SIS Geometry Factor
and
Bow Tie Analysis

ACE Memo ID: 2006.1.11.CMSC
11 January 2006
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SIS Geometry Factor:

The geometry factors that are currently used in the SIS level 2 processing are derived from a Monte Carlo simulation program (written in FORTRAN) originally created by Richard Selesnick and modified by myself. The program utilizes correct detector shapes, positions, and center thicknesses (as given in Brian Dougherty's memo 1997.10.23.BLD) as well as detector thresholds (as given in Dick Mewaldt's memo 1997.9.12.RAMa). As individual strips are not modeled (the matrix detectors are treated as a single active region), effects of raised strip thresholds and off strips are not accounted for.

As the instrument response is reasonably well represented by a square wave for most ranges, each range has been characterized by a geometry factor (corresponding to the flat-top level of the instrument response), a minimum energy and a maximum energy. These values for instrument ranges 0-7 and for He and O are given in Table 1 and show graphically in Figure 1. Although the program allows for the input particle population to be a specified function (power law, exponential in energy, exponential in rigidity, or flat), as the geometry factor is determined by the physical geometry of the instrument and the detector thresholds, the response shown in Figure 1 is independent of the incident spectrum as long as all energy bins are sampled adequately. The results shown (Figure 1 and Table 1) are for a flat incident spectrum.

Table 1: Geometry Factors and Energy Ranges for SIS He and O

Range	Helium			Oxygen		
	GF (cm^2 sr)	E min (MeV/n)	E max (MeV/n)	GF (cm^2 sr)	E min (MeV/n)	E max (MeV/n)
0	42.8	3.4	4.7	42.8	7.1	10.0
1	42.8	4.7	6.1	42.8	10.0	13.1
2	41.2	6.1	7.3	41.2	13.1	15.6
3	41.2	7.3	9.7	41.2	15.6	21.0
4	39.0	9.7	13.6	39.0	21.0	29.4
5	37.6	13.6	18.0	37.6	29.4	38.9
6	32.2	18.0	29.4	32.2	38.9	63.8
7	24.6	29.4	41.0	24.6	63.8	89.8

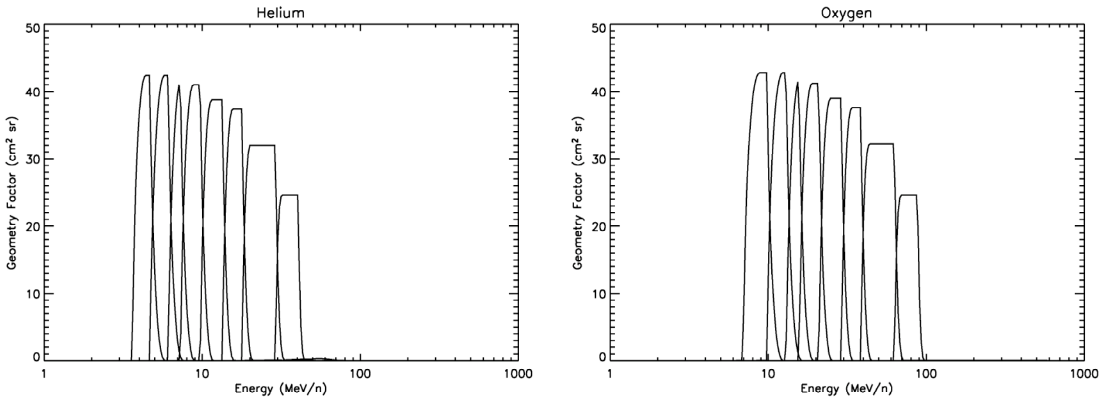

Figure 1. SIS instrumental response (geometry factor) as a function of incident energy for He (left panel) and O (right panel).

Bow Tie Analysis:

The bow-tie analysis (e.g., *Van Allen et al., JGR 79, 3559, 1974*) is a method of characterizing an instrument response by a geometry factor x ΔE (herein referred to as Γ) and an <E> which is independent of the spectral index of the incident particle population. This allows one to calculate the particle intensity (for a given energy range) and plot it at an energy (<E>) which is appropriate without a priori knowledge of the incident spectrum. This method was used in Lauren Scott's Ph.D. Thesis (*Washington University, 2005*) for CRIS data analysis.

Assuming a power law spectrum, the value of Γ can be expressed as the function of the instrument response R(E) in the following manner:

$$\Gamma(E,\gamma) = \frac{\int_0^\infty R(E)E^{-\gamma}dE}{E^{-\gamma}}.$$

Plotting Γ as a function of energy for many different values of γ results in a set of lines (for each instrument range) which will intersect at (roughly) a single point. That point provides values of <Γ> and <E> that are approximately independent of the incident spectra and thus can be used for plotting (and calculating particle intensities). To calculate Γ, I have numerically integrated the response function (Figure 1) multiplied by $E^{-\gamma}$ for γ = -4, -3, -2.5, -2, -1.5, -1.1, 0, 0.25, 0.5, 0.75, 1. The results are shown for the 8 instrumental ranges in Figure 2. From these plots values of <E> (vertical lines) and the corresponding <Γ> (horizontal lines) were determined and are given in Table 2 for He and O.

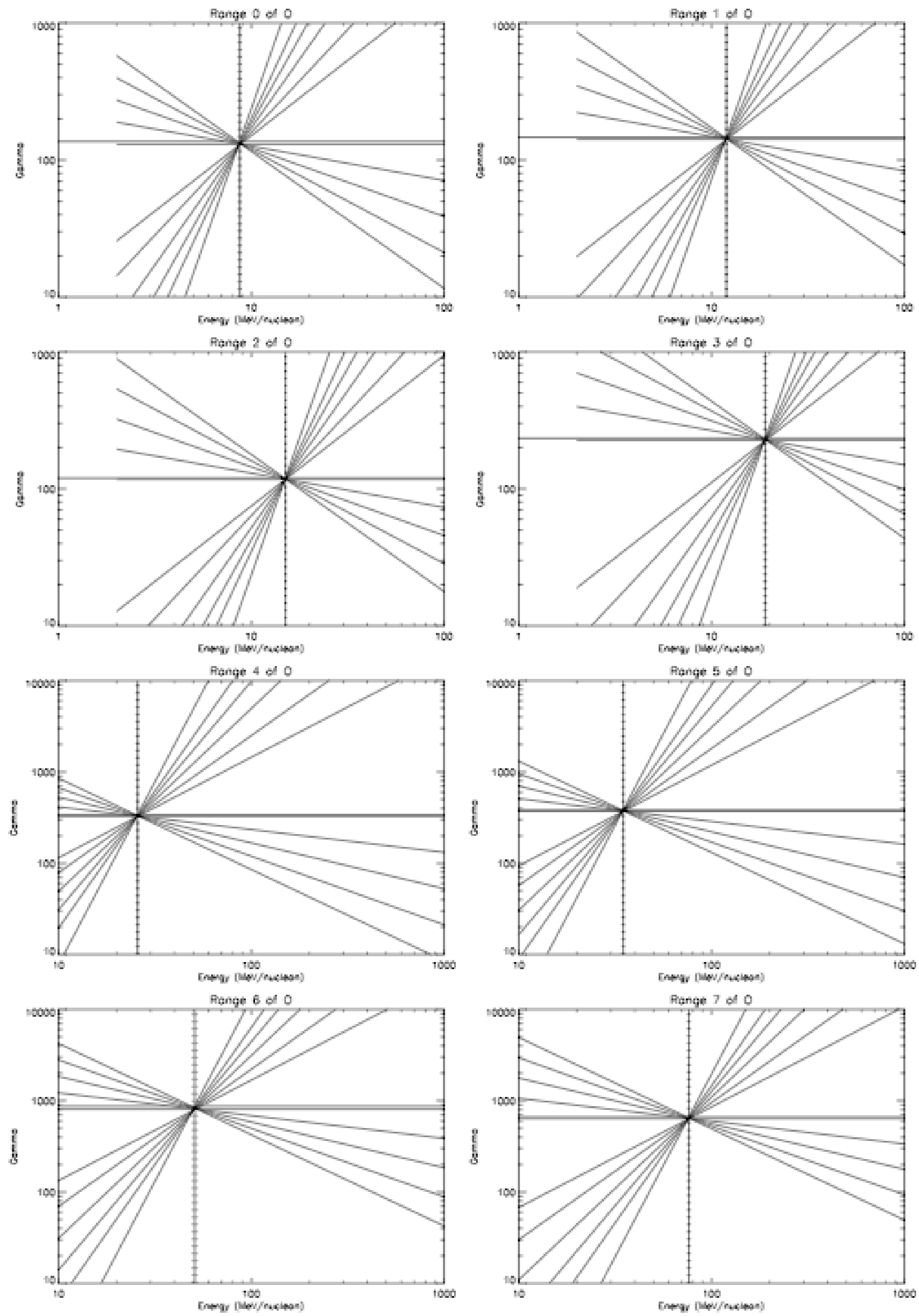

Figure 2. Results for the calculation of Γ(E,γ) for different values of γ for each of the 8 instrumental ranges for oxygen.

Table 2: Spectral Independent <E> and <Γ> and Normalization Factor for SIS He and O

Range	Helium			Oxygen		
	<Γ> (cm^2 sr MeV/n)	<E> (MeV/n)	A_{BT}	<Γ> (cm^2 sr MeV/n)	<E> (MeV/n)	A_{BT}
0	49.58	4.32	1.13	136.7	8.71	0.84
1	65.71	5.62	0.91	146.6	11.9	0.90
2	53.90	7.01	0.89	119.7	15.0	0.88
3	108.5	8.84	0.92	234.0	19.0	0.94
4	154.8	11.9	0.97	339.7	25.7	0.97
5	179.1	16.1	0.92	383.5	34.8	0.93
6	401.5	23.5	0.91	873.3	50.8	0.92
7	297.7	35.1	0.98	661.1	76.2	0.97

Changes to Level 2:

For the current level 2 analysis, the geometry factors and ΔEs (= E_{max} -E_{min}) used are those of Table 1. Rather than recalculate particle intensities using the bow-tie analysis, it was decided to make the values of <E> from Table 2 (and for other level 2 elements) available through the level 2 documentation. In addition, a 'normalization' factor will be provided for each instrumental range which would convert the reported level 2 intensities to those appropriate for plotting at <E>. This factor (A_{BT}) is calculated as

$$A_{BT} = \frac{GF \times \left(E_{\max} - E_{\min}\right)}{\langle \Gamma \rangle},$$

and is given in Table 2.