SCIPP 97/32
November 1997

# Tray Assembly Precision for the GLAST Si Tracker

Hartmut F.-W Sadrozinski
*SCIPP, University of California Santa Cruz, Santa Cruz, CA 95064*

*Abstract*
The mechanical tolerances for the assembly of trays carrying silicon strip detectors are discussed for the large satellite-based gamma detector GLAST.

INTRODUCTION

In a large detector like GLAST with 20,000 silicon detectors, it is important to be able to treat as large an assembly as possible as a rigid body, which can then be described by 3 position and 2 angle variables. If the assembly proceeds with high precision, the survey of the alignment with cosmic rays both on the ground and in orbit can be used as a check, using the construction tolerances as a constraint. In addition, the fact that GLAST measures only two projected angles without correlation between them means that for events with more than one track in a tower, corrections from a survey can't be uniquely applied. Thus the precision of the instrument depends on the assembly tolerances. The unit which is ideally suited for precision assembly is the tray which carries 25 detectors each on its two sides.

ASSEMBLY TOLERANCES

The mechanical scale is set by the resolution of the silicon strip detectors, which for a single plane is pitch/$\sqrt{12}$ = 56µm. Mechanical tolerances, which can introduce systematic errors, should, when related to the single plane resolution, be 1/3 of this, i.e. $\Delta$ = 20µm.

In the following different mechanical tolerances in the tray are discussed.

*1) Placement of the detectors in a tray:*

25 detectors of 6.4cm x 6.4 cm are placed on each face of the tray, and are wire bonded together in groups of 5 to be read out together. These groups of 5 have to be aligned, i.e. placed, to a tolerance of $\Delta$ = 20µm normal to the directions of the strips. In the directions along the strips, the maximum distance between detectors is of the order 100µm. Thus the placement should be done to 50µm, which is anyway the tolerance of the detector outside dimensions. The tolerance on the rotation of the detectors has to be such that it produces an displacement over the length of the detectors (6.4cm) of less than $\Delta$ = 20µm , i.e. which means less than 0.3mrad. These tolerances ensure also that wire bonding can proceed with identical maps for different detectors. In order to avoid error build-up, the

placement device should be able to place detectors at random, i.e. independently from the location onto which the previous detector was placed.

### *2) Rotation of two x planes in a tray relative to the other:*

There are two different requirements. A plane rotated by an angle $\phi$ appears as having a pitch scaled down by $\cos\phi$. For a track with inclination $\alpha$ relative to the normal, the effective error made over the length of the tray should again be less than $\Delta$:

$$d(\tan\alpha) = x/z - x*\cos(\phi)\ /z = 1/2*x/z*\phi^{2} \cdot \leq \Delta/z \quad .$$

For x=32cm,this results in $\phi \leq \sqrt{2*\Delta/32cm} = 11mrad \approx 2/3^{o}$ .

Applying the much more stringent requirement for the rotation of a detector in part 1) above to the rotation of the plane too. one would get 0.06mrad!

### *3) Distance of two planes in a tray:*

The precision of measuring the projected angle in two adjacent planes of a single tray is angle dependent. Moreover, it depends on the energy of the track because of multiple scattering, pair creation angle and nuclear recoil. In order to have a reasonable stringent specification for high energy tracks, the pointing accuracy PAT in a single tray of thickness z is calculated for incident angle $\alpha$:

$$PAT = \sqrt{2} * (\cos^{2}(\alpha)) * \sigma_{X}/z \quad .$$

The PAT is an essential ingredient for the determination of the point spreading function PSF, i.e. PSF $\approx$ 1/n * PAT, where n is the number of planes traversed by the track. The PAT is shown for 20GeV photons as a function of the angle of incidence in Fig. 1. Note the strong angle dependence of the PAT, which becomes very small at large angles of incidence, because the effective pitch gets reduced with the cosine and the lever arm of the angle measurement increases with 1/cosine. Assuming that the precision in the tray thickness $\sigma_{Z}$ should not exceed the projected PAT at every angle of incidence $\alpha$, the required precision in the distance and planarity of the two faces of the tray is

$$\sigma_{Z} = z*PAT/\sqrt{2}/(\cos^{2}(\alpha)*\tan(\alpha)) \quad .$$

This required precision in the separation of the two planes is also shown in Fig. 1, indicating that at zero degree and close to 90degree, there is no sensitivity to the distance of the planes either from the steep angle or from multiple scattering, but that at angles in between, a tolerance of about 50 $\mu$m is required in the planarity and distance of detector planes in a tray.

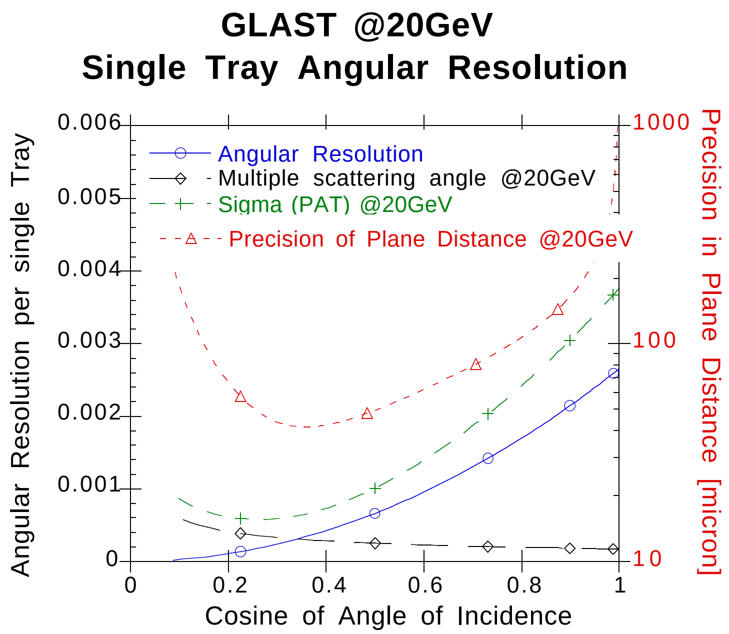


Fig. 1 Angular resolution, multiple scattering angle and pointing accuracy for single tray PAT for 20GeV photons as a function of the angle of incidence. The required precision for the distance of two planes are shown too.

Another way of looking at the required precision in building the trays is to evaluate the pointing accuracy per tray PAT as a function of angle and adding in quadrature the error due to different levels of precision of the tray distances z. This is shown in Fig. 2 for 20GeV photons and infinite precision, and tolerances of 50, 100, and 200 μm on the tray precision.

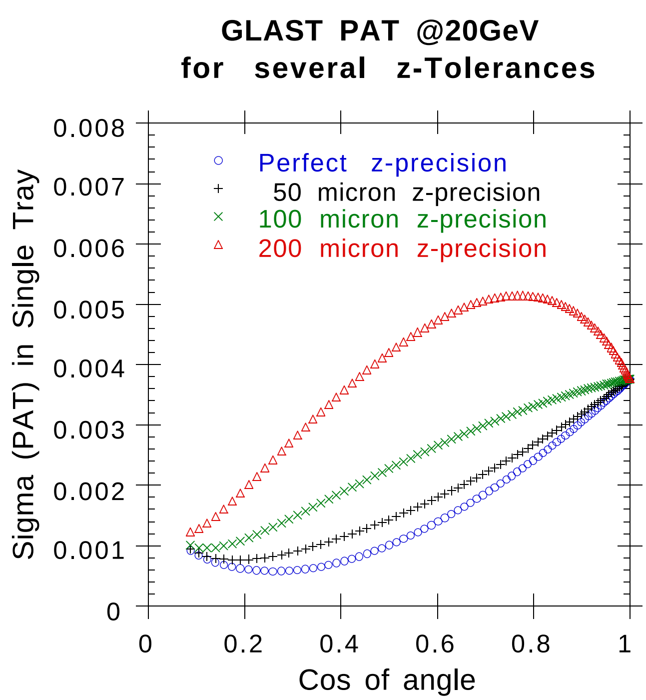


Fig. 2 The point ing accuracy per tray PAT for 20GeV photons vs the angle of incidence for several tolerances for the separation of the tray faces.

As expected, the worsening of the resolution for 50 μm is at most a factor 1.4, while it is a large effect at 100 μm precision and above. One should note that this might lead to serious detoriation of the point spread function PSF because the increase appears in the region of large angle of incidence where the number of planes on a track is reduced. Thus the required precision of the separation of the detectors on a tray should be of the order 50 μm or less. Clearly, the effect of precision of the tray assembly is the largest for the higher energy photons, while the measurement for the lower energy photons is multiple scattering limited at larger angles of incidence.

The mechanical tolerances of the tray assembly are summarized in Table 1. They are quite exacting for a large instrument, and need to be checked with a MC simulation including angled tracks. If necessary, the positions need to be corrected for with the help of a survey. In addition, before and after launch cosmic ray data runs with high energy muons will help with the alignment of the trays.

Table 1 Assembly Tolerances of the GLAST Tracker

| Parameter | Tolerance |
|---|---|
| Placement of detectors in tray: | |
| normal to strip direction | 20μm |
| in strip direction | 50μm |
| rotation | 0.3mrad |
| Rotation between pairs of planes | 0.67$^{o}$ (0.06mrad) |
| Separation of pairs of planes | 50μm |

## CONCLUSIONS

The required mechanical tolerances for the GLAST slicon tracker have been derived. A placement accuracy of the order 50μm will be needed.