Development of a New L1 Muon Trigger System and New Readout Electronics for the ATLAS MDT Chambers at High LHC Luminosities

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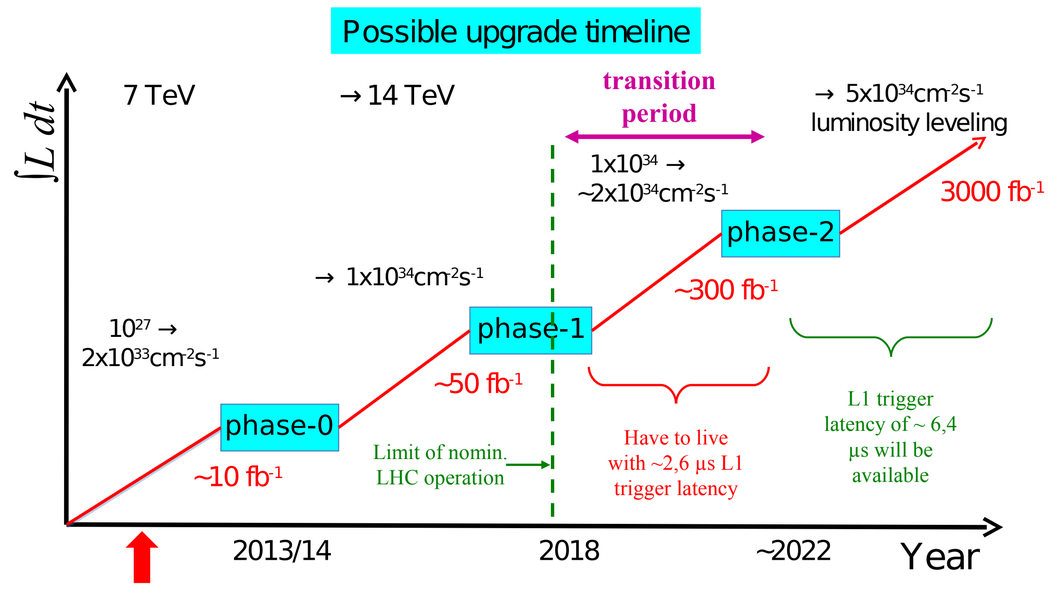
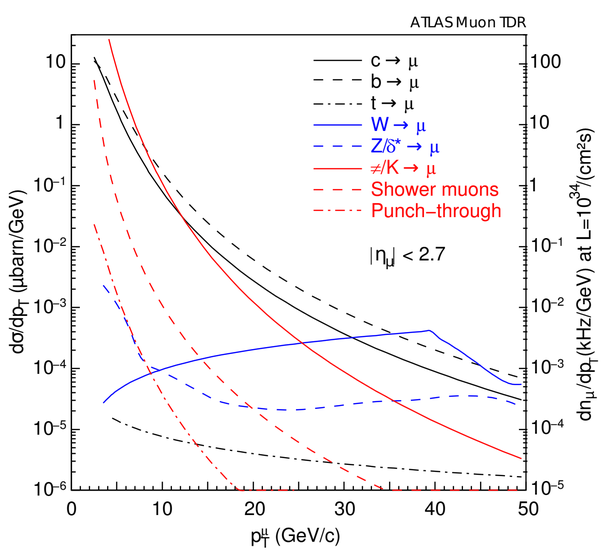
Abstract

The planned upgrades of the Large Hadron Collider (LHC) towards higher luminosities require among other detector improvements also a significantly higher selectivity of the ATLAS level-1 muon trigger in order to efficiently reject the large low-momentum muon background without losing interesting signal events. The momentum resolution of the L1 muon trigger can be sufficiently improved by using the precision muon tracking detectors, the Monitored Drift Tube (MDT) chambers, in the trigger. This has the advantage that no new trigger chambers with higher spatial resolution need to be installed which is hardly possible for the largest part of the muon detector. A MDT chamber based muon trigger scheme has been developed and validated by simulation. Its implementation requires the replacement of the existing MDT on-chamber electronics which will also need higher radiation hardness and bandwidth. New readout chips in radiation hard technology and new frontend boards are under development.

Long Term Planning for the LHC

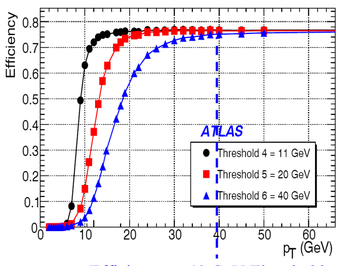


Problem of the Muon Trigger: Diff. Cross Section vs. p_T



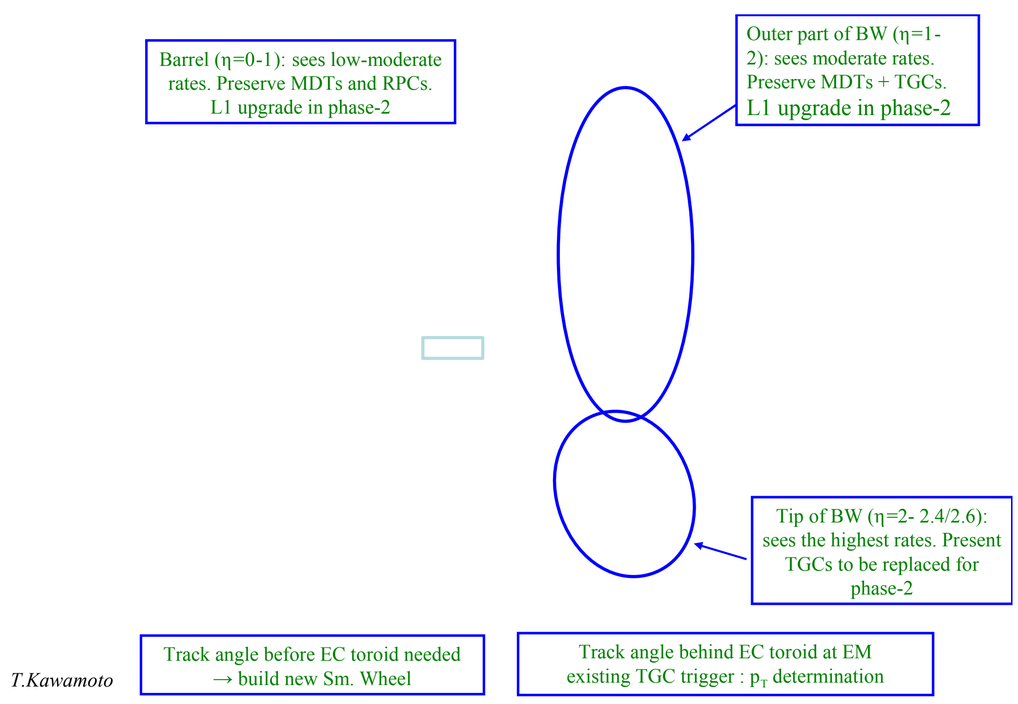
Integrated XS	> 10	> 20	> 30	> 40	GeV
"Signal" Σ(W, Z)	0,0106	0,0085	0,0056	0,0018	µb
"BG" Σ(b,c,π/K)	0,7344	0,0474	0,0102	0,0035	µb
"Signal / BG"	1,4%	17,9%	54,9%	51,4%	
Trigger rate, theor.	7,5	0,56	0,16	0,05	kHz
Triggerrate, real	110	24	15	11	kHz

The width of the real p_T resol. curve combined with the steep slope of the p_T spectrum leads high trigger rates.
→ The real p_T-dependance of the trigger rate is determined by the spatial resolution of the trigger chambers along η.

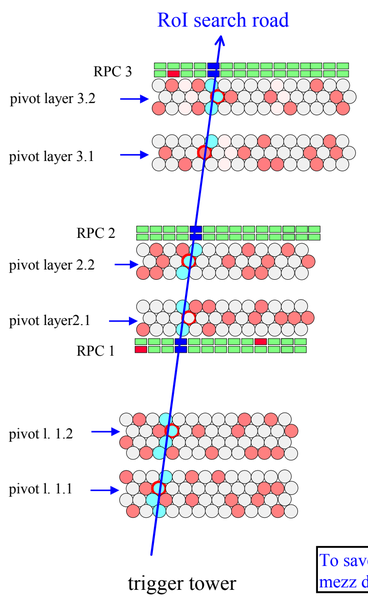


Efficiency at 40 GeV Threshold

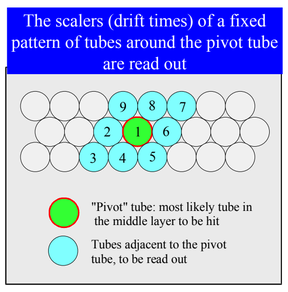
Overview of L1 Muon Upgrade, Phase-1 & Phase-2



A Tentative Recipe for Tube Readout (always read a fixed set of tubes)



The scalers (drift times) of a fixed pattern of tubes around the pivot tube are read out

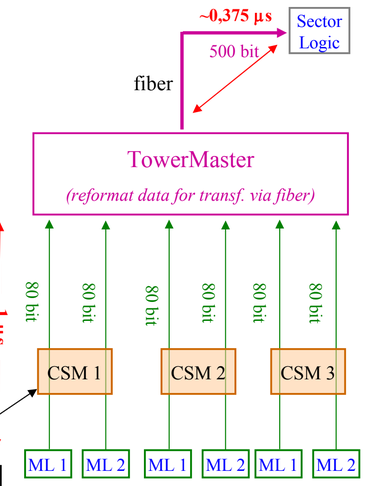


Use of a fixed readout format:
1 bit/tube for hit/no hit = 9
9 x drift time (7 bits) = 63
header, parity bit ~ 1
80 bit

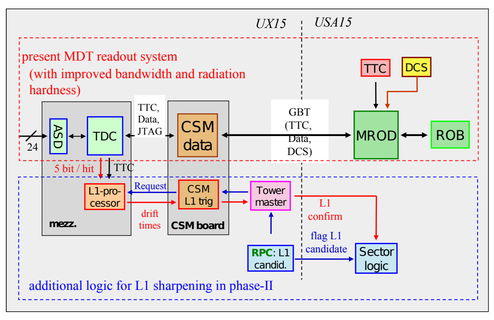
At a rate of 12,5 ns/bit the transfer to the CSM takes 1µs

To save R/O time, the CSMs are transparent to the mezz data: no formatting, no intermediate storage

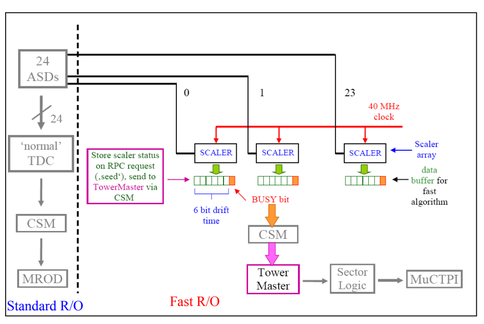
6 x 80 + BX-id + ovhd = 500 bit
At a rate of 0,8 ns/bit the trf. to the SL takes ~375 ns (excl. travel time)



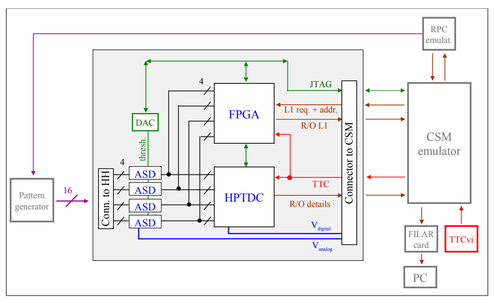
Architecture of MDT Readout



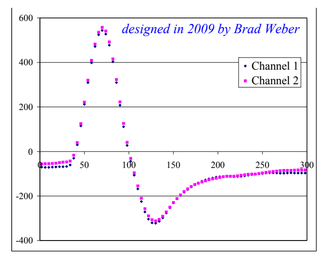
Fast and Standard Readout



Mezz. Prototype with new ASD



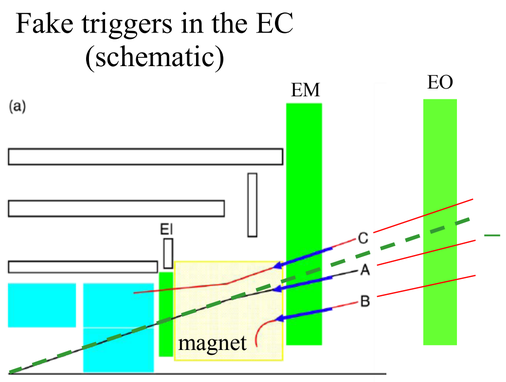
Analog Performance of ASD2 vs. 1



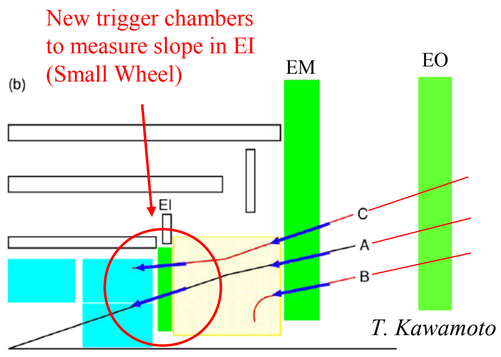
Results of prototype:
Came out like designed and simulated:
- Analog parameters (risetime, linearity, shape)
- Gain matching btw. channels: 2 %
- X-talk < 1,5 %
- Power consumption (30 mW/ch.)

Mesaured by S. Abovyan and V. Danielyan

Limitations of the L1 Trigger in the Present Muon Endcap



Present L1 trigger: slope and position of the muon are only measured in the EM wheel. Tracks are assumed to come from the IP (A).
However, there are many fake triggers from muons from decays and scattering, not coming from the vertex (C).
Coiling tracks from the EC-magnet also create fakes (B).



Future L1 trigger: slope and position of the muon will also be measured in the EI wheel.
Fake triggers type C and B will be discarded.
→ slope diff. before and behind magnet defines momentum
→ The slope has to be measured **with < 1 mrad accuracy**.

Conclusions

- The selectivity of the ATLAS L1 muon trigger needs to be improved for higher luminosities.
- Longer latency in phase-2 of $\gtrsim$6.4 µs allows to use MDT information in L1.
- The proposed scheme does not need new trigger chambers to be installed.
- New radiation hard MDT readout electronics with L1 functionality are being developed and tested.