Do we see an 'Iron Peak' ?

Erlykin A.D., P.N.Lebedev Physical Institute, Moscow, Russia
Wolfendale A.W., Physics Department, Durham University, UK

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* New data
  - Sharpness
  - Fine structure
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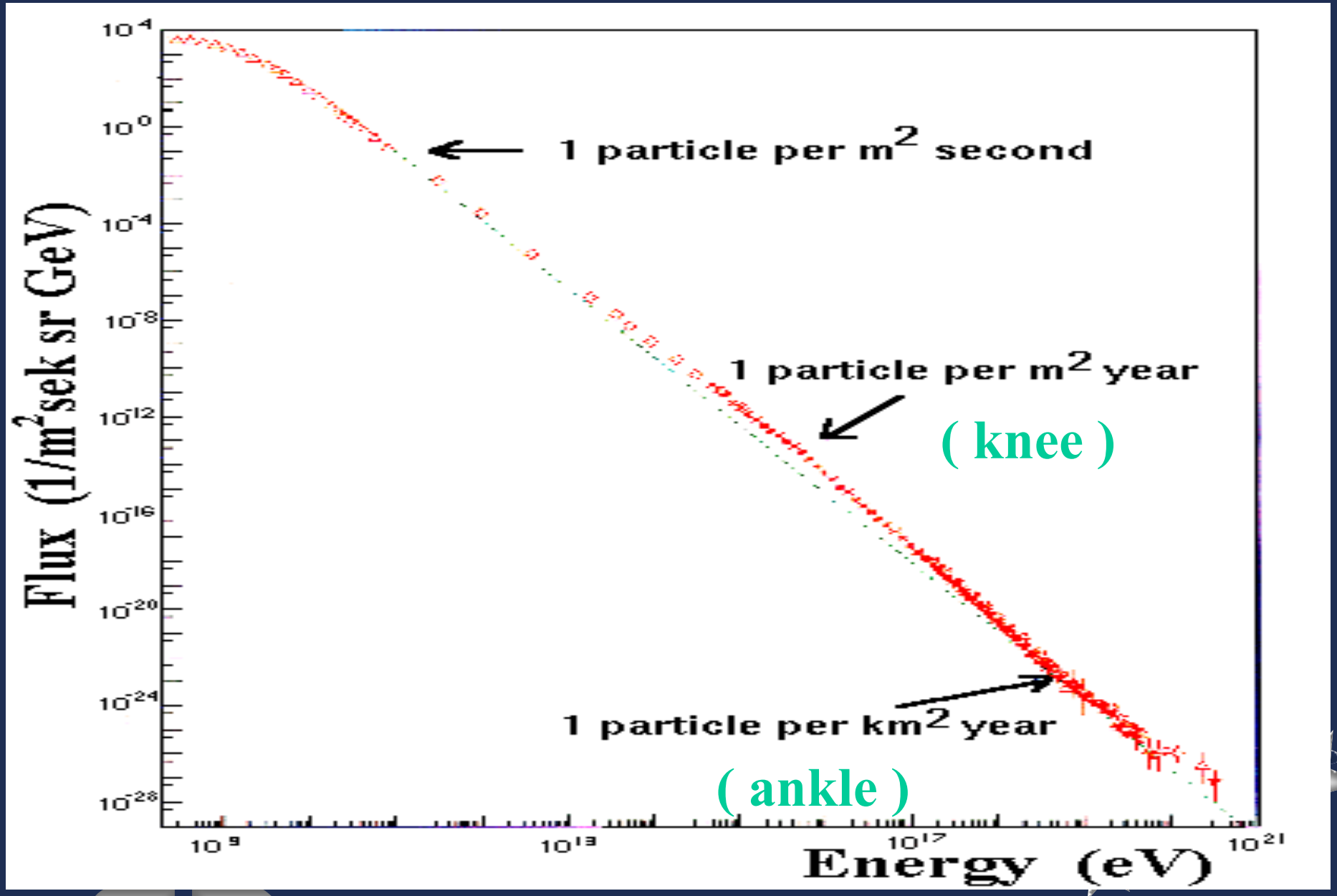
Traditional image of the CR energy spectrum

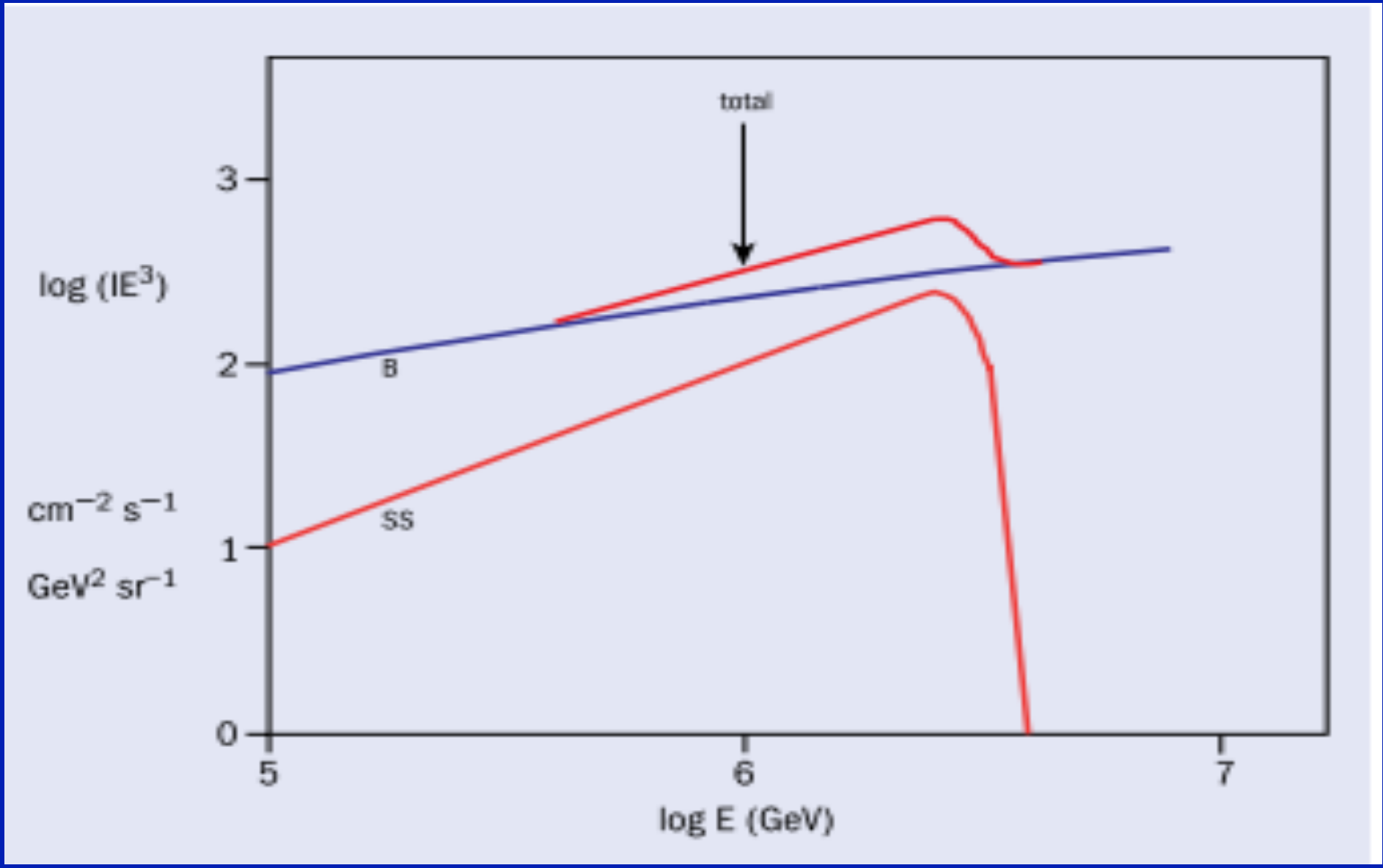


The essence of the Single Source Model of the knee is the non-uniform, stochastic distribution of CR sources in space and time.

The knee is due to the contribution of the nearby and recent supernova explosion.

Single Source Model of the Knee

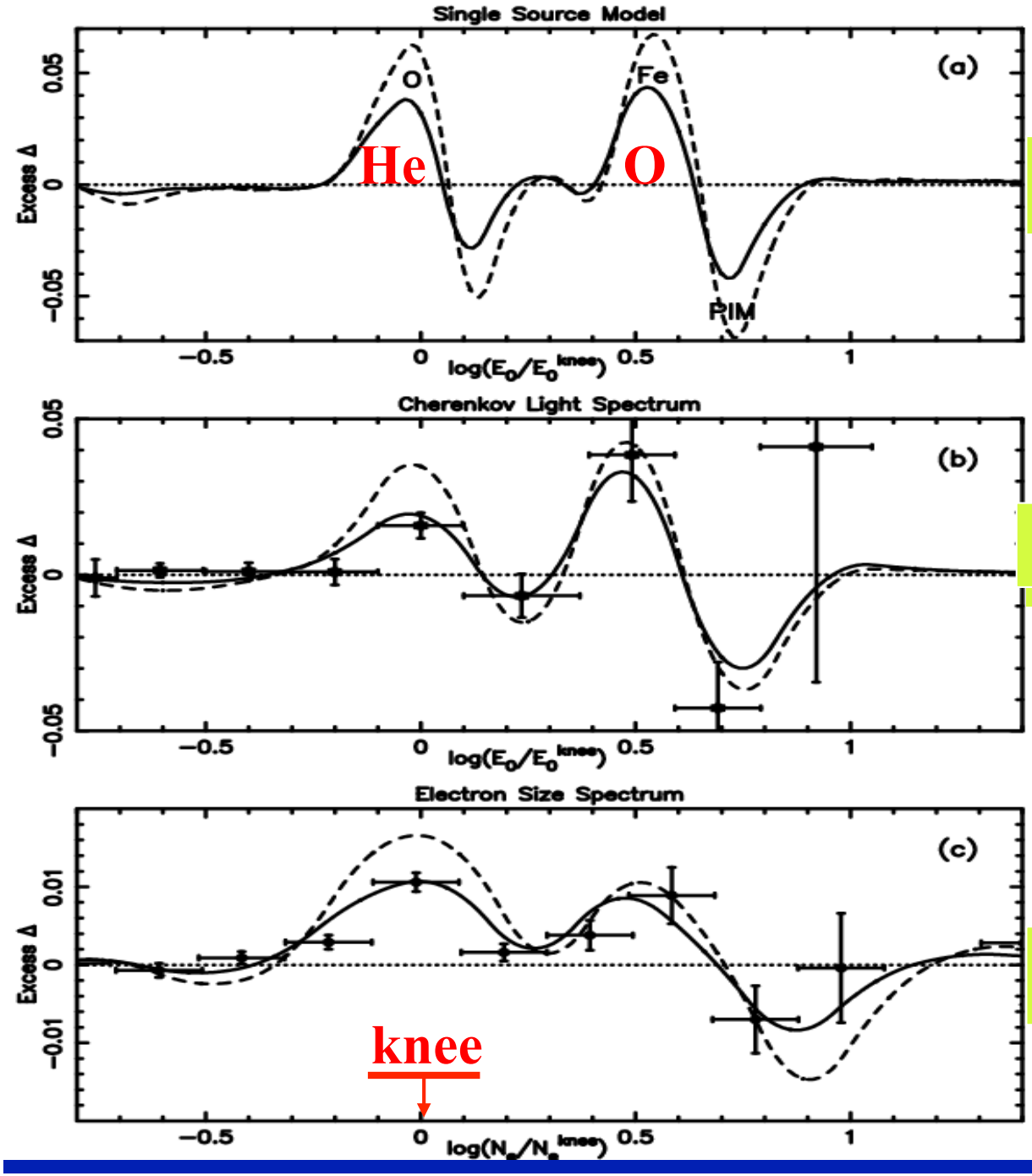
(basic idea)



The main arguments for the Single Source Model of the Knee are:

*** its sharpness**
*** fine structure of the spectrum**

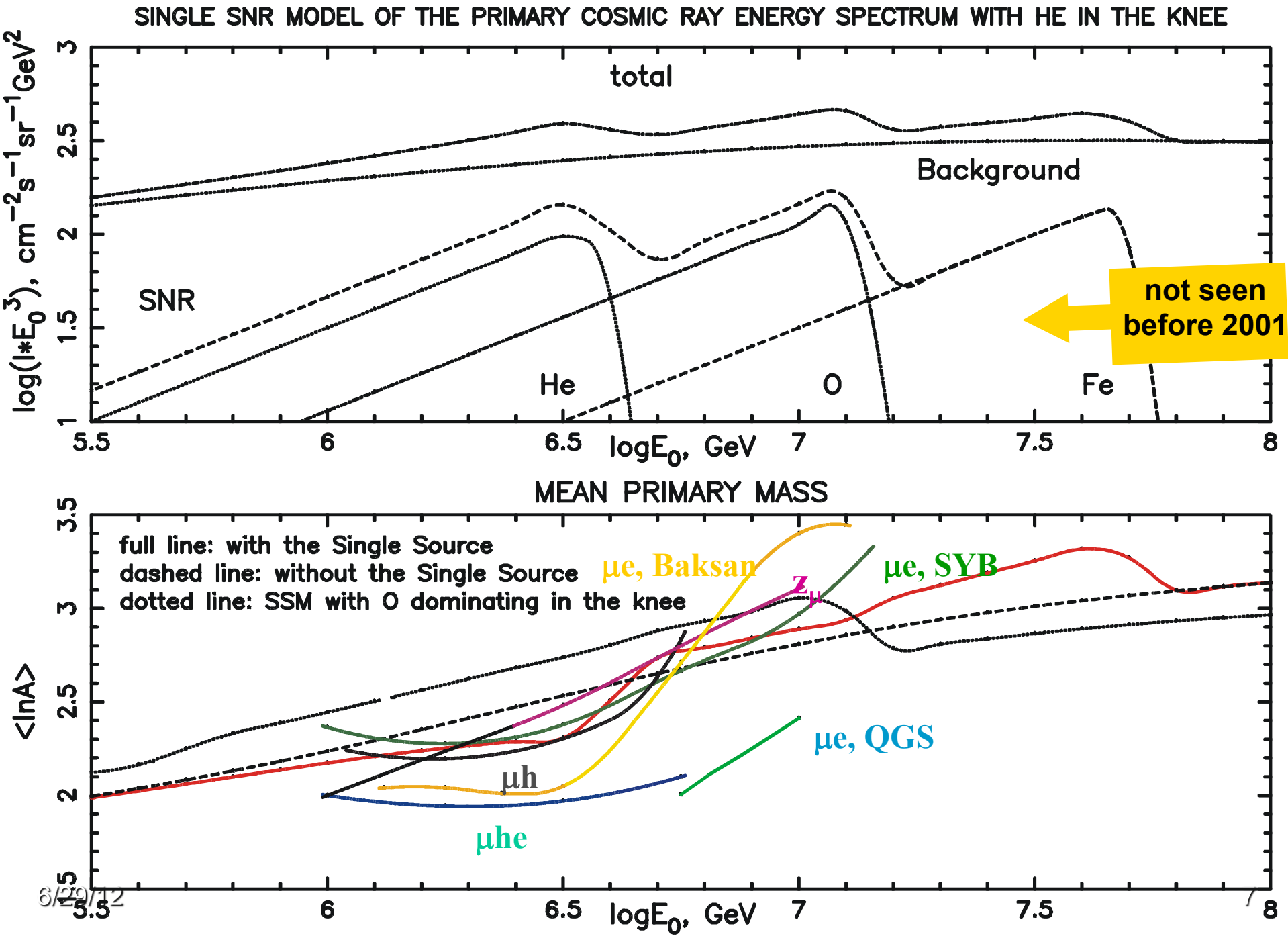
Fine Structure of the Knee



in the ‘Single Source Model’

in Cherenkov light spectra

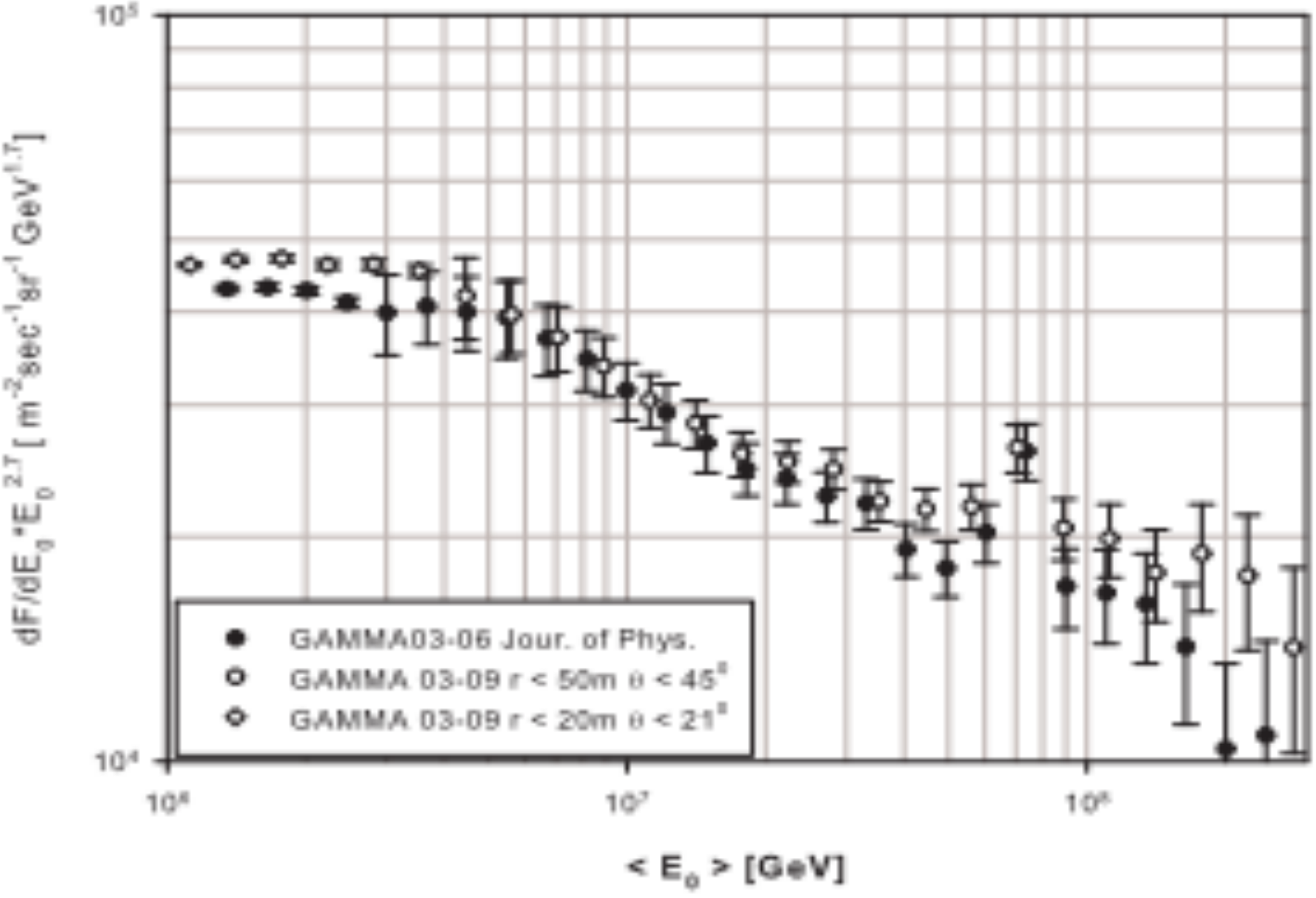
in EAS size spectra


SINGLE SNR MODEL OF THE PRIMARY COSMIC RAY ENERGY SPECTRUM WITH HE IN THE KNEE
total
Background
SNR
He
O
Fe
not seen before 2001
log(I*E0^3), cm^-2 s^-1 sr^-1 GeV^2
logE0, GeV
MEAN PRIMARY MASS
full line: with the Single Source
dashed line: without the Single Source
dotted line: SSM with O dominating in the knee
μe, Baksan
μe, SYB
μe, QGS
μh
μhe
<lnA>

New data after 2001

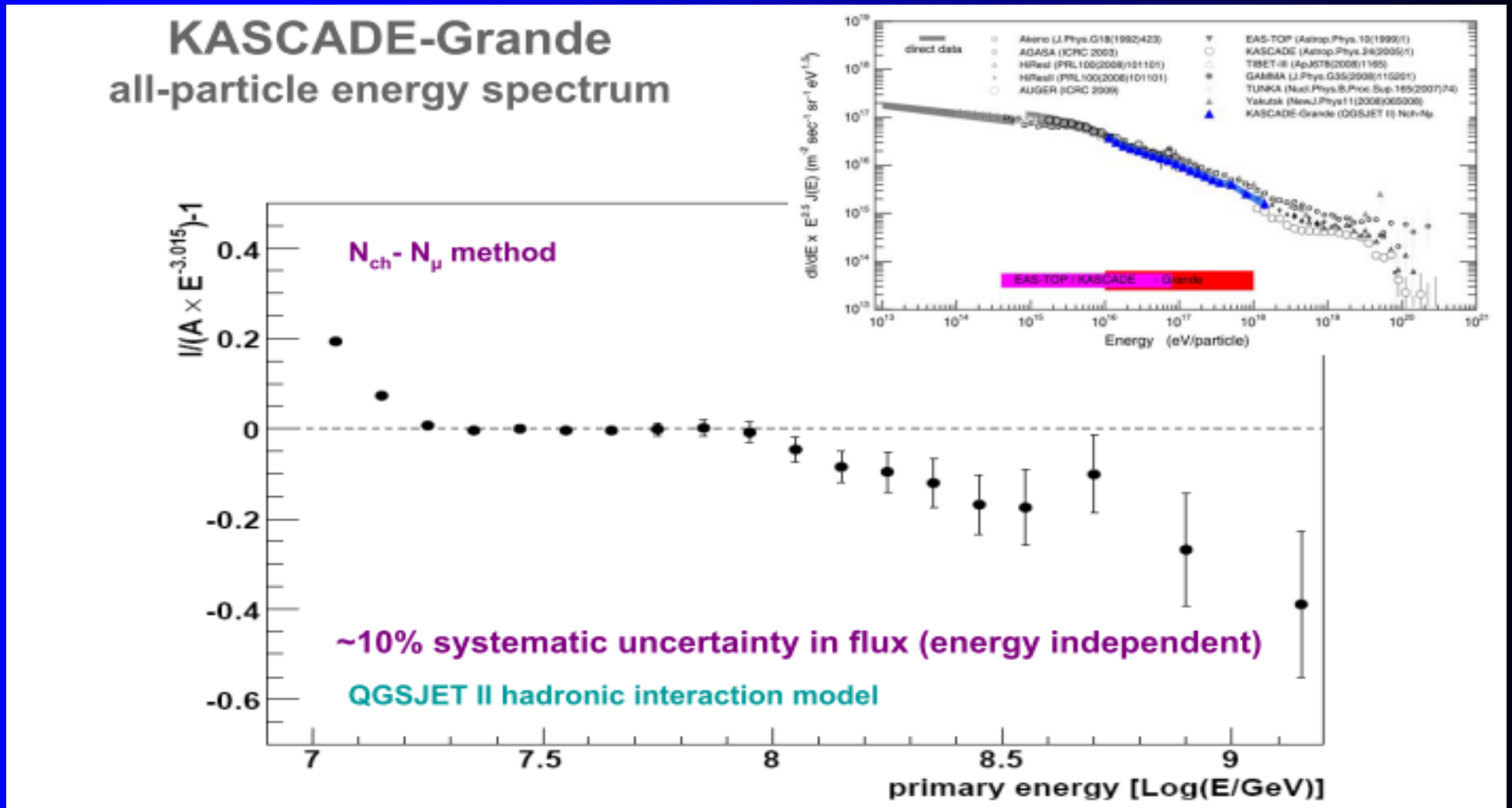
* Tibet – III (e)
* Gamma 2008 (e+μ)
* Maket-ANI (e)
* KASCADE (μ)
* Yakutsk (Č)
* Tunka (Č)
* Gamma 2002 (e)
* KASCADE-Grande (e+μ)
* MSU (e+μ+Č)
* Andyrchi (e+μ)

GAMMA 2011


10^5
10^4
10^6
10^7
10^8
$dF/dE_0 * E_0^{2.7}$ [$m^{-2} sec^{-1} sr^{-1} GeV^{1.7}$]
$< E_0 >$ [GeV]
GAMMA03-06 Jour. of Phys.
GAMMA 03-09 $r < 50m$ $\theta < 45^\circ$
GAMMA 03-09 $r < 20m$ $\theta < 21^\circ$

TUNKA - 133

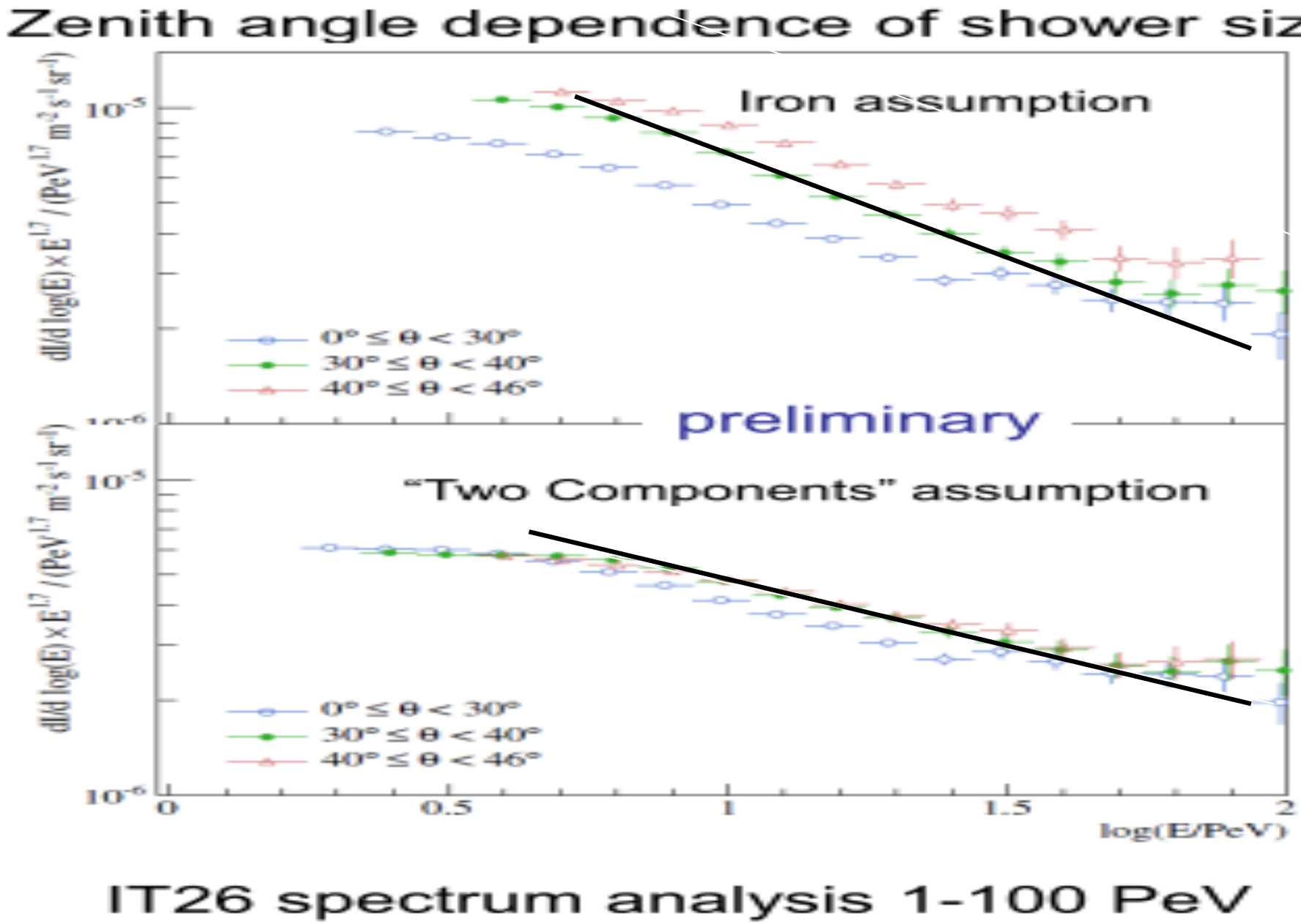
KASCADE-Grande



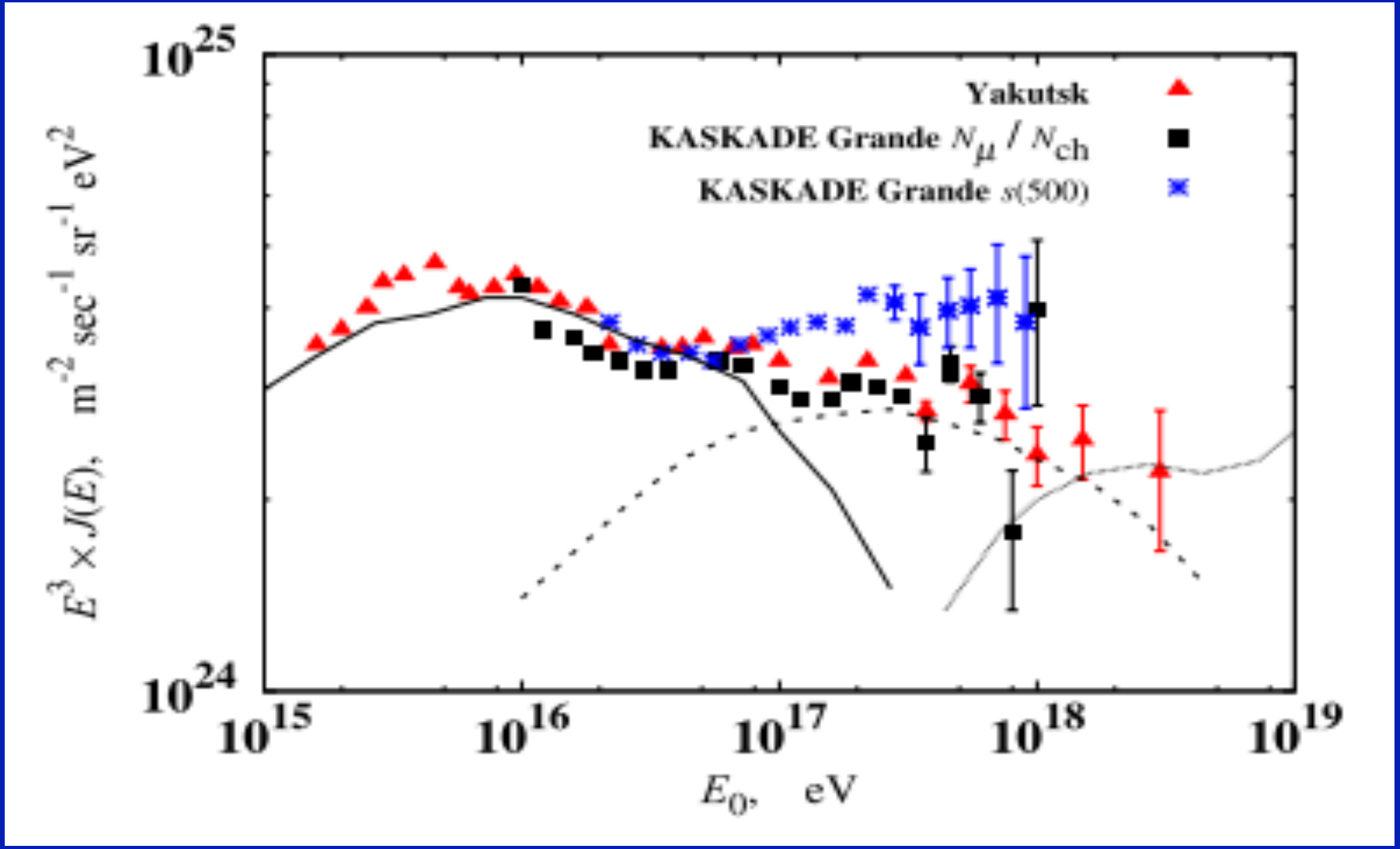
- spectrum not describable by a single power law at 10^{16}-10^{18}eV
- hardening of the spectrum above 10^{16}eV
- small, but significant steepening close 10^{17}eV

M.Bertaina et al, ECRS 2010

Ice-Top 2011

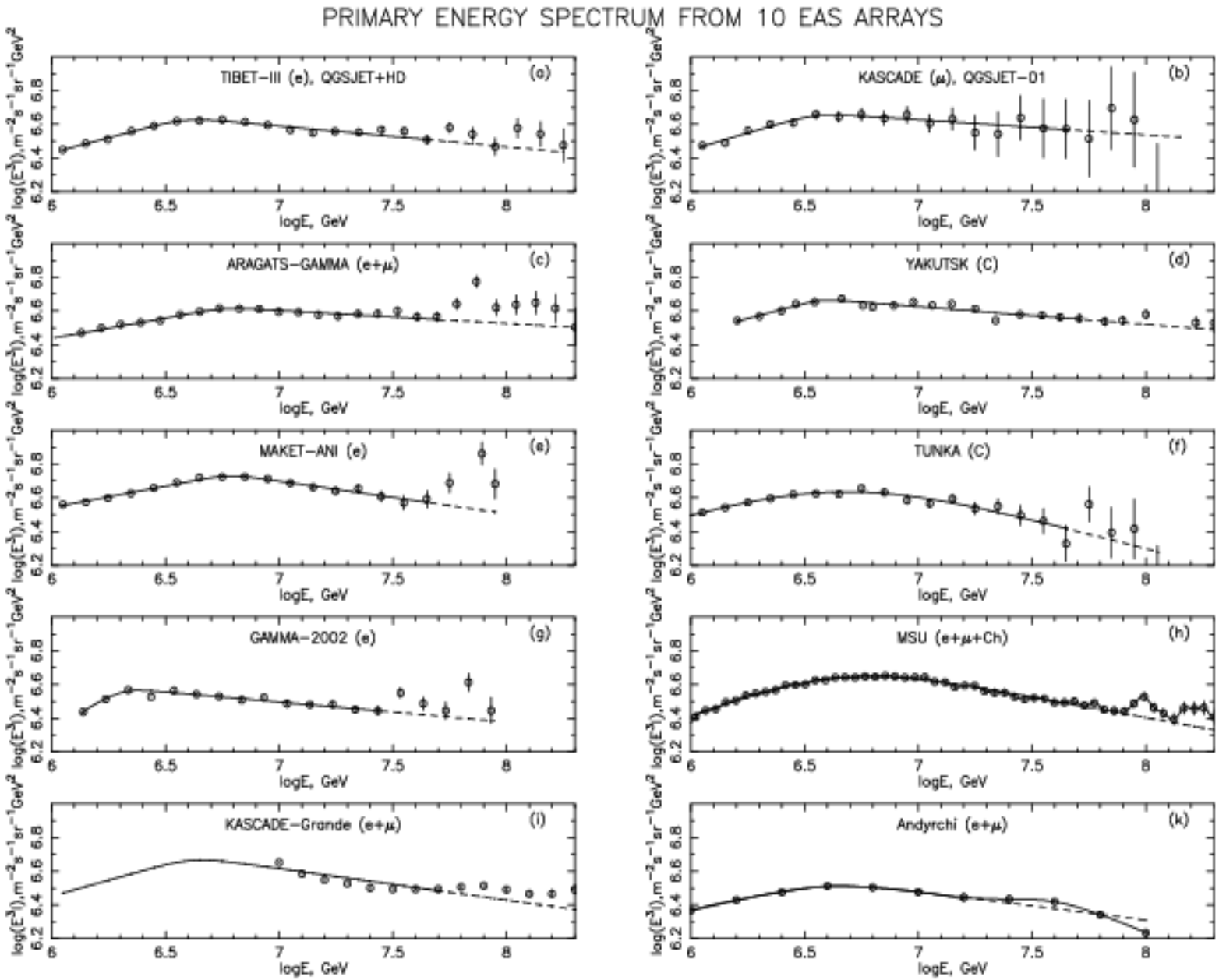

Zenith angle dependence of shower size
Iron assumption
0° ≤ θ < 30°
30° ≤ θ < 40°
40° ≤ θ < 46°
preliminary
"Two Components" assumption
0° ≤ θ < 30°
30° ≤ θ < 40°
40° ≤ θ < 46°
dI/d log(E) x E^1.7 /(PeV^1.7 m^-2 s^-1 sr^-1)
log(E/PeV)
IT26 spectrum analysis 1-100 PeV

Yakutsk 2011

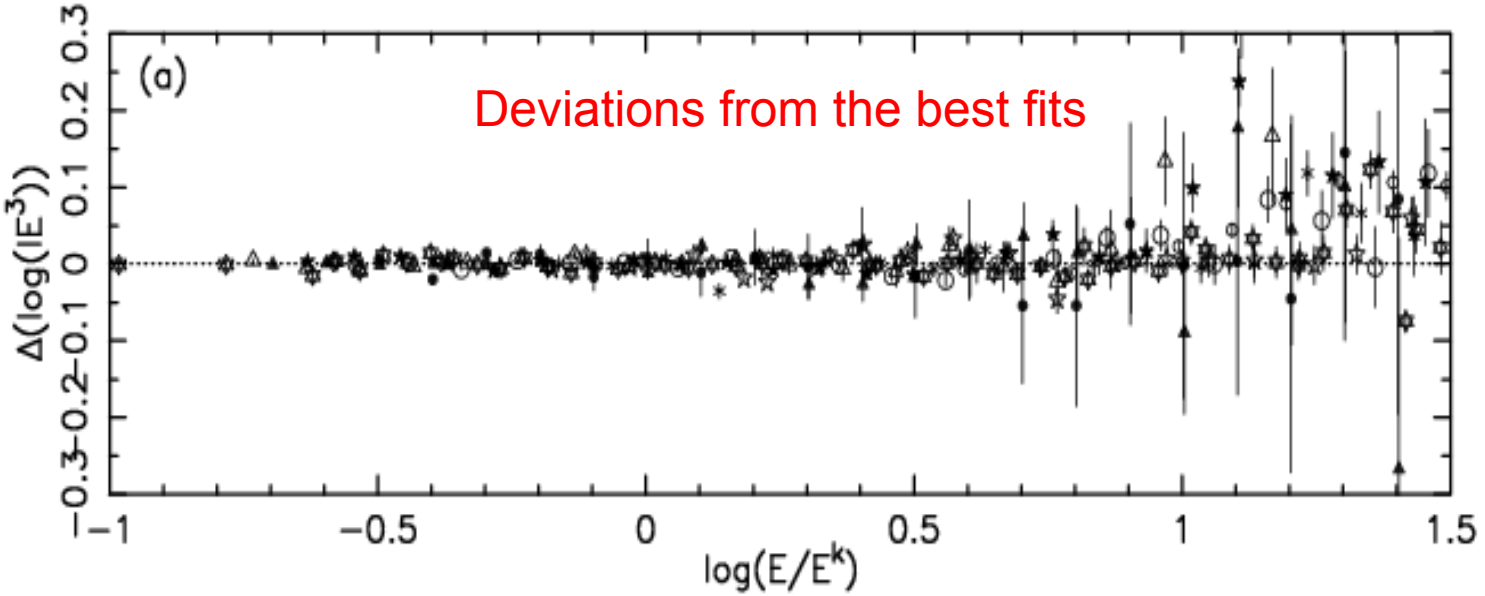


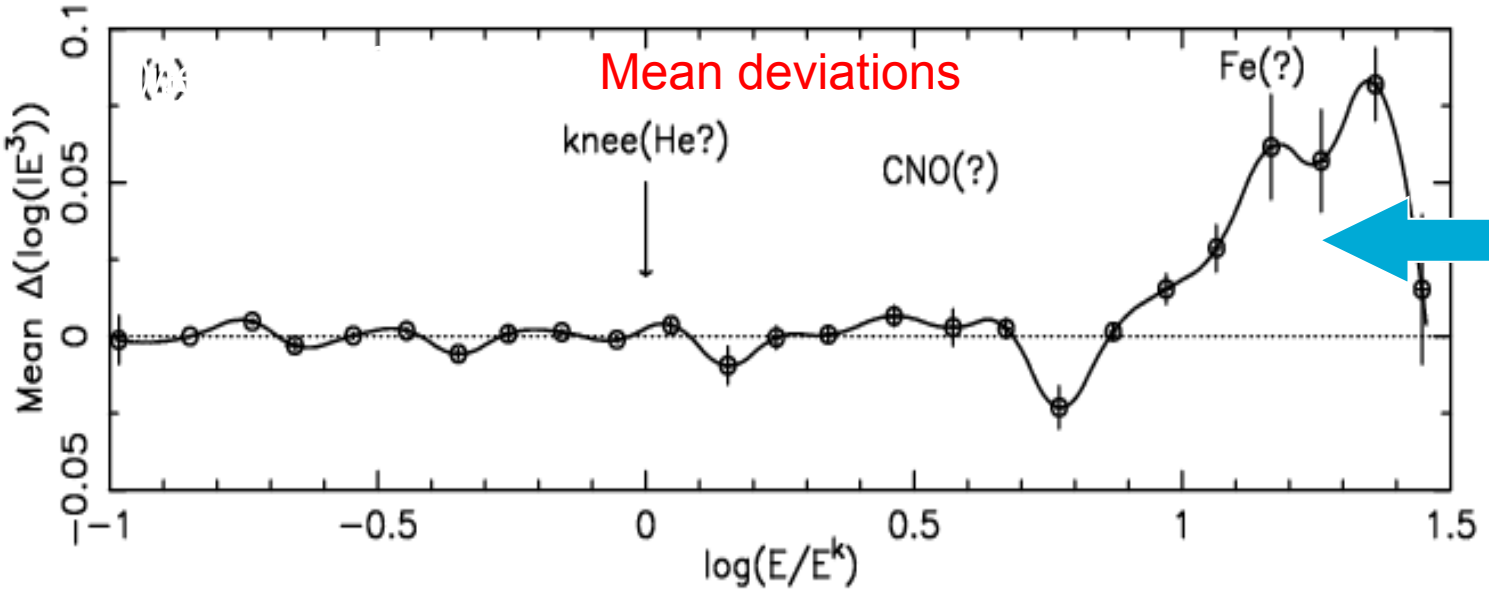
'Within the energy range (5-8)*10^{16}eV there is a small peak generated by primary iron nuclei'

Confirmation of GAMMA results by other experiments



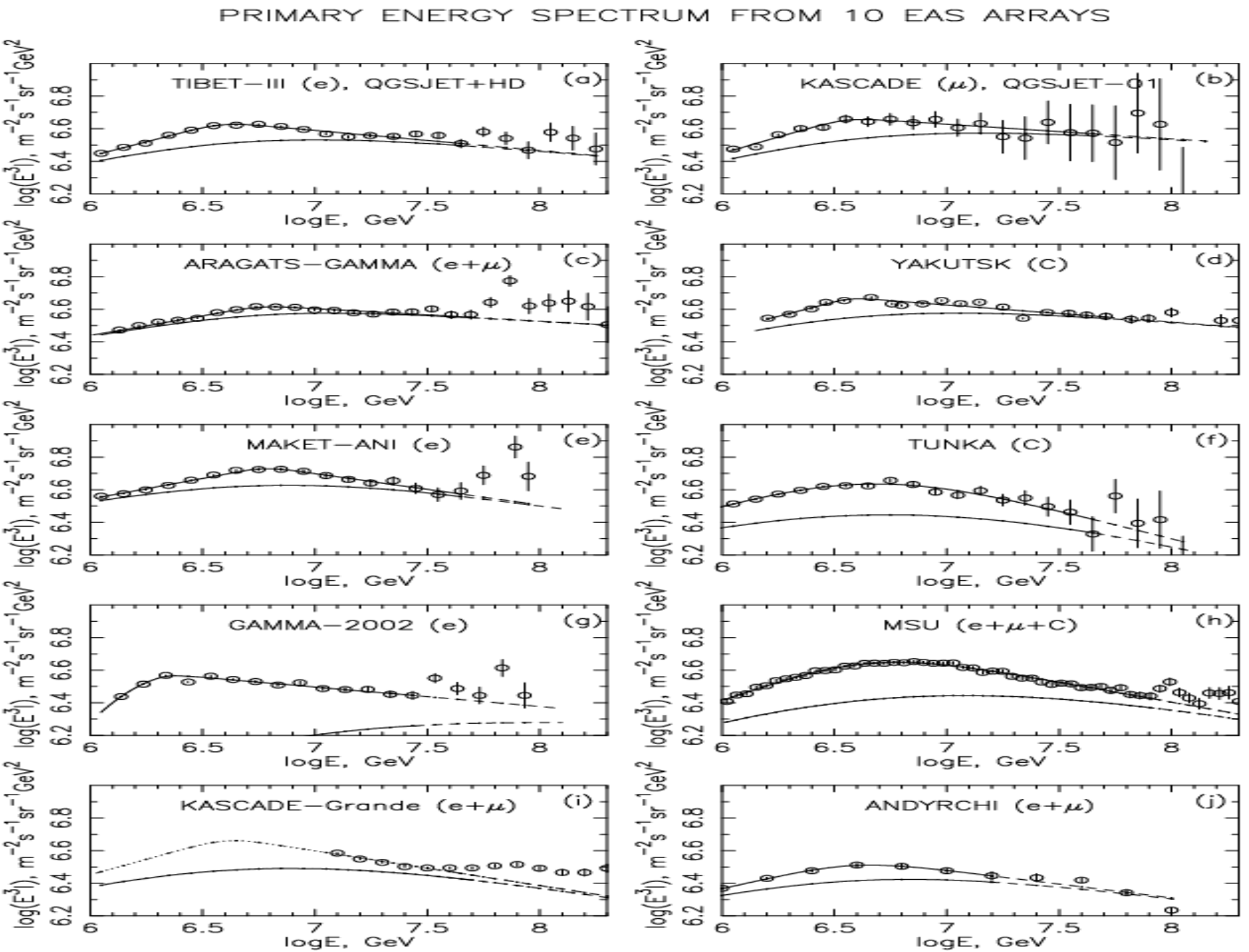
Fine structure of the primary CR energy spectrum in the knee region



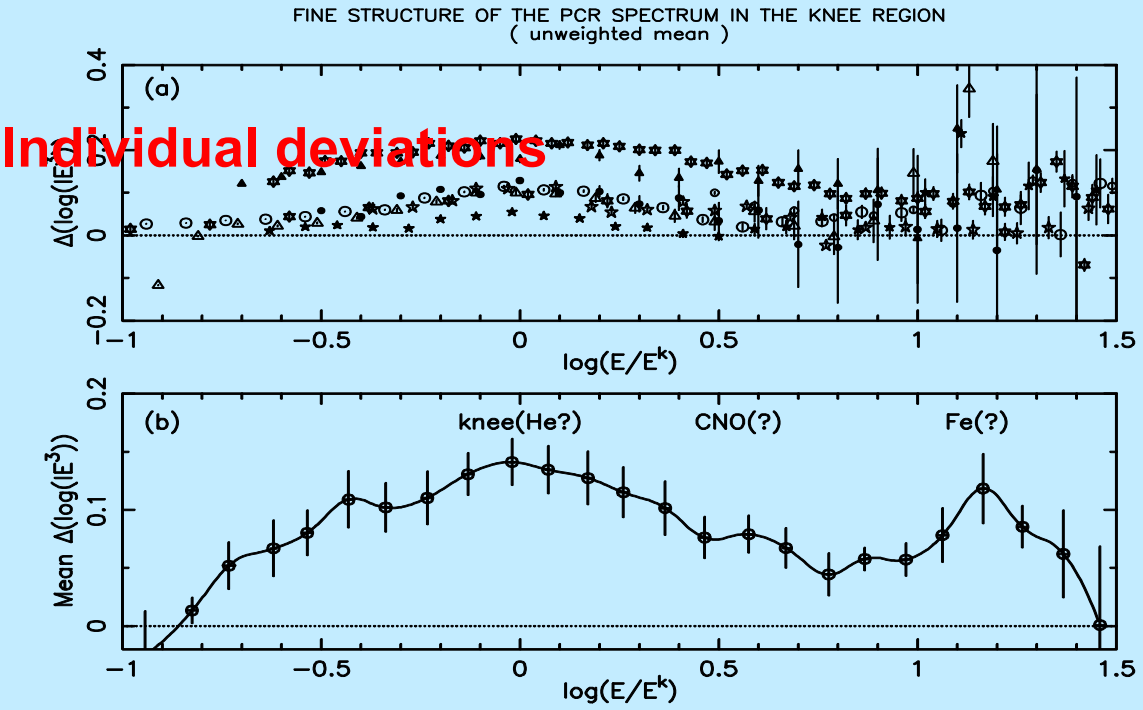


'Iron peak' ?

Comparison of the observed spectra with expected from Galactic Diffusion Model



Deviation of the observed CR intensity from that expected in the Galactic Diffusion Model



Individual deviations

Mean deviation

Energy spectrum of CR from the Single Source

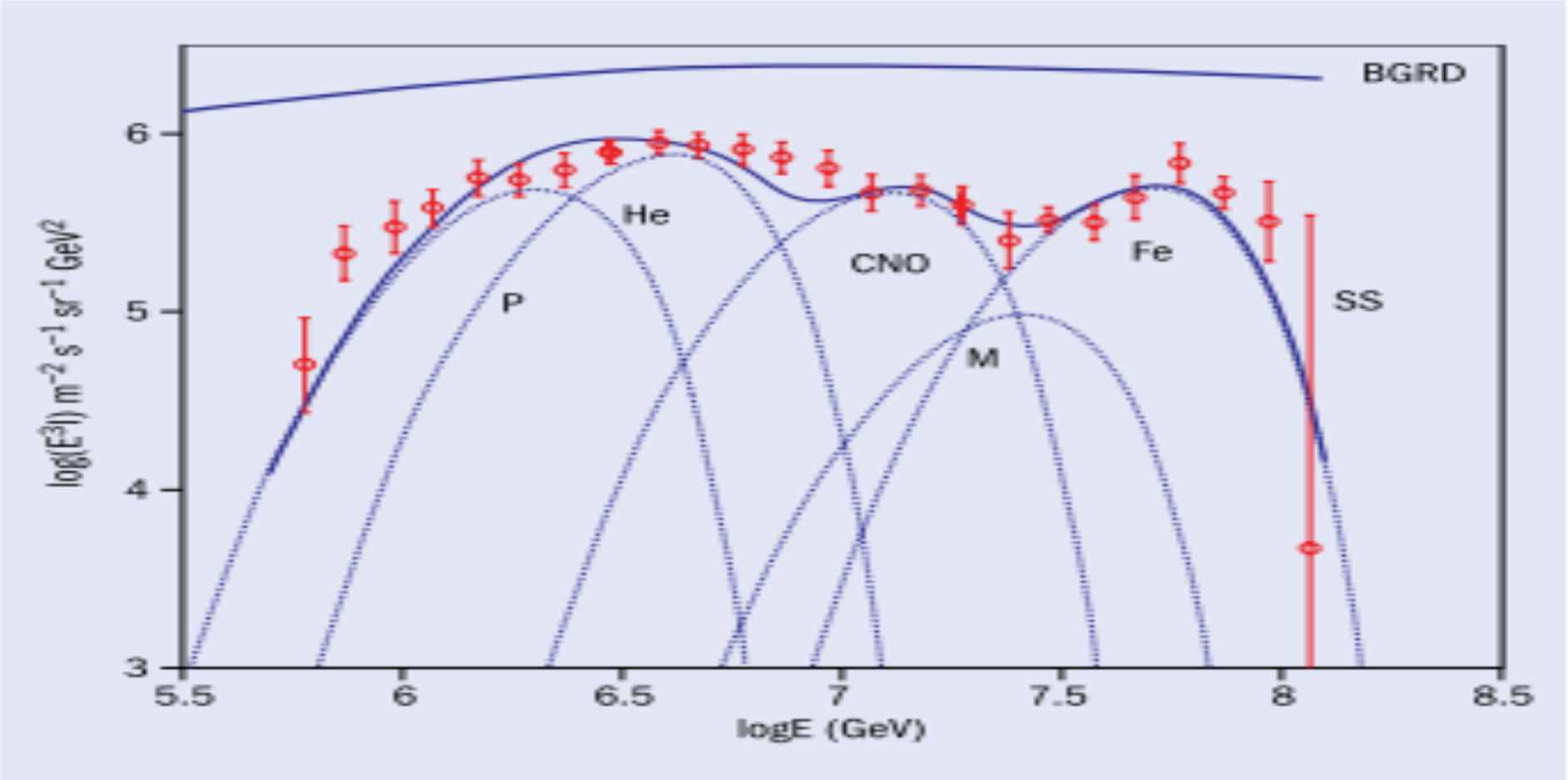
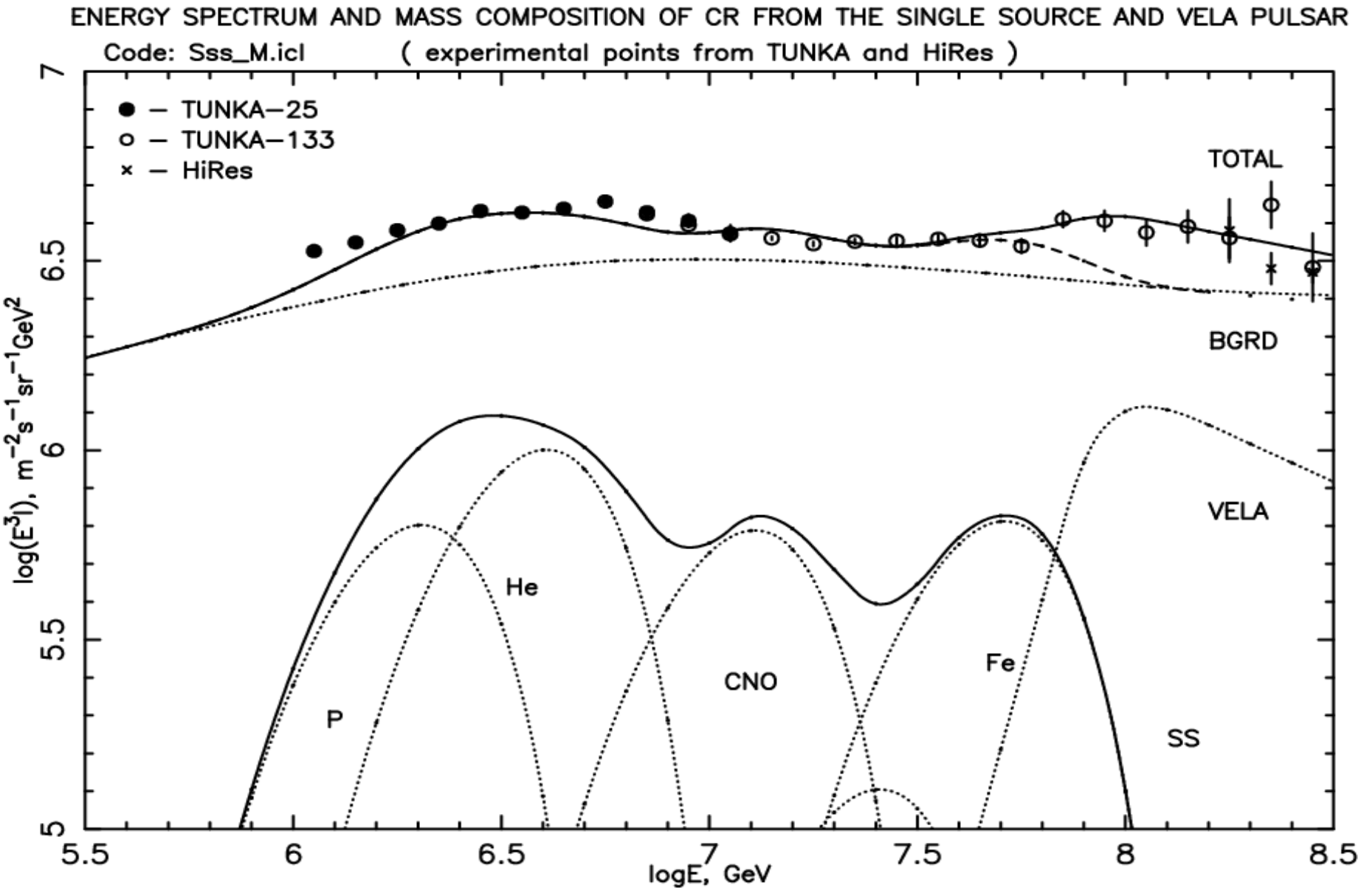
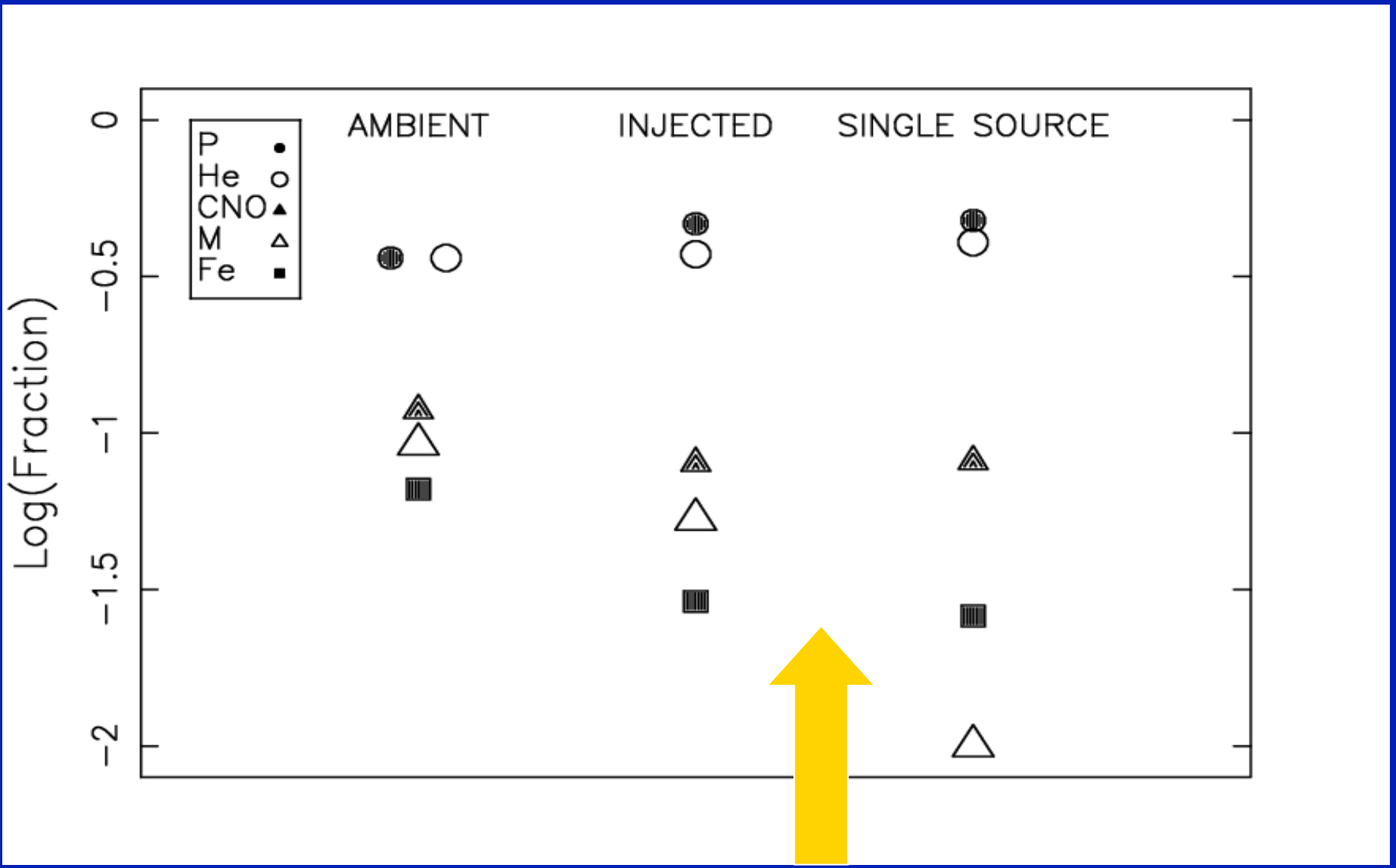


Fig. 3. The energy spectrum of the single source and its interpretation. The full line denoted as BGRD is the background spectrum. Dotted lines are best-fit contributions from five cosmic-ray mass groups: P, He, CNO, M and Fe. The full line denoted as SS is the sum of these five components.

Energy spectrum and mass composition of cosmic rays from t single source and Vela pulsar



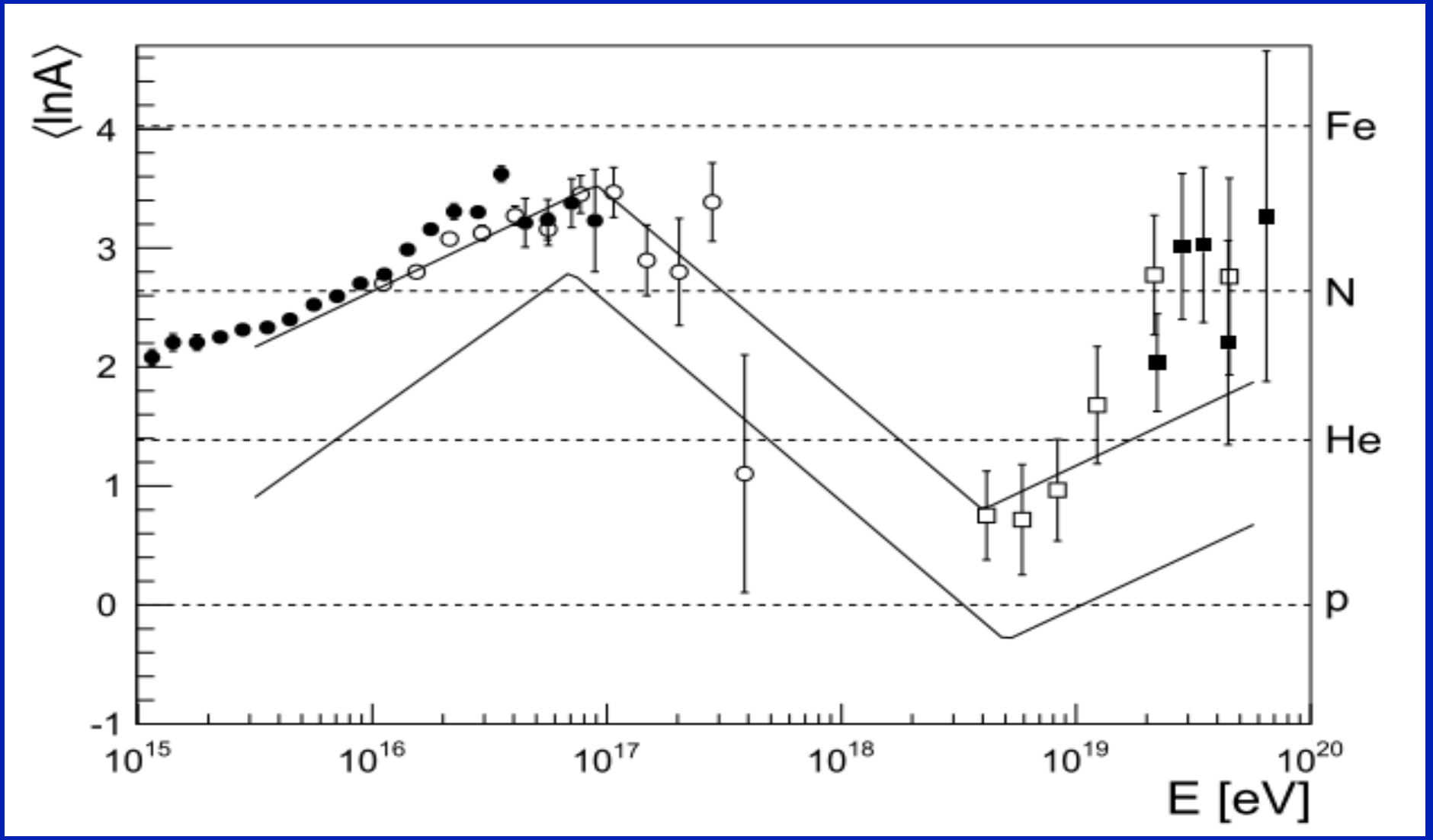
Mass composition of cosmic rays



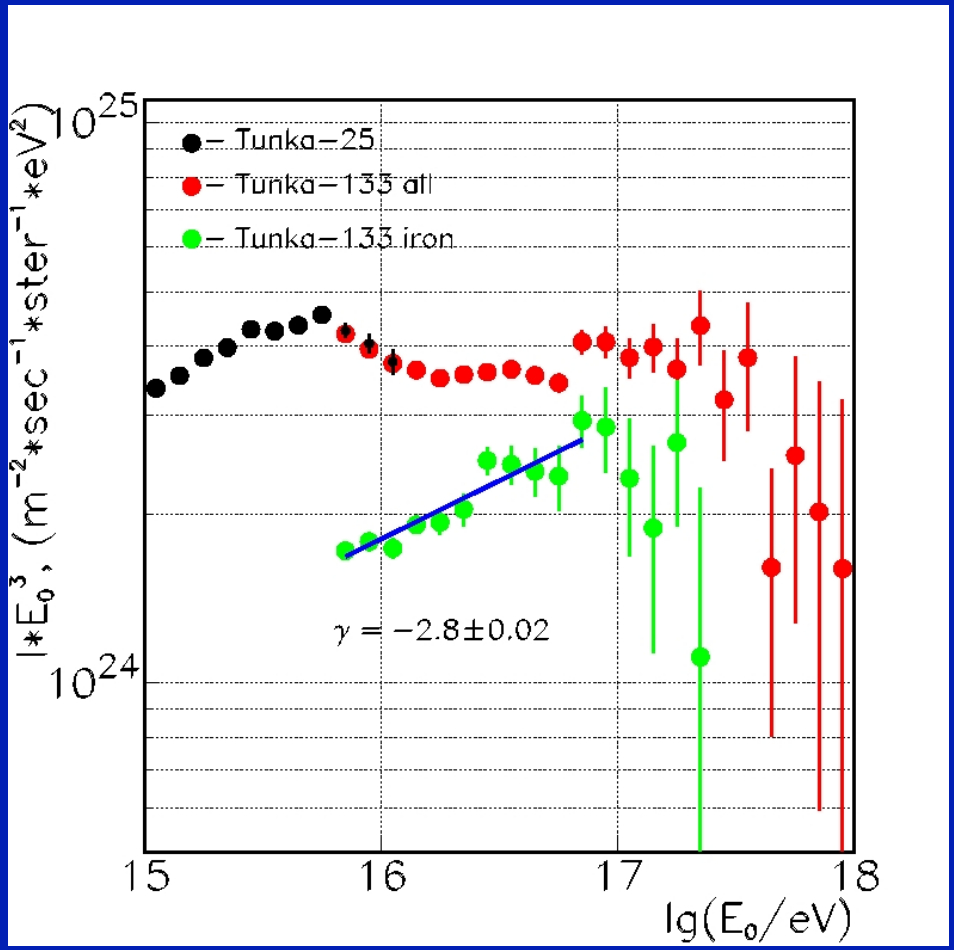
Note the similarity of injected and single source CR mass compositions

<lnA> vs Energy

(K-H.Kampert & M.Unger, 2012, Astropart.Phys.,35, 660)

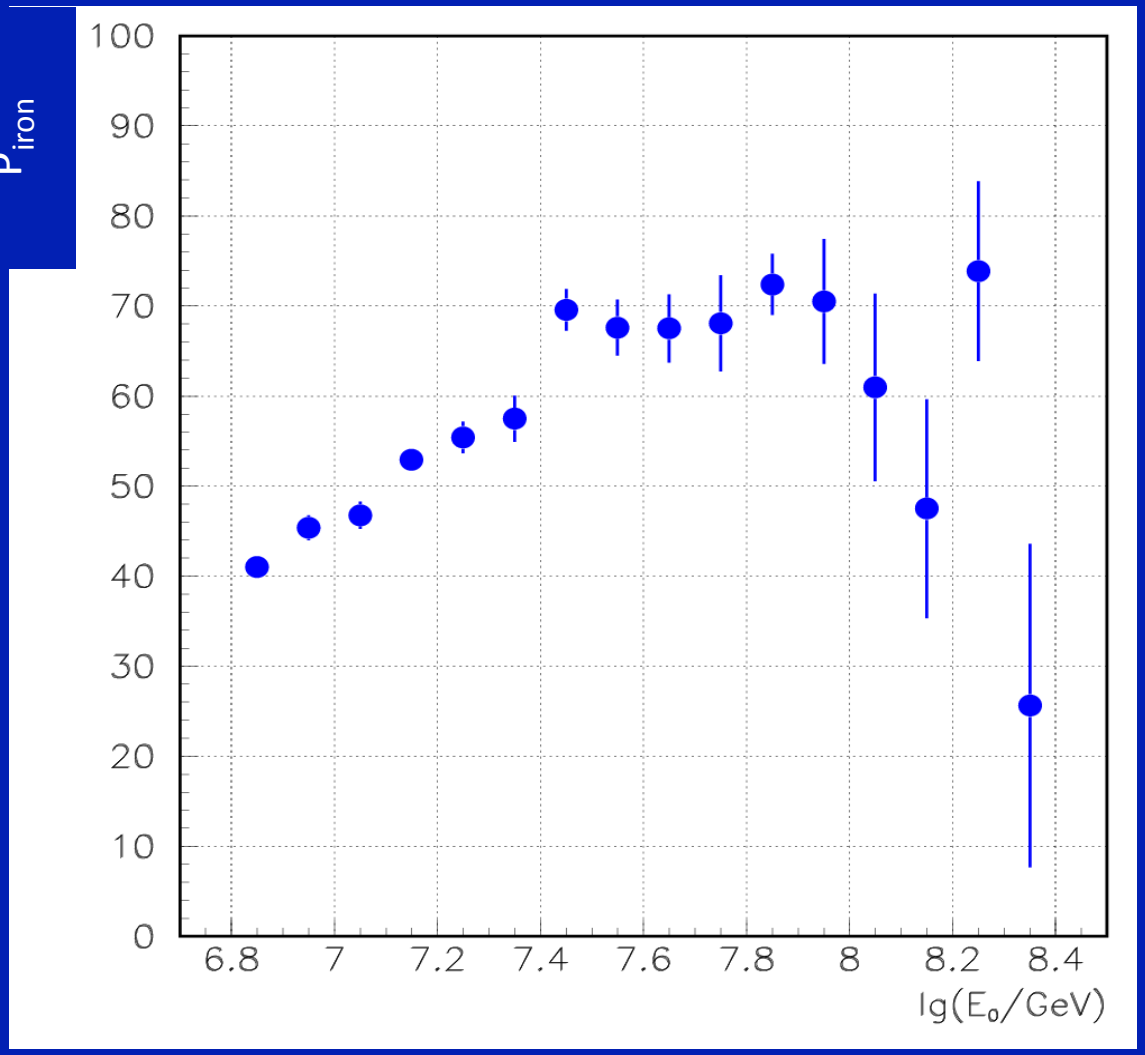


Iron spectrum (iron knee)



$I_{iron}=I_{all}\cdot P_{iron}/100$

Iron percentage



Conclusion

Deviations from the smooth fit in the new data confirm the irregularity at $\log(E/E_k)=0.5\text{-}0.6$ ('CNO peak') and reveal the possible existence of the peak at $\log(E/E_k)=1\text{-}1.2$ ('Fe peak')

Conclusion

If the 'Iron Peak' is a real feature, its origin is most likely the end of contribution of Single Source. The background of Galactic CR continues further up to the ankle.

Thank you for your attention