Effect of the Al Strip Resistance in GLAST Detectors

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In order to estimate the effect of the final strip resistance of the GLAST detectors on the noise performance, we use the results of a complete 2-dim SPICE simulation by Issy Kipnis of the ATLAS modules (LBNL-39307).
The 12cm long detectors are assumed to have 1.5pF/cm distributed capacitance and strip resistance of between 10 and 20 Ohm/cm. The front-end electronics has (at a shaping time of about 20ns) a noise charge of about

$$e = 600+40*C \text{ [e-]}. \qquad (1)$$

Adding a distributed resistance R increases the noise by a contribution to be added in quadrature:

$$e = C\sqrt{\frac{4kT * R_{eq}}{\tau}} \qquad \left[= 100 * \sqrt{R_{eq}} \quad for C = 18 pF \right] \qquad (2)$$

The equivalent resistance Req of a distributed resistor is theoretically a third of the total resistance R; Issy's simulations show more like 40% of the total resistance, which might be a function of the shaping time selected:

$$Req = 0.4*R \qquad (3)$$

In the following we will use the value of eq. 3. In Table 1 we compare the results from eq. 2 with the fully simulated noise numbers by Issy.

Table 1: ATLAS Case

Resistance [Ohm/cm]	Equivalent Resistance of 12cm Req [Ohm]	R Noise Contr. (eq 2) [e-]	R Noise Contr. (Sim) [e-]
10	48	690	640
15	72	850	770
20	96	980	860

Table 1 shows that we can trust our approximate equation 2 and 3 for an order of magnitude comparison. A 16micron wide Al strip was measured to have a resistance of about 10Ohm/cm.

For GLAST, the capacitance is somewhat smaller (1.2pF/cm), and the noise is given at 1.5usec shaping time by

$$e = 170+32*C \text{ [e-]}, \qquad (4)$$

which for 32cm long detectors results in noise of 1400e-.
Scaling the resistance of the ATLAS detector strips by the width, we find for the GLAST strips the following resistances: 3.2 Ohm/cm for the 50micron wide Al strip, and 8Ohm/cm for the 20micron wide bypass strip (certainly the right order of magnitude, a measurement will be performed soon). The bypass strips were measured to have a capacitance which is 8% lower than the regular strips. For GLAST, due to the longer shaping time, Equation (2) becomes:

$$e = C\sqrt{\frac{4kT * R_{eq}}{\tau}} \qquad \left[= 25 * \sqrt{R_{eq}} \qquad for \quad C = 38\,pF \right] \qquad (5)$$

Thus with equation (5) and (3), we get the following noise contribution due to the finite resistance of the Al trace (Table 2).

Table 2: GLAST Case

Resistance [Ohm/cm]	Total Capacitance of 32cm [pF]	Equivalent Resistance of 32cm [Ohm]	R Noise Contr. [eq 5] [e-]	Total Noise [e
0	38	0	0	1386
3.2	38	41	160	1395 (+0.7%)
8	35	102	232	1311 (-5.4%)
4 x 3.2 and 1 x 8	37.4	53	179	1378 (-0.5%)

Row one is the noise without resistance; row two is the case of 5 normal detectors, giving a less than 1% increase. Row 3 is the unrealistic case of 5 bypass strips, which due to the reduced capacitance has actually less noise, and Row 4 is the case of 4 normal strips and one bypass strip.

Our estimation shows that the finite strip resistance of both readout and by-pass strips will be negligible for GLAST detector performance.

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