

Update on 2019 Reach Estimates

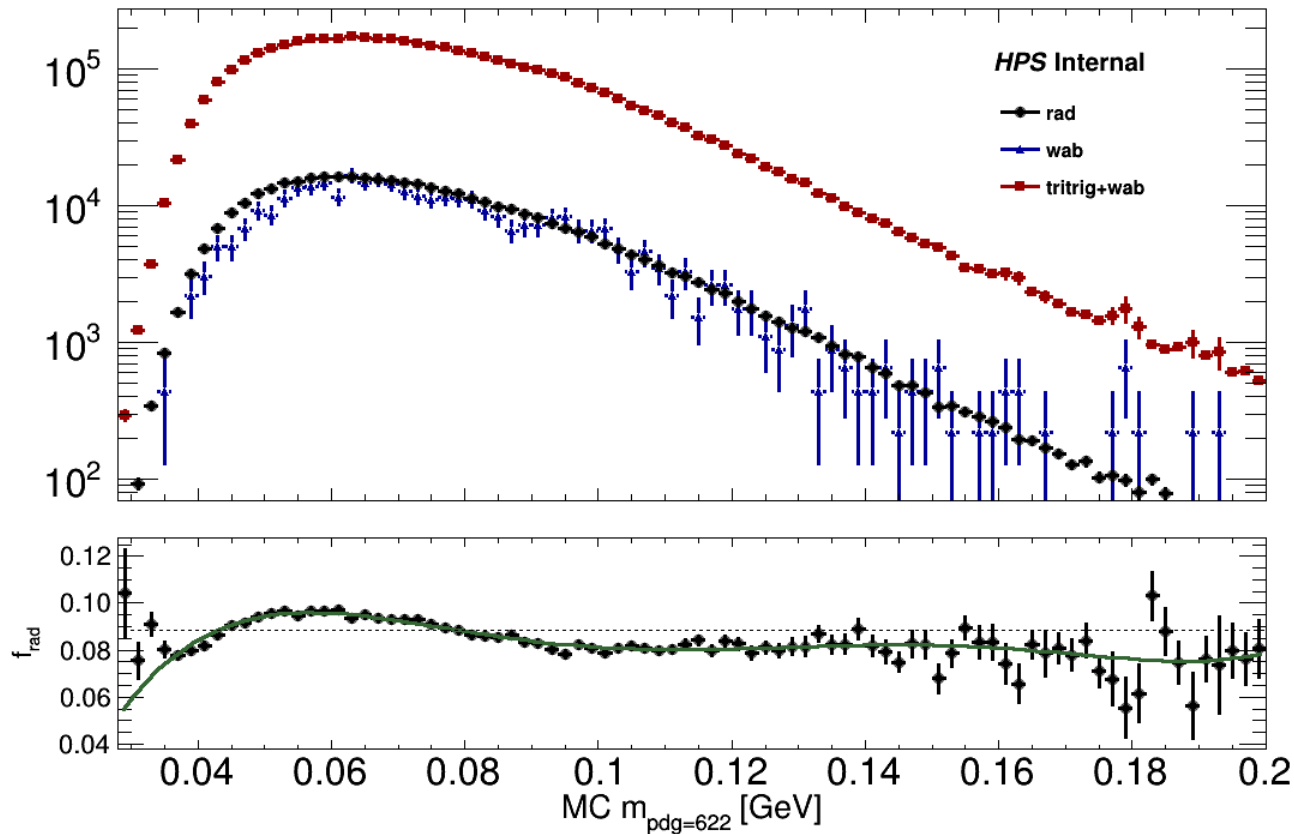
Cameron Bravo (SLAC)



Start with 2016 MC

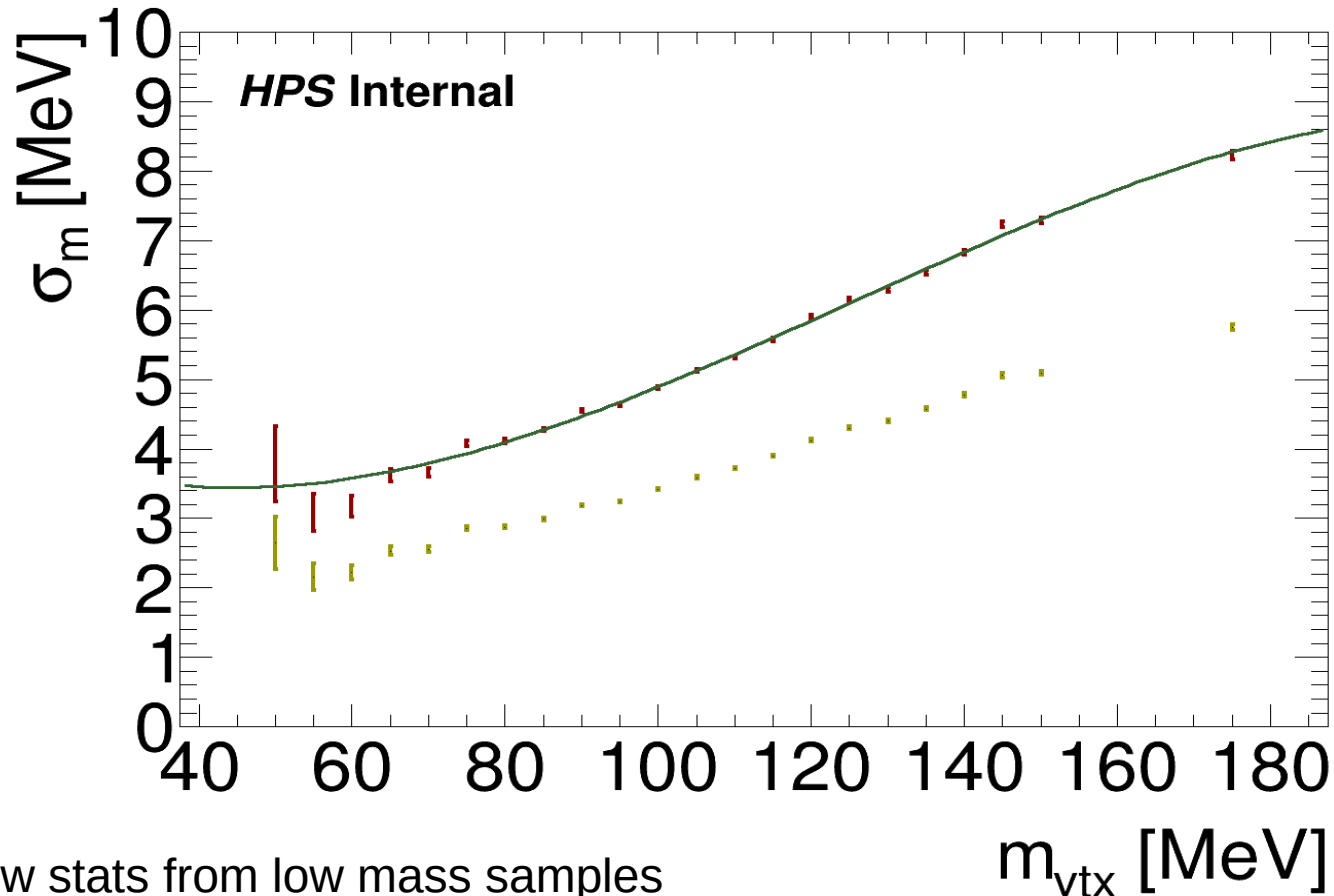
- Develop and validate tools in hpstr using 2016 MC
 - MC for 2019 was not ready to produce reach initially
 - Tools needed to be ported into hpstr
- Use same pre-selection as 2016 vertex analysis
- Also include several of the “Tight” selection requirements
 - Unconstrained vertex fit $\chi^2 < 4.0$
 - Energy sum > 2.0 GeV
 - Both tracks have layer 1 hit (L1L1 signal region only)
 - Only one vertex in event passing selection requirements

Radiative Fraction



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

Mass Resolution



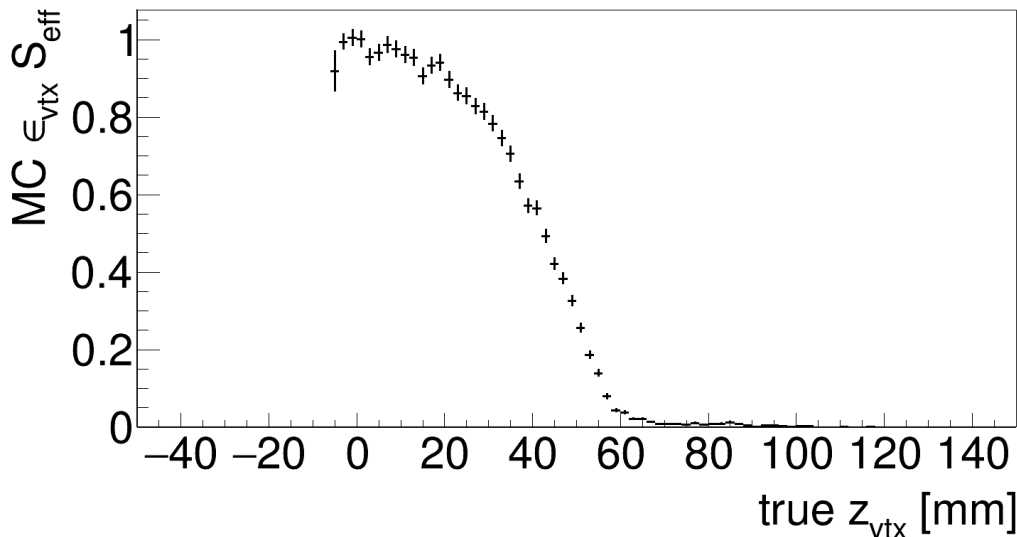
- Low stats from low mass samples
- Appears to be close to result from Matt S, slightly higher
- Fit resolution scaled by 1.43 (this number came from Matt S)
- Parameterized by 3rd order polynomial, chosen via f-test

Expected Signal Rate Theory

$$s_{bin, zCut} = f_{rad} N_{bin} \frac{3\pi\epsilon^2}{2N_{eff}\alpha} \frac{m_{A'}}{\delta m_{A'}} \epsilon_{bin} \int_{zCut}^{zMax} \frac{e^{(z_{targ}-z)/\gamma_{CT}}}{\gamma_{CT}} \epsilon_{vtx}(z, m_{A'}) dz$$

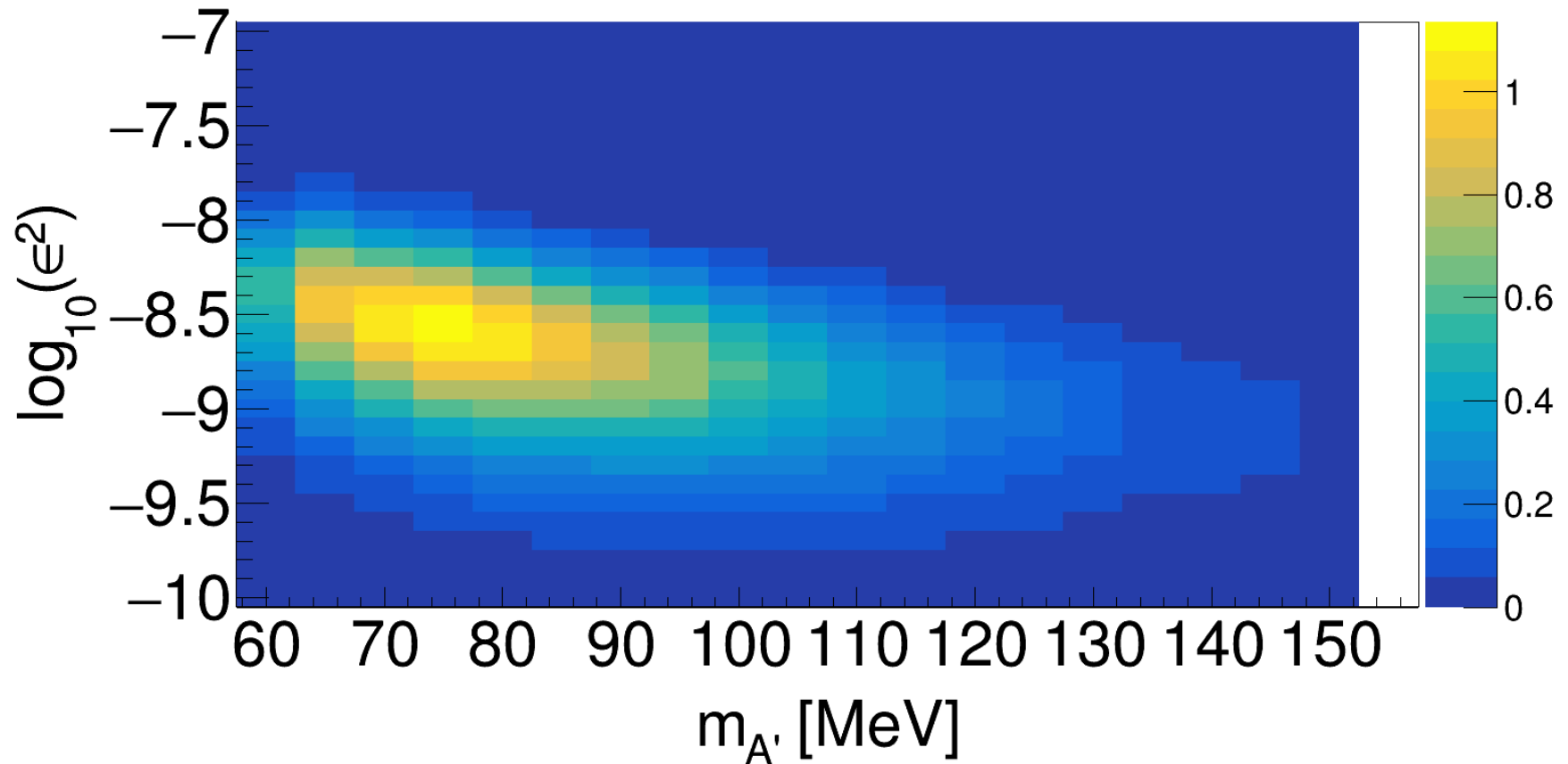
$$N_{sig} = \frac{3\pi\epsilon^2 m_{A'}}{2N_{eff}\alpha} f_{rad} \frac{dN}{dm_{bkg}} \cdot \epsilon_{vtx}(m_{A'}) \cdot S_{eff}$$

$$\epsilon_{vtx}(m_{A'}) = \int_{-4.3}^{\infty} \frac{e^{(-4.3-z)/\gamma_{CT}}}{\gamma_{CT}} \epsilon_{vtxsel}(z, m_{A'}) dz$$



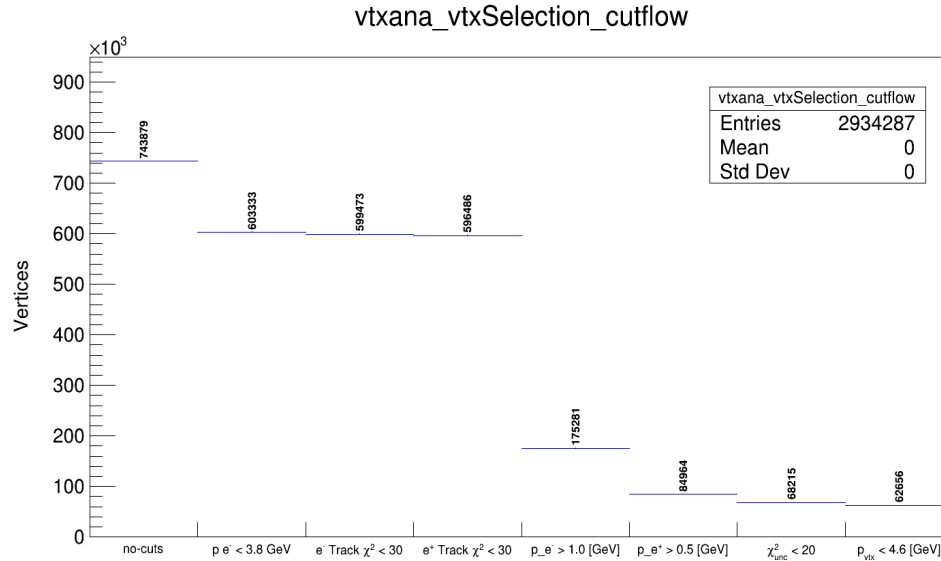
- My way of writing this
- Example efficiency is NOT the bottom equation
 - $m_{A'} = 100$ MeV
 - MC eff with selection before z_{cut}
- Approximate integral by only integrating to 150 MeV

Expected Signal Rate for 100% of 2016

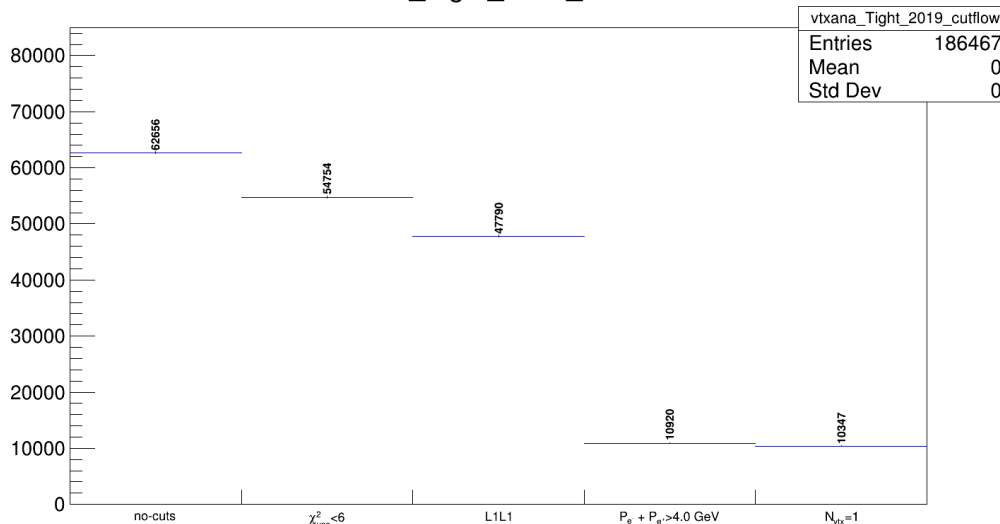


- Took zcuts directly from Matt S for best comparison
- This agrees well with what [Matt S showed yesterday](#)

2019 MC Cutflow from Tritrig

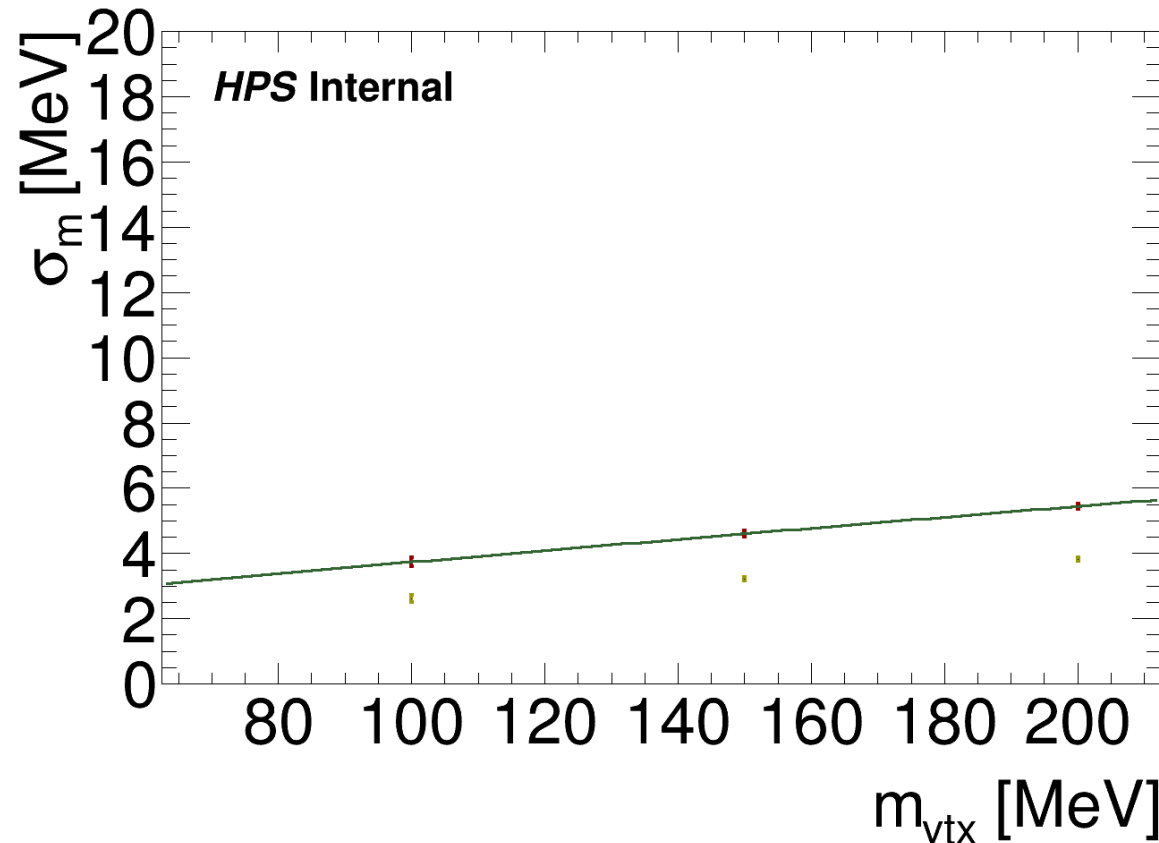


vtxana_Tight_2019_cutflow



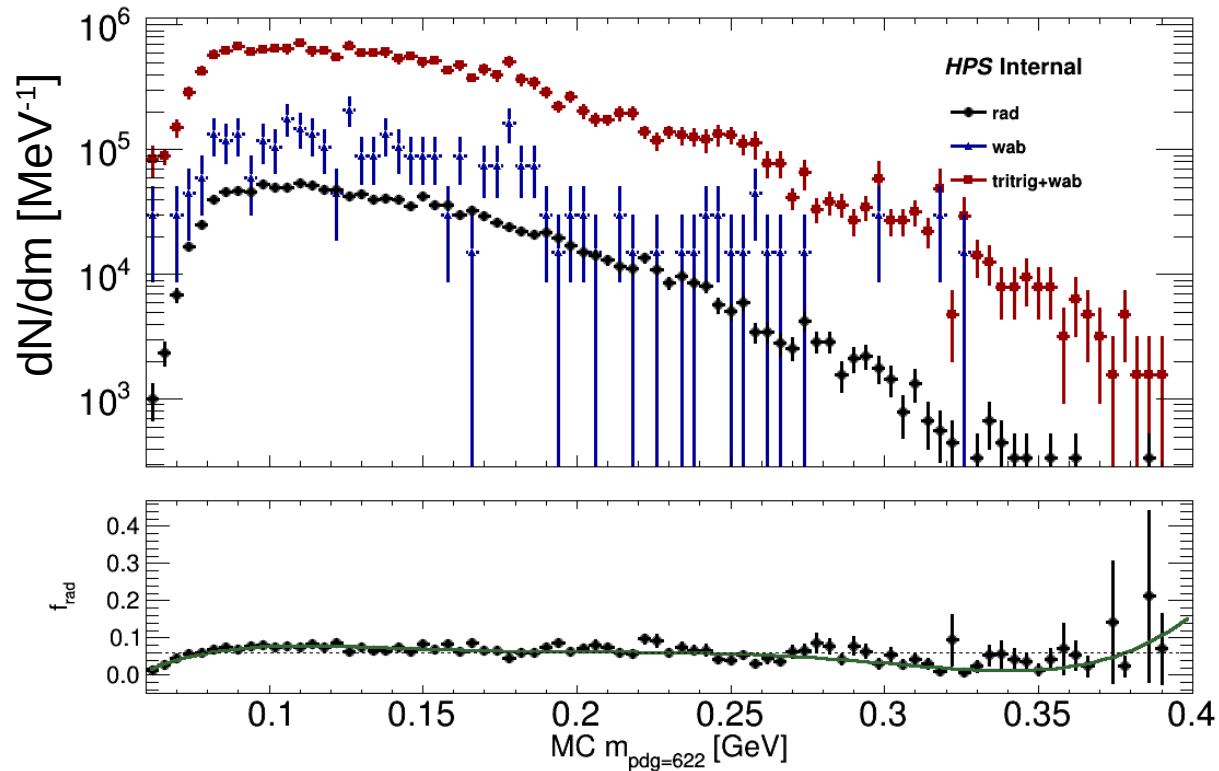
- Saw 351,508 tritrig events pass the trigger, using only good files
- This can be easily changed if we want to use a different selection
 - Running on all the A' MC again would take a couple days
 - This seems to be at good place to start
- End with 10,347 events after the full selection

Mass Resolution for 2019



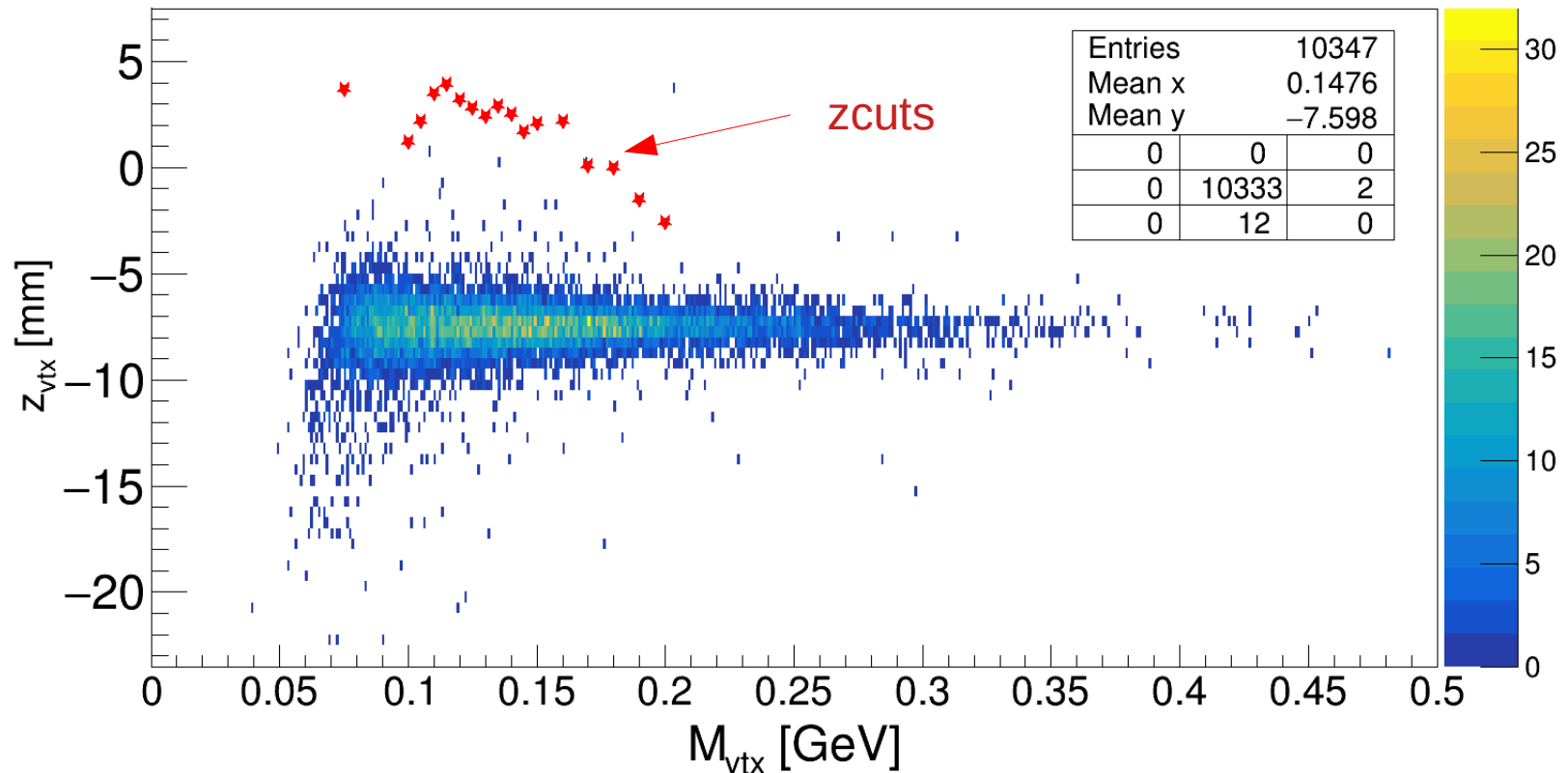
- Truth matching is broken somehow in newest A' samples, haven't had time to investigate exactly where it is broken
- Using result from first set of mass points produced by TongTong for now
- This isn't super important for a reach, though it is related to the zcuts

Radiative Fraction for 2019 MC



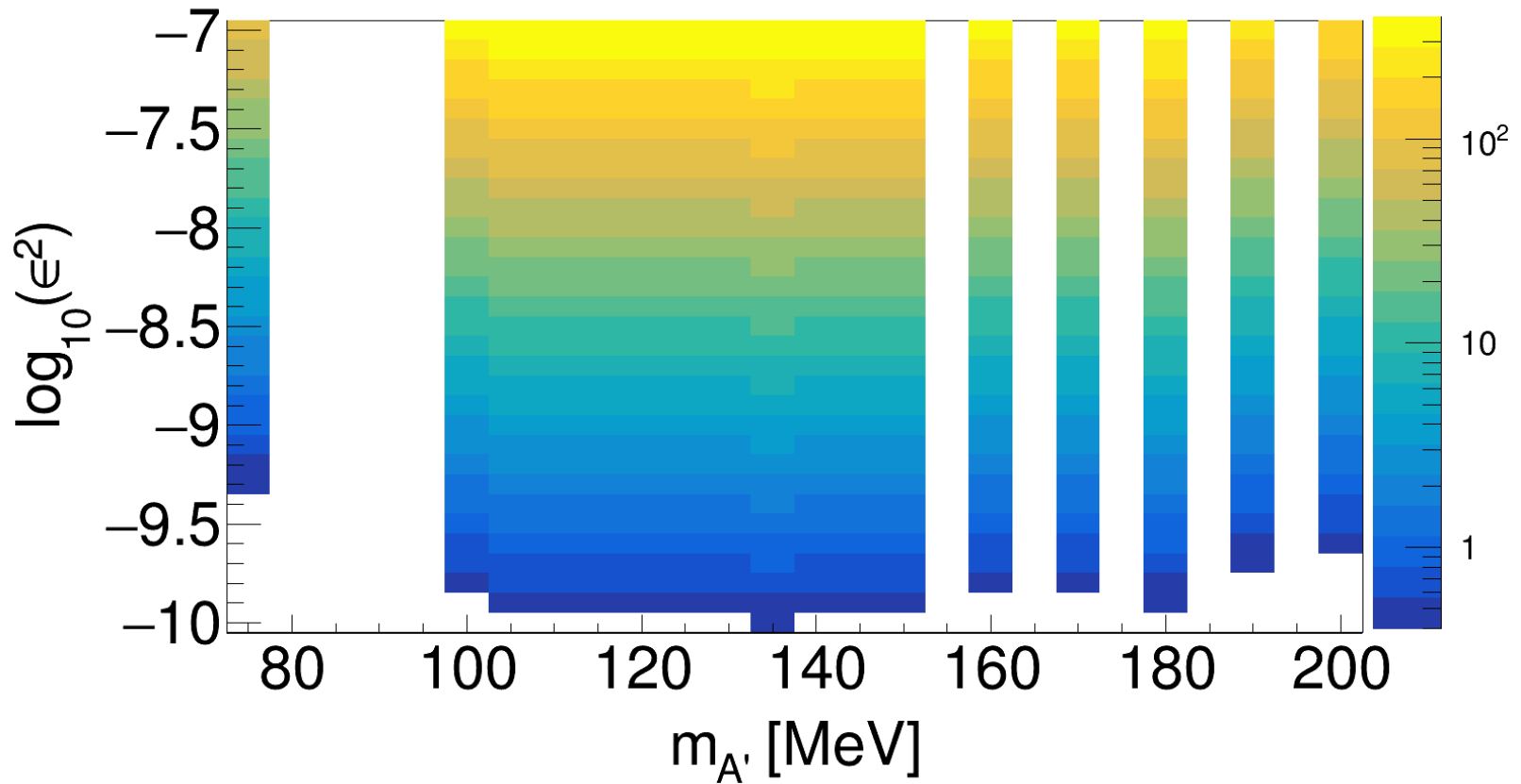
- Thanks to TongTong for generating the 4.55 GeV MC
- Scaled to Lumi of 125 1/pb
- Selection pretty much the same as 2016 scaled appropriately for beam E
- Bins here 4 MeV wide, highest bin has ~ 10 events

vtxana_Tight_2019_vtx_InvM_vtx_z_hh



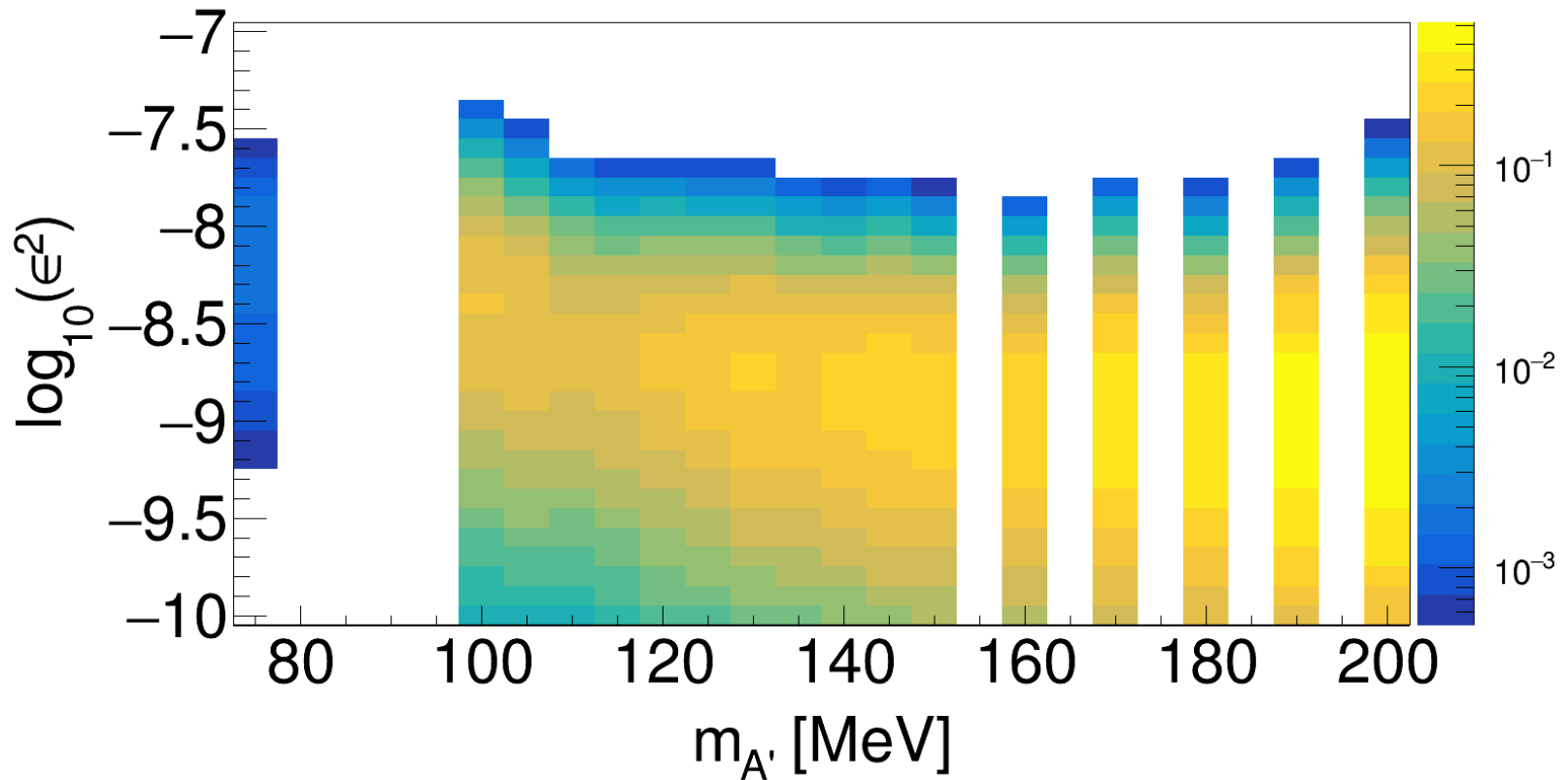
- This is pretty tough to judge based using so little MC stats
- This is using Matt S procedure, based on half-event tail integrals of a “gaussian+exponential” fit directly lifted from his code, applied to tritrig

A' Production Rate



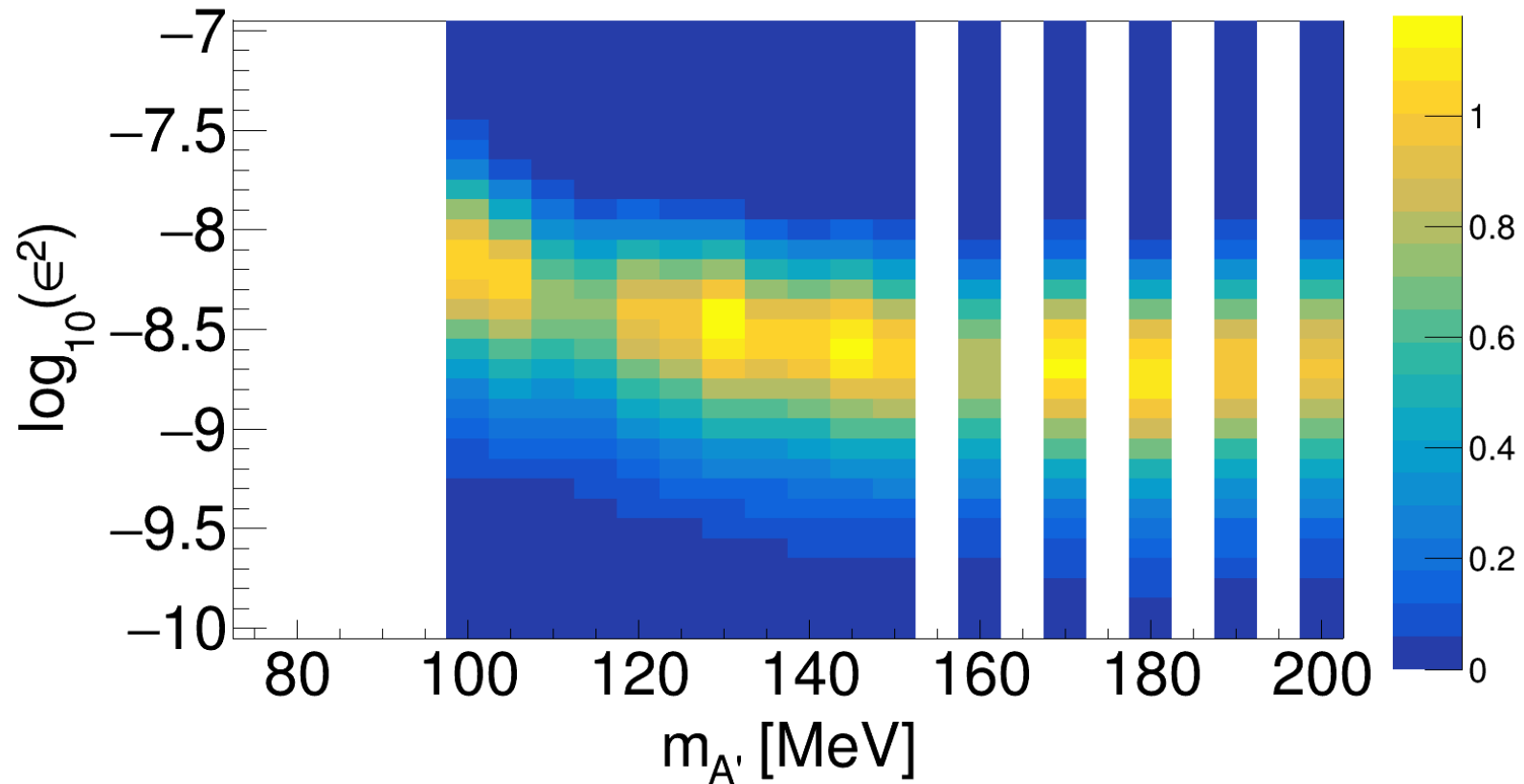
- This looks a little lower than I would hope for but we did only get about half the lumi we wanted in 2019 and we are a bit suspicious of the MC trident rate at the moment
- Let's see what is happening with the vertex efficiency

A' Vertex Efficiency



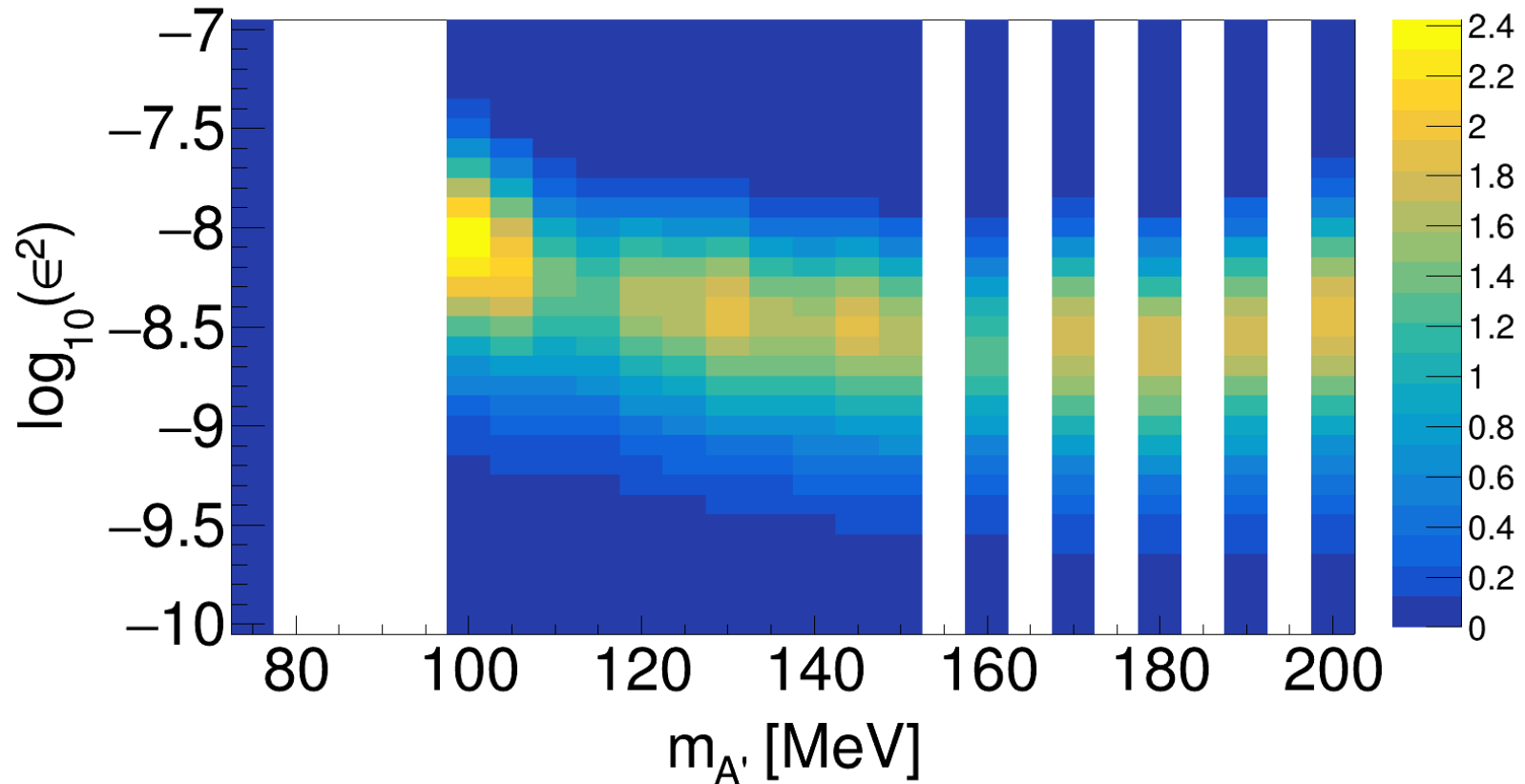
- This looking hairy is related to the MC stats and the zcuts
- Let's see the money plot now

Expected Signal Rate



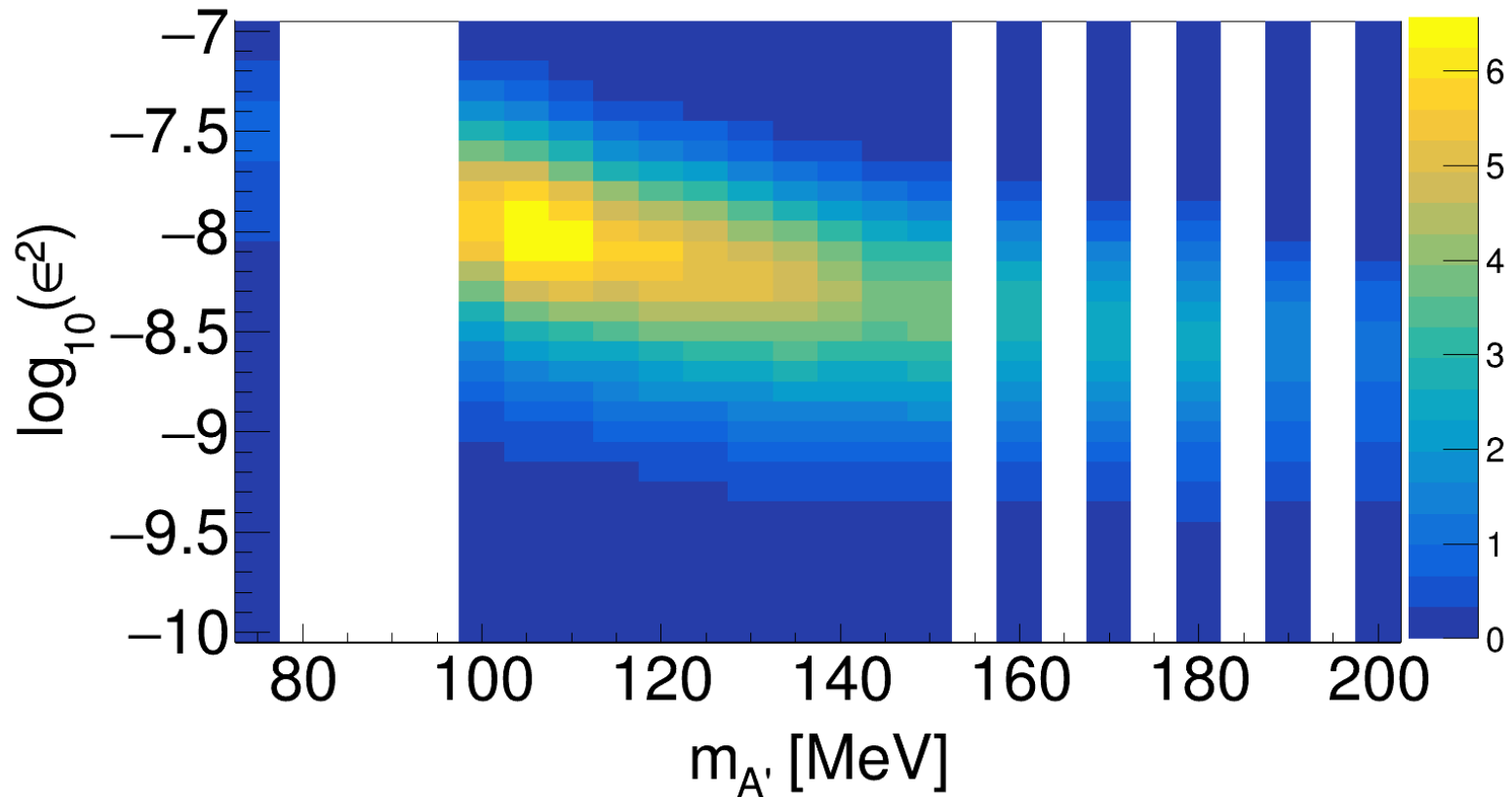
- This is very preliminary, maximum is about 1.2 events
- Working with Matt G to sort through where his reach and my reach diverge
 - Seems like he has a ~5x higher tritrig rate
 - Bunch of other smaller factors, still going through details

Expected Signal Rate with a Shifted Zcut



- Shift zcuts towards target by 2 mm for all masses
 - The zcuts I was getting were always higher than Matt S because he fits the data to get them and not MC, and he has more cuts
 - Keep in mind I don't have all Matt S cuts yet
- This and the dN_{bkg}/dm discrepancy could be most of the issues

Expected Signal Rate with Zcut = -3 mm



- Tried putting the zcut at -3 mm for all masses
 - This isn't a realistic at all, just trying to get some insight into the situation
 - These numbers make sense given the production rate we are seeing
- Need to understand what is going on in the MC better, the rate of tridents after the trigger seems low

- Now using hpstr to do reach studies
- Extracting Zcut is difficult with low stats MC
 - Planning on developing a technique to mitigate this issue
- Production rate seems low to start
 - This number pretty much just comes from f_{rad} and the differential background rate
 - f_{rad} seems to be reasonable
- Need to understand what is going in MC chain better
 - Trigger is new and little validation has been shown
 - Phase space cuts @ MadGraph biasing us at 4.55 GeV?
 - Matt G is seeing MC rate $\sim 2x$ lower than data