Radiative Fraction and Selection Cuts for the 2016 Vertex Search

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Spring 2019 HPS Collaboration Meeting

Contents

- 2016 radiative event selection cuts
  - Selection criteria
  - New cut proposal with a high wab/A’ rejection
- Radiative fraction
  - Vs. radiative cut
  - How the new cut affects it

Preliminaries

- 2016 pass4 MC:

/mss/hallb/hps/production/PhysicsRun2016/pass4/npt224npt08n4pt3_npt33/recon/

- RAD-WBT:
  - Radiative tridents with “wab-beam-tri” background events in the trigger window
- Tritrig-WB:
  - Full tridents with “wab-beam” background events in the trigger window
- Wab-BT:
  - Wide-angle bremsstrahlung with “beam-tri” background events in the trigger window

- A’-WBT:
  - Displaced A’s with “wab-beam-tri” background events in the trigger window

Preliminaries

{x,y,z} = {-0.224, -0.08, -4.3}mm
$\{\theta_x, \theta_y\}$ = {-0.33, -0.33}mrad

- 2016 pass4 MC:

/mss/hallb/hps/production/PhysicsRun2016/pass4/npt224npt08n4pt3_npt33/recon/

- RAD-WBT:
  - Radiative tridents with “wab-beam-tri” background events in the trigger window
- Tritrig-WB:
  - Full tridents with “wab-beam” background events in the trigger window
- Wab-BT:
  - Wide-angle bremsstrahlung with “beam-tri” background events in the trigger window

- A’-WBT:
  - Displaced A’s with “wab-beam-tri” background events in the trigger window

Radiative Event Selection Criteria

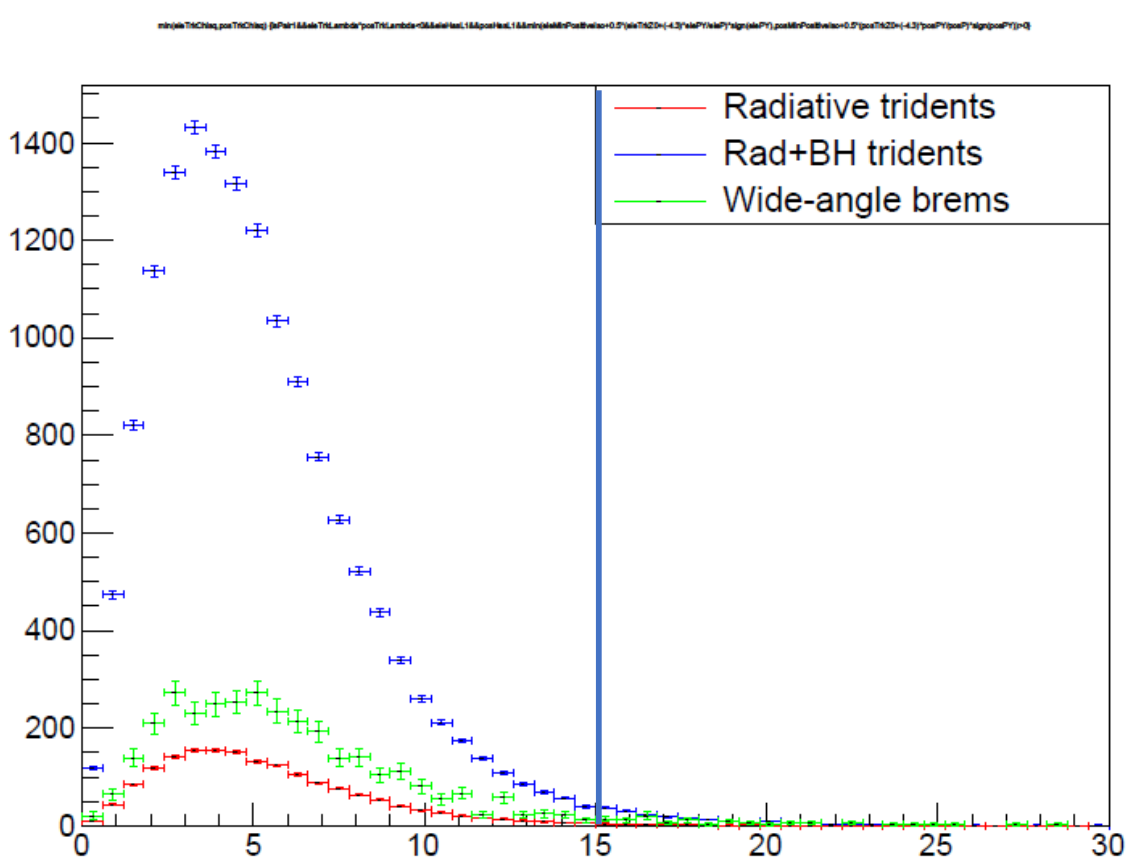
Idea:

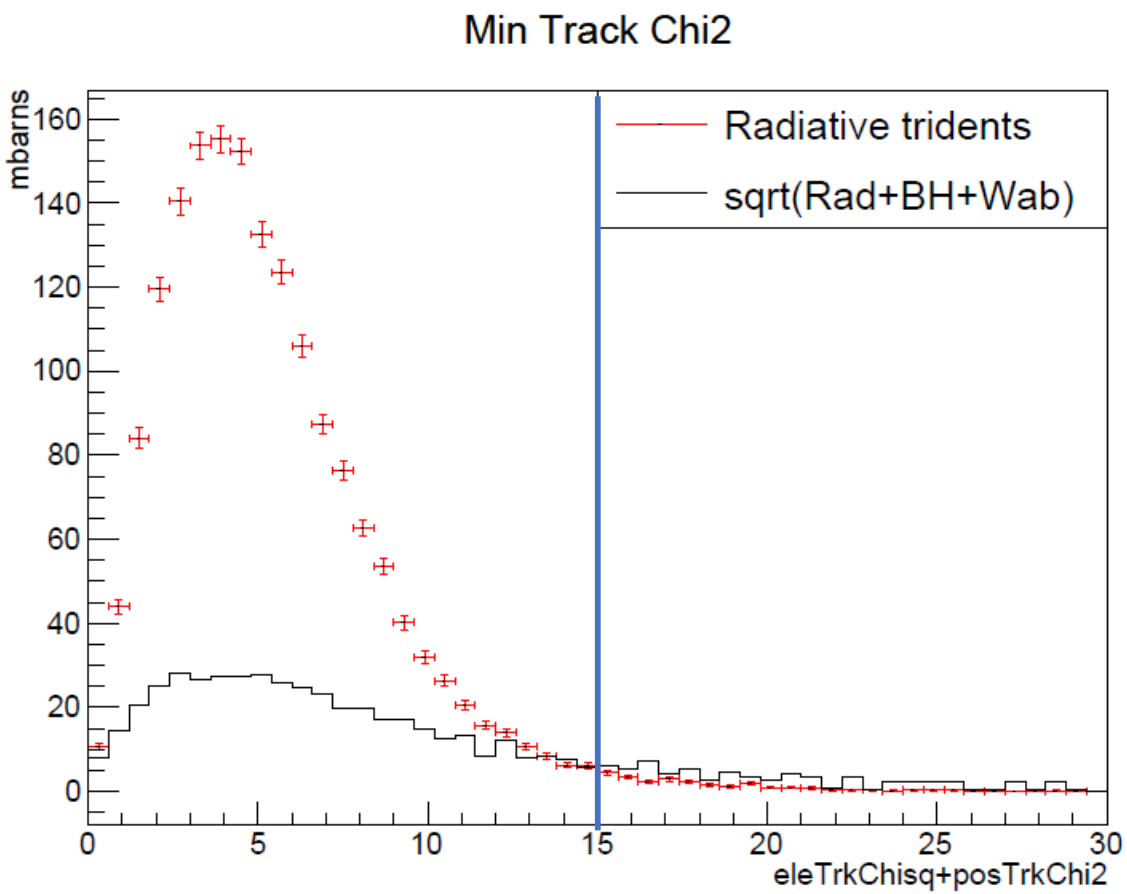
- Normalize RAD, tritrig, wab by cross section $\left(\frac{\sigma_{generated}}{\#\ generated}\right)$

- Look at overlain plots, signal vs. noise, and cumulative significance

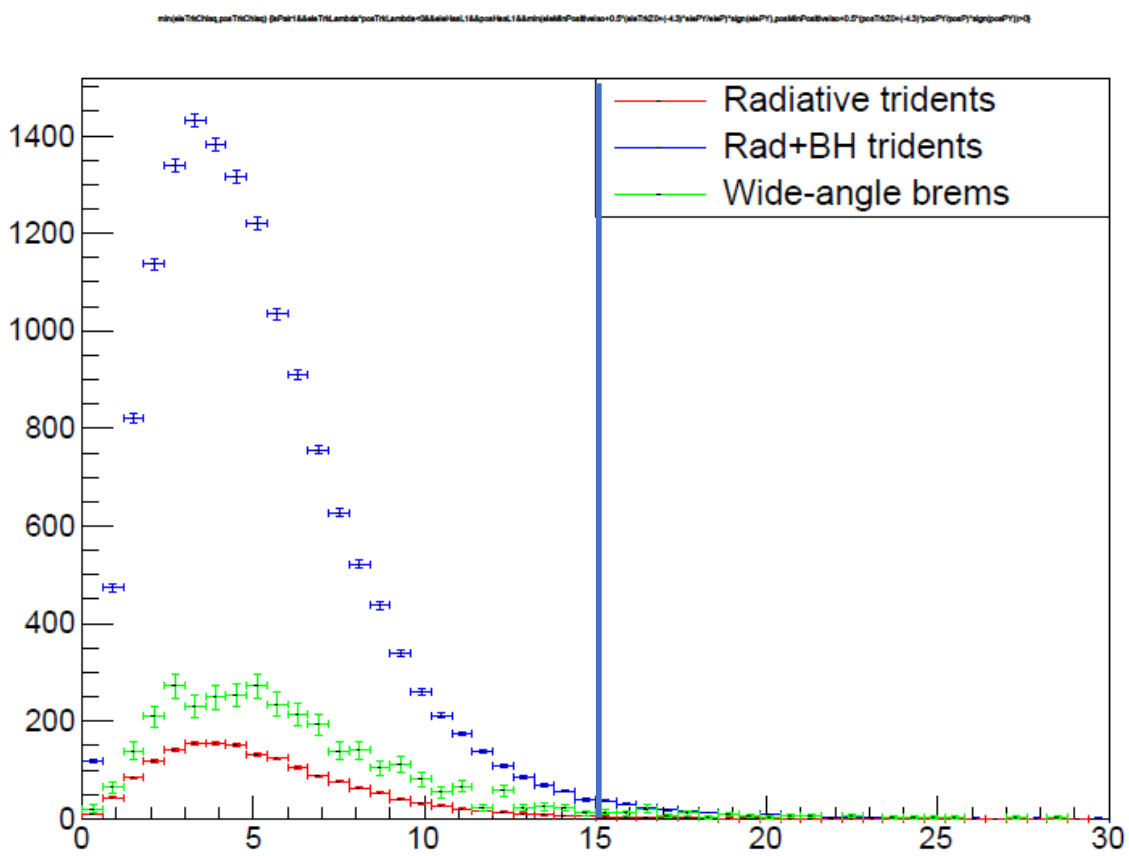
- Make a judgement on where to put cuts

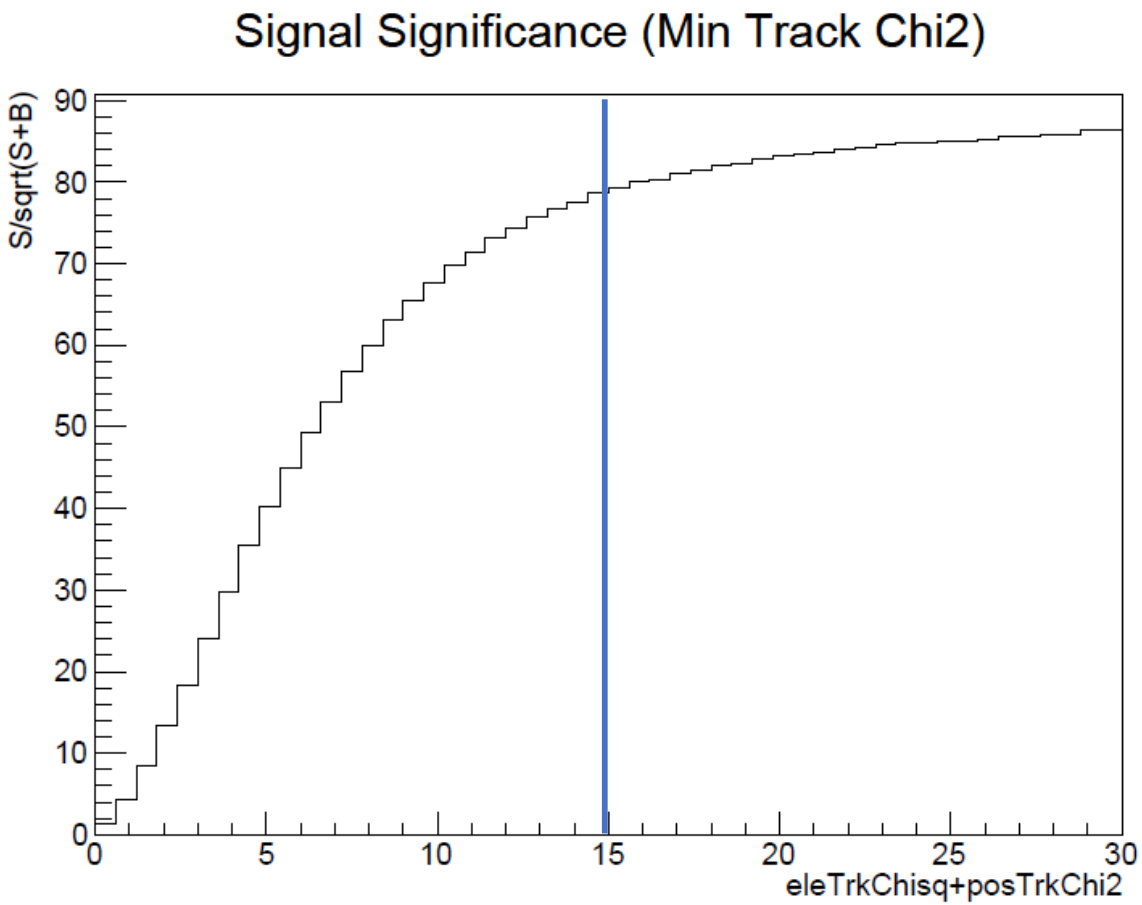
Min. Track Chi2 < 15



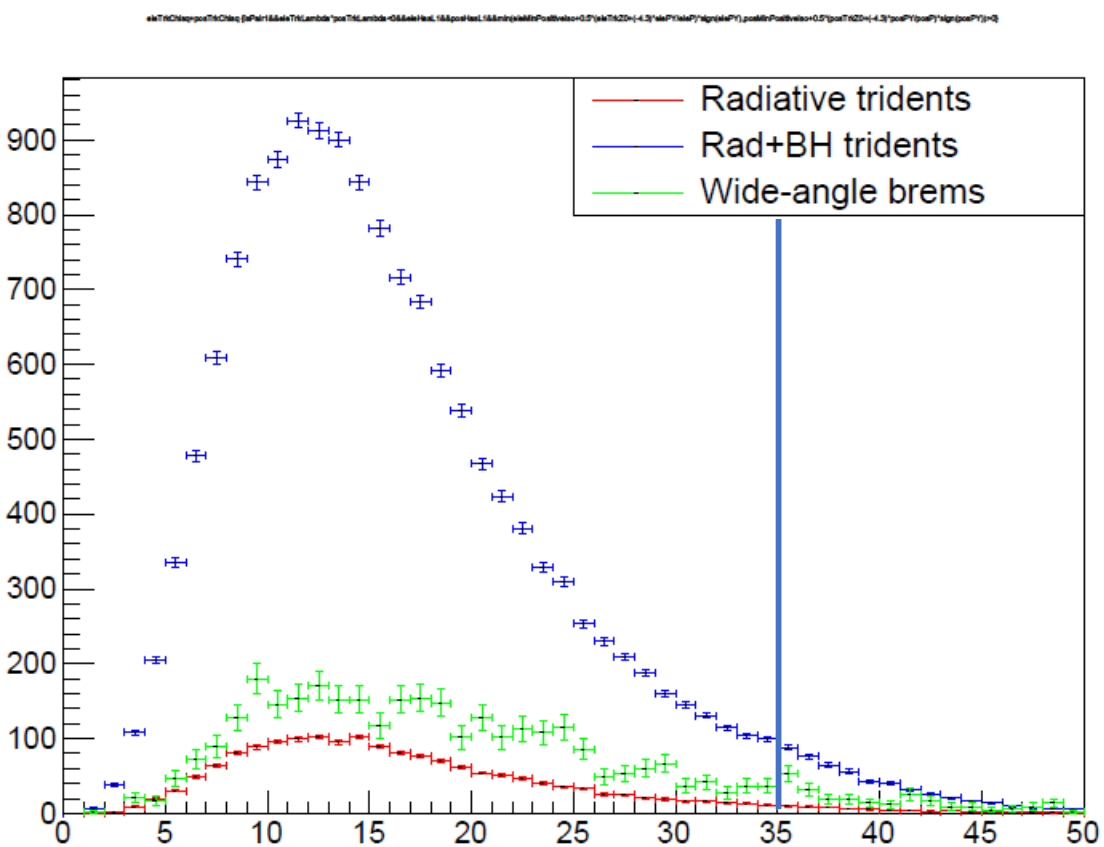


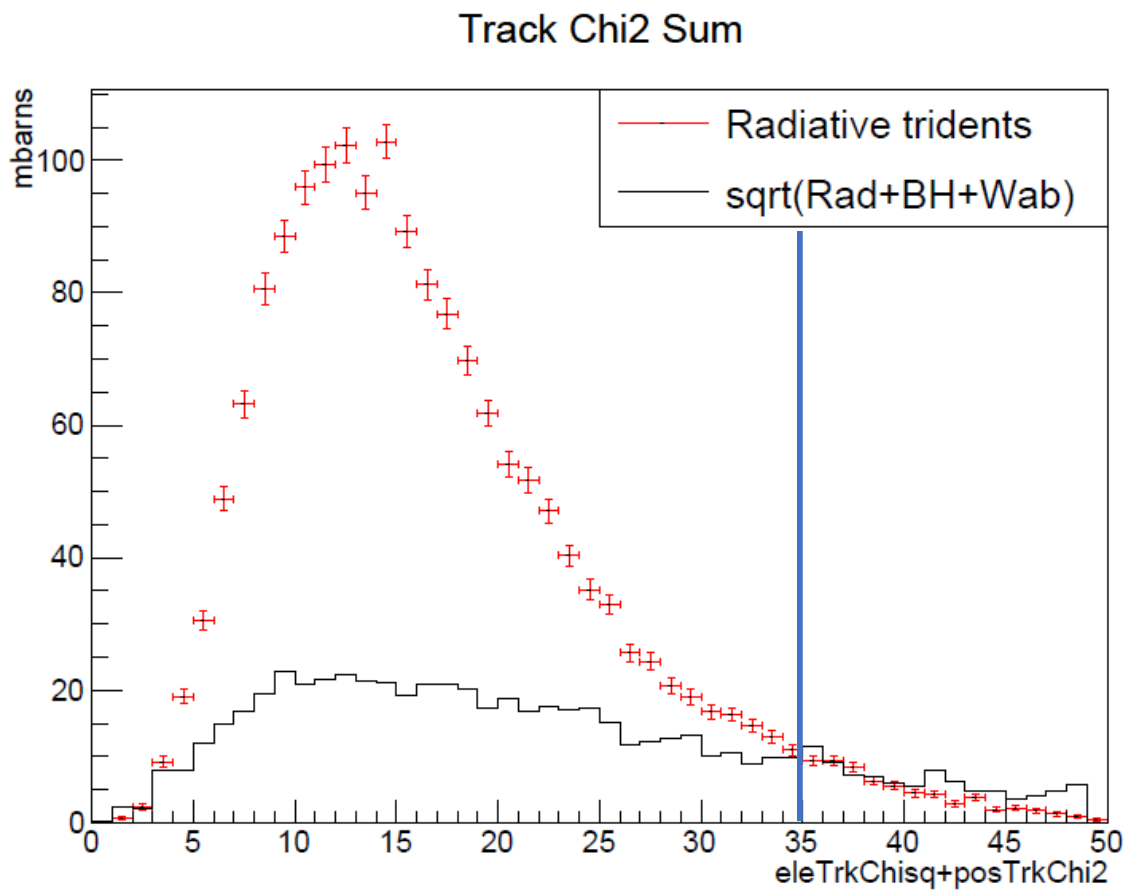
Min. Track Chi2 < 15



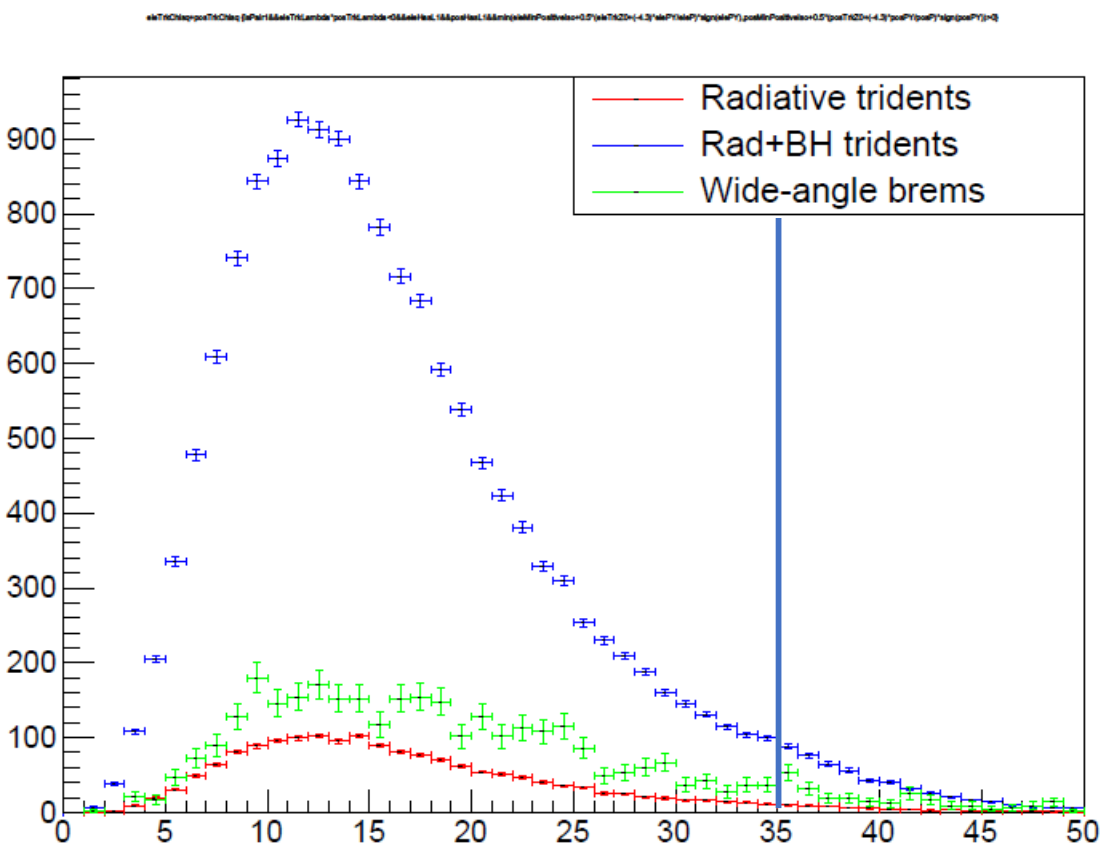


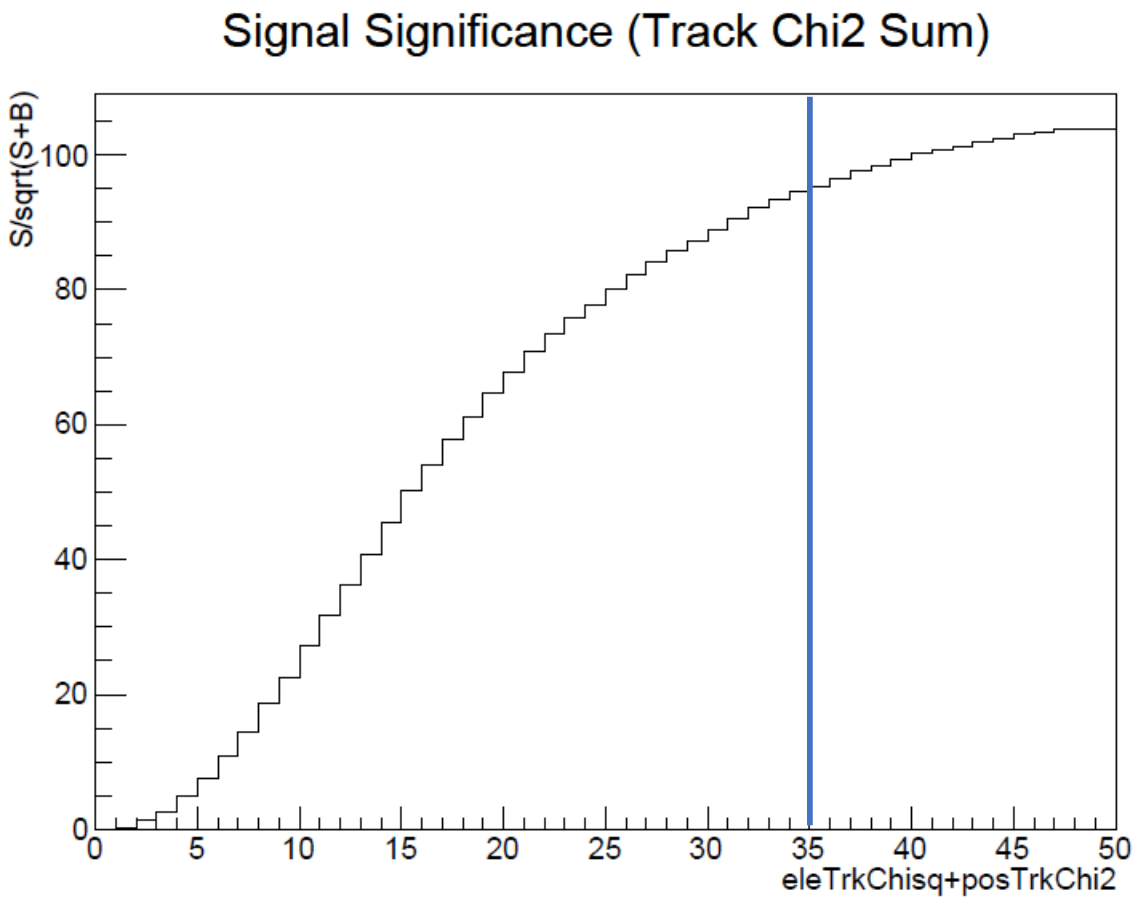
Track Chi2 Sum < 35



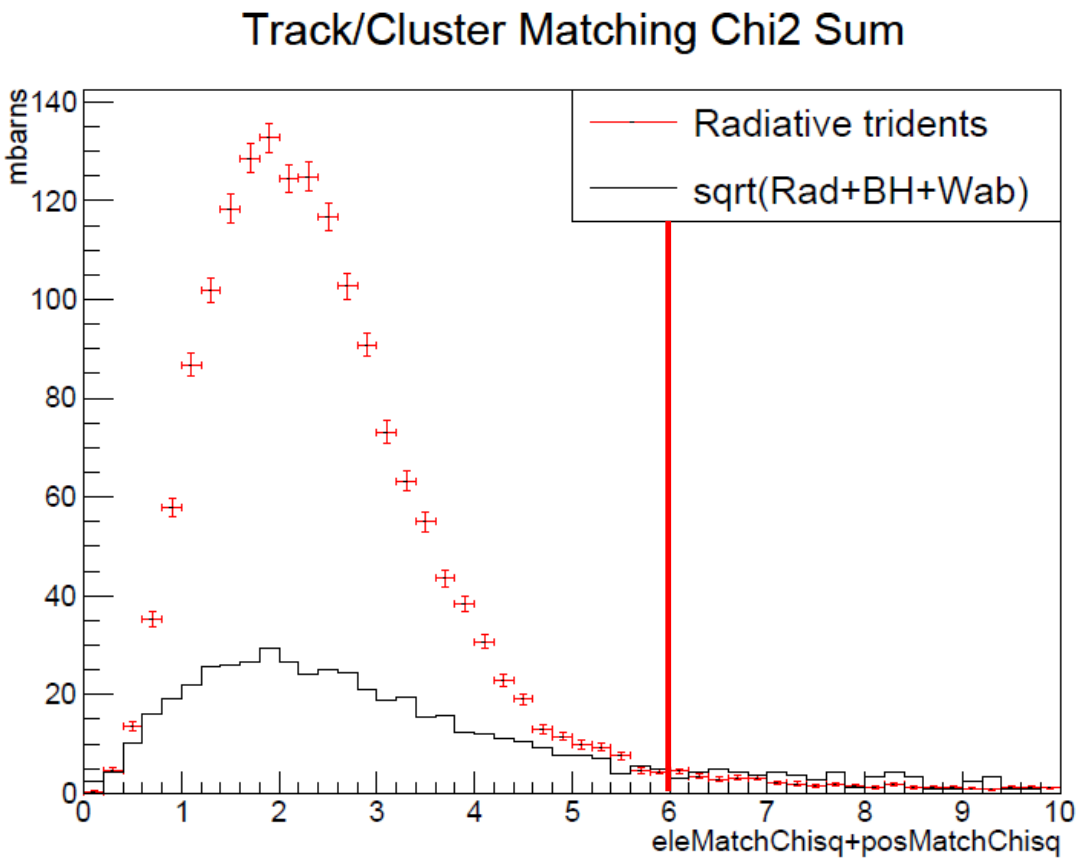


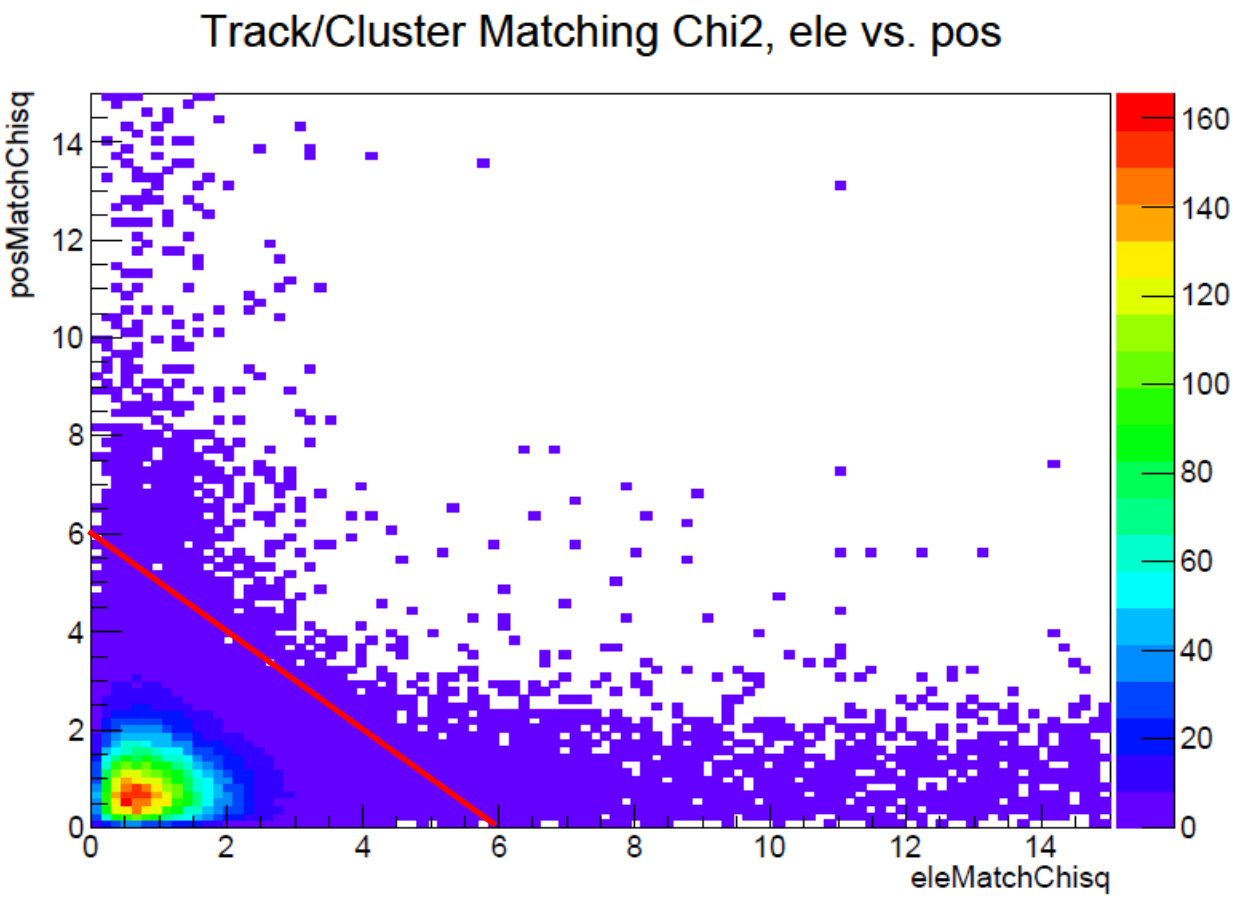
Track Chi2 Sum < 35



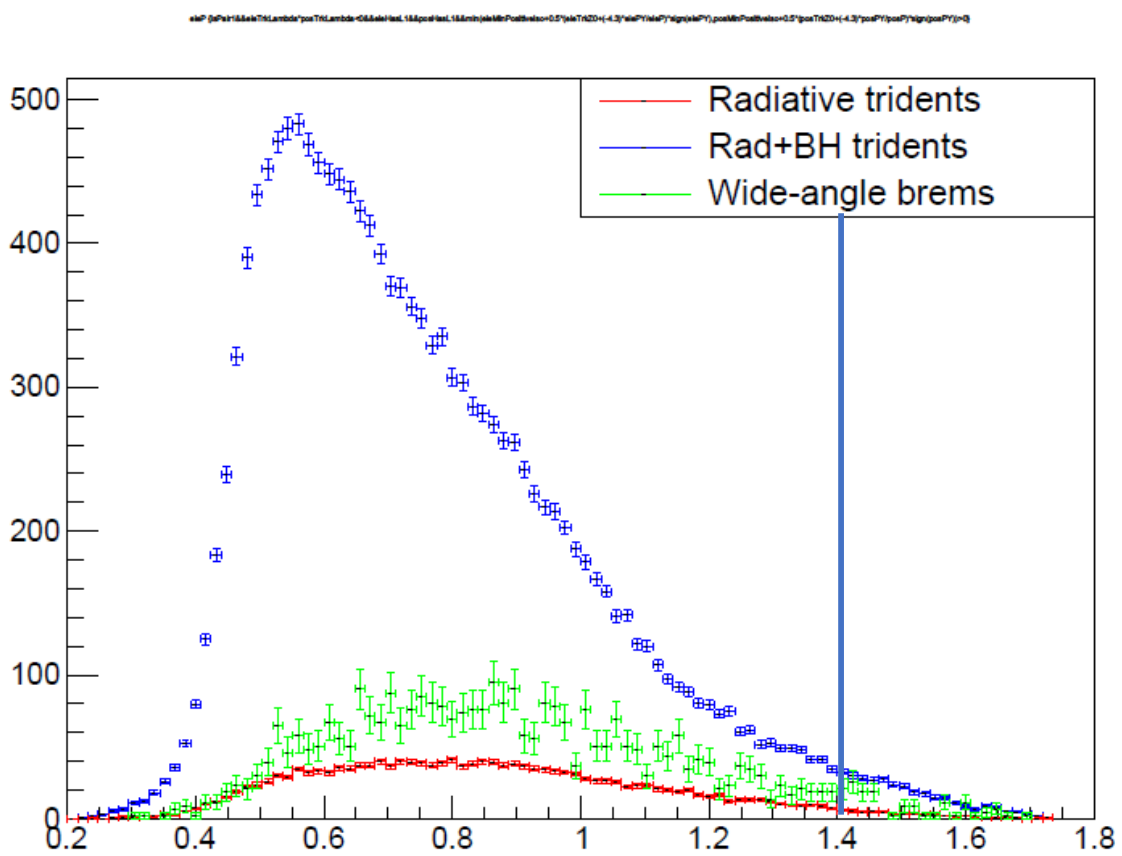


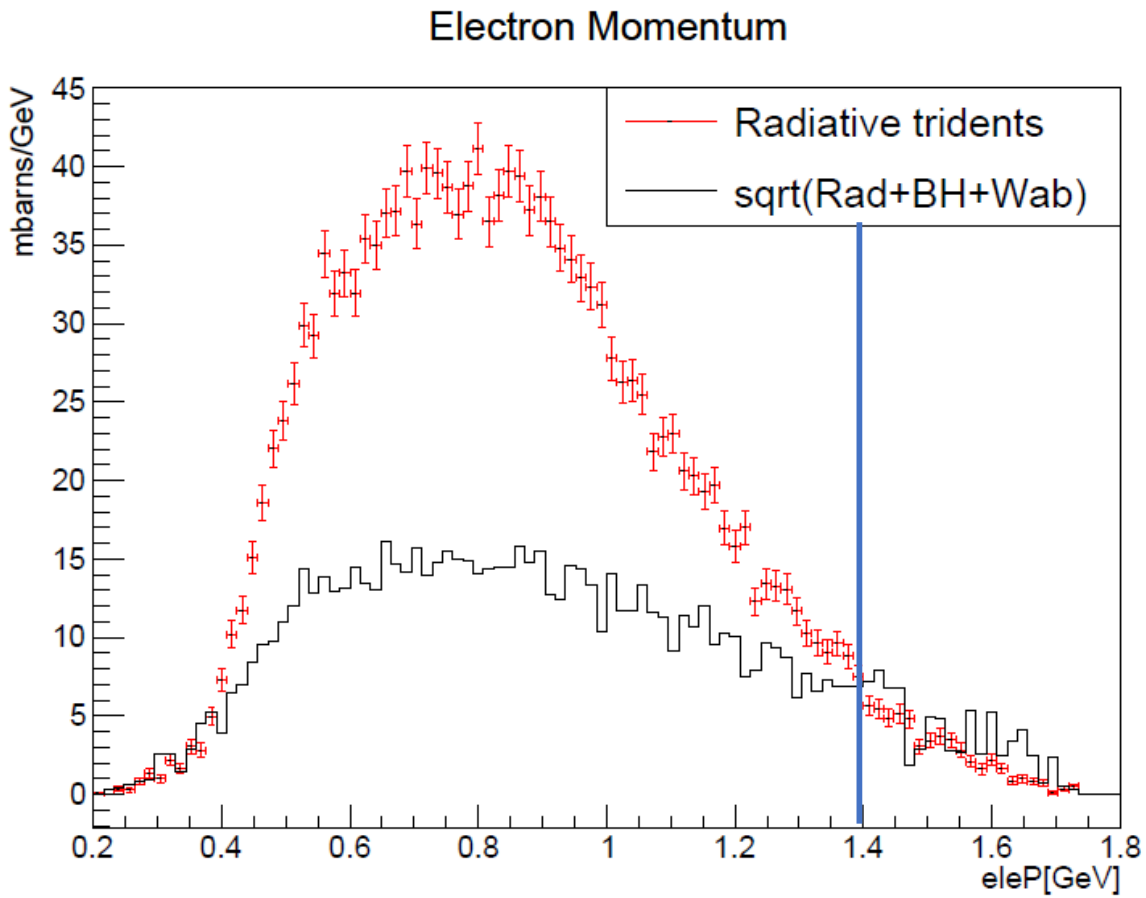
Matching Chi2 (NSigma) Sum < 6 (+ min. Track Chi2 < 3)



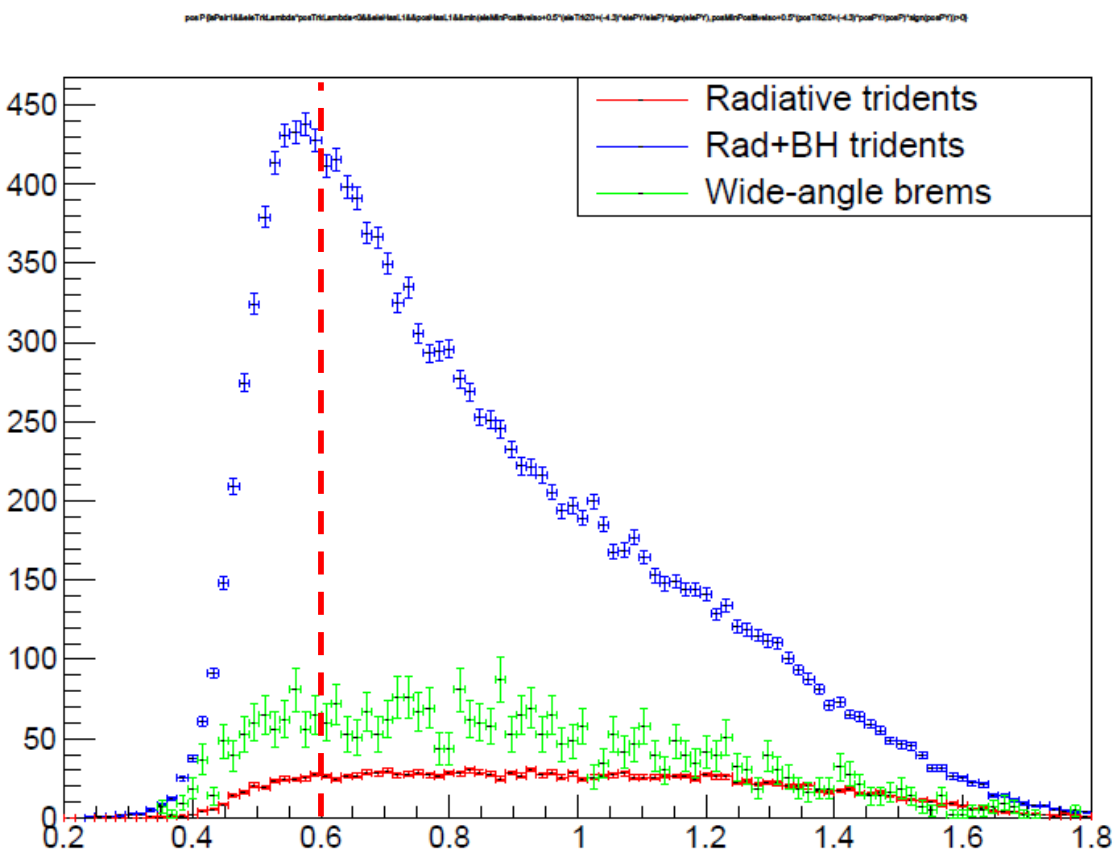


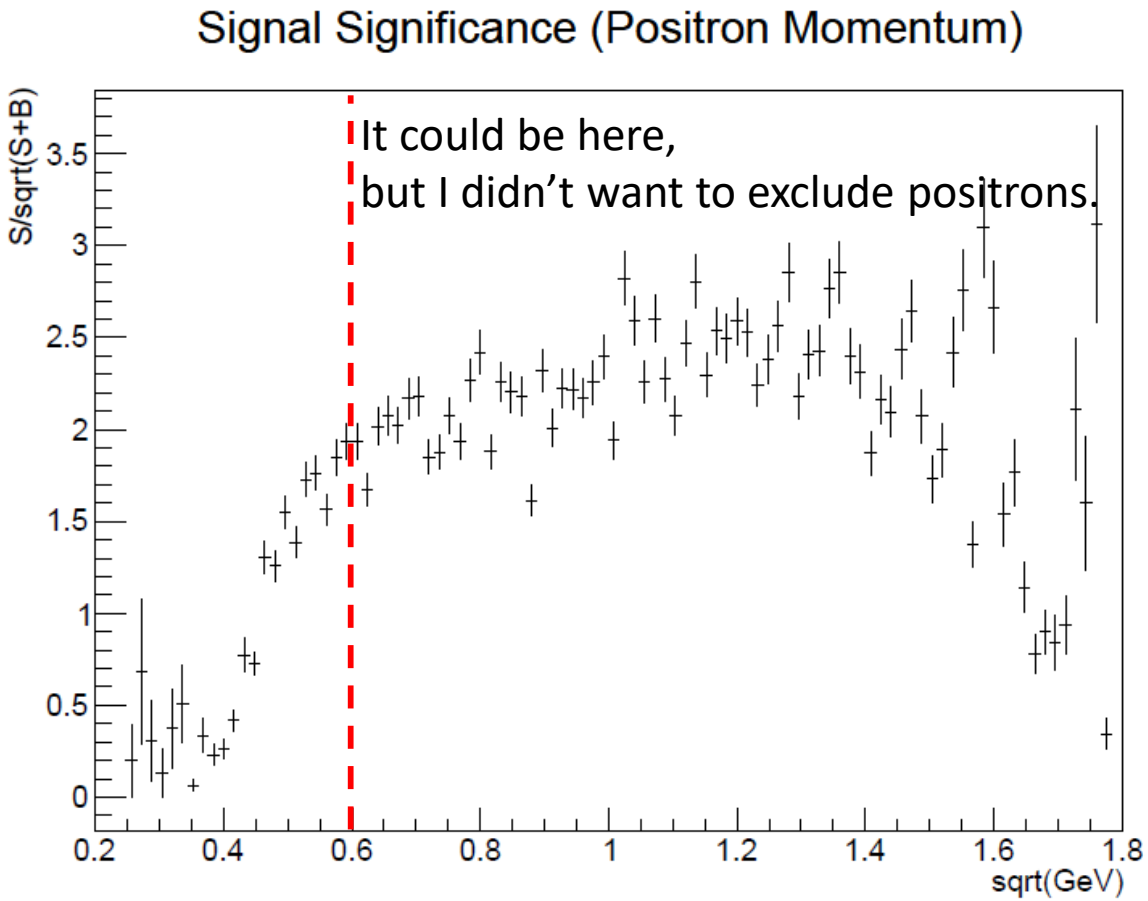
Electron Momentum < 1.4GeV (FEE cut)





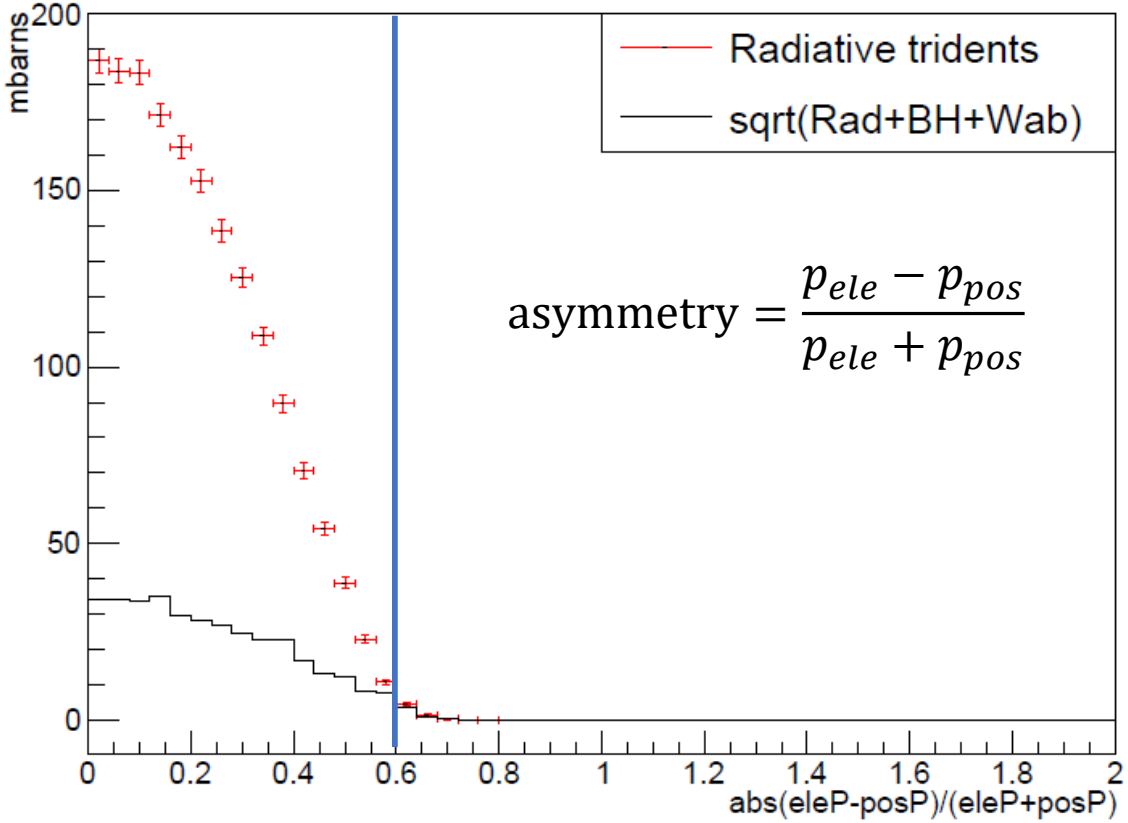
No Positron Momentum Cut





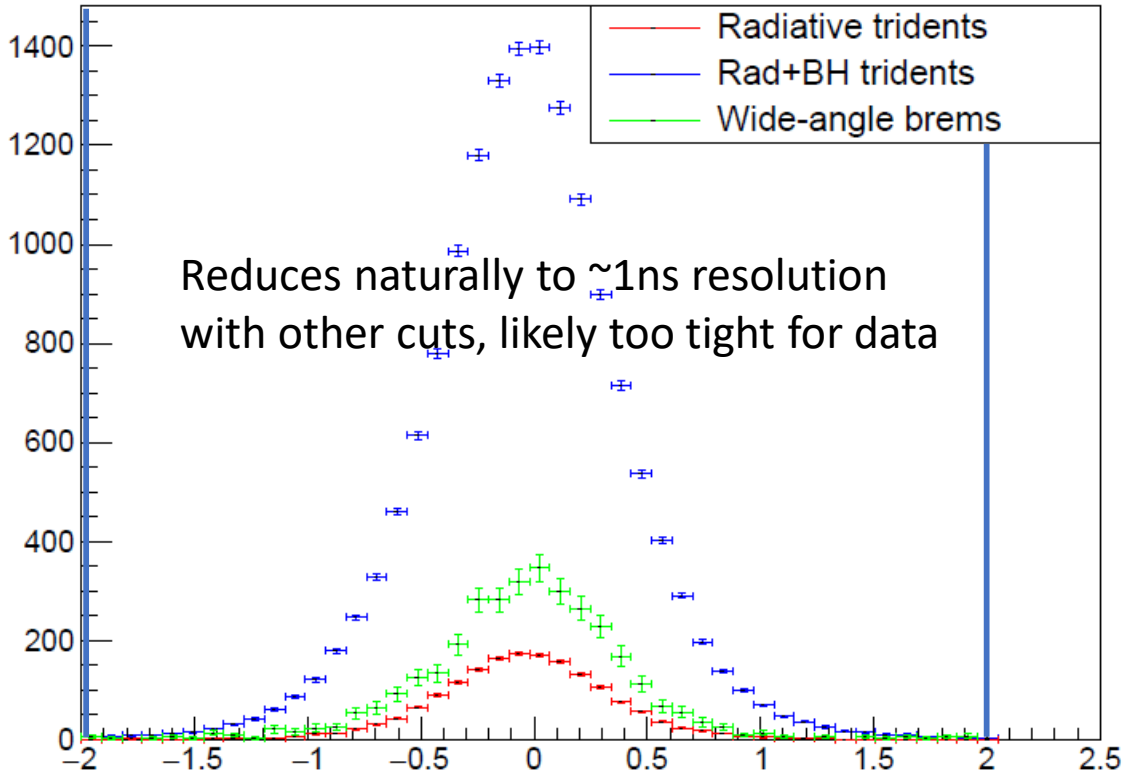
A few more “useless” cuts for MC (to be set using data)

Momentum Asymmetry



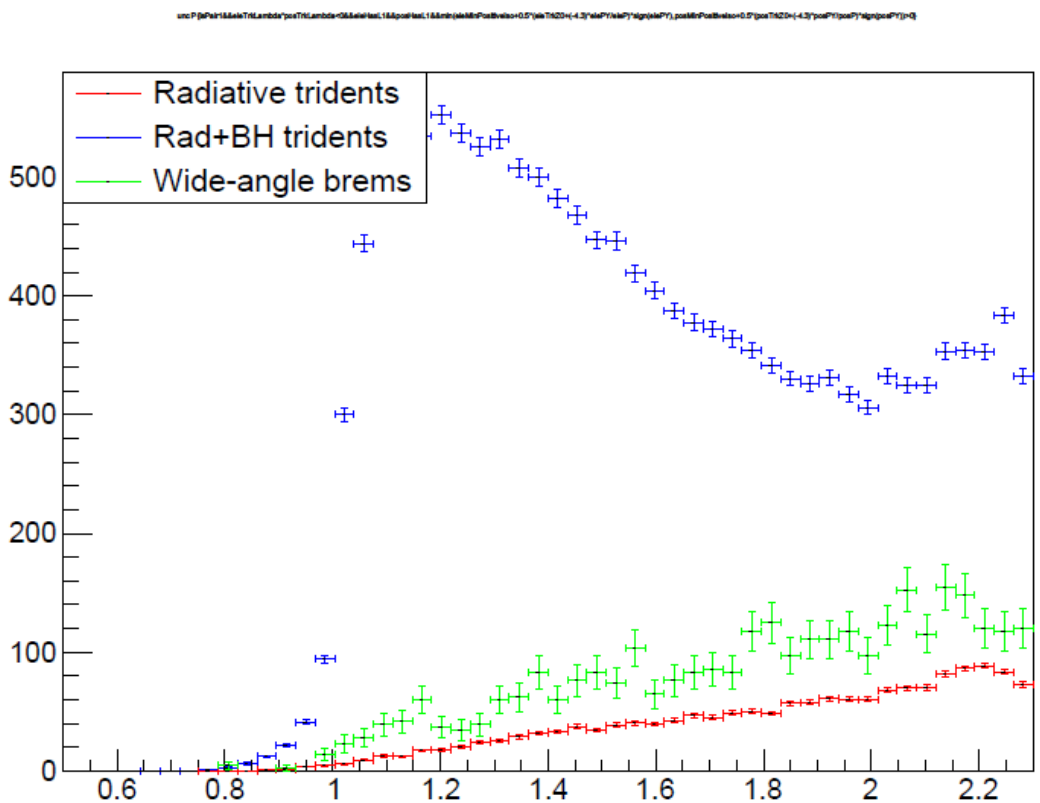
$$\text{asymmetry} = \frac{p_{ele} - p_{pos}}{p_{ele} + p_{pos}}$$

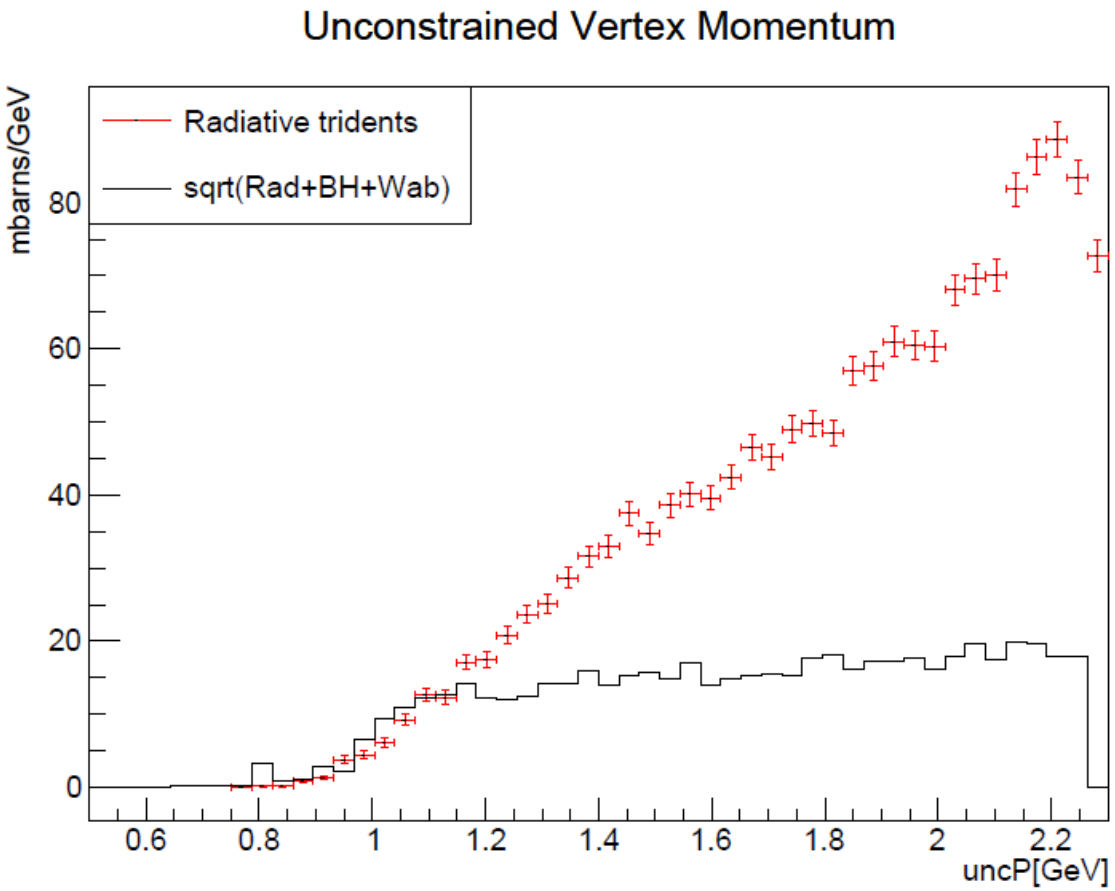
Cluster Coincidence



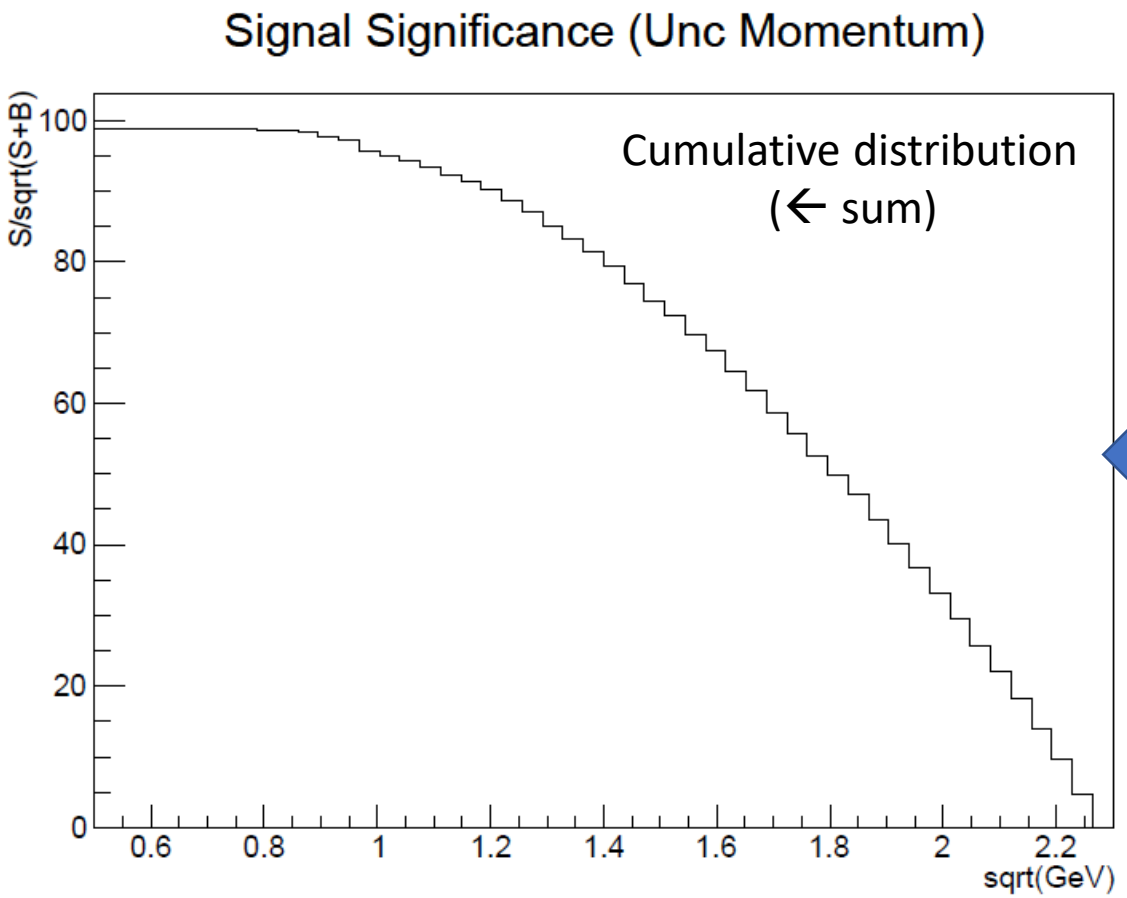
Reduces naturally to ~1ns resolution with other cuts, likely too tight for data

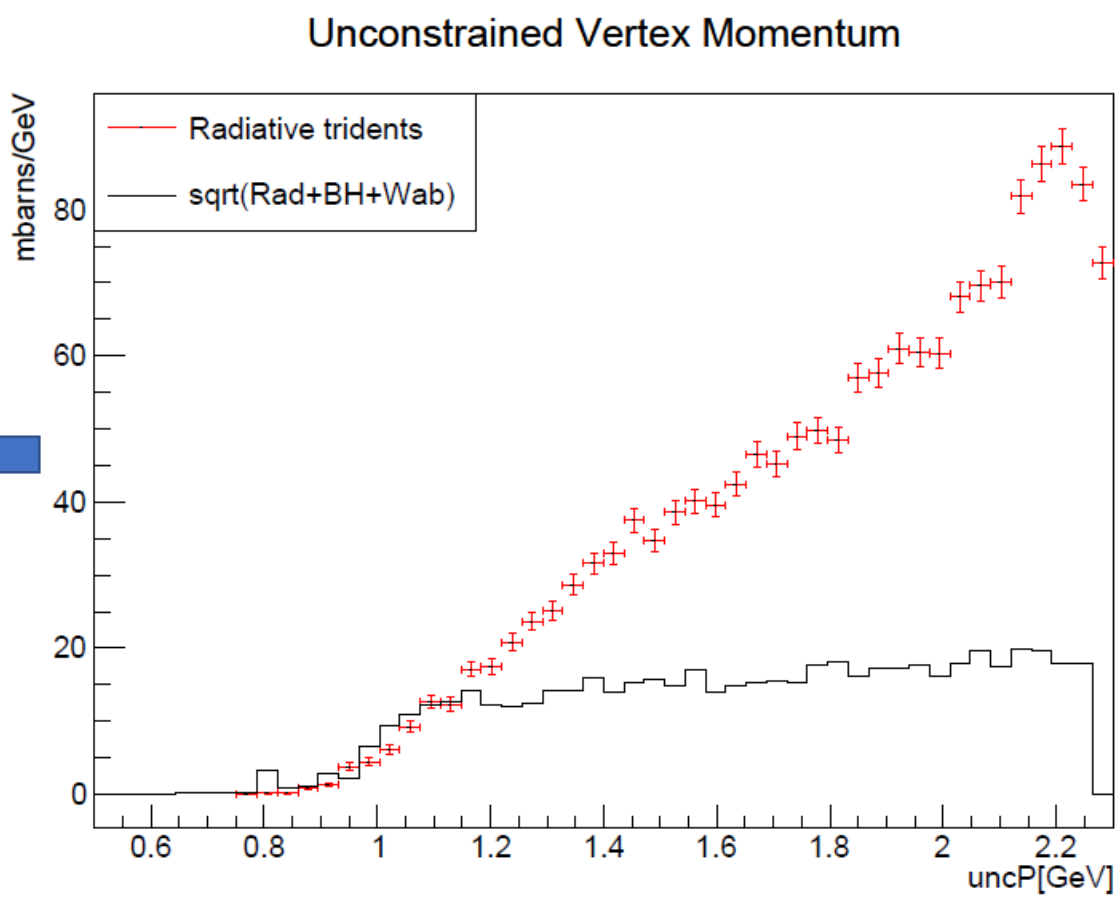
But for the Radiative Cut…



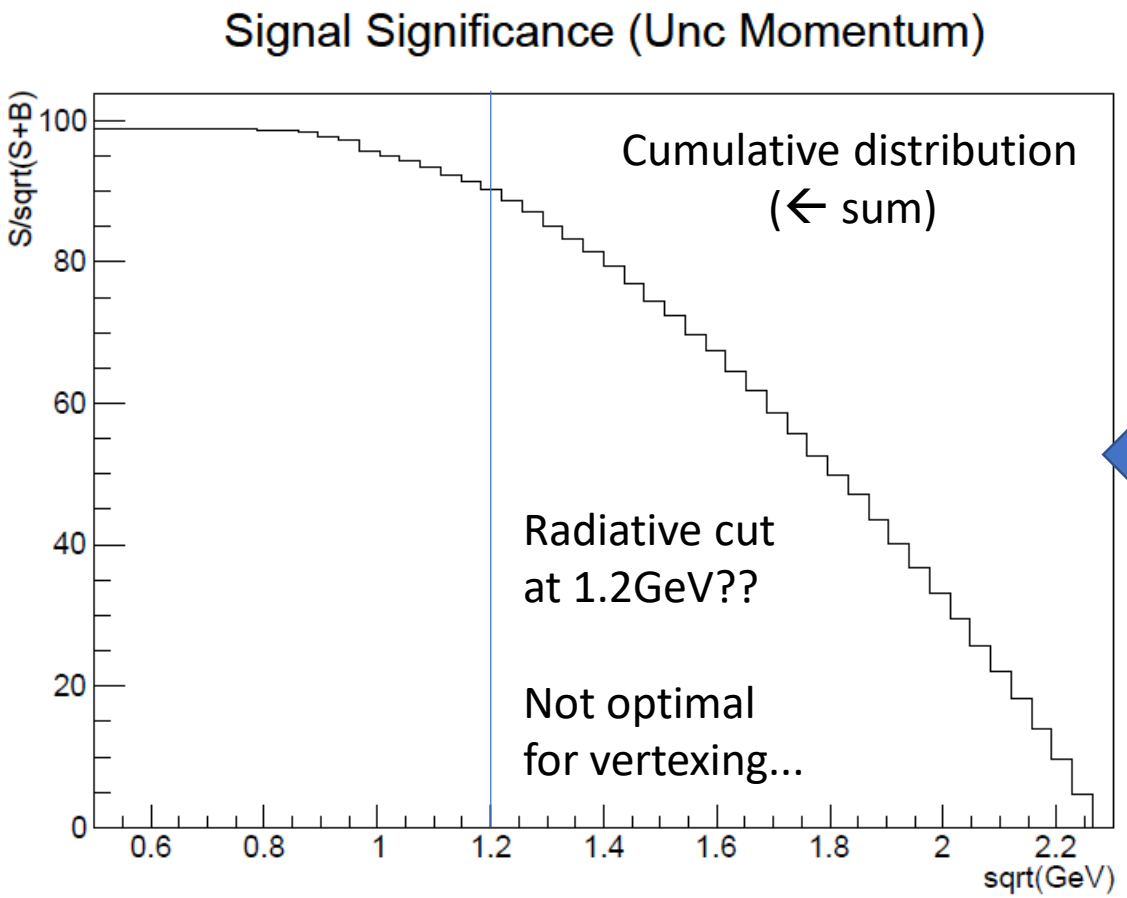


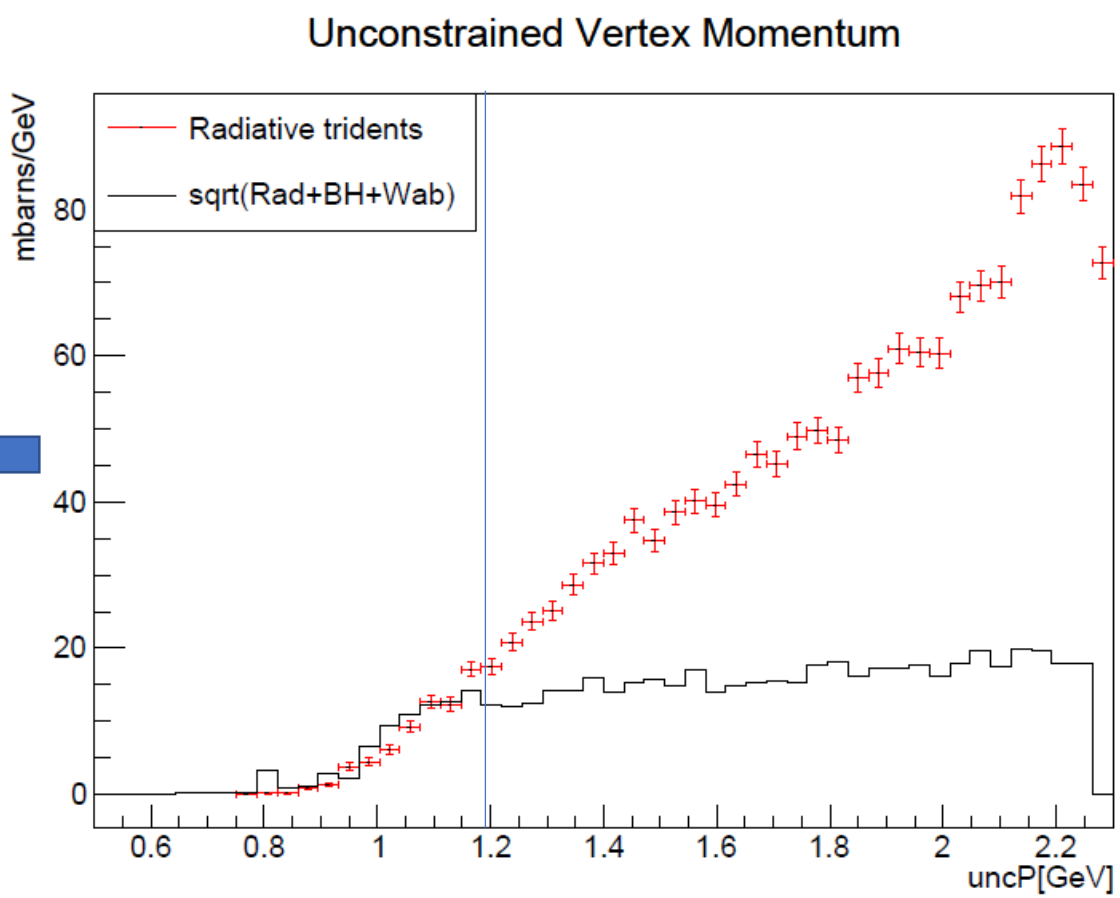
Radiative Cut



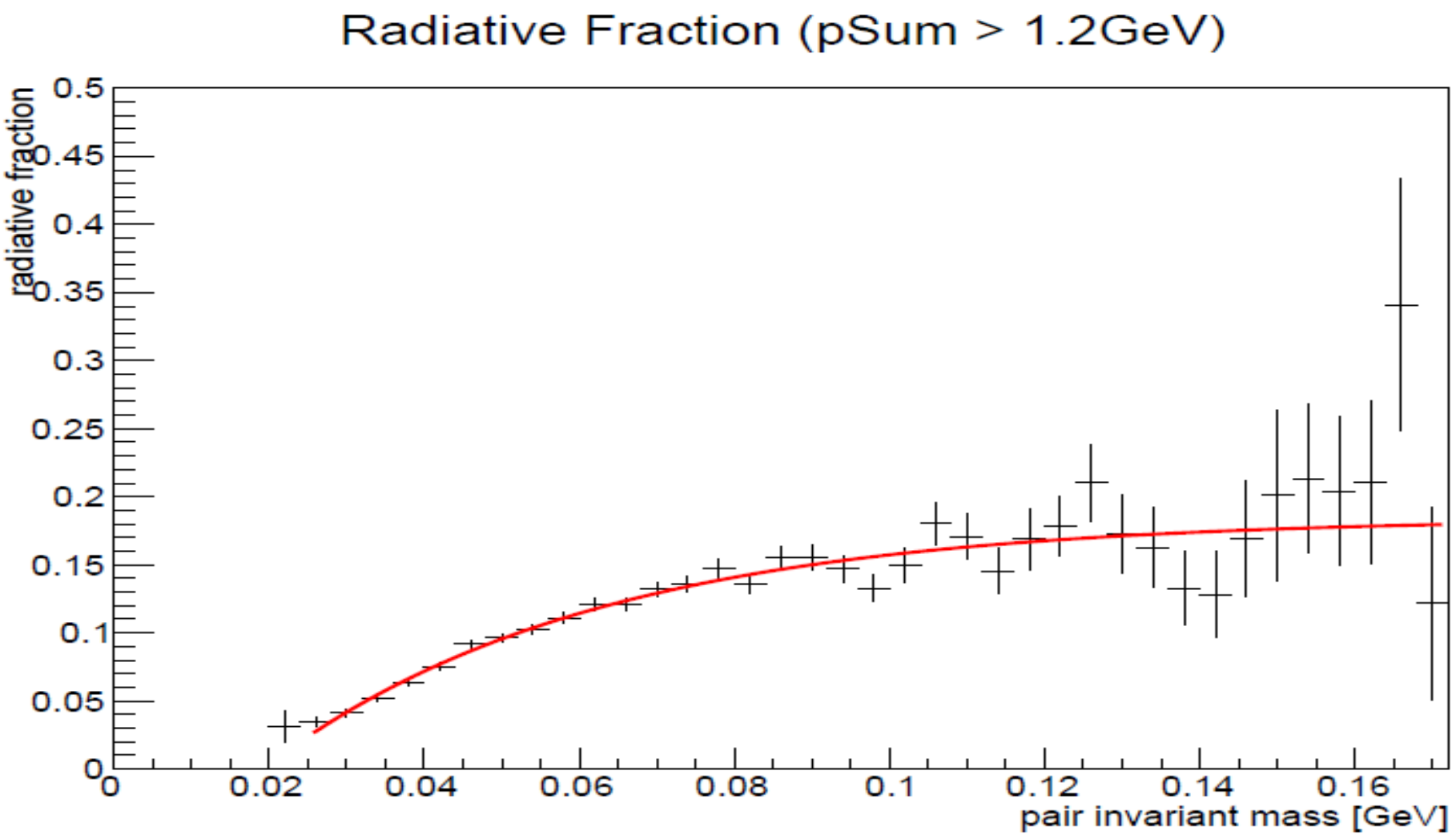


Radiative Cut

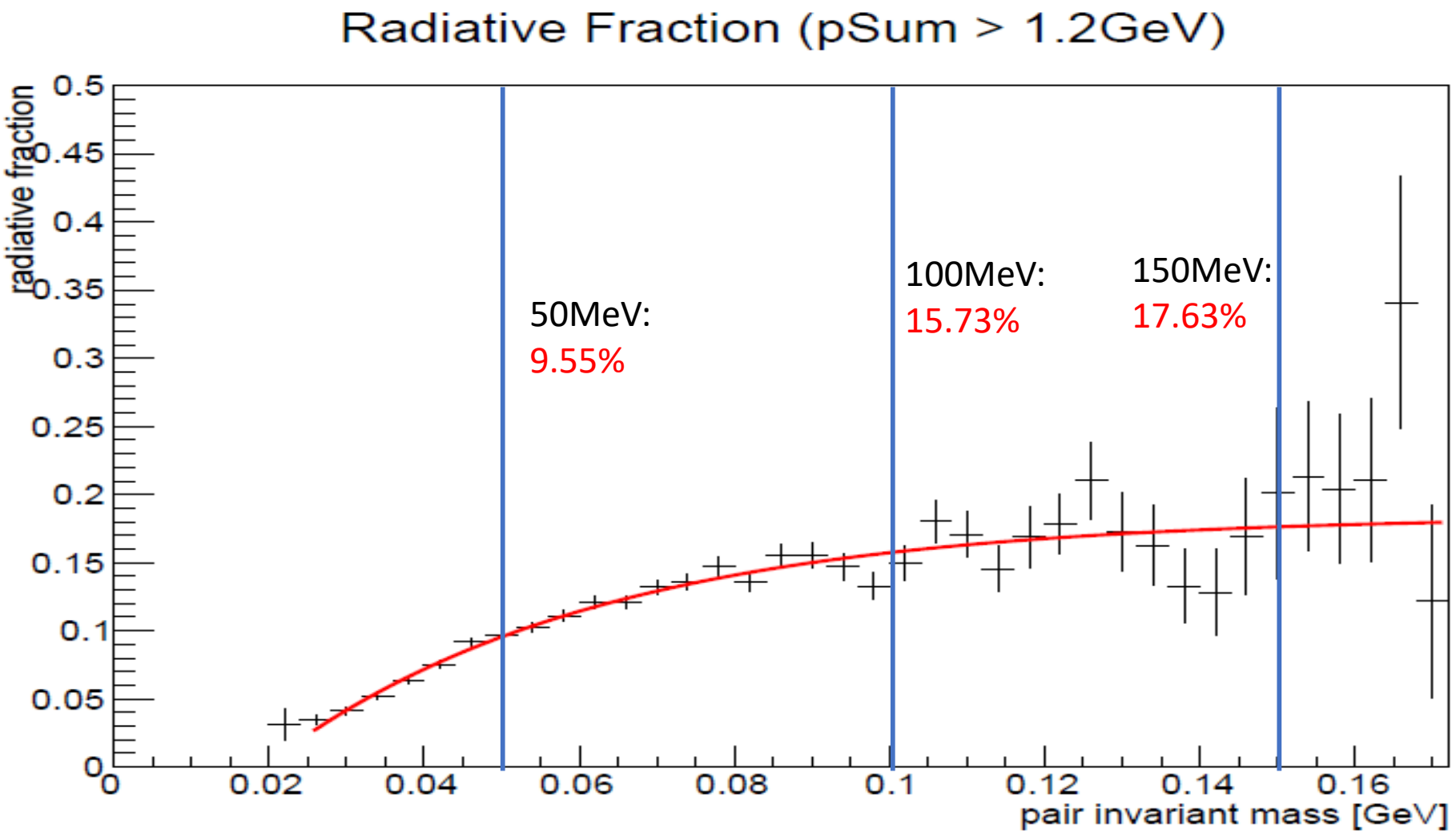




Radiative Fraction, pSum > 1.2GeV (plus all other cuts so far)

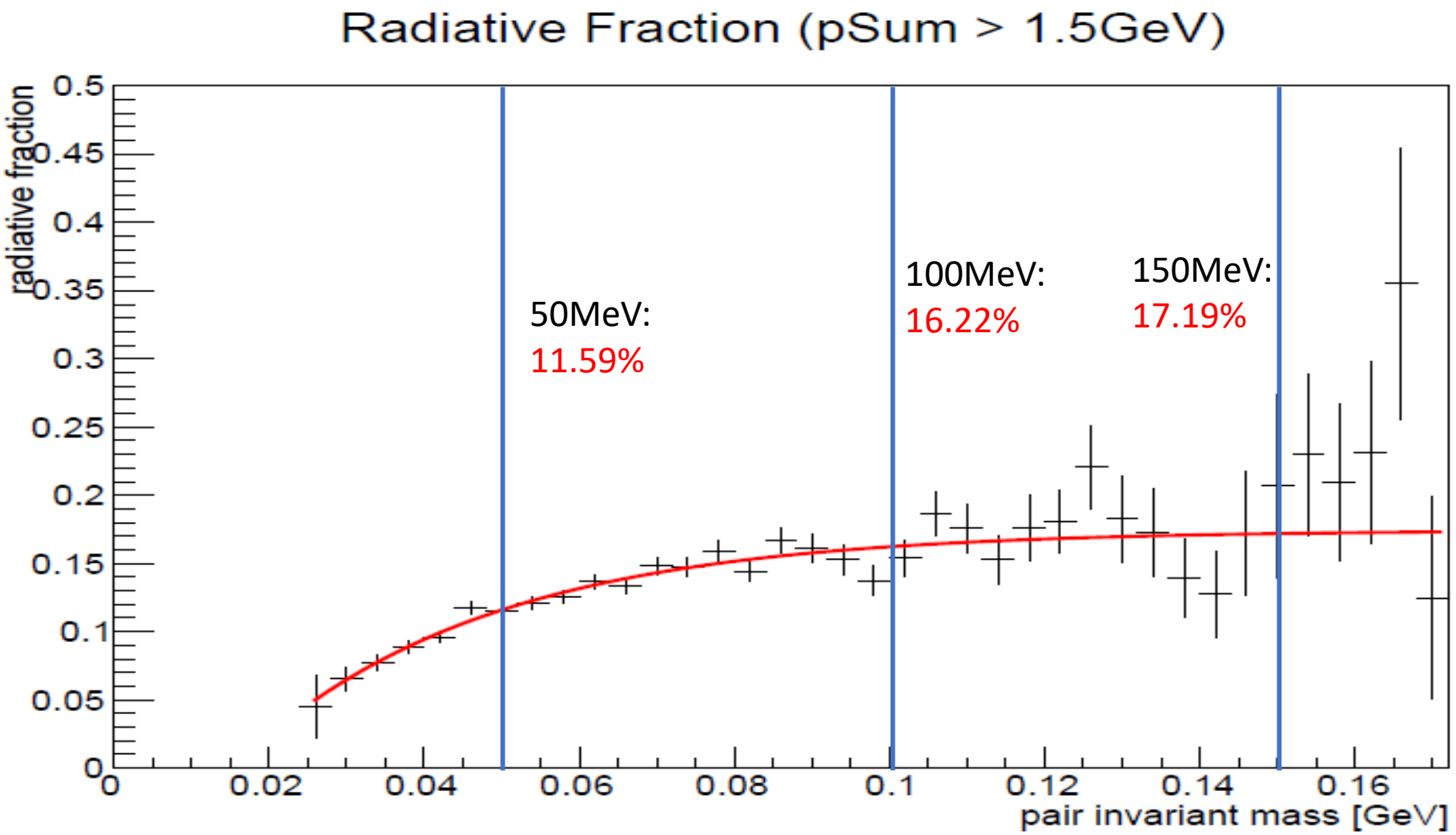


Radiative Fraction, pSum > 1.2GeV (plus all other cuts so far)

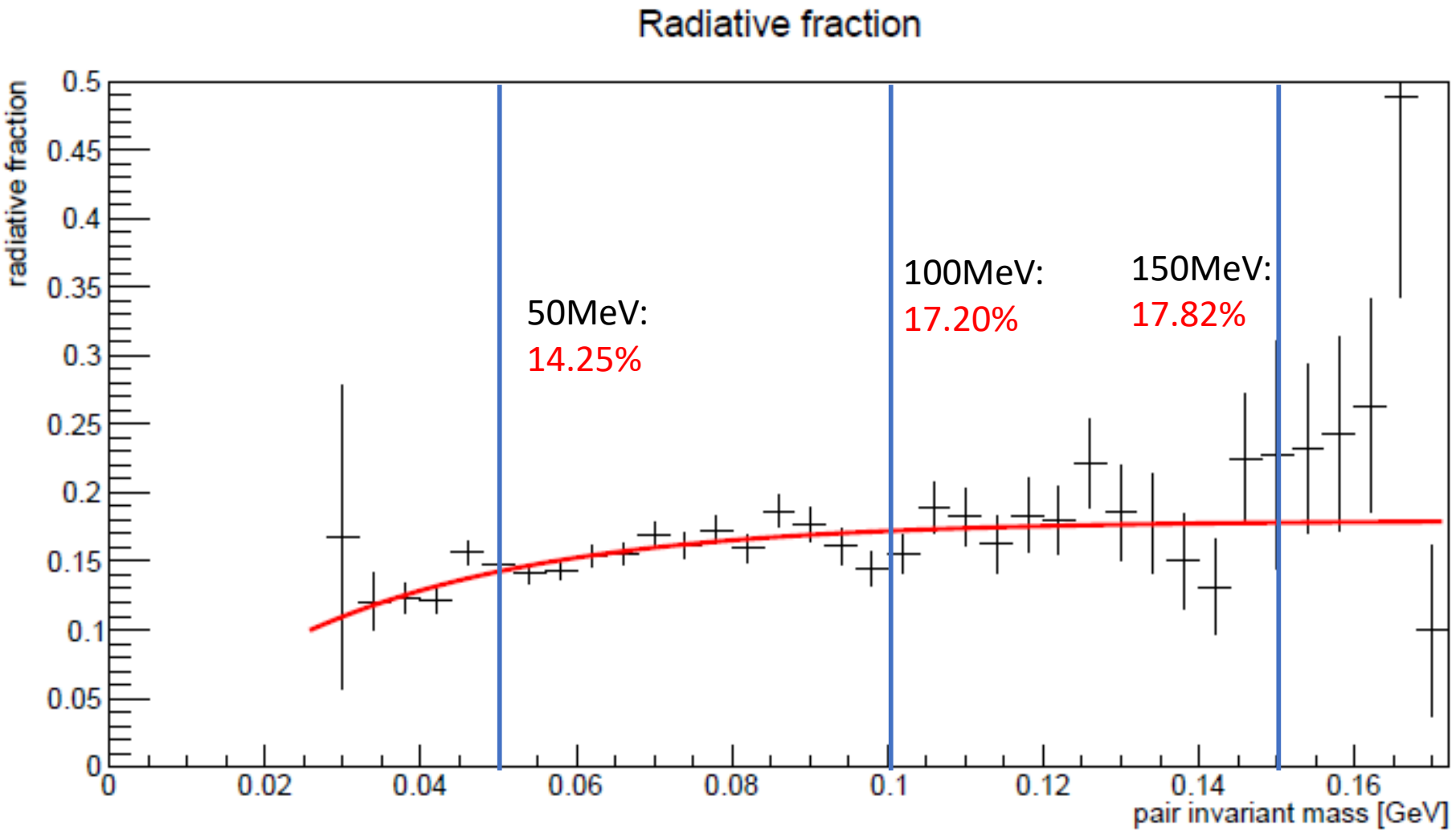


Radiative Fraction, pSum > 1.5GeV (plus all other cuts so far)

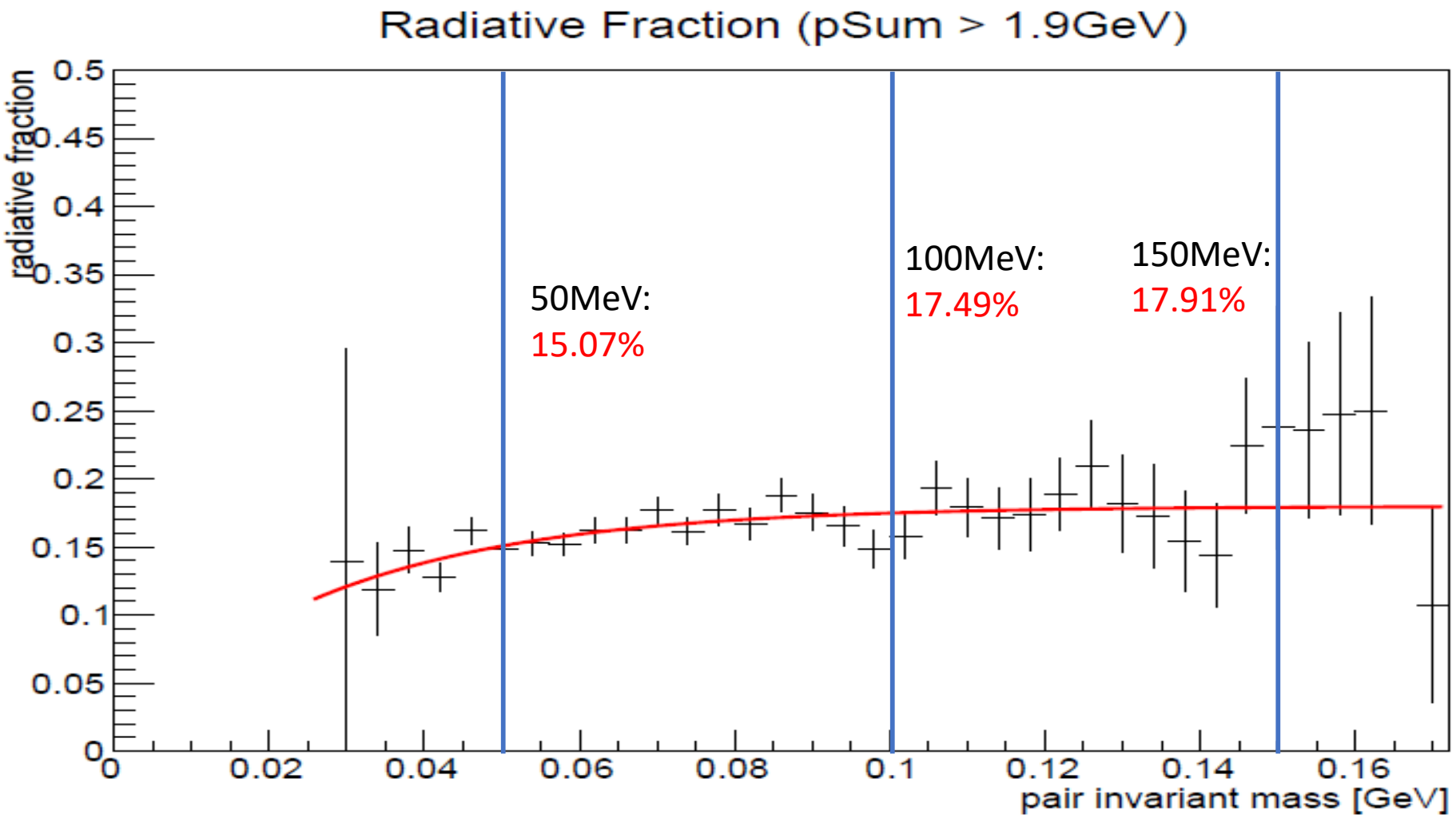
~Sebouh's Bump hunt



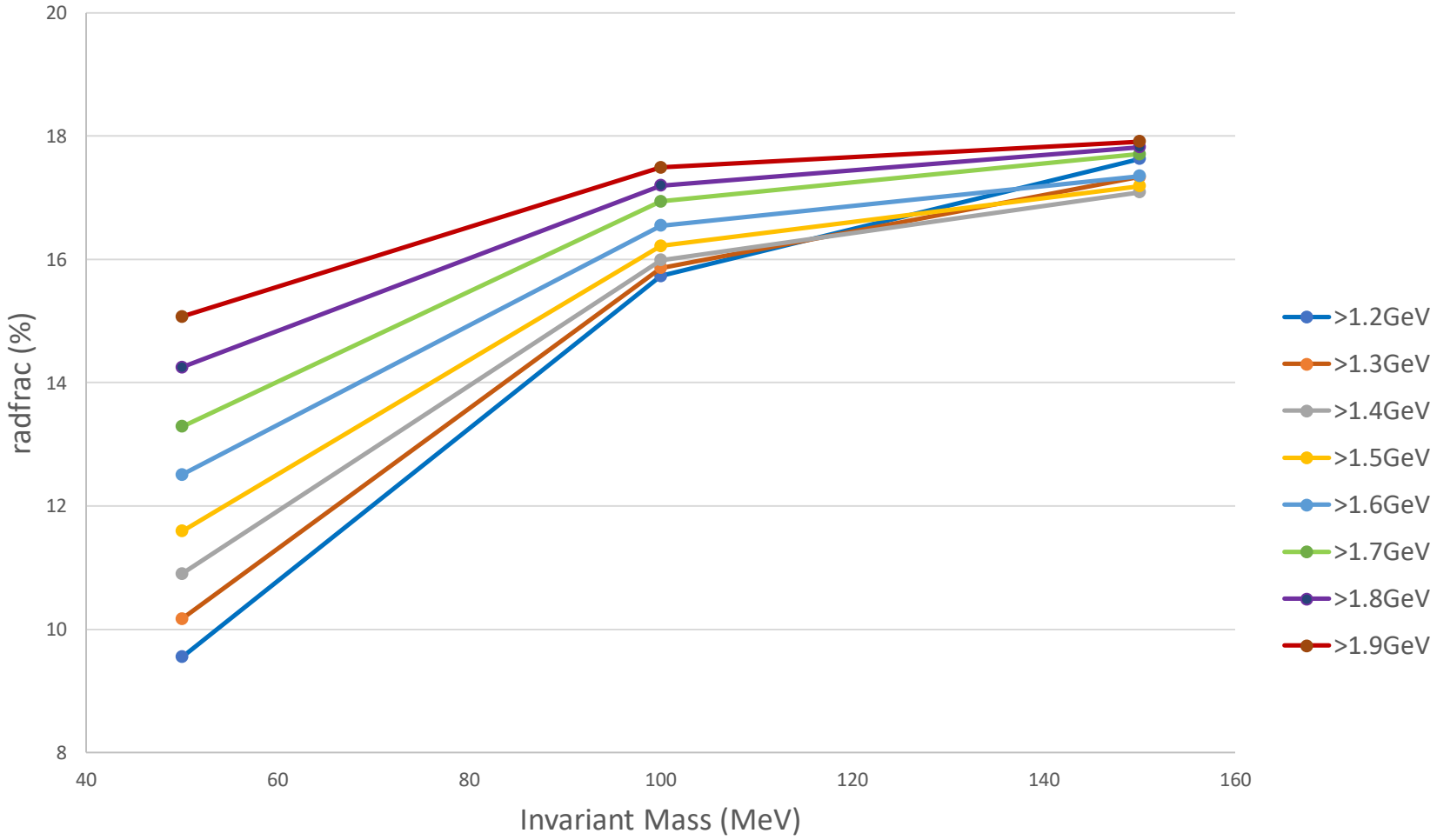
Radiative Fraction, pSum > 1.8GeV (plus all other cuts so far)



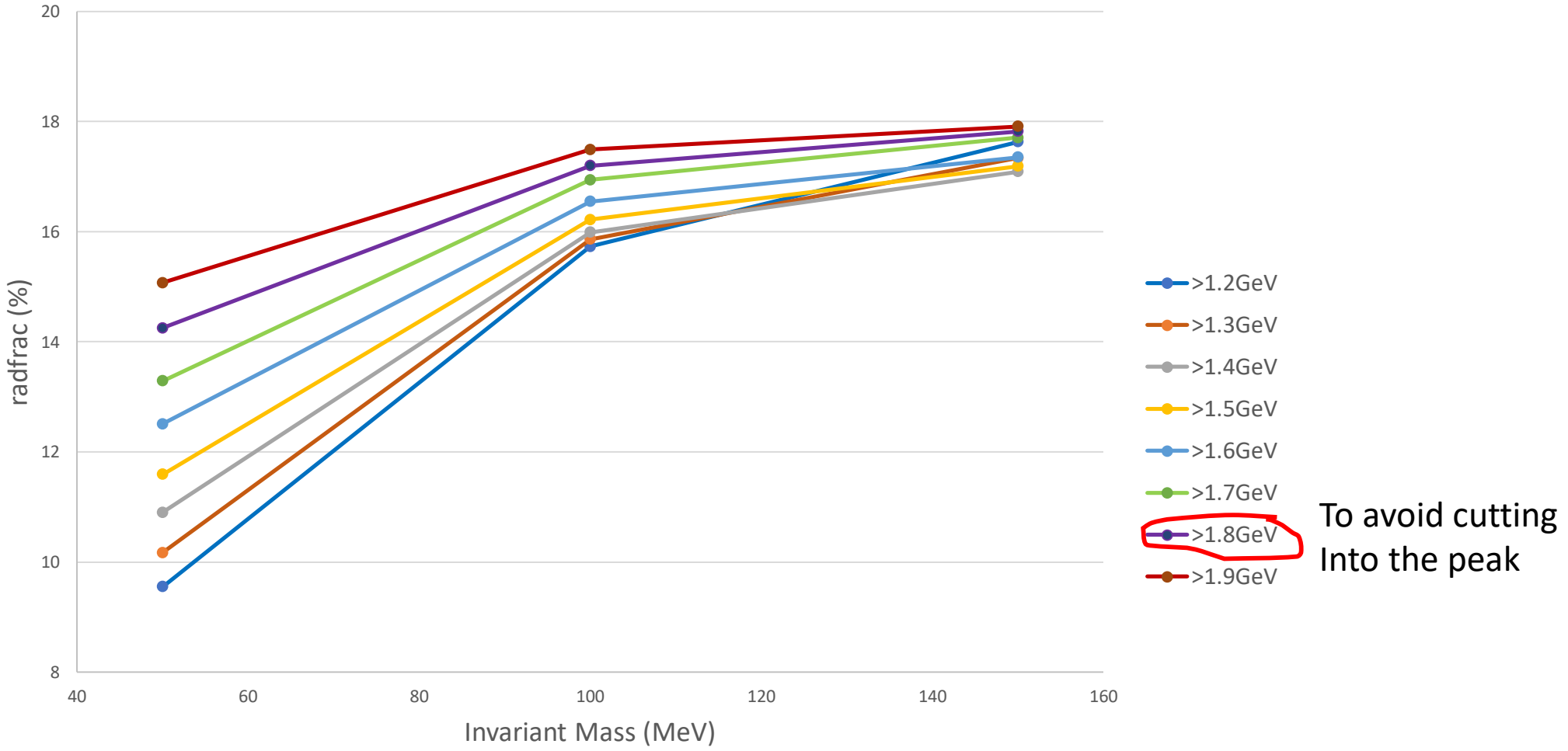
Radiative Fraction, pSum > 1.9GeV (plus all other cuts so far)



Radiative Fraction vs. Radiative Cut



Radiative Fraction vs. Radiative Cut



Vertexing Cut Summary (pairs1)

- **Opposite volumes:** $tan\lambda_1 * tan\lambda_2 < 0$
- **Isolation Cut:** $\min\{ Iso_{el} + 0.5 * (z_{tar}) * sign(p_{y,el}), Iso_{pos} + 0.5 * (z_{tar}) * sign(p_{y,pos}) \} > 0$
- **Elastics/FEE:** $p_{\mathrm{el}} < 1.4GeV$
- **Radiative Cut:** $p_{\mathrm{unc}} > 1.8GeV$
- **Cluster Coincidence:** $| t_{clust1} - t_{clust2} | < 2ns$

-4.3mm

TBD from data

Chi^2 cuts:

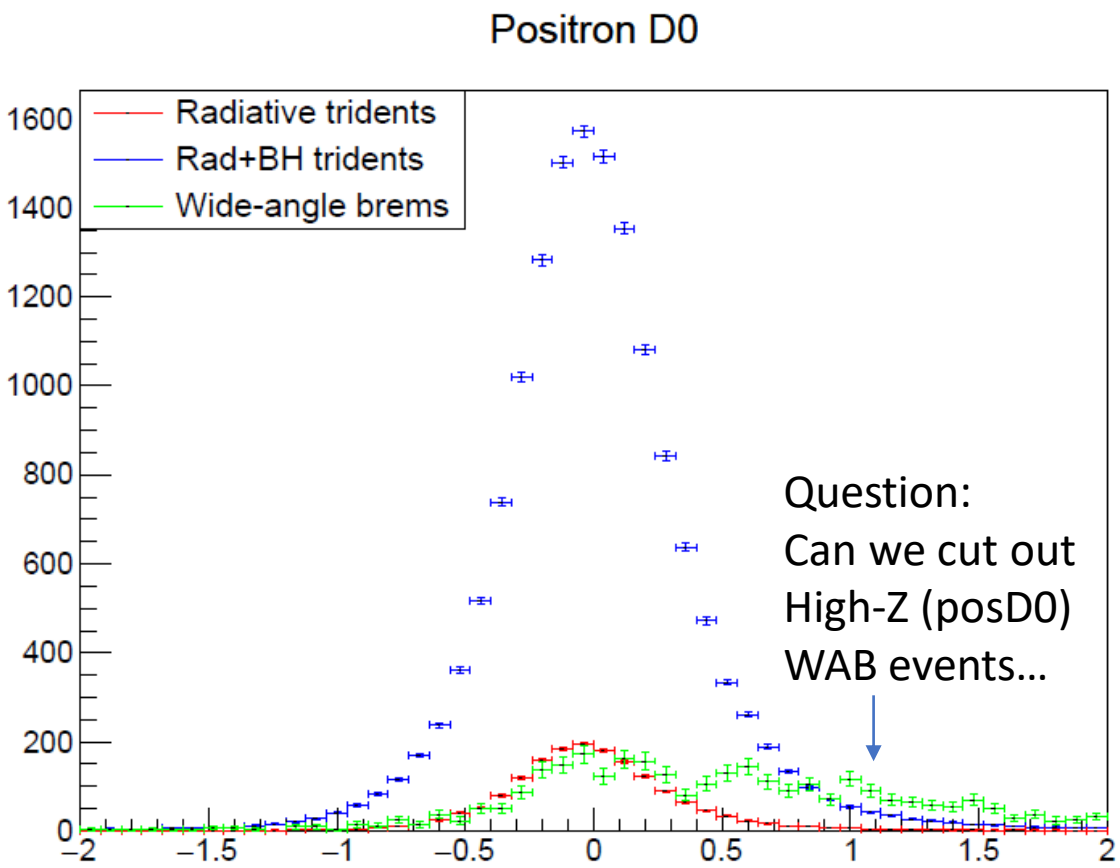
- $min(\chi^2_{track,\,el}, \chi^2_{track,\,pos}) < 15$
- $\chi^2_{track,\,el} + \chi^2_{track,\,pos} < 35$
- $min(\chi^2_{match,\,el}, \chi^2_{match,\,pos}) < 3$
- $\chi^2_{match,\,el} + \chi^2_{match,\,pos} < 6$

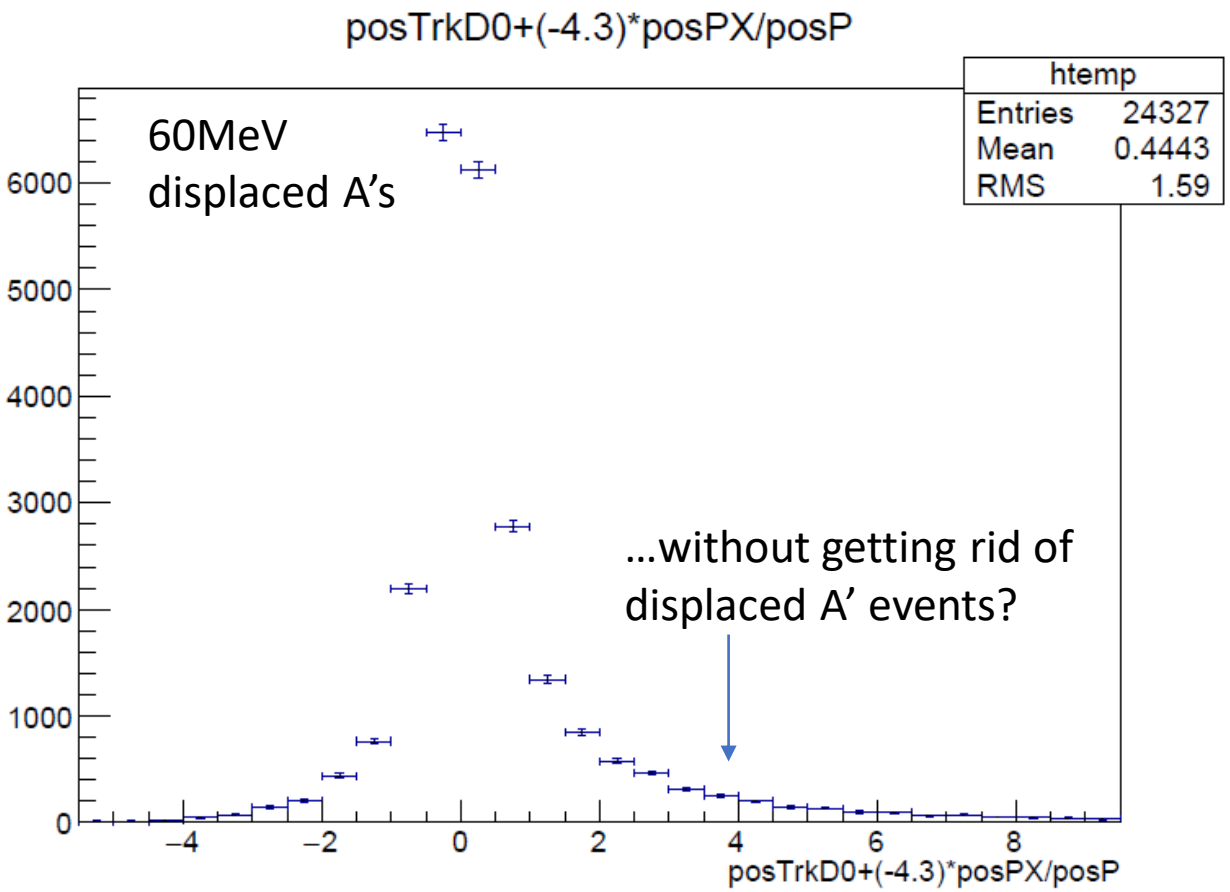
Wab rejection:

- **L1/L1:** Pair1, eleHasL1, posHasL1 &&L2L2
- **Momentum Asymmetry:** $|p_{el} - p_{pos}|/(p_{el} + p_{pos}) < 0.6$ ← Not really needed for MC, may be useful for data
- ~~**Positron D0:** $d_{0,pos} + (-4.3mm) * posPX/posP < 0.8mm$~~
- **Positron target-constrained X-Tilt difference cut** *New*

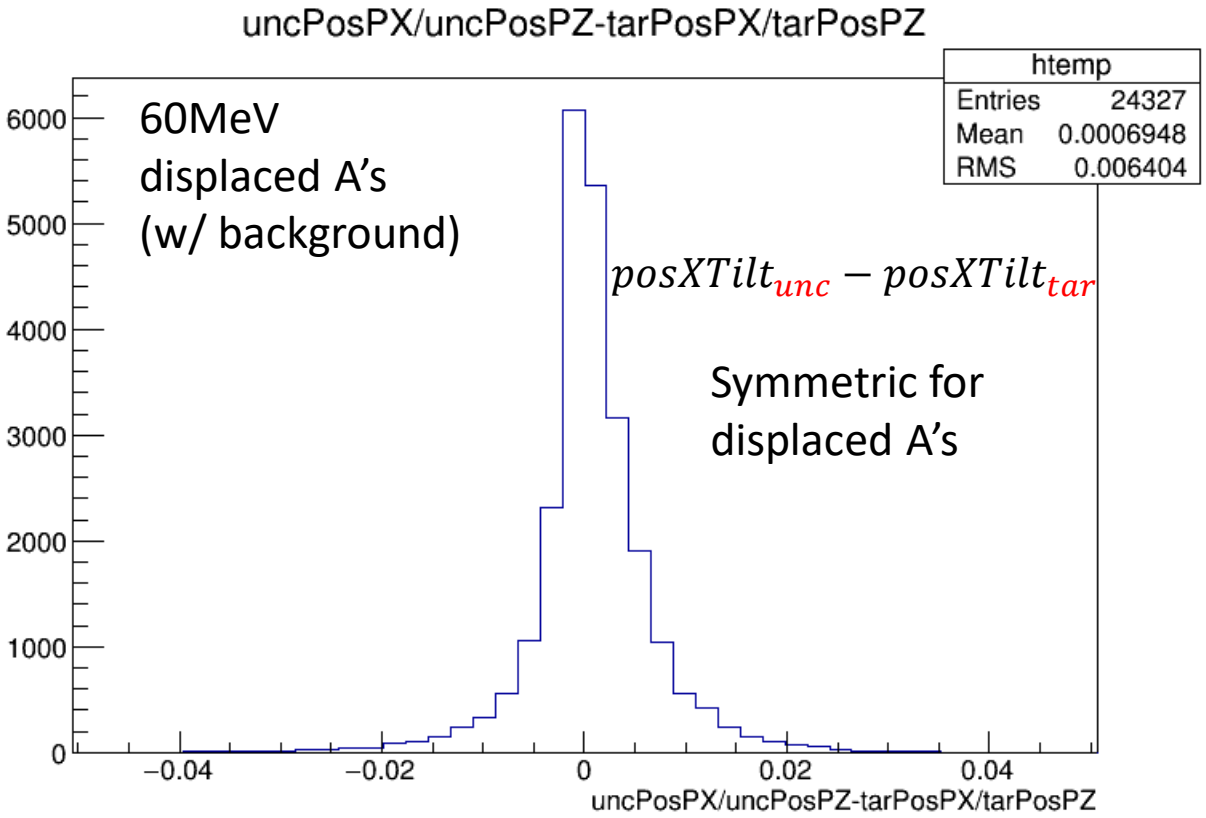
Also cuts displaced A's,
an alternative is needed

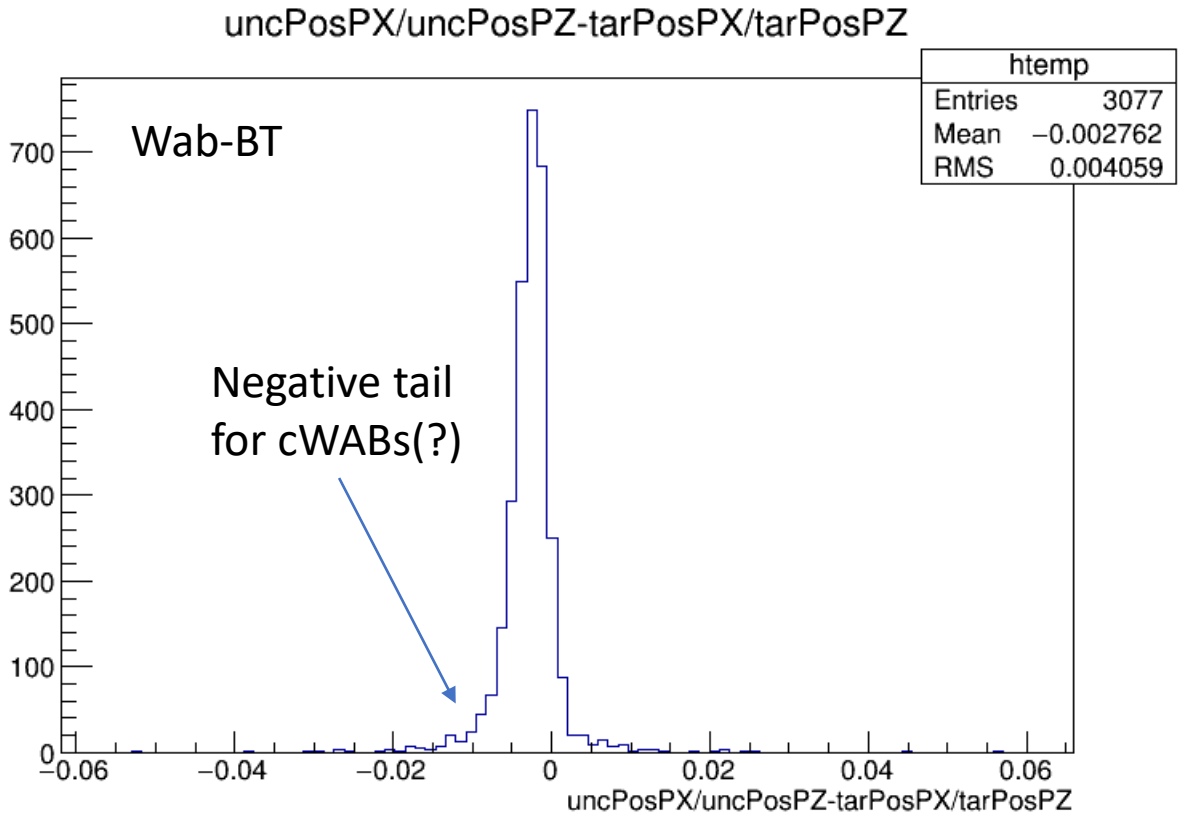
Replacement for the positron D0 cut?



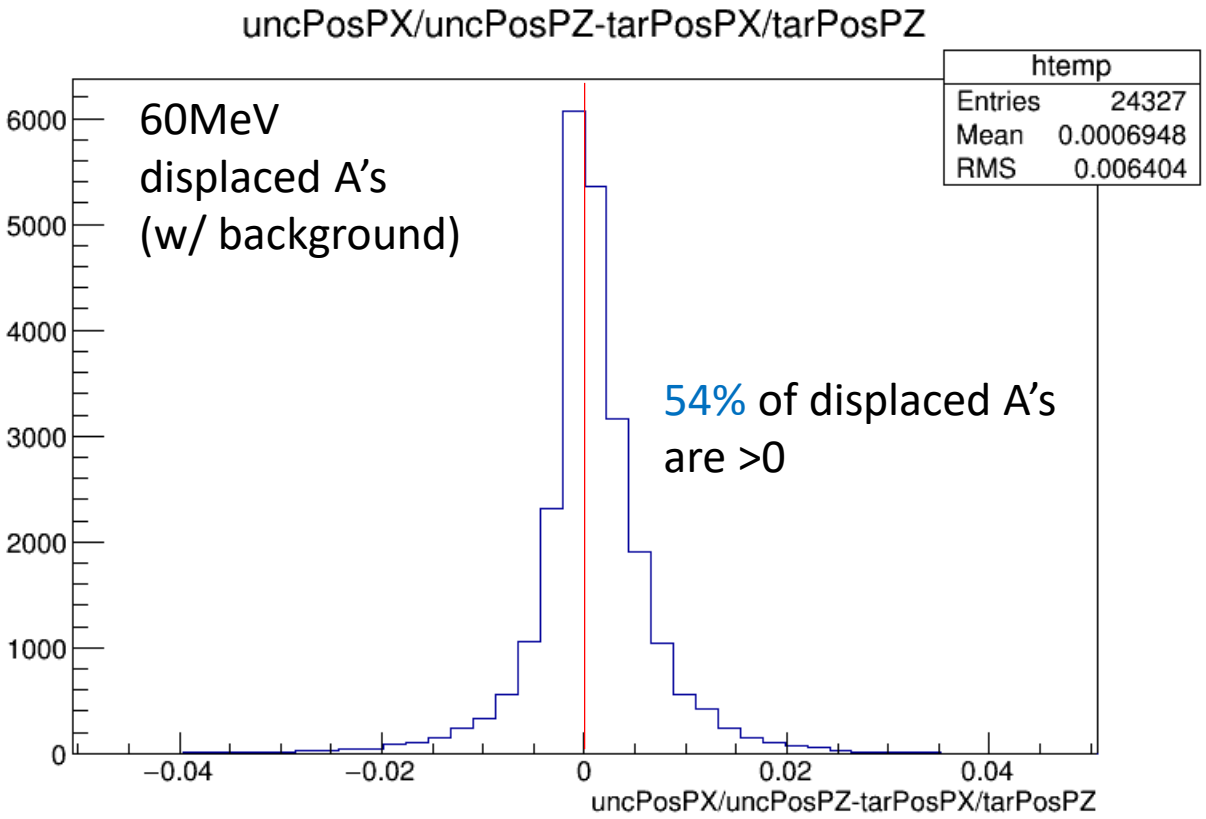


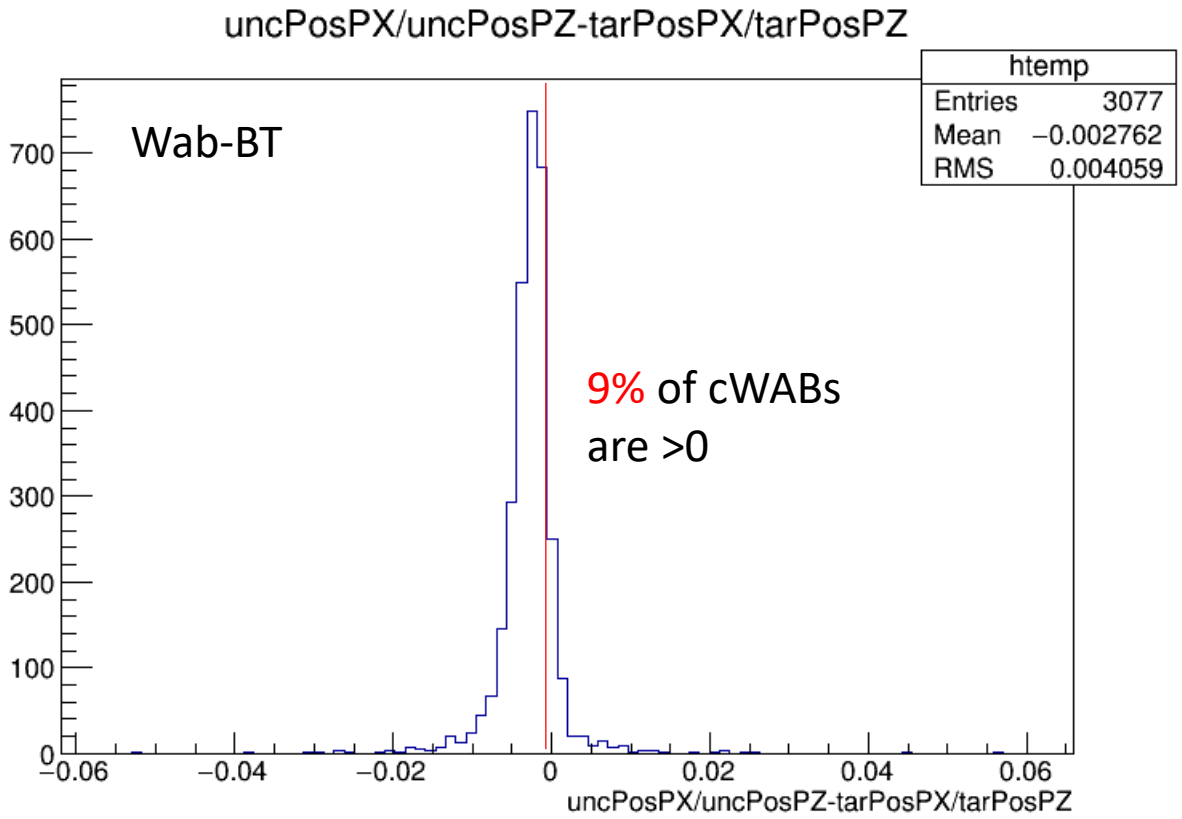
“Positron X-Tilt difference cut”





“Positron X-Tilt difference cut”





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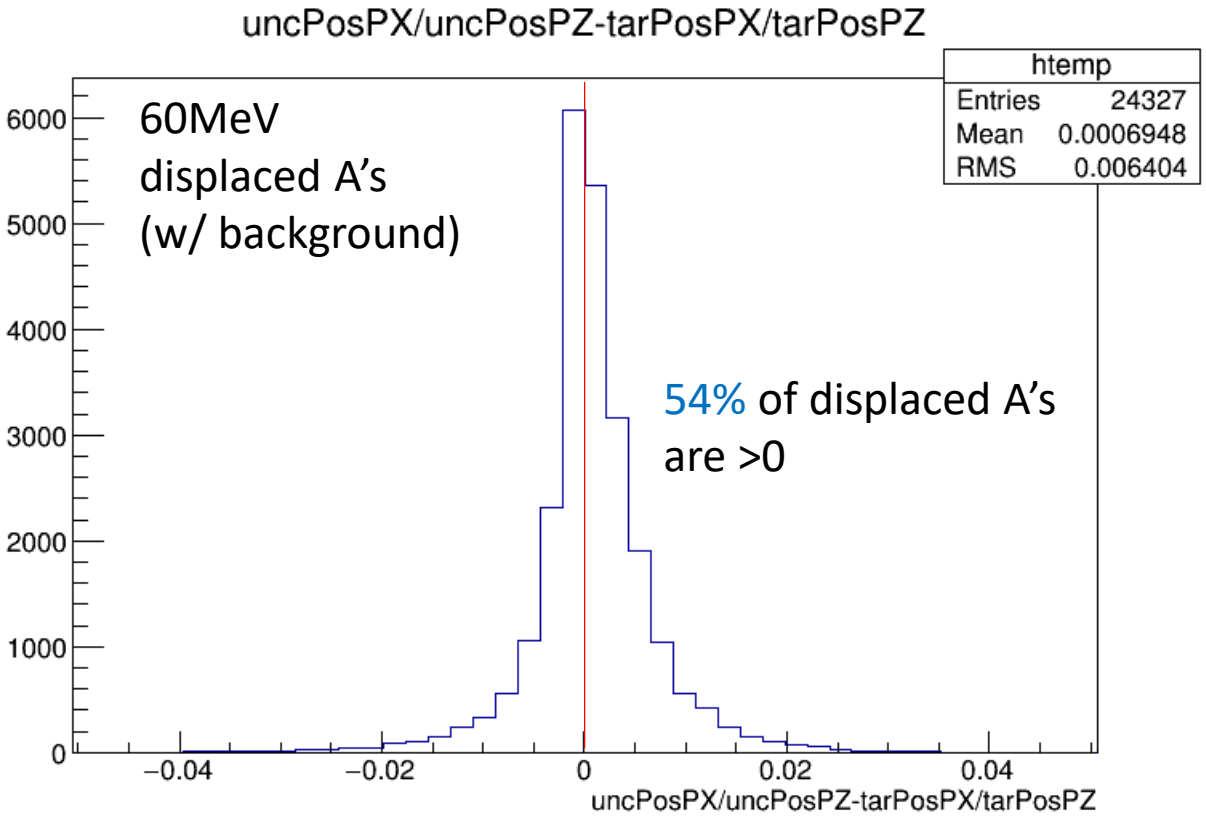
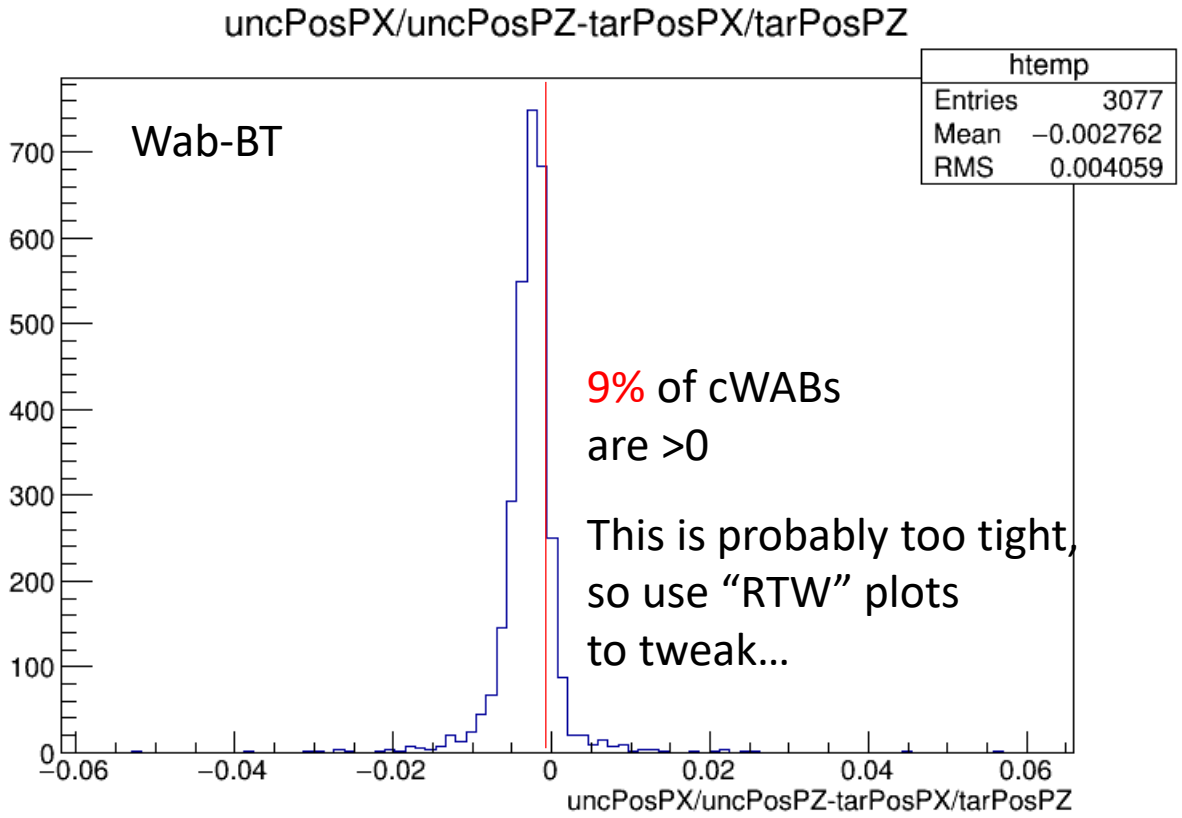
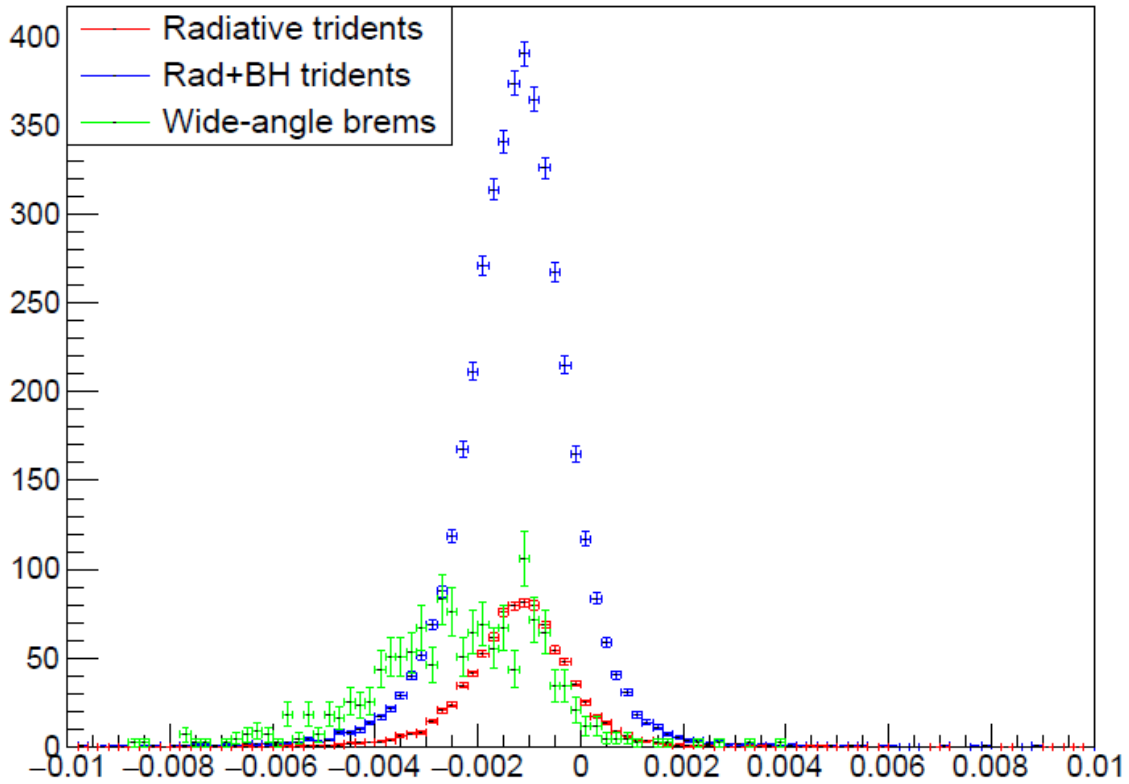
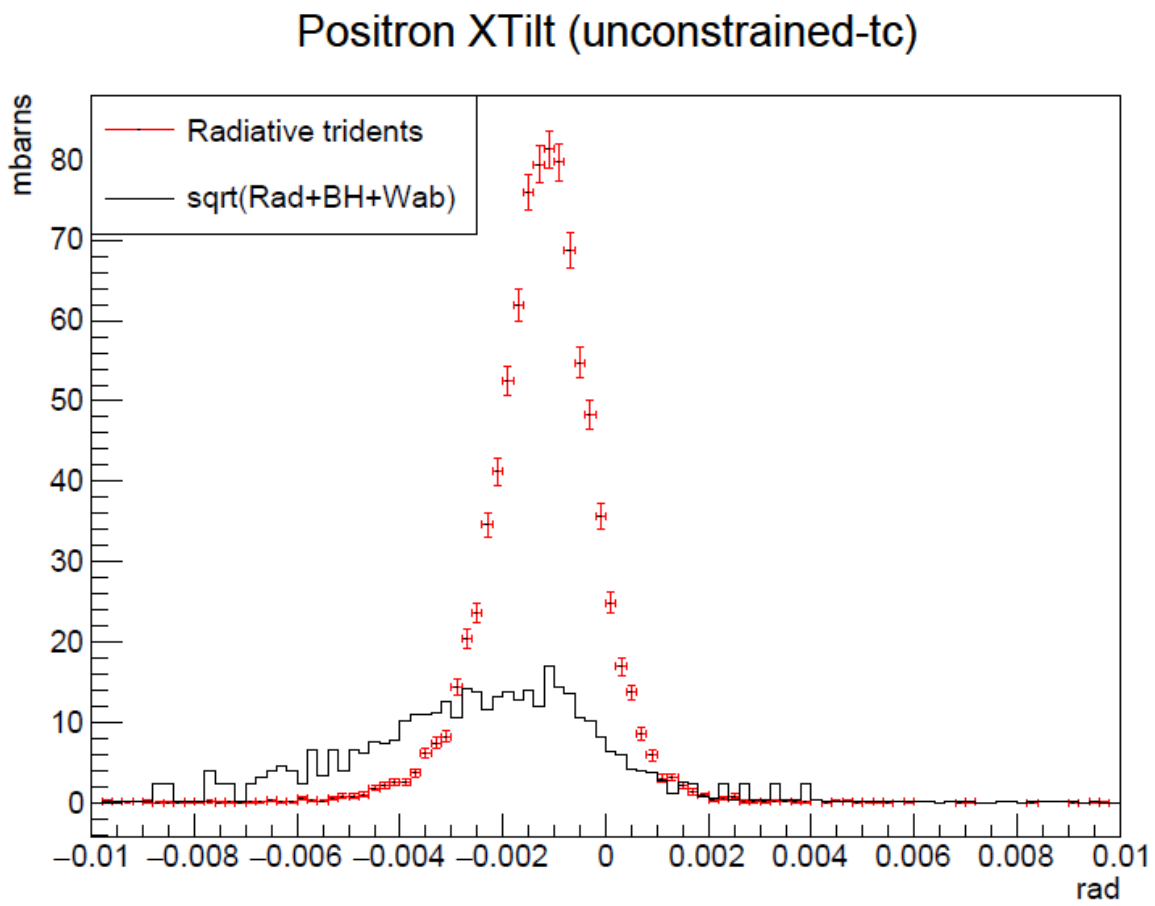


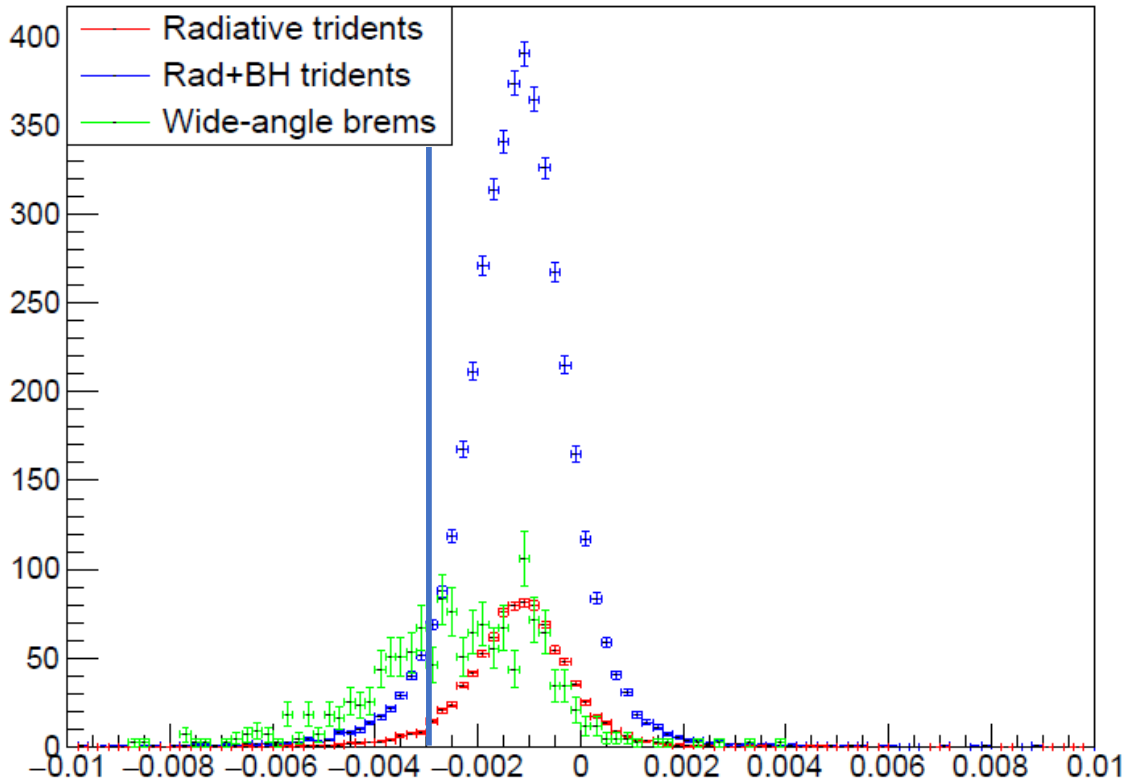


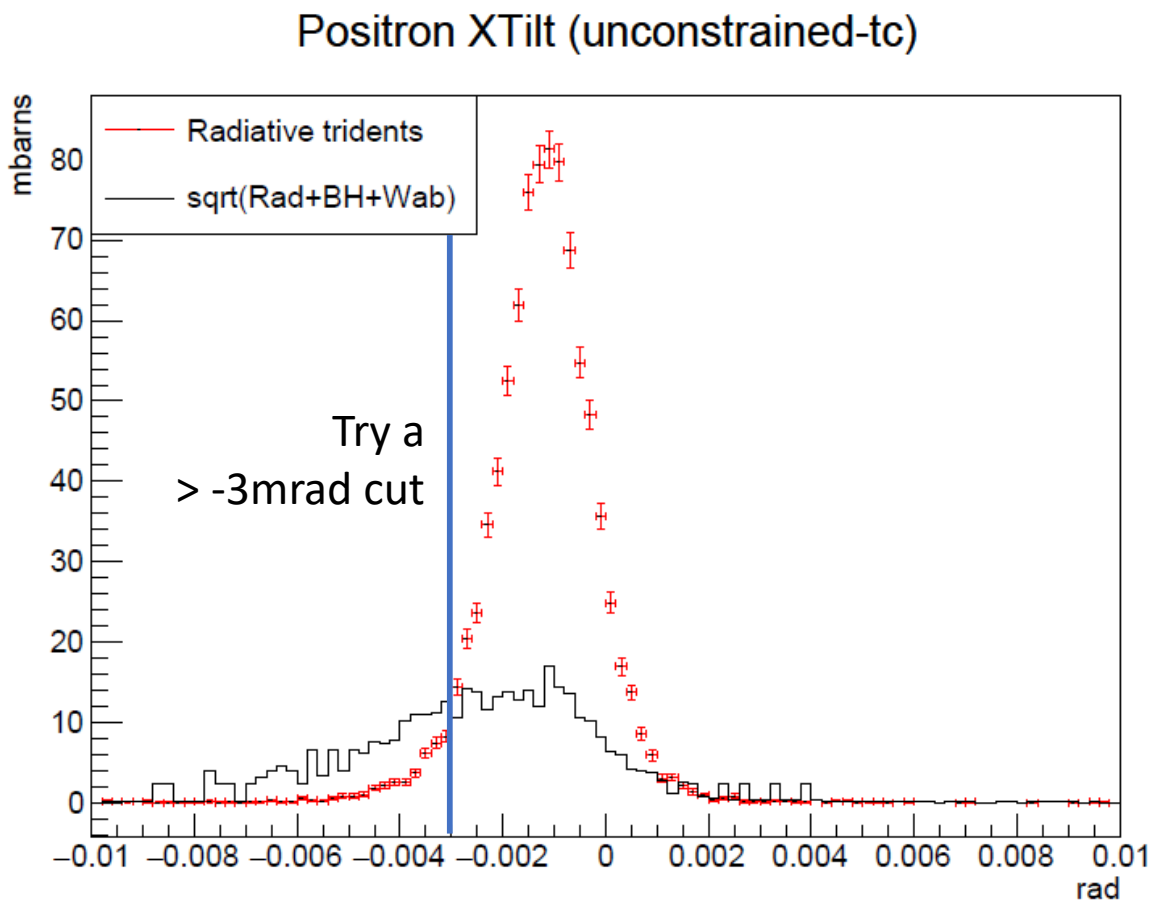
Looking at RAD, tritrig, wab…



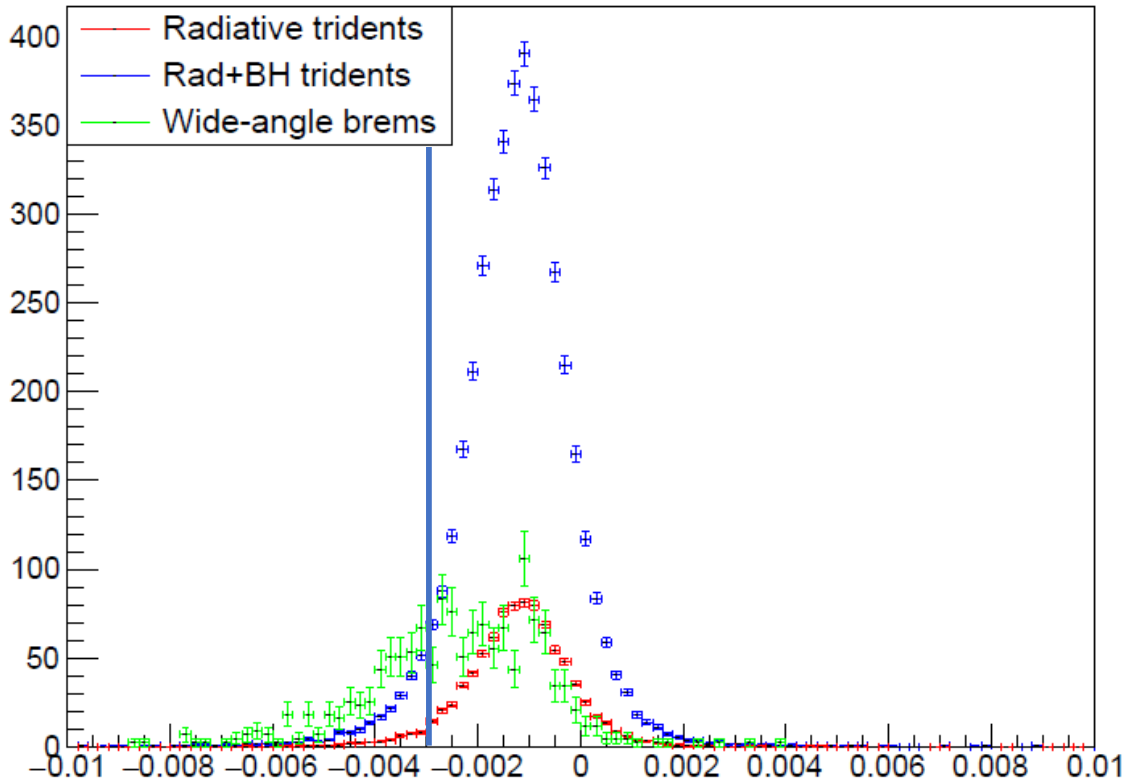


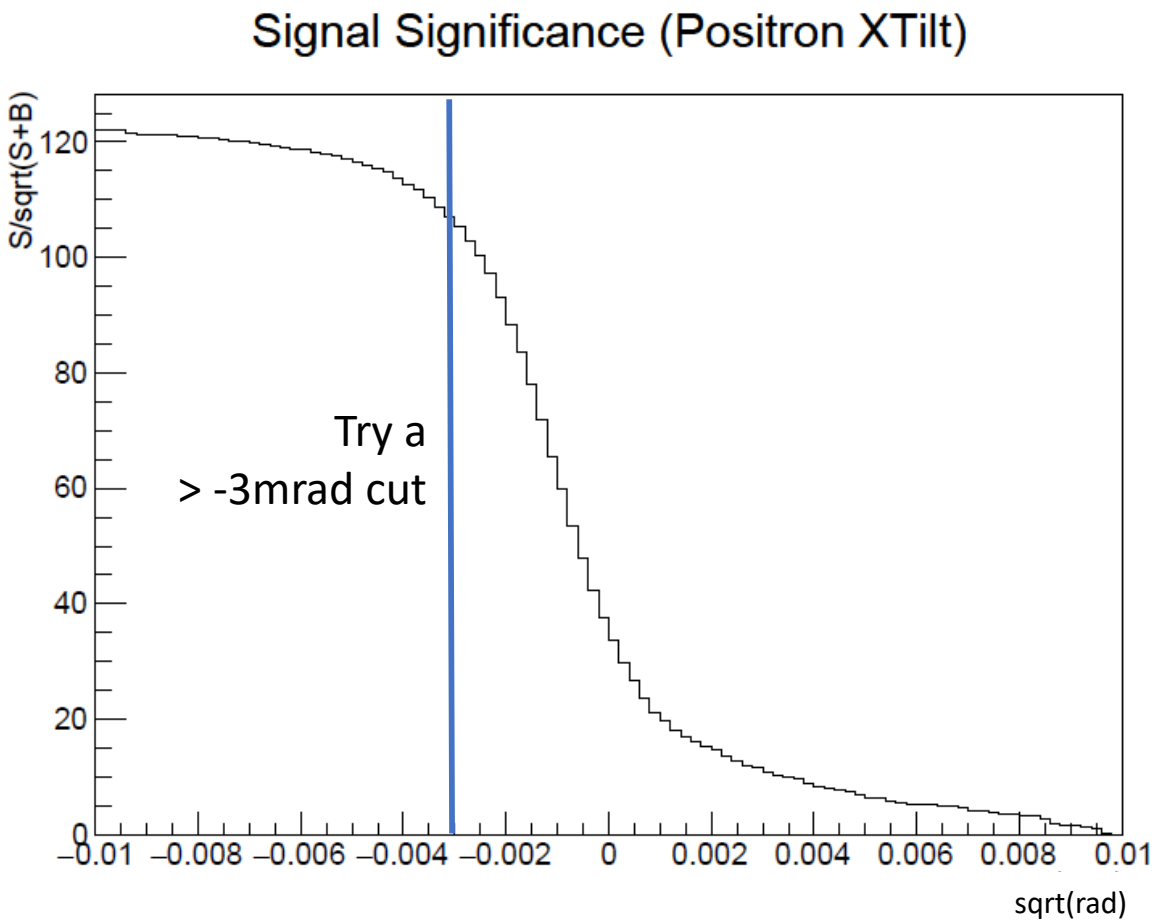
Looking at RAD, tritrig, wab…



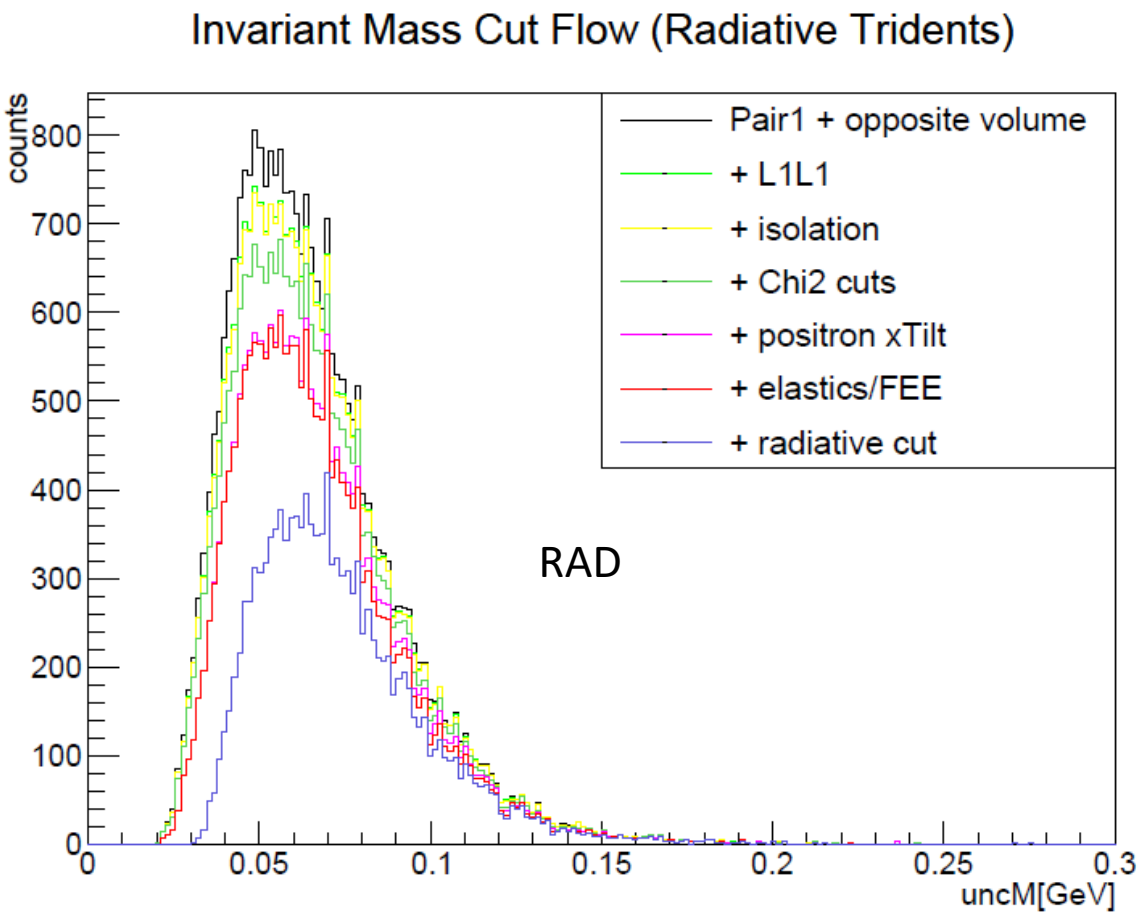


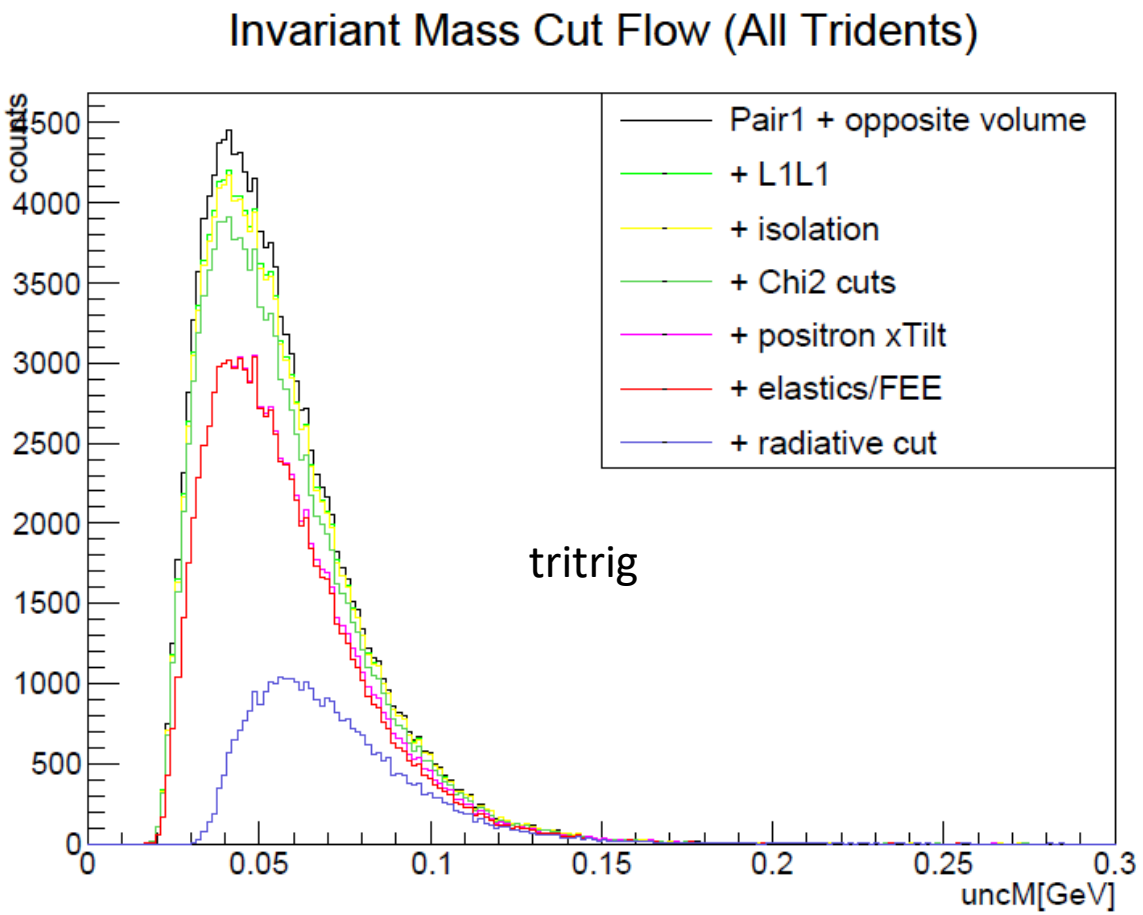
Looking at RAD, tritrig, wab…



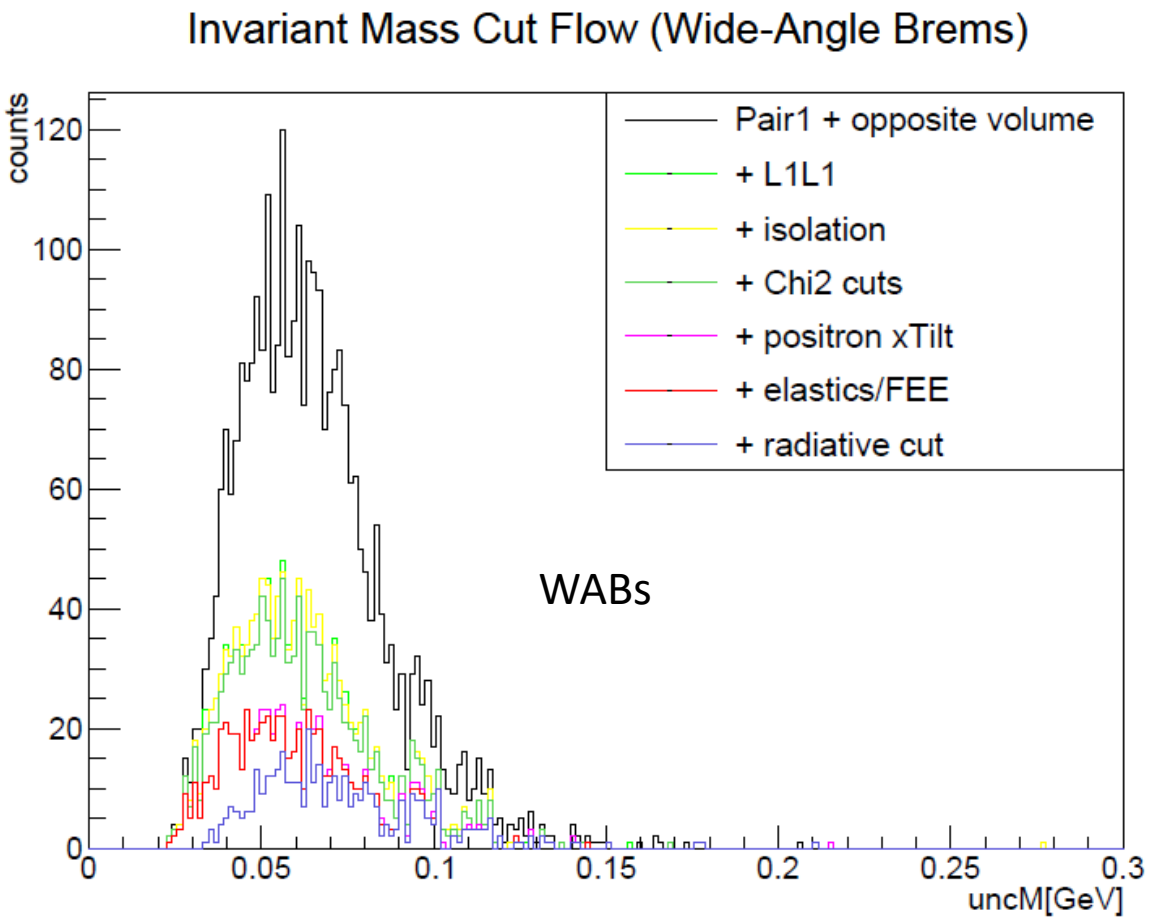


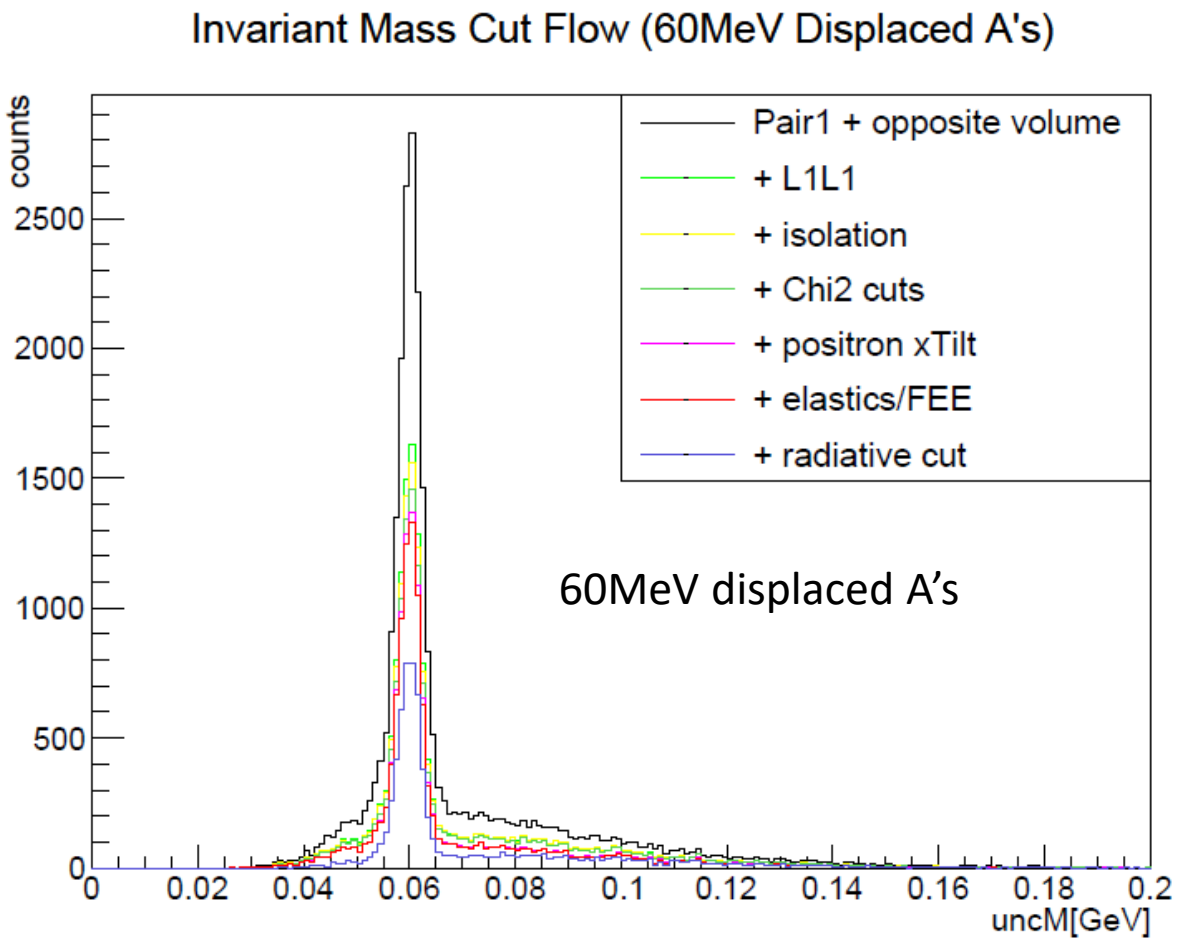
Cut Flows


Invariant Mass Cut Flow (Radiative Tridents)
counts
uncM[GeV]
Pair1 + opposite volume
+ L1L1
+ isolation
+ Chi2 cuts
+ positron xTilt
+ elastics/FEE
+ radiative cut
RAD

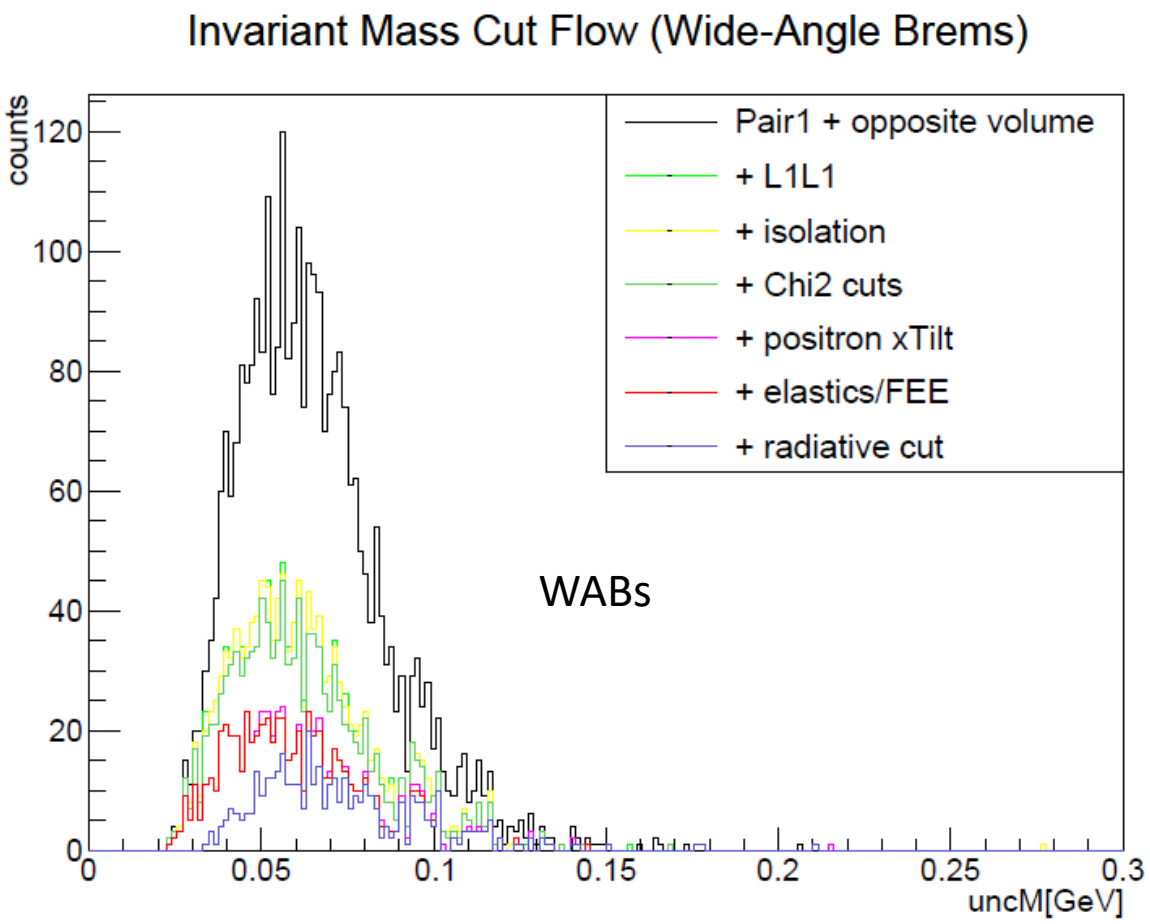

Invariant Mass Cut Flow (All Tridents)
counts
uncM[GeV]
Pair1 + opposite volume
+ L1L1
+ isolation
+ Chi2 cuts
+ positron xTilt
+ elastics/FEE
+ radiative cut
tritrig

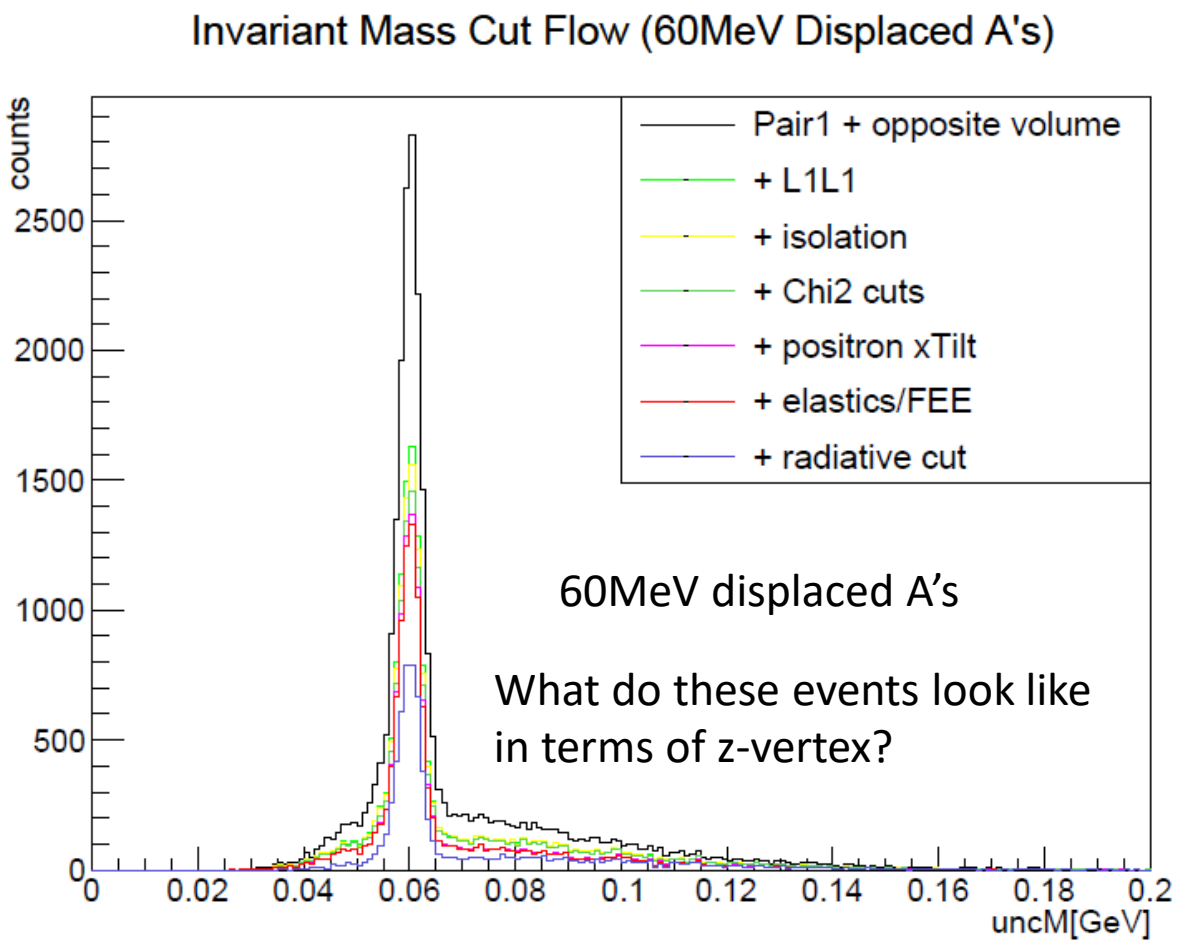
Cut Flows


Invariant Mass Cut Flow (Wide-Angle Brems)
counts
uncM[GeV]
Pair1 + opposite volume
+ L1L1
+ isolation
+ Chi2 cuts
+ positron xTilt
+ elastics/FEE
+ radiative cut
WABs

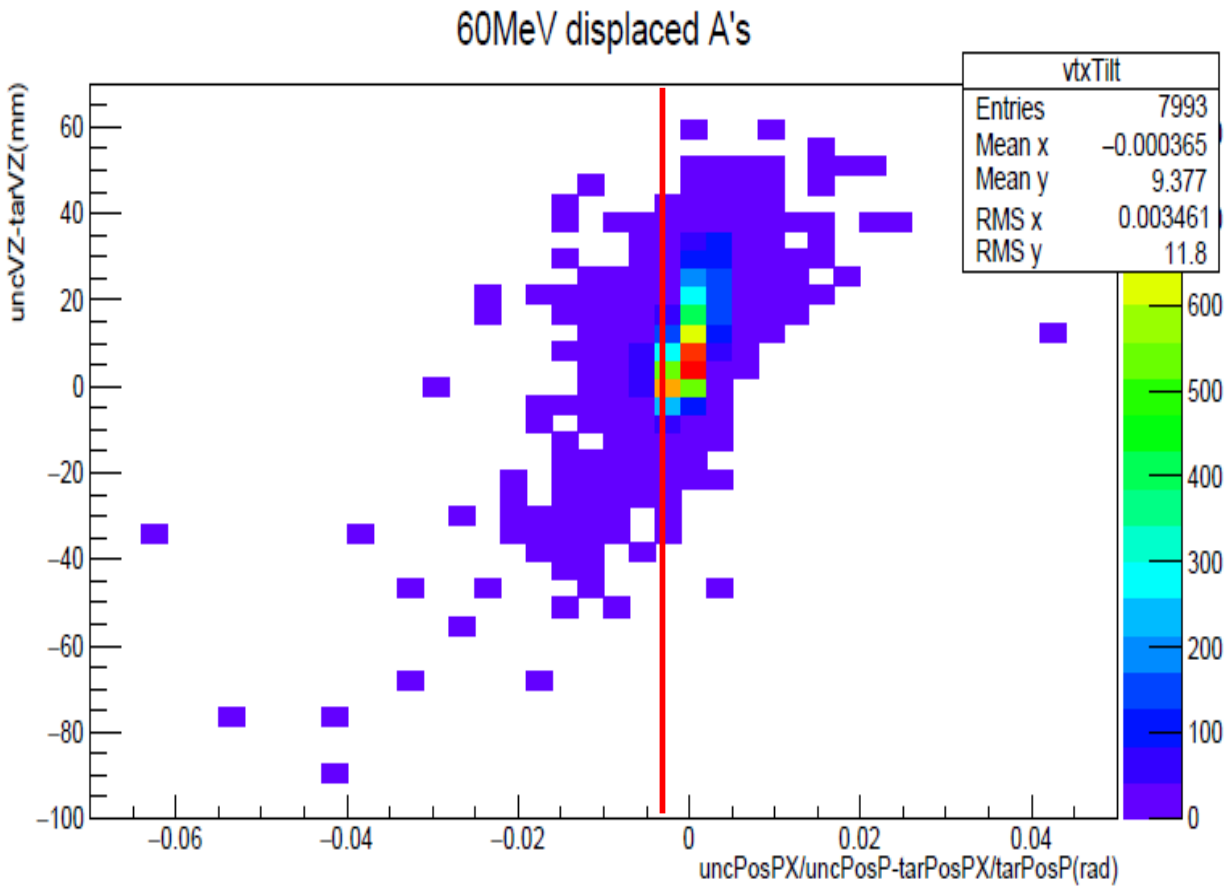

Invariant Mass Cut Flow (60MeV Displaced A's)
counts
uncM[GeV]
Pair1 + opposite volume
+ L1L1
+ isolation
+ Chi2 cuts
+ positron xTilt
+ elastics/FEE
+ radiative cut
60MeV displaced A's

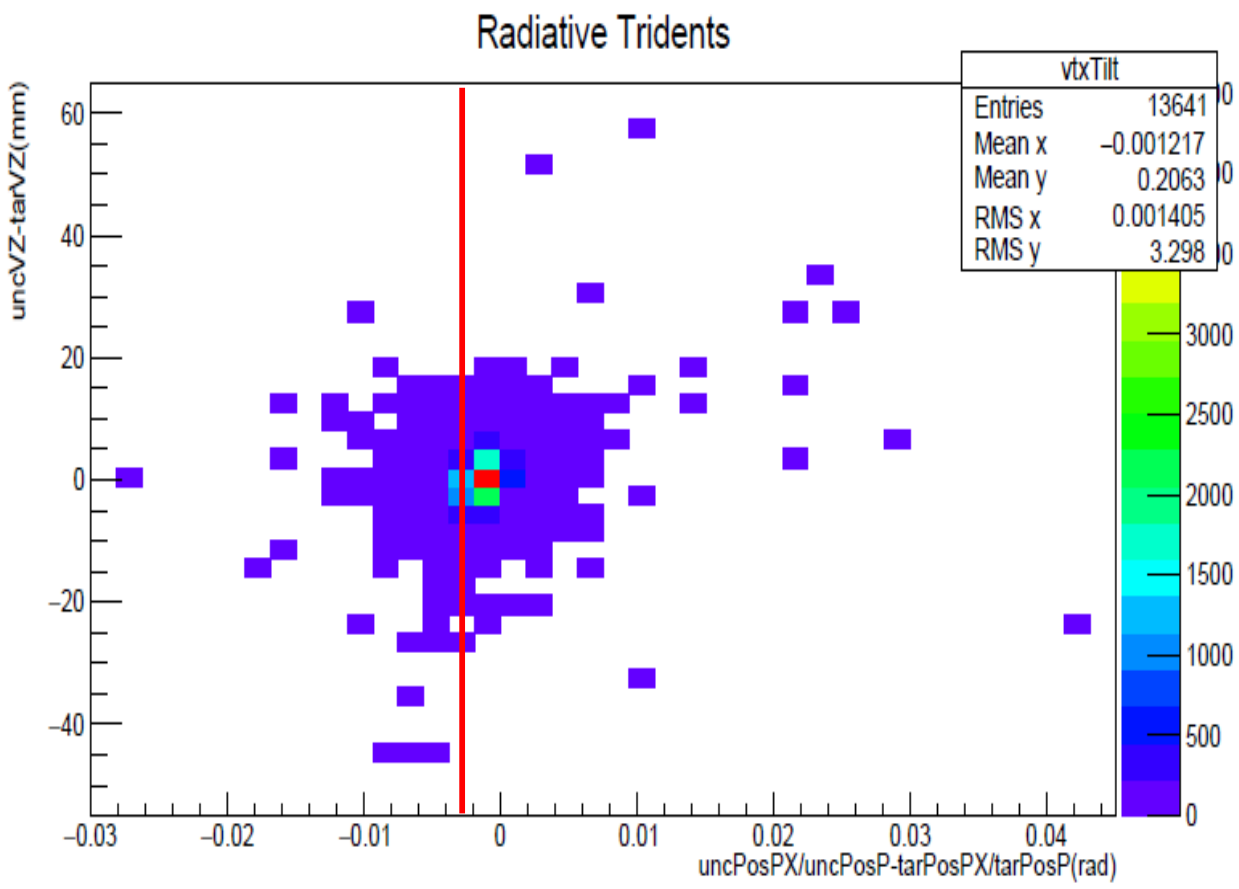
Cut Flows


Invariant Mass Cut Flow (Wide-Angle Brems)
counts
uncM[GeV]
Pair1 + opposite volume
+ L1L1
+ isolation
+ Chi2 cuts
+ positron xTilt
+ elastics/FEE
+ radiative cut
WABs

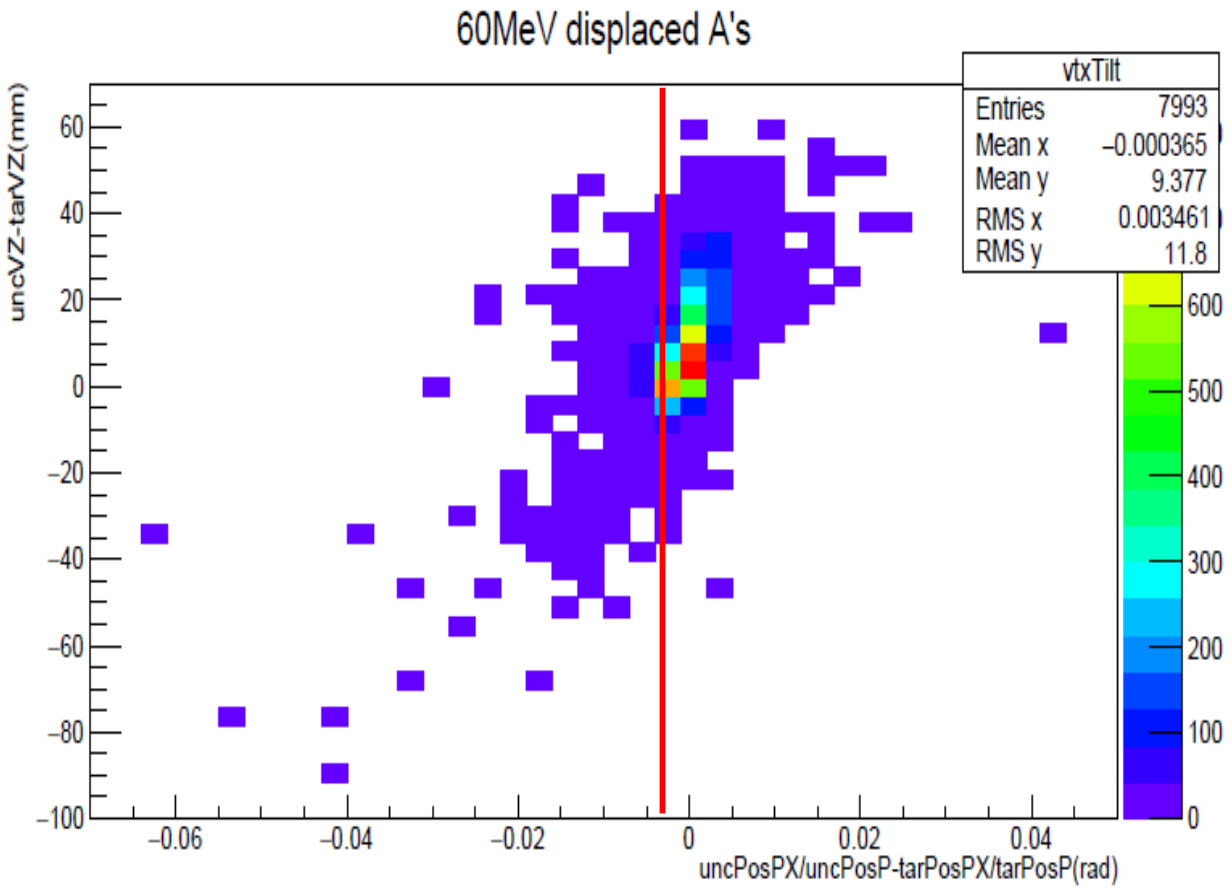

Invariant Mass Cut Flow (60MeV Displaced A's)
counts
uncM[GeV]
Pair1 + opposite volume
+ L1L1
+ isolation
+ Chi2 cuts
+ positron xTilt
+ elastics/FEE
+ radiative cut
60MeV displaced A's
What do these events look like in terms of z-vertex?

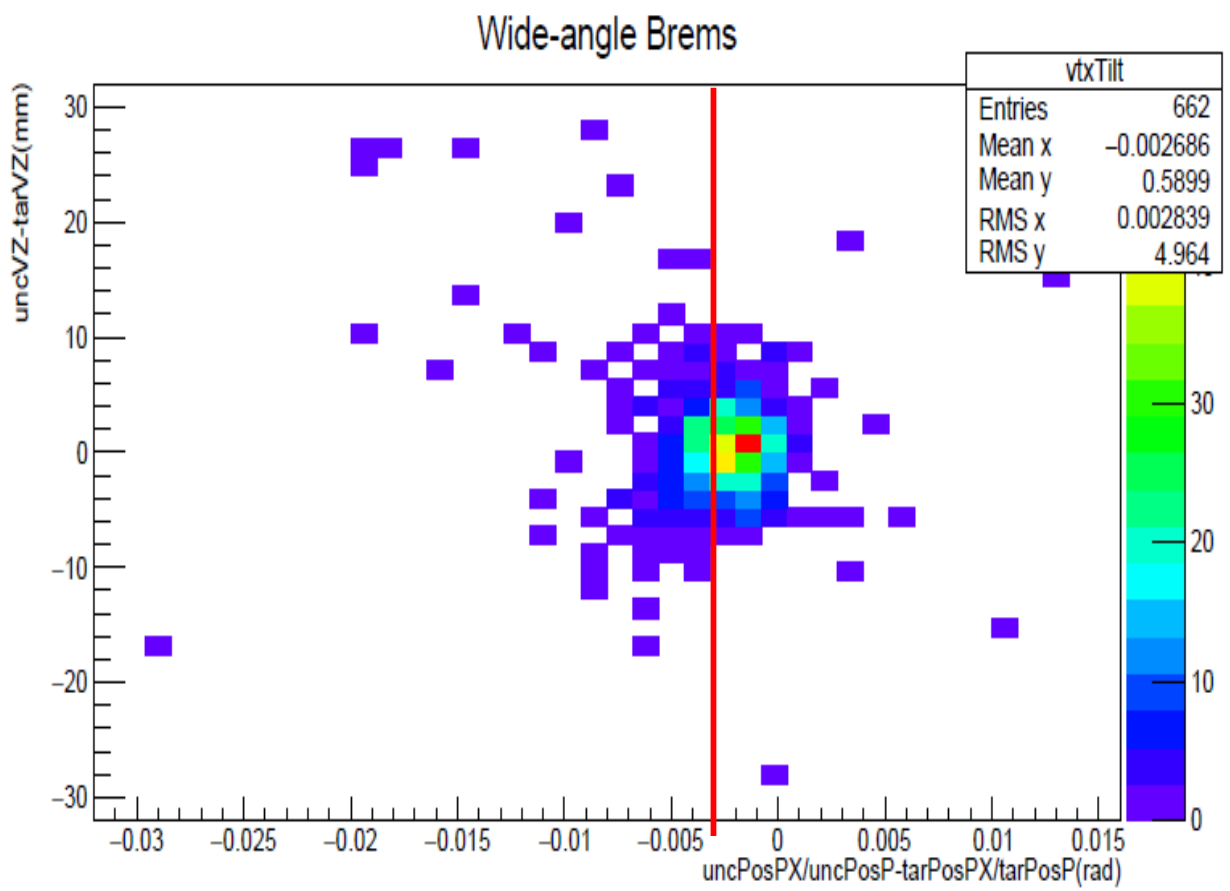
Z-Vertex vs. Positron X-Tilt Diff.



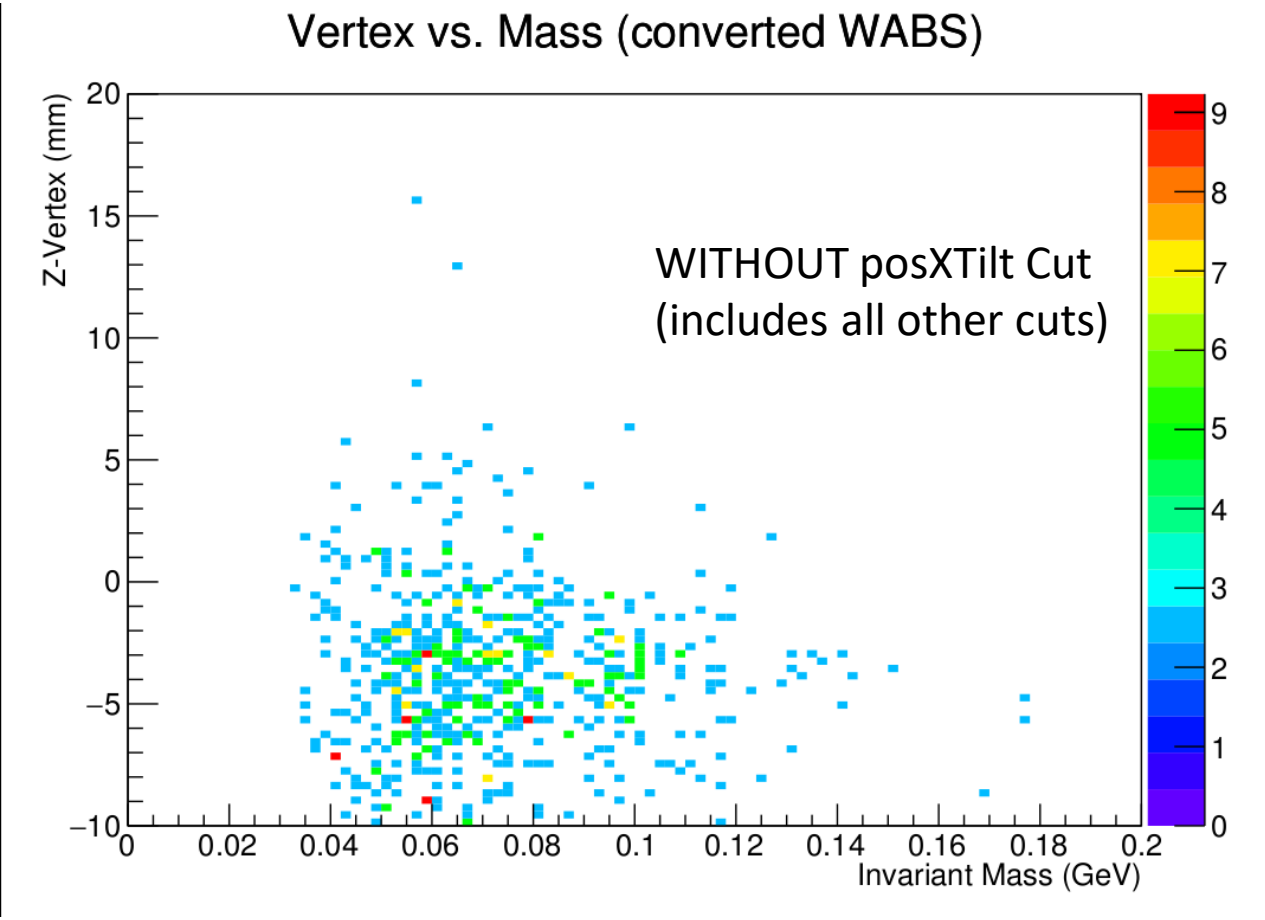


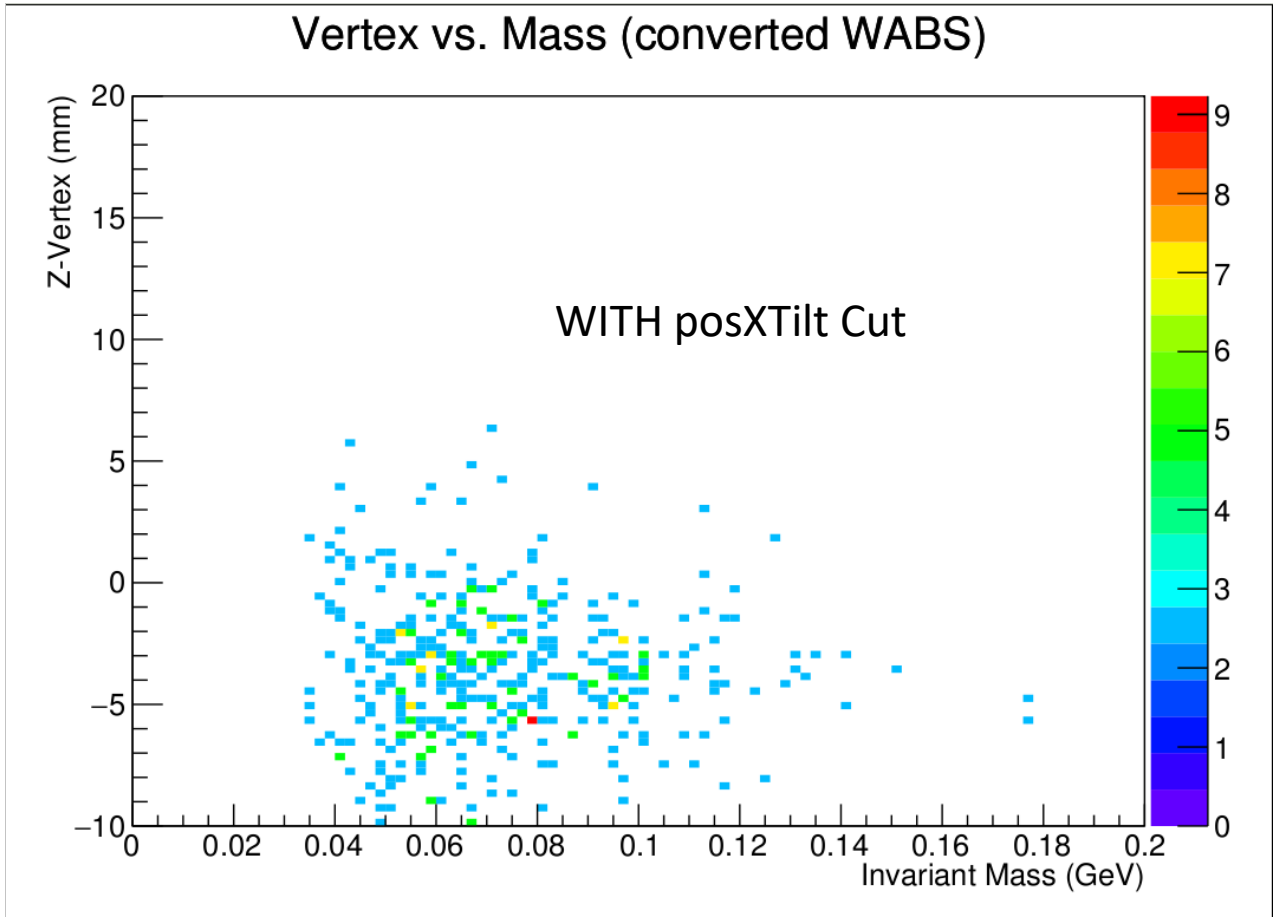
Z-Vertex vs. Positron X-Tilt Diff.



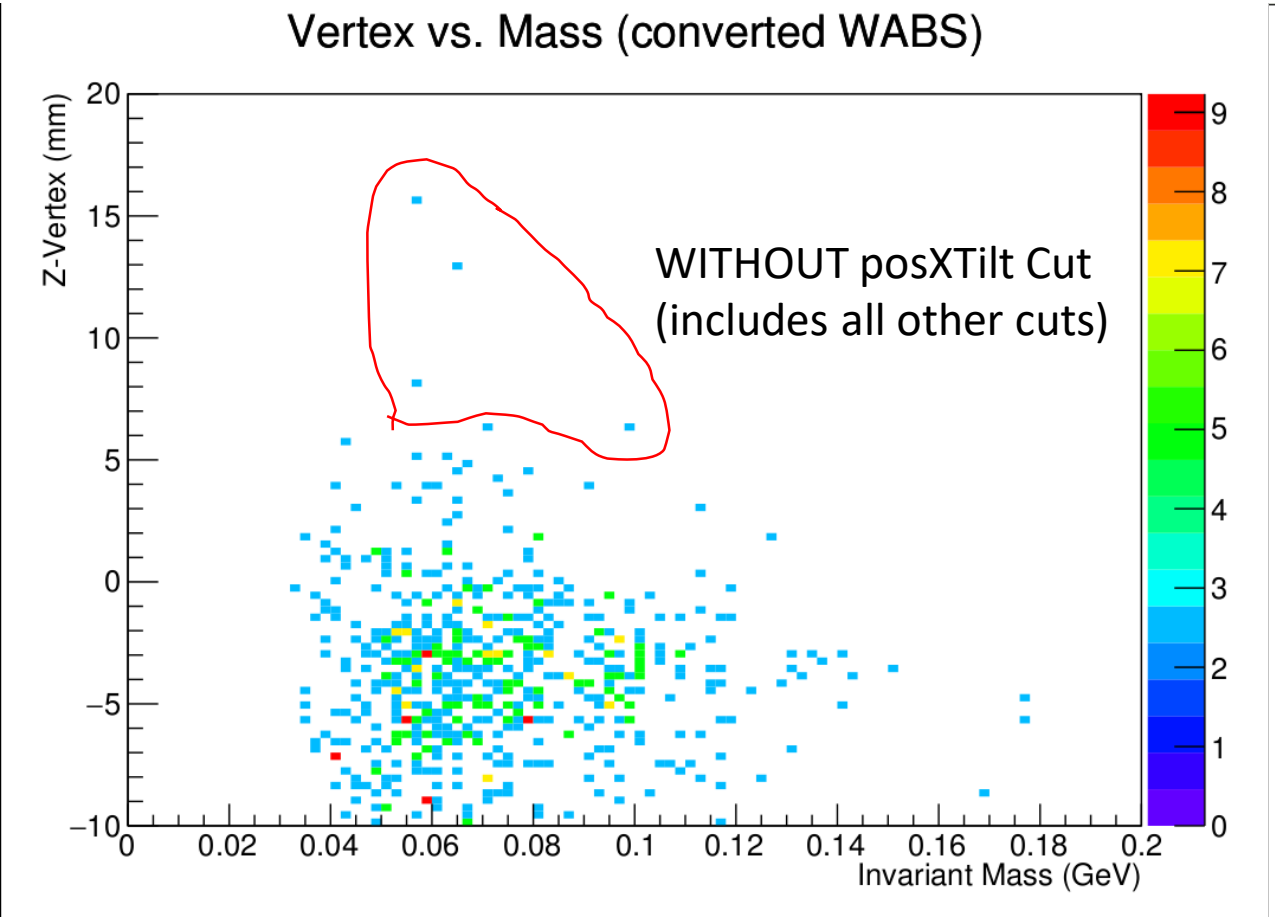


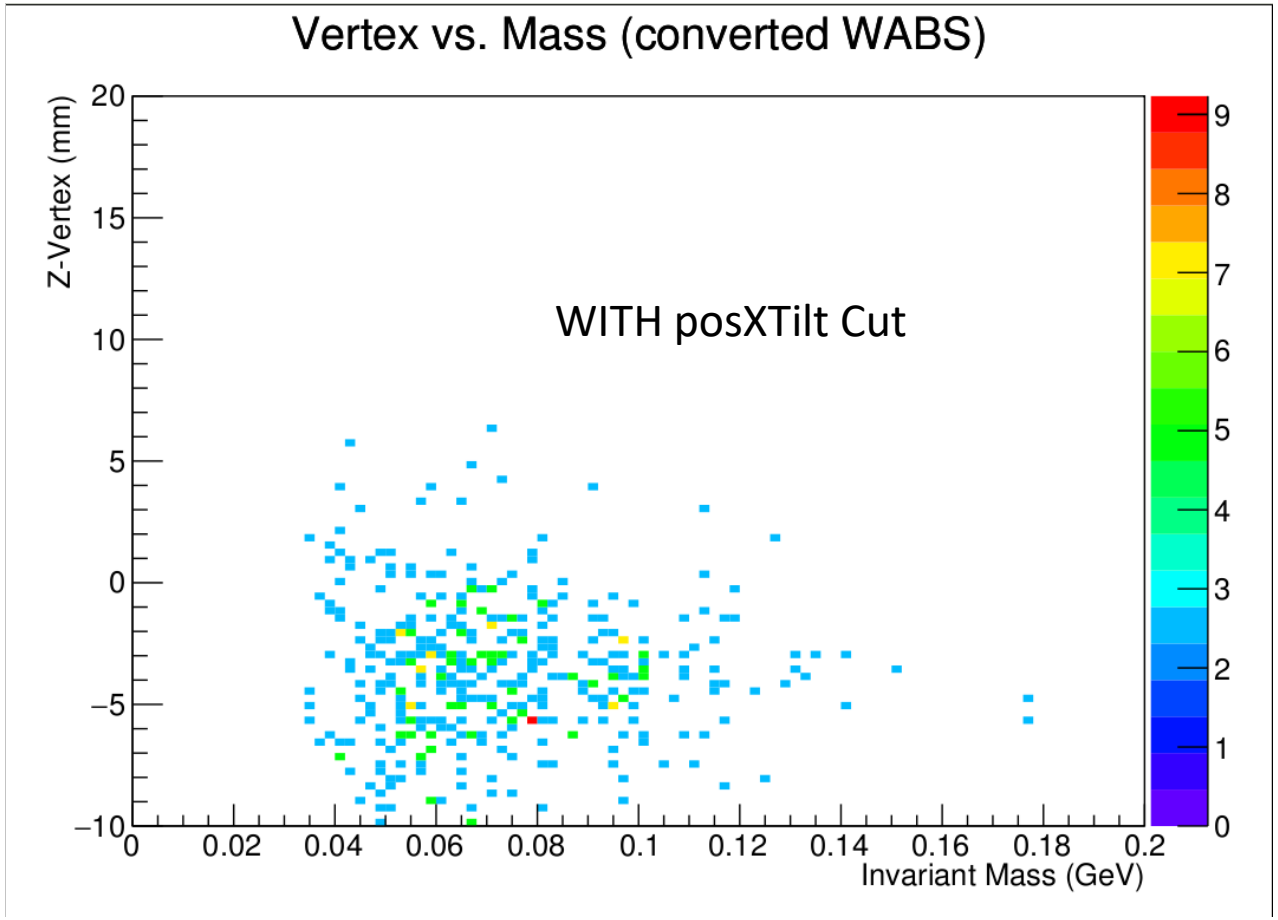
WABs (all other vertexing cuts)



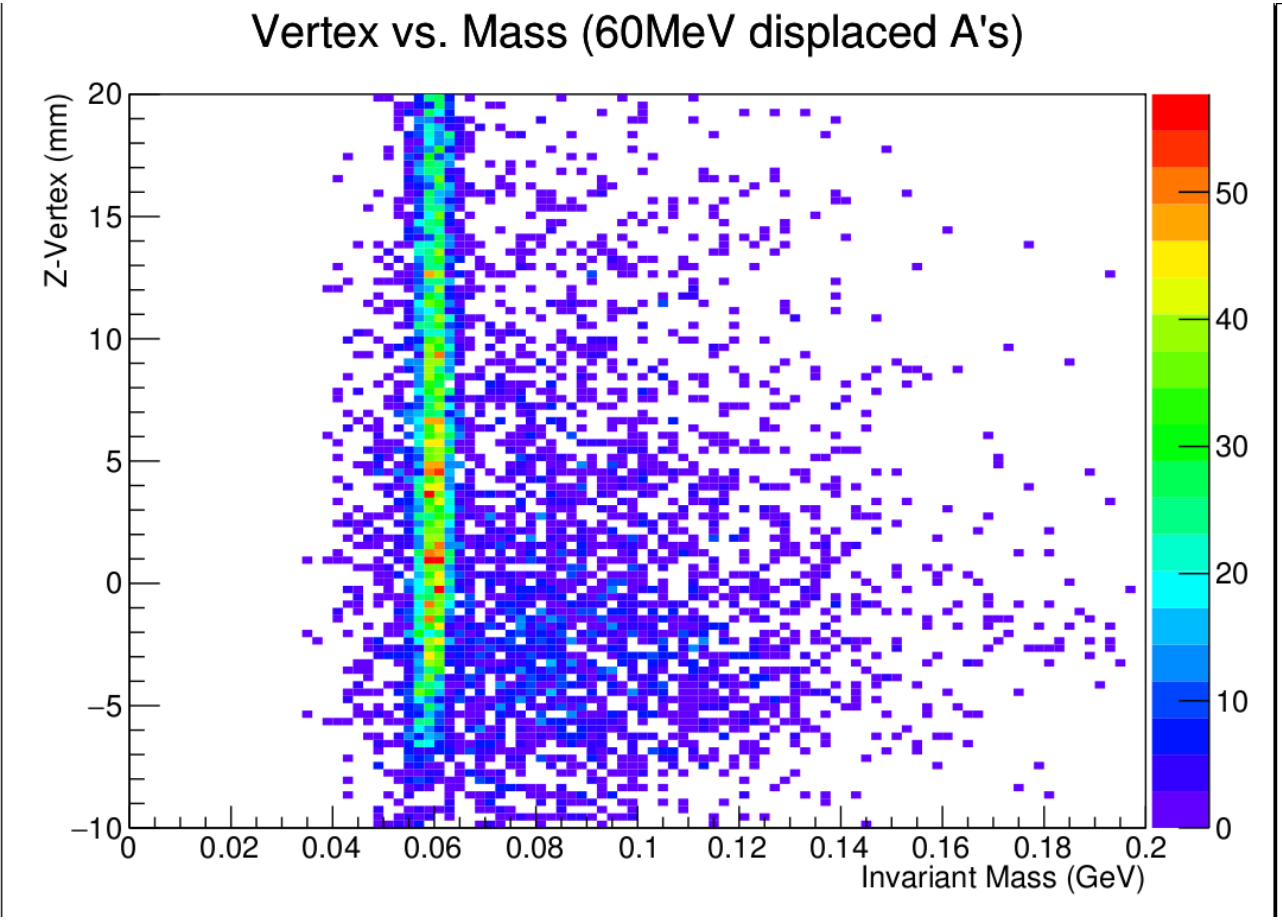


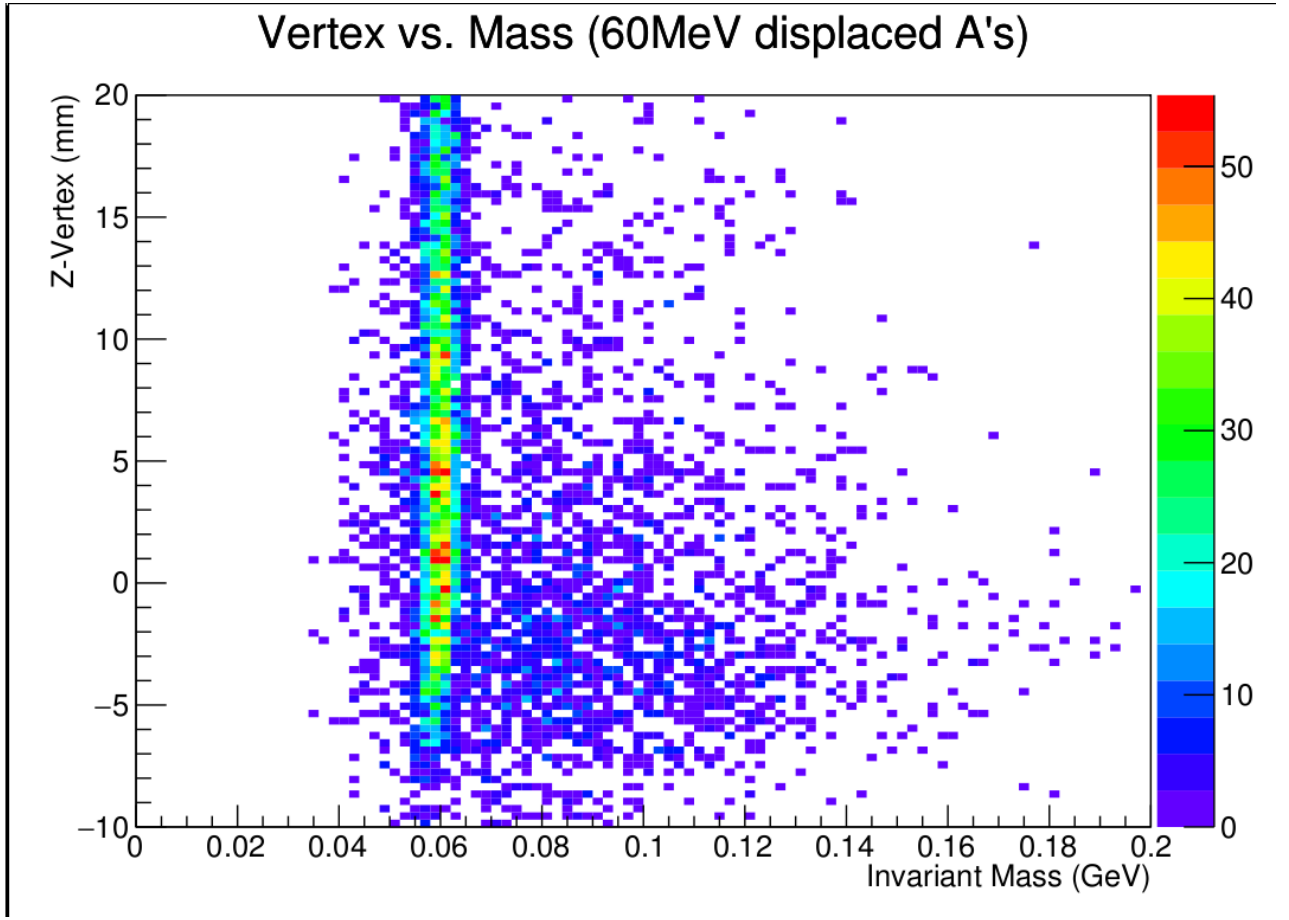
WABs (all other vertexing cuts)



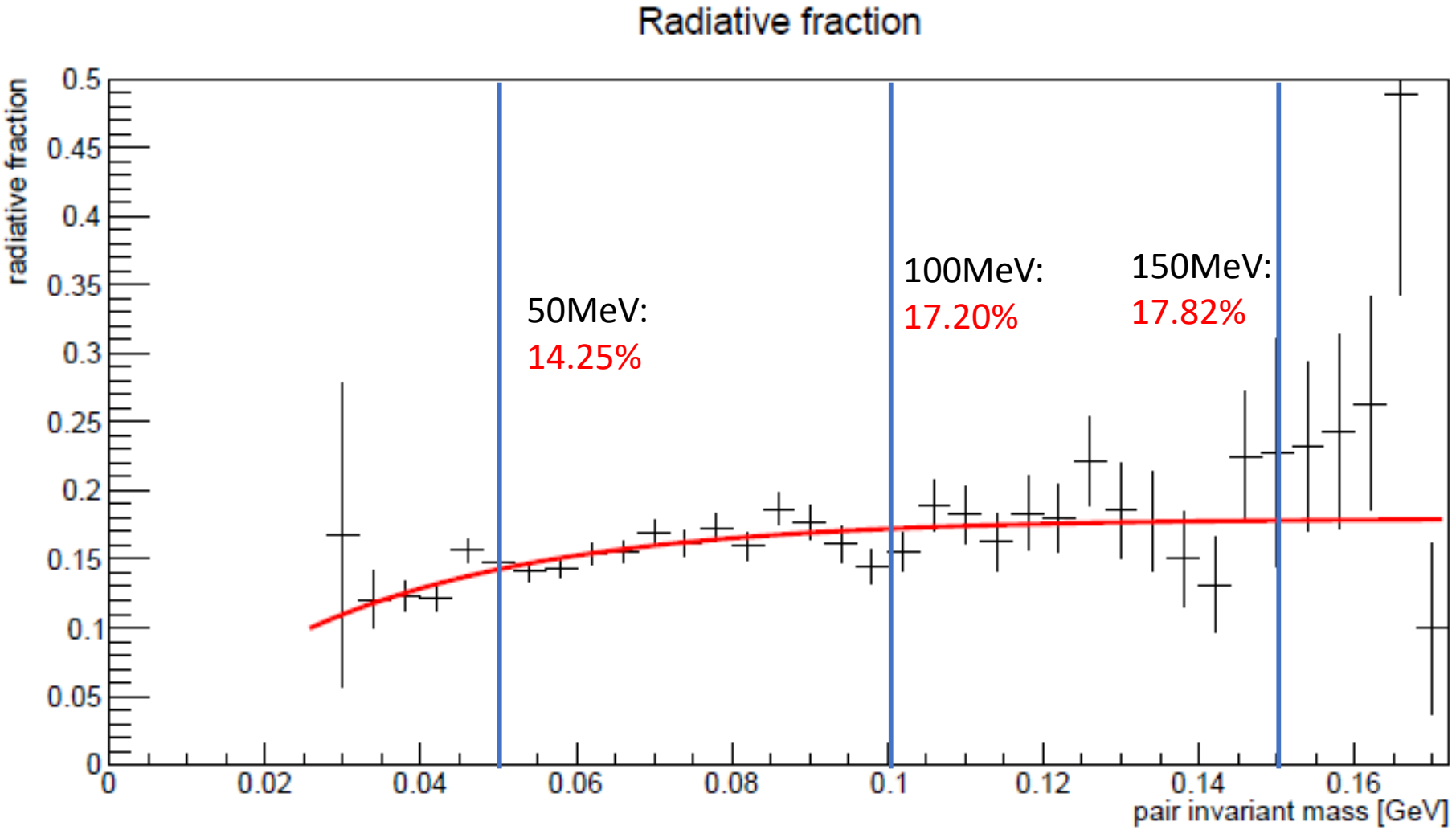


Compare to 60MeV A's…

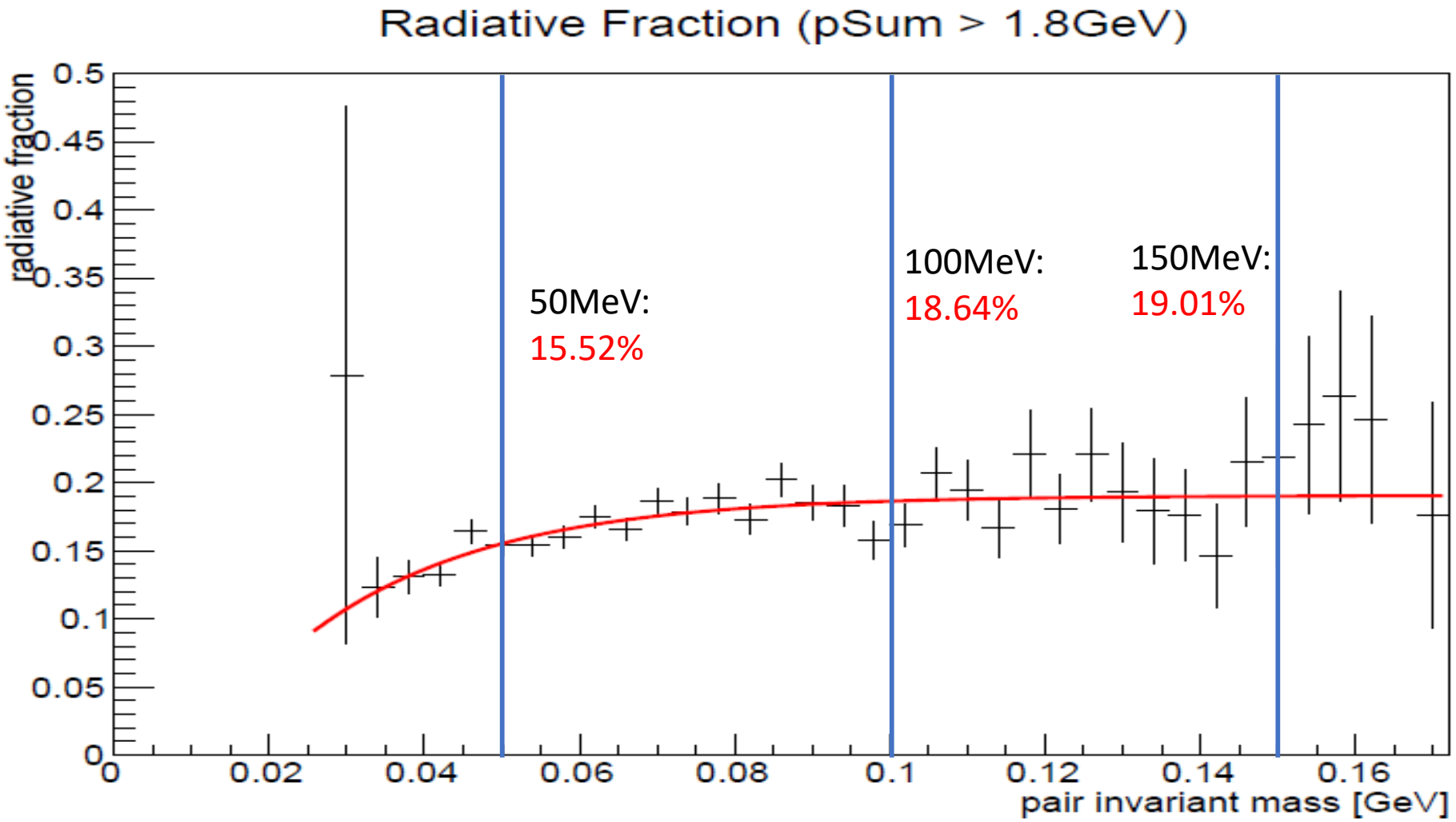




Radiative Fraction, pSum > 1.8GeV (without posXTilt cut)



Radiative Fraction, pSum > 1.8GeV (including posXTilt cut)



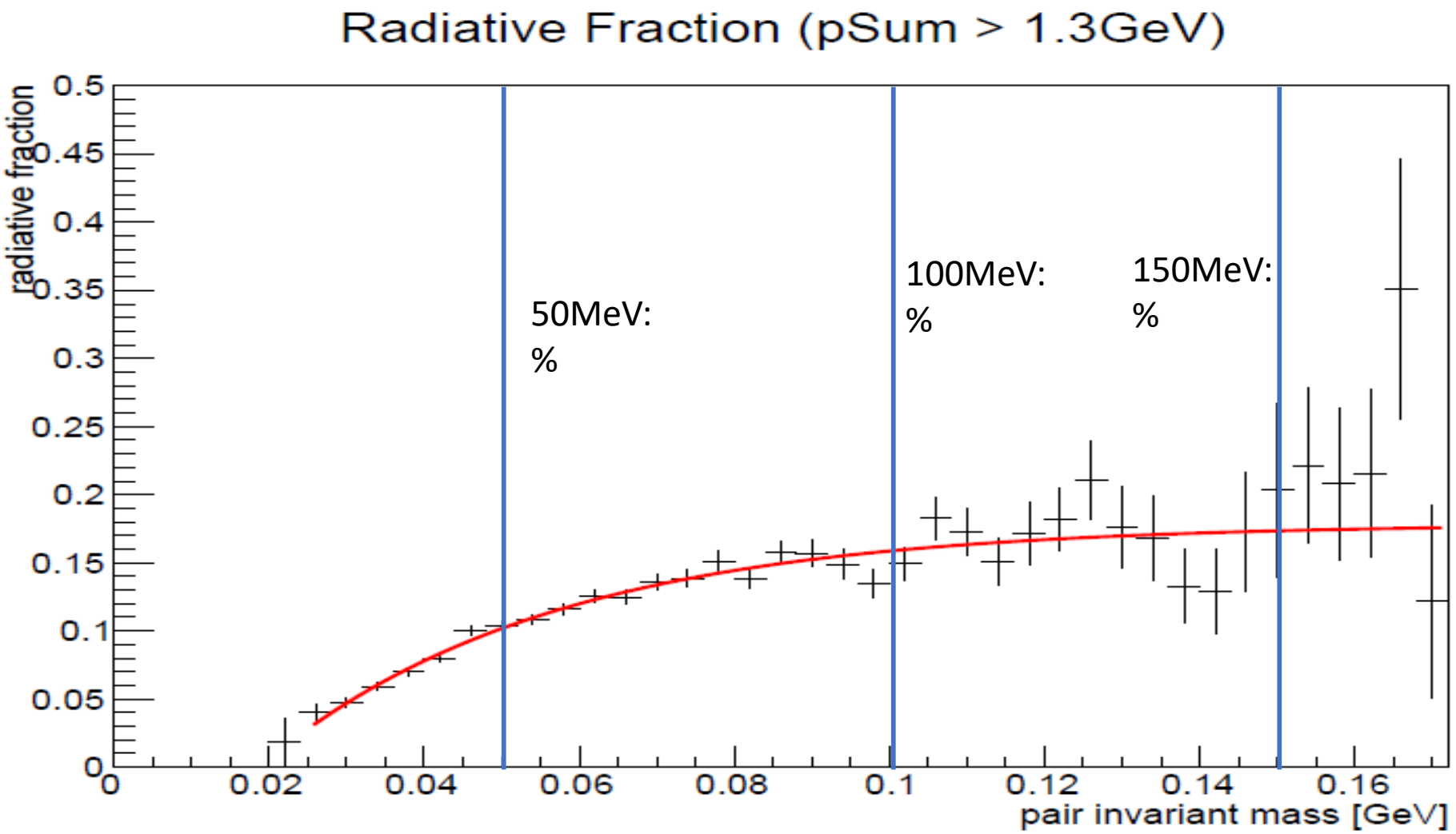
Summary

- The 2016 radiative fraction is still at ~15%, if using the previous pSum>1.5GeV radiative cut

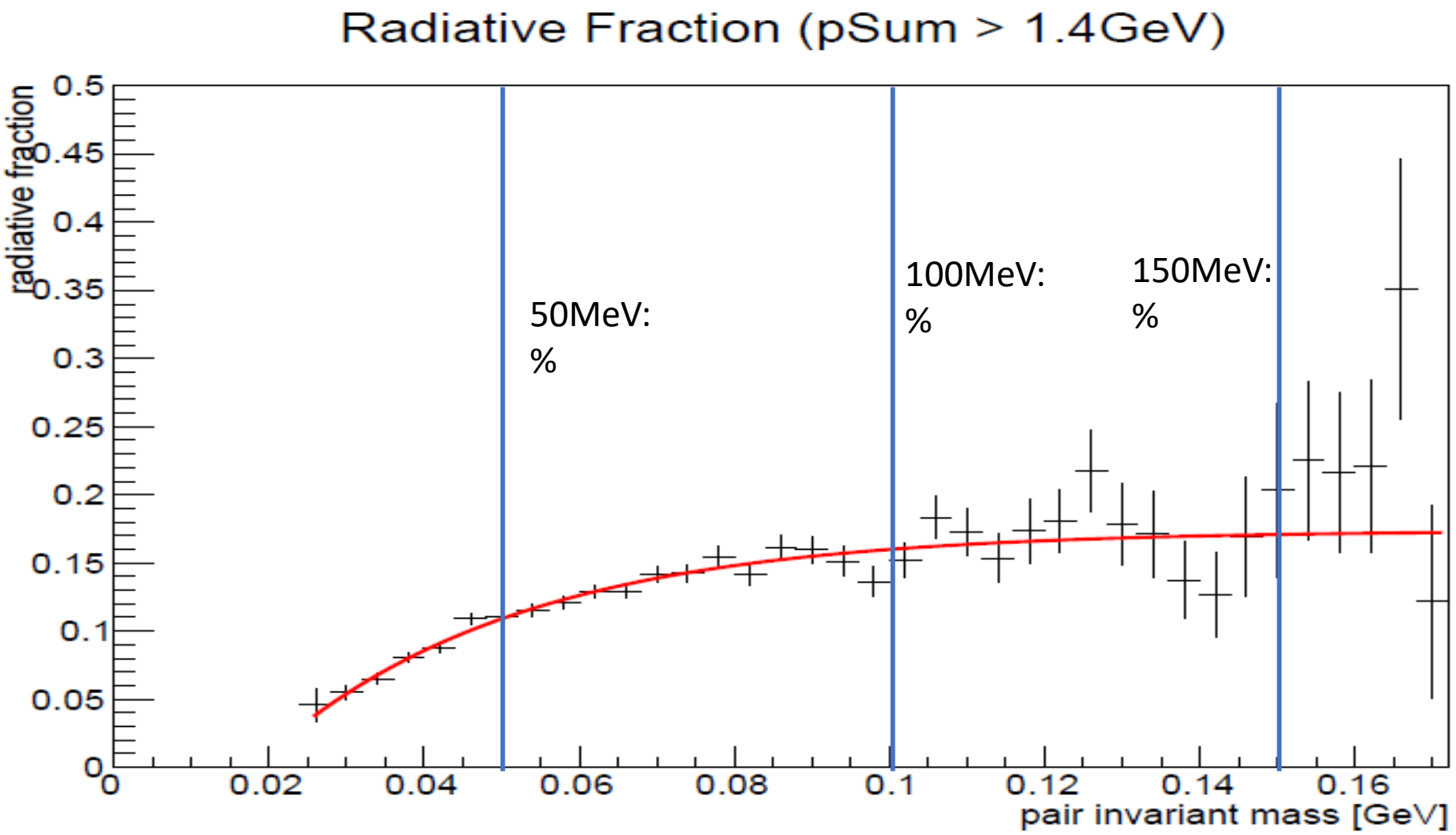
- This should be tighter for vertexing, since the search is more about excluding backgrounds than searching for a bump on top of it
  - pSum>1.8GeV gives a radiative fraction of 17%

- Displaced A's do not seem to be affected by a target-constrained px/pz cut as cWABs are (why?).
  - If adding this cut to the others, the radiative fraction increases to 18-19%
  - It also eliminates some high-z background
  - Are there even better cuts, that exploit A'-wab differences?

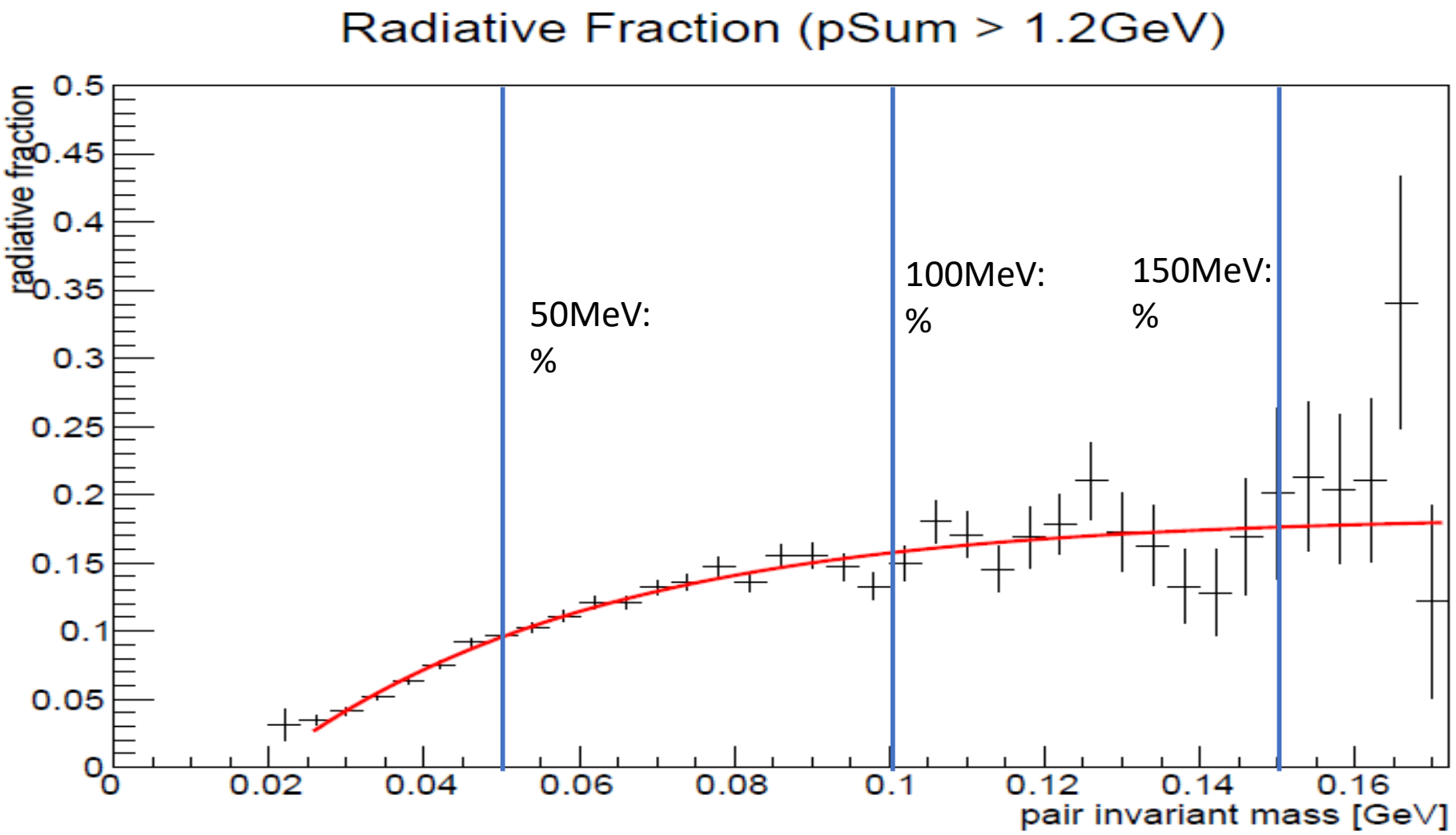
Radiative Fraction, pSum > 1.3GeV (plus all other cuts)



Radiative Fraction, pSum > 1.4GeV (plus all other cuts)



Radiative Fraction, pSum > 1.6GeV (plus all other cuts)



Radiative Fraction, pSum > 1.7GeV (plus all other cuts)