Do we see an 'Iron Peak' ?

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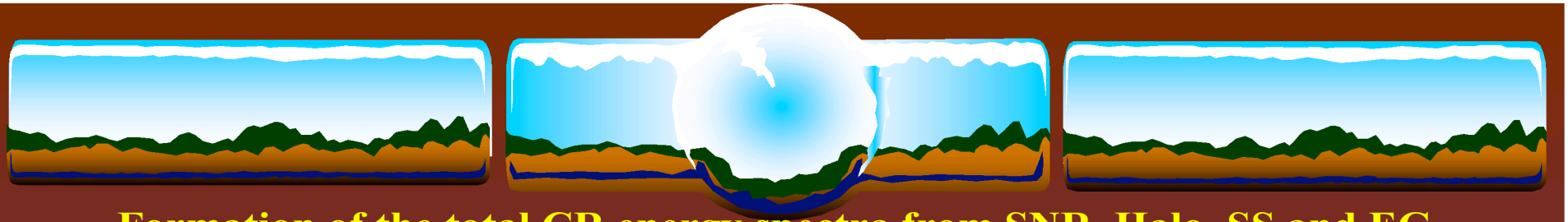
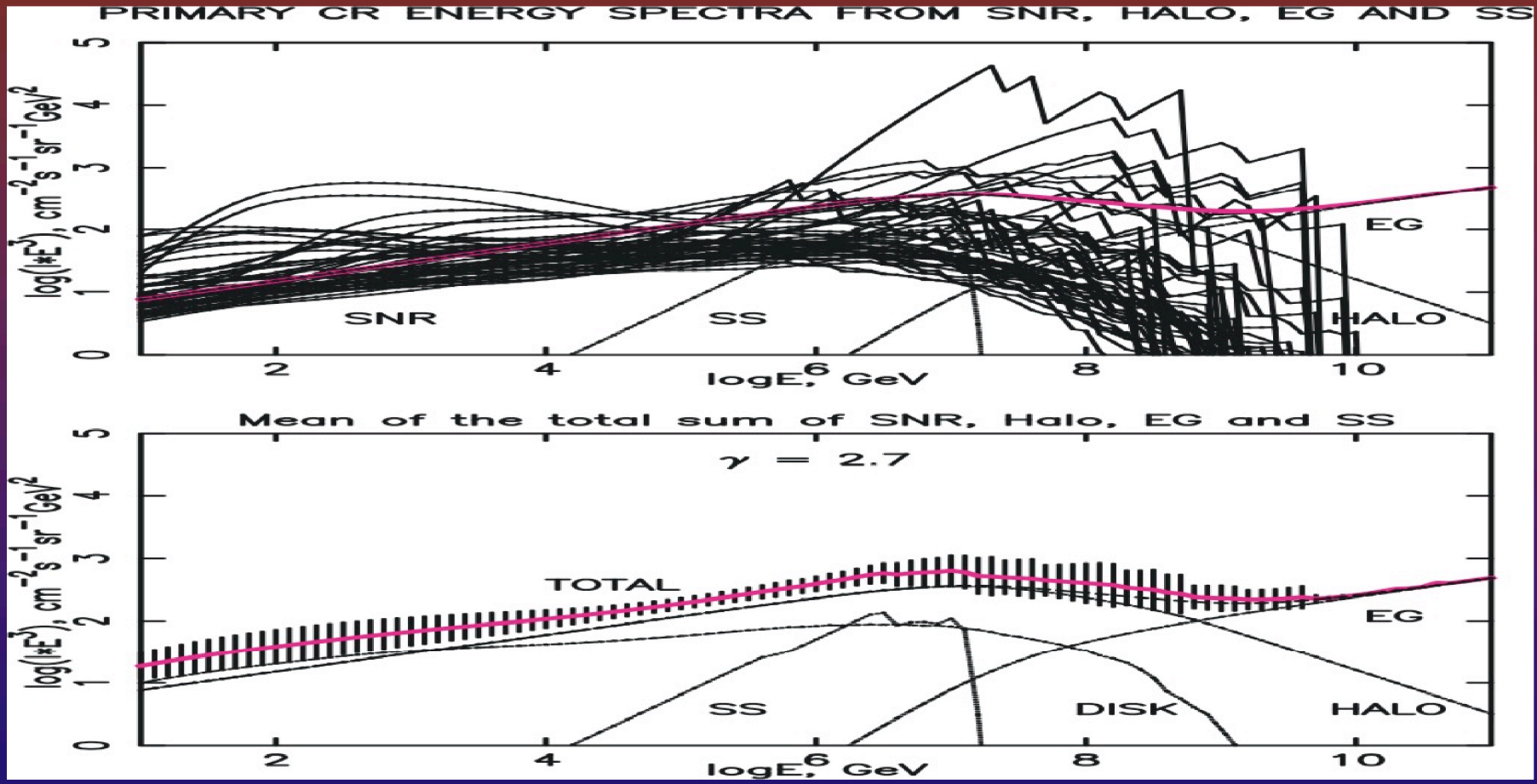
Contents

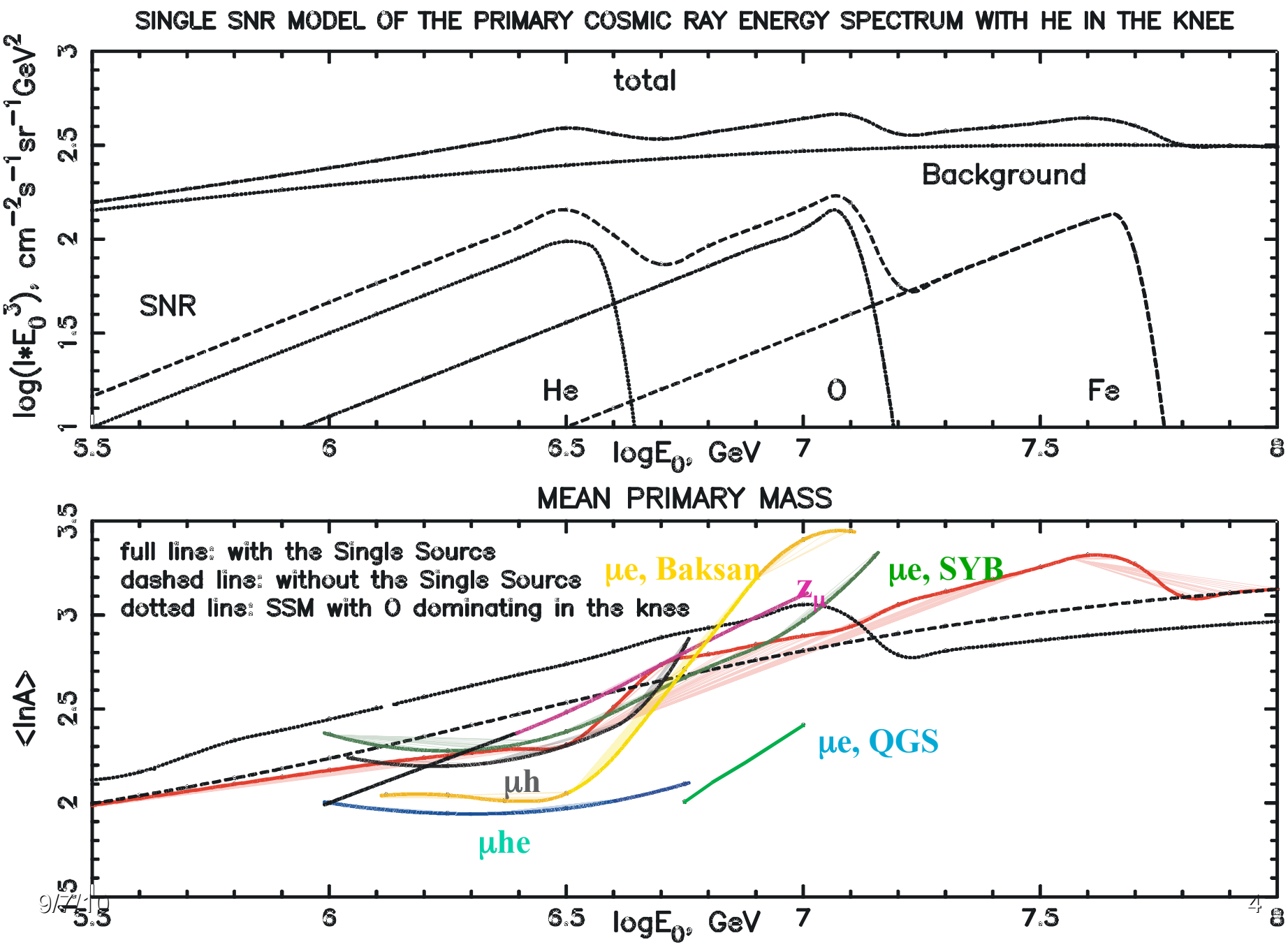
The essence of the Single Source Model of the knee is the non-uniform, stochastic distribution of CR sources in space and time.

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



Formation of the total CR energy spectra from SNR, Halo, SS and EG




SINGLE SNR MODEL OF THE PRIMARY COSMIC RAY ENERGY SPECTRUM WITH HE IN THE KNEE
log(I*E0^3), cm^-2 s^-1 sr^-1 GeV^2
total
Background
SNR
He
O
Fe
logE0, GeV
MEAN PRIMARY MASS
<lnA>
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
Zμ
μe, QGS
μh
μhe
logE0, GeV

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

* its sharpness
* fine structure of the spectrum

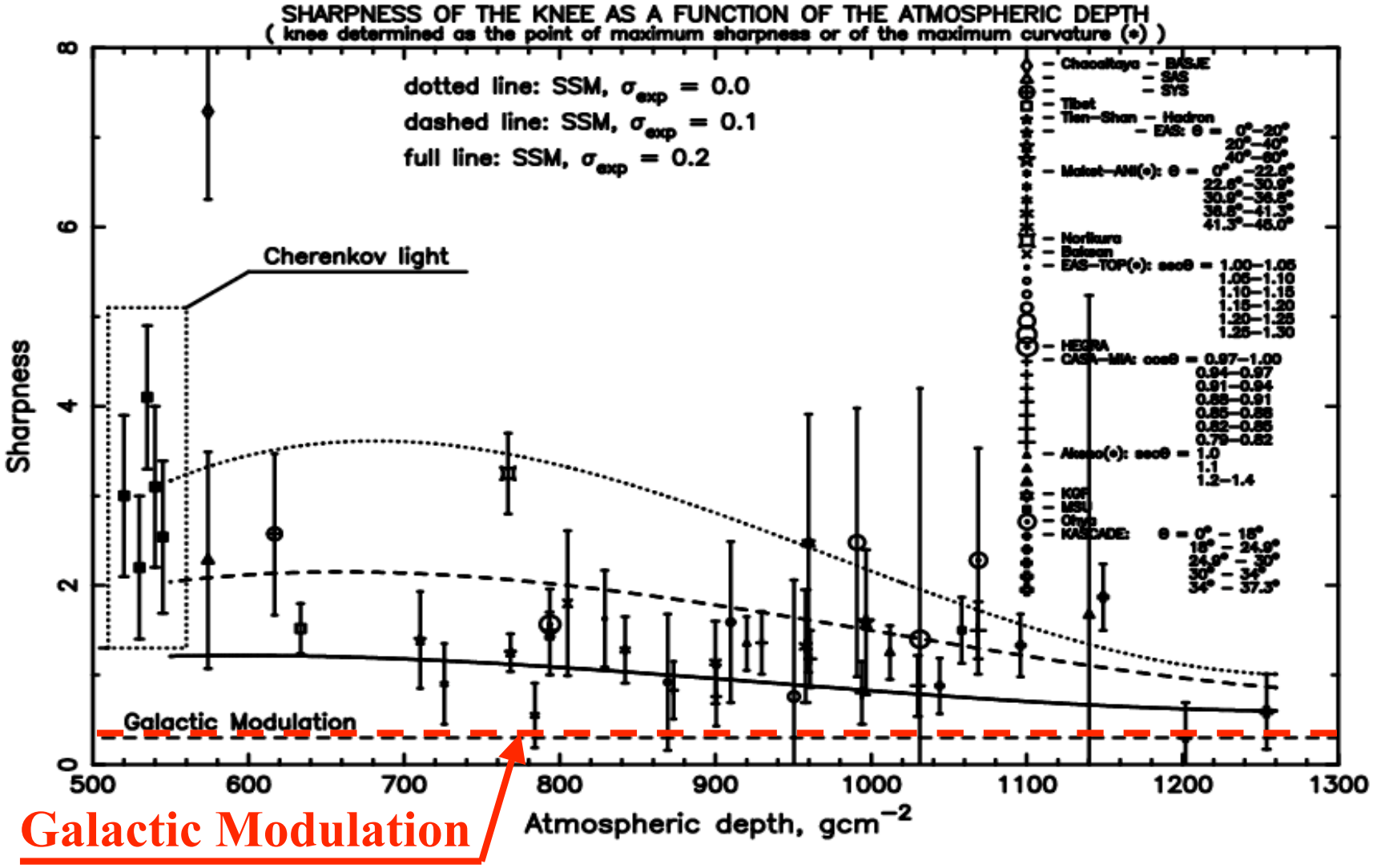
Sharpness of the knee

Definition:

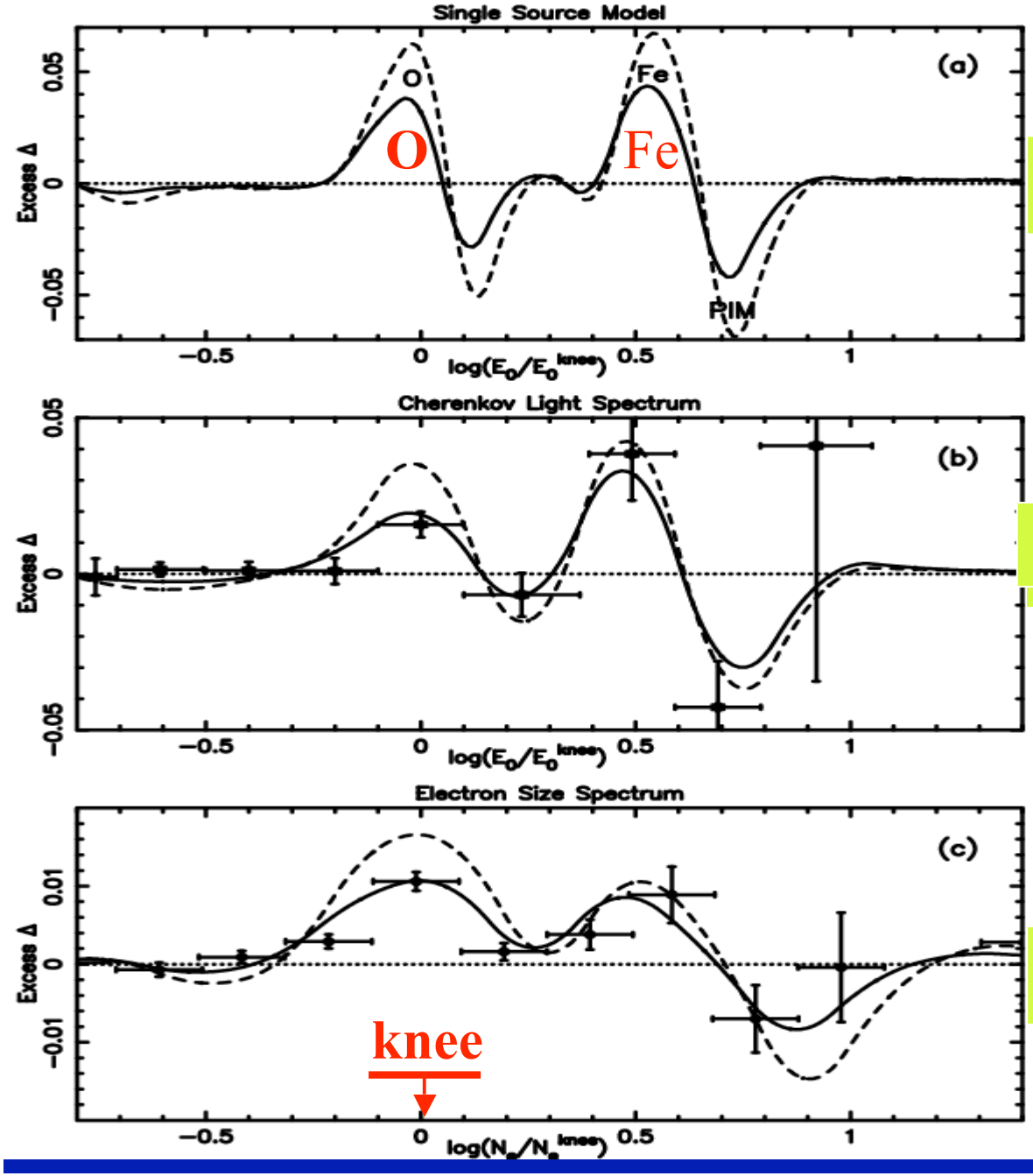
$$S = \frac{d\gamma}{d(\log E)} = -\frac{d^2(\log I)}{d(\log E)^2}$$

S does not depend on absolute values of I and γ

Sharpness of the knee at different atmospheric depths



Fine Structure of the Knee

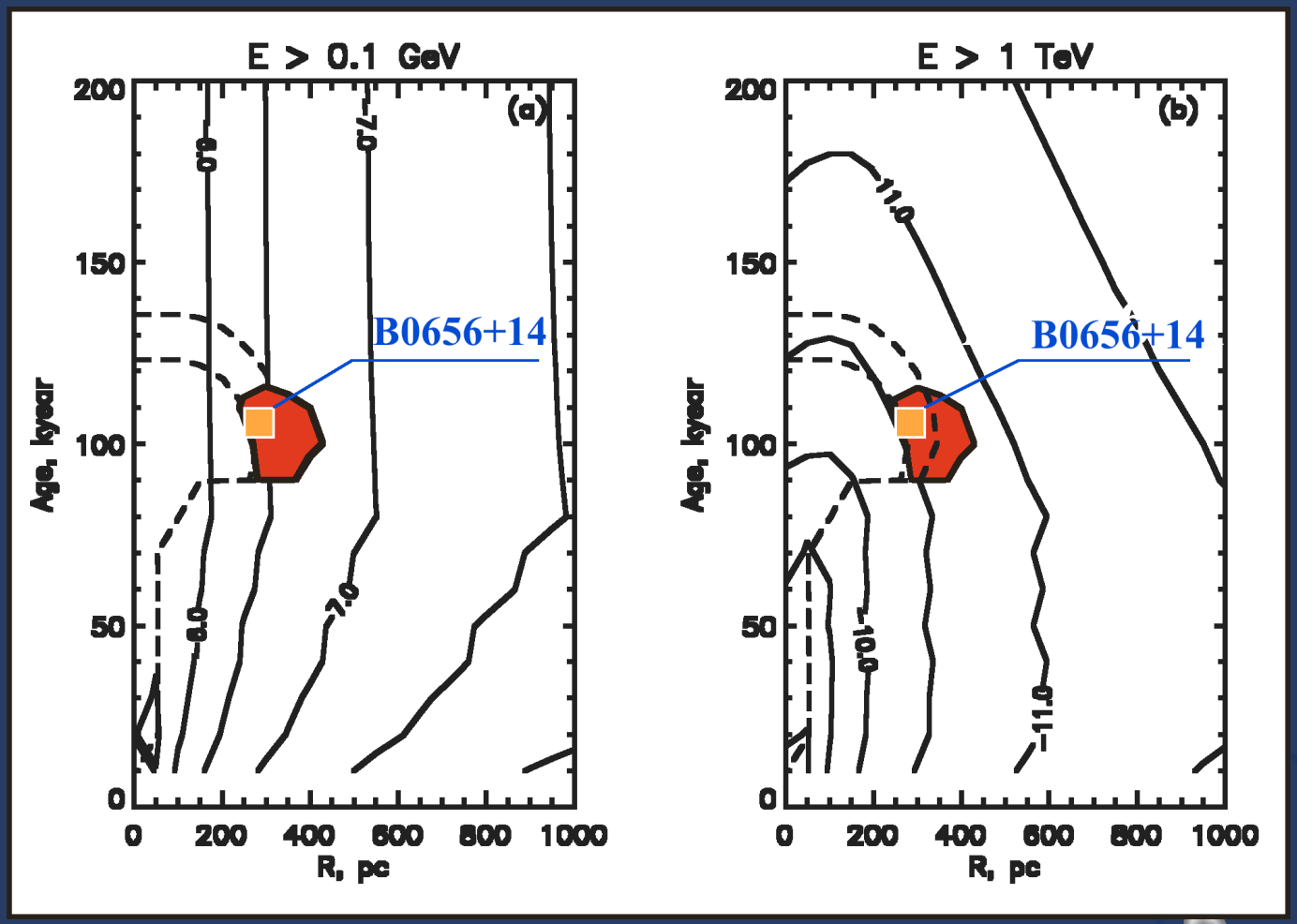


in the ‘Single Source Model’

in Cherenkov light spectra

in EAS size spectra

The distance and the age of Single Source SNR



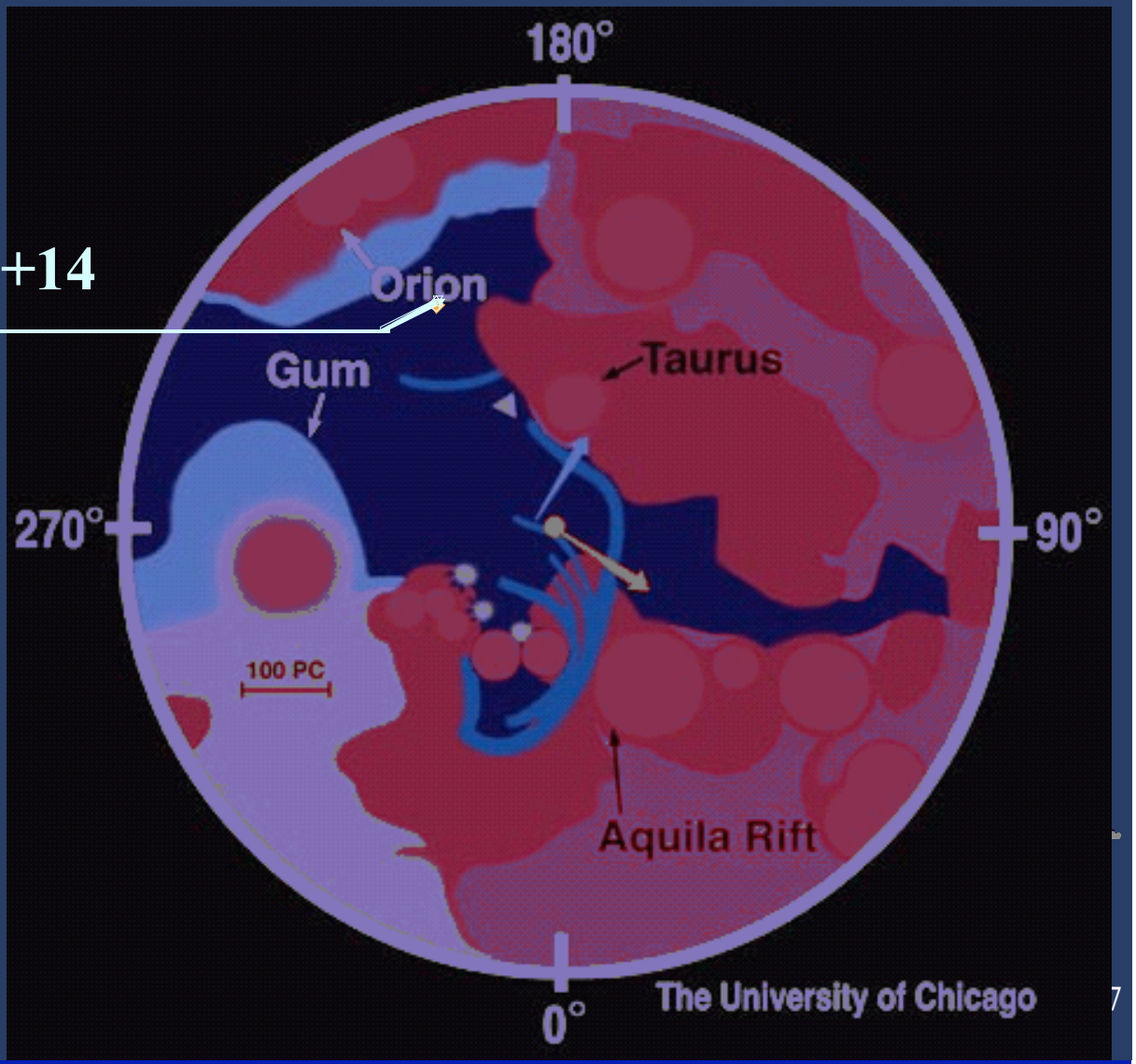
R = 288 +33-27 pc

Thorsett S.E. et al., 2003, ApJ,592,L71

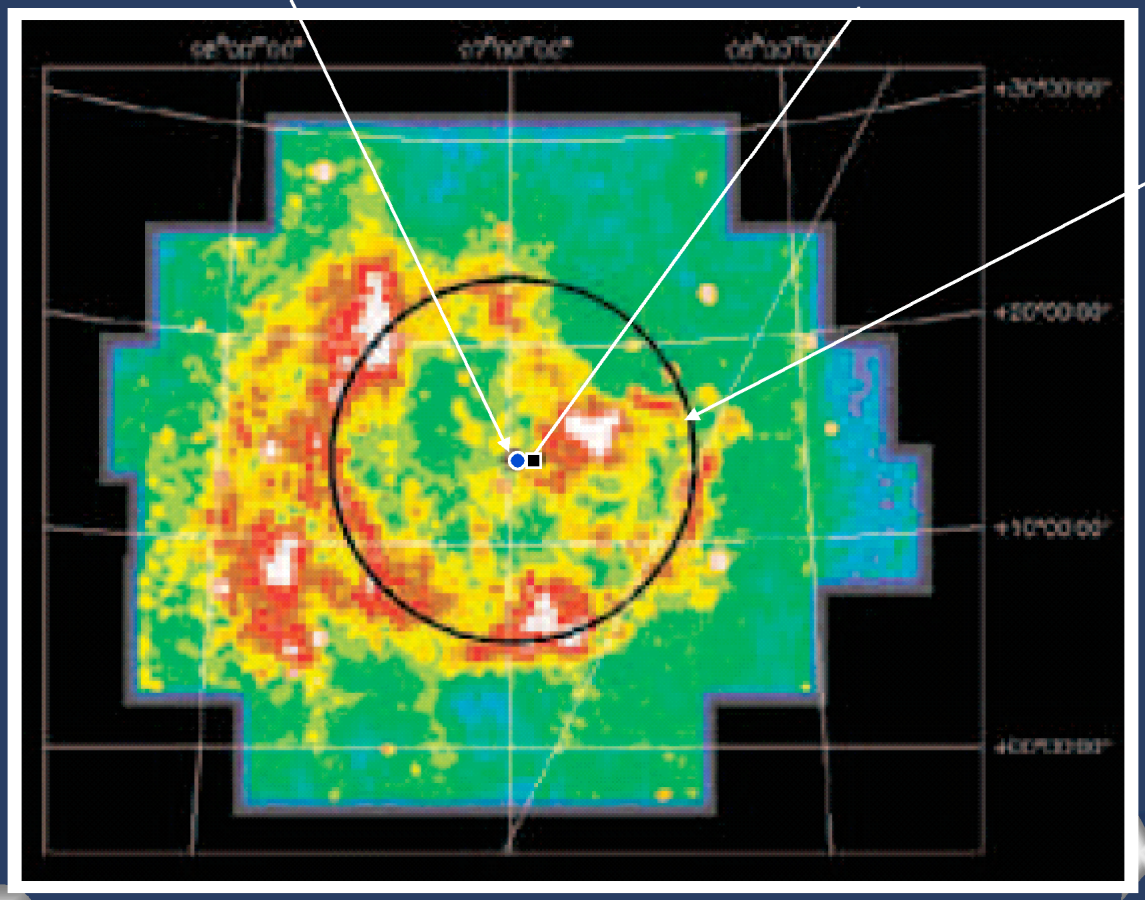
The Solar Neighborhood

(nearby 500 pc)

B0656+14



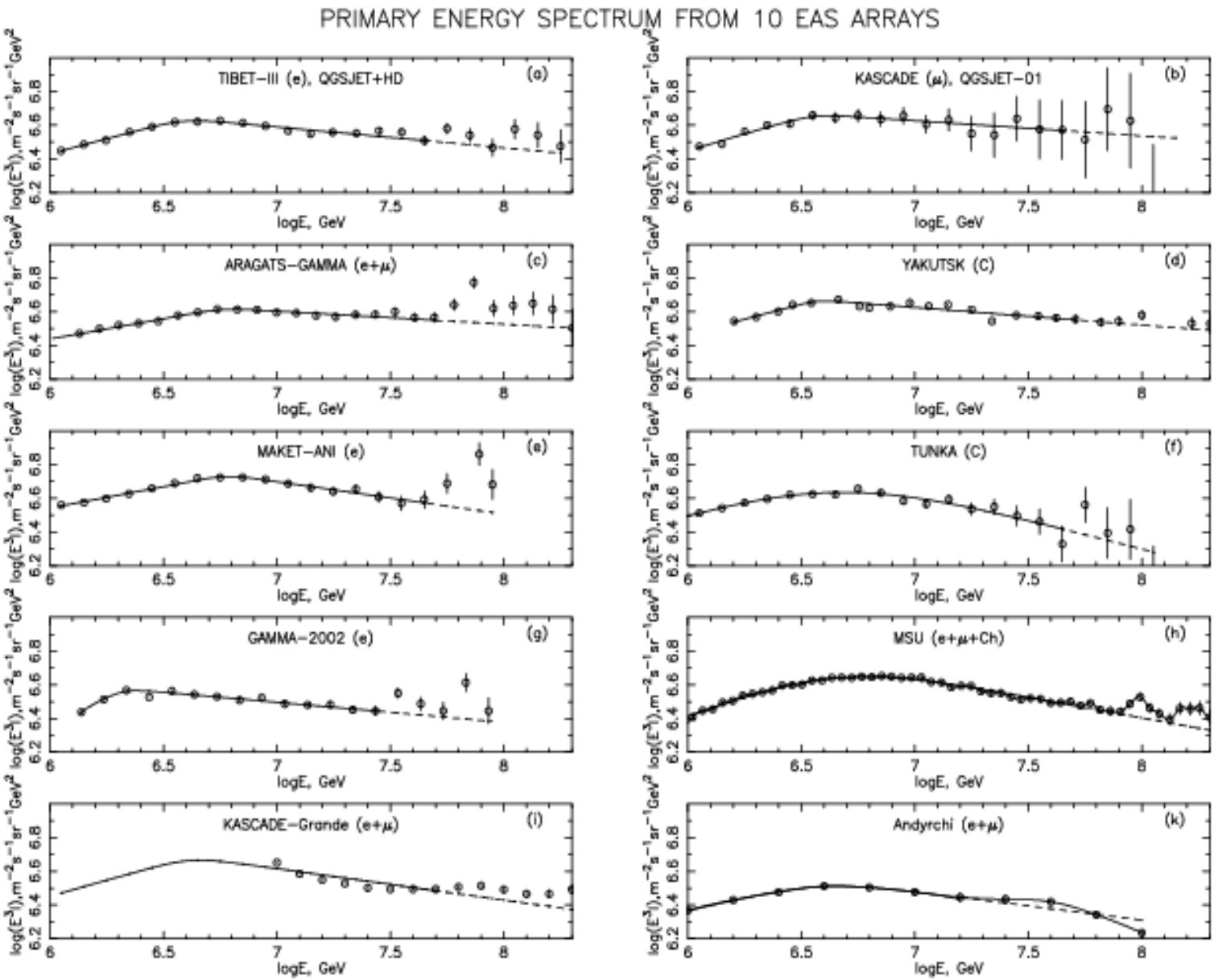
Monogem Ring SNR and B0656+14 pulsar



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)

Confirmation of GAMMA results by other experiments



Fit of the energy spectrum

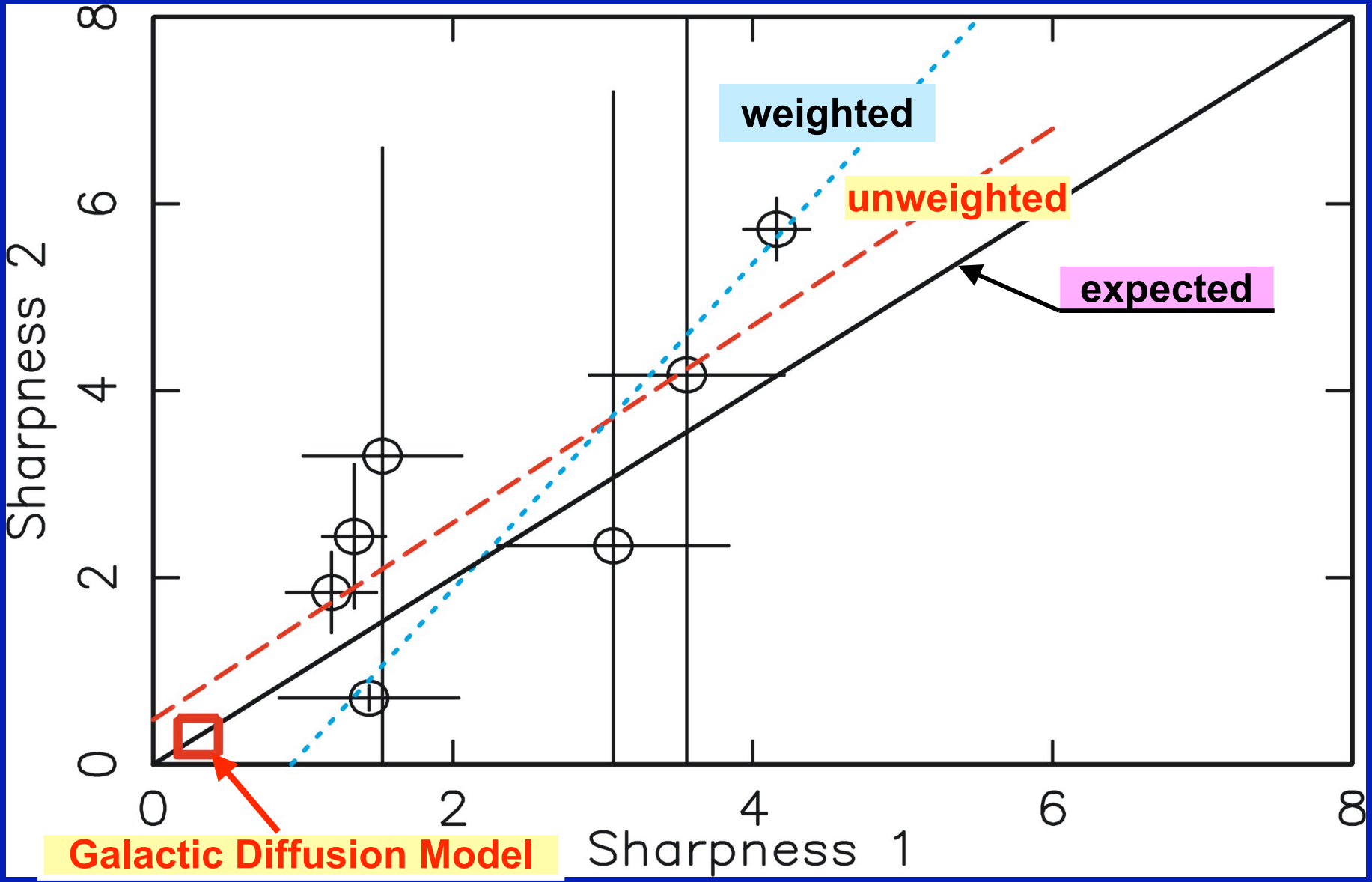
(Ter-Antonyan S.V., Haroyan L.S., 2000, hep-ex/0003006)

$$\frac{dI}{dE} = AE^{-\gamma}\left(1+\left(\frac{E}{E_k}\right)^{\delta}\right)^{\frac{\Delta\gamma}{\delta}}$$

δ

δ - sharpness parameter, S = ¼ δ Δγ ln10

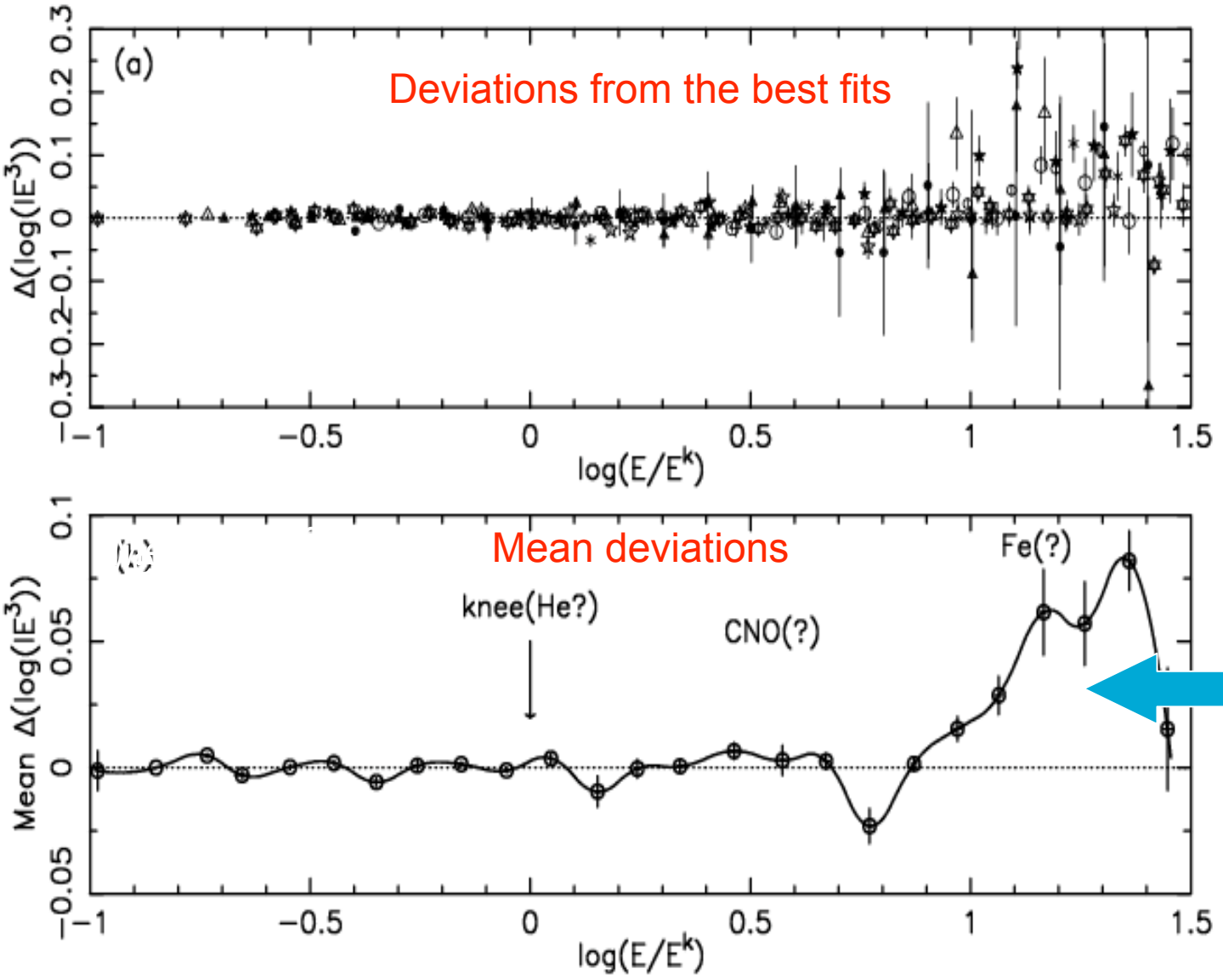
Sharpness in the new data



Conclusion I

All new energy spectra have the knee with the sharpness more than 1, which exceeds the sharpness of 0.3 expected for the Galactic Diffusion Model

Fine structure of the primary energy spectrum around the knee



'Iron peak' ?

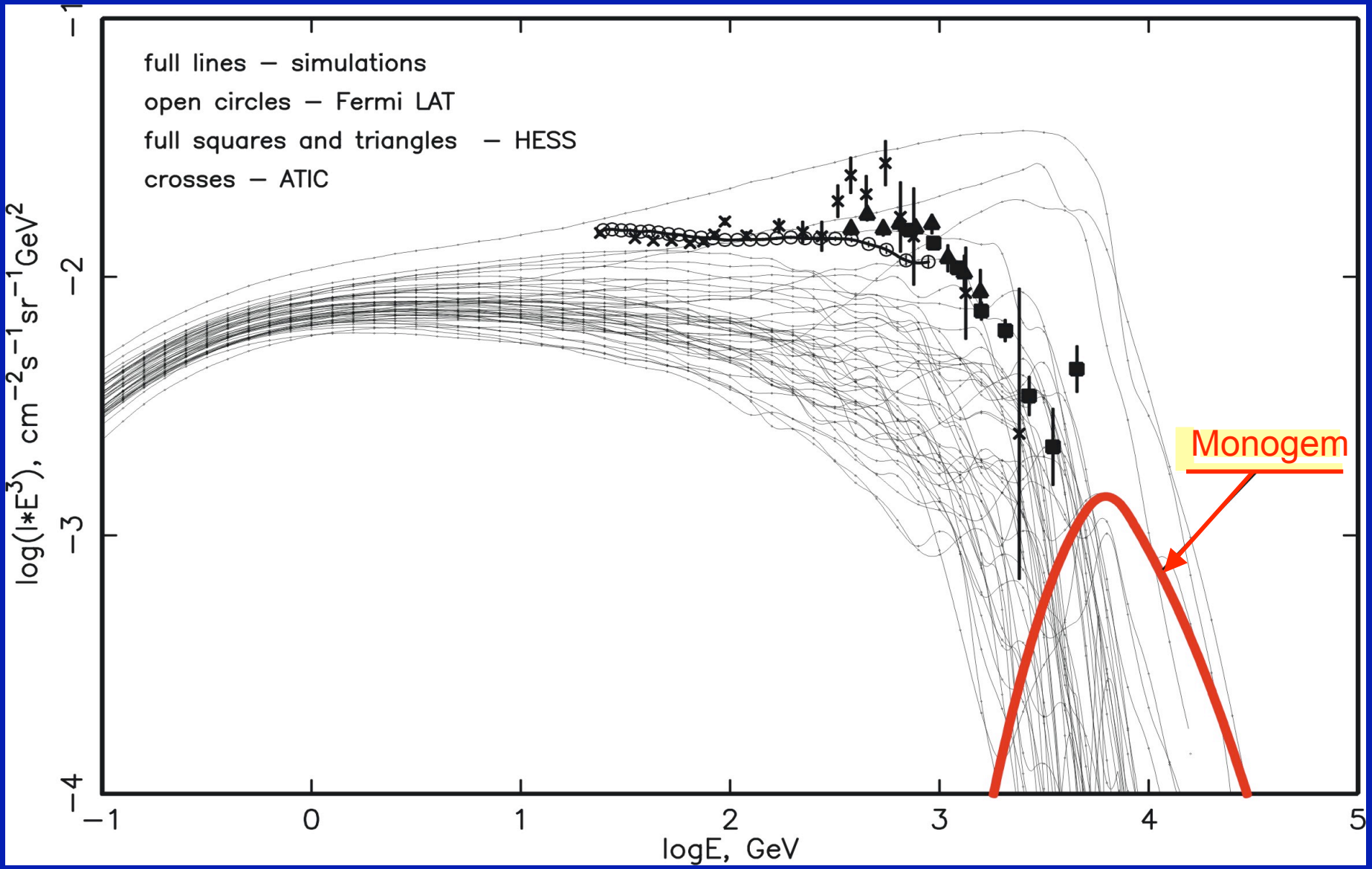
Conclusion II

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')

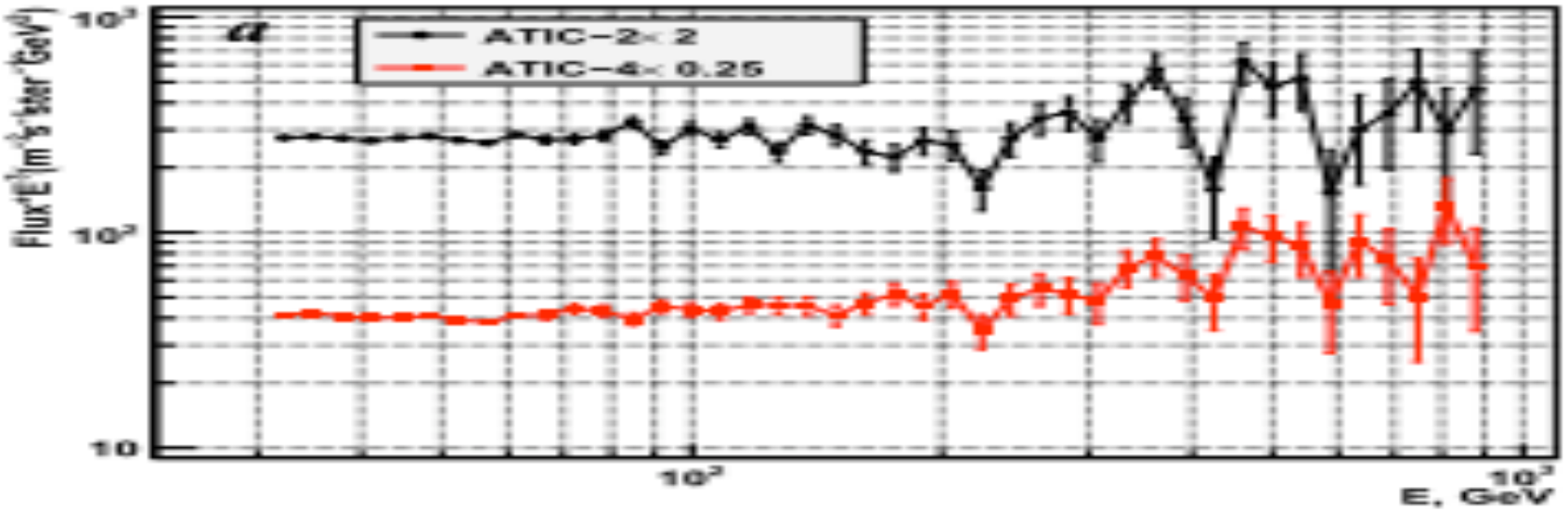
Indications from the e^-,e^+ spectra :

* PAMELA
* ATIC
* HESS
* Fermi LAT

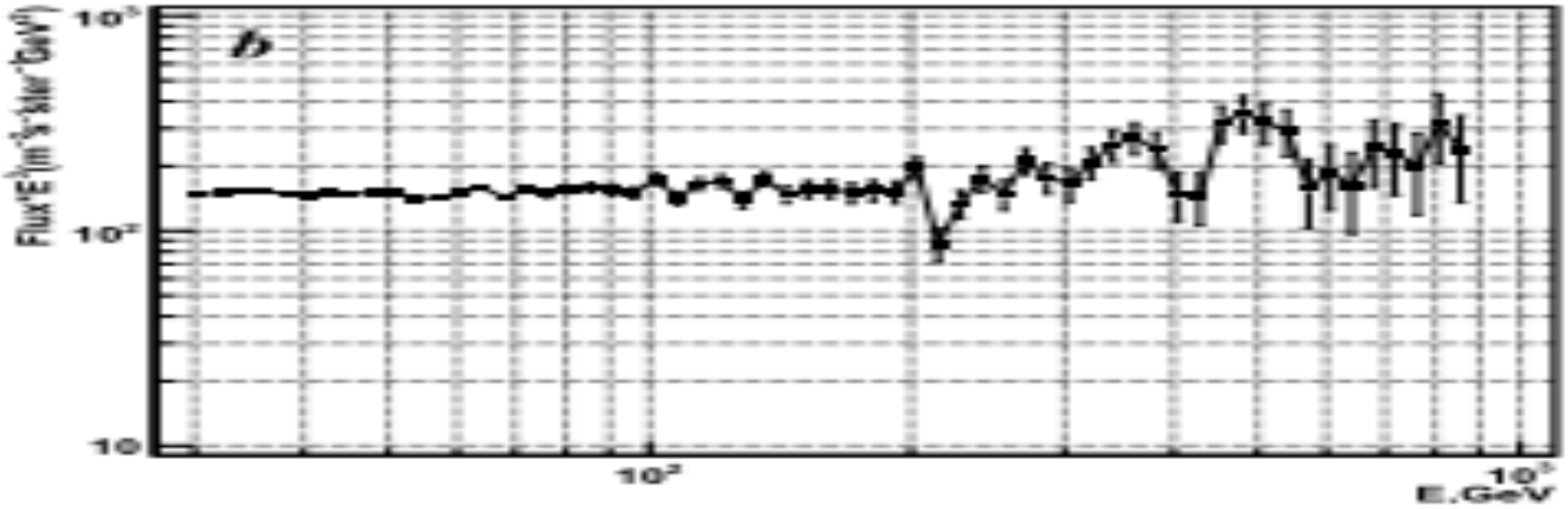
Primary electron energy spectrum



Fine structure of the e^+e^- spectrum in two ATIC flights (A.D.Panov et al.,31 RCRC, Moscow, July 2010)



Summed spectrum



Conclusion III

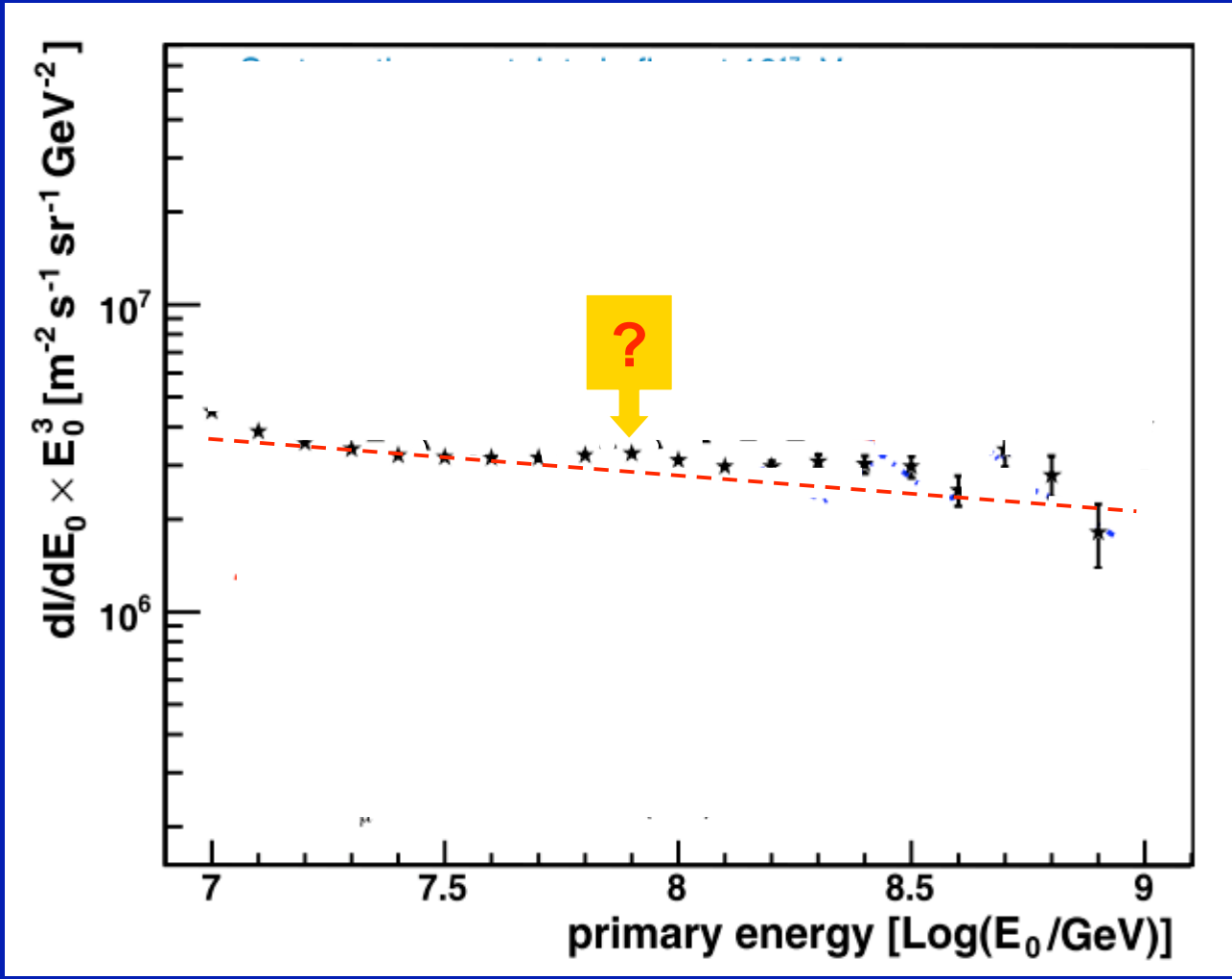
* Fine structure of the e^- spectrum can be expected above 100 GeV
* The 'bump' in the e^- spectrum can be due to the presence of the nearby and recent SNR ('Single Source')

General Conclusion

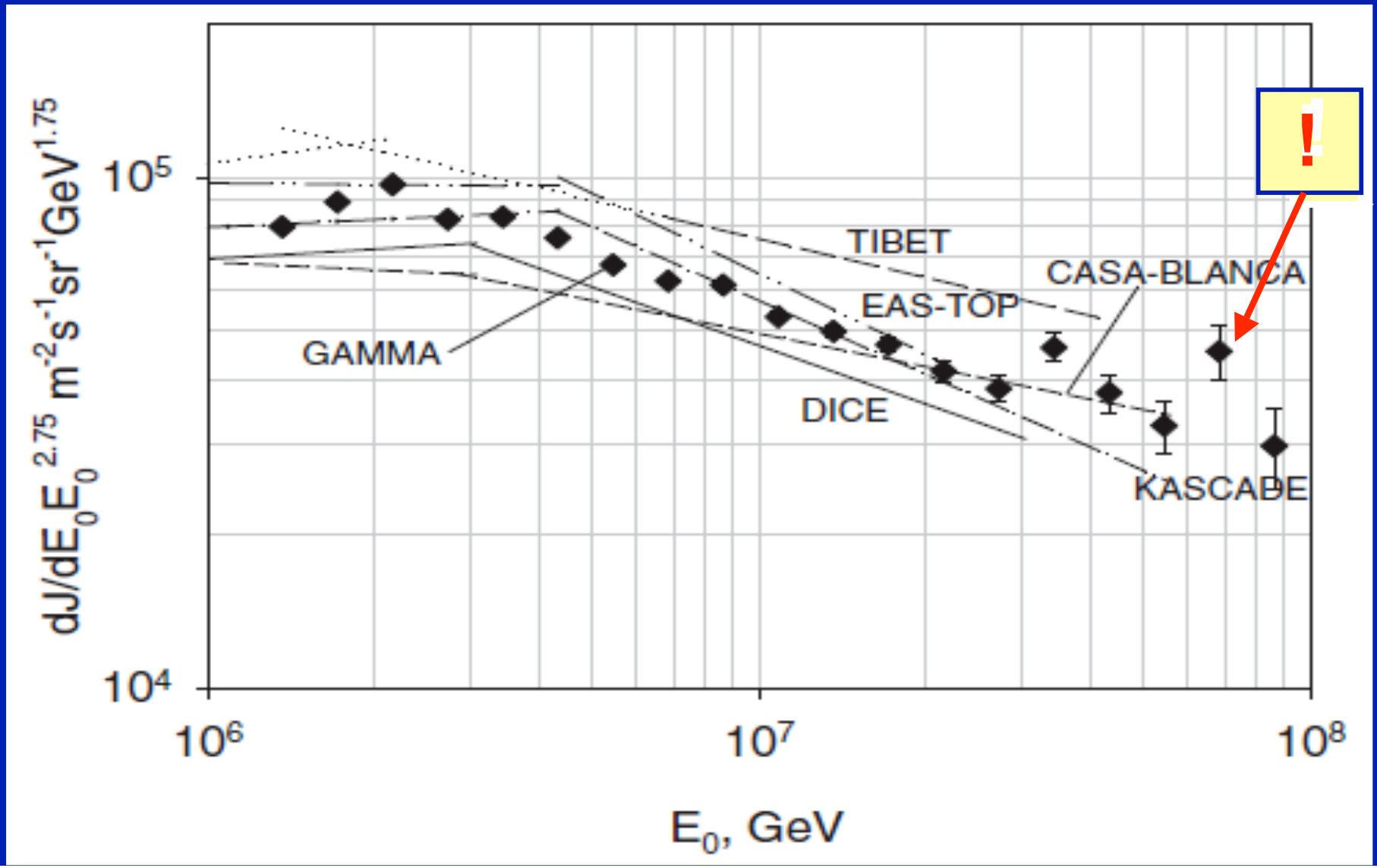
New data manifest substantial non-uniformity of the CR source distribution in space and time and the evidence in favour of the presence of a 'Single Source' is even stronger than before

Thank you for your attention

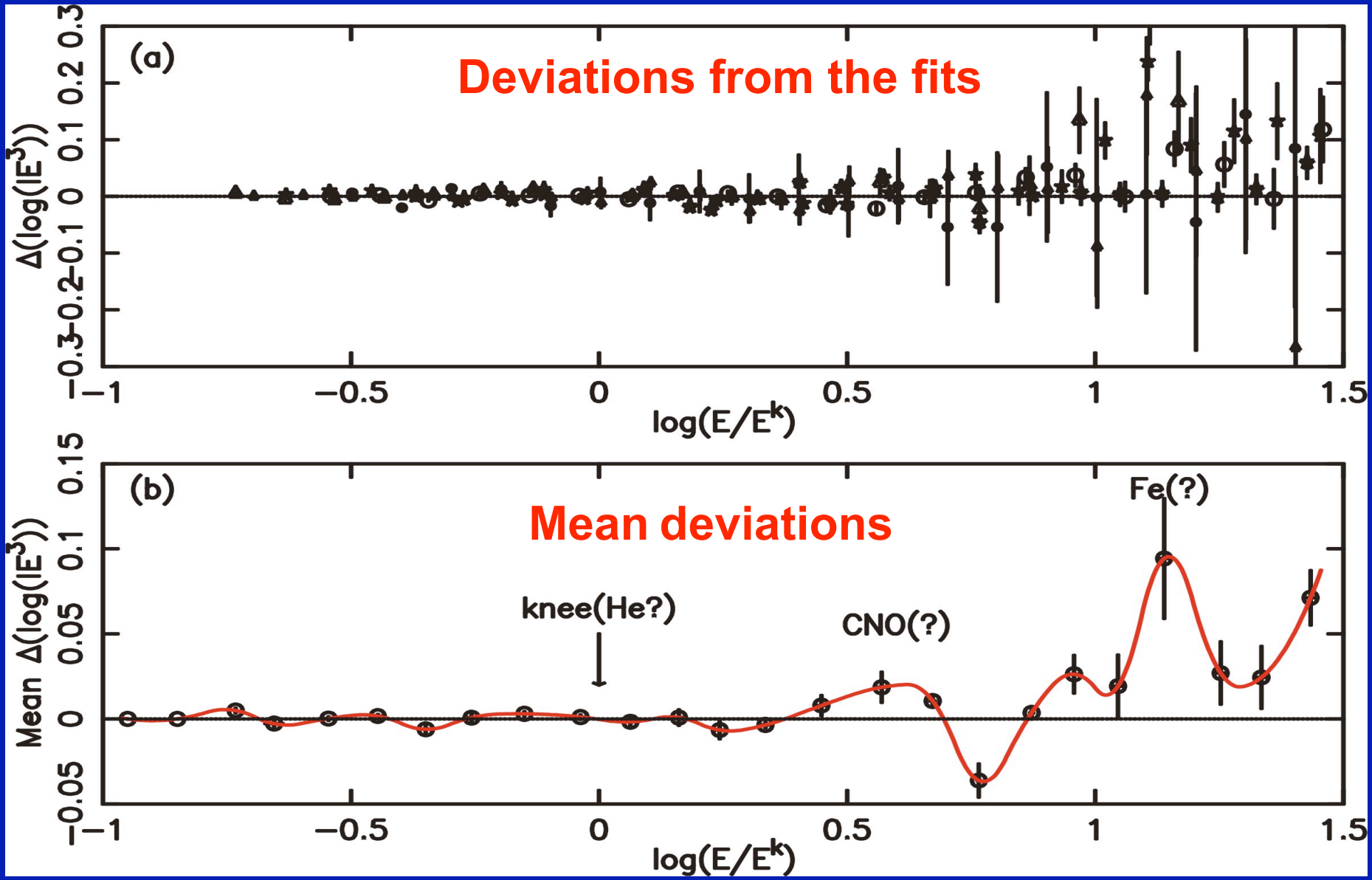
KASCADE-Grande, 2009, 31st ICRC, Lodz, Poland



GAMMA 2002 (e)


!
TIBET
CASA-BLANCA
EAS-TOP
GAMMA
DICE
KASCADE
10^5
10^4
10^6
10^7
10^8
$dJ/dE_0 E_0^{2.75}$ $m^{-2}s^{-1}sr^{-1}GeV^{1.75}$
E_0, GeV

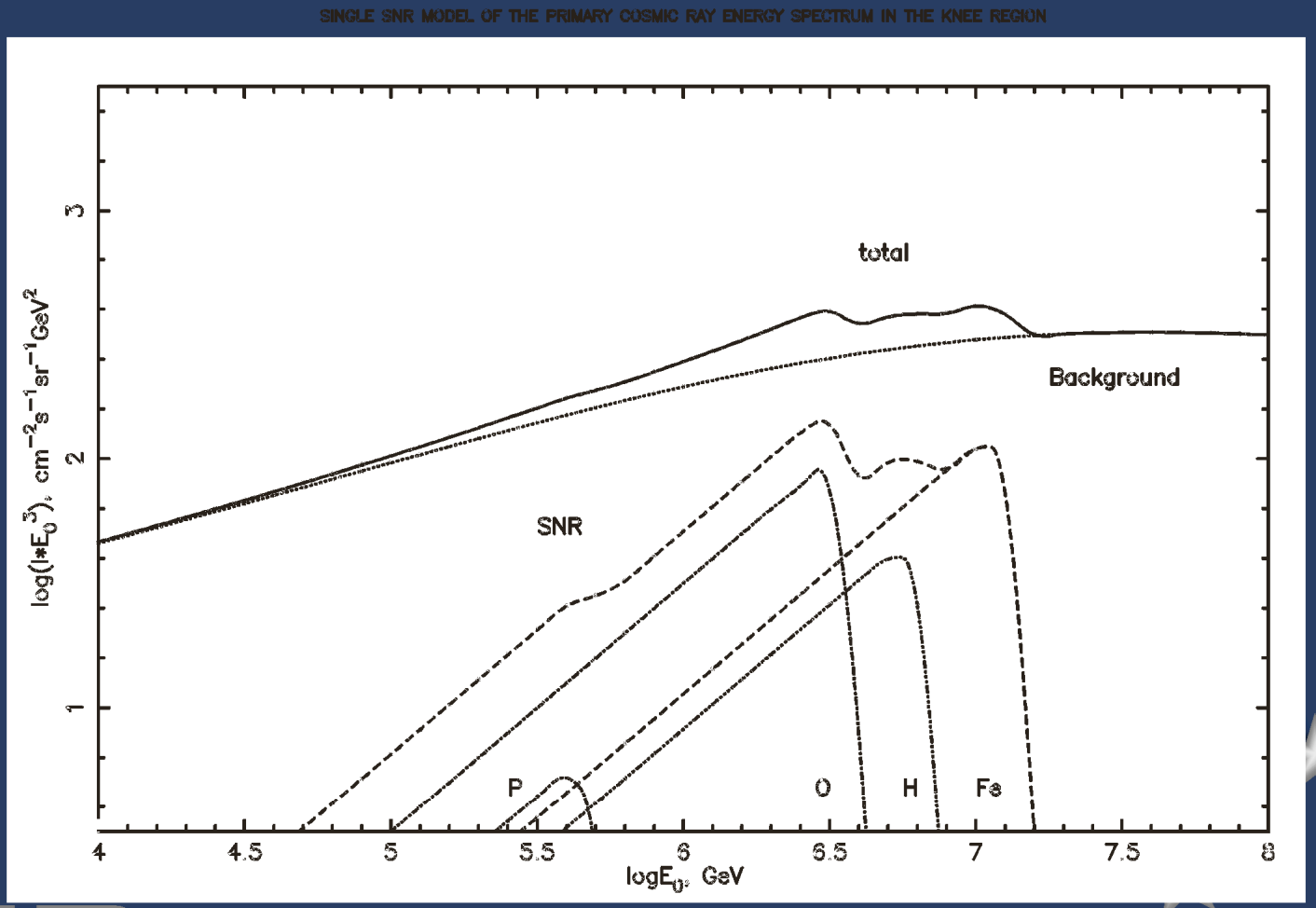
Fine structure of the primary energy spectrum around the knee



“… The only malady I could conclude
I had not was housemaid knee.
I felt rather hurt about this at first;
It seemed somehow to be a sort of slight.
Why hadn’t I got housemaid knee ?
Why this invidious reservation ?…”

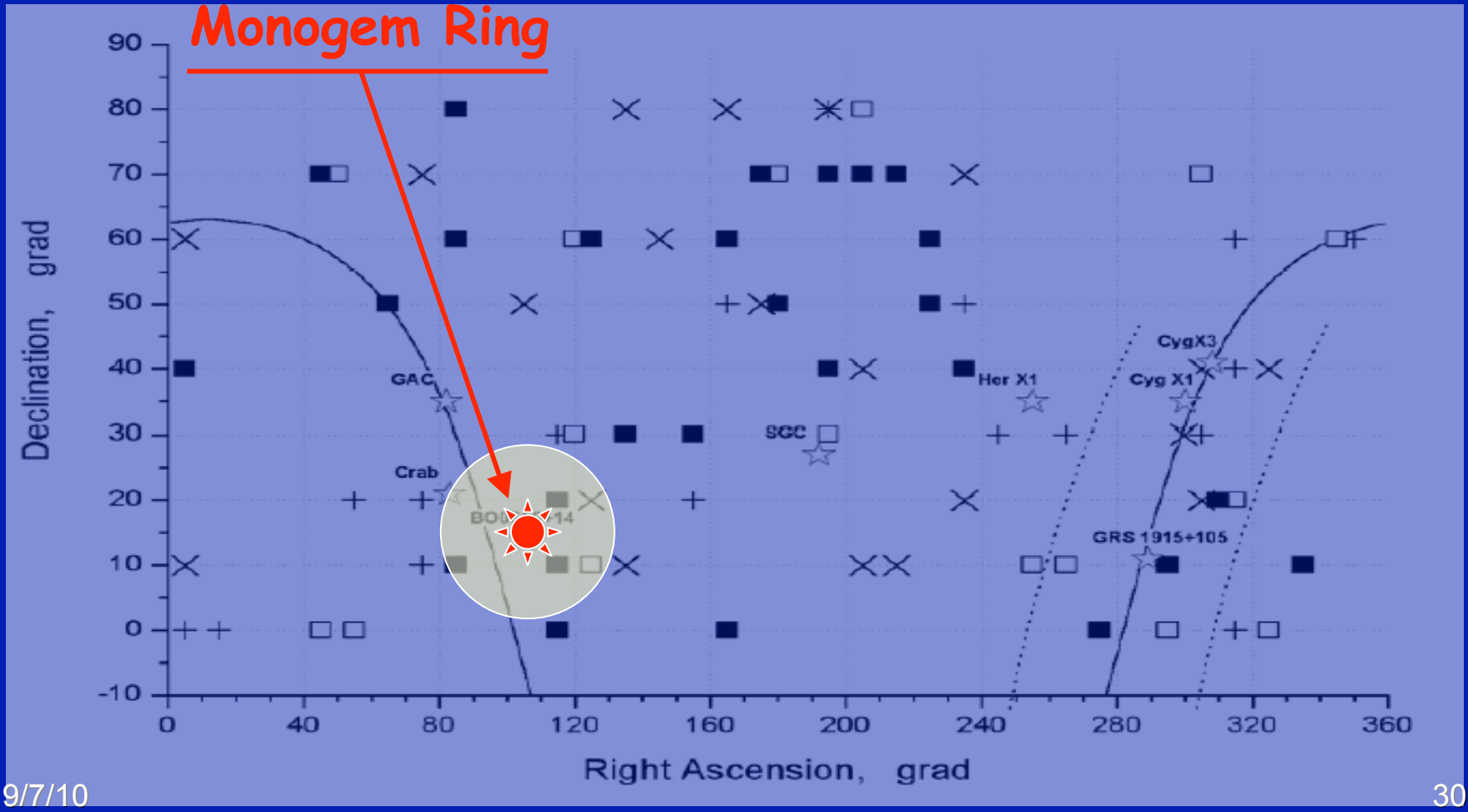
Jerome K. Jerome “Three men in a boat.
To say nothing of the dog”

Single Source Model of the Knee



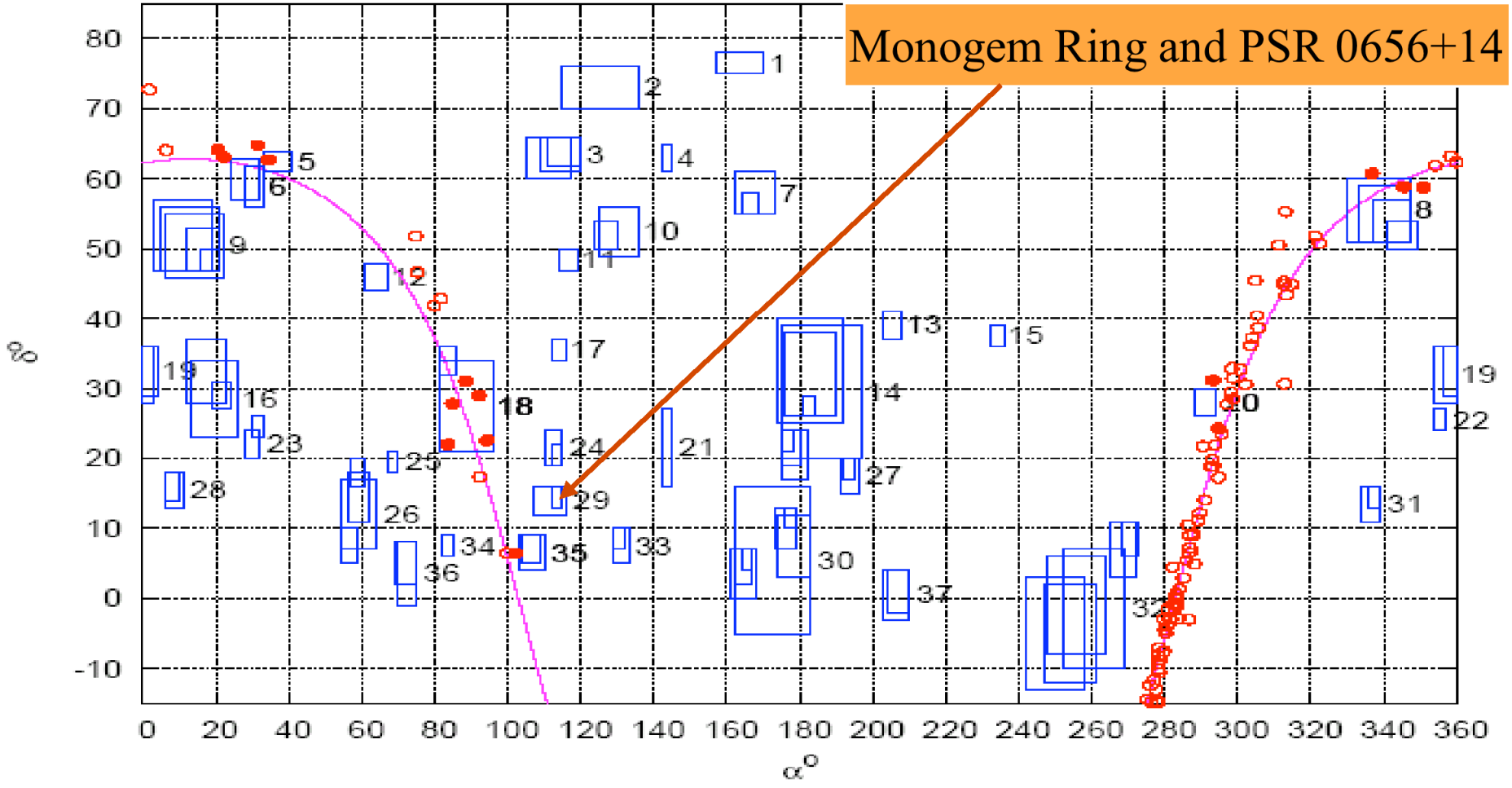
EAS intensity excess at PeV energies

G.Benko et al., astro-ph/0502065,
Изв.РАН, сер.физ.,2004, 68, 1599;

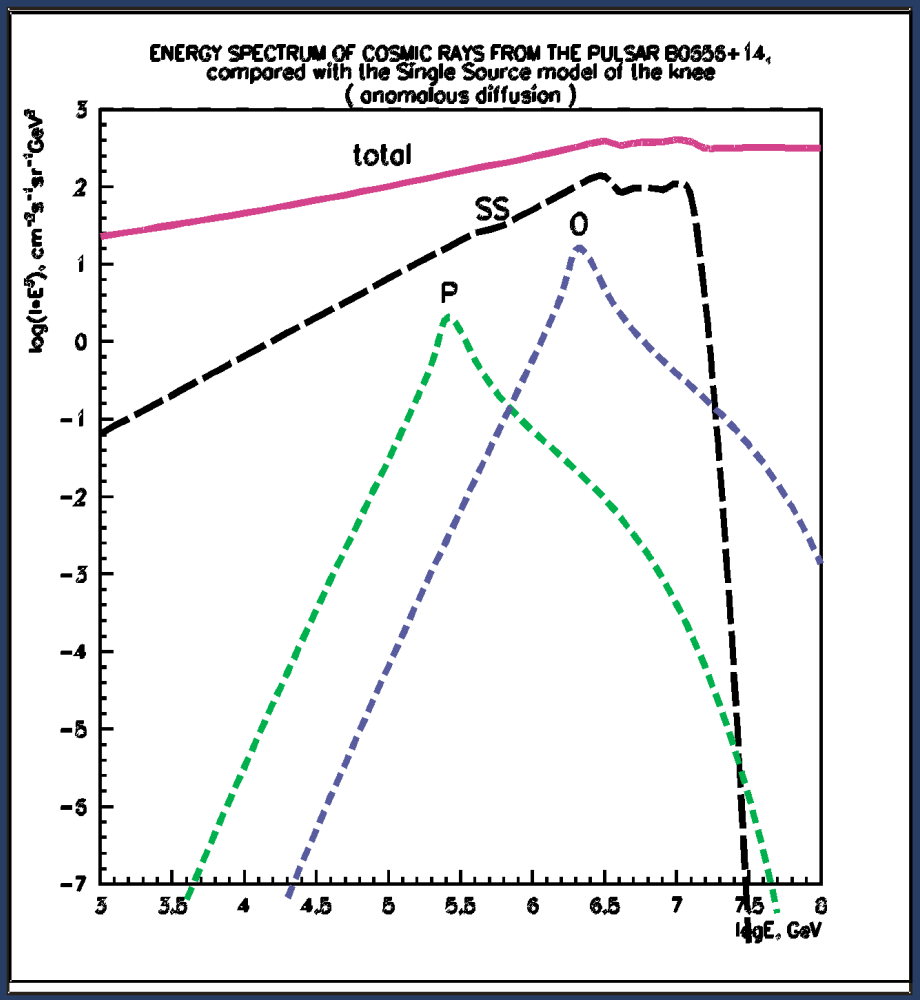


EAS intensity excess at PeV energies

Kulikov G.V., Zotov M.Yu., astro-ph/0407138;
Èçâ.DÀÍ , ñåð.ô èç.,2004, 68, 1602



Contribution of the isolated PSR B0656+14 to CR



P = 0.3848 sec

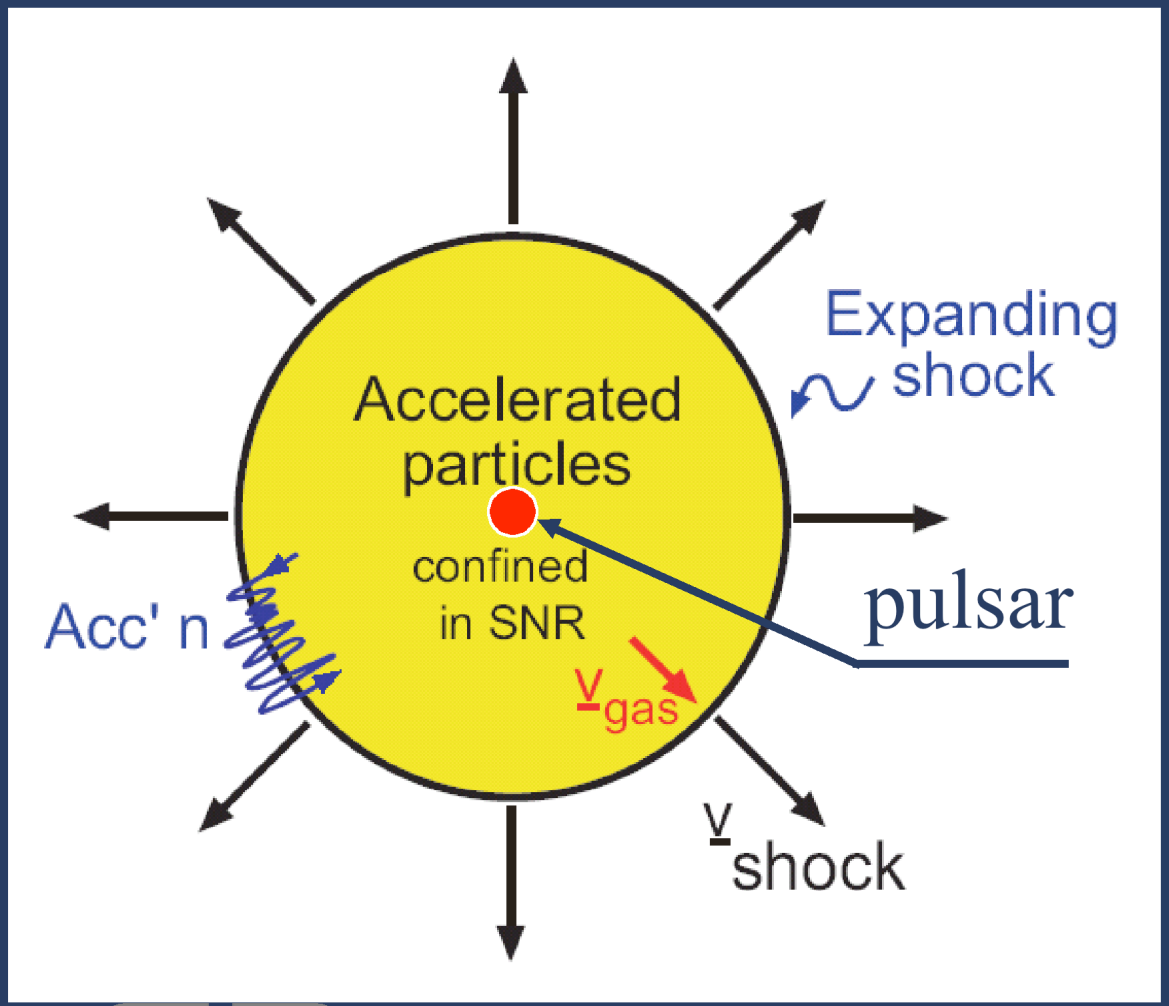
$dP/dt = 5.5032*10^{-14}$

* The rigidity peak is at 0. 25 PV ;

* Pulsar can contribute to CR intensity at the knee if it emits Oxygen ;

* Pulsar's contribution to the Single Source CR cannot exceed 15%

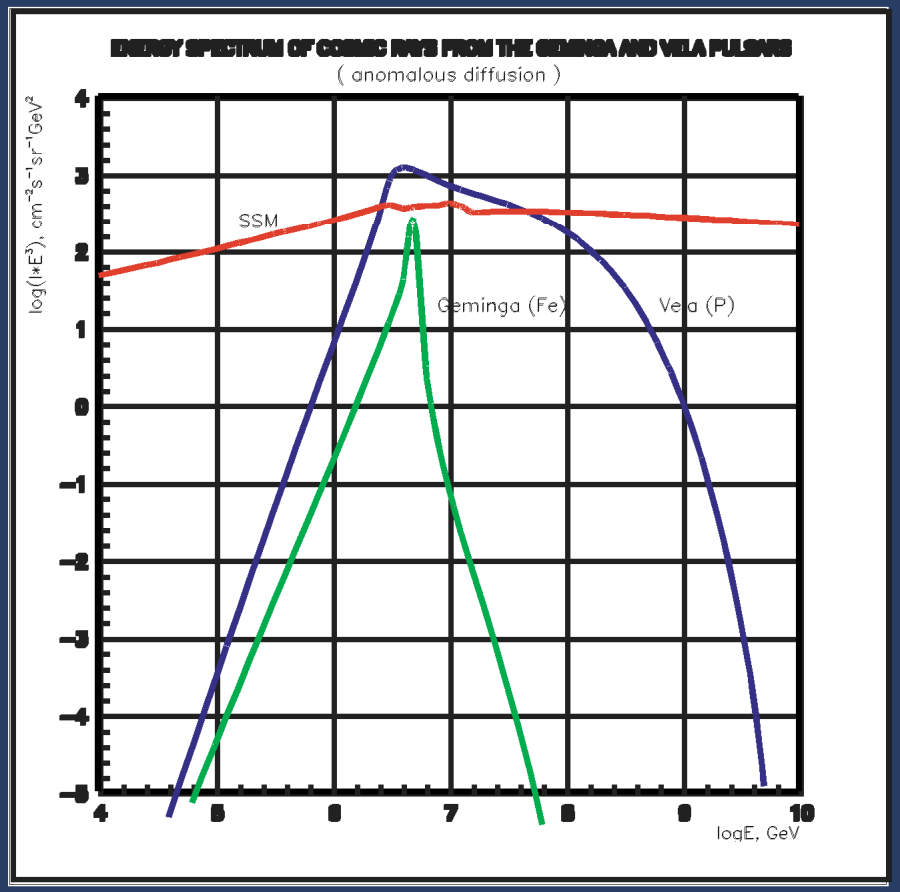
Confinement inside the SNR



If the particles accelerated by the SN are confined within the shock, the particles from the pulsar inside the SNR should be confined too.

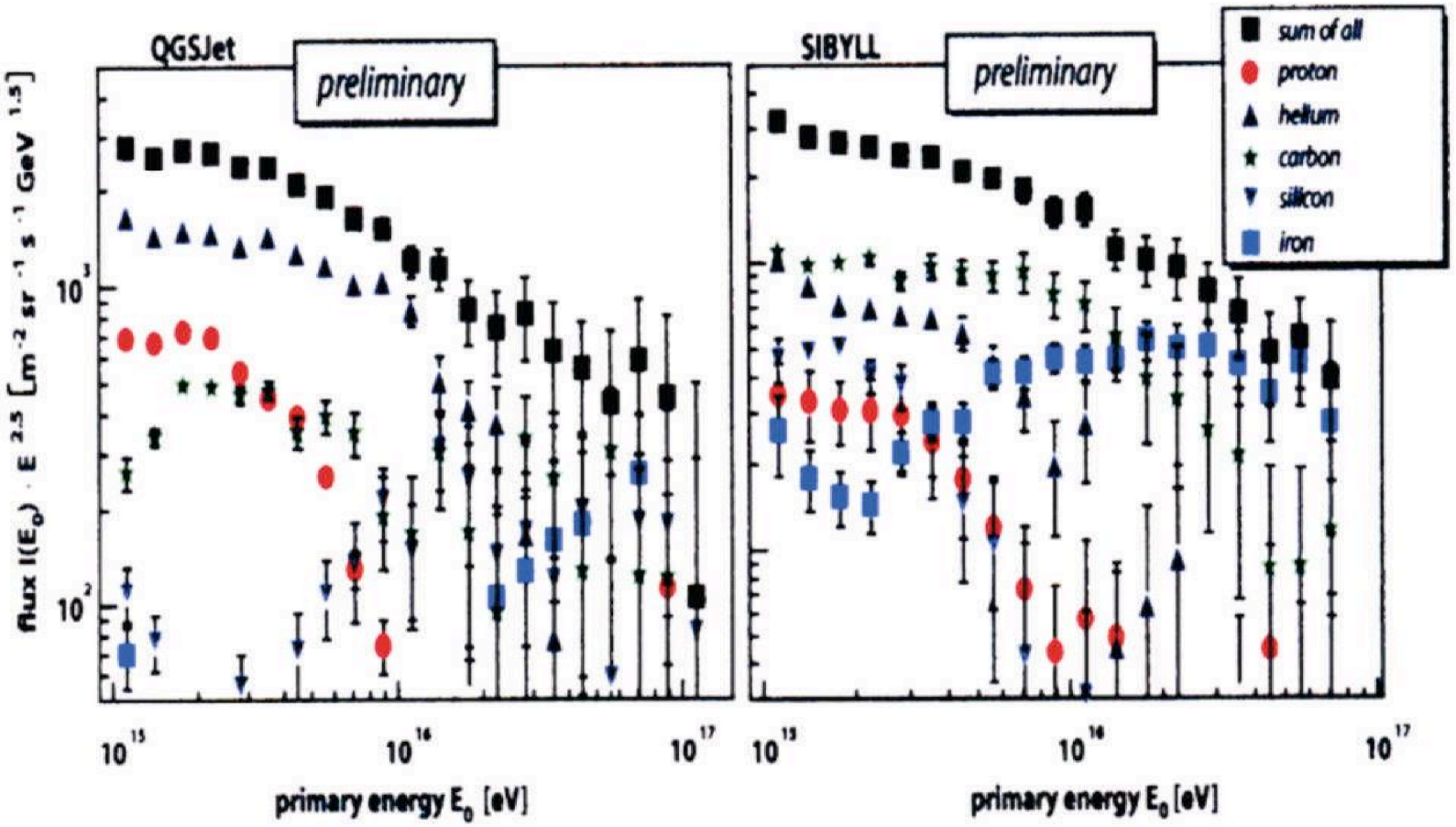
$E_{max} \sim 300 * 3_{\mu G} * 200_{pc} \sim$ **0.5 EeV**

Possible contribution of other pulsars to the knee

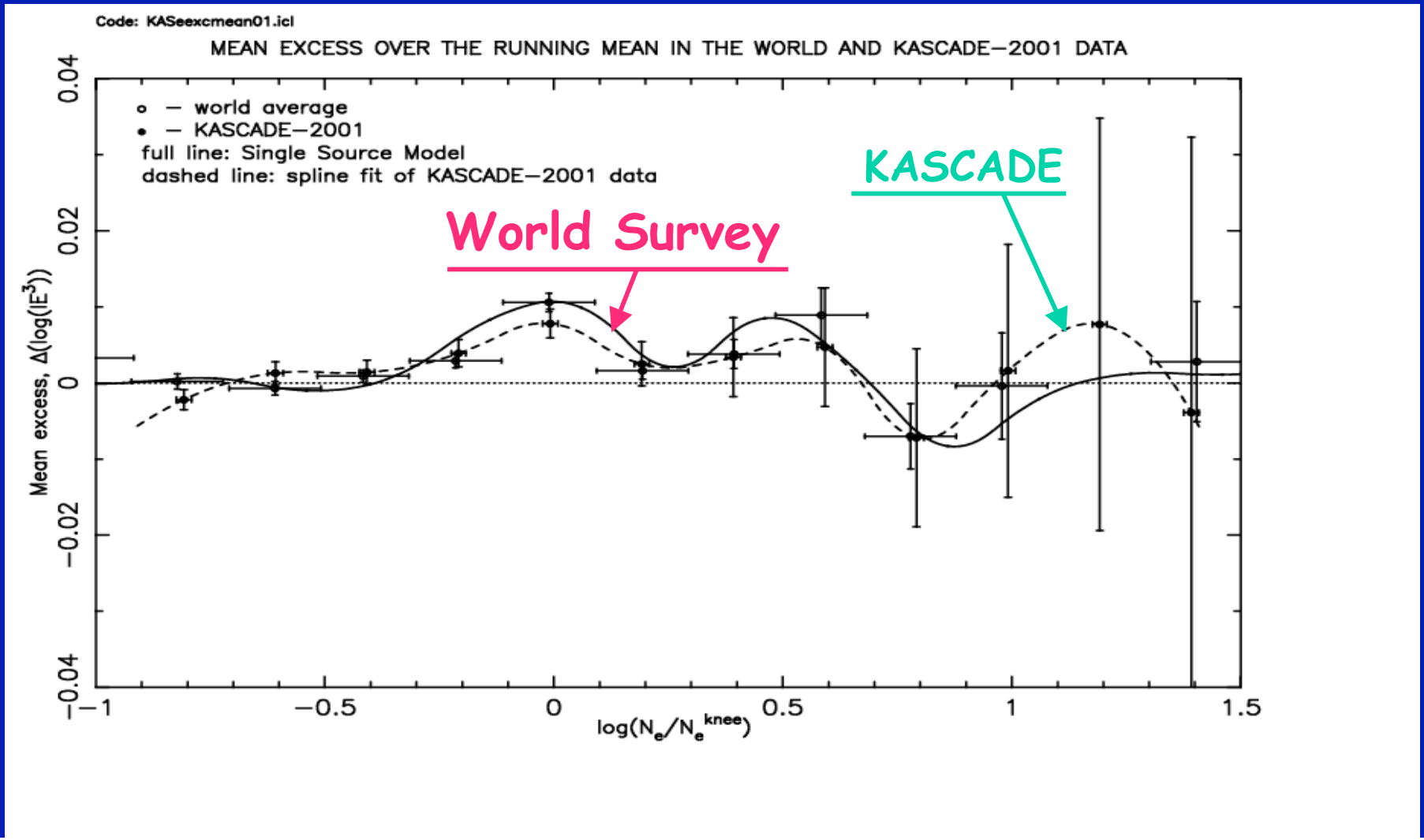


- **Geminga** could contribute only if it emits Fe nuclei ; (there is no room for the second Fe peak)
- **Vela** could contribute even if it emits P, but it is too young (~10ky) and CR are confined

Cosmic ray energy spectrum unfolded with different interaction models

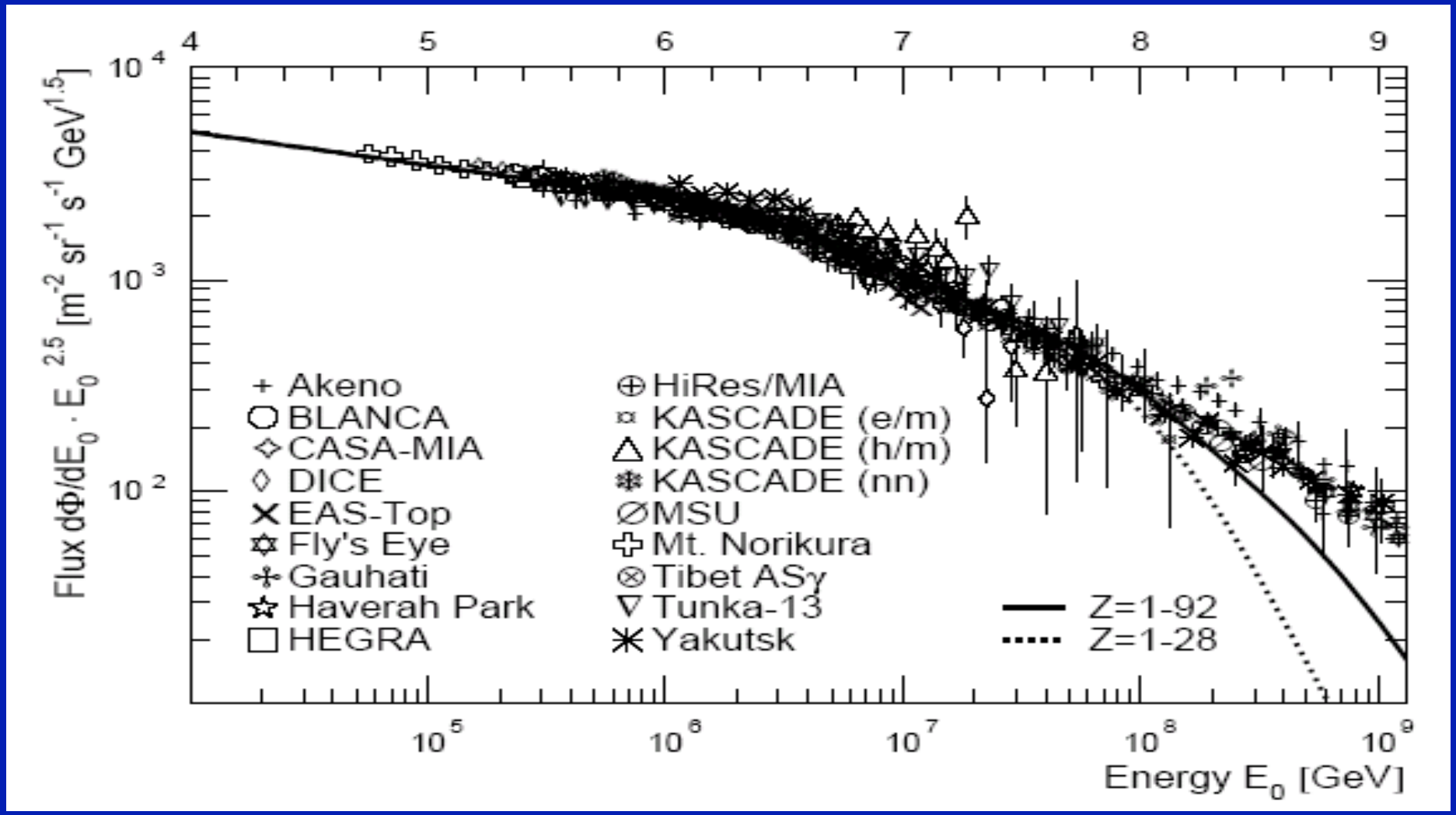


Comparison of KASCADE-2001 and World Average Data



Compilation of the primary CR energy spectra

J.R.Hoerandel, astro-ph/0407554



Direct measurements of the primary CR mass composition

(ATIC-2, Zatsepin V.I. et al., 2004, 28th RCRC; Изв.РАН, сер.физ., 2004, 68, 1593)