Trigger Performance Review: Alignment

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- Large overlap with physics triggers: single/double muon, minbias
  - turn-on curves are not important for alignment performance; only need a source of tracks
  - from Feb 4 Trigger Review: lean-menu physics triggers satisfy alignment needs
- Specialized alignment triggers:
  1. tracker-pointing cosmic rays: visible progress toward implementation
  2. BSC beam-halo: see Gaelle's talk
  3. CSC beam-halo: see Joe's talk

In this talk:

- Status update on tracker-pointing cosmic ray trigger
- Alignment performance and diagnostic with cosmic rays
- Alignment performance with CSC beam-halo

Tracker-pointing cosmics

- ▶ Need to collect cosmic rays during collisions because
    - ▶ non-projective tracks constrain systematic distortions (!)
    - ▶ they offer "live" diagnostics, such as track splitting
    - ▶ CRAFT-like runs before and after collisions would have limited applicability: $\mathcal{O}(100~\mu\mathrm{m})$ variations from time-dependent effects ($\vec{B}$, stress, temperature, humidity. . .)

Status

- ▶ L1 emulator (Andrés Osorio)
    - ▶ mature in offline testing, code in CVS since January 2009
    - ▶ started integrating into CMSSW release with 3_1_0_pre5

- ▶ HLT_TrackerCosmics (Yohann Tschudi)
    - ▶ still just a pointer to L1, but in the latest menu
    - ▶ studying tracker-pointing features of L1; no plots yet
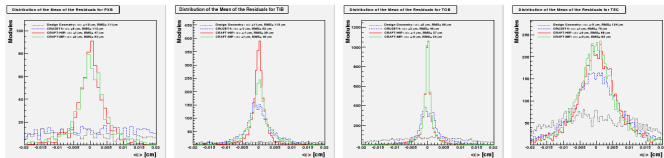   - ▶ developing reconstruction for cosmic rays mixed with minbias

Alignment with cosmics

From Andrei Gritsan's Trigger Review talk:

- CRAFT + CRUZET provides very good experience

  – with $\sim$ 4 million <u>selected</u> tracks $\Rightarrow$ $\sim$30-70 μm precision (rms)

  – non-uniform in ϕ: never enough horizontal cosmics!

  – pixels and endcaps in disadvantage with cosmics

- Private estimates:

  $\sim$50 Hz based on CRAFT and CSA08 (all muon cosmics)

  $\sim$5 Hz in Tracker $\leftarrow$ want to keep all of them

  $\sim$1-2 Hz in Tracker after timing in L1 (not known yet)

- How we could use:

  $\sim$50k events in 24 hours $\Rightarrow$ constraints, large-structure alignment

  $\sim$1m events in 3 weeks $\Rightarrow$ detailed alignment (with other samples)

"Track splitting" diagnostic

- Single cosmic ray muon is reconstructed as two LHC-like tracks

- Mismatch in parameters at origin is purely instrumental

- Only way to measure resolution of all 5 track parameters in data
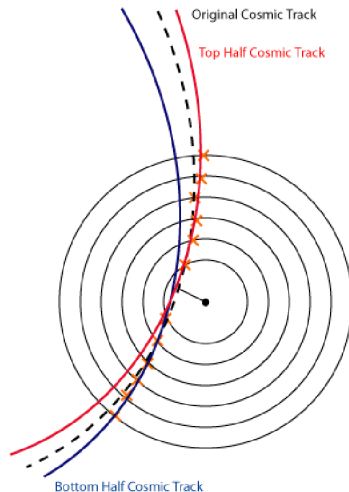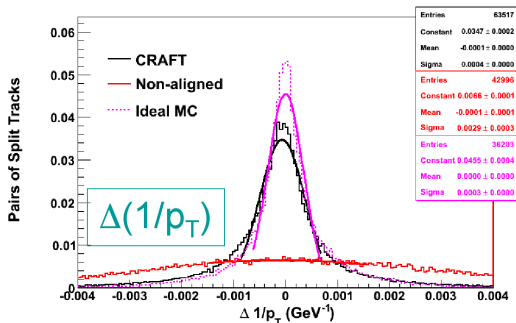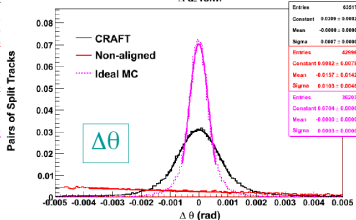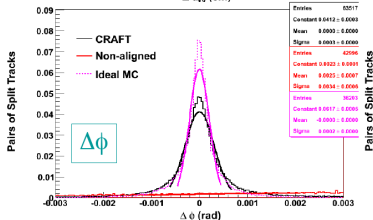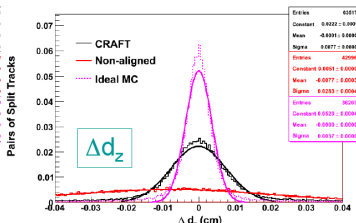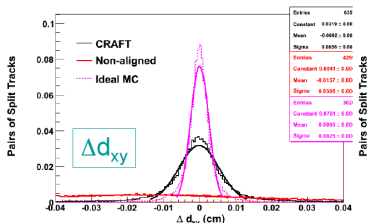

Alessio Bonato, Andrei Gritsan, Nhan Tran

- 1% precision in resolution measurement from 0.9 million SuperPointing cosmic rays in 15 million TrackerPointing dataset

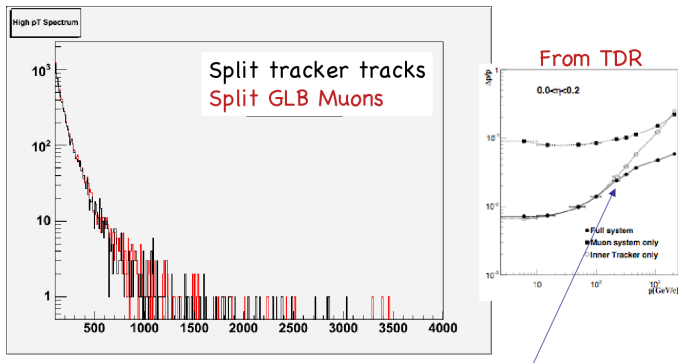- $\sigma_\sigma = 1\% \sqrt{\dfrac{15 \times 10^6}{1\text{–}2 \text{ Hz} \cdot t}}$, or 1–2 days for a 10% measurement

...for high-p_T resolution

- Only known way to measure μ resolution well above the Z peak
- Several hundred GeV: a qualitatively different environment
    - p_T of nearly straight tracks depends on muon spectrometer
    - muons create showers of delta rays in the tracking chambers
- Cosmic ray spectrum drops as $E^{-2.7}$

Focus on p > 200 GeV spectrum – expect muon system starts to improve things...
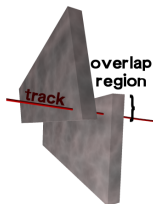
- Beam-halo tracks passing through overlap of pairs of CSCs can be used to rapidly align with high precision

- Demonstration with 9 minutes of 2008 LHC beam-halo: 270 μm accuracy verified by an independent method (photogrammetry)
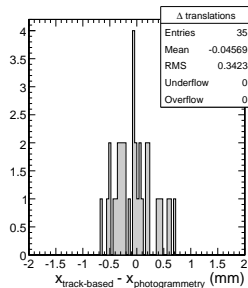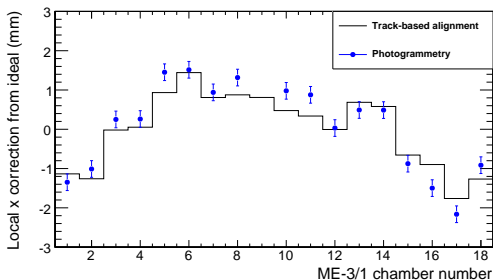
- Used 33,000 HLT_CSCBeamHaloOverlapsRing1 events for the above

- For one alignment/day: HLT_CSCBeamHaloOverlapsRing1 at 0.4 Hz, HLT_CSCBeamHaloOverlapsRing2 at 0.8 Hz

- ▶ Only tracks that pass through overlaps are strictly needed for alignment, about 5% (from geometry; does not fluctuate)

- ▶ Beam-halo rate is higher close to the beamline
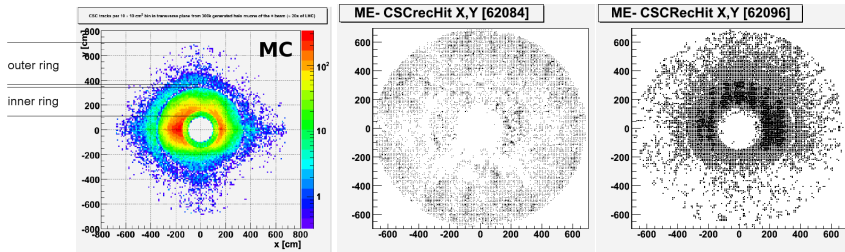
- ▶ Four HLT paths allow for tuning of prescales

  - ▶ HLT_CSCBeamHalo   set by commissioning studies
  - ▶ HLT_CSCBeamHaloRing2or3   2× (twice as many chambers)
  - ▶ HLT_CSCBeamHaloOverlapsRing1   0.4 Hz
  - ▶ HLT_CSCBeamHaloOverlapsRing2   0.8 Hz

Conclusions

- ▶ Existing physics triggers are satisfactory for alignment needs

- ▶ CRAFT and beam-halo experiences set estimates for alignment and diagnostic precision with specialized alignment triggers

- ▶ Cosmic ray rate can't be increased above natural rate: 1–2 Hz
  - ▶ all of that will be needed for resolving global distortions
  - ▶ in-situ resolution diagnostics can be performed regularly
  - ▶ high-p_T resolution will require longer accumulation of cosmics

- ▶ Beam-halo rate can potentially be high and unpredictable
  - ▶ only 0.4+0.8 Hz needed to align the muon endcaps
  - ▶ trigger paths split by geometry to control fluctuations in rate

- ▶ These are the same triggers that Gaelle and Joe will be covering next. . .