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Problem 1

Use the known physical characteristics of charged particles (e.g. charge (q), mass (m), velocity (v), kinetic energy (E), momentum (p)) to conceptually design the following instruments:

1a) An energetic charged particle instrument with a restricted field-of-view (assume a 5 degree conical FOV) that measures energetic protons from 0.1 to 5 MeV, providing a multi-point energy spectrum (assume a 10-point energy spectrum) using only a fixed (non-temporally varying) magnetic field to disperse the particles.

Sketch the instrument concept, show important functional features, and demonstrate (by calculation) that the energy response meets the requirement (0.1 to 5 MeV). Describe the nature (appearance) of the entrance system that provides the conical FOV. Describe (conceptually) the detector(s) (i.e. the device that produces the electronic signal. Calculate the Geometrical factor.

1b) Describe what changes are required to convert the instrument from a proton detector to an electron detector covering the same energy range and having the same FOV. (this may be a relatively short answer, but be quantitative about any changes in the magnetic field that may be needed.

Problem 2

Assume that you have an opportunity to place an instrument on a satellite that will be placed in a near-polar circular orbit at 1500 km altitude. You need to characterize the flux of auroral electrons from 1 – 30 keV and the full angular distribution over 4-pi steradians once every second. (Full 64-point energy spectrum and full angular distribution with an angular resolution of 10 degrees by 10 degrees every one-second). The instrument will use an electric field.

2a) Describe the approach. What methodologies will you use (describe the physics of your technique). Sketch the geometry of the instrument. Describe the detector configuration (e.g. geometrically) and the major functional components. Note: You may allow the spacecraft to "help" you achieve some of your measurement requirements (for example, (big clue here) you might allow the satellite to be spin stabilized). Describe your approach whether, or not, you choose to use the satellite to "help" you.

2b) Now convert the instrument in 2a) to an ion instrument covering the same energy range and angle space. Describe the changes that are required (again fairly short answer will do, but describe the modification that are needed in the electric field (if you did use an electric field).

What is the relationship of charge to mass (q/m) of the particles that are instantaneously analyzed by your instrument?

2c) EXTRA CREDIT. Now describe an approach to further enhance the ion instrument in problem 2b) by converting it to an energetic ion mass spectrometer (or spectrograph) to uniquely determine the mass of each particle passing successfully through the instrument. Describe the operational principals of this instrument.