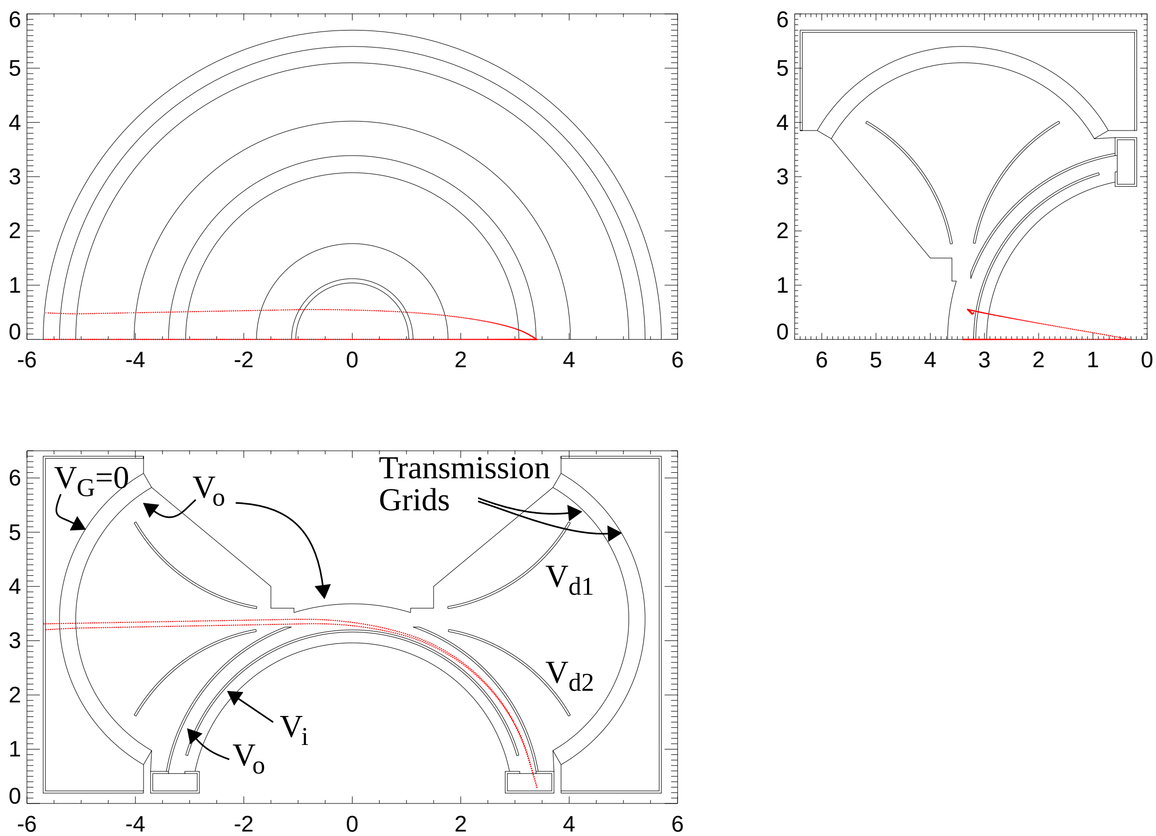
A possible geometry for the SWEA detector is shown below. The design is basically the same as other top hat analyzers except the outer hemisphere here is allowed to have a variable potential. The outer (toroidal) grid is held at spacecraft ground. The inner toroidal grid is held at the same potential as the outer hemisphere, V_o. The deflection voltages, V_{d1} and V_{d2} are held at V_o when no deflection is required. When deflection is used, only one of V_{d1} or V_{d2} is changed, the other is held at V_o. If no attenuation is desired then V_o is set to ground and the instrument behaves the same as a top hat in normal operation. With qV_o set to a positive value, incoming particles are decelerated in the region between the two entrance grids. Deflectors can be used to guide particles into the entrance aperature, and then the hemispherical analyzer is used to select an energy band-pass. The geometric factor is lower and the relative energy resolution is reduced.

The toroidal entrance grids are required in order to use the deceleration and angle deflection at the same time. If no deflection is desired, then these entrance grids could be avoided.



The reponse characteristics of this analyzer are easily estimated. With V_i and V_o defined as the potential of the inner and outer hemispheres, we define:

$$\delta V = V_o - V_i$$

The passband energy and energy resolution are easily determined:

$$\langle E \rangle = qV_o + k_a q\delta V = q\delta V(\alpha + k_a)$$
$$\delta E = wk_a q\delta V$$

Here k_a and w are characteristics of the geometry of a top hat analyzer and we have defined $\alpha = V_o/\delta V$. For typical Berkeley analyzers, k_a~7 and w~0.1 (10%). By varying the value of α the relative energy resolution can be varied:

$$\frac{\delta E}{\langle E \rangle} = \frac{w}{1 + \alpha/k_a}$$

Geometric factor can be calculated by modelling a detector, calculating trajectories of particles, and summing over the trajectories that succesfully reach the MCP plane.

$$G = \int R(E, \theta_v, \phi_v, z, \phi, r) dE d\Omega dA$$

Here the Response function, R(...) is either 1 or 0 depending upon whether or not a trajectory starting outside the detector, passes through the given phase space coordinates and stops at the MCP plane.

Conservation of phase space volume provides the following useful result:

$$E dE d\Omega dA = \text{Constant}$$

This can be used to calculate how the geometric factor, G, will vary with α. Assuming the energy bandpass of the detector is narrow:

$$G_\alpha \approx \frac{G_0}{1 + \alpha/k_a}$$

where G_0 is the geometric factor of the instrument for α=0:

$$G_0 = g_0 k_a q\delta V = g_0 \langle E \rangle$$

The effective geometric factor is defined as:

$$g_\alpha = \frac{G_\alpha}{\langle E \rangle} = \frac{g_0}{(1 + \alpha/k_a)^2}$$

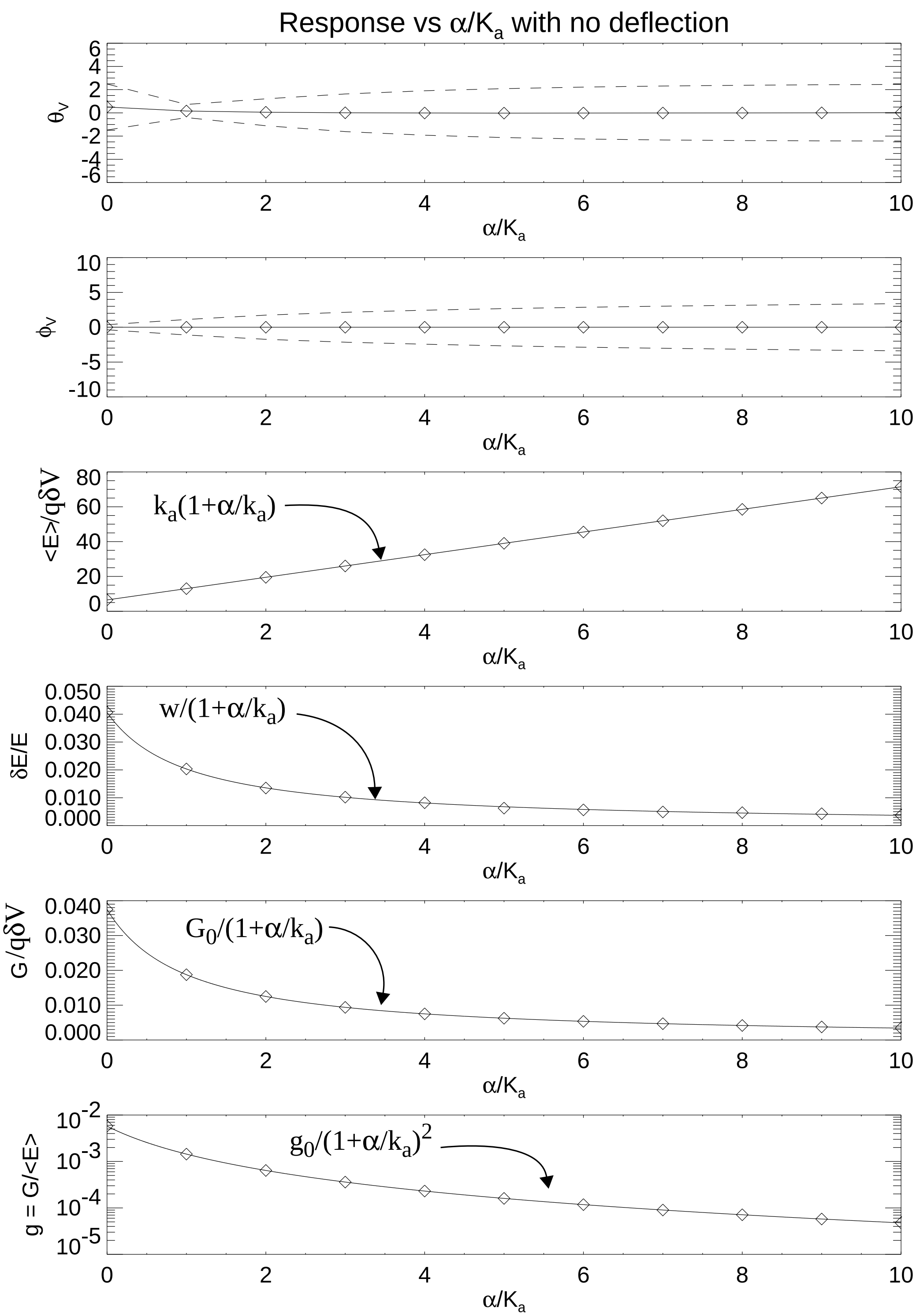
Thus the net effect of the retarding potential is to decrease (improve) the energy resolution by a factor of $(1+\alpha/k_a)$ and lower the geometric factor by $(1+\alpha/k_a)^2$.

Although the SWEA detector is strictly for electrons, this scheme can be used for ions as well. Typically the solar wind E/q spectrum is very narrow and intense at the proton peak. When measuring the narrow portion of the ion spectrum, attenuation can be used to avoid saturation of the detector and improve the energy resolution at the same time.

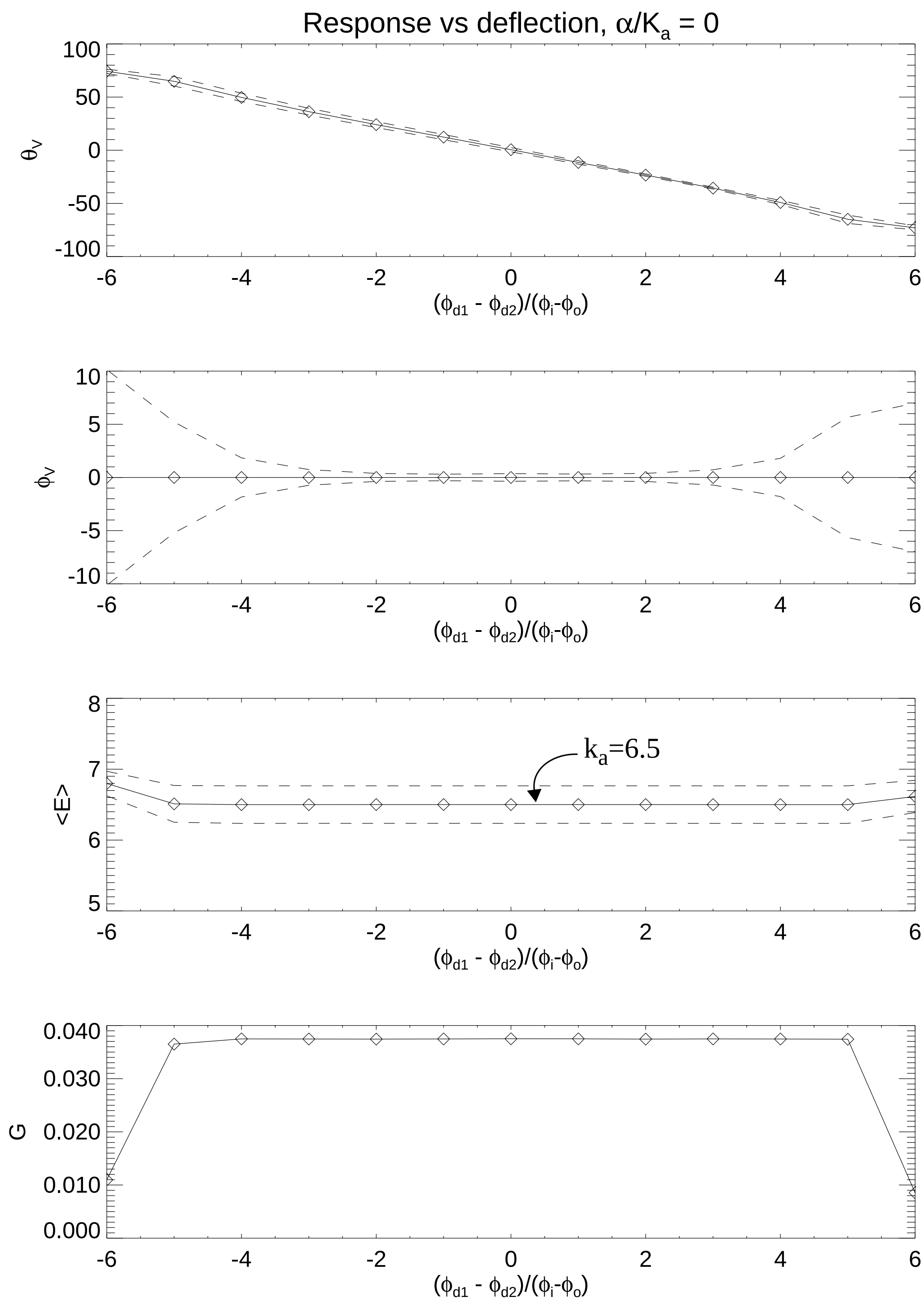
If α is negative, then the geometric factor is increased. This may be useful for improving the counting statistics of minor ion species that typically have higher E/q values than protons. However this is done at the expense of energy (and angle) resolution.

The geometric factor is dependent upon V_i-V_o, which can be very small compared to the magnitude of either V_i or V_o. Thus small uncertainties in V_i or V_o can produce large uncertainties in the overall geometric factor. High voltage supplies need to be fairly precise (at least very well understood). Perhaps the inner hemisphere potential (V_i) and both deflector supplies (V_{d1}, V_{d2}) can be referenced to V_o instead of spacecraft ground.

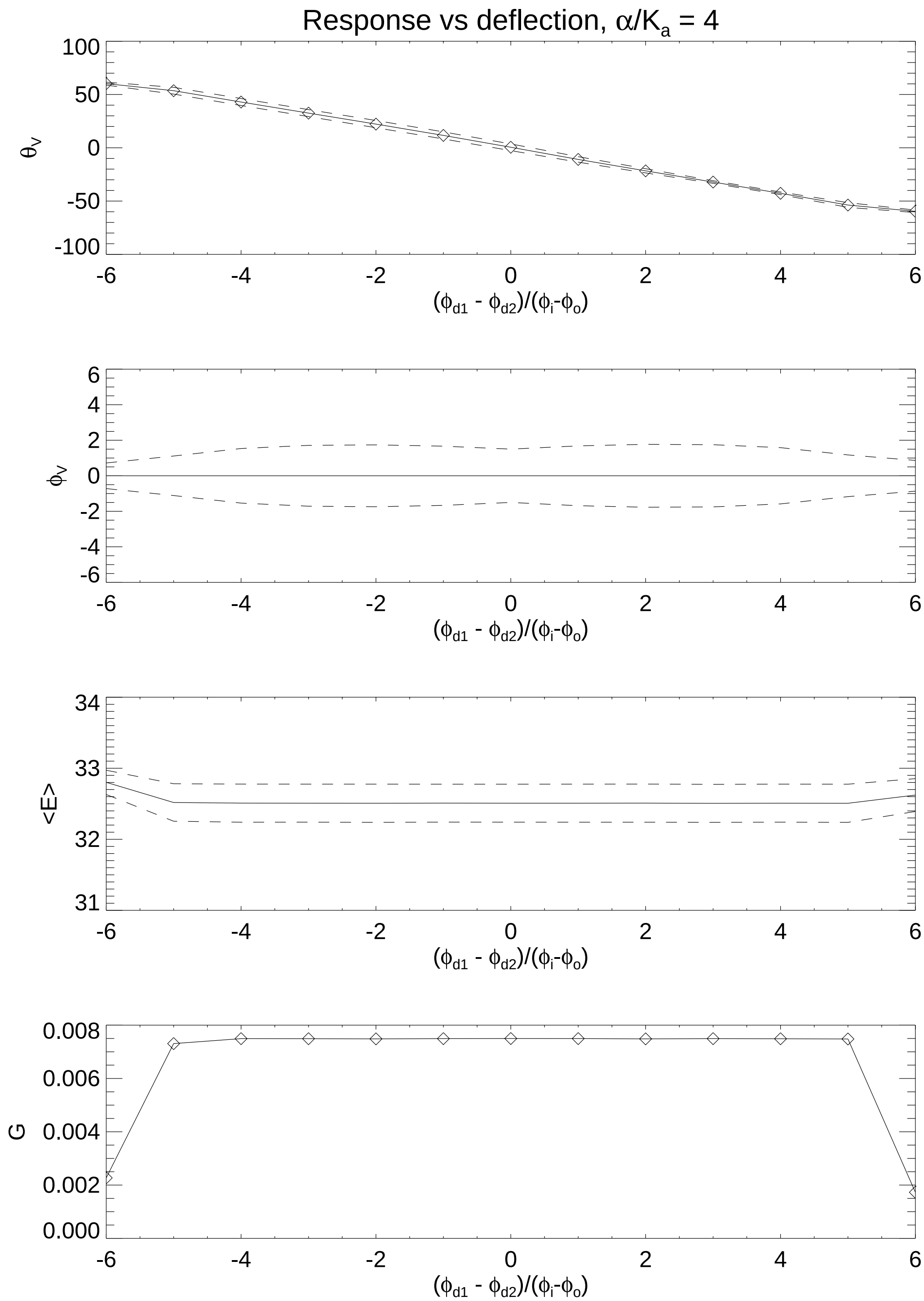
The following pages show instrumental responses.



Instrument characteristics as a function of $\alpha = V_o/(V_o - V_i)$. a) Poloidal response. b) Azimuthal response. c) Energy bandpass. d) Relative energy resolution. e) Geometric factor. f) Normalized geometric factor. Dashed lines represent one sigma.



Instrument characteristics vs. deflection voltage. Deflections upto ~65^o degrees are possible with little loss of geometric factor. Note: Deflectors are not operated symmetrically: either $V_{d1}=V_o$ or $V_{d2}=V_o$.



Deflection response with attenuation on. A 65^{o} deflection is not quite attained, however this can be fixed on future designs.