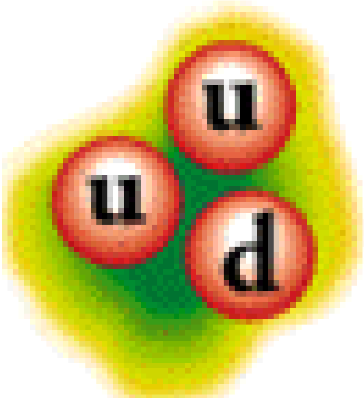
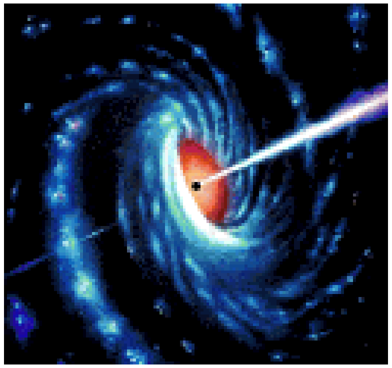
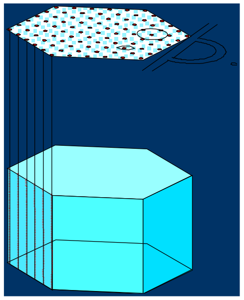
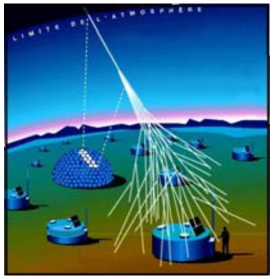
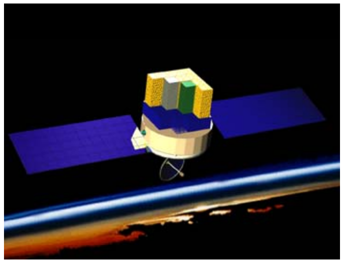


VHE PARTICLE ASTROPHYSICS



Science, Projects, Roadmap, & SLAC




Outline

1. SCIENCE

   Astrophysics motivations

   - "New astronomy" with γ-rays, ν's, cosmic rays.
   - Important astrophysics topics.

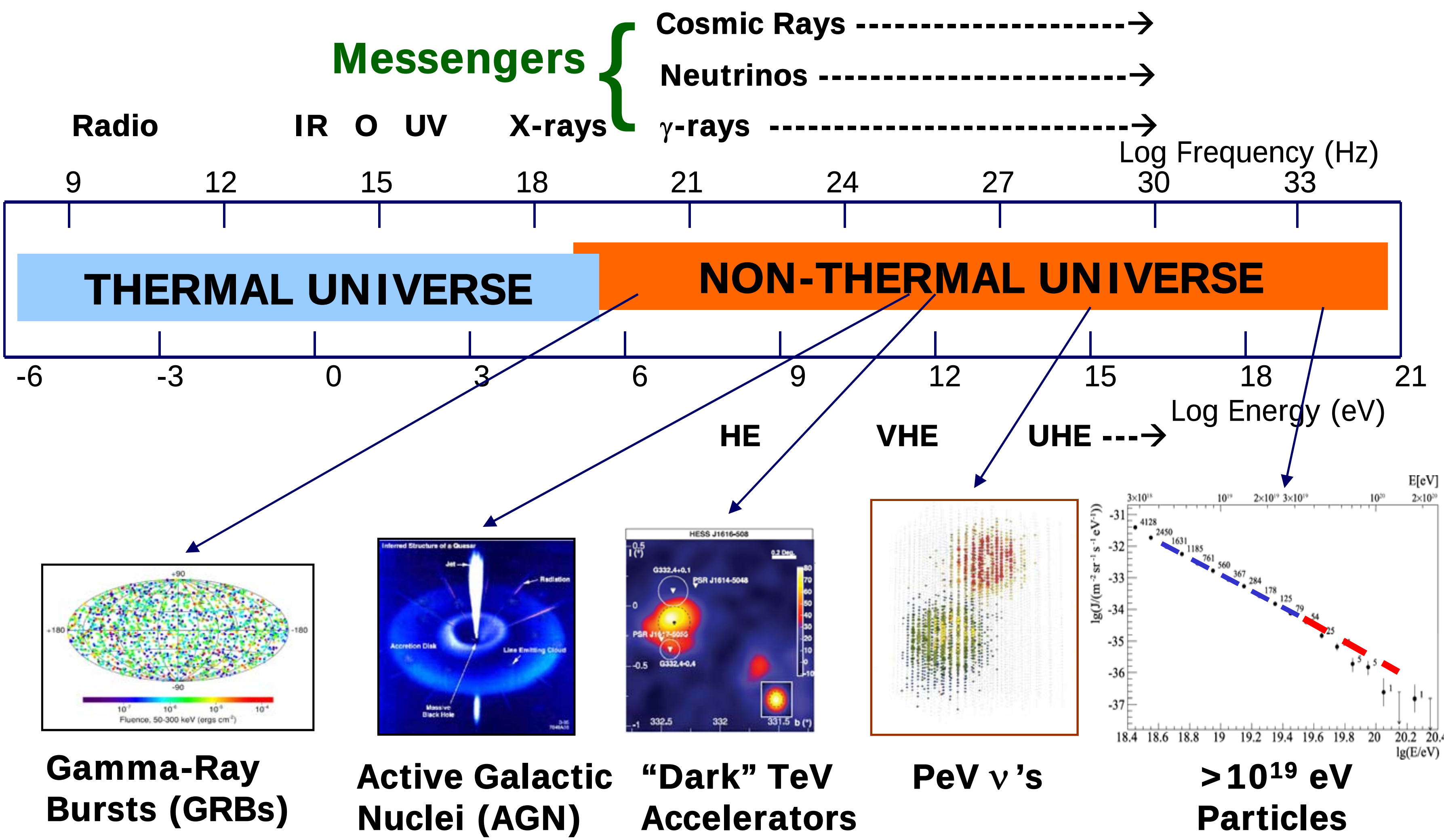
   Particle Physics motivations

2. PROJECTS
   - Present and Future.
   - Planning: SAGs, Roadmap, etc.

3. IMPORTANCE/ROLE FOR NATIONAL LAB(s), especially SLAC

NB: This talk specifically attempts to provide a "big view" on the field and not just one or two expts where SLAC could play a main role. This results in a subjective, incomplete review of the science and projects, but it tries to be a community-based view and a strong rationale for the science.

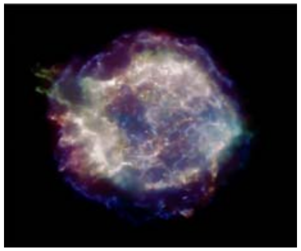
New Windows & Messengers



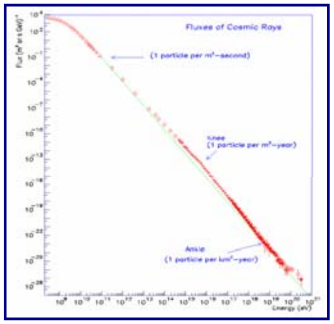
Important Astrophysics Topics

It's <u>much more</u> than just detecting new objects:

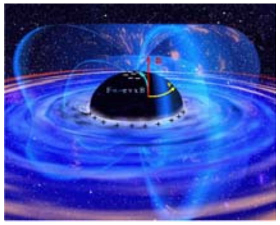
- Shock acceleration in many contexts
  mechanisms, magnetic fields ...
- Origin of cosmic rays 10^{12}-10^{20}eV
  Galactic E balance, propagation
- Physics of compact objects
  black holes: AGN, binaries ...
  neutron stars: pulsars ...
- Interaction with cosmic radiation fields



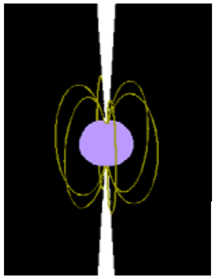
SNR's



Cosmic rays



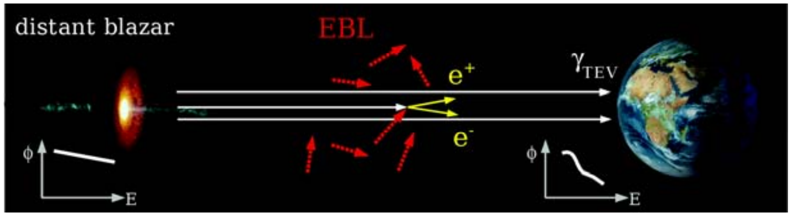
BH's



Pulsars

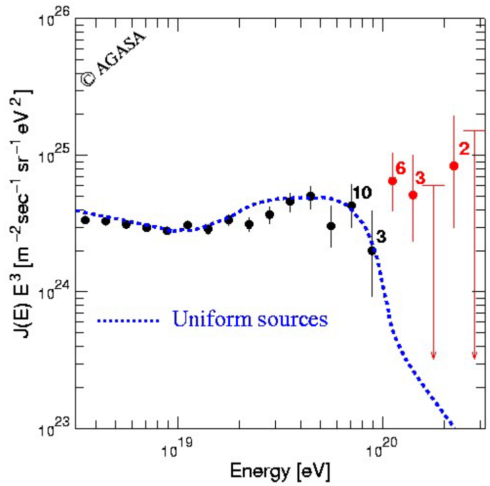
$\gamma + \gamma$ (EBL) → $e^+ e^-$

10^{12} eV

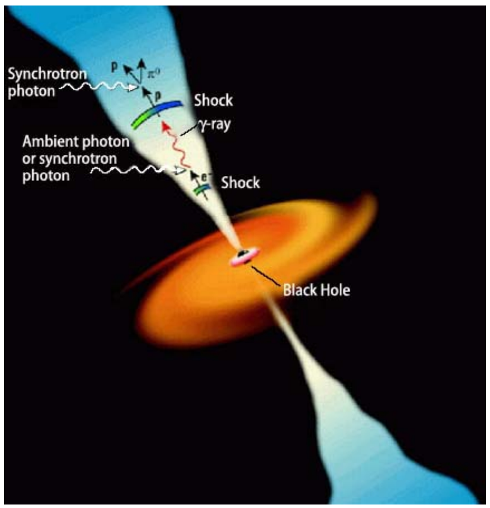


P + γ (CMB) → Δ → π
GZK effect

10^{20} eV

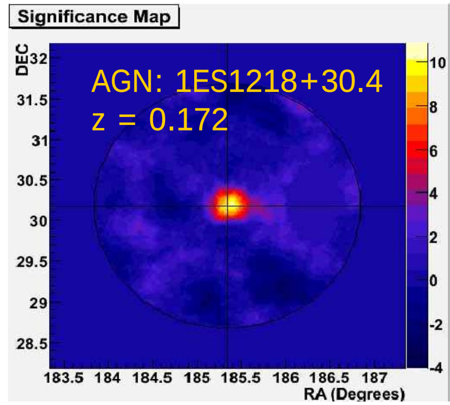


Multi-Messenger Example: AGN



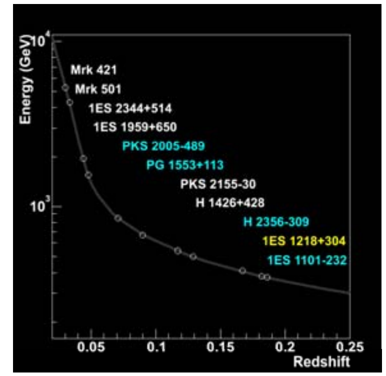
Conceptual Picture

- Supermassive Black Hole
- Shock acceleration in Jets
- Particle (γ, ν, CR) product.



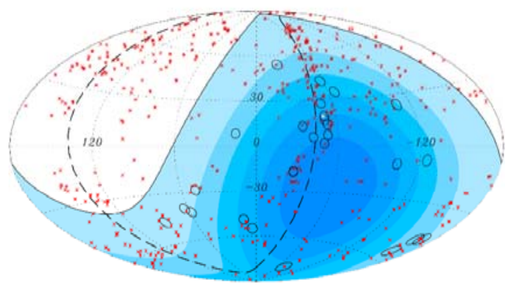
Detected in TeV γ-rays

- Spectrum, variability



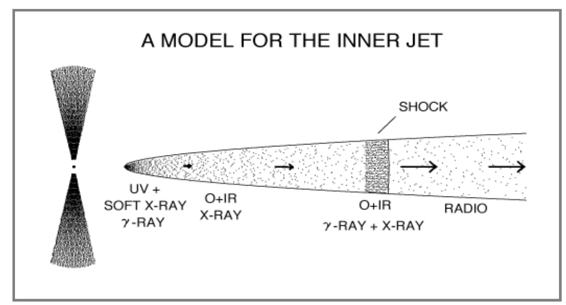
γ-ray absorption

- Intergalactic rad. fields



Source of $>10^{19}$ eV particles ?

- Extreme particle accel.



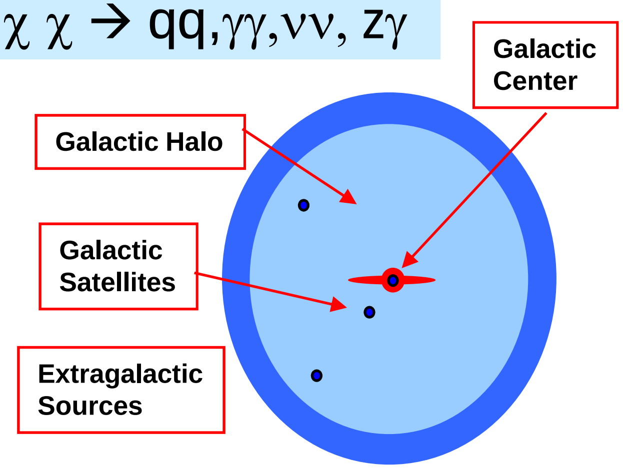
VHE ν Source ?

- Particle content of jet

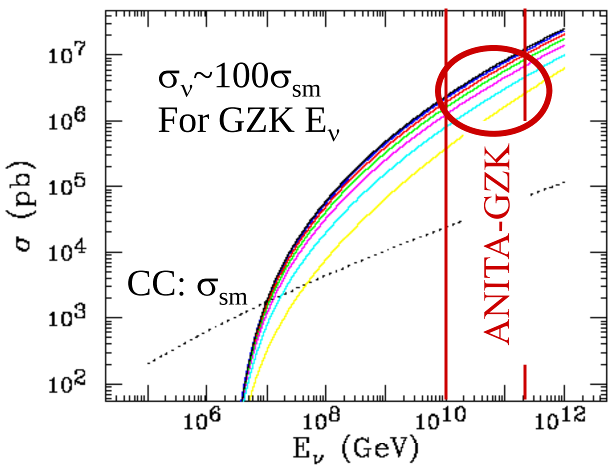
Particle Physics Motivations

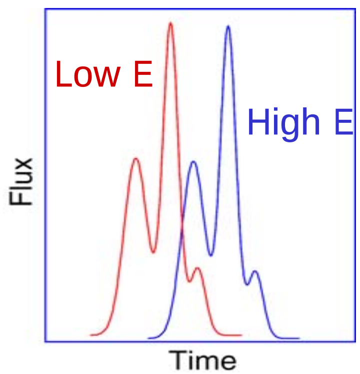
- Dark Matter
  - SUSY: WIMP annihilation to γ's, ν's, anti-matter
  - Axion like particles (ALP's)
  - Compl. to LHC, direct det.
- Top-down Production
  - GUT scale physics, BB relics
- Neutrino properties
  - cross-section at UHE
- Lorentz symmetry violation
- Others ...

$\chi\,\chi \rightarrow q\bar{q}, \gamma\gamma, \nu\nu, z\gamma$

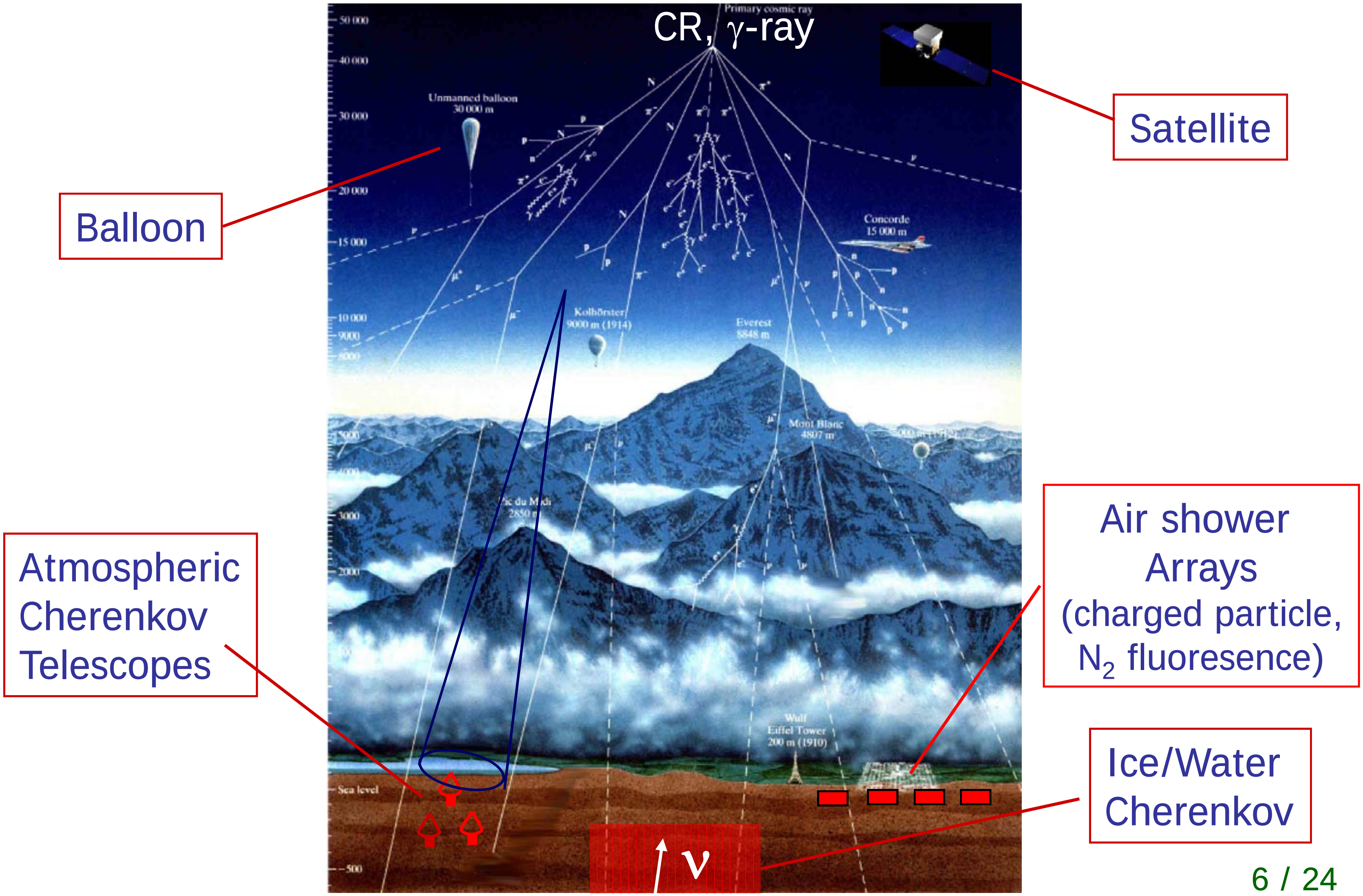


Dwarf Satellites



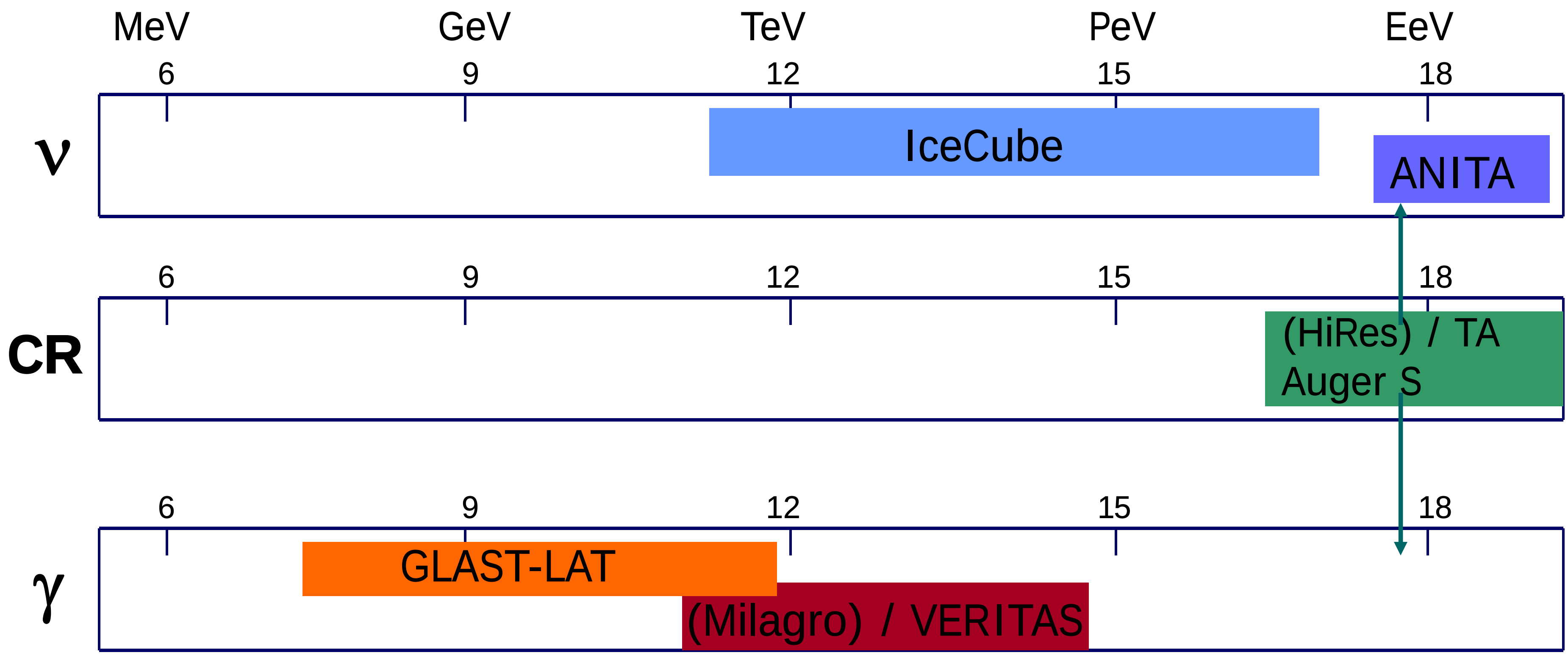


Experimental Techniques



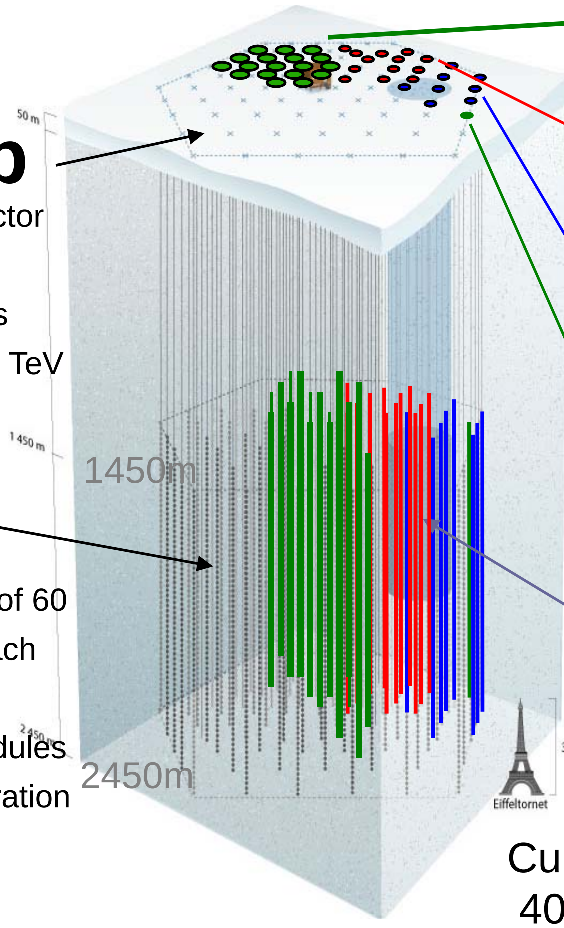
Projects: Current or Soon to Be

Divide projects by messenger and energy band.
Projects from (recent past), operational, or soon to be.



U.S. has an exceptional program – a strong presence in all areas.

IceCube



IceTop

Air shower detector
80 pairs of ice
Cherenkov tanks
Threshold ~ 300 TeV

In Ice

Goal of 80 strings of 60 optical modules each

17 m between modules
125 m string separation

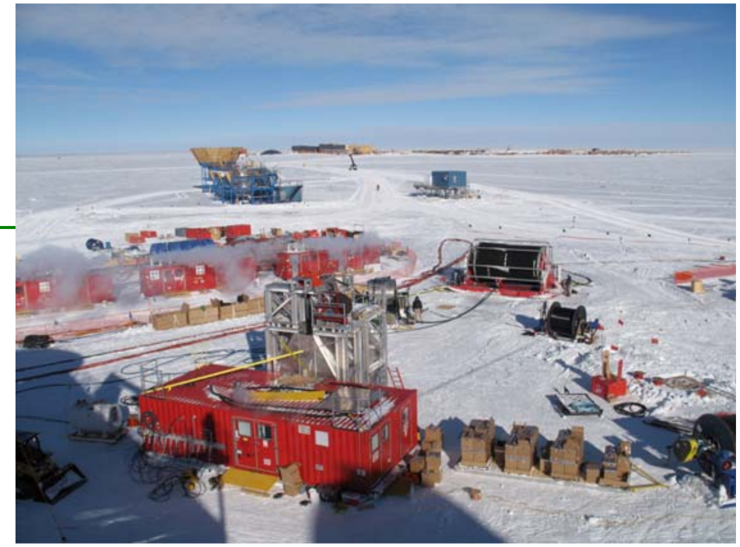
2007-2008 :
18 strings

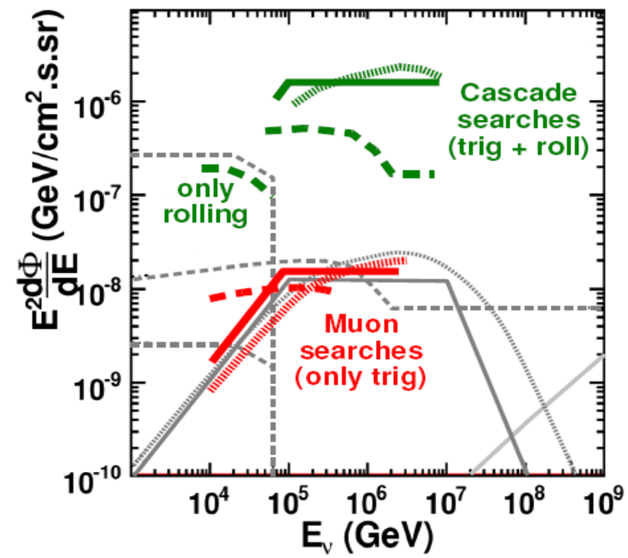
2006-2007:
13 strings

2005-2006:
8 strings

2004-2005 : 1 string

AMANDA-II
19 strings
677 modules





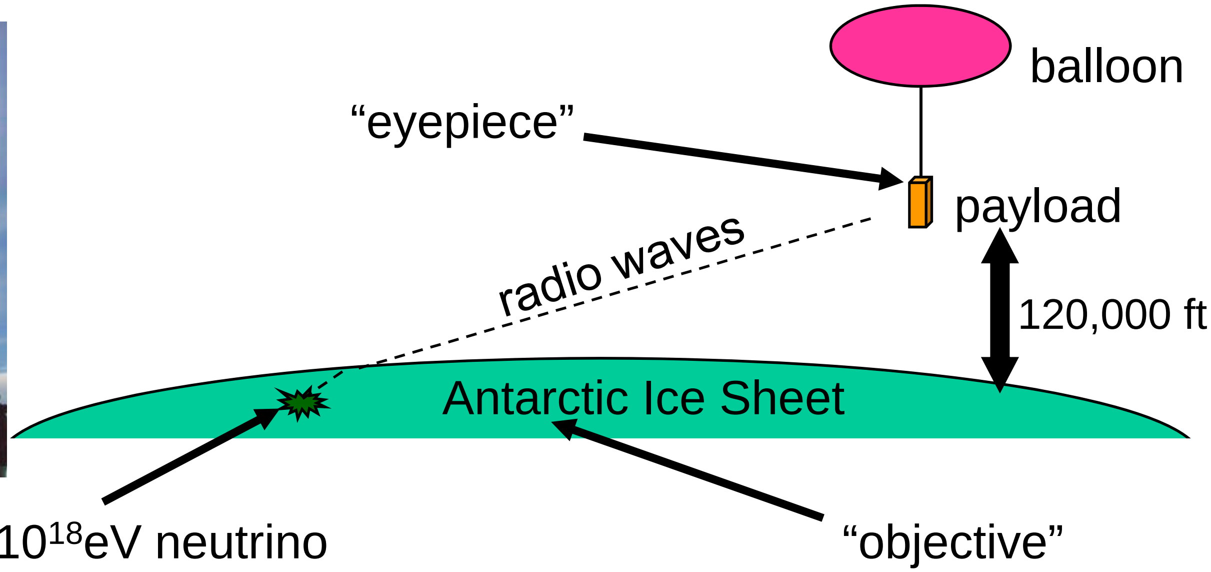
GRB Limits
AMANDA: rule out models
IceCube: x70 in volume

Current configuration:
40 strings,
40 IceTop stations
plus AMANDA

2008/09: add 18 strings and tank stations

Completion by 2011.

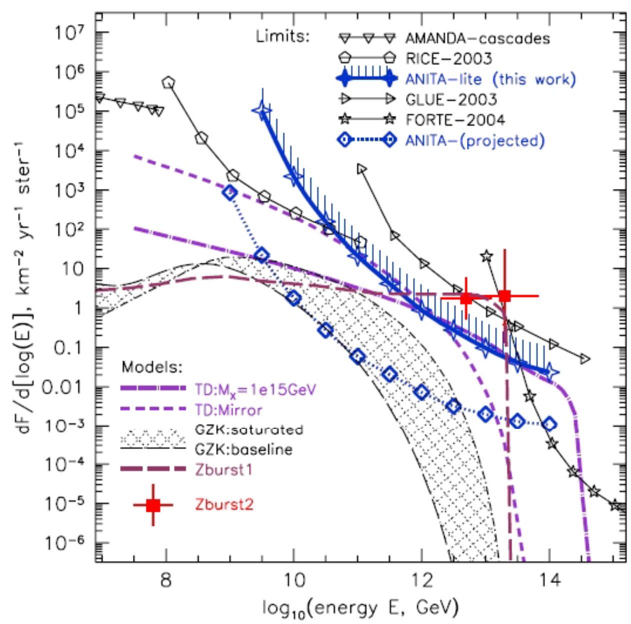
ANITA



ANITA:

- Looking for "GZK neutrinos".
- View 1 Million km^3 of ice.
- 32 day flight in Dec. 2006.
- 2008-09 upcoming LDB flight.
- Important SLAC contribution.

Projected sensitivity

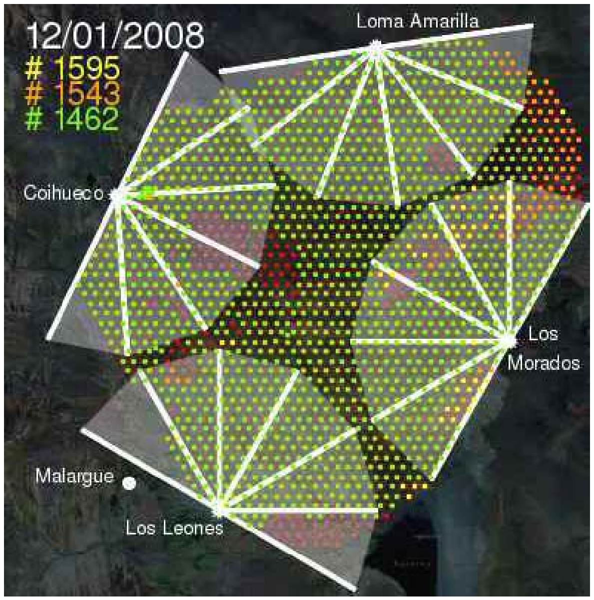


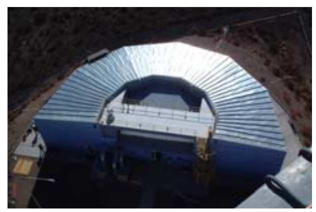
ANITA: Major Role by SLAC

Demonstration of Askayran Effect
(sand, salt in FFTB)

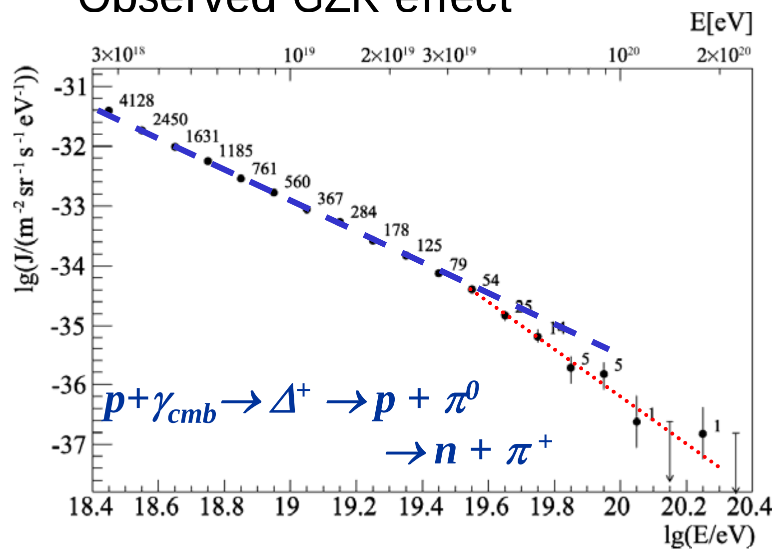
Calibration in famous
End Station A

Auger Project (South)





Observed GZK effect



AUGER S:

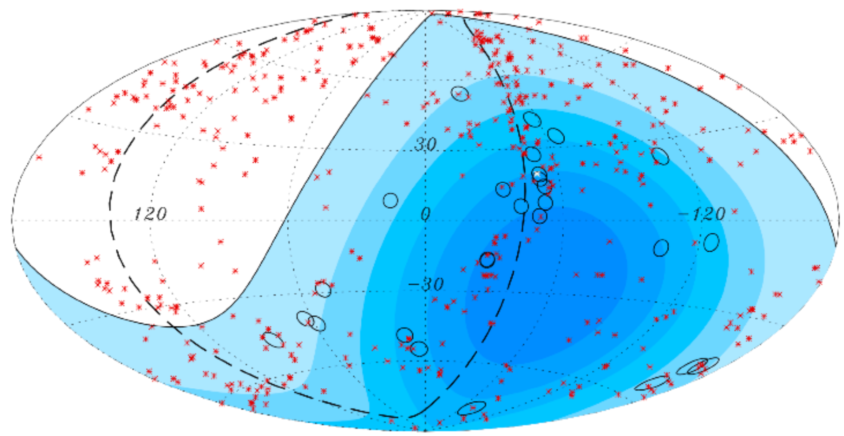
3000 km^2 area observatory in Argentina.

1600 water Cherenkov detectors.

4 fluorescence sites overlooking the array.

Built to understand origin of UHECR's.

Now fully operational.



Events correlate with nearby AGN
"Charged particle astronomy"

VERITAS

VERITAS:

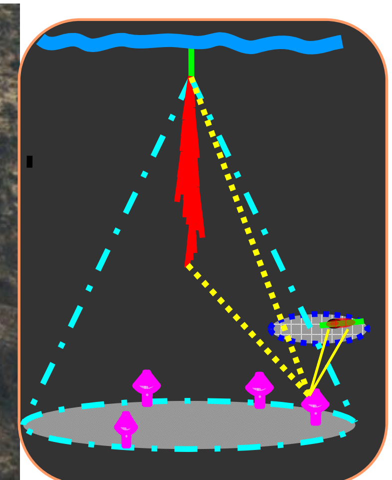
4 x 12m Cherenkov telescopes.

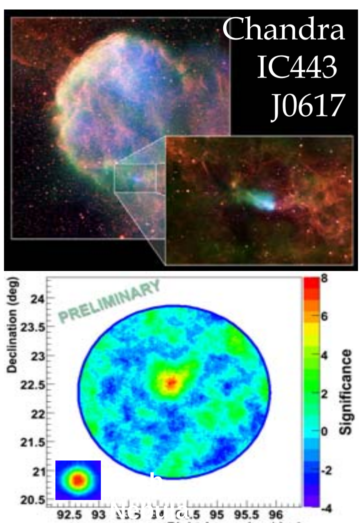
0.1-50 TeV γ-ray range.

Mt Hopkins, AZ (1280m).

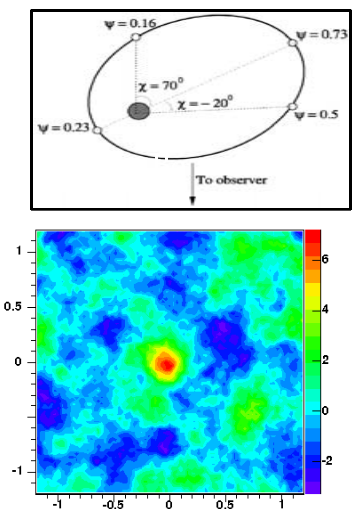
Fully operational & numerous results from first 6 months.

Large synergy with GLAST.

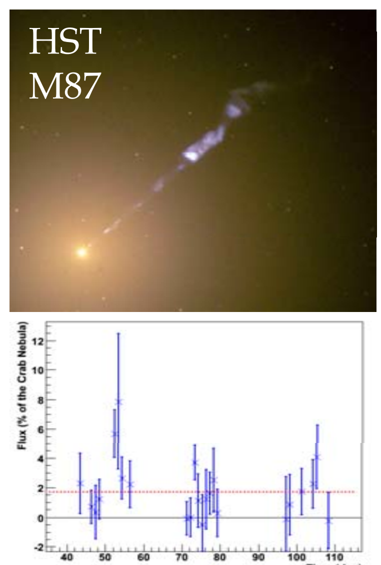




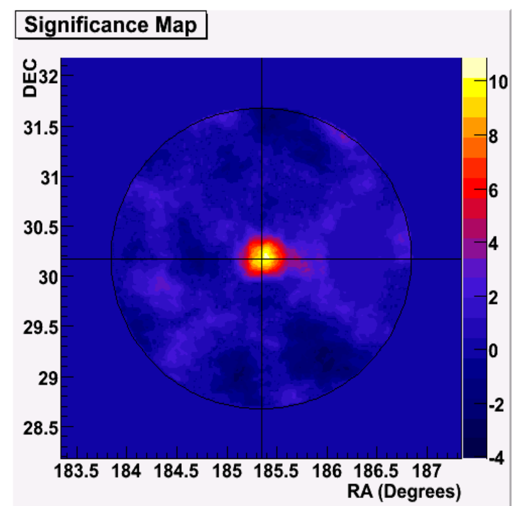
SNR: IC 443



XRB LSI +61



M87 Radio Galaxy



Blazar 1ES 1218+30
z=0.182

GLAST

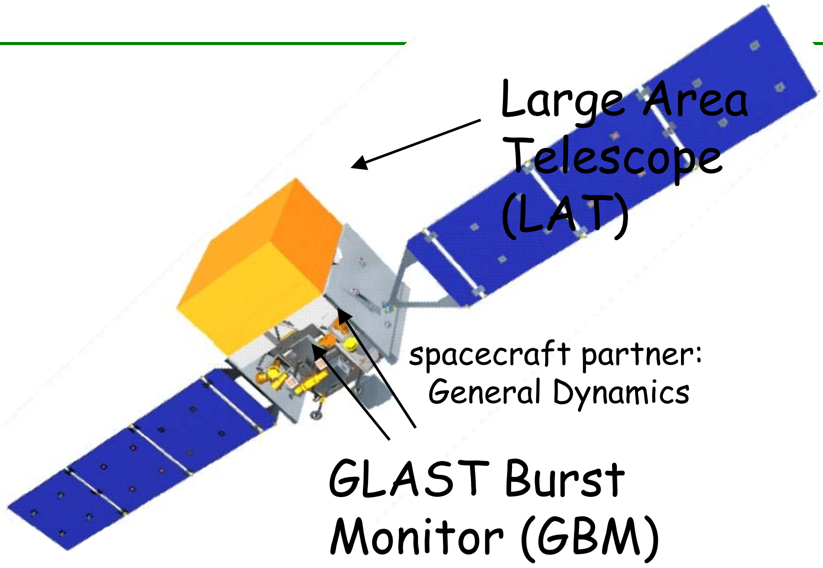
GLAST: γ-ray space Telescope.

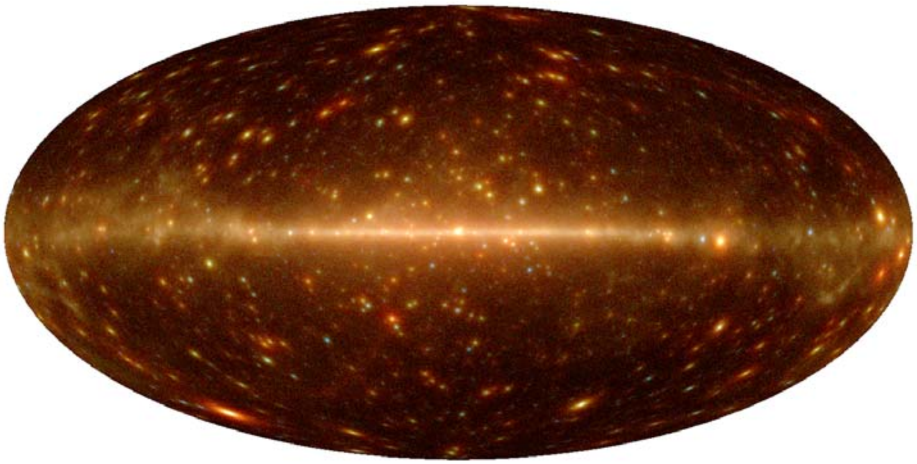
Wide FOV and wide energy range 30 MeV – 300 GeV.

NASA-DOE-Int. partnership.

Major role for SLAC in LAT: construction, operations, science.

Launch soon: MAY 2008





>10 improvement in sensitivity over EGRET.

Comments on Current Program

1. Broad and vibrant program in U.S. with first-rate projects. We expect many exciting results in next few years.

2. Large overlap in techniques and collaborations between particle physics and astrophysics. Very effective merger of cultures.

3. Projects are typically "moderate" in cost/size relative to acc. HEP.

4. Funding from more than one of U.S. agencies: DOE, NSF, NASA.

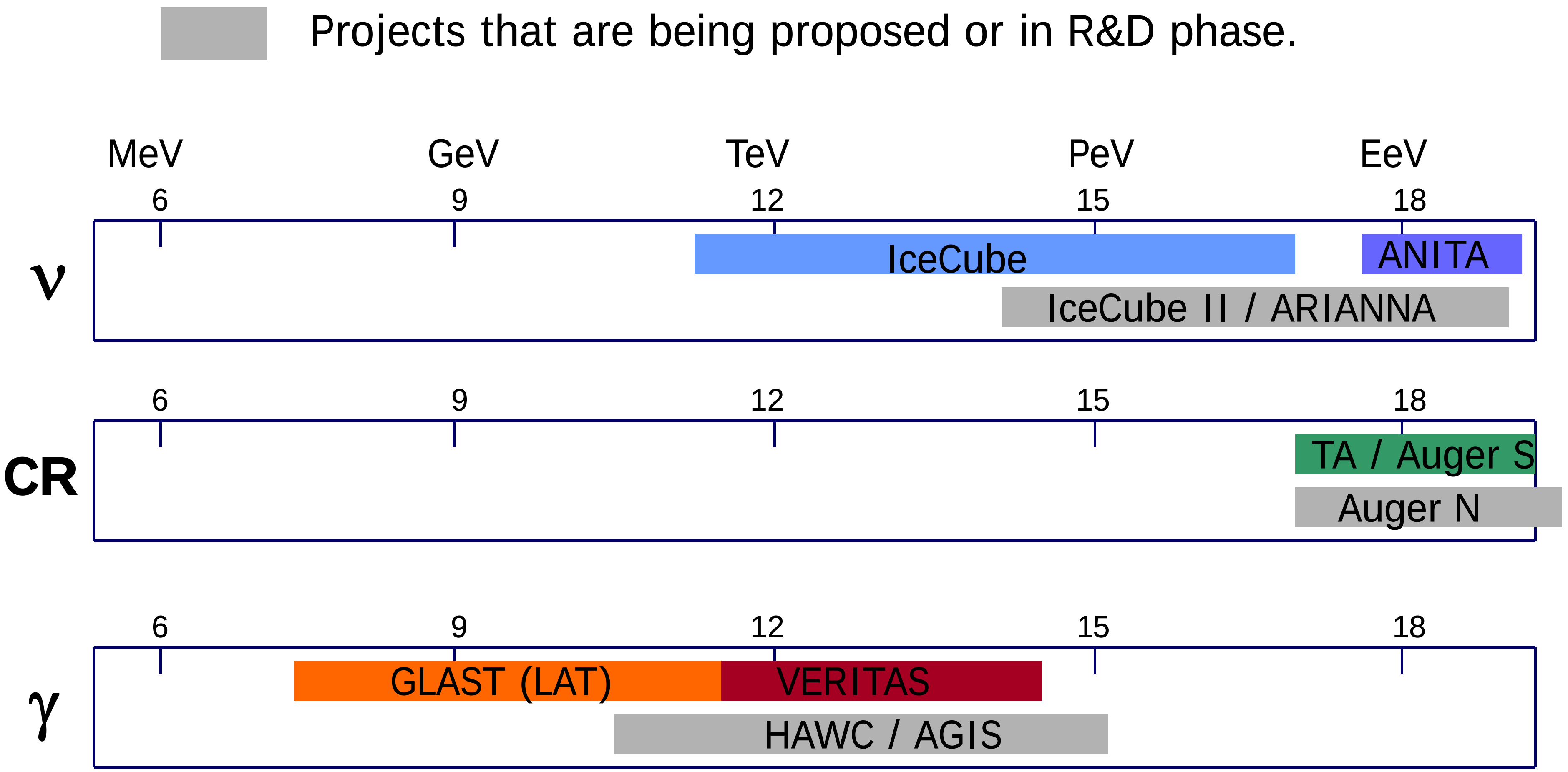
5. Construction model varies significantly from very centralized (GLAST) to very distributed (Auger, VERITAS).

6. HEP National labs played/are playing a significant role in this field:

   IceCube (LBNL), ANITA (SLAC), Auger (FNAL), VERITAS (ANL), GLAST (SLAC).

Now.... what about the FUTURE ??

Future: Lot's going on !



NB: does not include all suggested efforts.

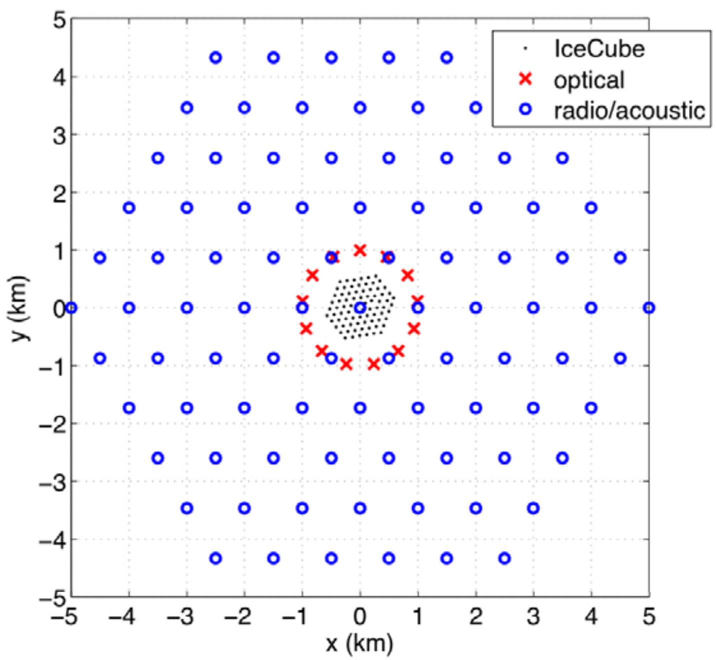
New Neutrino Efforts

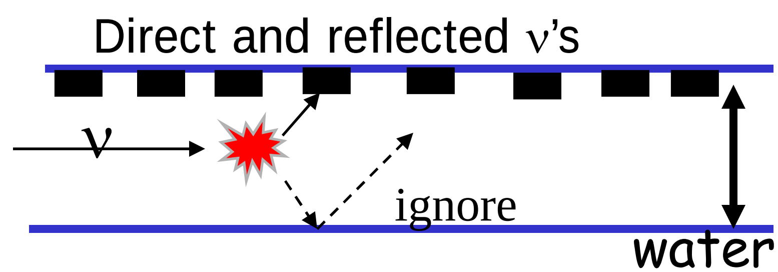
IceCube II:

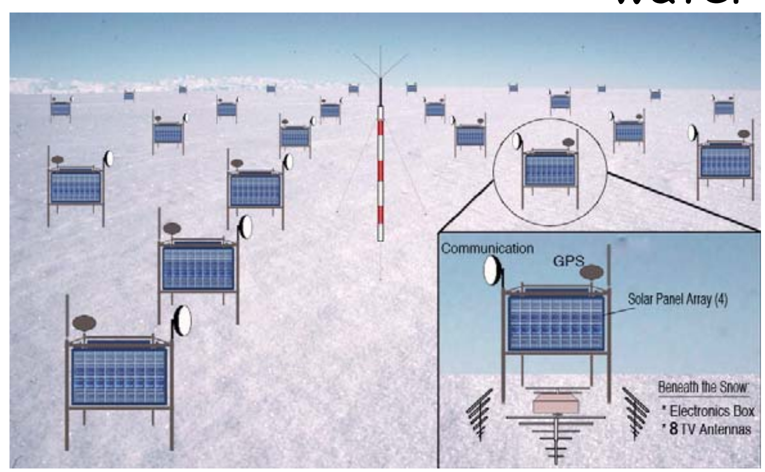
1. Dense core to reduce E threshold.
2. Expansion of size and sensitivity:
    - accoustic detection and/or
    - radio detection

ARIANNA:

1. Greatly increased sensitivity to GZK neutrinos, esp. 10^{17}-10^{18} eV.
2. Radio detector array on Ross Ice Shelf.







Auger Project (North)

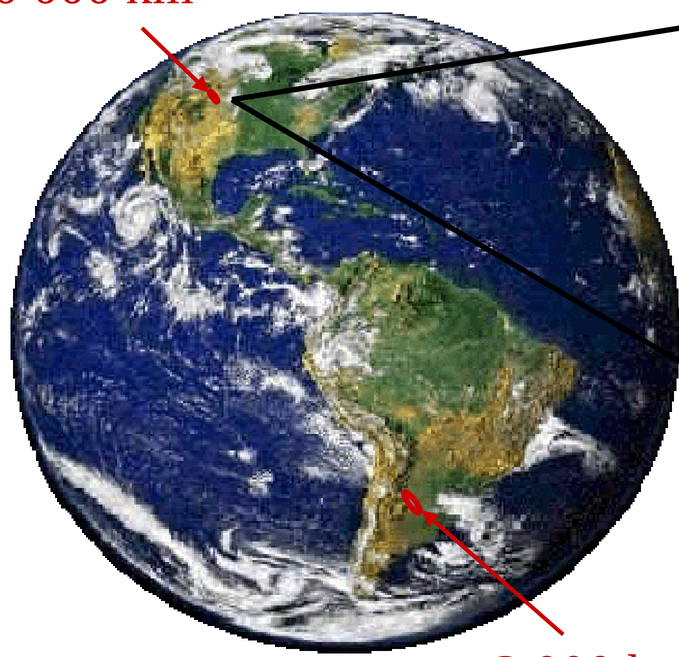
Auger N:

Full sky coverage crucial and
Large area to reach very high statistics:

- Discover all sources within GZK sphere
- Measure spectra of brightest sources

Northern site

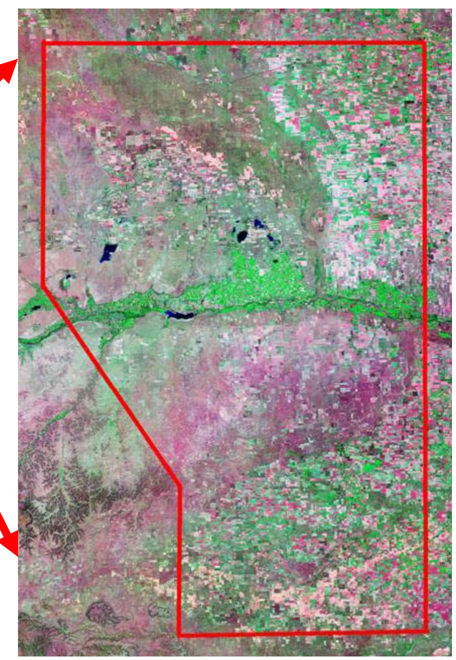
20 000 km^2



3 000 km^2

Southern site

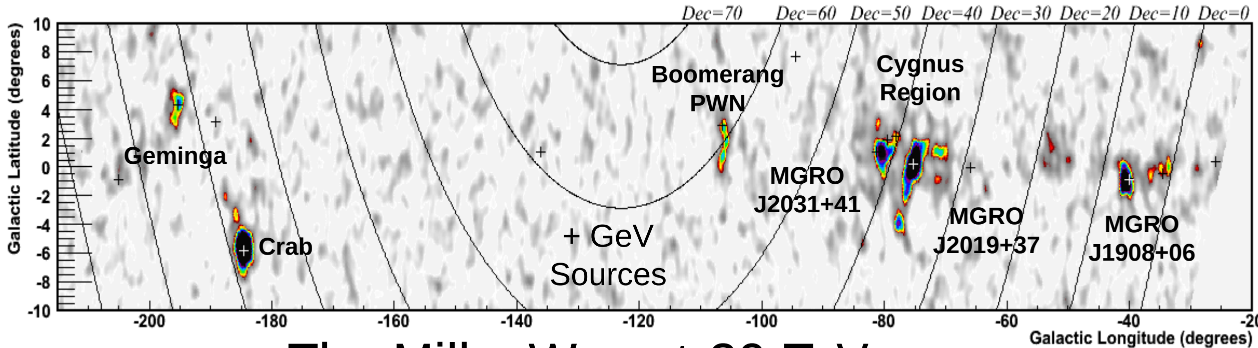
Site in SE Colorado.



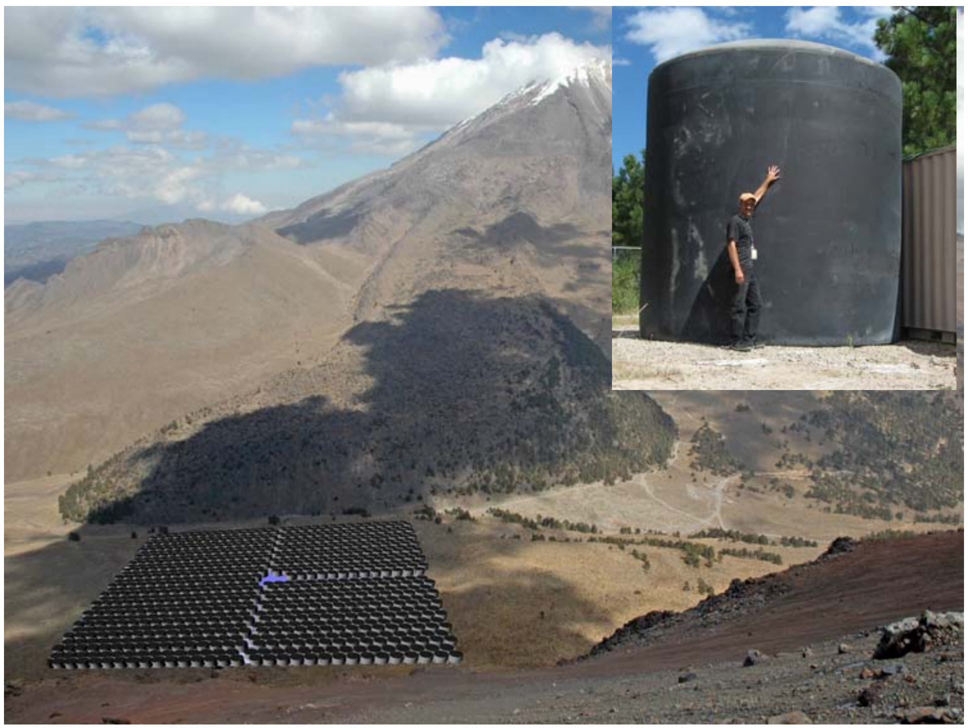
HAWC (High Altitude Water Cherenkov)

Milagro:

Operated 2000-08.
Detected numerous,
new >10 TeV sources
& Gal. diffuse emission.



The Milky Way at 20 TeV



HAWC:

- Wide FOV, high duty-cycle telescope.
- 900 large water tanks, 8” PMTs.
- Sierra Negra, Mexico (4100m).
- Compared to Milagro:
  15x more sensitive
  wider E range (100 GeV-100 TeV)

AGIS (Advanced Gamma Imaging System)

AGIS:

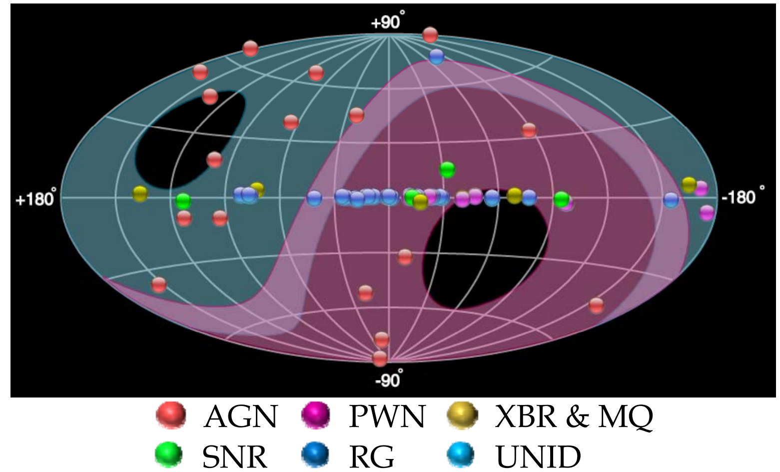
Cherenkov telescopes have detected many new TeV sources. Motivates:

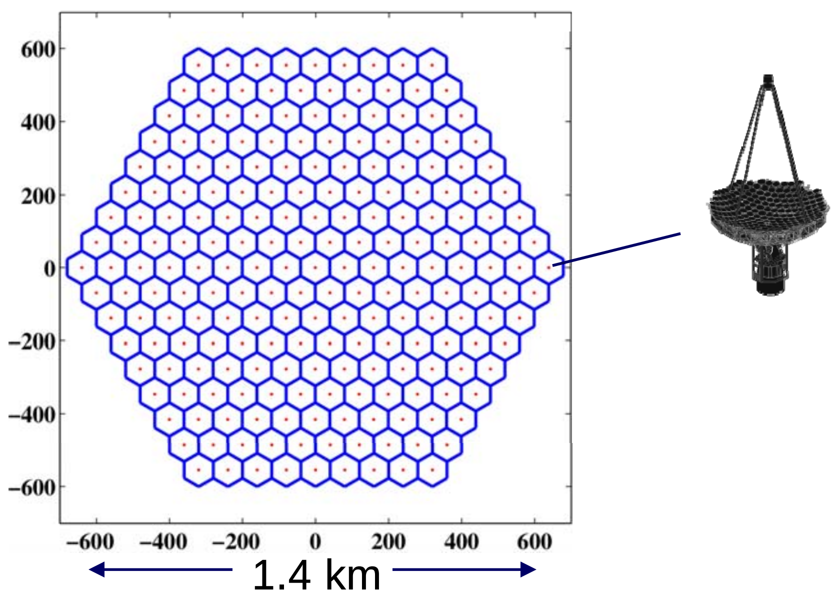
- Large (1 km^2) array.
- ~100 telescopes, aperture 8-20m.

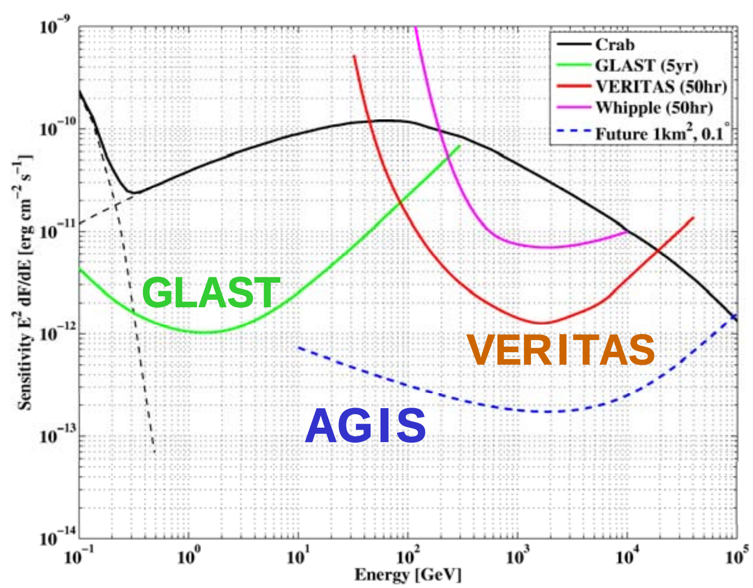
Much more sensitive than GLAST/VERITAS.
CTA project in Europe – well underway.

APS White Paper study.
Potential for significant role for SLAC.

TeV γ-ray sources







Funding, Roadmaps, SAGs

- In the context of P5 planning, a strong case can be made for the exciting science of this area and its role in U.S. HEP program.
- Important to note that other "non-HEP" communities and funding are involved: e.g. NASA, NSF-AST, private, international. GLAST is a good example of this.
- Planning/roadmapping for "non-accelerator" physics is unclear and fragmented. This is partially because of the the demise of SAGENAP.

  Agencies encouraged the use of Scientific Assessment Groups (SAGs) – e.g. CMB Task Force, DETF, DMSAG. This has semi-worked, but still little way to go from SAG → P5 or Decadal Survey.

  In VHE Particle Astrophysics – now is the time to push for a SAG, to get going with a proper roadmap.

SLAC as a Center in VHE PA ?

What about the role of SLAC?
Can it / should it serve as a center in VHE particle astrophysics ?

Have discussed this with numerous people in VHE community. Some general thoughts (not carefully vetted!):

- There is a clear role for national labs, and SLAC specifically, to be a center in this area. Not *the* center, but *a* center.
- SLAC has unique capabilities to play an important role in enabling the science and projects to move forward.
- Depending on projects, timing, & SLAC's interest, it's natural to contribute significantly to a reduced set of instruments.
  A natural possibility right now may be AGIS.
- Important to recognize that this community is broadly-based at grass-roots level. More so than accelerator-based HEP.
  It is key for SLAC to <u>work together</u> with community.
- A key issue is how does SLAC serve as a center for a project that is off-site. Compare various projects: GLAST, Auger, etc.

SLAC Strengths

Some of the mostly obvious strengths/roles for SLAC:

- BEAMS – still very important.
- Facilities for construction and testing (larger instruments).
- Unique technical capabilities: mechanical, electronic, computing.
- Center for science meetings, workshops (e.g. SSI 2008), etc.
- Managerial expertise for large projects.
- Strong science base: faculty, researchers, etc.

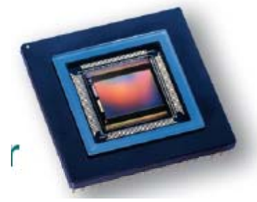
This research area has projects that are well-suited for strong contributions from <u>both</u> National Labs and from community.

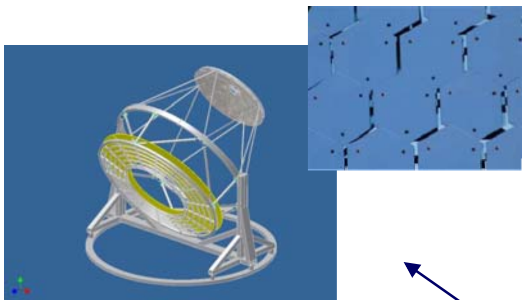
AGIS as an Example ...

Possible areas for participation by SLAC in AGIS:

Electronics

Camera





Telescope Construction
(with ANL + Univ.)

Site Development

COMPUTING
+
SOFTWARE

MANAGEMENT

... and SCIENCE !

Summary

- VHE Particle Astrophysics is a vibrant and exciting field.
- U.S. program is very strong in essentially all areas γ, CR, ν. Major projects in progress (IceCube, Auger, VERITAS, GLAST), but next generation is being formulated now.
- Science and projects are well suited for strong contributions from <u>both</u> community and National Labs.
- Need for some sort of roadmap in "non-accelerator physics" and for a SAG specifically in VHE Particle Astrophysics.
- SLAC has unique capabilities that are important for projects in this area.
- This area is a natural for strong SLAC involvement, working together with community. Important to figure out how SLAC will work for users with an off-site project.

Thanks to ...

Steve Barwick, Gerard Bonneaud, Jim Buckley,
Stefan Funk, Tom Gaisser, Francis Halzen,
Alex Konopelko, Henric Krawczynski,
Mel Shochet, Angela Olinto, Steve Ritz,
Roger Romani, David Saltzberg, Gus Sinnis,
Simon Swordy, and Vladimir Vassiliev

for input and help with slides.

Please contact me if you have any questions about any specific projects ... e.g. if you'd like to join !

END