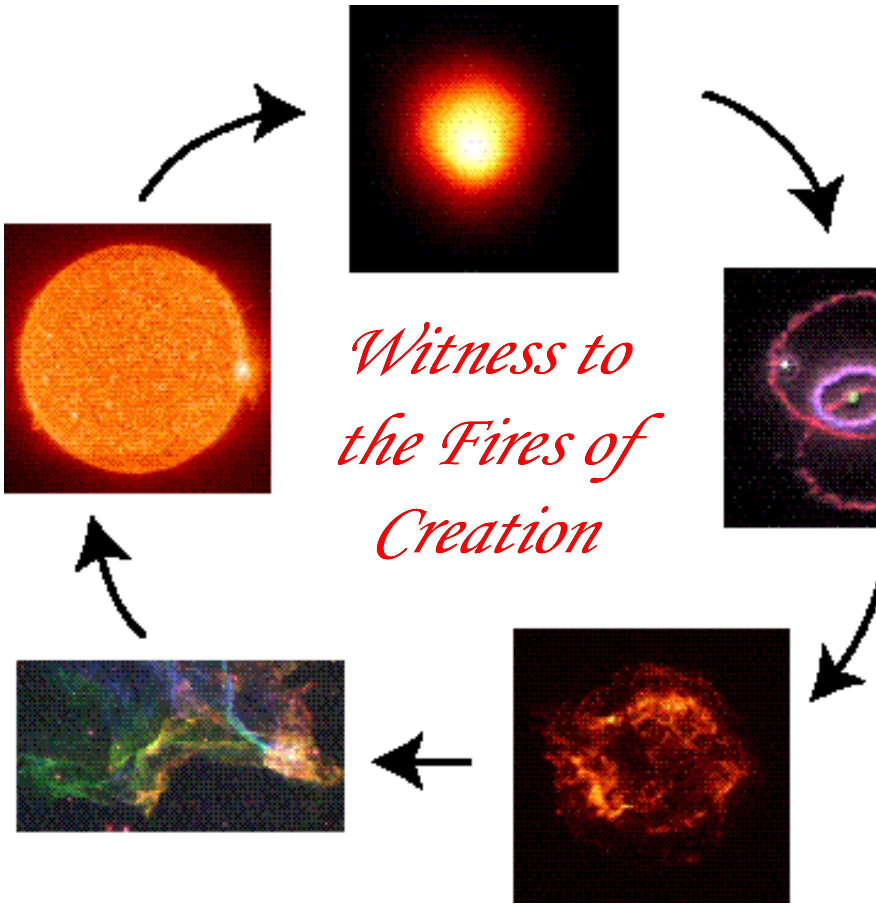
The Advanced Compton Telescope

NASA Vision Mission Concept Study 2003-2007



"to uncover how supernovae and other stellar explosions work to create the elements"
-SEU Roadmap 2003

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Deputy PI, COSI SMEX

ACT in NASA's Strategic Plan

✓ Nuclear astrophysics was identified by the Gamma-Ray Astrophysics Working Group (GRAPWG) in 1999 as the 'highest-priority science goal', and ACT as the 'highest priority major gamma-ray mission'

✓ACT identified in the 2003 SEU Roadmap under *Cycles of Matter and Energy* ("will be undertaken after Beyond Einstein has begun")

✓ Space Science strategic objective 5.12 – understand the development of structure and the cycles of matter and energy in the evolving universe (2003)

✓Selected in March 2004 for a NASA Vision Mission concept study

✓2005 NASA Universe Strategic Roadmap identifies the Nuclear Astrophysics Compton Telescope as a Pathways to Life Observatory

1999-2005, ACT was showing up in NASA strategic roadmaps, with a specific emphasis on nuclear astrophysics. Led to 2004 Vision Mission concept study.

ACT Collaboration

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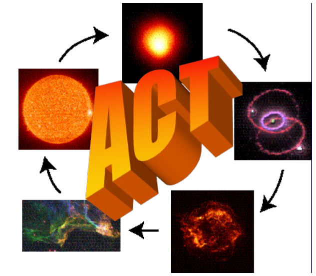
Included many (not all) of the leaders of the US MeV community at the time.

ACT Science Overview

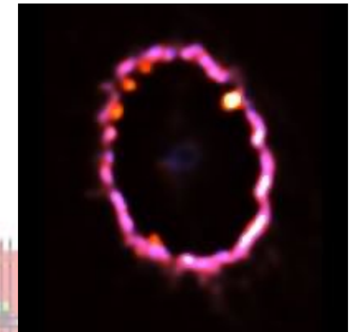


Where do the chemical building blocks of life, planets, stars originate?

How do the chemical elements evolve?

What powers supernovae explosions?

Resolved spectroscopy and flux of nuclear lines from the heart of supernovae



What is the physics at the edge of a black hole?

How do matter & antimatter behave in extreme environments?

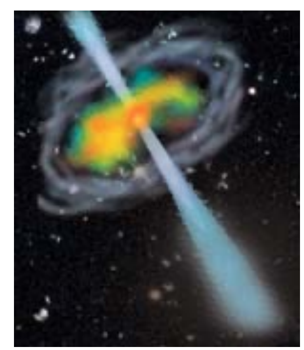
Spectroscopy, polarization, and timing of photons from black holes, neutron stars, and novae

When did the first stars form?

Can gamma-ray bursts measure the geometry of the Universe?

(J. Wilms)

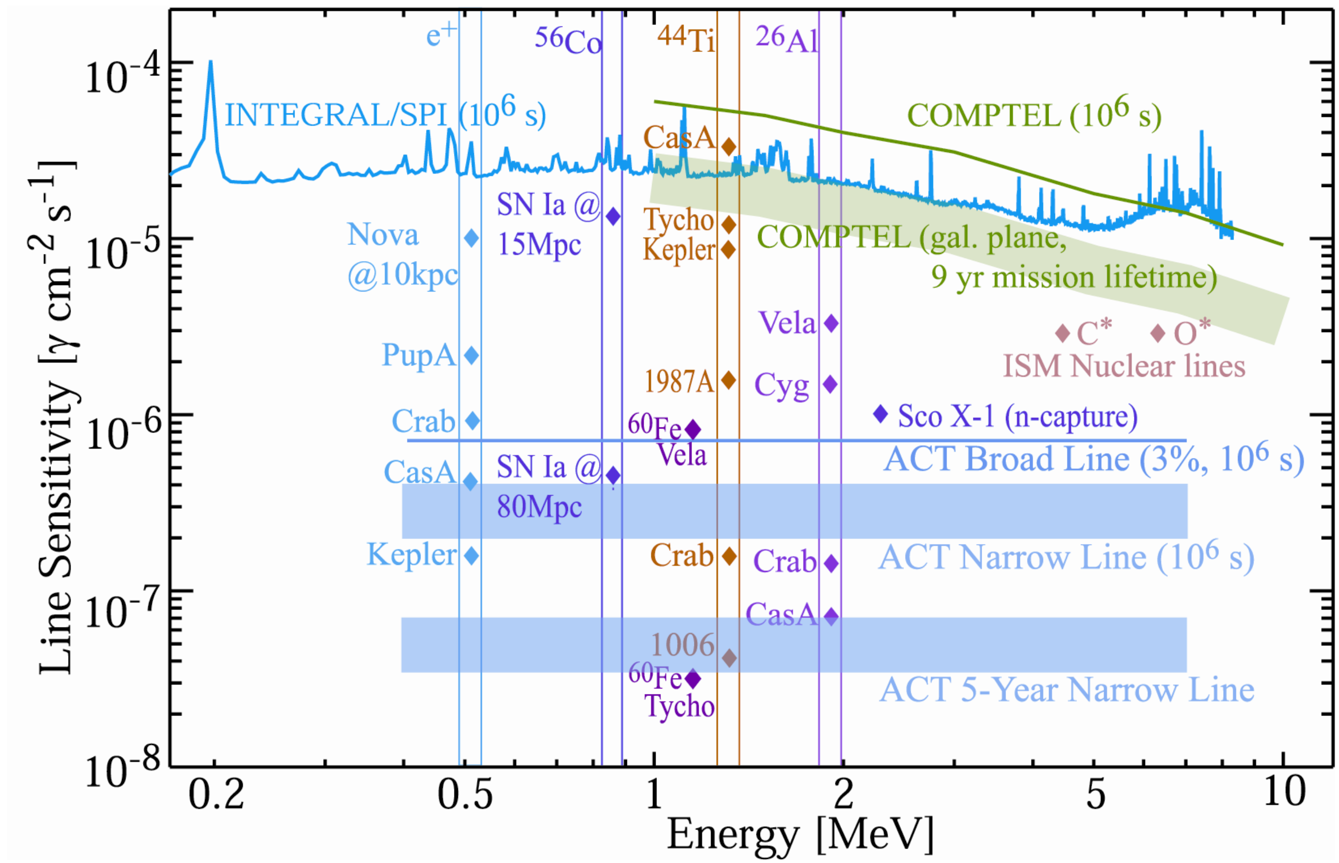
Gamma-ray burst localization, spectroscopy, polarization and timing



Emphasis was on spectroscopy and 100x improvement in sensitivity, 0.2-10 MeV.
Most of these science objectives still survive, but emphasis has shifted.

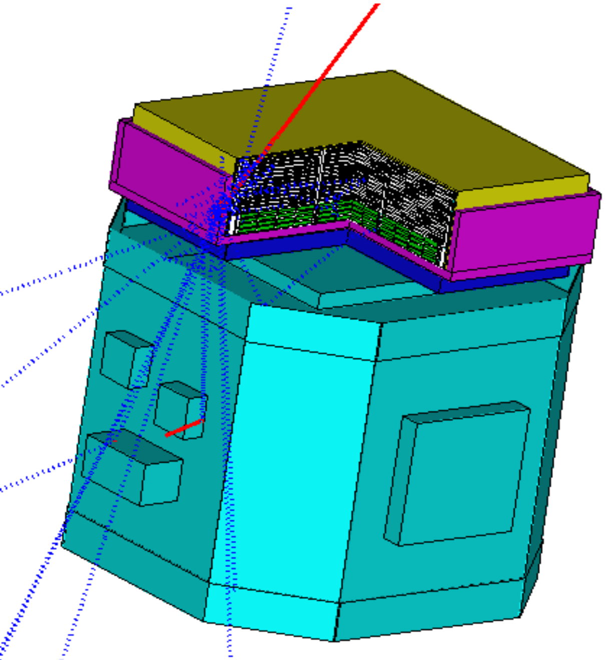
Nuclear Line Sensitivity

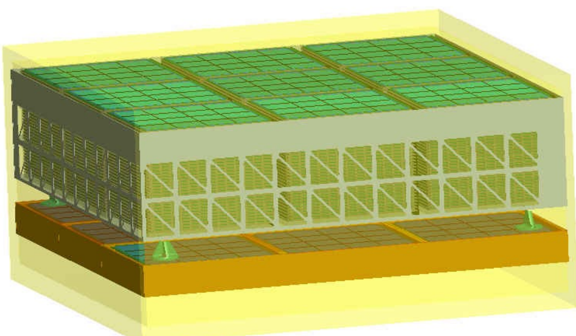
Primary science requirement: systematic study of SNIa spectra, lightcurves to uniquely determine the explosion mechanism, ^{56}Co (0.847 MeV) abundances.



Detailed spectroscopic survey of Type Ia supernova gamma-ray lines was defined as the primary science goal, driving the sensitivity and spectroscopy.

Baseline ACT Instrument





D1: 27 layers 2-mm thick Si

- 10x10 cm2, 64x64 strips
- 3888 det., 248,832 chns
- -30° C, Stirling cycle cooler

D2: 4 layers, 16-mm thick Ge

- 9.2x9.2 cm2, 90x90 strips
- 576 det., 103,680 chns
- 80 K, Turbo-Brayton cooler

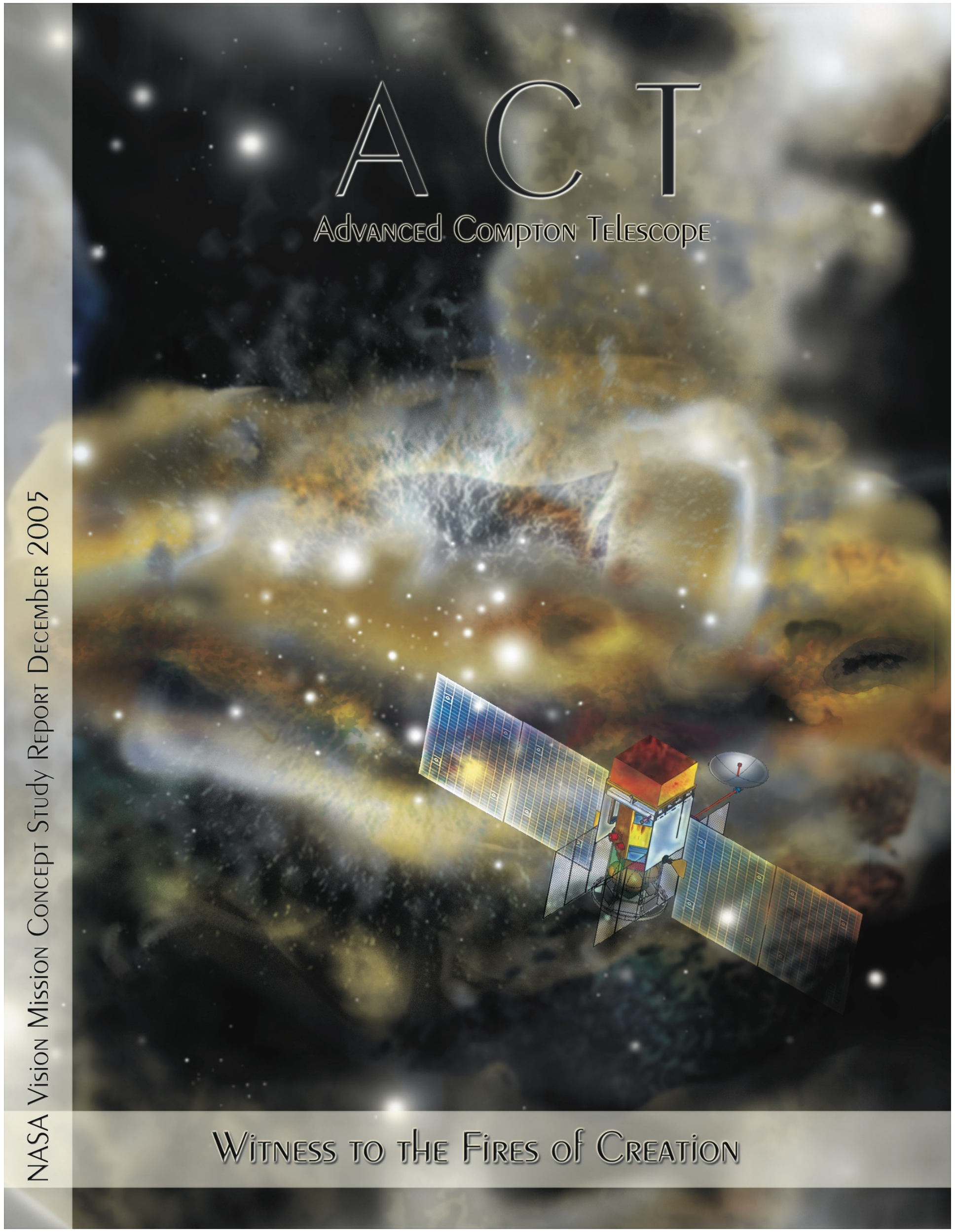
BGO: 4-cm thick shield

ACD: plastic scintillator

ACT Apples/Oranges Envelope:

- 1850-kg instrument (w/o margin)
- 2000 W instrument (w/o margin)
- Delta IV shroud (~4m dia.)

Needed a standard for comparison with alternate instrument designs.



astro-ph/0608532

- full science goals
- detailed performance
- mission design & readiness
- technology recommedations

Multiple mission concepts were presented in detail in the report.

ACT Vision Mission Concept Study Successes

Increased APRA support for:

- detector development
- readout development
- simulation and analysis tools
- suborbital demonstrations

Continued development and community support for a large CCT

Helped train the current generation of gamma-ray astrophysicists through the resulting APRA programs

Inspired reflection and a deeper community discussion on science priorities

Helped solidify gamma-ray polarimetry as a primary science objective

Much of the MeV gamma-ray activity that we see in the community today evolved in response to, or in reaction to, this study.

What wasn't in the report….

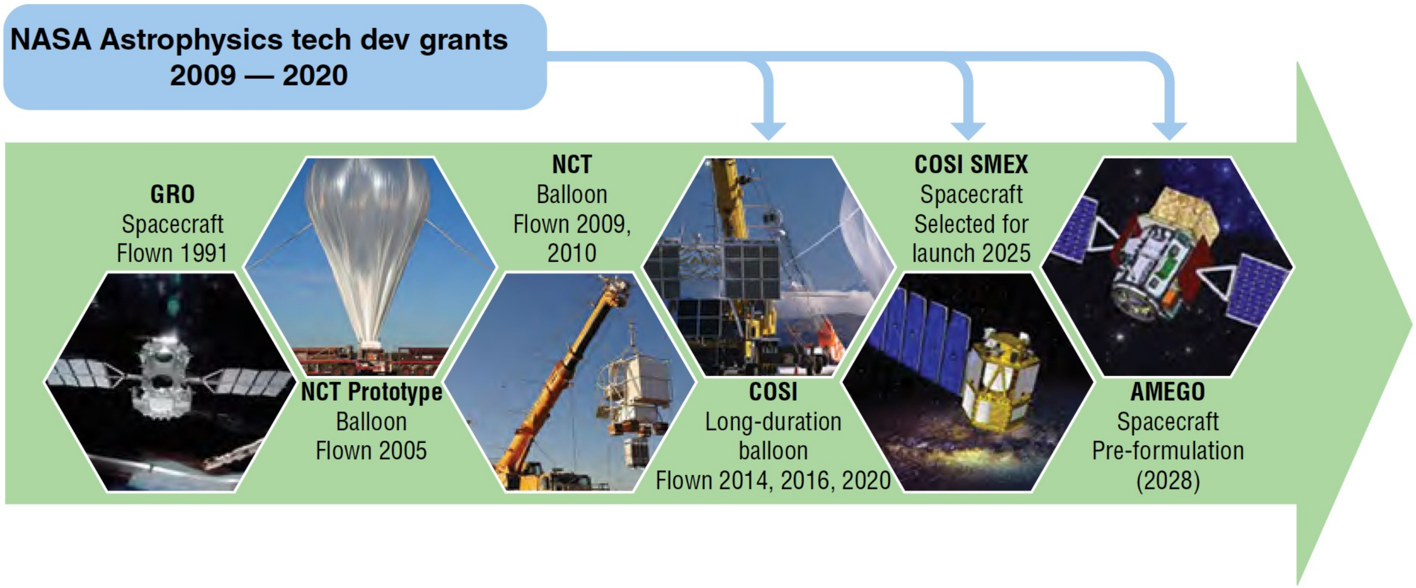
- Internal debate on the scope of the primary science goal (Type Ia SNe)
- Disagreement on whether to recommend an Explorer-class pathfinder
- Detector fiefdoms were not eager to develop consensus on a baseline design
- General community skepticism to gamma-ray sensitivities after INTEGRAL
- Perceptions: electron tracking <1 MeV, active shielding in CCTs
- Impression that gamma-ray astrophysics was a small and aging population

Ultimately, an unsuccessful proposal to NASA's Astrophysics Strategic Mission Concept Studies 2007 program (despite Excellent ratings, and publication of the Vision Mission Study Report).

Community returned focus to developing and demonstrating enabling technologies and building interest in the broader science case.

COSI as a NASA technology development example

COSI
Gamma-ray Space Explorer



- NASA Astrophysics Biennial Technology Report 2022
  - From Compton telescope (GRO)
  - To Compact Compton Telescope (CCT) = COSI (2027)
  - To scaled-up CCT = AMEGO in the future

ACT has evolved. COSI is a direct descendent. The concept of a large CCT, but with a broader science program, is alive and well. MeV community remains strong and relevant.