First light...
at HAWC Observatory’s high altitude
TeV gamma ray detector in Mexico

Daniel Fiorino for the HAWC Observatory
4 March 2012
Rencontres de Moriond
Aerial View of HAWC Site

Mt. Blanc ~ 4800m
La Thuile ~ 1450m

Pico de Orizaba
5636m

Sierra Negra
4640m

Parque Nacional Pico de Orizaba,
Mexico
(97° W, 19° N)

HAWC Site
4100m

Large Millimeter Telescope

Daniel W. Fiorino
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HAWC Observatory
The HAWC Observatory

High altitude 4100m

Next generation water Cherenkov detector (Milagro was previous generation)

High energy air shower array ~100 GeV – 100 TeV

Cosmic Ray Origins, Gamma Ray Bursts, many more

HAWC 300
Upon Completion
**Cherenkov Tanks**
Corrugated Steel
4.0m tall, 7.3m wide
Target for Cherenkov light
4 photomultiplier tubes

**Photomultiplier Tubes**
900 Hamamatsu 8” bulb
Reused from Milagro
Sensitive to UV-optical blue
300 High quantum efficiency (~30%)
Lower energy threshold
Science Goals

Unbiased Skymap

Galactic Sources of Gamma Rays
- Supernovae Remnants
  - Crab Nebula (SN 1054)
  - Standard Candle... Recent Flares
- Extended Objects (e.g. Molecular Clouds)
- Galactic Plane

Extragalactic (z<0.1) Sources of Gamma Rays
- Active Galactic Nuclei flaring
- multiwavelength campaign (Fermi-LAT)
- Gamma Ray Bursts counterpart (Fermi-LAT/optical telescope alerts)
- assumptions of spectra, constrain EBL
- Nearby Galaxies
  - starburst galaxies (many SNRs)
Verification and Monitoring of Systems

- 7 Cherenkov tanks
- 3 months of data
- 7 photomultipliers per tank

Exceeded set milestones
Improved deployment technique
Online systems running
Analysis Chain → Skymap
First Light

Skymap
- Compare data with background estimated using data
- "On source" vs. "Off source" comparison
- Li and Ma Statistics

Analysis by D. Fiorino (UW)

Analysis by Jim Braun (UMD)
30 Tanks are scheduled to be operational this Fall (2012)

Site is leveled
Tank positions are laid out
Electronics ~ May 2012

Verify Cosmic Ray Rates
Zenith Alignment
Cosmic Ray Anisotropy?
Moon Shadow?

HAWC 100 Tanks
(> Milagro sensitivity)
Thank You!
Colorado State University
George Mason University
Georgia Tech University
Harvey Mudd University
Los Alamos National Lab
Michigan State University
Michigan Tech University
NASA/Goddard

Ohio State at Lima
Pennsylvania State University
University of California-Irvine
University of Maryland
University of New Hampshire
University of New Mexico
University of Utah
University of Wisconsin-Madison

Benemerita Universidad Autonomica de Puebla
Centro de Investigacion y de Estudios Avanzados
Universidad Autonoma de Chiapas
Universidad de Guadalajara
Universidad de Guanajuato
Universidad Michoacana de San Nicolas de Hidalgo
Universidad Nacional Autonoma de Mexico
The HAWC Observatory

Pico de Orizaba
5636m
Inactive Volcano

VAMOS Test Array

500 year old lava flow

HAWC-300 Final Array

HAWC Observatory

Upon Completion
HAWC Improves Upon Milagro

Water Cherenkov experiments provide unbiased information that no others can provide. HAWC is the logical next step.

Optically isolated tanks
   Better resolution (timing and charge)

Higher altitude
   Closer to shower maximum
   More particles, lower energy threshold

High quantum efficiency PMTs
   More Cherenkov light yield
**Improved Angular Resolution**

Error in reconstructing arrival direction

Simulated showers (CORSIKA) incident on simulated HAWC (GEANT4)

Competitive with imaging air Cherenkov telescopes at highest energies

Optical isolation

Dense sampling

PSF = Point spread function
Improved Energy Resolution

Error in reconstructing energy

Simulated showers (CORSIKA) incident on simulated HAWC (GEANT4)

Improved source spectra over Milagro

Energy measured at ground is not a perfect indicator of primary energy

Primary

Actual error in estimating primary energy

At Ground

Energy resolution to energy at ground level
Improved $\gamma$/Hadron Separation

Error in determining species

Simulated showers (CORSIKA) incident on simulated HAWC (GEANT4)

Optical isolation

High quantum efficiency PMTs
Improved Effective Area

Effective area of detector of shower

Simulated showers (CORSIKA) incident on simulated HAWC (GEANT4)

Trigger on lower energy showers

Milagro had outriggers