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ATLAS

BIL Chamber Tests in Roma Tre

A. Baroncelli, P. Branchini, F. Ceradini, I. Di Sarcina, M. Iodice, D. Orestano, A. Passeri, F. Pastore F. Petrucci, E. Spiriti, A. Tonazzo

Dipartimento di Fisica, Università Roma Tre
and INFN, Sezione di Roma III

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Abstract

The ATLAS group of INFN and Roma Tre University is responsible for the test and certification of 60 Barrel Inner Large MDT chambers for the ATLAS muon spectrometer.

The gas distribution assembling techniques, the Quality Assurance and Quality Control (QA/QC) tests, the MDT read out and data acquisition at the cosmic ray stand and the standard analysis performed to certify the chambers performance are described.

Our man power time estimate for each procedure is also reported. A section is dedicated to the procedures adopted to certify the chambers, together with a proposal for a "Chamber Certification Document" which should be used as a reference document for each assembled, equipped and tested chamber. Finally, a status report of the first 10% Roma Tre QA/QC test is provided.

1 Introduction

The Quality Assurance and Quality Control tests of Barrel Inner (BIL, BIM and BIR) chambers are main responsibilities of the Roma Tre ATLAS group. The tubes are wired in Cosenza, the MDT chambers are built in Roma "La Sapienza" at a rate of one in fifteen days and transported to Roma Tre. In our laboratory the chambers are equipped with the gas distribution system, HV and front-end electronics boards. The gas tightness and high voltage behaviour are tested and chambers performance with cosmic rays is studied. The chambers hence undergo to a standard certification procedure.

2 Chamber gas distribution system

The MDT chambers operate at 3 bar absolute pressure with an $ArCO_2$ (93/7) gas mixture. The gas leak rate must be below 10^{-8} *bar·l/s* for each drift tube end connection. During ATLAS nominal operating conditions the gas flow will be of one volume per day. The drift tubes assembled on the chambers are already checked for gas leaks at the construction sites before chamber assembly and those with leaks higher than 10^{-8} *bar·l/s* are rejected.

The chambers are connected to the gas distribution lines by means of four gas manifolds (gas-bars), one for the inlet and one for the outlet of each multilayer. The connection between the gas-bar and the drift tubes is made by small tubes (tubelets) supplying a series of three drift tubes. The serial connection between these tubes is ensured by jumpers (Fig. 1).

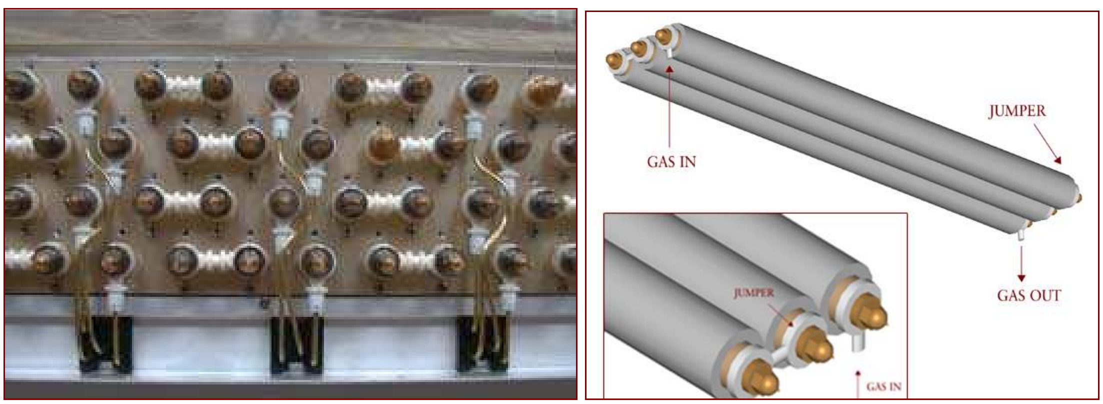

Fig. 1 Three drift tubes serial gas distribution layout.

2.1 Gas-bar assembly

The first phase in the gas distribution system assembly is represented by the gas-bar mechanical machining, cleaning and welding. The general layout of the gas-bar and the details of the hole design are reported in *Fig. 2*a and *Fig. 2*b.

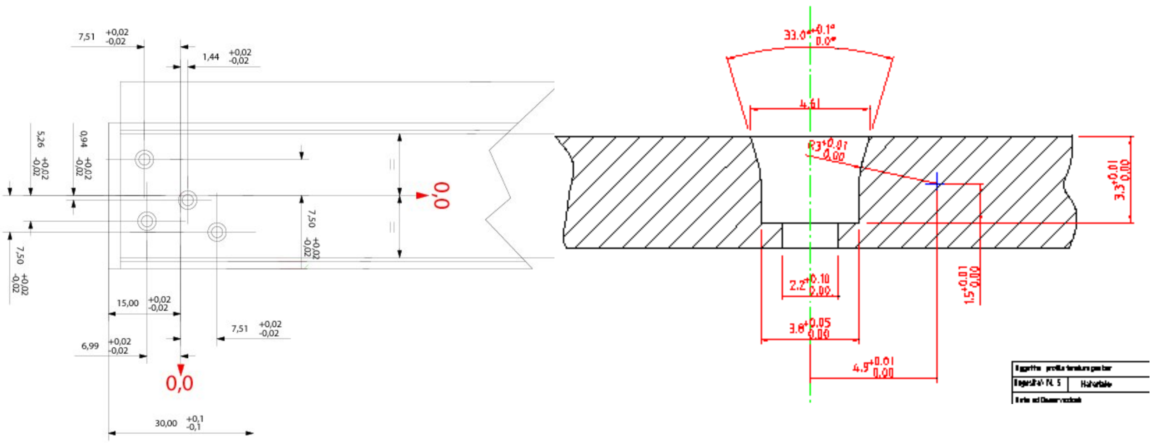

Fig. 2 Gas bar layout. a) Hole position for tubelets; b) The hole profile detail.

The tubelet mounting procedure is shown in Fig. 3 and consists of the following steps:

i) *snap ring (7)* mounting on the tubelets;
ii) *gas connector (8)* insertion with O-rings *(9)*;
iii) tubelet assembly *on connector plate (1)* through *fixation rings (6)*;
iv) mounting of the four tubelets assembled group (Fig. 3b) on the *gas-bar*.

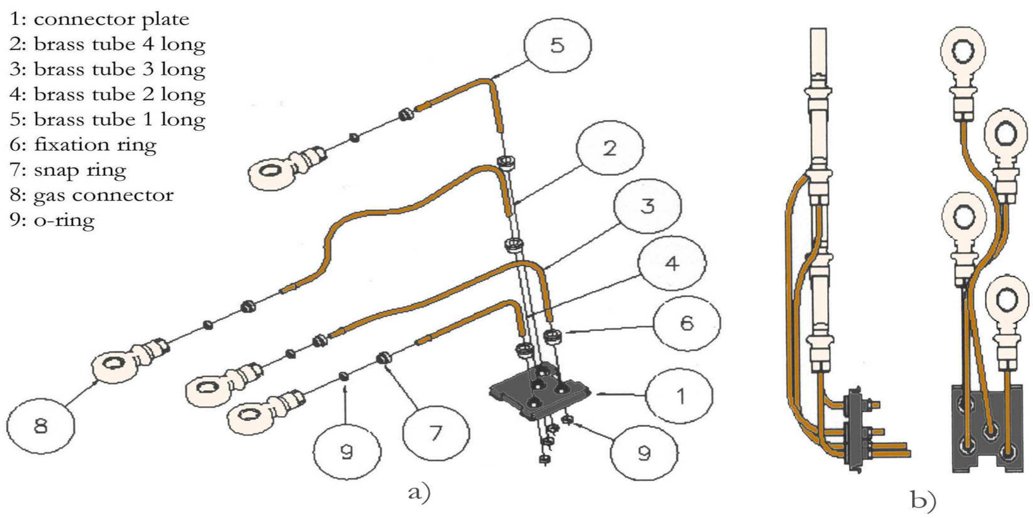

Fig. 3 Gas system tubelets assembly

Our time estimate for the gas-bars assembly for one chamber is the following:

- tubelet preparation (snap rings + gas connectors) : 1 person for 8 hours per chamber (4 gas-bars);
- tubelet assembly on connector plates : 1 person for 5 hours per chamber (4 gas-bars);
- assembly of connector plates on gas-bar : 1 person for 4 hours per chamber (4 gas-bars);

In total: 2 - 2.5 man-days/chamber.

In our laboratory we will assemble 60 barrel chambers divided in groups of different length: 38 chambers with 36 drift tubes per layer, 20 with 30 tubes per layer and 2 with 24 tubes per layer. Hence a total of 240 gas-bars have to be built, equipped and tested with a total of 10752 tubelets, and 21504 O-rings.

2.2 On Chamber Gas Distribution Assembly

The procedure followed to mount the gas-bars and the jumpers on the chamber is schematically described in the present section.

The first step is the measurement of the end-plug misalignment at each drift tube end in order to select the appropriate jumper for each tube pair. The jumpers are produced in three types with calibrated surfaces steps to account for possible non planarity of the end-plug surfaces. As shown in Fig. 4, misalignments up to 300 μm can be re-absorbed by the choice of the corresponding jumper.
Once a map of the end-plug planarity is produced, the ground plate is fixed on the chamber, the O-ring location on the end-plugs is carefully cleaned with alcohol and the jumpers are finally mounted.

The next step is the gas-bar leak test, described in the next section. Four certified gas-bars are then mounted on the chamber and fixed through five screws per gas-bar to the cross-plate. A small (variable) spacer is placed between the gas-bar and the cross plate to avoid stresses on the tubelets.

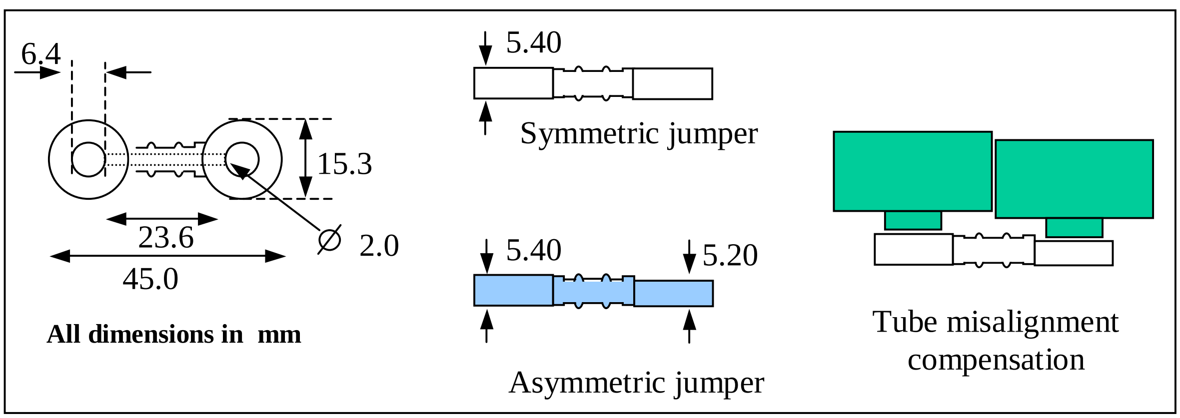

Fig. 4 Sketch of the jumpers profile and drift tube assembly misalignment compensation.

This chamber preparation, jumper and gas-bars mounting phases are estimated to take about 1.5 man-days. Finally the single multilayer and then the full chamber leak tests are carried out, as described in the next section.

2.3 Gas Leak Tests

The main tool adopted for gas leak rate measurements at reference pressure of 3 bar and higher, is a sensitive differential manometer [1]. The scheme of the system is shown in Fig. 5. Gas leaks are detected by monitoring the difference in pressure between the chamber (or the gas-bar under test) and a reference volume assumed (and checked) to be gas tight. In Fig. 5 P1 and P2 represent the two sides of the differential manometer.

The operating procedure is straightforward: to fill the system the valve on the outlet line is closed and the valves 1 and 2 are open. When the requested pressure is reached, after few hours needed to stabilise the system for temperature effects, the two valves (1 and 2) are closed and the volumes (the chamber/gas-bar and the reference) are decoupled. Any leak on the volume under test will be measured as a positive increment of $\Delta P = P2 - P1$. The differential manometer gives a current signal proportional to the ΔP value which is read-out by a National Instruments interface [2] and recorded by a DAQ system based on LabView [3].

The manometer operates with a linear response in a ΔP range of $\pm$ 8 *mbar* and has a sensitivity of 1% of the full range.

During debugging, and usually before the tests with the differential manometer, we use both a portable sniffer [4] based on a thermal conductivity cell sensitive to Ar, CO_2 and other gasses and a mass spectrometer helium detector [5]. The portable sniffer is very useful and frequently used for preliminary checks, mainly to find leaks larger than 10^{-4} *ml/s.* For smaller leaks the He detector is needed, which can be used both in “vacuum” mode and in “sniffing” mode. We mainly use it in vacuum mode for the single gas-bar test, while, for the whole chamber we use it in sniffing mode after filling the chamber with Ar/CO_2 gas mixture with an addition of about 5 % of Helium.

Fig. 5 The differential manometer based gas leak test layout.

Taking into account the ATLAS requirements (see sect. 2), for a *n* drift tubes chamber, the maximum pressure drop is expressed as:

$$\Delta P = \frac{Q}{V_{tot}} = \frac{n \cdot 2 \cdot 10^{-8} bar \cdot l/s}{nV_{tube}} = \frac{2 \cdot 10^{-8} bar \cdot l/s}{V_{tube}} = 10^{-5} mbar/s \approx 1 mbar/day$$

where Q represents the maximum allowed gas leak rate for n drift tubes, V_{tube} is the single tube volume ($V_{tube} = \pi\,(1.5)^2\,267\ cm^3$ = 1.9 liters). The pressure drop limit is hence independent of the number of tubes and only depends on the volume of the single tube. The maximum leak rate of **1 mbar per day** is the same for the whole chamber or for a single multilayer.

2.3.1 GAS-BAR LEAK TEST

If we assume possible leaks to come only from the gas connections (both from the gas-bar connector plate and from the jumpers) and not from the drift tubes, the maximum pressure drop for a single gas-bar is:

$$\Delta P_{gasbar} = \Delta P_{multilayer} \cdot \left(\frac{V_{multilayer}}{V_{gasbar}}\right) \cdot \frac{1}{2} \cdot \frac{1}{n_{serialtubes}} \approx 1 mbar/day \cdot 443 \cdot \frac{1}{2} \frac{1}{n_{serialtubes}}$$

where the factor 2 accounts for the two connections of each drift tube and $n_{serialtubes}$ accounts for the fact that similar leaks can occur from jumper connections. For the three tubes serial distribution ($n_{serialtubes}$ = 3) the maximum allowed pressure drop is **3 mbar/hour**, while it is **9 mbar/hour** for the full parallel system ($n_{serialtubes}$ = 1).
Each gas-bar is tested individually by mounting it on an aluminium mock-up that closes all outlets (from the gas connectors) as it would be when mounted on a multilayer. A quick check is first done with the use of the portable sniffer. A finer check is then performed with the helium mass spectrometer detector in vacuum mode. In Fig. 6 the system is shown with the gas-bar positioned on the mock-up.
The gas-bar is connected via a stainless steel tombak to the vacuum pump of the instrument. When a vacuum level of about 10^{-6} mbar is reached, the test can start. A light breath of helium is directed from outside towards each tubelet connection, checking for detection of helium penetrated inside the gas-bar. At this occurrence the most frequent solution is the replacement of the whole group of four tubelets.
When no leaks are found, the quantitative test with the differential manometer is finally performed. In Fig. 7 , a typical plot of the pressure drop for a gas-bar as a function of time, is reported. The superimposed line shows a pressure drop of 1.2 mbar/hour measured at 4 bar, within the specifications of < 3 mbar/hour at 3 bar.

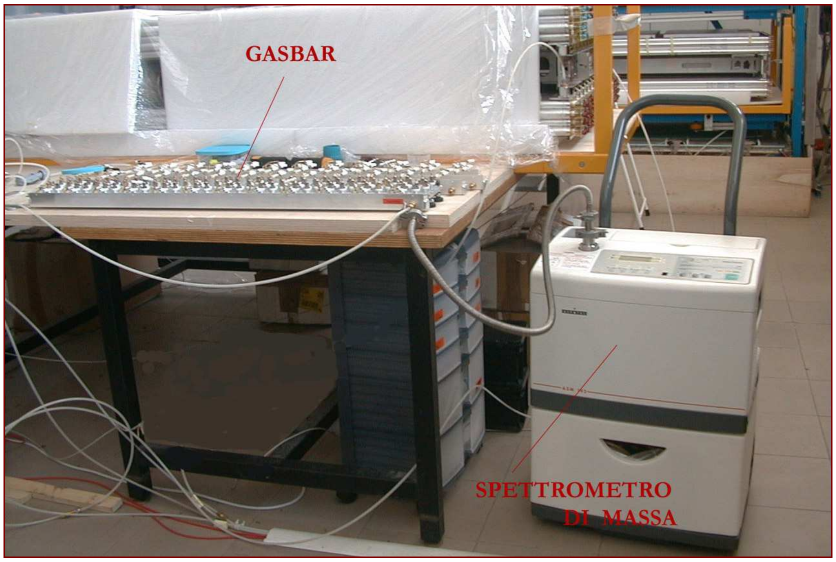

Fig. 6 Helium mass spectrometer detector used for gas leak test, connected to a gas-bar placed on a mock-up.

Elapsed time (hour)

Fig. 7 Pressure drop vs. time for a gas-bar as measured by the differential manometer.

After the test, the gas-bar is dismounted from the mock-up and stored, ready to be mounted on the chamber.
The time estimate to carry out the described test for four gas-bars can vary from 2 to 3 days.

2.3.2 CHAMBER LEAK TEST

Once the gas-bars are checked to be gas tight, the full gas distribution system (gas-bar and jumpers) is mounted on the chamber, as described in section 2.2. The test of the chamber is similar to that of the gas-bar.

A leak rate of about 1 mbar/day can in principle be measured with the differential manometer in few hours but, when dealing with a chamber, temperature effects become a major problem. A differential pressure measurement is not sensitive to temperature variations, but the different thermal capacitances and conductivities of the volumes cause a different response of the chamber and of the reference volume to temperature variations. Moreover, temperature gradients can arise over the large gas volume of the chamber, as drift tubes in the centre or at the border are differently exposed to external temperature variations. As it is not easy to model these effects to correct for temperature variations, the measurement is extended for at least 2 days (usually during the weekend) to evaluate pressure differences over periods in which the temperature effects can be monitored. To minimise temperature effects, a large insulating box to contain both the chamber and the reference volume has been recently built and will be used in the future. The plots shown in Fig. 8a refer to the measured pressure drop of chamber BIL2A01 which has a leak rate of about 2 mbar/day. Oscillations caused by temperature variations (also induced by working activities on the chamber) are clearly visible.

Fig. 8 a) leak test on chamber BIL2A01; b) leak test on chamber BIL6C01.

With similar plots, Fig. 8b demonstrates the occurrence of a large leak after several hours of very good behaviour. In several cases, in fact, we have experienced serious problems with developments of leaks in parts previously checked to be gas tight, in analogy of the experience already reported by the Michigan group [6]. The main source of such a problem has been identified, independently by different groups, in the development of cracks in the tubelets, due to the brass material quality, treatment and machining.

All these problems had an important impact on the man power necessary to bring the chambers within specifications for gas leak. Although the gas-bars mounted on the chambers were already tested, during the (long) tests of the chambers we end-up with a high failure rate of tubelets, up to about 6 per multilayer (about 6% of tubelets).
Based on our experience this test lasts for at least 7 days and requires at least 2 man-days but may take much longer in presence of tubelets failures and when several small leaks difficult to locate occur.
This test certainly slowed down all the QA/QC chain test, so far, and we hope to speed-up this part with the new tubelets.

2.4 On Chamber Gas System Man Power Needs

Based on our experience, the man-power needed for a complete gas distribution construction, assembly, mounting, and test, is summarised in Table 1

Gas bar related Item	Man power (man-days)	Time (days)	Chamber related Item	Man power (man-days)	Time (days)
Gas bar assembly Gas bar tests	2.5 2.5	2.5 2.5	On chamber mounting Chamber tests	1.5 > 2	1.5 > 7
Total gas bar	5	5	Total chamber	> 3.5	> 8.5

Table 1 Man-power and time needed for complete gas distribution construction, assembly, mounting and test. Time includes the measurements done overnight and during weekend.

Operations on gas-bars are listed separately from the ones on the chamber since they can be carried out independently and eventually in parallel to the chamber equipment and test. On the other hand the time required by the on-chamber operations can't be compressed and reflects directly into the production schedule.

3 High Voltage Test

When a chamber has been validated by the gas leak test, it is flushed with the Ar/CO_2 gas mixture (four volumes exchange at 3 bar) and then filled at the working pressure of 3 bar.
The next step is the equipment with HV boards and front-end electronics. For the first four chambers shipped to CERN the final HV boards were not available and tests were

performed using prototype boards. The electronics for the full final read-out chain is still not available and a test pre-production is used both for mezzanines and signal hedgehogs, therefore final hedgehogs are not tested and not connected to the chambers yet.
The chamber is connected to the HV power supply and the HV is slowly increased monitoring the current drawn by the chamber; this has to be less than 5 nA per tube, less than 750 nA per multilayer. Chambers are tested at 3400 V (10% larger than the operation voltage of 3080 V) for few hours. Up to now, 8 chambers have been tested and no problems with the HV distribution has been found.
The HV and electronic boards equipping procedure takes about 3 man-hours. The HV test is about 4 hours long.
The next step is the Faraday cage mounting which takes about 2 man-hours.

4 Chamber read-out at the Cosmic Ray Stand

For the read-out test and certification of the BIL, BIM and BIR chambers, in Roma Tre a cosmic ray hodoscope [7] that reproduces on a smaller scale the MDT configuration in the ATLAS spectrometer has been built. The hodoscope provides an almost uniform illumination of the whole chamber surface and allows for the simultaneous operation of three chambers.
Three planes of RPC measure the coordinate along the drift tubes and provide a fast trigger with a time resolution of about 1 ns. Each plane of RPC cover a surface of 288x124 cm^2; the distance between the lower two planes is 12 cm and they are separated by 5.5 cm of lead. The third plane, at a distance 2.4 m from the middle one, is positioned on top of a rigid structure made of iron square tubes.
Each MDT chamber is inserted in the hodoscope in its own frame (used also for transportation) and positioned on a movable drawer. Reference marks ensure an accuracy of 0.1 mm on the chambers' positioning. During tests a gas flow rate of approximately one volume per day (at 3 bar) is mantained.
The RPC trigger information is divided in 6 regions (towers) in the coordinate along the MDT wires. With this configuration, usually adopted for chamber performance studies, the cosmic event acquisition rate is about 20 Hz. In 24 hours data taking, a sample of about 1.5 million events can be collected. In Fig. 9 the cosmic rays stand experimental layout is shown. More details about the hodoscope can be found in [7].

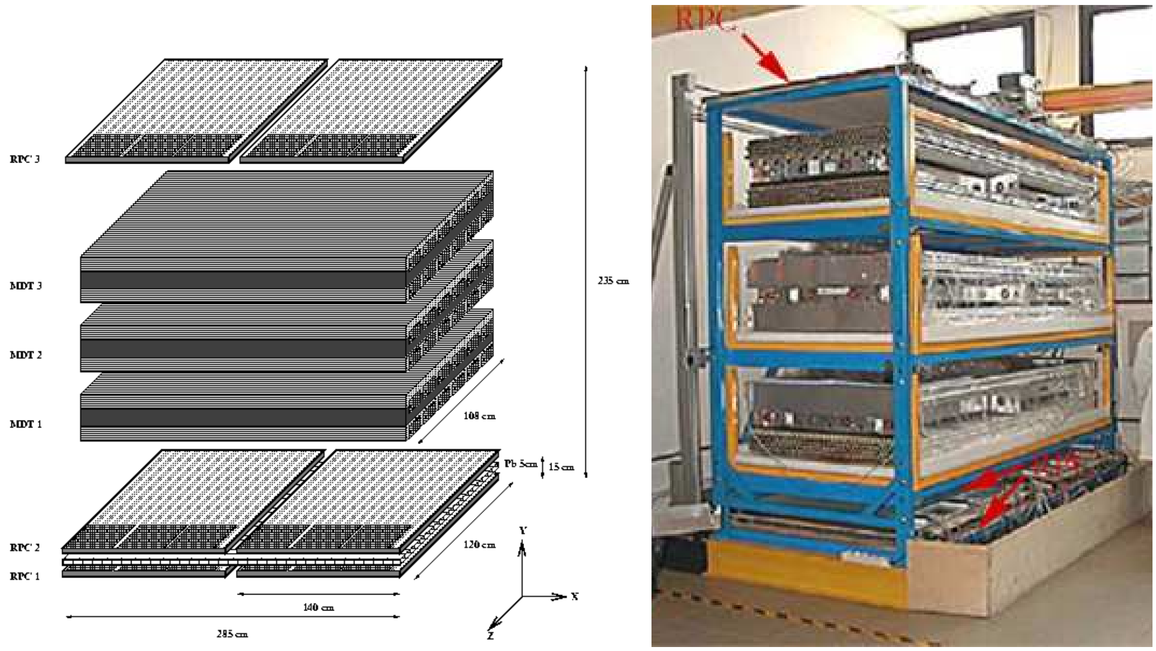

Fig. 9 Cosmic Rays Stand Experimental Layout.

4.1 Data Acquisition

The data acquisition, DAQ, of the cosmic ray test stand was designed to sustain a trigger rate of about 100 Hz with an average data size of about 500 bytes per event. The DAQ system is a VME based architecture. In its standard version, it consists of 3 Chamber Service Modules CSM0 [8] reading the events from the front-end level 1 buffer of the Chamber TDCs and perform single chamber event building. The mezzanine [9] front-end boards we are using hosts eight 4-fold ASDs and a 24 channel TDC AMT1.
The discriminator threshold is programmable via a JTAG interface hosted on the CSM and it is set to 60 mV. The timing information coming from each of the 6 towers is encoded with a 1.04 ns count TDC. The RPC strip information from the trigger telescope is digitized and sent to a hardware Fifo. Finally the hardware Fifo, the RPC TDC and the CSMs are all acquired through the VME bus.

The on-line processes are distributed over several nodes in the acquisition network, therefore they have to communicate by means of an efficient message system. All processes have to change their state of activity coherently, following local or remote commands. Monitoring of the process activity should not interfere with its cooperation in moving data. A message system based on Simple Network Management Protocol, SMNP, developed in the KLOE Collaboration [10] is used.
A Command is delivered to a process sending an interrupt to it. The procedure which is used to deliver commands is the *ask* utility which is active over the same node where the command has to be delivered. To distribute the commands to the various nodes a library based on remote procedure call has been developed.

Processes involved in the 'DAQ stream', from the front end electronics to the on line farm-disk, are shown in Fig. 10. The *Collector* initializes the hardware modules in its VME chain and, in case of failure, executes debugging instructions to identify possible error sources. When the initialization phase is over it reads the front end Fifo using BLT cycles over the VME bus. Events are stored in a shared memory with a Fifo structure. The *Sender* which runs asynchronously with respect to the *Collector*, extracts packets from the shared memory and sends them to the farm using TCP/IP connections that remain open throughout the run activity. The *Receiver* reads data coming from the *Sender* and loads it in a shared memory with a Fifo structure. The *Farmwrite* process runs asynchronously with respect to the *Receiver* and then writes the events to disk.

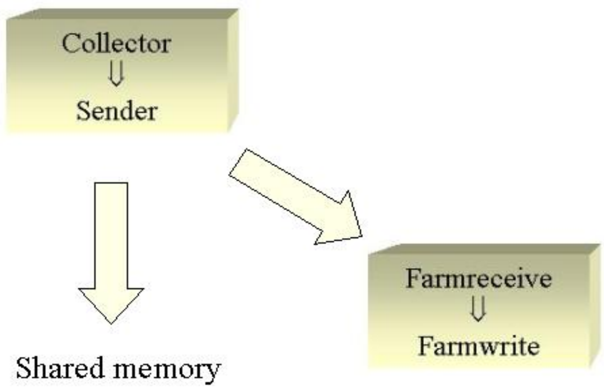

Fig. 10 Schematics of the data moving processes.

A user interface based on Motif has been developed to deliver commands to the DAQ. This interface is written in “ansi C” therefore is fully portable and can run on any UNIX based system which contains standard Motif library.

4.2 Data analysis

When a chamber is ready to take data, some standard analysis is performed “quasi-on-line” in order to optimise the electronics and read-out set-up (e.g. to reduce the noise level, to fix fake cable or Faraday cage contacts, etc.) and to bring the chamber to optimal conditions for a large cosmic tracks data sample acquisition. The data monitoring and analysis are based on the *Calib* package [11]. In the following subsections, examples of the adopted standard procedures are reported.

4.2.1 TUBE MAPS AND NOISE LEVEL

The first check is related to the noise level detected with a random trigger. The standard procedure consists of the acquisition of 100K random trigger events with the chamber

HV off to check for major problems, usually due to bad groundings or bad faraday cage contacts. Then another sample of 100K events with HV on at the nominal voltage of 3080 V is collected.
The noise level is evaluated from the distributions (maps) of tube occupancy. If noisy channels are spotted, interventions on the electronic set-up are performed.
In Fig. 11 an example of the tube map occupancy obtained with HV ON in a sample of 100K random trigger events is reported for the upper multilayer of chamber BIL6A05 before any intervention (red) and after the electronic set-up optimisation (blue). In this scale a single tube noise level of 1KHz corresponds to 200 entries. After interventions all tubes have a noise level below 200 Hz.
Most common sources of troubles are related to bad grounding between hedgehog and ground plate. In these cases one should identify the channel, dismount the hedgehog(s), tighten screws and pins, mount it back. Troubles can be also due to connections of mezzanine to adapter: a clean cabling helps.
Less common troubles (occurred twice) can be due to noisy capacitors (same operation as before but improving ground doesn't help, then change the signal hedgehog).
In all cases a minimal data tacking, as reported in this sub-section is necessary and a clever and reliable debugging program is needed.
In order to optimize the effort for this debugging phase, it is important to define the maximum single-channel noise, how many noisy channels per chamber and how many dead channels per chamber can be left (at least for now with not final electronics).
As a rule, only when the noise level is less than 1-2 KHz per tube, the acquisition is switched to cosmic trigger.

The "electronic set-up" phase takes about 1 man-days.

4.2.2 COSMIC DATA ANALYSIS

In order to monitor the performance of the chamber with good accuracy, a sample of at least 20000 cosmic events per tube is needed. With our set-up, such a statistics is reached for nearly all tubes with samples of at least one million events per chamber, collected in one night in cosmic trigger mode.

The first check is based on the tube occupancy and allows us to spot malfunctioning channels, such as dead tube or noisy electronics channels, and fix them when possible. Typical distributions, with the peculiar "Panettone-like" shape due to the trigger angular coverage, are shown in Fig. 12. The identification of dead and noisy channels is straightforward. Fig. 12 left (linear scale) shows that three tubes are missing (these are the same tubes with broken wires). Fig. 12 right (log scale) shows six missing and one noisy tubes (there are three tubes with broken wires while the read-out problem of the other three tubes was fixed afterwards).

Fig. 11 Channel occupancy plot for one multilayer in a typical random trigger run with HV on, before (red) and after (blue) electronic optimization. In this scale, with 100K random trigger events, a noise rate of 1KHz corresponds to 200 counts.

Chamber RM012: central position

Chamber RM007: top position

*Fig. 12 Channel occupancy plots in cosmic runs for two chambers, located in the central (left, linear scale) and the top position of the cosmic test stand (right, log scale). Tube number = (1:36)*layer.*

Fig. 13 Drift time spectra (in TDC counts) in two different tubes, with the fit described in the text.

The following step of the chambers' performance monitoring is based on the analysis of the time spectrum of each tube. Typical spectra are shown in Fig. 13 in TDC counts, the bin width being 2*0.78=1.56 ns. Each spectrum is fitted with the function [12]:

$$N(t) = P_1 + \frac{P_2\left[1 + P_3 \exp\left(\frac{P_5 - t}{P_4}\right)\right]}{\left[1 + \exp\left(\frac{P_5 - t}{P_7}\right)\right]\left[1 + \exp\left(\frac{t - P_6}{P_8}\right)\right]}$$

where N(t) is the number of hits in each time interval, and the values of the parameters P_1... P_8 are fitted, using the maximum likelihood method. P_1 represents the amount of uncorrelated background, P_4 describe the slope of the distribution. P_5 and P_6 correspond to the minimum and maximum drift time, hereafter referred to as T_0 and T_{max} respectively. The parameters P_7 and P_8 describe the rise of the leading and trailing edges. Distributions of the fitted parameter values for one chamber are shown in Fig. 14.
The multi-peak behaviour of the total drift time distribution (top-left panel) is discussed later (see Fig. 15).
An automated procedure has been developed to spot significant deviations of the drift time distribution from the reference spectrum, which can be an indication of problems in the tube, such as noise or gas contamination. The following quantities are checked:

- tube occupancy: for each tube, the number of entries is required to be between 2 and 0.5 times the average of the adjacent tubes;
- quality of the fit, inferred from the χ^2;
- noise level, computed from the P_1 parameter;
- maximum drift time, given by Tmax-T0;
- slope of the distribution, described by the value of the P4 parameter.

Fig. 14 Distributions of the parameters obtained from the fit to the time spectra of all tubes in one chamber.

Fig. 15 Length of the drift time spectrum in all tubes of one chamber.

Each of these quantities should not differ by more than 3 RMS from the average of the distribution over the tubes in the chamber.

The results of the time spectrum analysis can be summarised as in Fig. 15: the length of the drift time spectrum, T_{MAX}-T_0, in each tube is plotted, and the tubes with some parameter lying outside the tolerance range quoted above are marked.
The spectra of the marked tubes are then inspected in detail to check whether the anomaly is relevant. The modular variation of the length of the drift time spectrum has already been observed in 2002 H8 test beam on chambers equipped with serial gas distribution, and its analysis with cosmic data in Roma Tre will be presented in 13.

In Fig. 16 we report examples of spectra with parameters P_1 (noise Fig. 16a) and P_4 (top distribution slope - Fig. 16b) outside tolerances. Further analysis demonstrated that the behaviour of these tubes is acceptable.

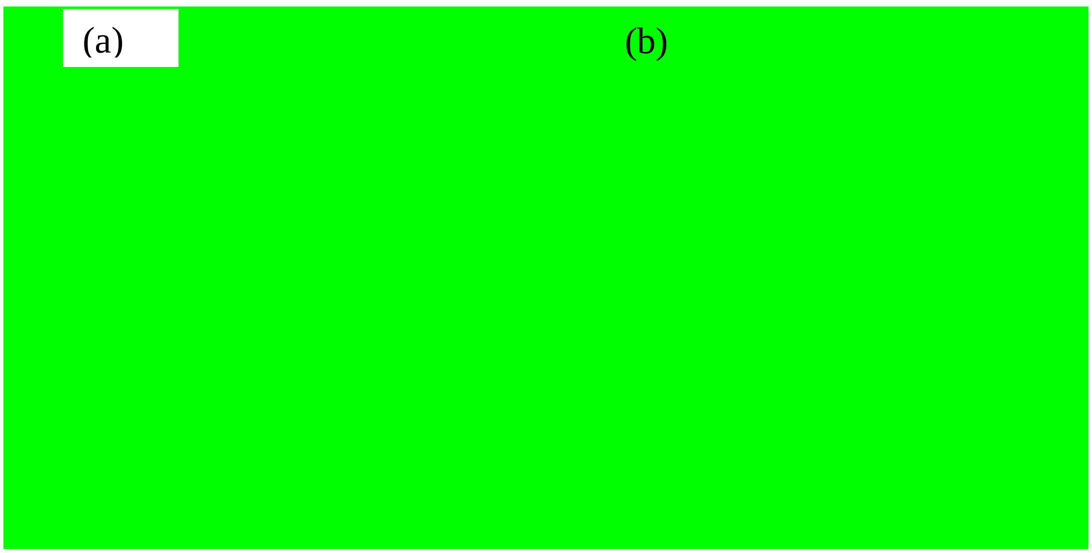

Fig. 16 Spectra checked for anomalies: parameters P_1 (a) and P_4 (b) outside tolerances.

A further step in the data analysis consists of the fit of the time spectra in each of the 6 trigger towers along the wire coordinate, in order to verify the uniformity of the wire response along its length. The length of the drift spectrum as a function of the trigger tower in one chamber is shown in Fig. 17. There seems to be a systematic dependence of the spectrum length on the position along the wire, that could be attributed either to temperature or sagitta effects, which is under investigation [13].

BIL2A01

Fig. 17 Drift time spectrum length (ns) as a function of the trigger tower number, defining the position along the tube coordinate. Each trigger tower spans over 46 cm along the MDT tube. Different symbols represent different run of the same chamber.

The data taking time to perform all these standard checks usually takes about 2 days. However each chamber can be left on the hodoscope for up to 2-3 weeks allowing for long term stability checks.
A more detailed analysis of the chambers' performance includes computation of the R-T relations, resolution studies, chamber alignment and track reconstruction and will be described in 13 .

5 Chamber Certification

In this section we report a proposal for a "Chamber Certification Document" to be produced for each chamber after assembly and QA/AC tests completion. It should be noted that the chambers produced so far are not fully equipped with all the services and final electronics, many components being still unavailable in the final form. Some information that should be included in the document is therefore still missing and not considered here. Moreover the relevant information on the chamber is also reported in the MMPDB DATABASE [14].
The document is hence meant for an easy access to the chamber validation tests and for inspection of significant plots.

5.1 Chamber Certification Document

The Chamber Certification Document includes:

- chamber type and location;
- chamber gas distribution type (serial or parallel);
- identification of gas-bars and their measured gas leak;

- measured gas leak, together with the plots showing the pressure drop versus time, (cfr. Fig. 8a);
- problems with current leak;
- the map of bad channels (cfr. Fig. 18);
- plots summarising the relevant information obtained from the cosmic data analysis:
    - channel occupancy maps (cfr. Fig. 12);
    - distributions of the fit parameters (cfr. Fig. 14);
    - map of channels with anomalies in the drift time distribution (cfr. Fig. 15).

Fig. 18 Channel map for chamber BIL2A01 (the HV final hedgehog were left on the chamber after test).

5.2 The first 10%.

In the period March 2002 - January 2003, we have equipped and tested 8 chambers (see table 2) representing more than 10% of the Roma chamber production. The average assembly and QA/QC test rate was rather slow. The causes were at the beginning mainly due to our training phase and tools set-up, later, the main issue was the chamber gas leak test as discussed in section 2. In Fig. 19 present equipment and QA/QC test schedule is reported.

	Serial Number	Gas Distribution	Gas leak @ 3 bar	Curr/ML @ 3.4 KV	Disconn Wires	HV hedgehogs	Data Analysis
RM-006	BIL4A05	Parallel	2 mbar/d	< 100 nA		YES	YES
RM-004	BIL2A05	Parallel	<1 mbar/d	< 100 nA			YES
RM-003	BIL6A01	Serial	1.4 mbar/d	< 100 nA	1		YES
RM-001	BIL2A01	Serial	2 mbar/d	< 100 nA	3	YES	YES
RM-008	BIL2A09	Serial	7 mbar/d	< 100 nA		YES	YES
RM-013	BIL6C01	Serial	<1 mbar/d	< 100 nA	4		YES
RM-012	BIL4C01	Serial	<1 mbar/d	< 100 nA	3		YES
RM-007	BIL6A05	Serial	<1 mbar/d	< 100 nA	3	YES	YES

Table 2. January 2003 chamber equipment and QA/QC test status.

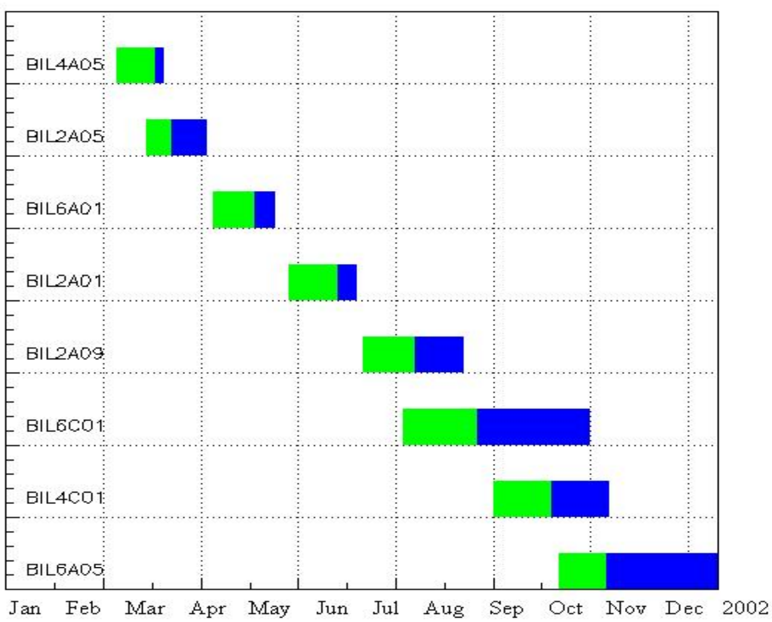

Fig. 19 Schedule of the first 8 chambers equipped and tested in Roma Tre. Green: gas distribution assembly and tests; blue: cosmic rays data taking.

6 Acknowledgements

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