Update on Muon-Jets Analysis

Jim Pivarski

Texas A&M University

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Random comment

- Impressiveness of results is *not proportional* to the amount of work needed to make them!

Status

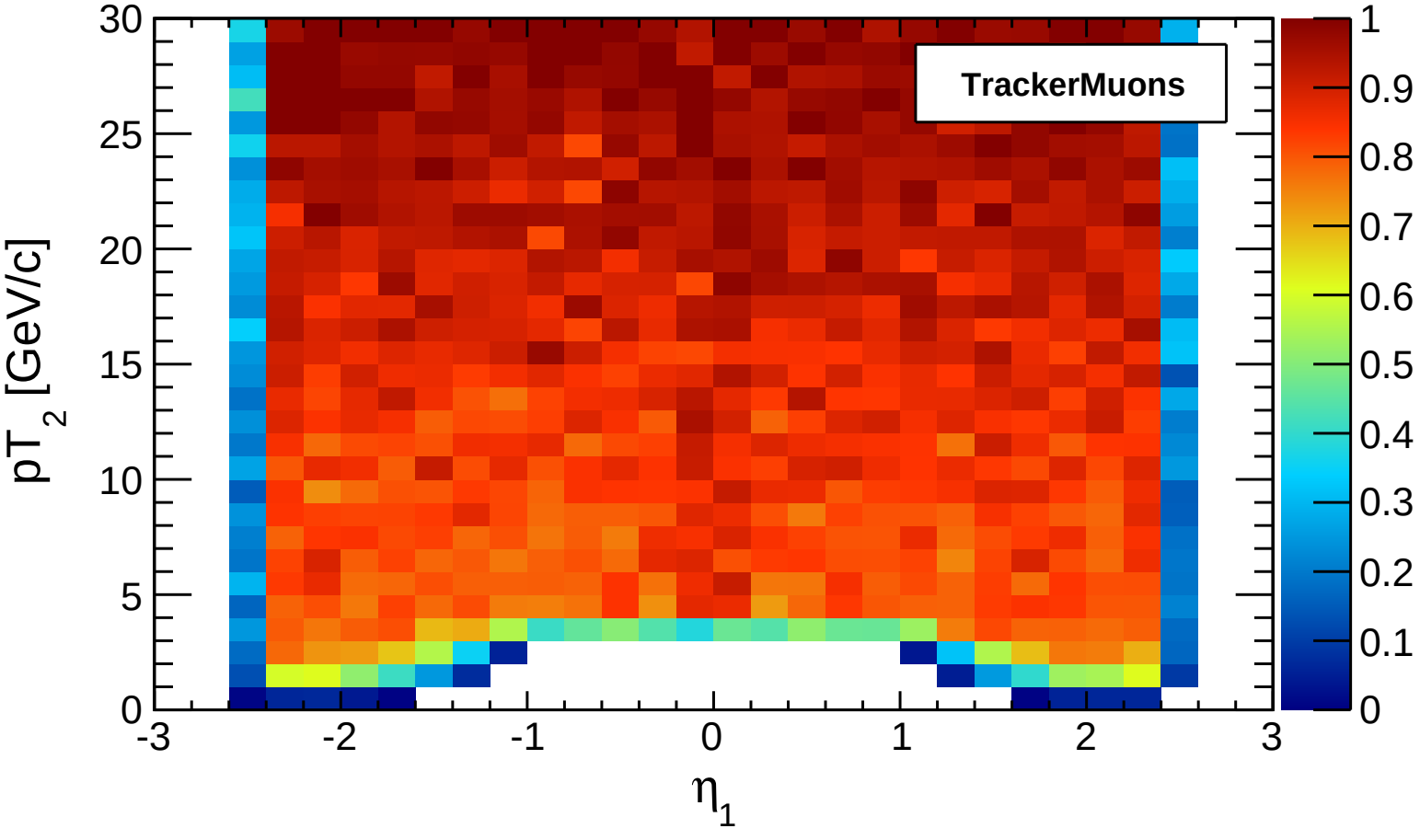
- Most efficiency plots are done, which tell us the baseline cuts for the backgrounds study

  (we want to start with ∼100% efficiency before adding additional cuts against background)

- Backgrounds are next
  - slight complication: globalMuons (now known to be a good starting point) were not properly saved as pat::Muons
  - perhaps they can be re-built from the reco::Tracks (I don't want to re-run all those CRAB jobs!)
- I'll be writing up the efficiency stuff in paper-format today
- Valerie posted an empty skeleton of an Analysis Note on Friday: I'll put all of my work there

The basic acceptance plot

For one muon-jet, we need $pT_2 > 5$ GeV/c (second-highest p_T) and $|\eta_1| < 2.4$ (highest absolute pseudorapidity)



From a dimuon gun uniform in dimuon mass, p_T (up to 100 GeV/c), and η, decaying spherically (used for all efficiency studies)

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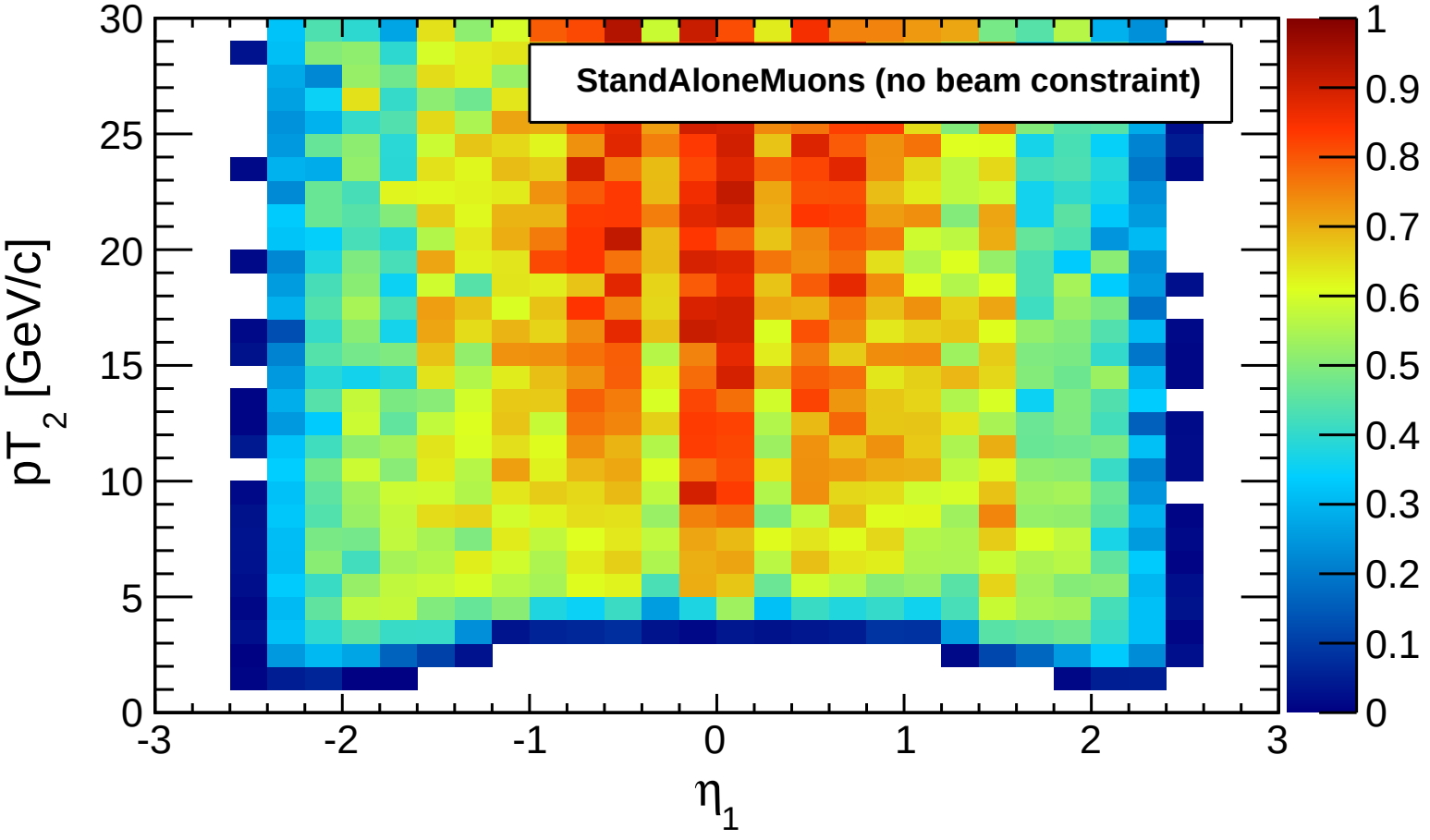
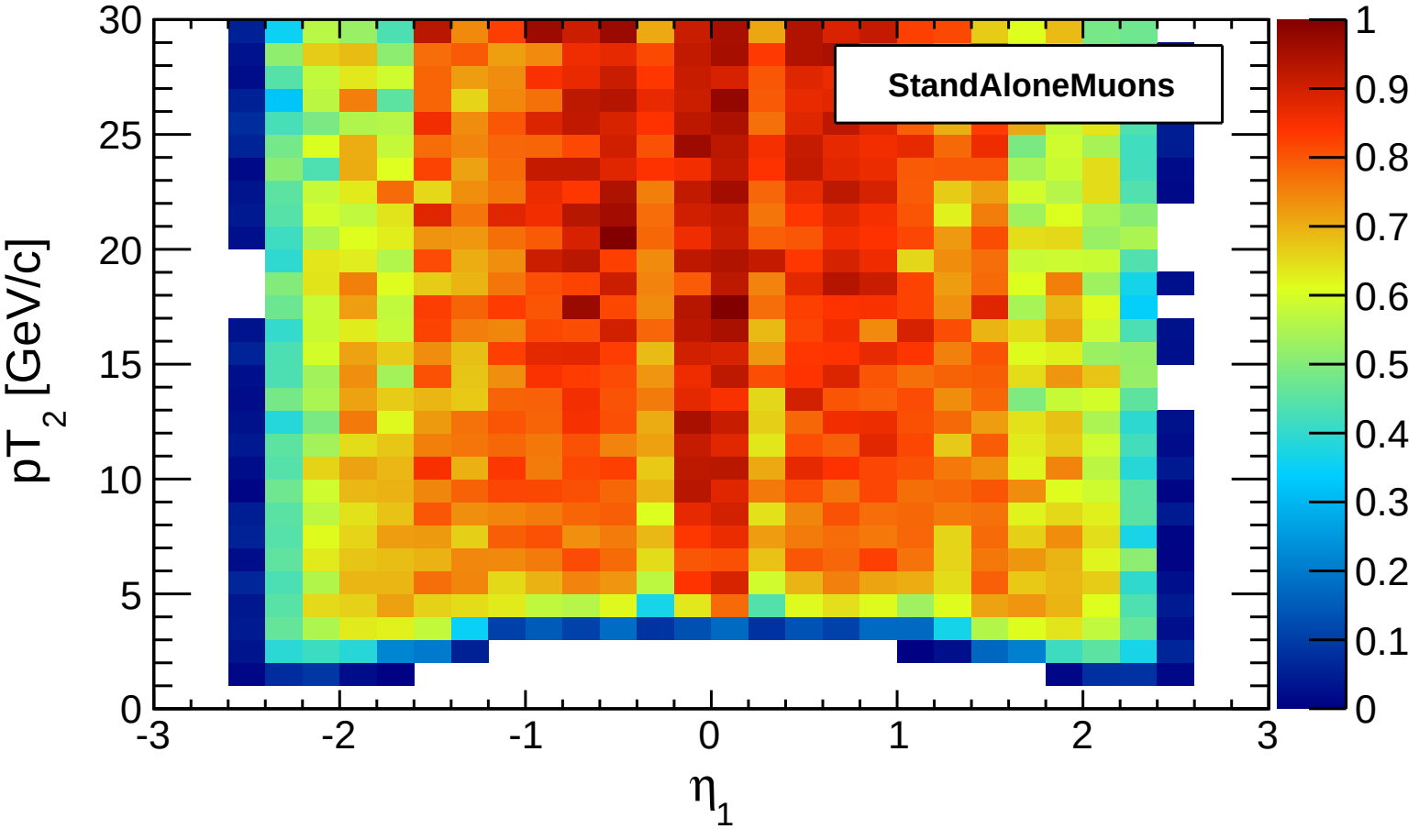


Also tested the StandAlone-SET algorithm, but that has a very low efficiency for nearby pairs (apparently has a cut against muons being within 10 cm in z in muon chambers)

The basic acceptance plot

For one muon-jet, we need $pT_2 > 5$ GeV/c (second-highest p_T) and $|\eta_1| < 2.4$ (highest absolute pseudorapidity)



StandAloneMuons with a beamline constraint has somewhat higher efficiency

The basic acceptance plot

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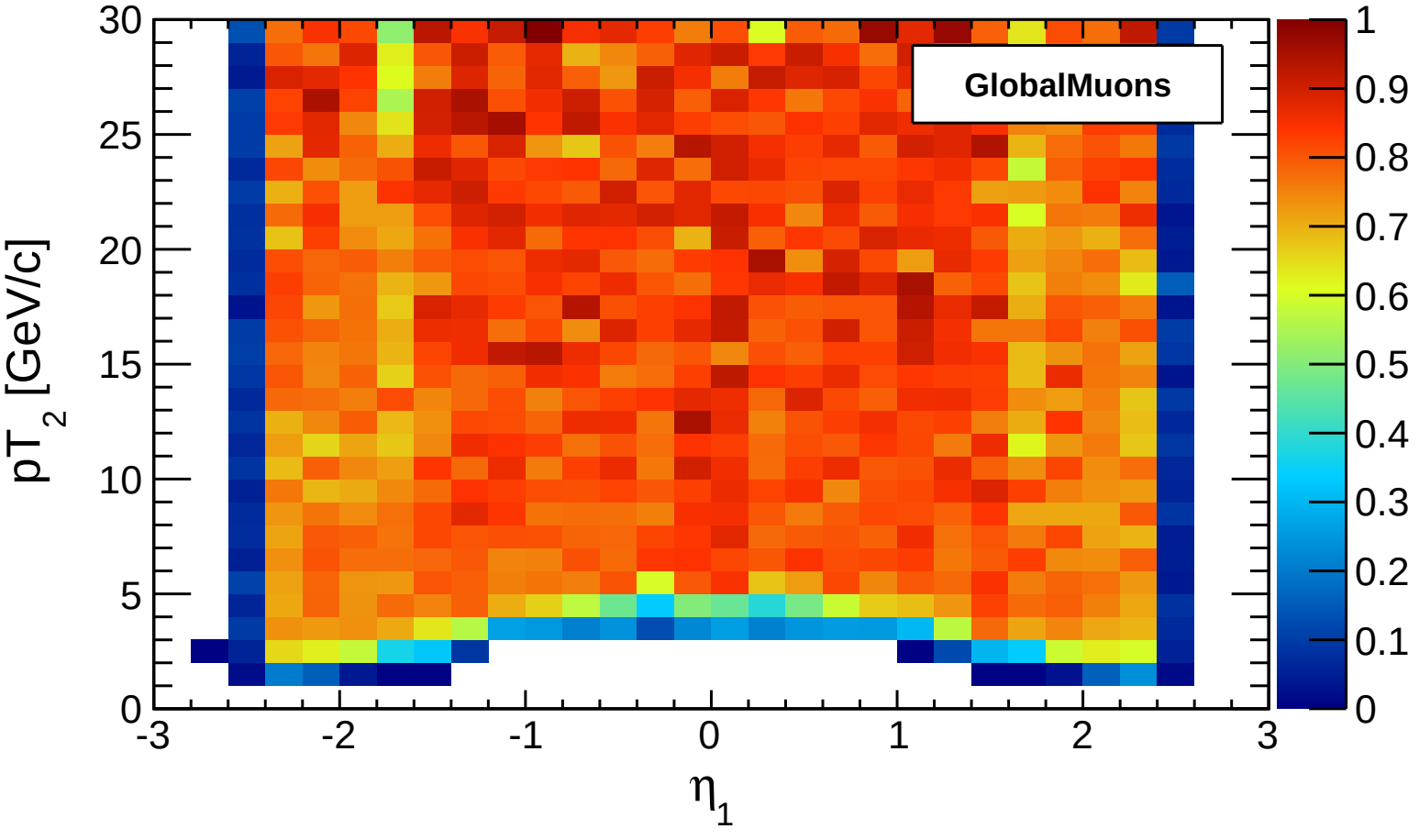
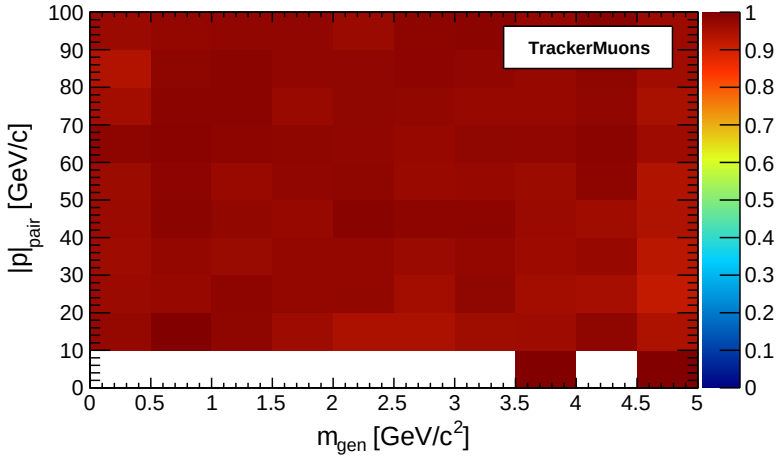
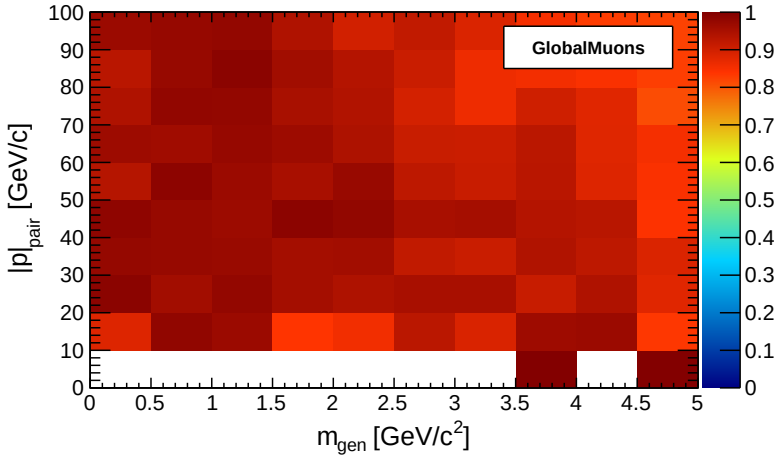


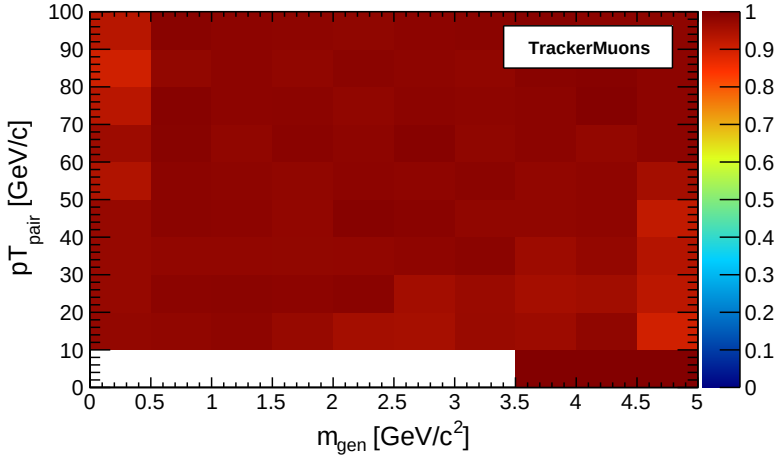
But not enough to explain the GlobalMuon efficiency: how can GlobalMuon efficiency be higher than StandAlone???

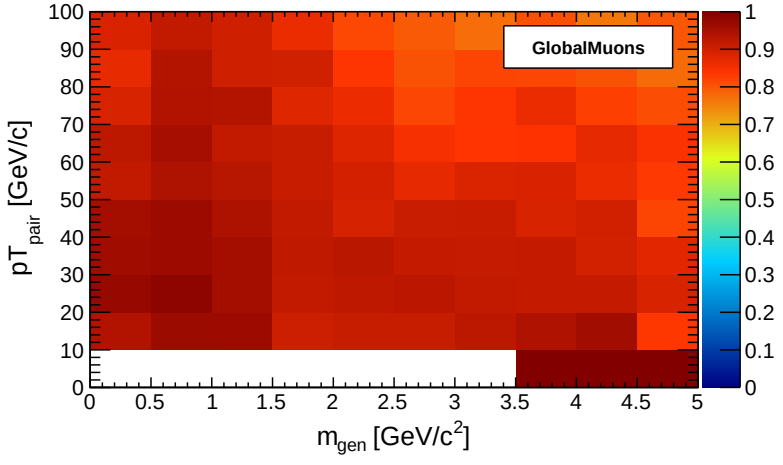
Efficiency for physics

Assuming $pT_2 > 5$ GeV/c and $|\eta_1| < 2.4$ are satisfied (that's the denominator), how sensitive are we to muon jets across the mass/momentum range?



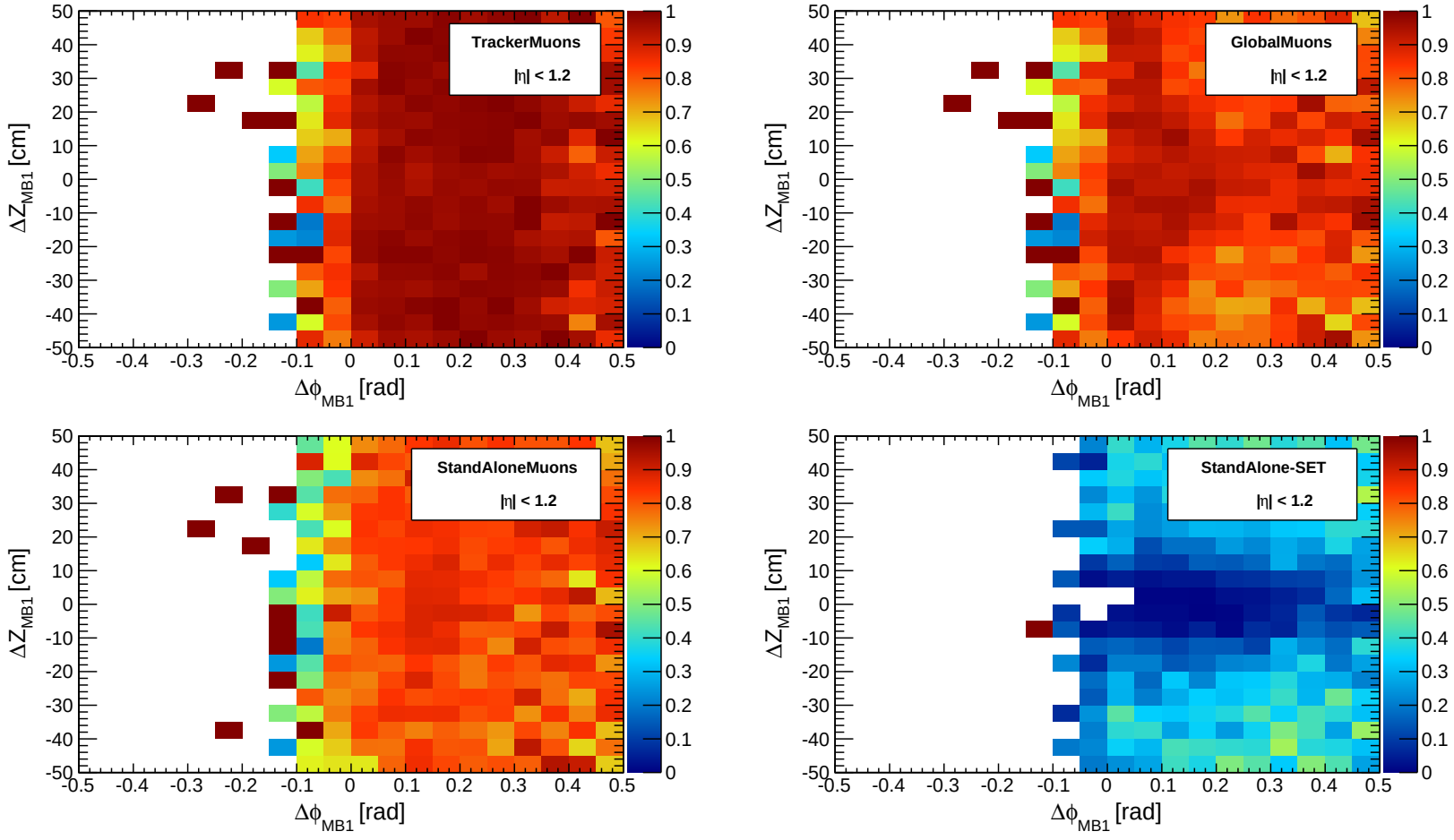






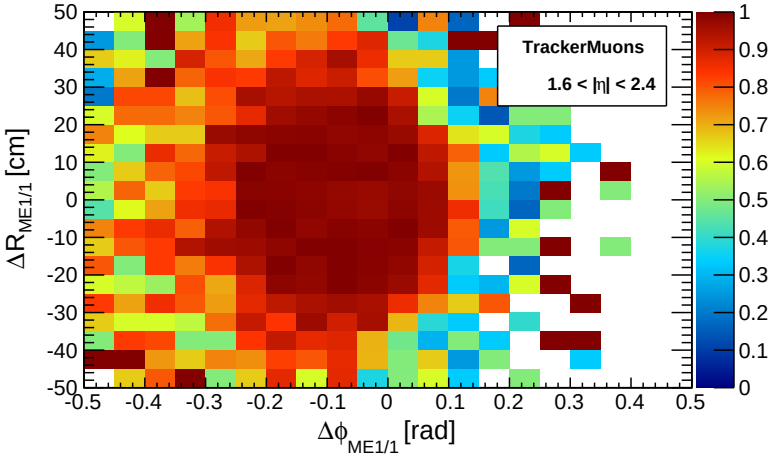
Separation in muon barrel

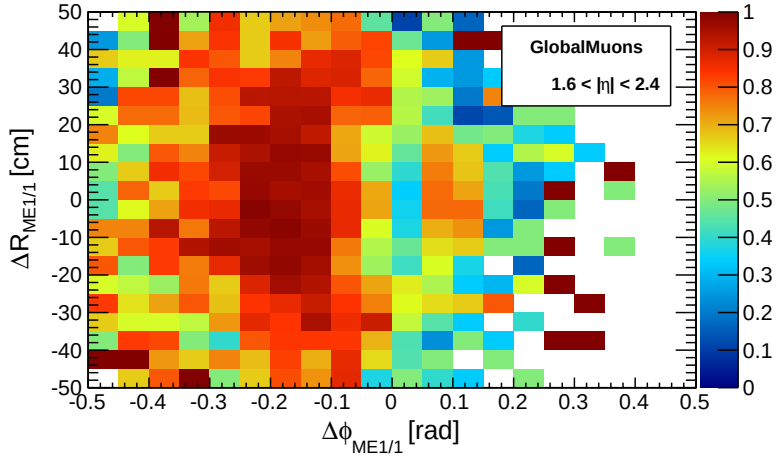
These plots also assume $pT_2 > 5$ GeV/c and $|\eta_1| < 2.4$ and ask what is the probability of reconstructing both muons as a function of where they cross in the muon system ($\Delta\phi = \phi_{\mu^+} - \phi_{\mu^-}$, $\Delta z = z_{\mu^+} - z_{\mu^-}$).

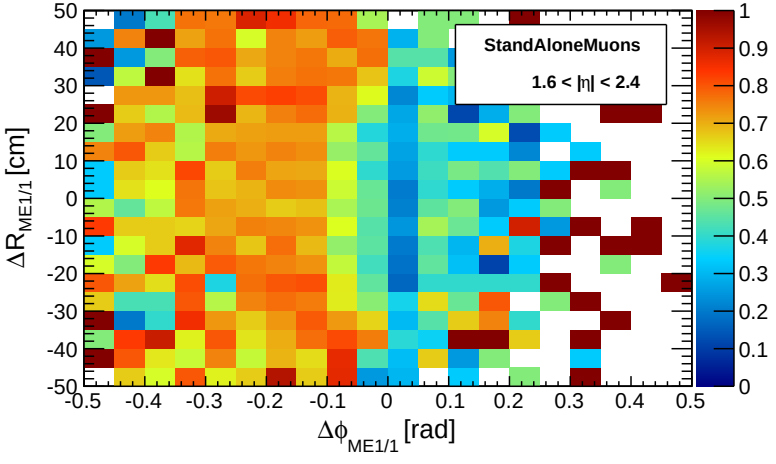


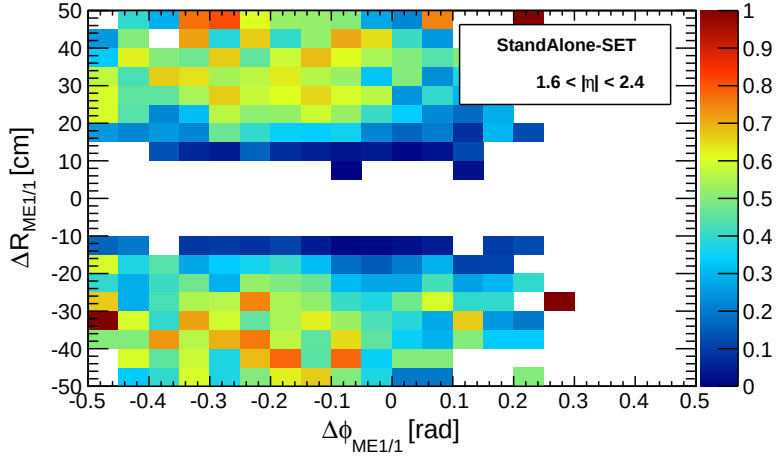
Stations 2, 3, and 4 are pretty similar. I'm not sure why the negative sides of these plots are not illuminated...

Separation in muon endcap

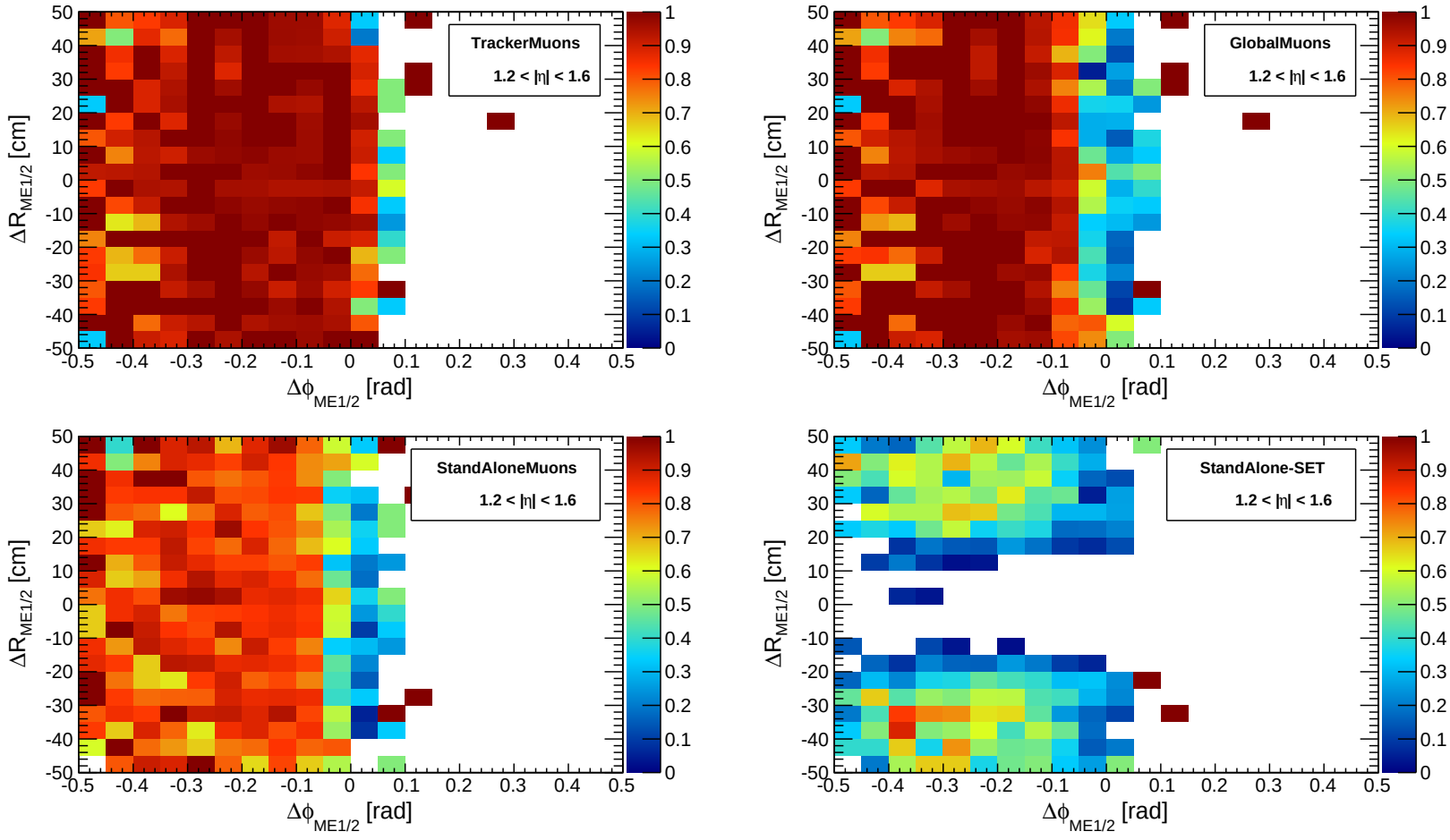








Separation in muon endcap

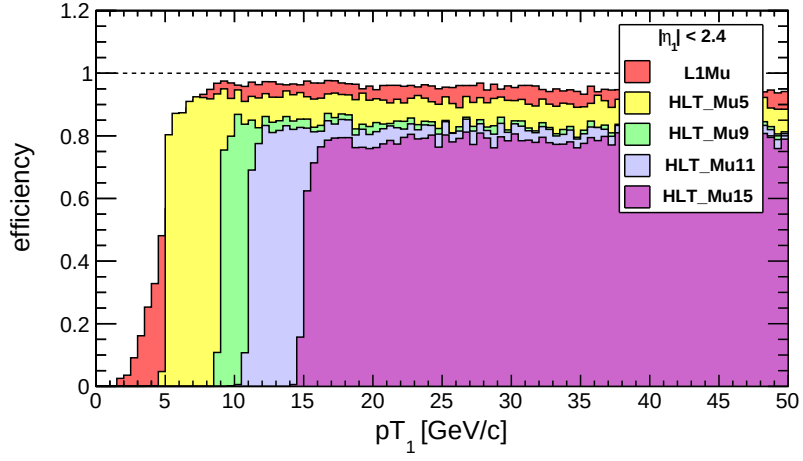


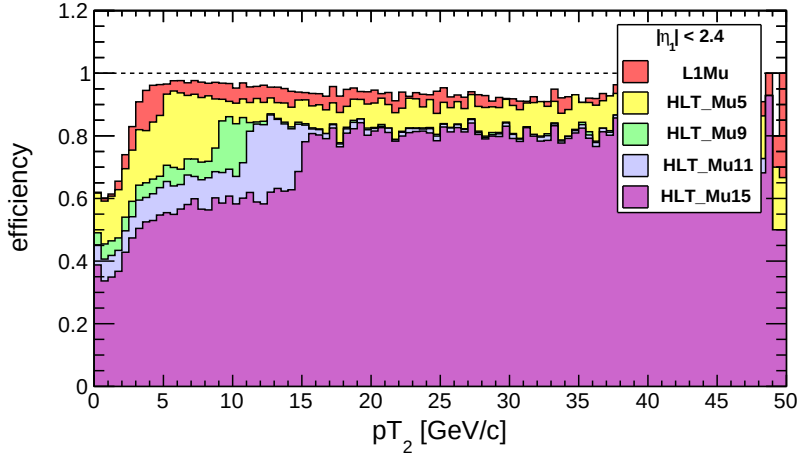
I'm not really satisfied with these yet— we need to understand why they're not more completely illuminated (and maybe generate some dimuon guns which would cover more, to tell us the whole story)

Trigger efficiency

Denominator: $\eta_1 < 2.4$; efficiency for triggering as a function of pT

pT_1 is highest pT, driving trigger-efficiency, pT_2 is second-highest, driving reconstruction-efficiency (both evaluated at generator-level)



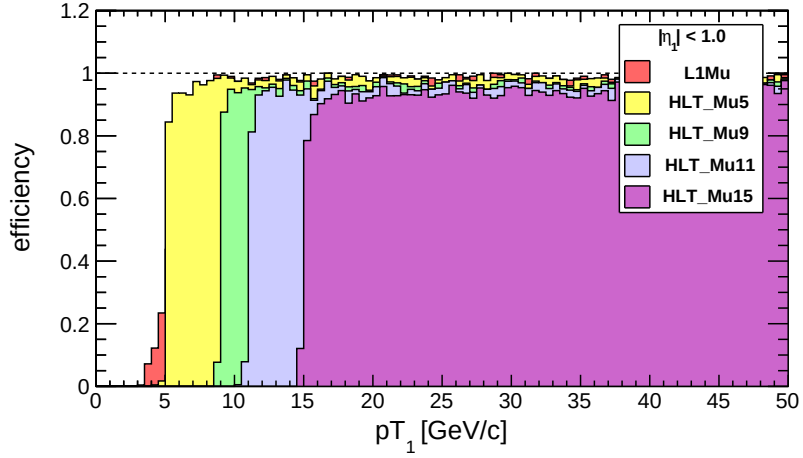


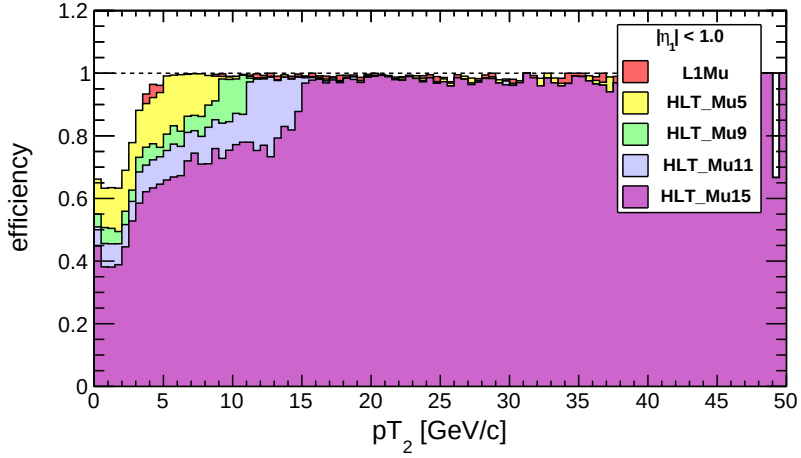
Is the L1Mu going below the HLT_Mu5 curve? It looks like it. I had thought that L1Mu was a prerequisite for HLT_Mu5 (according to ConfDB, "L1SingleMu3" is a prerequisite for HLT_Mu5, but L1Mu is "L1SingleMu3 OR L1SingleMu7")

Trigger efficiency: barrel

Denominator: $\eta_1 < 1.0$ (barrel); efficiency for triggering

pT_1 is highest p_T, driving trigger-efficiency, pT_2 is second-highest, driving reconstruction-efficiency (both evaluated at generator-level)





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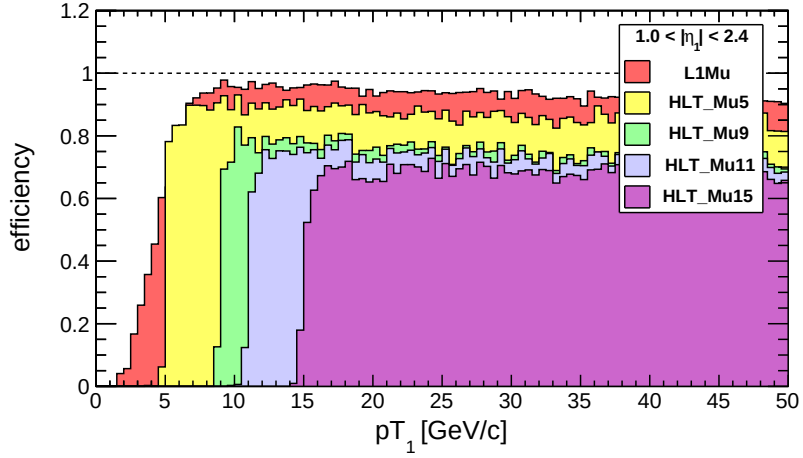
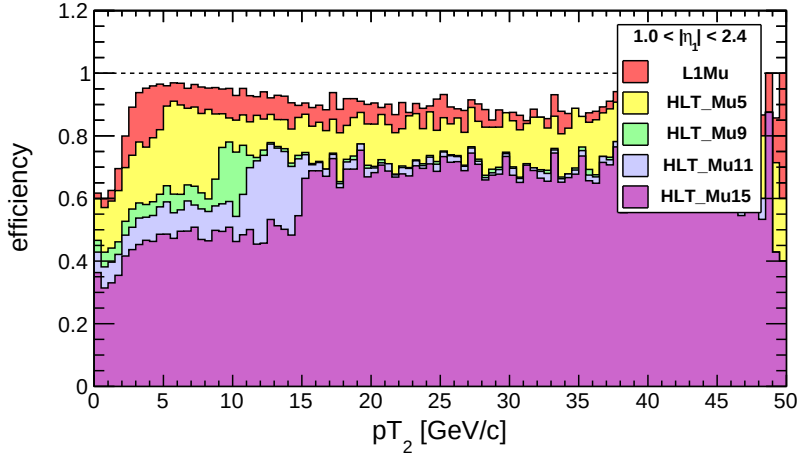
Trigger efficiency: endcap

Denominator: $1.0 < \eta_1 < 2.4$ (endcap); efficiency for triggering

pT_1 is highest p_T, driving trigger-efficiency, pT_2 is second-highest, driving reconstruction-efficiency (both evaluated at generator-level)





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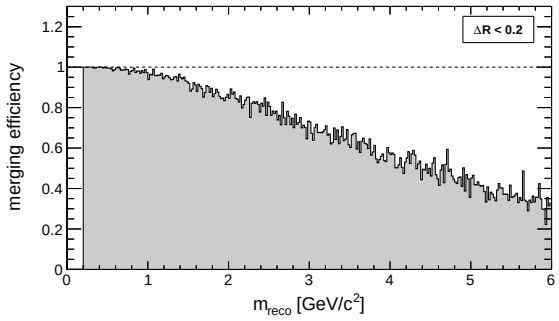
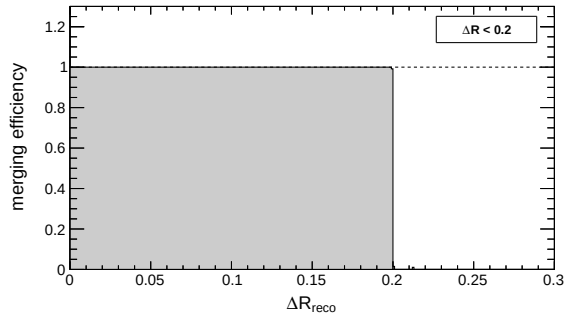
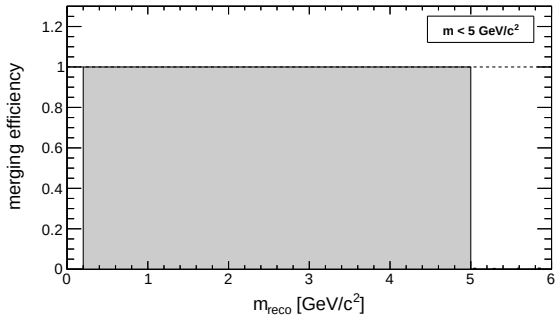
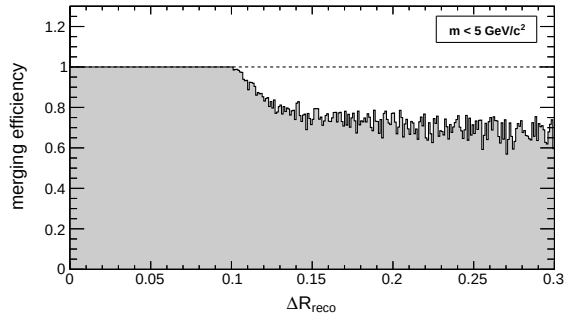
Merging efficiency

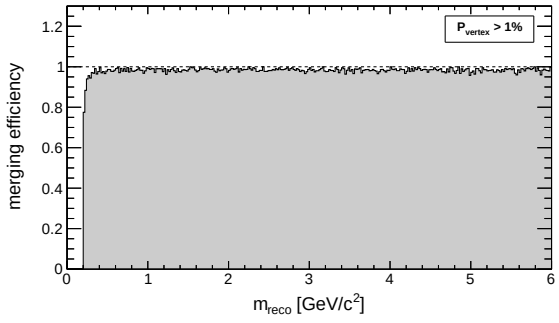
Assuming that we have reconstructed both TrackerMuons (denominator), what is the efficiency of grouping them in the same μ-jet?

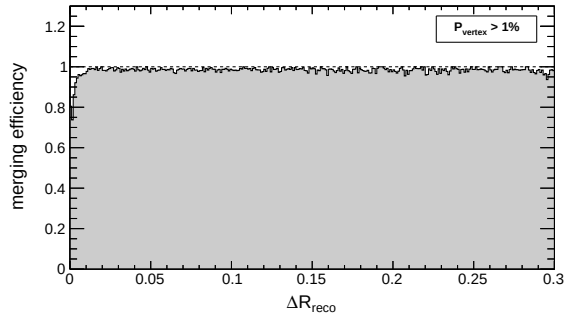












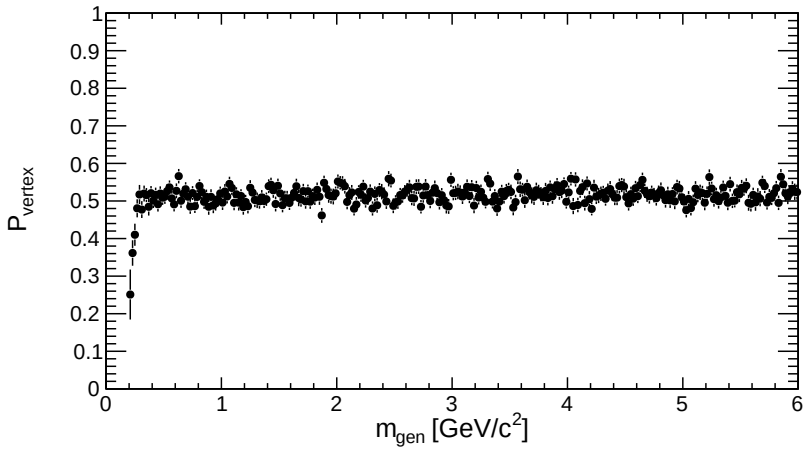
$\Delta R < 0.2$: finds muons that are geometrically close to each other

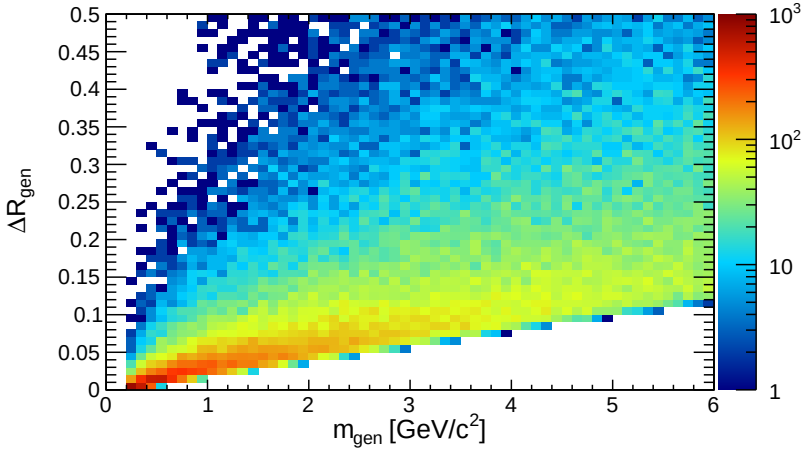
$m_{\text{inv}} < 5$ GeV/c: finds low-mass objects, our physics goal

$P_{\text{vertex}} > 1\%$: requires vertex compatibility (also physics goal); slightly inefficient when muons are nearly collinear

Supporting plots

1. Cross-check: the vertex probability really does dip at very small masses
2. Quantitative comparison of ΔR and m_{inv} (depends on sample's dimuon boost distribution, which goes up to $p_T = 100$ GeV/c)

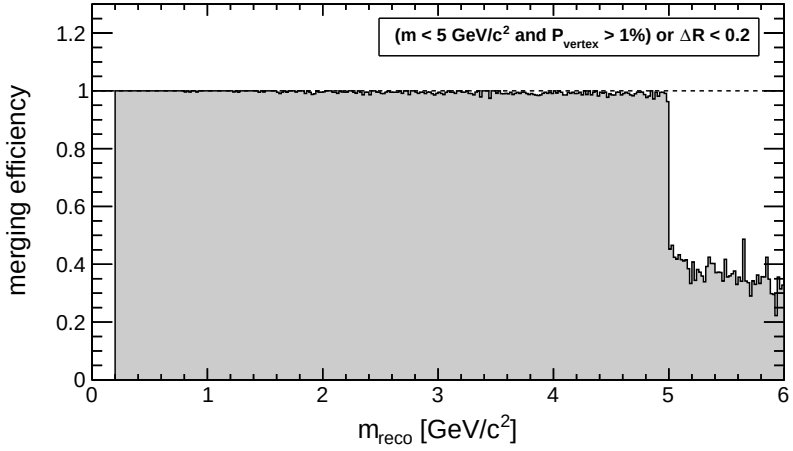


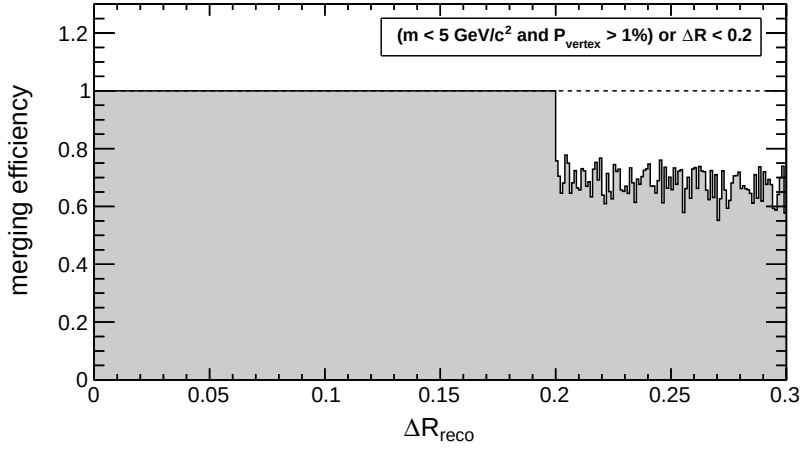


Merging efficiency

Best choice: group by ($m_{\text{inv}} < 5$ GeV/c **and** $P_{\text{vertex}} > 1\%$) **or** $\Delta R < 0.2$

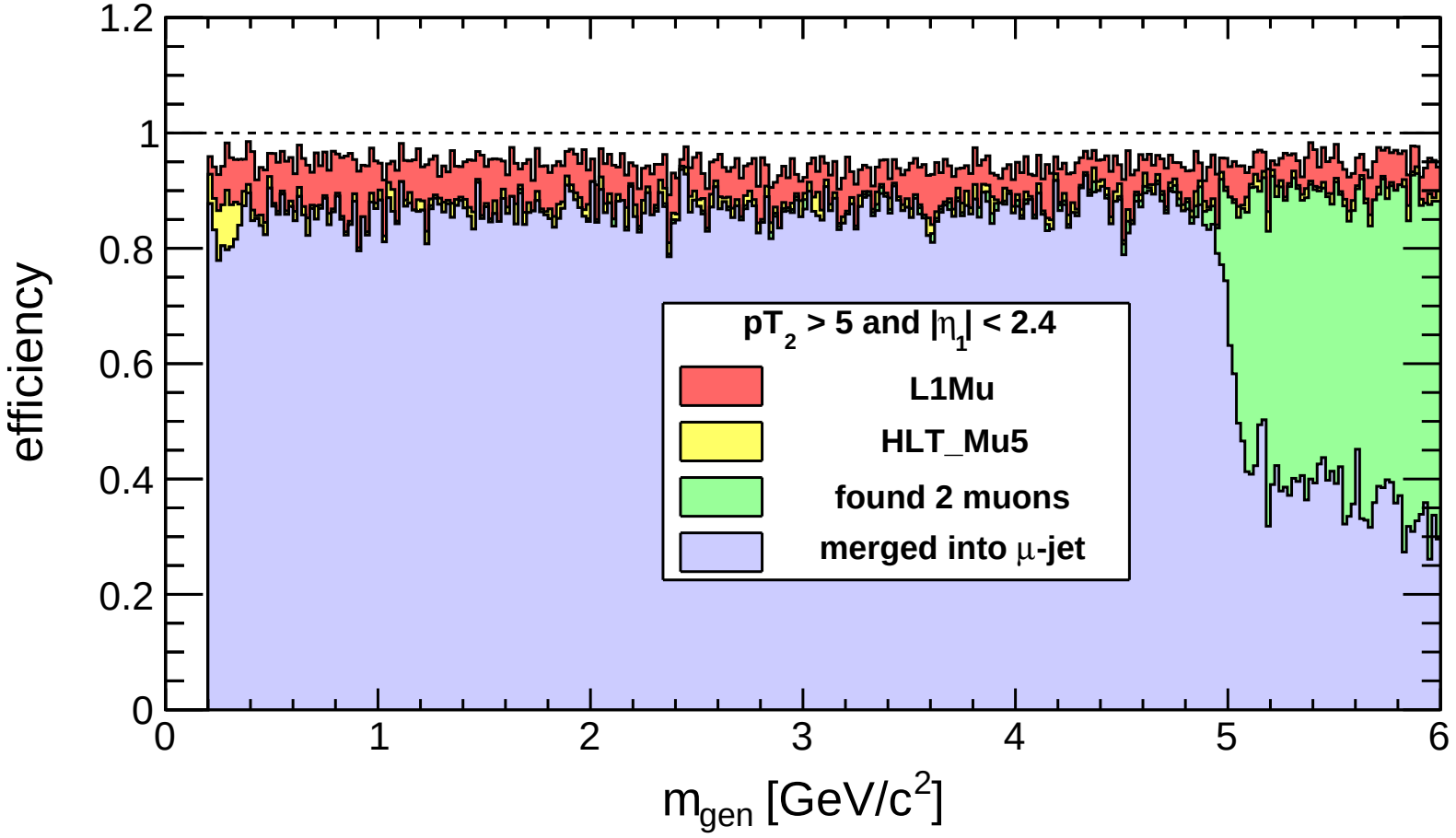
- guarantees that we get the low-mass objects, for any boost (cut later on boost)
- vertex probability guarantees that they came from the same origin
- ΔR gets the tiny-mass case (though may want to reduce to $\Delta R < 0.1$ or 0.05 or something)





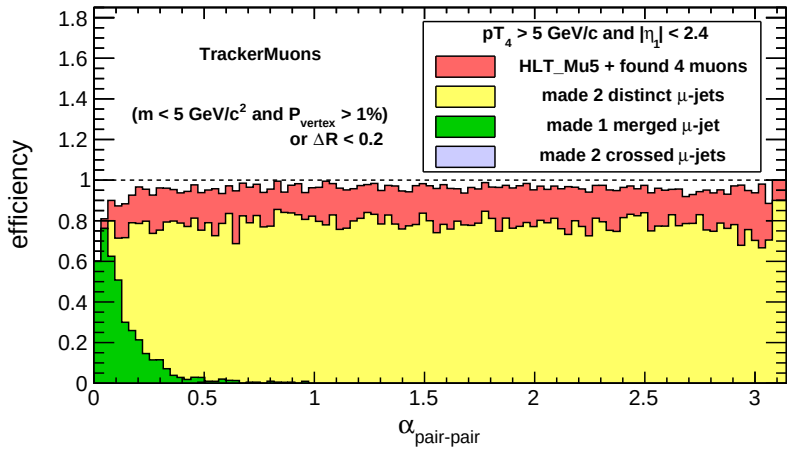
Summary of efficiency

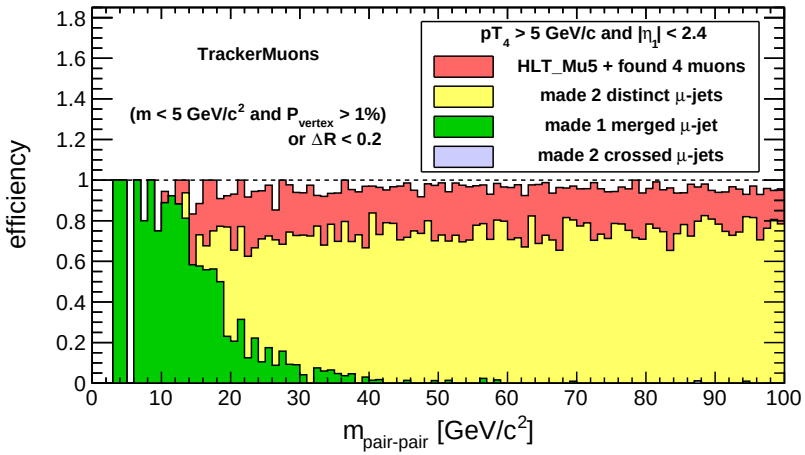
These are TrackerMuons, plotted against the variable that we care about most



μ-jet merging

- In a new sample with two dimuons per event, how often do we find the two μ-jets separately?
  - "two dimuons" and "one quadmuon" are both discovery modes
  - Δm_{inv} criteria in two searches can be tuned to make sure we overlap the whole discovery region
- $\alpha_{\text{pair-pair}}$ is the opening angle between the two dimuon axes
- "Crossed" μ-jets are when you get two pairs but with the wrong association (1-3, 2-4 instead of 1-2, 3-4)
- Varying the merging criteria changes this plot as you'd expect





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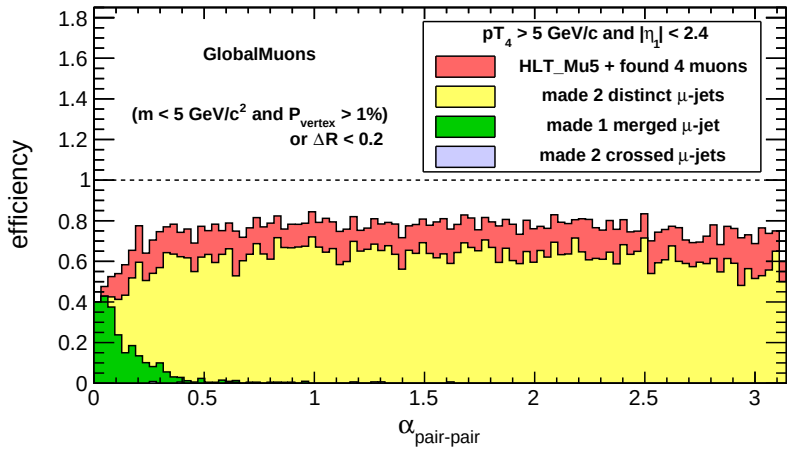
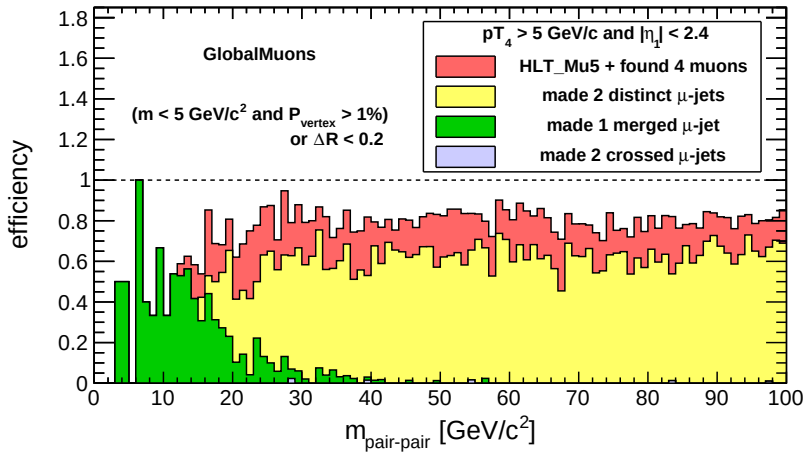
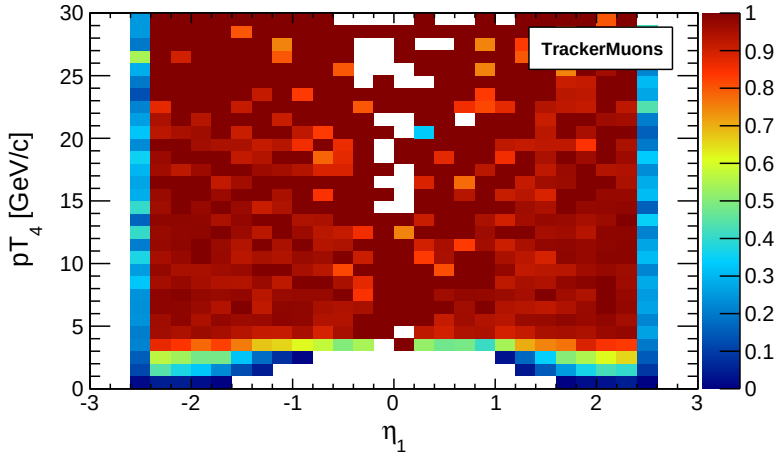
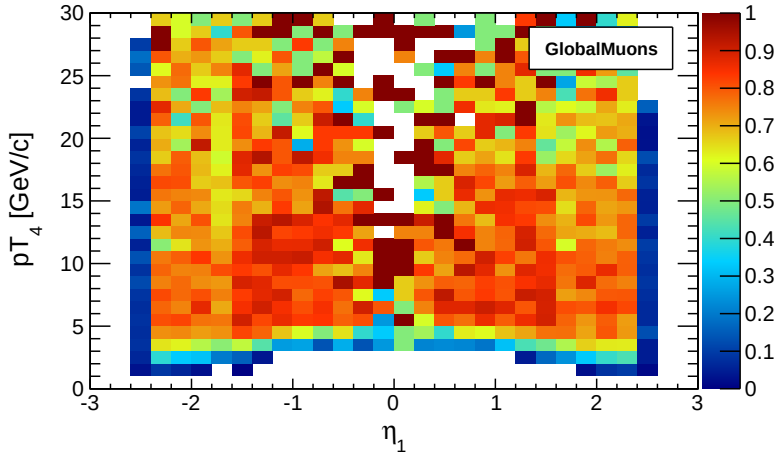




- This depends on pT_4 vs. η_1 (remember our paper?)
- Until I see the backgrounds, I would apply $pT_4 > 5$ GeV/c and $\eta_1 < 2.4$

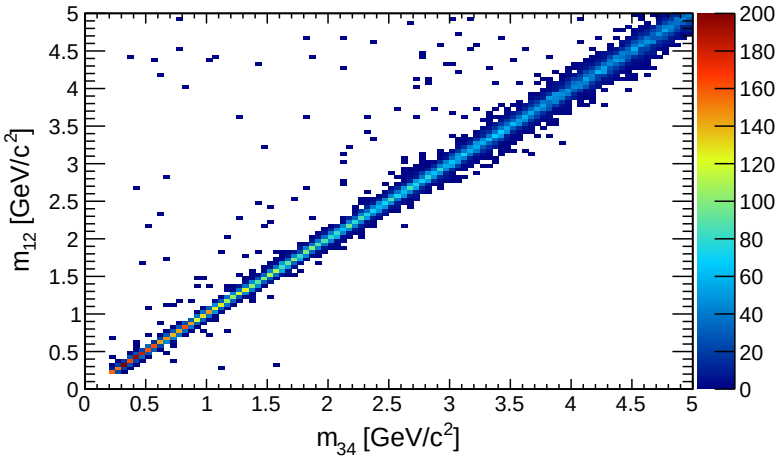
  (Our paper additionally had $pT_1 > 20$ GeV/c; I'll check to see if it's really needed)
- Also, I want to check the "optimized arbitration" I talked about last time to see if we can do the analysis with TrackerMuons, but that, too is a backgrounds study

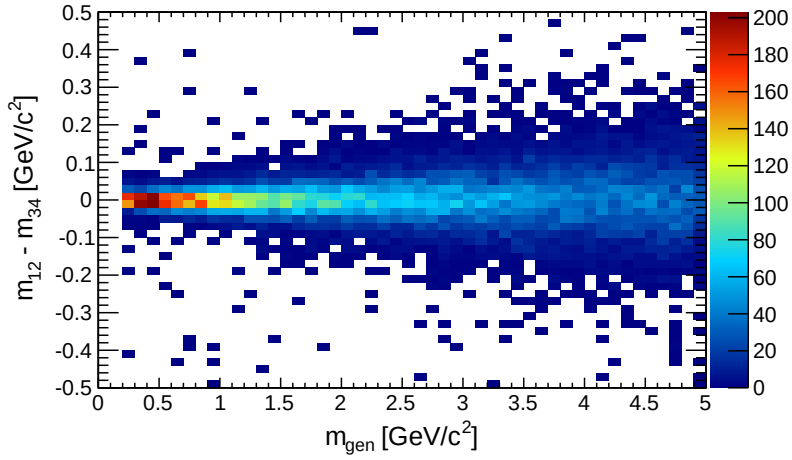


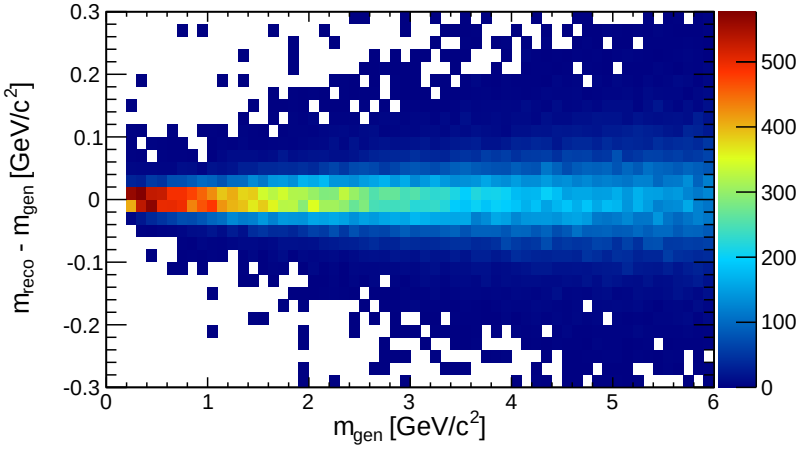


Pair-pair mass constraint

Mostly interesting for supressing backgrounds, but here are the signal studies

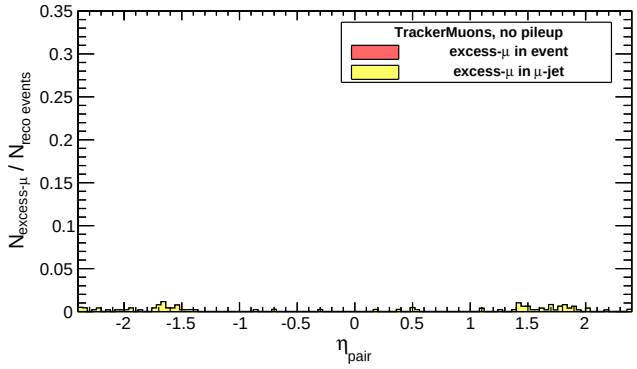


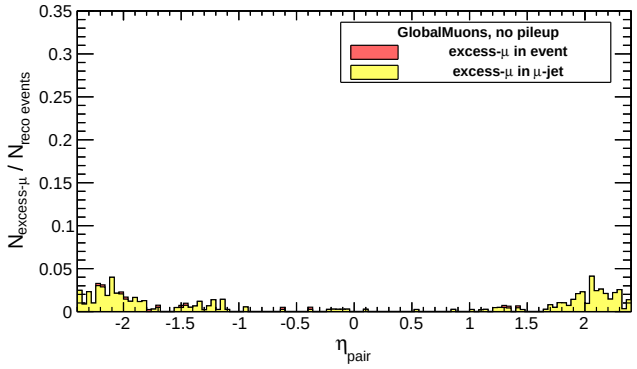


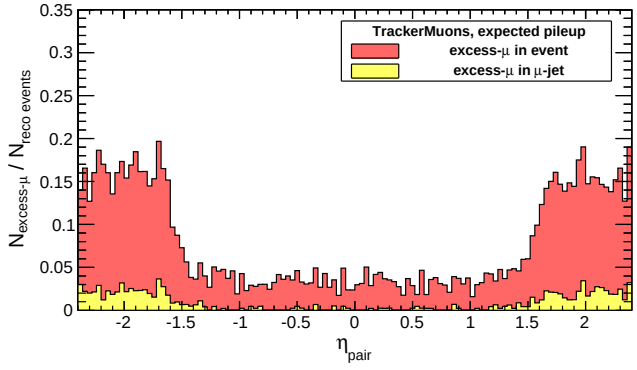


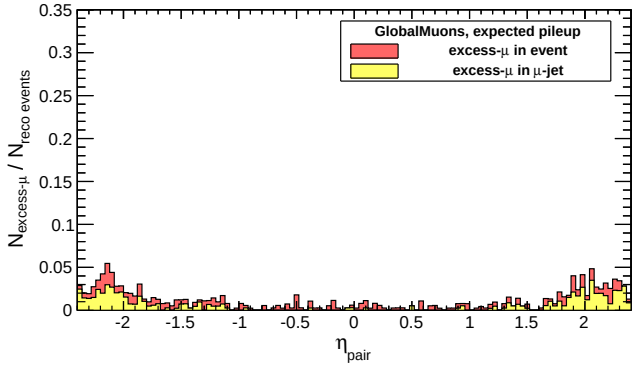
Too many muons

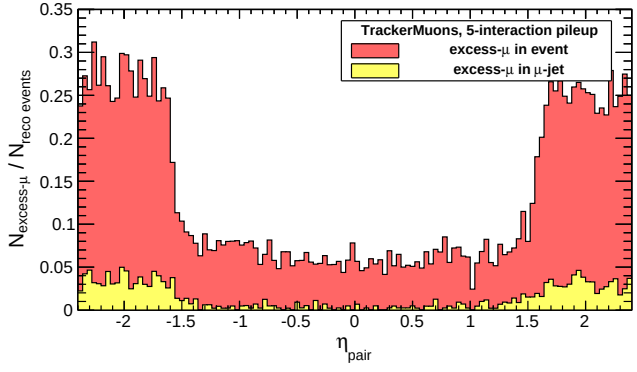
How often, in dimuon signal, do μ-jets pick up an extra muon?
(Can worsen mass resolution and cause too many mergers)

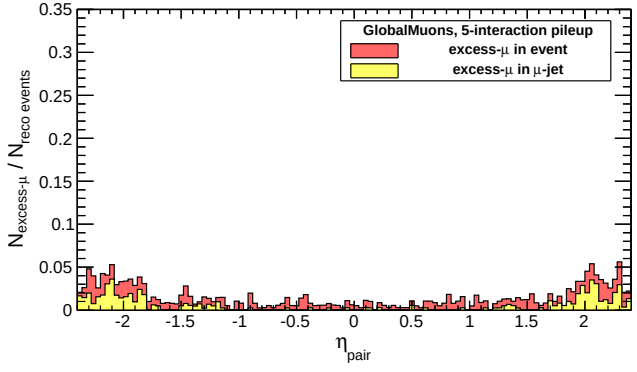










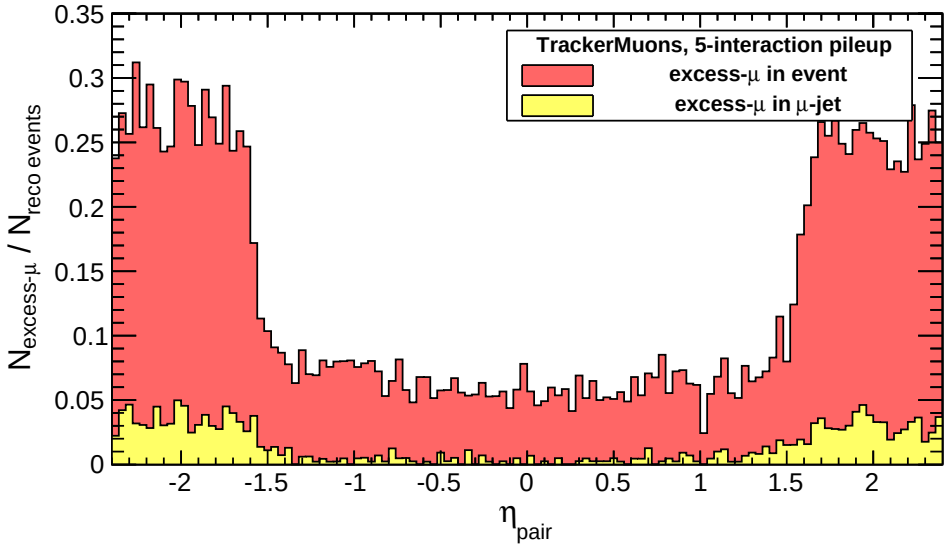


Depends on pile-up, naturally

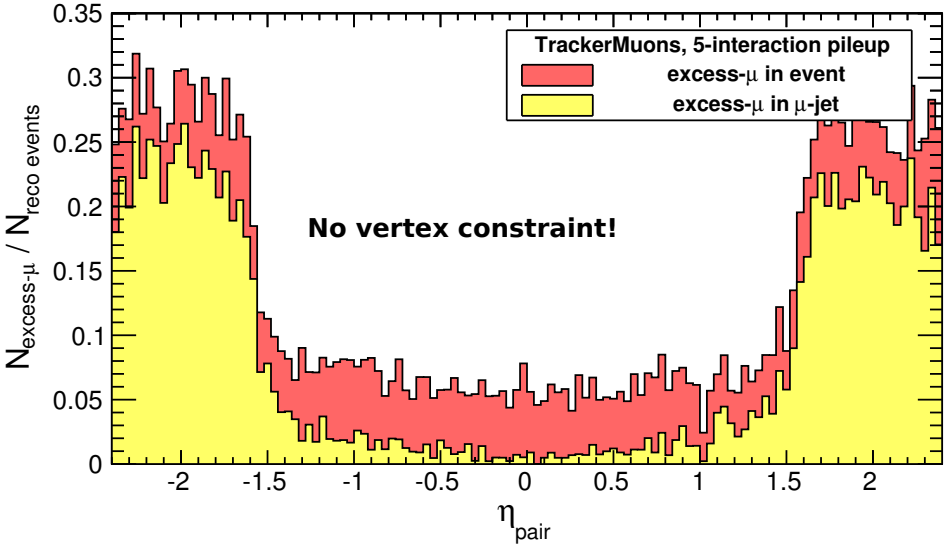
There are more TrackerMuons in high-pileup events, but not many of them get attached to μ-jets

Too many muons

The vertex compatibility criterion is very important!



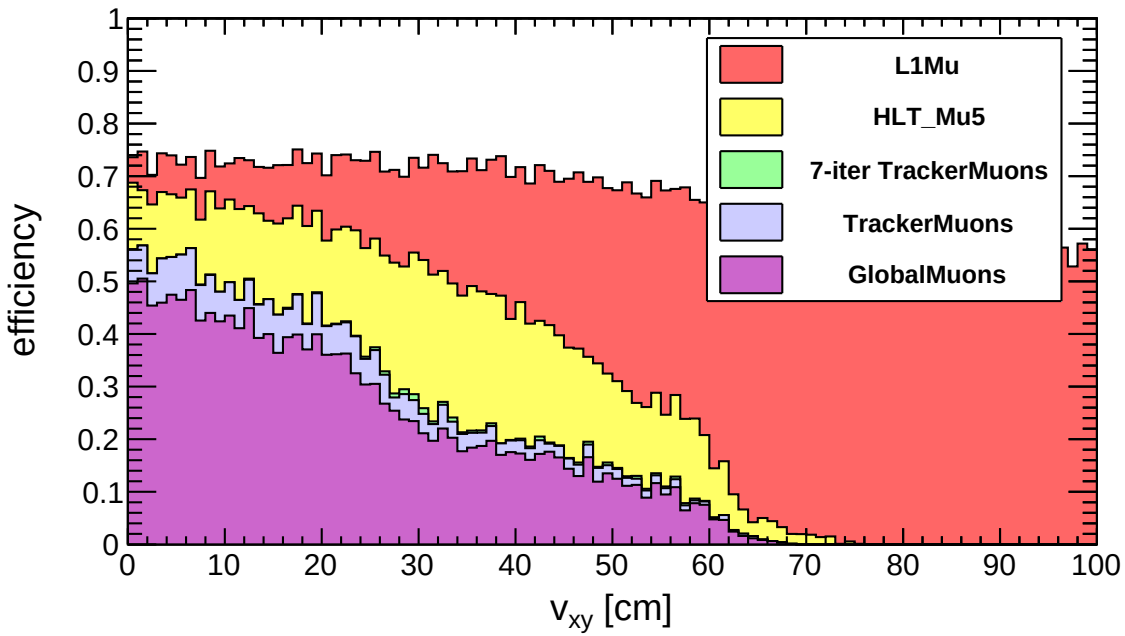
Normal μ-jet merging: ($m_{\text{inv}} <$ 5 GeV/c **and** $P_{\text{vertex}} >$ 1%) **or** $\Delta R < 0.2$



Normal μ-jet merging: ($m_{\text{inv}} < 5$ GeV/c) **or** $\Delta R <$ 0.2

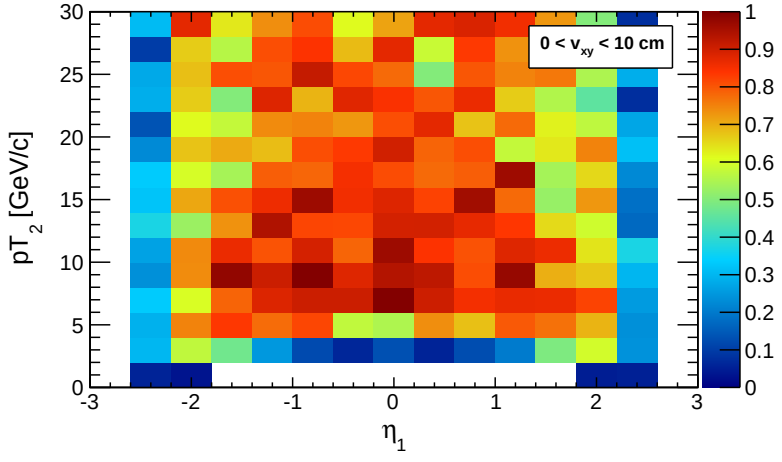
Displaced vertices

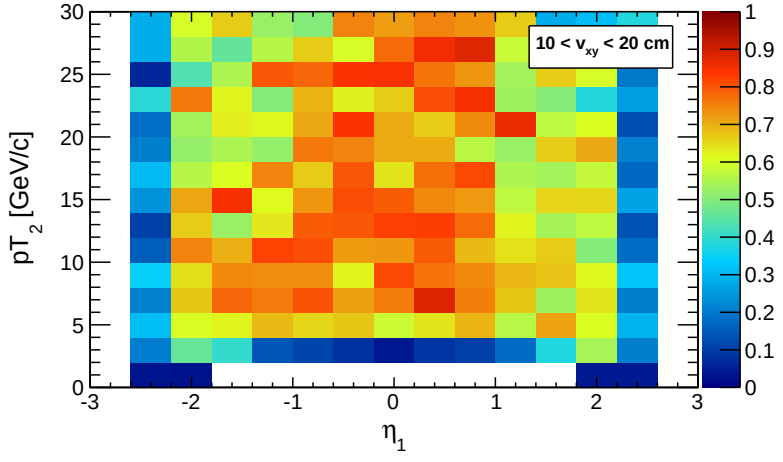
- This is one of the discovery channels: a single dimuon with a highly displaced vertex (background is mostly near zero)
  - HLT_Mu5 puts a limit on efficiency because it requires a StandAloneMuon with beamline constraint
  - To go farther, we'd need to use a cosmics trigger or something (not worth it)
  - $\gamma \to e^+e^-$ 7-iteration tracking helps negligibly in the muon case (possibly because of GSF tracking)
  - GlobalMuons are about as efficient as TrackerMuons

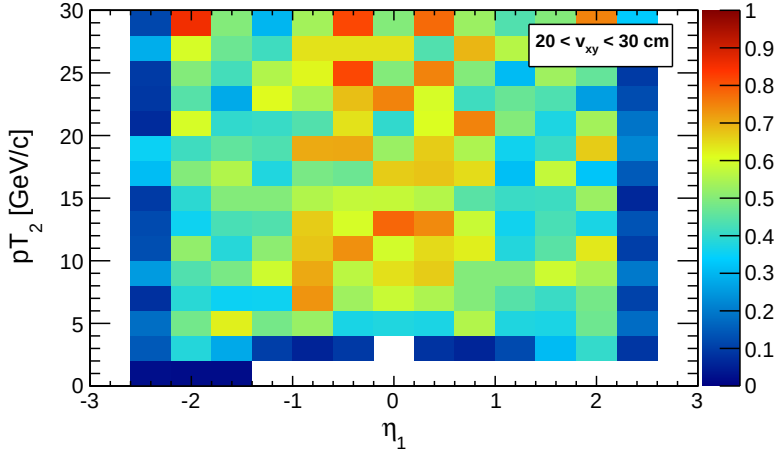


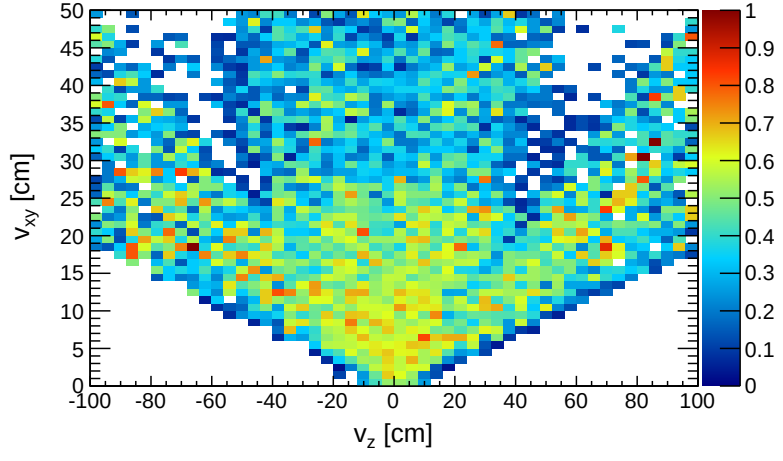
Displaced vertices

- Particularly inefficient in the barrel-endcap overlap region

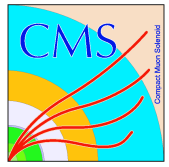








That's all for now



Next: backgrounds

Later: understanding a few of these unexplained issues...