UPDATED HET GEOMETRY FACTORS

H. Breneman

Space Radiation Laboratory
California Institute of Technology
Pasadena, California

SRL Internal Report #92
August 6, 1984

ABSTRACT

Some of the HET geometry factors calculated in March 1982 and in use from then until July 1984 have been found to be in error by as much as 8 percent. Revised values for these geometry factors will be presented.

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Geometry factors for the "A" end of the Voyager High Energy Telescope (HET) were calculated by A. C. Cummings in March of 1982 (Table I). For particles stopping in detector A2, the geometry factor was calculated exactly using the analytical formula for the geometry factor of two circular disks of radii a and b separated by a distance l:

$$S = \frac{\pi^2}{2}\left[l^2 + a^2 + b^2 - \sqrt{(l^2+a^2+b^2)^2 - 4a^2b^2}\right] \tag{1}$$

The formula is derived in Garrard, *SRL Internal Report #7*. For stacks of three or more detectors, the general geometry factor calculation must be done numerically. At that time no program was available for the calculation, so the geometry factors for particles stopping in the C detectors were approximated by using Eq. (1) with the top and bottom detectors in the stack as the two disks. This overestimates the geometry factor since the C detectors are larger than A1 and A2, hence there exist trajectories that pass through A1 and the C's but miss A2. The estimated error of 10% was deemed acceptable.

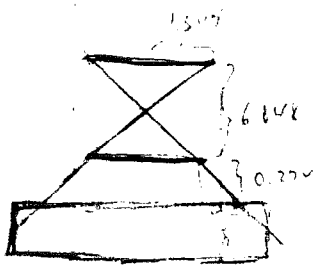
Since then a Monte Carlo computer program for geometry factor calculation was developed, and was recently applied to the HET telescope. Five independent runs were made, each consisting of 10^6 trajectories covering all solid angles. The results, shown in Table II and summarized in Table III and Fig. 1, show that the true geometry factor is about 8% below the old value for particles stopping near the front of detector C1. The discrepancy between the old and new values decreases as one progresses deeper into the C detector stack, and is negligible for particles stopping in C3 and C4. Note that the Monte Carlo program accurately reproduces the two-disk analytic solution for particles stopping in A2.

TABLE I. HET GEOMETRY FACTORS
(AC 3/9/82 CALCULATION).

3/9/82

HET Geometry Factors reduced ($A1, A2 = 0.94 \times 8\ cm^2$)

Range	Particle Range @ 13°	l (cm)	radius A1	radius 2nd det		$A\Omega$ ($cm^2 sr$)
A1		0				
A2	~300	6.848	1.547	1.547		1.096
top C1	~300	7.122	1.547	1.671	shadow of A1	1.182
mid C1	~1900	7.272		1.693		1.167 ←
bot C1	3375	7.422		1.693		1.124
top C2	3375	7.607		1.693		1.074
mid C2	6454	8.042				0.969
bot C2	9537	8.342				0.906
top C3	9533	8.527				0.869
mid C3	12610	8.961				0.792
bot C3	15690					
top C4	15690	9.446				0.717



$$\frac{6.848}{3.046} = \frac{.274}{\delta} \Rightarrow \delta = 0.124$$

use 1.096, 1.18, 1.17, 1.105, 0.95, 0.80

TABLE II. RESULTS OF MONTE-CARLO GEOMETRY FACTOR CALCULATION FOR VOYAGER HET.

GEOMETRICAL FACTORS

det #	detector	shape	radius	position	# traj.	geomf	particle angle (deg) min.	ave.	max.
1	A1	circle	1.5470	0.0000	1000000	23.6200	0.1	45.0	89.9
2	A2	circle	1.5470	6.8480	46320	1.0941	0.1	11.1	24.1
3	C1.front	circle	1.6930	7.1220	46320	1.0941	0.1	11.1	24.1
4	C1.middle	circle	1.6930	7.2720	46155	1.0902	0.1	11.0	23.9
5	C1.back	circle	1.6930	7.4220	45409	1.0726	0.1	10.9	23.3
6	C2.front	circle	1.6930	7.6070	44026	1.0399	0.1	10.6	22.8
7	C2.middle	circle	1.6930	8.0420	40299	0.9519	0.1	10.1	21.9
8	C2.back	circle	1.6930	8.3420	37832	0.8936	0.1	9.7	21.0
9	C3.front	circle	1.6930	8.5270	36398	0.8597	0.1	9.5	20.6
10	C3.middle	circle	1.6930	8.9610	33262	0.7856	0.1	9.1	19.6
11	C4.front	circle	1.6930	9.4460	30101	0.7110	0.1	8.6	18.7

GEOMETRICAL FACTORS

det #	detector	shape	radius	position	# traj.	geomf	particle angle (deg) min.	ave.	max.
1	A1	circle	1.5470	0.0000	1000000	23.6200	0.1	45.0	90.0
2	A2	circle	1.5470	6.8480	46186	1.0909	0.1	11.1	24.0
3	C1.front	circle	1.6930	7.1220	46186	1.0909	0.1	11.1	24.0
4	C1.middle	circle	1.6930	7.2720	46003	1.0866	0.1	11.1	23.9
5	C1.back	circle	1.6930	7.4220	45236	1.0685	0.1	10.9	23.6
6	C2.front	circle	1.6930	7.6070	43865	1.0361	0.1	10.7	22.9
7	C2.middle	circle	1.6930	8.0420	40096	0.9471	0.1	10.1	21.7
8	C2.back	circle	1.6930	8.3420	37648	0.8892	0.1	9.7	21.1
9	C3.front	circle	1.6930	8.5270	36159	0.8541	0.1	9.5	20.7
10	C3.middle	circle	1.6930	8.9610	33088	0.7815	0.1	9.1	19.6
11	C4.front	circle	1.6930	9.4460	30009	0.7088	0.1	8.7	18.9

GEOMETRICAL FACTORS

det #	detector	shape	radius	position	# traj.	geomf	particle angle (deg) min.	ave.	max.
1	A1	circle	1.5470	0.0000	1000000	23.6200	0.0	45.0	90.0
2	A2	circle	1.5470	6.8480	46220	1.0917	0.0	11.0	24.1
3	C1.front	circle	1.6930	7.1220	46220	1.0917	0.0	11.0	24.1
4	C1.middle	circle	1.6930	7.2720	46085	1.0885	0.0	11.0	23.8
5	C1.back	circle	1.6930	7.4220	45291	1.0698	0.0	10.8	23.5
6	C2.front	circle	1.6930	7.6070	43881	1.0365	0.0	10.6	23.0
7	C2.middle	circle	1.6930	8.0420	40235	0.9504	0.0	10.1	21.9
8	C2.back	circle	1.6930	8.3420	37795	0.8927	0.0	9.7	21.1
9	C3.front	circle	1.6930	8.5270	36359	0.8588	0.0	9.5	20.7
10	C3.middle	circle	1.6930	8.9610	33219	0.7846	0.0	9.1	19.8
11	C4.front	circle	1.6930	9.4460	30082	0.7105	0.0	8.6	18.7

TABLE II (CONTINUED).

GEOMETRICAL FACTORS

det #	detector	shape	radius	position	# traj.	geomf	particle angle (deg) min.	ave.	max.
1	A1	circle	1.5470	0.0000	1000000	23.6200	0.0	45.0	90.0
2	A2	circle	1.5470	6.8480	46612	1.1010	0.0	11.1	24.1
3	C1.front	circle	1.6930	7.1220	46612	1.1010	0.0	11.1	24.1
4	C1.middle	circle	1.6930	7.2720	46464	1.0975	0.0	11.0	23.9
5	C1.back	circle	1.6930	7.4220	45735	1.0803	0.0	10.9	23.4
6	C2.front	circle	1.6930	7.6070	44340	1.0473	0.0	10.6	22.9
7	C2.middle	circle	1.6930	8.0420	40583	0.9586	0.0	10.1	21.8
8	C2.back	circle	1.6930	8.3420	38102	0.9000	0.0	9.8	21.0
9	C3.front	circle	1.6930	8.5270	36657	0.8658	0.0	9.6	20.6
10	C3.middle	circle	1.6930	8.9610	33418	0.7893	0.0	9.1	19.7
11	C4.front	circle	1.6930	9.4460	30325	0.7163	0.0	8.7	18.8

GEOMETRICAL FACTORS

det #	detector	shape	radius	position	# traj.	geomf	particle angle (deg) min.	ave.	max.
1	A1	circle	1.5470	0.0000	1000000	23.6200	0.0	45.0	90.0
2	A2	circle	1.5470	6.8480	46483	1.0979	0.0	11.1	24.1
3	C1.front	circle	1.6930	7.1220	46483	1.0979	0.0	11.1	24.1
4	C1.middle	circle	1.6930	7.2720	46306	1.0937	0.0	11.0	23.8
5	C1.back	circle	1.6930	7.4220	45496	1.0746	0.0	10.9	23.4
6	C2.front	circle	1.6930	7.6070	44082	1.0412	0.0	10.6	22.8
7	C2.middle	circle	1.6930	8.0420	40394	0.9541	0.0	10.0	21.7
8	C2.back	circle	1.6930	8.3420	37922	0.8957	0.0	9.7	21.1
9	C3.front	circle	1.6930	8.5270	36486	0.8618	0.0	9.5	20.6
10	C3.middle	circle	1.6930	8.9610	33427	0.7895	0.0	9.1	19.8
11	C4.front	circle	1.6930	9.4460	30304	0.7158	0.0	8.6	18.7

TABLE III. Voyager HET "A"-end geometry factor ($cm^2 sr$)

Stopping position	AC 3/9/82 calculation	HB 7/26/84 calculation*	% error of old calc.
A2	1.096	1.0951 ± .0043	0.1 ± 0.4
C1 front	1.182	1.0951 ± .0043	7.9 ± 0.4
C1 middle	1.167	1.0913 ± .0043	6.9 ± 0.4
C1 back	1.124	1.0732 ± .0046	4.7 ± 0.4
C2 front	1.074	1.0402 ± .0045	3.2 ± 0.4
C2 middle	0.969	0.9524 ± .0043	1.7 ± 0.4
C2 back	0.906	0.8942 ± .0040	1.3 ± 0.4
C3 front	0.869	0.8600 ± .0043	1.0 ± 0.5
C3 middle	0.792	0.7861 ± .0034	0.8 ± 0.5
C4 front	0.717	0.7125 ± .0034	0.6 ± 0.5

* each point is an average of 5 runs of 10^6 trajectories each.

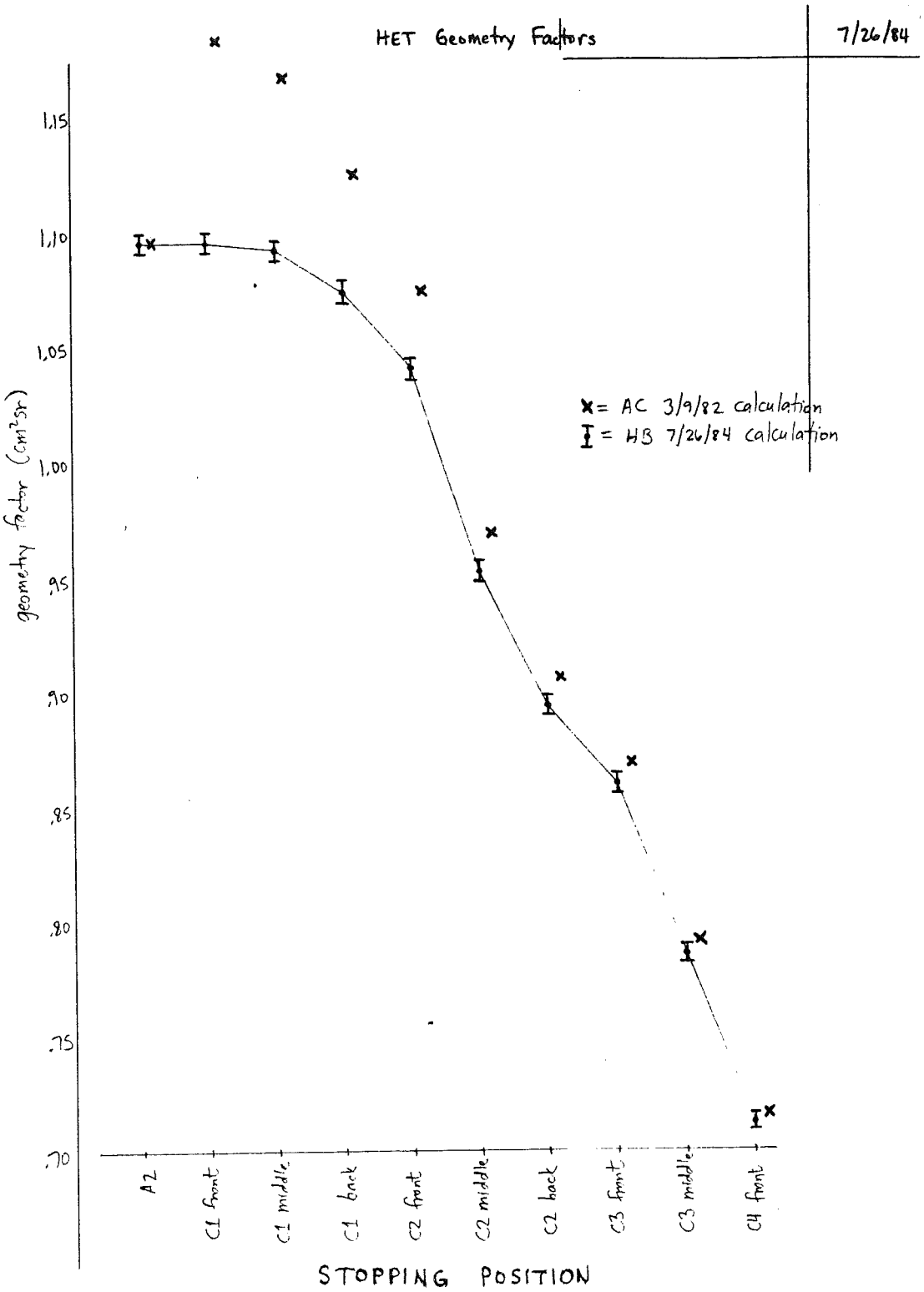


FIG 1. OLD AND NEW GEOMETRY FACTOR CALCULATIONS FOR VOYAGER HET.