Level-3 Trigger Update

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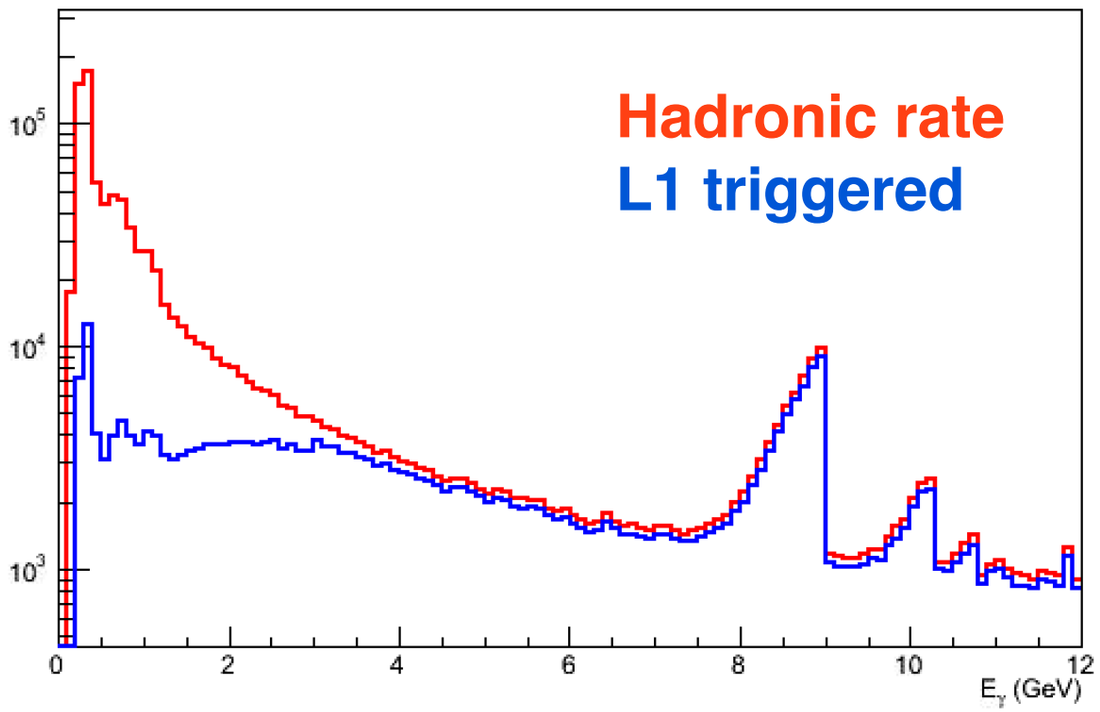
Trigger Working Group Meeting: 8.20.13

Level-1 Trigger

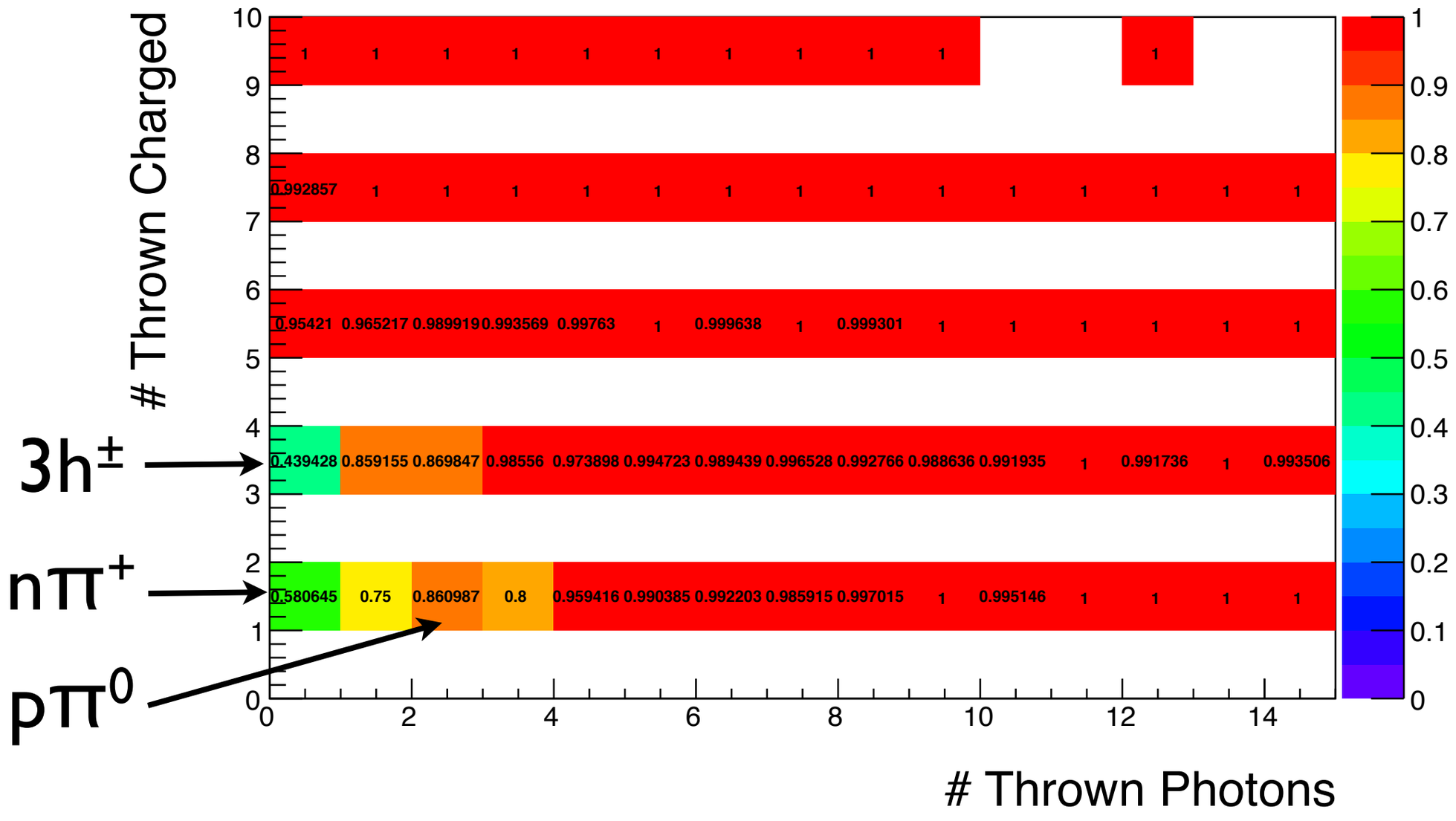
GlueX-doc-1043: Implemented in DMCTrigger



- 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 a signal efficiency of ~92%
- So far haven't considered EM 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;
```

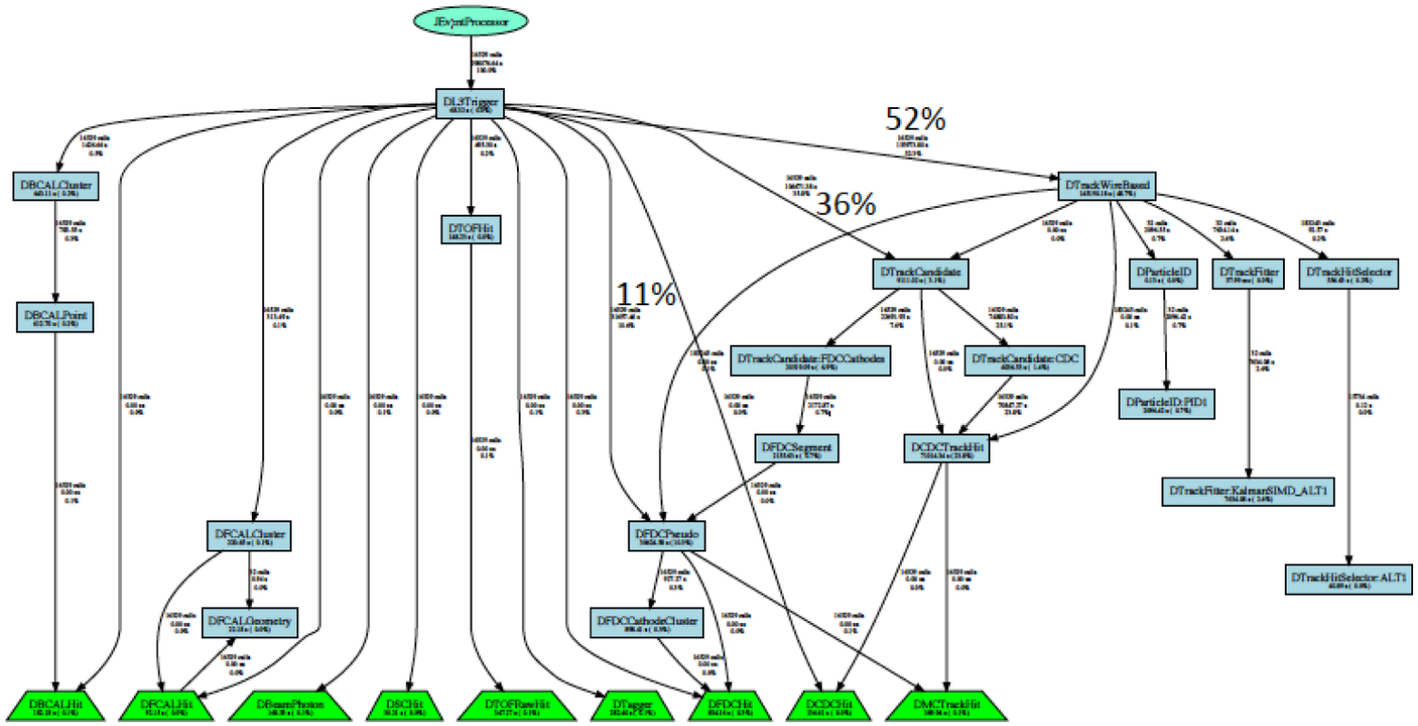
L1 Topology Efficiency



- Efficiency lower for low multiplicity events
- Plans to include TOF in L1 could improve $3h^{\pm}$?

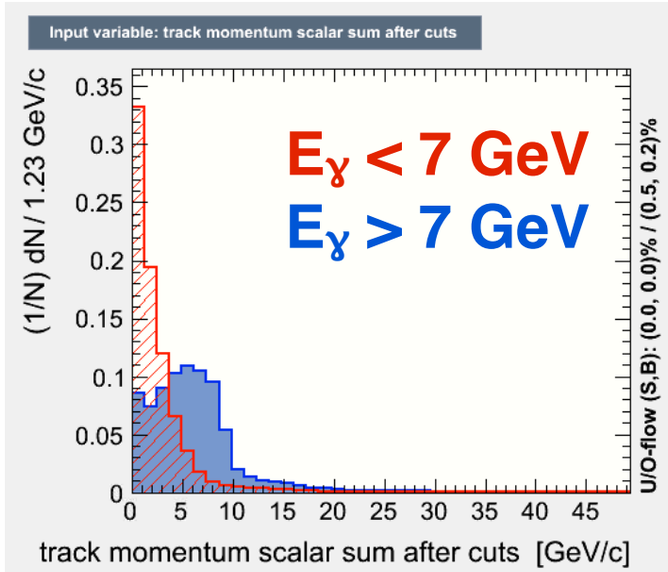
Level-3 Plan

- Start with a “min-bias” trigger for 5x10^7 ɣ/s running (all the coherent peak)
- Without doing full event reconstruction, obtain a set of variables to “quickly” make L3 decision
- Don’t do wire-based tracking to cut CPU time in ~half with small loss in performance
- Processing rate of 77 Hz from David’s earlier study
- Would require ~1300 cores for 5x10^7 ɣ/s with no speed improvements



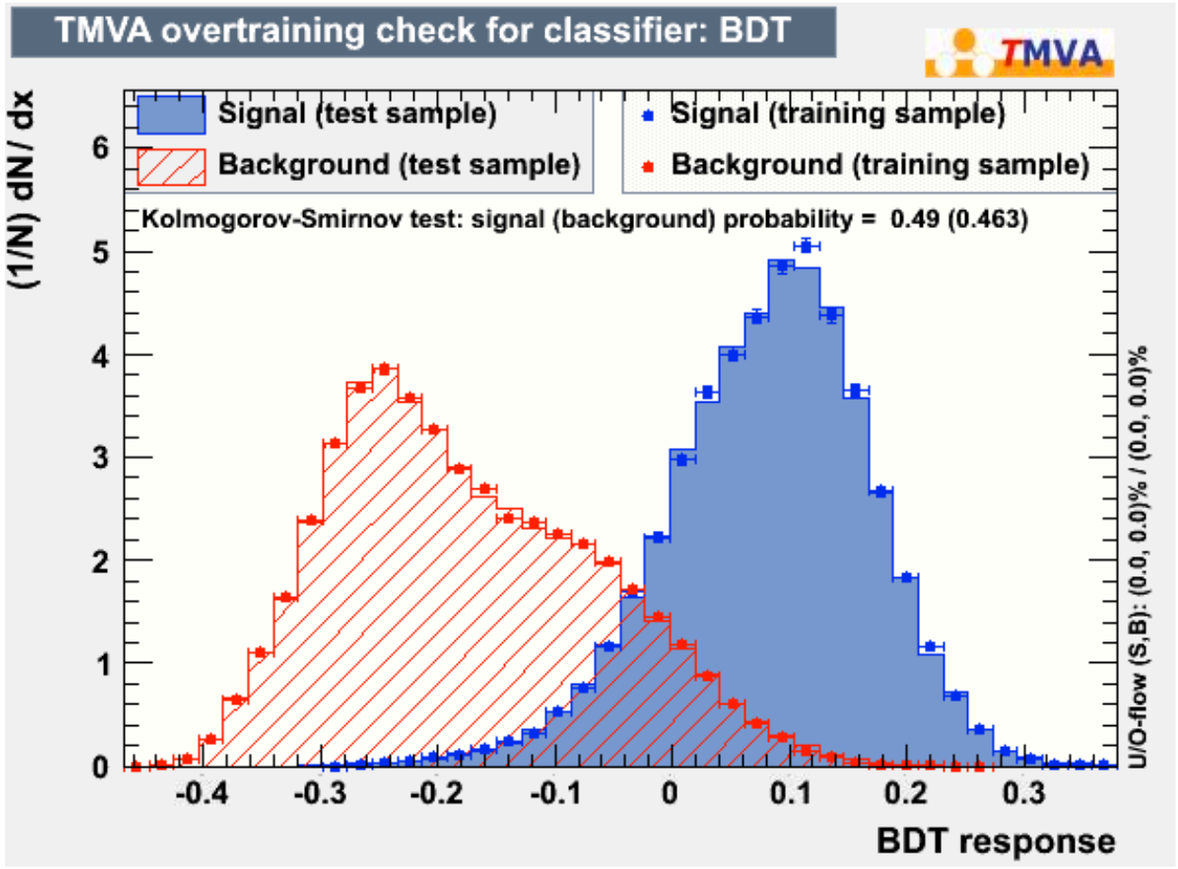
Level-3 Input

```
float Ntagger;            // Number of reconstructed tagger hits
float Nstart_counter;     // Number of start counter hits
float Ntof;               // Number of TOF hits
float Ncdc_layers;        // Number of different CDC layers hit
float Nfdc_planes;        // Number of different FDC planes hit
float Nfdc;               // Number of FDC hits (cathode + anode)
float Nfdc_pseudo;        // Number of FDC pseudo hits
float Ncdc;               // Number of CDC hits

float Nbcal_points;       // Number of BCAL points
float Nbcal_clusters;     // Number of BCAL clusters
float EbcalUnified;       // Total energy in BCAL (Unified Hits)
float EbcalPoints;        // Total energy in BCAL (Points)
float EbcalClusters;      // Total energy in BCAL (Clusters)

float Nfcal_clusters;     // Number of FCAL clusters
float Efcal;              // Total energy in FCAL
float EfcalClusters;      // Total energy in FCAL (Clusters)

float Ntrack_candidates_cut;  // Number of track candidates
float Ptot_tracks_cut;    // Scaler sum of total momentum from candidate tracks
```



- Using some additional quality cuts for track variables
- # of Hits ≥ 10 and DOCA R < 1.5 cm (still needs to be optimized)

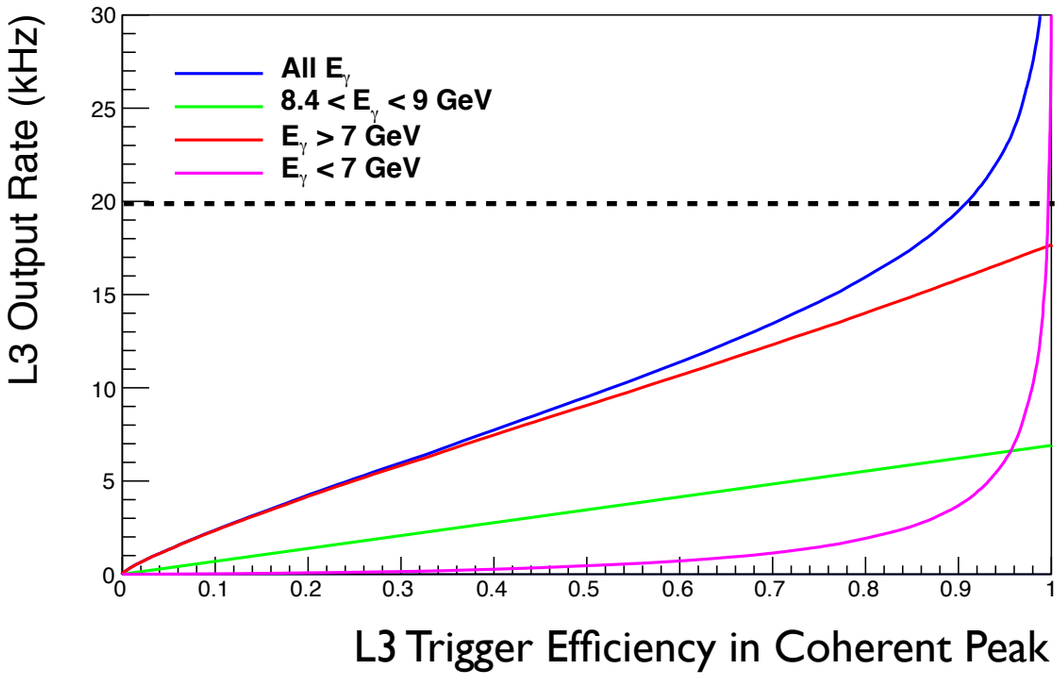
BDT for L3

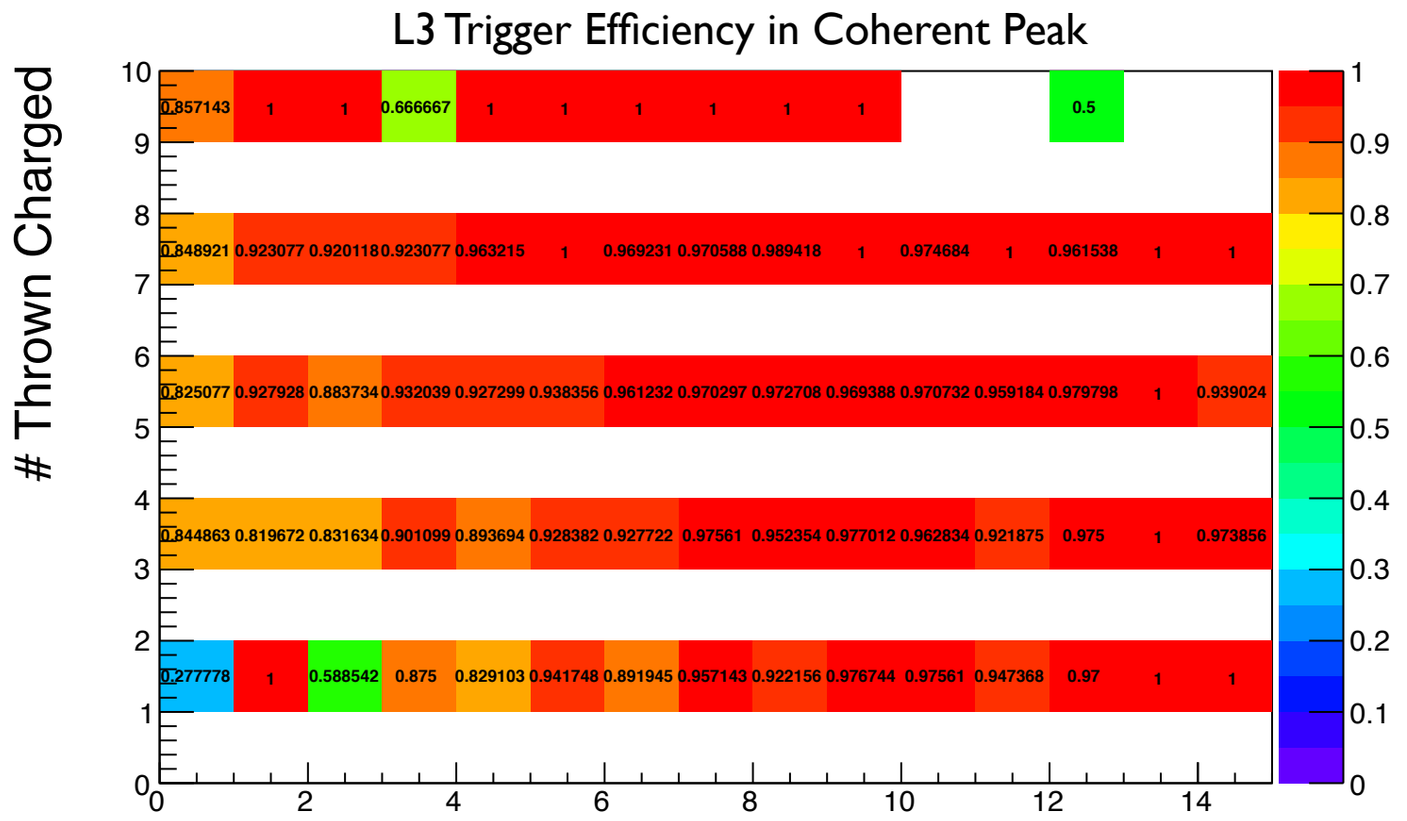


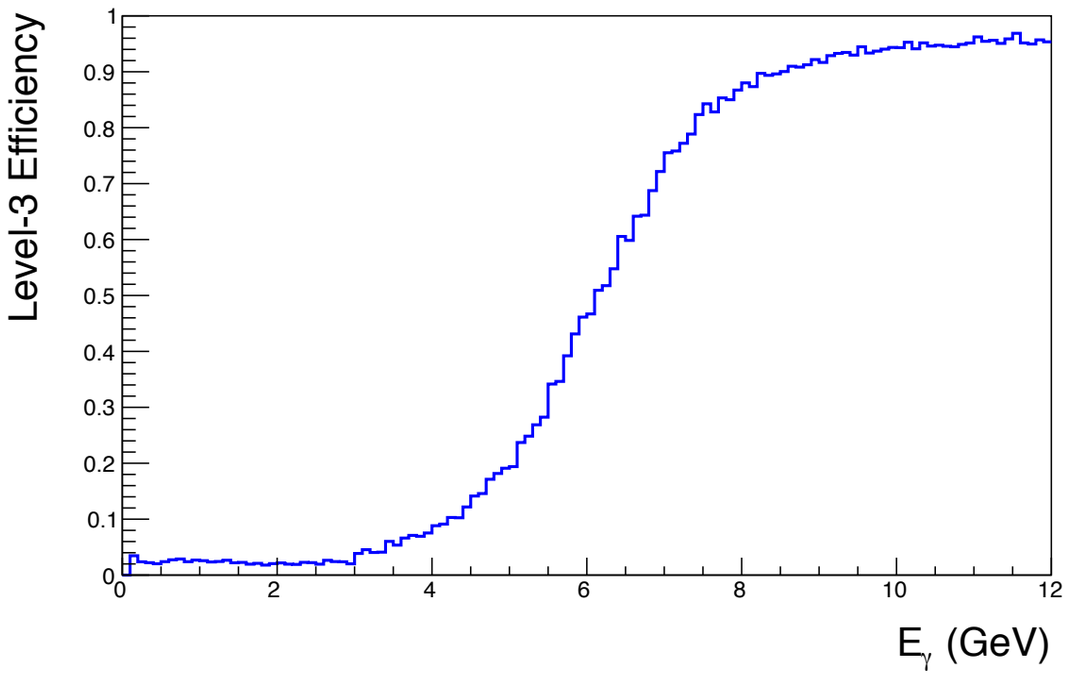

```
--- Factory             : Ranking input variables (method specific)...
--- BDT                 : Ranking result (top variable is best ranked)
--- BDT                 : ----------------------------------------------------
--- BDT                 : Rank :Variable                :Variable Importance
--- BDT                 : ----------------------------------------------------
--- BDT                 :    1 : Efcal                : 9.753e-02
--- BDT                 :    2 : EfcalClusters        : 9.121e-02
--- BDT                 :    3 : EbcalUnified         : 8.717e-02
--- BDT                 :    4 : Ptot_tracks_cut      : 8.463e-02
--- BDT                 :    5 : Ncdc                 : 7.115e-02
--- BDT                 :    6 : Nfdc                 : 6.757e-02
--- BDT                 :    7 : Nstart_counter       : 5.639e-02
--- BDT                 :    8 : Nfdc_pseudo          : 5.503e-02
--- BDT                 :    9 : EbcalPoints          : 5.090e-02
--- BDT                 :   10 : Ntof                 : 4.931e-02
--- BDT                 :   11 : Nfcal_clusters       : 4.455e-02
--- BDT                 :   12 : Nbcal_points         : 4.133e-02
--- BDT                 :   13 : Ntrack_candidates_cut : 3.713e-02
--- BDT                 :   14 : EbcalClusters        : 3.707e-02
--- BDT                 :   15 : Nbcal_clusters       : 3.473e-02
--- BDT                 :   16 : Ncdc_layers          : 3.335e-02
--- BDT                 :   17 : Nfdc_planes          : 3.122e-02
--- BDT                 :   18 : Ntagger              : 2.973e-02
--- BDT                 : ----------------------------------------------------
```

- Consider intensity of 5×10^7 from PAC 40 proposal (average value)
  - Recall at this intensity have $E_\gamma > 7$ GeV rate is ~18 kHz, so very little room in the allowed bandwidth to tape
  - Try a cut which gives ~20 kHz total rate out of L3

L3 Performance



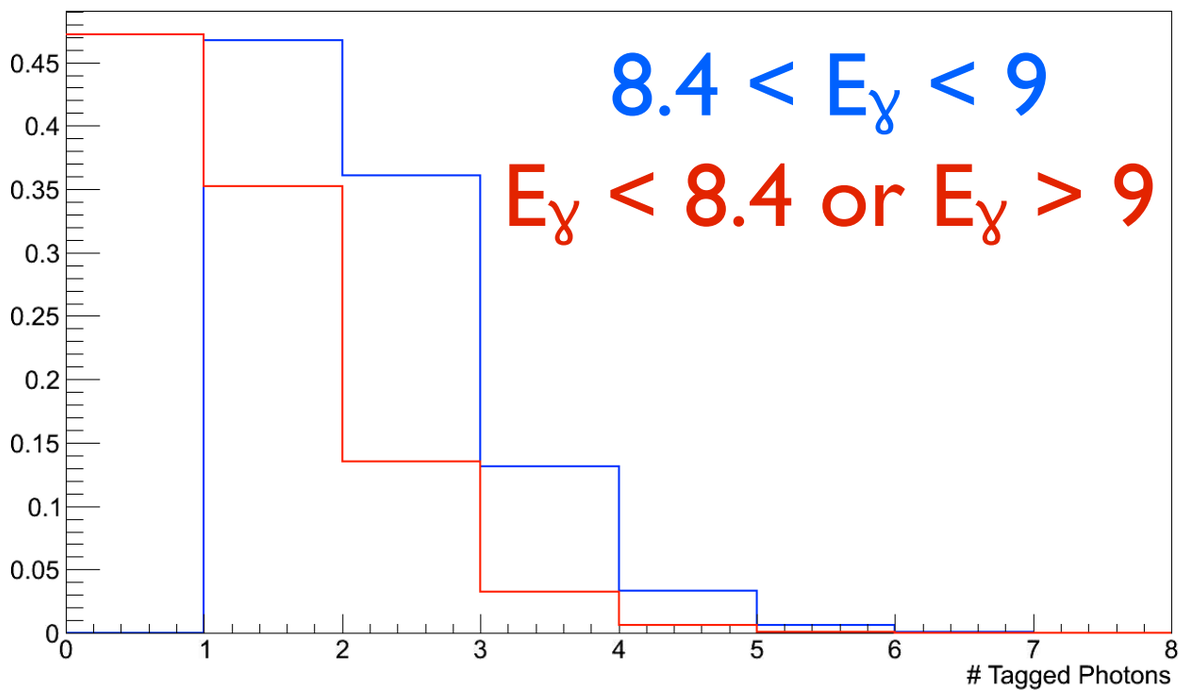




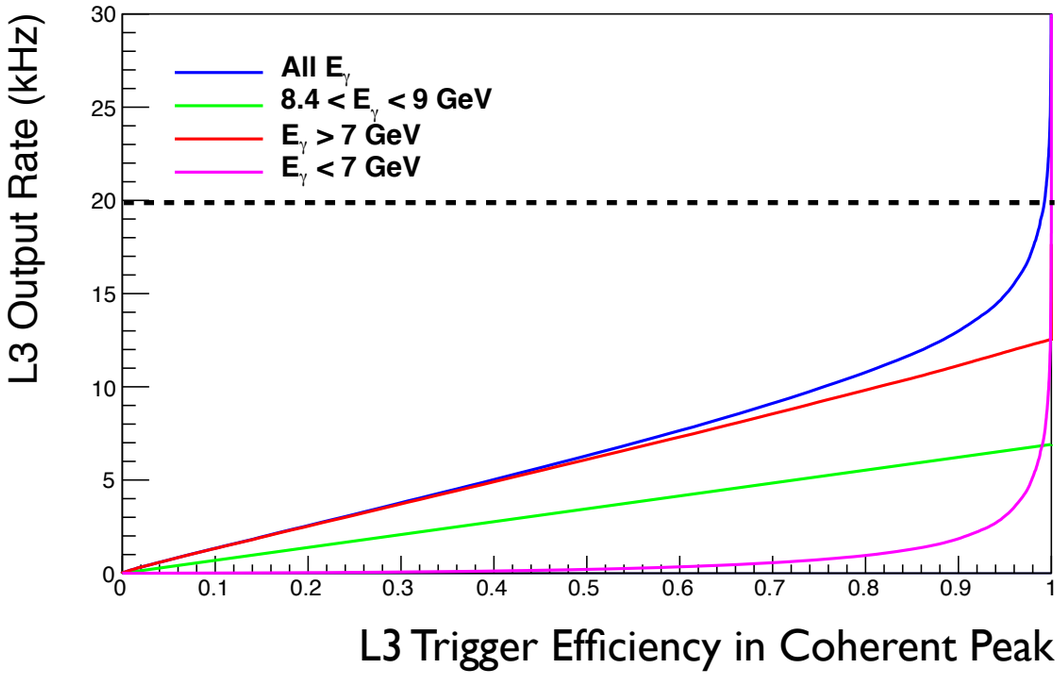
- For a rate of 20 kHz, achieve ~90% L3 average efficiency in the coherent peak
- Events with zero photons have lower efficiency of ~85%

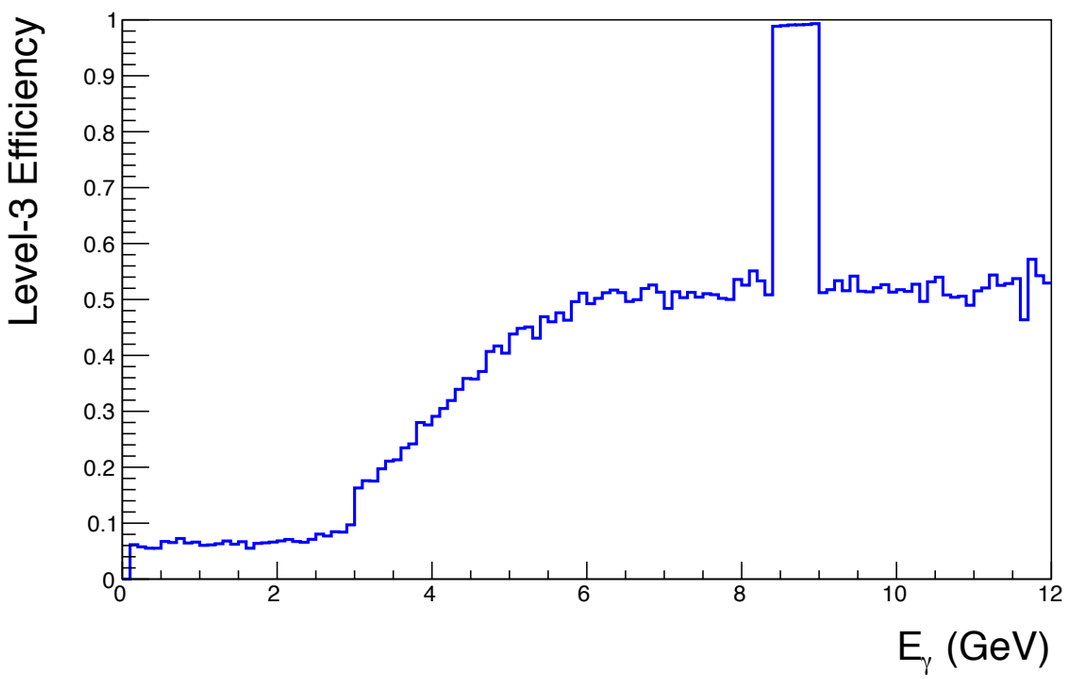
Tagger in L3

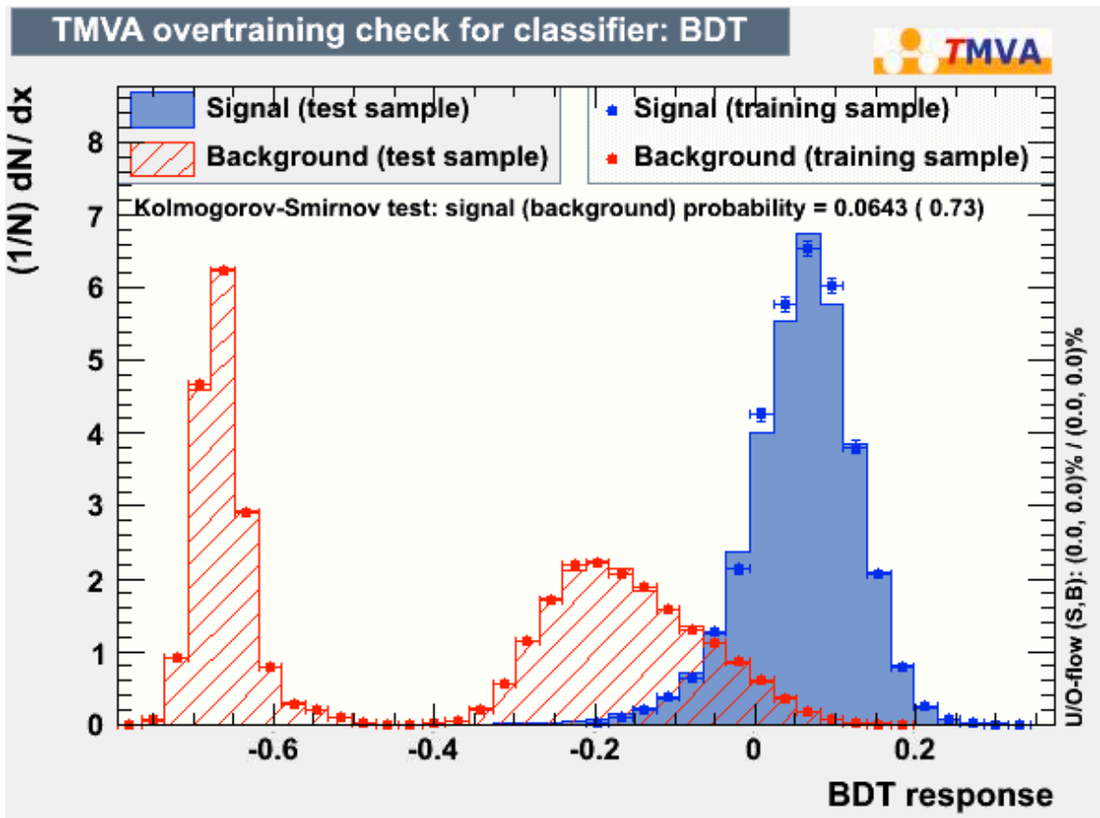
- Accidental tagged photon rate not currently in the simulation, but can model it with some numbers from Richard:
  - At $5x10^7$ running, expect 0.25 accidental tags per beam bucket
  - Beam pulses every 2 ns, and tagger window of ±3 ns
- Summary: Use simple poisson statistics for (on average) 1 true + 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



Tagger in BDT



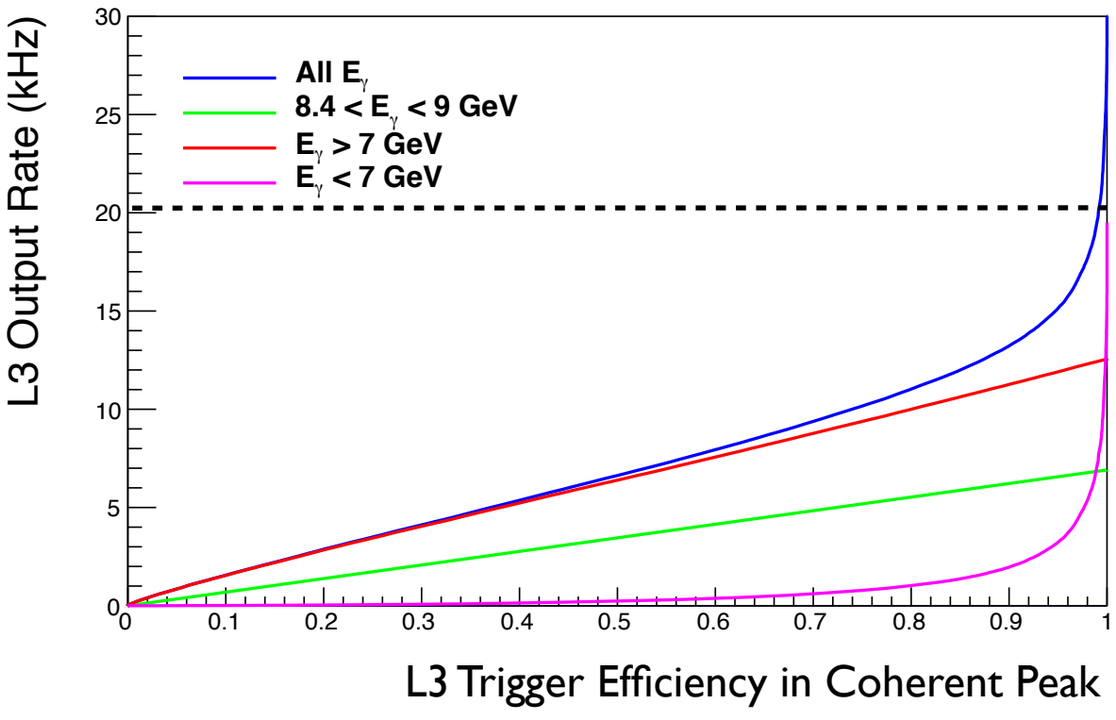


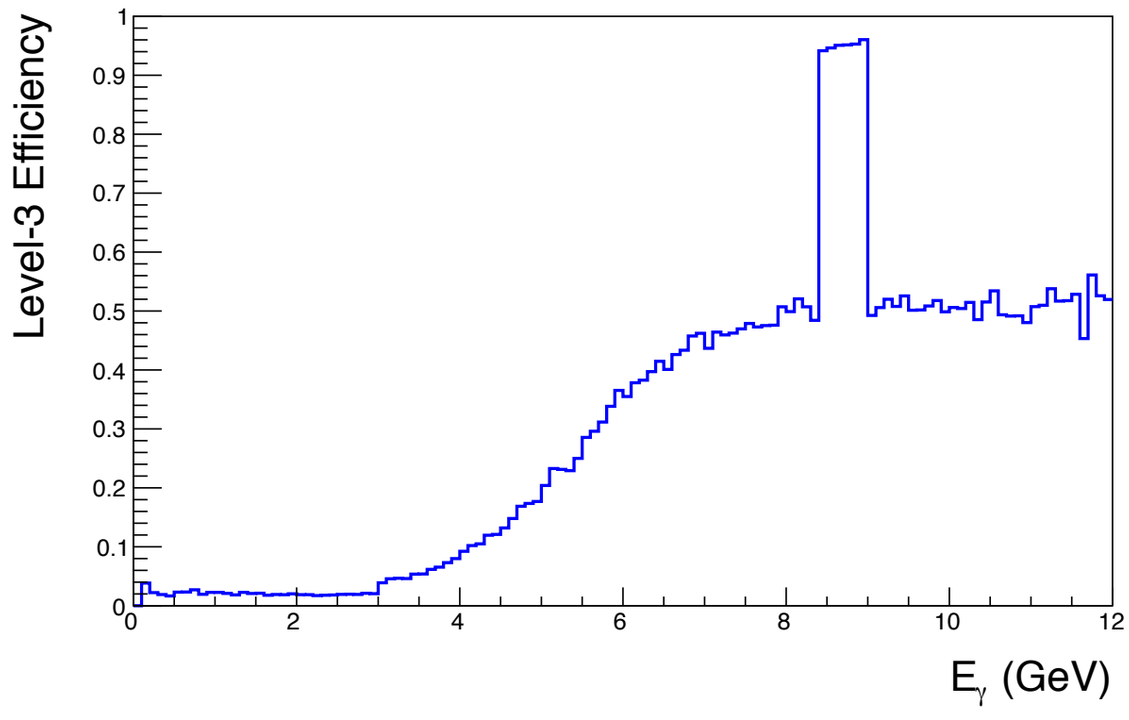


- For a rate of 20 kHz, achieve ~99% L3 average efficiency in the coherent peak
- Low efficiency for higher energy photons
- Events outside the coherent peak are biased towards a higher number of accidental tags

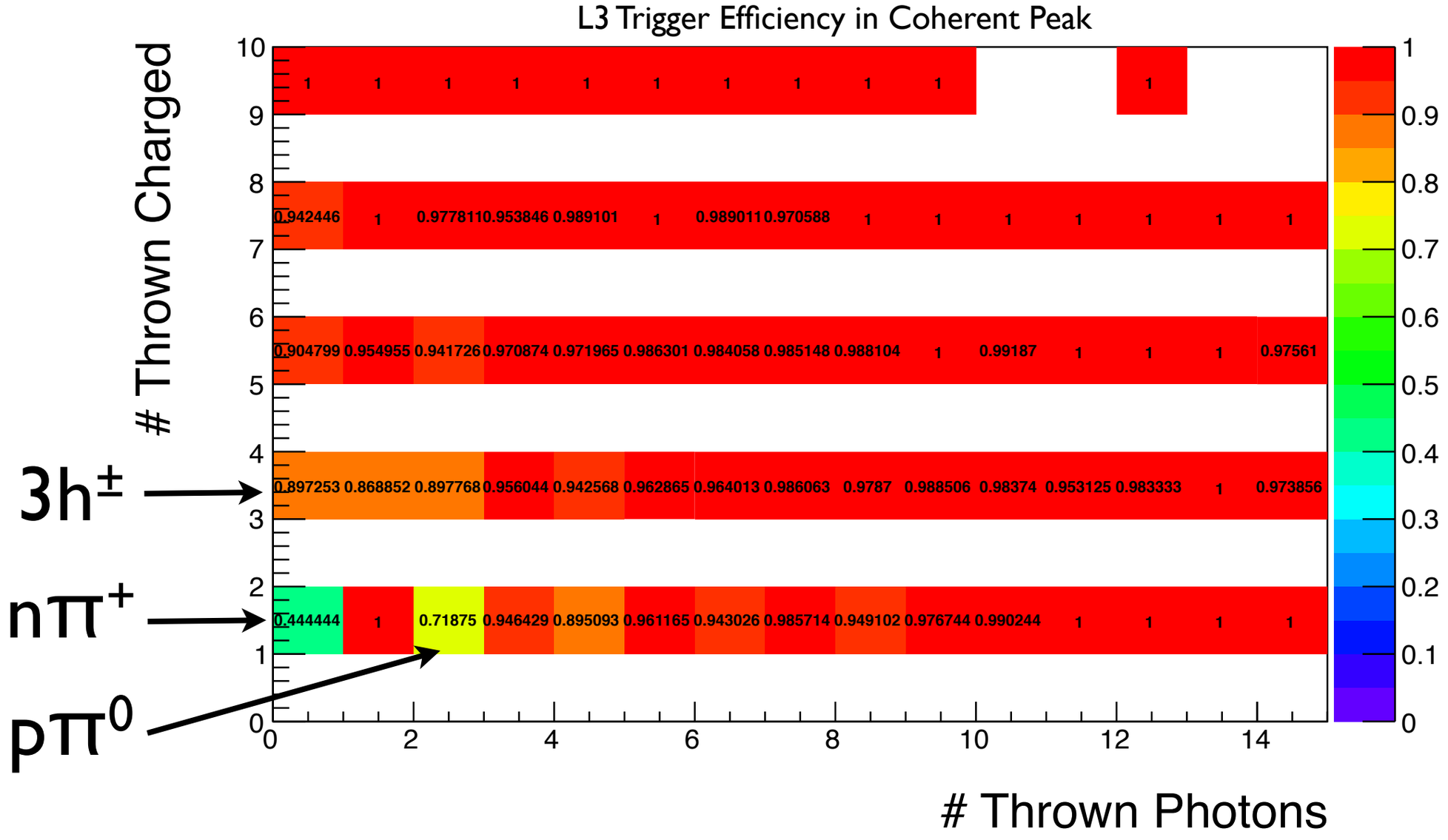
Cutting on Tagger

- Separate Level-3 into different trigger lines (or streams):
  1. # tagged photons > 0
     - Could run at 20 kHz rate to get highest coherent peak efficiency
     - Or choose BDT cut to give ~X% efficiency in the coherent peak and give bandwidth to other triggers
  2. # tagged photons = 0, but may still want high energy events





Tagger Cut Topology



- Chose 95% average efficiency for # tagged photons > 0 trigger line (leaves 5 kHz efficiency for other triggers)
- Improved efficiency for zero photon events (~90% now)

Summary

- Planning for 5x10^7 ɣ/s Phase IV running with a “minimum-bias” trigger to maximize efficiency in the coherent peak
- The tagger provides valuable new input to L3 in selecting events in the coherent peak
- The bandwidth needed for a 95% average efficiency in the coherent peak is only ~15 kHz which leaves room for other, more selective, triggers

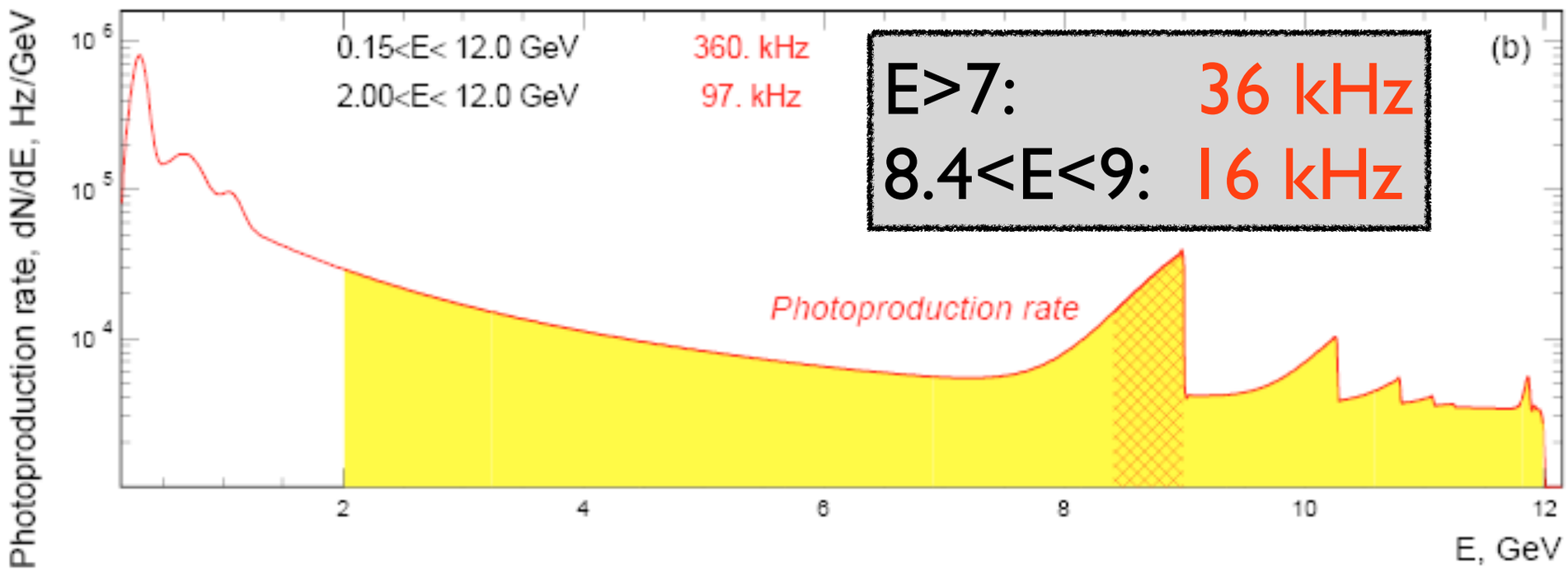
To Do

- Include EM only background sample
- Improve track variables
  - Better quality cuts for tracks
  - Other track combinations?
- Algorithm speed improvements
  - Faster tracking (only FDC?)
  - Multiple stages?

Backup

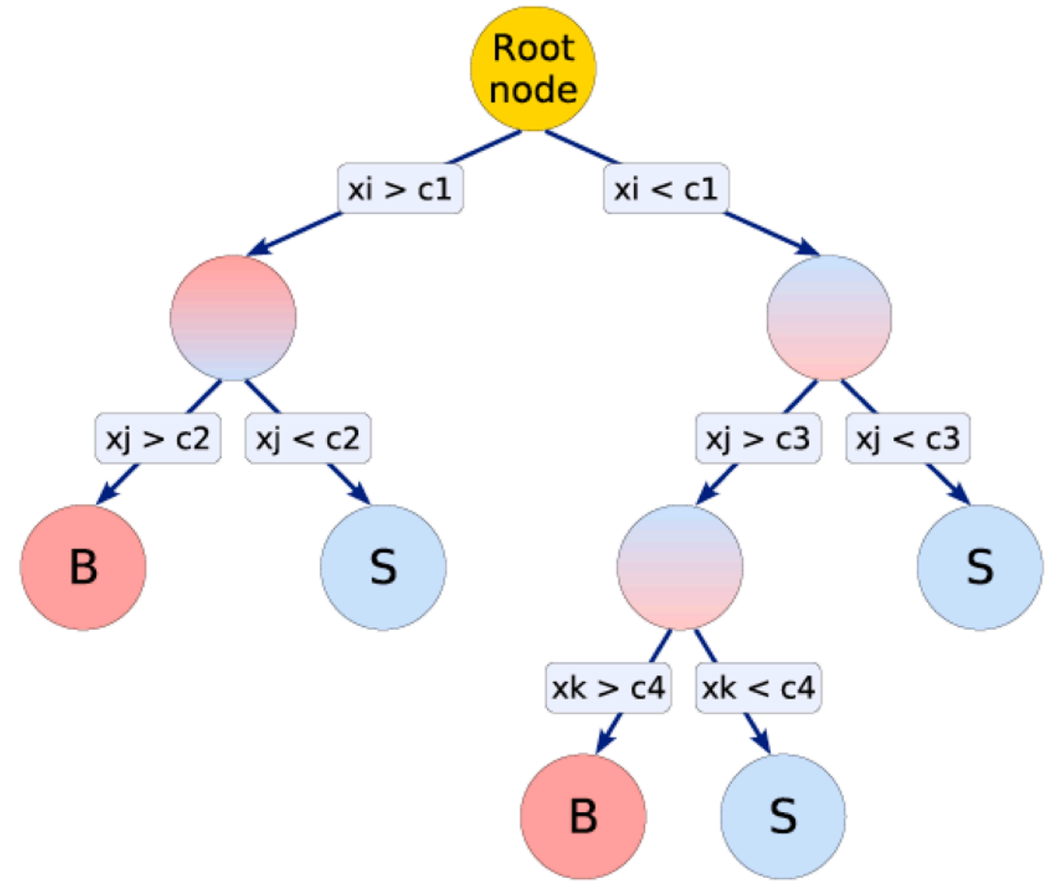
Why do we need L3?

- At an intensity of 5×10^7 ɣ/s expect a hadronic rate of ~180 kHz
- Expected to have Level-1 trigger rate ~100 kHz
- For a 15 kB event size, this would require writing out 1.5 GB/s to tape
- **Goal:** Reduce event rate to ~20 kHz to keep data rate below 300 MB/s allowed bandwidth



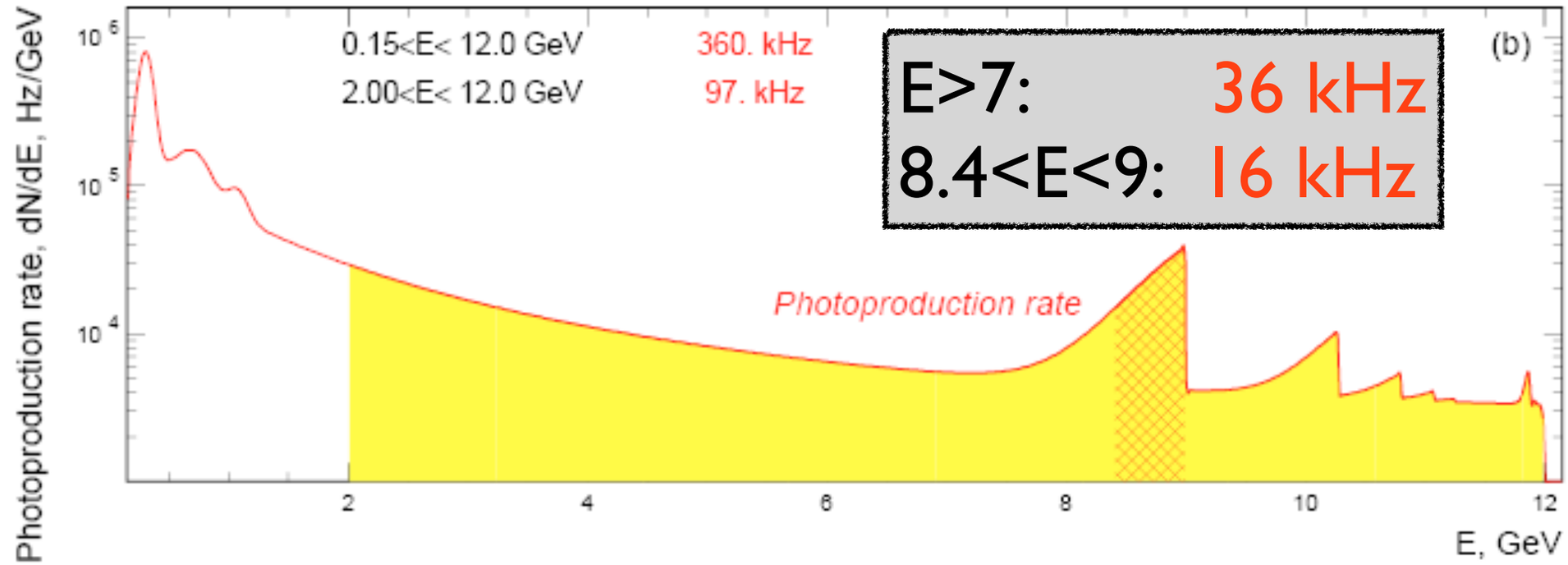
BDT for L3

- What background reduction can be achieved with a limited set of variables?
- Try a Boosted Decision Tree (BDT) as a possible “optimal” algorithm
- Used successfully in LHCb "Bonsai BDT" which converts the BDT response to a 1-D array lookup which contributes negligible CPU time



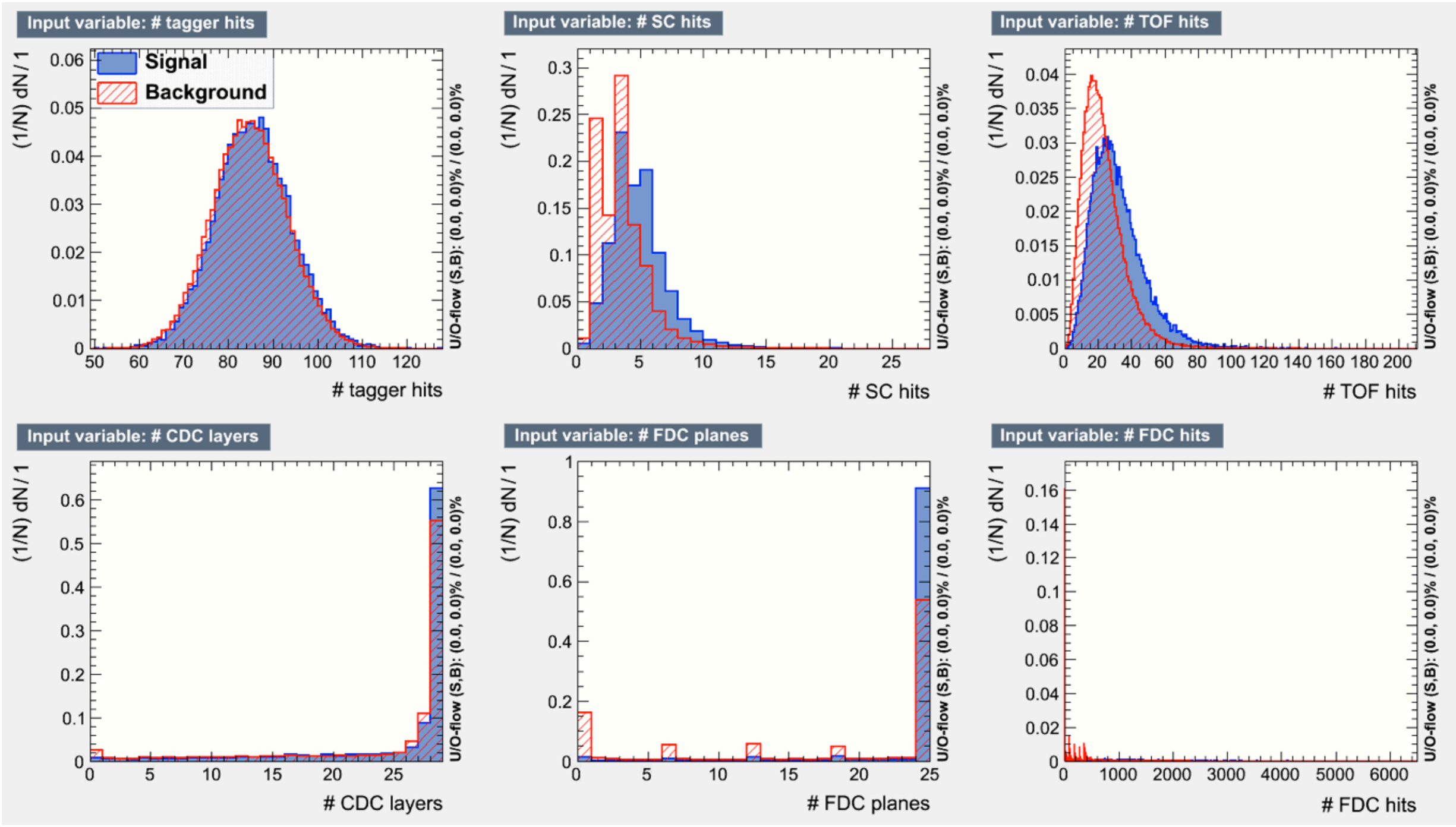
V. Gligorov and M.Williams, JINST 8 P02013 (2013) [arXiv:1210.6861]

High Intensity: 10^8

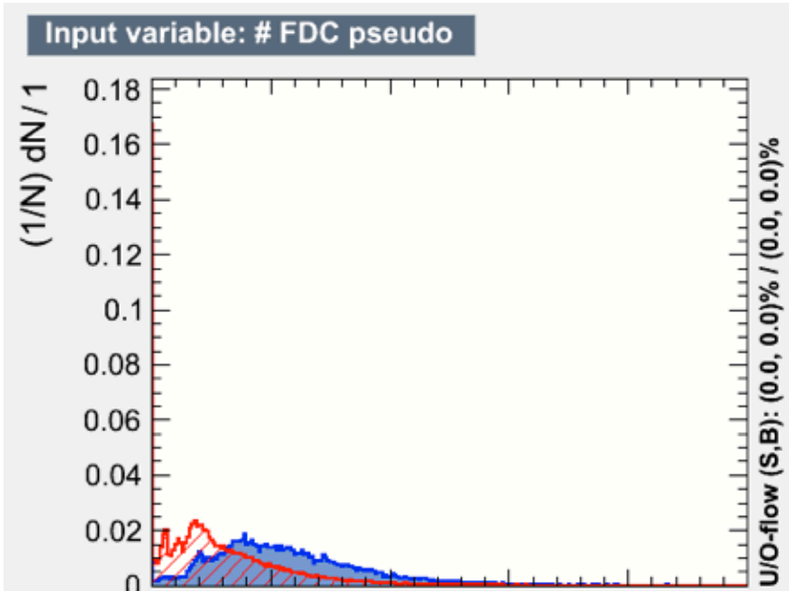


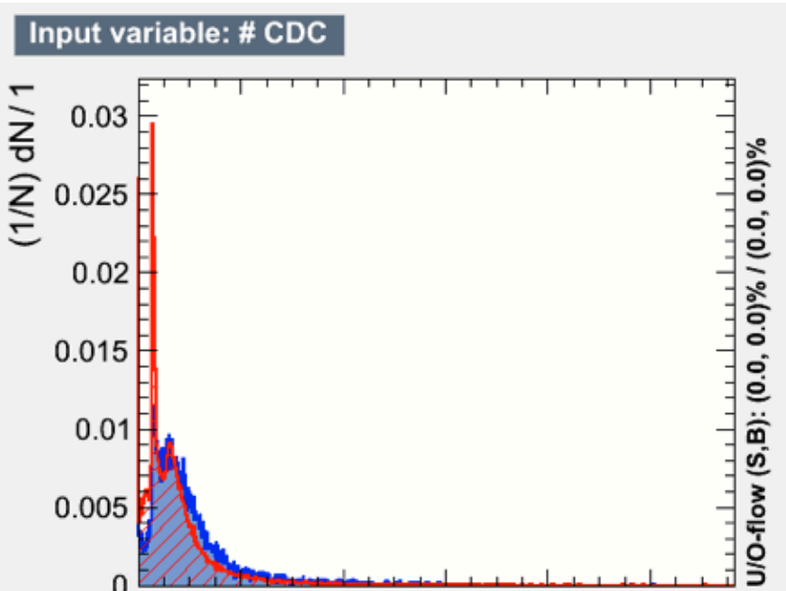
- Can't take all $E_\gamma > 7$ GeV in 20 kHz since $E_\gamma > 9$ GeV not easily separated from coherent peak
- Need to make choices about physics priorities, some options:
  - Identify lower interest channels (with huge statistics from earlier lower intensity running) to ID and prescale
  - Identify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

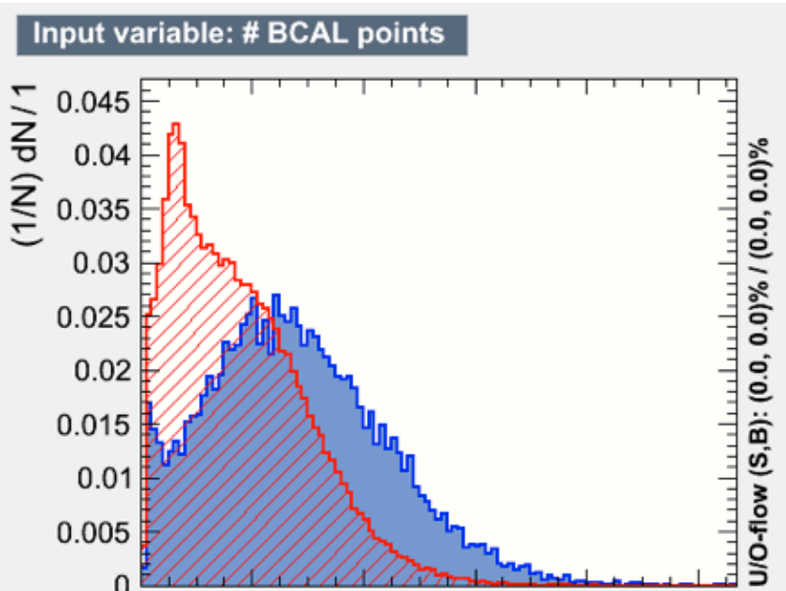
Input Variables

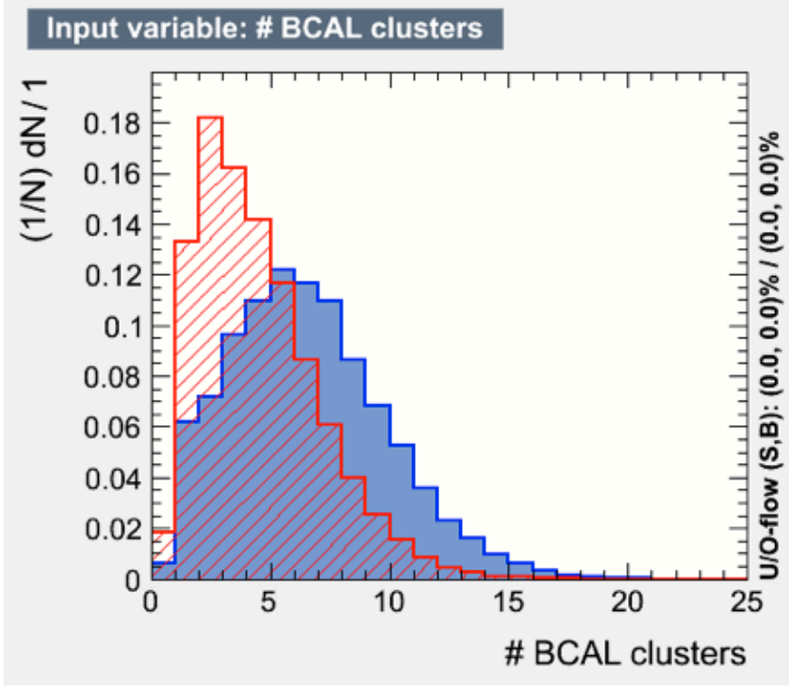


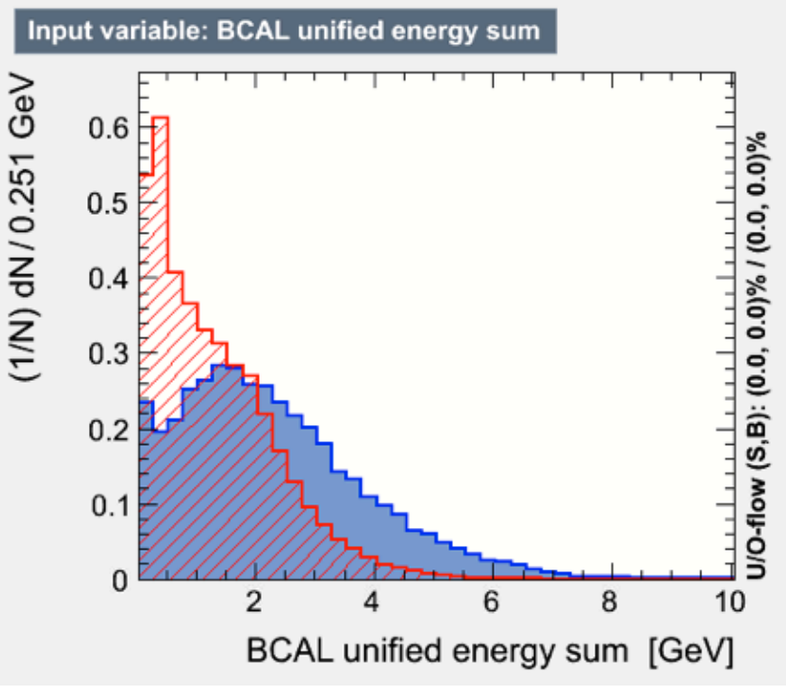
Input Variables

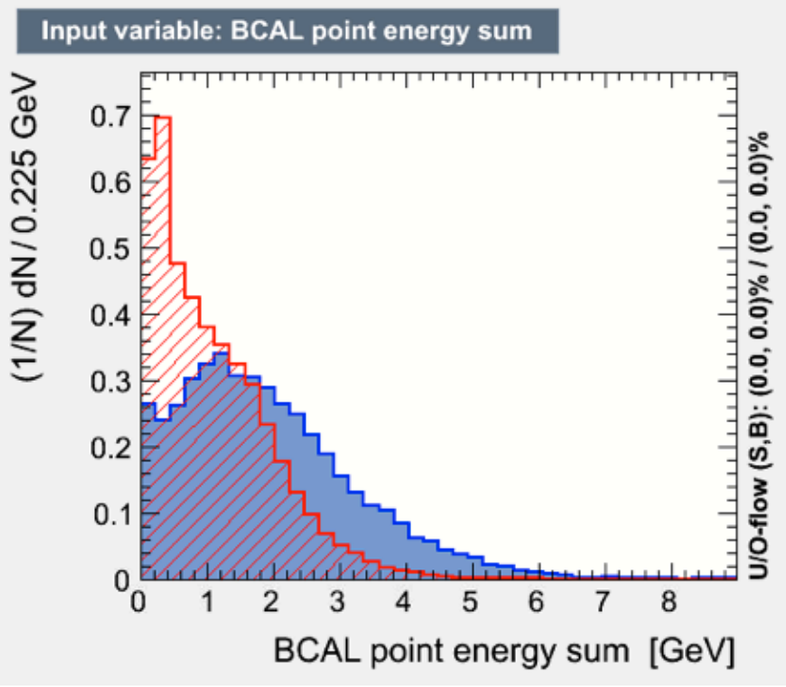












Input Variables