First Thoughts about an Upgrade of the ATLAS Muon Spectrometer for an LHC Luminosity Upgrade

S. Horvat, O. Kortner, H. Kroha, R. Richter

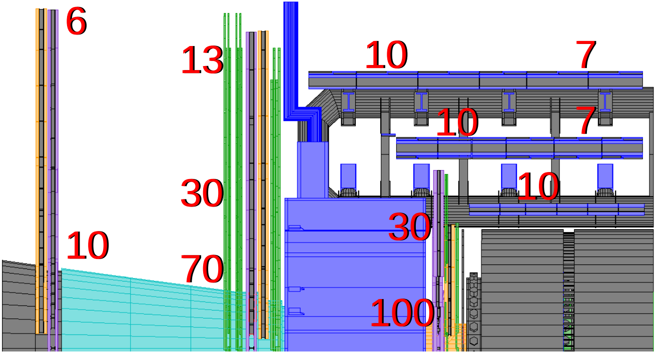
Max-Planck-Institut für Physik, Munich

MPI, 31.01.2005, ATLAS-Besprechung

Introduction

Main difficulty in μ spectroscopy: high $n-\gamma$ background.

Background count rates [$\mathrm{Hz\,cm^{-2}}$] at $L = 10^{34}\ \mathrm{cm^{-2}\,s^{-1}}$



Requirements for the ATLAS Muon Detectors

- Radiation hardness.
- Fast muon response:
  - $\sim$ 10 ns for the trigger chambers.
  - $\sim$ 700 ns for the MDT chambers.
- High granularity:
  - $\sim 3 \times 500 = 1500$ cm^2 segments for trigger and MDT chambers.

} for occupancy reduction

Baseline Upgrade Scenario for MDT Chambers

Background conditions: 10 times higher radiation background in the muon spectrometer after the LHC luminosity upgrade.

Radiation hardness: The chambers are designed to be radiation hard enough for 10 years of ATLAS operation.

Muon response time: Response time is a gas property. Improvement unlikely.

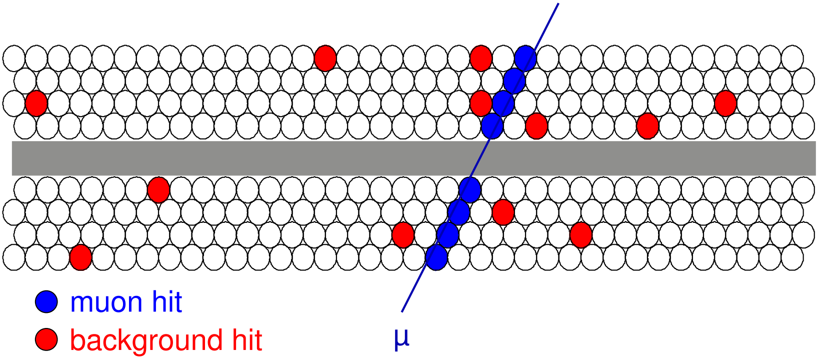
Granularity: Higher granularity requires new chambers. $\longrightarrow$ Improvement almost excluded.

Main focus on the upgrade of the read-out electronics.

(See next slides!)

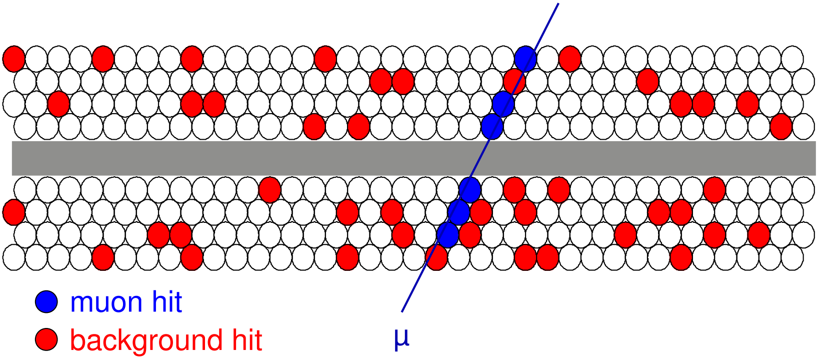
Hit Patterns in the Innermost Endcap Chamber

Nominal occupancy: 4%



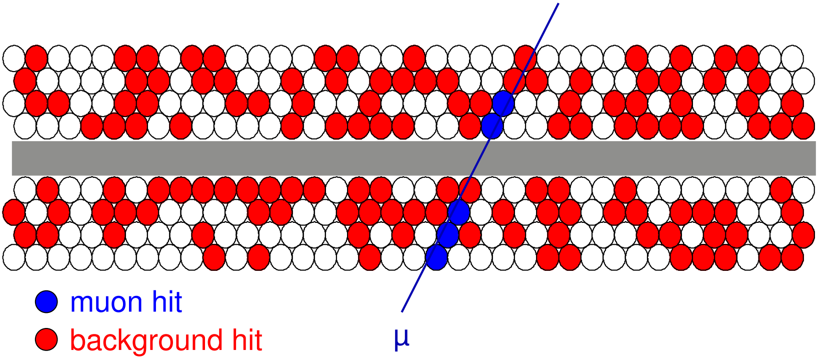
Hit Patterns in the Innermost Endcap Chamber

5x nominal occupancy: 20%

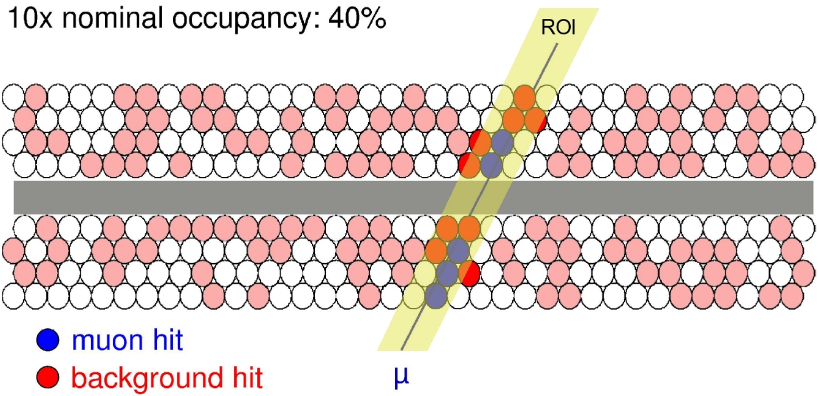


Hit Patterns in the Innermost Endcap Chamber

10x nominal occupancy: 40%

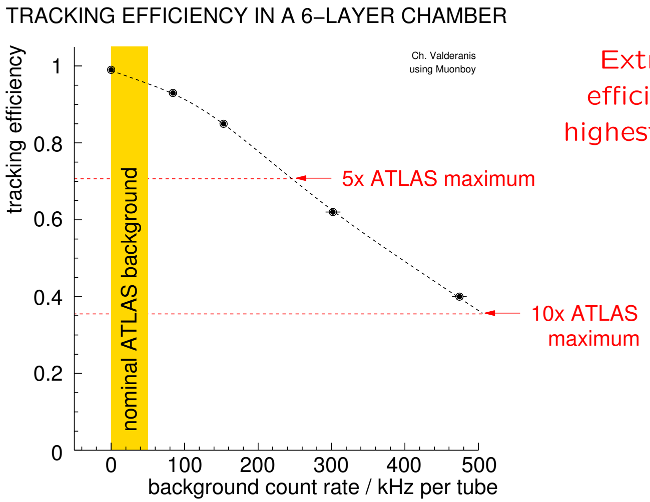


Pattern Recognition



Crucial: region of interest from trigger chambers.

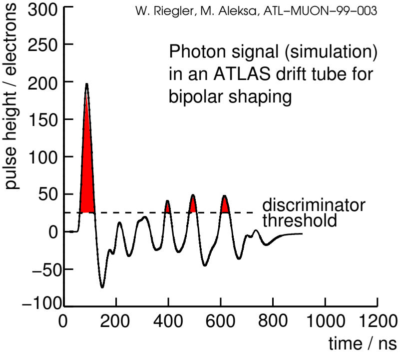
X5 Measurement of the Tracking Efficiency



Extremely low efficiency at the highest background rates.

First Attempt of Efficiency Improvement

Photon Signals in ATLAS Drift Tubes



Several threshold crossings of the photon signal within the $t_{drift,max}$ of ≈800 ns (measured: 1.5 on average at 200 ns dead-time)

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High count rate!

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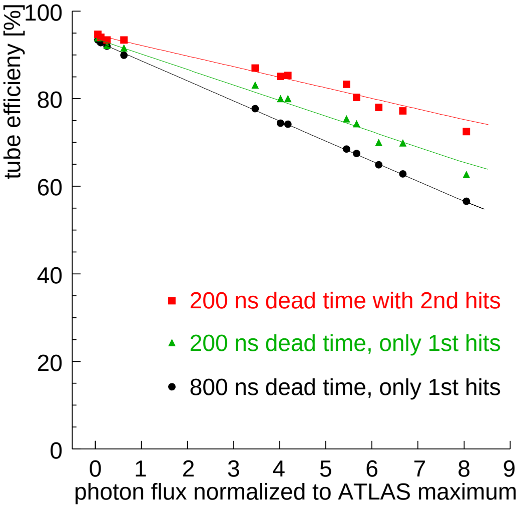
Solution for ATLAS:

Dead time setting: 800 ns.

Single Tube Efficiency with Reduced Dead Time



Significant tube efficiency improvement with lower dead time.

Tracking Efficiency with Reduced Dead Time

Estimation of the tracking efficiency

- $\epsilon(10 \times \text{bckgrd},\ t_{dead} = 200\ \text{ns}) = \epsilon(4 \times \text{bckgrd},\ t_{dead} = 800\ \text{ns})$.
- Tracking efficiency at "4×ATLAS" with 800 ns dead time: ≈80%.

→ Significant improvement of the tracking efficiency looks feasible.

Sketch of an Upgrade Programme

Component	Upgrade requirement
TDC	Rate capability up to 2 MHz/channel
CSM	Rate capability up to 400 MHz, data reduction capability (ROI information needed or second coordinate from double-sided read-out)
MROD	10 times higher rate capability than today

Present work at MPI:

- Tracking with reduced dead time.
- Development of an algorithm for the data reduction inside the CSM.