JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

FullSim Study:

Search for Charmonium Hybrid Candidate $\tilde{\eta}_{c1}$

-Status Report-

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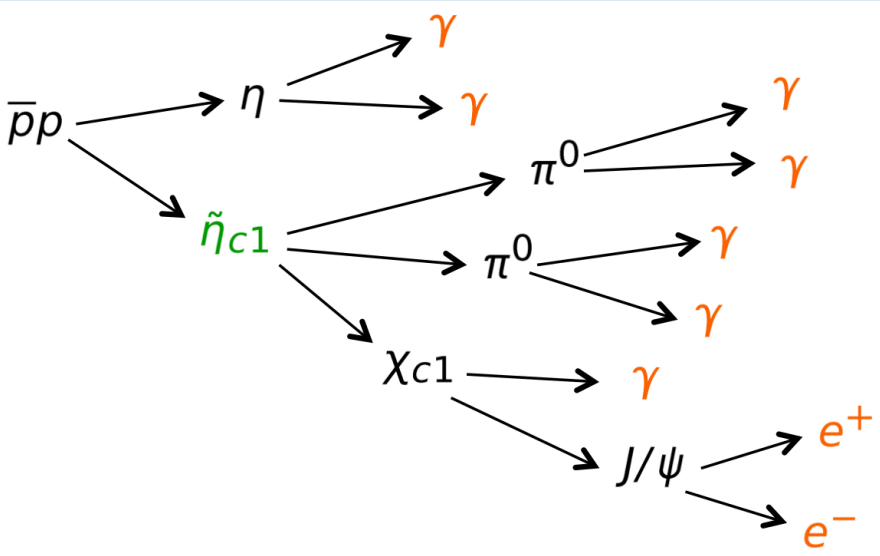
PANDA CM, March 2018

panda

HIC for FAIR
Helmholtz International Center

Charmonium Hybrid Candidate $\tilde{\eta}_{c1}$

- LQCD caculations:
  - 4.3 GeV/c^2
  - $J^{PC}=1^{-+}$
  - Crossection approx. 33 pb
  - Two favored channels:
    - $\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow \chi_{c1}\pi^0\pi^0\eta$
    - $\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow D^0\bar{D}^{0*}\eta$
- Simulation input parameter:
  - 10,000 events full sim.
  - No background
  - $\sqrt{s}$ = 4.7 GeV
  - noPhotos
  - All decays: PHSP
  - Except J/Ψ: VLL



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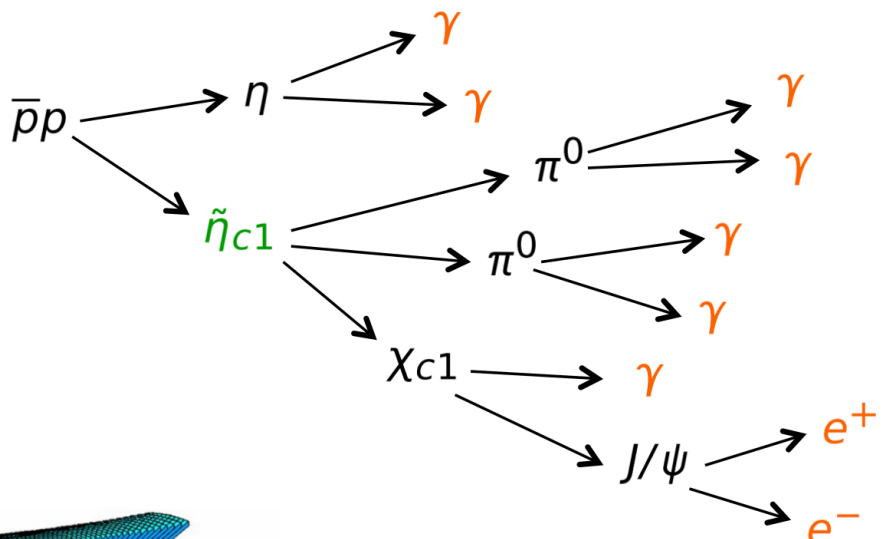
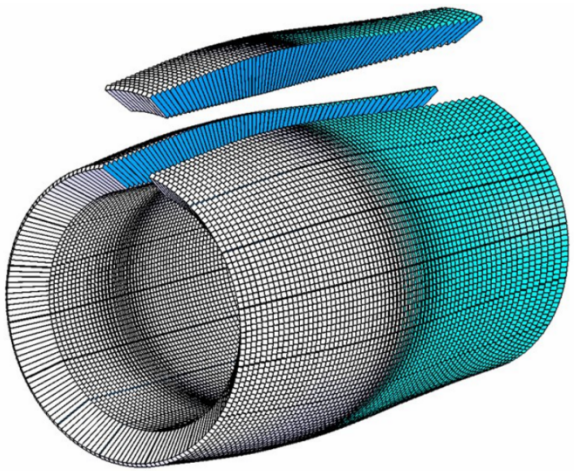
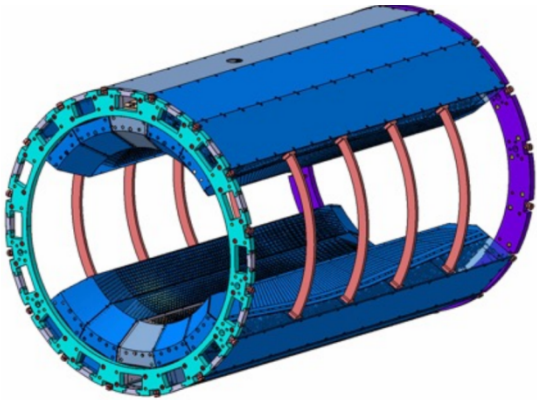


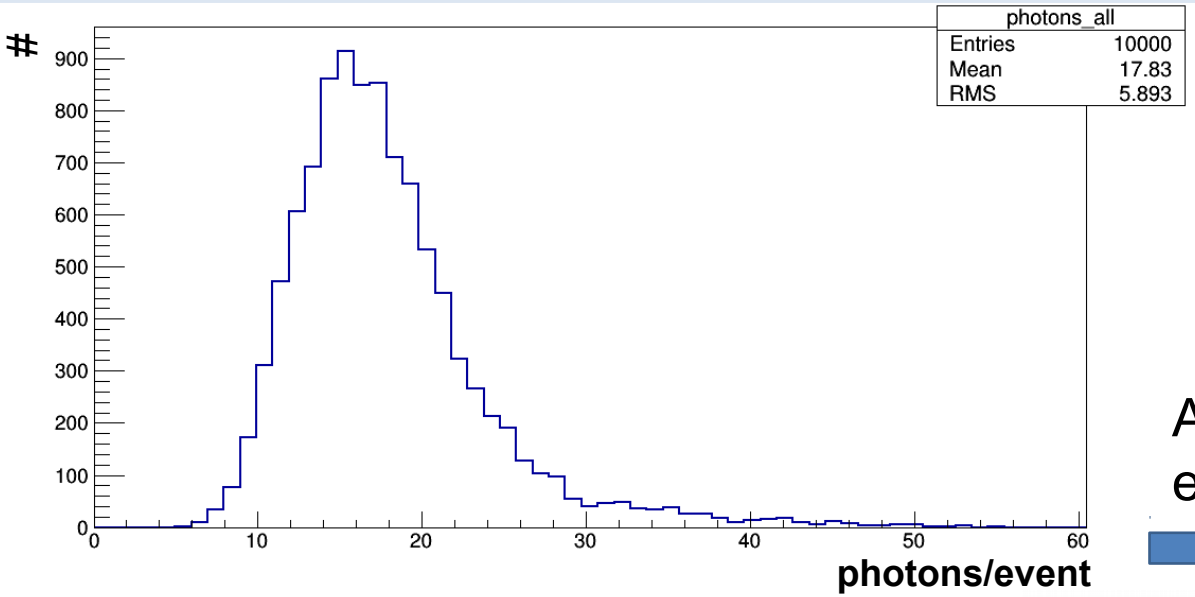


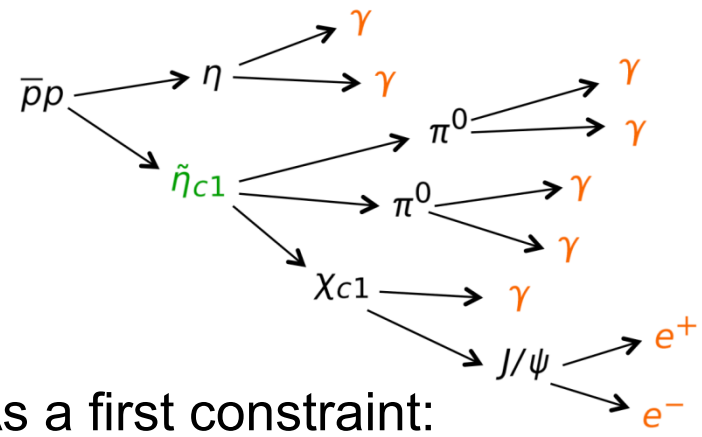
Full Barrel EMC



Day-1
worst case scenario

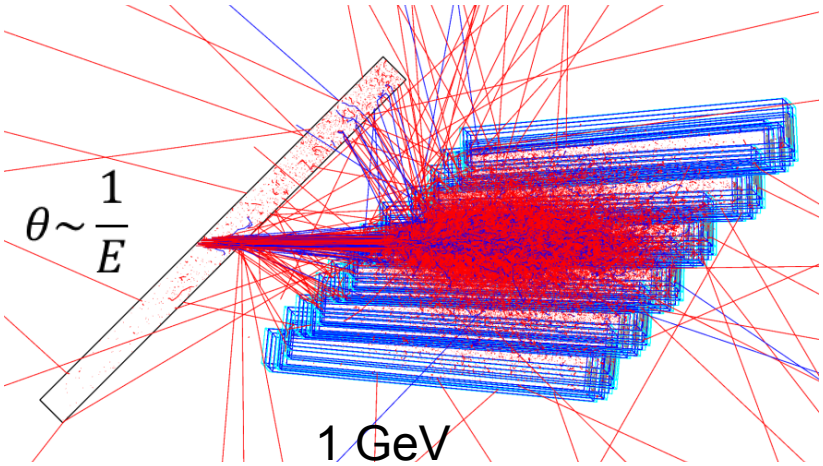
Event Selection

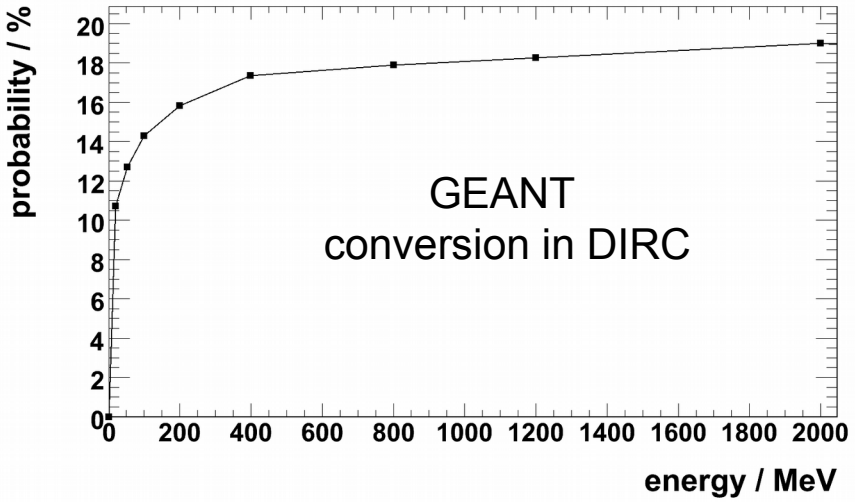




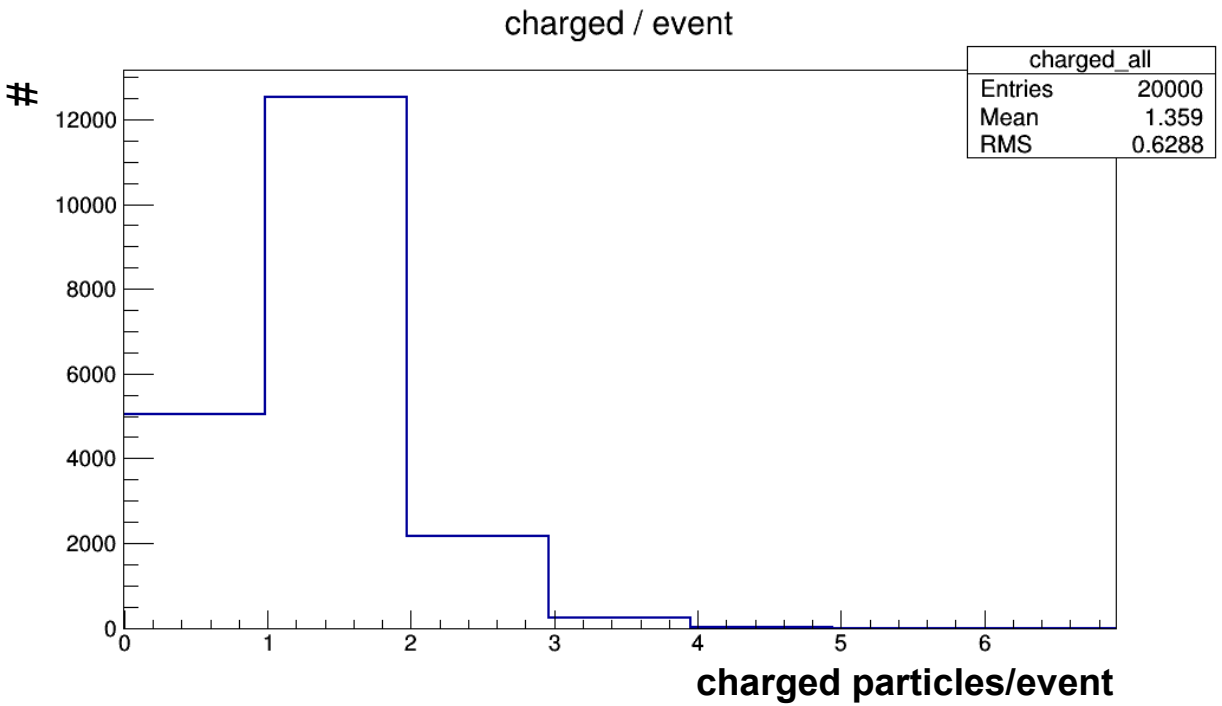
As a first constraint:
exact seven photons ?

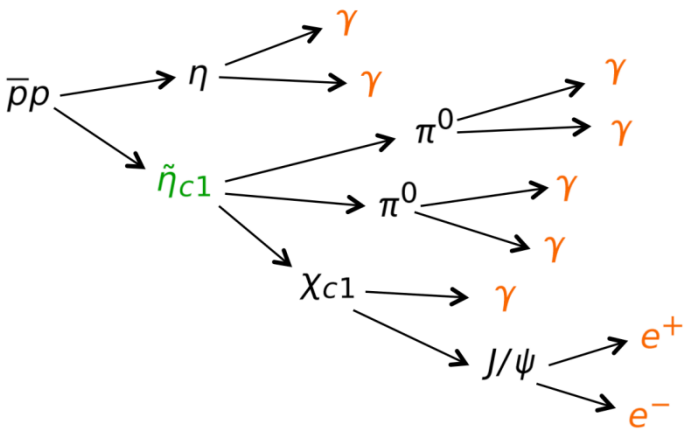
➡ min. 7 possible





Event Selection

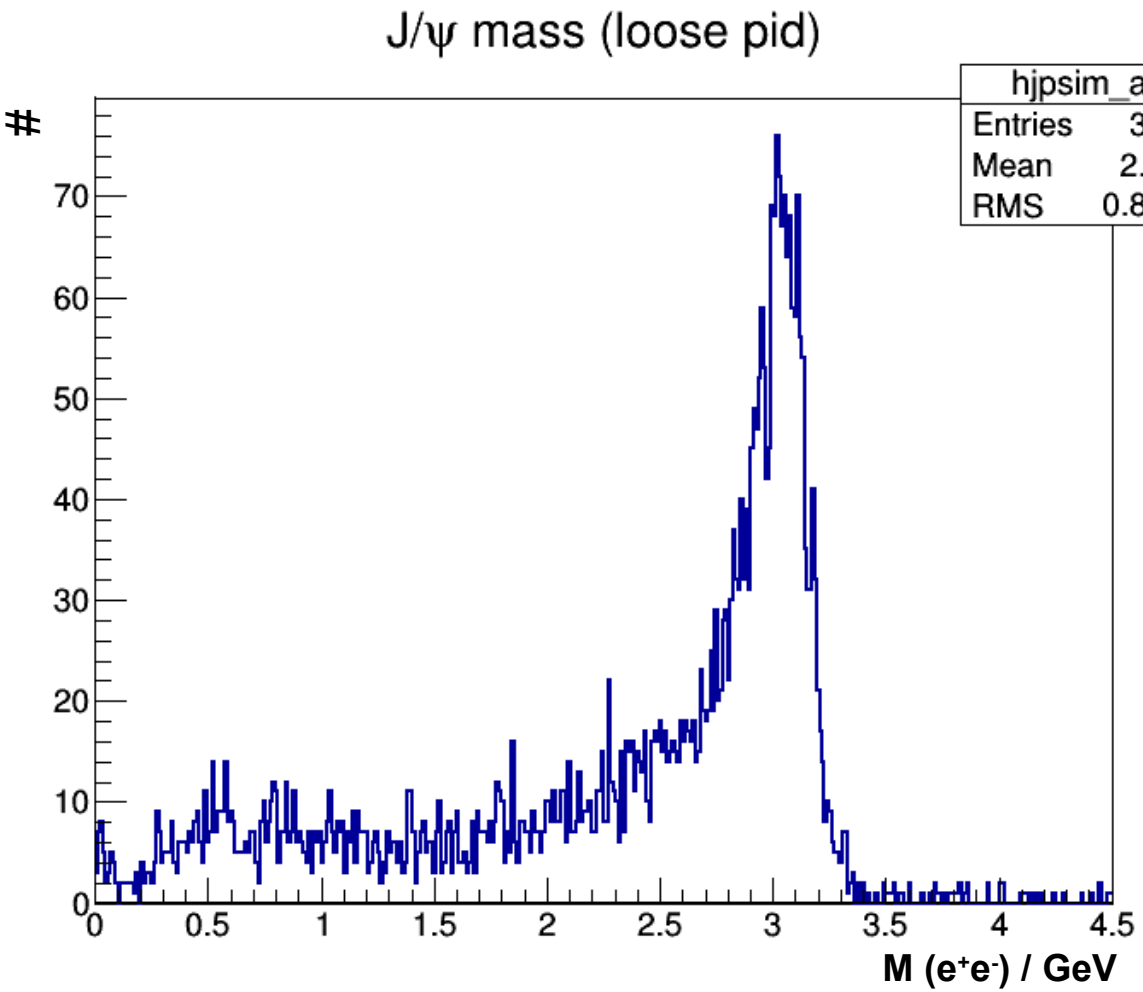


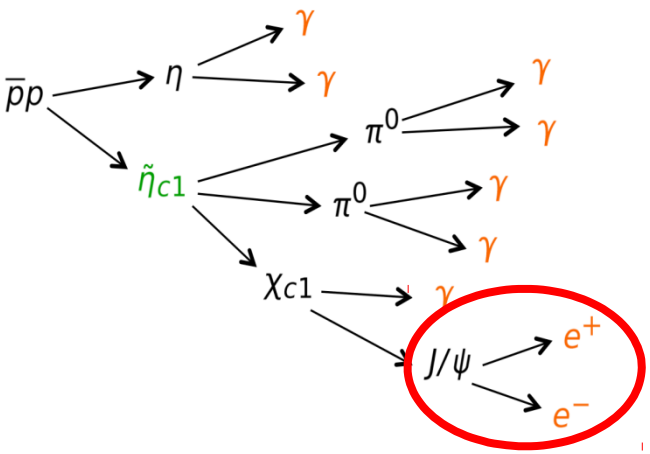


As a first constraint require a e^+e^- pair?

➡ promising

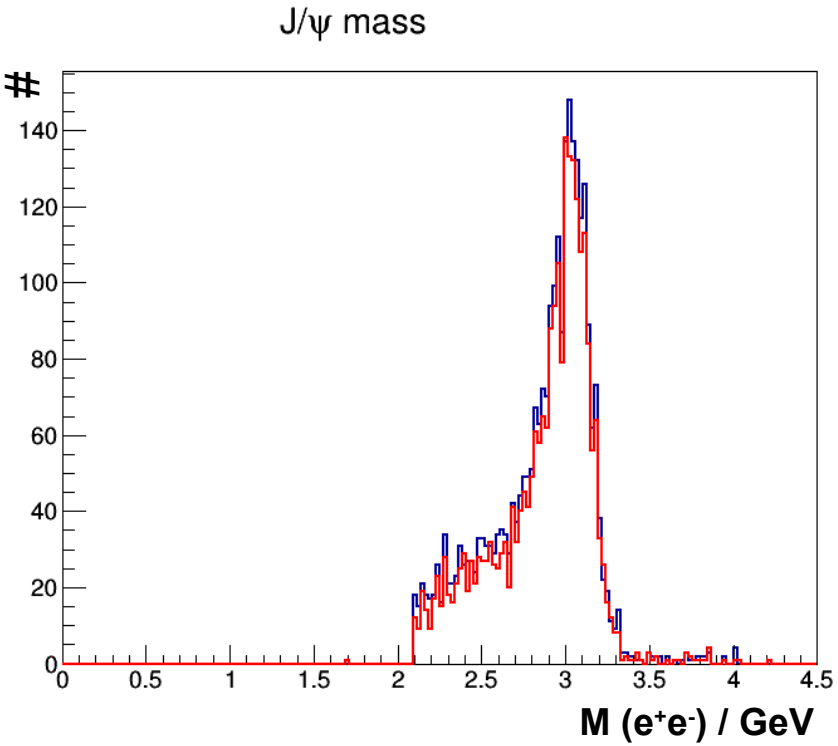
J/Ψ

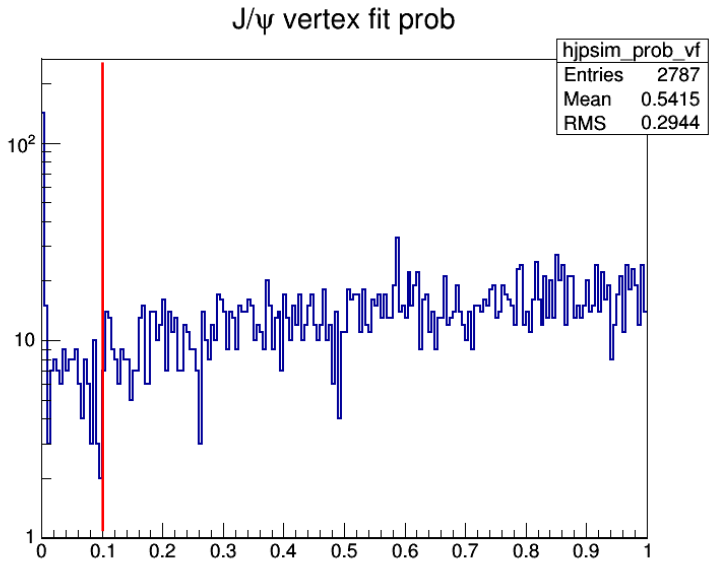

J/ψ mass (loose pid)
hjpsim_all
Entries 3973
Mean 2.358
RMS 0.8959
#
M (e⁺e⁻) / GeV

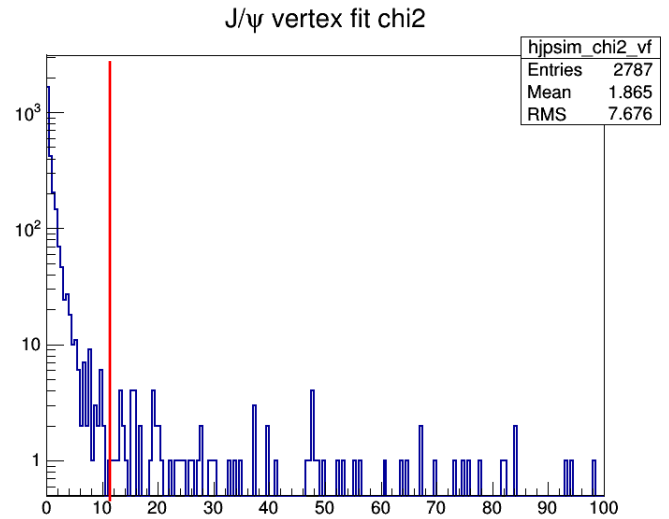

$\bar{p}p$
η
γ
γ
$\tilde{\eta}_{c1}$
π^0
γ
γ
π^0
γ
γ
χ_{c1}
γ
J/ψ
e^+
e^-

J/Ψ

1. Rough cut
   - +- 1 GeV/c^2
2. Vertex fit
   - prop > 0.1
   - chi2 < 10



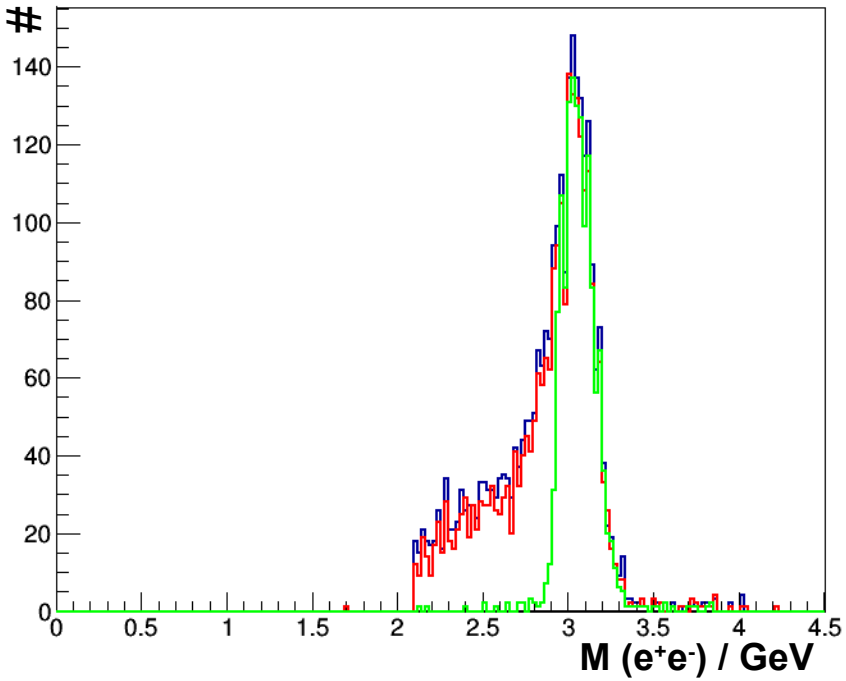




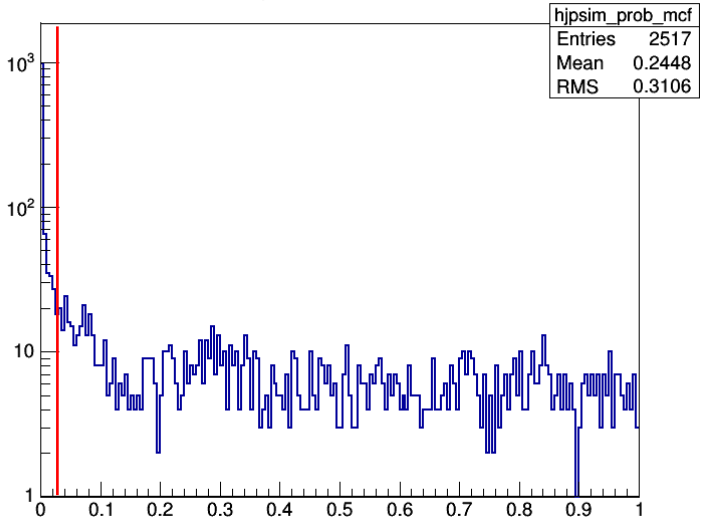
J/Ψ

1. Rough cut
   - +- 1 GeV/c^2
2. Vertex fit
   - prop > 0.1
   - chi2 < 10
3. MCF
   - prop > 0.02
   - Chi2 < 10

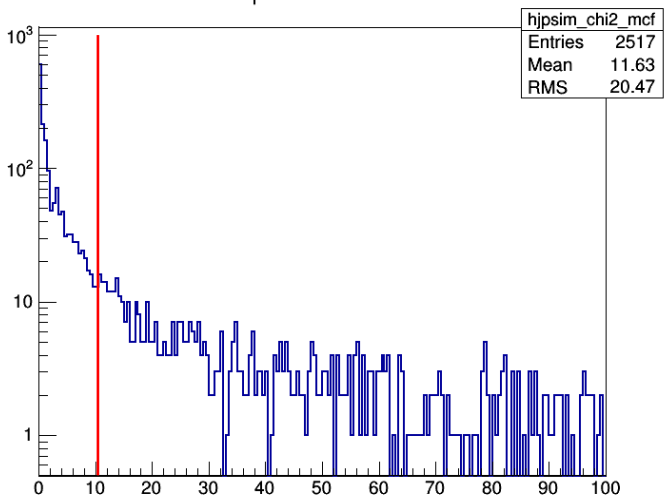
J/ψ mass



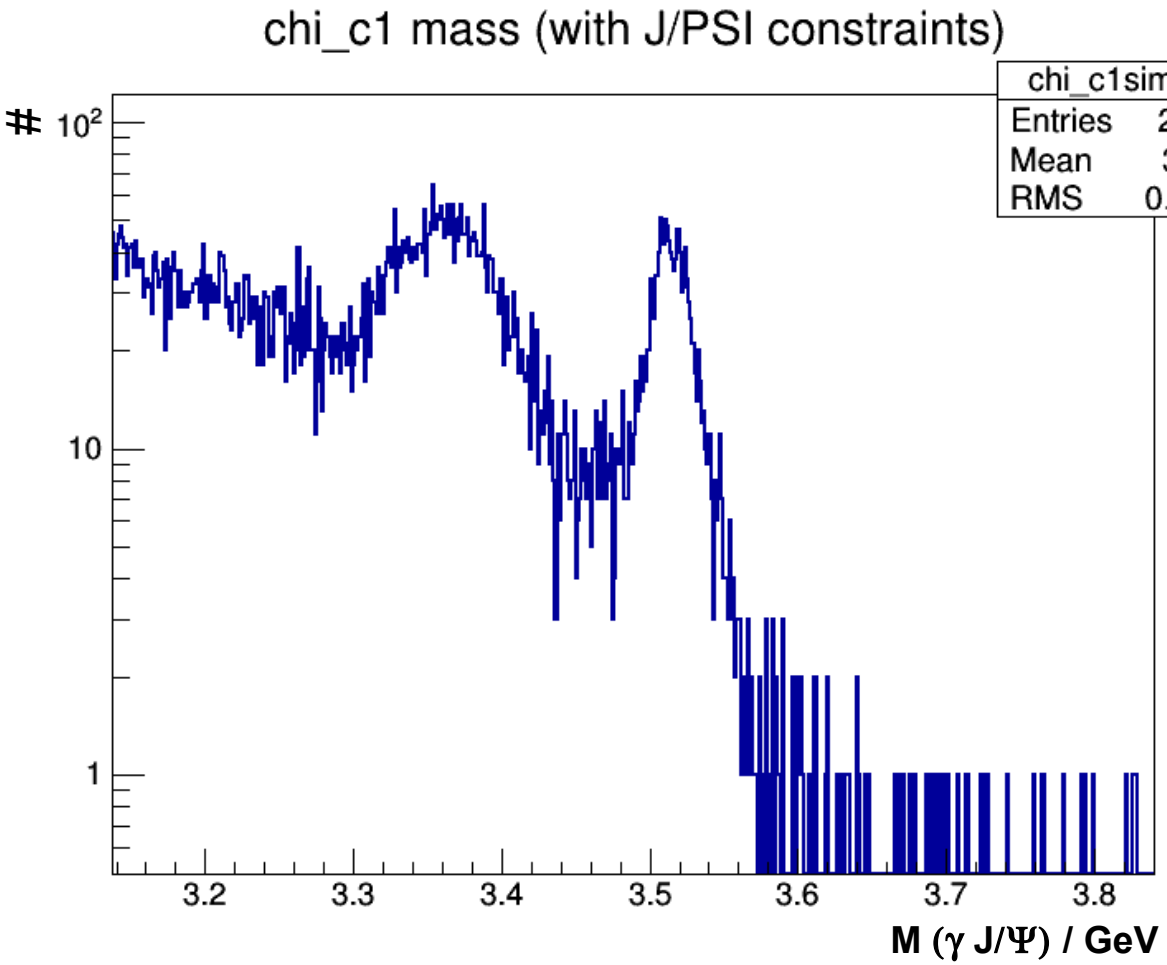
J/ψ mass fit prob.

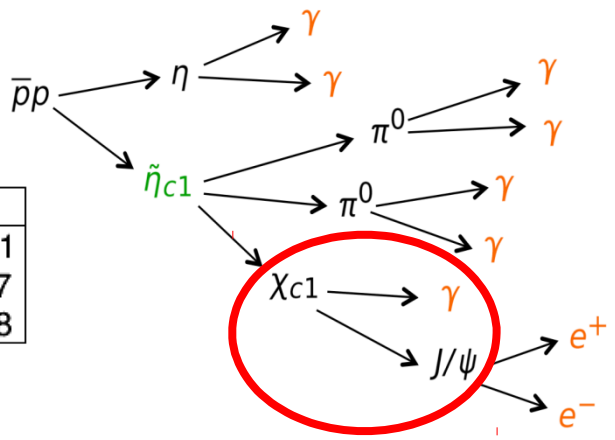


J/ψ mass fit chi2

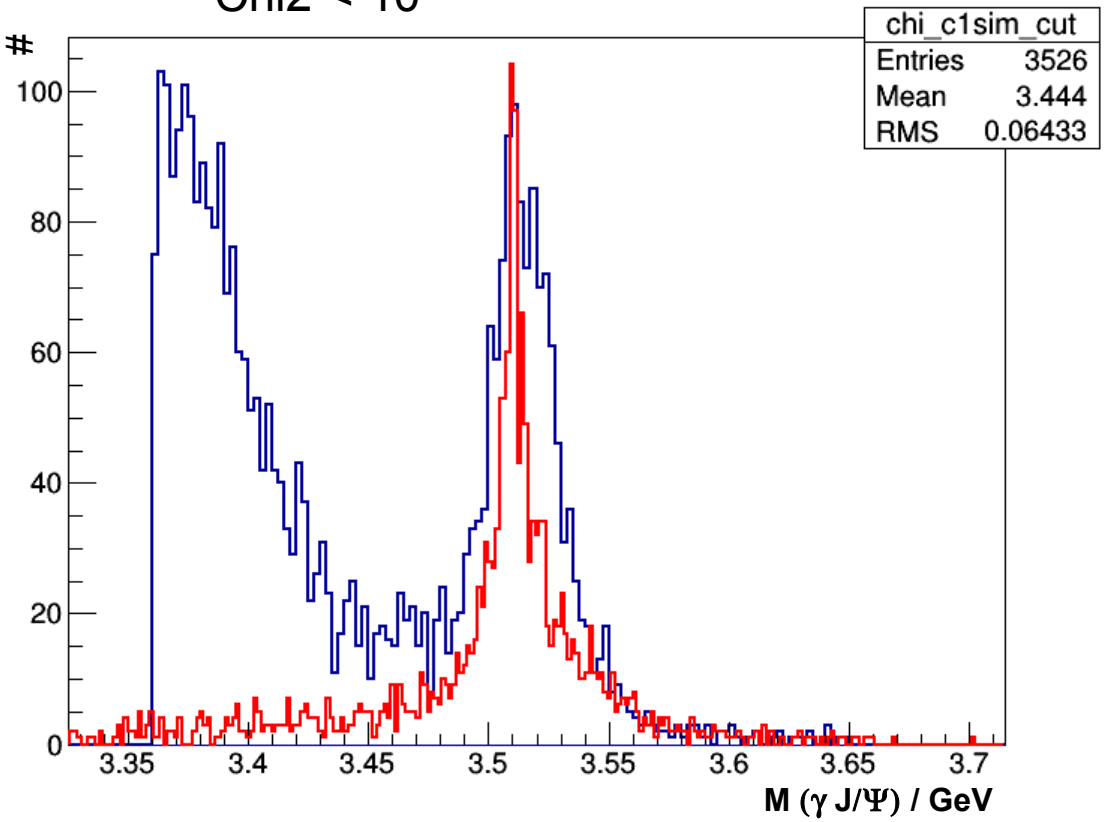


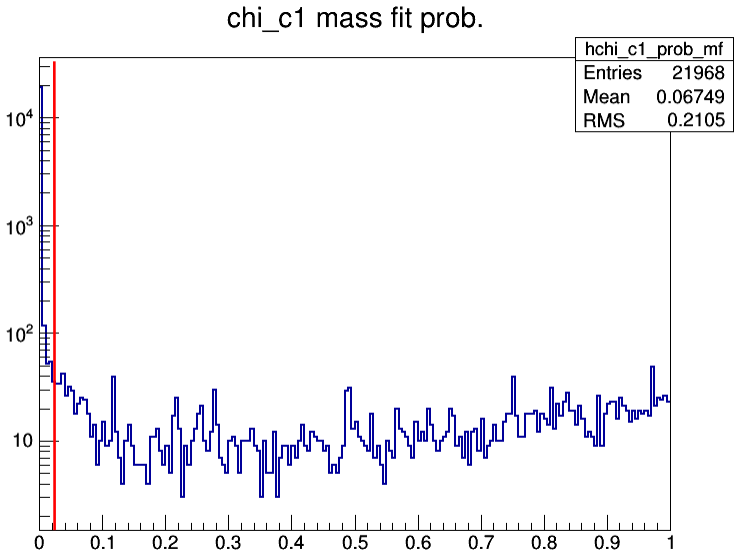
χ_{c1}

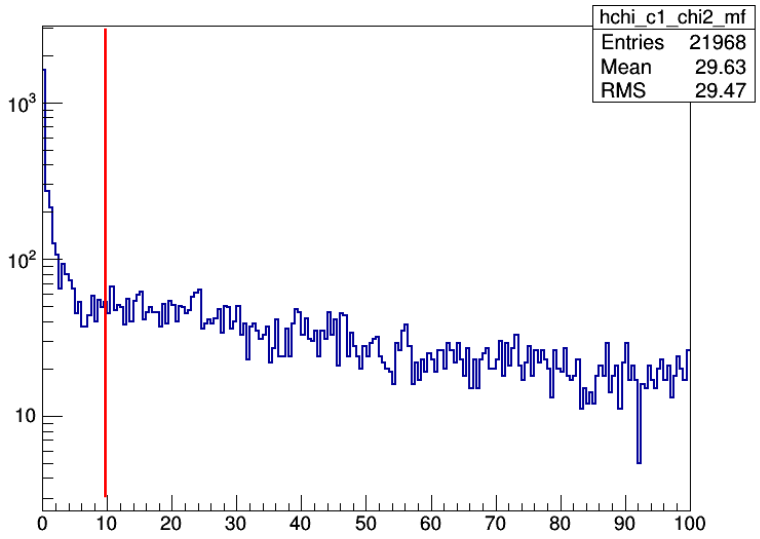

chi_c1 mass (with J/PSI constraints)
chi_c1sim_all
Entries 22221
Mean 3.327
RMS 0.1188
#
10²
10
1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
M (γ J/Ψ) / GeV


$\bar{p}p$
η
γ
γ
π^0
γ
γ
$\tilde{\eta}_{c1}$
π^0
γ
γ
χ_{c1}
γ
J/ψ
e^+
e^-

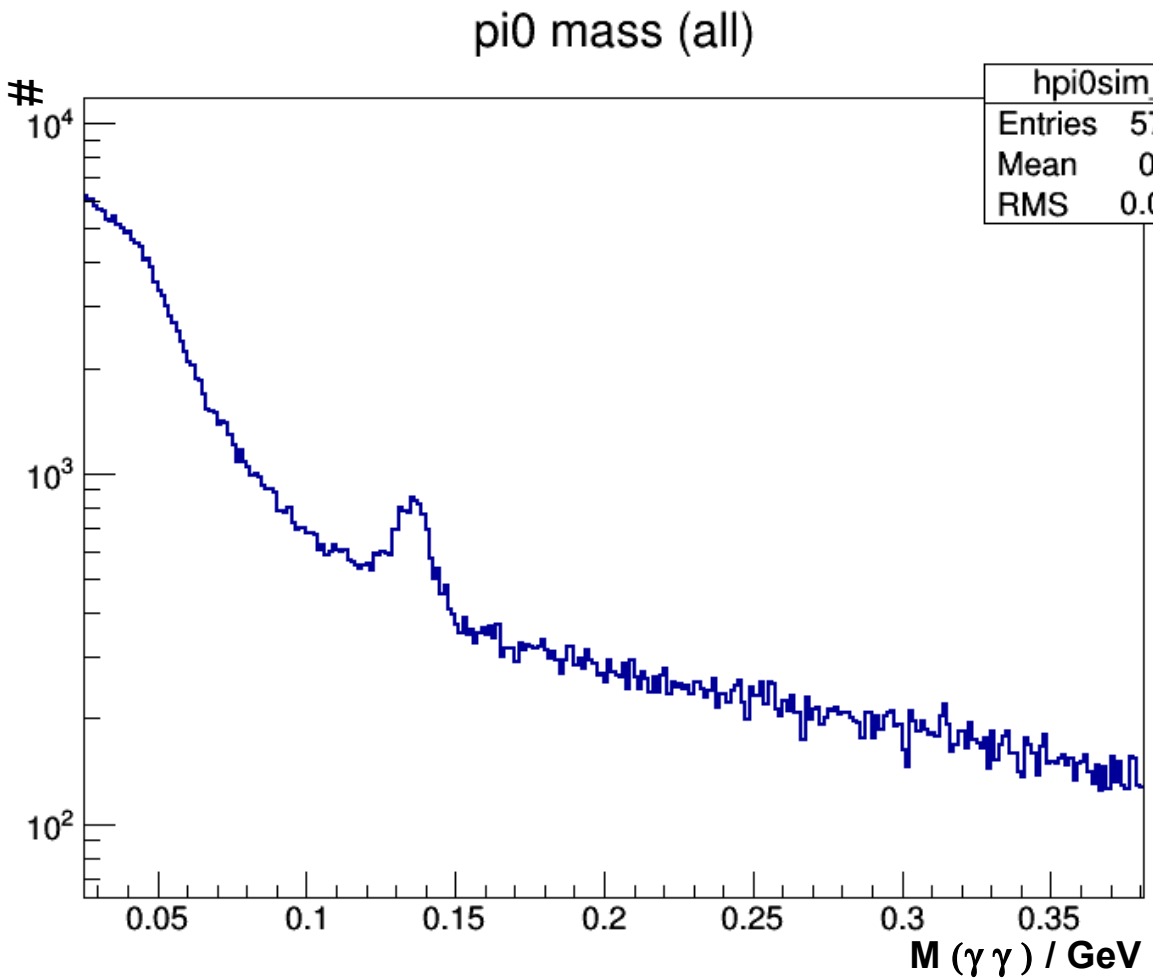
1. Rough cut +- 0.15 GeV/c^2
2. MCF
   - prop > 0.02
   - Chi2 < 10

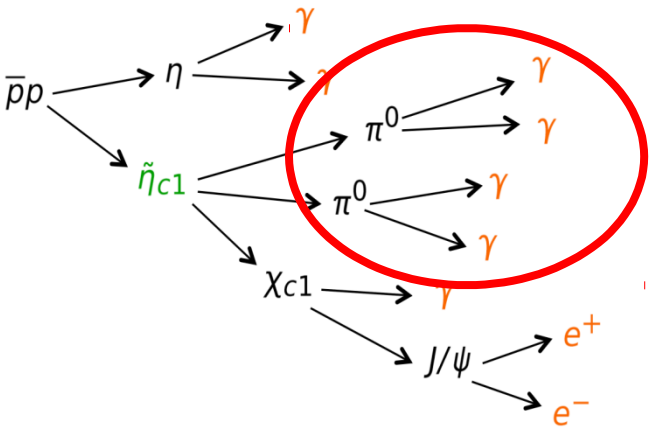




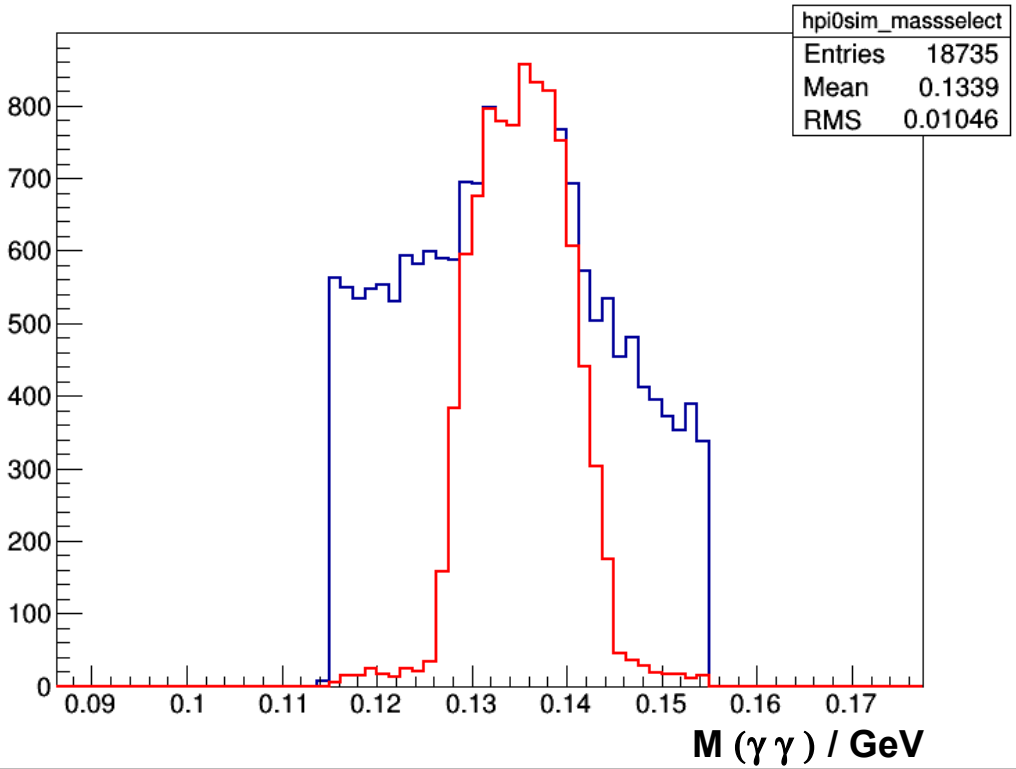


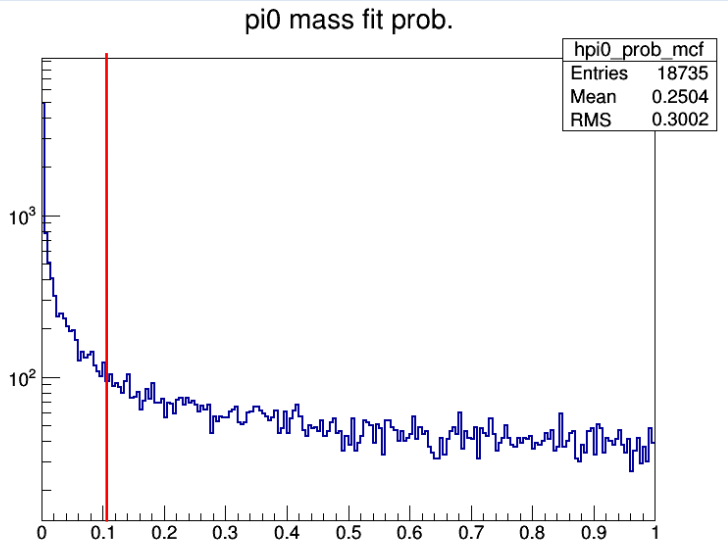
π^0

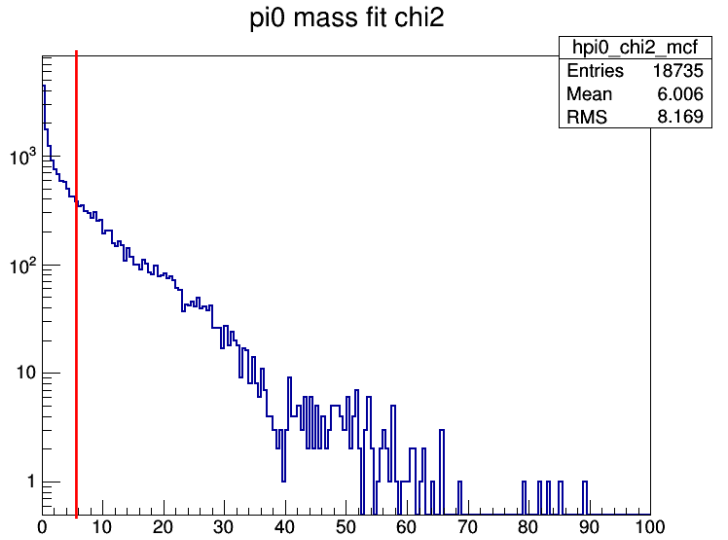

pi0 mass (all)
hpi0sim_all
Entries 571068
Mean 0.0932
RMS 0.08343
#
10^4
10^3
10^2
0.05
0.1
0.15
0.2
0.25
0.3
0.35
M (γ γ) / GeV


p̄p
η
γ
γ
ηc1
π0
γ
γ
π0
γ
γ
χc1
γ
J/ψ
e+
e−

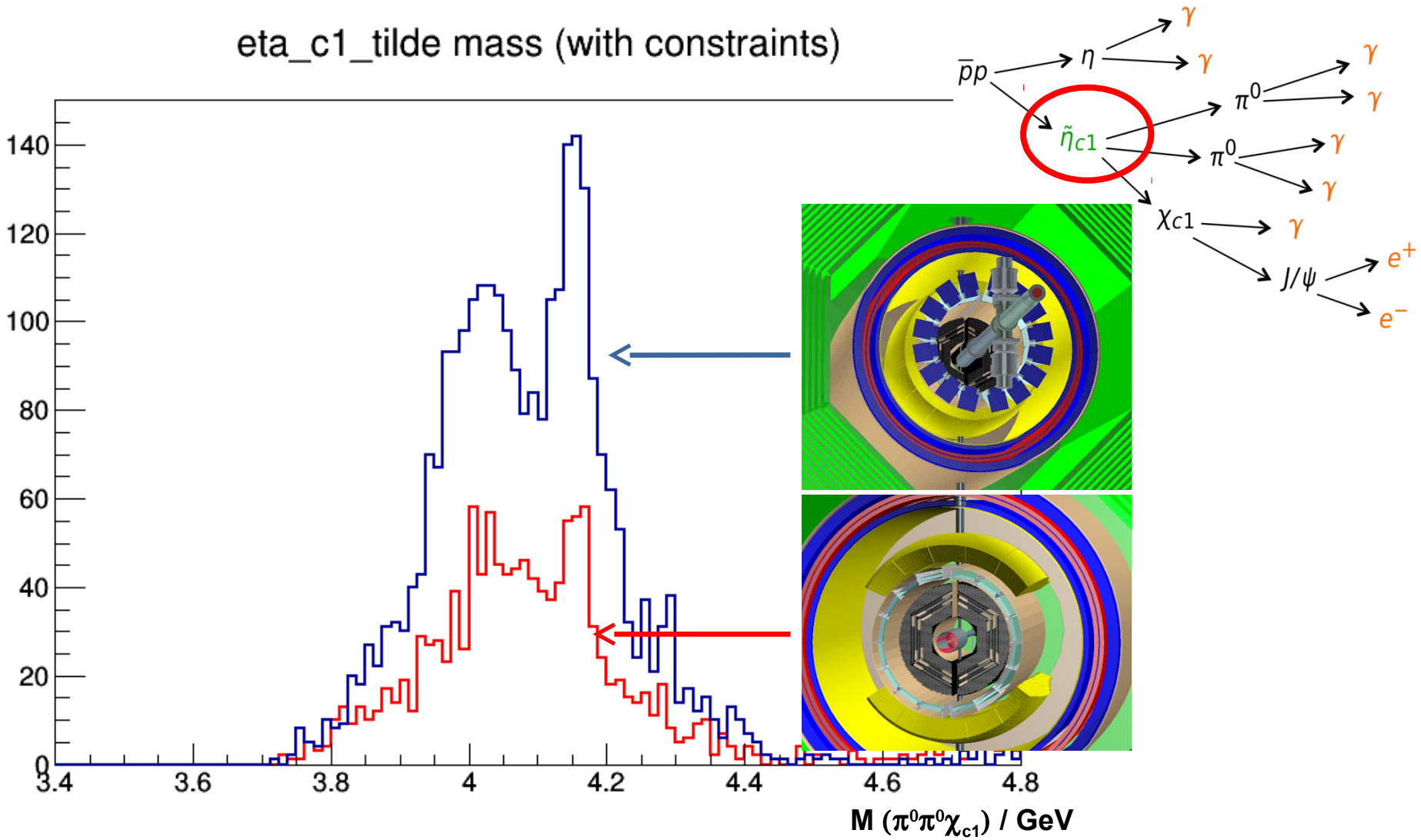
1. Rough cut +- 0.02 GeV/c^2
2. MCF
   - prop > 0.1
   - Chi2 < 5



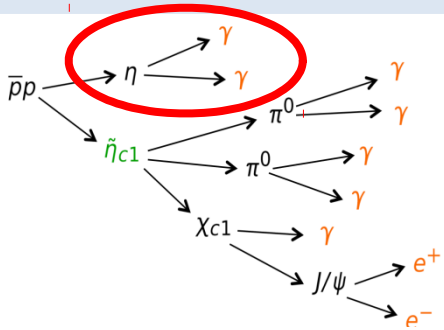




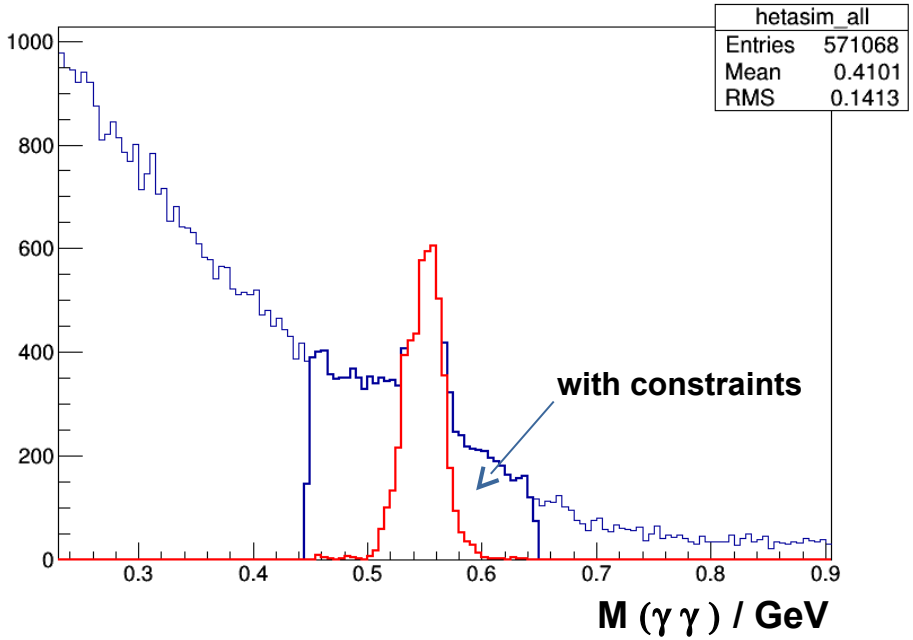
$\tilde{\eta}_{c1}$

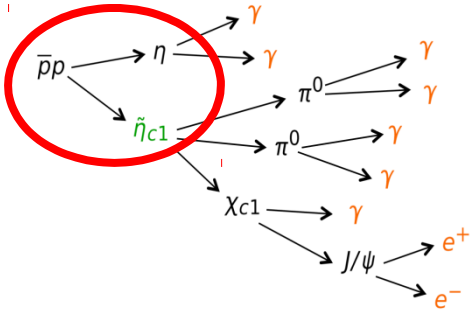

eta_c1_tilde mass (with constraints)
140
120
100
80
60
40
20
0
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
M ($\pi^0\pi^0\chi_{c1}$) / GeV
$\bar{p}p$
η
γ
γ
$\tilde{\eta}_{c1}$
π^0
γ
γ
π^0
γ
γ
χ_{c1}
γ
J/ψ
e^+
e^-

η & p̄p

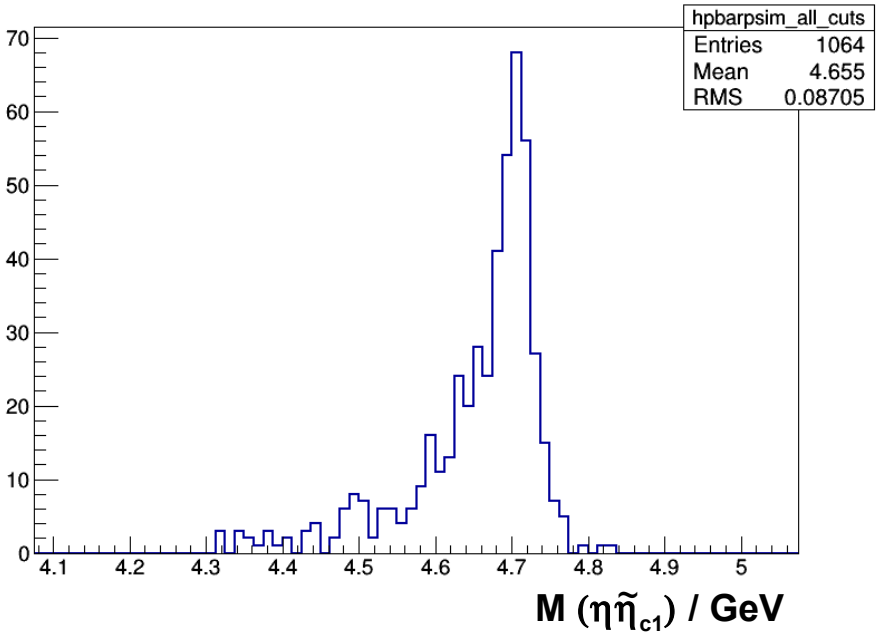


eta mass (all)





pbarp (with constraints)



Summary & Outlook

- **Summary**
  - Channel $\bar{p}p \rightarrow \tilde{\eta}_{c1}\eta \rightarrow \chi_{c1}\pi^0\pi^0\eta$ has many final states
    - e^+e^- pair
    - 7 photons -> high calorimeter coverage necessary
  - Day-1 worst case setup: 10 Barrel Slices
    - Crystal reduction ring wise mechanical not applicable
    - First simulations indicate clear reduced reconstruction efficiency
- **Outlook**
  - 4C fit ppbar system
  - Verify origin of high amount of photons
  - Setup PANDARoot @ Skylla
    - Run simulations with high statistics & background
    - Cuts optimization
  - Impact reduced Day-1 Barrel (worst case scenario)