Precision
drift chambers (MDT)
for ATLAS muon system.

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SOME GENERAL INFORMATION ABOUT ATLAS MUON SPECTROMETER.

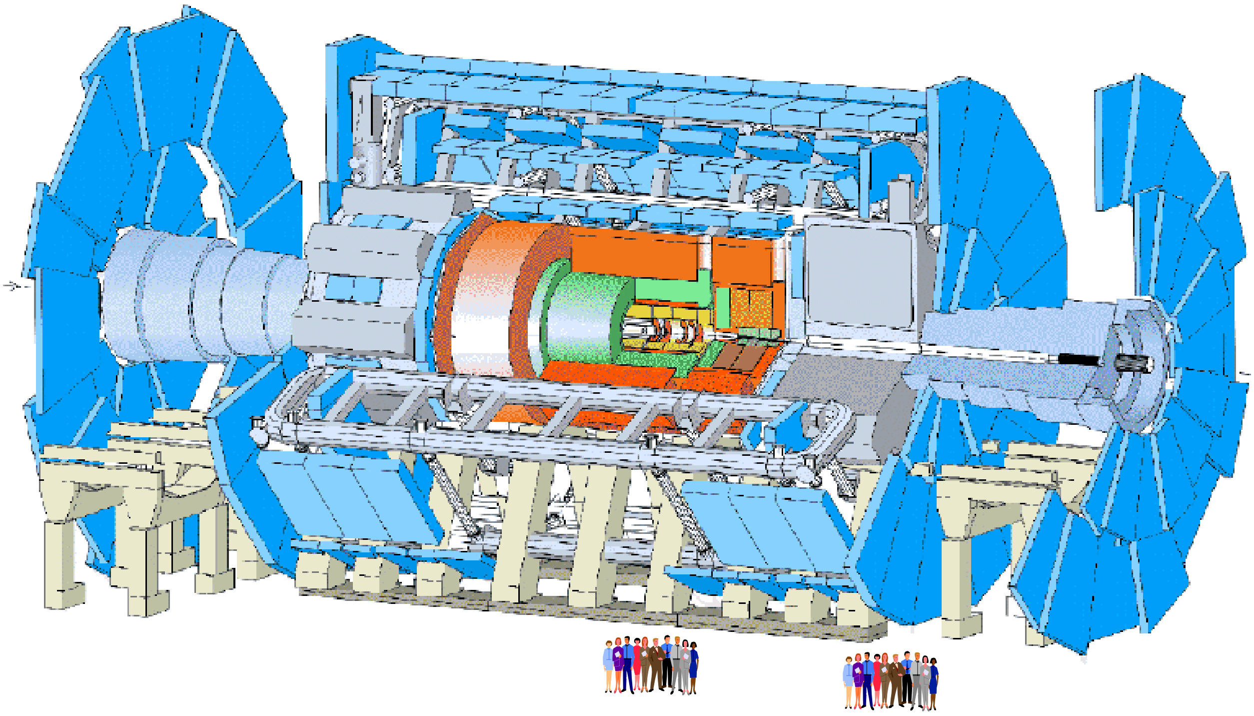
1. The quality of the muon measurement has been one of the guiding design criteria for the ATLAS experiment.

2.. Muon spectrometer is the outer layer of ATLAS detector (average dimensions about 22 meters high and 44 meters long).

3. For the muon trajectory the determination of 3 points in the muon track are the minimum needed.

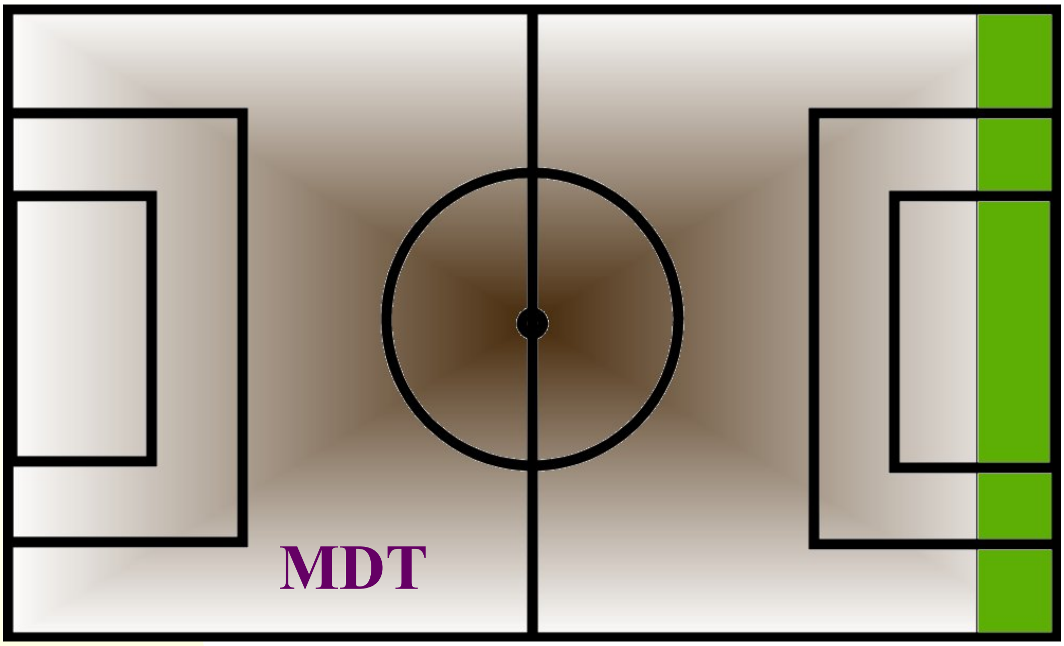
4. All together it lead us to the 5500 meters squared have to be covered by muon detectors or 400000 single drift tube detector, grouped in 1200 chambers.

ATLAS Detector



Geneva - Stockholm

Football ground



HOW WE ARE CONSRUCTING OUR CHAMBERS?

Given the large area of the muon spectrometer it was necessary to devise a cheap but precise means of capturing the data. Several types of coordinate detectors are used at the MUON system. I am talking now about MDT detectors only which covered the 98.6% of full area is covered by ATLAS Muon system
(5500 from 5580m2).

ATLAS has opted for a system of tubes (Monitored Drift Tubes chamber or MDT-chamber) grouped in 1200 chambers.

From mentioned above it should be clear that the process of MDT chamber construction and test is naturally divided into two parts:

- *Tube assembling (wiring) and test.*
- *MDT Chamber assembling and test*

MDT Muon Chamber

Chamber assembling scheme

Row materials

Al tubes (Menziken),end-plugs (Nief), 50μ wire (Lumo)

Clean room # I

DT assembling (wiring)

- *end-plug assembling*
- *Control of Al-tubes*
- *DT wiring*
- *Test of DT full length*
- *Test of wire tension*

Row materials

- *In-plane align.compon*
- *Spacer components*
- *Sensors (t,B)*

DT QA & DC

- *Wire position test (X-ray)*
- *Leak test*
- *Complex test (Gas mixture+HV)*

To MPI (Munich)

Clean room #2

Chamber assembling

- *Incoming components QC and preparation*
- *Spacer asssembling (gluin*
- *In-plane alignment installat*
- *Gluing of tubes →Layers →Superlayers →Camber*

To CERN

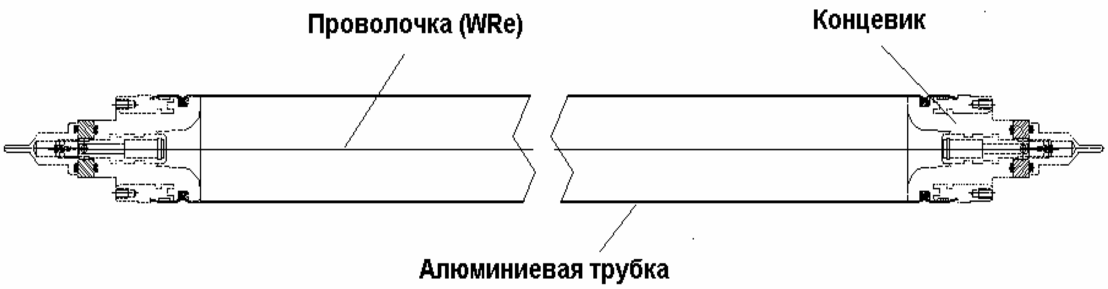
Procedure of drift tube wiring

The incoming industrially produced components for tube wiring is:

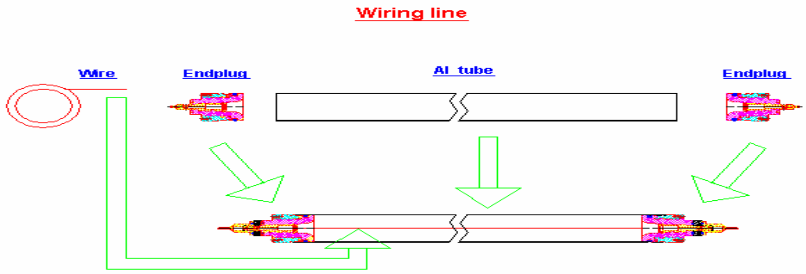
1. **Thin wall precision Al – tubes;**
2. **Gold plated 50 μ tungsten-rhenium wire;**
3. **End-plug (which consist from end-plug body with high precision reference surface, wire holder for precise wire positioning, O-rings)**

But as far as the performance of MDT muon system is determined by the performance of drift tubes and moreover there is no possibility to replace/repair single detector from the muon chamber the process of tube wiring and set of the tests must be relevant (QA/QC – procedure !!).

Drift tube construction and tube wiring



The scheme of the tube wiring is the following:



Drift tube components (photo)

Wiring Line

DT Quality Control

PDT Working parameters:

Gas mixture: Ar(93)-CO_2(7) at 3 Bar
Voltage : 3120 V

QC requirements:

Dark current at 3400 V	**2nA/m**
Max count rate	**20Hz/m**
Max gas leak	**10^{-8} Bar*l/s**
Wire tension tolerance	**17g**
Wire position tolerance	**25µ**

Tests Sequence:

- **Wire tension test (wiring line)**
- **Wire position test (X-ray)**
- **Gas leak & overpressure test**
- **HV&Functionality test**
- **Checking/packing/storing**
- **Wire tension (chamber assembling zone)**

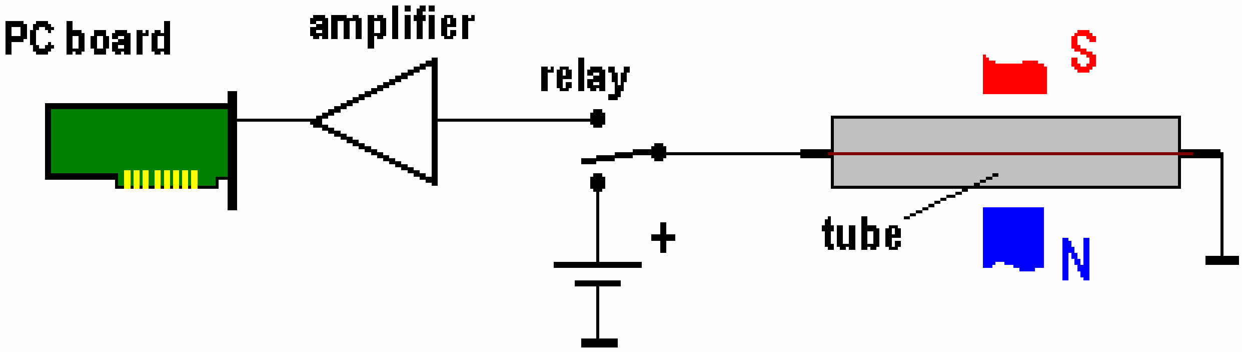
Test rate : 120 tube/day

Common solutions

- Each tube have unique Id code
- All tests are computer-based
- All results are automatically stored in DB
- Bar-code scanner is used for Id reading

Wire Tension Control

Simple wire tension meter based on "magnetic" method



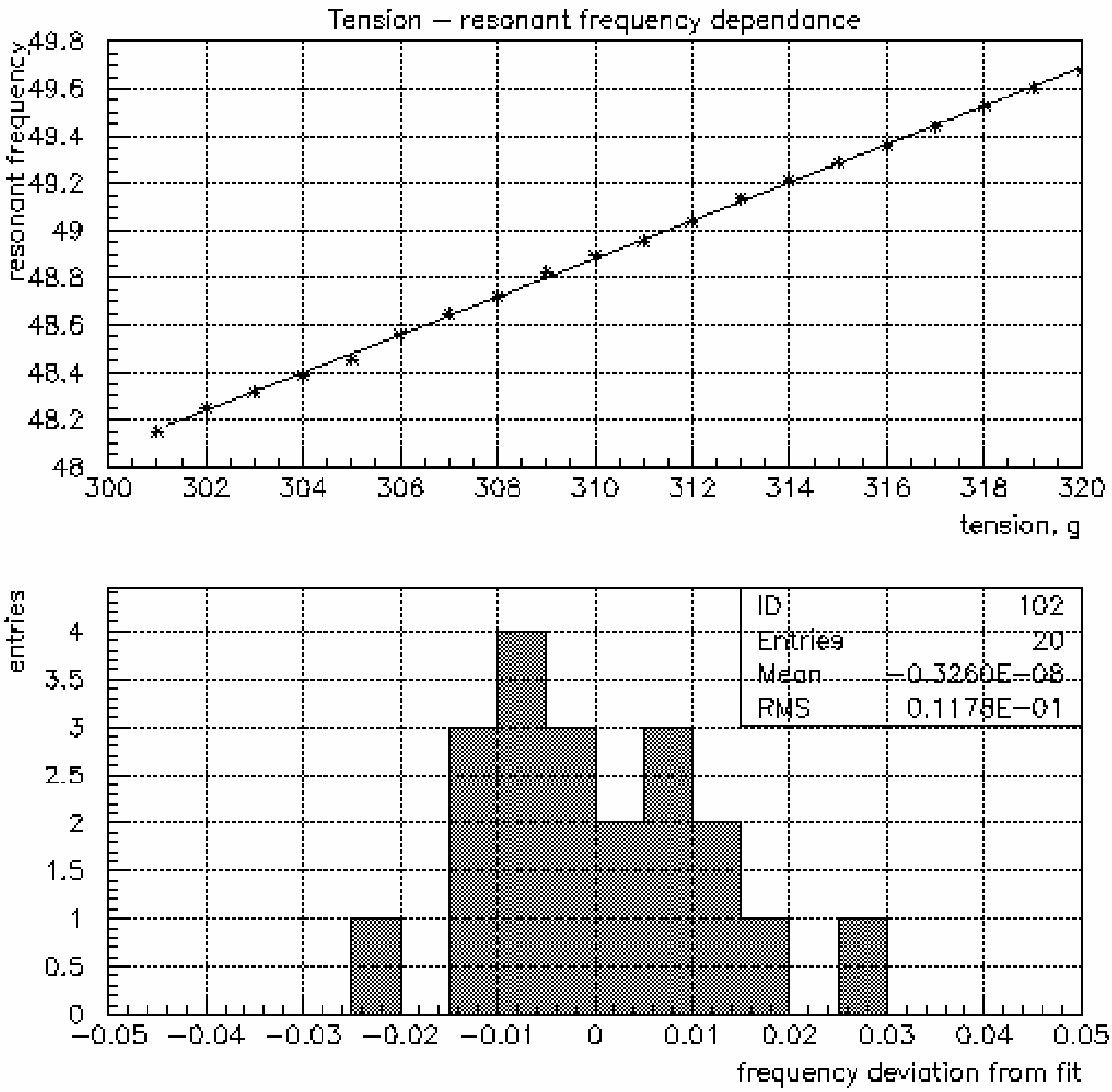
•Commercial PC extension board = 8 ADC & digital outputs
•Custom electronic module – DC source, amplifier and relay controlled via digital output.
• Wire may by connected either to DC source (send excitation pulse) or via amplifier to ADC

- Wire excitation by current pulses
- Digitization of the wire free oscillations
- Oscillation spectrum extraction with FTT
- Peak finding and base frequency extraction

No other equipment – even power is from PC
Fully programmable – easy to adopt and build-in into any PC – based system

Wire tension Control

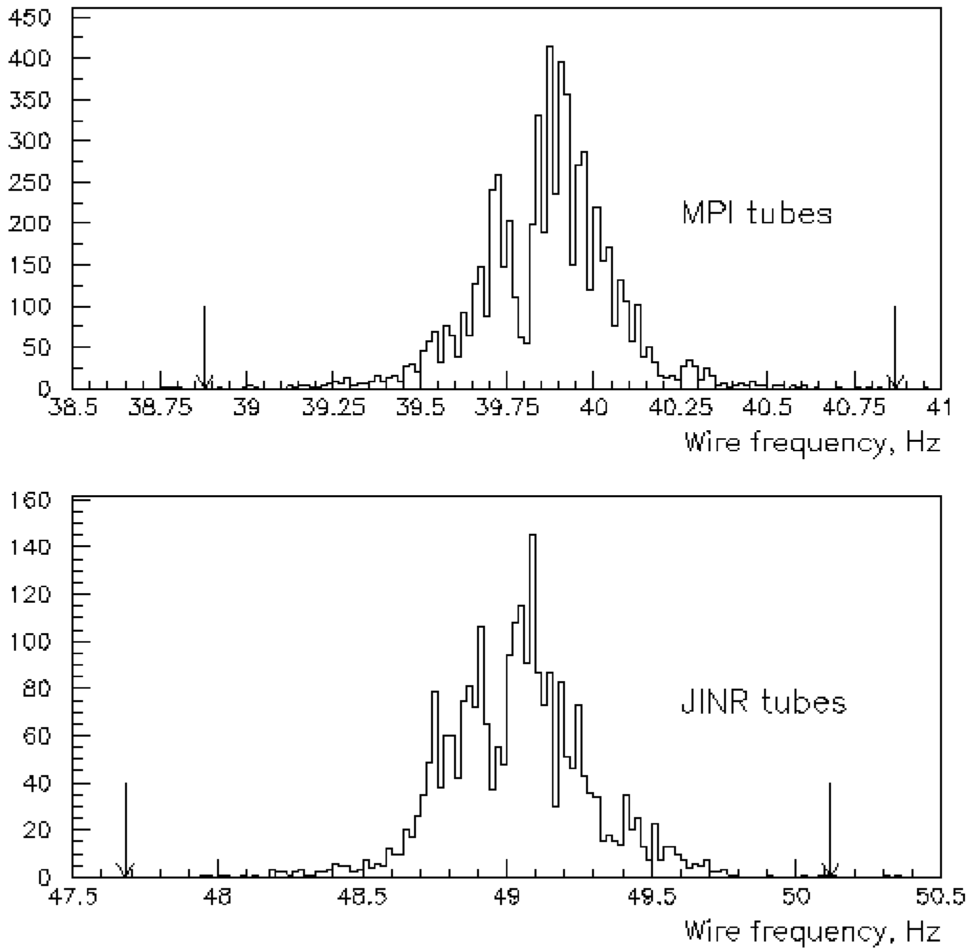
Accuracy



σ = 12 mHz at 50 Hz frequency

Wire Tension Control

PDT test results

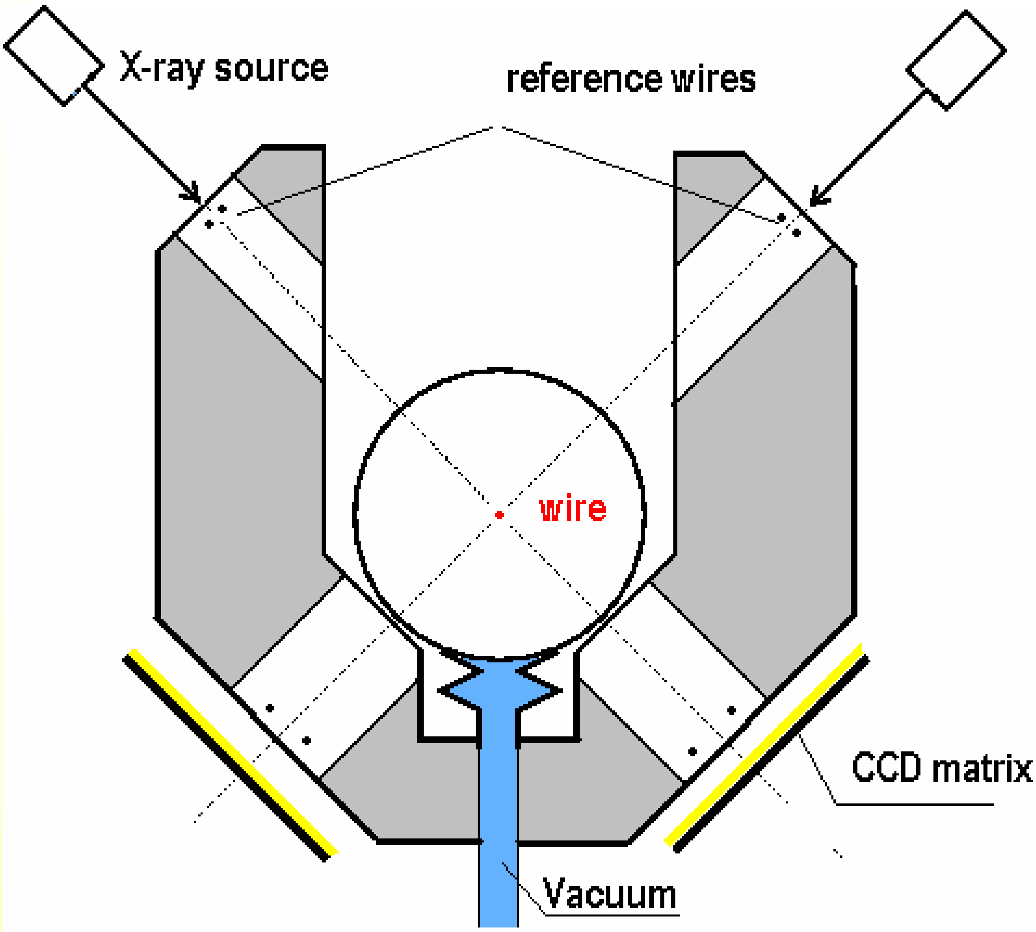


	since 1.10.2000	overall
tubes tested	**9130**	**10932**
tubes rejected	**31** **0.3 %**	**583*** **5.3%**

X-ray Test Station.
Operation scheme.

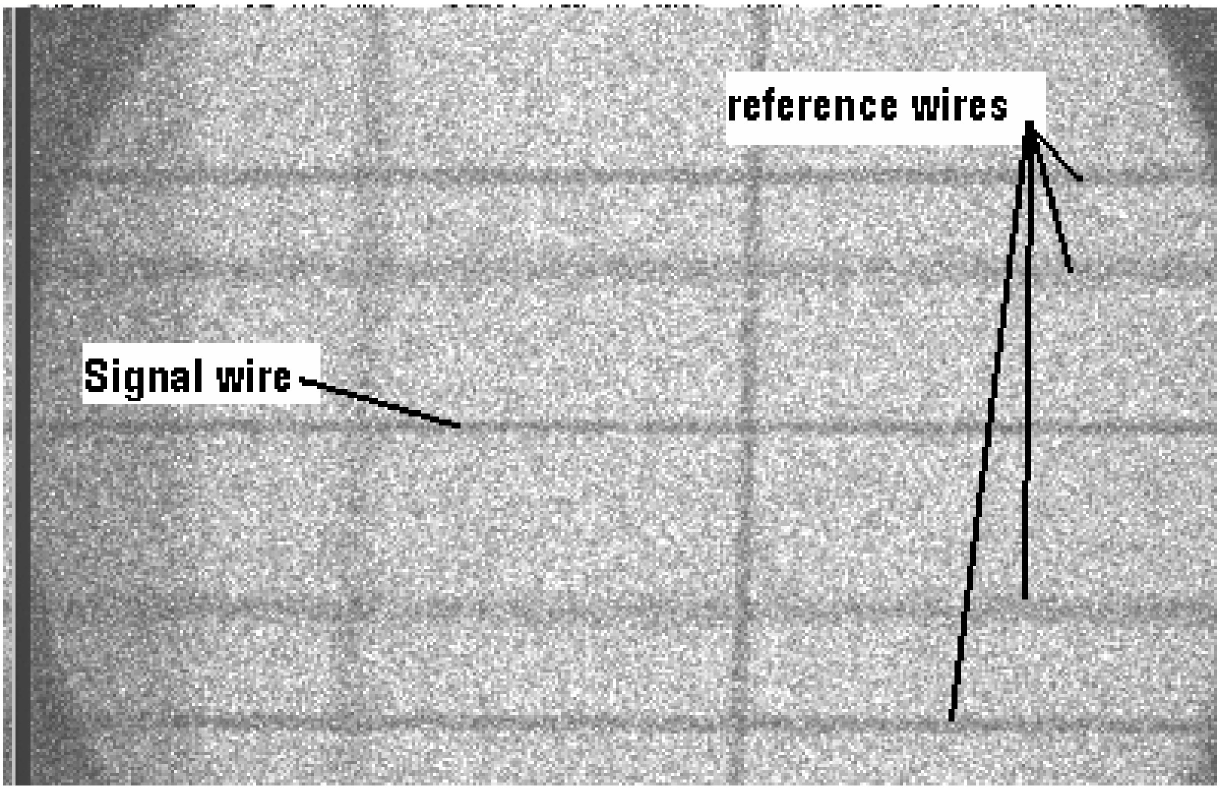
Wire position tolerance : 25µ

Operation scheme:



X-ray Test Station (CCD)

And what do we get ? –
image from CCD

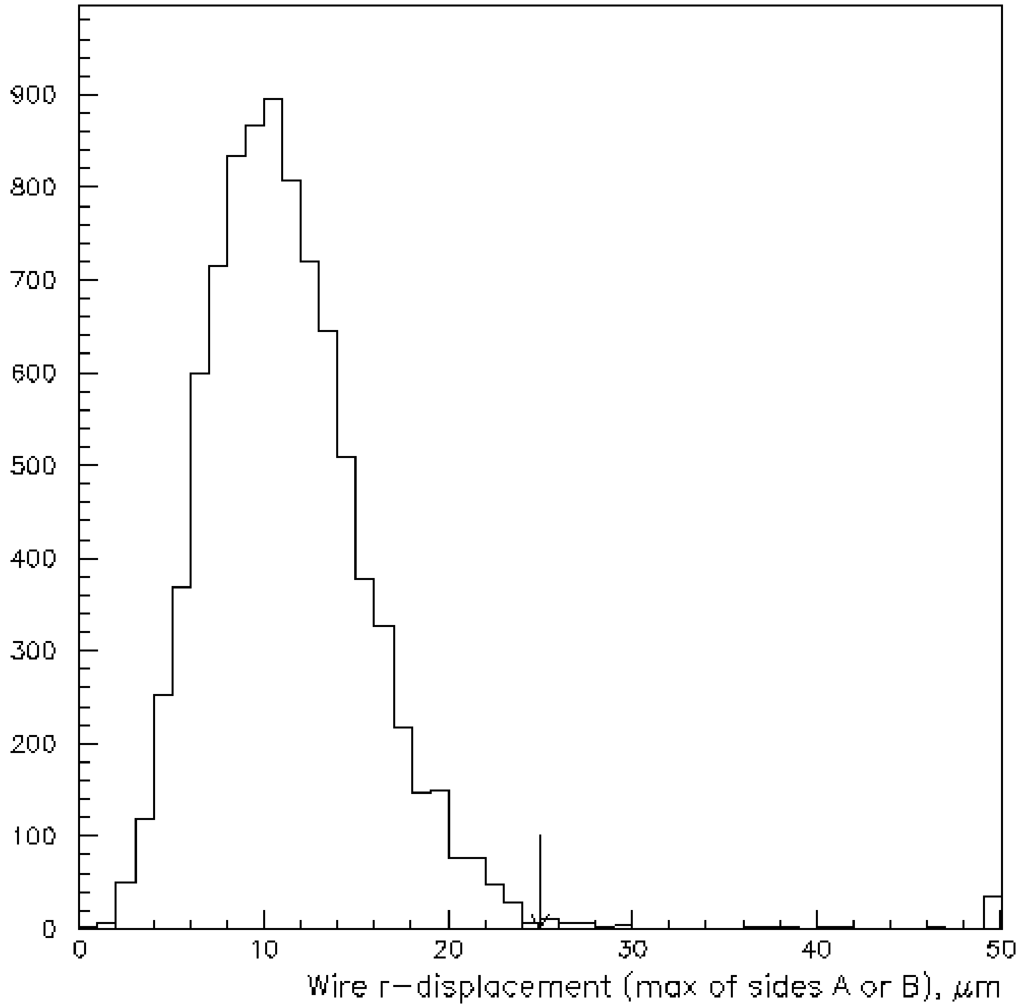


Reference wires completely define wire position with respect to V - groove

<u>Accuracy $\sigma = 2\mu$</u>

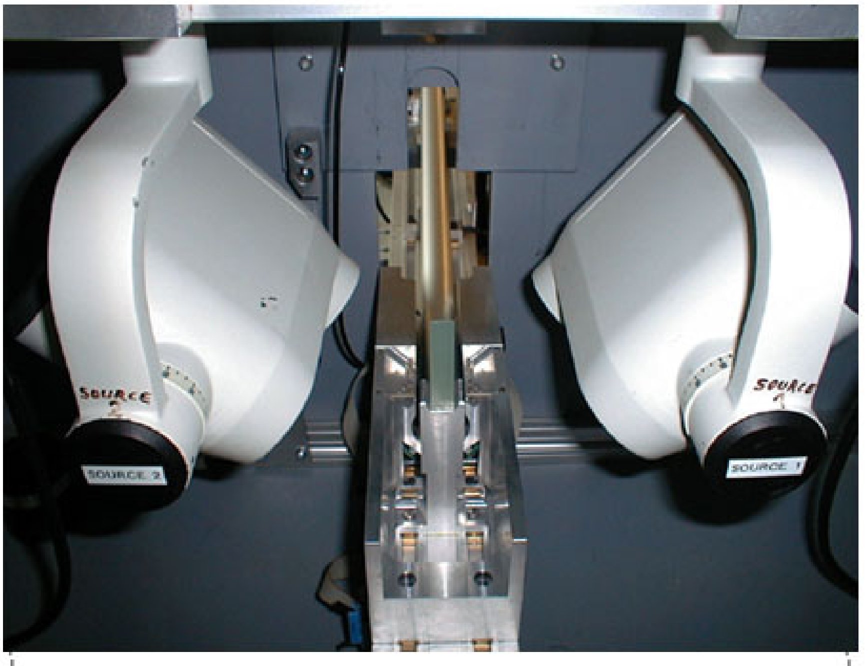
X-ray Test Station (statistics)

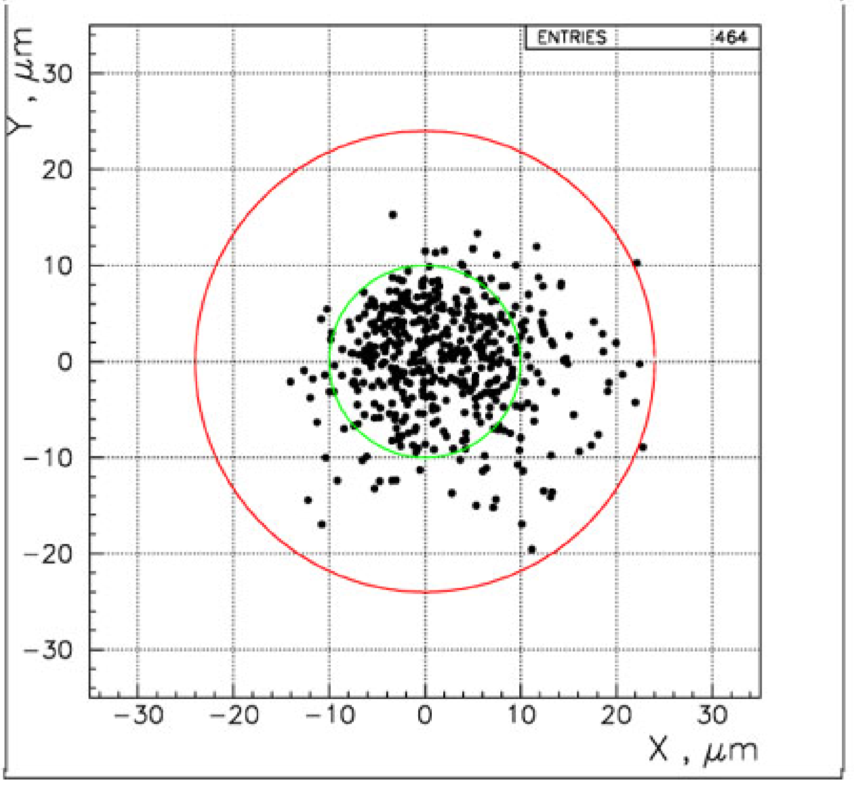
PDT test results



	since 1.10.2000	overall
tubes tested	8914	10710
tubes rejected	72 0.8%	149 1.4%

X-ray Test Station (photo)

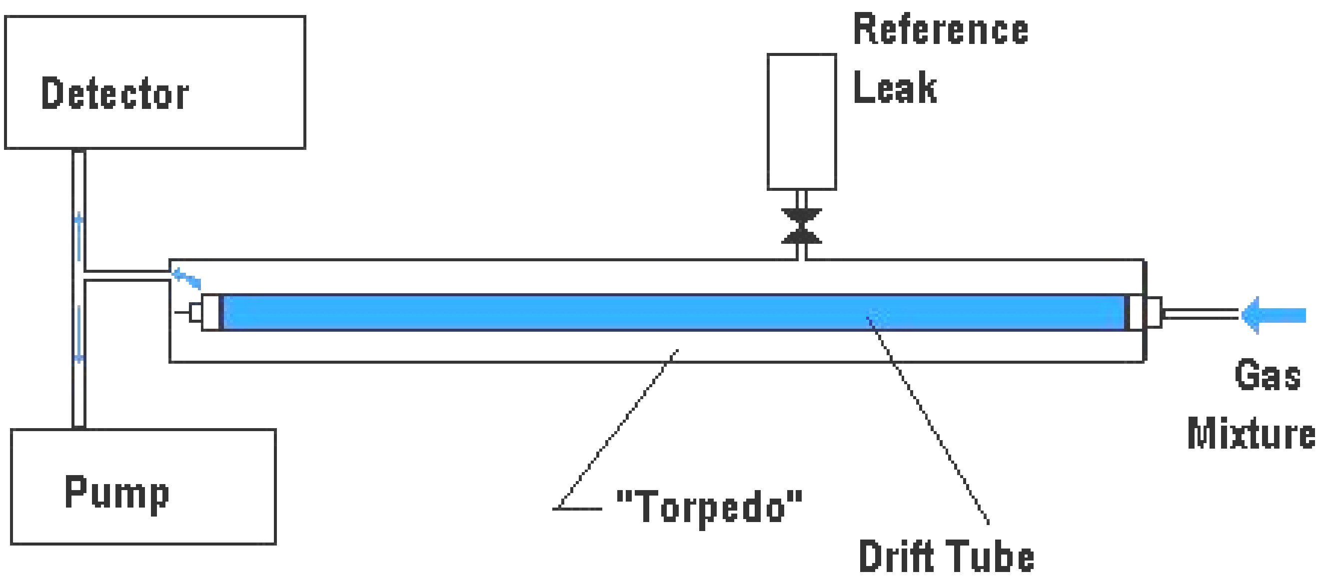




Gas Leak Test (scheme)

Max leak : 10^{-8} bar*l/s = 0.3 mbar/day

Measurement principles:



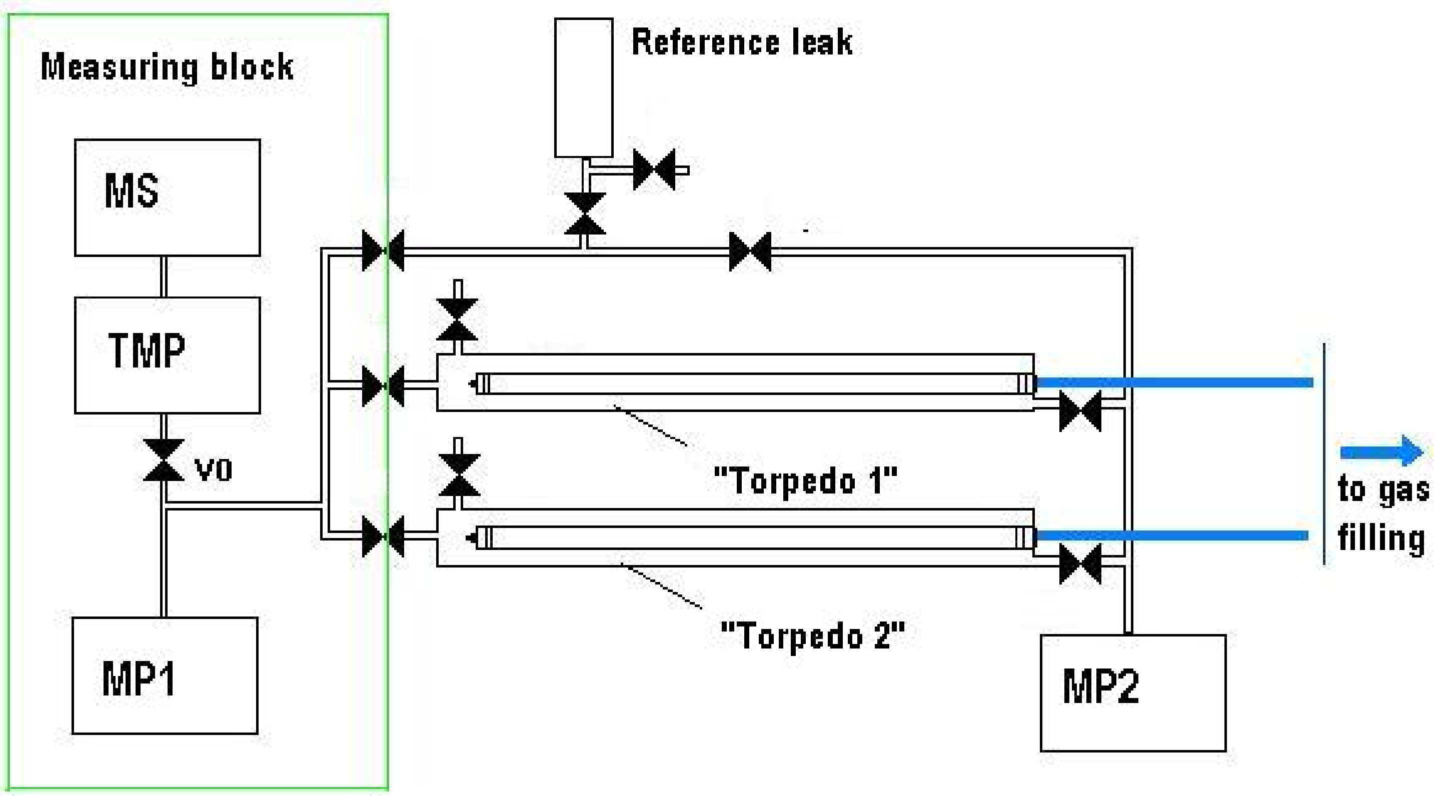
Equilibrium: **$P = k \times L$**

P – pressure
L - leak

- **Use reference leak to define k !**
- **Use He as trace gas to avoid outgasing problem and make measurements less sensitive to system leak (no He in atmosphere)**

Gas Leak Test (set-up)

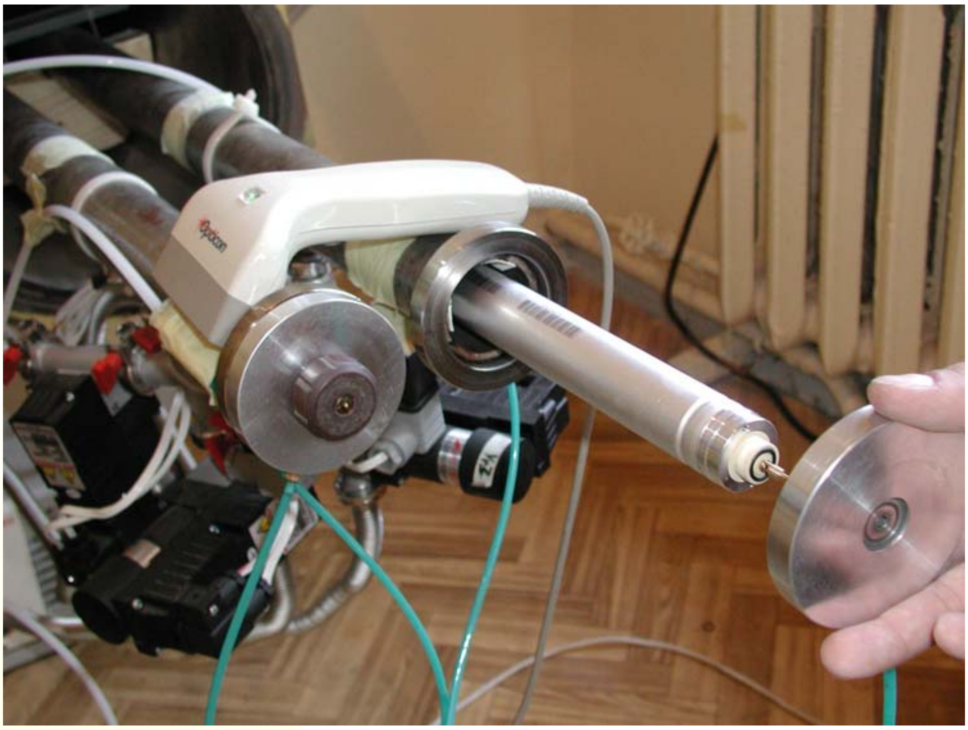
Setup scheme:

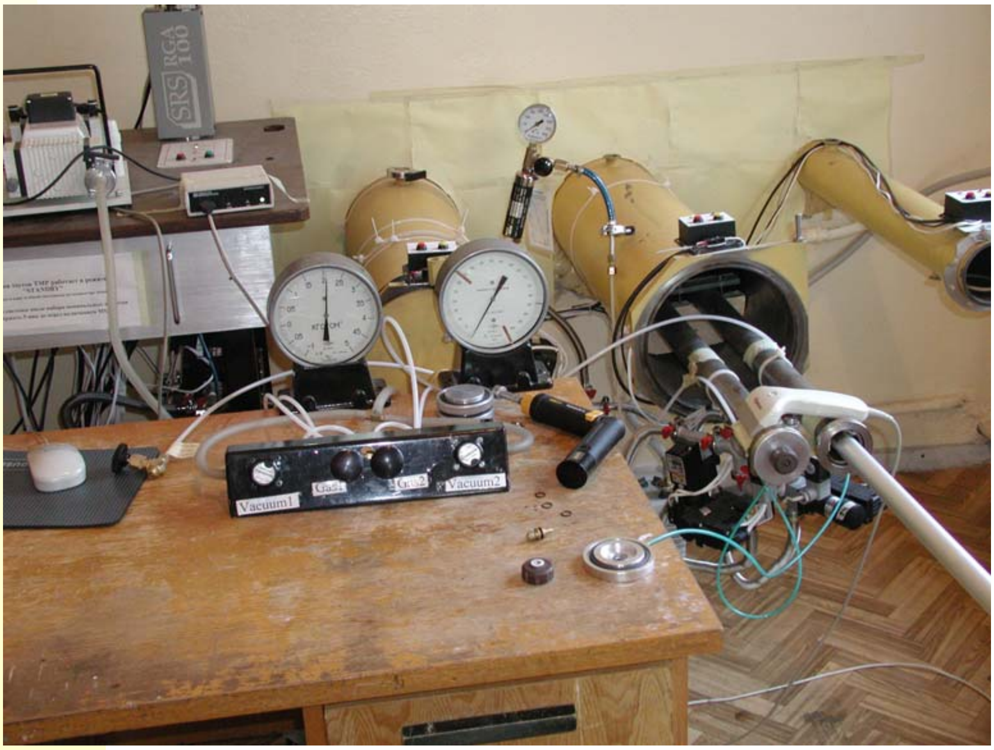


Working condition in MS camera – UHV (~ 10^{-6} mbar)
Pressure inside torpedo < 1 mbar

- **While first "torpedo" is under measurement another one is being prepared - "mass production"**
- **Measurement time ~ *3 min***

Gas Leak Test (photo)

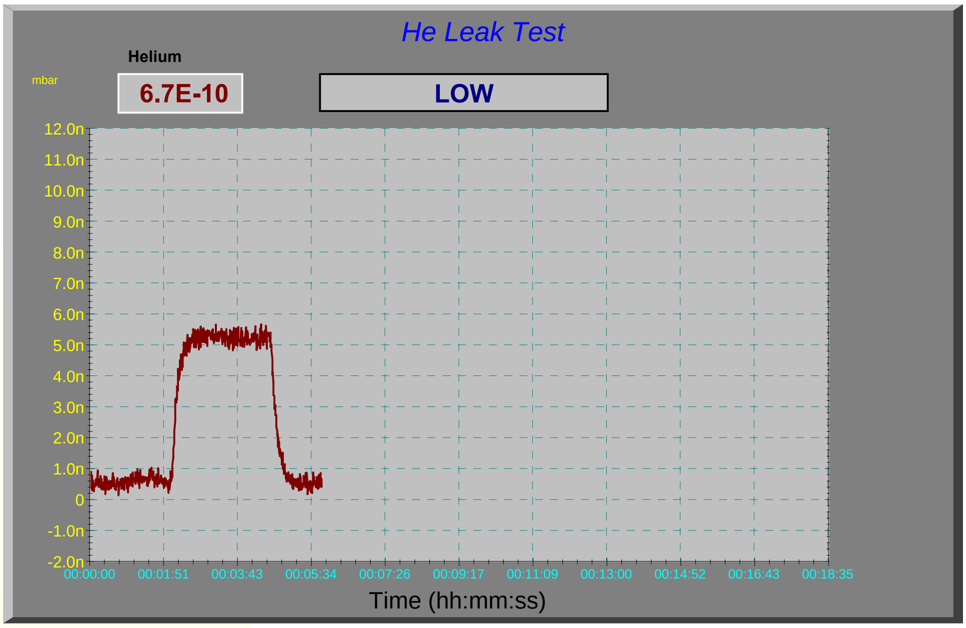




Gas Leak Test (LabView)

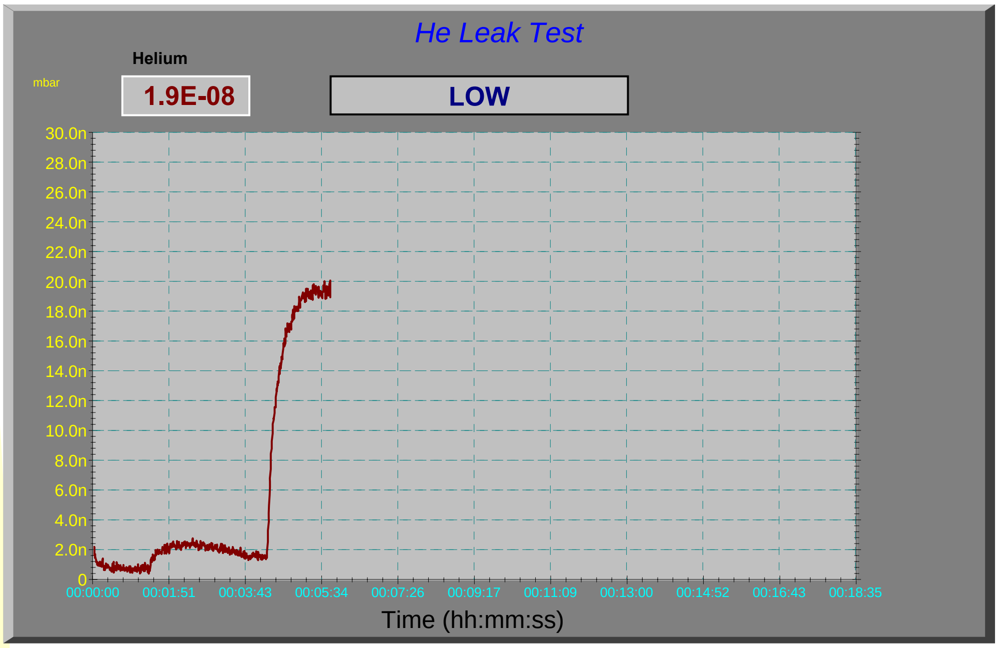
And how do we see the result? –

MS output for the $0.25*10^{-8}$ Bar×l/s calibration leak



Sensitivity - better then $0.5*10^{-9}$ bar*l/s

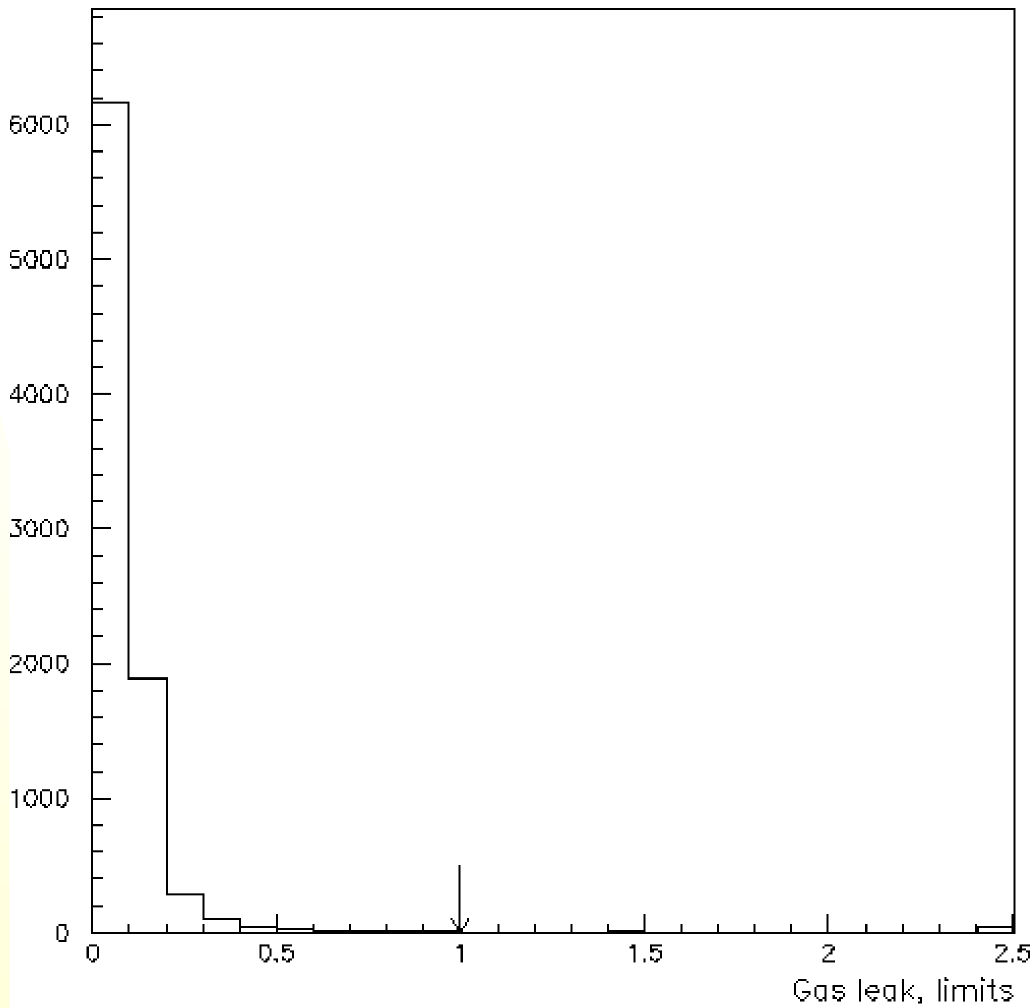
Accuracy ~ 15 %



Real graphs with trace for 2 tubes. Last one have a leak about $0.7*10^{-8}$ bar*l/s

Gas Leak Test (results)

PDT test results



	since 1.10.2000	overall
tubes tested	**8661**	**10395**
tubes rejected	**74 0.9%**	**111 1.1%**

HV & functionality test

Leak current limit : 2 nA/m

Principles

- **Test a batch (up to 96) of tubes filled with standard gas mixture for a long time**
- **Slowly rise voltage while controlling current**
- **Drop voltage and rise it again if necessary for tube training**
- **Keep low humidity in test area**

Based on CAEN 546 HV power supply module:

- **96 chanels , voltage is set by groups of 12**
- **Current in each channel is controlled with 1 nA accuracy**

L3 amplifier, 32-channel discriminators and 16-channel CAMAC scalers are used to control count rate

Test procedure is automatic

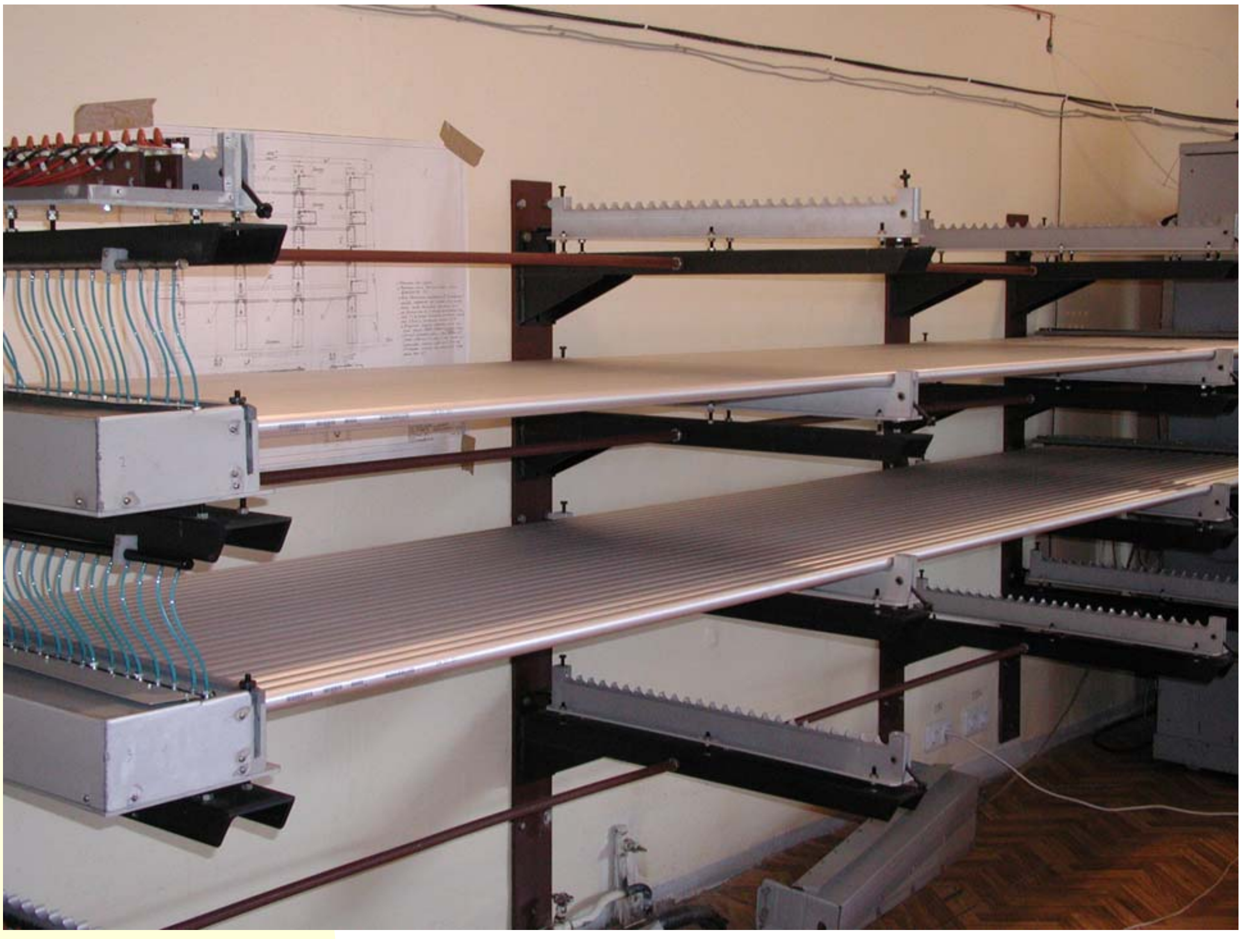
Time consumption :

~1 hour for tube connection

+ 1.5-12 hours for the test itself

HV test (photo#1)

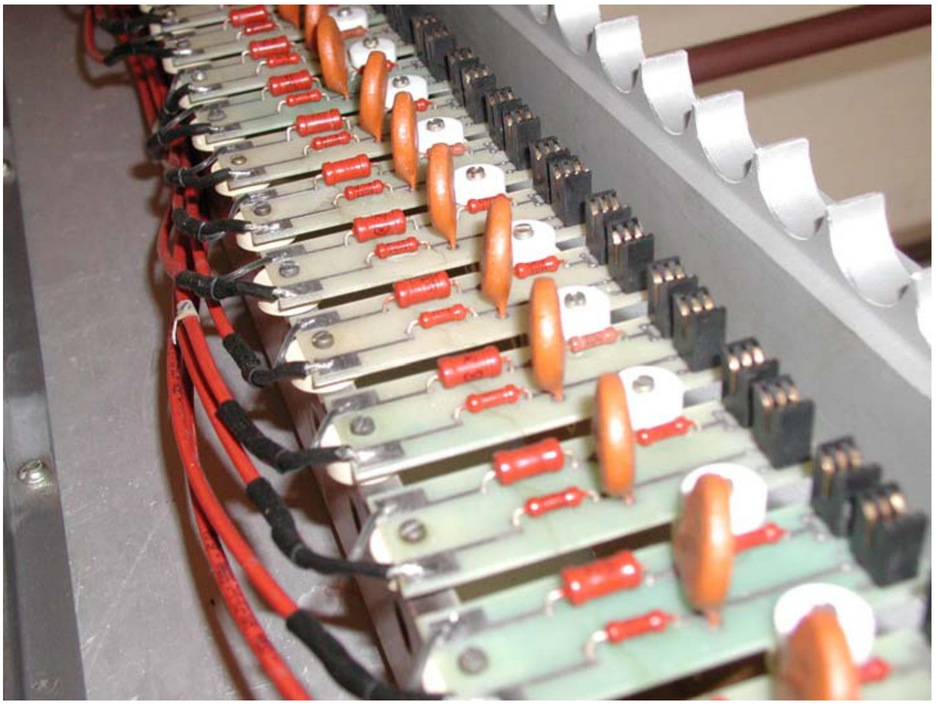
How it looks like:



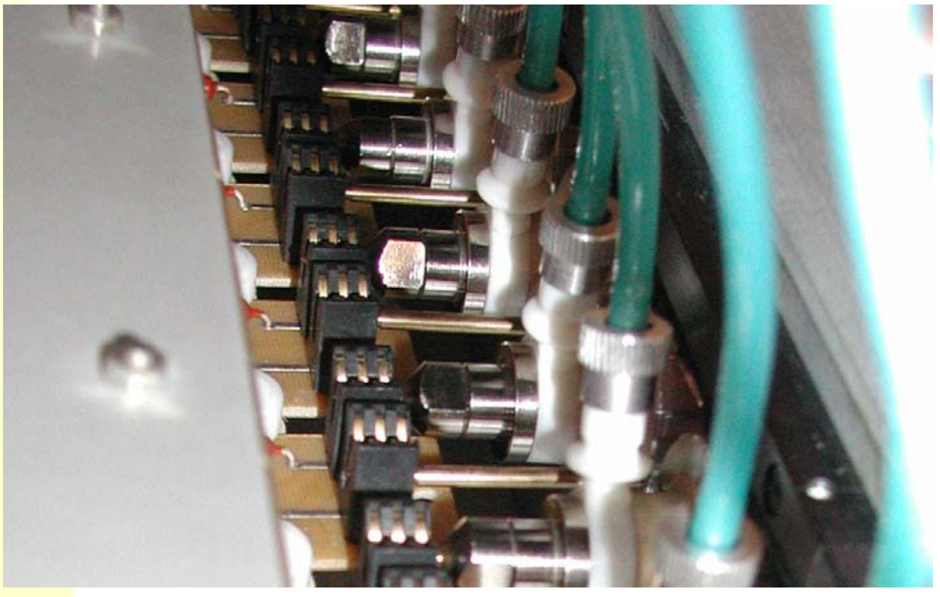
It is possible to test up to
96 tubes simultaneously

HV test (photo#2)

HV board

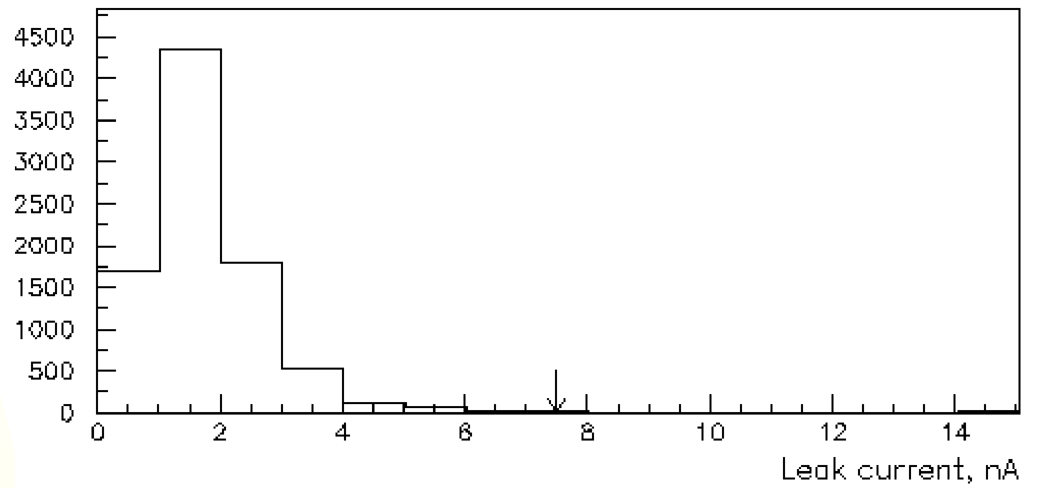


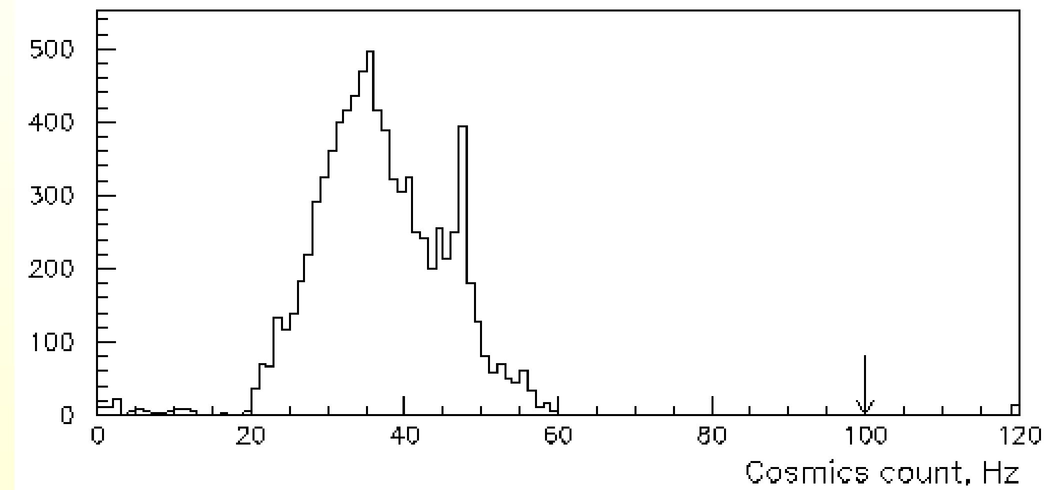
connected DTs



HV test (results)

PDT test results





	since 1.10.2000	overall
tubes tested	**8585**	**10299**
tubes rejected	**29** **0.3%**	**49** **0.5%**

QC –final results

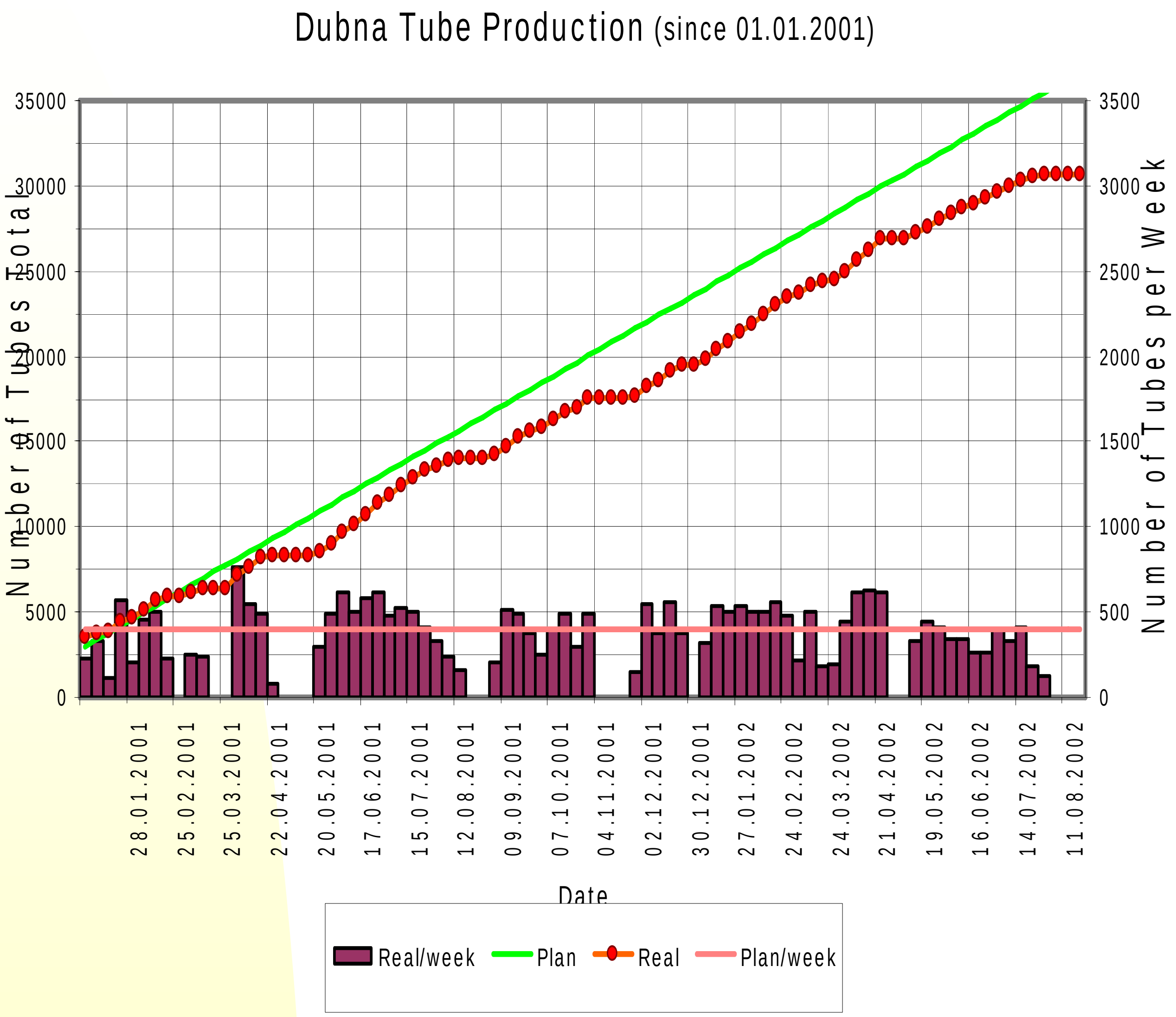
Our current results

	overall		Since 1.10.2000	
test	tested	rejected	Tested	Rejected
Wire tension	10932	583 5.3%	9130	31 0.3%
X-ray	10710	149 1.4%	8914	72 0.8%
Gas leak	10395	111 1.1%	8661	74 0.8%
HV & rate	10299	49 0.5%	8585	29 0.3%
Overall				About 2.2%

Find us at http://nuweb.jinr.ru/~dcbp/atlas/atlas.htm

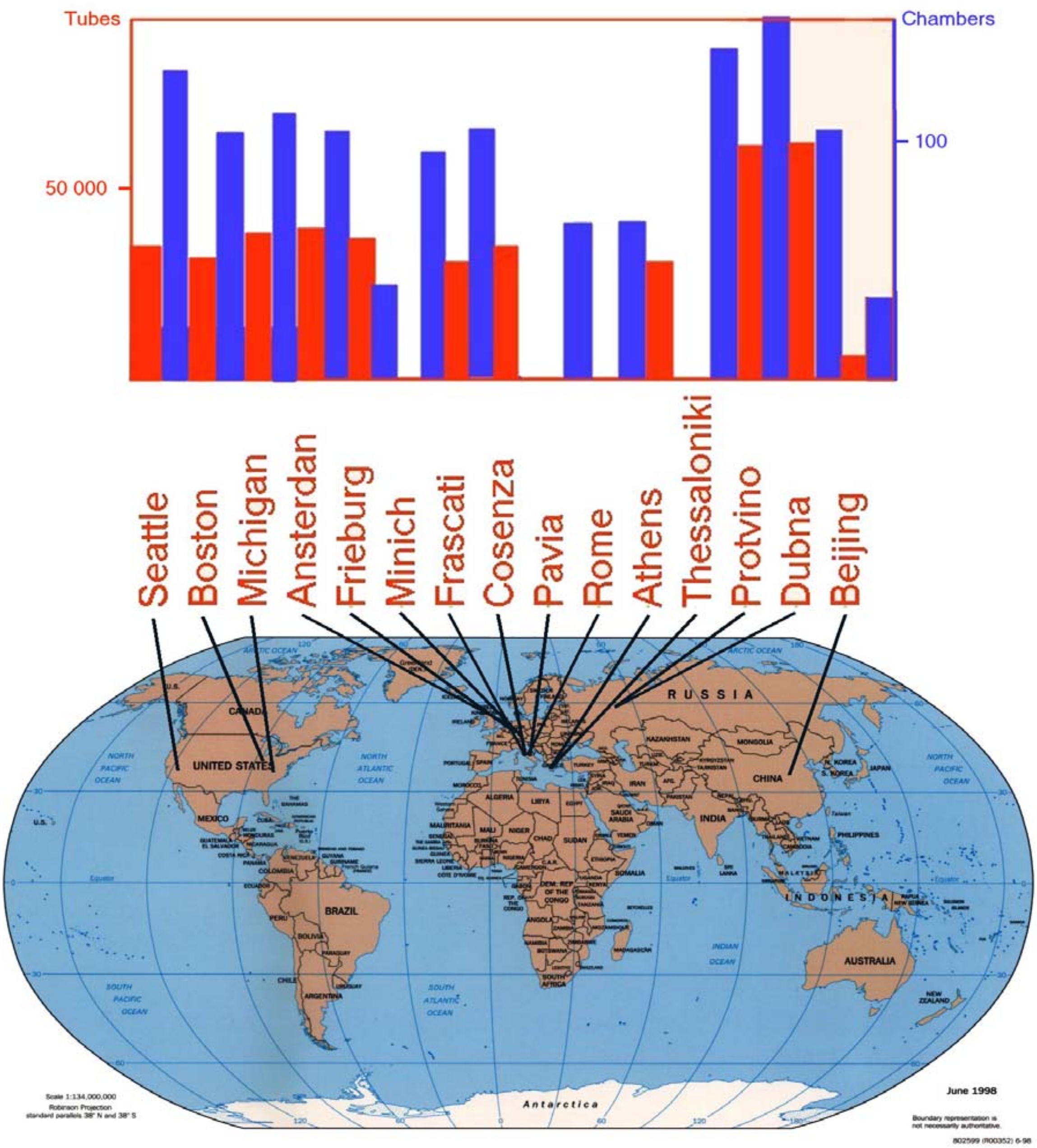
MDT Production and tests

Our current results



Responsibilities and work organization.

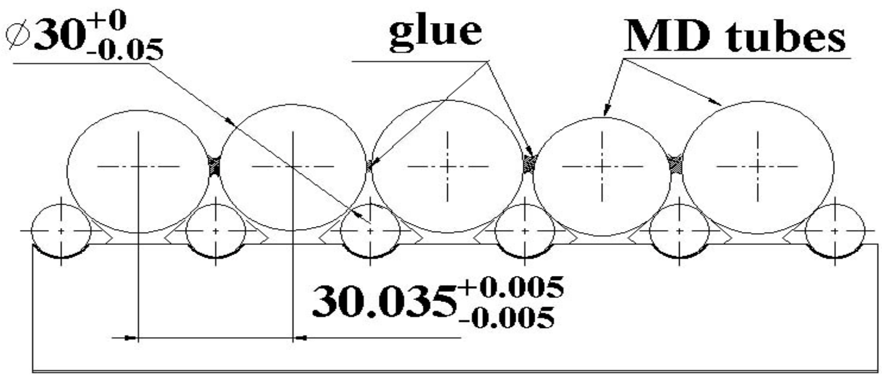
The construction of the Muon Spectrometer is such a big effort that it is shared between many laboratories:



Chamber assembling (1-st ruse).

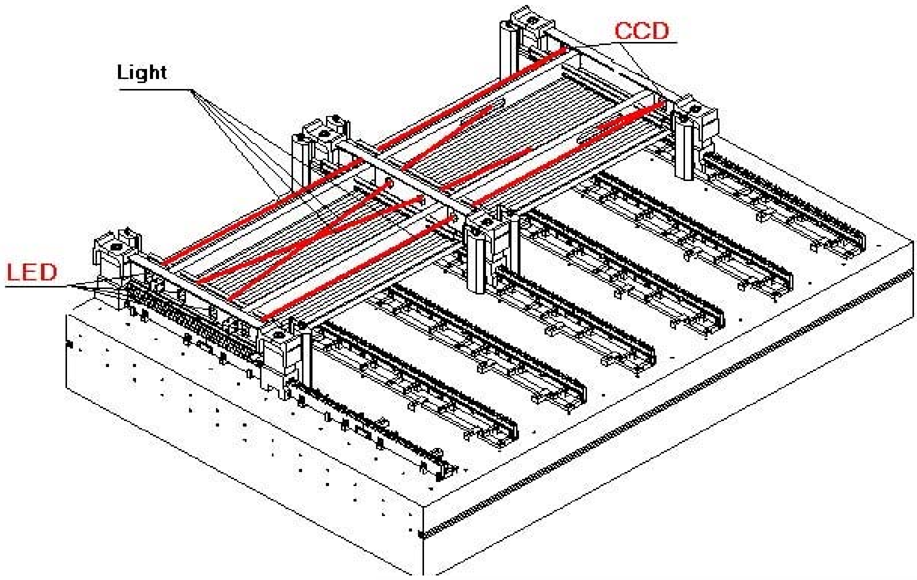
Two ruses widely used in the MDT chamber assembling procedure.

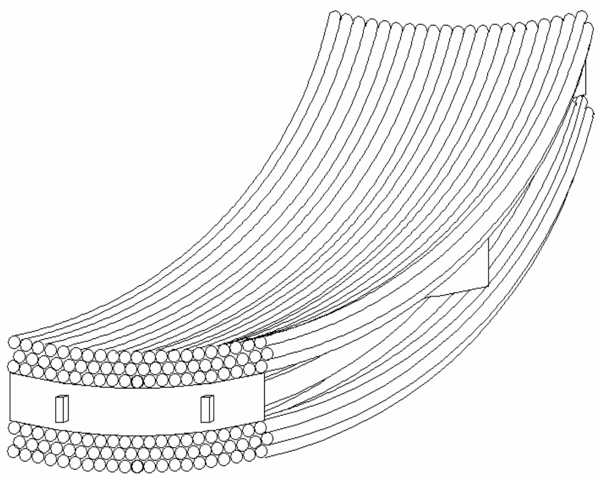
#1 - *Assembling (gluing) precision components form non-very precision elements using high precision combs and glue*



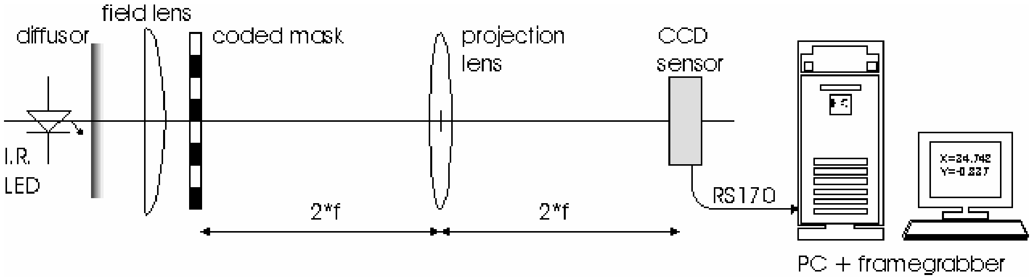
Chamber assembling (2-nd ruse).

#2 Since deformation of such large (about 10 m²) object made form Al (not from marble!) can not be eliminated, one have to be able to control (and to compensate in a reconstruction procedure!) this deformation during all time period of chamber operation.

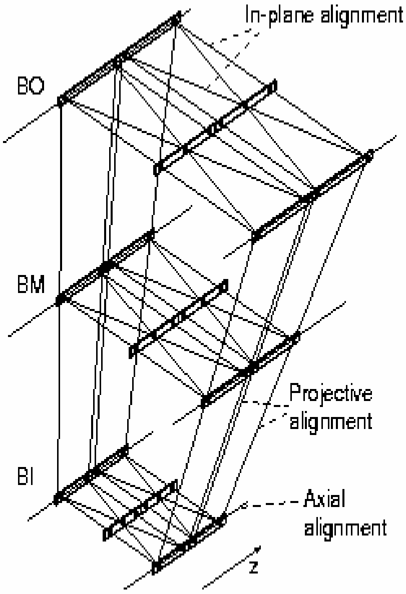




RASNIK



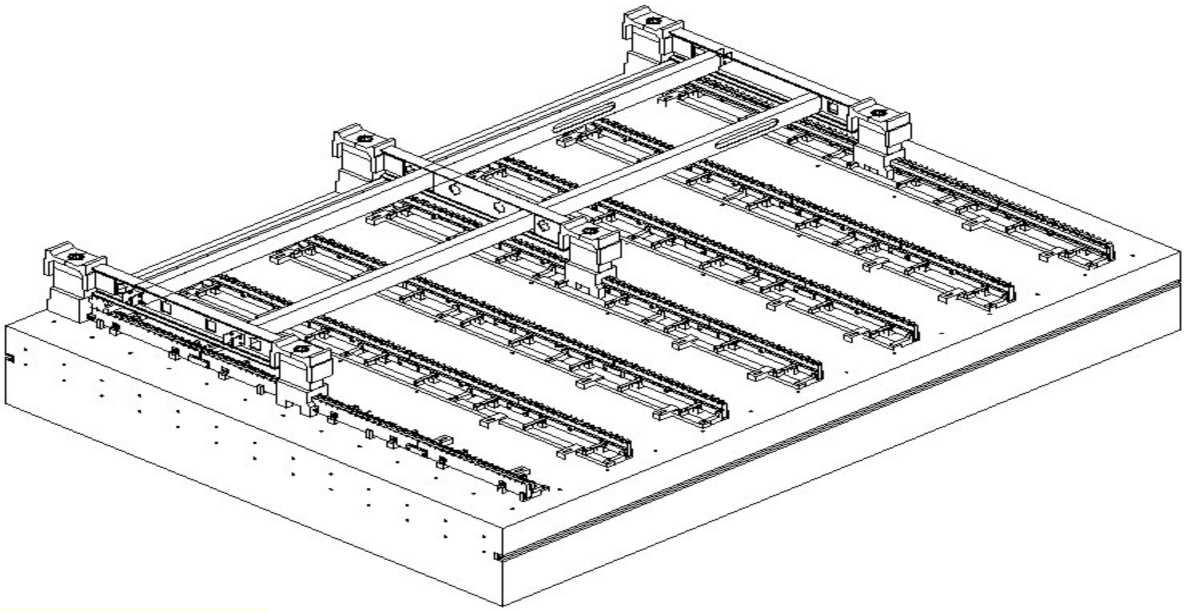
field lens
diffusor
coded mask
projection
lens
CCD
sensor
I.R.
LED
2*f
2*f
RS170
X=24.742
Y=-0.227
PC + framegrabber

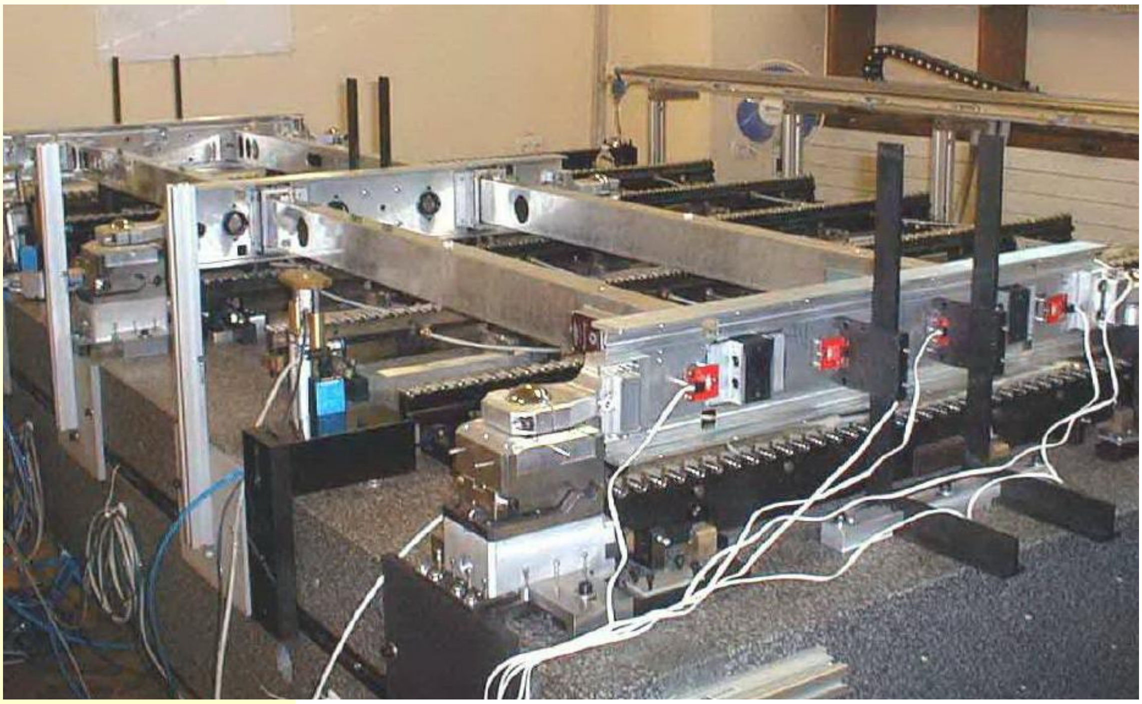


In-plane alignment
BO
BM
Projective
alignment
BI
Axial
alignment
z

MDT Production. Step#1

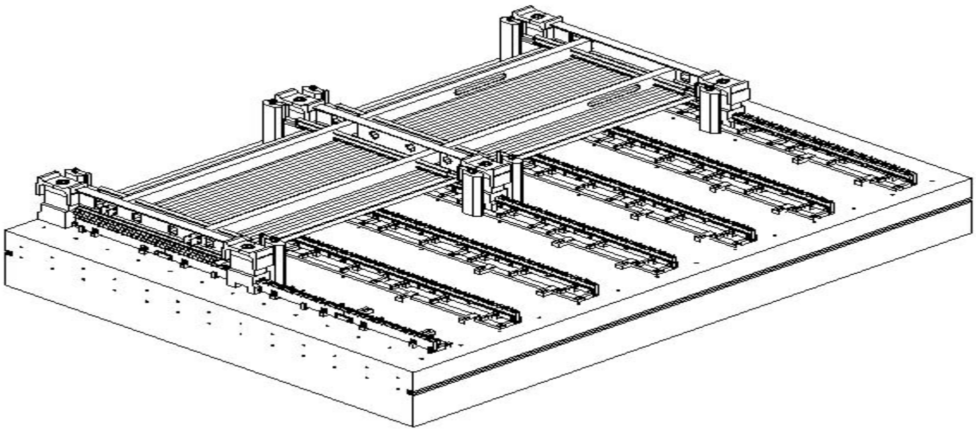
Spacer assembling





MDT Production. Step#2

First layer gluing

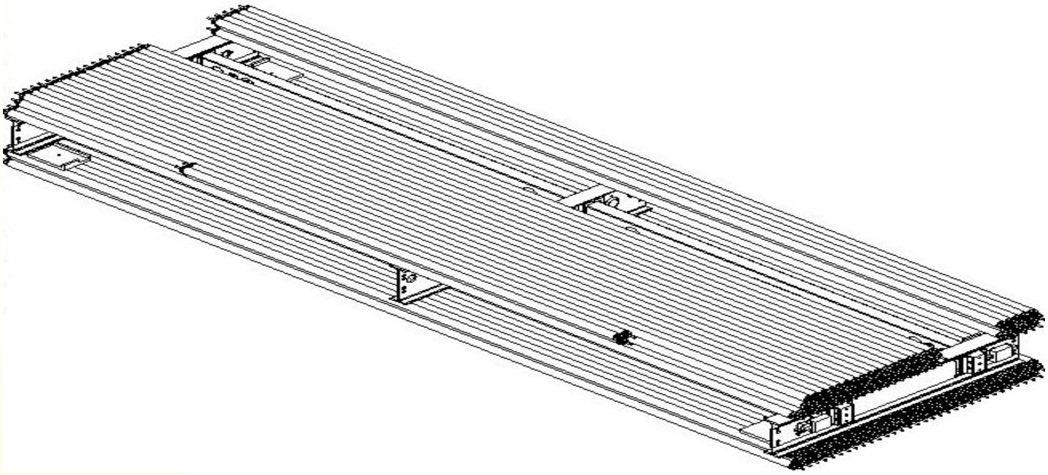


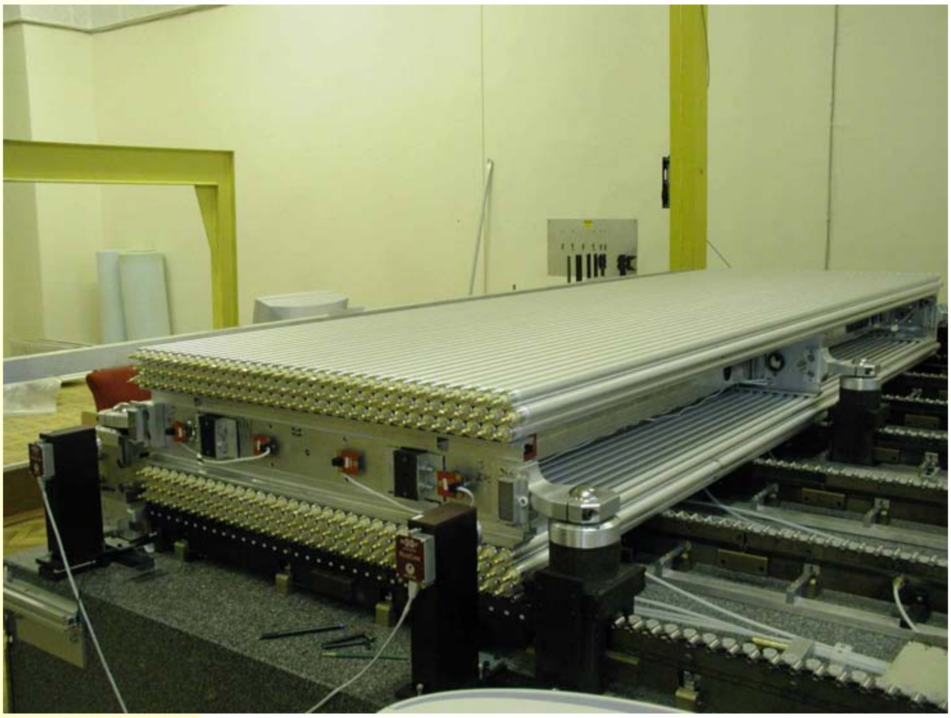
MDT Production. Final step

Step#3 →Turn up-side down. 2nd layer gluing

Step#4 →Turn up-side down. 3d layer gluing

Step#5-7 →Turn up-side down. Next layer gluing





Authors (not all)

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31

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31

31

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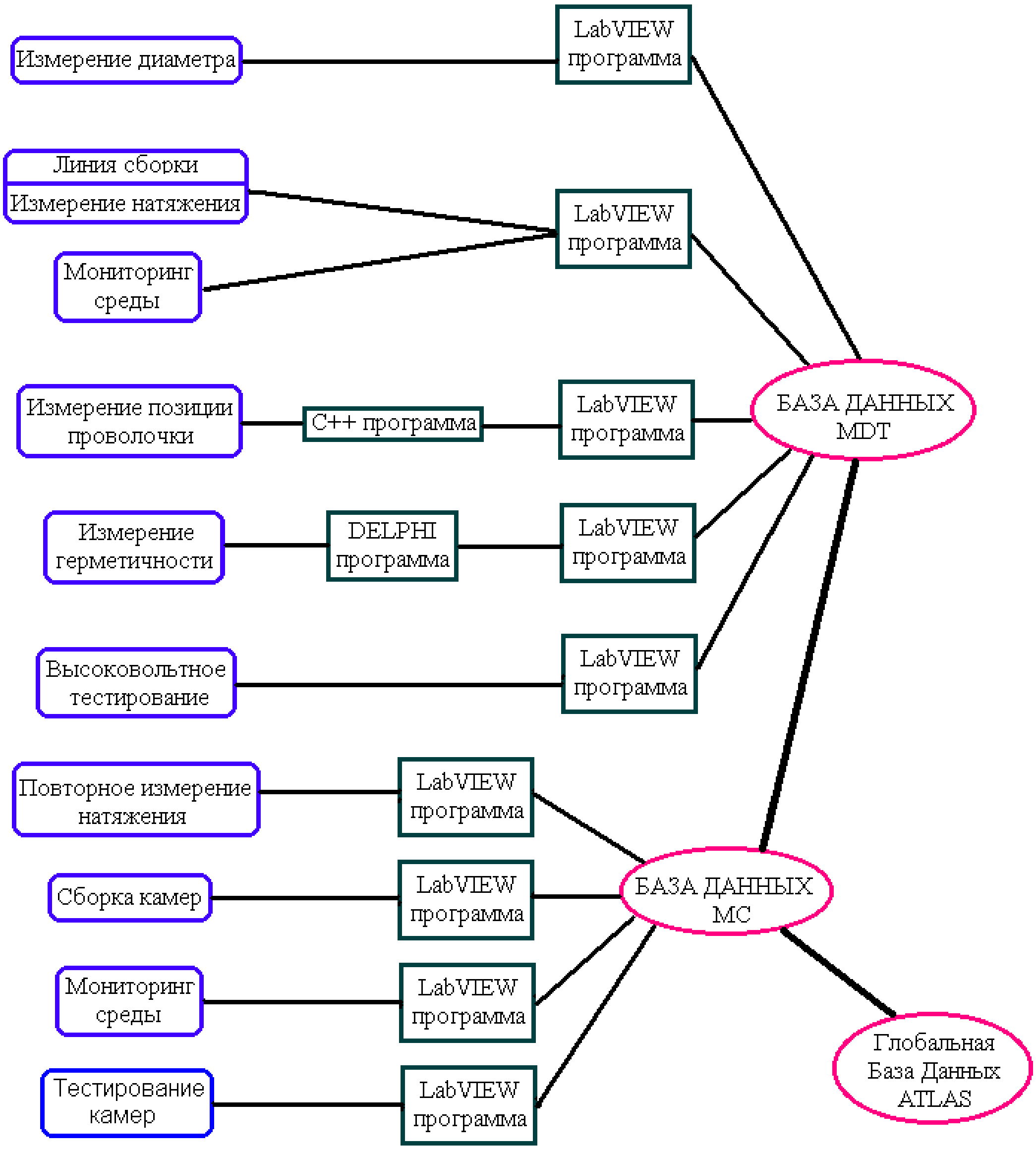
22

Data collection system



Workshop photos