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The Advanced Scintillator Compton Telescope (ASCOT) Balloon Payload

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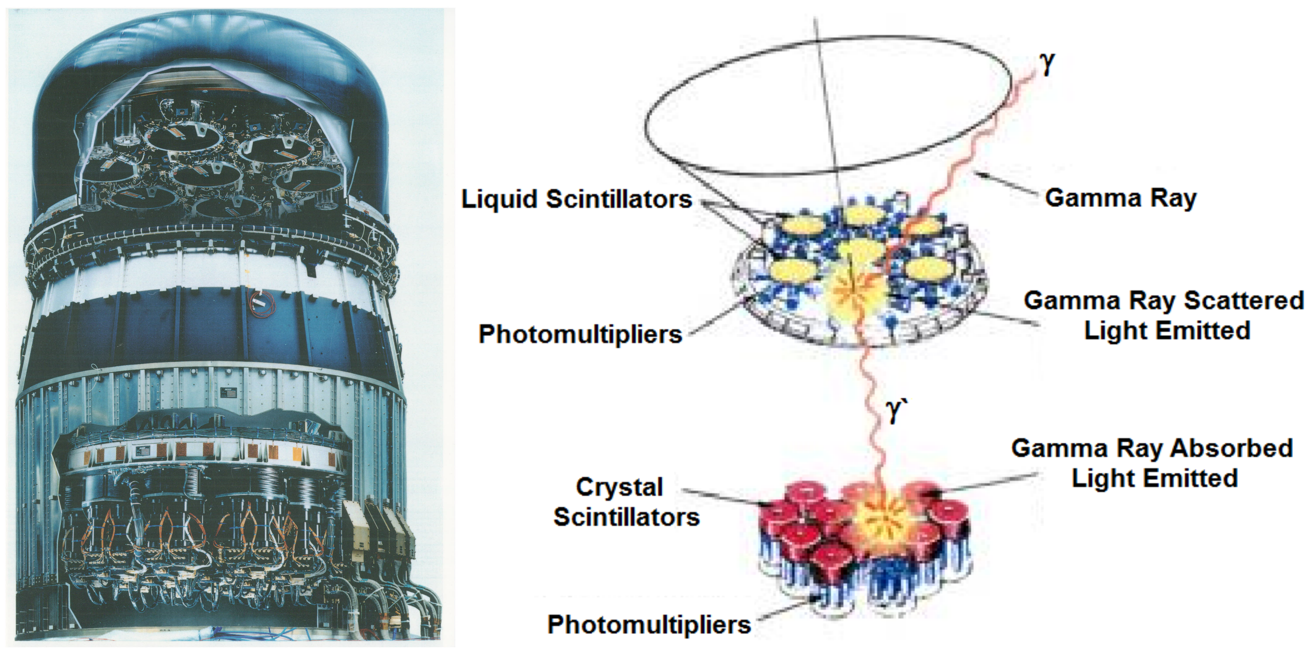
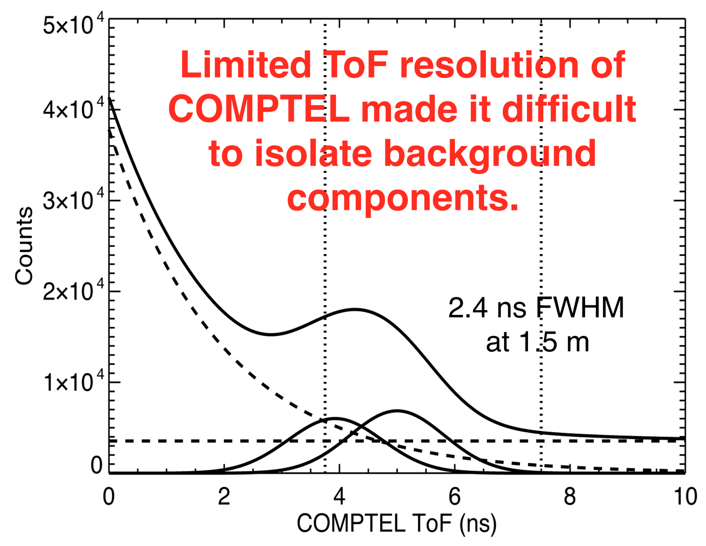
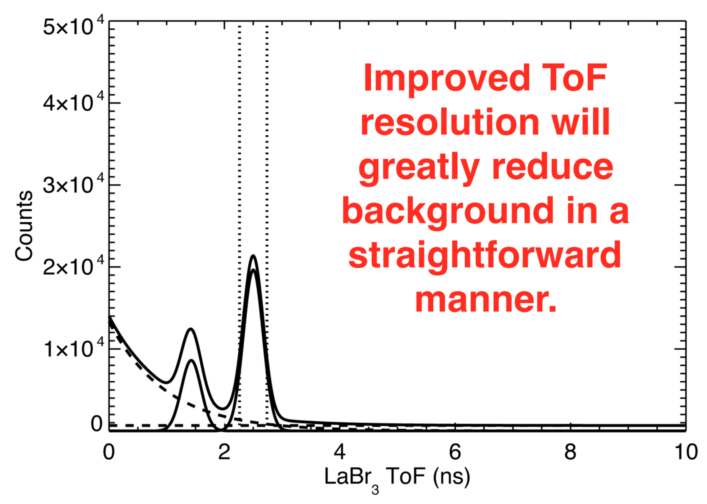
There is an urgent need in high-energy astronomy for a medium-energy gamma-ray mission covering the energy range from approximately 0.4 - 20 MeV to follow the success of the COMPTEL instrument on CGRO. We believe that directly building on the legacy of COMPTEL, using fast scintillators that improve the response while preserving time-of-flight background rejection, is the most promising path for such a mission. 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 have constructed a balloon instrument, the Advanced Scintillator Compton Telescope (ASCOT) with SiPM readout, 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







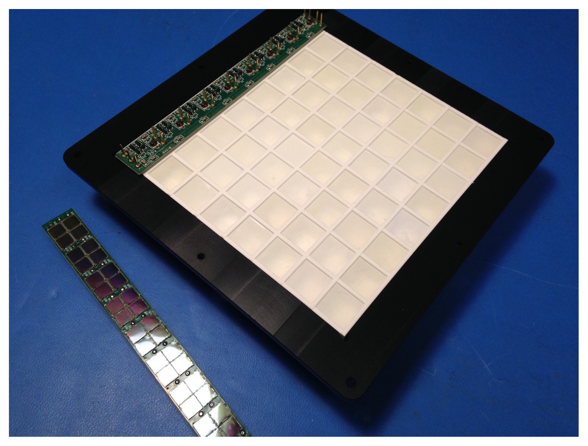
The COMPTEL instrument on CGRO was a double-scatter instrument (D1 - liquid scintillator D1 / D2 - NaI(Tl)) capable of imaging 0.75-30 MeV gamma rays. With a D1-D2 separation of 1.5 m, it relied on both pulse shape discrimination (PSD) and Time-of-Flight (ToF) to identify and reject various background 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.

ASCOT Detector Technology

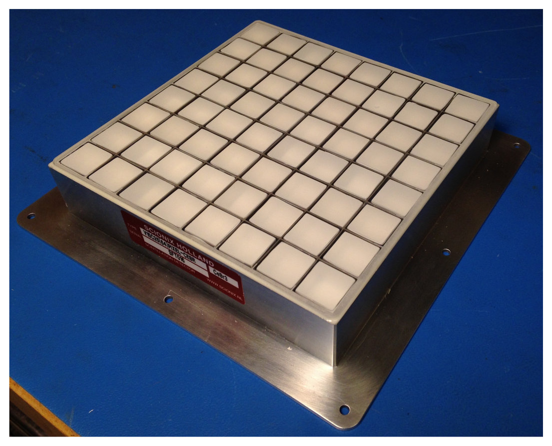
Advanced Scintillator Materials

P-terphenyl (Proteous, Inc.) & $CeBr_3$ (Scionix/BNC)

The ASCOT instrument is made up of **modules**, each containing an 8 × 8 array of scintillator elements. The scintillator elements are 15 mm × 15 mm × 25 mm.

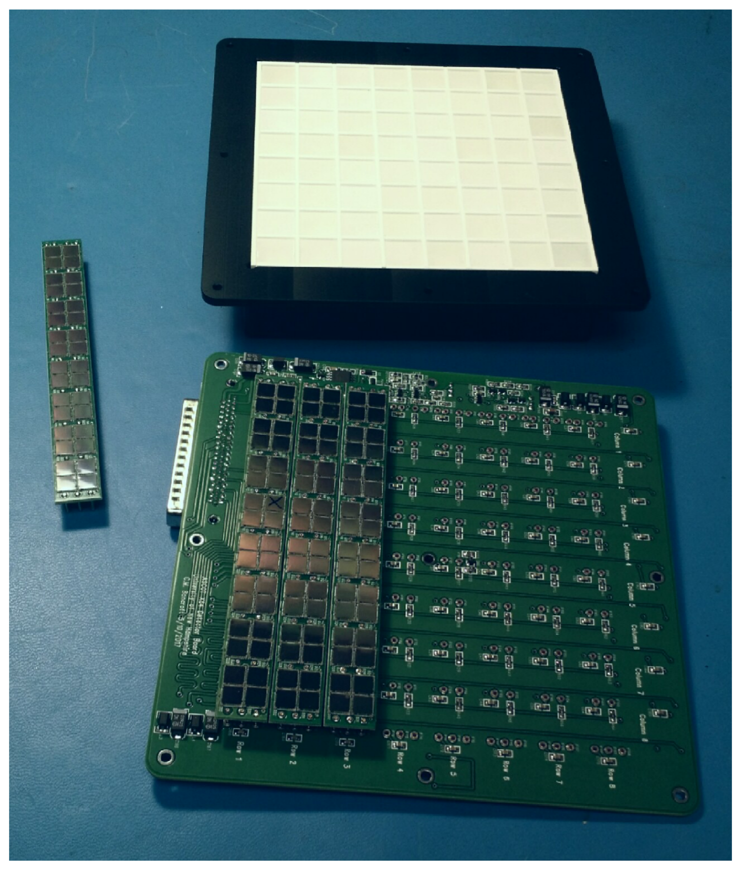


D1 module consisting of p-terphenyl crystals in black Delrin frame separated by Gigahertz Optik reflective slats.



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

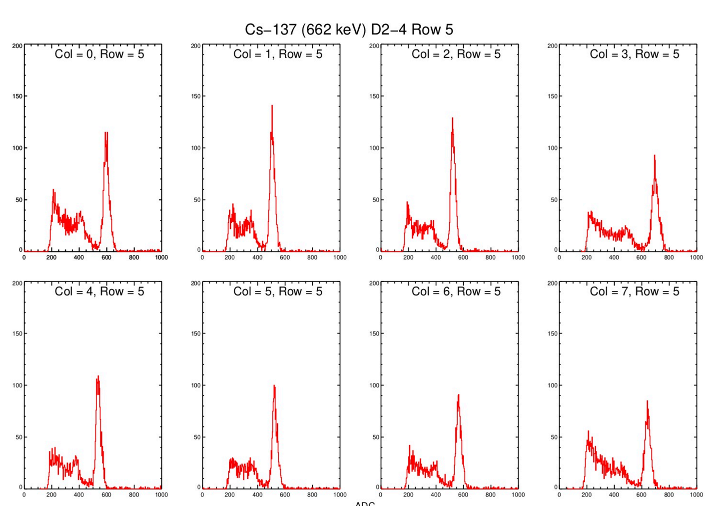
SiPM array board partially populated with SiPM strip boards.



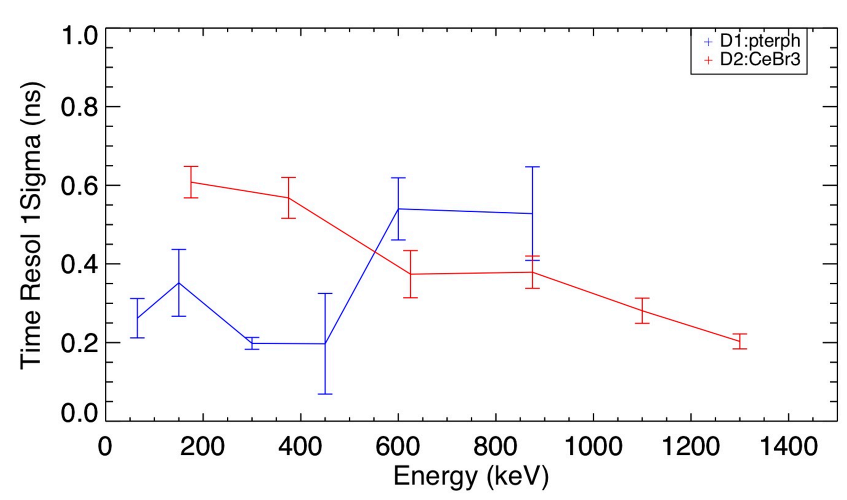
Silicon Photomultipliers

SensL MicroFC-60035-SMT SiPM

Each scintillator element is read out by a 2 × 2 sub-array of SiPMs. The 2 × 2 sub-arrays are mounted on custom "strip" boards, fabricated by IMS Corp. in Manchester, NH, corresponding to a row of the detector module. These strips boards are in turn mounted in an array mother board which provides front-end readout electronics and bias voltage (~29 V) with passive temperature-based gain correction.



Sample D2 spectra. Typical ΔE/E ~ 6% FWHM @ 662 keV



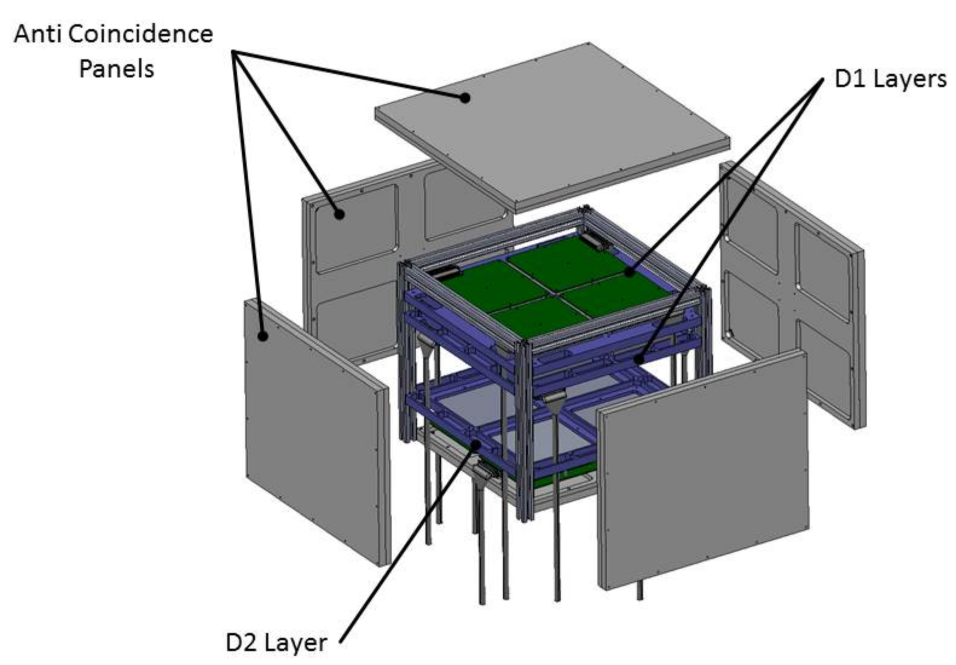
ToF resolution vs. energy for D1 and D2 pixel

ASCOT Balloon Payload

ASCOT Instrument

Detector Modules, Anti-Coincidence Panels, and Tagged Calibration Source

The telescope comprises two D1 layers (p-terphenyl) and one D2 layer ($CeBr_3$) separated by 13 cm. Smaller separation increases both the effective area and the FoV. Each detector layer consists of a 2 x 2 array of detector modules. The layers are surrounded by six anti-coincidence panels, each containing a plastic scintillator sheet read out by SiPMs at the four corners. A tagged calibration source made of plastic scintillator infused with ^{60}Co, also with SiPM readout, is located at the center of the D2 layer.



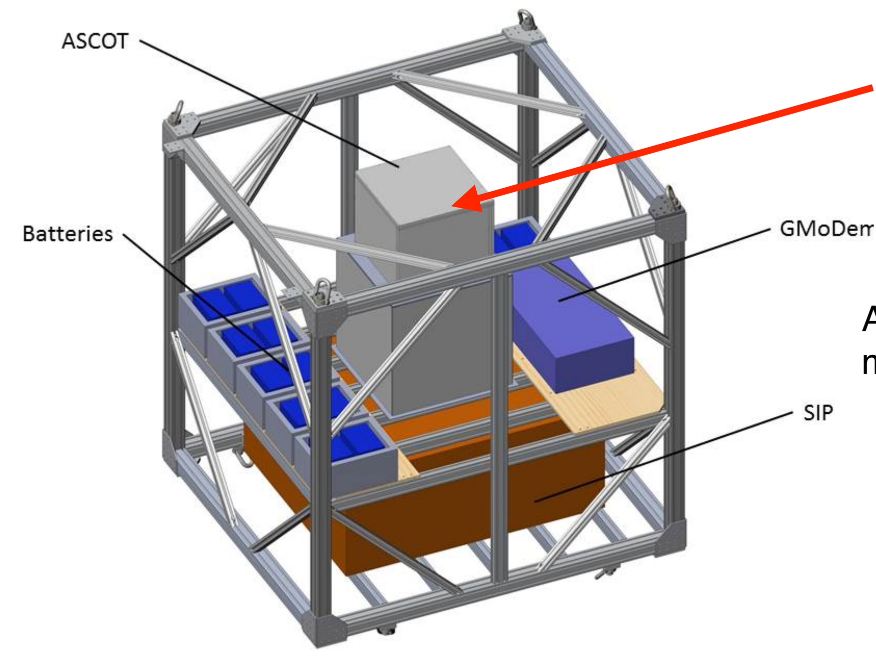
Assembled ASCOT instrument in the lab

Anti-coincidence panel being tested

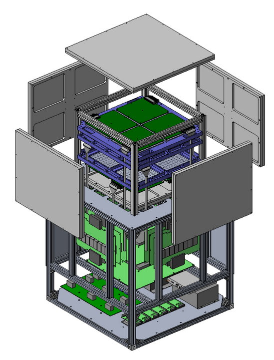
Balloon Payload

Instrument, Gondola, GPS Compass, and CSBF Equipment

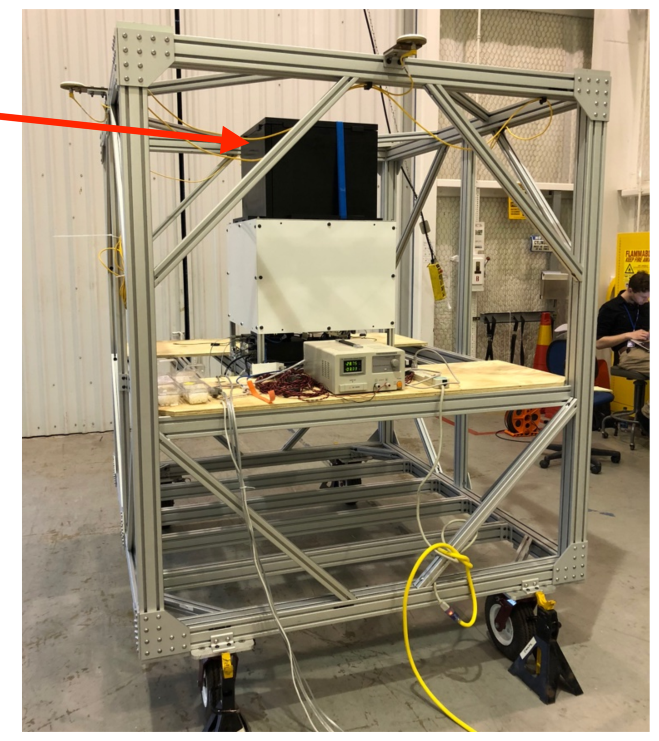
The instrument is held, pointed at the zenith, in the center of a gondola frame made of 8020 extruded aluminum T-slot elements. The batteries are mounted on the gondola deck next to the ASCOT telescope, as is a piggyback instrument, the GMoDem experiment provided by University College Dublin. The CSBF Mini-SIP package is mounted below. Attitude knowledge is provided by the ADU5 GPS compass. No attitude control is necessary. The total payload mass is expected to be ~2900 lbs, which should permit a daytime float altitude of at least 130,000 feet.



Mechanical drawing of ASCOT balloon payload

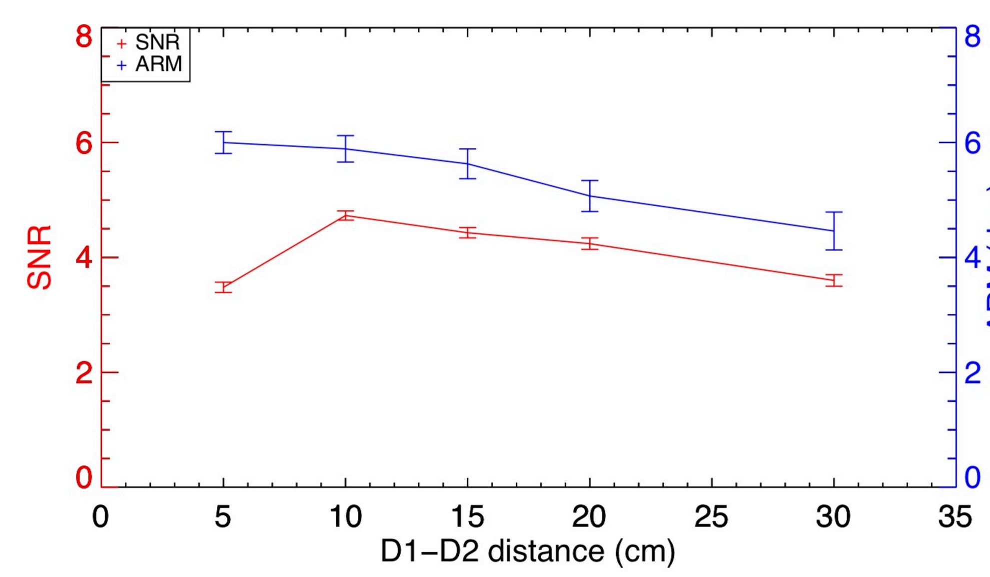


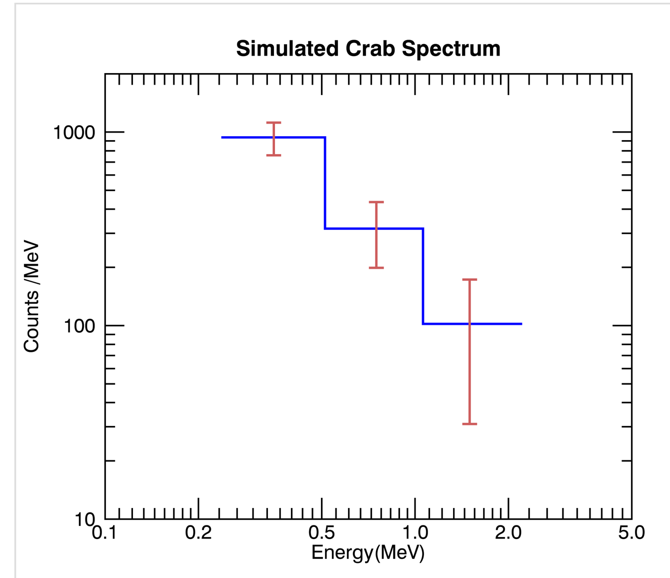
ASCOT instrument mechanical drawing



ASCOT payload being prepared for flight at CSBF in Palestine, TX

Expected Sensitivity





Response and balloon-flight background simulations performed with MEGAlib indicate that ASCOT will detect the Crab in 1 day at ~4.5σ

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

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