Work for the Upgrade of the ATLAS Muon Spectrometer for an LHC Luminosity Upgrade

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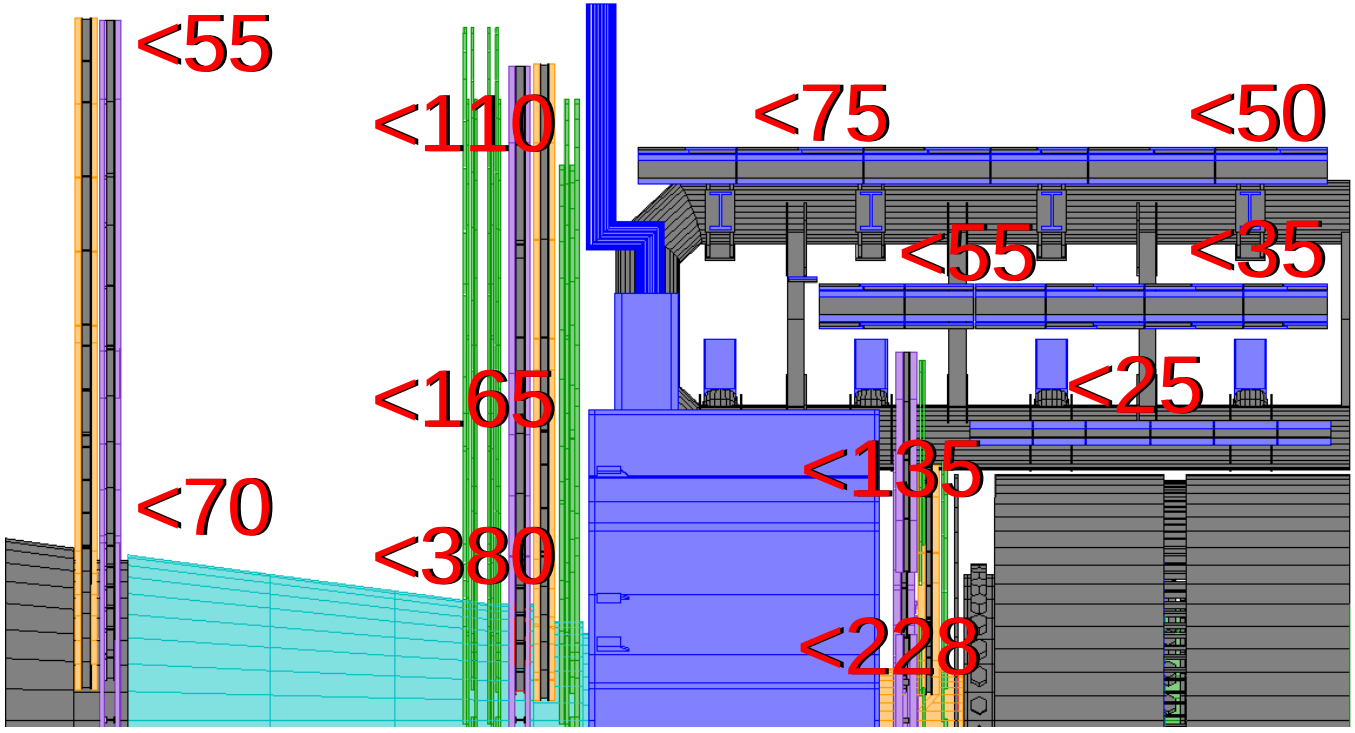
MPI, 04.04.2005, ATLAS-Besprechung

Introduction

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

Background count rates [kHz/tube] at $L = 10^{34}$ cm^{-2} s^{-1}

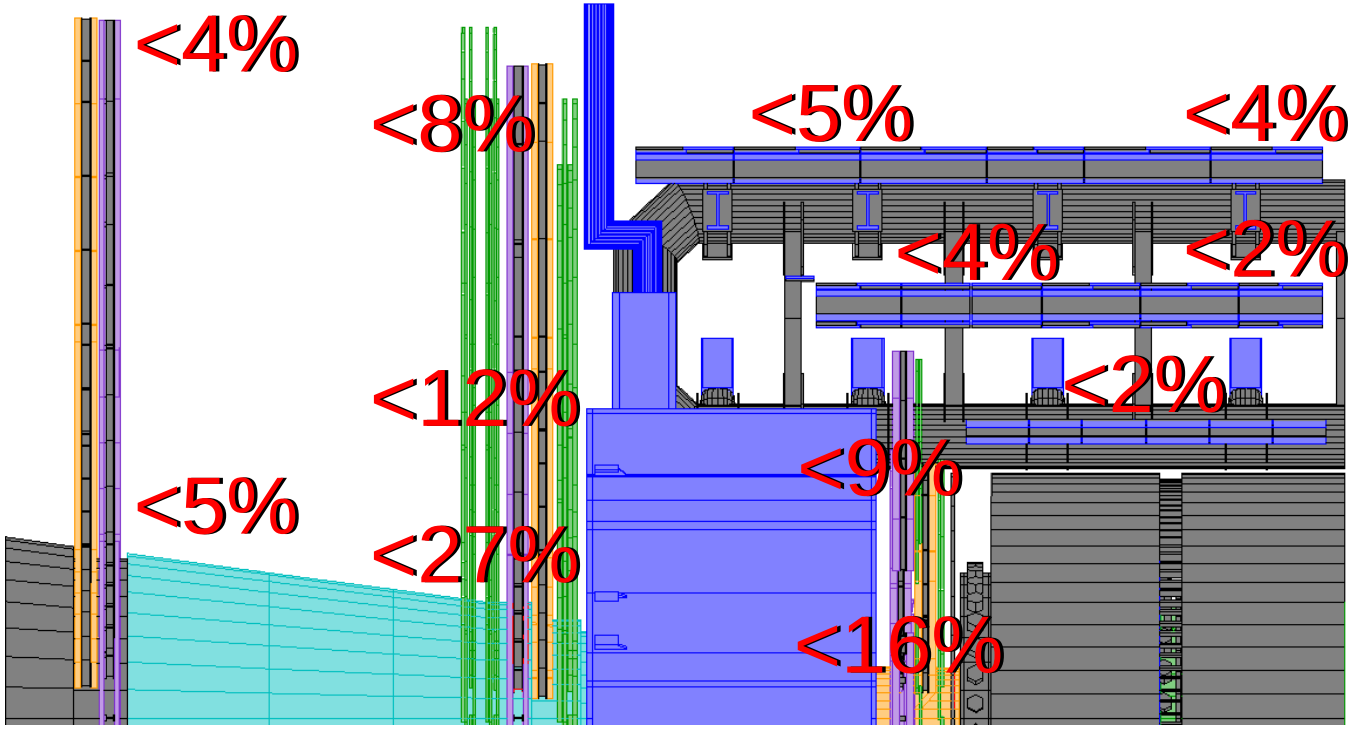


(Numbers include a safety factor of 5.)

Introduction

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

Occupancy at $L = 10^{34}$ cm^{-2} s^{-1}



(Numbers include a safety factor of 5.)

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: Up to 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 of the upgrade work

- Test of the radiation hardness of the muon detectors under SLHC conditions.
- Upgrade of the read-out electronics and trigger system.

Status of Upgrade Investigations

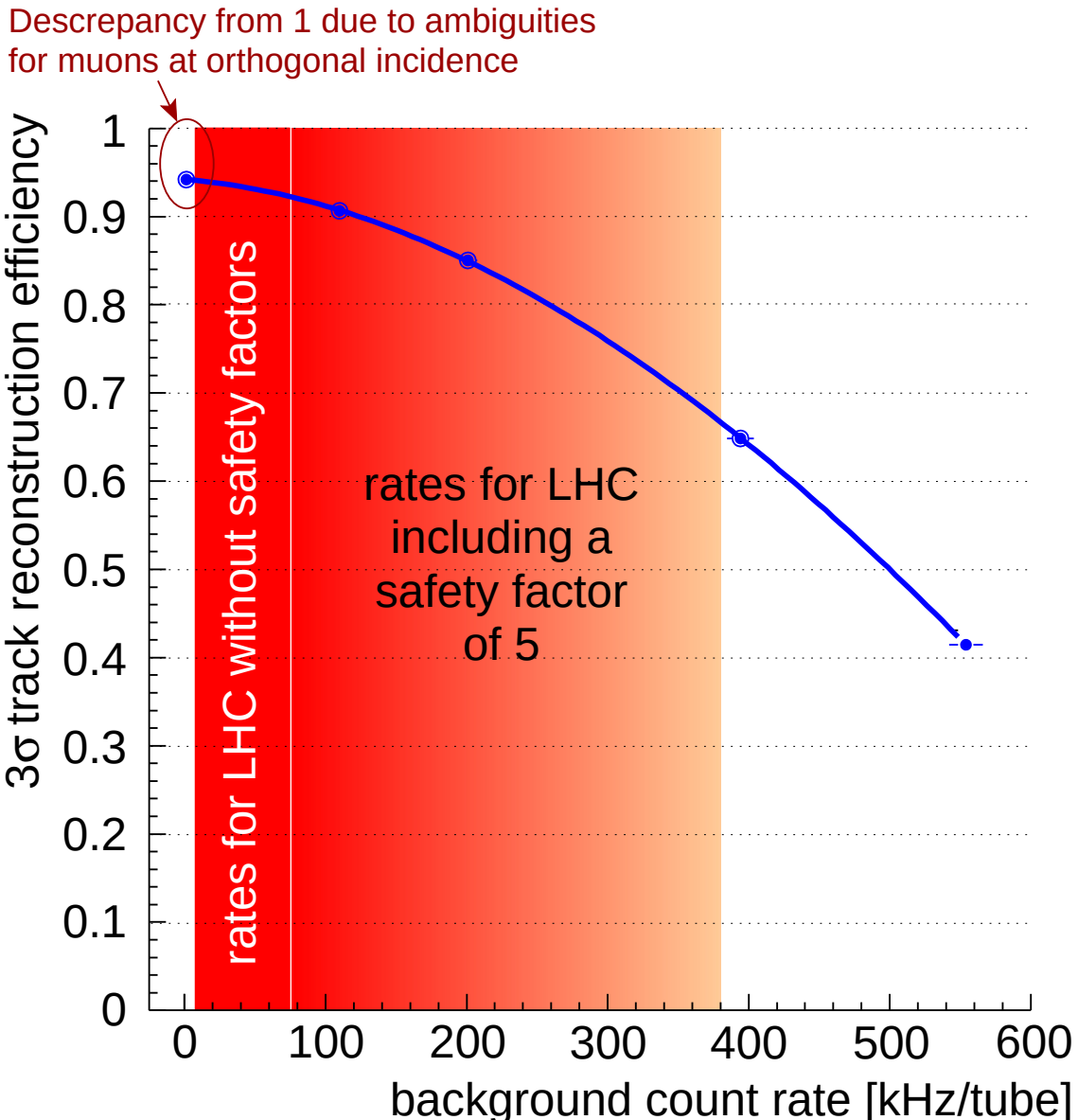
Radiation hardness of the MDT chambers:

- Studies only for LHC conditions.
- Studies mainly with γ rays.
- No aging studies with neutrons.

Muon detection and track-reconstruction measurements:

- Only data with high radiation background and ATLAS MDT chambers with final electronics: MPI-LMU test-beam data from X5/GIF 2003/2004.
- Test of first ideas for SLHC performed on 2004 data.

X5 Measurement of the Tracking Efficiency

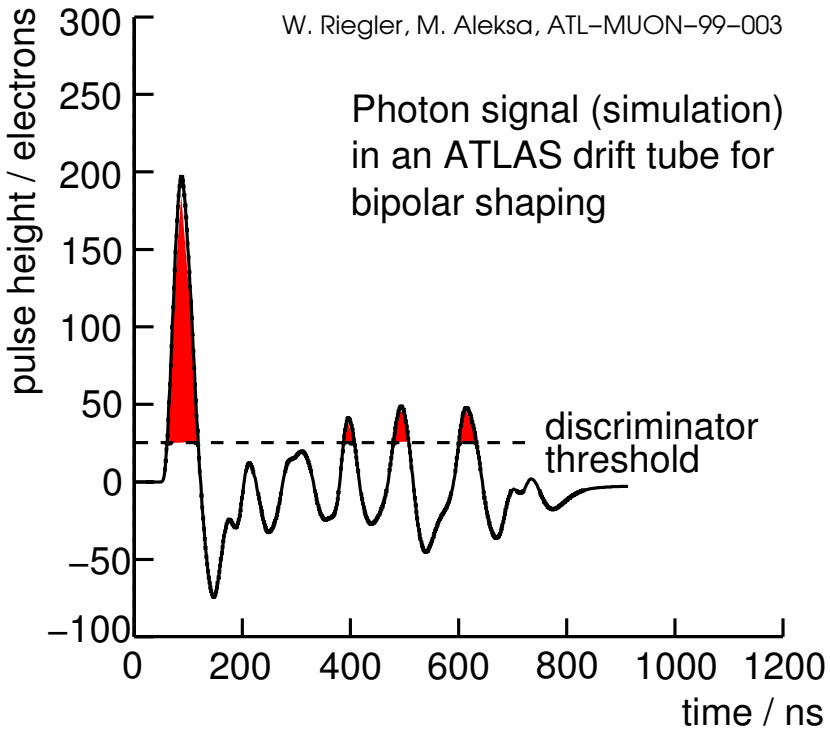


High reconstruction efficiency at nominal ATLAS rates without safety factor!

Significantly lower efficiency at the highest background rates at LHC design luminosity!

Reason for the Low Tracking Efficiency

Photon Signals in ATLAS Drift Tubes



Prediction: <number of threshold crossings> = 3.

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)

⇓

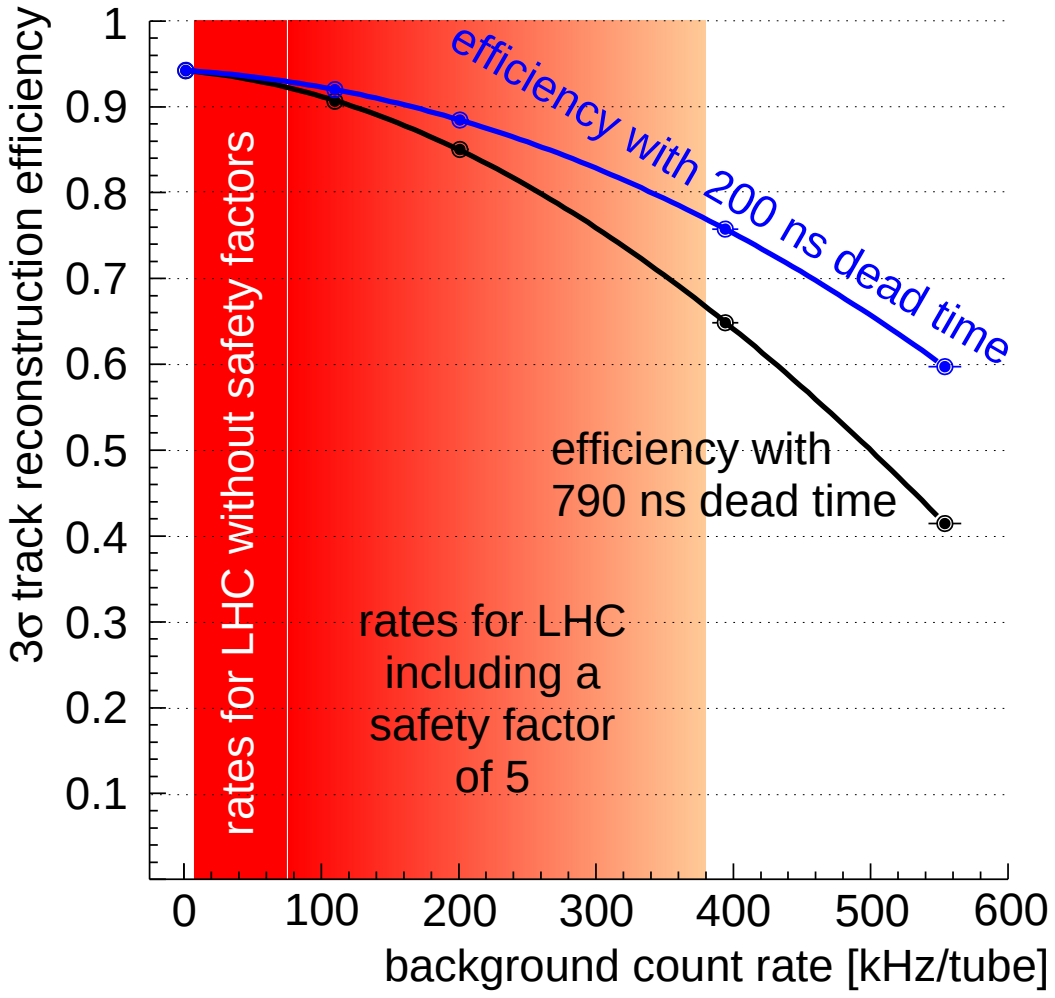
High count rate!

↓

Present strategy in ATLAS:

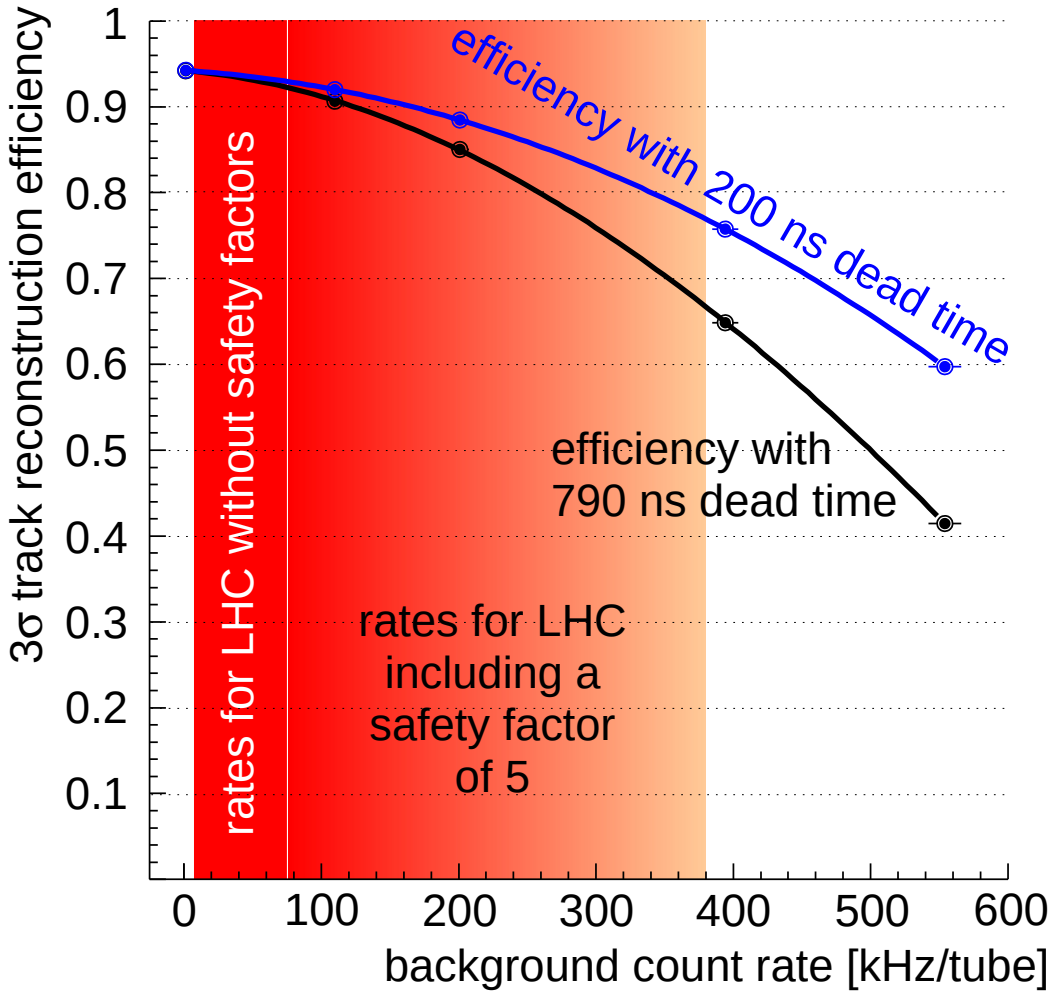
Dead time setting: 800 ns.

Tracking Efficiency with Reduced Dead Time



Much better tracking efficiency with reduced dead time!

Tracking Efficiency with Reduced Dead Time



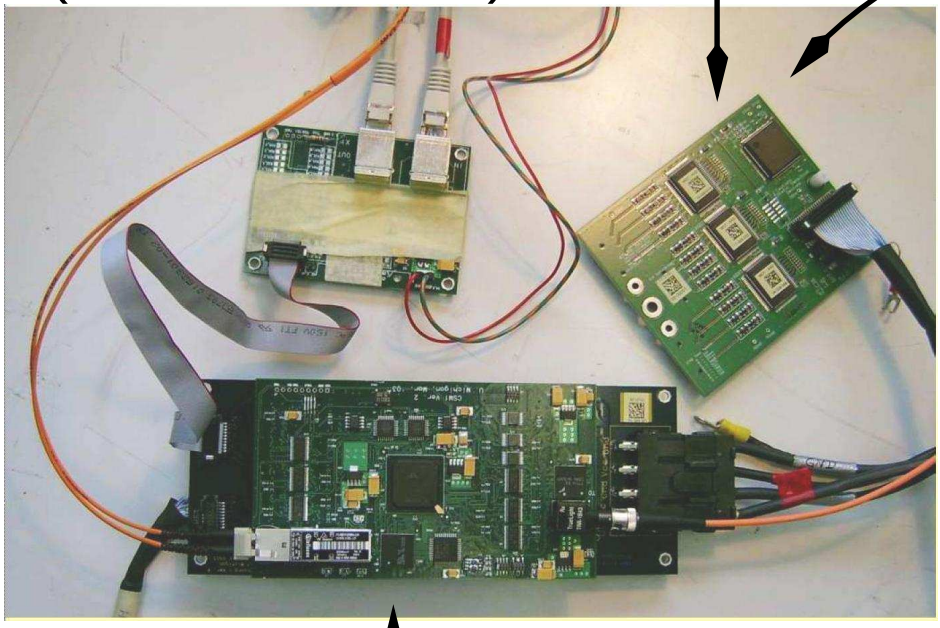
Much better tracking efficiency with reduced dead time!

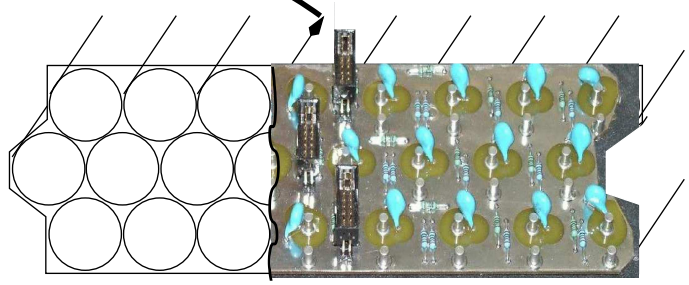
Problem in ATLAS:

limited bandwith of the MDT read-out chain.

MDT Read-out Chain

Amplifier shaper discriminator card
with 24 channel TDC und ADC
(mezzanine card)





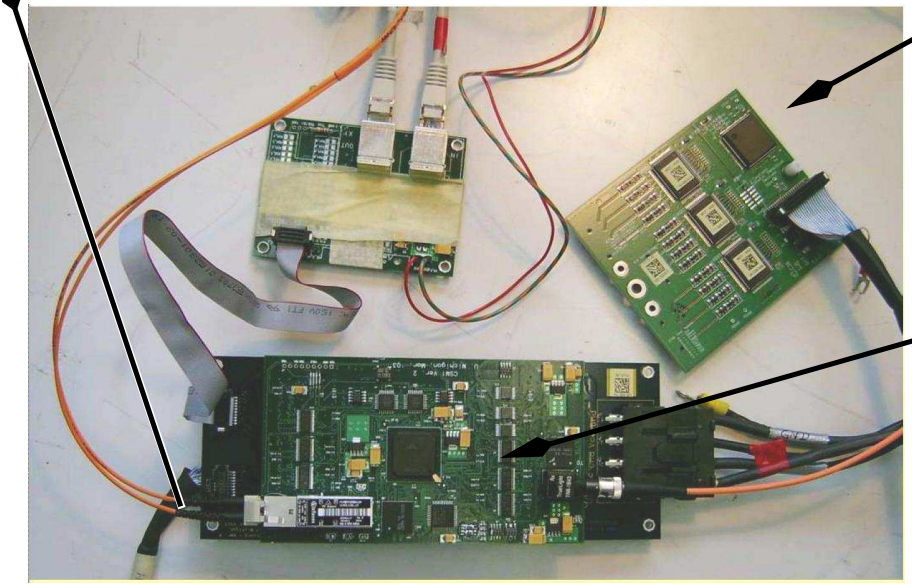
24 drift tubes connected to
a shielded passive
read−out hedgehog card

Adjustable dead time:
200−790 ns.

chamber service module → MROD

MDT Read-out Chain – Rate Capacities

MROD ✗ *needs upgraded rate capacity*



mezzanine card ✓

chamber service module ✓

but needs code for data recduction

CSM upgrade desirable for LHC at $L = 10^{34}$ cm^{-2} s^{-1} in order to be able to run with reduced dead time.

Work Plan for an MDT Upgrade

relevant also for LHC

CSM upgrade: Developement of a new CSM code for data reduction and preprocessing.

- Start autumn 2005: test of the new CSM code with cosmics on a spare BOS chamber.
- Summer 2006: high-rate test in a muon test beam at CERN.

MROD upgrade: Participation in the development and production of new MRODs with higher bandwidth.

relevant also for SLHC

- After 2007.
- Test with cosmics and test-beam data as soon as protoype is ready.

Level-2 trigger: Development and implementation of a fast tracking algorithm capable of multiple hits.

Radiation tests: Radiation test with neutrons at FRM-II in cooperation with LMU Munich and Freiburg.