GCR Rates for the Palestine Balloon Flight

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The Spring 2001 GLAST balloon flight will provide a number of galactic cosmic rays we can use to develop calorimeter calibration algorithms. I've run CRÈME for Palestine to estimate GCR count rates under 4 g/cm^2 of atmosphere and 1 g/cm^2 of aluminum.

Allan Tylka (NRL) generated the geomagnetic transmission function at 35 km above Palestine, TX, by interpolating the vertical cutoff from the Epoch 1995.0 International Geomagnetic Reference Field propagated forward to 2001 and adding angular dependence from Størmer theory. He confirmed the interpolation by ray-tracing propagation.

Figure 1 is a diagnostic plot generated by CRÈME showing the cosmic ray spectra at 35 km above Palestine. It includes primary GCRs, anomalous CRs, proton re-entrant albedo, and spallation reactions in the material over the detector. Splash albedo is not included. The upper-most black trace is protons, dominated (from low E to high E, respectively) by albedo, spallation reactions (the little wiggle near 1 GeV), and primary GCR flux. Helium is the next black trace. Higher Z species, all the way to Ni (Z=28), are shown.

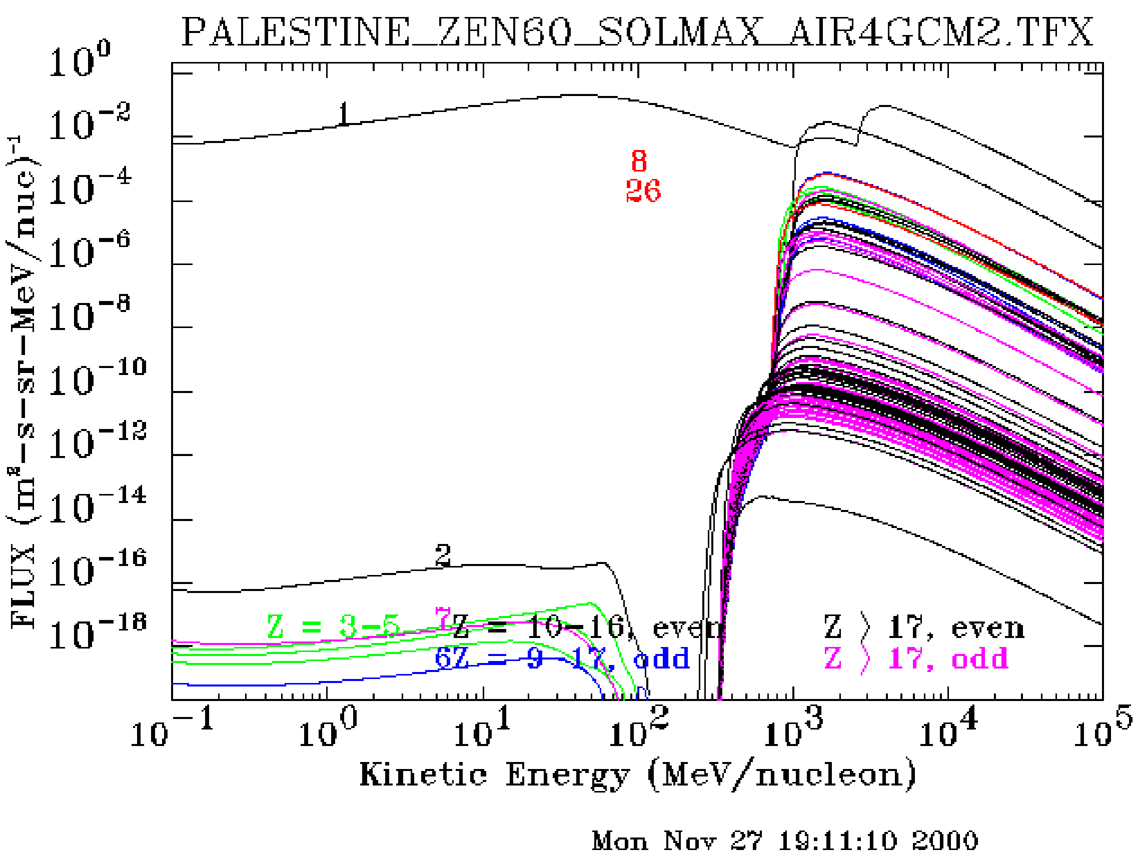

Figure 1: Cosmic ray spectra at balloon altitude over Palestine TX.

For the moment, I've selected C, N, O, Ne, Mg, Si, and Fe to study, because they're the most abundant species with Z greater than H and He. Figure 2 shows the spectra of these elements, extracted from those in Figure 1 and propagated through an additional 1 g/cm^2 of aluminum to simulate the pressure vessel. Using the Bradt-Peters cross sections, I propagated these CRÈME spectra through the ACD, TKR, and CAL. I took the ACD and TKR to be equivalent to 4 g/cm^2 of C and 10 g/cm^2 of Pb. The BFEM CAL is 76 g/cm^2 of CsI. I assumed an average zenith angle of 30 degrees.

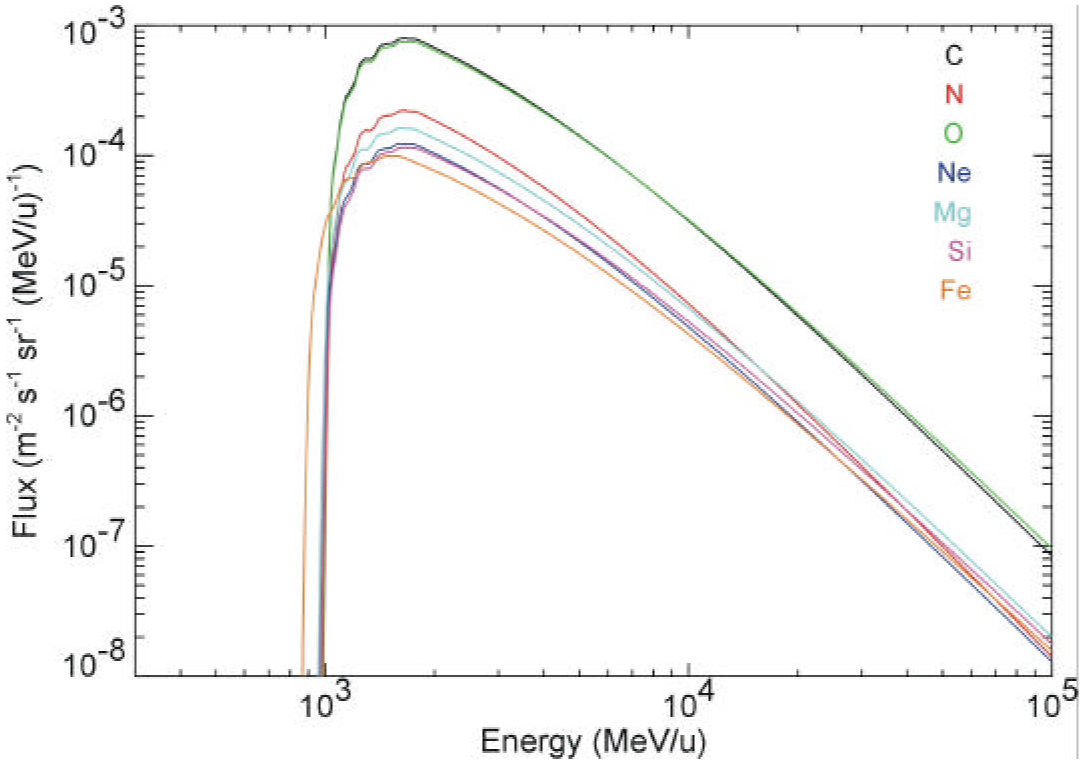

Figure 2: Spectra of the most abundant medium and heavy cosmic rays at Palestine at 35 km, under 4 g/cm^2 of air and 1 g/cm^2 of aluminum.

To be useful in the CAL calibration process, GCRs must pass through several layers of Si TKR to define a precise trajectory. I've chosen to require that GCRs travel from the uppermost complete Si layer through to the bottom of the CsI. From the GLAST Testbeam Users' Guide, I estimate that the distance between the uppermost complete Si layer and the bottom Si layer is about 0.215 m. The distance between the bottom Si layer and top of the CAL housing is 0.055 m. The distance from the top of the CAL housing to the bottom of the CsI is 0.230 m. Thus the distance from uppermost complete Si to bottom of the CsI is 0.50 m. The crystals have length 0.31 m. The geometry factor for two parallel square surfaces 0.31 m on a side separated by 0.50 m is 0.030 m^2 sr.

Table 1 lists the rates of GCRs passing between the topmost full layer of Si in the TKR and the bottom of the CsI for the balloon flight. Note that the rates are expressed in counts per *hour* at float altitude. Also listed is the fraction of each species that passes through the full detector system without suffering a charge or mass-changing interaction.

Species	Total rate (counts per hour)	Fraction not interacting	Non-interacting rate (counts per hour)
C	220	0.28	63
N	58	0.27	15
O	220	0.25	55
Ne	35	0.23	8
Mg	46	0.21	10
Si	35	0.20	7
Fe	29	0.13	4

Table 1: GCR rates between the topmost full Si layer and the bottom of the CsI. Note that the units are counts per hour.

It's clear from the table that the rate of useful medium to heavy GCRs is fairly modest. Assuming five hours at float, we'll have ~1000 each of C and O and ~150 Fe to search through for signatures of interactions. I consider the goal of that work to be to develop algorithms, rather than to provide a good and complete calibration for the balloon flight. Most useful for that calibration would be the ~300 each of C and O and ~20 Fe that do not interact within the BFEM.