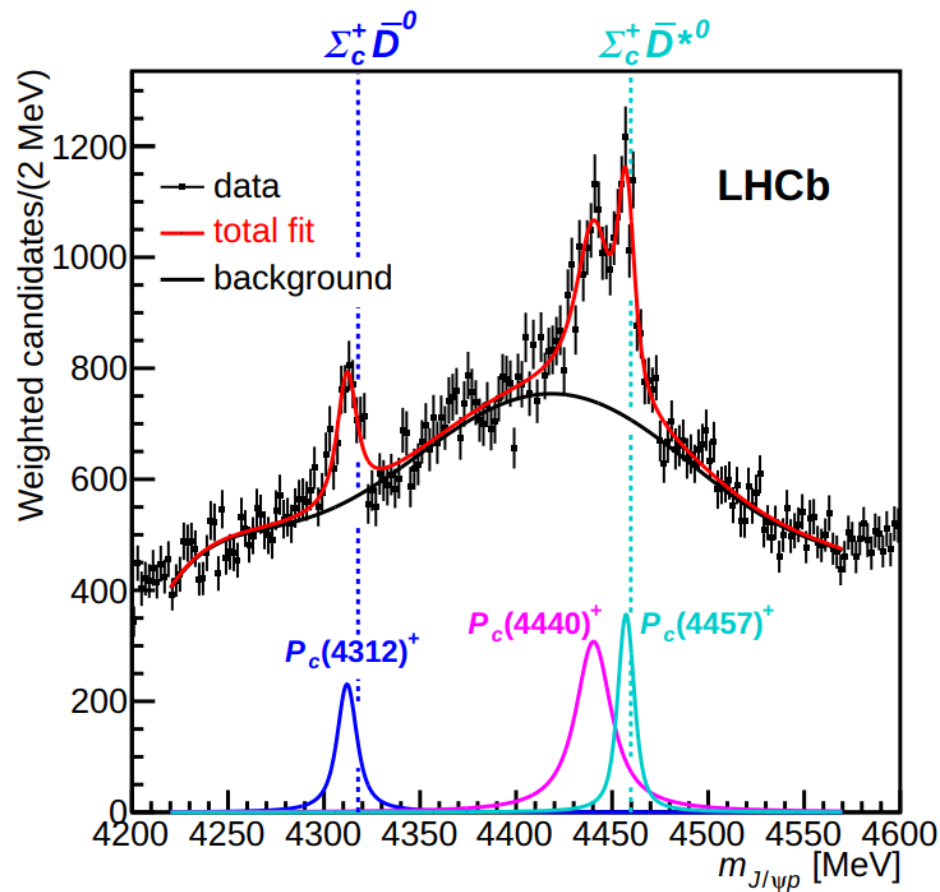


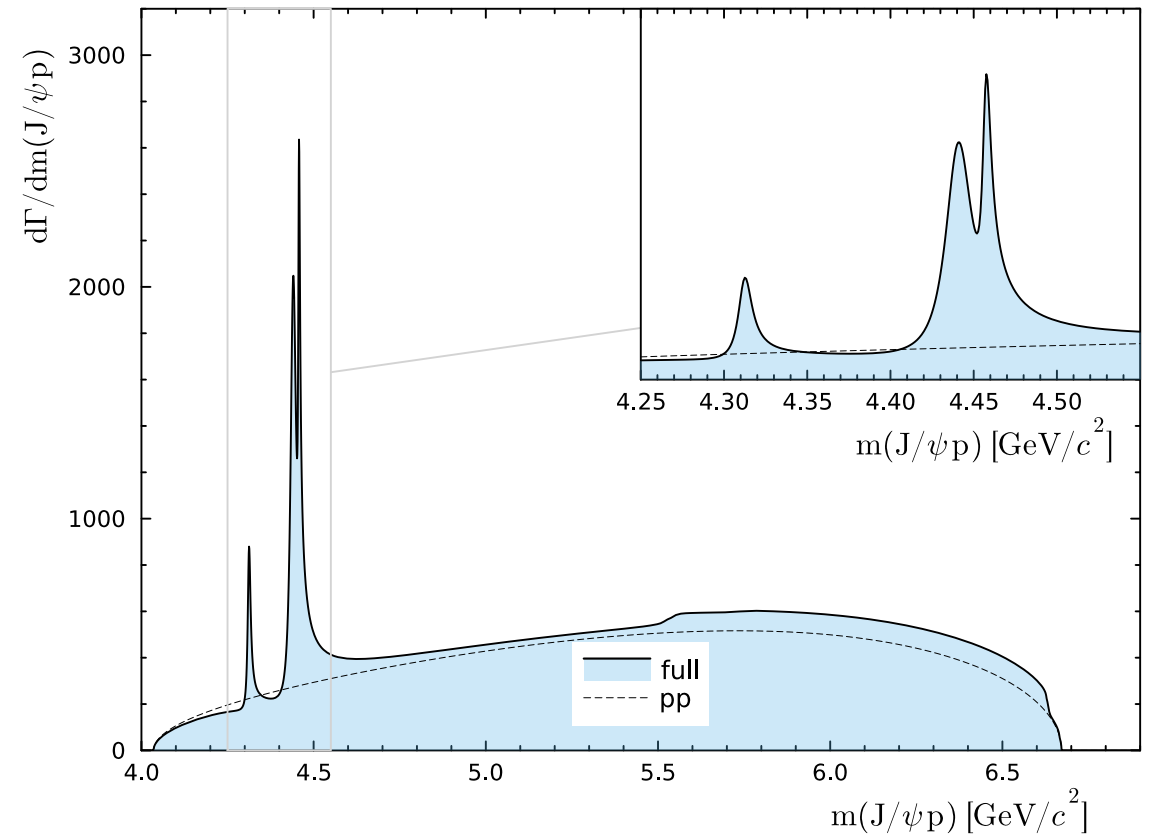
Feasibility Studies for hidden-charm Pentaquark searches

R. Kliemt, S. Roy

3 Pentaquarks Model



[<https://doi.org/10.1103/PhysRevLett.122.222001>]

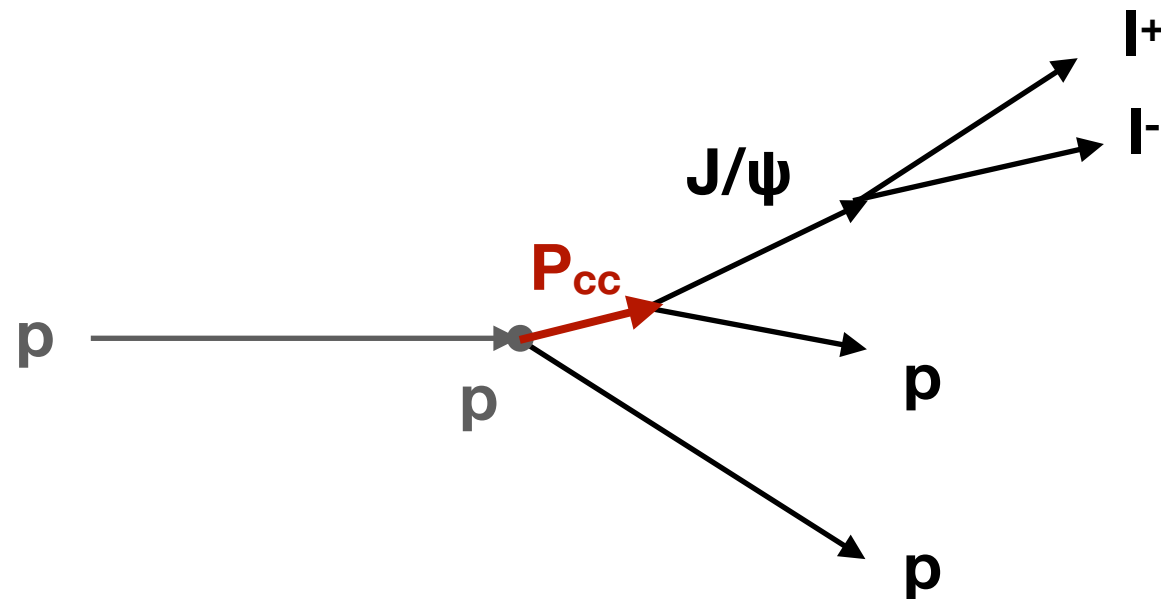


[<https://github.com/mmikhasenko/FairSim.jl.git>]

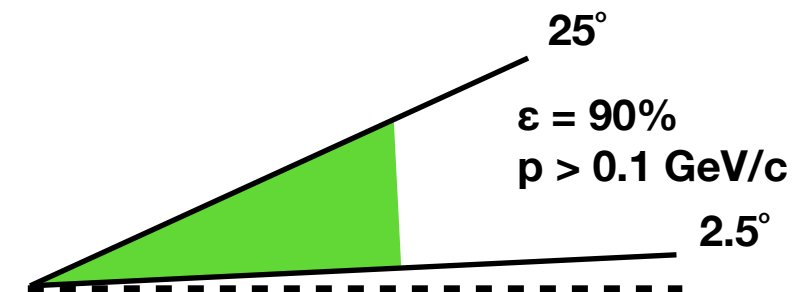
- Model from LHCb measurements (Misha Mikhasenko)
- Contains 3 Breit-Witgner resonances plus a PHSP component

masses	4.312	4.440	4.457
widths	0.01	0.02	0.006
couplings	0.1	0.35	0.08

$pp \rightarrow p p J/\psi \rightarrow p p l^+ l^-$



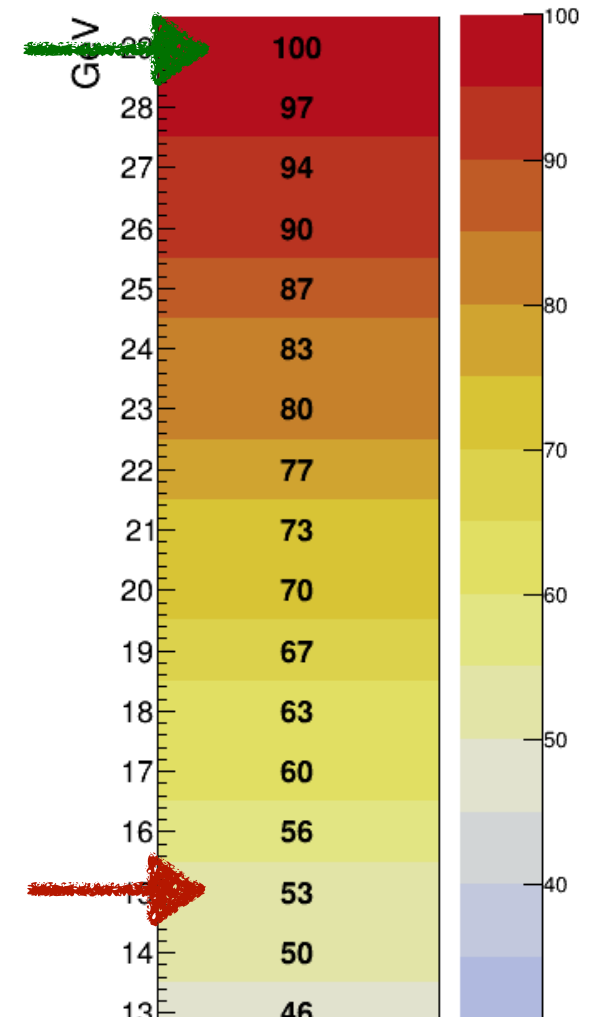
- threshold: $\sqrt{s} \geq 4.97346 \text{ GeV}$
 $T \geq 12.2070 \text{ GeV}$



- Expected Acceptance (Pluto): $\sim 18\%$
- 15, 20, 25 and 29 GeV, focus on 29 GeV
- e^+e^- (and $\mu^+\mu^-$) channels

Simulation chain

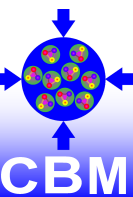
- CbmRoot Release jul24
- Virgo cluster: vae23.hpc (Debian10)
- json configuration files & production macros
- Pluto or Model input
- Simulation, digitization & reconstruction
 - `sis100_electron` & `sis100_muon_jpsi` settings
 - Magnetic field scaling
 - New hydrogen target
- Analysis with ntuple output
- Resonance extraction



Liquid Hydrogen Target

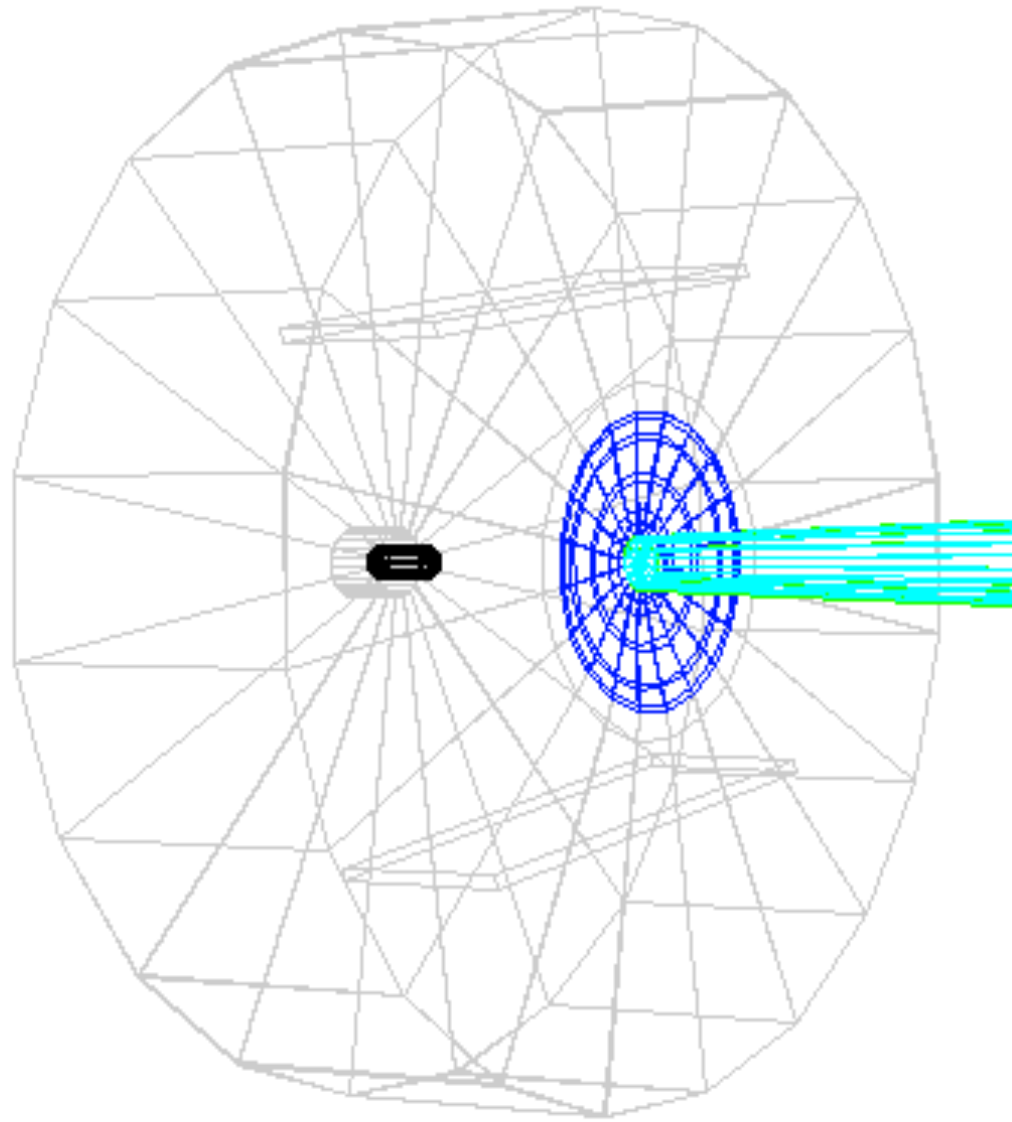
- Merge Request [!1869](#)
- Adds default hydrogen target density (CbmTarget)
- Add support to pass custom densities (CbmTransport, CbmTransportConfig)
- Actual settings in the json config:

```
"target": {  
  "material": "H",  
  "thickness": 5.0,  
  "diameter": 2.5,  
  "position": {  
    "x": 0.0,  
    "y": 0.0,  
    "z": -44.0  
  },  
  "rotation.y": 0.0,  
  "density": 0.07085  
},
```

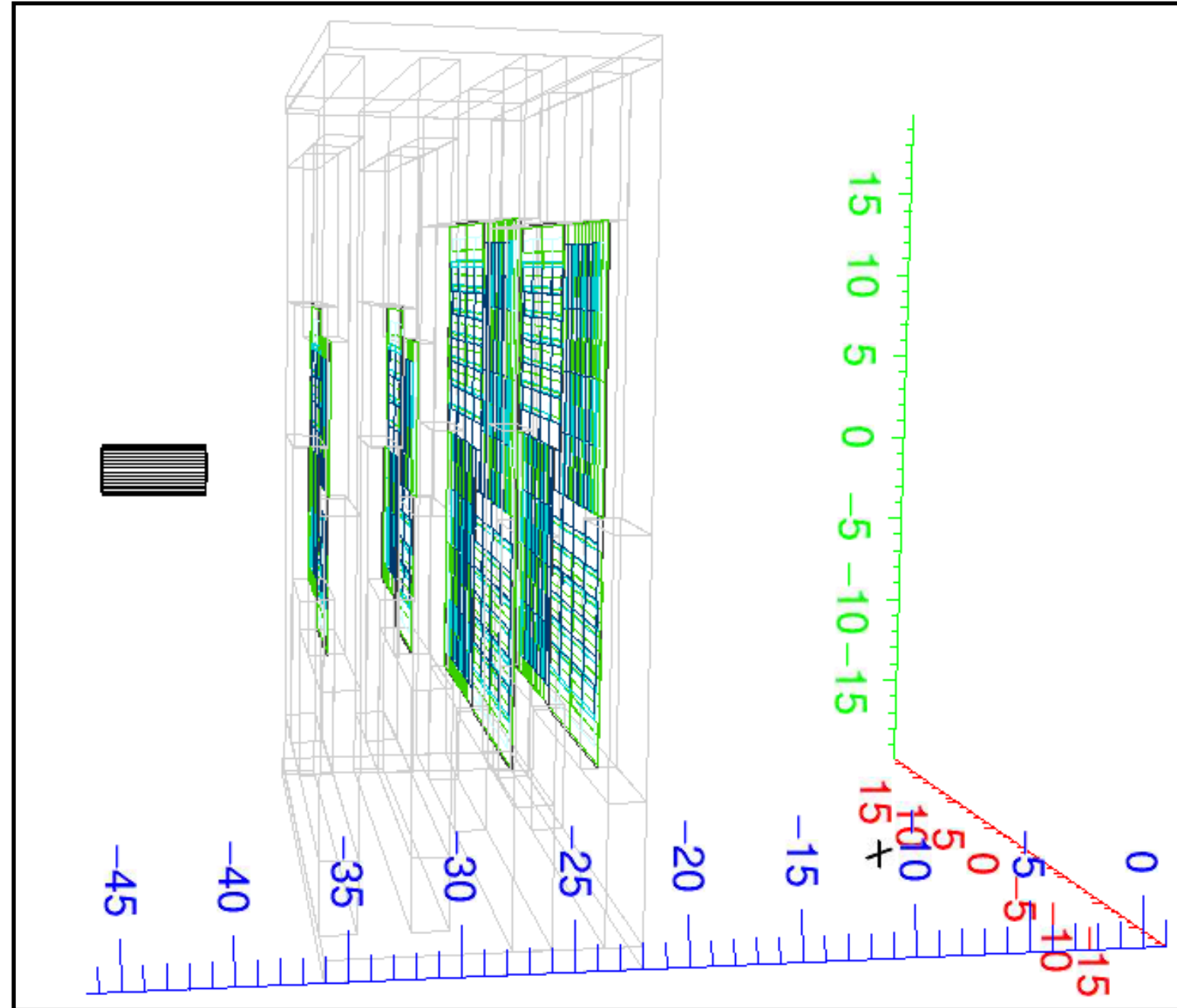


Geometry of the LH Target

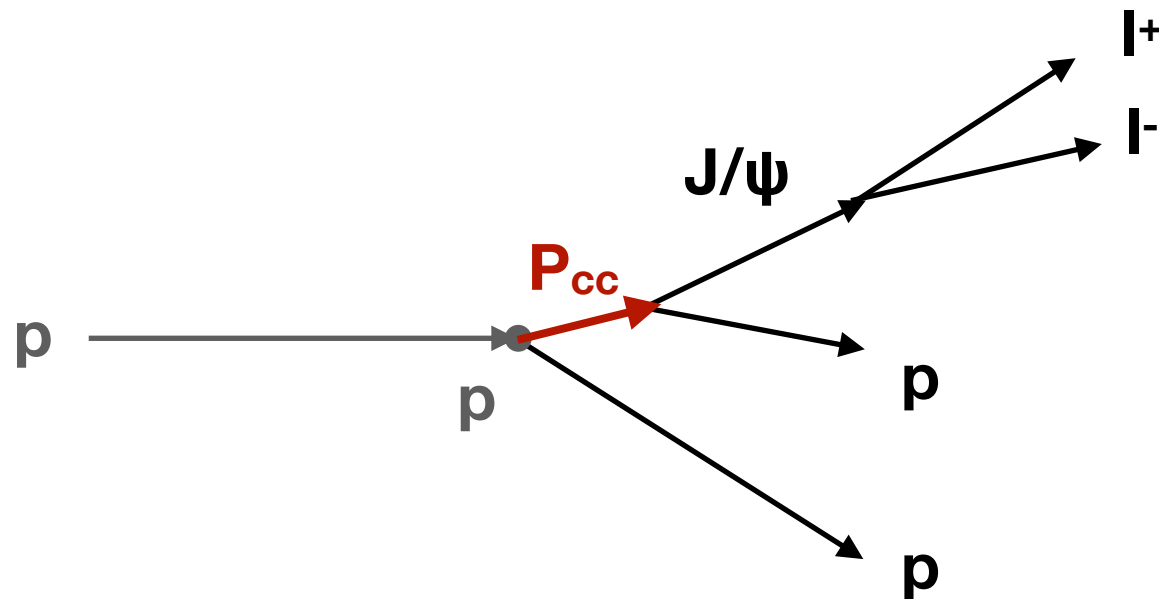
(black)



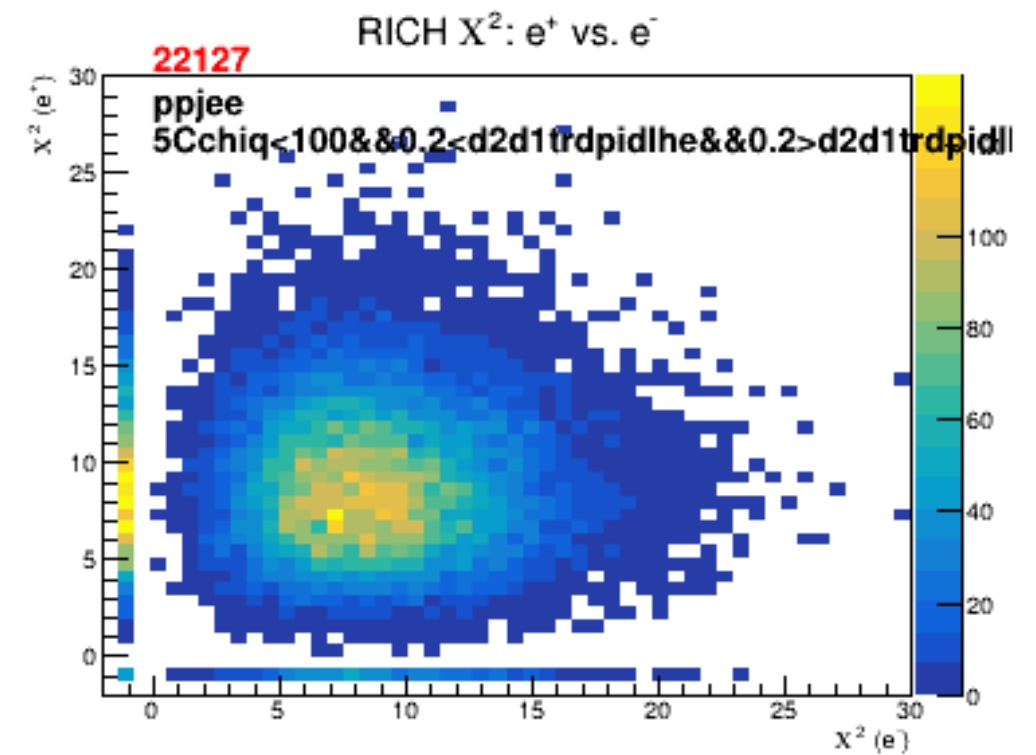
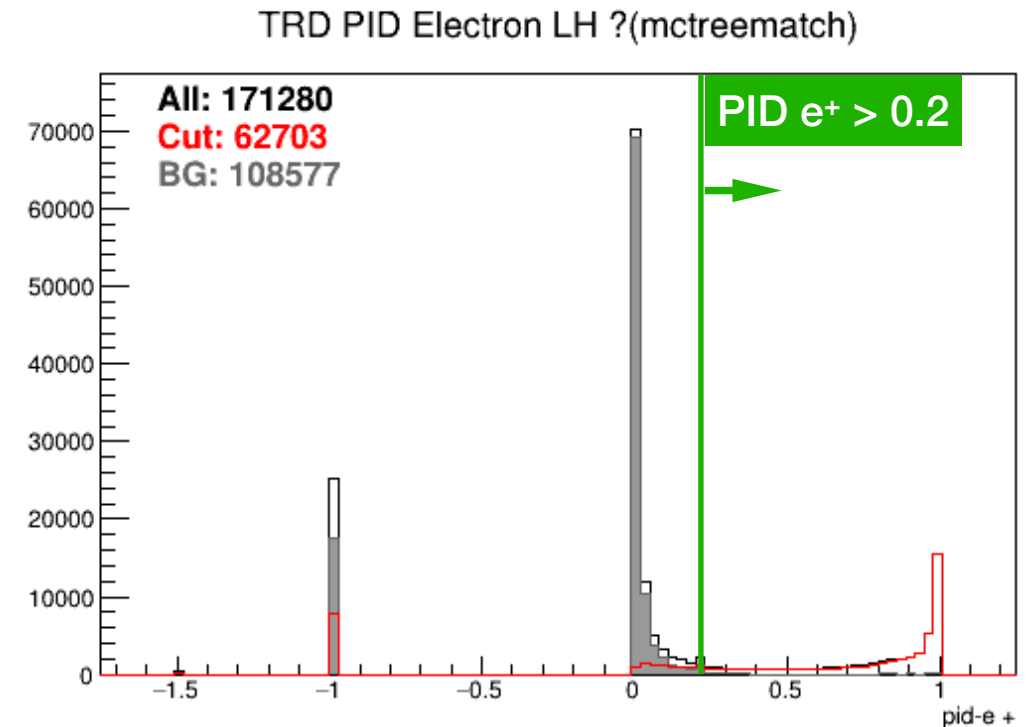
Volume “pipe*/pipevac1_0/Target”



Analysis



- Lepton PID & pion veto
- **Combinatorics loop**
- **$l^+ l^-$ composite (J/ψ)** candidate: mass in $(1.5, 4.5)$ GeV/c^2
- (4C Kinematic fit)
- **5C Kinematic fit:**
 - 4C beam-target
 - 1C J/ψ mass
- Store exclusive candidate with best χ^2 , ($\chi^2 < 1000$)

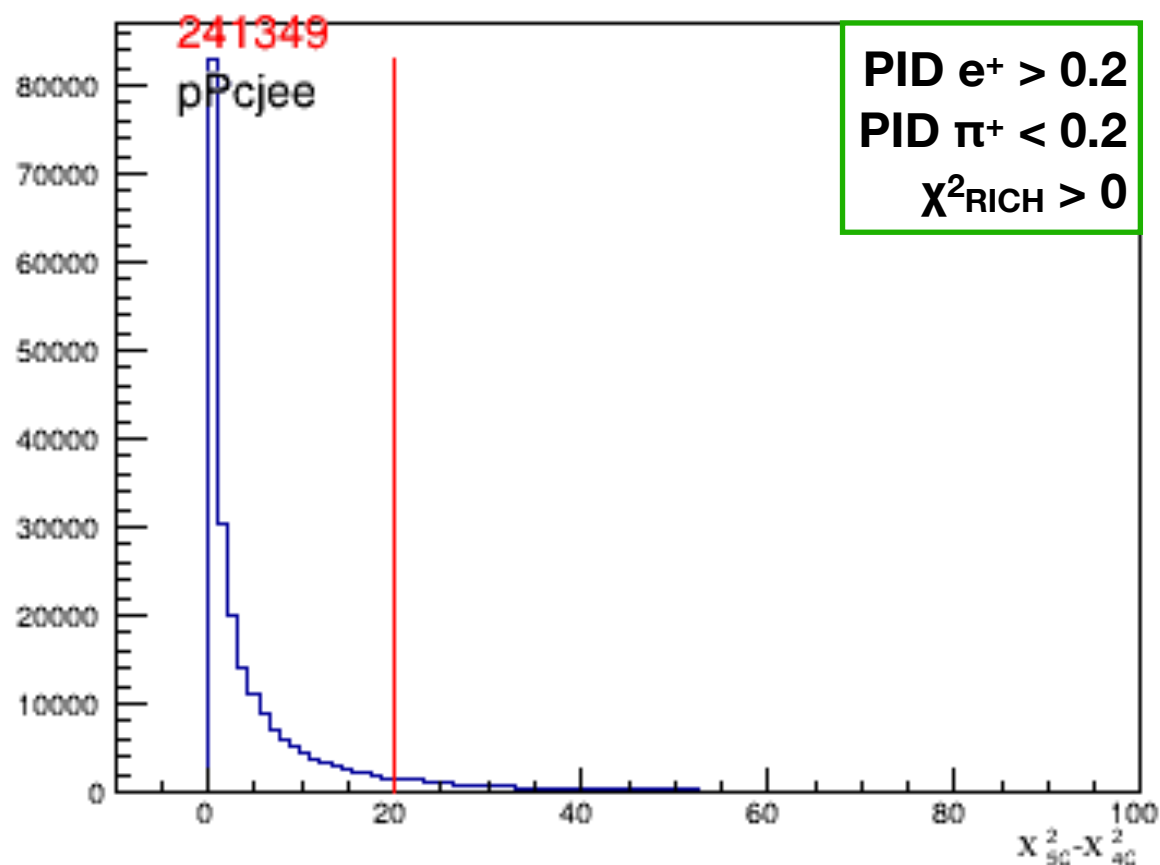


Kinematic fit

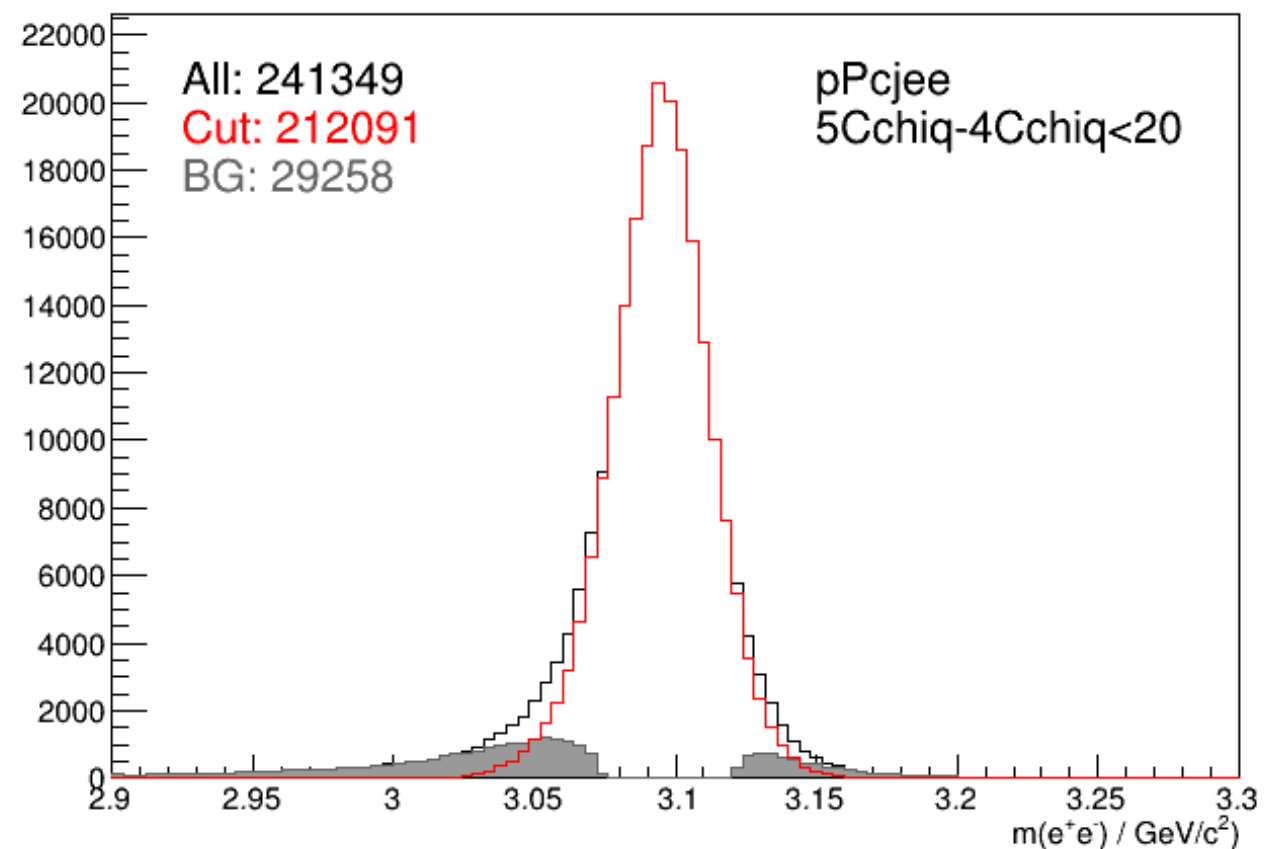
[KinFit: <https://link.springer.com/article/10.1007/s41781-023-00112-x>]
<https://github.com/KinFit/KinFit>

- 2 Fits: 4C & 5C
- Cut on difference in χ^2 : approx. Mass constraint on J/ ψ
—> soft J/ ψ mass cut

5C-4C fit quality



J/ ψ candidate mass



Signal & BG Efficiency: p p J/ψ

Preliminary	15 GeV	20 GeV	25 GeV	29 GeV
p p J/ψ (ee)	22.5 %	24.4 %	22.7 %	21.2 %
p p e ⁺ e ⁻	0.084 %	0.33 %	0.50 %	0.54 %
p p π ⁺ π ⁻	0.0002 %	0.0021 %	0.0007 %	0.0009 %
p p π ⁺ π ⁻ π ⁰	< 1e-6	0.0008 %	0.0005 %	0.0005 %
p p π ⁺ π ⁻ π ⁺ π ⁻	< 1e-6	< 1e-6	< 1e-6	< 1e-6
FTF	0.0006 %	0.0006 %	0.0006 %	0.0006 %

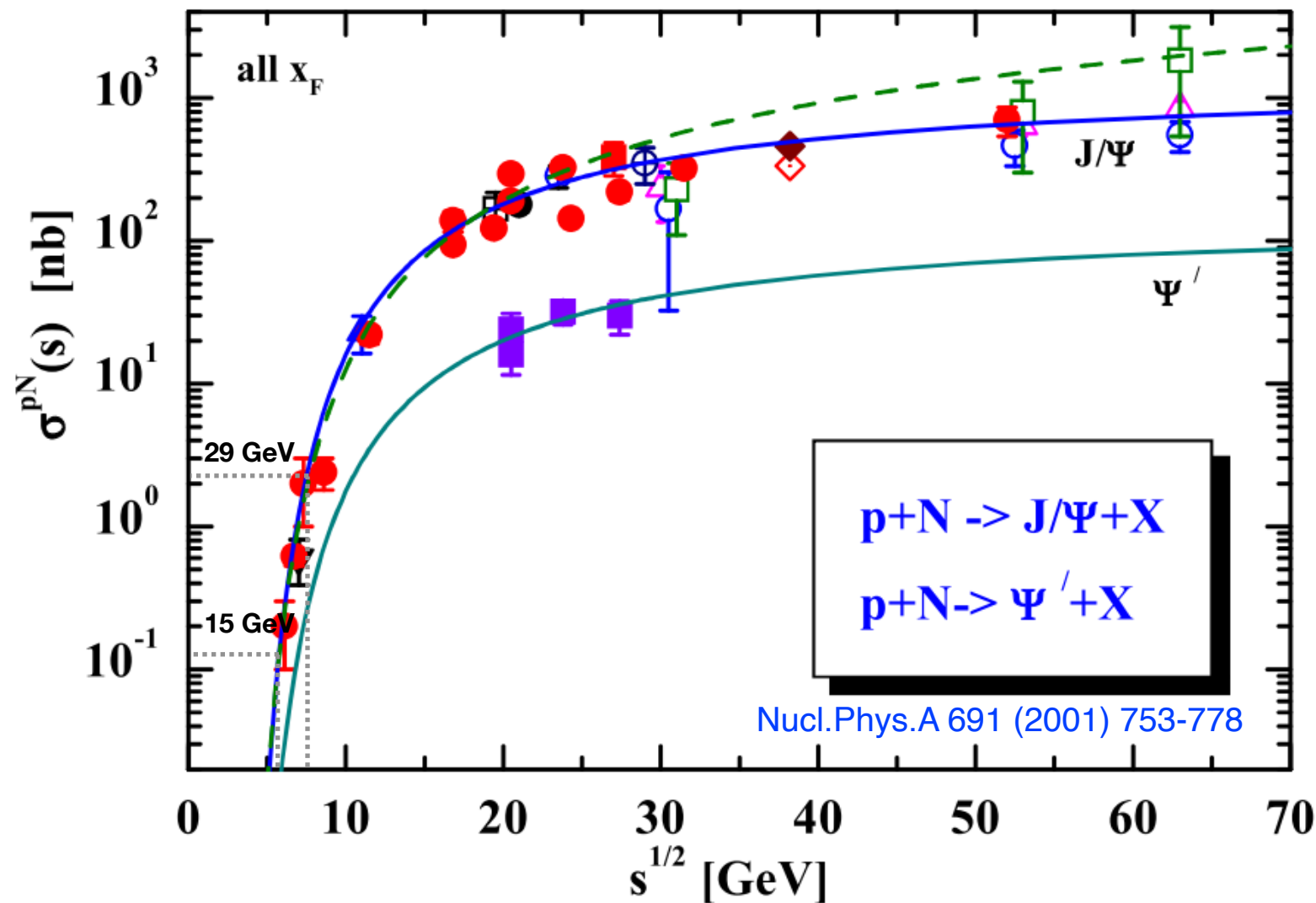
$\chi^2_{5C}-\chi^2_{4C} < 20$
PID e⁺ > 0.2
PID π⁺ < 0.2
 $\chi^2_{RICH} > 0$

Preliminary	15 GeV	20 GeV	25 GeV	29 GeV
p p J/ψ (μμ)	22.3 %	28.0 %	27.1 %	25.8 %
p p μ ⁺ μ ⁻	0.11 %	0.44 %	0.66 %	0.73 %
p p π ⁺ π ⁻	0.0007 %	0.0039 %	0.0051 %	0.0053 %
p p π ⁺ π ⁻ π ⁰	< 1e-6	0.0008 %	0.0005 %	0.0013 %
p p π ⁺ π ⁻ π ⁺ π ⁻	< 1e-6	0.0006 %	0.0003 %	0.0080 %
FTF	0.0008 %	0.0008 %	0.0008 %	0.0008 %

$\chi^2_{5C}-\chi^2_{4C} < 20$
μ⁺ ndf > 10

* background with max. field

Cross section estimate



$$\sigma \approx 1 \text{ nb}$$

10^{15} protons on target per day

~ 1300 $pp \rightarrow ppJ/\psi$ exclusive events/d detected

[CERN-HERA 84]

$p p \pi^+ \pi^-$

$\approx 1.6 \text{ mb}$ #391

$p p \pi^+ \pi^- \pi^0$

$\approx 1.7 \text{ mb}$ #385

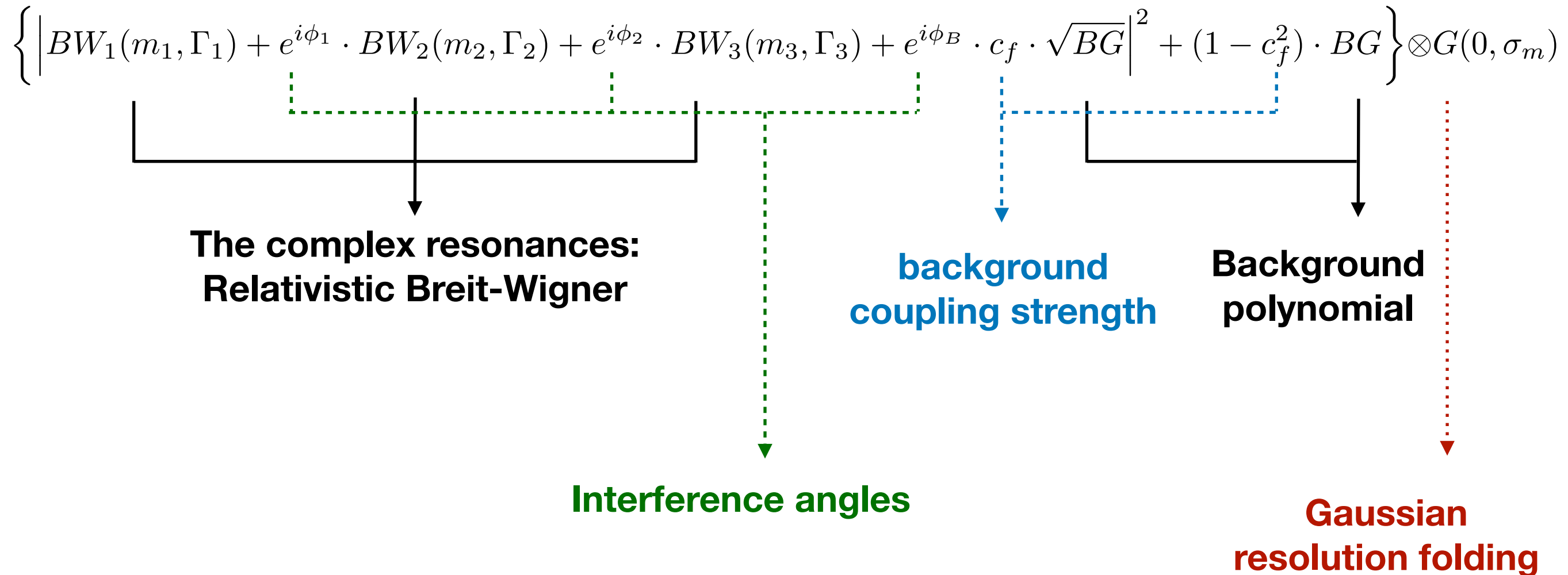
$p p \pi^+ \pi^- \pi^+ \pi^-$

$\approx 0.4 \text{ mb}$ #403

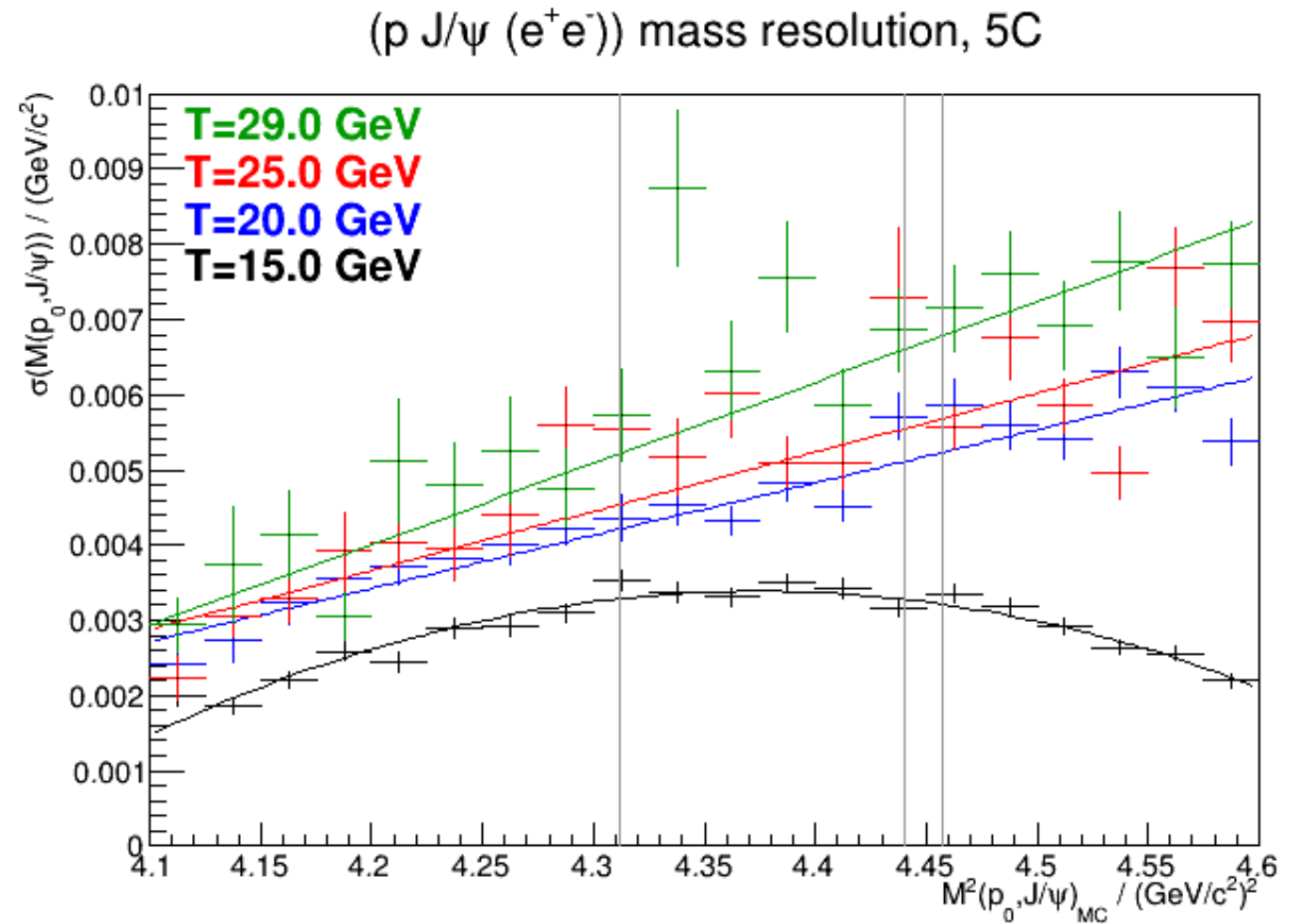
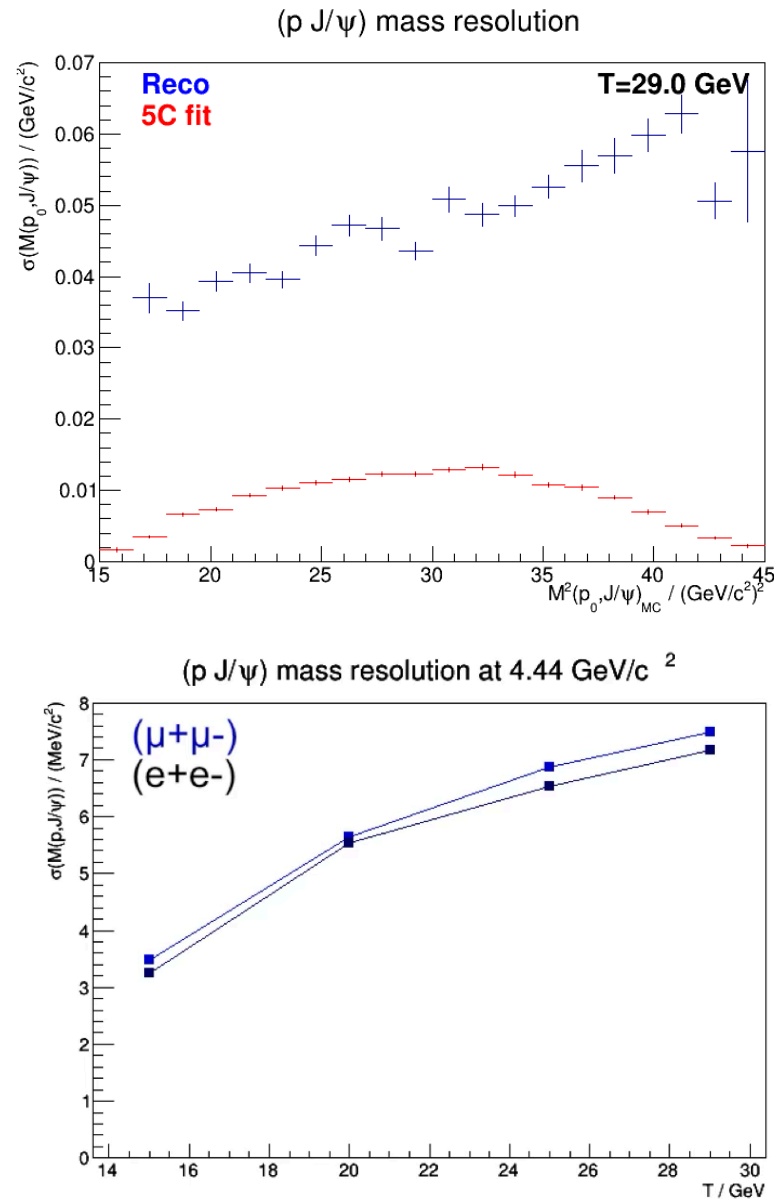
Background $O(10^6)$ larger cross section
More simulations & tighter cuts needed

Coherent Resonance Fits

(3 BW + Cheb4)*Gs

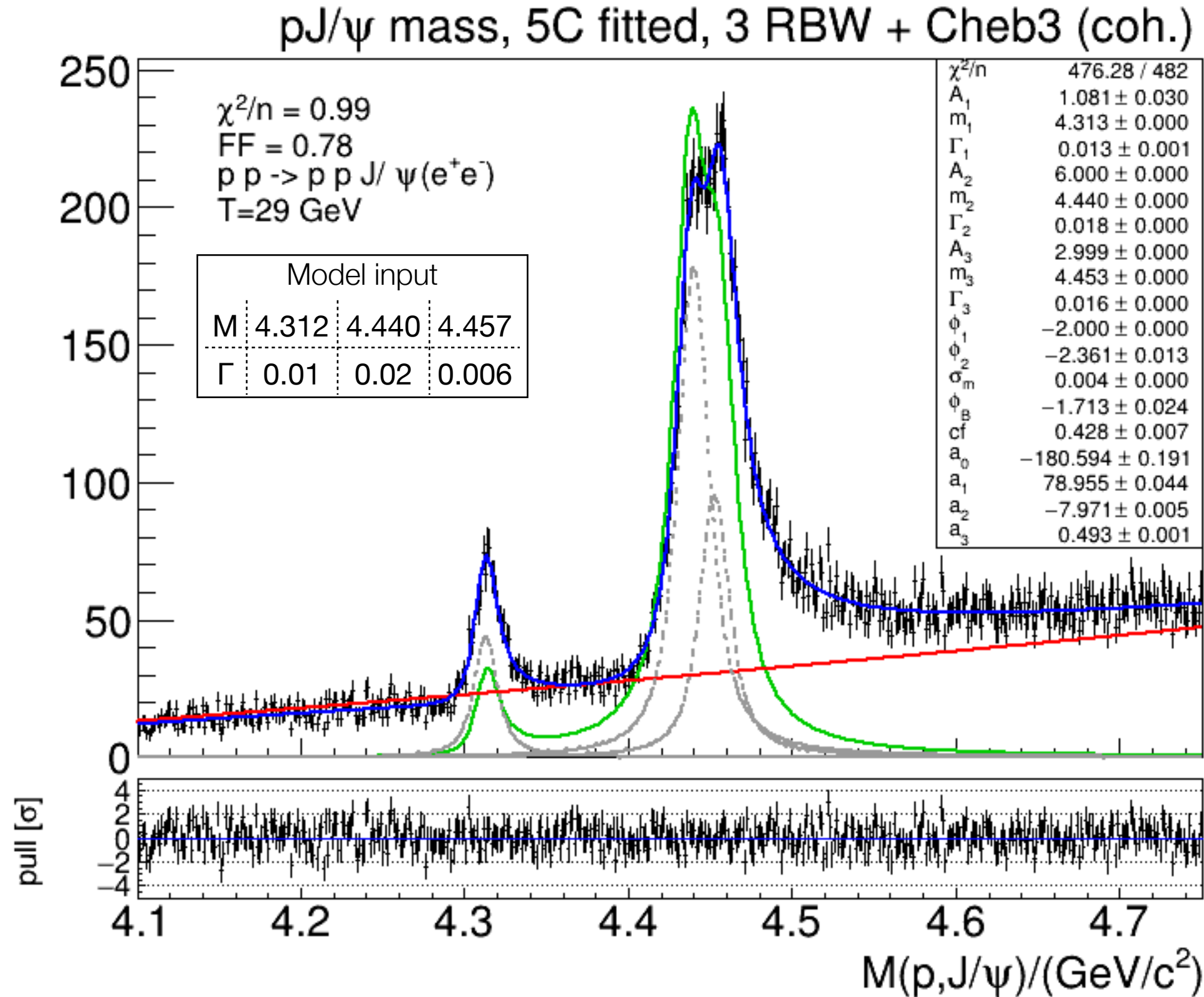


Resolution profile



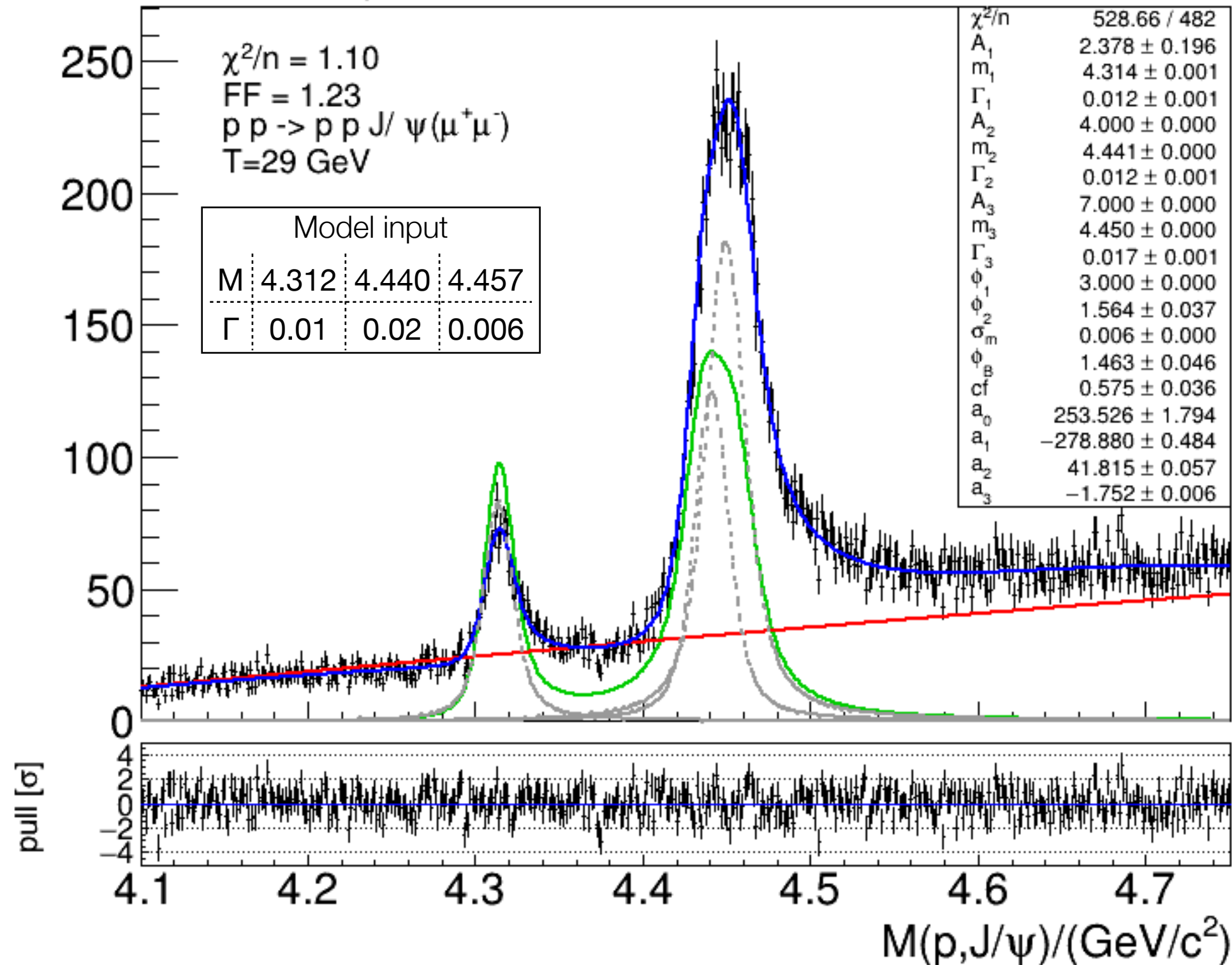
- Resolution best at 15 GeV
- Using linear trend in region of interest at 29 GeV

Electron Channel (ca. 100 days)



Muon Channel

pJ/ψ mass, 5C fitted, 3 RBW + Cheb3 (coh.)



Summary

- Hidden charm Pentaquark searches seem feasible
- Good acceptance, great resolution
- Electron and muon channel are similar
- Beam energy: tradeoff between statistics and resolution

Open points

- Detailed background estimate needed: lots of events!
 - > HepFastSim, Pluto filtering
- Systematics