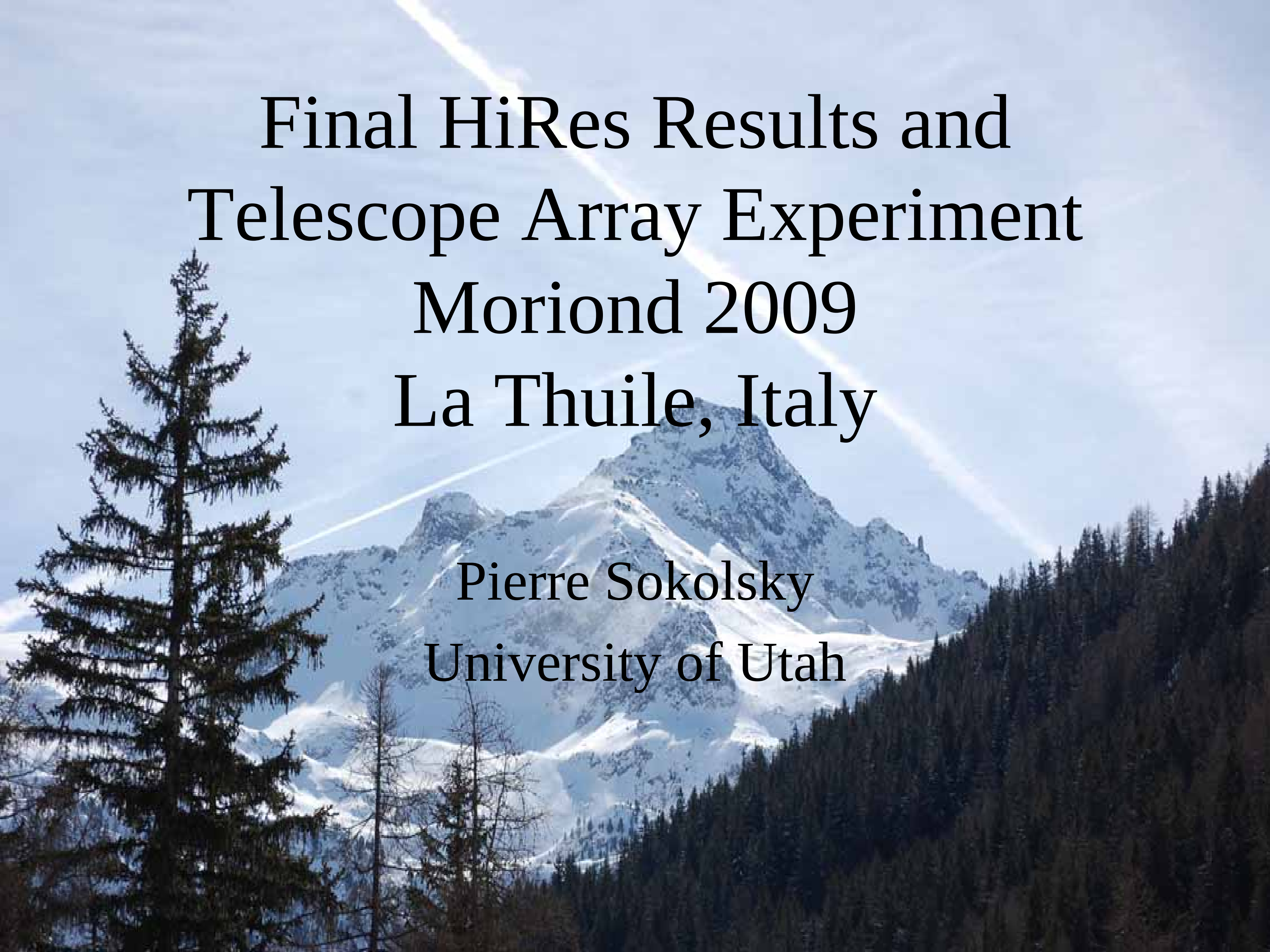
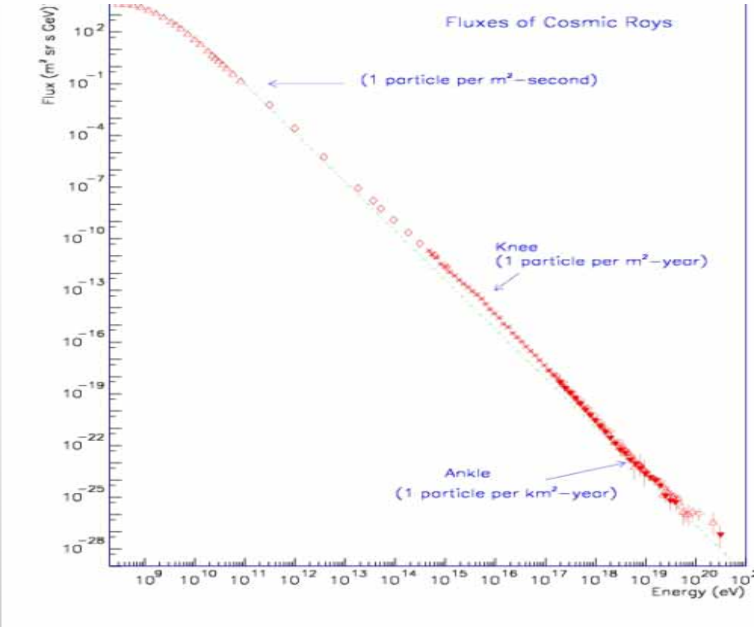
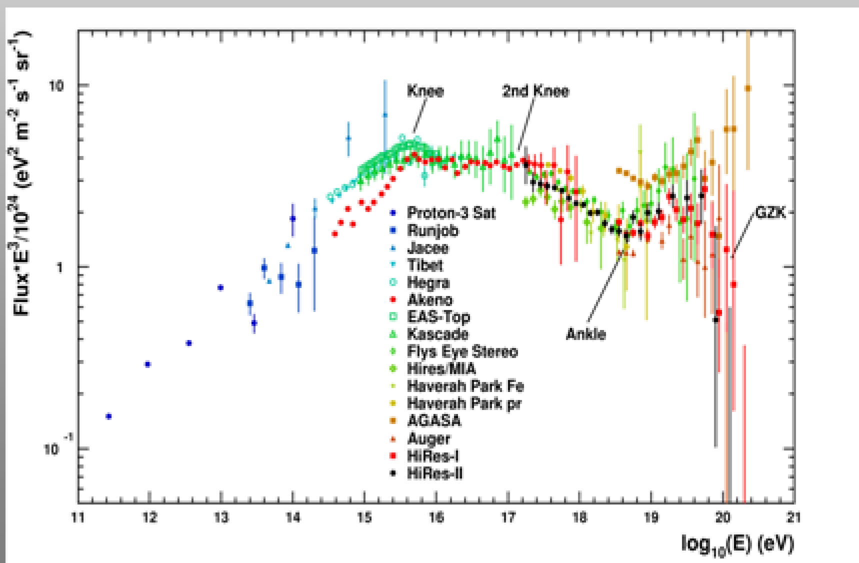


Final HiRes Results and Telescope Array Experiment

Moriond 2009
La Thuile, Italy

Pierre Sokolsky
University of Utah



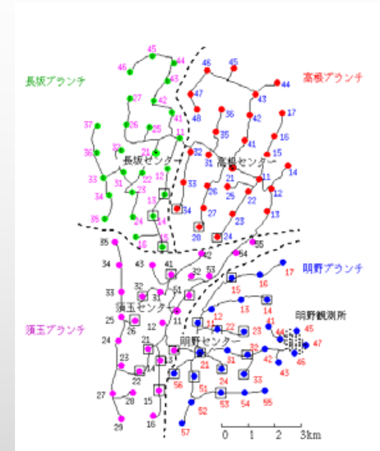


Cosmic Ray Spectrum
Exhibits significant
Structure

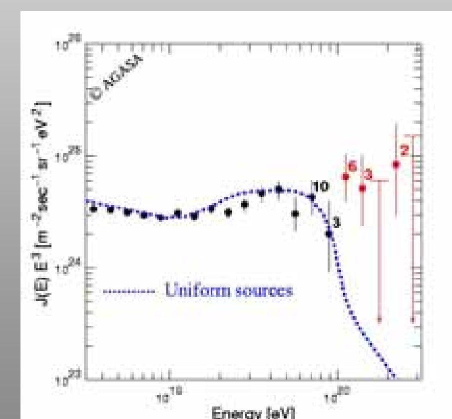
Structure reflects cosmic
Ray origin and propagation

GZK cutoff restricts max
Energy of cosmic rays
On earth

Controversy over its
existence



- Predicted in 1966 by K. Greisen, G. Zatsepin, and V. Kuzmin.
- Photons of CMBR interact with cosmic ray protons of extragalactic origin.
- Photoproduction of pions; Δ resonance is near threshold. for 6 x 10^{19} eV protons.
- Pion carries away 20% of proton's energy ➔ strong energy-loss mechanism for protons that travel > 50 Mpc.
- Causes a strong break in the spectrum if sources are distant.
- Should occur at about $6x10^{19}$ eV (10J) if Sources ~ universally distributed



AGASA spectrum

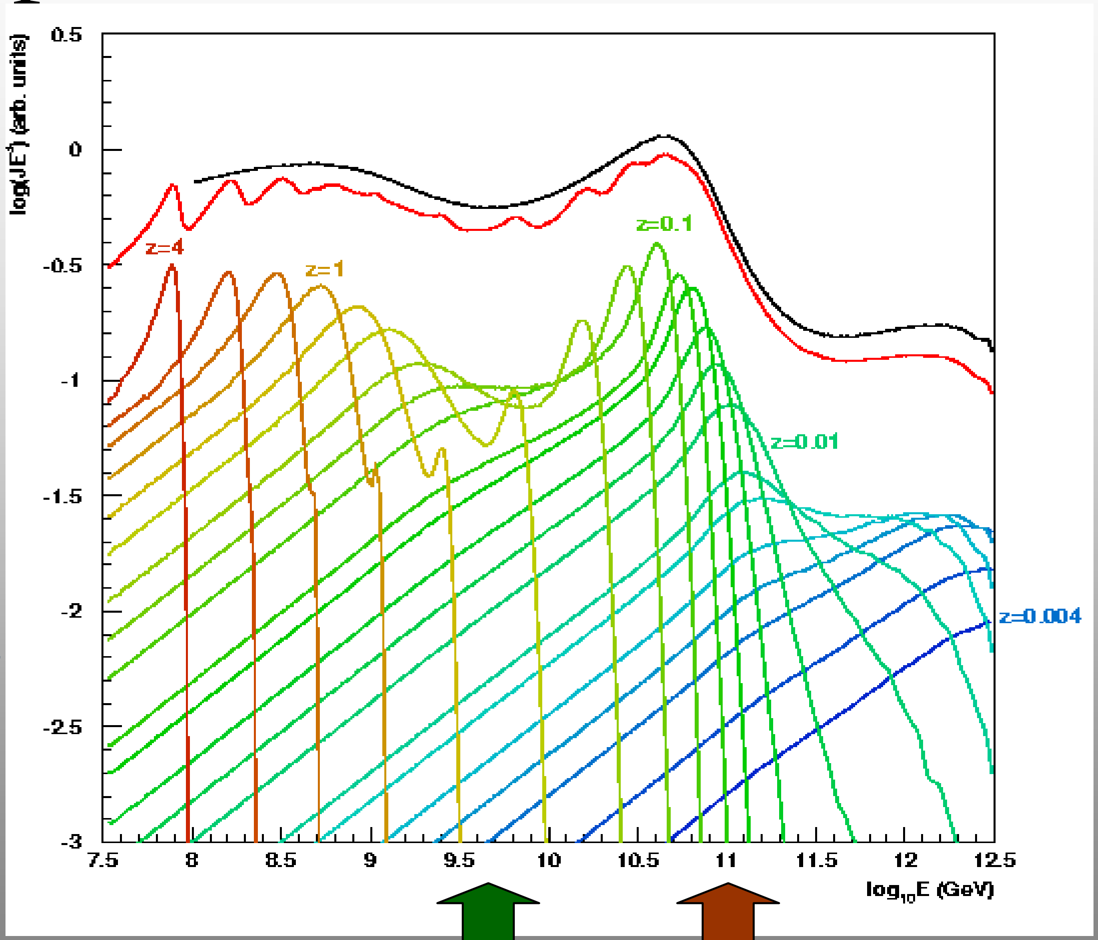
Contributions to Extra-galactic spectrum

The extra-galactic cosmic ray **spectrum fractionates with source red shift Additional e+ e- energy loss mechanism produces Ankle**

$p + \gamma_{CMB} \rightarrow \Delta(1232) \rightarrow \pi + N$

$\pi^{\pm} \rightarrow \mu^{\pm} + \nu_{\mu}$

$\mu^{\pm} \rightarrow e^{\pm} + \nu_{e} + \nu_{\mu}$



Ankle

GZK Cutoff

High Resolution Fly's Eye Collaboration:

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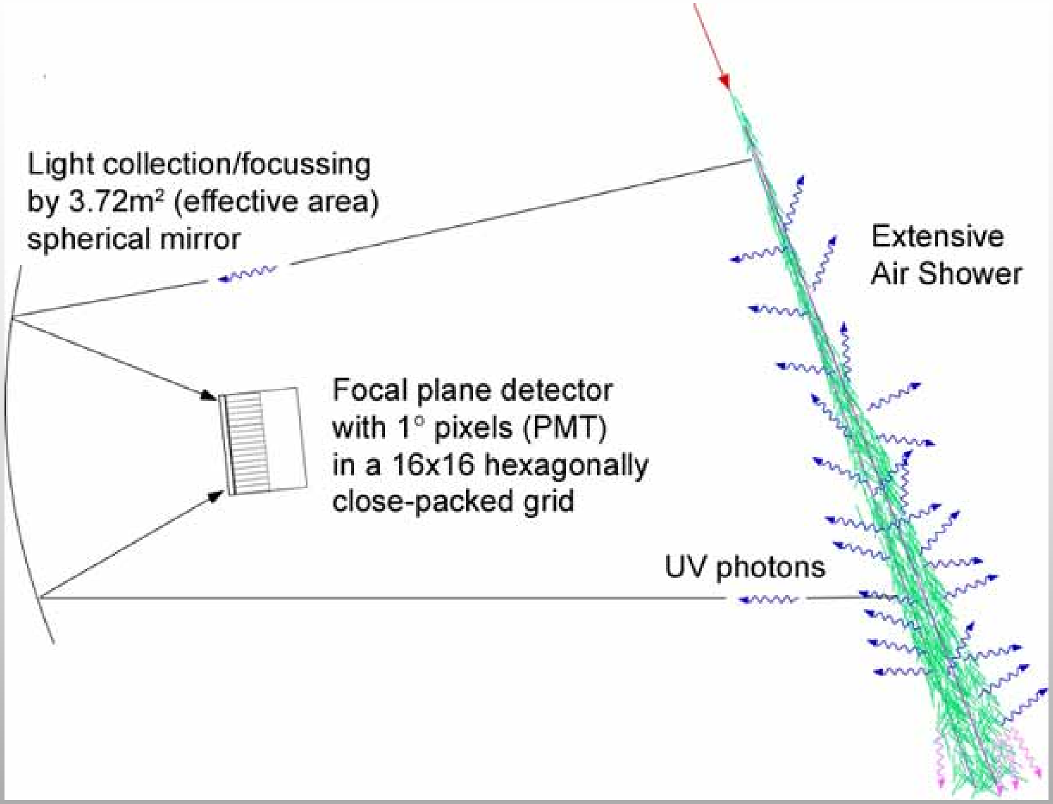
University of Utah

Until recently, HiRes was located on the U.S. Army's Dugway Proving Ground, ~2 hours south-west of the University of Utah

- HiRes1: @ Five Mile Hill (aka Little Granite Mountain)
- 21 mirrors, 1 ring (3^0<altitude<17^0)
- Sample-and-hold electronics (pulse height and trigger time)

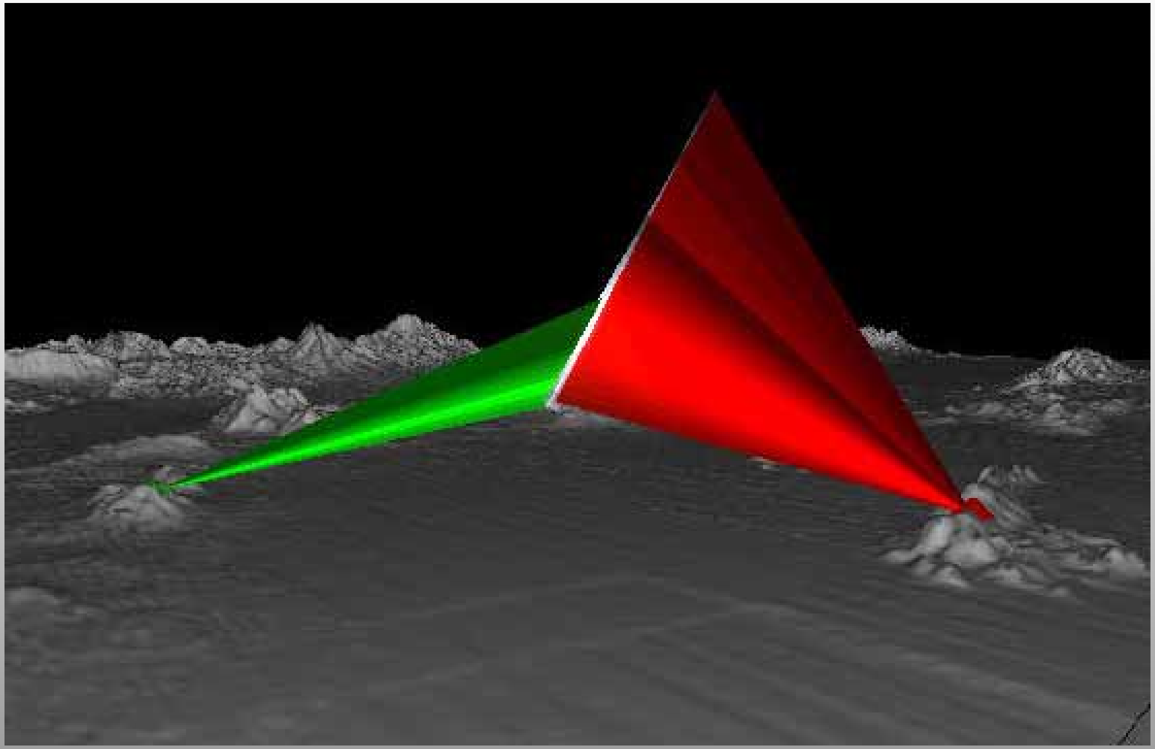
- HiRes2: @ Camel's Back Ridge 12.6 km south-west of HiRes1.
- 42 mirrors, 2 rings (3^0<altitude<31^0)
- FADC electronics (100 ns period)

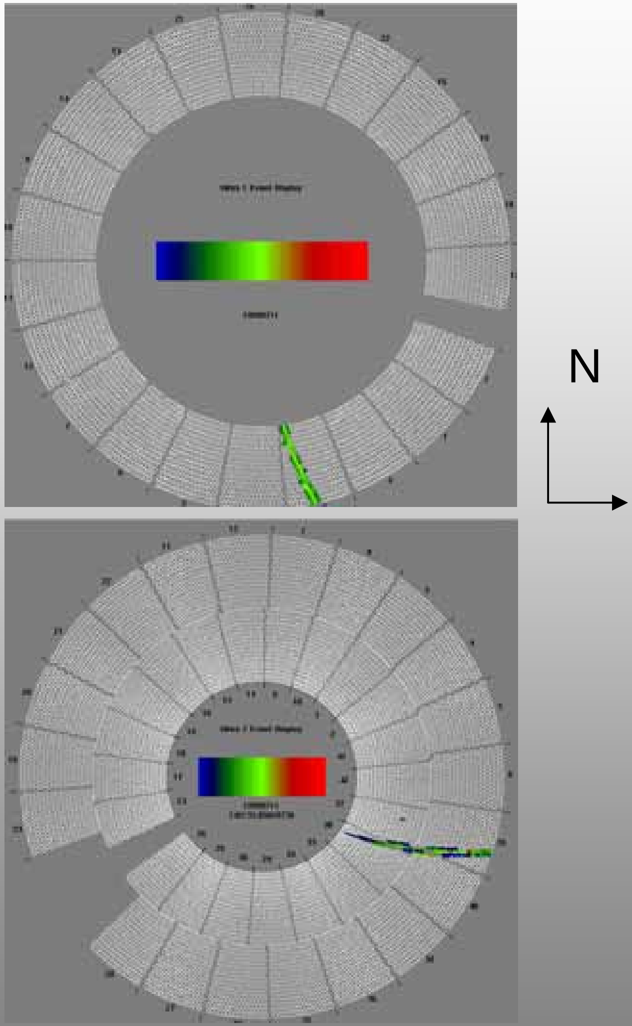
Detector Design



- UV-filter (300-400 nm band pass) to reduce sky+ambient background light
- Steel housing (2 mirrors each) with motorized garage doors

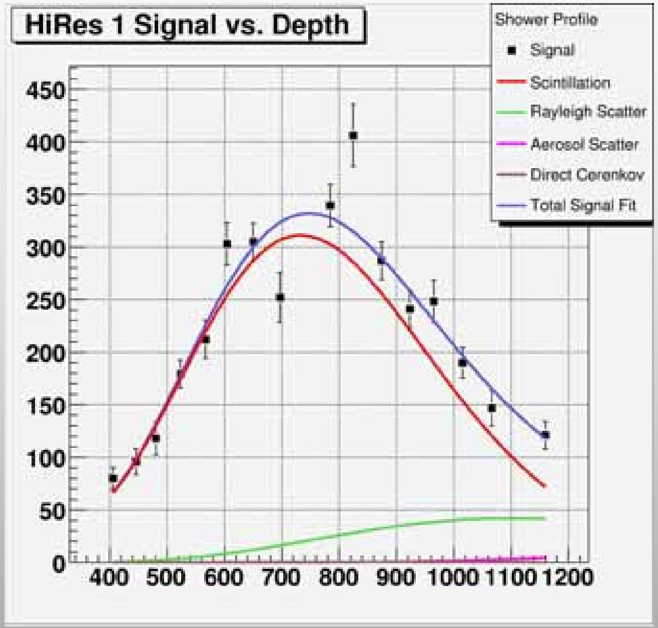
Typical HiRes Stereo Event

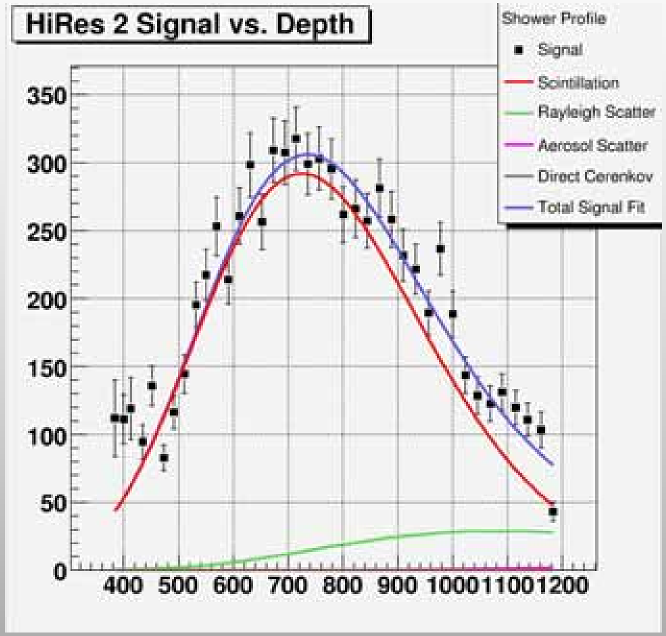




- $\sim 2\times10^{19}$ eV event
- (3**×** vertical scale)

Measured Shower Profile





Measured shower parameters.

Event by event:

- X_{max} in g/cm^2;
- Total energy of the primary particle:
- Arrival direction

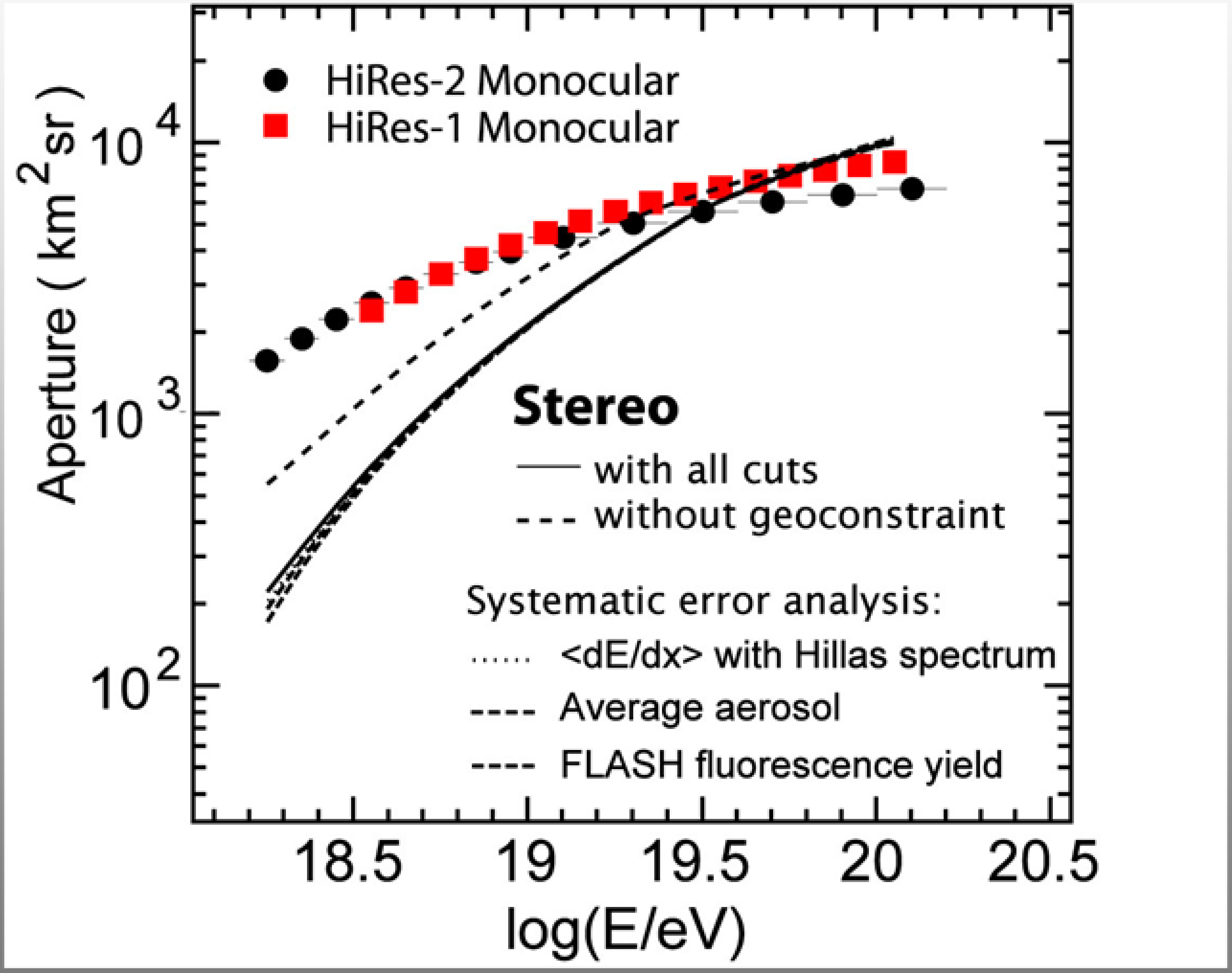
Statistically:

- Mass composition
- *p*-air inelastic cross-section

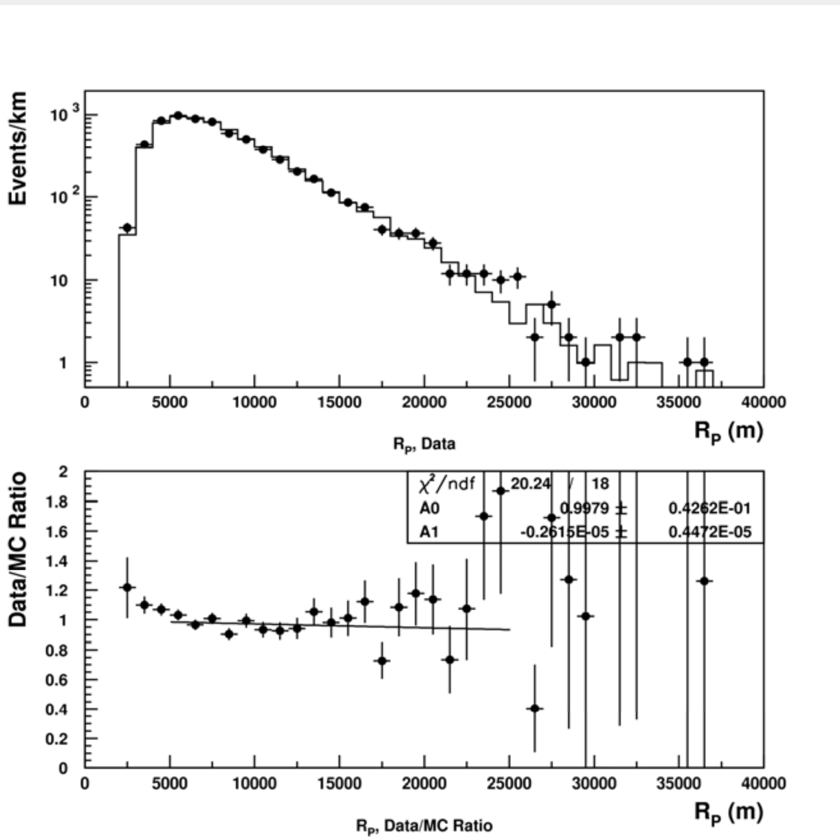
HiRes Spectrum

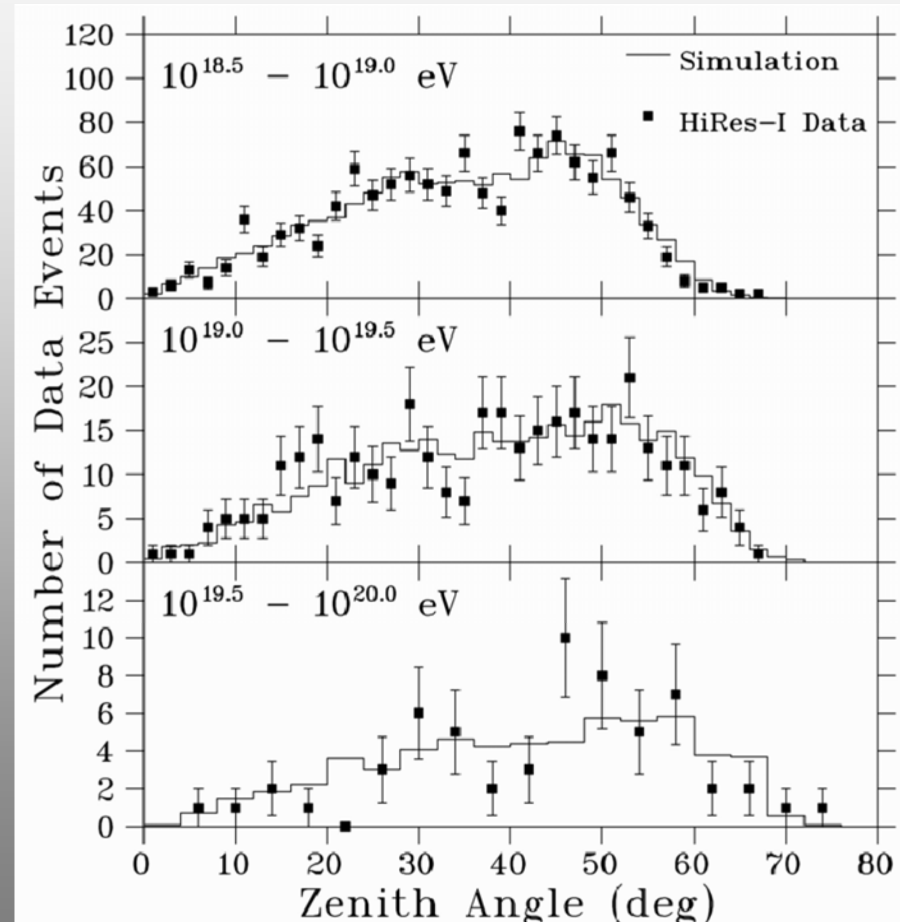
- Monocular spectra - HiRes I and II
- HiRes I - largest statistics, limited elevation angle viewing = high threshold energy
- HiRes II - best low energy response
- Stereo spectrum - best geometrical and energy resolution

Monocular and Stereo Aperture



Data/MC Comparison(mono)





Stereo Geometrical Resolution

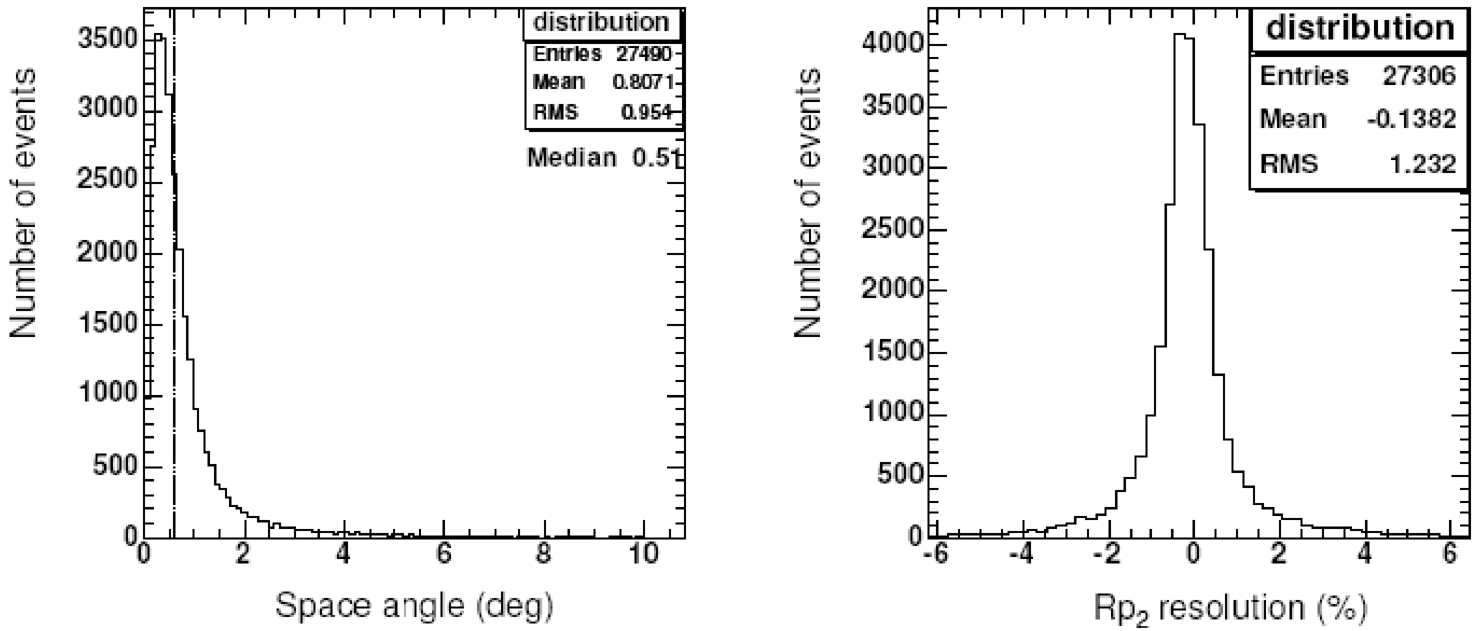


FIG. 5: Resolution functions of geometrical parameters. Left panel is the arrival direction resolution presented as the space angle between the reconstructed and known shower directions. The vertical dashed line indicates the median value of the distribution. Right panel is the R_p resolution showing a reconstruction accuracy of about 1.2%.

Stereo Energy Resolution

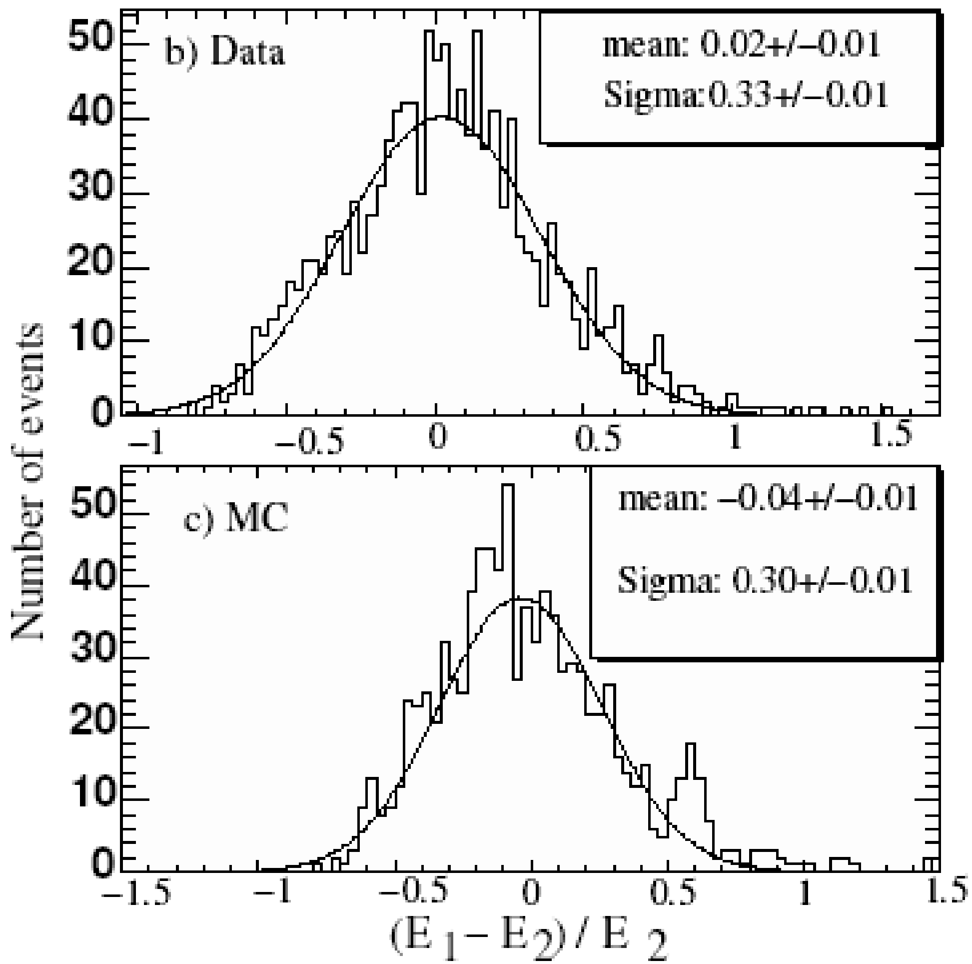
With Stereo Measurements, you have redundant measurements of Xmax and Energy

HR2 Energy

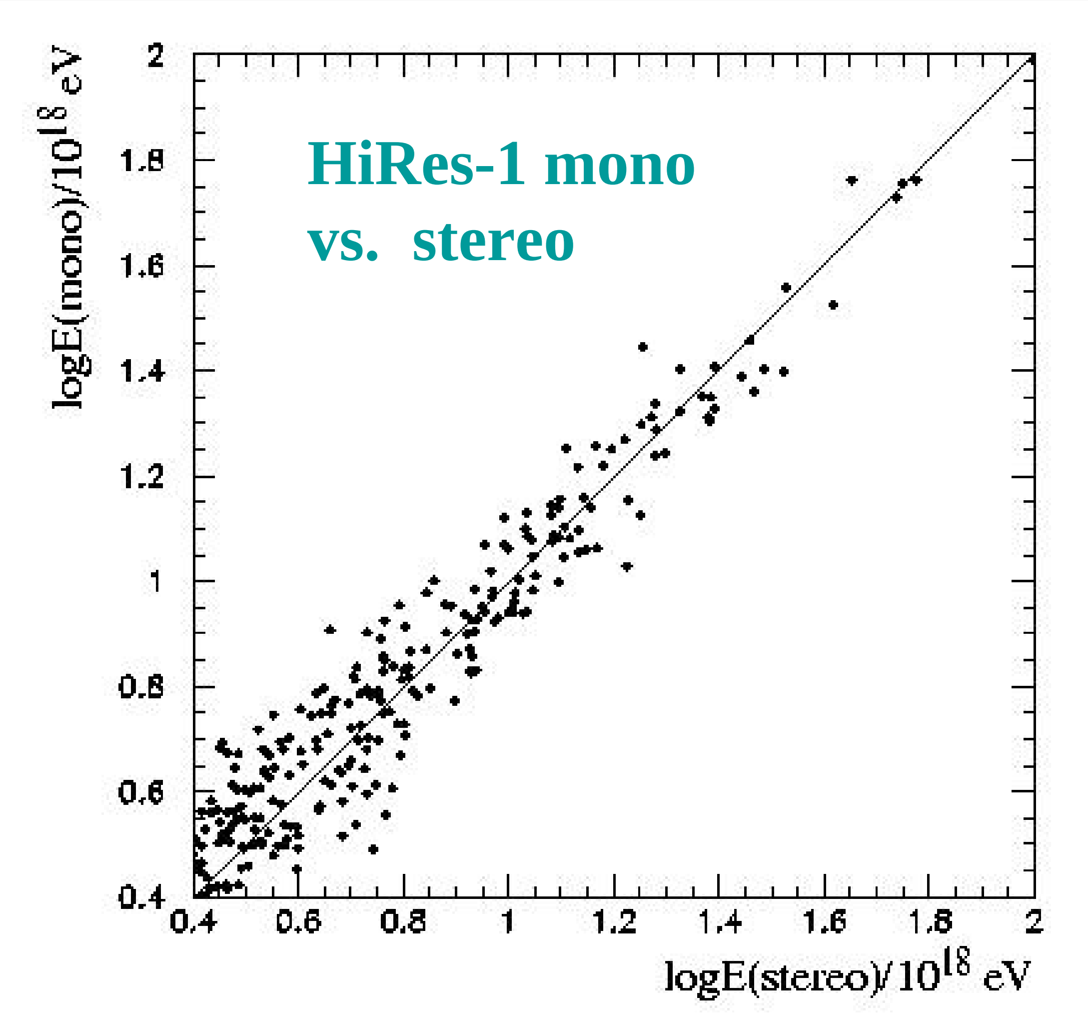
Resolution 15%

Systematic

17%



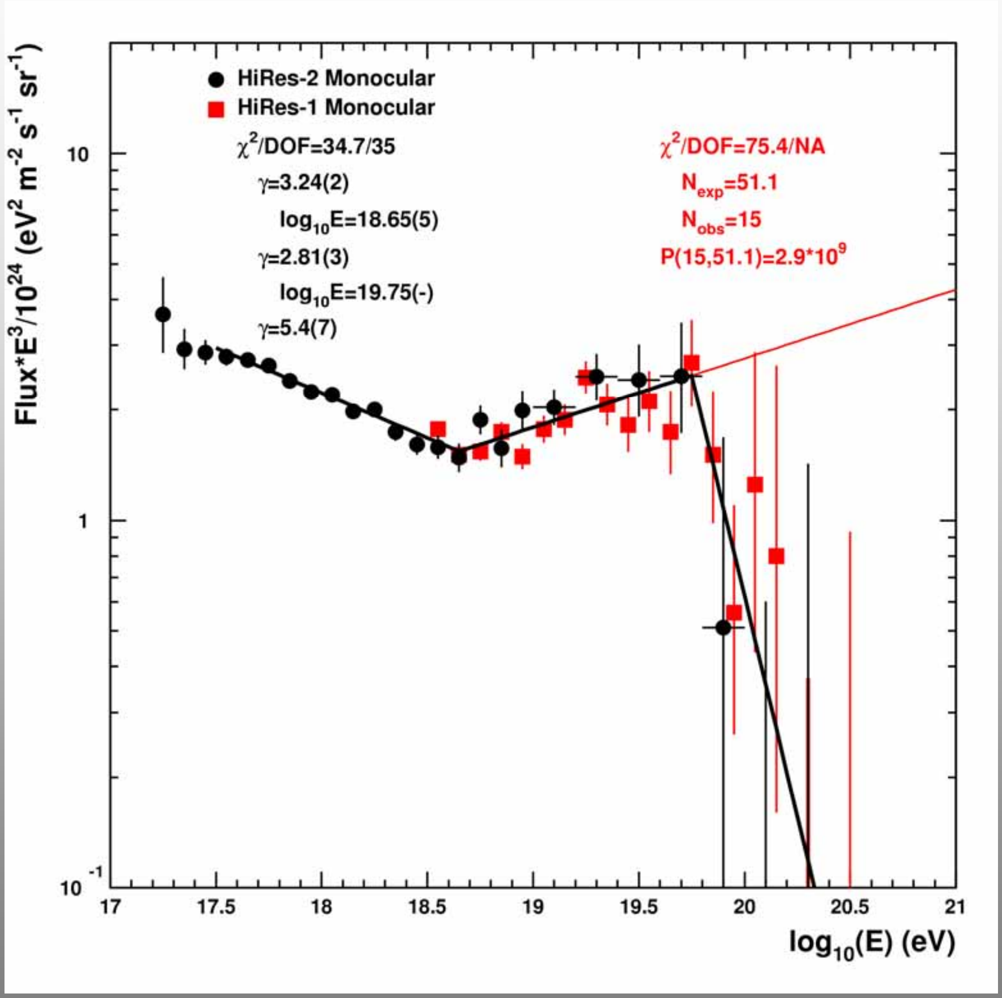
Mono versus Stereo Energy Measurements



The HiRes monocular energy is in excellent agreement with stereoscopic measurements !

5σ Observation of the GZK Suppression (mono)

- **Broken Power Law Fits (independent data)**
  - No Break Point
    - χ^2/DOF = 162/39
  - One BP
    - χ^2/DOF = 63.0/37
    - BP = 18.63
  - Two BP's
    - χ^2/DOF = 35.1/35
    - 1st BP = 18.65 +/- .05
    - 2nd BP = 19.75 +/- .04
  - BP with Extension
    - Expect 43.2 events
    - Observe 13 events
    - Poisson probability:P(15;51.1)= 7**x10^{-8}**(5.3σ)



First Observation of the Greisen-Zatsepin-Kuzmin Suppression

R.U. Abbasi,[1] T. Abu-Zayyad,[1] M. Allen,[1] J.F. Amman,[2] G. Archbold,[1] K. Belov,[1] J.W. Belz,[1] S.Y. Ben Zvi,[3] D.R. Bergman,[4,*] S.A. Blake,[1] O.A. Brusova,[1] G.W. Burt,[1] C. Cannon,[1] Z. Cao,[1] B.C. Connolly,[3] W. Deng,[1] Y. Fedorova,[1] C.B. Finley,[3] R.C. Gray,[1] W.F. Hanlon,[1] C.M. Hoffman,[2] M.H. Holzscheiter,[2] G. Hughes,[4] P. Hüntemeyer,[1] B.F Jones,[1] C.C.H. Jui,[1] K. Kim,[1] M.A. Kirn,[5] E.C. Loh,[1] M.M. Maestas,[1] N. Manago,[6] L.J. Marek,[2] K. Martens,[1] J.A.J. Matthews,[7] J.N. Matthews,[1] S.A. Moore,[1] A. O'Neill,[3] C.A. Painter,[2] L. Perera,[4] K. Reil,[1] R. Riehle,[1] M. Roberts,[7] D. Rodriguez,[1] N. Sasaki,[6] S.R. Schnetzer,[4] L.M. Scott,[4] G. Sinnis,[2] J.D. Smith,[1] P. Sokolsky,[1] C. Song,[3] R.W. Springer,[1] B.T. Stokes,[1] S.B. Thomas,[1] J.R. Thomas,[1] G.B. Thomson,[4] D. Tupa,[2] S. Westerhoff,[3] L.R. Wiencke,[1] X. Zhang,[3] and A. Zech[4]

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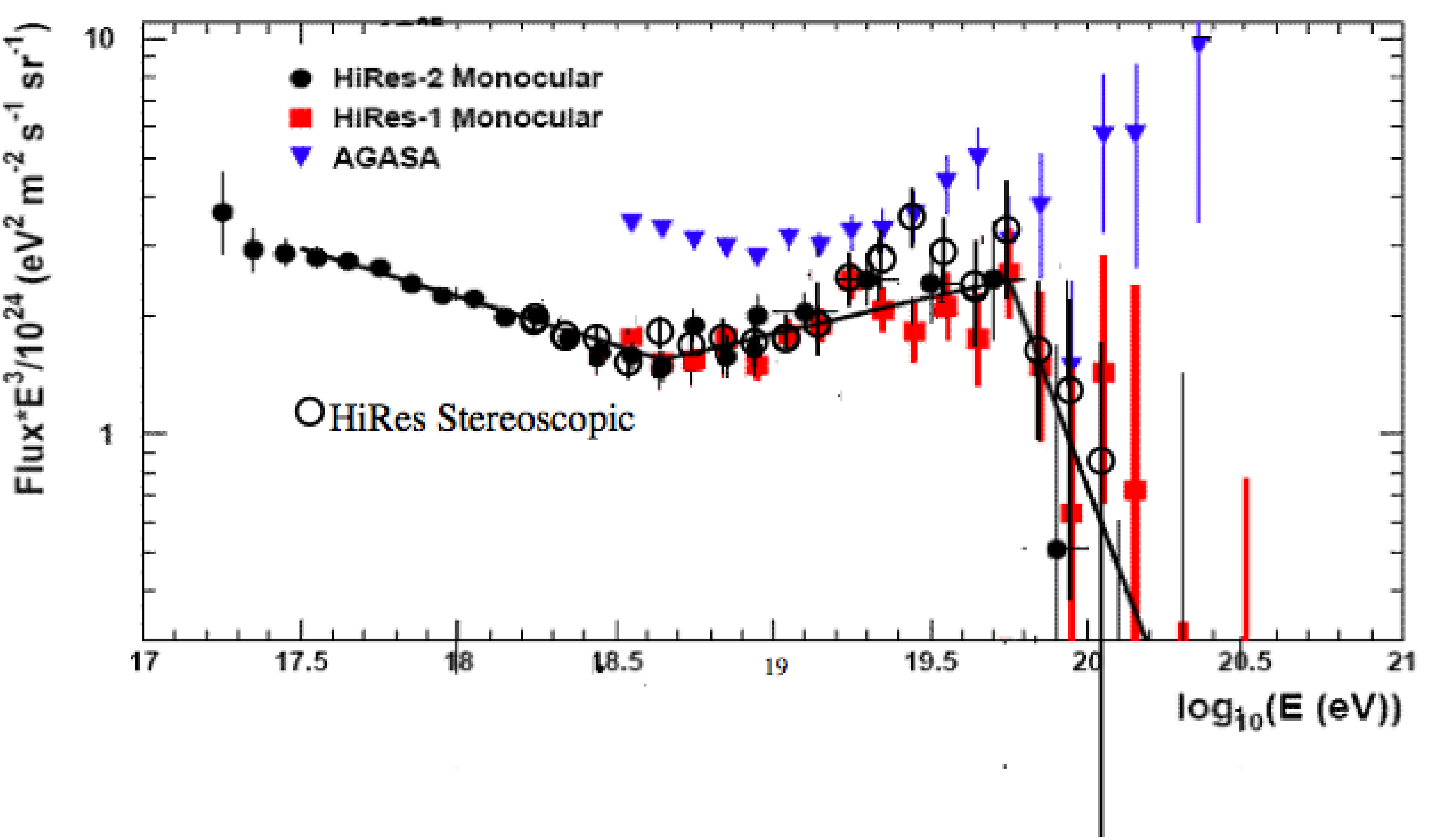
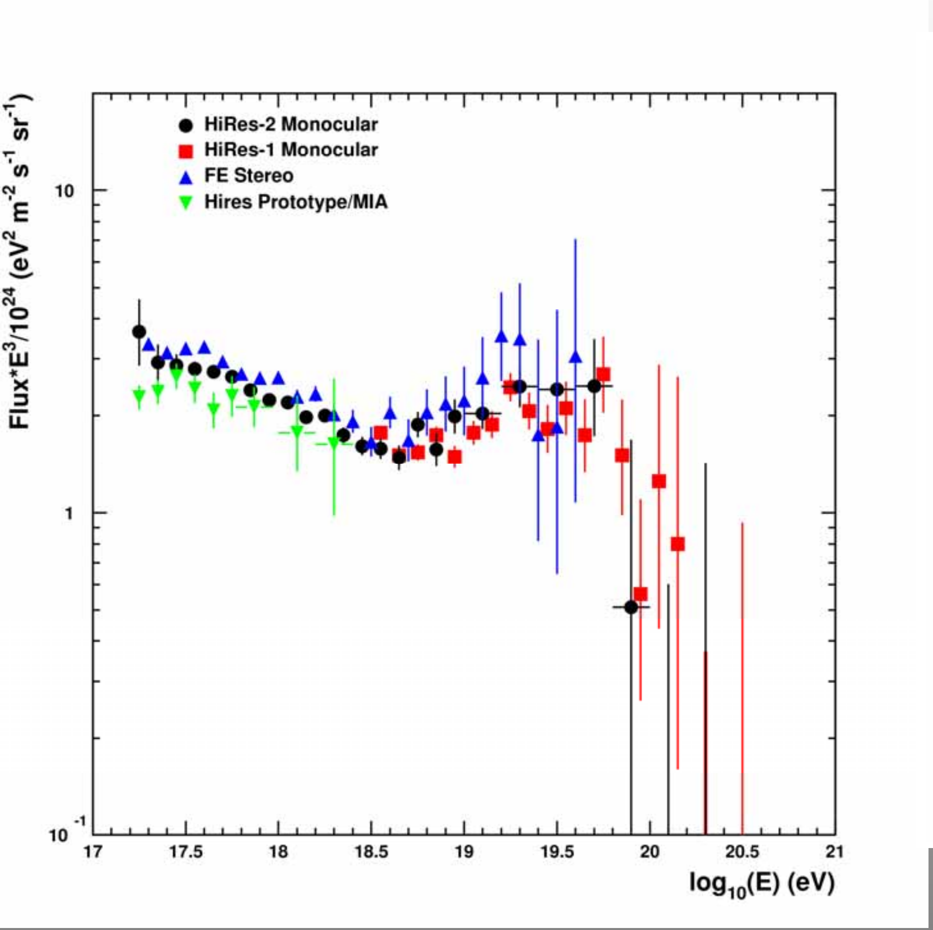
The High Resolution Fly's Eye (HiRes) experiment has observed the Greisen-Zatsepin-Kuzmin suppression (called the GZK cutoff) with a statistical significance of five standard deviations. HiRes' measurement of the flux of ultrahigh energy (UHE) cosmic rays shows a sharp suppression at an energy of 6×10^{19} eV, consistent with the expected cutoff energy. We observe the "ankle" of the cosmic-ray energy spectrum as well, at an energy of 4×10^{18} eV. We describe the experiment, data collection, analysis, and estimate the systematic uncertainties. The results are presented and the calculation of the statistical significance of our observation is described.

PACS numbers: 98.70.Sa, 95.85.Ry, 96.50.sb, 96.50.sd

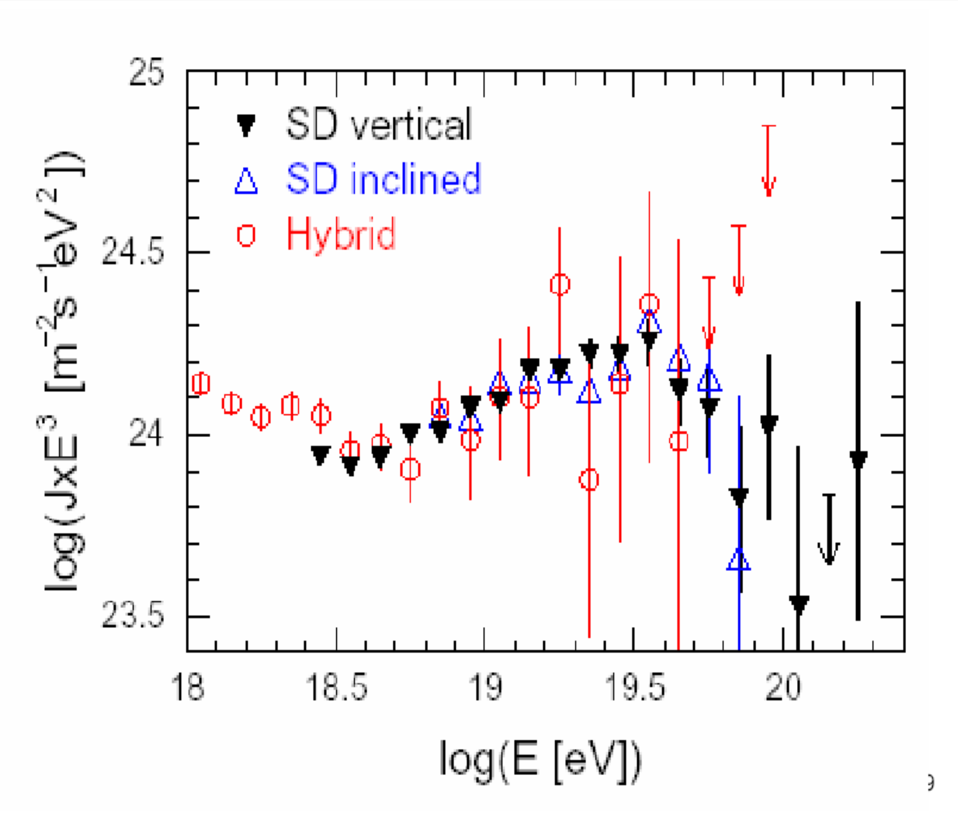
Stereo spectrum shows 3.8 sigma GZK cutoff in good agreement with mono result



HiRes and Other Experiments



HiRes, Fly's Eye Stereo, and HiRes/MIA



PAO Experiment

Composition

- Simulate p, CNO, Fe interactions using:

Hadronic models QGS-Jet, Sybill, etc..

Generate simulated data – Corsika + detector simulator

Assume a mass compostion

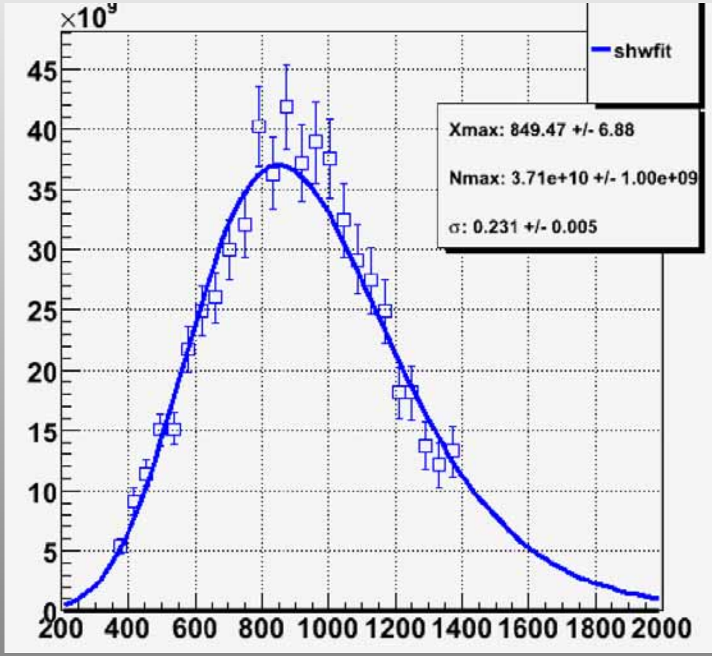
Compare simulated data to real data

Xmax distribution, mean and fluctuations

All carry composition information

How is Xmax defined?

- Generate CORSIKA showers in atmosphere
- Define Xmax numerically or by fitting
- “spline” numerical fit - previously used
- Gaisser-Hillas functional form - fit to simulation and data
- Gaussian-in-age functional form
- We now use Gaussian-in-age(GIA) for both real and simulated showers



Gaus-in-age fit

Xmax resolution

proton

Iron

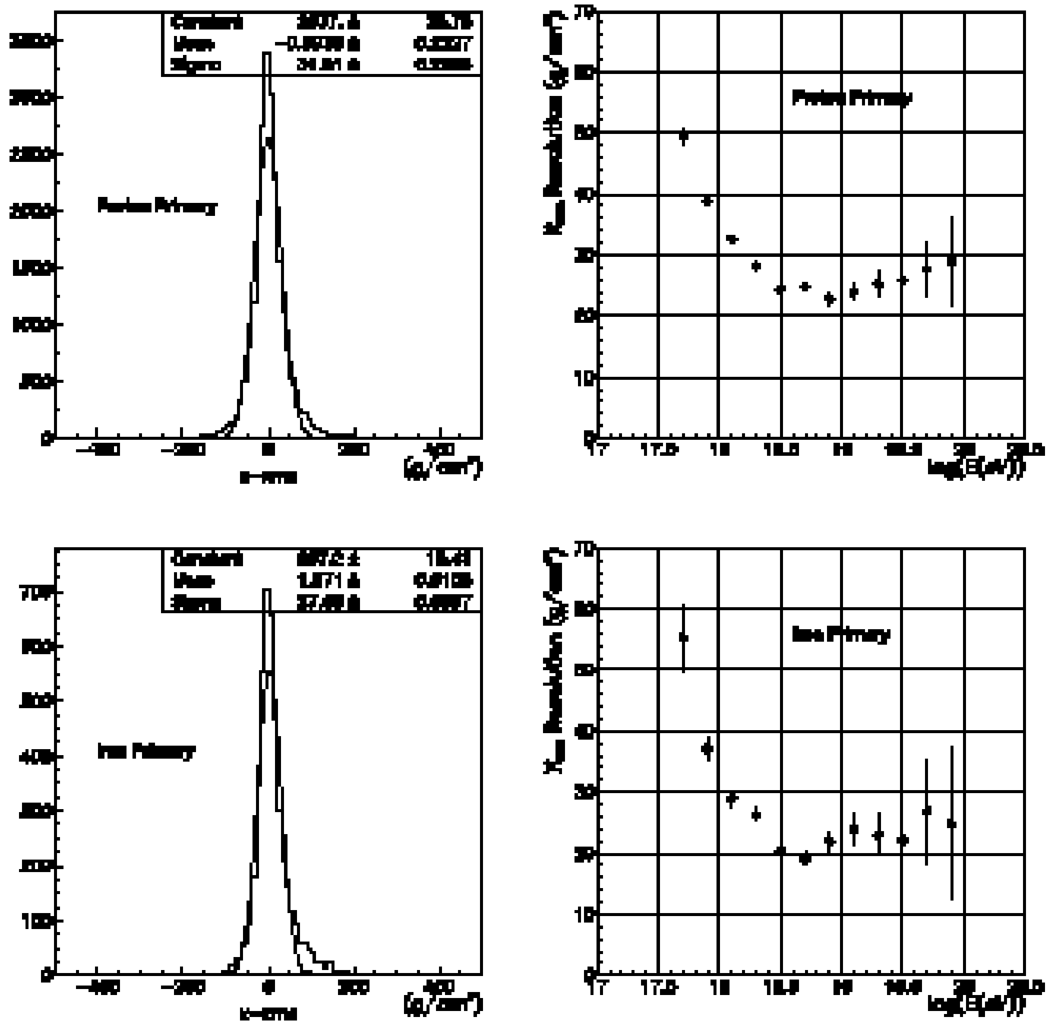
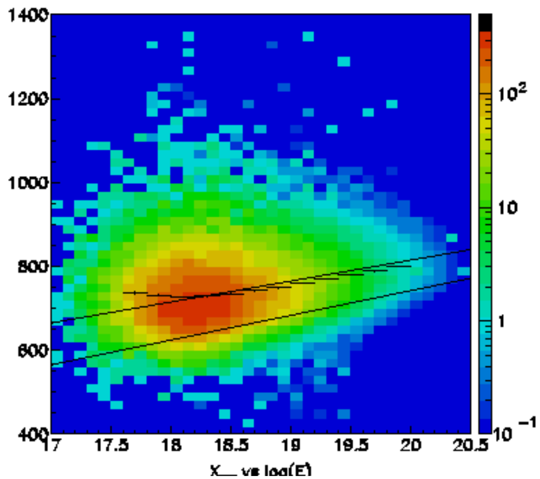


Figure 14: Left; X_{max} resolution in the present analysis. A histogram is formed of reconstructed minus generated X_{max} for all events. Resolution is defined as the width from an untruncated Gaussian fit to the histogram. Right; Resolution as a function of $\log(E)$.



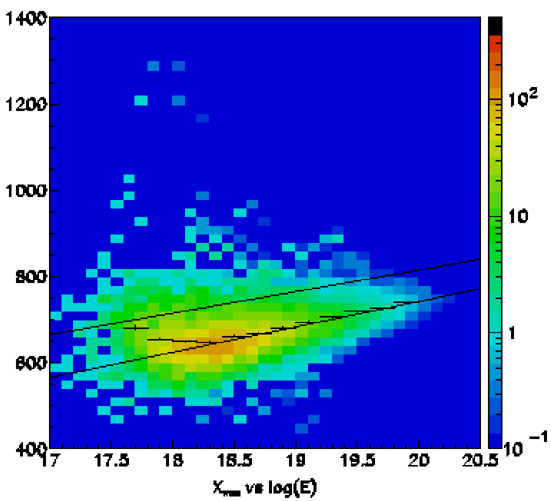


Figure 17: X_{max} versus energy distribution for the CORSIKA/QGSJET01 iron MC. No energy range restrictions or acceptance corrections have been applied to the samples. Superimposed (crosses) is the mean value of X_{max} in each energy bin, with uncertainty given by $RMS/\sqrt{n}$. Proton and iron rails are taken from Gaussian-in-age fits to shower library. (See also Figure 2.)

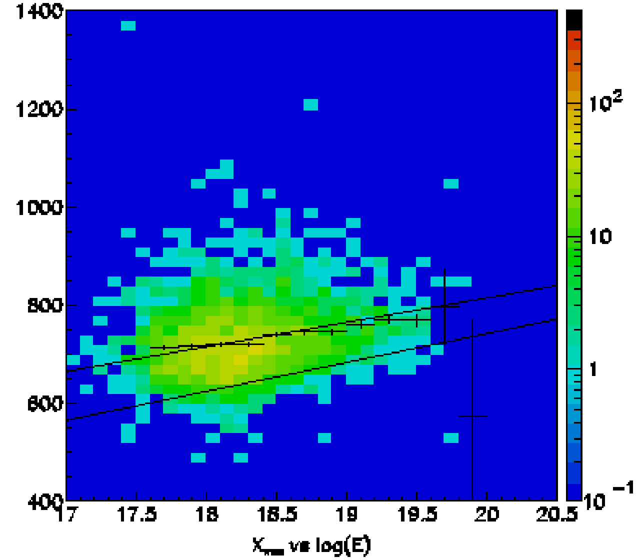


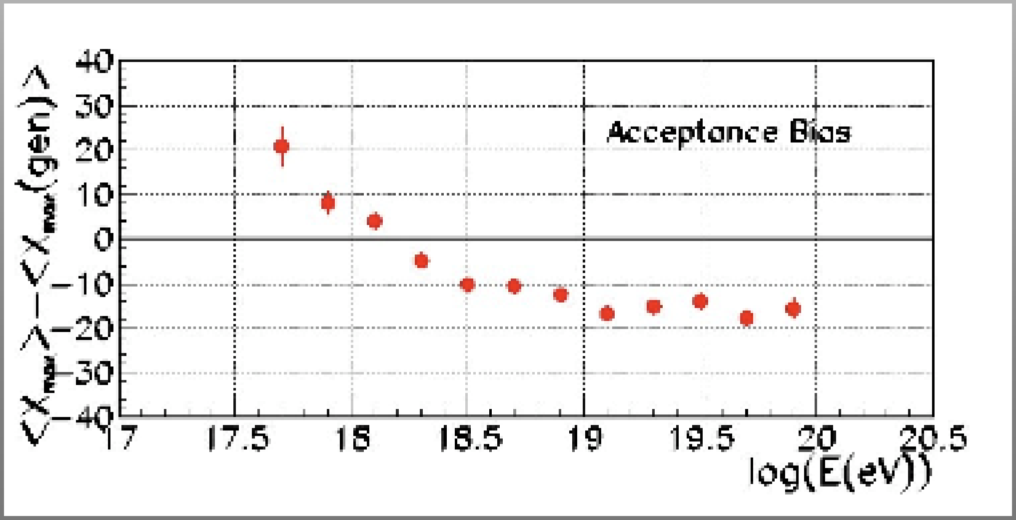
Figure 15: X_{max} versus energy distribution for the HiRes stereo data. No energy range restrictions or acceptance corrections have been applied to the samples. Superimposed (crosses) is the mean value of X_{max} in each energy bin, with uncertainty given by $RMS/\sqrt{n}$. Proton and iron rails are taken from Gaussian-in-age fits to shower library. (See also Figure 2.)

Data

Comparison of proton and Fe Xmax distributions, CORSIKA QGSJET-I Showers “as detected” by HiRes. Minimal cuts

Reconstruction vs Acceptance Biases

- After Energy, Rp and zenith angle cuts, no significant reconstruction biases persist.
- Acceptance bias for protons shifts mean Xmax by ~ 10 gm/cm2 ***shallower*** in atmosphere. Correct this using Corsika proton MC.



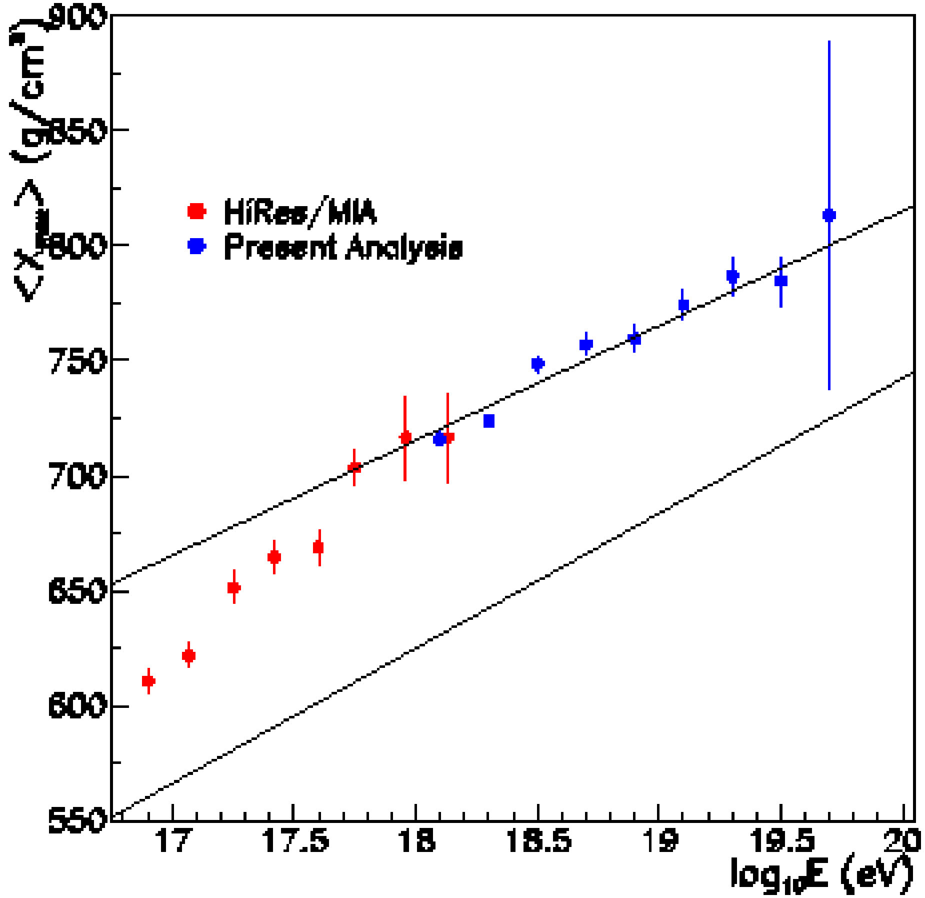
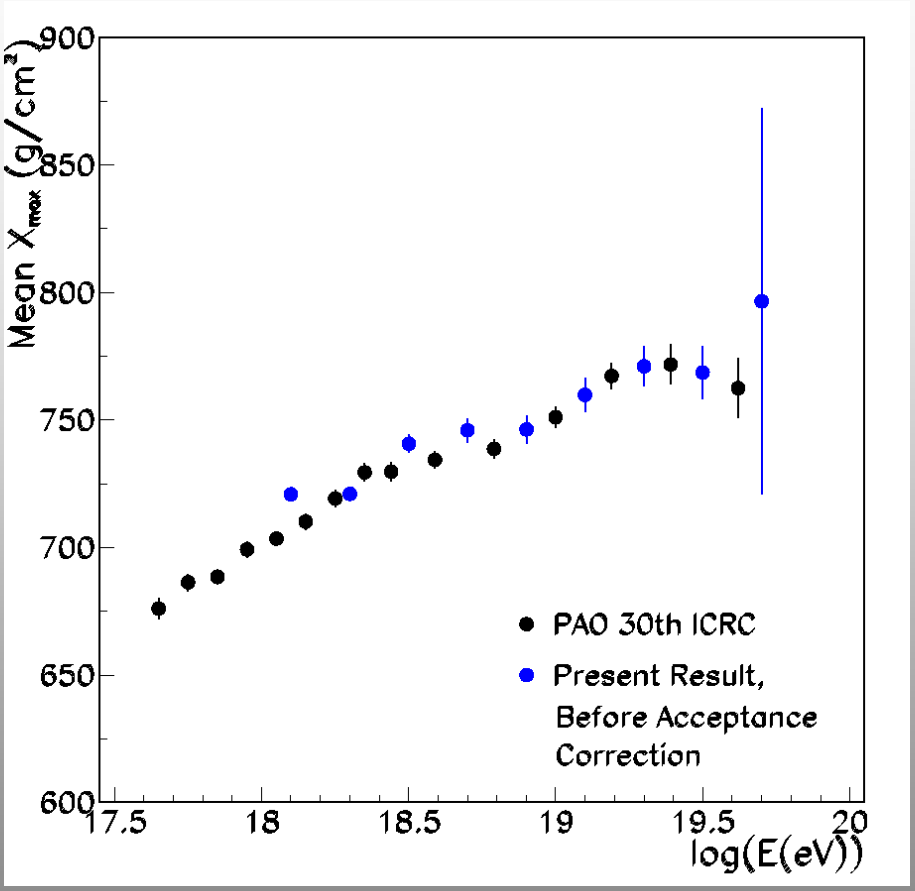


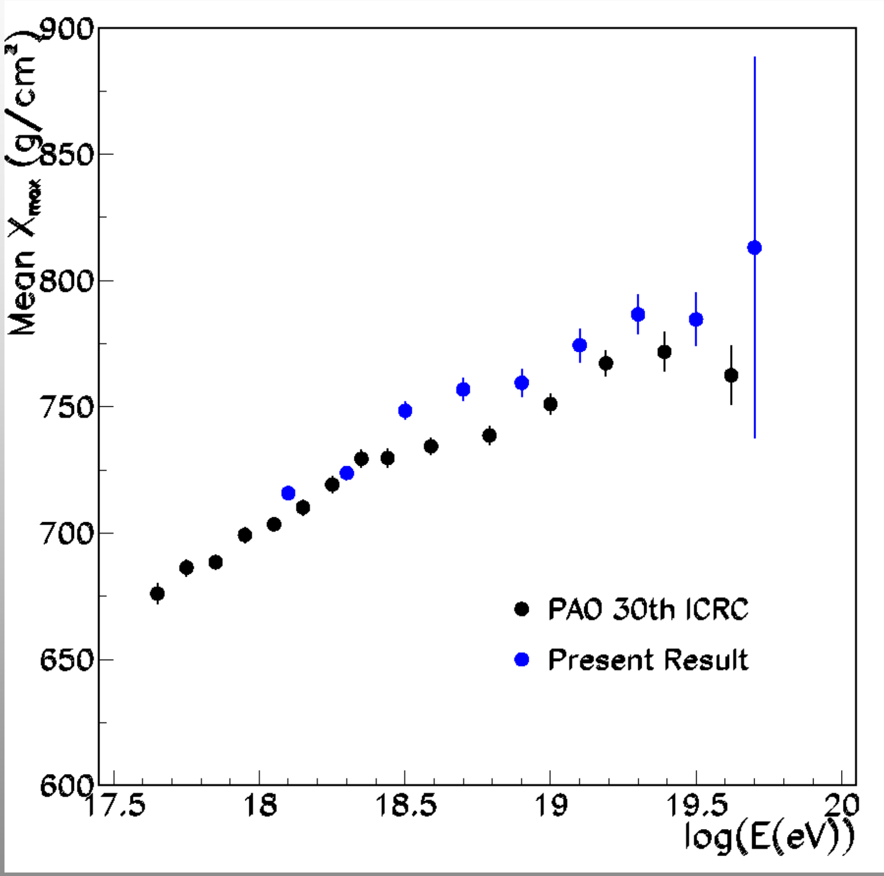
Figure 45: Comparison of present $\langle X_{max} \rangle$ data with HiRes-MIA result [19]. *Note on interpretation: HiRes-MIA mentions only Gaisser-Hillas in the PRL. If indeed profiles were fit to GH, direct comparison of the results is not possible. See Figure 2.*

↲Protons

↲Fe

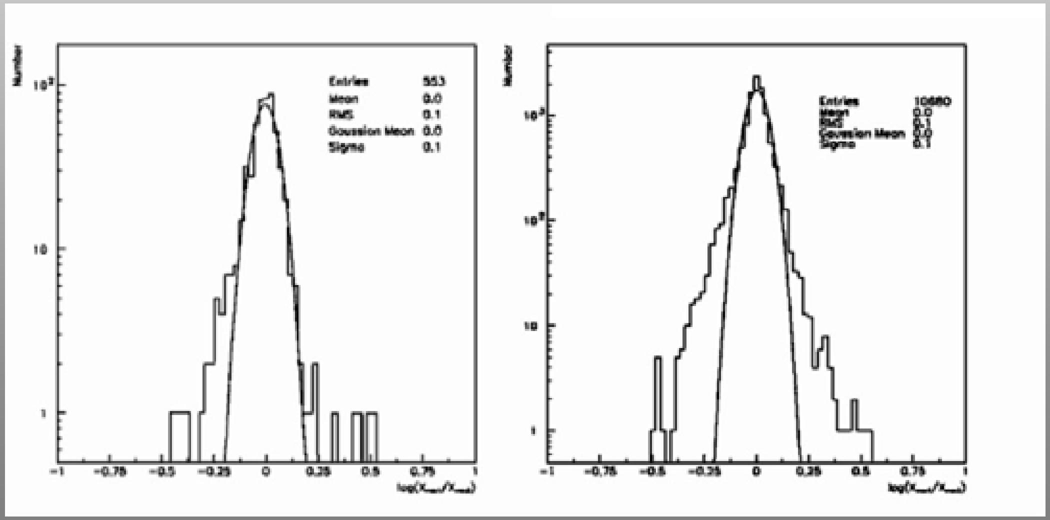
Comparison with PAO data, without and with acceptance correction



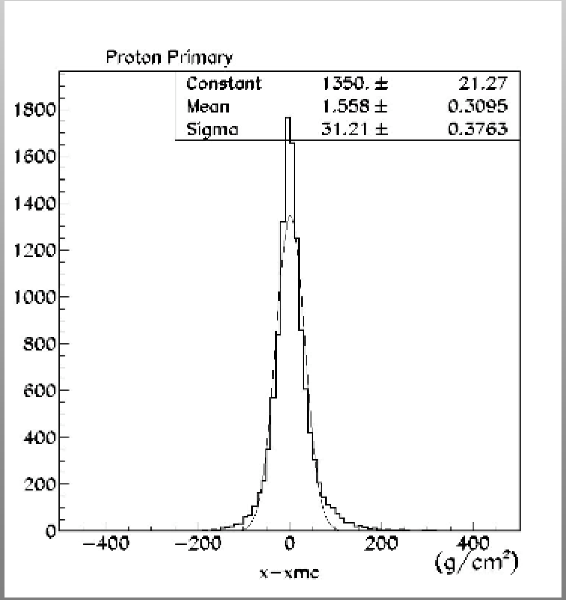


Is the Width of the Xmax Consistent with protons?

- Proton intrinsic shower fluctuations are larger than for heavy nuclei
- Fe is superposition of sub-showers – intrinsic + detector resolution fluctuations in Xmax ~ 45 gm/cm2
- Proton showers intrinsic + detector resolution fluctuations ~ 70 gm/cm2

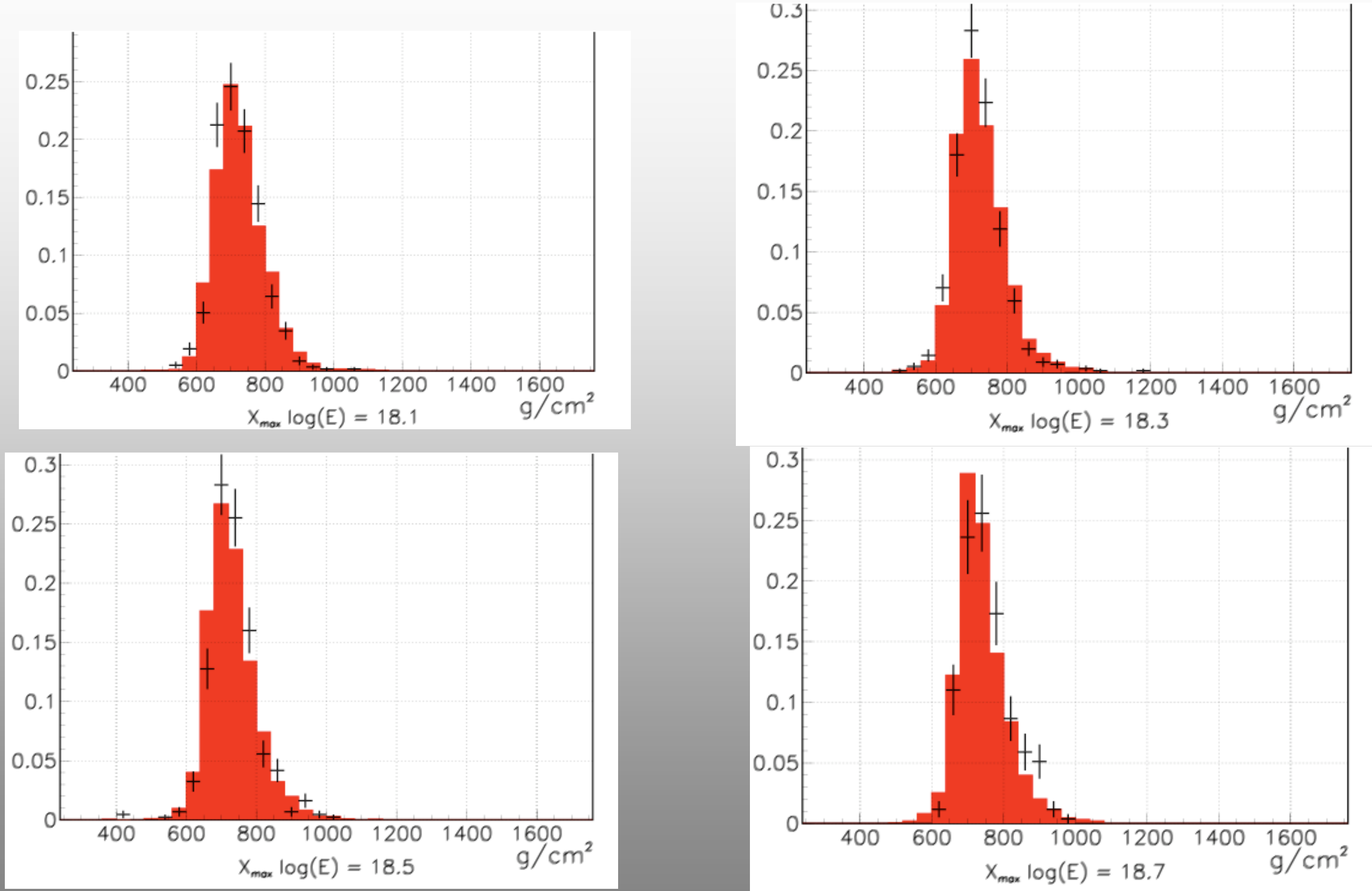


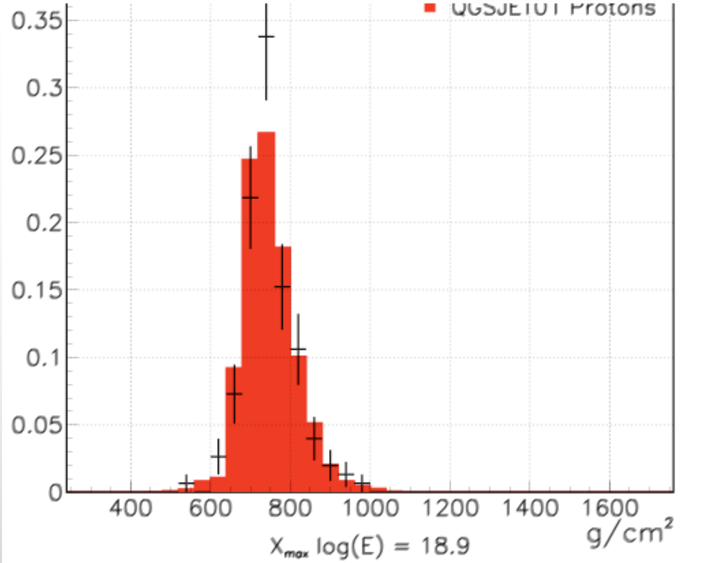
(Xmax-Xmax2/Xmax-av) – data vs MC

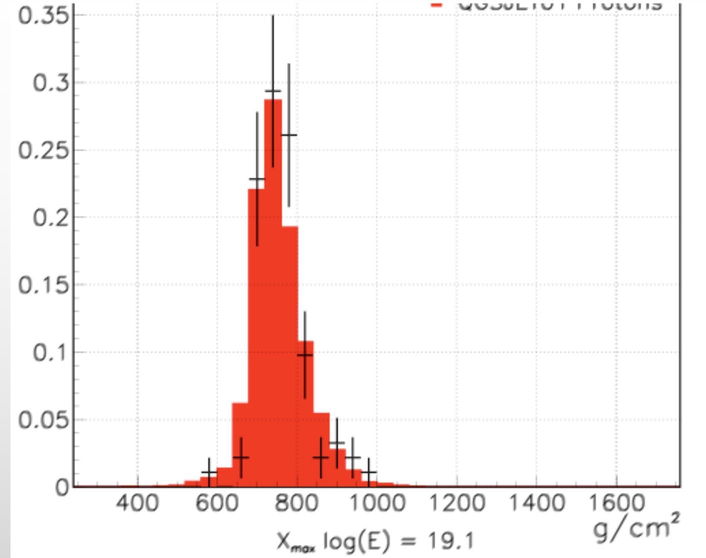


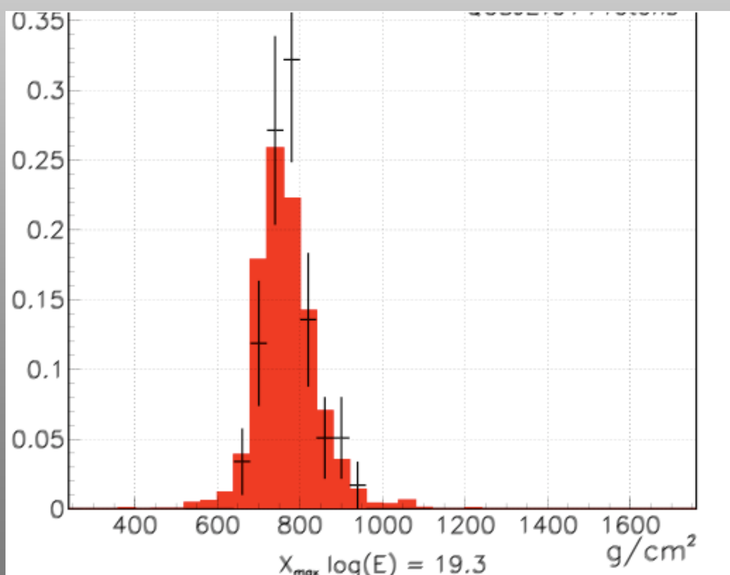
Xmax Resolution

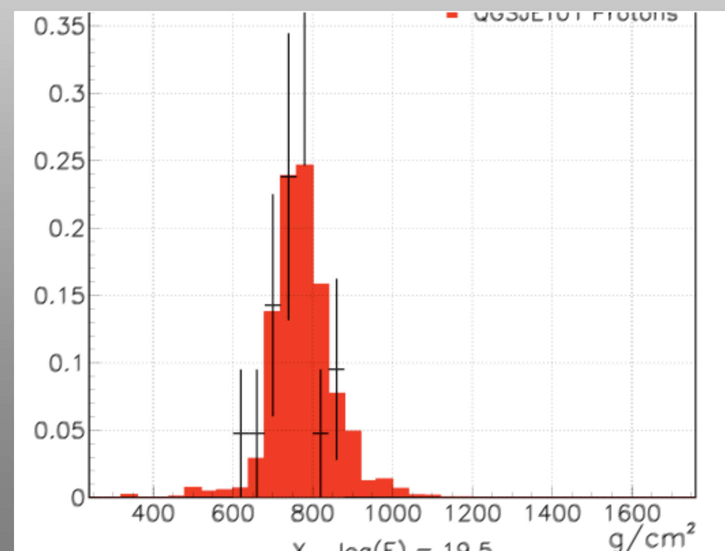
Xmax fluctuations as function of enery

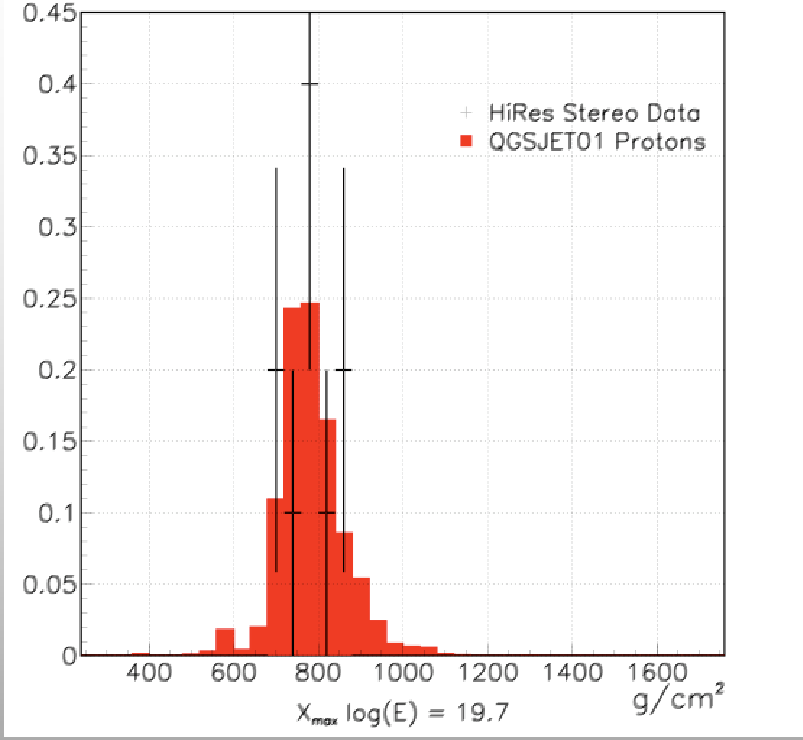


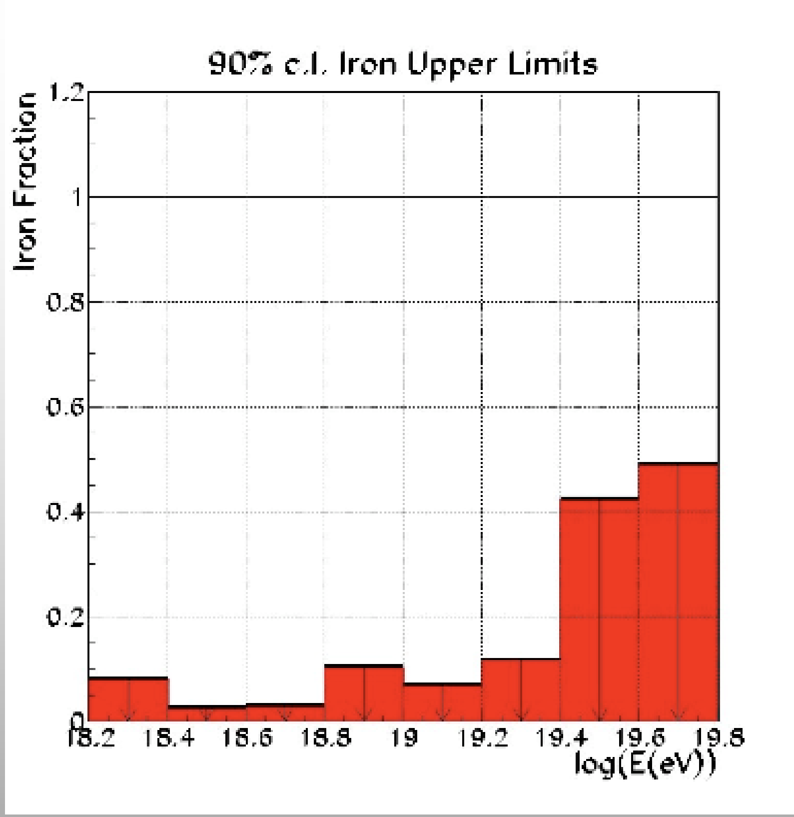

0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_{max} log(E) = 18.9


0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_{max} log(E) = 19.1


0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_{max} log(E) = 19.3


0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_{max} log(E) = 19.5





Xmax fluctuations are consistent with protons

Conclusions

- A cut off at the expected energy has now been clearly observed by two experiments in the North and in the South at the 5 sigma level.
- The composition is consistent with a light, mostly protonic flux.
- The cut-off is consistent with the GZK prediction.
- GZK neutrino’s need to be found to completely confirm the effect.
- A recent claim of correlation of cosmic ray events just below the GZK cutoff with nearby AGN’s, if confirmed, would also require a proton flux.

Anisotropy

- No significant large scale anisotropies found by HiRes at any energy.
- AGASA claim of clustering is not supported by HiRes data
- However, one AGASA triplet becomes a quartet - significance still not strong.
- Search for correlations with AGN’s and BL-Lacs

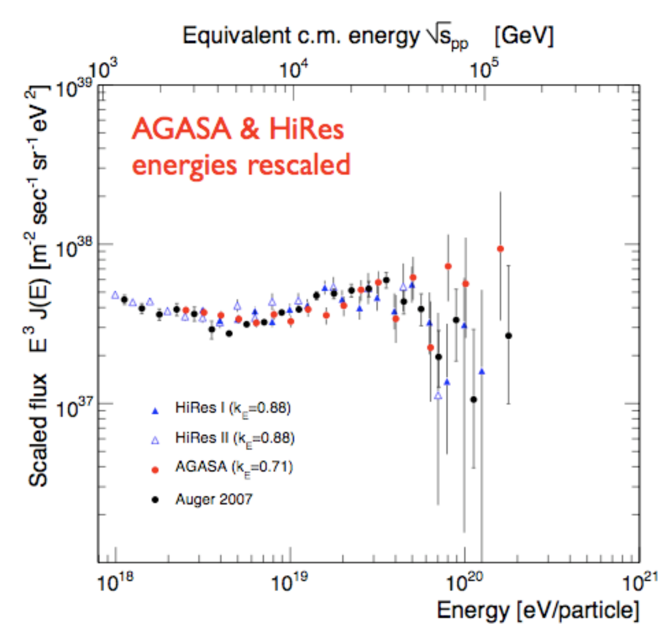
HiRes AGN Correlation Study

Takehome message:

- Apply PAO cuts - no significant correlation
- Split data in half and search for most significant cuts in z, theta, and Emin
- Apply cuts to second half of data - no signigicant correlation
- Use total data set using method proposed by Finley and Westerhoff (penalty for scanning over entire data set taken into account) - no significant correlation

HiRes with PAO cuts

- PAO has maximum significance for < 3.1 deg., Emin=.56 EeV, Zmax=.018
- 8 pairings from 13 events in confirming set.
- Expect 2.7 chance pairings
- PAO chance prob. = 0.0017
- HiRes with PAO cuts (10% shift)
- 2 pairings from 13 events
- Expect 3.2 chance pairings
- HiRes chace prob. = .82



Pao spectrum, 10% energy shift

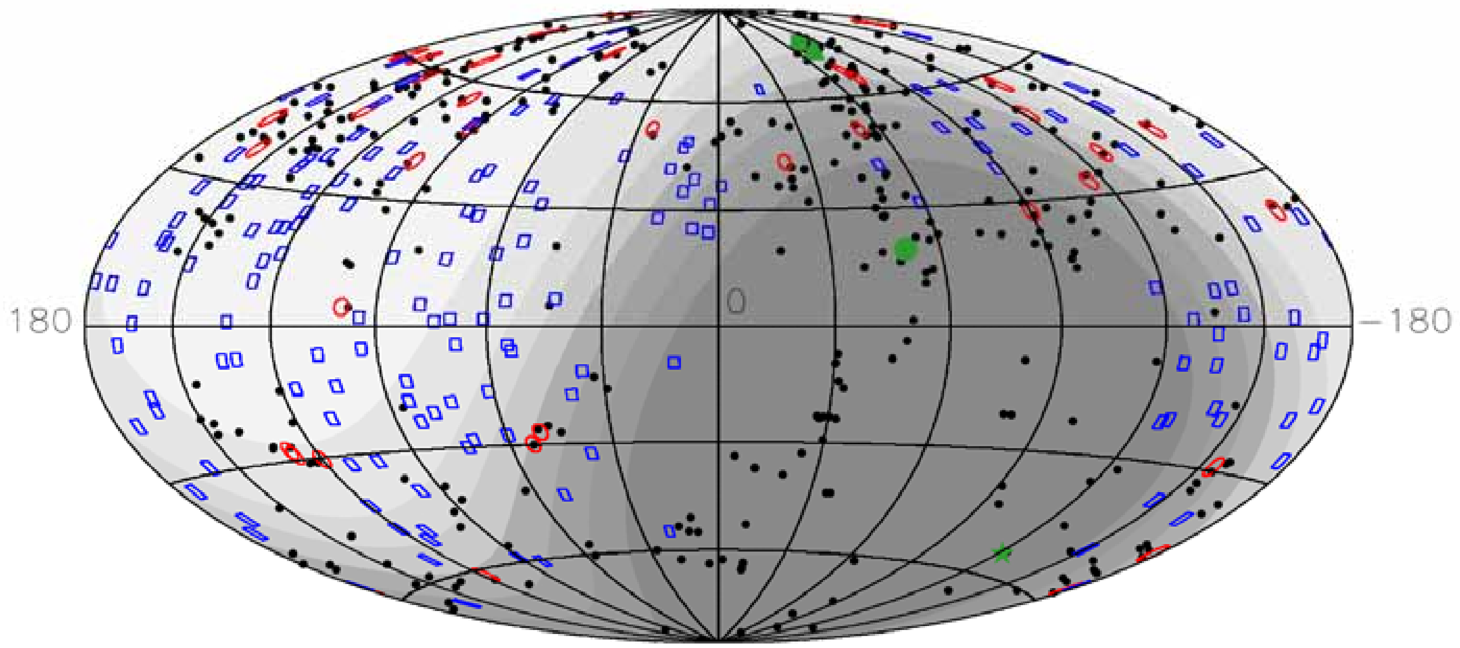
Independent HiRes search

- First data set scan
- Strongest correlation 1.7 deg., 15.8 EeV, zmax =0.02. (chance prob = 0.005)
- Apply to second data set
- 14 correlations out of 101 events
- Chance probability .15

Finley-Westerhoff Method

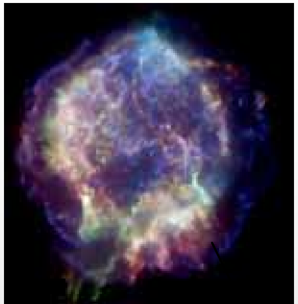
- Use entire data set
- Estimate penalty for scanning from simulated data sets
- Best correlation at 2.0 deg., 15.8 EeV, zmax=0.016.
- 36 correlated events out of 198
- Chance probability = .24

HiRes correlation with Veron AGN catalogue in North
Black - AGN’s
Blue - HiRes data
Red - correlated events (from scan in z, theta and Emin)



THE TELESCOPE ARRAY AND ITS LOW ENERGY EXTENSION (TA/TALE)

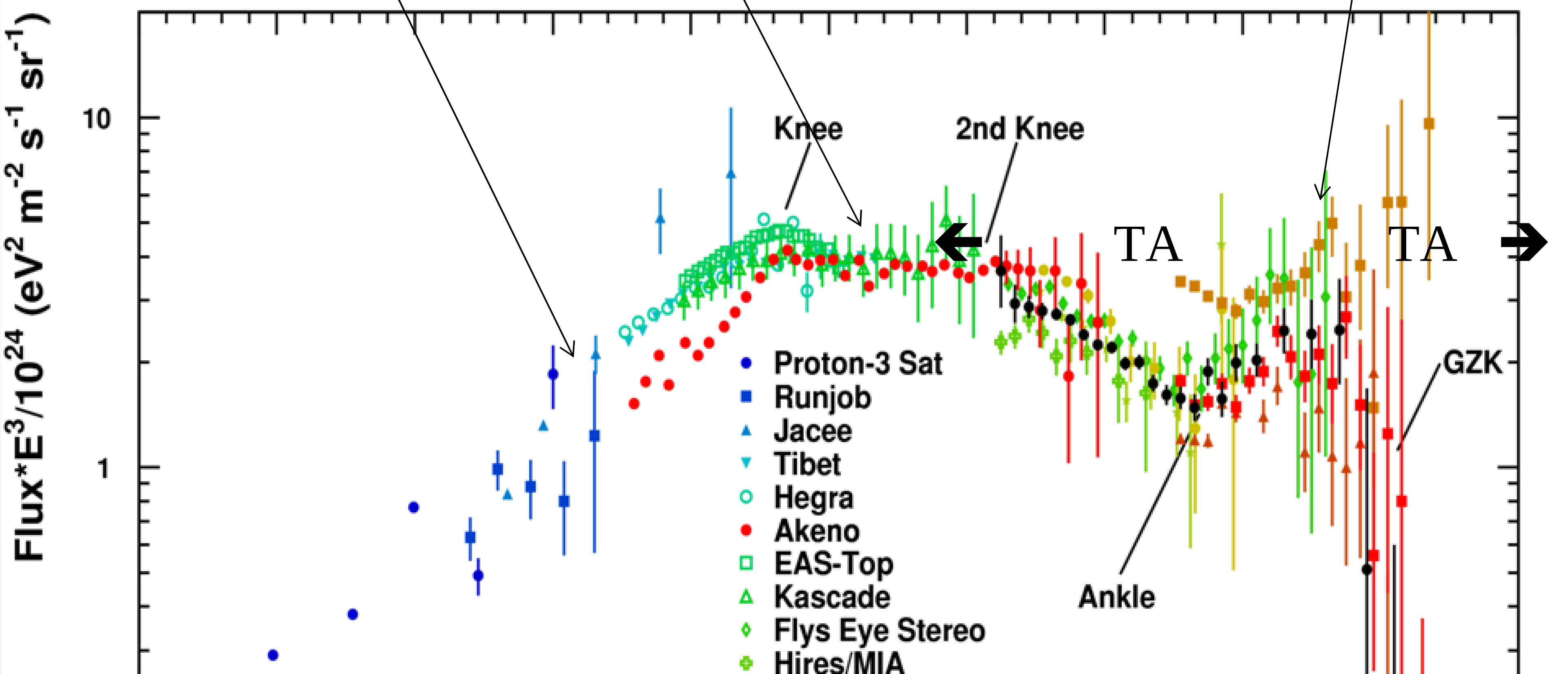
US, Japan, Korea, Russia, China Collaboration led by Utah/Rutgers, Univ. of Tokyo, IHEP, INR Moscow and Ewha U.



Σ Supernova +
Propagation + leakage

Tev γ
Astronomy

proton
astronomy



TA/TALE Objectives and Motivation

- Hybrid Detector: Combine ground array (AGASA) and Fluorescence (HiRes) technique to resolve the different results from the two techniques
  - **Ground Array** : Plastic scintillator (same as AGASA): Less sensitive to the hadronic interaction model. Trigger efficiency is 100% above $10^{18.7}$eV. Stand-alone energy determination.
  - **Fluorescence Telescopes**: 2 new telescopes and 1 HiRes telescope. 3rd TA-FD station is a 2/3 transfer of HiRes-1. Direct comparison of TA/TALE energy spectrum to HiRes.
- Create the largest cosmic ray detector in the Northern Hemisphere:
  - observe the same region of the seen by **AGASA** and **HiRes**:
    - ***Autocorrelation*** @ > 4×10^{19}eV.
    - AGASA ***doublets and triplets***
  - Investigate possible low z AGN correlation seen by AUGER

Technique- and site-independent answer to these issues

TA/TALE Objectives and Motivation

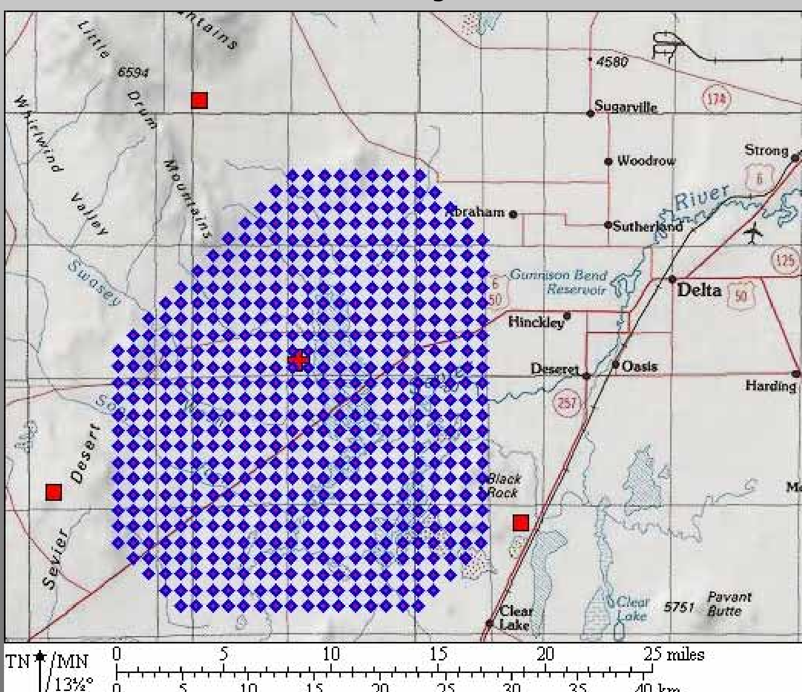
- To assemble an array of detectors with overlapping hybrid and stereo coverage over the widest possible range of energy:
- Include all three features in the UHE cosmic ray energy spectrum:
  1. **The GZK Suppression ~$10^{19.8}$ eV**
  2. **The Ankle ~$10^{18.5}$ eV**
  3. **The Second Knee ~$10^{17.5}$ eV?**
- Extend stereo fluorescence energy spectrum measurement to below 10^{18} eV

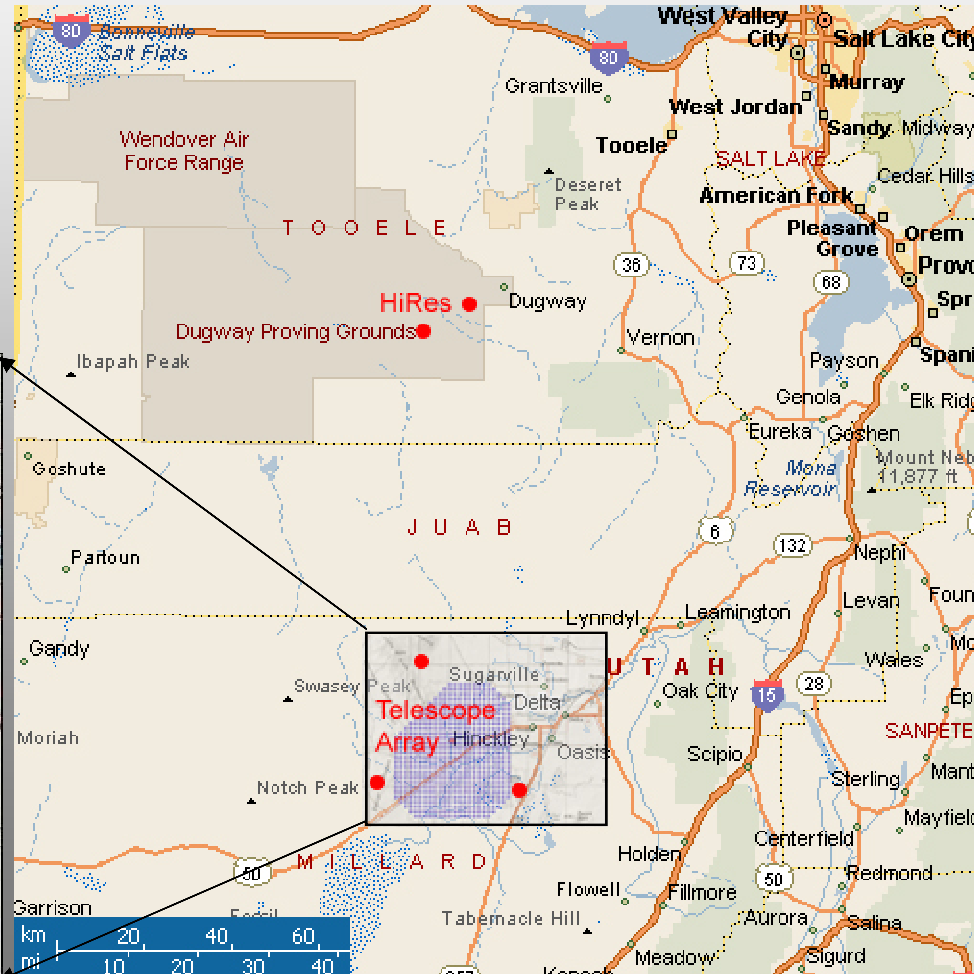
\+ Extend (to lower energies) fluorescence/hybrid measurements down to ~$10^{16.5}$ eV:
  - **Stereo and spectrum composition in the 10^{18}-10^{19} eV decade**
  - **Xmax and muon-based composition measurements through galactic/extra-galactic transition region and the second knee with long lever arm**

Telescope Array Experiment

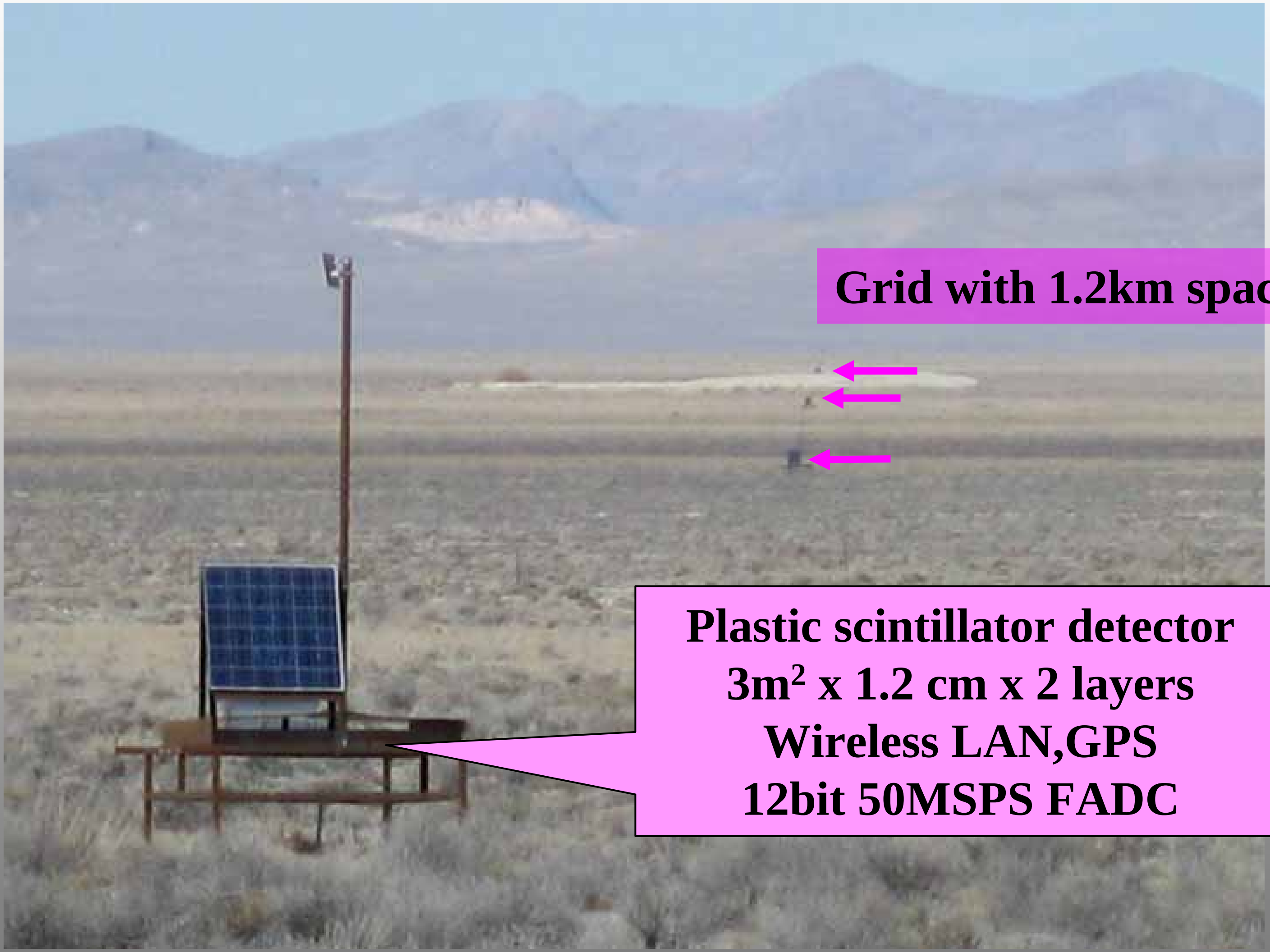
- TA is located just west of the city of Delta, UT

  ~200 km southwest of Salt Lake City





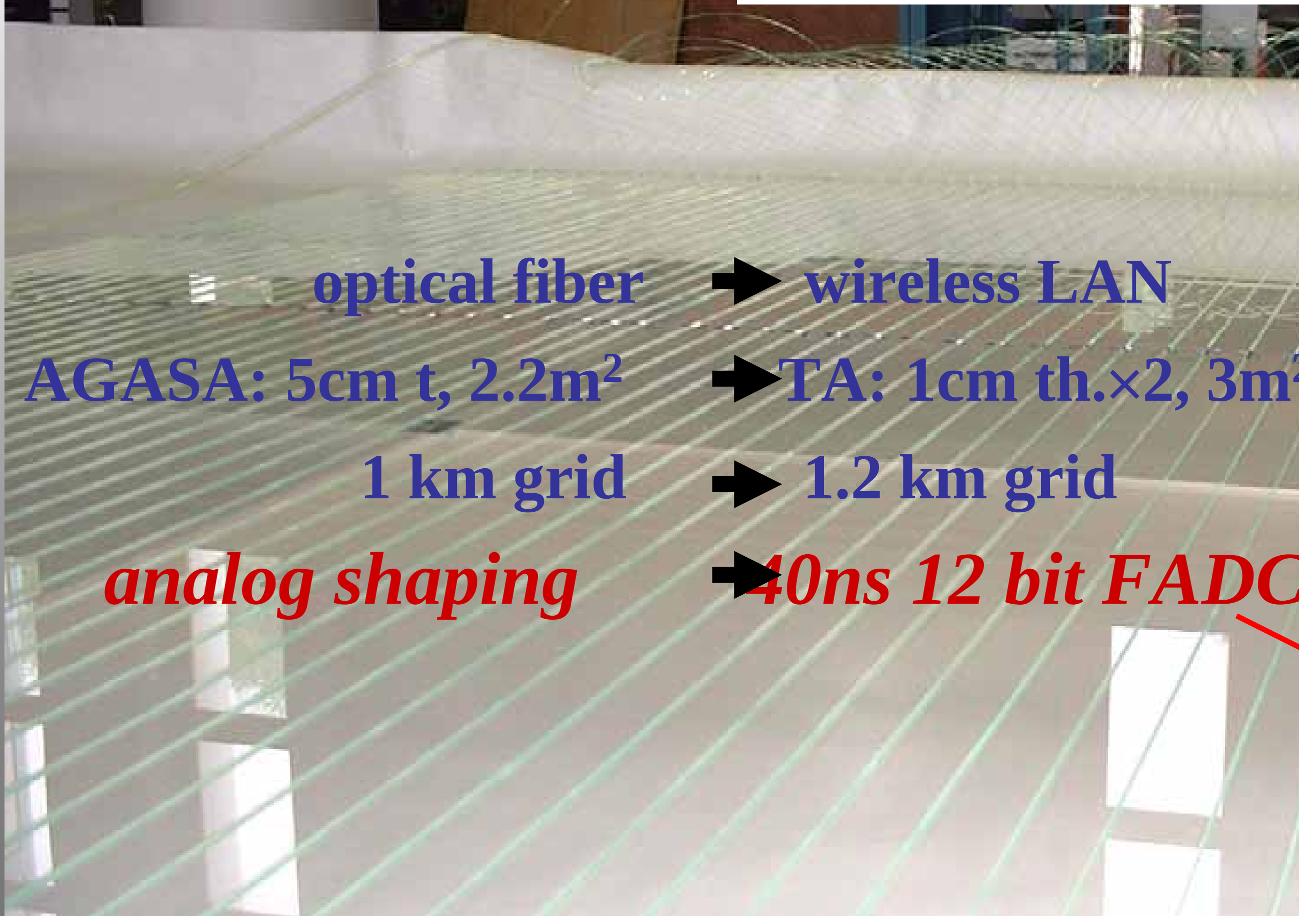
Ground Array



(Google earth)

J

Ground Array : Plastic Scintillators

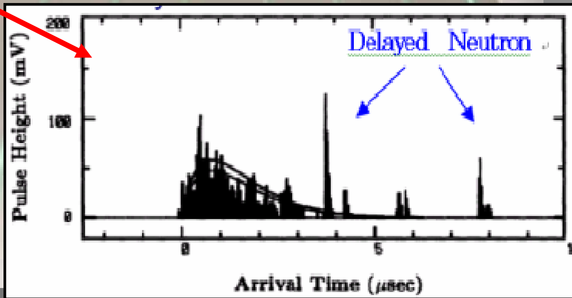


optical fiber → wireless LAN

AGASA: 5cm t, 2.2m^2 → TA: 1cm th.×2, 3m^2

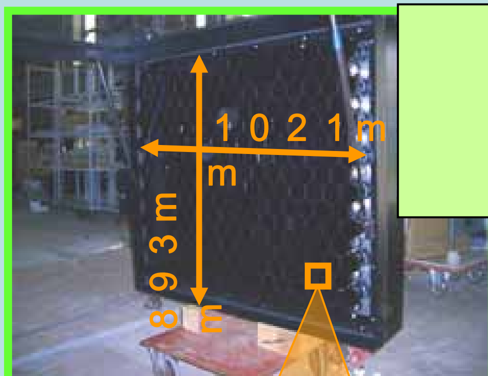
1 km grid → 1.2 km grid

analog shaping → *40ns 12 bit FADC*



Newly developed telescopes (BRM & LR)

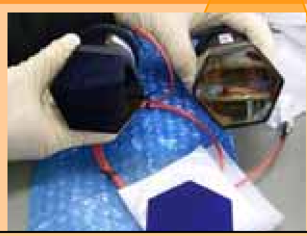
12 telescopes/station

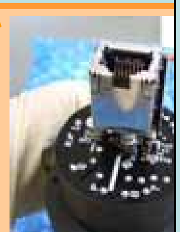


ca

60

25



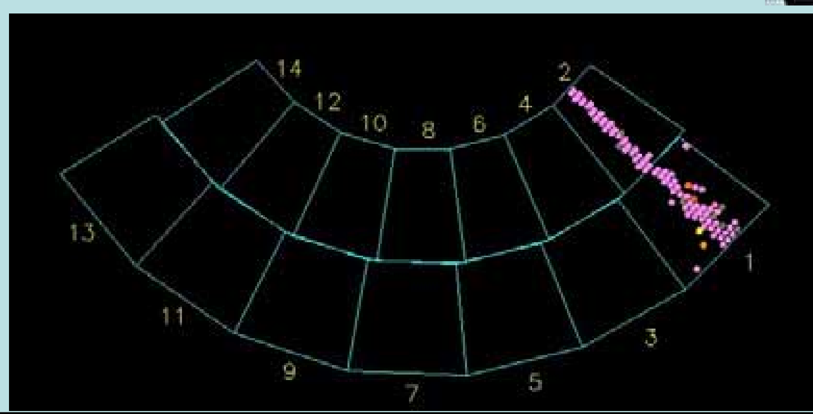


PMT:
HAMAMATSU
R9508

Bleede
pre

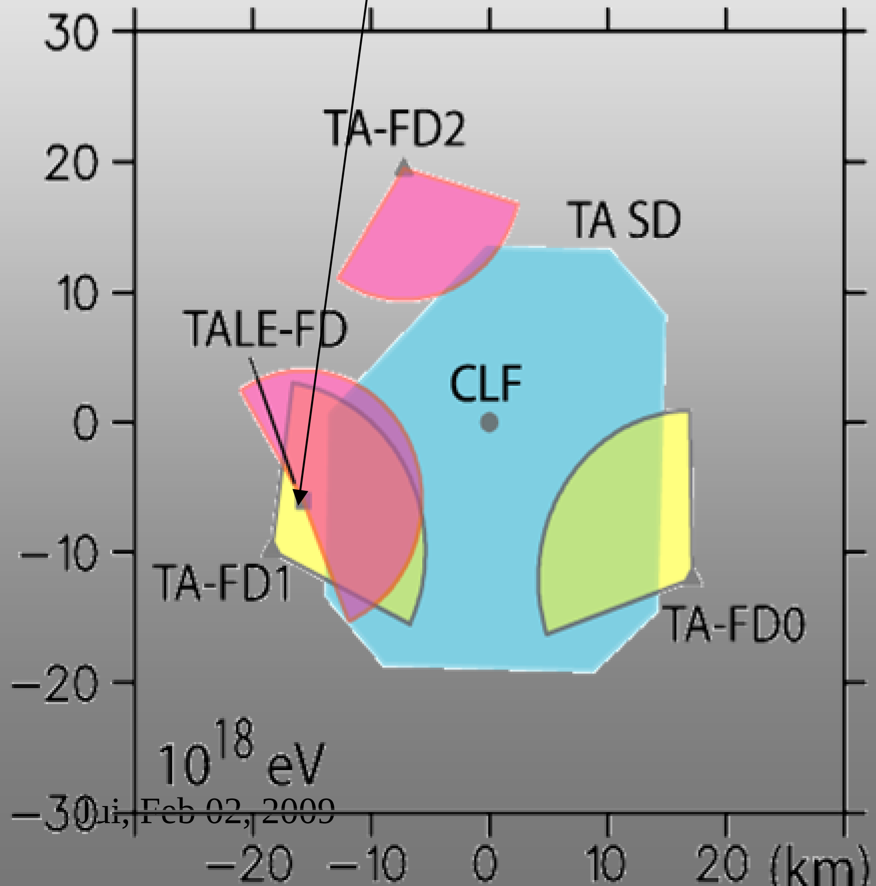
HiRes-1 system (Middle Drum station)

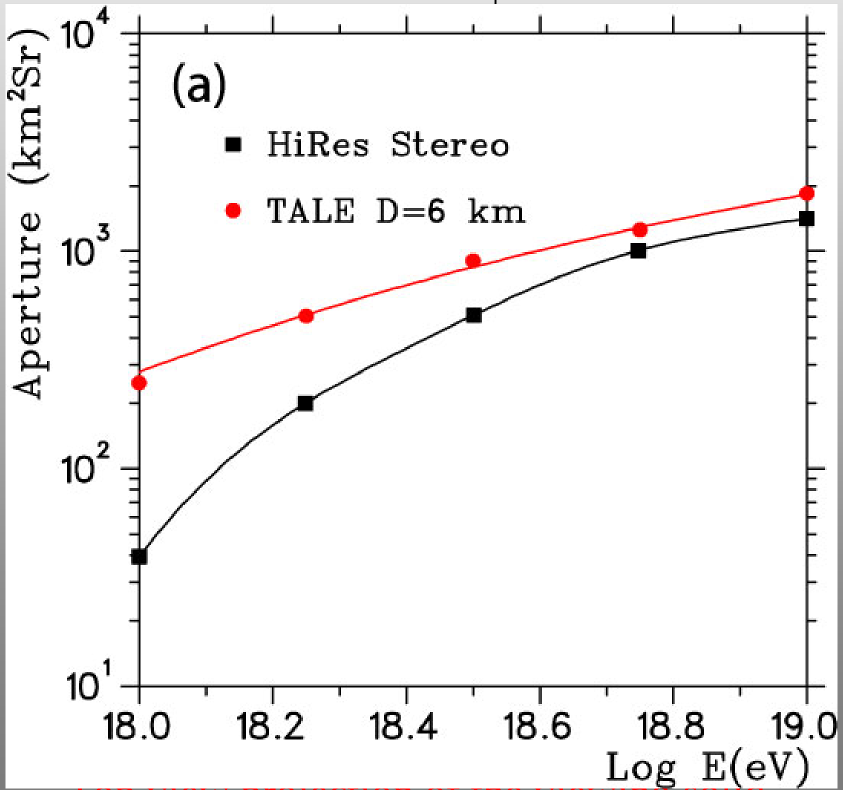
14 refurbished telescopes



TALE 6km Stereo Detector

- **TALE will deploy a 2-ring, 24 mirror detector (using HiRes FADC detectors) on Long Ridge, 6 km from TA-FD1.**
- **Site separation of ~6km: State trust land (SITLA) site available at the location shown (more flexibility in land-use than BLM land)**



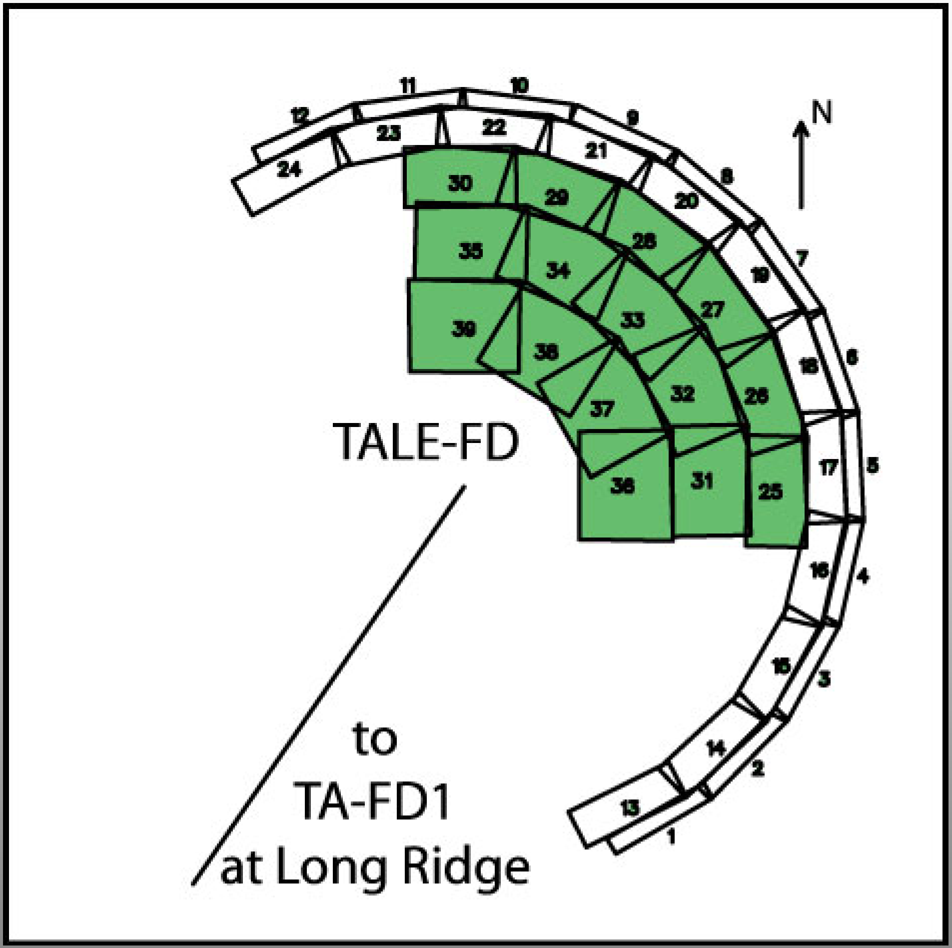


Top view projection of the viewing solid angles of the TALE telescopes

- The TALE Tower FD consists of 15 telescopes in its top three “rings”:
  - 6 (3) at 31-45°
  - 5 (3) at 45-59°
  - 4 (4) at 59-73°

  # in parenthesis shows the number of mirrors in the HiRes tower prototype at the same elevation
- The 6km telescopes also provide 16 telescopes directly below the top three rings compared to only 4 in the HiRes-prototype
- Stereo overlap with TA-FD1 at Long Ridge for direct validation of MC resolutions

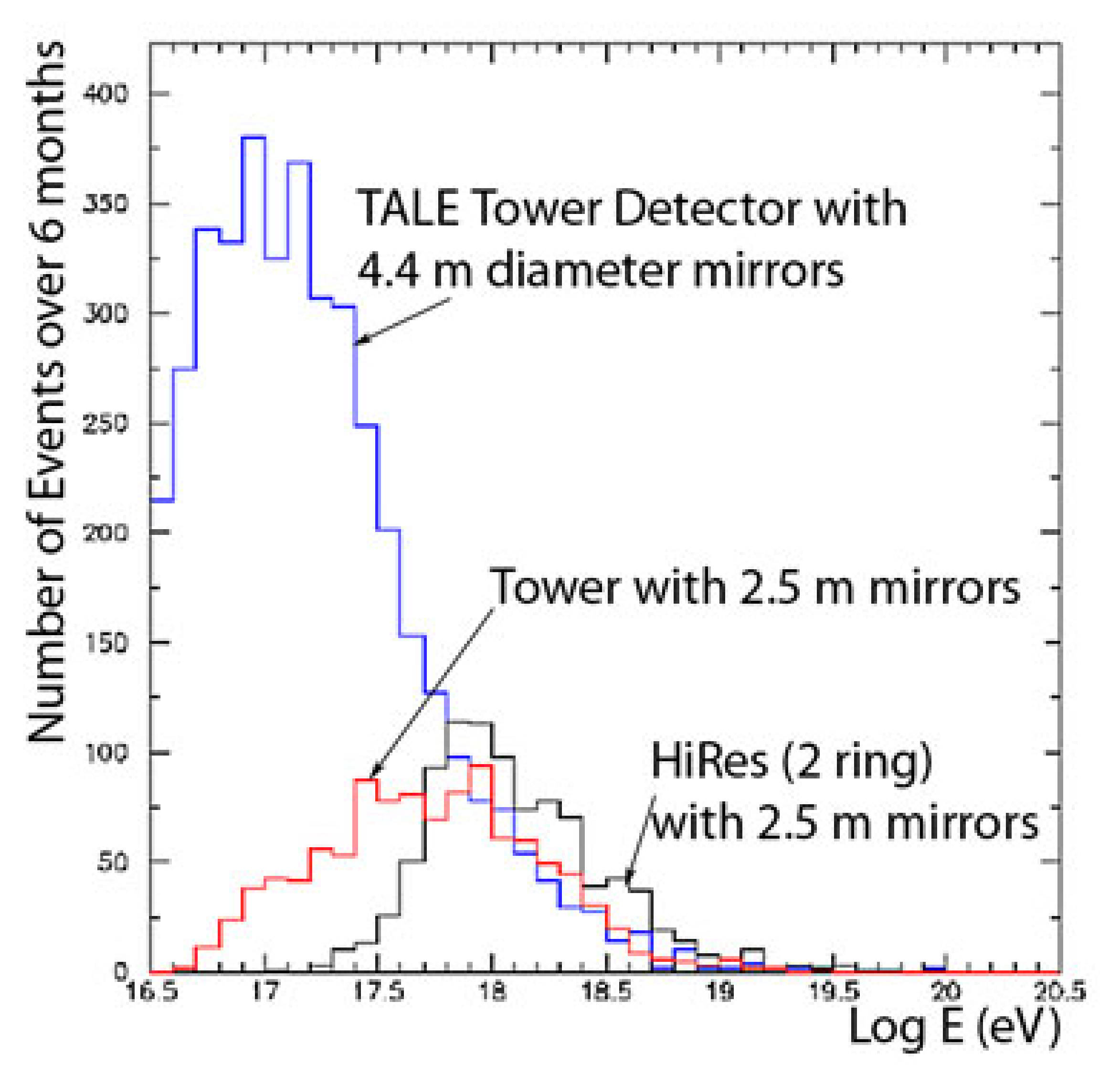
Tower FD



Top view projection of the viewing solid angles of the TALE telescopes

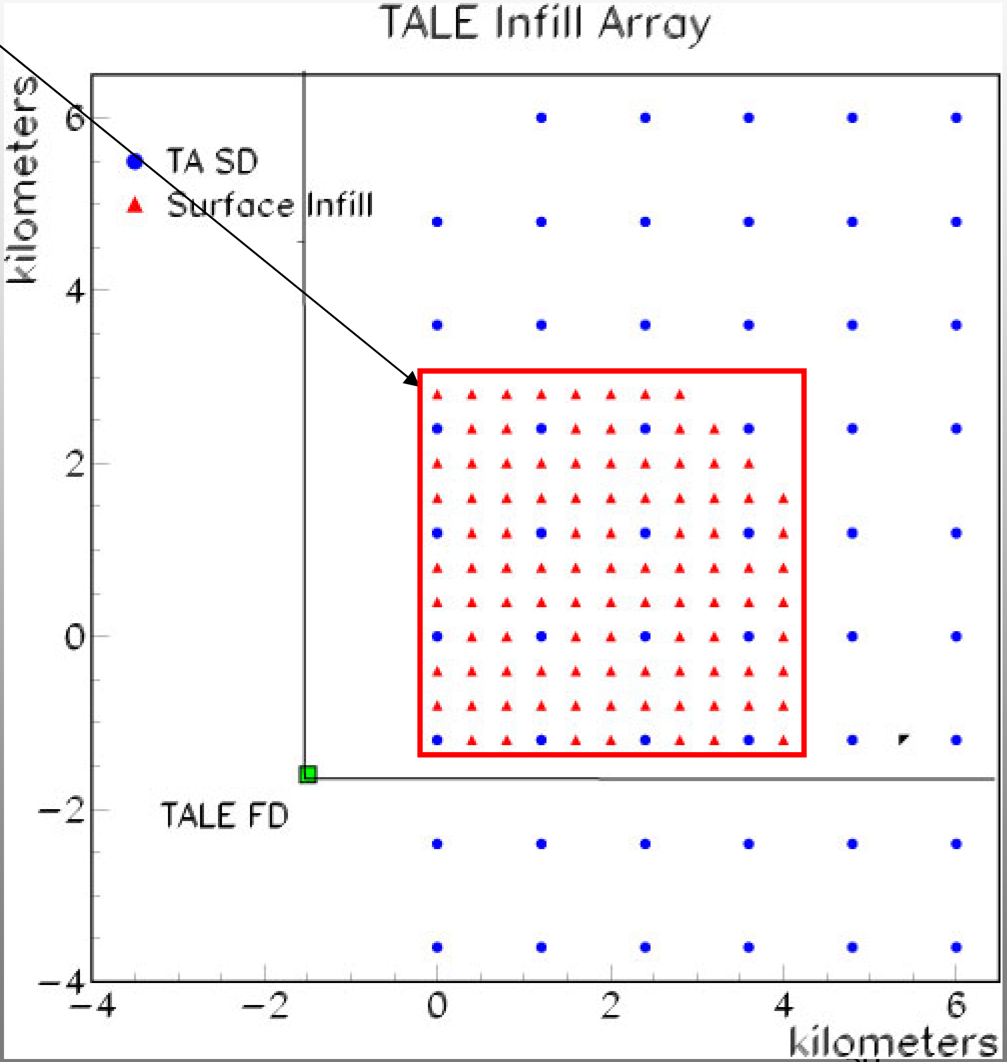
Improved Sensitivity

- The increased mirror size will improve substantially the sensitivity of TALE in the $10^{16.5}$-$10^{17.5}$ eV energy decade
- Note the gain in sensitivity comes from the improvement in signal.
- The HiRes trigger scheme is not S/N limited, but limited by having enough signal to reconstruct a reliable shower profile.



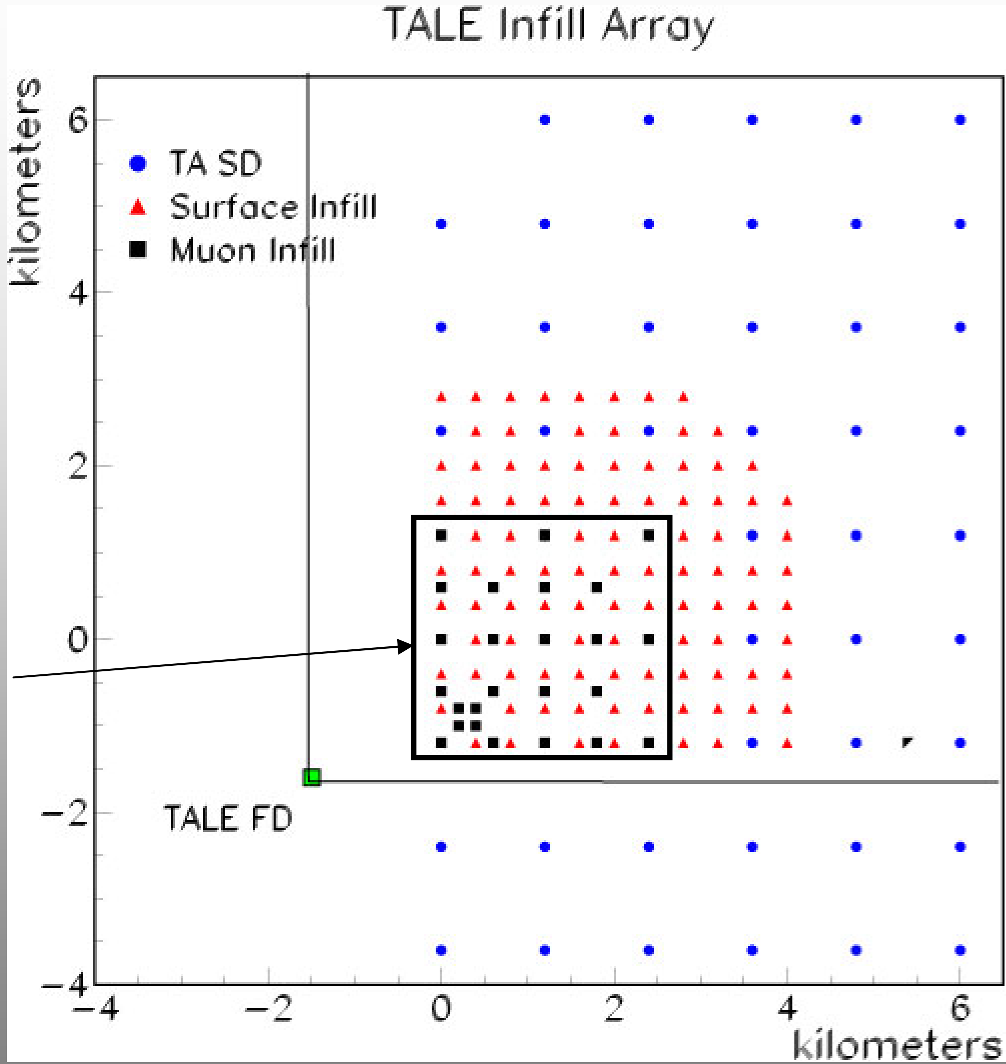
Infill Array

- Will place **111** additional surface array counters overlapping with main ground array: **4km x 4km**
- 16 of the counters in the main ground array will form part of the infill array



Muon Array

- One of the goals of TALE is to find where the (heavy) Galactic flux gives way to the (light) extra-galactic flux
- An **orthogonal composition measurement** (in addition to shower profile) will be a valuable addition to TALE
- **Measure the e/μ ratio.**
- Propose a **25 detector array** placed in the "inner corner" of the infill array.
- The current plan is to bury the counters **under 3m of packed soil**
- Negotiations under way with BLM to collaborate as part of a land-reclamation experiment



This 2.5km x 2.5km graded array is designed to work at $10^{16.5}$-10^{18} eV

Summary

- TA/TALE will bring together four different detector systems with overlapping energy ranges to give continuous coverage from $10^{16.5}$ eV to the highest energies.
- The cost will be shared between U.S., Japan, South Korea, and Russia.
- TA/TALE will be able to study all three spectral features in the UHE regime and measure the composition in each energy range.
- In the energy region of the Second Knee where we suspect Galactic/Extragalactic transition to occur, we will have two orthogonal composition measurements: FD shower profile + e/μ ratio.

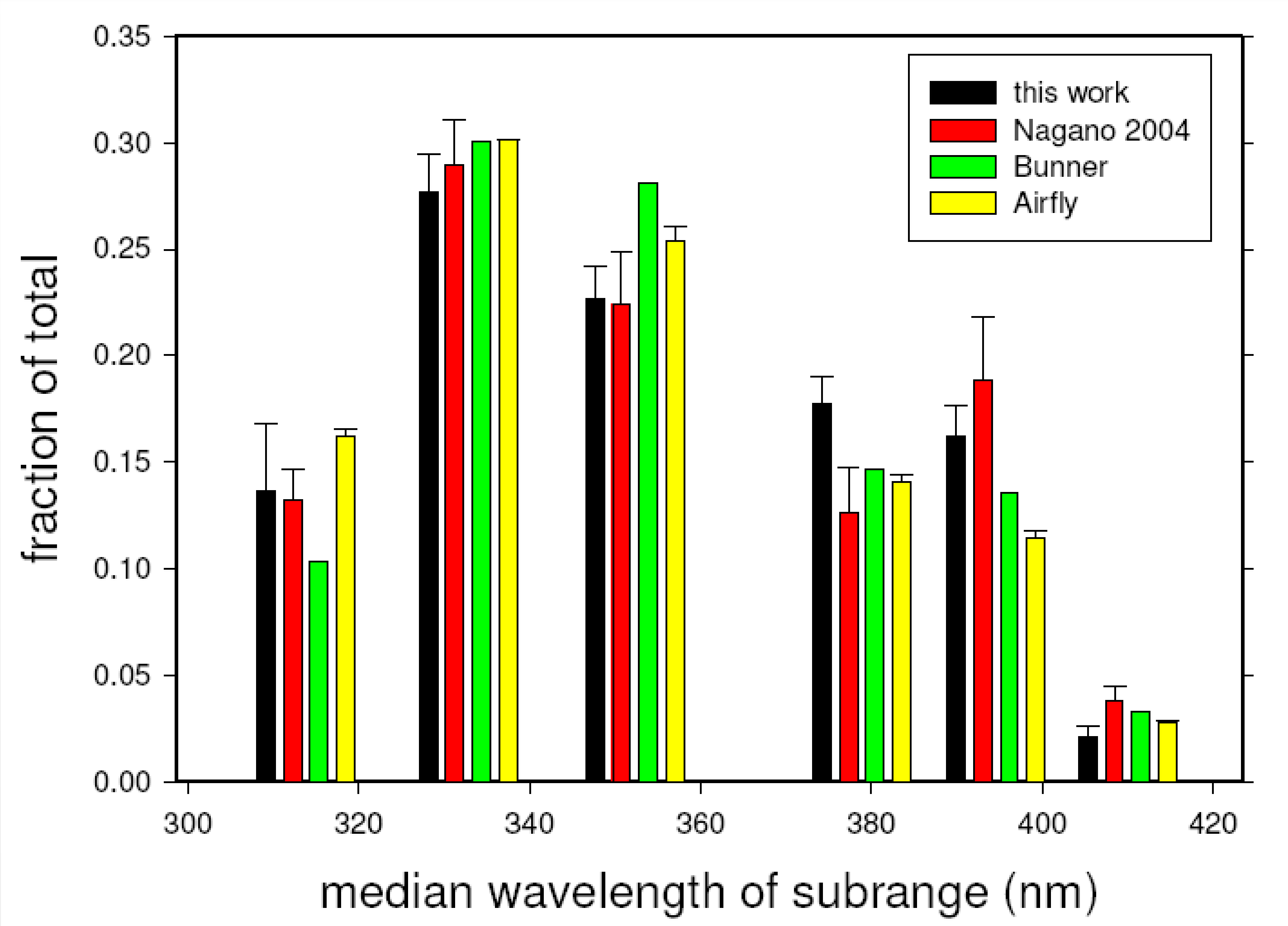
Thank you!

TA Specifications

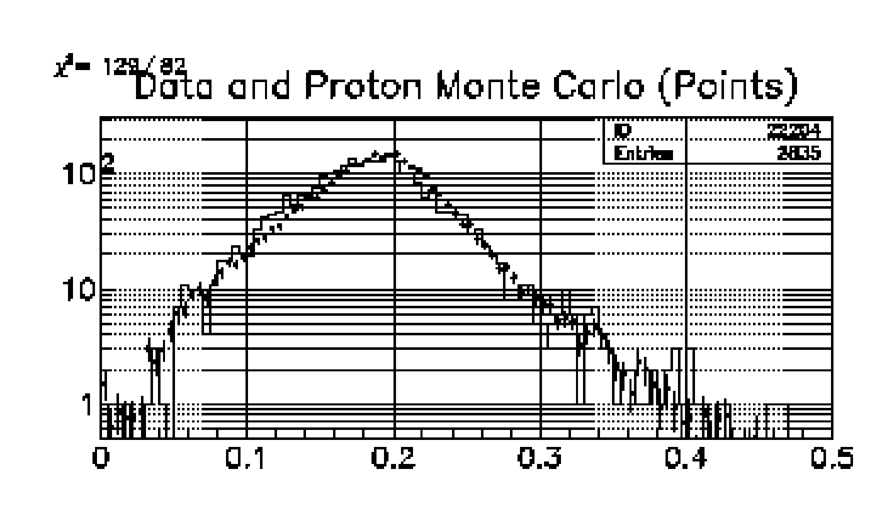
- Surface Array:
  - time-averaged aperture ~8× AGASA, ~1.4× HiRes.
  - ~1° angular resolution: ~40% better than AGASA
- Fluorescence detector:
  - Time averaged aperture ~4× AGASA, ~2/3× HiRes
  - ~0.6° angular resolution: equivalent to HiRes
- Combined total aperture: ~2× HiRes, ~10× AGASA

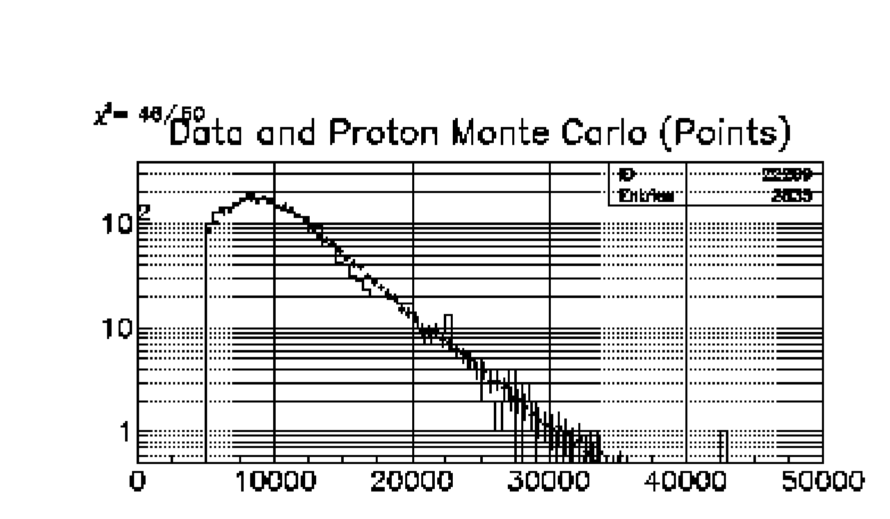
	Time-Averaged Aperture at 10^{20}eV (km^2sr)	Angular Resolution
HiRes	1000	0.6°
AGASA	160	1.6°
TA Ground Array	1300	1.0°
TA Fluorescence	670	0.6°
TA Hybrid	130	0.4°

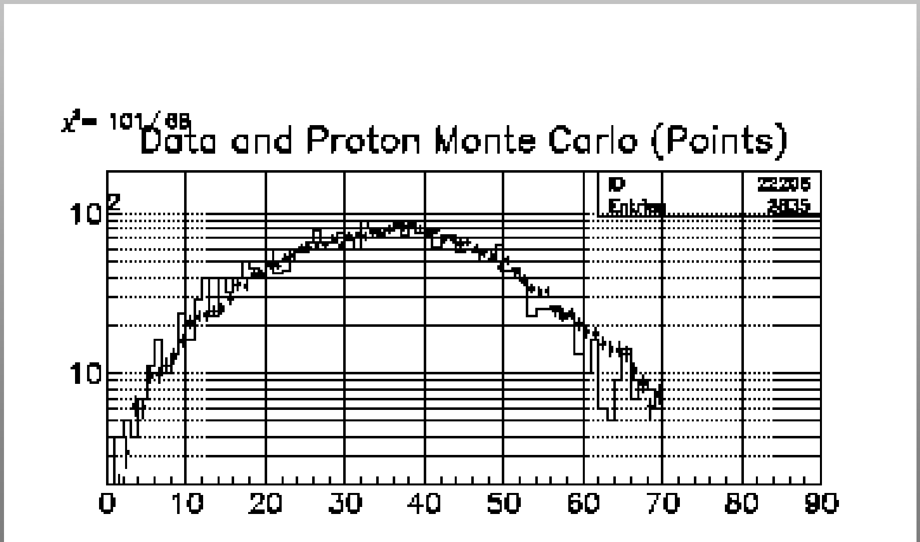
Air Fluorescence wavelength dependence

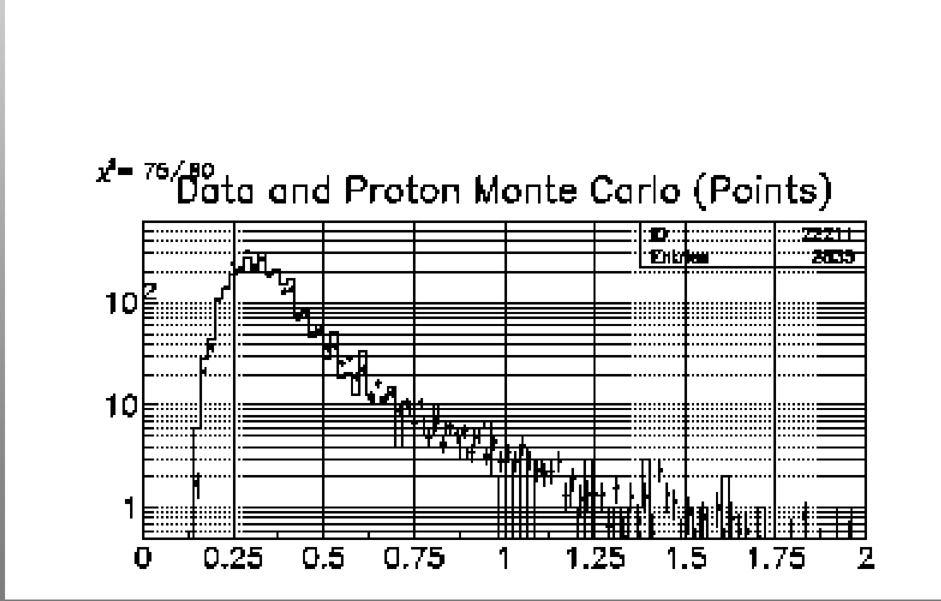


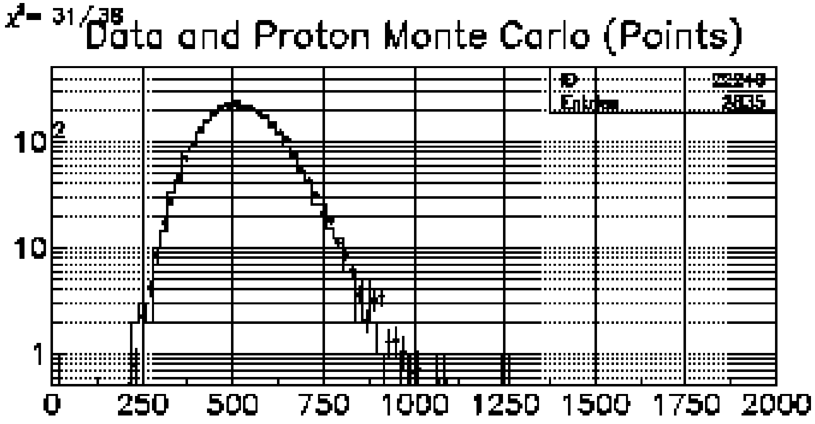
Data/MC Comparison - Stereo

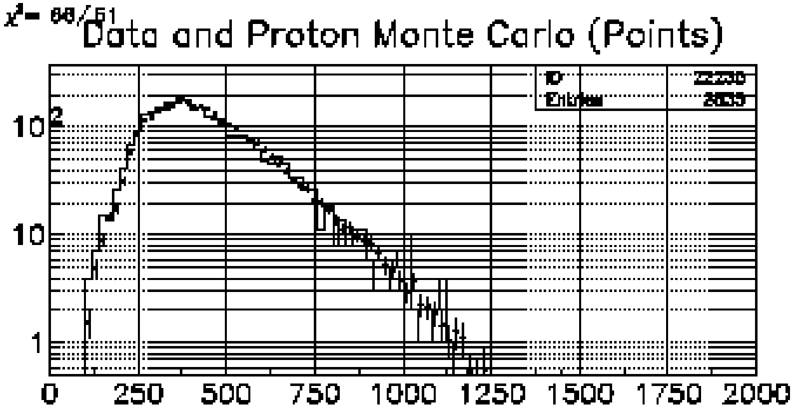


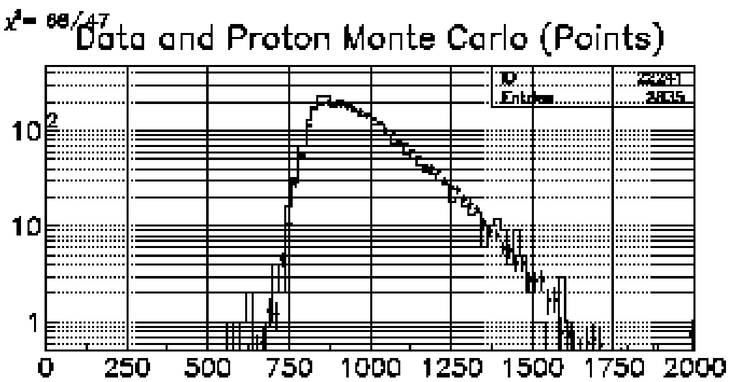






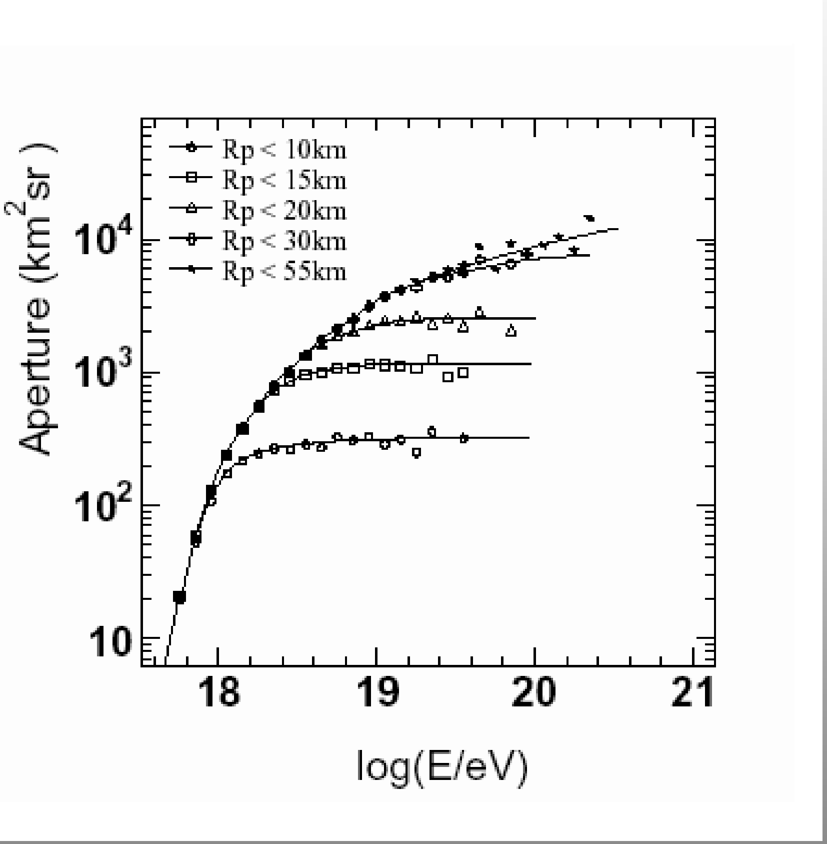


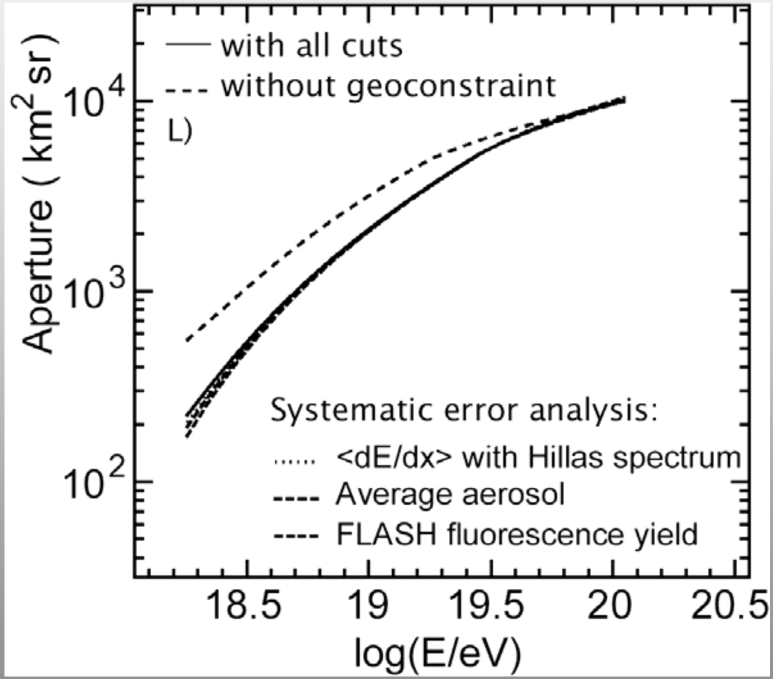




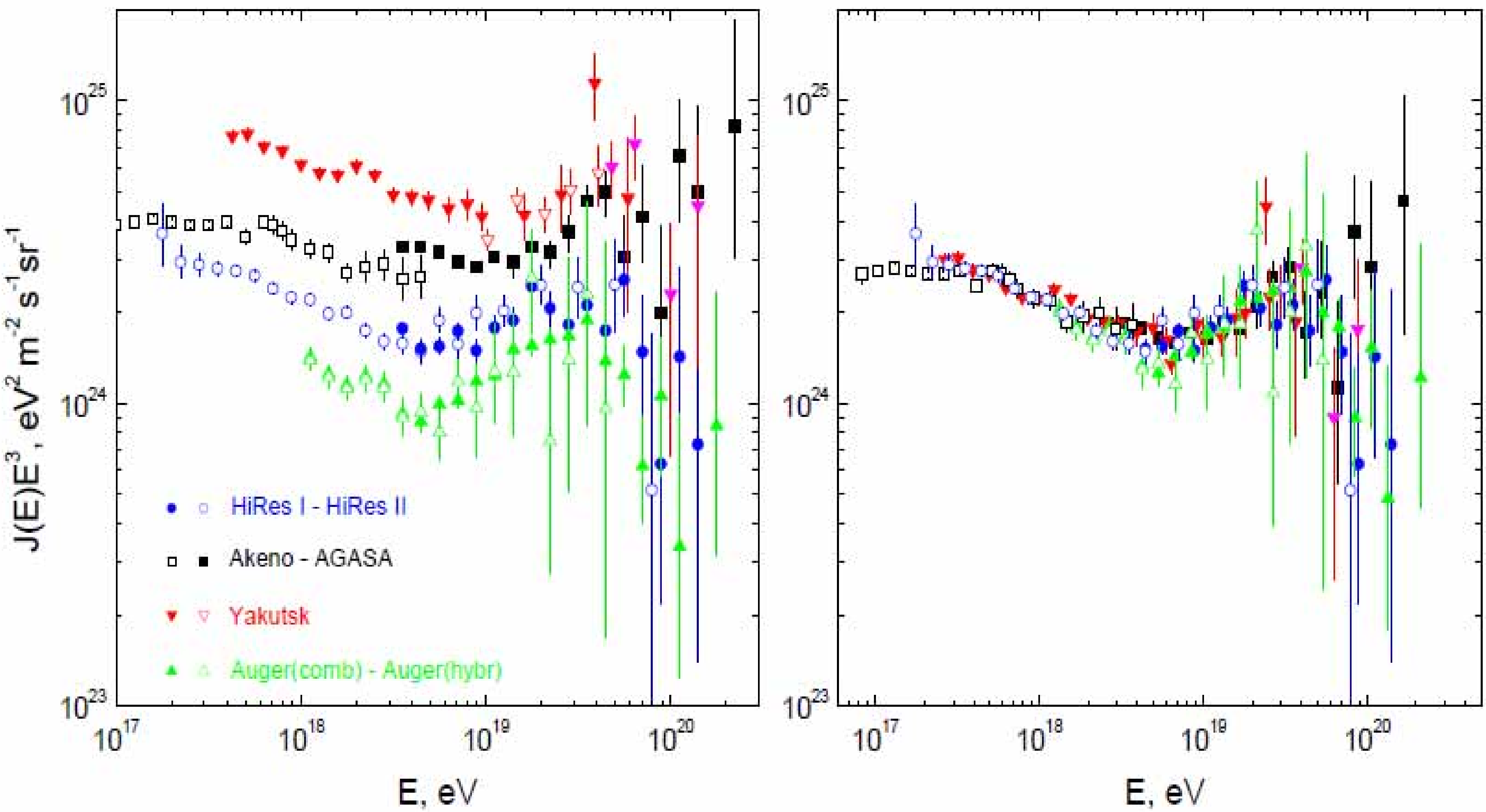
Excellent agreement between Simulation and observables

Stereo aperture - total and geometrically constrained (fully Efficient).





Minimum energy for stereo is logE 18.2



J(E)E³, eV² m⁻² s⁻¹ sr⁻¹
HiRes I - HiRes II
Akeno - AGASA
Yakutsk
Auger(comb) - Auger(hybr)
E, eV
E, eV

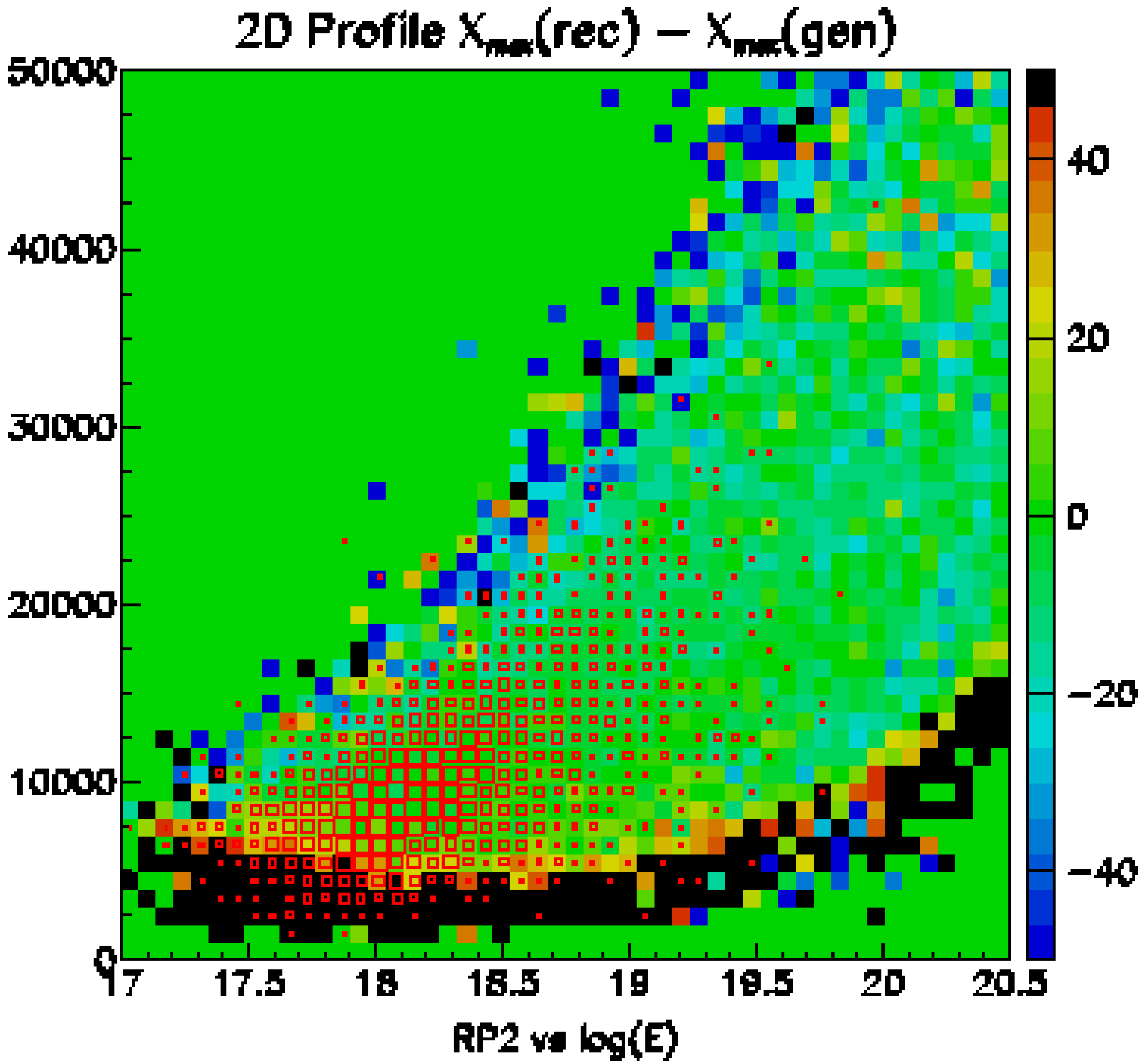


Figure 9: Same as previous plot, with HiRes stereo data (passing all cuts except those on energy and RP_2) superimposed as a red box plot.

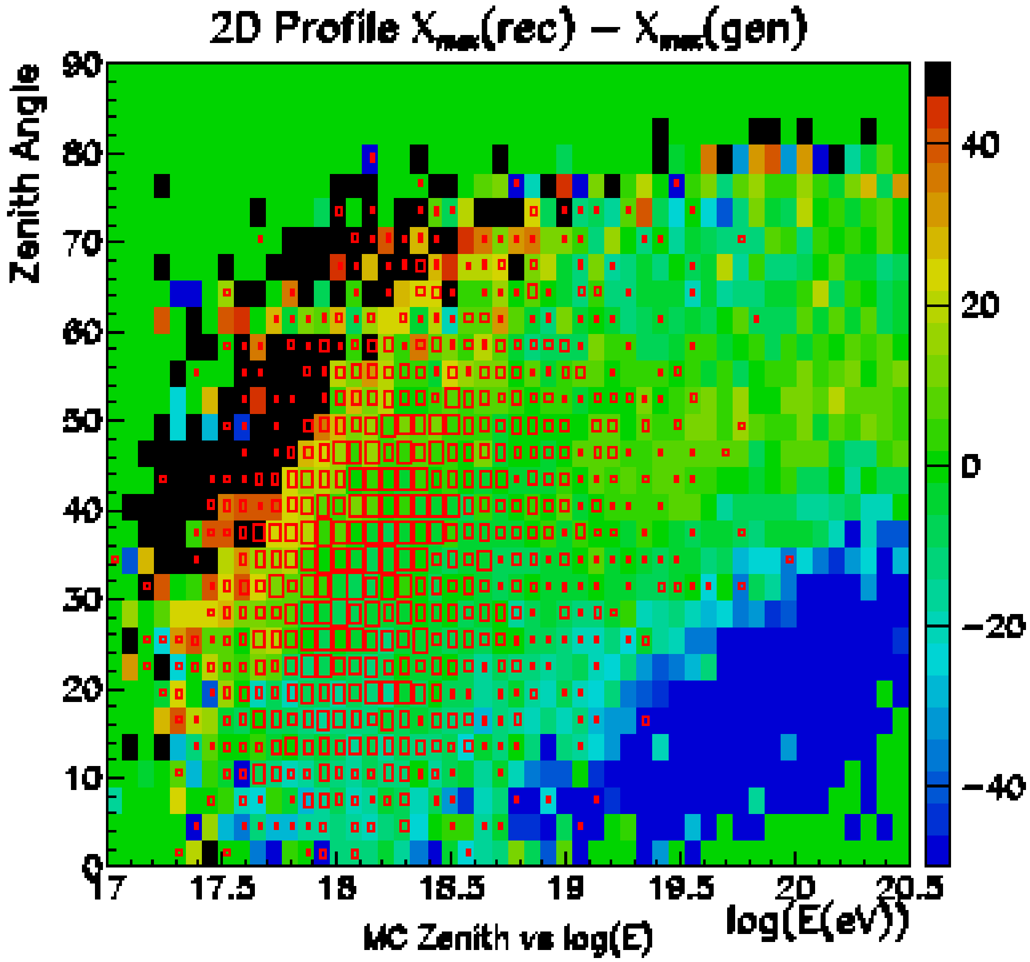


Figure 13: Same as previous plot, with HiRes stereo data (passing all cuts except those on energy and zenith angle) superimposed as a red box plot.

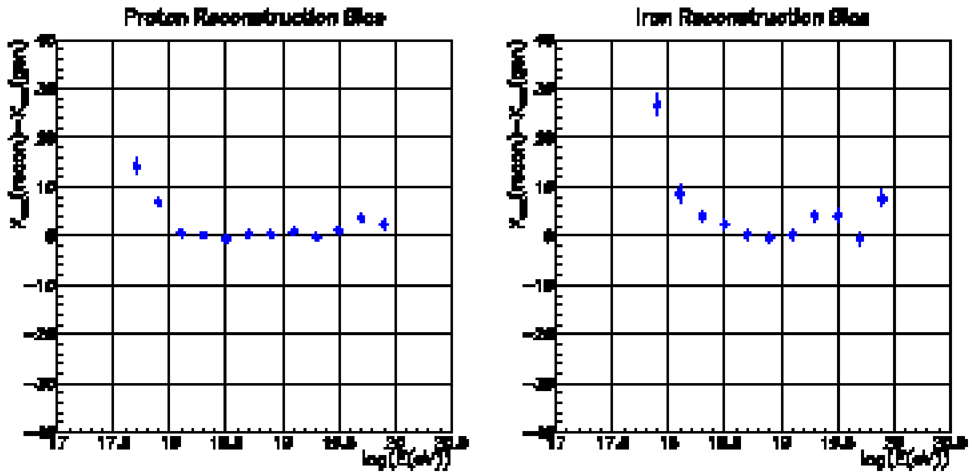


Figure 18: Left; Profile plot showing the mean value of X_{max}(reconstructed) versus X_{max}(generated) for proton MC events, as a function of energy. Right; Similar plot for iron.

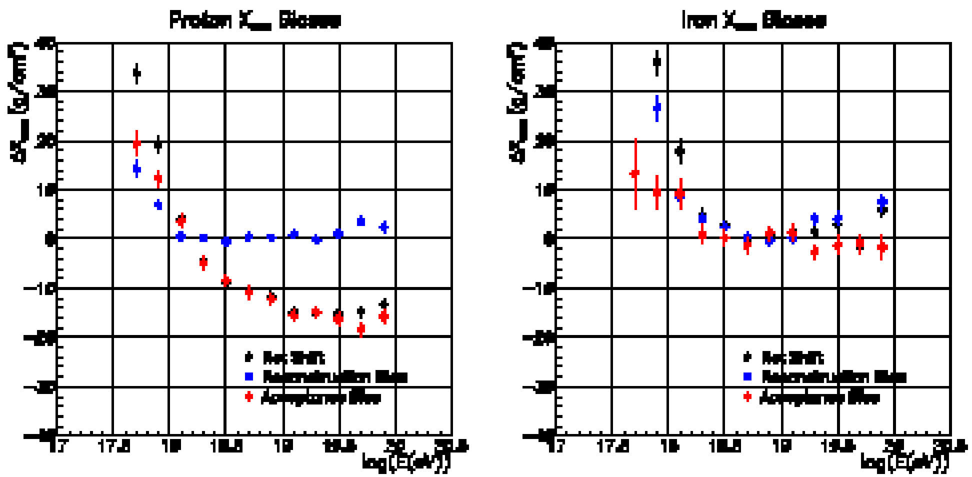


Figure 19: Left; Overlay of $<X_{max}>$ reconstruction bias (Figure 18, blue) with the net shift in $<X_{max}>$ from the proton rail (black) and the net shift minus the reconstruction bias (red). Right; Similar plot for iron.

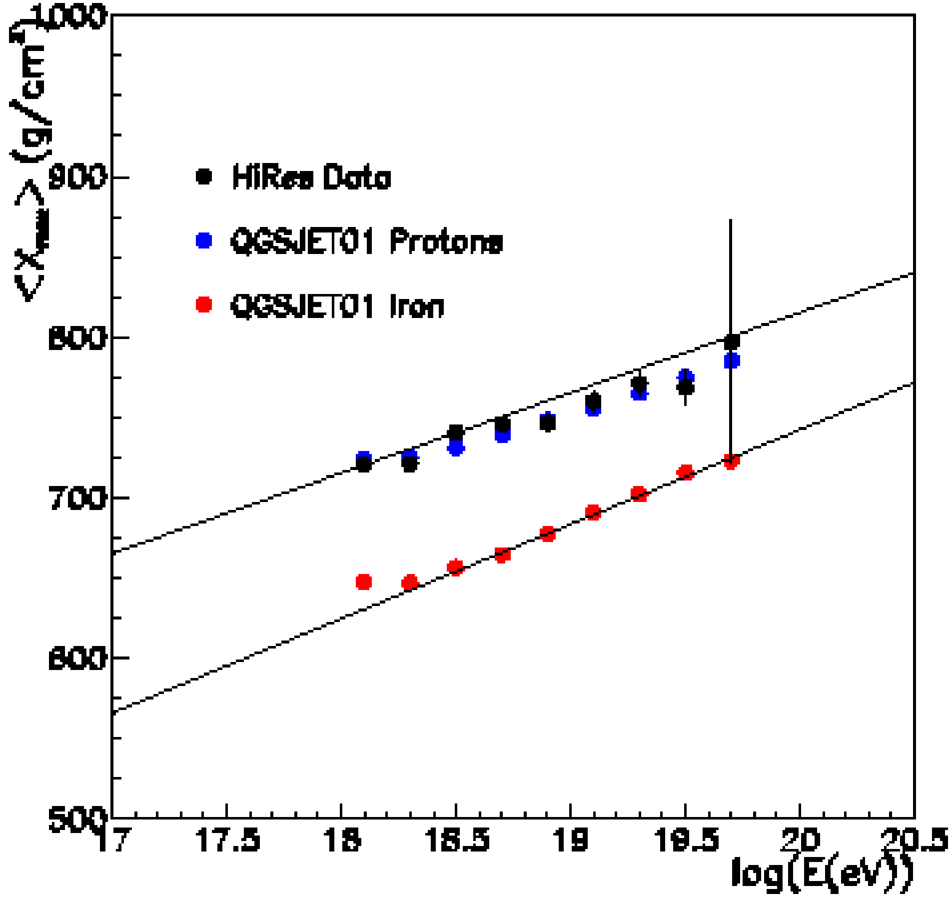


Figure 21: $<X_{max}>$ for HiRes stereo data, superimposed on QGSJET01 protons and iron, along with rails. Data is not corrected for acceptance biases, but energy cuts have been applied.

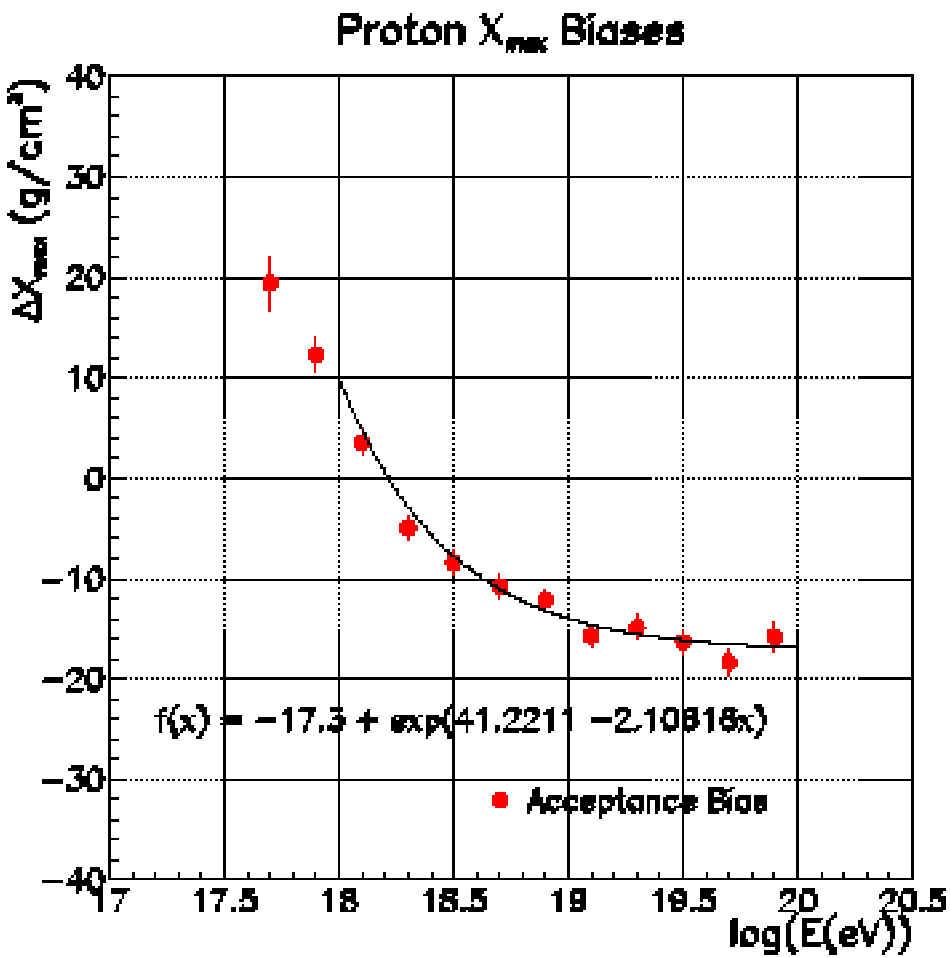


Figure 36: The acceptance bias in $<X_{max}>$ for proton Monte Carlo (see also Figure 19). Also shown is a smooth curve fit to the points. This data and curve are used to perform a bin-by-bin correction to the $<X_{max}>$ data of Figure 37.

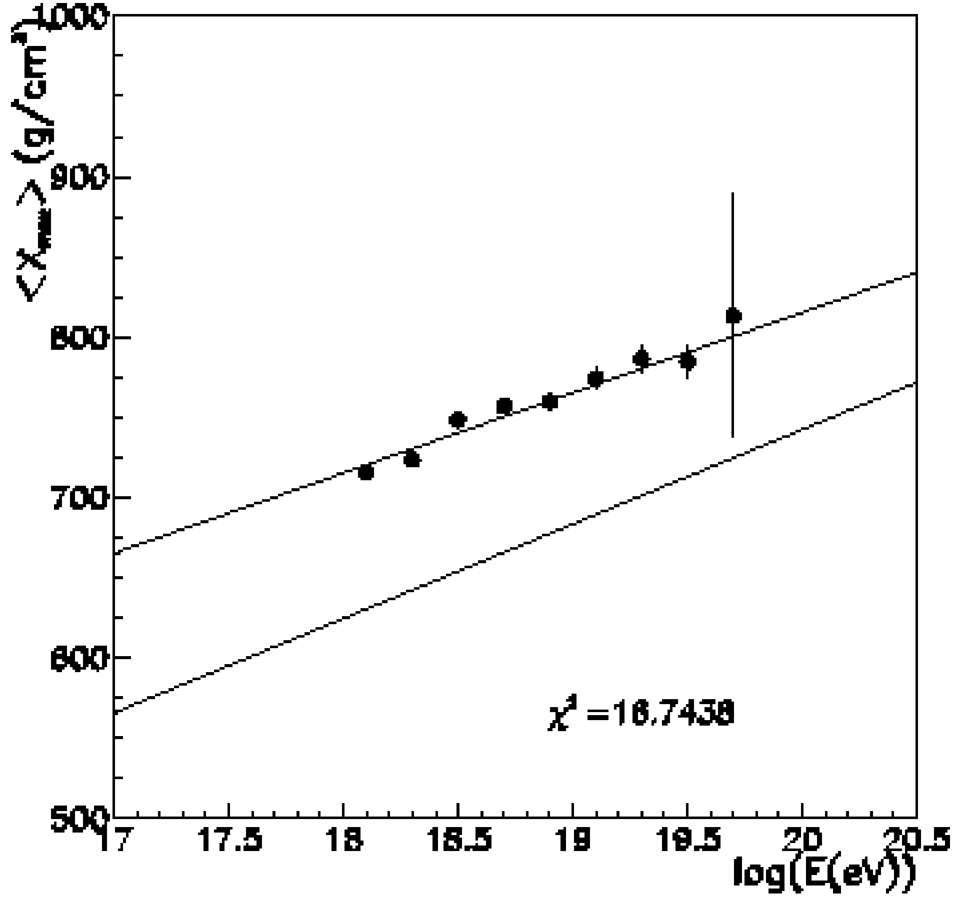
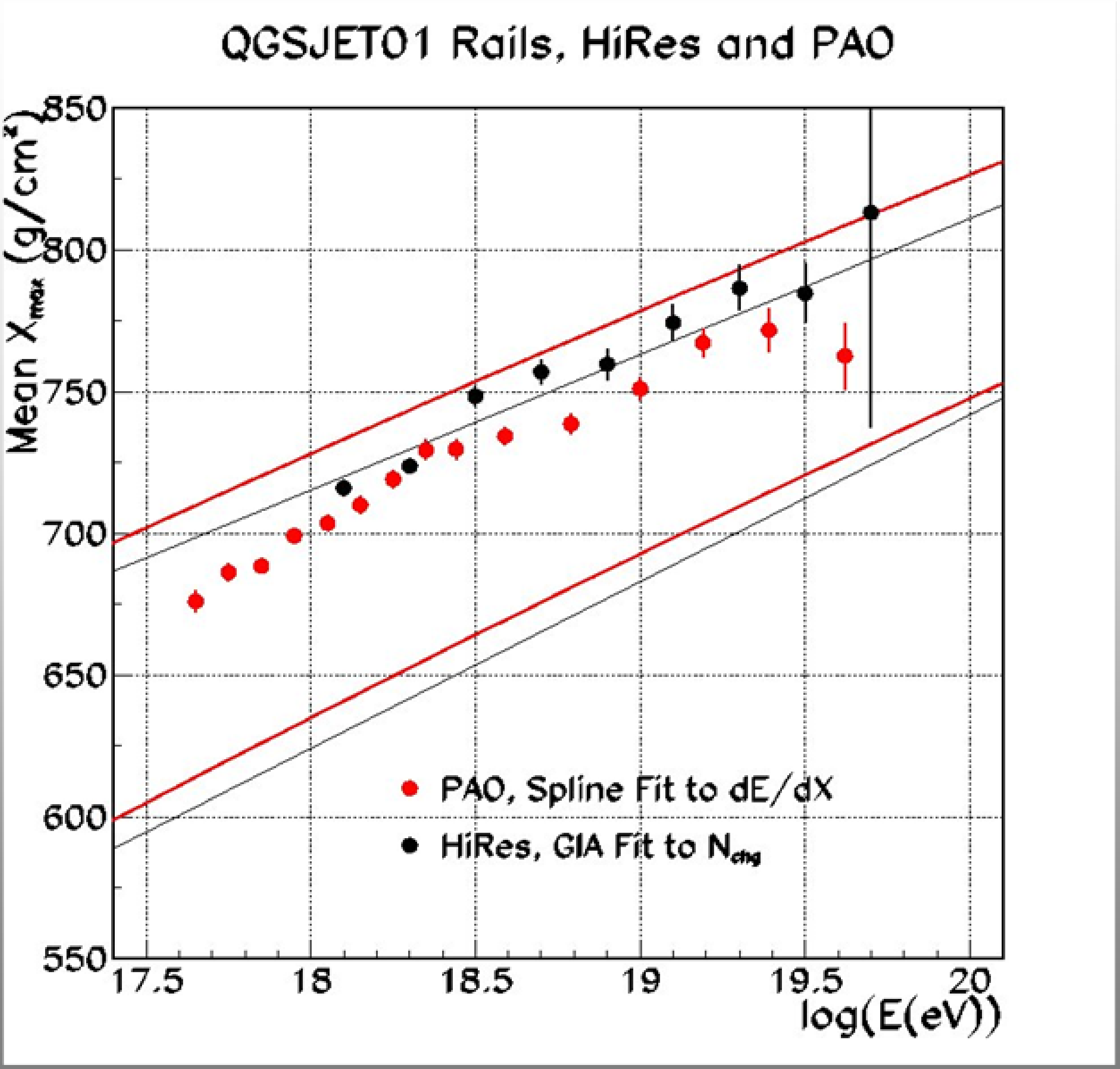


Figure 39: Bias-corrected $<X_{max}>$ in HiRes stereo data, after energy cuts. The χ^2 shown is *not* the result of a fit, but of a direct comparison with the QGSJET01 proton rail for the Gaussian-in-age parametrization.

Acceptance corrected data compared to input QGSJET p and Fe



QGSJET01 Rails, HiRes and PAO
Mean X_{max} (g/cm²)
850
800
750
700
650
600
550
17.5
18
18.5
19
19.5
20
log(E(eV))
PAO, Spline Fit to dE/dX
HiRes, GIA Fit to N_{chg}

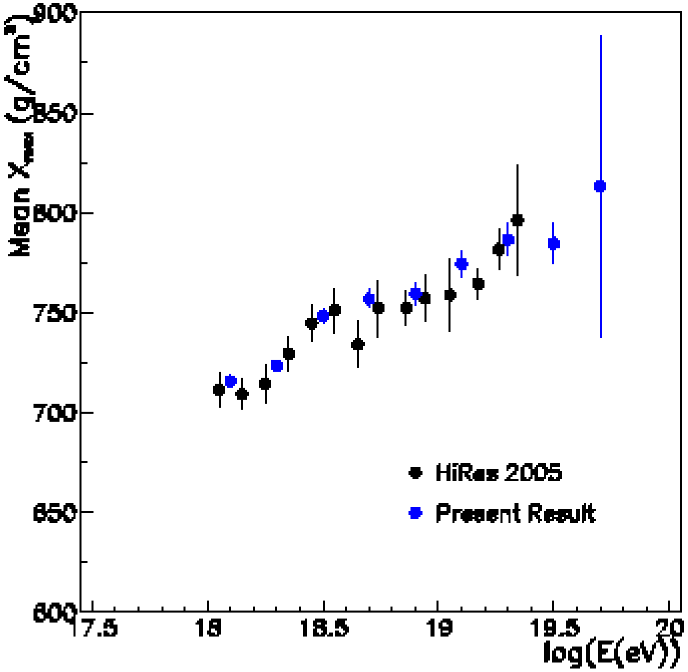


Figure 42: Comparison of present $<X_{max}>$ points with previous HiRes result [8].

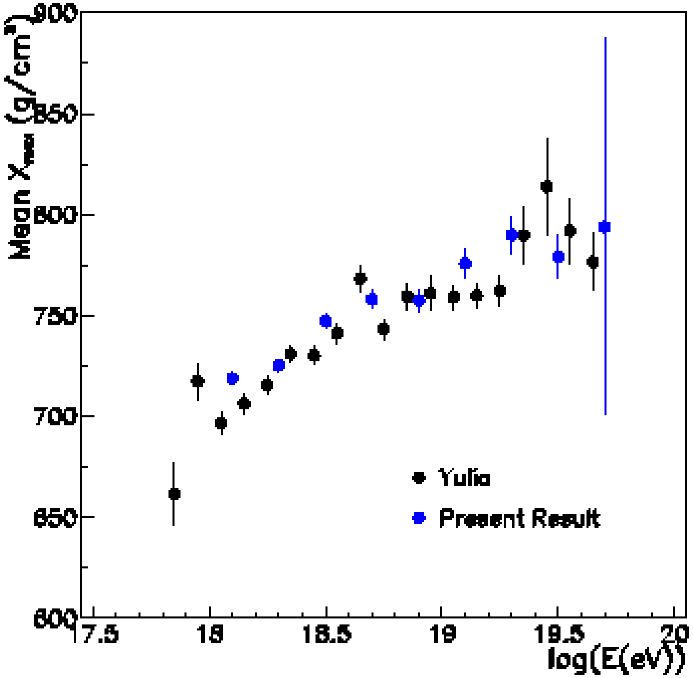
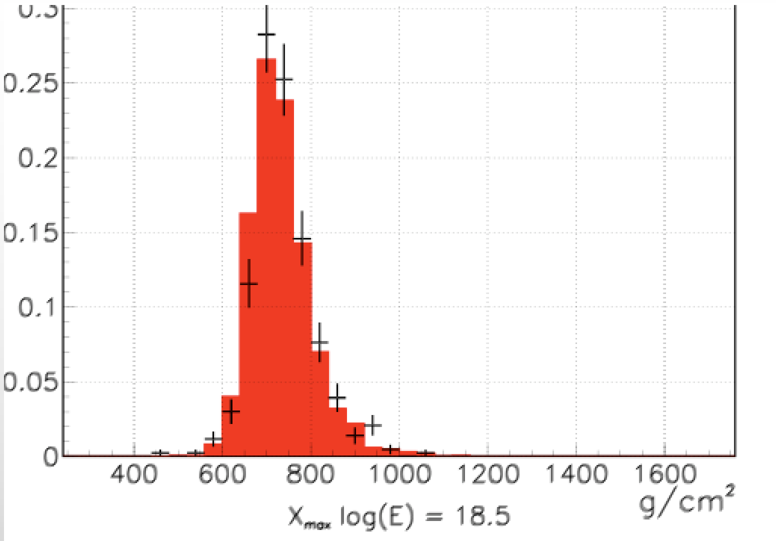
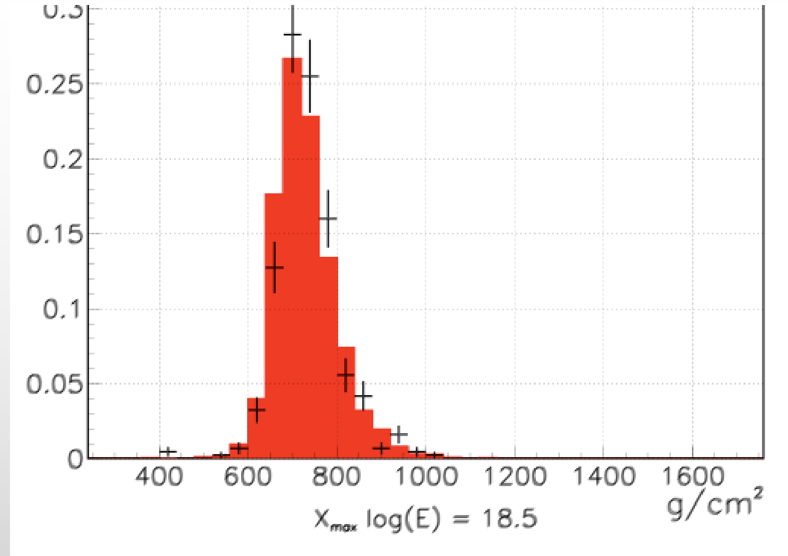
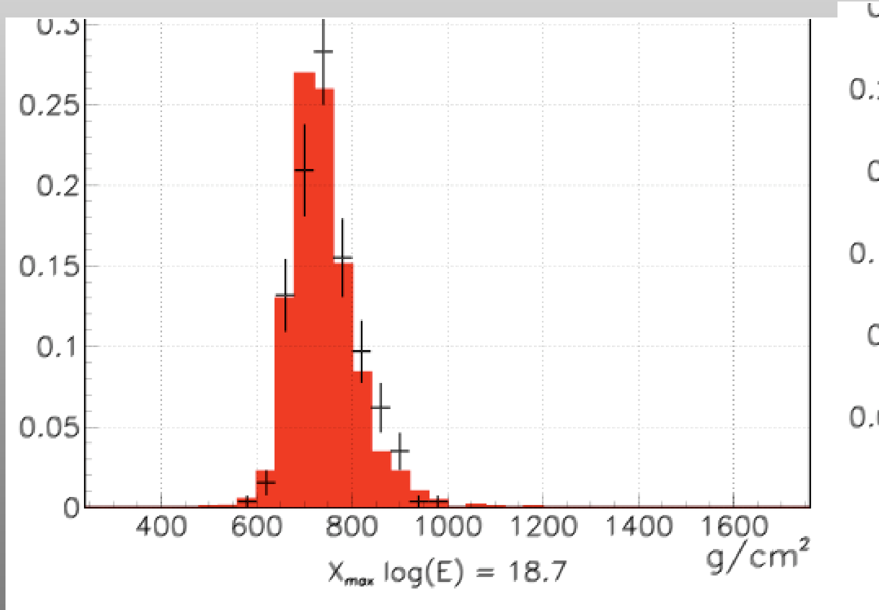


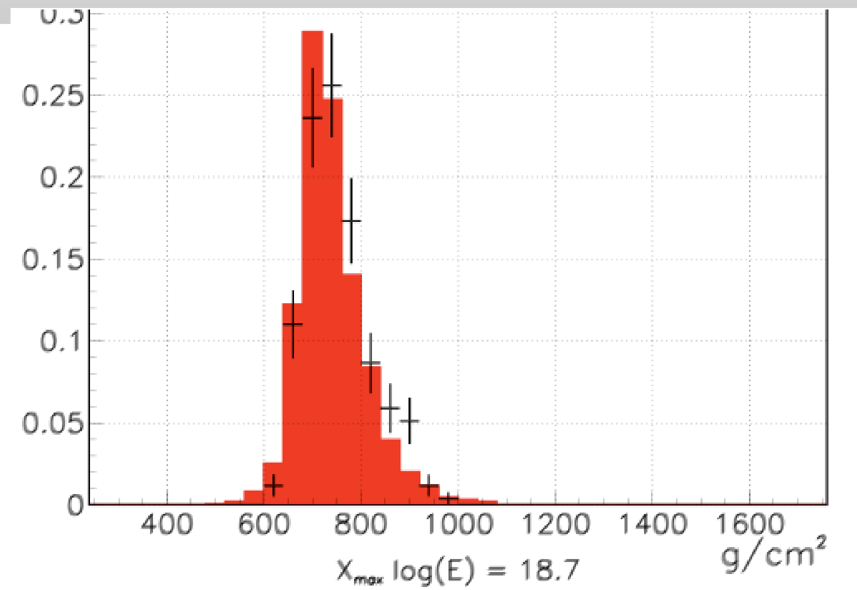
Figure 43: Comparison of present $<X_{max}>$ data with Y. Fedorova analysis [18].

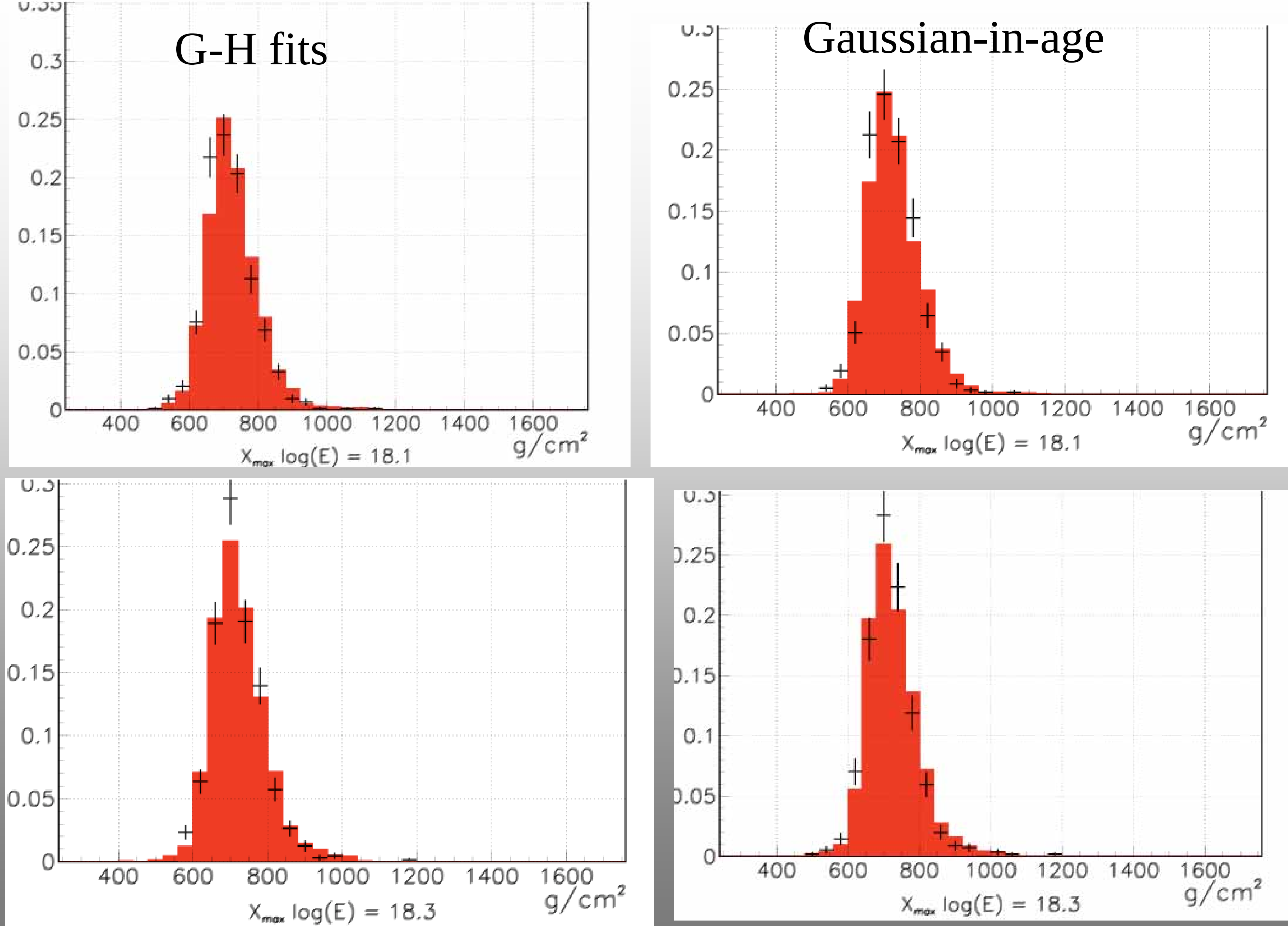
Comparison with previously published HiRes data and Y. Fedorova analysis using G-H fits


0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_max log(E) = 18.5

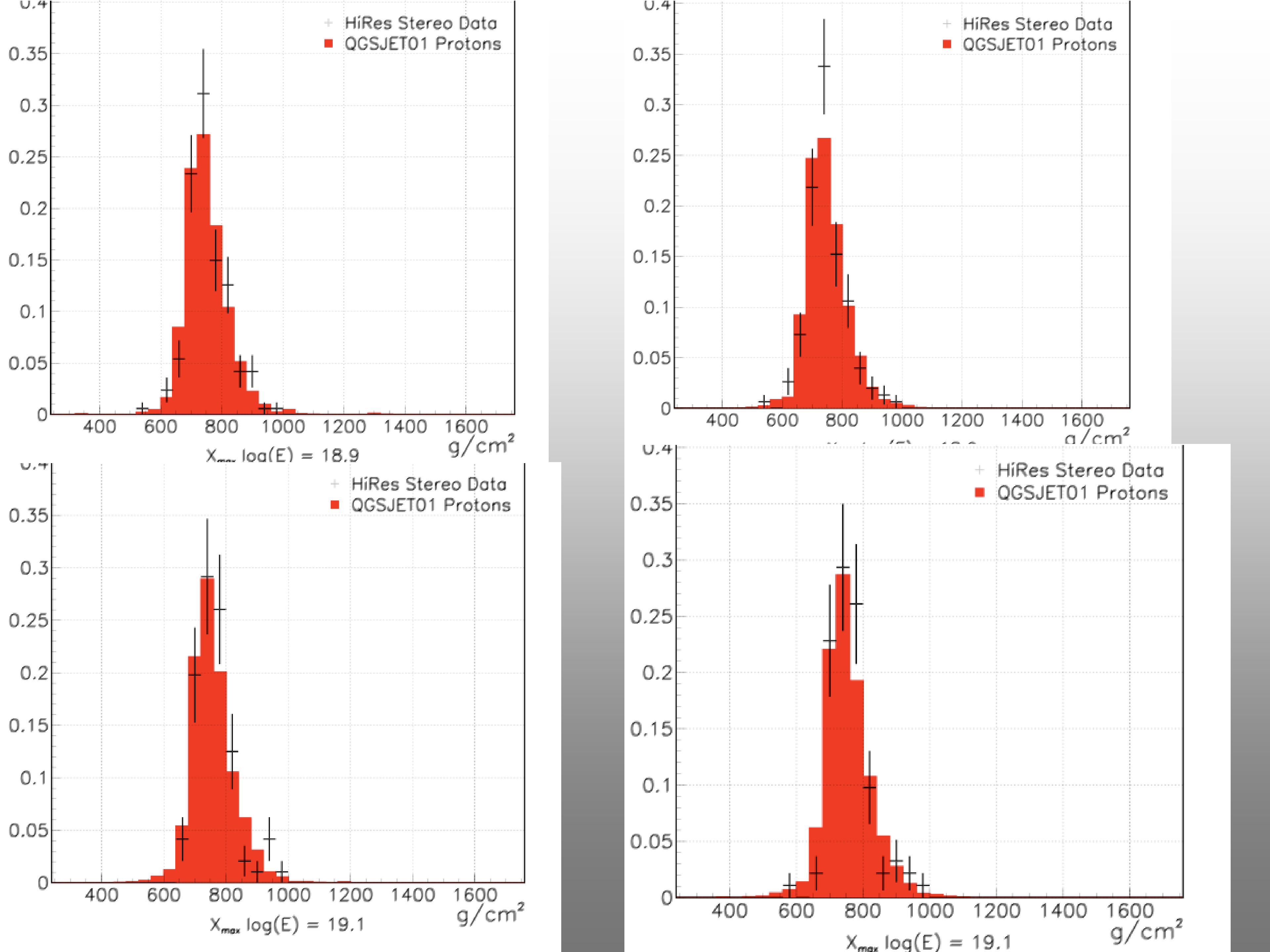

0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_max log(E) = 18.5

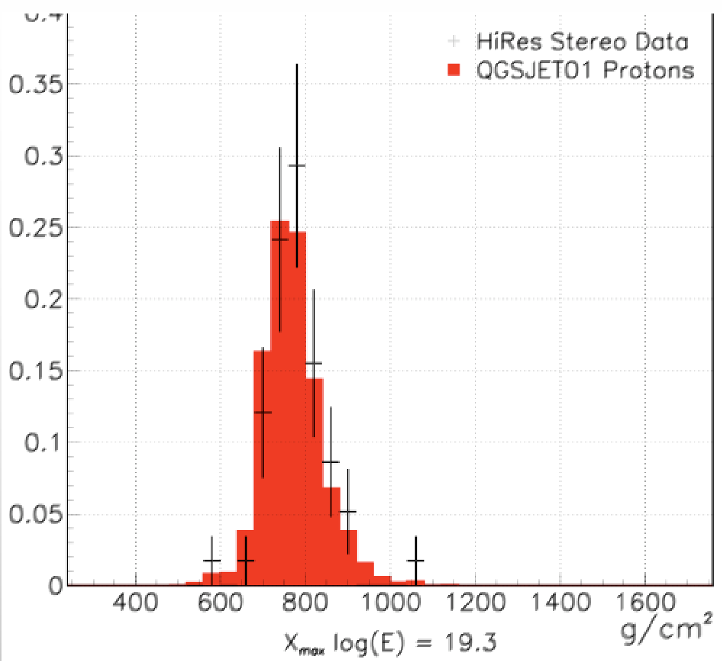

0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_max log(E) = 18.7

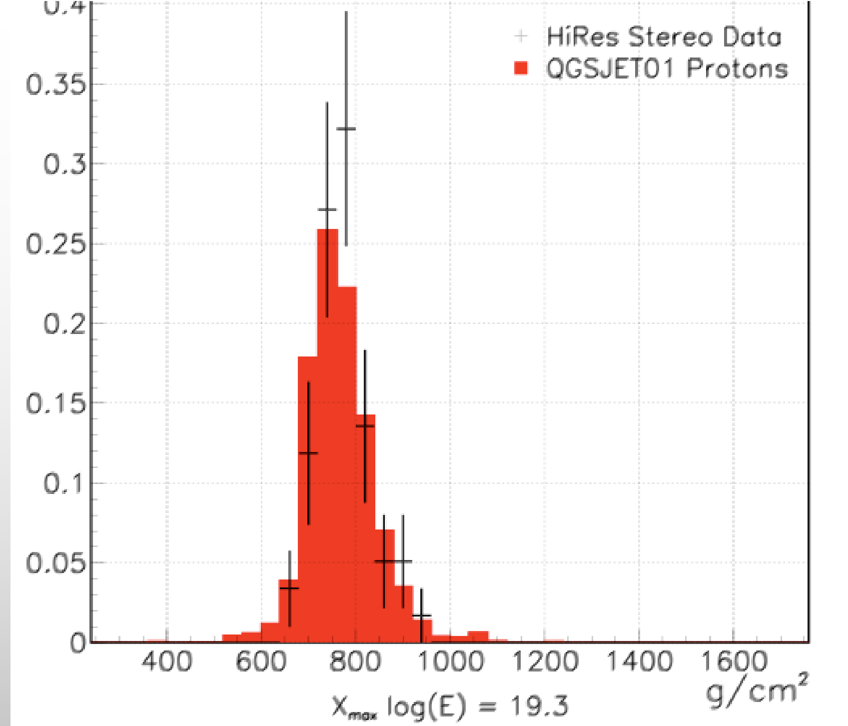

0.3
0.25
0.2
0.15
0.1
0.05
0
400 600 800 1000 1200 1400 1600
g/cm²
X_max log(E) = 18.7

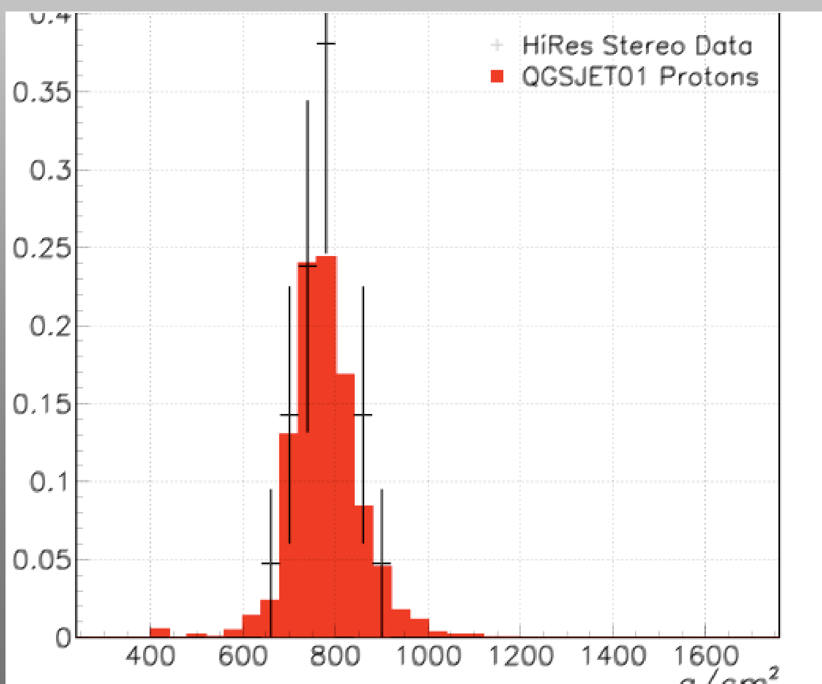


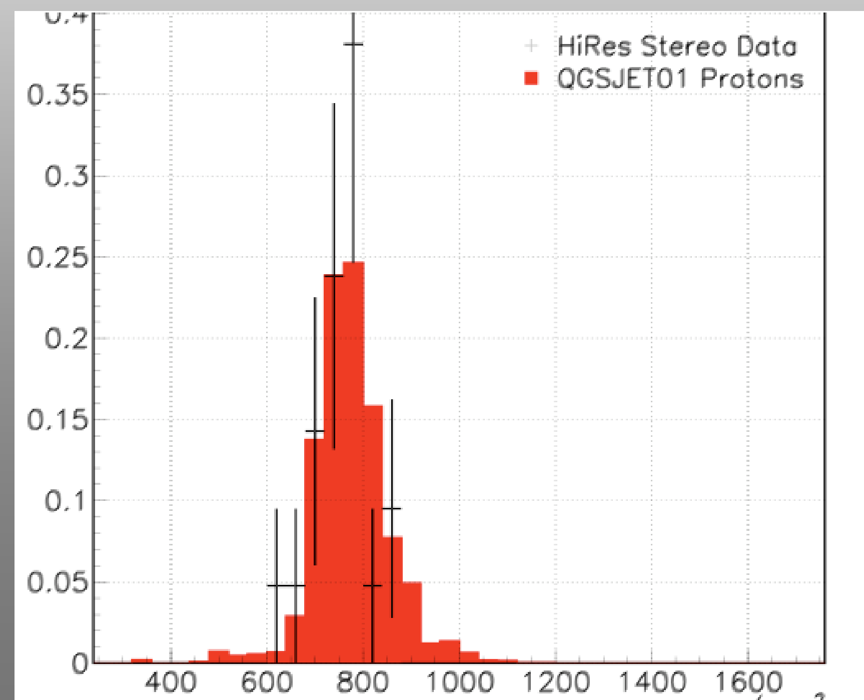
G-H fits
Gaussian-in-age
0.3
0.25
0.2
0.15
0.1
0.05
0
400
600
800
1000
1200
1400
1600
g/cm²
X_{max} log(E) = 18.1
X_{max} log(E) = 18.3

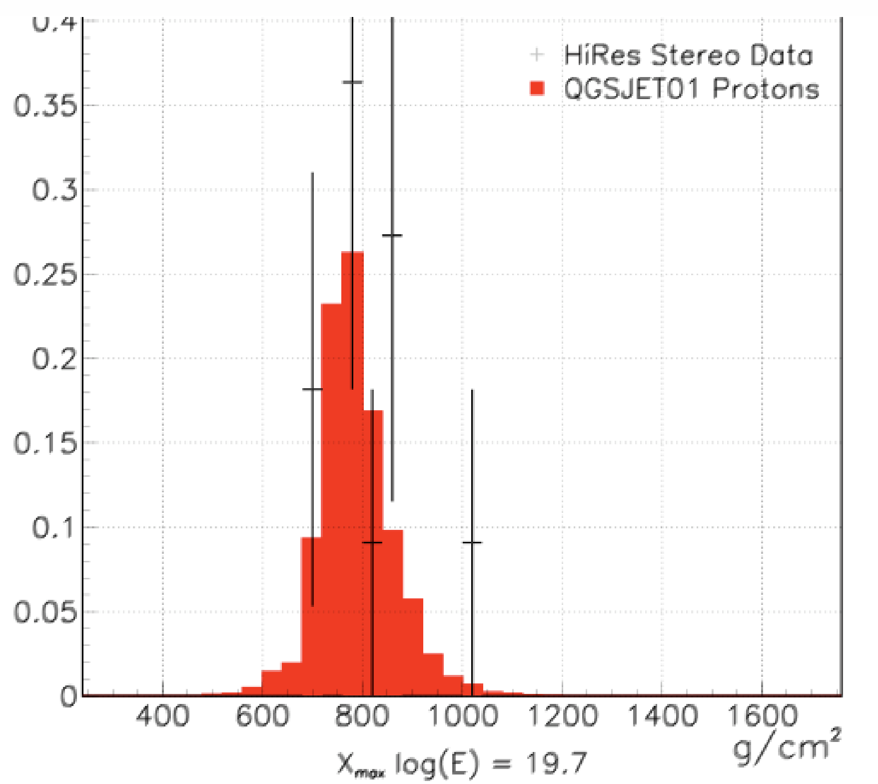

HiRes Stereo Data
QGSJET01 Protons
X_{max} log(E) = 18.9
g/cm²
HiRes Stereo Data
QGSJET01 Protons
g/cm²
HiRes Stereo Data
QGSJET01 Protons
X_{max} log(E) = 19.1
g/cm²
HiRes Stereo Data
QGSJET01 Protons
X_{max} log(E) = 19.1
g/cm²

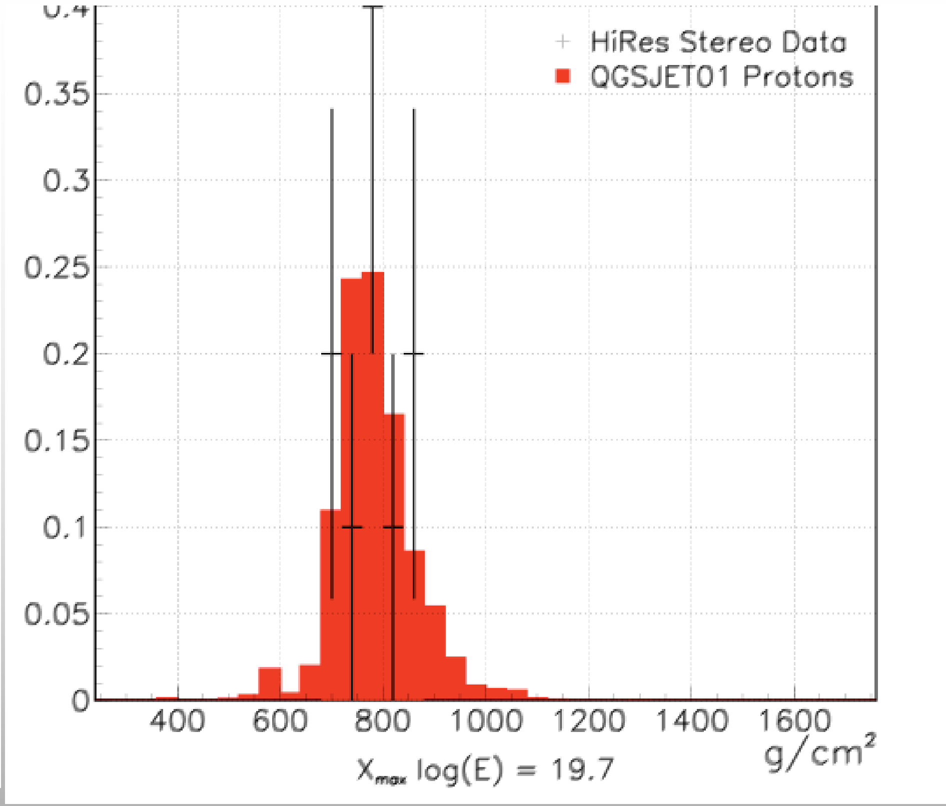

HiRes Stereo Data
QGSJET01 Protons
X_{max} log(E) = 19.3
g/cm^2


HiRes Stereo Data
QGSJET01 Protons
X_{max} log(E) = 19.3
g/cm^2


HiRes Stereo Data
QGSJET01 Protons


HiRes Stereo Data
QGSJET01 Protons





Good Agreement with proton fluctuations independent of fitting function

Comparison of predicted elongation rates using different Xmax definitions

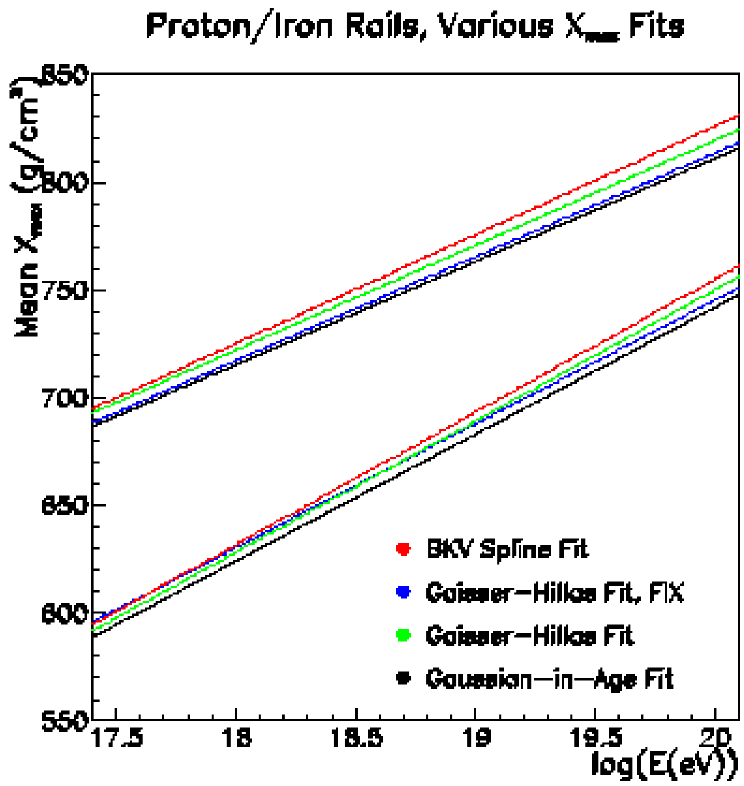
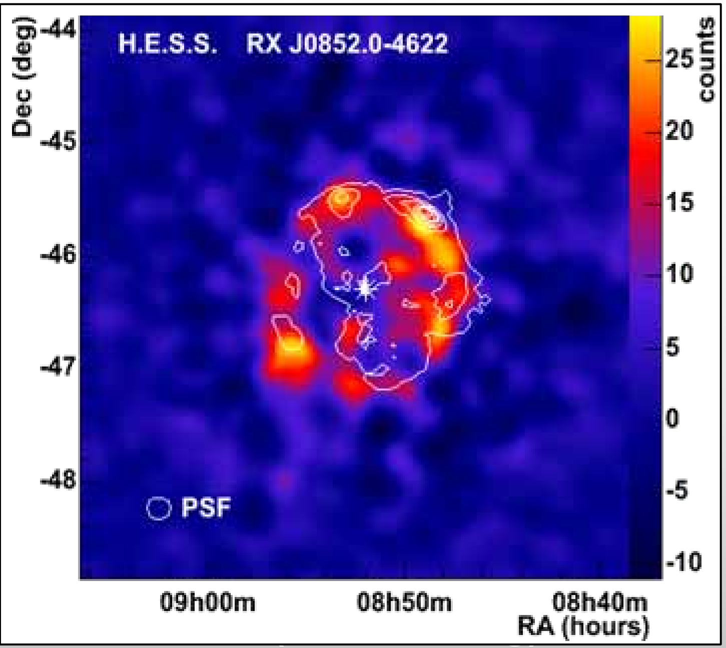
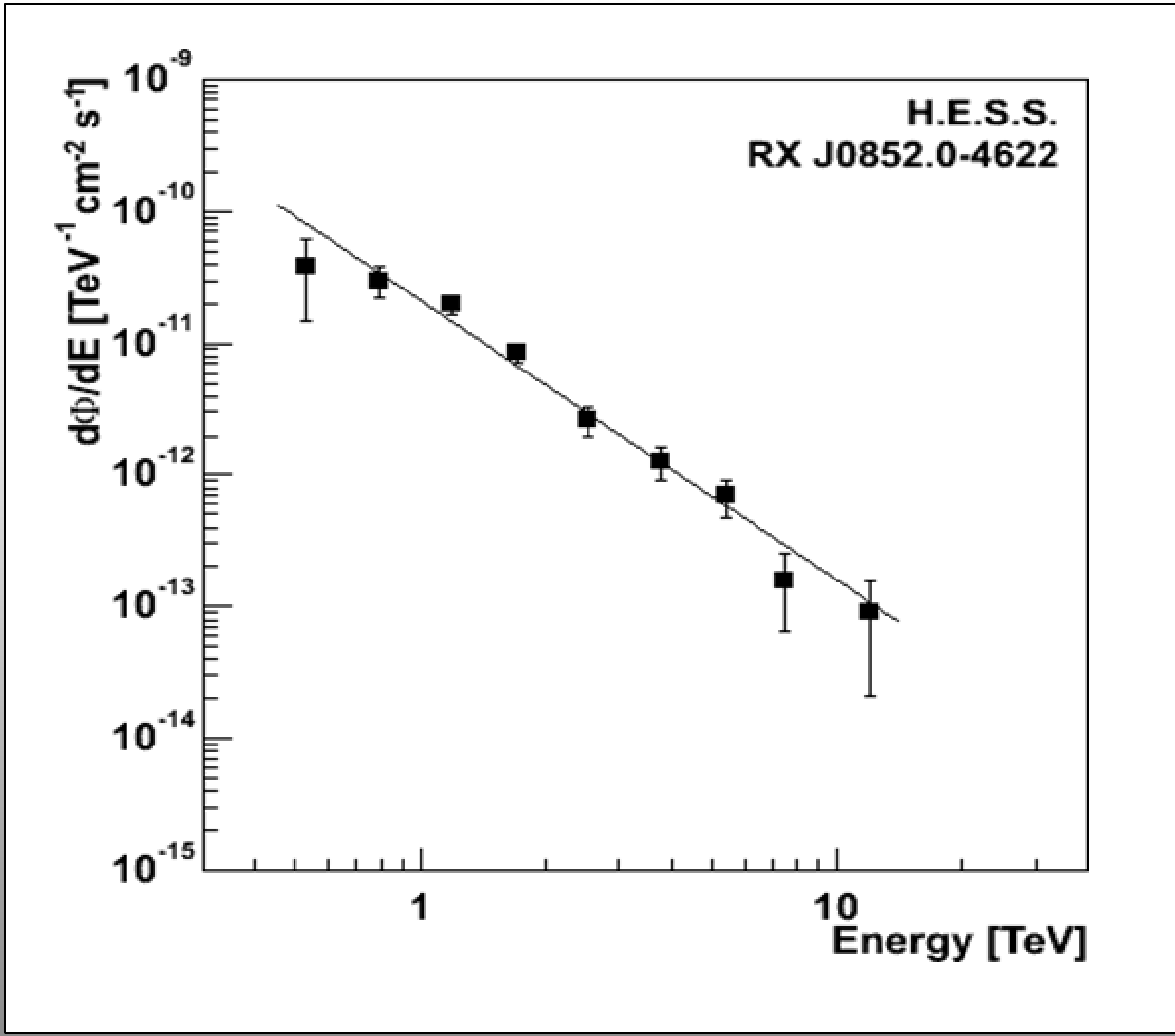


Figure 2: Evolution of the mean X_{max} for a set of CORSIKA [4] (QGSJET01 high-energy hadronic model) simulated proton (upper rail) and iron (lower rail) showers, under four different X_{max} definitions. Red – "spline" fit to extract peak of longitudinal distribution. Blue – fit to Gaisser-Hillas function [5] with X_0 and Λ fixed. Green – Gaisser-Hillas fit, all parameters floating. Black – Gaussian-in-age fit.

RX J0852.0-4622 — Vela Junior





~ 1 Crab flux

<u>2005</u>

--> further obs. ~15hr expected soon

--> **high ZA obs!**

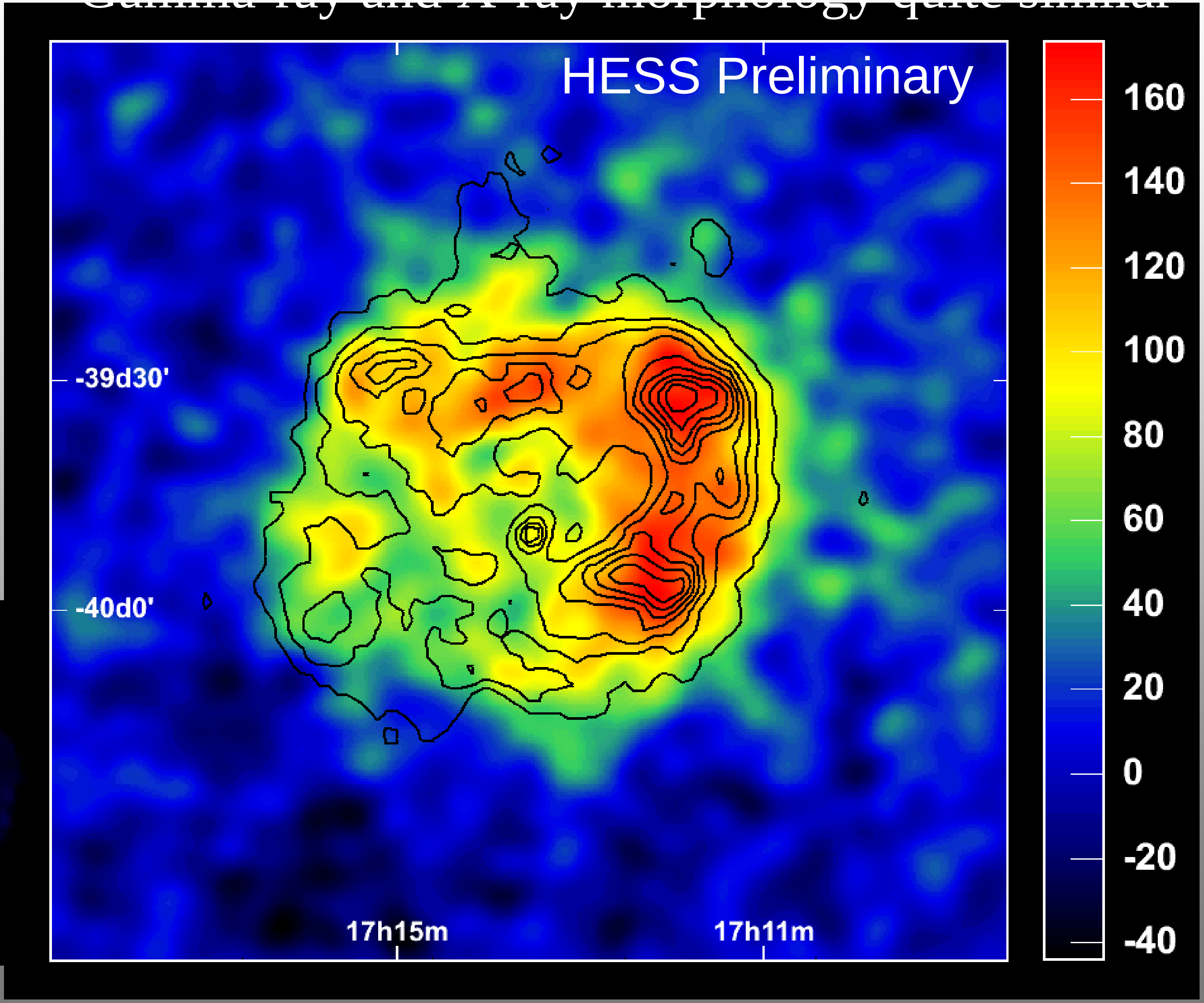
ASCA

0.7 – 10 keV

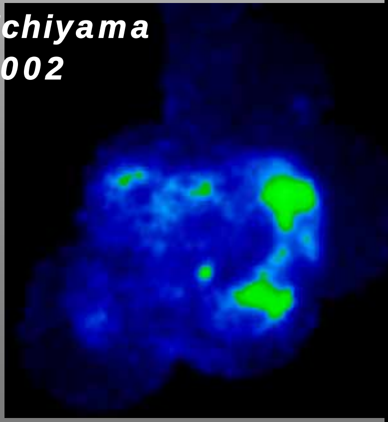
Slane 2001

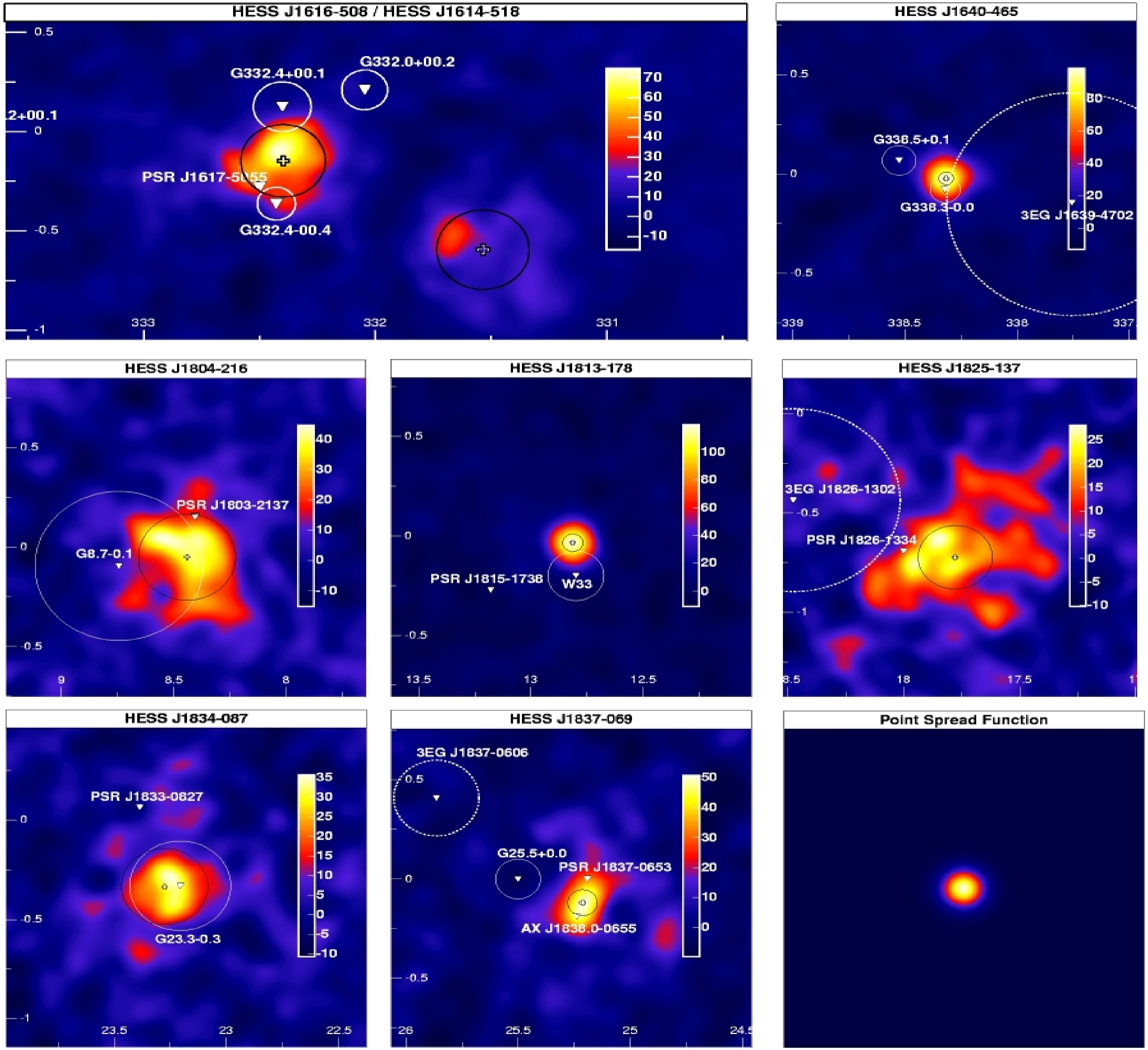
RX J1713 – H.E.S.S & ASCA

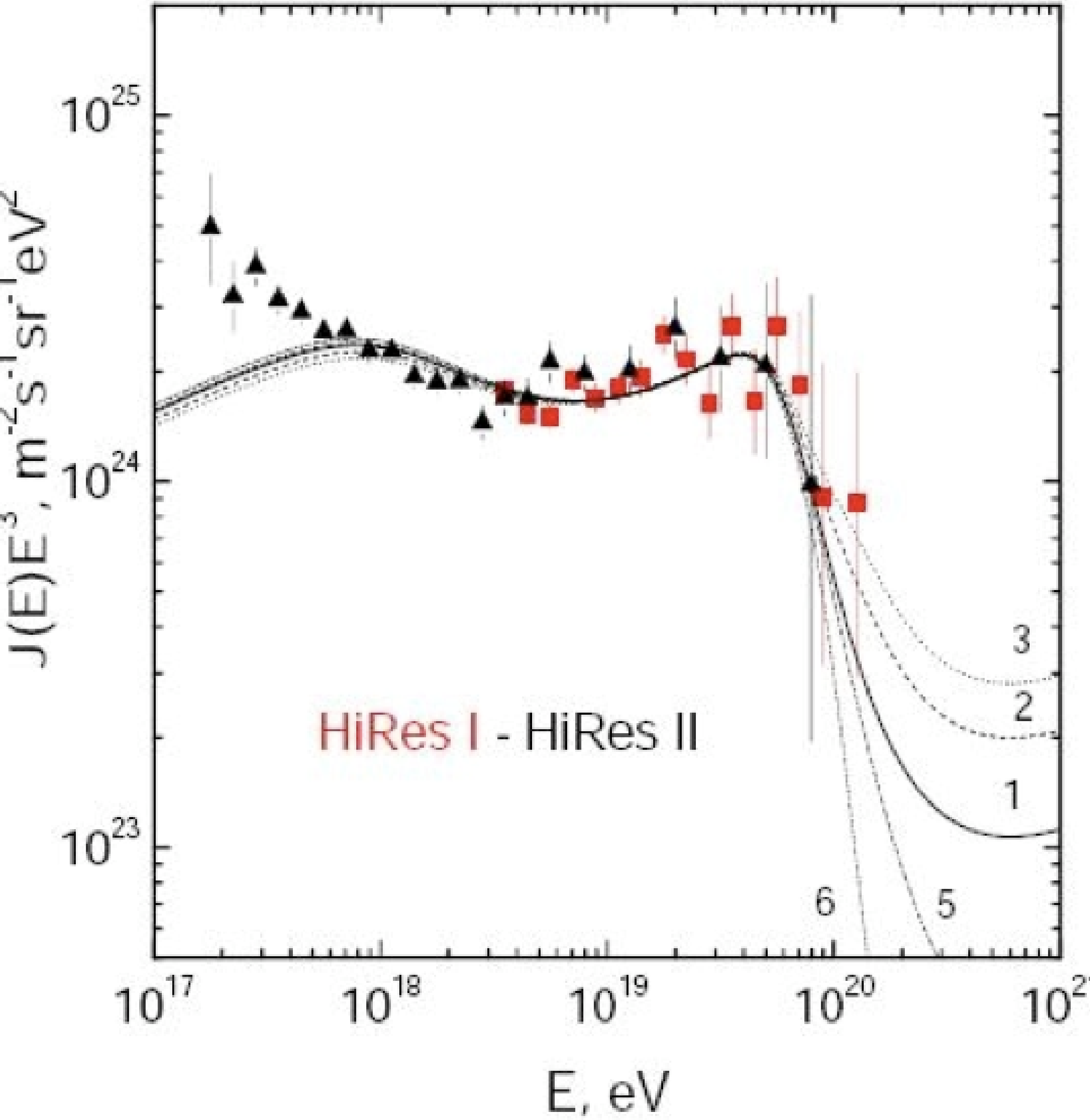
- Gamma-ray and X-ray morphology quite similar



ASCA
1 – 3 keV
Uchiyama
2002




HESS J1616-508 / HESS J1614-518
G332.4+00.1
G332.0+00.2
PSR J1617-5055
G332.4-00.4
HESS J1640-465
G338.5+0.1
G338.3-0.0
3EG J1639-4702
HESS J1804-216
PSR J1803-2137
G8.7-0.1
HESS J1813-178
PSR J1815-1738
W33
HESS J1825-137
3EG J1826-1302
PSR J1826-1334
HESS J1834-087
PSR J1833-0827
G23.3-0.3
HESS J1837-069
3EG J1837-0606
G25.5+0.0
PSR J1837-0653
AX J1838.0-0655
Point Spread Function



Berezinsky et al.

Inject Smooth power law Spectrum.

Let propagation leave its "imprint" on the shape of the spectrum.

"ANKLE" --> "DIP" e+e- production

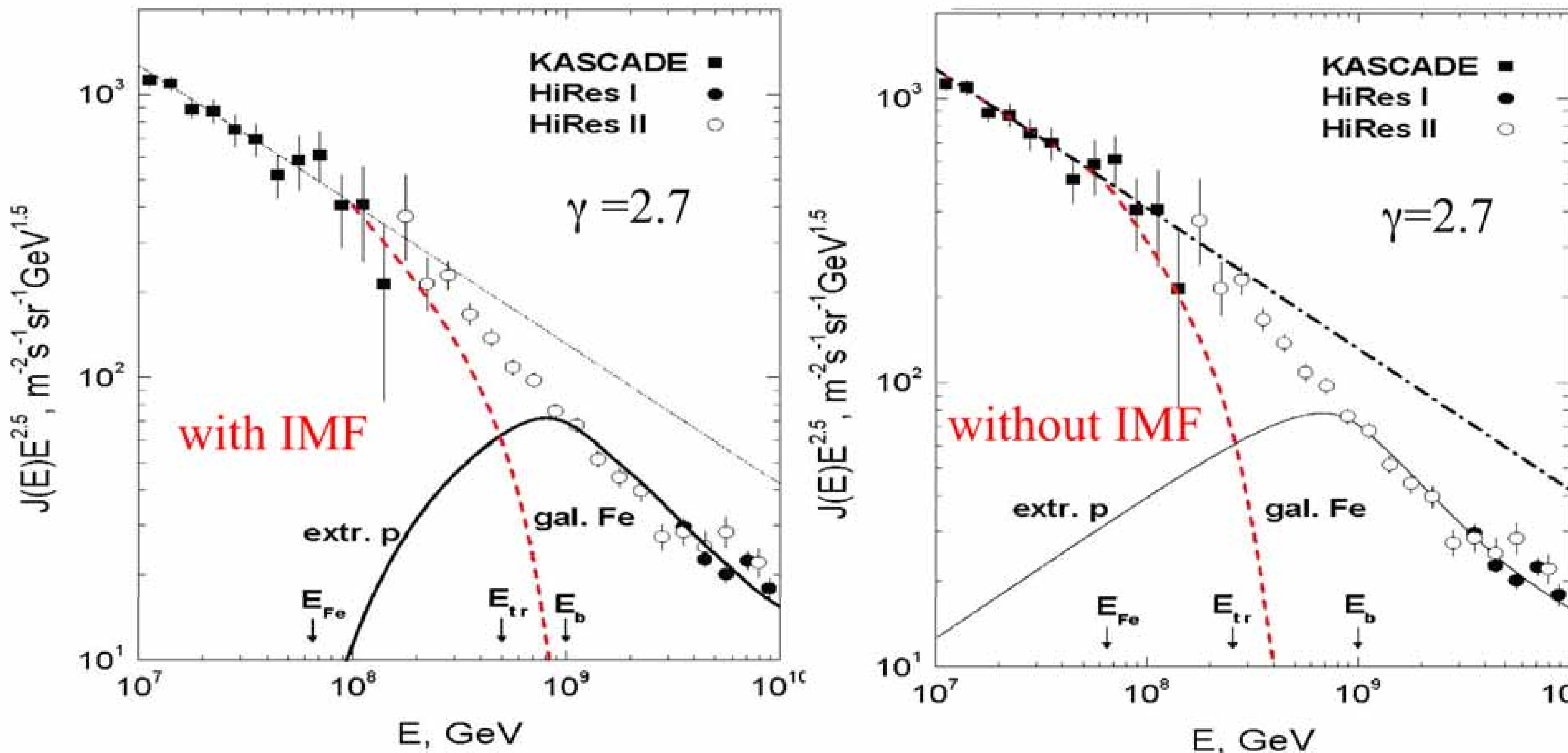
Galactic and ExtraGalactic I

dip scenario

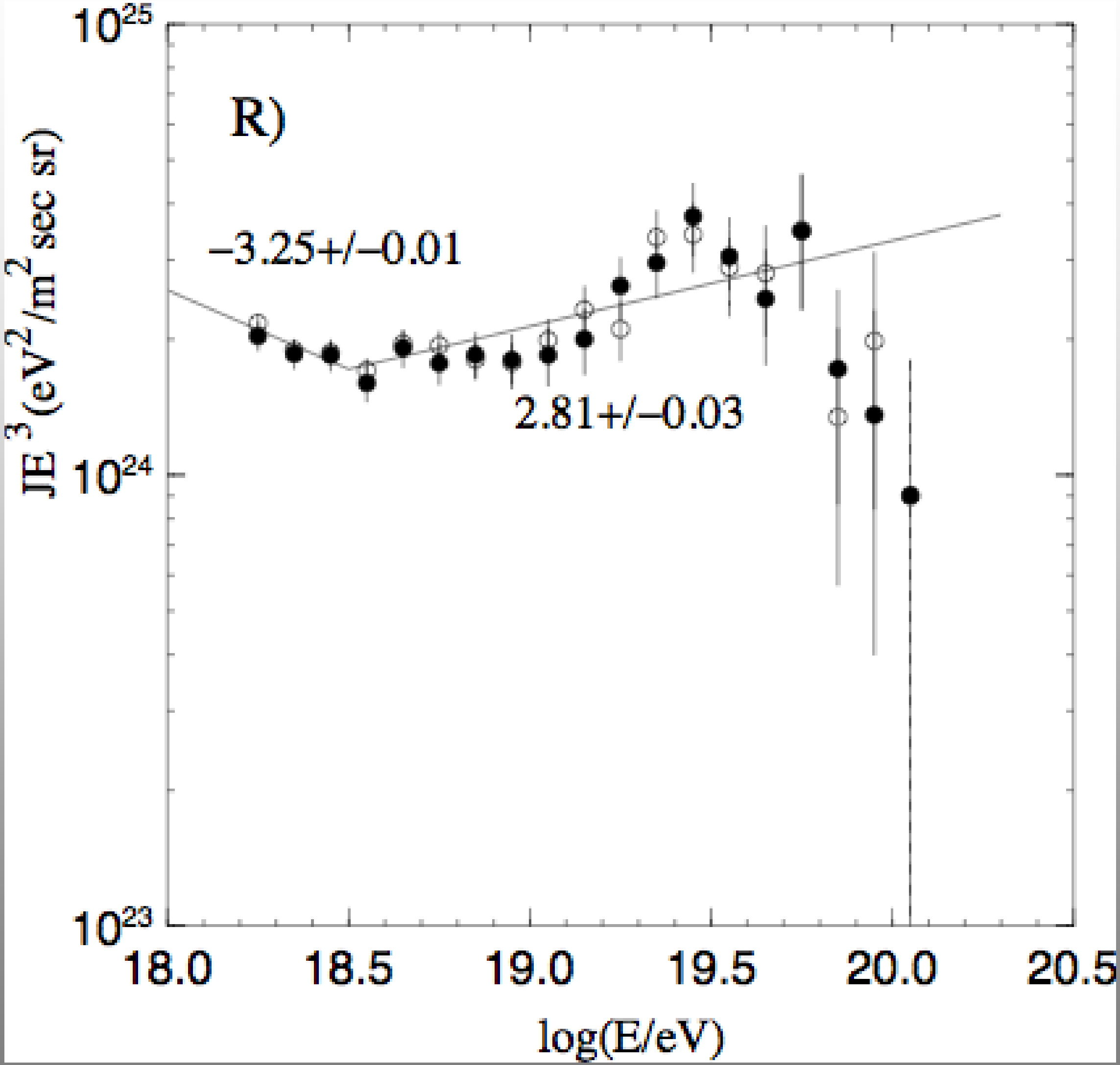
The Galactic CR spectrum ends in the energy range 10^{17} eV, 10^{18} eV.

2^{nd} Knee appears naturally in the extragalactic proton spectrum as the steepening energy corresponding to the transition from adiabatic energy losses to pair production energy losses. This energy is universal for all propagation modes (rectilinear or diffusive): $E_{2K} \approx 10^{18}$ eV.

RA & Berezinsky (2005)



Stereo Spectrum



Significance of GZK cutoff is 3.8 sigma in stereo Data.