

Basic Architectural Design of CPT: The Sensor System

ESTEC/Contract No. 13997/99/NL/PB

Document No.
ASRO/CPT/WP4100-TN

Issue 1
17 May 2000

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Abstract

The architectural design of the sensor system of the Charged Particle Telescope (CPT) is described. Various design approaches are first briefly evaluated. The first conclusion is that if all the functions of CPT would be included in a single sensor head, a complicated instrument with unproven techniques would be required. Therefore, consideration is given to the benefits and deficiencies of two approaches in dividing the functions of the instrument in two sensor heads. It is concluded that in a telescope type of an instrument the division of the functions according to the energy of particles is more natural than according to the particle species to be detected.

A design based on a Low Energy Telescope (LET) and a High Energy Telescope (HET) is further developed. The dividing energy is selected to be 4 MeV for electrons. Electrons below this energy are cut out from HET allowing a large geometric factor and the use of large-area detectors in HET, since the high fluxes of lowest energy electrons and protons do not enter the sensor. Small detectors with well-collimated acceptance cones are used in LET to measure these particles. LET has seven collimator tubes, pointing in different directions with a total view cone of 95° . With the detectors in these tubes, LET is capable of measuring electrons, protons, and heavier ions. In addition, LET has a stack of silicon detectors and one scintillator within which the energies of incident particles are totally absorbed. Differential measurements of proton and electron energy spectra can be performed in the range 1-65 MeV and 0.1-18 MeV, respectively. In the nominal operational mode, the total geometric factor of LET is $0.137 \text{ cm}^2\text{sr}$ for protons, $0.114 \text{ cm}^2\text{sr}$ for heavier ions, and $0.023 \text{ cm}^2\text{sr}$ for electrons.

HET applies the dE/dx -range method for measuring protons and electrons. It has 12 silicon detector layers with the last six interleaved with tantalum absorbers. Five of the silicon detectors are mosaic detectors with 31 parallel active areas. Separation of protons from electrons is based on the minimum pulse selection method and on the signatures of electromagnetic showers at the highest electron energies. Differential measurements of protons are carried out in the range 45-133 MeV. The energy range is extended by measuring penetrating particle up to 407 MeV in three energy channels. The energy range and resolution for electrons has to be derived from simulations and calibrations. HET is also capable of measuring angular distribution of protons with an angular resolution of $5\text{-}10^\circ$, depending on direction. The geometric factor of HET at the lowest operational energies is $6 \text{ cm}^2\text{sr}$.