POES SEM Omnidirectional Detector Moderators: Errata

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The Space Environment Monitor (SEM) Omnidirectional detectors that flew on TIROS-N and NOAA 6-8, 10, 12 and 14 had a similar design to the Dome detectors that flew on GOES 2-3 as part of the Energetic Particle Sensor (EPS) (Aeronutronic Ford 1976; Seale and Bushnell 1987; Cayton 2007). Data from these instruments are available from the NOAA National Centers for Environmental Information (NCEI). The purpose of this note is to correct an error in three SEM documents that was identified through a comparison of the two instruments. (SEM is sometimes referred to as SEM-1 to distinguish it from the thoroughly redesigned SEM-2 that first flew on NOAA-15.)

The SEM Omnidirectional detectors for channels P7 and P8 have the moderator thicknesses swapped in three NOAA documents (Hill et al. 1985, Table 2.2; Seale and Bushnell 1987; Raben et al. 1995, Table 2.2). To demonstrate this, we use projected range calculations for protons in the moderator materials using PSTAR (Berger et al. 2017), and drawings of the Omnidirectional detectors from Cayton (2007).

Table 1. P7 and P8 moderator materials and thicknesses and associated lower energies of protons that pass through the moderator, calculated for the published configuration and with the thicknesses swapped. Note that the actual areal density and lower energy for the P8 moderator are 10.80 g cm^{-2} and 80.4 MeV, respectively, using the correct tungsten alloy density.

Channel	Given Lower Energy (MeV)	Given Moderator Material	Given Thick-ness (inches)	Given Thick-ness (mm)	Given Areal Density (g cm^{-2})	Lower Energy from PSTAR (MeV)	Swap Thick-ness (mm)	Swap Areal Density (g cm^{-2})	Lower Energy from PSTAR (MeV)
P7	36	Copper	0.230	5.84	5.23	62.8	2.18	1.95	35.8
P8	80	Mallory	0.086	2.18	4.21	46.1	5.84	11.27	82.4

The PSTAR calculations give penetrating proton energies consistent with the documentation only if the moderator thicknesses for P7 and P8 are swapped but the materials are kept the same (Table 1). The materials and swapped thicknesses are consistent with the geometries used for the simulation of the three SEM Omnidirectional channels by Cayton (2007), shown in Figure 1.

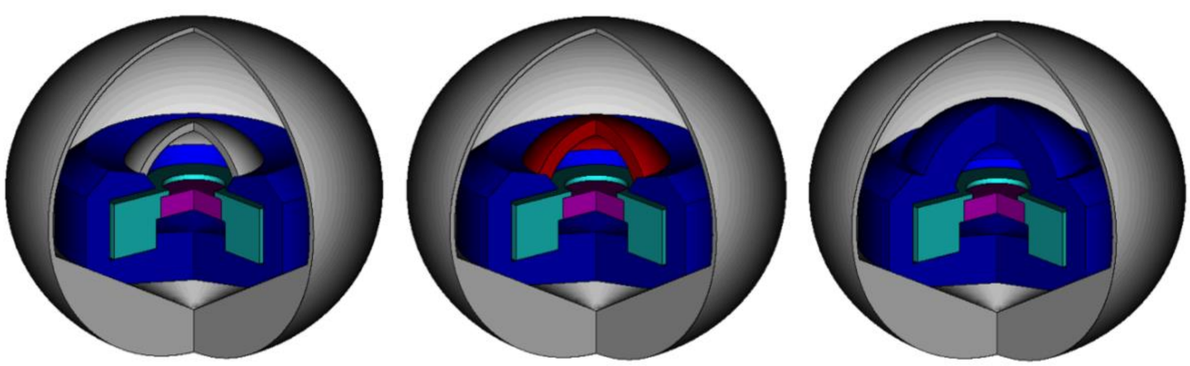

Figure 1. Geometries of POES SEM MEPED omnidirectional channels P6 (left), P7 (center), and P8 (right) used in numerical modeling of their responses to protons and electrons (from Cayton 2007). The colors indicate the materials used: magenta: Kevex Si (Li) detectors; cyan: plastic and G-10 insulation; gray: aluminum moderator and shroud; red: copper moderator; deep blue: tungsten moderator and shielding.

The P8 moderator characteristics in the GOES 2-3 and SEM documentation assume the density of pure tungsten (19.3 g cm^{-3}). This is inaccurate. Mallory metal is an alloy of tungsten, nickel and iron, and therefore is less dense than pure tungsten. For example, Mallory 3000, which is 90% tungsten, has a density of 17.0 g cm^{-3}. According to a TIROS MEPED drawing, the tungsten alloy used was mil spec T-21014, class 4, type 2. This particular alloy is 97% W, 2.1% Ni, and 0.9% Fe, and has a density of 18.5 g/cm^3 (T. Cayton, private communication, 2023). As a result, the areal density for the P8 moderator is corrected to be 10.80 g cm^{-2}, corresponding to a PSTAR lower energy of 80.4 MeV. The density of 18.5 g/cm^3 was correctly used in the simulations of the SEM MEPED omnidirectional detectors by Cayton (2007).

In estimating the P6-P8 lower proton energies, the SEM documentation does not account for the presence of the aluminum thermal shroud, though the shroud is shown by Seale and Bushnell (1987). The presence of the shroud has a significant effect on the lower energy (Cayton 2007). The P6 lower energy increases from 16 MeV to 20 MeV, and the P7 lower energy increases from 36 MeV to 39 MeV. The P8 response is affected more by other characteristics of the instrument. Details like the presence of the thermal shroud and the tungsten alloy density are essential for accurately quantifying the performance of an instrument.

It should be noted that, while the GOES 2-3 EPS Dome detectors and the SEM Omnidirectional directors had the same mechanical design, the deposited energy thresholds were different, resulting in different channels.

References

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