The ATLAS Trigger and Data Acquisition System Upgrade Plans for HL-LHC

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on behalf of the ATLAS Collaboration
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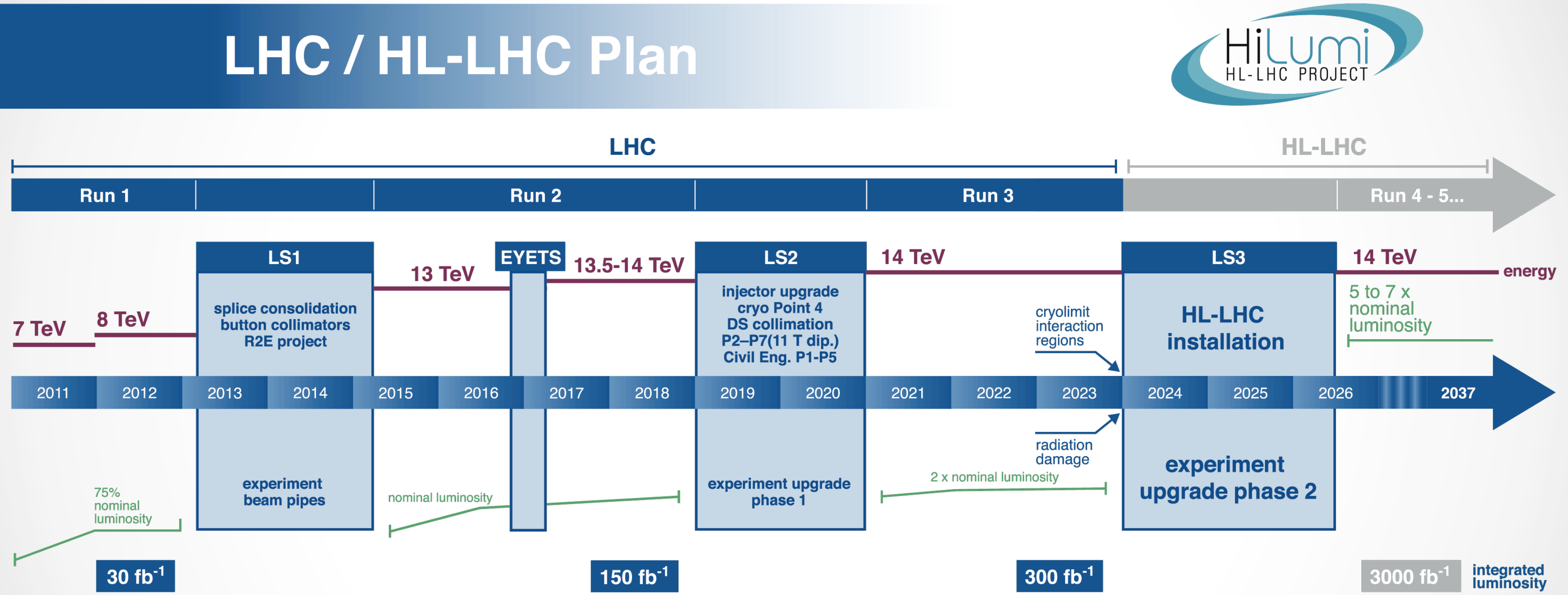
Outline

- Reminder of the physics motivation and establishing TDAQ goals
- Architecture choices and data flow through the system
- Target menus and rates

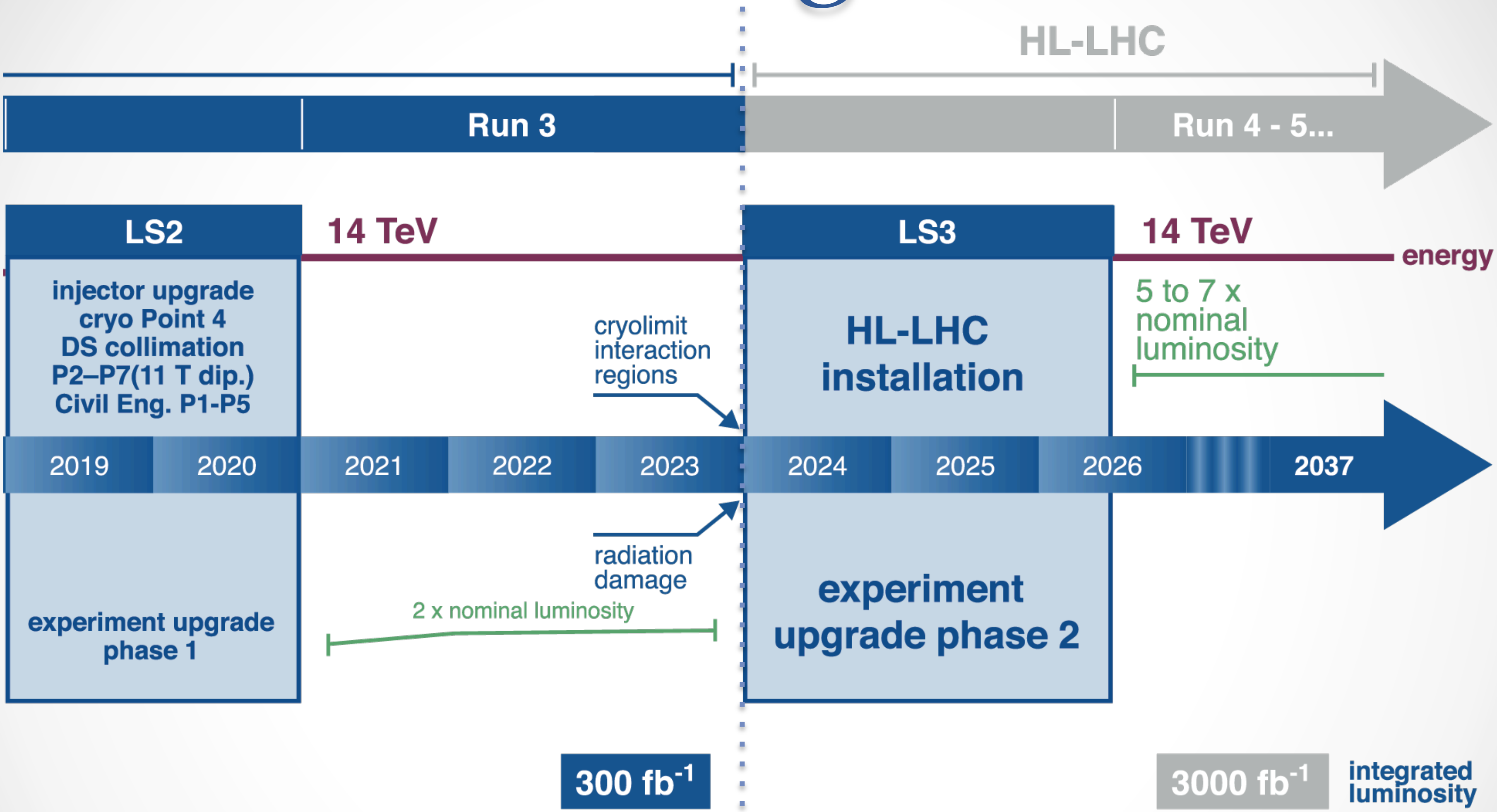
Schedule



Run 1 Run 2 Run 3 Run 4

- ATLAS will Release our HL-HLC TDAQ TDR to the LHCC in December, 2018
- I'm presenting basic ideas today – keep watch for details in December!

Zooming in…



<u>"Phase-1"</u>
2021 – 2023
Gather ~150 fb^{-1} of data
Peak luminosity: 2 $x10^{34}$ $cm^{-2}s^{-1}$

<u>"Phase-2" or HL-LHC</u>
2026 – 2037
Gather ~2700 fb^{-1} of data
Peak luminosity: 7.5 $x10^{34}$ $cm^{-2}s^{-1}$

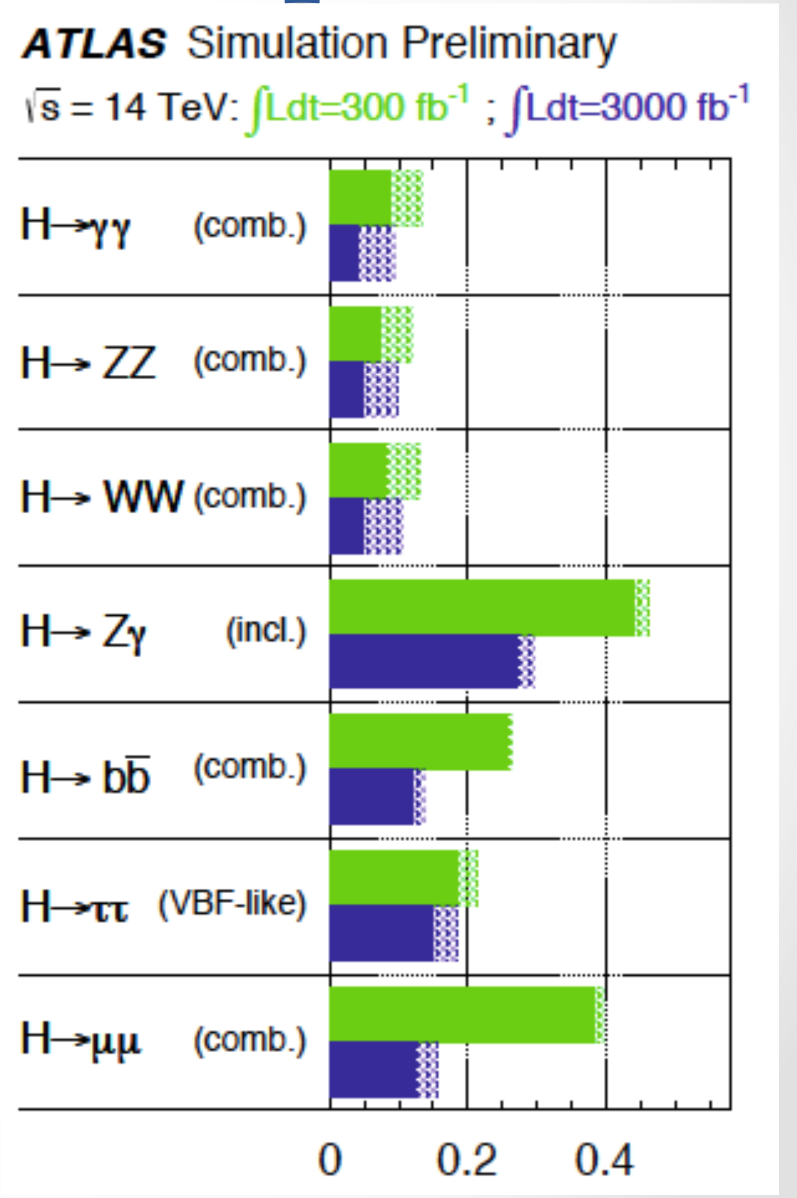
Physics Landscape

The High-Luminosity LHC brings us from 300 fb^{-1} to 3000 fb^{-1}

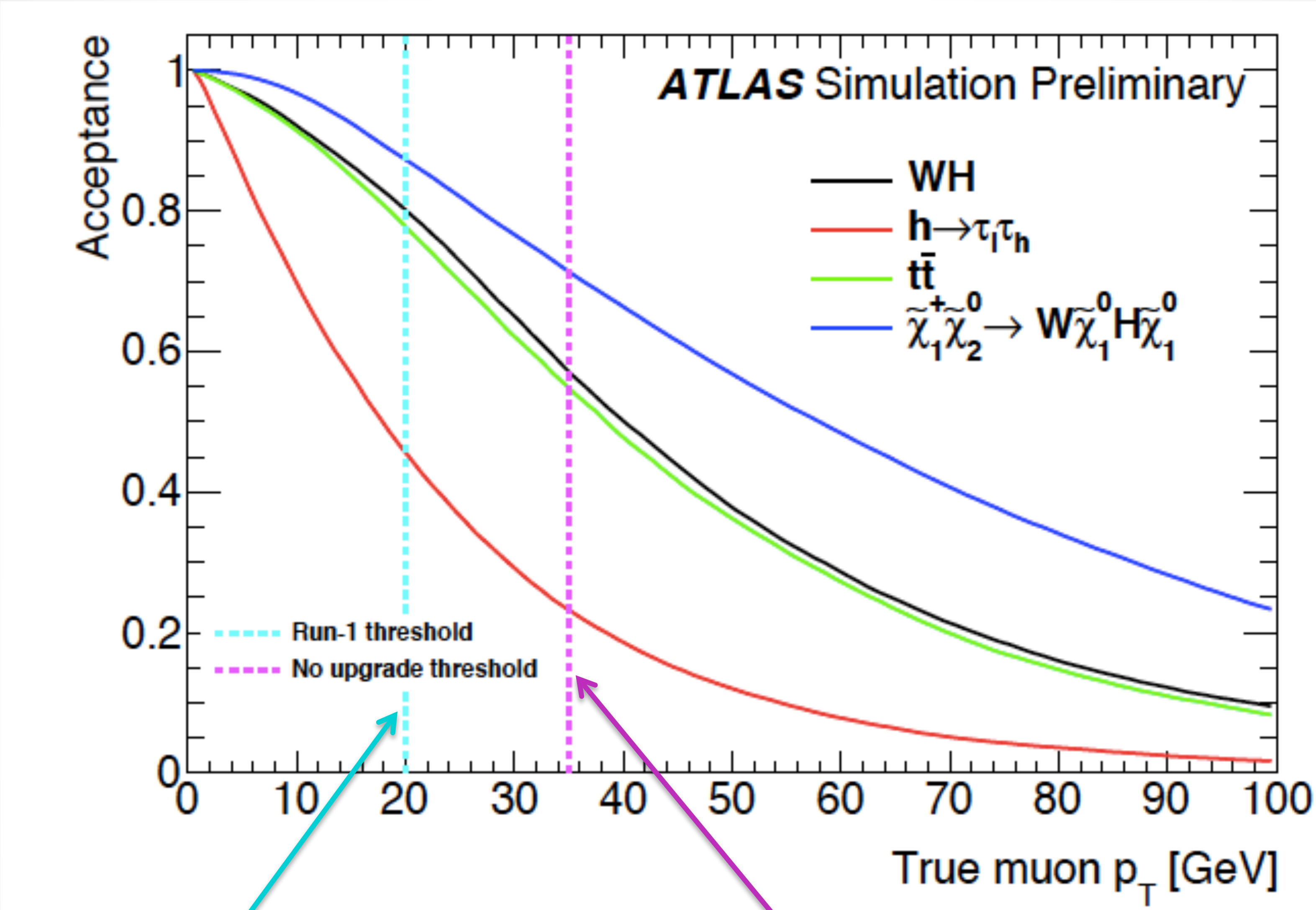
With this data we will

- Probe the Higgs Boson. Is it really the SM Higgs?
- Search for physics beyond the SM
- Follow other discoveries or hints from Runs 2 and 3

The ATLAS Trigger and Data Acquisition System must enable this broad and challenging physics program in spite of increased and sustained instantaneous luminosity



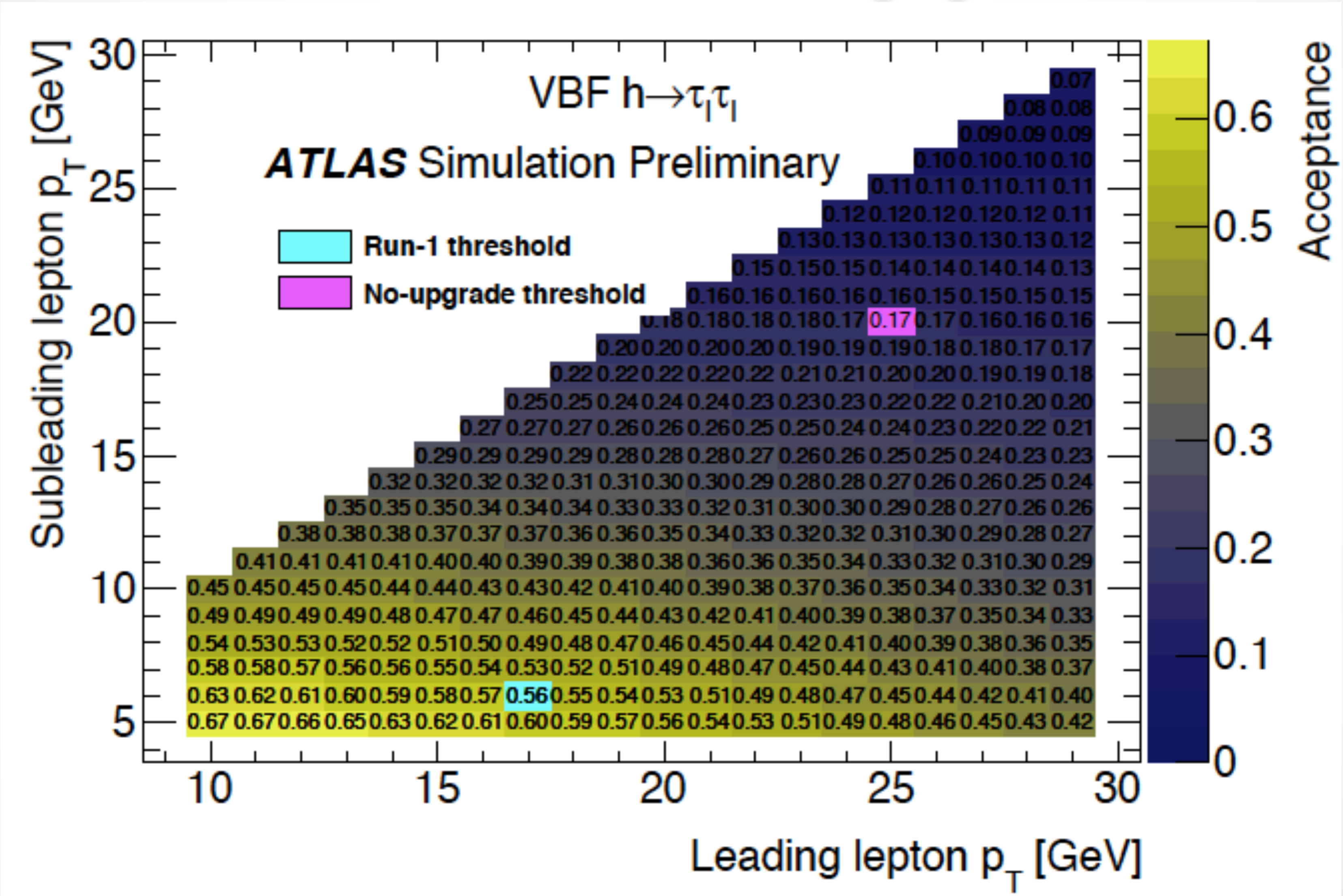
Physics Motivation: impact of muon threshold requirement



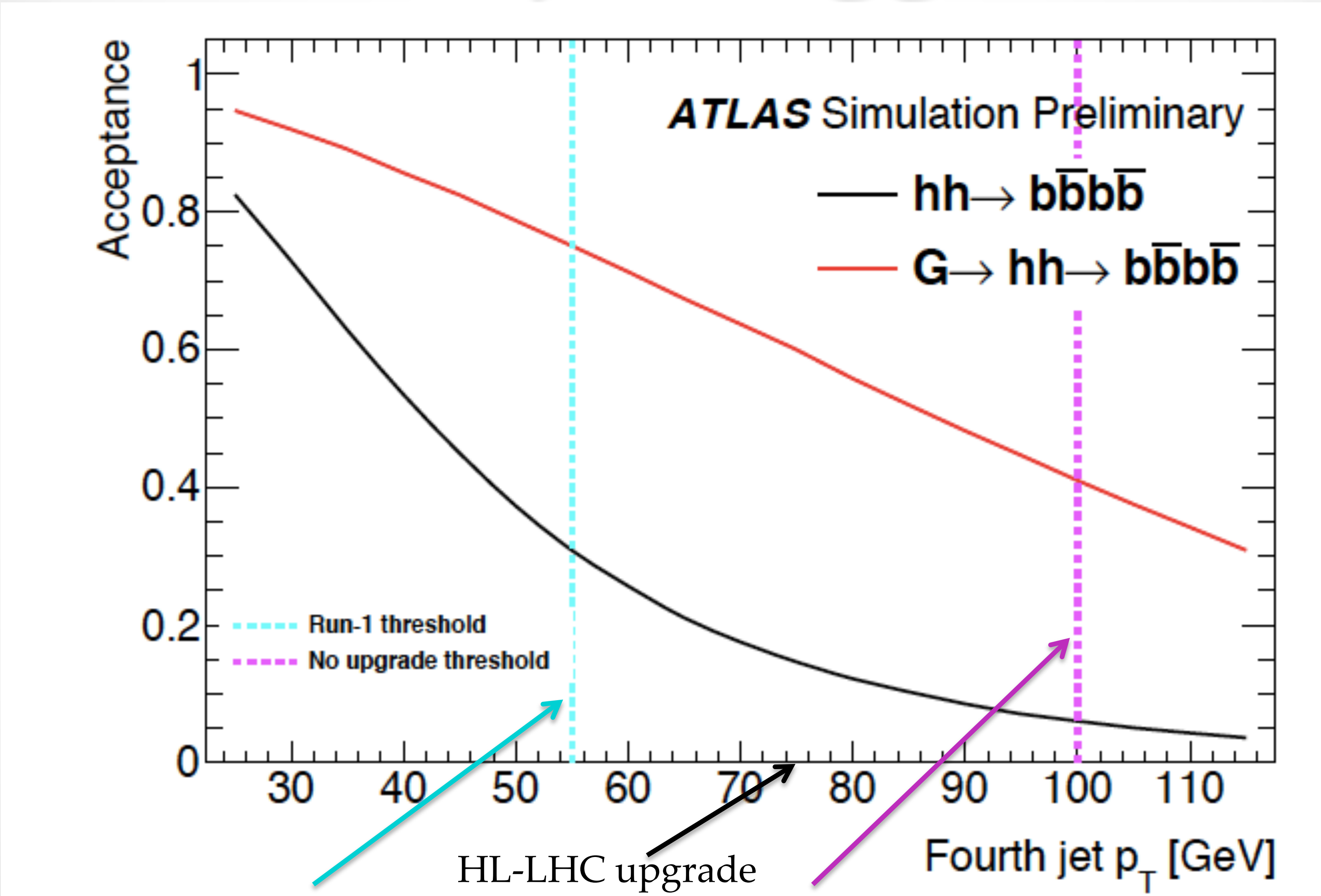
Run 1 Threshold

No Upgrade Threshold

VBF $h\text{->}\tau_l\tau_l$



Multijet Triggers



Run 1 Threshold

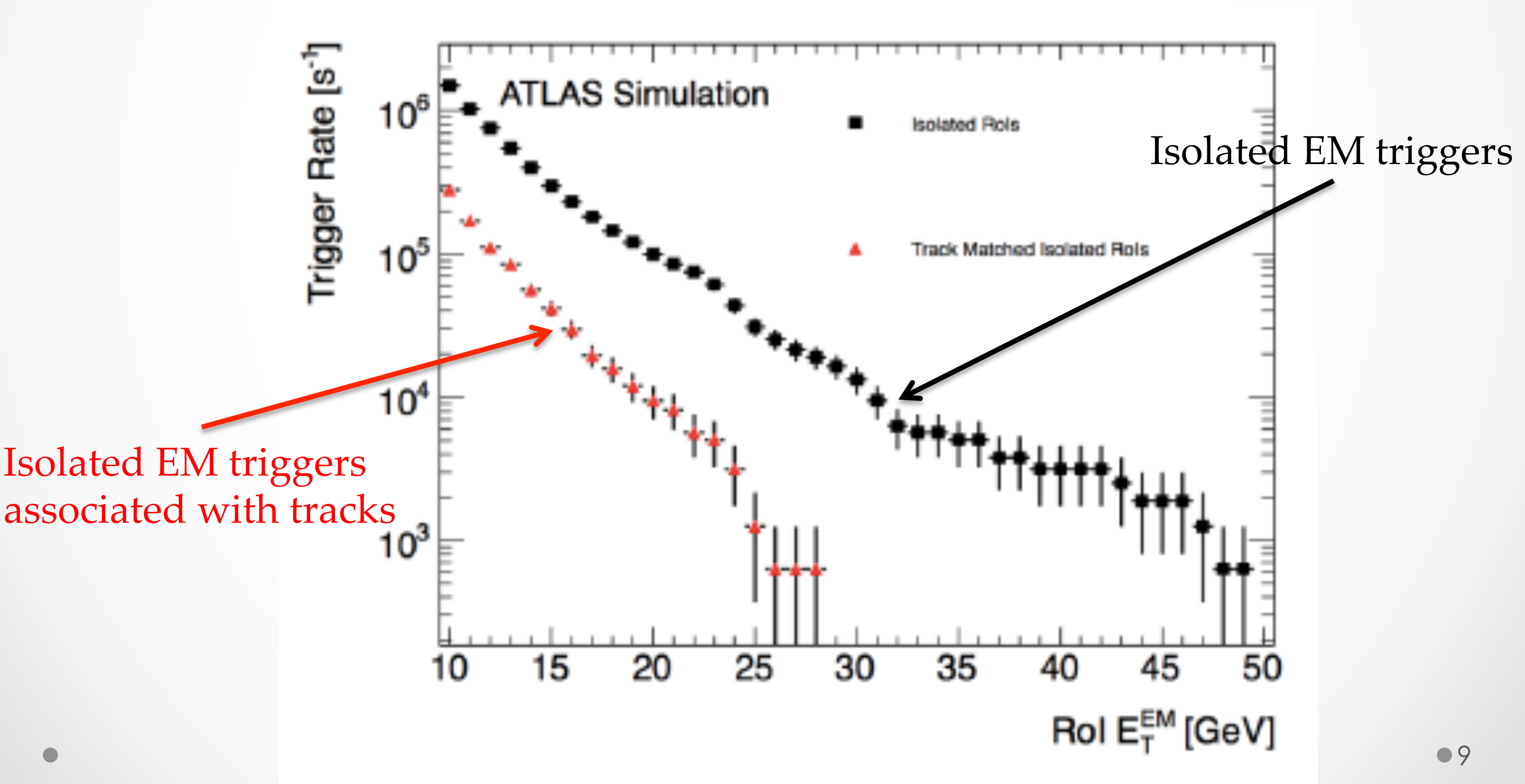
No Upgrade Threshold

General Strategy

1) loosen current 100 kHz L1 rate

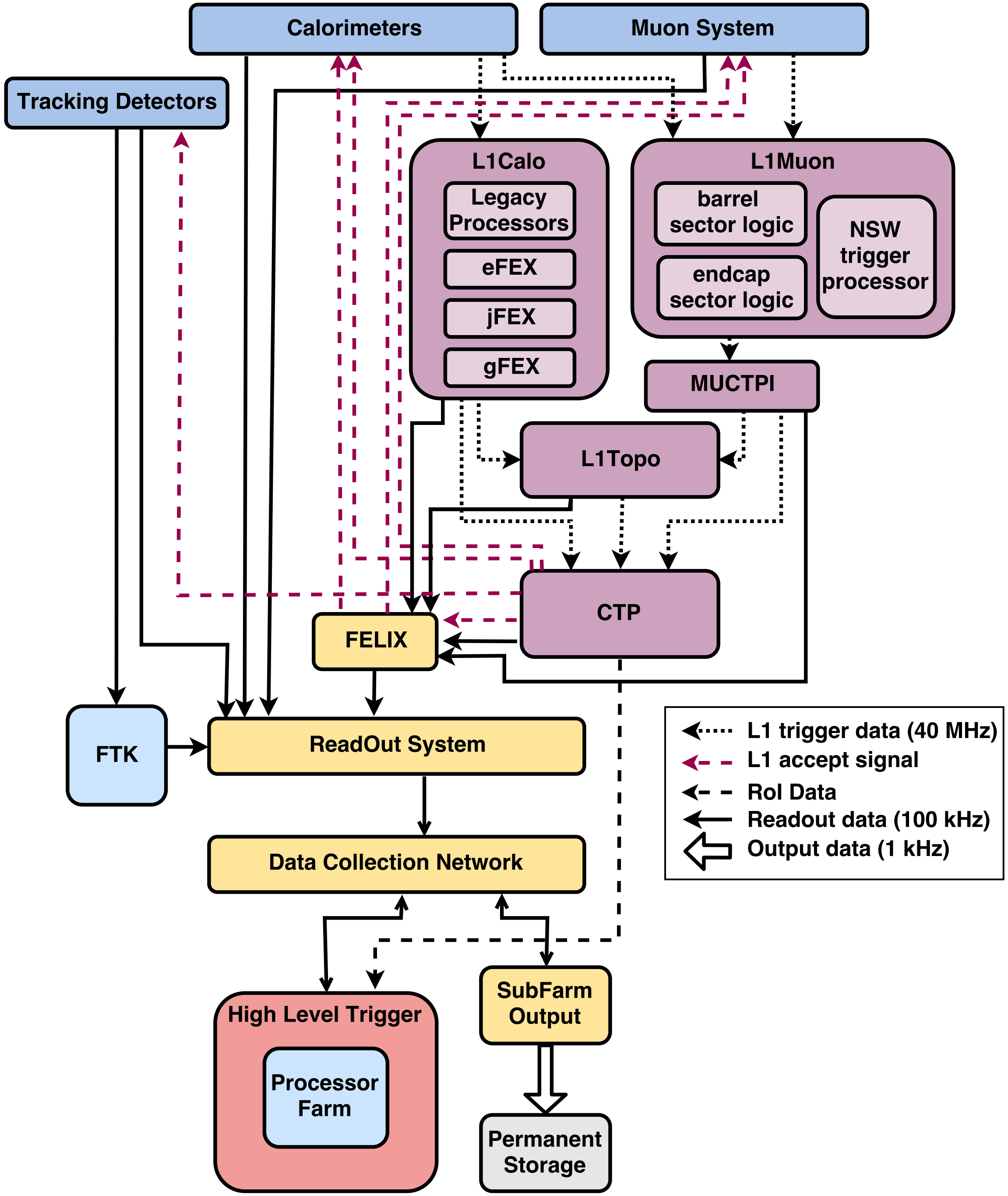
2) use offline strategies, like calorimeter clustering algorithms, in hardware trigger

3) access tracking information early

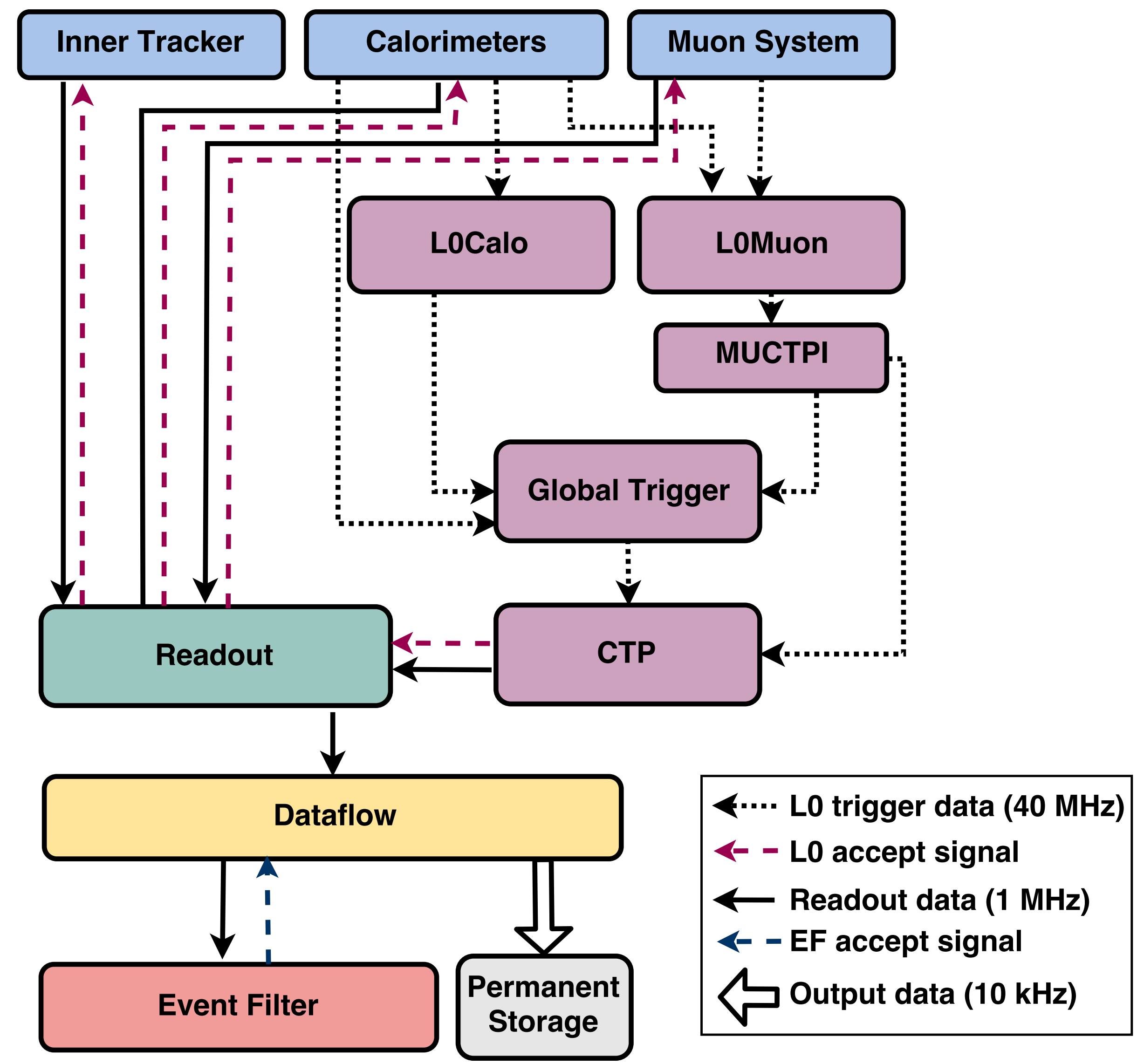


Phase-I (2021) Architecture

- higher-granularity calorimeter information at hardware trigger
- increased coverage of muon detectors

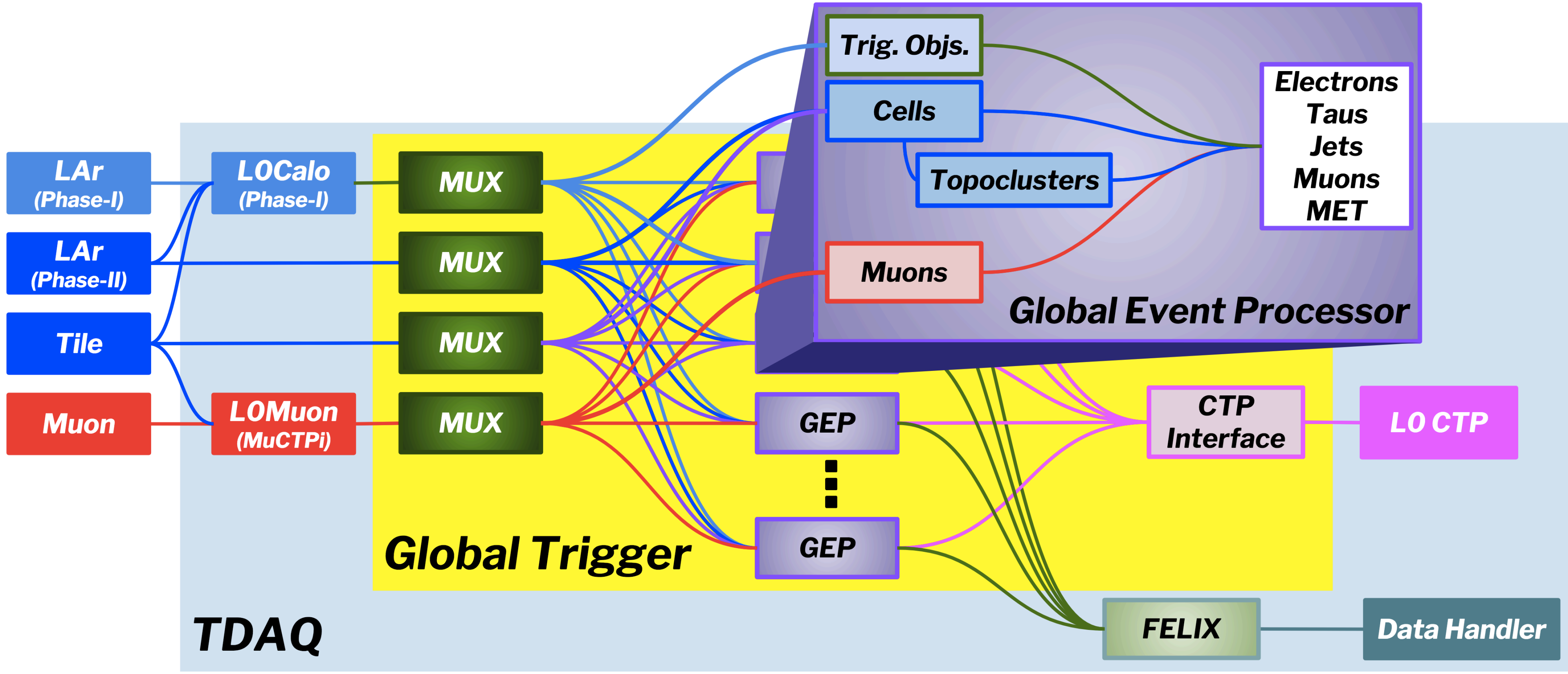


Phase-II (2025) Architecture



- Readout data goes from 100 kHz to 1 MHz
- Tracking is moved earlier in trigger chain
- Output data goes from 1 kHz to 10 kHz

Global Trigger



- Multiplexed data flow buys time for latency
- Receives trigger objects from calorimeters and muon systems and calorimeter cells
- offline clustering algorithms can be implemented to improve performance

Hardware Tracking

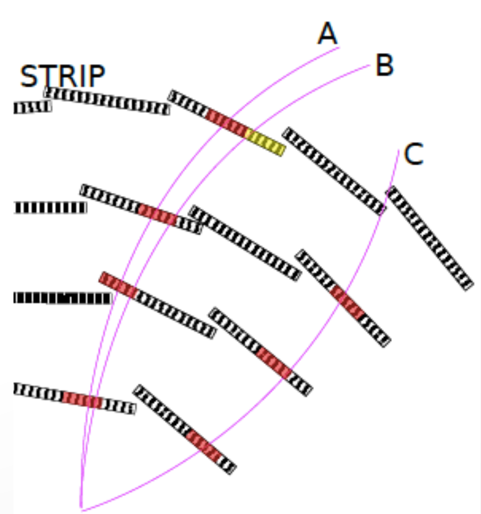
Regional Tracking

- Seeded by physics objects
- Can run on ~10% of detector at max trigger rate
- Finds tracks that are > 2 GeV in transverse momentum

Full Scan Tracking

- Seeded by event characteristics
- Tracking of full detector for ~10% of events
- Finds tracks that are > 1 GeV in transverse momentum

A large number of single muon tracks have been used to form banks of tracks that are stored on the chips and used for pattern recognition, with the tracking detector described by strips



HL-LHC ATLAS Target Menu: Lepton triggers

Assumes Instantaneous Luminosities up to 7.5 x 10^{34}

Description	Run 1 Threshold (GeV)	HL-LHC Threshold (GeV)	L0 Rate (kHz)	EF Rate (kHz)
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}

Description	Run 1 Threshold (GeV)	HL-LHC Threshold (GeV)	L0 Rate (kHz)	EF Rate* (kHz)
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

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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**

Conclusions

- The HL-LHC triggering ATLAS strategy is to
  - increase the rates allowed in earliest levels of triggering
  - bring offline algorithms online
  - bringing tracking information into the system at an earlier stage
- The TDAQ System can deliver lepton thresholds for the HL-LHC that meet thresholds seen in Run 1
- Hadronic triggers are extremely challenging in the high-pileup environment, but are strongly motivated (hh->4b, for example) and are supported by the flexibility of the upgraded trigger system
- The Global Trigger and Hardware Track Trigger bring increased flexibility and rejection power
- The ATLAS TDAQ TDR is in preparation, expected to be released to the LHCC at the end of the year.
- **Thanks for your attention!**