



Triggers for Muon Alignment

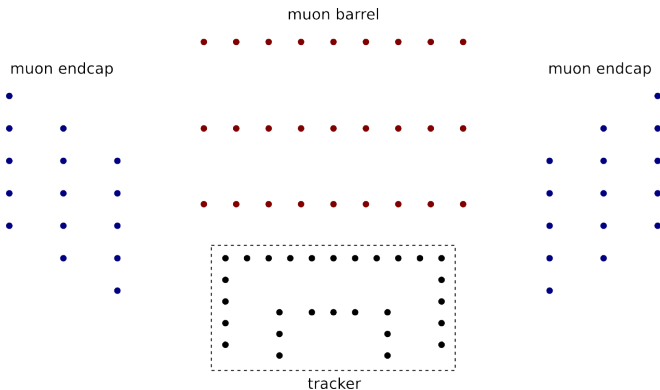
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4 February, 2009

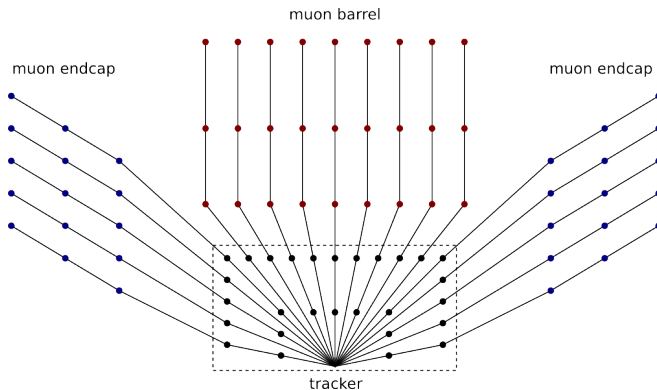


- ▶ Track-based alignment measures relative positions of detectors through residuals on the tracks that connect them
- ▶ Having “enough” tracks is a matter of connecting and completing the graph: samples are important for qualitatively different reasons
- ▶ Relevant triggers: *(next page)*



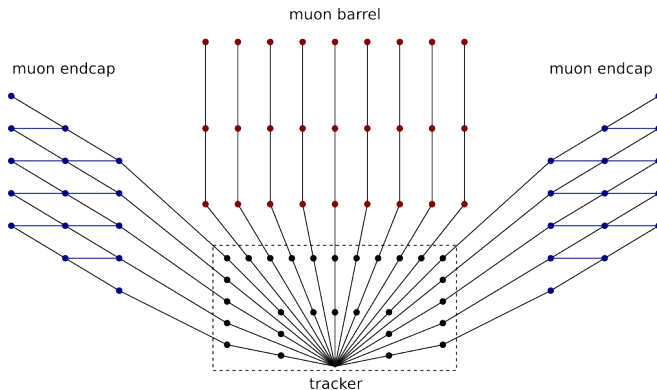


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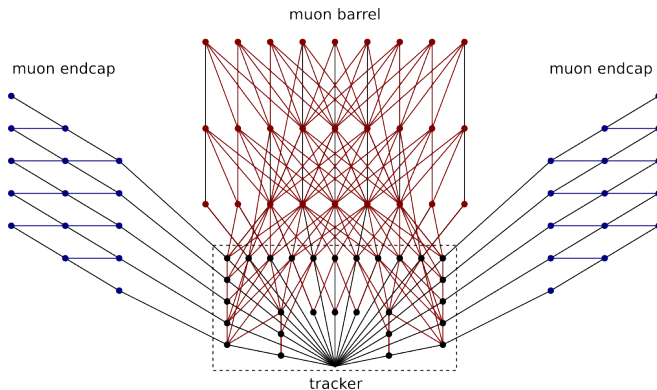


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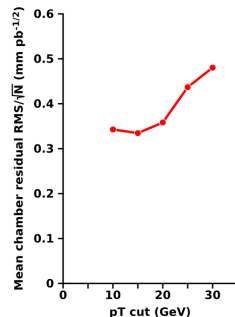
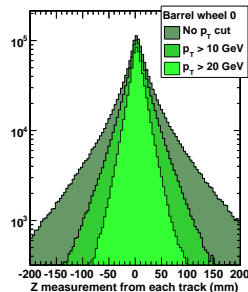
- ▶ Why the existing single-muon triggers are sufficient
- ▶ Why the tracker-pointing cosmics trigger will be sufficient
- ▶ CSC beam-halo trigger
 - ▶ radial distribution, special “CSC overlaps” events
 - ▶ calculation of required rate from alignment resolution
 - ▶ implementation, monitoring, people/institutions

Single-muon triggers

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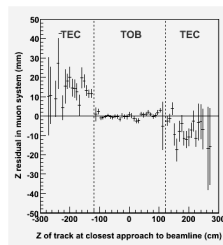
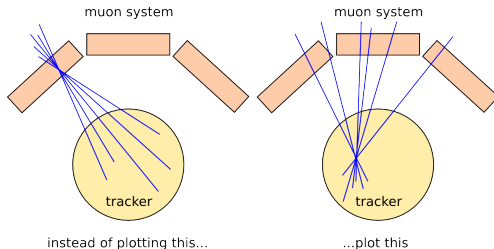


- ▶ Objective is to find the peak of the residuals distribution of each muon chamber with a resolution of 200–300 μm about once a month
- ▶ Distribution is broadened by propagation uncertainty (core) and muon scattering (tails)
- ▶ Scattering tails are highly dependent on track p_T (top plot from CRAFT, note log scale)
- ▶ Cutting low on p_T ...
 - ▶ increases statistics, which helps
 - ▶ adds tails, which hurts
- ▶ Optimum is $p_T \gtrsim 10$ GeV
 - ▶ tested different p_T cuts in CSA08 with inclusive single muons (bottom plot)
 - ▶ figure of merit is statistics-only; systematics better controlled at high p_T
- ▶ 8E29 and 1E31 muon triggers are unprescaled above 9 GeV ✓





- ▶ Collisions muons in a given chamber all pass through the same part of the tracker: a major source of systematic error
- ▶ Cosmic rays make the graph of alignables more complete, allowing us to diagnose muon alignment as a function of track source

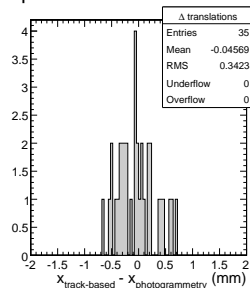
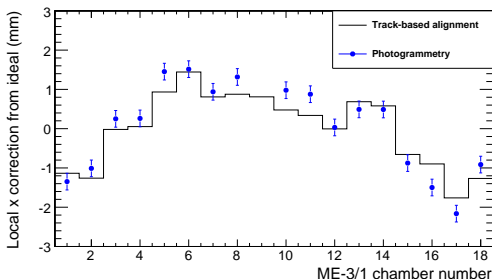


What cosmic rays do we need?

- ▶ Exactly the same cosmic rays the tracker alignment needs
- ▶ “All of them” = $\mathcal{O}(\text{few Hz})$ (between bunch crossings)
- ▶ If rate-limited, apply a ϕ -dependent prescale (see Andrei’s talk)



- Useful for early and rapid CSC alignment
 - track-based alignment of ME-2/1, ME-3/1 demonstrated with $270\ \mu\text{m}$ accuracy in the September 2008 run
 - validation of track-based alignment against an independent method:



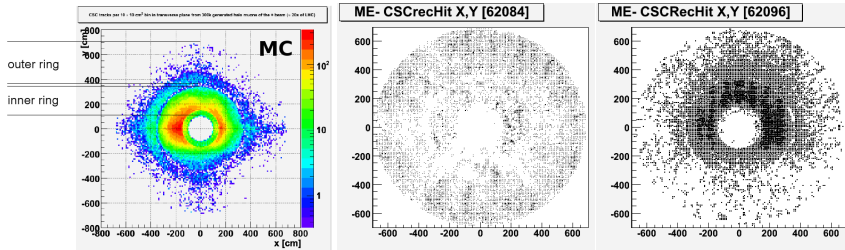
- takes advantage of physical overlap of pairs of chambers to compare tracks with very small propagation uncertainties
- an important part of the design of the muon endcap
- Beam-halo events are also useful for general CSC detector studies

What is our signal rate?

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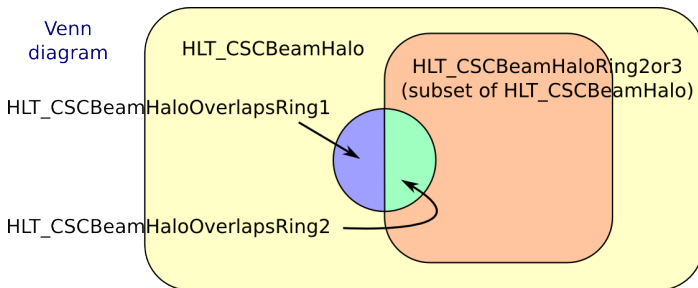
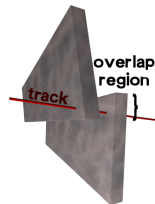
- **Unknown:** Monte Carlo differs from data, which differs from data



- LHC beam-halo will at some point “settle down” into a steady state, but we can’t know the exact profile yet
- We do know that the CSC inner ring (ring 1) will get more muons than the CSC outer ring (ring 2)
- There are twice as many chambers in ring 2 as ring 1; we’d like to balance the load



- ▶ **HLT_CSCBeamHalo** only passes the L1 bit (**L1_SingleMuBeamHalo**): can be prescaled if necessary
- ▶ **HLT_CSCBeamHaloRing2or3**: for general studies of outer detectors, less prescaled
- ▶ **HLT_CSCBeamHaloOverlapsRing1, Ring2**: special events for alignment where track passes through pair of neighboring chambers (rate is about $1/50^{\text{th}}$ of general beam-halo due to geometry)





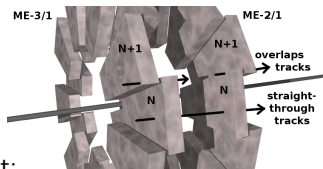
- ▶ Level 1: standard CSC trigger with a non-interaction point $|\eta|$ window (in the global menu, not a technical trigger)
- ▶ HLT: identifies ring with a minimum number of hltCsc2DRecHits
- ▶ identifies “overlap” by proximity of hits in neighboring chambers (no tracking)

What are our rate requirements?

- ▶ 2008 alignment used 33,000 HLT_CSCBeamHaloOverlapsRing1 events

1 alignment/day (a comfortable redundancy)

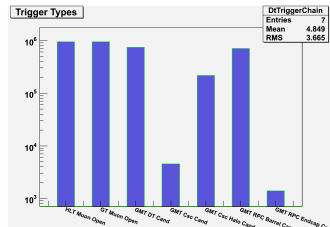
HLT_CSCBeamHaloOverlapsRing1	0.4 Hz
HLT_CSCBeamHaloOverlapsRing2	0.8 Hz
HLT_CSCBeamHalo	$\mathcal{O}(0.1\text{--}1\text{ Hz})$
HLT_CSCBeamHaloRing2or3	$2\times$ the above



- ▶ Overlaps are strictly necessary for alignment; other beam-halo events are used in cross-checks



- ▶ Maintenance of CSC beam-halo triggers (L1 and HLT):
Joseph Gartner, U. Florida
- ▶ Developed L1 beam-halo trigger diagnostics and monitoring
L1 \rightarrow HLT full-chain efficiency



Future plans:

<http://tier2.ihepa.ufl.edu/~gartner/plots/Cosmics/>

- ▶ Monitor more continuous distributions (e.g. radius, ϕ of hits)
- ▶ More HLT-level diagnostics
- ▶ Regular release validation for the 3_0_X cycle
 - ▶ DQM module already exists in `HLTriggerOffline/special/src/HaloTrigger.cc`

Answers to other questions:

Primary dataset? can be the same as cosmic ray sample, but not collisions

Range of luminosities? at least through the 1×10^{31} era



- ▶ Primary alignment workflows rely on single-muon triggers, but offline $p_T > 10$ GeV requirement makes proposed 8E29 and 1E31 menus (and any conceivable variant) acceptable
- ▶ Cosmic rays are needed to resolve systematic uncertainties, but we need tracker-pointing cosmics, just like tracker alignment group
 - ▶ “all” of the tracker-pointing cosmics (a few Hz) would be useful
 - ▶ see Andrei’s talk for details
- ▶ Beam-halo can align the muon endcaps early and on short timescales
 - ▶ demonstration of high accuracy with real beam in 2008
 - ▶ existing triggers can adjust for as-yet unknown radial distribution
 - ▶ 1 alignment/day requires 2–4 Hz
 - ▶ responsible person/institution: Joseph Gartner, U. Florida
- ▶ One last note: muon hardware alignment data are *not* transferred through the abort gap— no trigger issues