Updates from...

Search for the $Z_c(4430)$ in Y(4660) decay

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BESIII Italy Meeting
March 2021

PREAMBLE

My PhD analysis involves the study of two exotic states

$e^+e^- \rightarrow$ **Y(4660)** $\rightarrow$ **Z_c(4430)** $\pi \rightarrow \psi(2S)\,\pi\,\pi$

The study will make use of the ~4 fb^{-1} data above 4.6 GeV

Y(4660), already **observed by** the **BaBar** [PRD **89**, 111103(R)] and
the **BELLE** [PRD **91**, 112007] collaborations, was **hypothesised** to be a **baryonium**

Z^+_c(4430) was **observed and studied** in the **B meson decays** in the **$\pi\psi$(2S) invariant mass**
by the **BELLE** [PRD **88**, 074026] collaboration (and by the **LHCb** one [PRL **112**, 222002])

(SIGNAL) MC STUDIES

Y and Z_c Resonant

```
noPhotos

Decay dummy00_1
  0.5000 dummy10_1 pi- PHSP;
  0.5000 anti-dummy10_1 pi+ PHSP;
Enddecay

Decay dummy10_1
  1.0000 pi+ psi(2S) PHSP;
Enddecay

Decay anti-dummy10_1
  1.0000 pi- psi(2S) PHSP;
Enddecay

Decay psi(2S)
  1.0000 pi+ pi- J/psi PHSP;
Enddecay

Decay J/psi
  0.5000 e+ e- PHSP;
  0.5000 mu+ mu- PHSP;
Enddecay

End
```

Y(4660)

$M_Y = 4633 \pm 7$ MeV

$\sigma_Y = 64 \pm 9$ MeV

$Z_c(4430)^+$

$M_Y = 4478^{+15}_{-18}$ MeV

$\sigma_Y = 181 \pm 31$ MeV

$Z_c(4430)^-$

$M_Y = 4478^{+15}_{-18}$ MeV

$\sigma_Y = 181 \pm 31$ MeV

SIGNAL MC SAMPLE
300K EVENTS

(SIGNAL) MC STUDIES

Y and Z_c Resonant

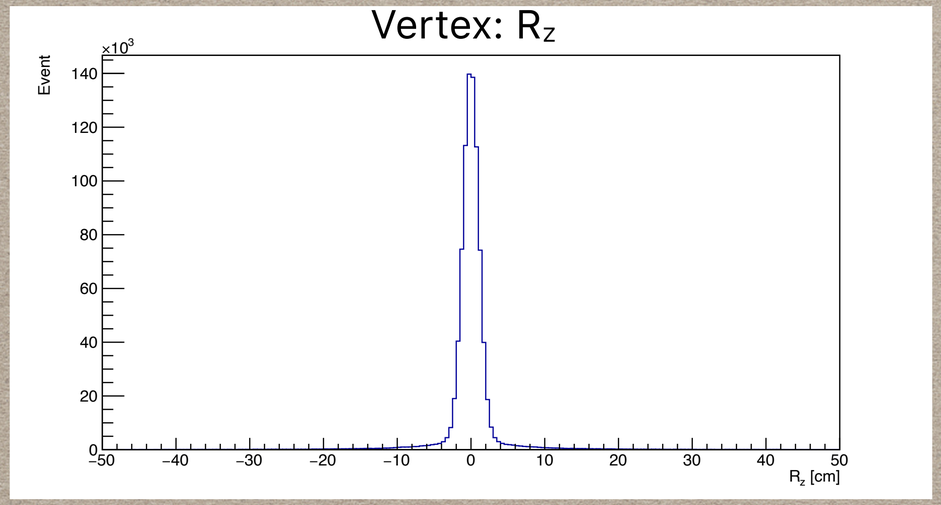
```
noPhotos

Decay dummy00_1
  0.5000 dummy10_1 pi- PHSP;
  0.5000 anti-dummy10_1 pi+ PHSP;
Enddecay

Decay dummy10_1
  1.0000 pi+ psi(2S) PHSP;
Enddecay

Decay anti-dummy10_1
  1.0000 pi- psi(2S) PHSP;
Enddecay

Decay psi(2S)
  1.0000 pi+ pi- J/psi PHSP;
Enddecay

Decay J/psi
  0.5000 e+ e- PHSP;
  0.5000 mu+ mu- PHSP;
Enddecay

End
```

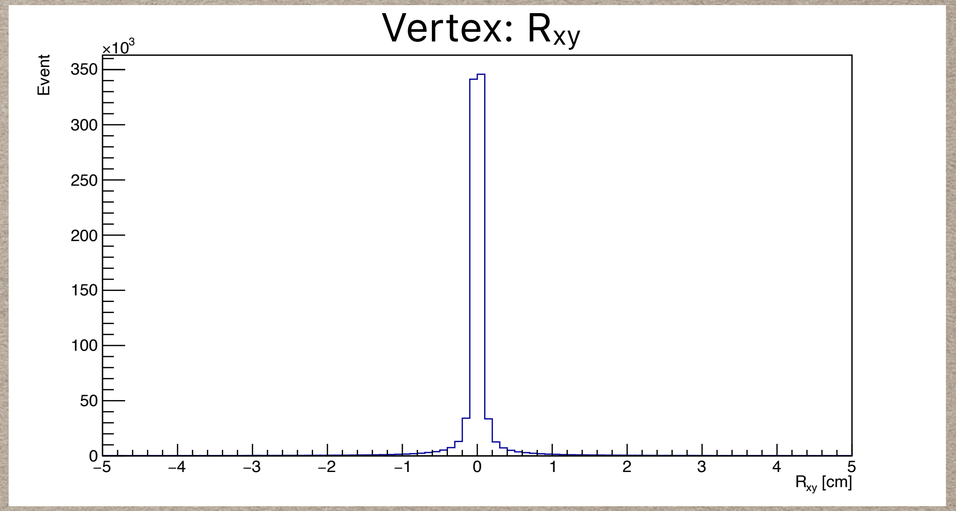
MC SAMPLES
300K EVENTS

Non Resonant Continuum

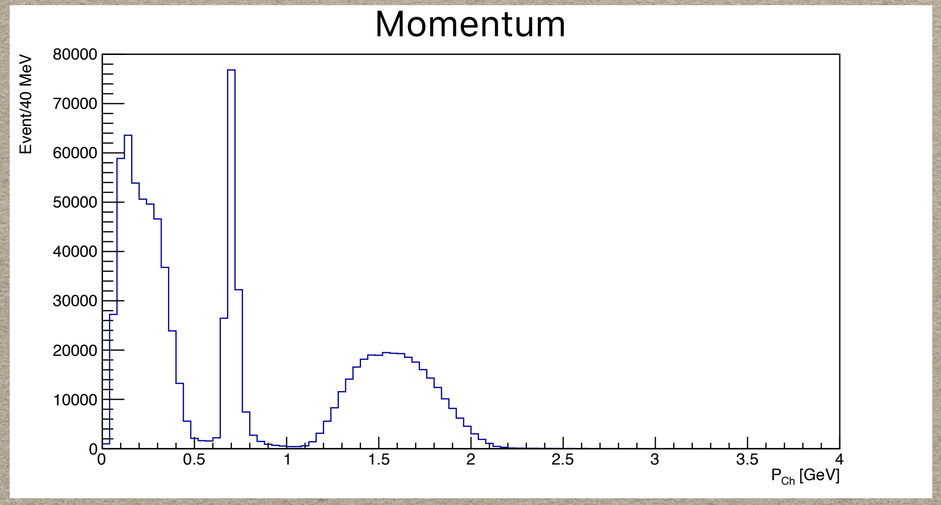
```
noPhotos
Particle vpho 4.633 0

Decay vpho
  1.0000 pi+ pi- psi(2S) PHSP;
Enddecay

Decay psi(2S)
  1.0000 pi+ pi- J/psi PHSP;
Enddecay

Decay J/psi
  0.5000 e+ e- PHSP;
  0.5000 mu+ mu- PHSP;
Enddecay

End
```

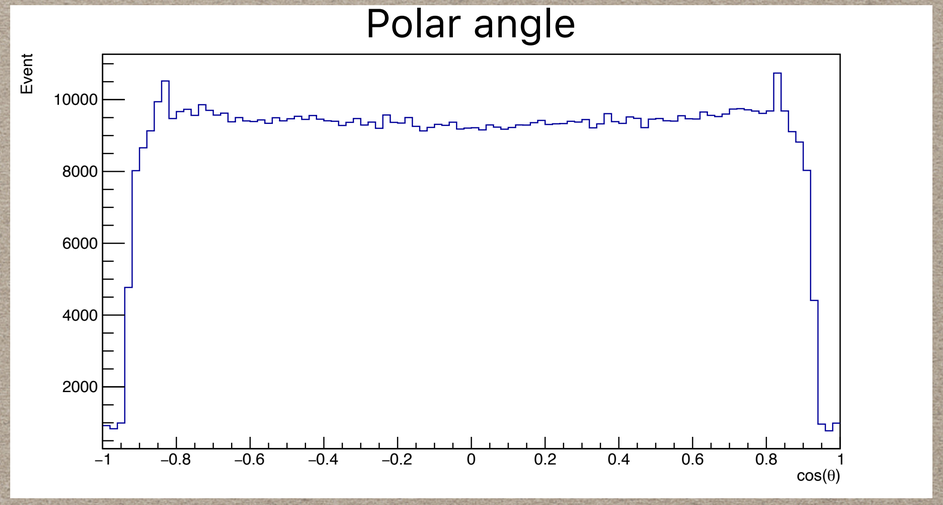
SIGNAL MC STUDIES



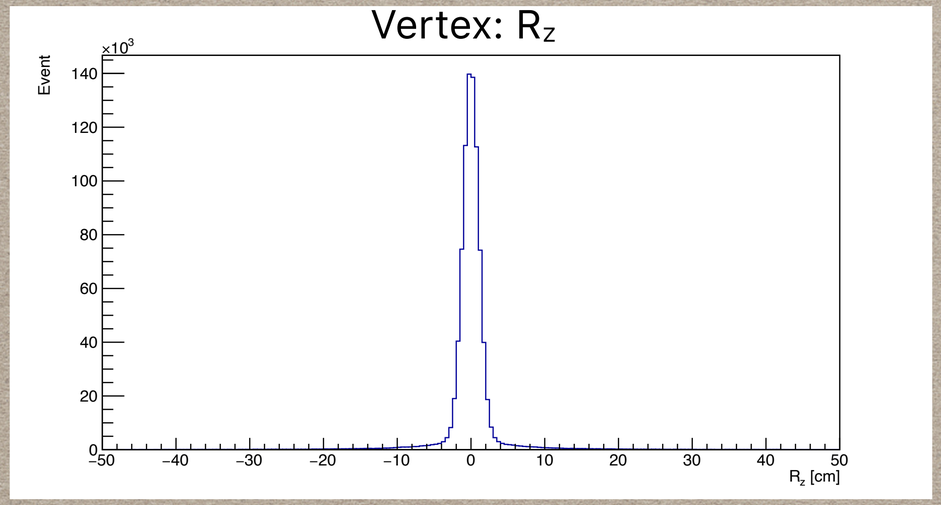


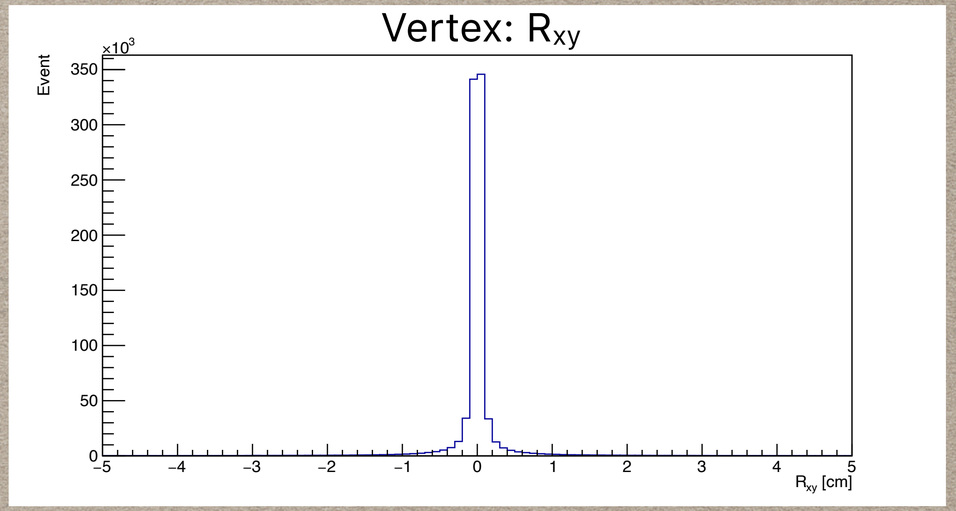
Charged Tracks





SIGNAL MC STUDIES





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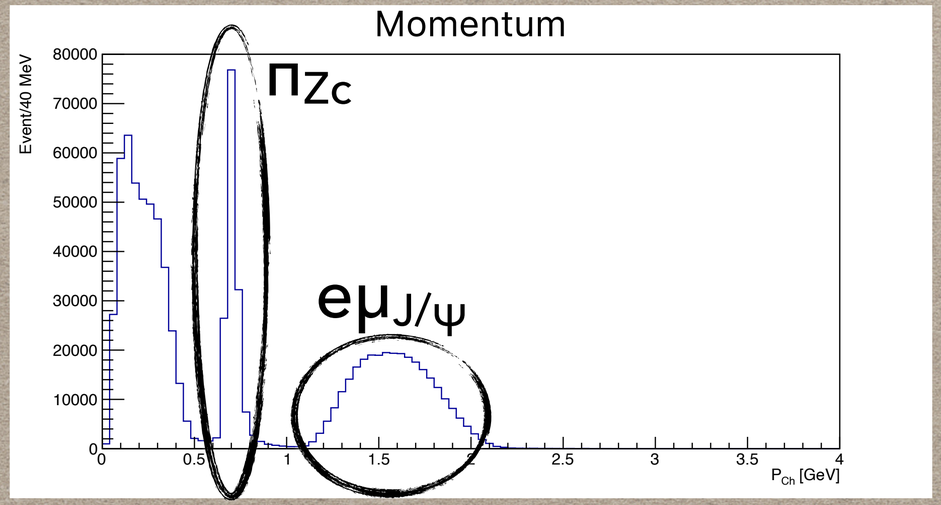
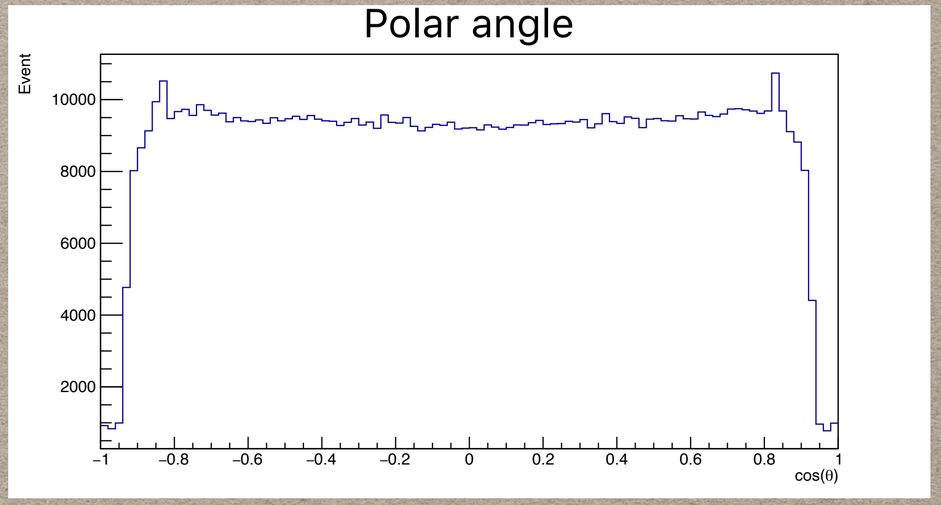
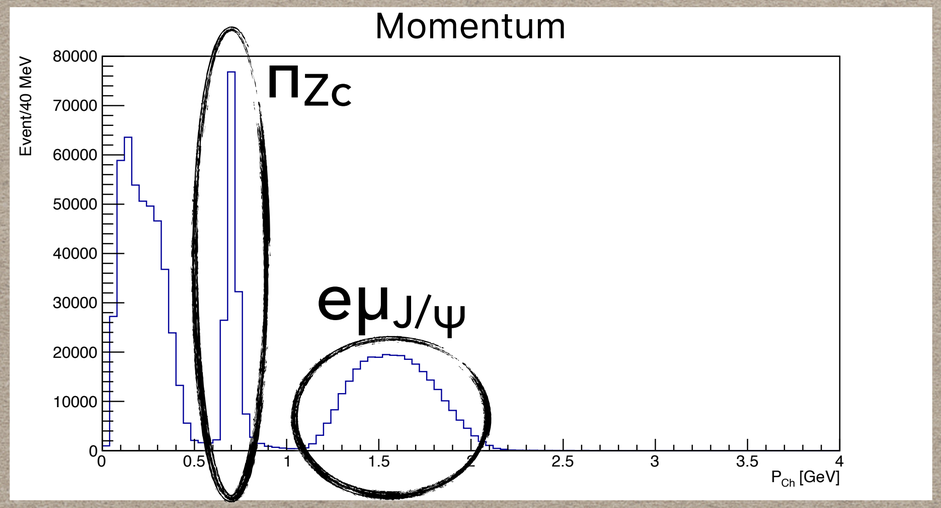
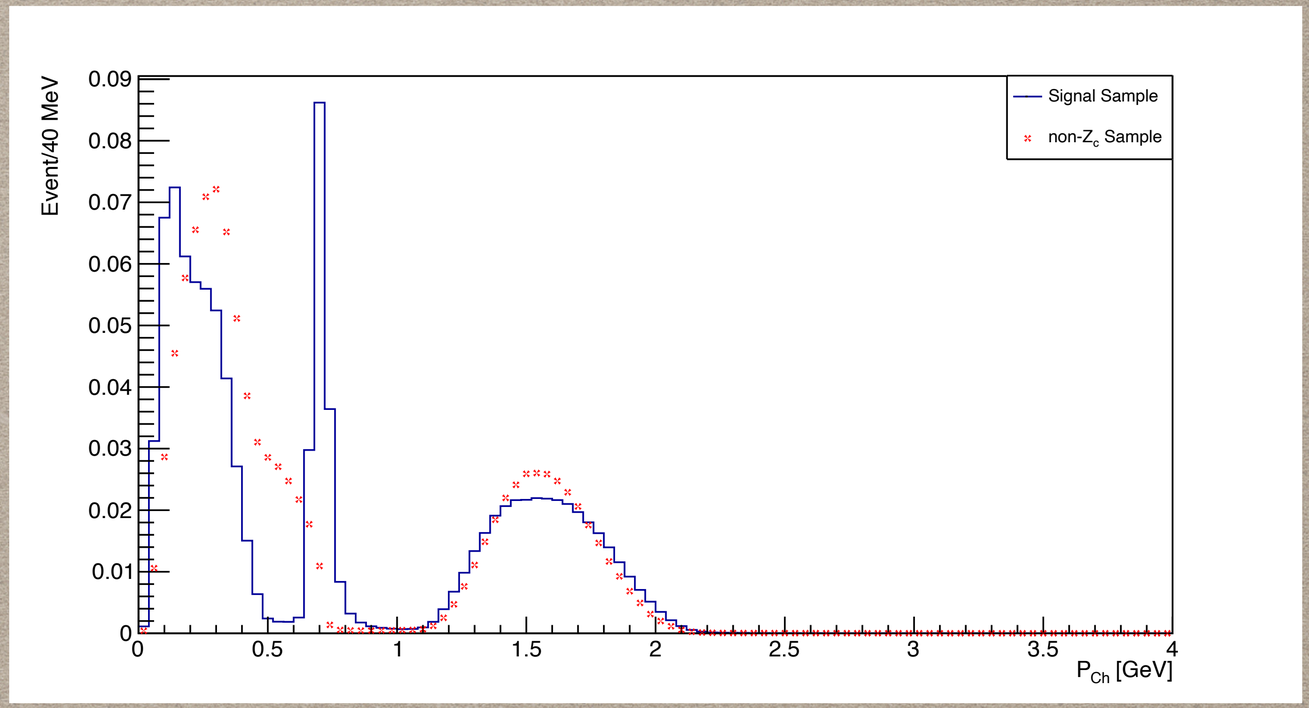




(SIGNAL) MC STUDIES

Charged Tracks

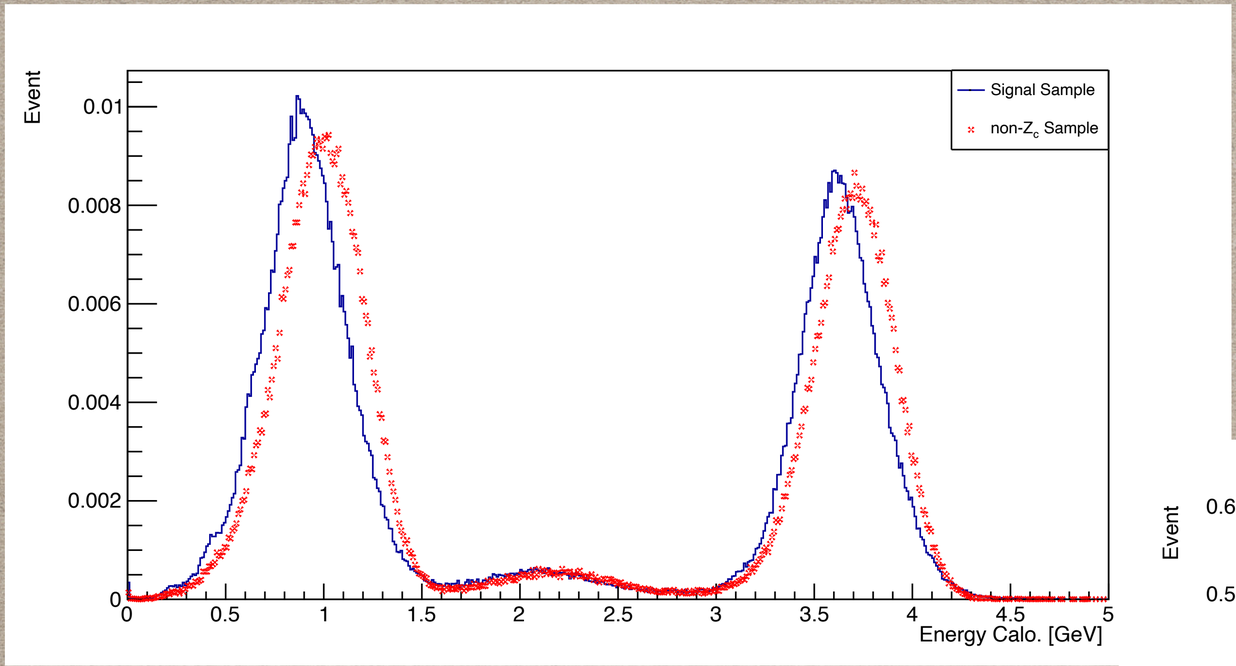




Continuum vs Resonant Comparison

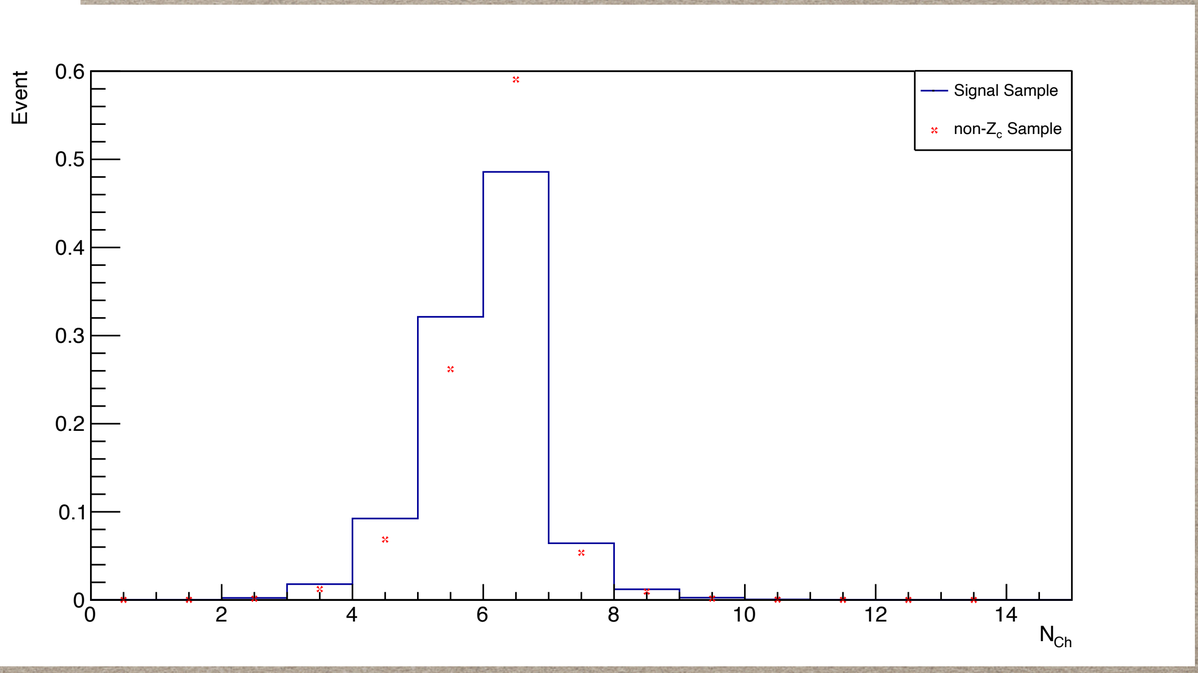
(SIGNAL) MC STUDIES

Continuum vs Resonant Comparison



EMC Energy

 # Charged Tracks



FEASIBILITY STUDY

By G. Graziano - Bachelor Thesis 12/2020

Exclusive MC datasets:

Signal	*100k events @$e^+e^- \to Y \to \pi Z_c$ ($M_{Zc} = 4478$ MeV & $\Gamma_{Zc} = 181$ MeV)*
Background	*100k events @$e^+e^- \to \psi(2S)\pi\pi$*
Resolution studies	*20k events @$e^+e^- \to Y \to \pi Z_c$ ($M_{Zc} = 4478$ MeV & $\Gamma_{Zc} = 0$ MeV)*

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Interesting to study also the absence of the πZ_c only, as some differences are to be expected

FEASIBILITY STUDY

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Events selection:

> 6 good charged tracks *(goodness defined by* ***R_{xy} < 1 cm***, ***R_z < 10 cm*** *&* ***$|\cos(\theta)| < 0.93$****)*

Distinguo pioni e leptoni in funzione dell'impulso > 1GeV

PID: p(π) > 0.001 e p(π) > p(K)

e/μ: $E/p|_e > 0.7$ & $E/p|_\mu < 0.7$

FEASIBILITY STUDY

By G. Graziano

Events selection (1):

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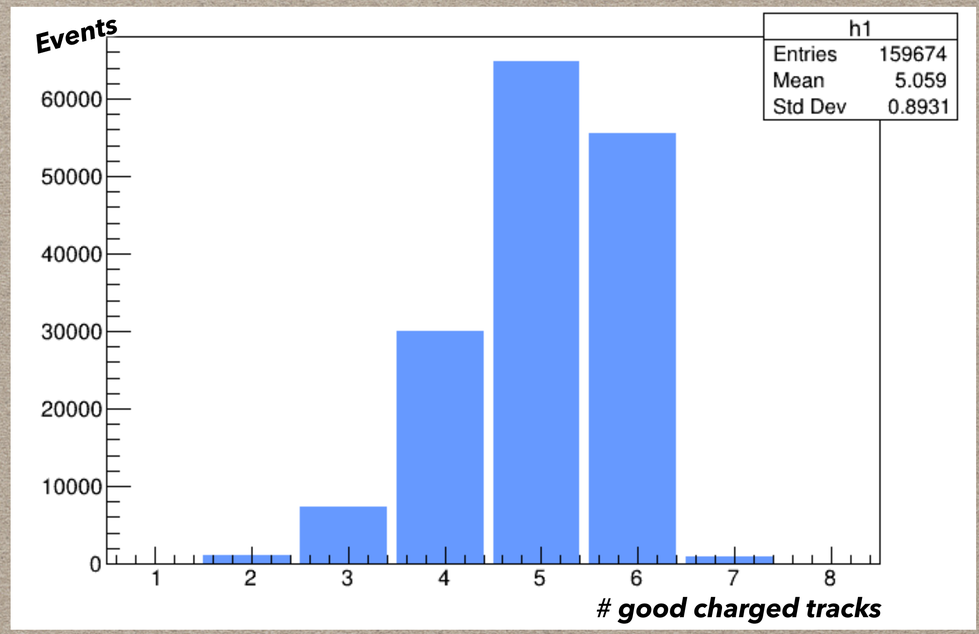
PID: $p(\pi) > 0.001$ *e* $p(\pi) > p(K)$

e/μ: $p_{CT} > 1GeV \div E/p|_e > 0.7$ *&* $E/p|_\mu < 0.7$



FEASIBILITY STUDY

By G. Graziano

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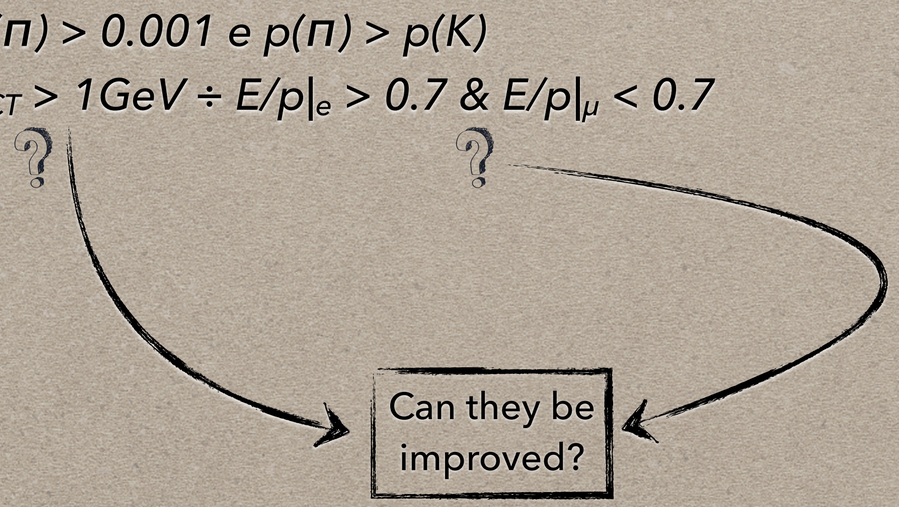

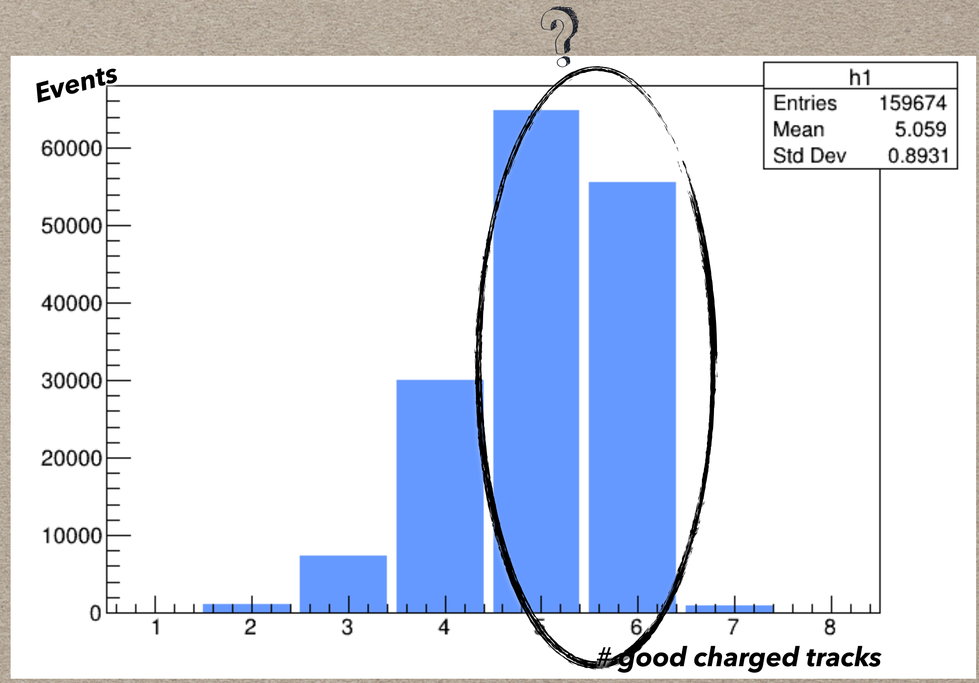

FEASIBILITY STUDY

By G. Graziano

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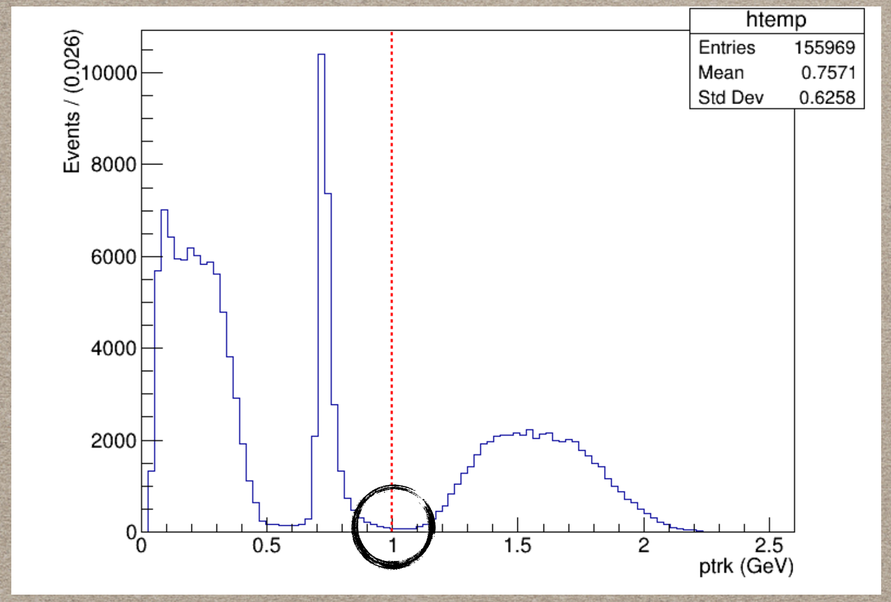

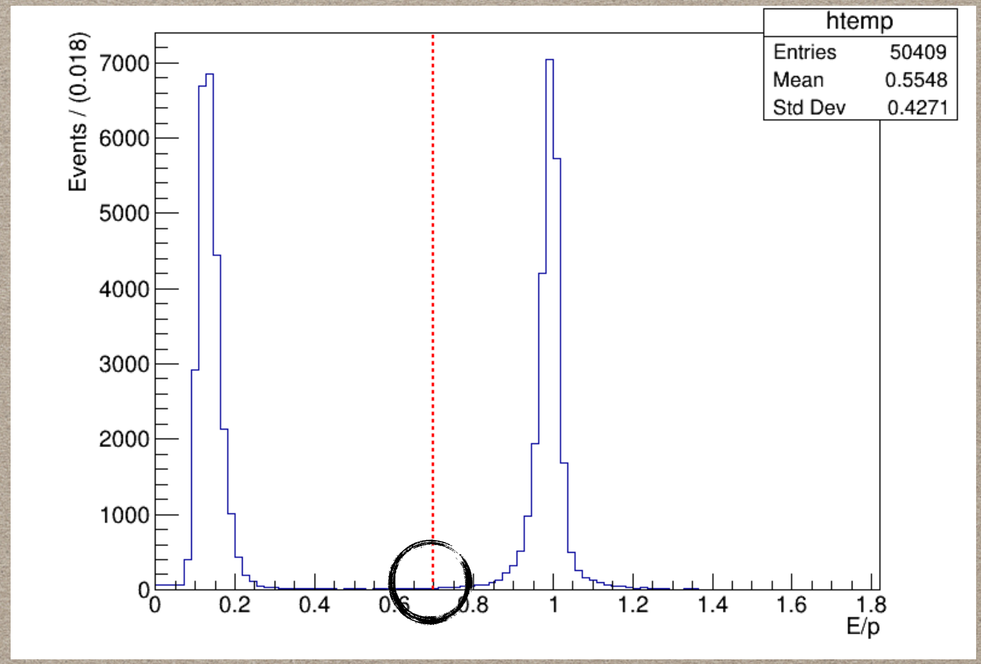

FEASIBILITY STUDY

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Events selection (1):

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PID: $p(\pi) > 0.001$ *e* $p(\pi) > p(K)$

e/μ: $p_{CT} > 1GeV \div E/p|_e > 0.7$ *&* $E/p|_\mu < 0.7$

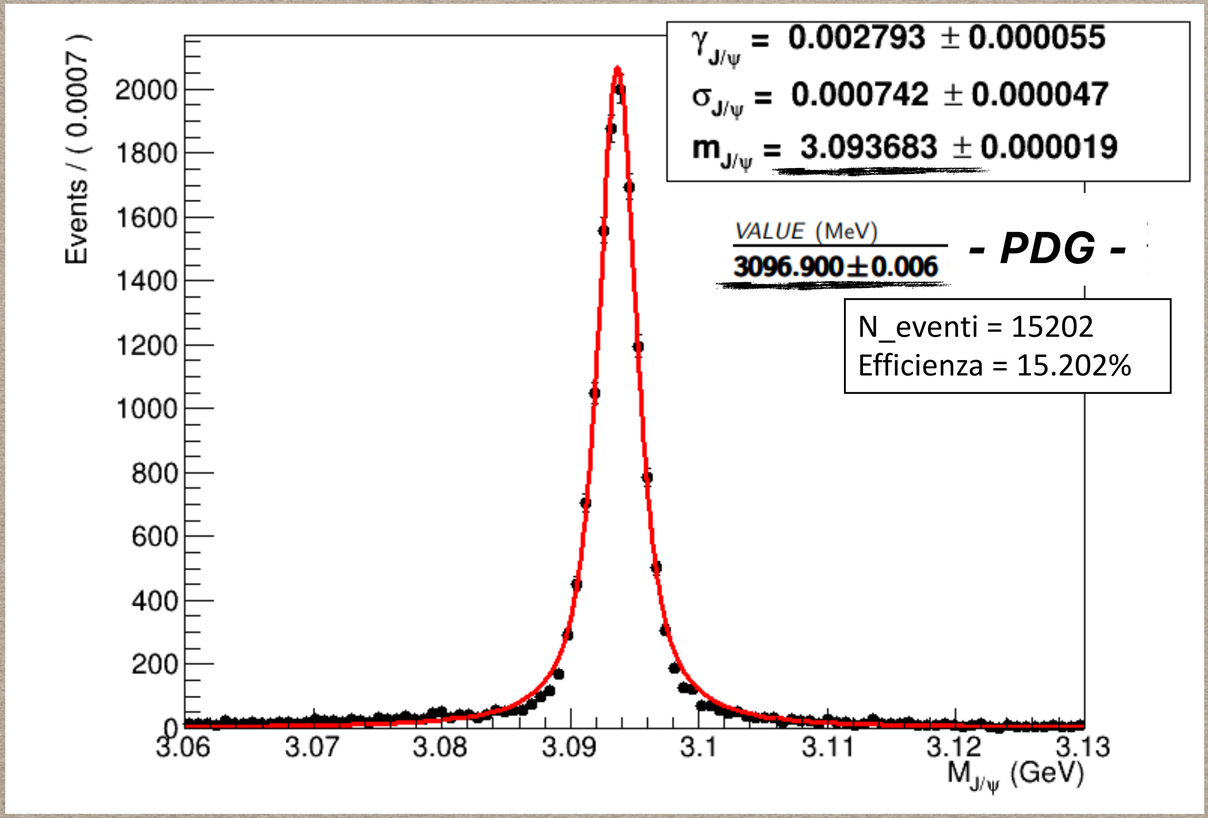
Events selection (2):

On the 6 good CT a 4C Kalman fit is applied constraining $\mathbf{p_{tot}} = (0.051, 0, 0, 4.63)$

On the events passing the 4C, a 5C Kalman fit is applied constraining also the ψ(2S) mass

FEASIBILITY STUDY

By G. Graziano



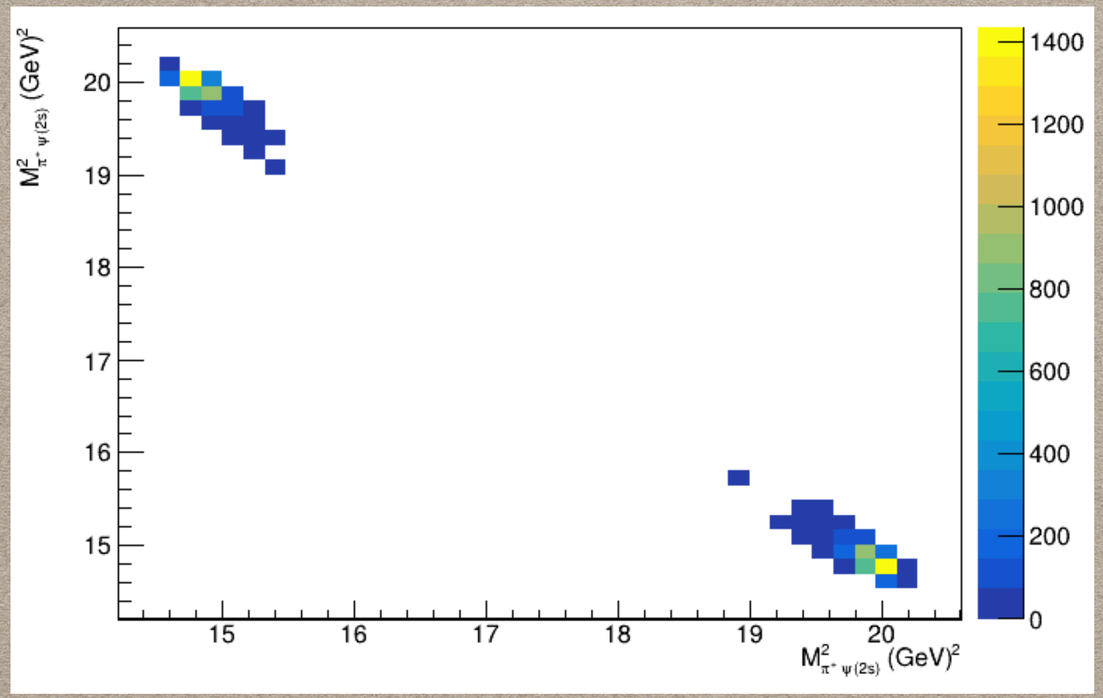
Tension on the J/ψ mass due to the difference between p_{Tot} (0.051, 0, 0, **4.63**) and the mass of the Y resonance (**4.633**)

Apart from the feature above, the fit proves the J/ψ is well reconstructed with a 15% efficiency

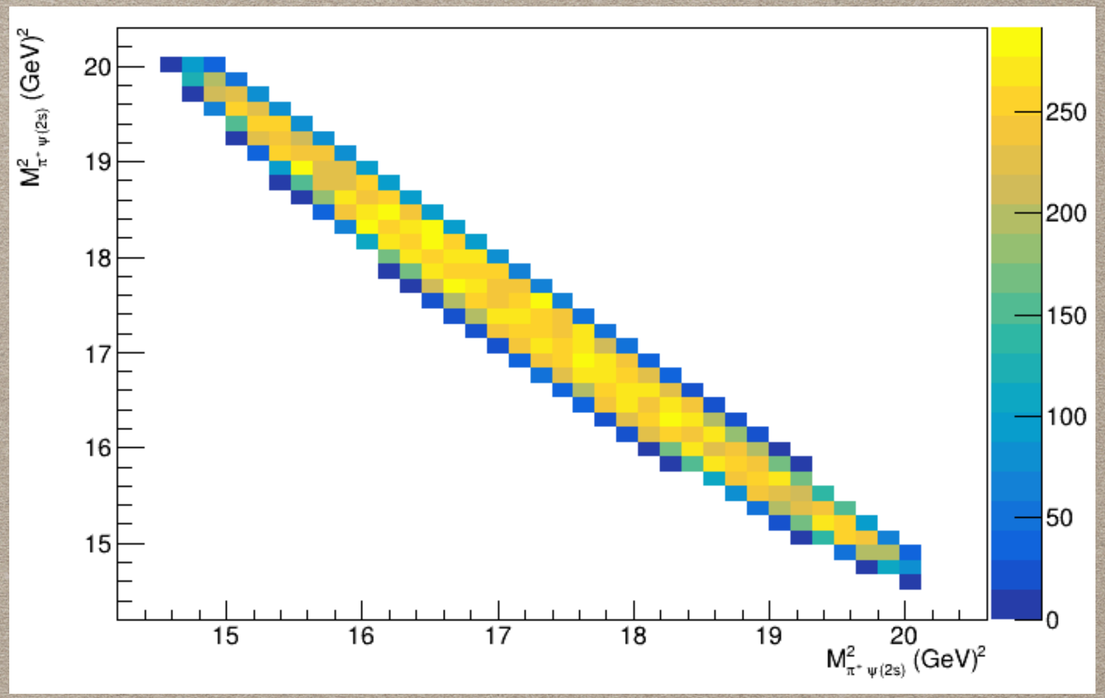
FEASIBILITY STUDY

By G. Graziano

$e^+e^- \rightarrow \psi(2S)\pi^+\pi^-$ Dalitz plots



Signal sample

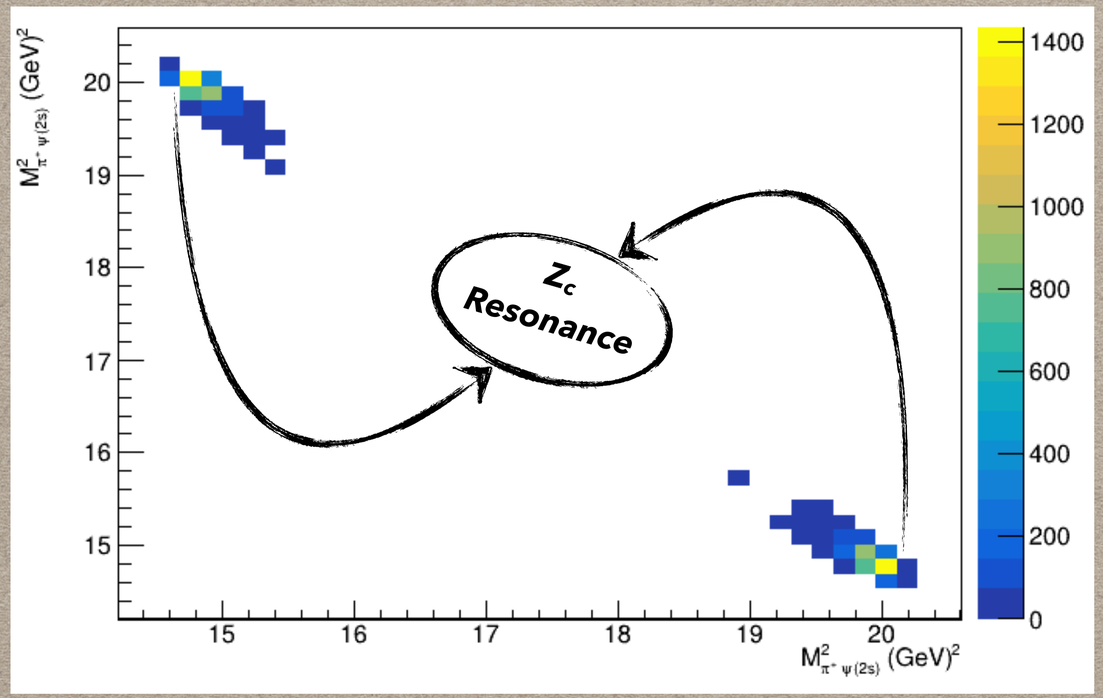


Background sample

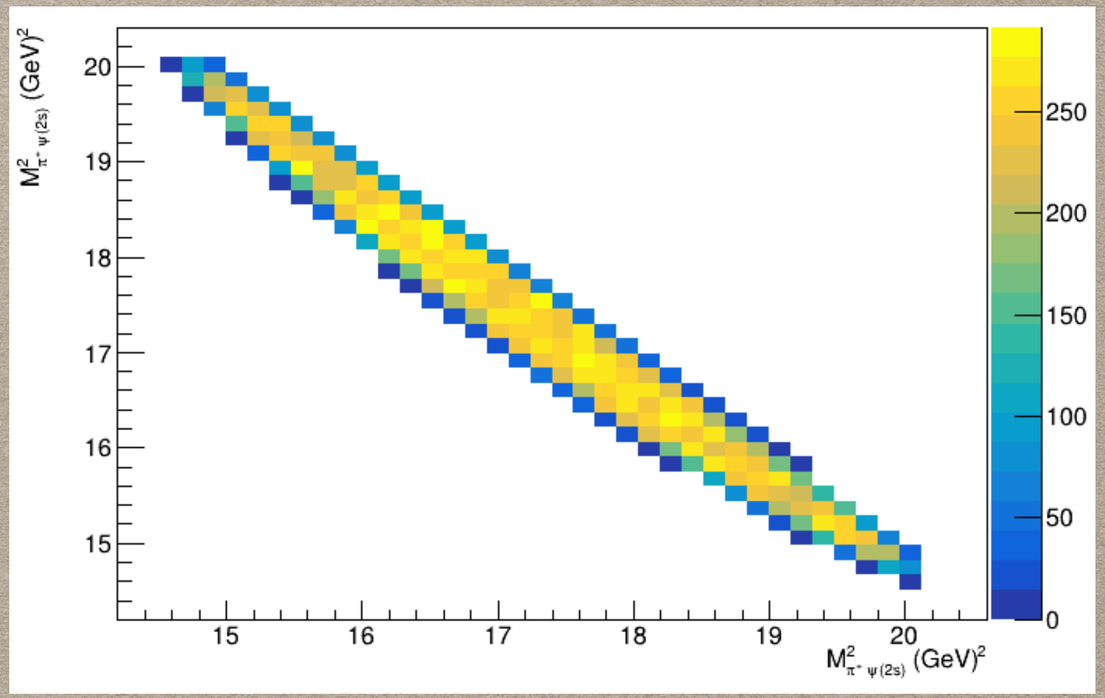
FEASIBILITY STUDY

By G. Graziano

$e^+e^- \rightarrow \psi(2S)\pi^+\pi^-$ Dalitz plots



Signal sample

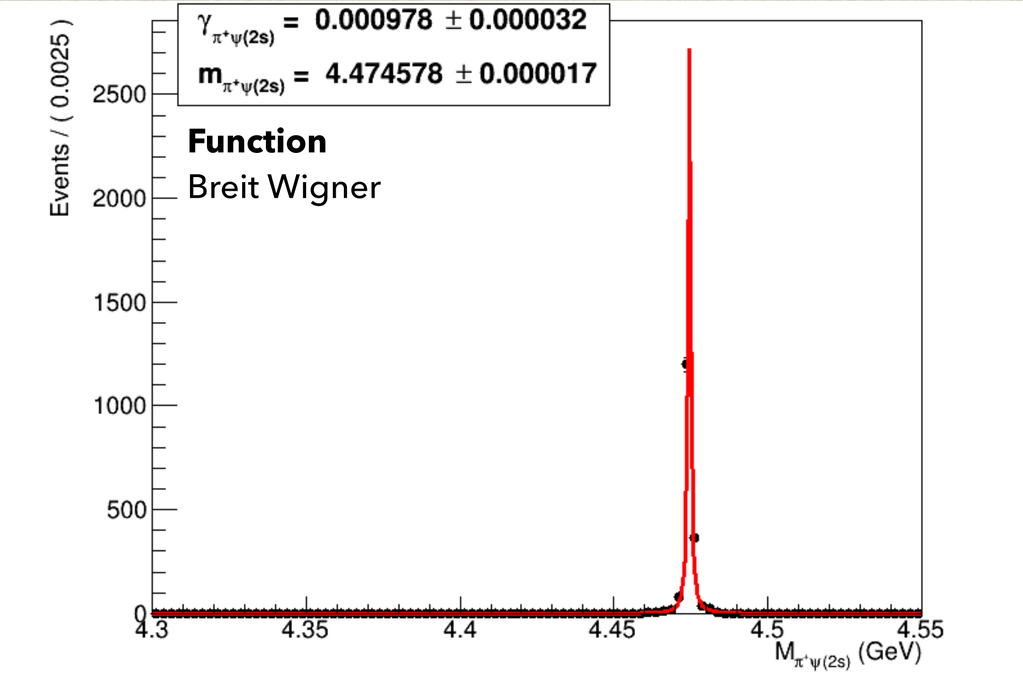


Background sample

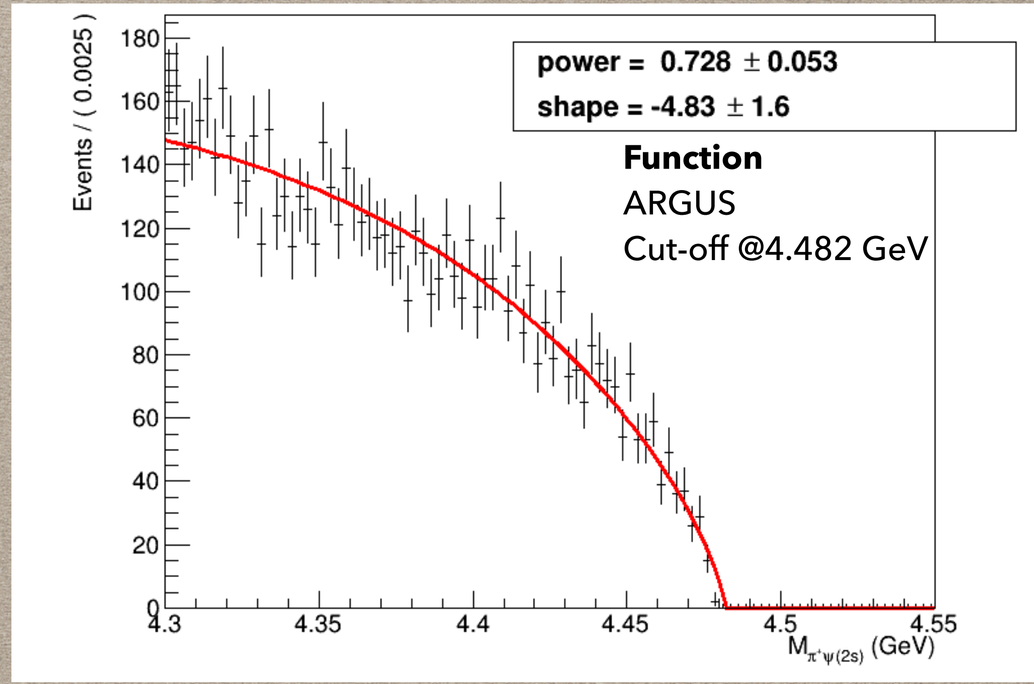
FEASIBILITY STUDY

By G. Graziano

$\pi^+\psi(2S)$ invariant mass fit



Resolution sample

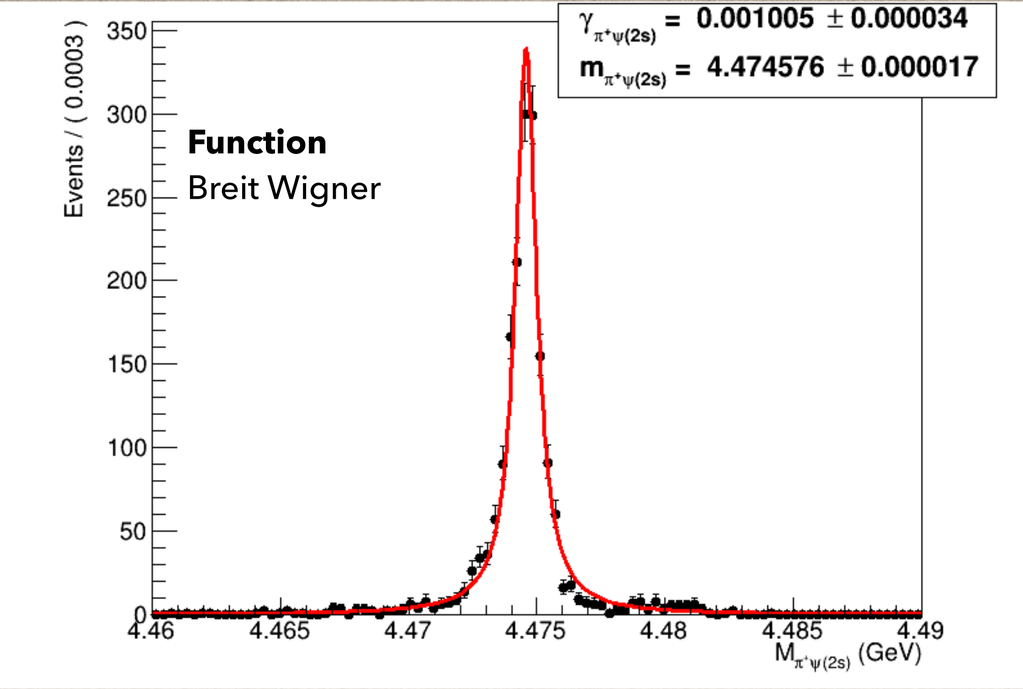


Background sample

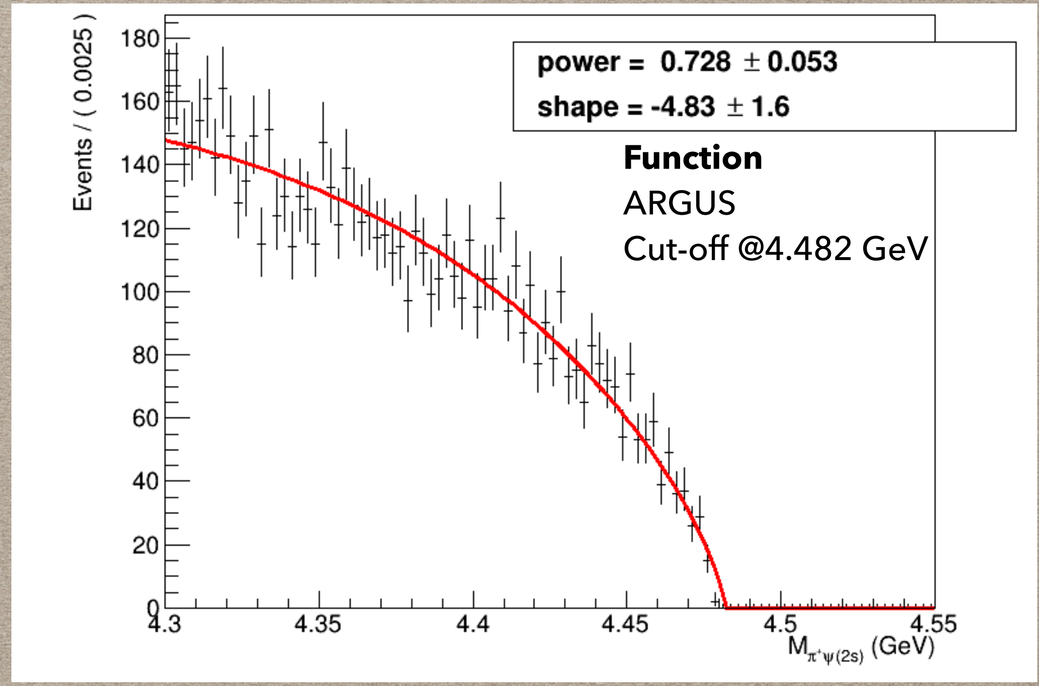
FEASIBILITY STUDY

By G. Graziano

$\pi^+\psi(2S)$ invariant mass fit



Resolution sample



Background sample

FEASIBILITY STUDY

By G. Graziano

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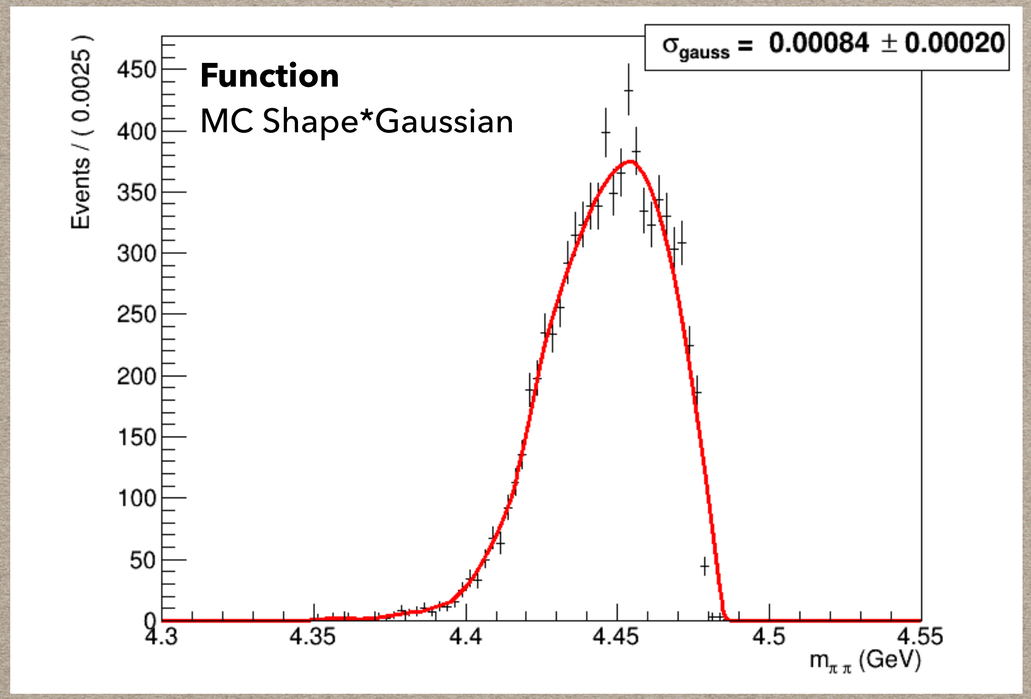
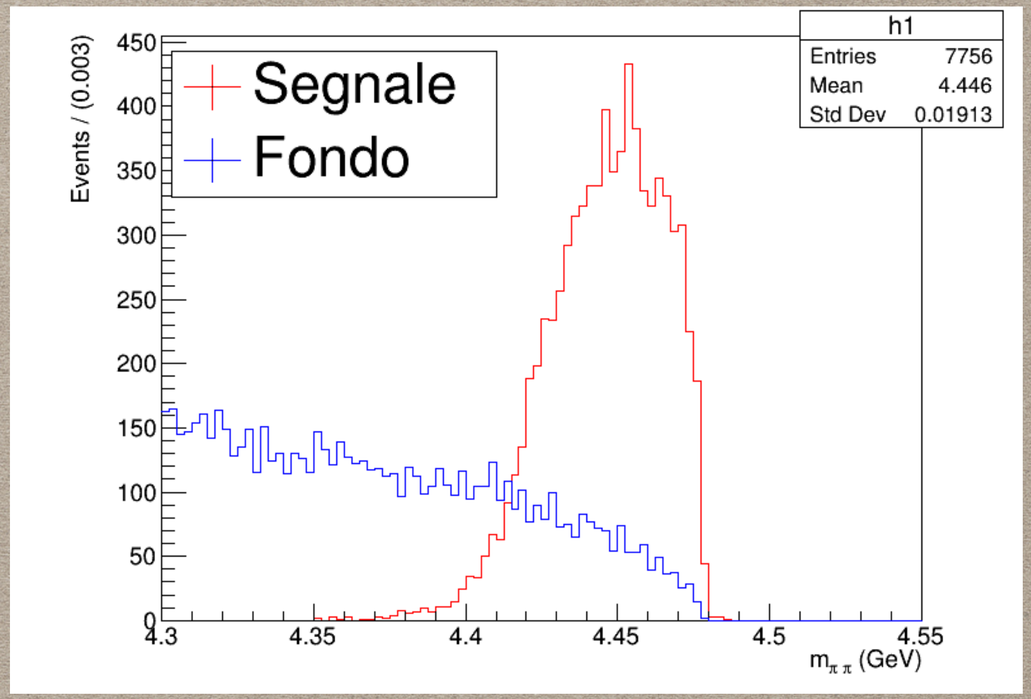


Signal sample



Sig÷Bkg comparison

FEASIBILITY STUDY

By G. Graziano

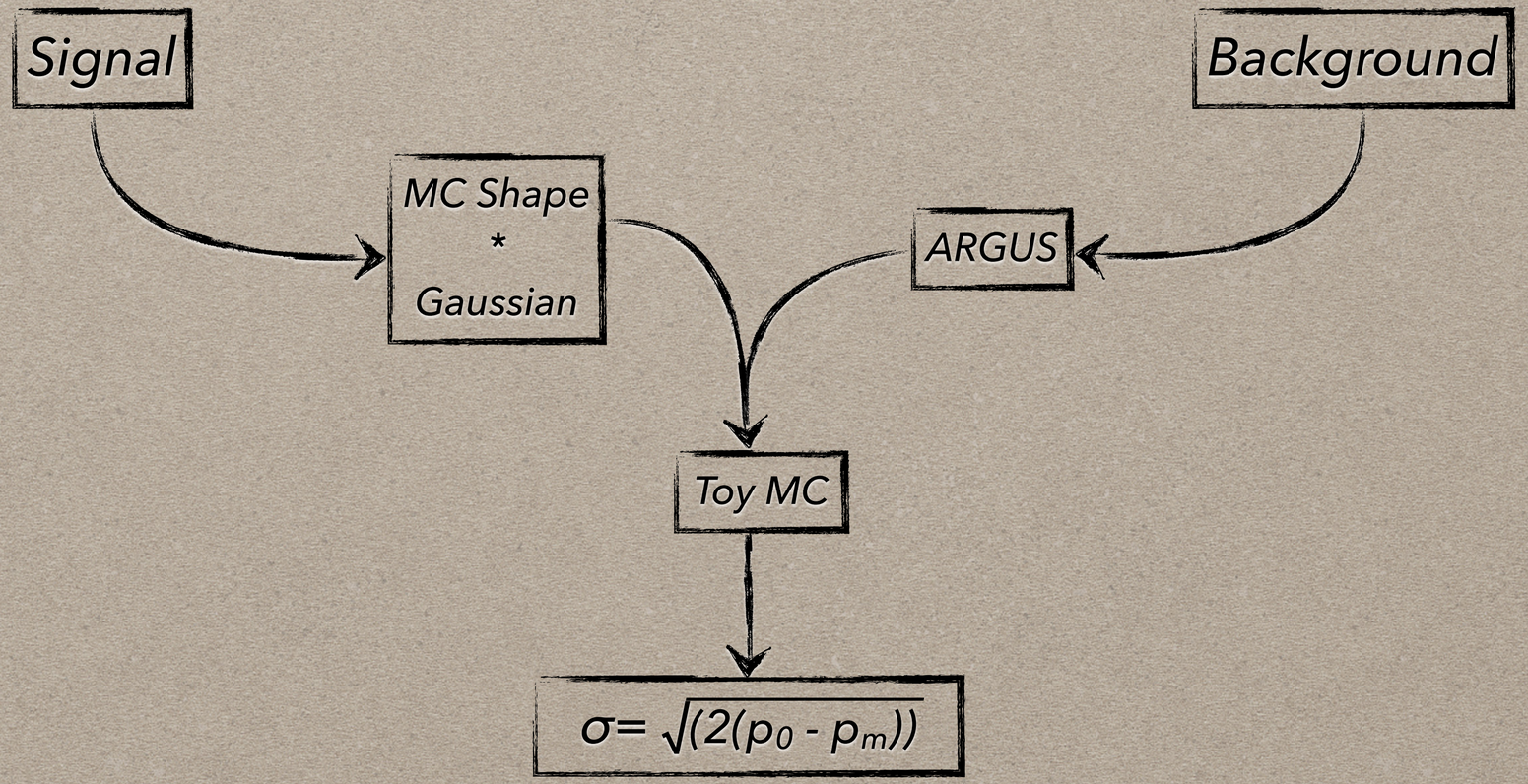
BR *x* SIGNIFICANCE

MC Sample

Fit Method

Let's merge them…

Significance

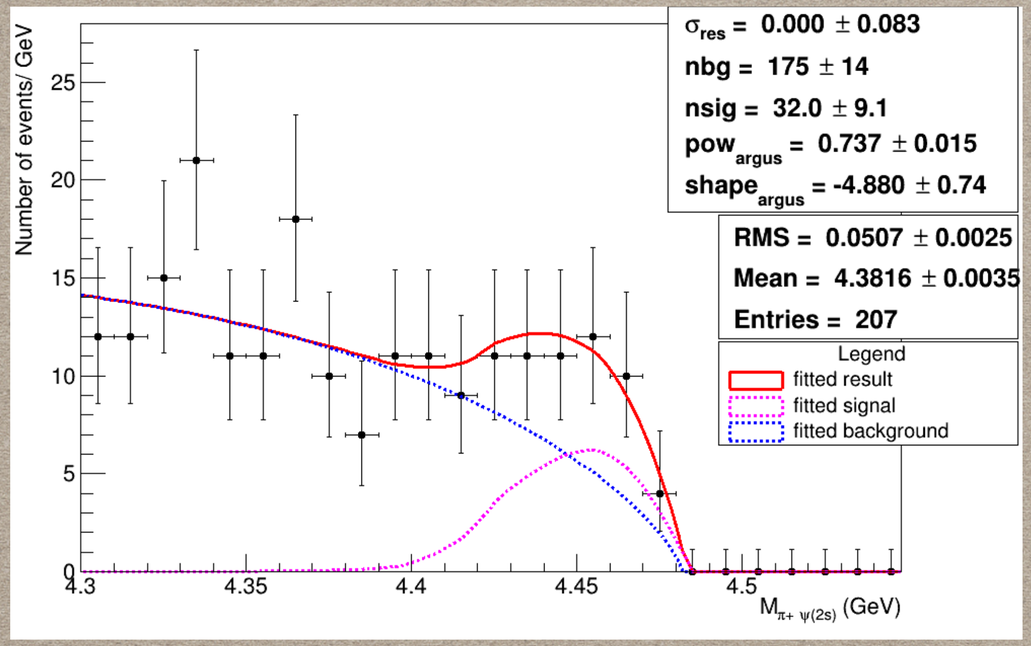


FEASIBILITY STUDY

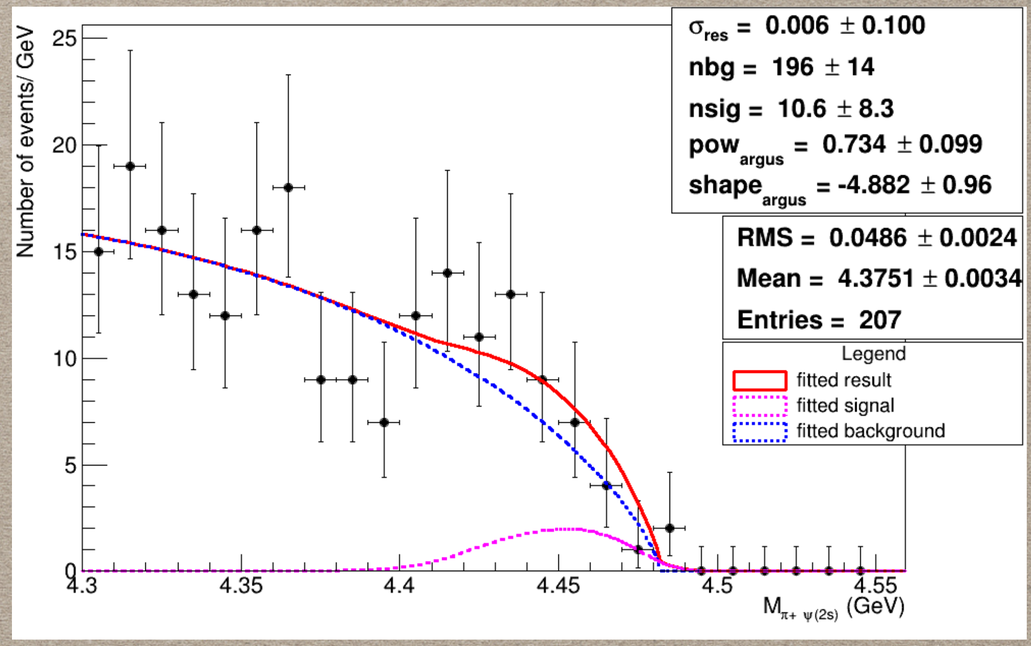
By G. Graziano

BR *x* SIGNIFICANCE

207 Events



BR 15% → 3.64σ



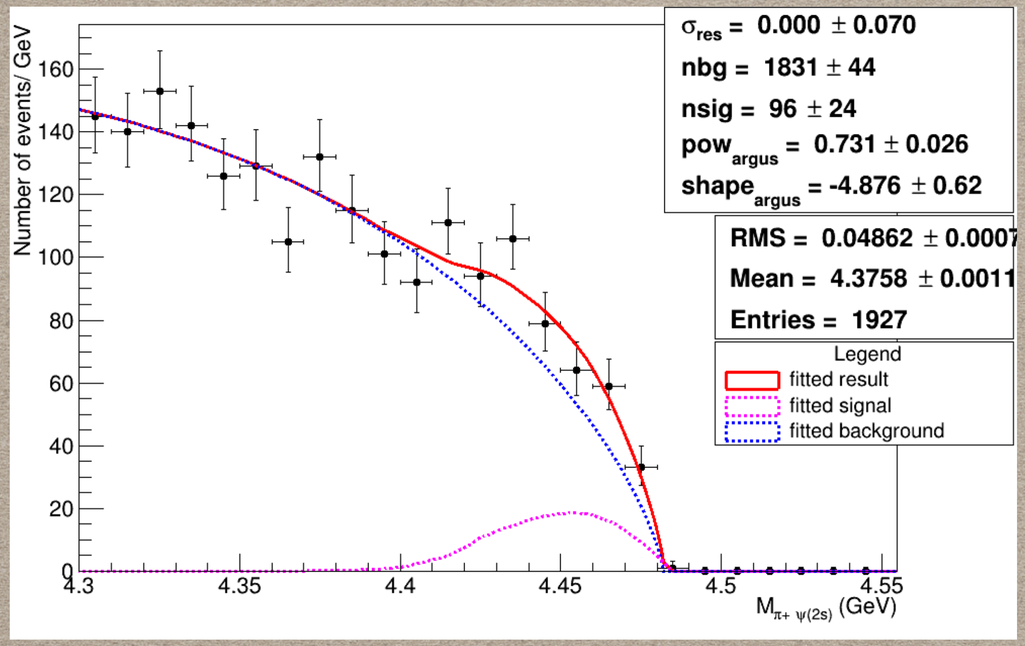
BR 5% → 1.18σ

FEASIBILITY STUDY

By G. Graziano

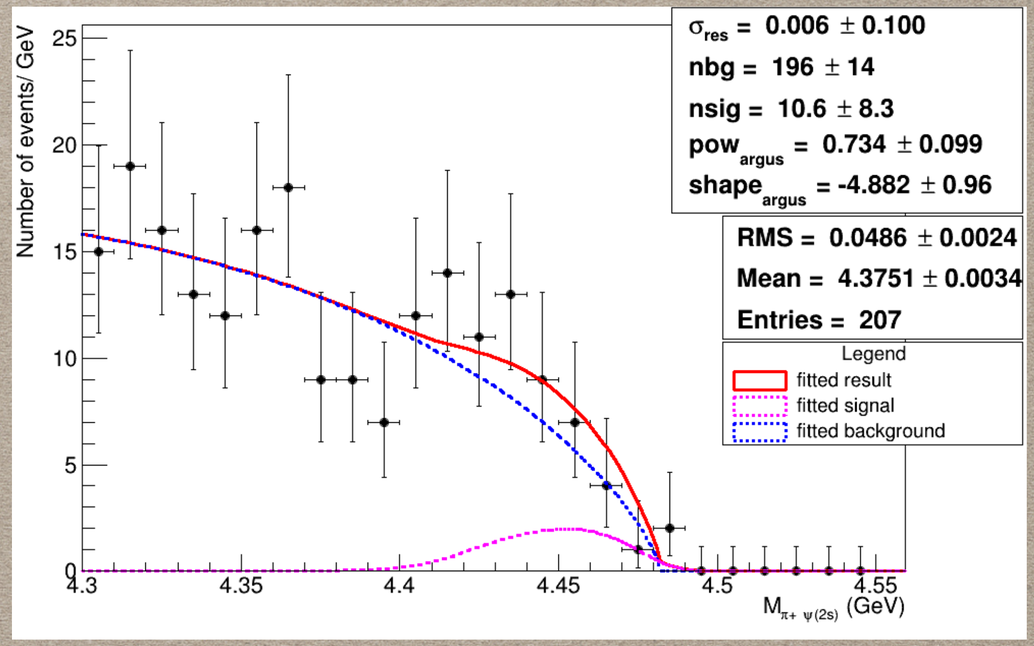
BR *x* SIGNIFICANCE

1927 Events



BR 5% → 3.85σ

7000 Events



BR 2% → 3.64σ

FEASIBILITY STUDY

By G. Graziano

BR *x* SIGNIFICANCE

Summary Table

BR	# Events for evidence	Significance [σ] BEST WORST
20%	125	3.75
15%	207	3.78
10%	487	3.70
5%	**1927**	**3.85**
2%	**7000**	**3.64**

CONCLUSIONS

Giovanni's work had important insights and results, which will be improved (if necessary) and implemented in my code

His significance study will be the lighthouse for the whole analysis

First step is to generate and study the "half-resonant" sample (i.e. with the Y and without the Z_c) - **Ongoing**

Starting from Giovanni's define robust cuts to increase efficiency and signal sensitivity- **Ongoing**

Many Thanks

For

Your Attention