ATLAS level-1 calorimeter trigger: Phase-I Upgrade Performance

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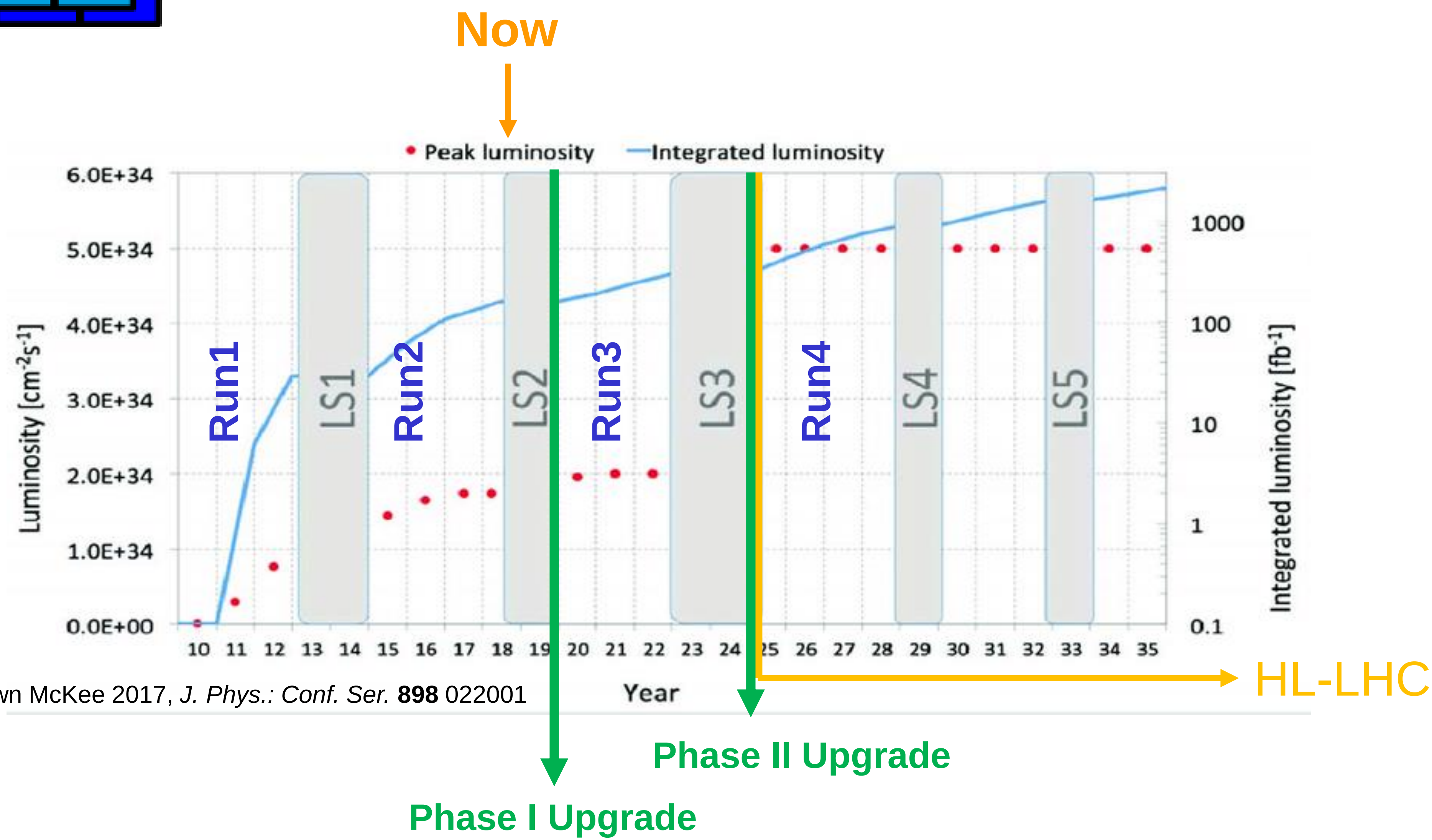
On behalf of ATLAS Collaboration

Outline

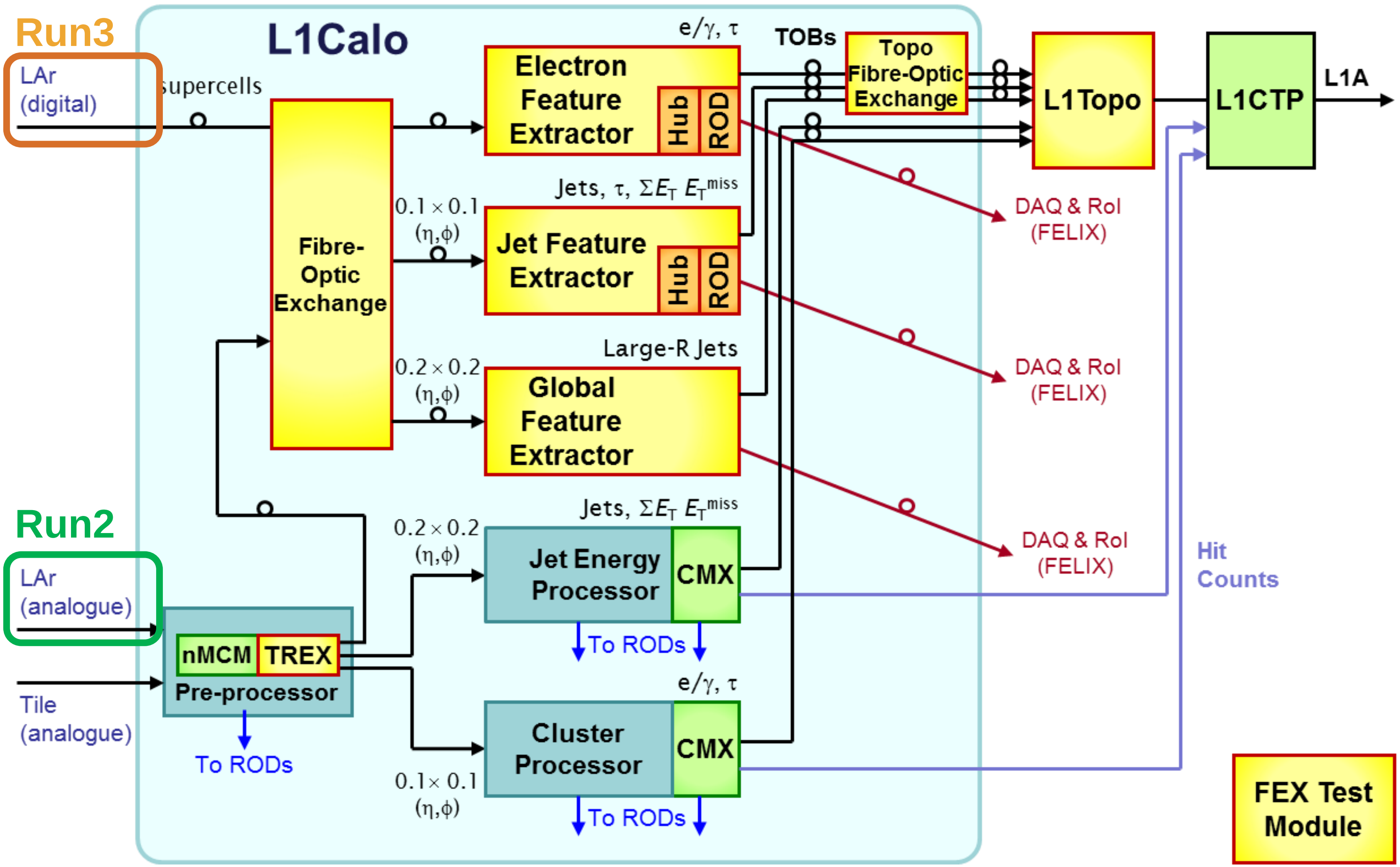
- LHC Upgrade
- ATLAS Phase-I L1Calo System
  - Structure
  - Expected Performance
- eFEX Algorithm
  - Supercell
  - L1 Electron
- jFEX Algorithm
  - jFEX Tower (jTower)
  - L1 Missing ET
  - L1 Jets

Upgrade Timeline



Shawn McKee 2017, *J. Phys.: Conf. Ser.* **898** 022001

ATLAS L1Calo Trigger Run3



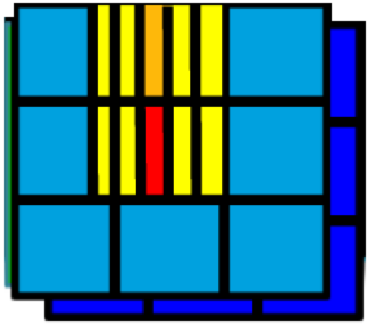
Required & Expected Performance

1. Low rate ➔ Hardware limitation (bandwidth & storage)
2. High efficiency ➔ Signal conservation (eg: W/Z events)
3. Consistency between trigger & offline objects

Run2 (Unprescaled Triggers)			**Run3 (Unprescaled Triggers)**		
Trigger	Offline threshold [GeV]	Rate [kHz]	Trigger	Offline threshold [GeV]	Rate [kHz]
EM30	38	14.0	EM25	32	14.0
XE90	250	10.0	XE70	200	13.0
J100	200	7.0	J100	200	7.0
4J25	4×60	3.3	4J25	4×60	3.3

$<\mu>=80$

Detail in ATLAS Phase-I TDR

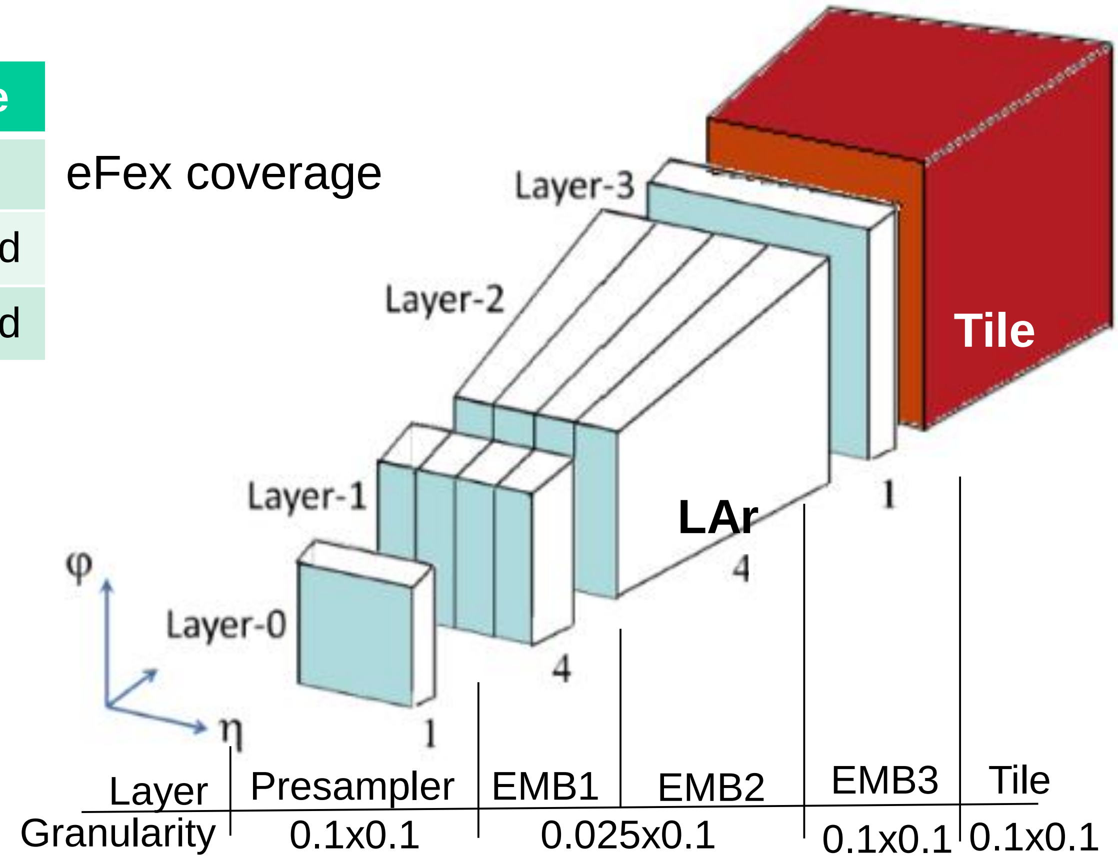


Supercell Structure

Granularity (η x φ) & Purpose:

η Range	$\Delta\eta$	$\Delta\phi$	layers	Purpose
0-2.5	0.025	0.1	2-4	EM
2.5-3.2	0.1	0.1	2	EM & Had
3.2-4.9	0.15	0.32	2-3	EM & Had

eFex coverage



Finer granularity in hardware (backup)

Signal: digitized input

No upgrade for Run3 Tile

→ Run2 system remains

L1 Electron - Algorithm

RoI Definition :

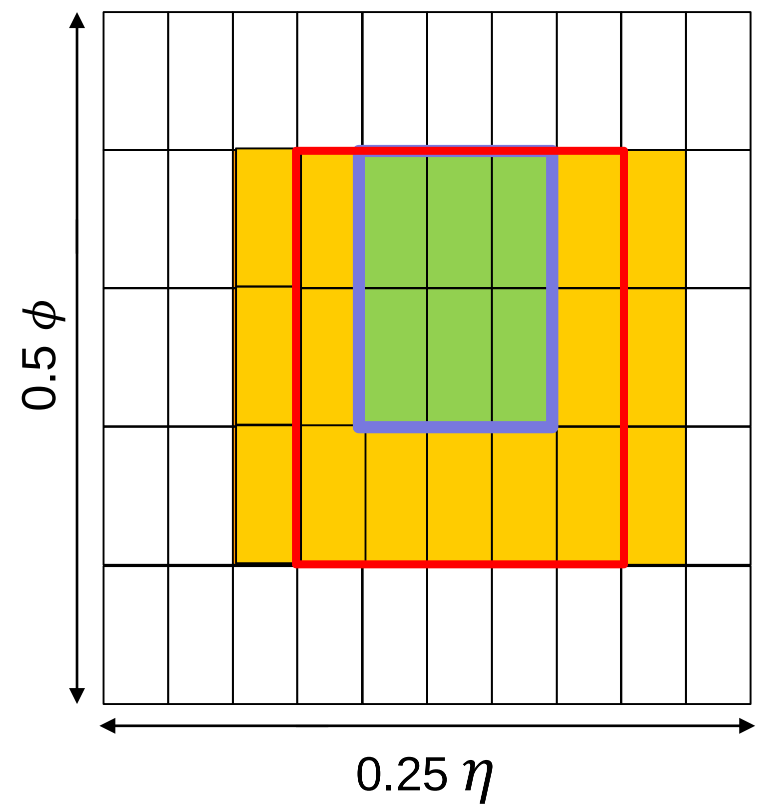
1. Local Maximum in EMB2

2. Isolation Selection with :

   a) $$R_\eta = 1 - \frac{3 \times 2E_T^{SC}}{7 \times 3E_T^{SC}}$$

   b) $$R_{had} = \frac{\sum E_T^{Tile}}{\sum E_T^{LAr} + \sum E_T^{Tile}}$$

   c) $$w_{tot} = \sqrt{\left(\frac{\sum_i E_T^{sc_i} \times \left(\eta^{sc_i} - \eta^{sc_{max}}\right)^2}{\sum_i E_T^{sc_i}} \right)}$$



3. Coverage : $0 < |\eta| < 2.5$

Performance for each variable in backup

L1 Electron - Performance

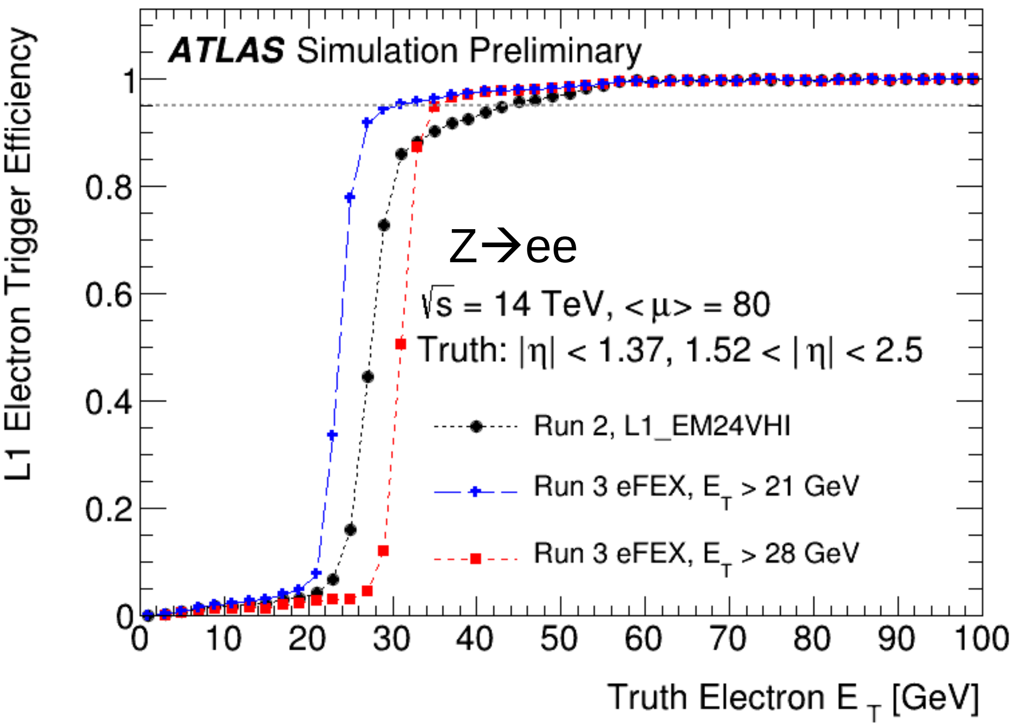
CDS Link

Same Rate to Run2

- Threshold: 20GeV
- Plateau: 34GeV

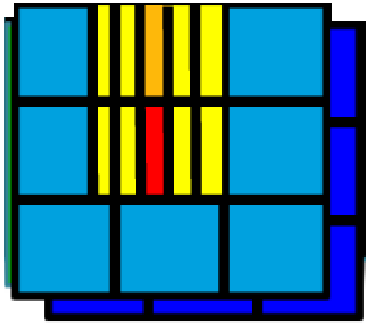
1/3 Rate to Run2

- Threshold: 28GeV
- Plateau: 37GeV



➔Better resolution
➔Better noise suppression

Variable	Et	R_η	R_{had}	w_{tot}
threshold	>28GeV	<0.12	<0.16	<0.02



jFEX Tower

Energy Evaluation: $\sum_i E_T^{sc_i}$

(summation on EM and Hadronic layers respectively)

Target objects: cone jets, MET, fat jet, tau

Granularity:

	Δη	Δφ
|η| < 2.5	0.1	0.1
2.5<|η|<3.1	0.2	0.2
3.1<|η|<3.2	0.1	0.2
3.2<|η|<4.9	Varied (~ 0.425)	Varied (~ 0.425)

L1 $E_T^{missing}$ – Algorithm

1. Histograms of Et per tower (minimum bias sample)
2. Noise standard : 1σ (each tower)
3. Threshold: ~5σ (optimized by best efficiency at rate=5.0kHz)
4. $E_T^{missing} = -(\sum \vec{E}_T^{tower_{EM}} + \sum \vec{E}_T^{tower_{Had}})$

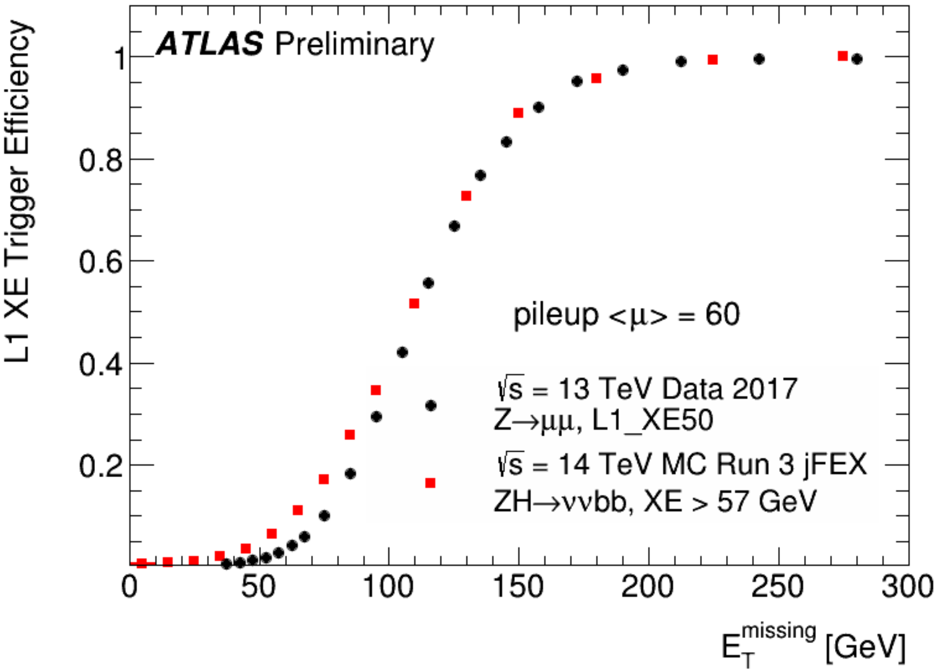
	EM			Had		
|η|	0-2.5	2.5-3.2	3.2-4.9	0-2.5	2.5-3.2	3.2-4.9
Noise [MeV]	40-60	40-100	N/A	0-20	40-100	40-300
Threshold [MeV]	200-300	200-500	N/A	0-100	200-500	200-1200

L1 $E_T^{missing}$ - Performance

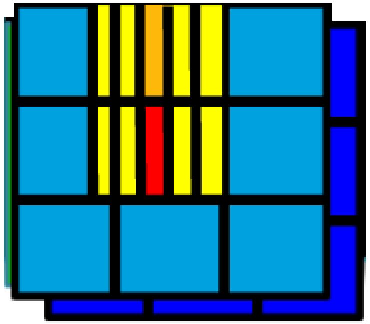
Threshold: ~ 57 GeV

Same rate: 5kHz
(lumi =2×10^{34}/s, <μ>=60)

Simple Cut-based algorithm
➔Similar turn-on to Run2

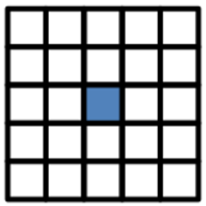


Rate	Threshold	efficiency	Negative Tower
5.0kHz	57GeV	28.8%	vetoed



L1 Jet - Algorithm

TT (0.1 x 0.1, blue):

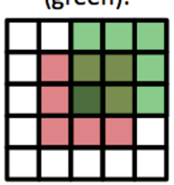


The centre of jet

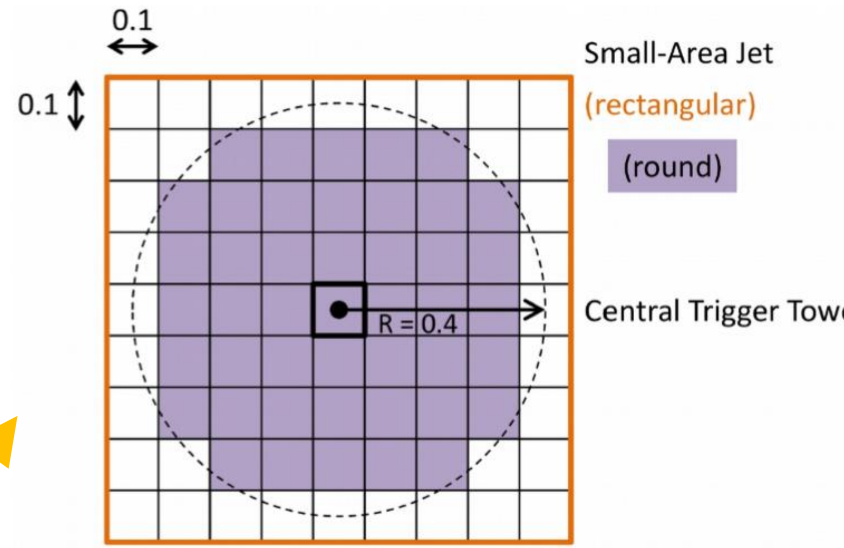
Seed (0.3 x 0.3, red):

Seed

central Seed (red),
1 of 8 Seeds to compare to
(green):



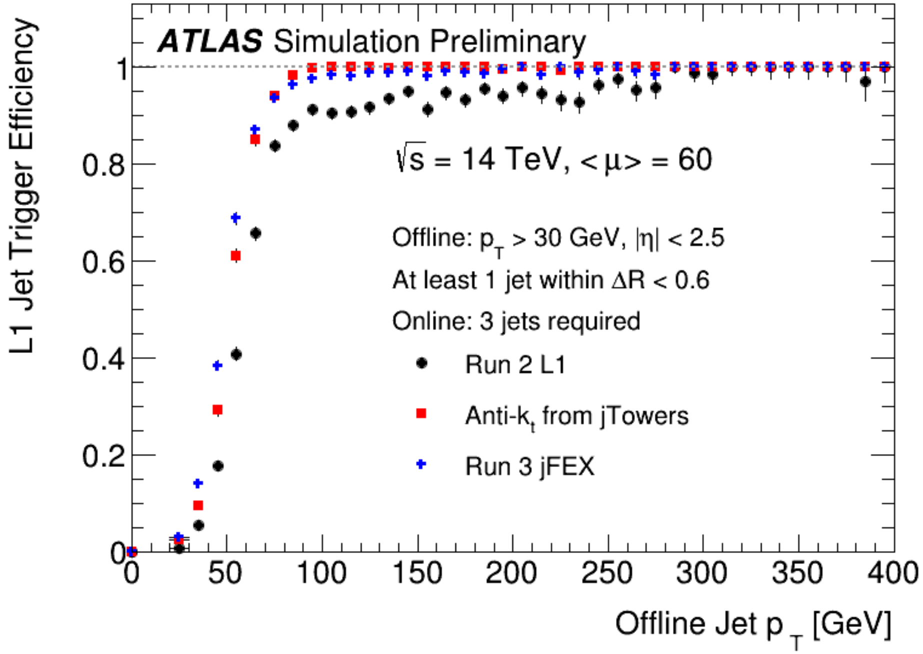
Seed as local Maximum



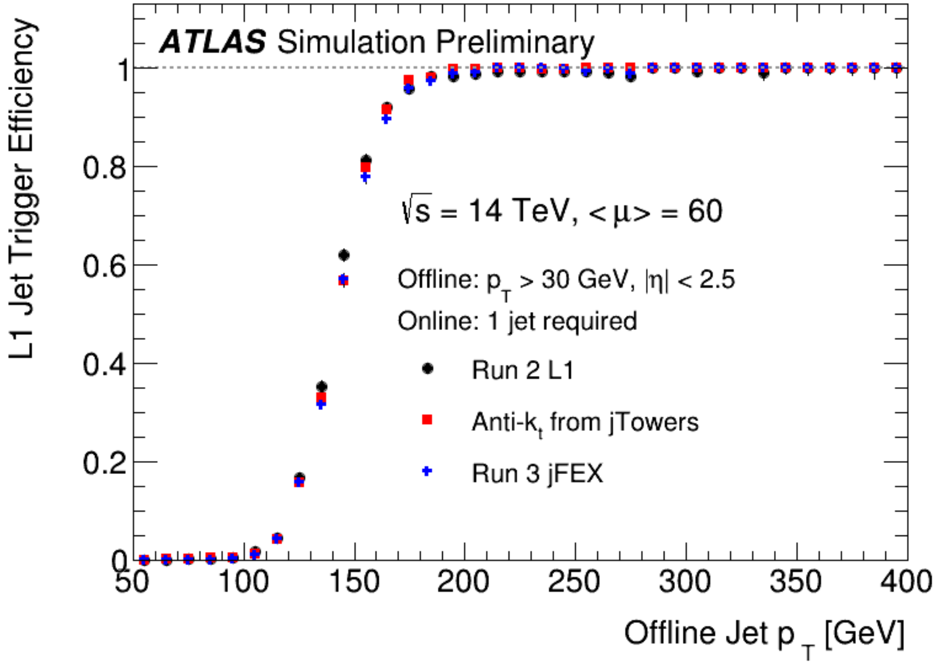
Reconstructed Jet

1. Seed candidate : all towers
2. Local maximum scan (shown above)
3. Jet construction
4. Tower threshold : E_T> 2GeV

L1 Jet - Performance



3 jet trigger threshold: 26GeV
Same rate to Run2



Single jet trigger threshold: 97GeV
Same rate to Run2

Summary

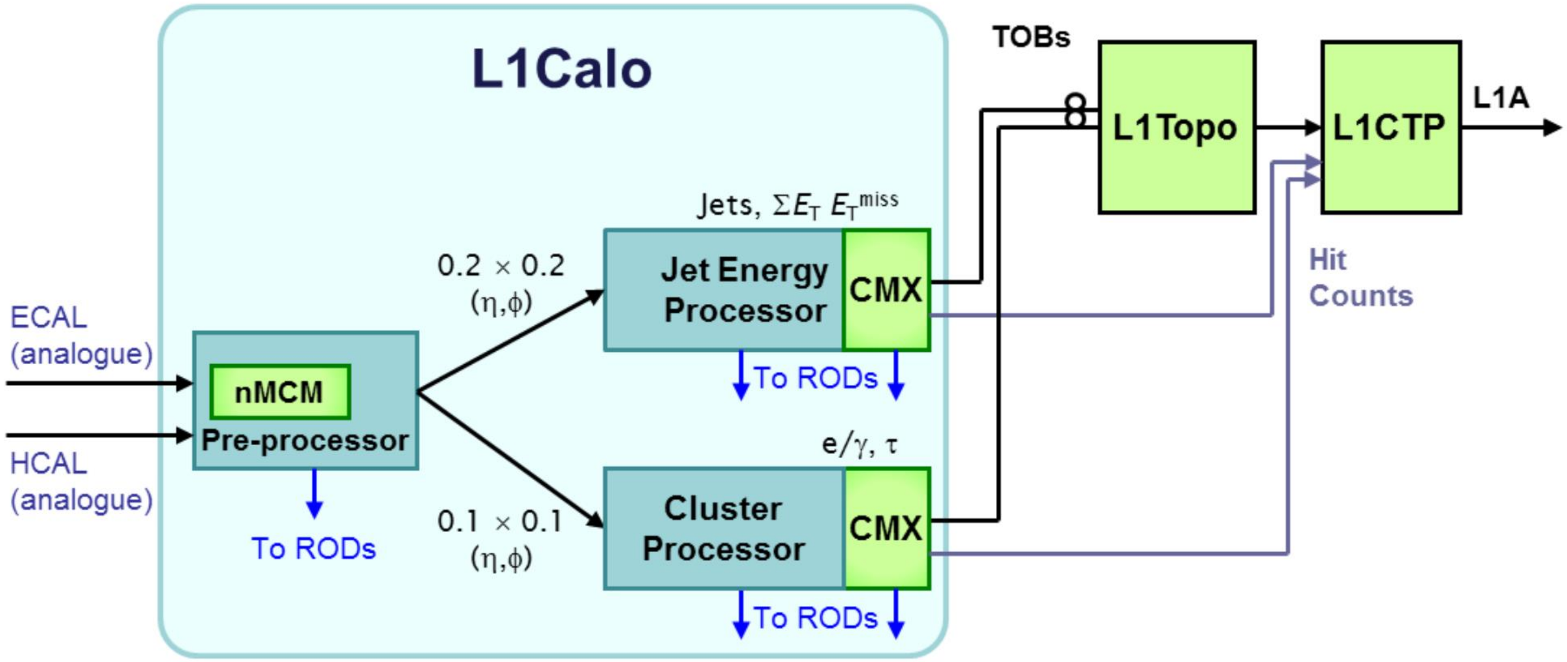
1. Preliminary study for simple algorithm

2. Improvement could be seen from simulation

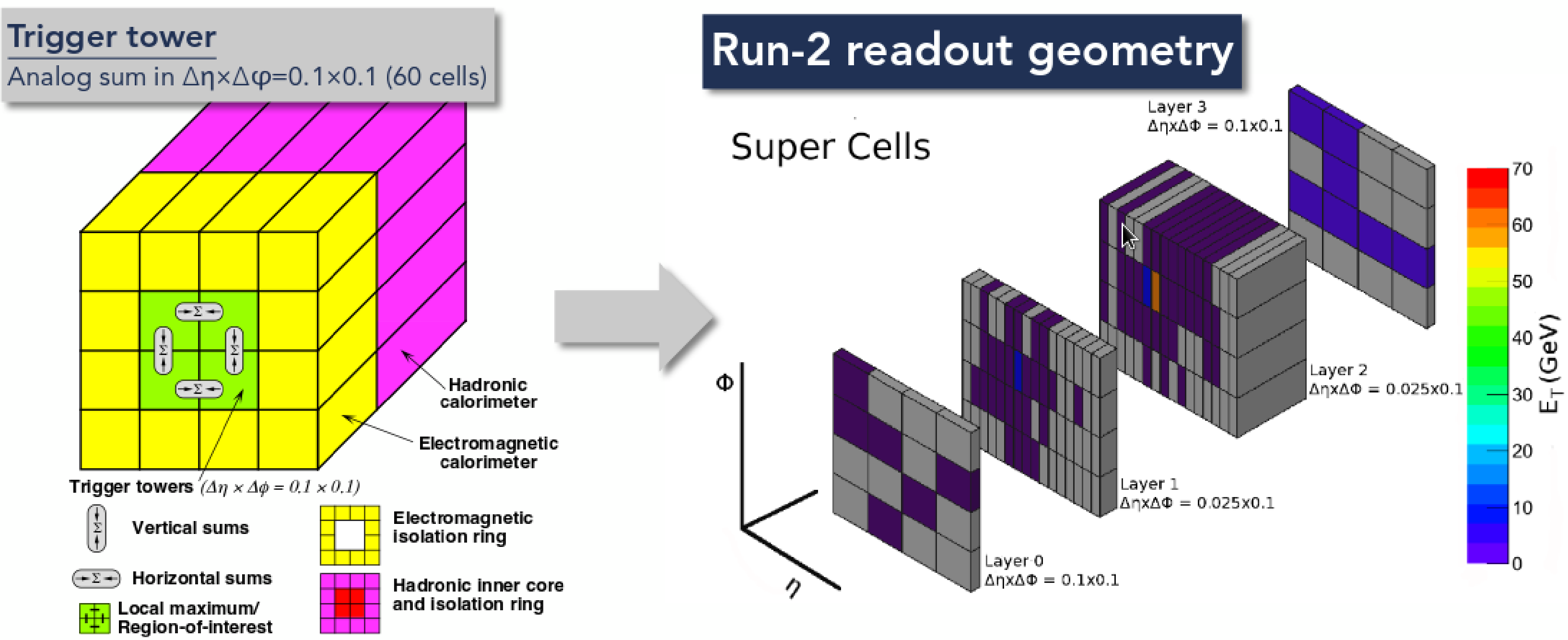
3. Significant potential in more algorithms (like pile-up suppression)

Backup

ATLAS Run2 Trigger System



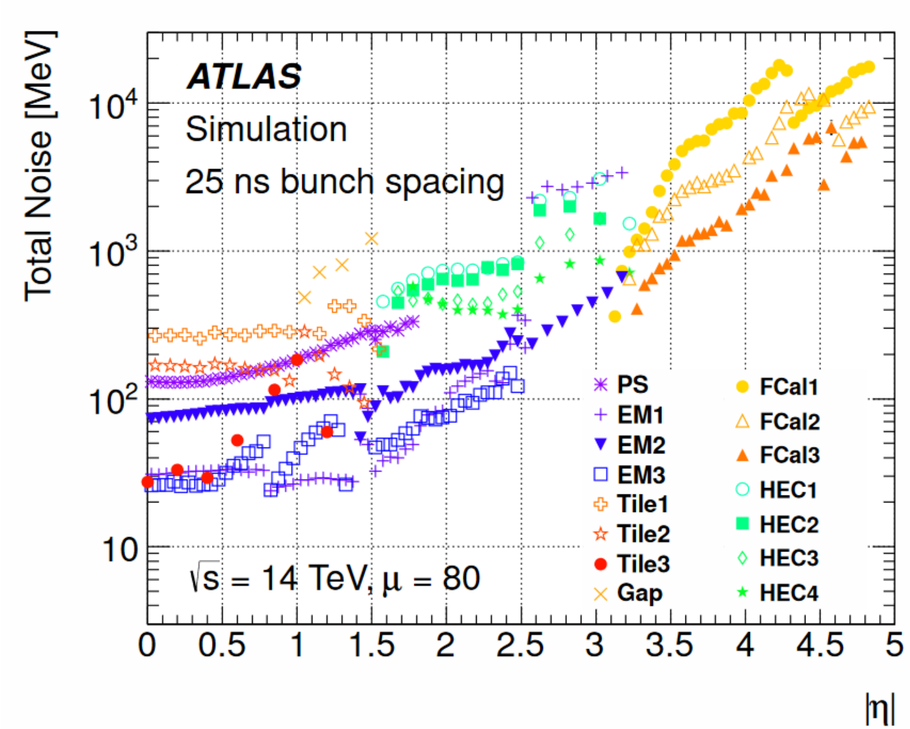
ATLAS Trigger Towers Comparison

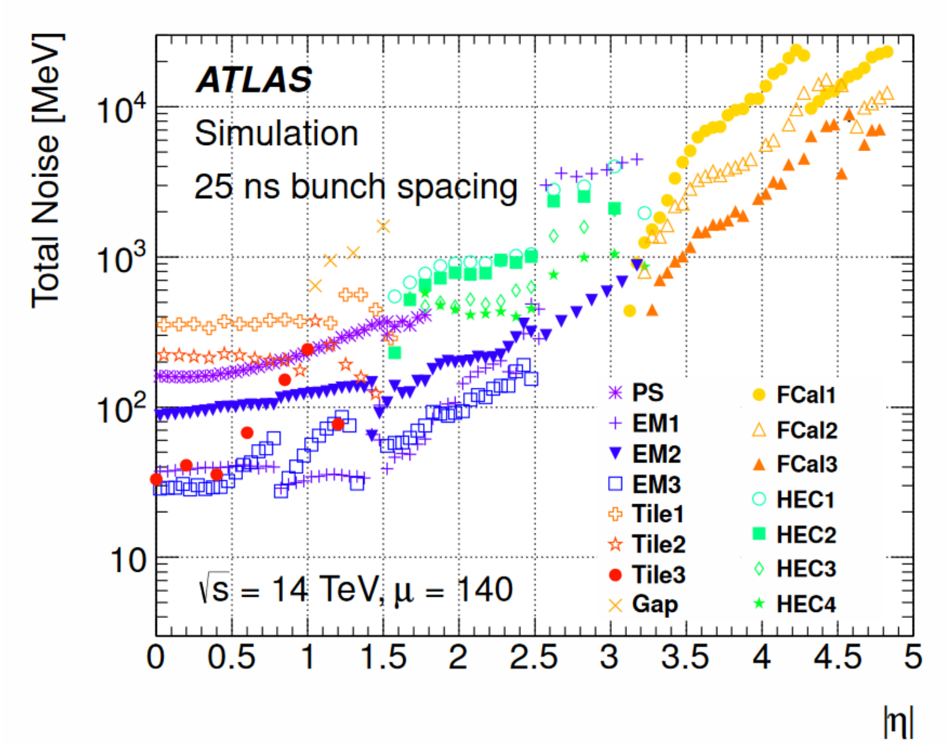


(box: minimal readout element)

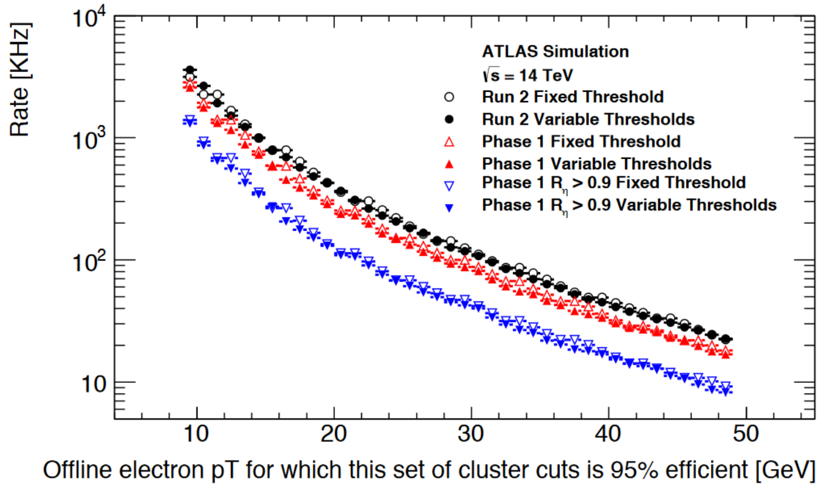
copied from https://cds.cern.ch/record/2017813/files/ATL-LARG-SLIDE-2015-268.pdf

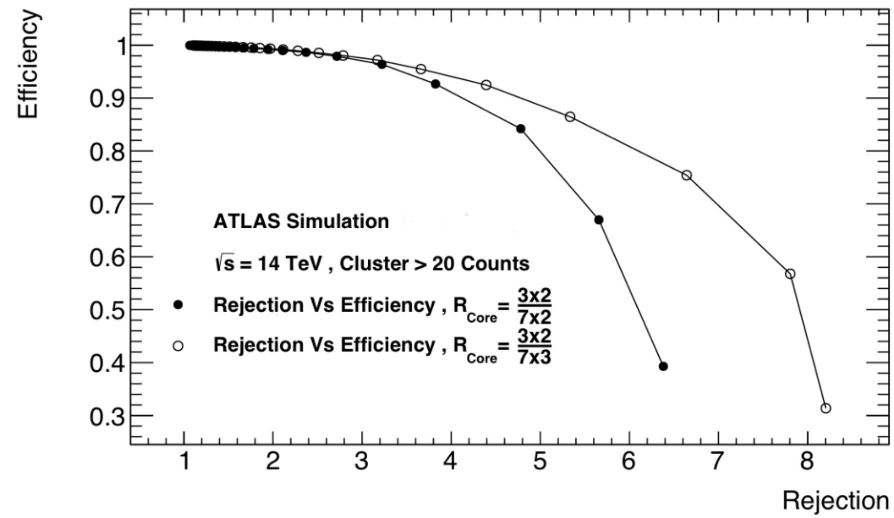
ATLAS LAr Noise Per Supercell Layer

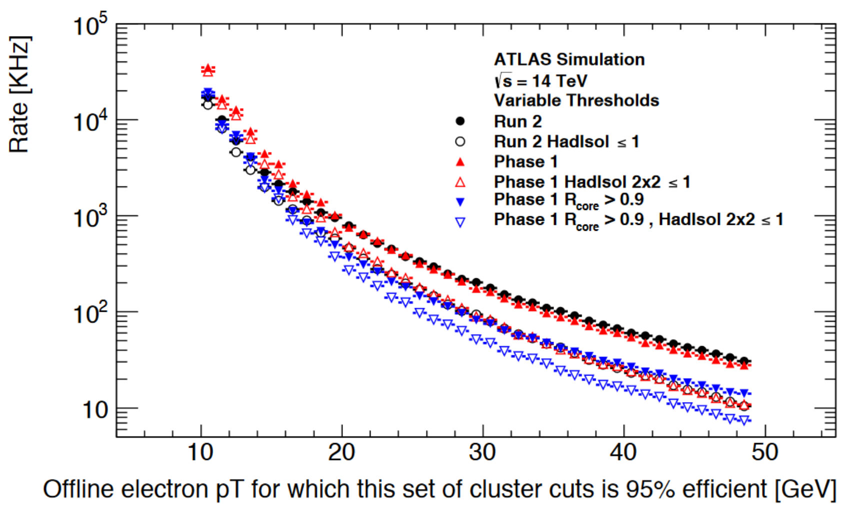




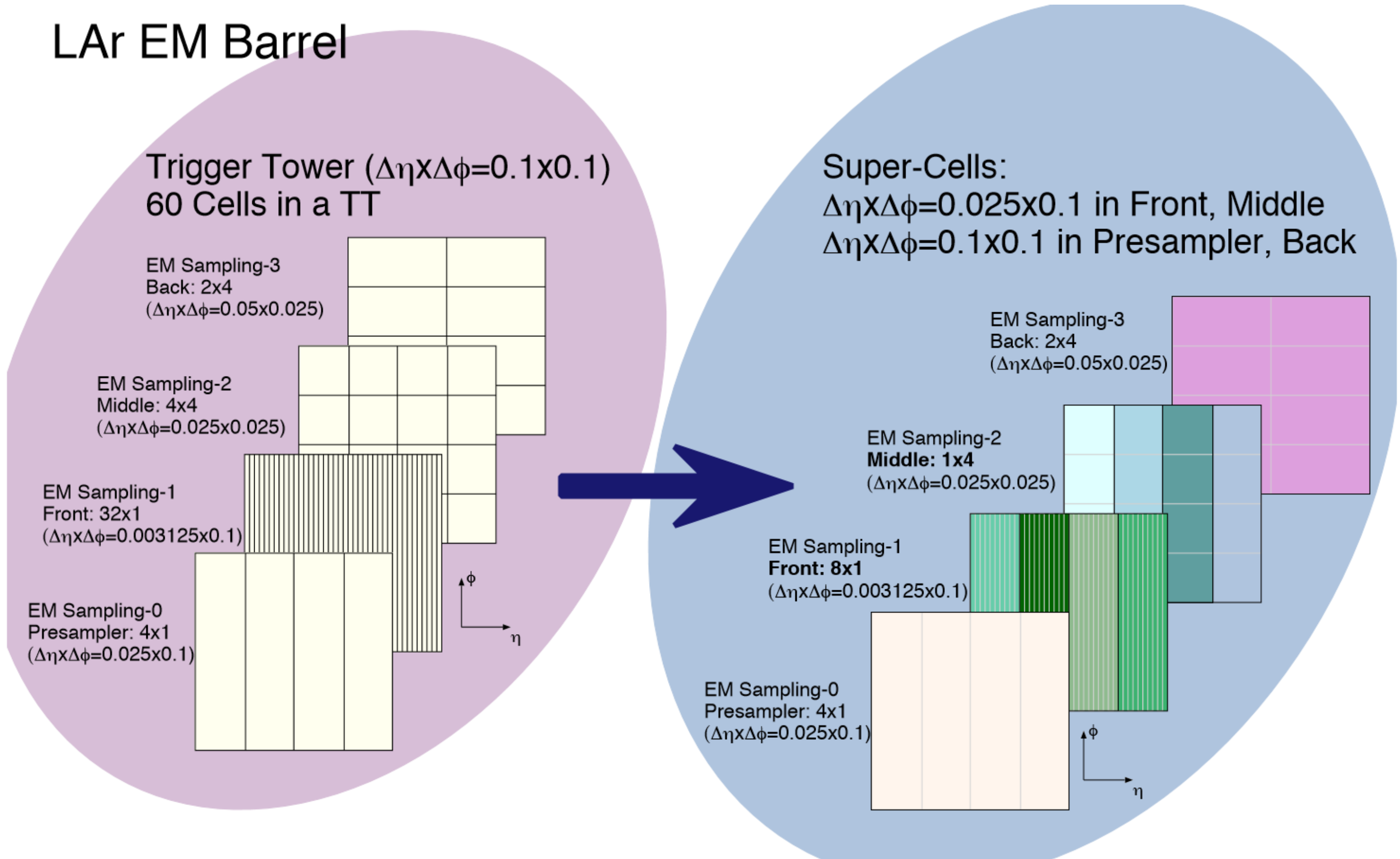
Supercell Variable Performance







Barrel Supercells



Presampler
SC_layer=0
SC_region=0
SC_eta=0...13 [$\Delta\eta$=0.1]
SC_region=1
SC_eta=14(15) [$\Delta\eta$~0.1(0.12)]
SC_phi=0...63 [$\Delta\phi$=0.1]

Front
SC_layer=1
SC_region=0
SC_eta=0...55 [$\Delta\eta$=0.025]
SC_region=1
SC_eta=56..58 [$\Delta\eta$=0.025]
SC_phi=0...63 [$\Delta\phi$=0.1]

Middle
SC_layer=2
SC_region=0
SC_eta=0...55 [$\Delta\eta$=0.025]
SC_region=1
SC_eta=56 [$\Delta\eta$=0.075]
SC_phi=0...63 [$\Delta\phi$=0.1]

Back
SC_layer=3
SC_region=0
SC_eta=0...12 [$\Delta\eta$=0.1]
SC_eta=13 [$\Delta\eta$~0.05]
SC_phi=0...63 [$\Delta\phi$=0.1]

Forward Supercells