Introduction to the Jet Trigger

Jet Trigger Readiness Review Meeting

Ricardo Goncalo, David W. Miller

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Todays overview of the Jet Slice

1. *Jet Trigger Menu, Operations and Infrastructure*
   - Jet trigger menu
   - Monitoring
   - Software developments and validation
2. *Jet Trigger Performance*
   - L1Topo emulation validation
   - Single jet efficiency studies
   - HLT jet calibrations
   - Plans for public results
3. *Open Issues*
   - Core software, Trigger Menu, Performance Metrics
4. *Summary and conclusions*

Jet Trigger Menu for Run 2 (I)

→ We have a large number of new options for jet reconstruction and calibration for Run 2!

- **Jet Algorithm:**
  - **`a4`** = anti-k_t jet finding algorithm with $R = 0.4$ **(default)**
  - **`a10`** = anti-k_t jet finding algorithm with $R = 1.0$
  - **`a10r`** = anti-k_t jet finding algorithm with $R = 1.0$ using $R = 0.4$ jets as input
- **Input objects used for jet finding:**
  - **`tc`** = TopoClusters reconstructed from calorimeter cells **(default)**
  - **`TT`** = Level 1 TriggerTowers read out in HLT to allow fast but coarse full calo scan (L1.5)
- **Calorimeter scan:**
  - **`PS`** = partial calorimeter scan seeded by L1 RoI or L1.5
  - **`FS`** = full calorimeter scan **(default)**
- **Pseudorapidity range:**
  - **`xxETAyy`** = jets in interval $xx < |\eta| < yy$; default is `0eta32` (old central jets)
- **Cluster Energy Scale correction:**
  - **`em`** = no weights applied **(default)**
  - **`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 **(default)**
  - **`nojcalib`** = no jet-level calibrations or corrections at all

Jet Trigger Menu for Run 2 (II)

Examples of jet trigger combinations for Run 2

- **`a4tcemnojcalib`**: $R = 0.4$ jets built from EM-scale clusters with no jet level calibration
- **`a10tcemsubjes`**: $R = 1.0$ jets built from EM-scale clusters with pile-up subtraction and jet-level calibration
- **`a4tclcwsub`**: $R = 0.4$ jets built from LC-scale clusters with only a pile-up subtraction applied at the jet level

A few HLT and L1 trigger chains for Run 2

HLT	Level 1
`j175`	`L1_J50`
`j175_jes`	`L1_J50`
`6j45`	`L1_4J15`
`ht400`	`L1_HT150-J20s5.ETA30`
`j360_a10r_L1J100`	`L1_J100`

Jet Trigger Menu for Run 2 (III)

Primary jet menu items at low & high lumi

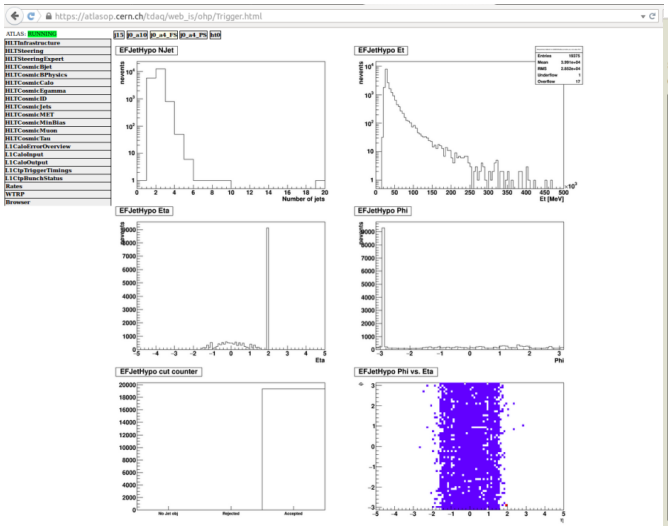
- 0.5×10^{34} cm^{-2}s^{-1} menu:
  - `j360_a4, j360_a10, 4j85, 5j60, 6j50.0ETA24`
- 2×10^{34} cm^{-2}s^{-1} menu:
  - `j400_a4, j450_a10, 4j100, 5j85, 6j50.0ETA24`
- Current default calibration: `emsubjes`

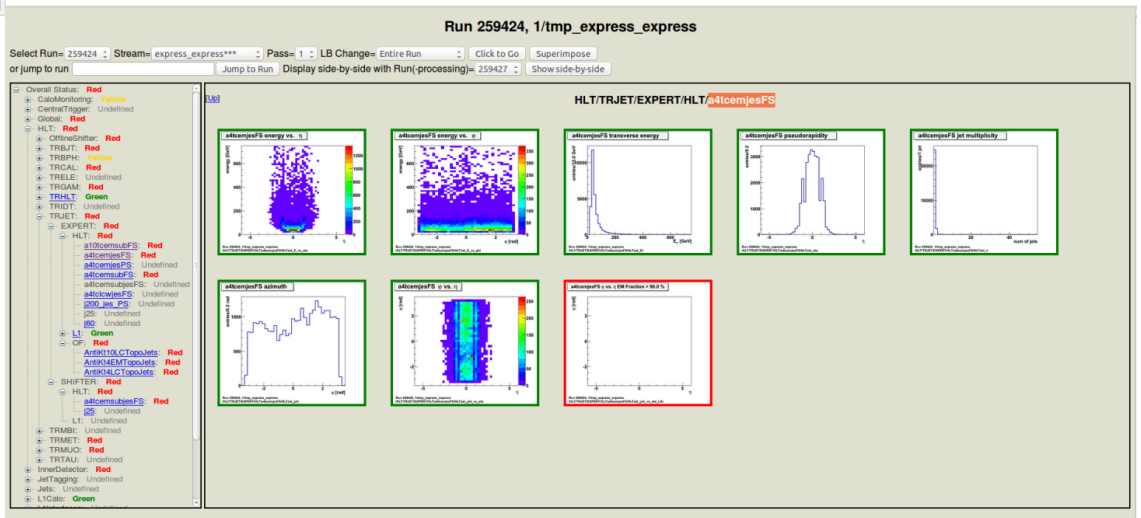
Primary jet chains at low & high lumi

Chain type	L1 at 0.5×10^{34}	HLT at 0.5×10^{34}	L1 at 2×10^{34}	HLT at 2×10^{34}
Single jet	J75	j360	J100	j400
Fat jet	HT150	j360_a10	HT190	j450_a10
4 jet	3J40	4j85	3J50	4j100
5 jet	4J15	5j60	4J20	5j85
6 jet	5J15.0ETA24	6j50.0eta24	5J15.0ETA24	6j50.0eta24
H_{T}	HT190	ht800	HT190	ht1000

Monitoring the jet trigger: online and offline

Giulio Grossi, Lee Sawyer





- Extensive and up-to-date **online and offline** monitoring in place
- Standard task in shifter duties
- Plans for extensions to the monitoring plots for efficiency comparisons and calibration checks w.r.t. offline

Open questions: What is missing? What can we do differently? What is working?

Software development and validation (I)

Peter Sherwood, Nuno Anjos, Lee Sawyer (+ offline group!)

```
TrigEDMChecker REGTEST Got jet container HLT_xAOD__JetContainer_a4tclcwsubjesFS, size: 7
TrigEDMChecker REGTEST Looking at jet 1
TrigEDMChecker REGTEST    pt: 152665
TrigEDMChecker REGTEST    eta: -0.00683636
TrigEDMChecker REGTEST    phi: 2.81077
TrigEDMChecker REGTEST    m: 7678.41
TrigEDMChecker REGTEST    e: 152861
TrigEDMChecker REGTEST    px: -144387
TrigEDMChecker REGTEST    py: 49588.2
TrigEDMChecker REGTEST    pz: -1043.68
TrigEDMChecker REGTEST    type: xAOD::Type::Jet
TrigEDMChecker REGTEST    algorithm (kt: 0, cam: 1, antikt: 2, ...): 2; should be 2
TrigEDMChecker REGTEST    size parameter: 0.4; should be 0.4
TrigEDMChecker REGTEST    input (LCTopo: 0, EMTopo: 1, TopoTower: 2, ...): 0; should be 0
TrigEDMChecker REGTEST    constituents signal state (uncalibrated: 0, calibrated: 1): 1; should be 1
TrigEDMChecker REGTEST    number of constituents: 8
TrigEDMChecker REGTEST    Got constituent vector, size: 8; should be 8
TrigEDMChecker REGTEST    FracSamplingMaxIndex: 2
TrigEDMChecker REGTEST    ActiveArea: 0.498666
TrigEDMChecker REGTEST    AverageLArQF: 111.318
TrigEDMChecker REGTEST    BchCorrCell: 0
TrigEDMChecker REGTEST    CentroidR: 1893.06
TrigEDMChecker REGTEST    HECQuality: 0
TrigEDMChecker REGTEST    LArQuality: 0
TrigEDMChecker REGTEST    NegativeE: -790.483
TrigEDMChecker REGTEST    Timing: 0.02109
TrigEDMChecker REGTEST    FracSamplingMax: 0.542925
TrigEDMChecker REGTEST    EMFrac: 0.812707
TrigEDMChecker REGTEST    HECFrac: 0
TrigEDMChecker REGTEST    N90Constituents: 2
TrigEDMChecker REGTEST    OotFracClusters10: 0
TrigEDMChecker REGTEST    OotFracClusters5: 0
```

Jet properties

Year:	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015	2015
Month:	3	3	3	3	3	3	3	3	3	3	3	3
Day:	21	22	23	24	25	26	27	28	29	30	31	31
rel	_5	_6	_0	_1	_2	_3	_4	_5	_6	_0	_1	_2
Job CPU time (sec):	5230	3656	3271	3342	3171	2911	1656	1246	1312	1875	1442	1434
Job Max memory (MB):	1662	1656	1658	1642	1649	1657	1589	1589	1600	1583	1595	1589
n events in test:	999	999	999	999	999	999	1000	1000	1000	1000	1000	1000
HLT_j55	920	920	920	920	920	920	934	934	934	934	934	934
HLT_j55_L1RD0	922	922	922	922	922	922	934	934	934	934	934	934
HLT_j60	890	890	890	890	890	890	901	901	901	901	901	901
HLT_j60_280eta320	27	27	27	27	27	27	27	27	27	27	27	27
HLT_j60_320eta490	24	24	24	24	24	24	22	22	22	22	22	22
HLT_j60_L1RD0	891	891	891	891	891	891	901	901	901	901	901	901
HLT_j85	655	655	655	655	655	655	644	644	644	644	644	644
HLT_j85_280eta320	19	19	19	19	19	19	17	17	17	17	17	17
HLT_j85_280eta320_jes	21	21	21	21	21	21	17	17	17	17	17	17
HLT_j85_280eta320_lcw	18	18	18	18	18	18	18	18	18	18	18	18
HLT_j85_280eta320_lcw_jes	21	21	21	21	21	21	18	18	18	18	18	18
HLT_j85_280eta320_lcw_nojcalib	18	18	18	18	18	18	14	14	14	14	14	14
HLT_j85_280eta320_nojcalib	9	9	9	9	9	9	4	4	4	4	4	4
HLT_j85_320eta490	14	14	14	14	14	14	9	9	9	9	9	9
HLT_j85_jes	778	778	778	778	778	778	644	644	644	644	644	644
HLT_j85_L1RD0	655	655	655	655	655	655	644	644	644	644	644	644
HLT_j85_lcw	600	600	600	600	600	600	641	641	641	641	641	641
HLT_j85_lcw_jes	737	737	737	737	737	737	643	643	643	643	643	643
HLT_j85_lcw_nojcalib	616	616	616	616	616	616	544	544	544	544	544	544
HLT_j85_nojcalib	410	410	410	410	410	410	337	337	337	337	337	337

Trigger counts

None of the above would have been possible without significant, persistent and skilled efforts to upgrade our software for in deep ways for Run 2

- Multiple jet definitions (`a4, a10, a10r`), calibrations, pile-up subtraction, and chain definitions
- Jet properties for jet cleaning and calibration (incl. GSC!)
- New and updated monitoring plots and capabilities (e.g. trigger aware monitoring)

L1Topo emulation validation

Imma Riu

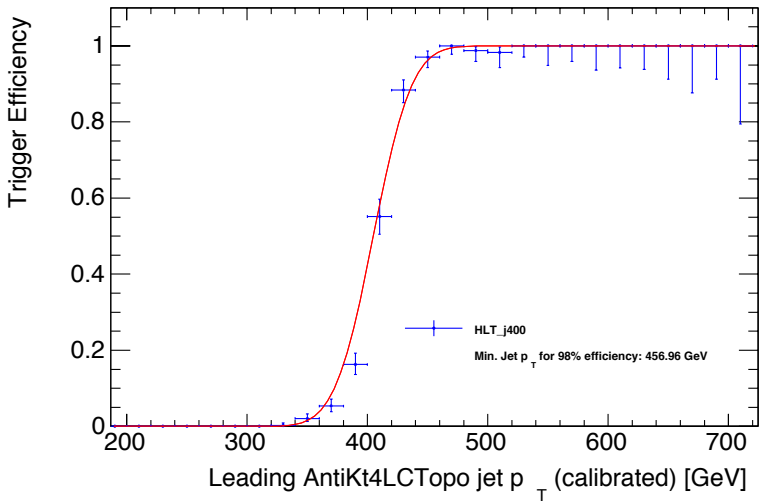
L1Topo item	Sample A accepts	Emulation accepts
HT190-J15.ETA20	1151	1151
HT190-J15s5.ETA20	1148	1144
HT150-J20.ETA30	1958	1958
HT150-J20s5.ETA30	1958	1957
HT20-AJj15all.ETA49	4879	4879

- Overall, very good agreement with the L1Topo simulation
- A small number of strange discrepancies found

Need to perform more detailed cross checks of the complex, multi-object triggers in L1Topo. What can we do better?

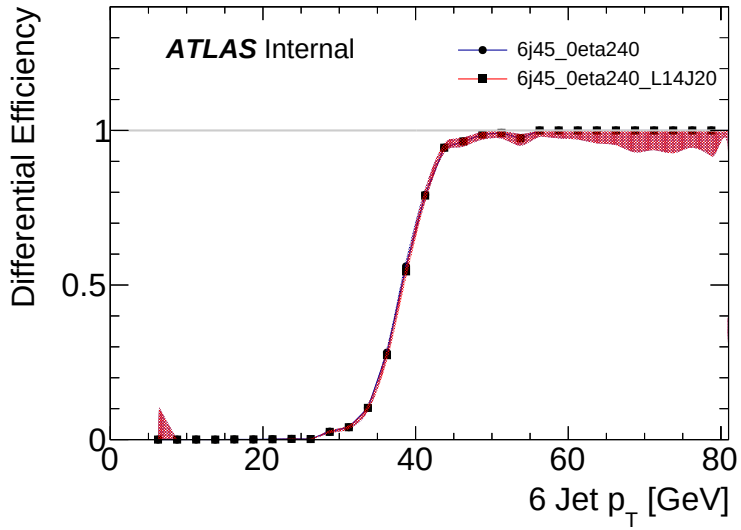
Jet trigger efficiency studies

Merlin Davies



HLT_j400 ($t\bar{t}$)

Will Fawcett



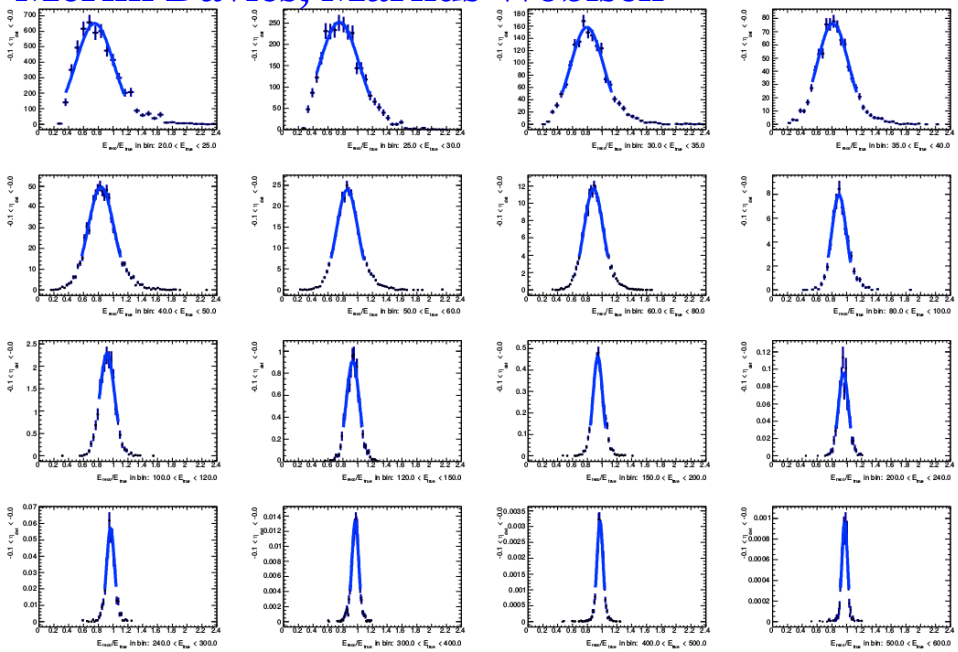
6 jet triggers

- Significant progress on performance studies; Focusing on trigger efficiency curves
- See very good (and expected!) threshold widths and values
- Studies continued with mutlijet trigger chains (primarily in context of SUSY multijet analysis)
- Initial indication that LCW has advantages, but *offline jet energy scale used as reference not in sync* (i.e. offline LCW jets used for HLT EM+JES jets)

For the future: refine details, cross-check rates, direct resolution studies, automated turn-ons, ... what else???

HLT jet calibration

Merlin Davies, Markus Wobisch

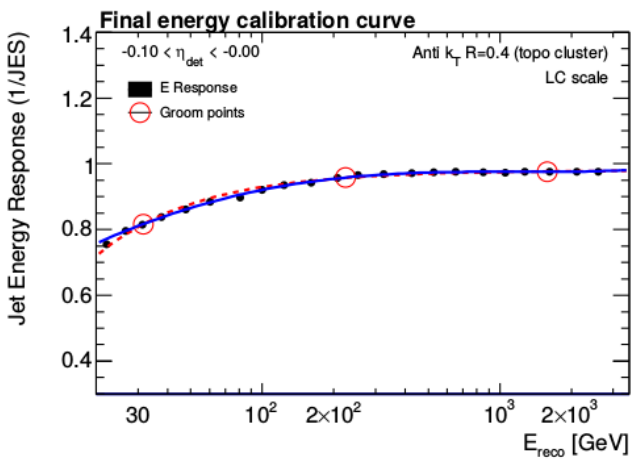


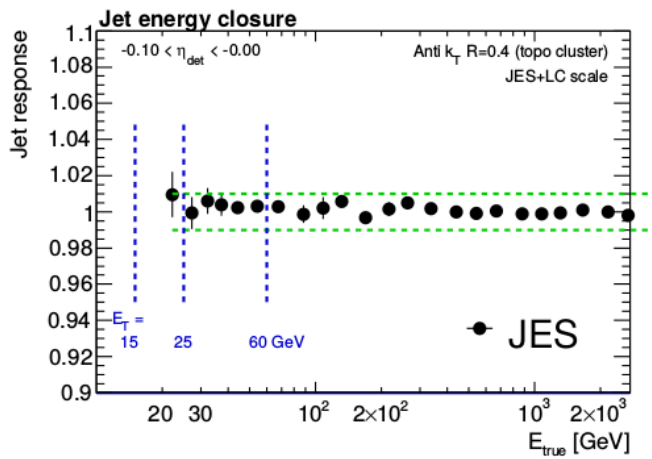
Jet calibration efforts

Good progress towards providing final jet calibrations

Flexible and extensive calibration menu implies many new calibrations required

Identical framework to offline jet calibration being used for HLT JES determination





Some ideas for initial public results

- **Jet trigger "standalone" performance and properties**
  - Number of topoclusters per event
  - Timing plots with partial scan
  - p_{T} spectra for all jets
  - Trigger rates for each chain
  - Rate vs. N_{PV} or ρ, with and without subtraction
  - Jet p_{T} vs. N_{PV} or ρ, with and without subtraction
  - Jet multiplicity vs N_{PV} or ρ, with and without subtraction
  - Re-clustered jet turn on curve compared to fat-jet turn on curve
  - Jet cleaning on data scouting jets with each successive cut
- **Online vs. offline comparisons**
  - Comparison of pile-up energy density online and offline
  - Turn on curves w.r.t. offline for different jet collections and calibrations
  - p_{T} resolution w.r.t. offline for different calibrations
  - Angular resolution for all jets w.r.t. offline
  - Jet energy resolution and invariant mass resolution for data scouting jets

A handful of the open issues

Core software

- Trigger Towers for Level 1.5 **(almost there!)**
- Trigger level analysis, needs byte stream converter (many thanks to Ricardo Abreu for helping here!)
  - https://its.cern.ch/jira/browse/ATR-9767

Trigger menu

- Global sequential calibration (GSC) **(almost there!)**
- E/p triggers for single isolated hadrons
- Jet cleaning hypo (in case "noisy" jets are an issue in data)
- Implement final HLT JES calibrations and deploy and test

Operations and monitoring

- Add efficiency to offline monitoring histograms
- Luminosity aware monitoring

Conclusions

- Jet trigger has come a very very long way in a matter of months!
  - Adapted to completely new offline software framework
  - Implemented completely new functionality in jet trigger
  - Built up new software development and operations teams
  - Put in place new monitoring to keep track of all of the new triggers
- **Could not have been done without numerous dedicated, clever, and hard-working individuals!**
- Still have many things to follow-up
  - HLT calibrations (*software workflow now in place!*)
  - Trigger level analysis core software
  - E/p triggers
  - GSC calibration capability (*core functionality in place!*)
- Validation of all of these new functionalities is now our most visible task (*see earlier efficiency studies!*)

Additional Material

Outline

Menu requests for special runs

Jet triggers in beam splashes menu

- Primary triggers will be L1Calo EM
- L1Calo jet triggers (`L1_J75A/C`) are available as backup

Jet triggers in low $\langle\mu\rangle$ run ($\langle\mu\rangle$ <0.01)

- No specific jet triggers requested
- E/p triggers would be important (see "Open Issues" later)

Jet triggers in moderate $\langle\mu\rangle$ run ($\langle\mu\rangle \sim 0.5$)

- `j10,j15,j25...j175` and `_320eta490` (i.e. from `j10` up to the first unprescaled jet trigger)
- Considering adding requests for multiple calibration configurations as well for early calibration comparisons

Jet trigger menu (I)

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			

Jet trigger menu (II)

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

Jet trigger menu (III)

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	
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	
4J20	0.5 / 1.9 kHz	5j60_a4tcemsubjes	40 / 170 Hz	170	
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	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	SUSY, SM (*)
HT150	3 / 12 kHz	j360_a10_a4tcemsubjes	14 / 60 Hz	60	exotics, jets
HT190	1.2 / 5 kHz	j460_a10_a4tcemsubjes	2 / 8 Hz	unprescaled	exotics, jets

Jet trigger menu (IV)

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

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	