README: REACH Dosimeter Response Files

This README document describes the Responsive Environmental Assessment Commercially Hosted (REACH) dosimeter response function files. These files provide the sensor's response to protons and electrons as a function of energy and angle of incidence. For further information contact the instrument PI Joe Mazur joseph.e.mazur@aero.org, the data curator Tim Guild (Timothy.B.Guild@aero.org) or the creator of these files, Paul O'Brien, paul.obrien@aero.org.

Four response files are provided:

- reach_all_flavors_response.h5 – Energy-angle response in PRBEM format (HDF5)
- reach_all_flavors_response.xml.gz – Energy-angle response in PRBEM format (gzipped XML)
- reach_all_flavors_response_proton_iso.csv – Energy response to isotropic proton flux (CSV)
- reach_all_flavors_response_ele_iso.csv – Energy response to isotropic electron flux (CSV)

The XML file is a "human readable" dump of the HDF5 file, compressed using gzip.

In addition to the data files, we have also computed bowtie flux conversion factors for the REACH dosimeters. Those values are given in Table 1 and described in TOR-2019-02016.

Table 1. Bowtie results for REACH dosimeters (from TOR-2019-02016)

Flavor	Electrons				Protons			
	E_0 (MeV)	G[2] (cm^2sr)	G* [3] (cm^2 sr rad)	G error[4] (%)	E_0 (MeV)	G[2] (cm^2sr)	G*[3] (cm^2 sr rad)	G error[4] (%)
U[1]	2.15	4.3E-5	6.7E-10	110	51.5	4.0E-2	6.2E-7	1
V[1]	2.20	5.9E-5	9.2E-10	103	43.9	3.6E-2	5.6E-7	2
W	1.43	4.5E-6	9.3E-11	7	10.5	1.1E-2	2.2E-7	<1
X	0.798	9.1E-4	1.4E-8	7	12.1	2.1E-2	3.3E-7	4
Y[1]	2.47	1.6E-4	2.5E-9	77	30.3	2.9E-2	4.6E-7	4
Z	0.0916	2.6E-6	7.3E-10	20	1.29	3.3E-5	9.4E-9	9

(1) The approximation to an ideal integral electron channel has large uncertainties for these channels due to the absence of a sharp turn-on in the response function.
(2) Factor for converting dosimeter counts per second to flux.
(3) Factor for converting dosimeter rads per second to flux.
(4) Conversion factor errors are percentages that apply to both G and G^*

Energy-angle (PRBEM) response files

The Energy-angle response files are provided using the Panel on Radiation Belt Environment Models (PRBEM) response file format (v1.1.1) which can be found here: prbem.github.io/docs/. In these files, the proton and electron response of the RPS sensor is given for each of the 6 flavors described in [TOR-2019-02016, TOR-2019-02361, and TOR-2021-01076]. Each satellite carries two dosimeters of different flavors. The sensor is represented as having a response that depends on incident energy and two angles: polar angle THETA (θ) and azimuth angle Phi (ϕ) (see Figure 1). Normally incident particles have an incident angle THETA (θ) of 0. Summary bowtie values for scalar flux conversion can be found in TOR-

2019-02016 (the source of figures in this paper). The PRBEM response files are provided both HDF5 (.h5) format and as a zipped XML file.

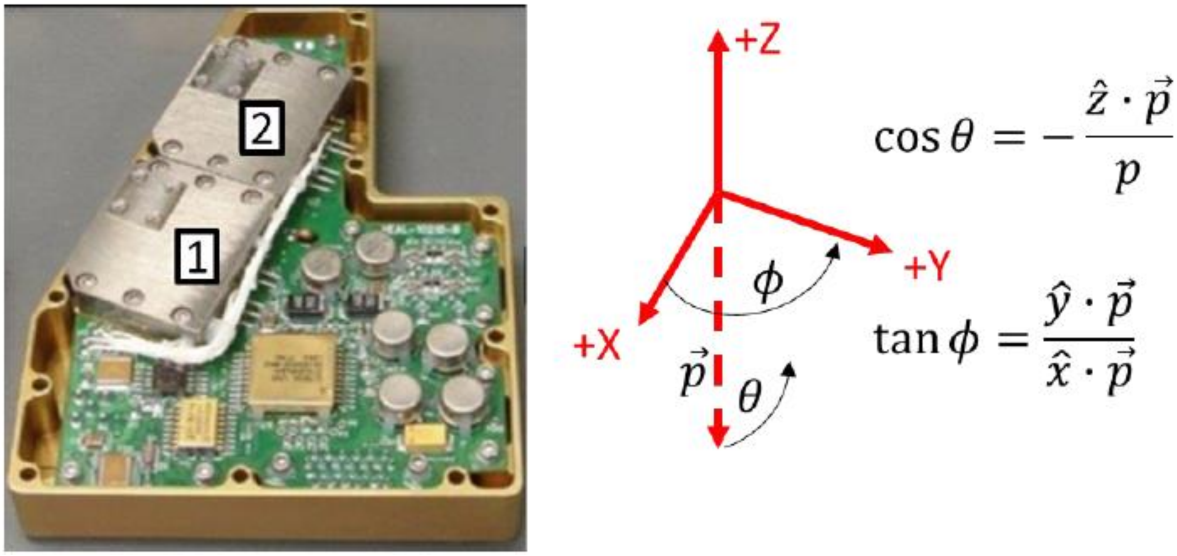

Figure 1 Photograph of a REACH pod with Dos1 and Dos2 labeled. Coordinate axes are also provided as well as the relationship between incident particle momentum *p* and the coordinates.

The HDF5 format PRBEM response file (.h5 extension) was produced from Matlab and has some subtleties in their structure. The following information may be helpful. The same applies to the XML file which was produce from the HDF5 file using the h5dump utility.

- HDF5 written from Matlab does not store strings. So, strings are stored in UTF-8 encoding as uint8 data. String variables have an attribute isString.
- Boolean variables are stored as uint8 and have an attribute isBoolean.
- Matlab stores arrays of strings as "cell arrays." These are captured in HDF5 as groups with an isArray attribute. Members of the group have variable names 000, 001, 002, … Enough digits are used to accommodate all members of the group with zero-padded variable names of the same length. When reading the group, the members should be sorted (by increasing variable name number) to restore the original order in the array.
- Most of the data are stored in groups and sub-groups, with isStruct attribute set.
- Matlab treats all variables as double precision and matrix by default. Thus, even scalars will have size 1x1, and many integers will be stored as double precision.

Isotropic response files

Isotropic response files are provided for both protons and electrons by numerically integrating the energy-angle response over the angular dependence. Each of these files has a single column providing the energy value in MeV and the one column per dosimeter flavor. The numerical values in the flavor columns are the response of the specified channel at the associated energy. The figures below provide the isotropic response to protons and electrons.

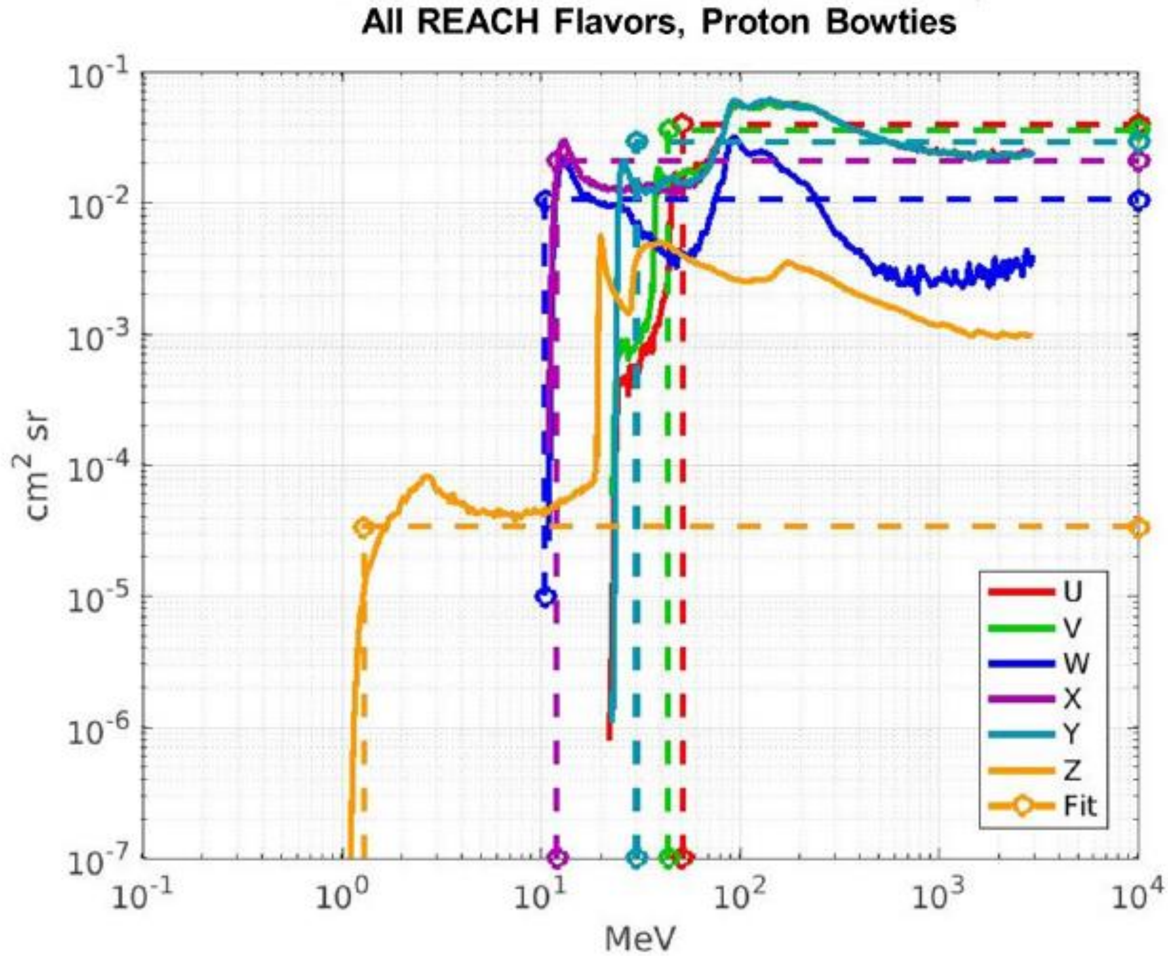

Figure 2. REACH isotropic proton response. Solid curves indicated the computed isotropic response of each channel. Dashed lines give the approximate integral channel from the bowtie analysis. From TOR-2019-02016

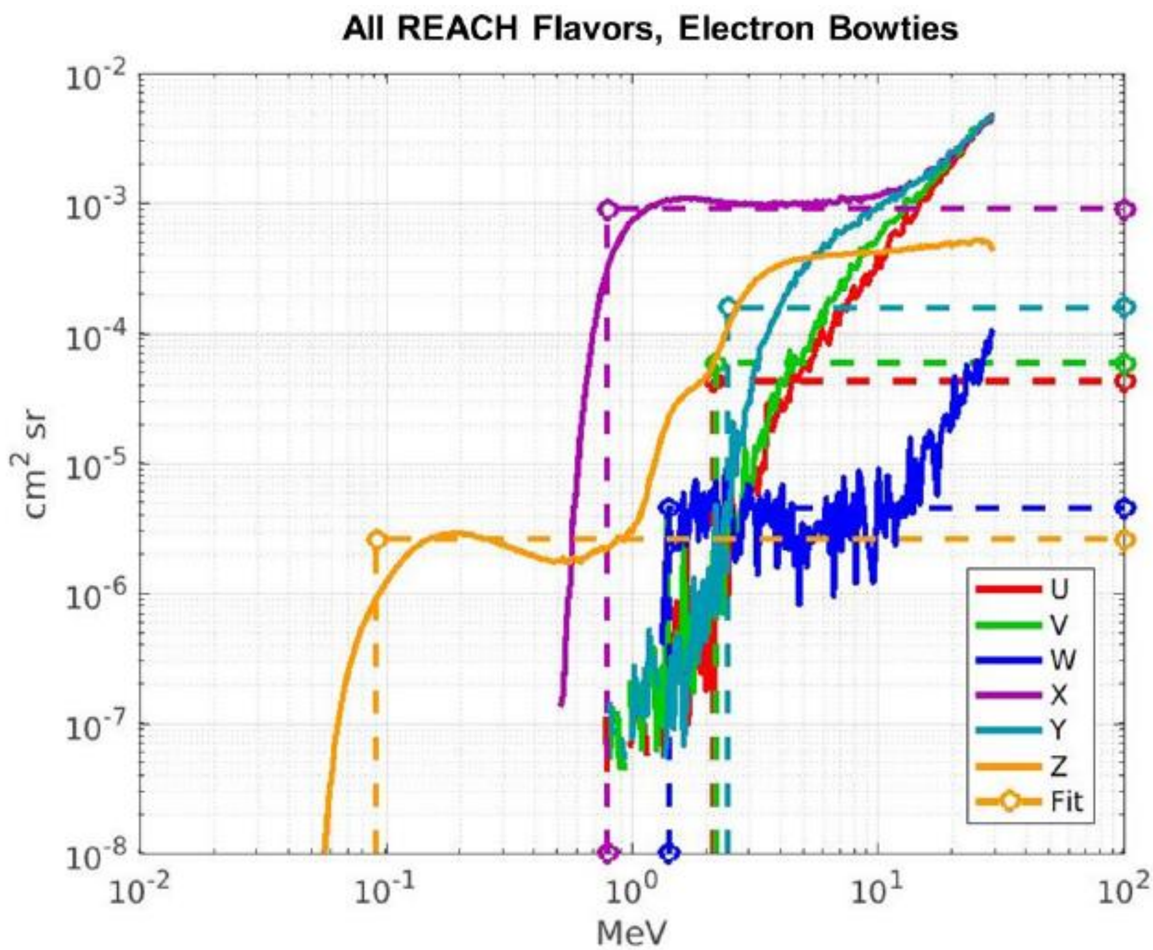

Figure 3. REACH isotropic electron response. Solid curves indicated the computed isotropic response of each channel. Dashed lines give the approximate integral channel from the bowtie analysis. From TOR-2019-02016

References

TOR-2019-02016, O'Brien, T. P., M. D. Looper, J. E. Mazur, REACH Dosimeter Equivalent Energy Thresholds and Flux Conversion Factors, The Aerospace Corporation, 2019.

TOR-2019-02361,T.B. Guild, T.P. O'Brien, A.J. Boyd, J.E. Mazur, and A.J. Halford, Intra-calibration of REACH Dosimeters, The Aerospace Corporation, 2019.

TOR-2021-01076, T.B. Guild, T.P. O'Brien, A.J. Boyd, and J.E. Mazur, REACH Historical Data README (v3.0), The Aerospace Corporation, 2021.

These reports may be obtained from library.mailbox@aero.org and from https://doi.org/10.5281/zenodo.5988170