Rapporteur Talk:

HE 1.1- Extensive Air Shower Observation for Energy < 10^{17} eV

HE 1.2 - Theory and Simulation (In atmosphere)

HE 1.5 - Instrumentation and New Projects (excepting UHECR)

HE 3.1 - Hadron Interactions

By Masato Takita, ICRR, U. of Tokyo,

@ICRC2003, Tsukuba, August 7, 2003

Presenter Index (HE 1.1)

Presenter Index (HE 1.1)

Presenter Index (HE 1.1)

Presenter Index (HE 1.2)

Presenter Index (HE 1.2)

Presenter Index (HE 1.5)

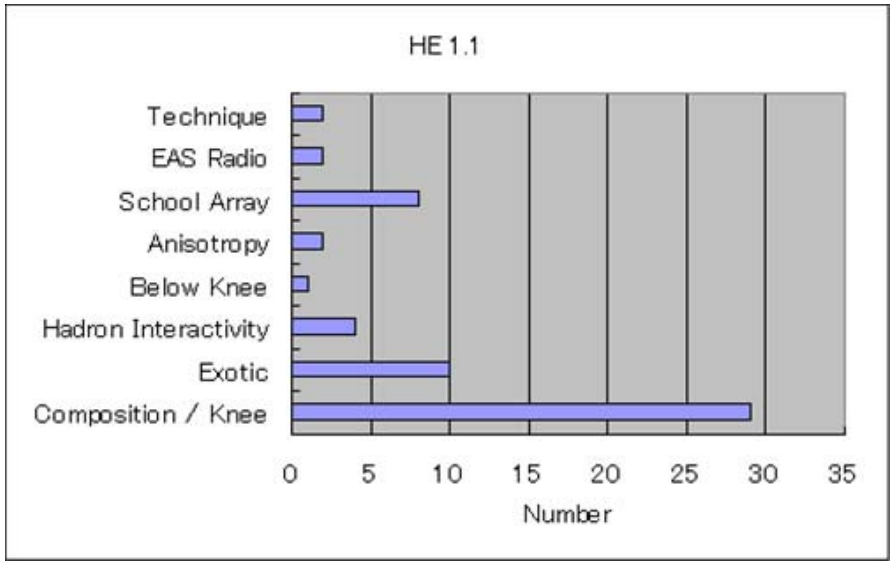
Presenter Index (HE 1.5)

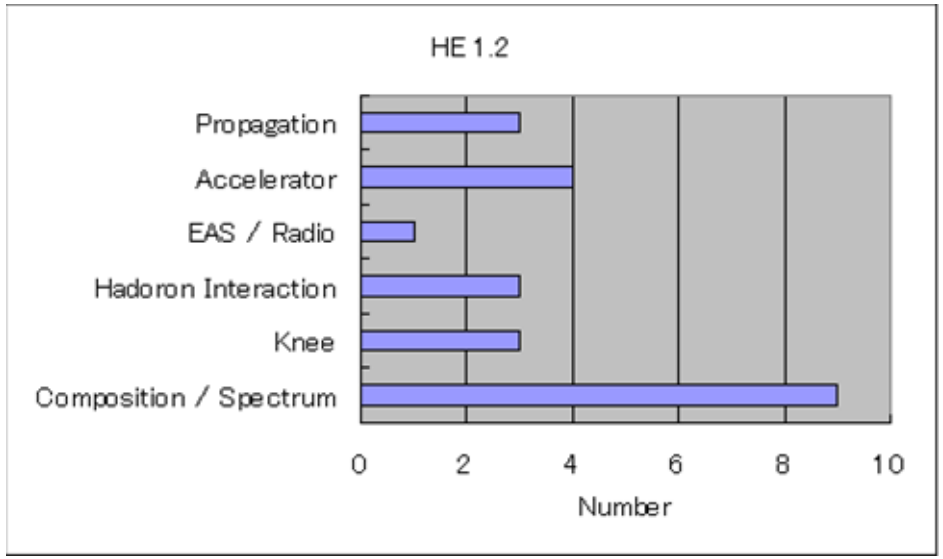
Presenter Index (HE 1.5)

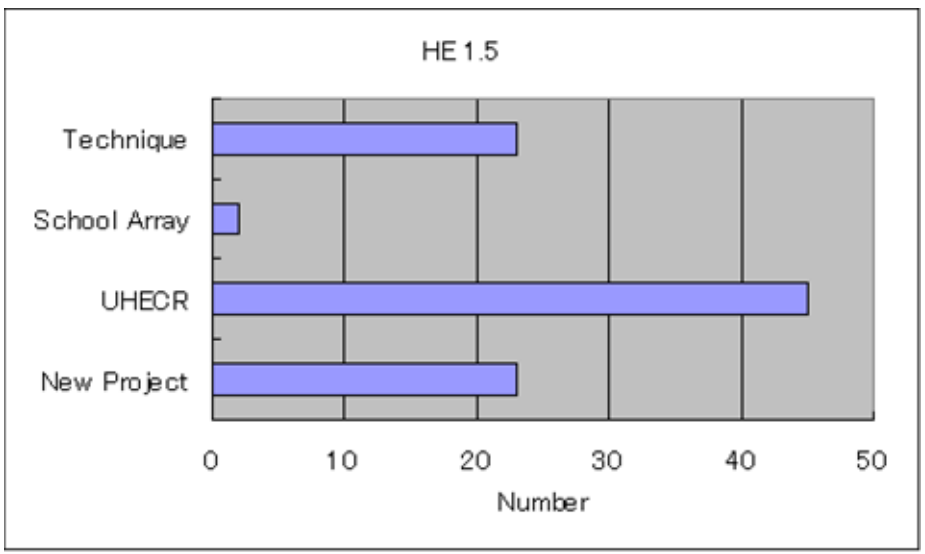
Presenter Index (HE 1.5)

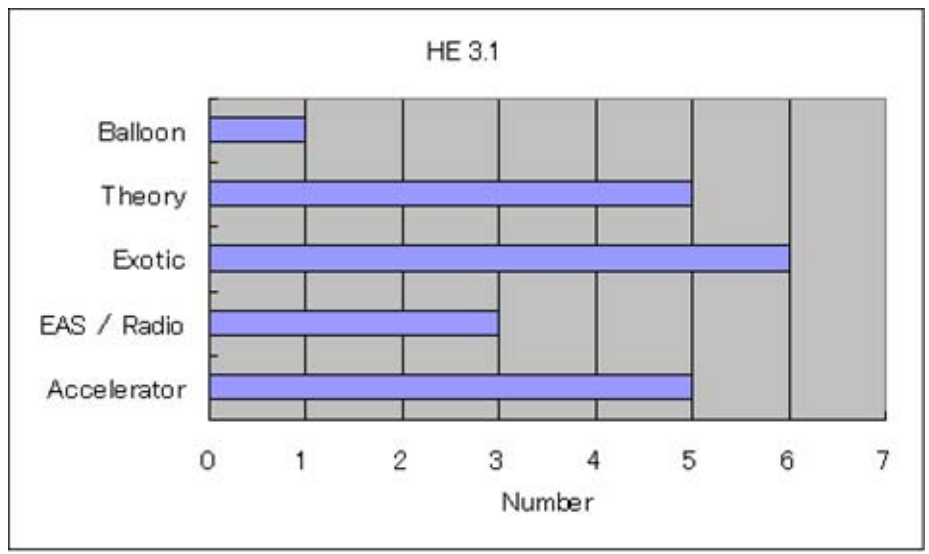
Presenter Index (HE 3.1)

STATISTICS (BREAK DOWN)

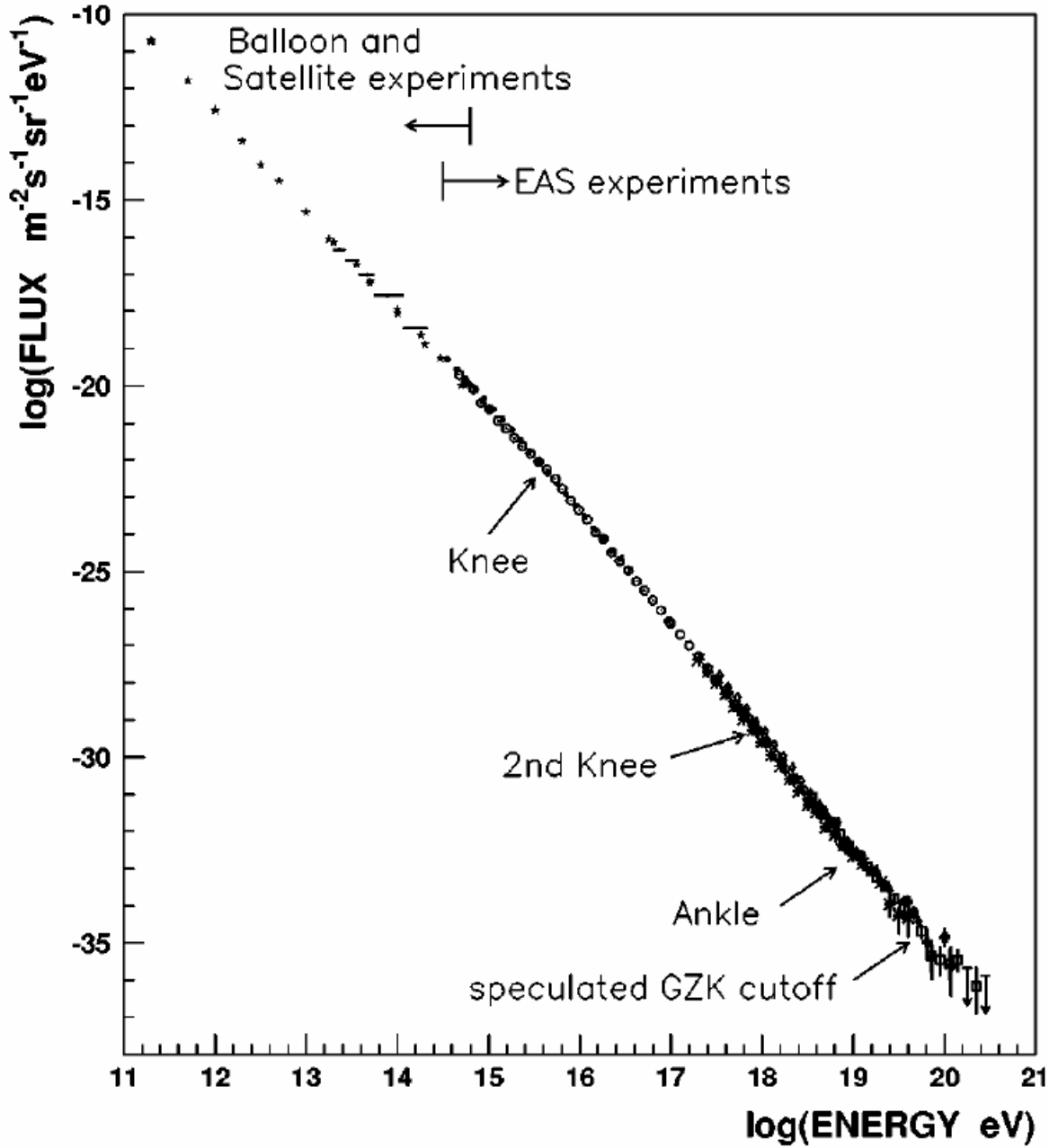






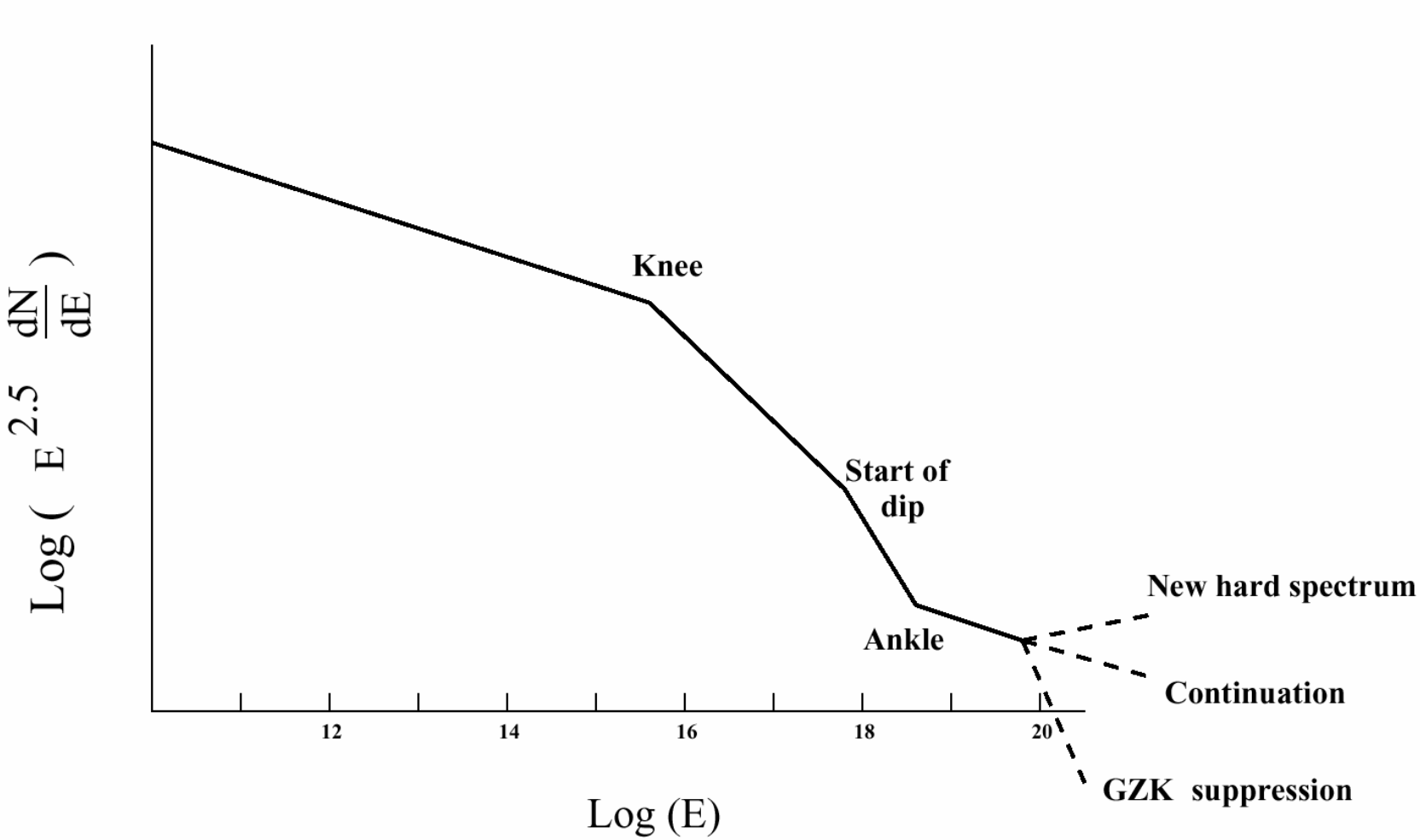


Cosmic Ray Energy Spectrum



M.Nagano, A.A.Watson (2000)

Cosmic Ray Energy Spectrum



Sommers (ICRC2001)

IL NUOVO CIMENTO Vol. XXII, N. 4 16 Novembre 1961

Primary Cosmic Radiation and Extensive Air Showers.

B. PETERS

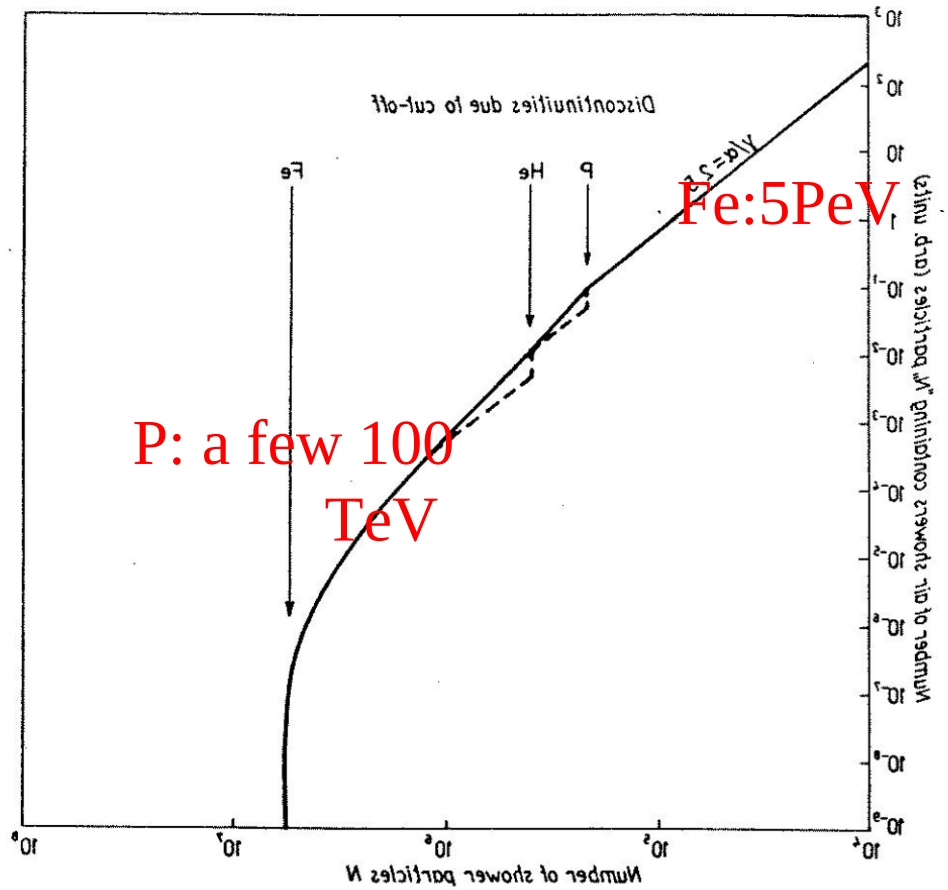
Institute for Theoretical Physics, University of Copenhagen - Copenhagen

(ricevuto il 19 Agosto 1961)

Summary. — The hypothesis, that separate sources of cosmic ray particles of widely differing strength predominate in different energy regions, has been examined. In particular the following questions are discussed: Can such separate sources dominate neighbouring energy intervals of the primary particle spectrum without introducing appreciable changes in slope or discontinuities in the size-frequency distribution of air showers? Can such separate contributions, if they exist, nevertheless be distinguished experimentally with existing techniques? Do available data on extensive air showers provide evidence for or against the hypothesis? It appears that, if such separate sources existed and even if they differed in strength by factors as large as thousand, no significant departure from smoothness in the size-frequency relation of air showers would

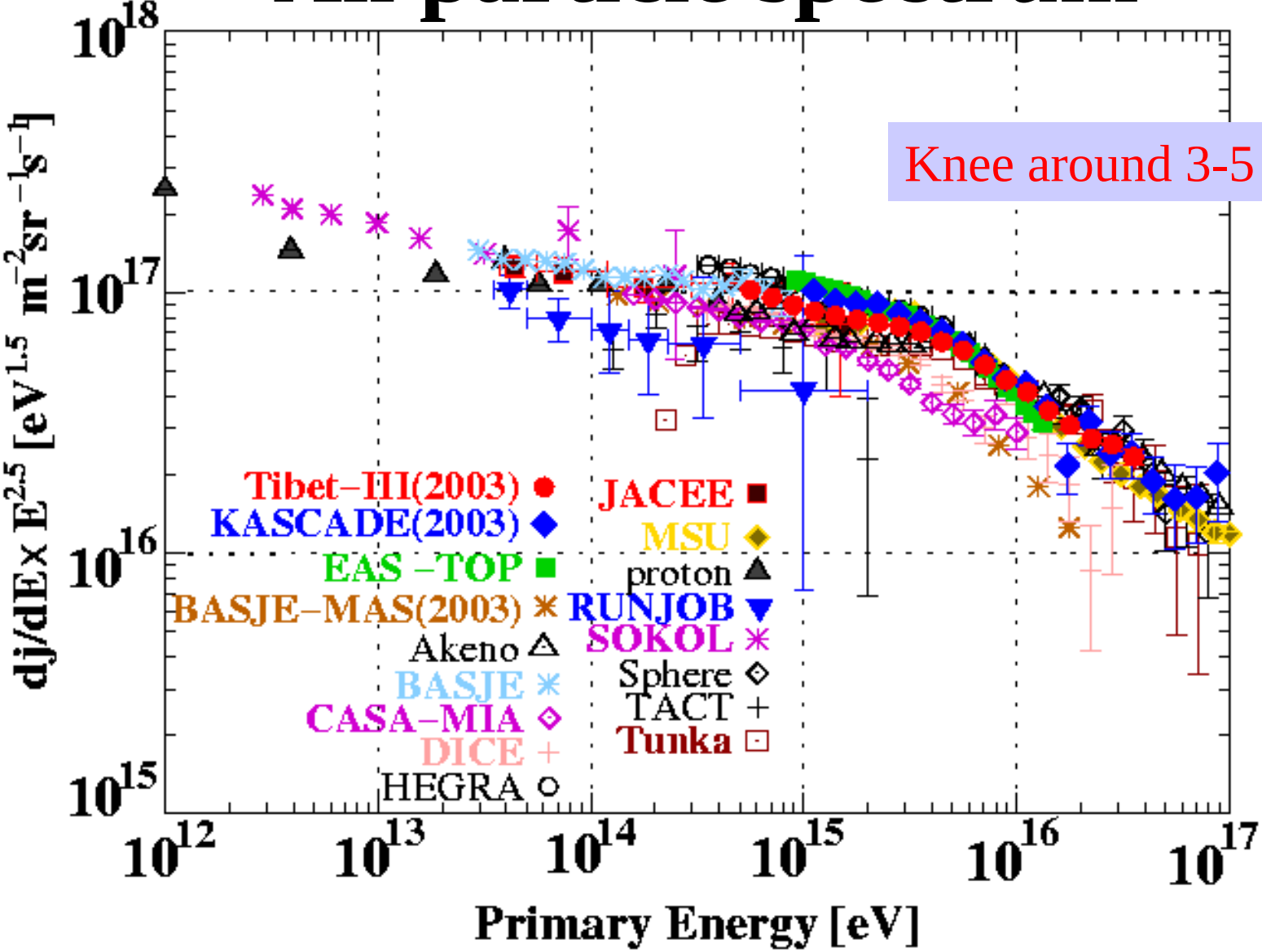
B.Peters (1961)

One of Ancient Predictions

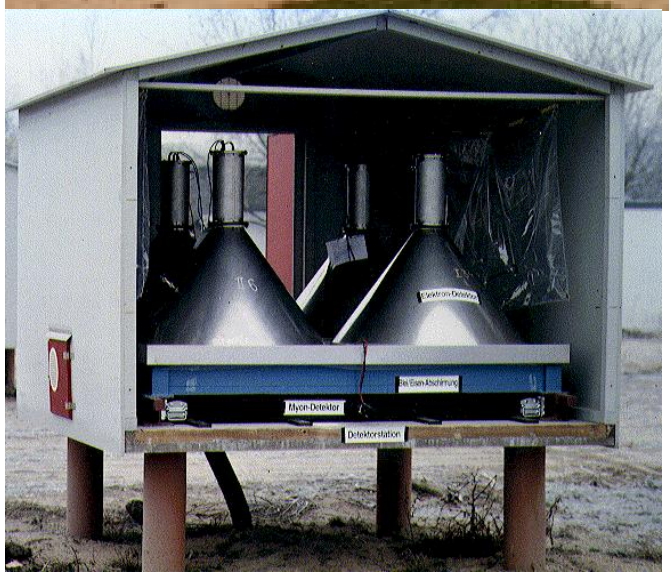


Experiment	site		g/cm^2	e	μ	h	$\check{}$C
AKENO	**Japan (35.5N, 138.5E)**		**930**	○	**1 GeV**		
BLANCA	**Utah(40.2N,112.8W)**		**870**	○			○
CASA-MIA	**Utah (40.2N,112.8W)**		**870**	○	**800 MeV**		
DICE			**860**	○	**800 MeV**		○
EAS-Top	**Italy (42.5N,13.6E)**		**820**	○	**1 GeV**		
HEGRA	**La Palma (28.8N,17.9W)**		**790**	○			○
KASCADE (electrons/muons)	**Germany (49.N, 8.E)**		**1022**	○	**230 MeV**		
KASCADE (hadrons/muons)			**1022**		**230 MeV**	**50 GeV**	
KASCADE (neural network)			**1022**	○	**230 MeV**		
MSU			**1020**	○			
Mt. Norikura	**Japan**		**735**	○			
Tibet	**Tibet (30.1N,90.5E)**		**606**	○			
Tunka-13			**680**				○
Yakutsk (low energy)			**1020**				○

All particle spectrum

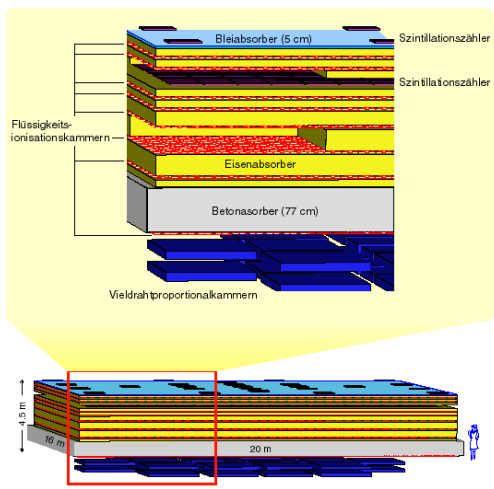


KASCADE



e/μ

Hadron



KASCADE UH SPECTRUM

Unaccompanied hadron > 50 GeV, Zenith<30deg

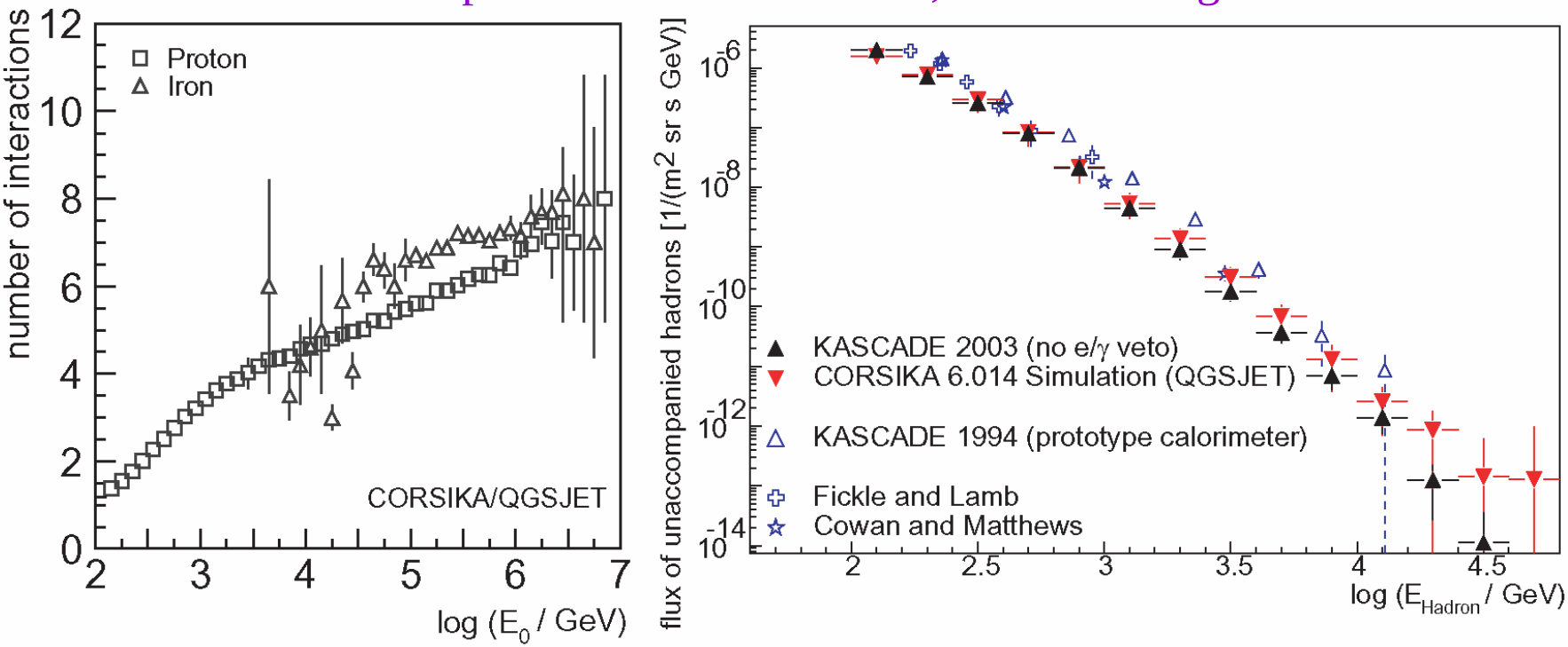


Fig. 1. Left: Number of interactions versus hadron energy at ground level. Right: Flux of unaccompanied hadrons at ground level.

KASCADE Proton Spectrum (UH)

Strong model dependence & systematic errors under study!

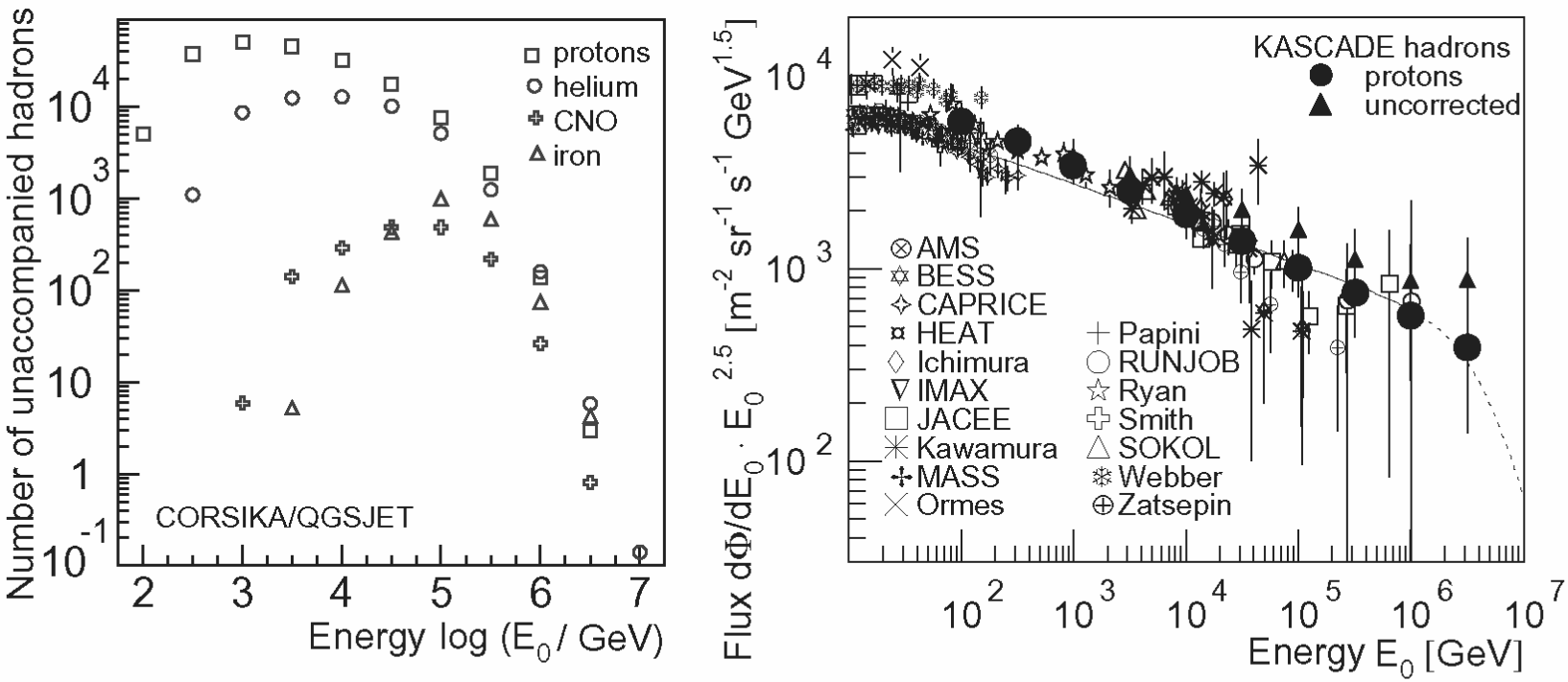


Fig. 3. Left: Number of unaccompanied hadrons versus primary energy for different elemental groups. Right: Primary proton flux reconstructed from unaccompanied hadrons compared to results of direct measurements, for references see [6]. The line represents a fit to the measurements [6].

KASCADE Ne vs. Nμ

HE 1.1-18 Markus Roth and H. Ulrich

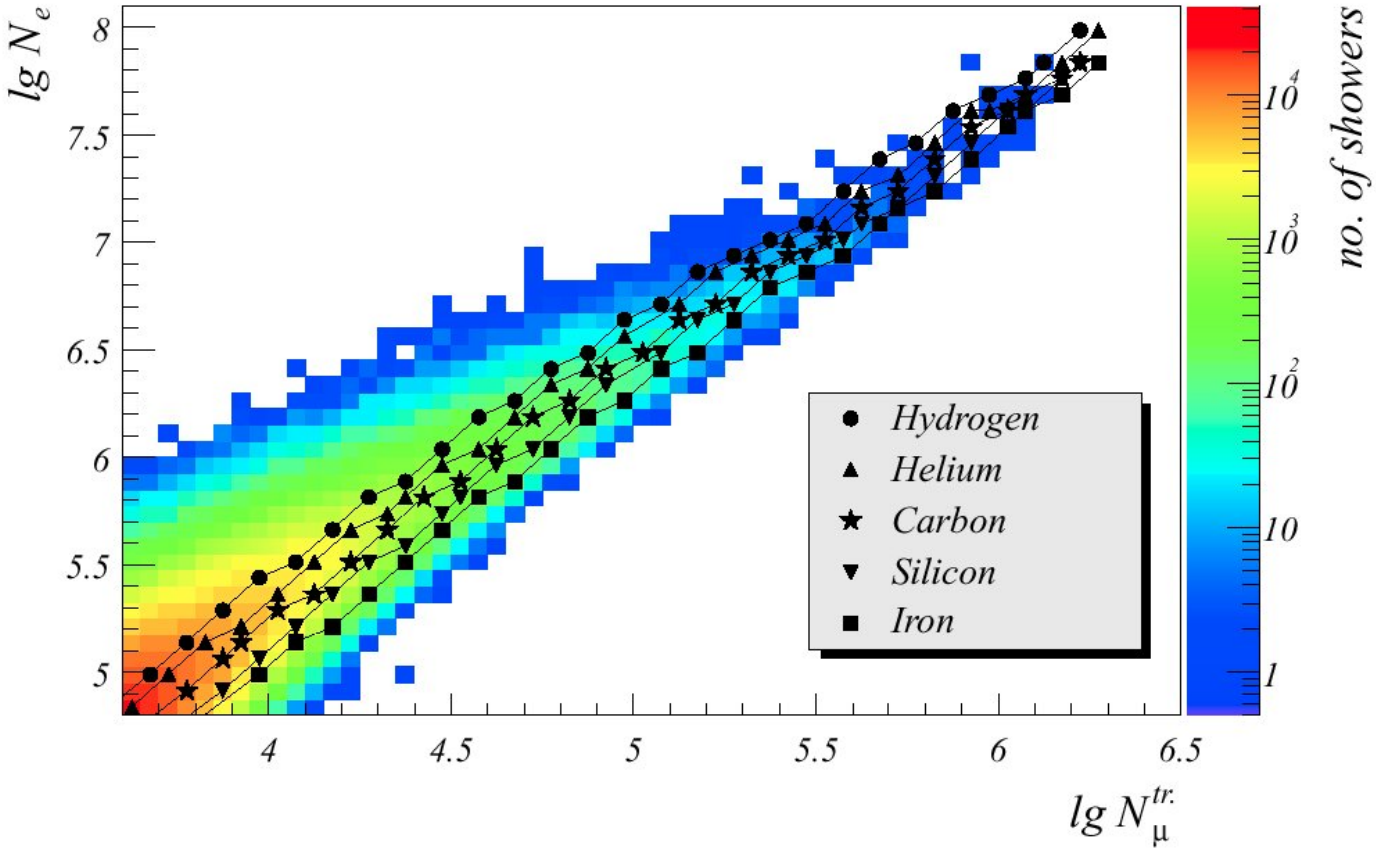
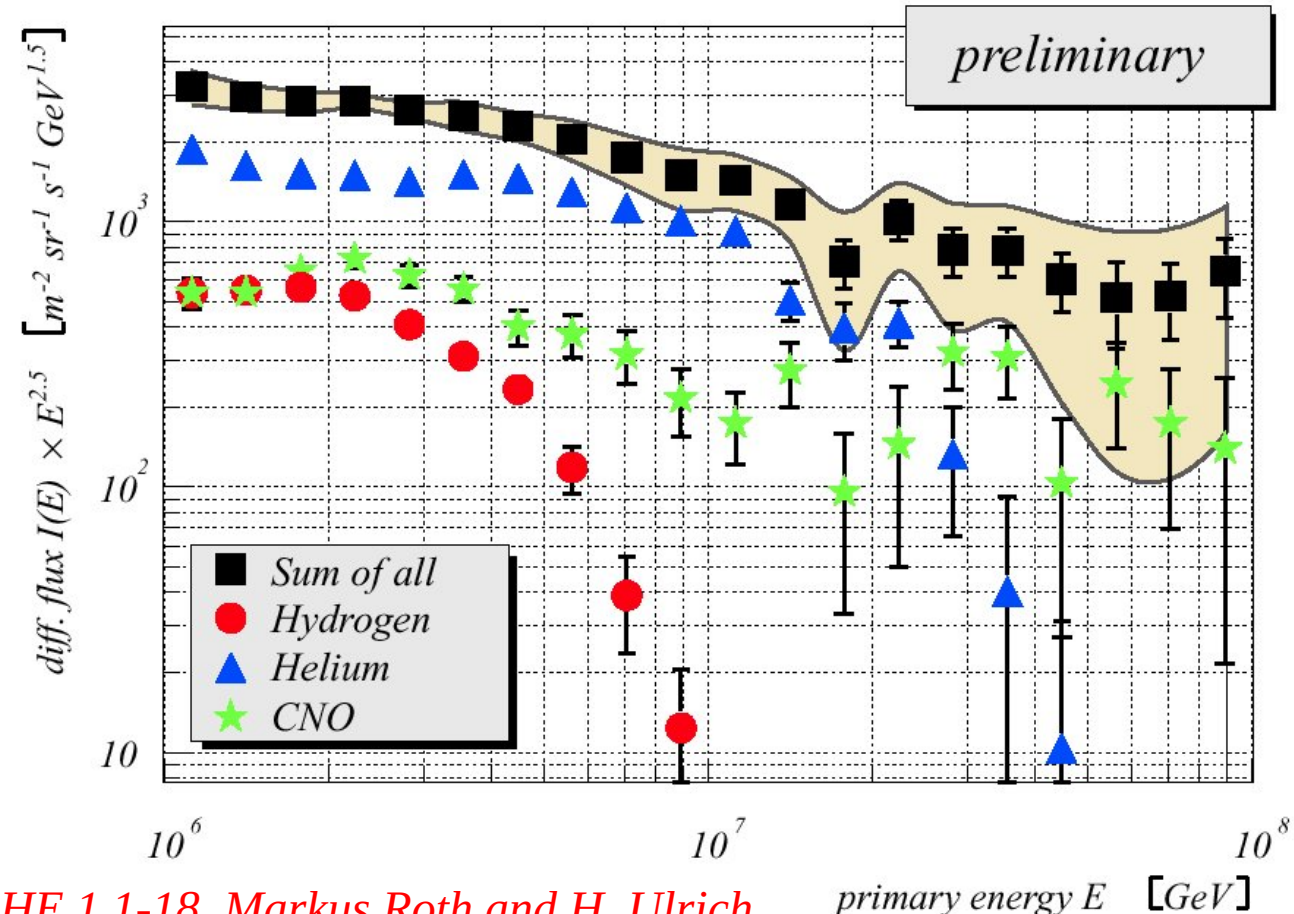


Fig. 1. The two-dimensional shower size spectrum of lg N_e and lg N_μ^{tr}. The zenith angle range of the showers is $[0°, 18°]$.

Caveat: MC does not reproduce the data (χ^2/d.o.f~170/100)

KASCADE PROTON SPECTRUM (Ne vs. Nμ)

Caveat: DATA vs MC (Ne vs. Nμ)difference under study



HE 1.1-18 Markus Roth and H. Ulrich

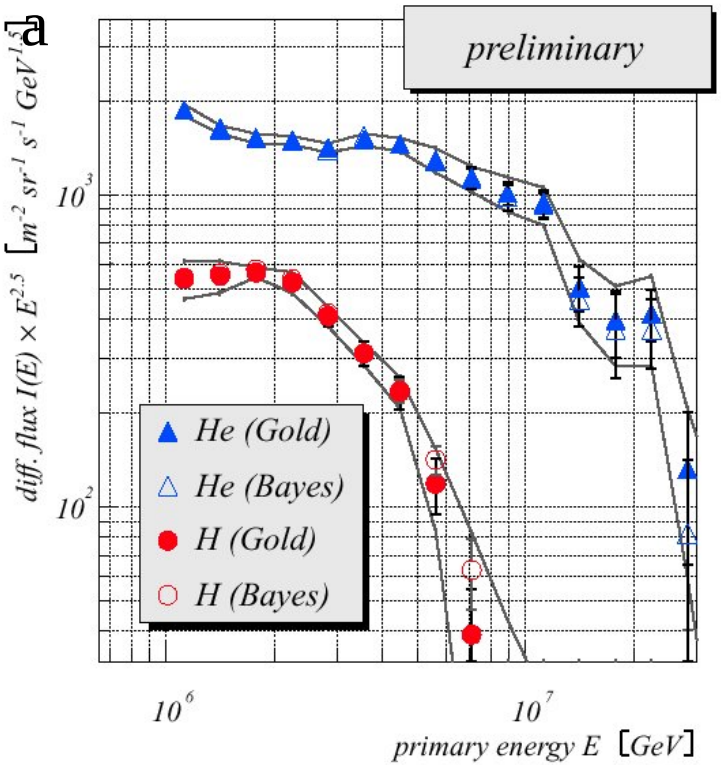
Fig. 2. Result of the Gold unfolding procedure. The given error bars reflect the statistical errors due to the measurement and simulation. The all-particle spectrum as well as the spectra for light elements are displayed. Systematic errors for the all-particle spectrum due to the applied method are indicated by the shaded area.

KASCADE Ne vs. Nμ

HE 1.1-18 Markus Roth and H. Ulrich

k

a



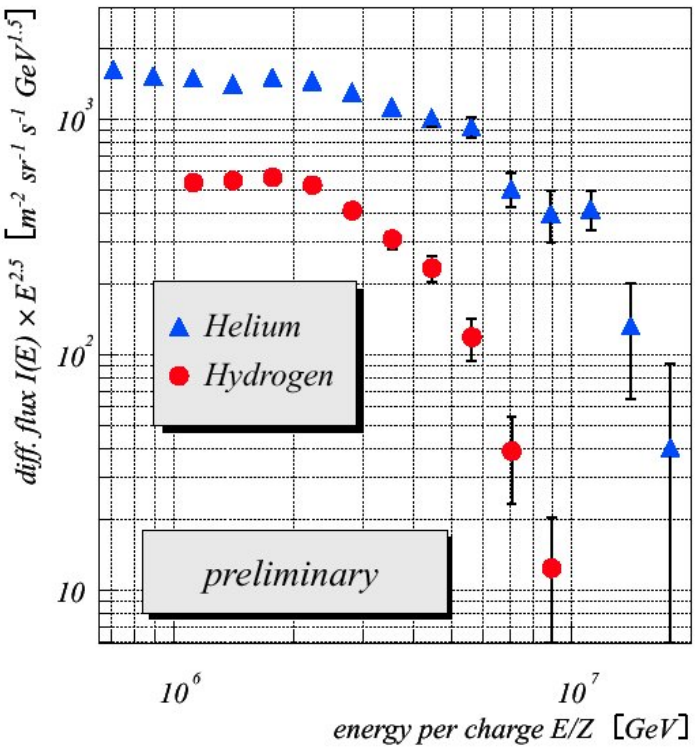
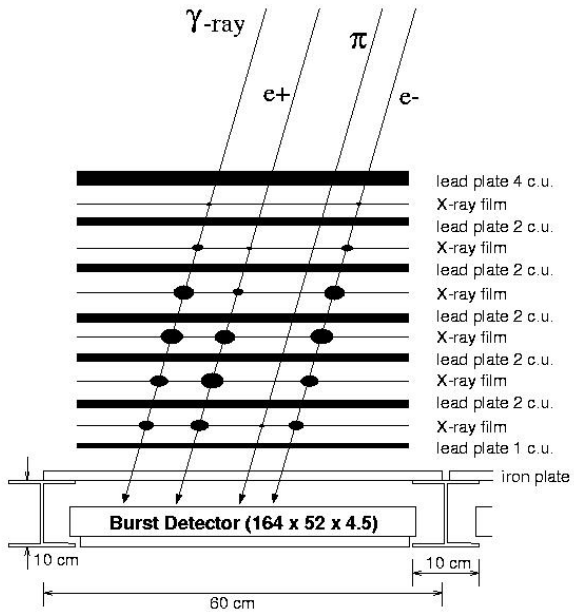


Fig. 3. Comparison of the deconvoluted H and He spectra using Bayesian [2] and Gold [3] unfolding. The solid lines mark the systematic uncertainty of the Gold algorithm.

Fig. 4. Individual spectra as a function of the rigidity $R \propto E/Z$. The knee positions of the H and He spectra are nearly at the same position.

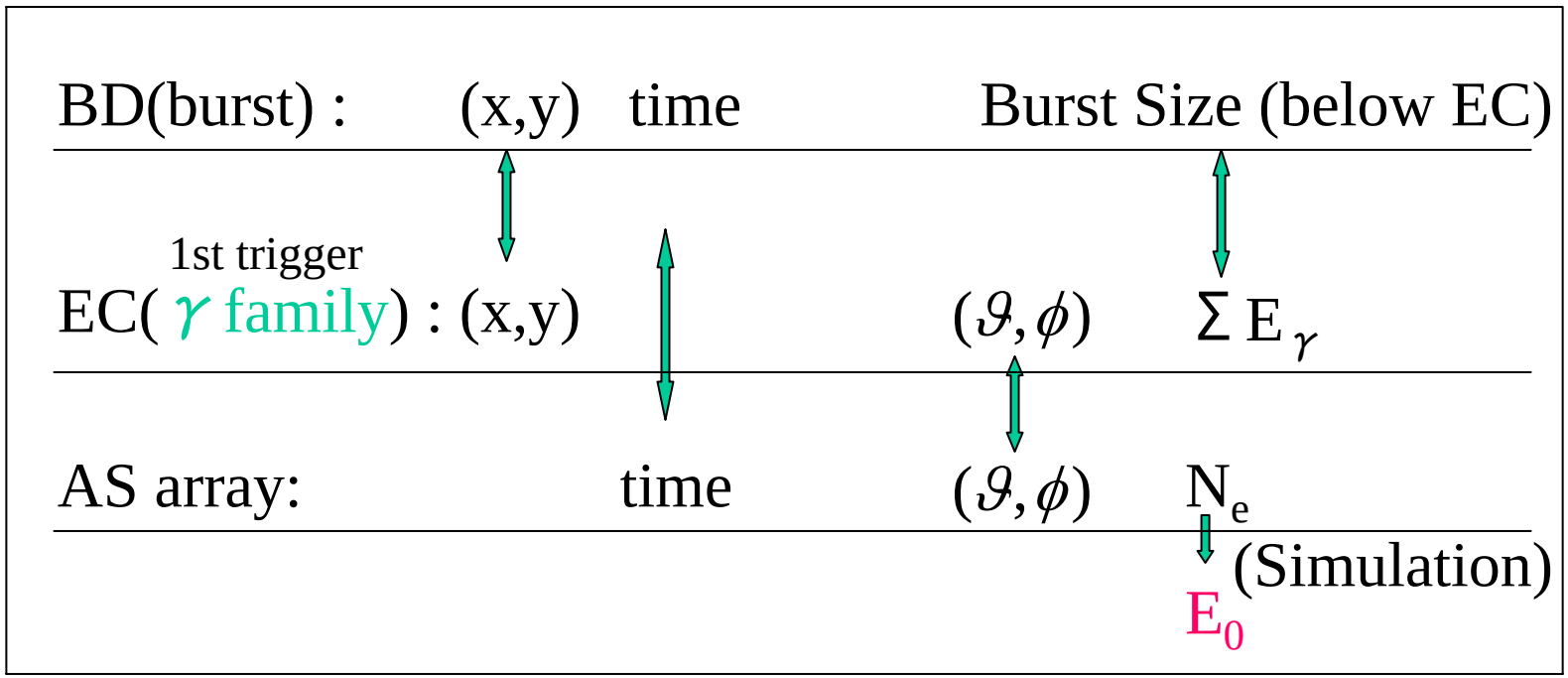
TIBET


γ-ray
π
e+
e-
lead plate 4 c.u.
X-ray film
lead plate 2 c.u.
X-ray film
lead plate 2 c.u.
X-ray film
lead plate 2 c.u.
X-ray film
lead plate 2 c.u.
X-ray film
lead plate 2 c.u.
X-ray film
lead plate 1 c.u.
iron plate
Burst Detector (164 x 52 x 4.5)
10 cm
10 cm
60 cm

Tibet Proton: *HE1.1-13 M. Shibata*

How to obtain proton spectrum?

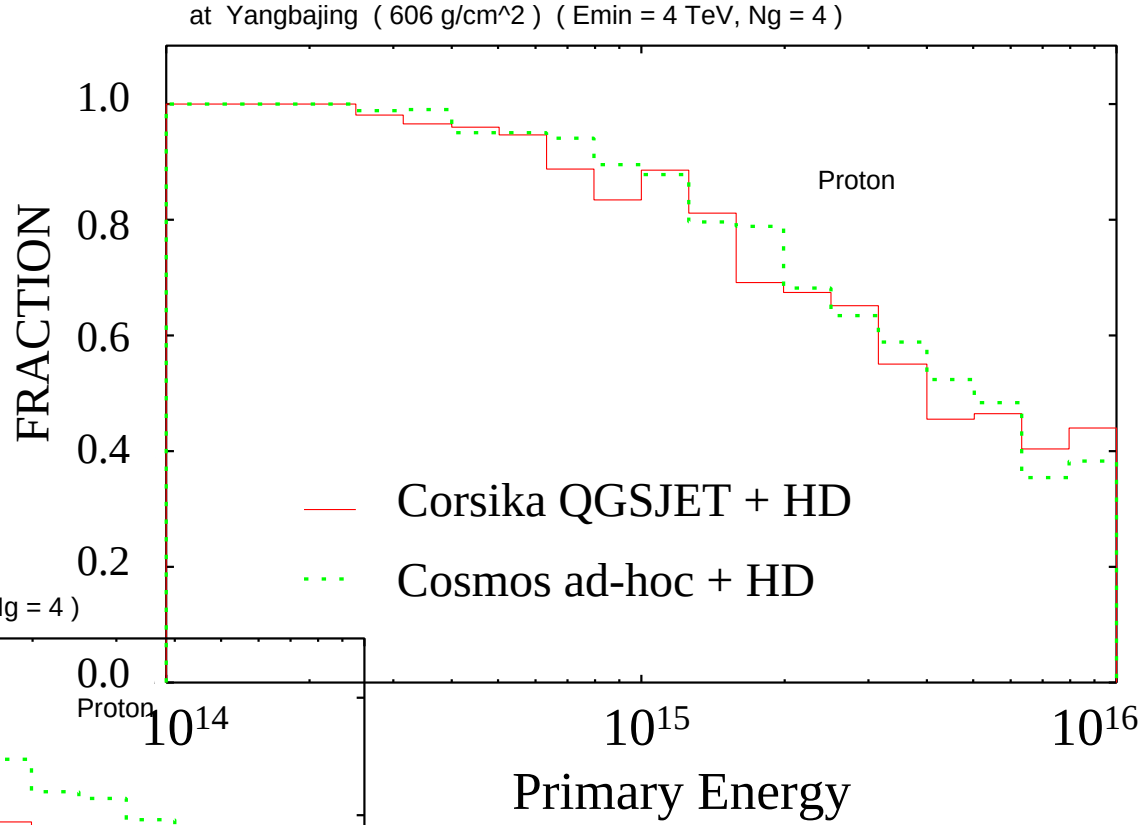
Hybrid system

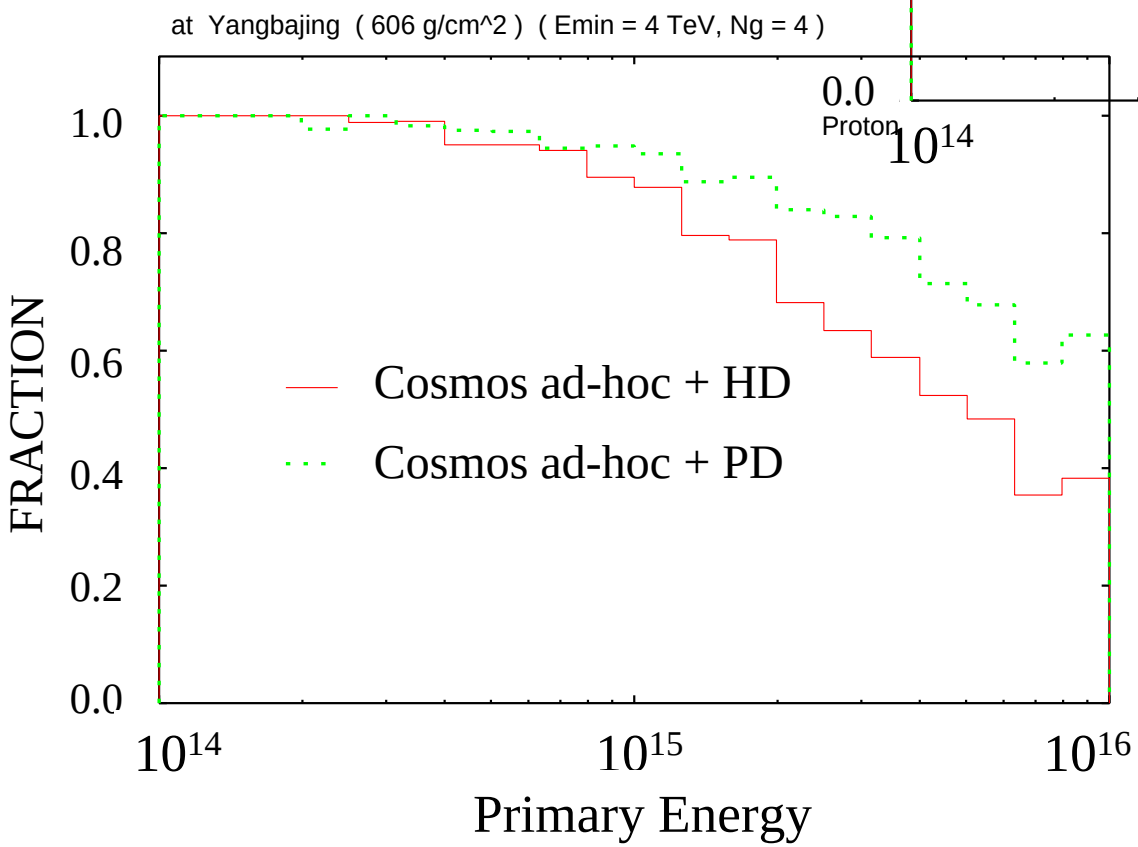


EC-Xray film image → Scanner (GUI Software) → family detection

AS+family matching event → ANN (Correlations) → Proton identification

ε p-tag by ECC

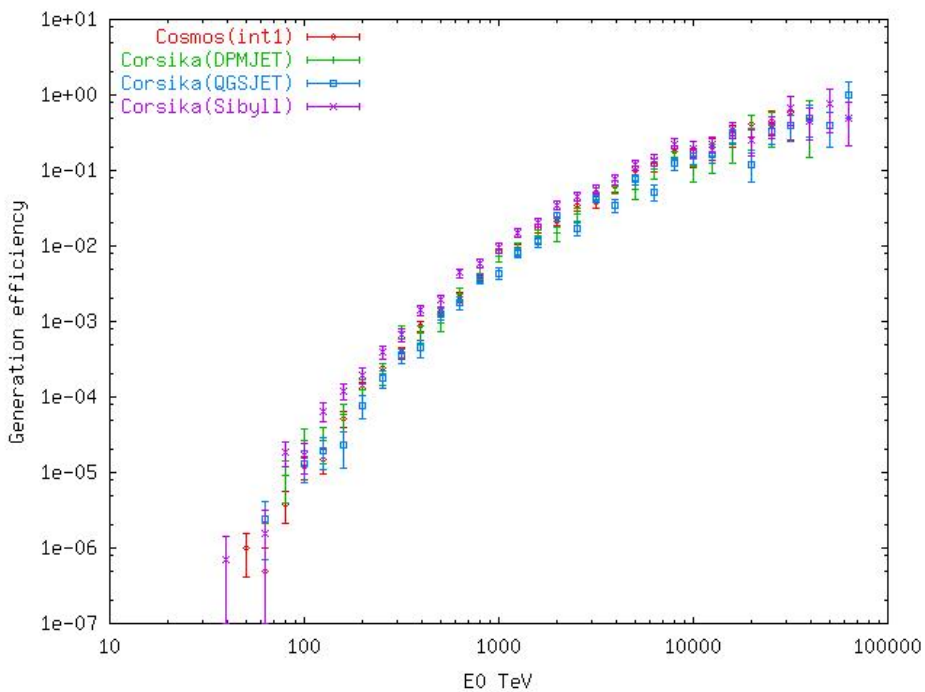


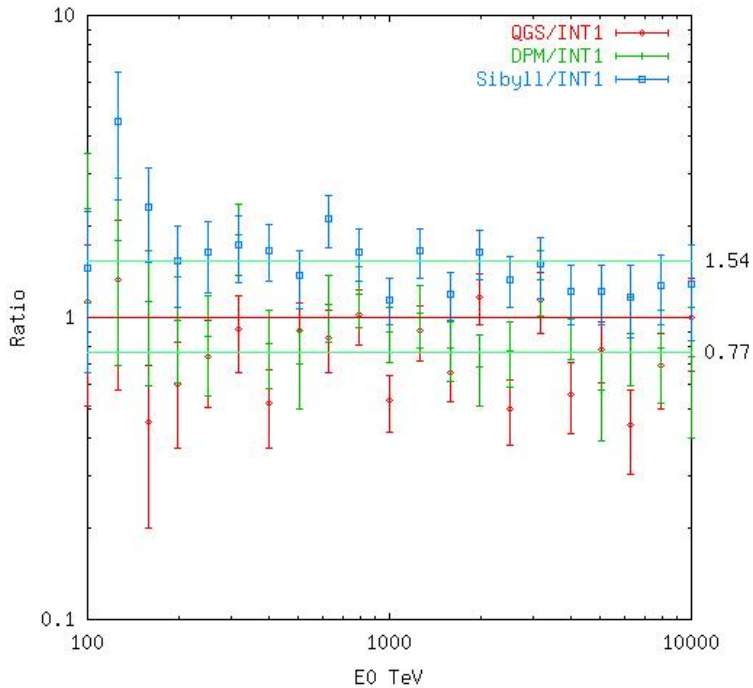


From Shibata Makio

Tibet Proton Spectrum

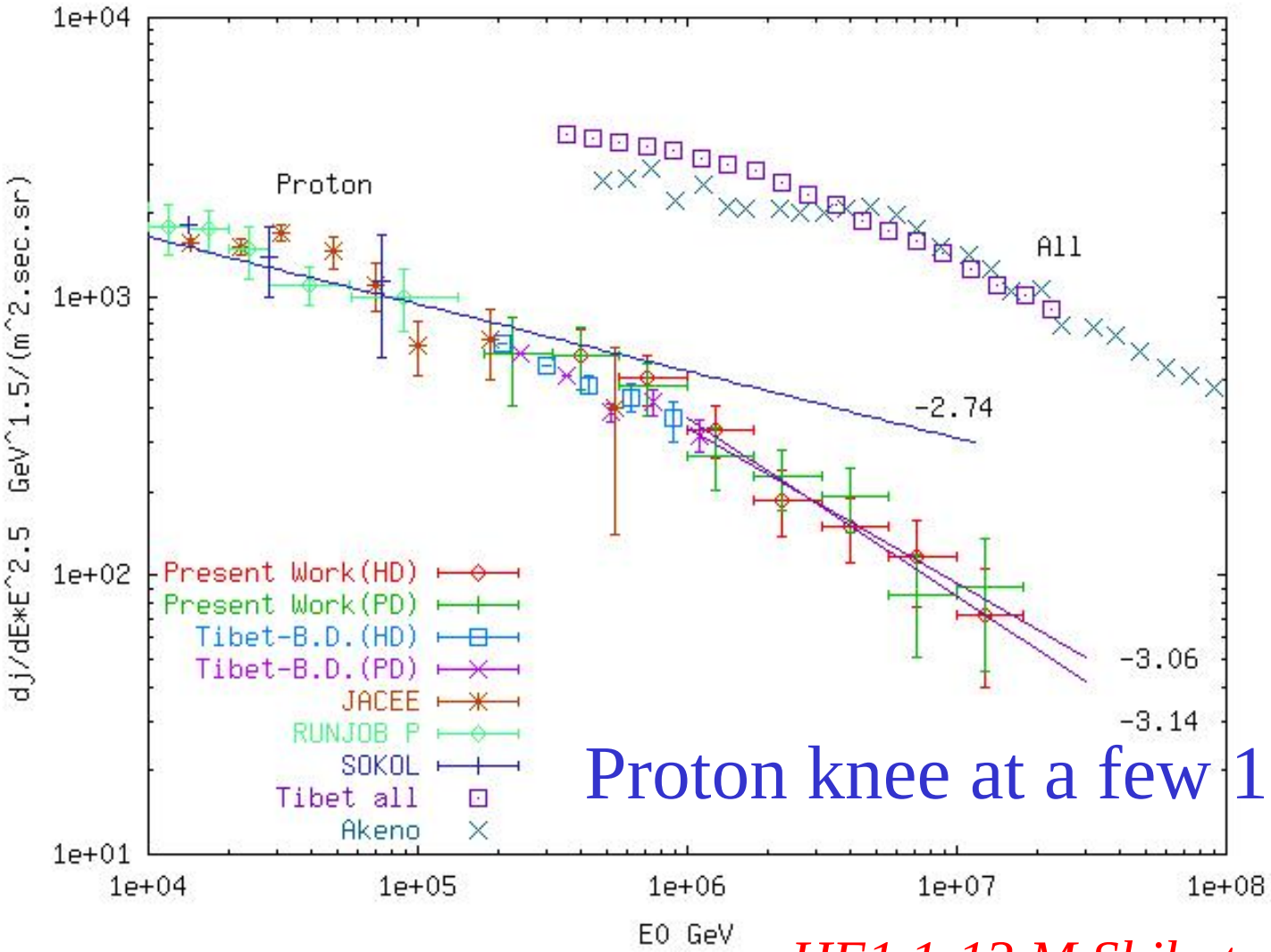
Efficiency of family generation by protons





HE1.1-13 M.Shibata

Tibet Proton spectrum



Proton knee at a few 100 TeV

HE1.1-13 M.Shibata

Summary (Tibet Proton)

Steepening of the proton energy spectrum in the knee region is observed.

power index=-3.14 ± 0.10 (HD analysis)

-3.06 ± 0.09 (PD analysis)

Comparison with direct measurement suggests the break point of protons exists at a few 100 TeV. The knee of all particle spectrum (3-5PeV) can be interpreted as produced by iron(Z=26) component.

HE1.1-13 M.Shibata

Tibet Proton Spectrum

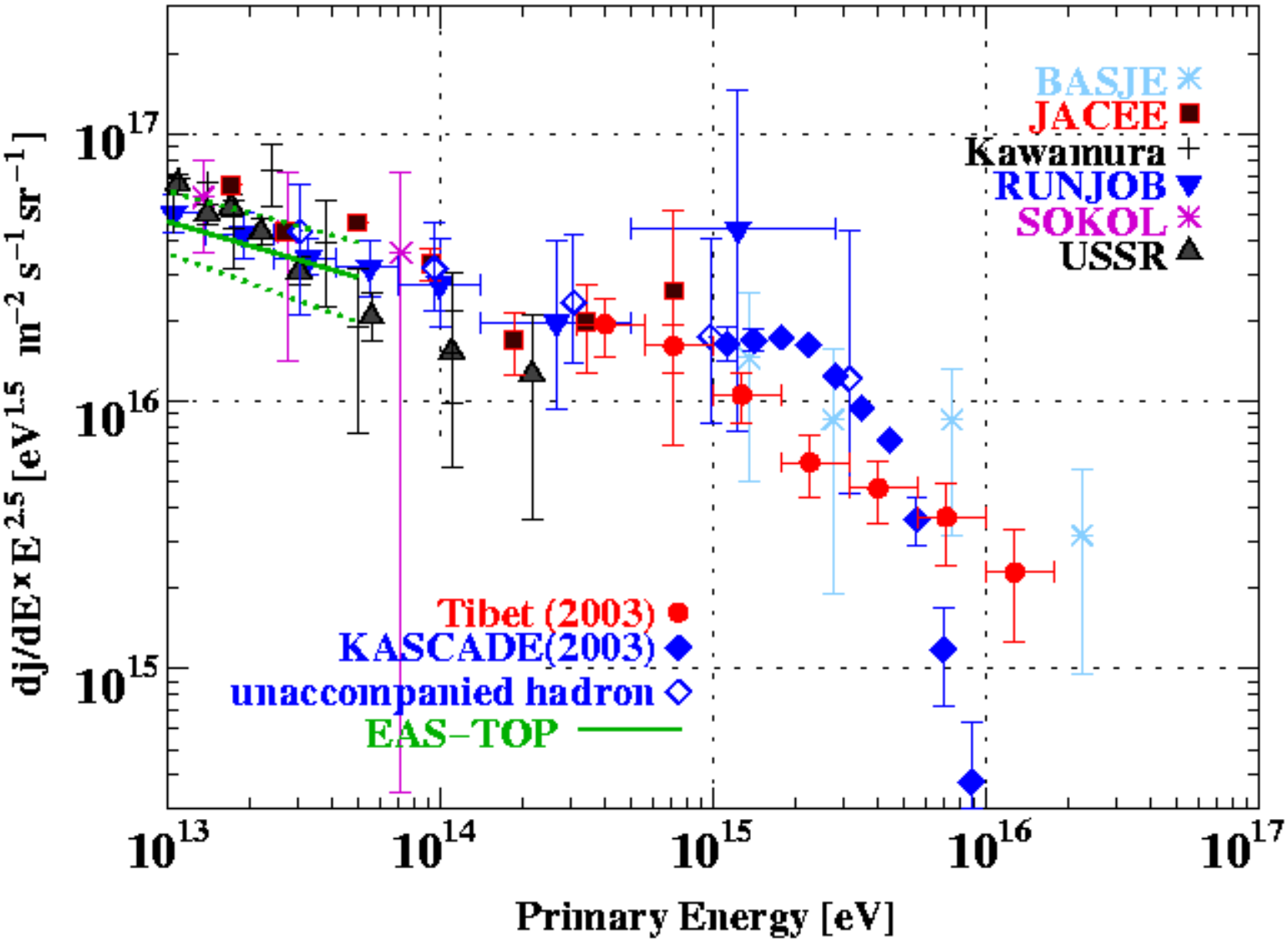
Systematic errors

Absolute flux by interaction model 20 %

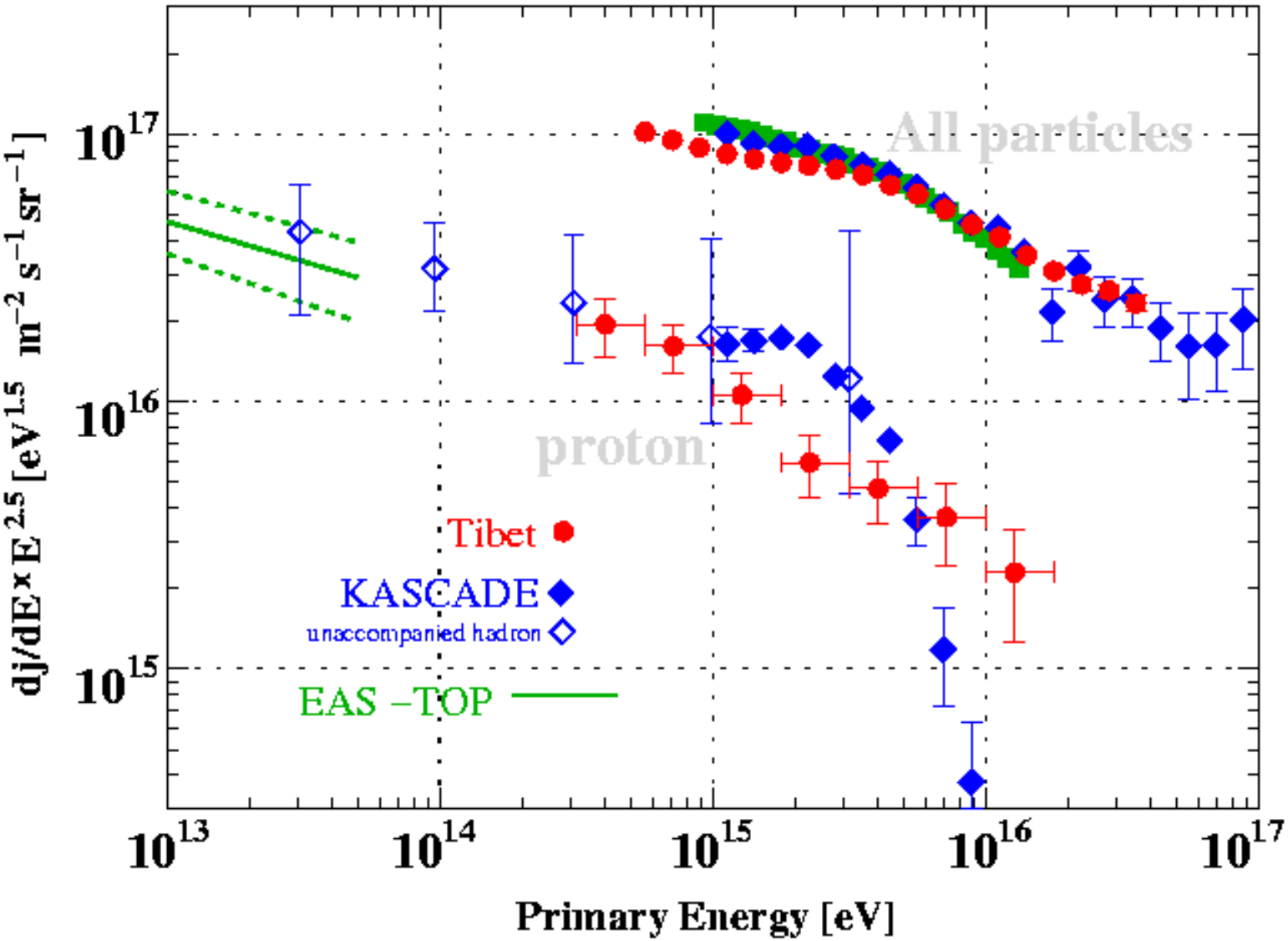
(however, no effect on power index)

HE1.1-13:M.Shibata

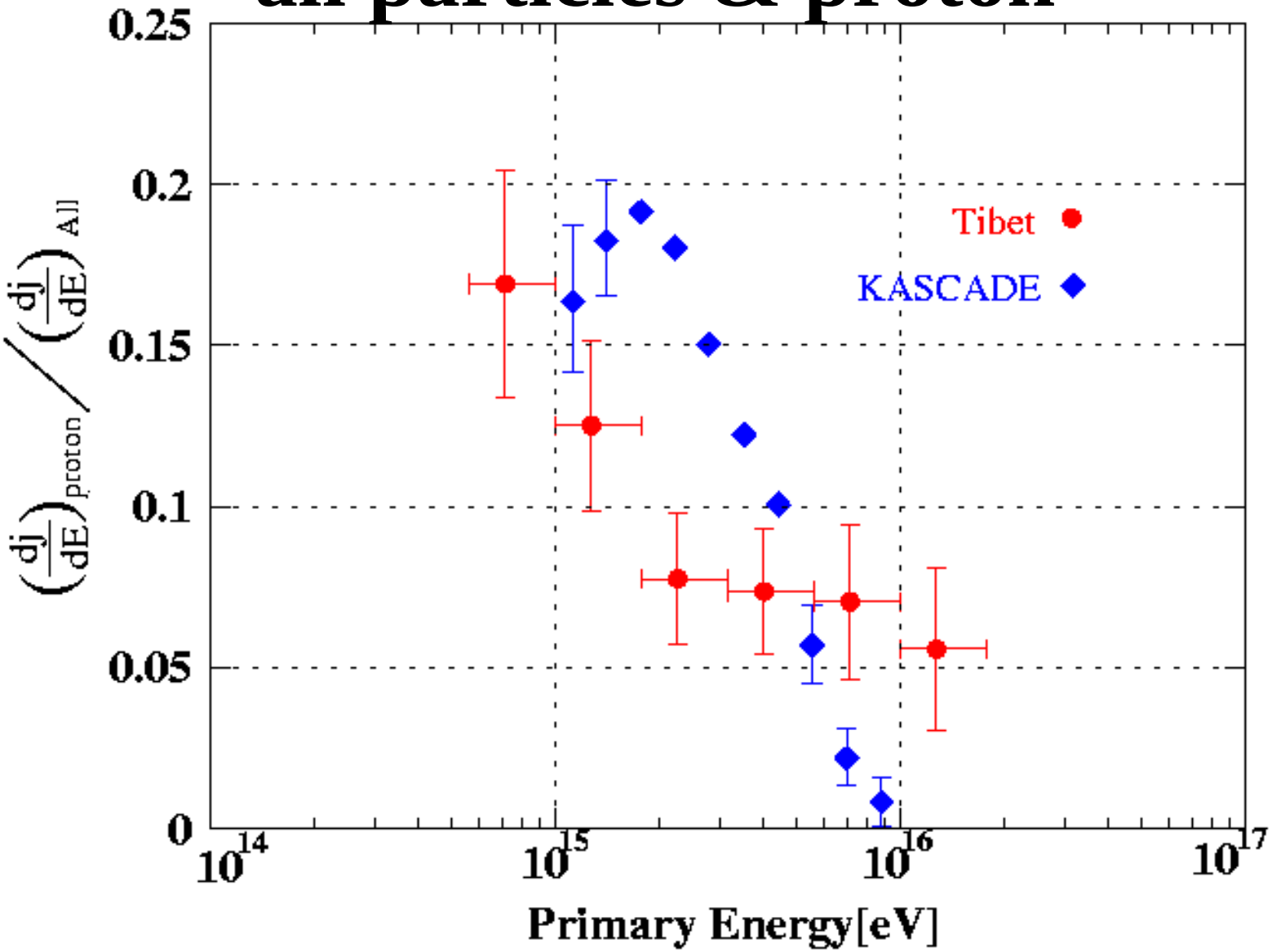
Proton spectrum



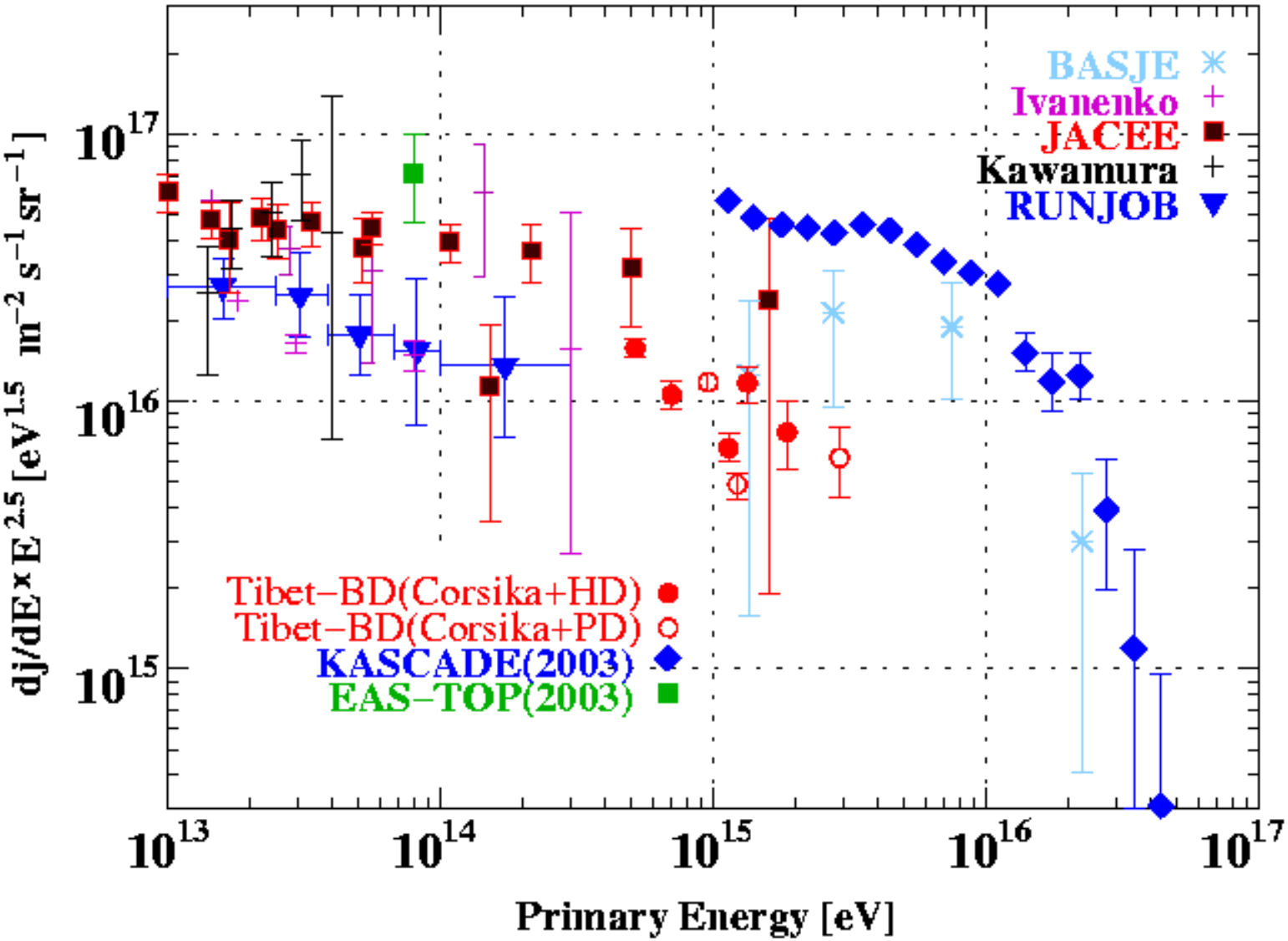
All particles & Proton



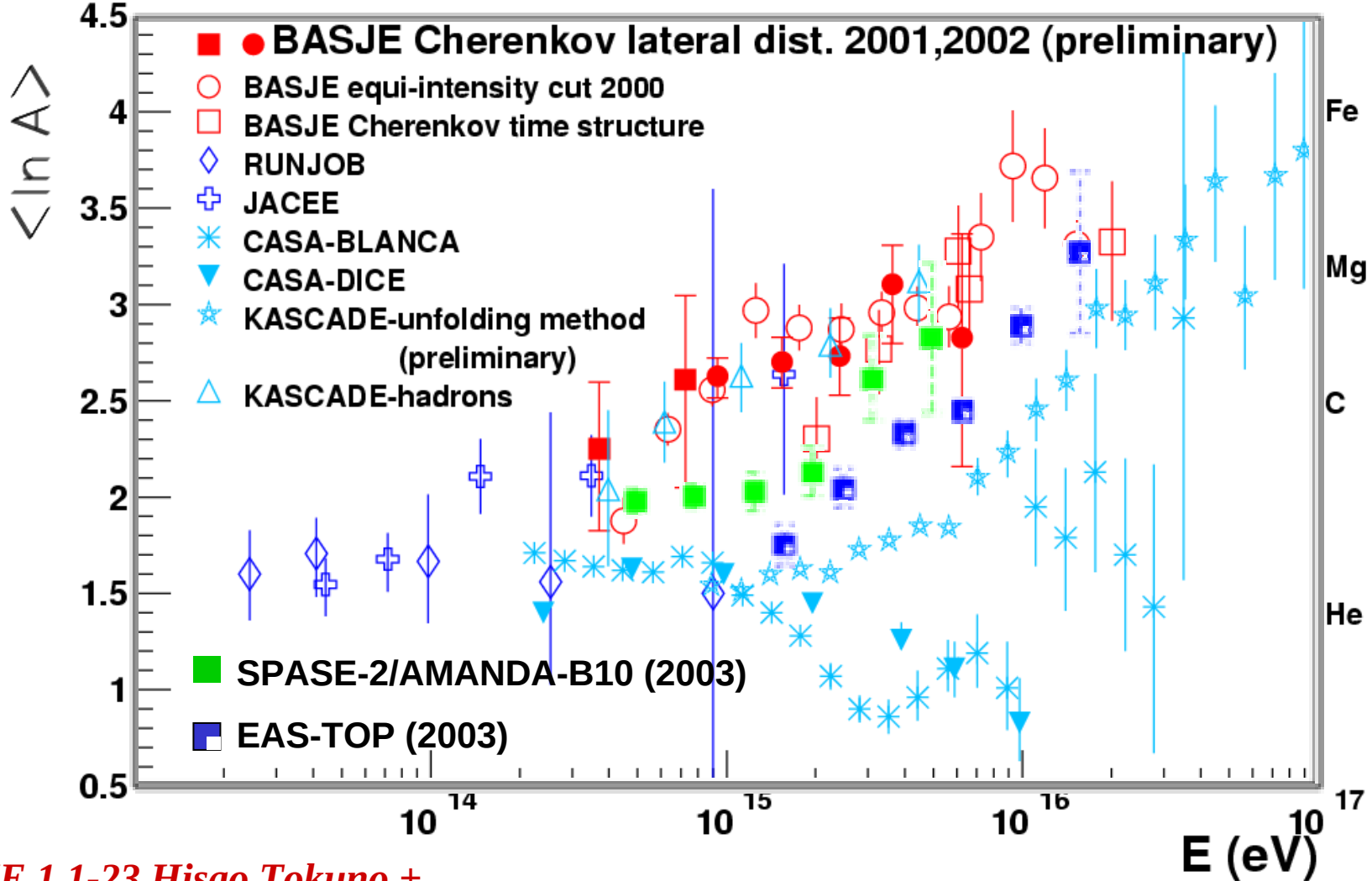
Comparison with all particles & proton



Helium spectrum



Cosmic Ray Composition <ln A>



HE 1.1-23 Hisao Tokuno +

HE 1.1-25 Katherine Rawlins for the SPASE and the AMANDA Collaboration

HE 1.1-21 Gianni Navarra for the EAS-TOP Collaboration

KASCADE Anisotropy (1)

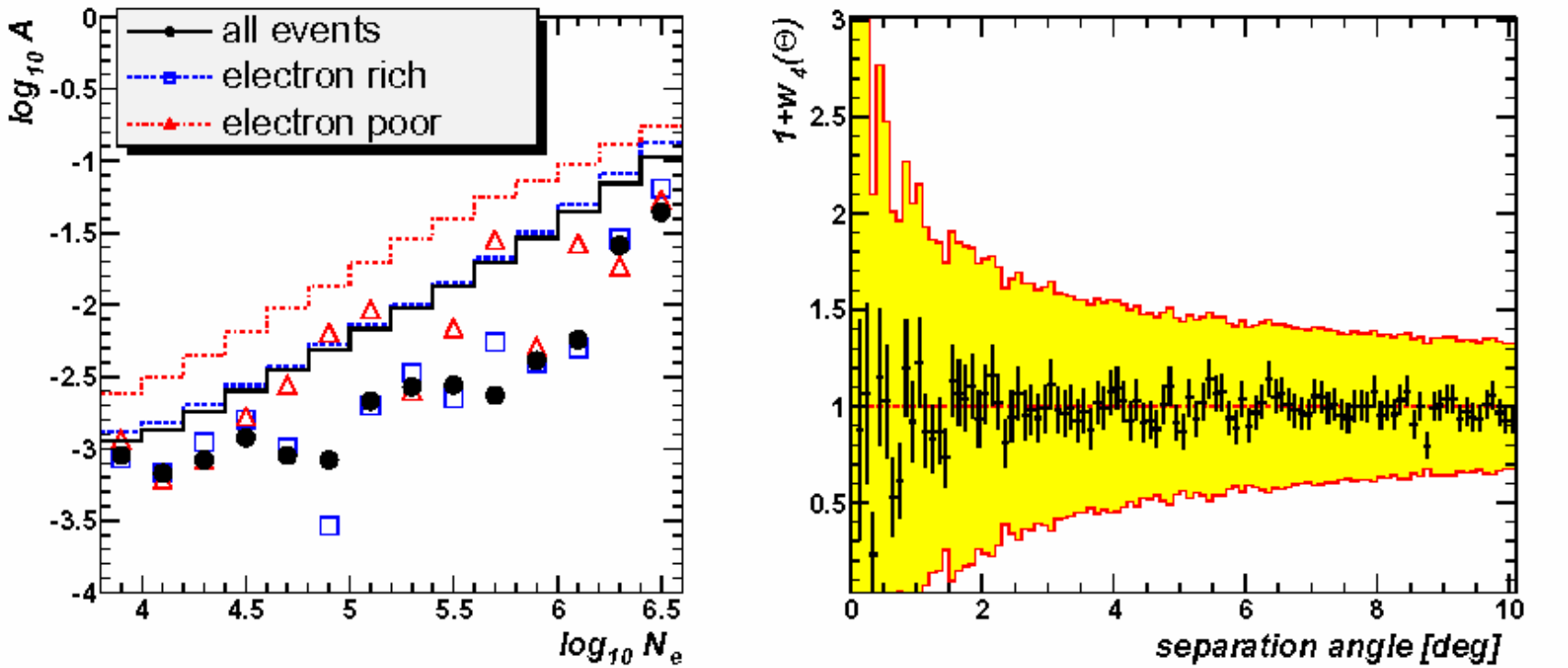


Fig. 1. Left: Rayleigh amplitudes. Right: autocorrelation of the 1000 largest showers.

HE 1.1-26 Gernot Maier for the KASCADE Collaboration

KASCADE Anisotropy (2)

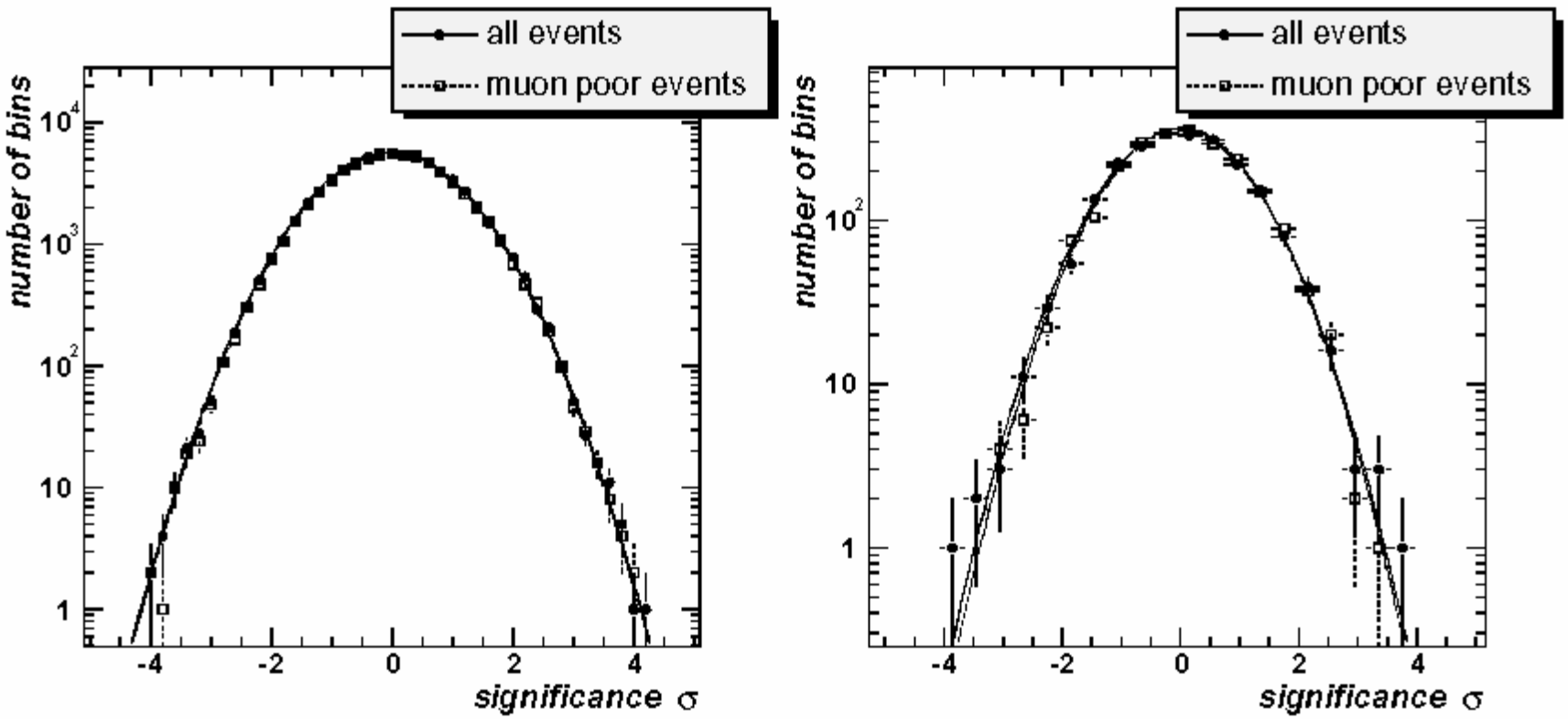
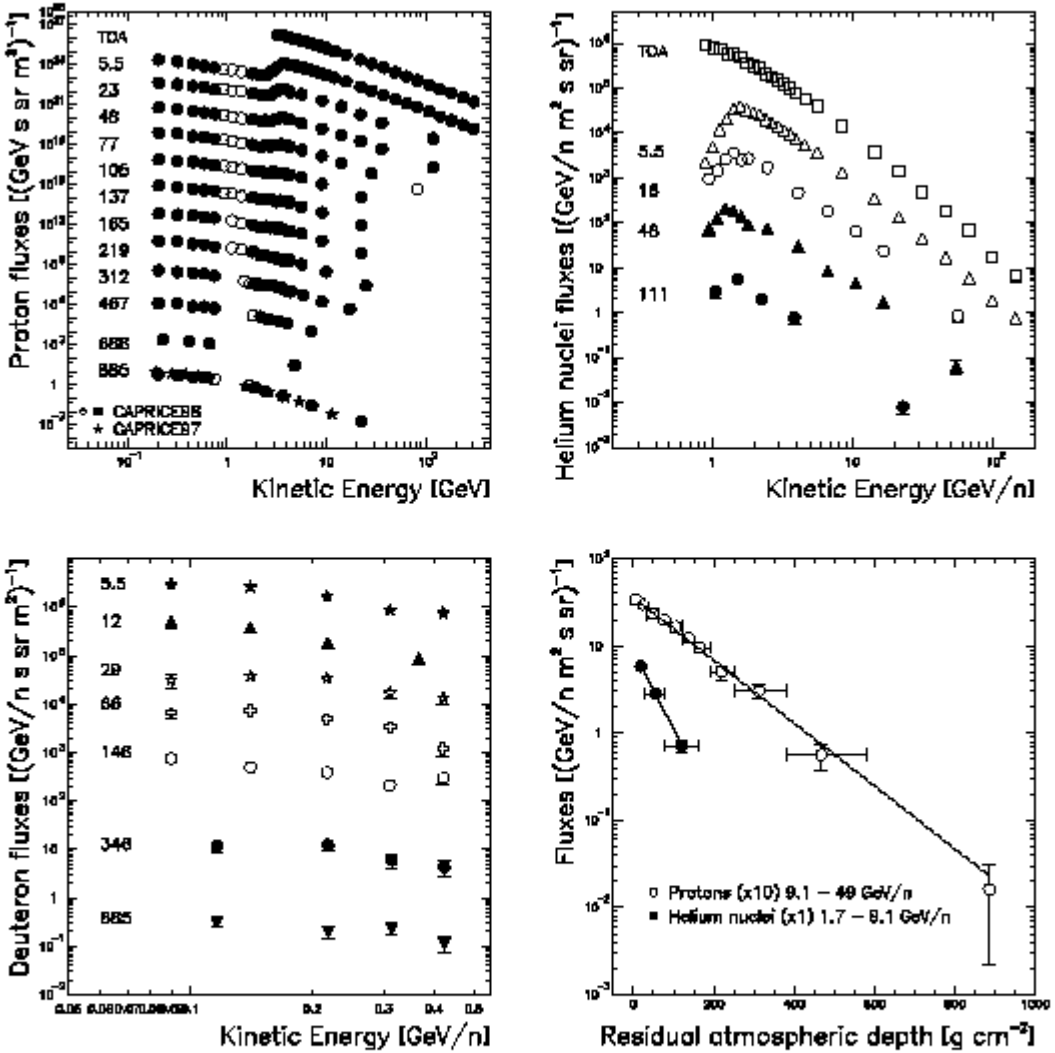


Fig. 2. Significance distribution of the visible sky of KASCADE (left) and of the sky inside a band of 6° around the galactic plane (right).

HE 1.1-26 Gernot Maier for the KASCADE Collaboration

Caprice98 (for tuning MC)



e^-spectra

e^+spectra

covered by a single experiment

Fig. 1. From the upper left clockwise: the proton spectra, the helium nuclei spectra, the proton and helium nuclei fluxes as function of the atmospheric depth and the deuteron spectra. Spectra are scaled as described in the text, the average residual atmospheric depth is reported and expressed in g/cm^2.

HE3.1-9: E.Mocchiutti et al.

FLUKA - recommended GHEISHA – wrong in LE part

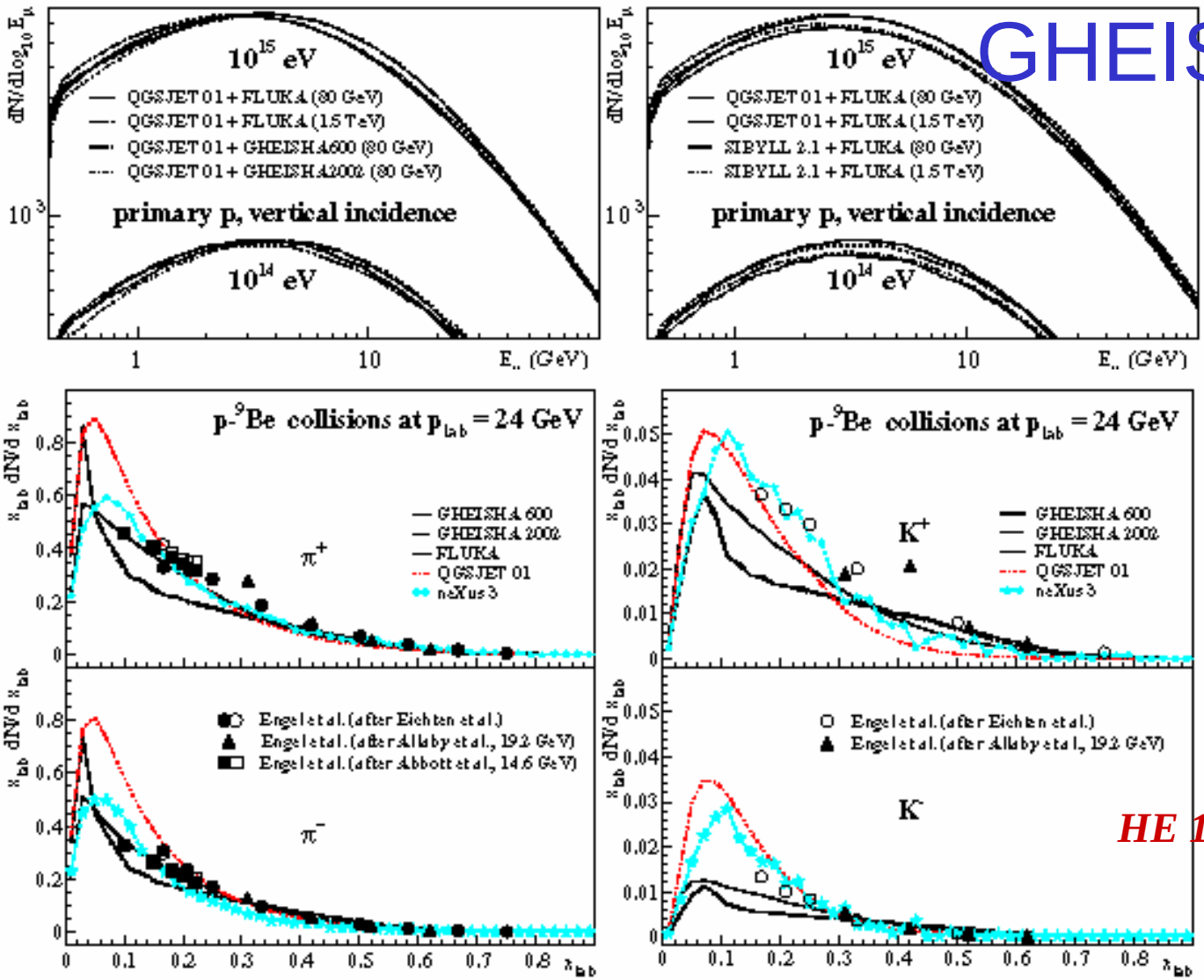


Fig. 1. Distribution of secondary particle momenta $x_{\mathrm{lab}} = p_{\mathrm{tot}}/p_{\mathrm{beam}}$ in p-^{9}Be collisions at $p_{\mathrm{lab}} = 24$ GeV. *Left:* Pions. *Right:* Kaons. The experimental data points were derived [8] from the measurements of [6, 2, 1].

HE 1.2-5 Ralph Engel et al.

Motivation and outline

- TARGET 3D (old version: 2.1, current version: 2.4)
- very flexible and tunable hadronic interaction model
- simple and fast Monte Carlo code
- optimization for inclusive muon/neutrino fluxes
- event generation structure and recent improvements
- comparison to data
- application: L3+C muon flux

Forthcoming New DATA

Being analyzed-> results soon

NA49 at CERN

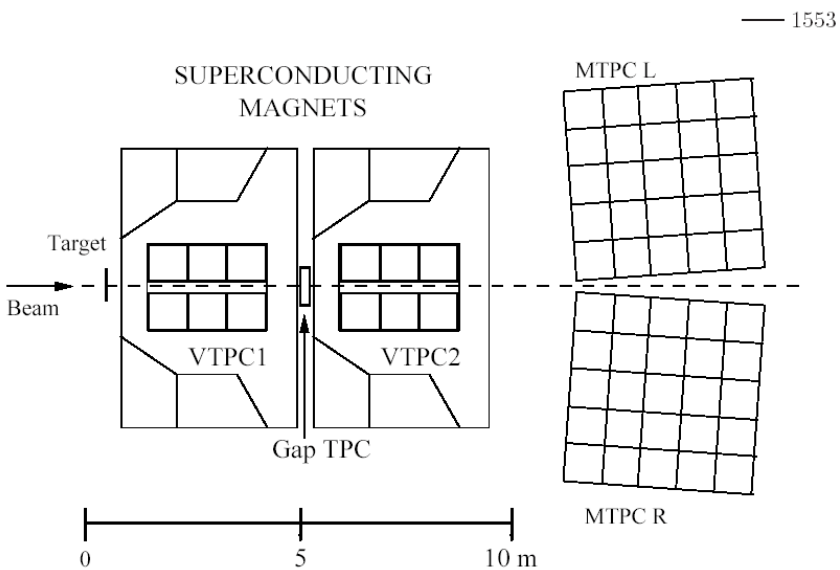


Fig. 1. Schematic layout of the main components of the NA49 experiment used in the hadroproduction measurement.

HARP at CERN

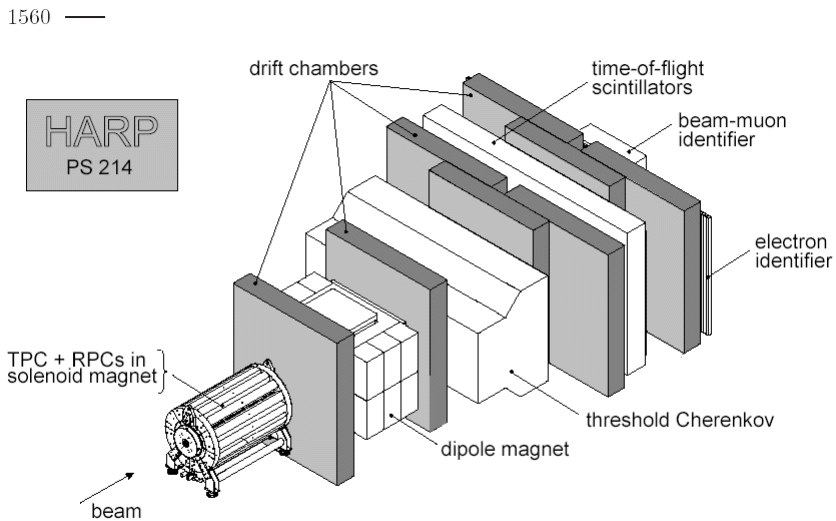
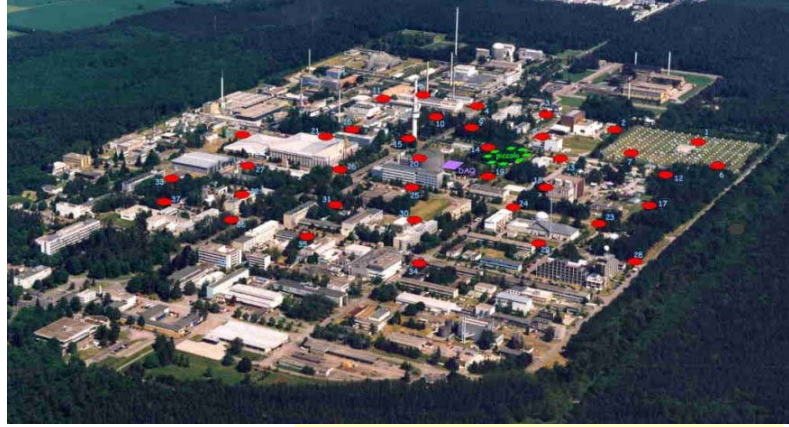


Fig. 1. Schematic of the components of the detector

HE3.1-1: G.Barr et al.

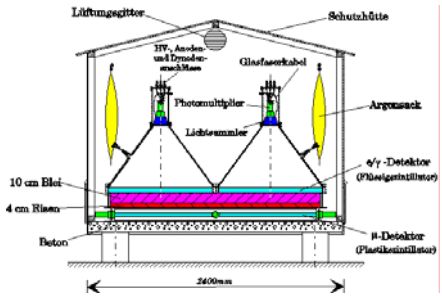
Future Experiments

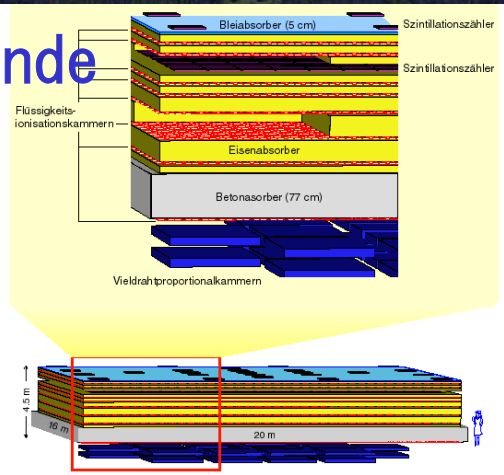
Experiment	site	Depth (g/cm^2)	Energy (eV)	e	μ (GeV)	h (GeV)	Č	year
ARGO-YBJ	**Tibet** (30.1N,90.5E)	**606**	**$<10^{12}$**	○				**2005 -**
ASHRA-1	**Hawaii** (--,--)	**600?**	**10^{12} - 10^{20}**				○	**2005 -**
ICE-TOP	**Antarctic** (--,--)	**?**	**>300TeV**	○				**200?-**
KASCADE-Grande	**Germany** (49.N, 8.E)	**1022**	**10^{15} – 10^{17}**	○	**230** **490** **800** **2400**	**50**		**Jul.2003 -**



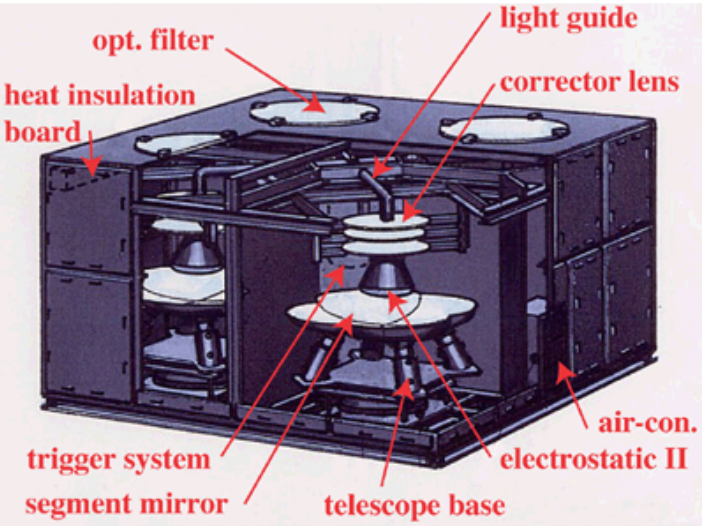
ARGO-YBJ

KASCADE-Grande





ASHRA



ICE-TOP

Conclusions

- Lots of Interesting & Exciting Presentations, among them,

  All-particle Spectrum Consistent between Tibet & KASCADE

  Tibet Knee:

  Protons at a few 100 TeV &

  Fe at 3-5 PeV (~all particles' knee)

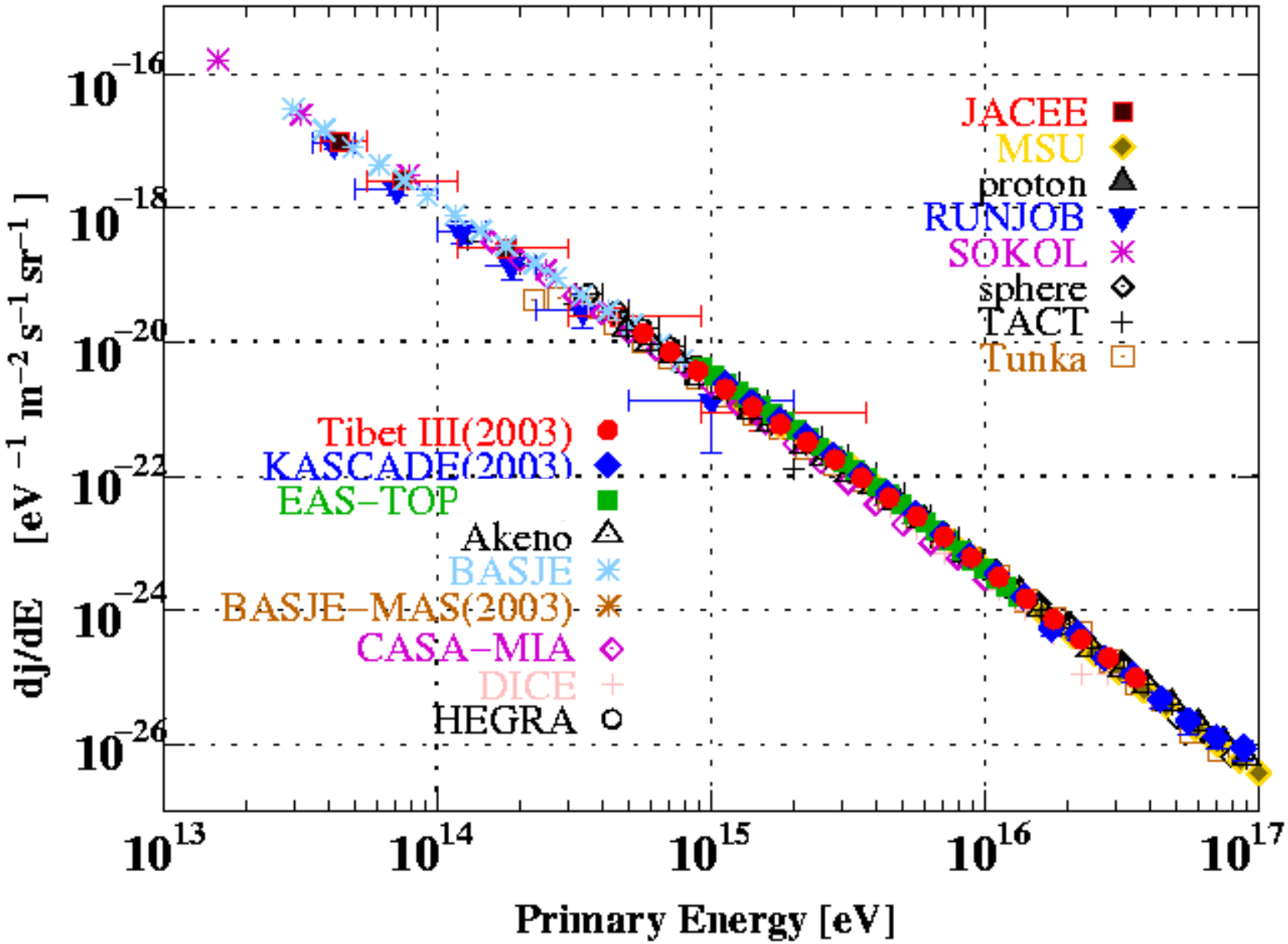
  KASCADE Knee:

  Protons at 3-5 PeV &

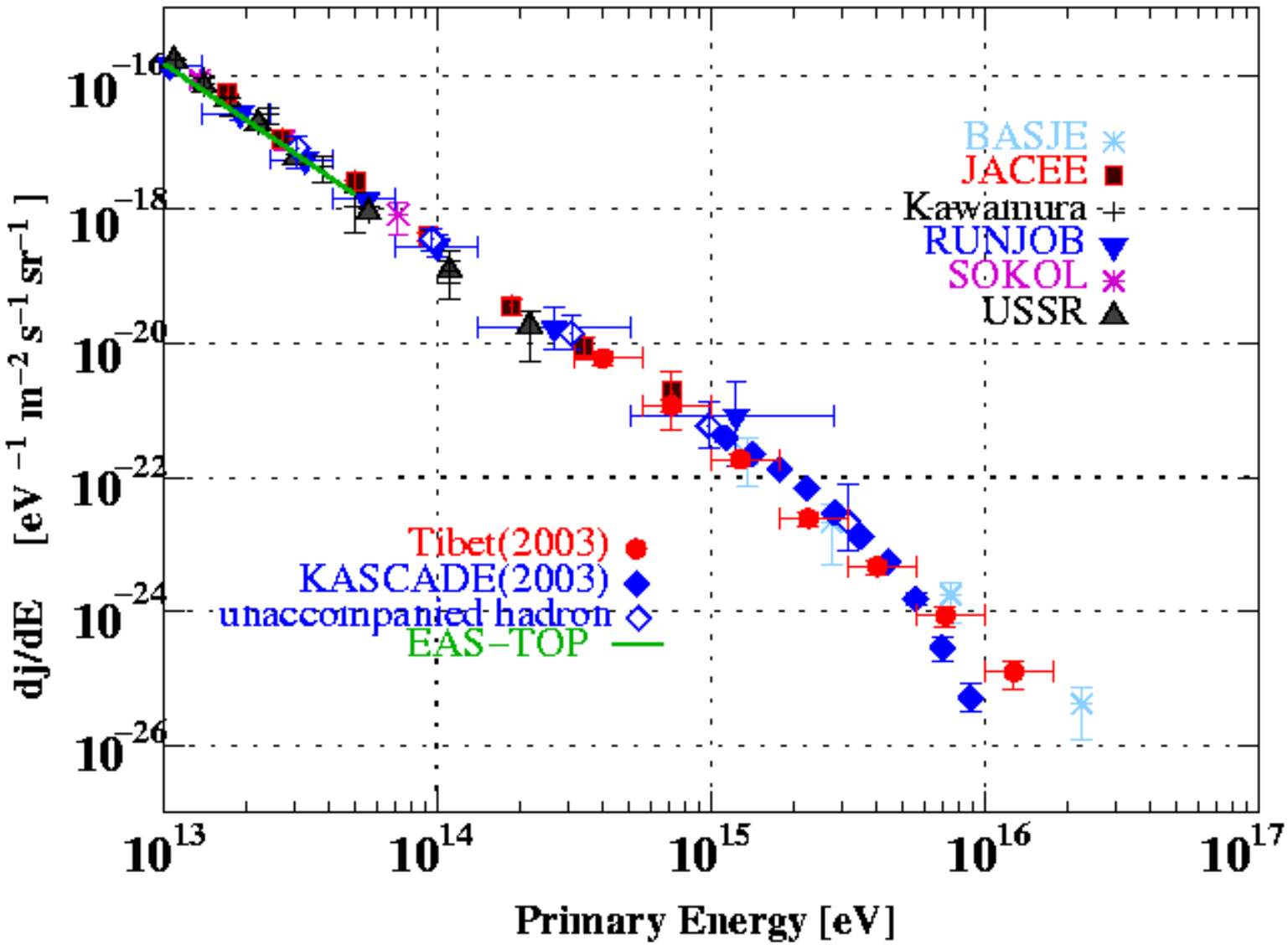
  Fe (NOT FOUND YET) at~10^{17} eV(KASCADE-Grande)

- FLUKA Recommended for L.E. Hadron Interaction Model in stead of GHEISHA.
- Looking forward to Exciting New Results at ICRC2005.

All particle spectrum



Proton spectrum



Helium spectrum