The High Altitude Water Cherenkov Observatory

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The High Altitude Water Cherenkov (HAWC) Observatory is a TeV gamma ray detector currently under construction at Sierra Negra in Mexico. HAWC will utilize the wide-angle, high duty cycle water Cherenkov technique developed by Milagro, but use new technology, a larger detection area, and higher altitude to improve sensitivity by an order of magnitude. HAWC will survey the TeV gamma ray sky, measure spectra of galactic sources up to and beyond 100 TeV, and map galactic diffuse gamma ray emission. With its wide field of view and continuous operation, HAWC will also be a powerful instrument with which to study transient phenomena. HAWC will have significant overlap with space and ground-based detectors.

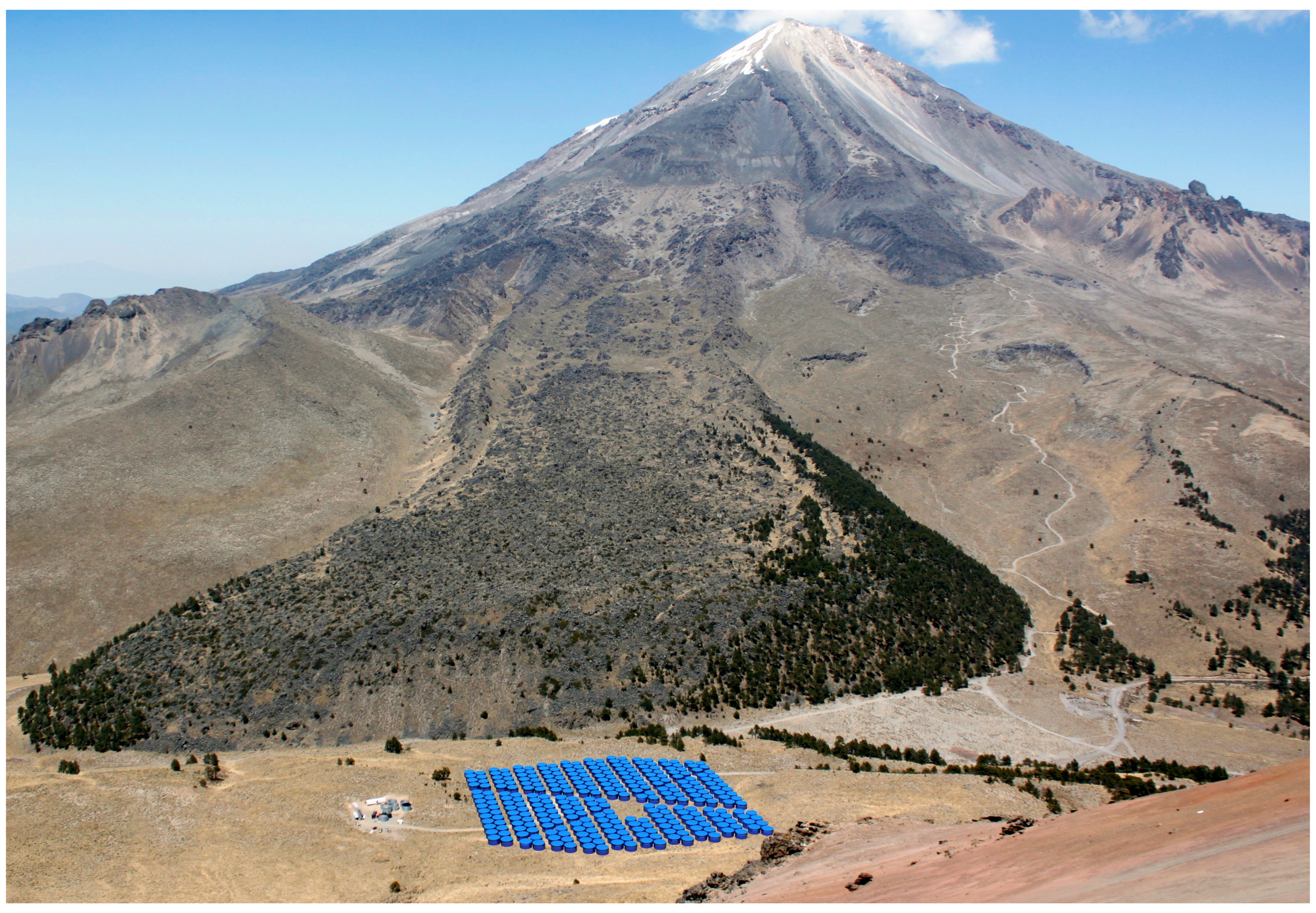

Figure 1: A simulated view of the HAWC detector at 4100m a.s.l. at the vulcan Sierra Negra site with the Pico de Orizaba near Puebla, Mexico in the background.

THE HAWC OBSERVATORY

HAWC builds on the success of the first generation, wide field-of-view, high duty cycle, TeV gamma-ray observatory, Milagro. HAWC is a large water Cherenkov air-shower detector consisting of 300 large water tanks (7.3m diameter x 5m depth), each instrumented with three 20 cm upward-looking photomultiplier tubes mounted on the bottom of the tank. The tanks will be densely packed to cover an area of ~20,000 m^2. The expanded detector area (~10x that of the Milagro bottom layer), increased altitude (4100 m vs. 2630 m), and optical isolation of the detector elements lead to a 15-fold increase in sensitivity relative to Milagro, which performed the deepest wide-field survey of the TeV sky to date. This enormous increase in sensitivity comes at a dollar cost that is only slightly more than that of Milagro. This is achieved by applying our experience with Milagro to the design of HAWC and by reusing the 900 Milagro PMTs and front-end electronics. HAWC will have approximately the same sensitivity to hard spectrum galactic sources as Fermi, but at ~1000 times the energy.

Figure 2: The first full size HAWC tank of 7.3m diameter with a custom designed bladder. Filled in Austin Texas with 200,000 liters of water and light leak tested with a HAWC PMT.

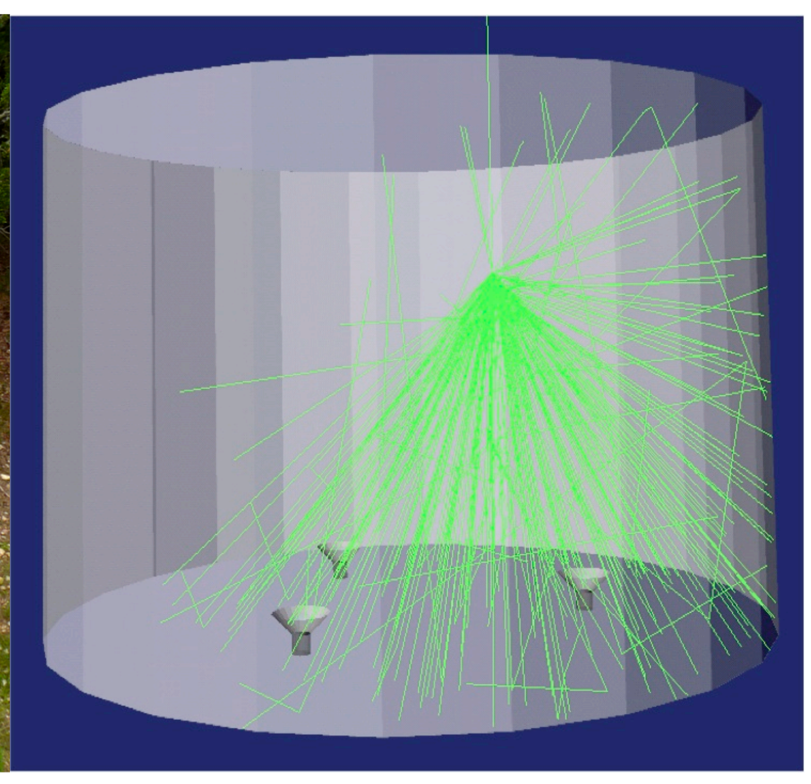

Figure 3: An image of a single HAWC tank in the GEANT4 simulation. The tracks from the EM shower produced by a single 100 MeV gamma-ray are shown (50x thinning).

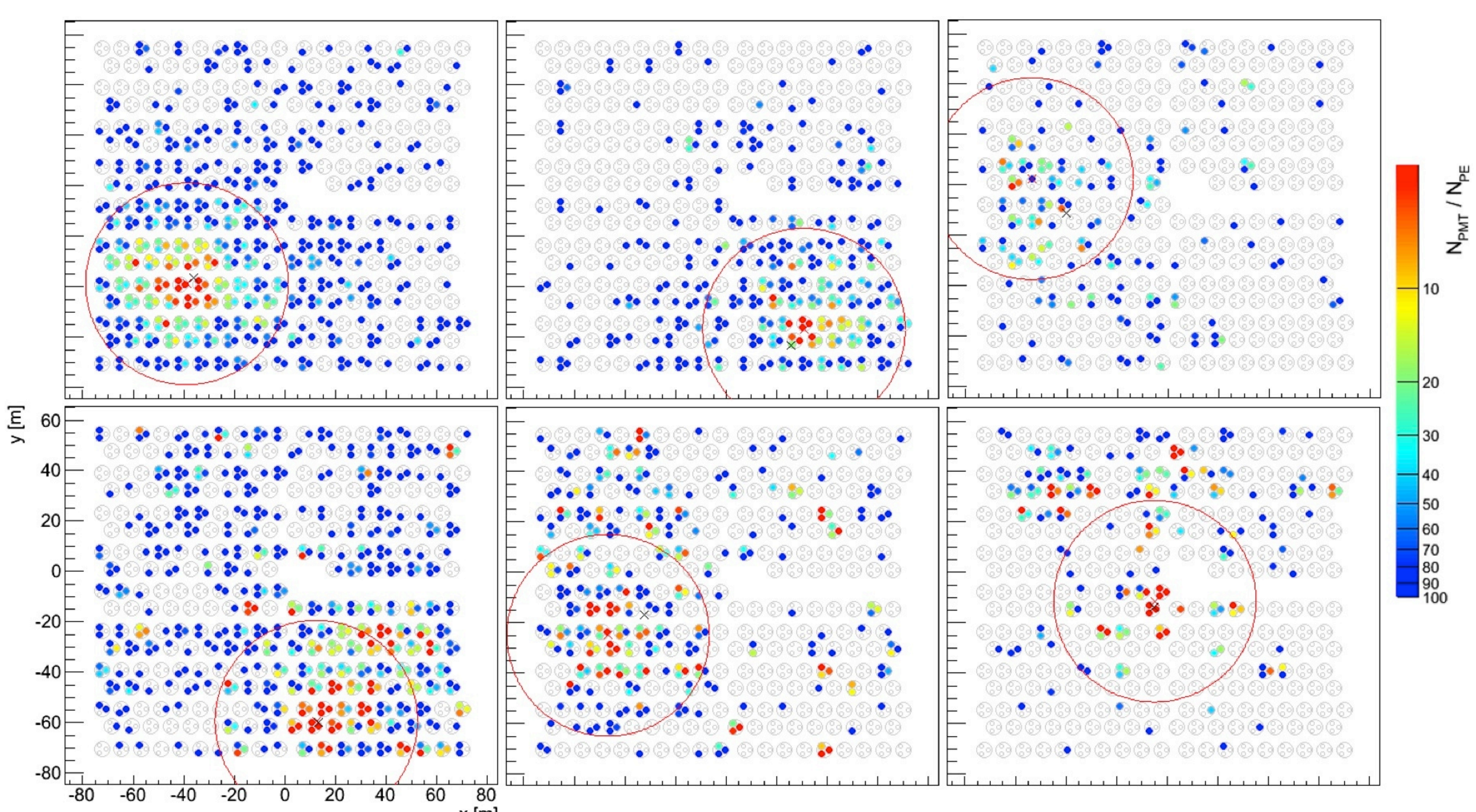

Figure 4: Images showing the energy depositions by 3 gamma-ray events (top) and 3 hadron events (bottom). The position of the fit core is shown as a circle of radius 40m. A compactness cut rejects events with large hits (shown here in red) outside the circle enclosing the core. The efficiency for rejecting hadrons is shown in Figure 7b.

Figure 5 Panorama of the HAWC site VAMOS test array shown on the left and the simulated positions of the HAWC tanks shown in blue.

Figure 6: Verification And Measuring Observatory Subsystems, VAMOS, test array being deployed adjacent to the HAWC Site.

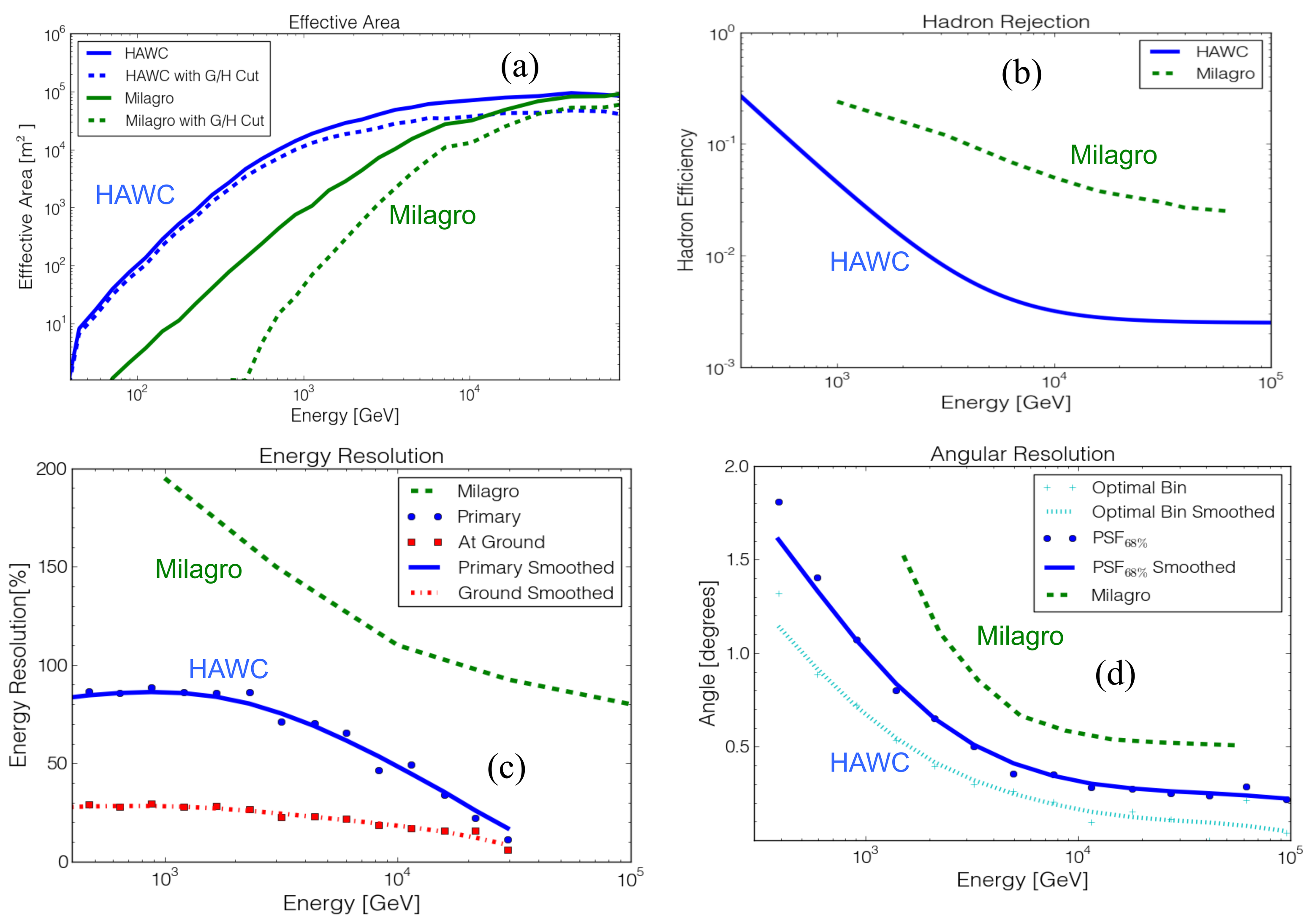

Figure 7: Illustration showing the sensitivity of HAWC and Milagro as a function of primary gamma-ray energy. Panel (a) shows the effective area for HAWC and Milagro. HAWC and Milagro have similar effective area at high energies, but HAWC has a ~4x lower threshold, principally due to the higher elevation. This results in a 2 order of magnitude increase in the effective area below 1 TeV. Panel (b) shows the efficiency of the gamma-hadron cut for passing hadronic background when the efficiency for accepting gamma-ray events is fixed at 50%. HAWC will reject approximately 10x more background than Milagro at similar energies. Panel (c & d) show the angular and energy resolution of Milagro and HAWC vs energy.

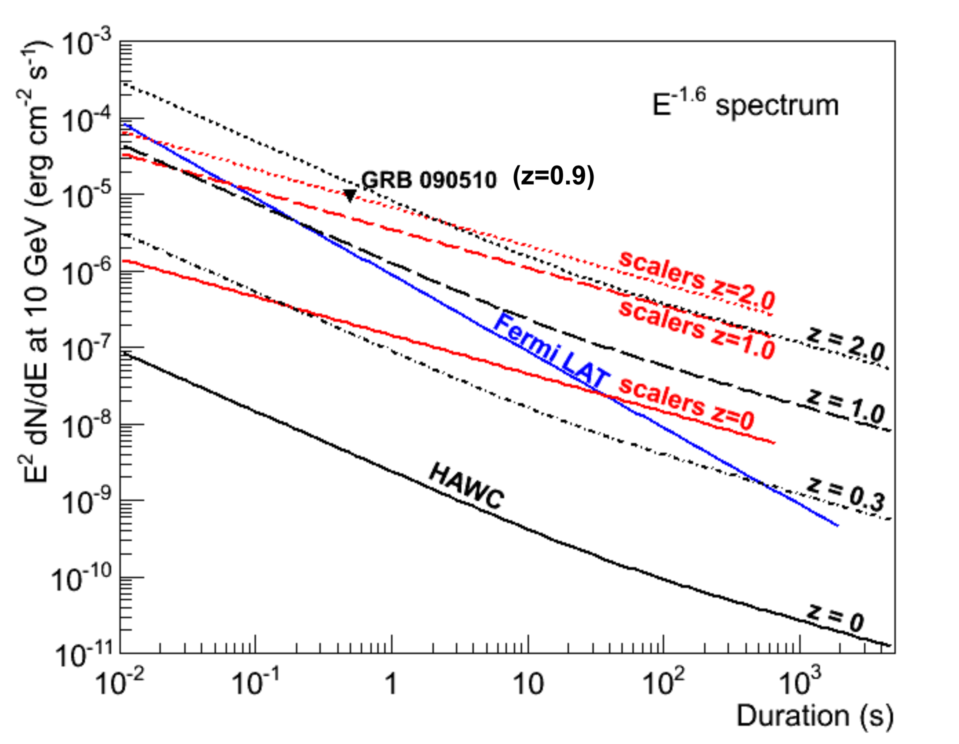

Figure 8: HAWC sensitivity with normal trigger and scalers to extragalactic transients at different redshifts for a 5 σ detection threshold. The y-axis is the flux mormaiization at 10 GeV assuming an optical depth due to absorption by the extragalactic background light from the model of Gilmore, 2009. Also, shown is the flux necessary for a Fermi detection of one gamma ray above 10 GeV.

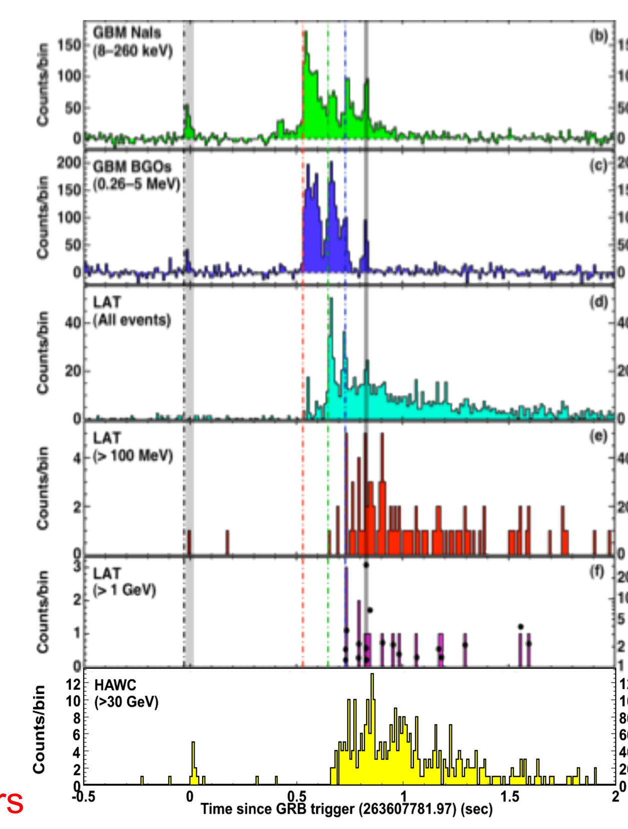

Figure 9: Fermi observation of GRB090510 at z=0.9 (top 5 panels) and HAWC's simulated lightcurve (including background). Approximately 200 events are simulated within the 0.5-1.0s interval which corresponds to a cutoff energy of about 125 GeV if the GRB were observed with cosθ > 0.9.

HAWC construction and operations are being funded jointly by the NSF and DoE in the US and CONACyT in Mexico. The total construction cost of HAWC is estimated to ~$13M USD.

HAWC Schedule	Number of Tanks	Scheduled Completion
VAMOS	7	Summer 2011
HAWC 30	30	Spring 2012
HAWC 100	100	Summer 2013
HAWC 300	300	Fall 2014