Mid-Week Status Update

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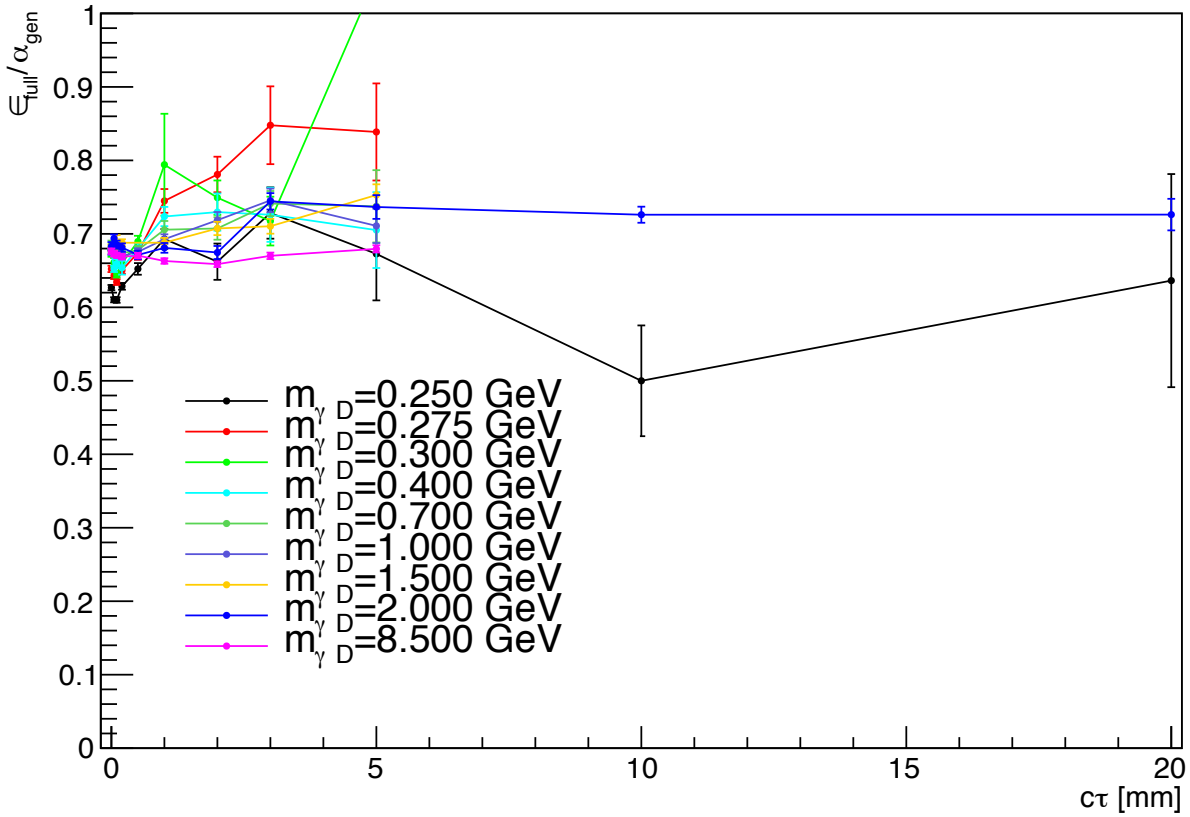
$\varepsilon_{full} / \alpha_{gen}$

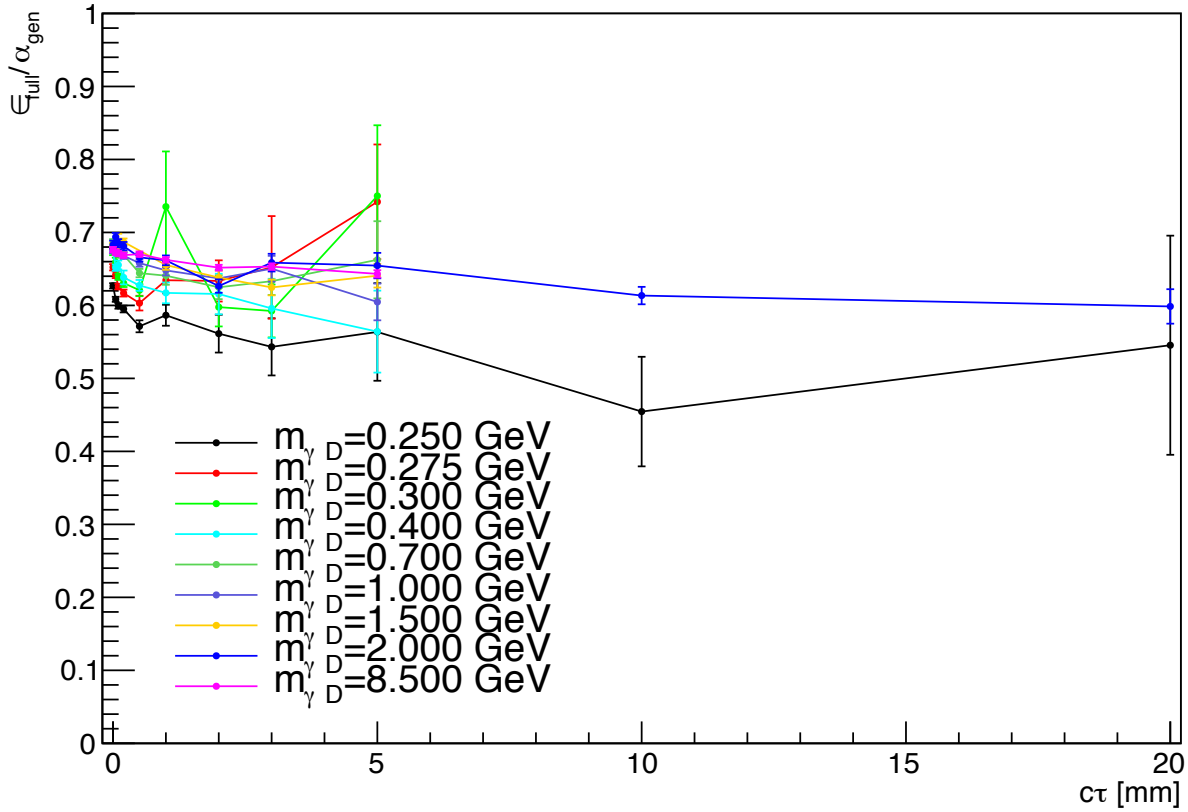
From last time:



- 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

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

From last time:



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- Numerator:
  - **Dark photon $L_{XY} < 4.4$ cm && $L_Z < 34.5$**
  - 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

Separation of real and fake events

- If an event passes the numerator (reconstruction) selection, but not the GEN fiducial cut (Dark photon $L_{XY} < 4.4$ cm && $L_Z < 34.5$) **and also has $L_{XY} > 5$** then the event is labeled as "fake"
  - This should ensure a pure sample of fakes
- If an event passes both the reconstruction selection and the fiducial cut, then the event is labeled as "real"
- These fake events are the source of the rise in efficiency as cT increases
- As fakes are eliminated via 2 (or 3) dimensional cuts, the ratio plot on slide 2 should approach the behavior of the ratio plot without errors on slide 3.

Efficiency vs Eta

Definition of efficiency

$$\frac{\#\,Events\;\;That\;\;Pass:\;\;RECO\;\;reqs\;\;\&\;\;\;Fid.\;Cut\;\;\&\;\;\;Elliptical\;\;Cut}{\#\,Events\;\;That\;\;Pass:\;\;RECO\;\;reqs\;\;\&\;\;\;Fid.\;Cut}$$

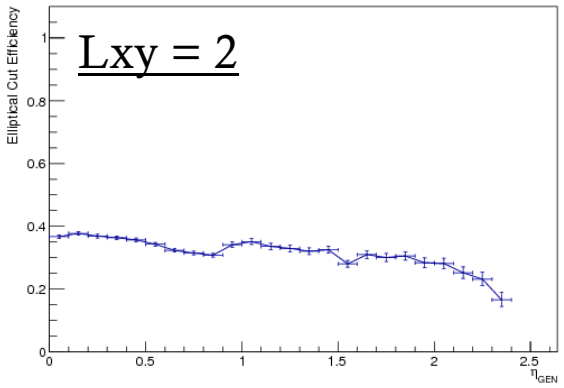
- RECO reqs
  - Numerator from slide 2
    - 4 RECO mu $p_T > 8$ ($|\eta| < 2.4$) && 1 RECO mu $p_T > 17$ ($|\eta| < 0.9$)
    - VtxOK, 2 Dimuons, 2DimVtxOK, 2DimDzOK,HitPixOK , 2DimMassOK, 2DimIsoOK, 2DimHLT
- Fiducial Cut
  - GEN level Dark photon $\mathbf{L_{XY} < 5\ cm}$ && $L_Z < 34.5$
  - See backup slides for the rational for 5 cm
- Elliptical Cut
  - $$\frac{\eta_{\mathrm{dim}}^2}{\eta_{cut}^2} + \frac{Lxy_{\mathrm{dim}}^2}{Lxy_{cut}^2} \leq 1$$

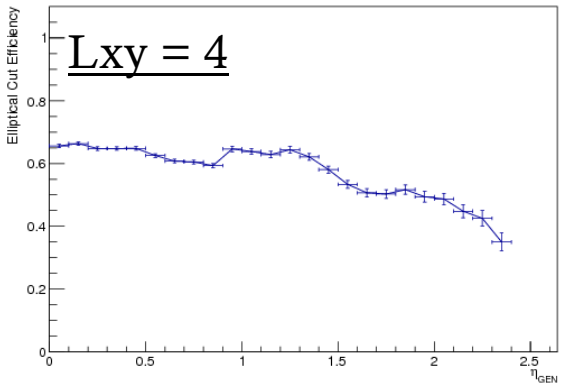
Definition of efficiency

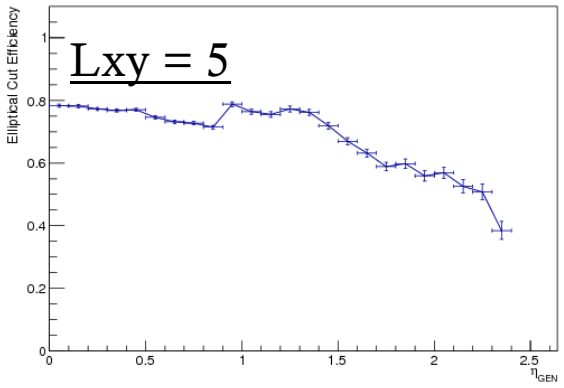
$$\frac{\#\,Events\;\;That\;\;Pass:\;\;RECO\;\;reqs\;\;\&\;\;\;Fid.\;Cut\;\;\&\;\;\;Elliptical\;\;Cut}{\#\,Events\;\;That\;\;Pass:\;\;RECO\;\;reqs\;\;\&\;\;\;Fid.\;Cut}$$

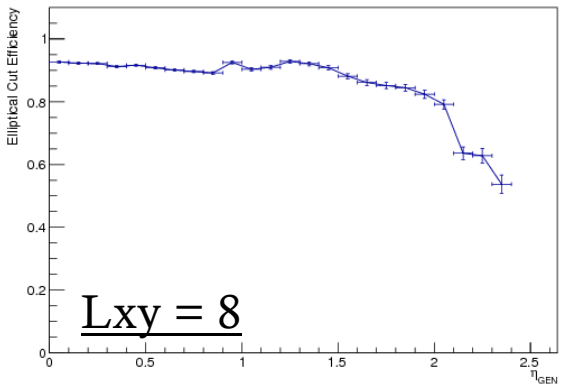
- Ran with elliptical cut parameters of
  - eta: 0-2.4 with step size of 0.1
  - Lxy: 0-25 with step size of 1
- All plots available at
  - https://bmichlin.web.cern.ch/bmichlin/DarkSUSY/FakeDimuonInvestigation/January_26_2016/Efficiency/
- Select plots shown on following slides

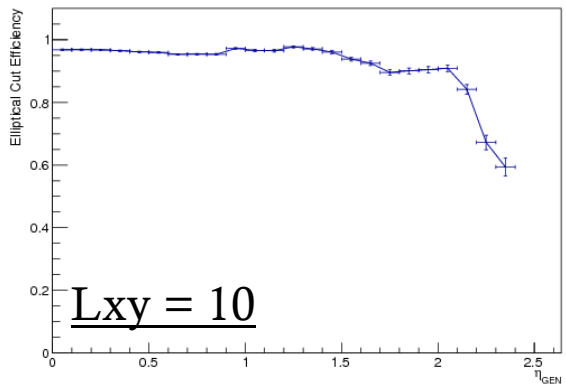
0.25 GeV, eta=2.4

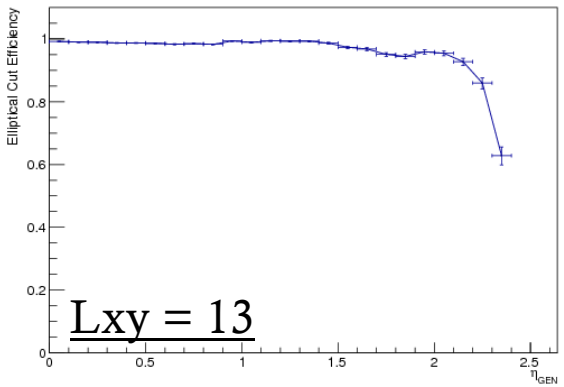


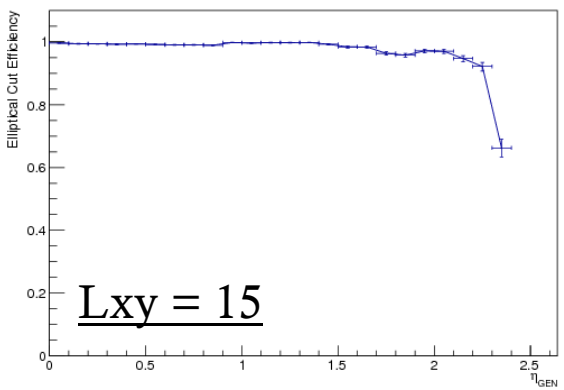


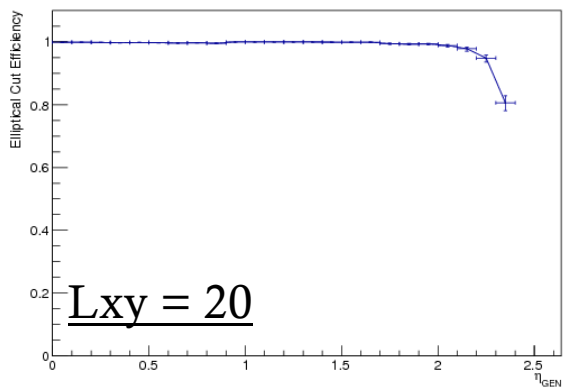


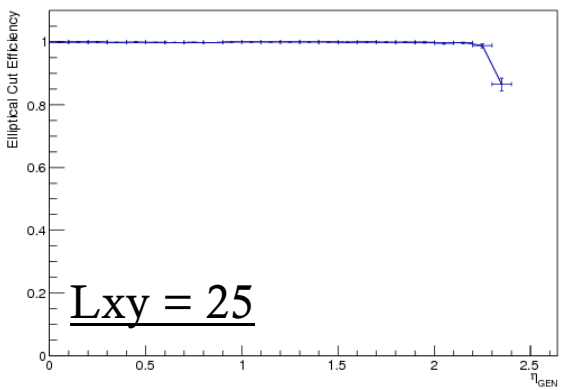




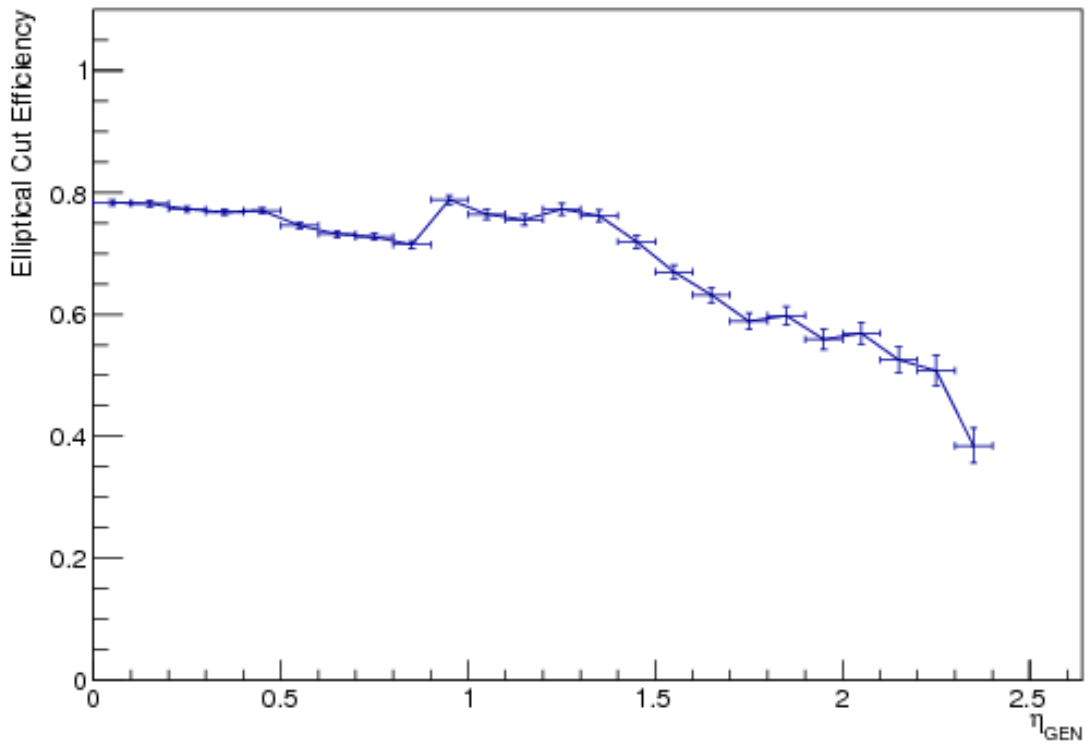






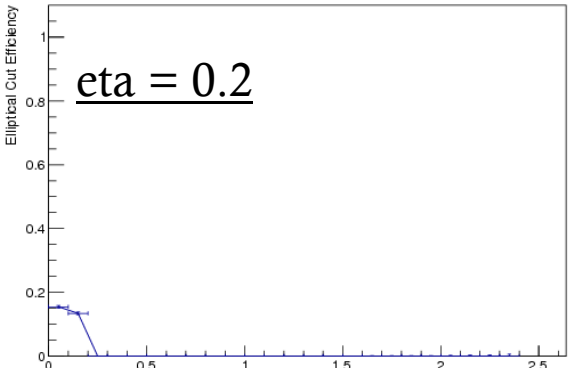


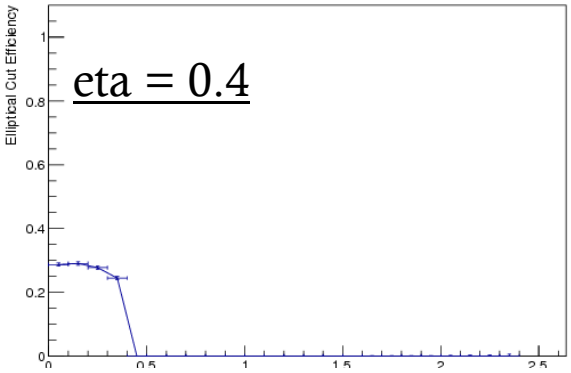
0.25 GeV, eta=2.4, Lxy = 5

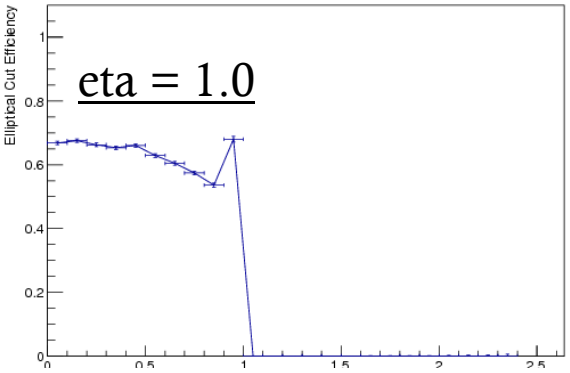


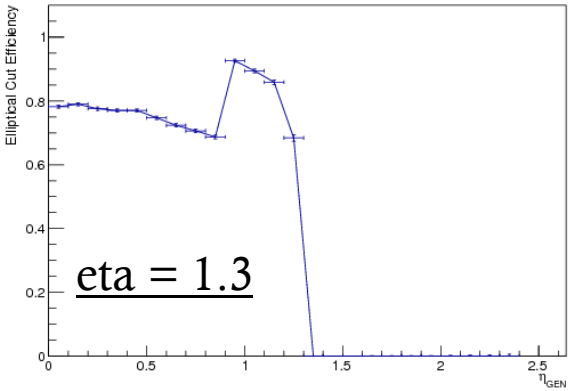
- Eta Regions
  - Barrel <= 0.9
  - 0.9 <= Overlap <= 1.2
  - Forward >= 1.2
  - ME1/1 >= ~1.5

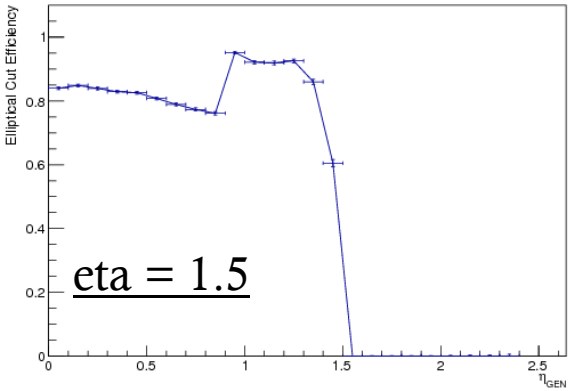
0.25 GeV, Lxy = 10

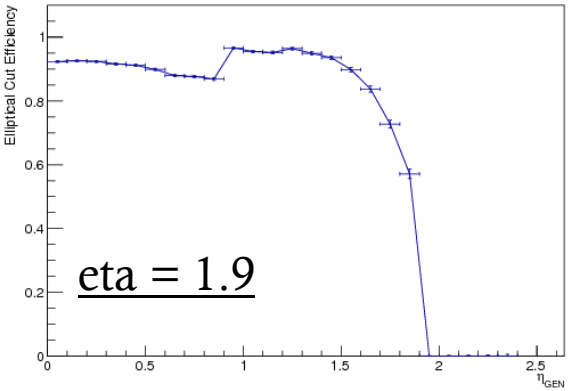


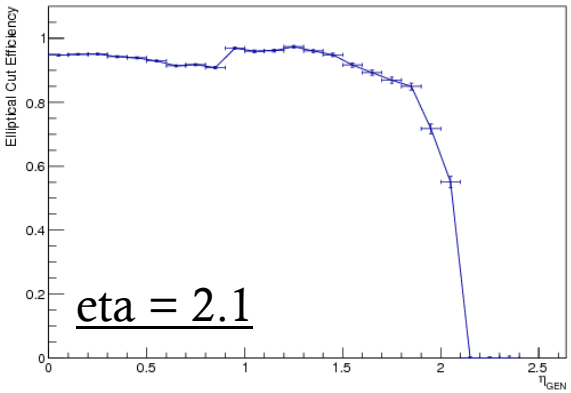


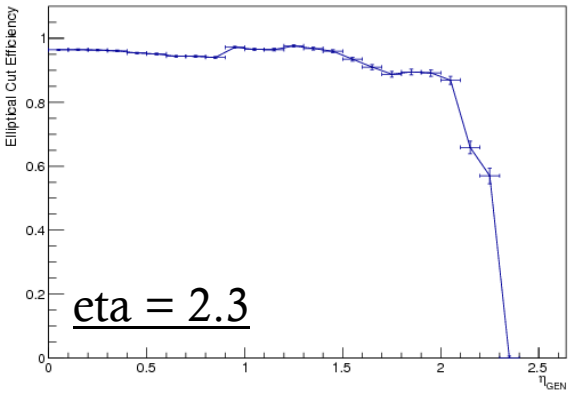


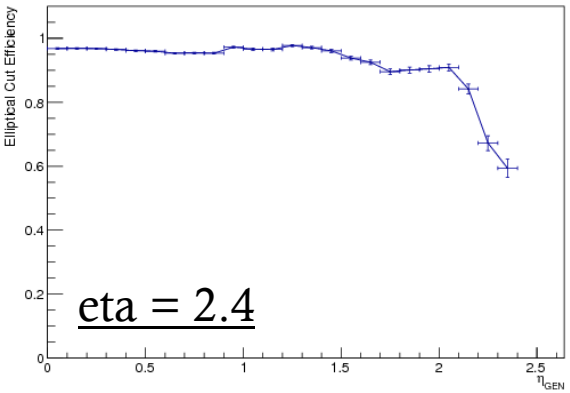






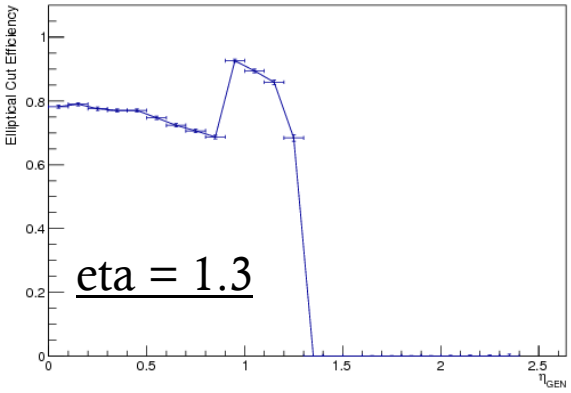


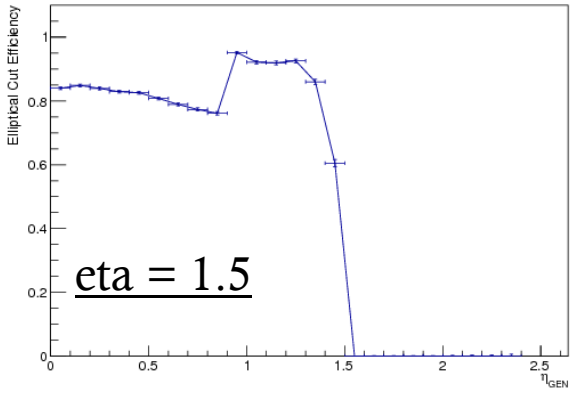


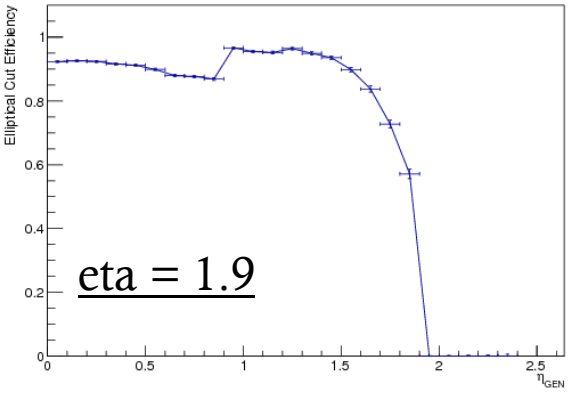


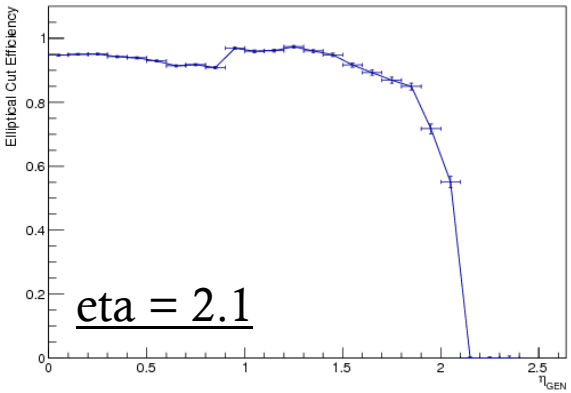
0.25 GeV, Lxy = 10

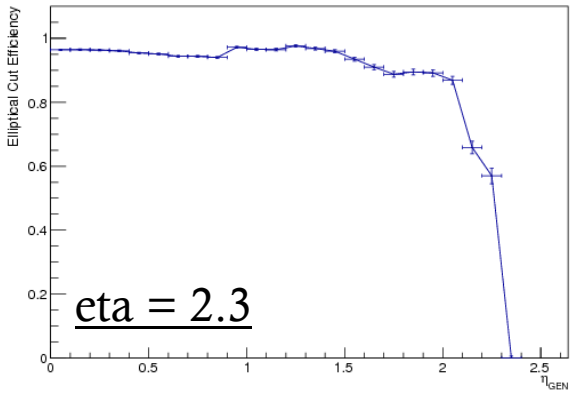
- A large increase in efficiency begins at the overlap region that only begins to flatten at large eta
- Decrease in efficiency in endcap even for large eta
  - TODO: This could be due to edge affects of the ellipse. Might flatten for larger eta

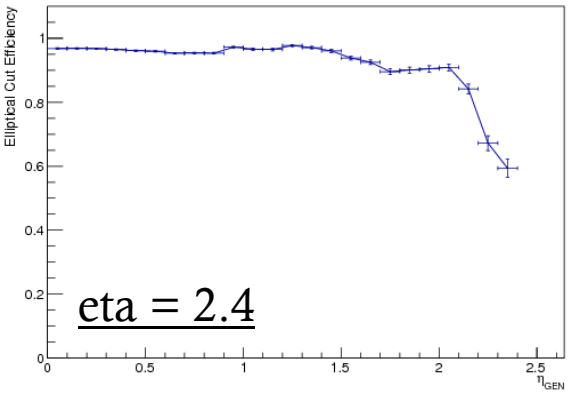








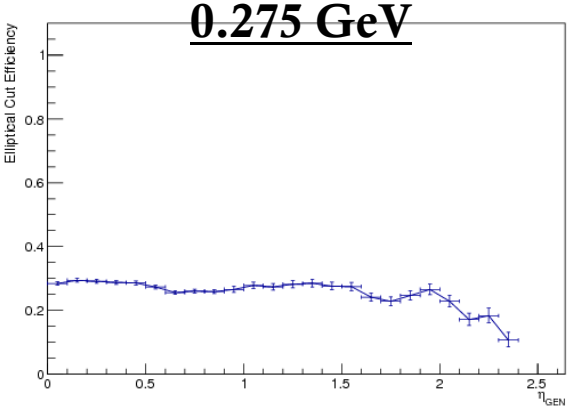


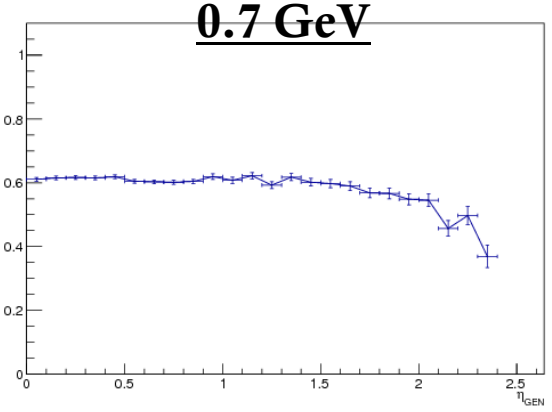


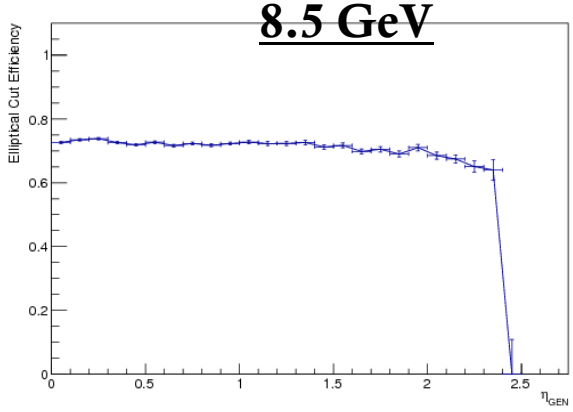
Comparison to other masses (eta = 2.4)

0.275 GeV | **0.7 GeV** | **8.5 GeV**

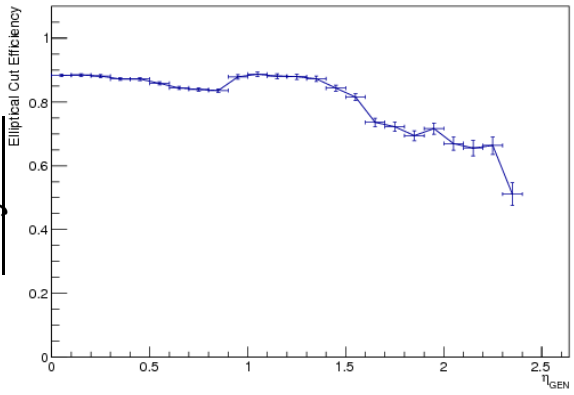
Lxy = 1

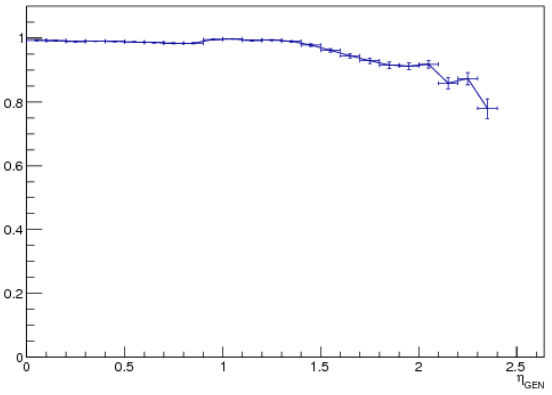


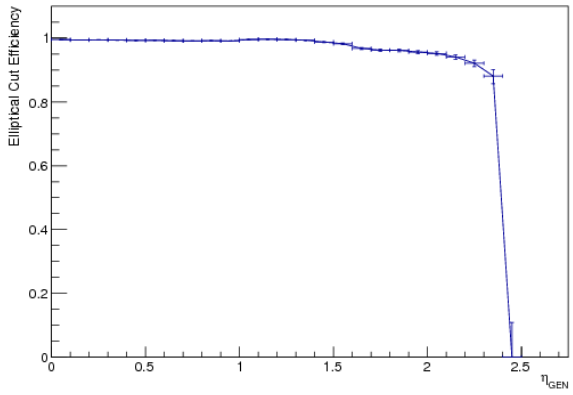




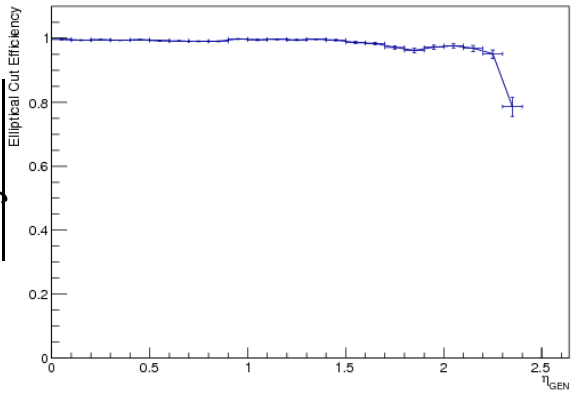
Lxy = 5

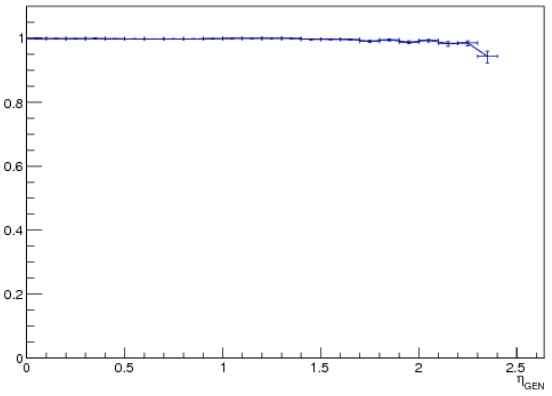


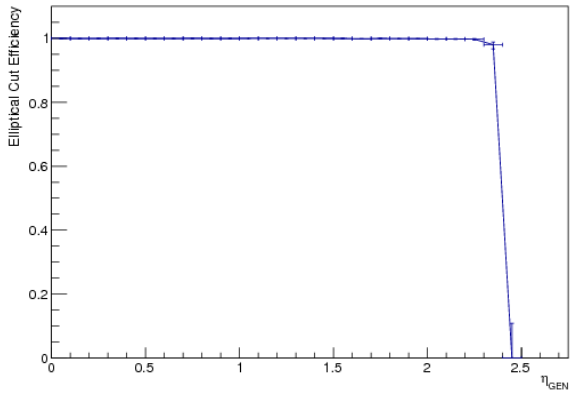




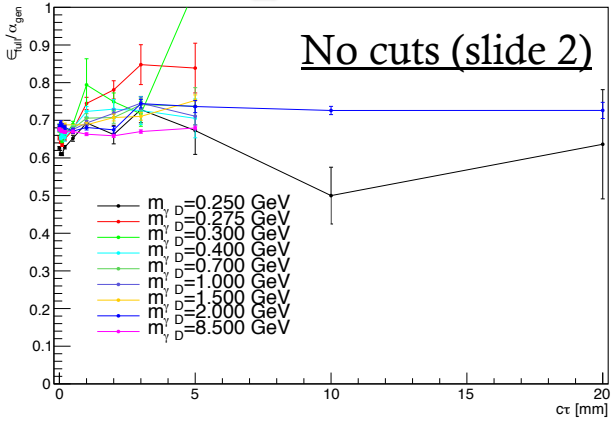
Lxy = 15

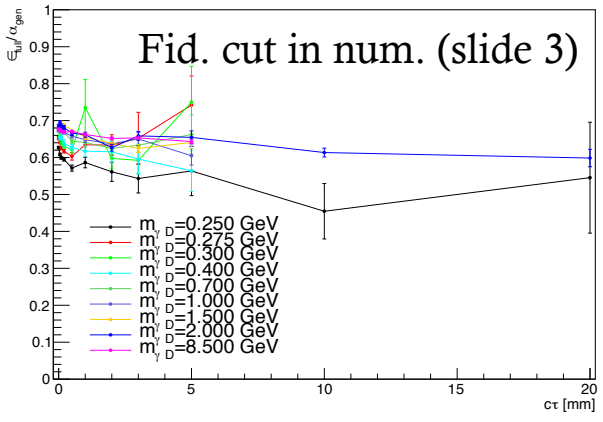


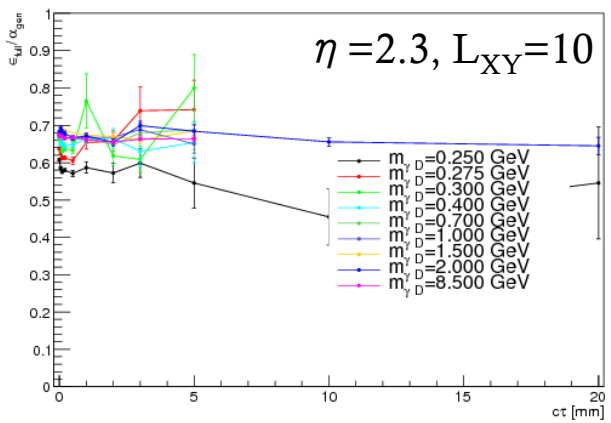


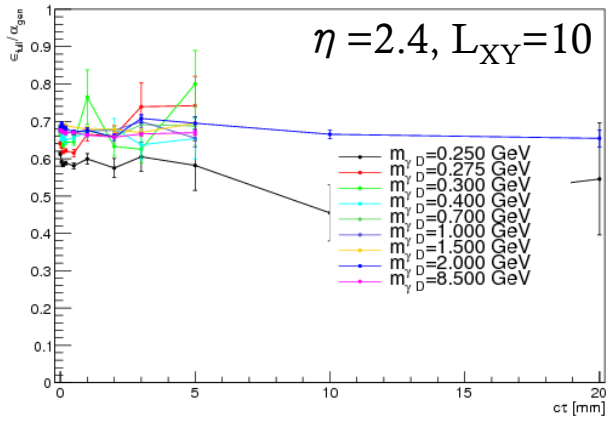


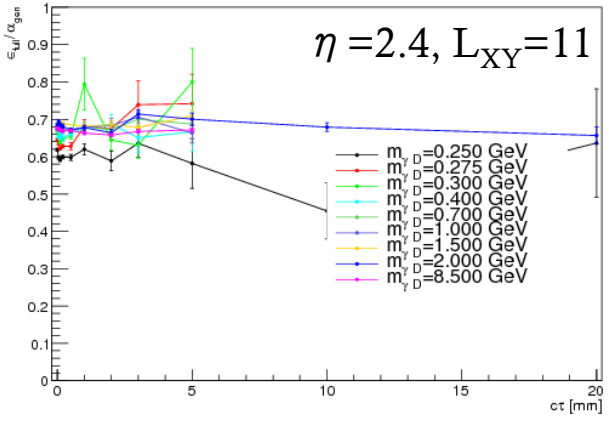
Ratio plots

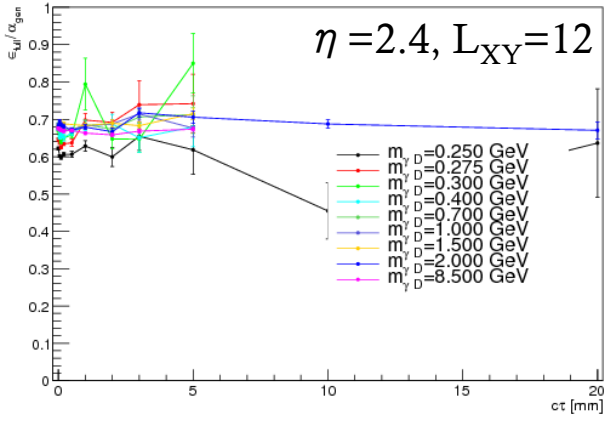

No cuts (slide 2)
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV

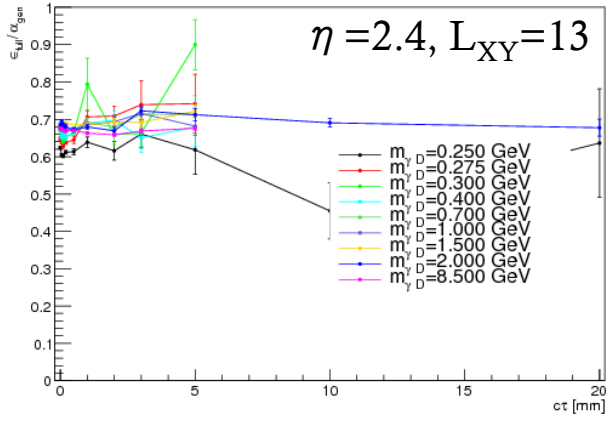

Fid. cut in num. (slide 3)
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV

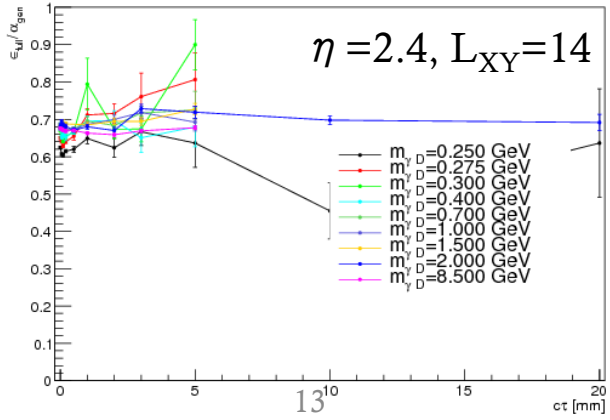

η =2.3, L$_{XY}$=10
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV

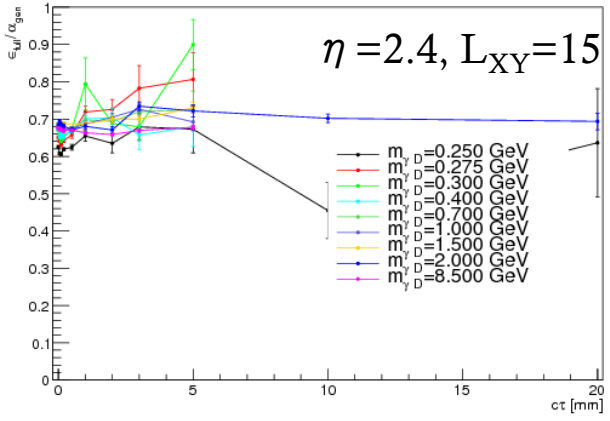

η =2.4, L$_{XY}$=10
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV


η =2.4, L$_{XY}$=11
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV


η =2.4, L$_{XY}$=12
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV


η =2.4, L$_{XY}$=13
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV


η =2.4, L$_{XY}$=14
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV


η =2.4, L$_{XY}$=15
$\epsilon_{full}/\alpha_{gen}$
cτ [mm]
m$_{\gamma_D}$=0.250 GeV
m$_{\gamma_D}$=0.275 GeV
m$_{\gamma_D}$=0.300 GeV
m$_{\gamma_D}$=0.400 GeV
m$_{\gamma_D}$=0.700 GeV
m$_{\gamma_D}$=1.000 GeV
m$_{\gamma_D}$=1.500 GeV
m$_{\gamma_D}$=2.000 GeV
m$_{\gamma_D}$=8.500 GeV

Thoughts

- How can the efficiency, as it is currently defined, on its own determine the parameters of the elliptical cut?
  - If our only requirement is that the efficiency is flat and high, then the larger the ellipse parameters the better.
    - ie: an ellipse that encompasses every point (reals and fakes)
    - Am I misunderstanding something?
- Maybe we can compare the current efficiency (which is really the efficiency of the cut on the signal) to a *background* efficiency and then minimize their ratio…
- Background efficiency:

$$\frac{\#\,Events\;\;That\;\;Pass\;\;RECO\;\;reqs\;\&\,FAIL:\;\;Fid.\;Cut\;\;\&\;\;\;Elliptical\;\;Cut}{\#\,Events\;\;That\;\;Pass\;\;RECO\;\;reqs\;\&\,FAIL\;\;Fid.\;Cut}$$

Thoughts

Signal Efficiency:

$$\frac{\#\,Events\;\;That\;\;Pass:\;\;RECO\;\;reqs\;\&\;\;Fid.\;Cut\;\&\;\;Elliptical\;\;Cut}{\#\,Events\;\;That\;\;Pass:\;\;RECO\;\;reqs\;\&\;\;Fid.\;Cut}$$

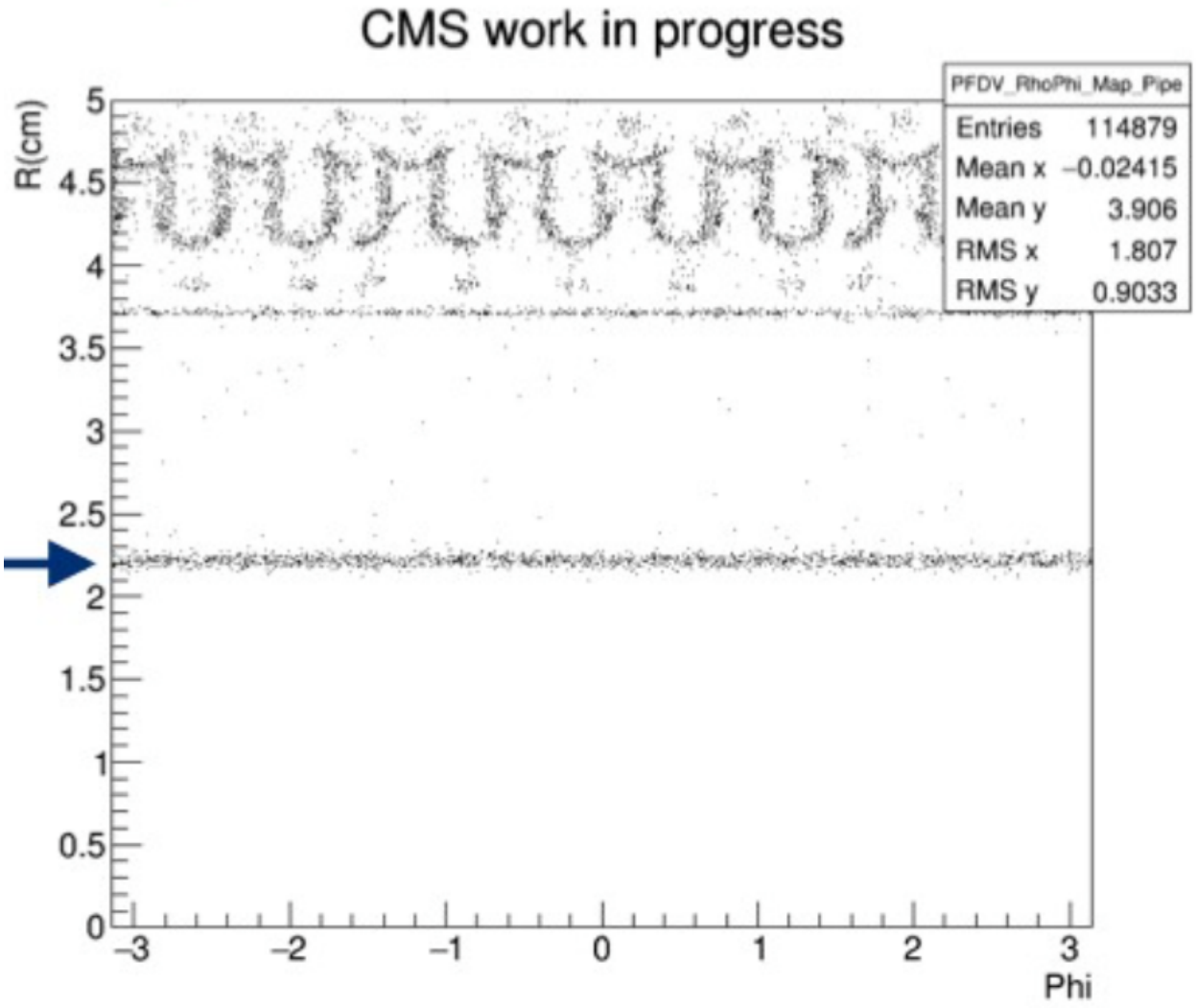
Background Efficiency:

$$\frac{\#\,Events\;\;That\;\;Pass\;\;RECO\;\;reqs\;\&\,FAIL:\;\;Fid.\;Cut\;\&\;\;Elliptical\;\;Cut}{\#\,Events\;\;That\;\;Pass\;\;RECO\;\;reqs\;\&\,FAIL\;\;Fid.\;Cut}$$

- For very large eta and Lxy, the signal efficiency goes to 1 (all events accepted by elliptical cut), and the background efficiency goes to 0
- For very small eta and Lxy, the background efficiency goes to 1 (all events {here, only the fakes because of denominator requirements} rejected), signal efficiency goes to 0
- Extrema of the ratio of the efficiencies may provide optimal cut

Backup

Location of pixels



https://indico.cern.ch/event/395619/session/2/contribution/10/attachments/1125480/1606608/DPGsummary.pdf