Construction of a High-Resolution Muon Drift Tube Prototype Chamber for LHC Upgrades

B. Bittner[a], J. Dubbert[a], M. Kilgenstein[a], O. Kortner[a], S. Kortner[a], H. Kroha[a], J. v. Loeben[c], R. Richter[a], Ph. Schwegler[a], S. Adomeit[b], O. Biebel[b], A. Engl[b], R. Hertenberger[b], F. Legger[b], F. Rauscher[b], A. Zibell[b]

[a]*Max-Planck-Institut für Physik, Föhringer Ring 6, D-80805 München, Germany*
[b]*Ludwig-Maximilians-Universität-München, Am Coulombwall 1, D-85748 Garching, Germany*

Abstract

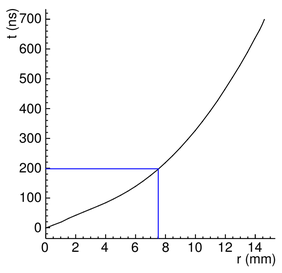
The proposed upgrade of the Large Hadron Collider at CERN to luminosities above 1×10^{34} cm^{-2}s^{-1} necessitates the replacement of a large number of tracking chambers of the muon spectrometer of the ATLAS experiment to avoid deterioration of the muon identification and the momentum measurement at high background rates. Based on the standard ATLAS Monitored Drift Tube chambers (2×3 or 4 tube layers, drift tube diameter 30 mm), a new design with 15 mm diameter tubes and matching services has been developed, offering an increased rate capability by and better pattern recognition and redundancy due to the higher cell density. A full-sized prototype chamber consisting of 1152 tubes arranged in 2×8 tube layers and covering an area of 1 m^2 has been built to validate the assembly procedures and to test its performance.

Advantages of Smaller Drift Tube Diameter

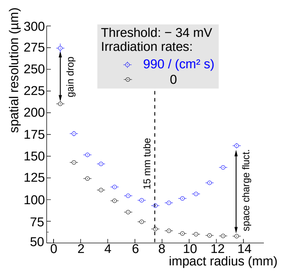
- Reduced occupancy (shorter max. drift time)
- Reduced counting rate per tube (smaller cell area)
- Reduced effect of space charge fluctuations on resolution
- Reduced effect of gain drop ($\sim 1/r^3$)

Luminosity (cm^{-2} s^{-1})	Background hit rate (kHz cm^{-2})	Occupancy (%) 15 mm ⌀	30 mm ⌀
1×10^{34}	1.7	5	35
2×10^{34}	3.4	10	70
5×10^{34}	8.5	25	100

Tube occupancies for nominal and increased LHC luminosities



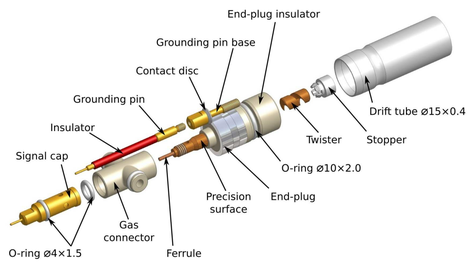
Space drift time relation (simulation) of ATLAS drift tubes



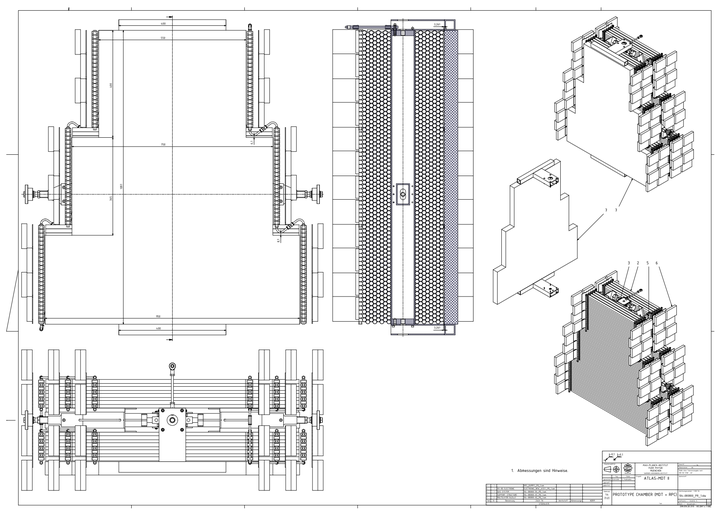
Resolution of ATLAS drift tubes (30mm diameter) at different photon background rates (test beam measurement)

Design of 15 mm Drift Tubes Prototype Chamber

Outer tube diameter	15 mm $\pm$ 0.1 mm
Tube wall	0.4 mm Al
Anode wire	50 µm W-Re
Gas	Ar/CO_2 = 93/7
Pressure	3 bara
Operating voltage	2730 V
Gas gain	20000
Max. drift time	200 ns



Exploded view of a drift tube



Prototype chamber

- Trapezoidal shape for ATLAS endcap
- Tube length: 560 mm, 760 mm, 960 mm
- 2×8 tube layers
- 1152 tubes
- Optional integrated trigger chamber

Note: The currently used ATLAS active front-end electronics cards extend beyond the chamber envelope. New electronics are under development.

Drift Tube Production and Quality Assurance

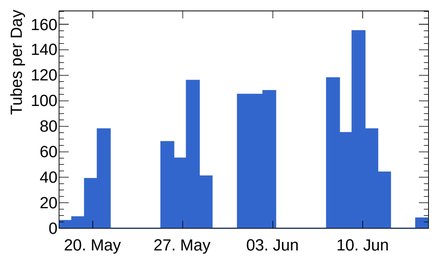
- 1204 tubes produced, 3 different lengths
- Entirely manual production, manpower 4 persons
- Production rate: up to 100 tubes / day

Full quality assurance of all tubes

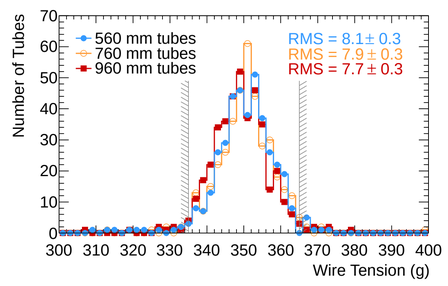
- Wire tension measurement, limit (350 $\pm$ 7) g
- Gas leak test, limit 1×10^{-5} mbar L/s
- HV dark current measurement at 3010 V, limit 5 nA

Test	Tested Tubes	Passed	Failure Rate (%)
Wire Tension	1204	1129	6.3[1]
Leak Test	1171	1164	0.6
HV	1164	1159	0.4
Total	**1208**	**1116**	**7.7**

1) High failure rate at beginning of production only



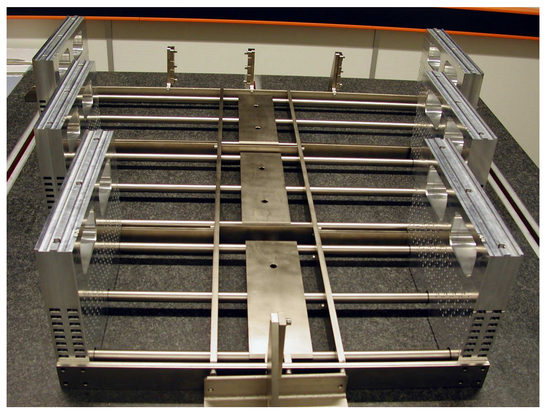
Daily tube production



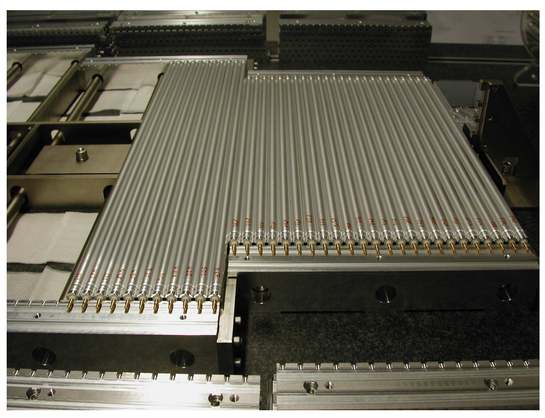
Measured wire tension

Chamber Assembly

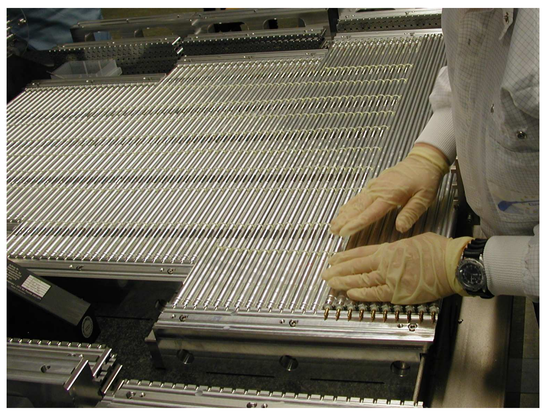
Assembly speed: 1 multilayer (8 tube layers) per day
Wire position defined to to better than 20 µm by precision endplug and jigs



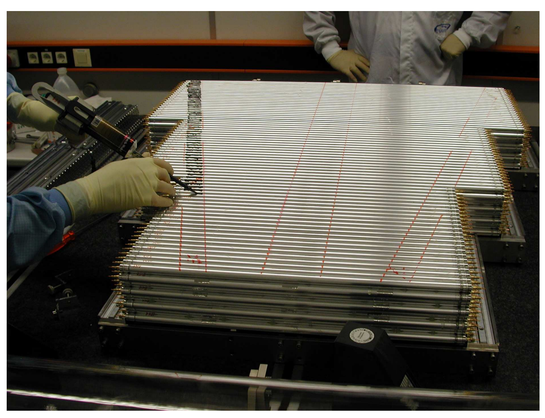
Precision jigs



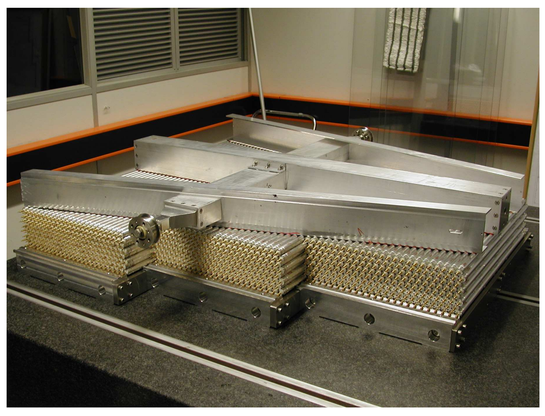
Inserting first tube layer into jigs



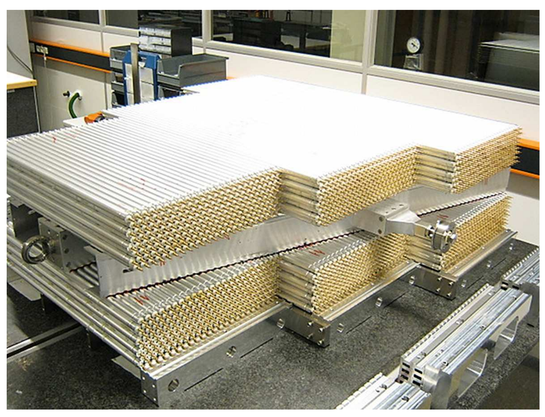
Gluing of second tube layer



Applying glue for spacer frame



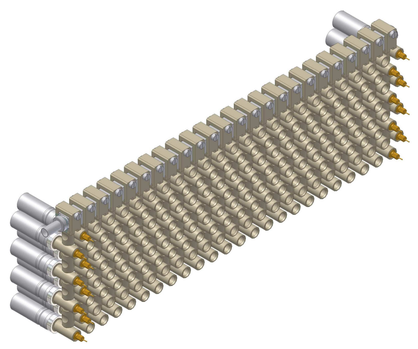
Spacer frame glued to first multilayer



Finished chamber

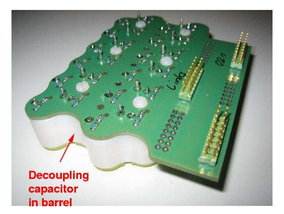
Modular Gas System

- Allows any chamber shape (trapezoidal, rectangular etc.)
- Primary gas bar distributes gas along each multilayer
- Interconnections between tubes of different layers



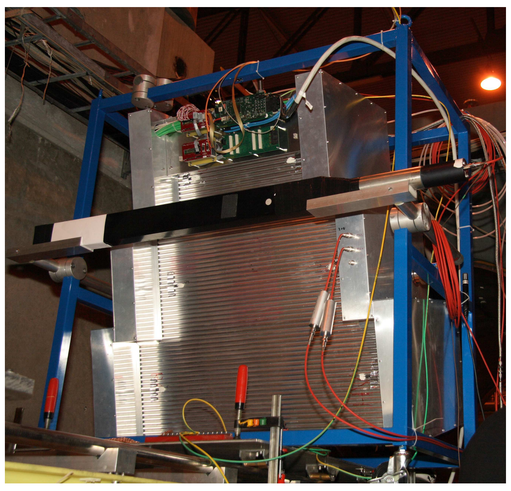
Front-End Electronics

- New passive front-end cards
  High connector density necessitates 3-dimensional design
  Some components in insulated barrels between circuit boards
- Compatible with ATLAS active front-end cards and read-out scheme
- New Amplifier-Shaper-Discriminator chip under development, see this conference, poster N47-113



Conclusions

- Successful production of 1200 15mm drift tubes, low failure rate
- Chamber assembly procedures and time frame (1 multilayer per day) validated
- Successful production of passive front-end electronics cards
- Continuous successful operation of prototype chamber for 5 weeks in muon test beam and at Gamma Irradiation Facility at CERN (see this conference, presentation N69-4)



joerg.von.loeben@cern.ch