Status Update

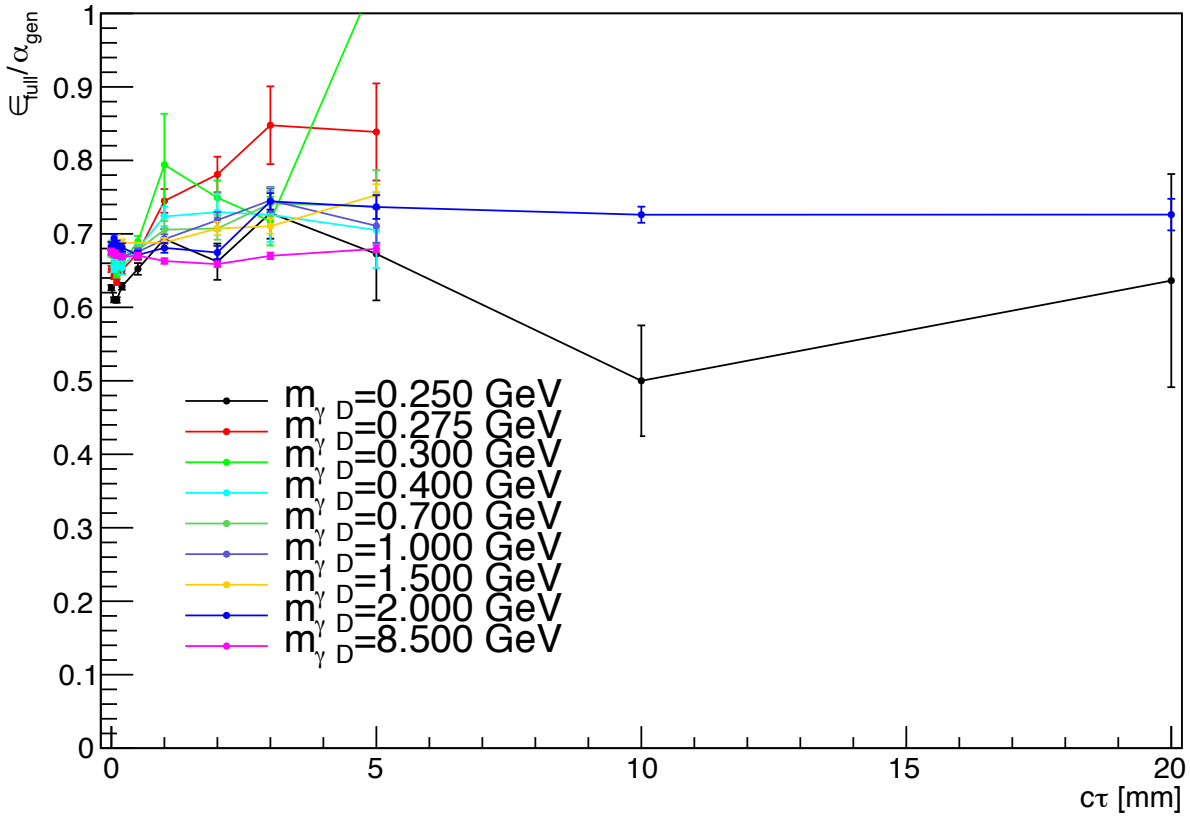
Texas A&M + Rice Joint Meeting on Muon Analysis

Benjamin Michlin

Rice University

$\varepsilon_{full}/\alpha_{gen}$

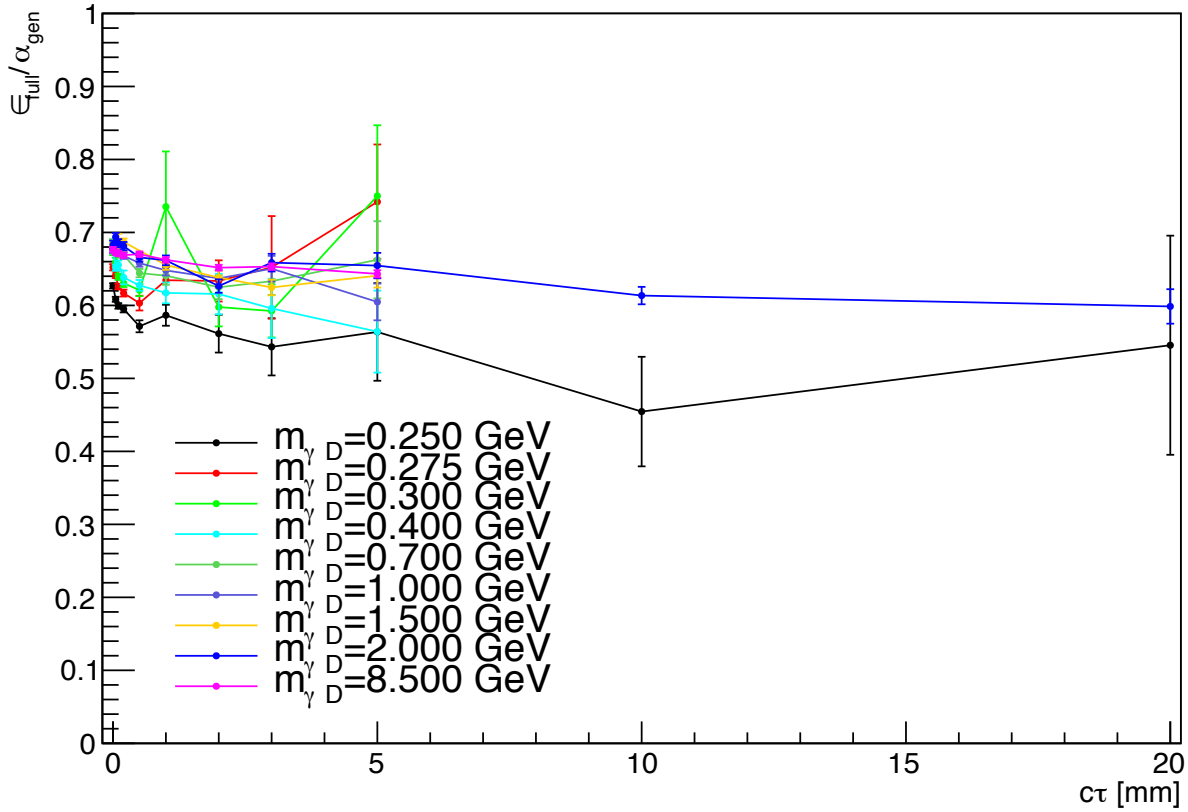
From last time:



- Ratio of full analysis acceptance at reco level to gen level acceptance as a function of dark photon cT
- Denominator:
  - 4 GEN mu $p_T > 8$ ($|\eta| < 2.4$) && 1 GEN mu $p_T > 17$ ($|\eta| < 0.9$)
  - Dark photon $L_{XY} < 4.4$ cm && $L_Z < 34.5$
- Numerator:
  - 4 RECO mu $p_T > 8$ ($|\eta| < 2.4$) && 1 RECO mu $p_T > 17$ ($|\eta| < 0.9$)
  - VtxOK, 2 Dimuons, 2DimVtxOK, 2DimDzOK,HitPixOK , 2DimMassOK, 2DimIsoOK, 2DimHLT

$\varepsilon_{full}/\alpha_{gen}$ with fiducial cut in numerator

From last time:



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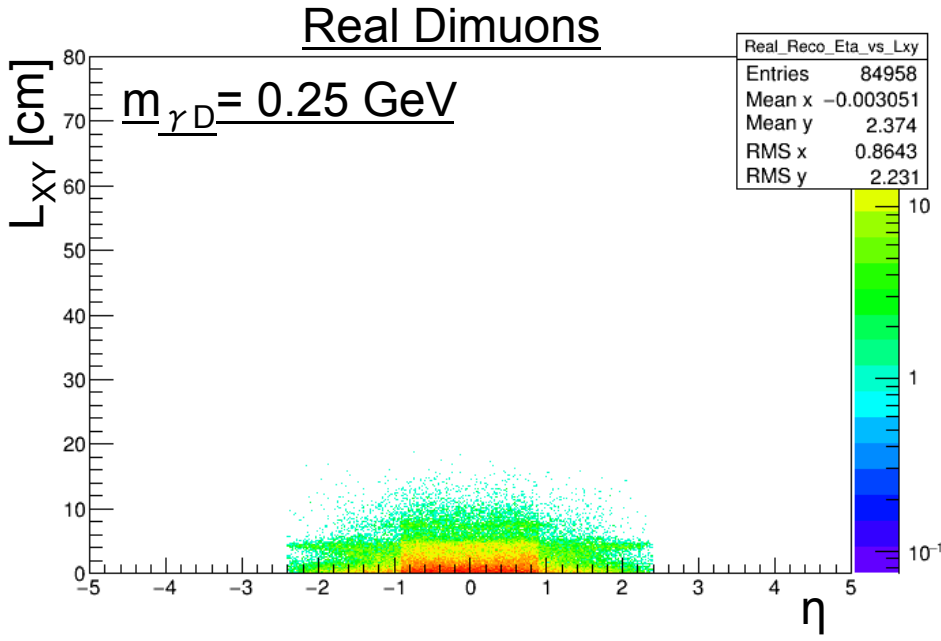
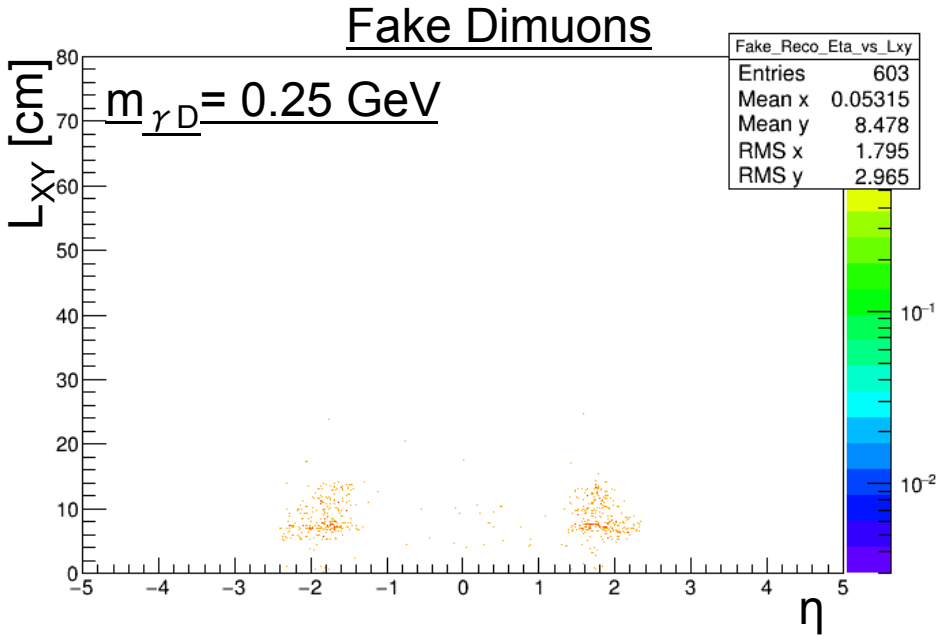
  - VtxOK, 2 Dimuons, 2DimVtxOK, 2DimDzOK,HitPixOK , 2DimMassOK, 2DimIsoOK, 2DimHLT

Mitigation of fake dimuons

- Closely spaced high η tracks
  - Small mismeasurement in η substantially moves vertex position
  - Imprecise L_{XY} measurement
- Fake dimuons pass offline selection but fail GEN fiducial cut
- The plan: model signal shape to remove fakes and remain model independent

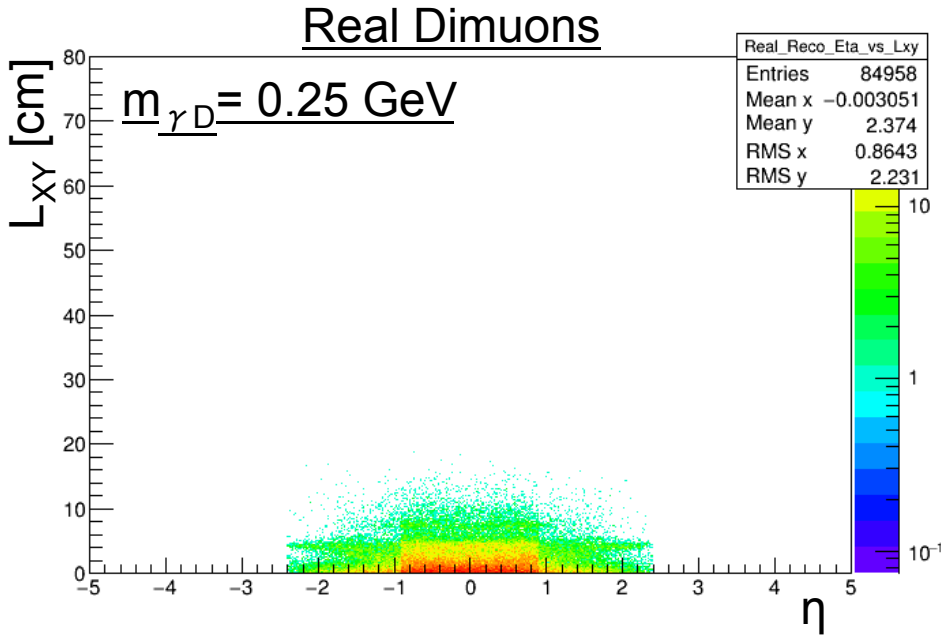
Previously shown plots

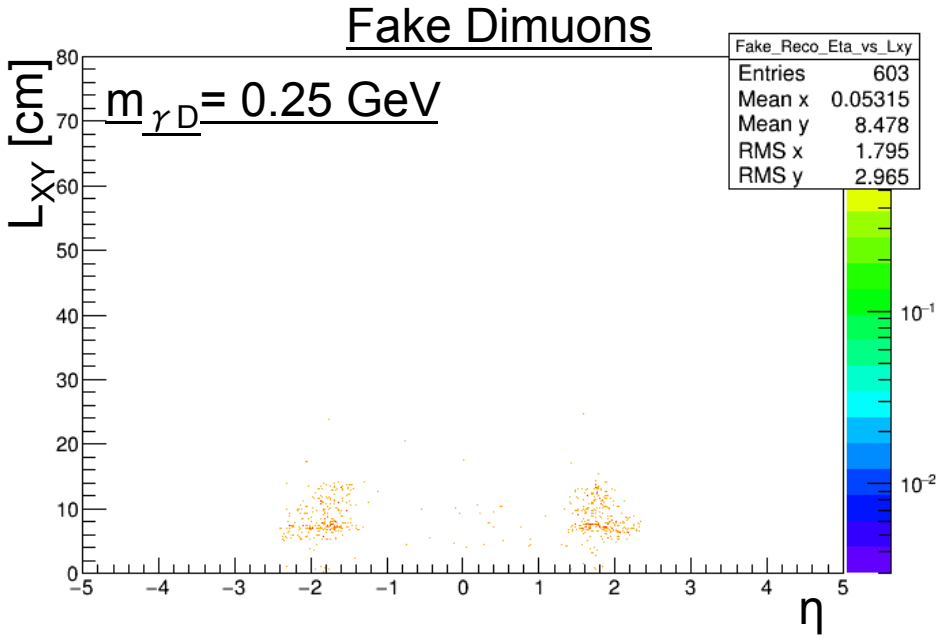




- 2-dimensional η-L_{XY} cut is promising discriminant for real and fake dimuons
- Making cut while maintaining high efficiency turned out to be non-trivial

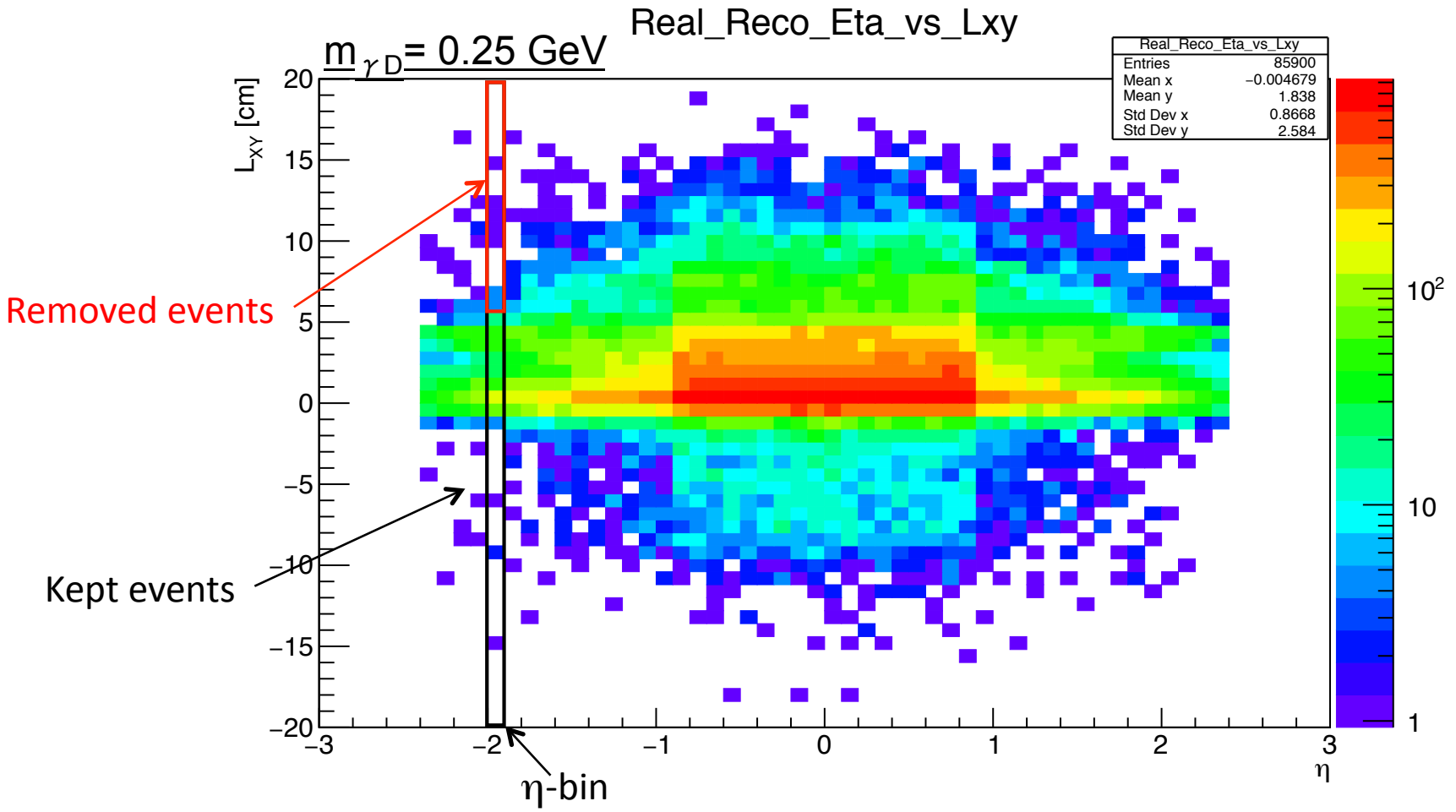
Previously shown plots





- Since fake dimuons are at high L_{XY} and high η Alexei suggested removing the top ~3% of events from each η-bin
- This will guarantee a high efficiency (>97%) and should remove most fakes

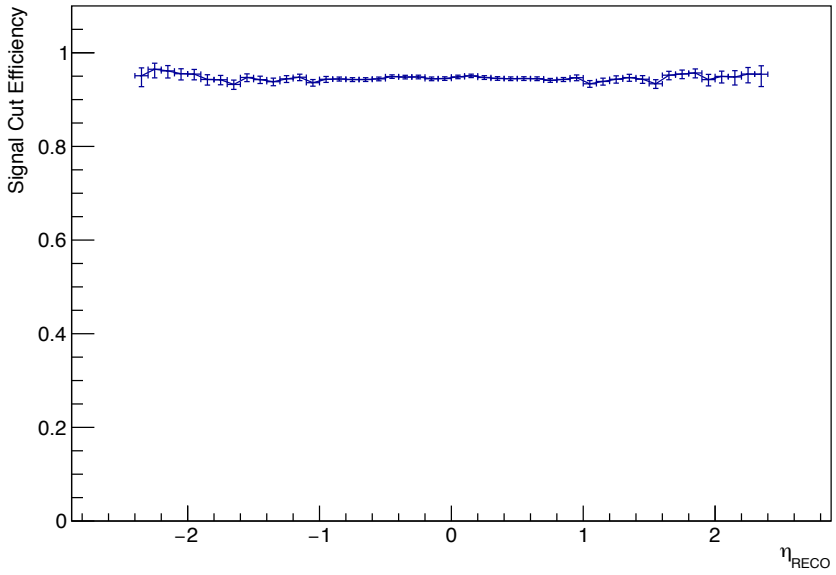
Remove 3% of highest L_{XY} events per η bin signal events

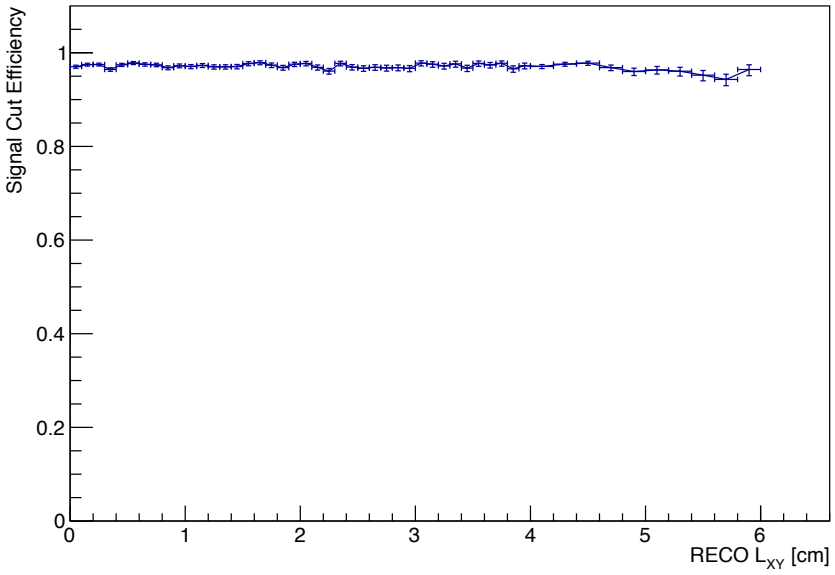


- L_{XY} allowed to be negative
- Cut made for each η-bin (individually) for $m_{\gamma D}$= 0.25 GeV sample

Cut made for each η-bin results

RECO level results:

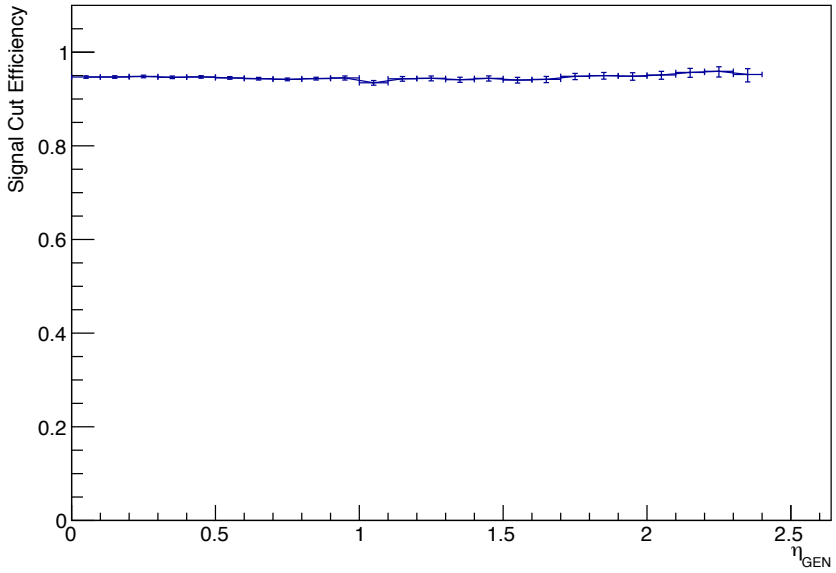


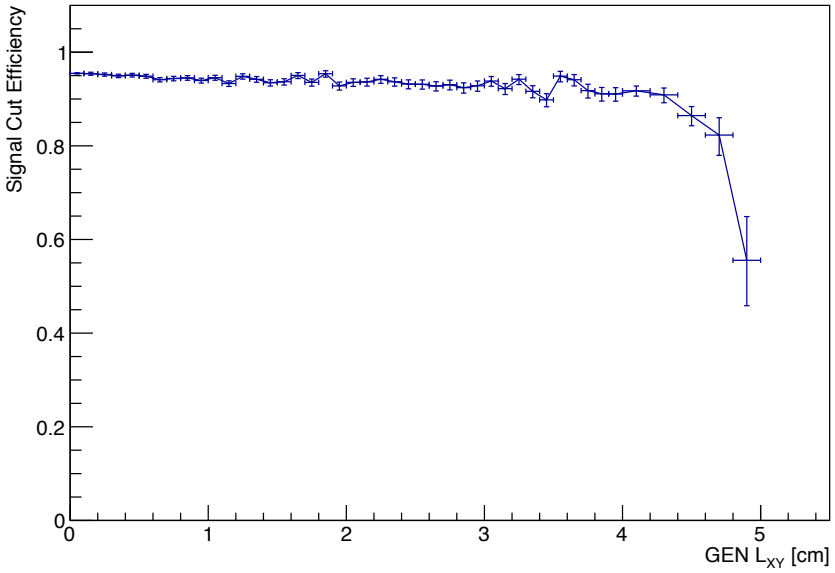


- Efficiency looks really good!
- Why is efficiency vs η not perfectly flat at ~97%?
  - When cut is determined individual dimuons are counted and removed
  - When cut is used both dimuons in an event are required to pass cut

Cut made for each η-bin results

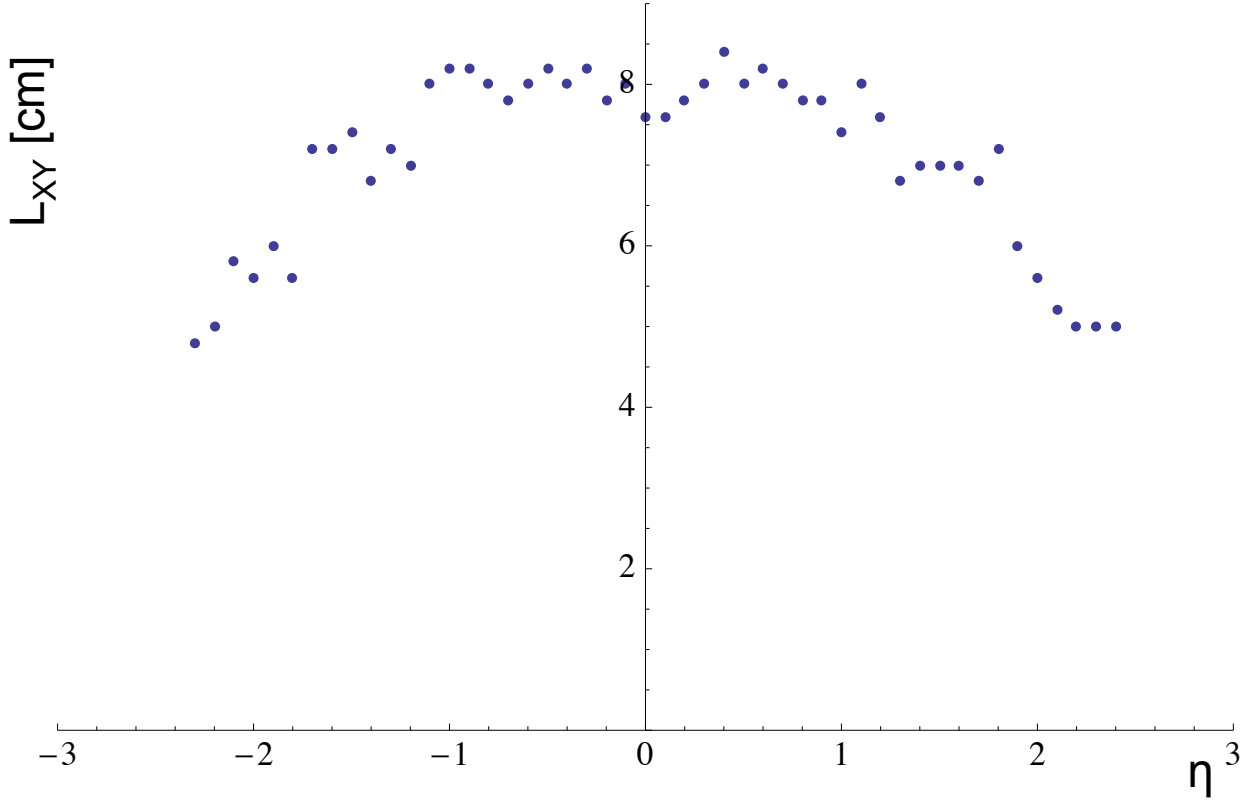
GEN level results:





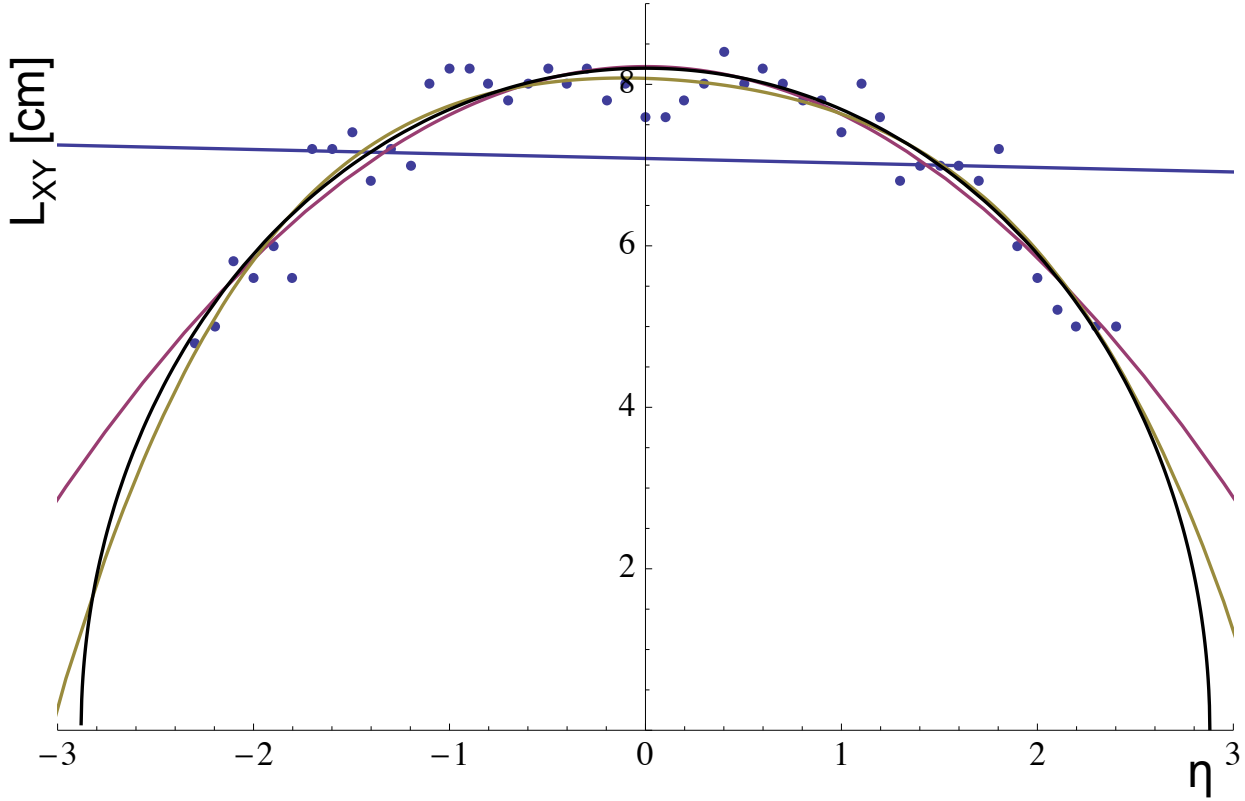
- Efficiency looks really good!
- Efficiency vs GEN L_{XY} decreases after 4.4 cm
  - This is passed the fiducial cut
  - We are unconcerned with this area at GEN level
- Recall that cut is made on RECO level quantities

Adjustment of bin-width



- Exact cut made is sensitive to bin width
- I chose a reasonable bin width that gave reasonably smooth cuts
  - Increasing → flat → decreasing
  - η-bins are 0.1 wide
  - L_{XY}-bins are 0.2 cm wide

Adjustment of bin-width



Linear

Parabola

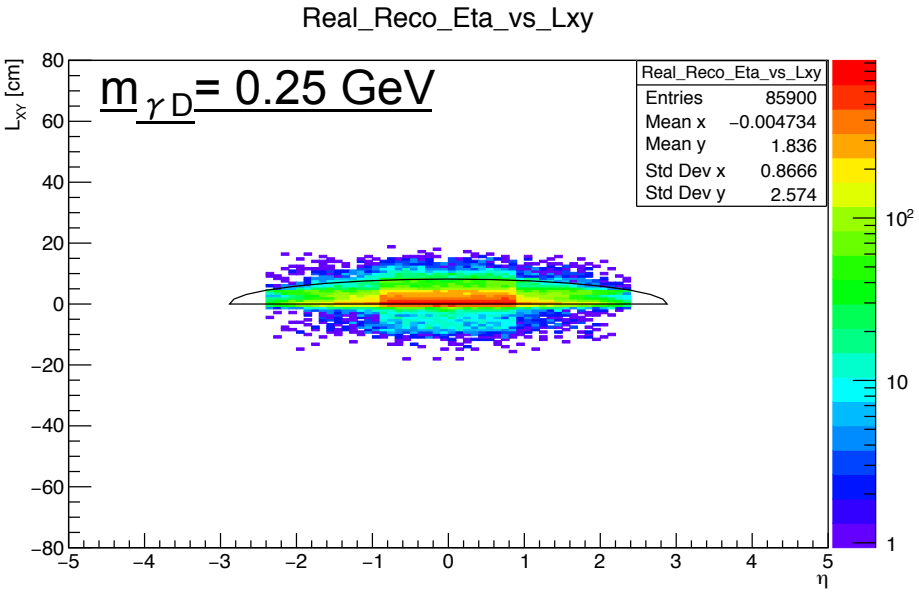
Quartic

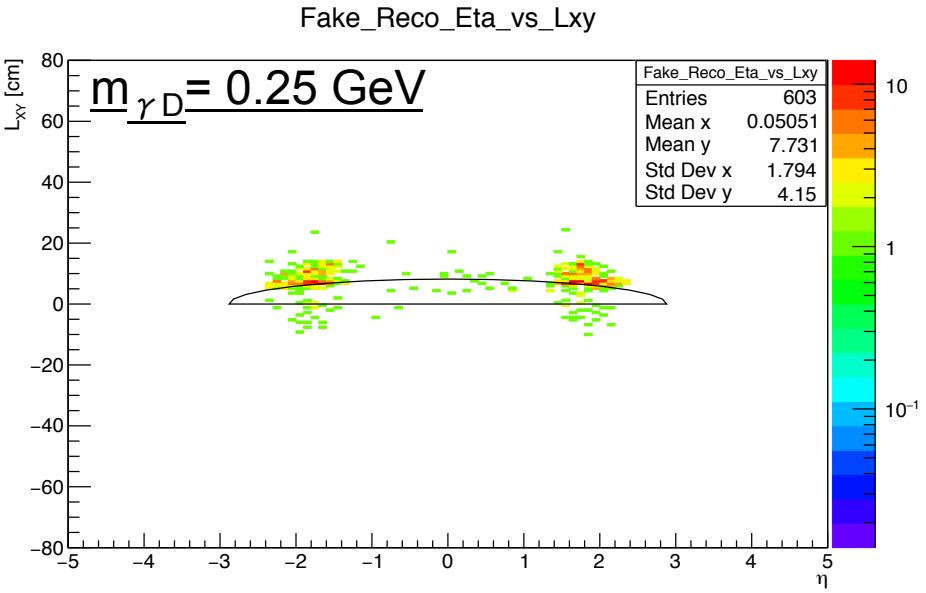
Ellipse

- Want smooth curve rather than discrete cut for every bin
- Several shapes attempted using
  - Linear, parabola, quartic, ellipse
  - Quartic and ellipse have reasonable χ^2
    - Increasing order of polynomial will produce arbitrarily good fit
- Using ellipse because that was initial idea and is simple

$$\frac{\eta_{\mathrm{dim}}^2}{2.88^2} + \frac{Lxy_{\mathrm{dim}}^2}{8.20^2} \leq 1$$

Visualization of smooth cut

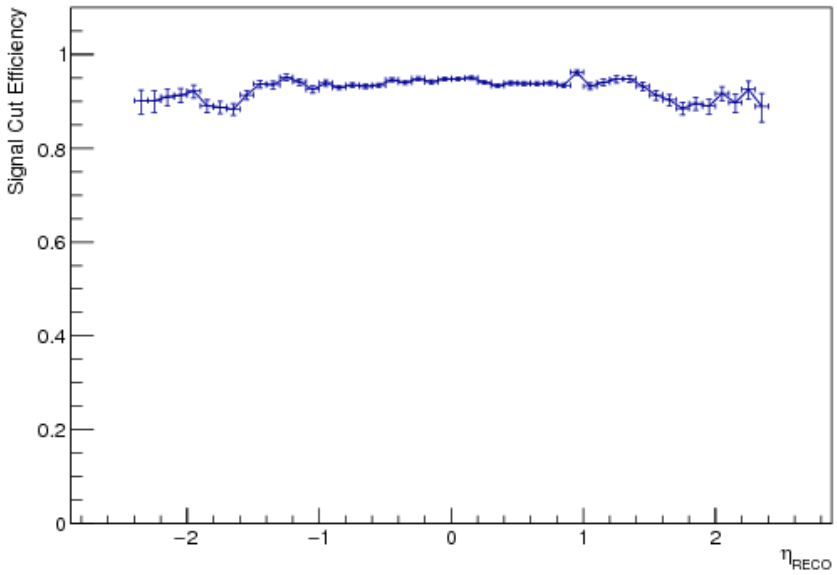


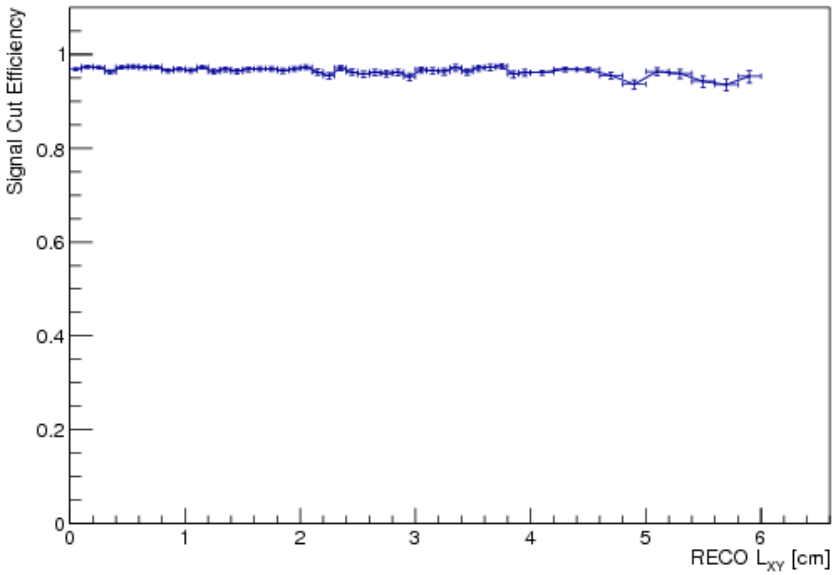


- Only top half of ellipse is used
  - Negative L_{XY} dimuons are never rejected
- Cut looks good!
- Recall that if cut works for $m_{\gamma D}$= 0.25 GeV sample then all samples are expected to work

Efficiencies with elliptical cut

RECO level results:

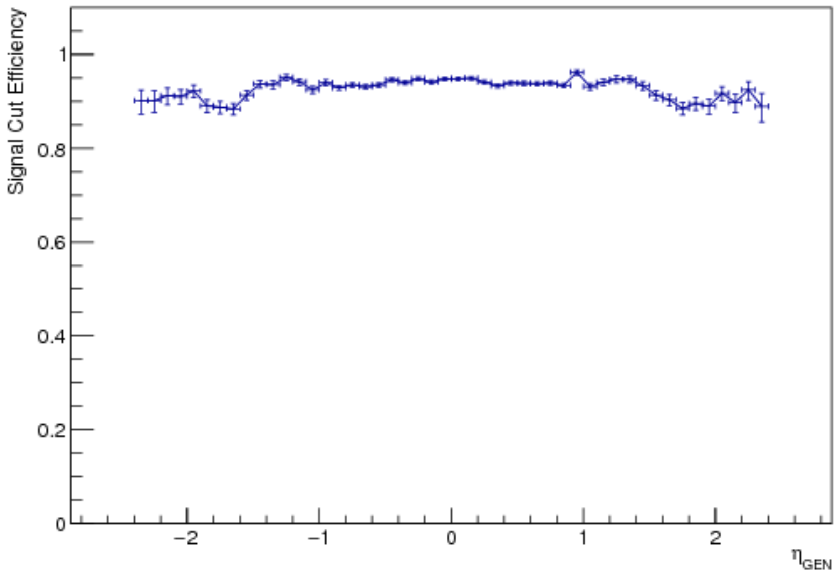


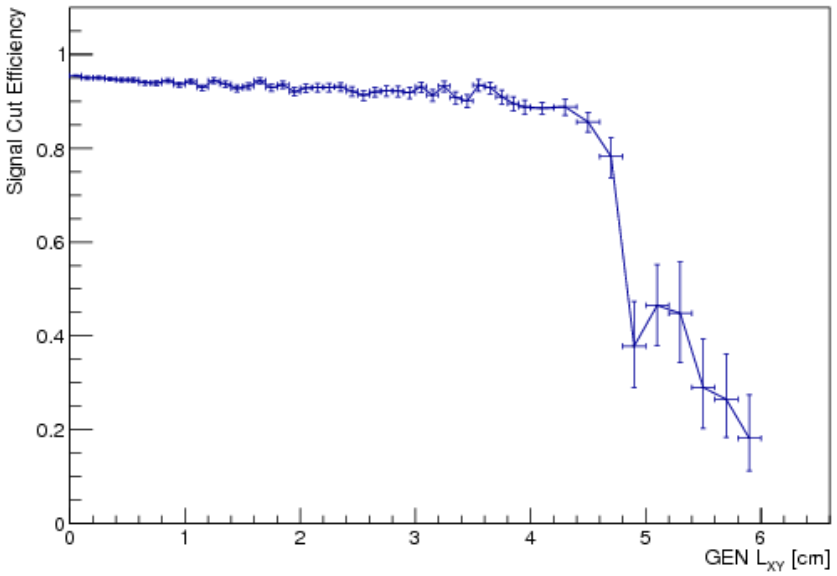


- RECO level efficiencies look good!

Efficiencies with elliptical cut

GEN level results:



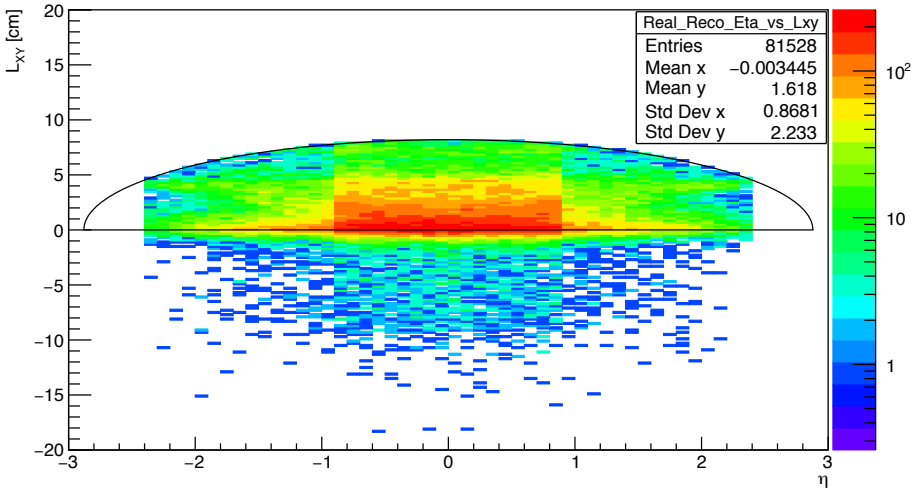


- GEN level efficiencies look good!
- Efficiency vs η nearly (but not) identical for GEN and RECO
- Efficiency vs GEN L_{XY} decreases after ~4.4 cm
  - This is passed the fiducial cut
  - We are unconcerned with this area at GEN level

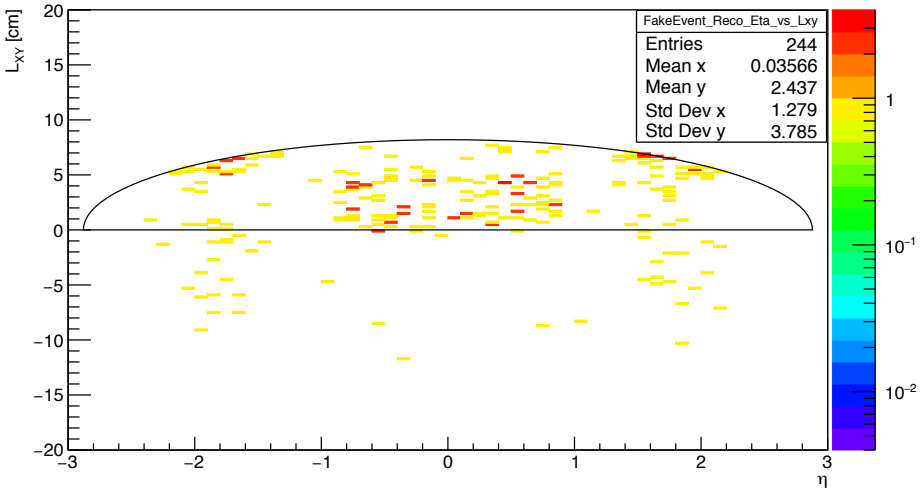
Elliptical cut on real and fake dimuons

$m_{\gamma_D} = 0.25$ GeV

Real_Reco_Eta_vs_Lxy

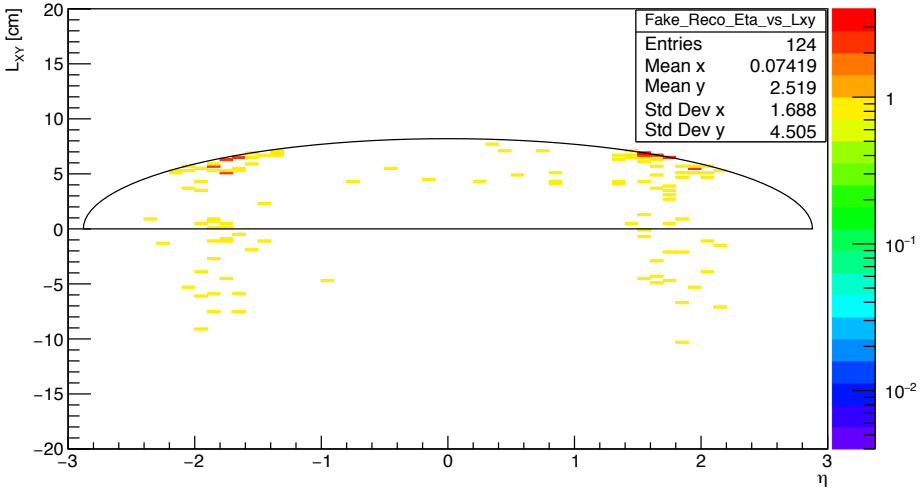


FakeEvent_Reco_Eta_vs_Lxy



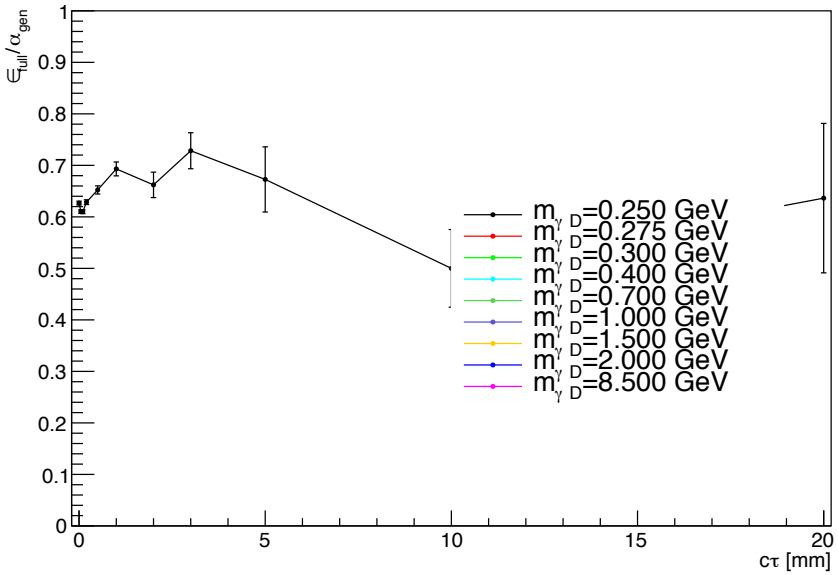
- After cut only 124/603 fakes remain
- Top-right
  - Both dimuons plotted if one dimuon in event is fake
- Bottom-right
  - Only fake dimuon plotted
- Events with low η in top-right are partners to fake dimuons

Fake_Reco_Eta_vs_Lxy

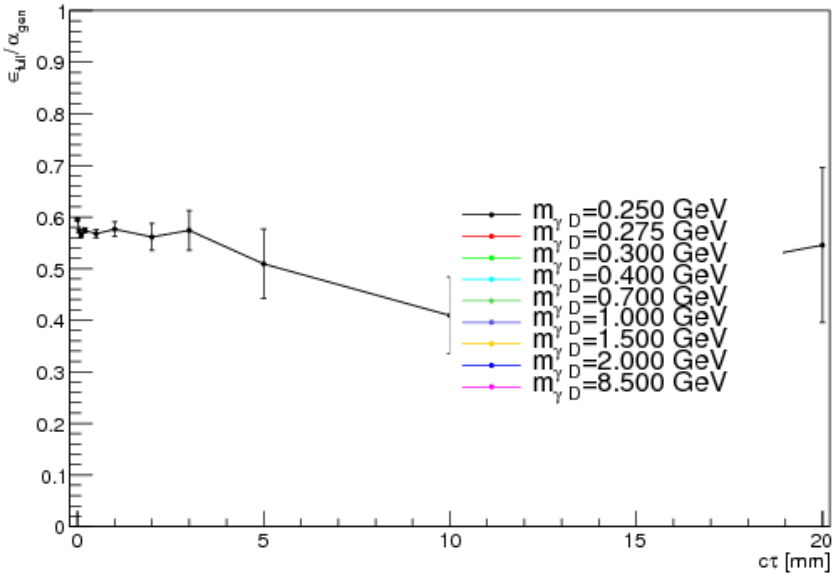


$\varepsilon_{full}/\alpha_{gen}$ with elliptical cut

Without Elliptical Cut

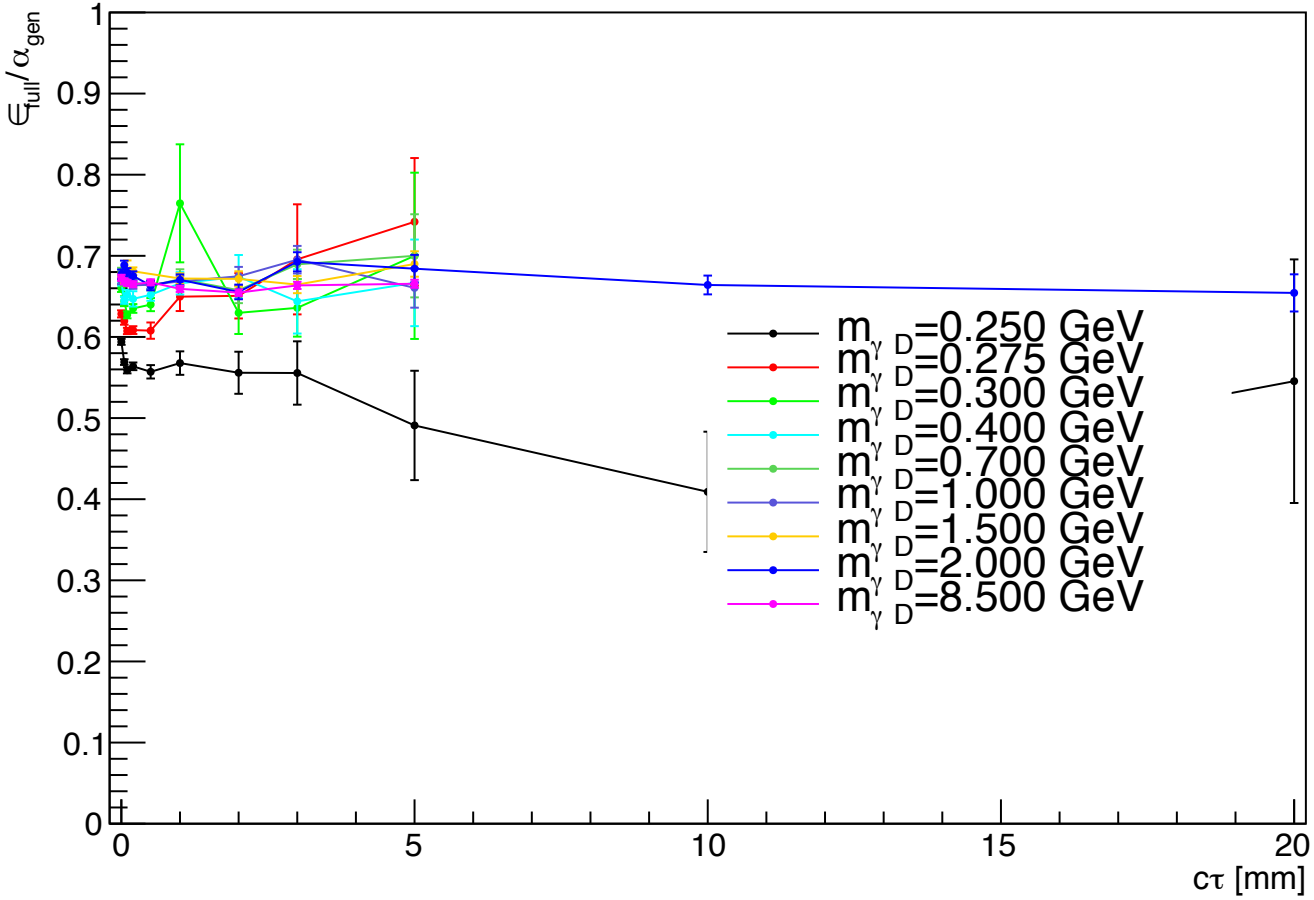


With Elliptical Cut



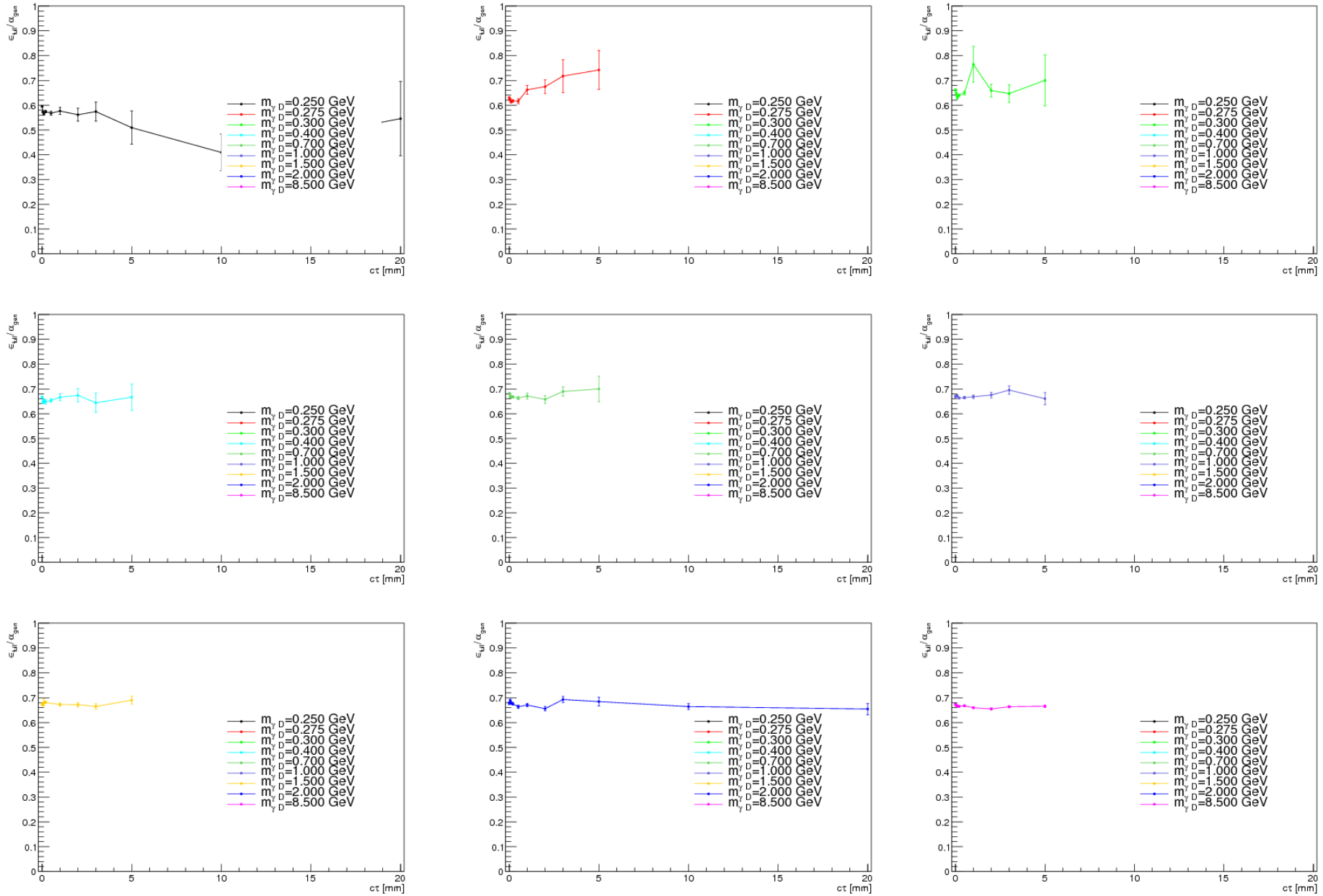
- Ratio plot is mostly flat within uncertainty
  - Minor deviation should be fixed with pixel hit recovery
  - 10 cm is likely due to statistics

$\epsilon_{full}/\alpha_{gen}$ with elliptical cut



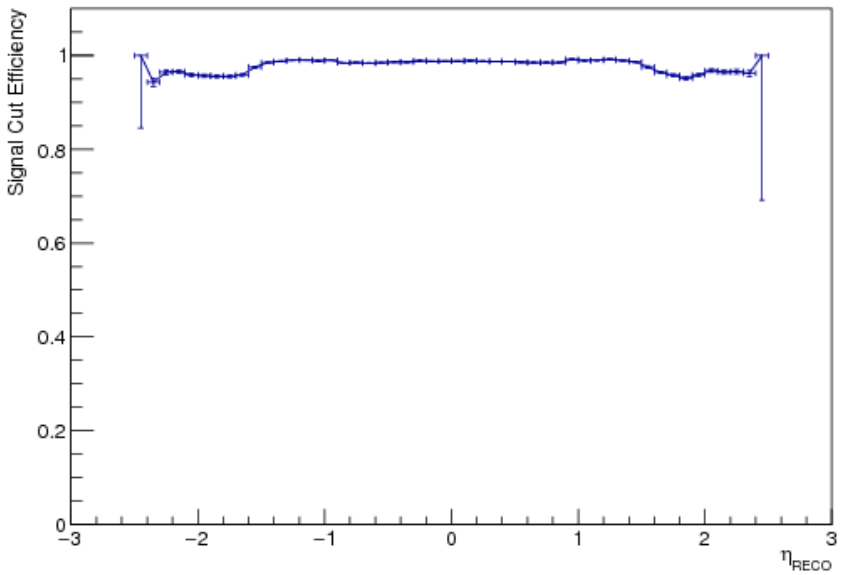
- Looks pretty good!
- Slight variation in low mass samples
  - Also seen with fiducial cut in numerator (slide 3)
  - Individual plots on next slide

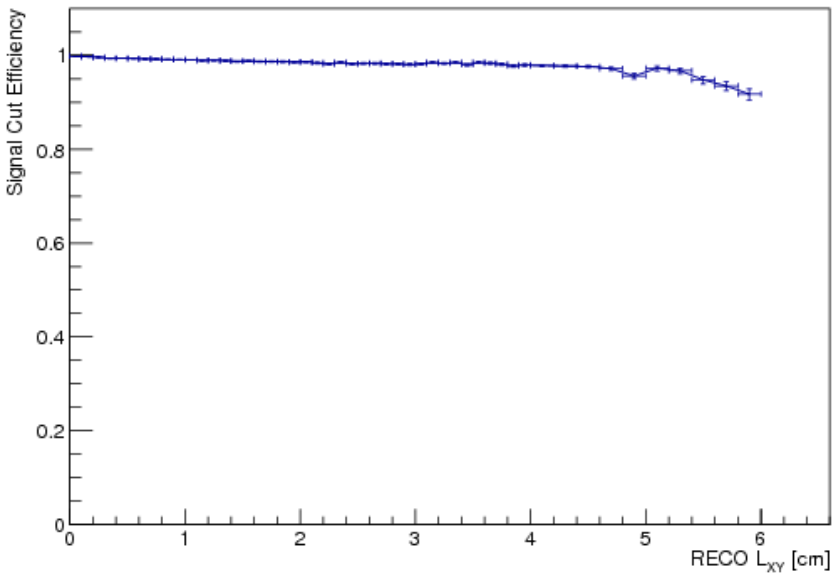
$\varepsilon_{full}/\alpha_{gen}$ with elliptical cut

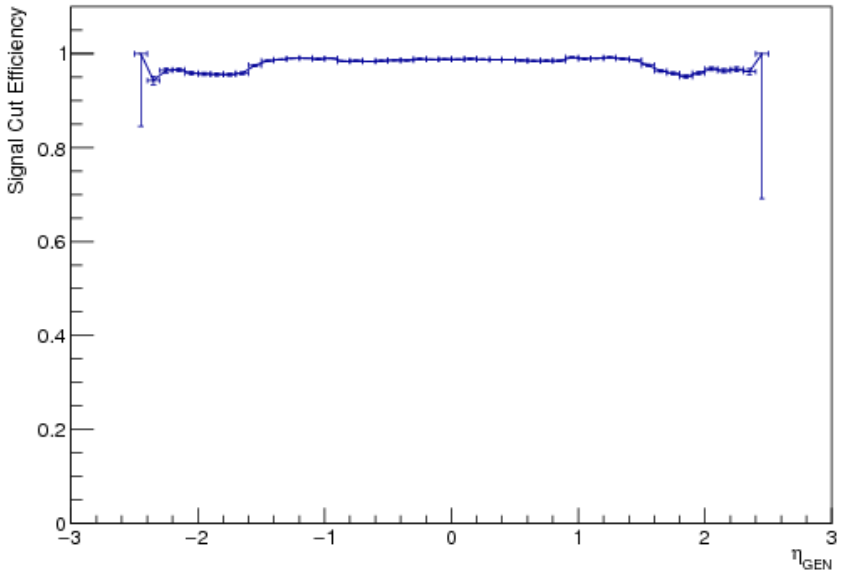


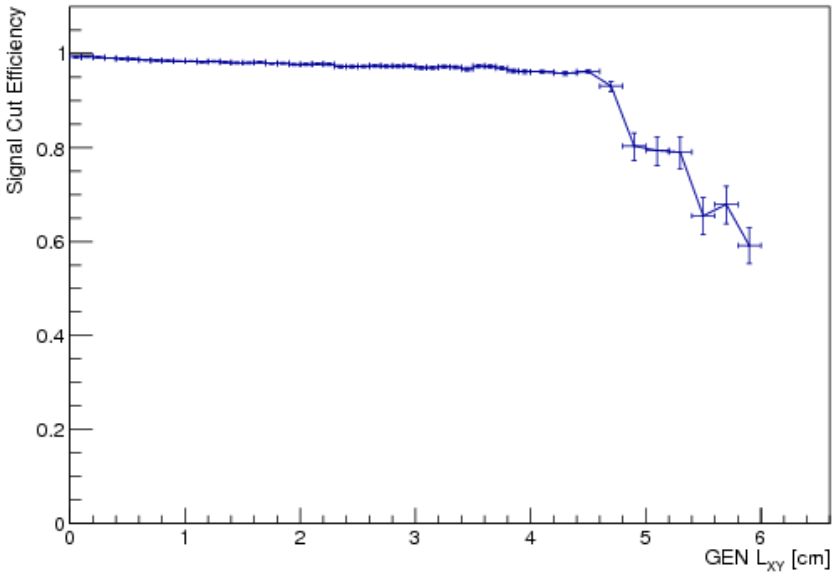
Overall efficiency with elliptical cut (all samples combined)

- Efficiency is flat and high!

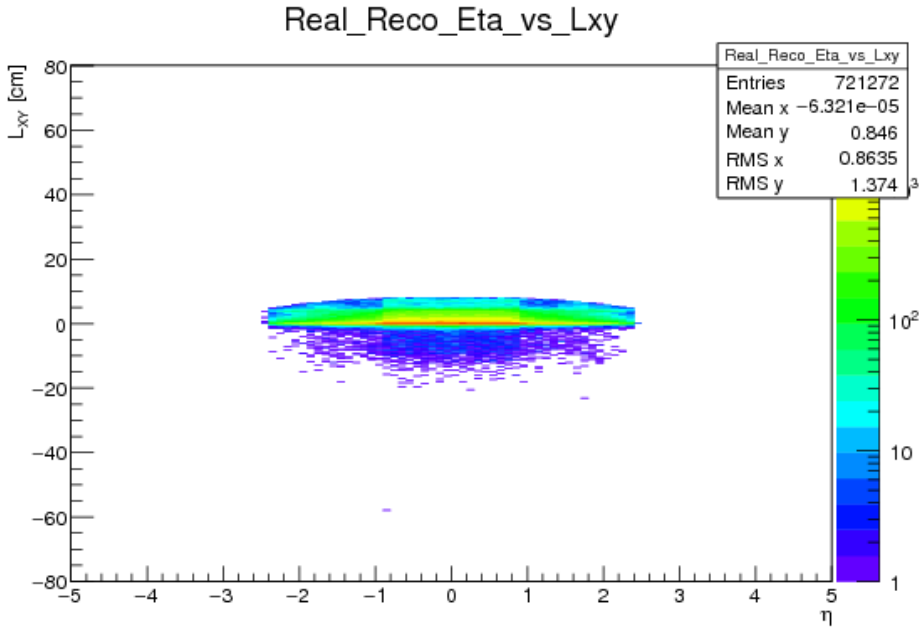


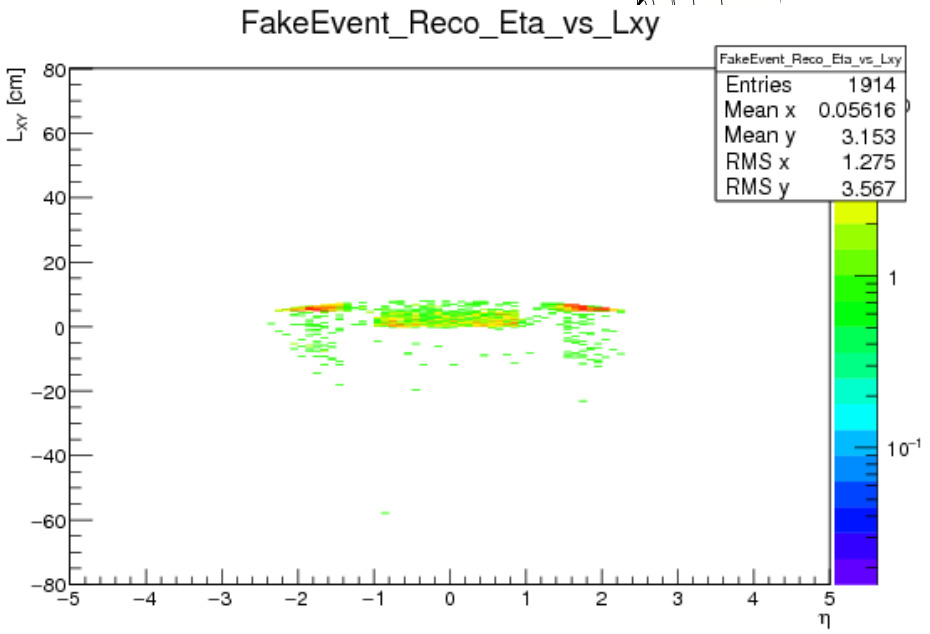


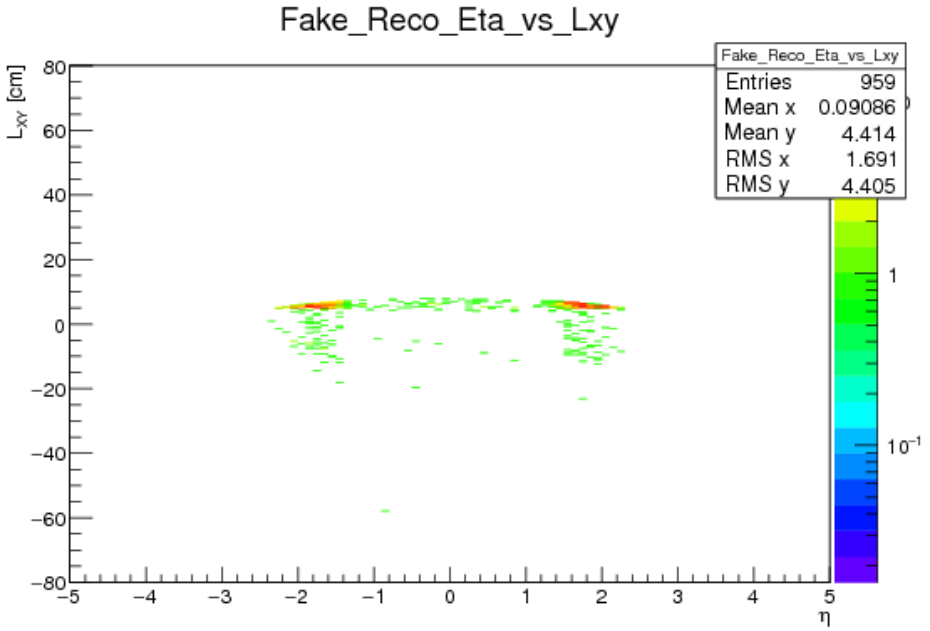




Elliptical cut on combined real and fake dimuons







- Only 959/3158 fake dimuons remain!
  - 70% reduction in fakes with <5% reduction in reals
- Top-right
  - Both dimuons plotted if one dimuon in event is fake
- Bottom-right
  - Only fake dimuon plotted

Summary

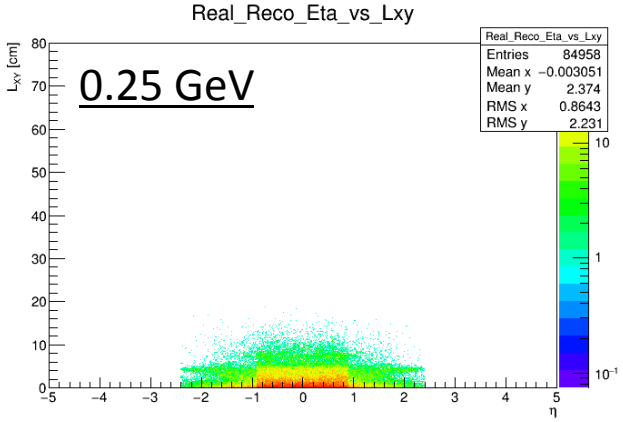
- A model of the signal shape has been determined which removes the vast majority of fake dimuons
- The resulting ratio plot is very flat for all mass samples

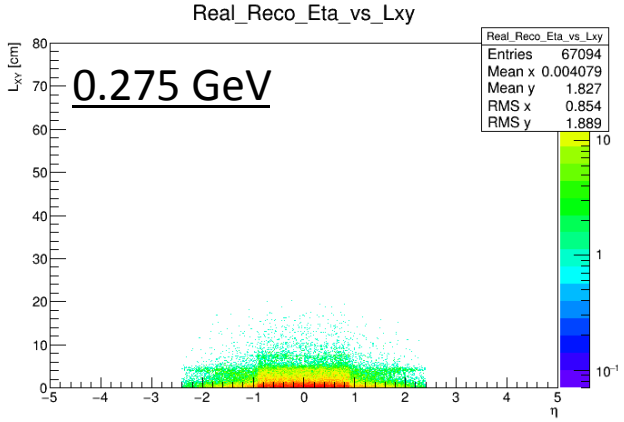
Discussion

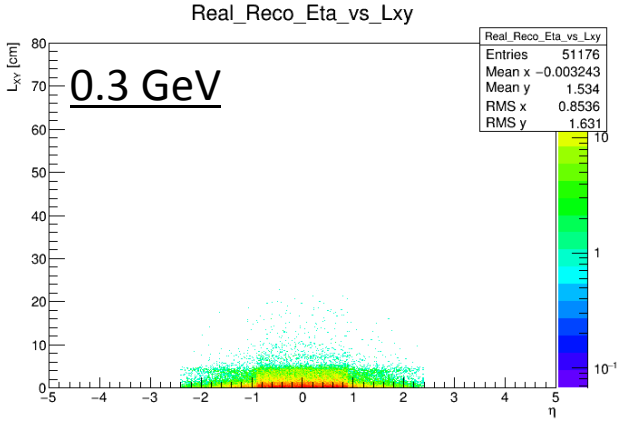
- Is this method of determining the signal shape rigorous enough?
  - Bin width influences results and was quasi-arbitrarily chosen
  - Uncertainty on cut placement not considered when fitting ellipse
- Have the fake dimuons been sufficiently mitigated?
  - If not
    - Use other signal shapes (super ellipse, higher order polynomials, etc.)
    - Investigate adding additional variables in to cut
  - If so
    - What can I work on next? Does anyone need help?
    - My only other task that is in progress is the J/ψ estimation
      - I need to bug hunt Luca's MC and my analysis, but I really need the SPS MC before this can move forward

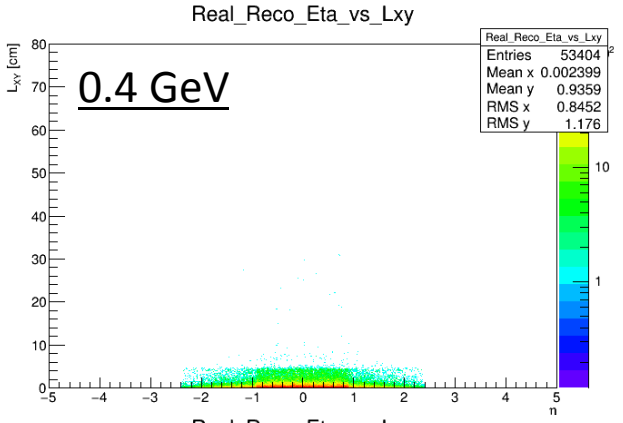
Backup

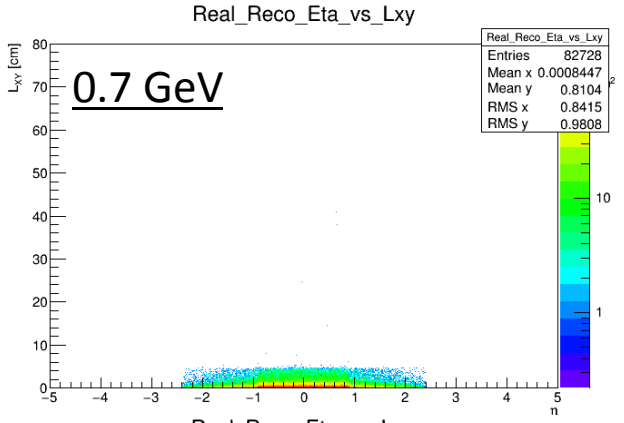
Real RECO L_{XY} vs RECO eta for individual mass samples

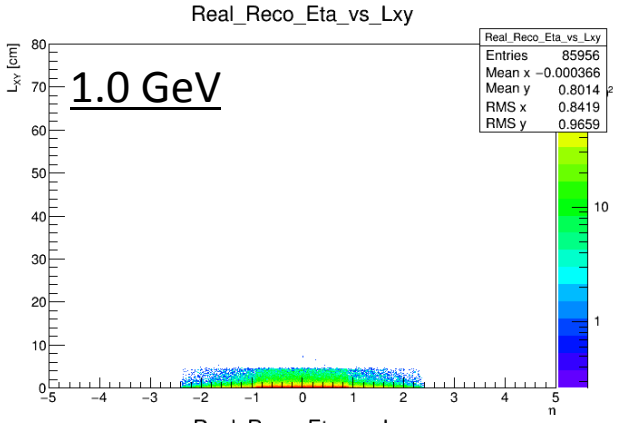


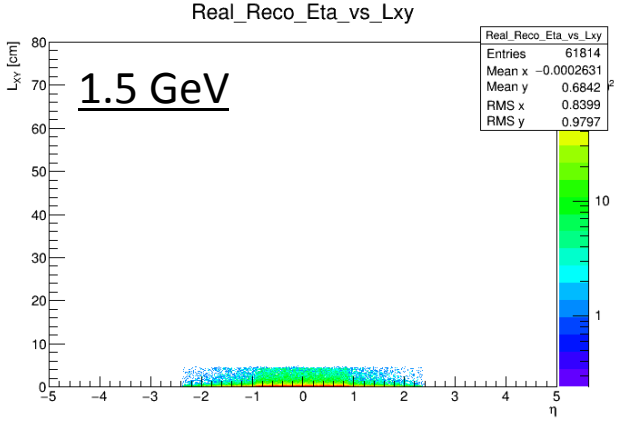


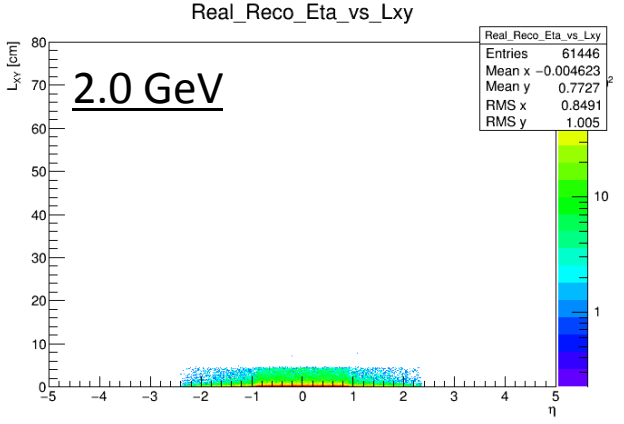


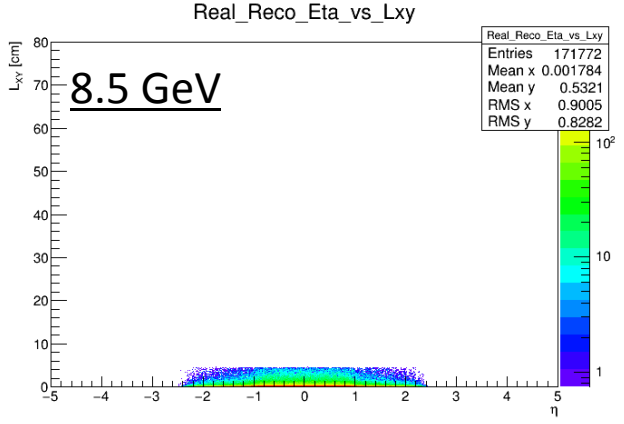




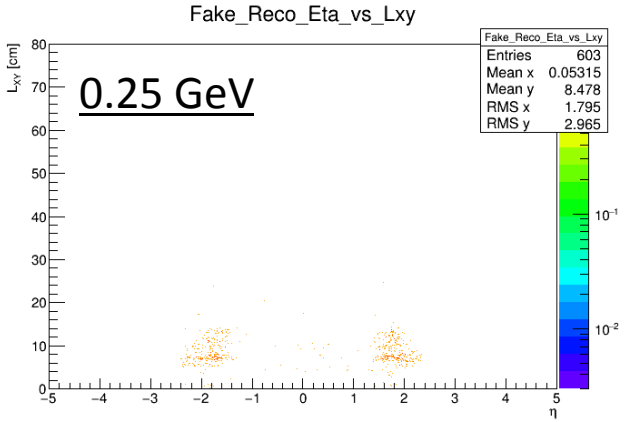


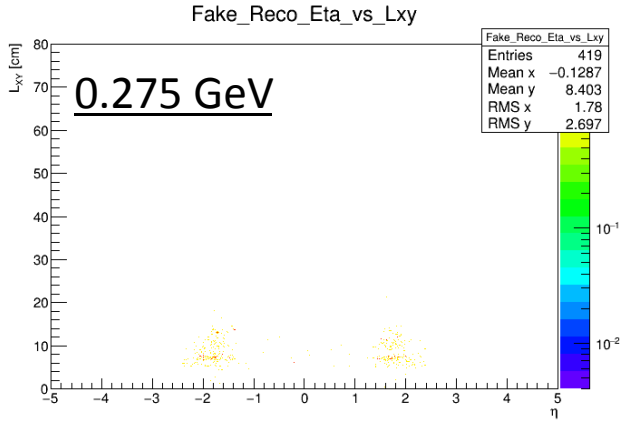


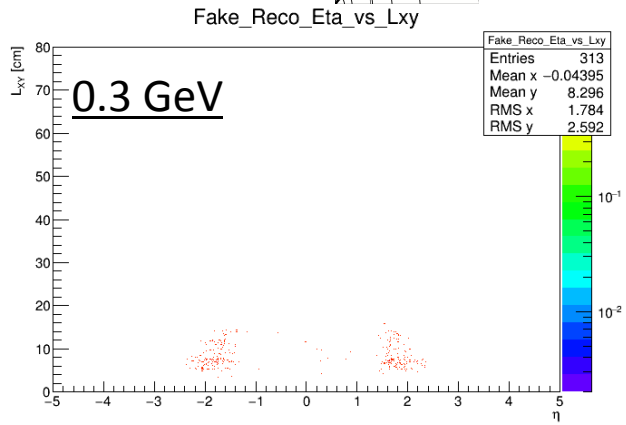


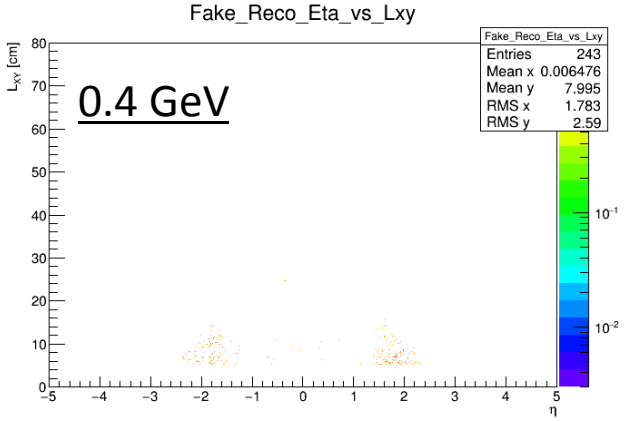


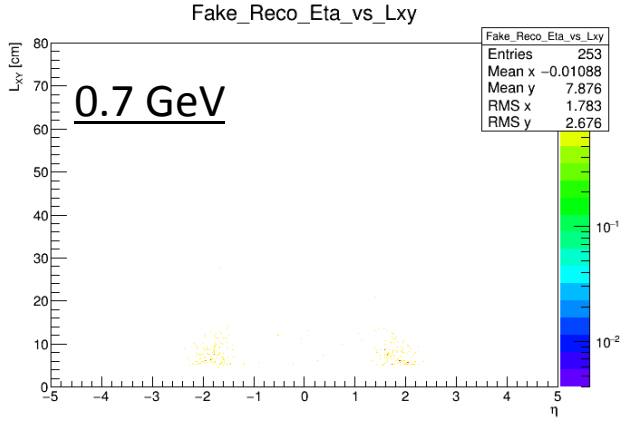
Fake RECO L_{XY} vs RECO eta for individual mass samples

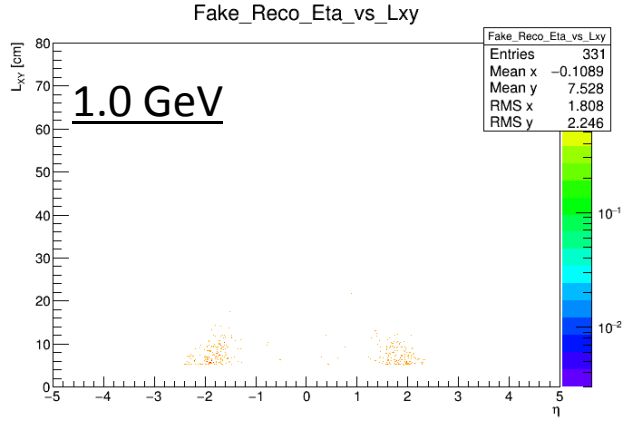


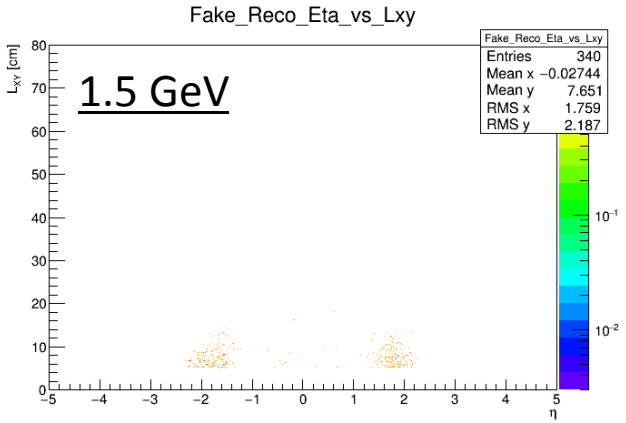


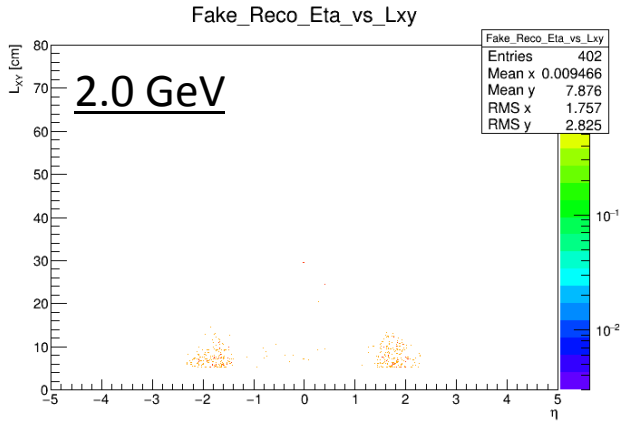


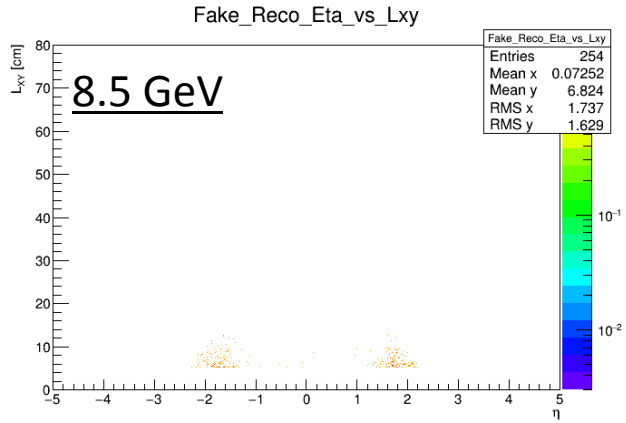




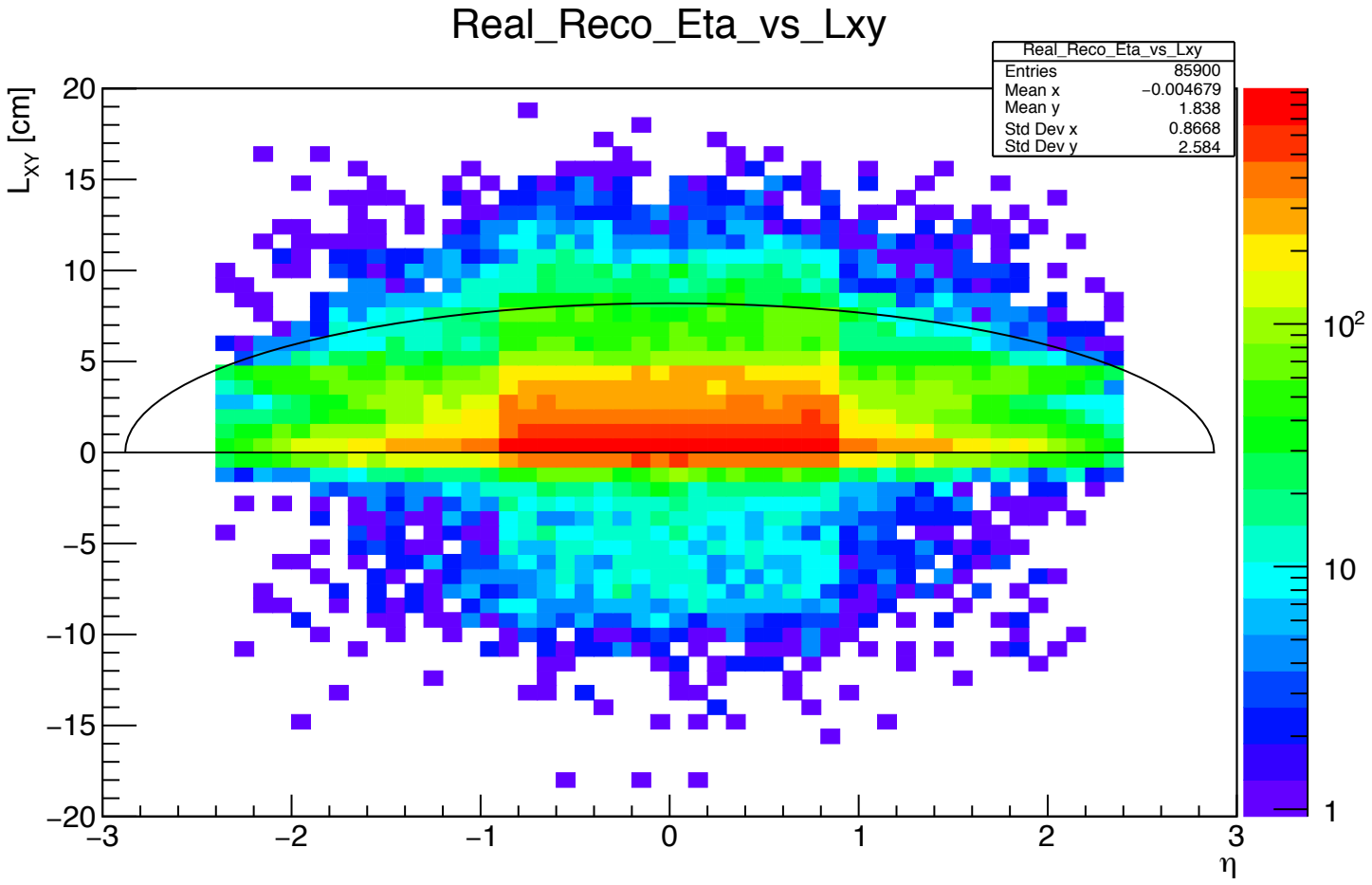




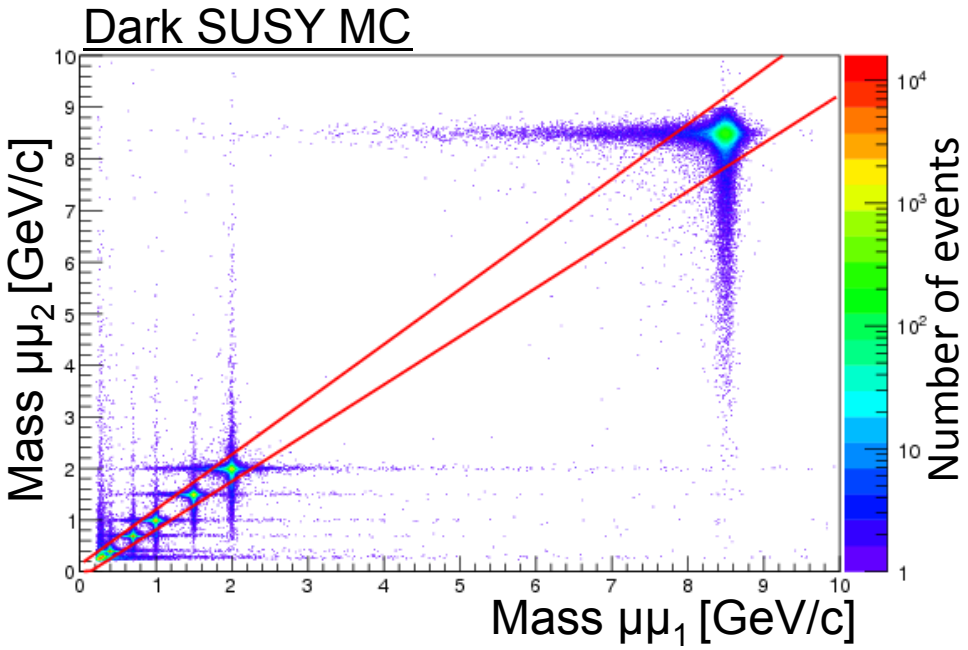


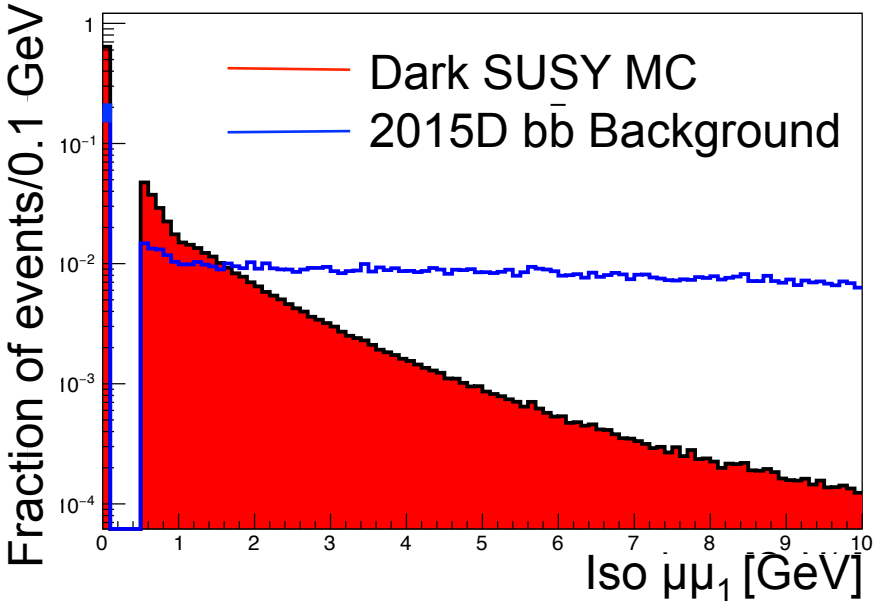


0.25 GeV sample zoom



Update of offline selection plots

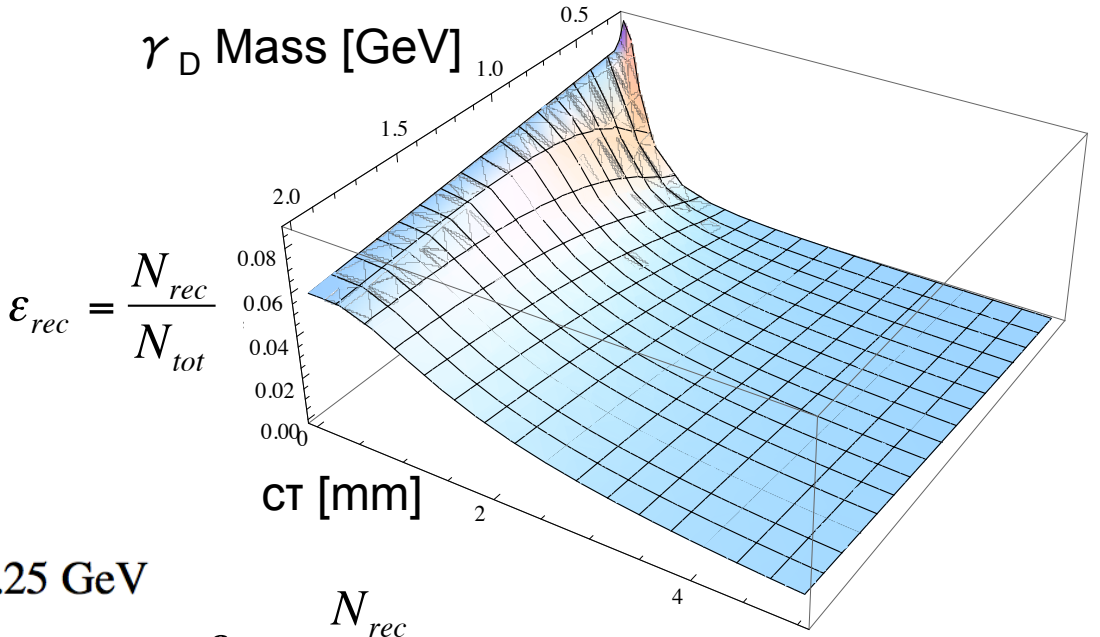




- All MC samples added to offline selection plots

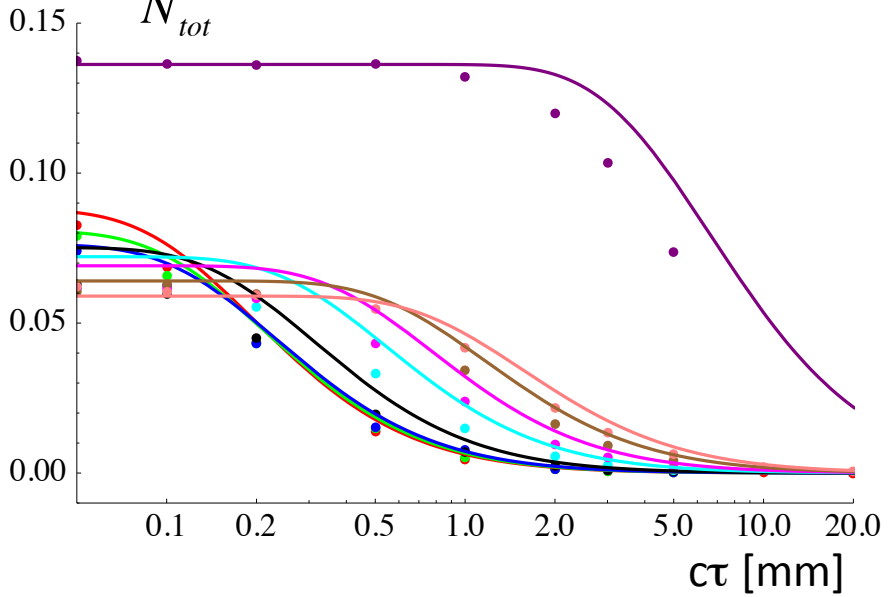
Update of model of the event acceptance as a function of $m_{\gamma D}$ and $c\tau_{\gamma D}$

- Added all new MC samples/mass points
- MC values used includes fiducial cut in numerator)
  - See backup plot for details



$$\varepsilon_{rec} = \frac{N_{rec}}{N_{tot}}$$

- 0.25 GeV
- 0.275 GeV
- 0.3 GeV
- 0.4 GeV
- 0.7 GeV
- 1.0 GeV
- 1.5 GeV
- 2.0 GeV
- 8.5 GeV



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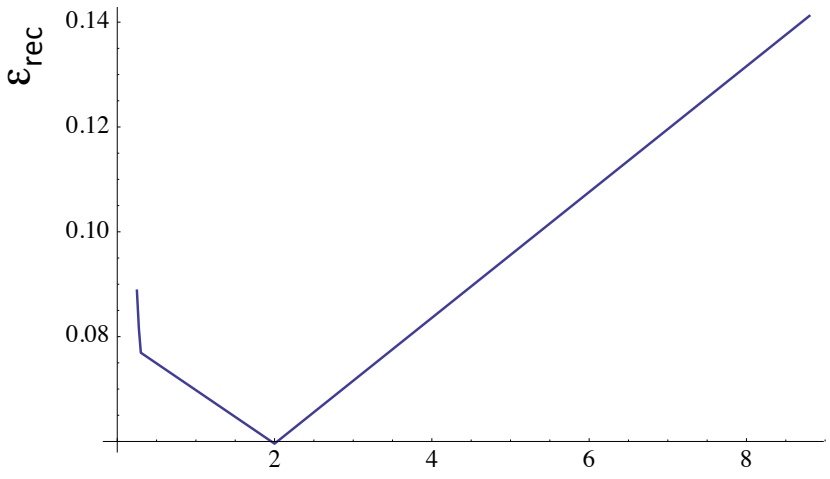
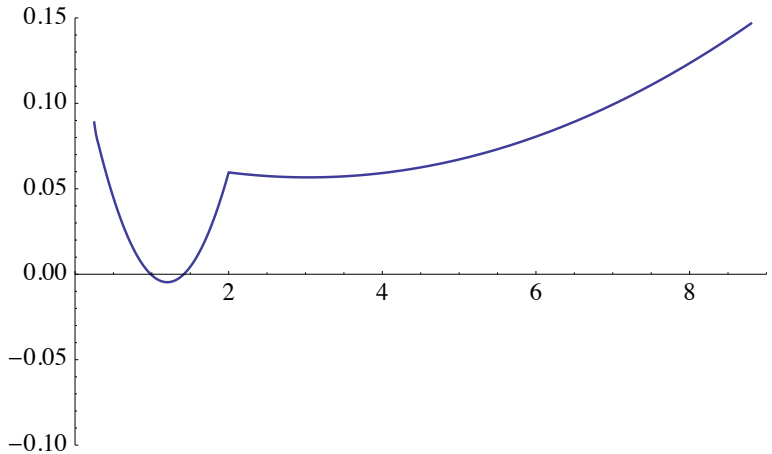
Interpolation order

Order 1



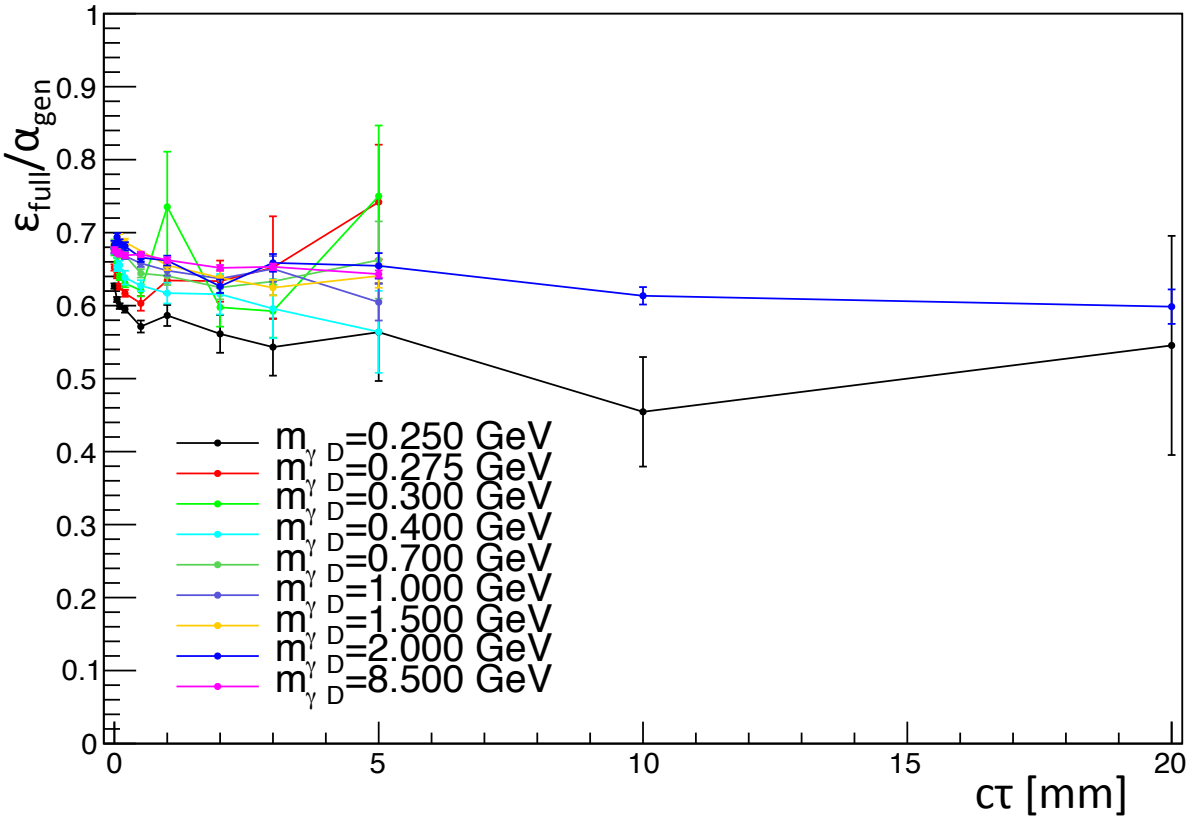
Order 2



$m_{\gamma D}$ [GeV]

- Interpolation order 1 still used
  - Order 2 used in previous AN
- We had hoped that adding in more mass points would stop ε_{rec} from dropping below zero

εfull/αgen (fiducial cut in numerator)



- Denominator:
  - 4 GEN mu $p_T > 8$ ($|\eta| < 2.4$) && 1 GEN mu $p_T > 17$ ($|\eta| < 0.9$)
  - Fiducial cut: Dark photon $L_{XY} < 4.4$ cm && $L_Z < 34.5$
- Numerator:
  - 4 RECO mu $p_T > 8$ ($|\eta| < 2.4$) && 1 RECO mu $p_T > 17$ ($|\eta| < 0.9$)
  - **Dark photon $L_{XY} < 4.4$ cm && $L_Z < 34.5$**
  - Event has a primary vertex, 2 dimuons in the event, both dimuons have a valid vertex, dimuon vertices pass Δz cut, both dimuons have a hit in the first pixel layer, dimuons pass mass compatability cut, fired HLT