Suppressing Fake Dimuons from ME1/1a Triplets

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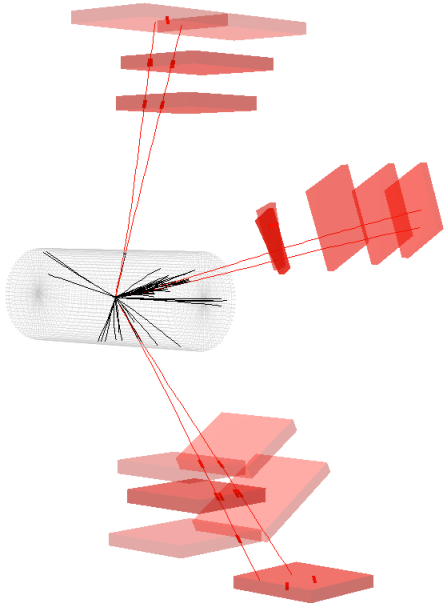
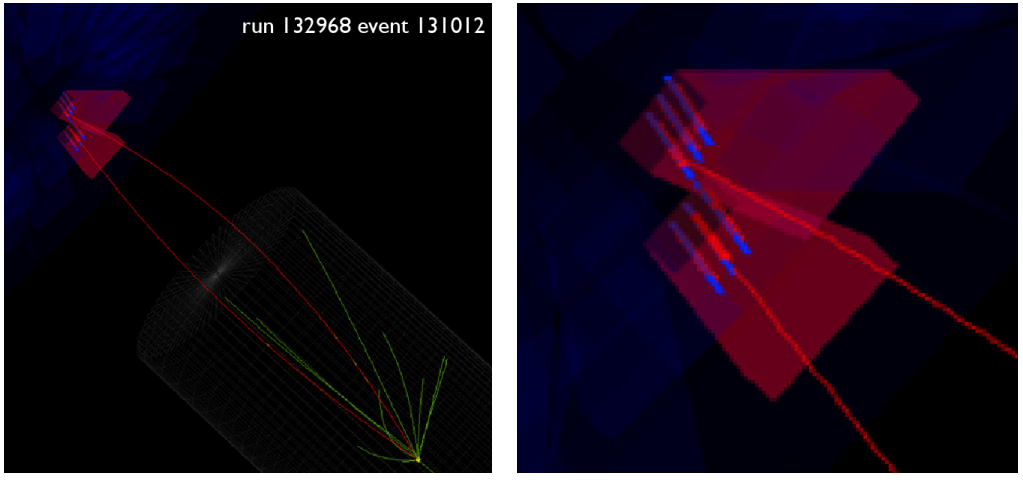
Motivation

- Groups of near-by muons are a typical signature of hidden valley models used to explain PAMELA positron excess
- For details, see *Lepton Jets as a Signature for Dark Matter* (C. Boulahouache, March 16 Exotica)

  http://indico.cern.ch/materialDisplay.py?contribId=2&materialId=slides&confId=87421
- Problem: we're already seeing fake "muon jets" due to ganging of ME1/1a strips:



event from a $U(1)_{\text{dark}}$ model



N. Kypreos

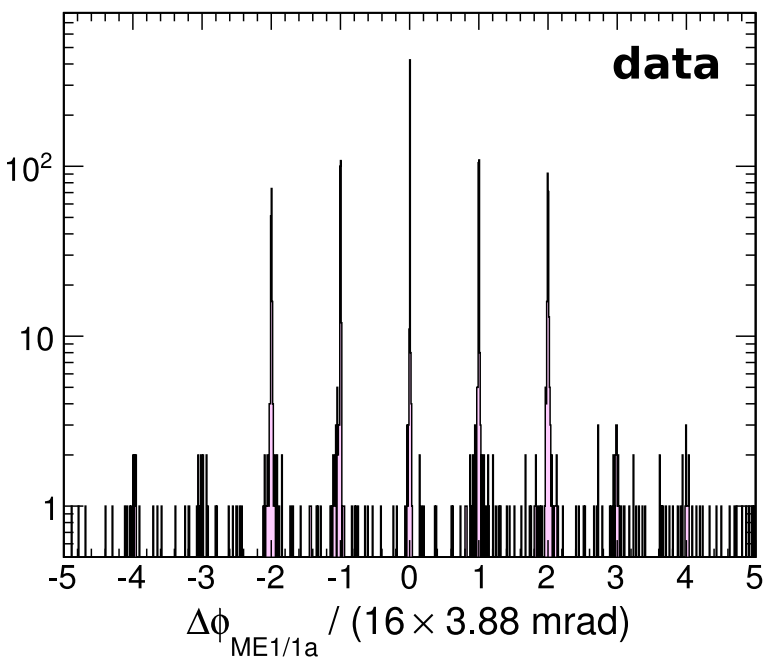
- One real muon produces three parallel segments in each ME1/1a chamber
- Non-muon tracks can be associated with the other segments

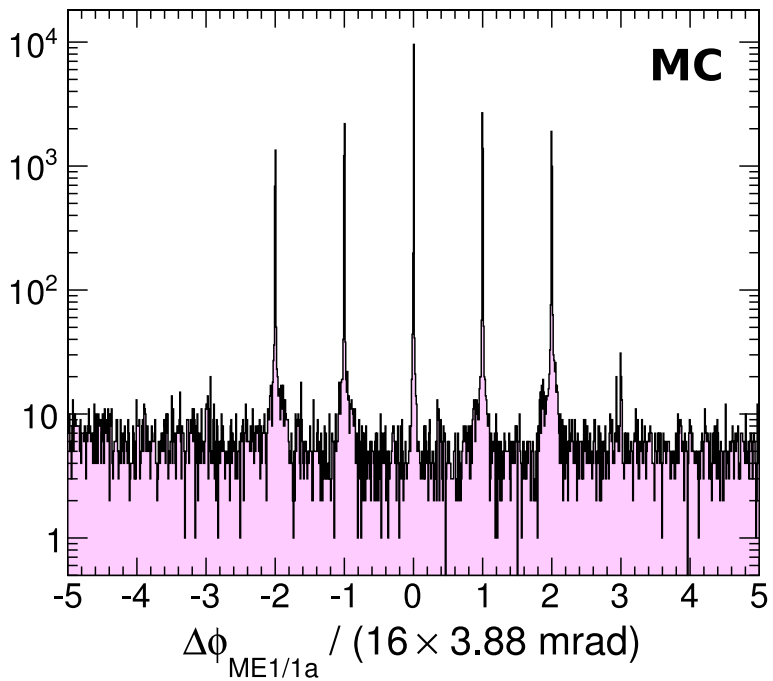
Scalpel-cut for ME1/1a triplets

- D. Kovalskyi and N. Kypreos have shown ways to suppress backgrounds from muons that approach or overlap each other

  http://indico.cern.ch/conferenceDisplay.py?confId=88576

- However, these methods might eliminate legitimate muon jets
- The effect: strip number mod 16 are read out of the same channel, triplicating hits with an offset of 16×3.88 mrad
- Differences in matched segment ϕ position for dimuons in ME1/1a:





Implementing the cut

Method 1:

```
int stripnumber = cscGeometry->layer(layerId)->geometry()
  ->nearestStrip(LocalPoint(segMatch->x, segMatch->y, 0.));
long channel = chamberId.rawId()*16 + ((strip-1) % 16);
```

and make sure the two muons don't share a "channel".

Method 2:

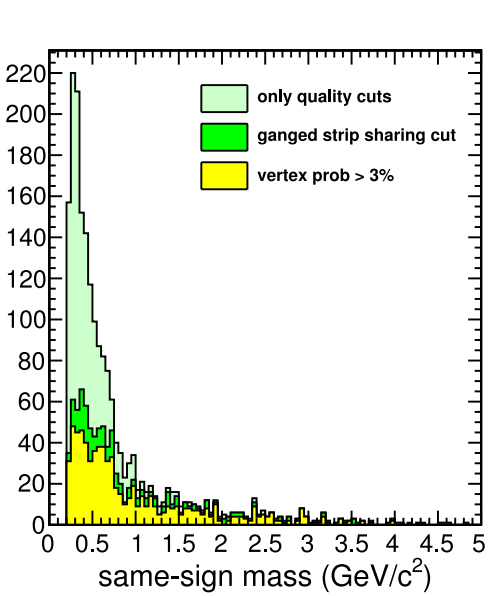
```
const Surface &s = cscGeometry->idToDet(chamberId)->surface();
GlobalPoint point =
  s.toGlobal(LocalPoint(segMatch->x, segMatch->y, 0.));
GlobalVector direction =
  s.toGlobal(LocalVector(segMatch->dXdZ, segMatch->dYdZ, 1.));
```

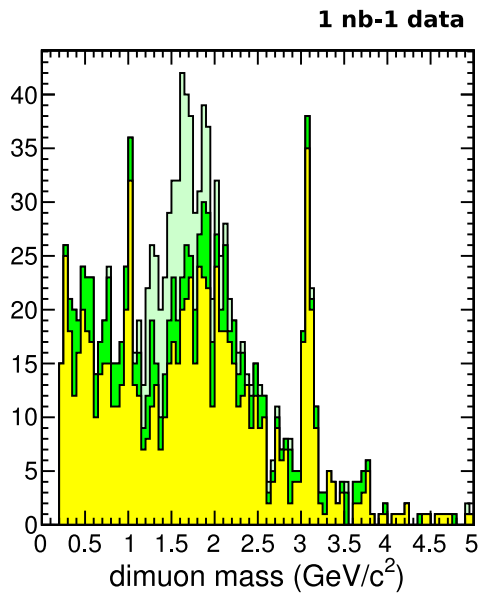
linearly extrapolate to a common z-plane (e.g. 602.3 cm), and make sure they don't overlap with a small tolerance (plots on previous page).

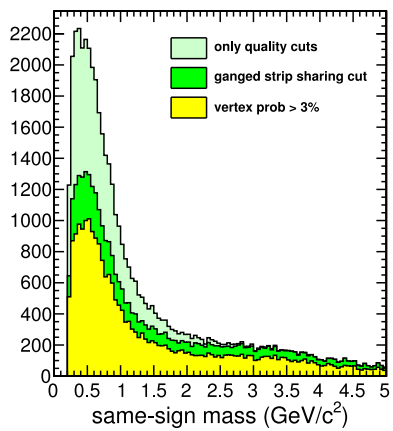
Both methods require access to CSCGeometry.

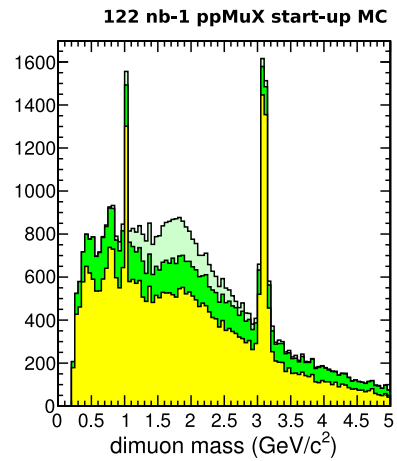
Results

- trackerMuons only (from a Muon collection with only trackerMuons)
- Quality cuts (following N. Kypreos and M. Chen):
  - $p_T > 1$ GeV/c, $|\vec{p}| > 2.5$ GeV/c
  - $N_{\text{tracker hits}} > 12$, $\chi^2/N_{\text{dof}} < 5$
  - $|d_{xy}| < 0.5$ cm, $|d_z| < 5$ cm,
  - TMLastStationAngTight
  - trigger bit 40 or 41, not beam-halo, physics declared, no beam scraping
- Ganged strip sharing cut (method 1) significantly reduces background with little effect on J/ψ and $\phi(1020)$



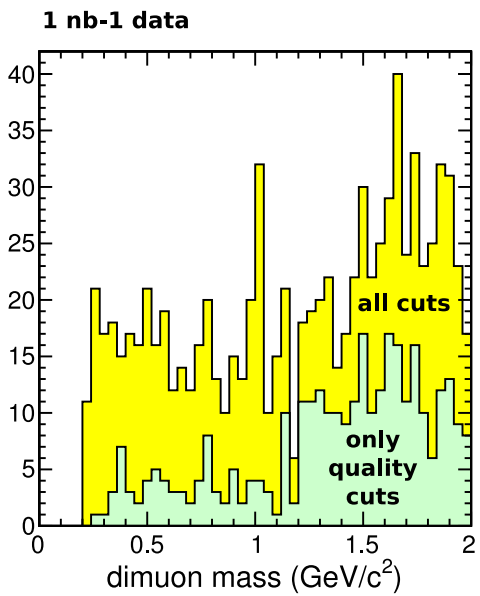


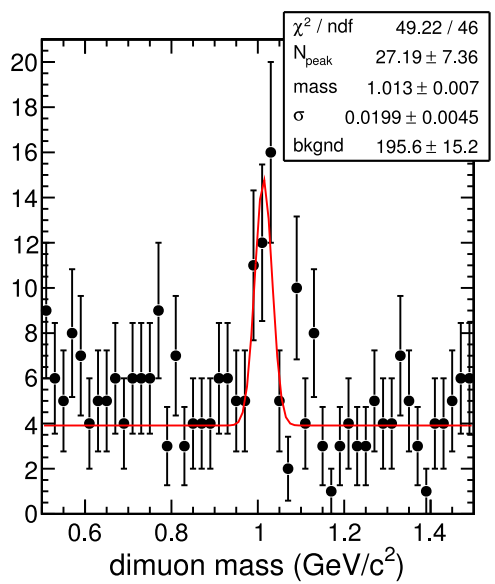


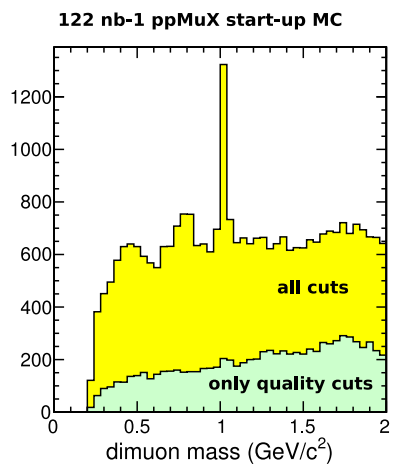


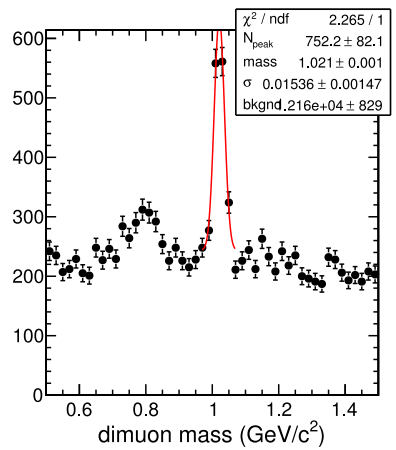
Excess in $\phi(1020) \to \mu\mu$

- More detail on the $\phi(1020)$ region shows that the excess is significant (3.7 sigma)
  - also hint in https://hypernews.cern.ch/HyperNews/CMS/get/muon-performance/531.html
- Even though $\mathcal{B}(\phi(1020) \to \mu\mu)$ is 2.8×10^{-4}, observation with 1 nb^{-1} is plausible (scaling from $\phi(1020) \to K^+K^-$, CMS IN-2010/001).
- Data/MC differences are related to a generator-level $p_T > 2.5$ GeV/c cut on one of the muons in ppMuX (see next slide)



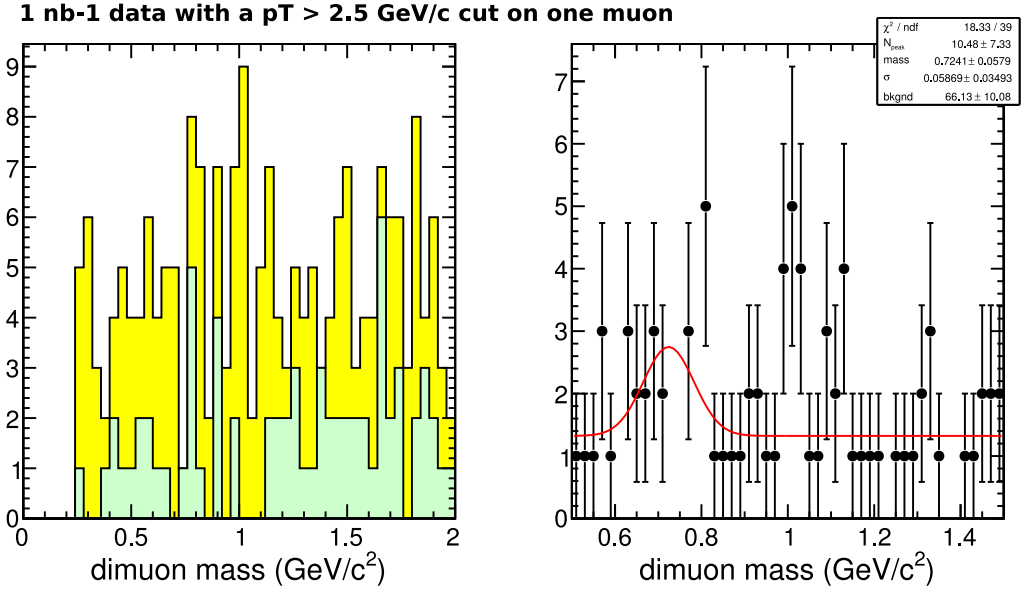


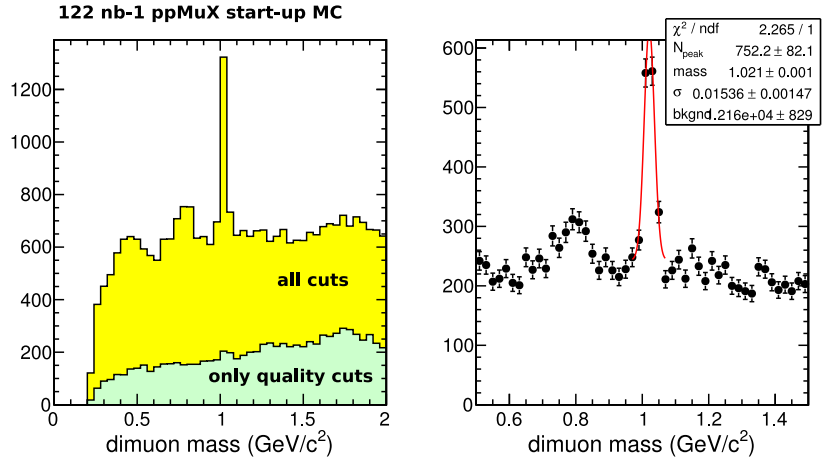




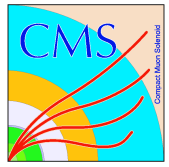
Apples-to-apples comparison

- Data/MC differences are related to a generator-level $p_T > 2.5$ GeV/c cut on one of the muons in ppMuX
- Applying the same cut in data, we lose the $\phi(1020)$ peak but get better agreement between data and MC
  - background levels before and after cuts scale by a factor of 120
  - scaling of signal cannot be tested





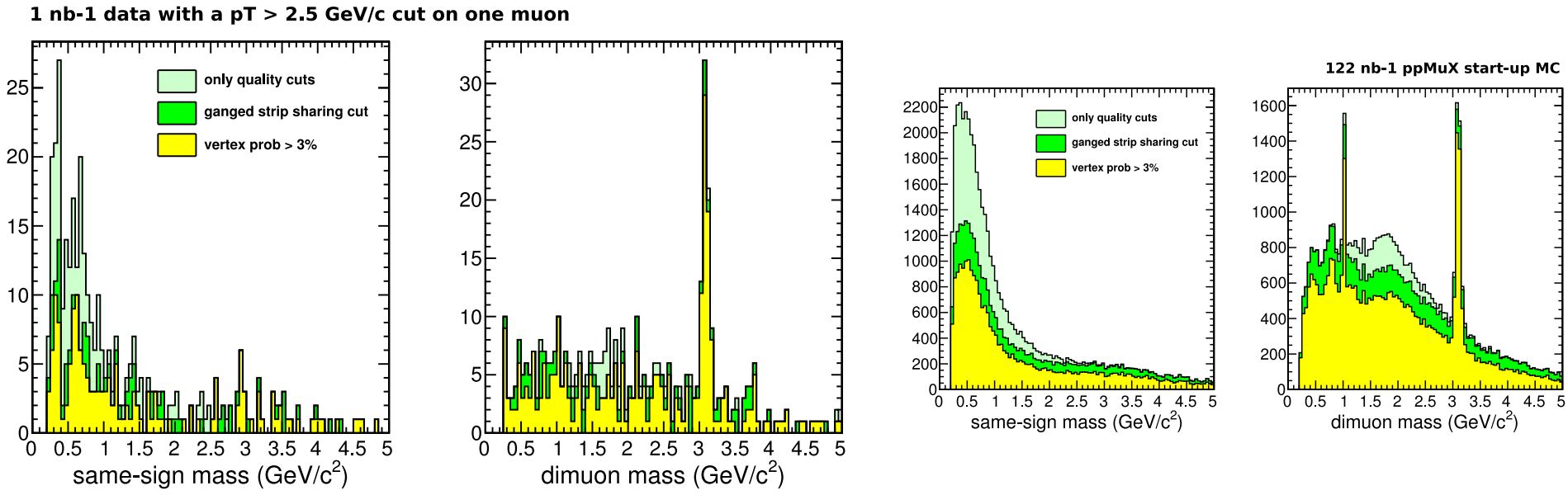
Conclusions



- Some physics signatures need to be able to reconstruct close-by muons
- Primary source of fake close-by muons is a very precise effect from ME1/1a electronics
  - can be cut with high efficiency for real dimuons
- $\phi(1020) \rightarrow \mu\mu$ peak is at the level of 3.7 sigma

One more apples-to-apples

- Applying the $p_T > 2.5$ GeV/c cut to same-sign muon pairs for a proper comparison with MC
- Similar background levels (scaling by 120), but J/ψ appears to be under-produced in MC by a factor of 2.4



Vertex probability cut

- Vertex compatibility of the two muons, cut at prob $> 3\%$
- This is data