




# Status of Analyses

# $\bar{p}p \rightarrow D_s D_{s0}^*(2317)$

# $\bar{p}p \rightarrow \phi\phi$

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**PANDA Collaboration Meeting**

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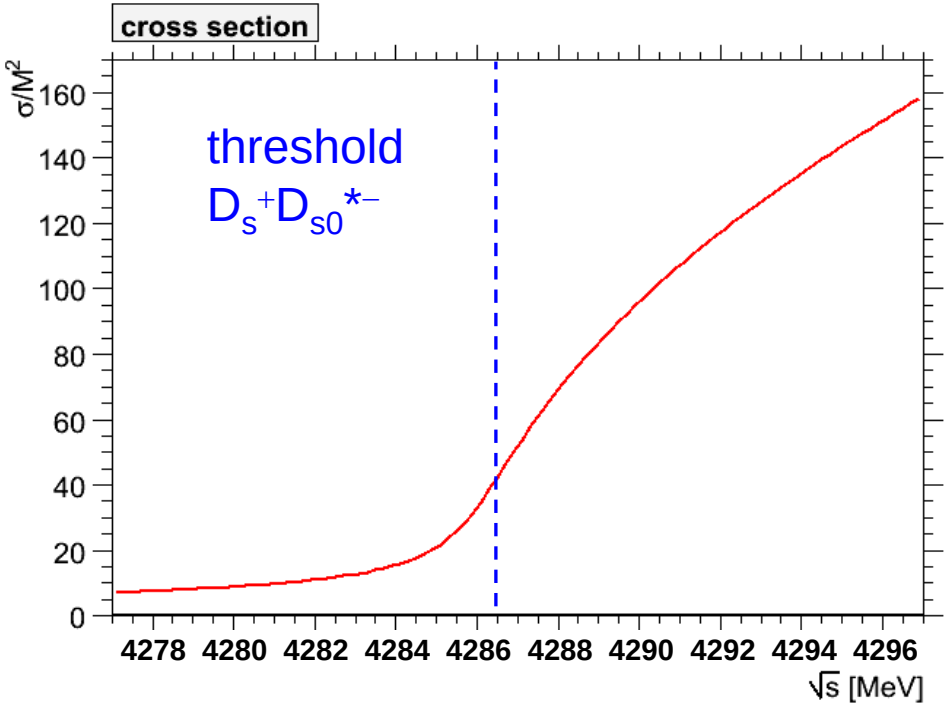
$$\bar{p}p \rightarrow D_s D_{s0}^*(2317)$$

# Measurement

- Determine width $\Gamma$ of $D_{s0}^*(2317)$
- Method for real data
  - Energy scan around $D_s^+ D_{s0}^{*-}$ threshold,
    Determine number of reactions of signal type for each step
    $\rightarrow$ signal cross section energy dependent (excitation function)
  - Shape of excitation function tells you about width
- Method for MC
  - cannot scan, cross sections are not reproduced correctly
  - analysis at some points above threshold to determine behaviour of signal shape
  - model #signals according to energy and determine sensitivity of measurement



# Reminder - Timescale

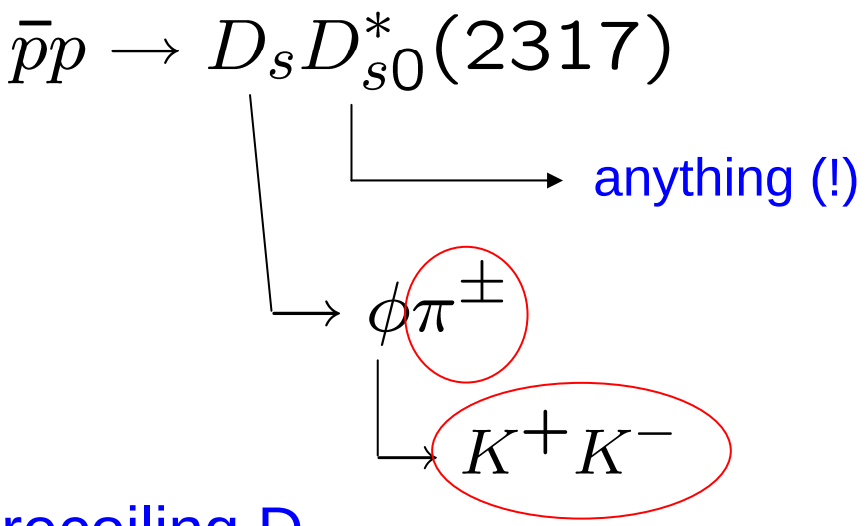
- How long do we have to measure?
- Assumption:
  - $\sigma_S \approx 1$ nb
  - int. luminosity/day $L_{int} \approx 10\ pb^{-1} = 10000\ nb^{-1}$
  - $N_S/day = \sigma_S \cdot L_{int} = 10000$
- Exclusive reconstruction:
  - $N_{S,reco}/day = N_S \cdot \varepsilon_{S,ex} \cdot f_{ex} = 10000 \cdot 6.58 \cdot 10^{-5} = 0.658$

    $N_{S,reco} \stackrel{!}{=} 1000 \Rightarrow t_{ex} = 1510d = 50$ months 
- Inclusive reconstruction:
  - $N_{S,reco}/day = N_S \cdot \varepsilon_{S,inc} \cdot f_{inc} = 10000 \cdot 7.7 \cdot 10^{-3} = 77$

    $N_{S,reco} \stackrel{!}{=} 1000 \Rightarrow t_{inc} = 13d$ 

# Reconstruction $D_sD_{s0}^*(2317)$

- Decay Tree



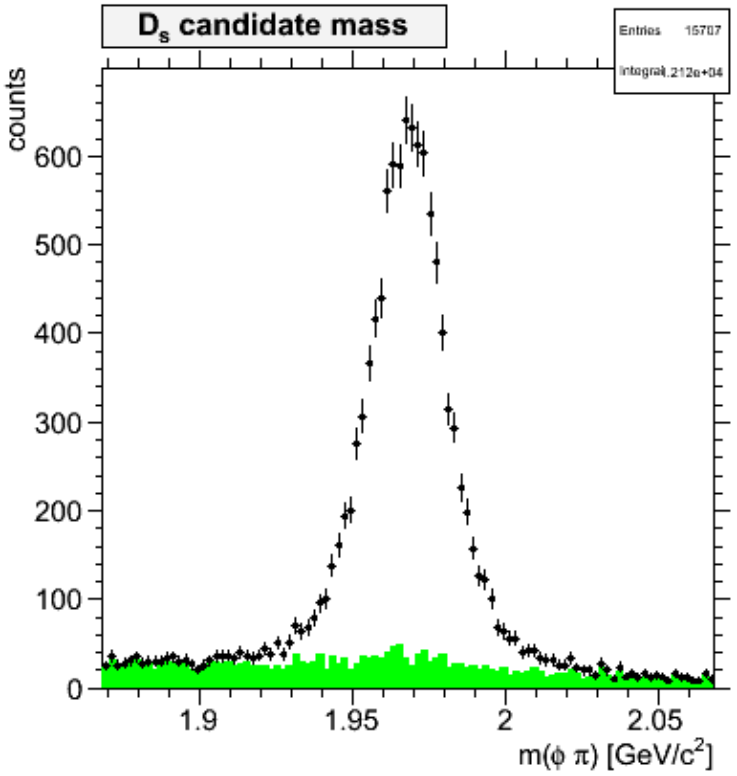

- Reconstruction
  - Inclusive; reconstruct recoiling $D_s$

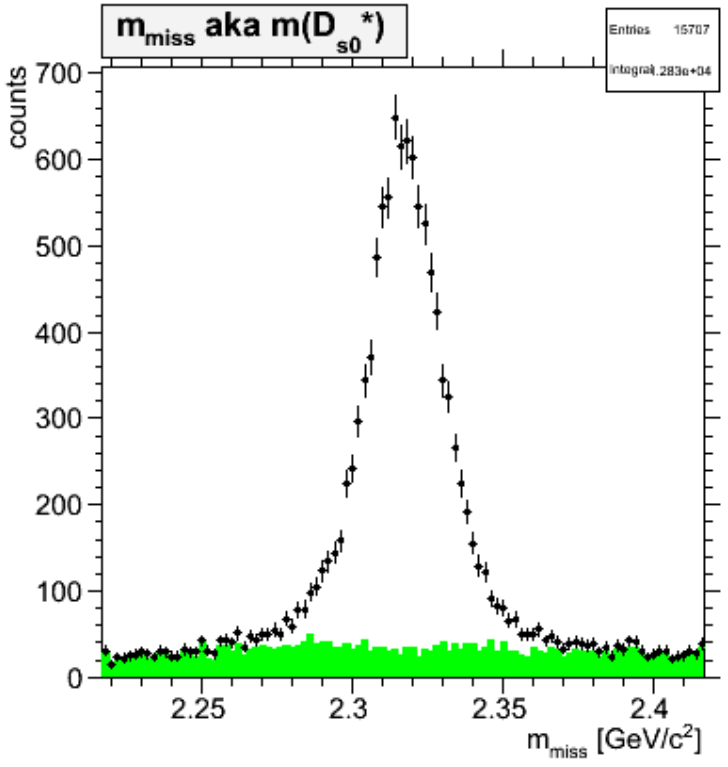
- Datasets
  - Signal @ 4.286, 4.291, 4.296, 4.306 GeV, $\Gamma_{Ds0}$=0.1 / 2MeV
  - Background: DPM 1M @ 4.291 GeV
  - Specific backgrounds @ 4.291 GeV (14k - 24k)
    - $D_sD_s\,\pi^0$ , $D_sD_s2\pi^0$ , $D_sD_s\gamma$ , $D_sD_s\pi^+\pi^-$
    - $D_sD_s^*(2112)$ , $D_sD_s^*(2112)\pi^0$ , $D_sD_s^*(2112)\gamma$

# Inclusive Signal

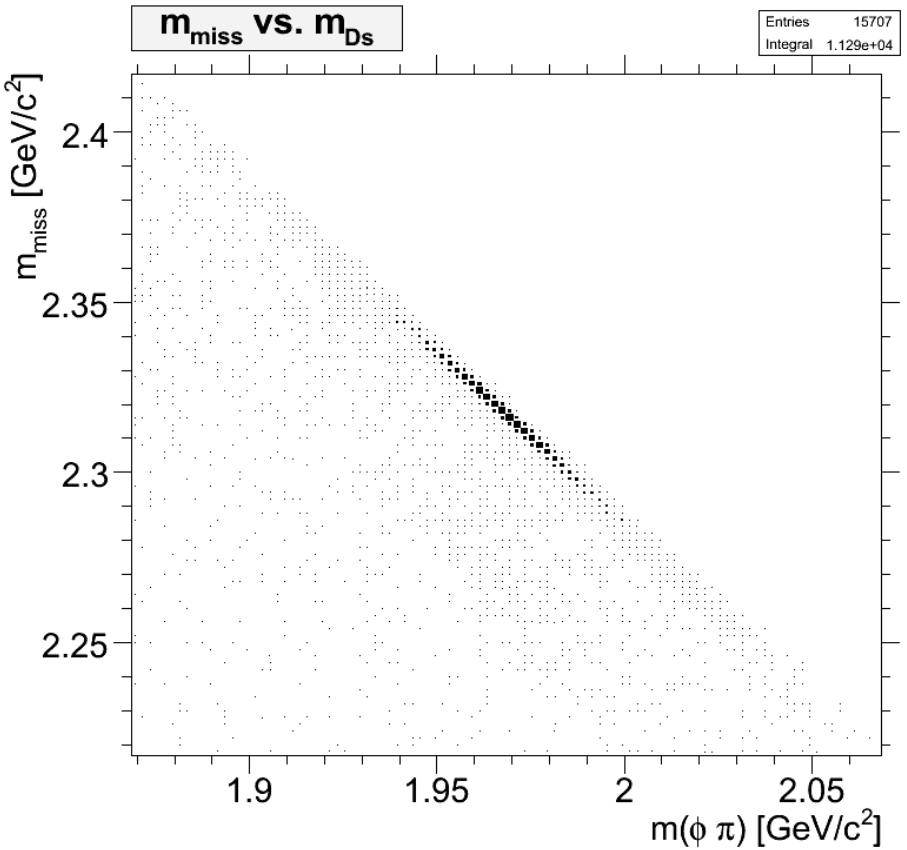
- Inclusive Selection
  - veryLoose kaon/pion PID
  - vertex fit of the $\phi$ (P > 0.001)
  - vertex fit of the $D_s$ (P > 0.001)
  - $|m(\phi\pi) - 1968.5| < 30$ [MeV/$c^2$]

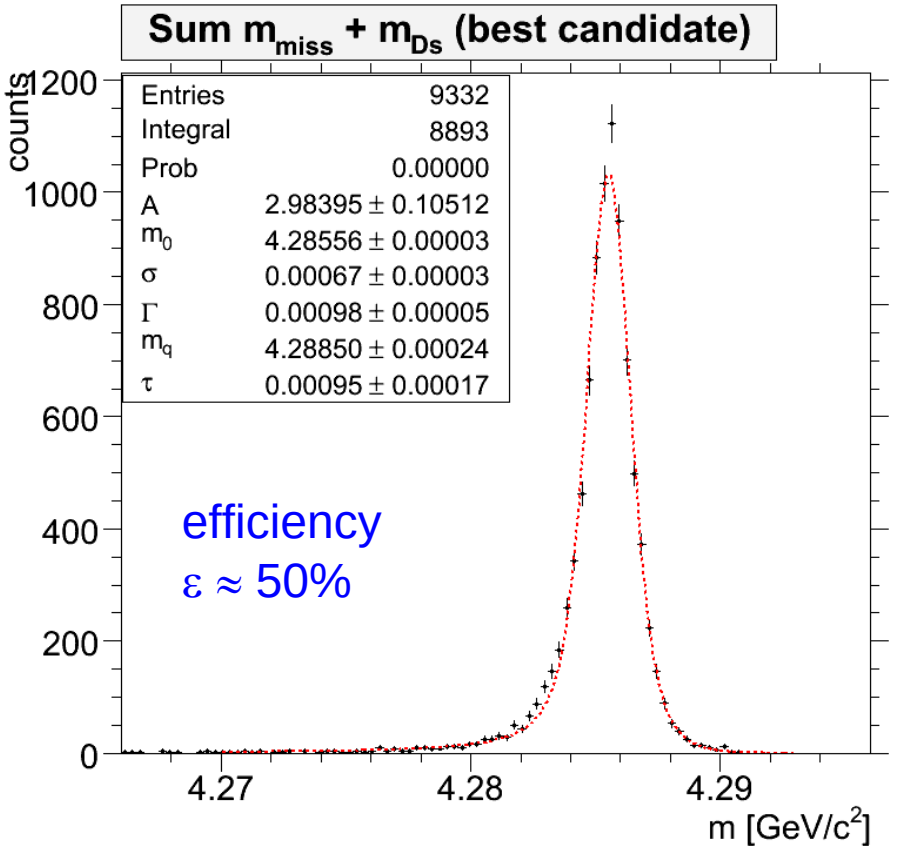
***no*** MC match



# Inclusive Signal

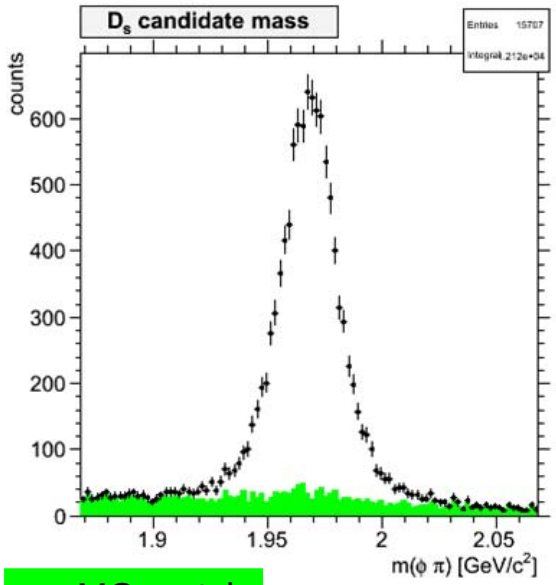


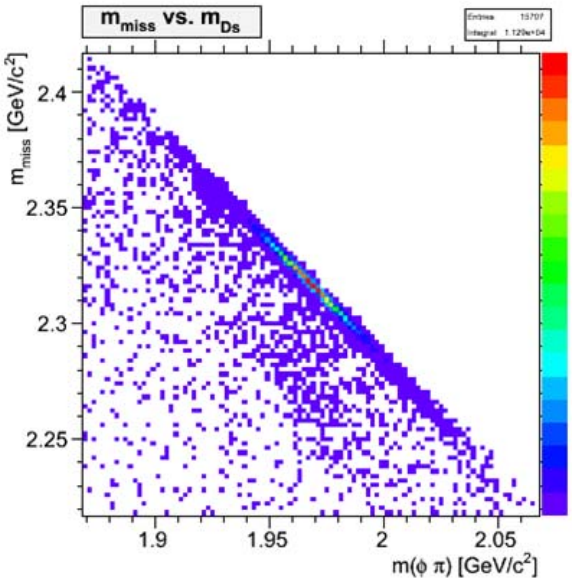



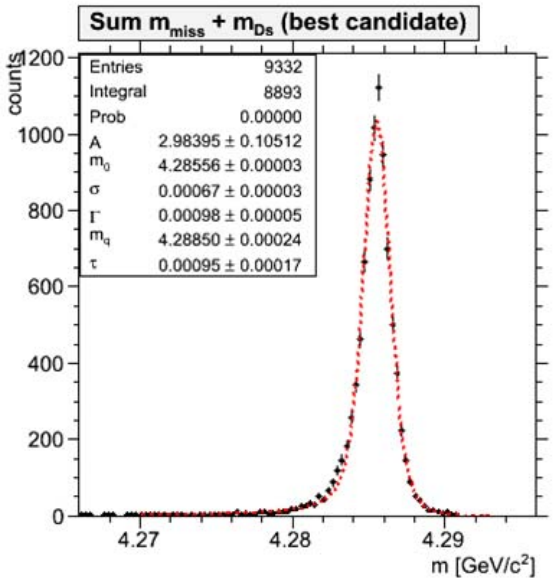

Fit model: Voigtian with naive damping

$$f(m) = A \cdot V(m; m_0, \sigma, \Gamma) \cdot \frac{1}{1 + e^{\frac{m - m_q}{\tau}}}$$

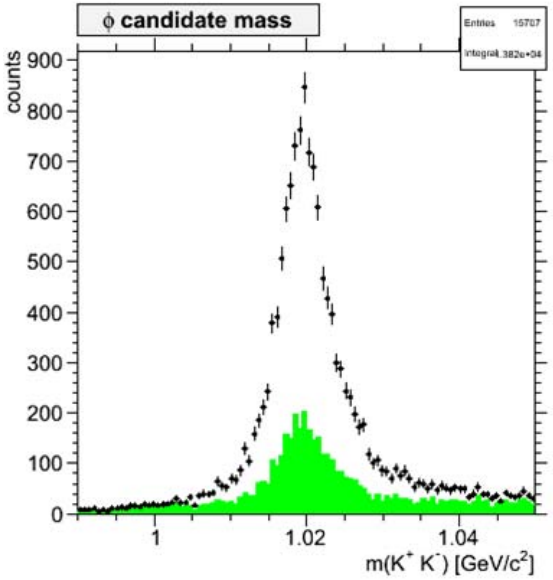
# Signal @ 4.291 GeV, Γ=0.1GeV (18k)

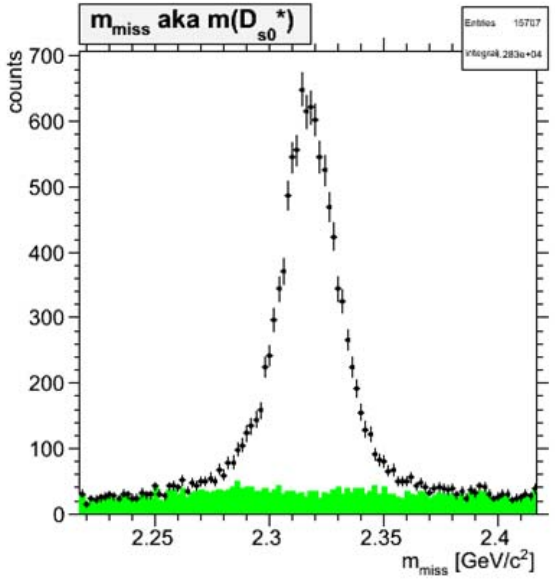


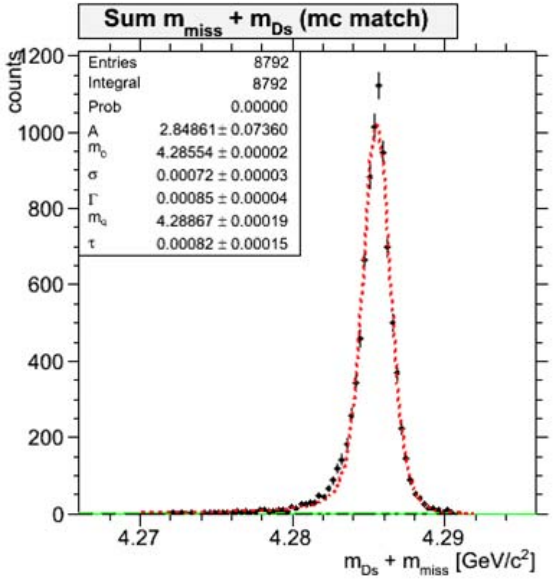



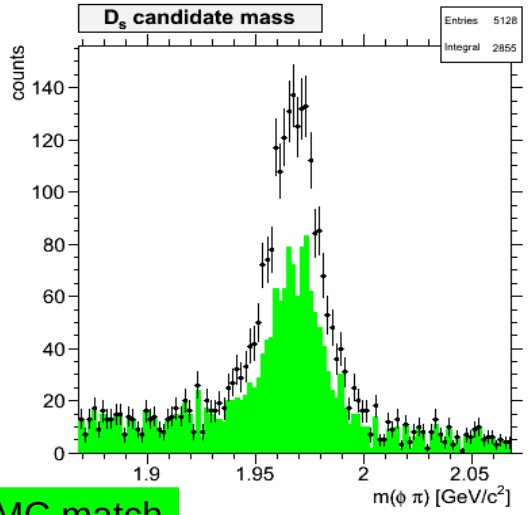

***no*** MC match

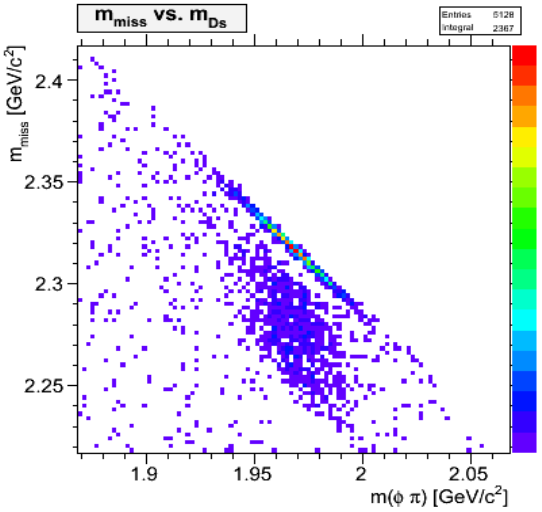


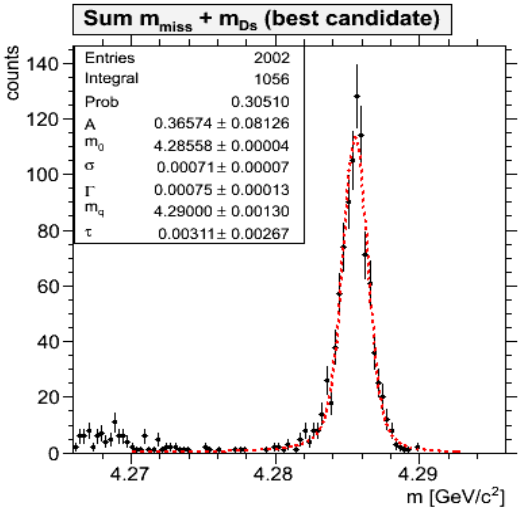



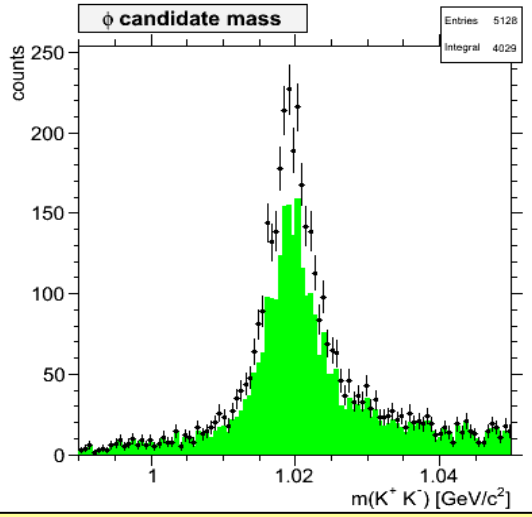
# $\bar{p}p \rightarrow D_s D_{s0}^* \rightarrow$ anything (74k)

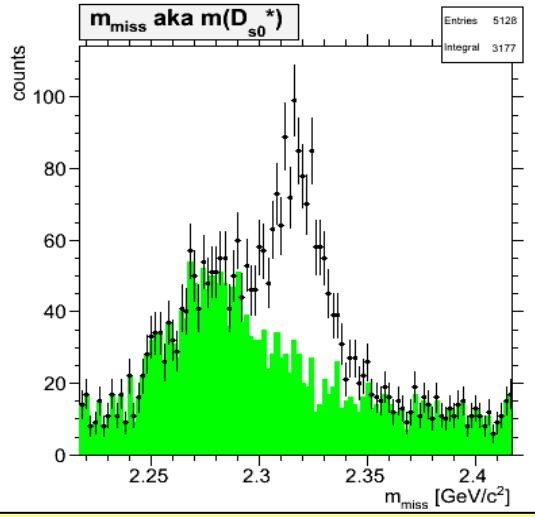


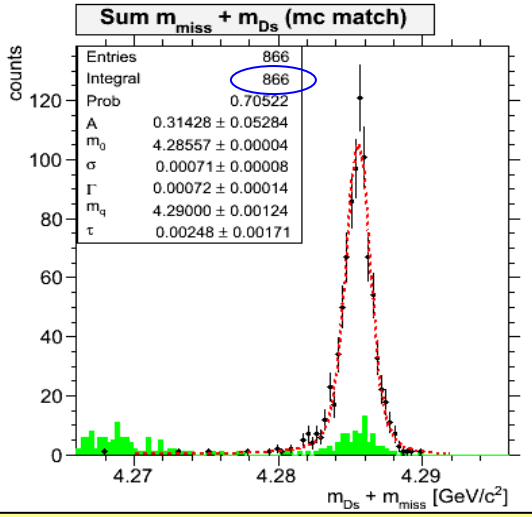




***no*** MC match



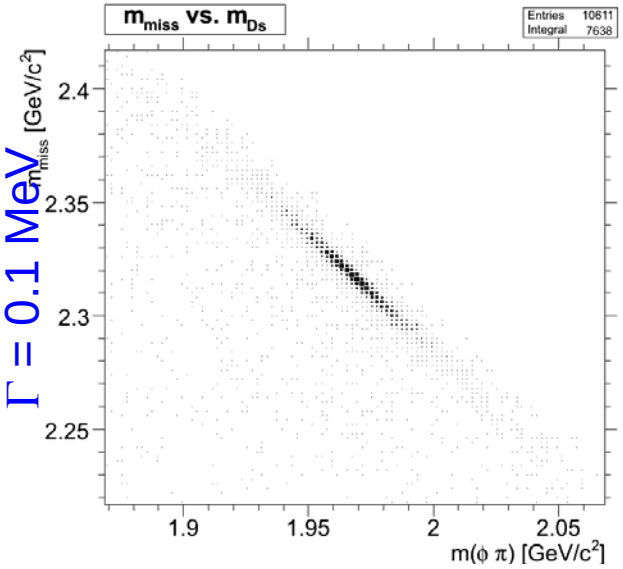

measured: S = 866

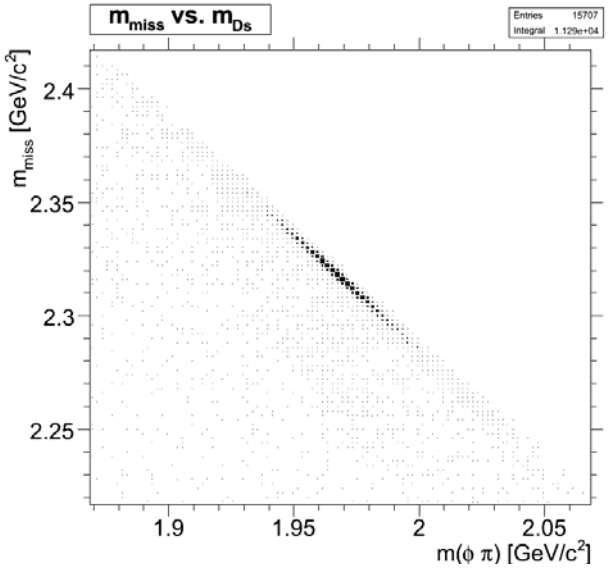
expected: $74k \cdot BR(D_s \rightarrow \phi\pi) \cdot BR(\phi \rightarrow K^+K^-) \cdot \varepsilon = 74000 \cdot 0.044 \cdot 0.492 \cdot 0.5 = 801$

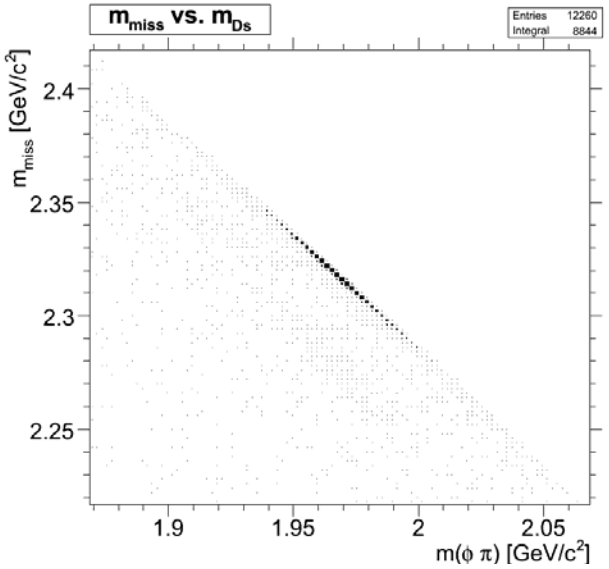
# Signals @ 4.286, 4.291, 4.306 / Γ = 0.1/2MeV

4.306 GeV | 4.291GeV | 4.286 GeV

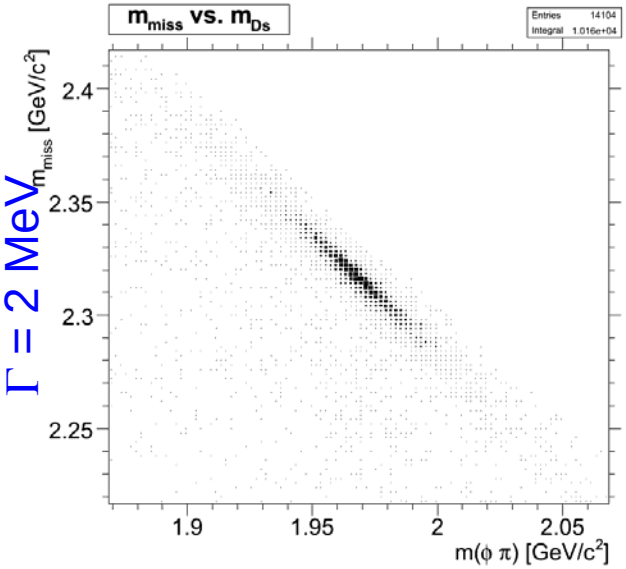
Γ = 0.1 MeV

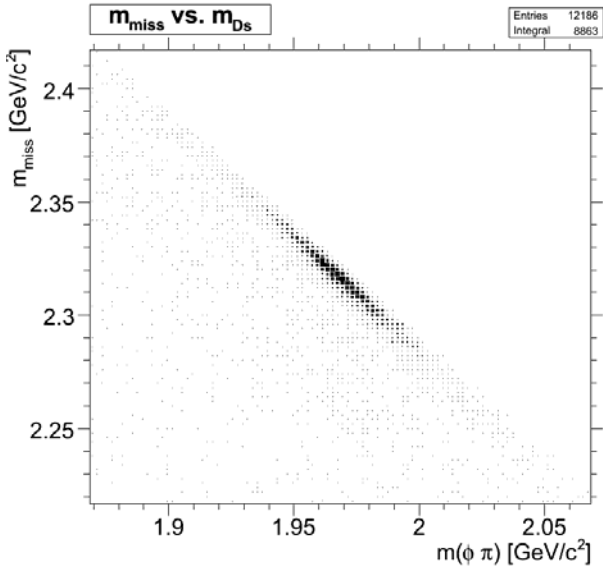


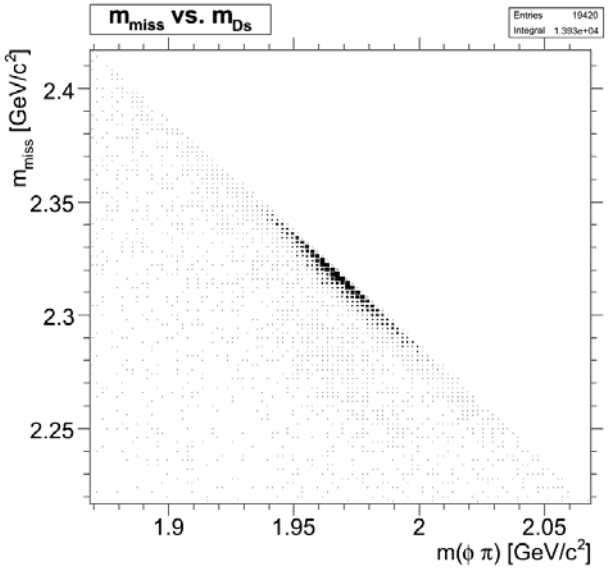




Γ = 2 MeV



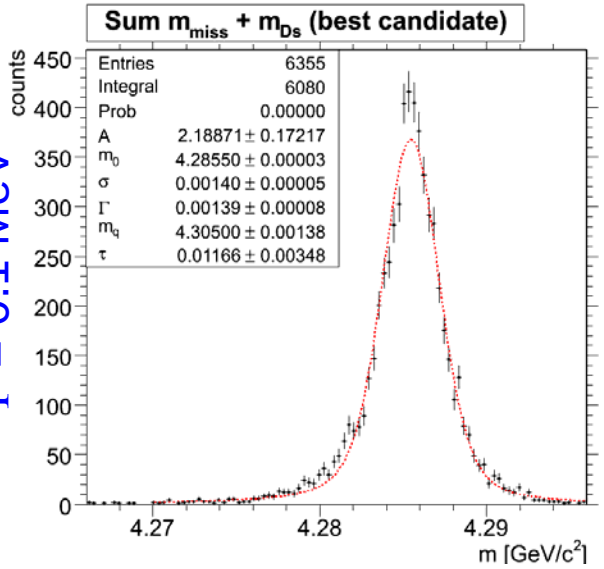



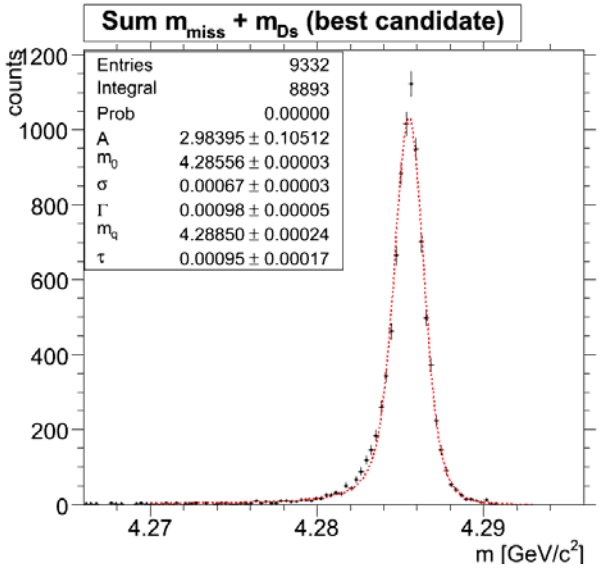



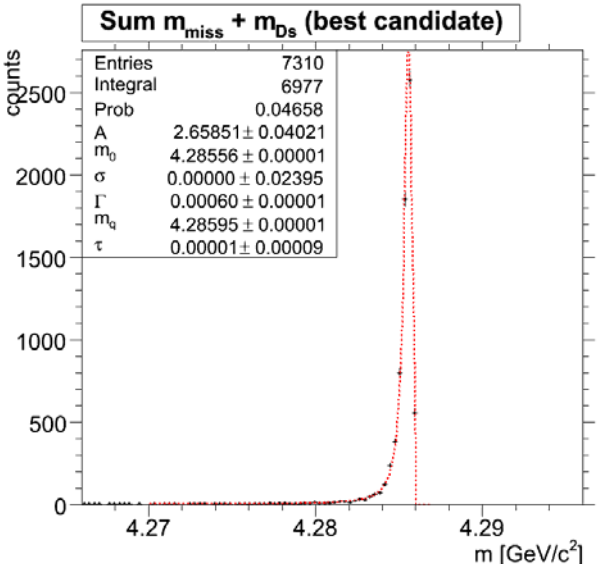
# Signals @ 4.286, 4.291, 4.306 / Γ = 0.1/2MeV

4.306 GeV | 4.291GeV | 4.286 GeV

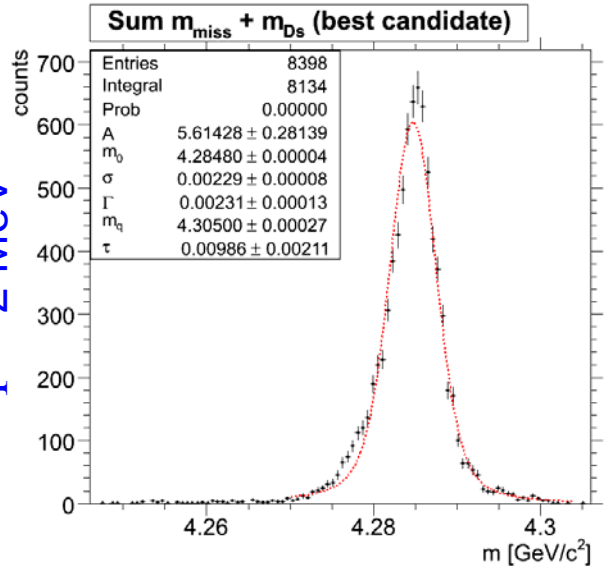
Γ = 0.1 MeV

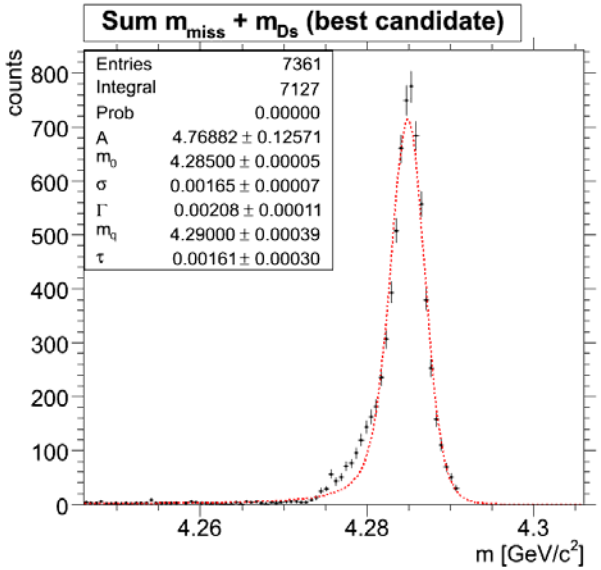


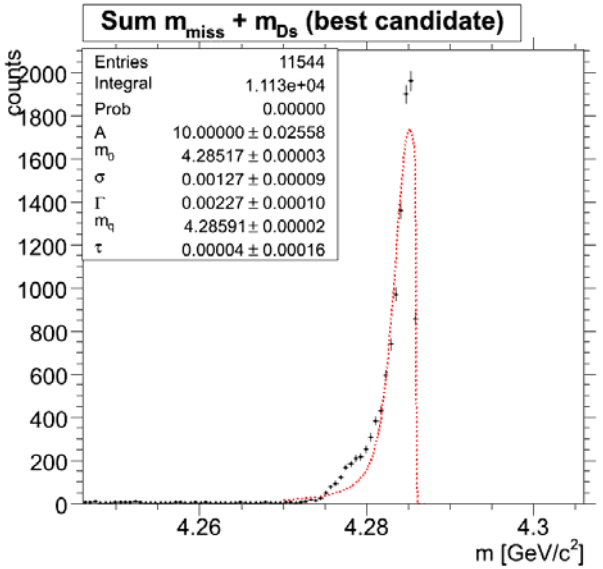




Γ = 2 MeV



# Backgrounds

- Considered 8 backgrounds (recoiling Ds $\rightarrow \phi\,\pi$)

$$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} \pi^0$$

$$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} 2\pi^0$$

$$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} \gamma$$

$$\bar{p}p \rightarrow D_s^{\pm} D_s^{\mp} \pi^+ \pi^-$$

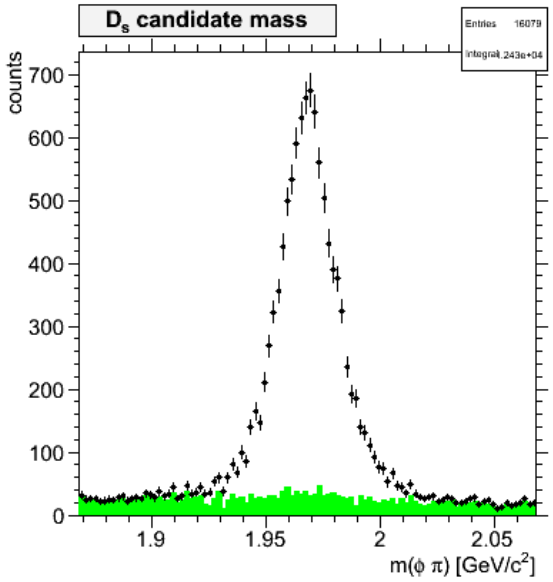
$$\bar{p}p \rightarrow D_s^{\pm} D_s^{*}(2112)^{\mp} \pi^0$$

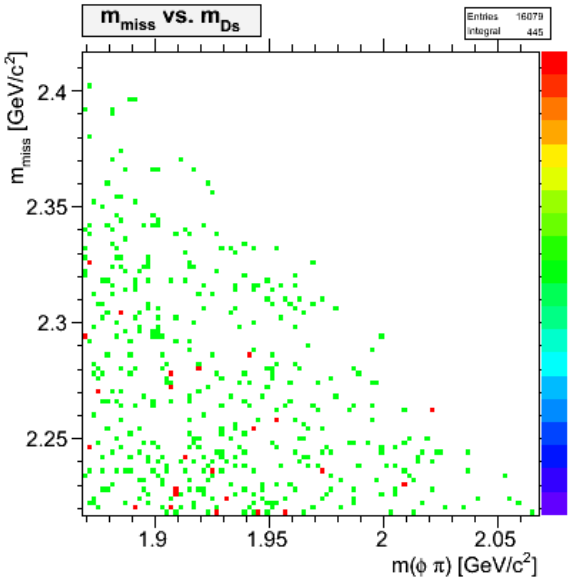
$$\bar{p}p \rightarrow D_s^{\pm} D_s^{*}(2112)^{\mp} \gamma$$

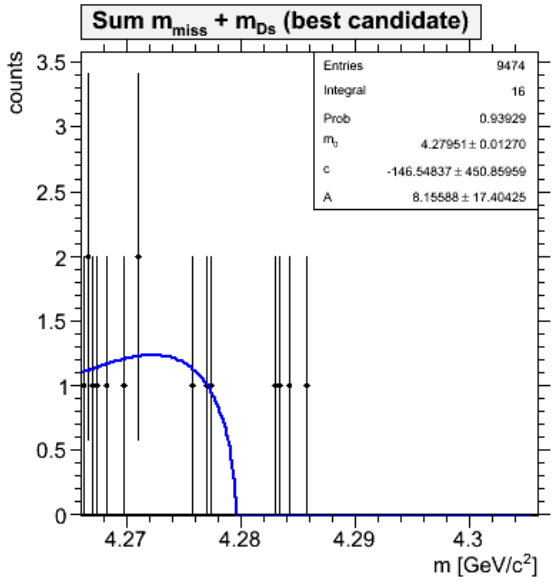
$$\bar{p}p \rightarrow D_s^{\pm} D_s^{*}(2112)^{\mp}$$

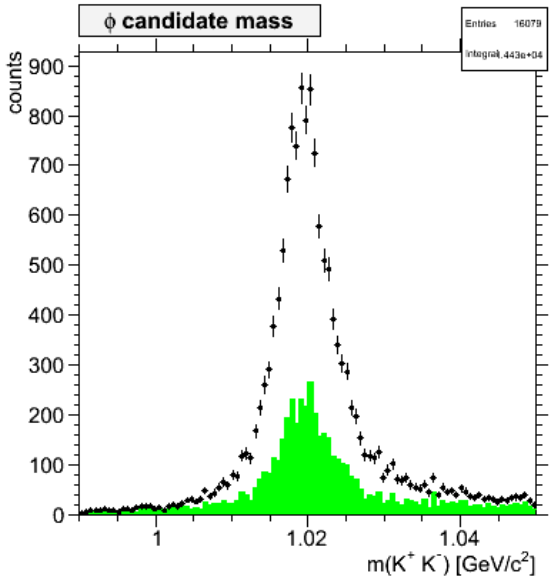
$$\bar{p}p \rightarrow \text{anything (DPM)}$$

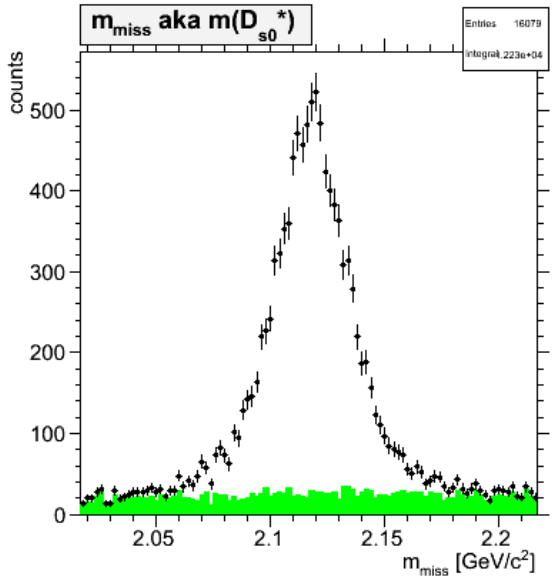
# $D_s$ $D_s(2112)^*$

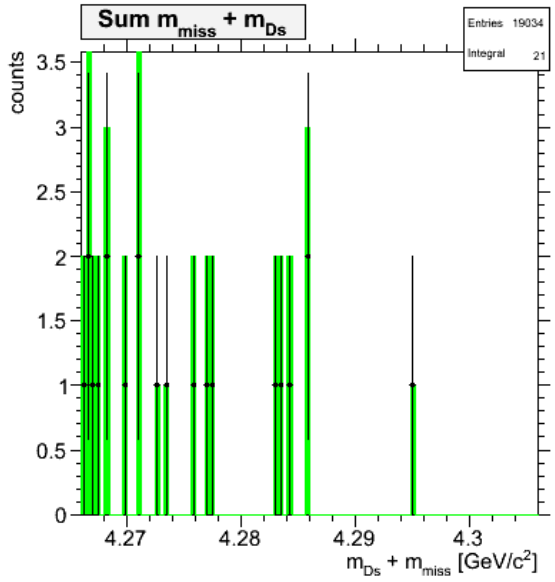

$D_s$ candidate mass
Entries 16079
counts
m(ϕ π) [GeV/c²]


$m_{miss}$ vs. $m_{Ds}$
Entries 16079
Integral 445
$m_{miss}$ [GeV/c²]
m(ϕ π) [GeV/c²]

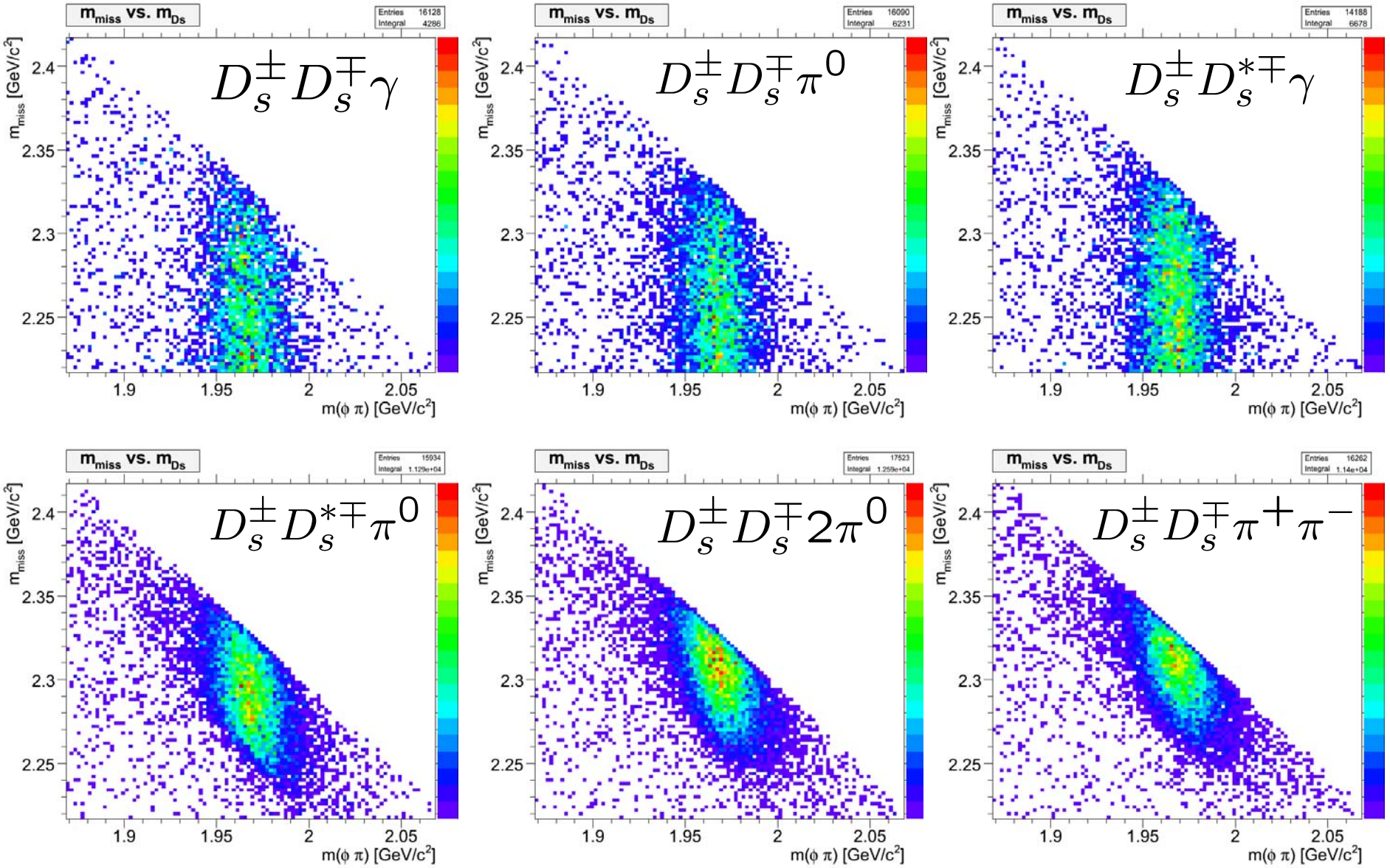

Sum $m_{miss}$ + $m_{Ds}$ (best candidate)
Entries 9474
Integral 16
Prob 0.93929
$m_0$ 4.27951 ± 0.01270
c -146.54837 ± 450.85959
A 8.15588 ± 17.40425
counts
m [GeV/c²]


ϕ candidate mass
Entries 16079
counts
m(K⁺ K⁻) [GeV/c²]

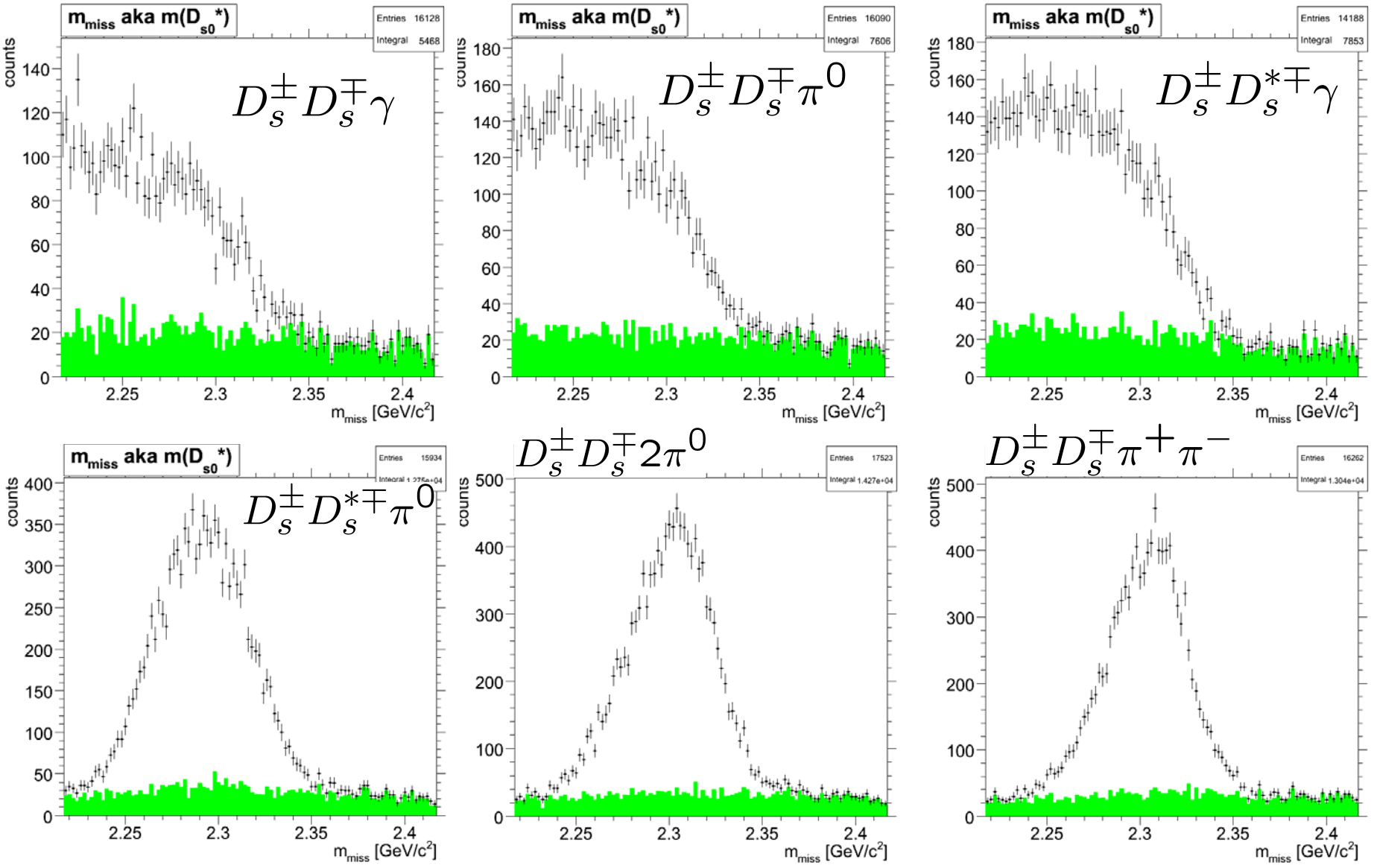

$m_{miss}$ aka m($D_{s0}$*)
Entries 16079
counts
$m_{miss}$ [GeV/c²]


Sum $m_{miss}$ + $m_{Ds}$
Entries 19034
Integral 21
counts
$m_{Ds}$ + $m_{miss}$ [GeV/c²]

# Backgrounds @ 4.291 GeV

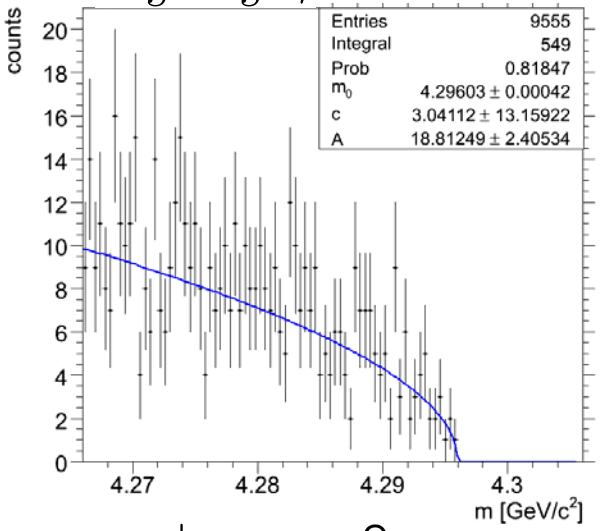


# Backgrounds @ 4.291 GeV

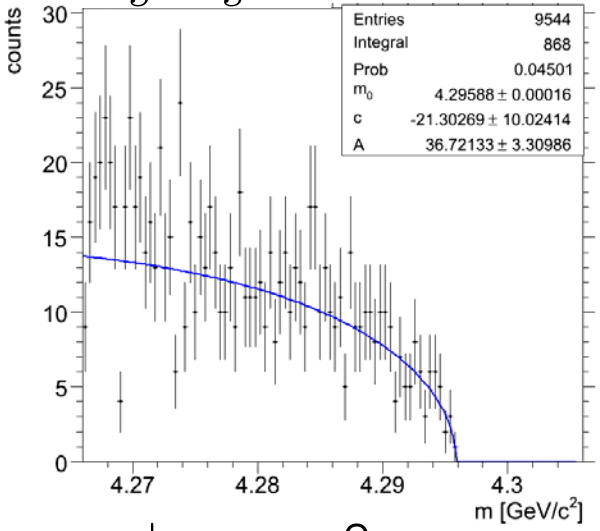


# Backgrounds @ 4.291 GeV

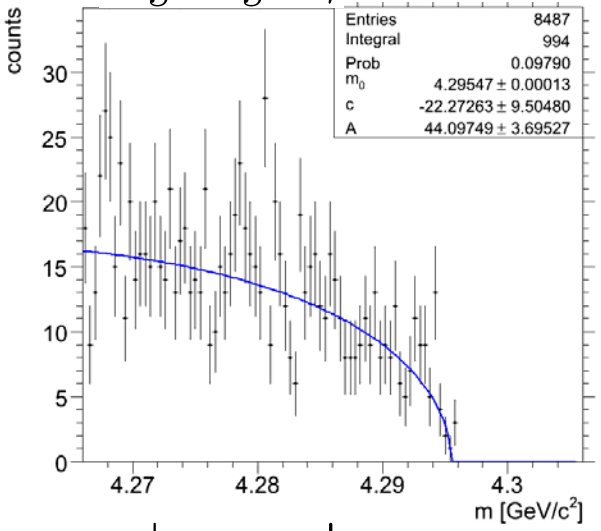
$D_s^{\pm} D_s^{\mp} \gamma$



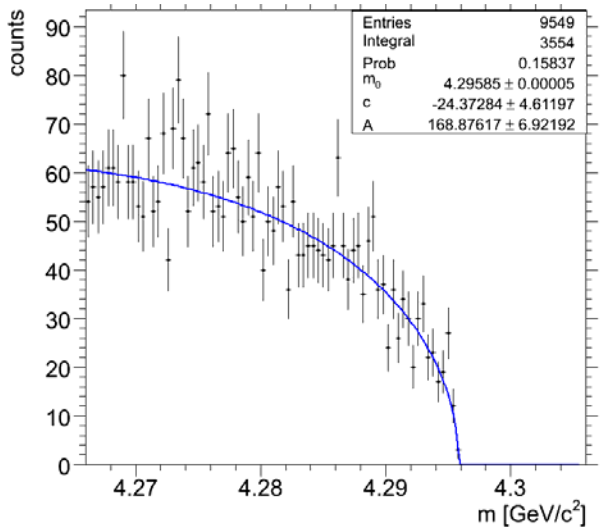

$D_s^{\pm} D_s^{\mp} \pi^0$



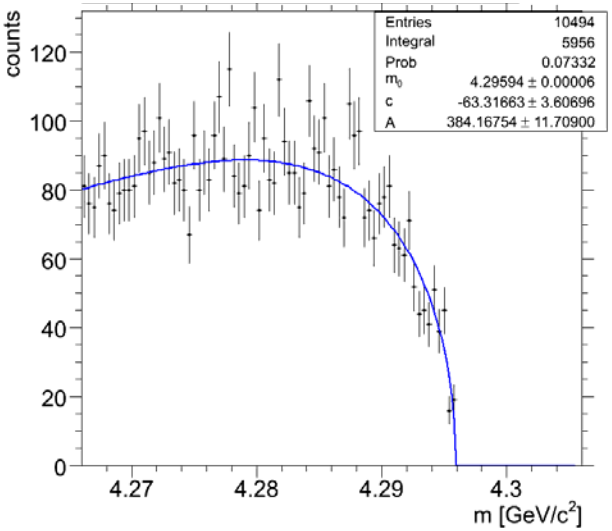

$D_s^{\pm} D_s^{*\mp} \gamma$



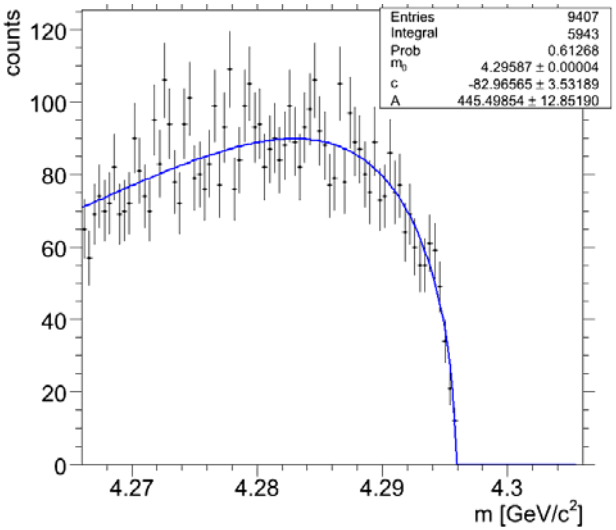

$D_s^{\pm} D_s^{*\mp} \pi^0$




$D_s^{\pm} D_s^{\mp} 2\pi^0$




$D_s^{\pm} D_s^{\mp} \pi^+ \pi^-$

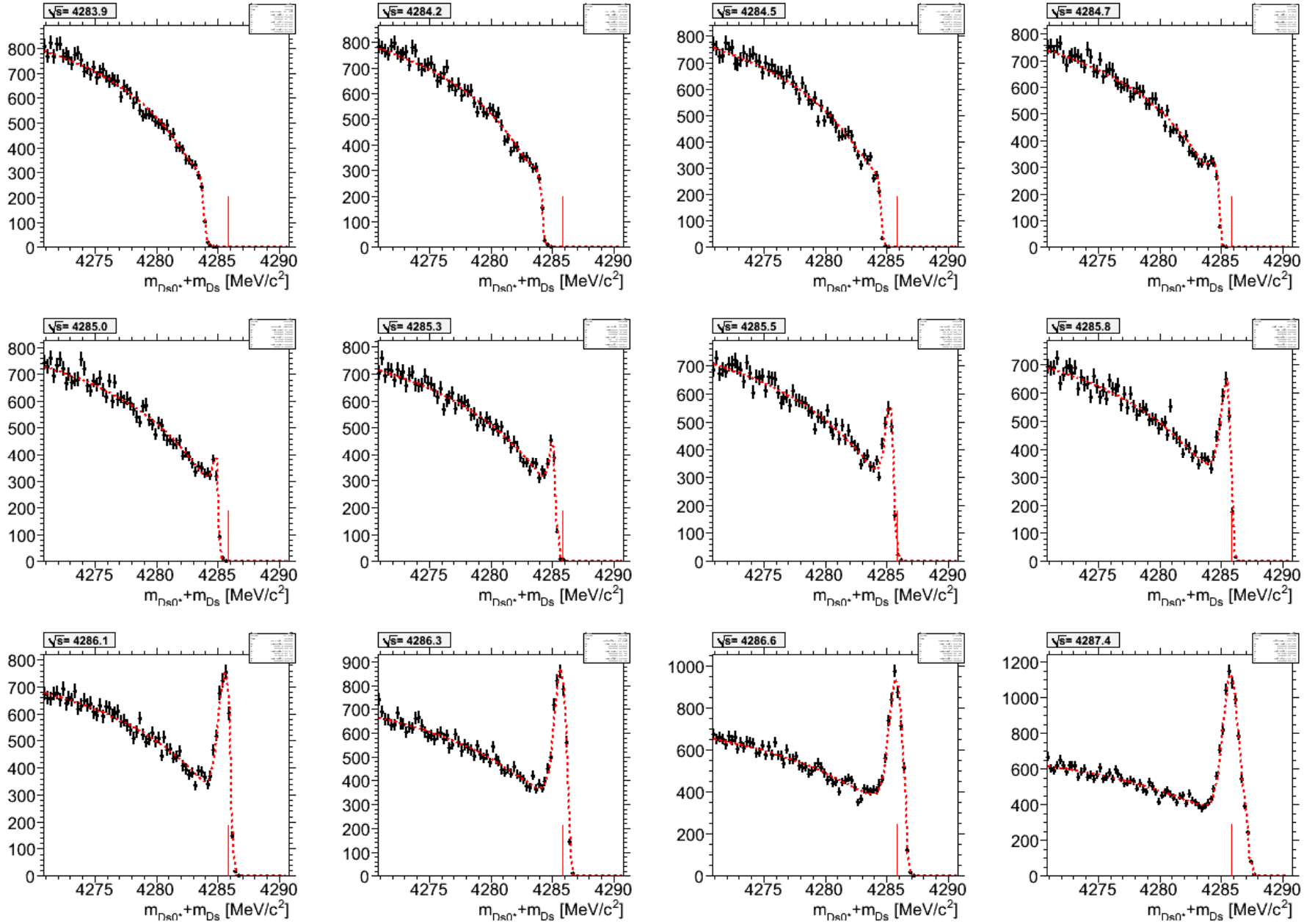



$$f_{BG} = A \cdot \sqrt{1 - m^2/m_0^2} \cdot \exp\left[c \cdot (1 - m^2/m_0^2)\right]$$

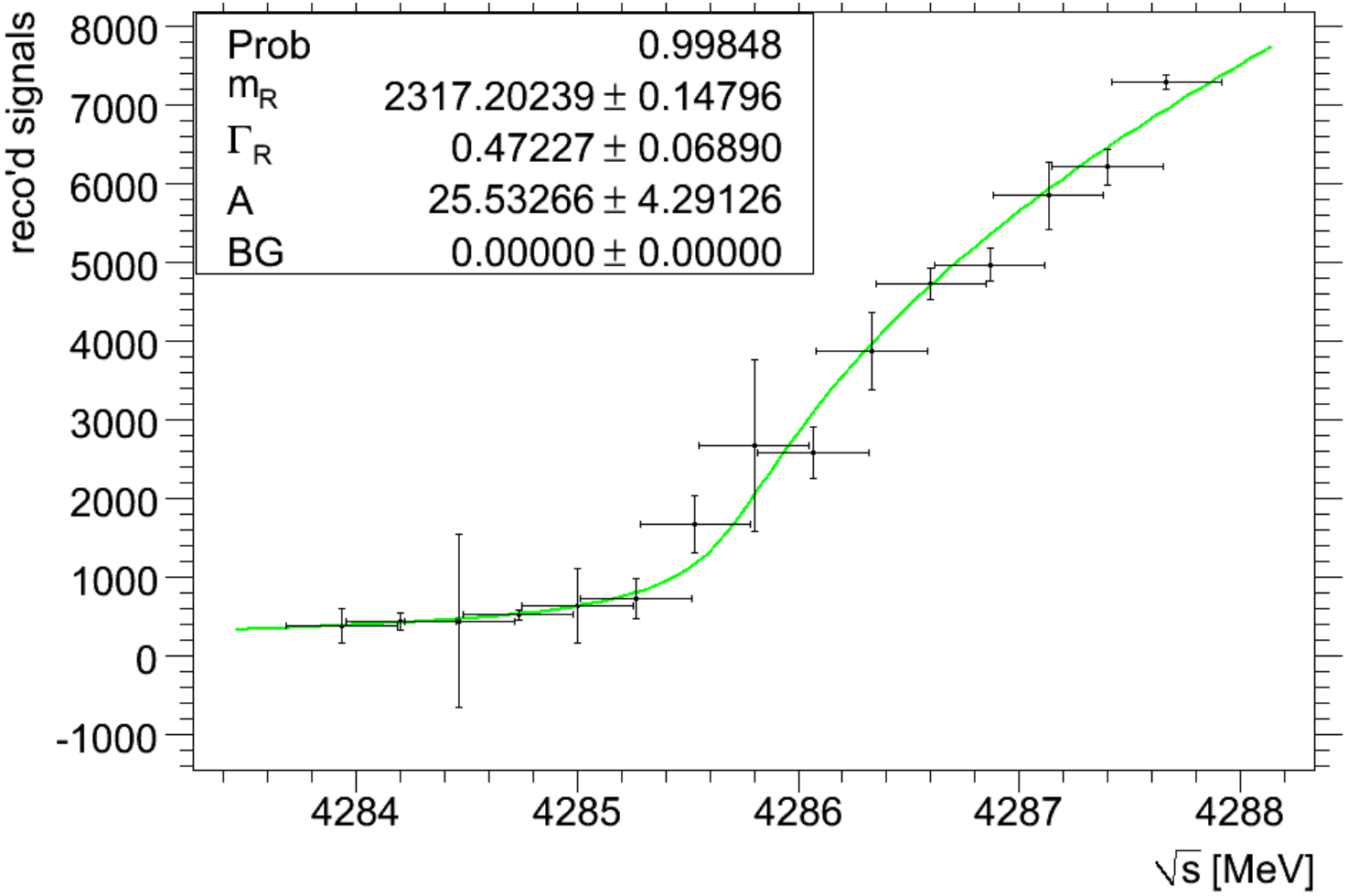
# Scan procedure

- Consider the following scenario:
- Data taking at n energies around threshold
- Reconstruct inclusive spectra as introduced
- Determine number of signals S in the peak $m_{miss}+m_{Ds}$
  - Voigtian with damping for signal
  - Argus function as background
- Fill S into a graph for all scanpoints
- Fit excitation function to this distribution
  $\rightarrow$ extract $\Gamma$, mass
- Parameters to vary
  - total number of signals
  - Width $\Gamma$
  - Signal to noise ratio S/B
  - (scanpoints – number & positions)

# Scan


√s= 4283.9
√s= 4284.2
√s= 4284.5
√s= 4284.7
√s= 4285.0
√s= 4285.3
√s= 4285.5
√s= 4285.8
√s= 4286.1
√s= 4286.3
√s= 4286.6
√s= 4287.4
m_Dsπ+m_Ds [MeV/c²]

# Fit to excitation function



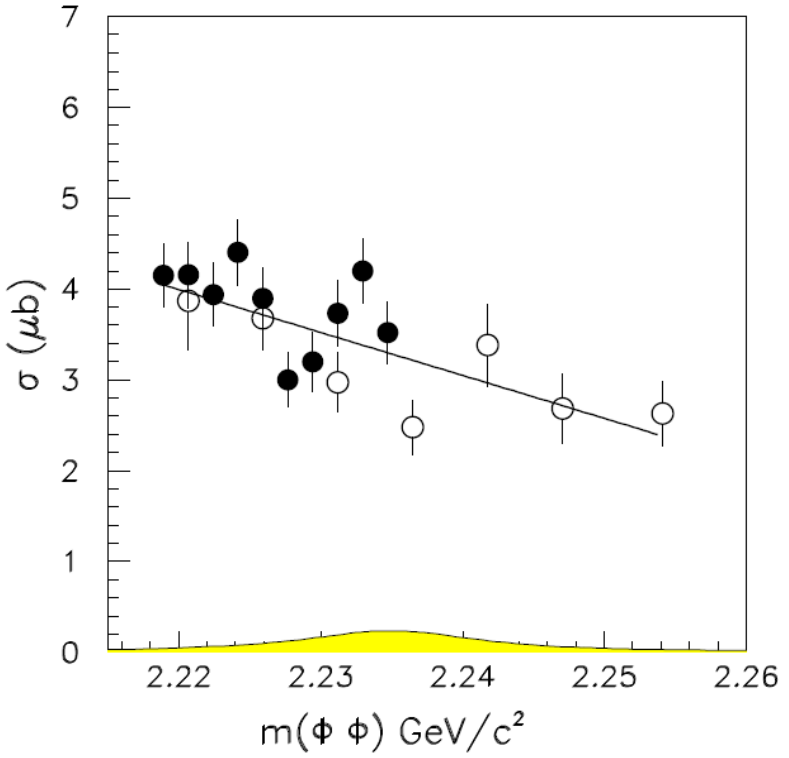

$\Rightarrow \Gamma$ **= 0.47** with significance 0.47/0.07 = **6.7** $\sigma$

(ok, models are not perfect ... signal was created with $\Gamma$=1 MeV...)

$\bar{p}p \rightarrow \phi\phi$

# Measurement

- Find glueballs, e.g. $\xi(2230)$
- Method for real data
  - Energy scan around glueball relevant energies
  - Determine number of reactions of signal type for each step
    $\rightarrow$ signal cross section energy dependent
  - PWA to disentangle non resonant $\phi\phi$
- Method for MC
  - PWA not possible!
  - analysis at some points above threshold to determine efficiency & background suppression
  - check whether efficiency is independent of decay angles involved to ensure PWA is possible



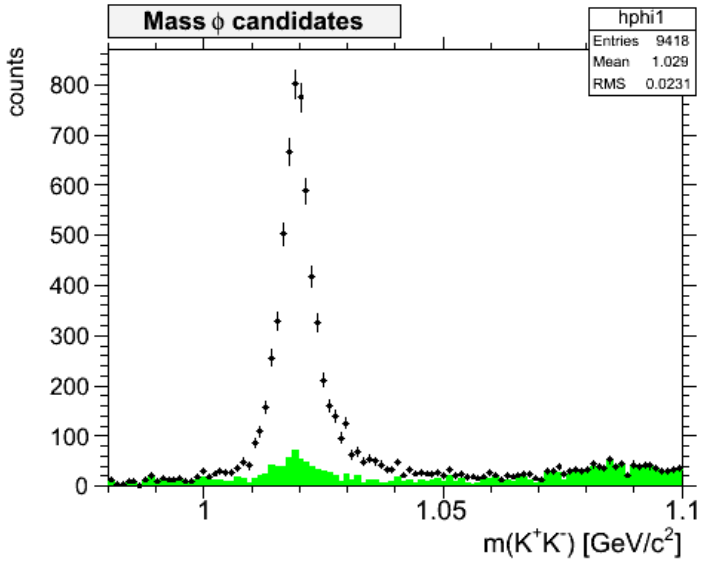
# Reconstruction $\phi\phi$

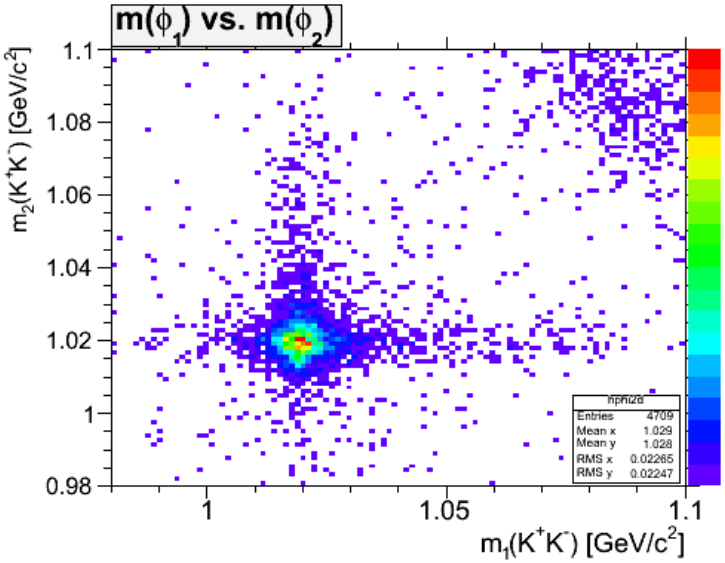
- Decay tree

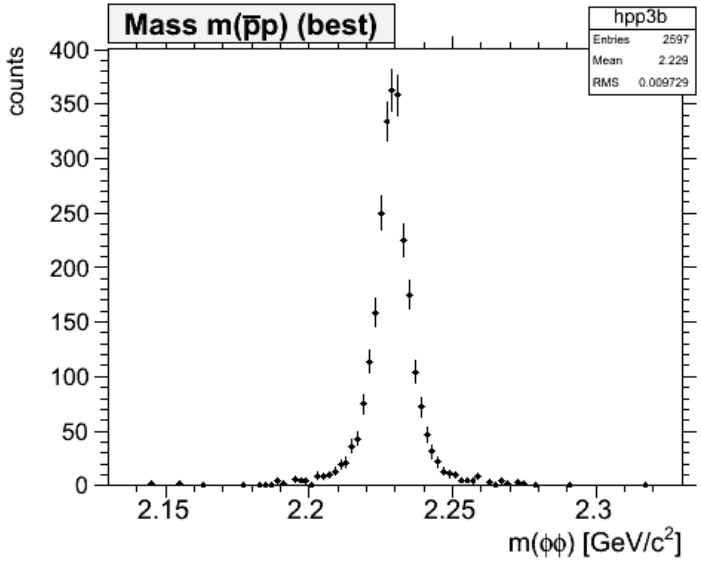
$$\bar{p}p \longrightarrow \phi\phi$$
$$\phi \hookrightarrow K^+K^-$$
$$\phi \hookrightarrow K^+K^-$$

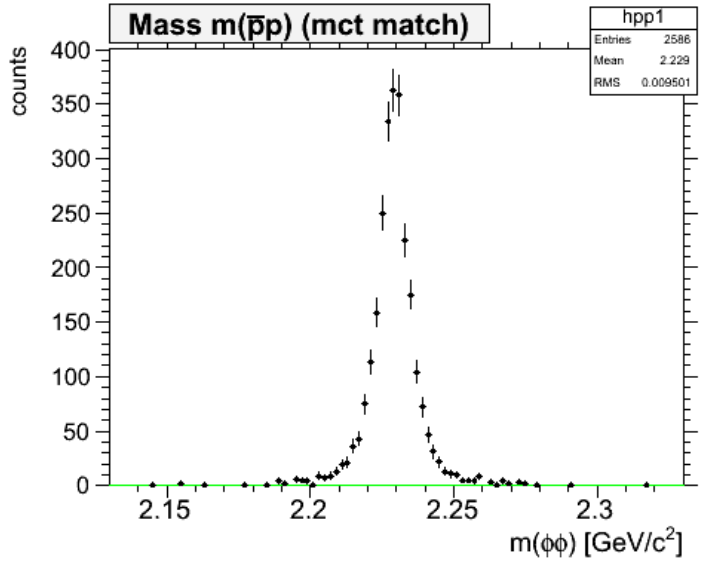
- Final state: 4 charged kaons
- Exclusive reconstruction
- Data
  - Signal @ 2.230, 2.330, 2.430 GeV
  - DPM events
  - Background channels: $\bar{p}p \rightarrow \phi\rho$, $4K^{\pm}$, $2K^{\pm}2\pi^{\pm}$, $4\pi^{\pm}$
- Selection
  - veryLooseKaon PID for all 4 kaons
  - vertex fit for the $\phi$'s, $\bar{p}p$ system
  - $|m(K^+K^-) - 1019.5| < 20$ [MeV/$c^2$]

# Exclusive Signal (7k evt)



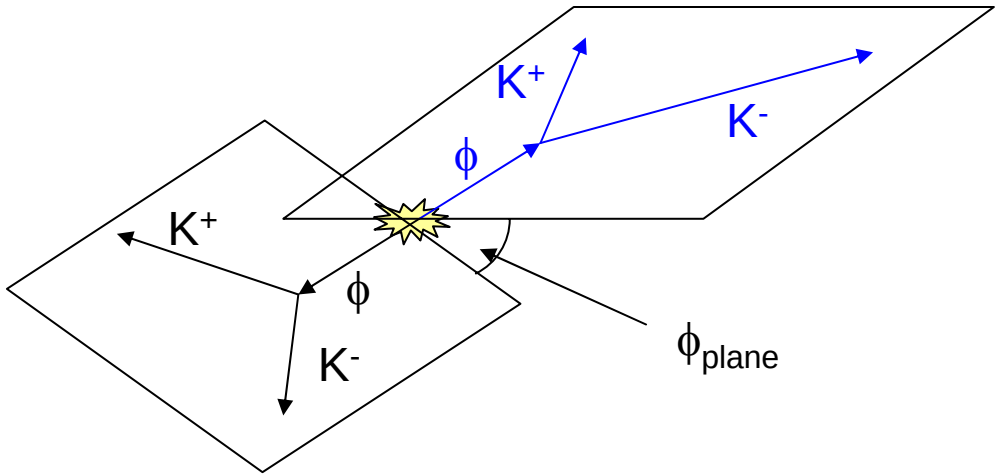



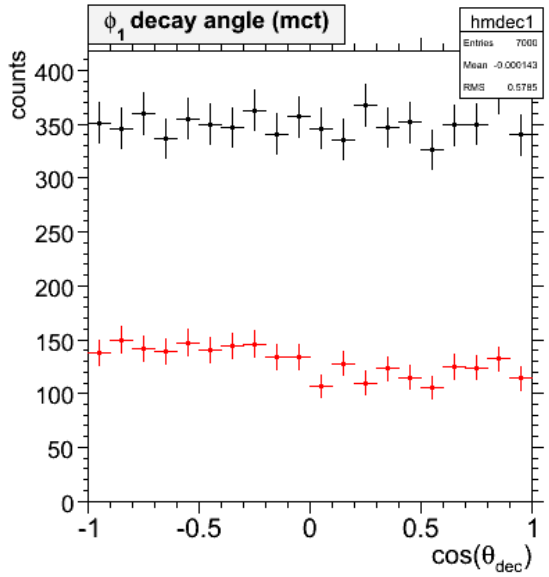
# Angular efficiency dependence

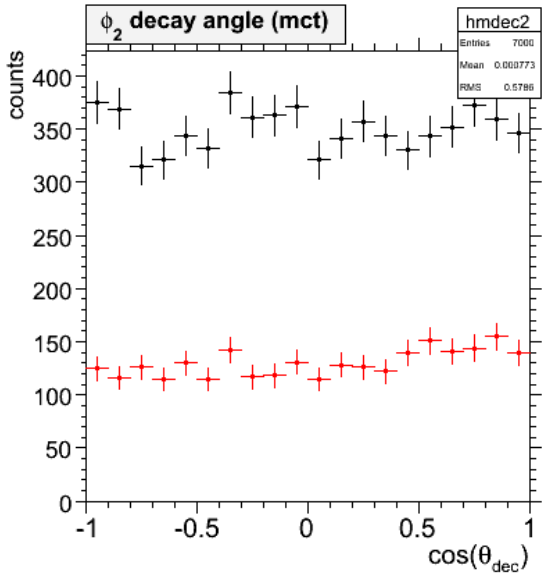
- In order to properly do PWA
- Efficiency should have ‚good' angular behaviour

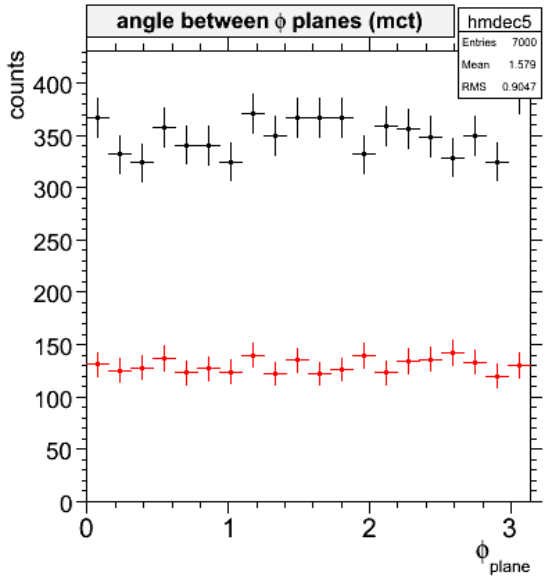
- Three angles are involved
  - decay angle $\theta_{dec}$ of the 2 $\phi$
  - angle between decay planes of the $\phi$ s

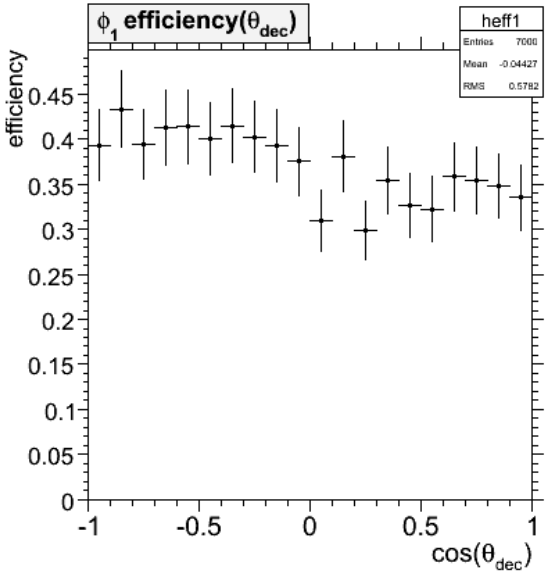


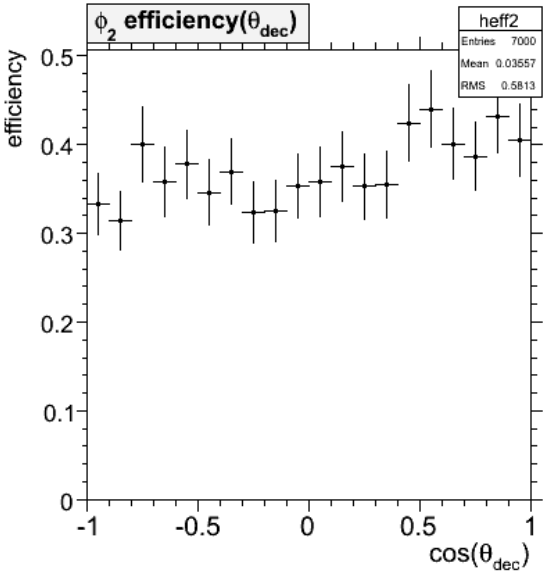
# Angular efficiency dependence

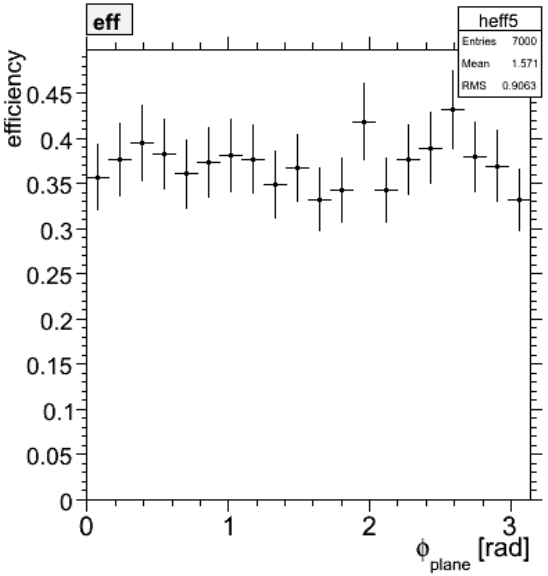


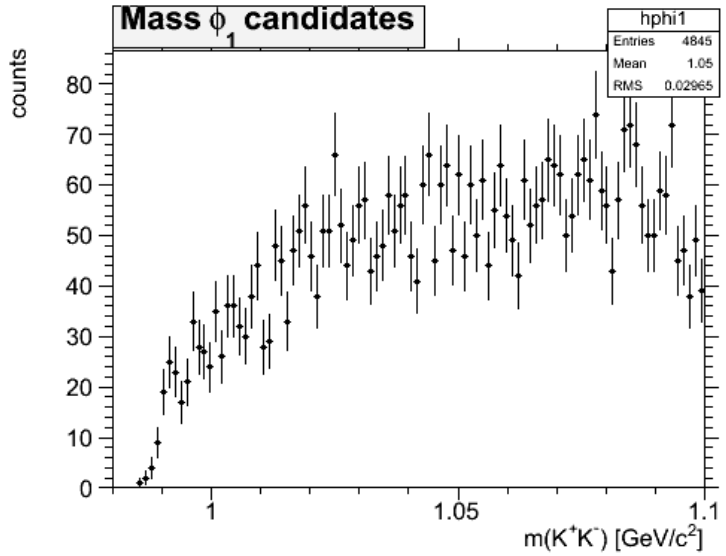



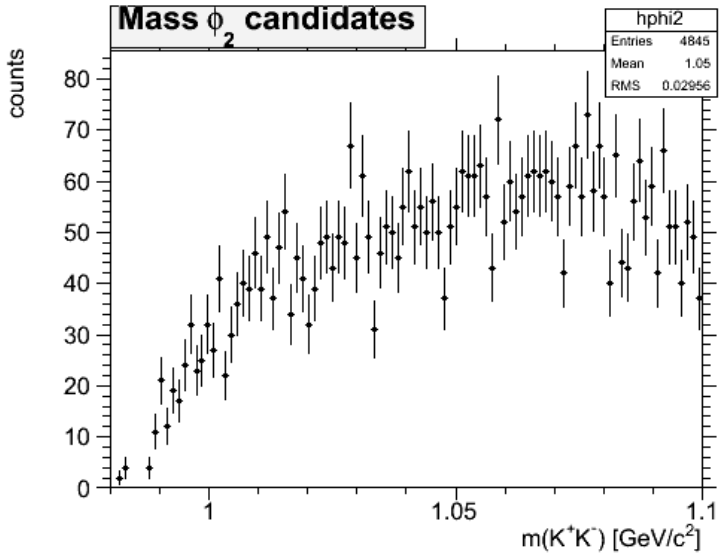



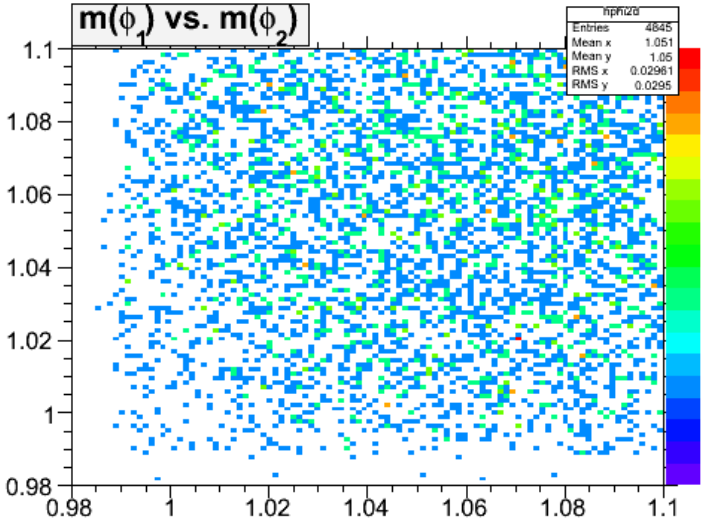



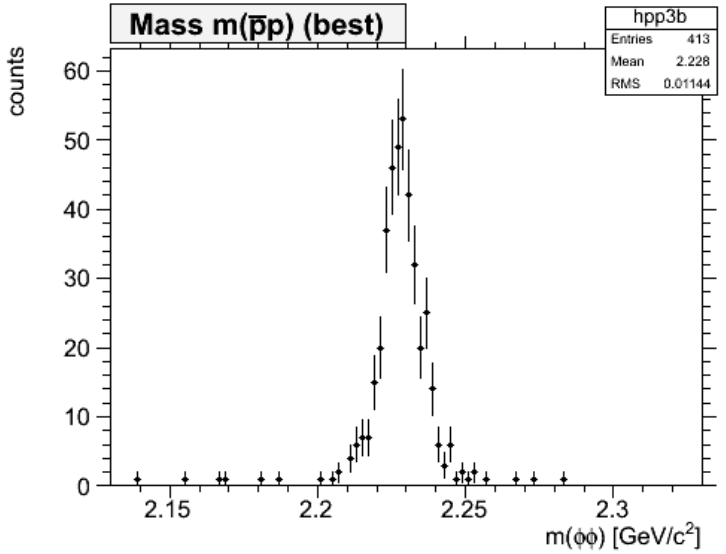



# Background $\bar{p}p \rightarrow 4K^{\pm}$



# Summary/Conclusion

- Inclusive reconstruction of $D_s$ $D_{s0}$*(2317)
  - Reasonable method to extract signal
  - High efficiency (50%), good resolution close to threshold
- Considered some backgrounds
  - Problems might come from those with low phasespace
- Scan scenario with more realistic signal/bkg shapes
  - Very sensitive to line shapes/correct models

- Exclusive reconstruction of $\phi\phi$
  - Efficiency around 40%
  - seems more or less independent of various angles
- Backgrounds
  - modes with 4K in final state might be a problem
  - cannot be removed even with 4C fit