README: NOAA 15-19 and Metop A-C SEM-2 MEPED Omnidirectional Detector Response Functions

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The second-generation Space Environment Monitor (SEM-2) Medium-Energy Proton and Electron Detectors (MEPED) that flew on NOAA 15-19 and Metop A, B and C included four Omnidirectional detectors. The channels from these detectors were referred to as P6, P7, P8 and P9, and were nominally sensitive to >16, >36, >80 and >140 MeV protons (Evans and Greer 2000). The P6 and P7 channels were also sensitive to MeV electrons, though less so than the first-generation SEM Omnidirectional detectors.

Dr. Thomas E. Cayton modeled the responses of the SEM-2 P6, P7, P8 and P9 channels, using an approach similar to that he used to model the responses of the SEM-1 Omnidirectional channels (Cayton 2007). He simulated the effect of a 2.0-3.0 MeV range of deposited energy thresholds in order to bound the effect of threshold variation on the performance of the instrument. The nominal deposited-energy threshold is 2.5 MeV. The geometries used in these simulations are shown in Figures 1-4. The various colors indicate the materials used in the Omni sensors as follows. The silicon detector element is exhibited in magenta; plastic insulator, blue; G-10 detector package and circuit board, brown; tungsten shielding, purple; aluminum shroud, filter, and housing, gray; lumped elements of the "back side", yellow (this simulation material involves the same composition as 6061 aluminum but an artificially higher density, 8.1 g/cm^3). The tungsten alloy used is 97% W, 2.1% Ni, and 0.9% Fe, and has a density of 18.5 g/cm^3.

Dr. Cayton has graciously given permission to NCEI to share the modeled response functions with the SEM-2 user community. The responses are provided in the form of ASCII lists.
For each channel there are two separate proton responses, one due to isotropic proton fluxes incident from above, and the other due to isotropic proton fluxes incident from below. The electron responses are total responses due to isotropic electron fluxes incident from above and below.

The energies are in MeV and the response functions are in cm^2 sr.

The filenames use the following template:

sem2_omni_pN_electron.txt, where N = 6, 7, 8 or 9
sem2_omni_pN_proton_above.txt, where N = 6, 7, 8 or 9
sem2_omni_pN_proton_below.txt, where N = 6, 7, 8 or 9

The contents of these files are plotted in Figures 5-16.

Each ASCII file includes 12 entries, as follows:

column 1 -- incident energy in MeV
column 2 -- response in cm^2-sr for threshold exactly 2.0 MeV
column 3 -- response in cm^2-sr for threshold exactly 2.1 MeV
column 4 -- response in cm^2-sr for threshold exactly 2.2 MeV
column 5 -- response in cm^2-sr for threshold exactly 2.3 MeV
column 6 -- response in cm^2-sr for threshold exactly 2.4 MeV
column 7 -- response in cm^2-sr for threshold exactly 2.5 MeV
column 8 -- response in cm^2-sr for threshold exactly 2.6 MeV
column 9 -- response in cm^2-sr for threshold exactly 2.7 MeV
column10 -- response in cm^2-sr for threshold exactly 2.8 MeV
column11 -- response in cm^2-sr for threshold exactly 2.9 MeV
column12 -- response in cm^2-sr for threshold exactly 3.0 MeV

Because the simulations are for a wide range of threshold energies (2.0-3.0 MeV), it is important to know the range of actual threshold energies. The as-measured, pre-flight thresholds for omnidirectional channels P6-P9 are summarized in Table 1. This table shows that all but one of the thresholds are in the range 2.4-2.6 MeV. These data show that the variations from the design threshold of 2.5 MeV are small. Moreover, the thresholds have been stable. According to the instrument contractor, as of June 2024, the Metop-C omnidirectional thresholds have varied 0.3% or less since launch in November 2018. Assumptions commonly used to interpret data from integral, omnidirectional channels like these, such as the flux energy spectrum and pitch-angle dependence, may have a greater effect on the results than these small variations in threshold energies. Therefore, it should be adequate to use the curve with the nearest threshold value to the as-measured value.

Table 1. *As-measured, pre-flight thresholds for SEM-2 MEPED omnidirectional channels P6-P9. The thresholds are given in MeV. The ratios are with respect to the design value of 2.5 MeV.*

	NOAA-15		**NOAA-16**		**NOAA-17**		**NOAA-18**	
Omni. Channel	Calibrated (MeV)	Ratio	Calibrated (MeV)	Ratio	Calibrated (MeV)	Ratio	Calibrated (MeV)	Ratio
P6	2.499	0.9996	2.501	1.0004	2.510	1.0040	2.480	0.9920
P7	2.487	0.9948	2.493	0.9972	2.525	1.0100	2.499	0.9995
P8	2.505	1.0020	2.509	1.0036	2.532	1.0128	2.498	0.9991
P9	2.495	0.9980	2.493	0.9972	2.530	1.0120	2.507	1.0026
	NOAA-19		**Metop-A**		**Metop-B**		**Metop-C**	
Omni. Channel	Calibrated (MeV)	Ratio	Calibrated (MeV)	Ratio	Calibrated (MeV)	Ratio	Calibrated (MeV)	Ratio
P6	2.488	0.9953	2.510	1.0040	2.625	1.0500	2.546	1.0183
P7	2.497	0.9989	2.505	1.0020	2.537	1.0148	2.472	0.9889
P8	2.482	0.9928	2.448	0.9792	2.517	1.0068	2.512	1.0046
P9	2.490	0.9960	2.491	0.9964	2.553	1.0212	2.507	1.0027

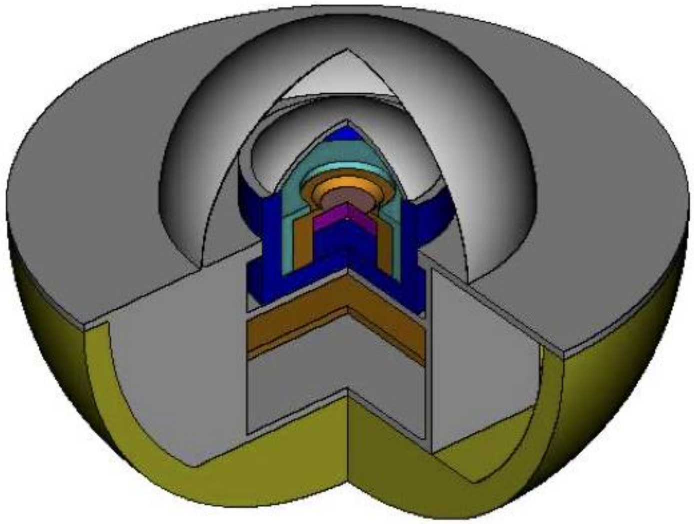

Figure 1. Modeled P6 geometry.

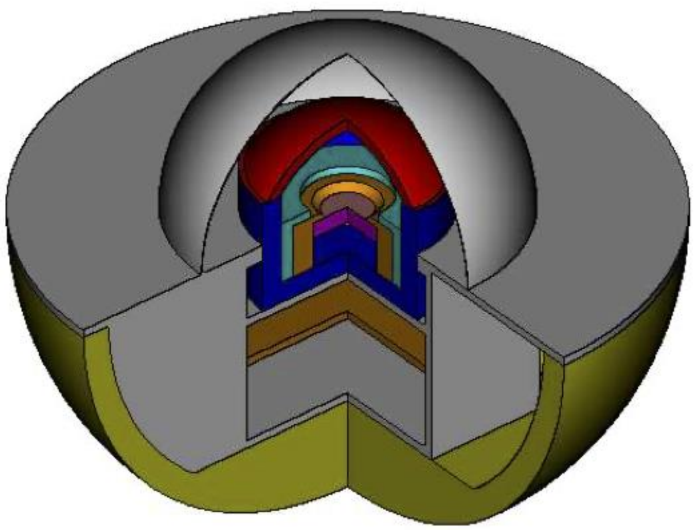

Figure 2. Modeled P7 geometry.

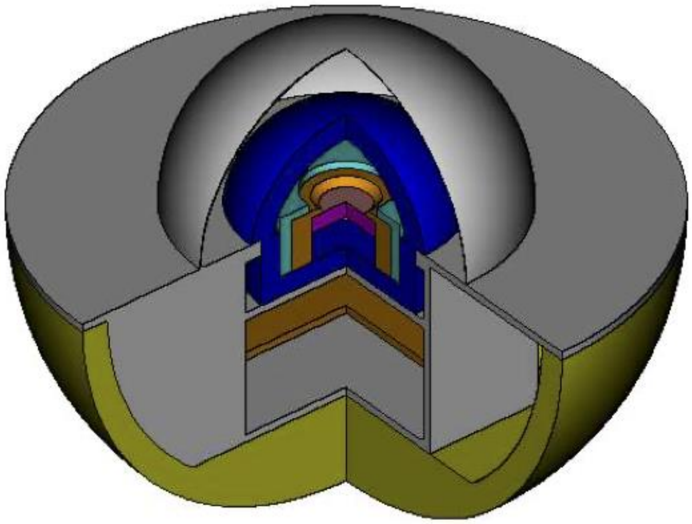

Figure 3. Modeled P8 geometry.

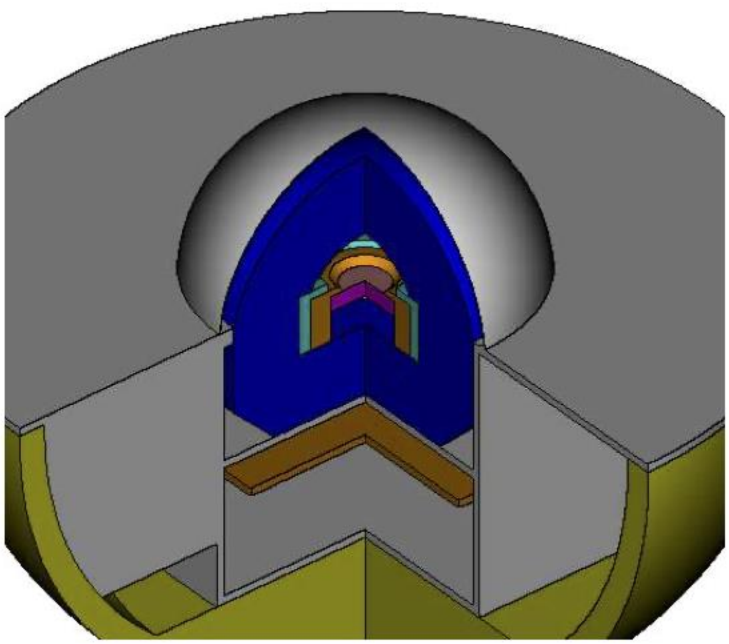

Figure 4. Modeled P9 geometry.

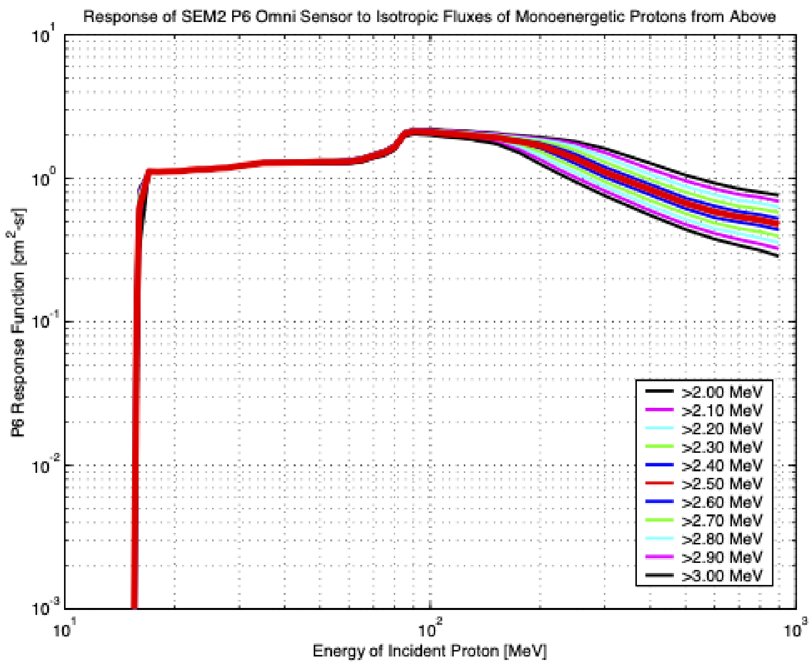

Figure 5. Responses of the P6 channel to isotropic proton fluxes incident from above for eleven energy thresholds.

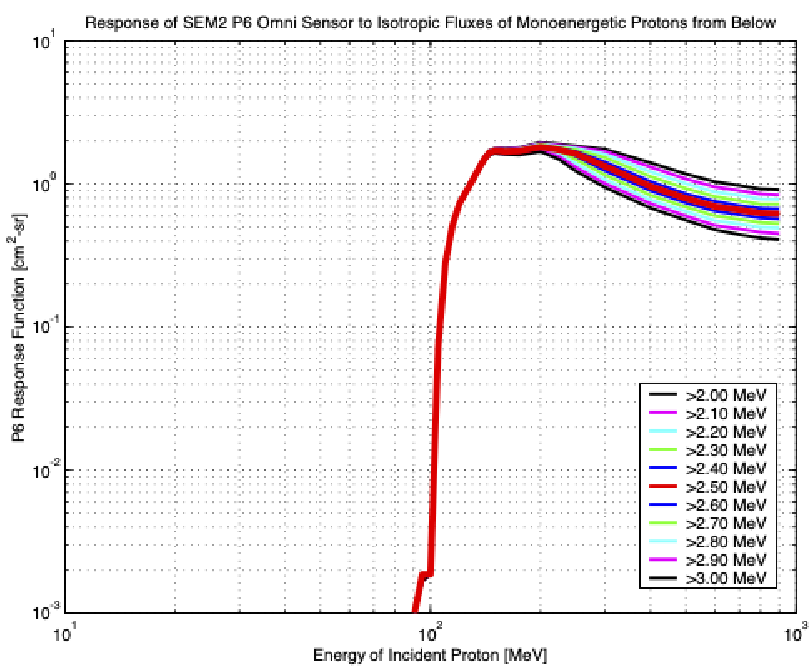

Figure 6. Responses of the P6 channel to isotropic proton fluxes incident from below for eleven energy thresholds.

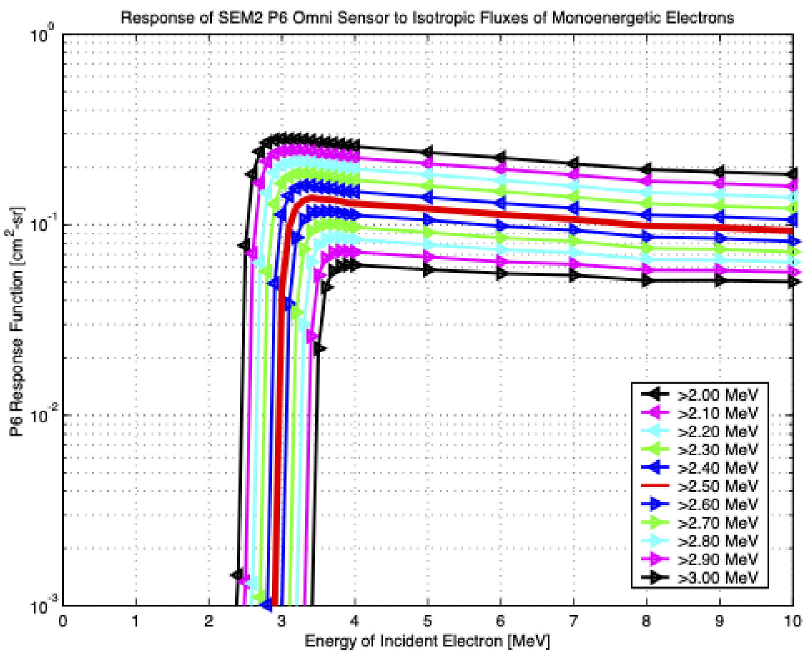

Figure 7. Responses of the P6 channel to isotropic electron fluxes incident from both above and below for eleven energy thresholds.

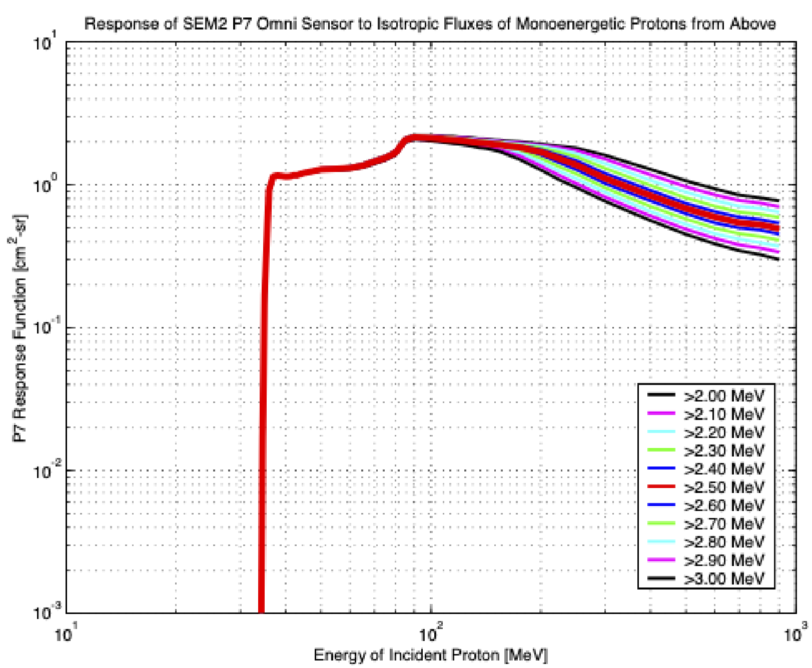

Figure 8. Responses of the P7 channel to isotropic proton fluxes incident from above for eleven energy thresholds.

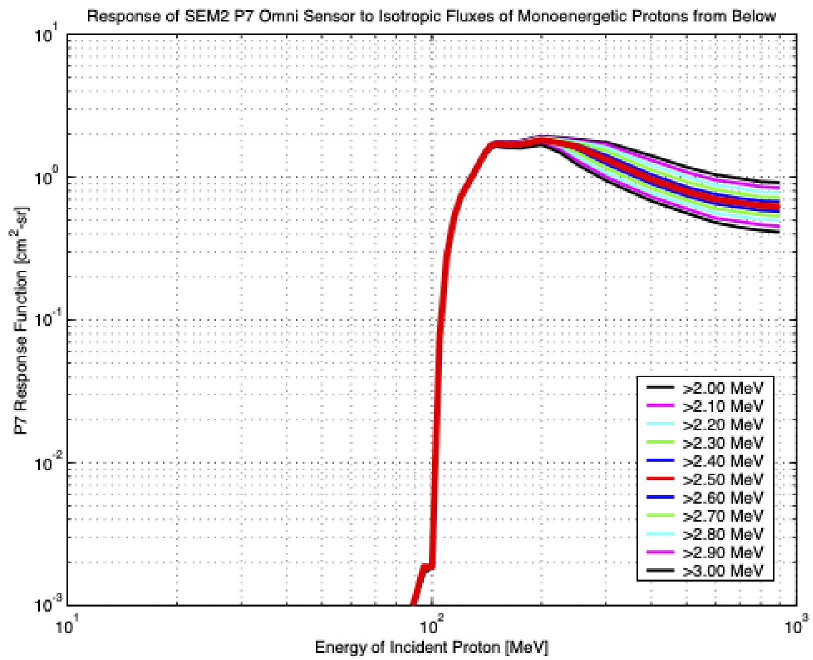

Figure 9. Responses of the P7 channel to isotropic proton fluxes incident from below for eleven energy thresholds.

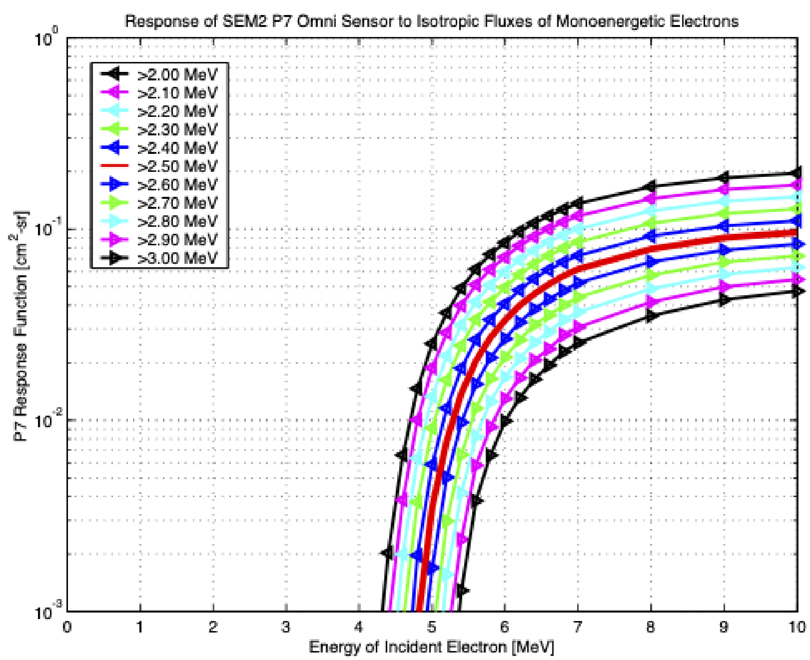

Figure 10. Responses of the P7 channel to isotropic electron fluxes incident from both above and below for eleven energy thresholds.

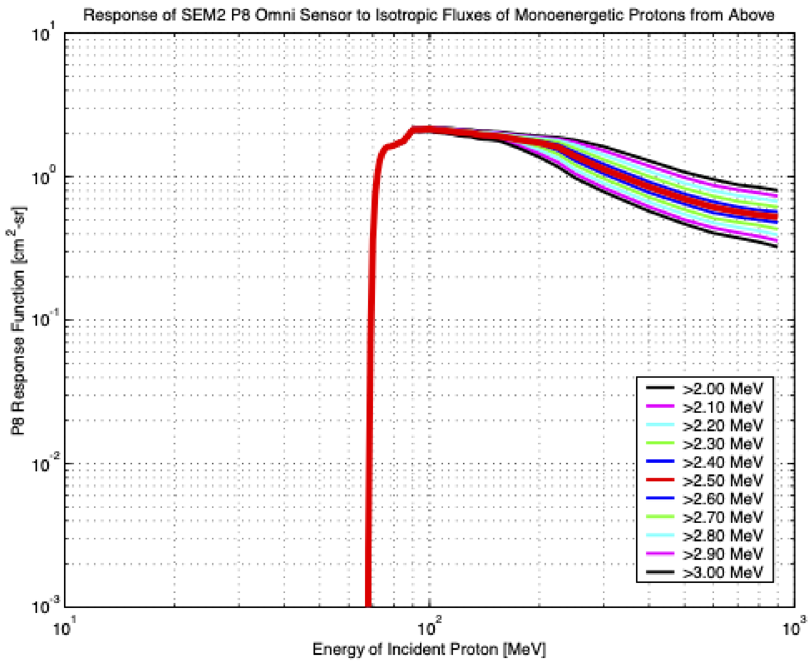

Figure 11. Responses of the P8 channel to isotropic proton fluxes incident from above for eleven energy thresholds.

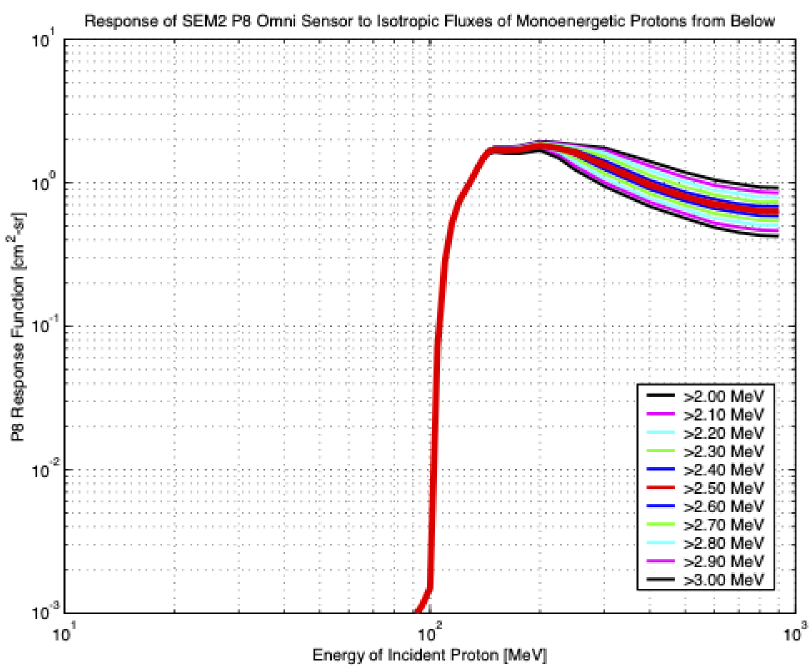

Figure 12. Responses of the P8 channel to isotropic proton fluxes incident from below for eleven energy thresholds.

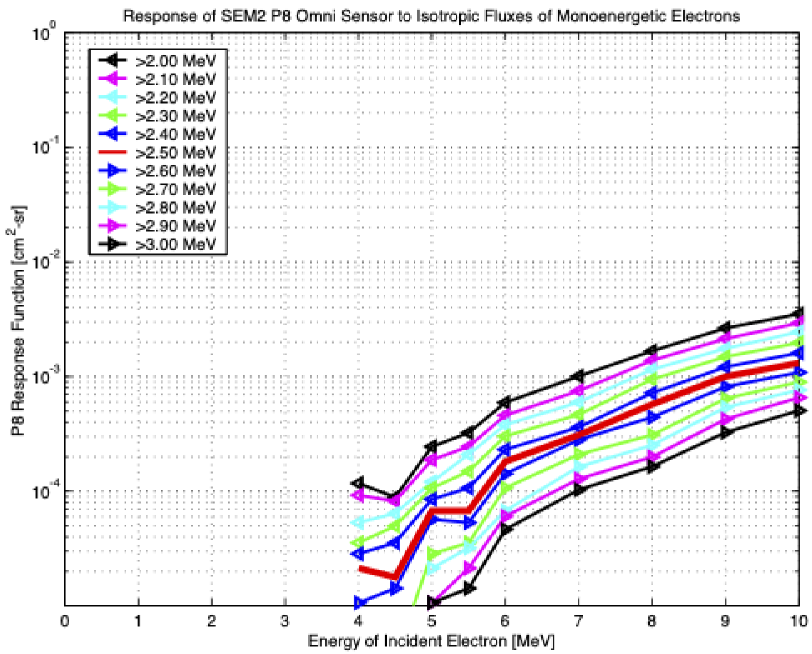

Figure 13. Responses of the P8 channel to isotropic electron fluxes incident from both above and below for eleven energy thresholds.

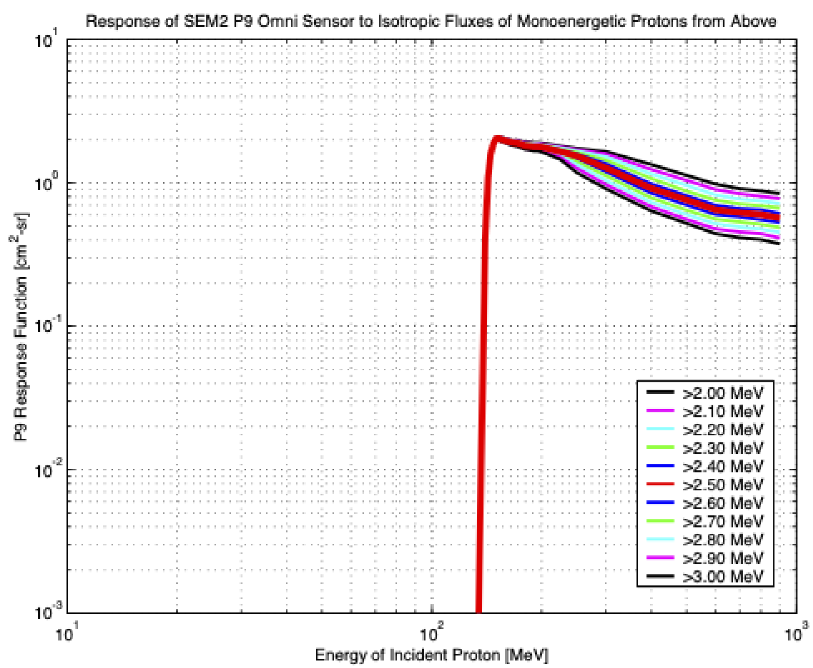

Figure 14. Responses of the P9 channel to isotropic proton fluxes incident from above for eleven energy thresholds.

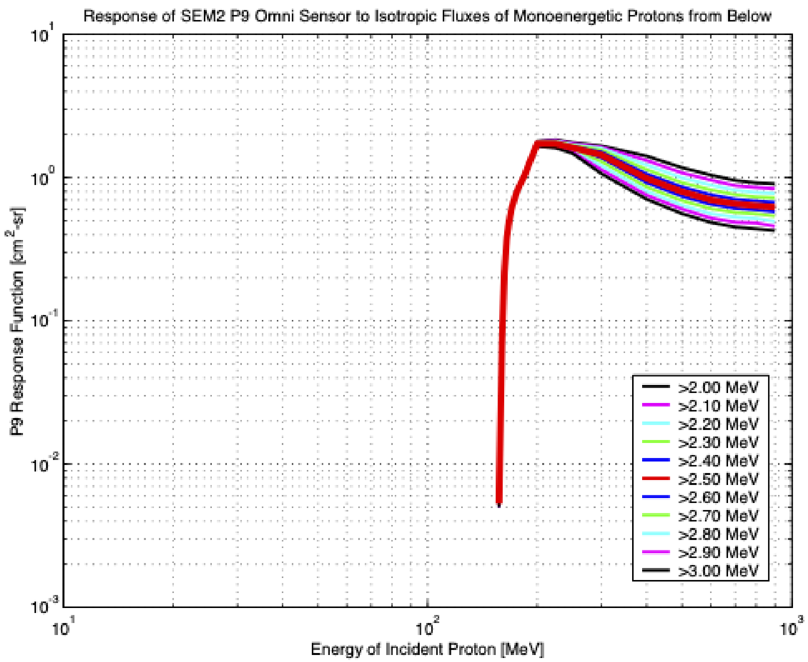

Figure 15.. Responses of the P9 channel to isotropic proton fluxes incident from below for eleven energy thresholds.

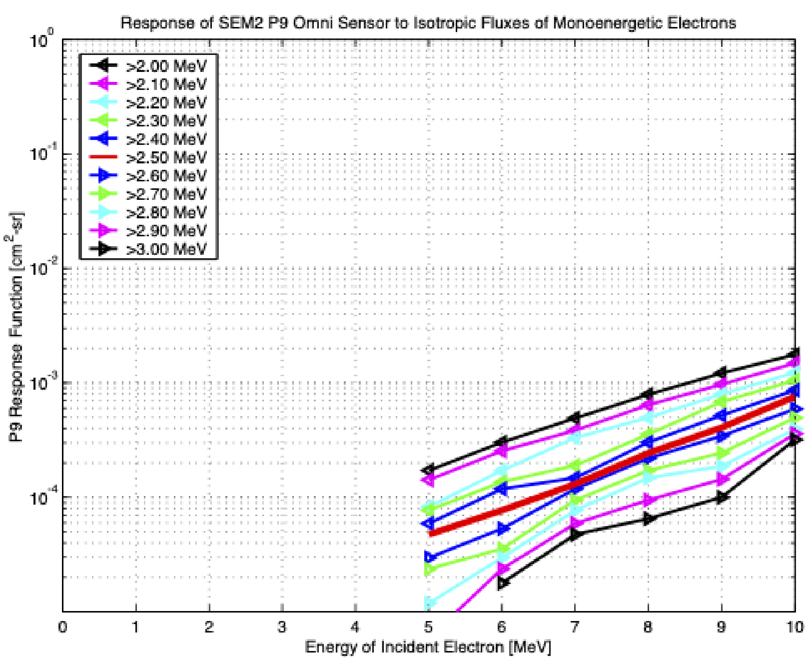

Figure 16. Responses of the P9 channel to isotropic electron fluxes incident from both above and below for eleven energy thresholds.

References

Cayton, T. E. (2007), Numerical Modeling of the Omnidirectional Spectrometer of the Medium Energy Proton and Electron Detector (MEPED) Subsystem of the Space Environment Monitor (SEM) that Flew Aboard Several Polar Orbiting Satellites, LA-UR-07-7314

Evans, D. S., and Greer, M. S. (2000), Polar Orbiting Environmental Satellite Space Environment Monitor – 2: Instrument Descriptions and Archive Data Documentation, NOAA Technical Memorandum OAR SEC-93.