SAND Software

Full Spill Studies of ECal

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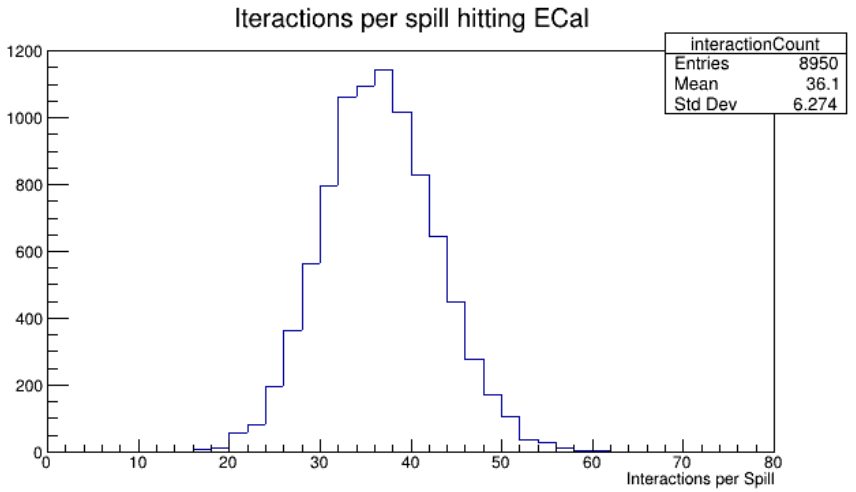
- The full spill simulation
  - These are ECal, 3DST & TPC centered
    - result probably applies to ECal & STT as well.
- ECal with 400 ns integration
  - RHC beam (anti-neutrino enriched)
  - FHC beam (almost pure neutrino) NOT COMPLETE
- ECal with 30 ns integration

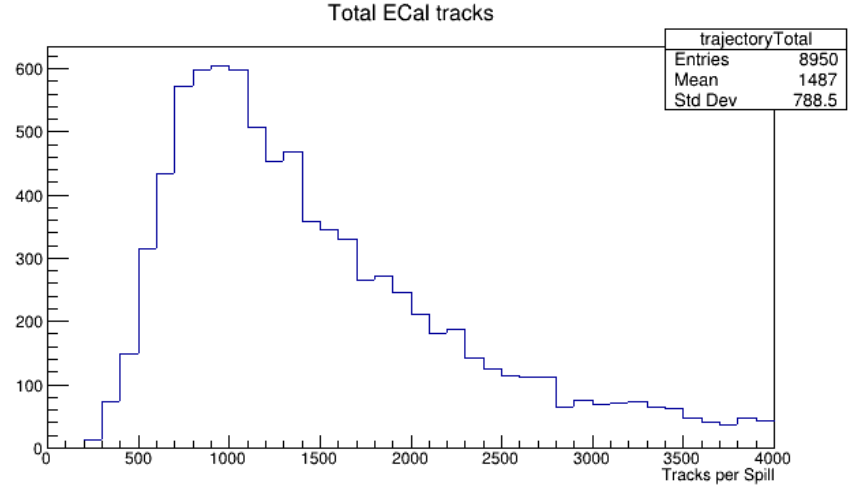
The Full Spill Simulation

- Use the full chain
  - GENIE:
    - RHC beam with 7.5×10^{13} POT per spill
    - Includes 250 m of rock upstream of hall
  - EDepSim:
    - Track all particles, but only save trajectories hitting sensitve detectors
  - sand-stt:
    - Simulate ecal response for each individual interaction
  - ERepSim:
    - Overlay interactions (~3500 per RHC spill).
    - Simulate 3DST and TPC
      - Overlay edep-sim results and simulate electronics response
    - Use sand-stt for ECal
      - Uses 400 ns integration, and does not include dead time and event overlap.
      - For each channel, sort hits by time, and combine hits within the targeted integration window (either 400ns or 30 ns).
  - CubeRecon
    - Already built to handle full spill, so just run it.

RHC interactions hitting the ECal

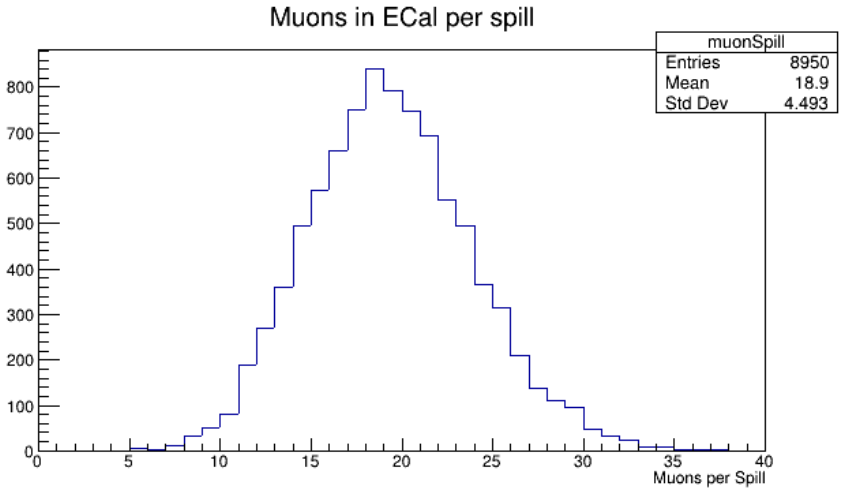
- An interaction hits the ECal if:
  - A charged particle deposits energy
  - Deposited energy generates enough light
- Interactions per RHC spill: 36.1
  - Most of the interactions are from the upstream side of the yoke
- Generated Tracks
  - Create a hit above threshold
  - Effect of overlaps not considered
- Generated Tracks per spill: 1487
  - Lots of small hits just above threshold

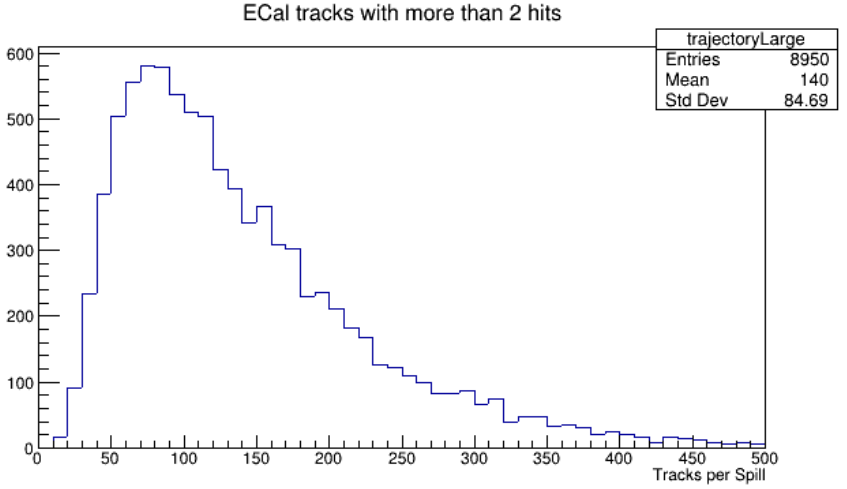




Resulting Particles per RHC Spill

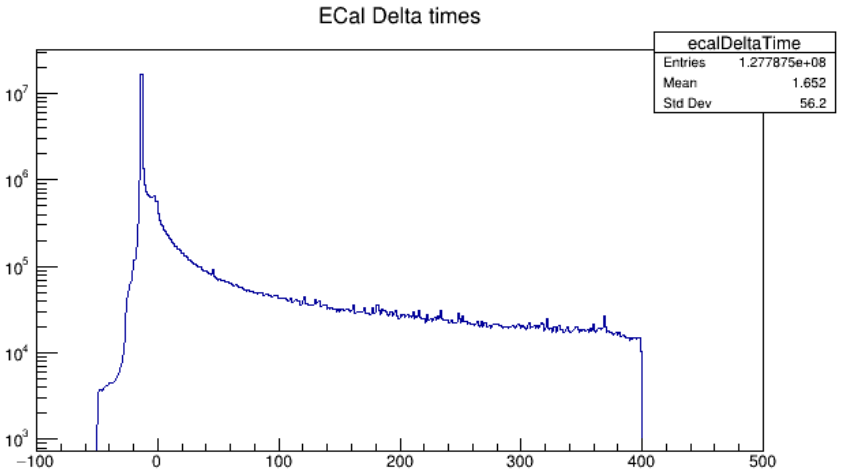
- Looking at particles that "should" make a cluster
- Muons: 19 per spill
  - These are muons that hit any part of the ECal
  - Muon entering upstream side
    - 15.1 per spill
- Tracks: 140 per spill
  - These are all tracks that generate hits in three or more cells



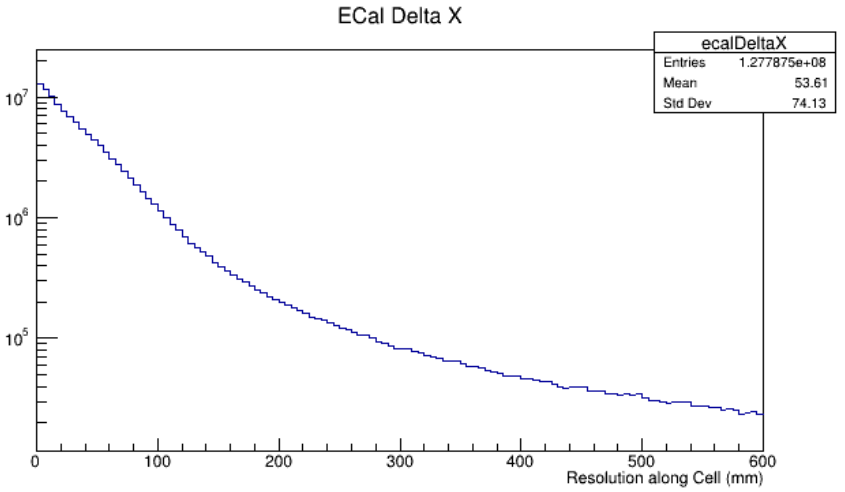


ECal Cell Time and Position in RHC Spills

- Double ended read-out means the time and position
  - These plots are for the 400 ns integration window
- Time is the average distance corrected time for both ends of the cell
  - Undershoot caused by geometric effects (tracks closer to sensors)
- Position is from the time difference between the ends of the cell



Not corrected for trigger time

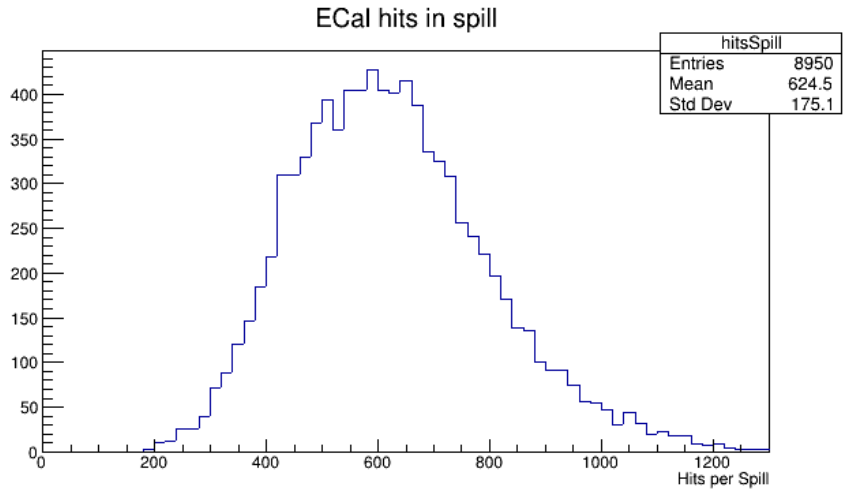


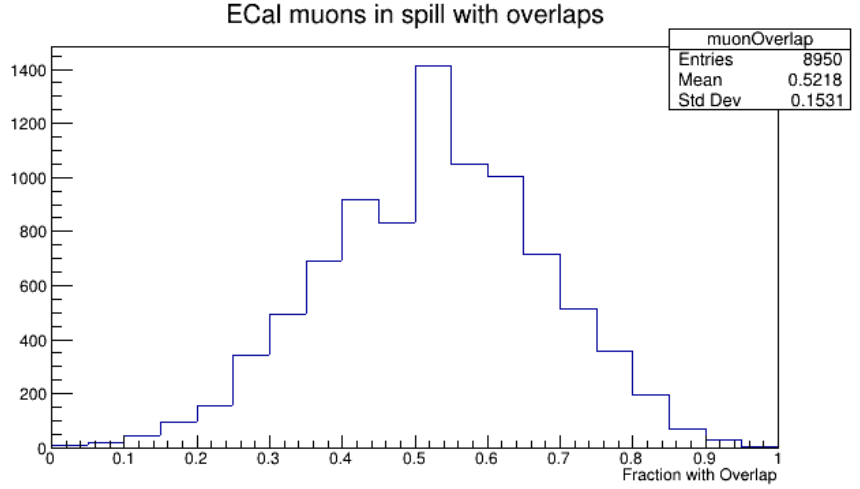
Overlap calculations

- A hit is considered to have overlap if (at least one must be true)
  - Collects energy from two or more separate neutrino interactions
  - Collects energy from two or more separate particles if
    - Particles are separated by 50 cm long cell axis
    - Or, particles are separated by more than 20 ns in time.
- Fraction of overlapping hits
  - The number of hits with overlaps divided by the total number of ECal hits
- Fraction of muons with overlaps
  - Check each hit for a muon to see if it has an overlap (from any source)
  - Number of muons with an overlapping hit divided by total number of muons.

RHC overlaps with a 400 ns integration

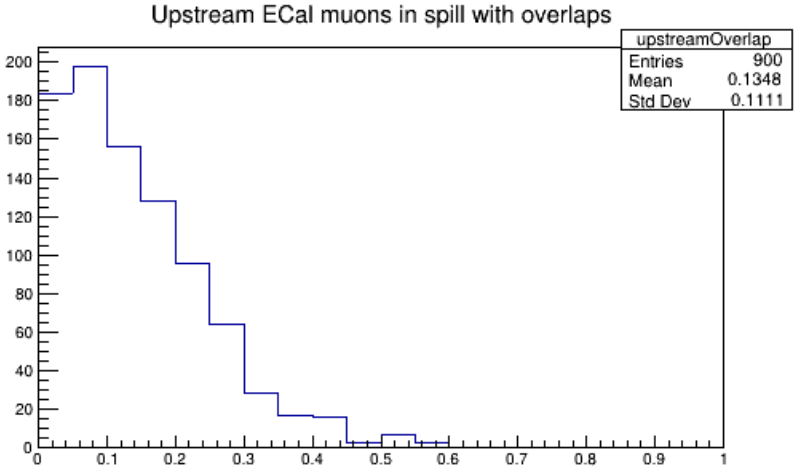
- This is the integration that is currently implemented in sand-stt
  - Simulated using a constant fraction discriminator
- Hits: 625 per spill
  - Overlaps: 26.7%
    - about 790 w/o considering overlaps
- Muons with overlaps
  - An overlap will distort both the hit time and hit charge
  - Total overlaps: 52%
  - Upstream overlaps: 38%
    - Only consider overlap it it is on the upstream side of the detector

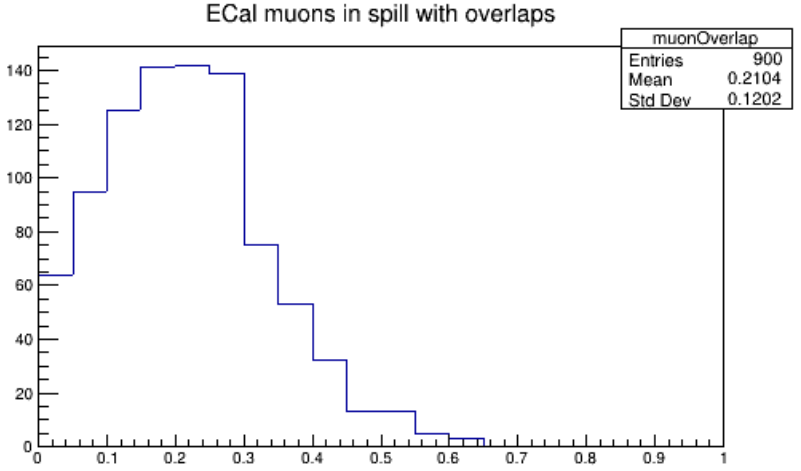




RHC overlaps with 30 ns integration

- Approximated by shortening integration window in sand-stt
- Current simulation is not self consistent for short windows
  - PMT pulses are long compared to 30 ns
  - 30 ns is short compared to the light transit time in fibers.
  - If sensor replaced, light yield will be different
- Take results with a "grain of salt"
  - But for short windows we don't expect problems (is that true?)
- Results of simplified simulation
  - Hits: 4% overlap
  - Muons: 21% overlap (13% upstream)





End Notes

- There is a lot of activity expected in the ECal due to external interactions
  - 36 interactions per RHC spill will deposit energy
  - 1490 particles per RHC spill (mostly low energy)
    - 140 particles creating clusters of 3 or more hits.
  - Close to 800 hits per RHC spill (not accounting for overlaps)
  - 19 muons per RHC spill hit the ECal
    - 15 muons per RHC spill in upstream part of ECal
  - about 2 interactions per RHC spill in upstream part of ecal.
- Activity in the T2K barrel ECal has proven problematic
  - Roughly 4x granularity of KLOE ECal
  - Much lower intensity beam
- ECal as a target for TPC and 3DST
  - Need to carefully evaluate external backgrounds and fiducial volume efficiency for full spills
    - 400 ns integration: likely problematic for RHC, and FHC will be worse
    - 30 ns integration: already see significant overlaps for RHC. Need a more detailed response simulation to evaluate efficiency.

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