SBS analysis
software status

Andrew Puckett
UConn. Sept. 13, 2021
SBS Weekly Meeting
SBS-Offline Status Overview:

- Decoding, analysis and ROOT output working for all subsystems needed at start of GMN (BB Calo, GEM, TH, GRINCH, HCAL)
- Calibration/replay/analysis scripts mostly ready, behind in some areas
- This update will focus mainly on:
  - the GEM/BigBite spectrometer analysis status and latest developments
  - Performance benchmarking and recent improvements
  - Issues seen in early GEM data from Hall A
  - Debugging of GEM analysis
• Cosmic data of varying quality have been obtained with and without online common-mode calculation and/or zero suppression
• Cosmic data interpretation difficult given non-optimal (for cosmics) GEM orientation and trigger conditions
• Limited data obtained with INFN GEMs, quality poor, efficiency APPEARS low
• Good tracks seen through three layers of UVA GEMs
• Initial alignment looks good
BigBite GEM Cosmic Run 339

- Preshower + Shower trigger
- Online CM calculation/subtraction and online zero suppression enabled
- 20M events
- INFN GEMs disabled
Run 339: Layer multiplicities
Run 339: “Track” Multiplicities

- Notes: Very generous definition of “track” (chi2/ndf < 10000)
- Require minimum of three layers with 2D hits on track
- About 38,000 events with one or more “tracks” found
Cluster size distributions (clusters on tracks only)

- Some issues suspected with clustering algorithm, under debugging, but signals are also quite small
- Larger than expected fraction of single-strip clusters after filtering by tracking
Cluster size correlation, “U strips” vs “V” strips

- Good correlation observed between U and V for clusters on tracks with size > 1 strip
Good correlation coefficient for clusters on tracks

**hccor_clust**

- Entries: 86007
- Mean: 0.71
- Std Dev: 0.356
Cluster ADC distributions and asymmetry

- Signals generally quite small compared to previous good cosmic (or beam test) data (however, clustering not entirely debugged)
- ADC asymmetry noisy, gain matching at APV card level needed
Good ADC correlation for clusters on tracks with large ADC values

- No filtering of 2D hits by ADC asymmetry yet
These distributions look fairly sensible given the trigger and the GEM stack orientation.
Track x vs y at first GEM layer and chi2 distribution
Tracking residuals (interpret with care)

- Residuals show a sharp peak close to zero on top of a wider, asymmetric background, and then an even wider, almost flat distribution (probably from fake tracks).
- Recall that we start with a very loose chi2 cut for tracking (thought initial alignment would be worse than it appears to be).
• Recall that INFN GEMs are disabled during this run
“Exclusive” Residuals

- These are the residuals excluding the hit in question from the fitted track to reduce bias
“Exclusive” residuals by layer

Note: Layer 4 exclusive residuals smeared due to small lever arm in layers 0 and 2, and large extrapolation distance
Crude “efficiency” for layer 2

- Track-based efficiency requires at least 4 layers (the way we do tracking in SBS-offline).
- For run 339, we can do a crude “efficiency” check by plotting the strip multiplicity for one layer requiring good 2D hits in the other two layers.
- Layers 2 and 4 appear to show ~97% “efficiency” by this method, Layer 0 ~90% (however, note that the layer 0 “efficiency” determination is biased by extrapolation, we did not make any cut on the projection of layers 2 and 4 to layer 0 to require that it be in the active area.)
Clustering issues

• Given the apparent strip multiplicities, it is unclear why such a large fraction of the clusters on good “tracks” are single-strip

• Need to investigate the behavior of the clustering algorithm with the small signals typically seen in run 339 (perhaps disable cluster “splitting” or optimize thresholds)

• Probably need to look at some single-event displays to really debug the clustering

• However, these data are simply not very “clean” in general and we should be careful about over-interpreting
Runs with INFN GEMs

- Completed full replay of runs 431, 433, and 463, which have all INFN GEMS under HV except J0 bottom and J2 top
  - 431: full readout, no CM subtraction
  - 433: full readout w/CM subtraction
  - 463: CM subtraction and online zero suppression
- Very small fraction of events with "good track" through UVA layers see hits in INFN layers where expected
- This shows up at the level of the raw strip multiplicities in all three runs—it is not obviously a mapping issue.
- The "Y" strips (vertical, measure horizontal dimension) appear to have very low efficiency and are missing from most events in these runs
- As of now, I could not say with confidence whether INFN GEMs were working properly during these runs
- While I cannot rule out a bug in the analysis code with 100% certainty, it appears that there is work to do to get INFN GEMs functioning properly (good HV, gas flow, etc?)
Analysis speed issues

• The decoding of the GEM Modules (not the reconstruction) is the main speed bottleneck for the analysis for the “full readout” events
  • Approximate processing rate for BigBite cosmic runs with full readout is \( \sim 40 \text{ Hz} \) (“sorting method” CM calculation) or \( \sim 60 \text{ Hz} \) (“Danning method” CM calculation).
  • When online zero suppression is enabled, BigBite cosmic run processing rate increases to \( \sim 1.5-2 \text{ kHz} \! \)
  • There are two issues limiting the speed:
    • Unpacking the sheer volume of raw data
    • CM calculation and subtraction
    • These bottlenecks are comparable for full-readout events
  • The “online” versions of these calculations appear to be working properly, at least for low-occupancy data
  • Note that the “online” versions are much faster than the “offline” versions because they run in parallel on a large number of MPD modules (and probably use more efficient arithmetic than the offline), whereas the offline calculations run in series on a single CPU core.
  • Strongly recommend running with online zero suppression during initial commissioning! \( \Rightarrow \sim 1-2 \text{ orders of magnitude faster data processing} \! \)