Commissioning Requirements from Hadronic Signatures

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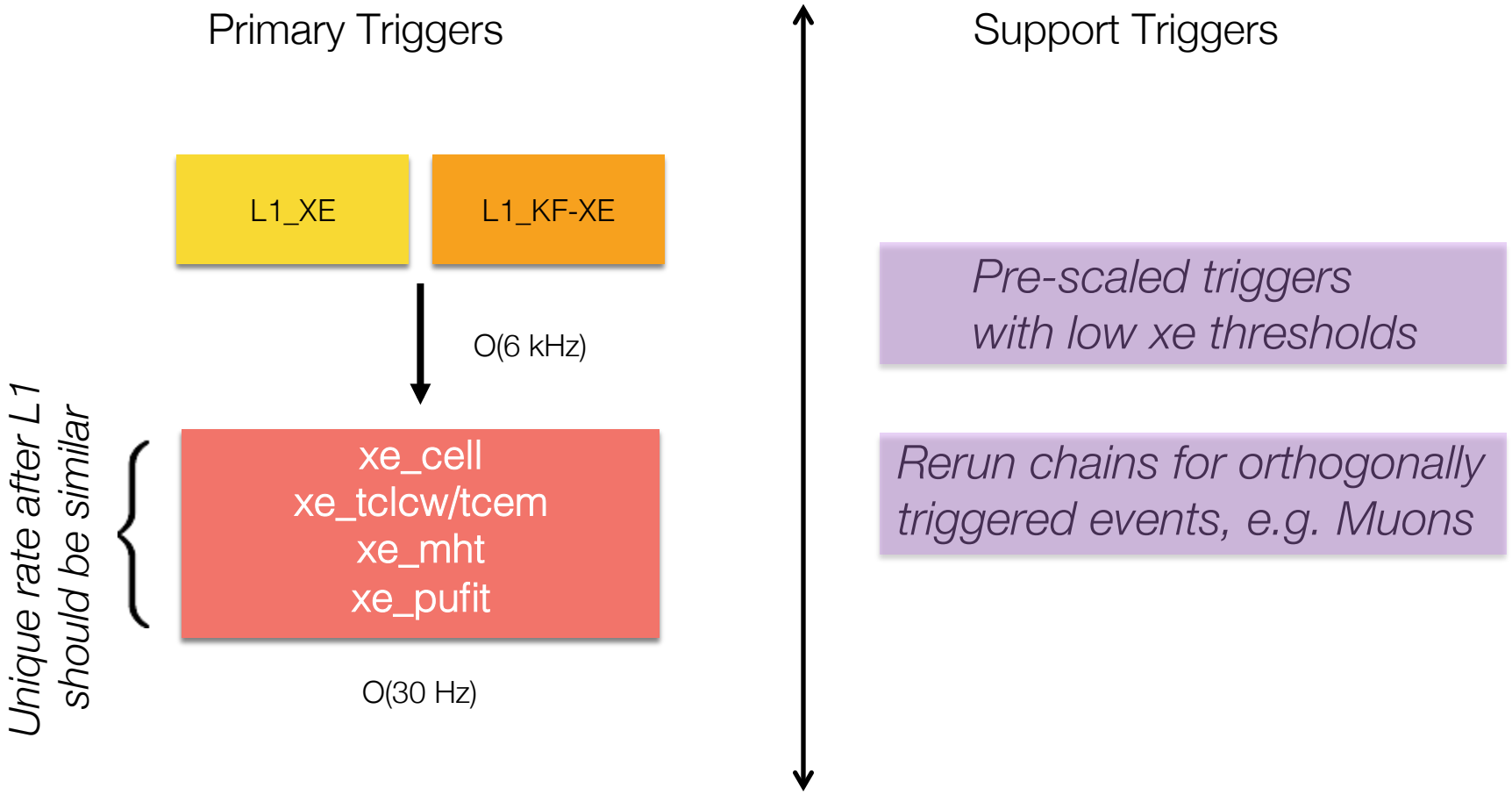
On behalf of the Jet and E_T^{miss} Signature Groups

TDAQ Week - 3 December 2014

Missing E_T Commissioning Plans

Overview

https://its.cern.ch/jira/browse/ATR-9566



Commissioning strategy of chains with KF-MET improved coefficients

- Plan to use the 50 ns run to derive a set of data-driven calibration coefficients and test the MC based coefficients.
  - Most physics analyses don't have dedicated plans for the 1/fb of the 50 ns run
  - Plan to make a full comparison of L1_XE met & L1_KF-XE MET to formulate a recommendation for combined chains.
  - Update coefficients then prior to the 25 ns data taking
- Repeat exercise with early 25 ns data; if no large problem isolated plan to use 50 ns coefficients for entire data taking period.

Changes required for 25 vs 50 ns running

- Plan to use the 50 ns run for quick performance studies on all HLT algorithms.
  - Goal is to reduce the number of HLT algorithm candidates down to maximal two.
  - For these duplicate the combined chains for the first 25 ns run.

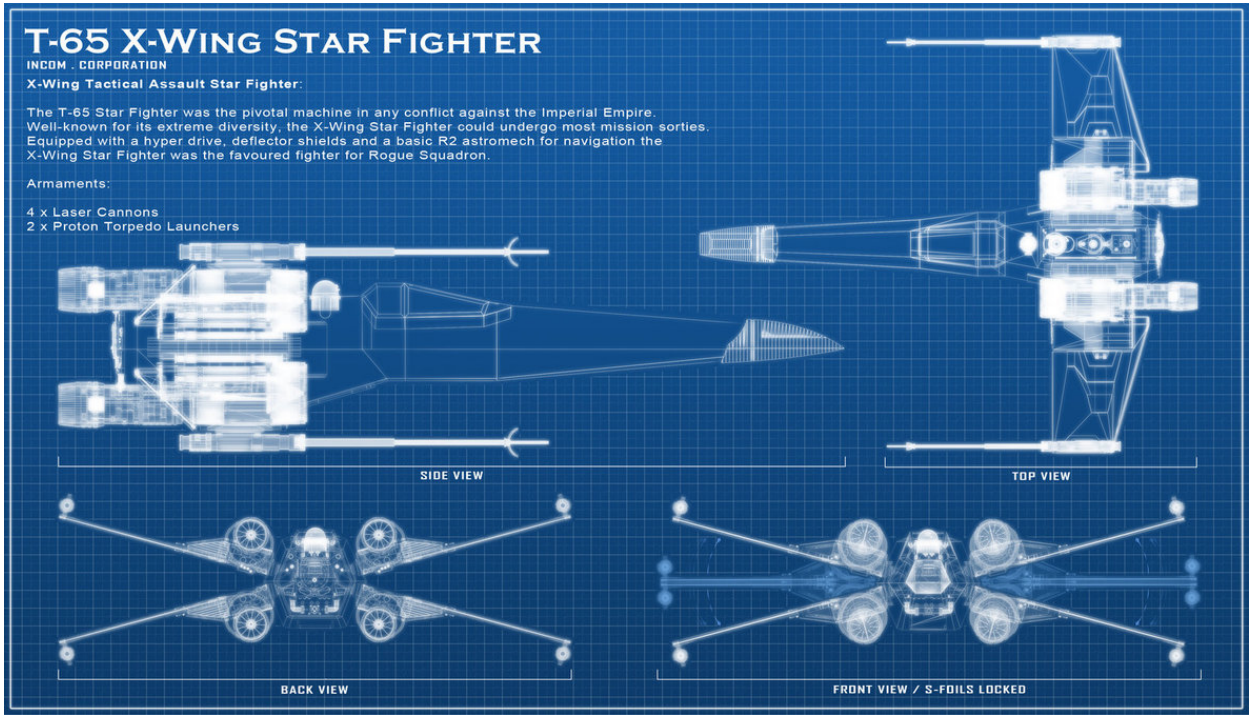
Use of FEBs in XE Triggers

- With the current implementation, FEBs can be calculated only by unpacking the full calorimeter information (as far as we understand)
  - Benefit of only unpacking partial information gone; but actual MET calculation still incredibly fast (factor of 10 faster than cell based)
- No use intended at the moment
  - But in a scenario of a lower L1 threshold (departing from the ~ 6 kHz upper limit), they could be used to protect the HLT whilst gaining overall turn-on.

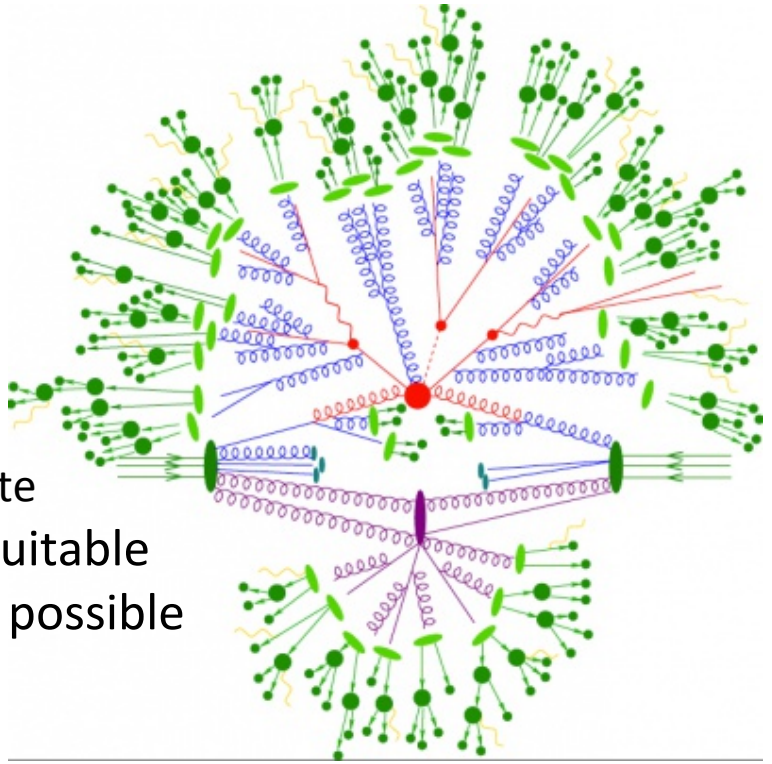
Need for L1.5 jets and calibration

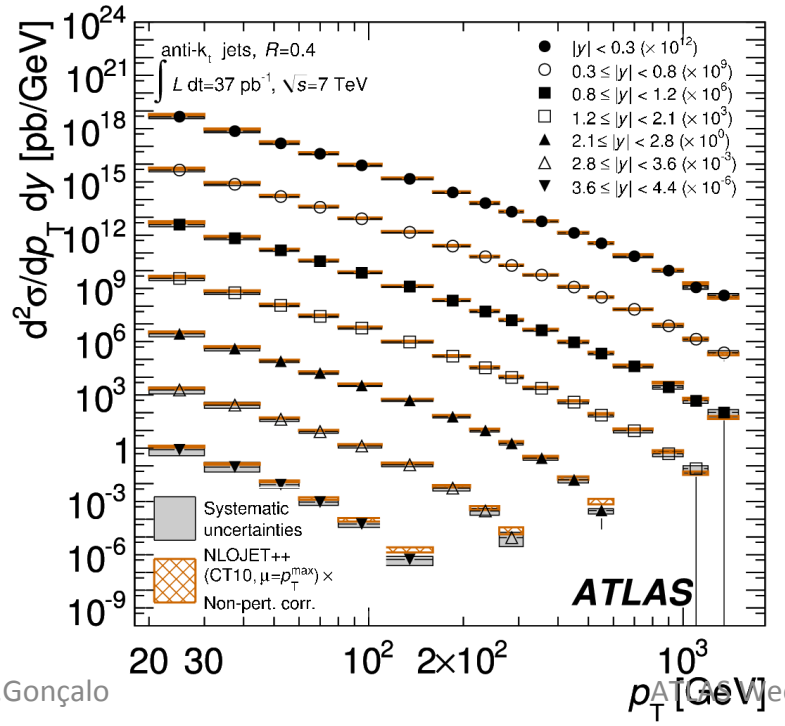
- At this point no use for L1.5 jets
- Calibration at HLT:
  - For MHT plan to use same prescription as jet signature group (i.e. uncalibrated clusters to build jets that are then calibrated)
  - For clusters: setup to use either uncalibrated or calibrated clusters. Current studies indicate that calibration has no big impact (contrary of what was seen in 2012)

Jet Trigger plans



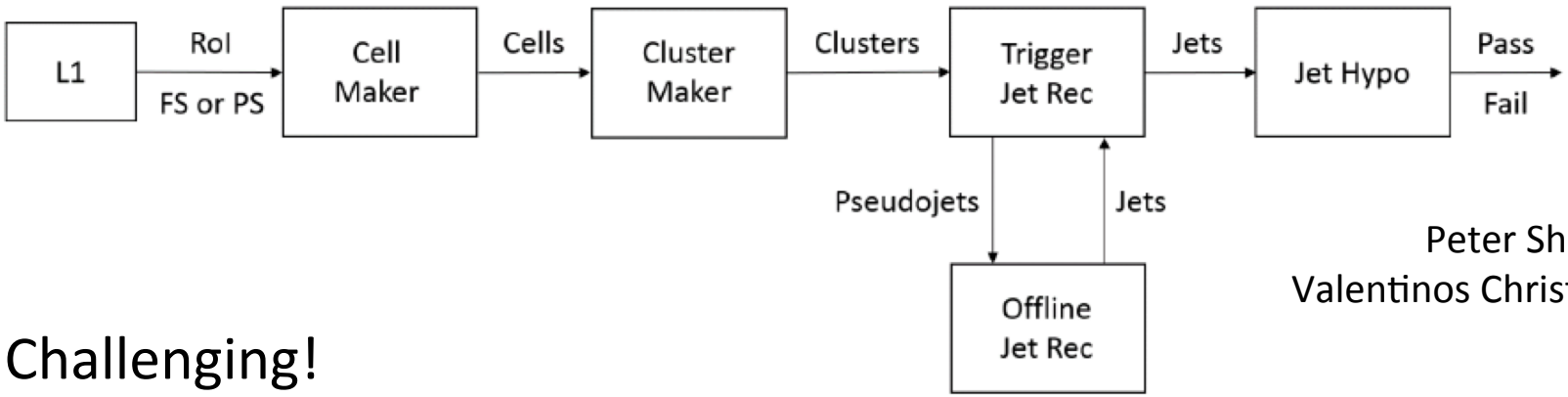
- Unusual trigger…
  - Jets *defined* by jet algorithm
  - Jets have non-negligible size in detector
  - Nearby jets influence reconstruction
  - Signal is *same* as background
  - Just selecting phase space (i.e. physics!)
  - Very steeply falling spectrum
  - Jet p_T resolution determines "background" rate
- Region of Interest (RoI) approach not really suitable
- Reproduce offline reconstruction as much as possible





Architecture & SW changes for Run II

- Merged High Level Trigger instead of separate L2 & Event Filter
- L1Topo topological processor at Level 1
- Migration to xAOD led to major software changes

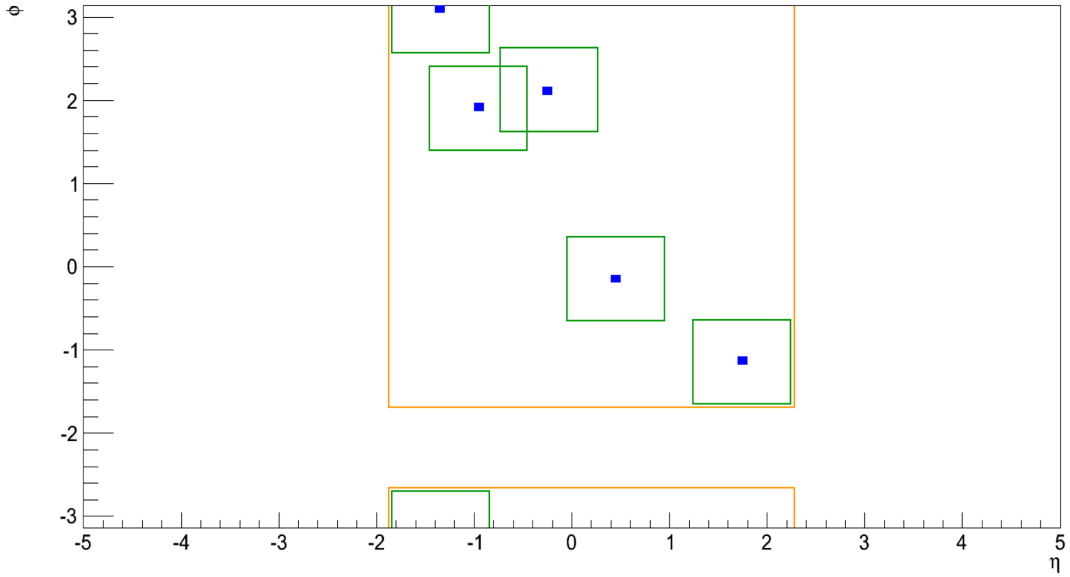


Peter Sherwood
Valentinos Christodolou

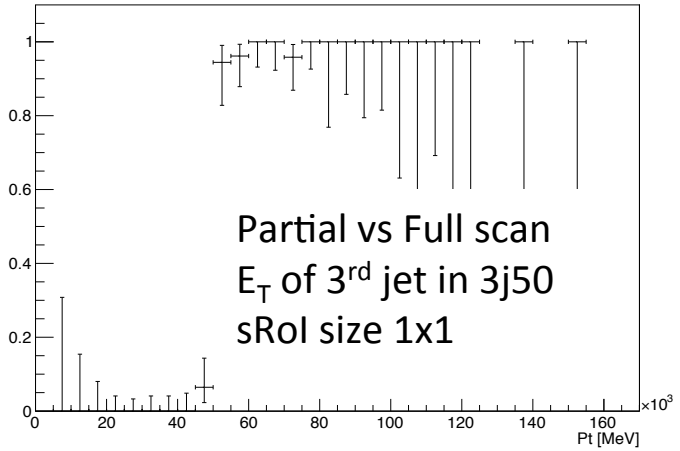
- Challenging!
  - Re-writing of jet trigger software and config, updated monitoring, etc
- Opportunities!
  - Improve on RoI-based jet reconstruction in Level 2
  - Greater re-use of offline jet reconstruction and calibration
  - Good collaboration with HLTCalo and offline jet groups (thanks!)
- Main obstacle: CPU time, mainly clustering

Partial solution: Partial Scan

Ademar Delgado, Mark Sutton

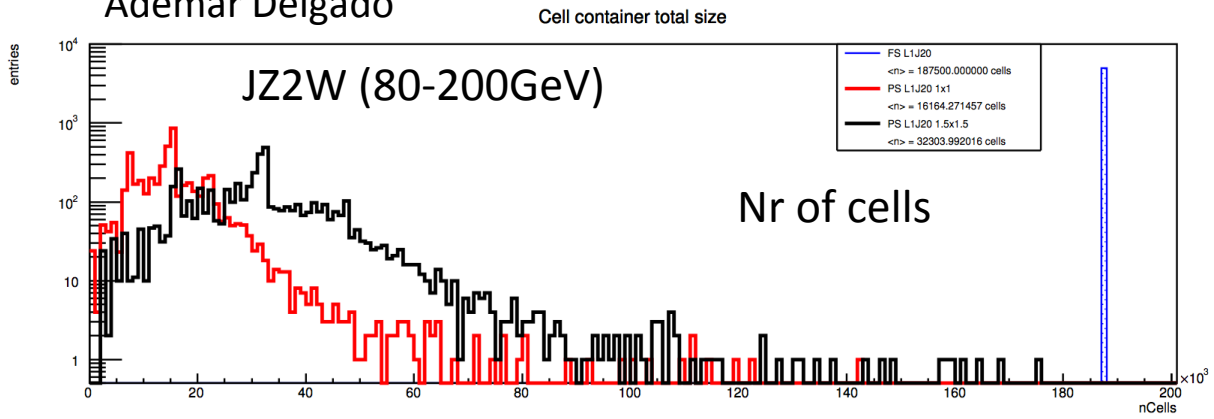


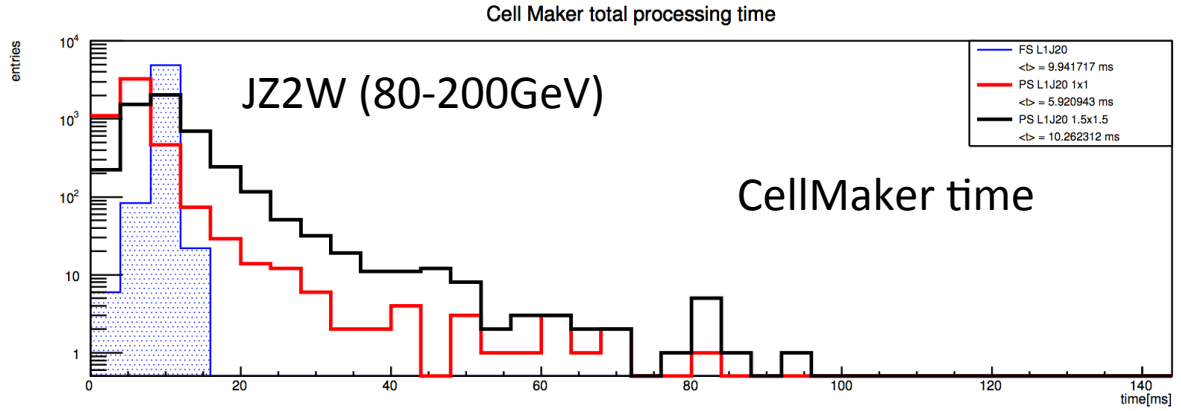
David Freeborn

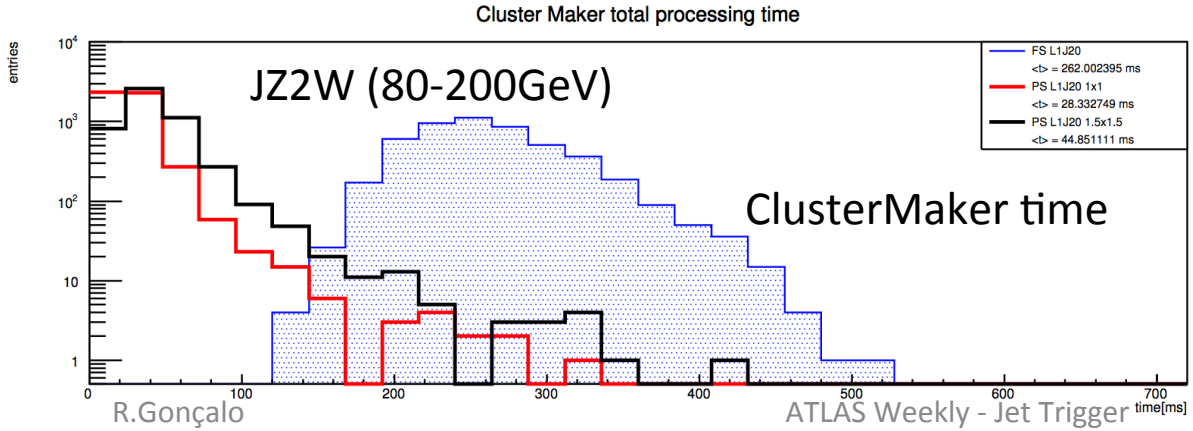


- HLT jet finding on **Super RoI** built from union of all L1 RoIs
  - Or better alternative: start from Trigger Tower full scan (L1.5)
  - Tuneable parameters: L1_Jx (or L1.5 seed), size of RoIs making sRoI
  - Good jet reconstruction performance and costs
  - Efficiency: (L1_J20) ≈ 99.5% wrt Full Scan (j110)
- **Major downside**: no jet area subtraction of pileup

Ademar Delgado







Cost…

Full Scan : <n> ≈ 190k cells

Partial Scan: L1_J20 1x1 :

<n> ≈ 16k cells

Partial Scan: L1_J20 1.5x1.5 :

<n> ≈32k cells

Full Scan : <t> ≈ 10ms

Partial Scan: L1_J20 1x1:

<t> ≈ 6ms

Partial Scan: L1_J20 1.5x1.5 :

<t> ≈ 10ms

Full Scan : <t> ≈ 260ms

(actually… this was a glitch)

Partial Scan: L1_J20 1x1:

<t> ≈ 30ms

Partial Scan: L1_J20 1.5x1.5 :

<t> ≈ 45ms

Improvements in clustering time

Updates to TopoCluster lead to much **improved CPU time**

TopoCluster:

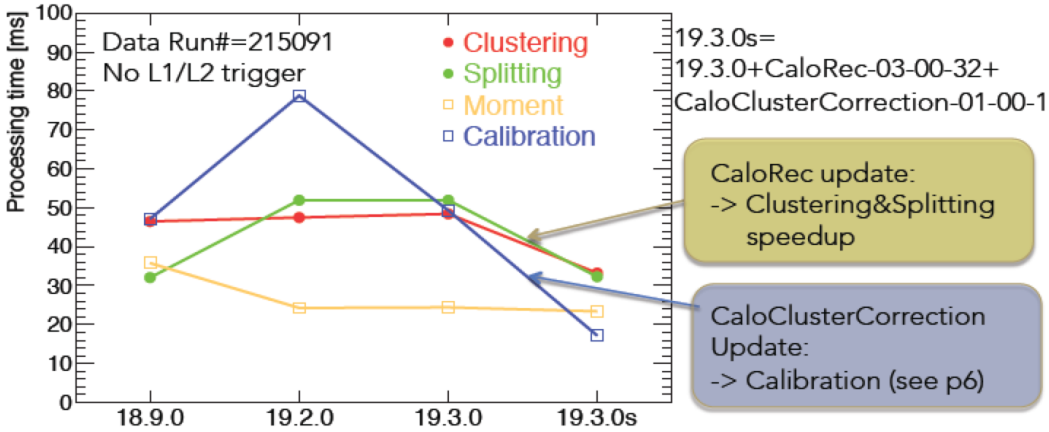
- Clustering
- Splitting
- Moment calculation
- Calibration

Full calorimeter scan in HLT

- Cluster making:
  - 80ms/evt
- Cluster+Calibration (LCW):
  - 140ms/evt

New baseline plan:

- **Full calorimeter scan**
- Keep Partial Scan: **plan B**
- Plan to use **L1.5** to reduce rate for TopoCluster scan (in progress)



	Pre-xAOD(18.9.0)	Post-xAOD(19.3.0s)
Clustering only	78ms	65ms (-17%)
Clustering+calibration	161ms	106ms (-35%)

* (NOTE) They are simple sums of timing cost in the above 4 processes

Naoko Kanaya, Craig Wigglesworth, Walter Lampl

Jet Trigger Commissioning Plans

Primary Jet Menu Items at low & high lumi

- Menu for MC15 under final discussion right now
  - $5x10^{33}$ menu: j360, fatjet360, 4j85, 5j60, 6j50.0ETA24, ht800
  - $2x10^{34}$ menu: j400, fatjet450, 4j100, 5j85, 6j50.0ETA24, ht1000
- Default calibration: **emsubjes**
  - Calibrated (**jes**) + pileup subtract jets (**sub**) EM-scale clusters (**em**)
- "Cross-check" chains with **alternative calibrations** for a few strategic thresholds
  - E.g.: j360_a4tcemjes/j380_a4tcemsubjes/j380_a4tcemjes/j380_a4tclcwsubjes
- Support triggers:
  - Low-E_T, prescaled, single and multijet chains; random-seeded low-ET chains

Chain Type	L1 Seed at $0.5x10^{34}$	HLT Item at $0.5x10^{34}$	L1 Seed at $2x10^{34}$	HLT Item at $2x10^{34}$
Single jet	J75	j360	j100	j400
Single fat jet	HT150	j360_a10	HT190	j450_a10
4 jets	3J40	4j85	3J50	4j100
5 jets	4J15	5j60	4J20	5j85
6 jets	5J15.0ETA24	6j50.0ETA24	5J15.0ETA24	6j50.0ETA24
HT trigger	HT190	ht800	HT190	ht1000

Jet trigger commissioning strategy

- Run new features online as early as possible for functional validation
- Compare with offline jets
  - Large overlap in performance is essential to avoid wasting bandwidth

- Tight coupling with commissioning of HLTCalo
  - Studies of clustering performance and timing are key
  - Will need *both* EM and LCW clusters early on

- Comparison with offline jets is critical
  - First few runs will already establish the baseline performance

- Would benefit from special early runs with relaxed prescales for low threshold supporting triggers
  - Forward jets typically very difficult to study early
  - Need J+FJ for calibration sample for jet eta intercalibration

Questions & Answers

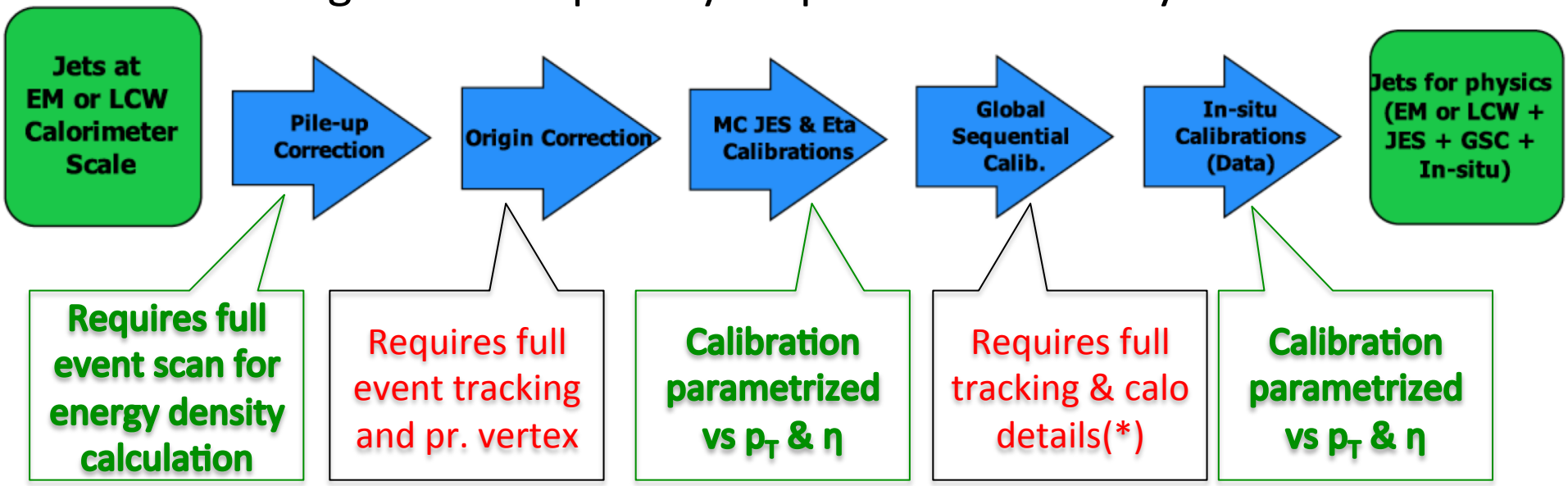
- Changes required from 50ns to 25ns run?
  - No particular changes required - no large differences expected
  - Plan to use early runs (run in May and 50 ns run) to compare different calibration options and make final decision on baseline calibration to be used
  - Repeat exercise with early 25 ns data to find any potential problems
  - Accumulate data as early as possible (50ns run) for jet and calorimeter calibration

- Need for L1.5 and calibration?
  - We plan to runL1.5 before cell-based full scan
  - Idea is to have a handle to reduce HLT input rate
  - Would benefit from being able to calibrate TriggerTower readout, to go beyond L1 resolution

- TopoClusters? Yes, definitely!
  - Would like to be able to choose best calibration for physics (CPU time allowing)

Jet Calibration in HLT

- Apply as much as possible of offline jet calibration
- Concentrate on steps leading to larger improvements
- Essential:
  - Pileup (jet area) subtraction and Jet Energy Scale: working
- In progress/plans:
  - Global Sequential Calibration: some factorizable steps possible
  - Tracking-based steps may be possible but not yet addressed



Peter Sherwood, Nuno Anjos

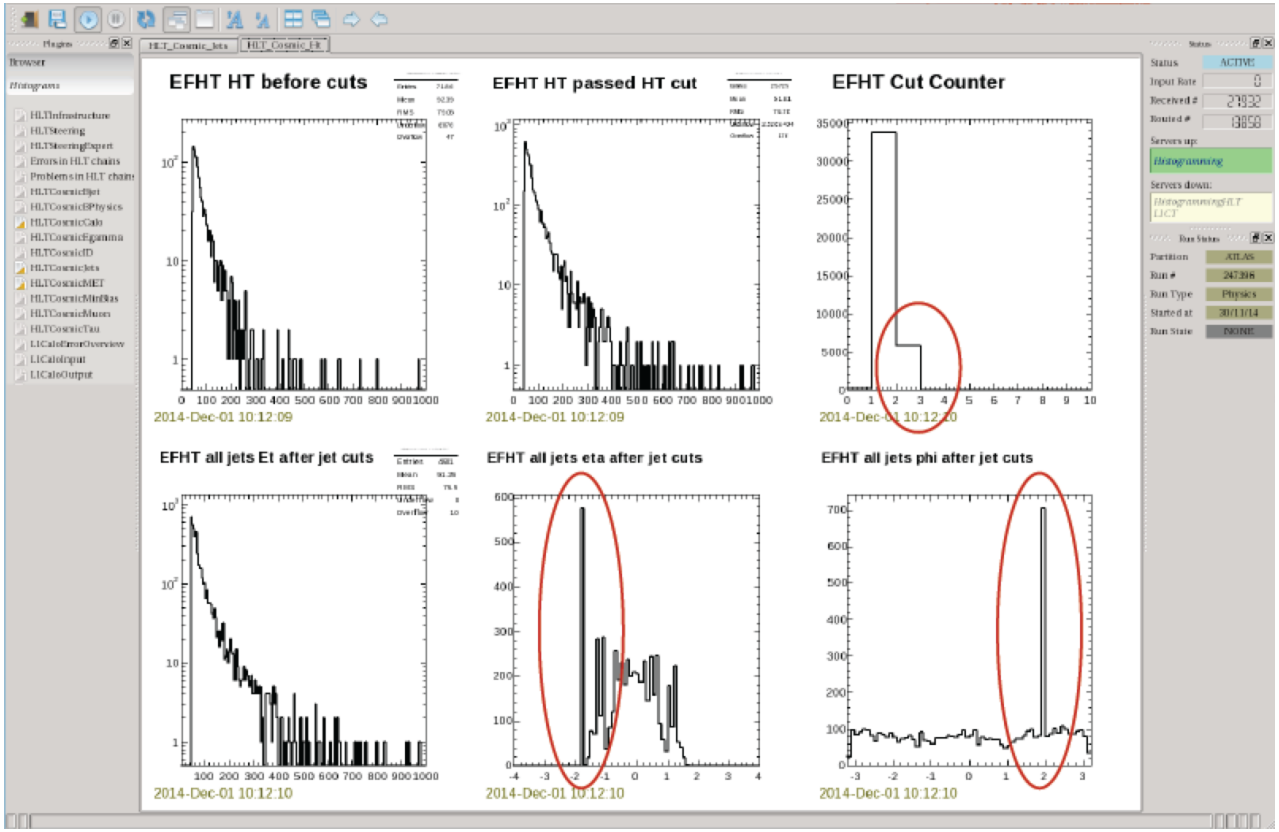
Key

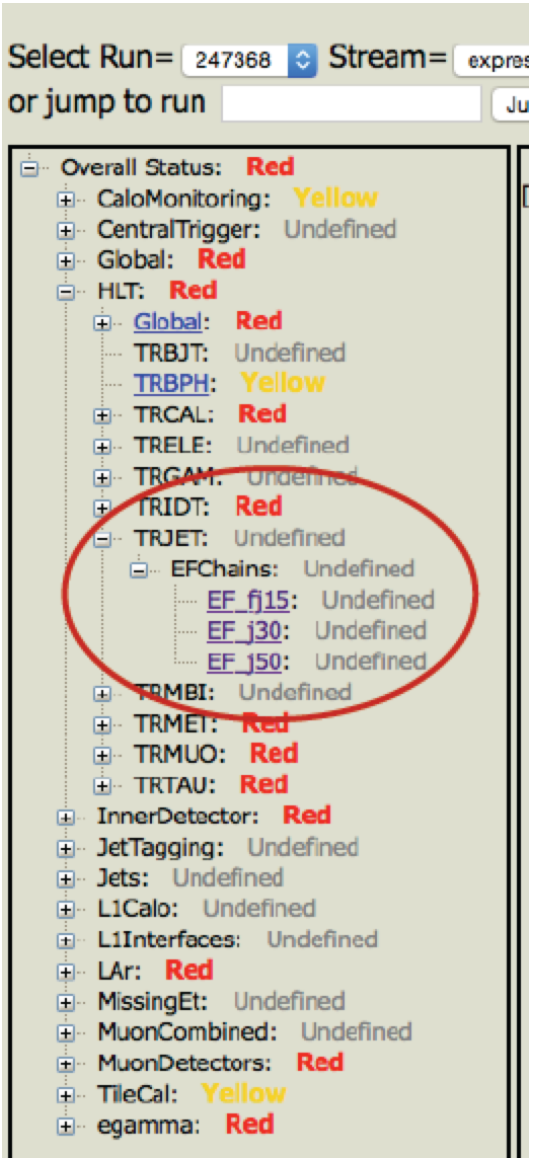
- Jet Algorithm:
  - **a4** = anti-kt jet finding algorithm with R parameter of 0.4
  - **a10** = anti-kt jet finding algorithm with R parameter of 1.0
- Input objects used for jet finding:
  - **tc** = TopoClusters reconstructed from calorimeter cells
  - **TT** = Level 1 TriggerTowers read out in HLT to allow fast but coarse full calo scan (a.k.a. Level 1.5)
- Calorimeter scan:
  - **PS** = partial calorimeter scan seeded by L1 RoI or L1.5
  - **FS** = full calorimeter scan (default)
- Pseudorapidity range:
  - **xxETAyy =** jets in interval xx < |η| < yy – default is **0eta32** (old central jets)
- Cluster Energy Scale correction:
  - **em** = no weights applied
  - **lcw** = local cluster weighting
- Jet Energy Scale correction:
  - **jes** = JES calibration factors without pileup subtraction
  - **sub** = pileup subtraction applied but no JES factors
  - **subjes** = both pileup subtraction and JES factors

- Some possible combinations:
  - **a4tcem** = jets built from EM-scale clusters with no jet level calibration
  - **a10tcemsubjes** = jets built from EM-scale clusters with pile-up subtraction and jet-level calibration
  - **a10TTem** = jets built from TriggerTowers with no jet level calibration
  - **a4tclcwsub** = jets built from LC-scale clusters with only a pile-up subtraction applied at the jet level
  - **a10tclcw_PS** = jets built from LC-scale clusters found in a SuperRoI seeded by all L1_Jx items

Commissioning so far…

- Running jet chains since M5
  - j0 seeded from MU10, J10, RD0; ht from J10; no hypo
- Online monitoring working
  - Improvements following experience from M weeks
- Offline monitoring now working as well
- Also allowing us to train team of experts





Lee Sawyer, Sebastien Prince, Aparajita Dattagupta

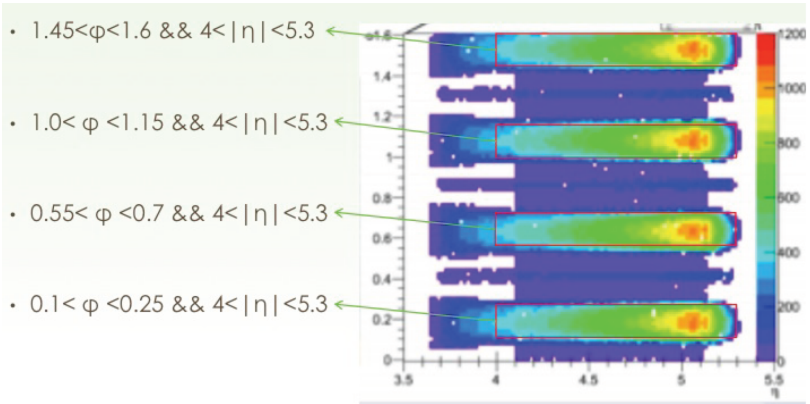
Conclusions

- Big changes in Jet Trigger for Run II
- Baseline plan:
  - Trigger Tower full scan to reduce input rate
  - Full calorimeter scan – Partial Scan as plan B
  - Jet area subtraction and as much as possible of offline calibration
- Long road to get here – but main features working
  - Much room for improvement! Volunteers (very) gladly accepted!

Bonus slides

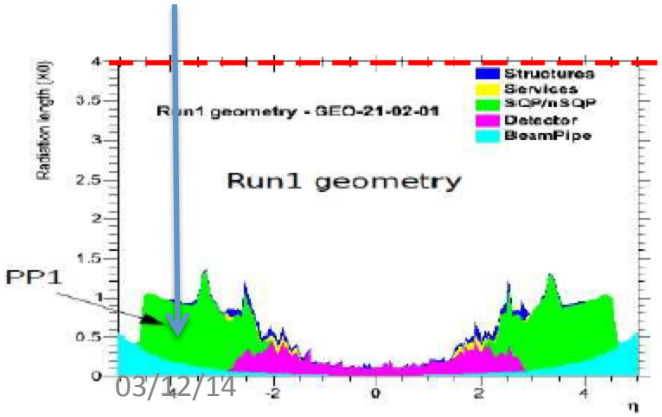
Specific issues – Jet calibration data

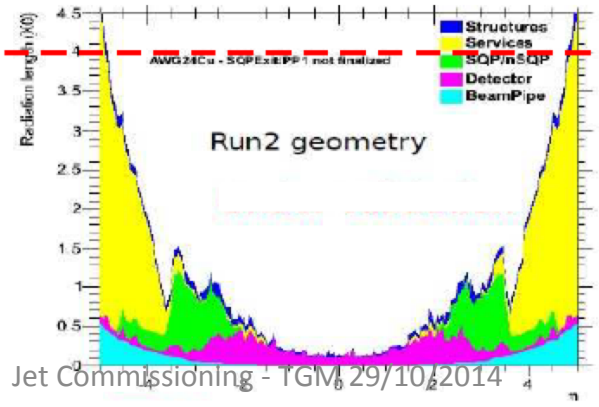
- Very important to collect enough data early on for offline jet calibration
- Forward region and intercalibration
- Even more important due to added material from IBL
  - Need ≈x16 increase in forward region

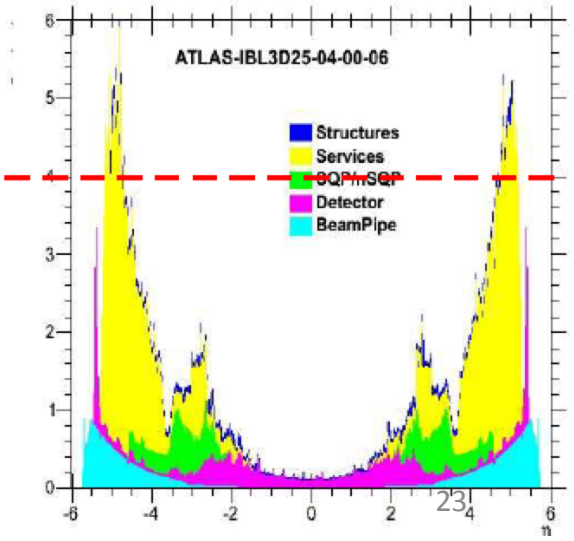


Run 1 **DC14** **Run 2?**

Eta=4







L1 Proposal

Item	0.5 x 10^{34}	1.0 x 10^{34}	1.5 x 10^{34}	2.0 x 10^{34}
L1_XE35	32 kHz	64 kHz	96.6 kHz	128.8 kHz
L1_XE40	19 kHz	38.3 kHz	57.5 kHz	76.7 kHz
L1_XE50	5.7 kHz	11.3 kHz	17 kHz	22.6 kHz
L1_XE60	2.1 kHz	4.3 kHz	6.4 kHz	8.6 kHz
L1_XE70	1.6 kHz	3.2 kHz	4.8 kHz	6.3 kHz
	50 ns run 1/fb	25 ns run 5/fb	25 ns run 9/fb	

Rates from menuFastTopo.py

Cannot add L1_KF-XE at this point to the menu, since simulation not ready; propose duplicate menu with similar thresholds

L1 Proposal

Proposed Evolution Pattern for unprescaled chains

Item	0.5×10^{34}	1.0×10^{34}	1.5×10^{34}	2.0×10^{34}
L1_XE35	35.3 kHz	70.7 kHz	106.0 kHz	141.3 kHz
L1_XE40	21.2 kHz	42.3 kHz	63.5 kHz	84.6 kHz
L1_XE50	6.1 kHz	12.2 kHz	18.3 kHz	24.4 kHz
L1_XE60	2.2 kHz	4.3 kHz	6.5 kHz	8.6 kHz
L1_XE70	1.4 kHz	2.8 kHz	4.1 kHz	5.5 kHz
	50 ns run 1/fb	25 ns run 5/fb	25 ns run 9/fb	

Rates from menuFastL1Calo.py

Foreseen rate at L1: ~ 6 kHz (3.5 kHz unique)

HLT Proposal

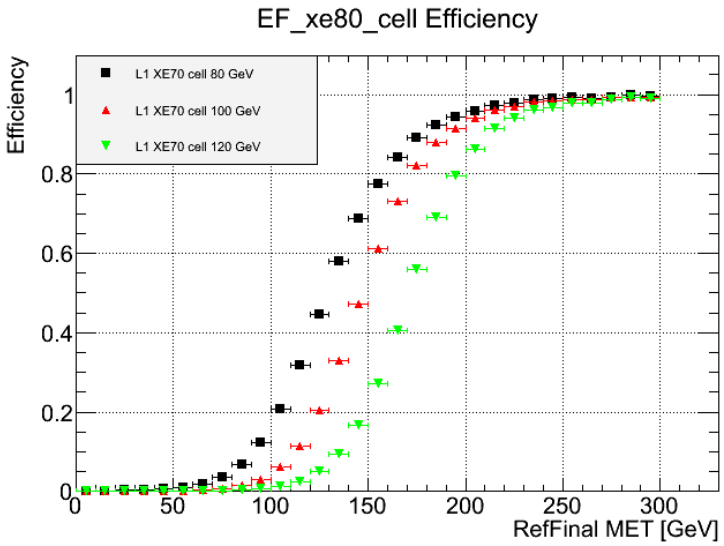
XE rates from menuFastTopo.py & menuFast.py differ a lot (factor of 10 not uncommon)

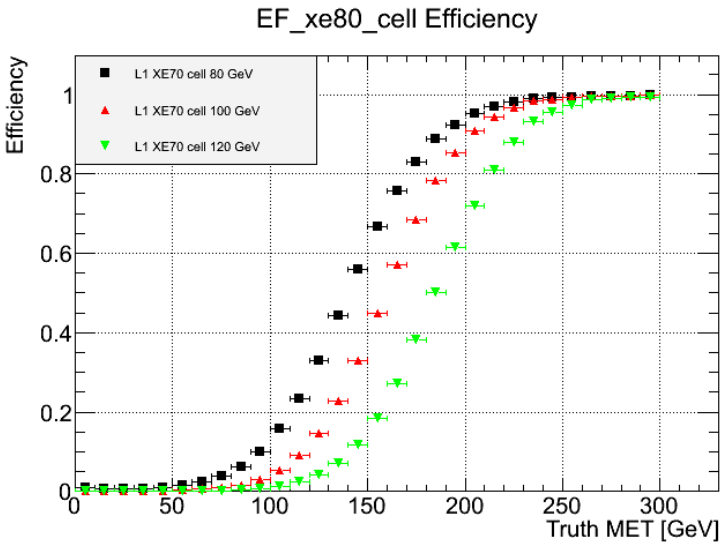
Item	0.5 x 10^{34}	1.0 x 10^{34}	1.5 x 10^{34}	1.5 x 10^{34}
	L1_XE50	L1_XE60	L1_XE60	L1_XE70
HLT_xe70	x	x		
HLT_xe80	x	x	x	
HLT_xe90		x	x	x
HLT_xe100			x	x
	50 ns run 1/fb	25 ns run 5/fb	25 ns run 9/fb	25 ns run 9/fb

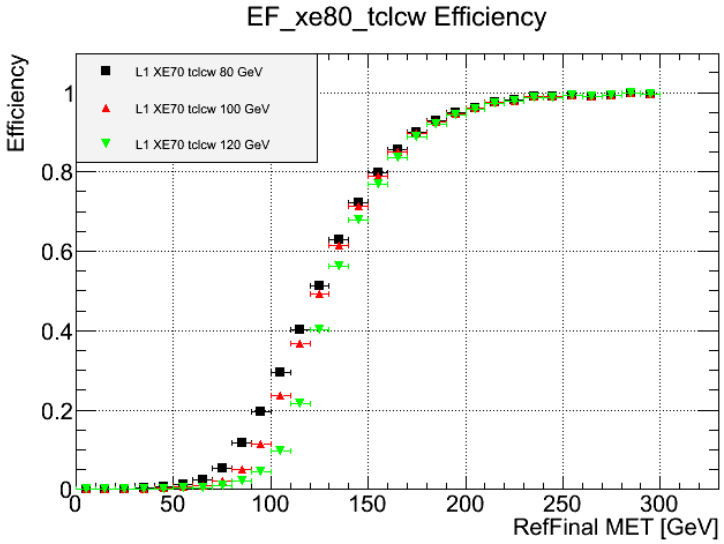
EM scale cuts; mht & tclcw should be higher

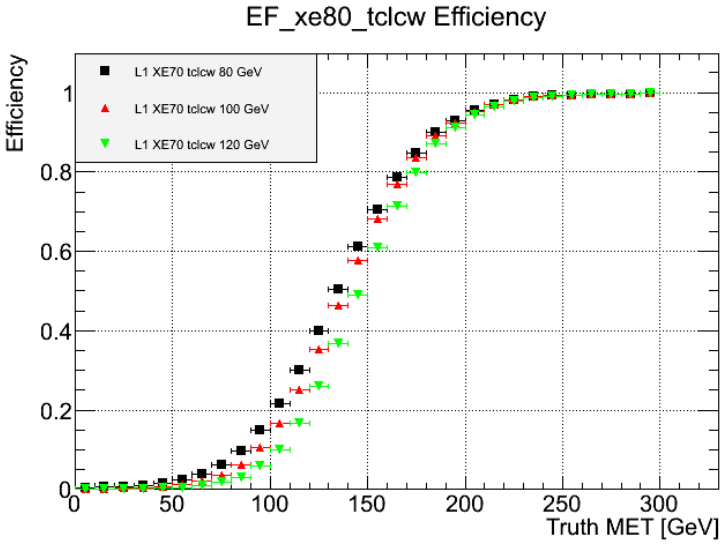
Contingency & learning from early data taking

Turn-on curves for L1_XE70 & HLT_xe_tclcw & cells









Bonus: rates with pileup correction

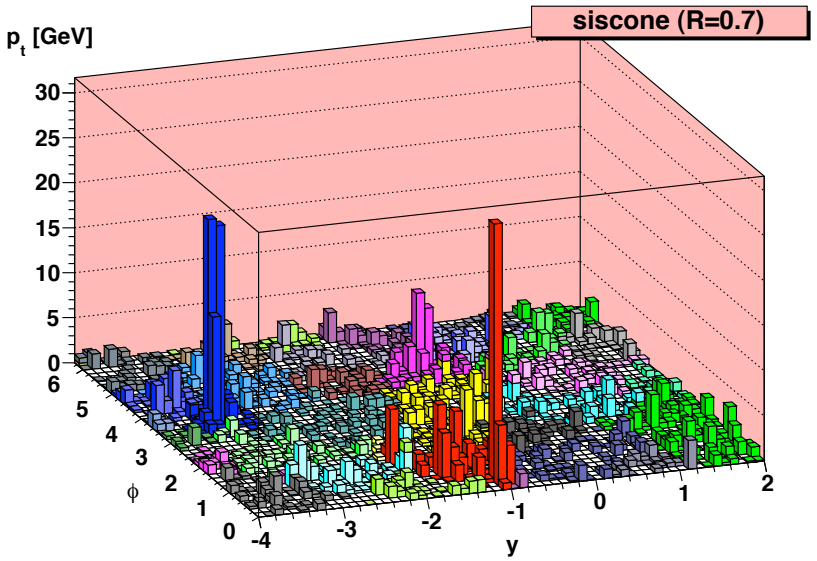
Erich Varnes

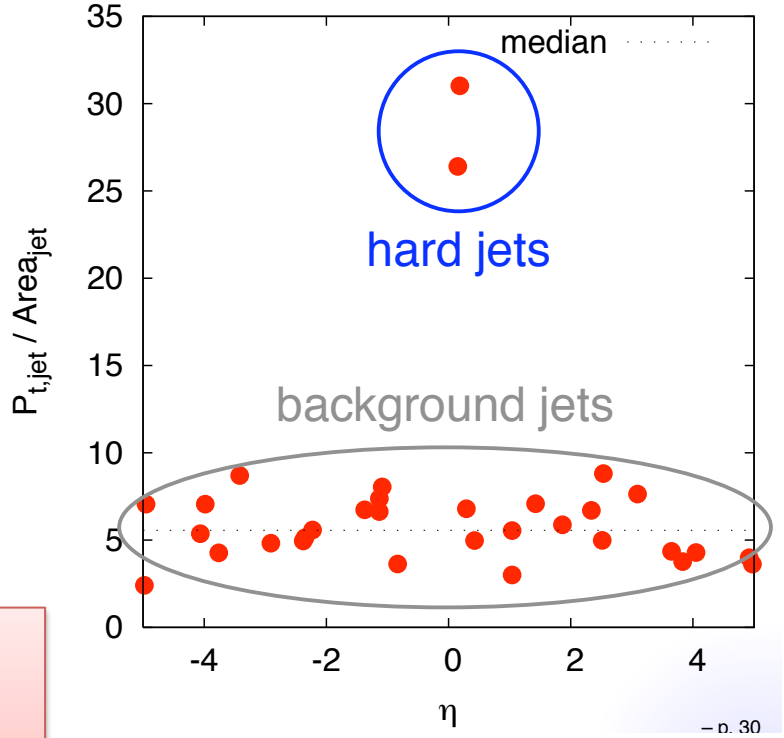
- Conditions:
  - L=2x10^{34}
  - 4j45 rate
  - No event weighting
- Only fixed **ρ=6** here
- ρ calculation works in private code so far
- **Top**: no areas subtraction
- **Bottom**: with ρ=6 area subtraction

Sample	Cross section	Filter eff	nevents	npass	rate
JZ0W	7.90E+07				
JZ1W	7.93E+07	3.11E-04	2800	18	3.17E+03
JZ2W	6.41E+04	5.39E-03	2900	18	4.29E+01
JZ3W	1.66E+03	1.90E-03	1700	7	2.60E-01
JZ4W	2.76E+01	1.49E-03	2100	26	1.02E-02
JZ5W	3.03E-01	5.51E-03	2400	52	7.23E-04
JZ6W	7.51E-03	1.52E-02	2600	83	7.29E-05
total rate (Hz)					3214.03

Sample	Cross section	Filter eff	nevents	npass	rate
JZ0W	7.90E+07				
JZ1W	7.93E+07	3.11E-04	1610	5	1.53E+03
JZ2W	6.41E+04	5.39E-03	1400	8	3.95E+01
JZ3W	1.66E+03	1.90E-03	1500	4	1.68E-01
JZ4W	2.76E+01	1.49E-03	1500	22	1.21E-02
JZ5W	3.03E-01	5.51E-03	1400	27	6.44E-04
JZ6W	7.51E-03	1.52E-02	300	9	6.85E-05
total rate (Hz)					1571.49

Pile-up subtraction: rho





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

Requires full event topoclusters for rho calculation

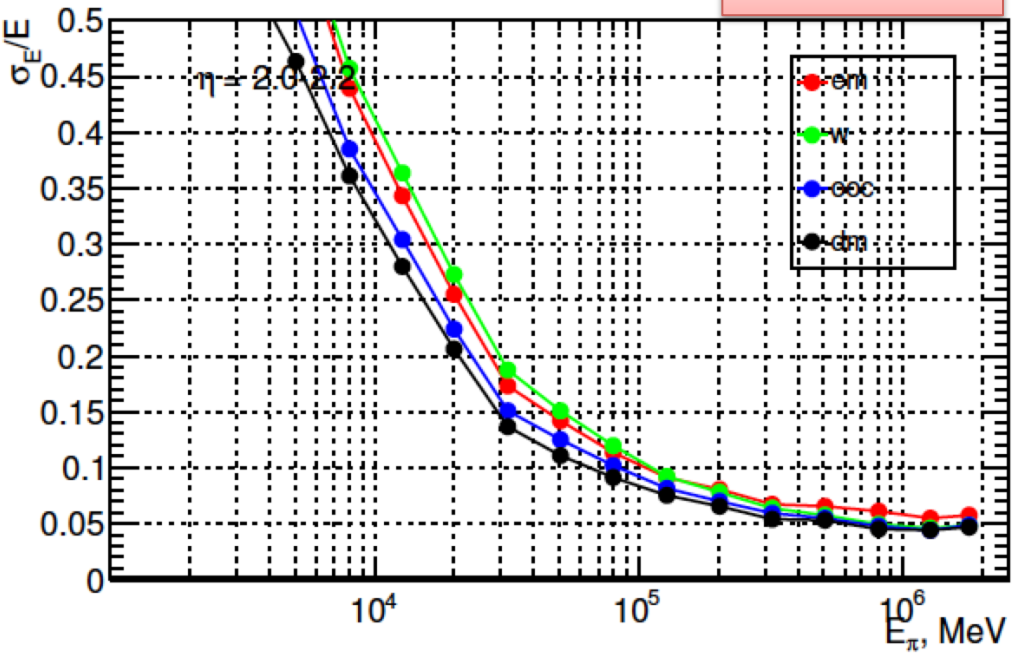
$$p_{t,\text{subtracted}} = p_{t,\text{jet}} - \rho_{\text{pileup}} \times \text{Area}_{\text{jet}}$$

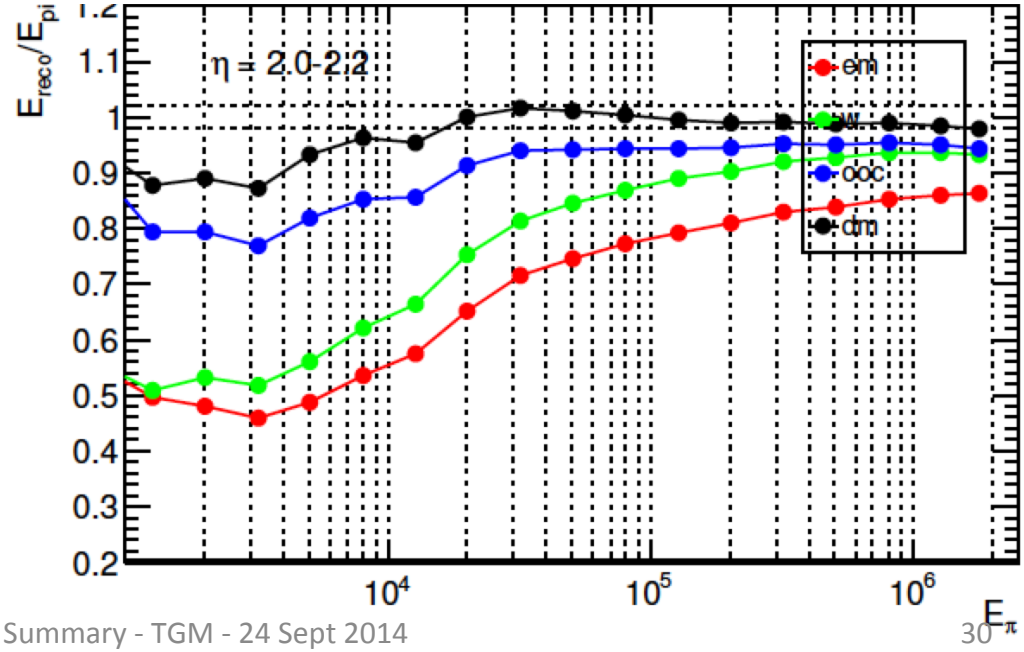
Cluster Calibration

Sven Menke

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

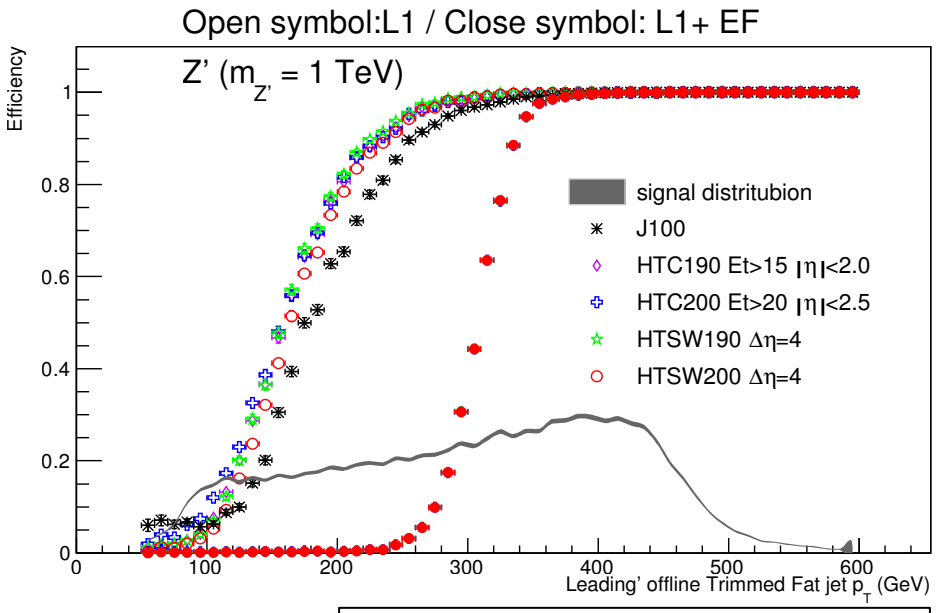
- Conditions:
  - <μ>=0
  - IBL geometry
  - 2<|η|<2.2
  - 4 samplings





L1Topo, Fat Jets, et al.

- L1Topo allows to cut on complex quantities using L1 objects
- Example here:
  - Optimization of fat-jet L1 seed
  - HTC: E_T sum of all jets with E_T>20GeV within $|\eta|$<2.5
- Several other studies, like:
  - HT trigger for stop searches
  - Fat-jet trigger for VV->jj
  - Razor triggers for resonances decaying to jets+invisible particles



UBA (Devesa, Reisin, Otero, Piegaia)

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
$\sum\sum E_T$ >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 Δη=4	5.3±0.8	1.9±0.6	1.1±0.5
HTSW>200 Δη=4	4.3±0.7	1.2±0.5	0.8±0.4