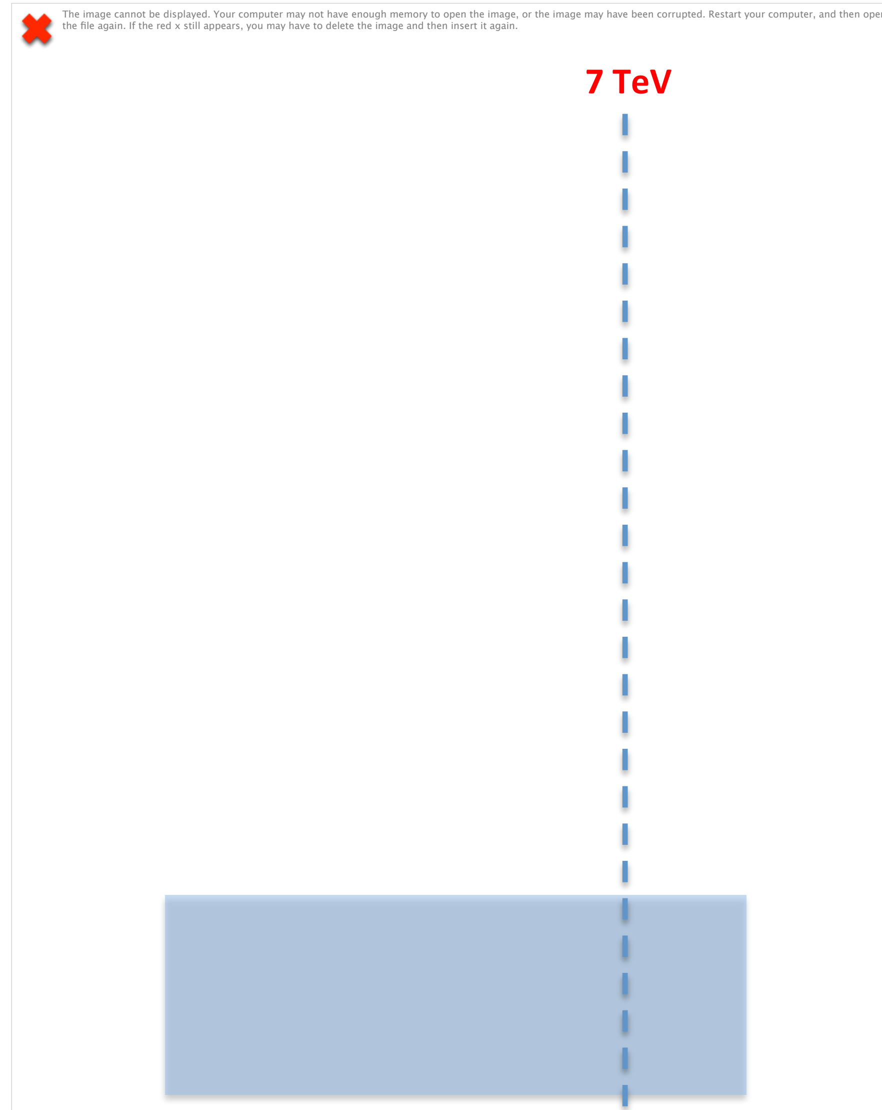
High Level Trigger Jets

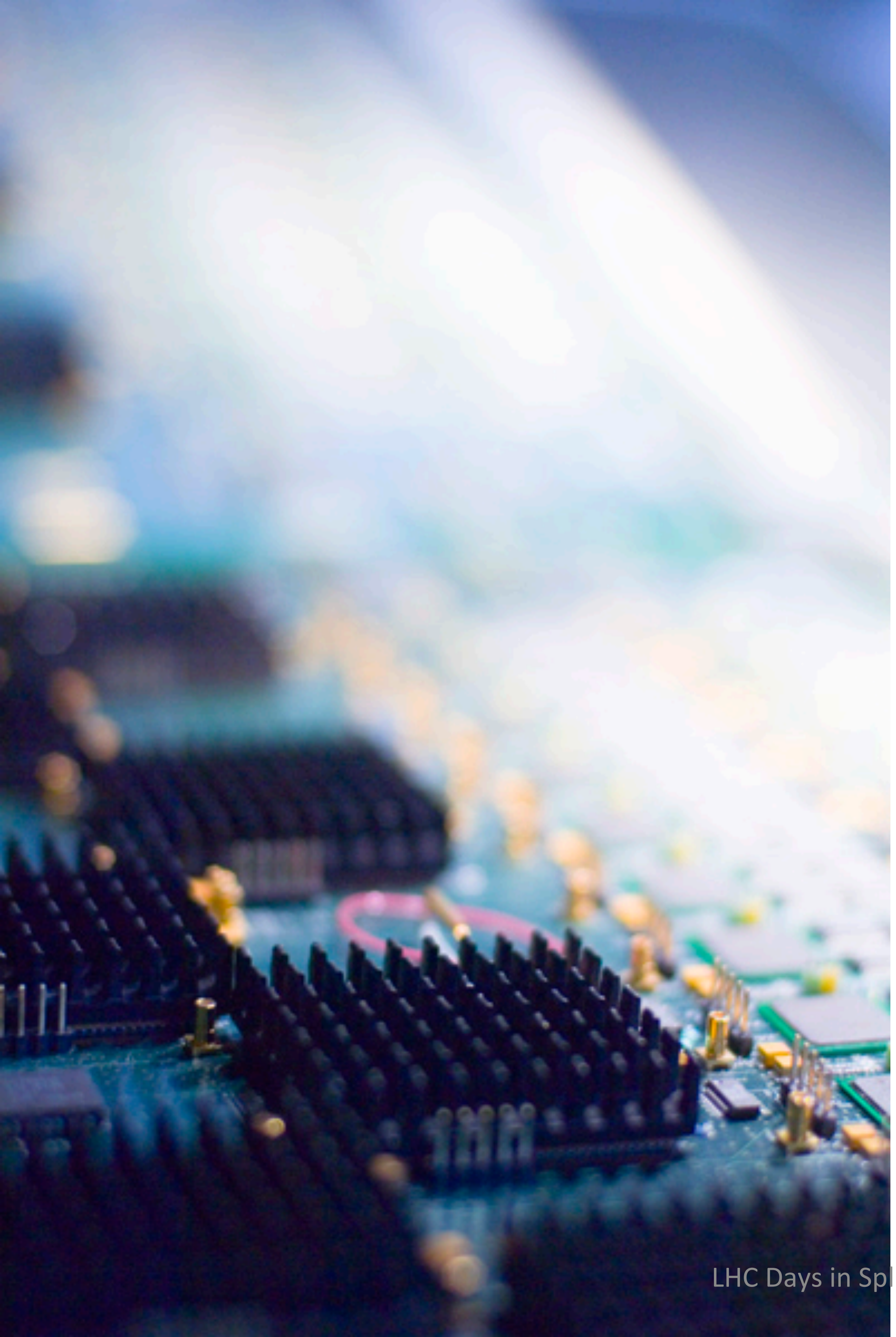
Ben Carlson, Kenji Hamano, Ricardo Gonçalo

Cofinanciado por:

The Trigger

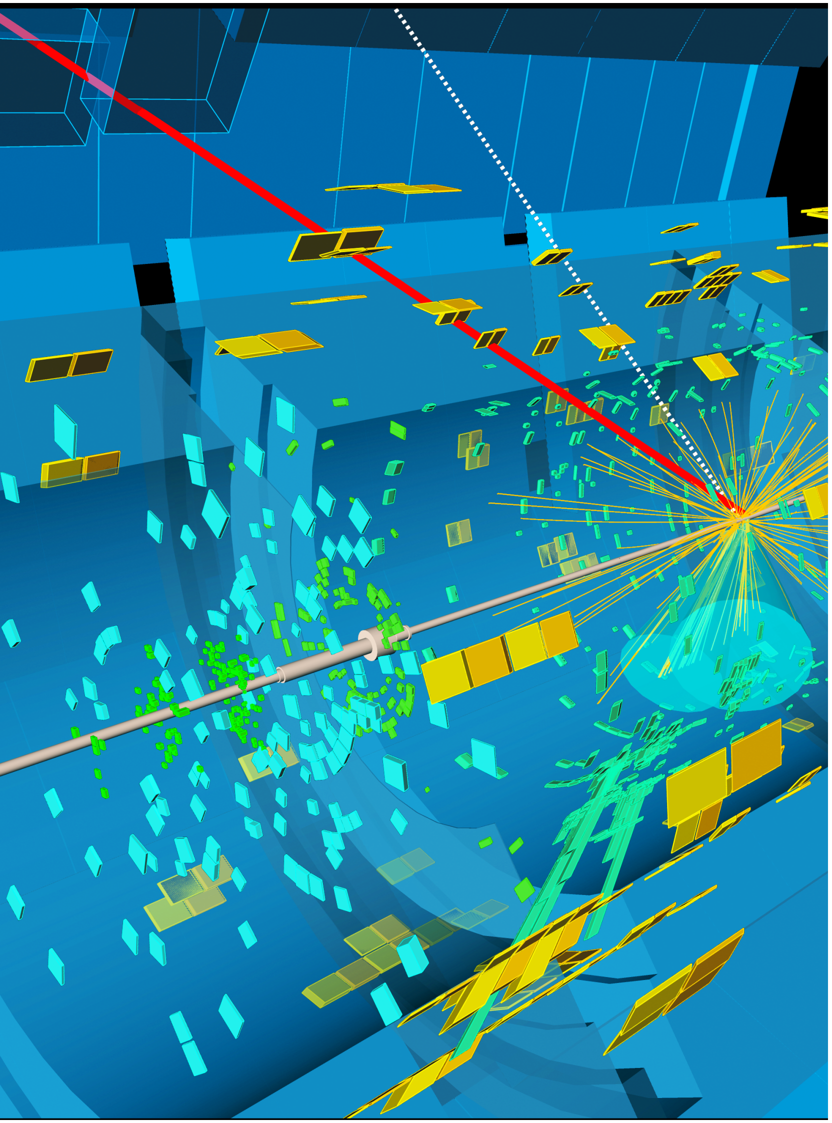
- First step in every physics analysis
- Similar goals:
  - Analysis optimizes **efficiency vs purity**
    - Searches: maximize significance
    - Measurements: minimize uncertainty
- But different constraints:
  - Maximize signal **efficiency vs rate**
    - To first order, all events are background
    - **Rate** and **latency** impose **strict limits**
- Escape constraints by being clever
  - Prescales, TLA, partial event building, etc
- Expect the unexpected:
  - Passthrough, error stream, etc
- Not only “signal”:
  - Calibration data, backup triggers, etc





THE JET TRIGGER

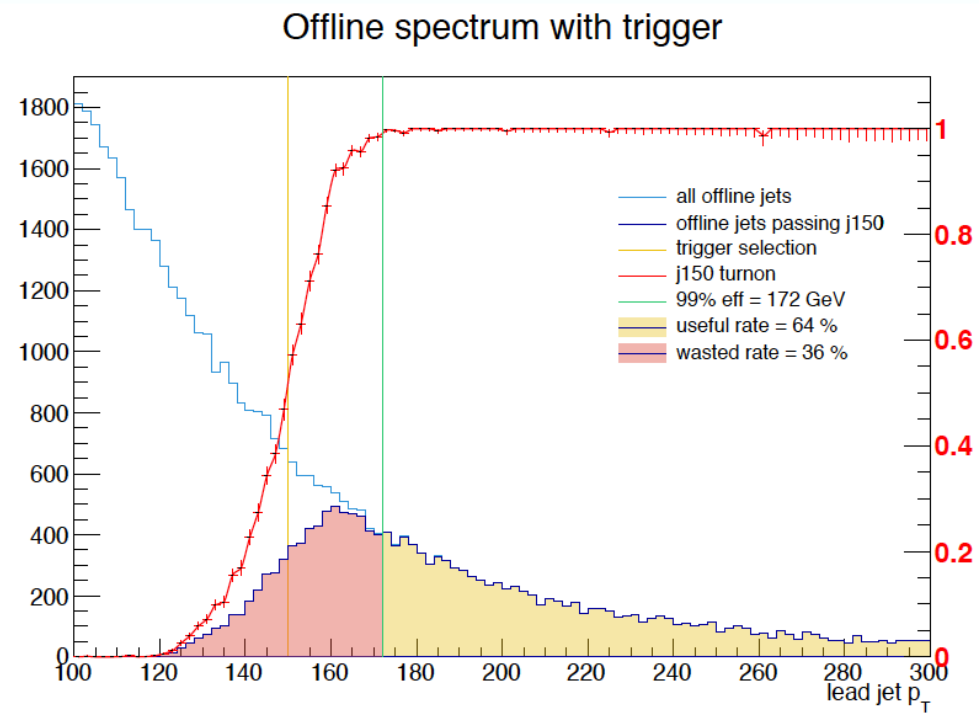
Jet and MET are not usual triggers



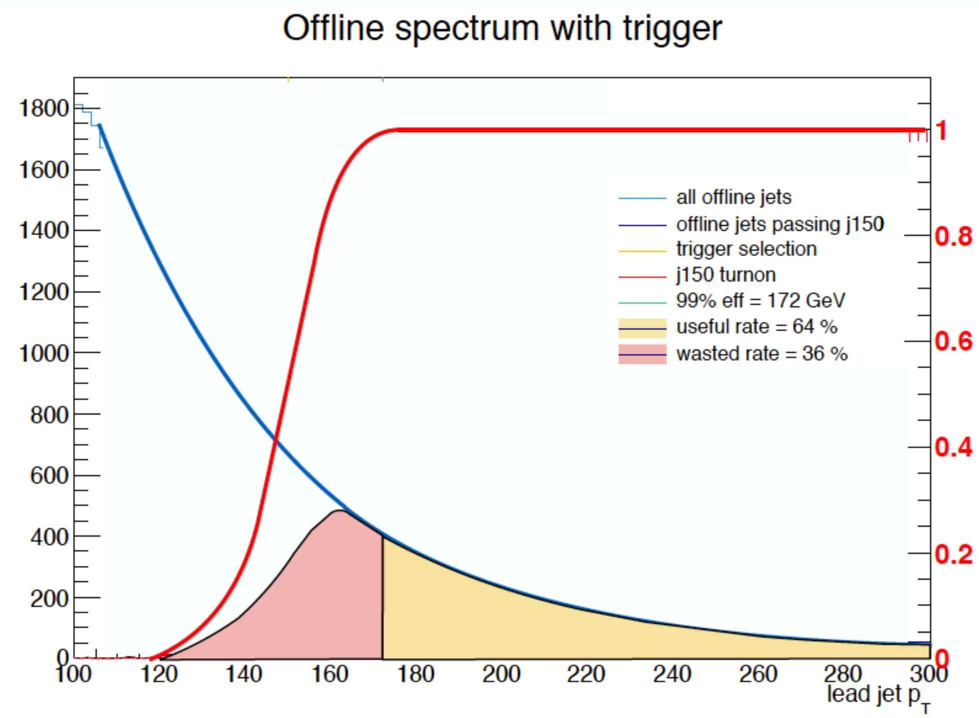
- Usual game is to trigger on distinctive objects
  - But **all** LHC collisions produce jets
- E.g. electron trigger: play with identification purity
- Jet and MET are different:
  1. Jets are **defined** by jet algorithm
     - Cut on phase-space
     - **Need resolution**!
  2. Then clean up false positives
     - Pileup jets, fake MET – need resolution!

Importance of calibration

- This plot: Emulate HLT_j150



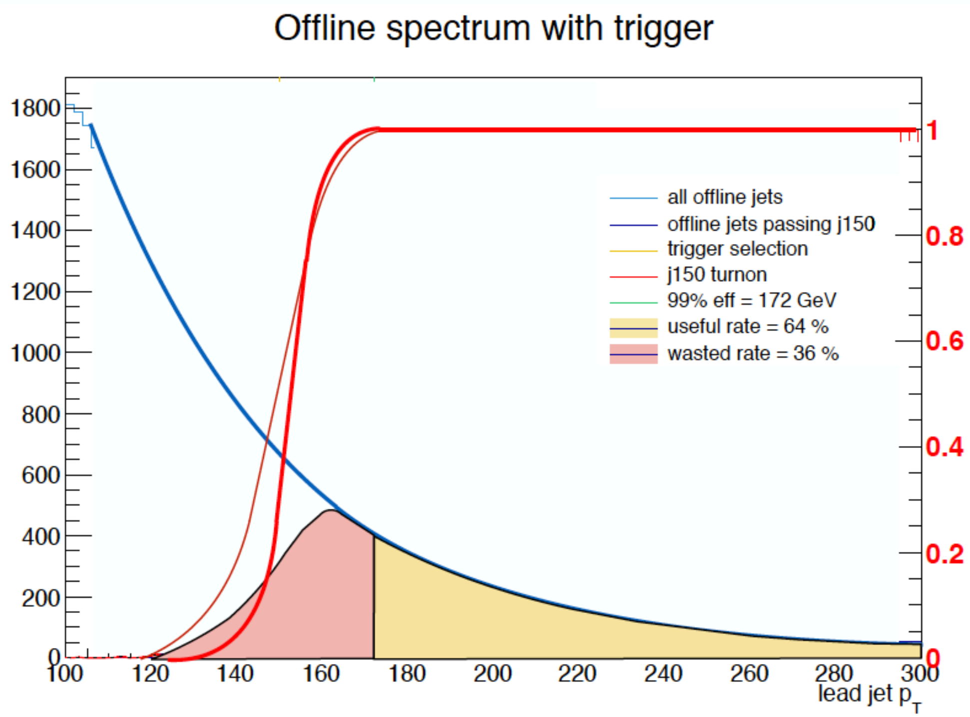
Importance of calibration



- This plot: Emulate HLT_j150
- Turn into cartoon

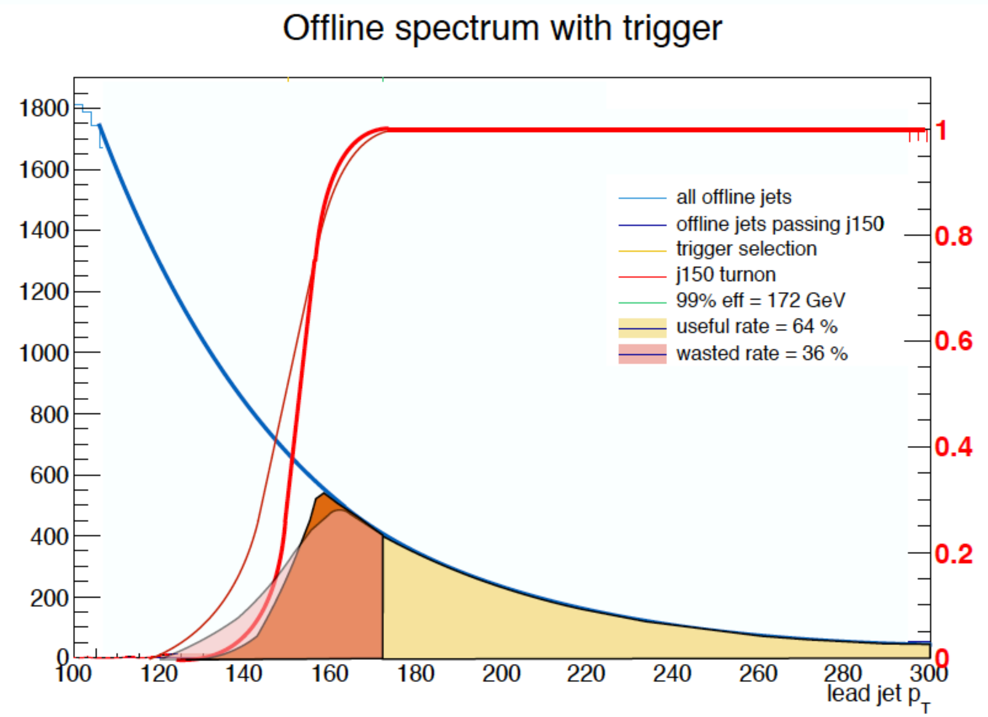
Importance of calibration

- So, if I improve the resolution, then…
    - The turnon will sharpen



Importance of calibration

- So, if I improve the resolution, then…
  - The turnon will sharpen
  - The recorded spectrum will match better



Importance of calibration

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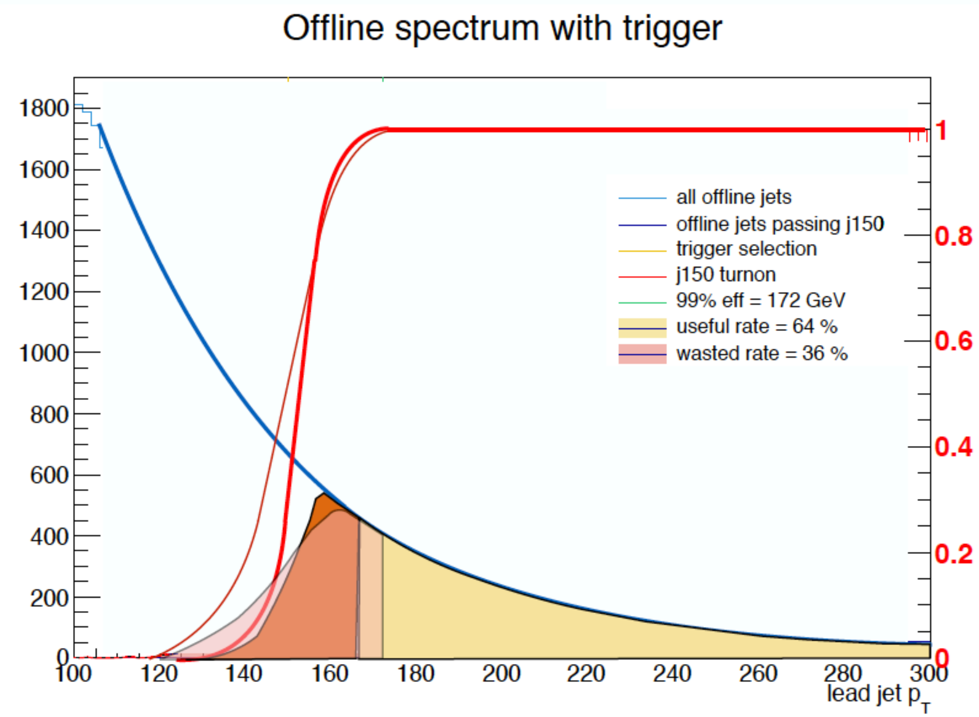
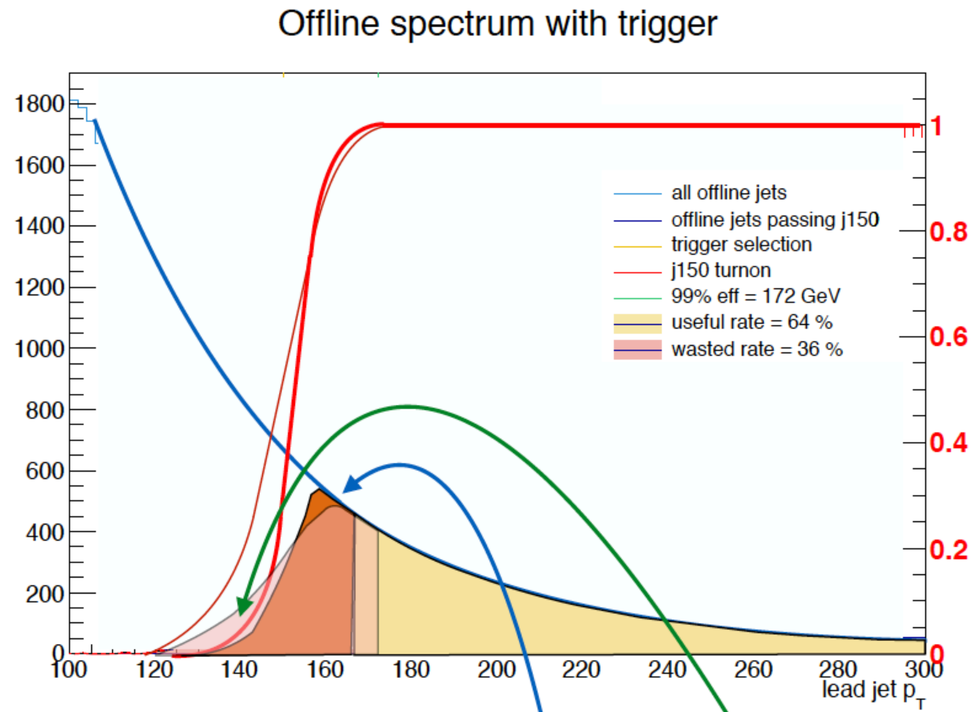
  - The recorded spectrum will match better
  - The 99% eff. point moves left



Importance of calibration

- So, if I improve the resolution, then…
  - The turnon will sharpen
  - The recorded spectrum will match better
  - The 99% eff. point moves left
  - More useful rate :-)



- The total rate may increase or decrease
  - Depends on shape of resolution before and after, and p_T spectrum
  - May have to shift trigger threshold to get equal rate as before (but guaranteed to have more useful rate either way)

Jet Trigger Calibration

Trigger jet calibration

Calibration	Purpose
Origin correction	Move jet origin to vertex
Pileup subtraction (Jet area / Residual)	Remove contributions from pileup
Jet Energy Scale correction	Restore hadronic energy
Global Sequential Correction (Calo-only / with tracks)	Reduce flavour (quark / gluon) dependence
In-situ eta intercalibration	Corrects detector effects along eta to central region
In-situ JES correction	Calorimeter response corrected to MC truth scale

Applied to?

Offline and HLT (2016 and 2017)

- Start with offline calibration chain

Trigger jet calibration

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Applied to?

Offline and HLT (2016 and 2017)

Offline only

- Start with offline calibration chain
- But: no tracks!

Trigger jet calibration

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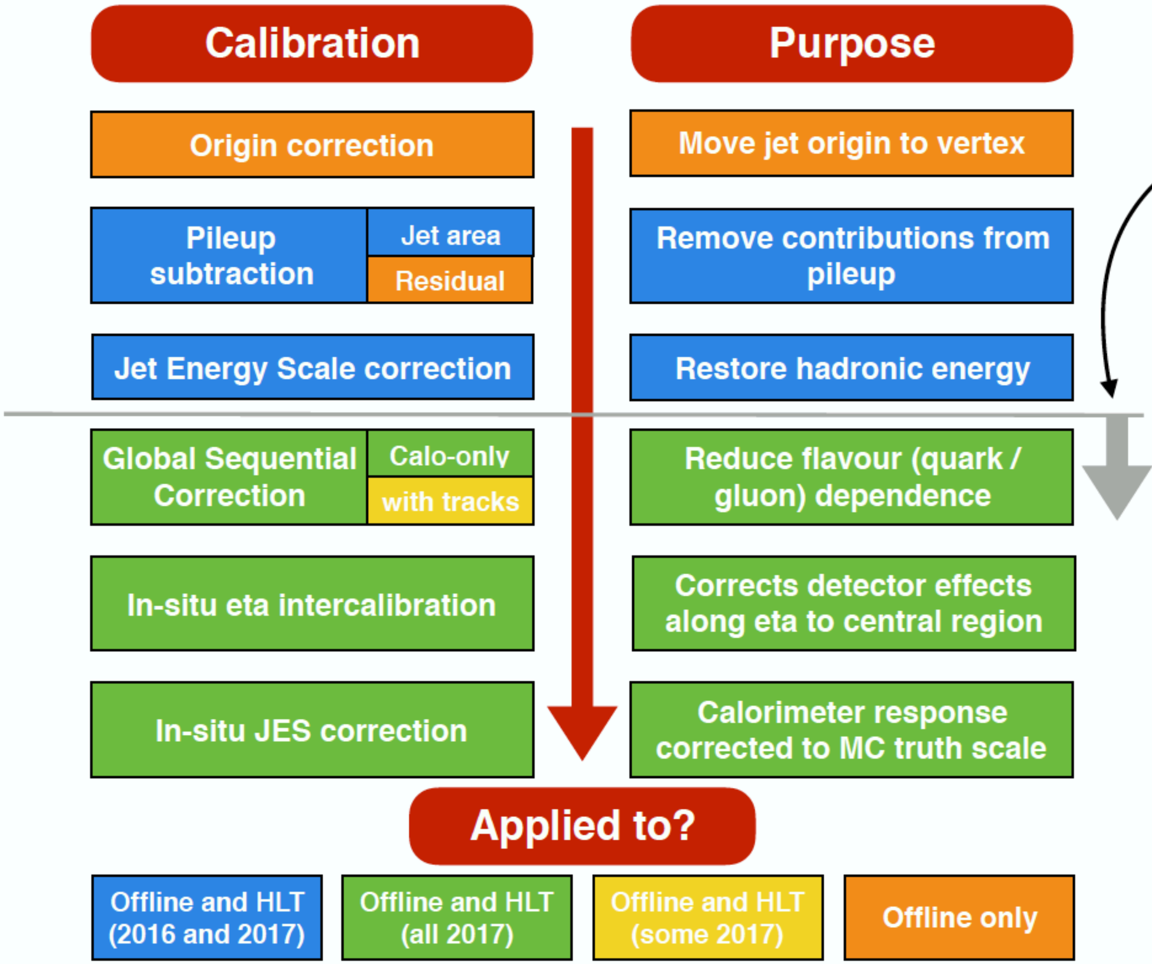
Applied to?

- Offline and HLT (2016 and 2017)
- Offline and HLT (some 2017)
- Offline only

- Start with offline calibration chain
- But: no tracks!
- Except when there are!

Trigger jet calibration



- New in 2017
  - Apply partial GSC and in-situ calibrations to all trigger jets
  - Some HLT tracking in jets for bjet chains - can apply GSC to some trigger jets!

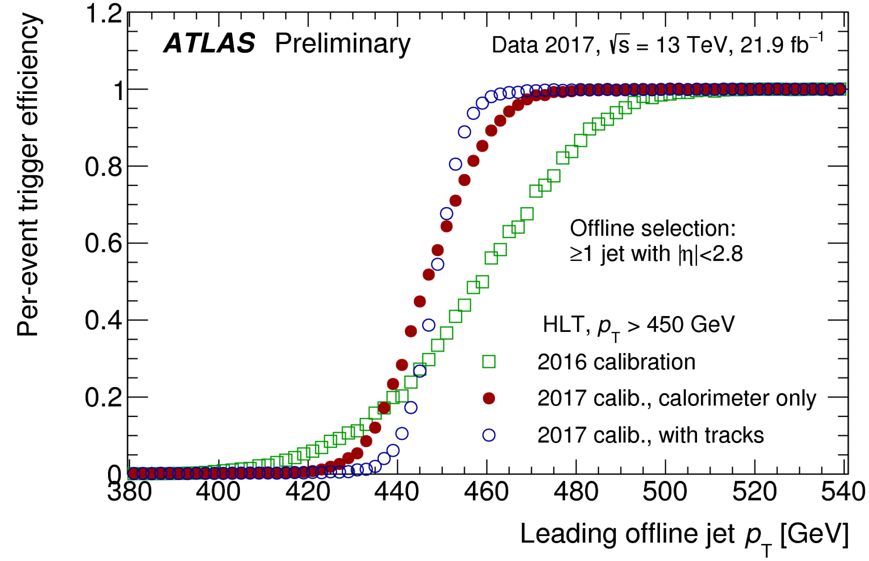
Ideal World

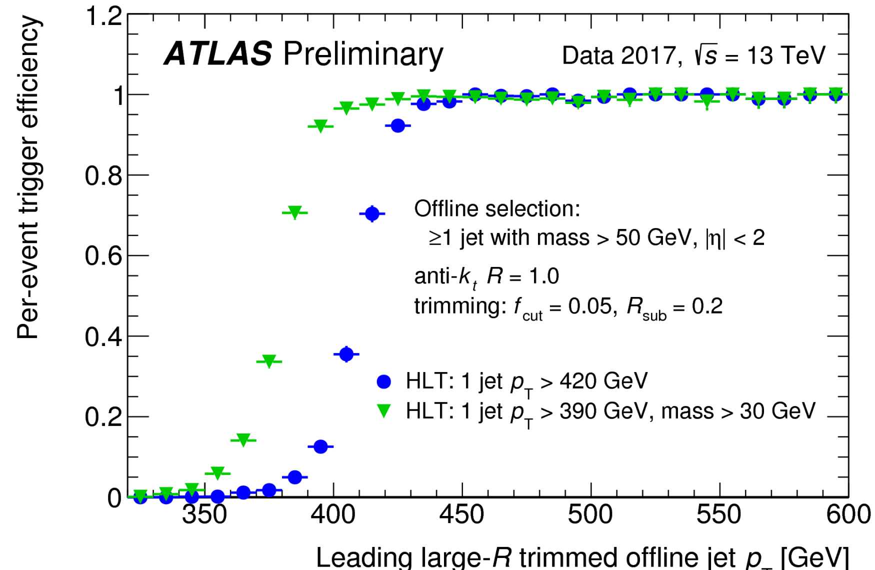
- Full-scan tracking at the HLT would mean:
- No complicated RoI-based tracking
  - All triggers would have tracking, not just b chains
- PFlow available for all thresholds
  - Better match with offline jets
  - Less rate wasted with migrations from below the threshold
- Pileup suppression with JVT
  - Less rate wasted from pileup effects

Jet Trigger Performance in Run 2

2017 Performance

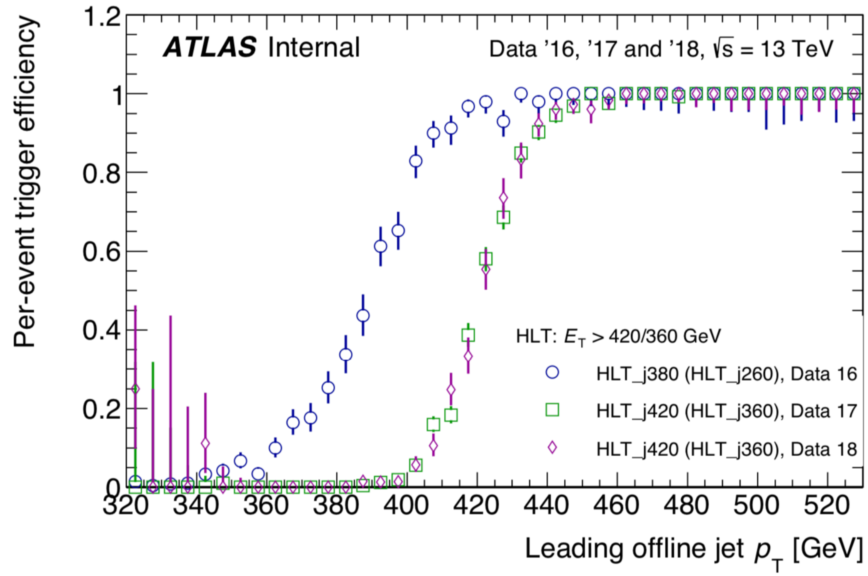
- See [ATL_DAQ_PUB_2018_002](ATL_DAQ_PUB_2018_002)
- Single-jet trigger with different calibrations
  - 2016 calibration
  - 2017 calorimeter-only calibration
  - 2017 calibration plus GSC and in-situ corrections
- Better jet resolution!
- HLT large-R single-jet triggers
  - |η|< 2.0
  - jet mass > 50 GeV

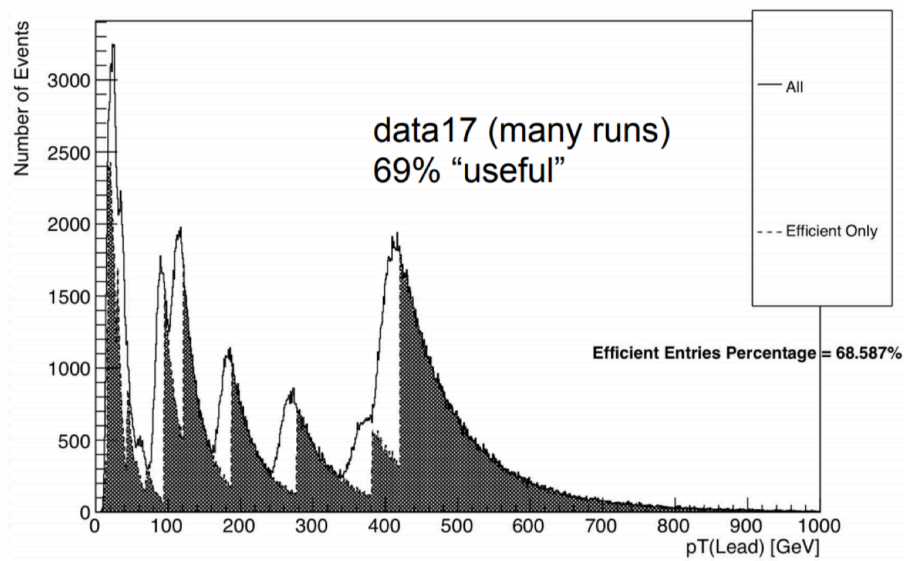




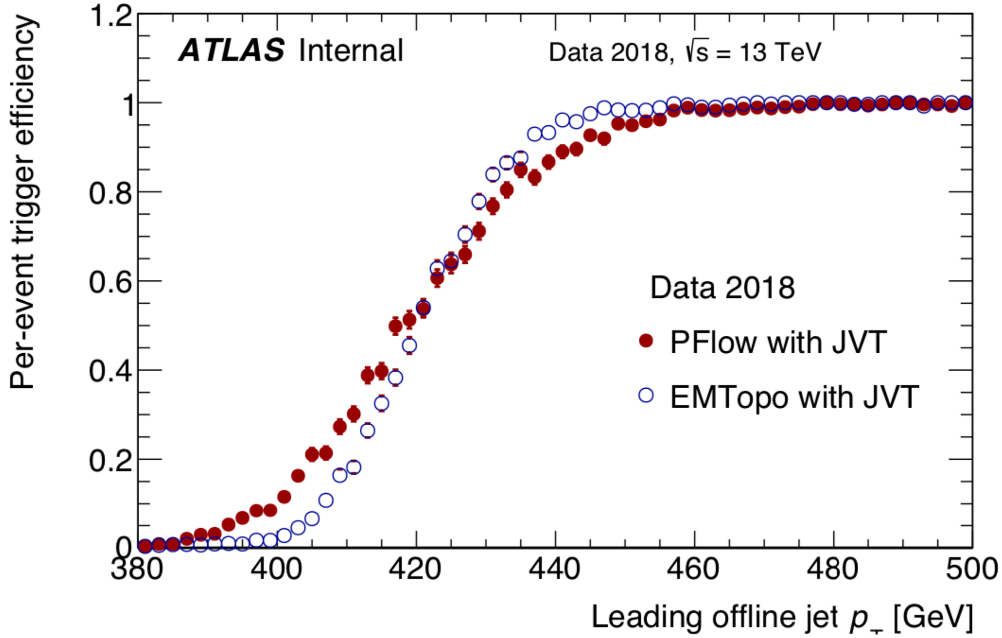
Latest updates

- Preliminary plots
  - Work in progress; not full stats
- Lowest unprescaled single jet turn-on
- 2016 data(*)
- NOTE: your latest calibration doesn't exist when trigger is running...
- 2017 and 208
  - Updated JES
  - Added GSC
  - Added in-situ correction
- Impact of HLT calibration: (shaded: >99% efficiency)
- Efficiency increased from 51% (2015to 69%

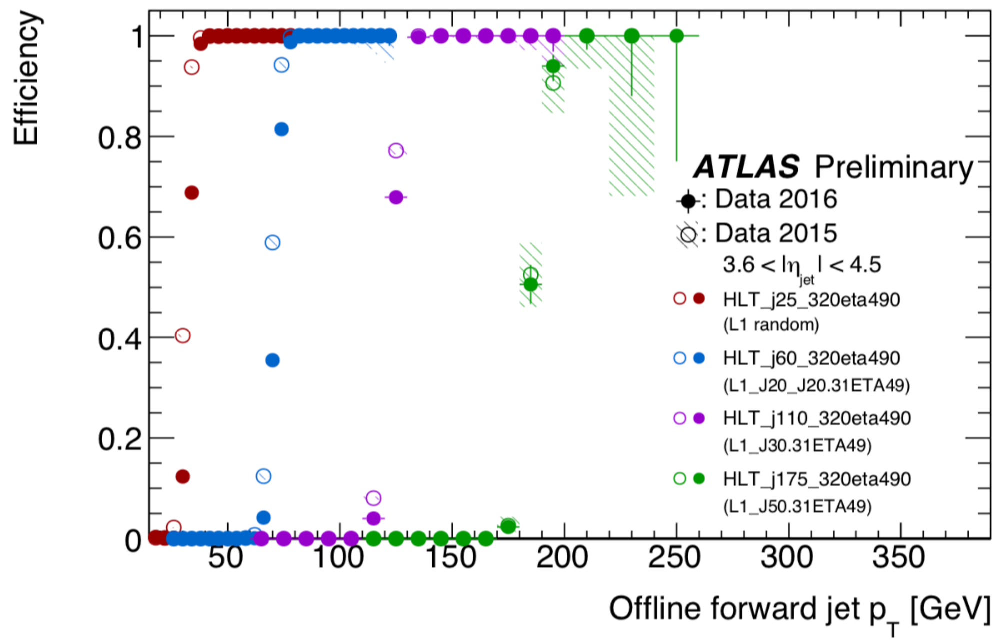




- EMTopo trigger jets plotted vs offline EMTopo or Pflow
  - Note: x-axis is either EMTopo or PFlow



- For completeness: forward jets



Tracking in the jet trigger(*)

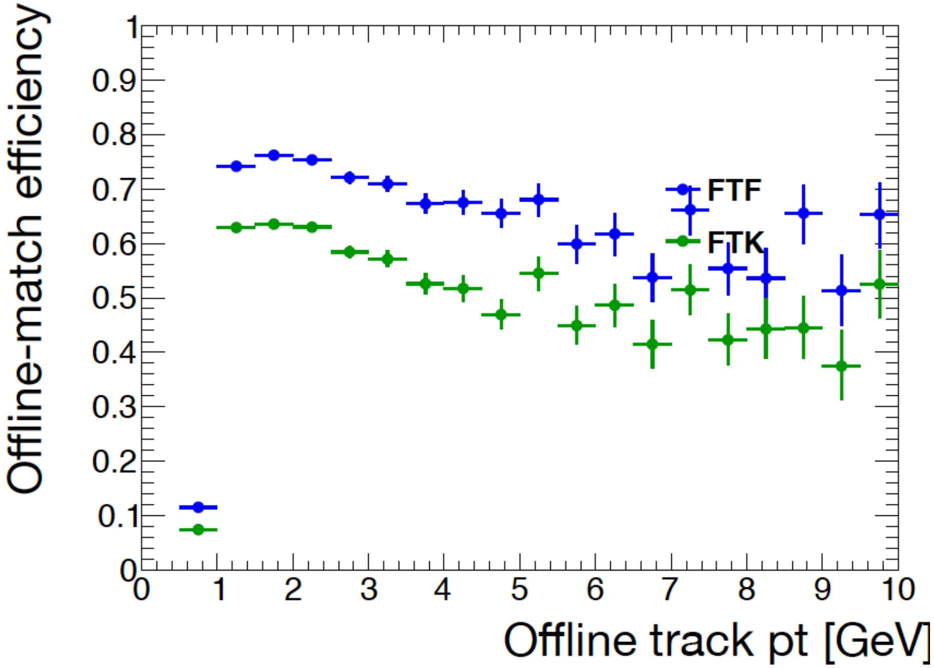
(*) In an FTK-less world

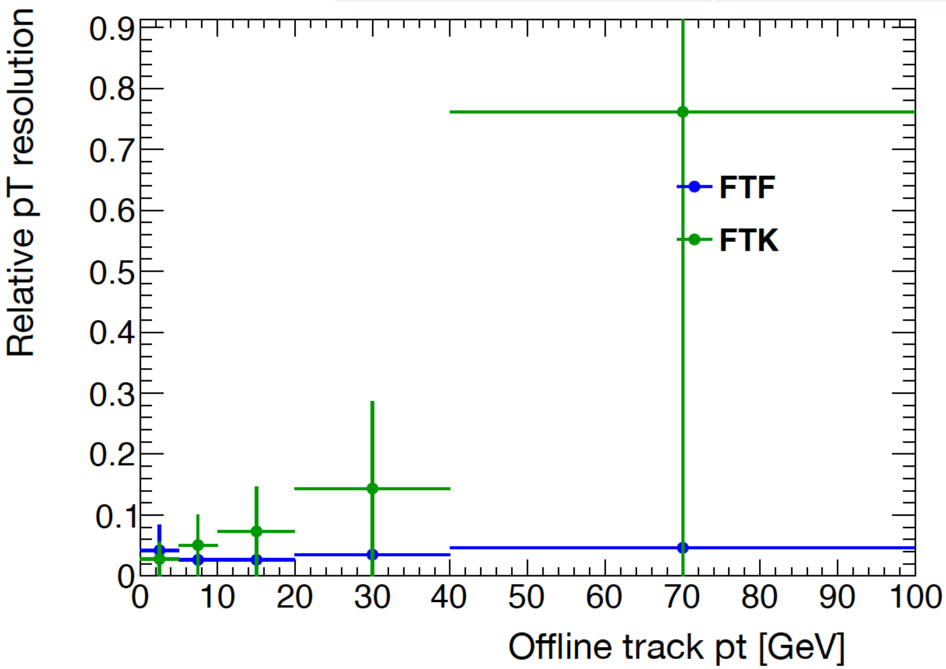
FTK vs FTF comparison

TJ Khoo

- Took 21.3 AOD sample with FTF & FTK tracks (ART test)
- Match tracks to offline with min deltaR cut of 0.01
  - Good enough, no overlaps
- Applied 500 MeV pT cut and TightPrimary WP
- Compare resolution and efficiency for FTF and FTK (non-refit)
- Resolution is width of Gaussian (fitted to +/- 2 sigma)

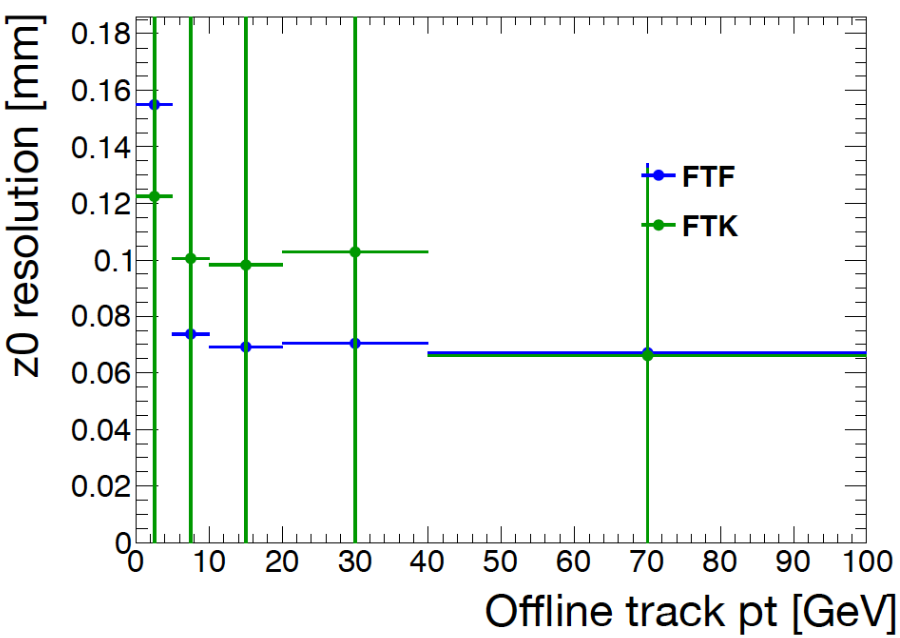
Rate wrt no JVT	JVT>0.15
HLT_j15	81%
HLT_j45	85%
HLT_4j15	13%
HLT_2j45	45%
HLT_4j45	76%
HLT_6j45	68%

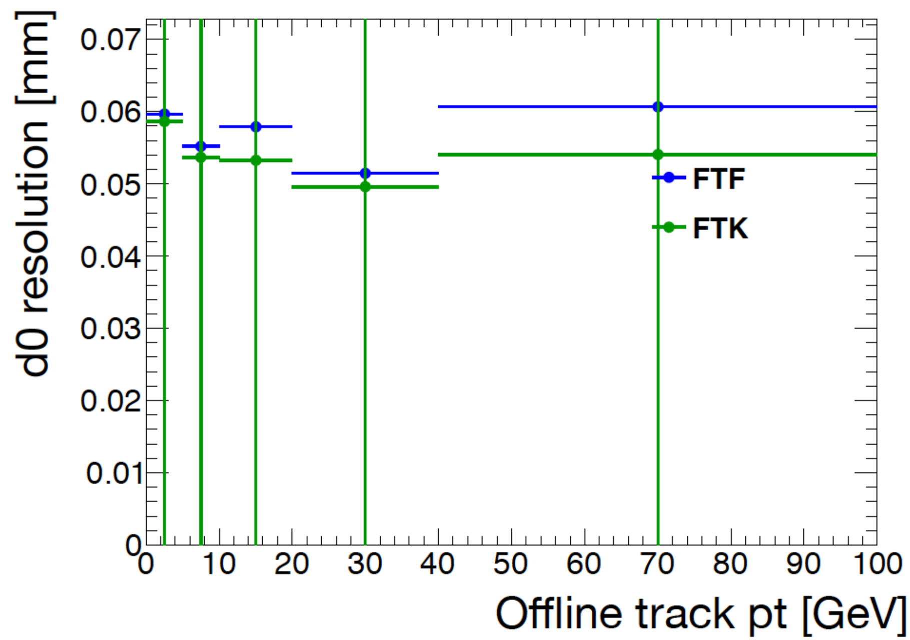




FTK vs FTF comparison

- Performance of **these** FTF tracks seems better than FTK benchmark
  - Except resolutions at very low p_T
  - And have not checked fake rate
- BUT: this version of FTF takes 5s/event
  - Not only tracks, also need vertexing algorithm
  - Goal is 1s/evt but compatible with FTK performance ; currently 5s/evt





Tracking scenarios

- First: need a better assessment of PFlow performance with HLT tracks
  - Initial results from 2016, but raised questions recently
  - Need to establish that the HLT PFlow gives us a significant benefit over pure calo triggers.

- Baseline procedure would be:
  1. Run HLT fast-tracking (re-optimised for speed, performance similar to FTK)
  2. Run PFlow with HLT tracks & clusters
  3. Run PFlow jet-finding

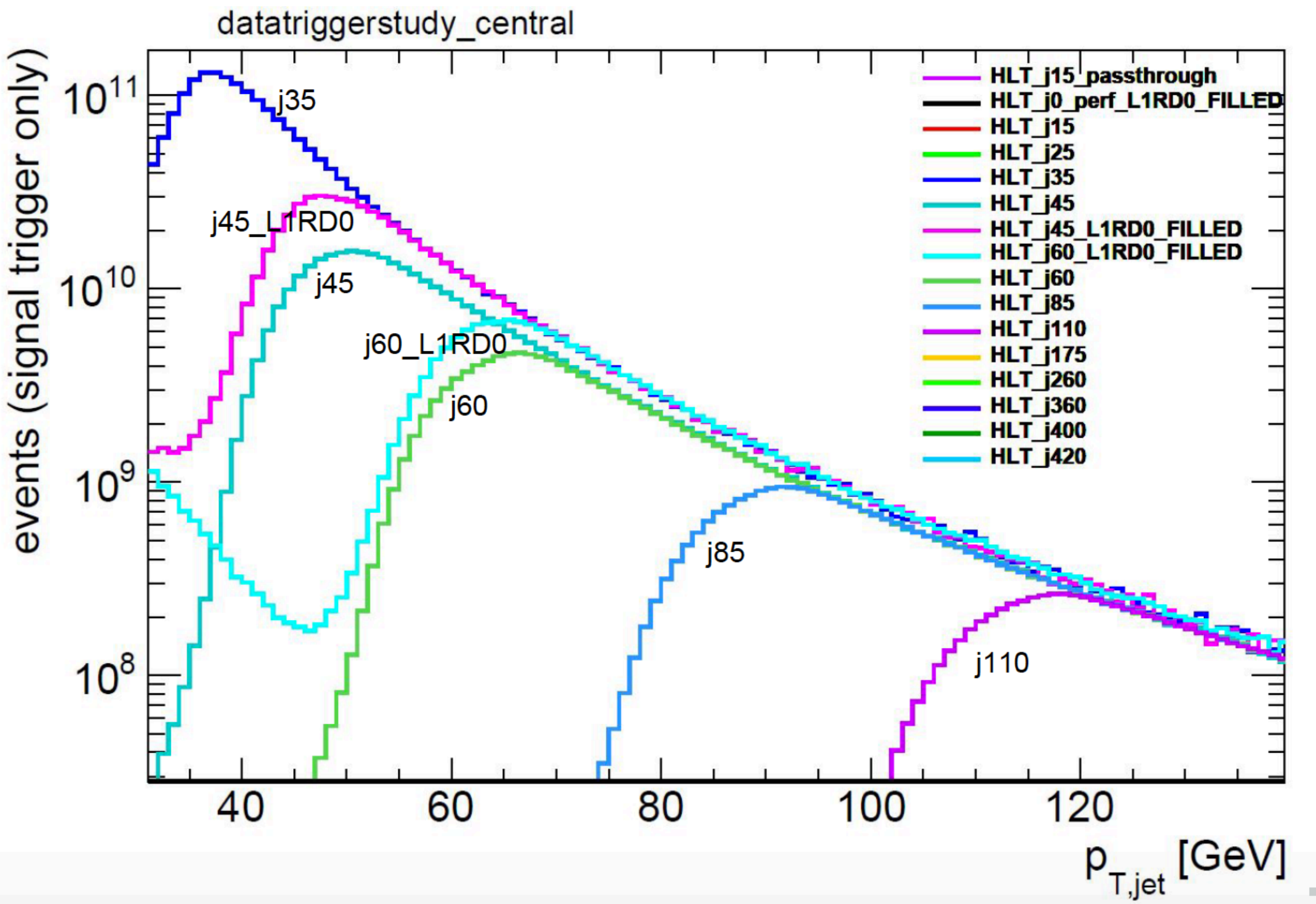
- Plan B (if we get decent FTF track performance but fail CPU constraints):
  1. Build jets from topoclusters for pre-filtering (no track GSC)
  2. Run HLT fast-tracking (reoptimised for speed, performance similar to FTK)
  3. Run PFlow with HLT tracks & clusters
  4. Run PFlow jet-finding

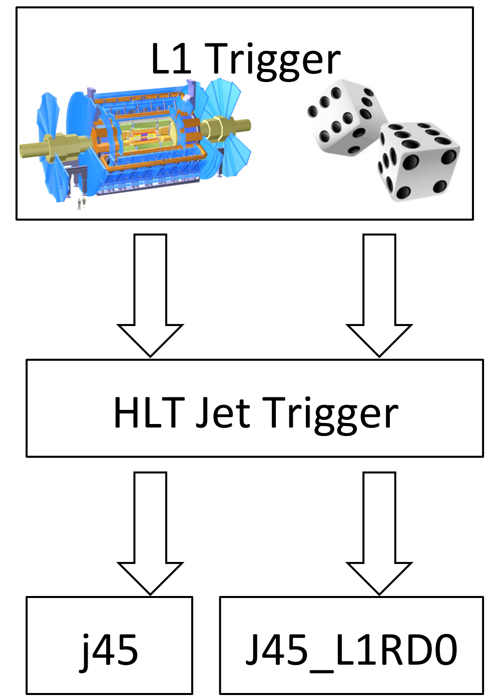
- Plan C (if PF still worth it but plans A and B fail CPU constraints):
  1. Do tracking only in RoIs around jets (a la current b-jet tracking) with low enough thresholds to build vertices and achieve some pileup suppression

JET TRIGGER INPUTS

Tancredi Carli, Tigran Mkrtchyan

Jet trigger performance in low-μ data



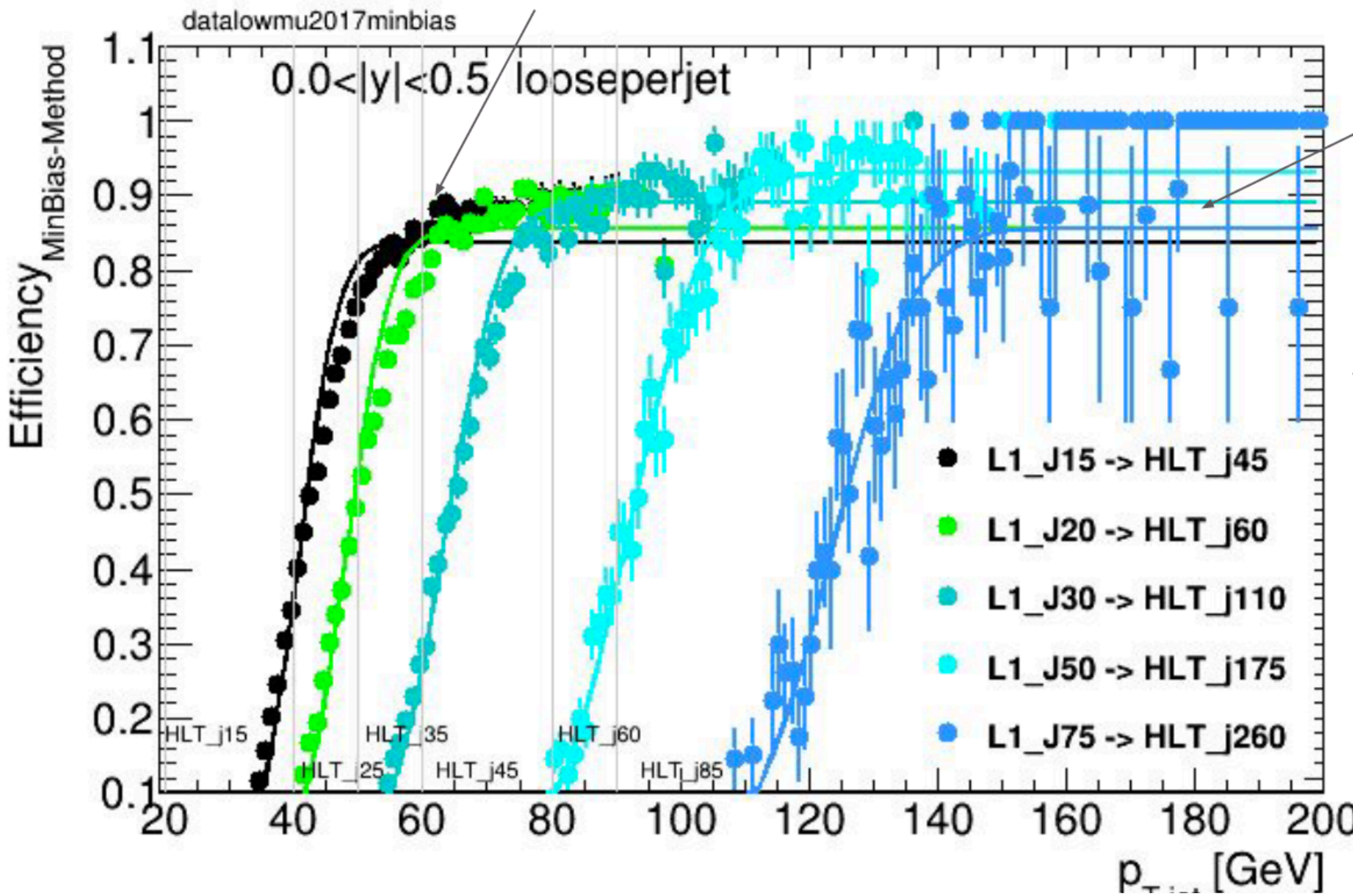


Evaluated efficiency jet trigger efficiency in **2017 data** using the **minimum bias** trigger

L1Calo efficiency wrt L1 MB trigger

0 <|y|< 0.5

HLT_j45 10-20% inefficient at 55 or 60 GeV → compatible with jet spectra



Problem also at high-pt ?

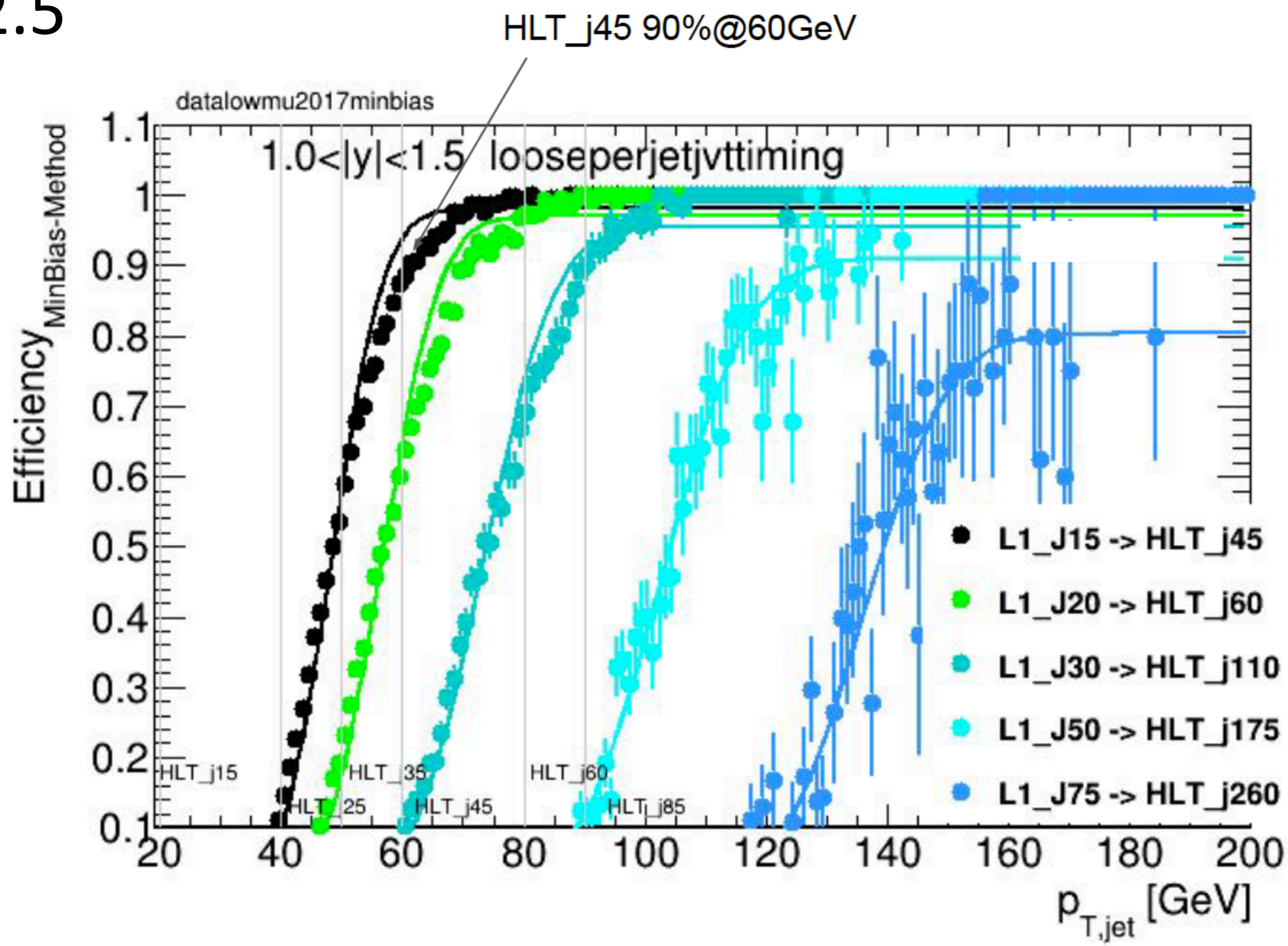
10-15% inefficiency

L1Calo efficiency wrt L1 MB trigger

2 <|y|< 2.5

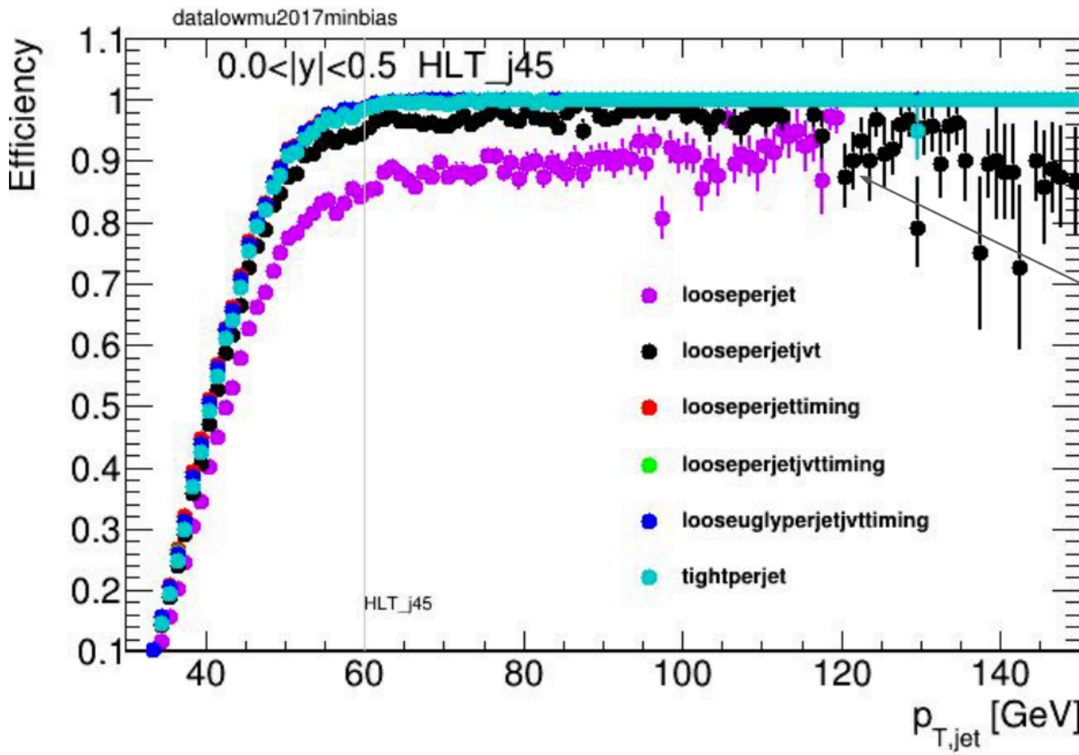
Clue:

- Ok for higher y



Still problematic in the Tile barrel/end-cap transition region.

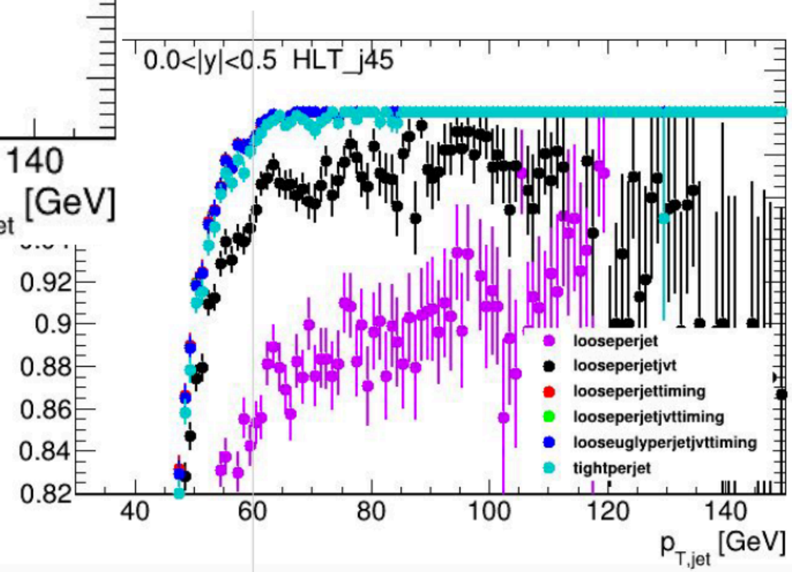
L1Calo efficiency wrt L1 MB trigger



Clues:

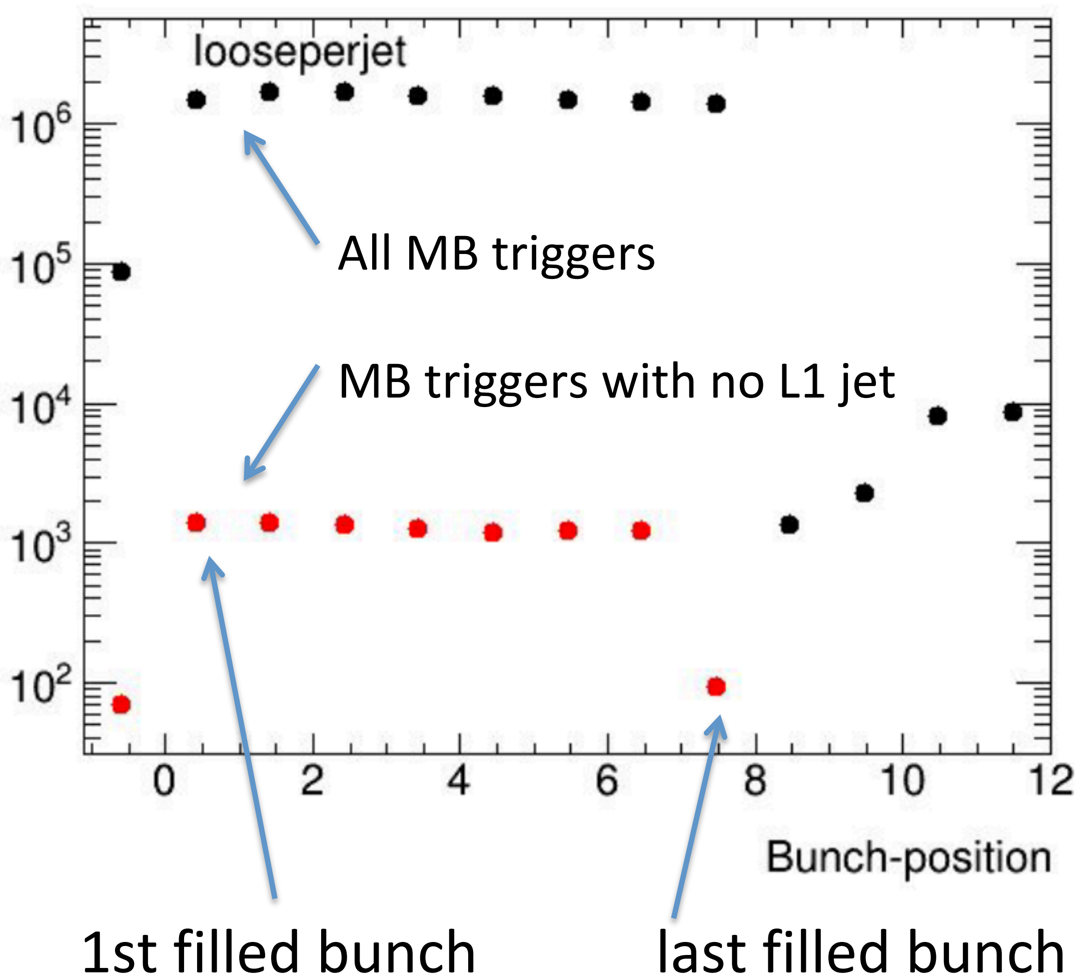
- Ok after JVT and timing

JVT cut only applied up to 120 GeV
~10% efficiency drop !



$0 < |y| < 0.5$

Rate vs position in bunch train



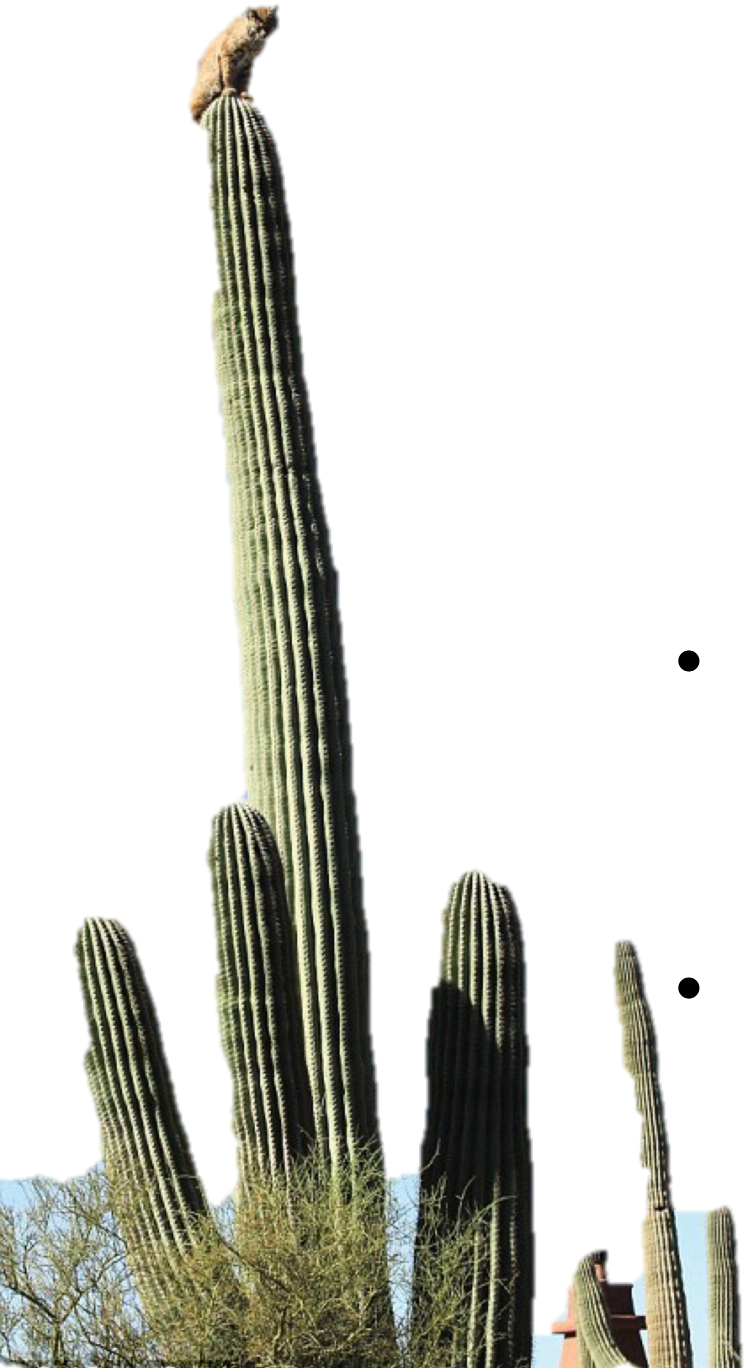
Filling scheme:
8 filled, 4 empty

Possibility is that effect comes from 1st empty bunch

Current understanding

- There is a 10-15% inefficiency in L1 jets wrt L1 random-triggered events
  - Under investigation
  - Observed for |y| < 2
  - Full efficiency is regained by applying jet timing cut

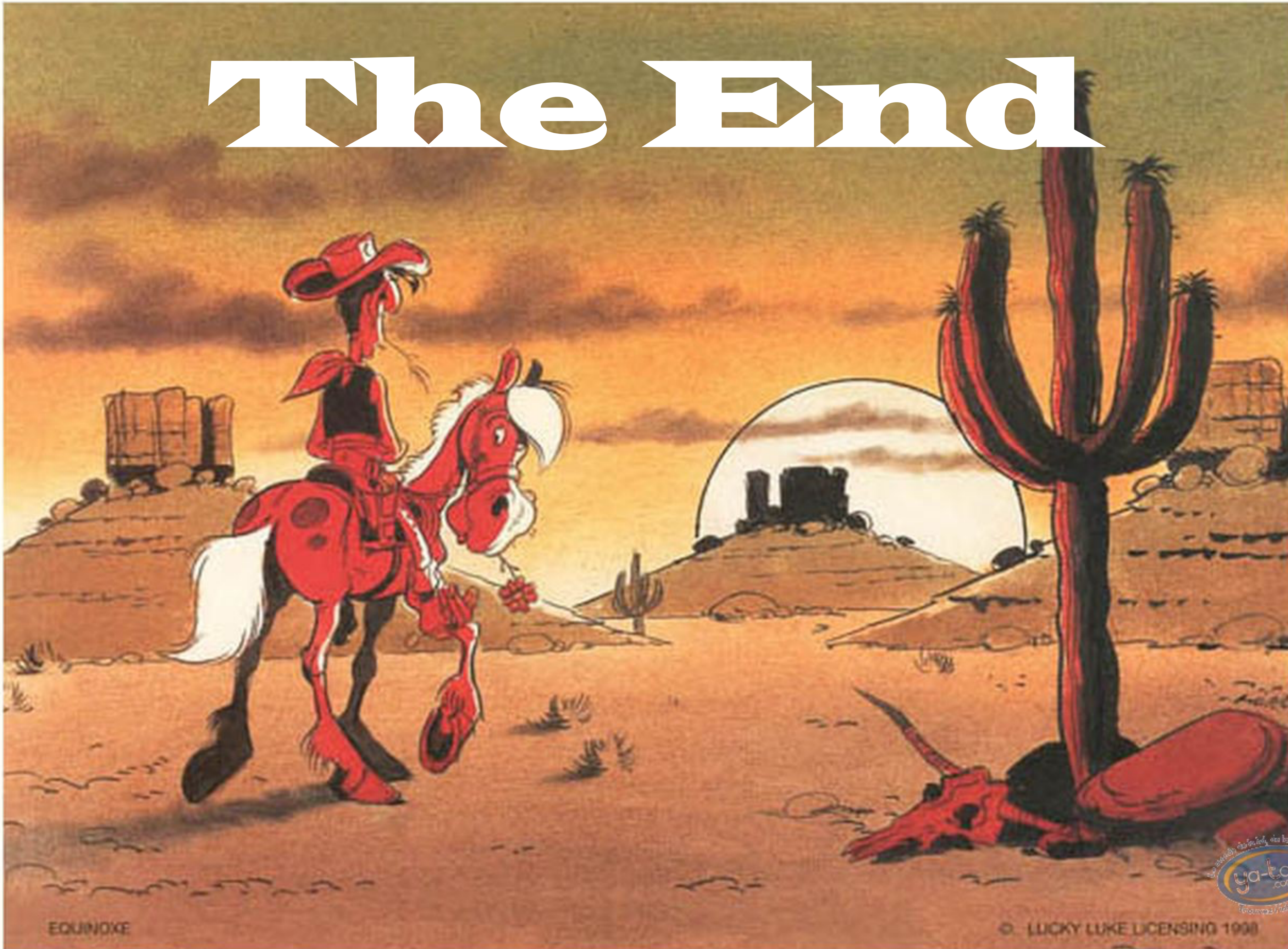
Steve’s explanation
My theory is that the effect seen is mostly due to jets in the next BC (since if there was a bigish jet in the previous BC in low mu data, we'd have probably triggered it already, so be in the deadtime of a genuine L1A). This means you should not see the effect in the last bunch in a train, since there are
no genuine jets 25 ns later in that case. This corresponds well to the plots on 29/30 where Tancredi sees little L1Calo 'inefficiency' in the last bunch of these 8b4e trains. Let’s put it another way, in those bunches, there are no out of time jets to be over-counted by his analysis!



Conclusions

Thank you for a great workshop!

- Jet trigger performance has steadily improved by increasing commonality with offline jets
- Currently at a crossroads: HLT tracking is necessary to continue to evolve


The End
EQUINOXE
© LUCKY LUKE LICENSING

Backup

Cofinanciado por:

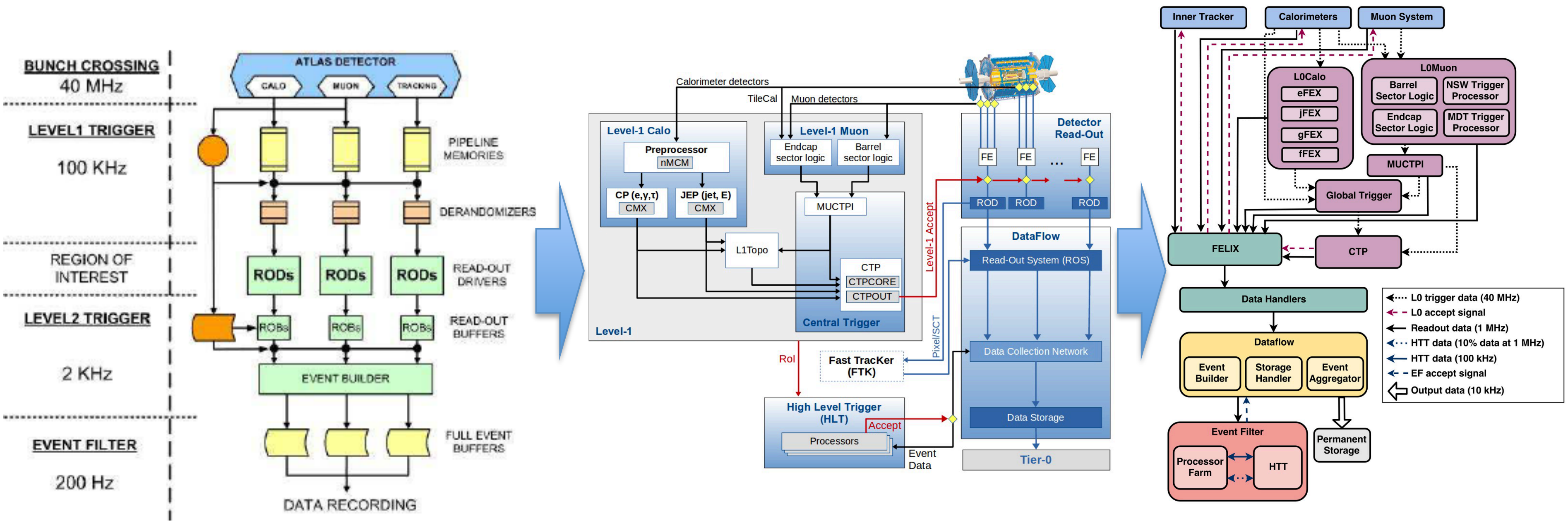
Run 3 Menu

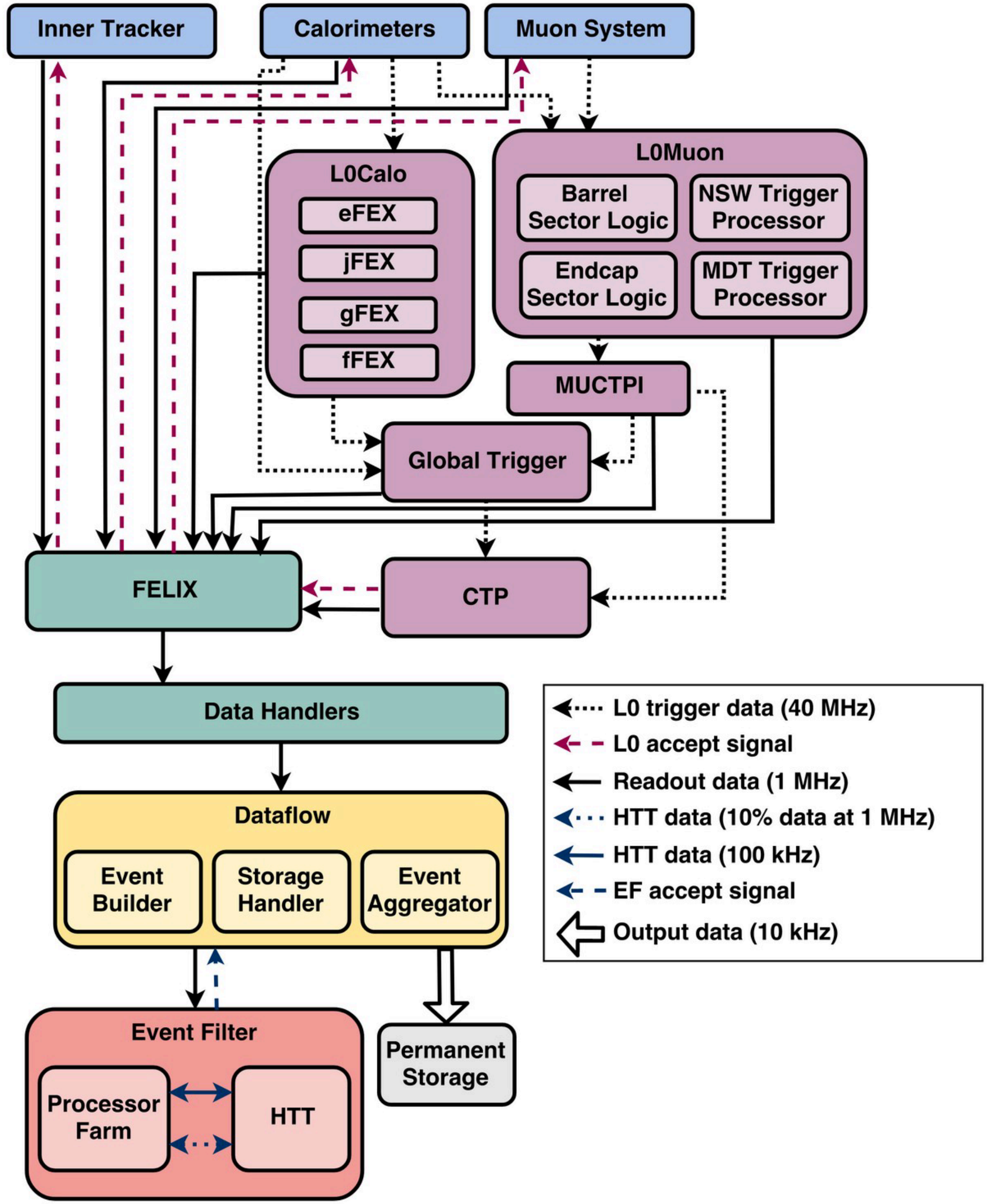
- Described in note ATL-COM-DAQ-2019-116

Category	Trigger	Rate 2e34
1J ($\|\eta\| < 3.1$)	L1_J100	3.7 kHz
TLA	HLT_j0_perf_ds1	3.7 kHz
1j	HLT_j420	36 Hz
1j gsc	HLT_j225_gsc420_boffperf_split	37 Hz
3j	HLT_3j200	11 Hz
3j ($\|\eta\| < 2.4$) gsc	HLT_2j225_gsc250_boffperf_split_0eta240	
asymmetric	_j85_gsc120_boffperf_split_0eta240	25 Hz
3J ($\|\eta\| < 3.1$)	L1_3J50	0.5 kHz
4j	HLT_4j120	12 Hz
4j gsc	HLT_4j85_gsc115_boffperf_split	16 Hz
4j ($\|\eta\| < 3.1$)	L1_4J15	4.3 kHz
5j ($\|\eta\| < 2.4$)	HLT_5j70_0eta240	20 Hz
5j ($\|\eta\| < 2.4$) gsc	HLT_5j50_gsc70_boffperf_split_0eta240	26 Hz
5j	HLT_5j85	9 Hz
5j gsc	HLT_5j60_gsc85_boffperf_split	10 Hz
6j ($\|\eta\| < 2.4$)	HLT_6j55_0eta240	12 Hz
6j ($\|\eta\| < 2.4$) gsc	HLT_6j45_gsc55_boffperf_split_0eta240	15 Hz
6j	HLT_6j70	4 Hz
6j gsc	HLT_6j50_gsc70_boffperf_split	5 Hz
7j	HLT_7j45	15 Hz
7j gsc	HLT_7j35_gsc45_boffperf_split	16 Hz
10j	HLT_10j40	0.2 Hz

Table 9: Run-3 central jet primary triggers and their corresponding rates at 2e34. L1 items are not appended to the HLT chain name for simplicity.

The Jet Trigger Wants YOU!


BUNCH CROSSING
40 MHz
LEVEL1 TRIGGER
100 KHz
REGION OF INTEREST
LEVEL2 TRIGGER
2 KHz
EVENT FILTER
200 Hz
ATLAS DETECTOR
CALO
MUON
TRACKING
PIPELINE MEMORIES
DERANDOMIZERS
RODs
READ-OUT DRIVERS
ROBs
READ-OUT BUFFERS
EVENT BUILDER
FULL EVENT BUFFERS
DATA RECORDING
Calorimeter detectors
TileCal
Muon detectors
Level-1 Calo
Preprocessor
nMCM
CP (e,γ,τ)
JEP (jet, E)
CMX
Level-1 Muon
Endcap sector logic
Barrel sector logic
MUCTPI
L1Topo
CTP
CTPCORE
CTPOUT
Central Trigger
Level-1
Level-1 Accept
Detector Read-Out
FE
ROD
DataFlow
Read-Out System (ROS)
Data Collection Network
Data Storage
Tier-0
Pixel/SCT
RoI
Fast TracKer (FTK)
High Level Trigger (HLT)
Accept
Processors
Event Data
Inner Tracker
Calorimeters
Muon System
L0Calo
eFEX
jFEX
gFEX
fFEX
L0Muon
Barrel Sector Logic
NSW Trigger Processor
Endcap Sector Logic
MDT Trigger Processor
MUCTPI
Global Trigger
FELIX
CTP
Data Handlers
Dataflow
Event Builder
Storage Handler
Event Aggregator
Event Filter
Processor Farm
HTT
Permanent Storage
L0 trigger data (40 MHz)
L0 accept signal
Readout data (1 MHz)
HTT data (10% data at 1 MHz)
HTT data (100 kHz)
EF accept signal
Output data (10 kHz)



Inner Tracker
Calorimeters
Muon System
L0Calo
eFEX
jFEX
gFEX
fFEX
L0Muon
Barrel Sector Logic
NSW Trigger Processor
Endcap Sector Logic
MDT Trigger Processor
MUCTPI
Global Trigger
FELIX
CTP
Data Handlers
Dataflow
Event Builder
Storage Handler
Event Aggregator
Event Filter
Processor Farm
HTT
Permanent Storage
L0 trigger data (40 MHz)
L0 accept signal
Readout data (1 MHz)
HTT data (10% data at 1 MHz)
HTT data (100 kHz)
EF accept signal
Output data (10 kHz)

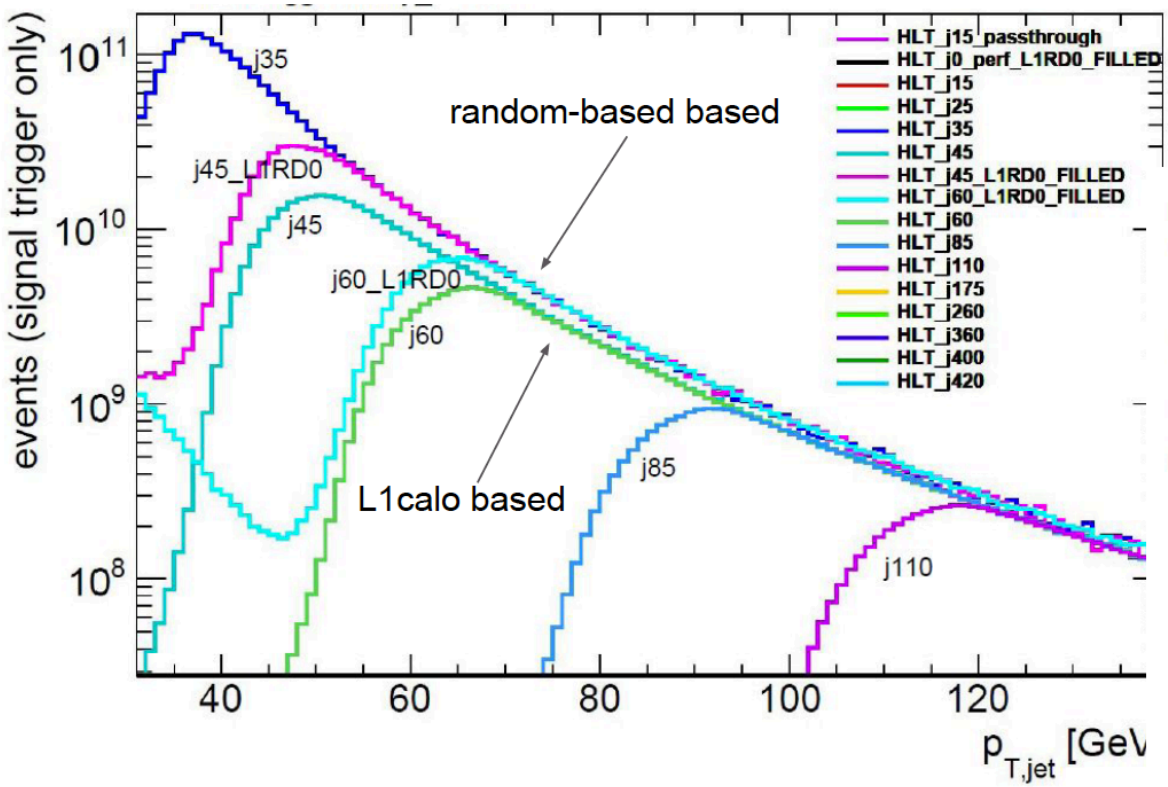
Tracking

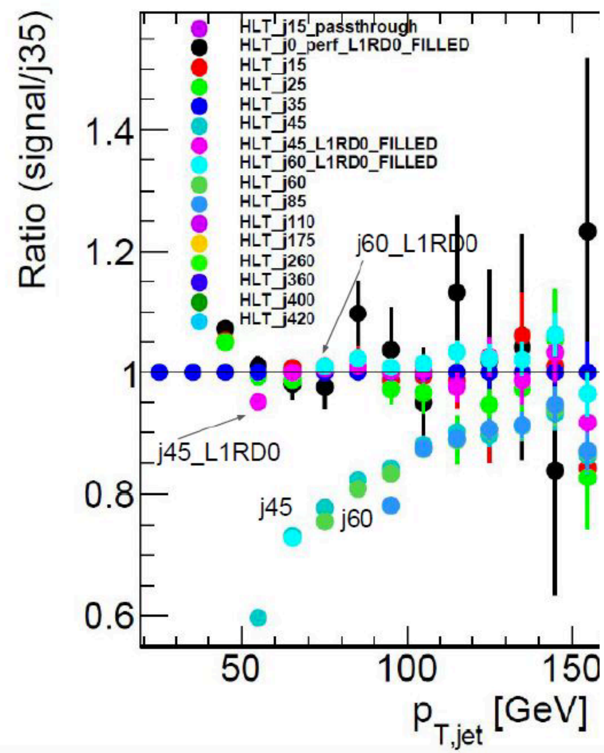
- HLT full-scan tracking considered possible if tracking CPU is <1s/evt.
- Maximal scenario of 22 kHz HLT tracking+PF rate considered viable with 2022 HLT farm — 175% of CPU needed w/o FTK

Problem?

Reminder: Jet transverse momentum spectra per trigger

More info here

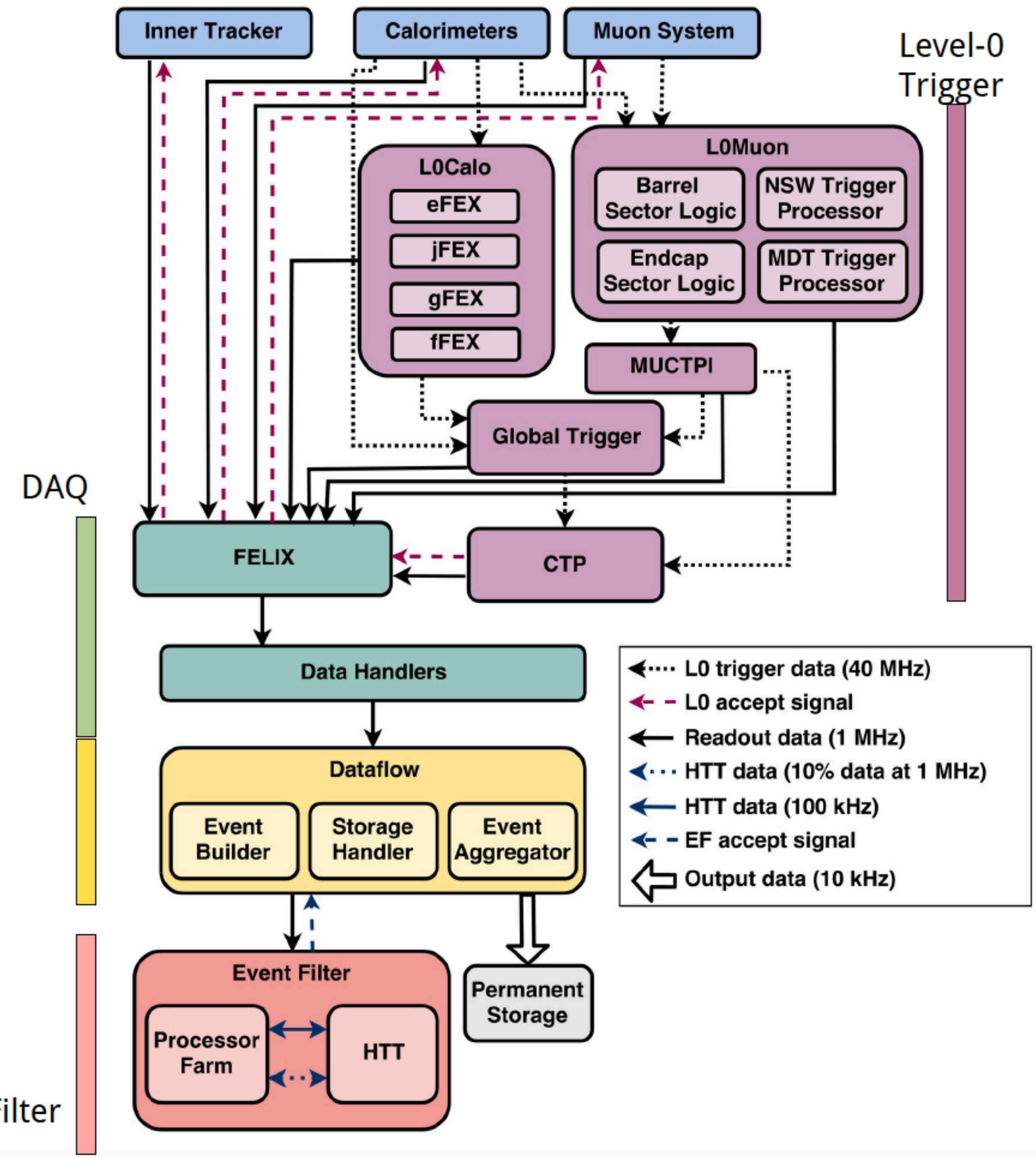




Phase-II TDAQ Architecture

- Two-Level Trigger and Data Acquisition System
  - hardware-based L0 trigger system
  - software-based Event Filter, aided by dedicated tracking accelerator

- Storage-based data-flow infrastructure
  - decouple real-time domain from software processing
  - enable advanced data processing strategies



Phase-II TDAQ Evolution Architecture

- Evolution path to a two-level hardware trigger included in the design
  - L0 – 4 MHz
  - L1 – 1 MHz
  - Event Filter – 10 kHz
- Possible transition from baseline to evolution driven by physics requirements
  - hadronic trigger rates
  - occupancy of inner layers of ITk
- Avoid the baseline TDAQ implementation restricting the trigger menu at the ultimate HL-LHC operating conditions
- Level-1 Trigger combines L0 objects with track information from a dedicated subsystem to discriminate against pileup in the calorimeter