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# Remarks on MWPC pre-installation tests

S. De Capua, G. Carboni, C. Bosio

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## 1 Introduction

In this note we try to draw our conclusions on chamber tests, in the light of the following information

- LNF FEE tests on more than 120 chambers
- recent CERN chambers test results
- discussions with several colleagues inside and outside meetings

The purpose is to fix a common mode of test, and to stop the somewhat anarchical development of testing software which is becoming extremely dangerous in this installation phase.

It has been generally agreed that all chambers will be subjected to two kind of tests prior installation:

1. a test of the FEE boards
2. a Cosmic Ray test

It has also been agreed that all the relevant information must be stored in the Chamber Database which also contains the consntruction data, in order to be able to reconstruct the history of any given chamber. It has to be remarked that this Database is not fully defined and is still evolving, so some modifications are still possible.

## 2 On-chamber FEE test

All the CARDIAC boards have been individually checked after burn-in at Eletis, therefore we do not expect to find many broken boards during the assembly and a new test of the cards before dressing is by no means necessary.

The On-chamber test FEE has the purpose of spotting problems either on the card (it should be a rare event) or on the interconnection with the chamber (e.g. defective SPB board, unsoldered connectors, unsoldered capacitors, shorts, broken signal lines from the pads to the FEE).

This test has already been performed in Frascati for INFN chambers and it is now being repeated at CERN. On the CERN and PNPI chambers it will performed immediately after the installation of the boards.

A full FEE test must check three things:

1. the correct response of the internal DIALOG counters and of the LVDS drivers, by injecting a suitable pulse train in the DIALOG. Inconsistencies between the number of injected and detected pulses may be due to internal chip problems or to problems on the output signal transmission (wrong levels or a bad cable, either lossy or noisy).

2. the appropriate noise behavior of the various channels, which is monitored by a threshold scan where the output count rate vs. threshold is recorded. In interpreting the shape of the curve one must include the effect of the chamber capacitance since this affects the noise of the preamplifier. It has been shown that the overall noise can be characterized by measuring the effective capacitance and its deviation from the real capacitance. Deviations indicate an abnormal behavior of the channel and also point out to disconnected or shorted channels. Fig. 1 shows the distribution of the measured capacitance of 4000 pads of M5R4 chambers. Pathological cases typically show up with values of $C > 300$ pF ("high-$C$").

   The noise behavior can be also estimated by eye or by performing some fits on the noise peaks. The first method is unsatisfactory since it is subjective and does not leave a recordable numerical information; the second can be quantitative but one should of course agree which kind of information should be recorded (amplitude, rms, slopes etc.) Since the capacitance information has been already used on the first large batch of chambers (INFN), we believe that the Muon Group should adopt this method uniformly for all chambers rather than developing alternative ideas at the very last minute.

3. the final requirement is that the chamber can be operated with an acceptable electronics noise rate. It has been agreed that this value corresponds to 100 Hz noise at a 14 fC threshold for wire readout and 8 fC for pad readout. There is nothing magic about these numbers, and in the experiment we could tolerate much higher values. However we will see that, in order to perform the Cosmic rays test (see later), the noise should be quite low. So the requirement of 100 Hz electronic noise is quite reasonable.

   Therefore the database should at least include the noise rate at this threshold and possibly at a few other threshold values (like 10 and 12 fC for wire readout chambers).

It is obvious that all the recorded data should of have a uniform format across the production sites.

The automatic test program (**Test A**) developed jointly by Roma 1 and Roma 2 fulfills all the above characteristics, including a barcode reader to record chamber and CARDIAC information automatically. It has been used on more than 120 chambers in LNF and is fully supported and constantly improved, and therefore should be adopted as the most efficient way to ensure a compatible test of the chambers from the various sites.

The use of different FEE test procedures is therefore to be discouraged and so is the development of new software (as suggested by PNPI) since it is basically a waste of time in a period when all the efforts should be directed to the actual chamber testing. It should be understood that, in any case, the format of the data should be precisely the same as the one provided by the Test A software in order to assure compatibility.

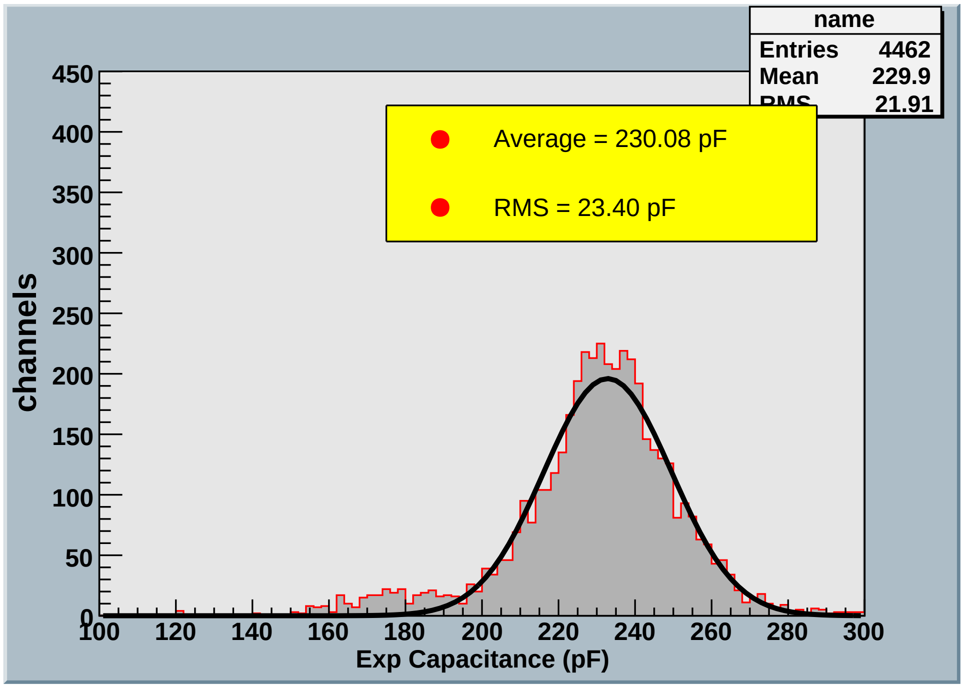


**Figure 1** Effective capacitance as measured for 4462 M5R4 wire pads. The expected capacitance is 230 pF. Chambers with $C > 300$ pF are considered suspect.

# 3 Cosmic Rays test

It has been agreed that the final validation should be given by a Cosmic Rays (CR) counting test. This test requires a low noise of the chamber, which can be fulfilled once Test A has been properly executed.

Counting CR vs HV provides a kind of plateau from which one can decide if the chamber is acceptable. We know that in our simple setup the plateau shape is affected by the so-called z-talk (i.e. cross-talk between the two bigaps) so it will not so nice and "flat" like when performed on a test beam.

Since August we tested in Bdg. 156 18 chambers with CR. Out of these, 16 were also submitted preliminarly to Test A (not 100 % since at the beginning things were not properly organized).

Fig. 2 shows the plateau curves for 15 chambers. Of the original 18 three do not appear in the plot since showed high-$C$ values in Test A and noisy/dead channels with CR. The rate for the large majority of chambers at the typical operating voltage (2550 V) is about 2 Hz, in good agreement with expectations for a vertical chamber. Chamber LNF045 has a much higher count rate than the rest, and the reason is due to one of the gaps drawing high dark current and injecting noise in two channels. This chamber also showed a high-$C$ value in Test A. This chamber should have been "put aside" for further conditioning before the CR test, since the dark current at 2800 V is well above 10 nA. It could be probably rescued if conditioning allows to reduce the dark current.

Also FIR047 shows a slightly high noise. Unfortunately the dark current has not been monitored. This should be done systematically to ascertain if there is a clear correlation between excess noise and dark current. Our feeling is that if a chamber has $I_{\text{dark}} < 10$ nA at 2800 V it

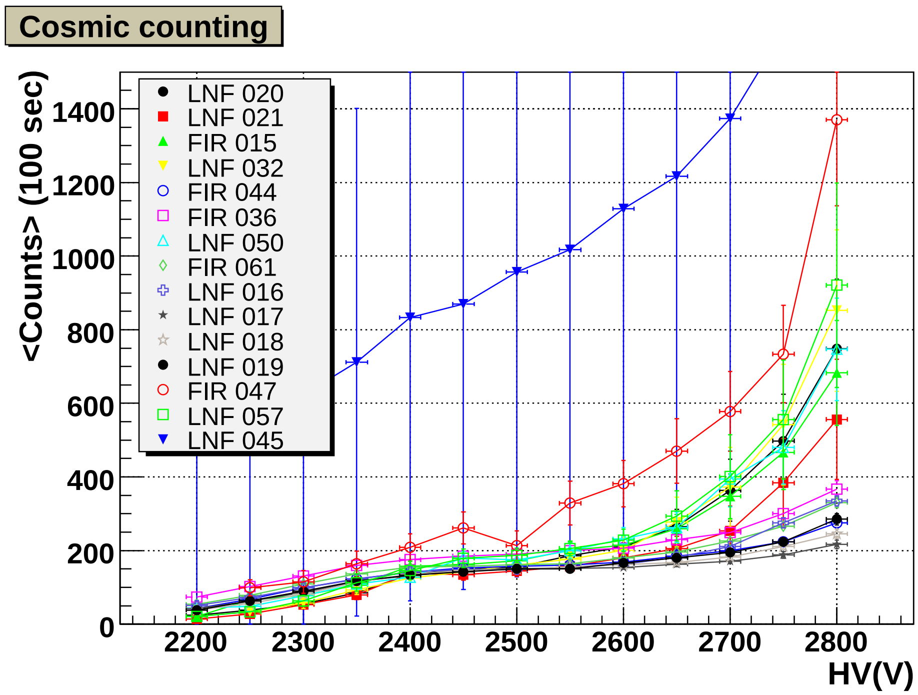


**Figure 2** HV scans (threshold 16 fC) of 15 M5R4 chambers.

has a high chance to be accepted because the noise at the operating voltage will be low enough.

From this plot one could assume that 13 (maybe 14) chambers can be safely considered OK and can be installed. Even assuming that LNF045 can be recovered by proper conditioning, it is rather worrying that we have 15/18 = 80 % of yield at this stage. We should soon start replacing the CARDIAC or SPB boards on chambers showing high-*C* since this will certainly help.

The other important aspect of the HV scan is to allow a check of the channel maps which should be uniform. It would be possible to spot dead channels which could have shown up with anomalously high C in Test A (see Fig. 3).

The HV scan is rather time consuming: 3-4 minutes per point, which means about 1 hour with 50 V steps and a large chamber. It will become much longer with smaller pad chambers. Therefore there is consensus, after an initial study phase, to limit the measurement to only 2 or 3 HV values: for example 2800, 2550 and 2200 V. The measurement at the nominal operating voltage should be collected with reasonably large statistics to spot disuniformities of response. Of course, on small chambers where the CR rate is maybe 0.06 Hz, collecting a large statistics is a time-consuming operation. In that case parallel operation would be extremely useful as it would be an automatic scan performed overnight. On large R4 chambers 10-15 minutes should be enough to collect about 1000 counts per pad.

The agreed acceptance criterion is therefore to measure at the nominal operating voltage (say 2550 V in this case) a given cosmics rate (2 Hz in this case) plus or minus 50 %, for ALL the channels. This implies that all channels have to be measured even if the so-called "super pads" (made of 4 pads in OR) are used in R4 region.

It is important that the Database information include the full maps separately per chamber and HV value. So the software should produce a separate file for each chamber measured.

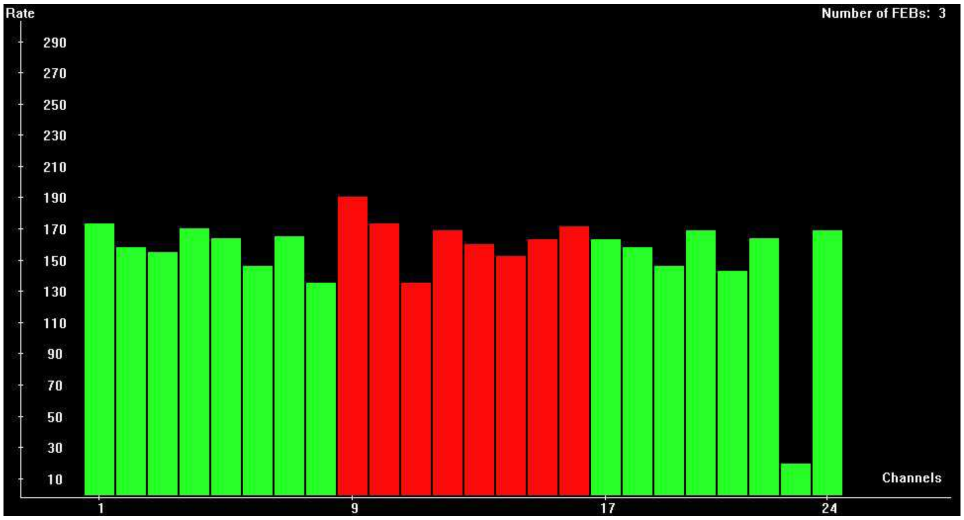


**Figure 3** Map of Chamber LNF040 at 2500 V (100 s time) showing a dead channel. The same channel showed high capacitance in Test A.

# 4 Correlation of A and CR Tests

As said above, Test A at the moment has not been run on 100 % of the chambers submitted to the CR measurement. Nevertheless, using only the chambers submitted to Test A we can have an idea of the correlation with the CR measurements from the Table below

| | Cosmics yes | Cosmics no |
|---|---|---|
| Test A yes | 12 | 0 |
| Test A no | 0 | 4 |

It is important to remark that failing Test A in practice only means failing sub-test 2 (anomalous capacitance value). The other sub-test (1 and 3, see Sect. 2) have always been passed. From the table there is a perfect correlation between Test A and the CR Test, therefore one could question the usefulness of the CR Test, given also the fact that the few cases of dead channels have always been correlated with high-$C$ values. Howevever more statistics should be accumulated before drawing a definite conclusion.

# 5 Recommendations for software developments

1. Test A software must be used for the FEE test and Rafael's one msut be used for the CR test
2. scans should begin from maximum HV downwards (quieter conditions)
3. Test A should preferably provide the list of the measured capacitances for all channels, not only the suspect ones. In its present form this SW must be re-run on the stored raw data files to get the $C$ information. Therefore $C$ may vary if there are refinements in the code. For this reason the code version to generate the $C$ value should also be recorded for future reference.

4. Rafael's software should be implemented with
    - chamber barcode information (either from the scanner or from the keyboard)
    - simple HV scan facility (min, max, steps, waiting time between steps)
    - automatic saving of the channels map in ASCII text and graphic format
5. all relevant output files should be in ASCII text format (except for graphics)
6. some simple scripting code should be made available to merge the output files from the two different programs in a single file which could be easily linked to the existing database.
7. to produce graphics some script based on Root or PAW should be provided
8. in order to label the files, their names should begin with (or in any case contain) the barcode of the chamber.
9. no manual manipulations of the files (renaming, cut and paste, etc.) should be allowed or relied upon.
10. transfer of data to the Chamber Database should be automatized.