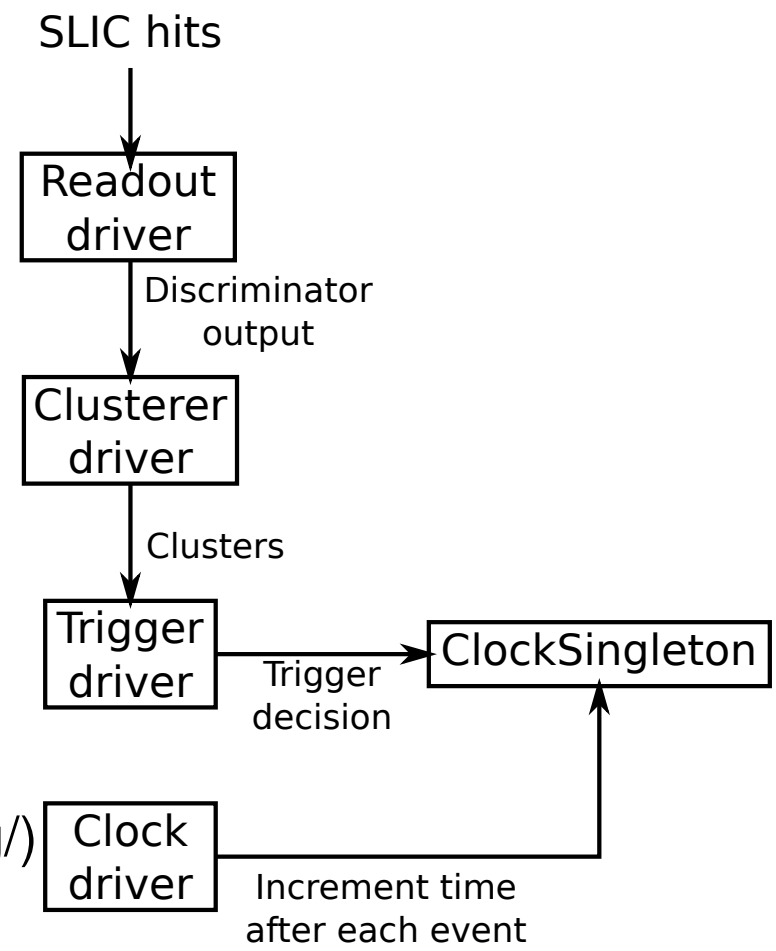
ECal in LCSim

- Events (1 bunch per event) are read and processed continuously
- Readout output and clusters are stored as collections
- Current time and trigger decision are stored in the clock
- Plots and simulated readout can use collections, clock and trigger
- Steering files for background and A' events are in hps-java (src/main/resources/org/lcsim/hps/steering/) — the location of the driver classes is also here

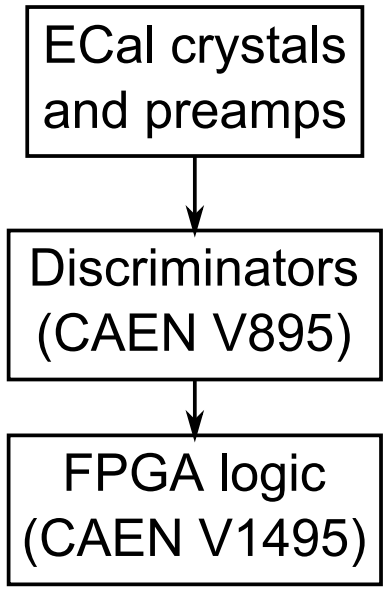


Readout drivers

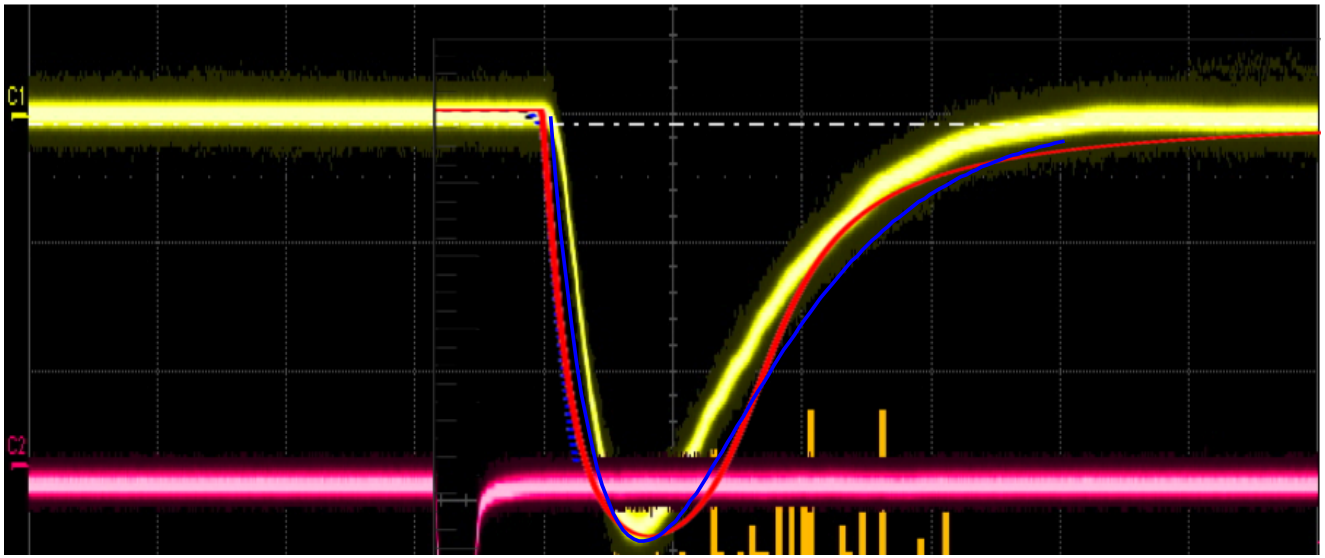
- HPSEcalSimpleReadoutDriver: sums energy depositions in readout window
  - Used for A' events (where we currently ignore time evolution)
- HPSEcalTimeEvolutionReadoutDriver: simulates pulse shape and samples it at the readout period
  - For FADC readout and trigger
- HPSEcalDiscriminatorReadoutDriver: simulates pulse shape and leading edge discriminator at the beam period; samples discriminator output at the readout period
  - For 1-bit trigger

1-bit trigger description

- Full description in trigger design document
  - Preamp output goes to retriggerable leading-edge discriminators, output pulse width is adjustable 5-40 ns
  - Discriminator output is read on a 15 ns cycle
  - For each 3x3 window of crystals, count hits
  - Peak detector eliminates all but one window in each cluster
  - Require two clusters, with at least 1 hit each, in opposite quadrants

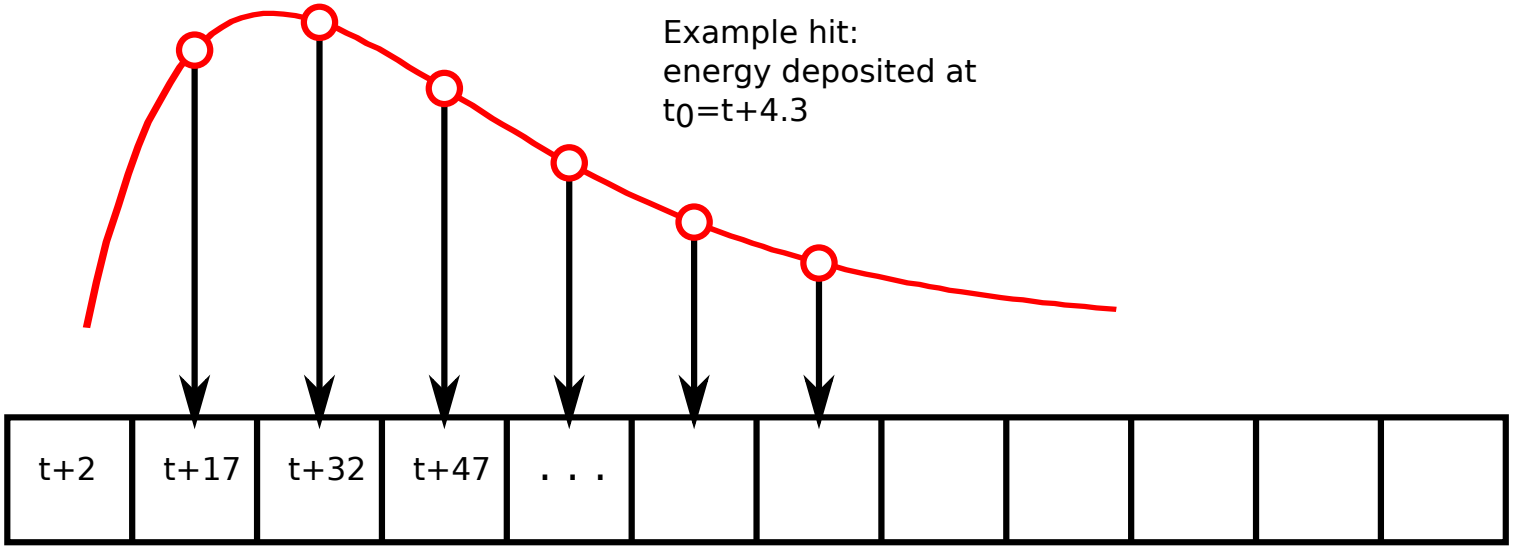


Pulse shape



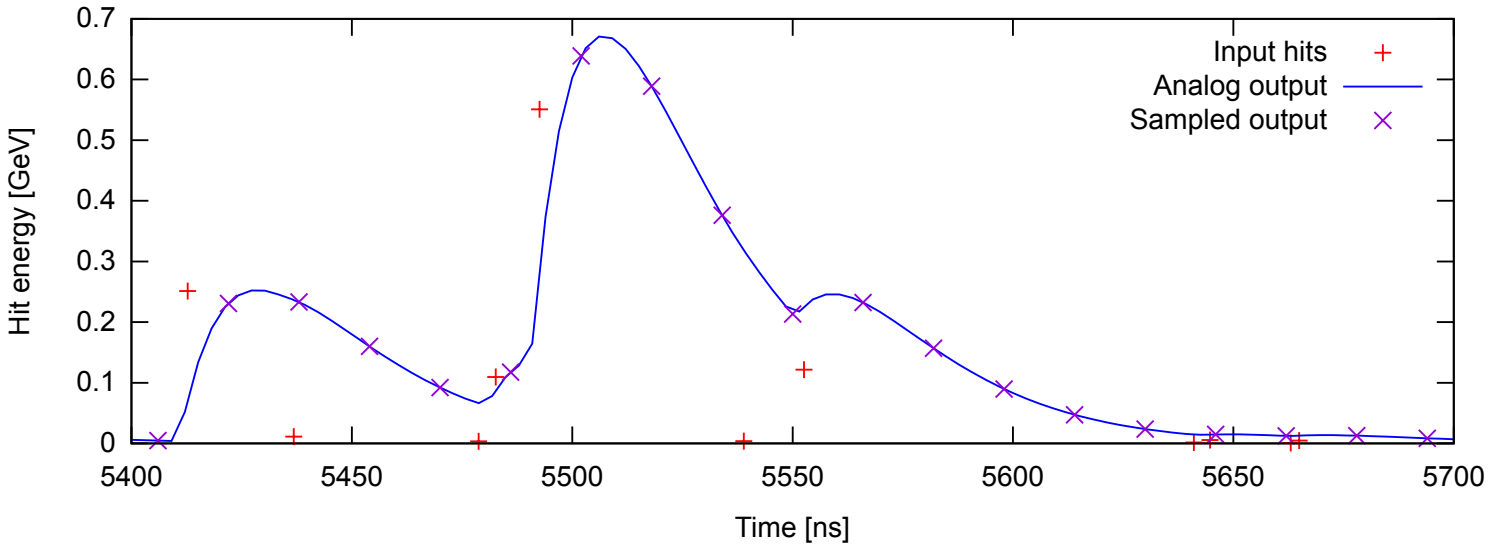
- For now, fitting with $(t/T_0)e^{1-t/T_0}$, with $T_0 = 18$ ns (blue curve)
  - Red curve is $\tan^{-1}$-based fit developed at JLab
  - A better fit than either of these might be a CR-RC shaper with different time constants for the integrator and differentiator
  - Easy to drop in a different pulse shape function once we have it

Time evolution simulation



- Ring buffer stores “buckets” — each bucket is a future sampling time
- For each hit, compute value of pulse at each sample time bucket; add this to the bucket
- With each bunch, read all hits into buffer and step $t \rightarrow t+\Delta t$
- When it’s time to read a bucket, dump its accumulated signal into a hit (for fADC readout/trigger)
- Can also read out past buckets (for DAQ simulation)

Time evolution simulation — cont.

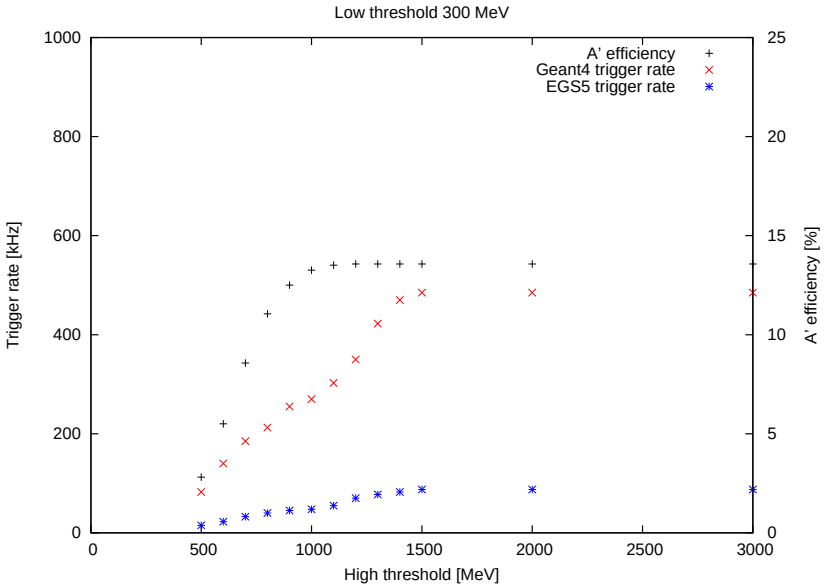


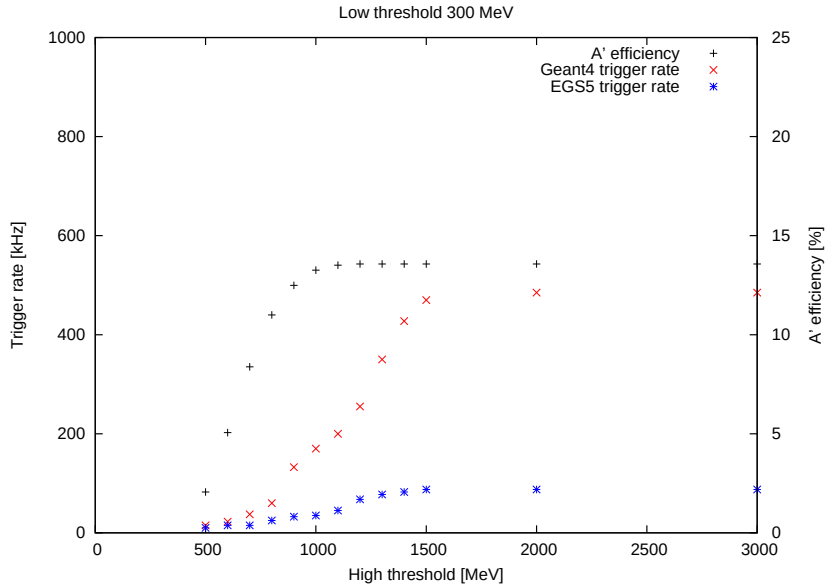
- To simulate discriminator, sample analog signal at 2 ns interval
- Rising edge: sample below threshold followed by a sample above threshold
- Store the time of the rising edge; on readout, output a “hit” if time since the last rising edge is less than the output pulse width
- This implies retriggerable operation

1-bit trigger

- Upper discriminator veto: each crystal has two discriminators with different thresholds
  - Crystal veto: upper discriminator hit removes the crystal from readout
  - Cluster veto: upper discriminator hit removes the 3x3 block around the crystal from clusterer (sets hit counts centered at those crystals to 0) — this is what we're going to have
  - Event veto: upper discriminator hit on any crystal removes all clusters from event

Cluster and event veto





- Upper discriminator veto: each crystal has two discriminators with different thresholds
  - Cluster veto (left) gives essentially the same background rates as crystal veto
  - Event veto (right) reduces background triggers, but effect on A' efficiency is unknown

Hot crystals: first look

- This plot: counts per crystal of hits above 300 MeV and below 1 GeV
- Good candidates to remove from trigger: crystals near the electron gap, crystals near the center on the positron side

fADC trigger

- fADC clusterer has been in LCSim for some time
- fADC trigger algorithm added by Omar; agrees with Takashi's results
- Some work needed to make this work with time evolution:
  - Hits created by SLIC have position given by the geometry
  - Hits created by LCSim (in readout driver) do not have position because LCSim code uses only cell IDs internally
  - Can make trigger algorithm calculate angles from cell ID, or could put that functionality in GeomConverter

Summary

- 1-bit trigger simulation work is wrapping up; trigger rates are under control
  - A' overlay on background
  - Trident background
  - Remove hot crystals
- New physics list for Geant4 may agree better with EGS5
- Next: fADC trigger simulation with time evolution
- As JLab progresses with trigger design, need to coordinate with the actual implementation