AMEGO

All-sky Medium Energy Gamma-ray Observatory

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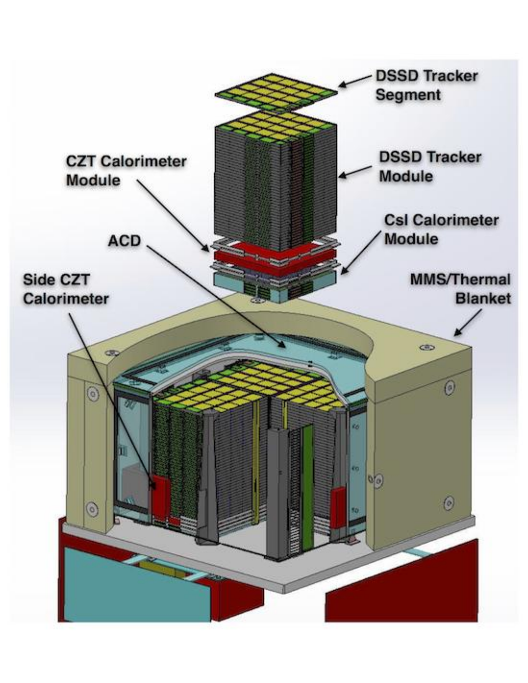

The All-sky Medium Energy Gamma-ray Observatory (AMEGO) is a probe-class mission in consideration for the 2020 decadal review designed to operate at energies from ~200 keV to >10 GeV. Operating a detector in this energy regime is challenging due to the crossover in the interaction cross-section for Compton scattering and pair production. AMEGO is made of four major subsystems: a plastic anticoincidence detector for rejecting cosmic-ray events, a silicon tracker for measuring the energies of Compton scattered electrons and pair-production products, a CZT calorimeter for measuring the energy and location of Compton scattered photons, and a CsI calorimeter for measuring the energy of the pair-production products at high energies. The tracker comprises layers of dual-sided silicon strip detectors which provide energy and localization information for Compton scattering and pair-production events. A prototype tracker system is under development at GSFC; in this contribution we provide details on the verification, packaging, and testing of the prototype tracker, as well as present plans for the development of the front-end electronics, beam tests, and a balloon flight.

1- University of Maryland College Park
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3- https://asd.gsfc.nasa.gov/amego/

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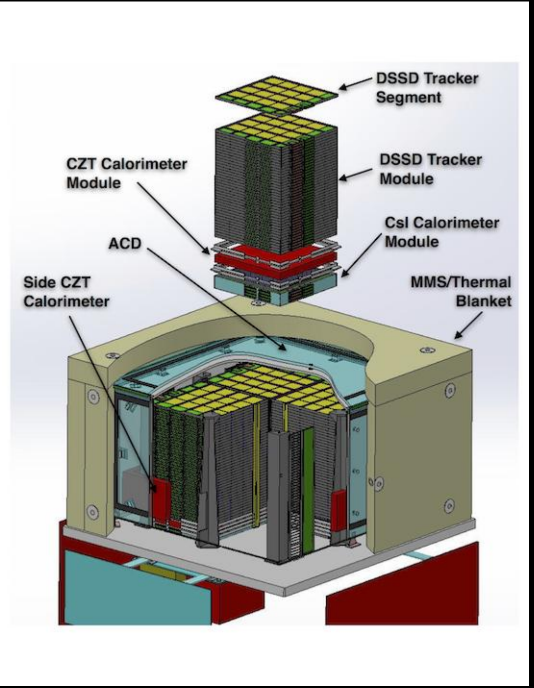
Context: The region of the electromagnetic spectrum between ~100 keV and 100 MeV has, to date, had very limited observations due to the challenging nature of detecting the gamma-ray photons, and is often referred to as the "MeV Gap". One of the difficulties in constructing a detector to operate at these energies is that above ~a few hundred keV, gamma-ray interactions are dominated by Compton scattering, and at higher energies e+/e- pair production is the dominant process, with a crossover at a few MeV. Thus, an instrument designed to work in this energy regime must be optimized for both Compton and pair-production events. Critical to this is the silicon tracker.

AMEGO: The All-sky Medium Energy Gamma-ray Observatory (AMEGO) is a probe-class mission concept designed to operate from ~200 keV to above 10 GeV being submitted to the 2020 Decadal Survey. AMEGO comprises four major subsystems: a plastic anticoincidence detector for vetoing cosmic-ray events, a slilicon tracker system for measuring the particle tracks, a CZT calorimeter for measuring the direction and energy of Compton scattered photons, and a CsI calorimeter for measuring the position and energy of pair-production events. The hardware design is given in to the right.



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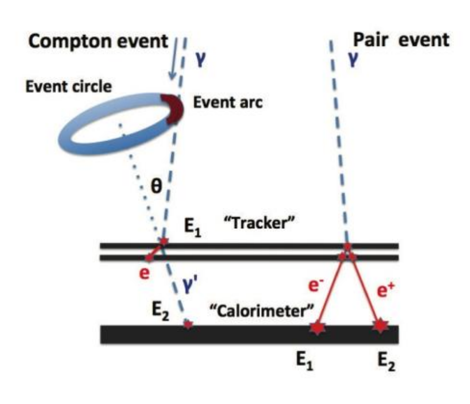
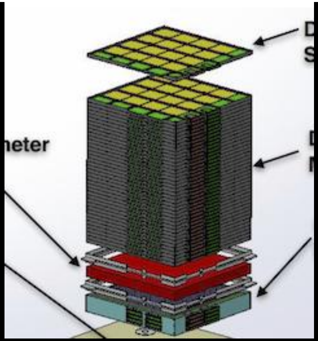


The Tracker:

- Operating in both the Compton- and pair production regime presents some design challenges pertaining to the tracker system.
- AMEGO uses dual-sided silicon detectors (DSSDs) which provide information on two axes simultaneously.
- This allows Compton scattered electrons to be tracked, reducing the uncertainty in their arrival direction to an arc rather than a cone.
- Silicon trackers are used as the conversion material for pair-production events; additional material between layers reduces sensitivity since Compton scattered electrons will be absorbed in the conversion material.

Design:

- 60 layers of 4x4 DSSDs separated by 1 cm, referred to as a "tower" (bottom right)
- Each individual wafer is a 10 cm square, 0.5 mm thick with 192 strips per side per detector.
- Readout electronics are positioned along two edges of each wafer (one for each direction).
- Full AMEGO tracker has four identical towers, simplifying integration and allowing for spare components.



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Testing:

- The first wafers will undergo extensive testing: full C-V and I-V curves for each channel in each direction will be made to verify the depletion voltage of the silicon, the parasitic capacitance, and leakage currents.
- Time consuming: two weeks per wafer, so results of initial tests will determine the subsequent testing strategy.
- Seven wafers will used in an “L-shape” (a proxy for a 4x4 segment) in to verify whether or not their combined capacitance (the dominant source of noise) is sufficiently low for four consecutively connected detectors.
- Readout electronics placed on each side of the corner of the “L” will make it possible to test position resolution in both the x- and y- directions using an XY positioner and radioactive sources.
- Up to 5 detectors will be used in a vertical stack. This configuration allows for particles to be tracked as they pass through multiple Silicon layers, allowing for track reconstruction algorithms to be developed and tested.
- This configuration is being designed so it can be used in beam tests and on a balloon flight.

Conclusions:

The proposed Silicon tracker will allow AMEGO to be sensitive to both Compton scattering and pair-production events. Over the course of the next year, prototype tracker configurations will be assembled and tested at GSFC.