Status of Analyses
$p\bar{p} \rightarrow D_s D_{s0}^*(2317)$
(and $p\bar{p} \rightarrow \phi\phi$)

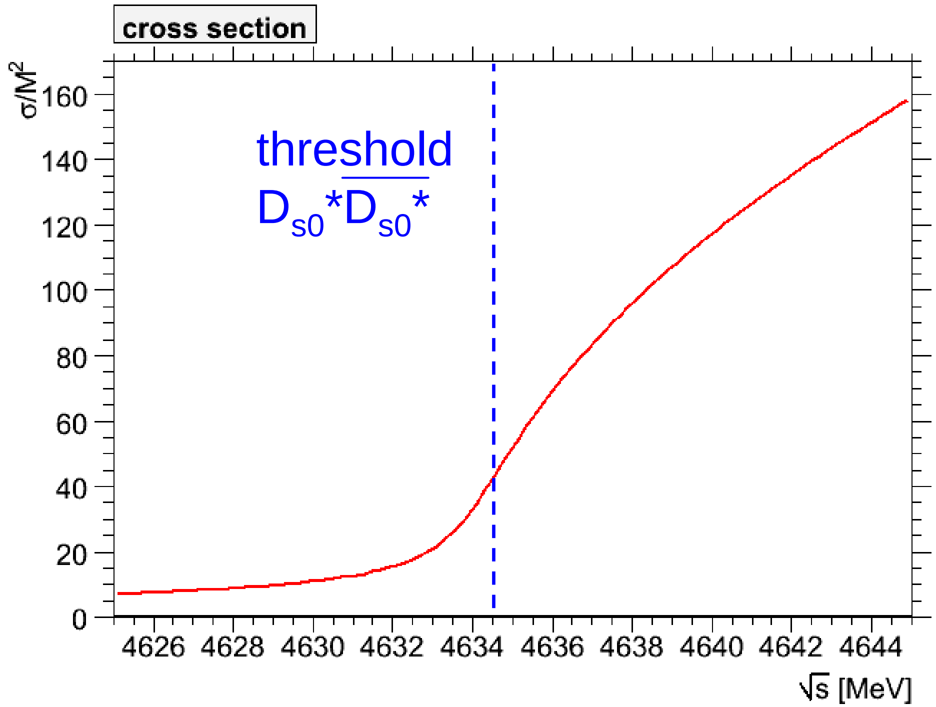
Klaus Götzen
Diana Schumacher
GSI Darmstadt

PANDA Collaboration Meeting
July 2007, Dubna

Overview

- Goal of Measurement
- Reconstruction/Selection of Signal
- Determination of Sensitivity

- Determine width Γ of D_{s0}*(2317)
- Method
  - Energy scan around threshold,
    e.g. 20 steps from -10 MeV to +10 MeV below/above threshold
  - Determine number of reactions of signal type for each step
  - $\rightarrow$ signal cross section energy dependend (excitation function)
  - Shape of excitation function tells you about width



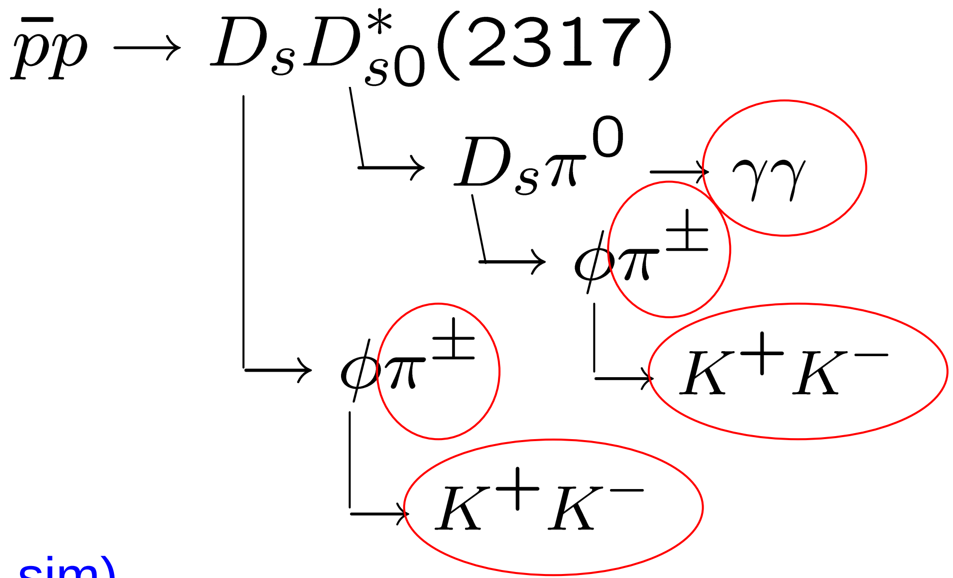
Statement from Simulation

- Problems:
  - we don‘t know the signal cross section
  - we don‘t know background cross section/channels
  - of course, we don‘t know width Γ

- Therefore, statement of this Monte Carlo study will be something like:

  „For a given beam resolution $\delta p/p$ and Γ, we need N signal events with a signal-to-noise ratio X to measure Γ with a significance of 3σ.“

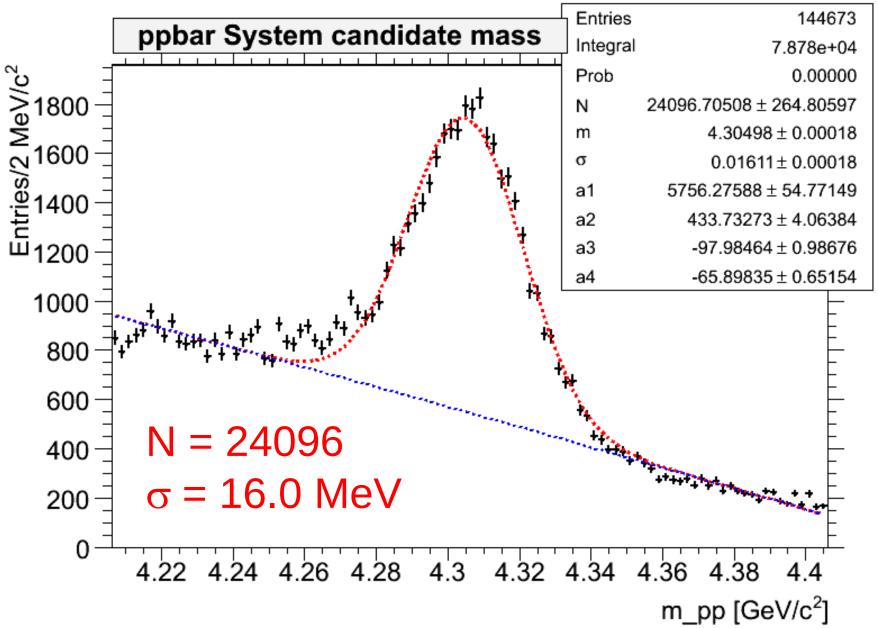
- Decay Tree

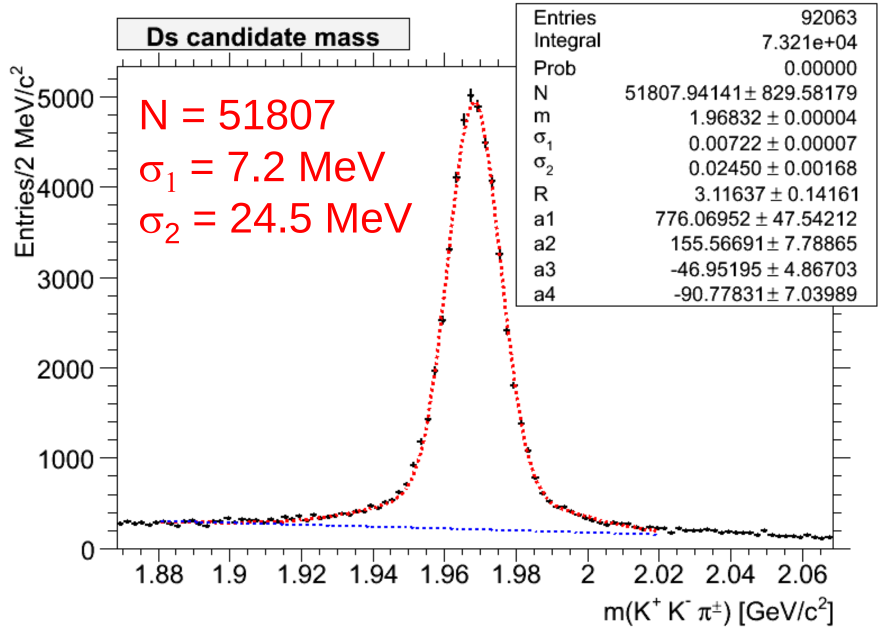


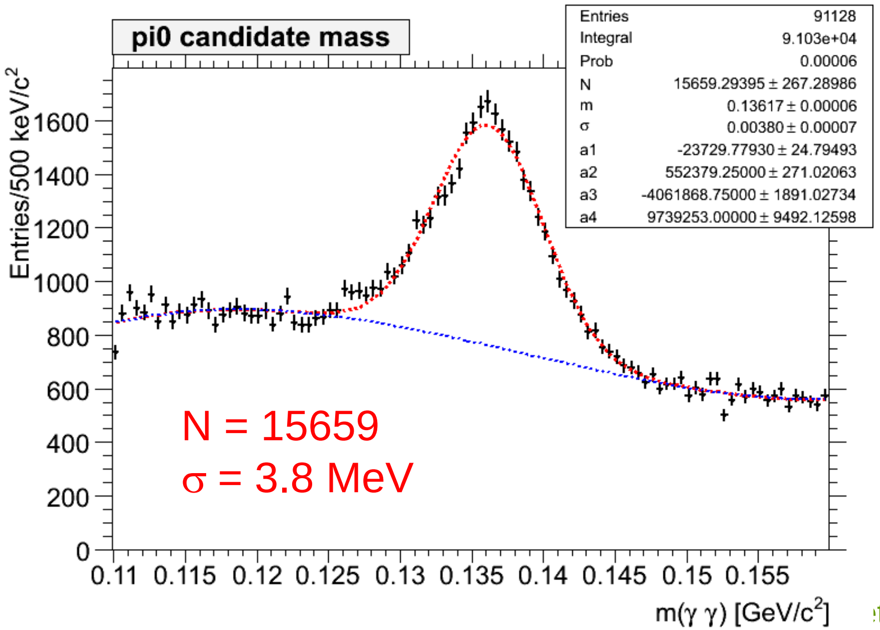
- 8 final state particles
- exclusive reconstruction

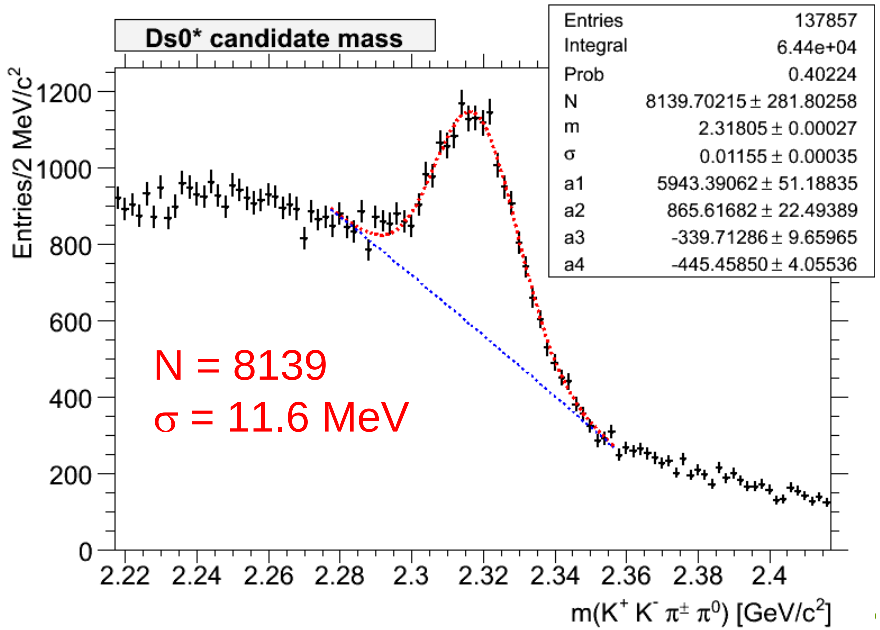
- Data
  - 90k signal events (full sim)
  - 40k signal events (fast sim)
  - 3-4M DPM events (fast sim)
  - 40k non-resonant $D_sD_s\pi^0$ (fast sim)
- Selection with low bias
  - very loose PID (kaons/pions)
  - very loose mass windows

Invariant masses





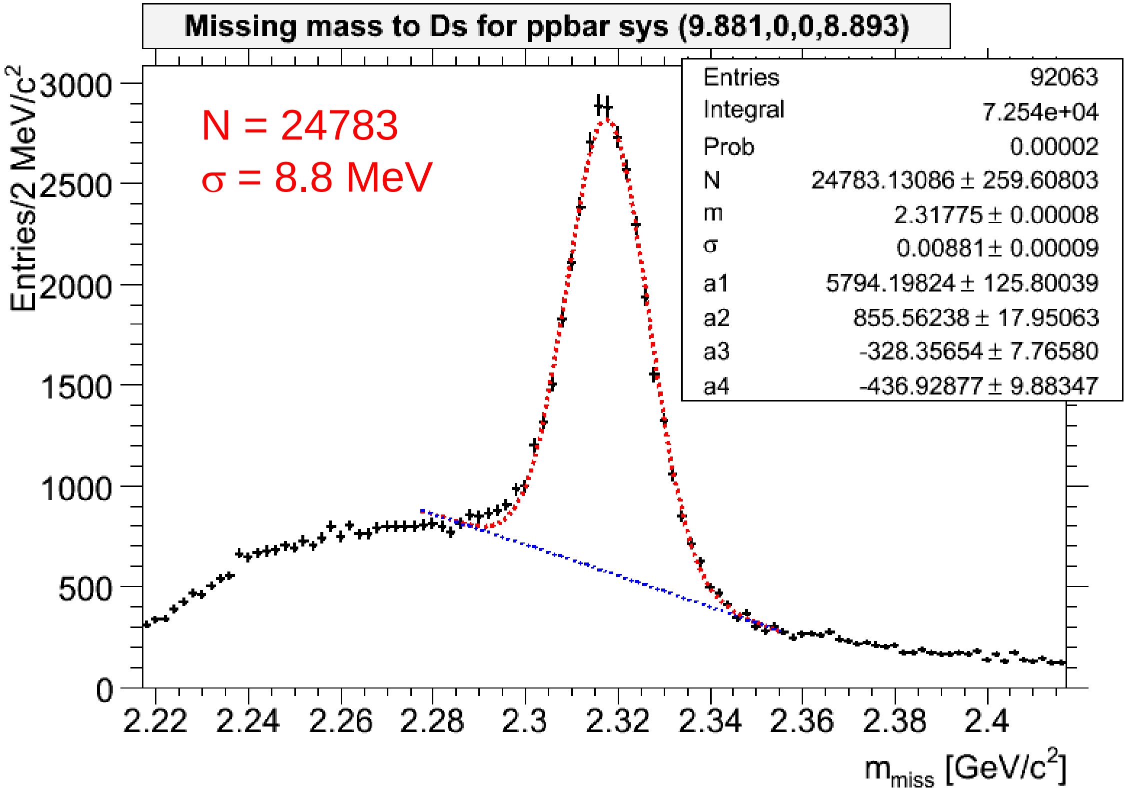




Missing mass to D_s

- Instead of full reconstruction of D_{s0}*, consider the missing mass

$$m_{miss} = \left| \vec{p}_{beam} - \vec{p}_{D_s} \right|$$

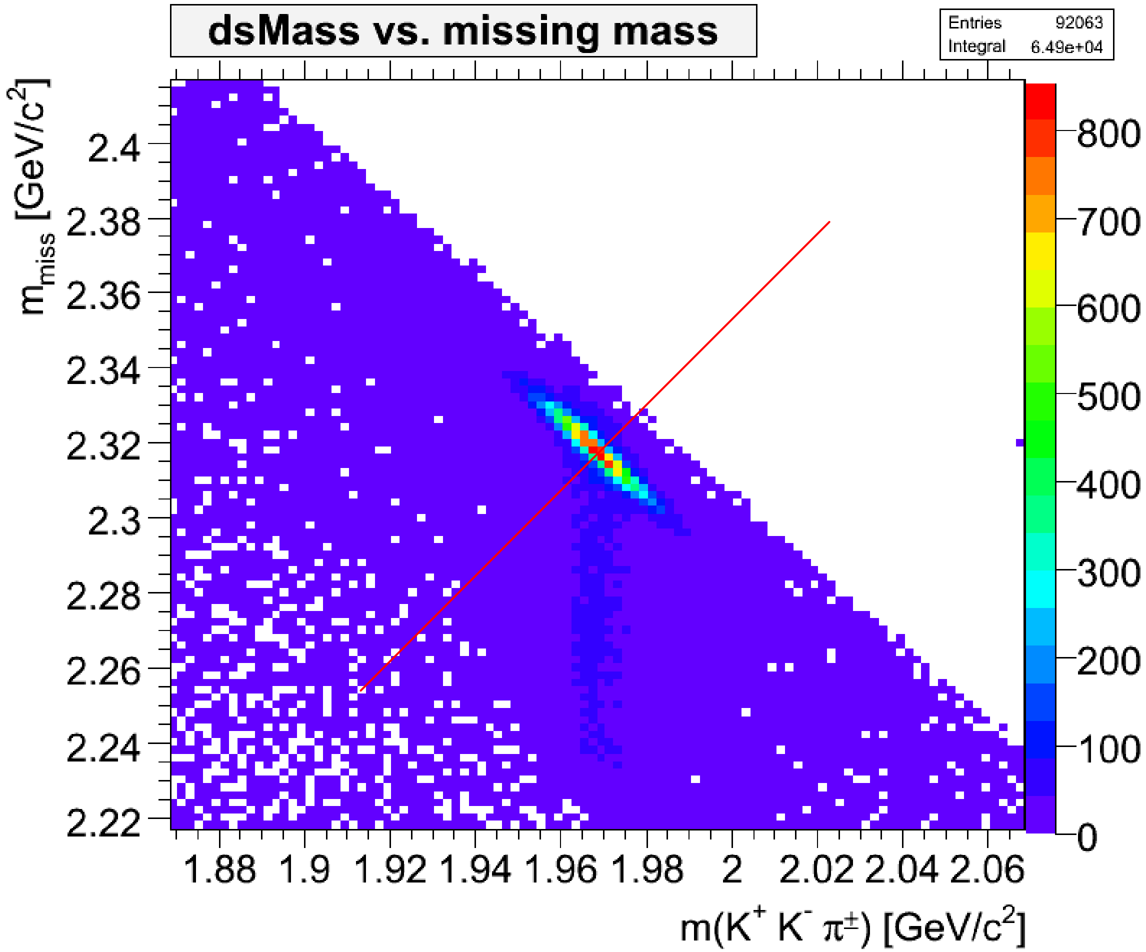


Resolution improves from

11.6 MeV → 8.8 MeV

Missing mass vs m_{Ds}

- Masses are correlated, since we‘re close to threshold
  $\Rightarrow$ exploit high beam resolution

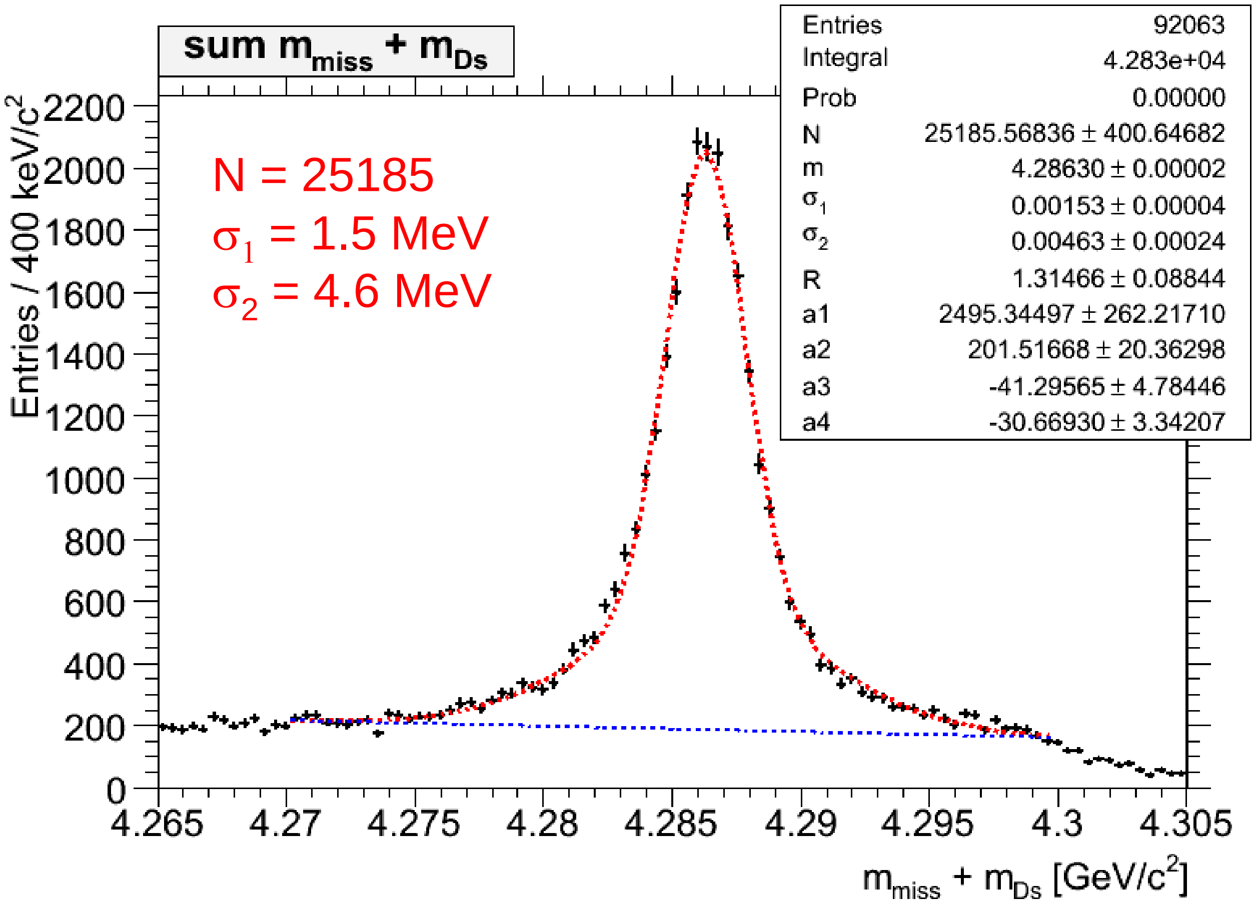


When we
project to red line,
we can gain
much resolution!

Simple approach:
sum of both masses!

Sum missing mass and m_{Ds}

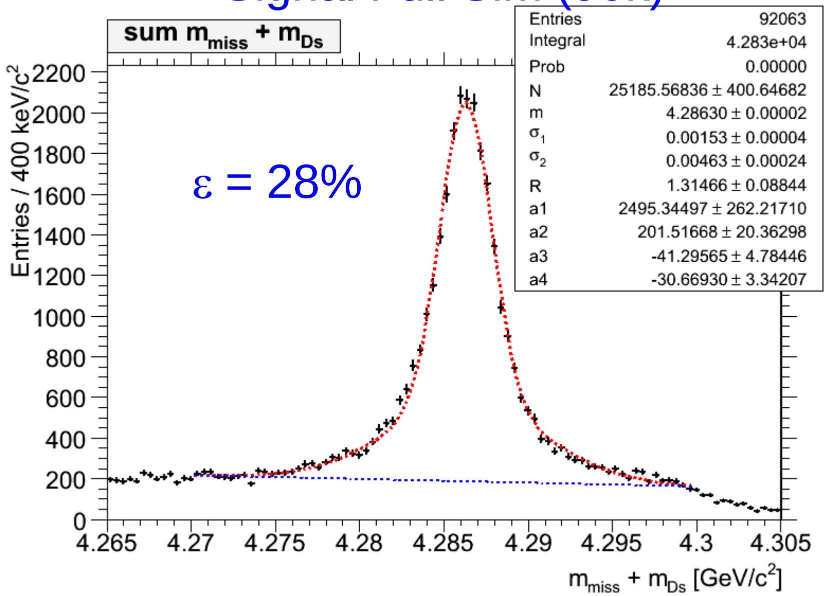
- Resolution improves from 8.8 MeV → 3 MeV (factor 3)
- Efficiency $\varepsilon \approx 25000/90000 = 28\%$

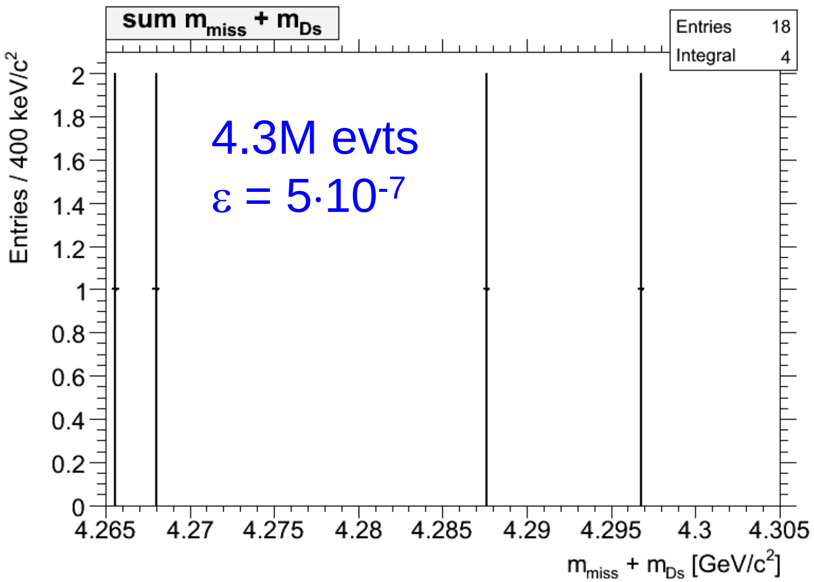


Backgrounds – PID – no PID

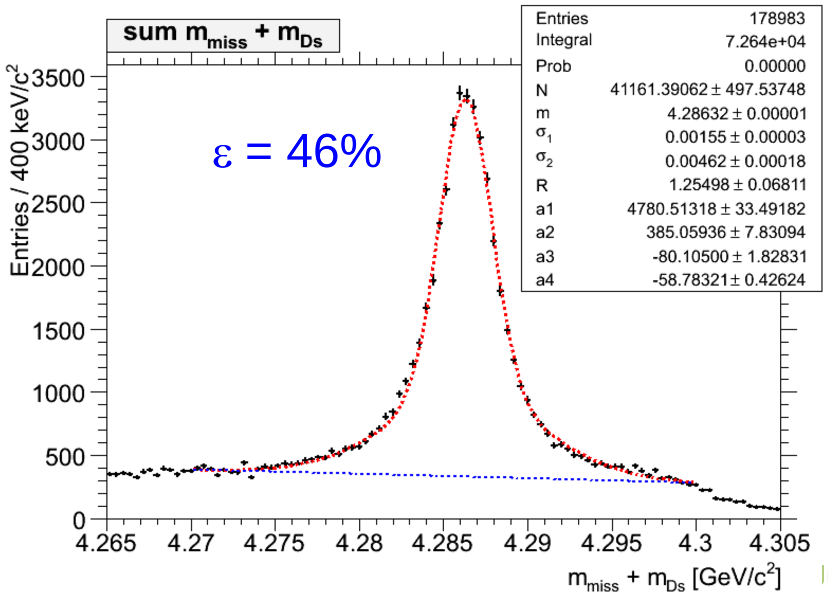
Signal Full Sim (90k) | DPM (fast sim)

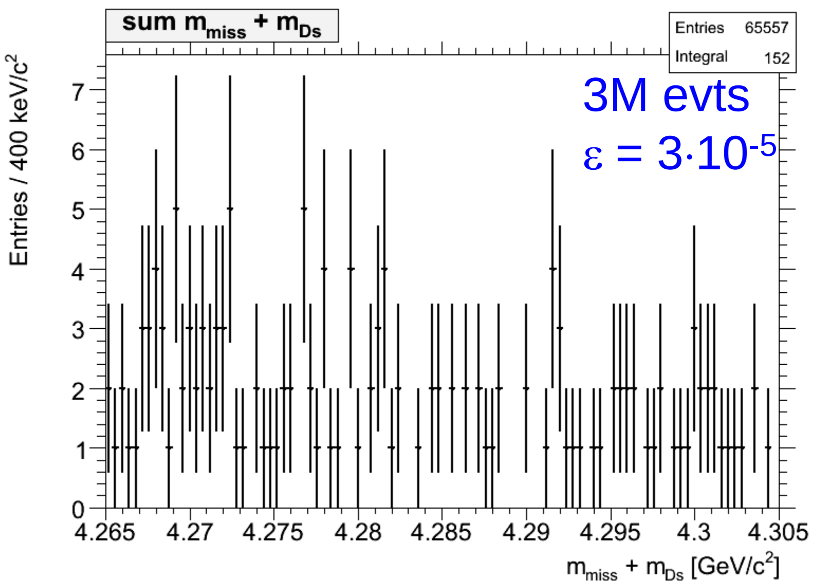
w/ PID





w/o PID

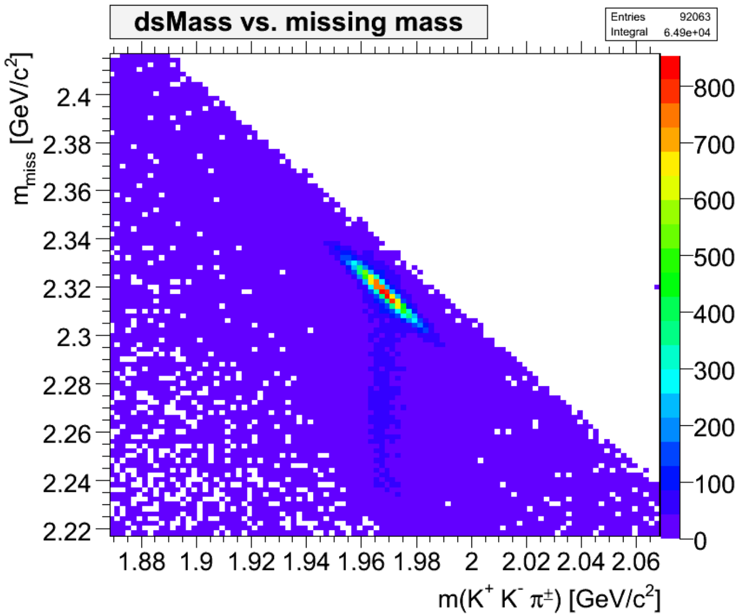


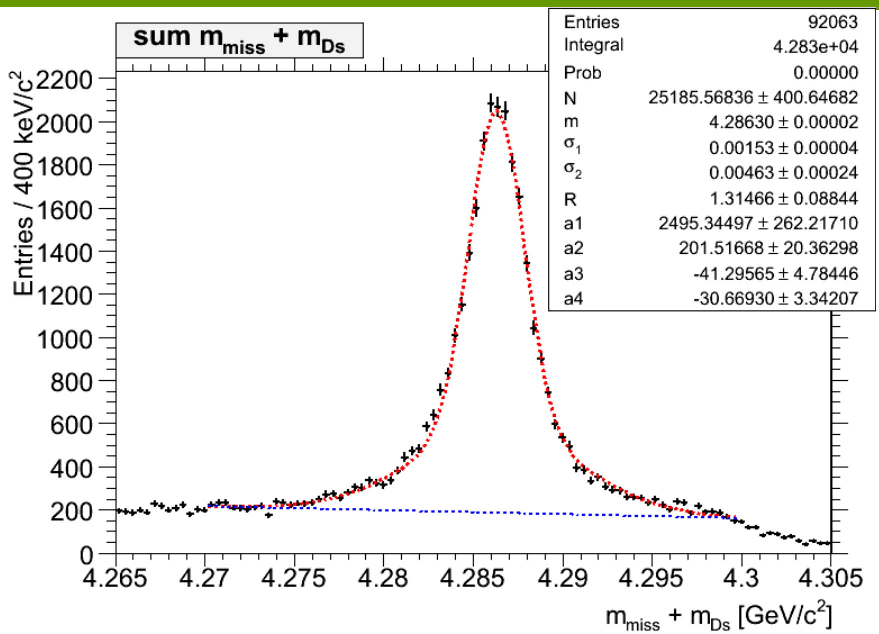


non resonant $D_sD_s\pi^0$

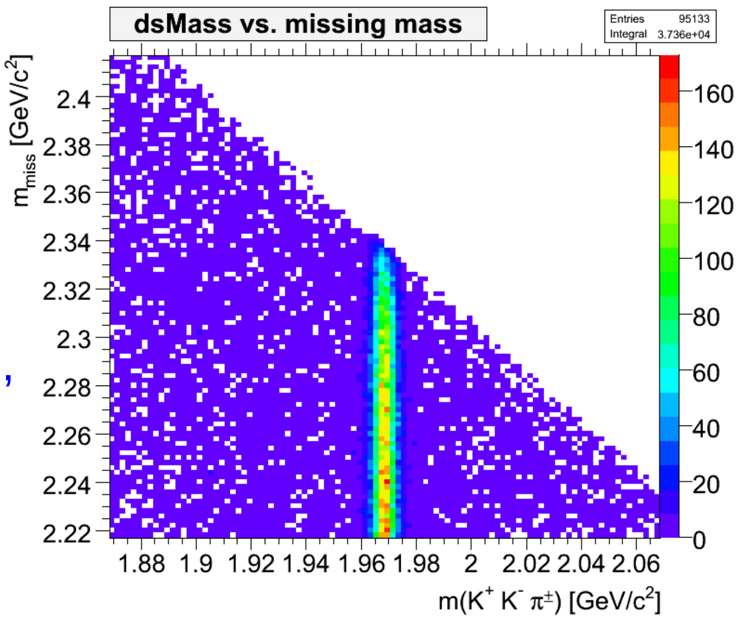
signal

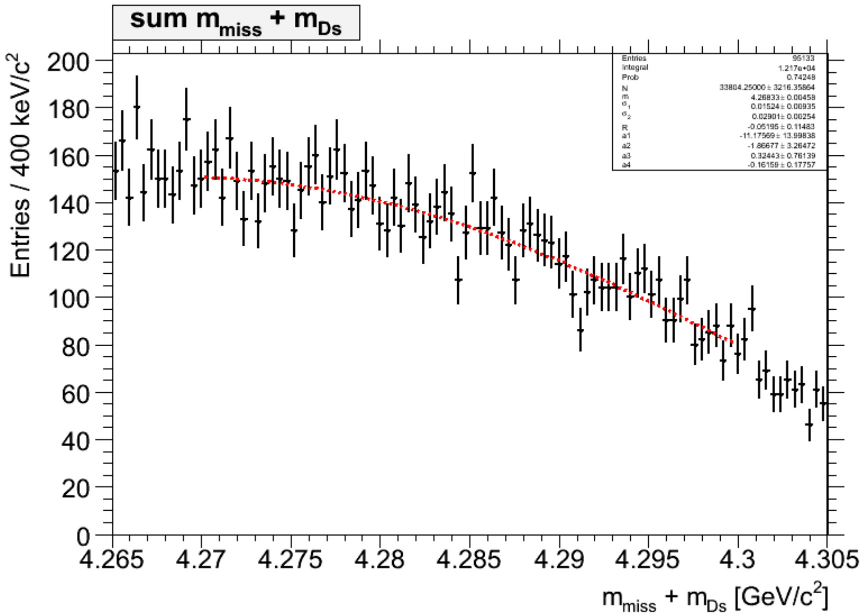
(full sim, 90k)





non res. (fast sim, 40k)





- Excitation function for reactions $\bar{p}p \rightarrow X\bar{X}$

$$\sigma(\lambda) = \sqrt{m_R\Gamma}\,|M|^2\,\frac{1}{\pi}\int_{-\infty}^{\lambda} dx\,\frac{\sqrt{\lambda - x}}{x^2+1}$$

$$\lambda = (\sqrt{s} - 2m_R)/\Gamma$$

For resonance X with parameters m_R = mass, Γ = width

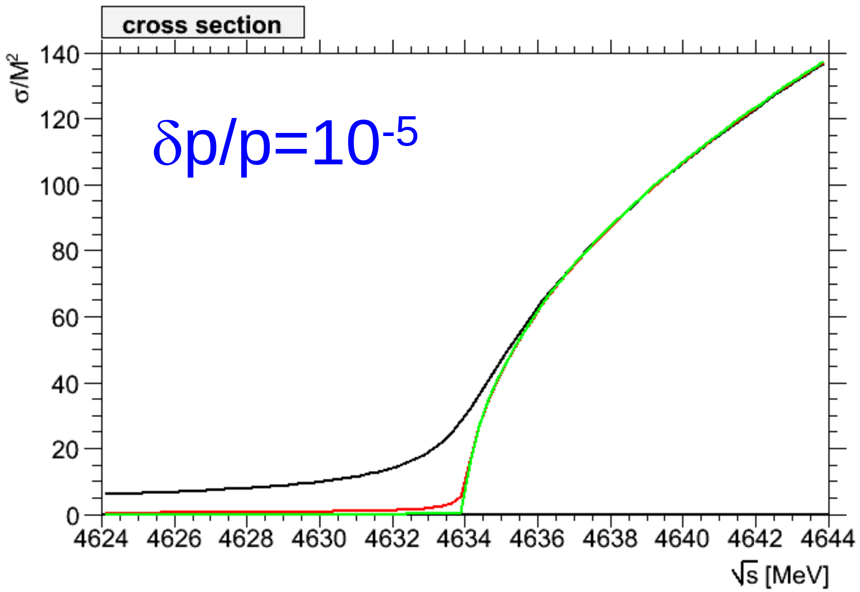
Convolute with gaussian to take into account beam spread

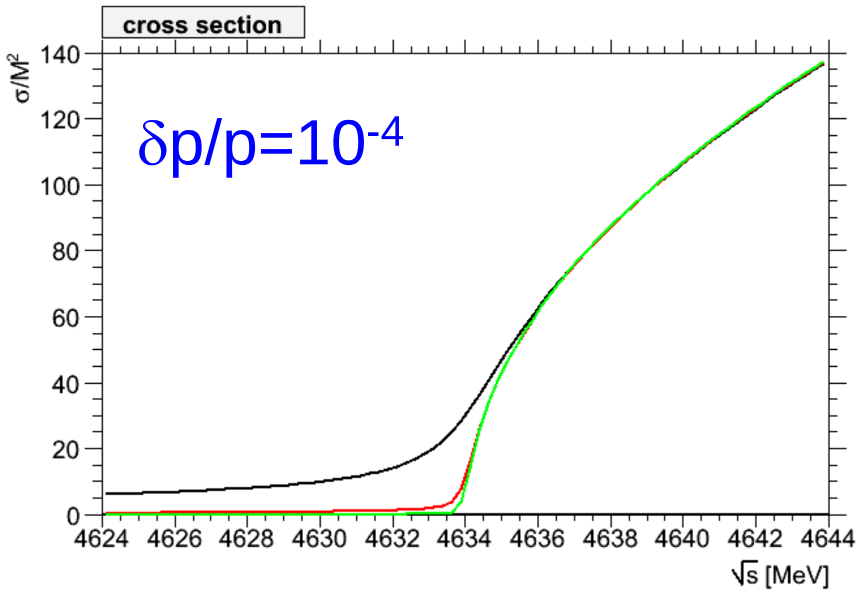
For our channel, we need a modification of this formula;
but for the moment it is sufficient

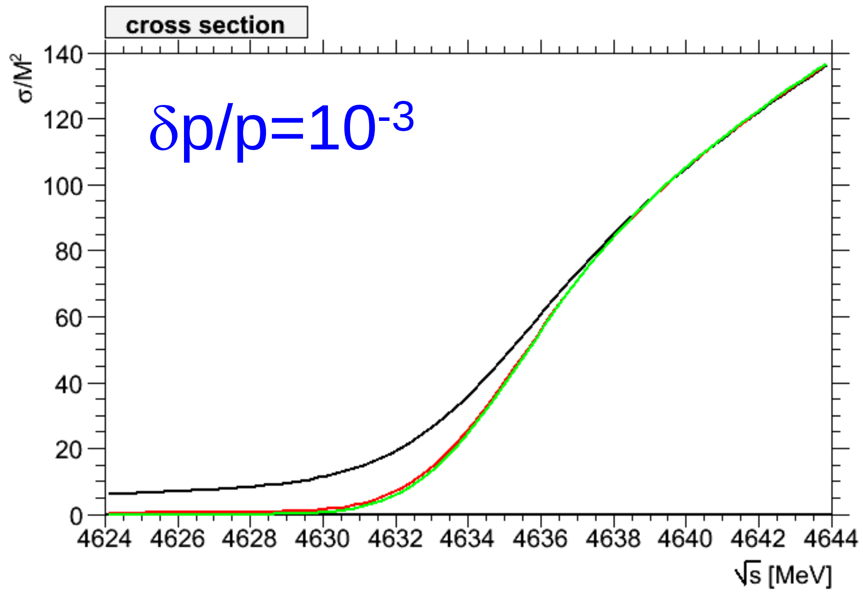
Excitation function

gaussian convolution
beam spread = $\delta p/p$

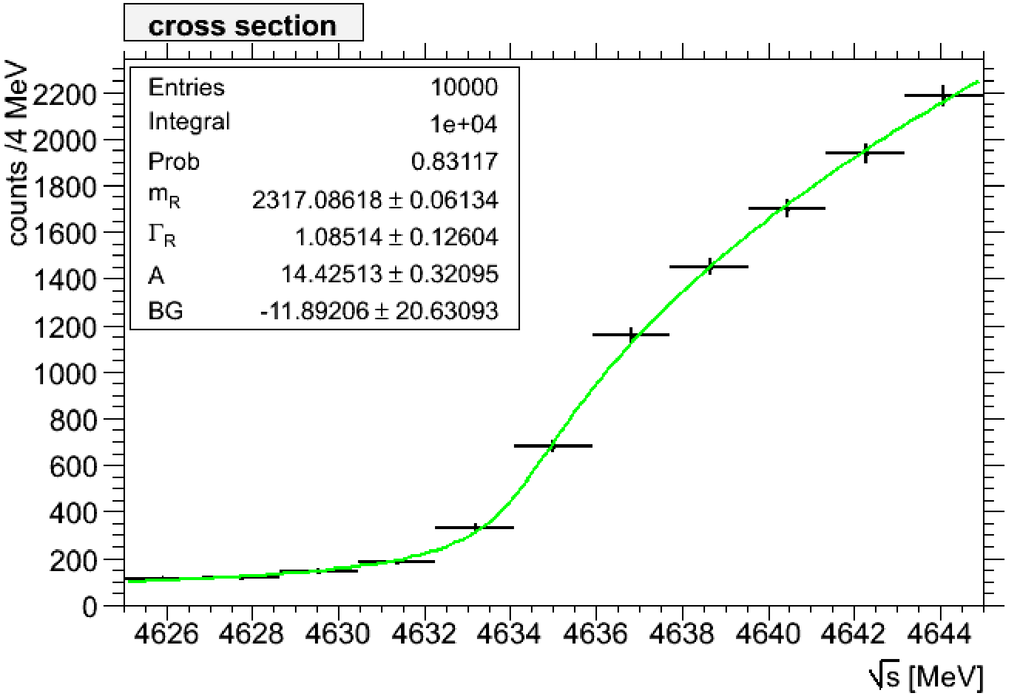
Γ = 1MeV
Γ = 0.1MeV
Γ = 0.01MeV







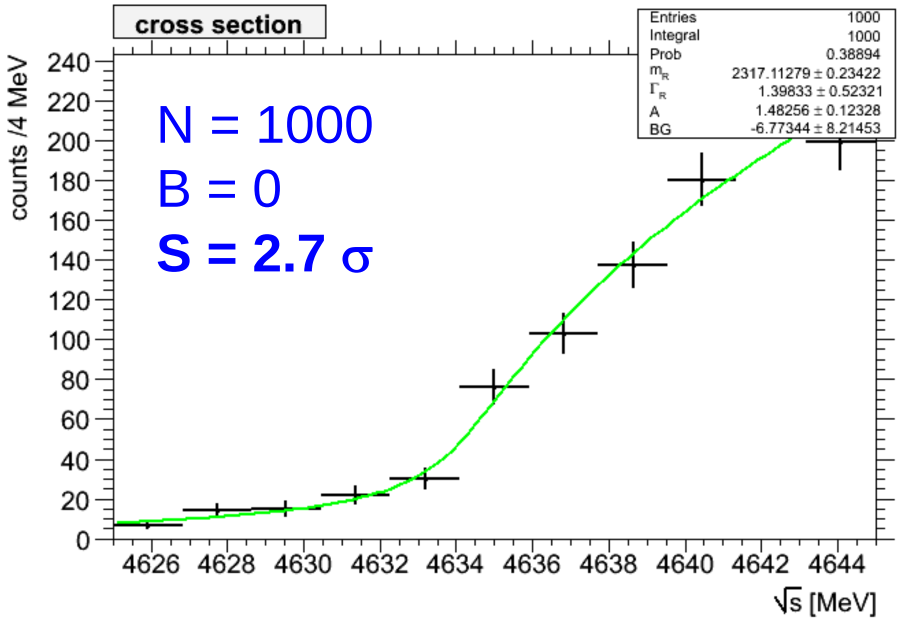
- **Idea:**
  - choose Γ, number of signal N and number of flat bkg B
  - create histogram with this distribution
  - fit excitation function to this histogram
  - extract $\Gamma \pm \Delta \Gamma$
  - Significance of measurement is $\Gamma/\Delta\Gamma$
  - (has to be extended for finite beam resolution!)

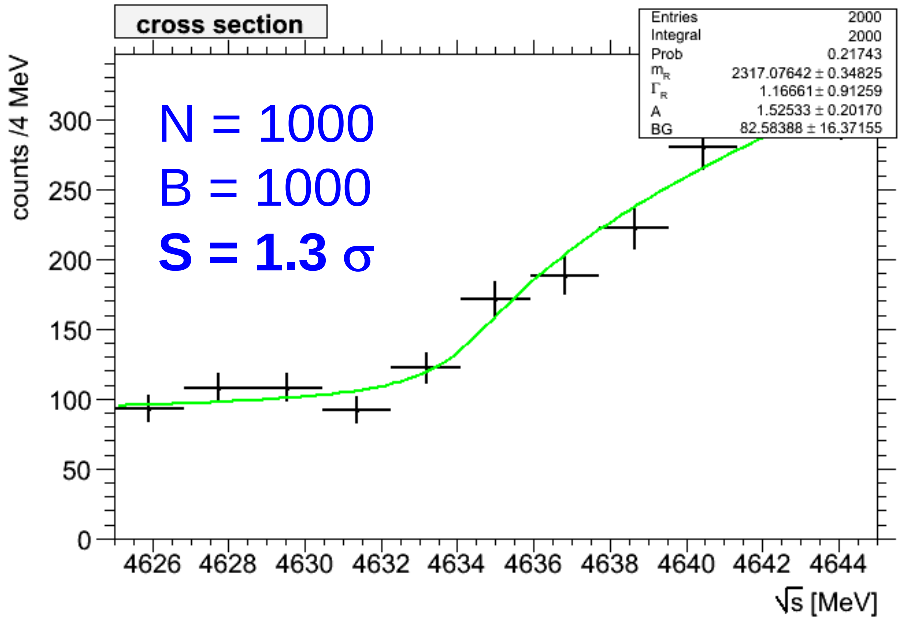


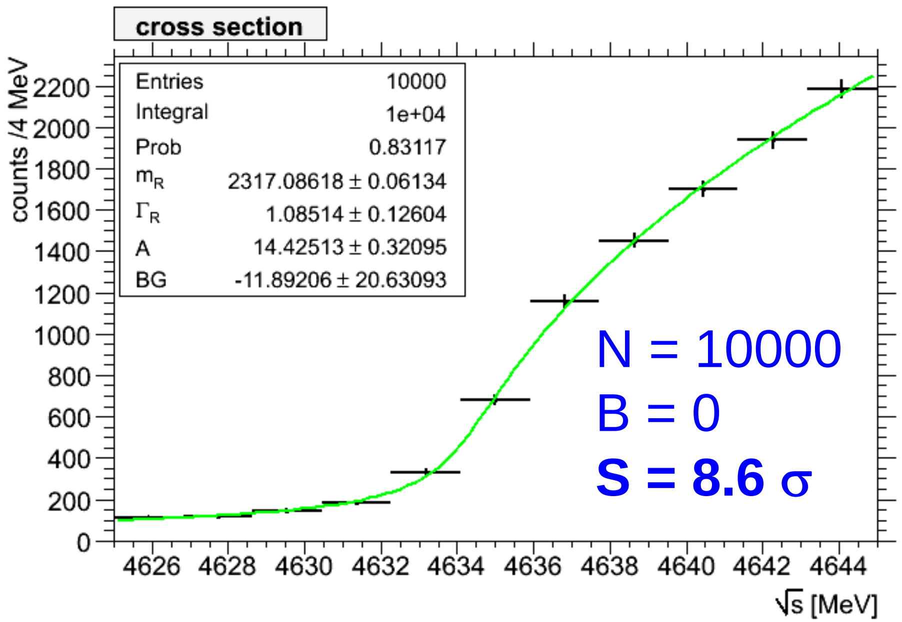
Example:

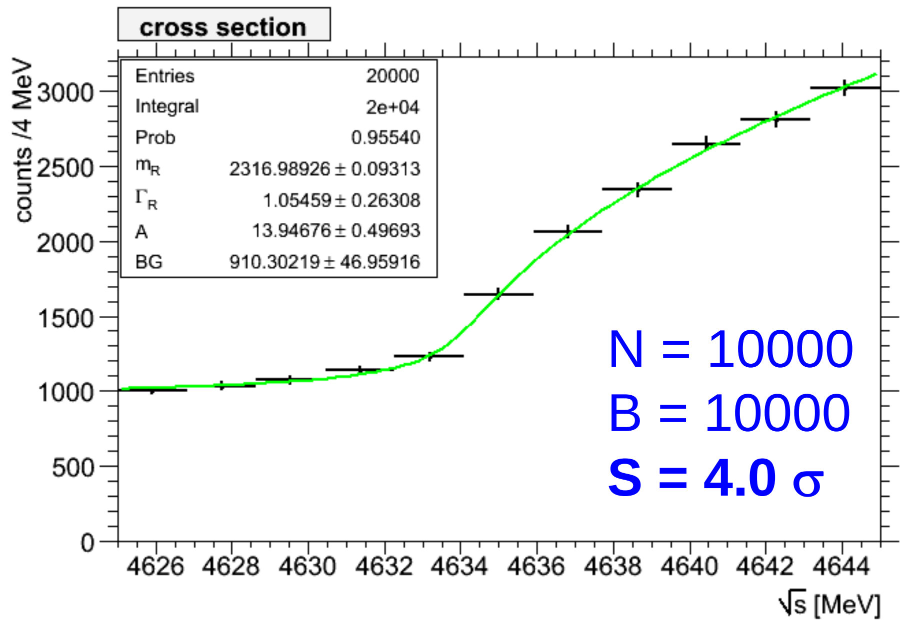
Γ = 1.085 ± 0.126 MeV
S = 1.085/0.126 = 8.6 σ

Sensitivity (Γ = 1 MeV)

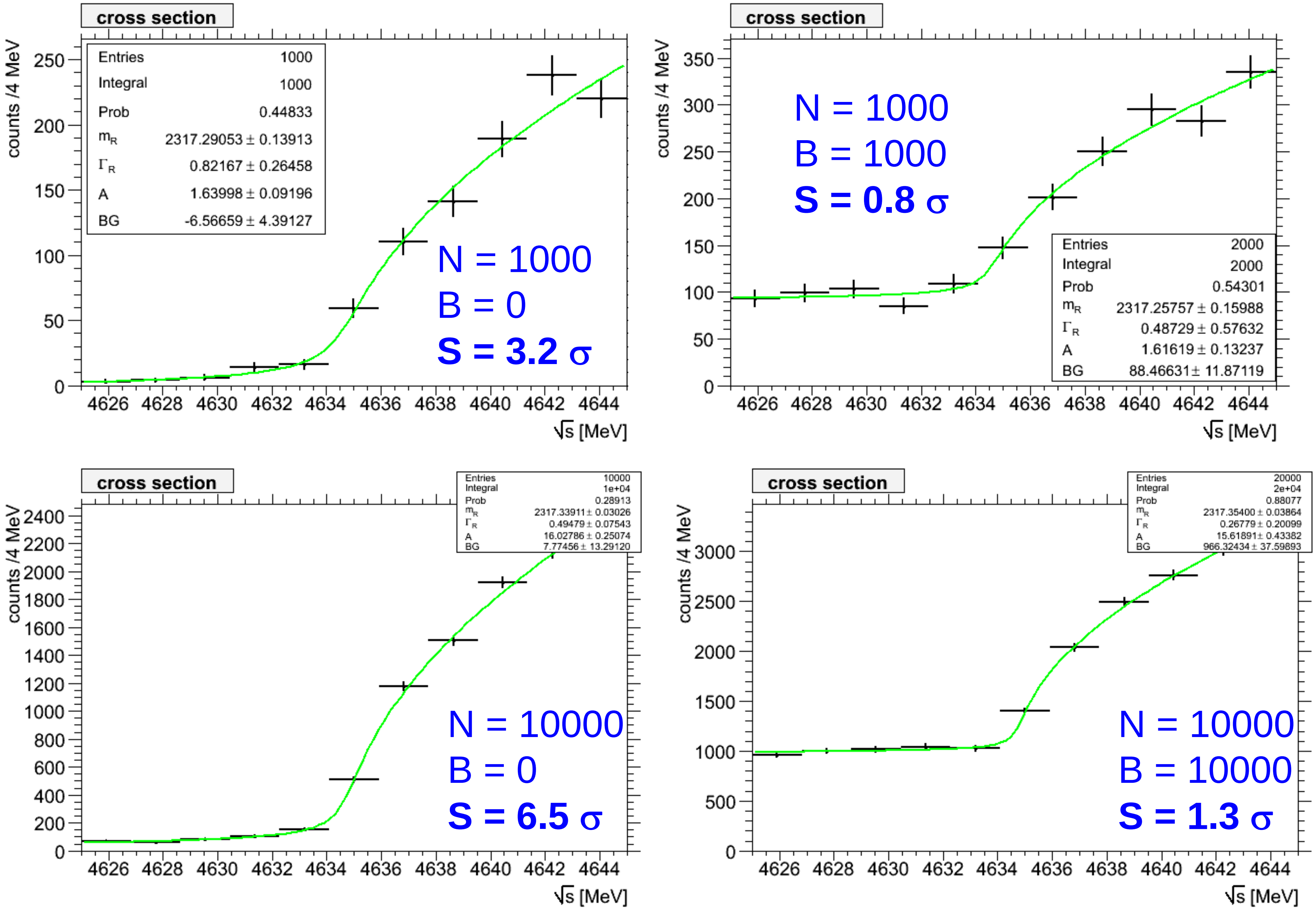




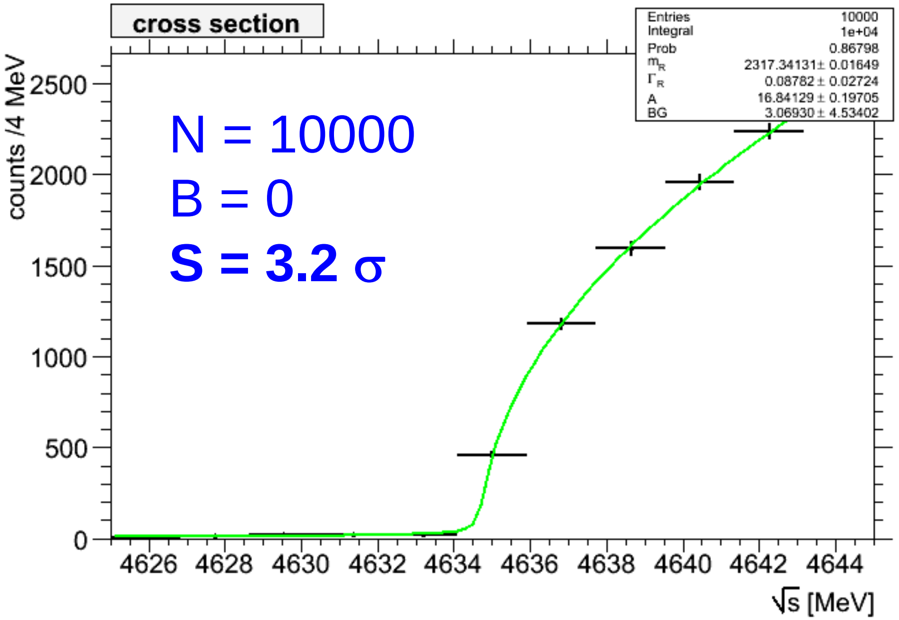


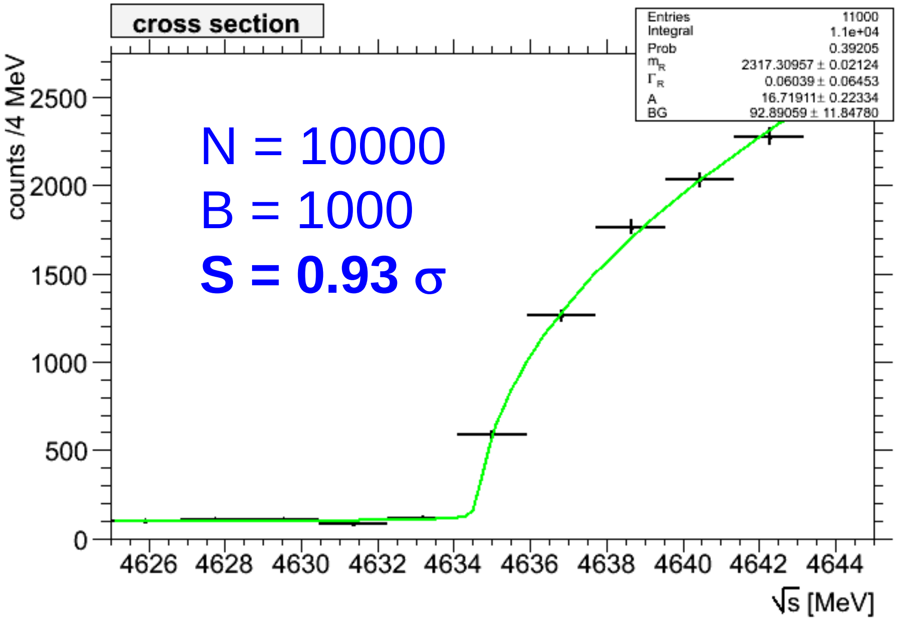


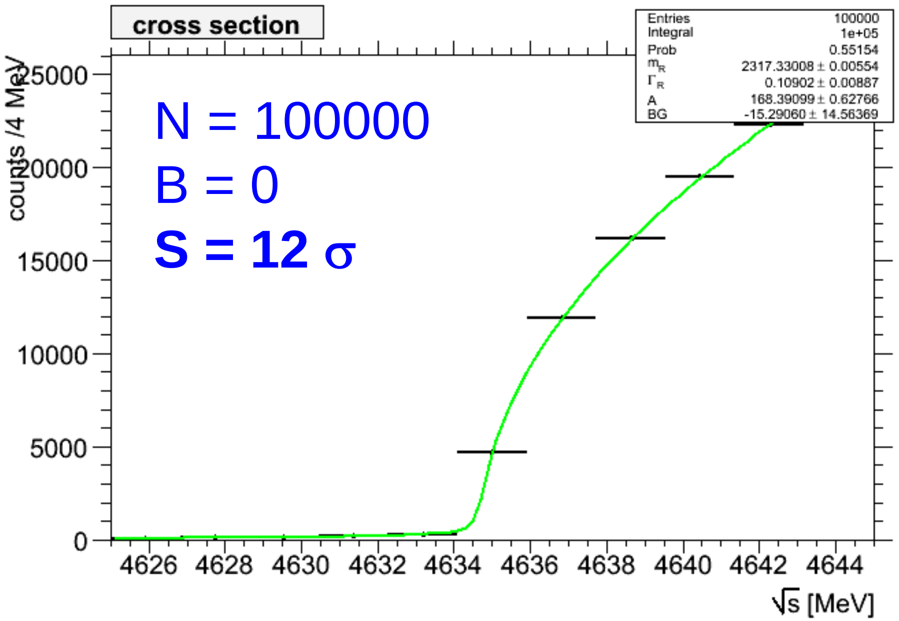
Sensitivity (Γ = 0.5 MeV)

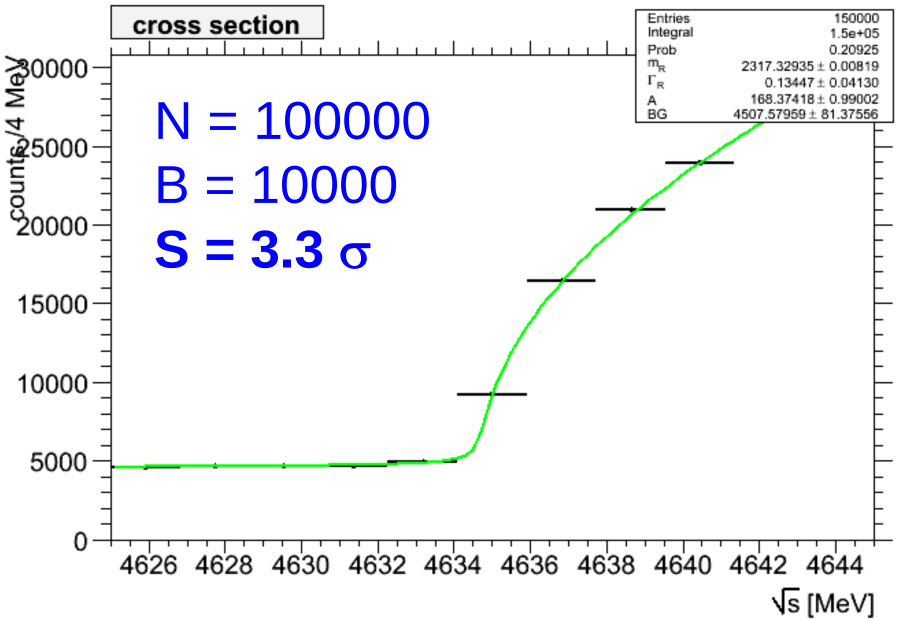


Sensitivity (Γ = 0.1 MeV)









Steps to do...

- Repeat with
  - the correct excitation function for $\bar{p}p \rightarrow XY$
  - convolution with beam spread
- Vary
  - scan region (sensitivity bigger below threshold!? – but longer runtime...)
  - number of steps
- Improve assumptions about background cross sections
- Refine selection
- Alternatives for measuring width:
  - lineshape of D_{s0}^* signal?
  - ratio $\sigma(0)/\sigma(\infty) \propto \sqrt{\Gamma}$ (only 2 scan points)?
- Extension for $D_{s1}(2460)$, ...

Status of Analysis

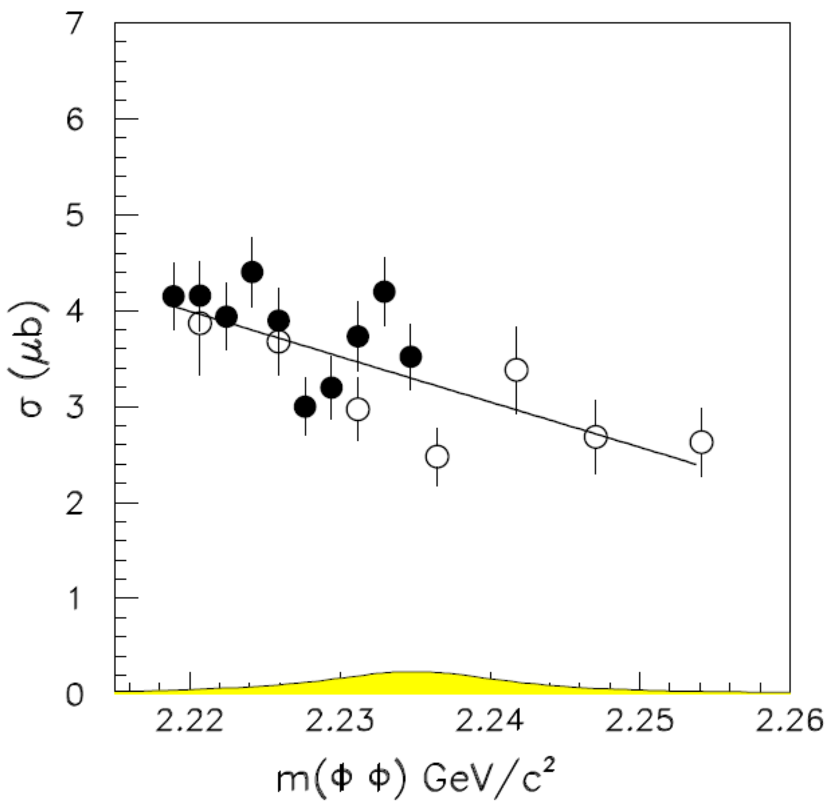
$p\bar{p} \rightarrow \phi\phi$

Channel $\bar{p}p \to \phi\phi$

- Intention: Look for $f_J(2230)/\xi$
- Method:
  Energy scan (10-20 points) around $\sqrt{s}$ = 2.2 GeV/c²
- Can we significantly observe resonant structure above non-resonant $\phi\phi$?

Cross section measurement from JETSET@CERN for

$$\bar{p}p \longrightarrow \phi\phi$$



Ref: hep-ex 9802016

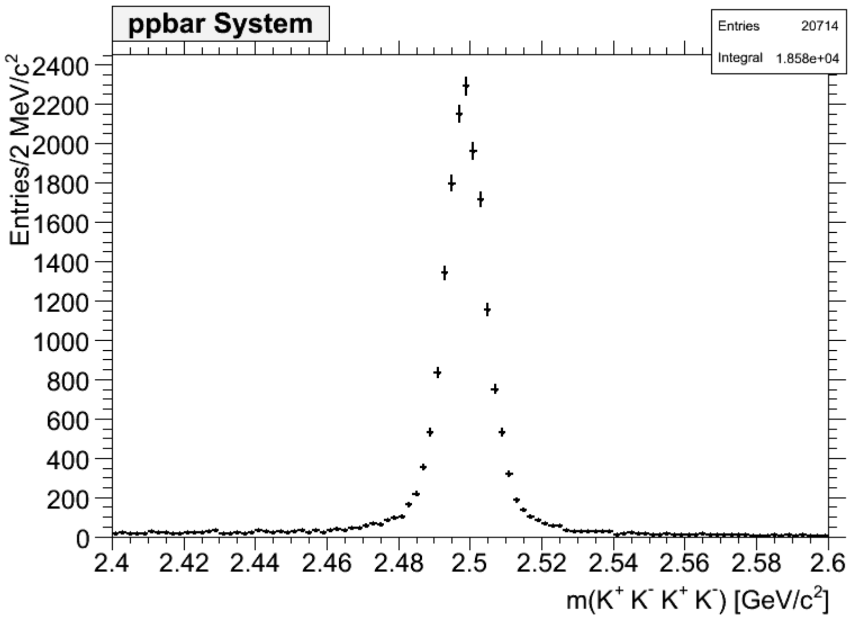
Reconstruction

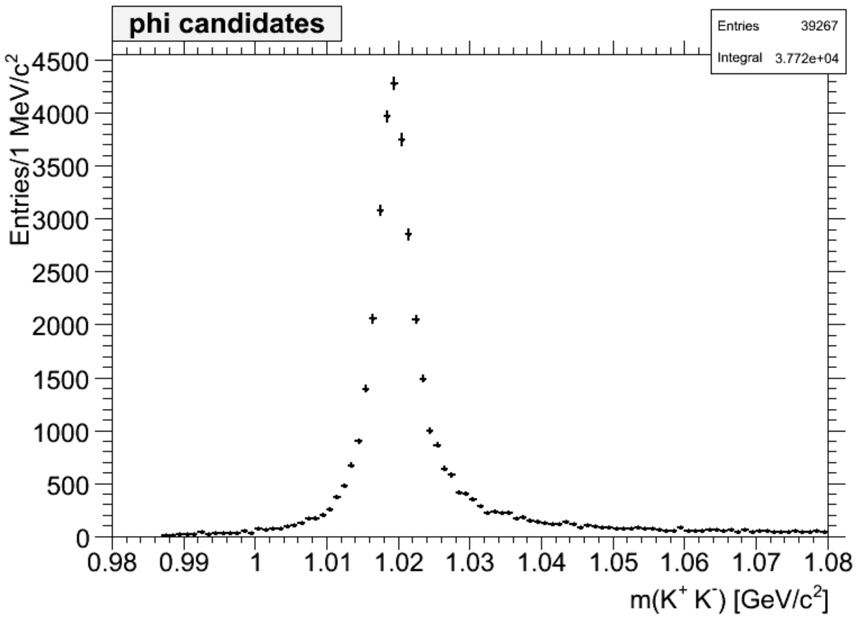
- Decay tree

$$\bar{p}p \longrightarrow \phi\phi$$
$$\phi \hookrightarrow K^+K^-(K_S^0 K_L^0)$$
$$\phi \hookrightarrow K^+K^- \qquad K_S^0 \hookrightarrow \pi^+\pi^-$$

- Final state:
  - mode 1: 4 charged kaons
  - mode 2: 2 charged kaons, 2 charged pions,
    K_L via missing mass (later)
- Data
  - 37k signal events mode 1 (full sim)
  - 940k DPM events (fast sim)
- Selection:
  - VeryLooseKaon Identification all 4 kaons
  - Fit with geometrical vertex constraint for the ϕ's

Reconstruction Signal

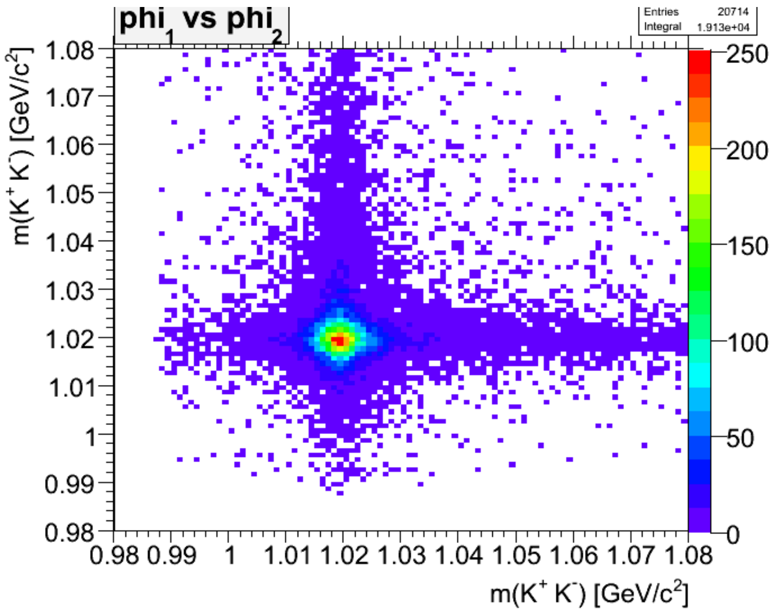




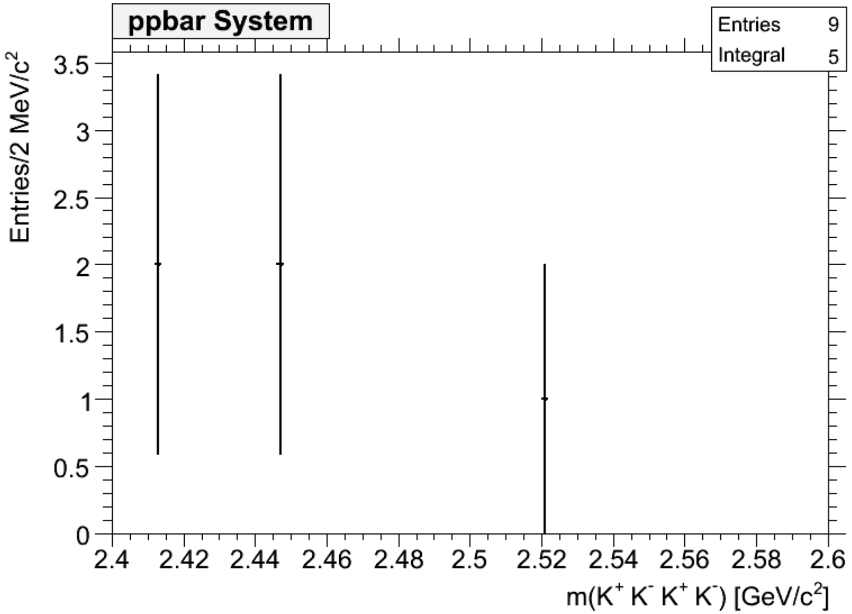
No cuts on phi mass!

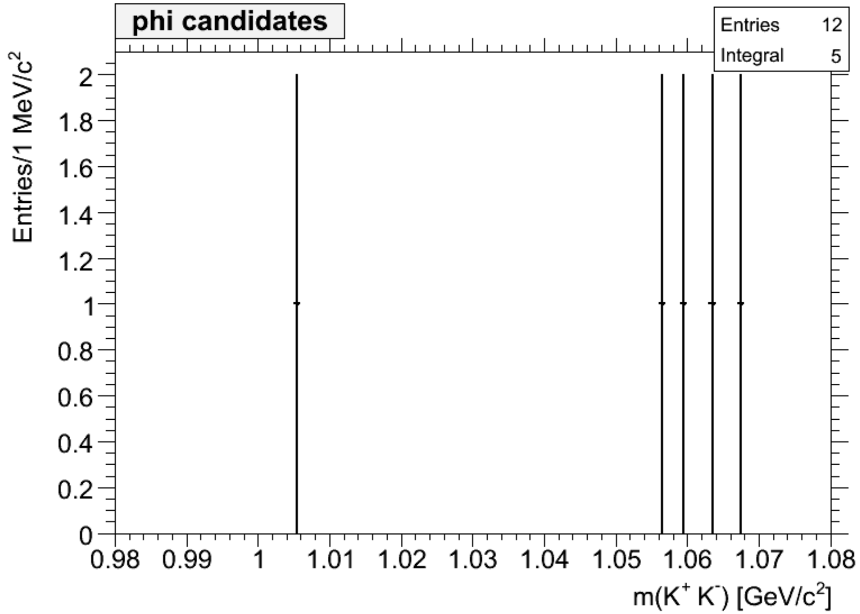
N = 37k events

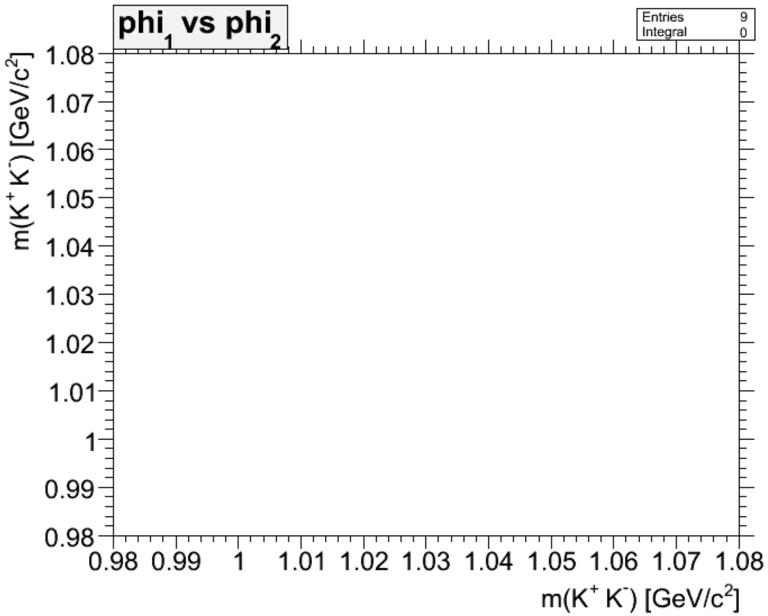
Efficiency ≈ 50%



Reconstruction DPM







No cuts on phi mass!

N = 940k events

Efficiency $\approx 5\cdot10^{-6}$

Sensitivity

- Estimate minimum integrated luminosity L to measure for a given signal cross section signal with 10σ significance
- We know inclusive pp$\rightarrow$ $\phi\phi$ cross section from JETSET
- With efficiency ε from MC
  - $N = L \times \sigma(\sqrt{s}) \times \varepsilon$ for scan point at $\sqrt{s}$
  - $S = L \times \sigma_{\xi} \times \varepsilon$
- Fill histogram with N entries distributed via $\sigma(\sqrt{s})$ and S entries distributed via Breit-Wigner with Γ=15 MeV and m = 2235 MeV
- Fit combined model and extract significance of resonance

Sensitivity