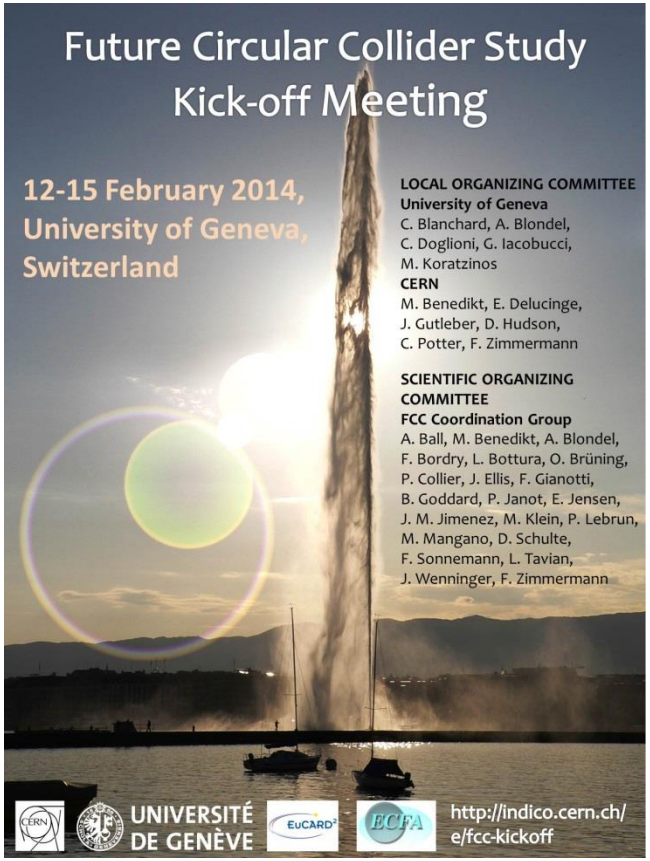
TLEP: Plans for Working Group 10
Online Software & Computing

Christos Leonidopoulos

THE UNIVERSITY of EDINBURGH



Future Circular Collider Study Kick-off Meeting
Geneva – 12-15 February 2014

TLEP WG10: Mandate

- Define work areas, deliverables, timelines
  - Calculate trigger rates for physics & background
  - Propose hardware & software solutions
  - Evaluate event sizes
  - Evaluate needs for online event reconstruction

- NB: Mandate is under construction

“Is it conceivable to collect
15 kHz of Z and 60 kHz of Bhabha
at a TLEP experiment?”

Rates & Event sizes at TLEP

- Three (or four) parameters here
  - Rate of interesting physics to record
  - Event size
  - Data throughput (ie. Read-out & write-out capacity)

- Relevant parameter: data throughout, not rate!
  - Capacity: data volume per time unit =

    (event size) × (interesting physics rate)

Rates & Event sizes at TLEP #2

- In the absence of detector layout & simulation
  - Start from today's knowledge
    - ie. Cross sections & ATLAS + CMS technology
  - Extrapolate (~20-25 years) into the future
    - By using today's guesses about TLEP detectors
  - Estimate how far off we are from our "comfort zone"
    - ie. How difficult is the problem we are trying to solve? 10x, 100x, 1000x harder than today?

Drake Equation

Estimate the number of active, communicative extraterrestrial civilisations in the Milky Way galaxy

$$N = R_* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L$$

where:

N = the number of civilizations in our galaxy with which radio-communication might be possible (i.e. which are on our current past light cone);

and

R_* = the average rate of star formation in our galaxy
f_p = the fraction of those stars that have planets
n_e = the average number of planets that can potentially support life per star that has planets
f_l = the fraction of planets that could support life that actually develop life at some point
f_i = the fraction of planets with life that actually go on to develop intelligent life (civilizations)
f_c = the fraction of civilizations that develop a technology that releases detectable signs of their existence into space
L = the length of time for which such civilizations release detectable signals into space[8]

Rates at TLEP

- Rate of interesting physics to record
  - 15 kHz of Z events and 60 kHz of Bhabha events: All of it

- Assumptions
  - Trigger input = trigger output = DAQ rate = interesting physics (signal efficiency ~ 100%, background rejection ~ 0)
  - Ignore beam halo, synchrotron radiation, other backgrounds
  - No need for “hadron collider” trigger: all collisions to be saved (“minimum bias” trigger), no need for algorithmic suppression of background

Event sizes

- ATLAS and CMS
  - Nominal average pp event size: 1 MB
  - ~100 M channels per experiment: Different magnet systems & detector layouts, BUT: similar tracking performance/momentum resolution, and event size

Data throughput: Readout

- ATLAS and CMS
  - Level-1 trigger accept rate: 100 kHz → this drives DAQ requirements for feeding events into HLT (1 MB/evt)
  - Technology: Gigabit Ethernet/Myrinet with 1-2 Gbit/s
  - Nominal DAQ throughput: 100 GByte/sec
    - NB: actual performance for ATLAS below this (20-30%); this is not a technology limitation, it is a design choice

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- TLEP
  - 15 kHz of Z events, 60 kHz of Bhabha events
  - Technology (20 years from now): "who knows"
  - For event sizes ≤ "LHC event" sizes: should fit in today's budget
  - For events larger by X: would need to increase network capacity accordingly

Data throughput: Output to disk

- ATLAS and CMS
  - HLT output rate: ~ 1 kHz or 1 GB/s
    - ATLAS & CMS can output much more (with larger T0 disk buffer): factor of 10 (ATLAS; S. George) or 2 (CMS; E. Meschi) (Estimate: not tested and/or commissioned)
  - Technology: HLT algorithms & Storage Manager (CMS)/SubFarm Output Units (ATLAS): C++
  - NB: Disk space capacity the actual bottleneck here, ***not*** trigger rate or output to disk

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- TLEP
  - 15 kHz of Z events, 60 kHz of Bhabha events
  - Technology (20 years from now): "who knows"
  - For event sizes ≤ "LHC event" sizes:
    - Z-stream: factor of 2 below today's capabilities
    - Bhabha stream: factor of 8 below today's capabilities

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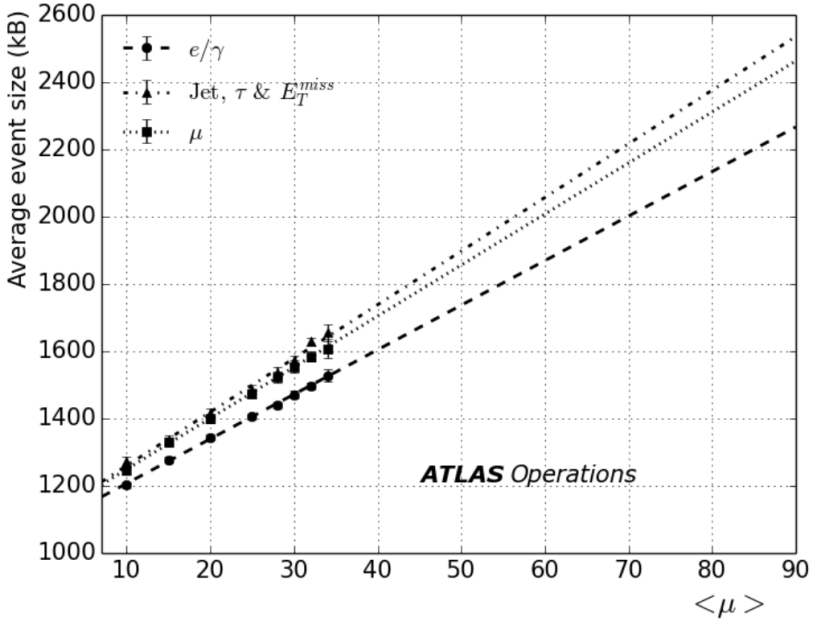
- TLEP
  - Using CMS Simulation for TLEP projection (P. Janot et al)
    - Z events: factor of 10 smaller than average pp event
    - Bhabha events: another factor of 10 smaller

  - Are these “pure” (physics-only) sizes, ie with the overhead (headers & trailers) subtracted?

Event size at ATLAS (and CMS)



ATLAS TDAQ system
Phase I Upgrade TDR

Figure 57: The measured total event size versus μ and its projection to a μ of 90 for different types of HLT selection

Questions to address for TLEP

- Zero-suppression at trigger compatible with potentially noisy calorimeter? If not, impact on event size?
- Beam background's contribution to average event size?

TLEP Event size

- First one needs a detector layout and a simulation!
- Estimates from FCC reports (F. Gianotti et al) and CLIC
  - Potential need for better (×10) momentum resolution (CLIC)
  - Resolution per "hit": expected improvement 50 μm → 25 μm
  - Calorimeter granularity: remains the same?

$$\frac{\sigma_{p_\perp}}{p_\perp} = \frac{\sigma_s}{s} = \frac{\sqrt{3/2}\sigma_y}{(0.3L^2B)/(8p_\perp)} = \frac{8p_\perp\sqrt{3/2}\sigma_y}{0.3L^2B} = 32.6\frac{p_\perp\sigma_y}{L^2B}$$ **(m, GeV/c, T)**

  - Improving momentum resolution by factor of ~10 would have to be accommodated by new L^2B factor. Impact of larger detector on event size?

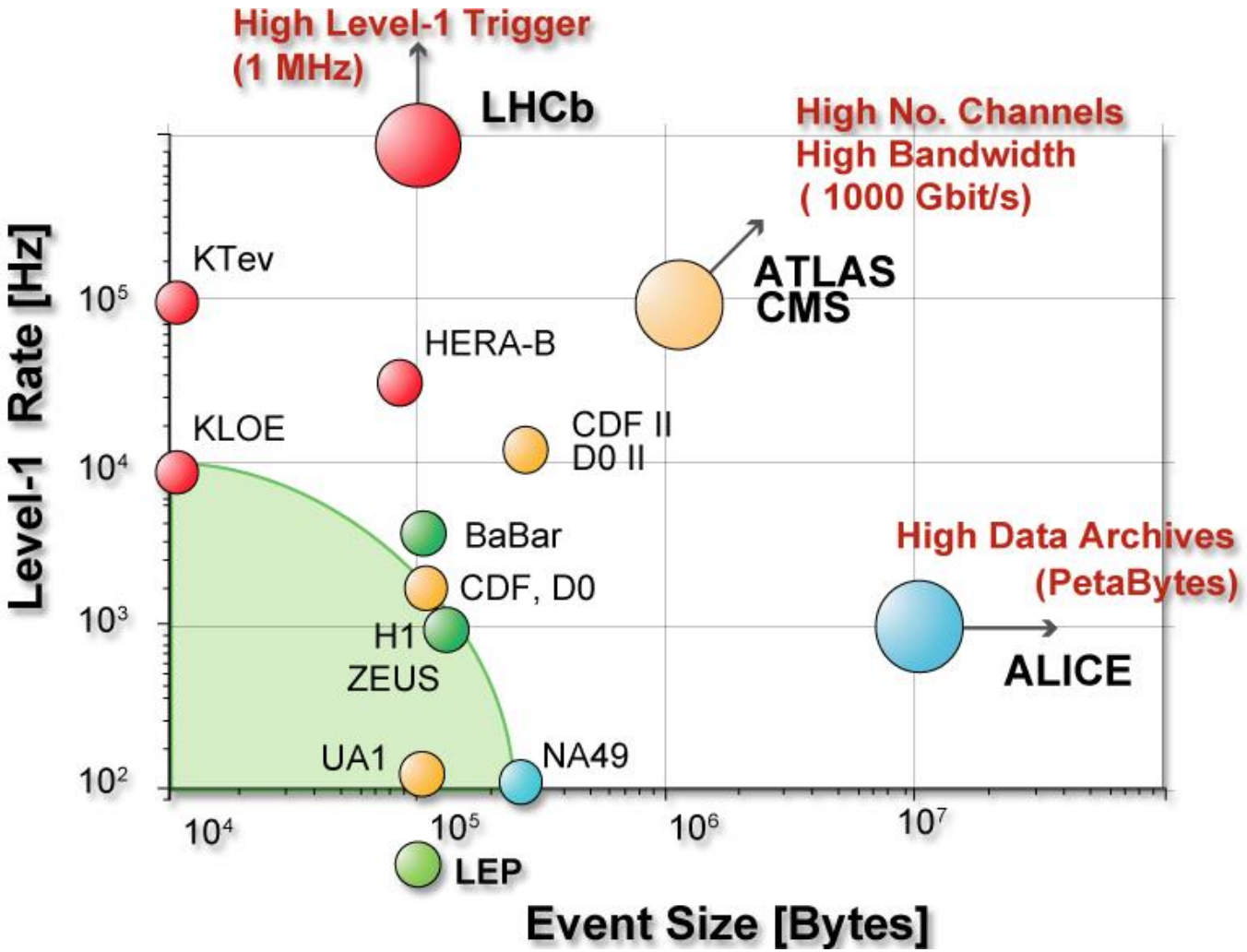
Estimates summary

- Event sizes
  - Assumption that event size is fraction of LHC event size
  - Need to evaluate potential impact of increased detector length, granularity, beam background and calorimeter noise
- Readout
  - Rates are ~same with today's experiments
  - Capacity would not need to increase if event size remains small
- Output to disk
  - Rates are ~15 (Z) -60 (Bhabha) ×larger than today's experiments
  - Assuming that today's capacity is ×10 larger than operations
  - Capacity must increase unless event size considerably small

Disclaimer:

The math presented here is *way* conservative: in declaring “comfort zones” we are assuming that no further technological advances are expected over the next 15-20 years, which is obviously unnecessarily pessimistic

Trigger trends



Summary

- Software tools to evaluate event size, background rates
  - ➢ When detector layouts are discussed, and a simulation is available, studies are necessary for a realistic comparison to ATLAS/CMS specs

- My personal opinion
  - ➢ In all likelihood we are (ie. will be) very far from any bottlenecks. Homework: start eliminating some of these question marks.

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