Level-3 Trigger Update

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Trigger Meeting 12.10.13

Level-3 Node Count

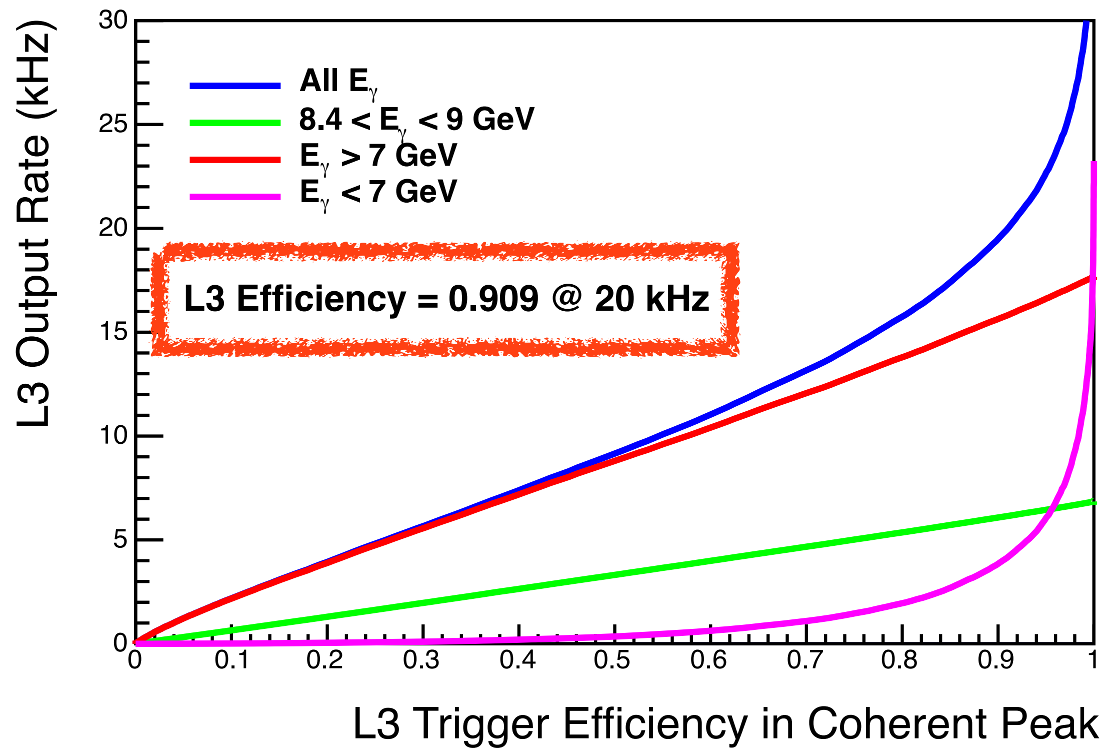
- During the online data challenge achieved an L3 processing rate of ~1.6 kHz/node with borrowed machines (includes ~25% hyperthread gain)
- Currently have 10 nodes (16 cores each) in the counting house with better specs (8 assigned to L3 at the moment)
- Scaling by increased performance for the new nodes corresponds to an L3 processing rate of ~3.9 kHz/node
  - The version of the L3 algo used did not do any "staging" to make decisions based on FCAL/BCAL first (expect factor of ~2 algo speedup from previous studies)
  - It also only used DTrackCandidates instead of DTrackWireBased (would slow down by factor of ~2-3 if wanted to use wire based)

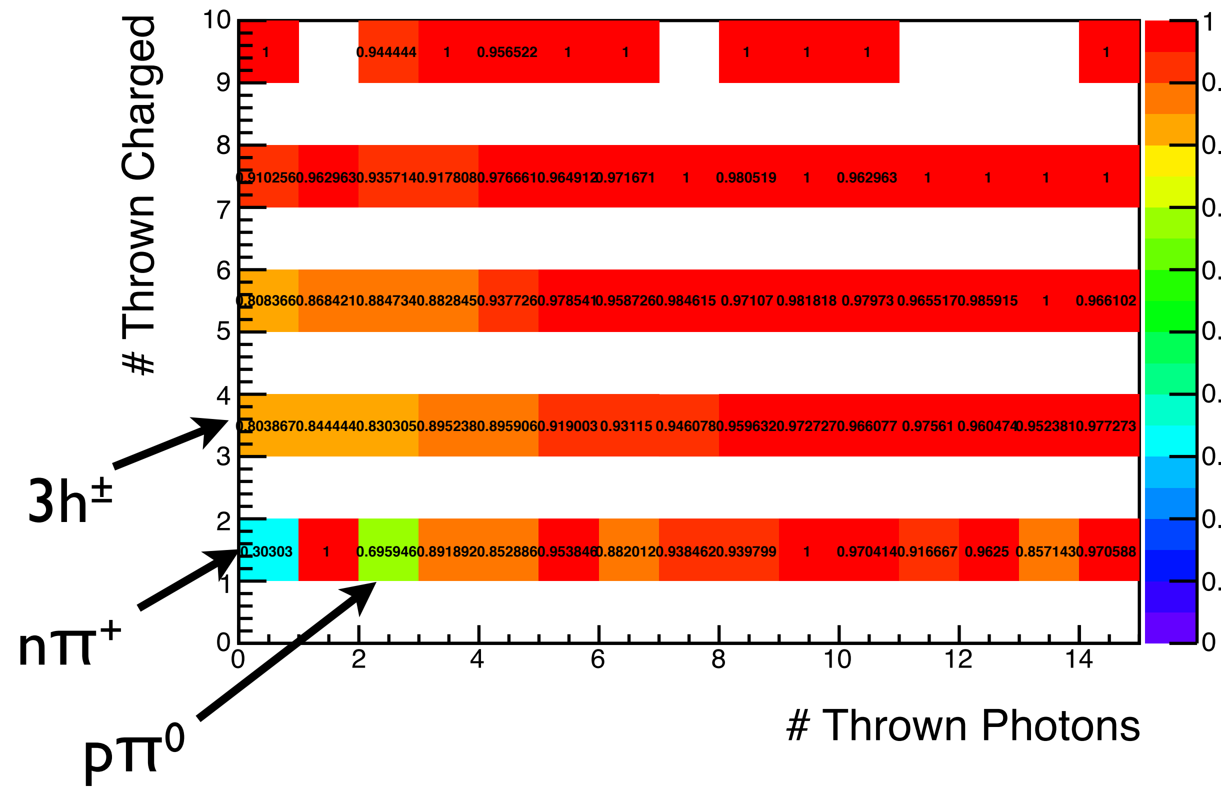
Phase	Photon Rate	Nominal L1 Rate	Required Nodes
III	$1x10^7$	20 kHz	5
IV	$5x10^7$	100 kHz	25
IV+	$1x10^8$	200 kHz	50

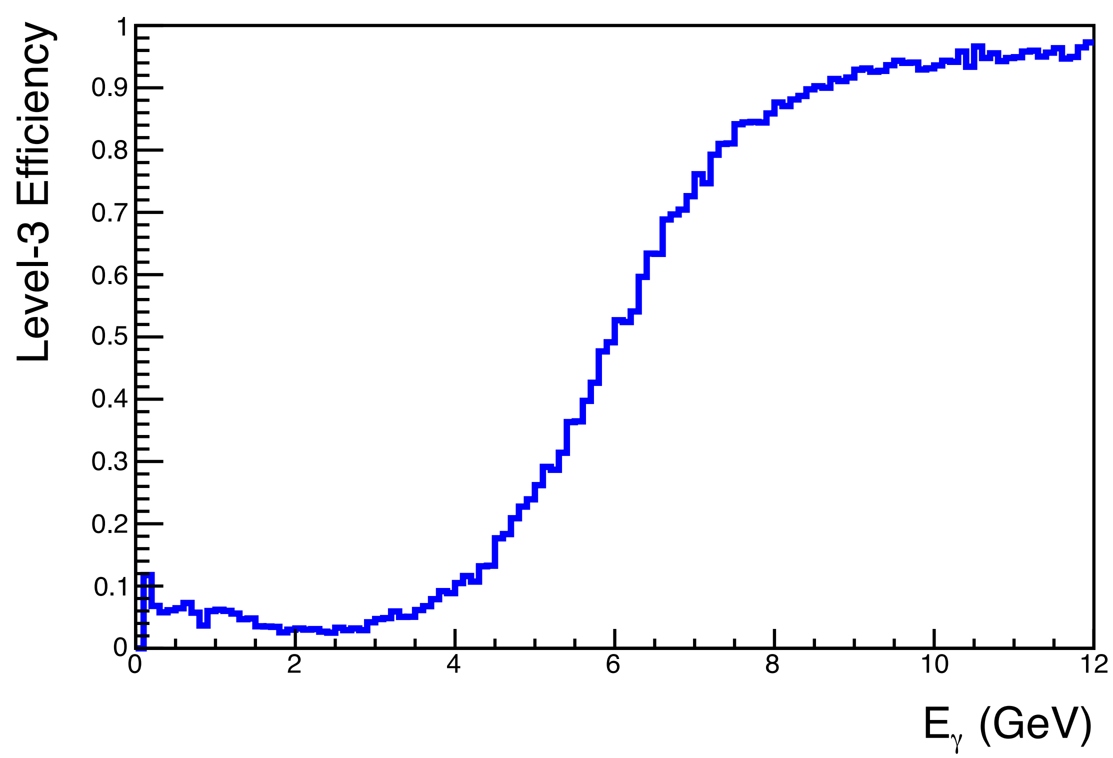
The 10 nodes we have now will allow us to tag events with L3 in 2016

ODC info: http://argus.phys.uregina.ca/cgi-bin/private/DocDB/ShowDocument?docid=2341

Level-3 Evaluation (**w/** EM pileup)



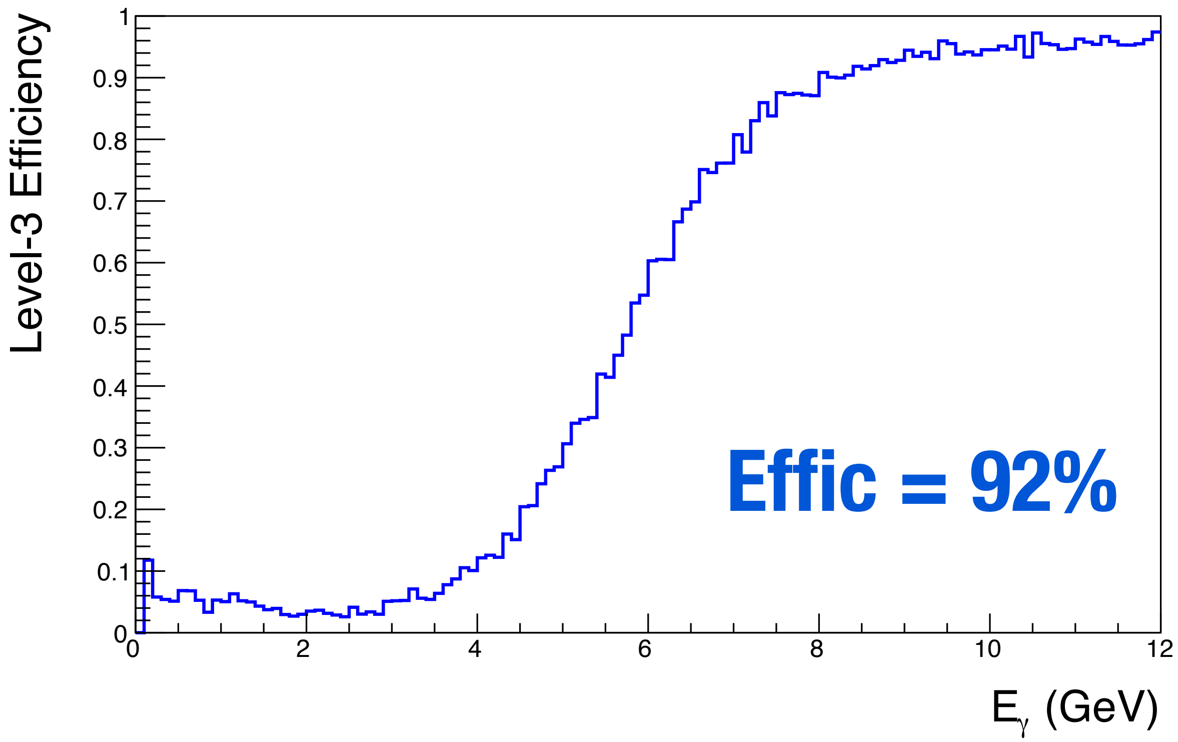


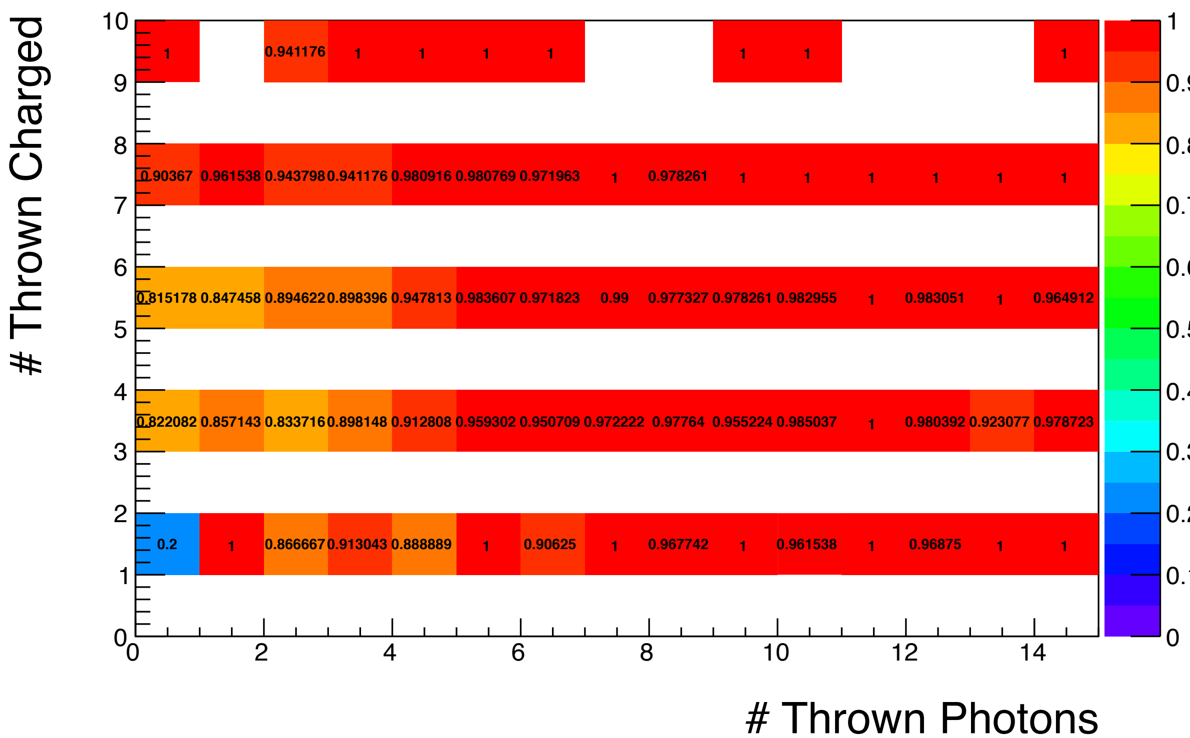


- Critical variables for BDT are sum of BCAL and FCAL energy as well as track momentum sum
- For a rate of 20 kHz, achieve ~91% L3 average efficiency in the coherent peak
- Events with less photons have lower efficiency (~80% for zero photons)

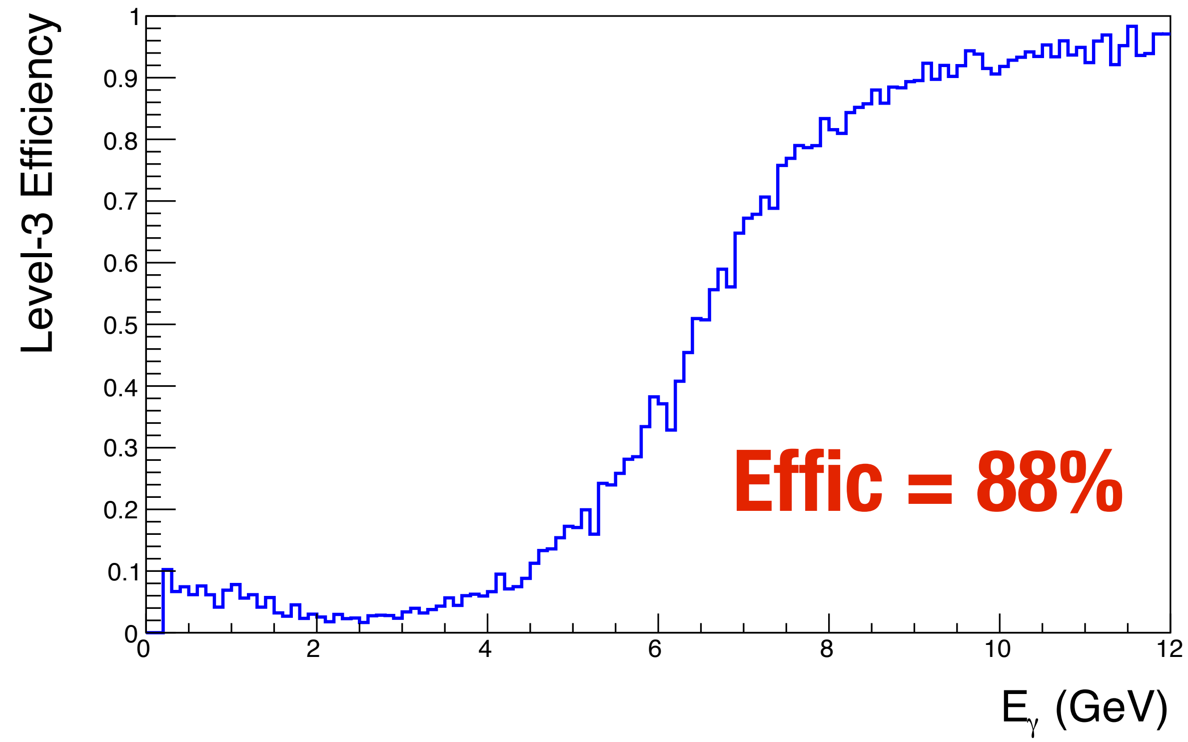
Proton vs Neutron (**w/** EM pileup)

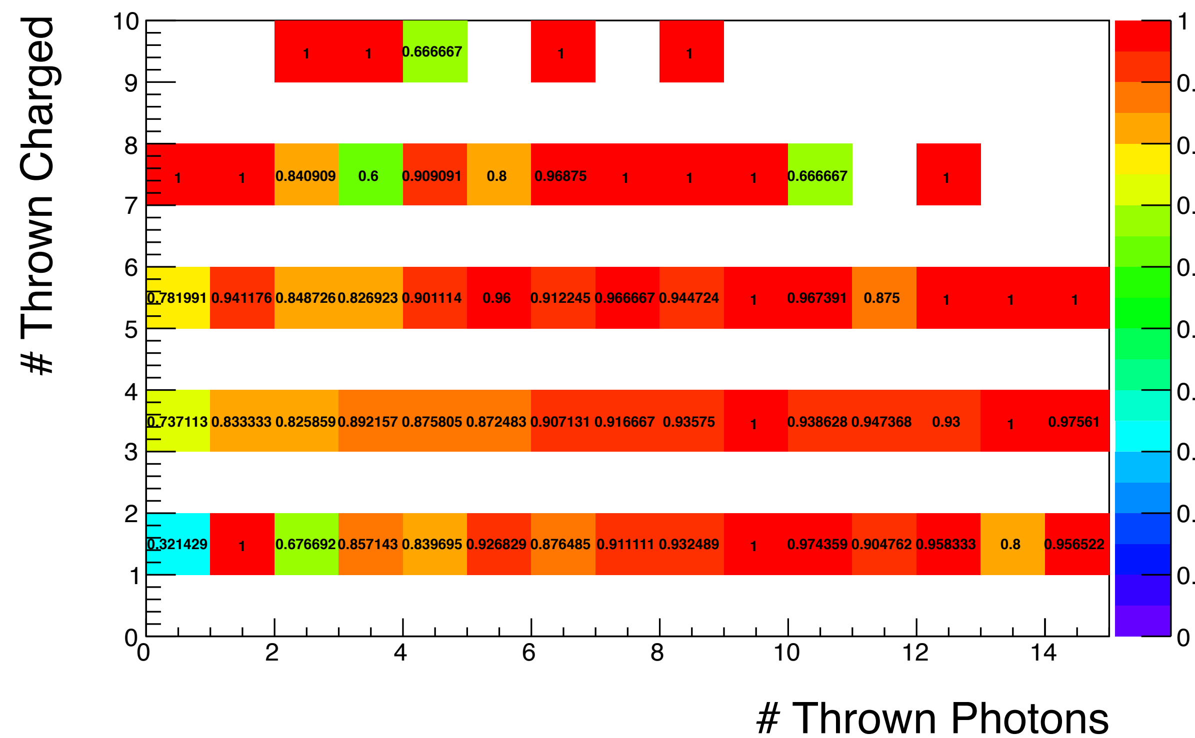
Neutrons = 0



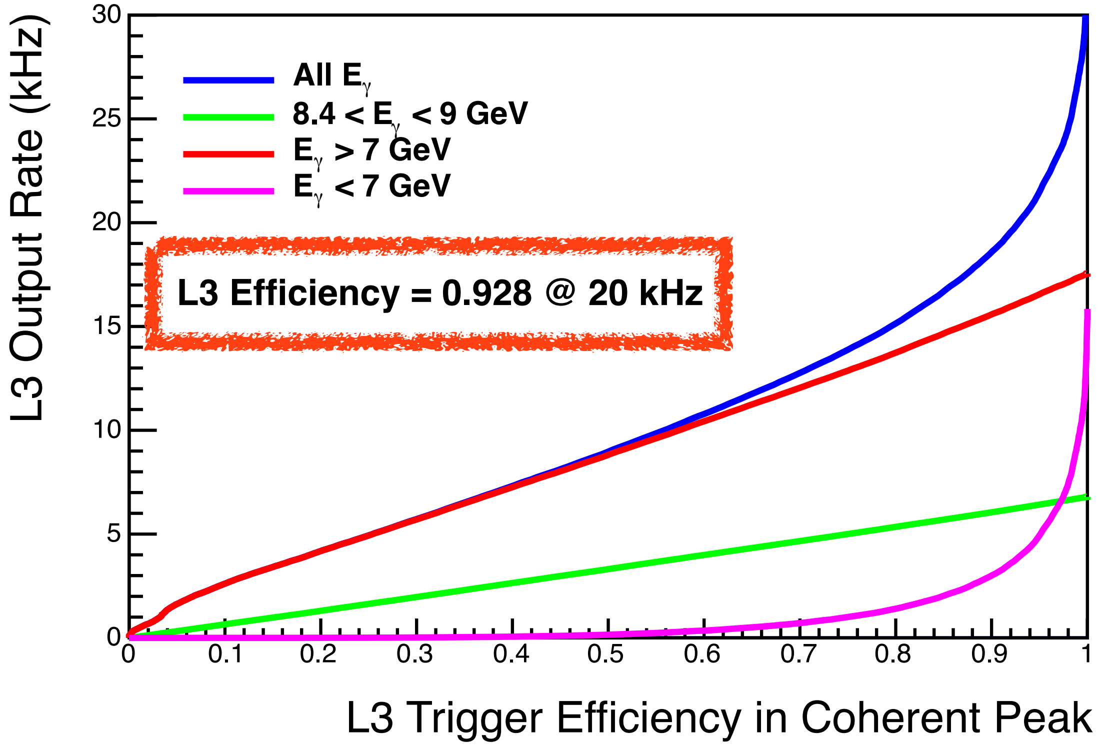


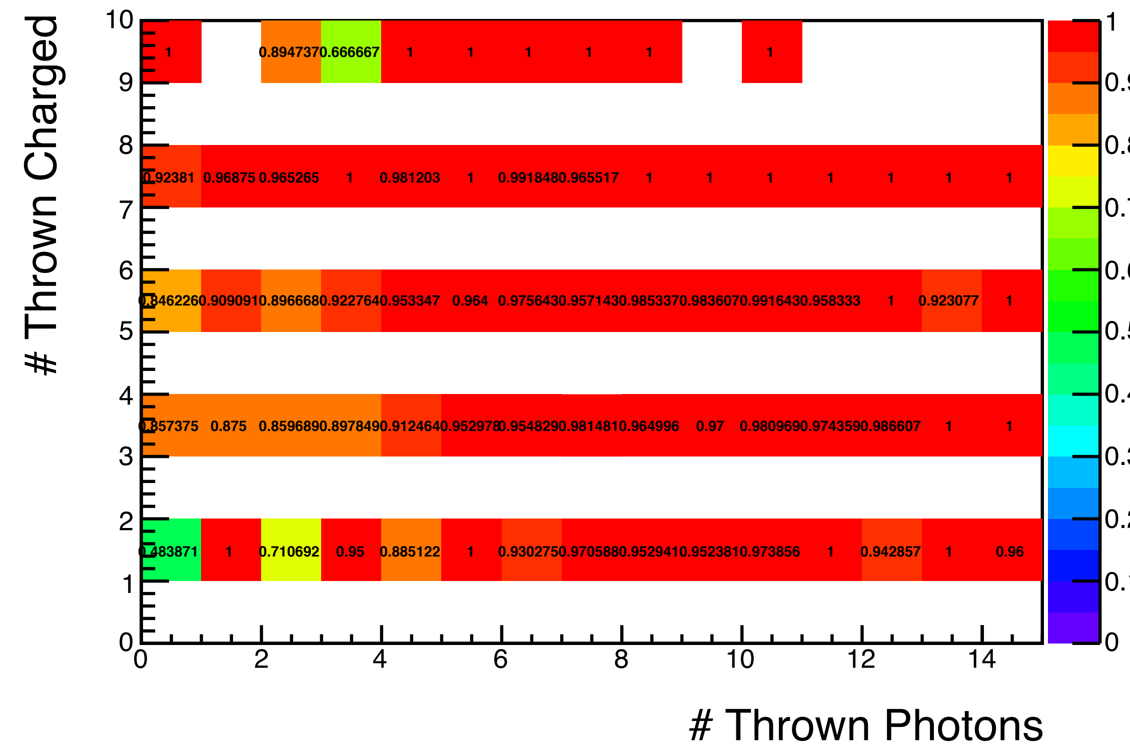
Neutrons > 0

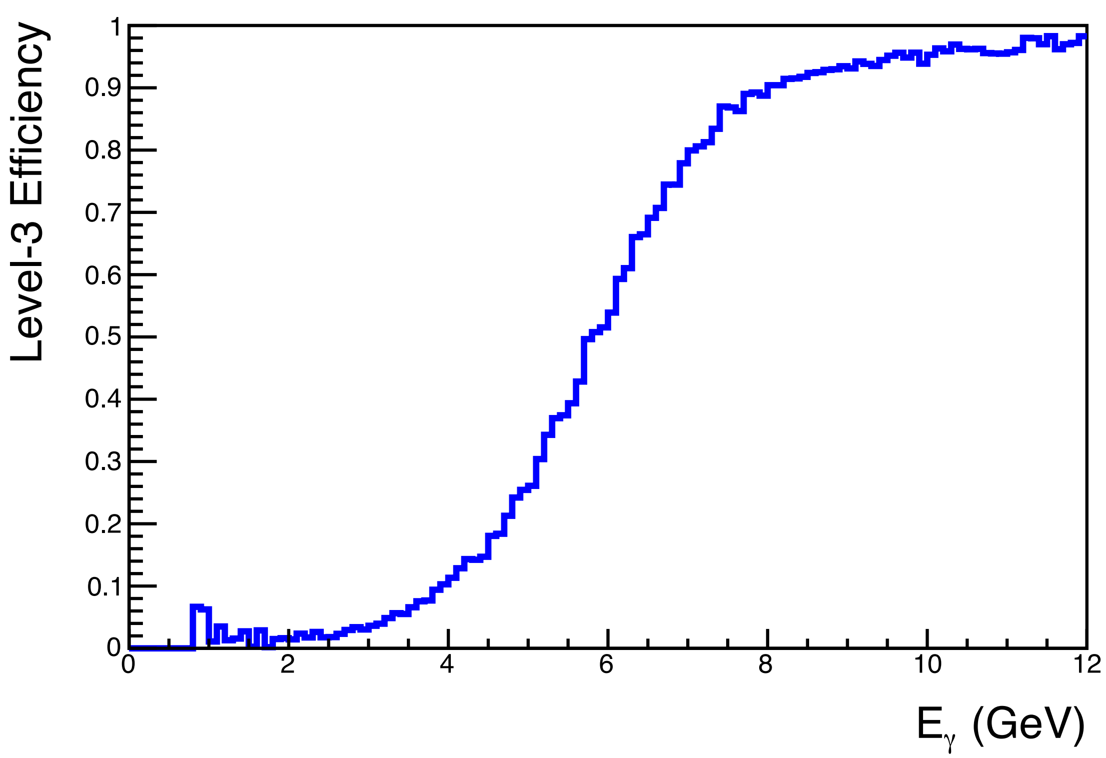




Level-3 Evaluation (**w/o** EM pileup)





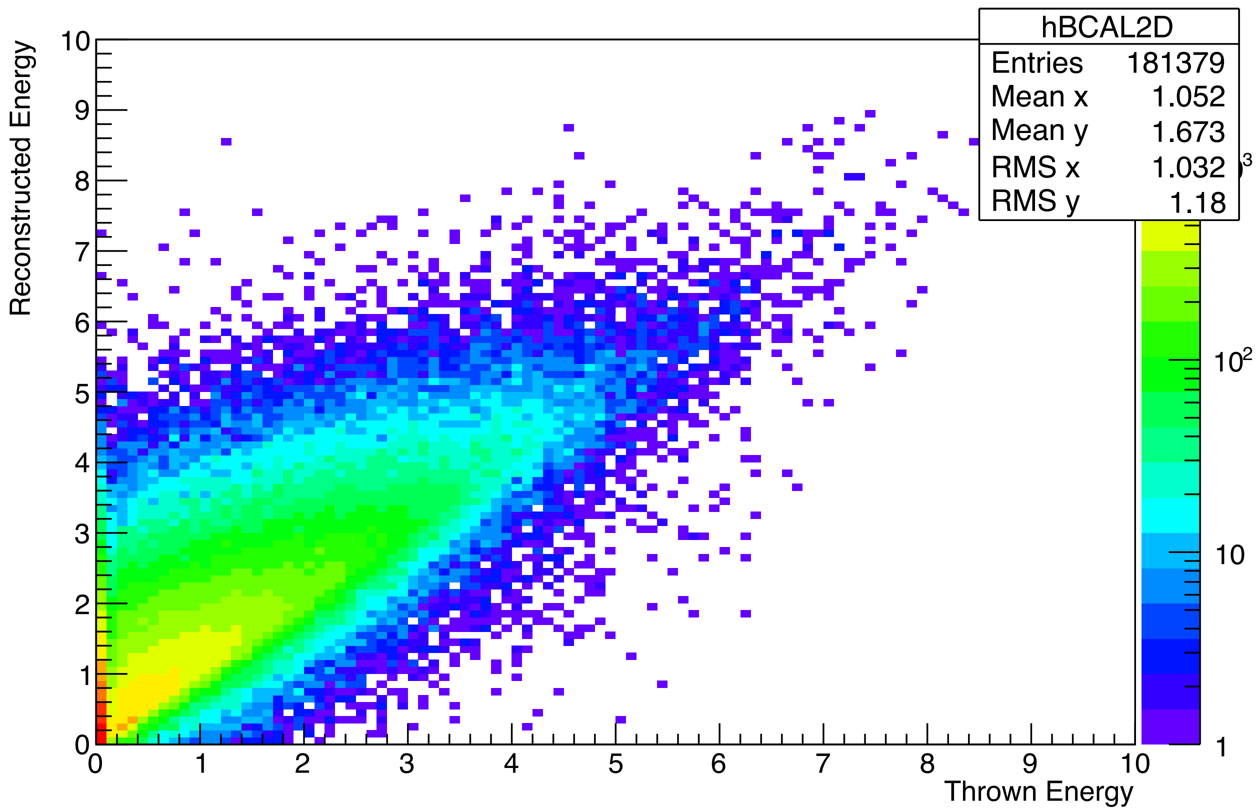


- How much of the rate is due to EM pileup?
    - **Try a bggen only sample**
- For a rate of 20 kHz, achieve ~93% L3 average efficiency in the coherent peak
- Events with less photons have lower efficiency (~85% for zero photons)
- Some gain in performance, but “background” not dominated by EM pileup

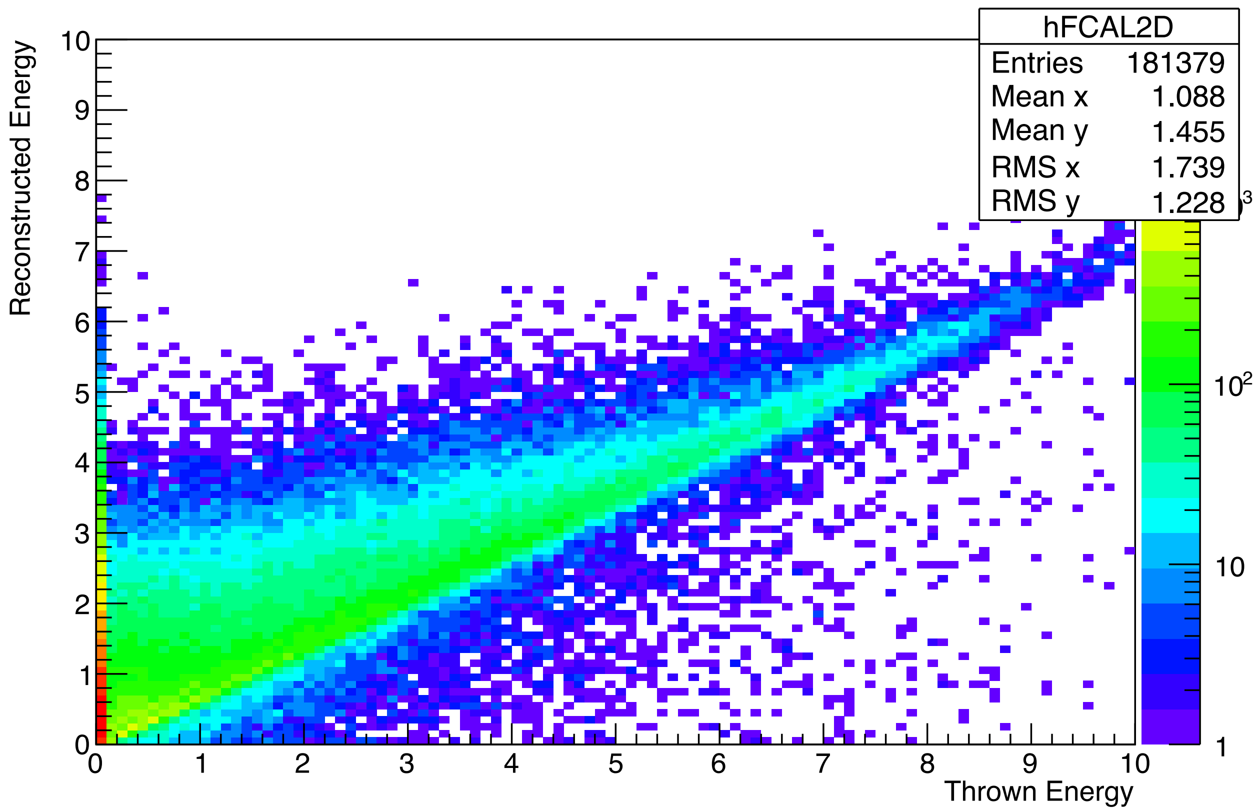
How to improve the input variables?

- Critical variables are FCAL and BCAL energy sums and track momentum sum
- How well do calorimeter energy sums correlate with the thrown photon energy sum?

BCAL



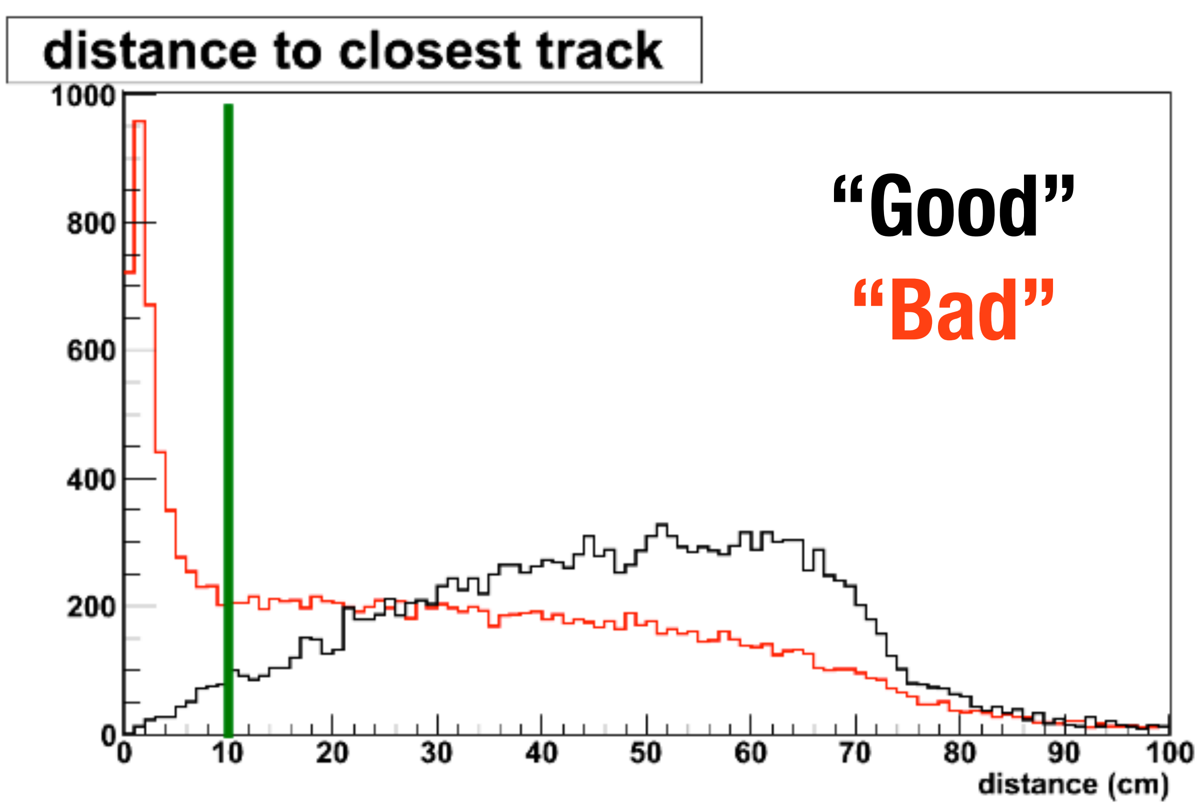
FCAL

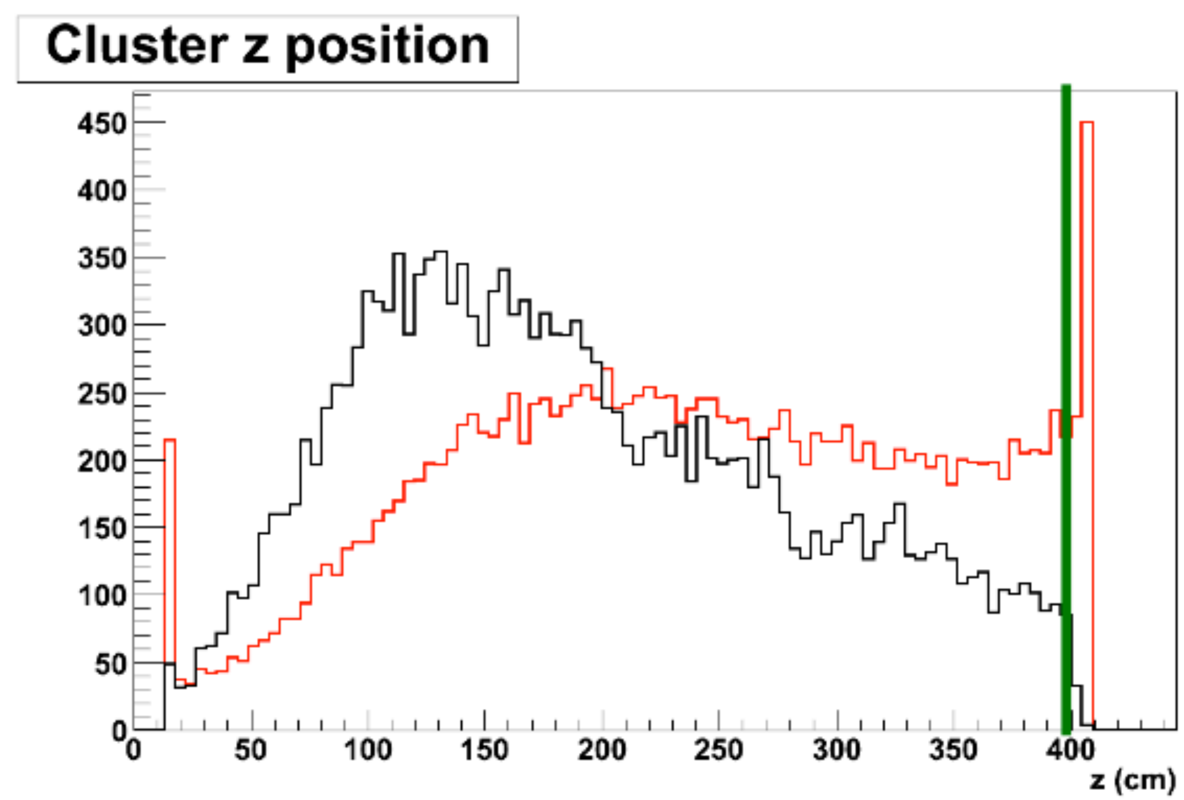


Improving the calorimeter inputs

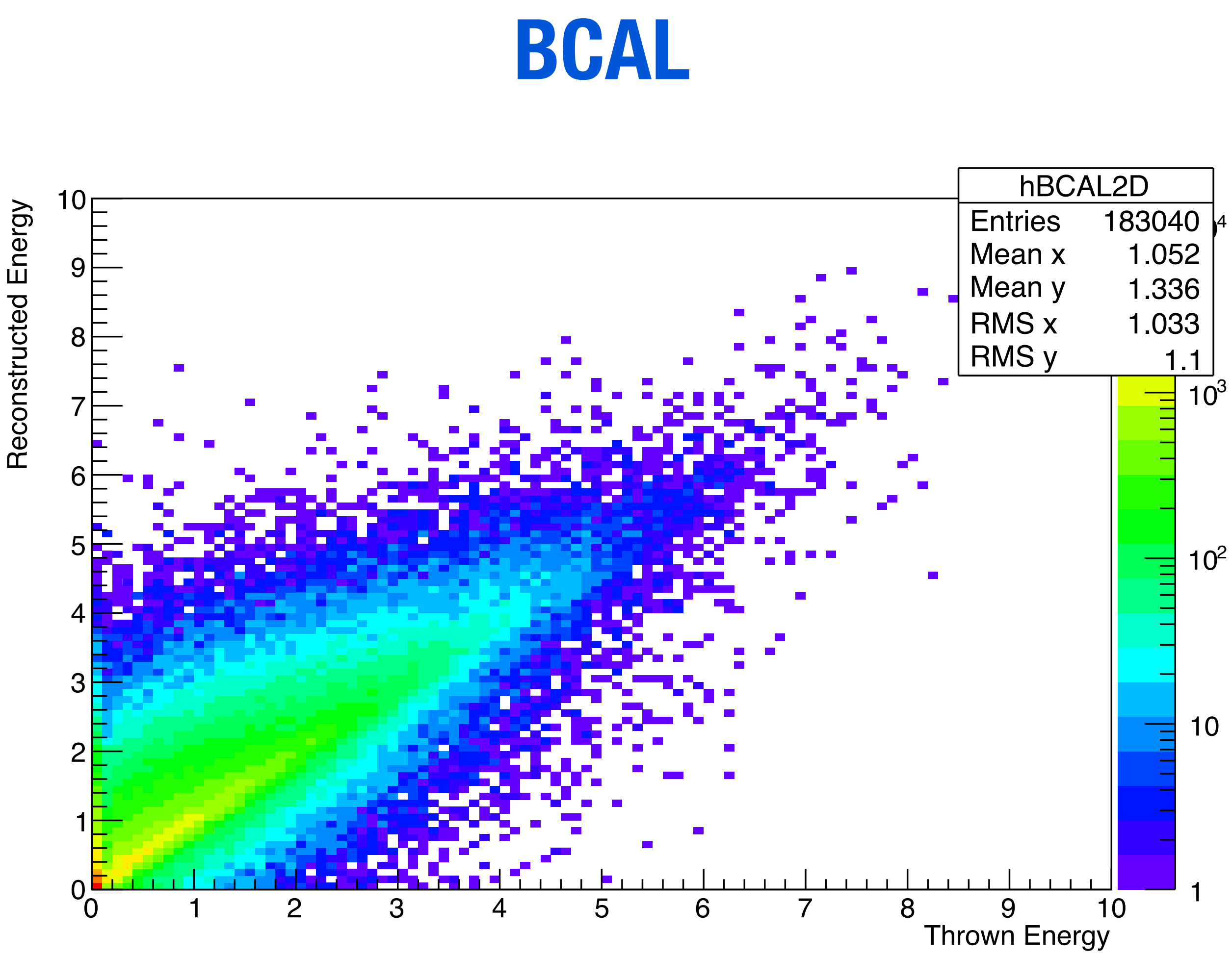
- "Extra" energy in FCAL and BCAL:
  - Will's study for BCAL **"good"** vs **"bad"** clusters (slides 17 and 18)

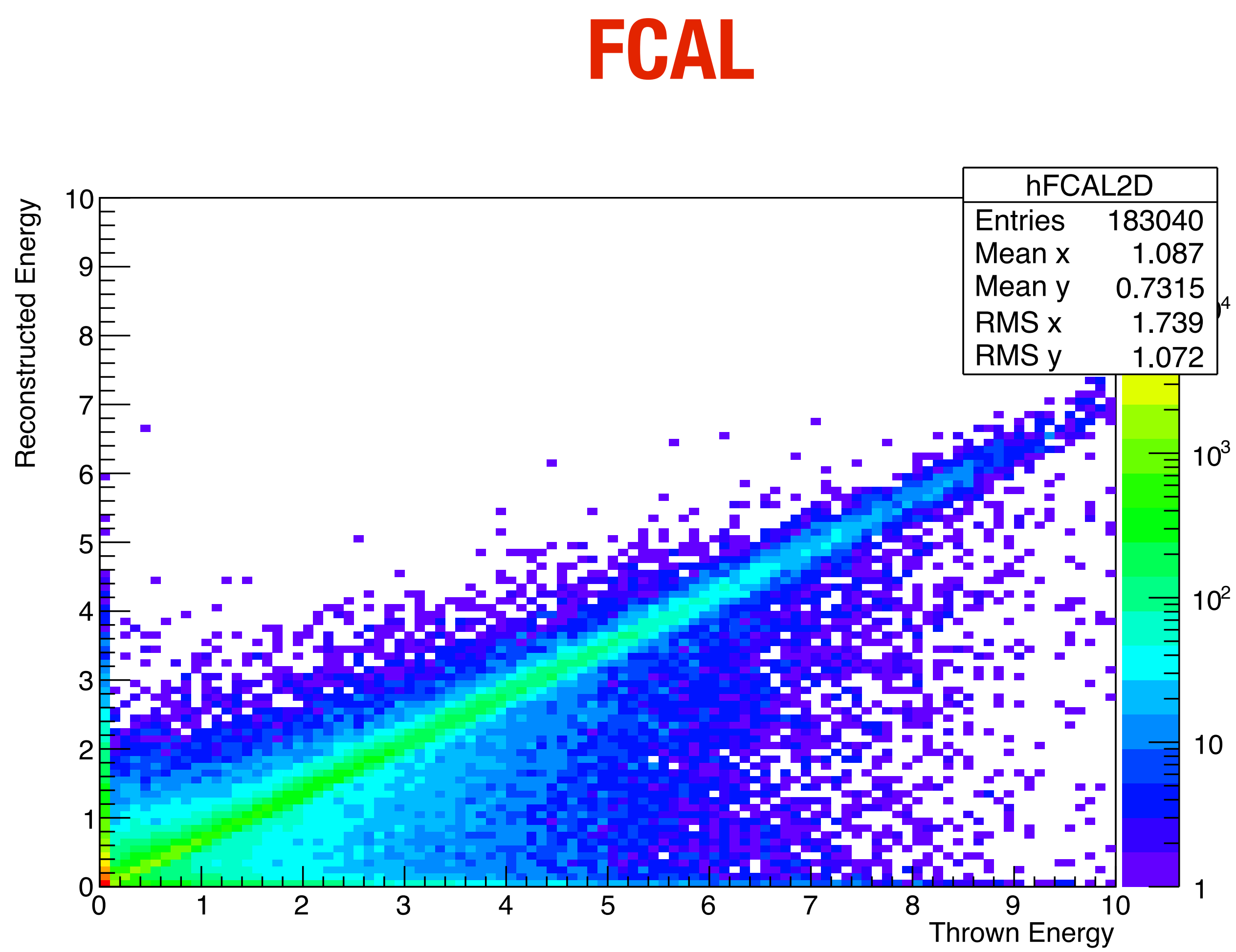
    http://argus.phys.uregina.ca/cgi-bin/private/DocDB/ShowDocument?docid=2324
  - Cuts on cluster distance to closest shower (d > 10 cm) and cluster z position (for BCAL only: z < 400 cm)





Improving the calorimeter inputs

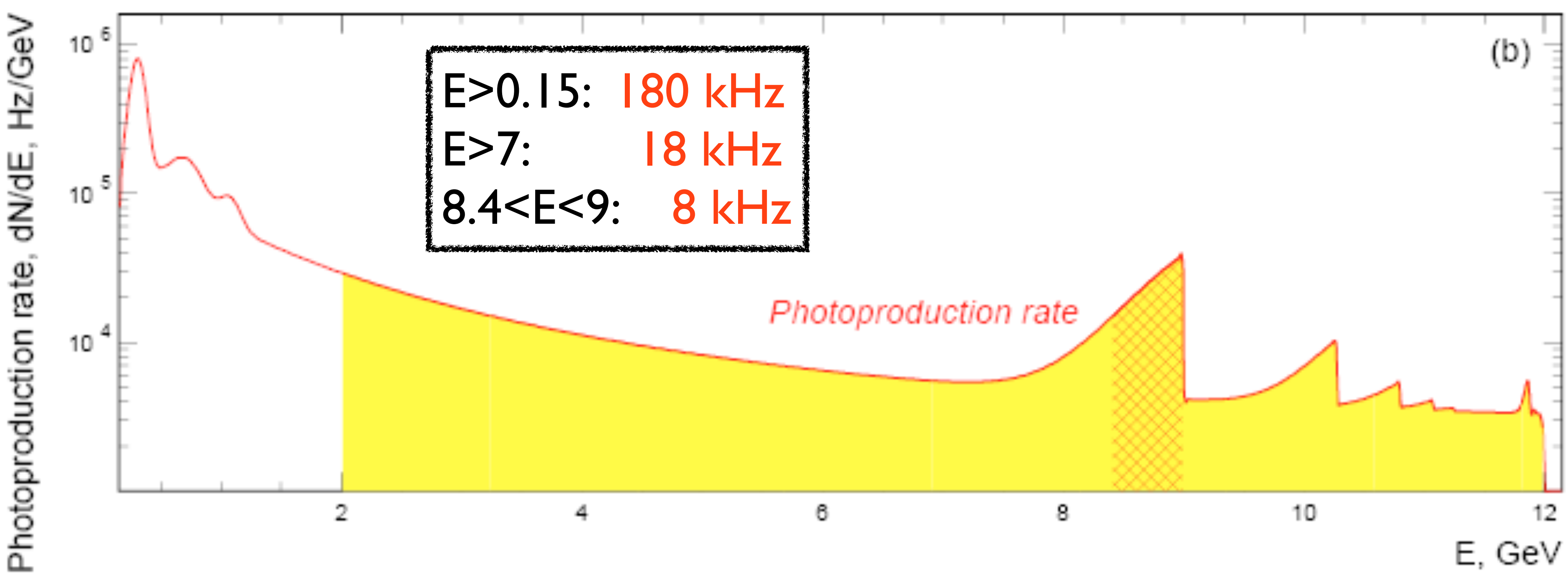




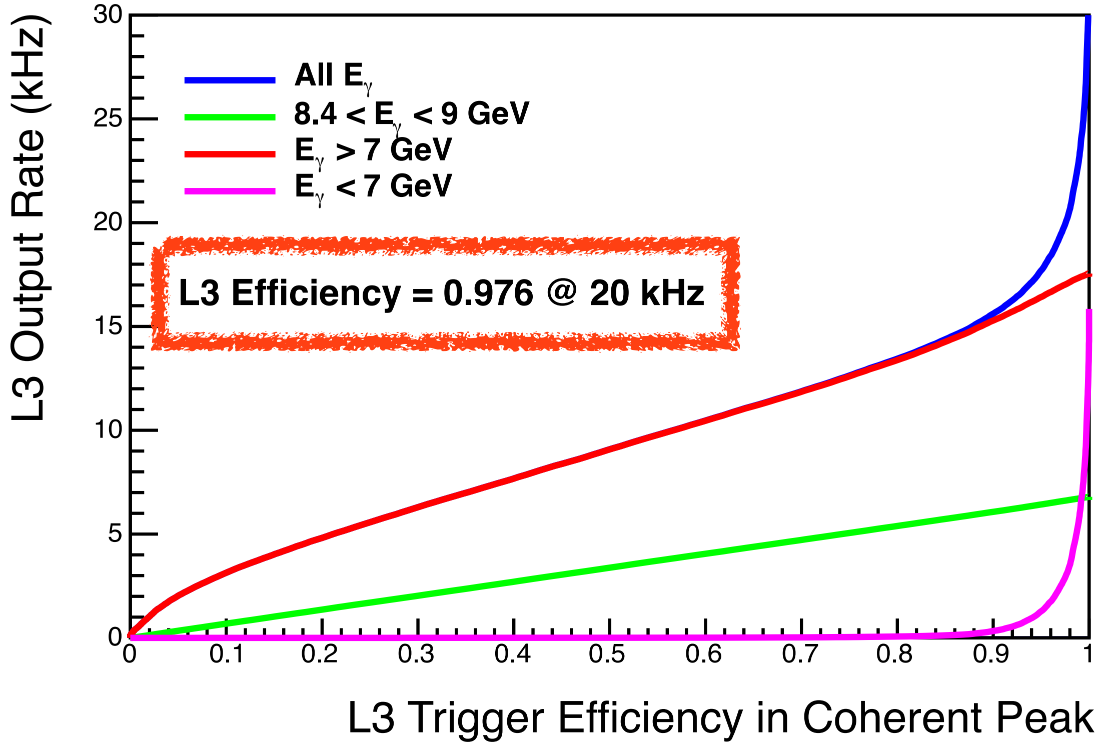
- Seems to improve correlation, but also rejecting some good clusters
- Training with these inputs to the BDT actually leads to worse overall trigger performance
- Might get better if we improve "good" cluster selection (timing, etc.)

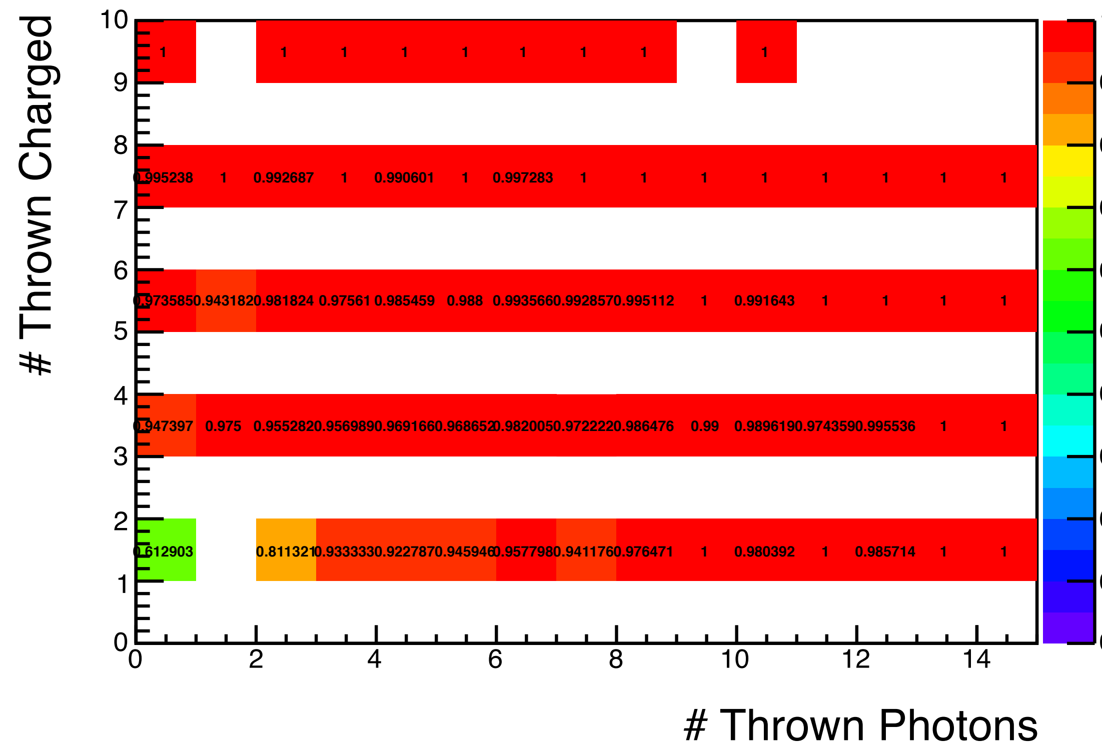
Improving inputs

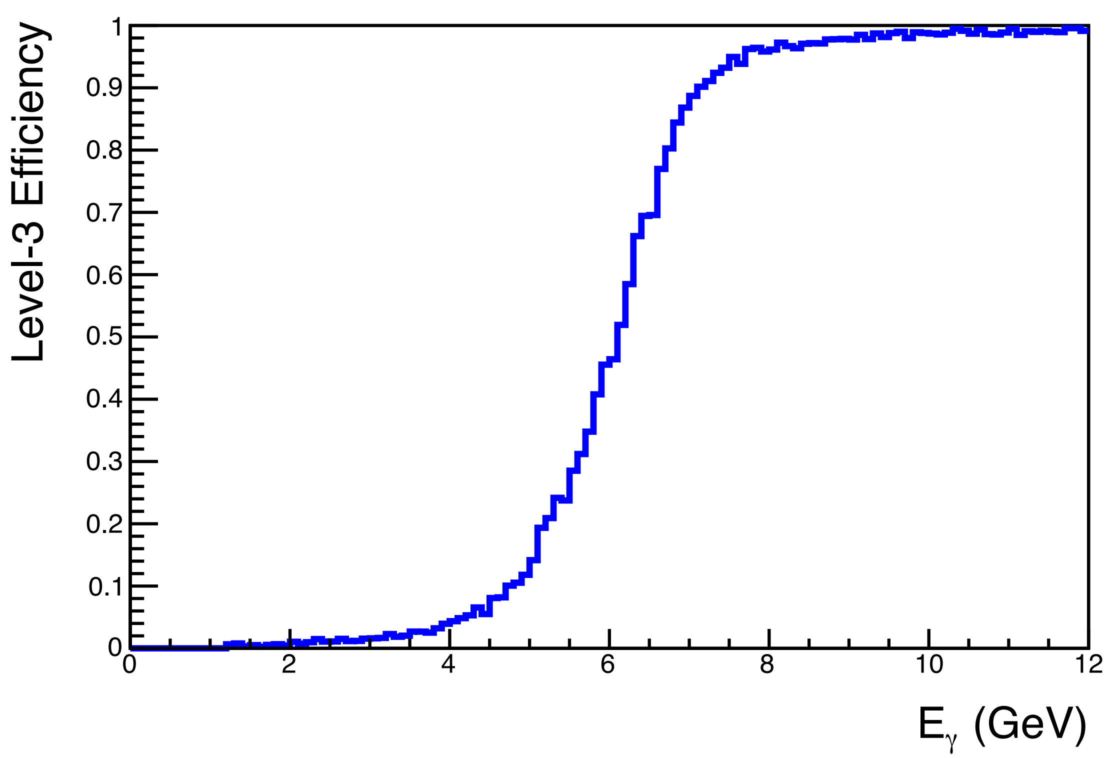
- So can try to improve the current inputs with better track and cluster selection, but what is the limiting factor?
- Remember: only ~2 kHz of bandwidth excess for "background" E_γ<7 GeV events
- Depending on reconstructed "E_γ" resolution of downstream GlueX being good enough to separate 7.0 from 8.4 GeV events



Thrown $\pi^{\pm}/K^{\pm}/p(\bar{p})/\gamma$ momentum sum

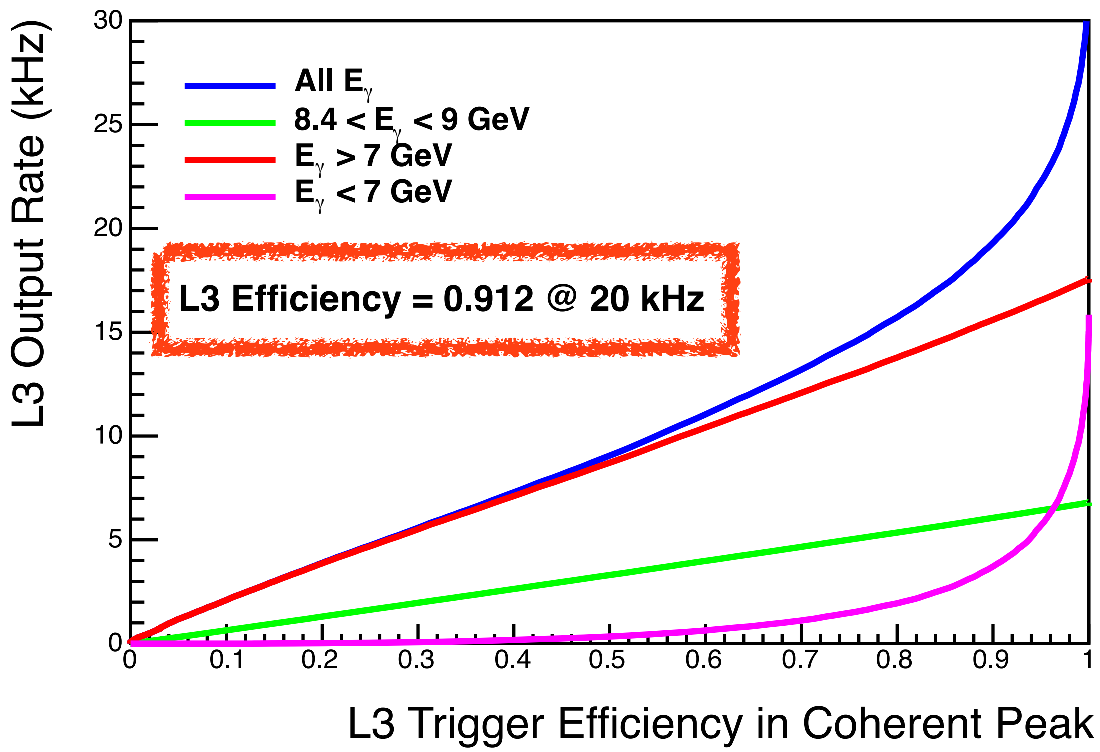


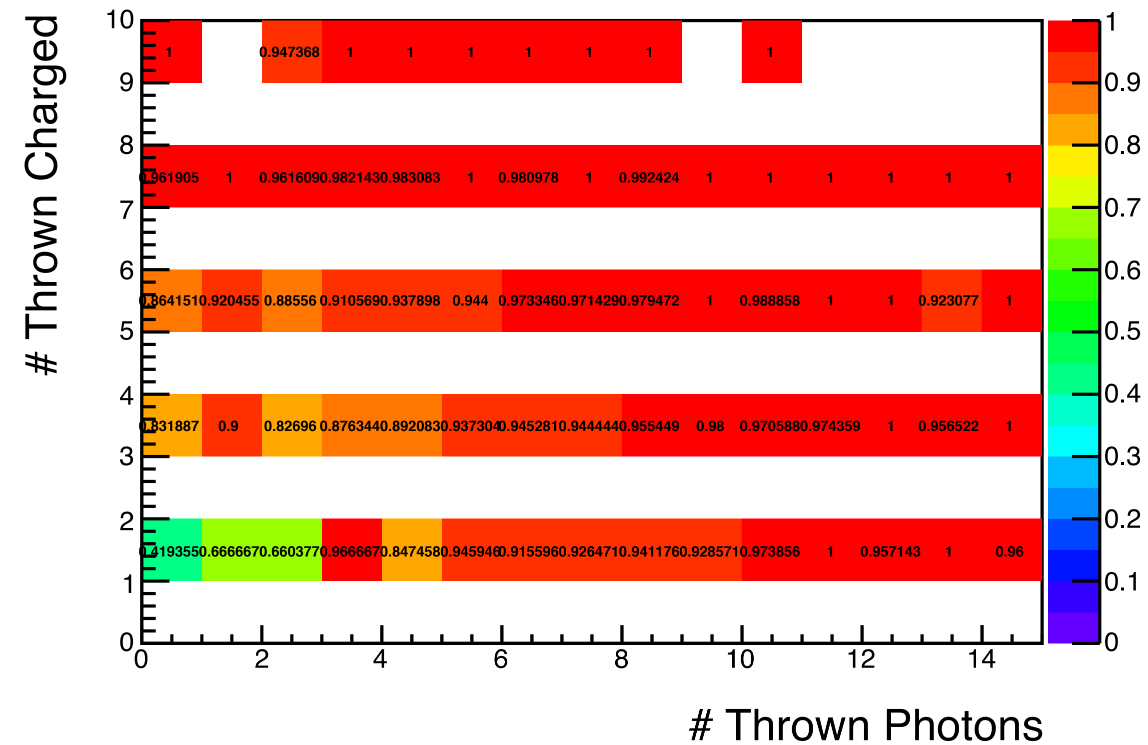


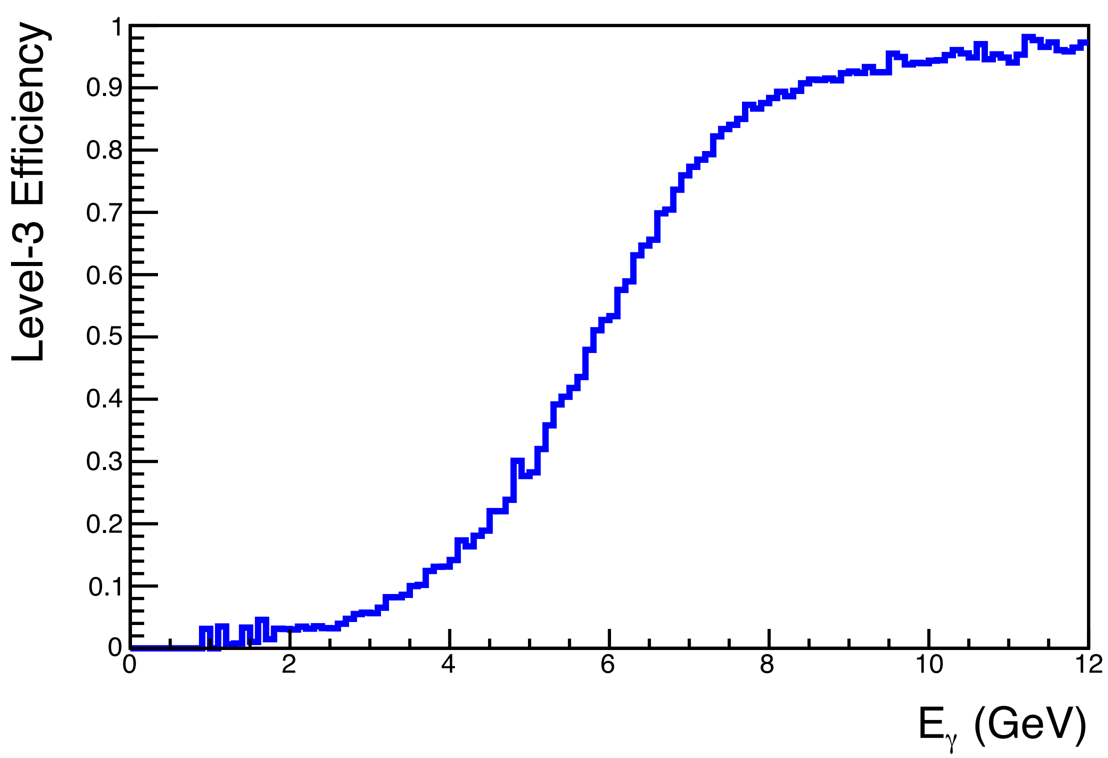


- Use only thrown particle information for $\pi^{\pm}/K^{\pm}/p(p)$ and photons
- Very high efficiency as expected, with deviation from 100% coming from lack of neutron information
- Try using “pieces” of thrown information to see where the current weaknesses are

Sum of thrown photon energy (instead of FCAL and BCAL sums)

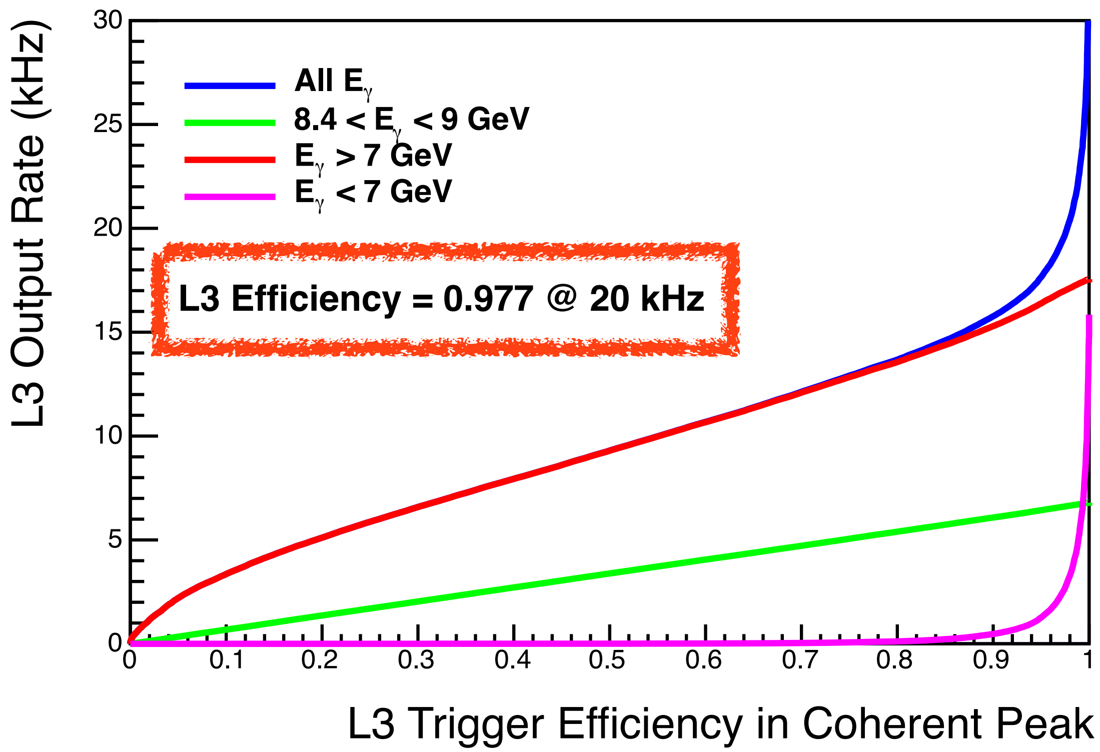


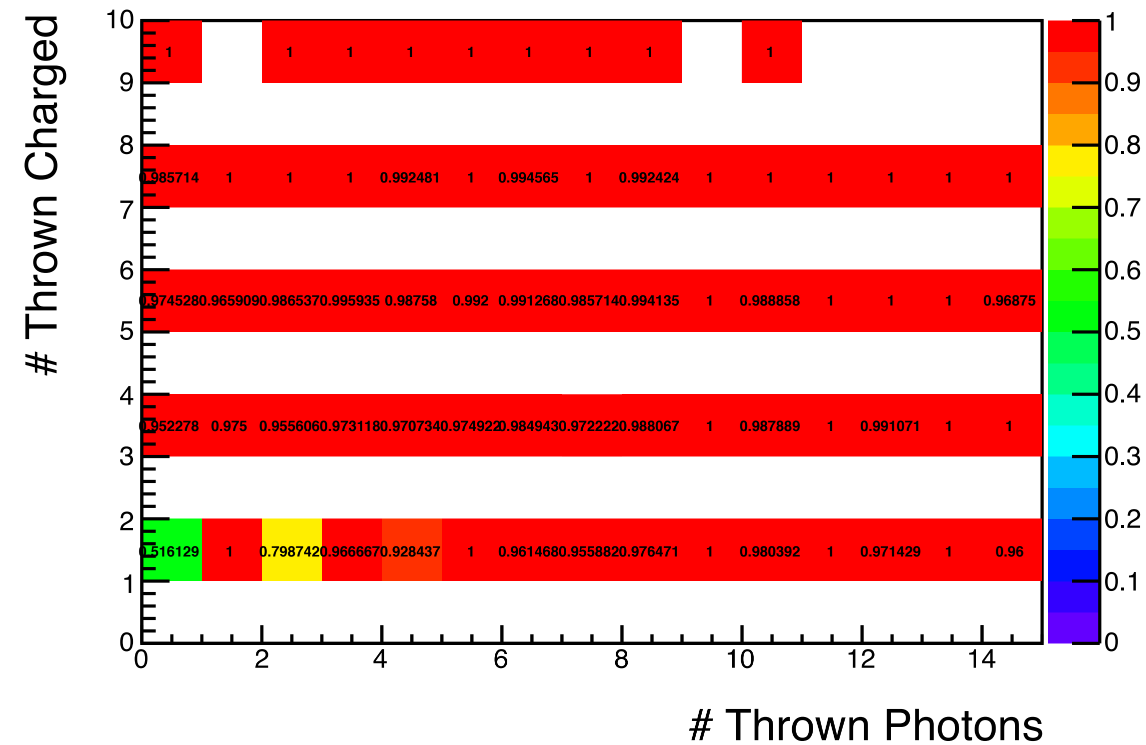


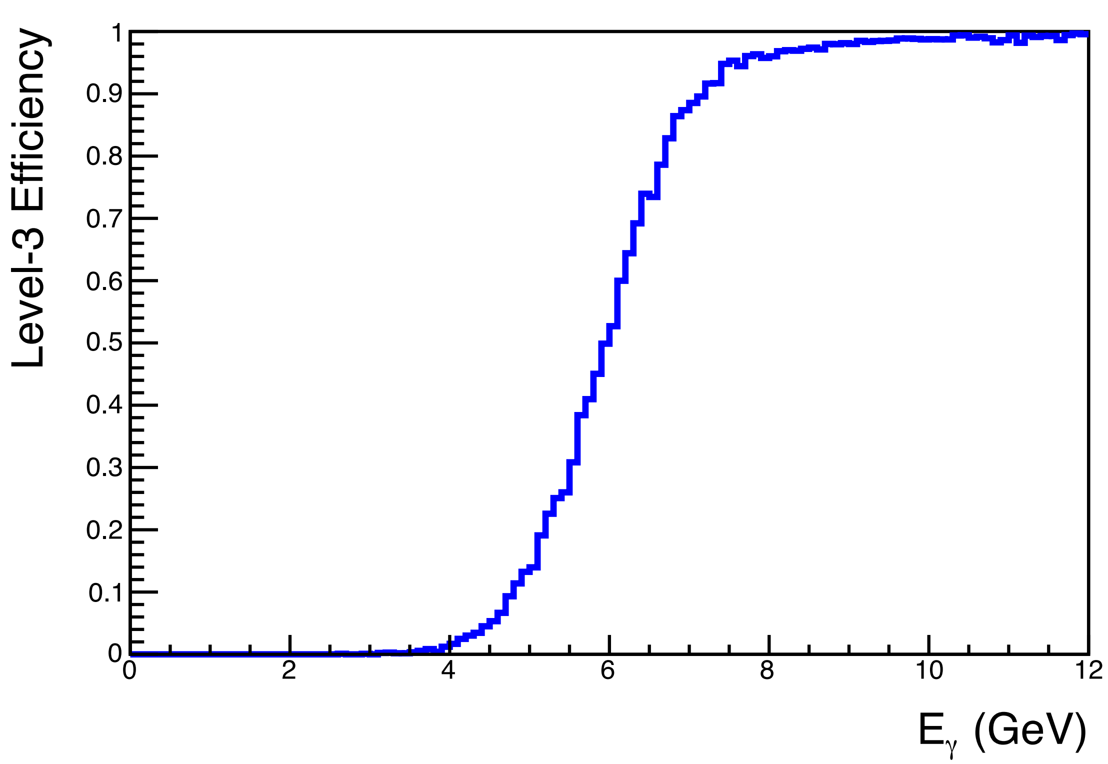


- Use **reconstructed** track momentum sum, but **thrown** photon energy sum
- For a rate of 20 kHz, achieve ~91% L3 average efficiency in the coherent peak
- Slightly worse performance than “standard” FCAL+BCAL energy sum (ie. there is additional information in hadron energy deposits)
- Conclusion: FCAL+BCAL energy sums are not the limiting factor

Sum of thrown charged particle momentum (instead of reconstructed track momentum sum)



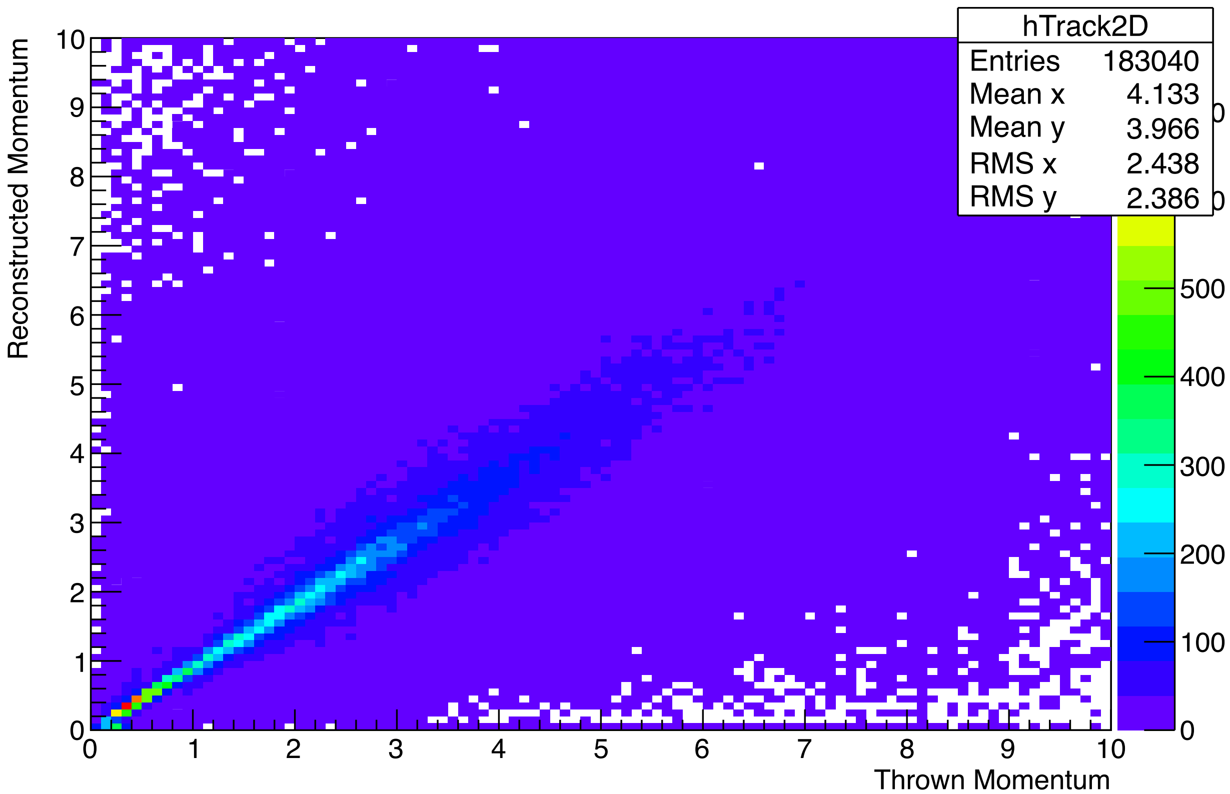




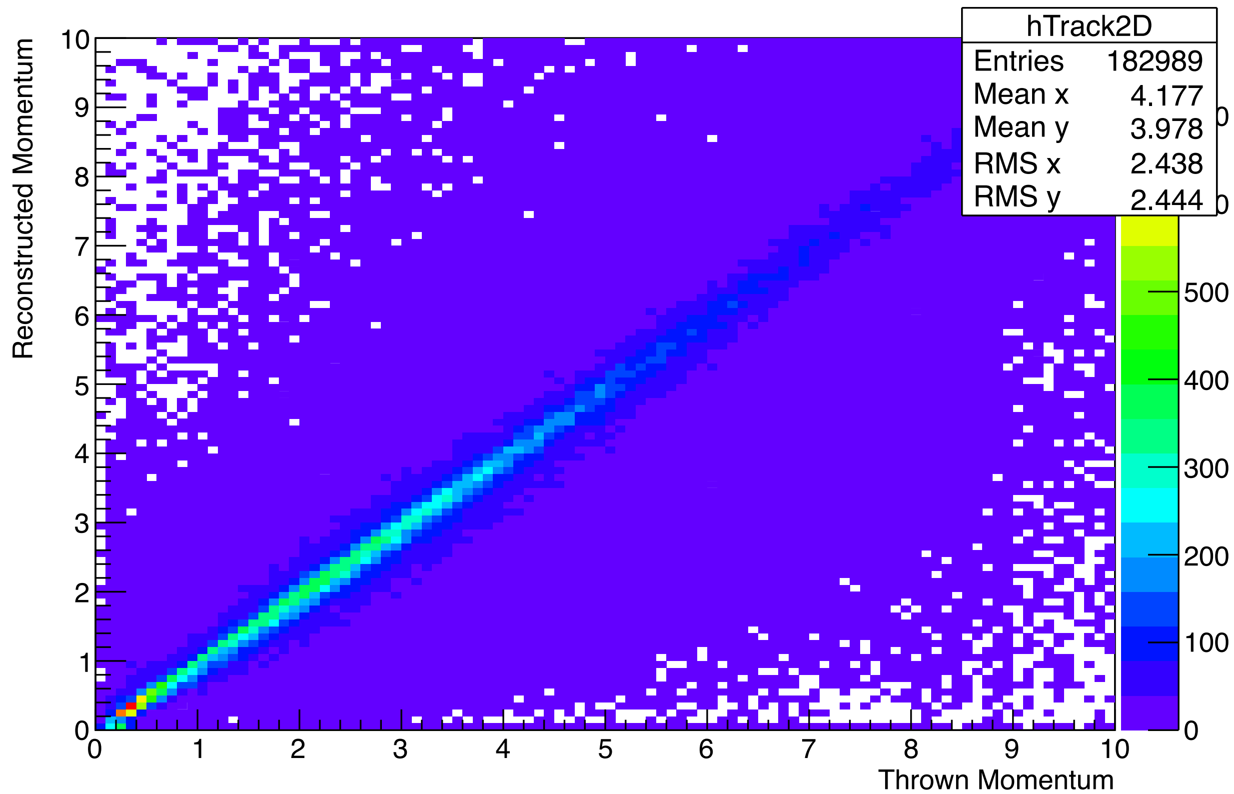
- Use **thrown** charged particle momentum sum, but **reconstructed** FCAL+BCAL energy
- For a rate of 20 kHz, achieve ~98% L3 average efficiency in the coherent peak
- Much improved performance, especially for zero photon events!
- Conclusion: track momentum sum resolution **is** the limiting factor in the current algo

Tracking: momentum resolution

DTrackCandidate

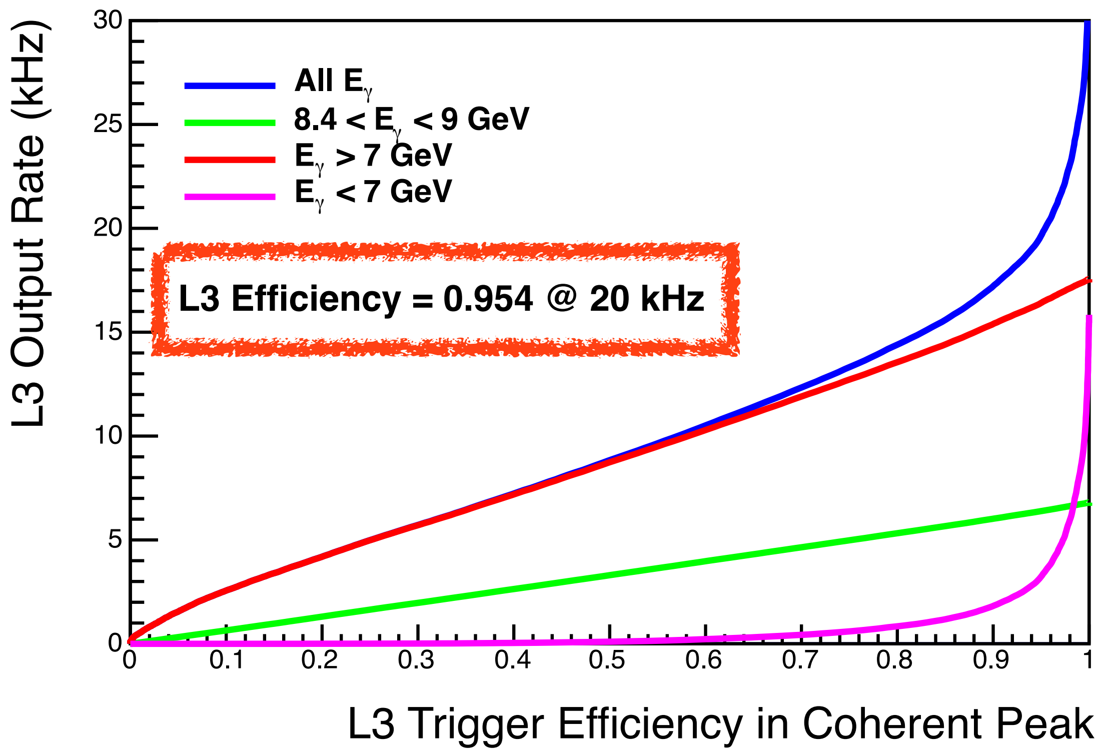


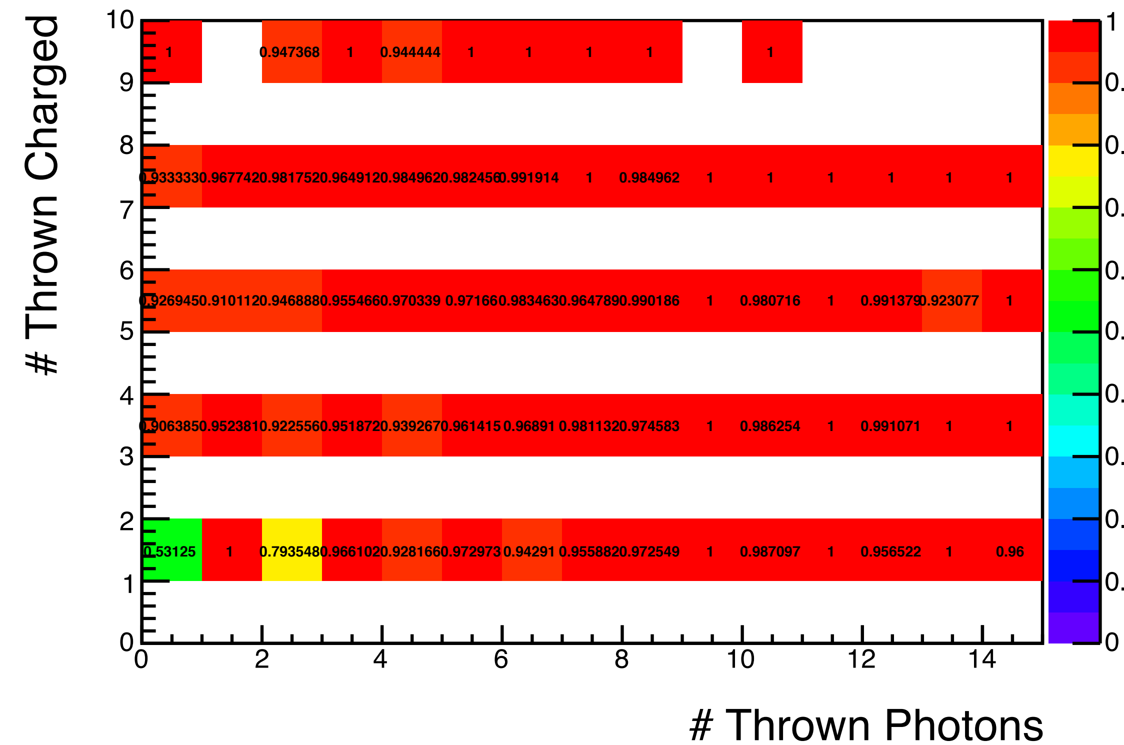
DTrackWireBased

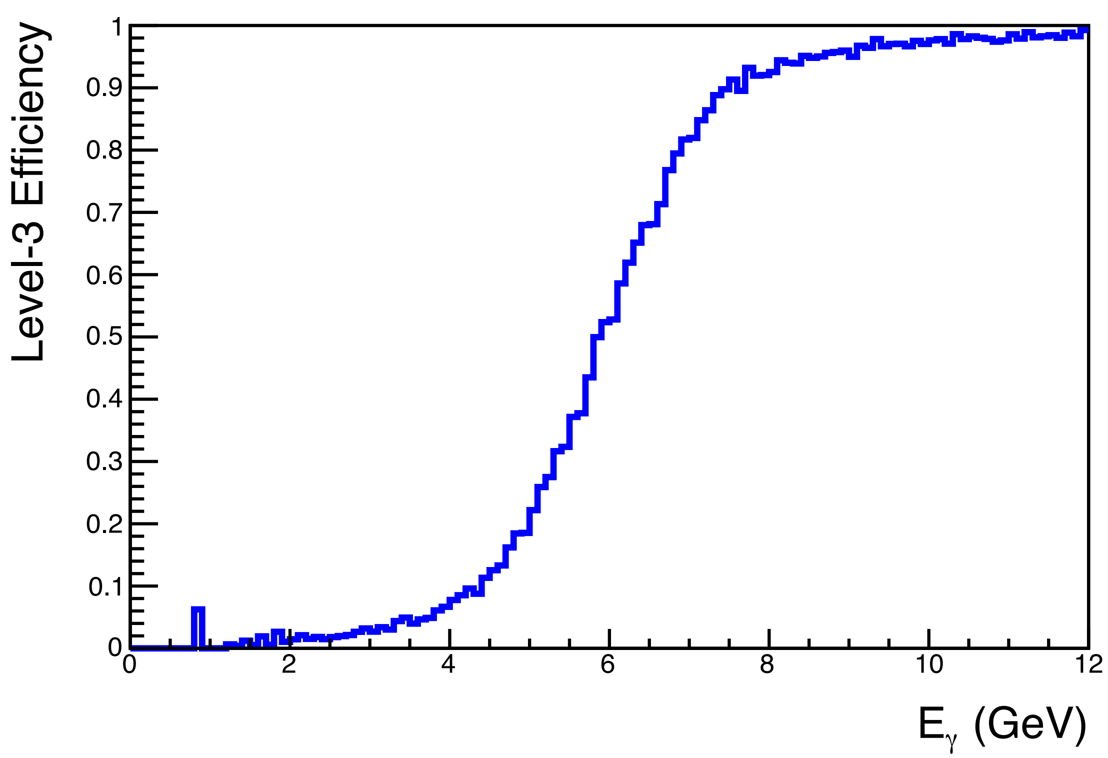


- Momentum resolution appears to be the limiting factor when the BDT is trained with DTrackCandidate
- How much does DTrackWireBased help?

Wire-based tracking (**w/o** EM pileup)

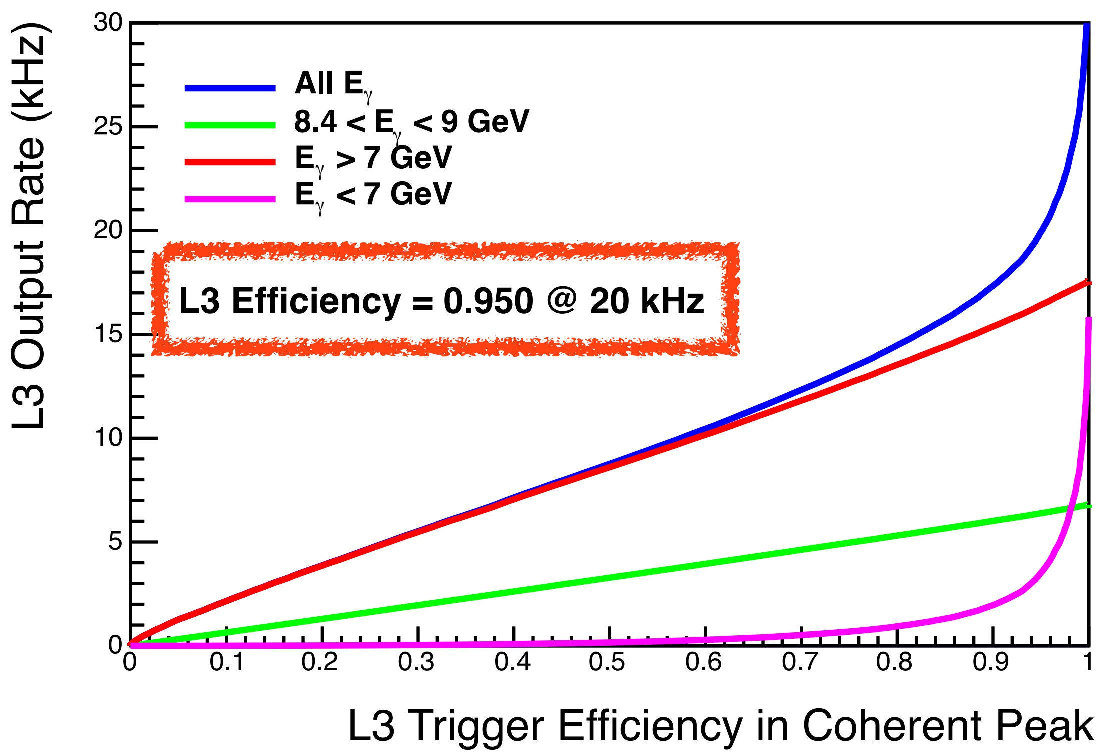


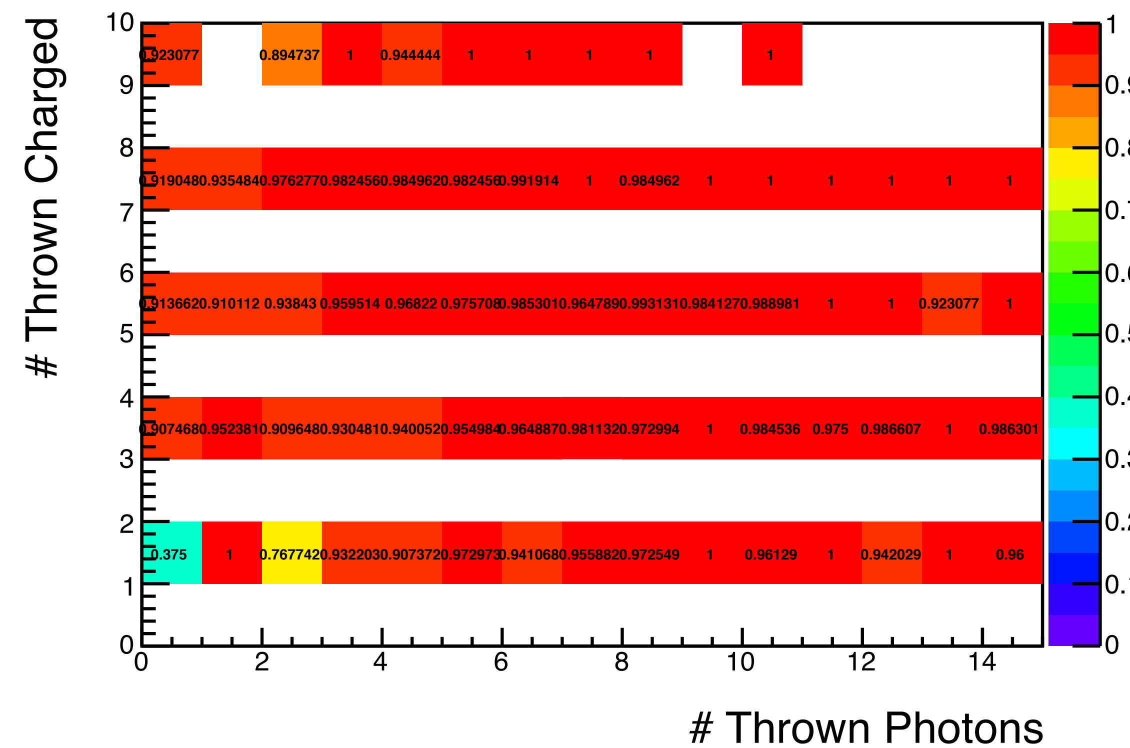


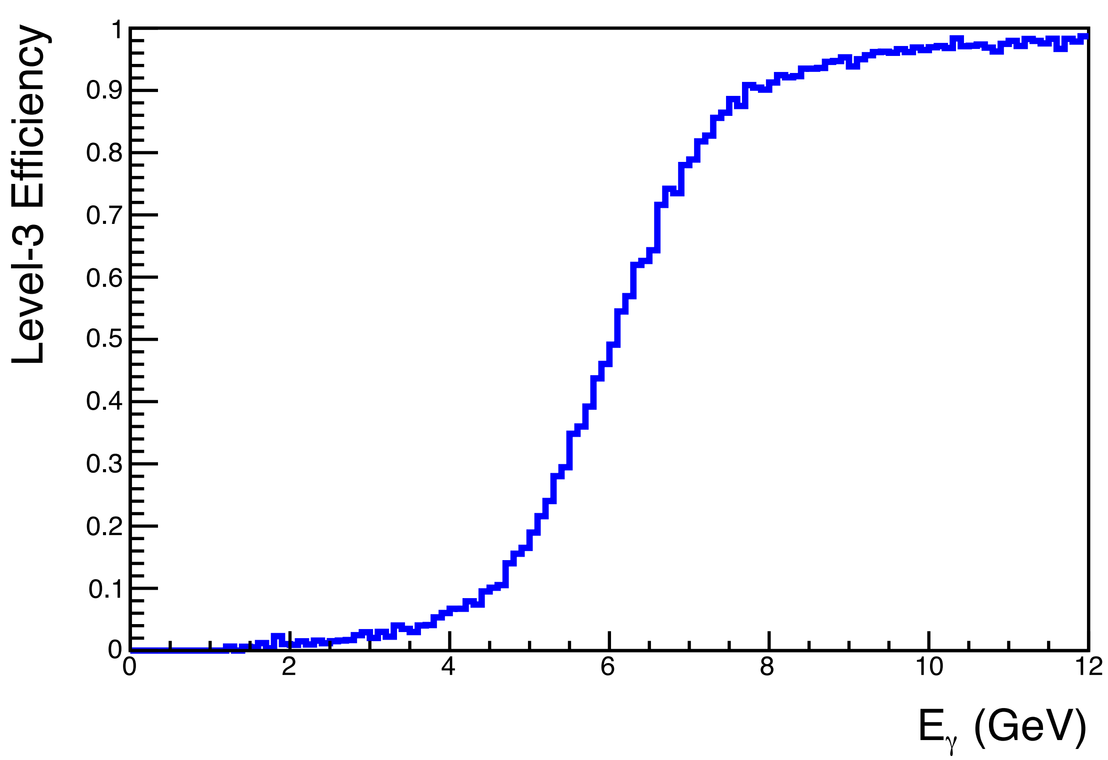


- Now use only reconstructed variables, but **wire-based tracking** as well
- For a rate of 20 kHz, achieve ~95% L3 average efficiency in the coherent peak
- For # neutrons = 0, have ~97% effic
- Performance in between thrown track momentum sum and using sum of DTrackCandidate's momentum

Wire-based tracking (**w/** EM pileup)





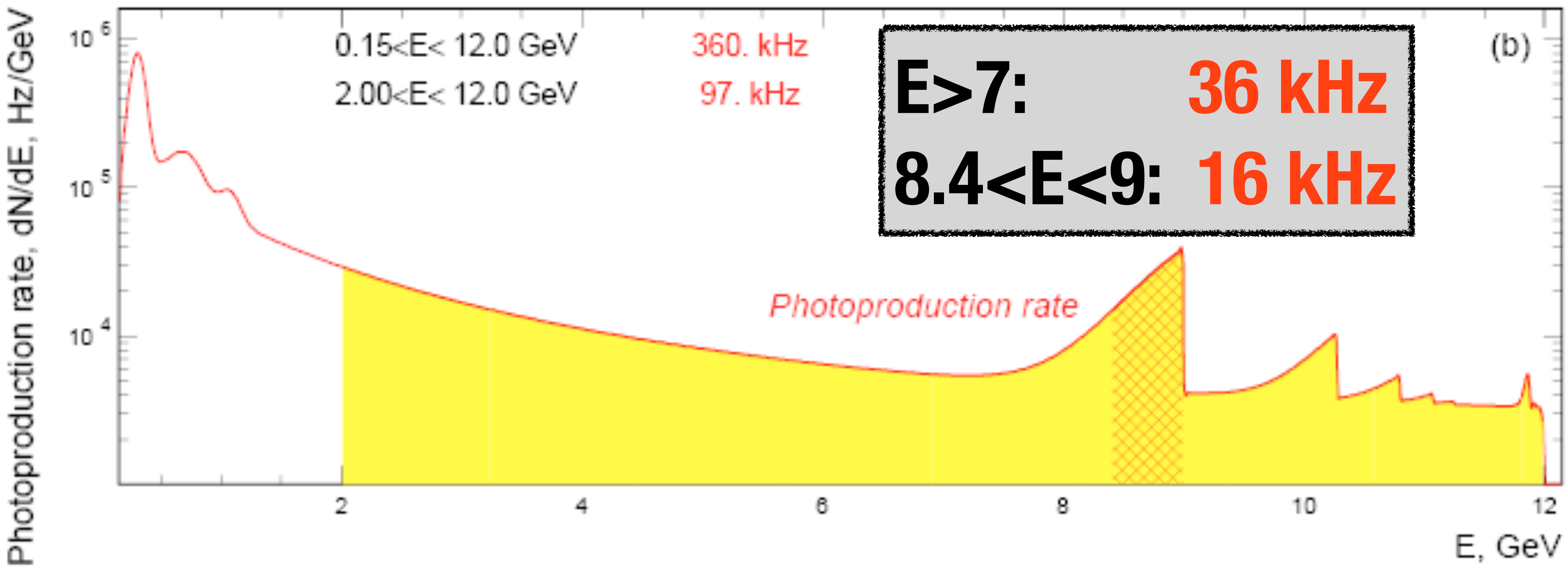


- Add EM pileup again
- Using only reconstructed variables with **wire-based tracking**
- For a rate of 20 kHz, achieve ~95% L3 average efficiency in the coherent peak
- For # neutrons = 0, have ~96% effic
- Performance in between thrown track momentum sum and using sum of DTrackCandidate's momentum

To Do List

- Wire based tracking with only $\pi^{\pm}$ mass hypotheses increases algo CPU time by a factor of ~2 (when used for all events)
  - Try wire based tracking for selected fraction of tracks with large momentum or small θ (have code from Simon)
  - Wait to do wire based tracking at last "stage" of algo, so only on subset of events passing L1 trigger
- Include toy simulation of tagger microscope again: cuts rate in ~half when requiring one photon in tagger microscope at 5×10^7
- Study more samples with current algorithm:
  - EM only background events
  - Some reactions of interest (eg. n3pi, b1pi, ...)

High Intensity: 10^8

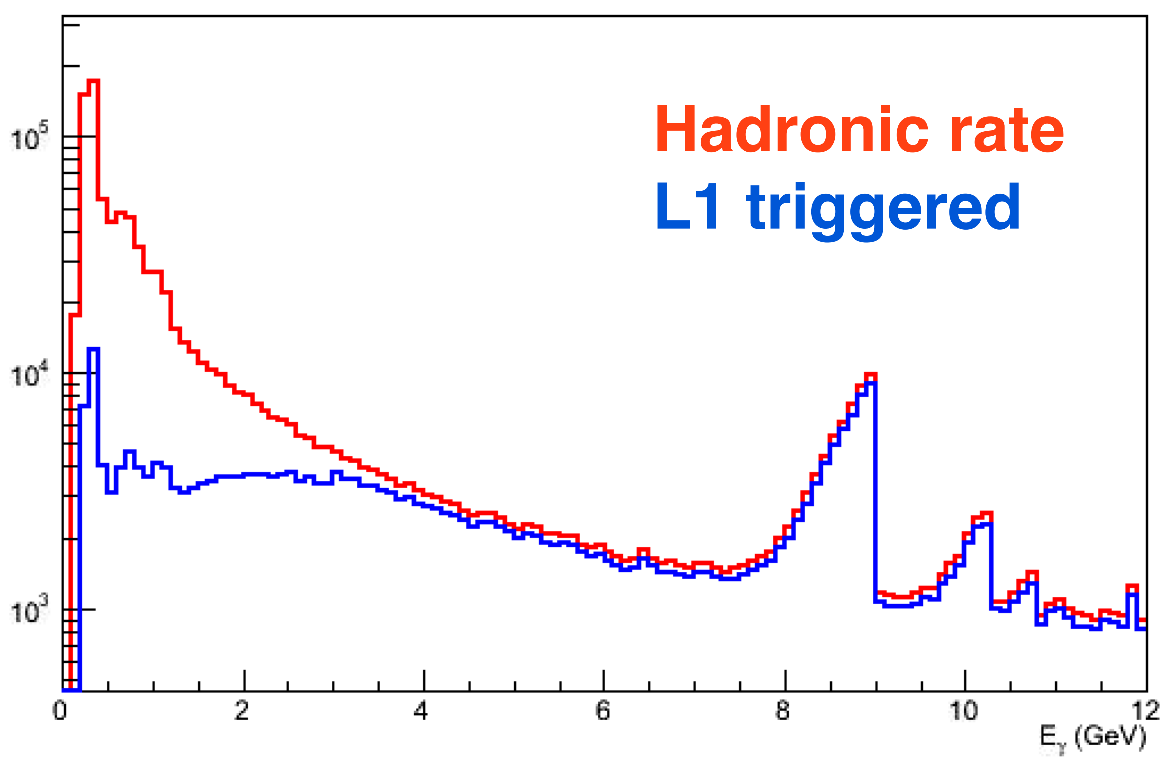


- Can't take all $E_\gamma > 7$ GeV in 20 kHz since $E_\gamma > 9$ GeV not easily separated from coherent peak
- Need to make choices about physics priorities, some options:
  - Identify lower interest channels (with huge statistics from earlier lower intensity running) to ID and prescale
  - Identify characteristics of interesting channels (eg. strangeness: displaced vertex, CKOV upgrade, etc) to select events

Backup

Level-1 Trigger

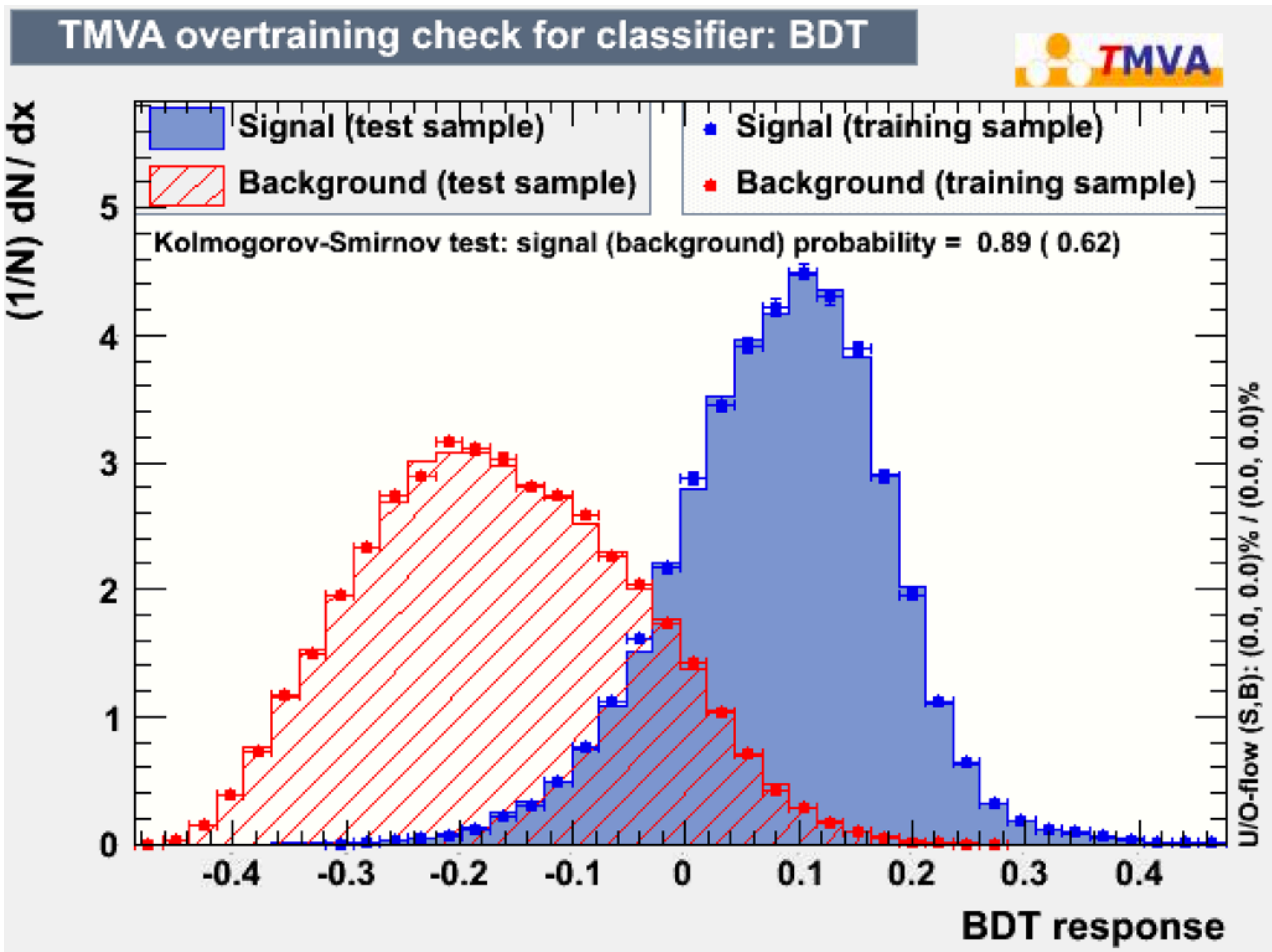
GlueX-doc-1043: Implemented in DMCTrigger



- Sample of bggen events with high-luminosity EM pileup
- Define "signal" as $E_\gamma > 7$ GeV and "background" $E_\gamma < 7$ GeV
- Accept events which fire L1a or L1b emulated trigger
- Reject ~77% of background with signal efficiency of 92%
- So far haven't considered EM only background rate

```
bool sum_cut = (Ebcal + 4.0*Efcal)>=2.0;
trig->L1a_fired = sum_cut && Ebcal>0.200 && Efcal>0.030;
trig->L1b_fired = sum_cut && Ebcal>0.030 && Efcal>0.030 && Nschits>0;
```

Level-3 Training




```
--- Factory   : Ranking input variables (method specific)...
--- BDT       : Ranking result (top variable is best ranked)
--- BDT       : ----------------------------------------------------
--- BDT       : Rank : Variable                  : Variable Importance
--- BDT       : ----------------------------------------------------
--- BDT       :    1 : EfcalClusters             : 1.636e-01
--- BDT       :    2 : Ptot_tracks_cut           : 1.366e-01
--- BDT       :    3 : EbcalPoints               : 1.245e-01
--- BDT       :    4 : EbcalClusters             : 1.110e-01
--- BDT       :    5 : Ntrack_candidates_cut     : 9.658e-02
--- BDT       :    6 : Ntof                      : 8.451e-02
--- BDT       :    7 : Nfcal_clusters            : 7.634e-02
--- BDT       :    8 : Nstart_counter            : 7.554e-02
--- BDT       :    9 : Nbcal_points              : 7.453e-02
--- BDT       :   10 : Nbcal_clusters            : 5.663e-02
--- BDT       : ----------------------------------------------------
```

- Only use tracking variables expected to be "stable" and able to simulate offline: Sum of track momentum and # of tracks
- This version of the algo was attempted to be used in the online data challenge (more in David's talk)

Multiple Stages of Level-3

- Reconstruction of some input variables are more "expensive" than others

	SC	TOF	FCAL	BCAL	Tracking
Reco time (ms)	0.02	0.25	0.19	0.30	13.5

- Train BDT in stages adding more expensive variables at each stage to mainly reduce CPU from tracking

- For example, start with hadronic rate of ~50 kHz out of Level-1

  - Train BDT at each stage with a subset of variables and make cut at $\epsilon = 0.99$

Stage	BDT Variables	Output Rate (kHz)
1	SC+FCAL	40.0
2	SC+FCAL+TOF	32.3
3	SC+FCAL+TOF+BCAL	30.1

- Save roughly a factor of two in CPU time by staging

Tagger in L3

- Accidental tagged photon rate not currently in the simulation, but can model it with some numbers from Richard:
  - At 5×10^7 running, expect 0.25 accidental tags per beam bucket
  - Beam pulses every 2 ns, and tagger window of ±3 ns
- Summary: Use simple poisson statistics for (on average) 1 true + 0.75 accidental tagged photons for coherent peak events, and 0.75 accidentals for non-coherent peak events.
- Either cut on # of tagged photons or include in BDT