Opportunities and Challenges for Future MeV/GeV Gamma-ray Missions

Dave Thompson
NASA Goddard Space Flight Center

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Caveats

These are personal opinions, not representing any group or institution.

I am not an expert in all the technologies being discussed.

Please feel free to disagree with any or all of this material, although some things are fairly obvious.

Outline

Challenges – some general ideas

Opportunities – some candidate approaches:

1. **High-resolution spectroscopy/polarimetry**
2. **High-sensitivity continuum**
3. **High-resolution imaging/polarimetry**

The Biggest Challenge: Making the Science Case

Reason One – the success of Fermi; the promise of CTA. Incremental science is not compelling.

Reason Two – no "hot topics" like exoplanets or Dark Energy

Reason Three – even for good science topics, it is hard to guarantee results

The Biggest Challenge: Making the Science Case

Having a long list of science objectives may not be a good strategy.

A list implies that there is no single (or few) major scientific question(s) to be answered.

A list allows reviewers to focus on the weakest items. This may have been part of the ASTROGAM case.

Another Challenge:
No Obvious New Breakthrough Technology

In the 1990s, silicon strips had reached the point of being feasible for a space mission – in terms of availability, cost, and power.

There seems to be no one technology now that represents the same level of advancement.

A Third Challenge: One Size Does Not Fit All

Gamma rays cover a huge part of the electromagnetic spectrum, and gamma-ray detection involves several different physical processes.

Trying to do too much with a single instrument drives up the cost and may require compromises in performance.

Don't Panic!
All these challenges can be met.

The ASTROGAM effort has been a positive development, with the community cooperating to produce a good proposal.

One possibility – look for multiple opportunities instead of trying for one instrument – short- medium- and long-term; small, medium, and large; low-energy and high-energy.

Small, short-term projects

Small => lower energies, where there are more photons

Short-term

Specific, limited science goals

Existing technology

Small, short-term project

COSI – Compton Spectrometer and Imager
Proposed Small Explorer using this concept - GRX

Technology: cooled germanium Compton telescope. 200 keV – few MeV. Spectroscopy, imaging, polarimetry.

Science: Galactic lines, GRB polarimetry. Limited but achievable.

Medium size, medium-term project

Various groups have converged on the idea that a plausible follow-on to Fermi is an instrument optimized for the energy range below 1 GeV, using pair production and/or Compton scattering for detection.

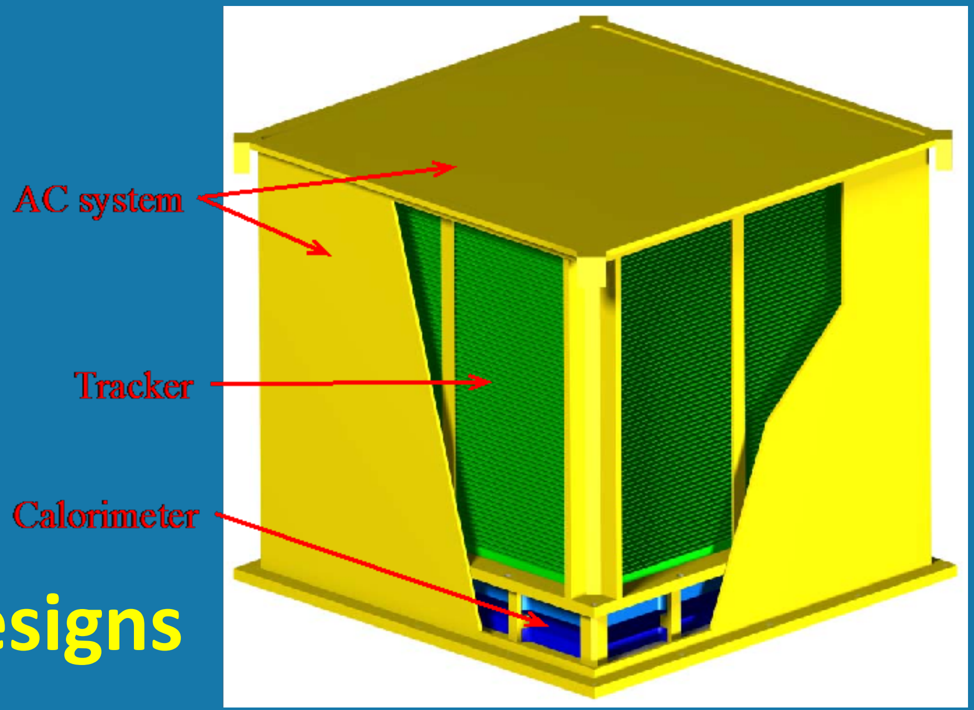
Basic concepts: like LAT/AGILE without passive converters or pure Compton design.
Limited or no technology development
Smaller than LAT because lower energy range (more photons to detect).

Medium size, medium-term project

ASTROGAM – proposed as ESA M4 mission, but not accepted. Mass constraint was severe.

Technology: silicon strips, CsI calorimeter, anticoincidence.

Science: broad range of topics



ComPair, Pangu similar
Various Compton-only designs possible.

Best resolution: Long-term technology development

Limited angular resolution has been a major stumbling block for gamma-ray astrophysics. Getting the best angular resolution requires new technologies and probably larger detectors.

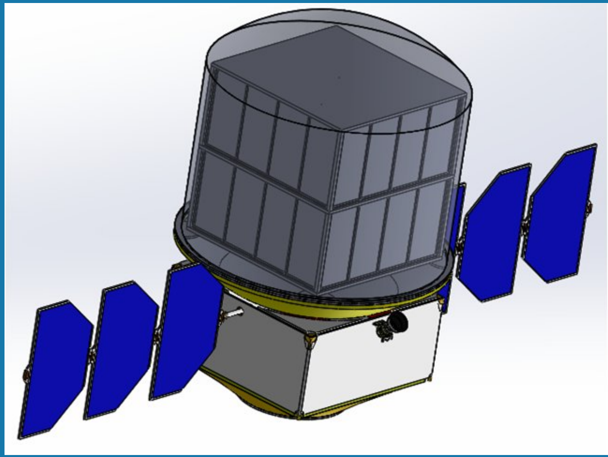
Basic concept: move to Time Projection Chambers (TPC), in which the converter is active (gas or liquid). Still not going to produce optical-quality imaging, but approaching the best the physics will allow.

Best resolution:
Long-term technology development

Science: angular resolution, polarization topics

Example Technologies: liquid argon TPC – LArGo; gas TPC – AdEPT, HARPO

Added challenges:
Qualifying such technologies for space flight.
Higher cosmic-ray to gamma-ray ratio analysis issues.



Summary

Despite the challenges, which are quite real, there are multiple opportunities for the future of MeV-GeV astrophysics.

Ongoing space and ground-based discoveries provide scientific incentives.

The gamma-ray astrophysics community has expanded greatly.

I would argue that we should be following a multi-pronged approach, being cautious not to fall into the trap of criticizing a particular concept because it cannot do everything we would like.