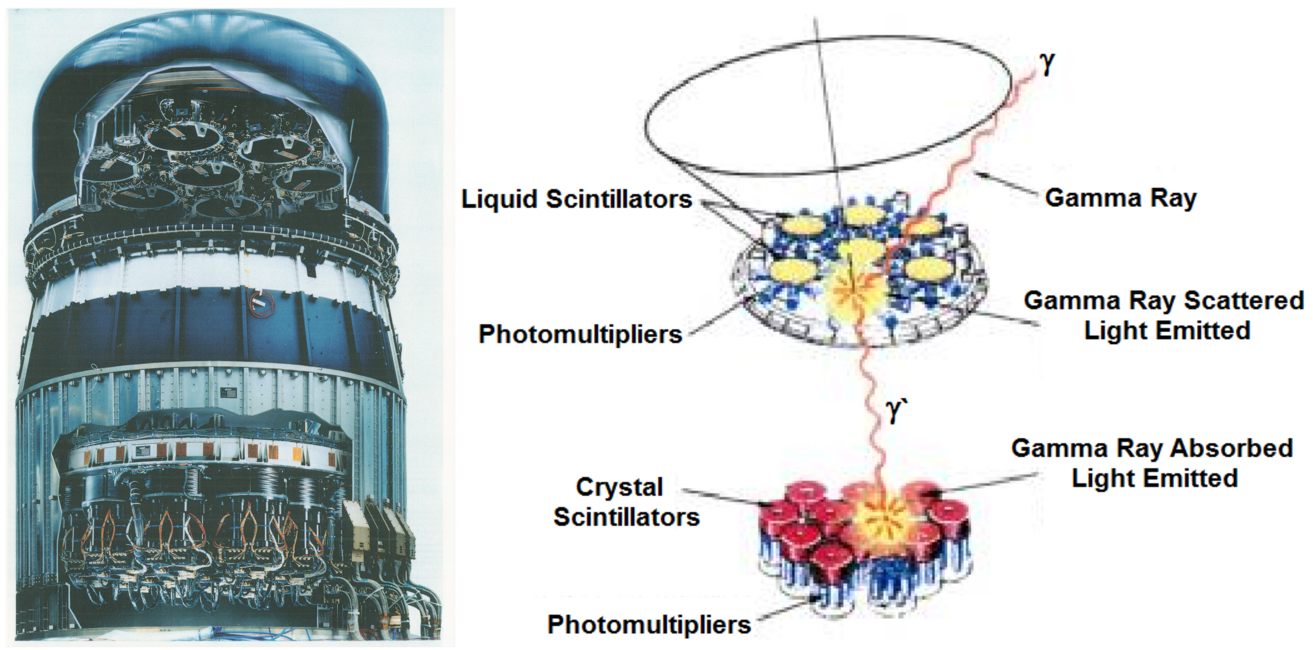
#9905-206

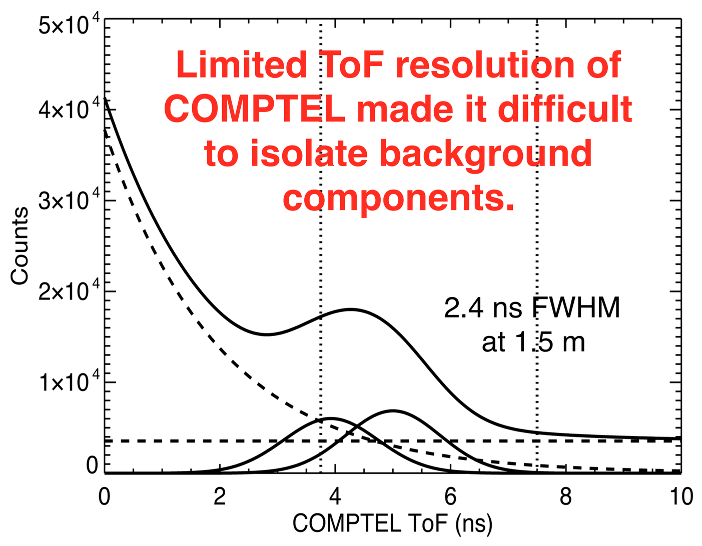
The Advanced Scintillator Compton Telescope (ASCOT) Balloon Project

P. F. Bloser, T. Sharma, J. S. Legere, C. M. Bancroft, M. L. McConnell, J. M. Ryan, and A. M. Wright
Space Science Center, University of New Hampshire, Durham, NH, USA
University of New Hampshire

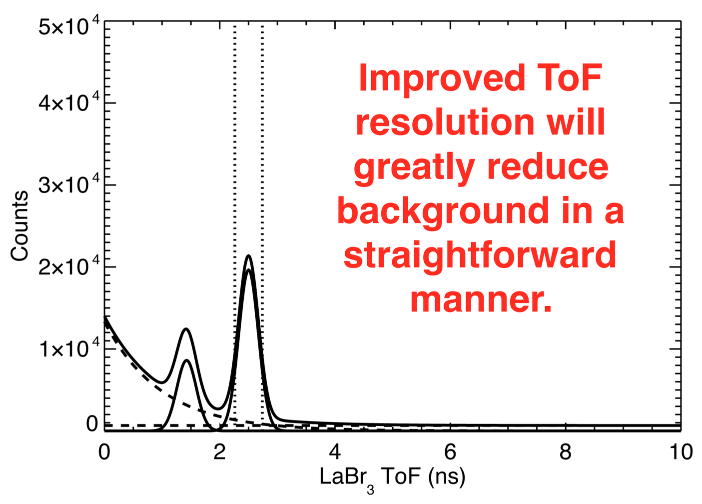
There is an urgent need in high-energy astronomy for a medium-energy gamma-ray mission covering the energy range from approximately 0.4 - 20 MeV to follow the success of the COMPTEL instrument on CGRO. We believe that directly building on the legacy of COMPTEL, using relatively robust, low-cost, off-the-shelf technologies, is the most promising path for such a mission to become reality. High-performance scintillators, such as Cerium Bromide ($CeBr_3$) and p-terphenyl, and compact readout devices, such as silicon photomultipliers (SiPMs), are now commercially available. We are now beginning work on a balloon instrument, an Advanced Scintillator Compton Telescope (ASCOT), with the goal of imaging the Crab Nebula at MeV energies in a one-day flight. If successful, this will demonstrate that the energy, timing, and position resolution of this technology are sufficient to achieve an order of magnitude improvement in sensitivity in the medium-energy gamma-ray band, were it to be applied to a ~1 cubic meter instrument on a ULDB or Explorer platform.

CGRO / COMPTEL and ToF





The COMPTEL instrument on CGRO was a double-scatter instrument (D1 - liquid scintillator D1 / D2 - NaI(Tl)) capable of imaging 0.75-30 MeV gamma rays. With a D1-D2 separation of 1.5 m, it relied on both pulse shape discrimination (PSD) and Time-of-Flight (ToF) to identify and reject various background components (e.g., neutrons and activation of passive materials). The ToF proved to be a crucial aspect of COMPTEL data analysis. We believe that ToF techniques utilizing the latest technologies offer a significant advantage for future Compton telescopes.

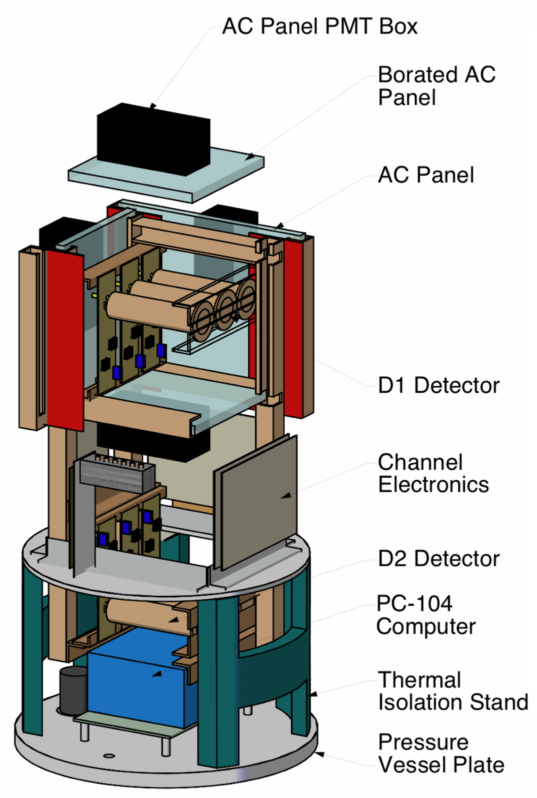


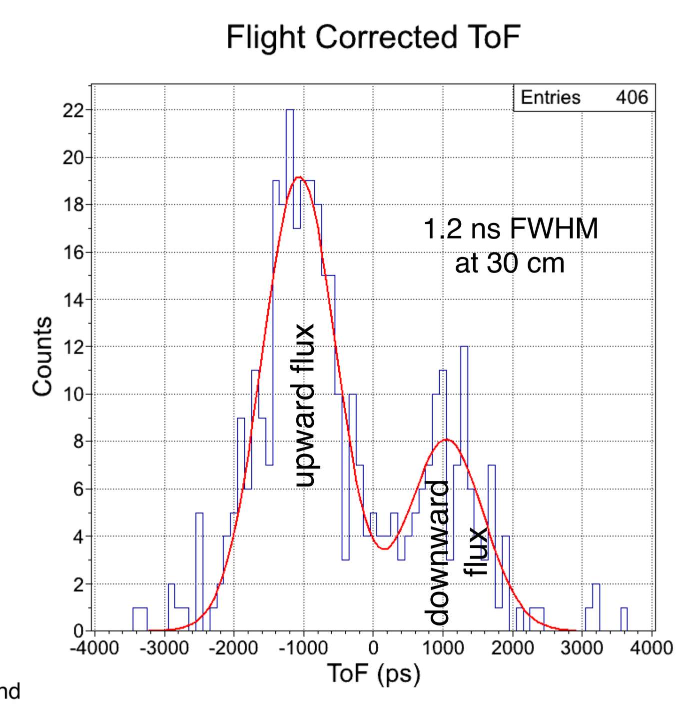
2011 & 2014 Balloon Flights

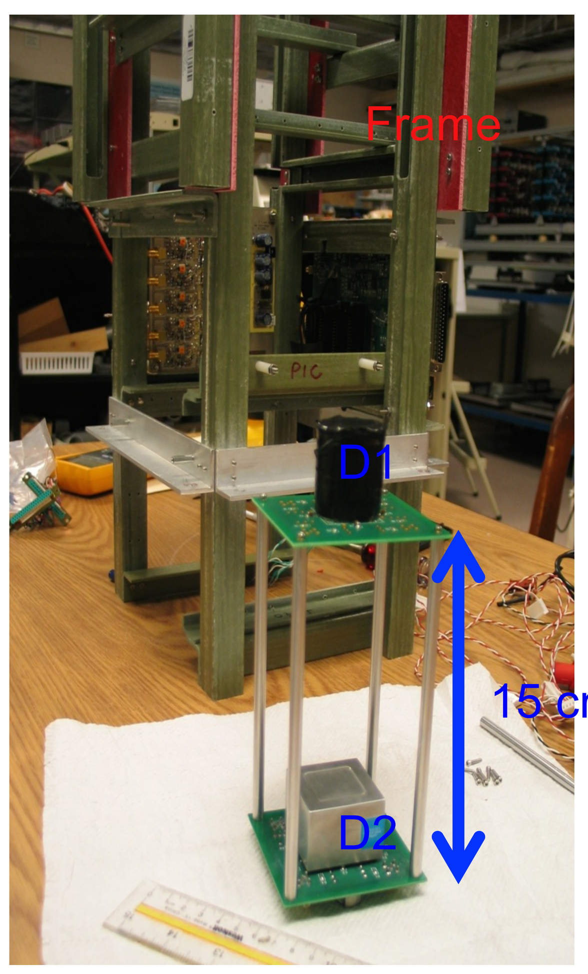
Fast Compton Telescope (FACTEL)

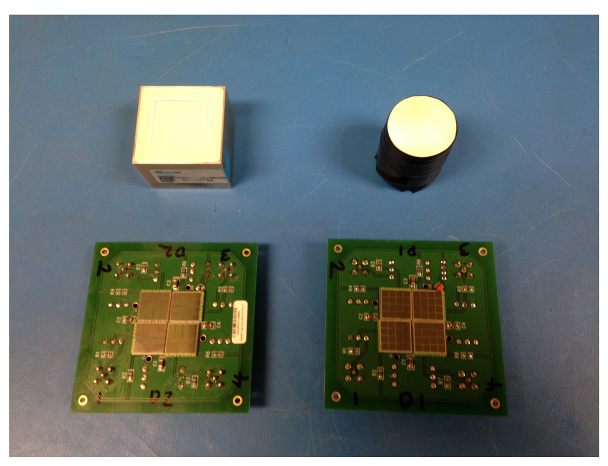
Demonstration of New Scintillator Technology ($LaBr_3$)

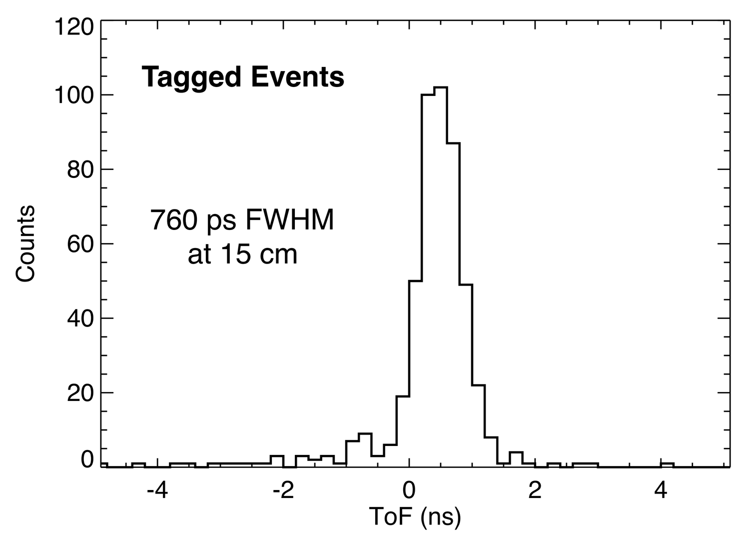
Compton telescope consisting of three 1-inch liquid organic scintillators (D1) and three 1-inch $LaBr_3$ scintillators (D2). Both very fast scintillators (3 ns and 16 ns, respectively), all read out by fast PMTs. Payload remained at float for 26 hours. ToF spectrum clearly separates upward and downward fluxes, even at 30 cm separation. Flight background consistent with simulated spectrum.











Solar Compton Telescope (SolCompT)

Demonstration of New Readout Technology (SiPM)

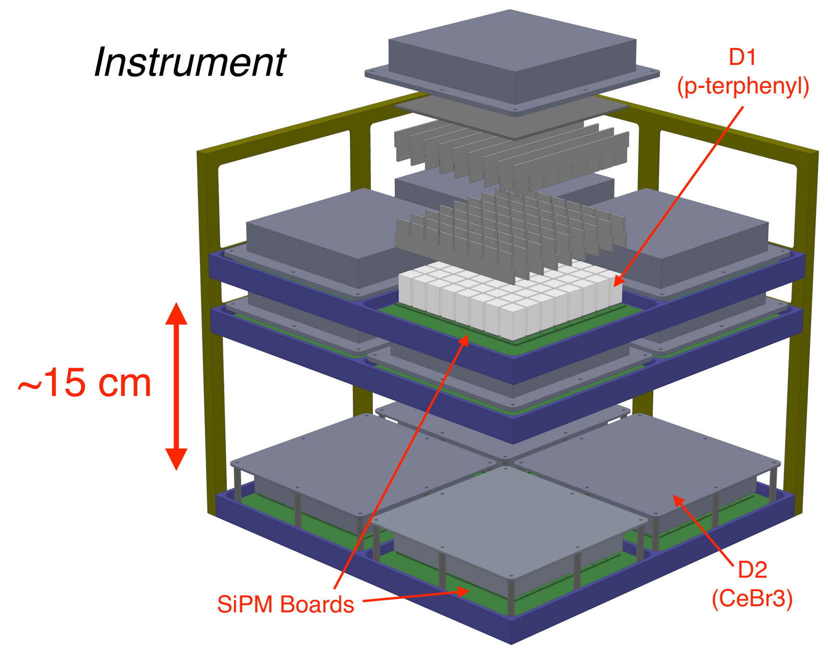
Silicon photomultipliers (SiPMs) offer fast readout in a compact, low-power, rugged package, ideal for space applications. SolCompT was a small Compton telescope consisting of one D1 detector (1-inch organic stilbene with 5 ns decay time) and one D2 detector (1-inch $LaBr_3$ with 16 ns decay time), both read out by SiPMs (Hamamatsu S11828-3344 MPPCs). A tagged ^{60}Co source (~240 nCi) was used to monitor gain and energy resolution throughout the 3.5 hour flight. Background ToF spectrum somewhat harder to interpret due to small separation (15 cm).

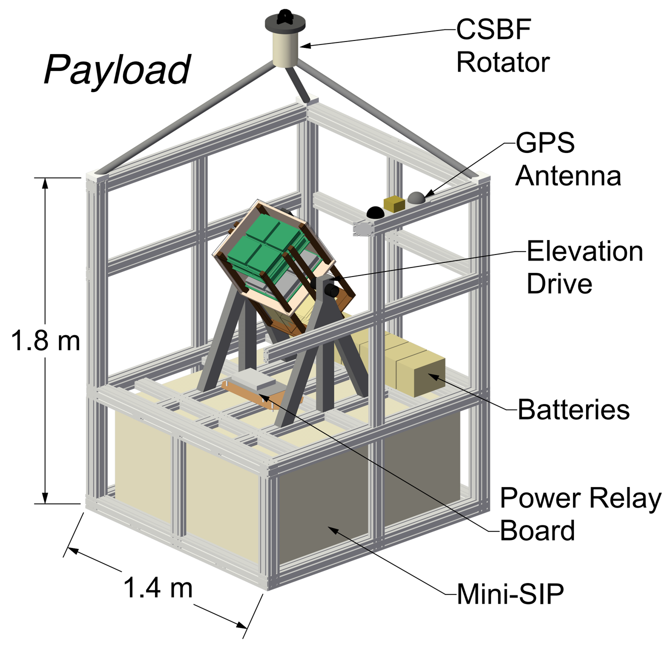
ASCOT Balloon Instrument (2017)

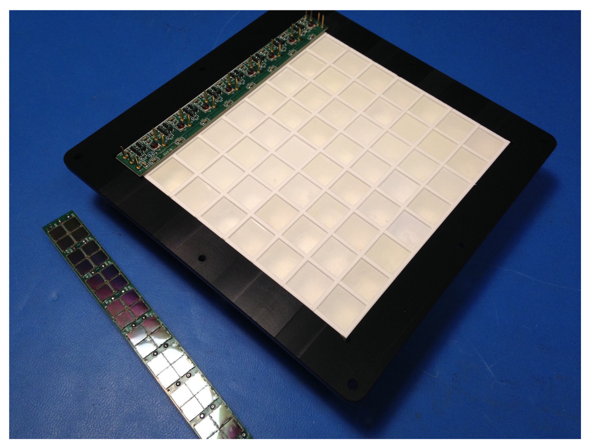
Advanced Scintillator Compton Telescope (ASCOT)

Scientific Validation of the Design

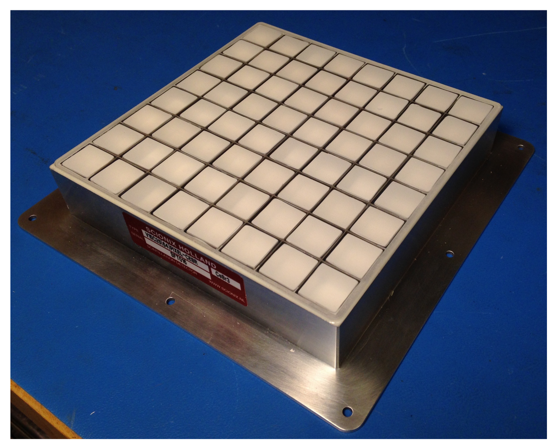
Balloon payload (to be launched in 2017) will be capable of measuring the Crab in a 1-day flight. The telescope consists of two D1 layers (p-terphenyl) and one D2 layer ($CeBr_3$) separated by 15 cm. Smaller separation increases both the effective area and the FoV. Each detector module consists of an 8 x 8 array of scintillator elements (each of which is 15 × 15 × 25 mm³). Scintillator array is read out by an 8 x 8 SiPM array (composed of 8 x 8 array of 2 x 2 SensL MicroFC-60035-SMT SiPM subarrays). Each detector layer consists of a 2 x 2 array of detector modules. The p-terphenyl is being purchased from Proteus, Inc. The $CeBr_3$ arrays are being assembled by Scionix Holland / Berkeley Nucleonics Corp.



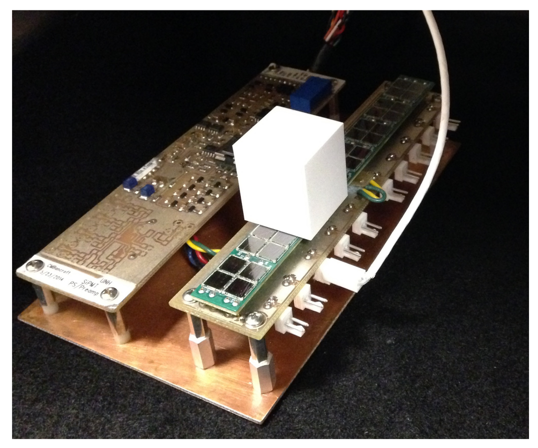




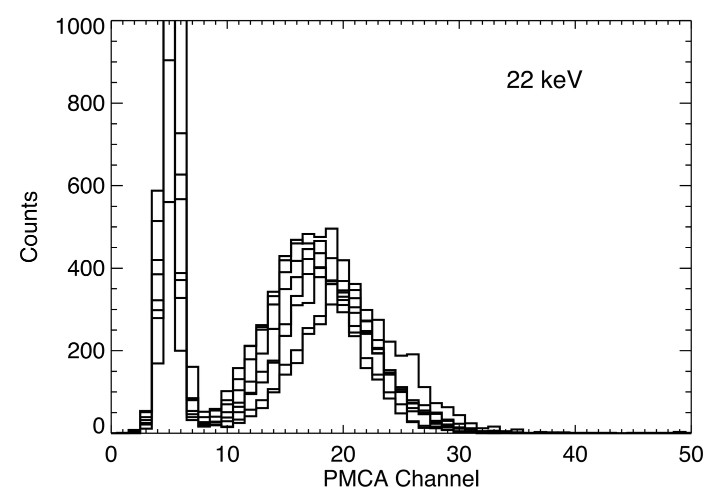
D1 module consisting of p-terphenyl crystals in black Delrin frame separated by Gigahertz Optik reflective slats.



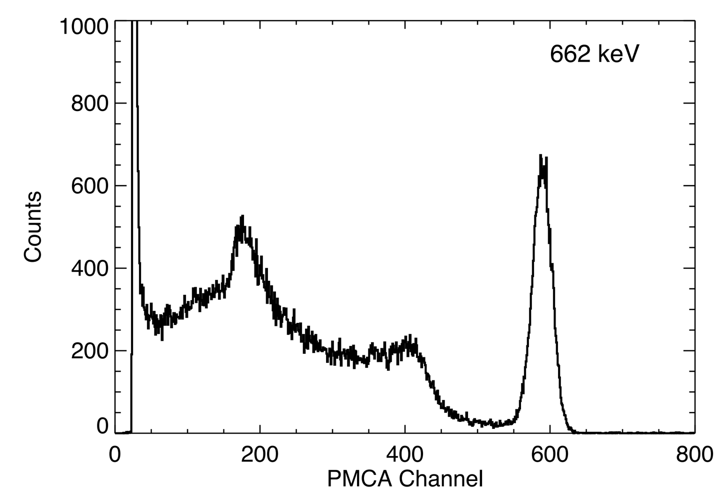
D2 module consisting of $CeBr_3$ crystals in vacuum-rated hermetic package.



SiPM (MicroFC-60035-SMT) strip board being tested with a single p-terphenyl crystal.

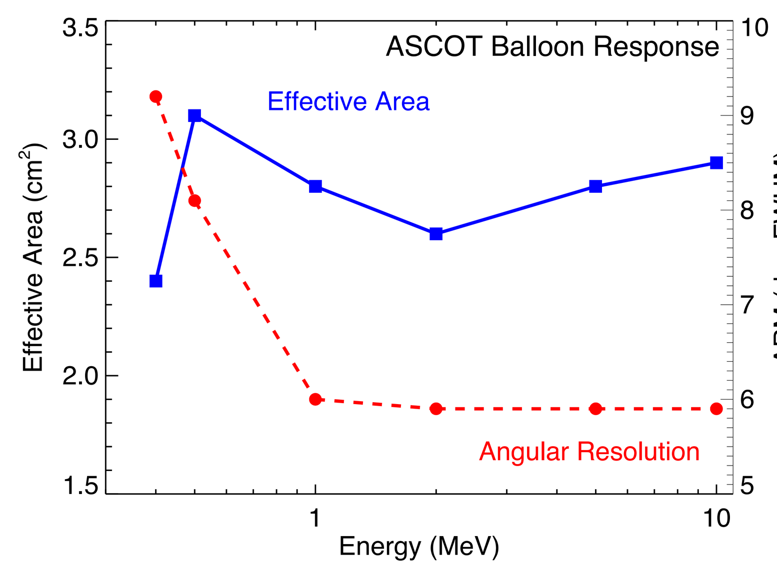


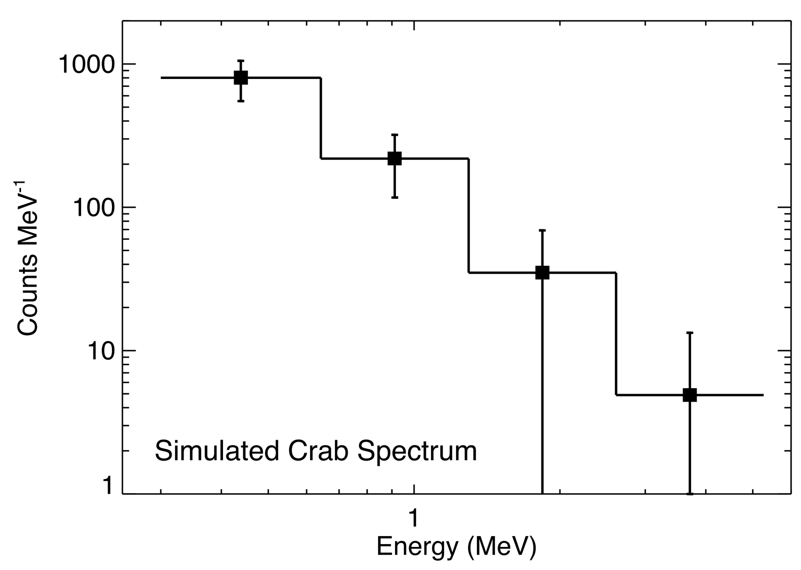
22 keV pulse-height spectra for all eight sensing position elements in the SiPM strip board, measured using a p-terphenyl crystal.



662 keV pulse-height spectrum measured using one position element in the SiPM strip board, measured using one crystal of the D2 $CeBr_3$ array. Resolution is ~6.1% (FWHM).

Initial Monte Carlo Simulations





Preliminary response and balloon-flight background simulations performed with MGGPOD indicate that ASCOT will detect the Crab in 1 day at ~4σ

For more information, please contact Peter.Bloser@unh.edu

This work was supported by NASA grant NNX15AE49G