Summary of the Jet Trigger Contributions to the Jet & MET Trigger Session at HCW 2014

(the **first** – but not last – dedicated trigger session at HCW!)

Trigger General Meeting – 24/9/2014

Ricardo Goncalo, David Miller

Very lively and useful workshop!

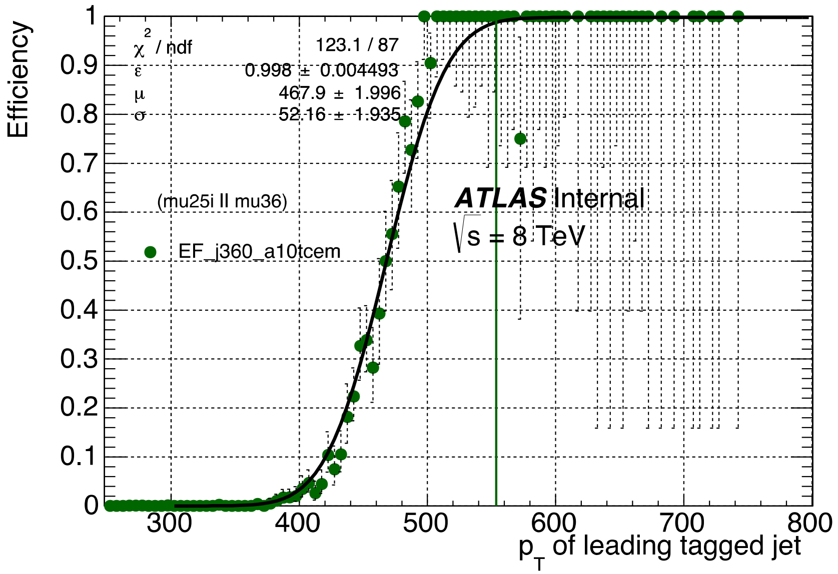
- First time there was a trigger session in HCW – very good for harmonisation!
- 192 contributions to HCW, 25+ in Jet/MET trigger session
- Won't cover full set of subjects here
  - Particle flow coming of age
  - Simulation / fast simulation / ISF
  - IBL and increased dead material
  - Calibration and noise suppression
  - Jet cleaning
  - Jet energy scale and resolution
  - Substructure techniques
  - Tagging (q/g, boson, top, etc)
  - Missing ET
  - Monitoring and validation
  - Software and analysis model
  - Jets in run III and HL-HLC
  - etc

- Concentrate on issues involving trigger:
  - Jet trigger use cases; – Jet trigger monitoring
  - Jet calibration and pileup subtraction plus TopoCluster timing measurements

Single jet triggers in the hadronic diboson resonance search (VV->JJ)

VV->JJ team (Enrique Must)

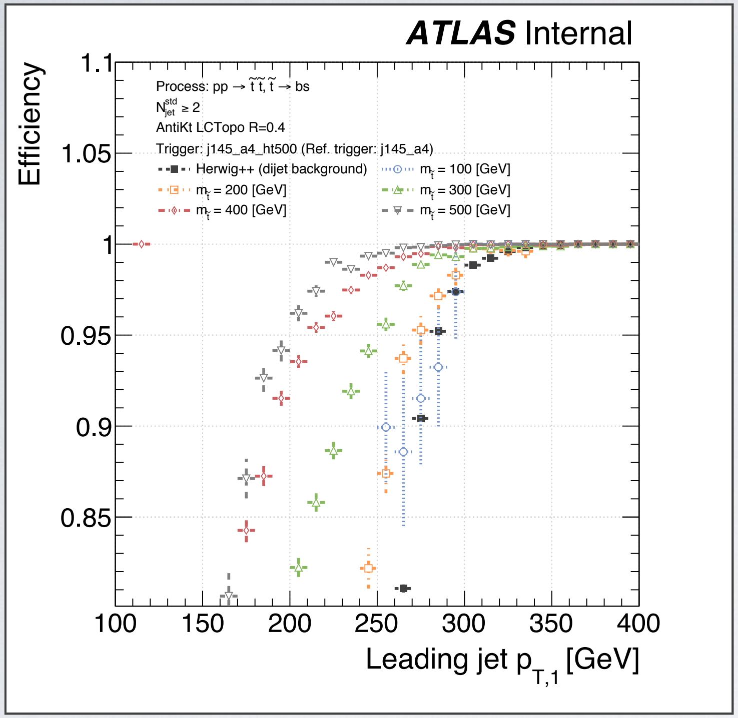
- Use events triggered by a muon trigger
  - Study EF_j360_a10tcem trigger turn-on as a function of
    - Leading jet-pt
    - Leading tagged jet pT



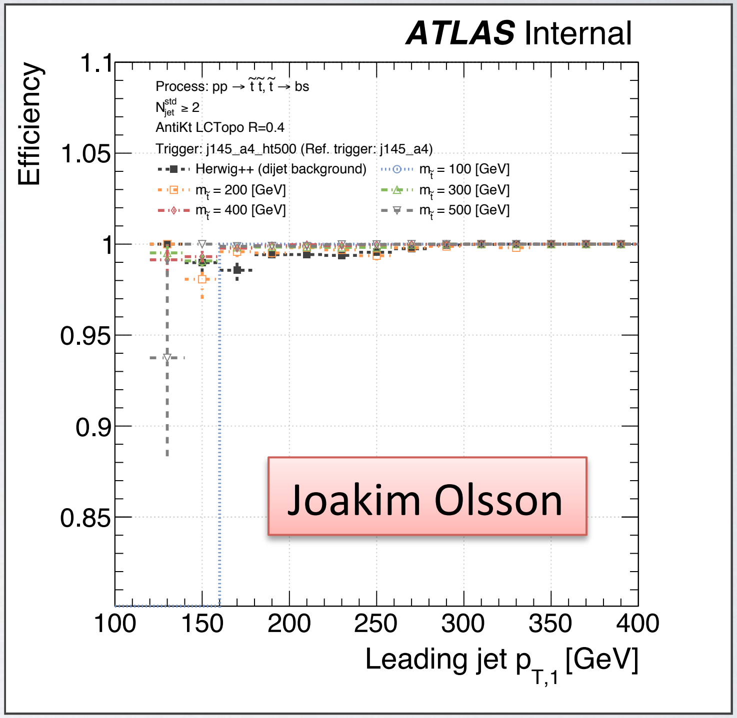
(Ungroomed pT)

Jet-H_T Triggers

Turn-On Curves: `EF_j145_a4tchad_ht500_L2FS_delayed`



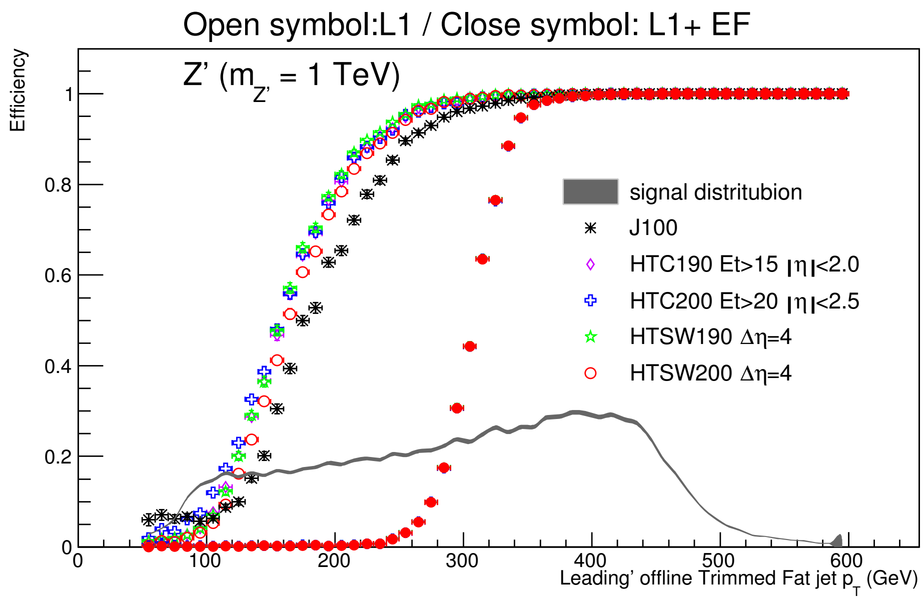
(a) jet p_{T1}, no H_T cut

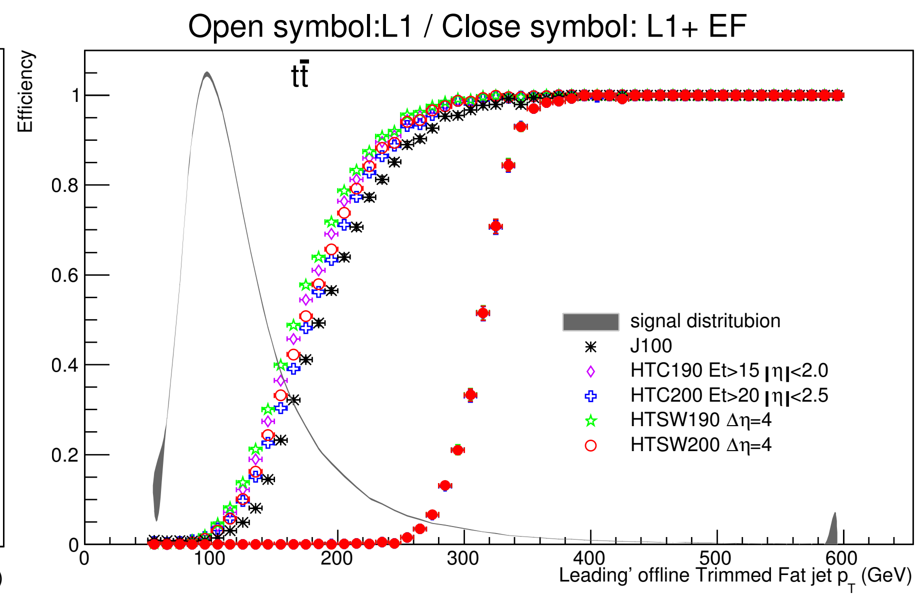


(b) jet p_{T1}, $H_T > 650$ GeV

- An offline cut of $H_T^{\Sigma} > 650$ GeV makes the `EF_j145_ht500` trigger fully efficient around $p_{T1} > 175$ GeV
  - This is a critical observation since a $p_{T1} \gtrsim 300$ GeV, as seems necessary in figure (a), would have made us much less sensitive to low stop masses down to 100 GeV

L1 HT triggers for fat jets: signal





UBA (Devesa, Reisin, Otero, Piegaia)

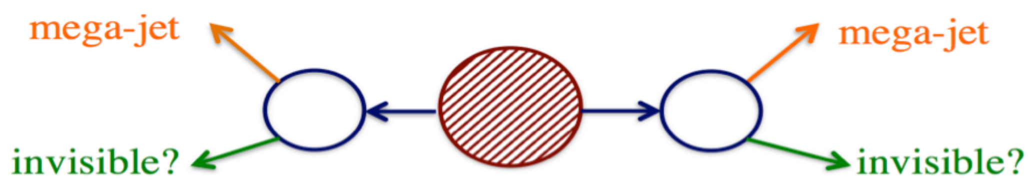
L1 selection	threshold	name
Sum of E_T of all jets with $E_T > 20$ GeV and $\|\eta\| < 2.5$	200 GeV	HTC200
As above but for a Sliding Window in η, of size $\Delta\eta$=1.0	100 GeV	HTSW100
Sum of E_T for (up to 2) jets closer than $\Delta R = 1.0$	100 GeV	$\sum E_{T(2)}$100

Explored a large number of trigger configurations, varying parameters in blue.

Studied di-jet, and three signal samples ($t\bar{t}$, $Z' \to t\bar{t}$, $W' \to tb$):

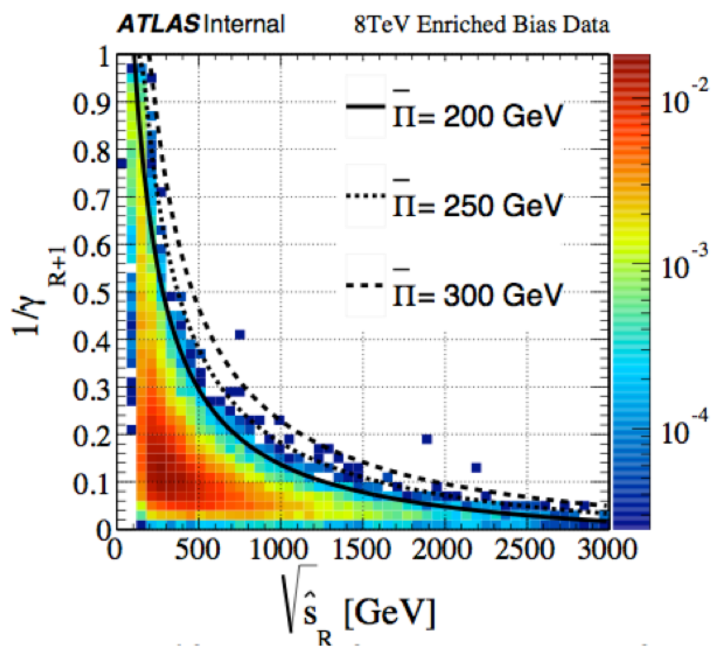
Trigger	Data (14 TeV)	Unique (wrt J100)	Unique (wrt J100+4J20)
J100 (default)	5.8 ± 0.7	-	-
HTC190 w/$E_T > 15$ $\|\eta\| < 2.0$	4.3 ± 0.8	2.9 ± 1.8	1.4 ± 1.0
HTC200 w/$E_T > 20$ $\|\eta\| < 2.5$	3.8 ± 0.6	1.0 ± 0.4	0.9 ± 0.7
HTC210 w/$E_T > 15$ $\|\eta\| < 3.0$	3.8 ± 0.6	0.6 ± 0.2	0.4 ± 0.2
$\sum E_T > 110$ ΔR<1.0	4.3 ± 0.7	0.3 ± 0.2	0.2 ± 0.2
$\sum E_T > 120$ ΔR<1.5	3.1 ± 0.5	0.1 ± 0.0	0.0 ± 0.0
$\sum E_T > 110$ ΔR<1.5	4.7 ± 0.7	0.6 ± 0.3	0.2 ± 0.2
HTSW$>$190 $\Delta\eta$=4	5.3 ± 0.8	1.9 ± 0.6	1.1 ± 0.5
HTSW$>$200 $\Delta\eta$=4	4.3 ± 0.7	1.2 ± 0.5	0.8 ± 0.4

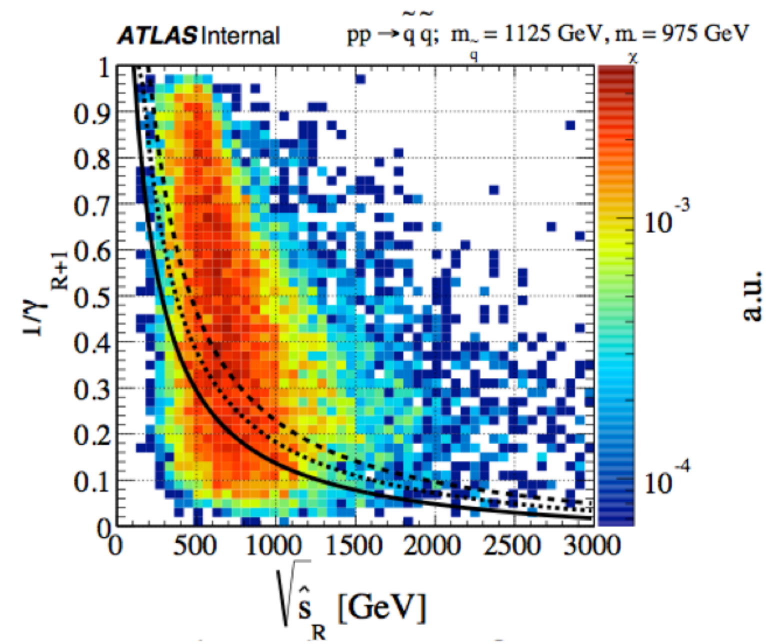
Razor triggers at HLT



- Interpret events as two mega-jets
- Build razor variables:
  - $\sqrt{\hat{s}_R}$ ~ mass scale
  - $1/\gamma_{R+1}$ ~ transverse event imbalance
  - $\cos\theta_{p_T,M_\Delta}$ ~ CM and mega jet mass imbalance

Chris Rogan, Emma Tolley





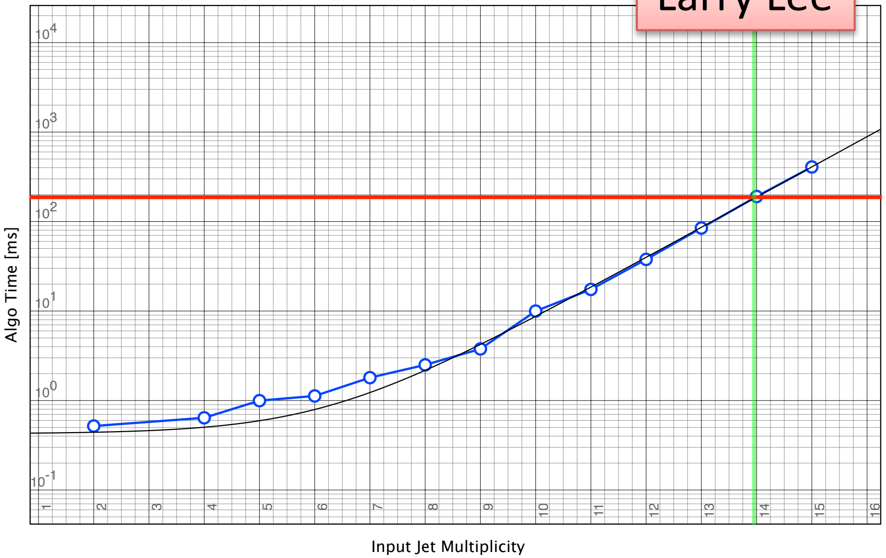
- Suppress background with hyperbolic cut:

$$\bar{\Pi} \equiv (\sqrt{\hat{s}_R} + 85\ \text{GeV})(1/\gamma_{R+1} + 0.048)$$

Razor trigger implementation

Larry Lee

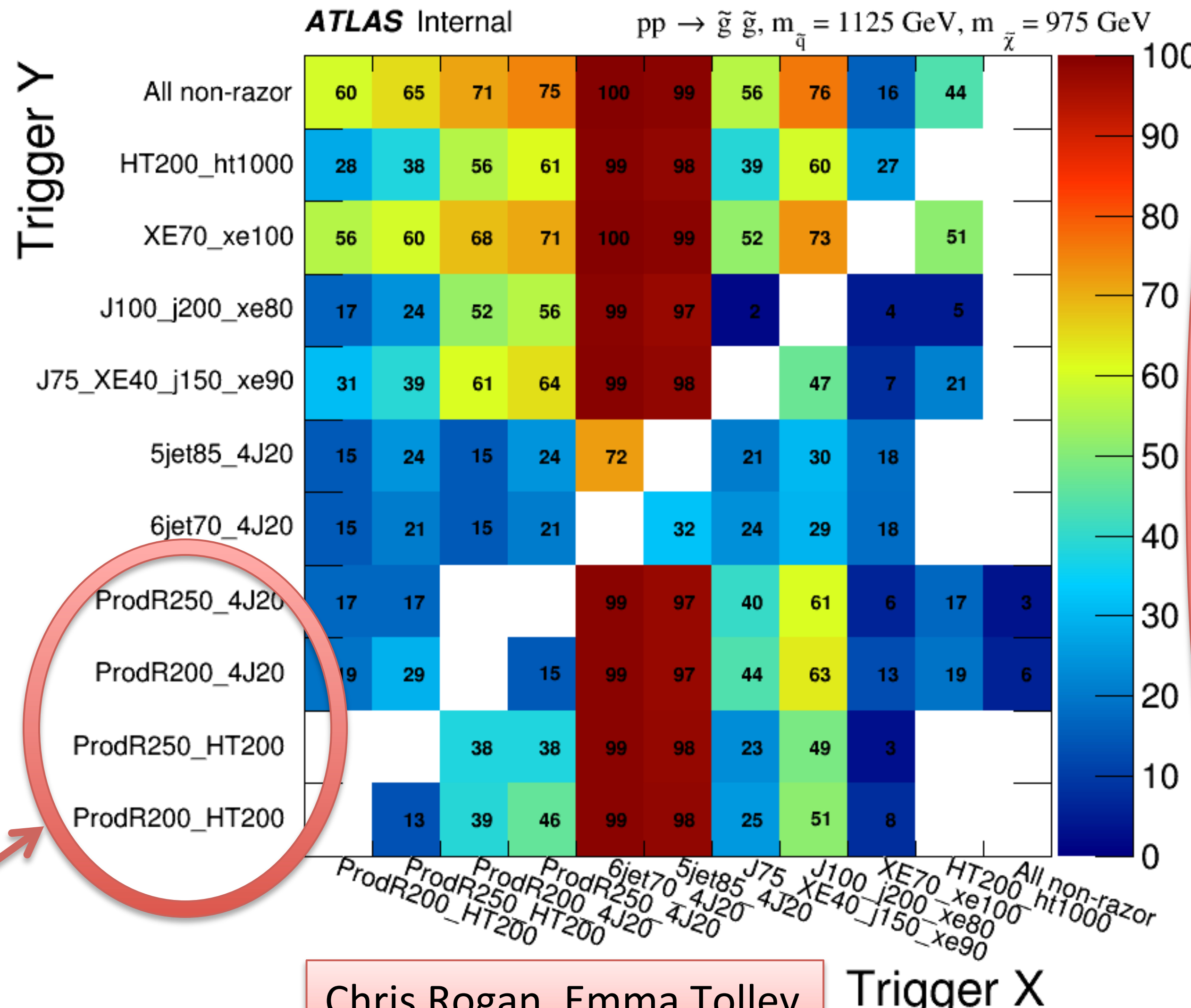
- Trigger/TrigAlgorithms/TrigHLTJetHemisphereRec
  - HLT::FexAlgo, Modeled on TrigHLTJetRec. Takes in an xAOD jet collection and attaches a new jet collection of exactly 2 jets which represent the hemispheres to the TE
- Brute force - all combinations of N jets into two hemispheres
  - Running time grows as $\sim 2^N \log N$ so needs some passthrough at N_{Max} jets where a multijet trigger should take the event anyway (then offline OR)
- jobOptions configurable jet pT, eta, N_{Max}



- Timing results on lxplus node
- Must keep algorithm under 200ms → ~14 Jets
  - N_{Max} ~ 10-13 should be safe

Unique efficiencies of the razor triggers

Read the ***Y-axis*** *for a given trigger and then look at the value for any trigger on the X-axis to see the benefit*



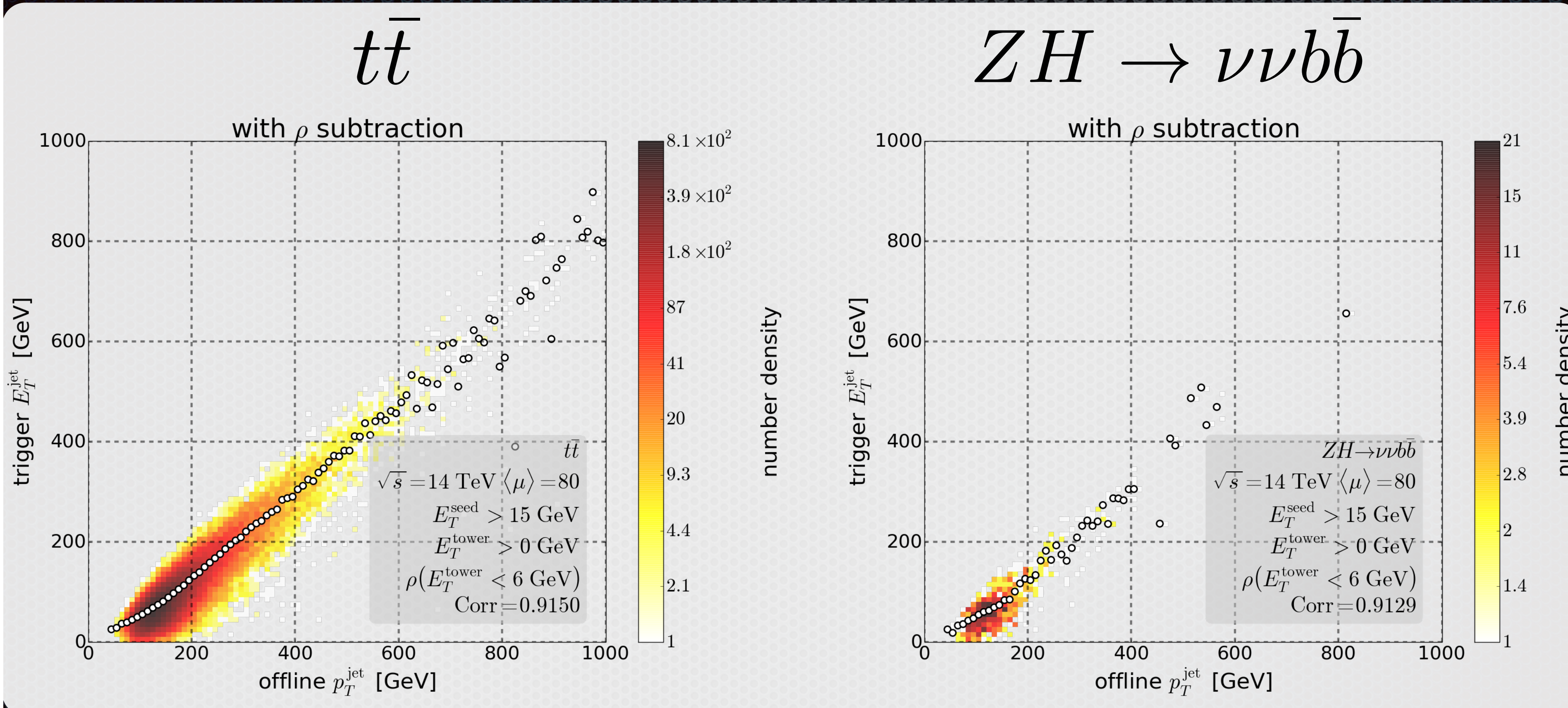
Razor triggers with Different L1 seeds (HT and multijet)

Chris Rogan, Emma Tolley

Fat jet trigger at L1 for Run III

Level 1 trigger: gFEX Jet correlation with offline jet P_T

Giordon Stark

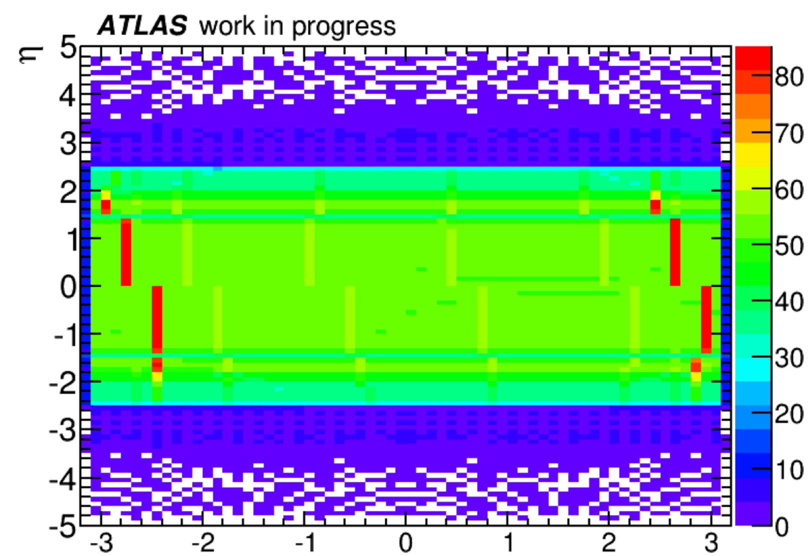


Monitoring and Validation (I)

Several levels of scrutiny:

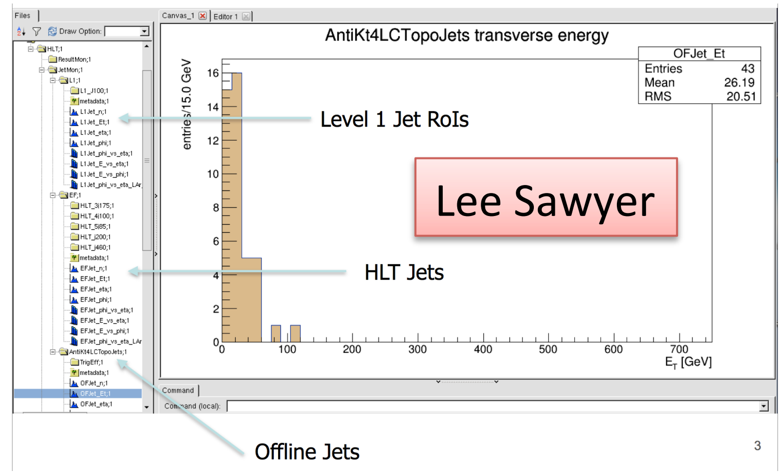
1. Software development validation
   - **Functional** validation (ATN/NICOS):
     - TriggerTest, TrigAnalysisTest, TrigP1Test
     - Regression tests on fixed reference: EDM, event counts, new menus, etc
   - **Performance** validation and infrequent errors (RTT)
     - Also runs same tests as ATN
     - Expanding tests as new developments are produced
     - Detailed validation: resolutions, cost monitoring, etc
   - Jet trigger **diagnostics**
     - Run in trigger chains for detailed studies
     - Allows greater access to input data as seen by trigger chains

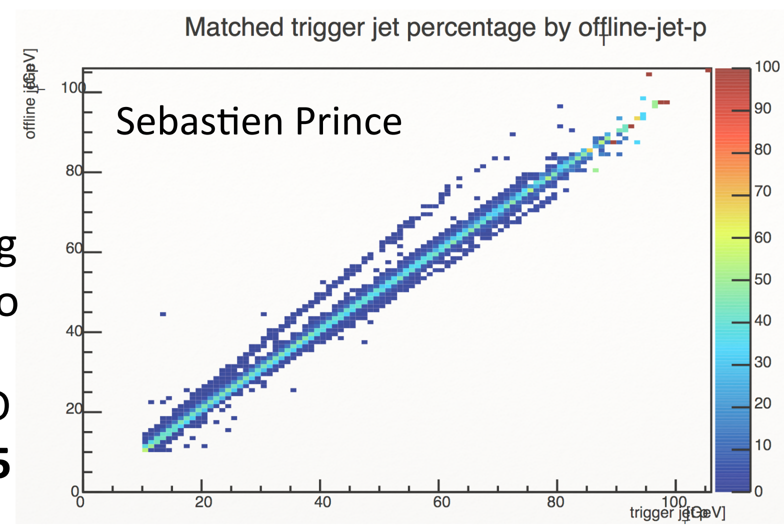
	rel_0 17th Aug	rel_1 18th Aug	rel_2 19th Aug
AOD_TrigDecTool	error error	error error	error error
AOD_TrigEDMCheck	error error	error error	error error
AthenaTrigRDOtoAOD_LS1	success success	success success	success error
AthenaTrigRDOtoAOD_MC	success error	success error	success error
henaTrigRDOtoAOD_Physics	error error	error error	error error
RDO_ElectronSlice_xAOD	success success	success success	success success
RDOtoAOD_DC14	error error	error error	error error



Monitoring and Validation (II)

1. **Software validation**
   - Previous slide
2. **Online monitoring**:
   - P1 operations
   - Fast detection of problems and fast response; not detailed analysis
   - Look for error situations affecting jet trigger performance
     - Hot towers, trigger rate, etc
3. **Offline monitoring**:
   - Examine data quality after Tier0 reconstruction
   - Comparison to offline jets
   - Harmonizing with offline monitoring
   - Trigger **menu awareness** essential to efficient operation
   - Migrated TrigJetMonitoring to xAOD
   - **Current priority/testing ground: M5**





Issues to watch out for and planning for coping with trigger issues in Run II

- Calibration of jets for the MET/MHT trigger
  - How important is the L1 jet calibration? Does the upgraded nMCM calibration proposal have a large impact?
  - How do we incorporate (technically) the jet area and rho calculations into the HLT?
  - How does calibration impact the Trigger Level Analysis (TLA)
- Fall back scenarios for jet/MET calibrations
  - What to do with errors/issues with calibrations in the trigger
  - How to handle missing calibration data or inputs (e.g. rho)?
- Impact of IBL material and services on MET trigger

Overview of the offline jet calibration

Begin with input jets...

1. Jet area and residual pile-up corrections decrease effects from pile-up conditions
2. Origin correction points reconstructed jet to primary hard scatter vertex
3. MC energy & η calibrations correct for effects such as leakage, dead material and noncompensation
4. Global Sequential Calibration (GSC) uses global variables to improve energy resolution and decreases systematics such as dependence on jet flavour
5. In-situ calibration applied to data uses reference objects to validate MC calibrations against data

... Jets ready for physics!

Overview of the offline jet calibration

Begin with input jets...

1. Jet area and residual pile-up ... decrease effects ... conditions ... reconstructe... hard scatter vertex

Requires full event topoclusters for rho calculation

Requires full event tracks and PV identification

3. MC energy & η calibrations correct for effects such as leakage, dead material and noncompensation

4. Global Sequential Calibration ...es global variables to ...

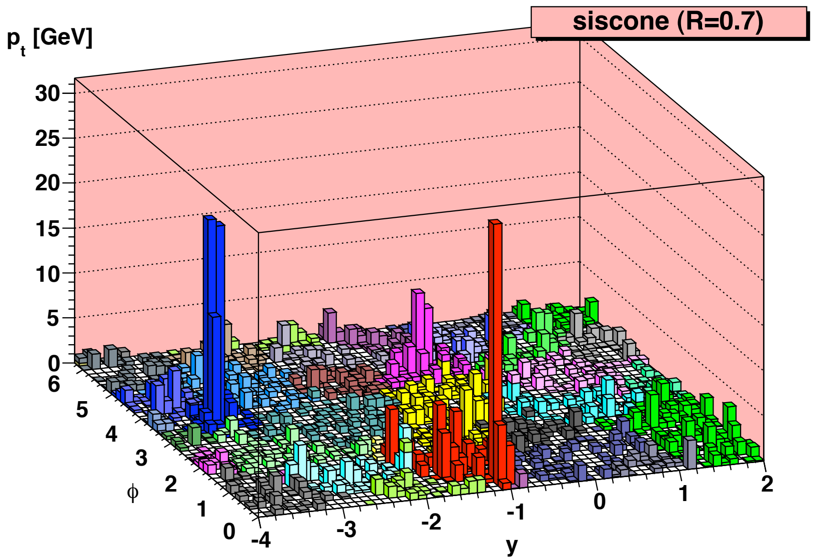
Only requires derived constants: f(pT, eta)

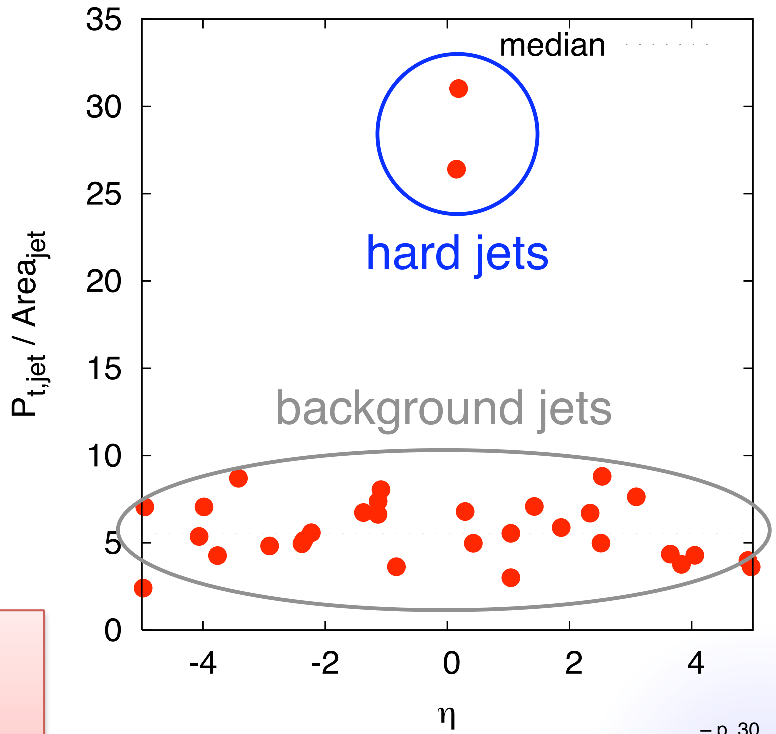
Requires extra jet info like layer energies and full tracking info

5. In-situ calib... data uses reference objects to validate MC calibrations against data

... Jets ready for physics!

Pile-up subtraction: rho





$$\rho = \text{median}\left\{\frac{p_{j,t}}{A_{j,t}}\right\}$$

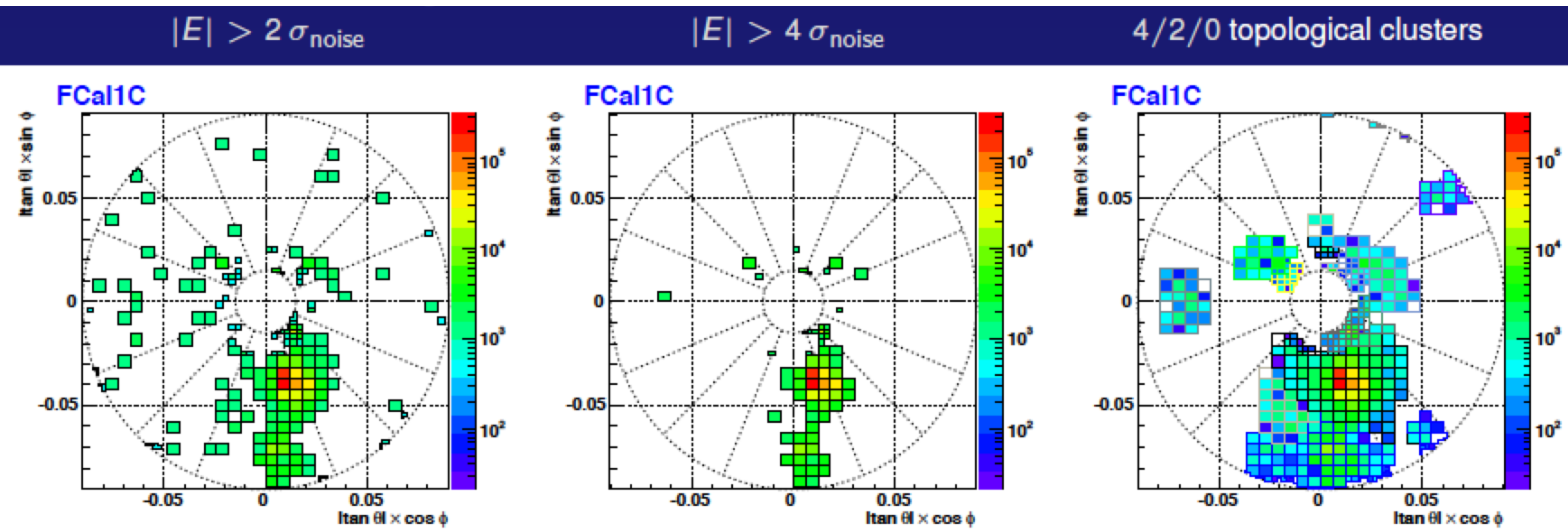
Requires full event topoclusters for rho calculation

$$p_{t,\text{subtracted}} = p_{t,\text{jet}} - \rho_{\text{pileup}} \times \text{Area}_{\text{jet}}$$

TopoClustering, Full and Partial Scan, and all that…

- Several techniques developed and maintained in the offline world that are needed in trigger
  - Pileup suppression will become more important
  - Calibration should be taken from offline
  - We don't have the capability to keep maintain our own versions (and would complicate things)

- TopoCluster making:
  - 3D groups of adjoining cells started from seed cells (4σ above noise)
  - Add adjoining cells if above 2σ above noise, plus an extra layer 0σ above noise (4/2/0 scheme)
  - Split initial clusters into smaller ones surrounding hot spots – splitting
  - Following that: calculate cluster moments, classify clusters (EM/HAD), apply calibration, find jets, calibrate



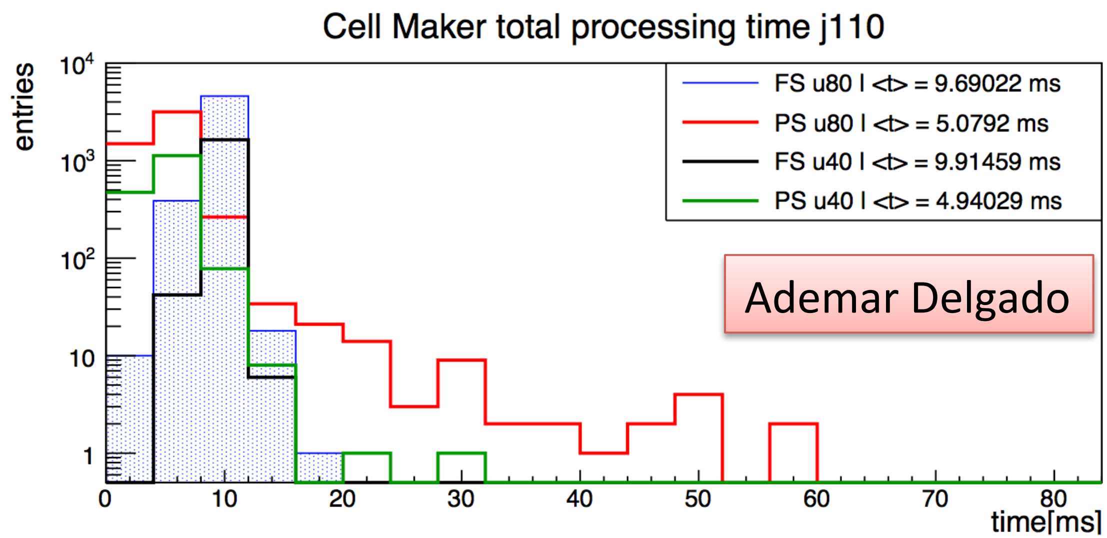
Ademar Delgado

Latest timing tests

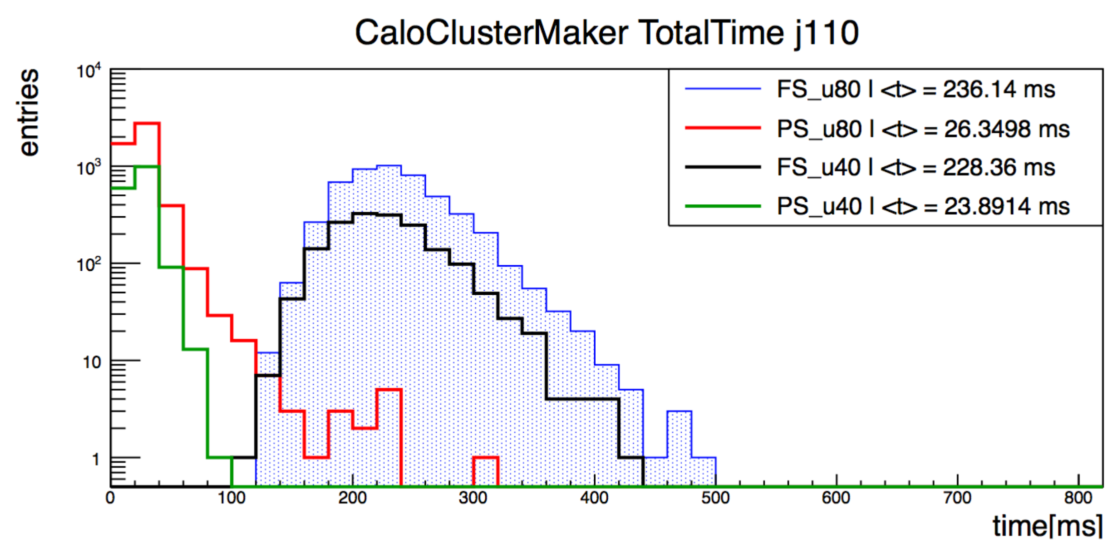
- Rel_0, devval, on a test bed pc
- RoI size of 1x1 (Partial Scan)
- Chains: L1 J20 → EF j110; also tried multijet chains for comparison
- Geometry - ATLAS-IBL-03-00-00
- ConditionsTag - OFLCOND-MC12-IBL-20-80-25
- p_T (lead Anti-k_T6 truth jet) = 80-200 GeV sample
- mc12 14TeV.147911.Pythia8 AU2CT10 jetjet JZ2W.recon.RDO.e1996 s1715 s1691 r4741
  - **pileup- 80**
- mc12 14TeV.147912.Pythia8 AU2CT10 jetjet JZ2W.recon.RDO.e1996 s1715 s1691 r4739
  - **pileup- 40**
- **Will redo with wider range of samples**

CellContainer and cluster making

- Cell maker:
  - Partial scan much less costly on average
  - But longer tails and bigger dependence on pileup



- Cluster Maker:
  - Full Scan total time much larger than Partial Scan
  - **Breakdown in next slide**



Ademar Delgado

Partial vs Full Scan – Timing Summary

- Cluster making time roughly same as calibration
- PS much less than FS but longer tails
- Small effect from pileup
- Comparing to r.17:
  - 6% increase in clustering in r.19
  - 6x reduction in cell container making (60 to 10ms/evt)

Clustering [ms]	<μ>=40	<μ>=80	Calibration [ms]	<μ>=40	<μ>=80
Cells	9.9	9.7	Moments	27.0	29.7
Clusters	53.7	52.7	Dead Material	18.5	17.2
Cluster splitting	57.7	61.9	Out of cluster	17.8	16.3
Full calorimeter scan			Local calibration	23.9	26.4
			Out of cluster Pi0	17.8	16
Totals:	121.3	124.3	Totals:	105	105.6

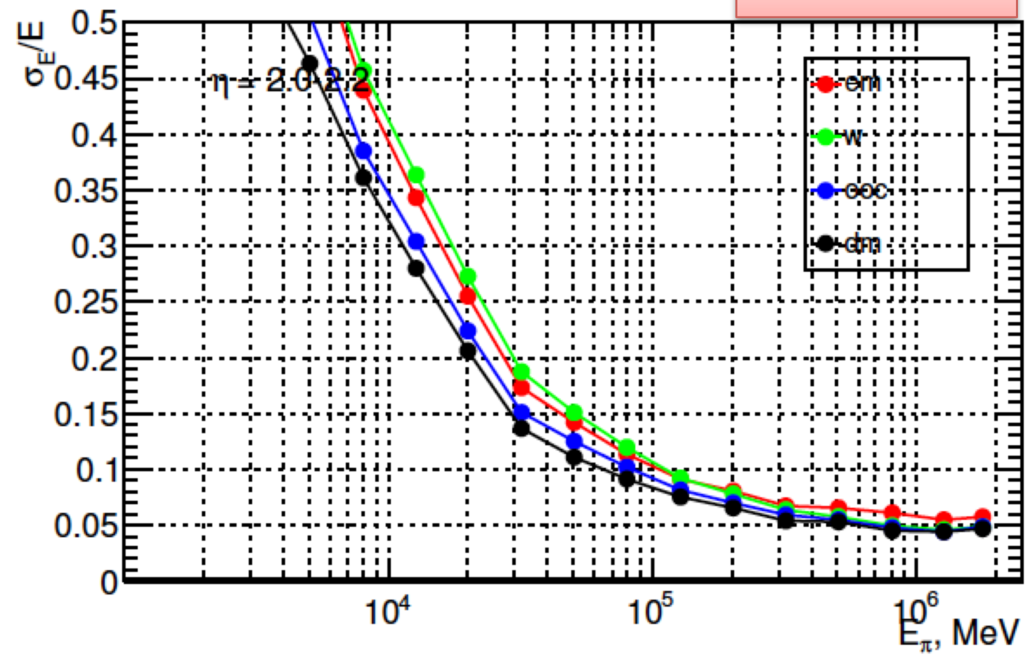
Clustering [ms]	<μ>=40	<μ>=80	Calibration [ms]	<μ>=40	<μ>=80
Cells	4.9	5.1	Moments	2.3	2.5
Clusters	4.8	5.4	Dead Material	2.1	2.4
Cluster splitting	6.0	6.6	Out of cluster	2.0	2.2
Partial calorimeter scan			Local calibration	2.9	3.2
			Out of cluster Pi0	2.0	2.2
Totals:	15.7	17.1	Totals:	11.3	12.5

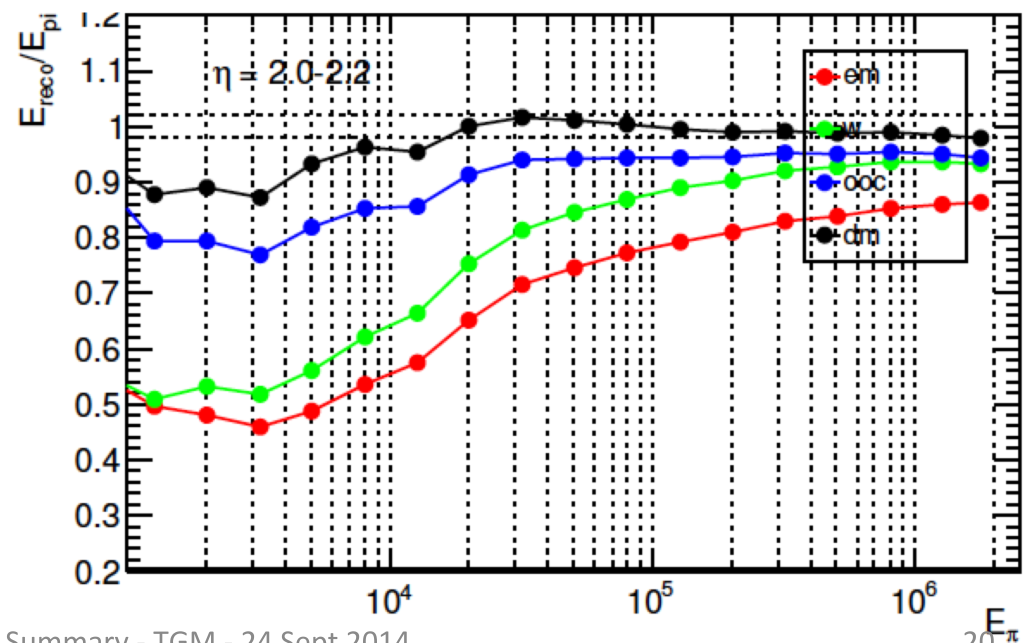
Sven Menke

Calibration

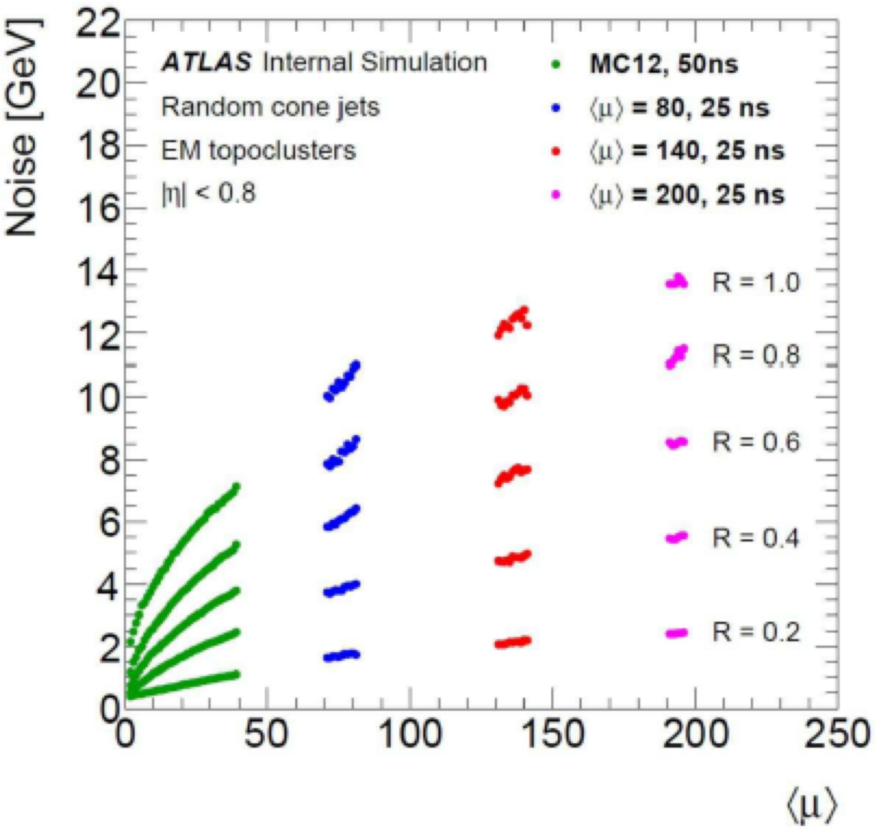
- Resolution and linearity improvement for charged pions after each correction:
  - EM
  - LCW
  - Out of cluster
  - Dead material

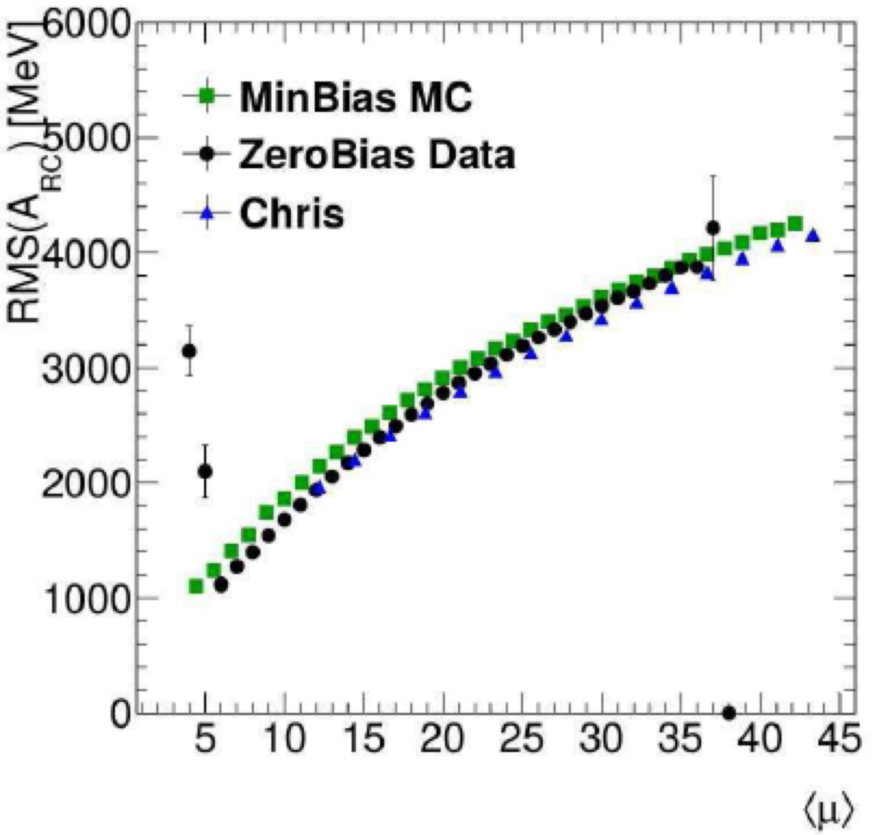
- Conditions:
  - <μ>=0
  - IBL geometry
  - 2<|η|<2.2
  - 4 samplings





Jet Resolution — Noise Term





This is a major advance towards measuring the jet energy resolution noise term. It is so exciting, I just had to show it.

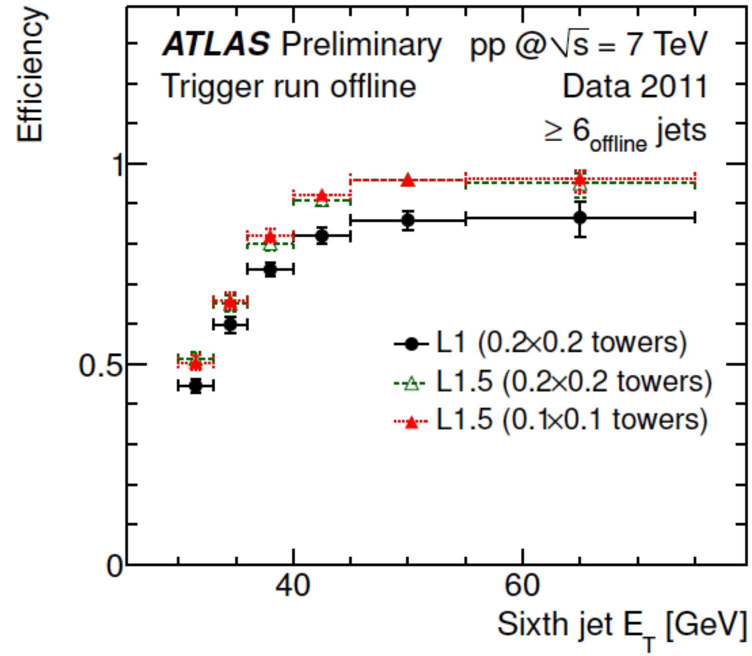
Summary

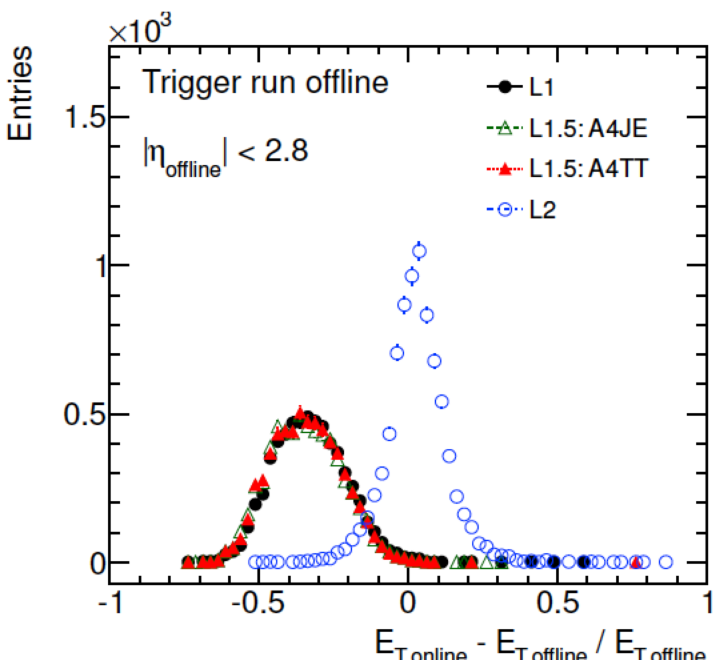
- Very lively discussions and many issues covered
- Great interaction with offline jet/MET group
  - Extremely useful for e.g. software development and monitoring
- Made clear that we should strive for full-scan as default solution if at all possible
  - Pileup subtraction essential to good performance in coming LHC runs
  - Keep in sync with offline developments to help maintainability and make use of offline effort
  - New timing breakdown suggests solutions
- Keep studying performance impact from L1 (nMCM), L1.5 (calibration?), HLT clustering and pileup, etc

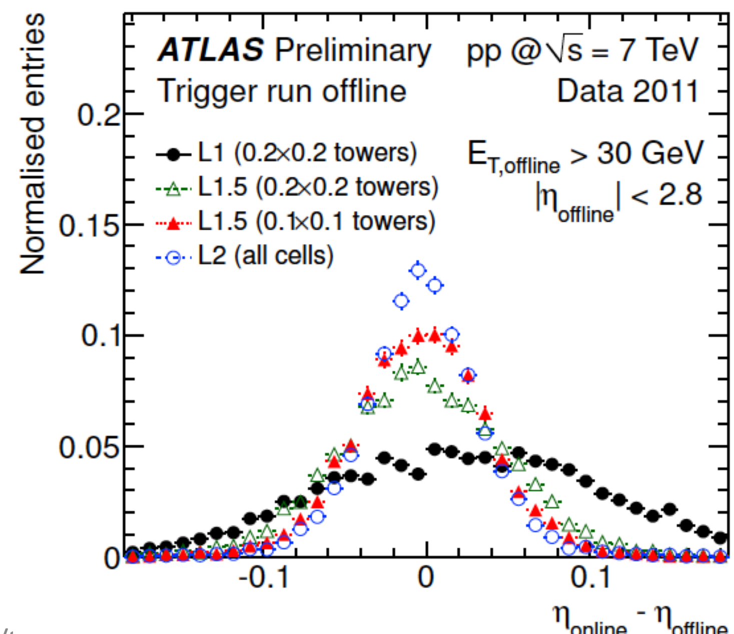
Backup

L1.5 performance

- The TriggerTower full scan recovers L1 inefficiency for close-by jets
  - See [ATL-COM-DAQ-2012-009]()
- Reasonable spacial resolution
- Energy resolution same as L1
  - See [ATL-COM-DAQ-2012-009]()

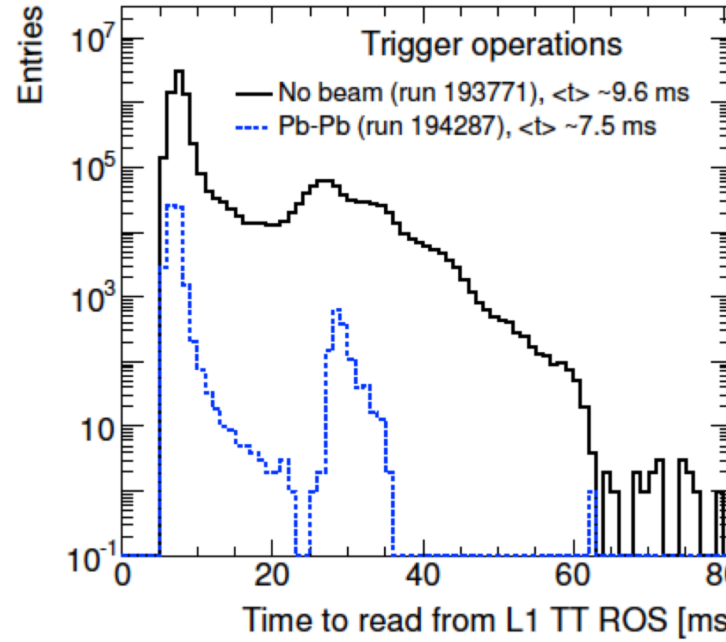


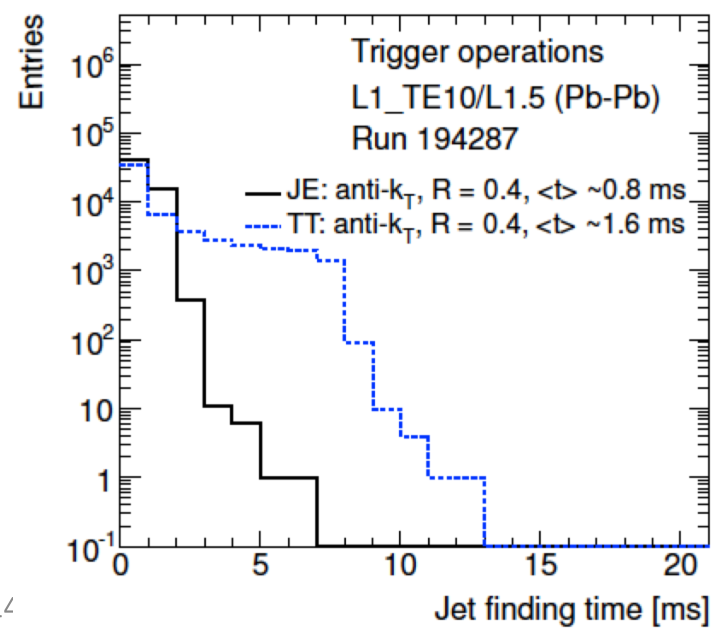


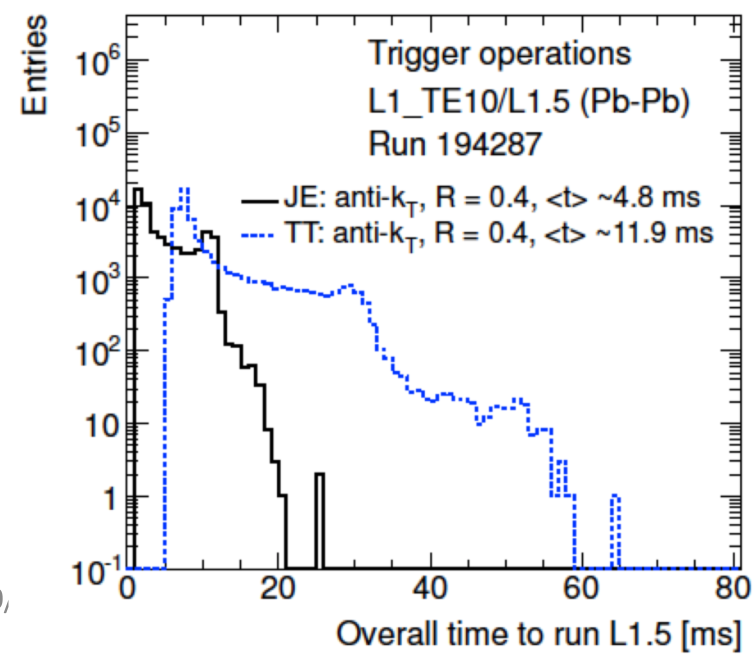


L1.5 cost

- From **Run I tests** (see [ATL-COM-DAQ-2012-015]):
  - L1Calo ROSes (3 for TT, 1 for JE) read out at up to 7kHz
  - Expect up to 15kHz with upgraded ROSes
- Total time around 12ms
  - Readout time around 9ms
  - Jet finding (anti-kT 0.4) around 1-2ms



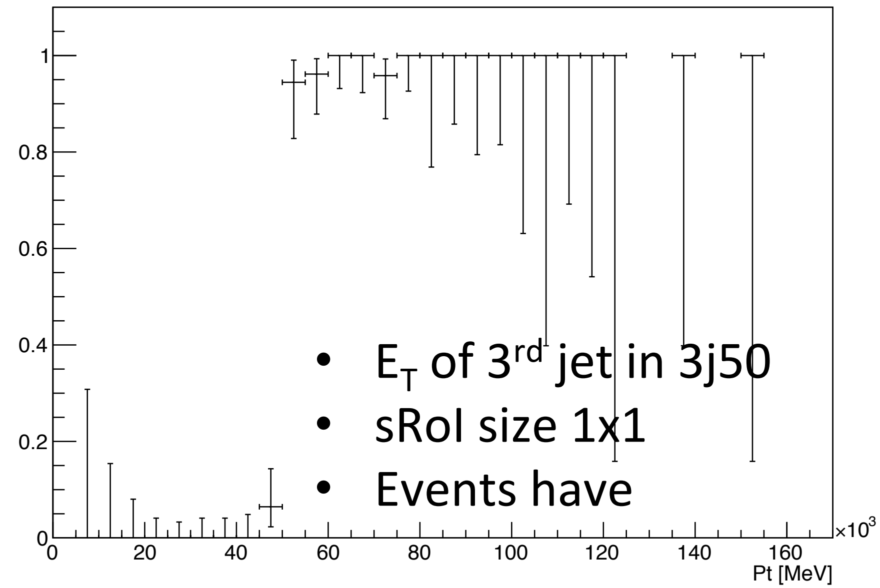




TopoCluster performance

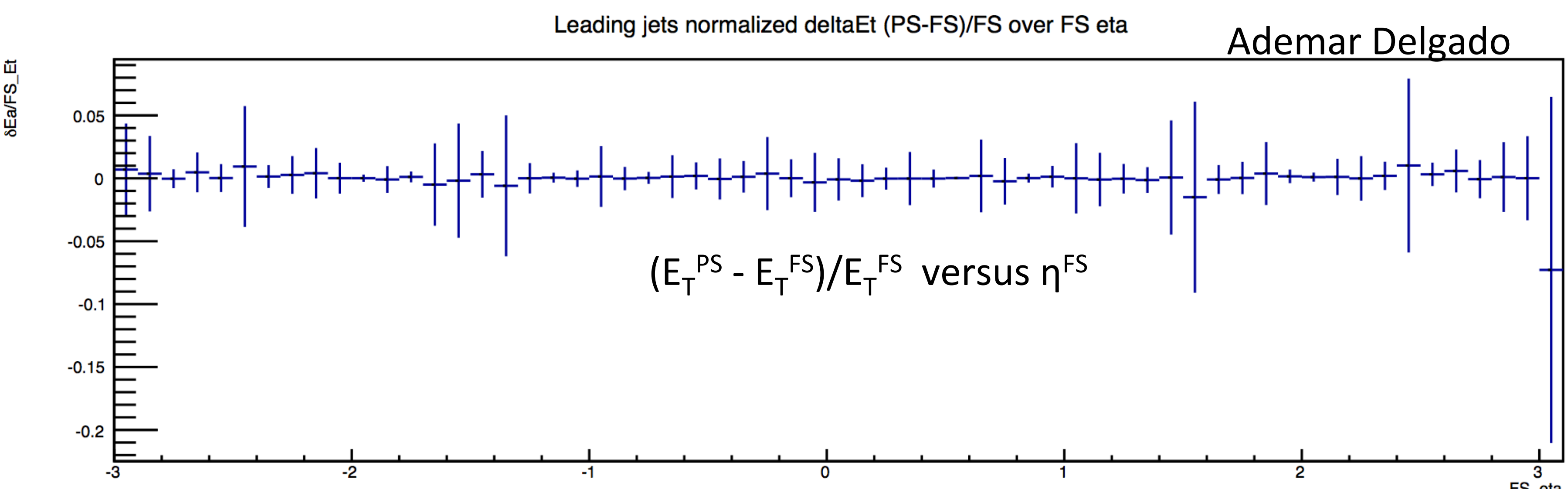
- Comparing PS to FS
- Assumes FS performance is closer to offline

David Freeborn



- E_T of 3rd jet in 3j50
- sRoI size 1x1
- Events have

Ademar Delgado



$(E_T^{PS} - E_T^{FS})/E_T^{FS}$ versus η^{FS}