A High Energy Telescope for Solar Orbiter

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POSTER
S2 –391

SUN – 360 Workshop
July 25 – 29,2011,
CAU, Kiel, Germany

Abstract

The High-Energy Telescope (HET) on ESA's Solar Orbiter mission, will measure electrons from 300 keV up to about 30 MeV, protons from 10 – 100 MeV, and heavy ions from ~20 to 200 MeV/nuc. Thus, HET covers the energy range which is of specific interest for studies of the space environment and will perform the measurements needed to understand the origin of high-energy events at the Sun which occasionally accelerate particles to such high energies that they can penetrate the Earth's atmosphere and be measured at ground level (ground-level events). These measurement capabilities are reached by a combination of solid-state detectors and a scintillator calorimeter which allows use of the dE/dx vs. total E technique for particle identification and energy measurement. The upper limits on energy listed above refer to particles (ions) stopping in the scintillator and careful modeling of HET properties will allow discrimination of forward/backward penetrating particles in a wider energy range. Here we will present design, simulation and initial calibration results of the instrument.

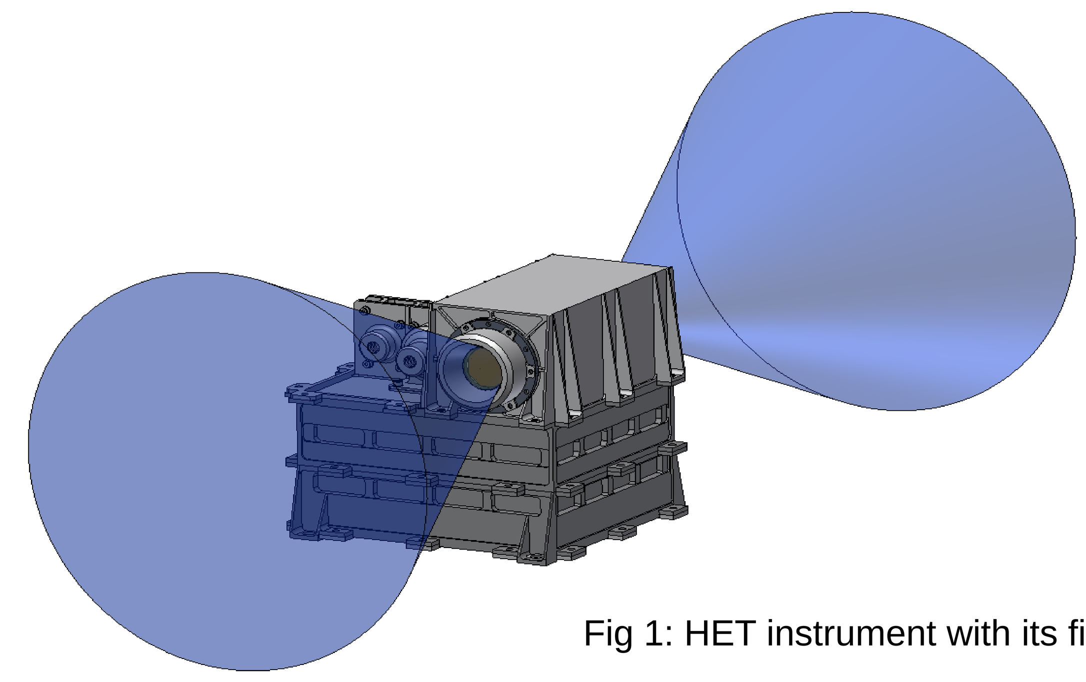

Fig 1: HET instrument with its field of view

Design of High Energy Telescope

Solar Orbiter is the next Europian Space Agency's mission to explore Sun-heliosphere connection. HET is one of the instruments in the Energetic Partical Detector (EPD) Consortium of Solar Orbiter mission. HET helps to understand the sources, acceleration mechanisms and transport process of high energetic particles. The CAD model of HET instrument with its field of view is shown in figure 1. HET will measure electrons from 300 keV up to about 30 MeV, protons from 10 – 100 MeV, and heavy ions from ~20 to 200 MeV/nuc. It is achieved by combination of Si and high density scintillation detectors. The schematic diagram of HET is shown in figure 2 and its energy coverage is shown in figure 3. HET is designed with Si tracking detectors and a BGO crystal as stopping detector. dE/dx vs.total E technique is used for particle identification and energy measurement. A CAD drawing of crystal, its holder and one of the tracking detector is shown in figure 4.

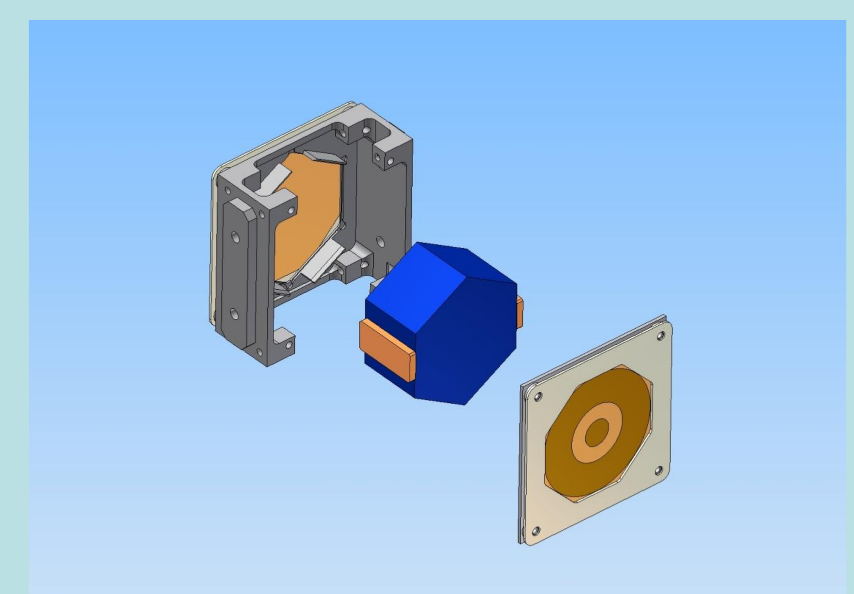

Fig 4: CAD drawing of crystal, its holder and one of the tracking Si detector

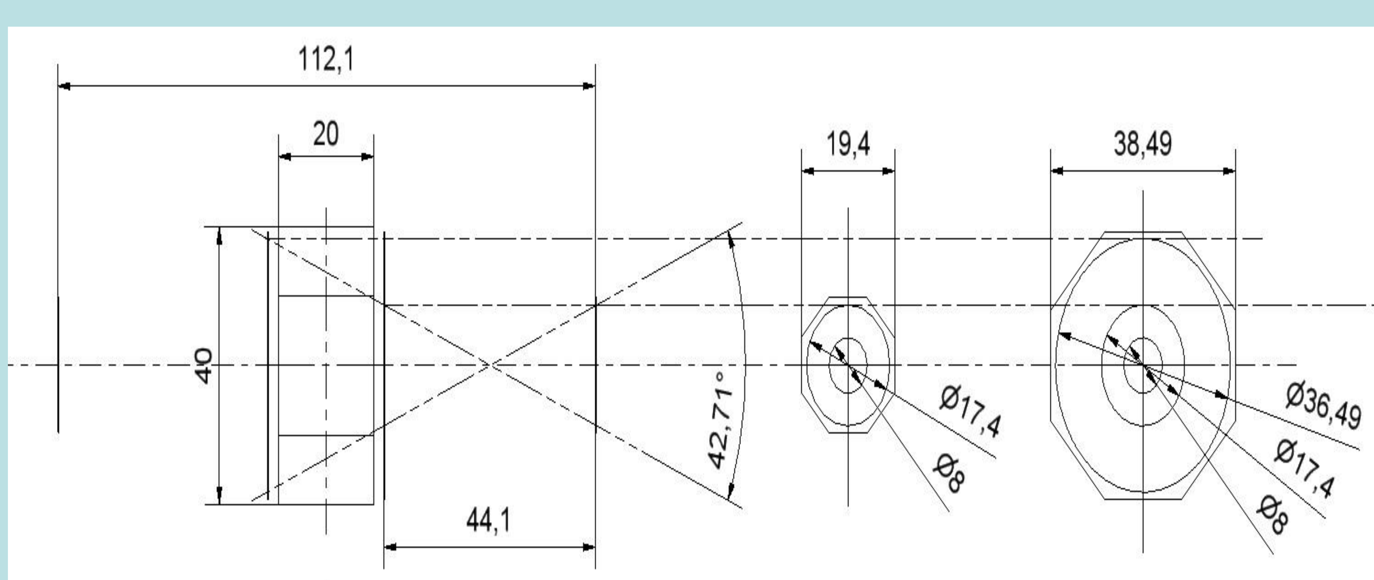

Fig 2: Schematic diagram of HET with dimensions.

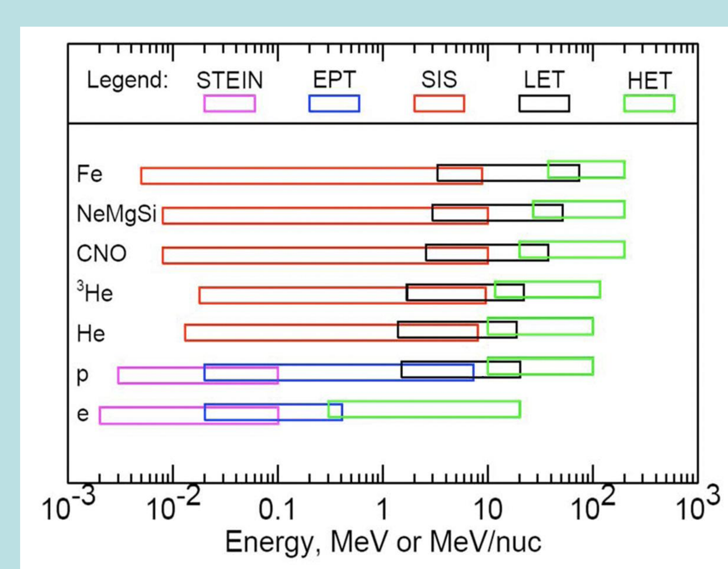

Fig 3: Energy coverage of HET (in green).

Specification of High Energy Telescope

Mass	1808 g per unit (including EPT, excluding harness)
Volume	14x14x13 cm^3 per unit (including EPT)
Power consumption	5.21 W per unit (including EPT, excluding harness)
Geometrical factor	4x0.01 (proton) and 4x0.27(heavy ions) cm^2 sr

Simulation and Initial Calibration Results

Monte Carlo simulations were carried out using GEANT4 simulation tool kit to design as well as verify HET instrument, to ensure that it meets all science requirements. The results of GEANT4 simulations for few ions are shown in figure 5. GEANT4 simulation result shows that this model meets all science requirements.

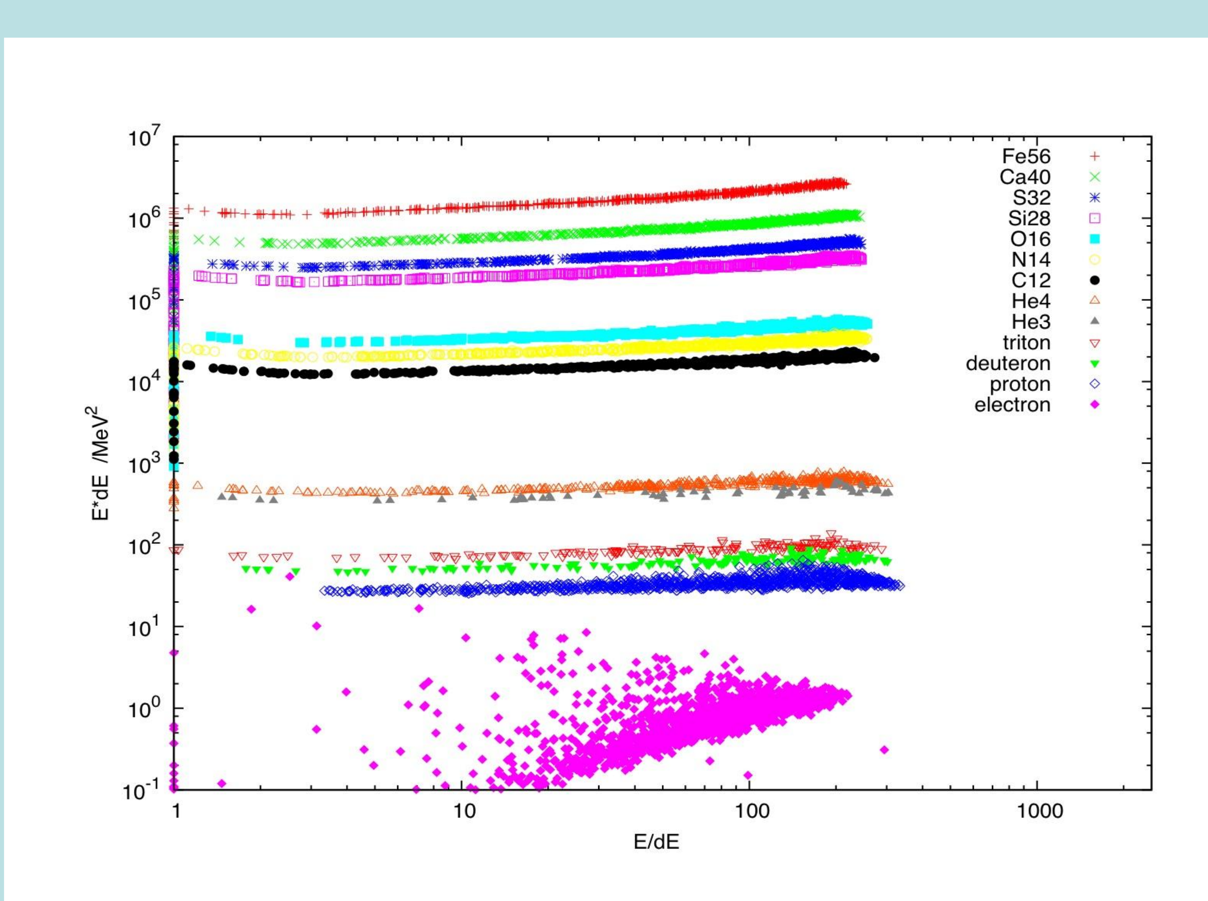

Fig 5 : GEANT4 simulation results .

A simple model of HET, we call it as a demonstration model, has been built with a 2 cm thick hexagonal BGO crystal and a 300 um thick Si tracking detector. A picture of the demonstration model shown in figure 6. This model was calibrated with high energetic heavy ions at HIMAC, Chiba, Japan. To calibrate the model He (180 and 230 MeV/nuc), C (400 MeV/nuc), O (400 MeV/nuc) Si (600 MeV) and Fe (500 MeV/nuc) ions were used. A plot of E*dE vs E/dE for O, Si and Fe is shown in the figure 7.

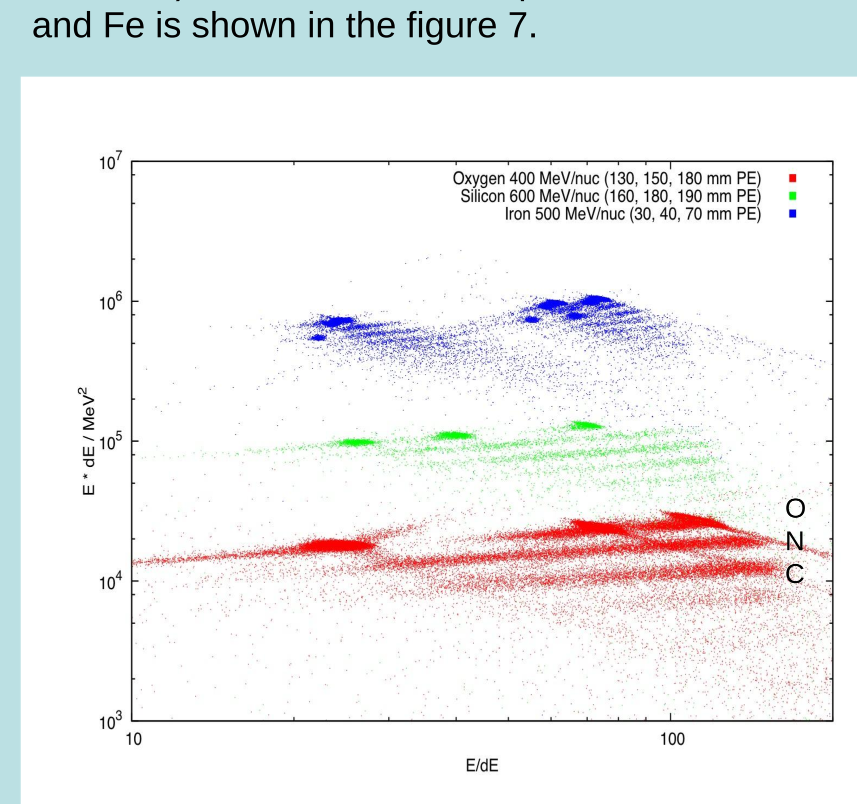

Fig 7: HETDM calibration results.

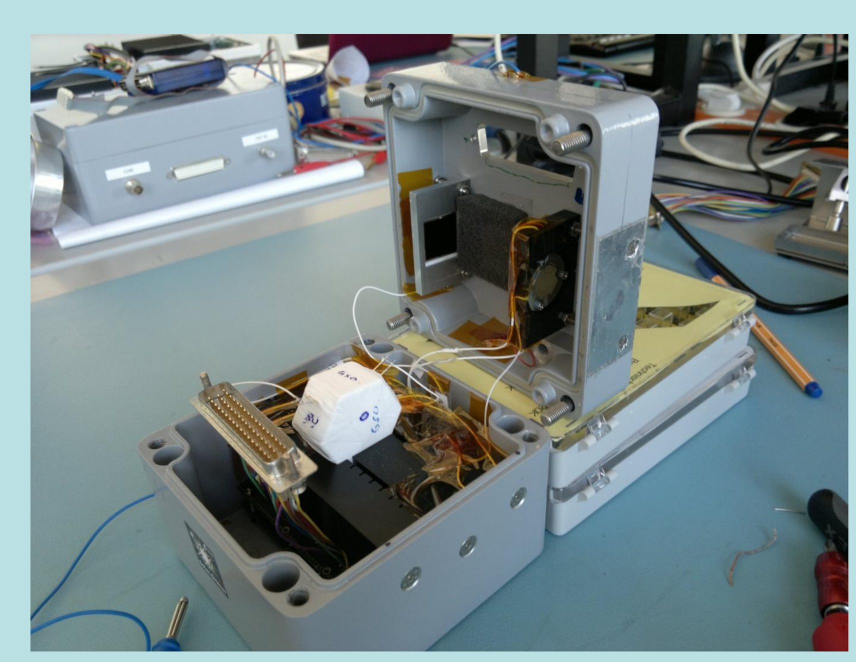

Fig 6: HET Demonstration Model

A polyethylene absorber is used to reduce energy of the primary ion beam and produce fragments (different thickness of polyethylene absorber are mentioned in the figure). In figure 7, red dots are O and its fragments , green dots are Si and its fragments and blue are Fe and its fragments (lower Z ions like Li, He, proton are not shown here).

By comparing the initial calibration results with simulation results, at first look it is clear that CNO and other ions are easily identifiable and measurable with this instrument.

Current status of HET

- CAD model of HET is designed, imported this model to GEANT4 for simulations and compared these results with results of demonstration model .
- Another demonstration model which is representing HET w.r.t. sensor head and electronics is designed. Production of parts of this model, assembling and testing is in progress.
- Frontend electronics of HET is designed and tested (not flight version). The other part of electronics are designed and production of these parts as well as testing are in progress (for demonstration model) .
- Preliminary Design Review (PDR) is scheduled in early next year.

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Acknowledgements: This work has been supported by the Deutsches Zentrum für Luft-und Raumfahrt (DLR) under grants SolO 50 OT 0901 and SolO 50 OT 1002.