AGASA and HiRes Energy Spectra

M. Teshima

ICRR, University of Tokyo

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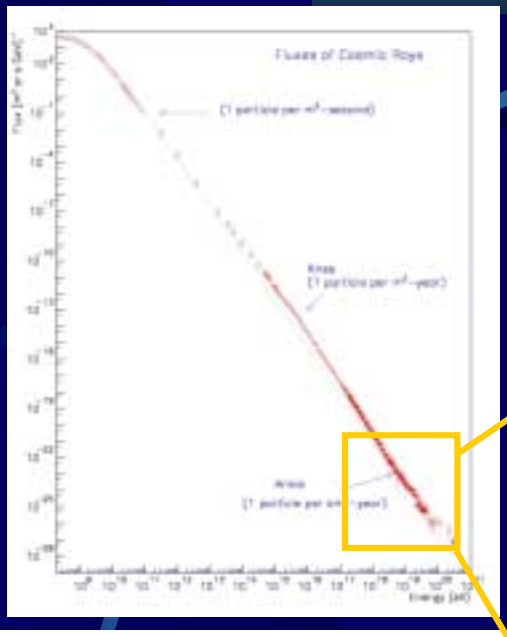
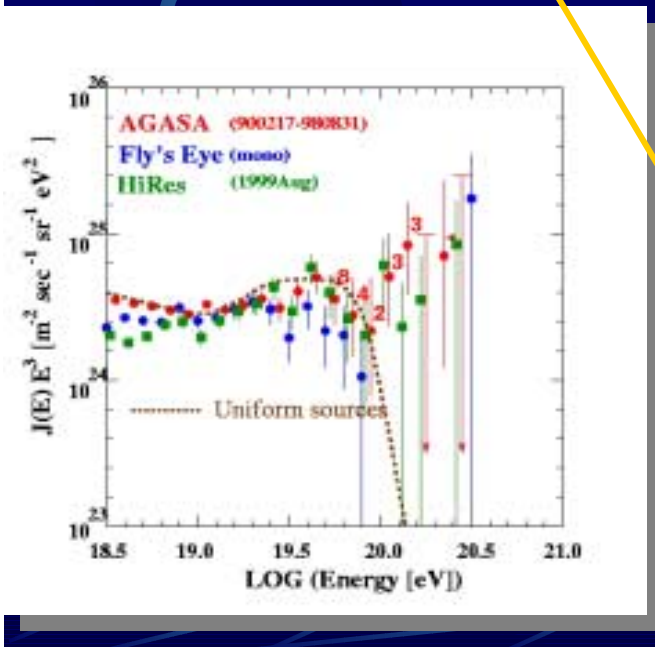
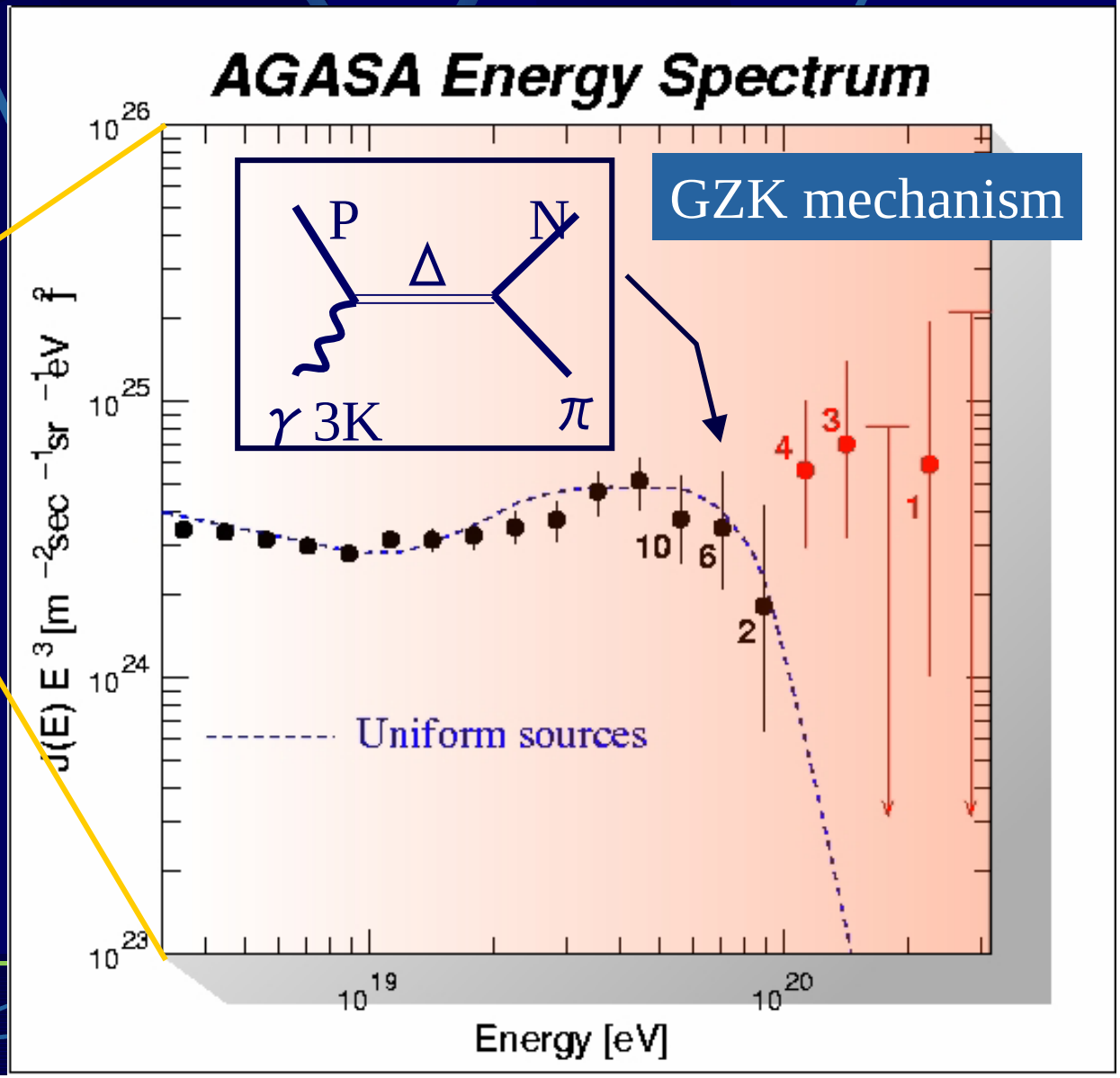
@Annecy, EUSO meeting

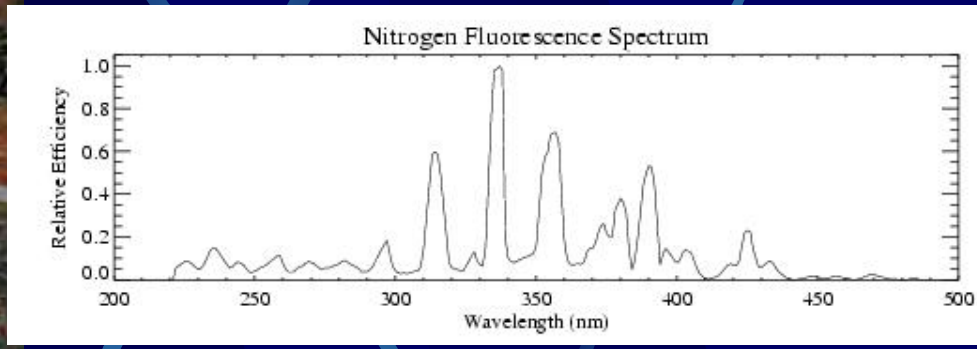
CR Energy Spectrum

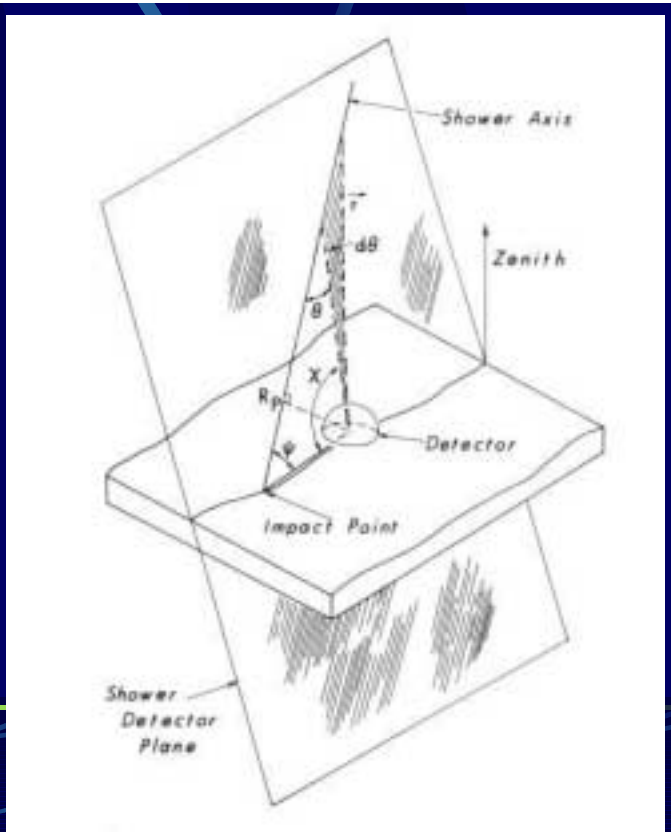






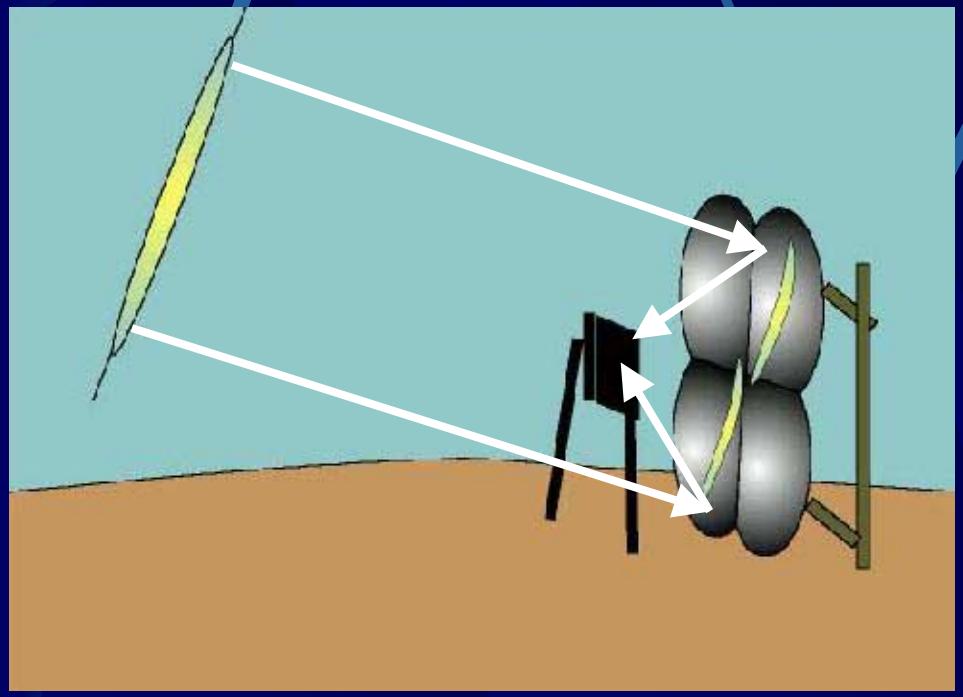
HiRes Experiment
Air Fluorescence detector

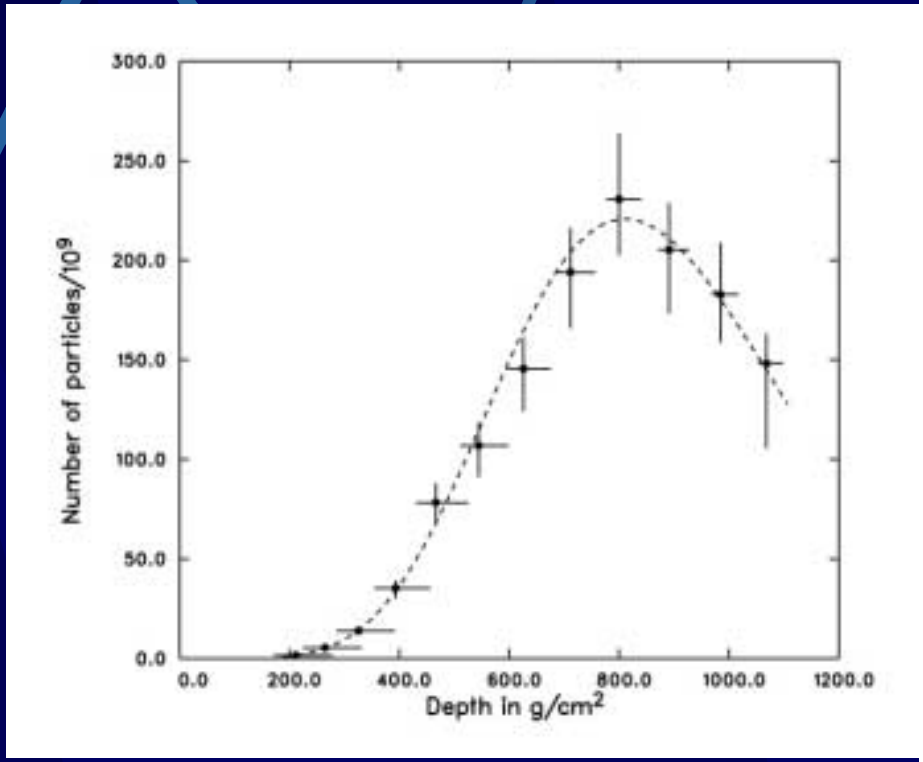




Air Fluorescence technique

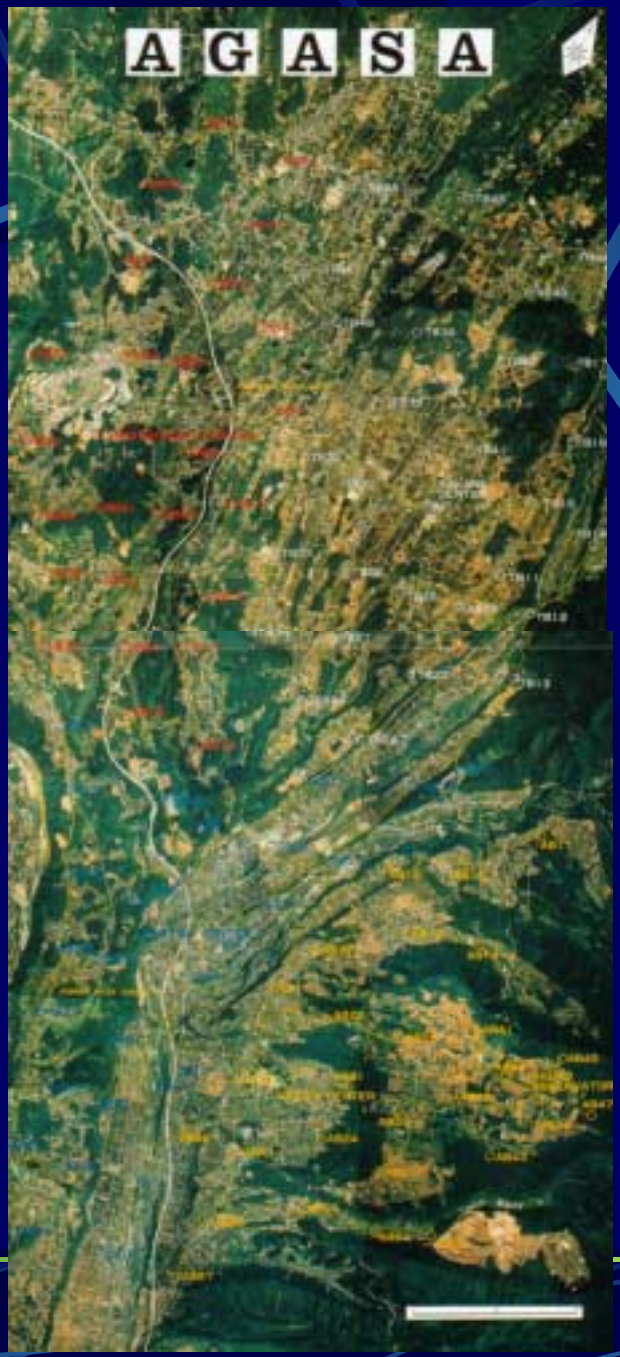
Measure Shower Development in the atmosphere
Essentially Carolimetric measurement

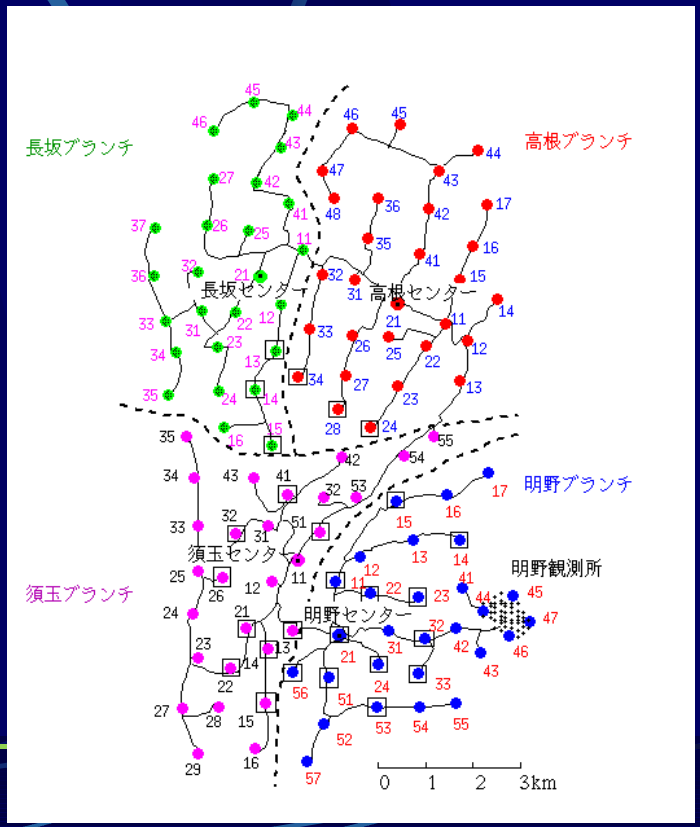




AGASA

111 Electron Det.
27 Muon Det.





Detector Calibration in AGASA experiment

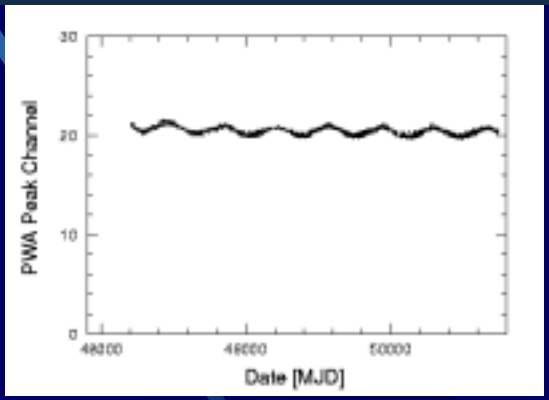
Detector Position

Survey from Airplane
ΔX, ΔY=0.1m, ΔZ=0.3m

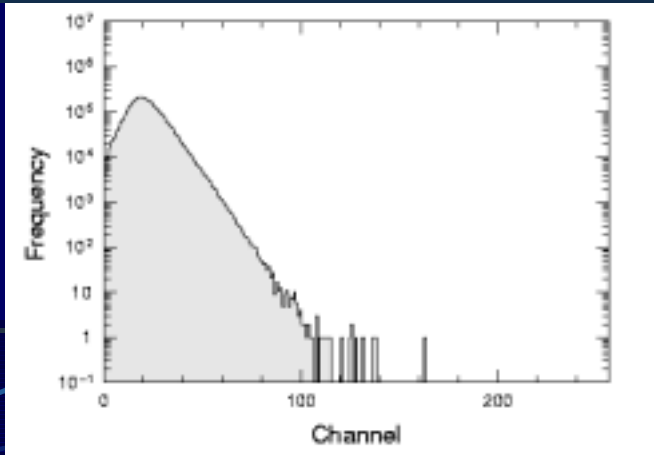
Cable delay (optic fiber cable)

Accuracy of 100ps by measuring the round trip time in each run

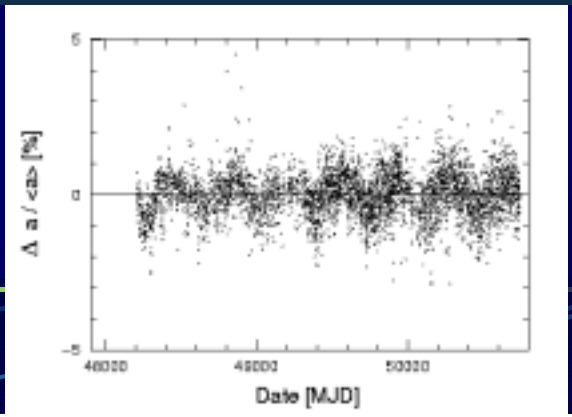
Gain as a function of time (7 years data)



Detector Gain by muons in each run

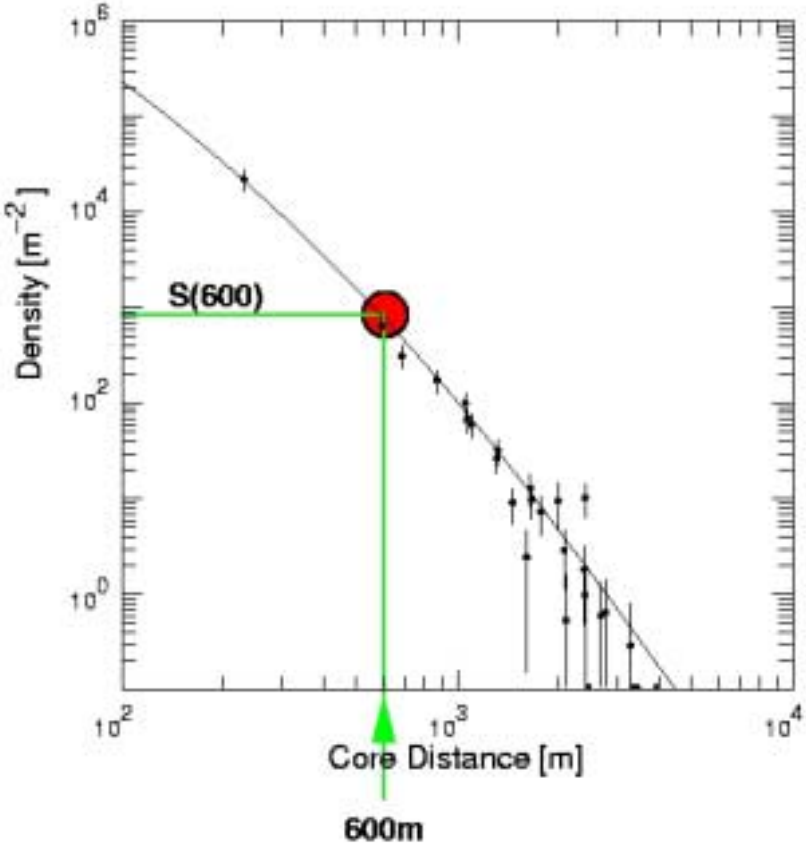


Linearity as a function of time (7 years data)

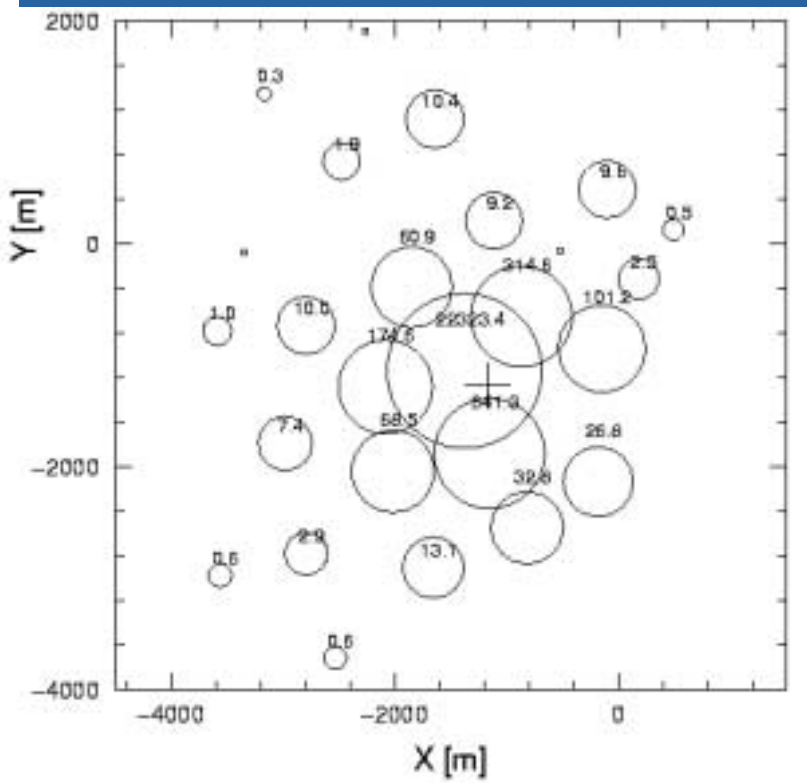


Energy Determination

- Local density at 600m
  - Good energy estimator by M.Hillas



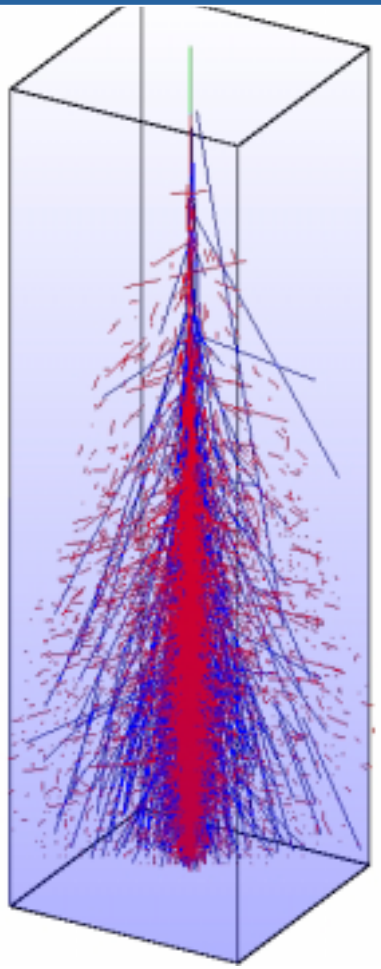
E=200EeV, Emin = 160EeV

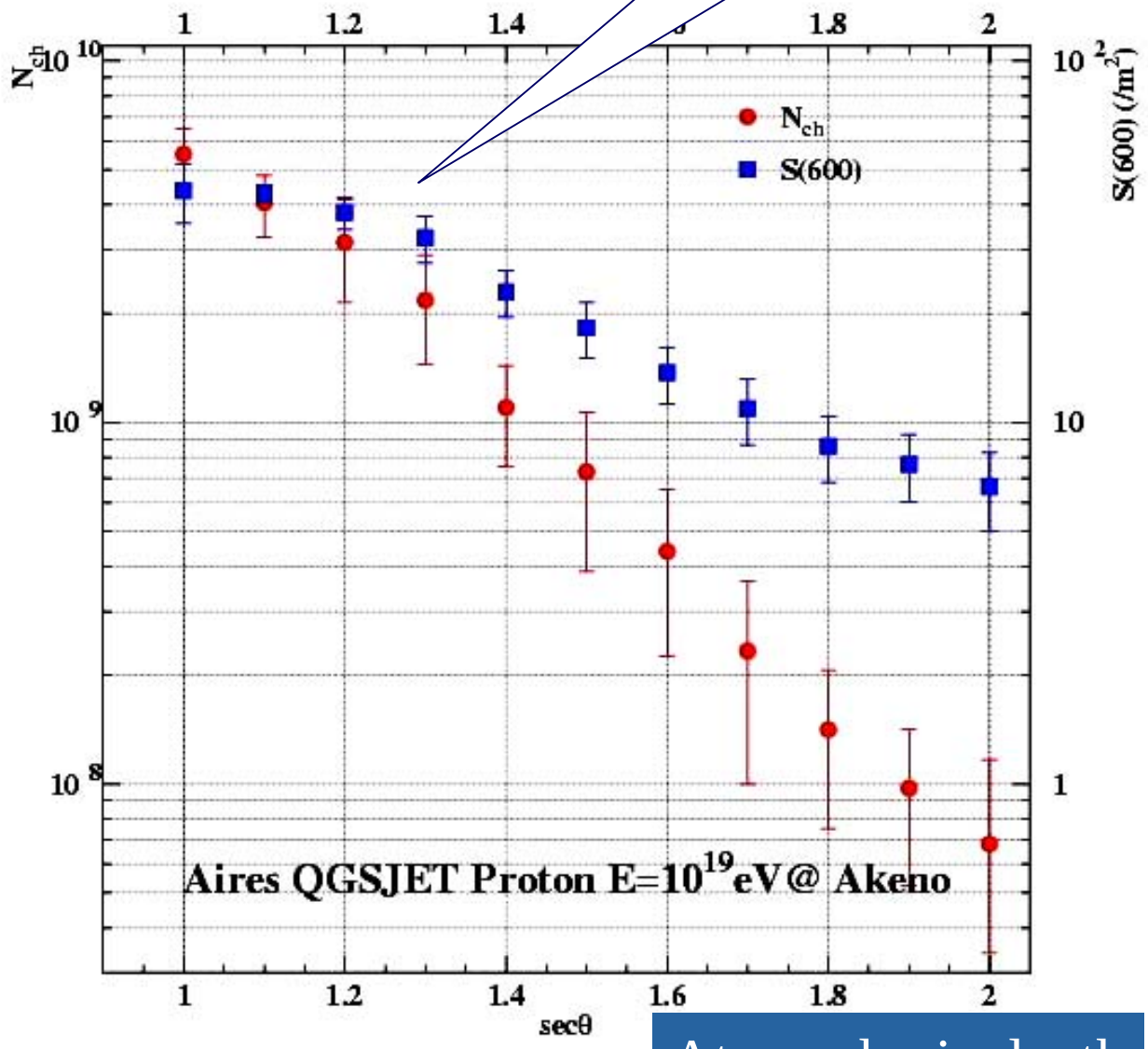


Attenuation curve

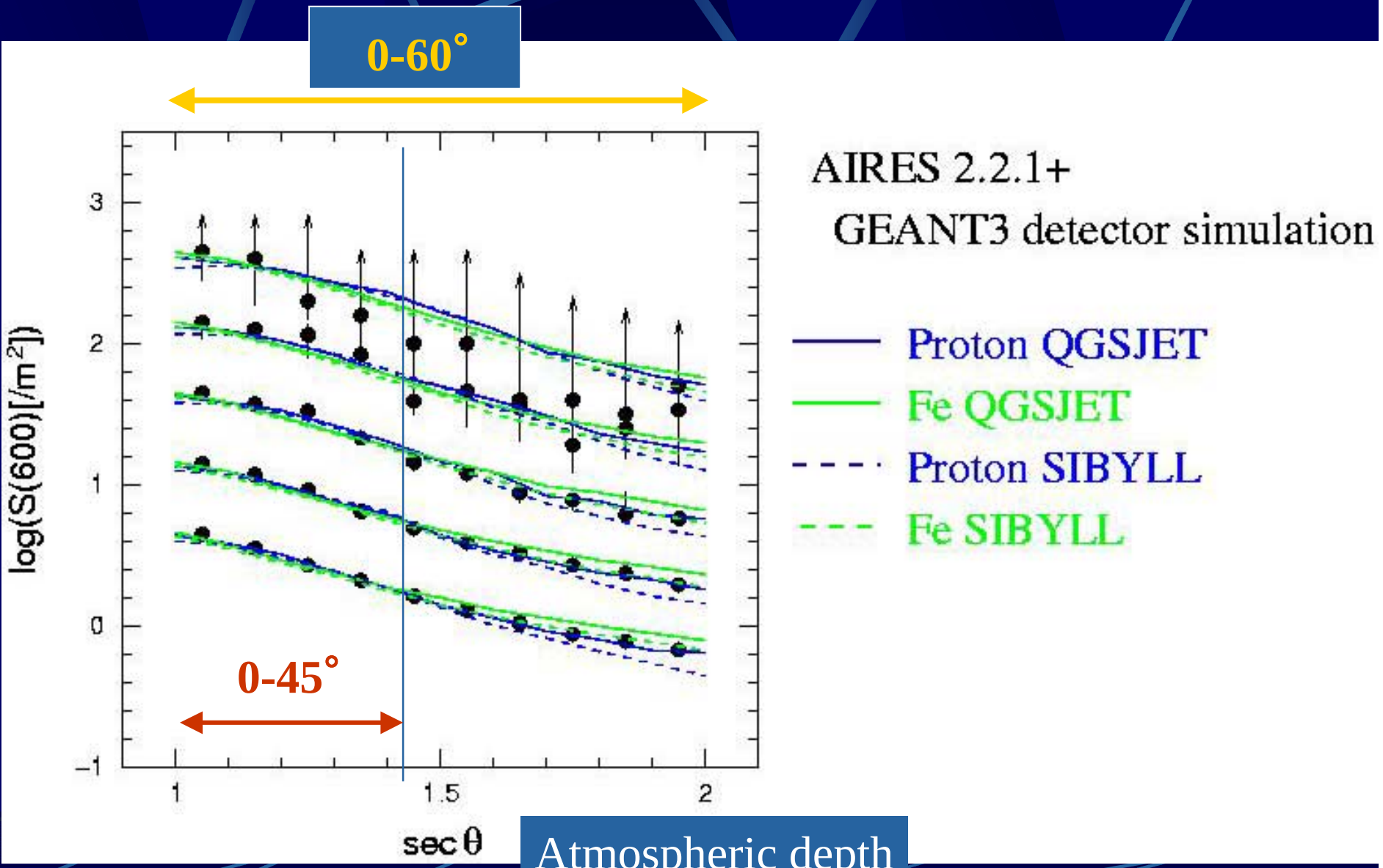
S(600) vs N_{ch}

10^{18}eV Proton



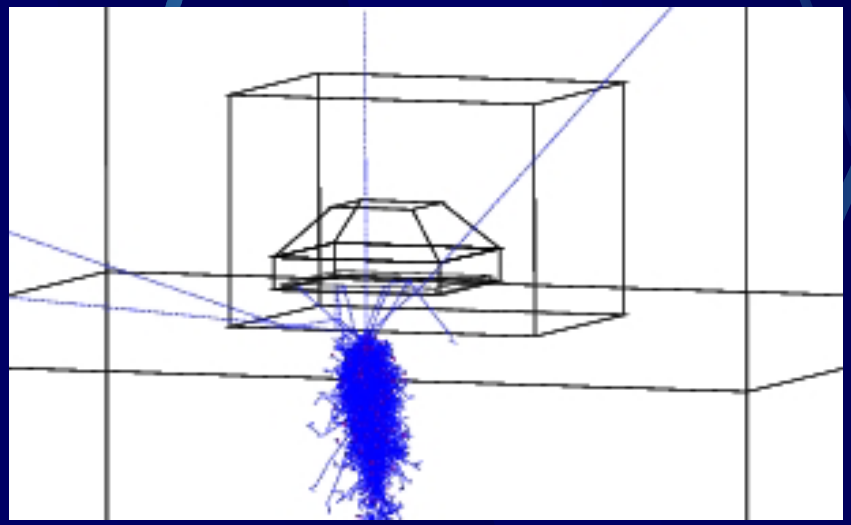


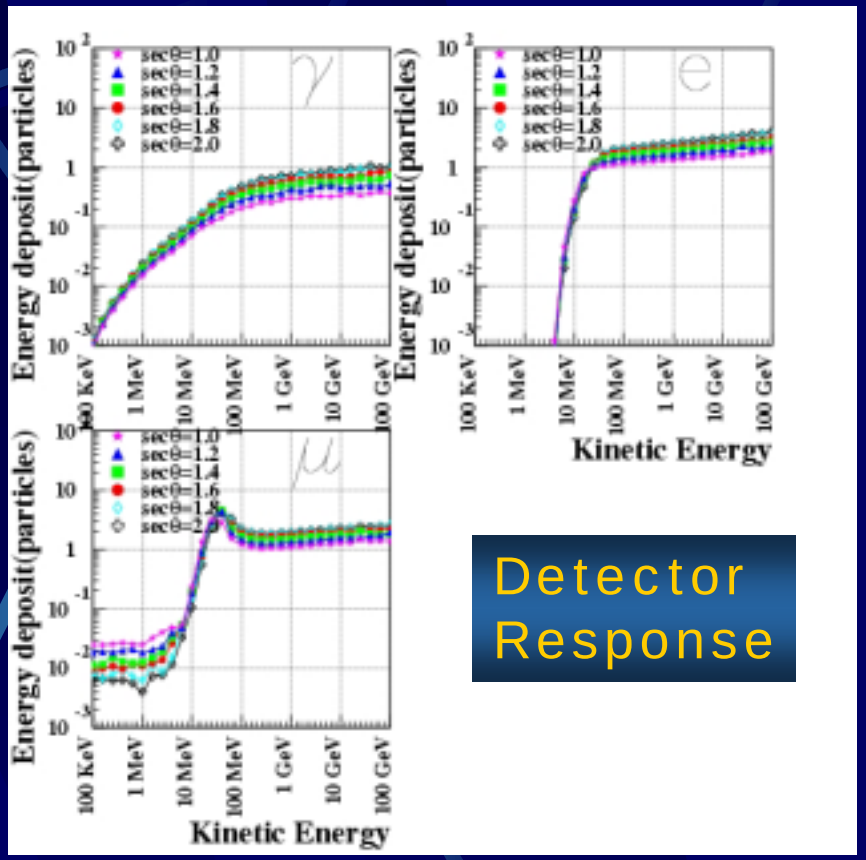
S600 Attenuation curve



Detector Simulation (GEANT)

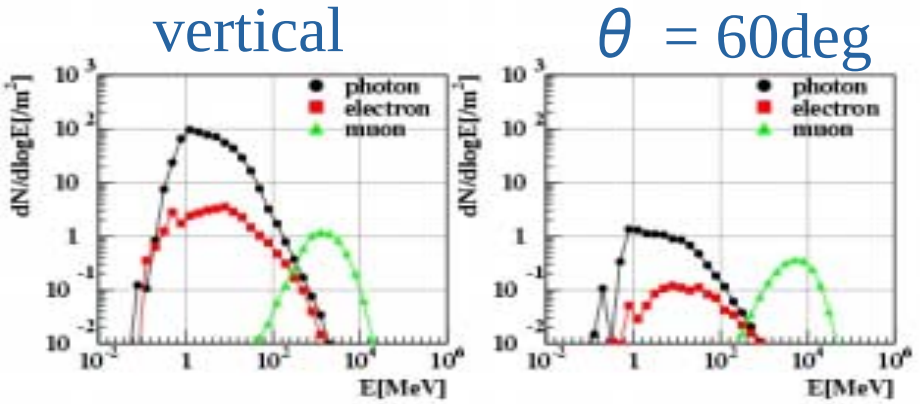
Detector Housing (Fe 0.4mm)
Detector Box (Fe 1.6mm)
Scintillator (50mm)
Earth (Backscattering)



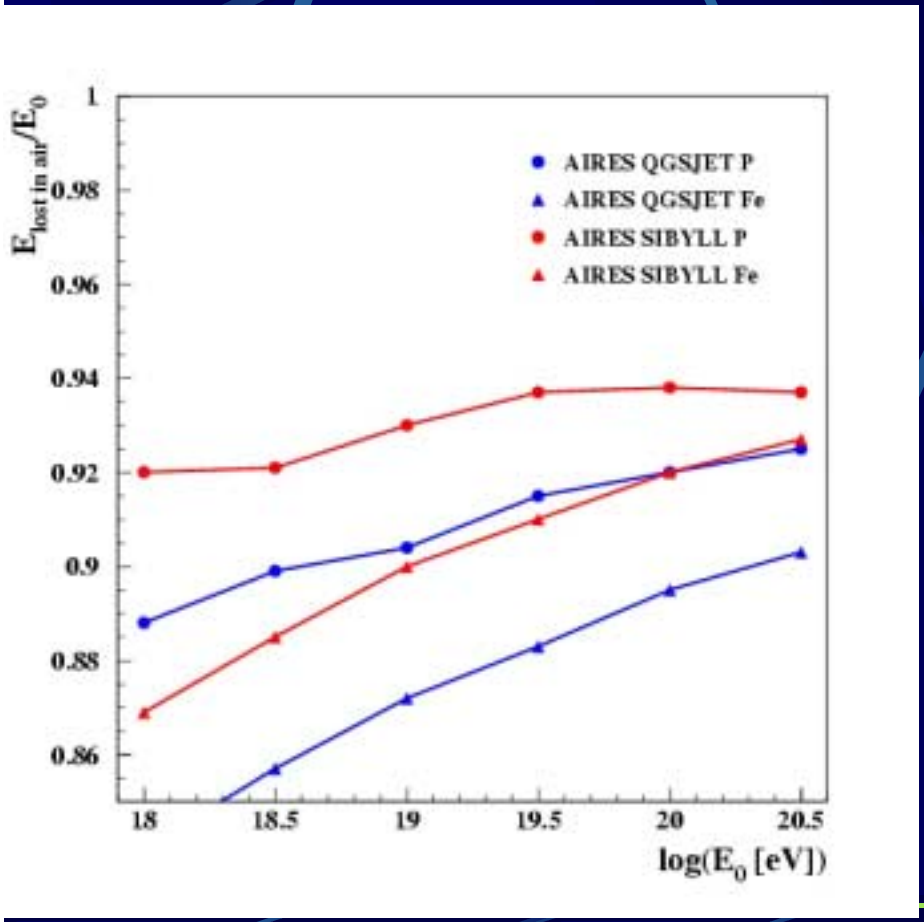


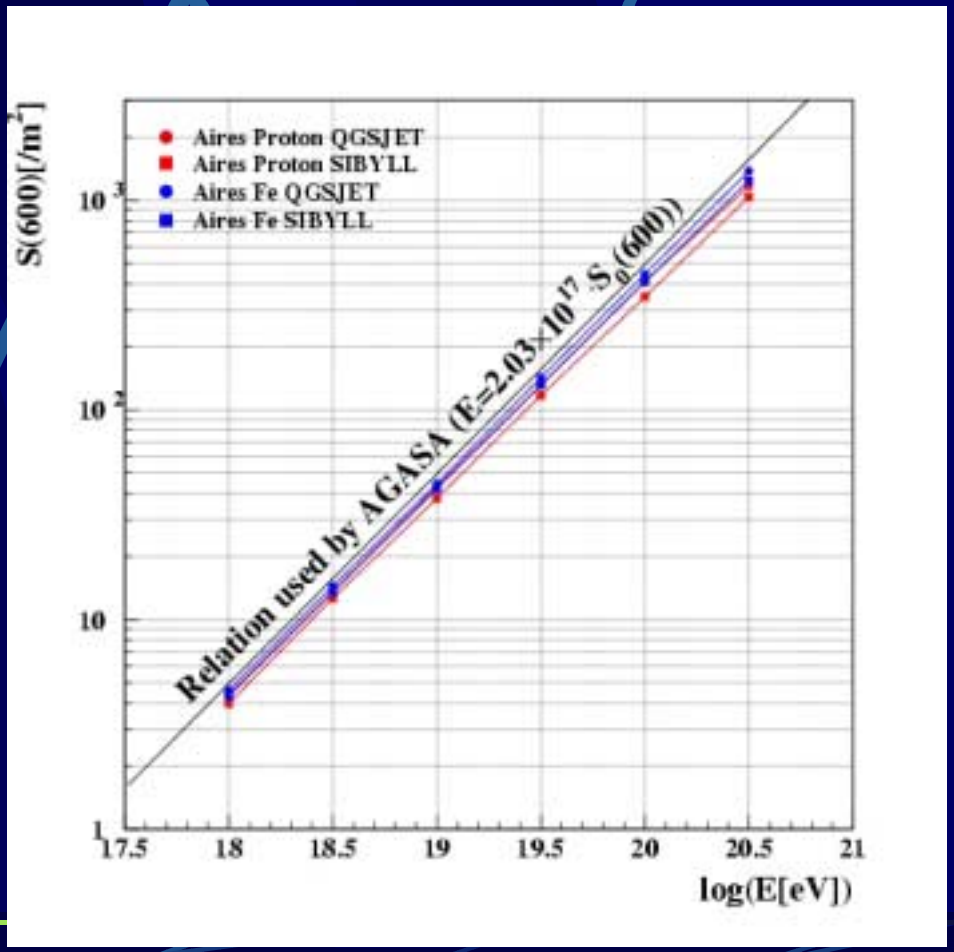
Detector Response

Energy spectra of shower particles

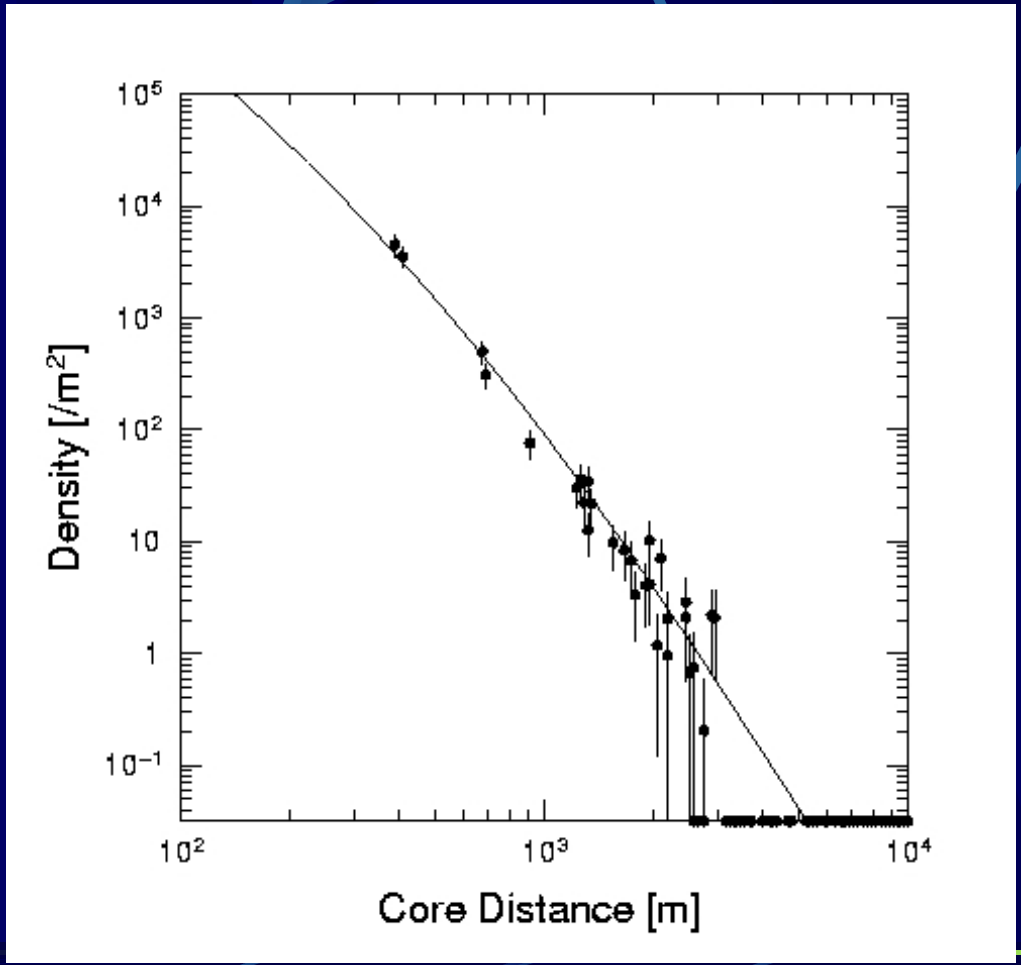


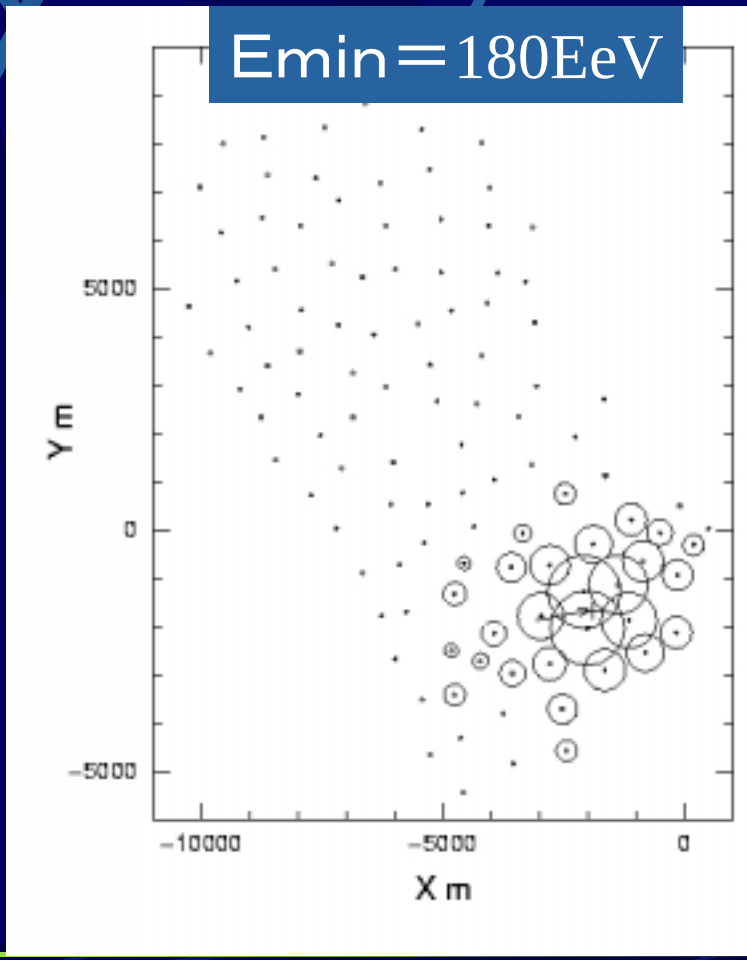
The Conversion from S600 to Energy



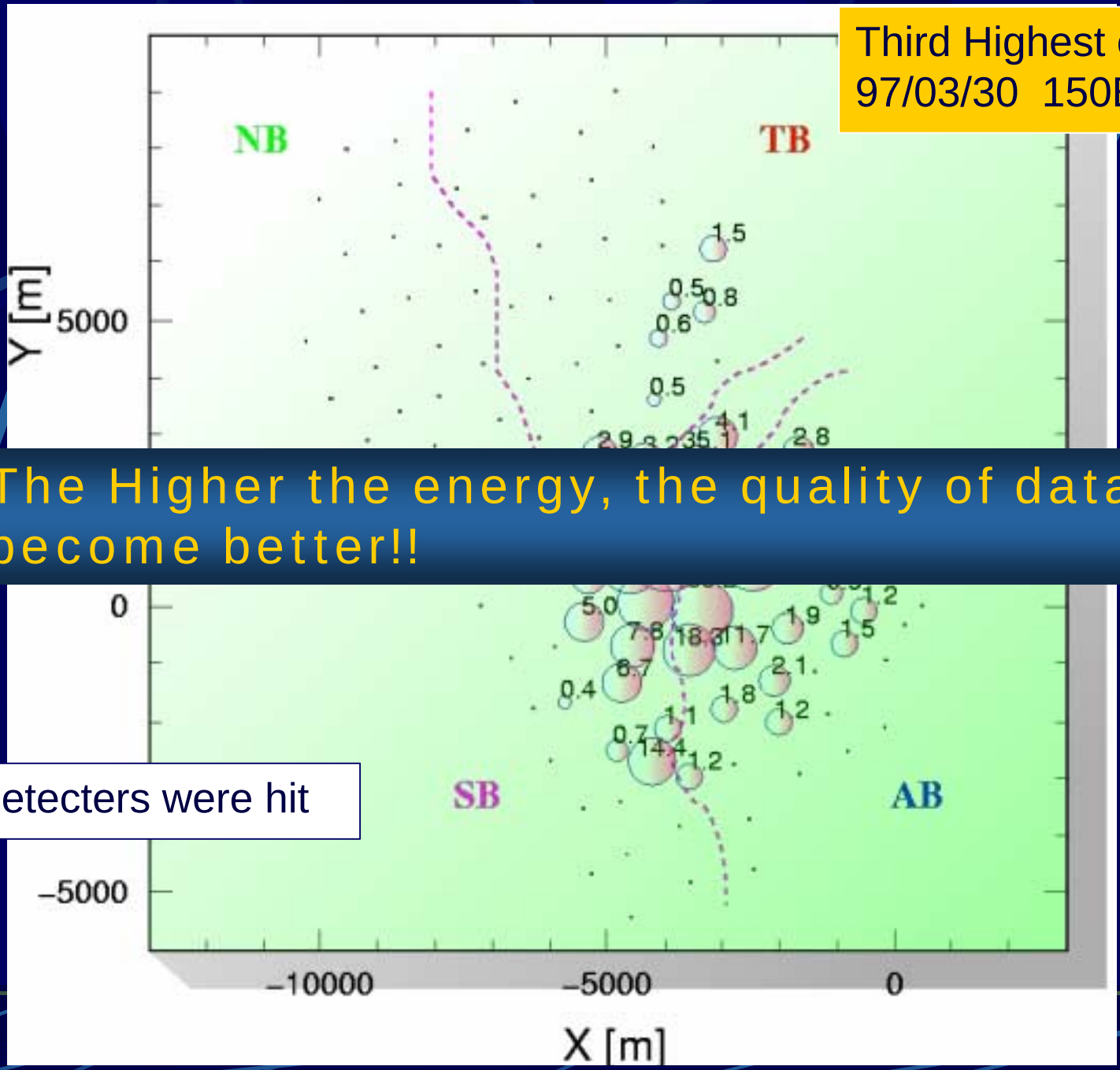


The New Highest Energy Event ($\sim 3 \times 10^{20}$eV) on 10 May 2001





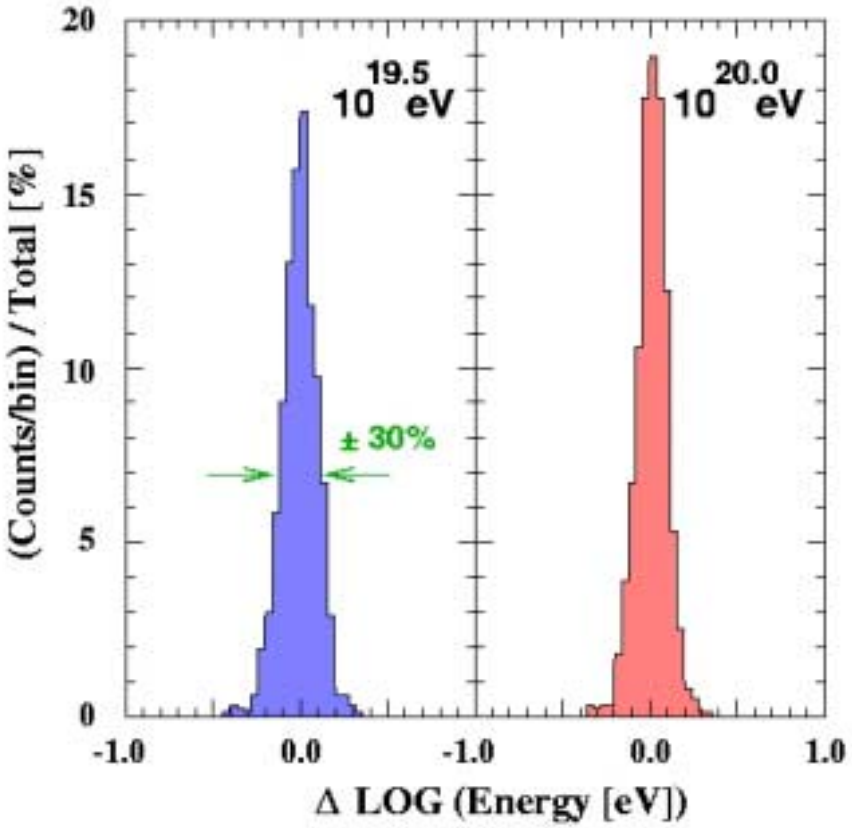
Third Highest event
97/03/30 150EeV



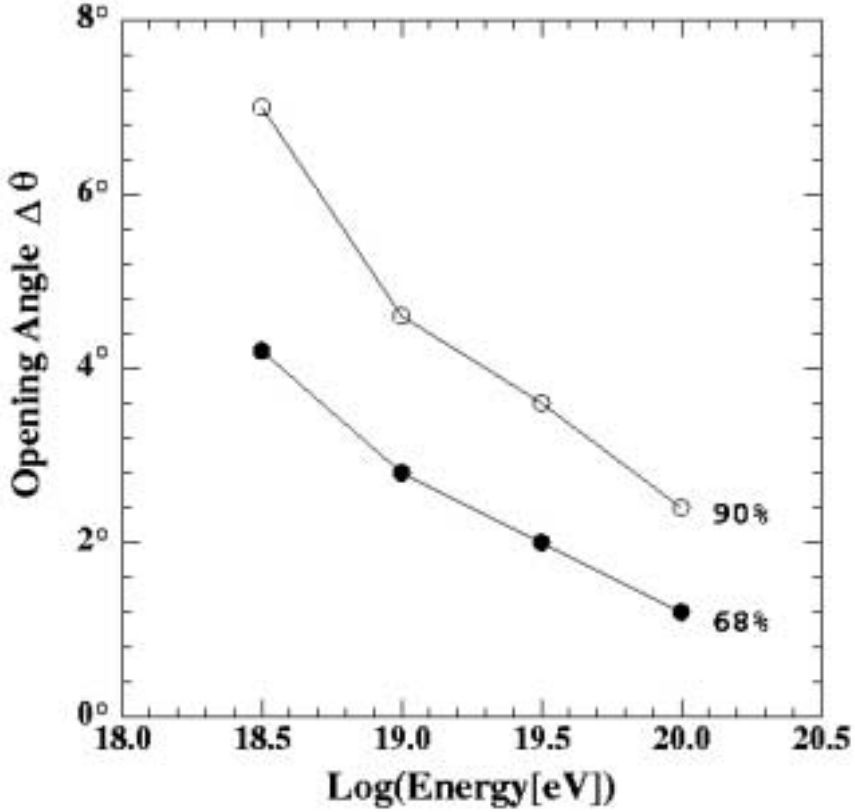
The Higher the energy, the quality of data become better!!

40 detecters were hit

Energy Resolution



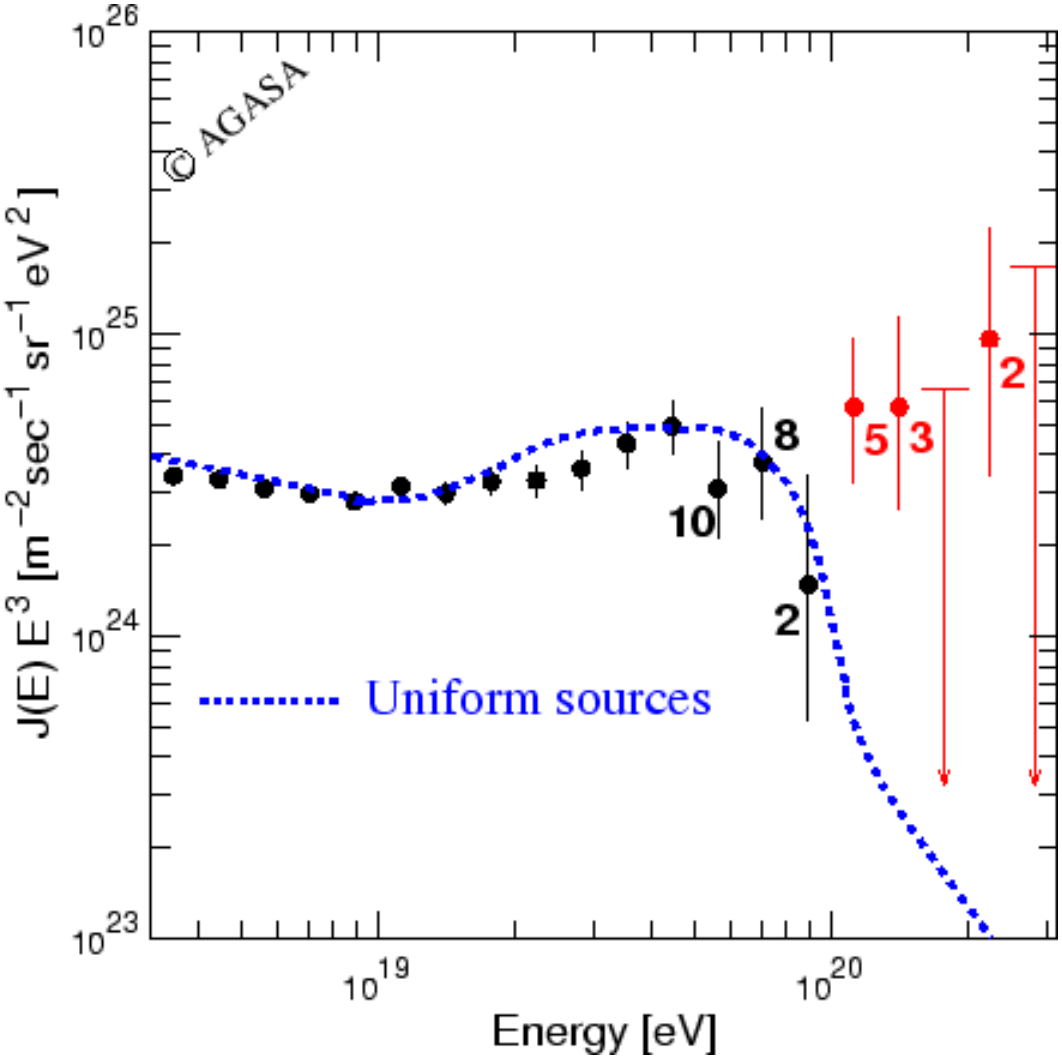
Angular Resolution



Major Systematics in AGASA

Energy Estimator S600	
Interaction Model	10%
Chemical Composition (P/Fe)	10%
Simulation Code	5%
Detector	
Detector Abs. Gain	3%
Detector Linearity	3%
Detector Response (Box Housing etc)	5%
Total	17%

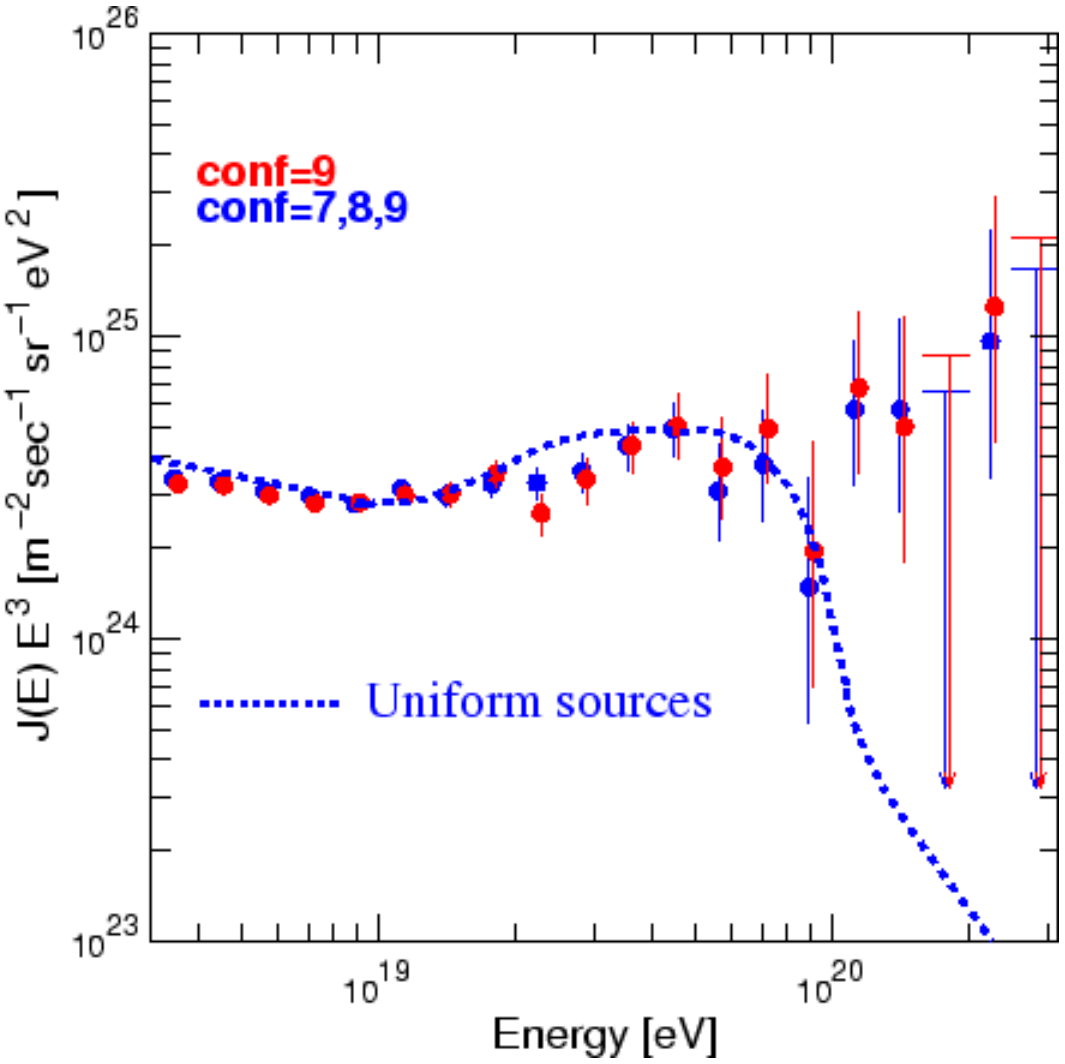
Energy Spectrum by AGASA (θ<45)



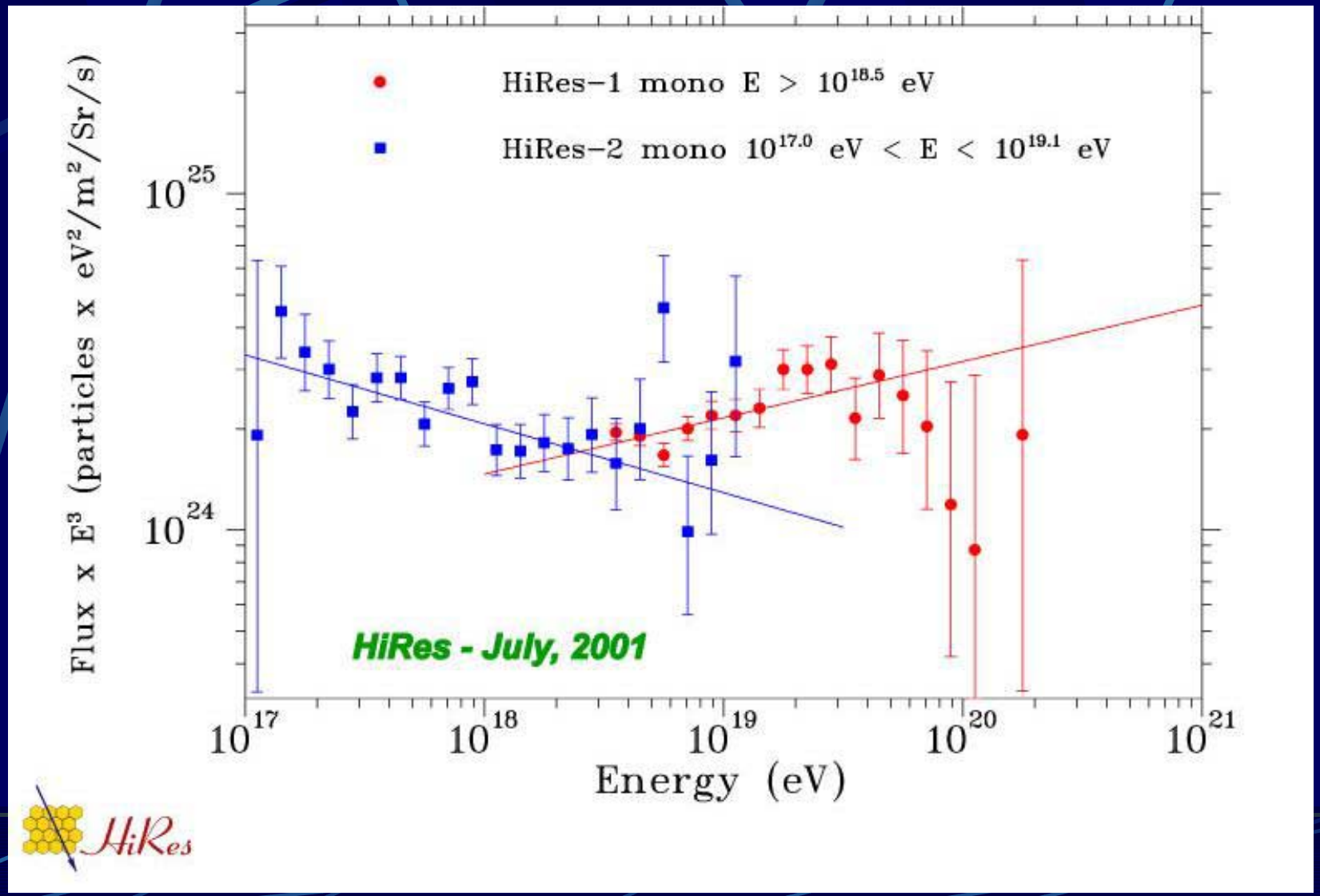
The Energy spectrum by AGASA

Red: Fully contained event

(Cut the event near the boundary of array)

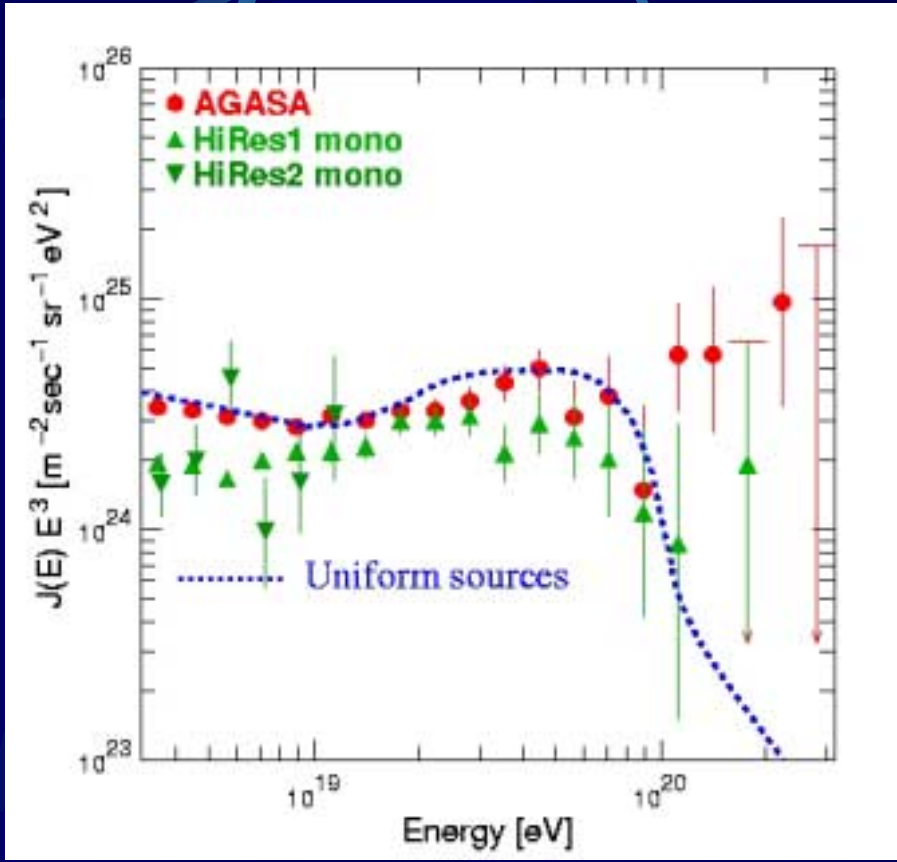


HiRes I mono, HiRes II mono Energy Spectrum

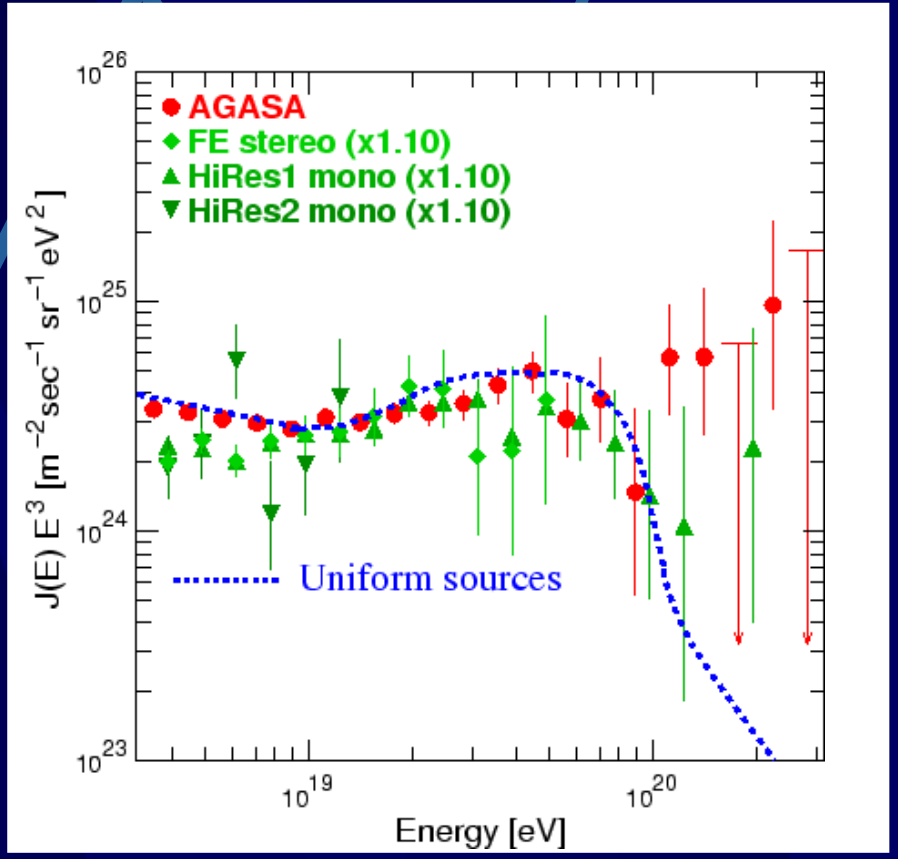


AGASA vs. HiRes I mono, HiRes II mono

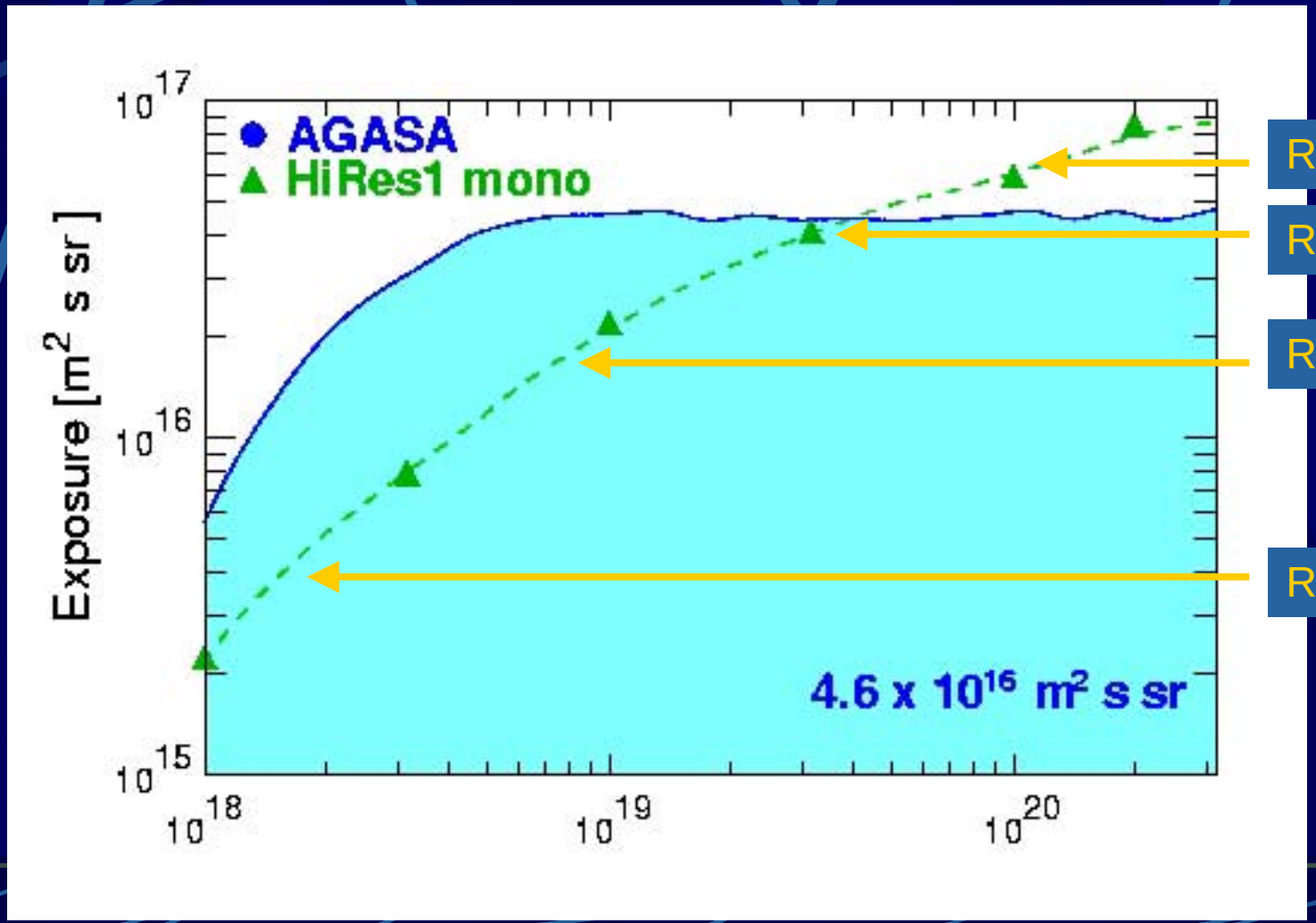
Original AGASA + Original HiRes



Original AGASA + HiRes x 1.1



Comparison of aperture



Possible Systematics in HiRes

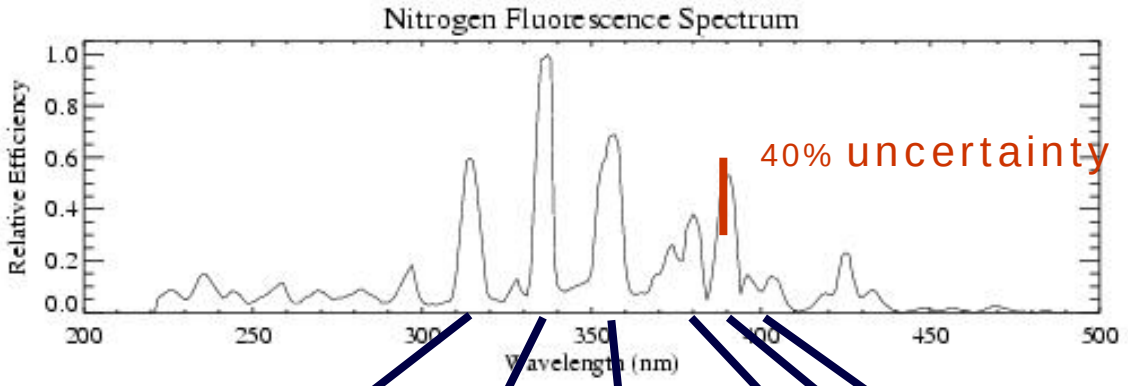
- Detector Constant
  - Mirror Reflection / PMT gain / Photo-cathod uni.
- Air Fluorescence yield
  - Total yield is known with 10% accuracy
  - Yields of individual lines are not known well
- Light transmission in air
  - Rayleigh Scattering ($\propto \lambda^{-4}$)
  - Mie Scattering by Aerogel
    - Horizontal attenuation, Scale Height
    - Wind velocity, Temperature
  - Horizontal 14km (1999) → 20km (2001)
- Errors in Mono analysis

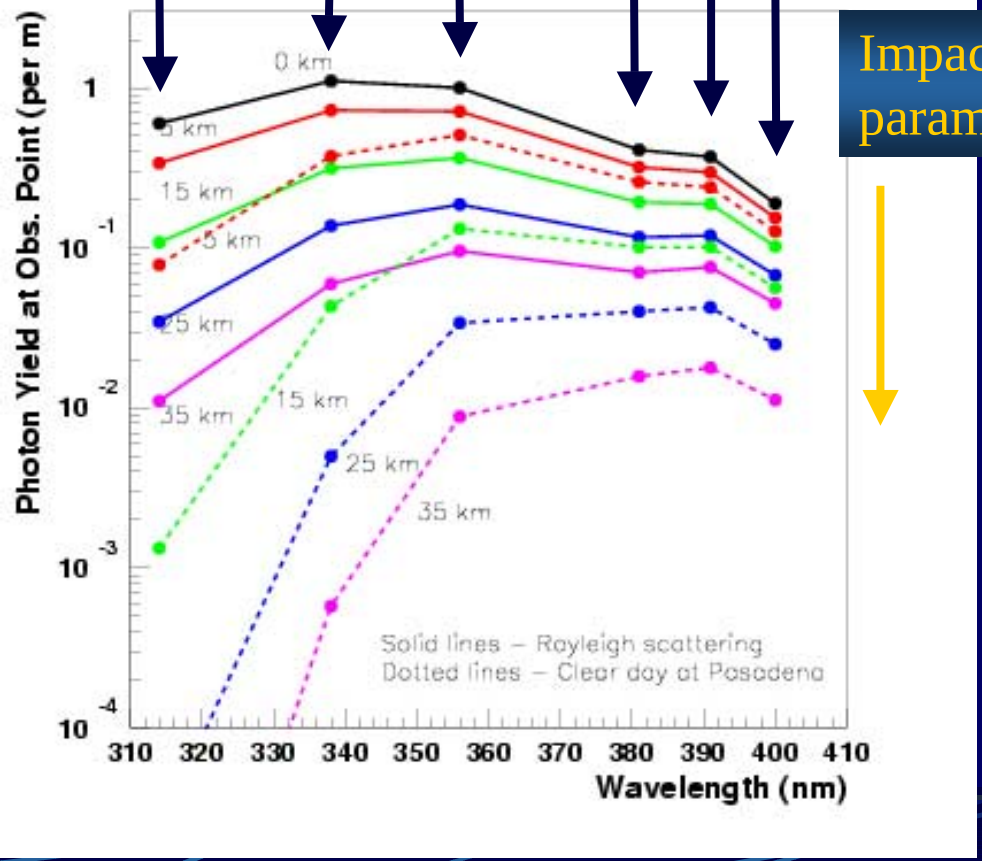
Air Fluorescence yield Measurement

1. Bunner
2. Kakimoto et al
3. Nagano et al

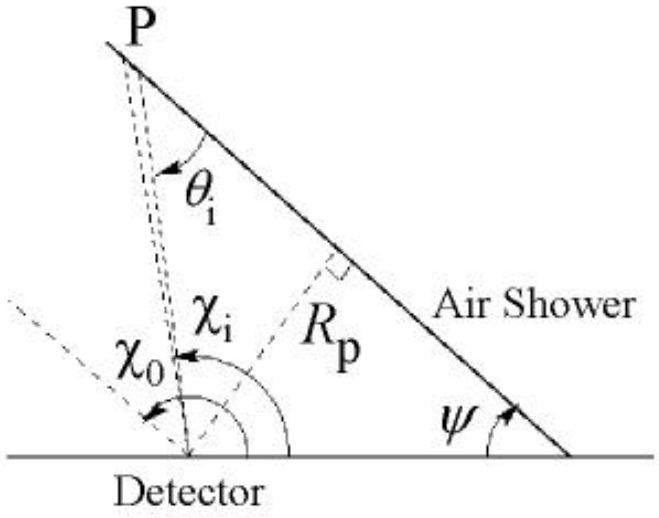
Rayleigh Scattering

$\propto \lambda^{-4}$





Mono Reconstruction



Fit: $t_i = t_0 + (R_p/c)\ tan(\chi_0/2 - \chi_i/2)$

- Timing analysis
  - Degeneracy between Rp and ψ
- Xmax fit or Shower Profile fit was introduced
  - Possible systematic
    - chemical composition and Interaction dependent
    - Atmospheric correction dependent

The problems in both experiments

- AGASA
  - Energy estimation is dependent on Monte Carlo
    - Calibration by Air Fluorescence detector will be done in this winter with 4 x $3m^2$ Shcmidt type telescopes (2sr FOV)
- HiRes
  - Atmosphere
    - More detail atmospheric monitoring should be done in online. For example, measure the extinction between the telescope and the shower track.
  - Detail air fluorescence yield measurement is highly required especially for 391nm line.
  - Stereo Spectrum is really desired (Mono analysis may introduce systematic errors)