Report from Breakout Session #1

J. Belz
University of Utah
19 April 2007

Topics

- Consensus on Fluorescence Experiments
  - Recent Results
  - Use of fluorescence data by UHECR Observatories
- New Experiments; Ashra, JEM-EUSO
- Neutrino results and interpretation

Fluorescence Consensus

- Start thinking about issues for 5th FW:
- What is important experimental data?
  - Yield measurements
  - Spectra
- How will data be used?

5th Fluorescence Workshop

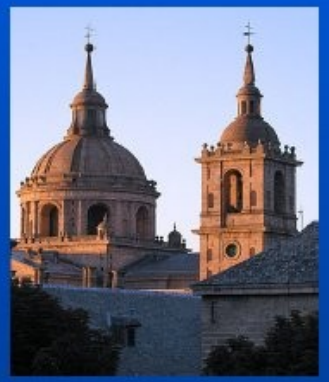
El Escorial - Madrid, Spain

16 - 20 September 2007

For the interpretation of the measurements of the fluorescence component of ultra-high energy air showers a precise knowledge of the air fluorescence efficiency and its dependence on particle energy and atmospheric conditions is mandatory. Goal of the workshop is to bring together the groups performing air fluorescence yield measurements in a wide energy range and using quite a variety of experimental techniques.

Topics include:

- air fluorescence emission
  - absolute fluorescence yield measurements
  - energy dependence
  - pressure, temperature, humidity dependence
- application to air shower detection
  - energy calibration of fluorescence events



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http://top.gae.ucm.es/5th_FW

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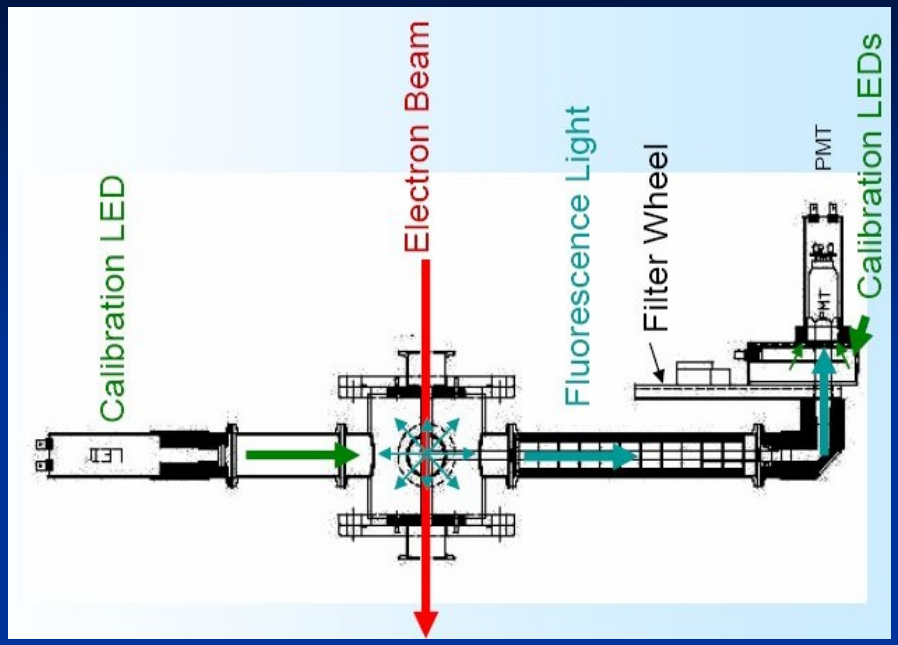
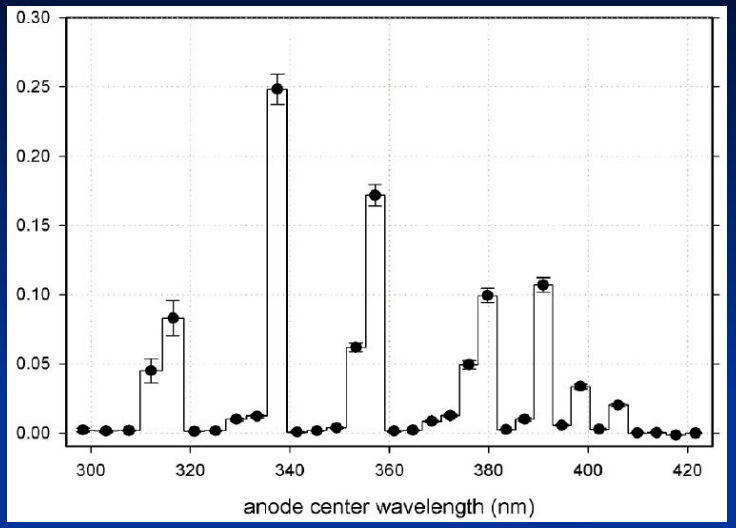
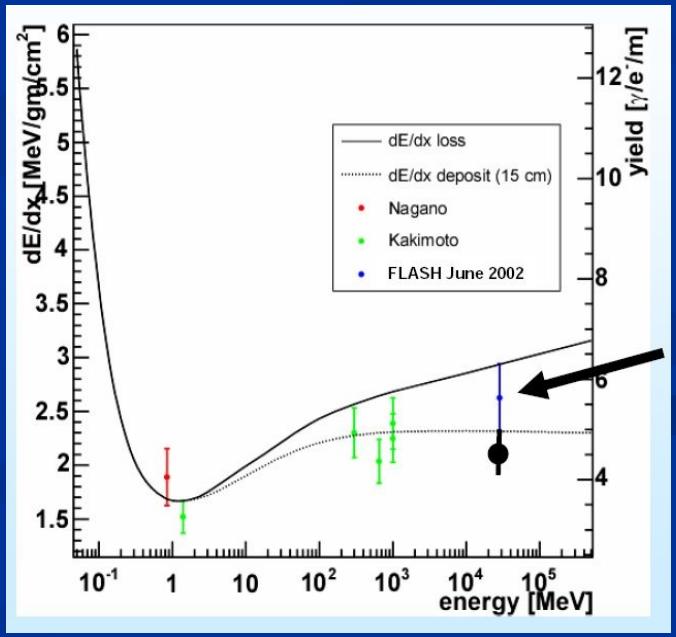
Recent Results from Fluorescence Experiments

Reil, FLASH Thin Target

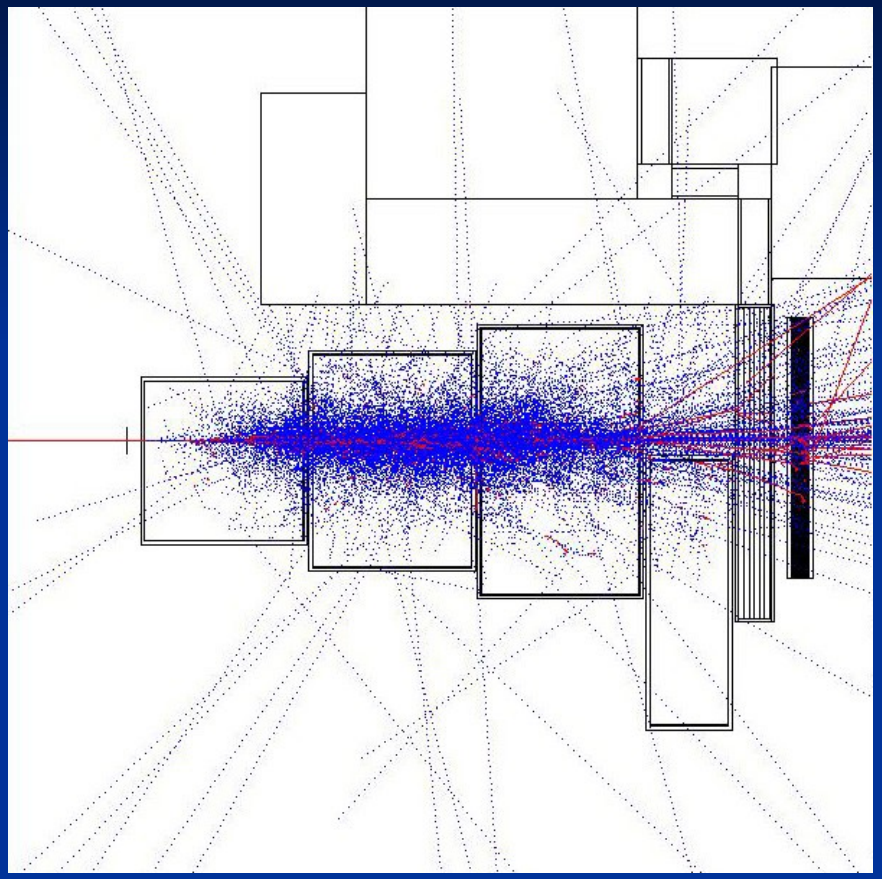


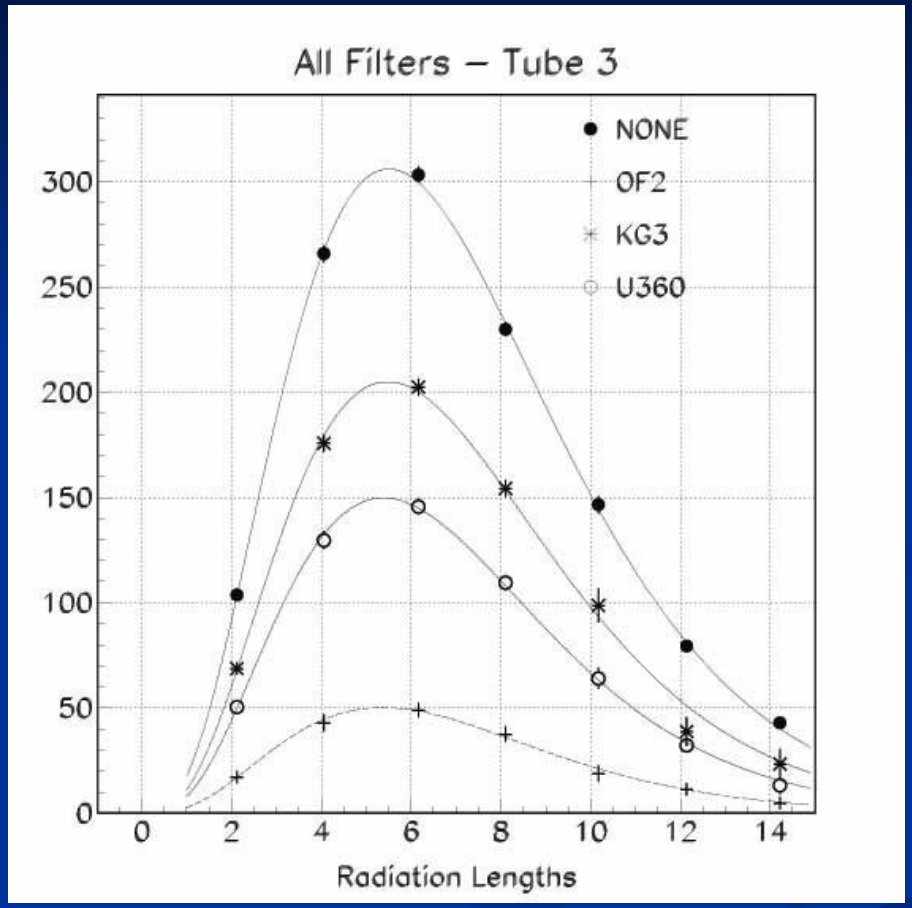


- Measurements at 28 GeV
- Spectrograph
- Total yield measurements



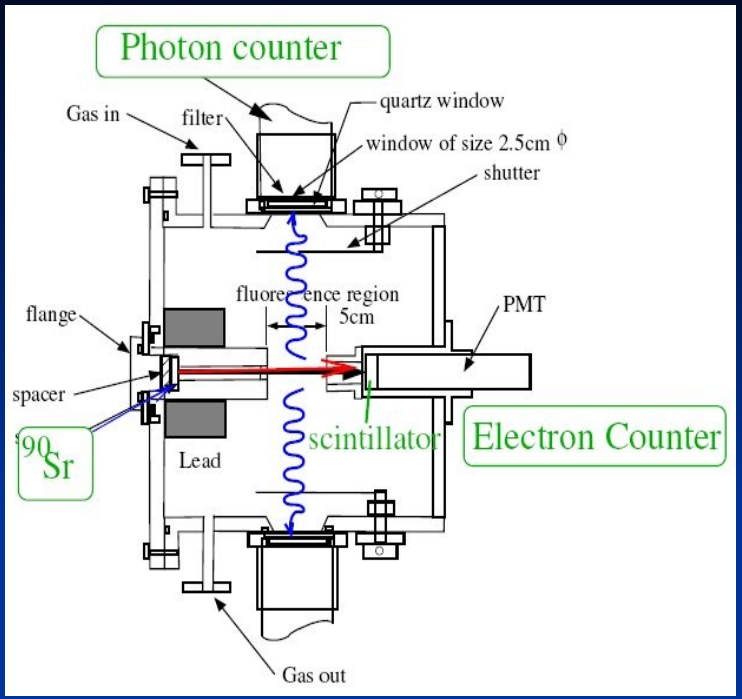
Belz, FLASH Thick Target



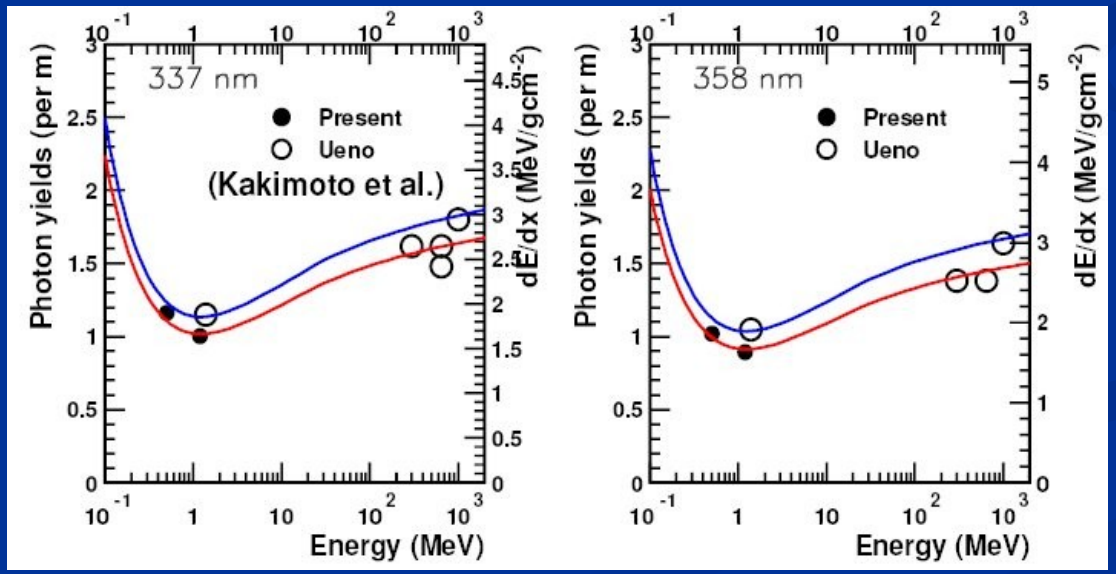


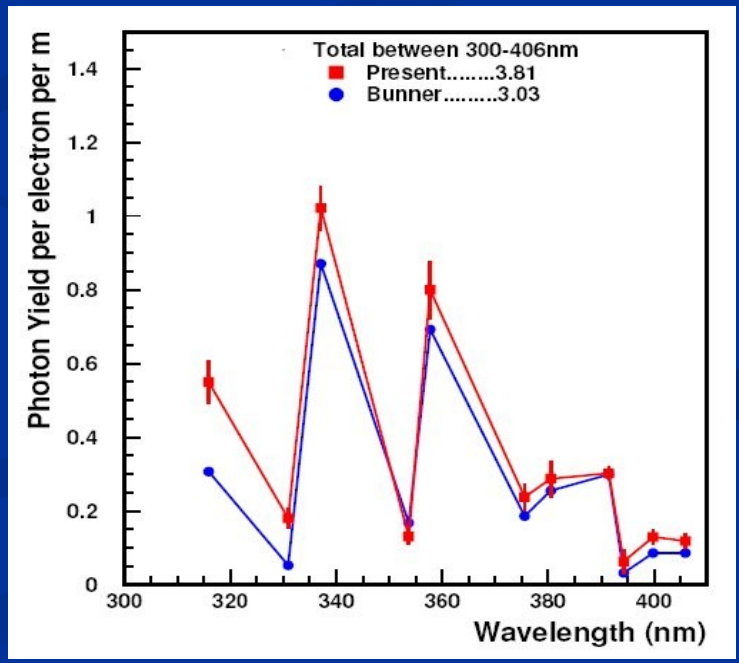
- Sanity check: Fluorescence proportional to dE/dX at all shower depths?
- Excellent (~1%) agreement with EGS/GEANT, various wavelength bands
- Belz et al, astro-ph/0510375 (Astroparticle Physics)

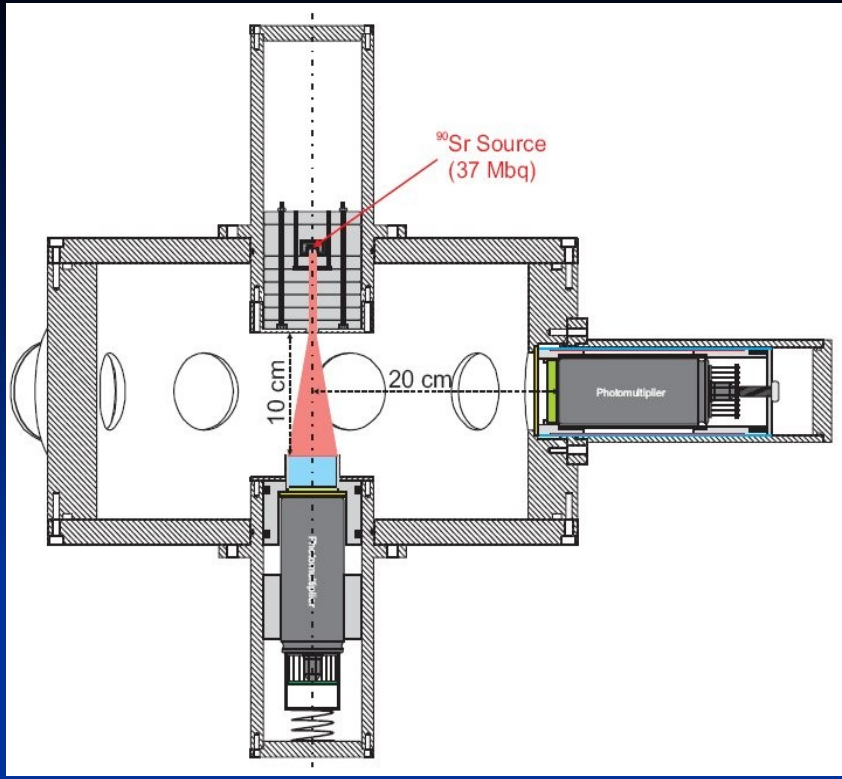
Sakaki, Sr90

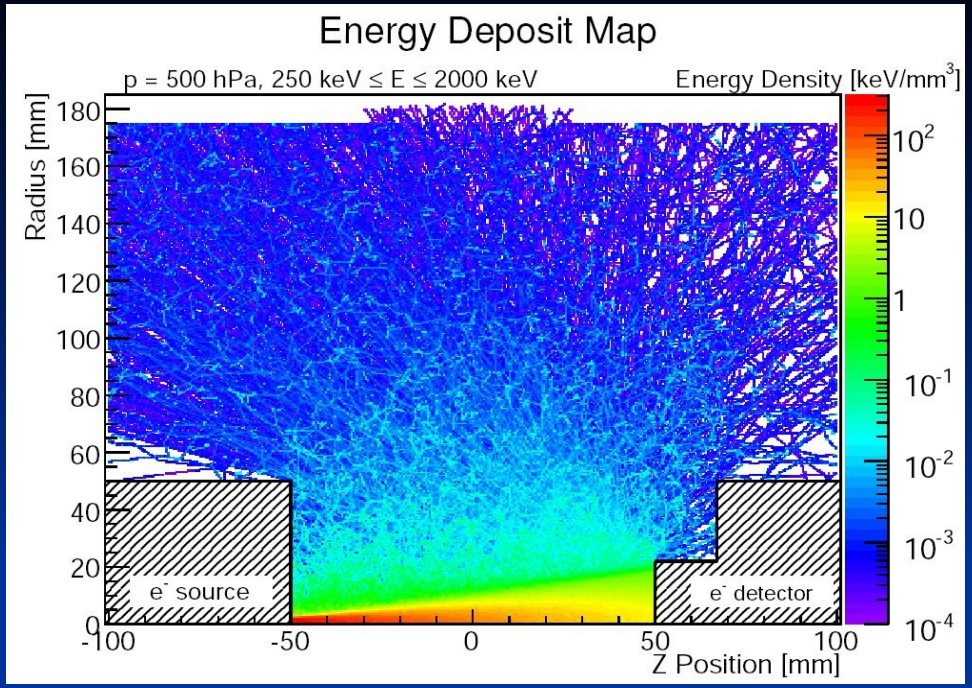


See also: Nagano et al APP 20 (2003)
Nagano et al APP 22 (2004)

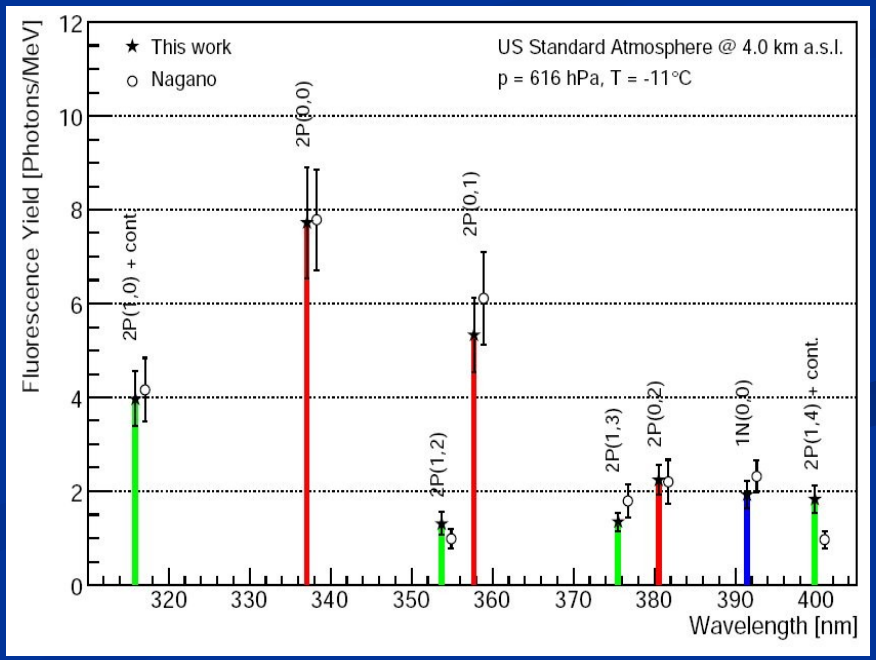








Waldenmaier, Airlight

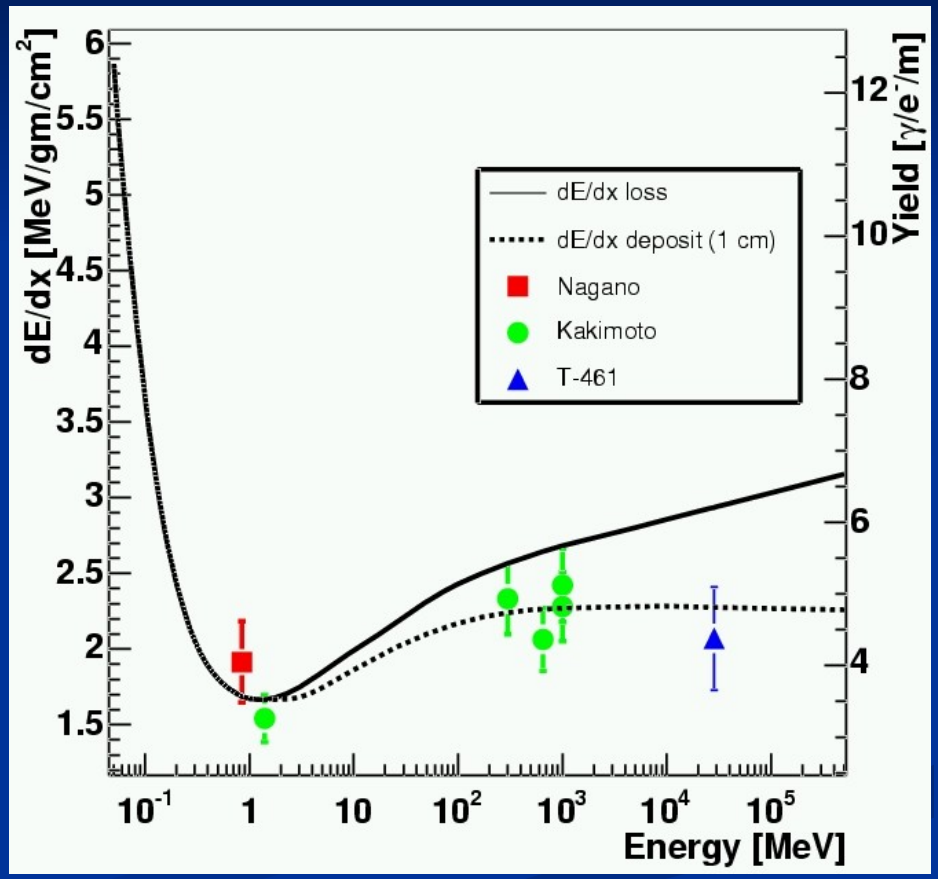


Use of Fluorescence Data

- HiRes (Abu Zayyad)
- Auger (Wiencke)
- TA/TALE (Bergman)

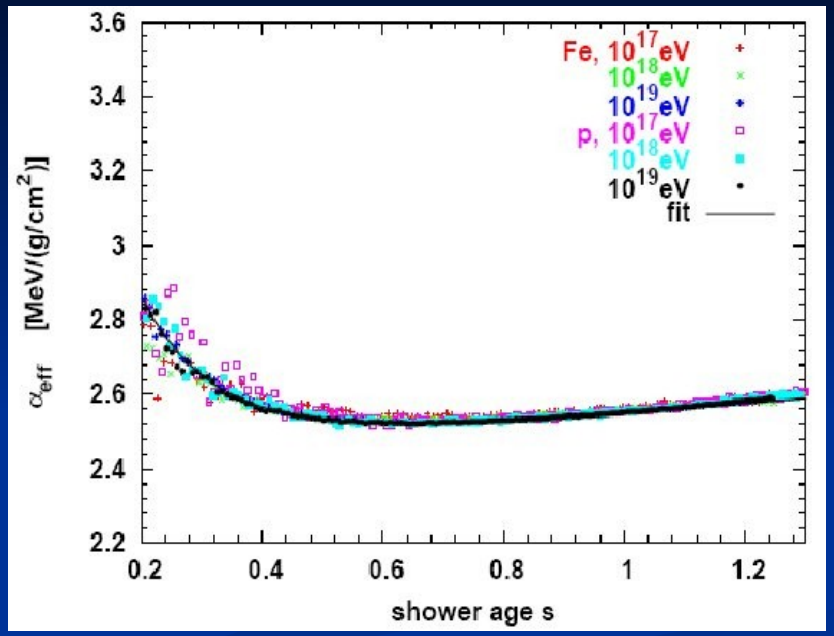
Use of Fluorescence: Total Yield

- Various numbers
  - HiRes - Kakimoto
  - Auger – Nagano
- Contributes 6-7% to σ_E
- Eventually: Weighted average

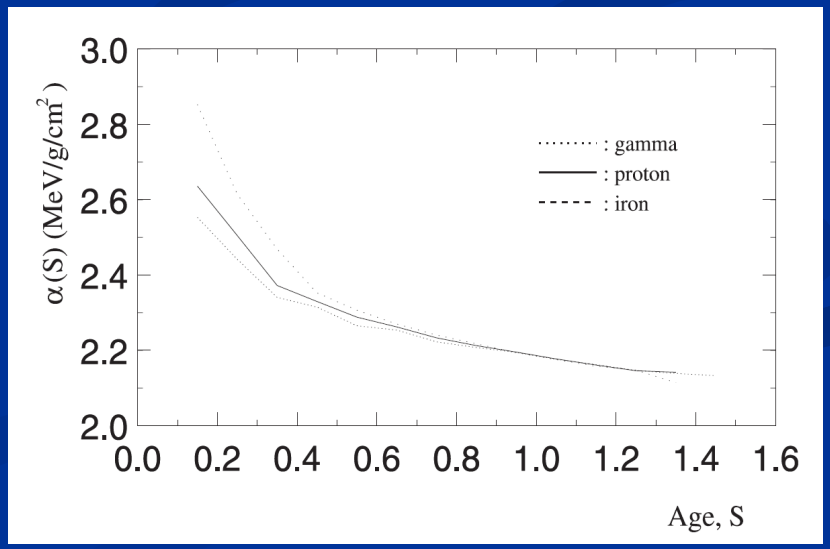


Use of Fluorescence: dE/dx

- Relating N_γ to N_e
- All - CORSIKA
- Contributes about 10% to σ_E
- Model dependence
- Interpretation questions...



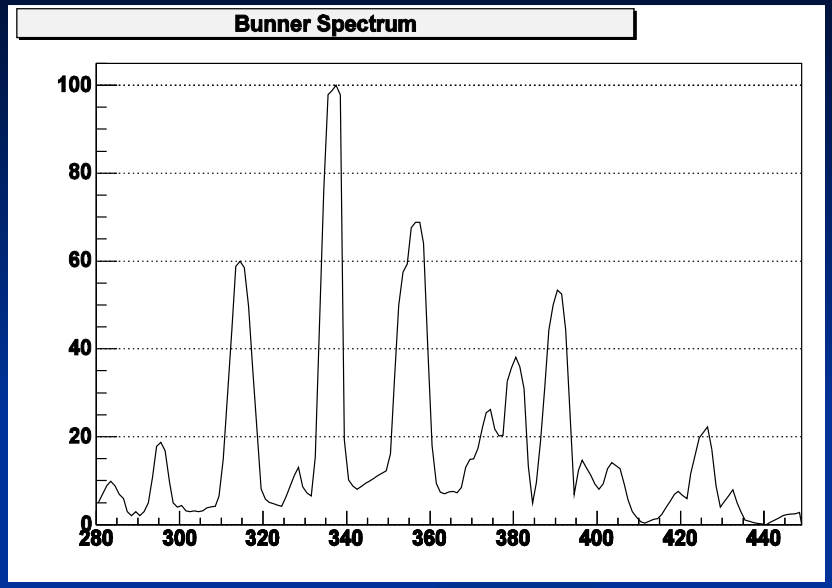
Nerling APP 24 (2006)



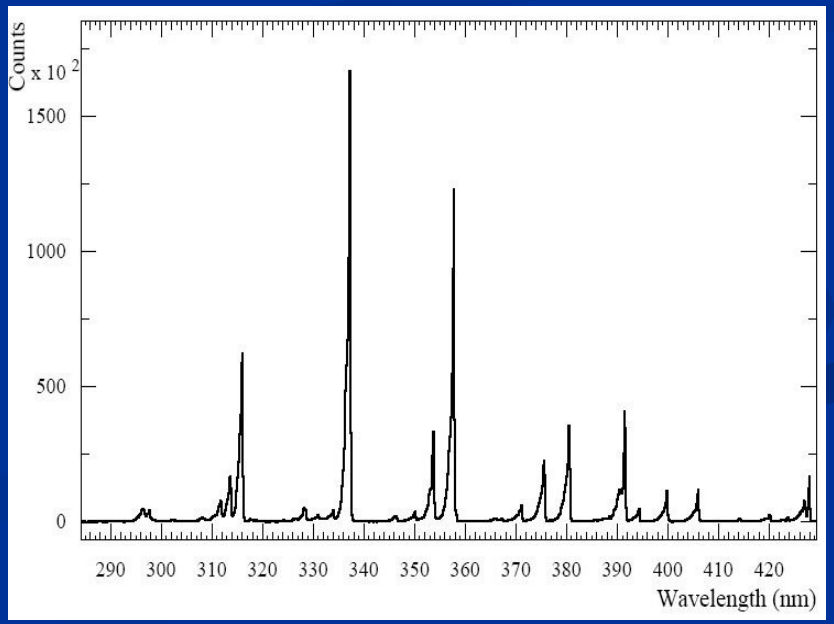
Song APP 14 (2000)

Use of Fluorescence: Spectrum

- Important for transmission through atmosphere
- Current usage
  - HiRes – Bunner (1963)
  - Auger – AirFLY (2007)
- Generally good agreement in relative contribution of various lines



Bunner thesis (1963)



AirFLY astro-ph/0703132

New Experiments

Ashra Overview (Sasaki):
Efforts Toward More Astronomical Approach

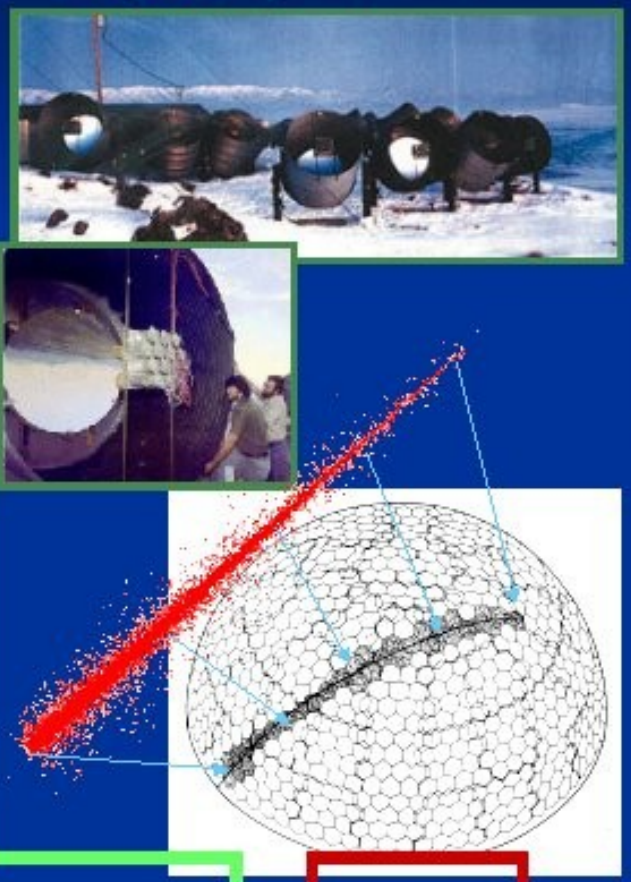
- Ashra: 1.2 arcmin/pix × 80% all-sky
  - Consecutive exposure of star lights
  - Triggered exposure of air-shower Cherenkov and fluorescence lights
- Aims: Identify Sources in the VHE Universe
  - Probing transients like
    - Gamma Ray Bursts (GRBs)
    - Soft Gamma Ray Repeaters (SGR)
    - Core-collapse Supernovae (CC-SNs)

    => Strong candidates of CR sources
  - Evidence of Cosmic Accelerators with
    - VHE neutrinos (Test charged pions)
    - VHE gamma rays (Test neutral pions or/and EM)

Optical Air-shower Detector

Progress of Resolution×FOV

Fly's Eye (1981-1993)



5deg/pix × All-sky

PMT

HiRes (1994-2006)

1deg/pix × 28deg

PMT

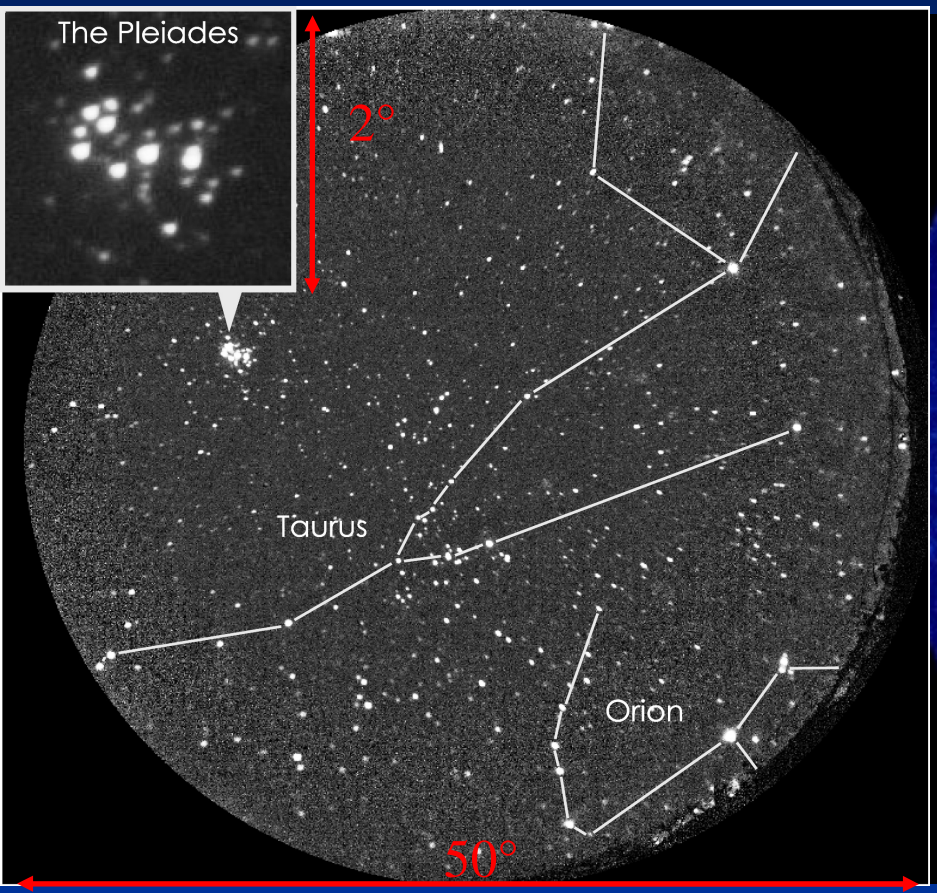
Ashra (2007-)

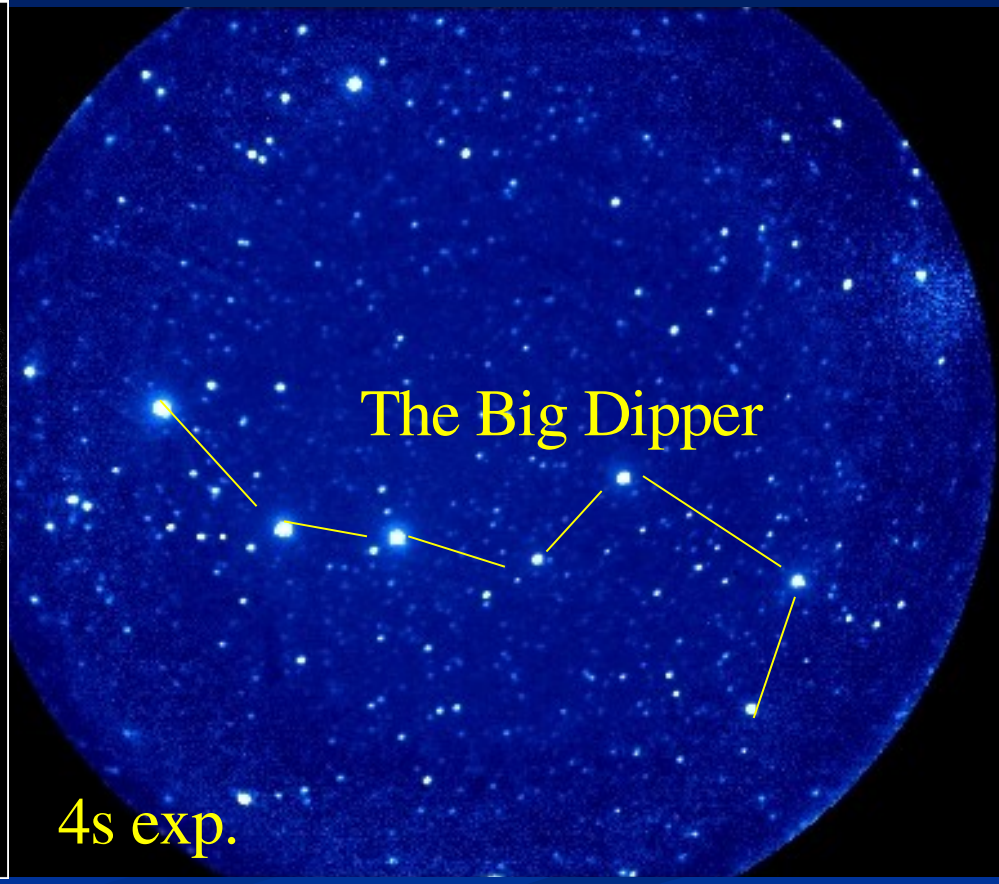
1.2min/pix×All-sky

Image Tube + CMOS

Star Images

Constellations Taurus and Orion &
close-up view of the Pleiades (Subaru)



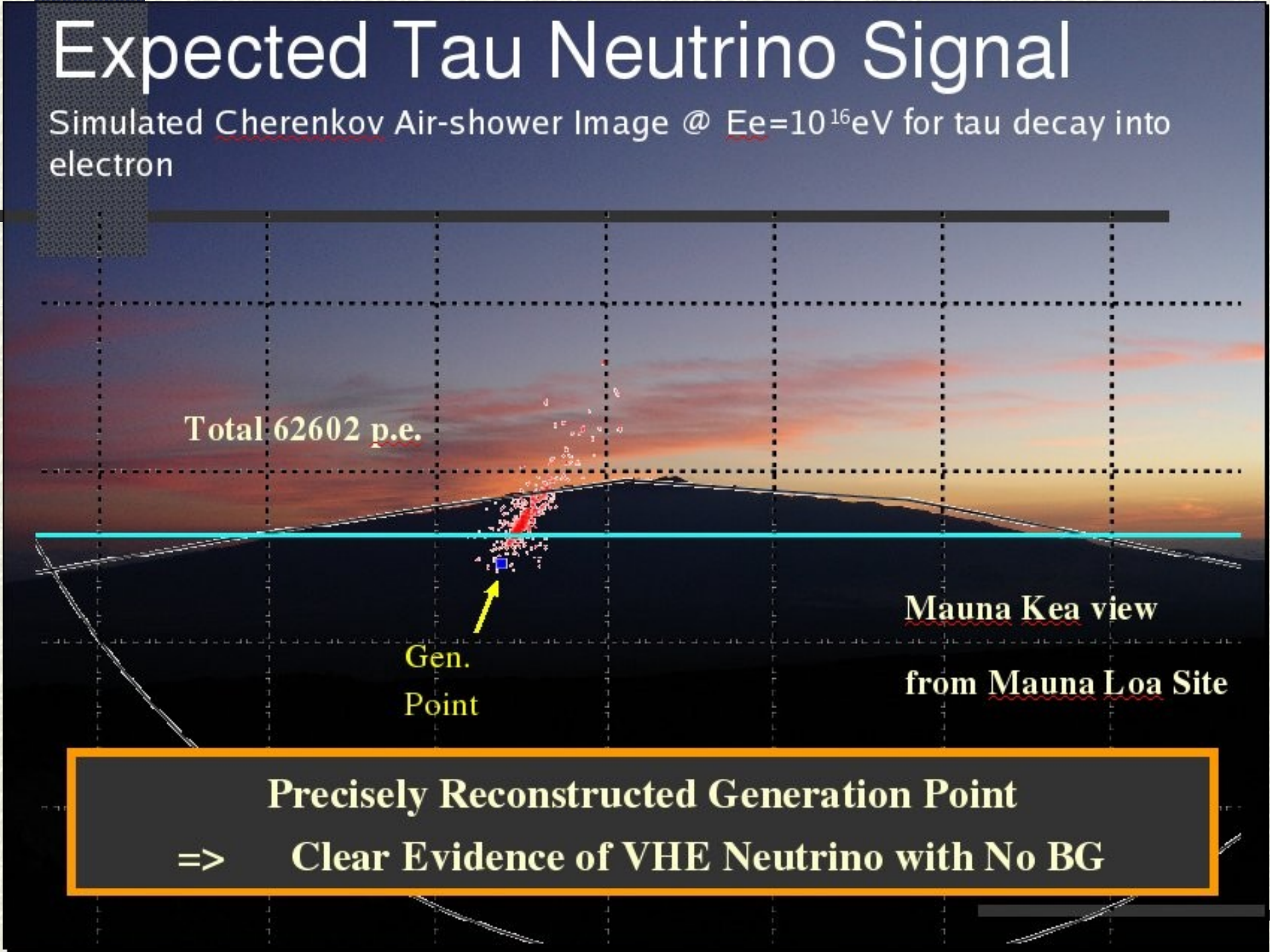


Concept of the optics ＝ “ Wide & High resolution”

Demonstrated well

Expected Tau Neutrino Signal

Simulated Cherenkov Air-shower Image @ Ee=10^{16}eV for tau decay into electron



Precisely Reconstructed Generation Point

=> Clear Evidence of VHE Neutrino with No BG

JEM-EUSO Telescope on ISS

JEM-EUSO Telescope will be attached to Exposure Facility of Japanese Experiment Module (JEM/EF) of ISS in 2012- 2013

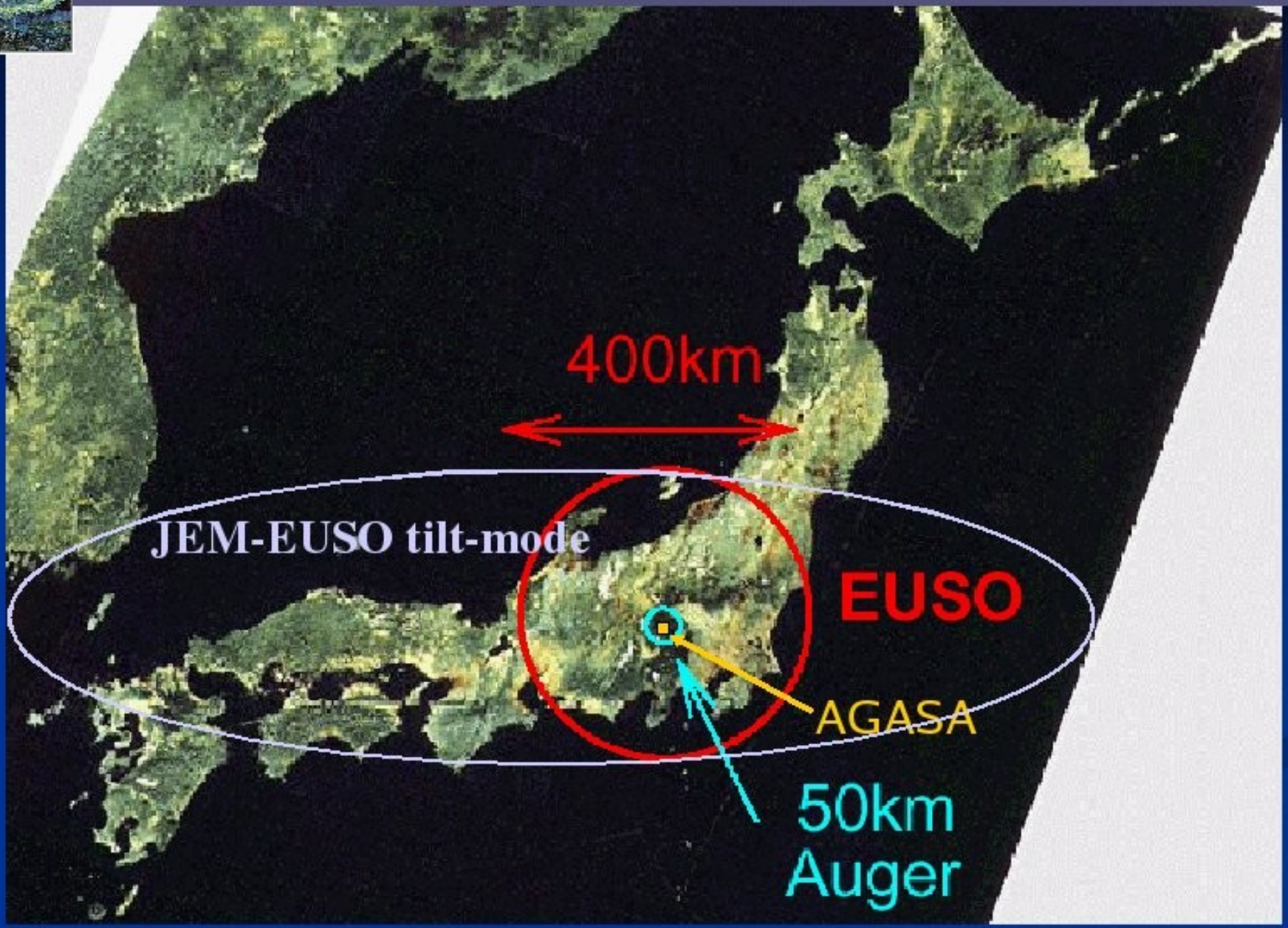
Vertical Mode

Tilted Mode

Larger effective area (x5) with ~35° tilt

EUSO ~ 300 x AGASA ~ 10-50 x Auger

EUSO (Instantaneous) ~3000-15000 x AGASA ~ 100-500 x Auger



Time schedule and etc.

- Time schedule
  - We will hear the judgment from JAXA this May – we are very optimistic
  - After two years of Phase-A study, there is a critical review of the mission
  - In 2009-2012, JEM-EUSO will be build
  - Launch is expected in 2012 or 2013, as a program in the second phase of ISS utilization
- Physics
  - More focus on the Astronomy with UHECRs (>1000 events above GZK cutoff, 10^{20}eV)
  - Deliver the skymap of UHECRs with 1000~10,000 events above 10^{20}eV

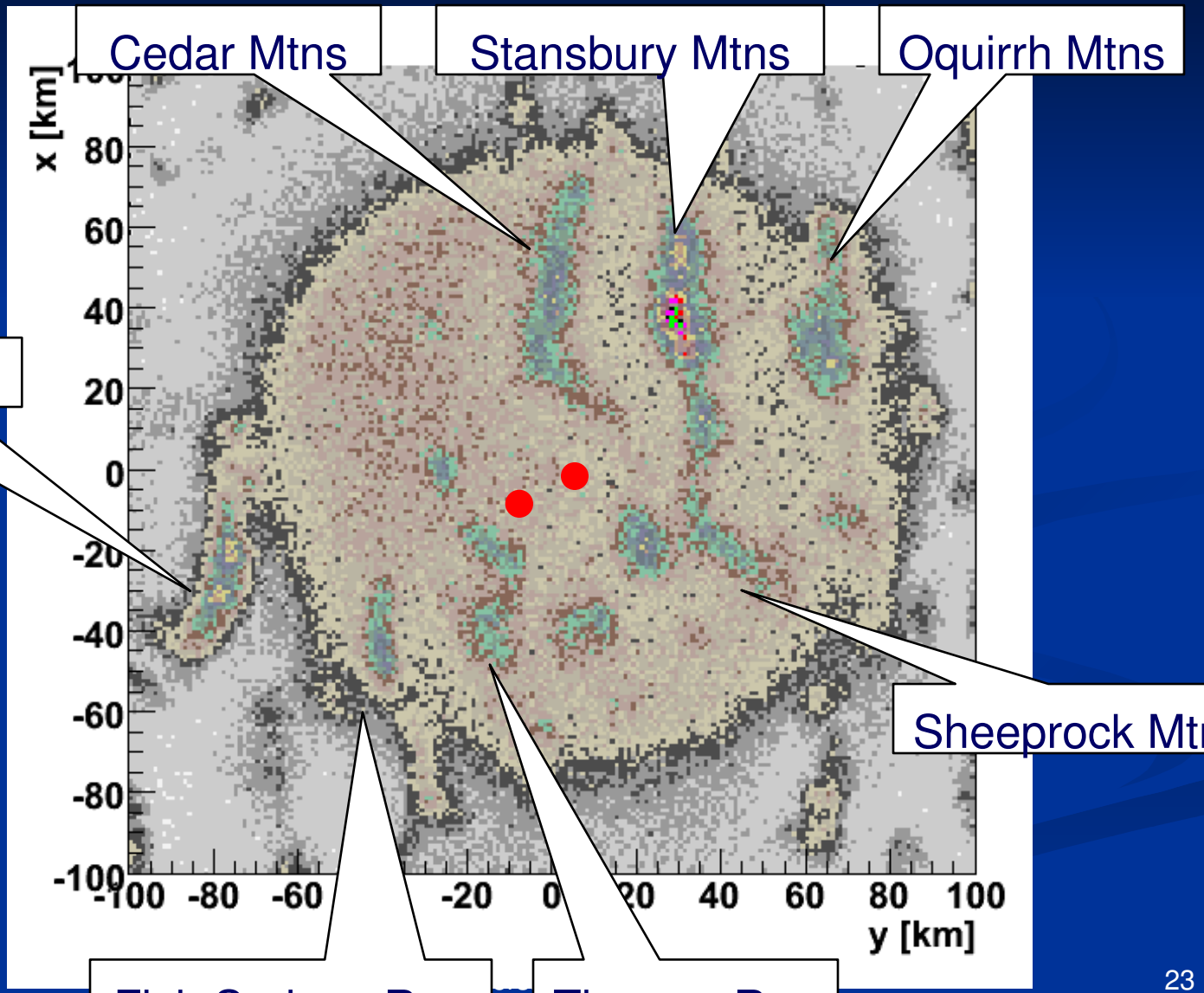
Neutrinos

Neutrino Talks

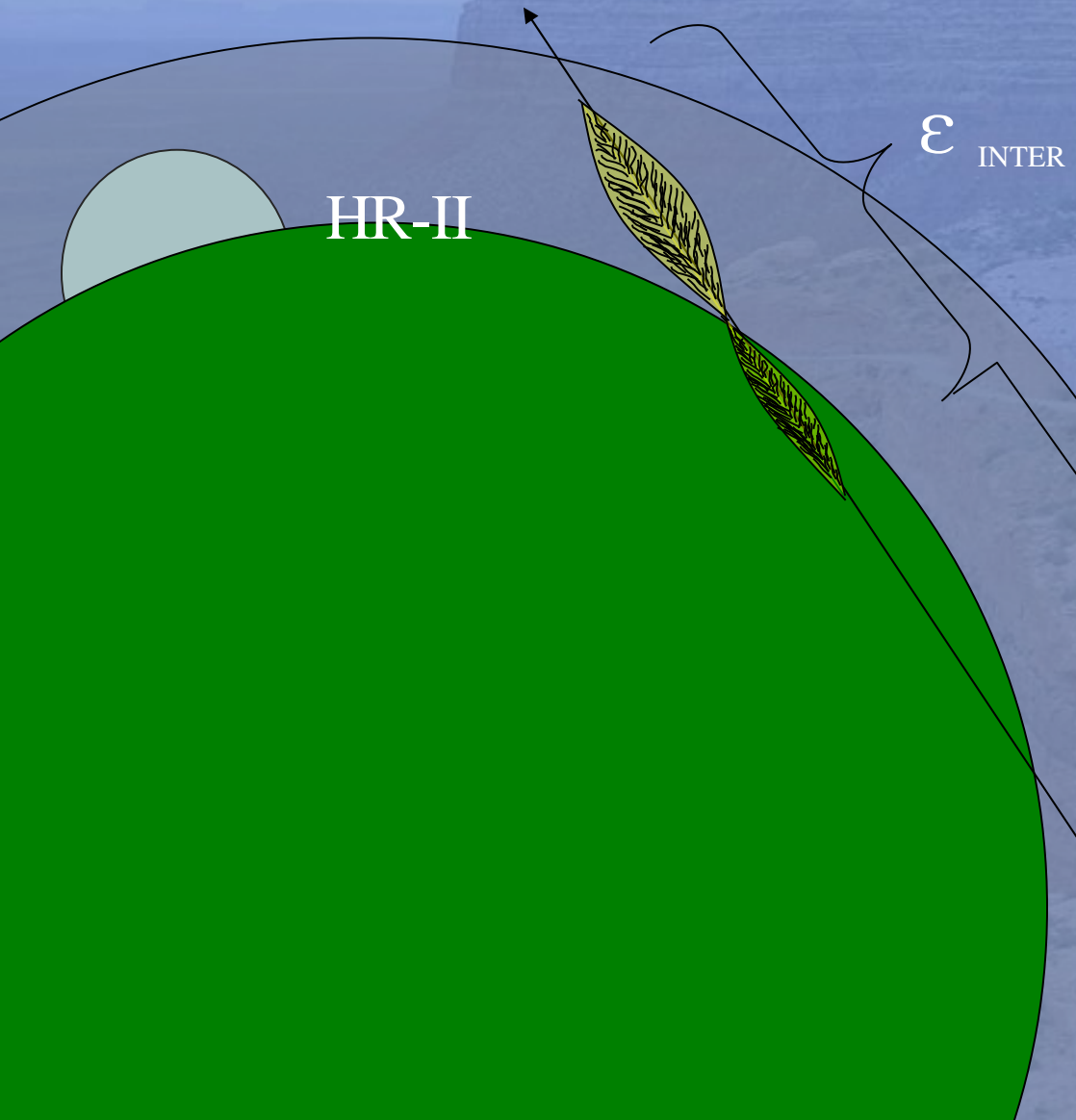
- HiRes ν_τ (Martens)
- HiRes ν_ε (Scott)
- Auger (Gora)
- Ice Cube (Grullon)
- Neutrinos and Composition (Hooper)
- Interpreting Limits (Becker)

MC: Topology at Work

Neutrino interaction points (tau decay above ground):



Monte Carlo Technique

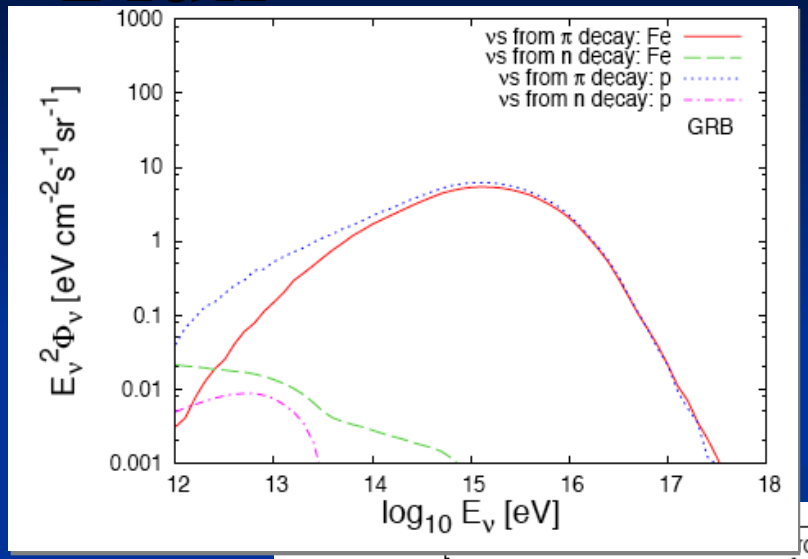


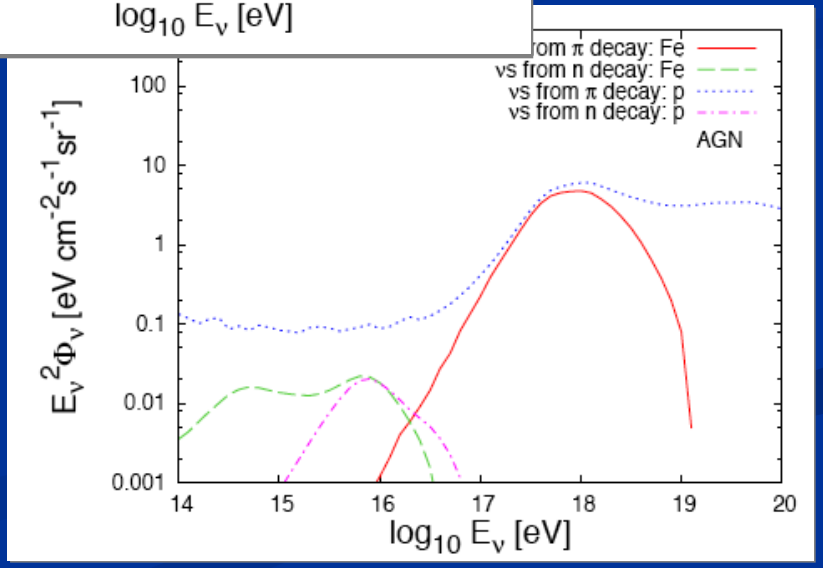
- Flat distribution of neutrino energies in log(E).
- Isotropic upward-going events.
- 70% CC events / 30% NC events (from ratio of cross sections)
- Each event, interpolate depth in rock that gives $N_{max} = 10^7$ in air.
- CC : superpose LPM airshower from spectrum at point of exit from earth
- NC : GH profile, unchanged from rock into air
- Calculate ε_{INTER} and ε_{INTER}.
- Force neutrino to interact along "interaction length."
- Run through full detector trigger simulation routine (`mcru`)
- Find geometry, plane-fitting for events that pass trigger (`rufpln`)

Nuclei and the Extragalactic Neutrino Flux

- Above ~100 TeV, GRB neutrino spectrum is largely unchanged (overall rate reduced by ~20%)

- For AGN, neutrino flux is reduced considerably (overall rate reduced by ~80%)





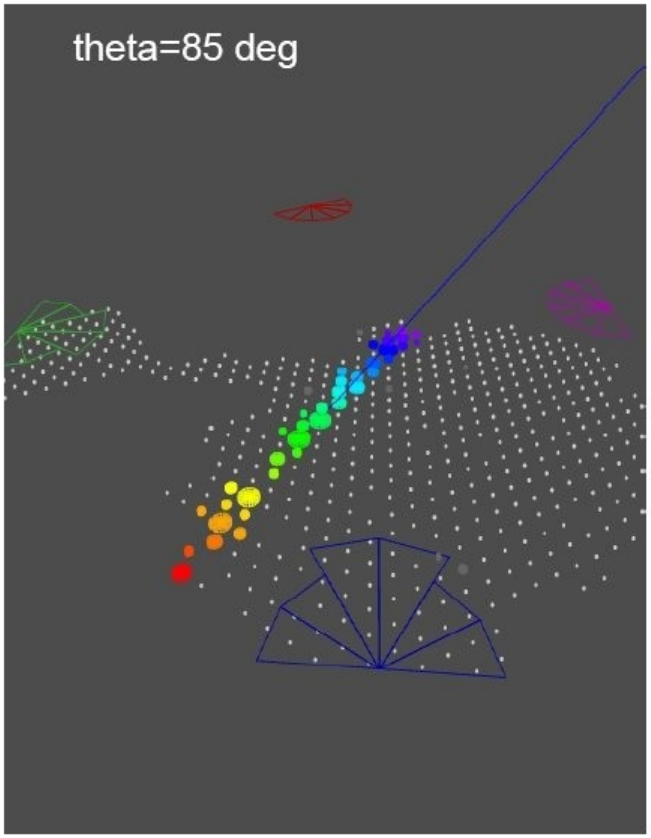
Anchordoqui, Hooper, Sarkar, Taylor, astro-ph/0703001

Identification of neutrinos

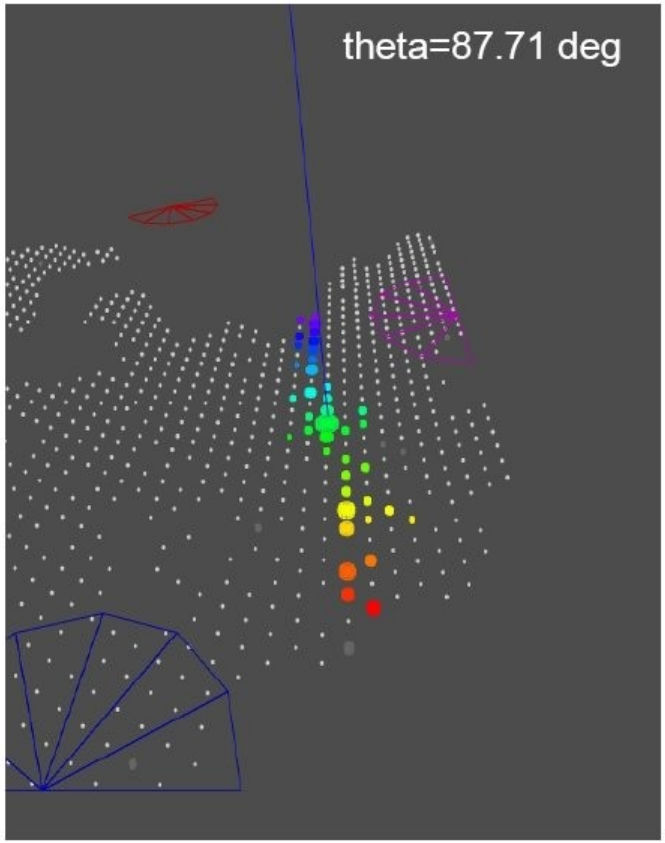
(Example of the real elongated events)

- **Elongated footprints are observed:**

event 1101015 Dec 2005

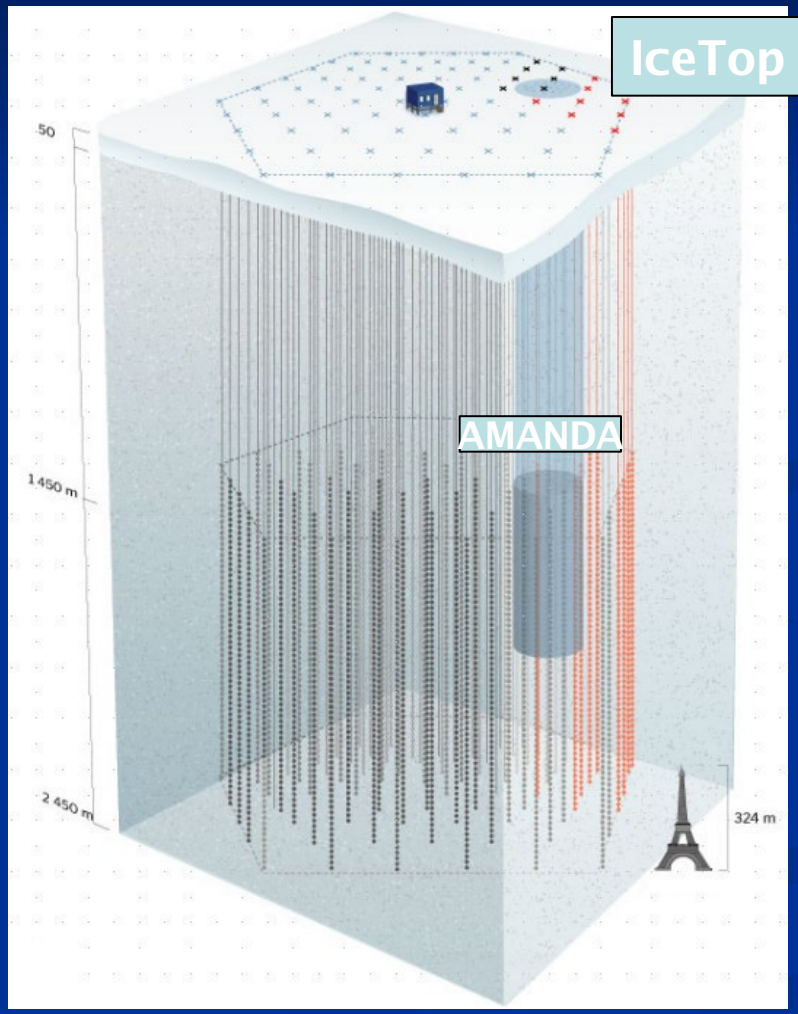


event 2924050 Dec 2006



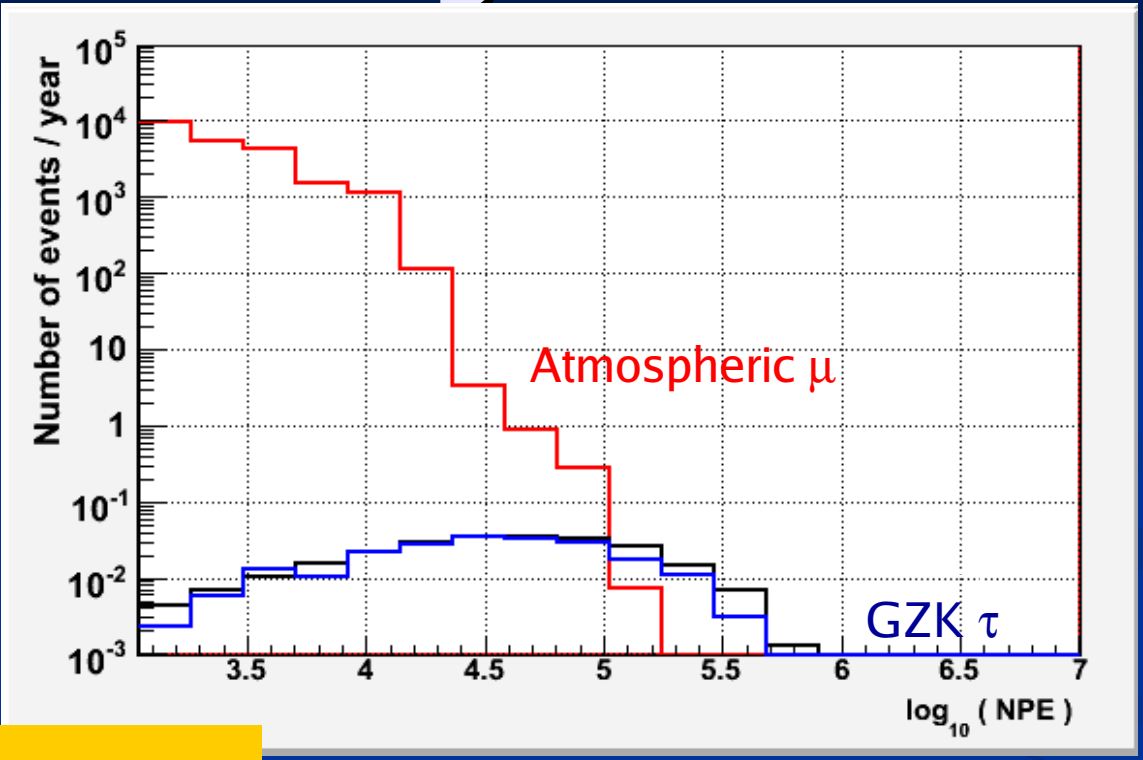
Sean Grullon

The IceCube Neutrino Observatory



- 70-80 Strings (60 DOMs each) by 2011
- 1km^3 instrumental volume
- Designed to detect neutrino energies from 10MeV (SN) to 100EeV (GZK, TD)

Preliminary Event Rate: 9 String Configuration

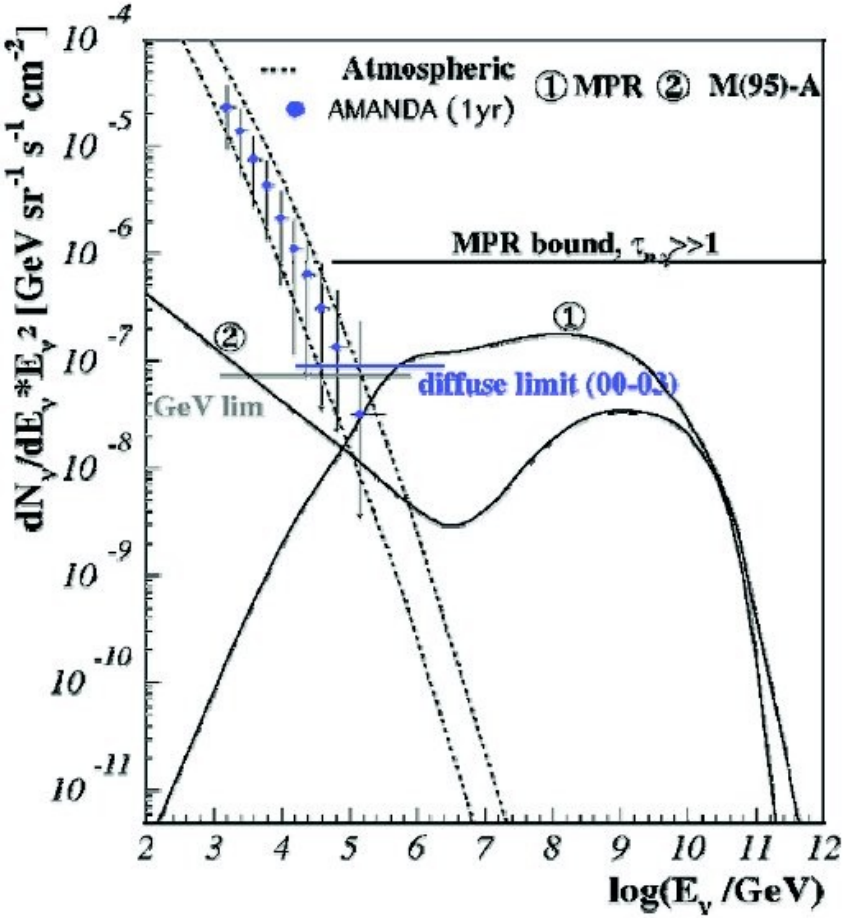


IceCube Preliminary

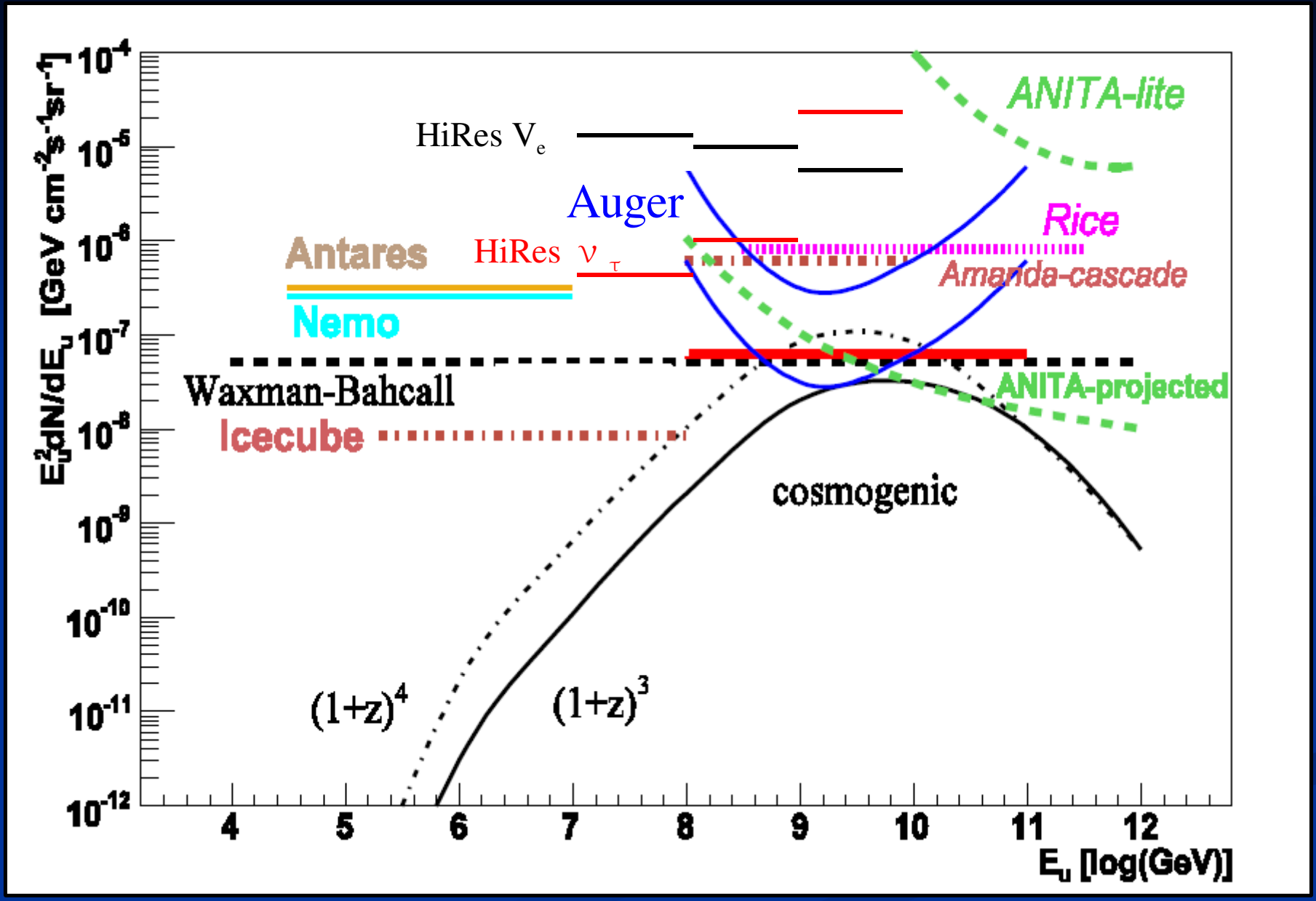
GZK μ	0.067
GZK τ	0.055
Atmospheric μ	0.009

EGRET-sources

- AGN of GeV Emission
- Fluxmodels normalized to the extragalactic background as determined by EGRET
- GeV limit: stacking diffuse
  - Limit starts to restrict models
  - Limit far below atmospheric background!



Gora



(additions by L. Scott)

Thank You!