All-sky Medium Energy Gamma-Ray Observatory (AMEGO): A Medium-Energy Gamma-ray Surveyor

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MOTIVATION

The MeV domain is one of the most underexplored windows on the Universe. From astrophysical jets and extreme physics of compact objects to a large population of unidentified objects, fundamental astrophysics questions can be addressed by a mission that opens a window into the MeV range. The time is right for an MeV mission. *Fermi*-LAT observations at GeV energies have opened a window to a rich and varied ensemble of astrophysical sources, and demonstrate the promise of an equally rich return from opening the MeV band. Secondly, we are at the dawn of the multimessenger era, with the recent discovery of high energy astrophysical neutrinos by IceCube and the first direct observation of gravitational waves by LIGO. By virtue of its focus on extreme environments, a medium energy gamma-ray surveyor is an excellent partner in these new scientific endeavors.

AMEGO will provide unprecedented advances in three areas of MeV astrophysics, 1) time domain astrophysics in the MeV regime, probing particle acceleration in a broad range of galactic and extragalactic objects, 2) deepest view of the entire MeV sky addressing the many new questions raised by *Fermi*. This is particularly relevant in the MeV energy band where most *Fermi* sources emit their peak power, 3) exploration of the nuclear line universe, probing the creation of key elements created in explosive and dynamic astrophysical environments.

TECHNICAL CAPABILITIES

Instrument: AMEGO will detect gamma-rays via Compton scattering at low energies (<~10 MeV) and pair production at higher energies (~>10 MeV). In the Compton regime, the use of solid state technology provides substantial performance improvements relative to COMPTEL, the Compton telescope flown on the Compton Gamma-Ray Observatory (CGRO). In the pair regime, AMEGO has been optimized for peak performance at lower energies relative to Fermi-LAT by minimizing passive material (e.g. conversion foils) in the tracker and enhancing low energy readout in the calorimeter.

Energy range	0.2 MeV – >10 GeV
Angular Resolution	3^o (1 MeV), 10^o (10 MeV),
Energy Resolution	<1% below 2 MeV; 1-5% at 2-100 MeV; ~10% at 1 GeV
Field-of-View	2.5 sr
Sensitivity (MeV s^{-1} cm^{-2})	$4x10^{-6}$ (1 MeV); $4.8x10^{-6}$ (10 MeV); $1x10^{-6}$(100 MeV)

Observatory: AMEGO will operate in low-earth orbit in two modes: a survey mode covering a large fraction of the sky every orbit and an inertially pointed mode. The large field of view allows a loose pointing requirement (~5°) with a requirement on pointing knowledge of ~20".

INSTRUMENT TECHNOLOGIES

AMEGO will consist of four hardware subsystems: a double-sided silicon strip tracker with analog readout, a segmented CZT calorimeter, a segmented CsI calorimeter and a plastic scintillator anticoincidence detector. Examples of each of these detector types have already been flown.

This instrument primarily makes use of flight-proven technologies (e.g., *Fermi*-LAT, AGILE, PAMELA, and AMS) and optimizes the energy resolution for MeV line studies through development of the CZT calorimeter configuration and accompanying dedicated electronics, for which development typically takes a couple years.

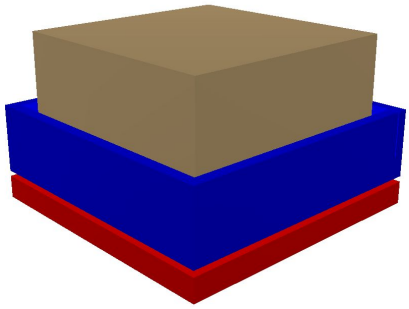

Figure 1: The AMEGO instrument subsystems: CsI calorimeter (red), CZT calorimeter (blue), Si-tracker (brown), ACD (not shown).

REASONS WHY A PROBE-CLASS MISSION IS NEEDED

An MeV gamma-ray surveyor probe mission has a unique capability to provide sensitive coverage of both the Compton (0.2 - 10 MeV) and pair conversion (10 MeV - 10 GeV) regimes. This allows a single mission to cover the entire gap between the current generation of hard X-ray instruments and the *Fermi*-LAT.

Enhancing the performance of the calorimeter for Compton events will open up new capabilities for MeV spectroscopy. AMEGO will address three key performance directions in MeV astrophysics. We will have an outstanding continuum sensitivity over a wide energy range and field of view to continue *Fermi*-LAT-like science down to lower energies. In addition we add a substantial science case from nuclear line astrophysics.

A smaller scale mission could not cover the entire energy range, and would necessitate a choice between a wide-field continuum sensitivity and nuclear line spectroscopy. With AMEGO we can do both.

AMEGO will have the very broad science menu appropriate for a probe class mission. As an all-sky surveyor it will collect data on all MeV sources in the sky and will provide a service to the whole astrophysical community.

COST ESTIMATE

The payload cost of $150M (not including contingency) has been derived by scaling a price-H cost estimate for a similar instrument. Adding contingency and rough estimates for spacecraft and launch vehicle, this results in a cost of $600-$800M, well within the bounds of a probe class mission.