GLAST LAT TECHNICAL DOCUMENT	Document # LAT-TD-00122-01	Date Effective 1st Draft – 3/29/01
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	Subsystem/Office Tracker	
Document Title **Evaluation of GLAST LAT SSD Leakage Current Specification**		

Gamma-ray Large Area Space Telescope

(GLAST)

Large Area Telescope (LAT)

Evaluation of GLAST LAT SSD Leakage Current Specification

1. ABSTRACT

We have compared the total leakage current observed on GLAST 2000 prototype sensors with individual strip leakage currents on the same SSD. We found a correlation between anomalous high total leakage current (40nA or ~1/4 of total strip current) and excessive high current on a single strip. Because of the low total strip current observed on the HPK GLAST 2000 SSD, we can thus monitor the number of noisy strips with a measurement of the total leakage current. To limit the number of bad strips with excessive current, we recommend lowering the GLAST LAT SSD specification on the total detector current from 240 nA to 200 nA on the average and from 800 nA to 390 nA, as the maximum allowed, both at bias of 150 V (Sec 5.h.ii of LAT-DS-00011). In order to eliminate SSD with breakdown close o the operating voltage of 150 V, we will require a maximum leakage current of 500 nA at 200 V.

2. DEFINITIONS

2.1 Acronyms

GLAST	Gamma-ray Large Area Space Telescope
JGC	Japanese GLAST Collaboration
LAT	Large Area Telescope
SSD	Silicon Strip Detector
TBR	To Be Resolved
TBB	To Be Determined

2.2 Definitions

AC Coupling	The Al metal electrode is covering almost the whole length of the p+ implant, separated from it by a dielectric material
AC Pad	Pad to access the Al metal electrode on the strips
Active Area	Area of the Volume from which charge is collected on the strips in <<1us
Buyer	Institution procuring GLAST LAT SSD
C	Capacitance
Contract	Purchase agreement to procure GLAST LAT SSD's
Coupling Capacitor	Capacitor formed by Al metal electrode, dielectric and implant
Customer	Institution involved in the procurement and testing of GLAST LAT SSD's
C-V	Measurement of body capacitance (C) as a function of voltage (V)
DC coupling	Al metal electrode and implant in ohmic contact.
DC Pad	Pad to access the strip implant
Bias Resistor	Resistor connecting every implant to the bias ring
Bias Ring	Implant surrounding the active area, connects to bias resistors
Fiducial	Physical mark in the Al metal layers for alignment and metrology
Guard Ring	Implant ring outside the bias ring without bias connection ("floating")
HPK	Hamamatsu Photonics
I-V	Measurement of leakage current (I) as a function of voltage (V)
N-sub	Substrate contact on the detector front
Pad	Area of the Al metal layer accessible through the passivation The pad area is defined as the bondable area.
Pitch	Distance between strip centers
Passivation	Topmost layer covering of inert translucent material
Seller	SSD Manufacturer, Vendor,
Sensor	Silicon Strip Detector (SSD)
um	Micro meter (10^{-6}meter)
us	Micro second (10^{-6}second)
V	Voltage, Volt

3. REFERENCES

GLAST LAT AO Response	P. Michelson *et al,* Nov 1999.
Strip Technology	T. Ohsugi *et al.,* NIM A, 383 (1996) 167.
BTEM prototype detectors	P. Allport *et al,* SLAC-Pub-8471, June 2000.
Flow-down of GLAST LAT SSD Spec's	H. Sadrozinski, SCIPP 00/33.
GLAST LAT SSD Specifications	LAT-DS-00011-08
GLAST LAT SSD QA Provisions	LAT-CR-00082-01
Drawings SSD	LAT-DS-00026
Test structures	LAT-DS-00027

4. Evaluation of GLAST LAT SSD Leakage Current Specification

4.1 Abstract

We have compared the total leakage current observed on GLAST 2000 prototype sensors with individual strip leakage currents on the same SSD. We found a correlation between anomalous high total leakage current (50 nA or ~1/3 of total strip current) and excessive high current on a single strip. Because of the low total strip current observed on the HPK GLAST 2000 SSD, we can thus monitor the number of noisy strips with a measurement of the total leakage current. To limit the number of bad strips with excessive current, we recommend lowering the GLAST LAT SSD specification on the total detector current from 240 nA to 200 nA on the average and from 800 nA to 390 nA, as the maximum allowed, both at bias of 150 V (Sec 5.h.ii of LAT-DS-00011). In order to eliminate SSD with breakdown close o the operating voltage of 150 V, we will require a maximum leakage current of 500 nA at 200 V.

4.2 Introduction

The tracker (TKR) of the GLAST LAT will use silicon strip detectors (SSD) in an unprecedented number. GLAST needs to cover an area of about 74m^2 with 11,500 SSD (including spares), having a total of close to 4 Million strips. An extensive prototyping program lasting about 5 years was directed in developing SSD in the emerging 6" technology, which reduced the number of SSD to be procured by one half when compared to the 4" wafer technology. The criteria were simplicity and robustness of design, high quality and reliability, predictability and uniformity of performance and ease of testing. The replies of about 10 SSD manufacturers to our RFI in 1998 identified the testing of single strip currents as an important cost driver and a major schedule risk. Thus the GLAST SSD QA program is based on the premise that the number of single strips with large currents can be limited by tight limits on the total SSD current, which is easyly and reliably tested by the SSD manufacturers. Our experience is that one single strip failure is tolerable on an SSD. This includes not only noisy strips with high leakage currents, but also strips with broken coupling capacitors and failure of the metalisation. The GLAST LAT SSD specifications LAT-DS-00011 contain a limit on both the average and maximum strip current allowed (Sec 5.h.ii) and the number of bad strips due to capacitor and metal failure but not on single strip currents. The latter has to be inferred from the total SSD leakage current.

4.3 Results from 63 GLAST 2000 Prototypes from HPK

The first 600 GLAST flight SSD have been procured by JGC from Hamamatsu Photonics (HPK). In June of 2000, KEK announced an international offer for tender for GLAST LAT SSD, and then accepted in September a bid from HPK for delivery of 400 SSD in 2001, with prototypes to be delivered in Dec. 2000. An additional 200 GLAST LAT SSD's were ordered by other Japanese institutions. HPK has fabricated 35 prototypes and delivered them in Dec. 2000 to Hiroshima U. (20), INFN Pisa (10), and SLAC (5). Testing at these three GLAST institutions has shown that the test results agree well with the results from HPK and that the performance of the prototypes agrees with the specification LAT-DS-00011-07. The results from the tests are described in LAT-TD-00086-01. IHPK has manufactured an additional 28 SSD and has shown that the test results agree with those of the 35 previously delivered.

The distribution of total leakage current as a function of bias voltage (I-V) is shown in Figs. 1a and 1b for the 35 SSD delivered. The leakage current of a typical perfect sensor is less than 170 nA and averages at 143 nA at 150 V bias. This leakage current level for a SSD with area 8.95 cm x 8.95 cm is similar to the highest quality photo-diodes. Also indicated in Figs. 1 is the specification on the average leakage current of 240 nA at 150 V bias, set in the year 2000.

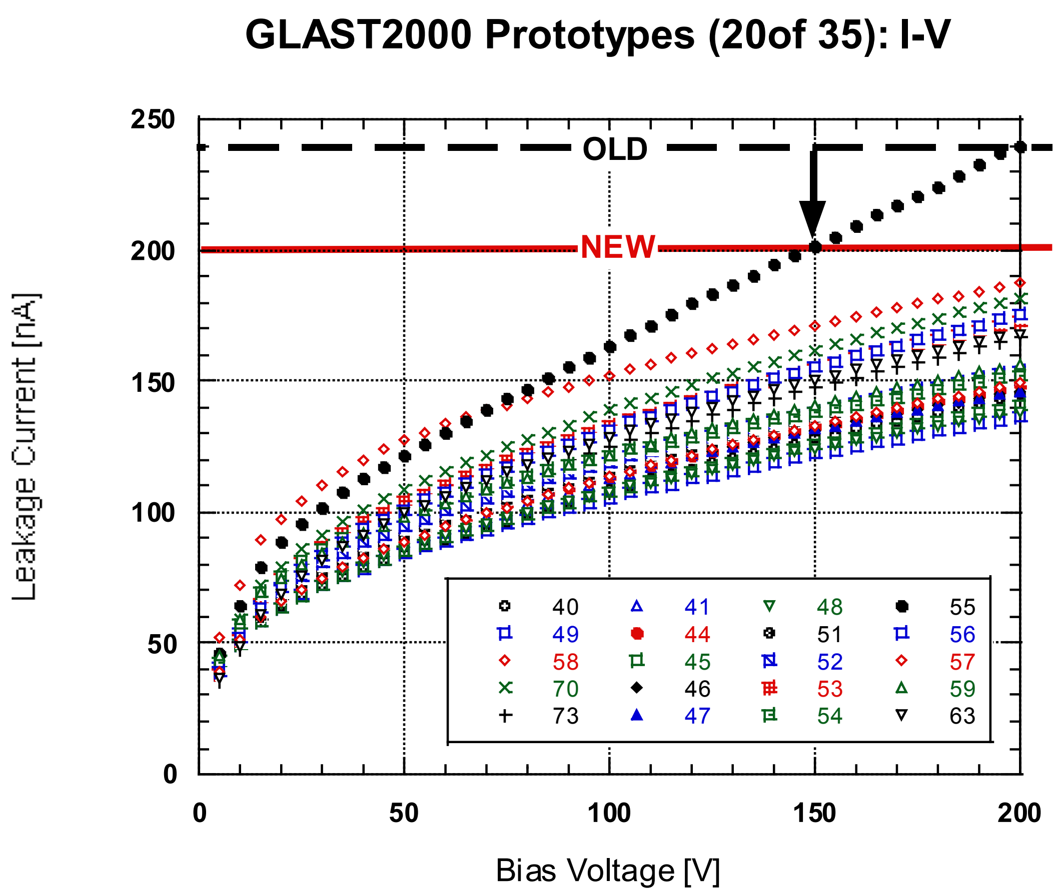

Fig. 1a Leakage current in nA vs. Bias Voltage for 20 of the 35 GLAST 2000 SSD delivered by HPK in December 2000. The one SSD with different I-V curve is SSD #55.

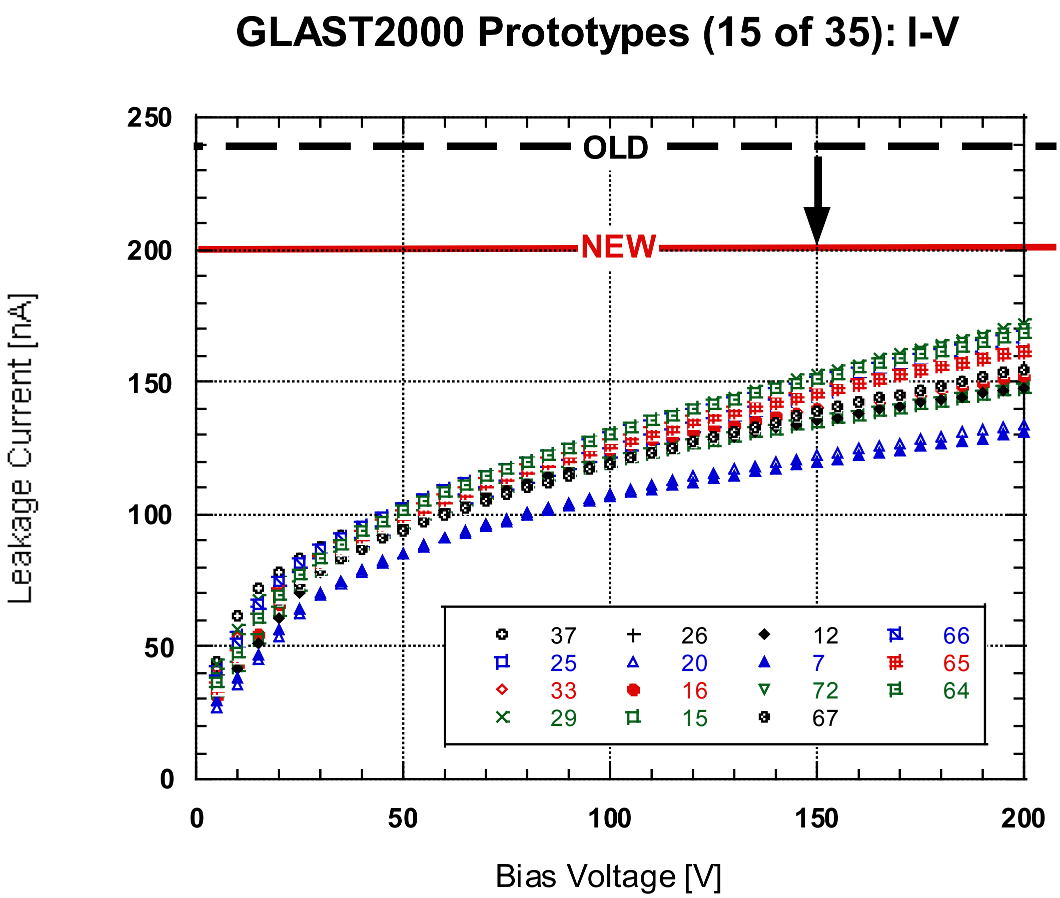

Fig. 1b Leakage current in nA vs. Bias Voltage for 15 of the 35 GLAST2000 SSD delivered by HPK in December 2000. The horizontal black line indicates the specification on the average total leakage current per SSD set in 2000.

Of all SSD shown in Figs. 1, SSD # 55 shows an anomalous behavior. At a bias of 150 V, it has a total leakage current of 200 nA which is ~50 nA higher when compared to other sensors. Moreover its I-V curve is almost ohmic, typically for a strip with a bad junction. Indeed, when looking at the single strip current of SSD # 55 in Fig. 2a, one bad strip is clearly seen and its current is 45 nA. Aside of this one strip, the single strip currents are the same as in a typical SSD measured, with an average of 0.2 nA and a maximum of 4 nA per strip. As an example, Fig. 2b shows the strip-by-strip current of SSD #46. Thus we can clearly state that the 50 nA higher total leakage is due to one bad strip. The strip with leakage current of 45 nA will be classified as a bad strip because the expected noise will be ~1000 electrons ENC with 1.3µs peaking time.

The specification on the average number of bad strips is one per SSD. Thus our specification on the average leakage current should allow us to identify SSD's with more than one bad strip. Thus we have to decrease the specification on the average of the total SSD current from 240 nA to 200 nA in order to avoid that we incur more than one bad strip per SSD. This change in specification on the average SSD leakage current at 150 V bias is shown in the change from the black to the red horizontal line in Figs. 1a and 1b.

In addition, we have to reject SSD having more than 3 bad strips with high currents. Our data indicates that the sensor having four bad strips is expected to have a total leakage current excess of 200 nA over that of a perfect sensor with no bad strip. Thus the upper limit on total leakage current per SSD should be set at < 390 nA. In order to eliminate SSD with breakdown close to the operating voltage of 150 V, we will require that the leakage current at 200 V is less than 500 nA.

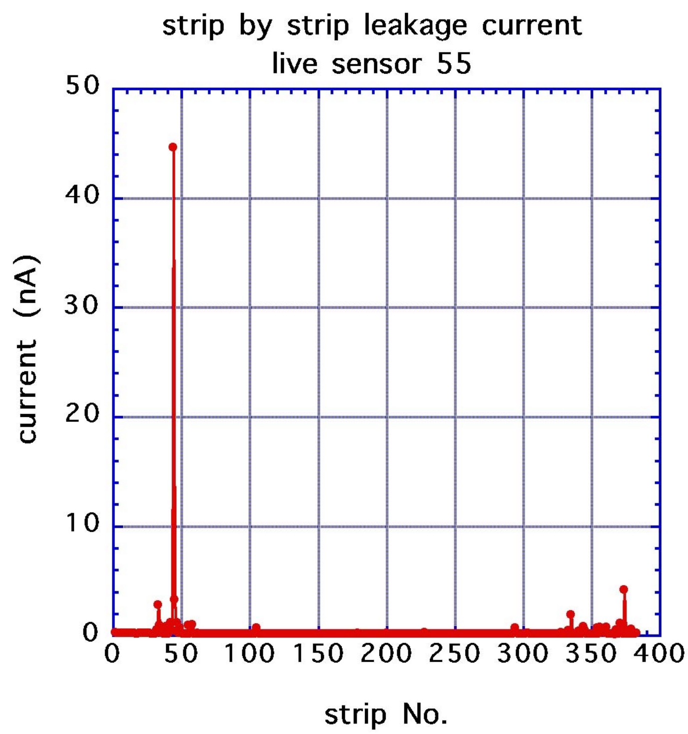

Fig. 2 a Single strip leakage current at 150V bias for SSD #55, which shows abnormally high total leakage current (see Fig. 1a). Except for SSD #55, the maximum strip current observed on all SSD investigated is 4 nA (see Fig. 2 b).

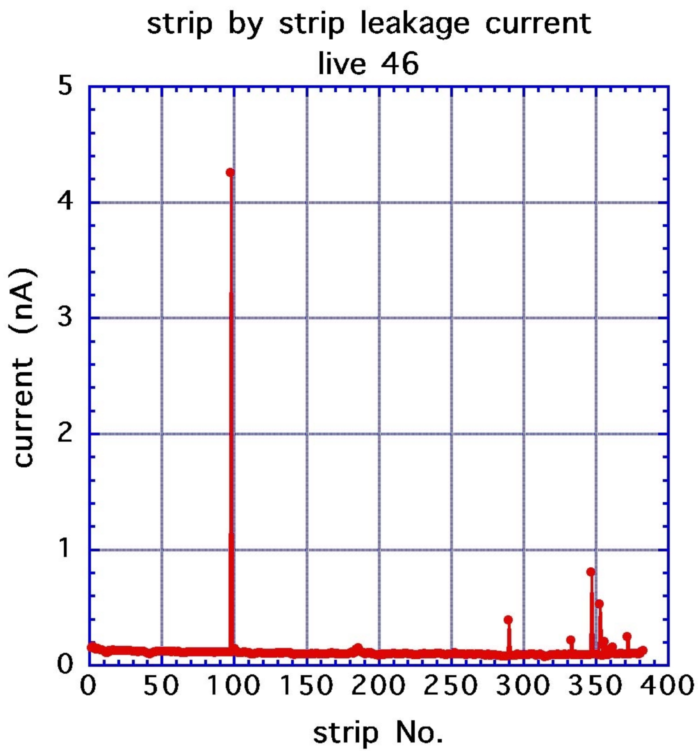

Fig. 2 b Single strip leakage current at 150 V bias for SSD #46, which shows normal total leakage current (see Fig. 1 a). Most of the strips have a leakage current of ~0.2 nA, with a maximum of about 4 nA. Note the current scale is a factor 10 reduced with respect to Fig. 2 a.