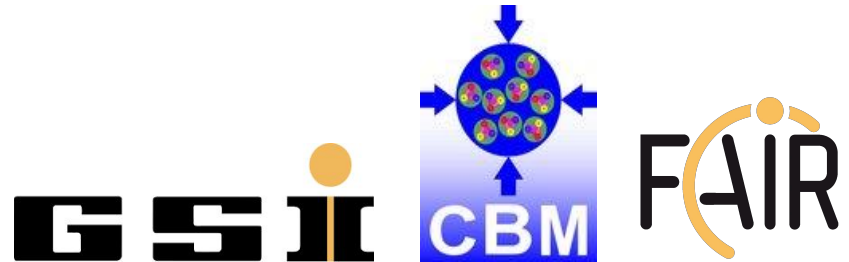


QCD@FAIR Workshop 2024, 13 November
- Simulation Chapter 9 session

Simulation of $pp \rightarrow pp J/\psi (\mu^+\mu^-)$ with CbmRoot

Shreya Roy



Outline

Motivation for $pp \rightarrow pp J\psi$

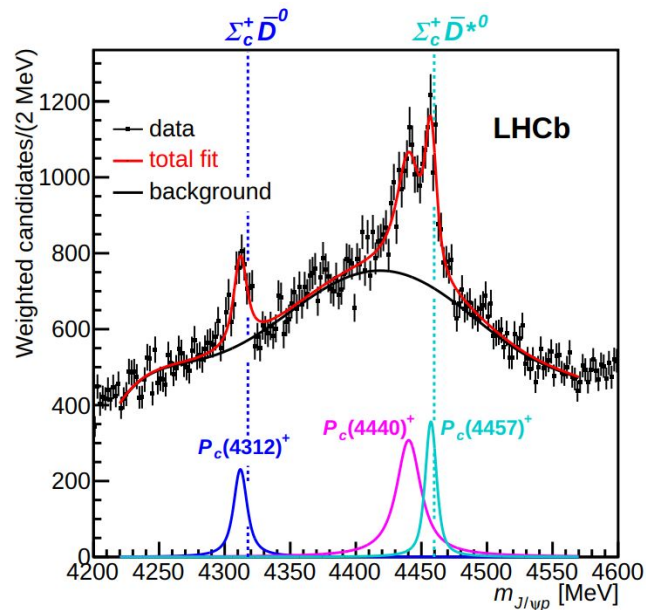
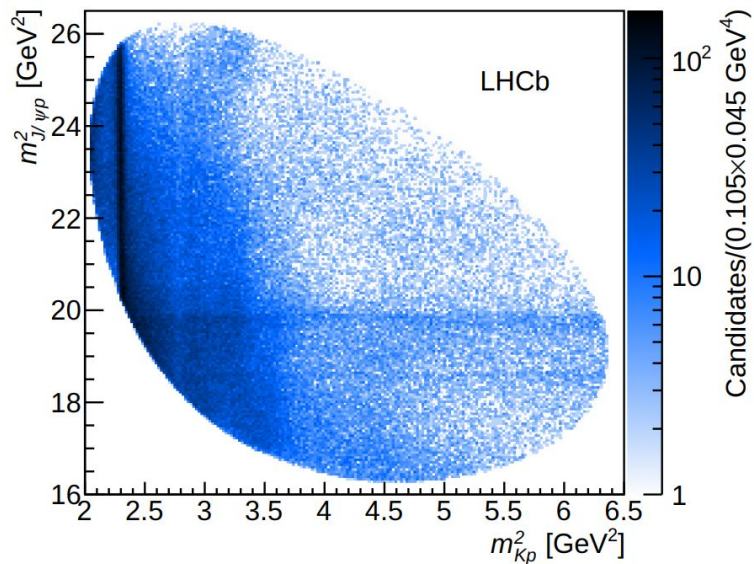
CBM acceptance for pp exclusive events studies

Event reconstruction & STS performance

Analysis strategy

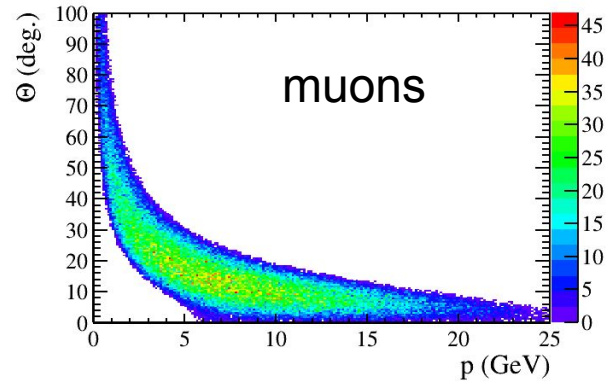
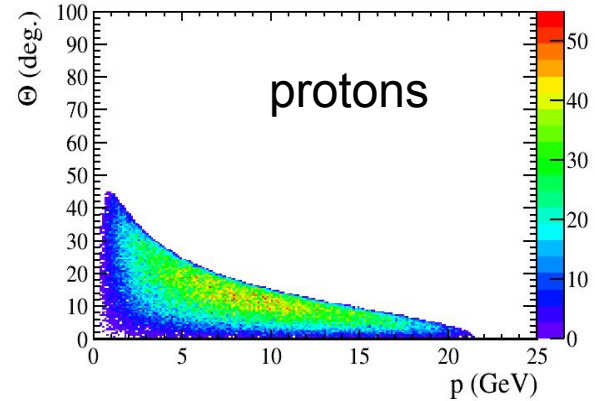
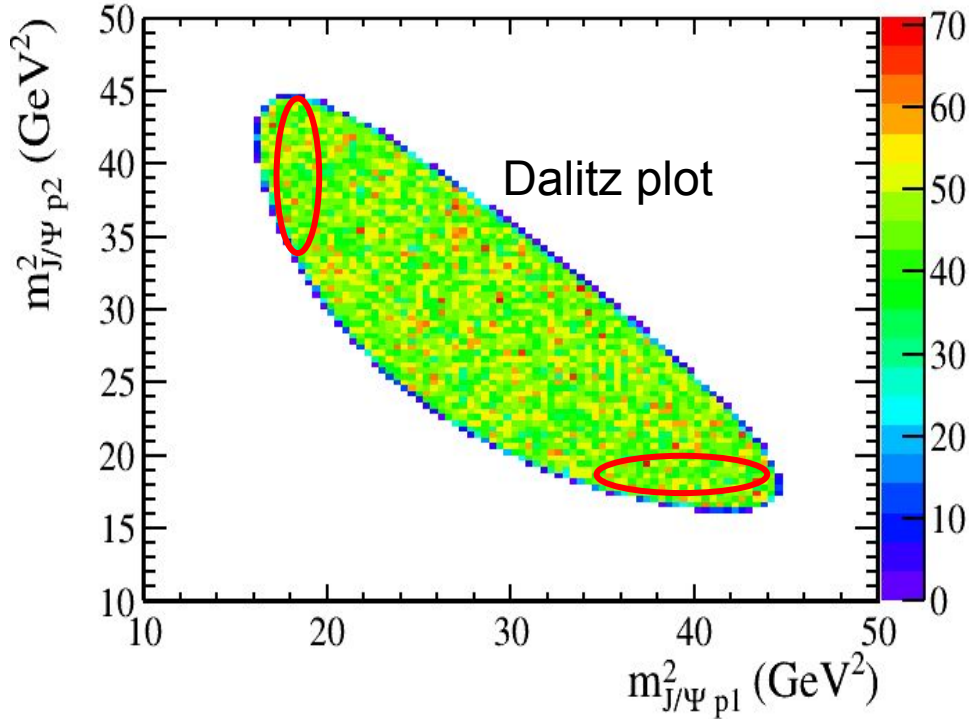
Results

LHCb (pentaquark state discovery)



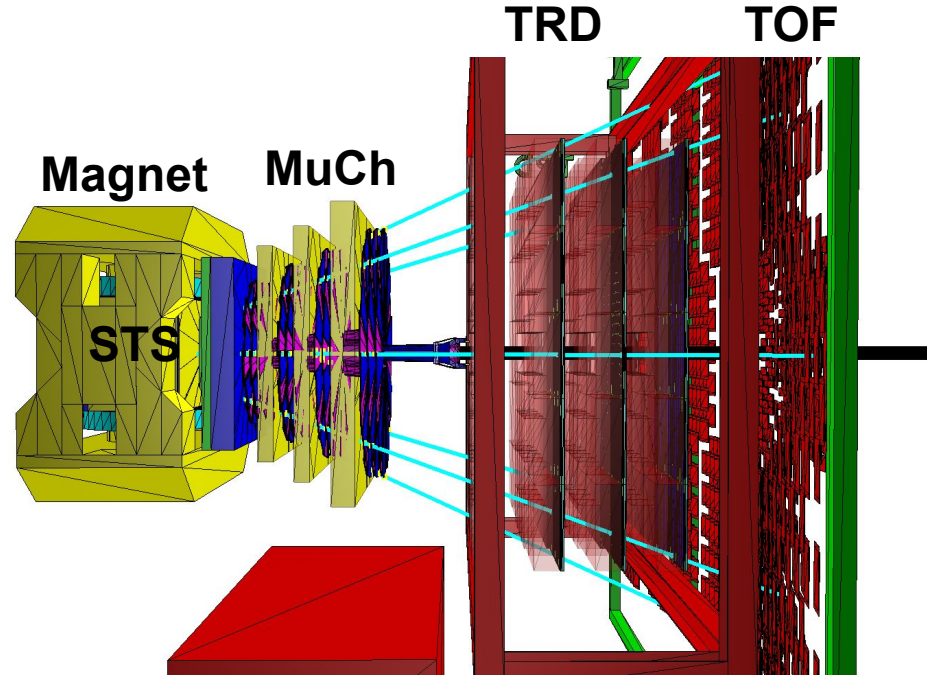
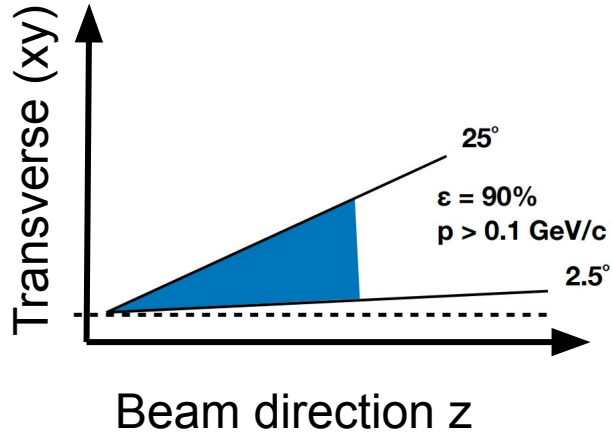
How does simulated events look? Pluto generator

→ pp at TLab = 29 GeV, 100k events

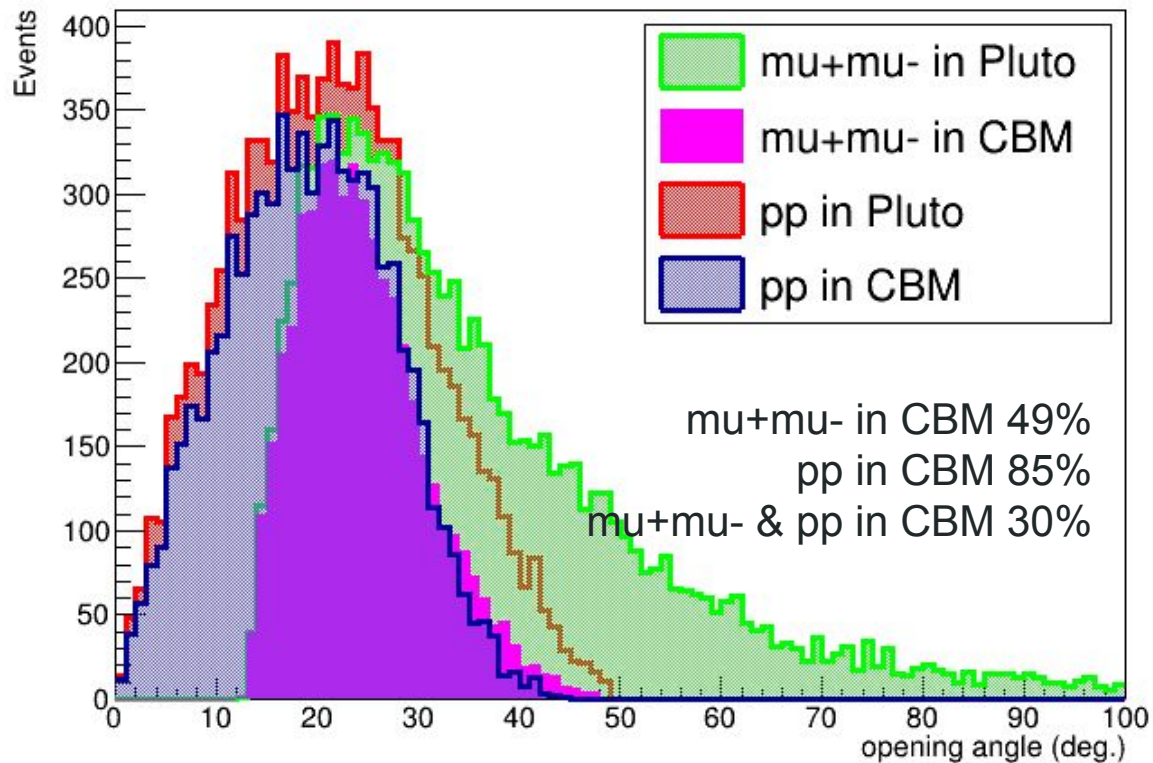


The CBM detector

Geometry : sis100_muon_1mvm



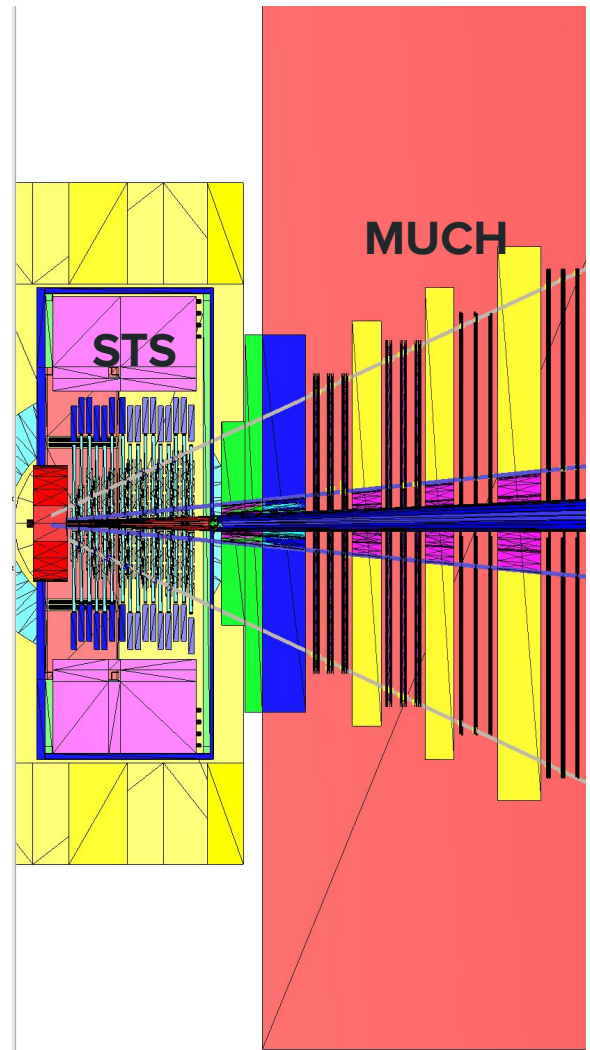
CBM opening angle acceptance



Simulation chain

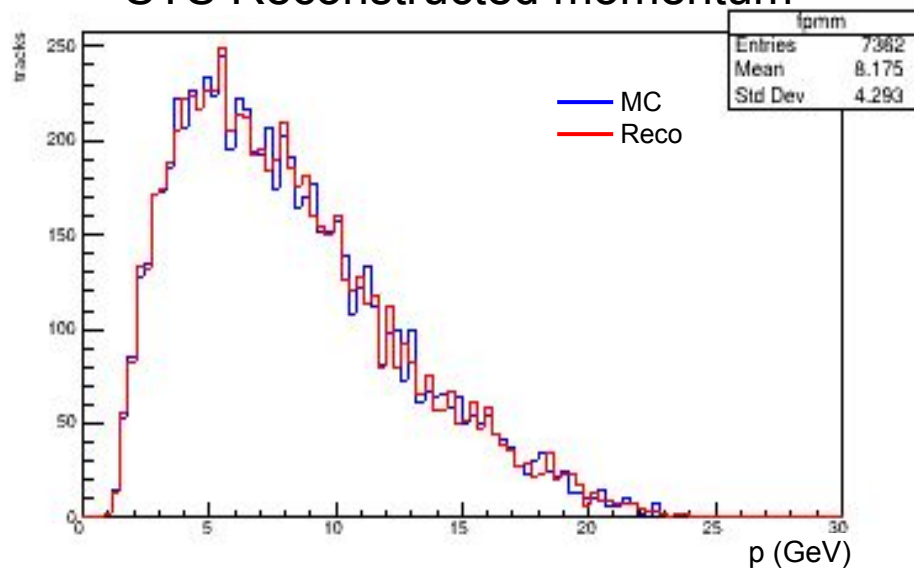
- Transport GEANT3
- Digitisation
- Hit reconstruction
- Track reconstruction STS (CA + KF)
- Global track reconstruction
- Analysis and Candidate selection (using MUCH PID)
- Exclusive reaction study exploiting high-level kinematic fitting tools with preliminary 4C response

Track reconstruction and PID



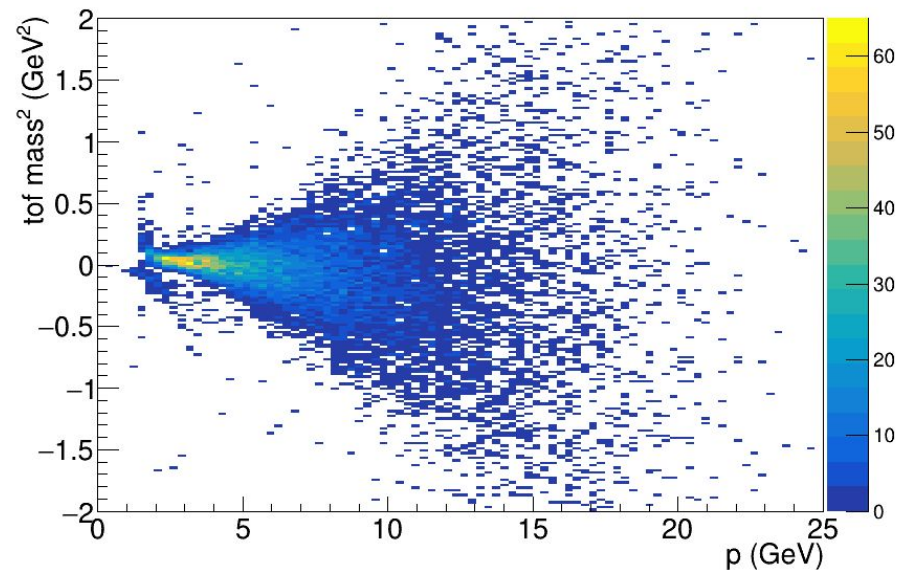
STS and TOF Performance

STS Reconstructed momentum



Muons

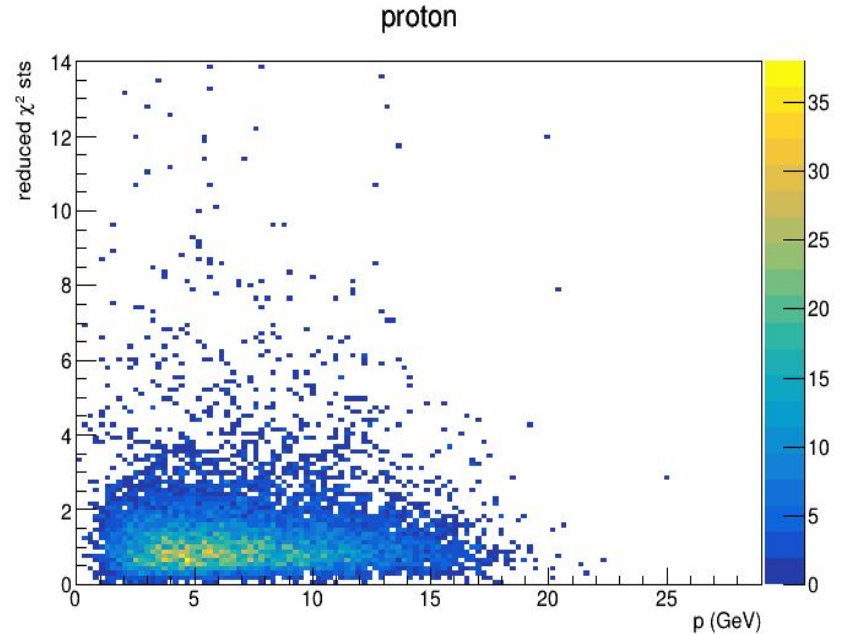
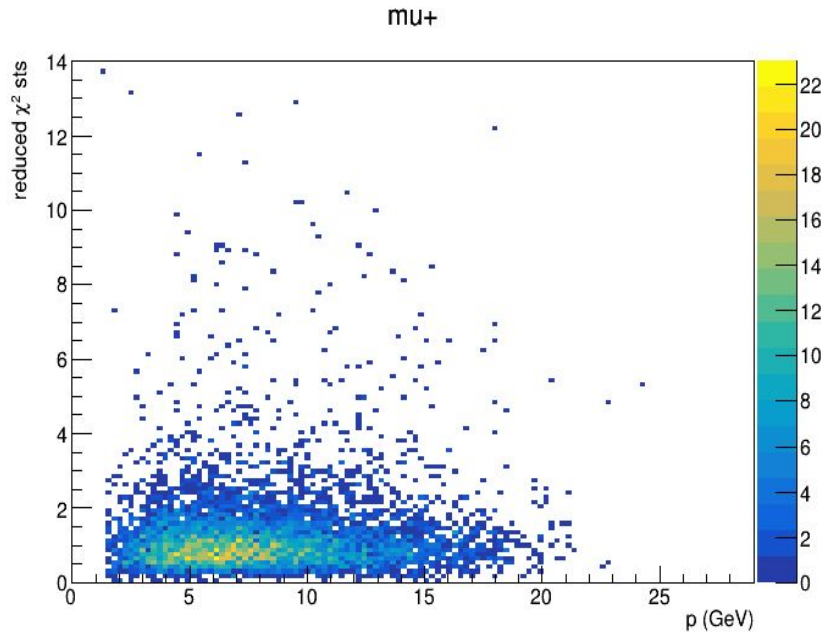
TOF mass



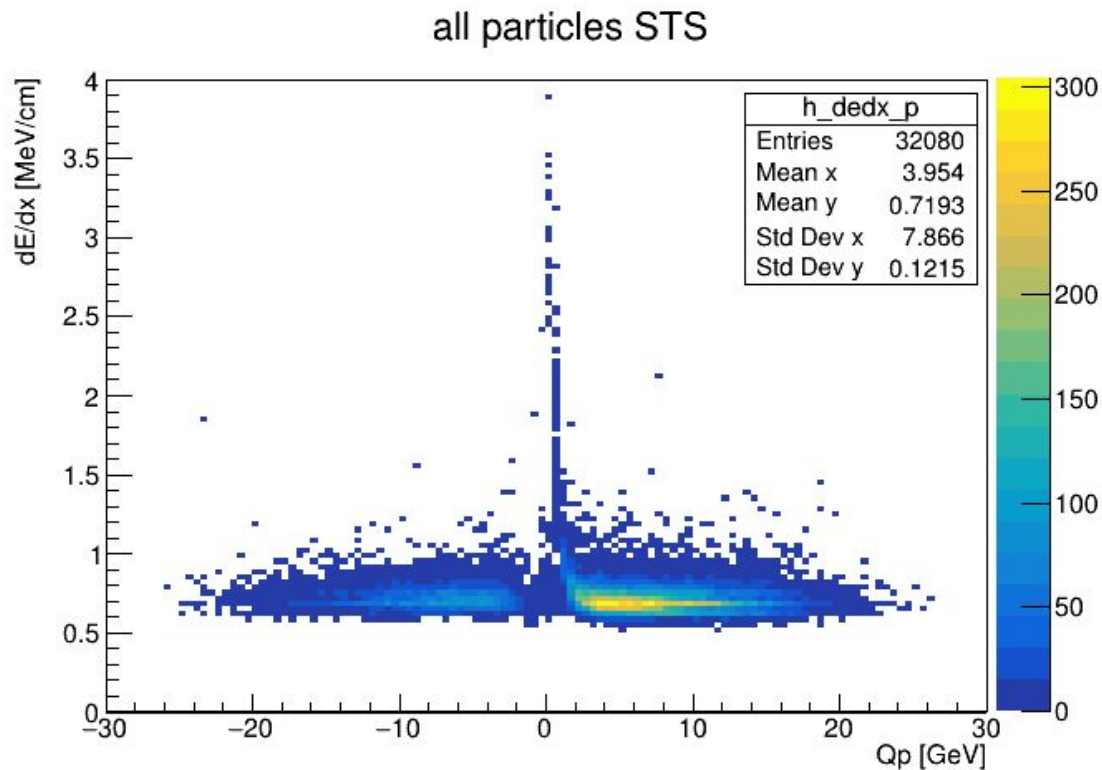
Muons and Protons

STS track properties

χ^2/ndf vs p

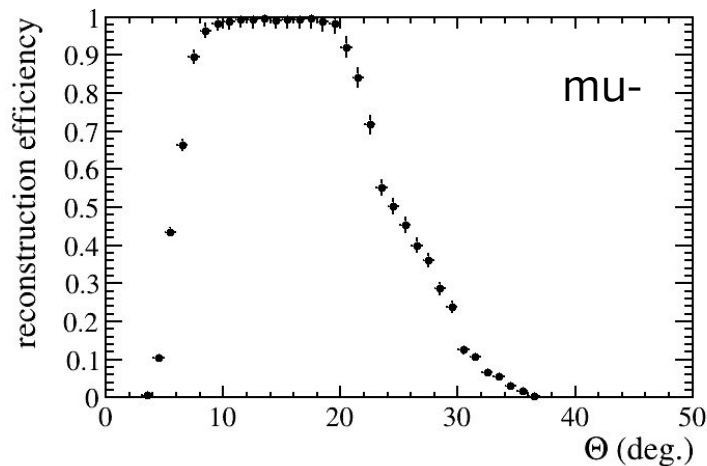
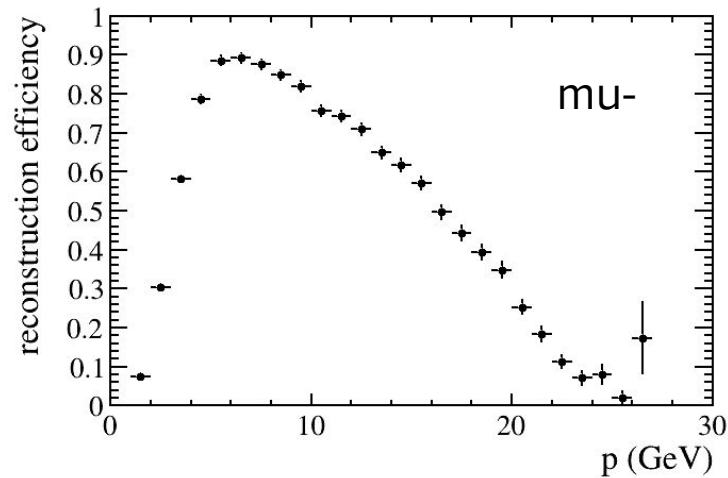
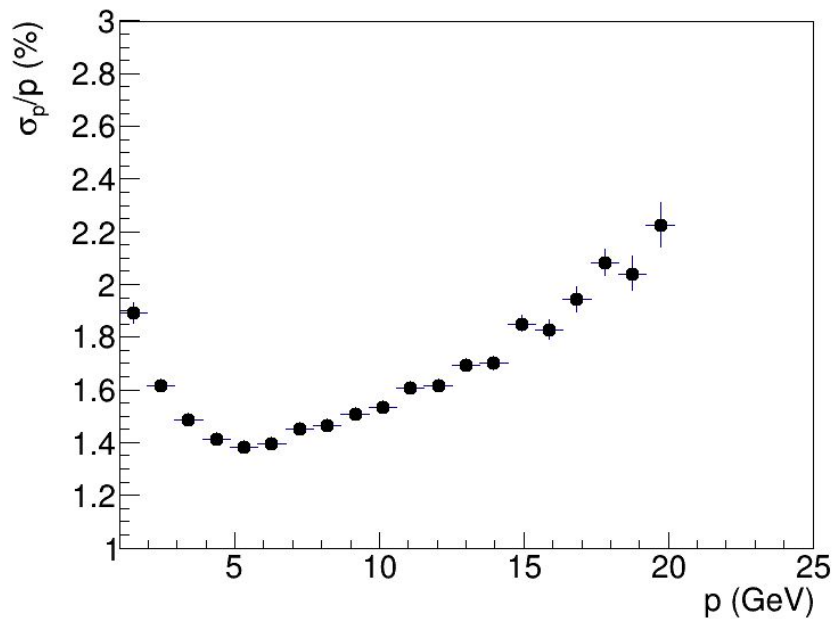


Energy loss in STS vs track Qp (reconstructed)

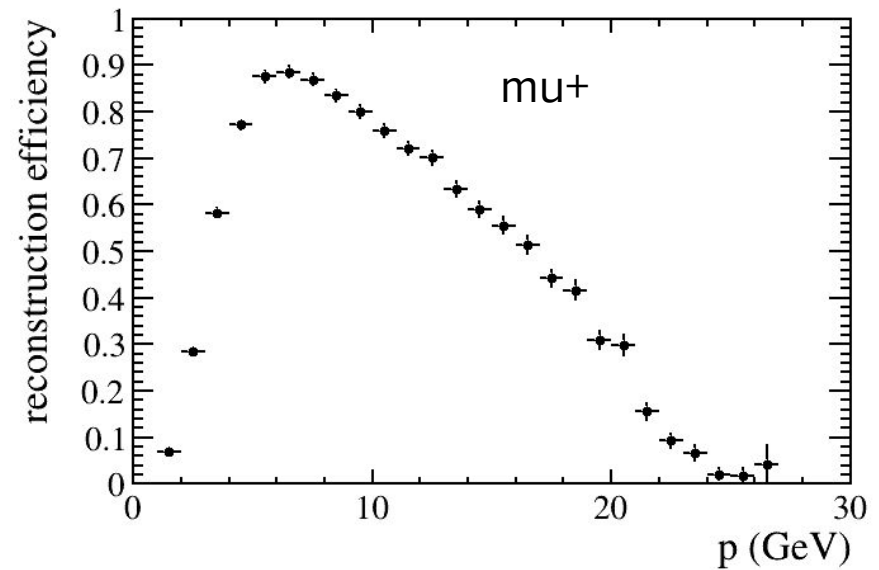
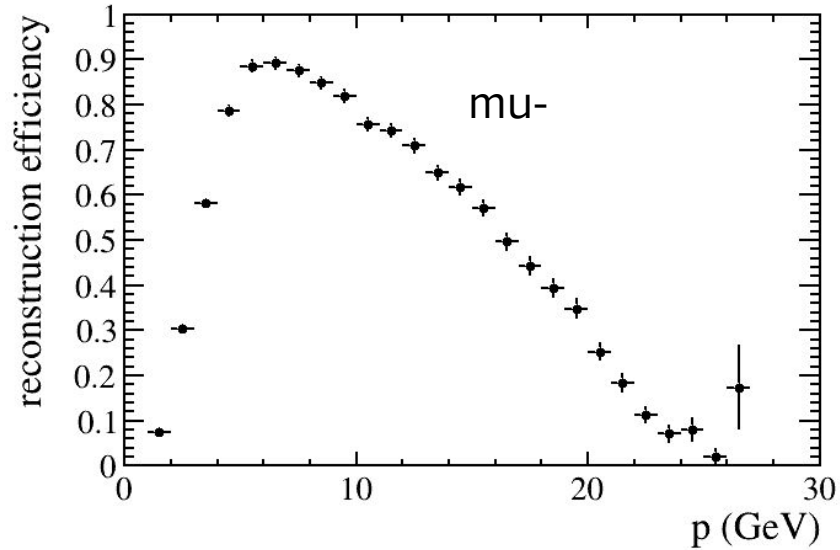


STS Performance

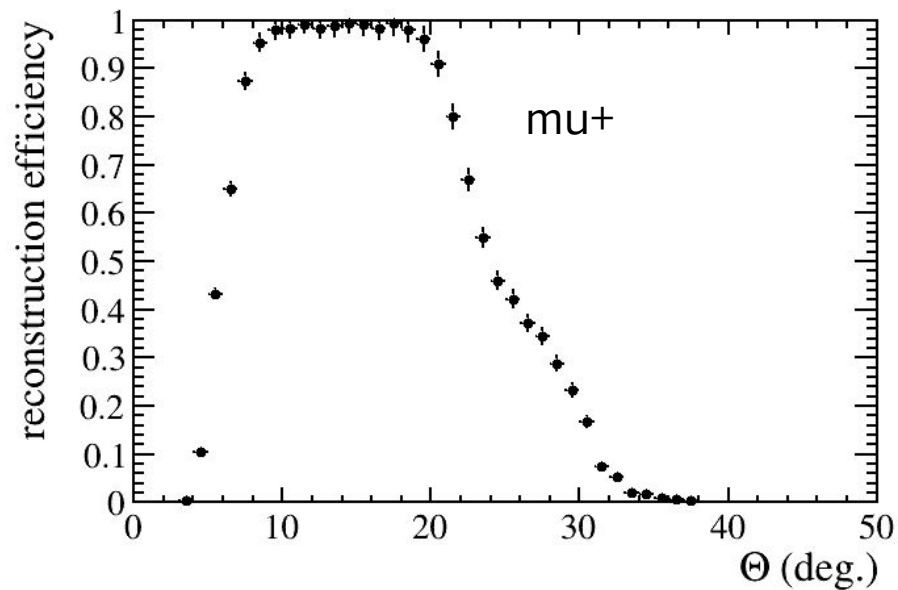
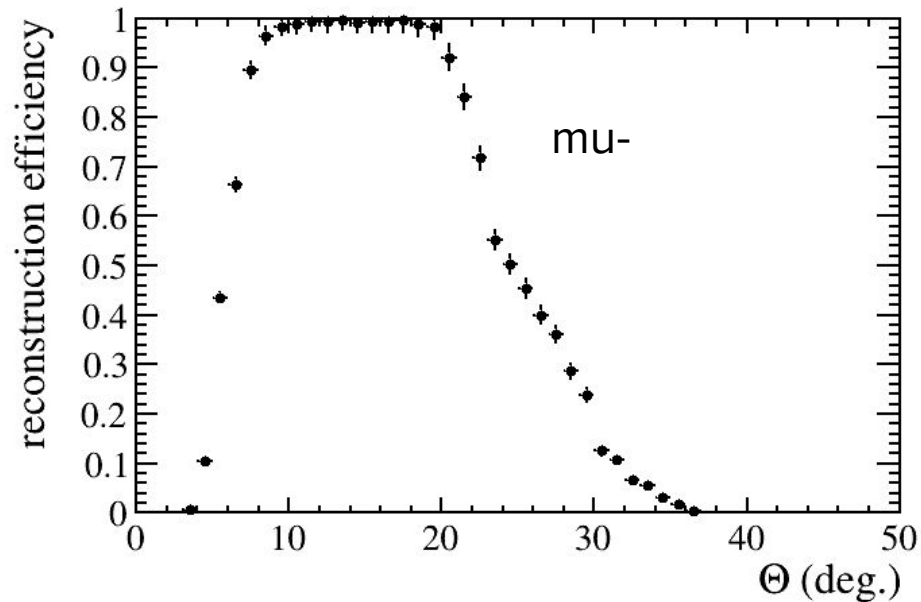
Momentum Resolution



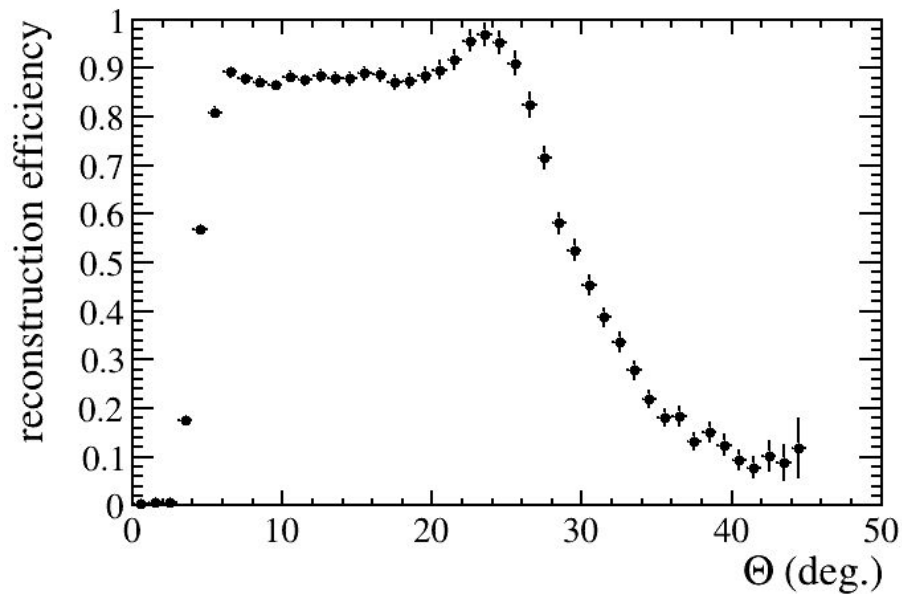
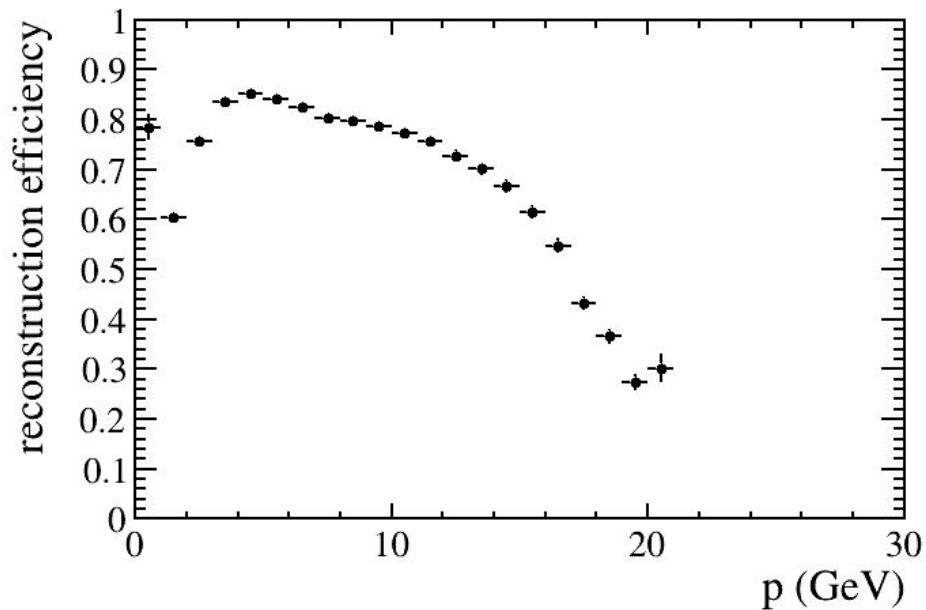
Reconstruction efficiency of muons (vs p)



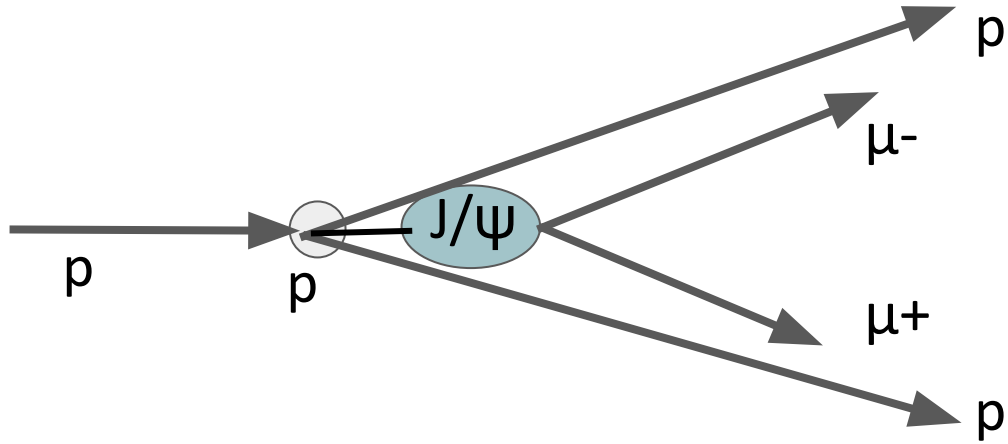
Reconstruction efficiency of muons (vs theta)



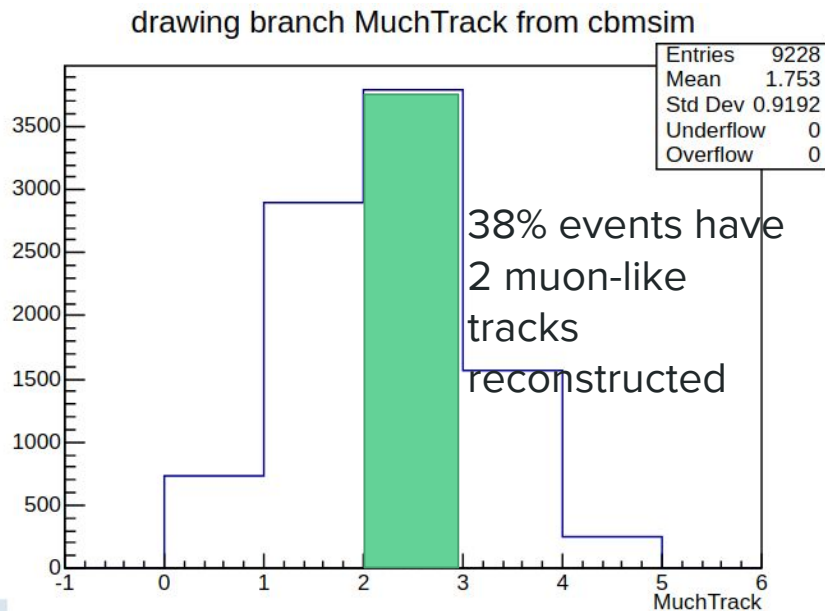
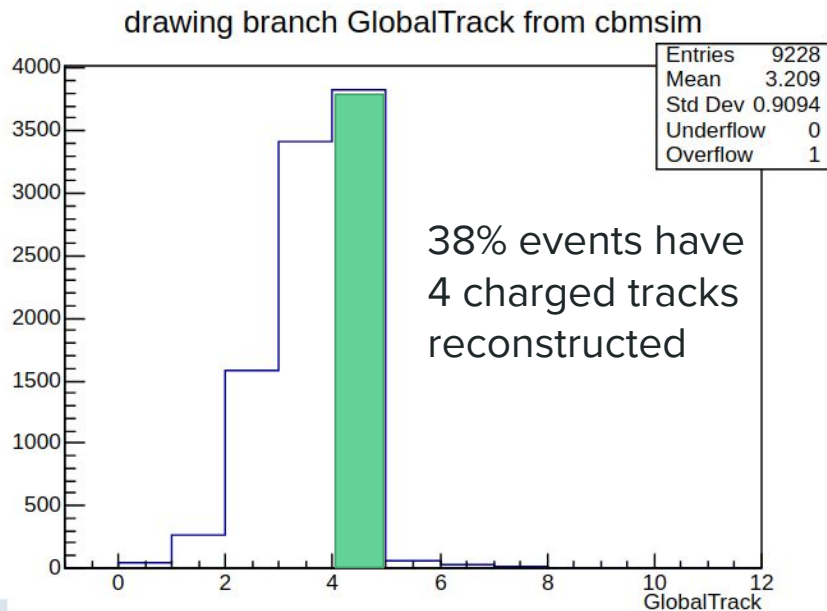
Reconstruction efficiency of protons



Candidate selection

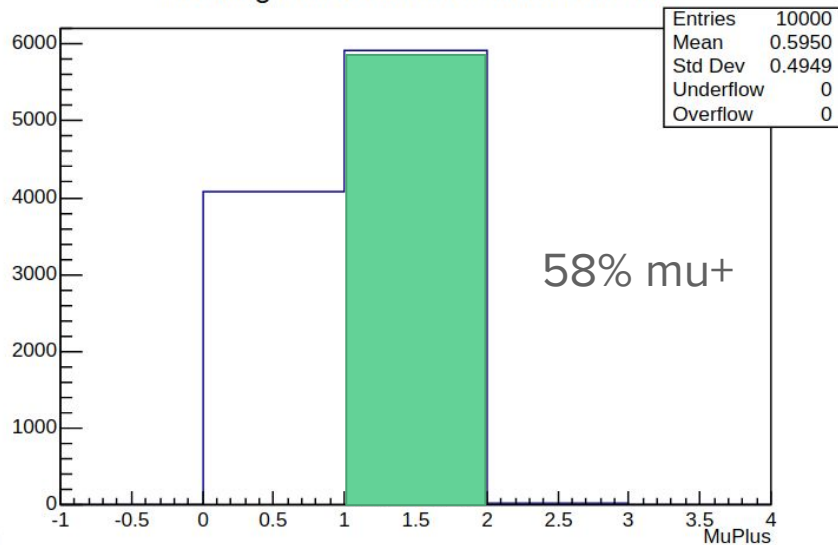


Global tracks per event

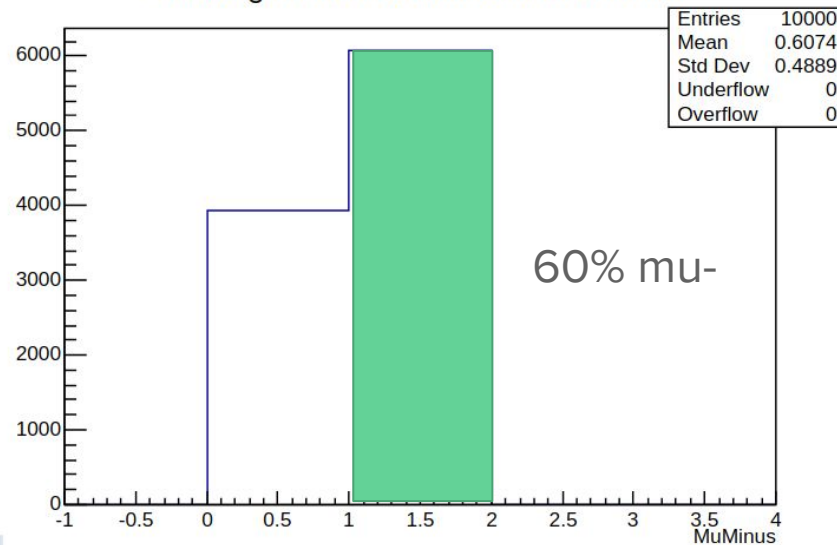


Selected Muon tracks

drawing branch MuPlus from cbmsim

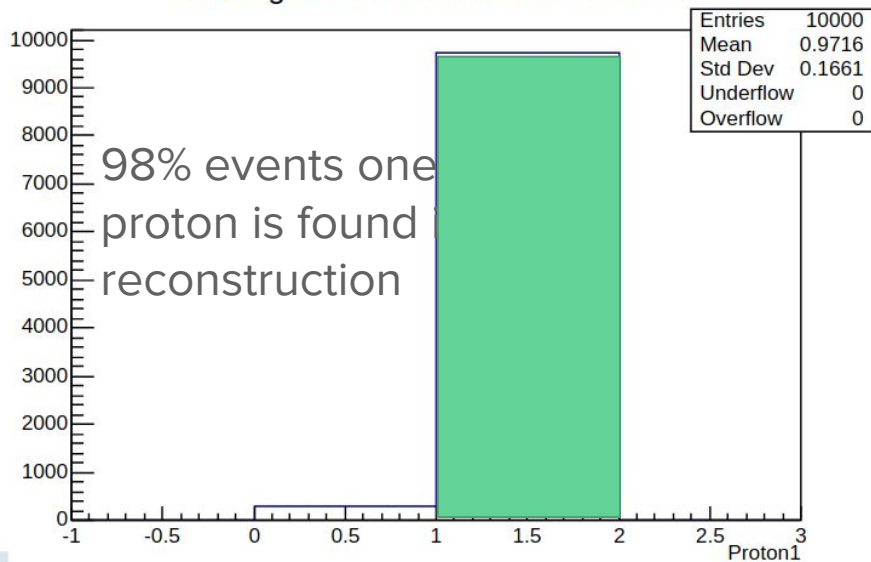


drawing branch MuMinus from cbmsim

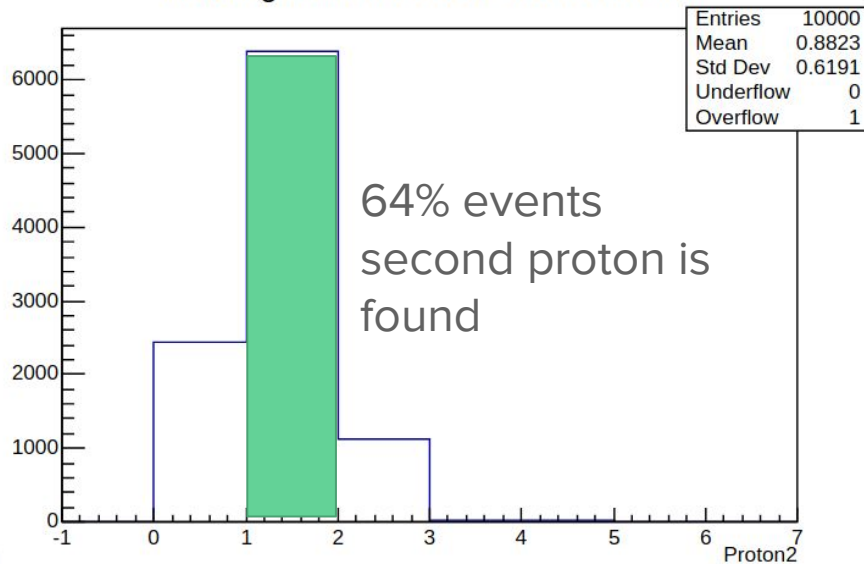


Selected Proton tracks

drawing branch Proton1 from cbmsim

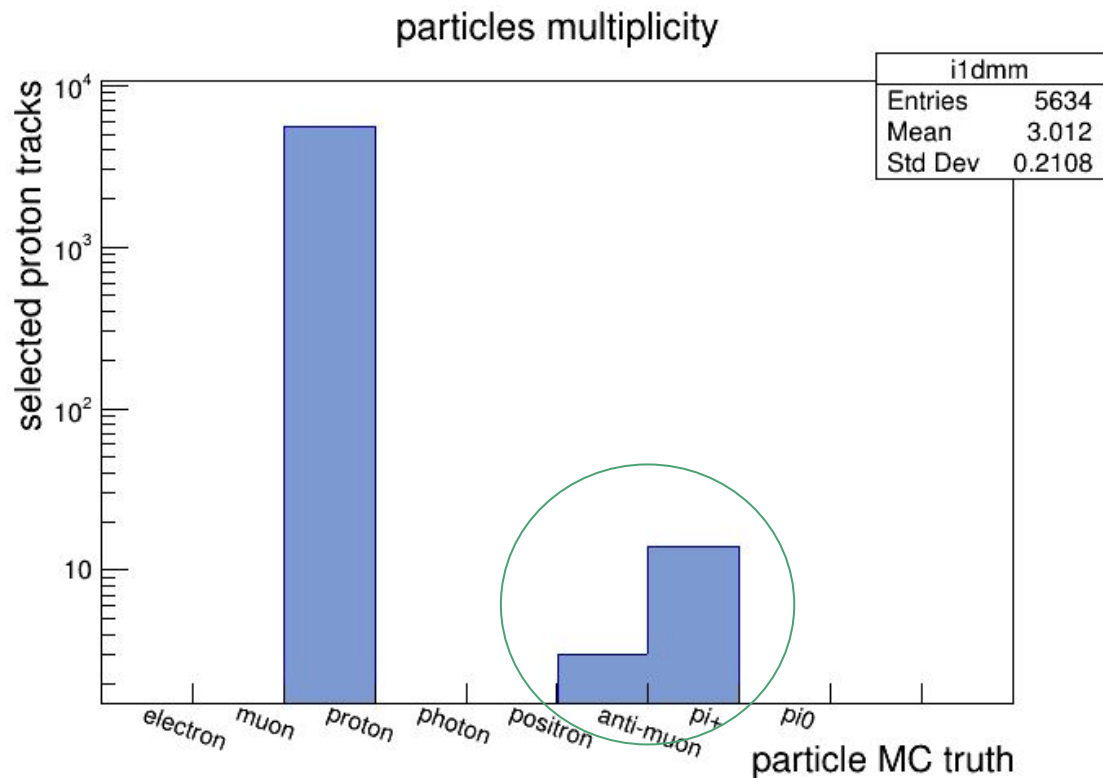


drawing branch Proton2 from cbmsim

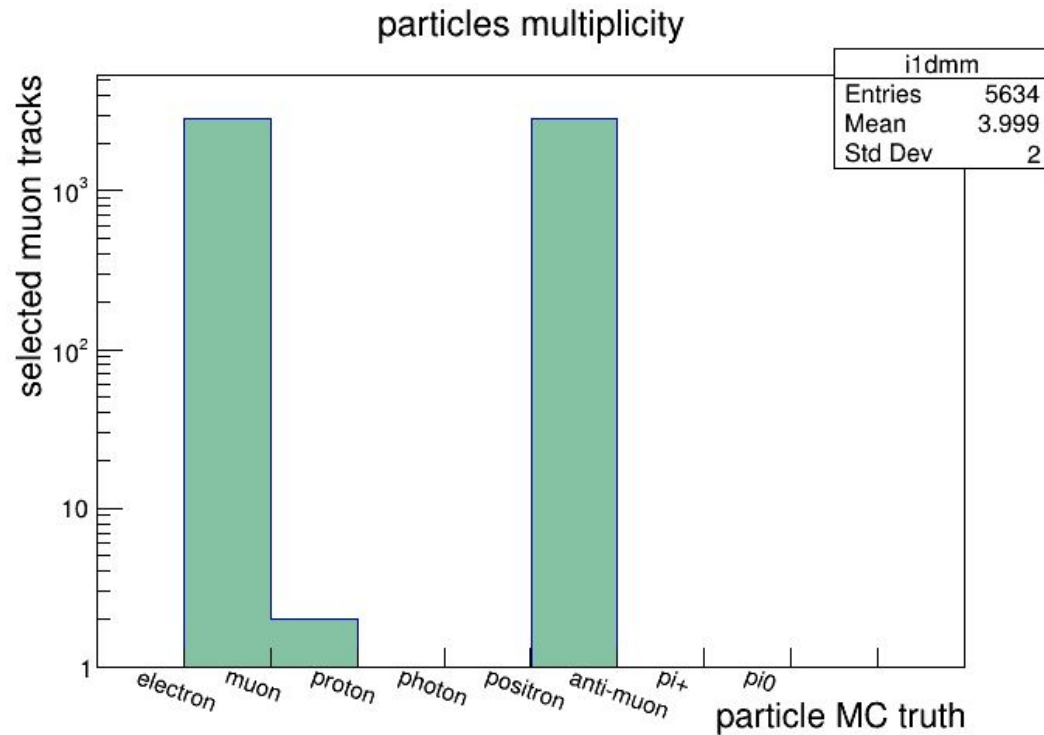


10% events there is a 3rd proton candidate (probably fake)

How well are the protons identified ?

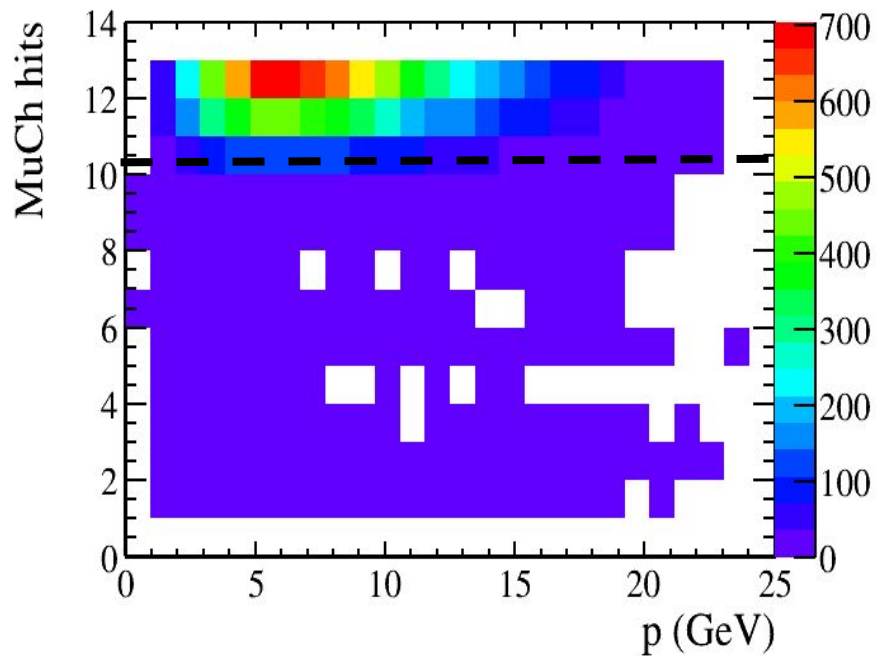


How well are the muons identified ?

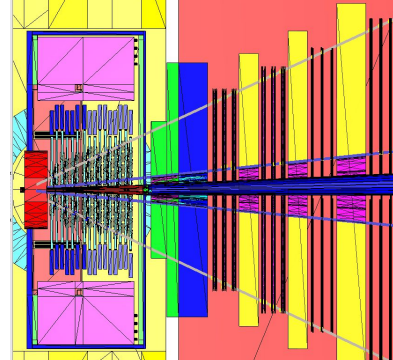
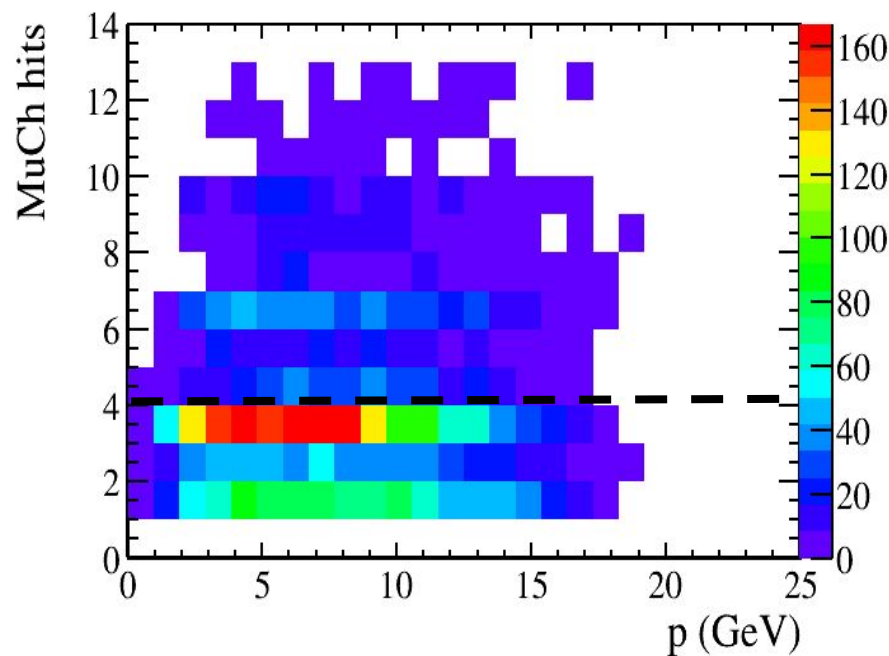


Muon PID with MuCh

Muons

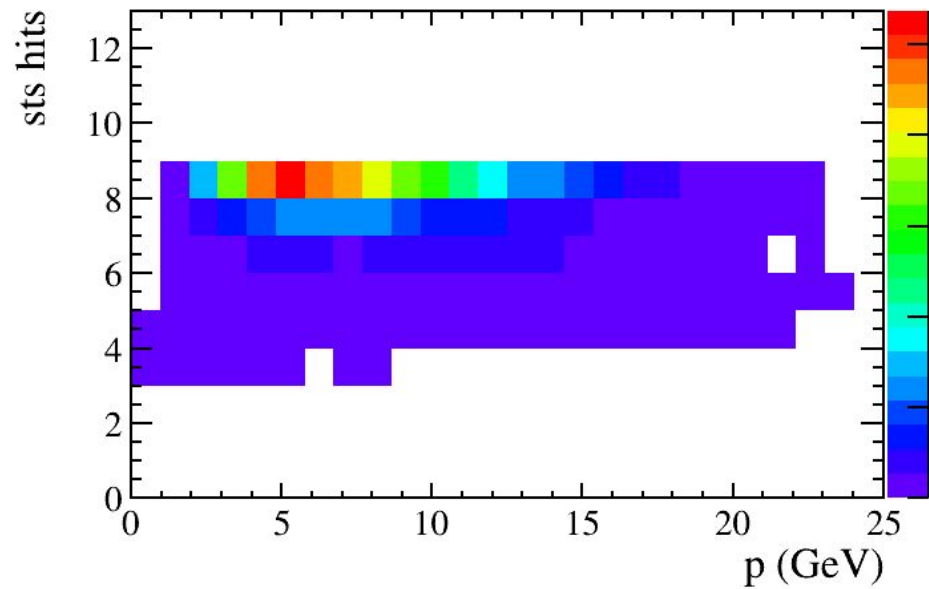


Protons

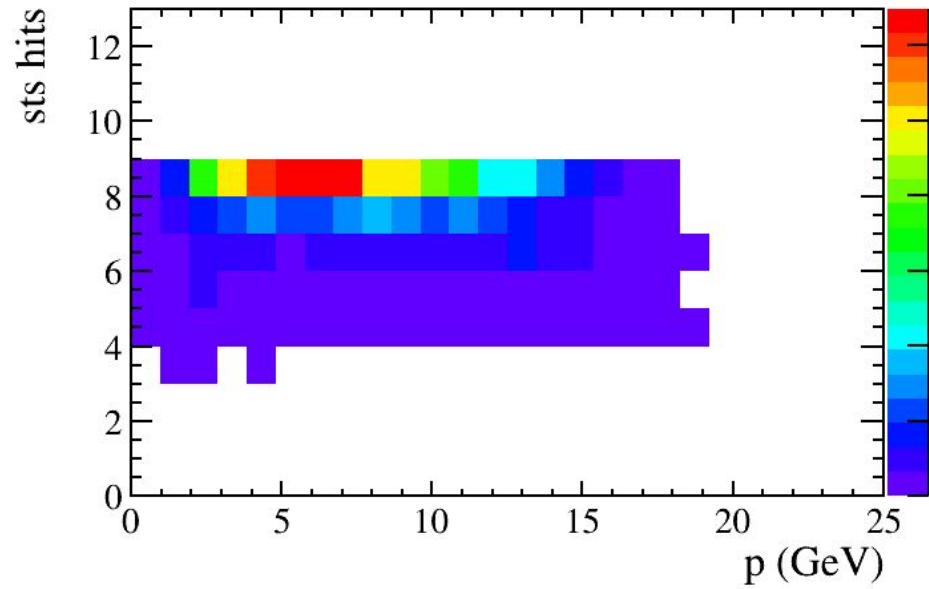


STS hits

Muons



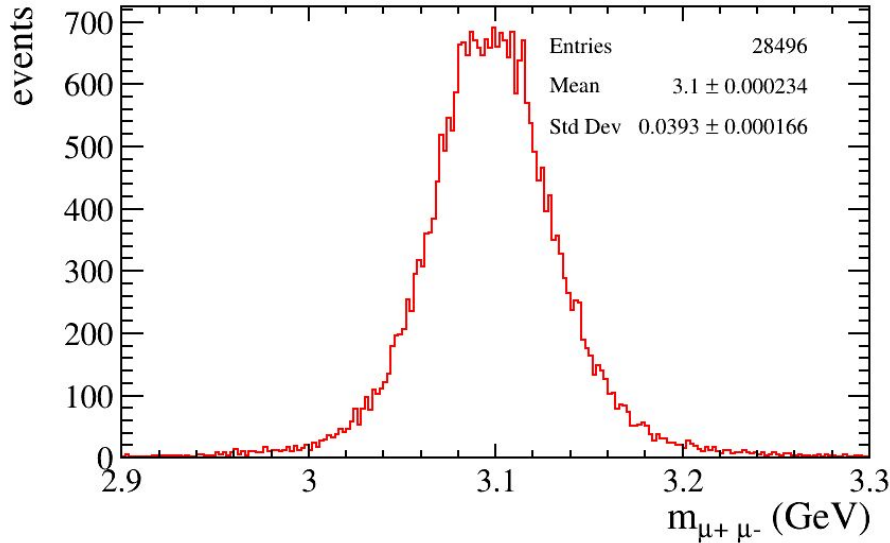
Protons



Results ($J/\psi \rightarrow$ invariant Mass)

$pp \rightarrow pp J/\psi (\mu^+\mu^-)$, 100k events

Cuts used:
Chi2 sts < 4
Chi2 vertex < 3
nMuchHits ≥ 10
nSTSHits ≥ 7



28% events are reconstructed

We were expecting 30 % from acceptance / fast sim calculations.

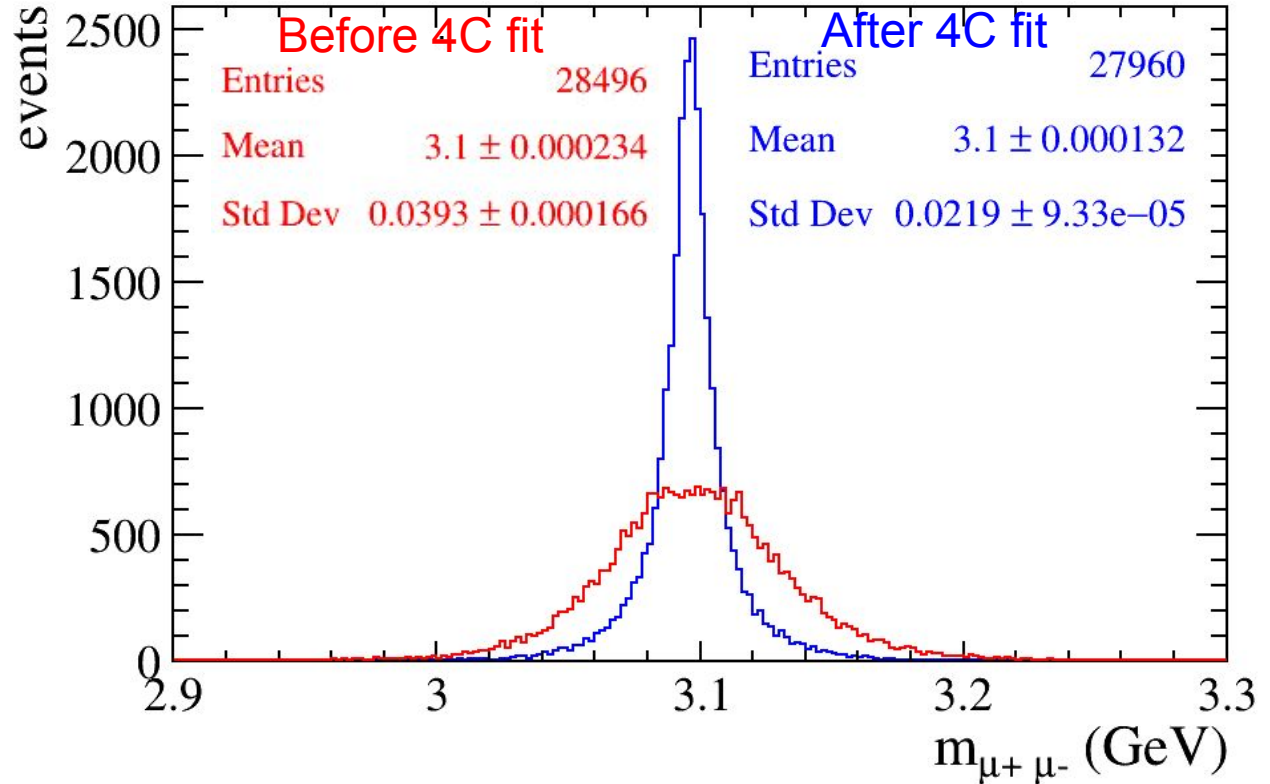
0.07% fake reconstructed J/ψ events

4C kinematic fit

KinFit - Experiment independent fitting tool
Chi2 minimization procedure based on Lagrange multiplier technique.

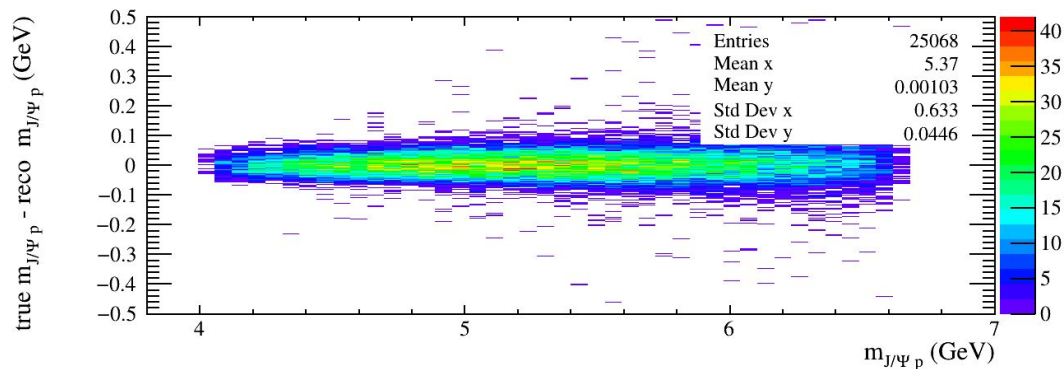
About the 4C fit :

- 4-momenta of all-final state particles conserved w.r.t. beam-target system

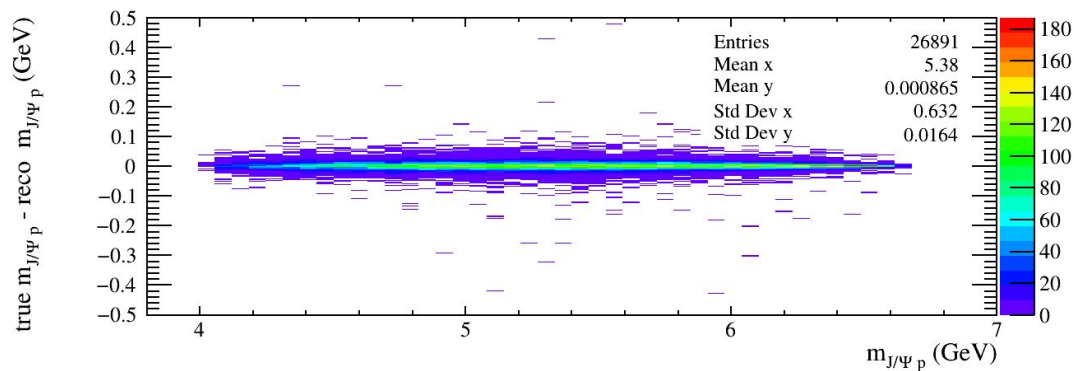


Results : J/ ψ p mass (MC truth - reconstructed)

Before 4C fit

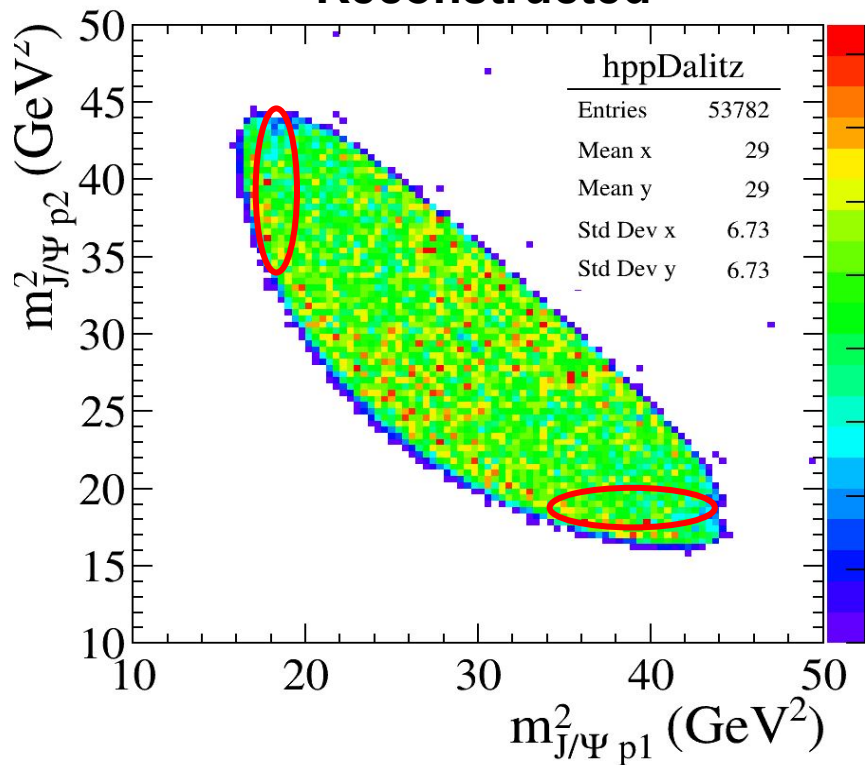


After 4C fit

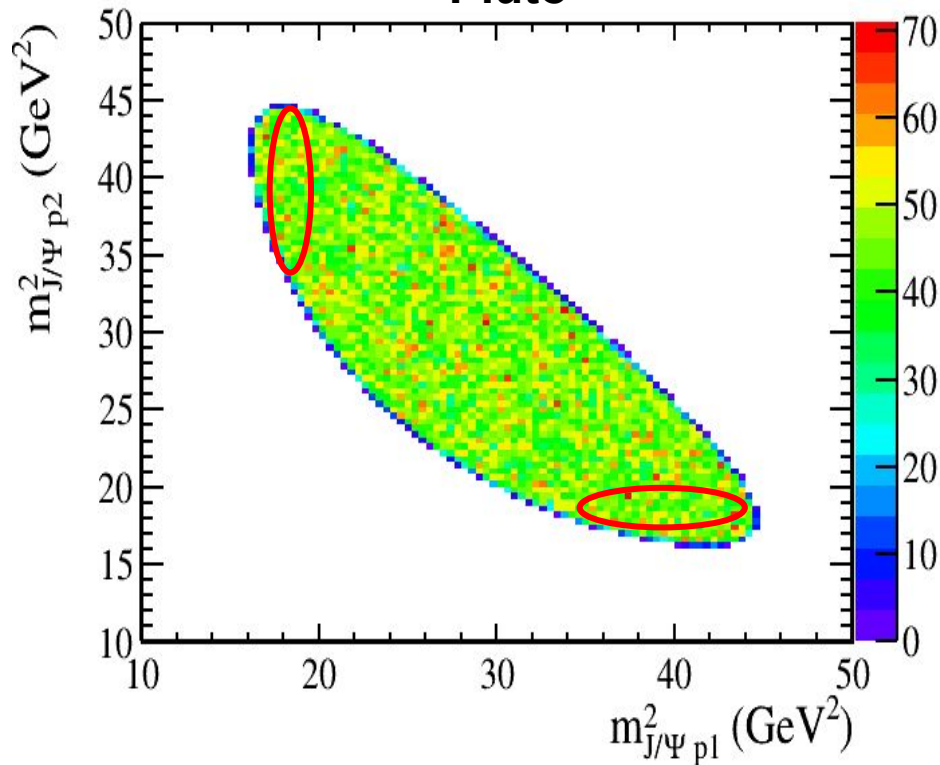


Results (Dalitz plot with 4C fit)

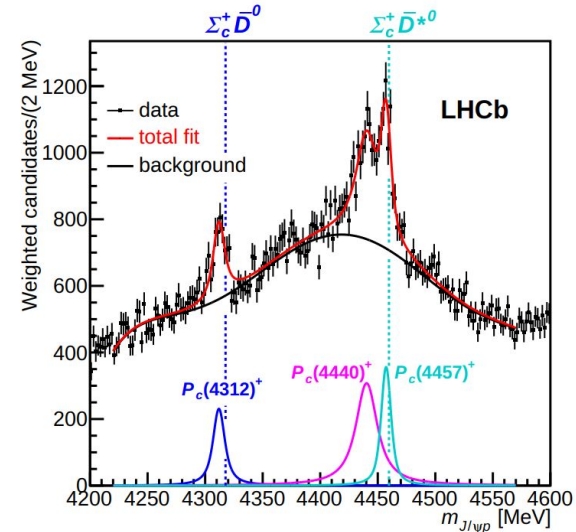
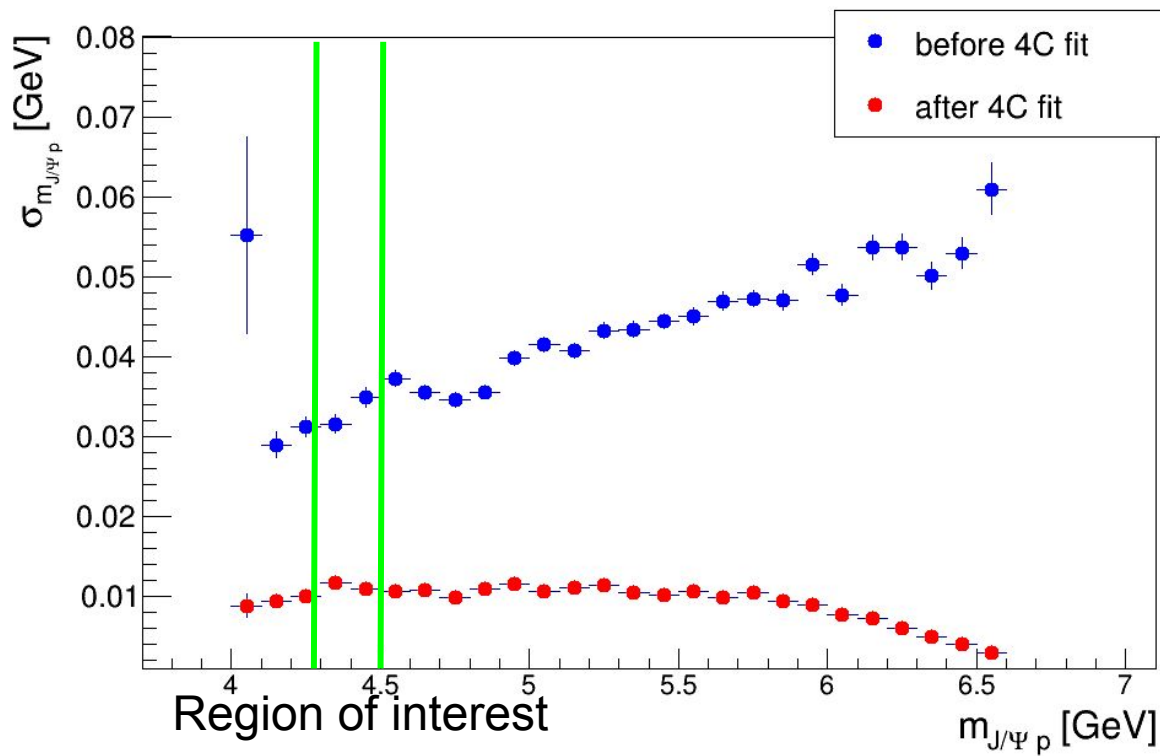
Reconstructed



Pluto



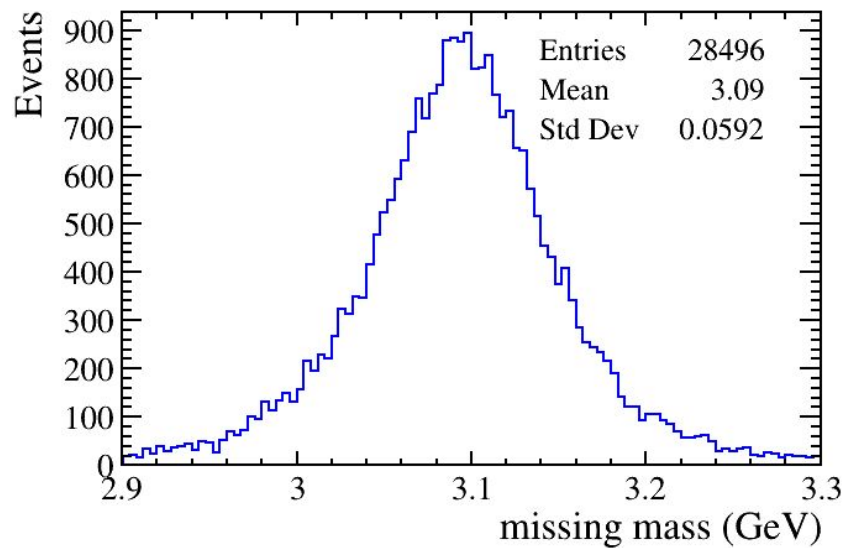
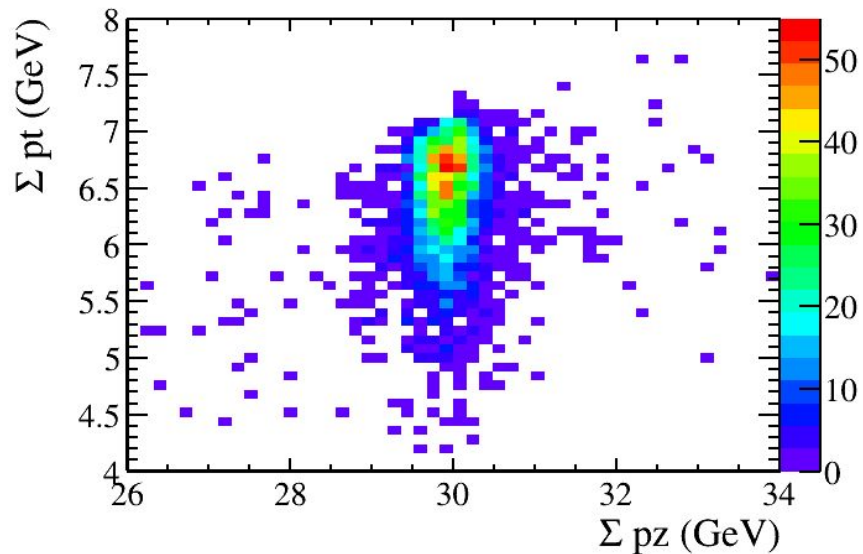
Mass Resolution of $J/\psi p$



Back up

Exclusivity

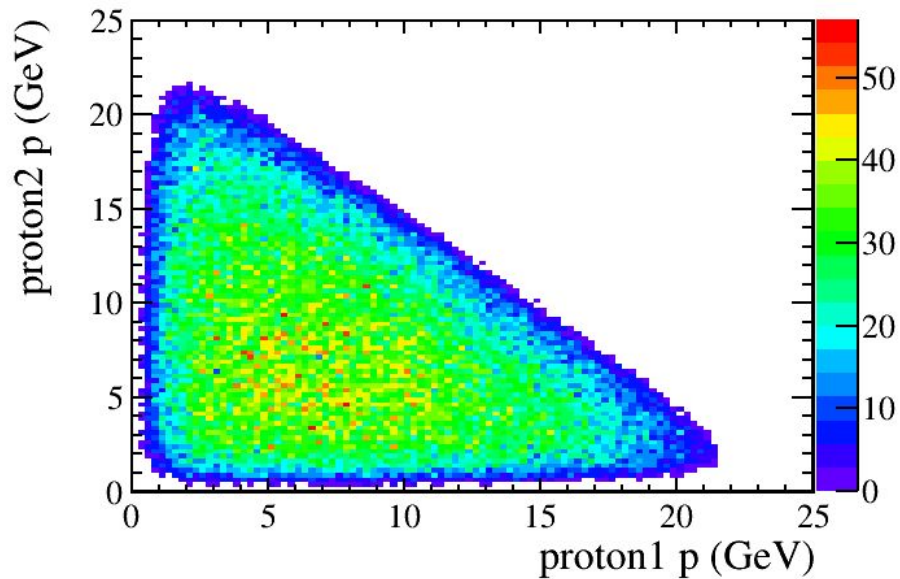
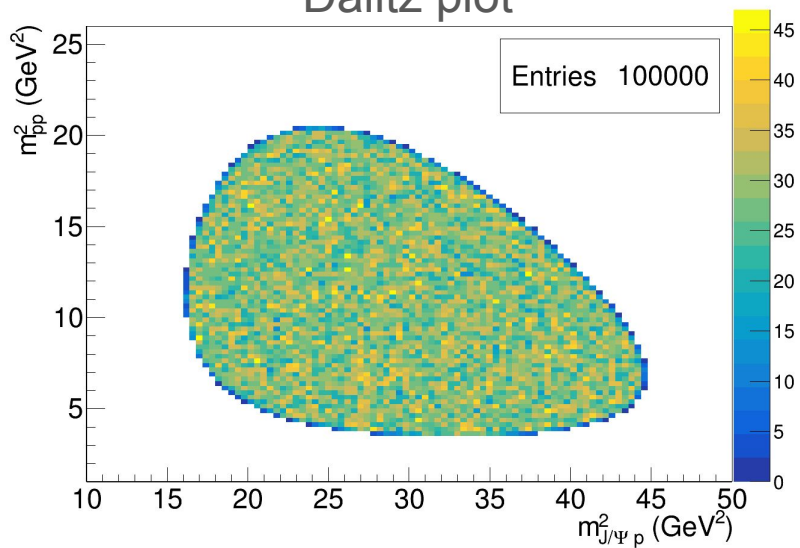
Check this plot



How the event looks like? Pluto generator (tbr)

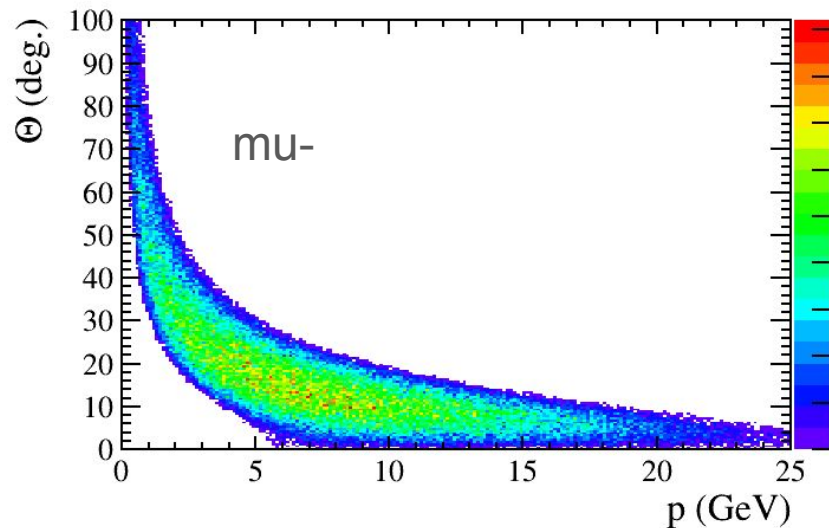
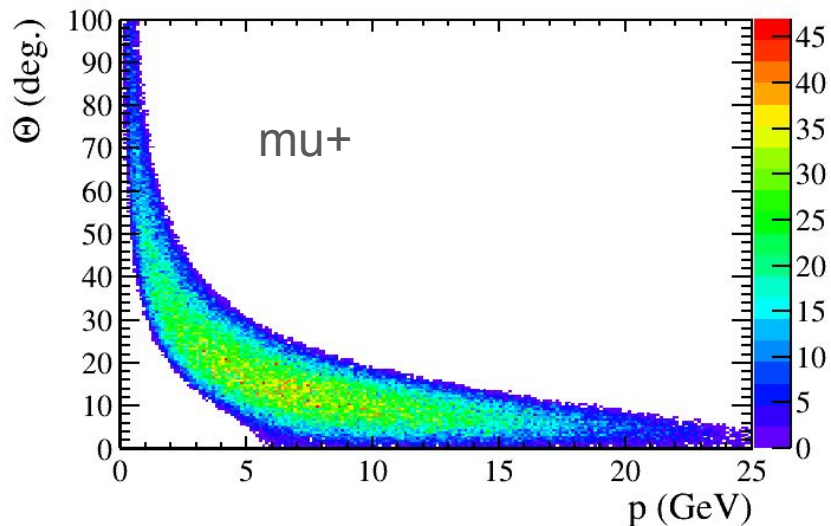
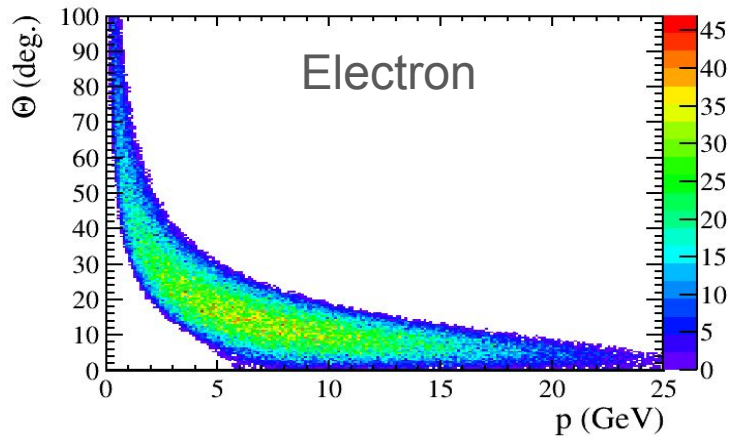
TLab = 29 GeV

Dalitz plot

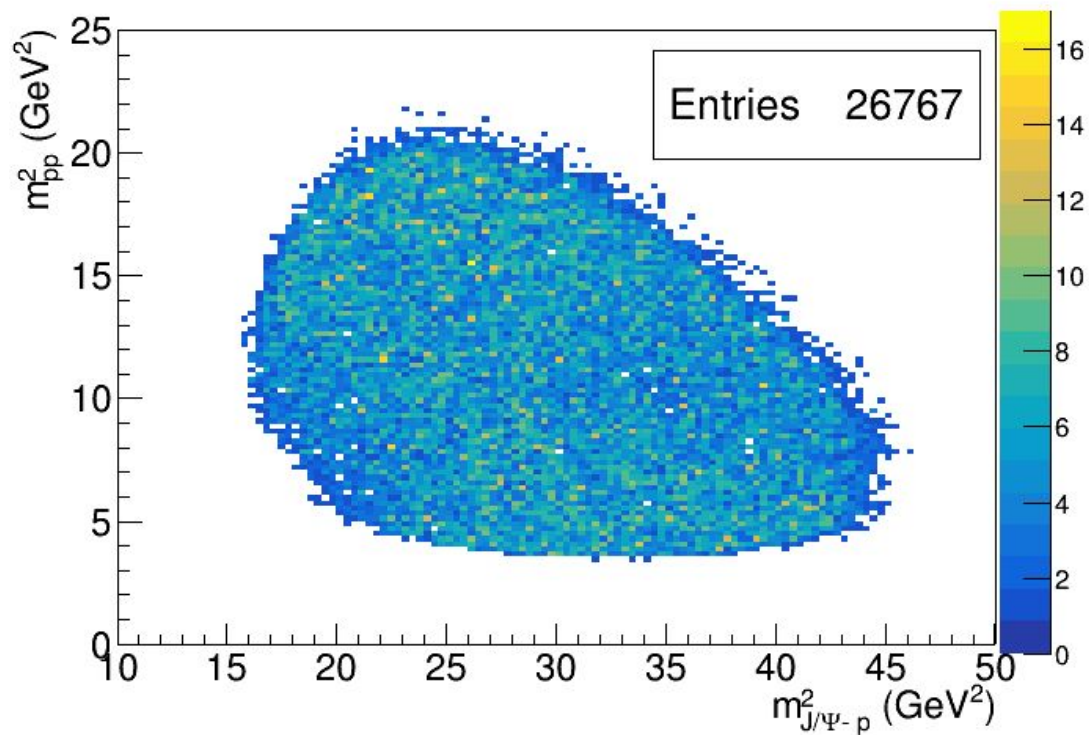


Momentum theta distributions Pluto Generator

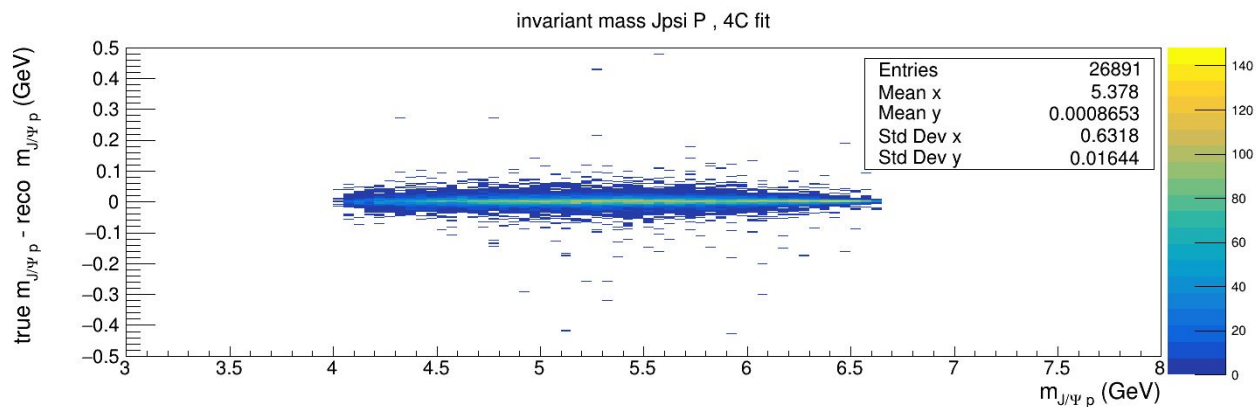
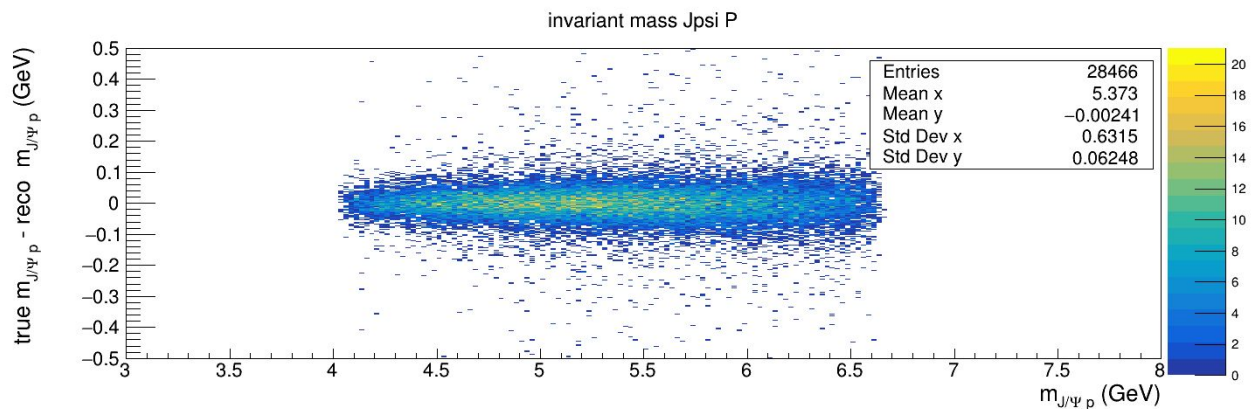
$pp \rightarrow pp J/\psi (\mu^+\mu^-) (e^+e^-)$



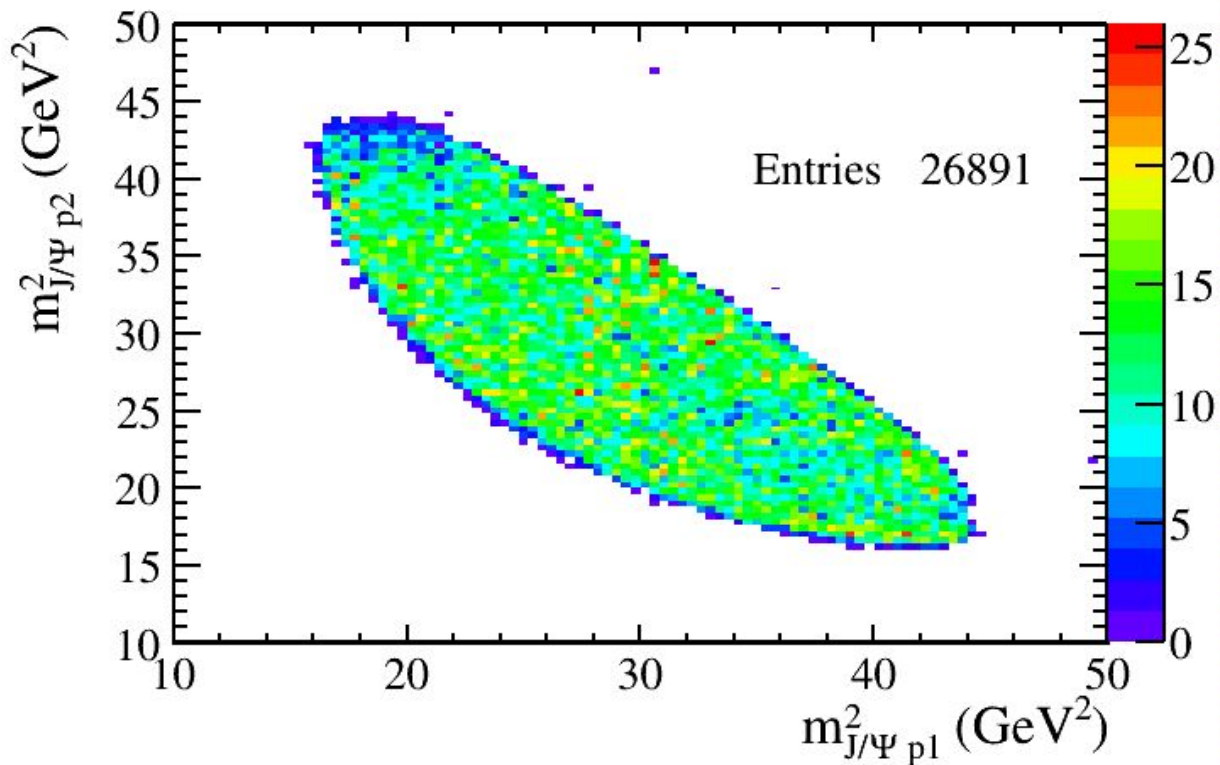
Results (Dalitz plot)



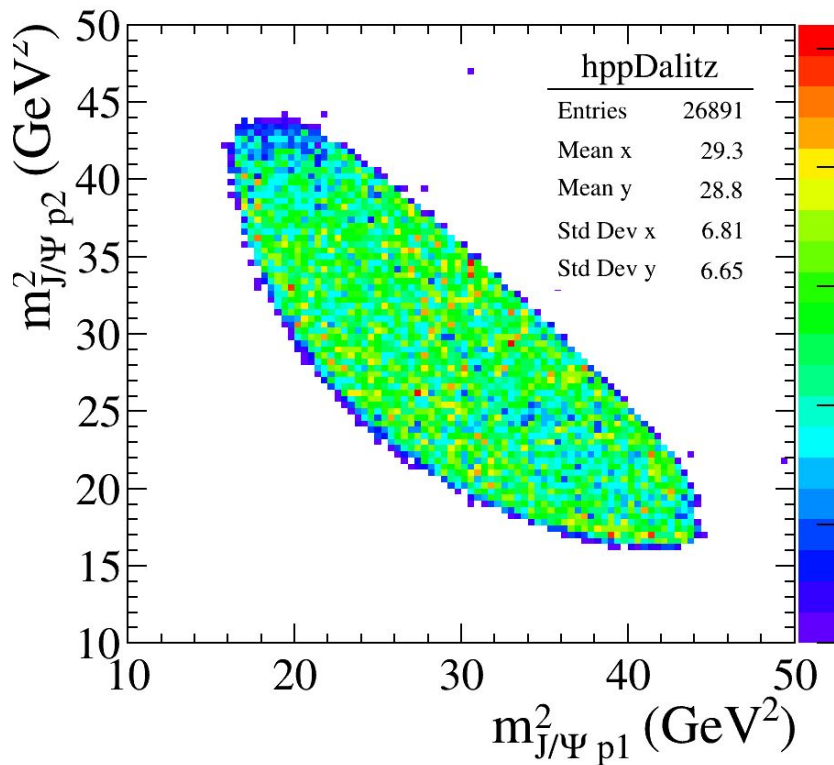
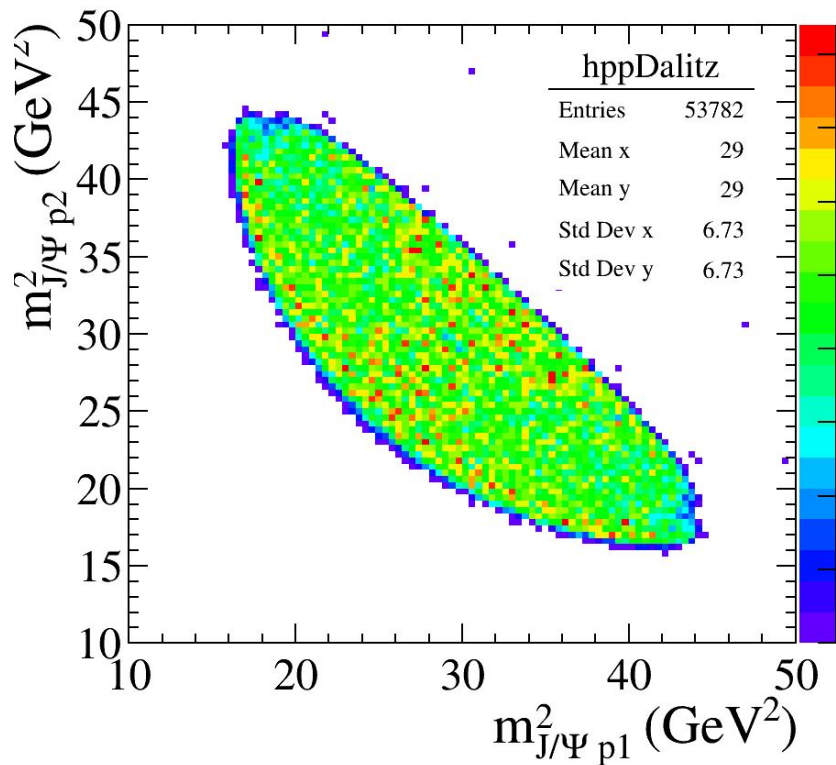
Results (J/ ψ p mass resolution)



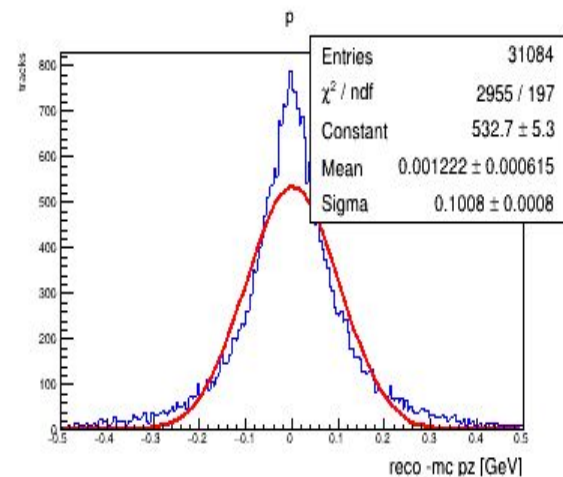
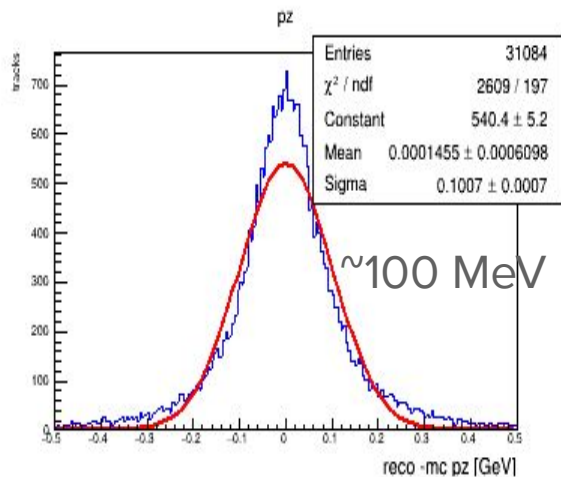
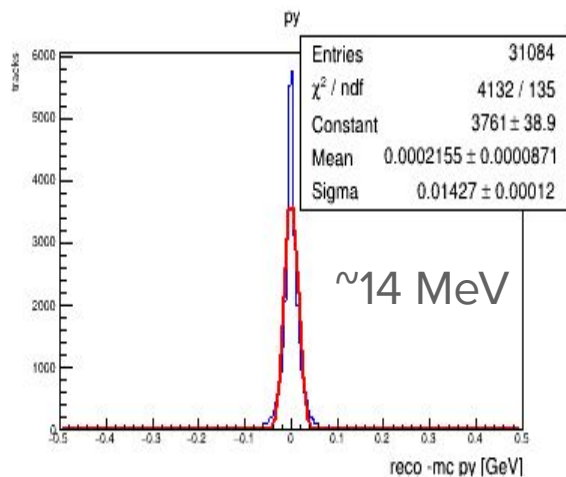
Results (Dalitz plot with 4C fit)

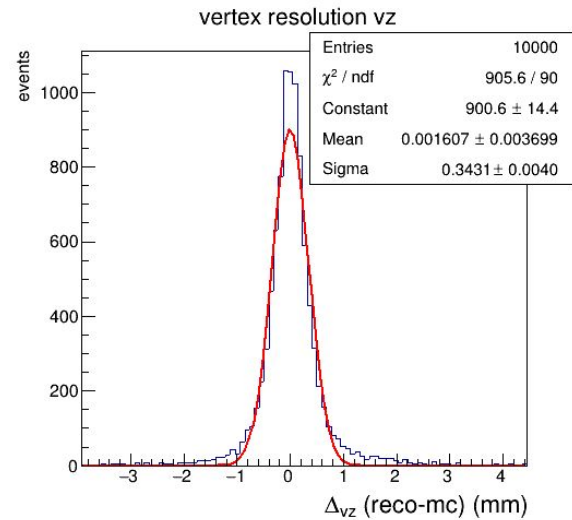
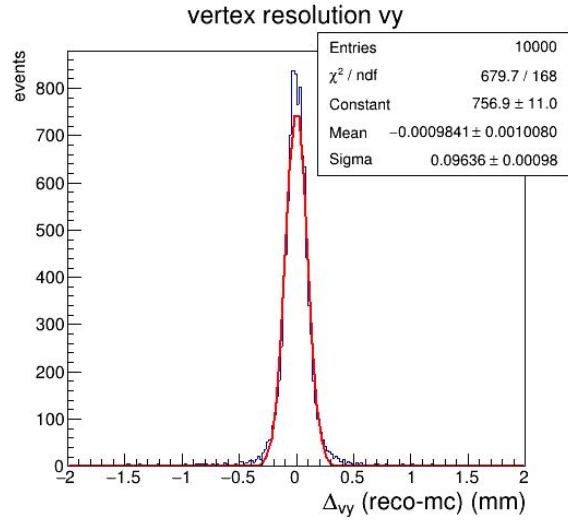
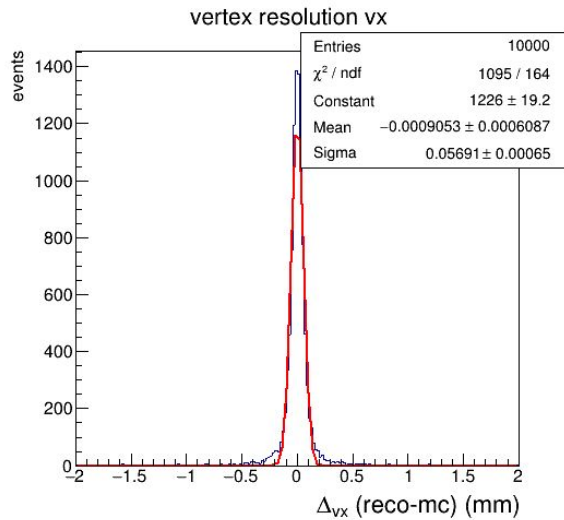
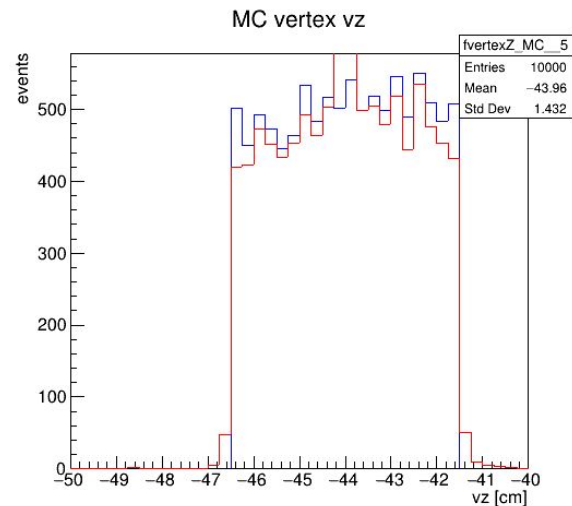
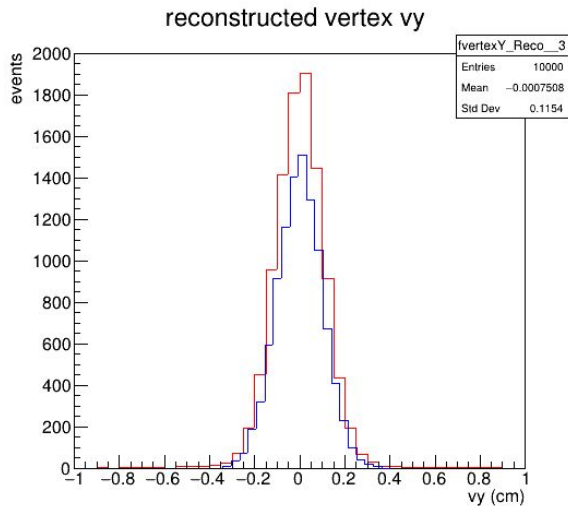
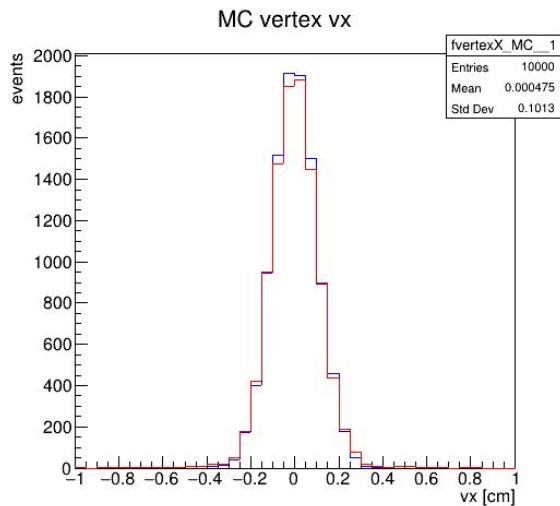


Results (Dalitz plot with 4C fit)



Momentum resolution





Why study $pp \rightarrow J/\psi pp$?

- 1) charm production as reference for HI reactions;
- 2) structure of the proton, such as intrinsic $c\bar{c}$ in proton wave function and "mass" radius via study of $J/\psi + p \rightarrow J/\psi + p$ final state interactions;
- 3) hidden-charm exotic states spectroscopy (LHCb example), e.g. $P \rightarrow J/\psi + p$ and $P \rightarrow D + \Lambda_c$ studies