Full Lumi Reach Estimates

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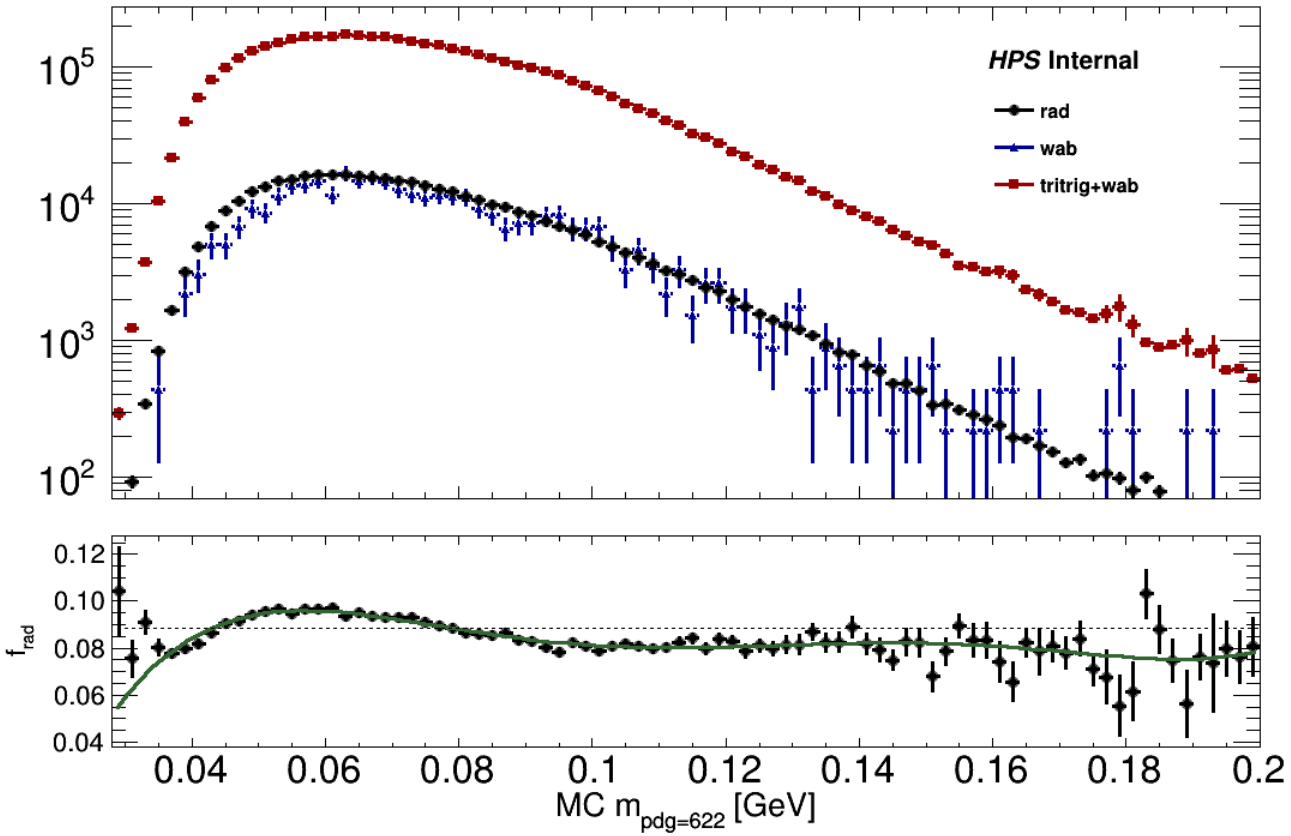
Start with 2016 MC

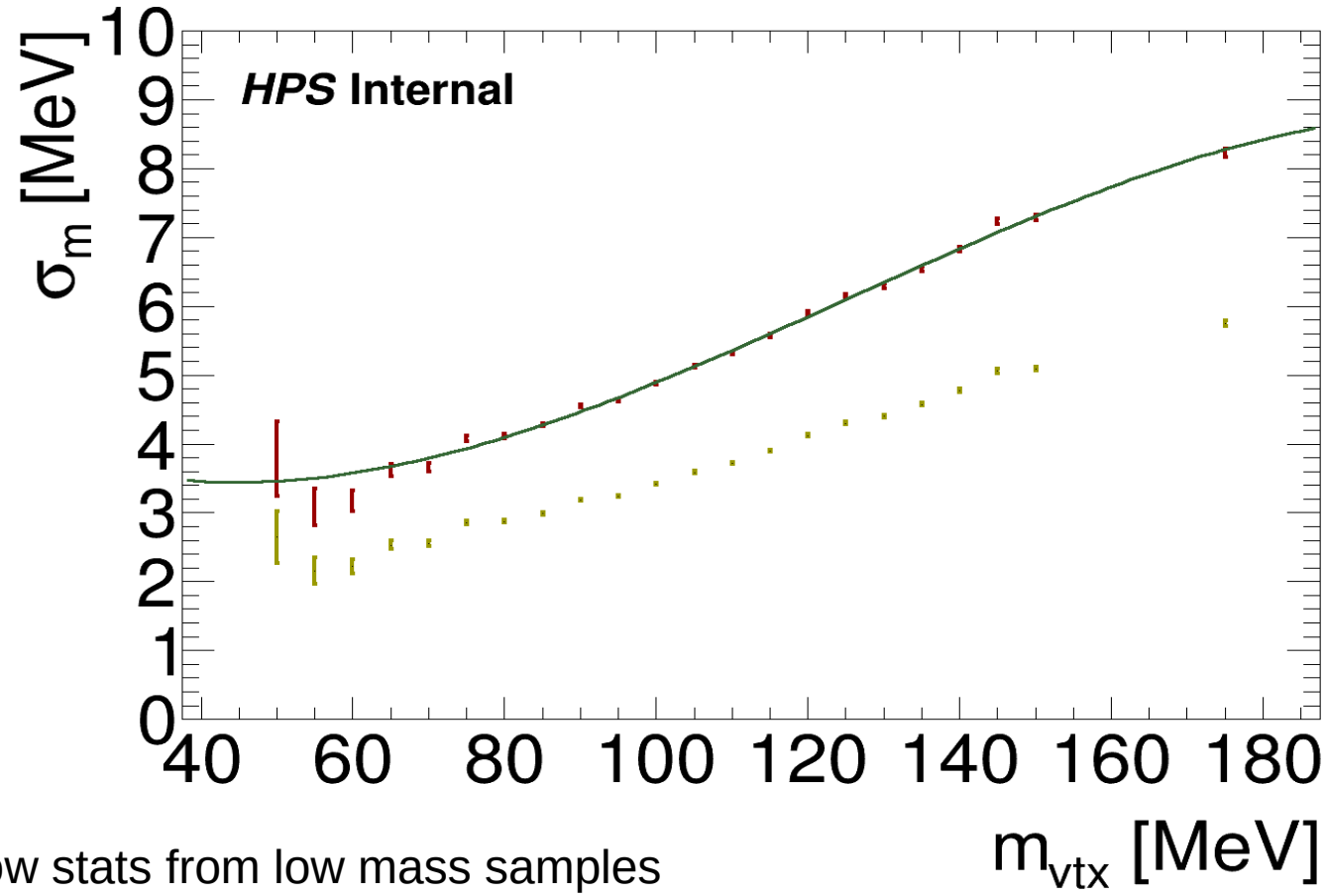
- Developed and validated tools in hpstr using 2016 MC
- Used same pre-selection as 2016 vertex analysis
- Also included several of the “Tight” selection requirements
    - Unconstrained vertex fit $\chi^2 < 4.0$
    - Energy sum > 1.84 GeV
    - Both tracks have layer 1 hit (L1L1)
    - Only one vertex in event passing selection requirements
- This selection is not “final”, just a reasonable working point to develop tools

Radiative Fraction



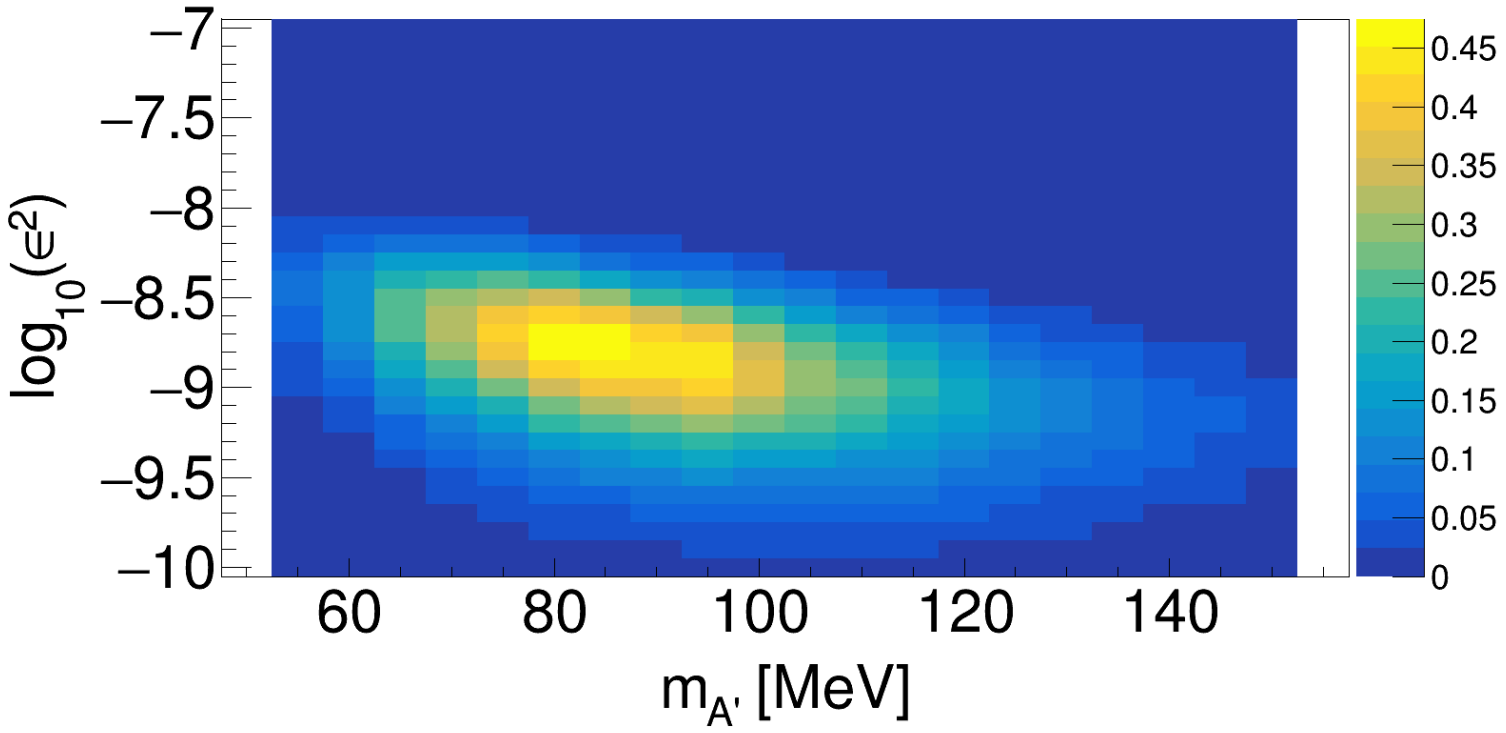
- Truth matching used for rad
- Appears to be close to result from Matt S
- Parameterized by 3rd order polynomial, chosen via f-test

Mass Resolution



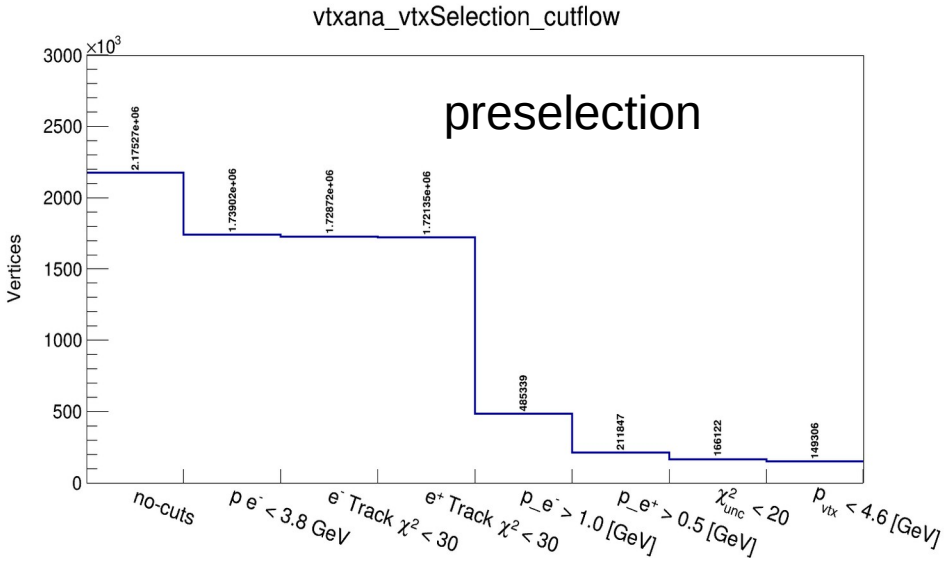
- Low stats from low mass samples
- Appears to be close to result from Matt S, slightly higher
- Resolution from fit scaled by 1.43 (this number came from Matt S)
- Parameterized by 3rd order polynomial, chosen via f-test

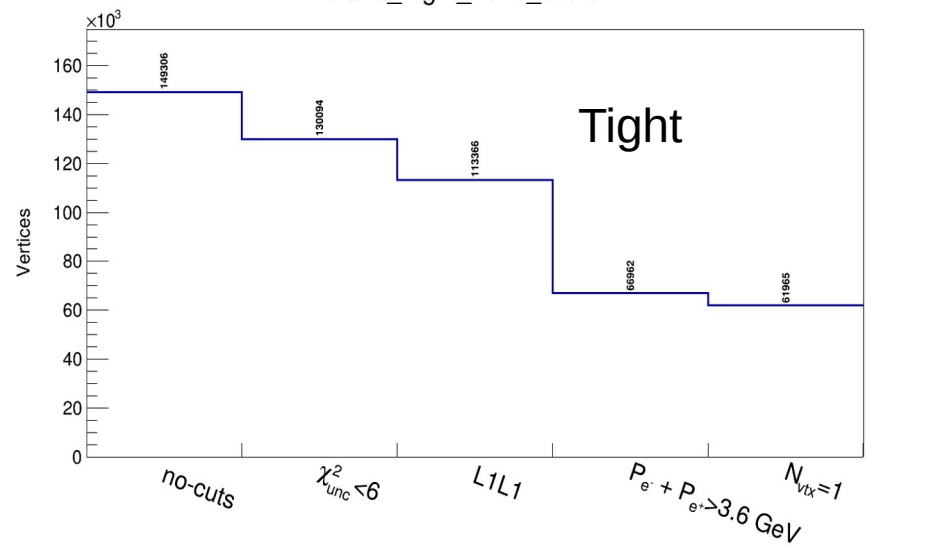
Expected Signal Rate for 100% of 2016 Lumi



- Used z-cut values from Matt S to validate expected signal rate calculation
- Expected signal rate appears to agree well with Matt S code

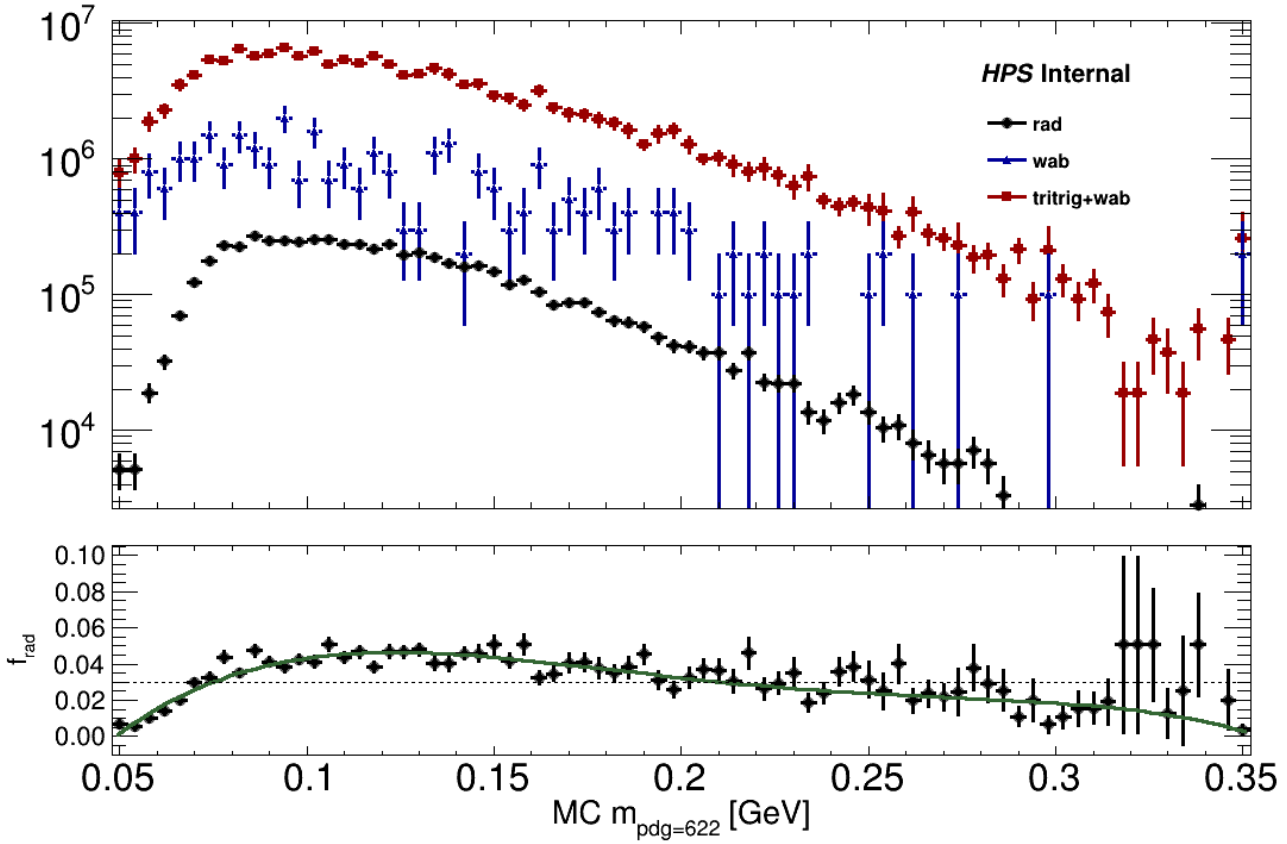
Rad cutflow for 2019 MC





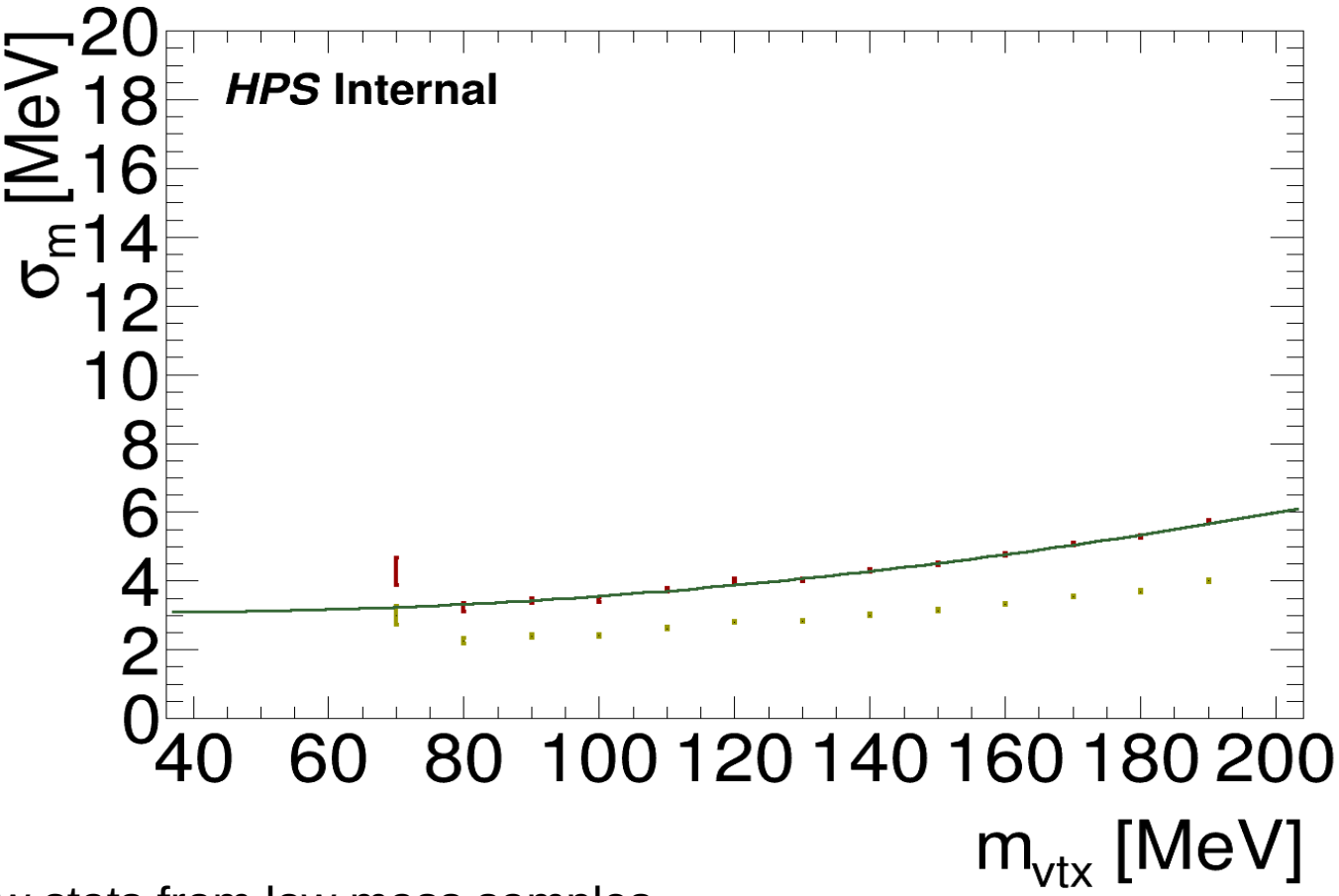
- 1071864 events passed the singles3 trigger
- 61965 events after the full selection
- 3.6 GeV is a loose Psum cut
- https://confluence.slac.stanford.edu/display/hpsg/pass0b+for+2019+MC

Radiative Fraction for 2019 Reach



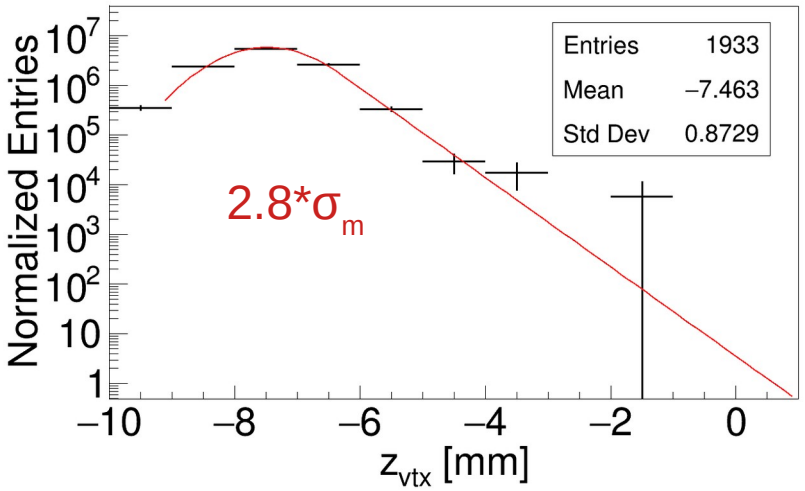
- “pass0b” using the singles3 trigger produced by TongTong
- This is weighted to the differential rate for 110/pb, which is the lumi from optimizing area for 16 total more weeks
- WAB stats are low as usual

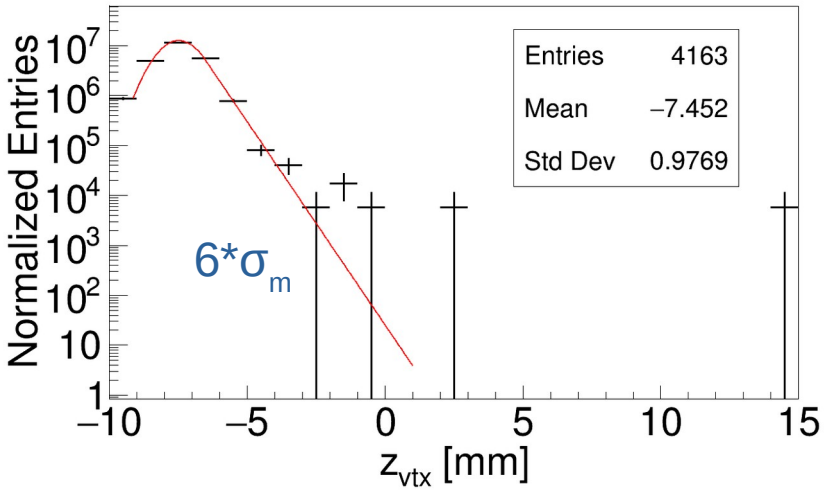
Mass Resolution for 2019 Reach

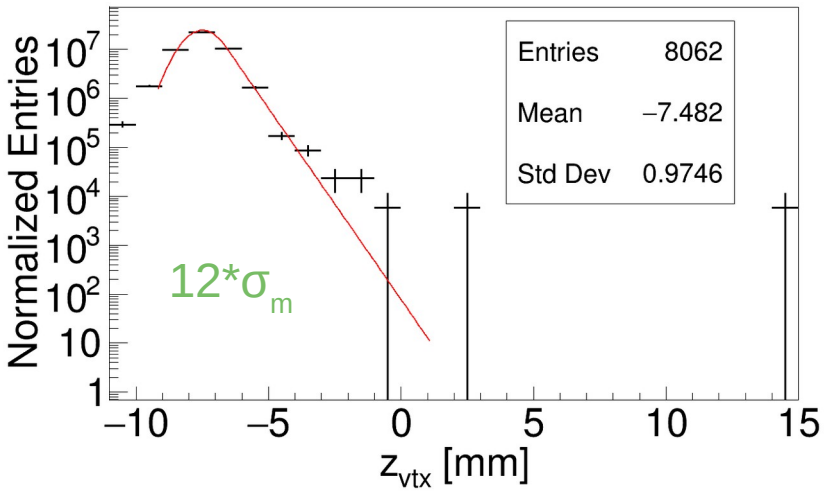


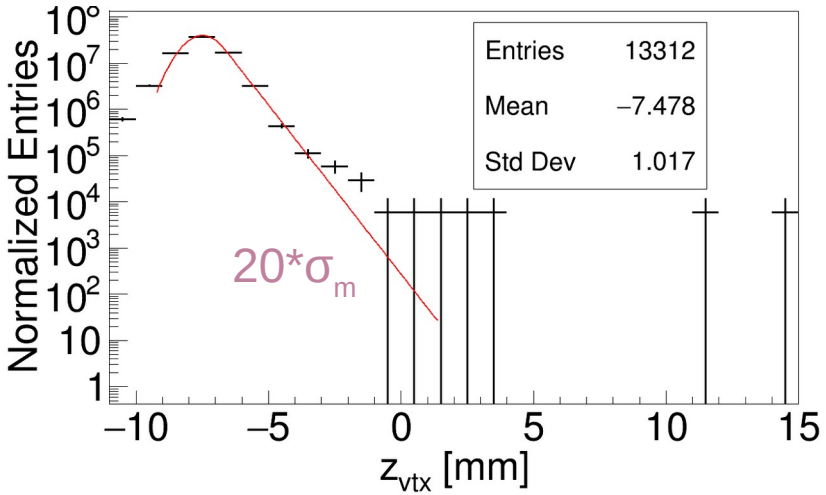
- Low stats from low mass samples
- Resolution from fit scaled up by 43%
- Parameterized by 3rd order polynomial, chosen via f-test

Vertex Z Distribution Fits for 2019 Reach



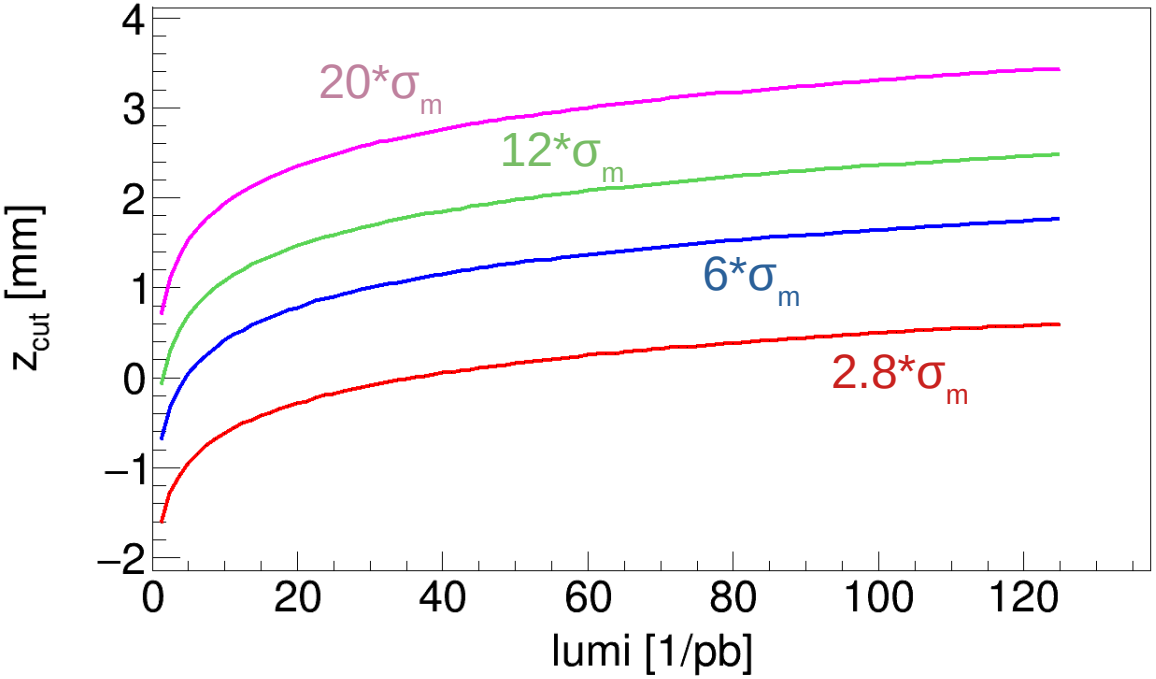






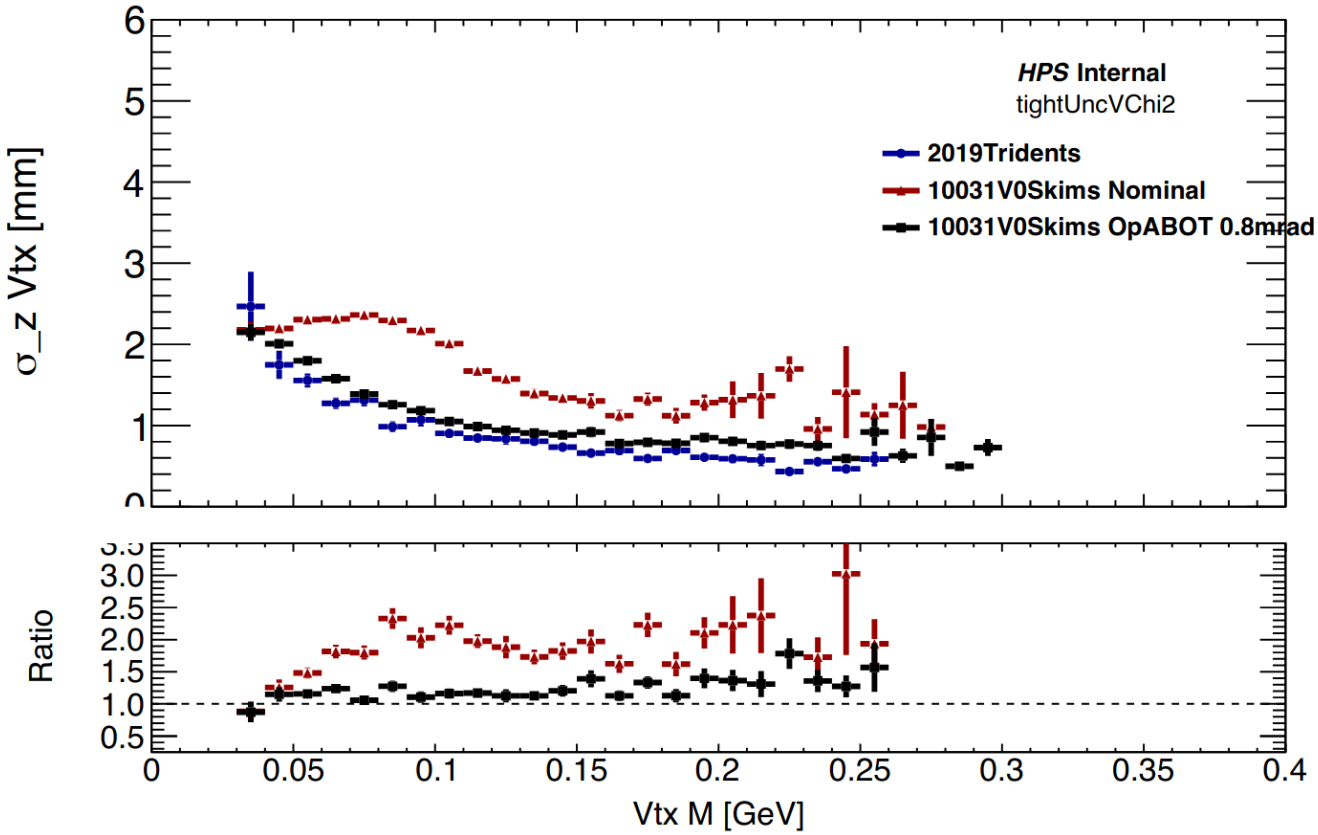
- Fits using different widow sizes in mass centered around 150 MeV

Zcut Luminosity Scaling Study



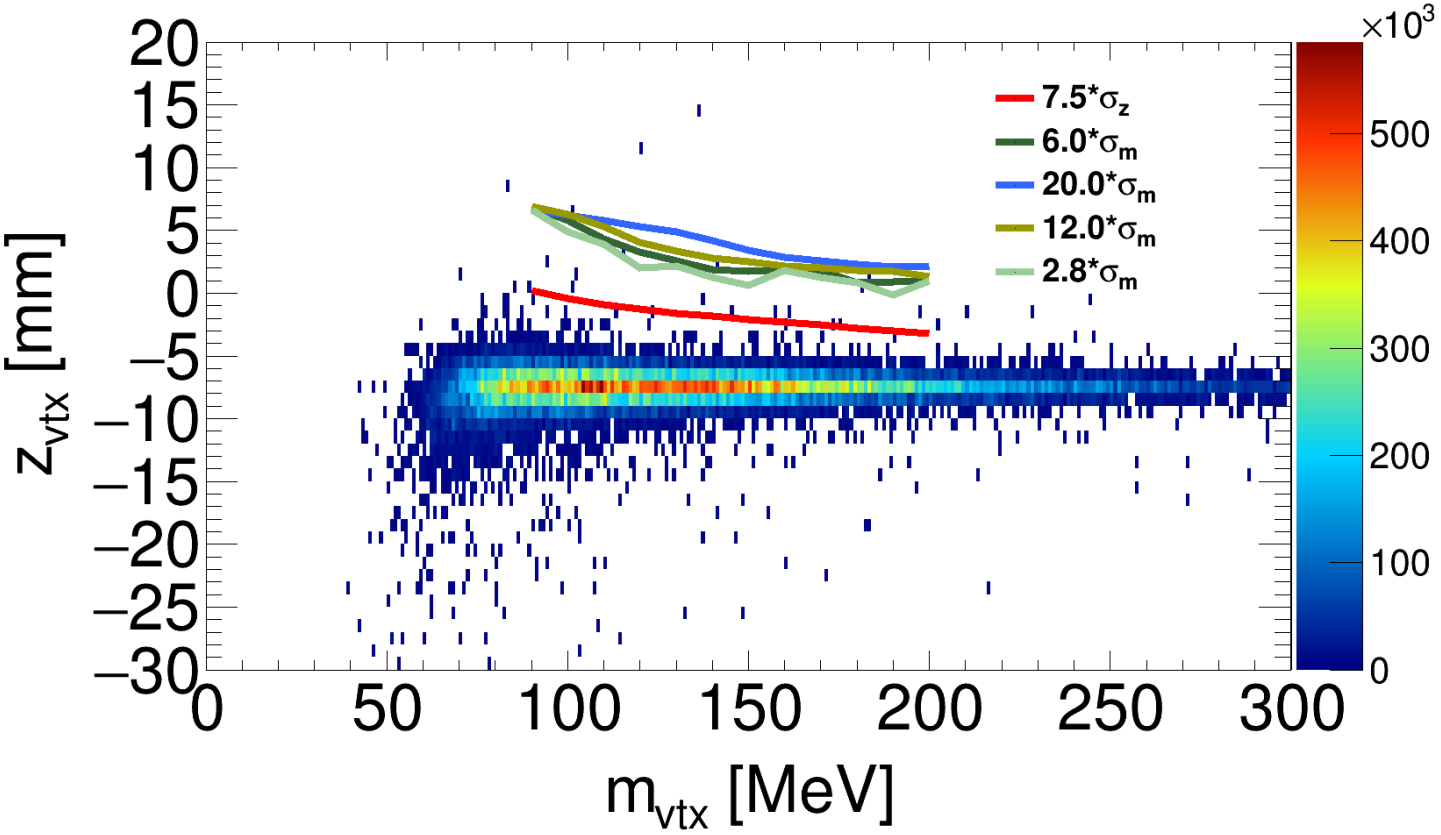
- Studied using the method used in 2015 and 2016 analysis notes applied to the 2019 MC
  - Scale the fit and recompute the 0.5 tail event interval
  - Fit result with A*log(Lumi)+B to estimate lumi scaling contribution to the zcut value

Vertex Z Resolution for 2019 Reach



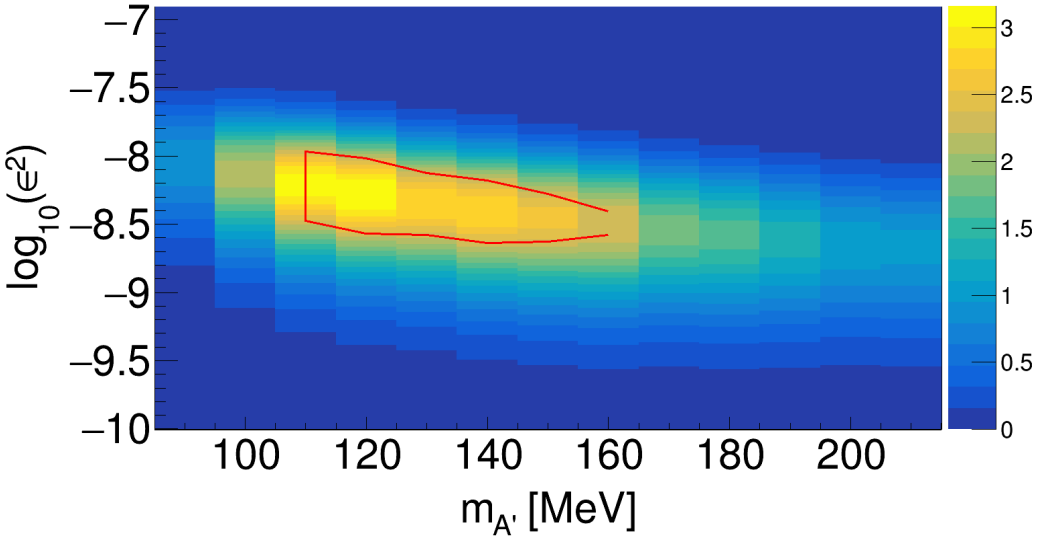
- Using MC vtx Z resolution from 2019Tridents
  - Thanks to PF for this plot
  - Fit the blue points with a polynomial, won't bore you with those details

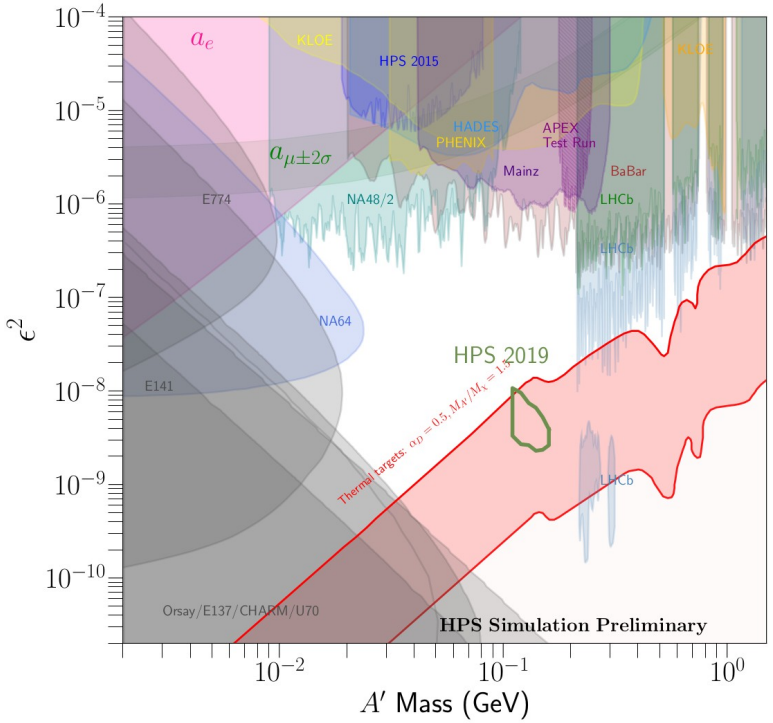
Comparison of Zcuts for 2019 Reach



- Zcuts taken from different procedures based on normal fits and via calibration of N*σ_z via “scaling” 2016 zcuts
- Zcut values from vtx distribution fits not great with small effective MC lumi

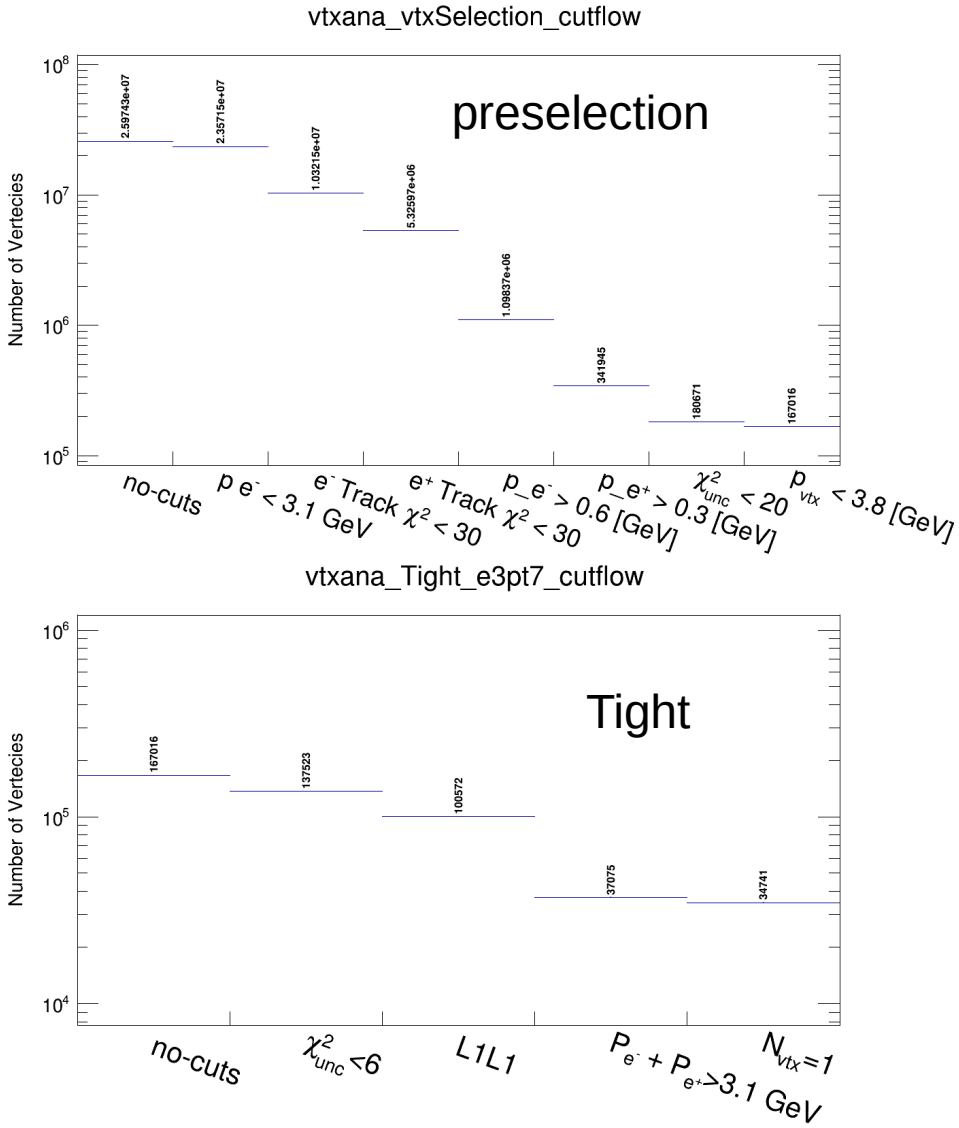
Expected Signal Rate for 2019 Reach





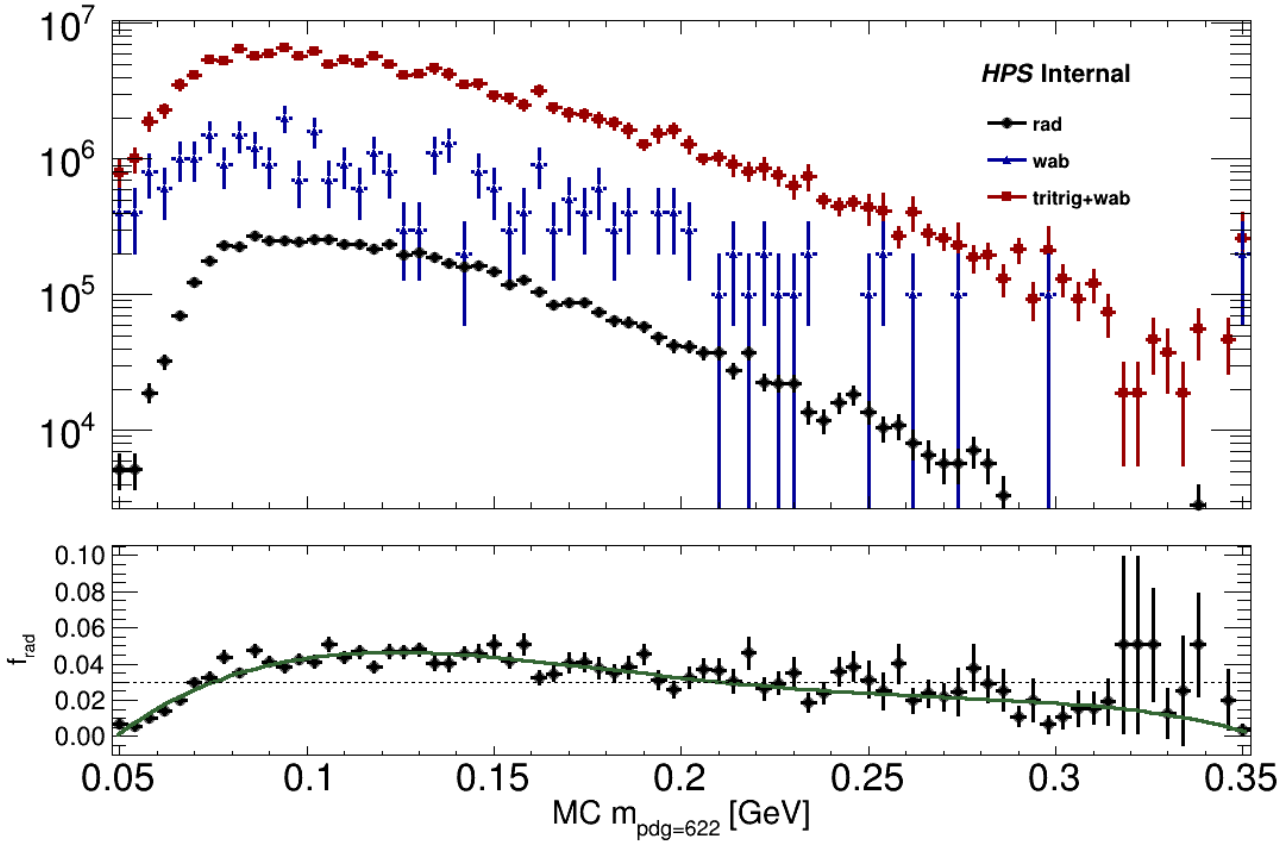
- Used z-cut values scaled from values used in 2016 analysis
- Look like we have a good shot at making an exclusion with the 2019 data!

Rad cutflow for 3.7 GeV MC



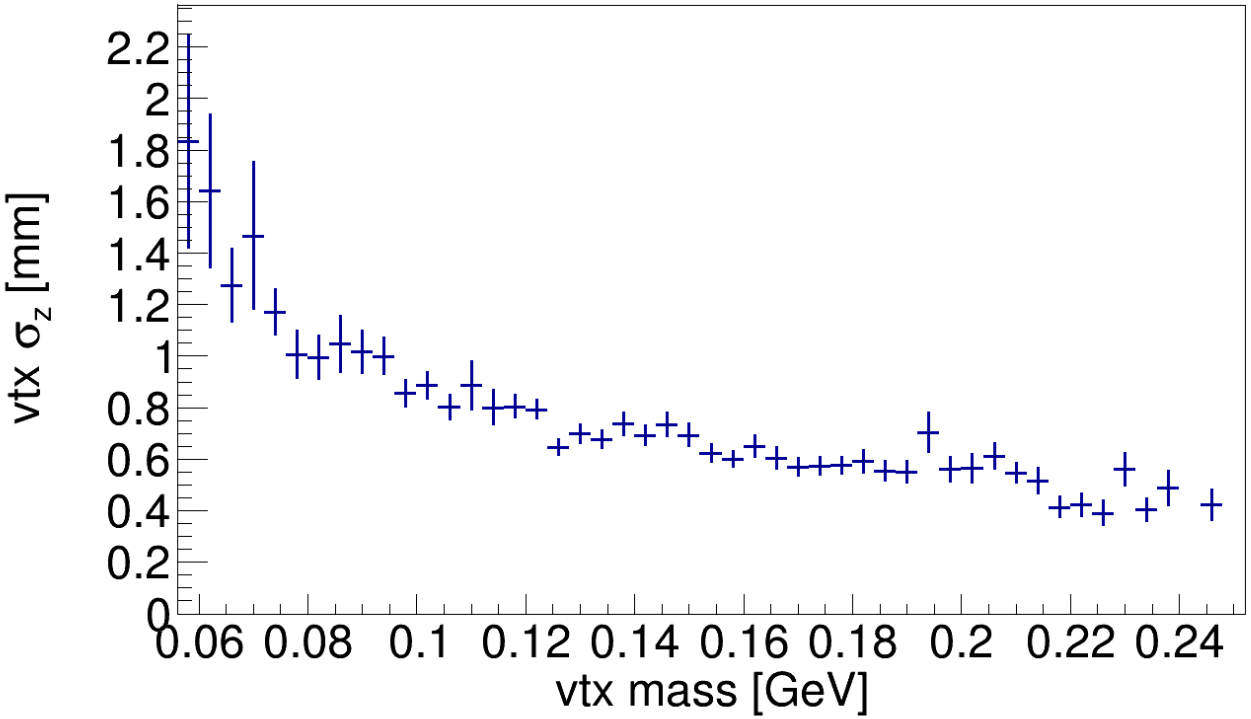
- 1143478 events passed the singles3 trigger
- 34741 events after the full selection
- 3.1 GeV is a loose momentum sum cut in my opinion
- https://confluence.slac.stanford.edu/display/hpsg/pass0b+for+future+3.7+GeV

Radiative Fraction for 3.7 GeV



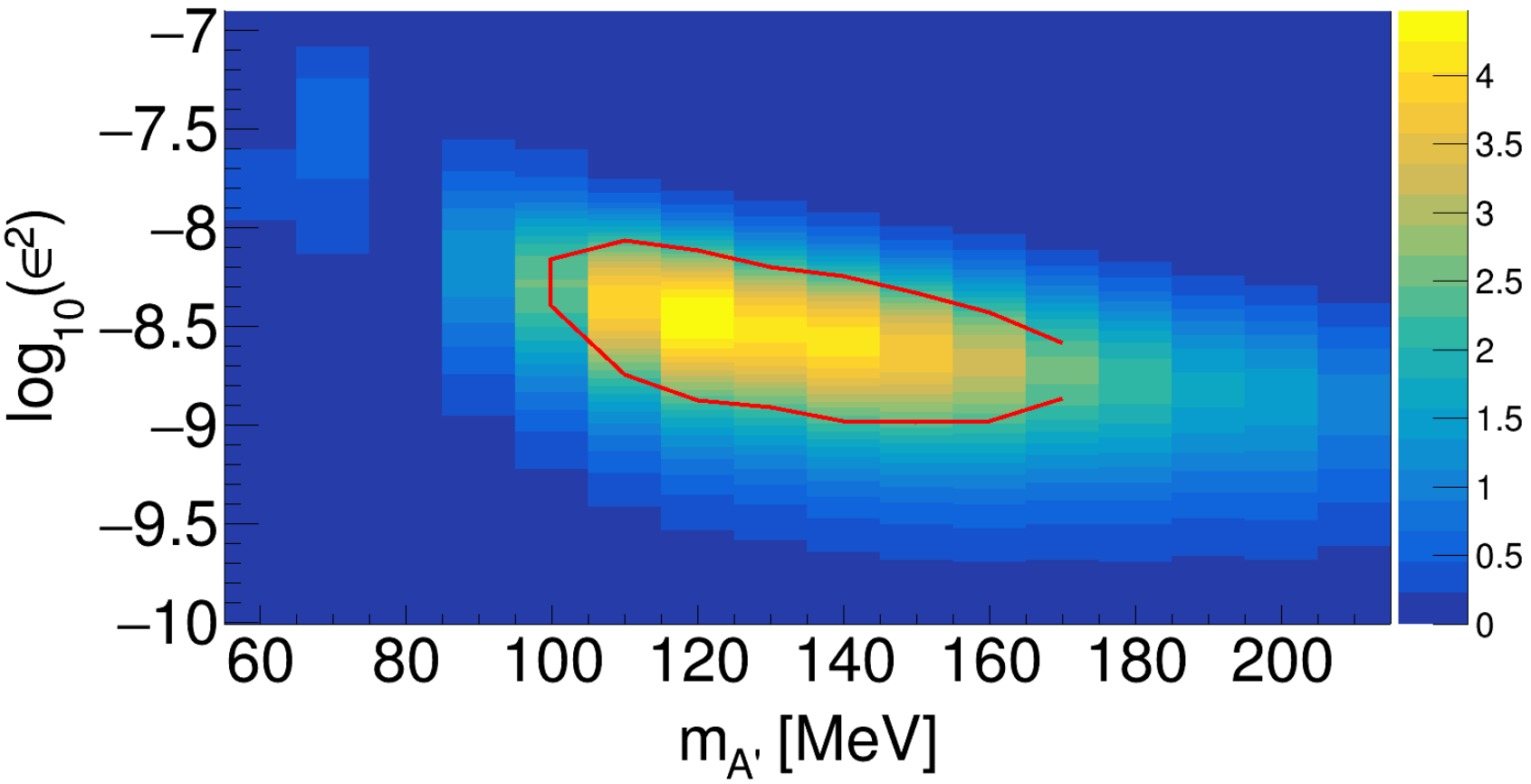
- “pass0b” using the singles3 trigger produced by TongTong
- This is weighted to the differential rate for 530/pb, which is the approximate lumi for 10 weeks
- WAB stats are low as usual

Vertex Z Resolution for 3.7 GeV



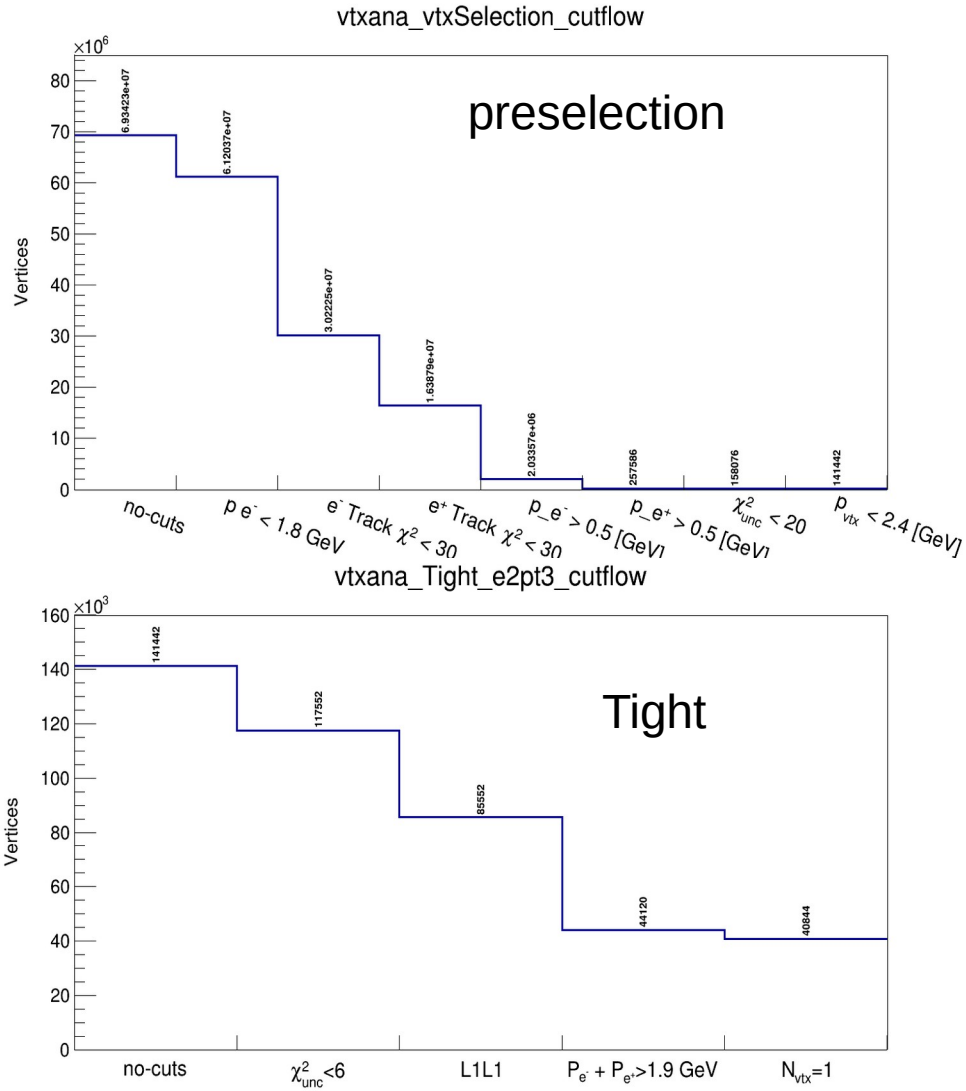
- Using MC vtx Z resolution from the 3.7 GeV tritrig sample
  - Thanks to PF for the assist on this
  - Fit the points with a polynomial, won't bore you with those details
  - At 150 MeV we have 0.7 mm, so 8.0*σ_z is a reasonable calibration, then add 1.5 for lumi scaling

Expected Signal Rate for 3.7 GeV Reach



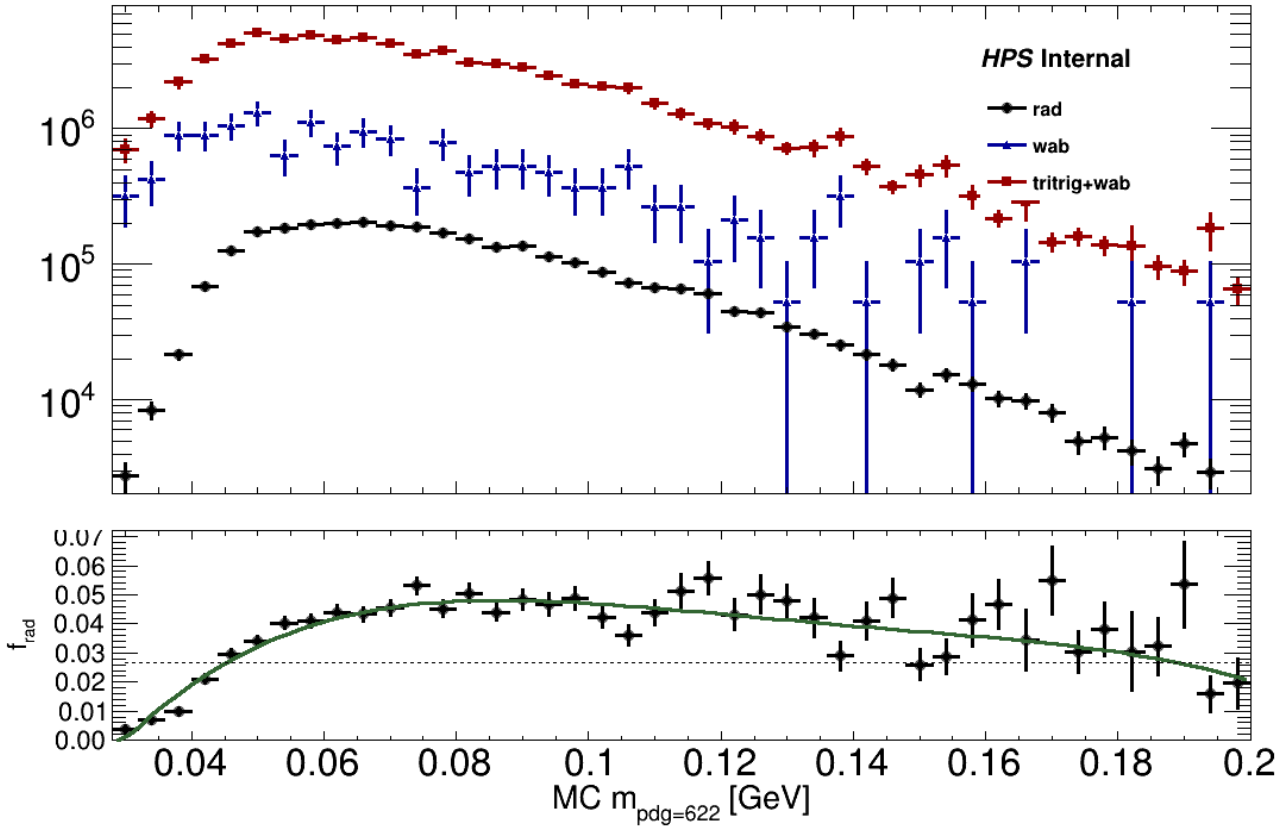
- Zcuts used are conservative
  - Zcut = 0.5*log(lumi) + 7.4*σ_z

Rad cutflow for 2.3 GeV MC



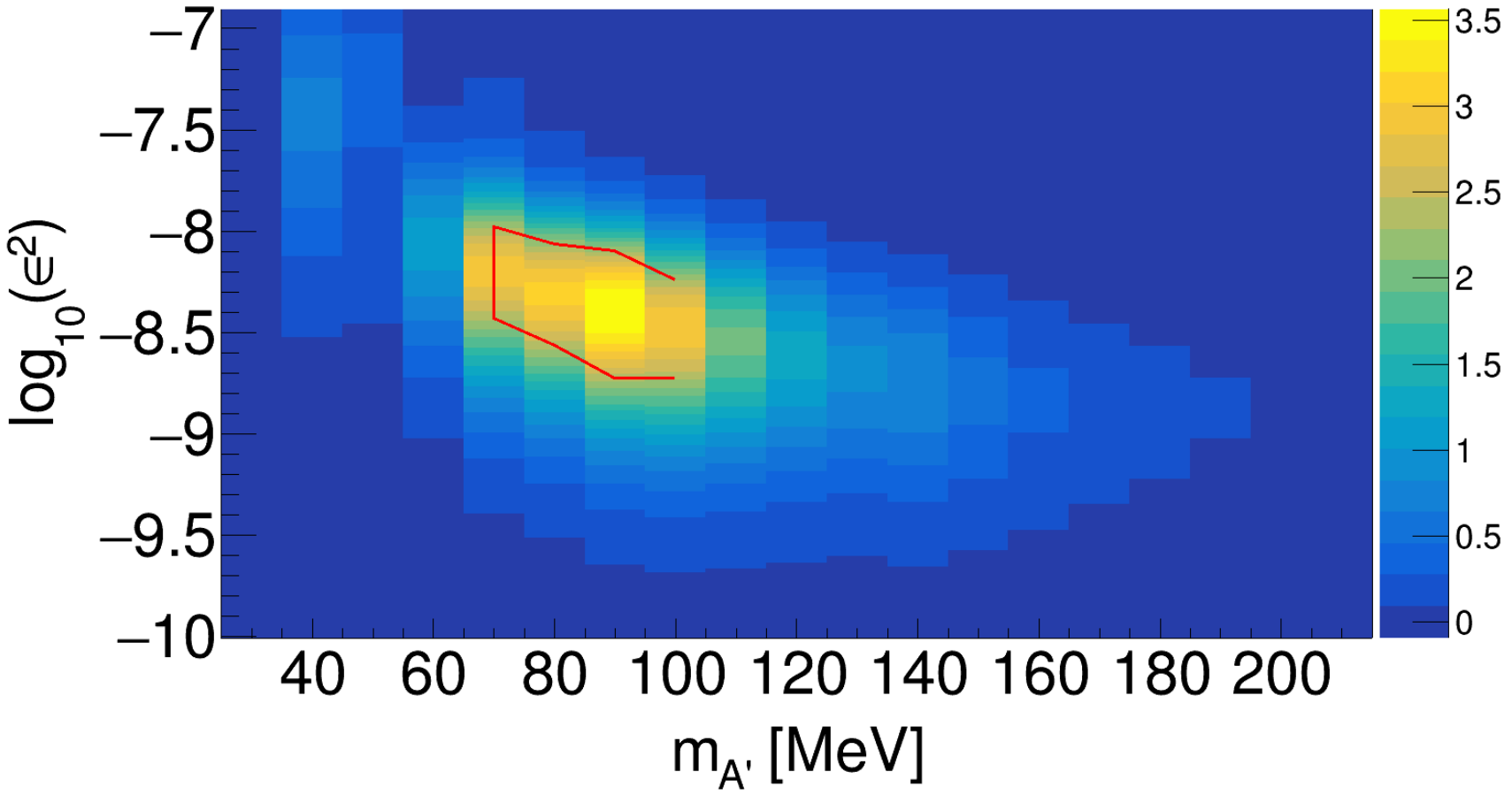
- 1378380 events passed the singles3 trigger
- 40844 events after full selection
- 1.9 GeV is a loose momentum sum cut in my opinion
- https://confluence.slac.stanford.edu/display/hpsg/pass0b+for+future+2.3+GeV

Radiative Fraction for 2.3 GeV



- “pass0b” using the singles3 trigger produced by TongTong
- This is weighted to the differential rate for 106/pb, which is the approximate lumi for 6 weeks
- WAB stats are low as usual

Expected Signal Rate for 2.3 GeV Reach

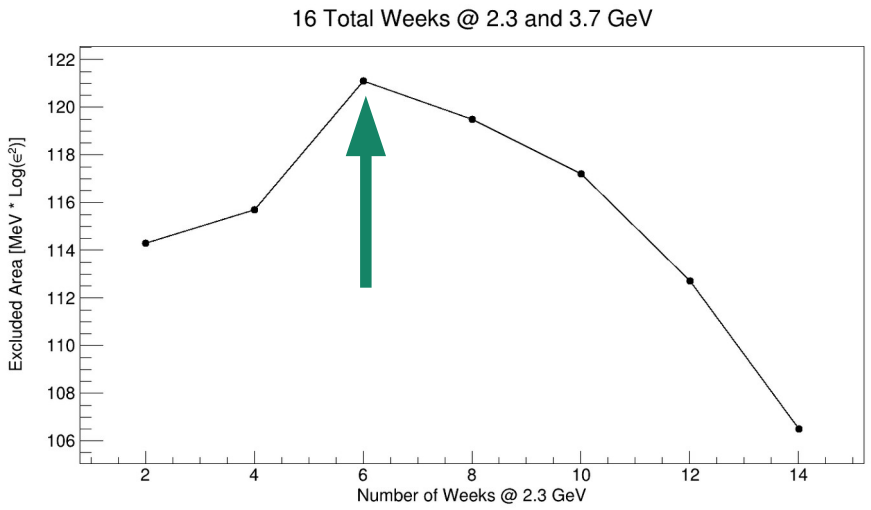


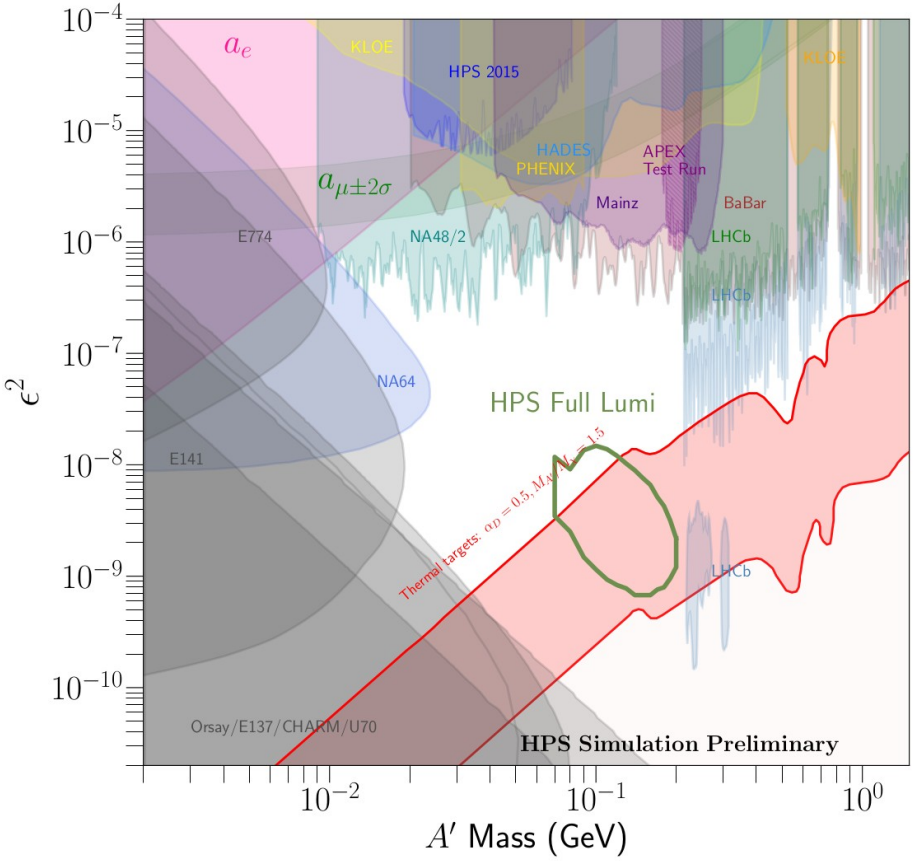
- Zcuts used are conservative (calibrated to ~2016 value / 2)
  - Zcut = 0.5*log(lumi) + 7.0*σ_z

Overview of Study for Full HPS Lumi

- Zcuts have a contribution from exponential tail which changes as a function of lumi
  - Fit using 2016 procedure, scale fit to different lumis, compute the 0.5 tail event interval
  - Used 0.5*Log(Lumi) for this contribution
  - It does vary by about 20% depending on the mass
  - Already have an uncertainty since we are “scaling” from 2016
- Add expected signal from 2019 run to that of 2.3 and 3.7 GeV future runs, calculate excluded area
  - Want to find best way to distribute remaining 16 weeks

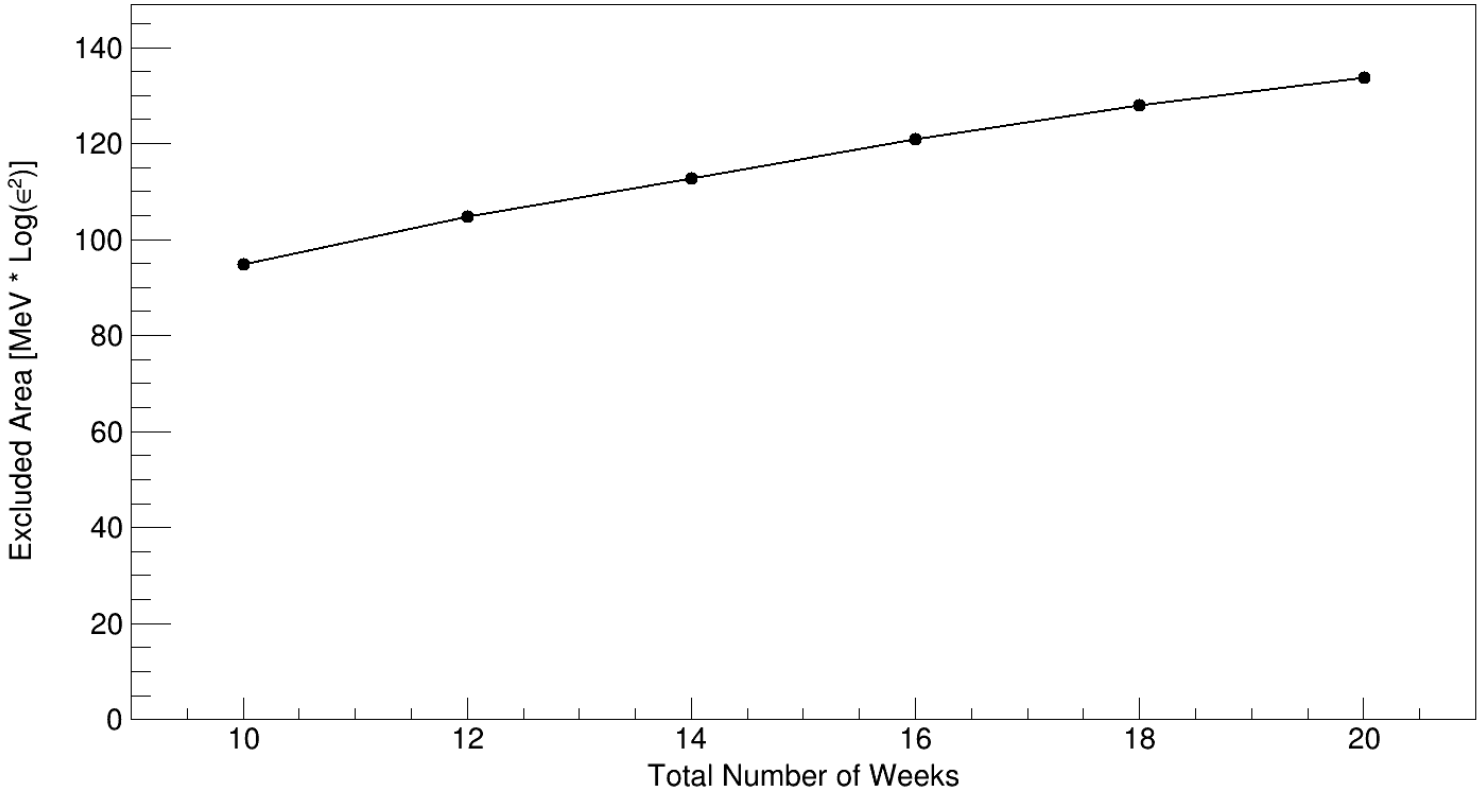
Optimizing Lumi Distribution between 2.3 and 3.7 GeV





- We can see the optimum for a total of 16 remaining weeks is to use 6 weeks at 2.3 GeV and 10 weeks at 3.7 GeV
- Repeat this for different N total weeks

Reach Estimate for Full HPS Lumi



- We seem to be able to exclude physics at roughly the same rate wrt to beam-time from 10 to 20 weeks!

Conclusion

- The results of this study were used in JLab PAC presentation for jeopardy
  - We were successful in defending ourselves
  - Can improve upon this after doing 2019 analysis because then we will have a better basis for “scaling” Zcuts for the analysis
- Need to find time to write an internal note to record all the details in a clear format, right now it is all just on my desktop at SLAC and a few sets of slides
  - Anyone have some spare time lying around?