Looking back at H1 (and ATLAS) LAr calorimeter and trigger operations

Juraj Bracinik
(University of Birmingham, UK)

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- Introduction
- Operation of H1 LAr(T)
- Is ATLAS different ?
- (Possible) implications for LHeC

Introduction

- Look back at Liquid Argon calorimeter of H1
- Mainly operations during Hera II period (2002-2007)
  - Biased towards trigger (I worked mainly on H1 LAr L1 trigger, now L1 calorimeter trigger of ATLAS)
- Try to think in which aspects is ATLAS operations different from H1
- Some possible implications to LHeC detector

Good starting point:

- calorimetry status talks at H1 weeks and H1 collaboration meeting
- given by Jozef Ferencei, Steve Aplin, j.b.

Typical operational topics

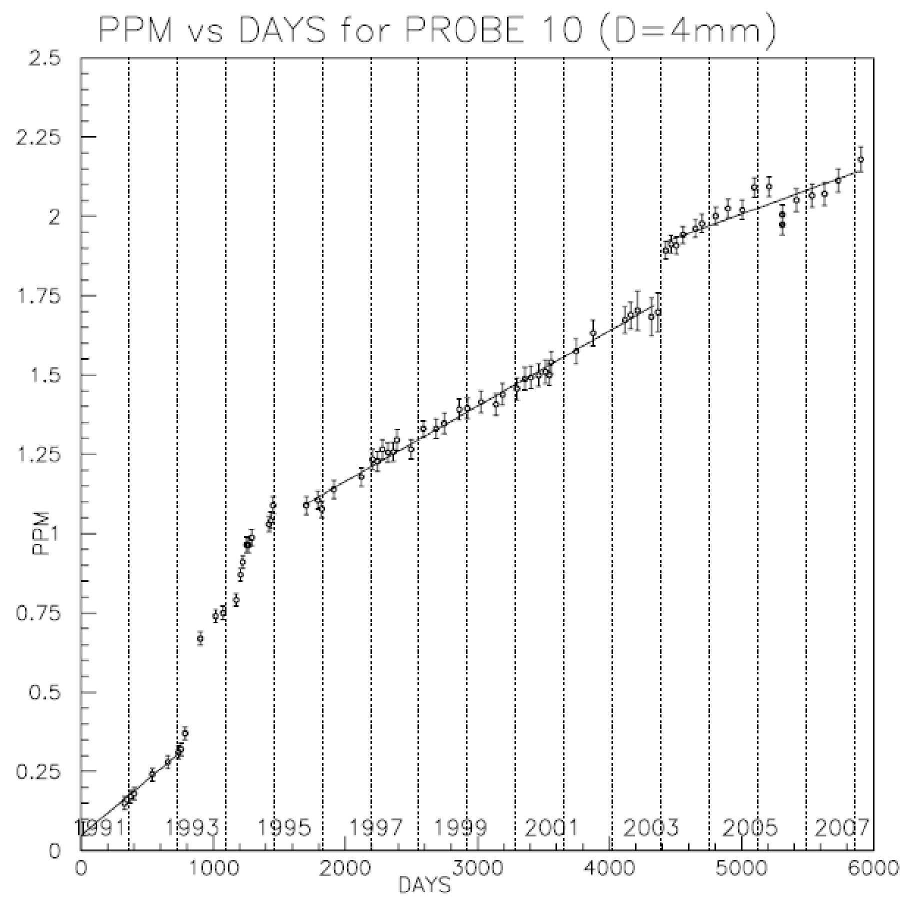
Regular topics:

- Purity of LAr
- LAr noise situation and number of channels supressed for energy reconstruction
- High Voltage situation
- Stability of energy scale
- Status of pulser system
- Noise in trigger and L1 rates
- Status of disabled channels (switches) in trigger

Emergencies:

- Hardware faults
- Readout problems
- Retriggering (on L2Rjt and L3Rjt)
- Beam-related trigger rates

H1 LAr purity monitor:



"Purity continues to Degrade at Expected Rate !"

Hardware problems and repairs

Most of LAr operation problems during HERA II:

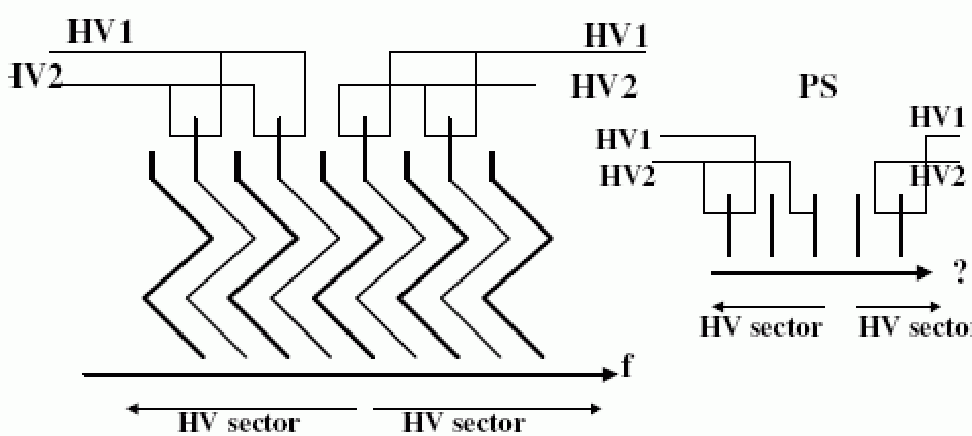
- Old failing electronics
- Unfortunate electronics design decisions

- failing power supplies (a lot of them custom-made)
- old electronics components (often two decades)
- Low-level SW running on ancient operation systems :-)
- ...

Electrolytic capacitors from LAr ANBX PS:

High Voltage status I

ATLAS LAr HV distribution

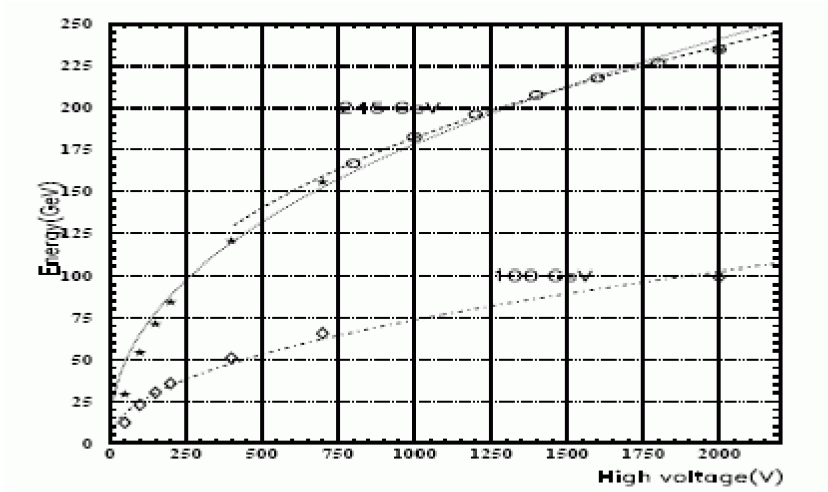


- Some channels can't be kept on nominal HV voltage (tripping)
  - reduce voltage or allow high current (hospital channels)
- Always took some time to reach equilibrium (~week)
- By the end of HERA II we had 157 HV channels in hospital (around 10%)
- Seems to be similar in ATLAS
  - (~653 receivers out of 5504 (12%) with HV>1.05)

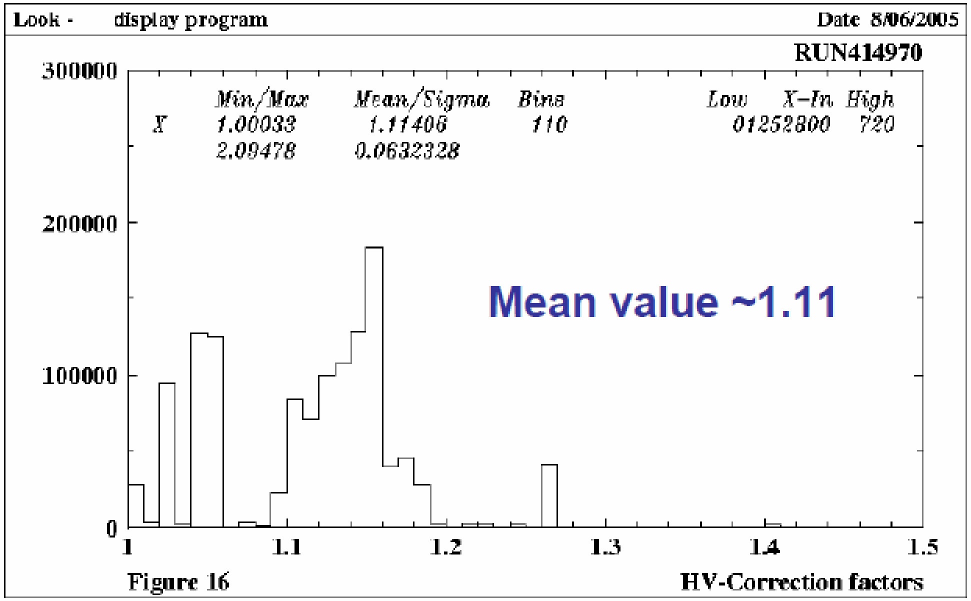
High Voltage status II

- Not a major problem (as long as HV can be kept at some stable value)
- Possible to correct offline using known energy on HV dependence (from test beams or HV ramps)
  - Smaller drift velocity, different pulse shape (ATLAS)
  - More electron attachment (H1)
- Trigger tends to be forgotten...

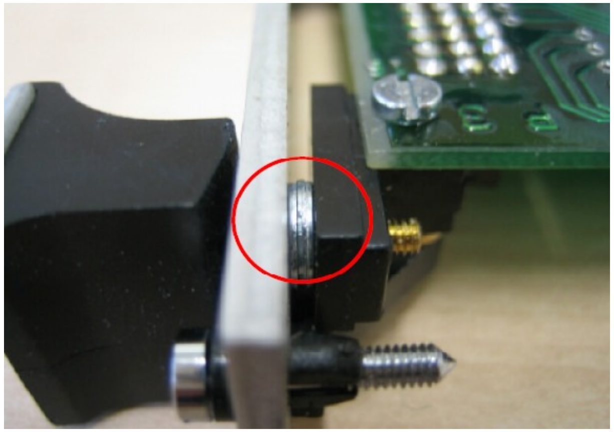
ATLAS Lar (testbeam):



Typical H1 Lar corrections (june 05):



Stability of energy scale

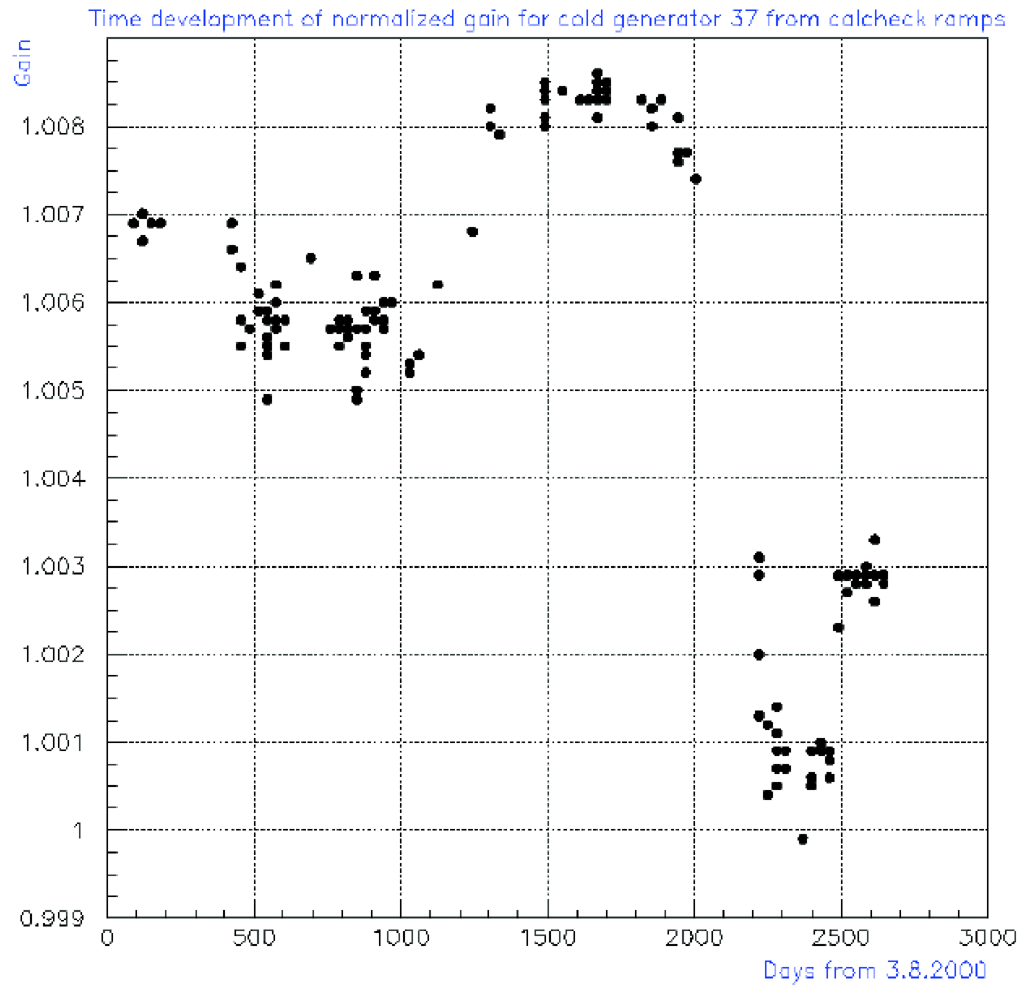


LAr energy scale:

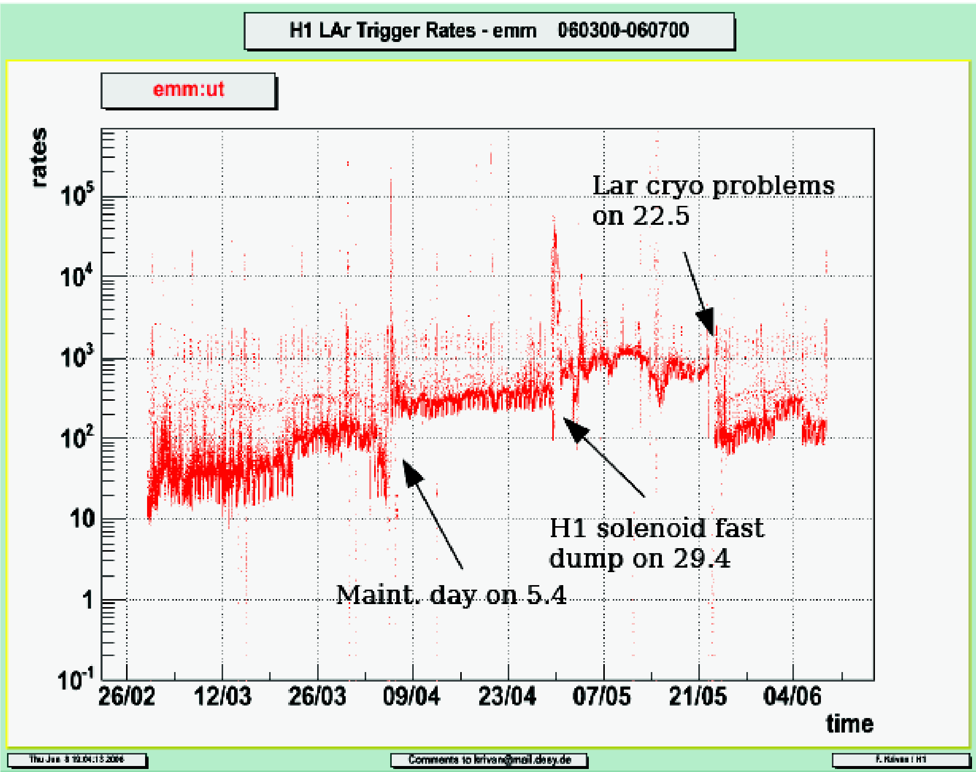
- Time stability coming from pulser
- Final energy scale determined from the data

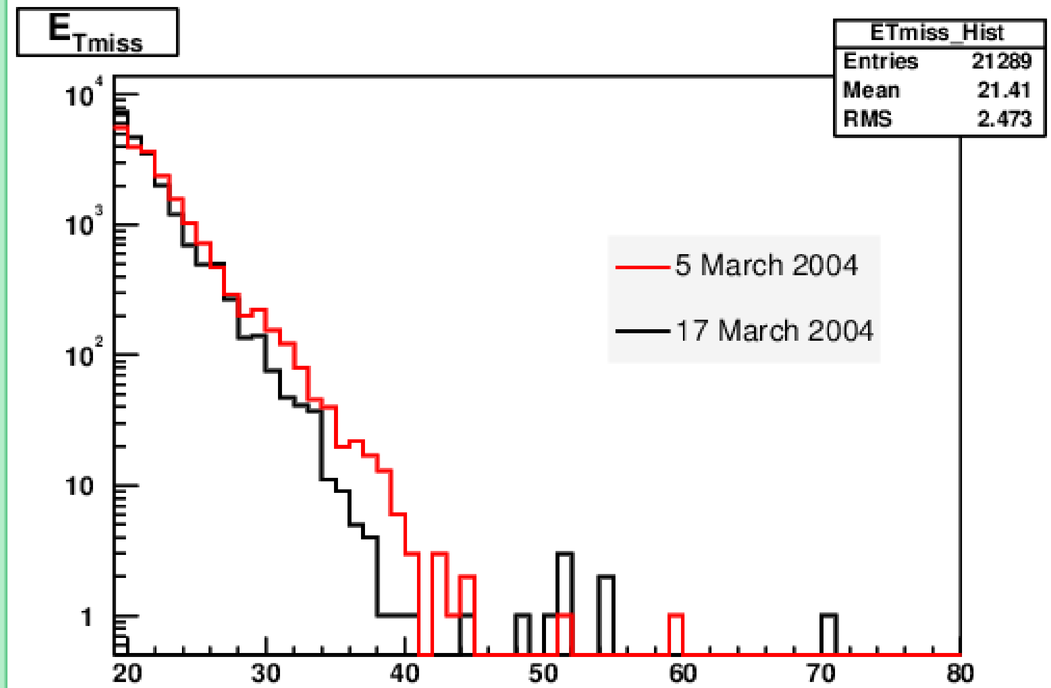
- Daily pulser calibration check
  - Usually very stable, instabilities mainly from malfunctioning pulser electronics
- Full calibration constants applied to DB ~1/month

Stability of gain as measured by a LAr cold generator (H1):



Noise in H1 LAr trigger I





- Trigger rates in LArT dominated by noise
  - Almost no dependence on luminosity
- Mainly individual noisy cells (electron trigger)

- Also long time fluctuations in rate (well visible in E_{Tmiss})
- difficult to supress as changes mainly in tails of noise distribution

Shielding of H1 LAr

Extended campaign to eliminate possible sources of noise and to shield LAr

- Shielding of Analog Front-end
- Monitoring of detector position
- ...

H1 Front-end

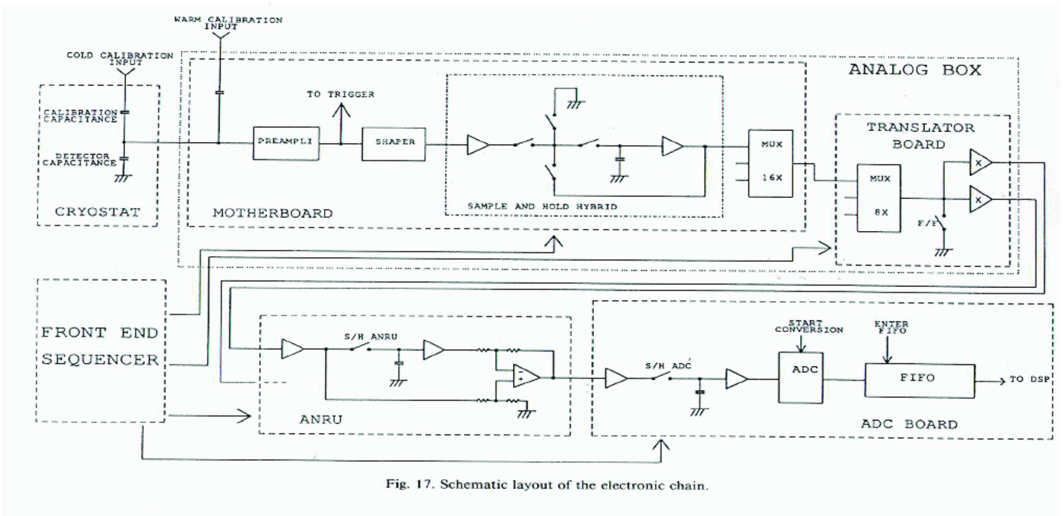
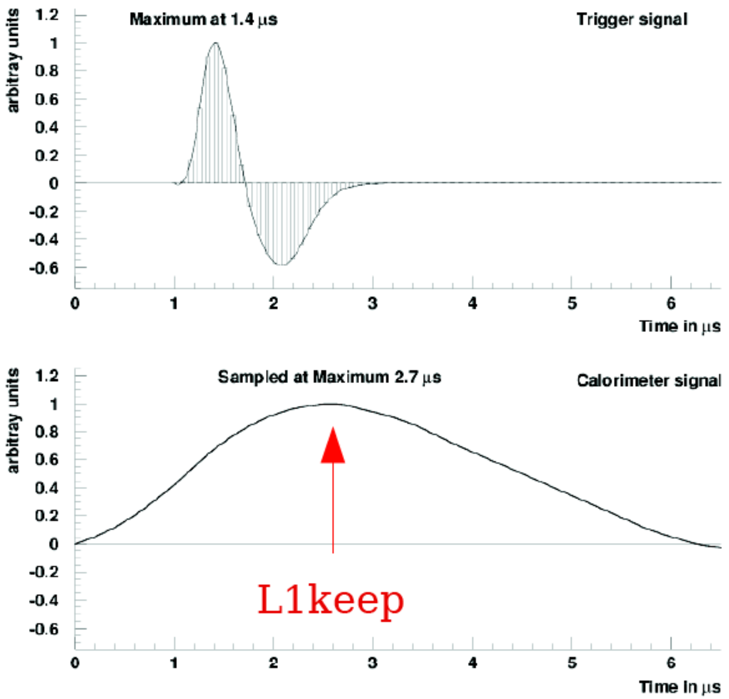


Fig. 17. Schematic layout of the electronic chain.



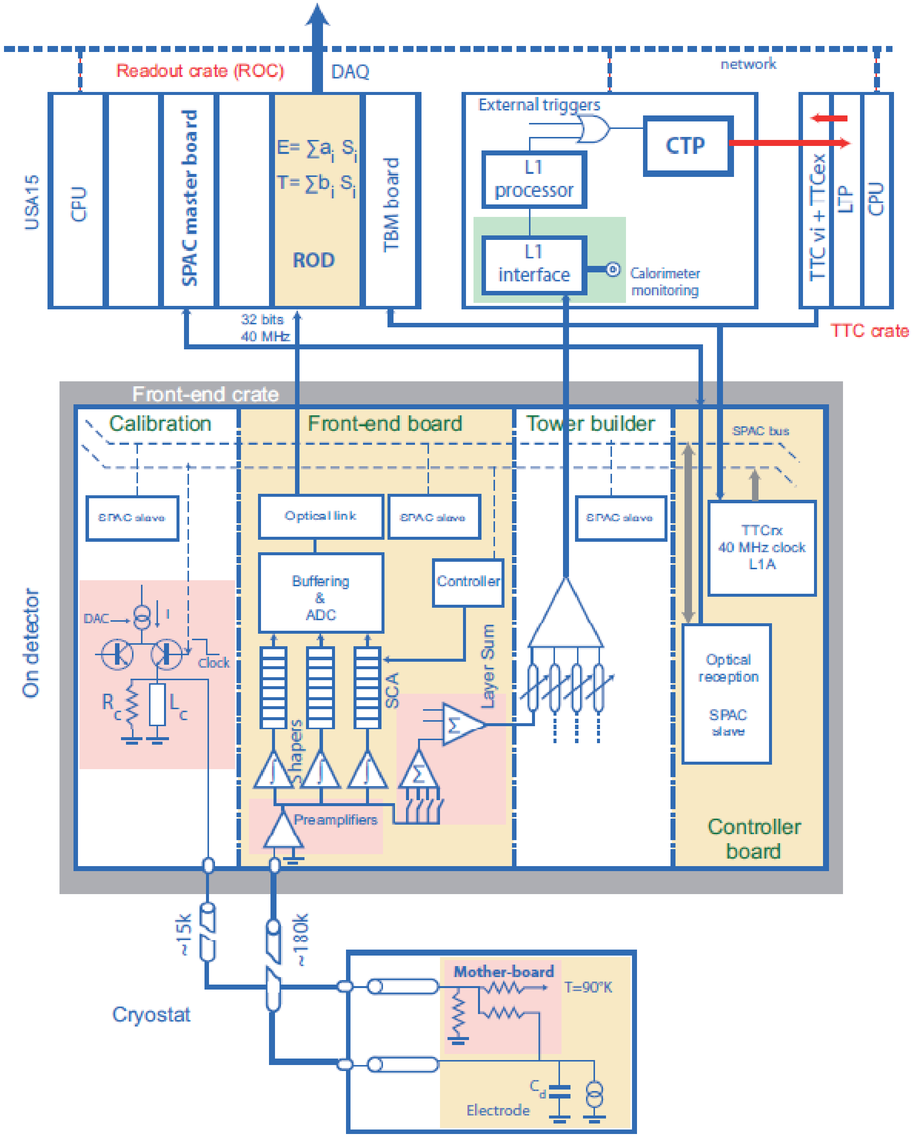
Signals from cryostat:

- Transferred to analog boxes mounted on the cryostat
- Preamplification, shaping (different shaping time for trigger and energy measurement)
- Trigger signals branching out, send in analog form off-detector

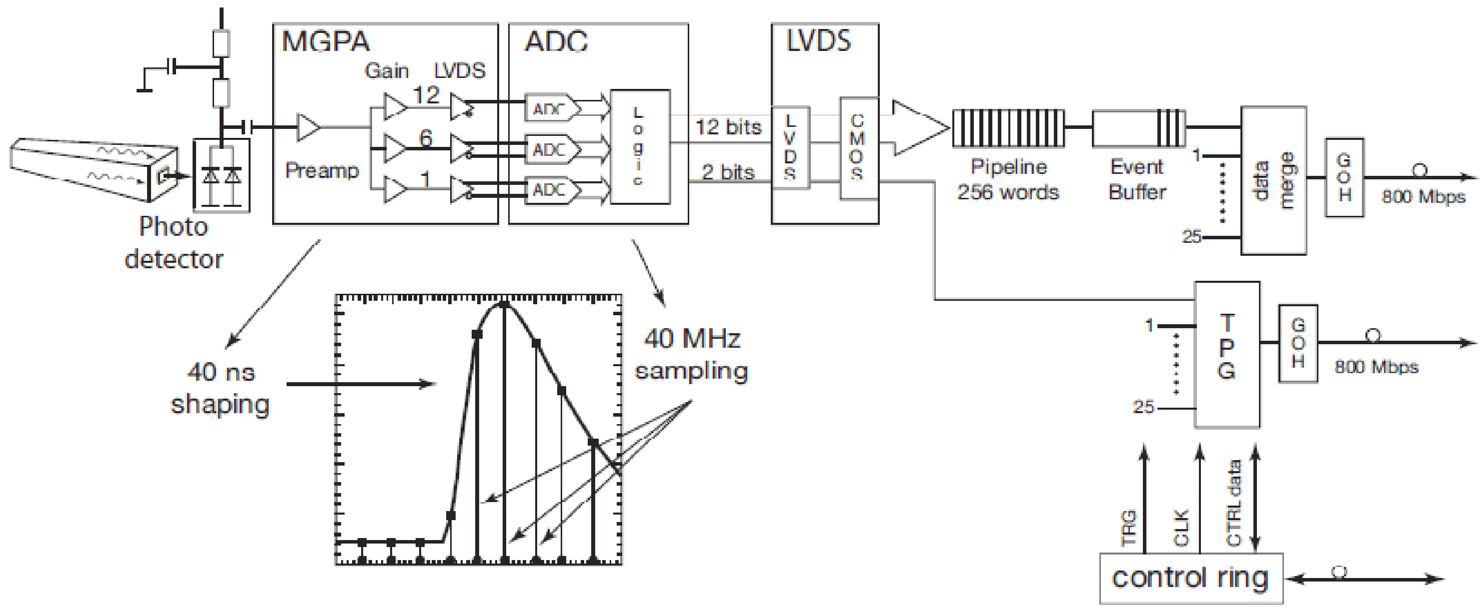
- On L1Keep calo signals sampled at maximum and stored in analog buffer (SCA)
- Multiplexed transfer of analog signals off detector
- Here processed in ADCs and DSPs

Atlas Front-end

- Analog signals brought out of cryostat, amplified and shaped
- Trigger signals branch out, analog sum to trigger towers, analog links to off-detector L1 trigger
- Calo signals stored in analog pipeline (SCA), on reception of L1keep digitized
- Sent on optical links off-detector
- There processed in DSPs

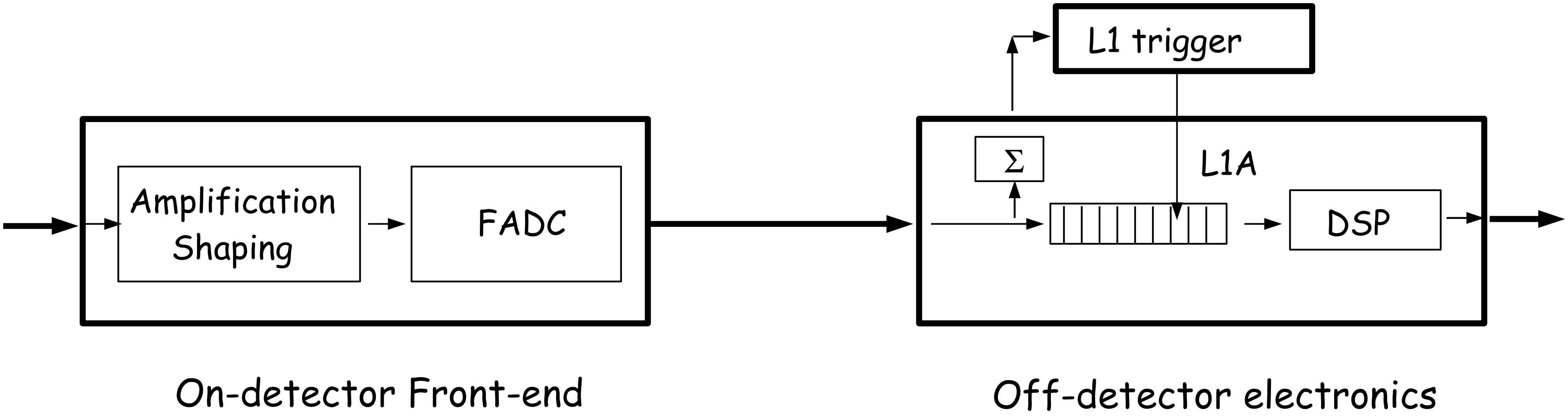


CMS Front-end



- Analog signals preamplified and digitized
- Trigger signals branch off, summed
- Calorimeter signals stored in digital pipeline
- In case of positive L1 decision sent off the detector on optical links

FE for next generation of experiments I (?)

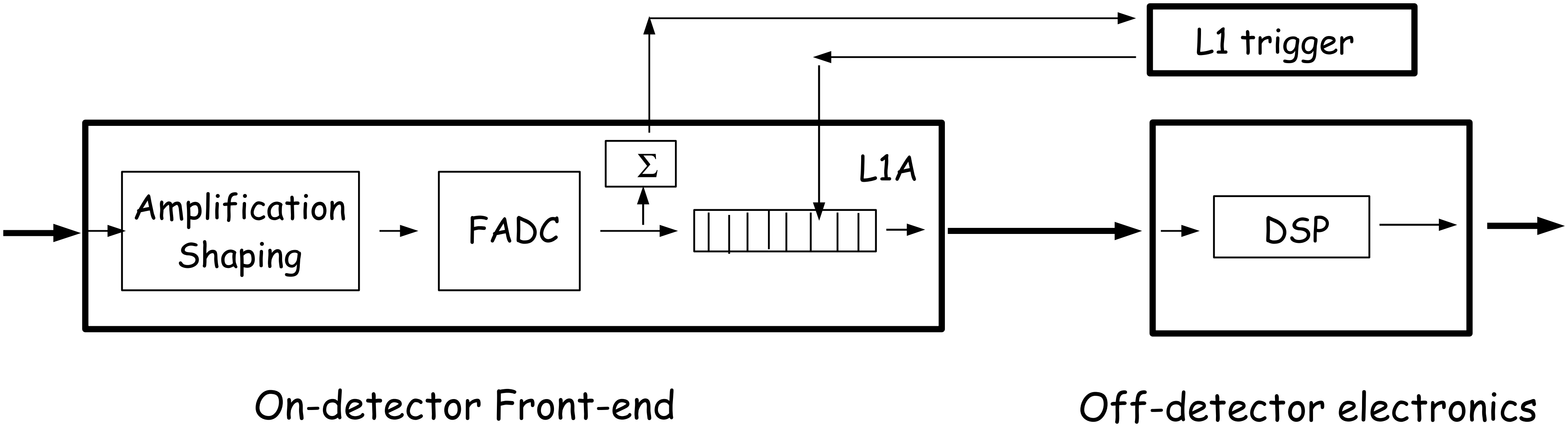


FE architecture nr I:

- Very simple front end (radiation hard electronics)
- Ship all digital data off detector
- Digital pipeline off the detector, can have large latency
- Need huge bandwidth between front end and off detector

- Time-scale of LHeC – early 2020s
- Similar to ATLAS/CMS Phase 2 upgrade, can take inspiration from there...

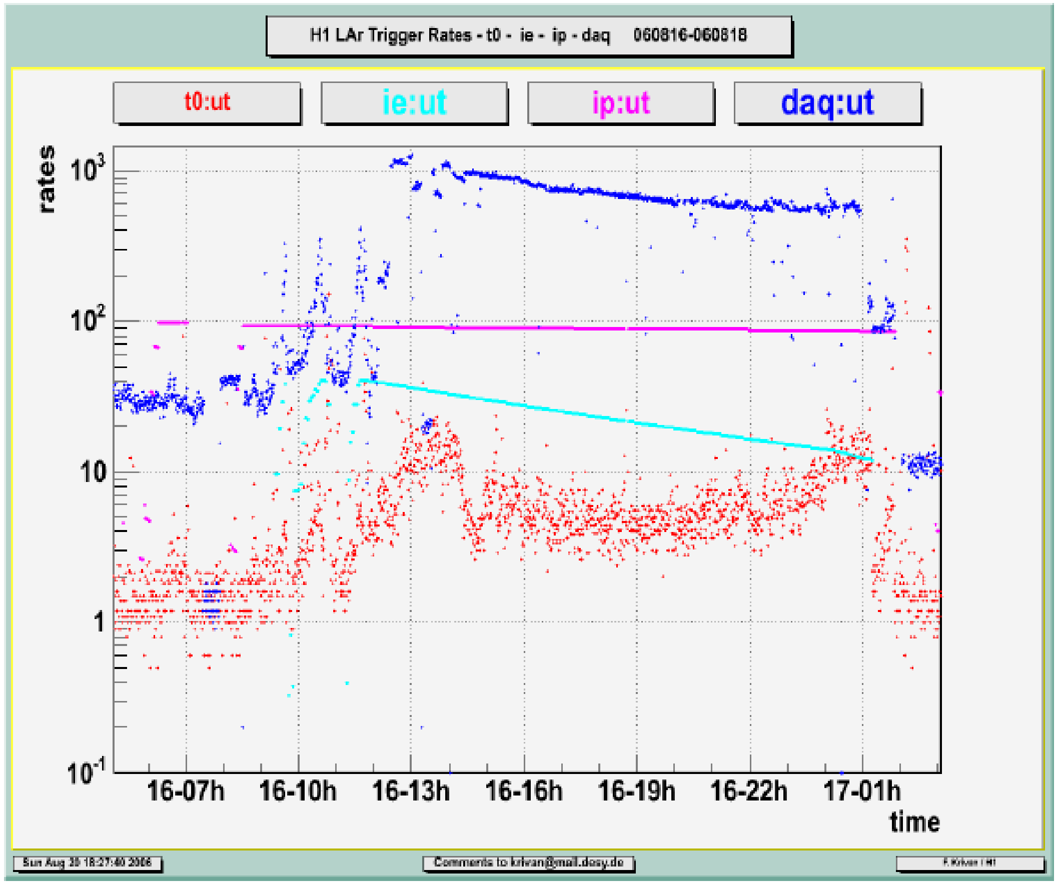
FE for next generation of experiments II (?)

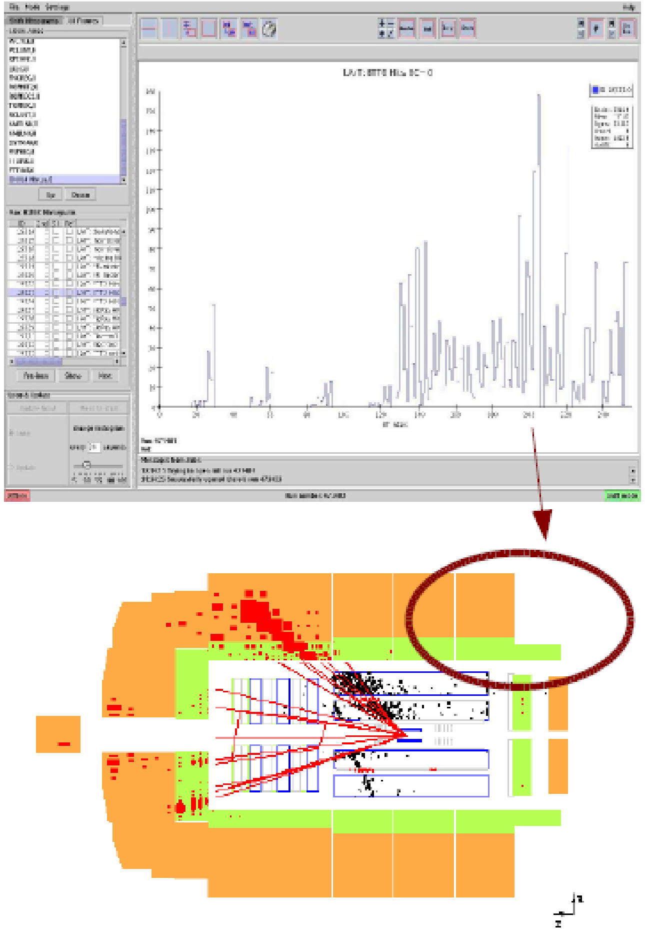


FE architecture nr II:

- ADCs and digital pipeline on detector
- Low granularity data to L1 trigger
- L1 sends its decision back to front-end
- Disadvantage is more complicated FE (shorter pipeline probably)
- Much smaller bandwidth between FE and off-detector electronics (especially if L1A rate is small)

Fluctuations in L1 trigger rate and backgrounds I





Large (beam related) trigger rates coming from barrel part

- Fluctuating (by order of magnitude) from fill to fill :-(

Typical rates at HERA

Expected number of events: $N = \sigma.\mathcal{L}$

Luminosity: HERA I $\mathcal{L} \simeq 14/\mu barn.s$

HERA II $\mathcal{L} \simeq$ factor 4 more

Hera bunch crossing frequency $\approx$ 10 Mhz (96 ns)

▷ Background:

Beam gas interactions:	50000	$events/s$
Showering cosmic muons:	$\simeq 1$	$events/s$

→ Larger than rate from collisions !

▷ Physics:

Untagged γp:	$\sigma \simeq 60\mu b$	1000	ev/s
Tagged γp:	$\sigma \simeq 1.6\mu b$	25	ev/s
$c\bar{c}$ total:	$\sigma \simeq 1\mu b$	15	ev/s
DIS low Q^2:	$\sigma \simeq 150nb$	2.2	ev/s
DIS high Q^2:	$\sigma \simeq 1,5nb$	1.4	ev/min
Charged Current:	$\sigma \simeq 50pb$	3	$ev/hour$
Real W:	$\sigma \simeq 0.4pb$	0.5	ev/day

$\Longrightarrow$ very different rates from various physics channels

Triggering inclusive electrons at H1

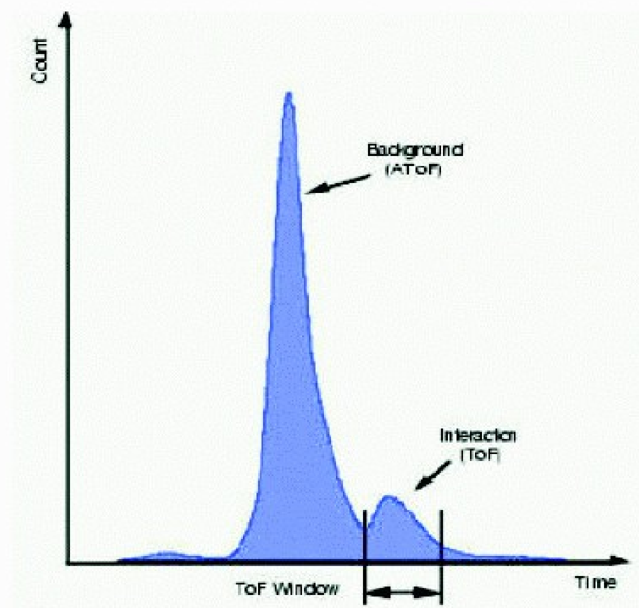
Run : 444307 Date : 17/02/06

L1:(LAr_electron_1) &&

(CIP_T0||(LAr_T0&&
(!CIP_T0_nextbc))) &&

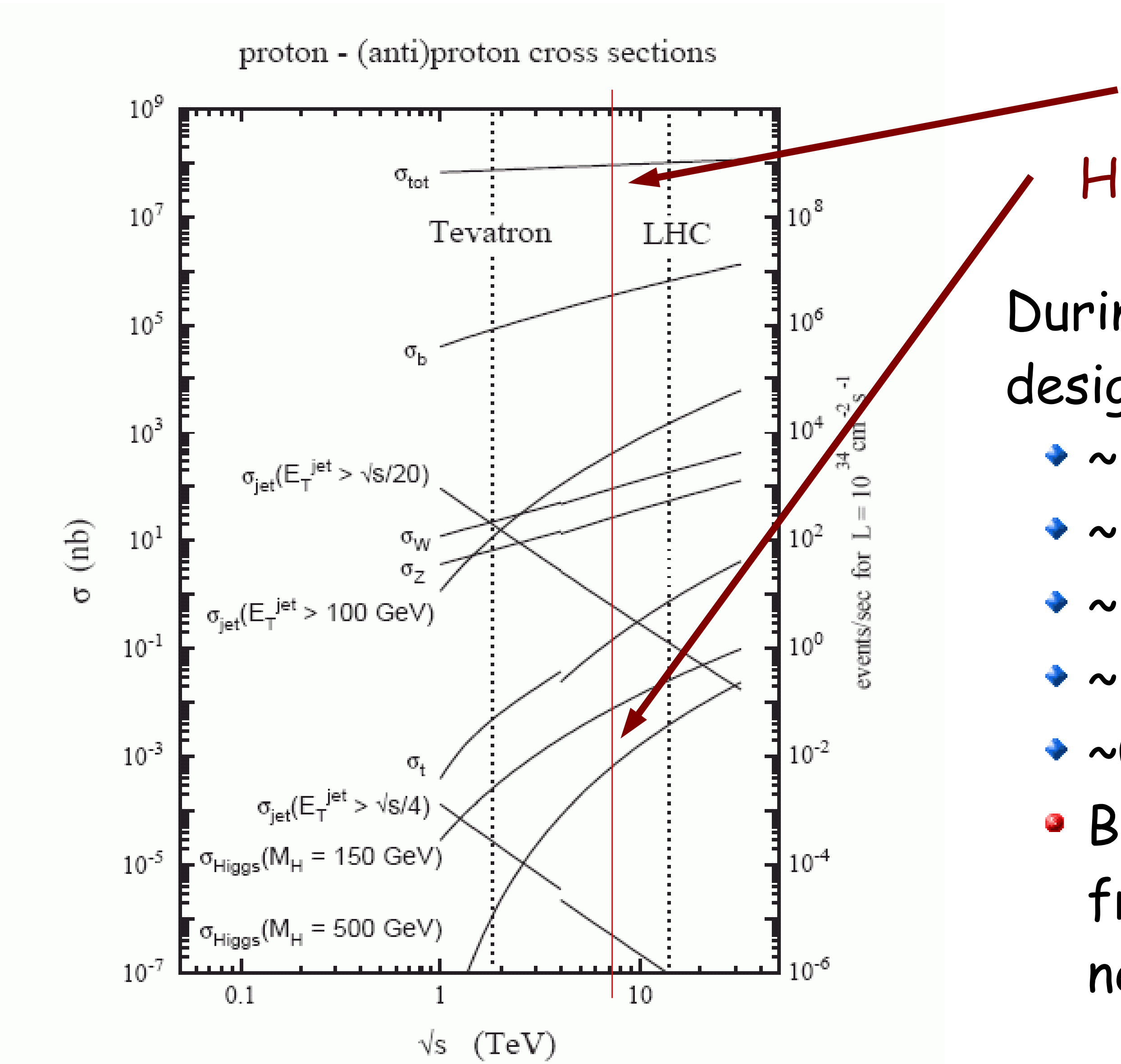
(!VETO_BG)&&((!BToF_BG)
&&(!SToF_BG))&&(FIT_IA||
(!FIT_BG))&&(!((CIP_mul>7)
&&(CIP_sig==0)))

- Energy requirement
- Timing
- Veto against background



Background rejection done using veto timing (ToF system) and vertex trigger requirement (CIP)

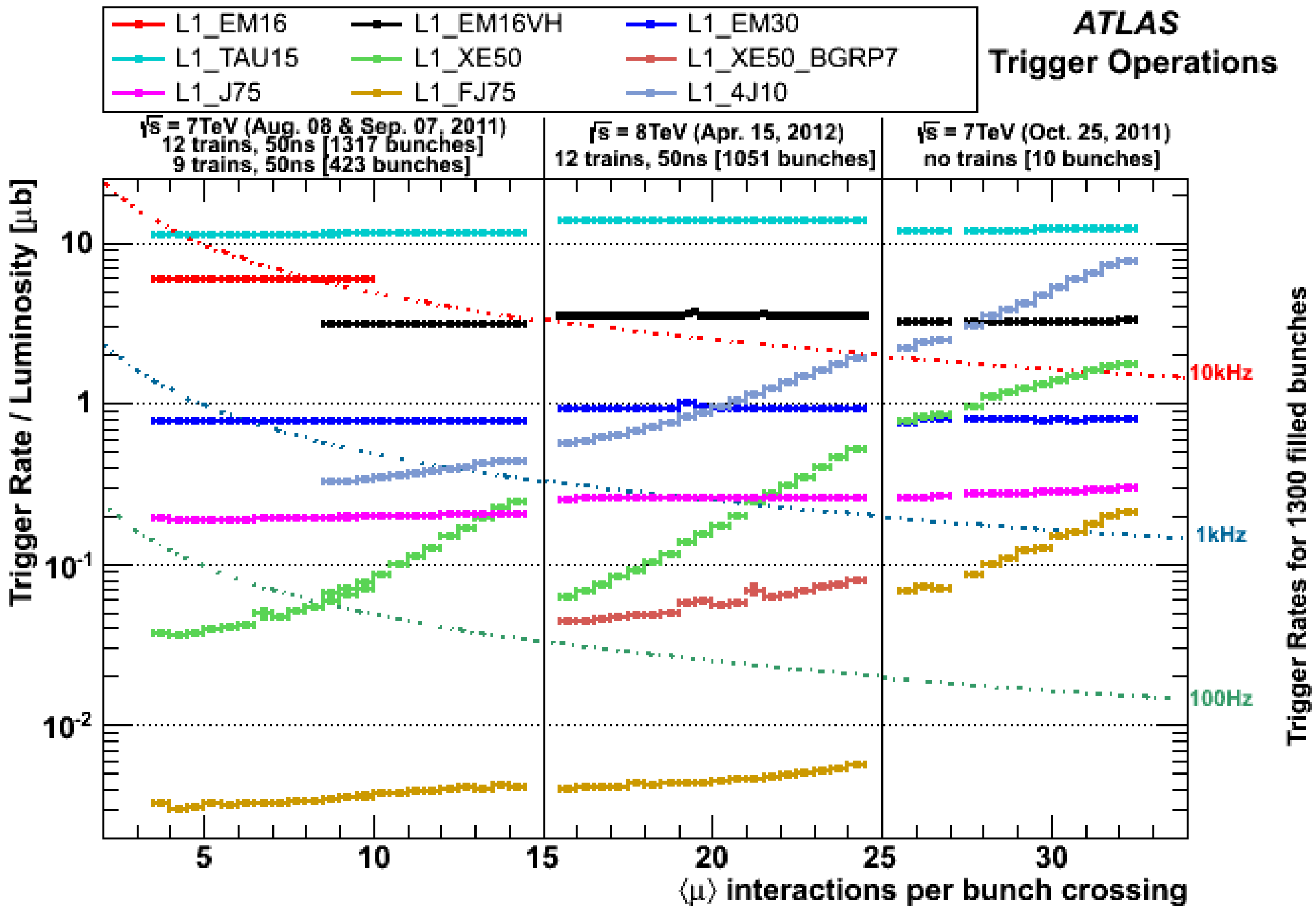
Triggering at the LHC



During one LHC second (at design luminosity):

- $\sim 10^9$ pp interactions
- $\sim 10^3$ W events
- ~500 Z events
- ~10 top events
- ~0.1 Higgs events (?)
- Background not coming from interaction point negligible!

L1 Triggering at ATLAS



- Most L1 triggers scale linearly with luminosity (EM, tau)
- For "global" L1 triggers see dependence on pile-up

Event rates at HERA and LHeC

Luminosity: HERA I $\mathcal{L} \simeq 14/\mu barn.s$
HERA II $\mathcal{L} \simeq$ factor 4 more

LHeC: ≅ 1000 1/μbarn . s

▷ Background:

Beam gas interactions:	50000	$events/s$
Showering cosmic muons:	$\simeq 1$	$events/s$

→ ???

▷ Physics:

Untagged γp:	$\sigma \simeq 60\mu b$	1000	ev/s
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Charged Current:	$\sigma \simeq 50pb$	3	$ev/hour$
Real W:	$\sigma \simeq 0.4pb$	0.5	ev/day

→ ≅ 100 000 ev/s

→ ≅ 200 ev/s

- Will beam-related background be an issue for trigger at LHeC?
- Rate of photoproduction background is close to current L1A rate at ATLAS (50kHz)
- Rate of low Q2 DIS close to frequency of ATLAS EF output rate (400 Hz)
- Looks like reasonable breathing space for LHeC trigger

Conclusions

Future is bright !

Thank you for your attention.