Jet clustering and $\not\!\!E_T$ at Level 2

L2CAL upgrade proposal

A. Bhatti, M. Convery, G. Flanagan, M. Jones

Aug 31, 2006

Physics Motivation

We have a Level-2 accept limited experiment

- Jets and $\not\!\!E_T$ contibute a lot to this at high inst luminosity

  $\longrightarrow$ Pacman showing its age at high luinosity

  $\longrightarrow$ Level-2 uses Level-1 $\not\!\!E_T$ (8-bit resolution instead of possible 10-bit)

We can fix this:

- Use Pulsars to send full trigger tower information to Level-2 cpu
- Use new Level-2 algorithm (fixed cone instead of Pacman) and recalculate $\not\!\!E_T$ at Level-2

  $\longrightarrow$ control trigger growth terms as we move to high inst luminosity

Physics Motivation cont

- With new L2 clustering, one will improve the L2 efficiency and thus either can increase L2 thresholds and adjust PS accordingly.
- Include $\not\!\!E_T$ at Level-2 using full Dcas info $\rightarrow$ rate control for MET + JET etc
- If L2 execution time for new clustering is not large:

  $\rightarrow$ calculate the dijet mass of two leading jets, calculate Sum Et from clusters.

  $\rightarrow$ $\Delta\phi$ ($\not\!\!E_T$ and jets)
- Gain can be made if we can trigger on di-jet mass at L2 for W/Z$\rightarrow$DiJet, Higgs to DiJet and improve Top multi-jet trigger.
- It will be great if we can correlate/match L2 clusters with SVT trigger. Then we can require at least 1 b-jet and trigger on dijet mass.

This is an incomplete list...

L2 Clustering

The present

- Physical towers are summed on the detector into trigger towers (24×24 in η, ϕ)
- Tower energies are weighted by $sin\theta$.
- Contiguous regions of calorimeter towers with non trivial energy are combined to form clusters
- Starting from low (η, ϕ) corner look for a seed tower (3 GeV) and all towers above the shoulder threshold (1 GeV) that form a contiguous region with the seed tower are added to the cluster
- This clustering appears to have a high junk rate (even after ROF was removed).
- Efficiency low for low E_T jets
- Seed tower location is used for cluster location

Outline of new L2Cone clustering

The cone algorithm:

- Order seed ($E_T > 3$ GeV) towers in E_T
- Cluster towers ($E_T > 500MeV$) in cone of radius R=0.7 around highest E_T seed
- Flag all towers in cone as used
- Move to next unused seed and start again- continue until seed list is exhausted
- Order clusters (currently limit algorithm to 20 clusters)

* $E_T = \sum_{tower=0}^{i} E_T^i$, $\eta = \sum(E_T^i.\eta^i)/\sum E_T^i$ and $\phi = \sum(E_T^i.\phi^i)/\sum E_T^i$

* Optimizing seed and shoulder thresholds - balance between well calculated η, ϕ, E_T and algorithm speed

We expect algorithm to be :

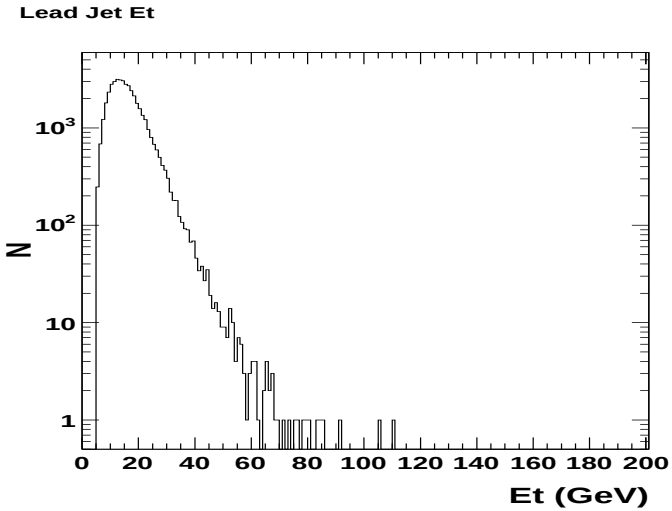
- Fast enough for L2 decision time
- less sensitive to inst luminosity than current clustering
- better estimate of offline jet E_T, η, ϕ and $\not\!\!E_T \rightarrow$ tighter cuts

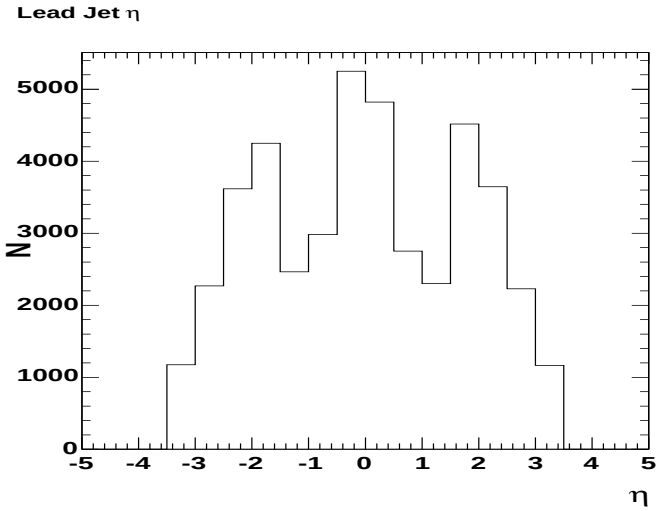
Outline of rest of talk

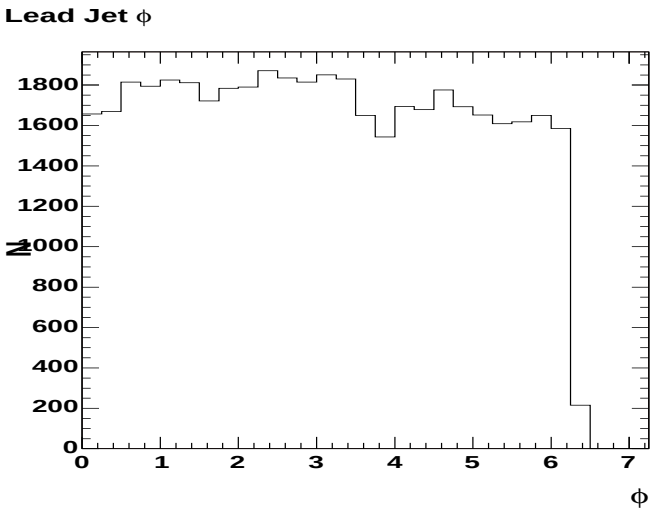
- The input sample- a quick look
- Compaing Pacman to the fixed cone algorithm (L2Cone):
  Will show only a subset- we did this study with various Seed, Shoulder choices and with and without ROF
- Level-2 jet trigger efficiency
- Level-2 jet rates: Jet15, Jet40
- Level-2 MET+JET rates

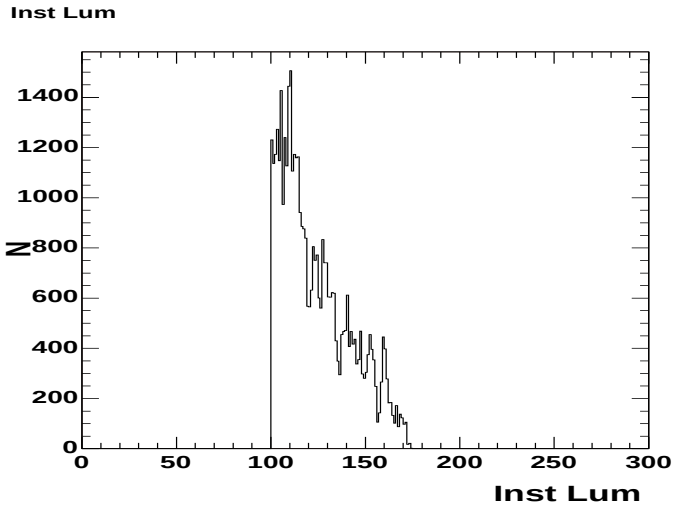
Test sample: STT5 (events with $E_T^{Lead\ \ Jet} > 5$ GeV)

* Only taking events with instantaneous lumi greater than $100e30$









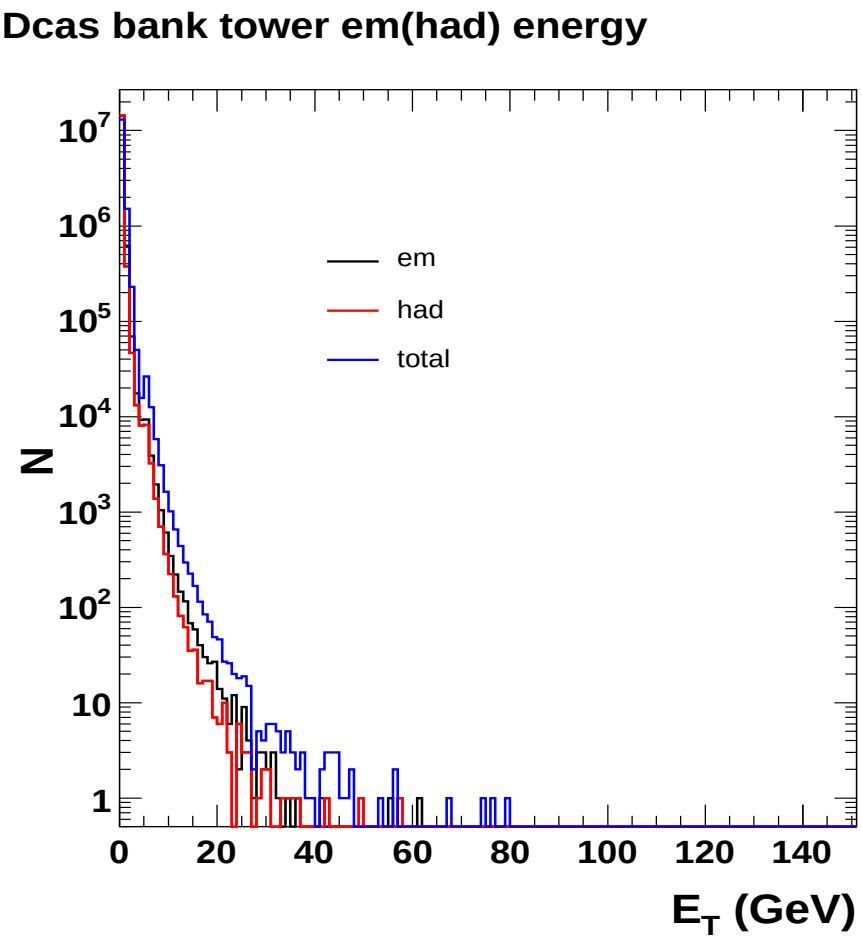
The input (DCas bank)

* Contains Had and Em energies for the 24×24 trigger towers

* Sum Had and Em energies and use these as input to the new clustering and calculation of Level-2 $\not\!\!E_T$

Starting from here study:

- Matching of L2Cones to Offline Jets
- How do L2Cones compare to the existing L2Clusters



Comparing Pacman with the fixed cone algorithm

Current system:

- Uses a seed threshold of 3 GeV
- Uses a shoulder threshold of 1 GeV
- excludes ROF from the trigger

*Comparisons made for L2Cone with seed/shoulder 3/1, 3/0.5, without ROF

*We plan to use seed/shoulder 3/0.5 and use this when checking effect of trigger rate growth

*Changing from shoulder of 1.0 $\rightarrow$ 0.5 improves η, ϕ, E_T calculation

*Include the ROF again: fixed cone not as sensitive to high η tower occupancy as it does not merge cones.

Further details can be found at cdf8415

Matching L2Cones to Lead Jet

* Require event to have a 5 GeV Offline jet with a 5 GeV Dcas tower associated with it

* Match cones to leading jets in (η, ϕ)

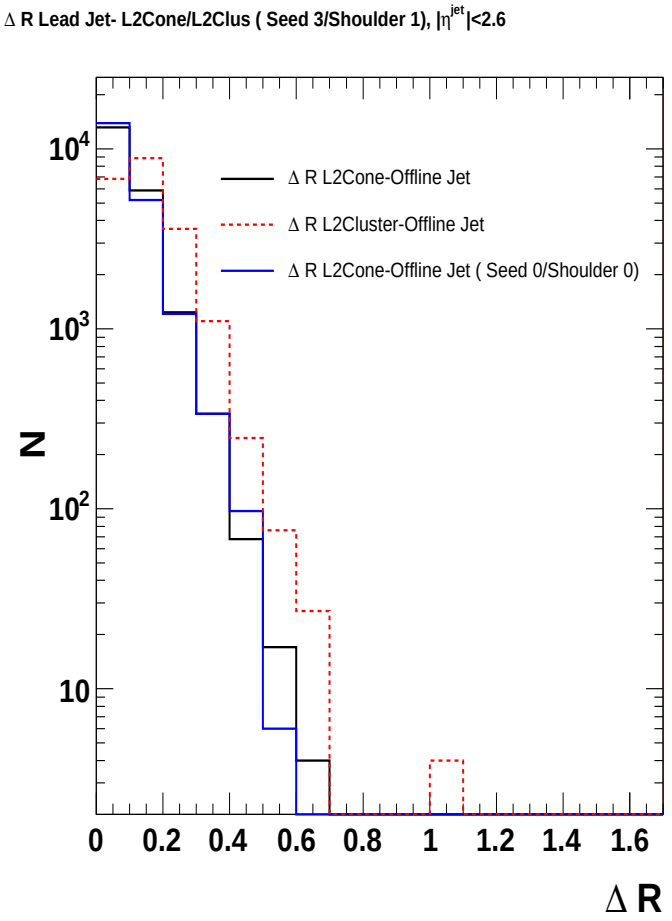
* Matching based on

$Min(\Delta R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2})$

* Feature above $\Delta R = 0.8$ related to seed/shoulder choice and ROF mssing in Pacman

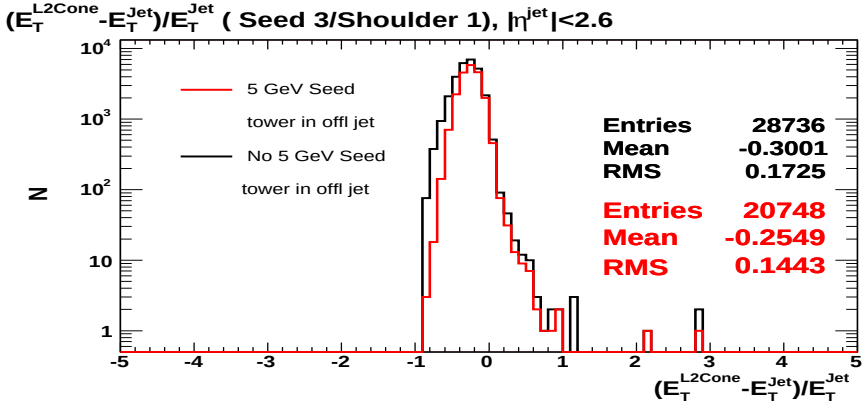
* For new L2cones 88% of sample has $\Delta R < 0.3$, for existing L2Cluster 70%

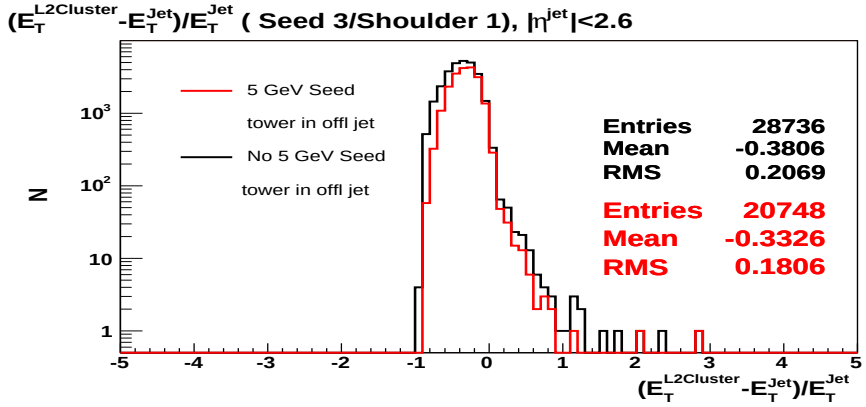
$\rightarrow$ For Seed and Shoulder of 0 GeV in L2cones: 89% of sample has $\Delta R < 0.3$



L2Cones vs Offline jets

- Match the L2Cone with offline jet (JetClu (R=0.7))

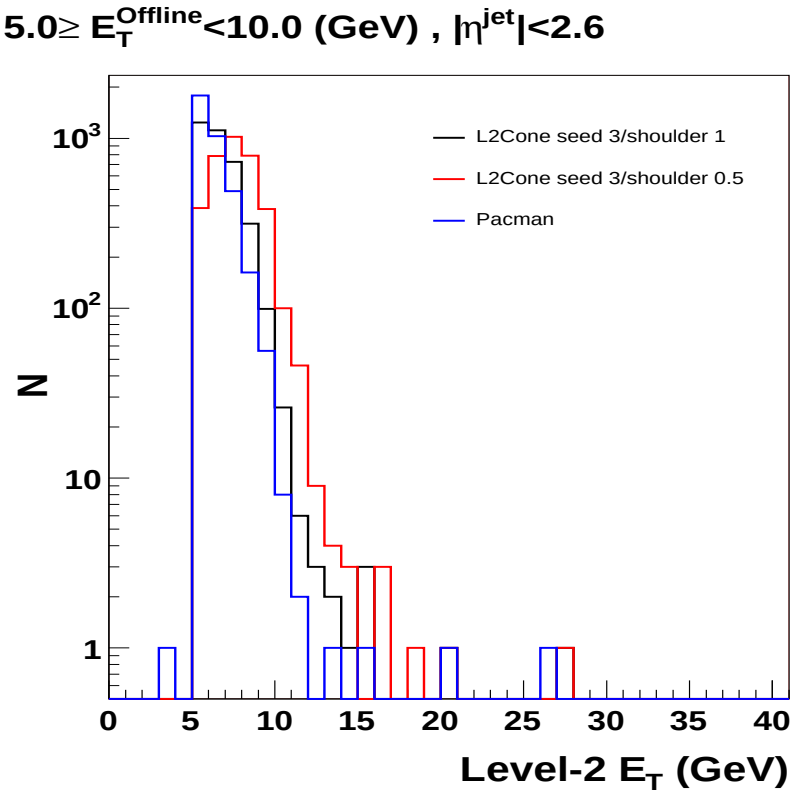


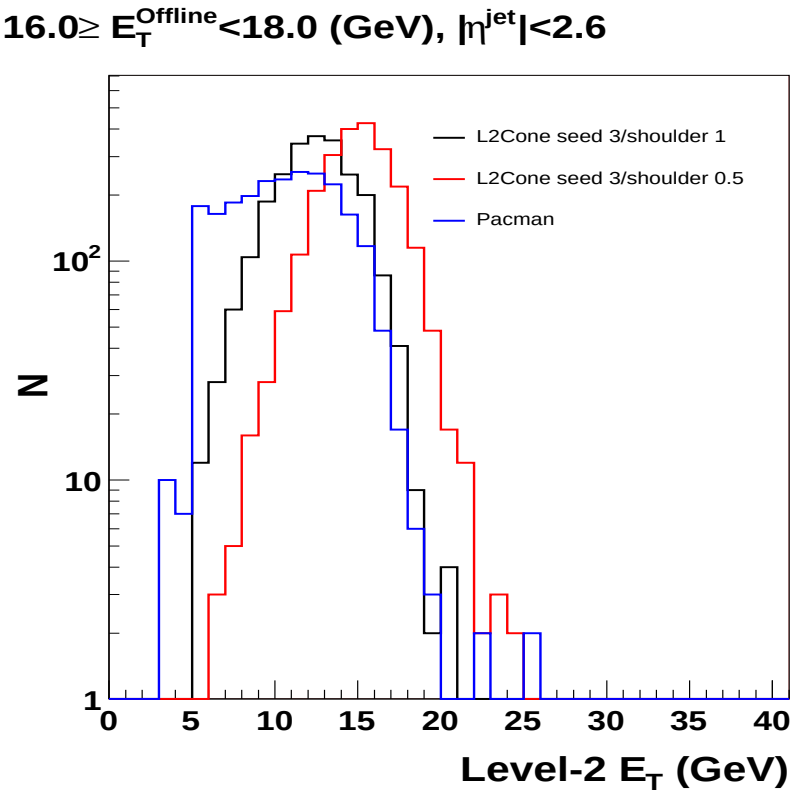


- After matching in (η, ϕ) compare Level-2 E_T to offline E_T
- New L2Cone with 3 GeV seed and 1 GeV shoulder does a good job of estimating offline E_T-
- Lowering shoulder will improve it further

Level-2 Cones(clusters) vs Offline jets continued

Fix the offline jet to have 5(16) $< E_T^{Offline} <$ 10(18) GeV :what Level-2 E_T's do we find contribute ?

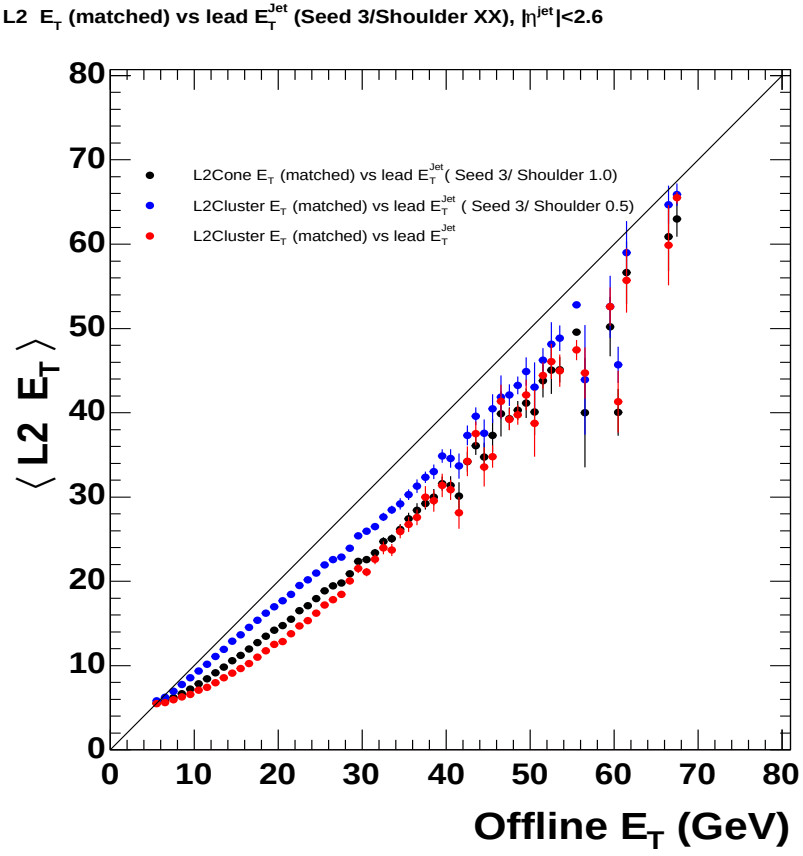


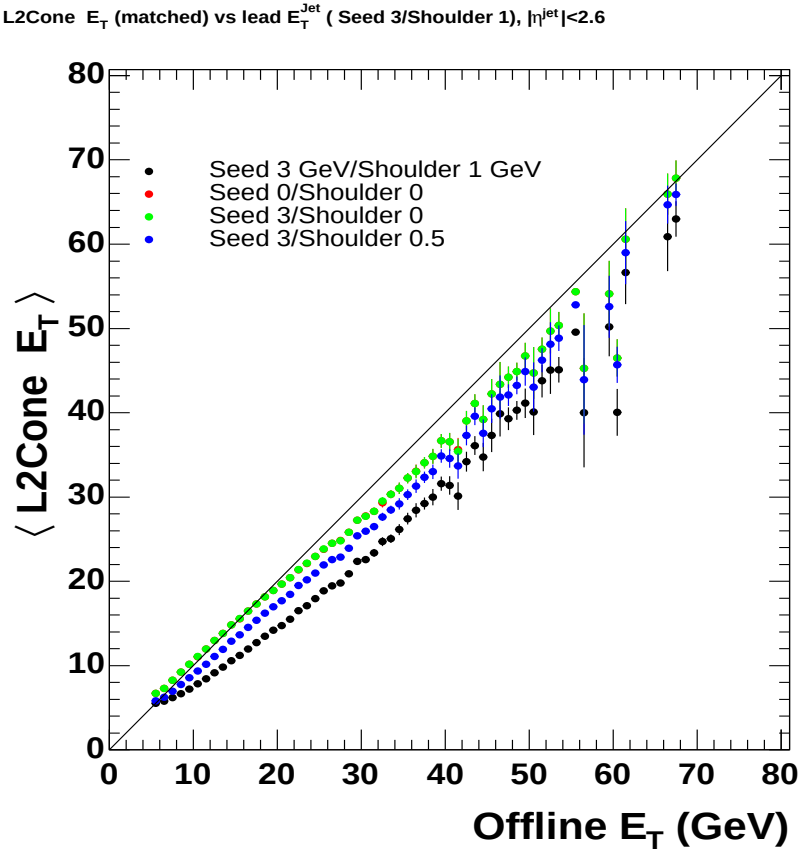


This evolves with E_T - see next few slides

L2Cones vs Offline jets continued

* E_T of L2Cone vs E_T of leading offline jet
* L2Cone Size is 0.7 and we are comparing to JetClu (0.7)



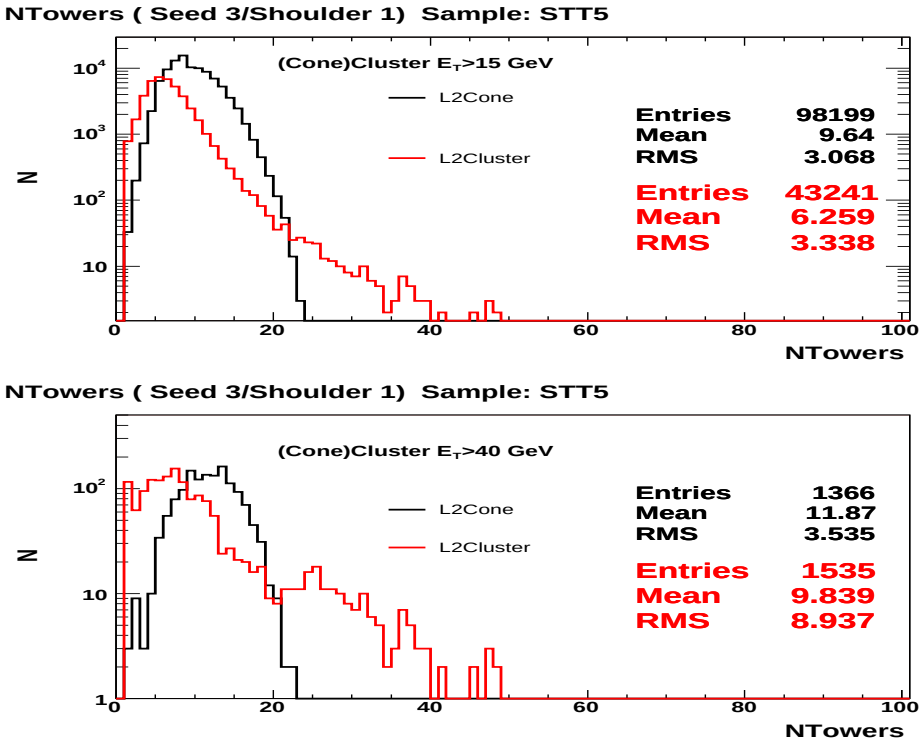


Black curve is the same in both plots ...

Level-2 Cones(clusters) vs Offline jets continued

* Current Level-2 clustering has a tendency to merge clusters: this effect has been limited since the ROF was removed

* However even at lumi $< 180 cm^{-2} s^{-1}$ we see tails in the number of Pacman towers in the leading cluster



* Fixed cone algorithm has upper limit to the number of towers- no merging

* May help with multi-jet efficiency at high lum ??

Jet rates at Level-2

Overview of the method:

- Find trigger efficiency for level-2 clustering (level-2 cuts 15,40,60,90)
- Find the fraction of events in an unbiased sample that pass the level-1 and level-2 cuts as a function of inst lumi: this shows the growth of the trigger as a function of inst lumi
- Repeat for L2Cones (after finding the L2Cone E_T cut that reproduces the current trigger efficiency)
- For L2Cones we look at the rate reduction with and without the ROF- curves for current system exclude ROF

Jet rates at Level-2: Efficiency

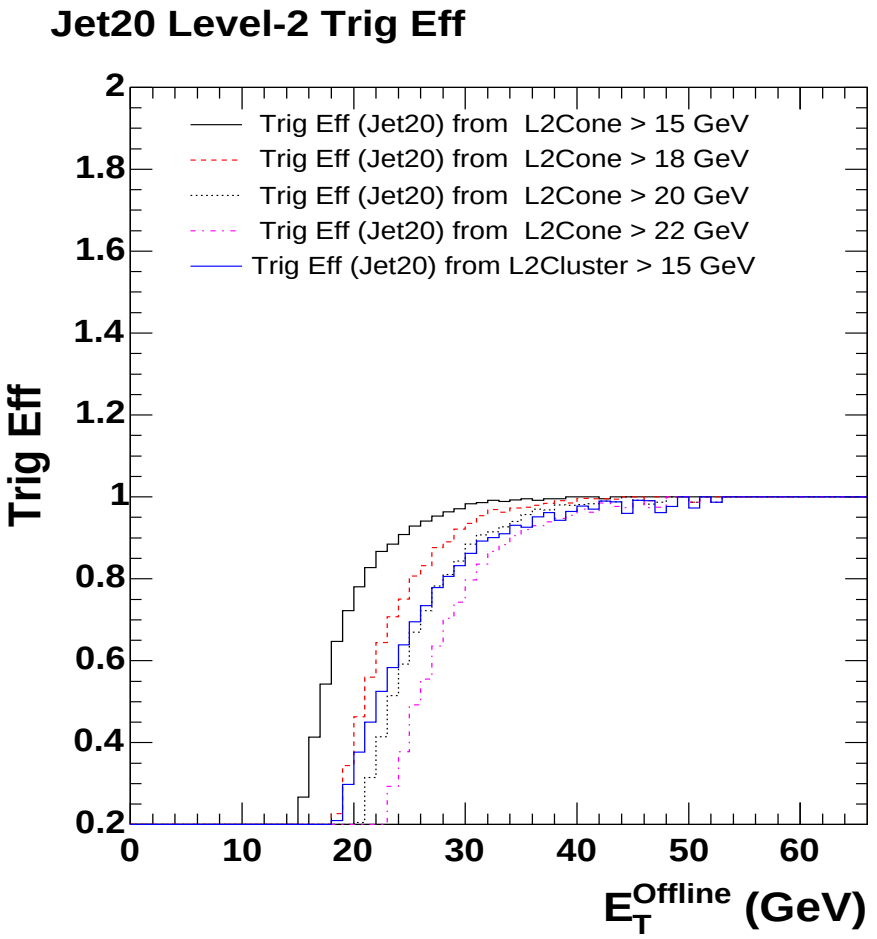
* Trigger efficiency for Jet20:

E_T distribution of events with L2Cone(L2Cluster)> 15 GeV divided by parent sample

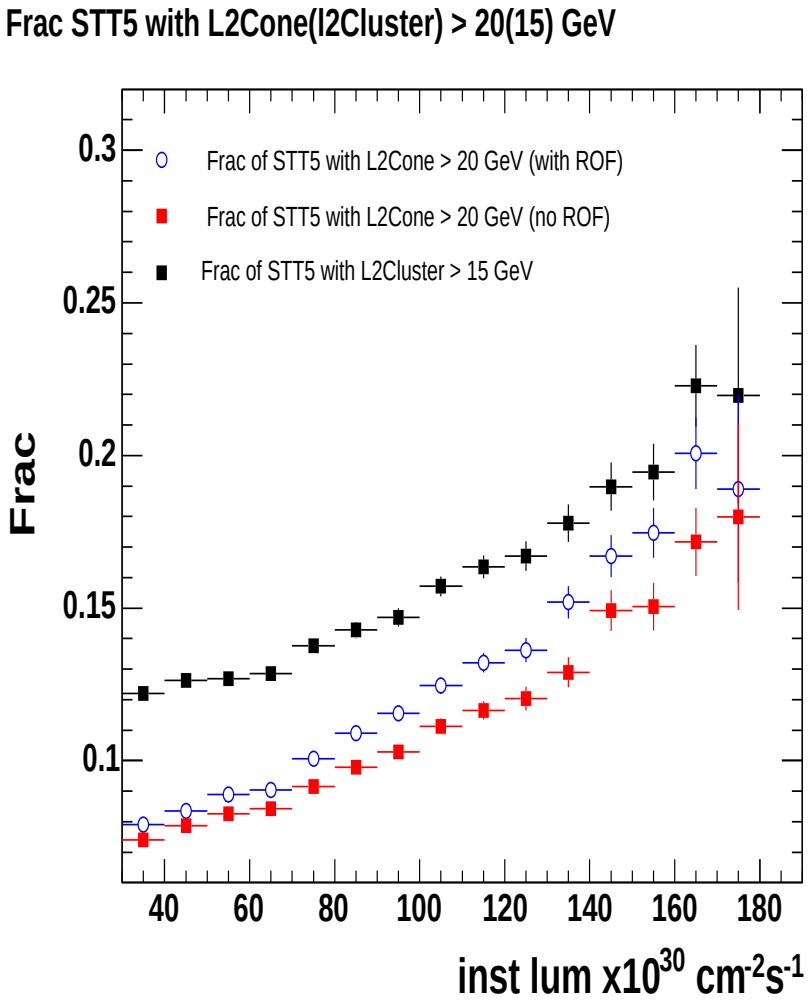
* ie/ require there is a 15 GeV Level 2 cone somewhere in the event

* For L2Cone we scan some E_T values to find the same trigger efficiency as existing clustering

$\rightarrow$ Find a L2Cone with $E_T > 20$ GeV is gives same efficiency as L2cluster $E_T > 15$ GeV

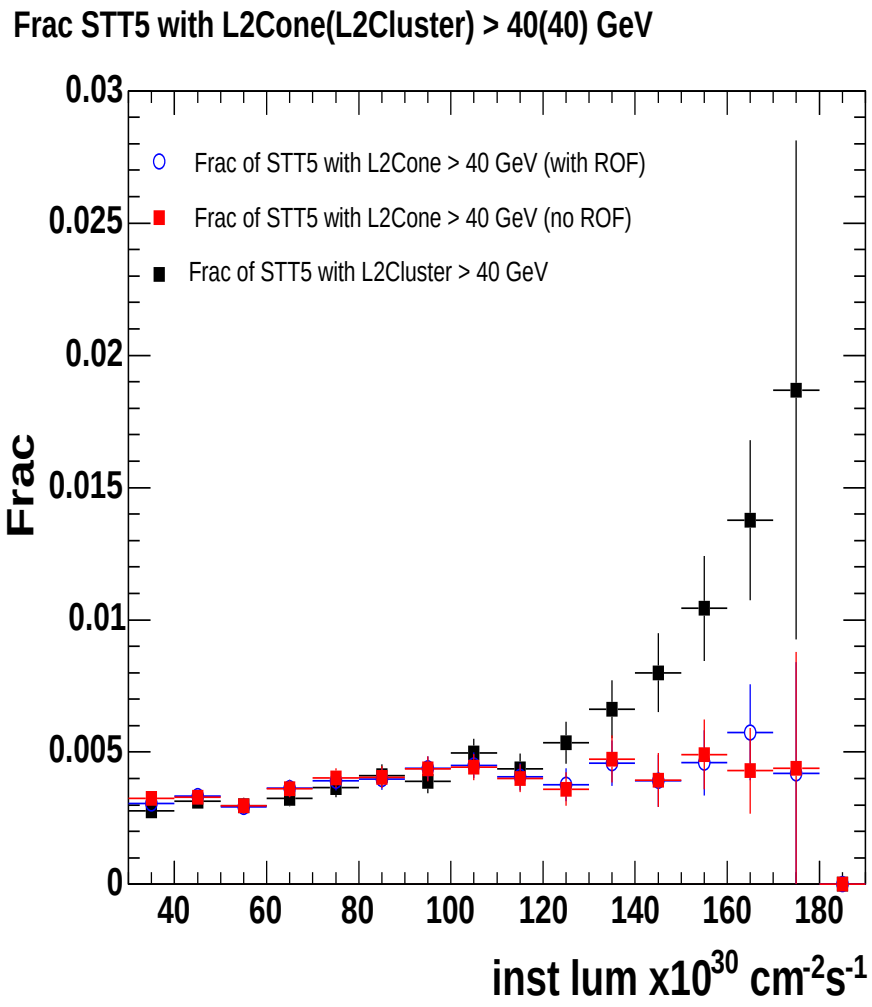


Jet rates at Level-2: Growth



- Overall size of rate is reduced - probably associated with higher E_T cut
- Growth rate as function of inst luminosity looks similar
- Note: used 20 GeV L2cone cut instead of 15 GeV (as for clusters) $\rightarrow$20 GeV L2cone cut reproduces the currect jet20 trigger efficiency
- See similar growth with and without ROF

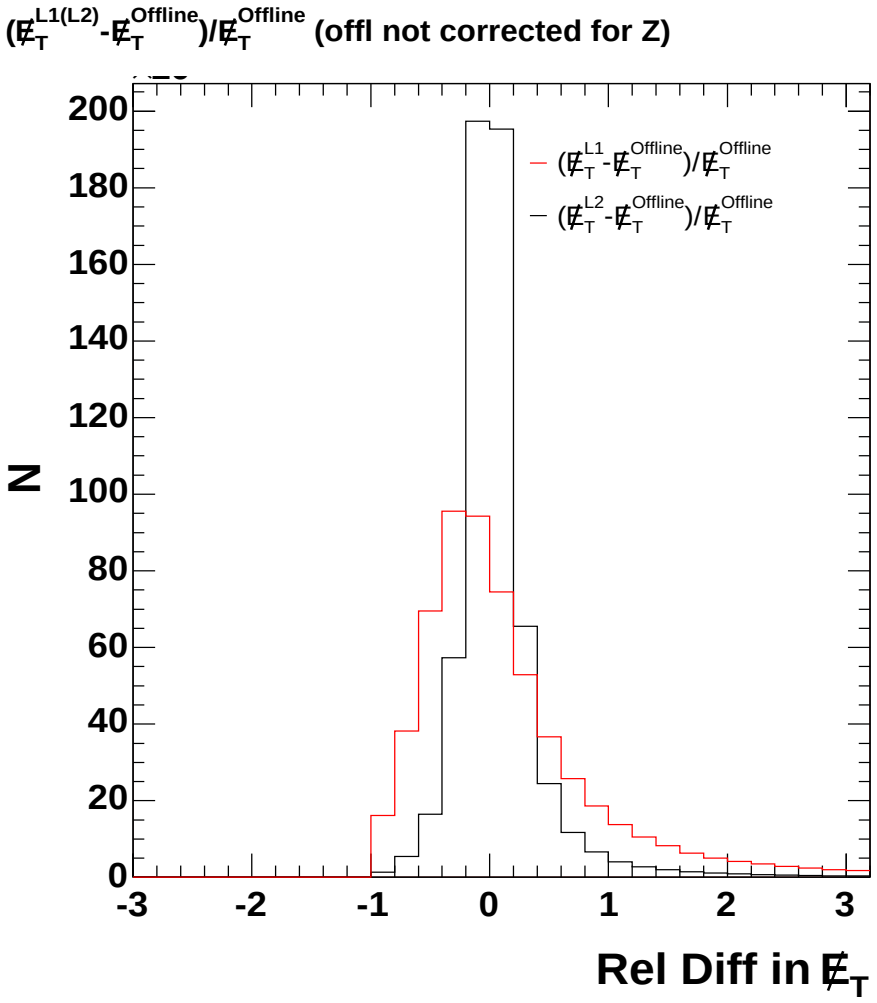
Jet rates at Level-2 cont: (Jet40)



- Found that L2Cone cut is 40 GeV $\sim$ same as current clustering
- Fixed cone algorithm seems to work well in suppressing growth of Jet40
- Not a lot of difference between including/excluding ROF

(L1)L2-$\not\!\!E_T$ vs Offline $\not\!\!E_T$

Still using STT5 as it provides an unbiased sample



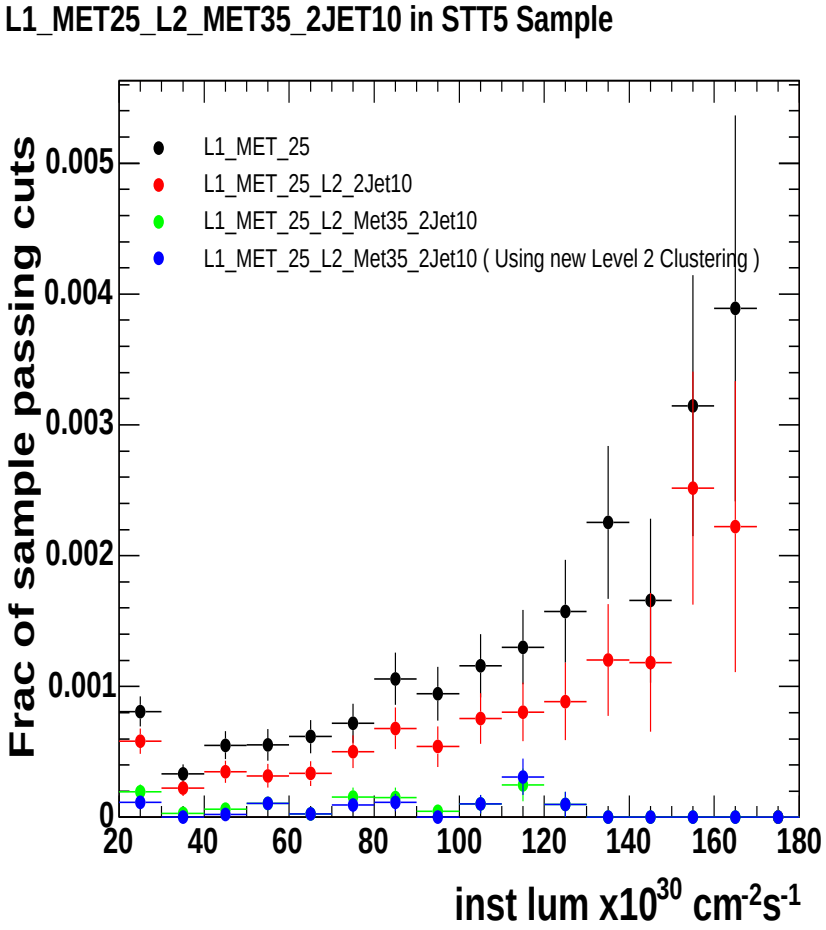
- Level-1 $\not\!\!E_T$ has 8-bit resolution

  $\rightarrow$Full Dcas information at Level-2 gives 10-bit $\not\!\!E_T$-closer to Level-3/offline

- make a $\not\!\!E_T$ cut at Level-2 (eg/ $\not\!\!E_T > 35$-same as Level-3)

- Can be used to control the growth of the level-2 rate for $\not\!\!E_T$ related triggers at high instantaneous luminosity

$\not\!\!E_T$ trigger rate growth at Level-2

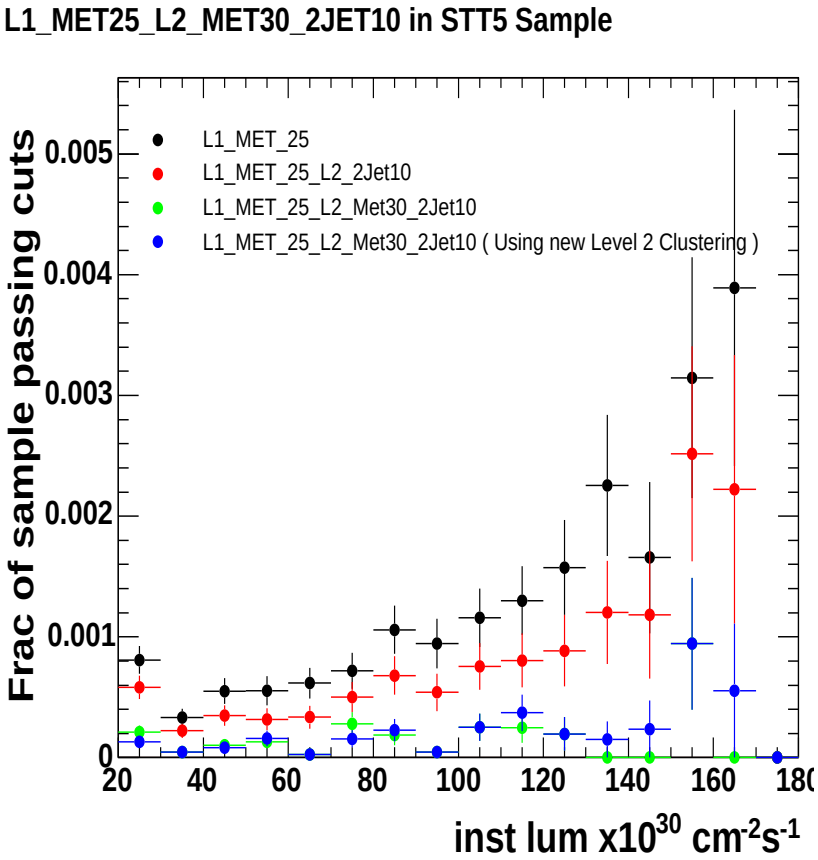


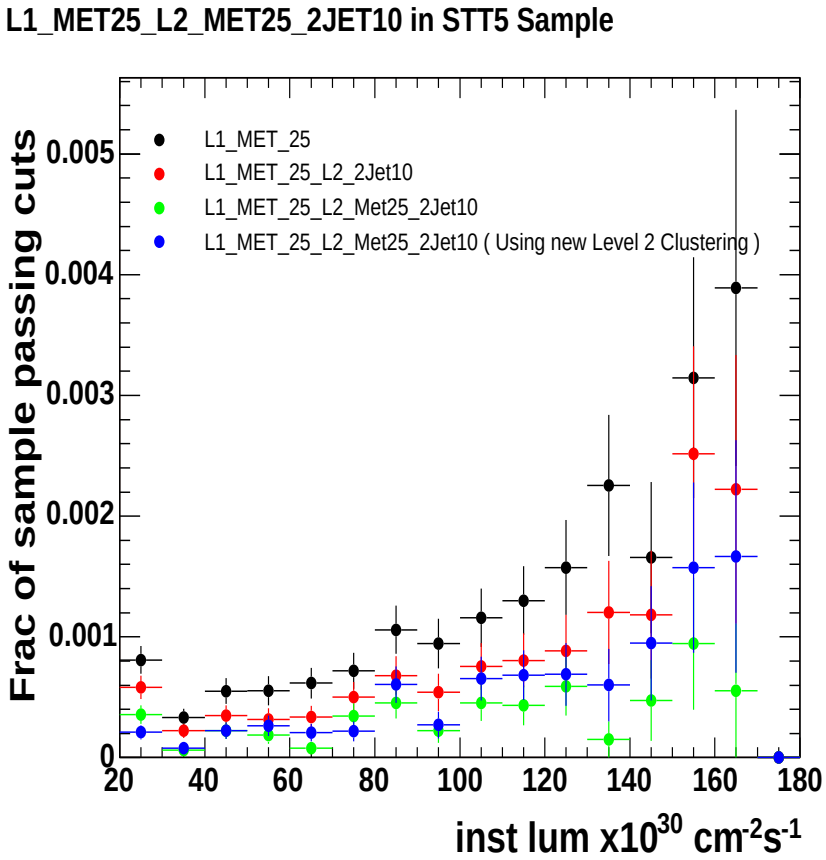
Using STT5 sample and mimic L1_MET_2JET trigger by requiring:

- Level-1 $\not\!\!E_T > 25$
- require 2 Level-2 clusters with $E_T \geq 10$ GeV
- Apply Level-2 $\not\!\!E_T > 35$ (like Level-3)
- Finally replace the 2 Level-2 clusters with 2 Level-2 Cones.
- Note: it is the Level-2$\not\!\!E_T$ that suppresses the growth term

Level-2 $\not\!\!E_T > 35$ was used as an example- other options next slide

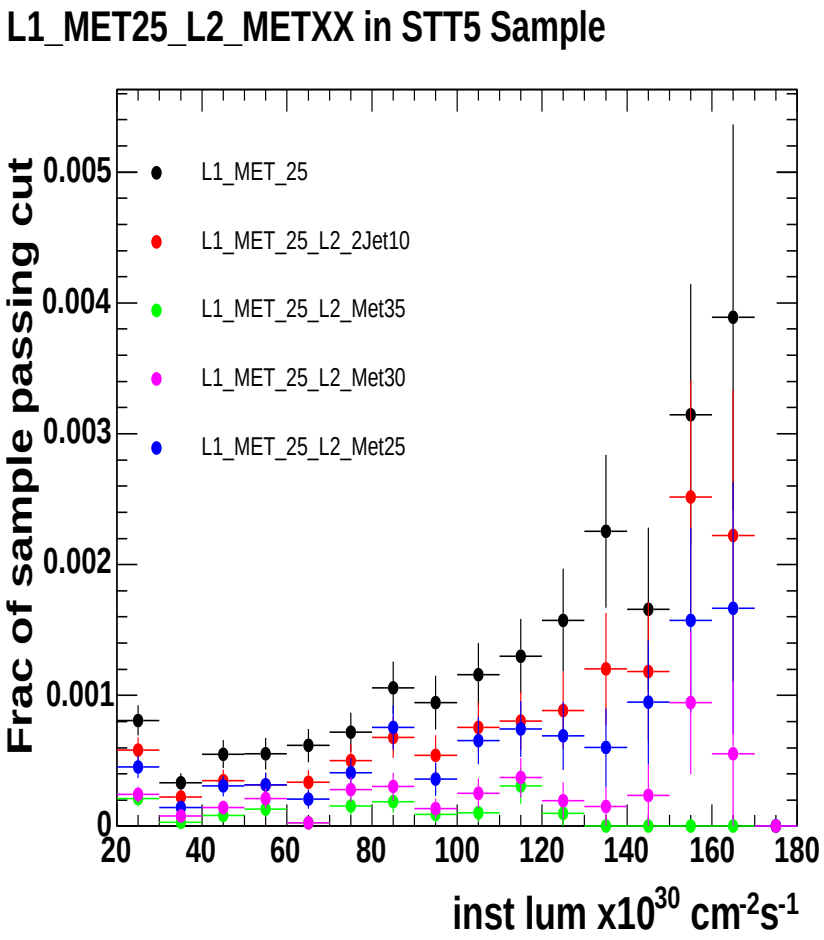
$\not\!\!E_T$ trigger rate growth at Level-2 Cont

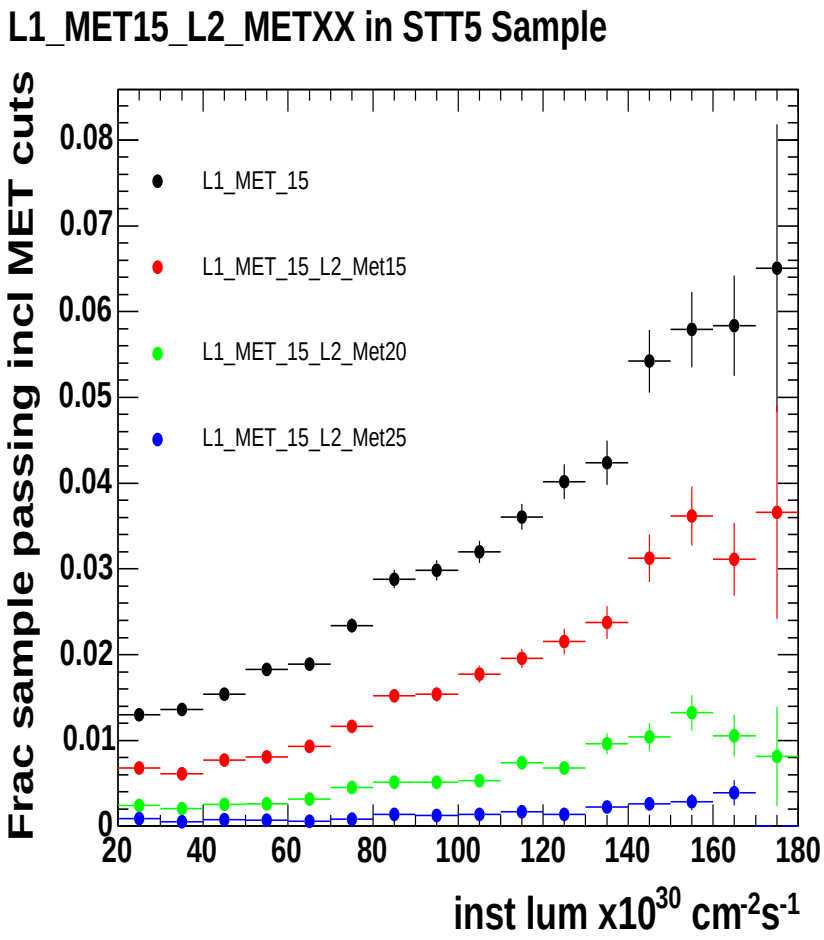




Possibility of running at $\not\!\!E_T = 25$ or 30 at Level-2

Inclusive $\not\!\!E_T$





Is it possible to run with an inclusive 15(25) $\not\!\!E_T$ trigger at Level-2 ?

Next Steps...

- Work underway on isolation code (have a version of code that reproduces current isolation)

- Started work on multi-jet studies (eg/ Top Multi-Jet)

  $\rightarrow$Have some preliminary results using STT5 data and also high lum ttbar MC

- More detailed study on MET_2JET trigger starting this week

Need to make sure we understand/(and validate) how to overlay additional MinBias events on MC to really start studying triggers at high Lum.

$\rightarrow$This is the foundation for the trigger/physics studies that need to be done