Upsilon reconstruction from full simulation

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EIC weekly meeting

Introduction

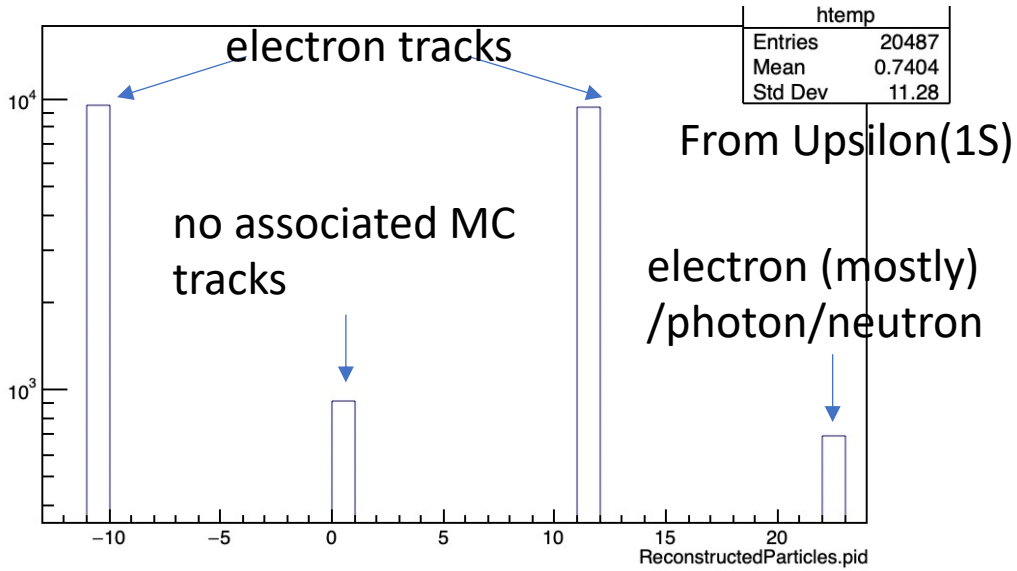
- Input MC events (HepMc format)
  - $ep \to ep\,\Upsilon, \Upsilon \to e^+e^-$ generated from eStarlight
    - from Spencer and Zakary Sweger
  - 10 K events for $\Upsilon(1S)/\,\Upsilon(2S)/\,\Upsilon(3S)$

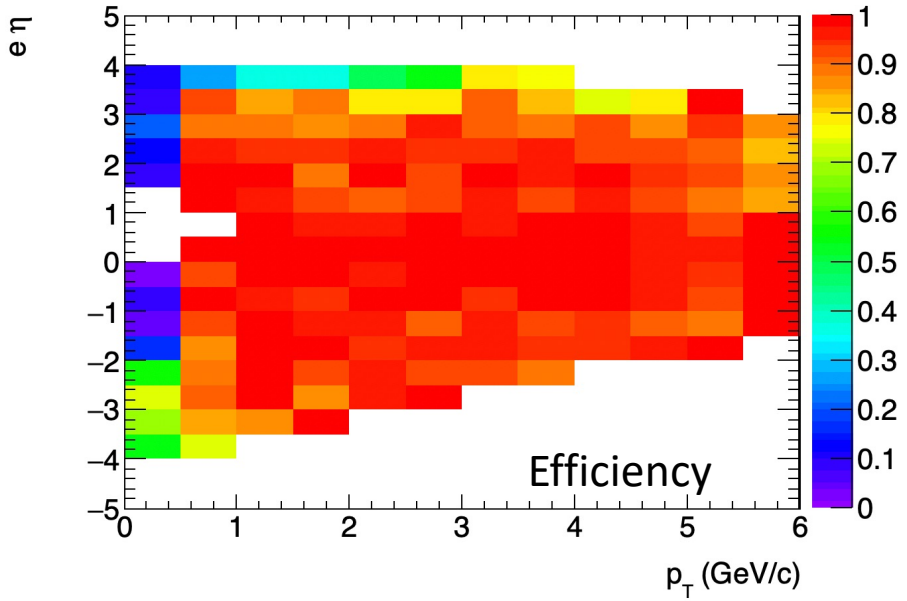
- Beam effects: Afterburner – from Brain Page

- DD4Hep Full simulation from recent detector setups
  - generated by Zhoudunming Tu (BNL)
  - produced at Oct 27, bugs on Far Forward (FF) detectors not fixed in this production (scattered proton) - take rough look: ~95% scattered protons detected

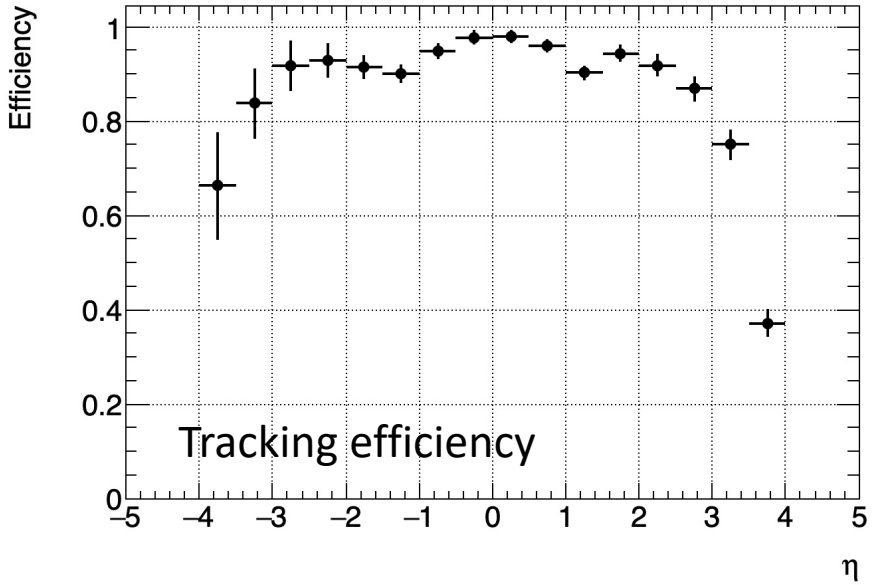
Single electron tracking

Reconstructed tracks PID

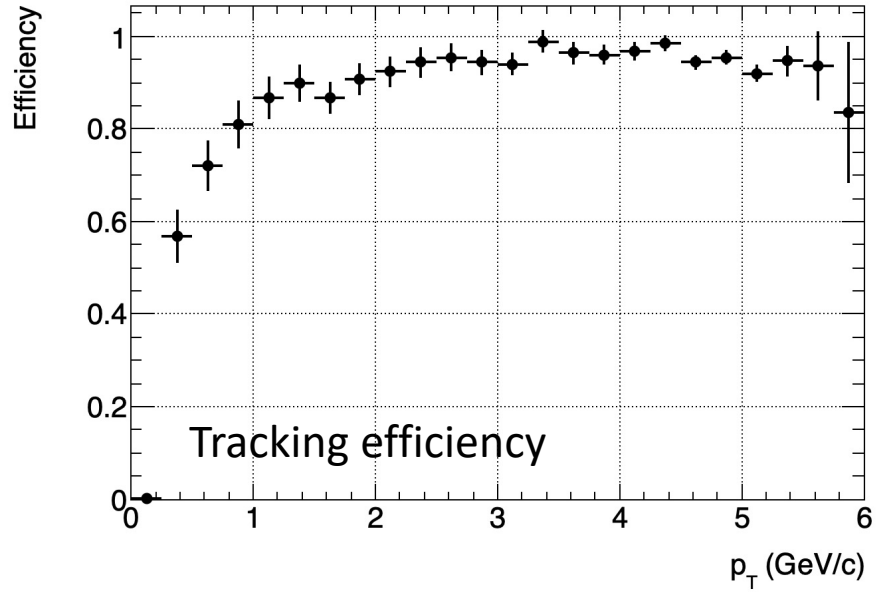




Combine all electron tracks from simulations

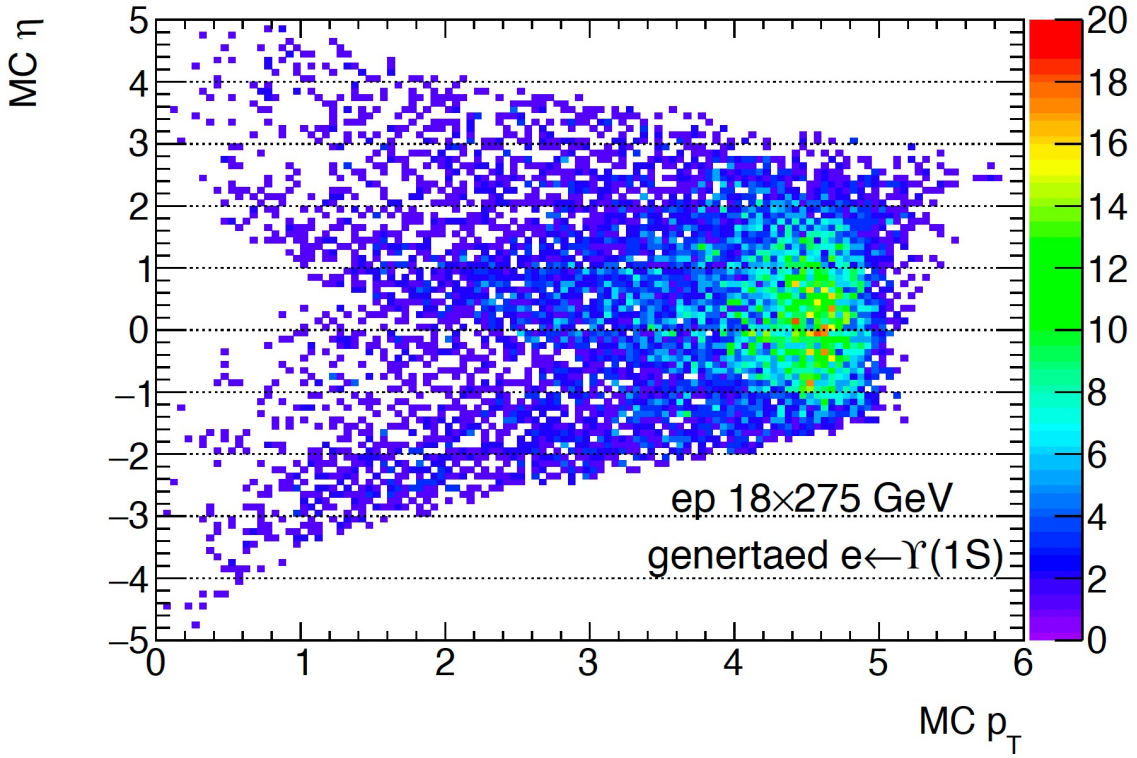


$$\frac{\text{gene. particle}}{\text{reco. particle}}$$

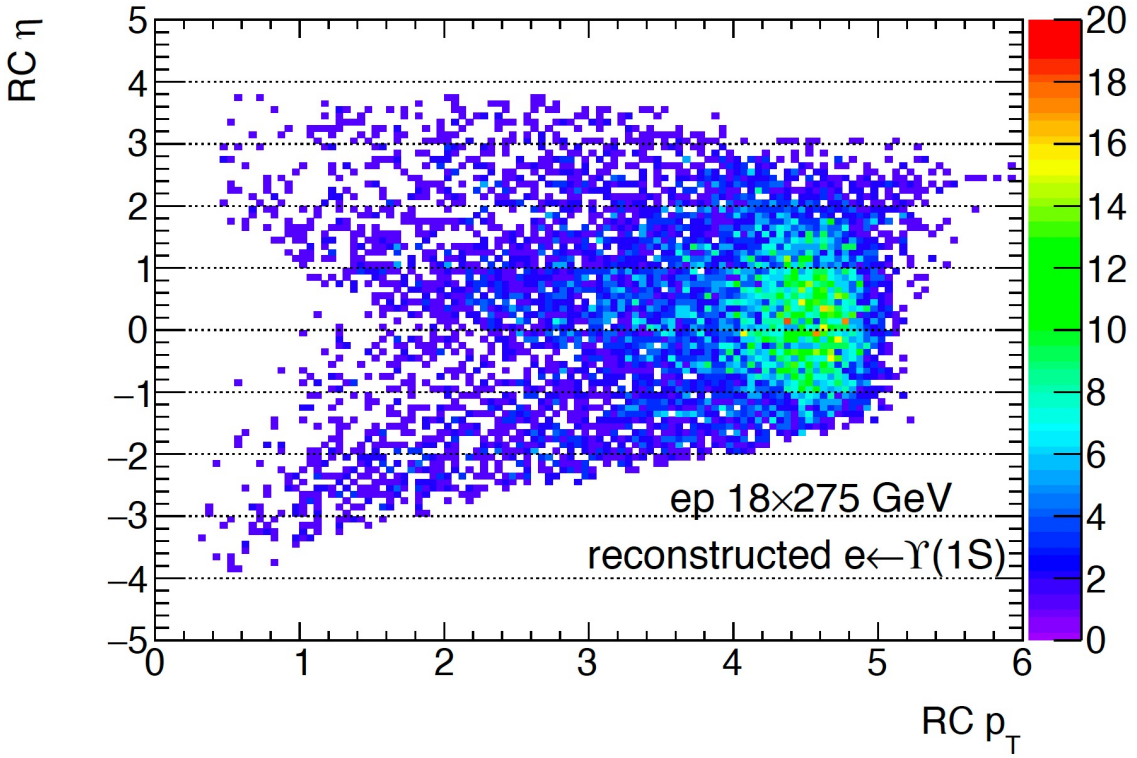


Daughter electron p_T vs η

- Select electrons from MC Upsilon or reconstructed Upsilon;
- Track acceptance is roughly within |eta|<3.5

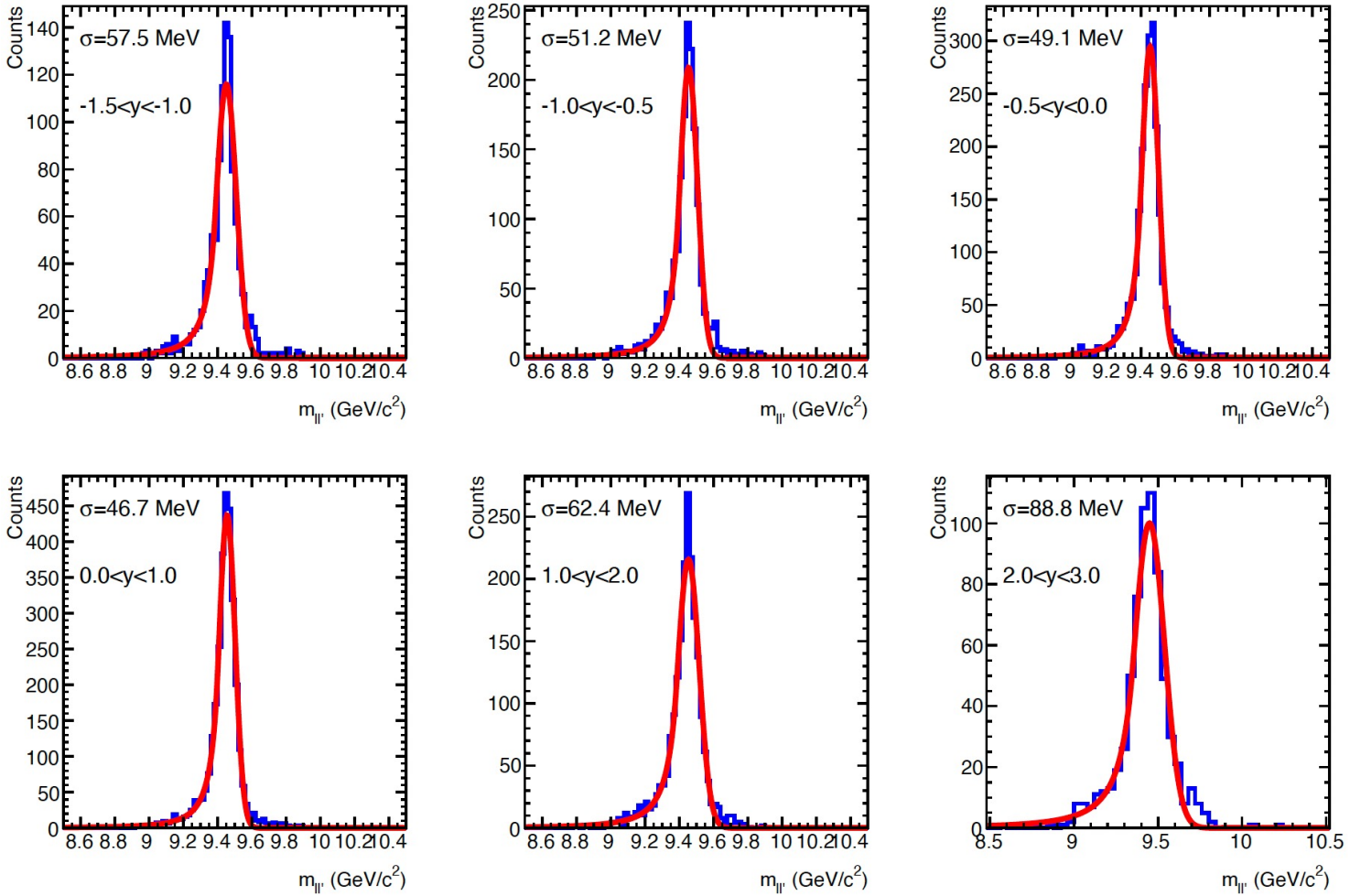


From generated particles (MC)



From reconstructed upsilon

Reconstructed $\Upsilon(1S) \rightarrow e^+e^-$ vs rapidity

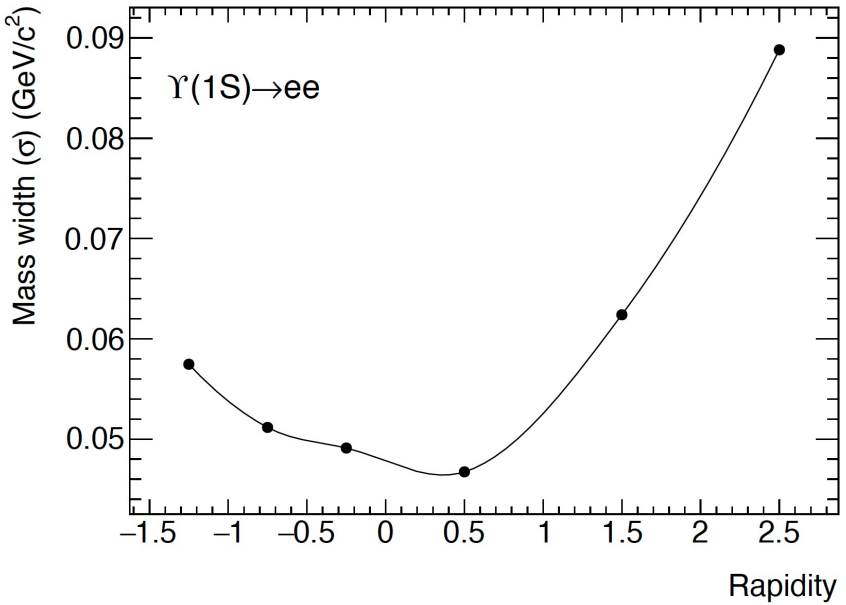


Fitting function:

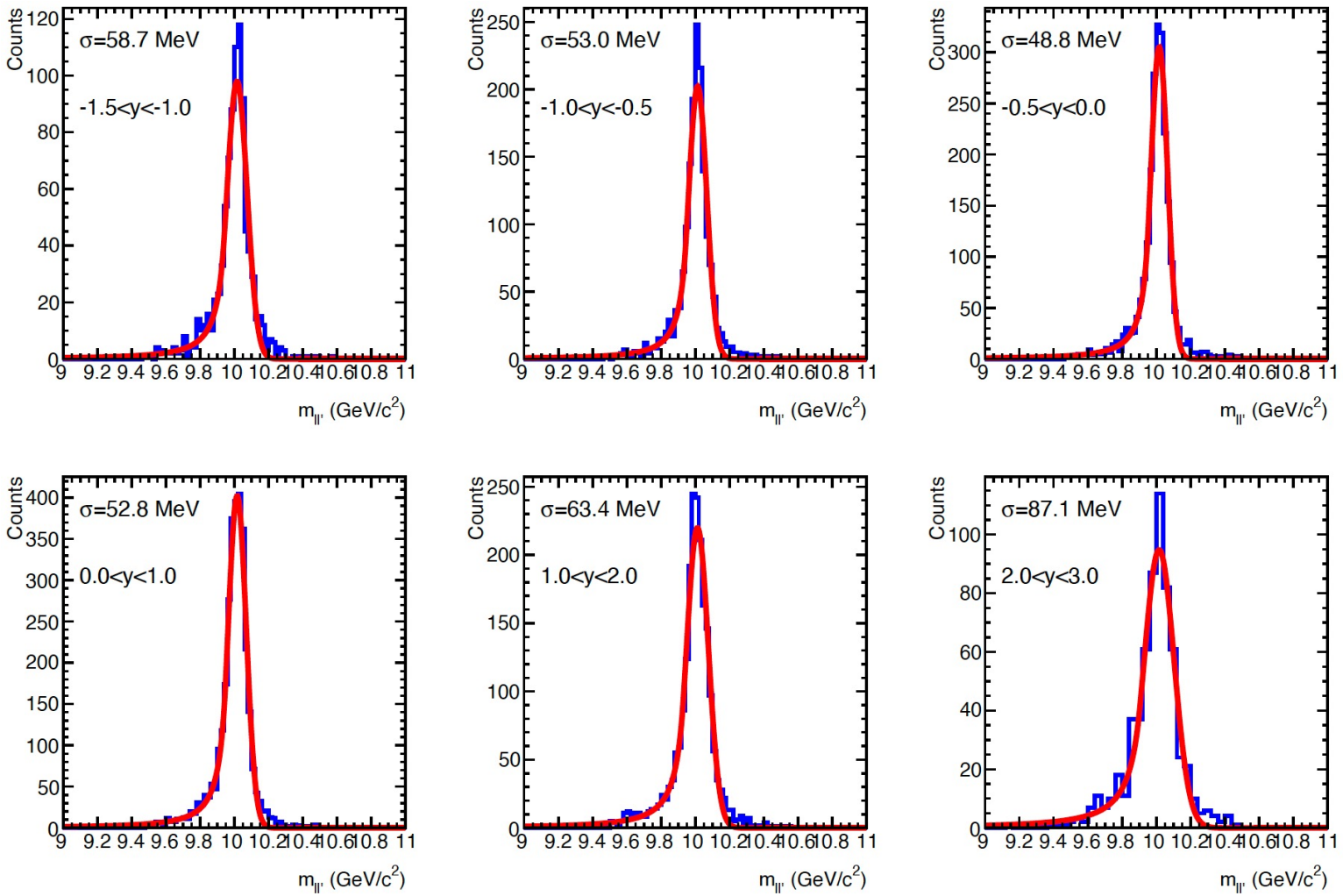
$$f(x;\alpha,n,\bar{x},\sigma) = N \cdot \begin{cases} \exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \frac{x-\bar{x}}{\sigma} > -\alpha \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} \leqslant -\alpha \end{cases}$$

α= 1.14; n= 2.5

Upsilon mass width



Reconstructed $\Upsilon(2S) \rightarrow e^+e^-$ vs rapidity

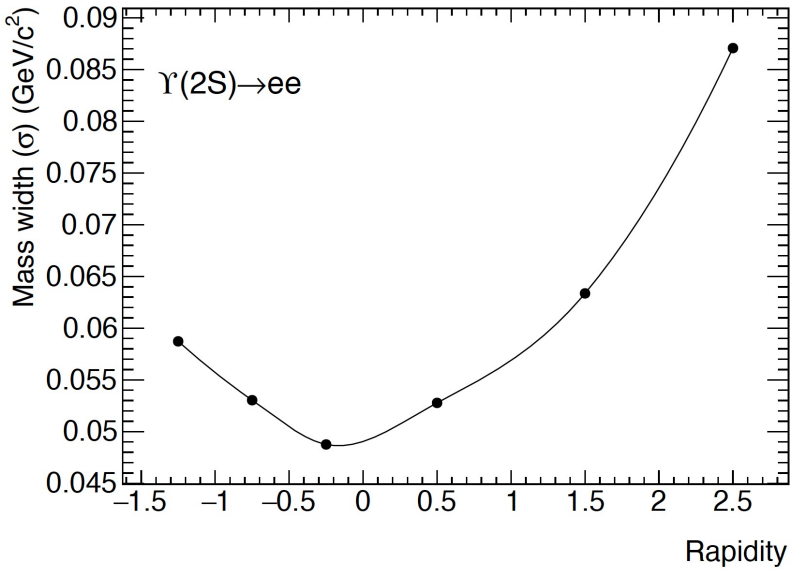


Fitting function:

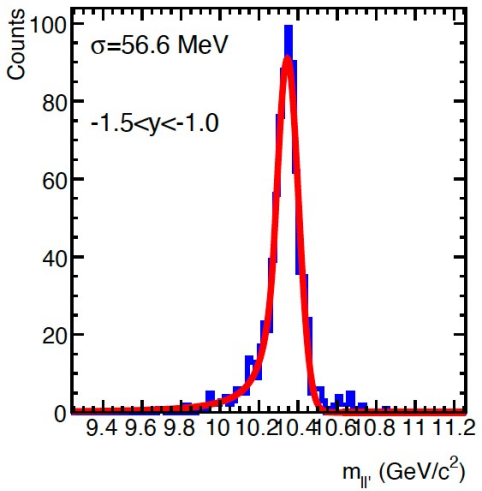
$$f(x;\alpha,n,\bar{x},\sigma) = N \cdot \begin{cases} \exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \frac{x-\bar{x}}{\sigma} > -\alpha \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} \leqslant -\alpha \end{cases}$$

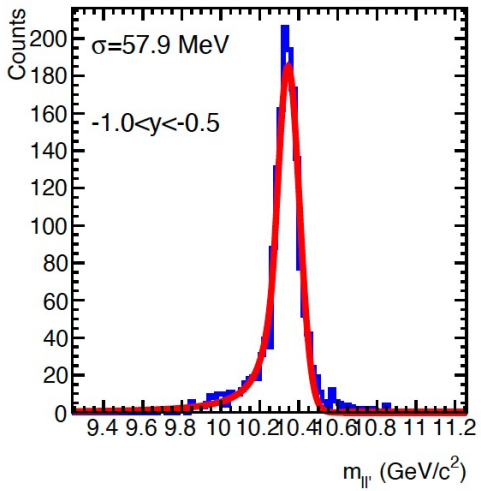
α= 1.29; n=1.82

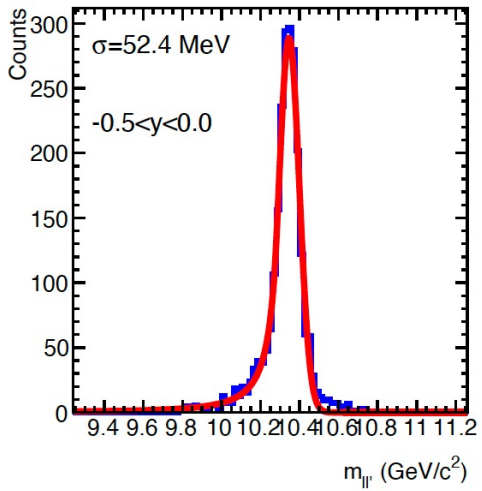
Upsilon mass width

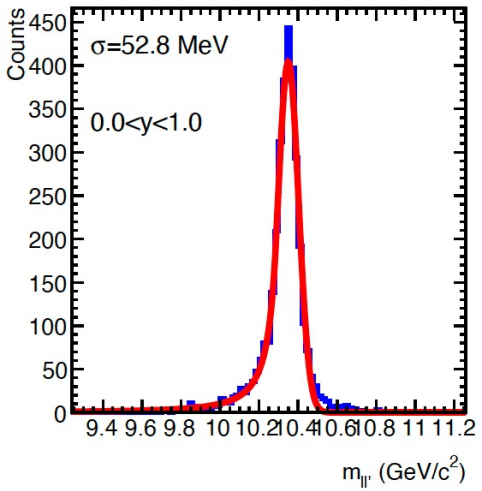


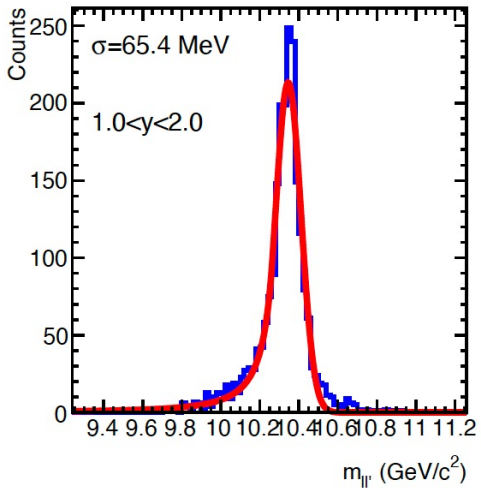
Reconstructed $\Upsilon(3S) \rightarrow e^+e^-$ vs rapidity

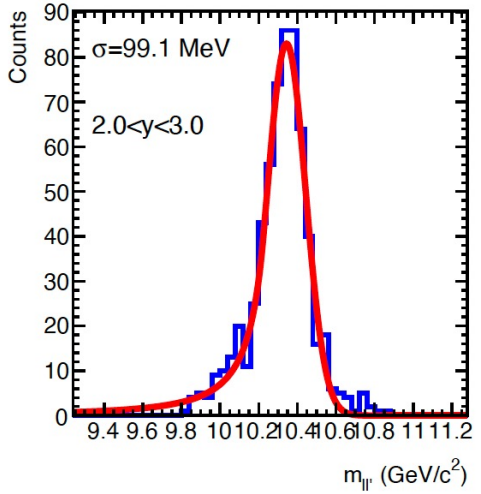












Fitting function:

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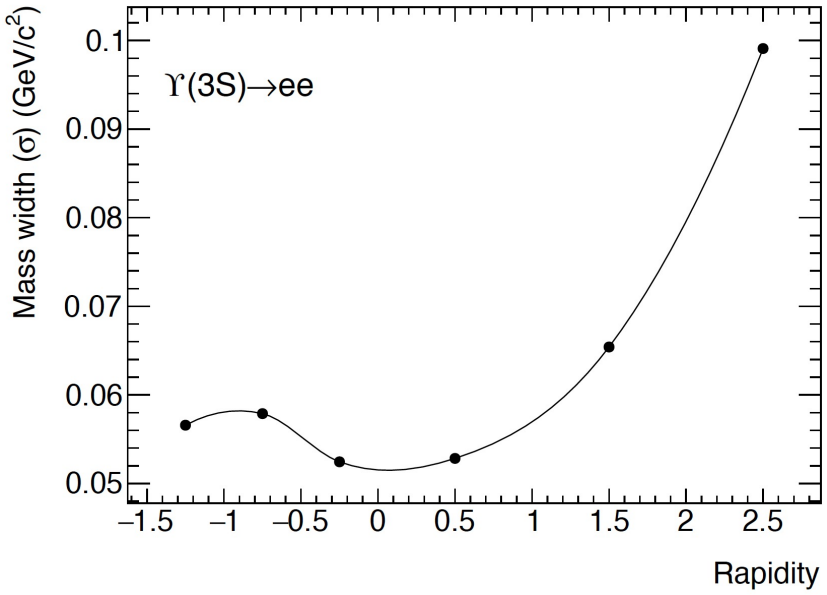
α= 1.22; n=2.04

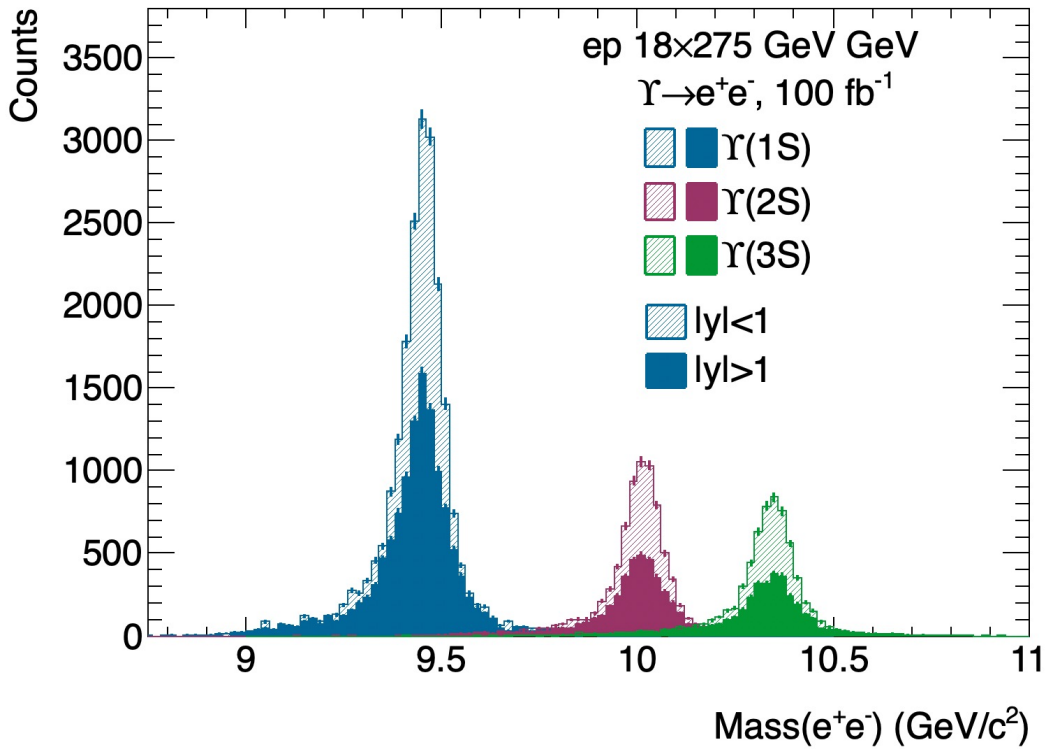
Upsilon mass width



Mass width Athena vs YR

B.R($\Upsilon \rightarrow e^+e^-$)=0.0238 used in the projection

Athena



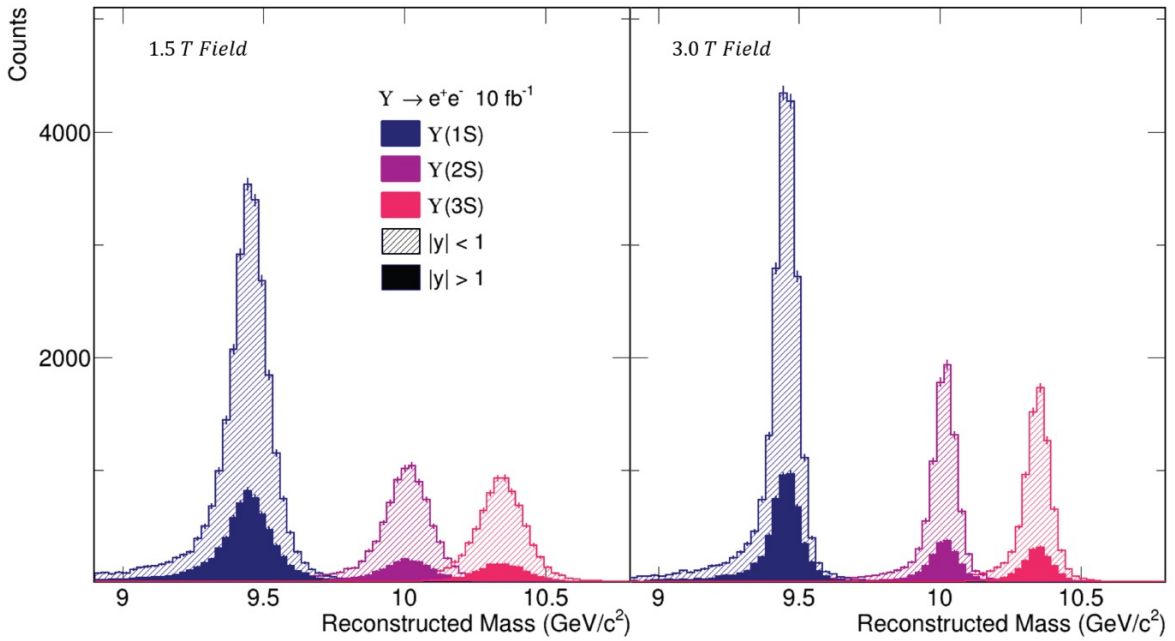
Fit with crystal ball function

Mass resolution with Athena

|y|<1, 49 MeV/c²

|y|>1, 65.9 MeV/c²

All silicon detector

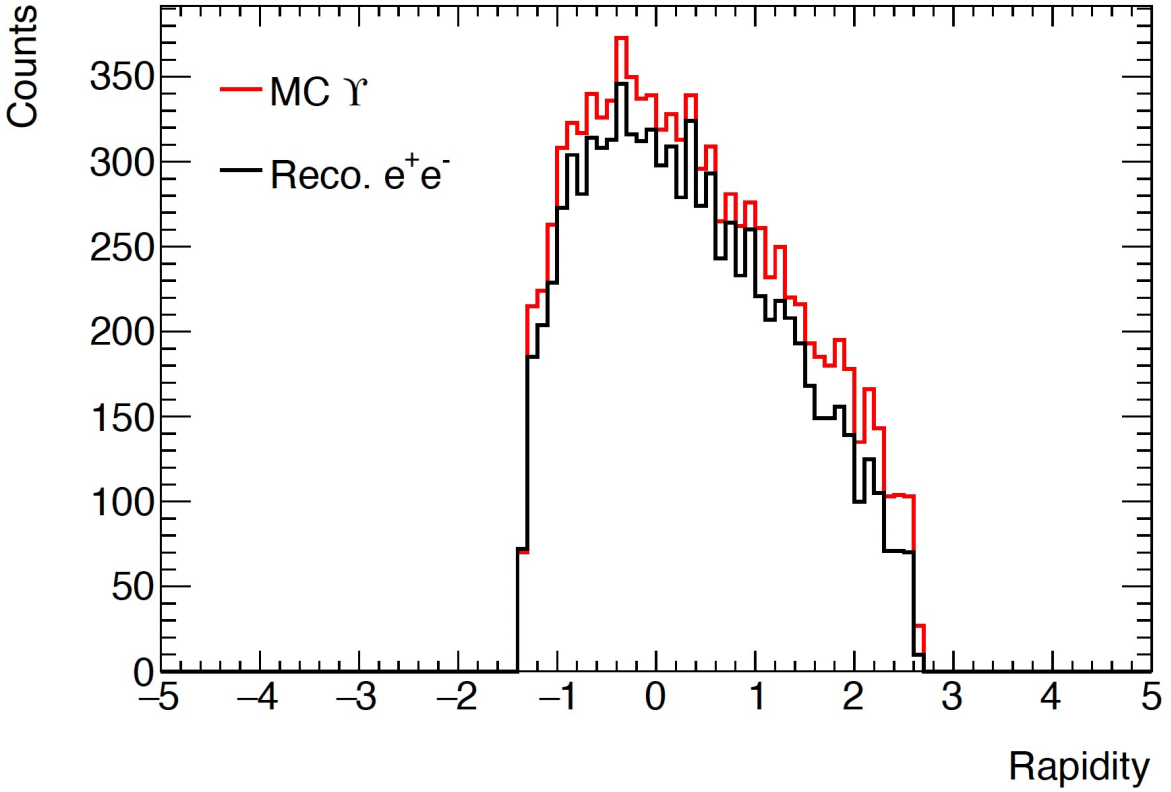


Mass resolution with all silicon detector

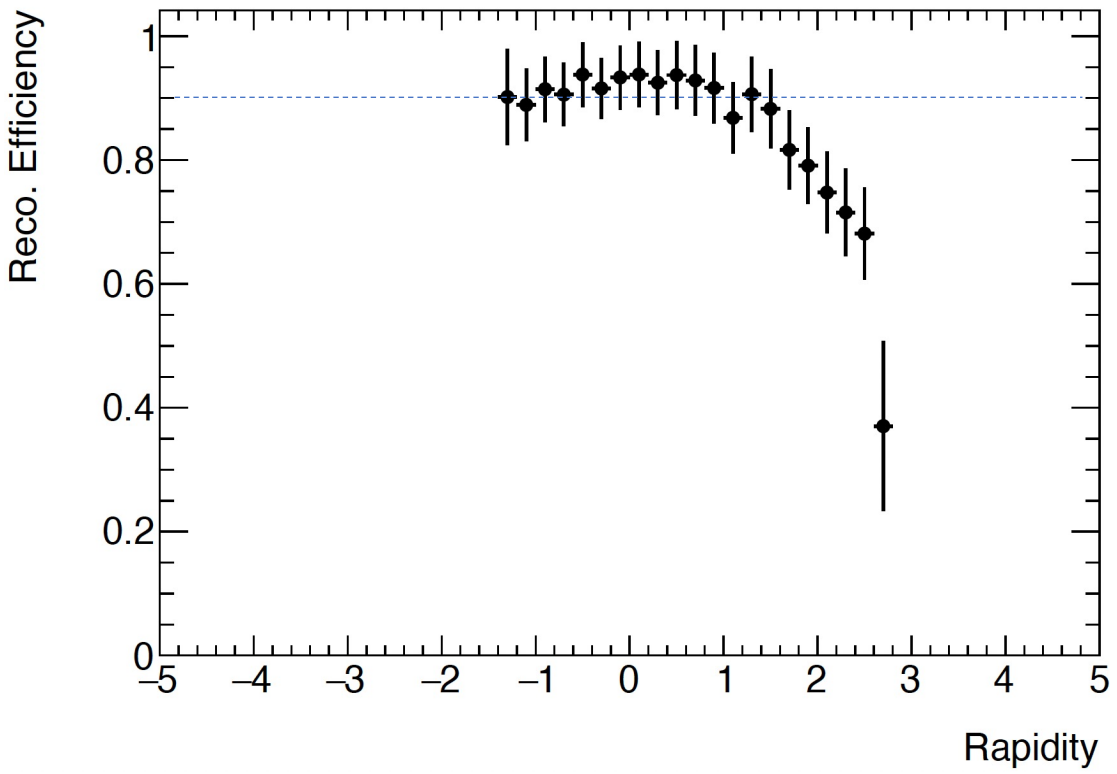
Rapidity	1.5 T field	3.0 T field
$\|y\| < 1$	66 MeV/c^2	40 MeV/c^2
$\|y\| > 1$	79 MeV/c^2	51 MeV/c^2

Reconstructed $\Upsilon(1S) \rightarrow e^+e^-$ vs rapidity

- Reconstruction efficiency decrease when the rapidity goes forward (corresponding to low W)
  - |y|<1 eff~0.9, y~2.5 eff~0.65

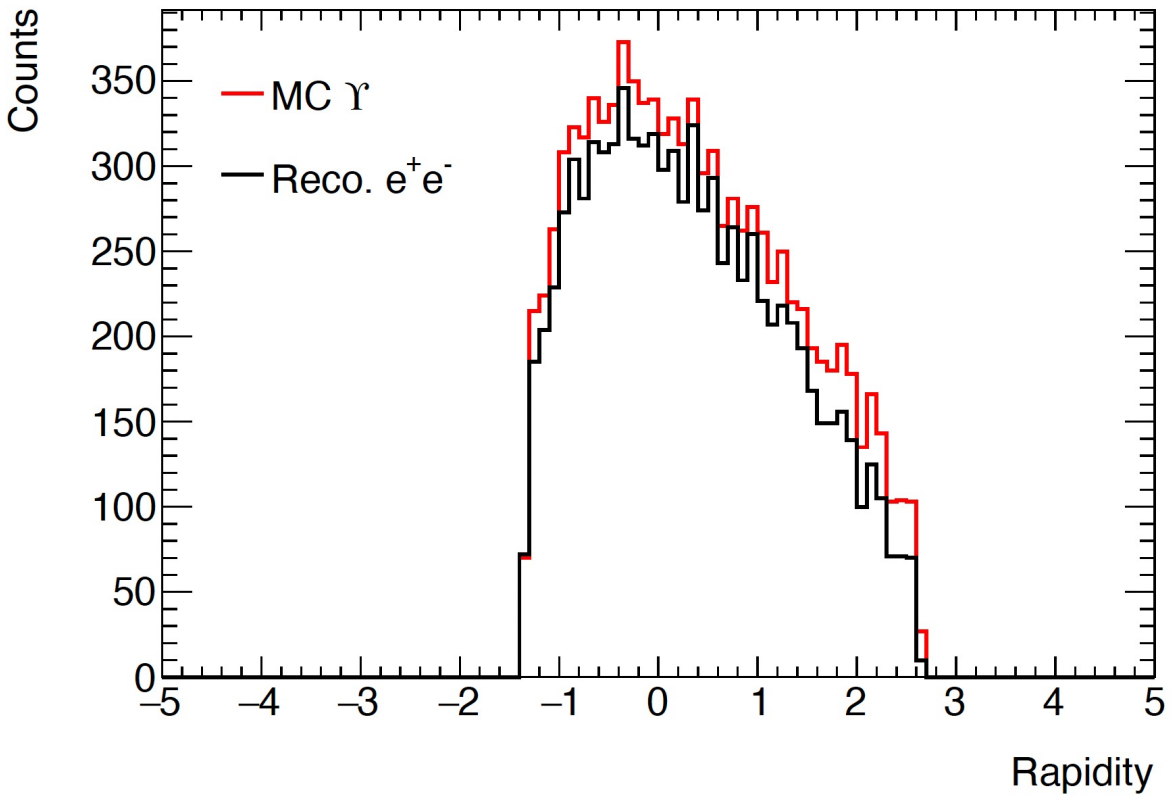


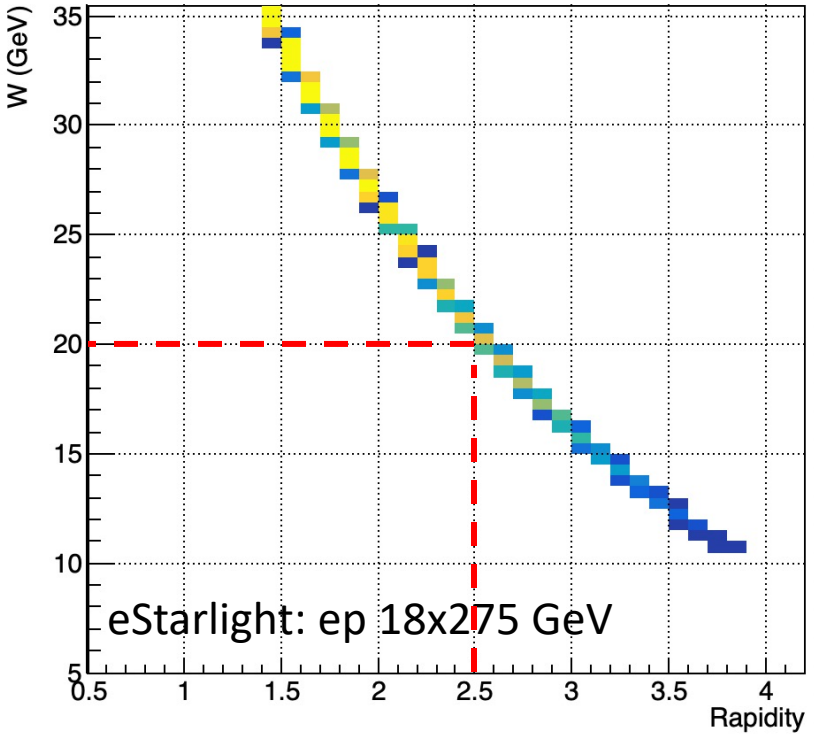
Upsilon reconstruction efficiency



Reconstructed $\Upsilon(1S) \rightarrow e^+e^-$ vs rapidity

- Reconstruction efficiency decrease when the rapidity goes forward (corresponding to low W)
- The generated MC file do not have much counts at near threshold (rapidity>2.5, W< 20 or so)
  - Next step is select only near threshold events to the input HepMC file

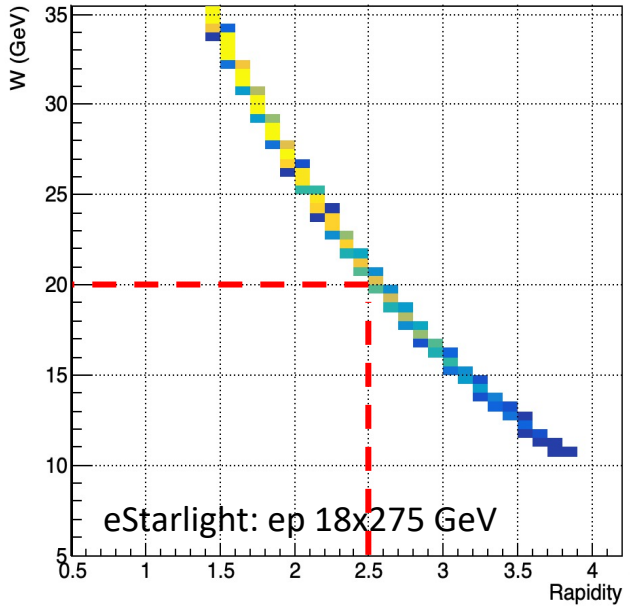


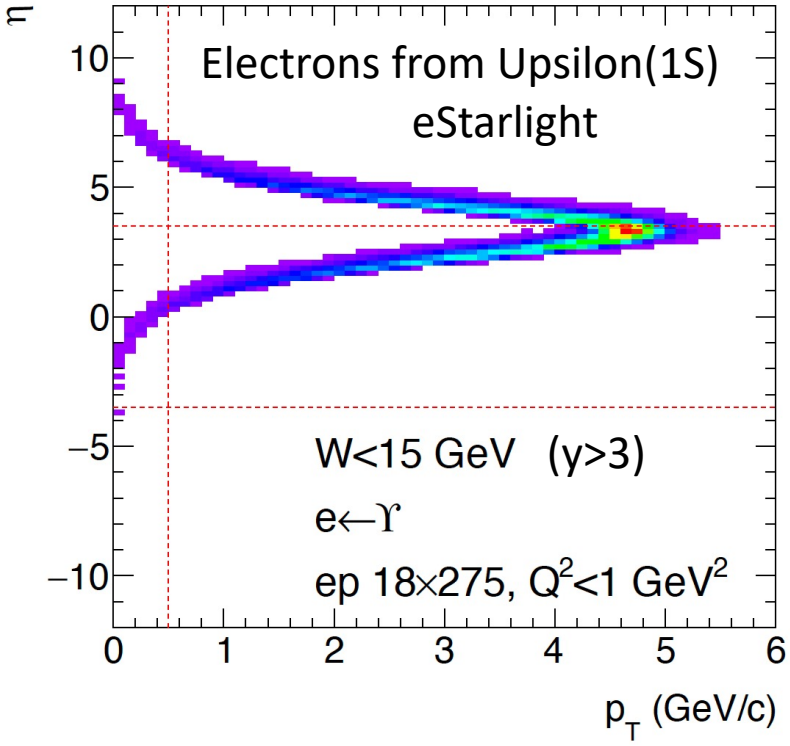


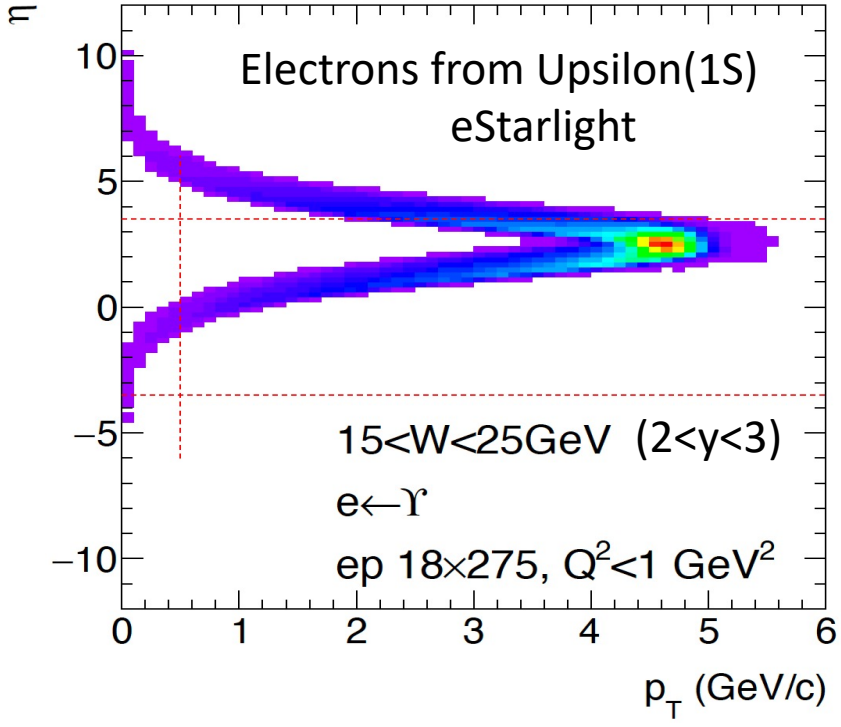
Upsilon rapidity vs W
from eStarlgiht

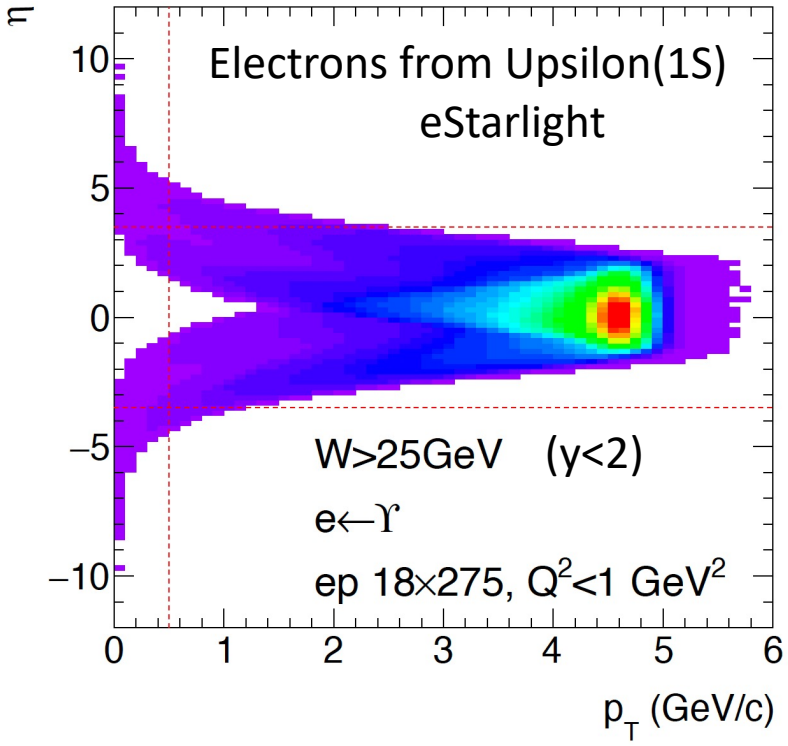
Reason for low eff. and wider σ at y>2

- y>2 ~ W< 25GeV for Upsilon(1S) in 18x275 GeV collisions
  - Daughter electrons move to forward η at low W
- Worse momentum resolution at $|\eta|$>2 compared to $|\eta|$<2

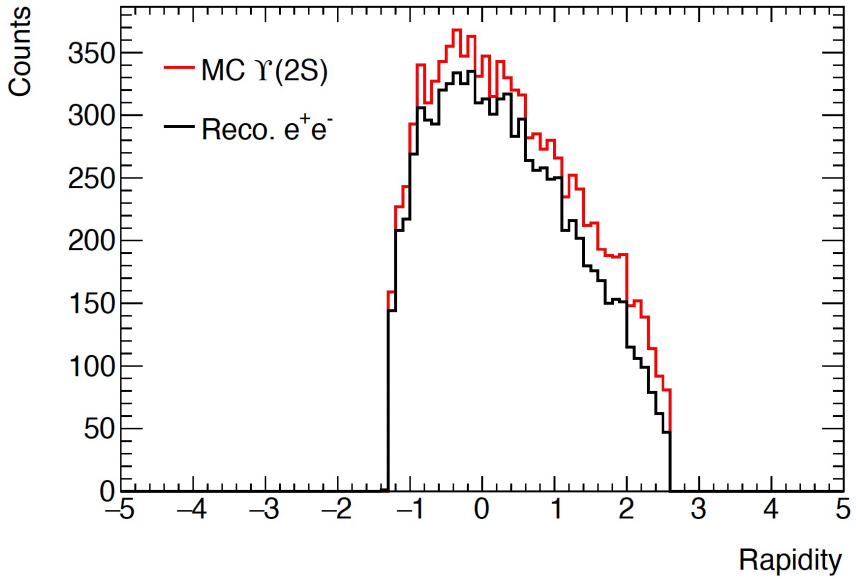


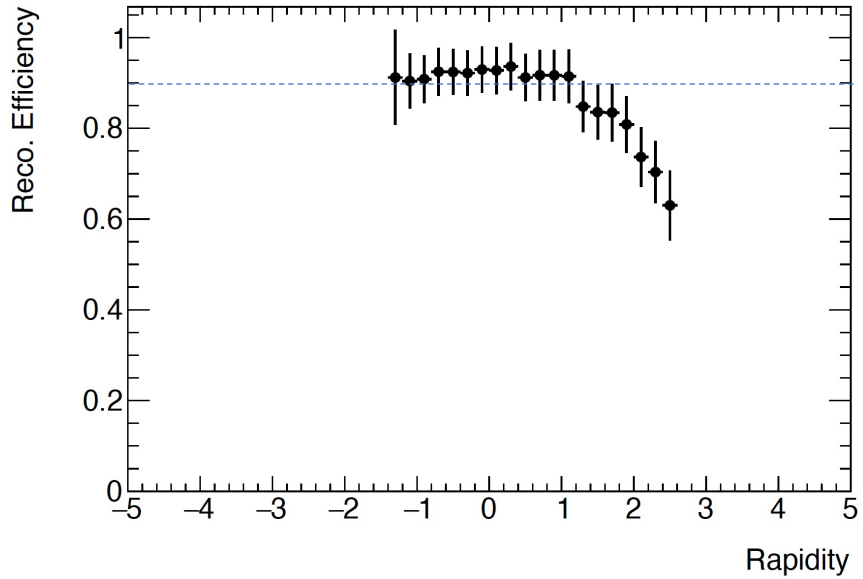


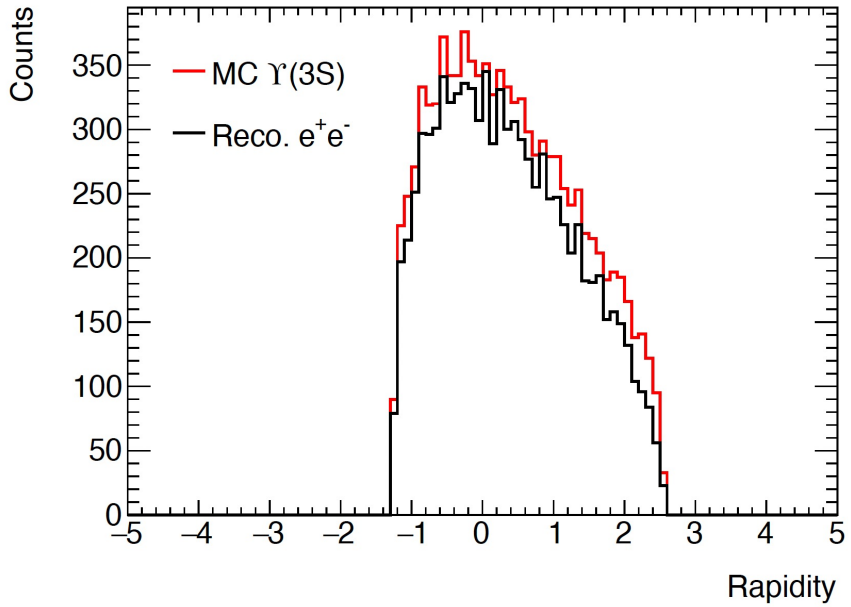


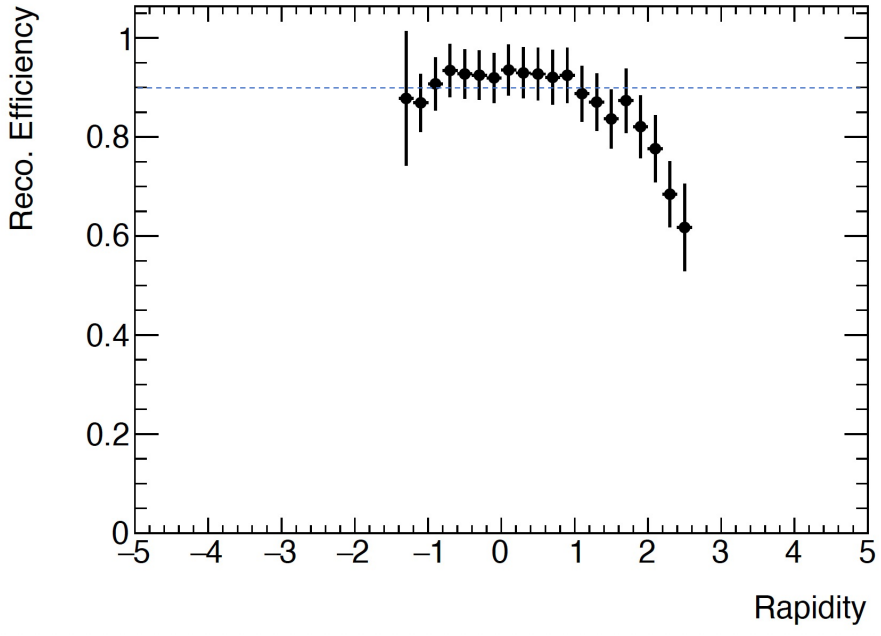


Reco. efficiency for $\Upsilon(2S)$ and $\Upsilon(3S)$







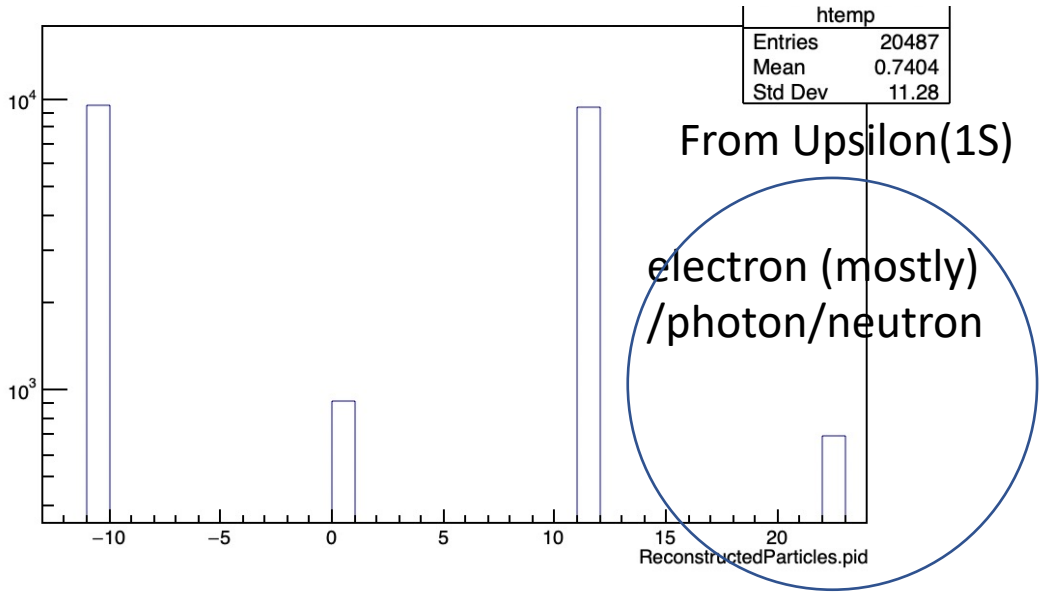


Summary

- Reconstruction efficiency (Rec. eff.) and mass over a wide rapidity (full energy range) for upsilon 3-states are gotten
  - Rec. eff. ~ 0.9 at -2<y<1, decrease to 0.6 at y~2.5 (low W)
  - Wider mass resolution at very forward rapidity (corresponding to low W)

- Next step: select only near threshold events into input MC files to enhance statistics

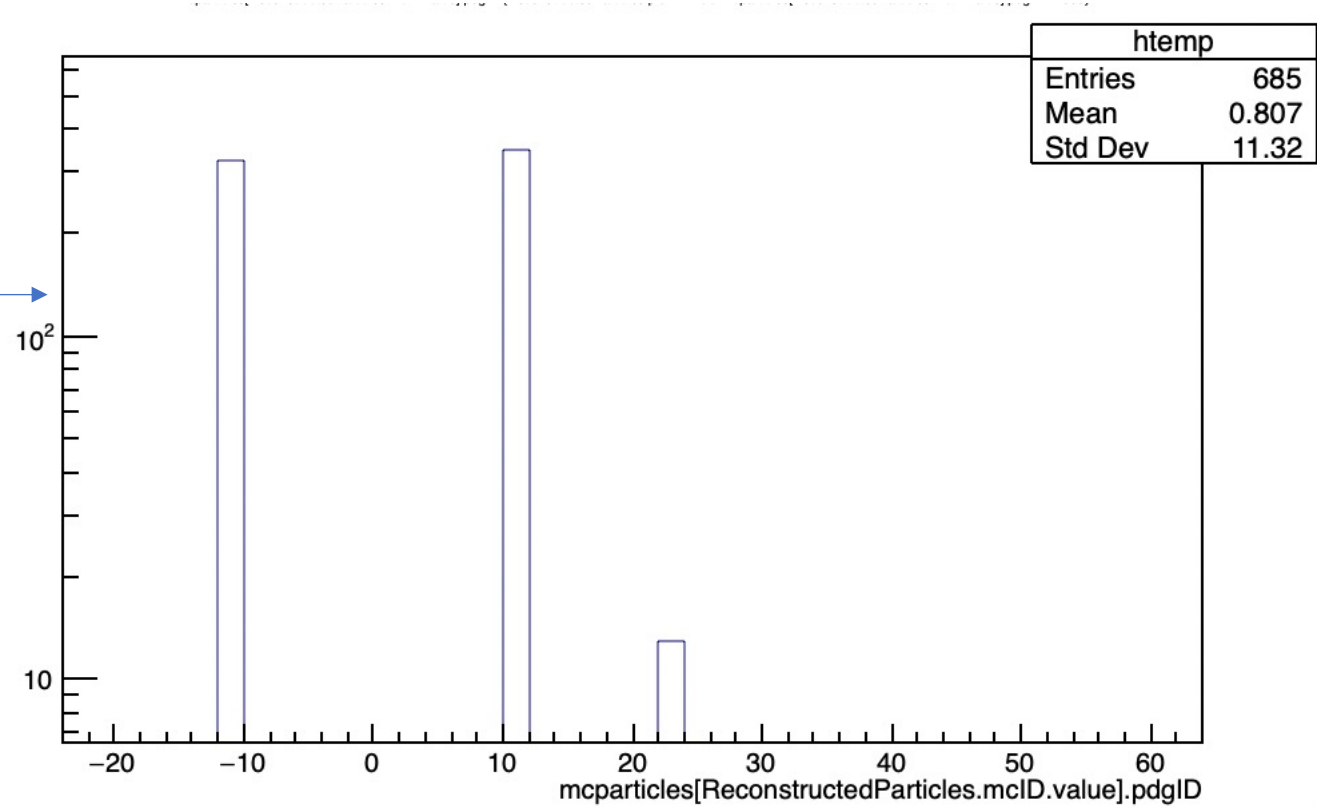
Back ups



From Upsilon(1S)

electron (mostly) /photon/neutron

Reconstructed tracks PID

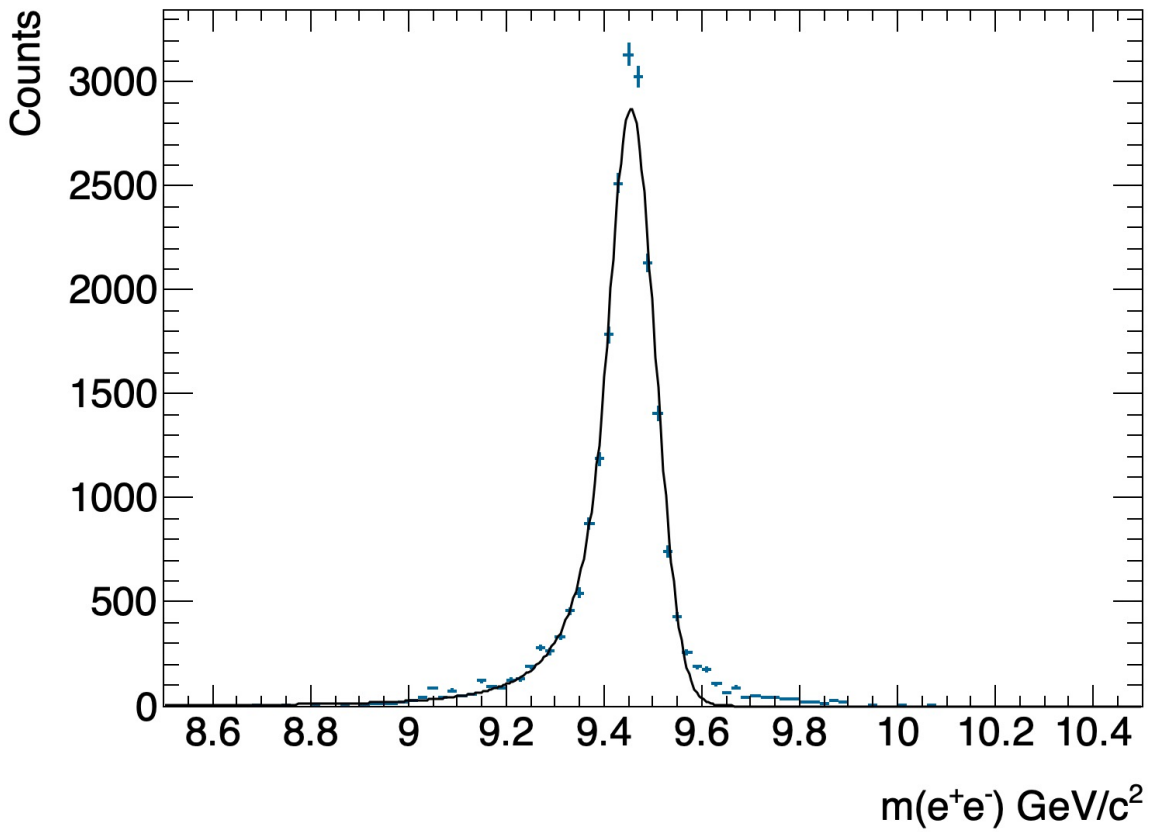


(also a small fraction of neutron which is not shown due to x-axis range)

Reconstruction algorithm

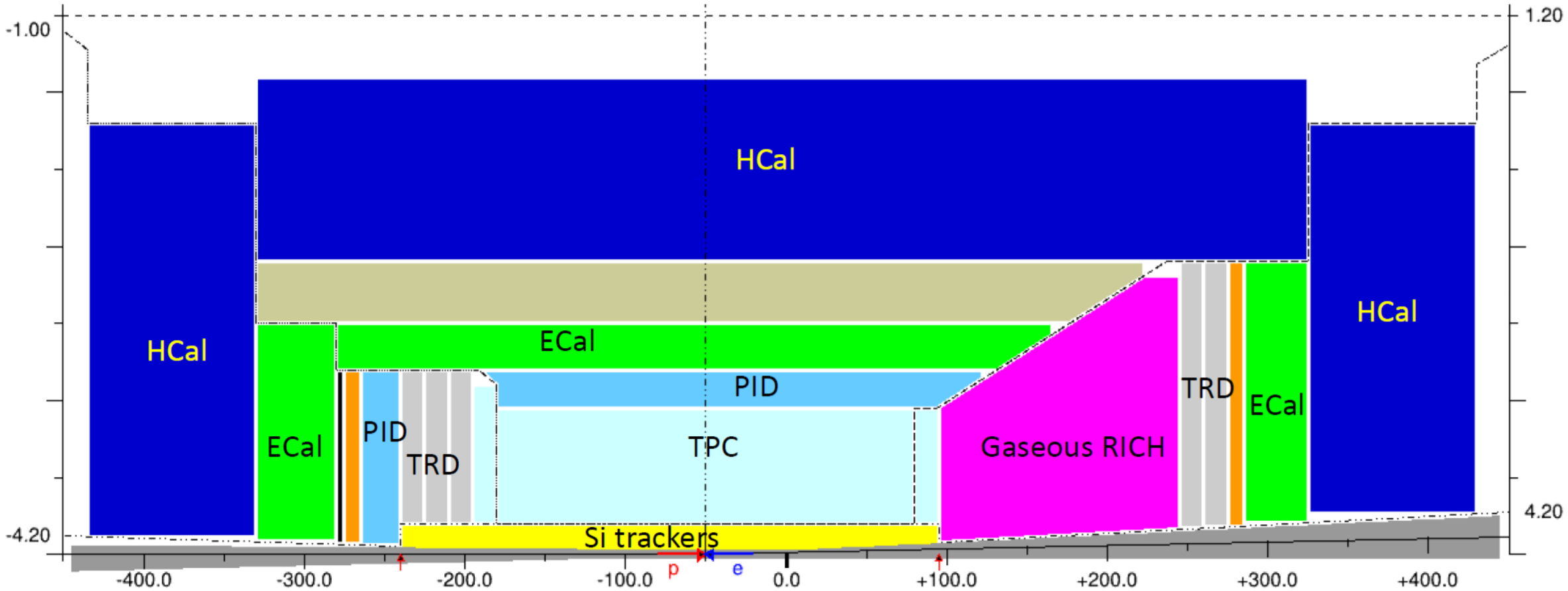
- Pair all reconstructed electron tracks (|pid|==11) in each events
  - Get $M_{ll'}$ for each pair
- Select lepton pair with minimum $|M_{ll'}$ -PDG Mass| as reconstructed Upsilon daughter pair in this event

|y|<1


Counts
3000
2500
2000
1500
1000
500
0
8.6
8.8
9
9.2
9.4
9.6
9.8
10
10.2
10.4
m(e+e-) GeV/c2

Reco. eff. from Fast simulation

- Back up plan for other energies and specific rapidity range
- Fast simulation set ups
  - Generate MC events from eStarlight
  - Set electron tracking efficiency vs p and eta as weight
  - To be done: compare with current full simulation


-1.00
1.20
HCal
HCal
HCal
ECal
ECal
PID
PID
TRD
TPC
Gaseous RICH
TRD
ECal
-4.20
4.20
Si trackers
p
e
-400.0
-300.0
-200.0
-100.0
0.0
+100.0
+200.0
+300.0
+400.0