

GRaNDScan
An Experiment to Study UHECR
Anisotropy Around and Below EeV

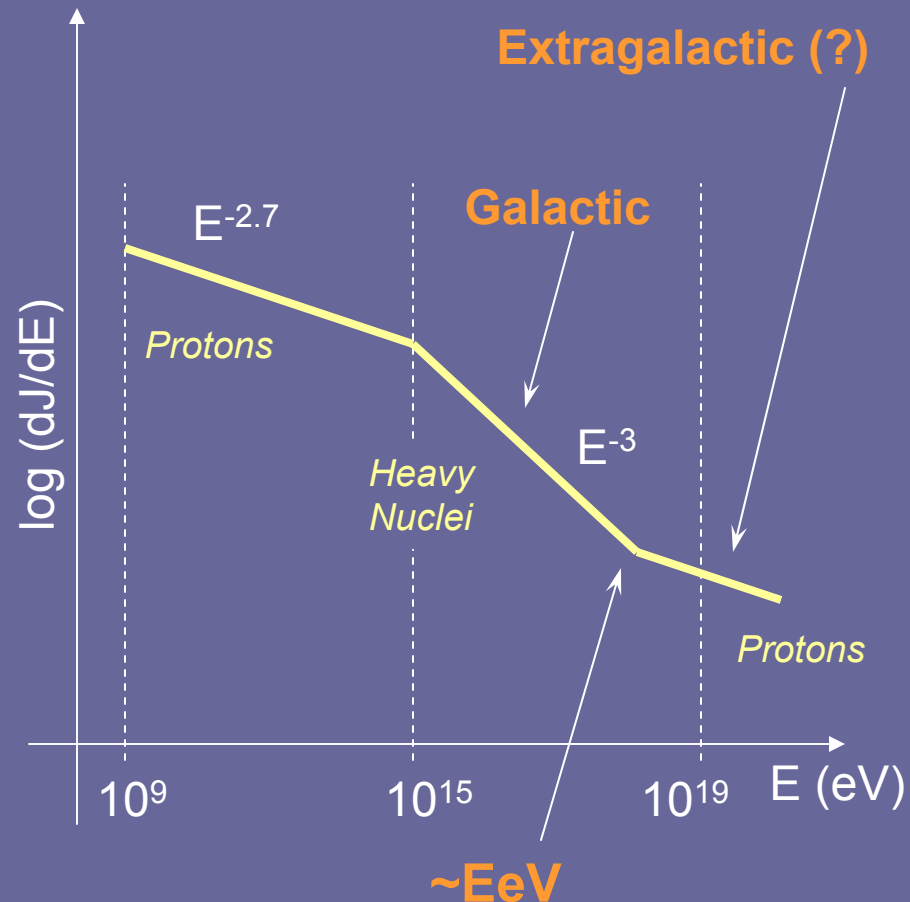
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Observational Status Near 1 EeV: Energy Spectrum and Anisotropy

- **Spectrum at 10^{17} - 10^{19} eV:**
 - Possible structure
 - Ankle
 - Second knee
 - Change in composition
 - Heavy nuclei to light primaries (protons)
 - Change in source:
 - Galactic to extragalactic?
- **NOTE: Flux enhancement** from Galactic center has been claimed (AGASA, SUGAR, Fly's Eye), but statistics are weak.



UHECR Physics at the Galactic Center

- GC is compelling source of particles originating in Galaxy
 - Most energetic region of the Galaxy
 - Peak region of star formation and supernova activity
 - Galactic center hosts a black hole of 10^6 solar masses
- Possible GC sources of the measured EeV flux enhancement:
 - Diffusion of charged particles through μG -strength fields (AGASA, Fly's Eye)
 - Neutral particles: SUGAR point source (Bellido et al., 2001). SUGAR data suggest *neutron* primaries
 - Neat coincidence: @ 1 EeV, neutron decay length is distance to GC
- But, Galactic production of EeV particles is not entirely clear-cut:
 - Hillas Limit: known Galactic sources have trouble accelerating particles to EeV
 - Black hole at center is not sufficiently active to produce many EeV particles (Biermann et al., astro-ph/9811361)
 - So, confirmation of Galactic sources of EeV cosmic rays would be of interest

Observation of EeV Galactic Sources: Experimental Constraints


- Southern hemisphere location (to view GC)
- Good angular and energy resolution
- Simple confirmation of excess isn't sufficient; detailed study of excess region is necessary
 - **Chemical composition** crucial clue to the nature of accelerator and accelerated particle
 - Need **on-source** / **off-source** study of composition.
 - If UHECR excess stems from neutrons, then composition should be *heavier* off-source and contain a *lighter* mix on-source.

Stereo air fluorescence method is the answer

Why Stereo Air Fluorescence?

- **Technique**
 - Extensive air showers induce atmospheric fluorescence light
 - Telescopes at multiple sights focus the fluorescence light
 - Photomultiplier clusters record the resulting signal
- **Method satisfies requirements for EeV studies of the Galactic center:**
 - Detector aperture is typically quite large
 - AF detectors yield statistical determination of primary composition via elongation rate
 - Shower reconstruction is accurate to tenths of degrees
 - Energy resolution is also good

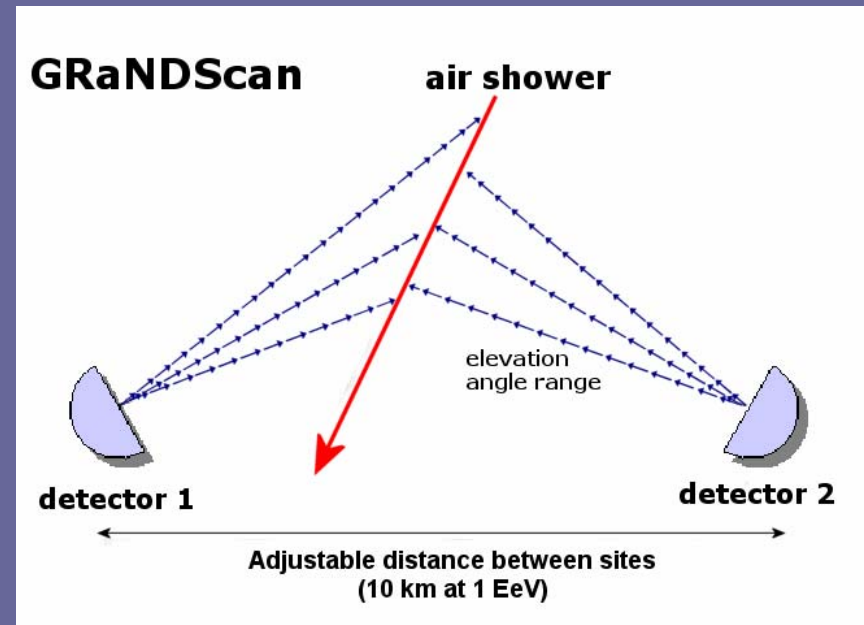
Air Fluorescence Infrastructure

- The air fluorescence technique requires
 - Dark, moonless nights
 - Good atmospheric conditions
 - No light pollution

remote desert area
- Restriction to remote locations means that ...
 - Extensive infrastructure needs to be minimized
 - **Small detector units** with little environmental impact
 - **Solar power** replaces power lines
 - PMT telescopes w/ **low power requirements**: ~50 to 100 W for 5-6 hours of nightly operation, with daily recharging

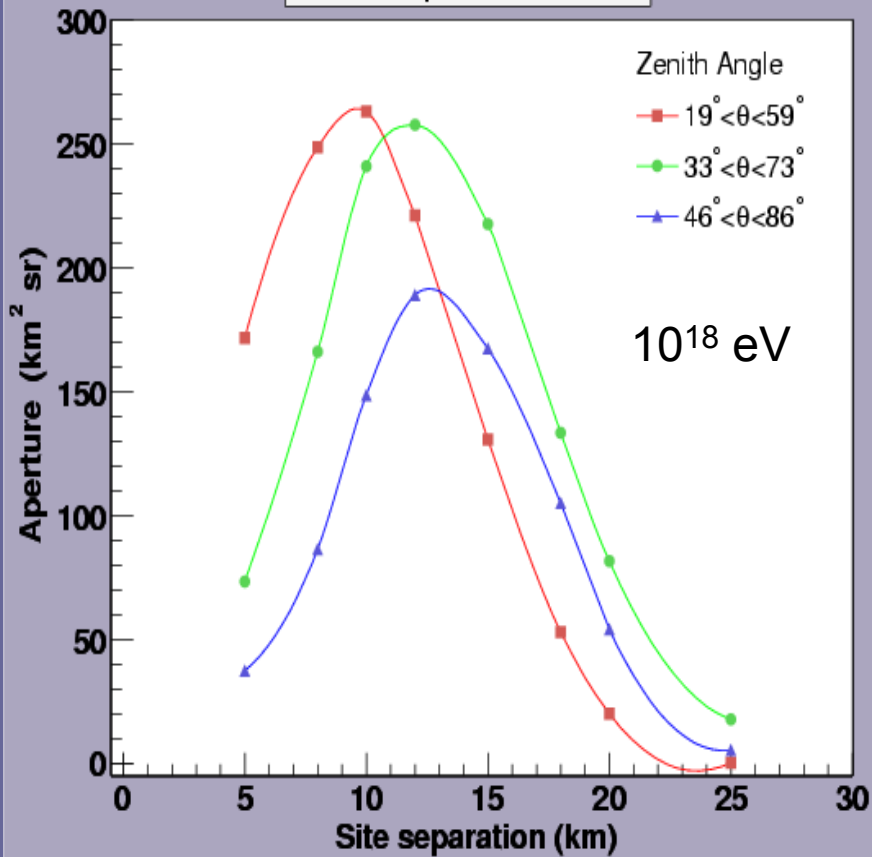
Scheme for GRaNDScan

- **Air fluorescence detector** with two facing sites, each viewing 90° in azimuth and 30° in elevation
- For EeV energies and below, fluorescence telescopes need to view **higher elevations** to see shower max
- To view the entire range between 10^{17} and 10^{19} eV, GRaNDScan will **adjust the site separation** to accommodate desired physics
- Mirror and PMT cluster assembly contained in a **portable box**, facilitating mobility of sites

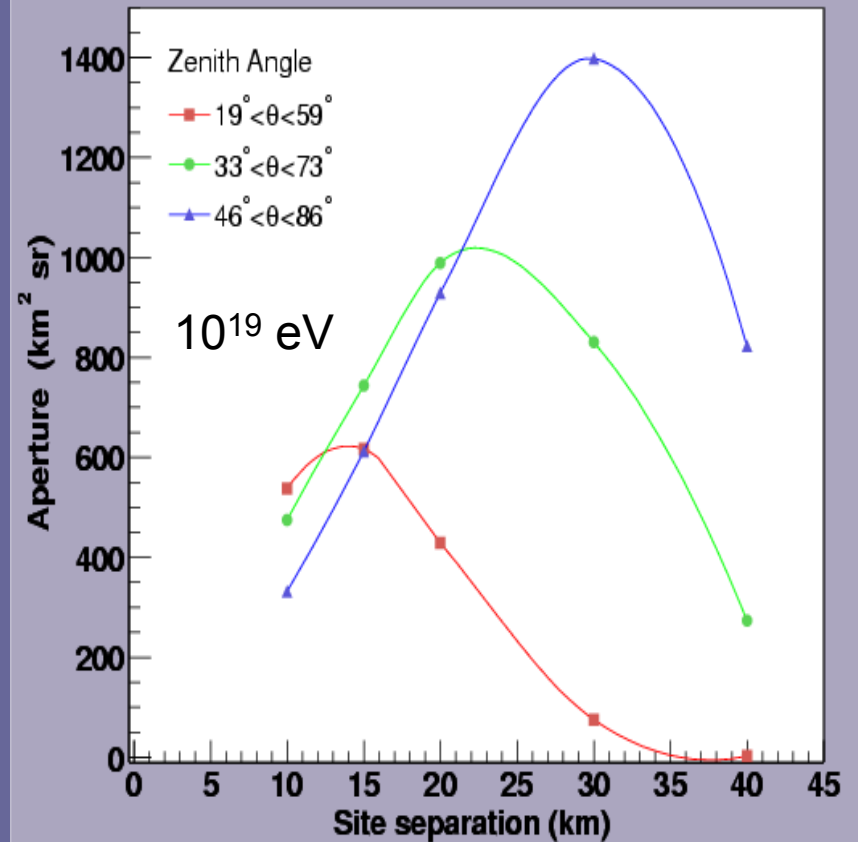


Aperture and Sensitivity

Detector Aperture at 10^{18} eV

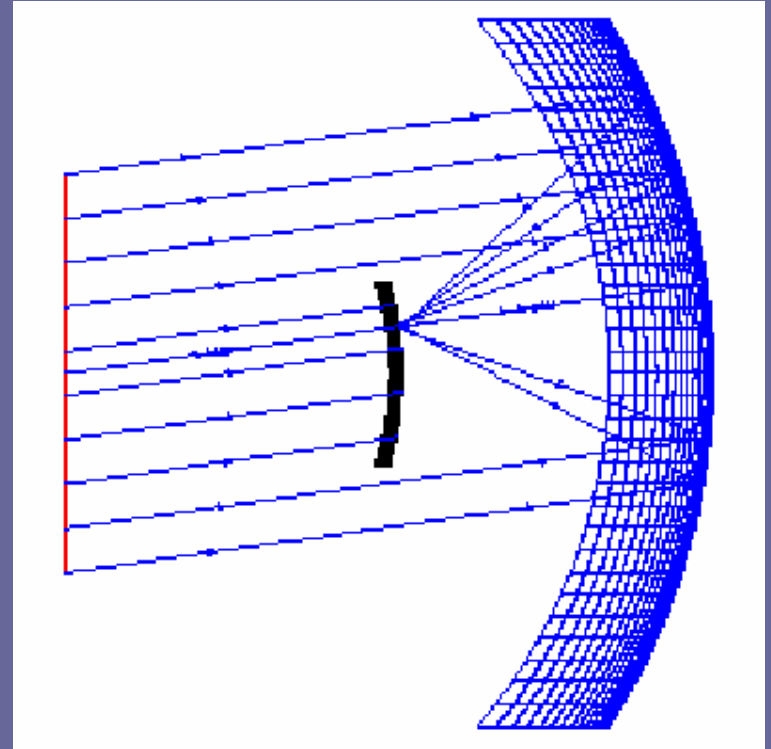


Detector Aperture at 10^{19} eV



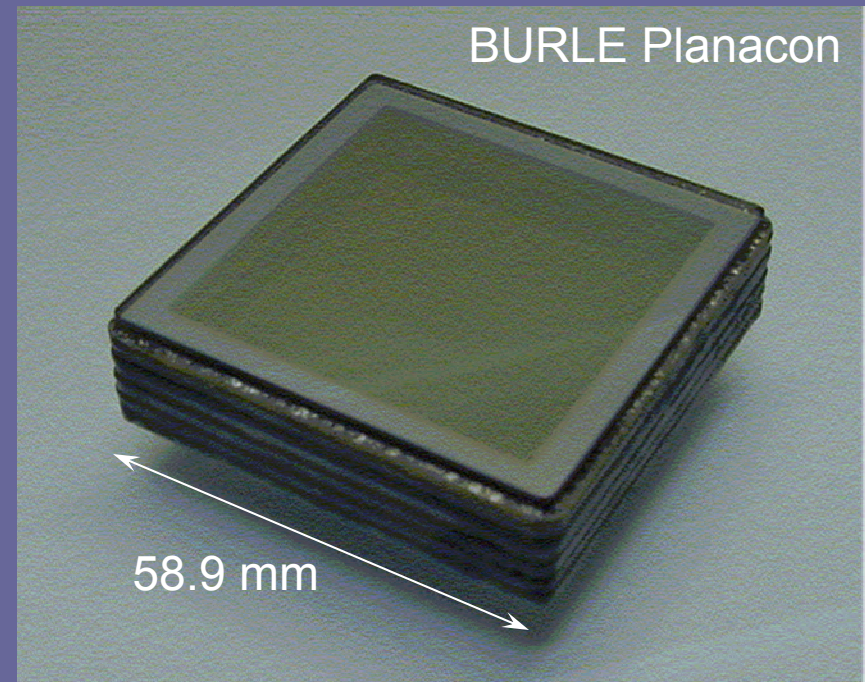
GRaNDScan: Photomultiplier Telescopes

- Two detector sites; **three telescopes per site**; 900 channels per telescope
- Build wide-angle telescopes to limit overall number of detectors
- Setup must be **flexible** and **lightweight**, for easy transport
- Mirror w/ wide viewing field, <25% focal plane shadow, <1° per pixel: **Schmidt optics w/o corrector** (purely reflective telescope)



PMTs Under Study

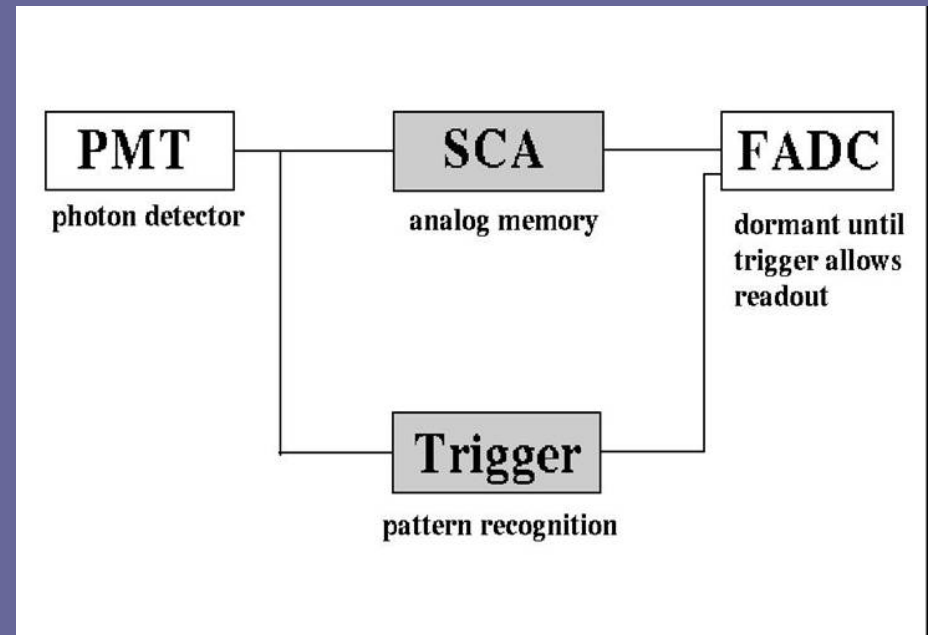
- **BURLE 2" Planacon** flat panel microchannel plate PMT
 - Low profile; good for tiling on focal surface
 - 4 anodes (2 x 2)
 - Low power consumption
 - Large dead area (25%)
 - Large dead time due to long pore recovery time (~1 ms)
- **Photonis XP3062** as a more conventional alternative



See S. BenZvi, J. Martin
HE 1.5 poster session

GRaNDScan: Low-Power Readout Electronics

- **Intelligent second level trigger** needs to reduce data rate and Cherenkov background
- Power-consuming elements (FADC) lie dormant while **pattern recognition algorithms** search for track-like events
- Showers at EeV and below are detected 3-6 km from each site; fast ADC sampling may be required (**20, 40 MHz** under study). BUT, there is a power trade-off for higher readout rate!
- 12-bit dynamic range sufficient for events between 10^{17} , 10^{19} eV



Summary

- Previous experiments claim weak evidence for a Galactic center flux enhancement around 1 EeV. There is a strong case for a dedicated study of the GC at these energies to verify excess
- No current experiment fully covers the energy range between 10^{17} and 10^{19} eV
- GRaNDScan proposes to operate a low-cost stereo AF detector in the Southern Hemisphere. The distance between the fluorescence “eyes” will be varied to optimize aperture around EeV
- **Experimental Aims:**
 - To confirm AGASA, Fly’s Eye, and SUGAR Galactic center excess within first year of data-taking
 - Then study region below EeV, where Galactic sources are still powerful

More Information...

- White Paper: astro-ph/0303484
- Discussion of BURLE Planacon photomultiplier:
 - HE Poster Session 2: **2-P-022**
 - *Proceedings of the 28th ICRC*, 869-872.
- <http://www.nevis.columbia.edu/grandscan>
(exists, but currently very sparse)