ATLAS project	# Measurements needed to test the Forward Module Electrical Performance before the FDR

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Measurements needed to test the Forward Module Electrical Performance before the FDR

Abstract

This document describes the measurements needed to evaluate the electrical performance of the SCT forward modules before holding the FDR.

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Distribution List

History of Changes

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1 Introduction.

This document describes the measurements needed to evaluate the electrical performance of the SCT forward module before the FDR could be held. The goal of the document is to establish what are the module properties to verify in order to assess their correct performance of and to establish the resources needed, in terms of number of modules, material and man power, to accomplish it.

The requirements set on the electrical performance of the SCT modules are:

- Output noise: ~1500 e^- ENC before irradiation and ~1800 e^- ENC after irradiation.
- Noise occupancy at 1 fC threshold smaller than 5×10^{-4}.
- Tracking efficiency greater that 99%.

These three simple lines have a number of implications on the electrical components of the module. Particularly for the ASICs, these requirements propagate to the front–end properties, such as the gain, noise, offset spread, timewalk, etc. The ABCD chip has proven to fulfill all those requirements and we should demonstrate that its performance does not degrade by the fact that the chips are assembled together into a module, or that a number of modules are *mustered* in an environment as close to the final operation as possible.

2 Single module tests.

The characterization of a single module has to demonstrate its functionality and that the performance of the ASICs does not degrade when assembled into the module. To this end, the front–end parameters, like the gain, output noise and offset of all the channels, need to be measured. A second step would be to verify that their values are uniform across single chips. For the spread, we should also confirm that we can effectively trim a chip so as to minimize the offset spread. For the trimming I would strongly suggest to do it on a chip by chip basis, trimming each of them to the minimum spread, instead of trimming all the chips to the same target value in the module. Related to the threshold and efficiency is the timewalk measurement and validation. Once the gain, the output noise and the offset of every channel is known, the noise occupancy and the equivalent charge noise can be computed and checked to stay within the limits. For the noise occupancy measurement, the ideal thing would be to use a random trigger, instead of a synchronous one. Finally, the power consumption needs also to be measured as well as the bit error rate in the optical transmission[1].

For the measurement conditions I would propose to run as close as possible to the hybrid temperature on the SCT. As an option, the noise dependence on temperature could be studied. For an FDR it is nor really needed, but it can help in comparing different measurements if measurements can be normalized to the same temperature.

At the end, the stability and robustness of the module should be demonstrated (it does not show features at reasonable low thresholds). Also important is to confirm that the chips do not perform much worse than in standalone, comparing with the data measured during the wafer screening.

To summarize, the measurements proposed on a single module are:

- Gain, gain uniformity and gain linearity in the appropriate range.
- Offset spread and capability of trimming to the minimum spread on each chip.
- Time walk.
- Output noise and ENC
- Noise occupancy at 1 fC
- Power consumption.
- Validation of redundancy mechanisms.
- Bit error rate
- Number of usable channels. This should take into account, and cross check, the number of dead strips from the detector characterization, the bad channels found after module assembly and the non trimmable channels.
- Detector IV curves
- Comparison with values measured during wafer screening.

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1 *Need the specifications for the Bit error rate. The TDR specifies a data loss below 0.1%. Is this the figure we want ? Does it include the losses at the ASICs ?*

For the electric measurements it is recommended to take the data after a few hours of running, when the noise stabilizes, and to use the calibration correction factors to quote the results.

3 System test measurements.

The aim of the system test measurements, from the electrical performance point of view, is to study possible *intermodule* effects, like cross talk in the overlap regions, or between outer and middle hybrids, as well as checking the immunity of the modules to malfunctioning of any of the neighbors. Also important is to verify that the performance of the modules does not degrade with the increasing complexity of the system. A characterization similar to the one made on a single module should be done in order to compare the gain, noise and noise occupancy figures.

The measurements proposed on the system test are:

- Gain and offset.
- Verification that the threshold correction factors obtained on the single module measurement are still valid.
- Time walk.
- Output noise, ENC
- Noise occupancy at 1 fC.
- Number of good channels.
- Power consumption.
- Comparison with values obtained in single module measurements.
- Study of dependence of performance upon the module position on the disk.
- Common mode
- Cross talk and immunity. To measure that it is proposed to leave some of the modules in an unstable state (very low threshold or feed through bit not set on the chips) and quantify the effect on the others .
- Long term stability studies. The idea of this test is to study the variation in time of some of the front–end parameters, like the gain, noise, etc.

As for the grounding and shielding, there are, currently, two options that could be implemented and there is no decision on which one to choose yet. As a consequence, all the above measurements have to be repeated for the two grounding schemes.

As for the measurement conditions, it is desirable, like for test box measurements, to run as close as possible to the hybrid temperature in the SCT, or being able to normalize to the test box measurements in order to compare properly the results. Also proposed is a cold run with the disk inside the freezer, in order to have an ambient temperature of -7^{o}C.

3.1 Number of modules needed.

Since the purpose of the system test measurements is to study intermodule effects, we should aim at building enough modules to ensure complete overlap for at least one module of each type. That makes the minimum number of modules 9, distributed as:

- 3 outer,
- 3 middle and
- 3 inner.

Certainly the best would be to have, for at least one type of module, the corresponding ring fully populated. If the outer ring is chosen, since it corresponds to the longest modules, that would mean, with the current forward quarter disk, 13 outer modules. As will be explained in the resources section, only 8 outer positions have the correct tapes. Given that it will not be easy to get the missing tapes fast enough, an intermediate solution would be to populate the outer ring with 8 modules.

4 Irradiation and beam test.

4.1 Irradiation.

The module should be irradiated and show an acceptable performance after that. After irradiation and annealing, a set of tests like the ones described for a single module should be performed. Eventually, if enough modules are irradiated, they could be put in the system test disk.

The minimum number of modules to be irradiated is 3. This will ensure redundancy and allow for module looses. We propose outer modules as the type to be built for the irradiation tests since it corresponds to the worse case.

4.2 Beam test.

In order to measure the tracking efficiency, a number of modules should be exposed to a test beam. Ideally, the modules could be the ones that have been irradiated plus some non–irradiated modules to allow for a comparison in performance. The minimal measurements to be done are:

- Threshold scan. This should serve to compute the efficiency of the module and to estimate the charge collection efficiency.
- Determination of space resolution.
- Signal over noise ratio
- Charge scale determination, that is, proper threshold calibration in terms of charge.
- Ghost hit rate

One can, optionally, make measurements in the presence of a magnetic field, and at various angles of incidence, as well as to reconstruct the pulse shape and determine the shaping time of the front end.

5 Resources

As for the system test, the disk has 33 module positions on 3 cooling circuits. This corresponds to 13 outer, 10 middle and 10 inner modules. All the positions have cooling blocks and opto–pluggins. 22 out of the 33 positions are equipped with on–disk (wiggly) power tapes (8 outer, 8 middle and 6 inner), and of those, only 3 of each type have the correct tapes for their position. For the cooling in the disk, probably the best solution will be to use parallel cooling lines (one chiller per cooling circuit) to ensure that they can stand the coolant flow required by the length of the circuits. The disk, plus a cooper box used as a thermal enclosure, could fit in the available freezer in the case of a cold run.

The number of modules to be built depends on the scenario chosen, as listed in Table 1. The bare minimum is three modules of each type for the system test plus the the 2 outer modules for the irradiation and the beam test. The other 2 cases only enlarge the number of outer modules used in the system test. The intermediate scenario would populate all the positions in the outer ring with the correct tapes, whilst the third scenario would populate the complete outer ring. We should aim, however, at getting the maximum possible number of modules, upgrading the disk services where needed. We should also check that the positions with wrong tapes will not affect the performance of the modules.

	Scenario 1	***Scenario II***	***Scenario III***
Option	Minimum number	Intermediate	Max. number
System test	3o + 3m + 3i	8o+3m+3i	13o+3m+3i
Irradiation	2o	2o	2o
Beam test	Irradiated + Non irradiated	Irradiated + Non irradiated	Irradiated + Non irradiated
TOTAL	5o+3m+3i	10o+3m+3i	15o+3m+3i

Table 1. Number of modules required for the test according to the three possible scenarios described in the text.