TDAQ Strategy for Phase 2

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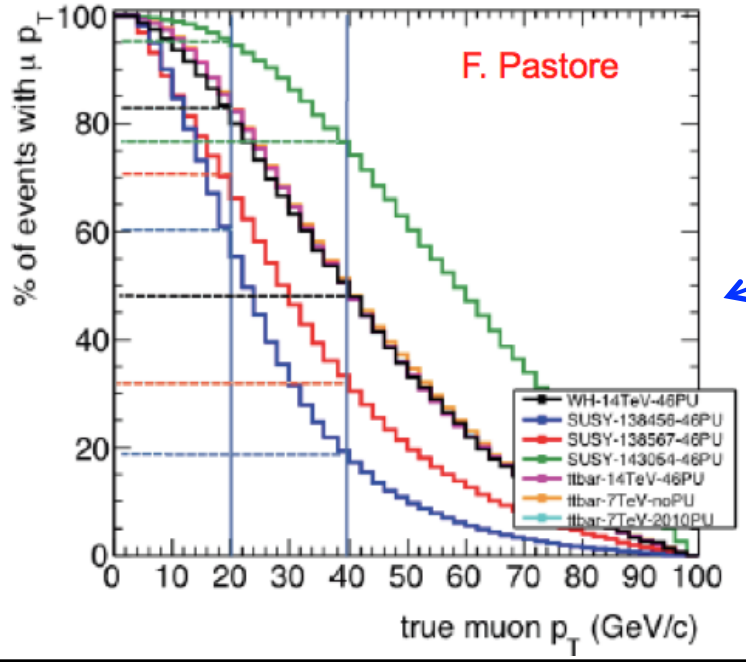
- ★ This talk
  - Physics requirements
  - Trigger requirements
  - Constraints from Detectors
  - Possible Architectures
  - Impact of a Track Trigger
  -

Physics Motivation

Physics Motivation for TDAQ upgrade:

- ★ Design of Phase-2 upgrade of TDAQ needs to be motivated by physics goals of experiment
- ★ At this stage – Phase-2 physics goals not fully worked through
- ★ Needs to be based on the gain going from **300 fb^{-1}** to **3000 fb^{-1}**
  - But, Phase-2 will represent 90 % of all ATLAS data
  - Trigger needs to be flexible enough maximize output
  - Strong desire to trigger on leptons at EW scale



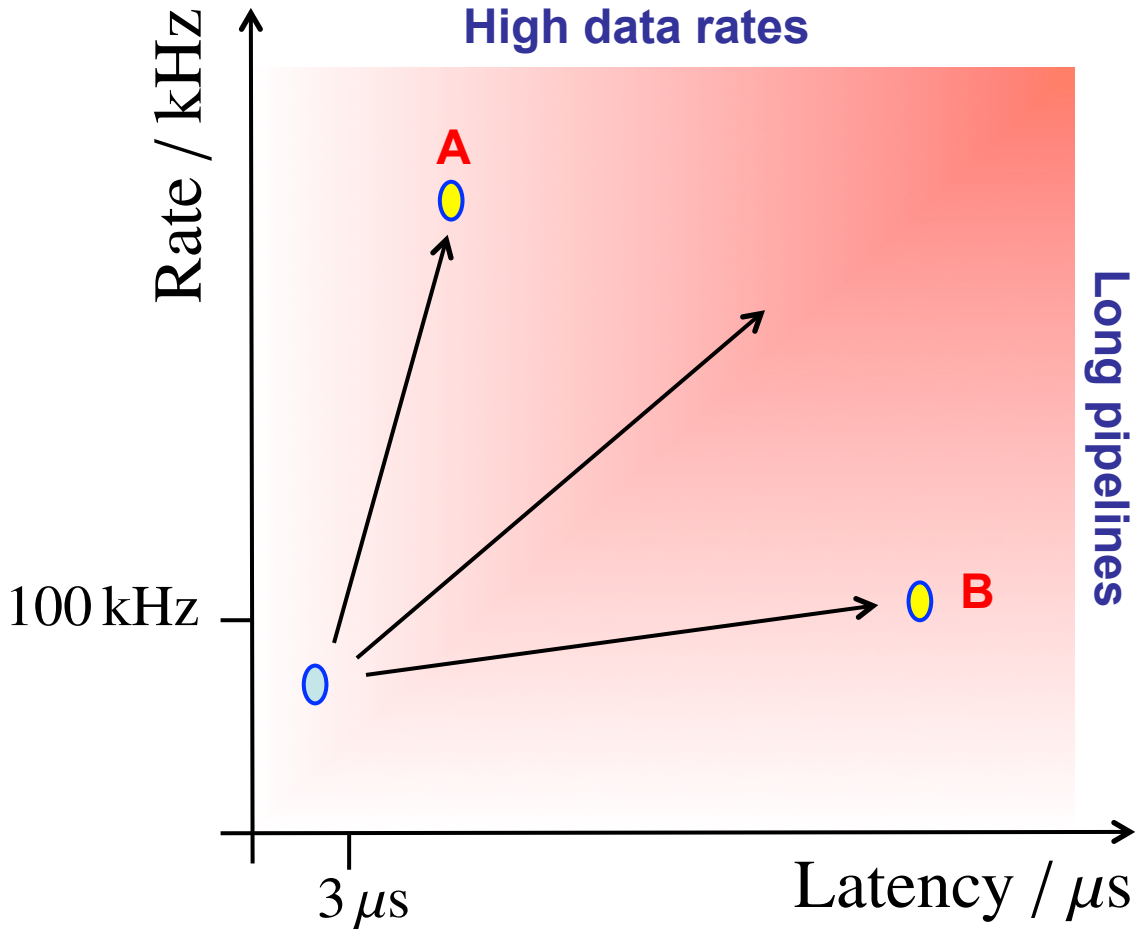
Already some nice studies on physics impact of lepton thresholds

Working Assumptions

Current thinking:

- ★ Aim to maintain "current" thresholds for single isolated leptons
- ★ Maintain trigger efficiency for
  - EM 20: 20 GeV electrons
  - MU 20: 20 GeV muons
- ★ Sufficient bandwidth for jet, missing ET, …

Possible Evolution of Trigger



★ **Direction A: e.g.**
high rate ~ 300kHz
low latency < 10μs

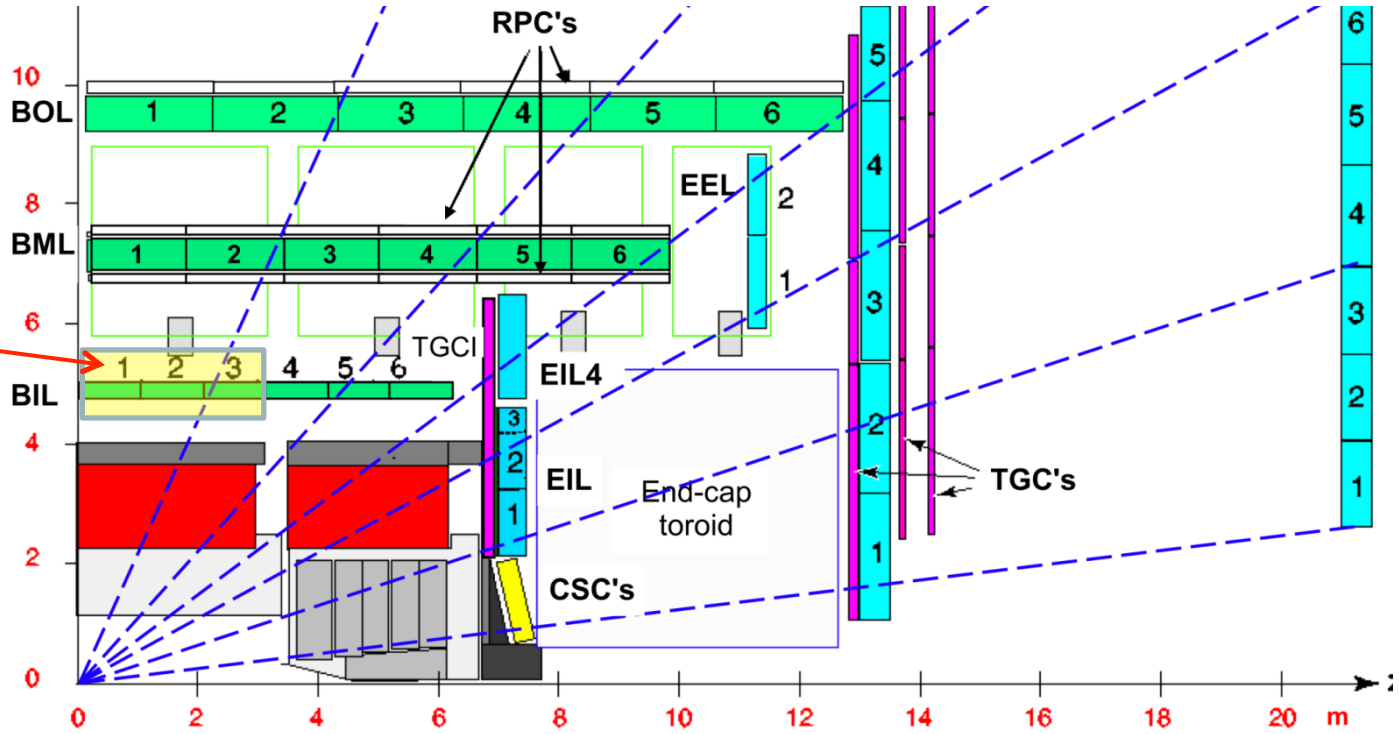
★ **Direction B: e.g.**
low rate ~ 100kHz
high latency ~ 30μs

★ **or choose a point**

But there are Constraints

- ★ Most detector system can replace electronics
  - can significantly extend pipelines
  - latency/rates mostly limited by cost
- ★ One (?) exception MDT
  - Inaccessible – no opportunity to replace FEE

Not possible to change FEE



Constraints from MDT

- ★ MDT imposes major constraint
  - ~30 % of electronics in Barrel Inner Layer (BI) of spectrometer are inaccessible
- ★ Impact
  - Progress with understanding cavern background
  - Tube rate ~ 100 kHz at 7E34
  - Barrel Inner layer MDTs FEE limited to:
    - ~200 kHz L1 accept
    - latency ~20 μs

Constraints

★ Current understanding of limitations across systems

	Max Rate	Max Latency
MDT	~200 kHz	~20 μs
LAr	any	any
Tile	>300 kHz	any
ITK	>200 kHz	< 500 μs

★ Emerging consensus on possible working point

- 200 kHz Level 1
- 20 μs latency

Trigger Rates at Phase 2

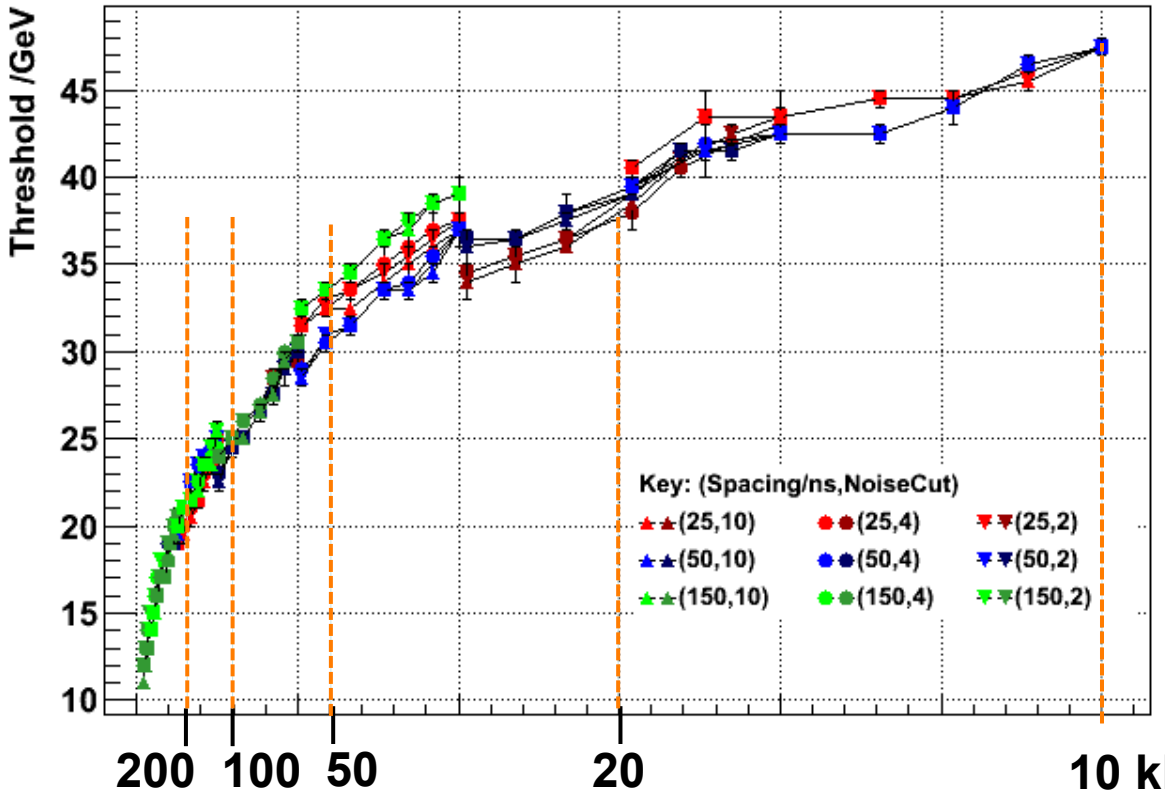
- ★ Evaluate rates at : **7E34**
- ★ Note **significant uncertainties** in rates
  - Need to fold in Phase 1 upgrades
  - Need HL MC simulation studies
  - **Work needs to be done prior to LoI !**

Caveat Emptor:

- ★ Following numbers represent my take on rates
  - they are estimates…

EM Triggers

★ **Estimates for 7E34 based on current system including estimated gains from Phase 1**



Non-isolated electrons

★ **EM_20 rate with isolation + phase 1 improvements:**

L1_EM20_VH : ~100-150 kHz

Muon/Tau Triggers

Muons:

- ★ L1_MU_20: estimated rate at 7E34: ~40 kHz
  includes all planned improvements
- ★ With MDT tracks in trigger could be ~25 kHz

Taus:

- ★ L1_TAU_40: estimated rate at 7E34: ~100 kHz
  but some overlap with EM triggers

EM triggers (electrons/taus)
more problematic than muons

Overall L1 Estimates

★ Estimate of overall picture

Object	Estimated Rate
EM 20	125 kHz
MU 20	20-40 kHz
TAU	~50 kHz ?
Others*	~100 kHz
Total	300-350 kHz

★ Tentative "conclusions":
- Very hard to keep EM/TAU thresholds within rate budget dictated by detectors (MDT/Tracker)
- No safety factors ! Need to build something in
- Would tend to argue for ~500 kHz of current EM/MU/JET

*crude extrapolation based on current division of rate budget

Options

★ Live with high L1 rate
- Let L2 do the work
- high ~500 kHz (inc. safety factor)

→ Simple
But probably excluded

★ Use full calo granularity
- L1 via RODs

→ Requires split L0/L1
- Gains not known
- May not be sufficient

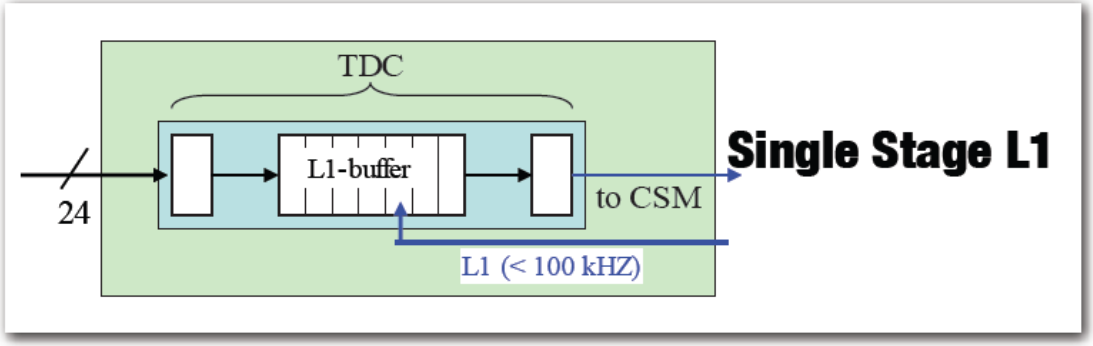
★ Implement Track Trigger

→ Single Level 1
- Self-seeded

→ Split L0/L1 trigger
- RoI-based

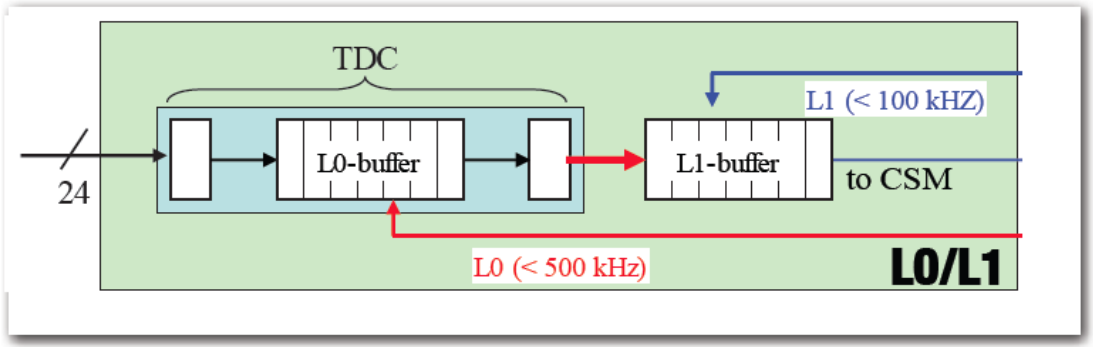
L0 vs L0/L1

Level 1: single L1 accept



"Simple"

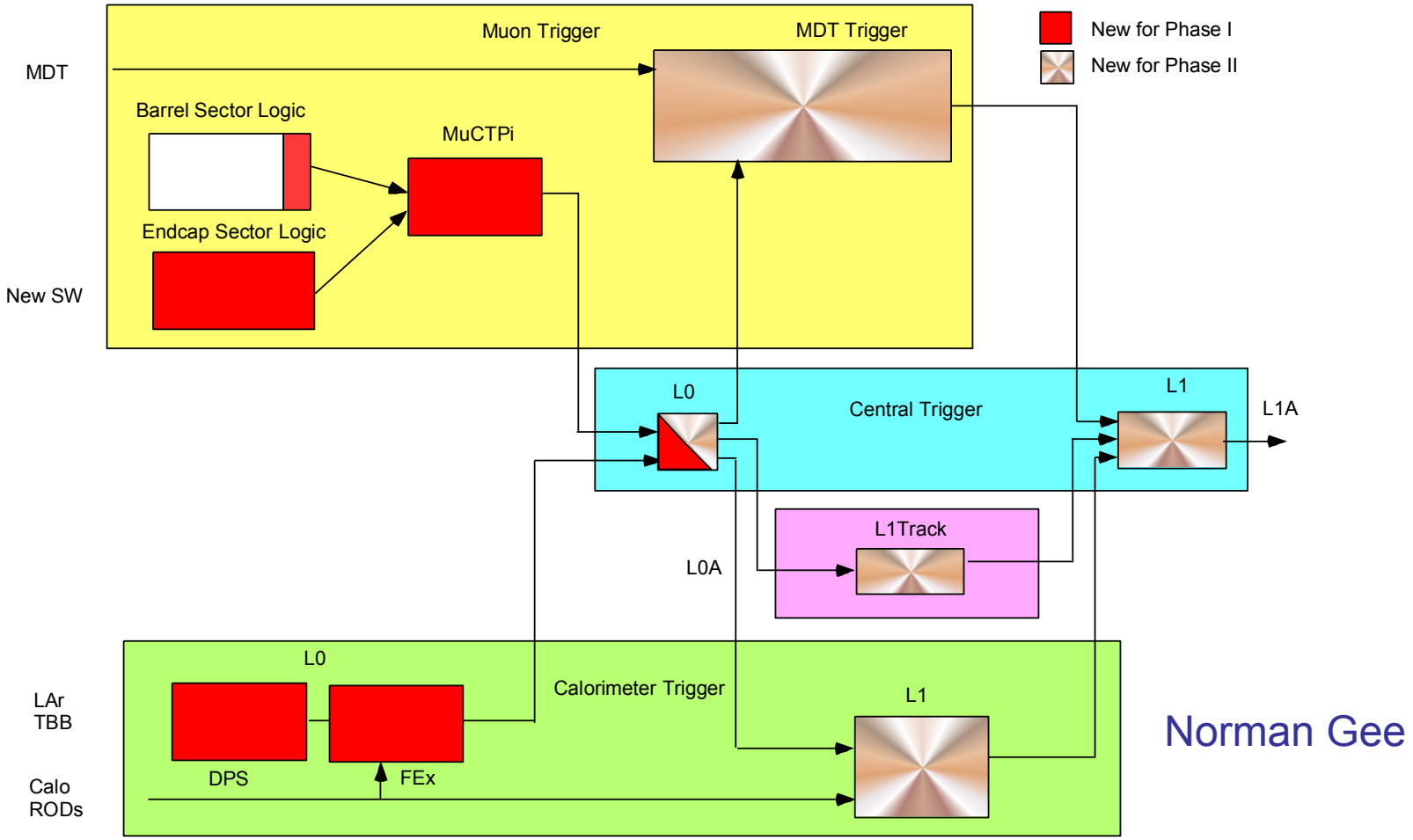
Level 0/Level 1:



"More Complex"

★ e.g. Fast L0 accept at <500 kHz
★ L0 distributed to detectors which could buffer L0A data

L0/L1 might look like…



Norman Gee

★ **L0/L1 allows time for additional processing without very long pipelines**

L0/L1 vs L1

Level 0/Level 1 vs Level 1

PROS:

★ Allows for additional processing without very long pipelines – potential reduction in material for tracker

★ Potential to use full calorimeter granularity via LAr/Tile RODs (only weapon for photons)

★ Provides option for RoI-based track trigger if needed

CONS:

★ More complicated trigger

Track Trigger

★ Track trigger would represent the single major change to ATLAS L1 trigger system

Two options (described in detail in next talks)

❶ ★ Self-seeded
- generate fast (<5 μs) on detector L1 accept

Pros:
- fits in with normal Level 1 architecture

Cons:
- technically challenging – higher risk
- potentially large impact on Tracker design

❷ ★ RoI-based
- "FTK-style" solution seeded by L0A RoIs
- Generate L1 accept on timescale of 10-20 μs

Pros:
- reduces impact on tracker

Cons:
- only works in more involved L0/L1 split trigger

Impact of Track Trigger

★ Need to quantify the impact of track trigger
- in context of possible trigger menu at Phase 2
- numbers below are my "estimates":

	No TT	With TT
Object	Estimated Rate	Estimated Rate
EM 20	125 kHz	25 kHz
MU 20	20-40 kHz	20 kHz
TAU	~50 kHz ?	20 kHz
Others*	~100 kHz	~100 kHz
Total	300-350 kHz	~175 kHz

These estimates need to be firmed up for LoI

★ TT (Self-seeded or RoI-based) may provide potential to trigger on 20 GeV isolated lepton triggers

*fairly crude extrapolation based on current division of rate budget

Summary

★ Two possible options (compatible with constraints as understood today)

❶ **Single Level 1**
- 200 kHz with ~5 μs latency
- self-seeded track trigger

❷ **Split Level 0/Level 1**
- 300-500 kHz L0 with ~5 μs latency
- 200 kHz L1 with ~20 μs latency
- possible L1Calo at full granularity
- track trigger

Conclusions

- ★ Limited menu of options for Phase 2
  - L0 vs L0/L1
  - Track trigger or no track trigger
  - If there is a track trigger – self-seeded vs RoI based
- ★ The decision on the working baseline for LoI
  - Strongly driven by track trigger
- ★ Opinion
  - At this stage need to build in flexibility…
- ★ For LoI need to firm up rate estimates, e.g.
  - Simulation of rates at 7E34 with phase 1 upgrades
  - Major shortage of effort in this area