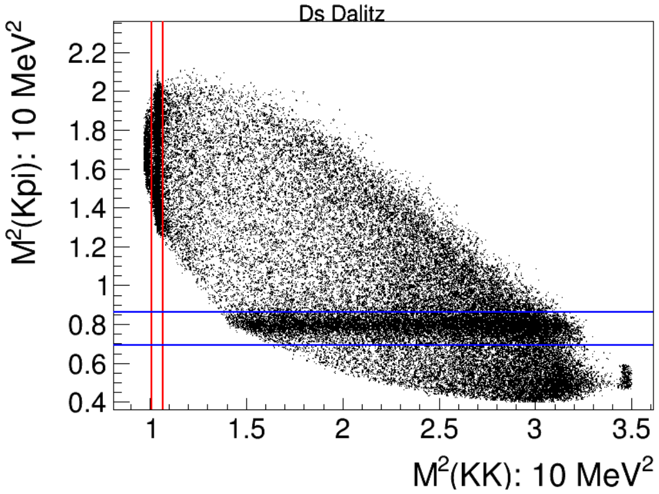
$D_s \to KK\pi$ MC vs Data

- $D_s \to \phi\pi$ and $D_s \to K^*K$ lie in the region between Red lines and Blue lines .

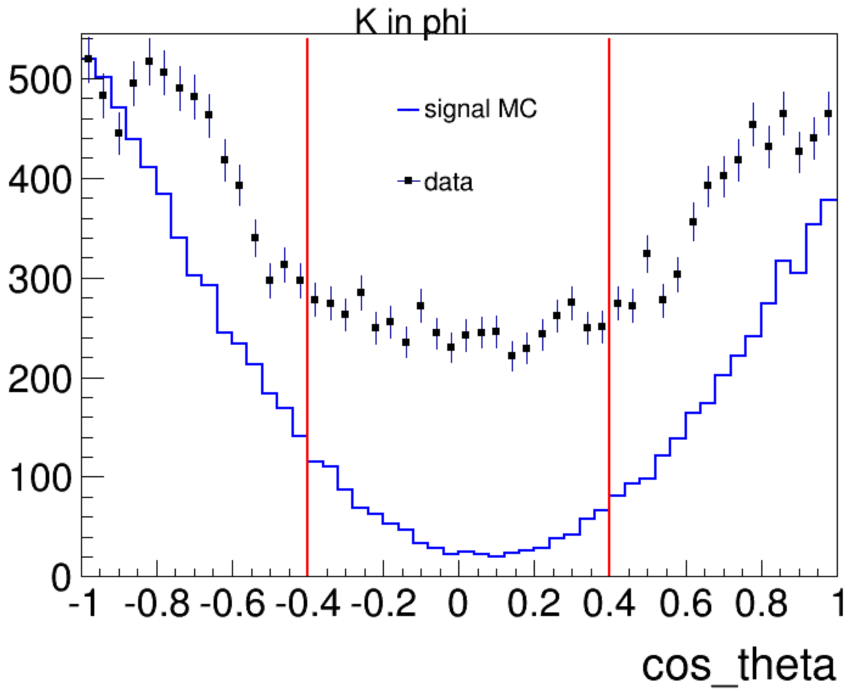


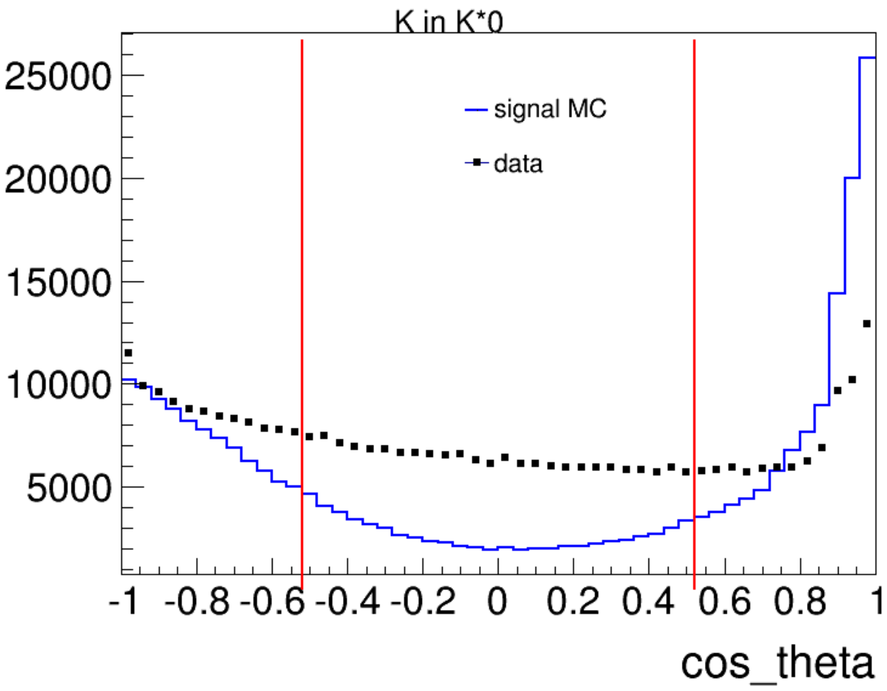






$\cos\theta_{helicity}$: K in ϕ & $K\ in\ K^*$

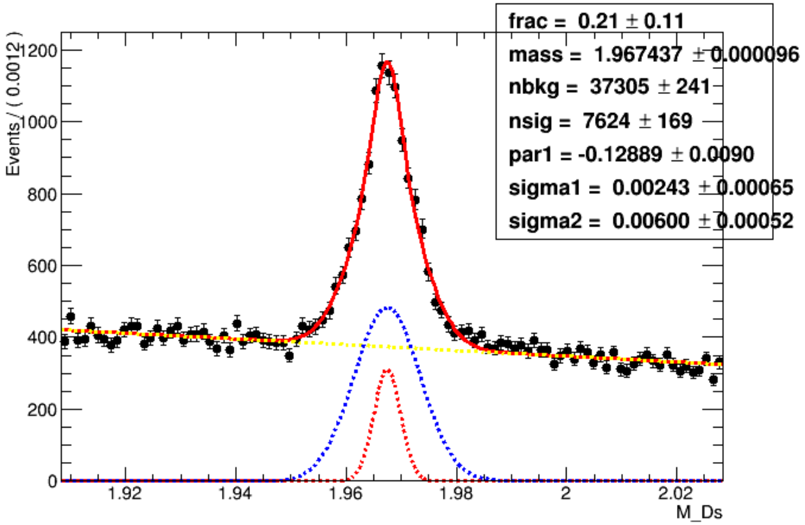


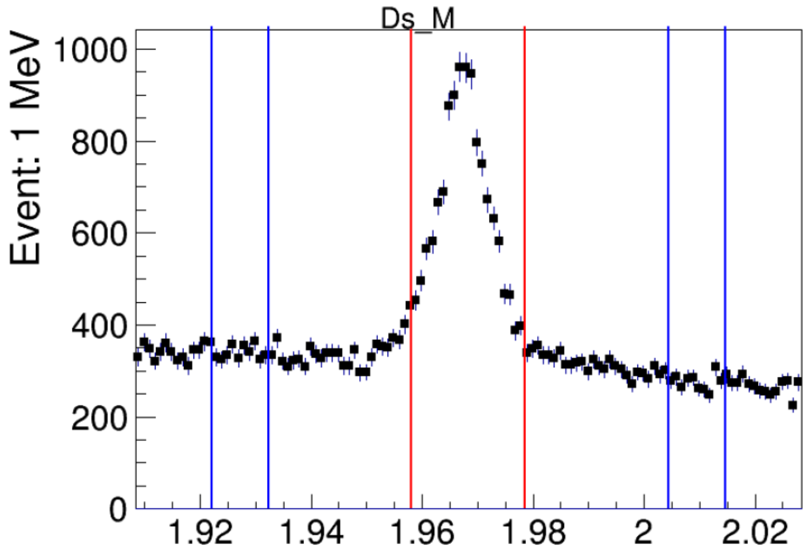


- For $D_s \to \phi\pi$ and $D_s \to K^*K$

cut the $|cos\theta| > 0.4$ &$|cos\theta| > 0.52$ to improve S/B ratio

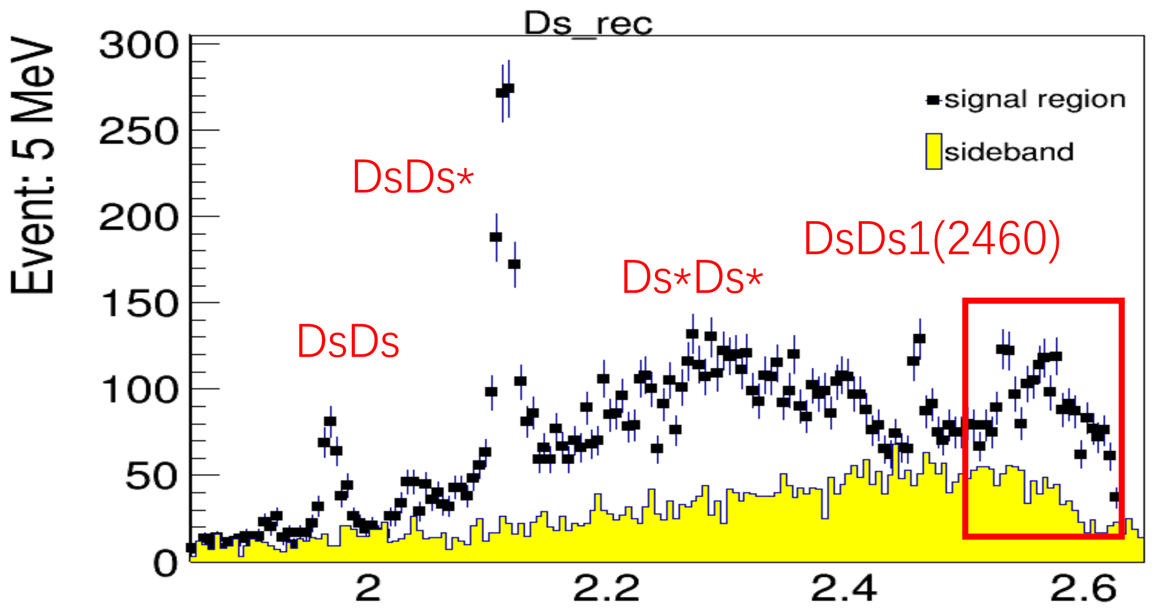
Signal region and sideband

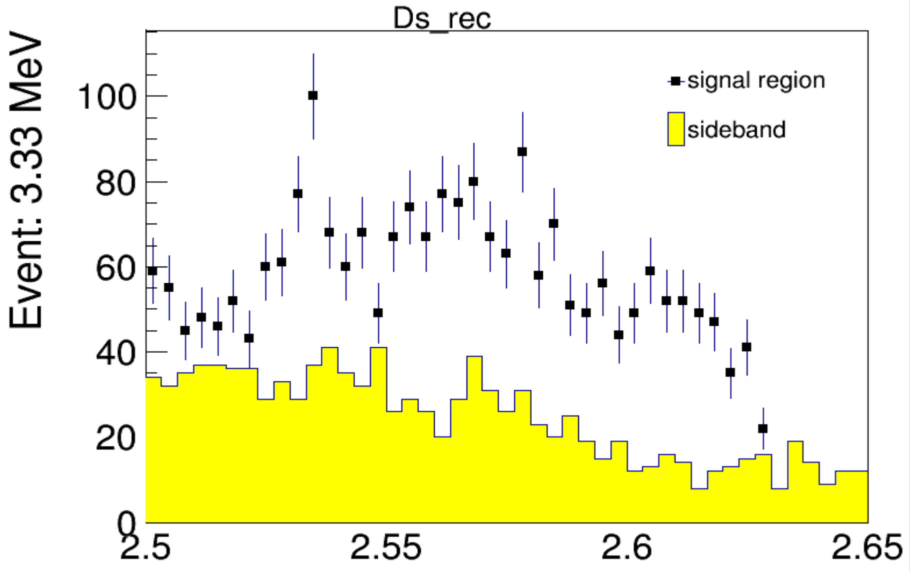




Fit the D_s's mass spectrum get the $\sigma = 0.514$,
Set the signal region: $M_{Ds} \pm 2\sigma$ kinematic fit to M_{Ds}
Side band region : $\{M_{Ds} \pm 7\sigma, M_{Ds} \pm 9\sigma\}$ kinematic fit to $M_{Ds} \pm 8\sigma$
Cut χ^2_{1C}<15

Spectrum of D_s recoil mass





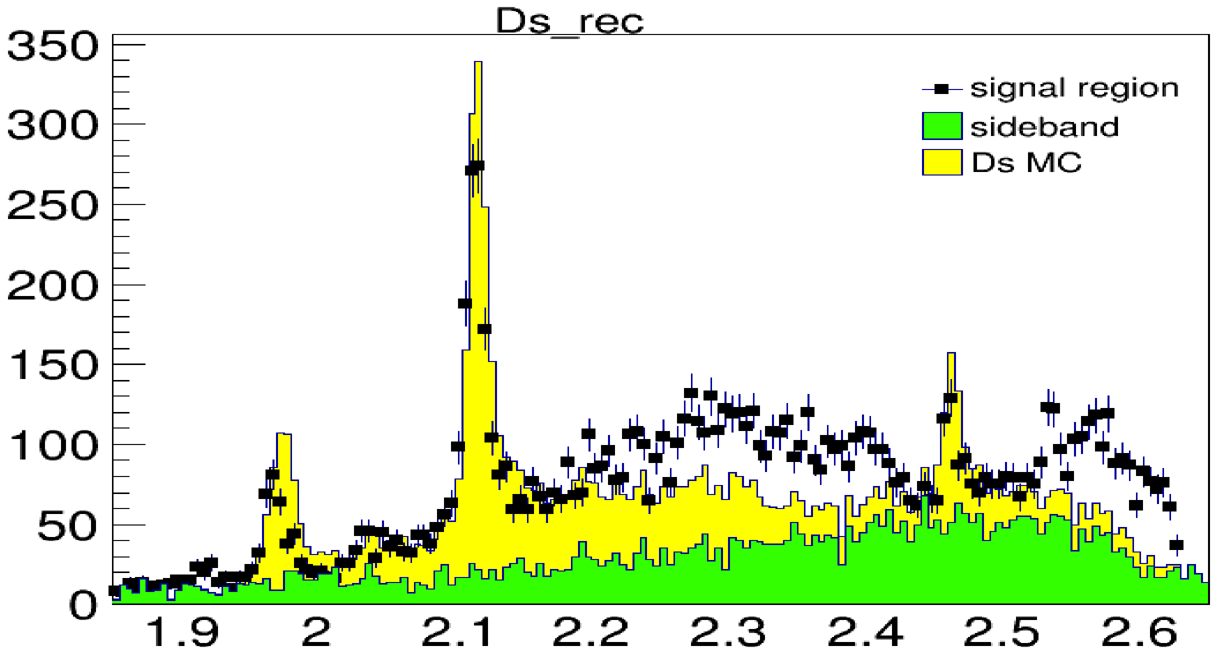
Try to fill the spectrum

The ISR decay always lied in the tail of the recoil spectrum.

Using the cross section published or proceeding of Ds to make MC sample filling the spectrum.

Try to describe the background under the Ds1&&Ds2.

1. DsDs by Li Ke
2. DsDs* by Sun Zhentian
3. Ds*Ds* by Sun Wenyu
4. DsDs1(2460) by Qi Tianyu

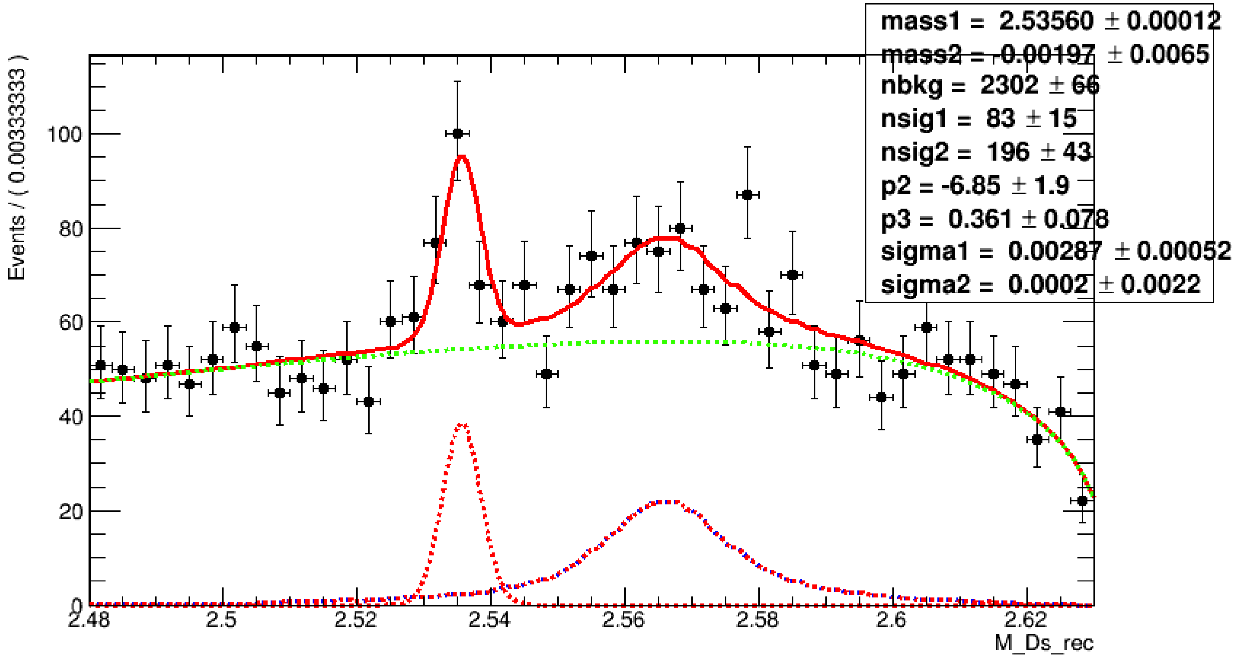


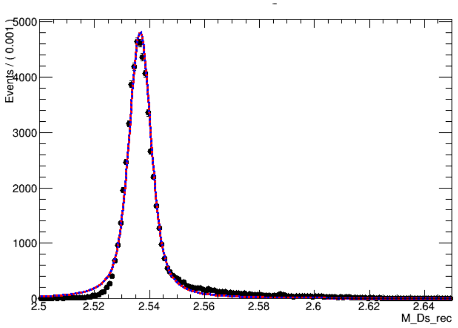
Fit to the data

Bkg: Argus shape

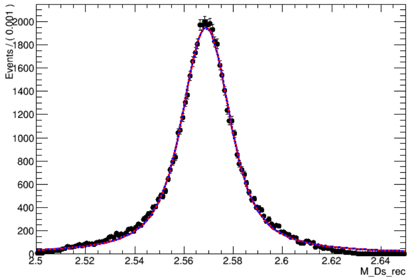
$D_{s1}(2536)$: gaussian shape

$D_{s2}(2573)$: MC shape convolved by gaussian shape





Ds1 Signal MC

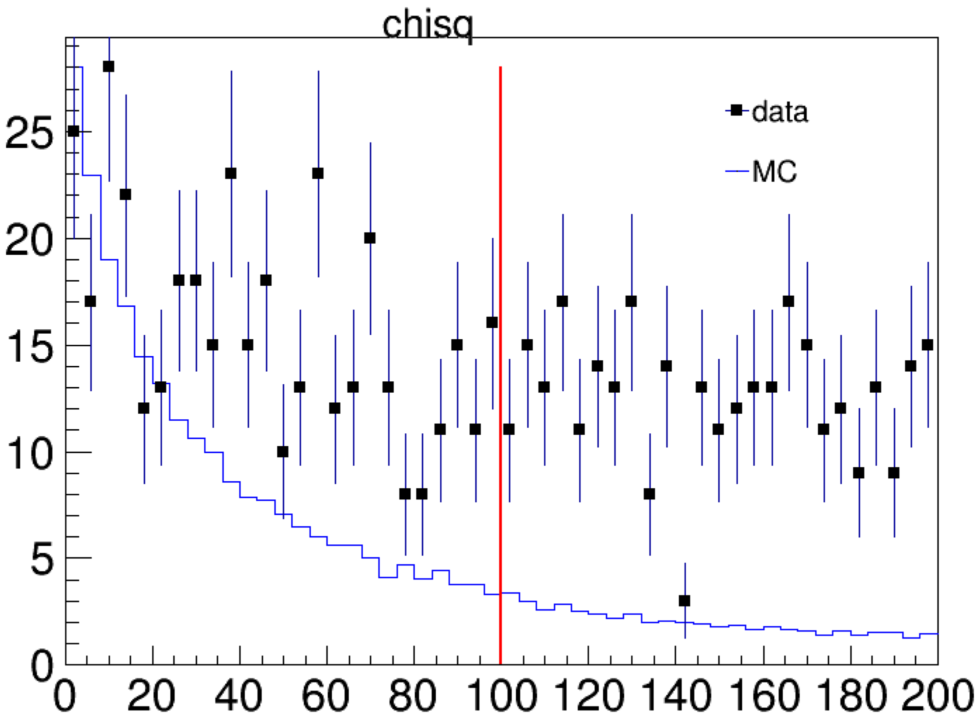


Ds2 Signal MC

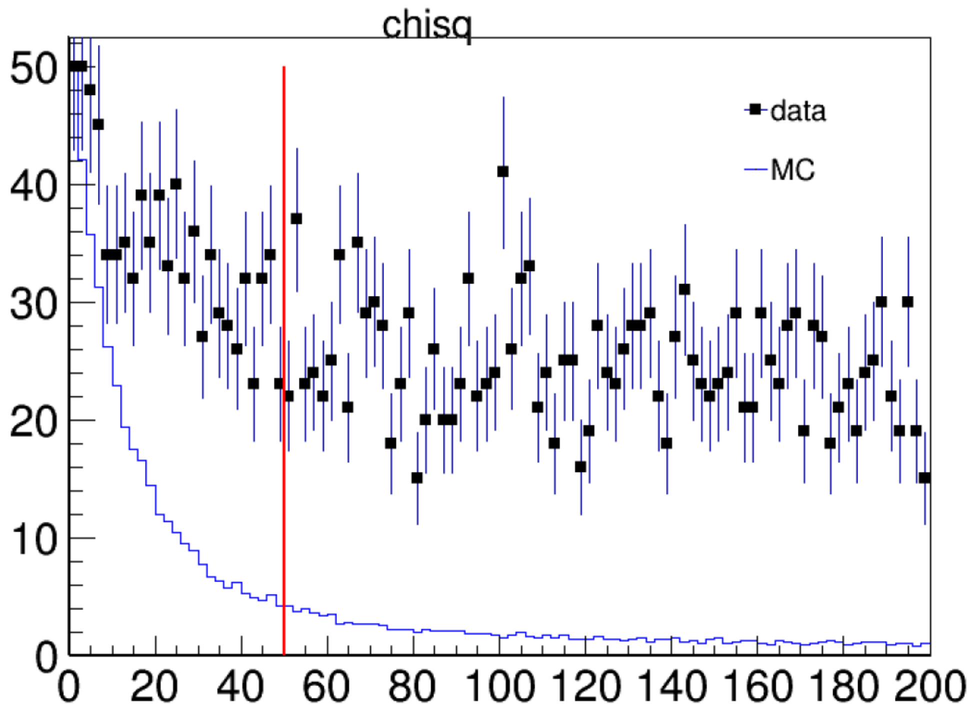
Exclusive Decay

- Use the $D_s \to KK\pi$ constrained to M_{Ds}
- Tag another K has the opposite charge to D_s
- Missing a track with mass $\mathrm{M}_{D^{*0}}$ for D_{s1} or M_{D^0} for D_{s2}
- 5 tracks constrained to $P_{initial}$

Cut χ^2

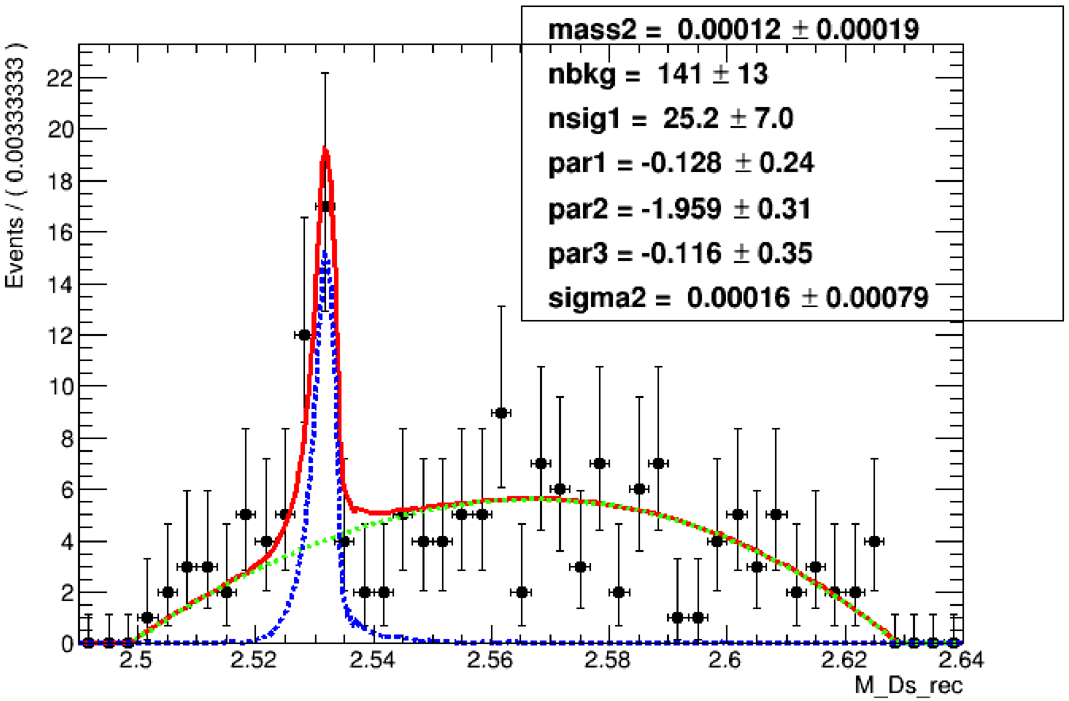


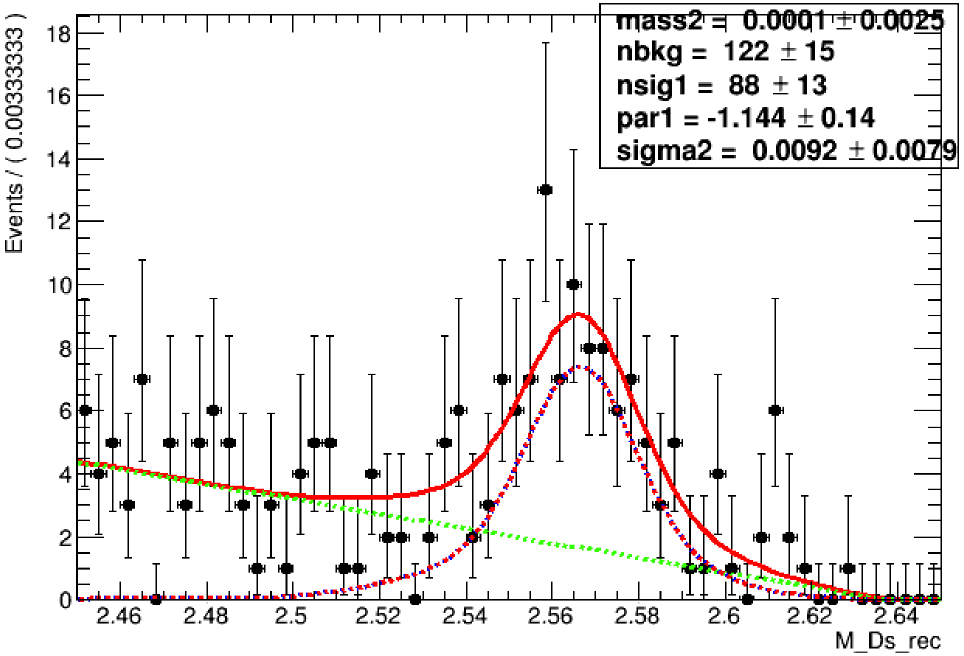
Ds1 $\chi^2 < 100$



Ds2 $\chi^2 < 50$

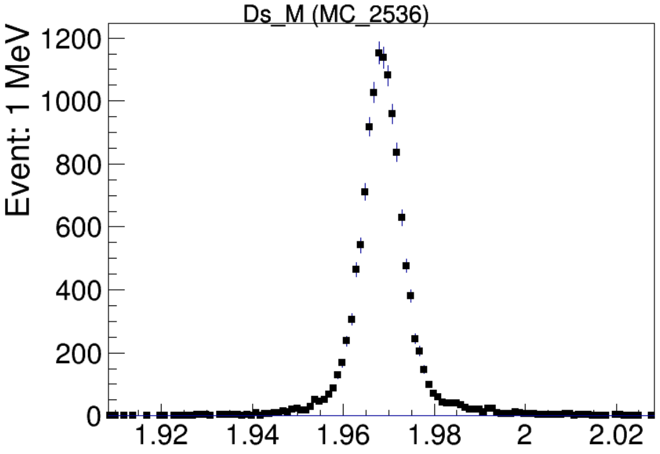
Fit to Data

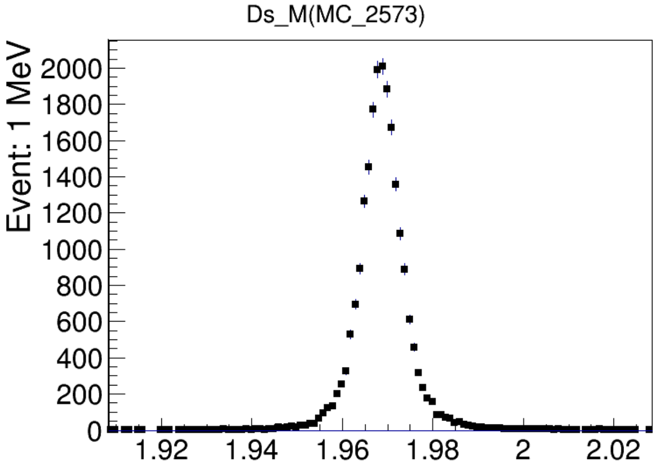


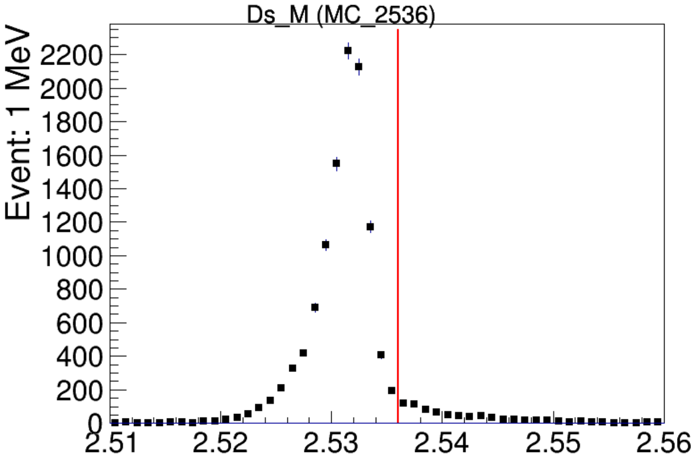


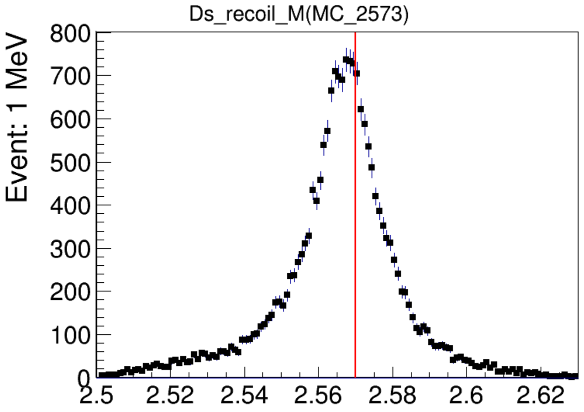
Use MC shape convolved a Gaussian to fit signal, Use 3rd/1st order Chebyshev to fit Bkg

MC sample D_{s1}&D_{s2}









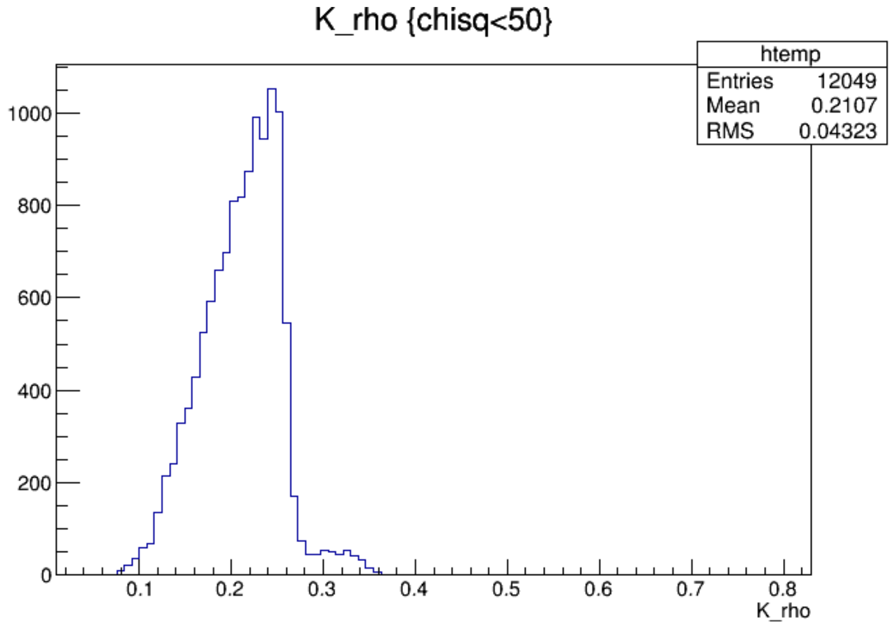
Summary & Next to do

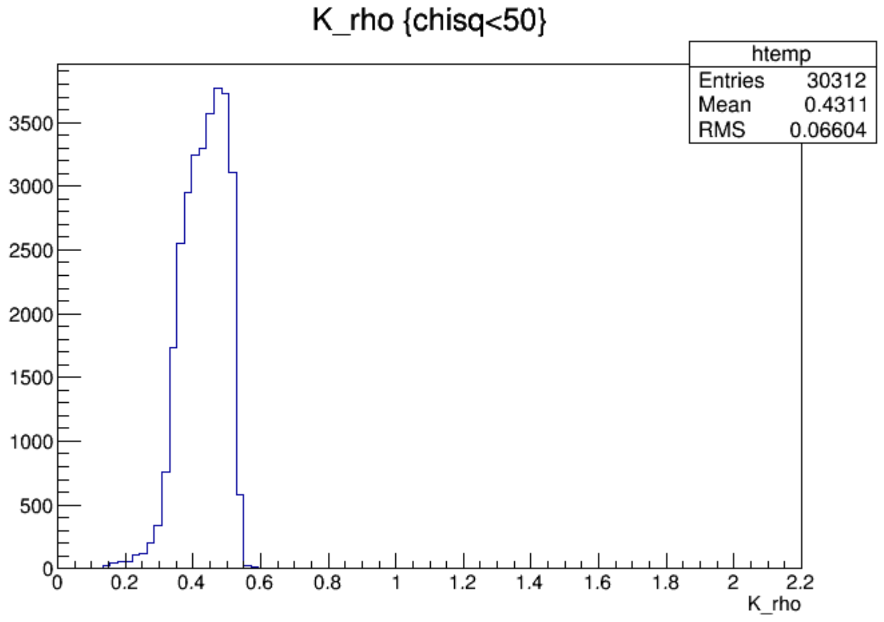
	inclusive EVT.	inclusive EFF.	exclusive EVT.	exclusive EFF.	Abs BRs
$D_{s1}(2536)$	83 ± 15	0.282	25.2 ± 7.0	0.118	0.727 ± 0.33
$D_{s2}(2573)$	196 ± 43	0.286	88 ± 13	0.194	0.686± 0.251

1. Optimize the cut and fit
2. Test more decay modes or methods
3. Study the Bkg more

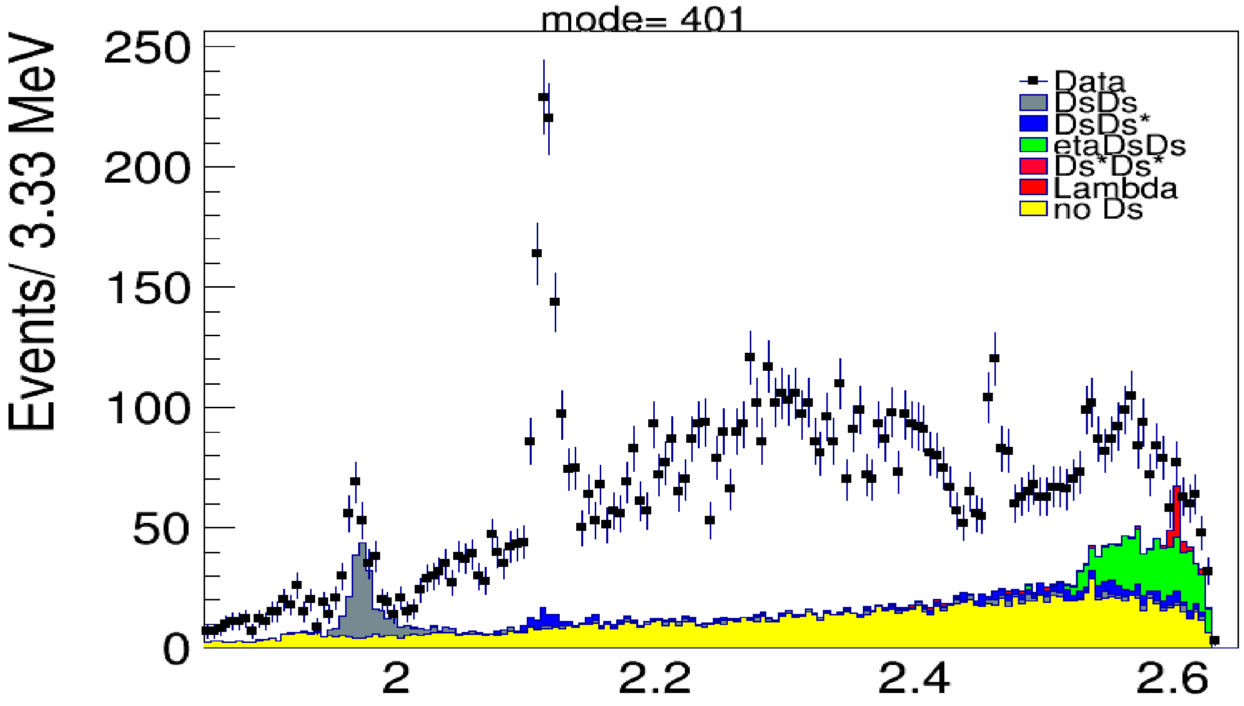
Thank You !!

Momentum of K_{tag} from D_{s1} & D_{s2}



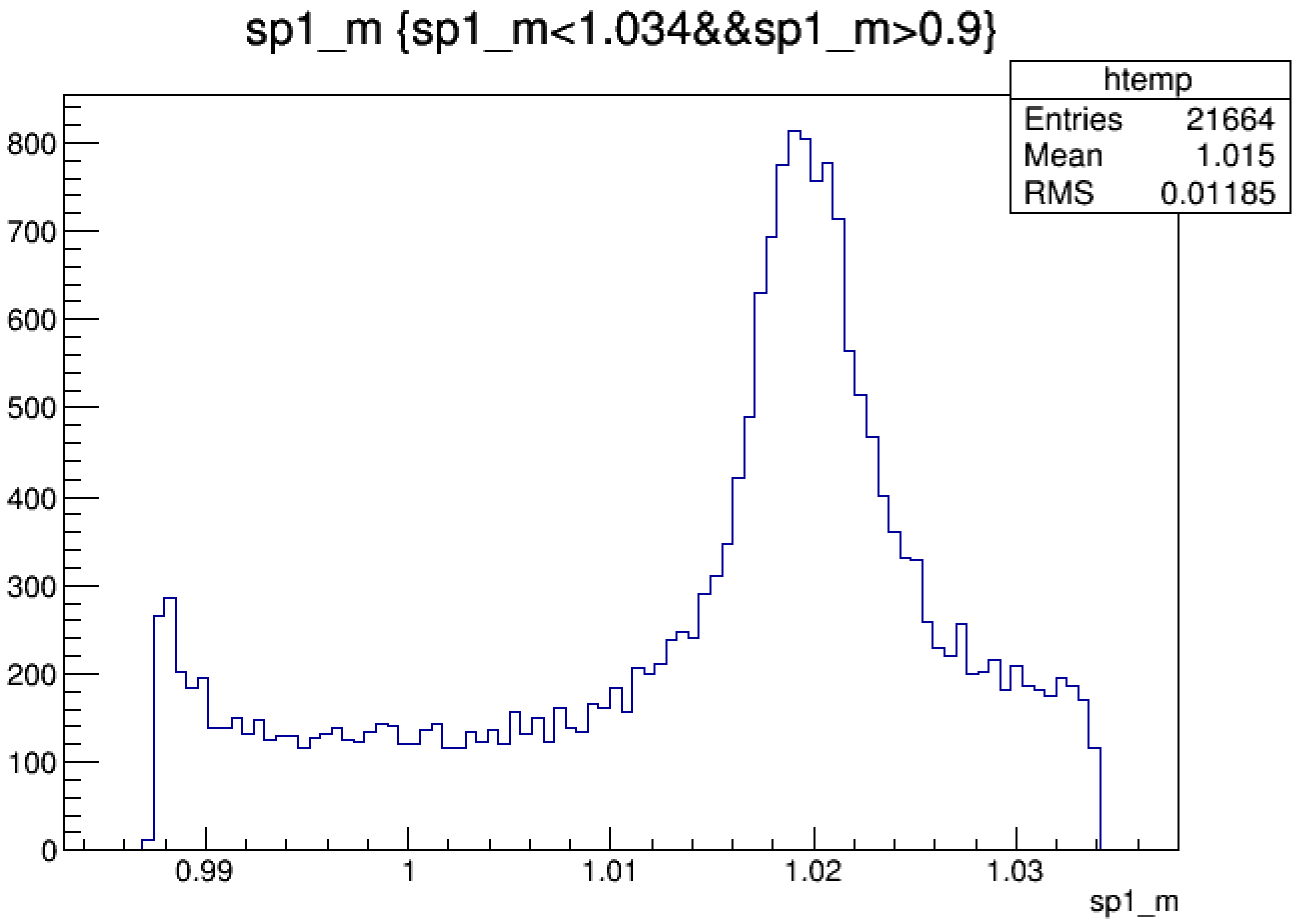


INC MC

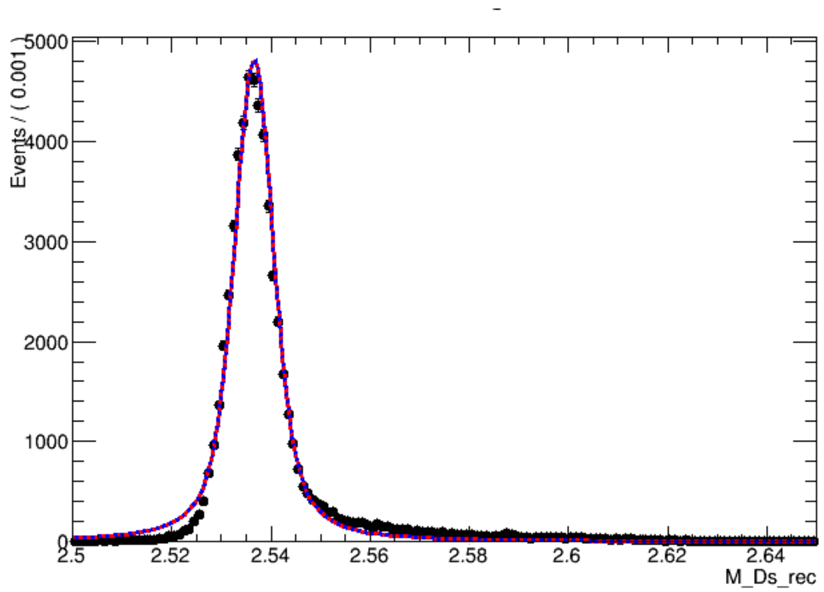


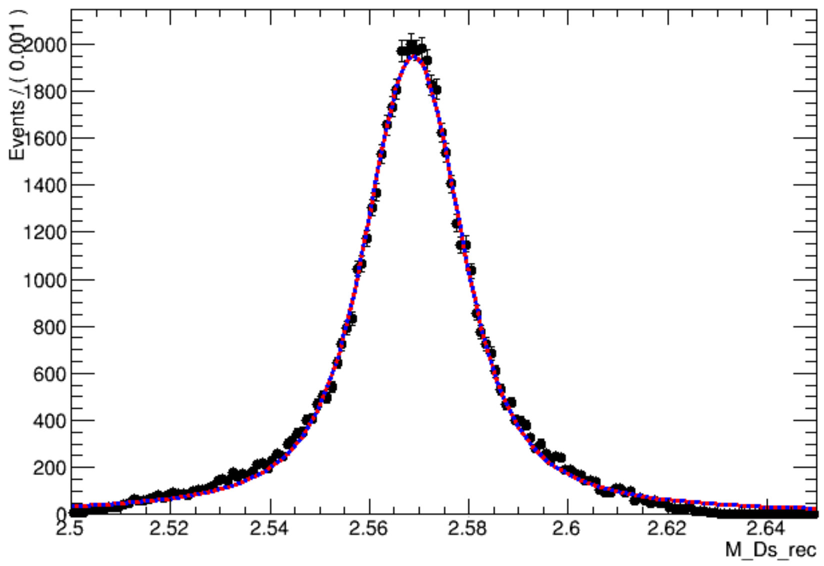
mode= 401
Events/ 3.33 MeV
250
200
150
100
50
0
2
2.2
2.4
2.6
Data
DsDs
DsDs*
etaDsDs
Ds*Ds*
Lambda
no Ds

Ds in phi


sp1_m {sp1_m<1.034&&sp1_m>0.9}
htemp
Entries 21664
Mean 1.015
RMS 0.01185
800
700
600
500
400
300
200
100
0
0.99
1
1.01
1.02
1.03
sp1_m

SIGMC


Events / (0.001)
5000
4000
3000
2000
1000
0
2.5
2.52
2.54
2.56
2.58
2.6
2.62
2.64
M_Ds_rec


Events / (0.001)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
2.5
2.52
2.54
2.56
2.58
2.6
2.62
2.64
M_Ds_rec