ATLAS Trigger Rates and Physics Menu

Sarah Demers, Yale University

October 6, 2016

ECFA Meeting

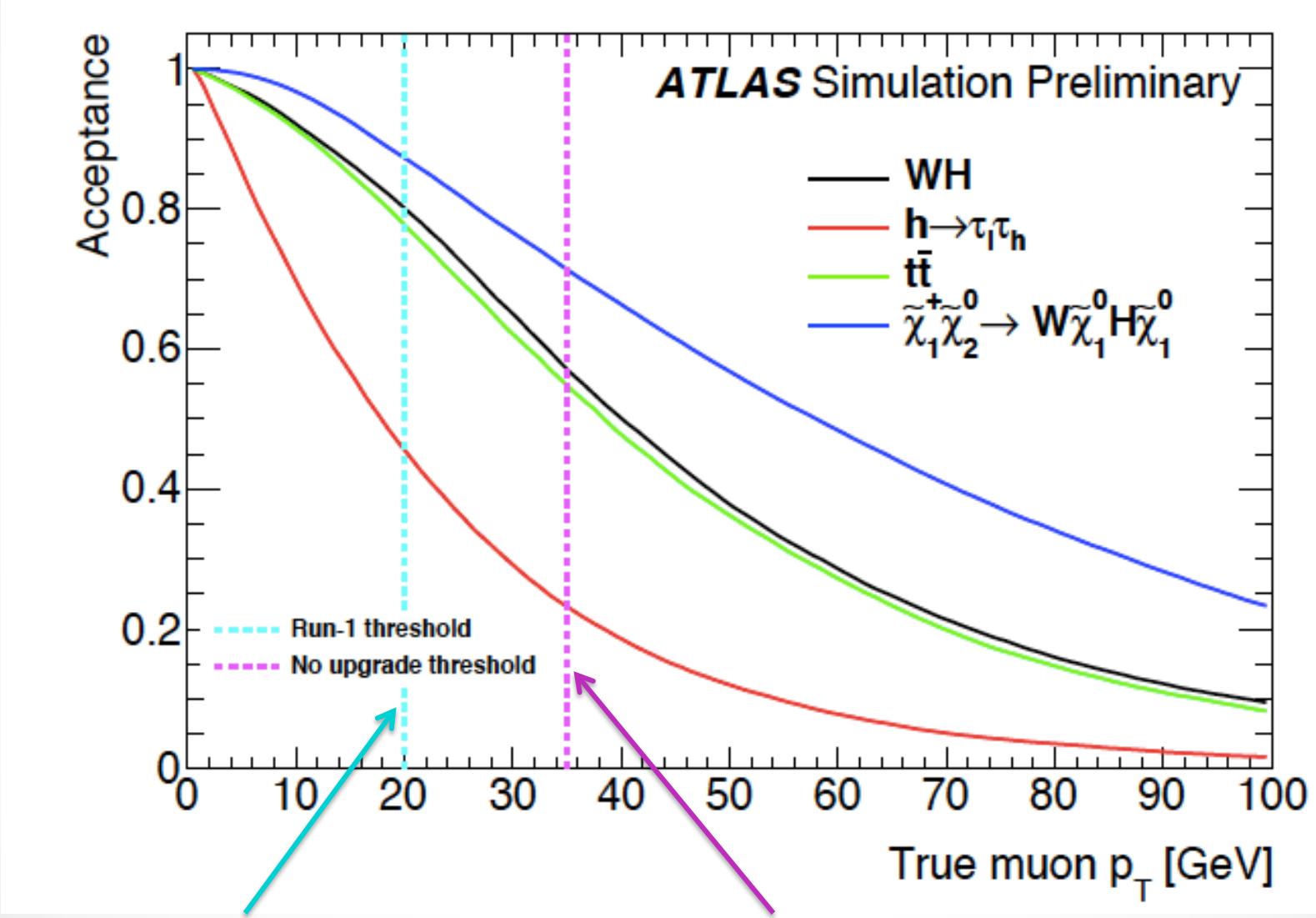
Outline

- Reminder of the physics motivation and establishing TDAQ goals
- Discussion of architecture choices, latency requirements and data flow through the system
- Target menu and rates
- Comments regarding rate predictions

The two previous talks by Masaya Ishino (calorimeters and muons) and Giudo Volpi (tracks) have described the main detector inputs to the trigger.

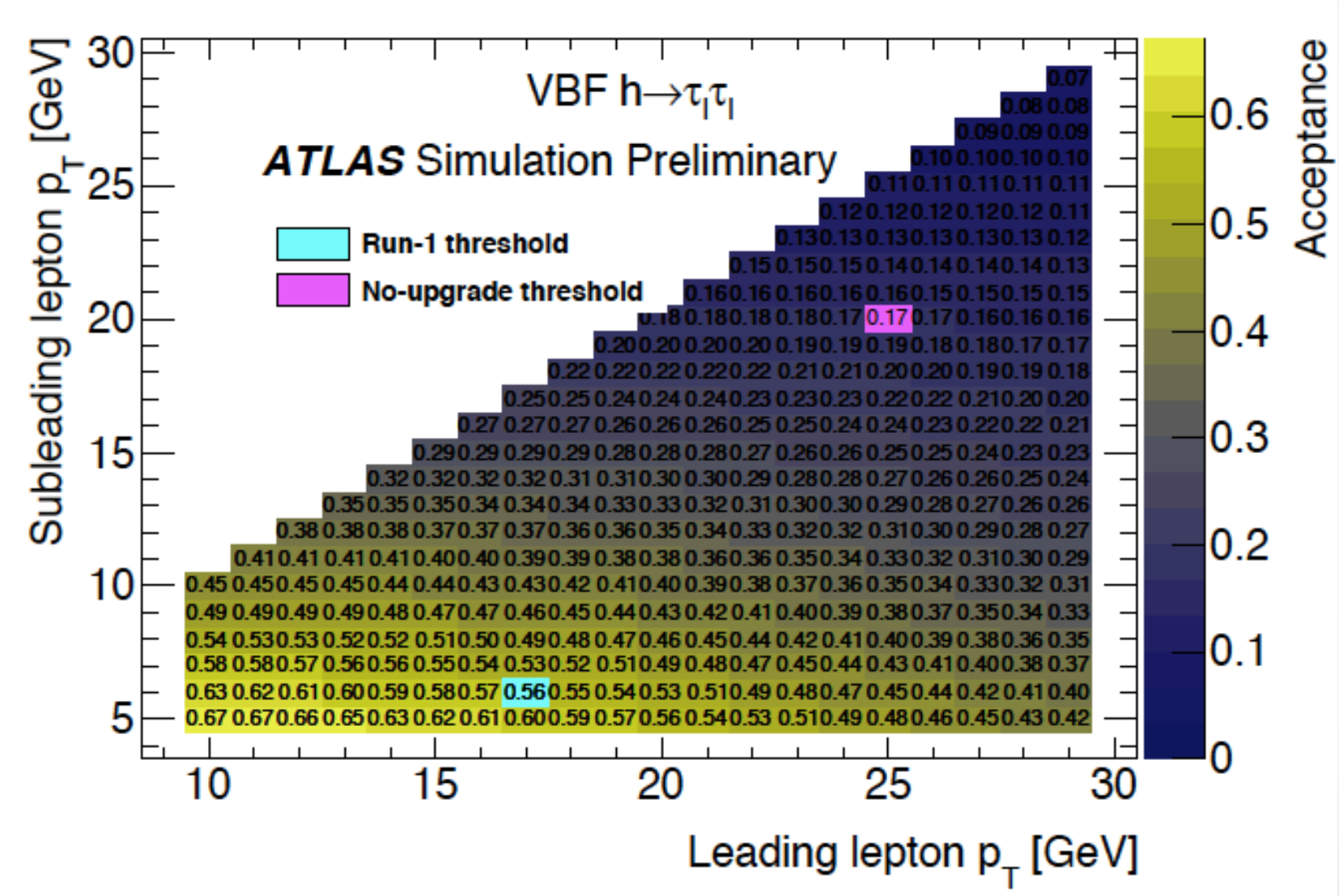
- In this talk we'll focus on the overall TDAQ system.

Physics Motivation: impact of muon threshold requirement

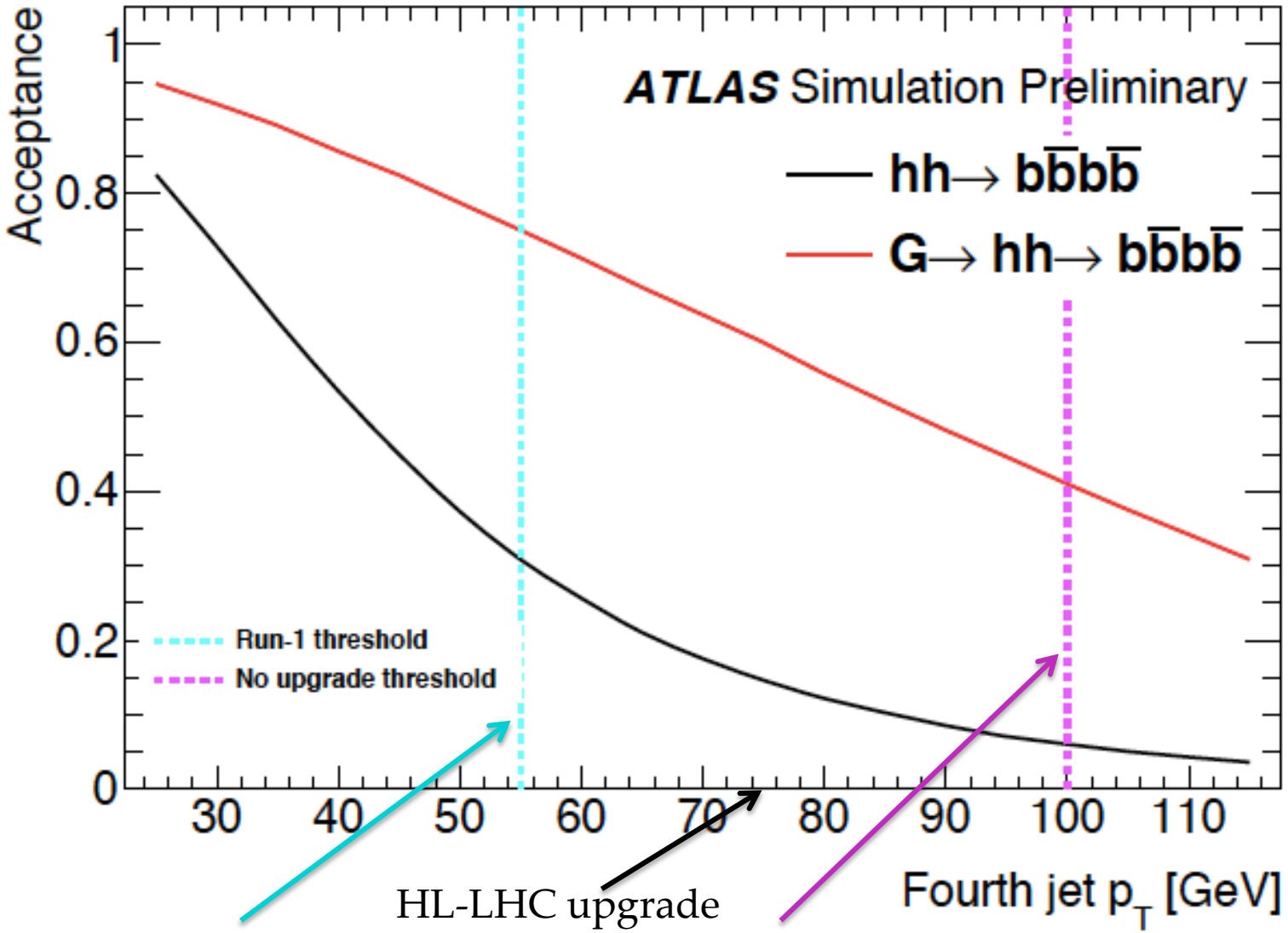


Run 1 Threshold **No Upgrade Threshold**

VBF h->$\tau_l\tau_l$



Mulijet Triggers



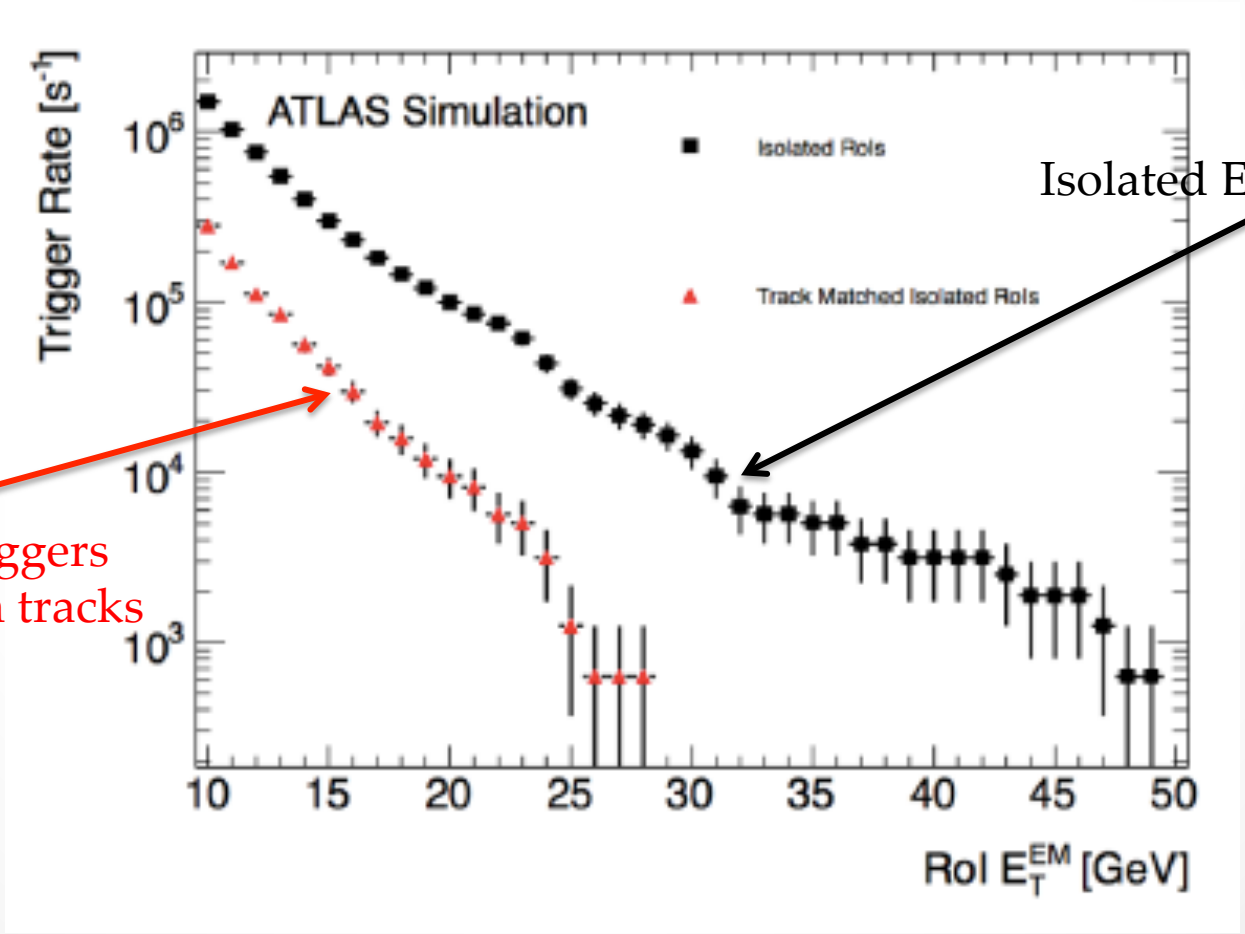
Run 1 Threshold

No Upgrade Threshold

General Strategy

1) loosen current 100 kHz L1 rate

2) access tracking information early

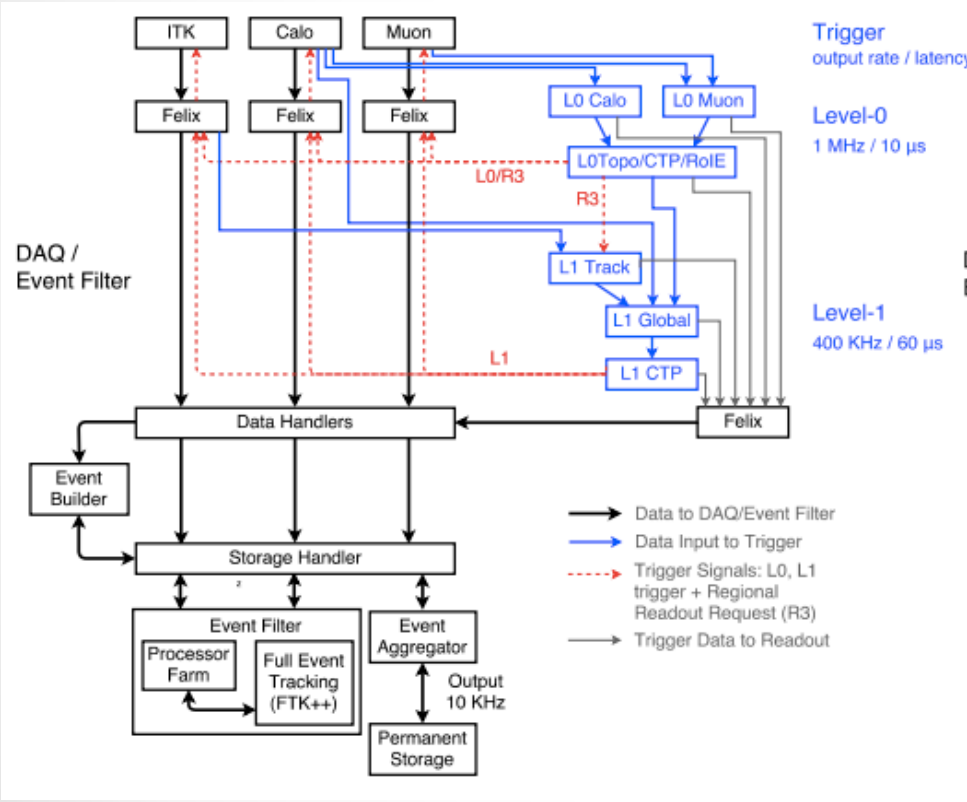


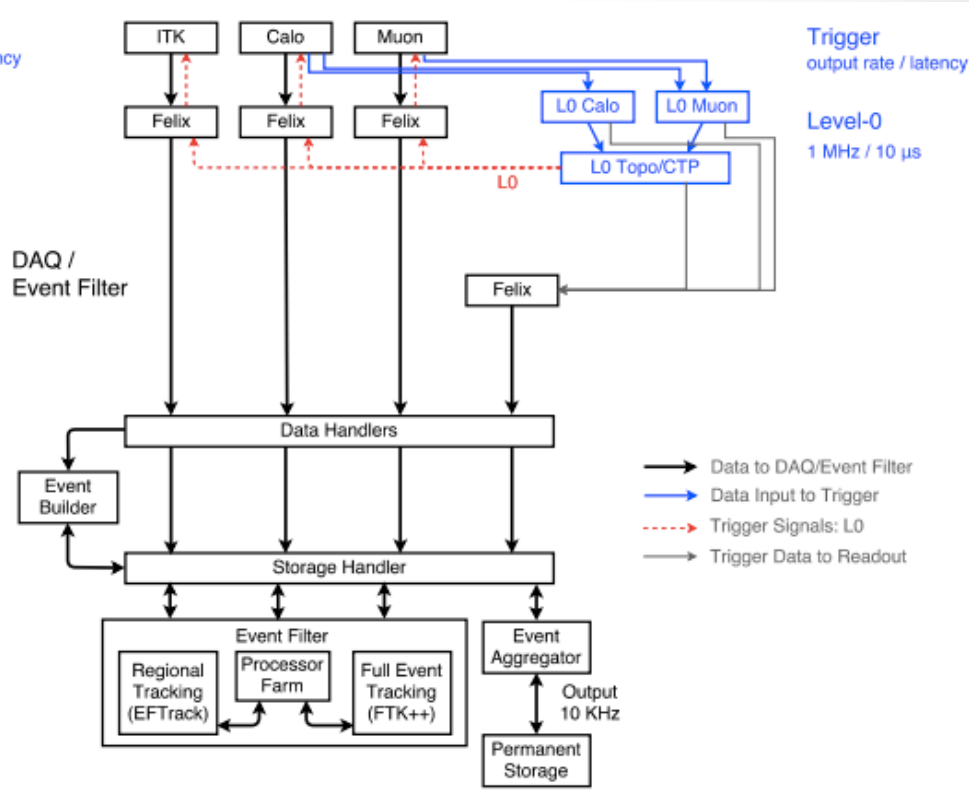
Isolated EM triggers

Isolated EM triggers associated with tracks

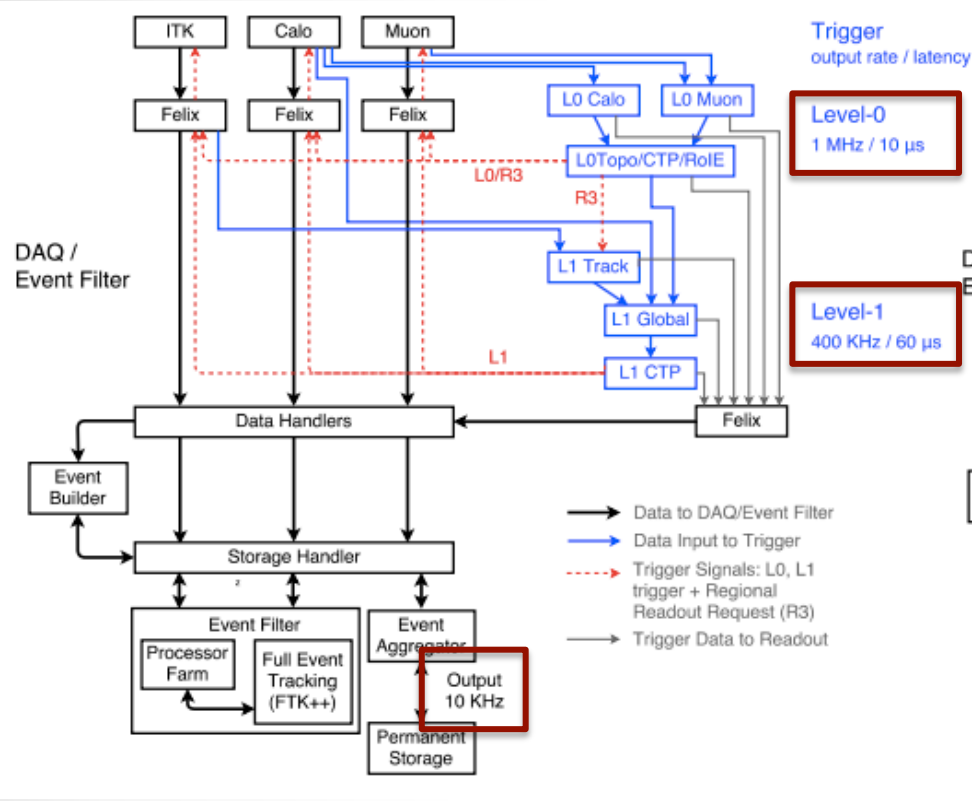
Possible architectures

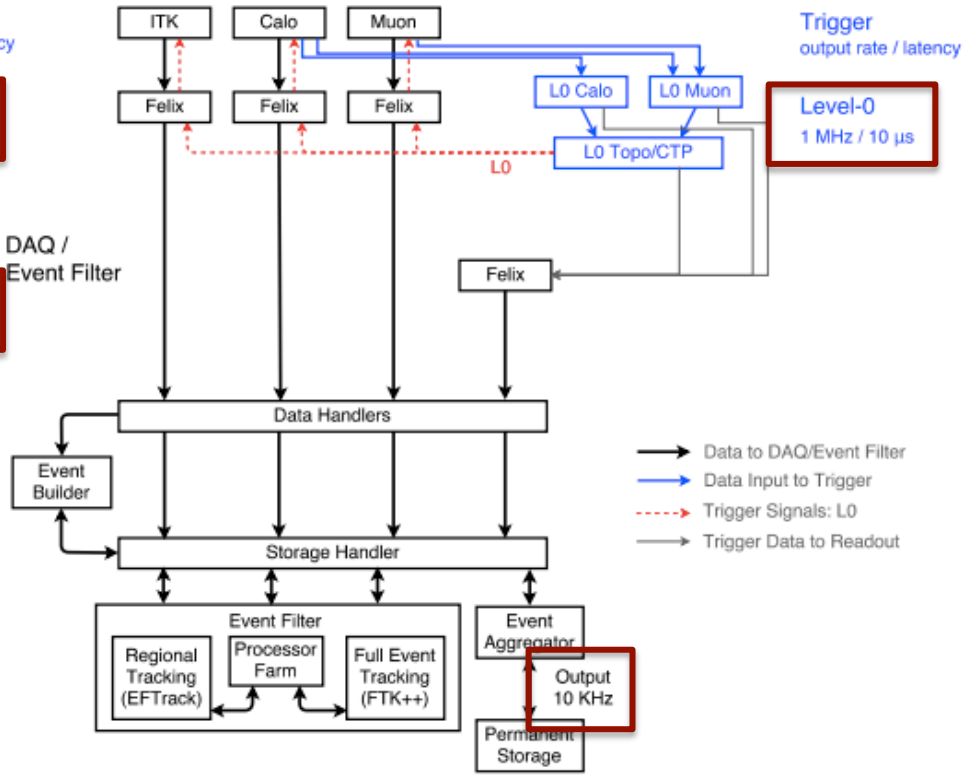
Introduced Monday morning, by Brian Petersen
https://indico.cern.ch/event/524795/contributions/2235126/attachments/1346960/2031430/StatusAndPlans.pdf





Possible architectures



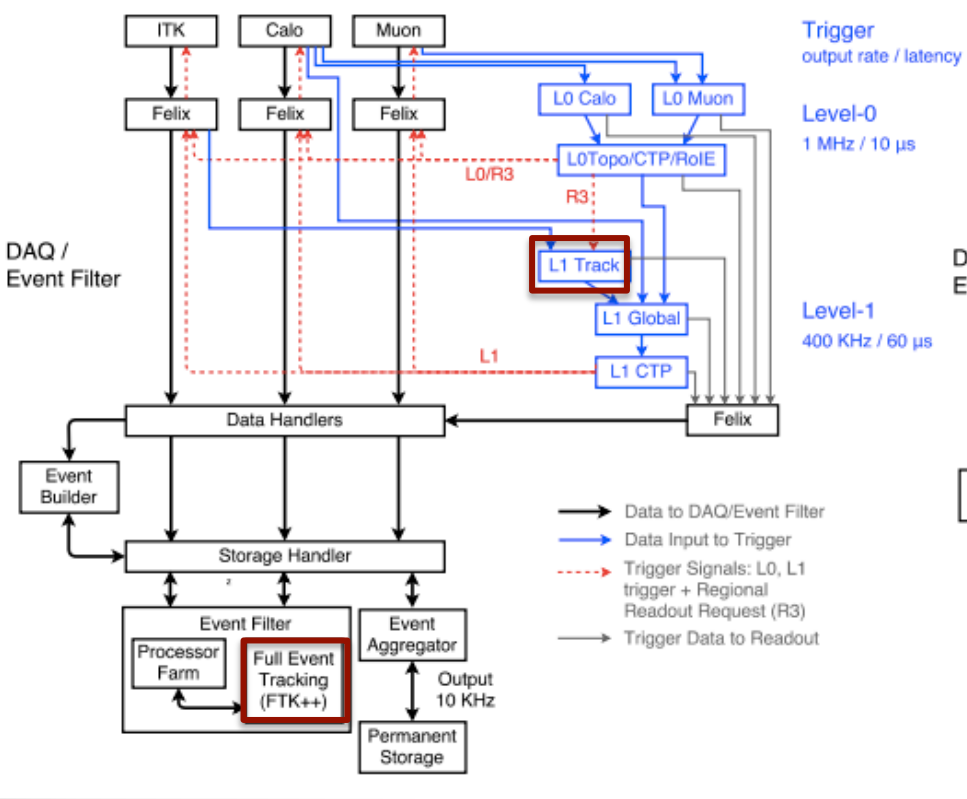


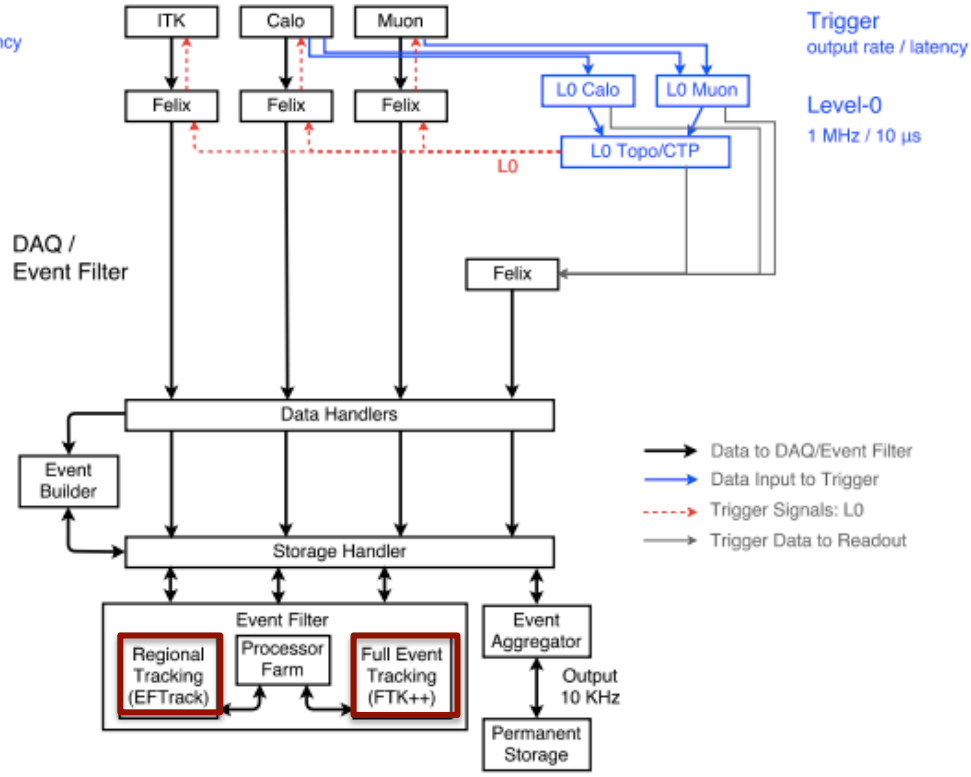
Rates and Latencies

Level 0: 1 MHz, 10 µs
Level 1: 400 kHz, 60 µs
EF output: 10 kHz

Level 0: 1 MHz, 10 µs
EF output: 10 kHz

Possible architectures





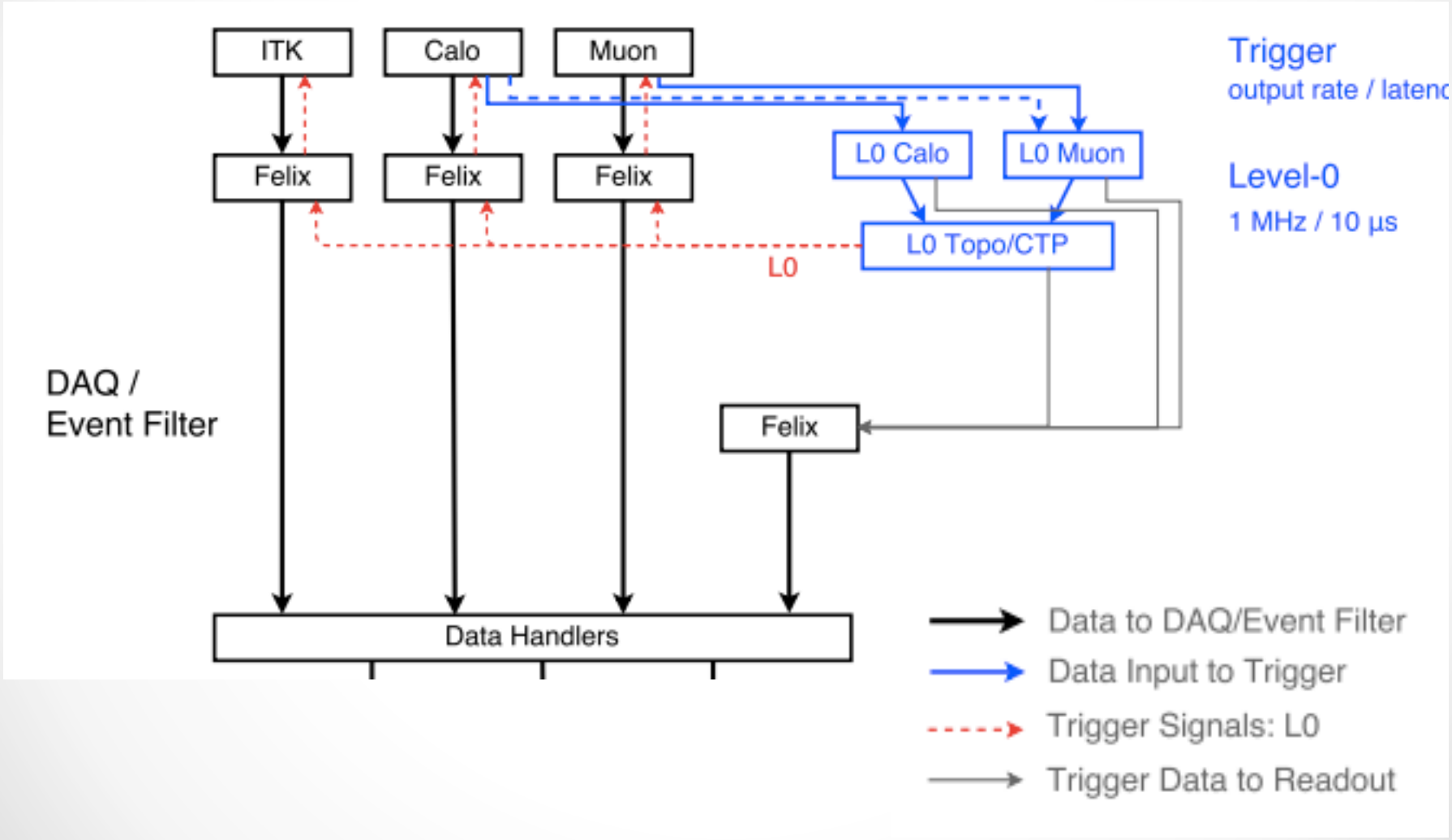
Track Information

Level 1: regional tracking w/ ITK
EF: Full event tracking w/ FTK++

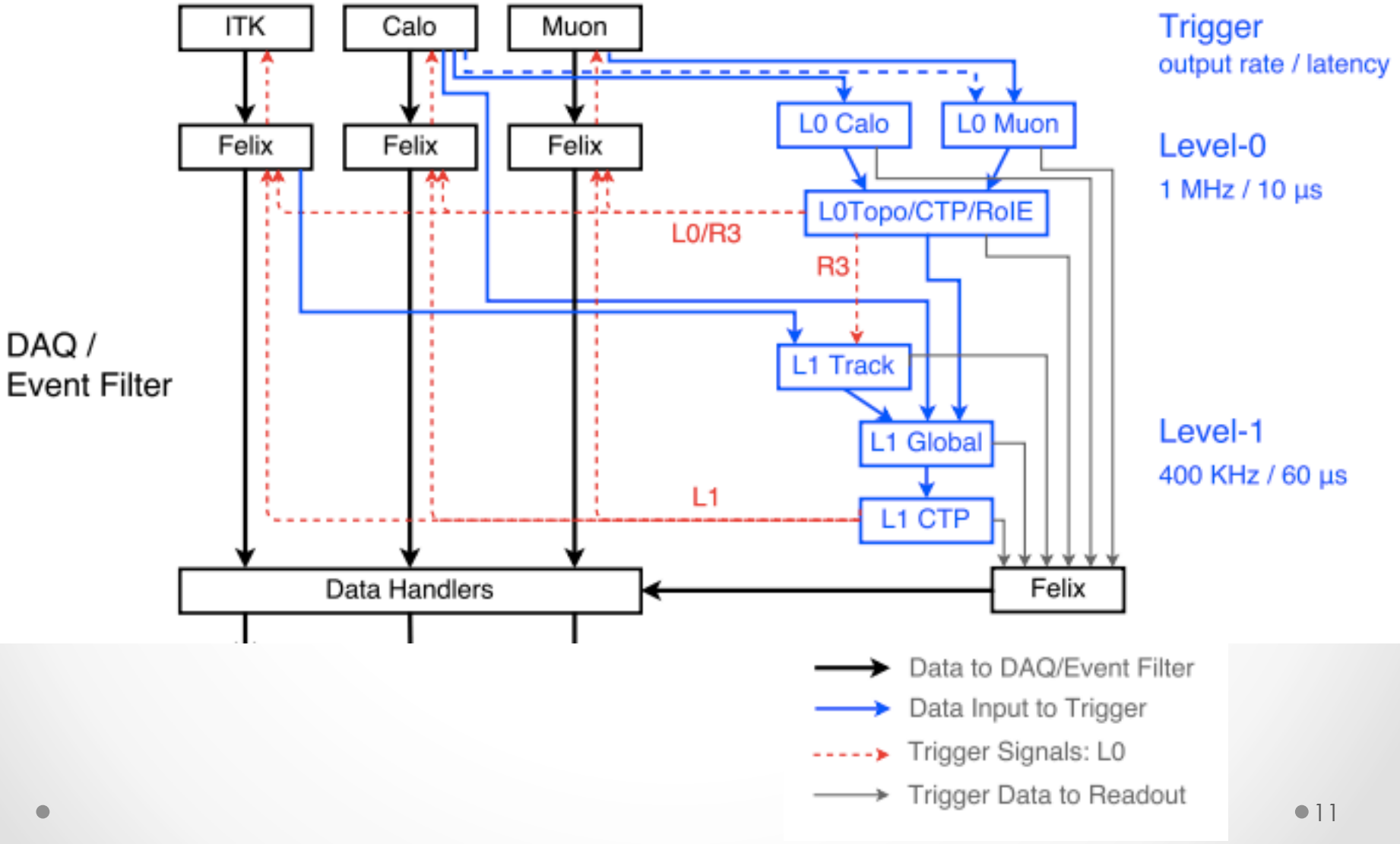
EF: regional tracking w/ EFTrack,
full event tracking w/ FTK++

(See previous presentation by Guido Volpi)

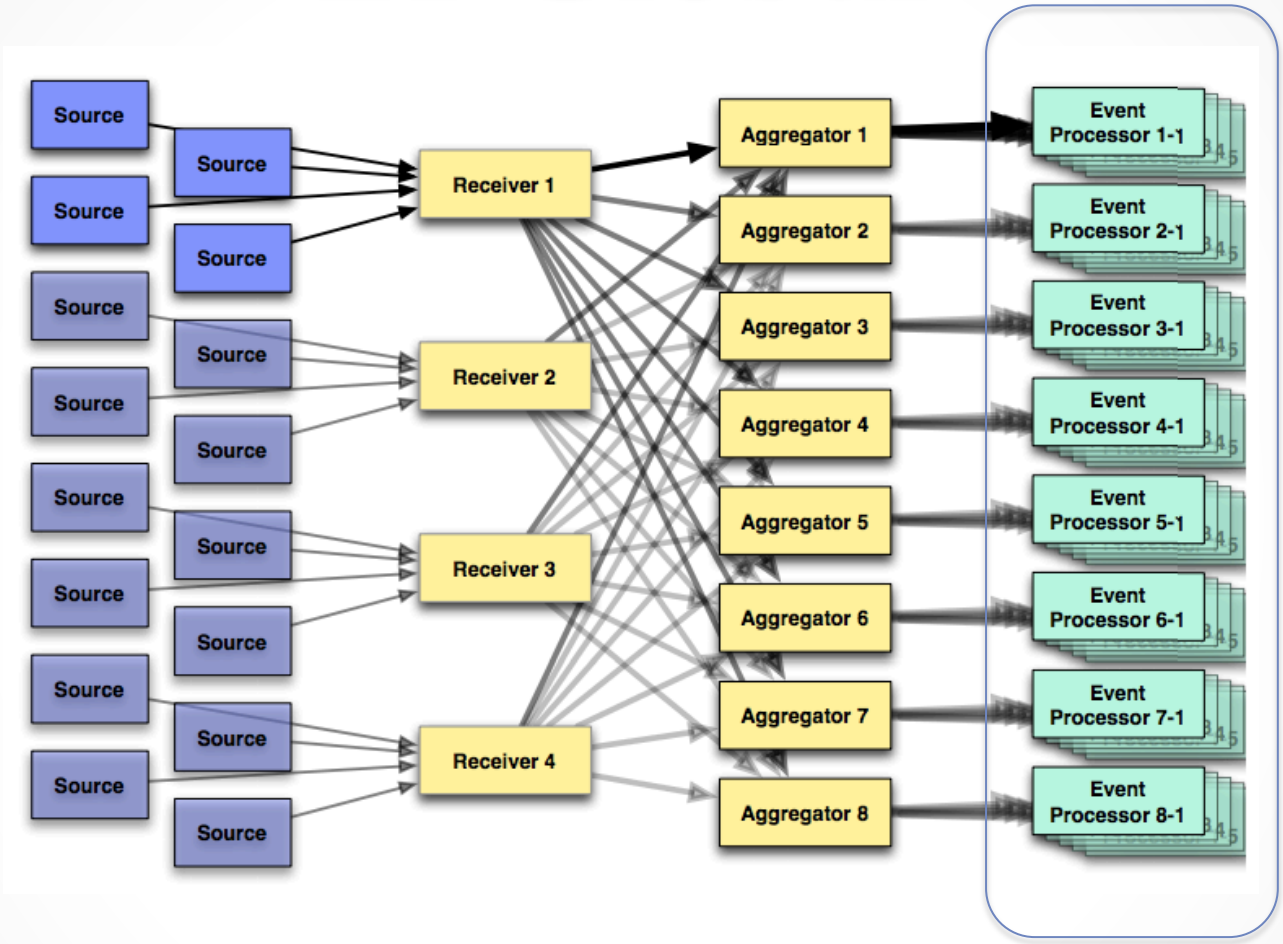
single hardware level architecture



two hardware level architecture

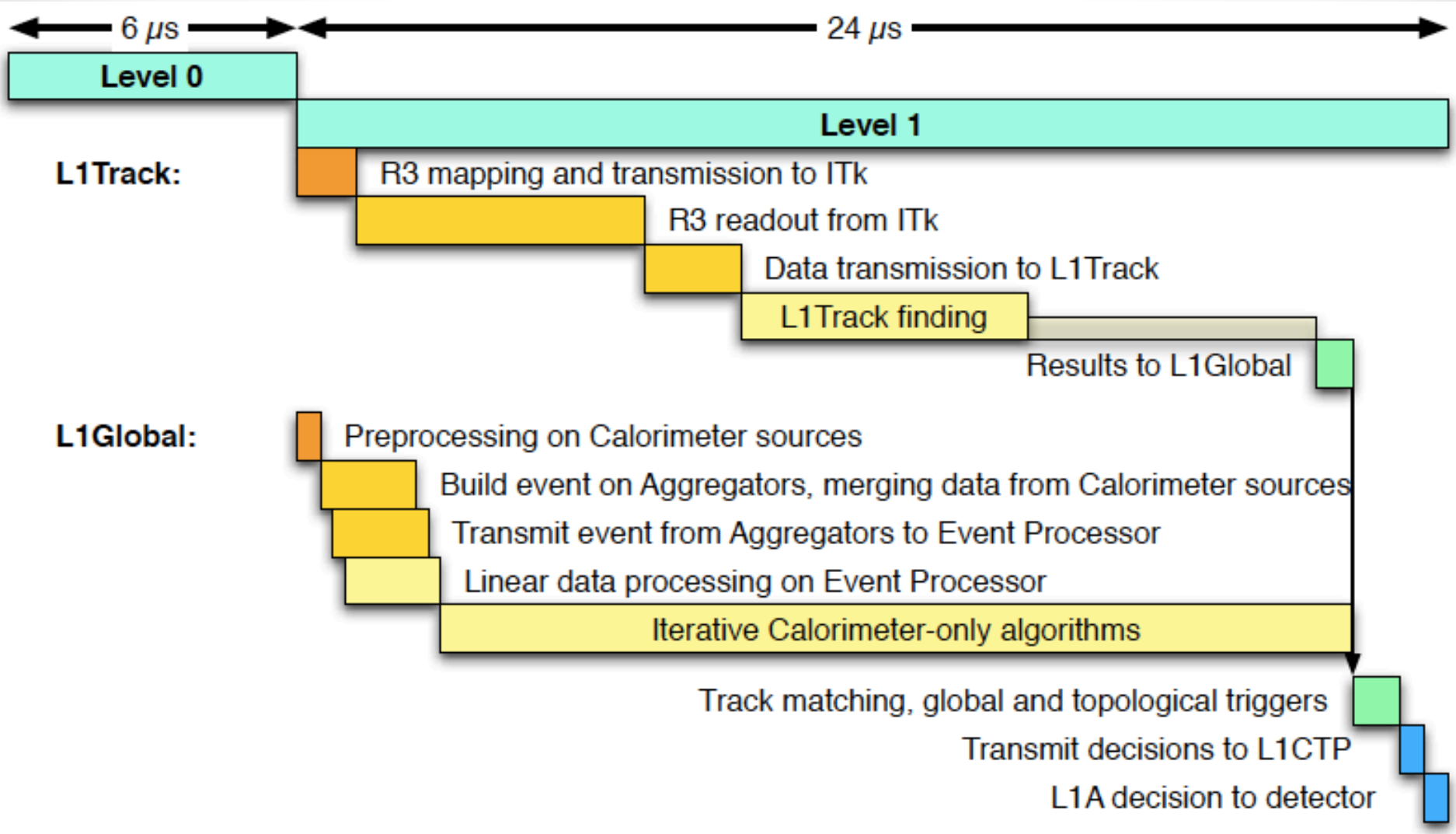


L1 Global



- Can perform jet finding on entire calorimeter with full granularity
- Receives L1 tracks in regions of interest and L0Muon objects
- Excellent pile-up rejection can be achieved with tracking information

Latency Budget: L0/L1



HL-LHC ATLAS Target Menu: Lepton triggers

Assumes Instantaneous Luminosities up to 7.5 10^{34}
Analysis Thresholds in **GeV**, Rates in **kHz**

Description	Run 1 Threshold	HL-LHC Threshold	L0 Rate	EF Rate
isolated e	20-25	22	200	2.20
di-electron	17, 17	15, 15	90	0.08
forward e	–	35	40	0.23
single γ	40–60	120	66	0.27
di-photon	25, 25	25, 25	8	0.18
single μ	25	20	40	2.20
di-muon	12, 12	11, 11	20	0.25
e-μ	17, 6	15, 15	65	0.08
τ	100	150	20	0.13
di-tau	40,30	40, 30	200	0.08

Total non-hadronic L0 rate: ~**750 kHz**, EF rate: **5.7 kHz**

HL-LHC ATLAS Target Menu: Hadronic triggers

Assumes Instantaneous Luminosities up to 7.5 10^{34}
Analysis Thresholds in **GeV**, Rates in **kHz**

Description	Run 1 Threshold	HL-LHC Threshold	L0 Rate	EF Rate*
single jet	200	180	60	0.6
large-R jet	–	375	35	0.35
four jet	55	4 x 75	50	0.50
forward jets	–	180	30	0.30
HT	–	500	60	0.60
MET	120	200	50	0.50
JET + MET	150, 120	140, 125	60	0.30

Total hadronic L0 Rate: ~**250 kHz**, EF Rate: **3.15 kHz**

750 kHz (leptonic) + **250 kHz** (hadronic) = **1000 kHz**

HL-LHC ATLAS Target Menu: Hadronic triggers

Assumes Instantaneous Luminosities up to 7.5 10^{34}
Analysis Thresholds in **GeV**, Rates in **kHz**

Description	Run 1 Threshold	HL-LHC Threshold	L0 Rate	EF Rate*
single jet	200	180	60	0.6
large-R jet	–	375	35	0.35
four jet	55	4 x 75	50	0.50
forward jets	–	180	30	0.30
HT	–	500	60	0.60
MET	120	200	50	0.50
JET + MET	150, 120	140, 125	60	0.30

assumes b-tagging

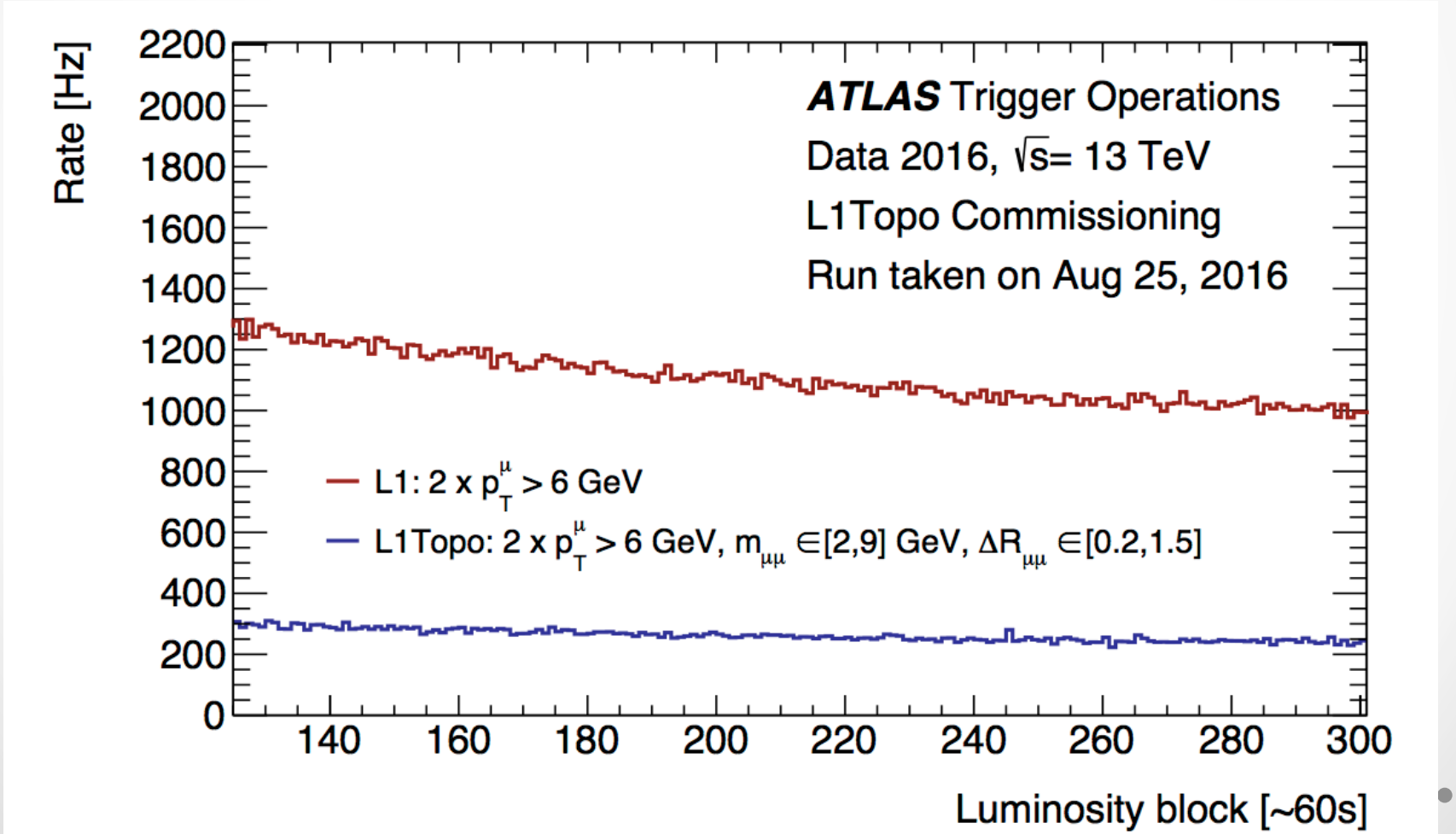
includes mult-jet + inv mass triggers

Total hadronic L0 Rate: ~**250 kHz**, EF Rate: **3.15 kHz**

750 kHz (leptonic) + **250 kHz** (hadronic) = **1000 kHz**

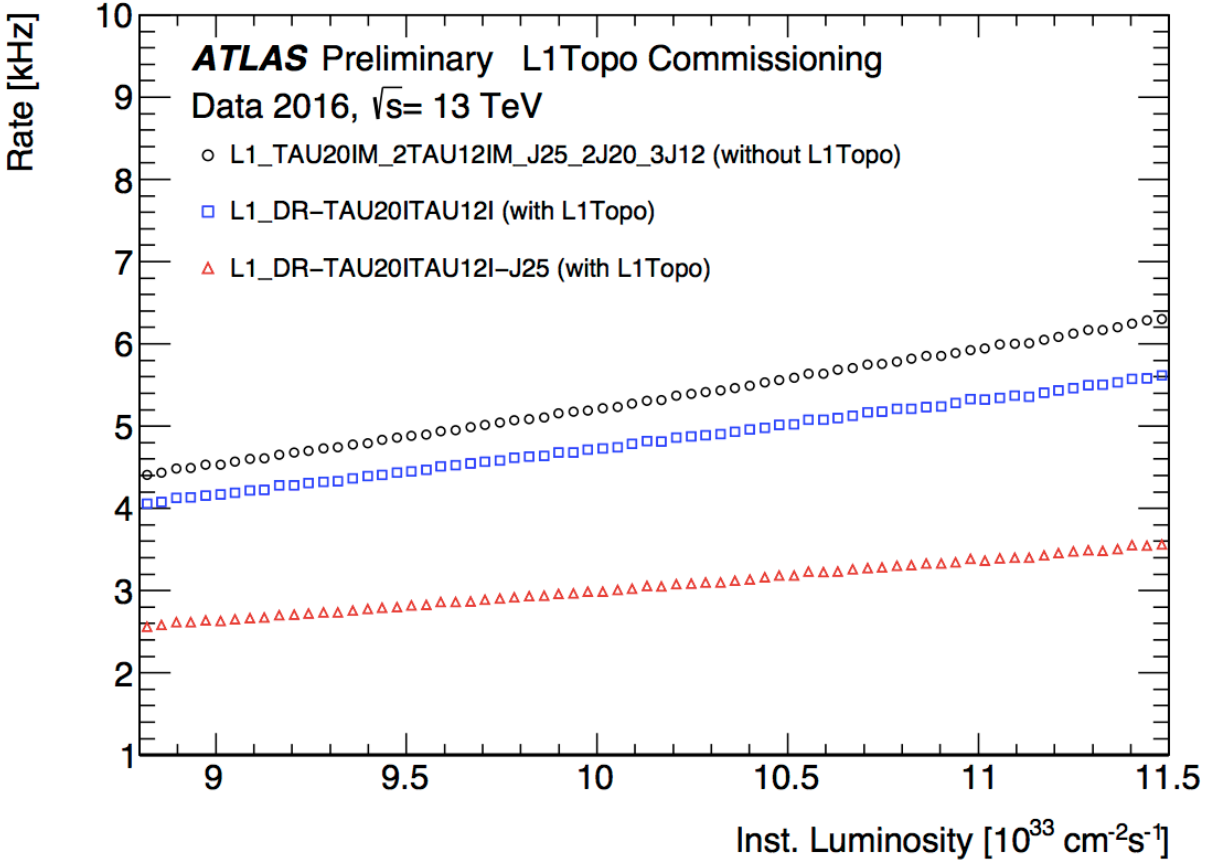
Additional selection power from hardware topology trigger (1)

A factor of four rate reduction is gained with mass and opening angle requirements



Additional selection power from hardware topology trigger (2)

In the di-tau signature, the (20, 12) GeV tau pair with $\Delta R < 2.9$ gives lower rate than with a 25 GeV jet requirement



Two taus (20, 12) GeV
+ a 25 GeV L1 Jet

Two taus (20, 12) GeV
with opening angle $\Delta R<2.9$

Two taus (20, 12) GeV
with opening angle $\Delta R<2.9$
+ a 25 GeV L1 Jet

Rate Predictions

- Standard method
  - Use enhanced bias data and extrapolate to higher luminosity
- Challenge of pile-up
  - extrapolation misses possible saturation of high cross-section items at high pile-up
  - neglects combinatorics
- Alternatives
  - high-pileup MC Simulation (requires excellent modeling of low p_T jets)
  - emulate trigger using trigger objects from enhanced bias events
- Currently have large uncertainties related to rates of jet triggers, but are gaining understanding of relationships between rates and thresholds
  - for example, for our multijet trigger, a ten GeV threshold difference on the 4^{th} jet results in a factor of ten difference in rate

Conclusions

- The general strategy for HL-LHC triggering at ATLAS is to increase the rates allowed in earliest levels of triggering while bringing tracking information into the system at an earlier stage
- The TDAQ System can deliver lepton thresholds for the HL-LHC that meet or beat thresholds seen in Run 1
- Hadronic triggers are extremely challenging in the high-pileup environment, but are strongly motivated (hh->4b, for example)
- Multiple architectures are currently under consideration, each supporting the HL-LHC physics program with low lepton thresholds and pile-up suppression from early tracking