SCT End-Cap Module FDR Document

SCT End-Cap Module Components: Silicon Microstrip Detectors

Abstract

This document describes the technical status and procurement of the silicon microstrip detectors for the SCT end-cap modules.

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Distribution List

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1 SCOPE OF THE DOCUMENT

This document describes the silicon microstrip detectors that form part of the ATLAS SCT end-cap module. It covers their Technical Specification; results from the detector Pre-series; procurement status, QA procedures in place and status of the Series deliveries.

2 INTRODUCTION

Each end-cap module contains four silicon microstrip detectors, with two on each side glued back-to-back on the spine, as described in ATL-IS-??-????. Few modules (inner ring and middle ring of disk 8) contain only two detectors. Depending on their radial position (inner, middle, outer) different module geometries are needed, each requiring different detector shapes. Altogether 5 different detector shapes are needed for the end-cap SCT, labelled W12, W21, W22, W31, W32 (from inner to outer, `W`= wedge).

A total of approximately 9000 detectors will be required for construction of the SCT end-caps, the exact number depending of the actual loss factors in series module construction and in the assembly of modules to disks. Because the lead time is long for the delivery and acceptance of such a large number of detectors, the procurement phase for this component was begun in 1999.

The ATLAS detector FDR was held in May 1999, and contracts for the Pre-series and Series production of detectors were placed in autumn 1999. The Pre-series detectors were delivered in the spring of 2000 and thoroughly evaluated by the ATLAS Institutes. The detector PRR was held in August 2000. The end-cap detector Series production was released with Hamamatsu Photonics, who will supply 64% of the end-cap SCT silicon detectors, and CiS, who will supply the remaining 36%, in November 2000.

The documents presented at the silicon detector PRR are located on EDMS. They are:

ATLAS SCT/Detector PRR/00-1	Contractual documentation, including Technical Specification, Delivery Schedule, Provisional Acceptance, Quality Assurance
ATLAS SCT/Detector PRR/00-2	Detector Procurement Arrangements
ATLAS SCT/Detector PRR/00-3	Database for Detectors
ATLAS SCT/Detector PRR/00-4	Quality Assurance at the Institutes
ATLAS SCT/Detector PRR/00-5	Reports on the Pre-series Detectors
ATLAS SCT/Detector PRR/00-6	Detectors in Modules.

Detector Type	# Detectors needed (nominal)	Hamamatsu order	CiS order	Total order
W12	800	430	600	1030
W21	1120	650	775	1425
W22	1280	650	975	1625
W31	1872	2165	290	2455
W32	1872	2165	290	2455
Total	6944	6060	2930	8990

Table 1: Detectors needed (nominal: for the modules on disks) and orders from Hamamatsu and CiS.

3 DETECTOR TECHNICAL SPECIFICATION

The full contractual Technical Specification of the detectors is located on EDMS, as are the detector engineering drawings. They are also appended to this document for completeness. (The Technical Specification covers also the detectors of the barrel SCT, which is not part of this FDR).

Following evaluation of both oxygenated and thin (260 μm thick) W12 detectors for the innermost ring modules, where the radiation levels are highest, the decision has been made to use 285 μm thick detectors for all rings of the SCT. The detectors made by Hamamatsu use standard silicon substrate while the W12 detectors produced by CiS use oxygen enriched silicon substrate.

The detectors have a wedge geometry, with 768 ac-coupled readout strips at an average pitch of 80 μm.

After 10 years of LHC operation, the detectors in the innermost regions are expected to be operated at about 400V bias, with over 90% charge collection efficiency.

4 PRE-SERIES AND SERIES PRODUCTION RELEASE

The results of the pre- and post-irradiation evaluation of the Pre-series production are summarised in ATLAS SCT/Detector PRR/00-5. The Pre-series detectors were in general of excellent quality with on average more than 99.9% for Hamamatsu and 99.7% for CiS of good readout strips per detector and a pre-irradiation average leakage current of only 140 nA (Hamamatsu) and 1.78 μA (CiS) at 350V bias at 20^{o}C. The post-irradiation characteristics, after exposure to $3x10^{14}$ pcm^{-2} 24 GeV/c protons, were as measured in the prototype R&D phase of the project, and fully satisfied the post-irradiation requirements of the Technical Specification.

There were five areas to be followed up with the manufacturers from the Pre-series results, before Series production release:

(a) *The quality of the cut edge of the detector*. It is important that the detector edges are clean, with no loose or rough pieces of silicon or aluminium present. This is because the edge is at the full post-irradiation bias potential, and so any danger of shorting to the grounded bond wires or to exposed grounded areas of neighbouring modules on the barrel structure must be avoided. The detector edge quality of the Pre-series was variable. As a result, new visual inspection procedures have been agreed and instituted at the manufacturers for the Series production, and these are being carefully checked during the QA of the Institutes. To-date, the edge quality of the delivered Series detectors has been satisfactory.

(b) *The detector passivation mask*. The prototype and Pre-series Hamamatsu detectors had openings in the passivation mask that were used by the Company for QA purposes. These again presented some risk of shorts developing to bond wires or to neighbouring modules. A new passivation mask, without these openings, has been made and is being used for the Series detectors to eliminate this particular risk.

(c) *Strip quality tests*. There were some discrepancies between the identification of bad strips between the QA at Hamamatsu and at the Institutes in the Pre-series detectors. This is now fully understood and resolved.

(d) *Orientation of silicon substrate*. Detectors have been processed on both <111> and <100> silicon substrates by Hamamatsu and fully tested both pre- and post-irradiation by the SCT. No significant differences in performance were found. The final choice of substrate was in the end dictated by the availability of supply; <111> silicon is being used for the Series production. CiS used always <111> silicon.

(e) *Series delivery schedule*. The schedule agreed with Hamamatsu and CiS for the basic supply is shown in Table 2. Additional Hamamatsu detectors were ordered in April 2002 through contract purchase options. No purchase option has been agreed with CiS where the original order already included a large contingency.

(f) *Guard Ring spacing*: The guard ring spacing of the CiS detectors was slightly altered to improve the breakdown characteristics at high voltage.

(g) *W12 geometry*. In 2000 the inner radius of the SCT had to be increased in order to allow a late insertion of the ATLAS pixel detector. For this the length of the W12 detectors had to be reduced, requiring a new detector layout and new photolithographic masks. The original W12 design was not released and a small pre-series of the new design was ordered. After successful tests of this pre-series the new W12 production was released in summer 2001.

All details of the Series production release were agreed with Hamamatsu and CiS in autumn 2000, and the Series detectors are now being delivered. The delivery schedule is shown in table 2. To date (May 2002) the detectors have been delivered according to schedule (87% delivered).

Year/month	Number to be delivered to Switzerland	Number to be delivered to UK	Number to be delivered to Spain	Number to be delivered to Germany	Total monthly delivery
	Hamamatsu	Hamamatsu	Hamamatsu	CiS	
01/01		20	20	200	**240**
01/02	50	210	80		**340**
01/03		140	60	400	**600**
01/04	110	100	40		**250**
01/05	130	130	60		**320**
01/06	130	100	40	550	**820**
01/07	130	130	60		**320**
01/08	130	100	40		**270**
01/09	130	50	60	550	**790**
01/10	130	180	40		**350**
01/11	130	100	60		**290**
01/12	130	100	40	550	**820**
02/01	130	100	60		**290**
02/02	130	130	40	550	**850**
02/03	130	100			**230**
02/04	130	130	40	130	**430**
02/05	130	100	50		**280**
02/06	130	100	40		**270**
02/07	130	130			**260**
02/08	130	100			**230**
02/09	130				**130**
02/10	130	240			**370**
02/11	200	40			**240**
total	2750	2530	830	2930	**8990**

Table 2a: Delivery Schedule for the basic supply of end-cap detectors

5 DETECTOR QA AT THE INSTITUTES

The detector acceptance QA carried out at the SCT Institutes is detailed in Appendix 1 of the Technical Specification. This is now in operation for the Series detector deliveries. The Institute responsibilities are shown in Table 1 of SCT-EC-FDR-xx..

Results of the QA (detector leakage currents) are shown in Figure 1a (for CiS detectors) and Figure 1b (for Hamamatsu detectors).

6 DETECTOR STORAGE

Since the module production will start rather late in autumn 2002, the detectors have to be stored safely. The institutes store the detectors in an inert atmosphere (Nitrogen/Argon).

7 DATABASE

The use of the SCT database is well developed for detectors. The Contractors enter their tests and agreed data directly into the database and ship the detectors electronically at delivery. The Institutes receive the detectors in the database and enter their acceptance test data. Detectors are shipped to the module building cluster after their provisional acceptance.

8 SUMMARY

The silicon detector procurement for the end-cap modules is so far proceeding to plan. Since the late start of series end-cap module production in autumn 2002 does not allow build yields to be assessed within the contractual timeframe of the detector delivery the purchase options for additional detectors had to be used.

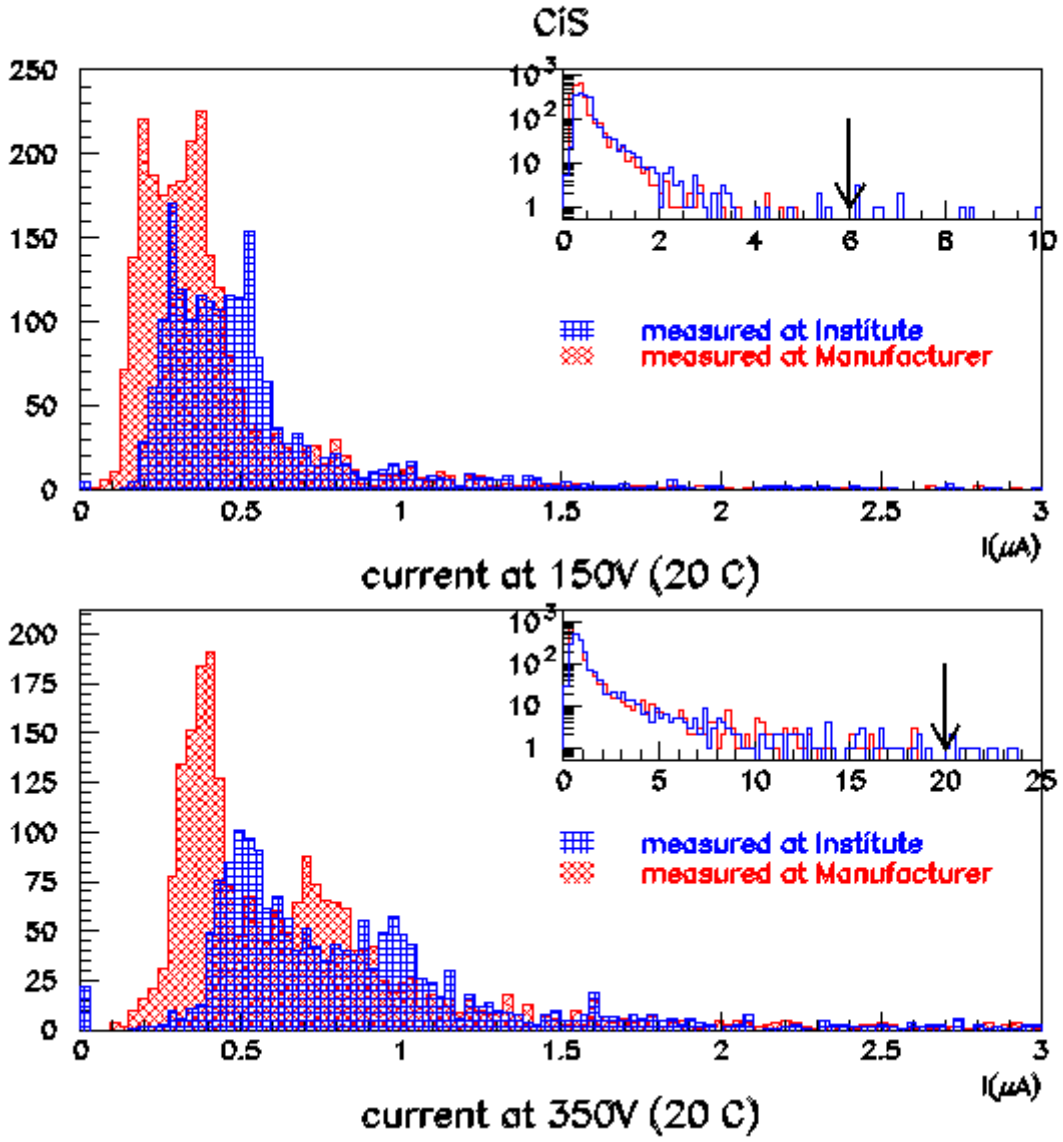

Figure 1a: *Detector leakage currents measured at 150 V (top) and 350 V (bottom) for CiS detectors. In red manufacturer data, in blue measurements at the institute. The inserts show the same distribution with an extended scale indicating the acceptance limits (arrows)*

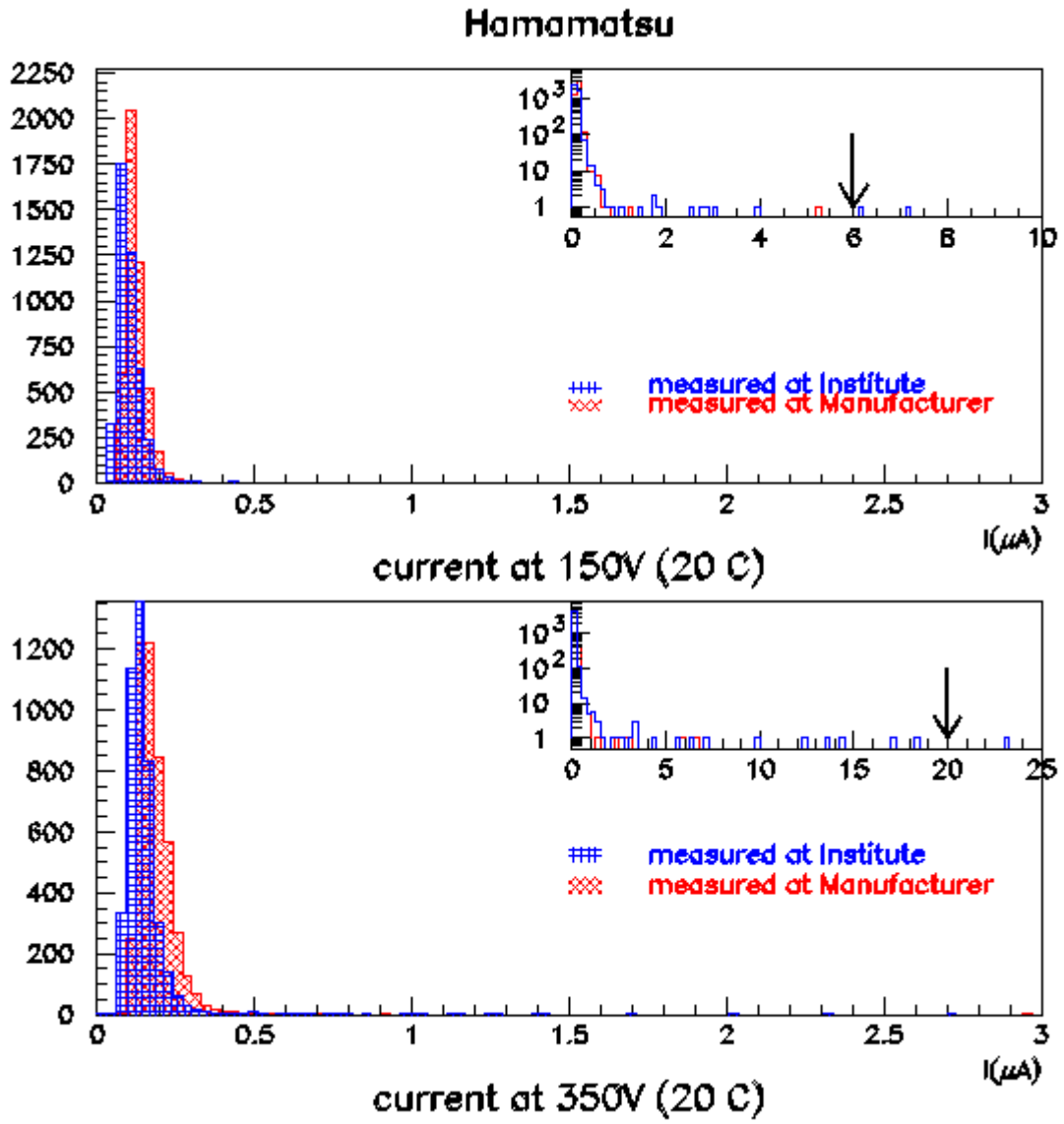

Figure 1b: *Detector leakage currents measured at 150 V (top) and 350 V (bottom) for Hamamatsu detectors. In red manufacturer data, in blue measurements at the institute. The inserts show the same distribution with an extended scale indicating the acceptance limits (arrows)*