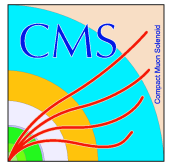


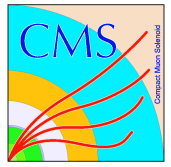
Update on Alignment and Analysis

Jim Pivarski

Texas A&M University

14 January, 2010

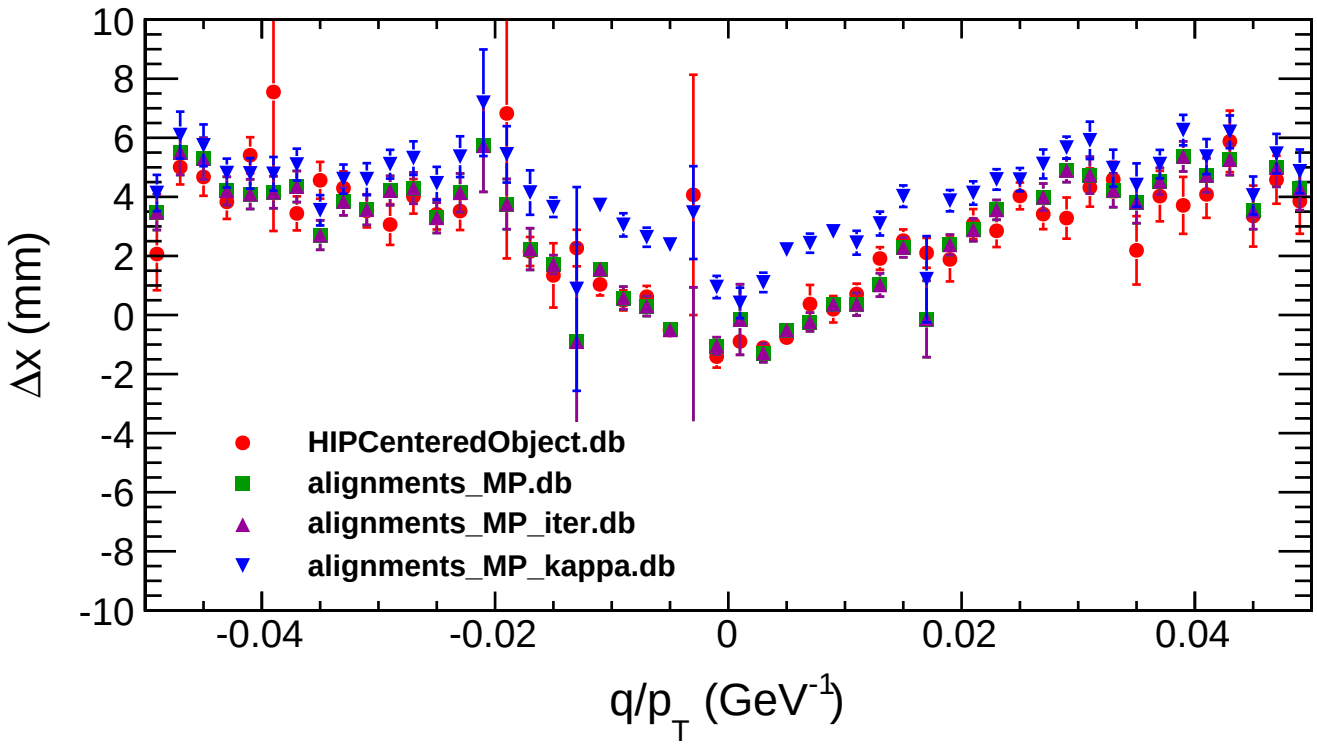
Outline



- Update in alignment
- Optimizing our skim definition (with PAT and all of that)
- Took a quick look at some $h \longrightarrow aa \longrightarrow 4\mu$ signal and $pp \longrightarrow \mu X$ background ($p_{T1} > 20$ GeV, $p_{T2} > 5$ GeV)

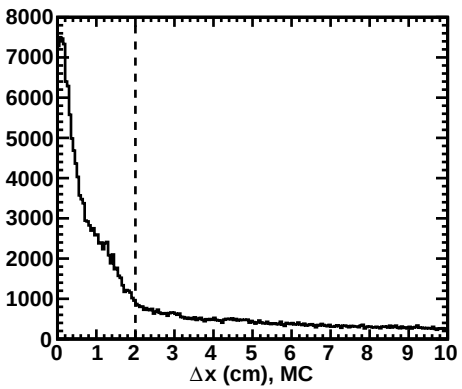
Tracker bias

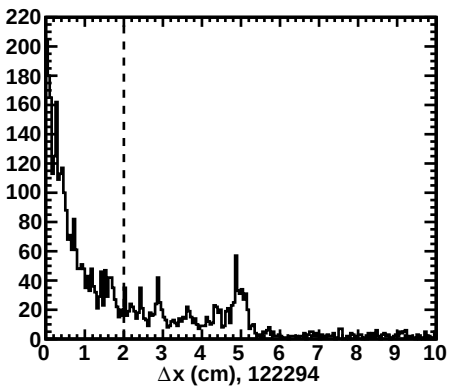
- CRAFT alignments showed that the tracker has some global distortion that tracker-tracks are insensitive to, but globalMuons are sensitive to it
- Appears as muon hit residuals being a function of momentum scale (low-p_T tracks disagree with high-p_T tracks about where to put a muon chamber)
- Markus Stoye is investigating this on the tracker side, sending me tracker geometries with global distortions which are weak modes of the tracker alignment
- This "kappa" alignment is a step in the right direction. . .

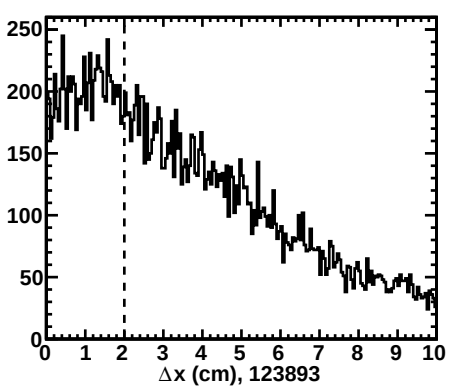


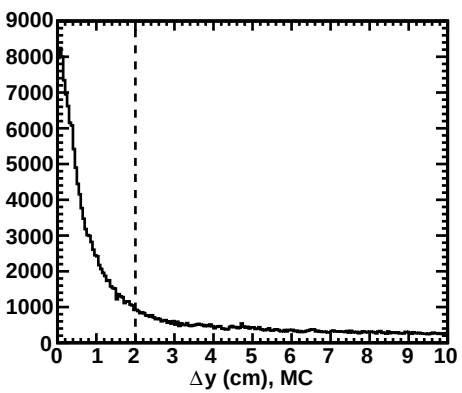
Beam-halo trigger losing events

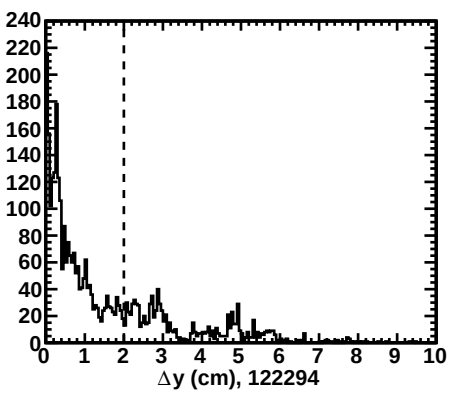
- Beam-halo tracks in overlap of neighboring CSCs are selected at HLT in a dedicated trigger, sent to a dedicated AlCa stream
- Hit pattern used to identify a track parallel to the beamline has a broader distribution in later runs (e.g. runs with $\vec{B}$-field on, not tested in MC)
- Muons travelling parallel to beam-line would be affected by radial component of $\vec{B}$-field: that could be what is broadening the distribution
- Working with Joe Gartner (now responsible for this trigger) to fix it

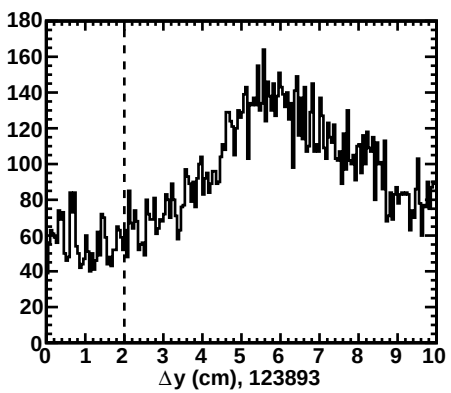






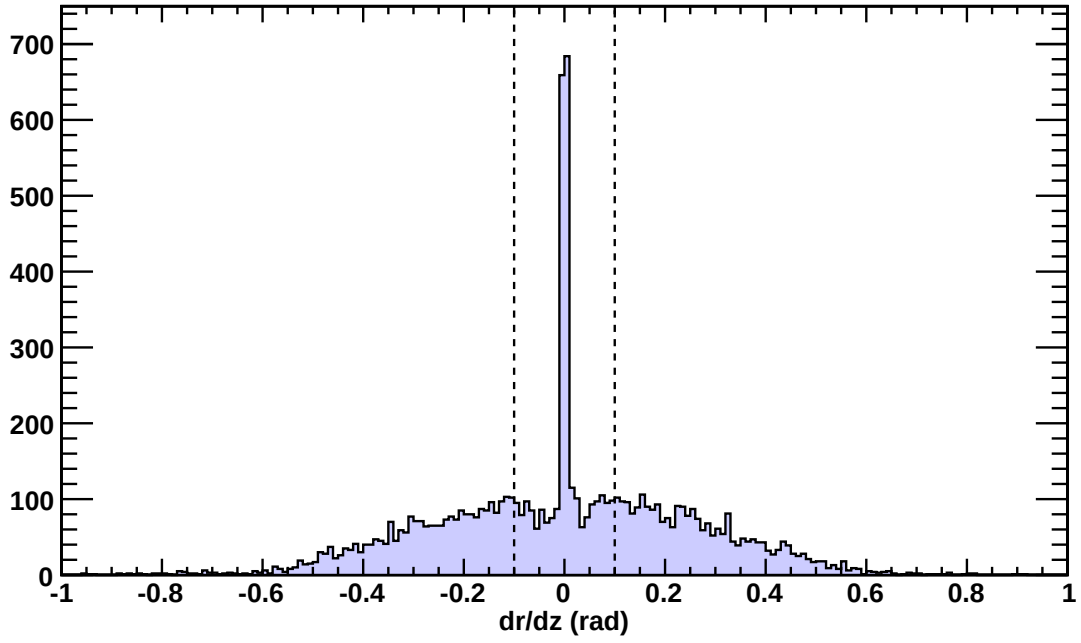




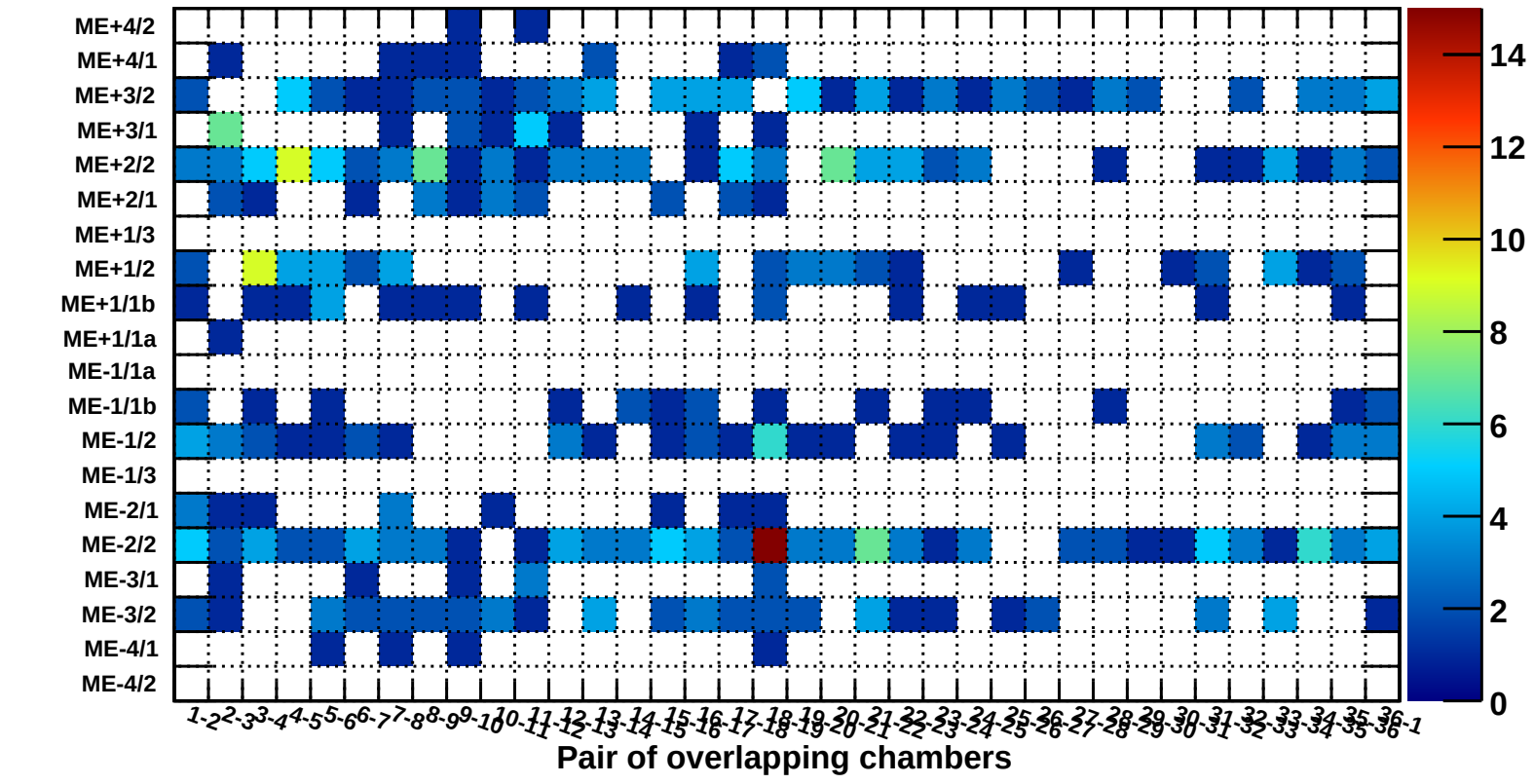


Work-around

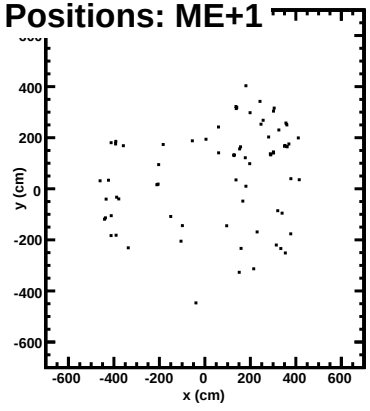
- We built in a work-around: another trigger and another AlCa stream that don't select overlaps
- Reprocessed this stream without the faulty HLT algorithm
- Still far too few beam-halo muons for alignment (we didn't *lose* an opportunity to align, but we learned something important about our trigger so that we don't lose anything in the future)
- First example plot: dR/dz for identifying beam-halo amid the cosmic rays

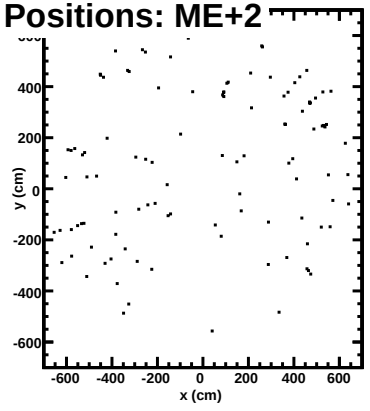


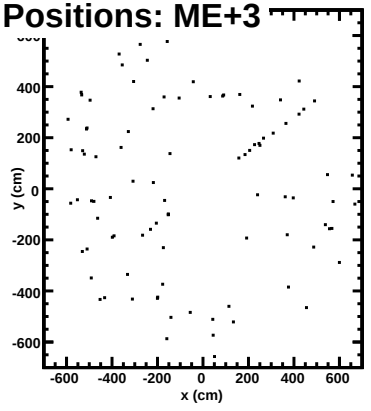
Occupancy by station/ring

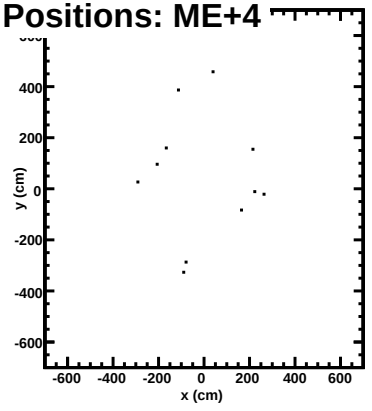


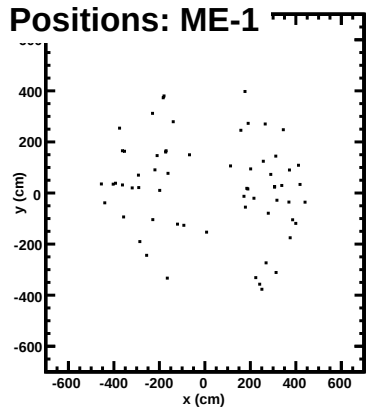
Hit distribution: global x-y

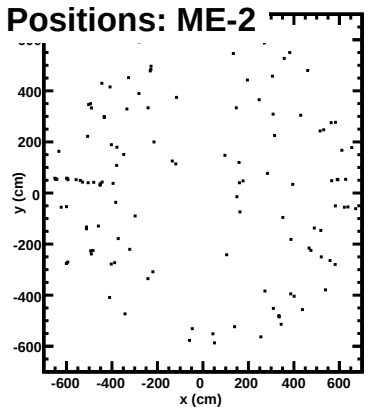


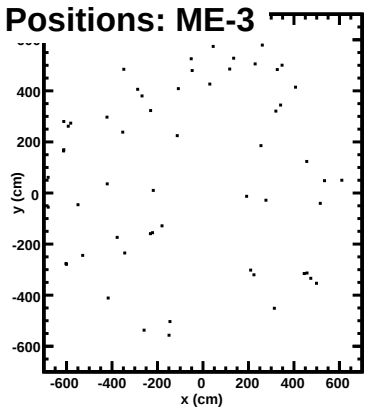


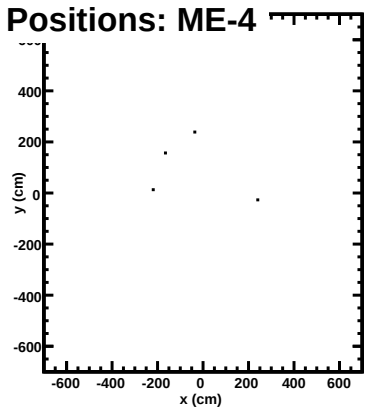




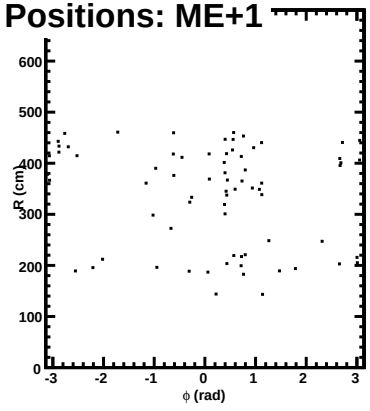


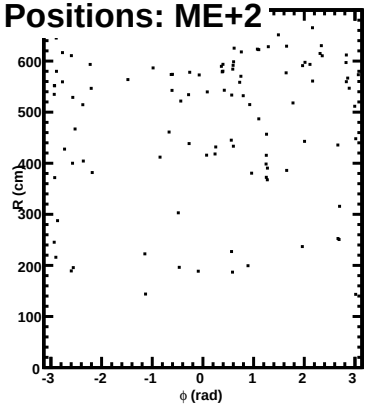


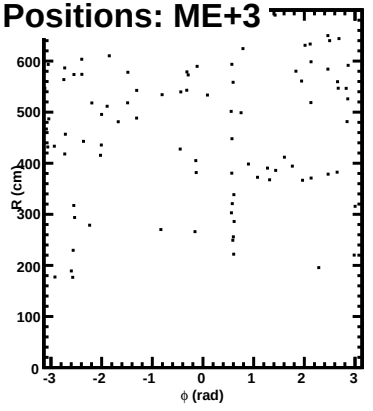


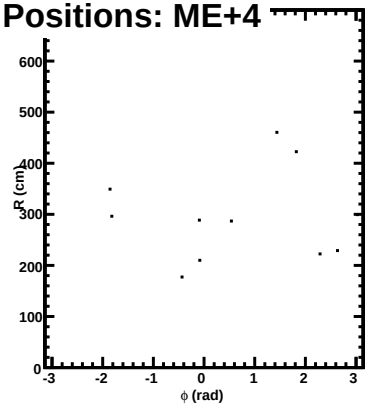


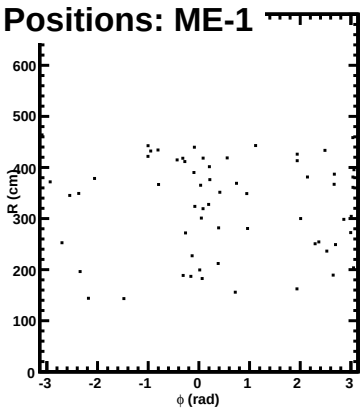
Hit distribution: r-ϕ

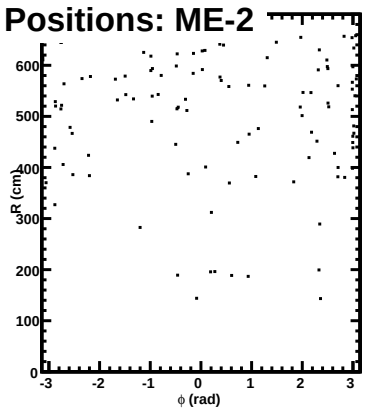


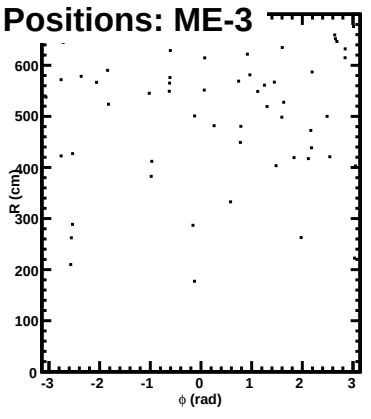


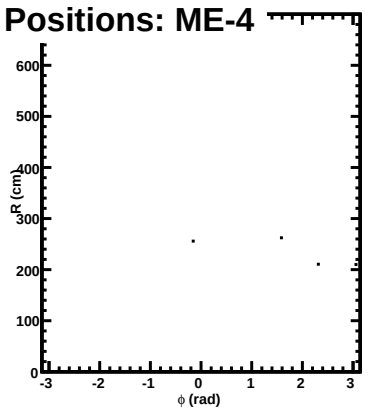




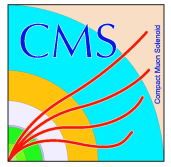








Analysis



- Read Alfredo's e-mail, and walked through the process of skimming and PATifying a sample
- Aysen did this on his own, too
- I optimized a set of keep statements for our purposes:
  - all generator-level information, including SimHits (which are big; we could save a lot by dropping these)
  - PAT muons and also RECO muons, including muons made with the SET algorithm
  - all tracks and the hits attached to tracks: a trick learned from AlCaRecos (we can refit tracks if needed)
  - all muon hits
  - enough calorimetry to re-run isolation, so that we can make isolation algorithms of any level of sophistication
  - beamspot, primary vertices, trigger data, which were essential in real-data exercises with prompt RECO
  - tested all of the above with the output, including calculation of MC weights (for PDF systematics studies) and event display
- Background skims of $p_{T1} > 20$ GeV, $p_{T2} > 5$ GeV are tight: we can make them looser

Important warning

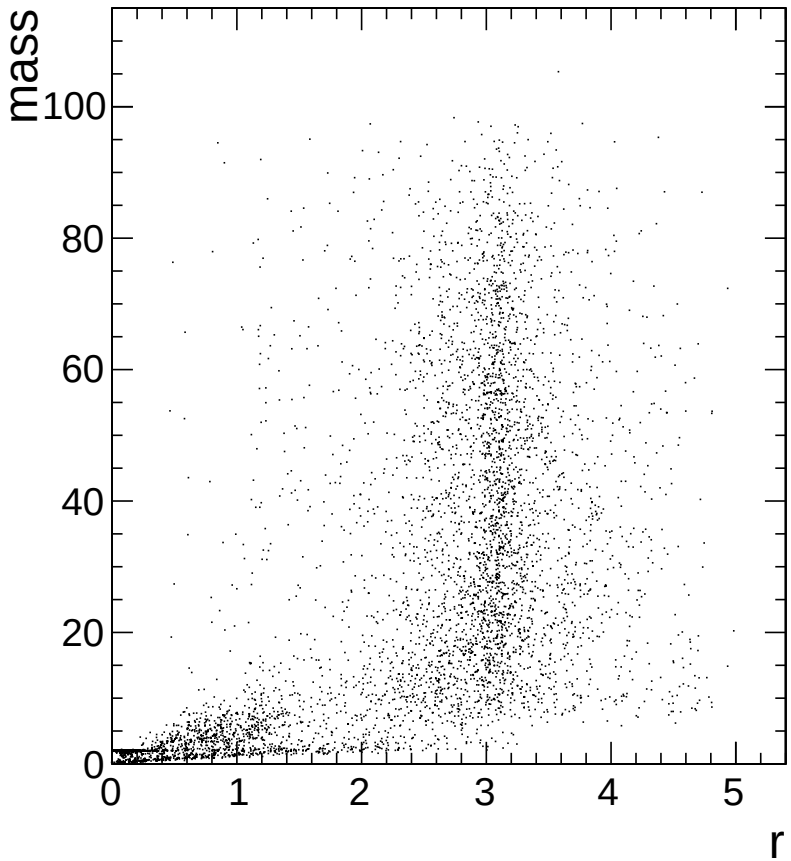
- PAT muons are a union of globalMuons, trackerMuons (tracker-track plus one or more segments), and standAloneMuons
- standAloneMuons are not useful for our analysis (too-loose identification and poor resolution)
- We'll want to control which algos we use: e.g. globalMuon-globalMuon, globalMuon-trackerMuon, trackerMuon-trackerMuon

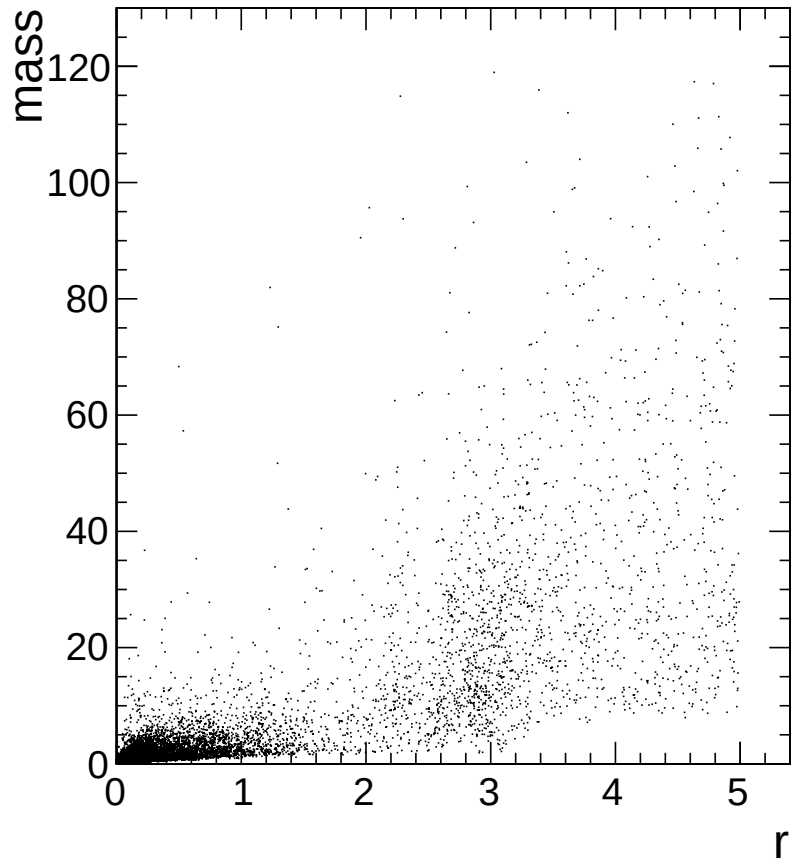
Location of samples

- Signal: we generate that at Fermilab
- $pp \to \mu X$: available at Fermilab and CERN (use Fermilab)
- For the others: need CRAB access, should get Aysen set up with an account
  - just use CRAB to get a skim, then we work with the skim locally

Mass vs. R

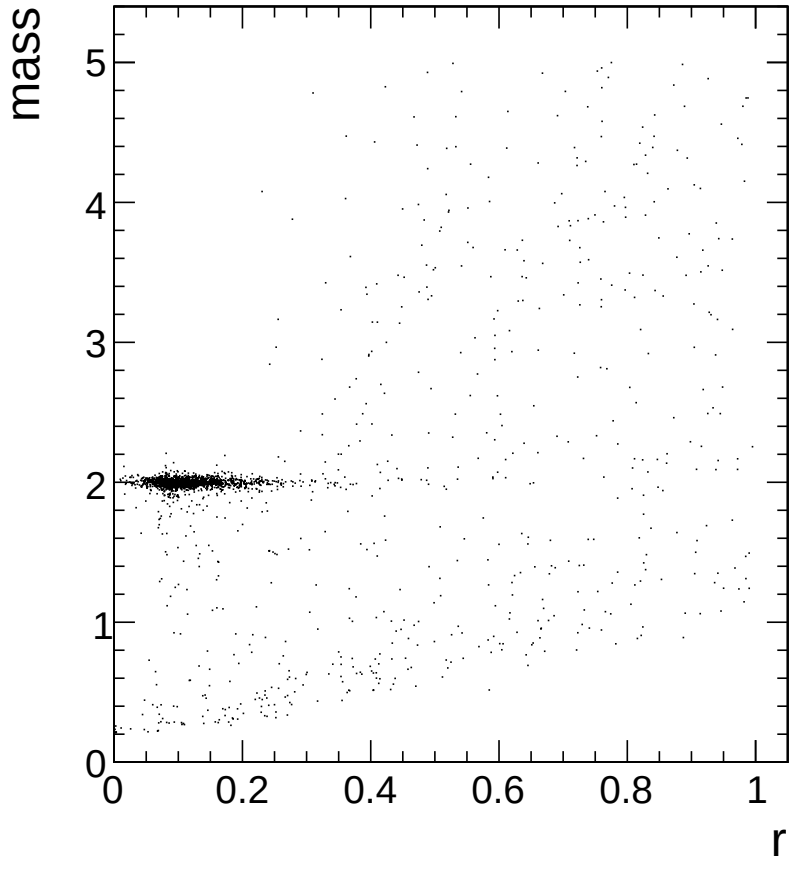
- These are just any pair of muons (6 pairs per 4-muon event): I'm not intending to reproduce Aysen's work! Just to check the samples and learn some things about what PAT provides
- Wrong combinations generally have high mass
- Signal always on left, background always on right

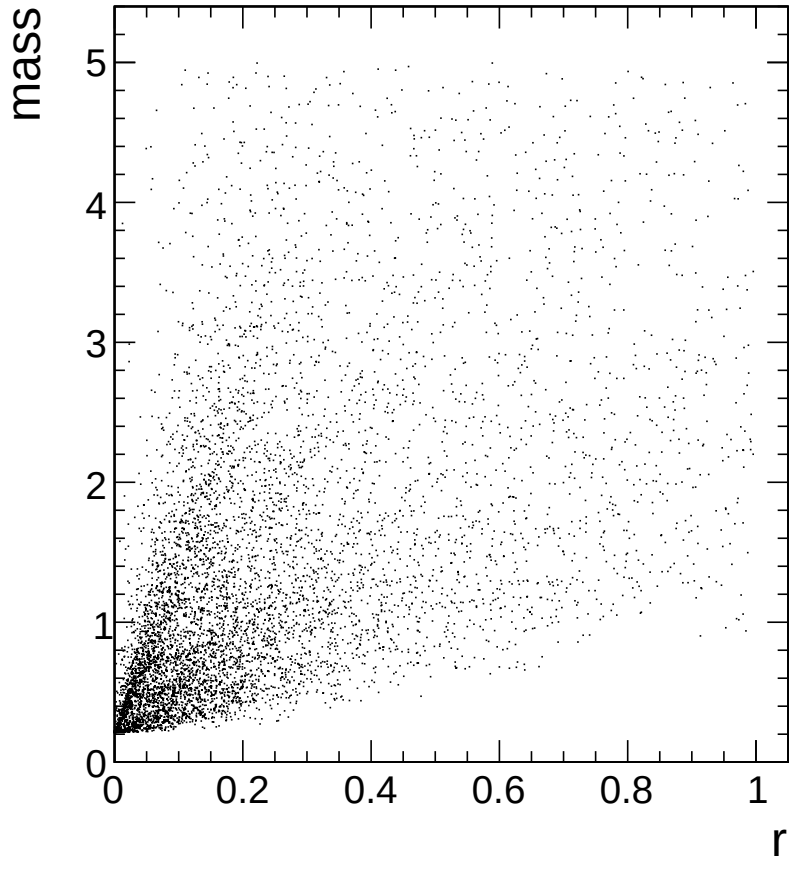




Mass vs. R

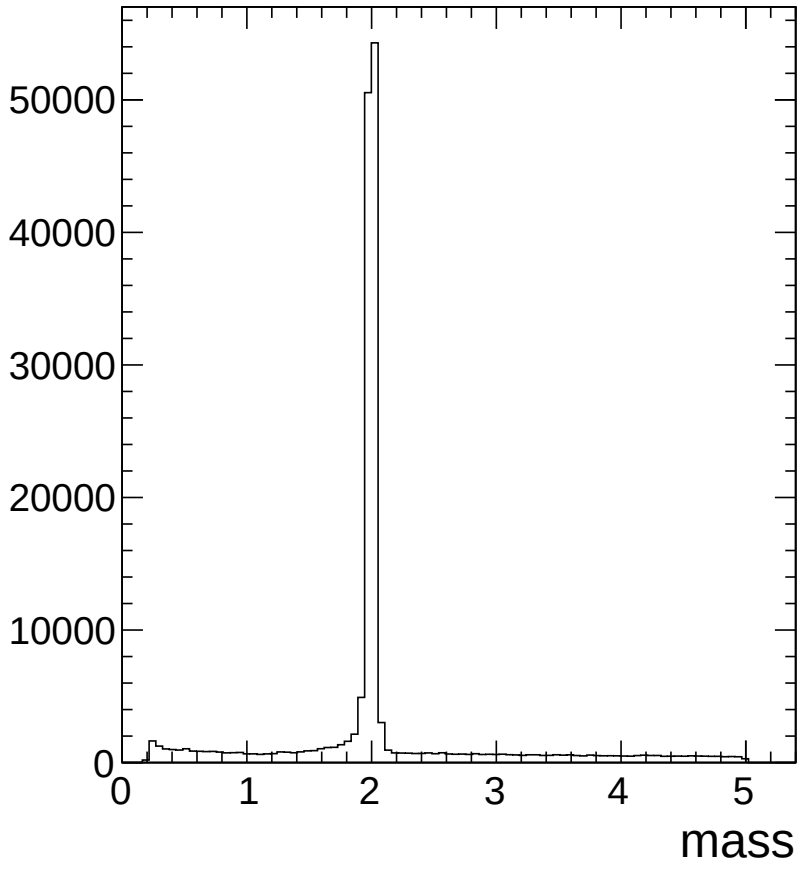
- Zoom in

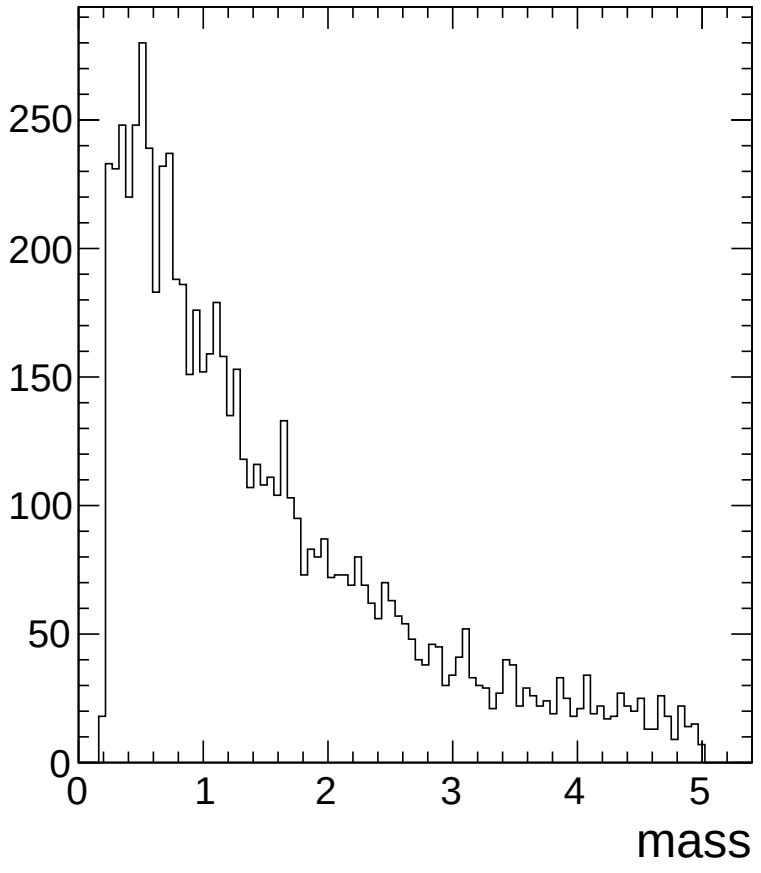




Mass distribution

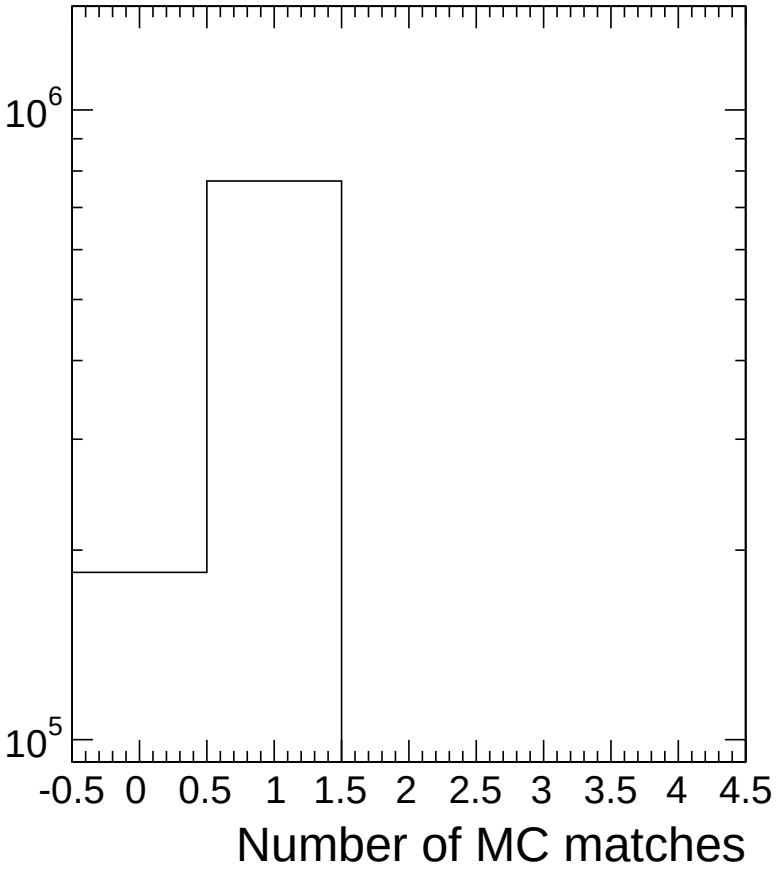
- No clean-up, just a raw look at the data

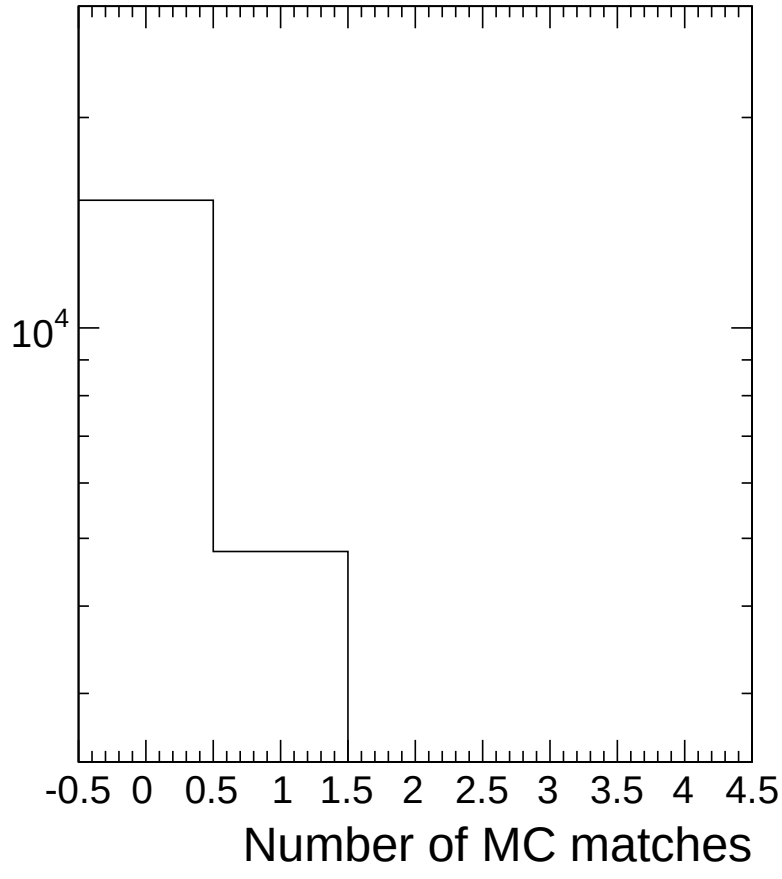




MC matches

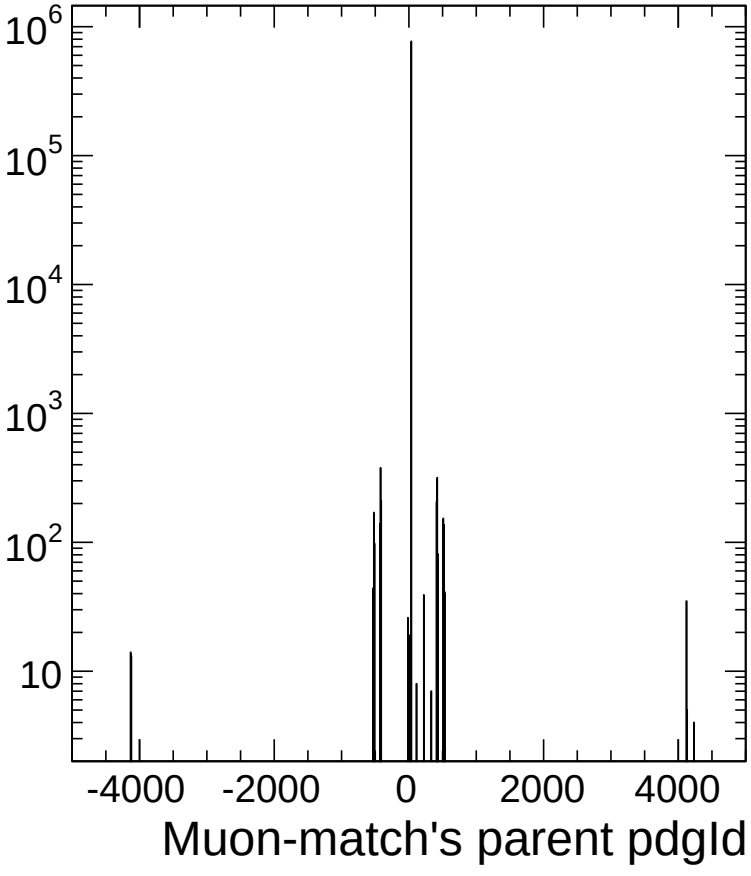
- PAT matches reconstructed muons to generator-level muons for free
- Remember that backgrounds have a lower p_T spectrum

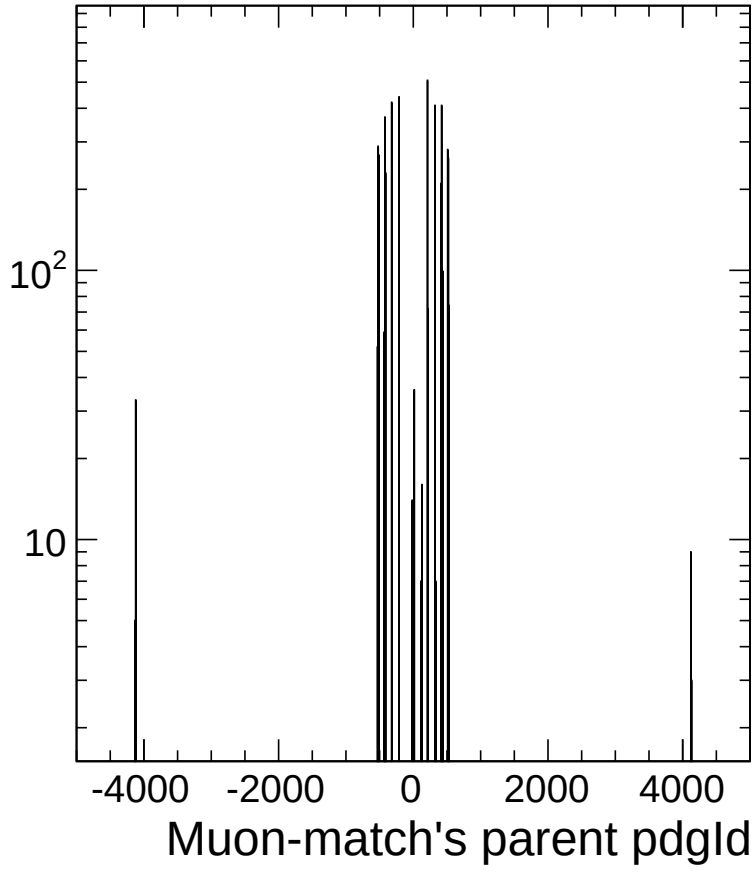




PDG-id of parent

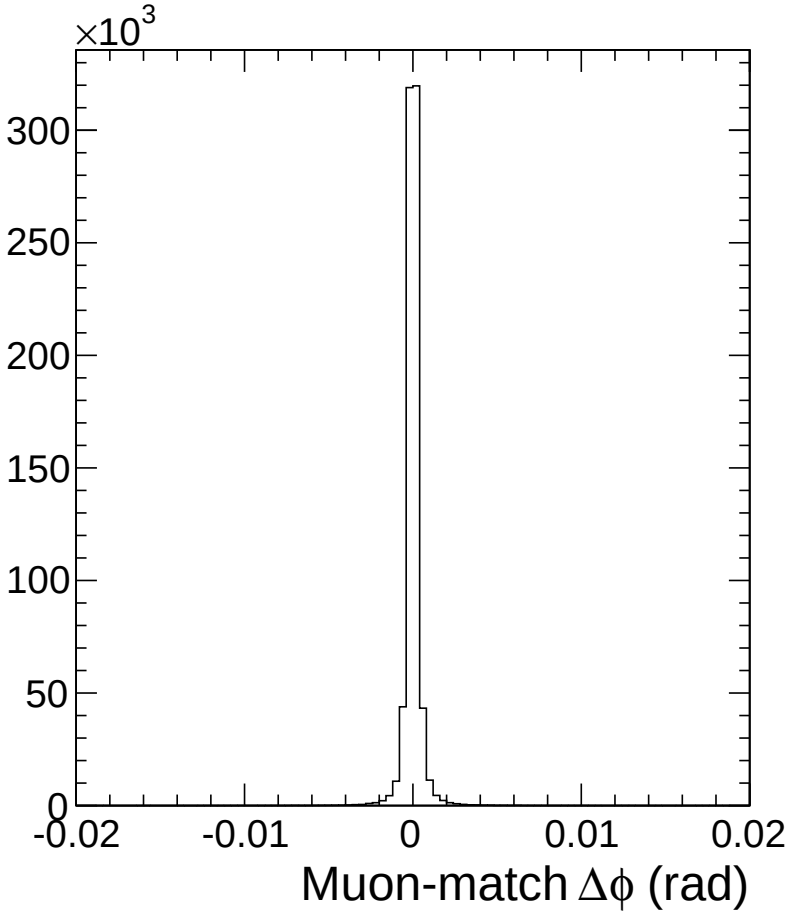
- Most signal muons come from a_1 (PDG-id = 36)
- The rest (signal and background) are from charm and bottom mesons (PDG-ids in the 100's) and baryons (PDG-ids in the 1000's)

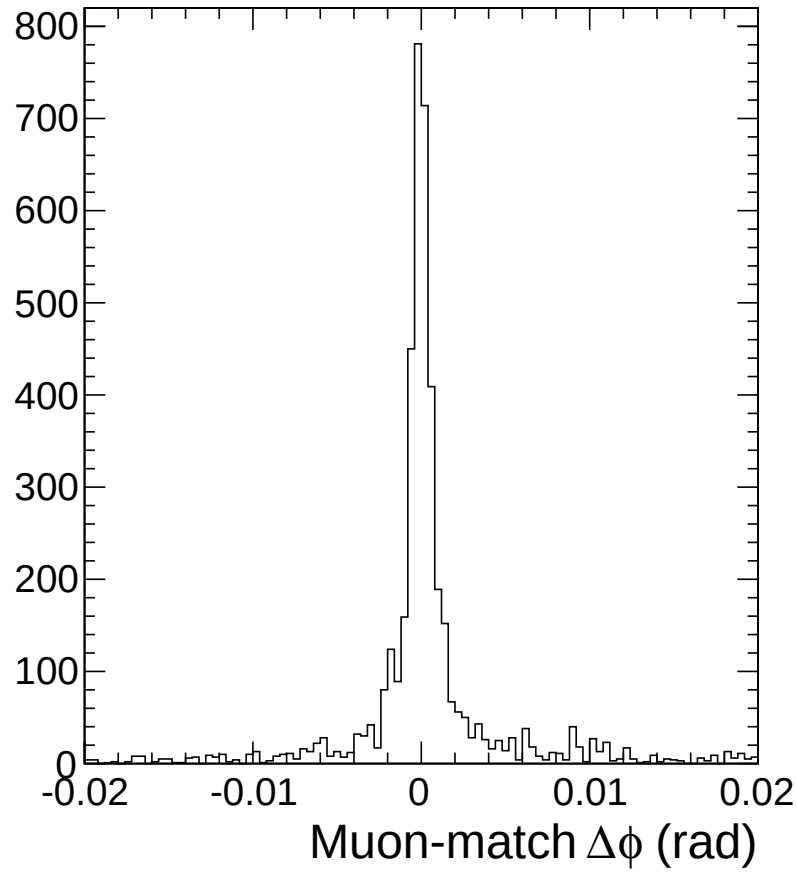




Matched muon $\Delta\phi$

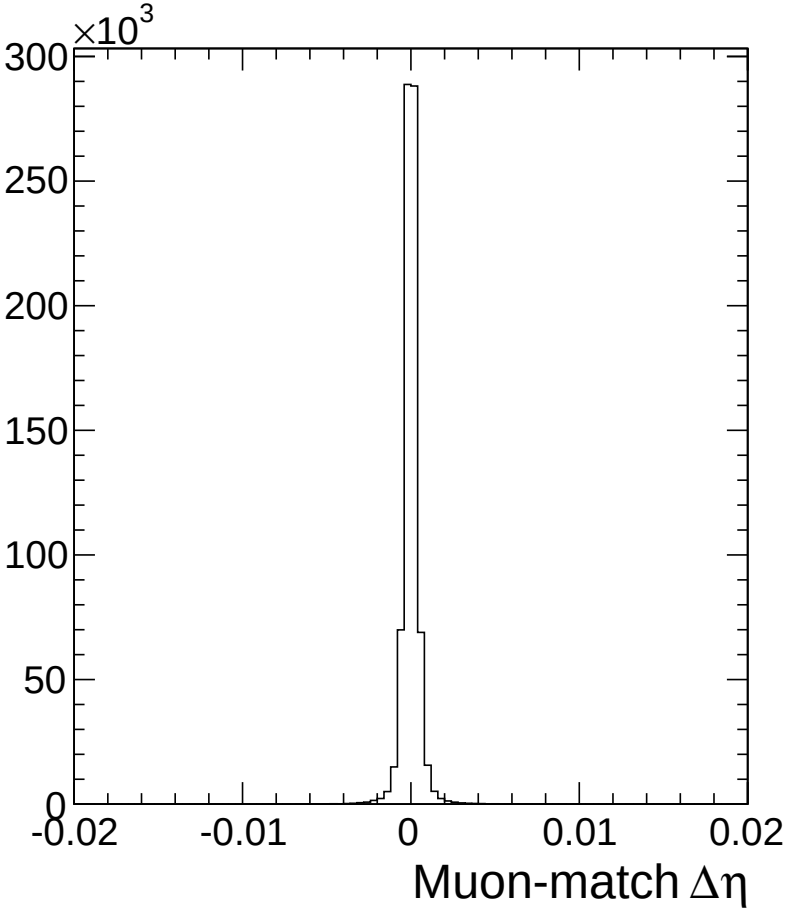
- These matches seem pretty reasonable

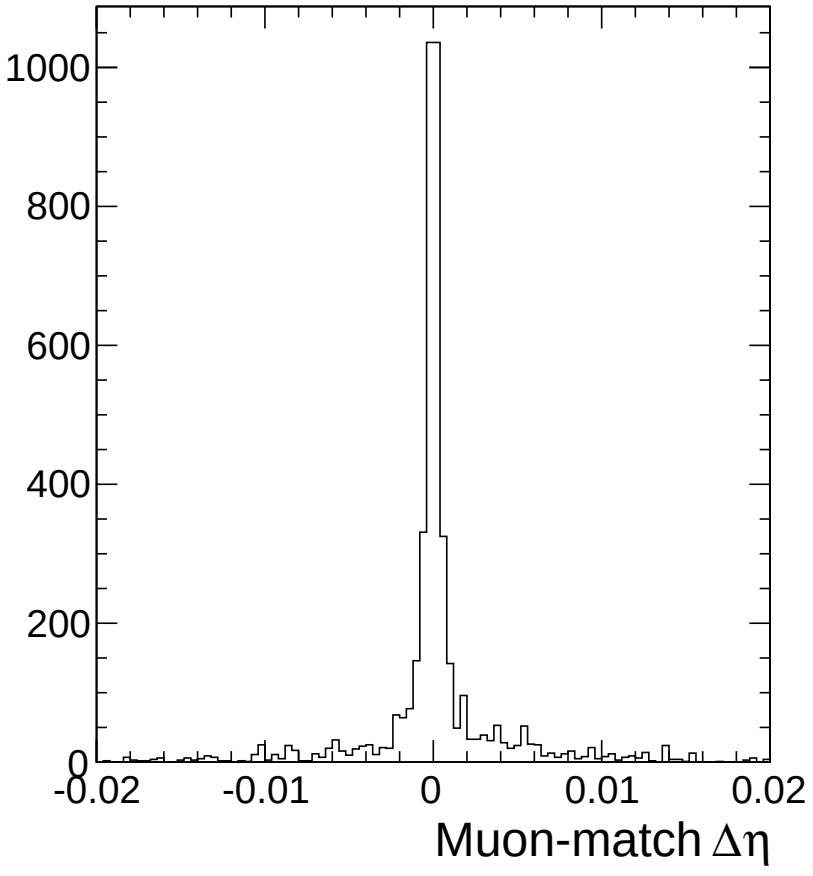




Matched muon $\Delta\eta$

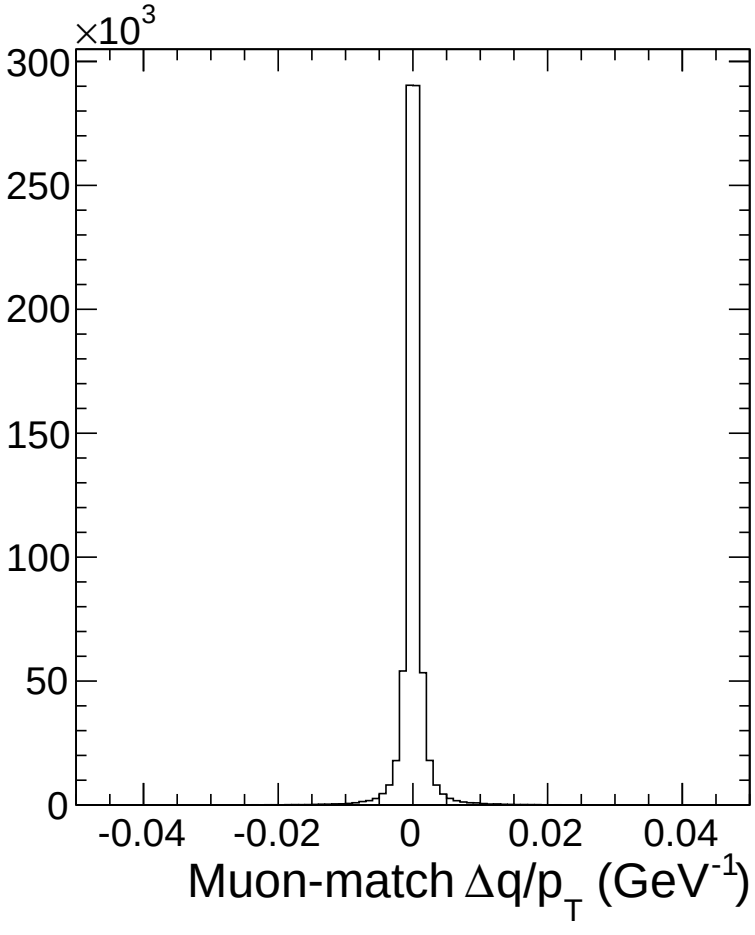
- Yes indeed...

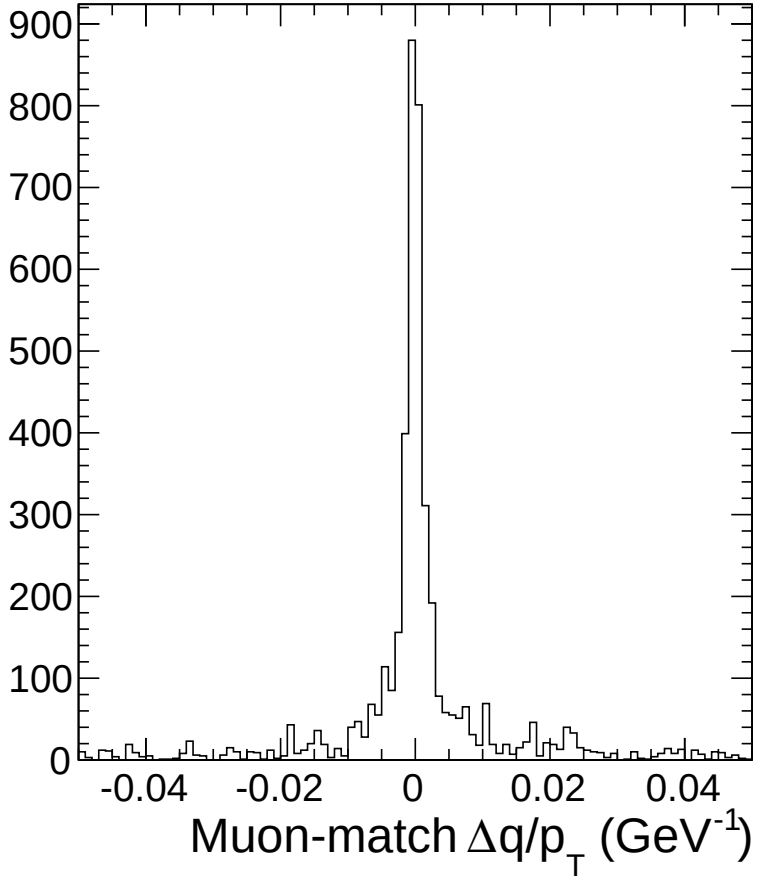




Matched muon $\Delta q/p_T$

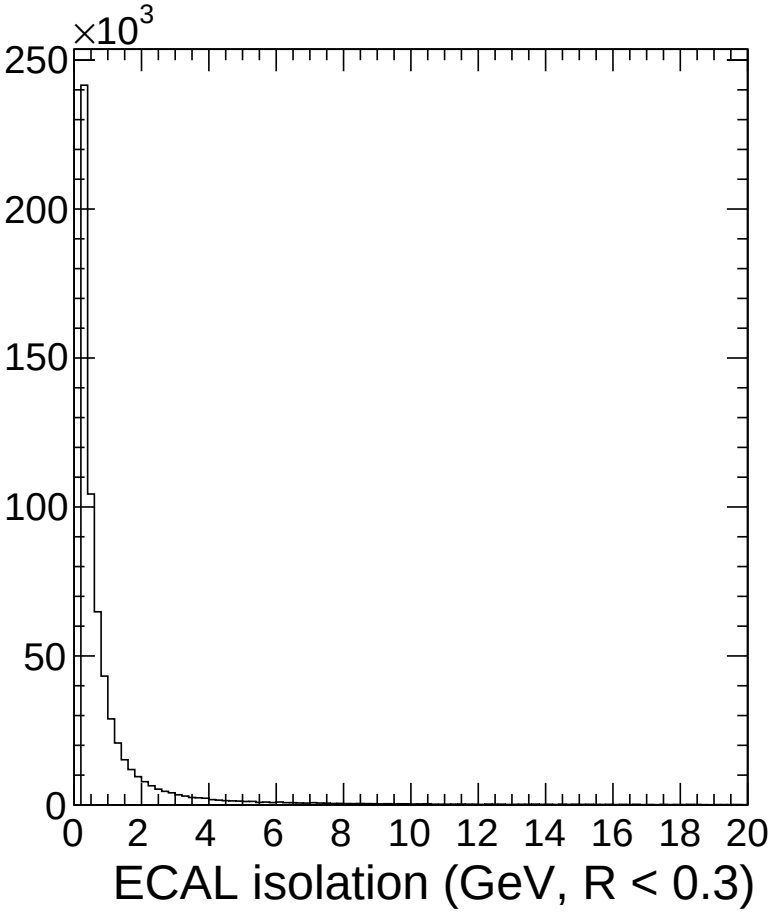
- q/p_T is curvature, the momentum scale that tracking actually measures (as opposed to p_T, $|vecp|$ or something)

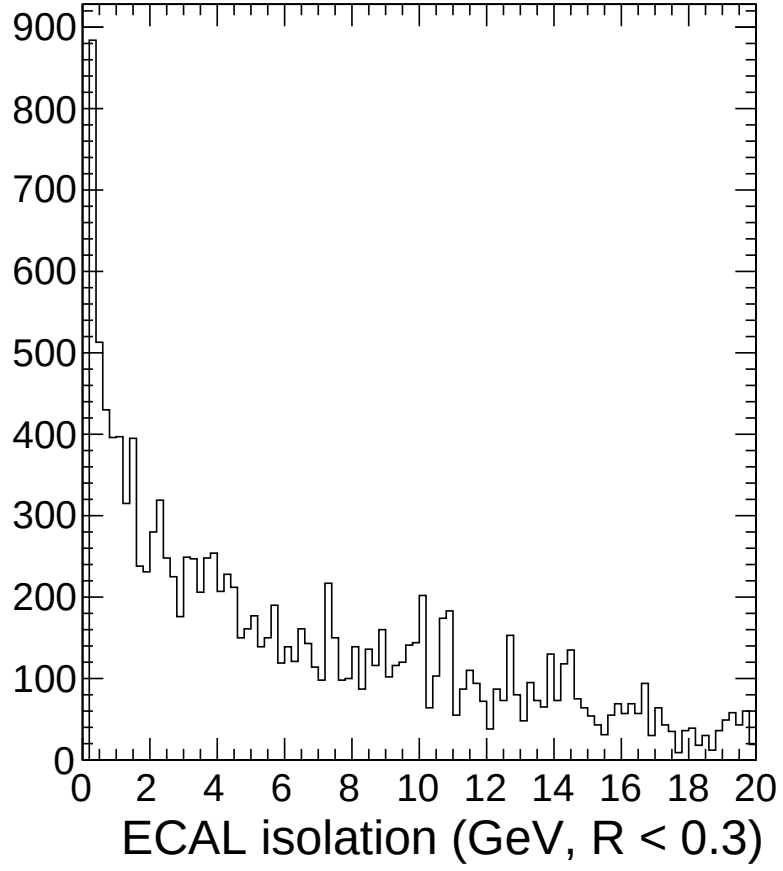




ECAL isolation variable

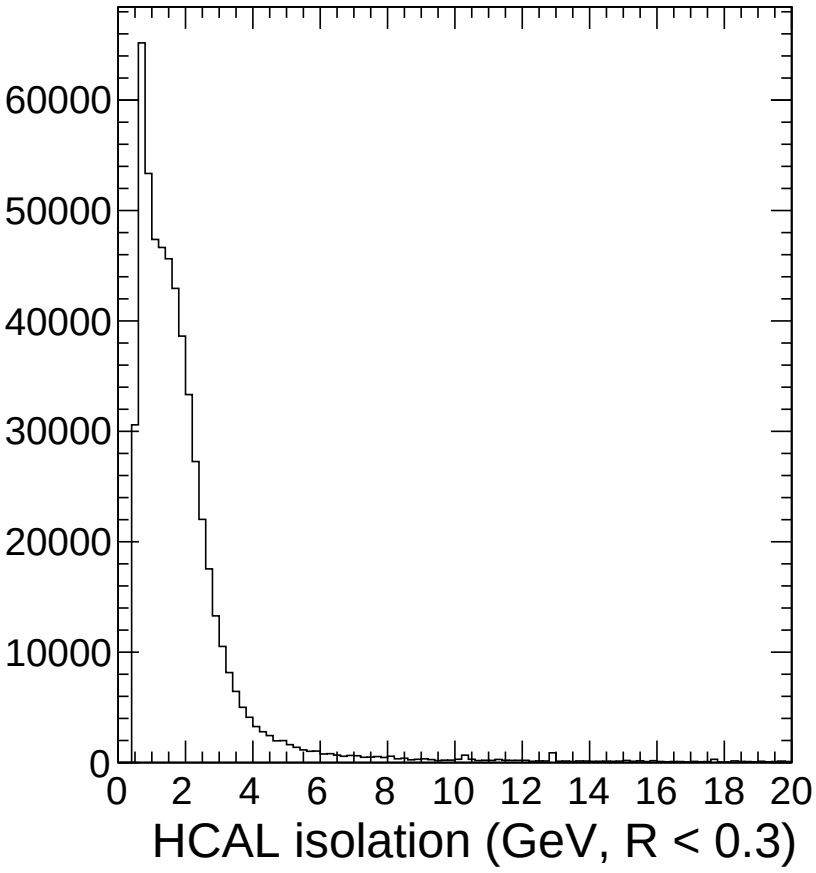
- PAT also gives us $\sum p_T$ around each muon ($R < 0.3$) for free
- Don't take these plots as definitive: when applied to muon pairs, they include double-counting
- Muons contribute negligibly to calorimeter energy (minimum-ionizing)

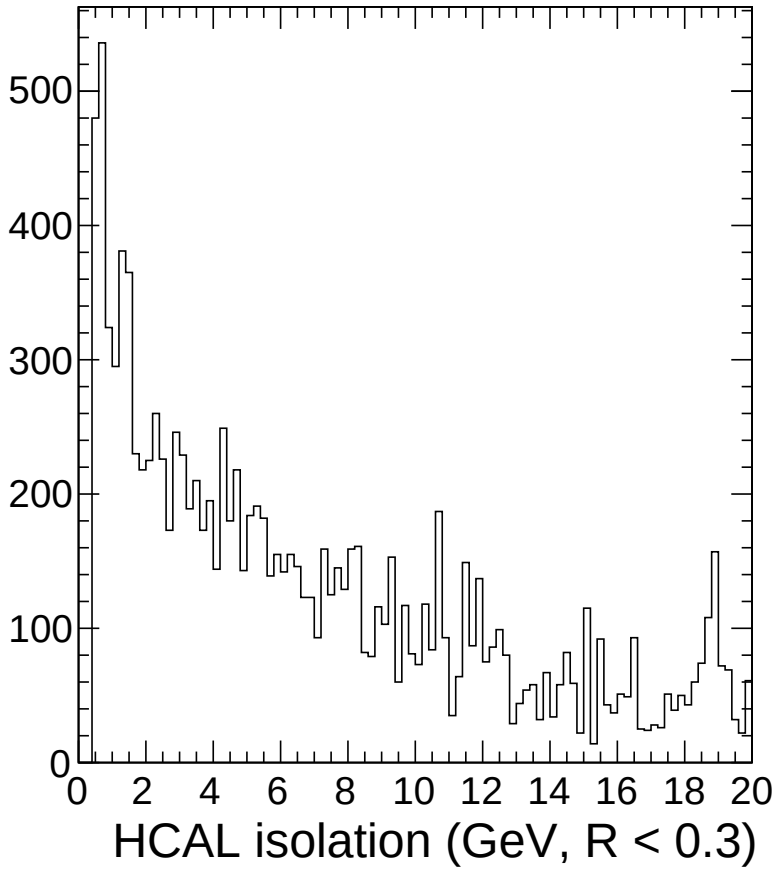




HCAL isolation variable

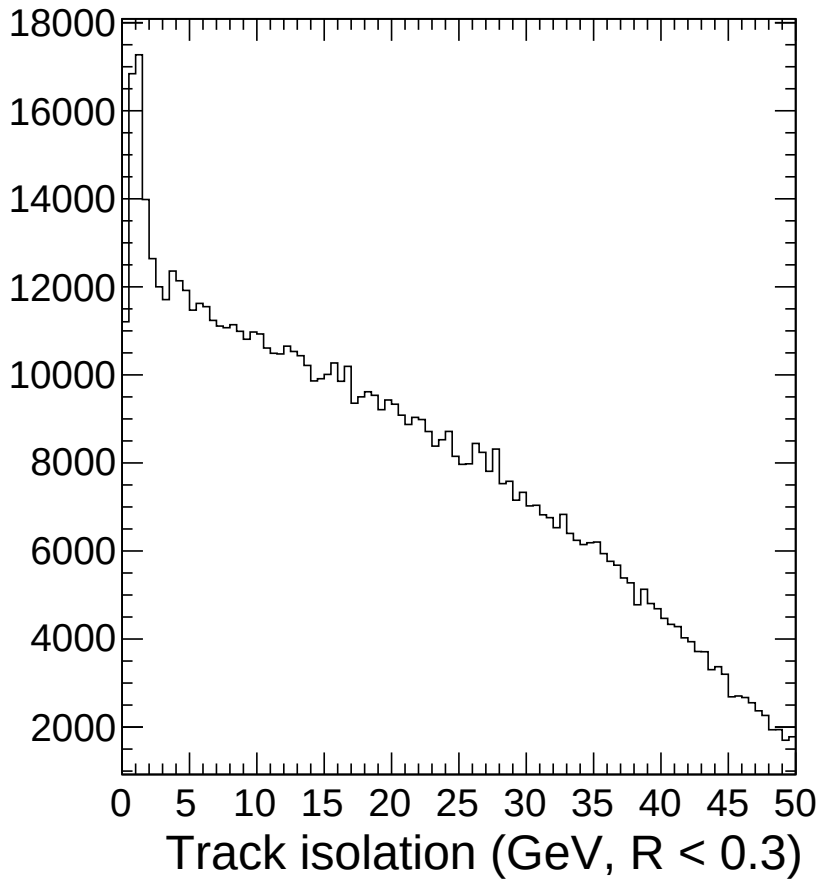
- Same thing for HCAL...

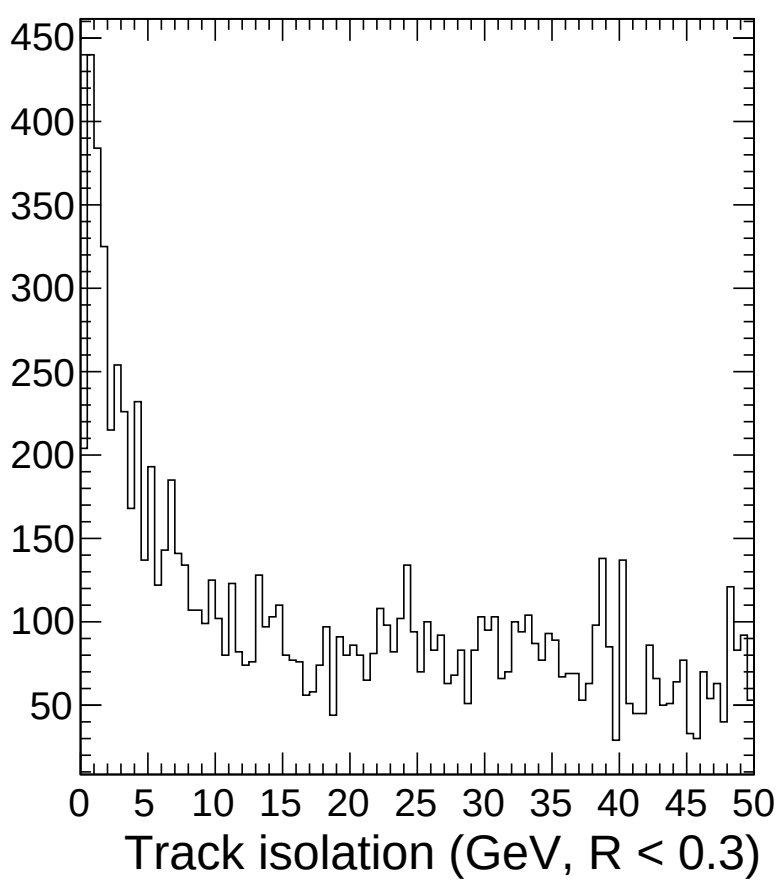




"Track isolation" variable

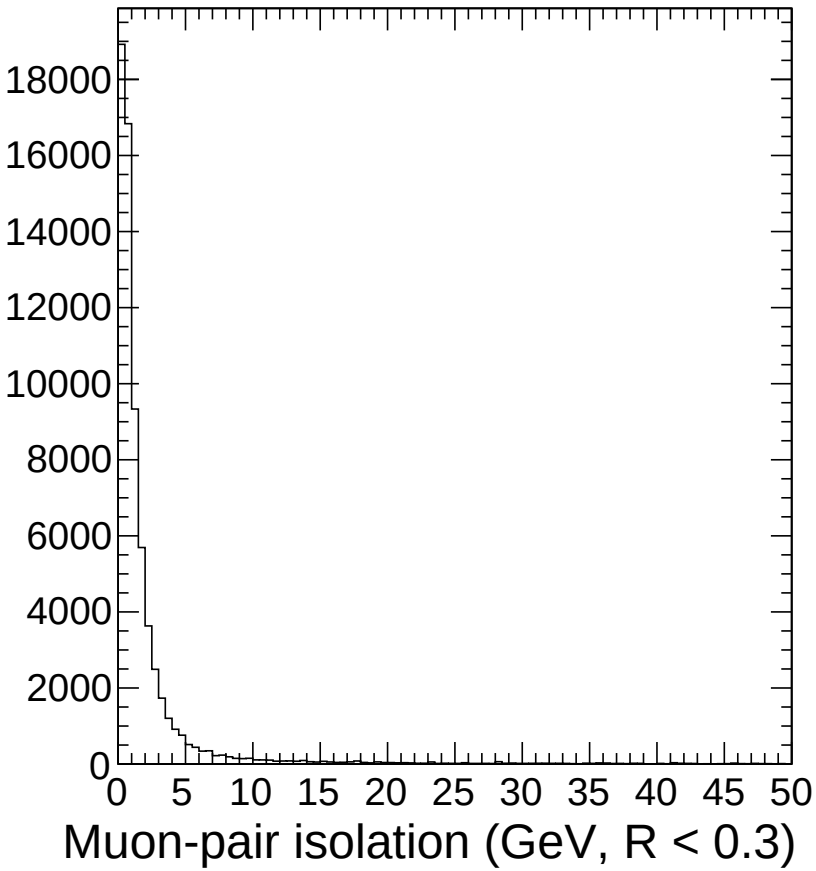
- PAT's "track isolation" is not what we want, because the second muon in each pair often appears in the other's isolation cone
- This is what our isolation definition improves

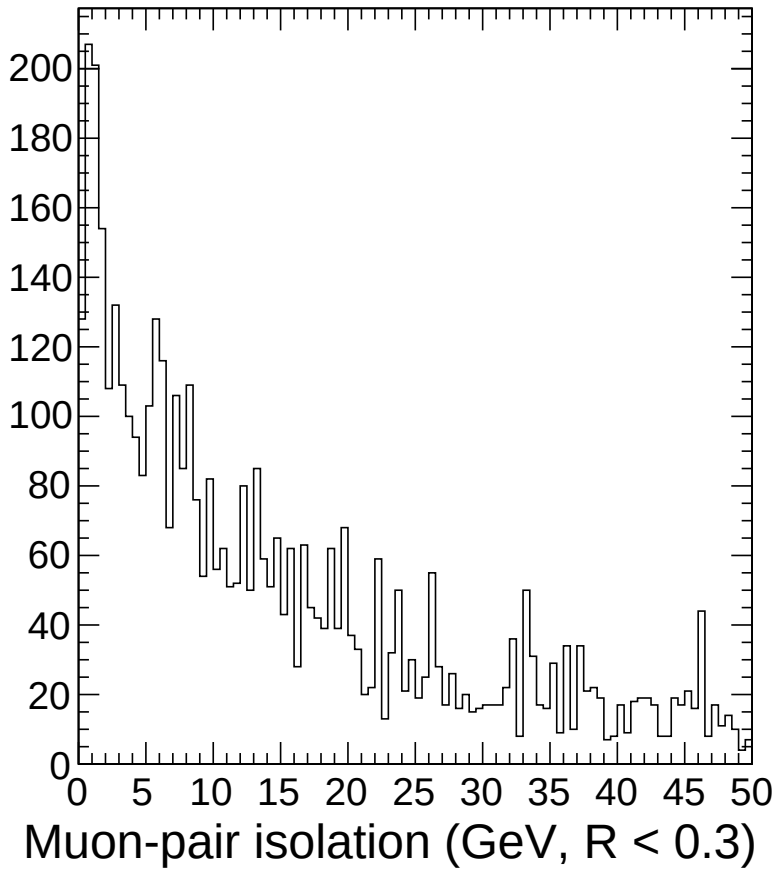




Good track isolation

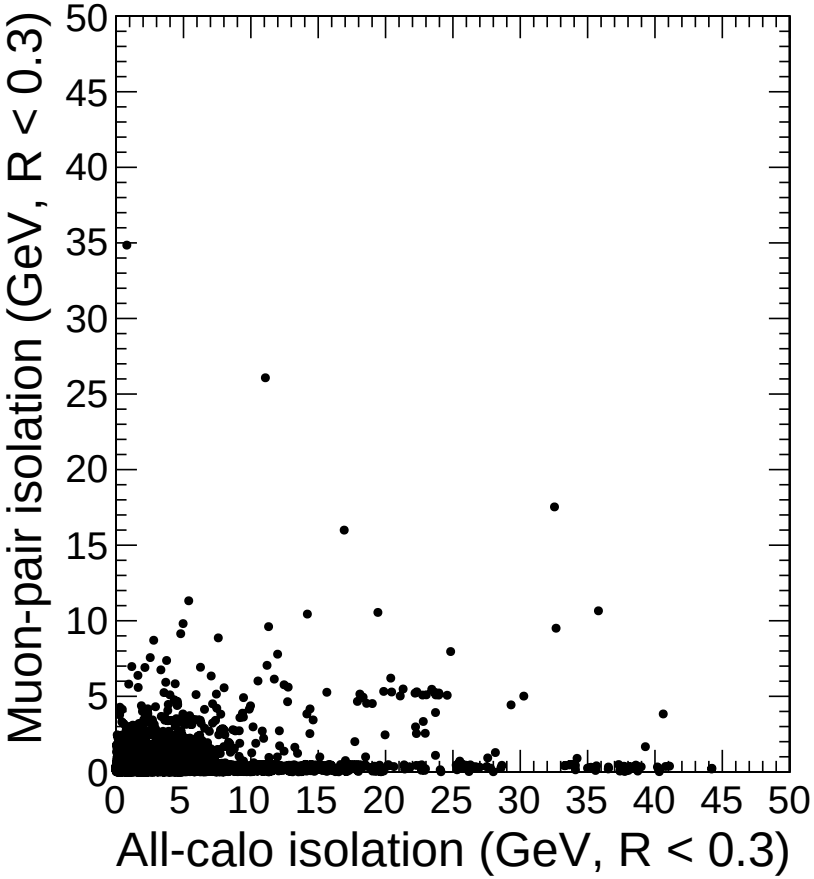
- Track isolation without counting the muons and without double-counting tracks in both muons' cones
- Aysen has developed an isolation variable like this, but we'd have to compare notes to see if it's exactly the same

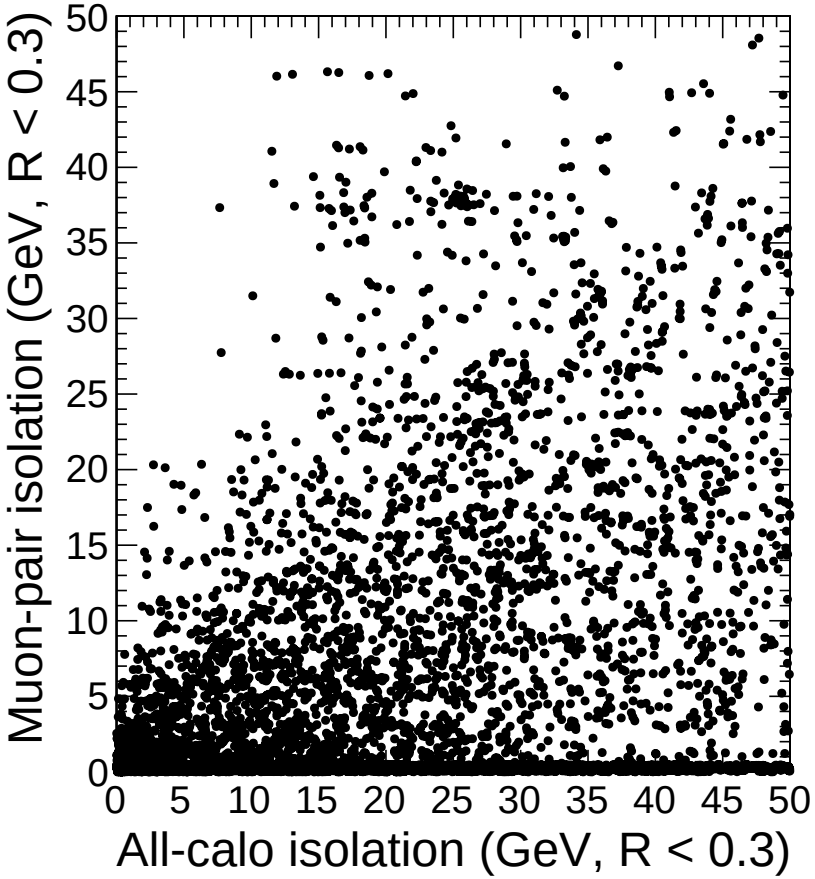




Good track iso vs. calo iso

- They're not strongly correlated: can improve isolation by cutting on both
- Careful with the interpretation: we're still double-counting some calo $\sum p_T$





An idea: $X(3872)$

- As we build our analysis to look for what has never before been seen ($h \to aa \to 4\mu$), we should show that we can see what's there
- The J/ψ is an obvious example, and we'll need to interact with many other groups whenever presenting anything related to J/ψ (because a lot of people are looking at it)
- Also in our sample: $X(3872) \to \pi^+\pi^- J/\psi$, four tracks with a different invariant mass topology
- In 500 pb^{-1} of 7 TeV data, we would see as many such events as the Tevatron's 8 fb^{-1}
- This is an interesting state in its own right, as it may be the first example of a molecular hadron: $c\bar{c} + c\bar{c}$
- `http://arxiv1.library.cornell.edu/abs/0911.2016`
- Unfortunately, not much discrimination power in pp vs. $p\bar{p}$: the interesting thing about an LHC analysis is the higher cross-section, which begins to matter in 2011

$X(3872)$ at CDF

- This is what it looks like at CDF
- `www-cdf.fnal.gov/physics/preprints/cdf9700_X_mass.pdf`
- 7 TeV LHC production is 15× larger, backgrounds are. . . ?

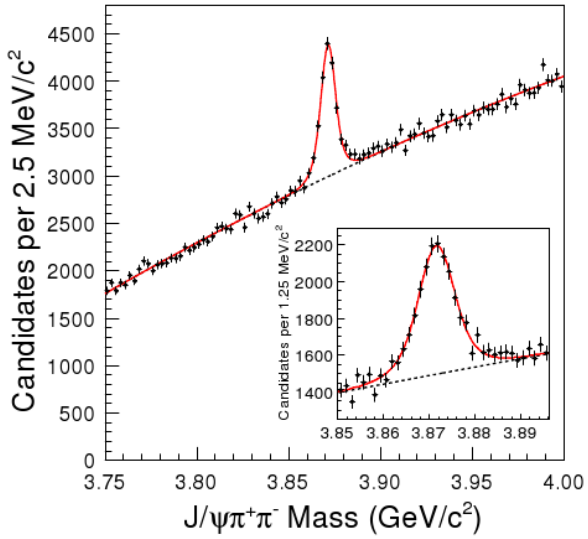


FIG. 1: Invariant mass distribution of the $X(3872)$ candidates. The points show the data distribution, the full line is the projection of the unbinned maximum-likelihood fit, and the dashed line corresponds to the background part of the fit. The inset shows an enlargement of the region around the $X(3872)$ peak.