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Status of MDT Production and Testing

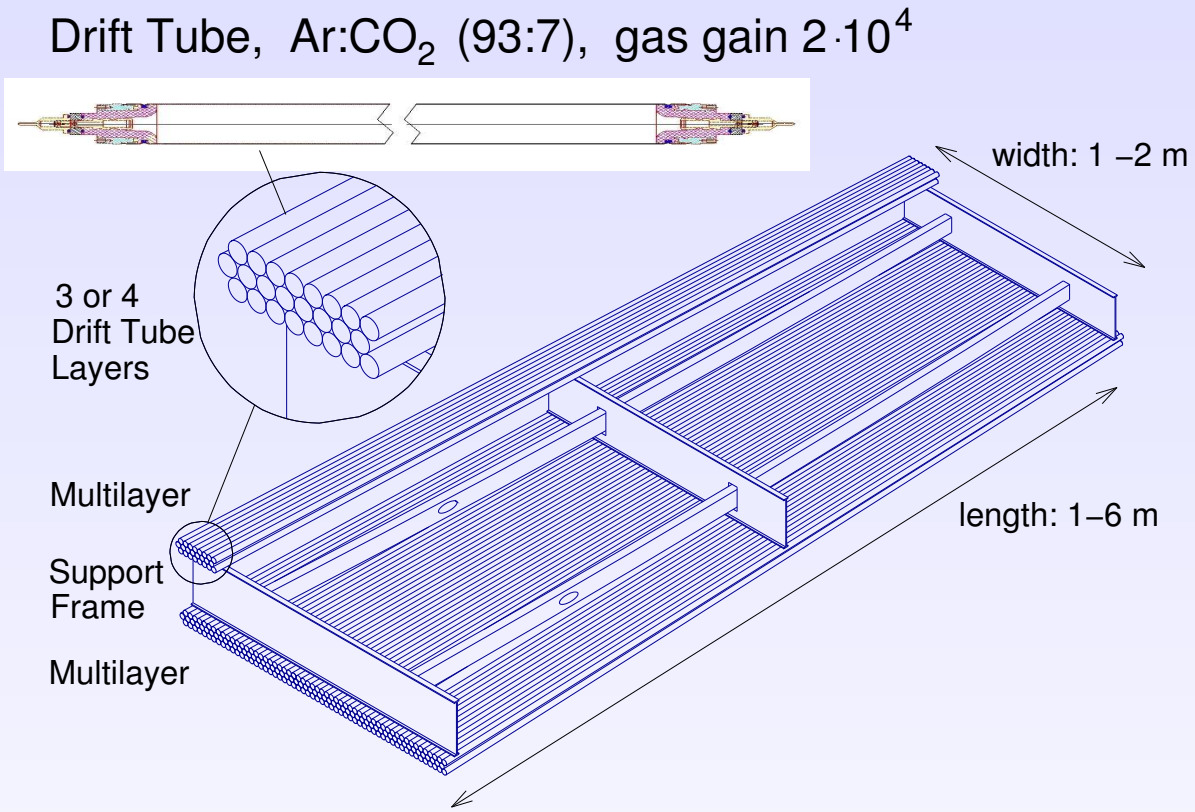
September 13-19, 2003 // ATLAS Overview Week // Praha, Czech Republic

Outline

- Introduction: MDT Chambers (Monitored Drift Tube)
- Chamber Production and Quality Control
  - ⋆ assembly monitoring at production sites
  - ⋆ X-ray tomograph at CERN
  - ⋆ cosmic-ray tests
- Plans for the preassembly at CERN
- Testbeam
  - ⋆ full system test in the H8 facility at CERN
  - ⋆ tests at the γ-irradiation facility (X5/GIF) at CERN
- Summary

MDT Chamber

1194 MDT tracking chambers covering 5500 m^2; 370 000 drift tubes



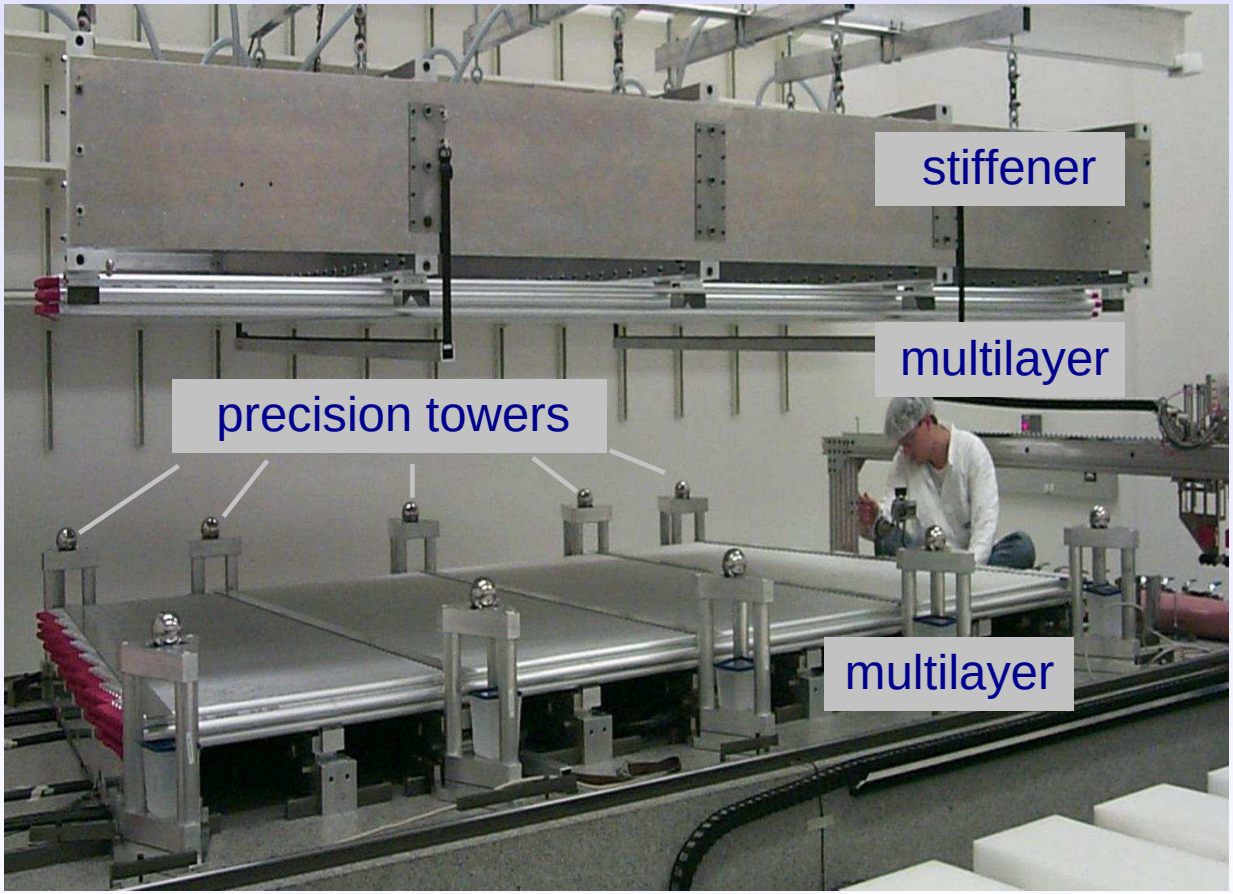
Requirements - chamber resolution of 40 μm $\Longrightarrow$

- $\star$ single tube resolution: better than 100 μm
- $\star$ positioning of the sense wires within the chamber: 20 μm rms

Chamber Production

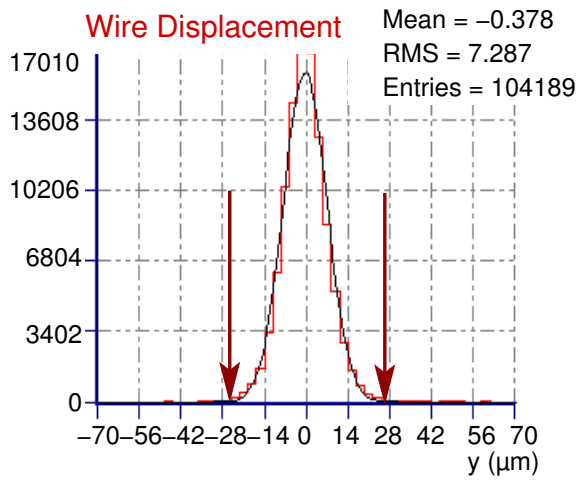
and quality control

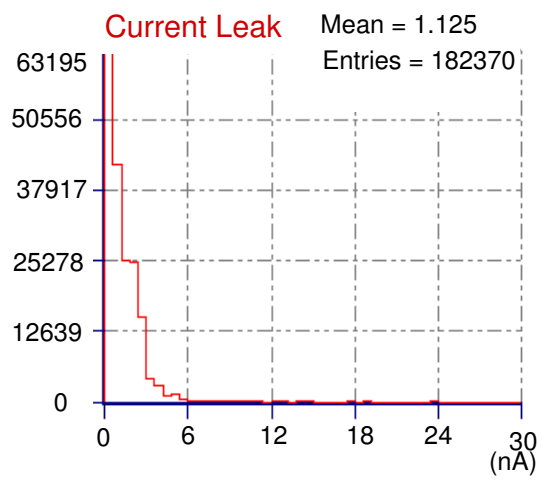
- precision assembly, monitored using various techniques

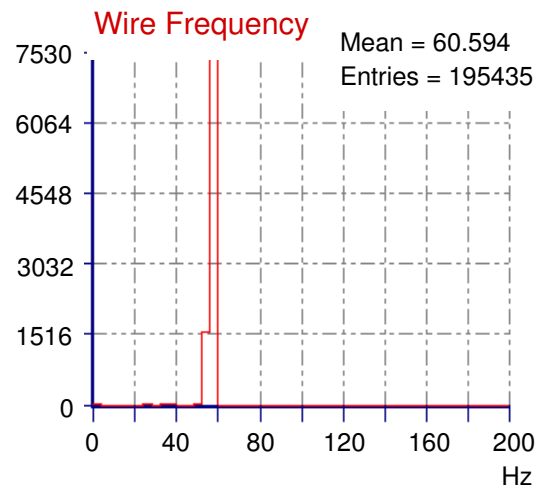


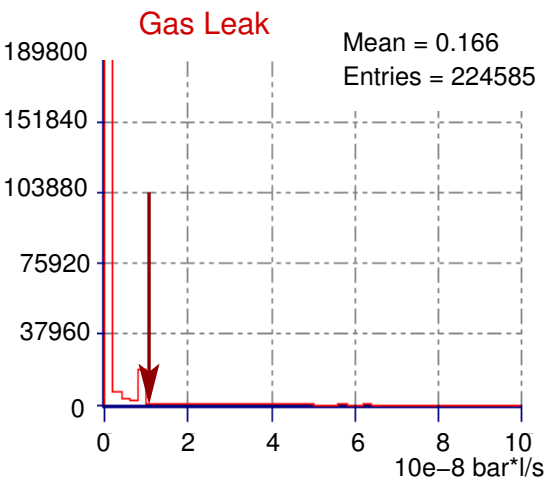
- ⋆ wires centered within the tube; X-ray verification
- ⋆ tubes (1 layer) positioned into the precision combs; position measured with feeler gauges
- ⋆ layers glued successively, attached to the support frame; deformations and displacements monitored by optical systems

Quality control of each produced drift tube:
information stored in the global production database



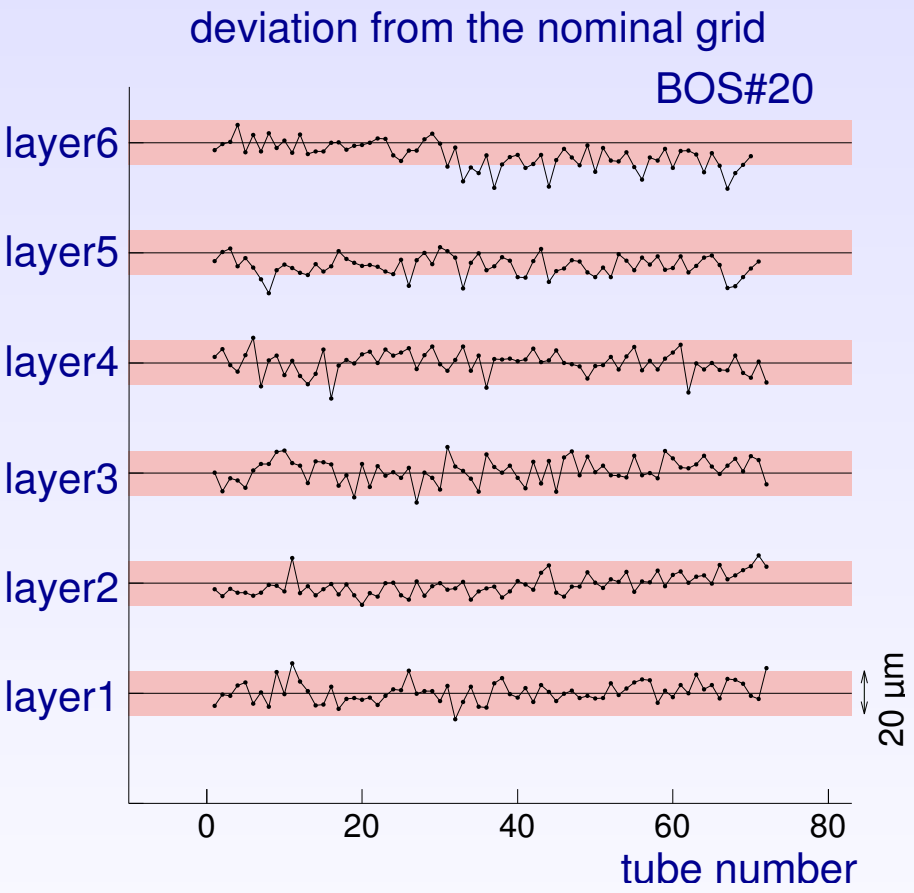


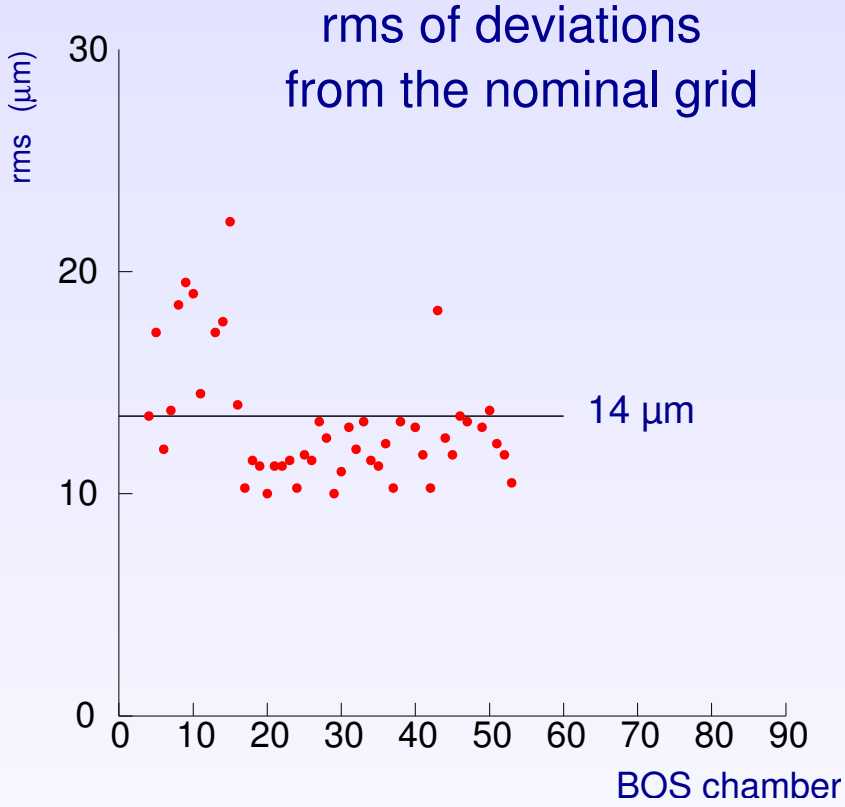




- ⋆ 75% of 370 000 tubes produced
- ⋆ total rejection of only 2.6%

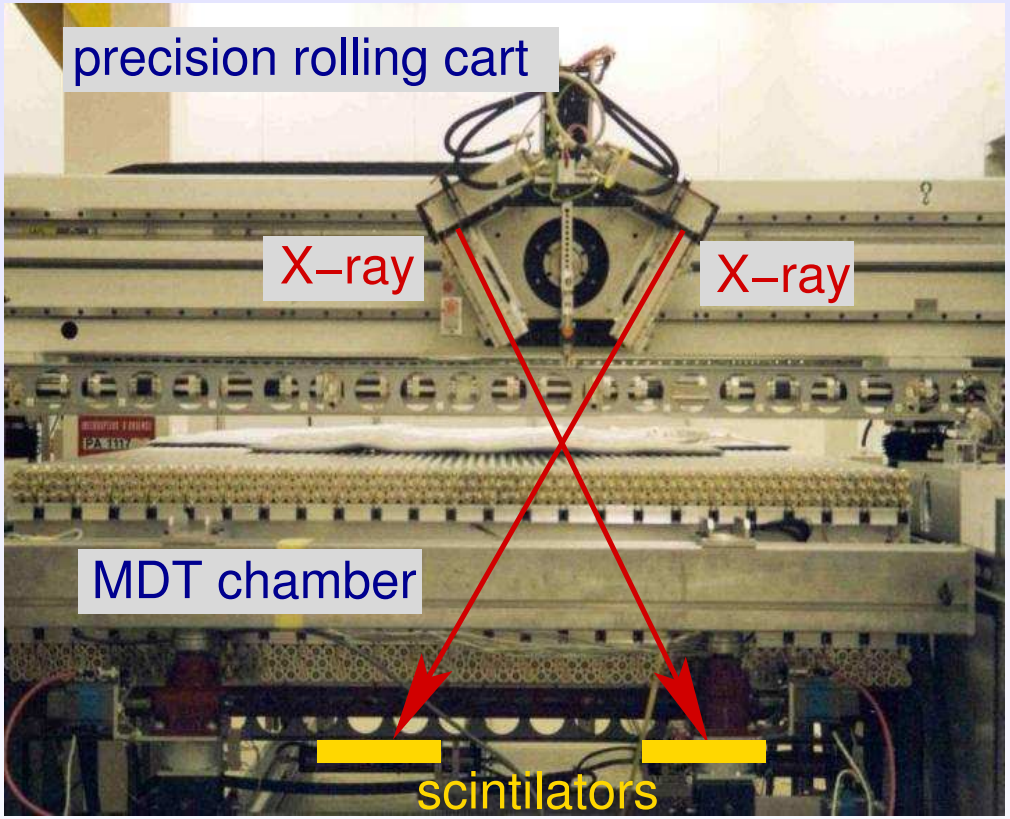
Reconstruction of the wire positions within the chamber:





⋆ wire positioning accuracy within the required 20 μm rms

- sample of chambers measured with an X-ray Tomograph at CERN
- wire measurement precision: 2 μm (stat.) + 2 μm (syst.)

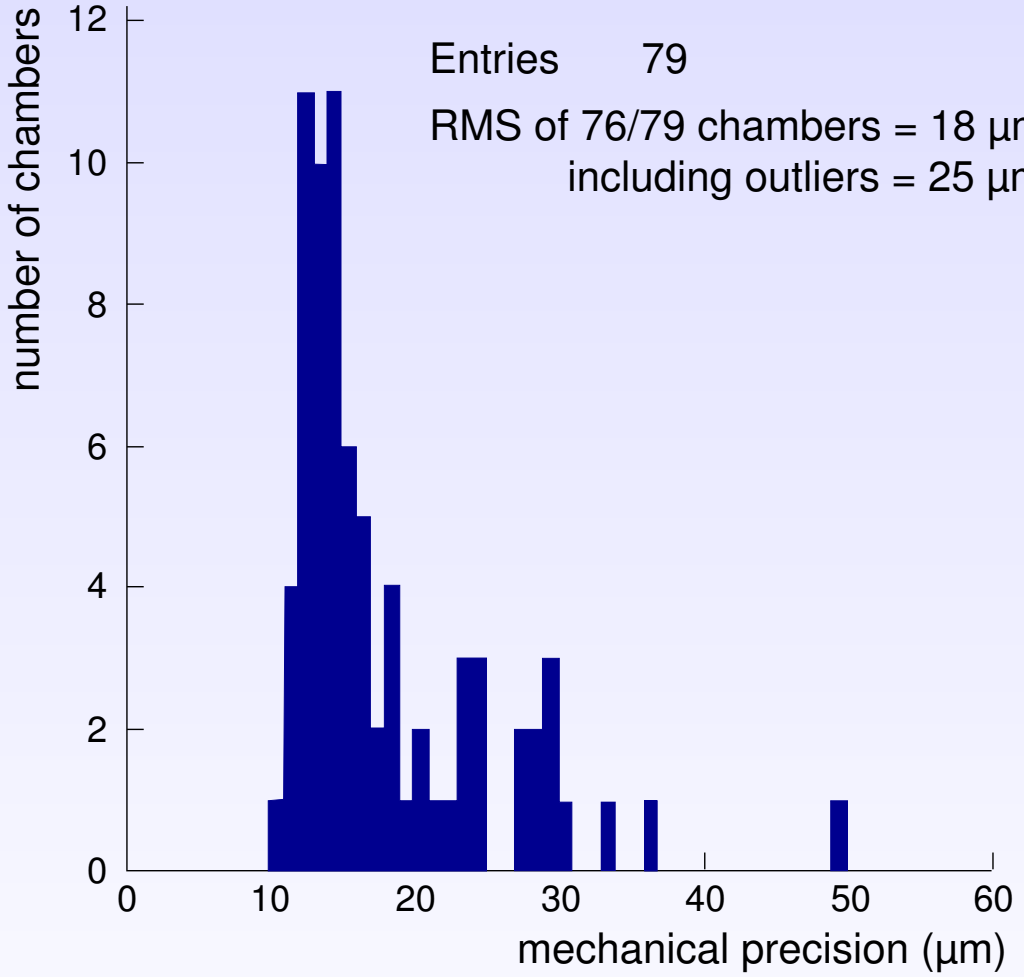


measurement of the intensity along the chamber

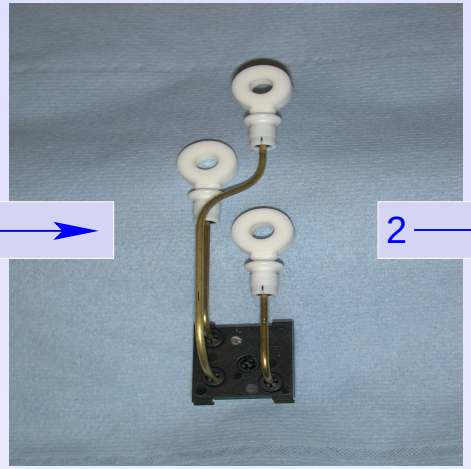
⋆ certification of the site construction procedure

⋆ check 15% of the chambers for consistency

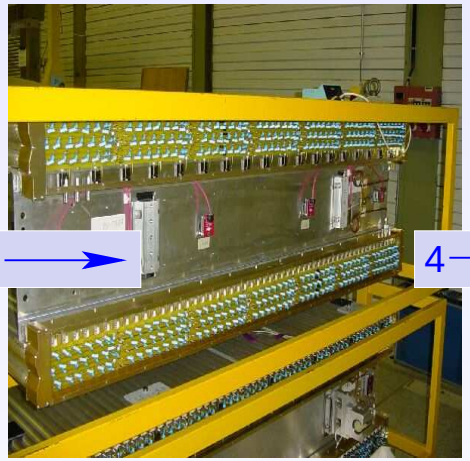
⋆ capacity:
present - 1.6 ch/week
from 2004 on - 2 ch/week

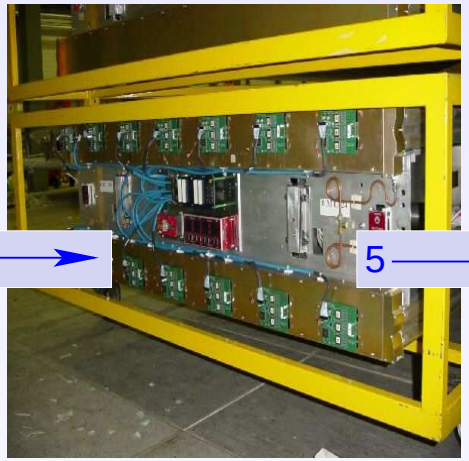


- ⋆ 79 of 739 produced chambers measured
- ⋆ 11 production sites certified
- ⋆ average rms of measured chambers: 18 μm



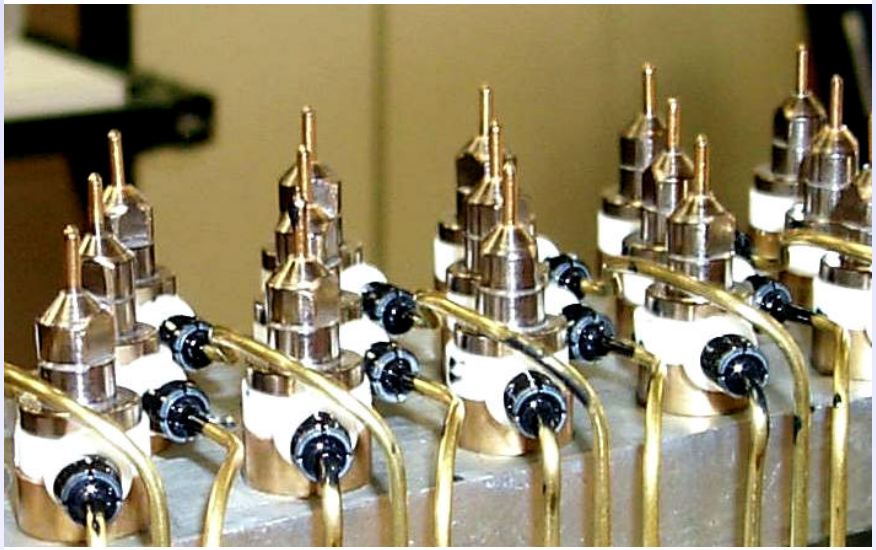
1. preparation of gas tubelets
2. mounting on the chamber
3. HV and signal hedgehog cards (HV distribution, signal decoupling)





4. mezzanine cards (Amplifier/Shaper/Discriminator, Time-to-Digital Converter) Faraday Cage (FC)
5. Chamber Service Module (interface between the chamber and the DAQ system)

Serious problem spotted for the MDT gas tubelets !



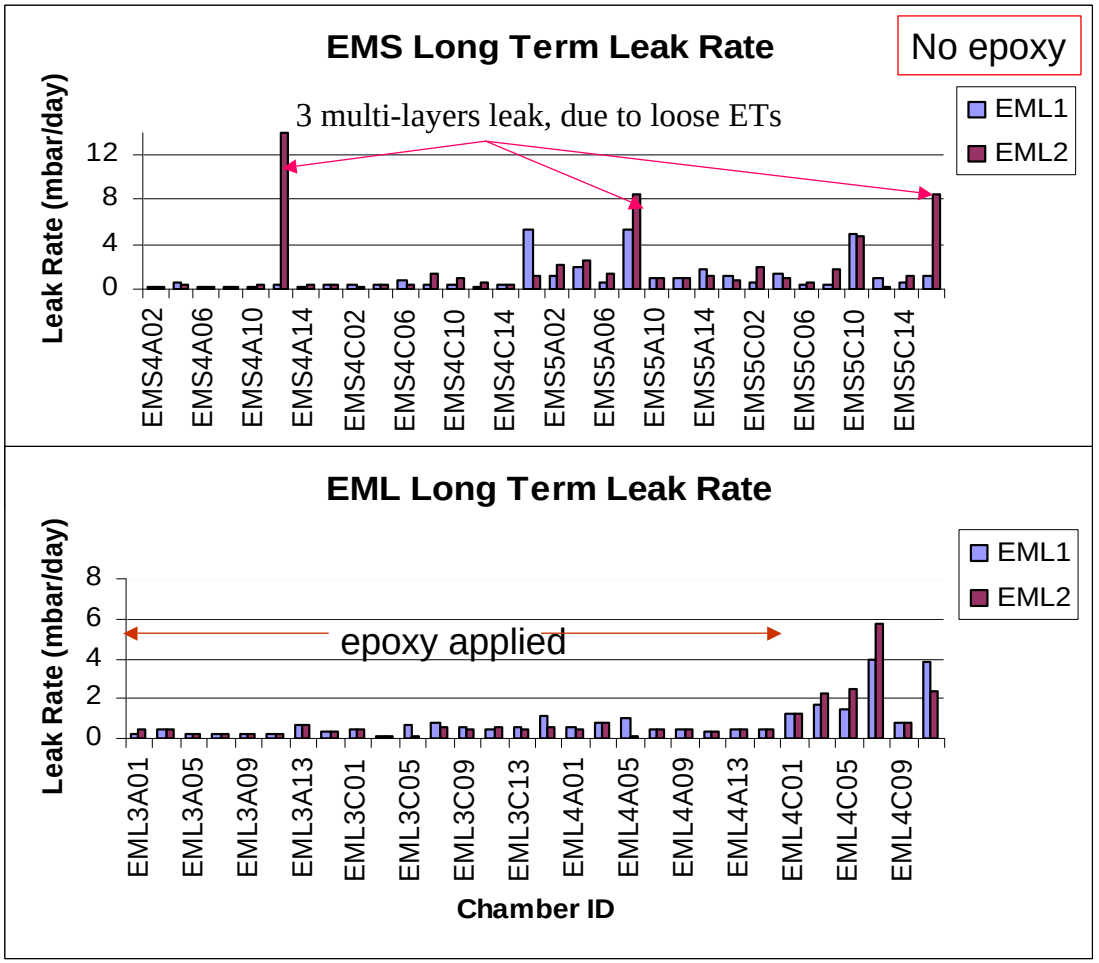
$\Longrightarrow$ corrosion of the brass tubelets by the cleaning agent through small cracks

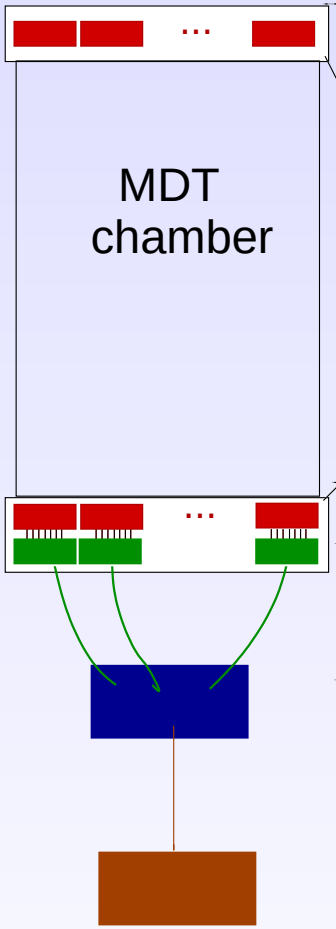
Action:

- ⋆ replacing all brass tubelets with stainless steel
- ⋆ exception are most of the equipped end-cap chambers, after being certified

Chambers (brass tbl.) certified in US and shipped to CERN:

- ⋆ under gas pressure for 5-11 months: showing no leaks
- ⋆ epoxy applied to the critical parts of the tubelets, for additional safety





HV hedgehog cards — under production, 40%

Faraday Cage (FC)

signal hedgehogs — under production, 30%

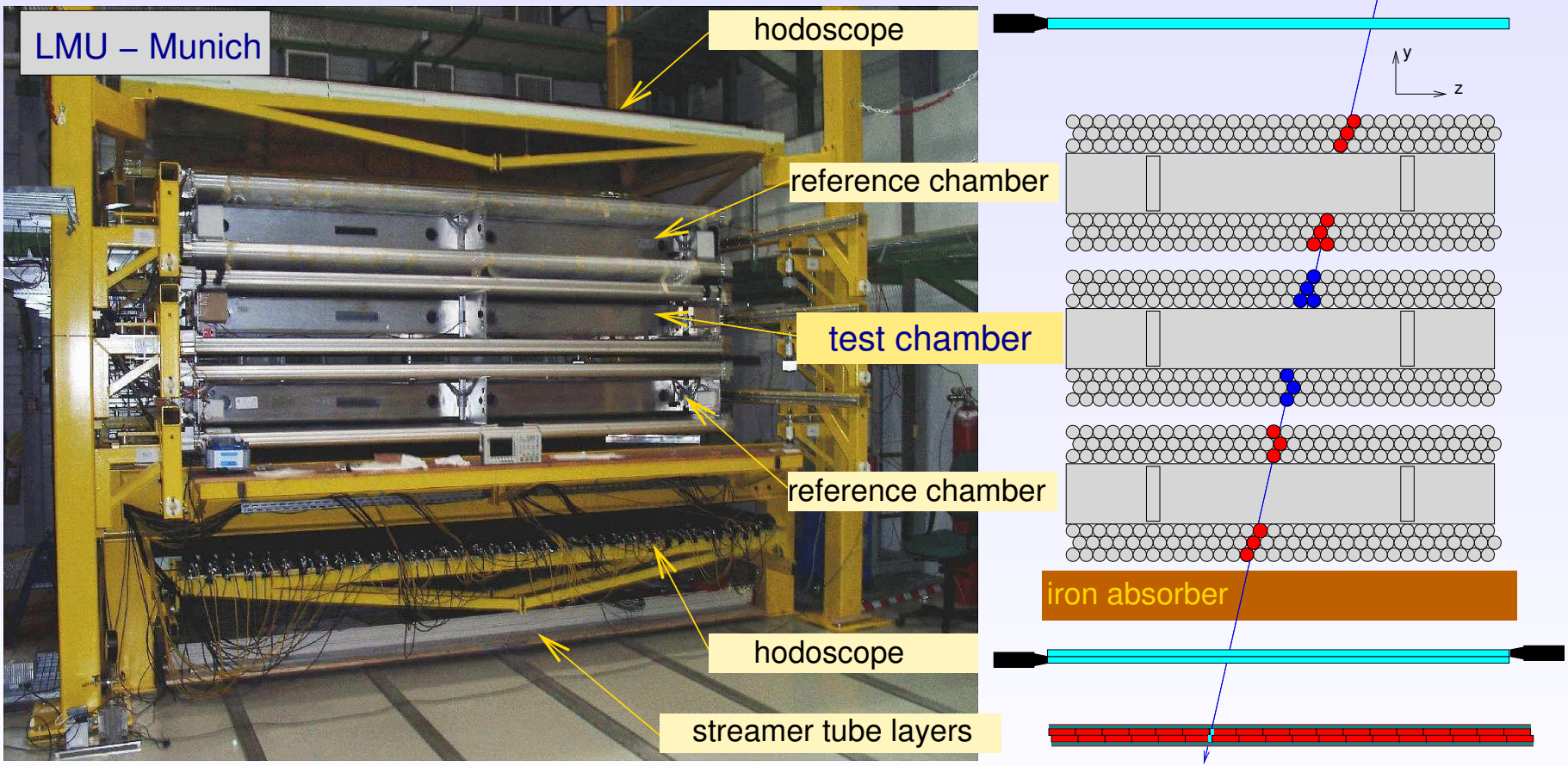
mezzanine cards — production starting

Chamber Service Module — 1st prototype working
2nd in preparation
(FDR November 2003)

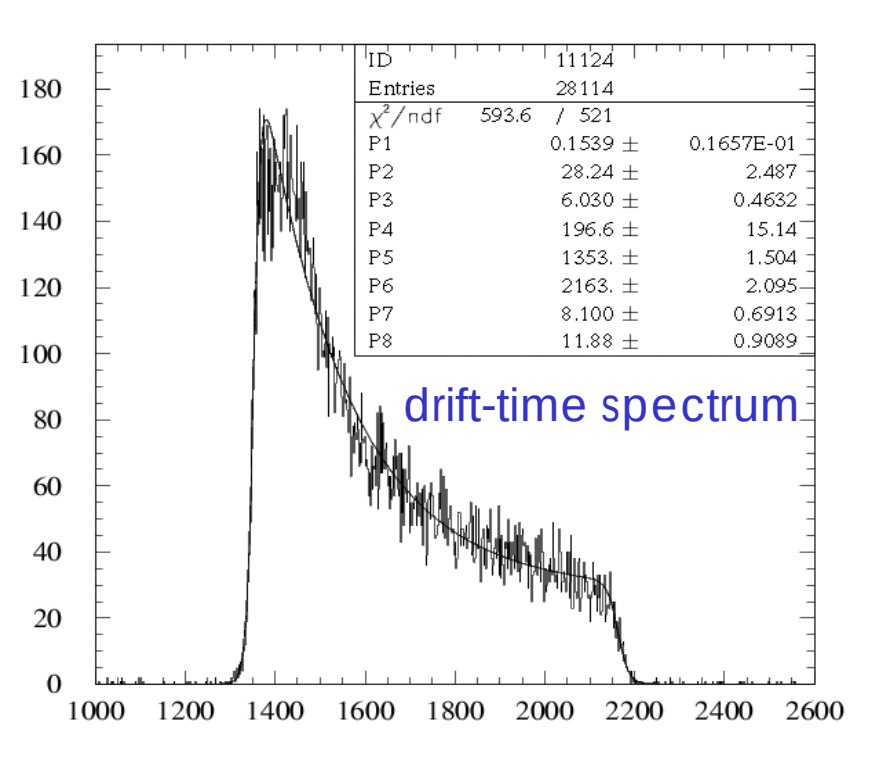
MROD — 1st prototype working
2nd in preparation
(FDR November 2003)

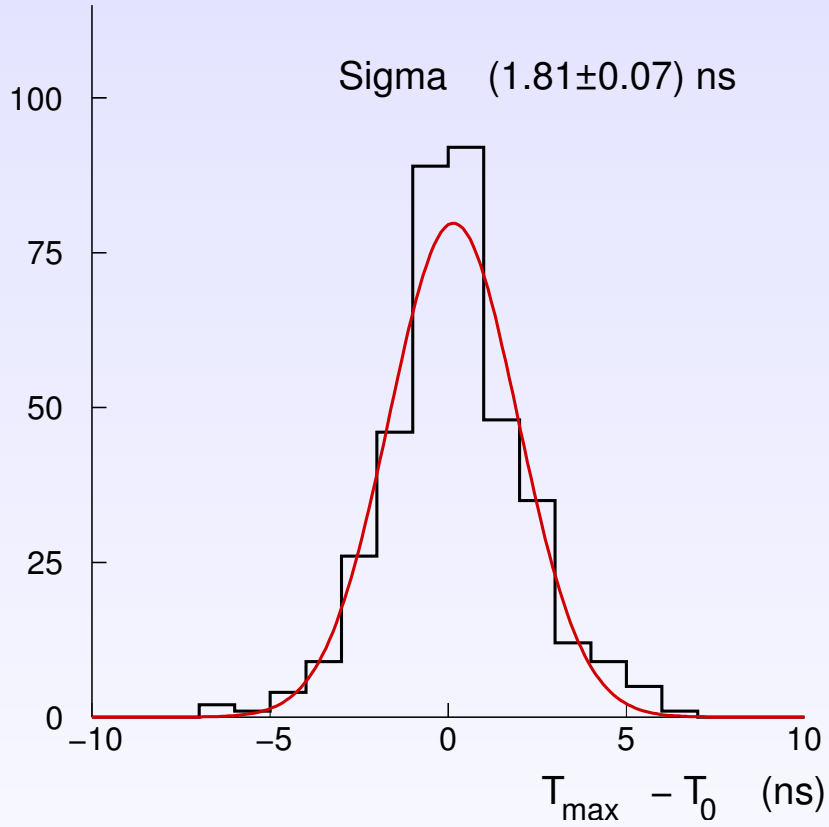
- for more information see the talk of R.Richter

Quality control of the chamber performance, for all chambers:
(leak test, HV stability, noise, efficiency, drift-time spectra, resolution)
- for some chambers: wire positioning accuracy (LMU)



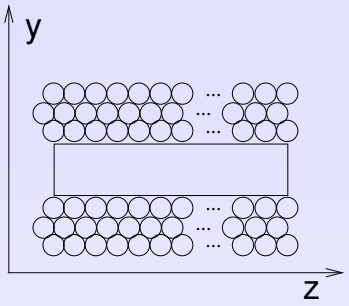
★ uniformity of the chamber response to muons:



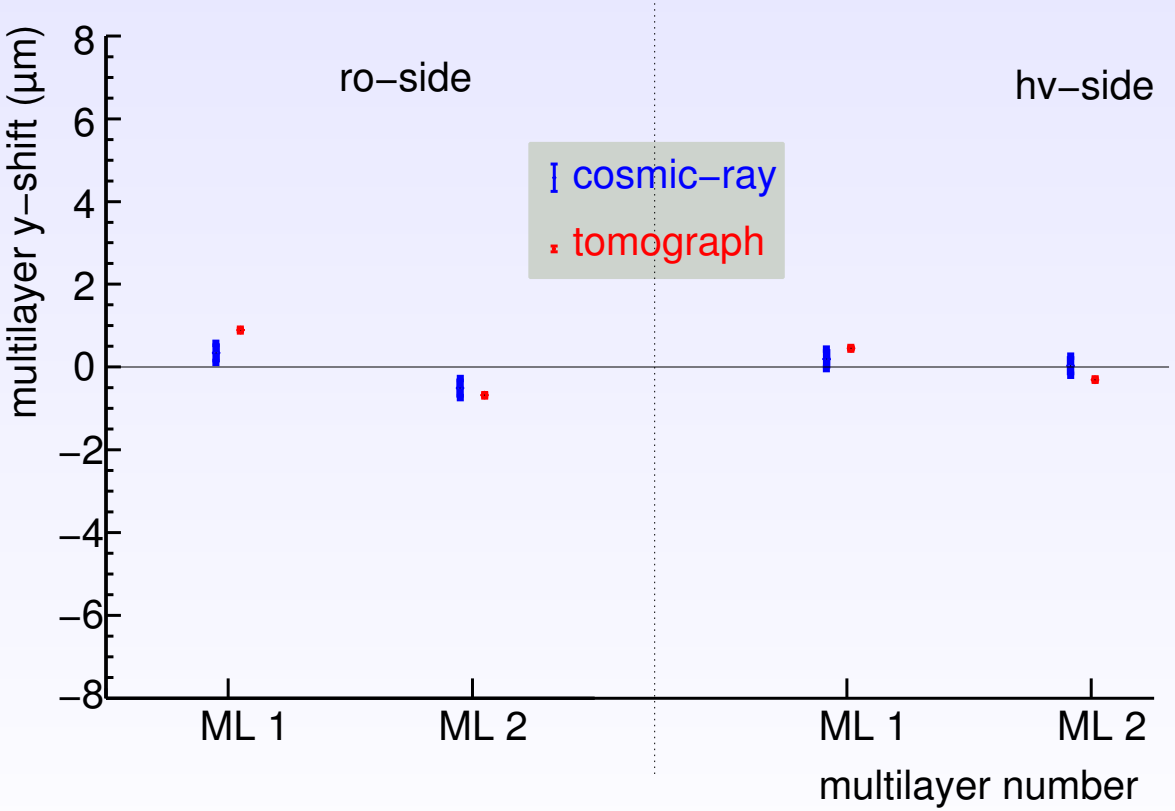


LMU-Munich:

- ⋆ measurement of the wire coordinates
  (achieved precision: rms_z=9 μm; rms_y=27 μm)



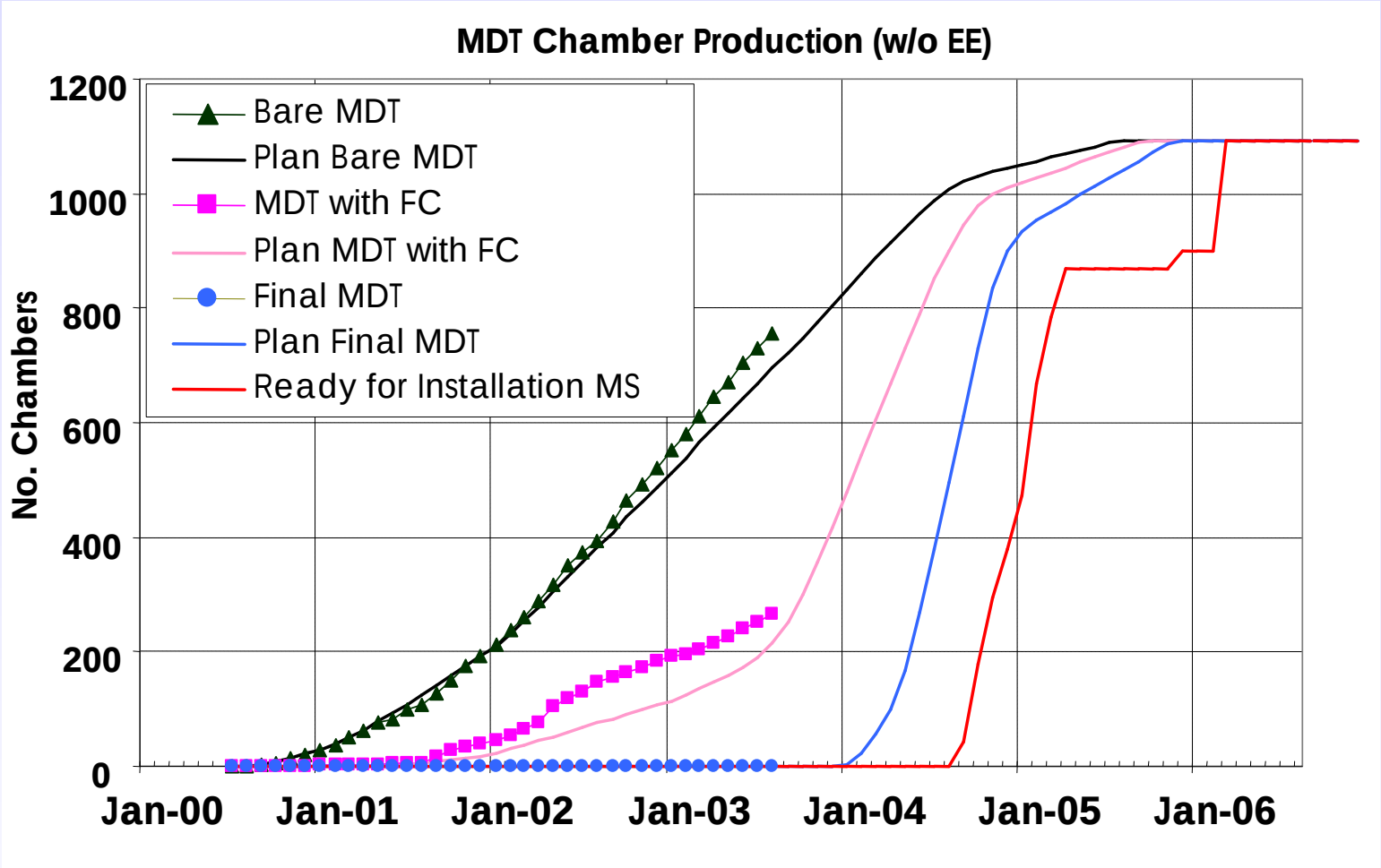
reconstruction of the geometrical chamber parameters



Production Status: 31.08.2003.

Site	Type	total/site	Bare MDT/Plan	MDT with FC/Plan
Boston	EI, EM	80	65/62	49/46
Univ.Washington	EI, EM	80	74/67	74/61
Univ.Michigan	EM	80	79/69	78/62
Protvino	EO	192	107/95	24/28
Beijing	BEE	32	0/0	0/0
Greece	BIS	128	90/87	0/0
Cosenza/Roma	BIL/BIR	64	40/41	16/6
Cosenza/Pavia	BIL/BIR	56	29/35	3/2
Dubna	BMS	84	62/52	0/0
Frascati	BML	94	76/64	13/7
Munich/Dubna	BOS/BOF	88	70/52	8/8
Freiburg	BOG	18	0/0	0/0
NIKHEF	BOL	96	63/61	2/2
All sites			755/685	267/222
TOTAL NUMBER		1092	1092	1092

Production Status



- ⋆ stable production of the bare chambers
- ⋆ assembly of services compatible with installation schedule (needs a strong effort from the production sites)

Preassembly at CERN

Preassembly tasks at CERN

Preparation of the chambers for the installation into ATLAS detector:

- ⋆ completion with gas distribution, electronics, DCS (if not yet done)
- ⋆ assembly of the barrel MDTs with RPCs
- ⋆ assembly of end-cap MDTs and TGCs on Big and Small Wheel
- ⋆ certification of the chambers and assemblies
- ⋆ storage until installation

Chambers and assemblies have to be ready four months before the installation date.

Preassembly areas and schedules: barrel

⋆ B283: BIS/L (chambers without RPC), Jan. - Nov. 2004

Chamber	days/ch	Total days	Work description
BIS	2.5	78	195 Preparation of MDT, mounting of electronics, tests, cosmic test
	1	50	50 Test of all components, cosmic test
BIL/BIM/BIR	1	128	Preparation of gas components (Done in Greece in three labs)
	1	116	116 Preparation of MDT, test of all components, cosmic test

Assembly line		2003						2004										
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Clean area/283	Chamber type							BIS	BIS	BIS	BIS	BIS	BIS			RFI [A]		RFI [C]
	expected no.							4	16	16	16	16	10					
283	Chamber type												BIS	BIS	BIS			
	expected no.												10	20	20			
People at CERN	Tech.							4	4	4	6	6	6	2	2			
	Phys.							2	2	2	2	2	2	2	2			
2	Type								BIL	BIL	BIL	BIL	BIL	BIL	BIL	BIL	BIL	RFI [C]
	expected no.								10	12	14	14	14	14	14	14	10	
People	Tech.								3	3	3	3	3	3	3	3	3	
	Phys.								2	2	2	2	2	2	2	2	2	
Cosmic stand *)	Type										BIS	BIS	BIS	BIS	BIS			
	No. of ch/day										2	2	2	2	2			
	Type										BIL	BIL	BIL	BIL	BIL	BIL	BIL	
	No. of ch/day										1	1	1	1	1	1	1	

***) Cosmic stand assumed to accommodate 3 BIS and/or BIL chambers in parallel;**

Preassembly areas and schedules: barrel

- ⋆ B283: BIS/L (chambers without RPC), Jan. - Nov. 2004
- ⋆ BB5 : BMS/L and BOS/L, Oct. 2003 - end 2004

Chamber	ch/day/line	Work description
BML	1	Assembly of RPCs and MDT on Common support + cabling of RPC + cosmic test of RPCs + MDT (2 days/RPC)
BML	0.3	Assembly of gas stuff, leak test
BMS	1	Assembly of RPCs and MDT on Common support + cabling of RPC + cosmic test of RPCs + MDT (2 days/RPC)
BOS/F/G	1	Assembly of RPCs and MDT on Common support + cabling of RPC + cosmic test of RPCs + MDT (2 days/RPC)
BOL	1	Assembly of RPCs and MDT on Common support + cabling of RPC; cosmic test of RPCs + MDT (2 days/RPC)

Assembly line		2003			2004											
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BB5-1	Chamber type expected no.		BML 2	BML 8	BML 10	BML 15	BML 15	BML 20	BML 20	BML 4	BOF 15	BOG/S 20	BOL 20	BOL 20	BOL 25	BOL 15
Clean area	Chamber type expected no.	BML 5	BML 5	BML 6												
BB5-2	Type expected no.						BMS 10	BMS 20	BMS 20	BMS 20	BMS 14	BOS 20	BOG/S 20	BOS 20	BOS 11	BOL 16
Cosmic stand *)	Type No. of ch/day		BML 1	BML 1	BML 1	BML 1	BML 1	BML 1	BML 1	BML 1	BOS 1	BOS 1	BOL 1	BOL 1	BOL 2	BOL 2
	Type No. of ch/day						BMS 1	BMS 1	BMS 1	BMS 1	BMS 1	BOS 1	BOS 1	BOS 1	BOS 1	

***) Cosmic stand assumed to accommodate three assembled stations at a time**

A complete MDT - RPC station

Preassembly areas and schedules: end-cap

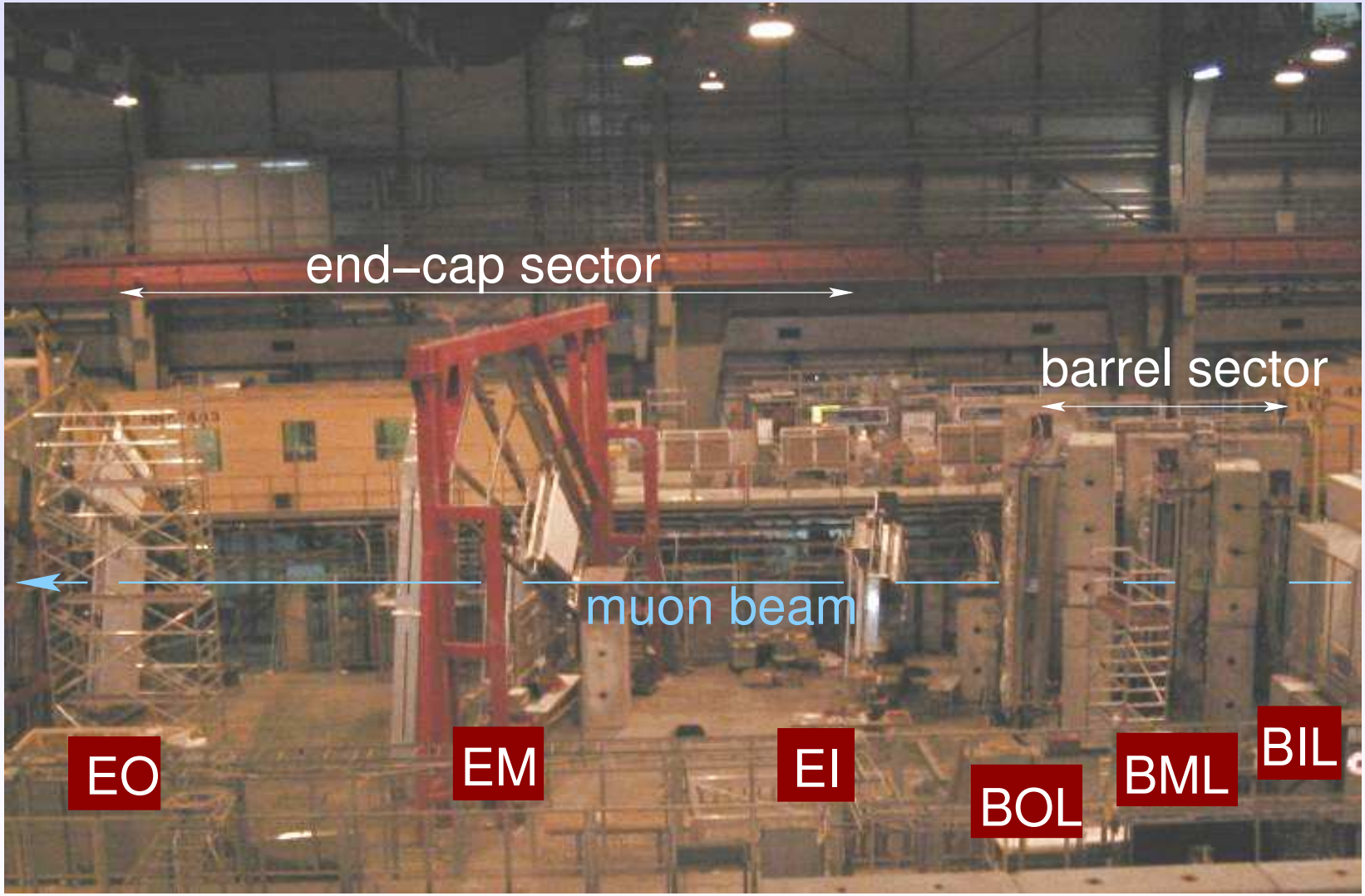
- ⋆ B184: MDT testing, Mar. 2004 - end 2005
- ⋆ B180: integration on the Big Wheel, mid 2004 - end 2005
- ⋆ B191: integration on the Small Wheel, from 2005

installation tests:

Testbeam Program

H8 Testbeam

Full system test:
12 MDT chambers, trigger system (RPC, TGC), alignment system



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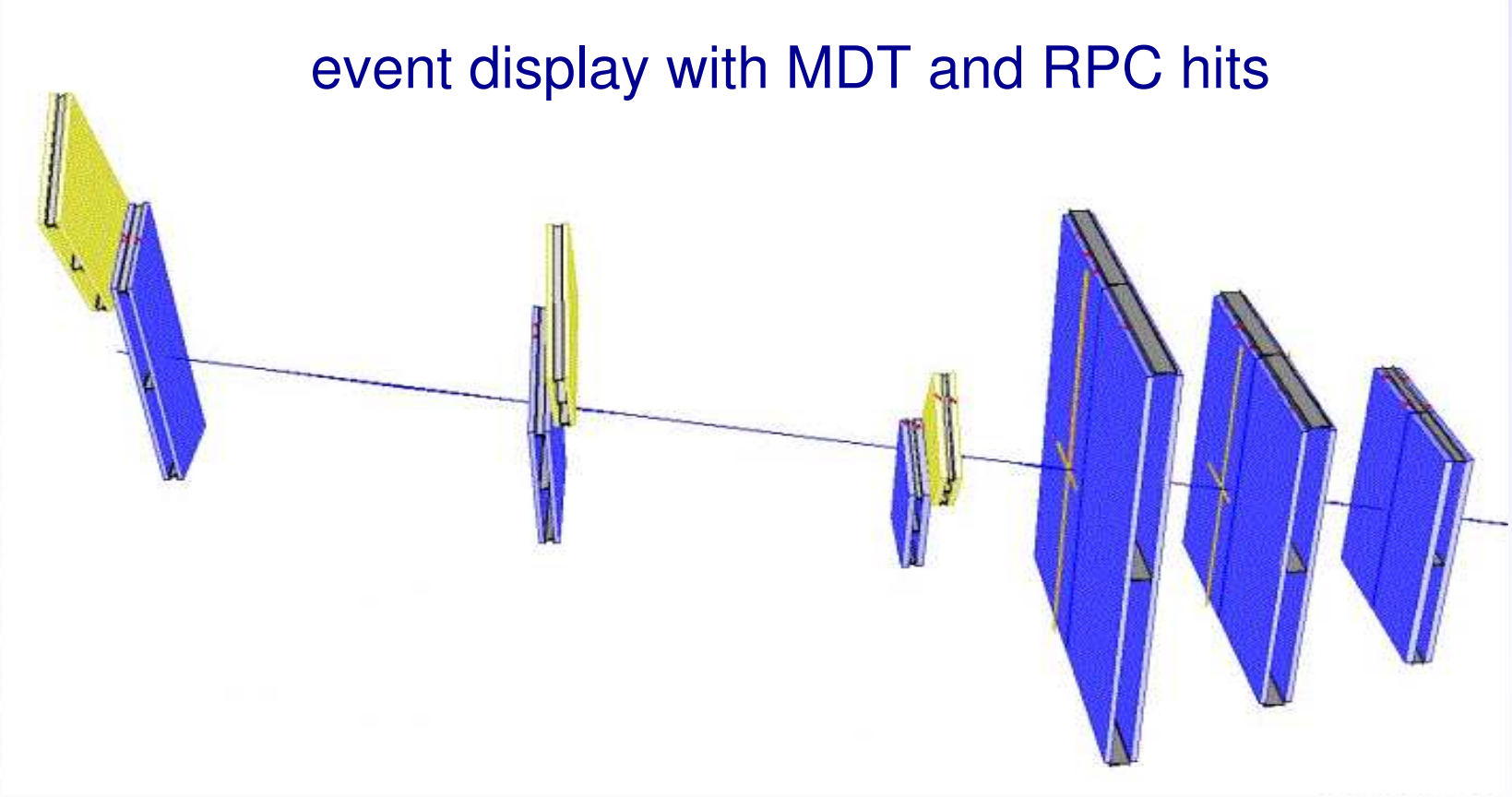


H8 System Test

Extensive program:

- ⋆ chamber installation with prototype installation tools
- ⋆ performance and long-term stability of the final electronics and DAQ system
- ⋆ test of the barrel and end-cap alignment system with controlled chamber displacements
- ⋆ test and development of the ATLAS-like software
- ⋆ integration test of tracking and trigger chambers
- ⋆ test of the trigger with the 25 ns beam

H8 System Test

Extensive program:

- ⋆ chamber installation with prototype installation tools
- ⋆ performance and long-term stability
  of the final electronics and DAQ system
  initial problems with DAQ identified and solved,
  12 MDT (3744 channels) running smoothly for two months
- ⋆ test of the barrel and end-cap alignment system
  with controlled chamber displacements
- ⋆ test and development of the ATLAS-like software
- ⋆ integration test of tracking and trigger chambers
- ⋆ test of the trigger with the 25 ns beam

H8 System Test

Extensive program:

- ⋆ chamber installation with prototype installation tools
- ⋆ performance and long-term stability
  of the final electronics and DAQ system

- ⋆ test of the barrel and end-cap alignment system
  with controlled chamber displacements
  (for more details on the alignment system see the talk of J.Bensinger)
- ⋆ test and development of the ATLAS-like software

- ⋆ integration test of tracking and trigger chambers
- ⋆ test of the trigger with the 25 ns beam

H8 System Test

Extensive program:

- ⋆ chamber installation with prototype installation tools
- ⋆ performance and long-term stability
  of the final electronics and DAQ system
- ⋆ test of the barrel and end-cap alignment system
  with controlled chamber displacements
- ⋆ test and development of the ATLAS-like software
  DAQ, Data Monitoring, tracking, Condition Database, Alignment
- ⋆ integration test of tracking and trigger chambers
- ⋆ test of the trigger with the 25 ns beam

H8 System Test

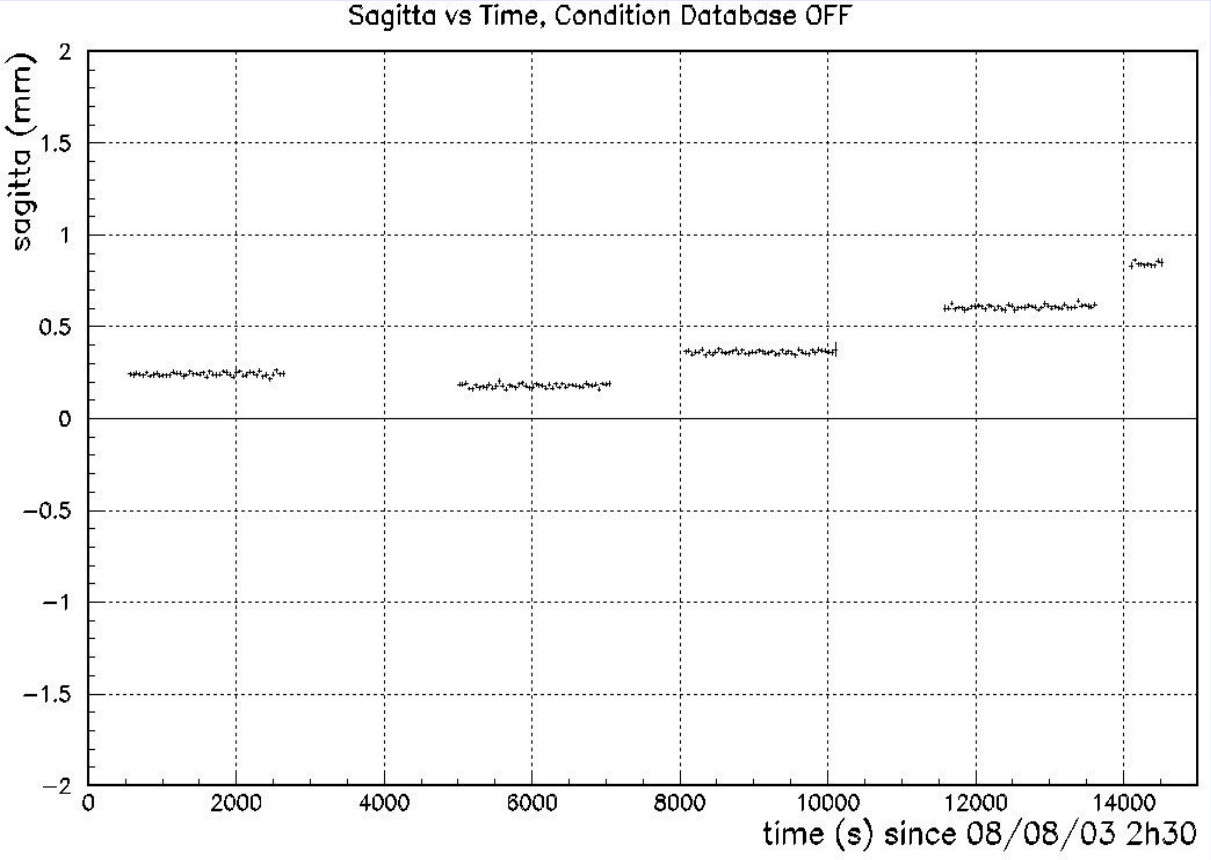
Extensive program:

- ⋆ chamber installation with prototype installation tools
- ⋆ performance and long-term stability
  of the final electronics and DAQ system
- ⋆ test of the barrel and end-cap alignment system
  with controlled chamber displacements
- ⋆ test and development of the ATLAS-like software
- ⋆ integration test of tracking and trigger chambers
- ⋆ test of the trigger with the 25 ns beam
  to be completed this month

H8 System Test

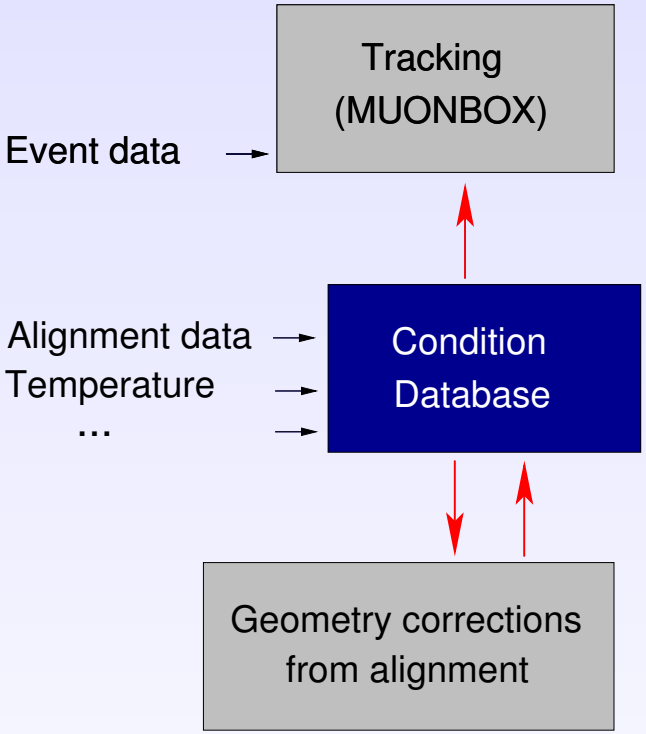
Example of an interplay of various systems:

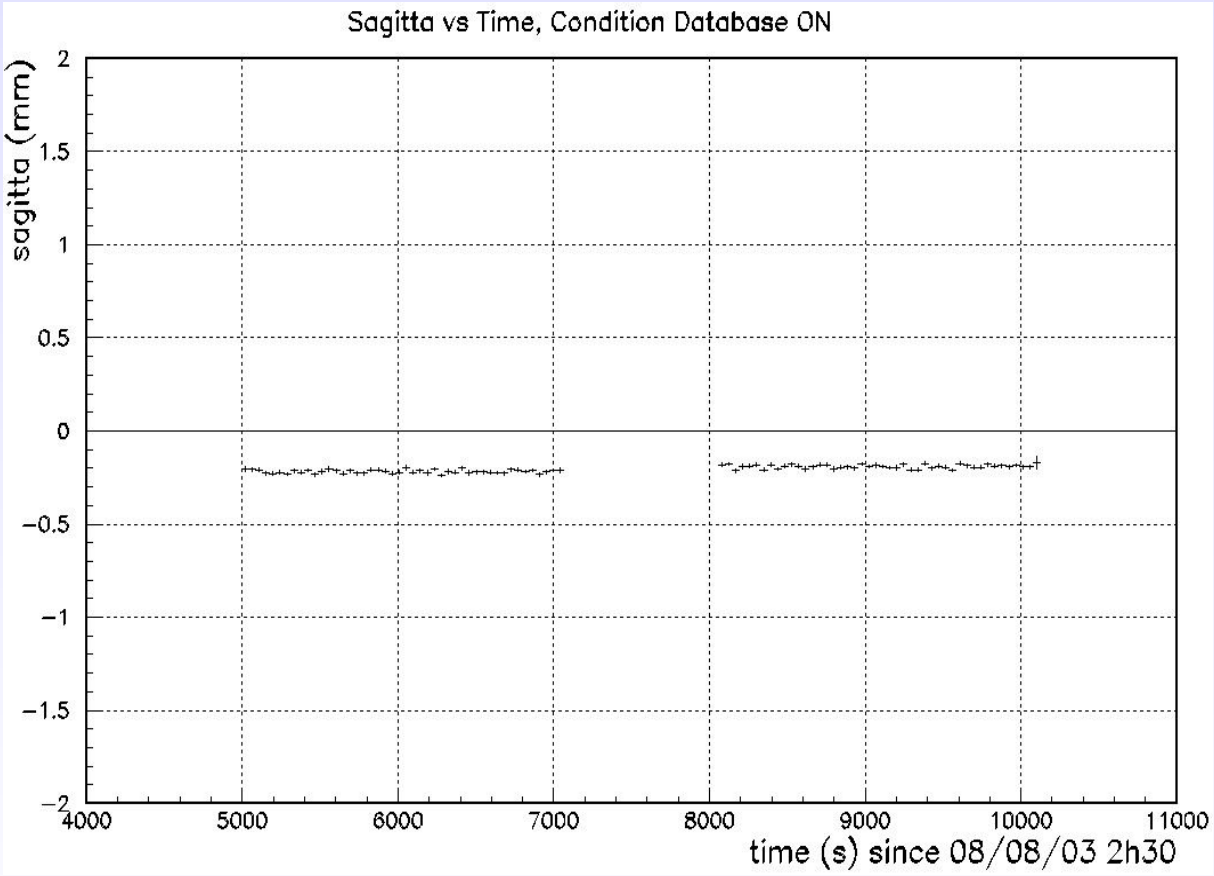
set of controlled chamber displacements:



H8 System Test

Example of an interplay of various systems:
Condition database describes the conditions in which the experiment runs at any given moment.





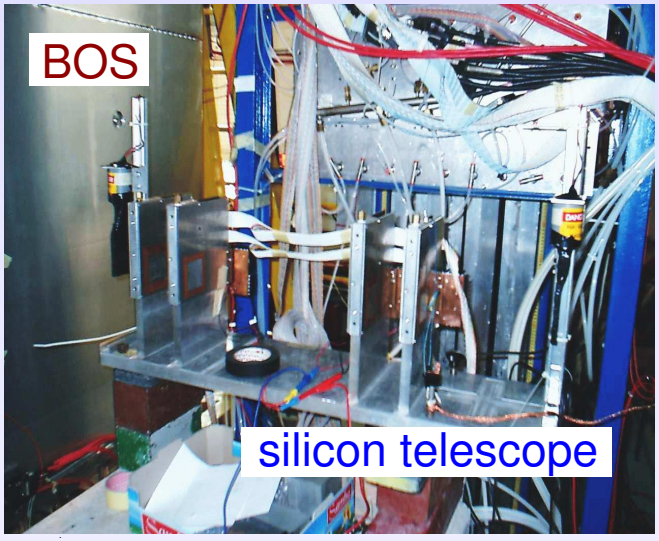
- alignment data applied to correct for the chamber displacement

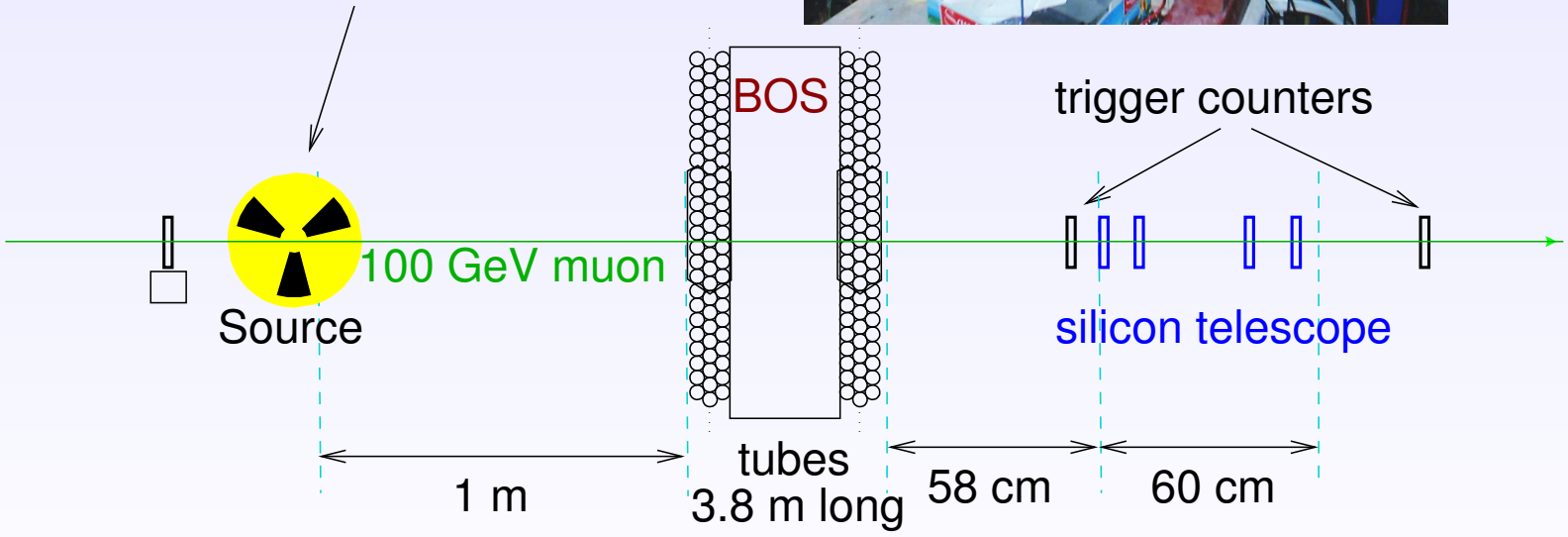
X5 Testbeam (Gamma Irradiation Facility)

- ⋆ influence of the γ-irradiation on the resolution and efficiency
- ⋆ time-slewing corrections
- ⋆ threshold optimisation

simulates irradiation rates
up to 4 times the
maximum ATLAS rate

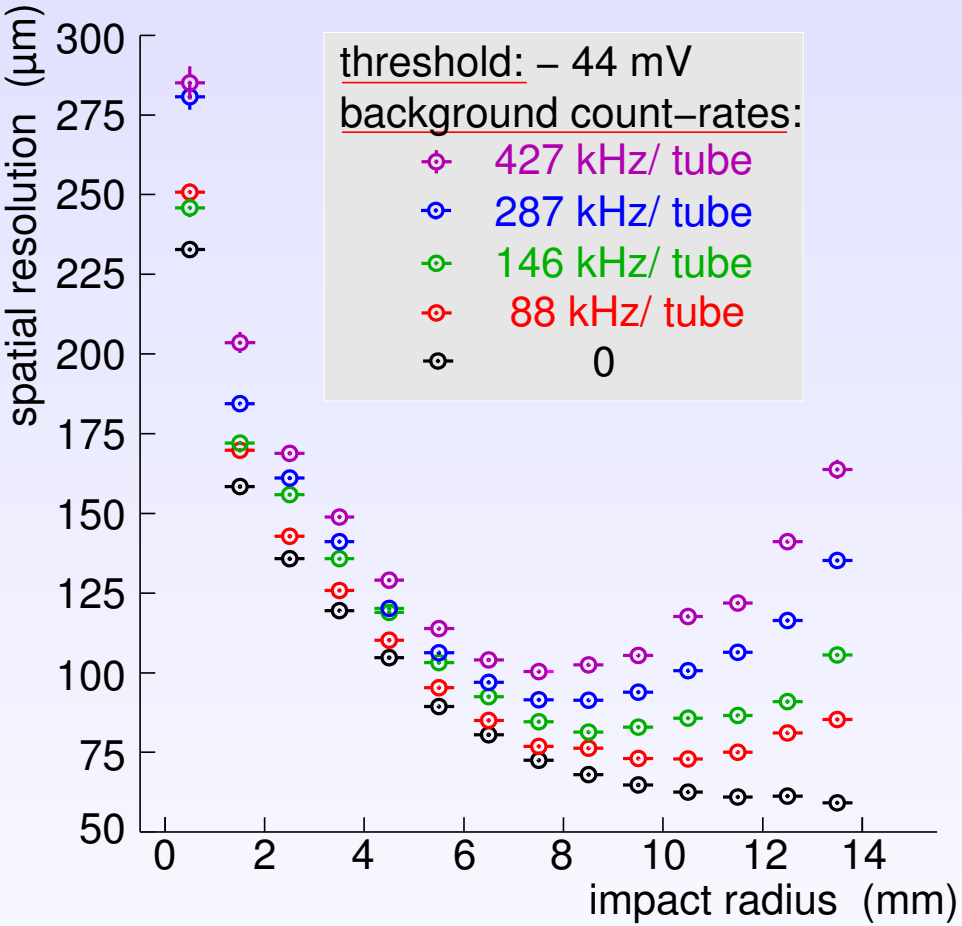
(400 Hz/cm^2 = 440 kHz/tube)





X5/GIF Testbeam

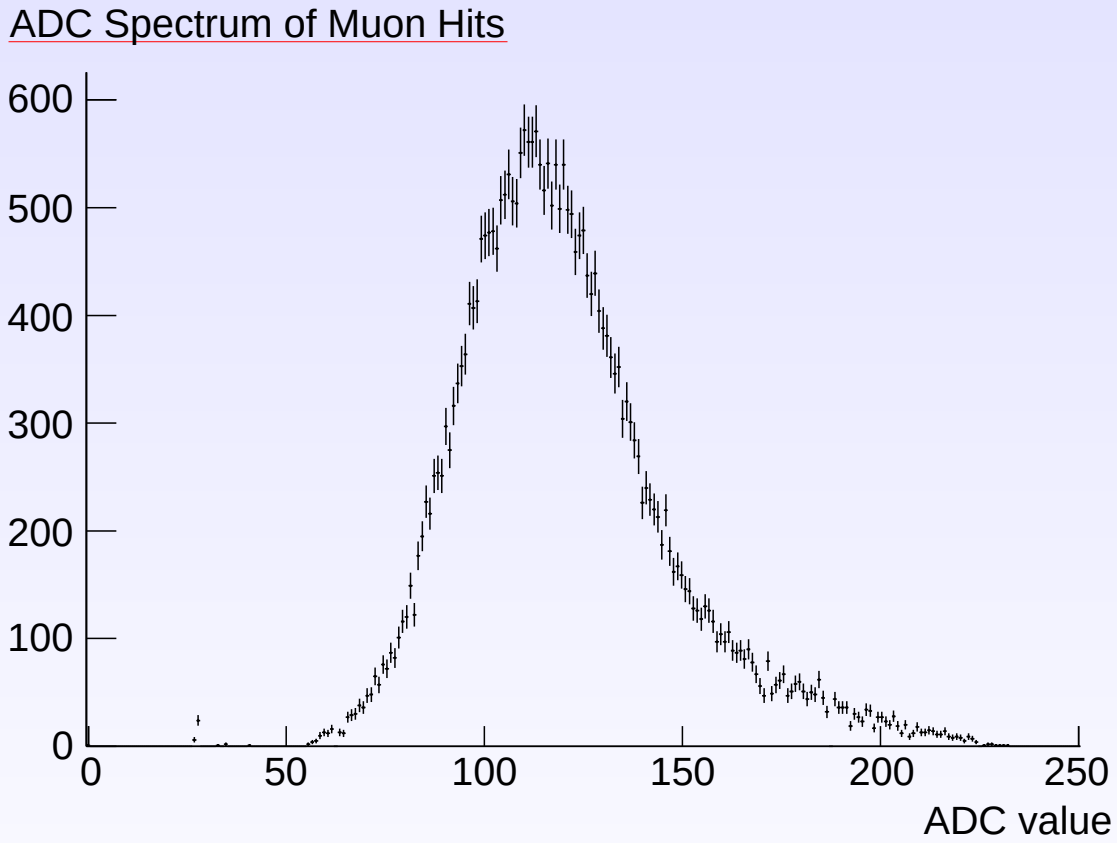
Single tube resolution:



- ⋆ degradation of the resolution for large drift radii due to increasing effect of the space charge fluctuations
- ⋆ average degradation of $\sim$10 μm at the maximum nominal ATLAS rate
- ⋆ price to be paid for using Ar:CO_2 (chosen to avoid the aging)

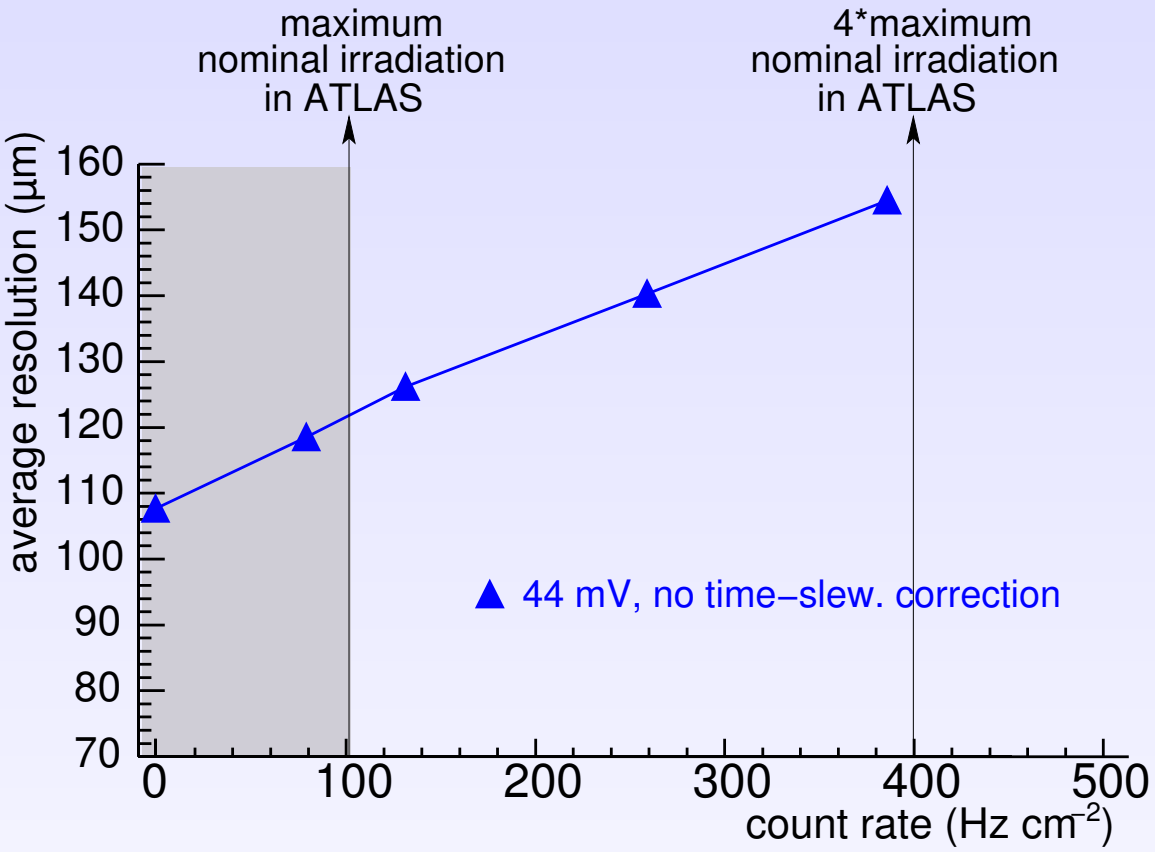
X5/GIF Testbeam

Final version of the read-out electronics:
measures the accumulated charge in a 15.5 ns time gate after the threshold crossing

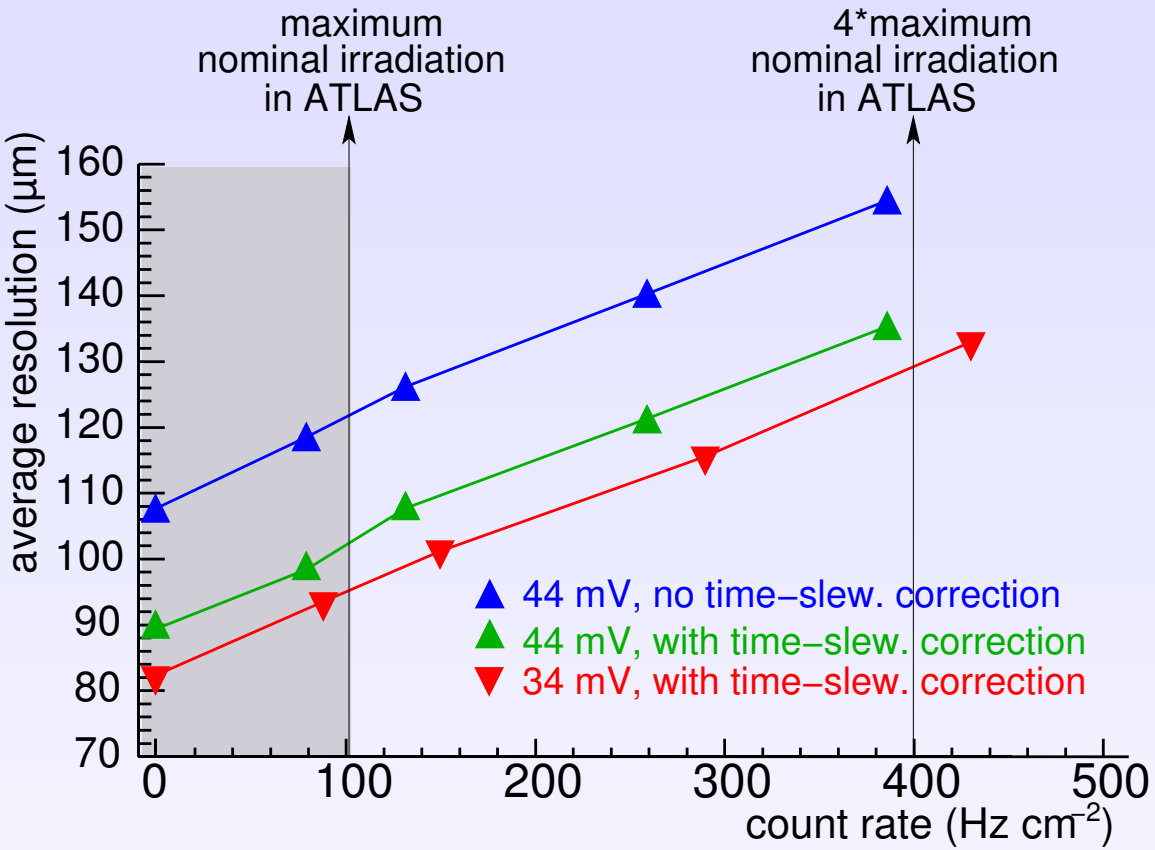


⋆ ADC information can be used for time-slewing corrections

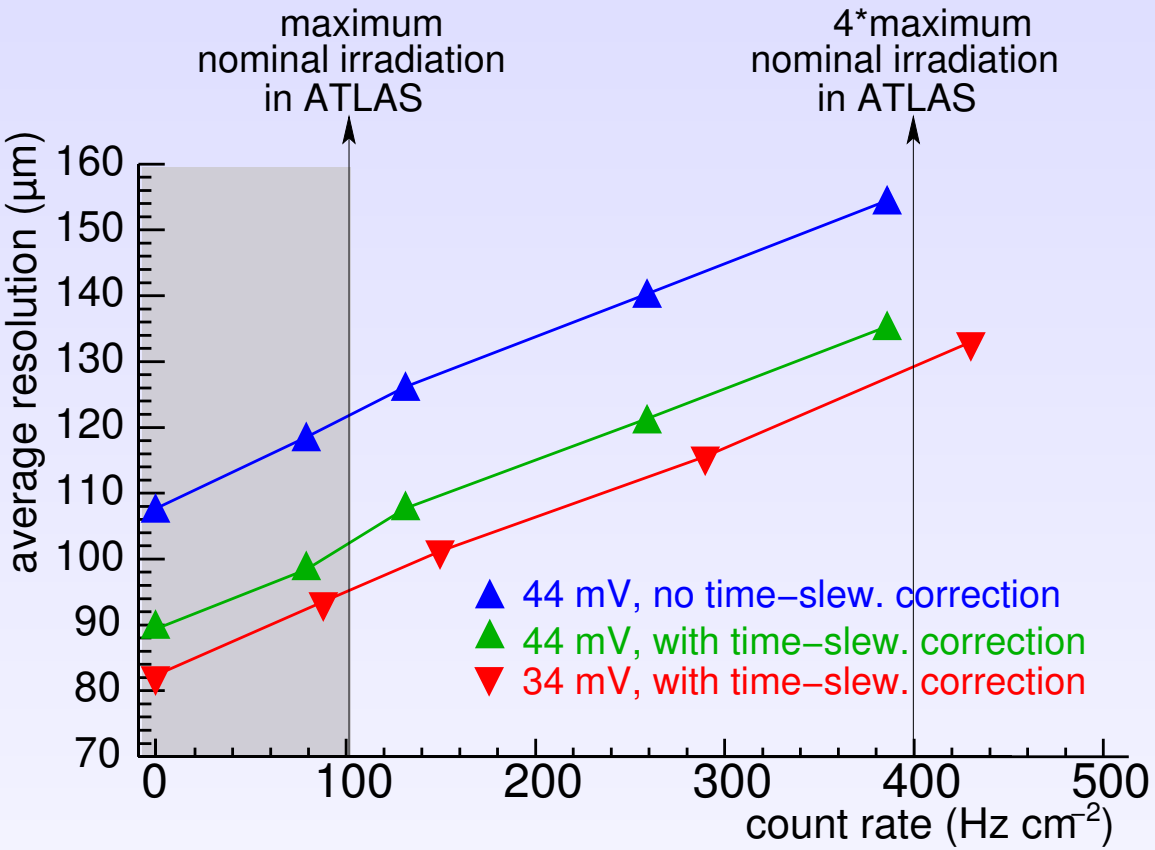
Chamber Performance Test in X5/GIF



Chamber Performance Test in X5/GIF



Chamber Performance Test in X5/GIF

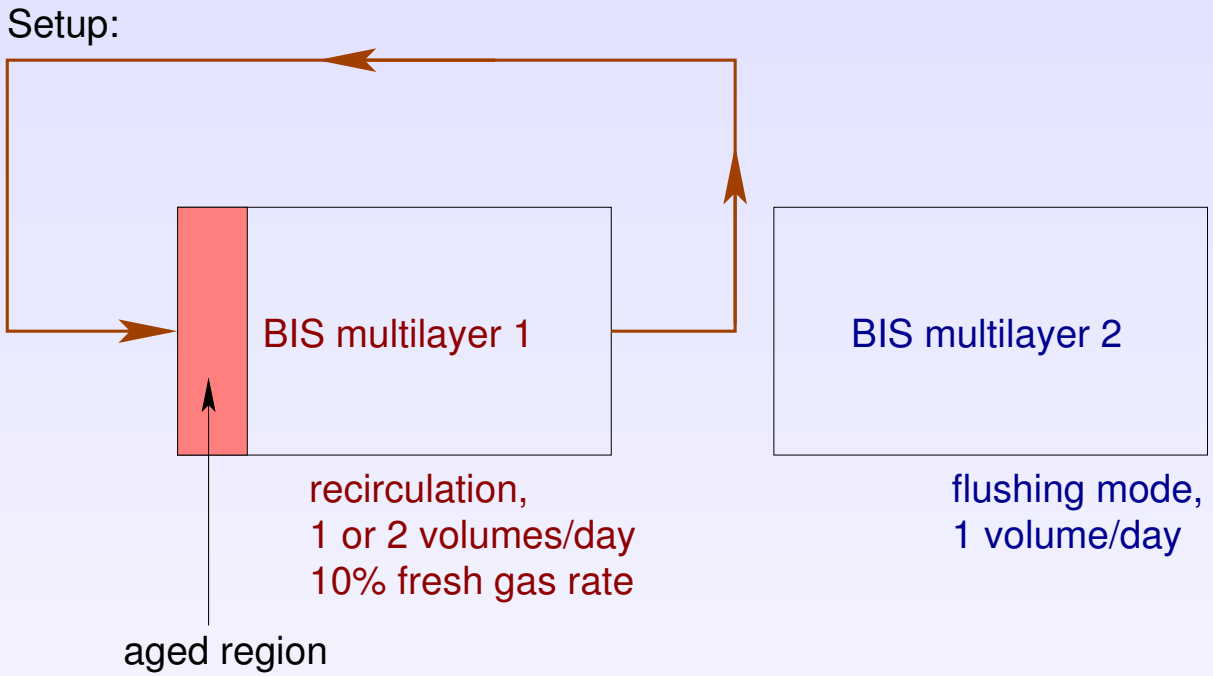


Without irradiation, the design resolution of 80μm is achieved.

Even at the maximum nominal ATLAS irradiation rates, this degrades by only 10 μm.

Aging studies at X5/GIF

- for the first time the recirculating gas system was used in long-term irradiation studies



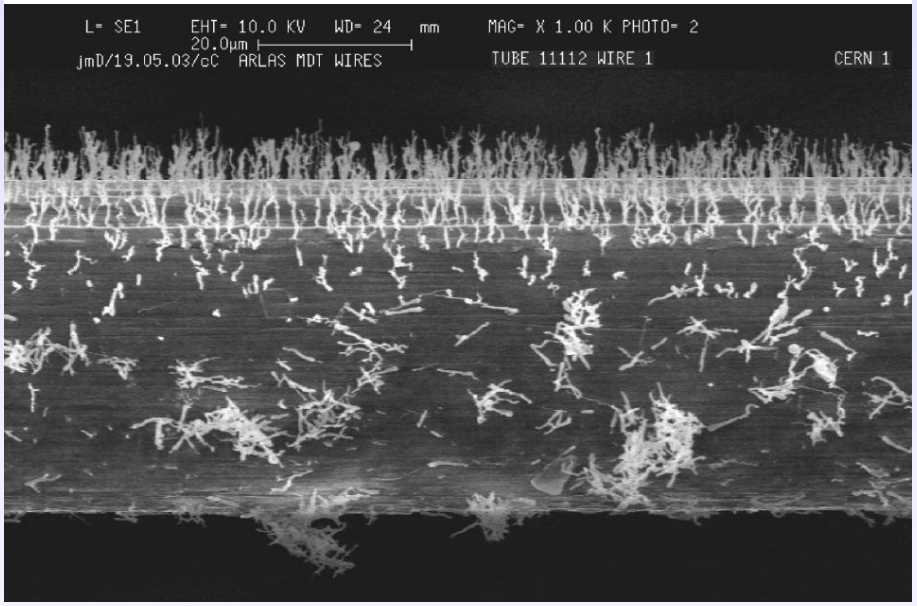
$\Longrightarrow$ strong decrease in the pulse height close to the gas inlet of ML-1, no such effect seen in ML-2

Where does the aging come from? Detailed investigation.

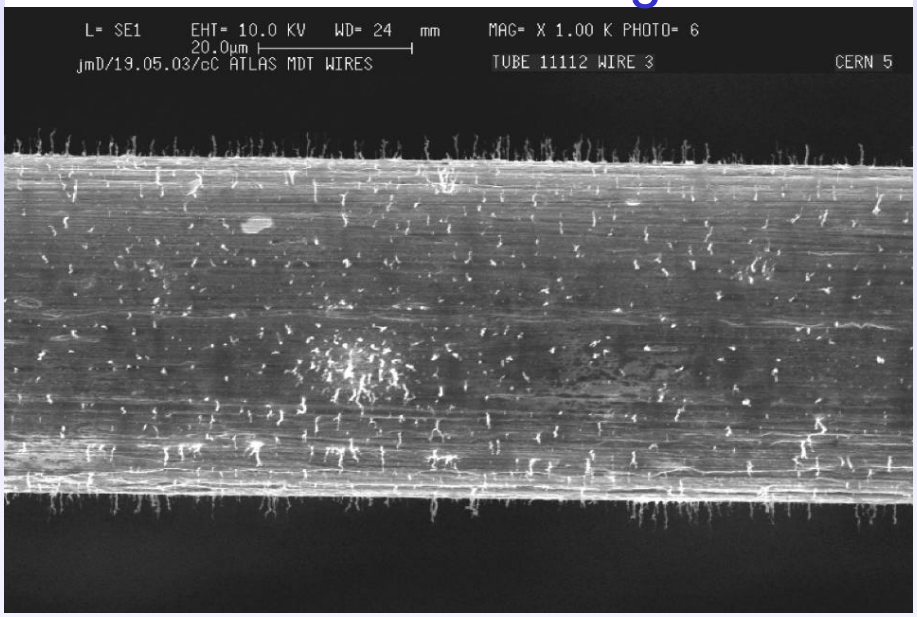
Aging studies at X5/GIF

Electron microscopy of the wire surface:
silicone deposits close to the gas inlet

vicinity of the gas inlet



L = 30 cm from the gas inlet



Cause: silicone grease decontamination was found in gas system components!

- ⋆ unprecedently strict quality control needed for the installation of ATLAS MDT gas system

Summary

Status of MDT Production...

- ⋆ production of the bare chambers proceeding according to schedule
- ⋆ mounting of the chamber services delayed, but soon to ramp up
- ⋆ infrastructure for the preassembly at CERN in preparation, chamber assembly and tests already started

...and Testing

- ⋆ aging effects in a recirculating gas system
  rigorous cleanliness control
- ⋆ functionality of the final read-out electronics verified
  resolution of better than 100 μm achieved even at the highest γ-irradiation rates
- ⋆ full system test in H8
  integrating MDT, RPC, TGC, and alignment

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// September 15^{th}, 2003. //