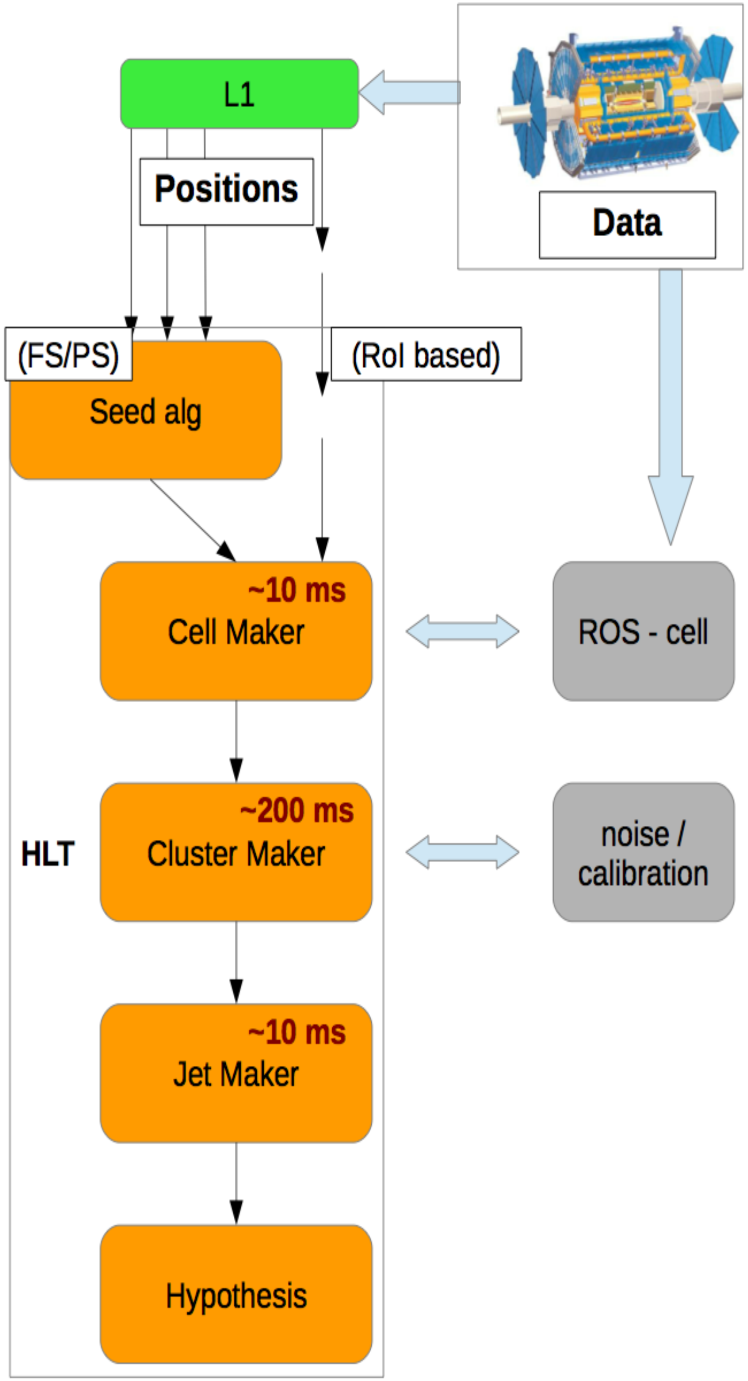
Overview of the Jet Trigger

Heavy Ion Trigger Menu Forum
10 February 2015
Ricardo Goncalo, David Miller
On behalf of Jet Trigger



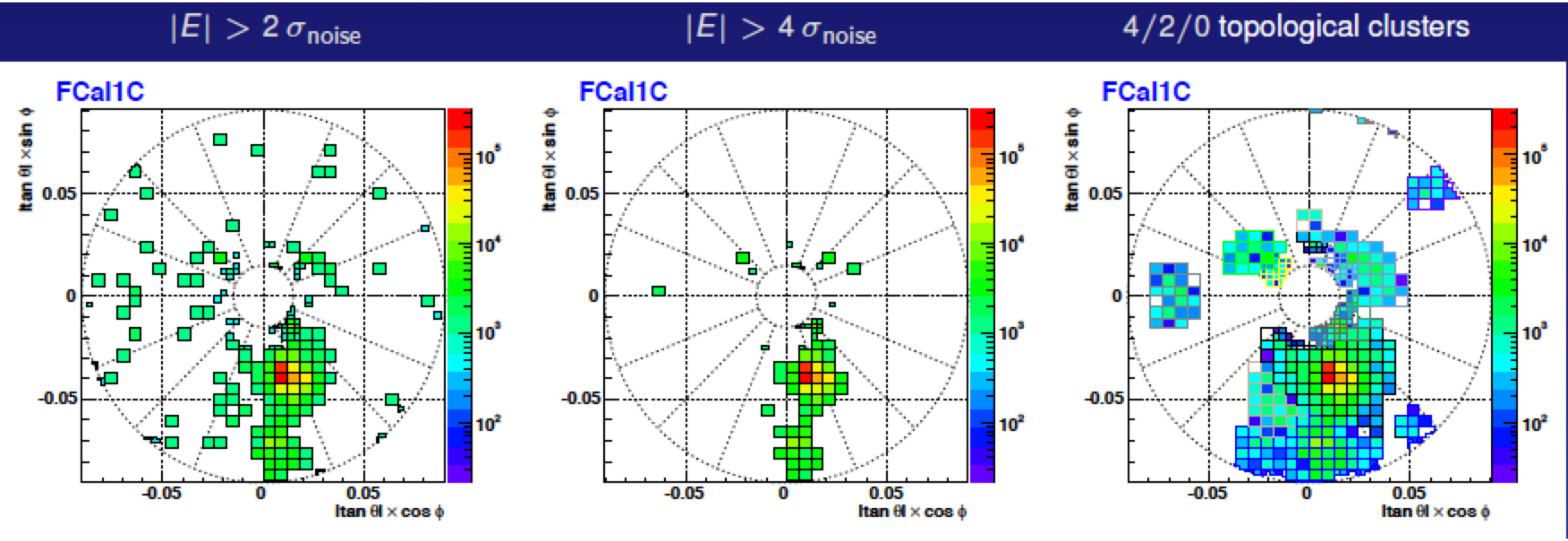
Changes Since Run 1

- No L2 anymore
  - And no EF, just High Level Trigger
- Move as close as possible to offline jet reconstruction
  - Add pileup subtraction (jet area)
  - Recover from L1 bias in close-by jets
  - Get best possible ET resolution to optimize use of bandwidth
    - Use offline calibration schemes
- Two possible readout schemes:
  - Full-scan of calorimeter: more accurate but takes time/CPU
  - Partial-scan as plan B if needed: no pileup subtraction
- Ongoing: Use L1.5 Trigger Tower full scan to reduce input HLT rate

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

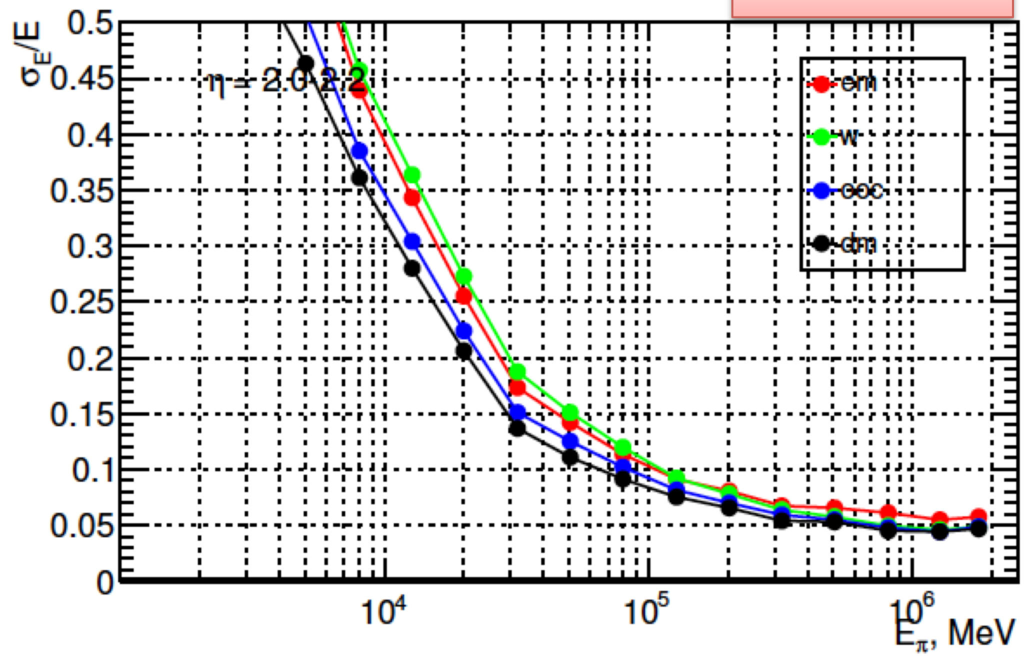


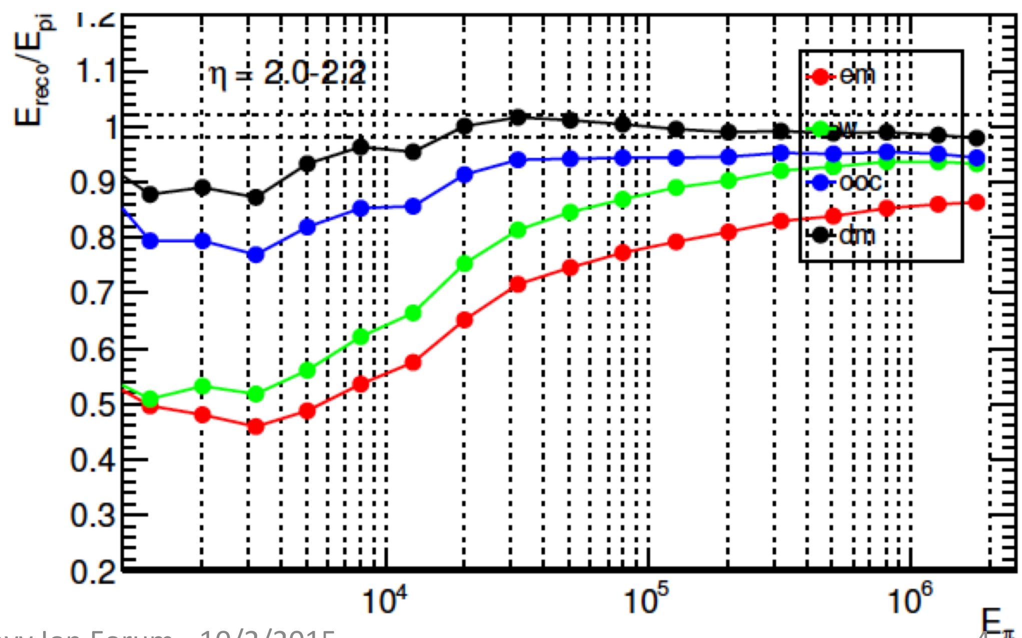
Sven Menke

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





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!

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Requires full event topoclusters for rho calculation

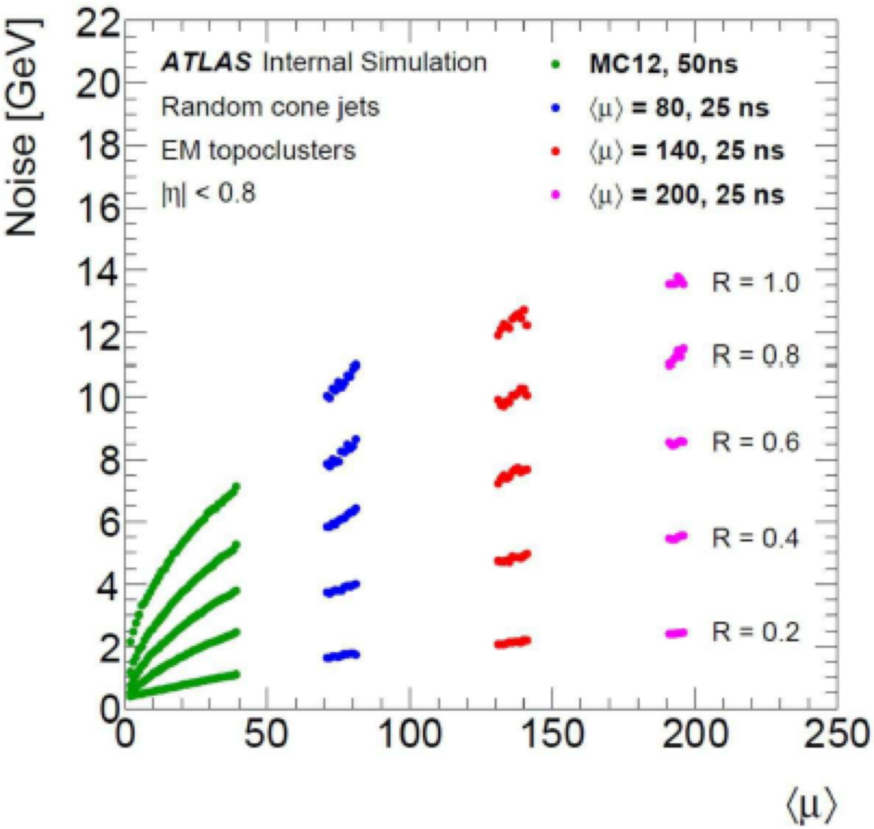
Requires full event tracks and PV identification

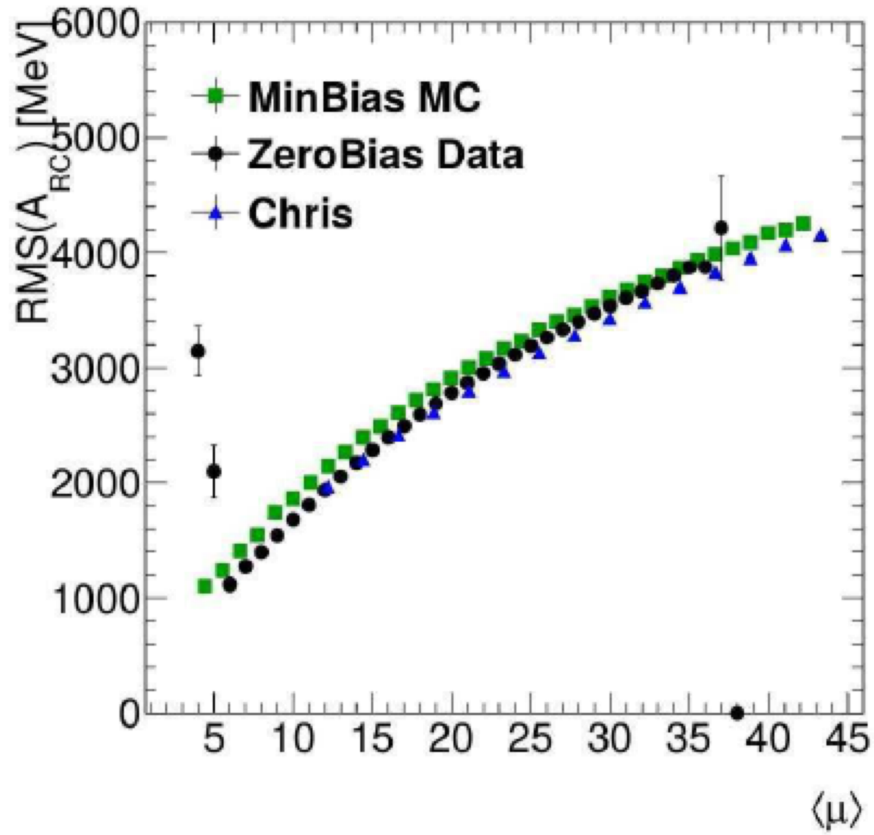
Only requires derived constants: f(pT, eta)

Requires extra jet info like layer energies and full tracking info

... Jets ready for physics!

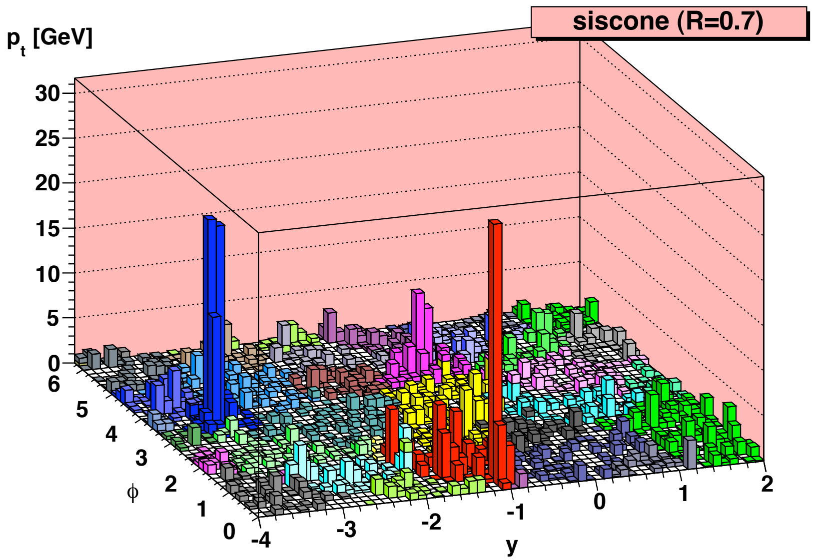
Jet Resolution — Noise Term

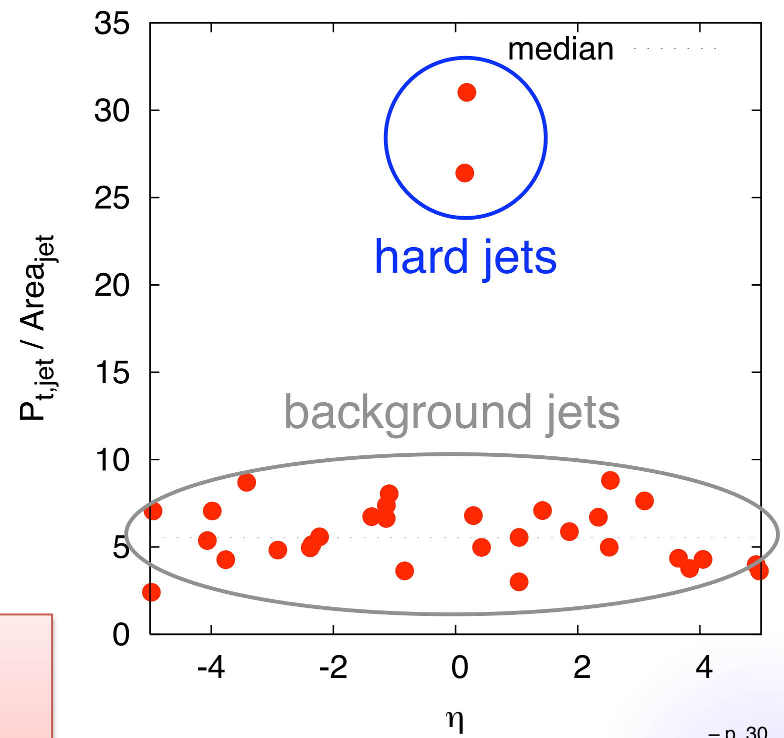




This is a major advance towards measuring the jet energy resolution noise term. It is so exciting, I just had to show it.

Pile-up subtraction: rho





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

Requires full event topoclusters for rho calculation

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

Ademar Delgado

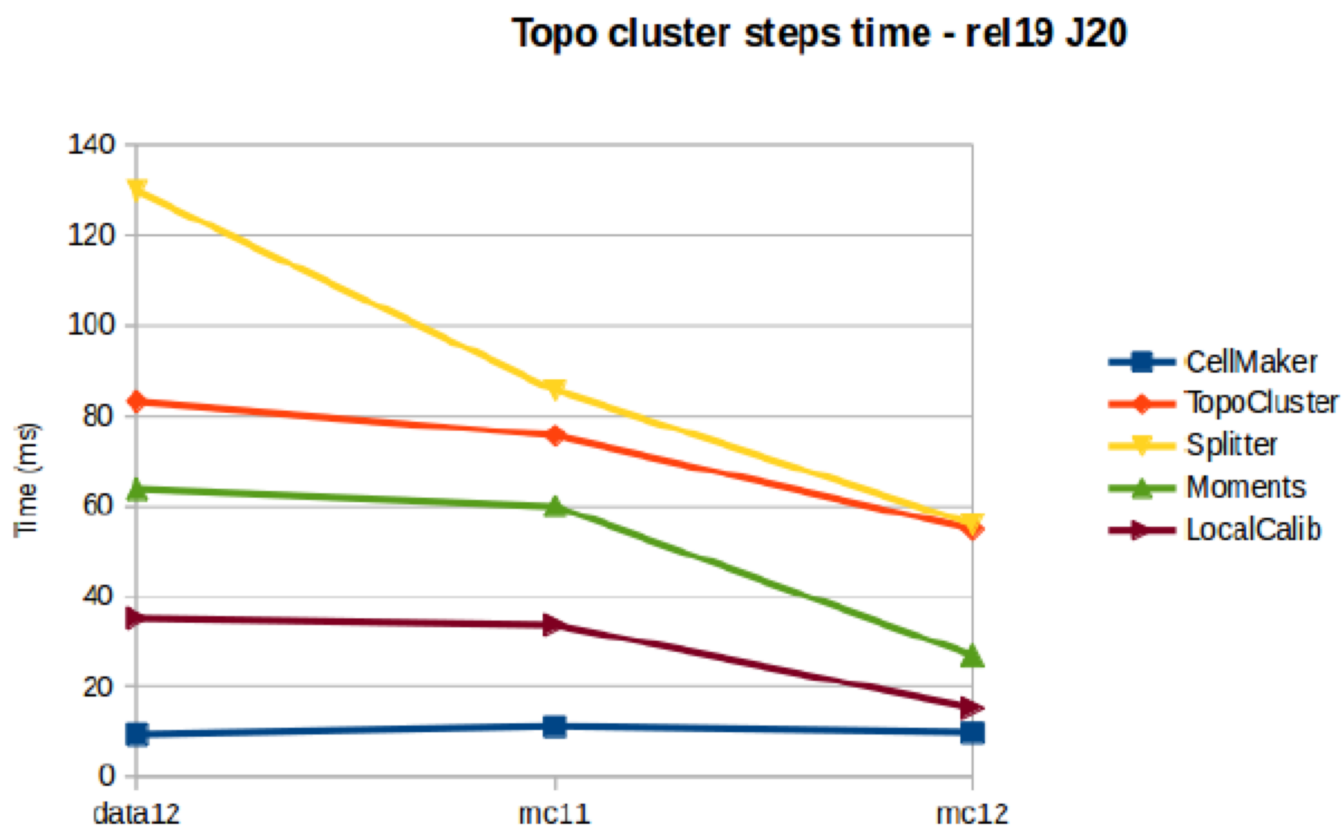
Partial vs Full Scan – Timing Summary

- **NOTE: indicative numbers only!**
- 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]	$\langle\mu\rangle=40$	$\langle\mu\rangle=80$	Calibration [ms]	$\langle\mu\rangle=40$	$\langle\mu\rangle=80$
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]	$\langle\mu\rangle=40$	$\langle\mu\rangle=80$	Calibration [ms]	$\langle\mu\rangle=40$	$\langle\mu\rangle=80$
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

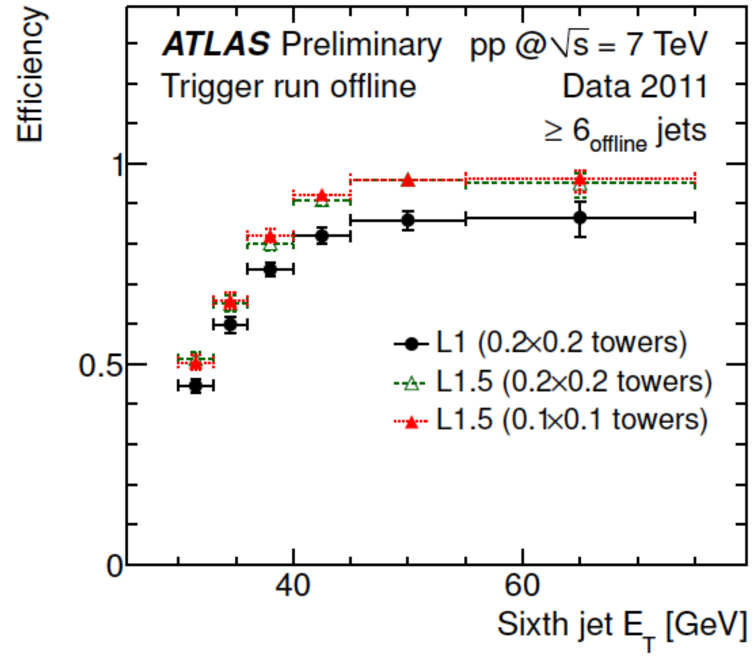
time vs different datasets: Cluster Maker Time

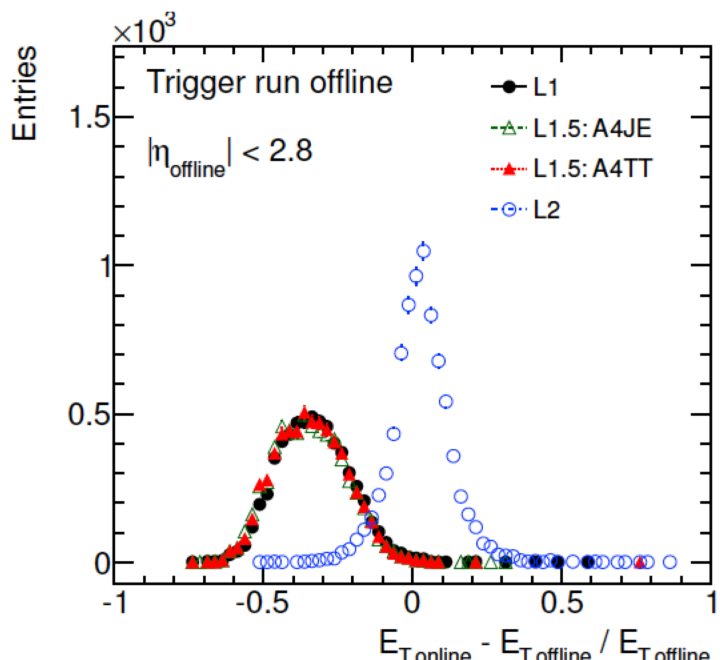


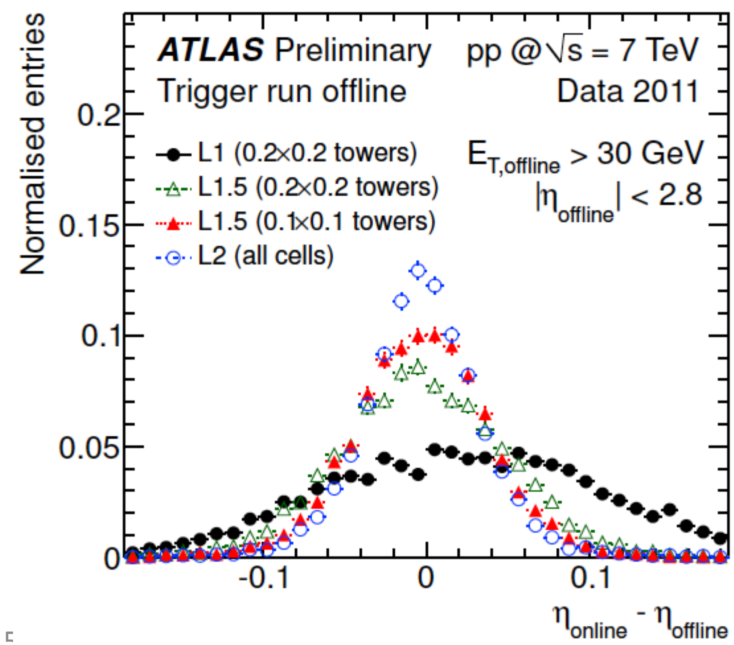
- data12: $< nClust >= 1476$
- mc11: $< nClust >= 1264$
- mc12: $< nClust >= 798.8$

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







Jet Menu for p-p Data

- 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
  - **nojcalib** = no jet calibration
- Defaults:
  - **Default options don't appear in chain names**
  - **0eta320**
  - **a10_tc_em_subjes_FS** = jets built from EM-scale clusters from calorimeter full scan, with pile-up subtraction and jet-level calibration
  - **a10_tc_em_nojcalib_FS** = jets built from EM-scale clusters from calorimeter Full Scan and no jet-level calibration or area subtraction

Key

```
# ---- Jet Dictionary of default
JetChainParts_Default = {
    'signature'     : ['Jet'],
    'L1item'        : '',
    'threshold'     : '',
    'multiplicity'  : '',
    'etaRange'      : '0eta320',
    'trigType'      :'j',
    'extra'         : '',
    'recoAlg'       :'a4',
    'dataType'      :'tc',
    'calib'         :'em',
    'jetCalib'      :'subjes',
    'scan'          :'FS',
    'addInfo'       : [],
    'topo'          : [],
    'bTag'          : '',
    'bTracking'     : '',
    'bConfig'       : [],
    'dataScouting'  : '',
```

Primary p-p jet menu

- Primary unprescaled triggers:
  - $5x10^{33}$ menu: j360, fatjet360, 4j85, 5j60, 6j50.0ETA24, ht800
  - $2x10^{34}$ menu: j400, fatjet450, 4j100, 5j85, 6j50.0ETA24, ht1000
- Default calibration: em_subjes
  - Plus cross check chains with different calibration for a few specific thresholds
- Additional chains to add segmented eta ranges
  - [0, 2.5] for e.g. b-tag (ID coverage)
  - [2.8, 3.2] + [3.2, 4.9] for granularity in forward region
- In each scenario, total jet menu rate adds up to around 100Hz

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

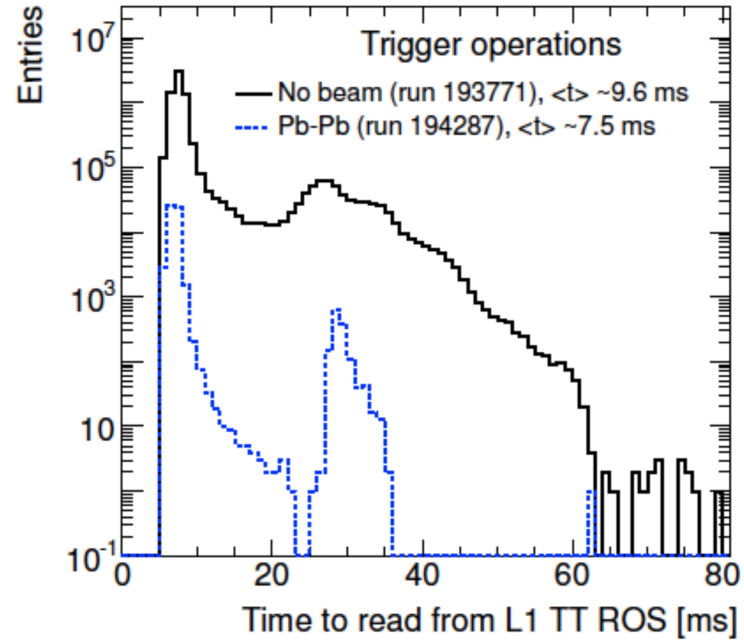
Summary

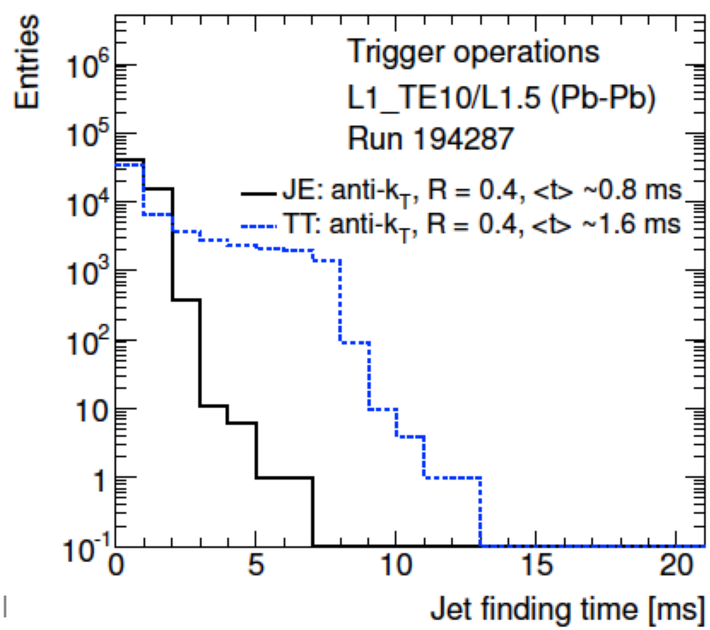
- Lots going on in preparation for the p-p run (much more than I could put here)
  - Huge migration from run-1 code
- Several unknowns still exist/things which are ongoing or haven't yet converged/been tested
  - L1.5 Trigger Tower full scan?
  - Calorimeter-only GSC?
  - Effect of nMCM L1Calo calibration on input rate
  - Data scouting
  - Jet reclustering
  - …
- Close interaction with offline jet/MET group
  - Extremely useful for software development and monitoring
  - Implies tight link with offline software – 2-edged sword
  - But expect great benefits from improved performance and sharing maintenance load
- Clear need for full-scan as default solution
  - 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
  - But keep partial scan as a crucial plan B
- NOW is time to include developments needed for HI run!

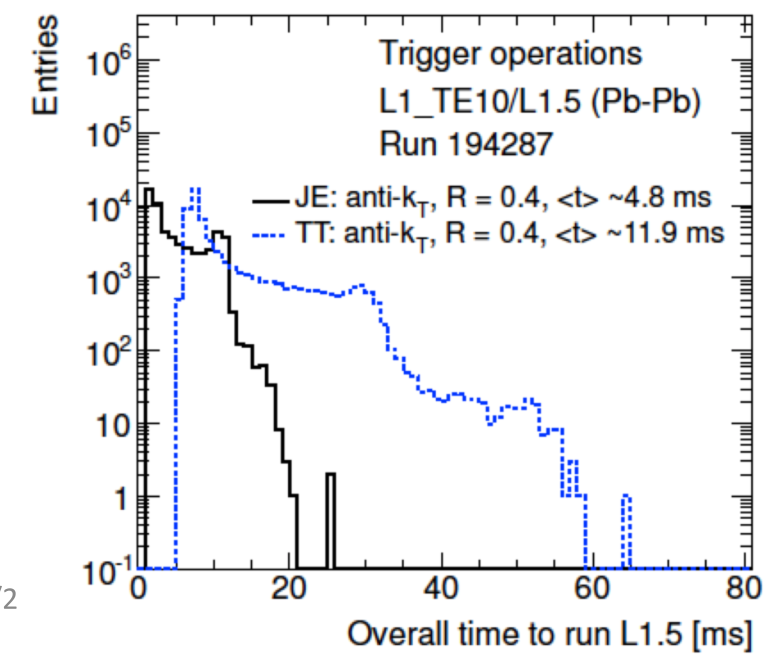
Backup

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







Bonus: rates with pileup correction

- 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
J20W	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
J20W	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

Inclusive single jet chains

Level 1 seed	Rate @ 0.5 & $2x10^{34}$	HLT chain	Rate @ 0.5 & $2x10^{34}$	Prescale@$2x10^{34}$	Clients
L1_RD0		j55_a4tcemsubjes	O(Hz)	?	bootstrap
		j60_a4tcemsubjes	O(Hz)	?	bootstrap
J12	0.95 / 3.8 MHz	j55_a4tcemsubjes	150 / 600 kHz	600,000 – 1 Hz	taus
J15	0.53 / 2.1 MHz	j60_a4tcemsubjes	100 / 400 kHz	400,000 – 1 Hz	taus, btag
J20	240 / 970 kHz	j85_a4tcemsubjes	21 / 85 kHz	85,000 – 1 Hz	taus, multi-j
		j85_a4tcemjes			
		j85_a4tclcwsubjes			
		j85_a4tclcwjes			
J25	130 / 510 kHz	j100_a4tcemsubjes	10 / 41 kHz	41,000 – 1 Hz	taus
J30	75 / 300 kHz	j110_a4tcemsubjes	6.5 / 26 kHz	26,000 – 1 Hz	LAr calib
J40	32 / 130 kHz	j150_a4tcemsubjes	1.6 / 6.5 kHz	6500 – 1 Hz	J+MET
J50	15 / 60 kHz	j175_a4tcemsubjes	0.75 / 3 kHz	3000 – 1 Hz	multijet
		j175_a4tcemjes			
		j175_a4tclcwsubjes			
		j175_a4tclcwjes			

Inclusive single jet chains

Level 1 seed	Rate @ 0.5 & 2x10^{34}	HLT chain	Rate @ 0.5 & 2x10^{34}	Prescale@2x10^{34}	Clients
J60	7.5 / 30 kHz	j200_a4tcemsubjes	0.4 / 1.6 kHz	1600 – 1 Hz	btag
J75	4 / 17 kHz	j260_a4tcemsubjes	140 / 400 Hz	400 – 1 Hz	btag, low Lumi
J85	2.5 / 10 kHz	j300_a4tcemsubjes	67 / 270Hz	200 – ≈1 Hz	multijet, medium Lumi
		j320_a4tcemsubjes	43 / 170 Hz	150 – ≈1 Hz	multijet, medium Lumi
J100	1.3 / 5 kHz	j360_a4tcemjes	22 / 90 Hz	100 – ≈1 Hz	unprescaled at 1x10^{32} or lower: aim for 1-2 points during year to change lowest unprescaled chain
		j380_a4tcemsubjes	16 / 65 Hz	50 – ≈1 Hz	
		j380_a4tcemjes			
		j380_a4tclcwsubjes			
		j380_a4tclcwjes			
		j400_a4tcemsubjes	9 / 35 Hz	unprescaled	Also re-think set of cross-check chains with different calibrations if needed
		j400_a4tcemjes			
		j400_a4tclcwsubjes			
		j400_a4tclcwjes			
J120	1.3 / 2.7 kHz	j460_a4tcemjes + cross-check chains	<1 / 2.8 Hz	unprescaled	High Lumi
J400	0 / 0 Hz	noAlg	5.5 Hz	unprescaled	Passthrough

Multi-jet and fat jet chains

Level 1 seed	@ 0.5 & 2x10^{34}	HLT chain	@ 0.5 & 2x10^{34}	Prescale@2x10^{34}	Clients
3J40	0.4 / 1.6 kHz	4j85_a4tcemsubjes	45 / 180 Hz	180 – 1 Hz	
3J50	0.3 / 1.0 kHz	4j100_a4tcemsubjes	12 / 50 Hz	unprescaled	SUSY, SM, top, jets
4J15	2.4 / 9.5 kHz	5j55_a4tcemsubjes	65 / 260 Hz	260 – 1 Hz	
4J20	0.5 / 1.9 kHz	5j60_a4tcemsubjes	40 / 170 Hz	170 – 1 Hz	
4J20	0.5 / 1.9 kHz	5j85_a4tcemsubjes	4 / 15 Hz	unprescaled	SUSY, SM, top, jets
		5j85_a4tcemjes			
		5j85_a4tclcwsubjes			
		5j85_a4tclcwjes			
5J15.0ETA24	0.1 / 0.3 kHz	6j45.0eta24_a4tcemsubjes	25 / 100 Hz	100 – 1 Hz	SUSY, SM (*)
5J15.0ETA24	0.1 / 0.3 kHz	6j50.0eta24_a4tcemsubjes	10 / 40 Hz	unprescaled	SUSY, SM (*)
5J15.0ETA24	0.1 / 0.3 kHz	6j55.0eta24_a4tcemsubjes	8 / 30 Hz	30 – 1 Hz	SUSY, SM (*)
HT150	3 / 12 kHz	j360_a10tcemsubjes	14 / 60 Hz	60 – 1 Hz	exotics, jets
HT190	1.2 / 5 kHz	j450_a10tcemsubjes	2 / 8 Hz	unprescaled	exotics, jets

(*) A new study from SUSY indicates that 6j chains can/should start from 4J20 to save bandwidth – need to understand if this is also ok for SM

Forward jet and HT chains

Level 1 seed	Rate @ 0.5 & 2x10^{34}	HLT chain	Rate @ 0.5 & 2x10^{34}	Prescale@2x10^{34}	Clients
J15.24ETA49	?	j60.24eta49	?	? – 1 Hz	egamma
J15.28ETA32	?	j60.28eta32	?	? – 1 Hz	SUSY, SM, top, jets
J20.28ETA32	?	j85.28eta32	?	? – 1 Hz	jets
J15.32ETA49	?	j60.32eta49	?	? – 1 Hz	jets
J20.32ETA49	?	j85.32eta49	?	? – 1 Hz	jets
J30.32ETA49	?	j110.32eta49	?	? – 1 Hz	jets
J50.32ETA49	?	j175.32eta49	0	unprescaled	Jets, SM
J75.32ETA49	?	j260.32eta49	0	unprescaled	SM
J100.32ETA49	?	j360.32eta49	0	unprescaled	SM

- Default R parameter and calibration is a4tcemsubjes
- Add cross-check chains (a4tcemjes, a4tclcwsubjes, a4tclcwjes) for:
    - j85.28eta32, j85.32eta49, j175.32eta49, j260.32eta49, j360.32eta49

Level 1 seed	Rate @ 0.5 & 2x10^{34}	HLT chain	Rate @ 0.5 & 2x10^{34}	Prescale@2x10^{34}	Clients
HT190	1.2 / 5 kHz	ht1000	3.5/14 Hz (0 unique)	unprescaled	
HT150		Ht500(?)		prescaled	