RAPPORTEUR TALK
SESSION OG-1

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Firenze, ITALY

ICRC'07
Mérida, México

The OG-1 SESSION in numbers

- **138 presentations (66 oral)**
- **Of the 66 oral presentations, 37 are on experimental results and 29 on theoretical/phenomenological issues**

NOT A CHANCE OF SUMMARIZING THE WHOLE BUNCH OF CONTRIBUTIONS…

IT HELPS TO REMEMBER WHAT THE OG SESSION IS ABOUT:

OG: <u>Cosmic Ray Origin and Galactic Phenomena</u>

OG1: Direct Measurements and Origin of Cosmic Rays

OG 1.1 Cosmic rays observed with balloons and satellites
OG 1.2 Cosmic ray source composition
OG 1.3 Cosmic ray propagation
OG 1.4 Acceleration of cosmic rays
OG 1.5 Instrumentation and new projects

THE EXPERIMENTAL ZOO

BALLOONS	SATELLITES	GROUND ARRAYS
❑ CREAM	❑ PAMELA	❑ HESS
❑ ATIC		❑ Tibet-Array
❑ Tracer		
❑ TIGER		
❑ BESS-Polar		
❑ PPB-BETS		

Cosmic Ray Energetics And Mass

MANY CONTRIBUTIONS:

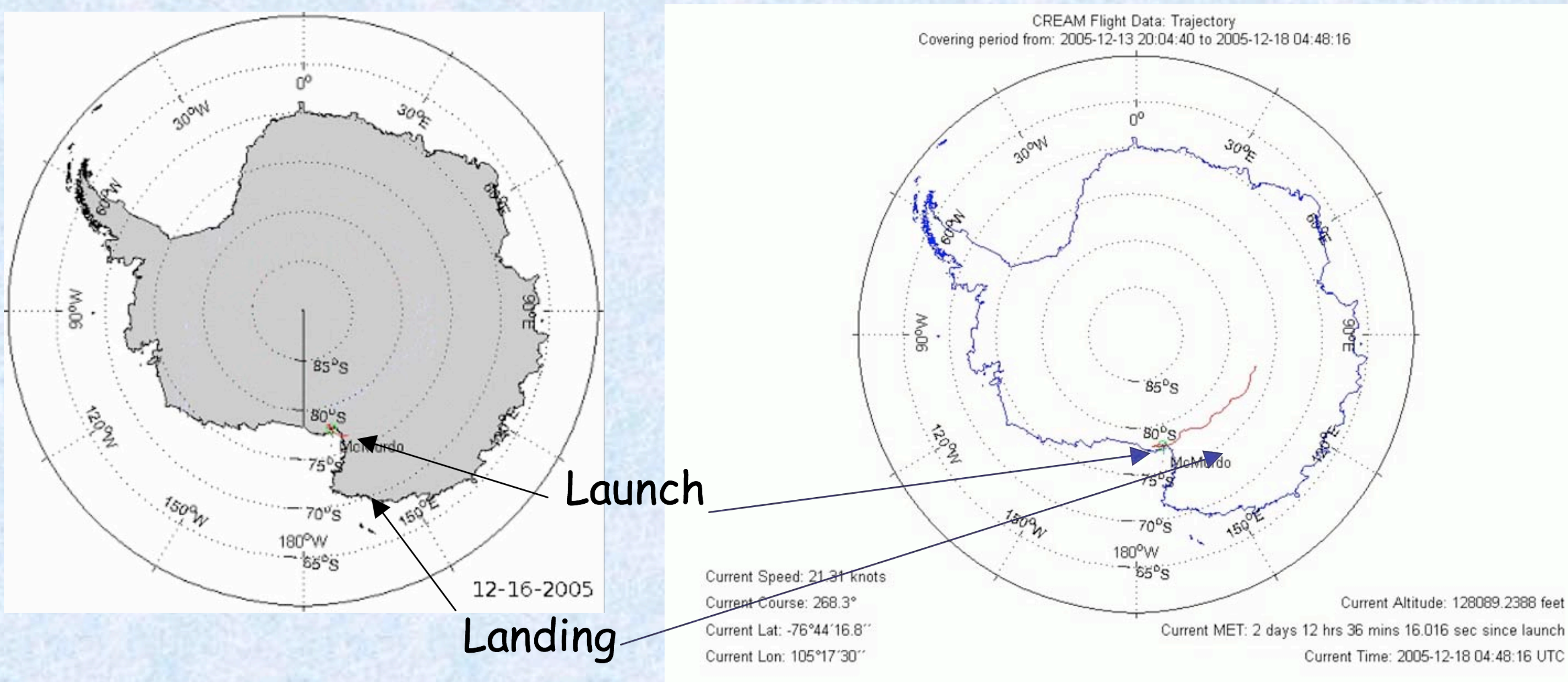
OG1055
OG778
OG301
OG677 (overview)
OG590
...

70 days of flight from 2 launches

Seo et al., Proc. 29th ICRC, Pune, 10, 185-198, 2005; Seo et al. COSPAR 2006

CREAM-I
12/16/04 – 1/27/05
Record breaking 42 days

CREAM-II
12/16/05-1/13/06
28 days



SCOPE: Accurate measurement of the spectra and Abundances of elements in cosmic rays

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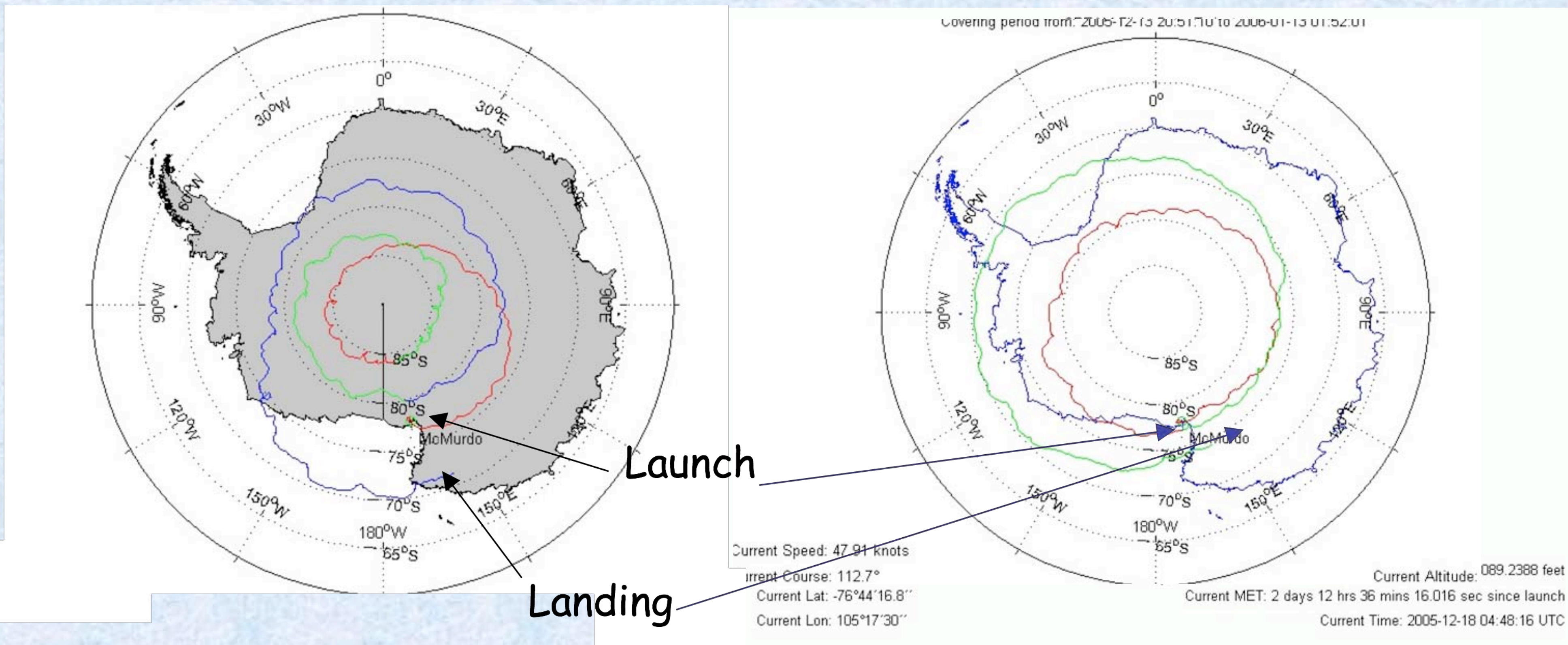


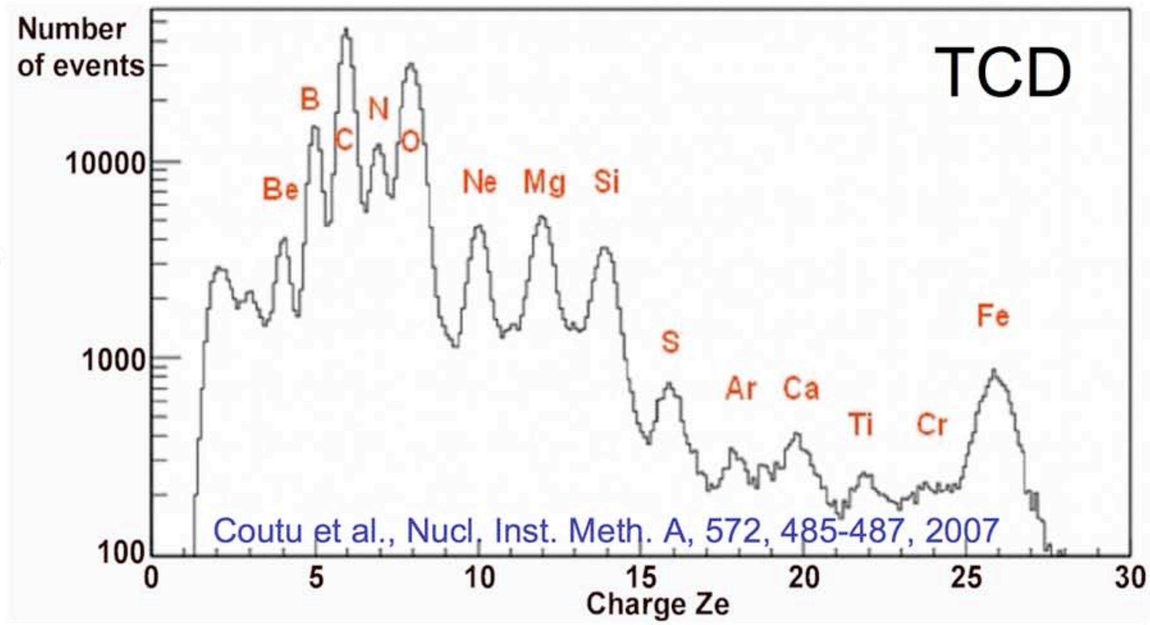
SCOPE: Accurate measurement of the spectra and Abundances of elements in cosmic rays

Individual elements with excellent charge resolution

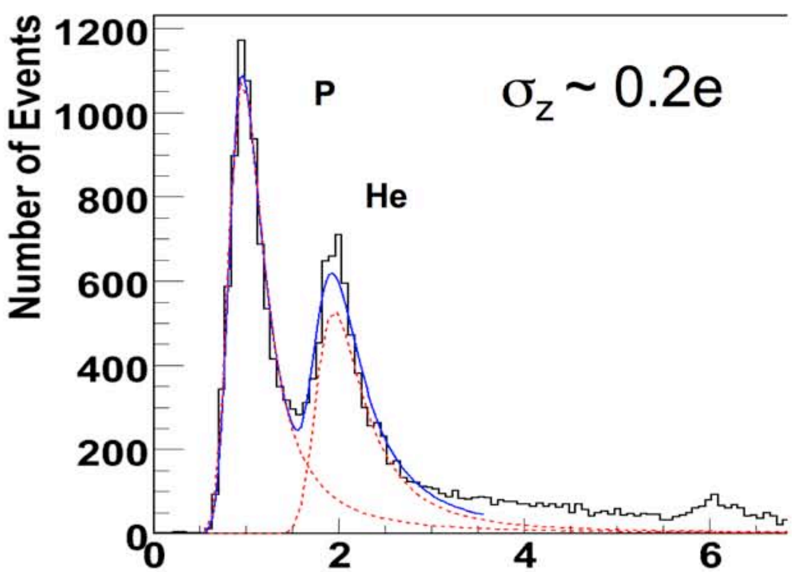
TCD: Timing Charge Detector

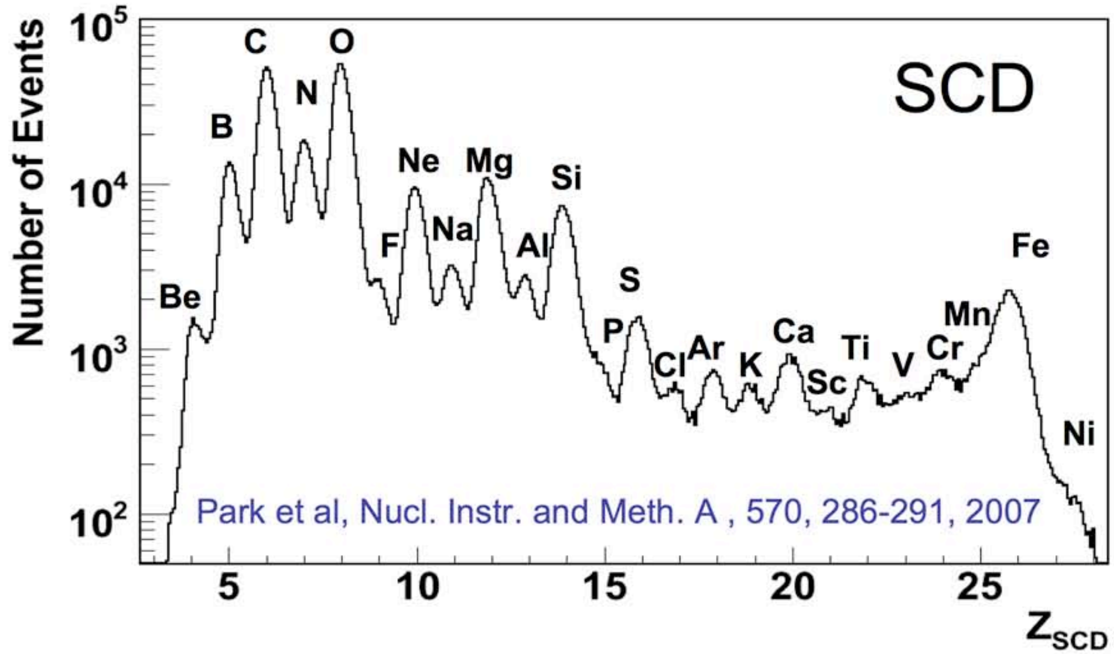
SCD: Silicon Charge Detector

Redundant measurement with TRD and Calorimeter



SCD charge distr. 1-10TeV

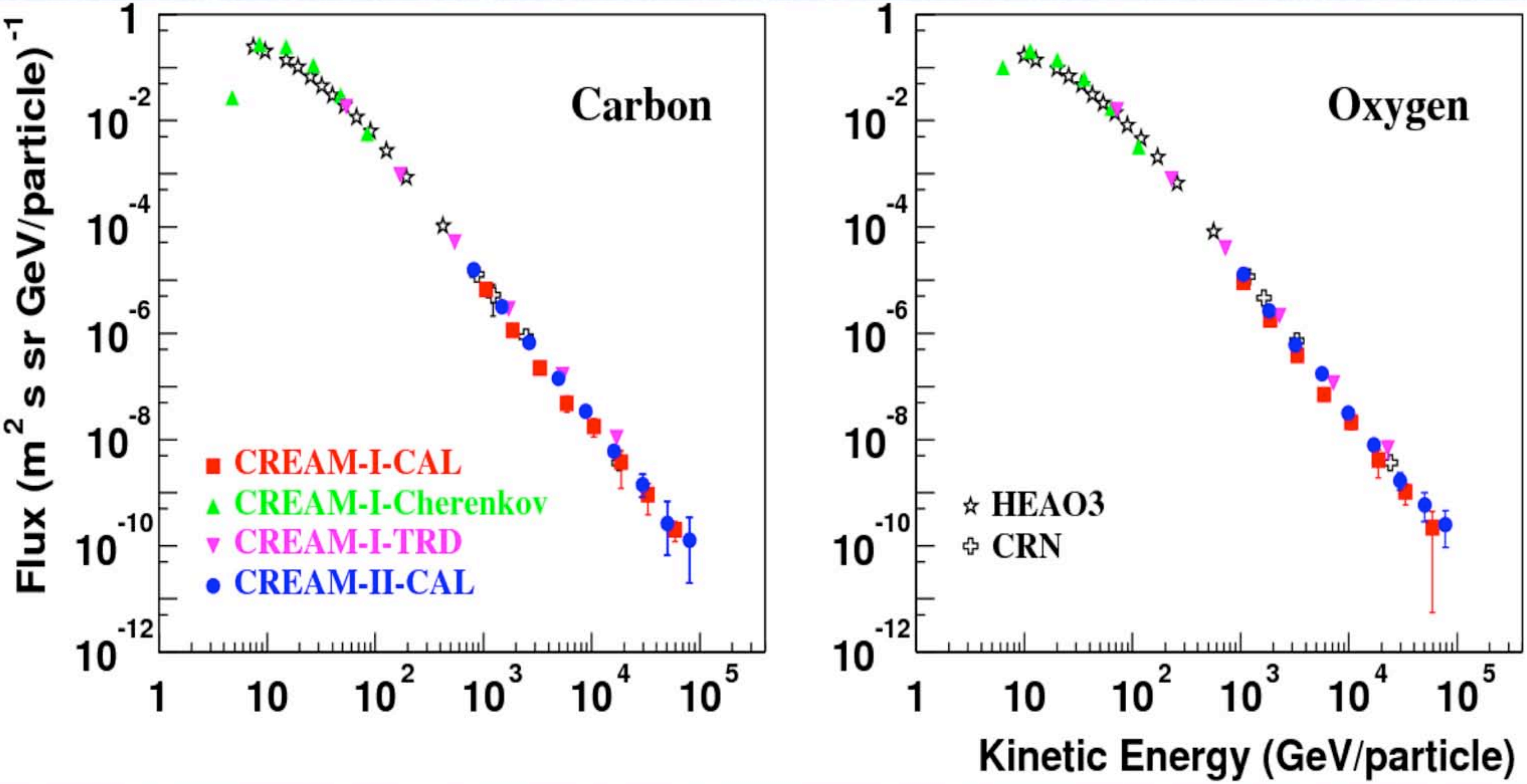




C & O spectra from CREAM

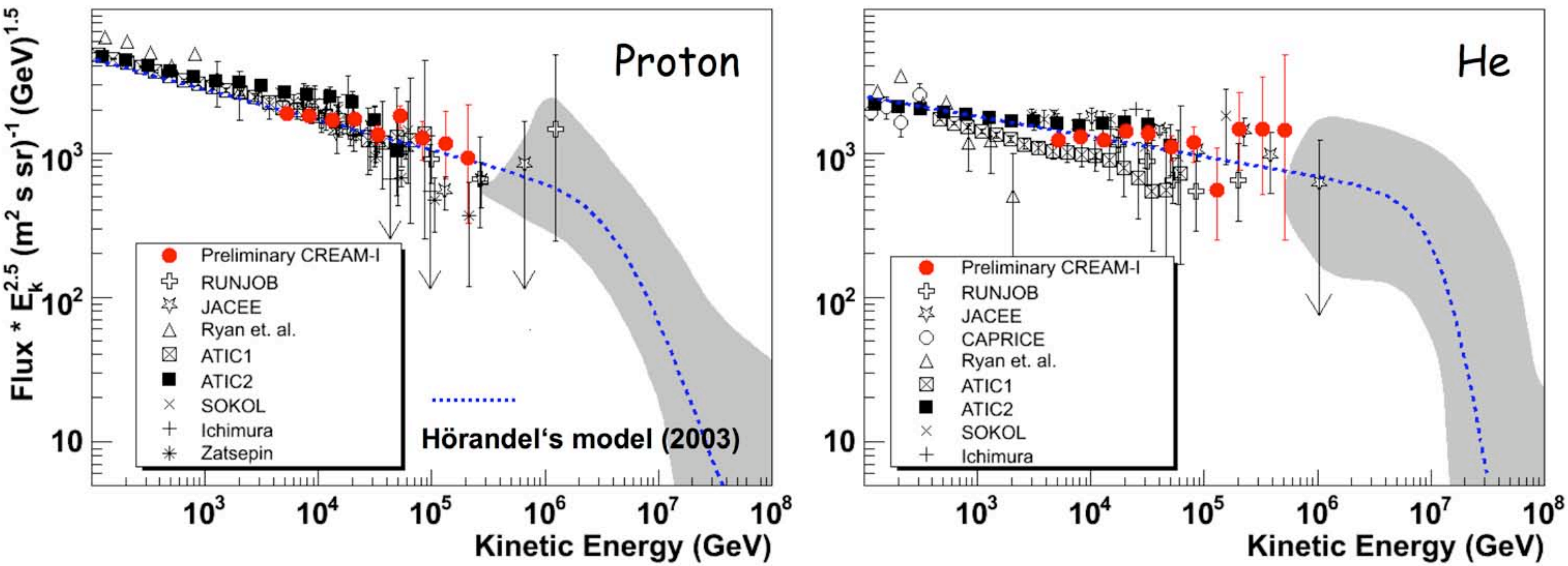
Wakely et al, OG1.3 oral; Zei et al. OG1.1 oral; Ahn et al. OG1.1 oral

- CREAM results span ~ 4 decades in energy: ~ 10 GeV to ~ 100 TeV
- Different techniques give consistent spectra



Approaching the "knee"

Yoon et al. OG1.1 oral; Seo et al. Proc. Int. Workshop on CRs and HE Universe, (Tokyo), in press, 2007



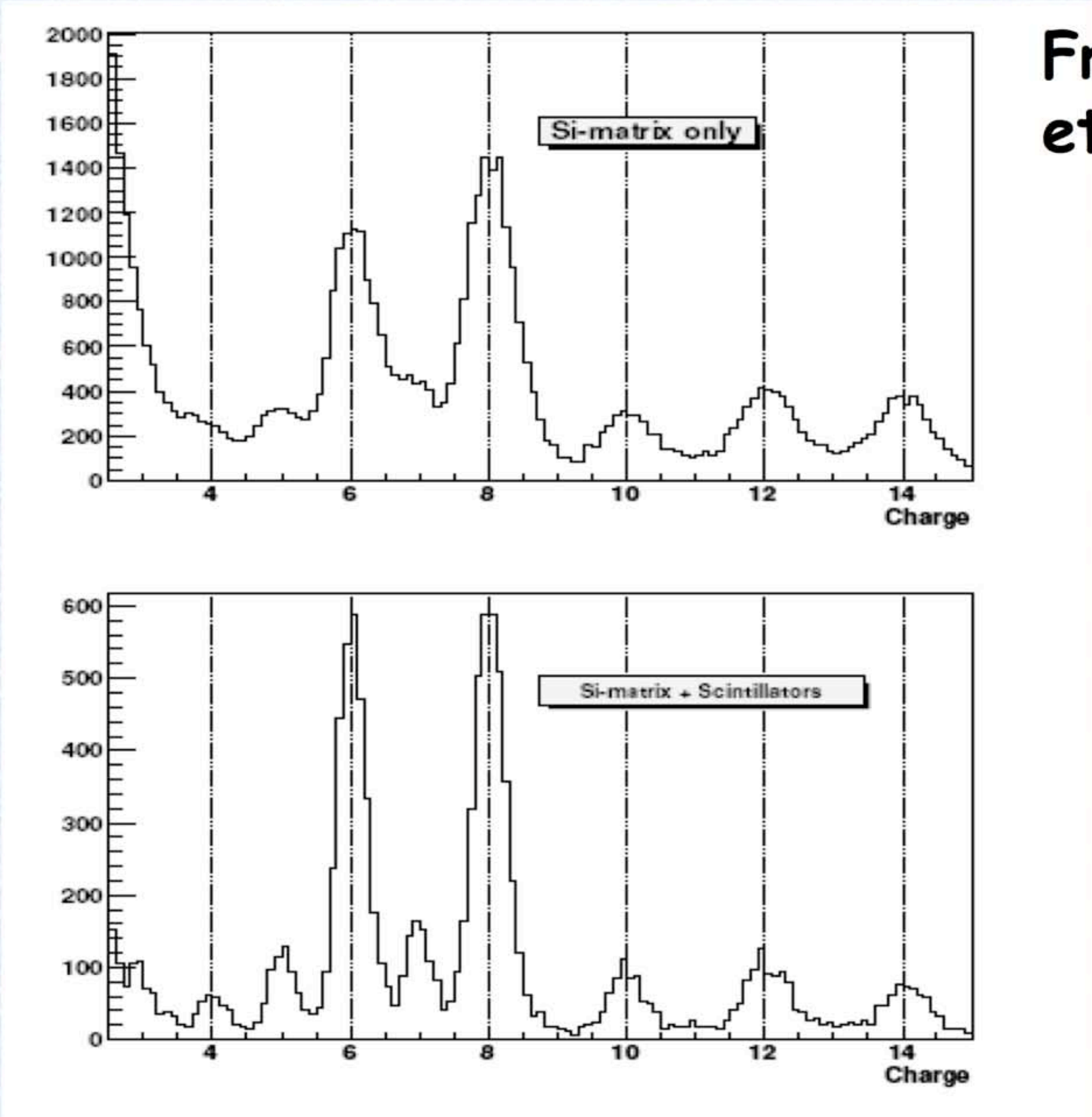
- The proton spectrum follows a power law with little change up to ~100TeV.
- The He spectrum seems harder than the proton spectrum.
  - He/p ratio is about a factor of 2 higher at ~10TeV/n than 10-100 GeV/n
- Future flights will extend the CREAM energy reach to higher energies

ATIC

OG18
OG1129

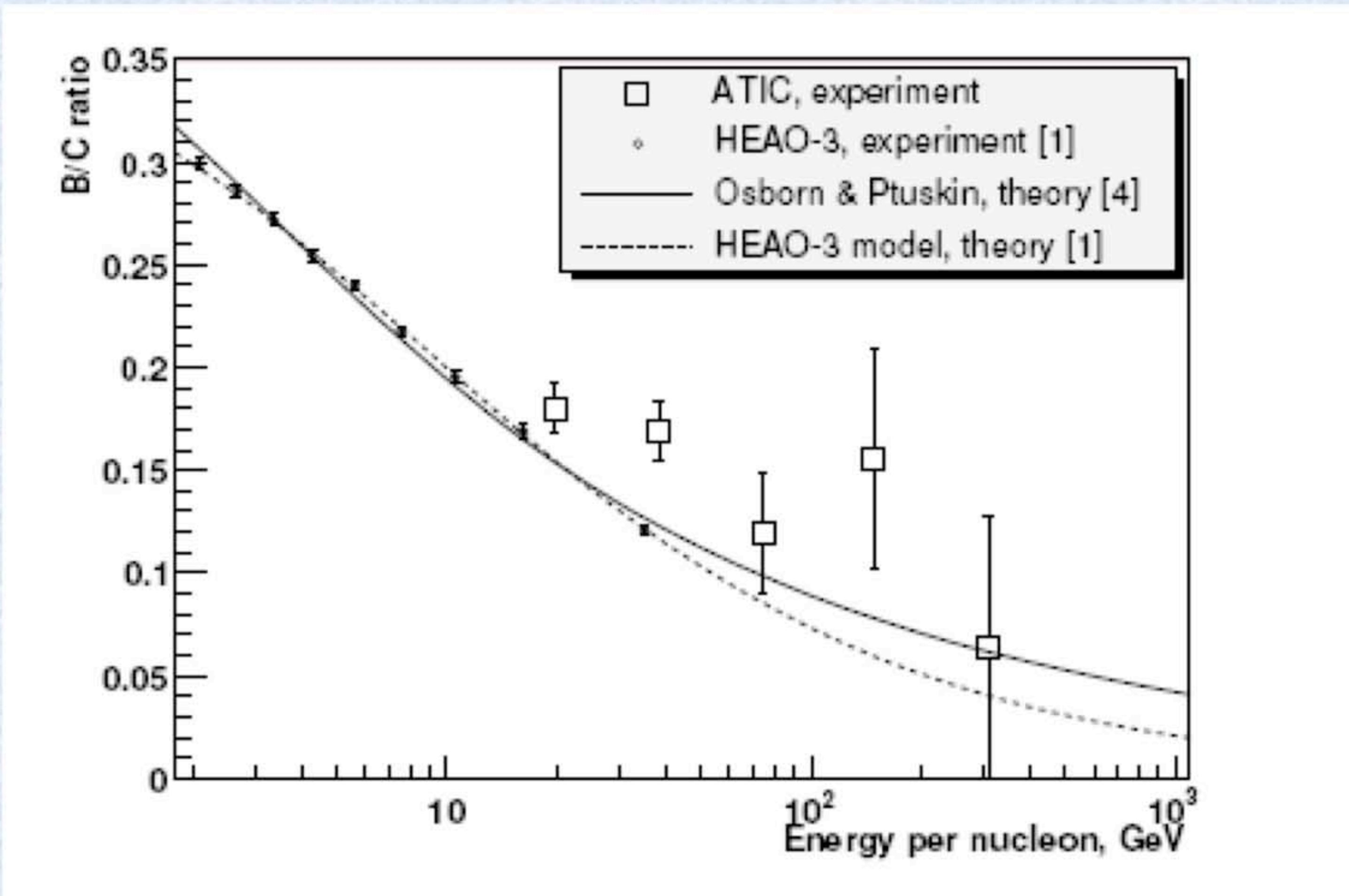
The ATIC experiment is a balloon-borne experiment
That measures the energy spectra of elements from
H to Fe in primary CR's from 100 GeV to 100 TeV

Improved charge spectrum



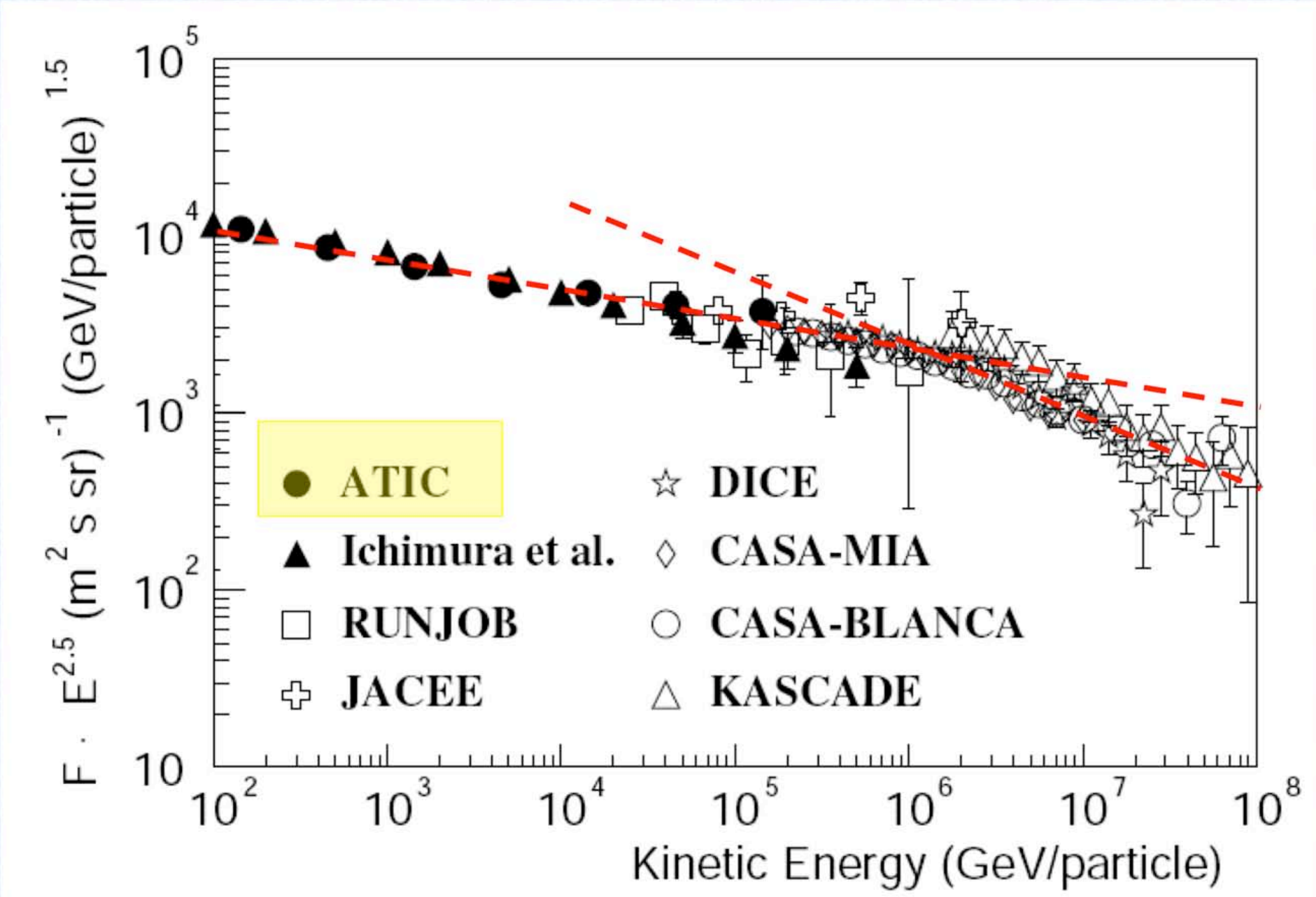
From Panov et al…

B/C ratio



B/C ratio
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10
10^2
10^3
Energy per nucleon, GeV
ATIC, experiment
HEAO-3, experiment [1]
Osborn & Ptuskin, theory [4]
HEAO-3 model, theory [1]

All-Particle Spectrum Measured by ATIC-1



OG1188
OG1192
OG1201

The TRACER Project:

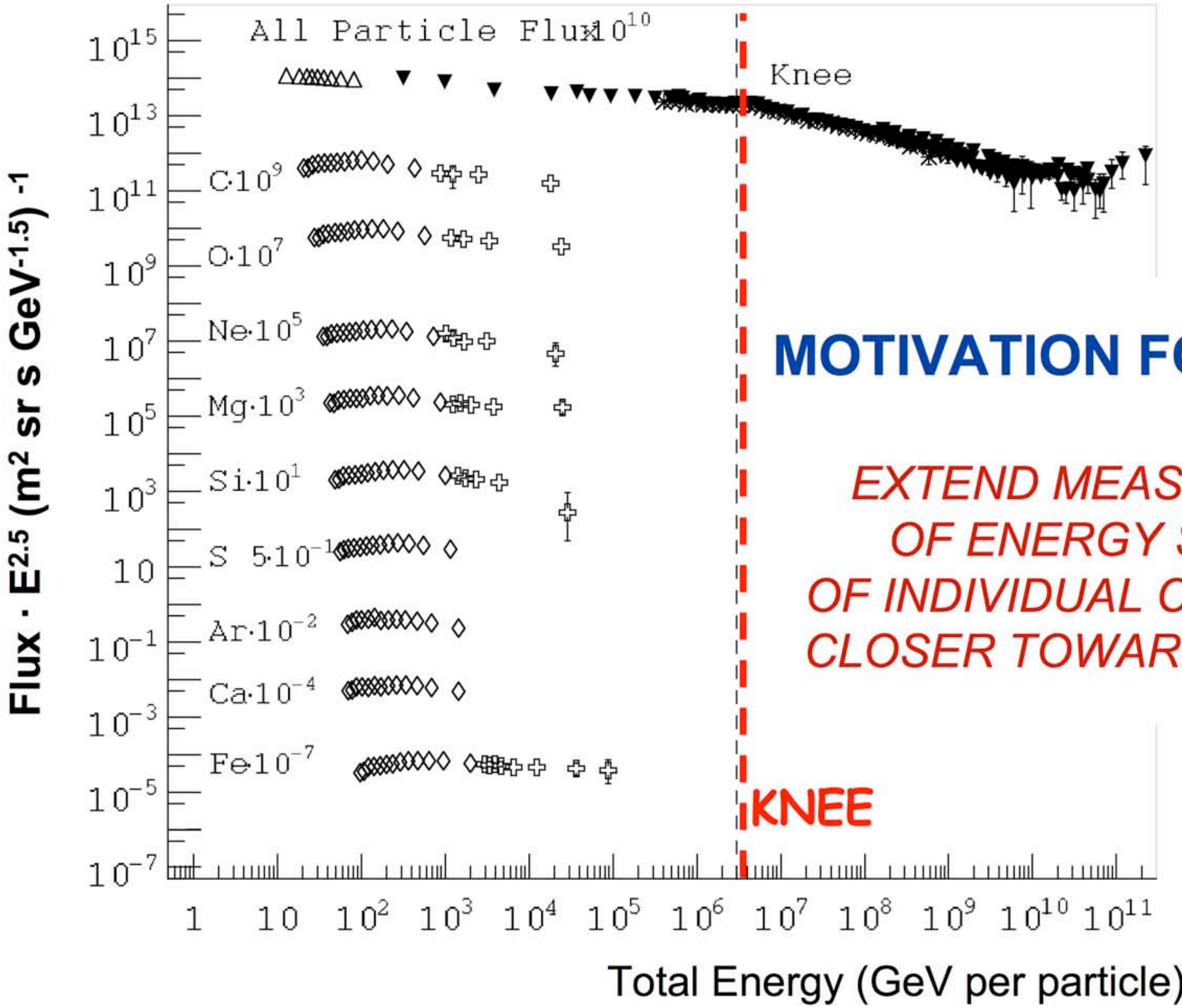
Instrument Concept, Balloon Flights, and Analysis procedures

1999 Test flight Ft. Sumner (N.M.), 1 day, charge range *oxygen (Z=8) to iron (Z=26).*
Results: ApJ 607, 333, 2004

2003 LDB flight McMurdo (Antarctica) 10 days, charge range *oxygen to iron.*
Preliminary data at ICRC 2005 Pune,
final results at ICRC 2007 Merida

2006 LDB flight Kiruna (Sweden) to Canada, 4.5 days, charge range expanded: *boron (Z=5) to iron (Z=26).* *Data analysis presently in progress.*

All particle flux · 10^{10}

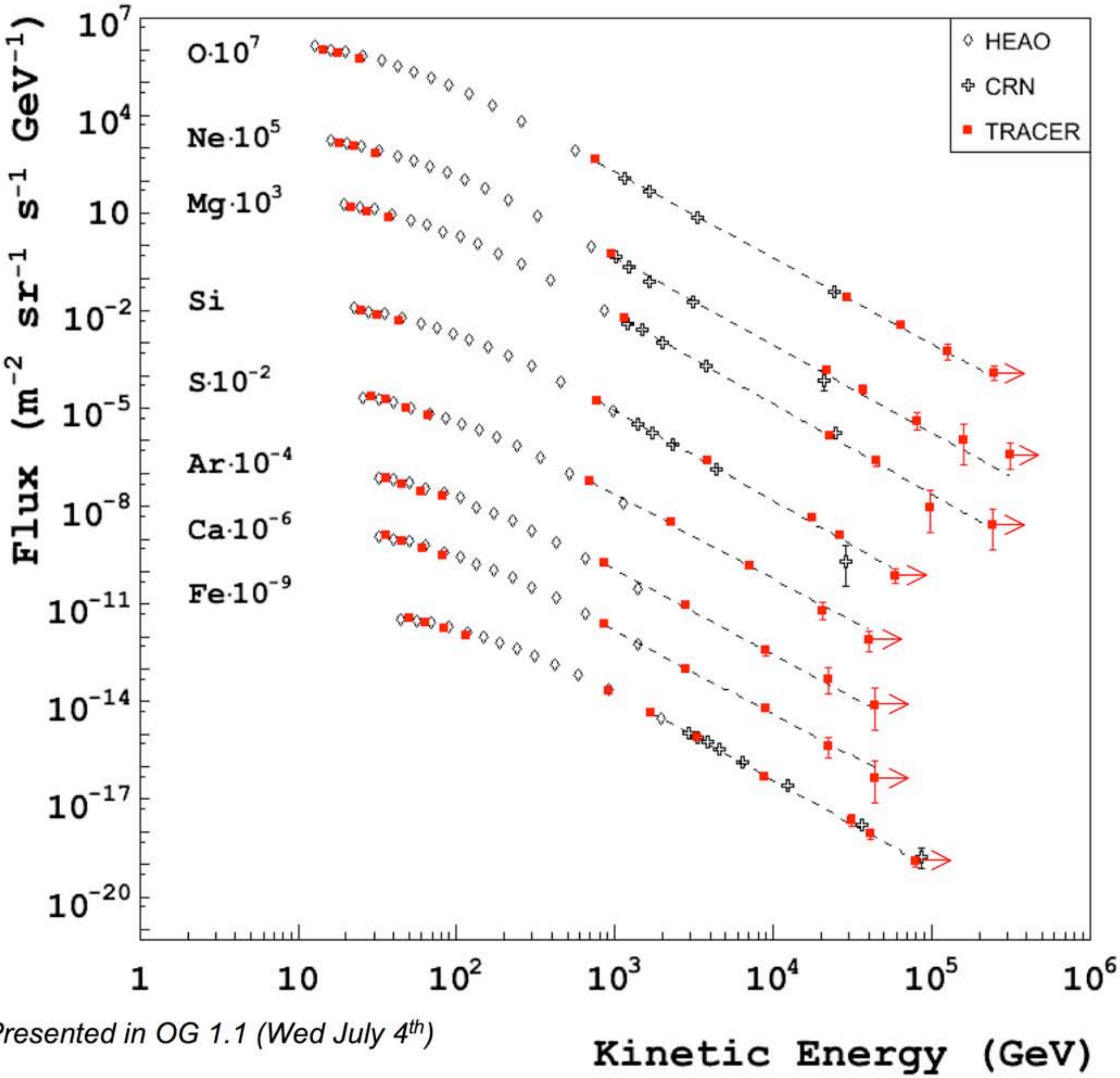


MOTIVATION FOR TRACER:

EXTEND MEASUREMENTS OF ENERGY SPECTRA OF INDIVIDUAL COMPONENTS CLOSER TOWARDS THE KNEE

Results from TRACER

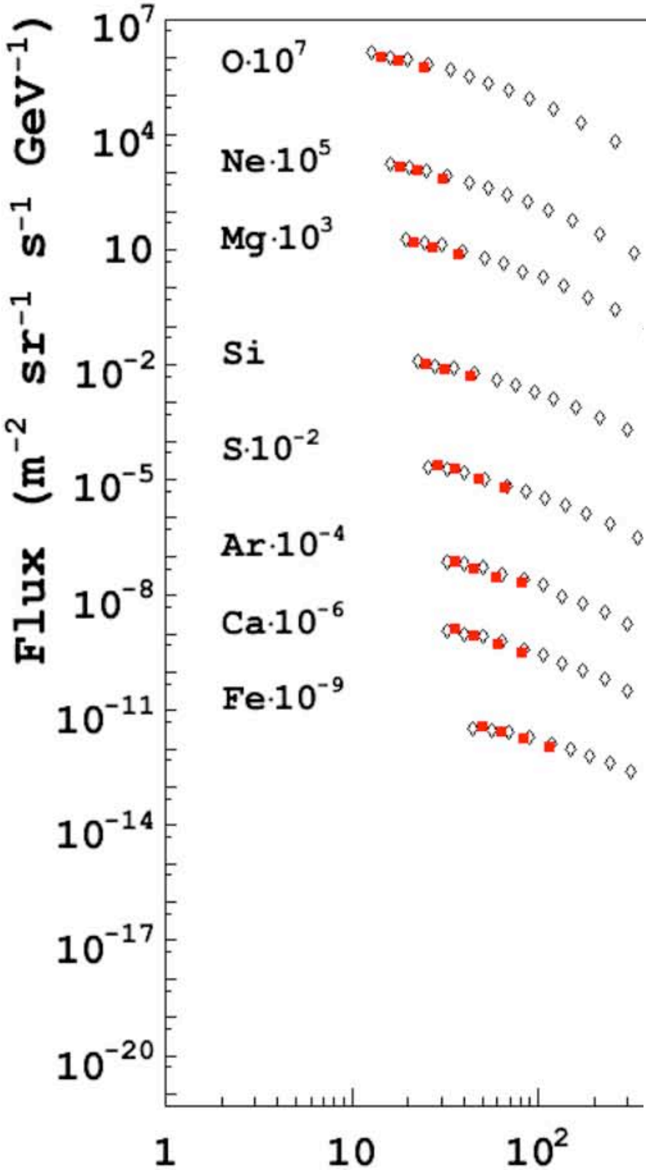
10 day Antarctic Flight 2003



Presented in OG 1.1 (Wed July 4th)

Results from TRACER

10 day Antarctic Flight 2003



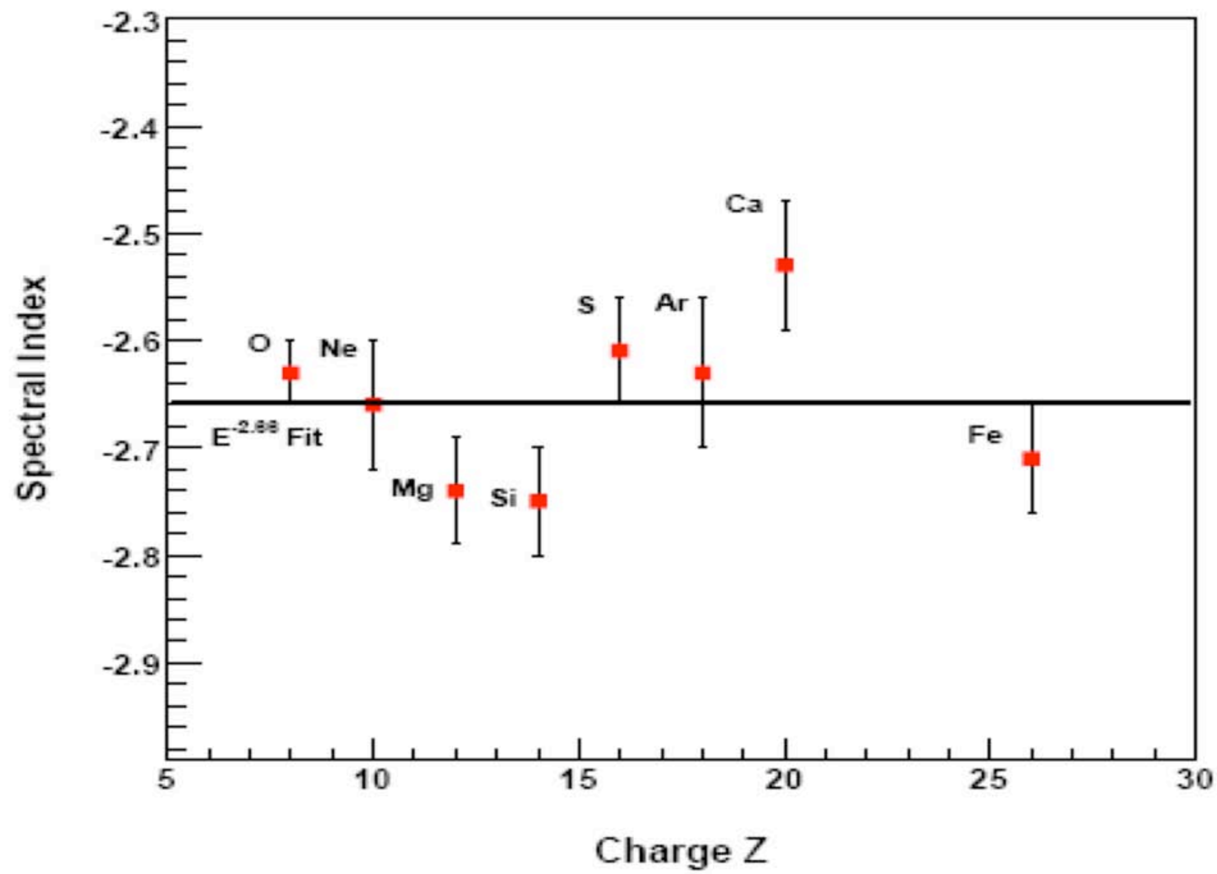
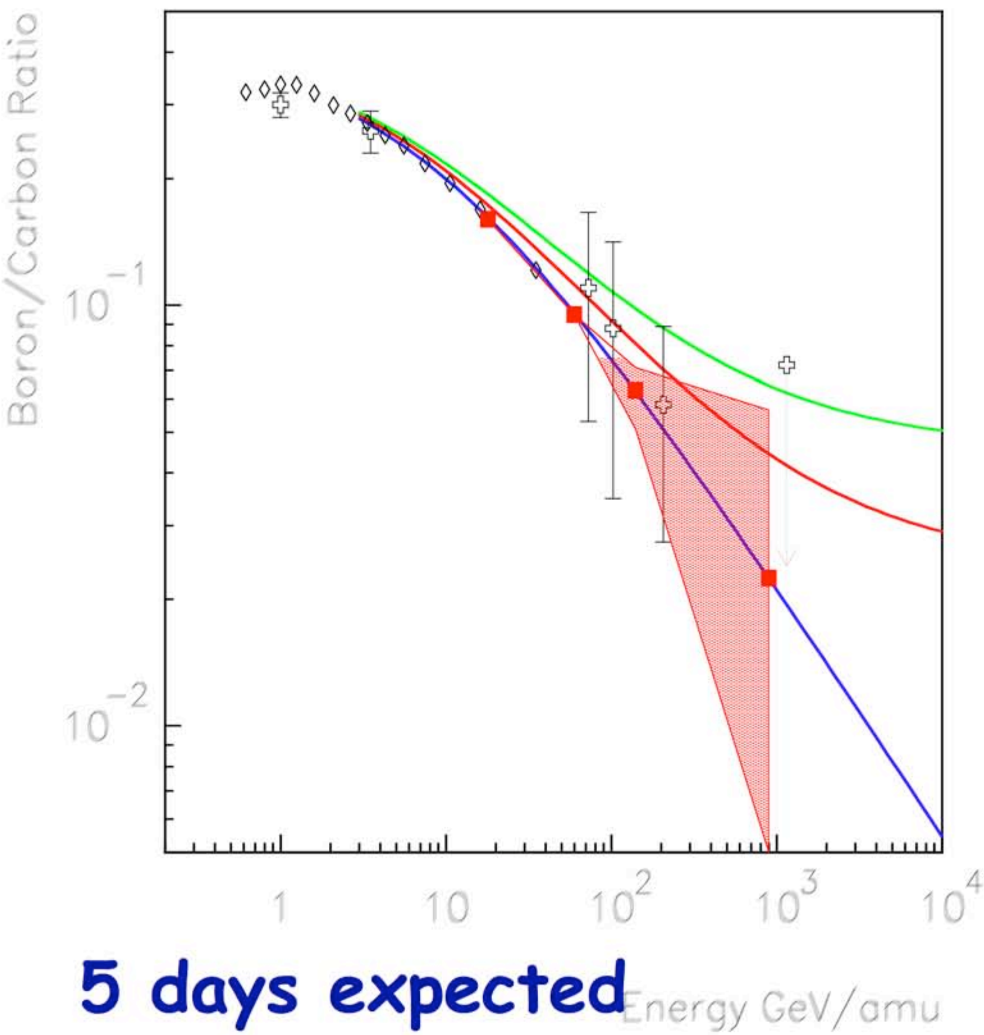


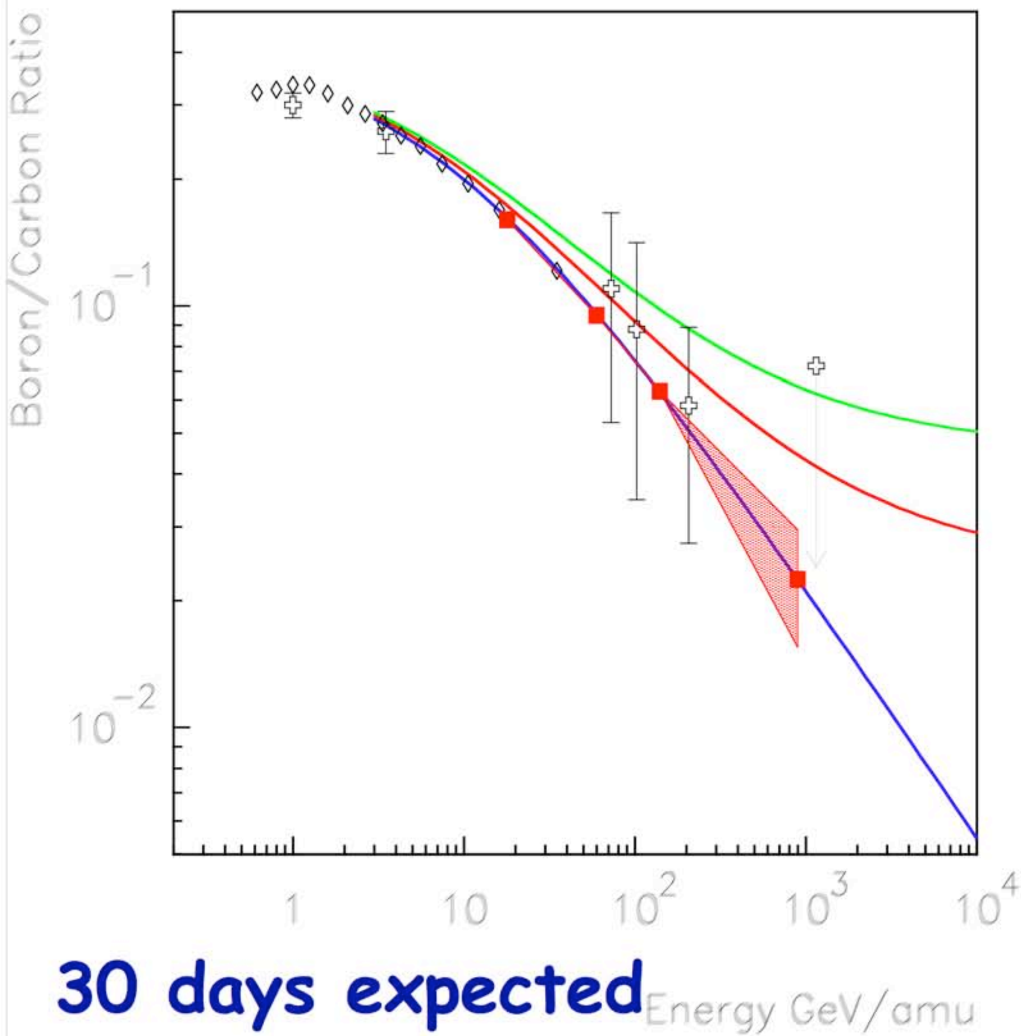
Figure 2: Spectral indices of a best power-law fit to the combined TRACER and CRN data above 20 GeV/nucleon. The line indicates the an average spectral fit of $E^{-2.65}$.

Presented in OG 1.1 (Wed July 4th)

B/C Ratio



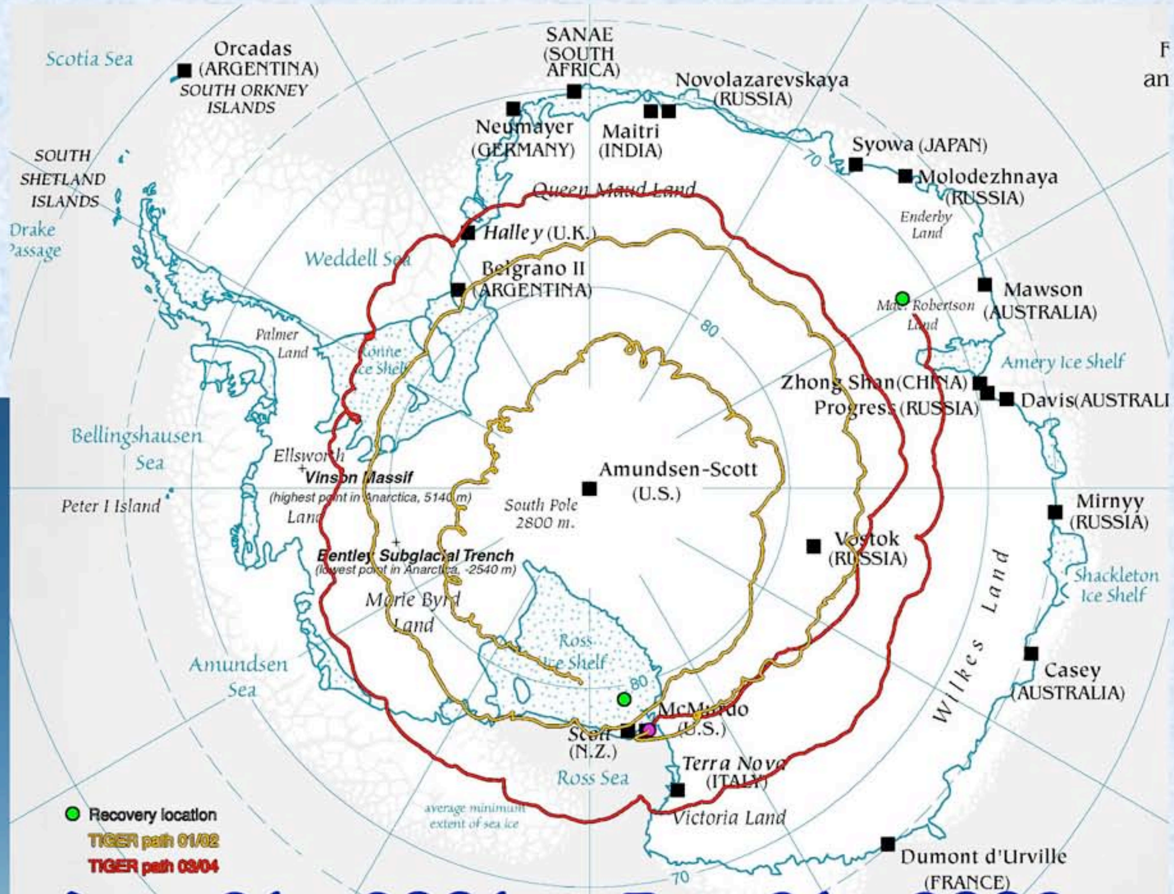
5 days expected



30 days expected

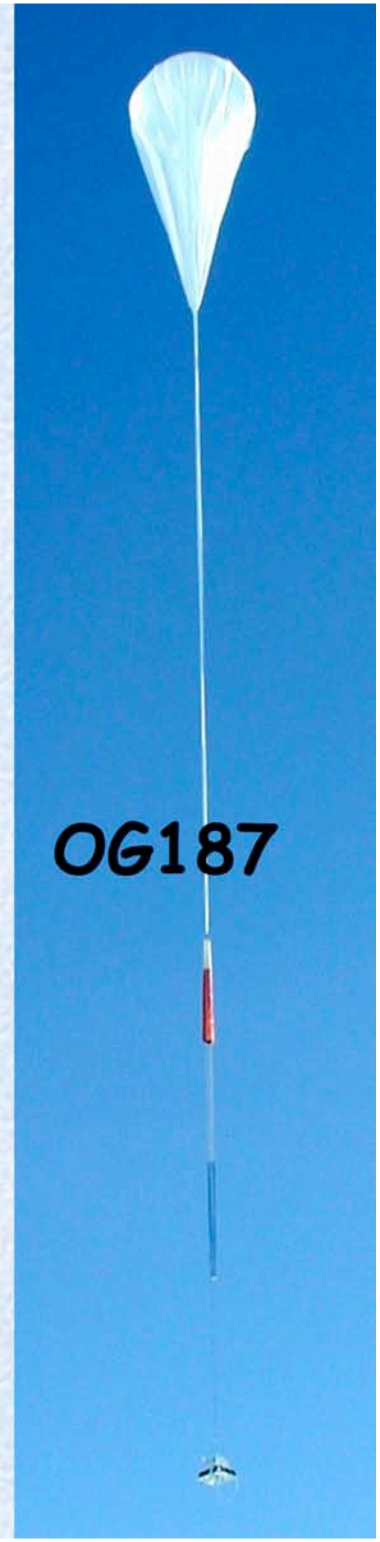
Measurement of the Relative Abundances of the Ultra-Heavy Galactic Cosmic-Rays ($30 \le Z \le 40$) with TIGER

Trans-Iron Galactic Element Recorder



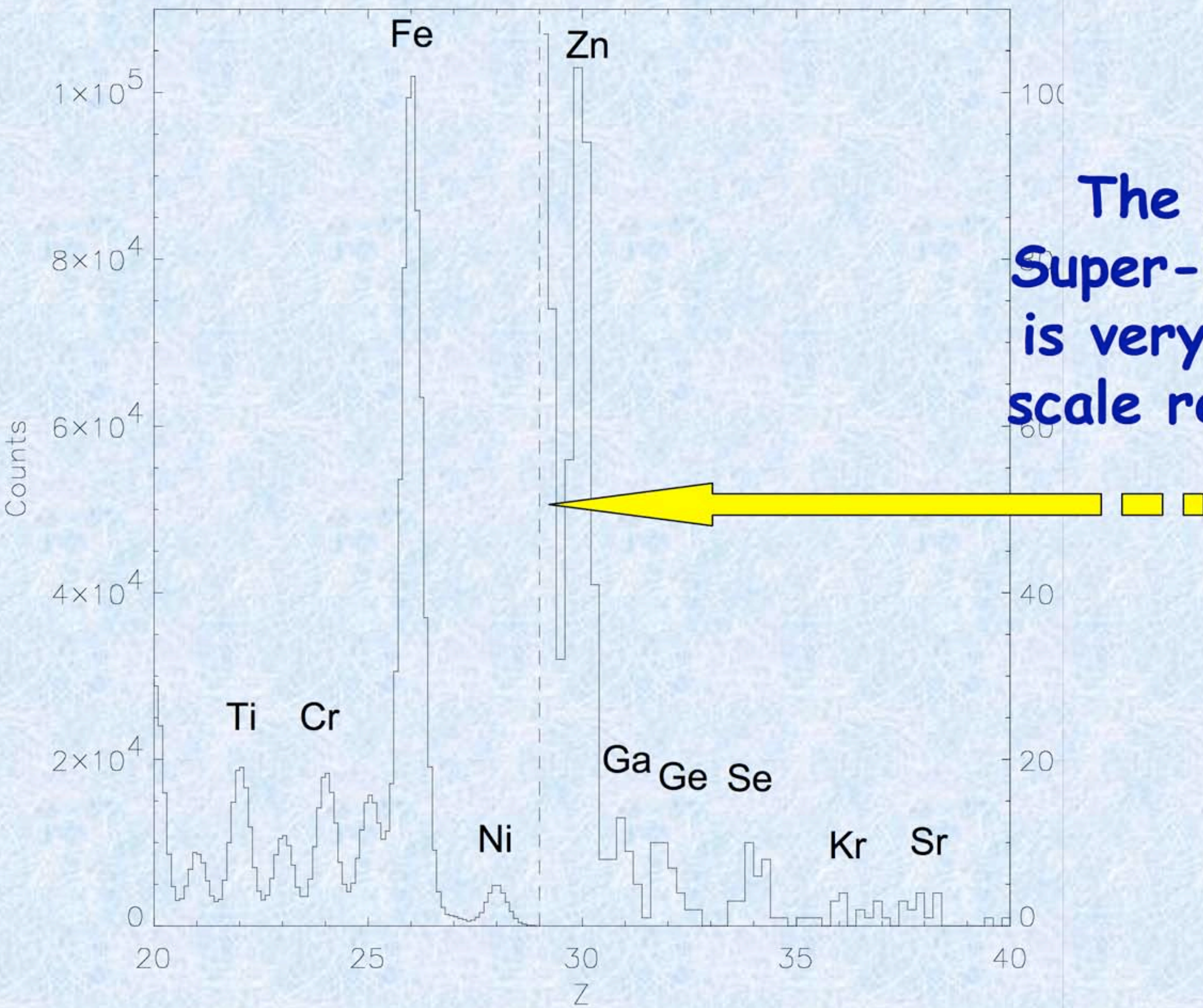
Dec 21, 2001 – Jan 21, 2002

Dec 17, 2003 – Jan 4, 2004



OG187

Combined 2001 and 2003 Data



The abundance of Super-Heavy Elements is very Low: change of scale required (X1000)

PHYSICS GOALS OF TIGER

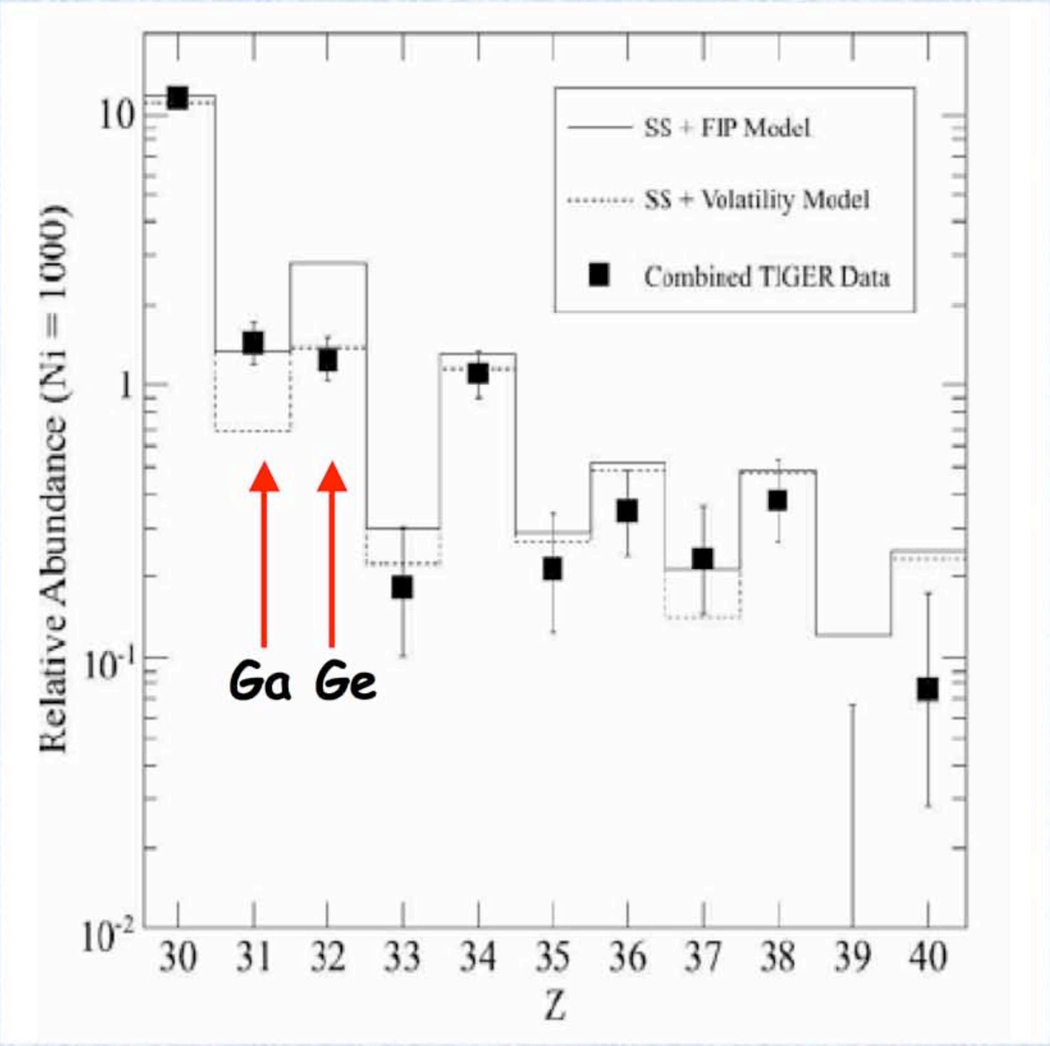
- Measurement of the abundances of SH elements with 26<Z<40

- Acceleration is expected to prefer elements which are easy to ionize (low FIP)

- Clarify the role of volatile elements

- The accurate measurement of the (under-abundant) SH elements can clarify aspects related to the origin of the bulk of CRs (e.g. origin in superbubbles,…)

RESULTS



- Starting with Solar System abundances the data are inconsistent with both a FIP and a volatility based model of acceleration
- Or may be the material in the proximity of CR accelerators does not have SS abundances

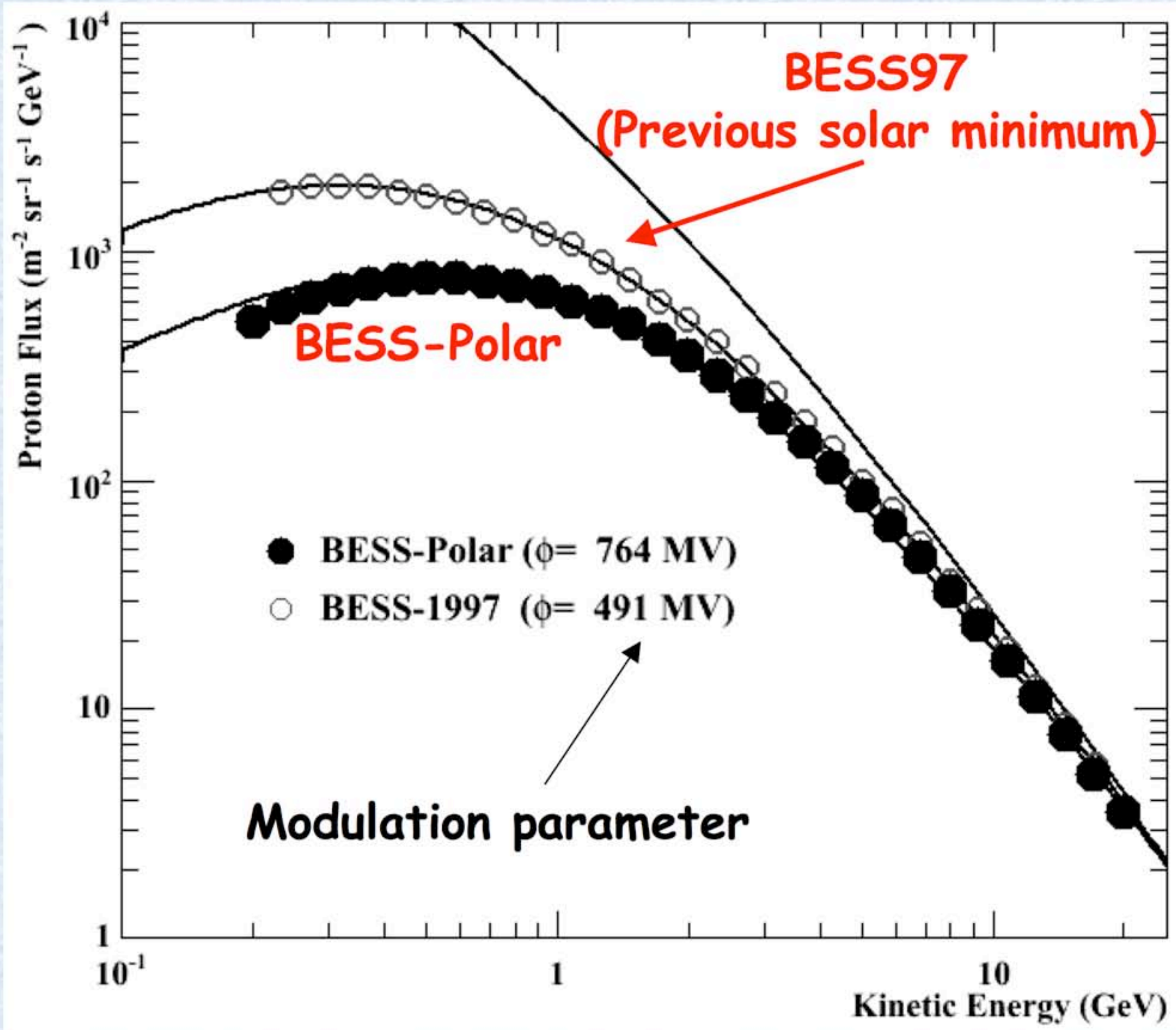
BESS-Polar (Balloon Experiment with a Superconducting Spectrometer)

T. Hams, **OG1119**

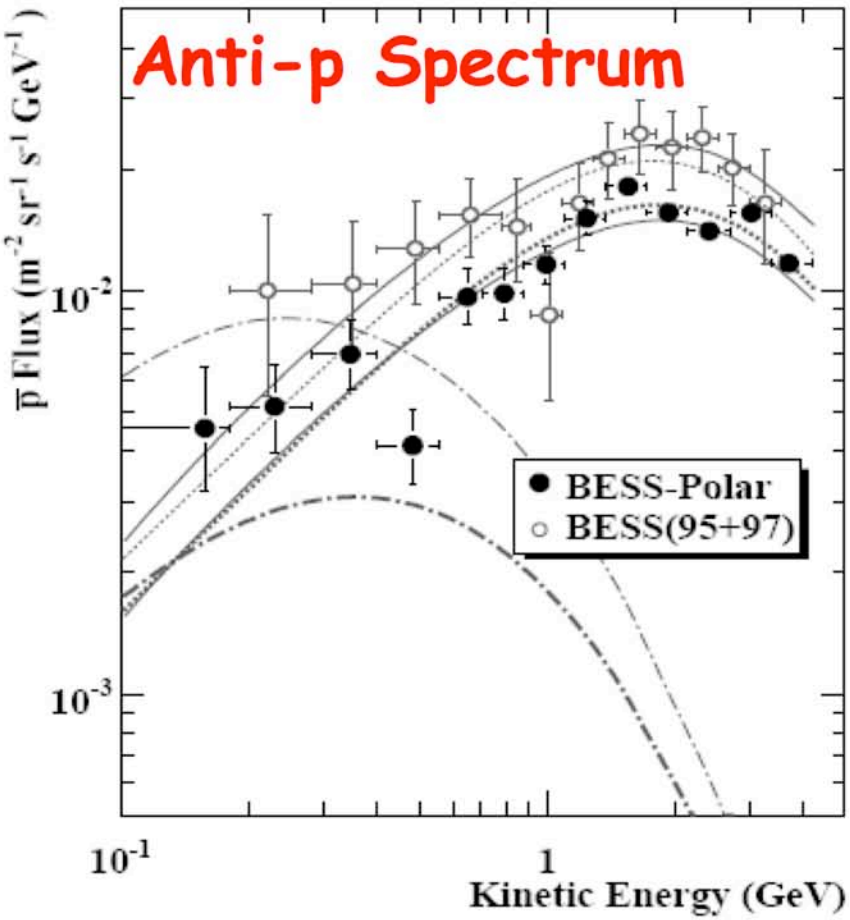
Main Science with BESS

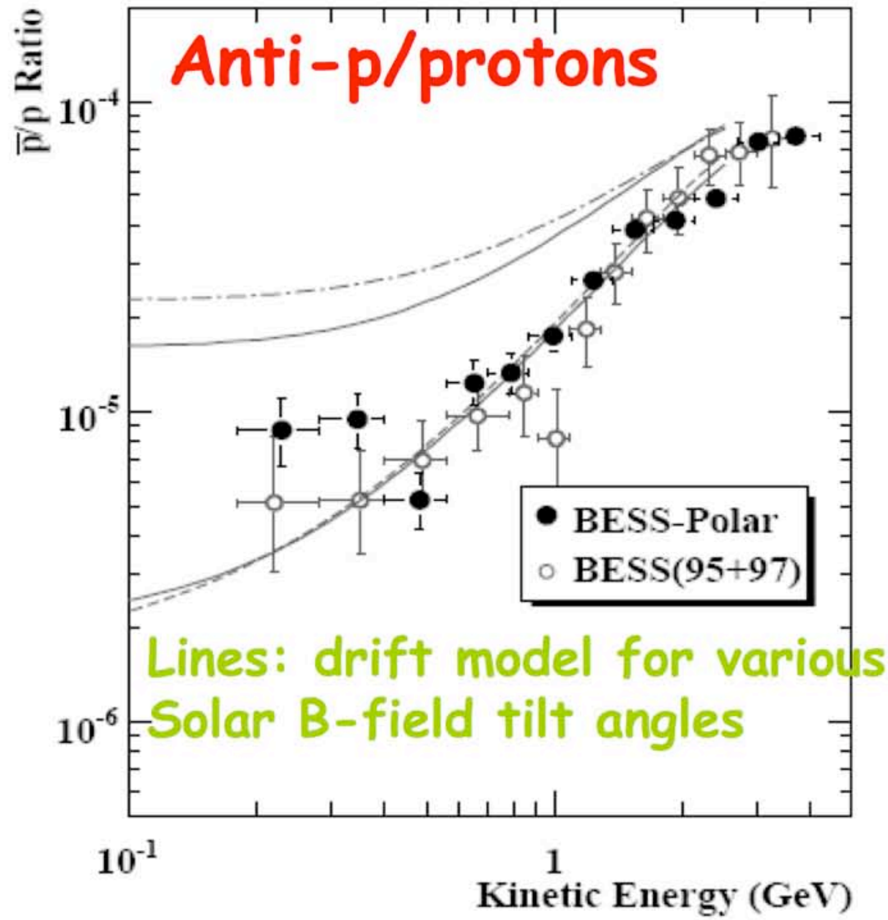
- Measurement of p, anti-p, nuclei, anti-nuclei
- In particular measurement of anti-He (if there is any)
- Signatures of dark matter in anti-p spectra
- Measurements of CR fluxes
  - p, He, Li, Be isotopic and elemental spectra
  - B, C, N, O elemental spectra

The proton spectrum in the low energy region



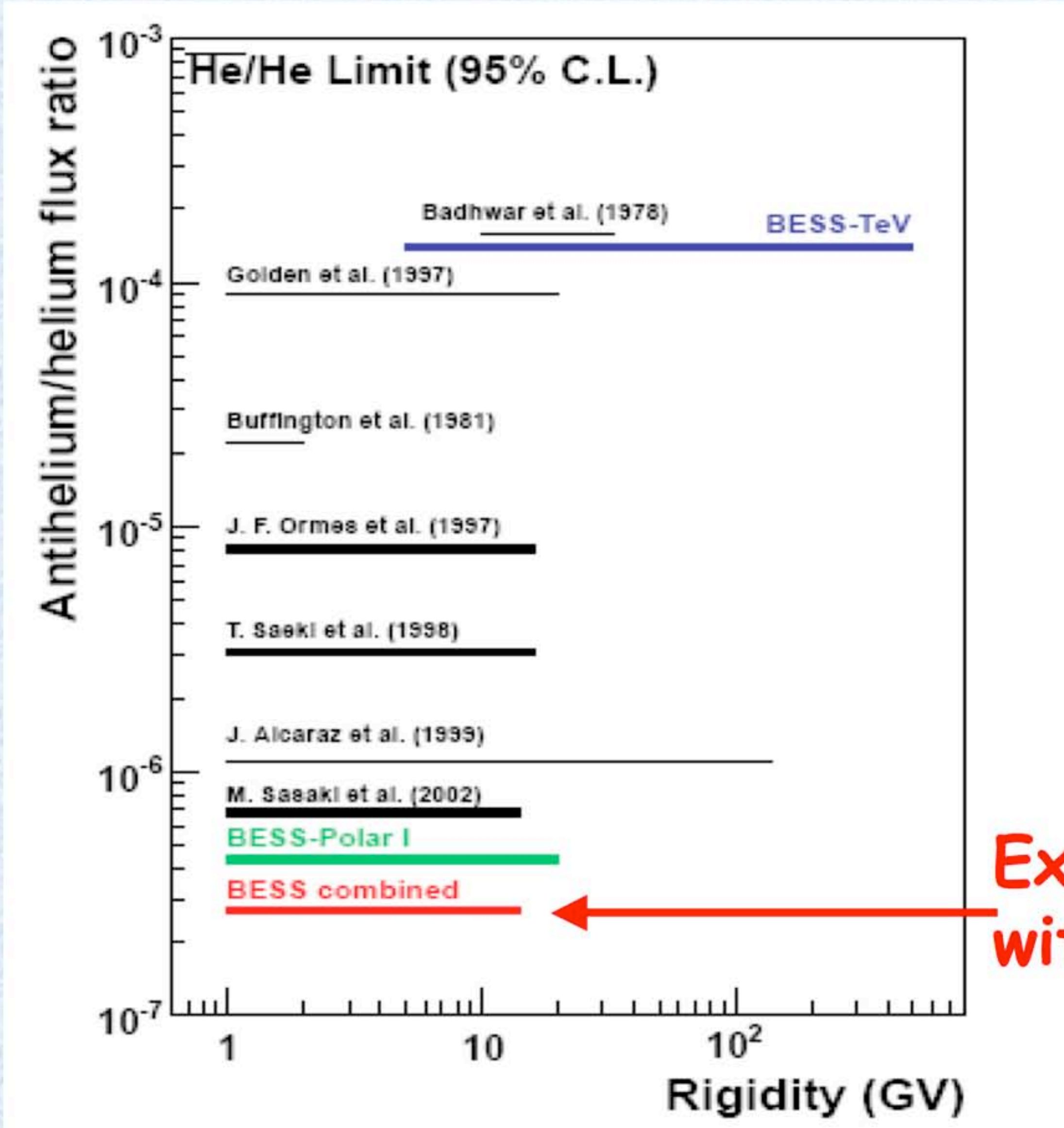
The anti-proton flux





DOTTED: Standard Leaky Box with modulation
DASH-DOTTED: Anti-p from BH evaporation
SOLID: Propagation with GALPROP

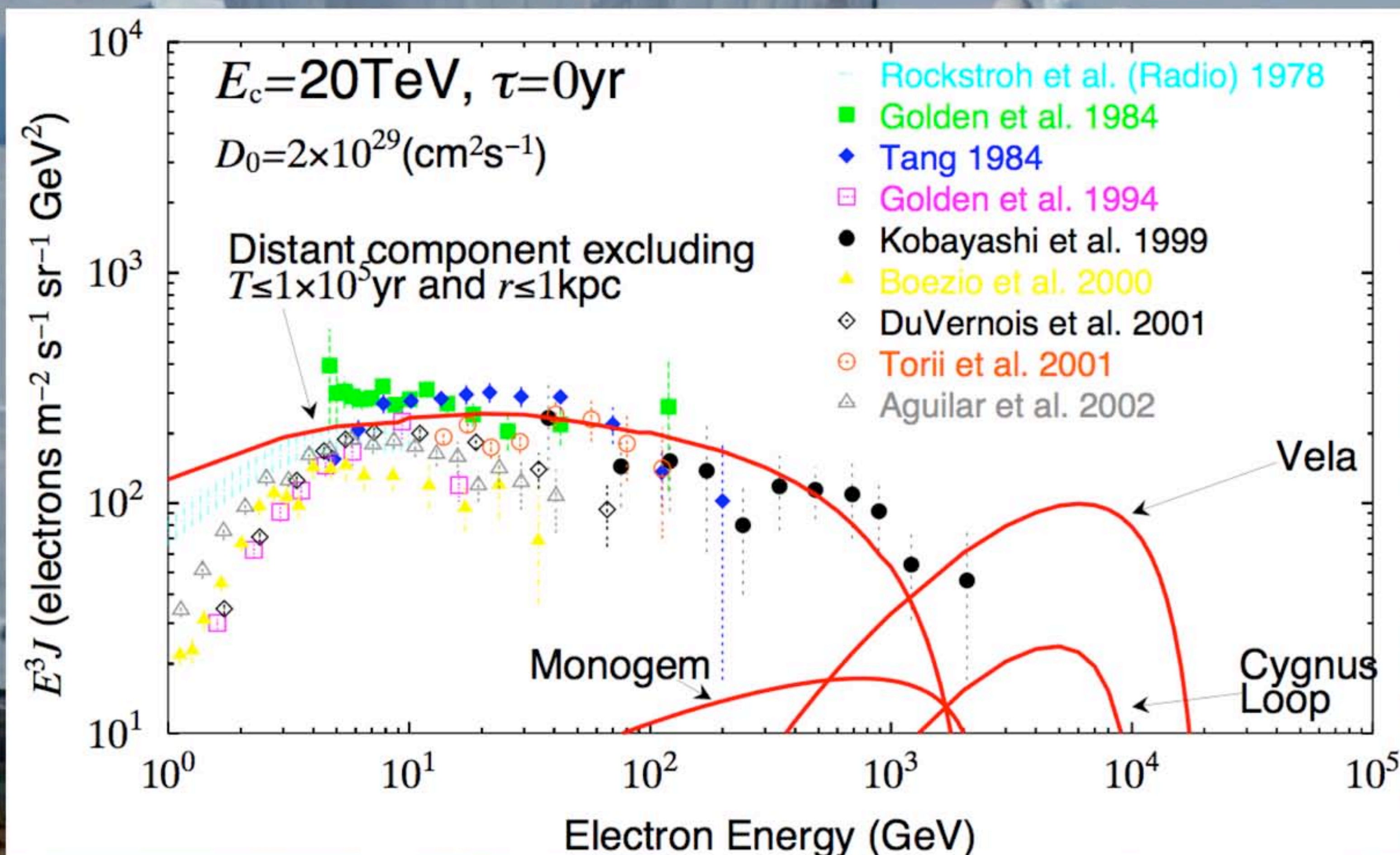
Limits on Anti-He



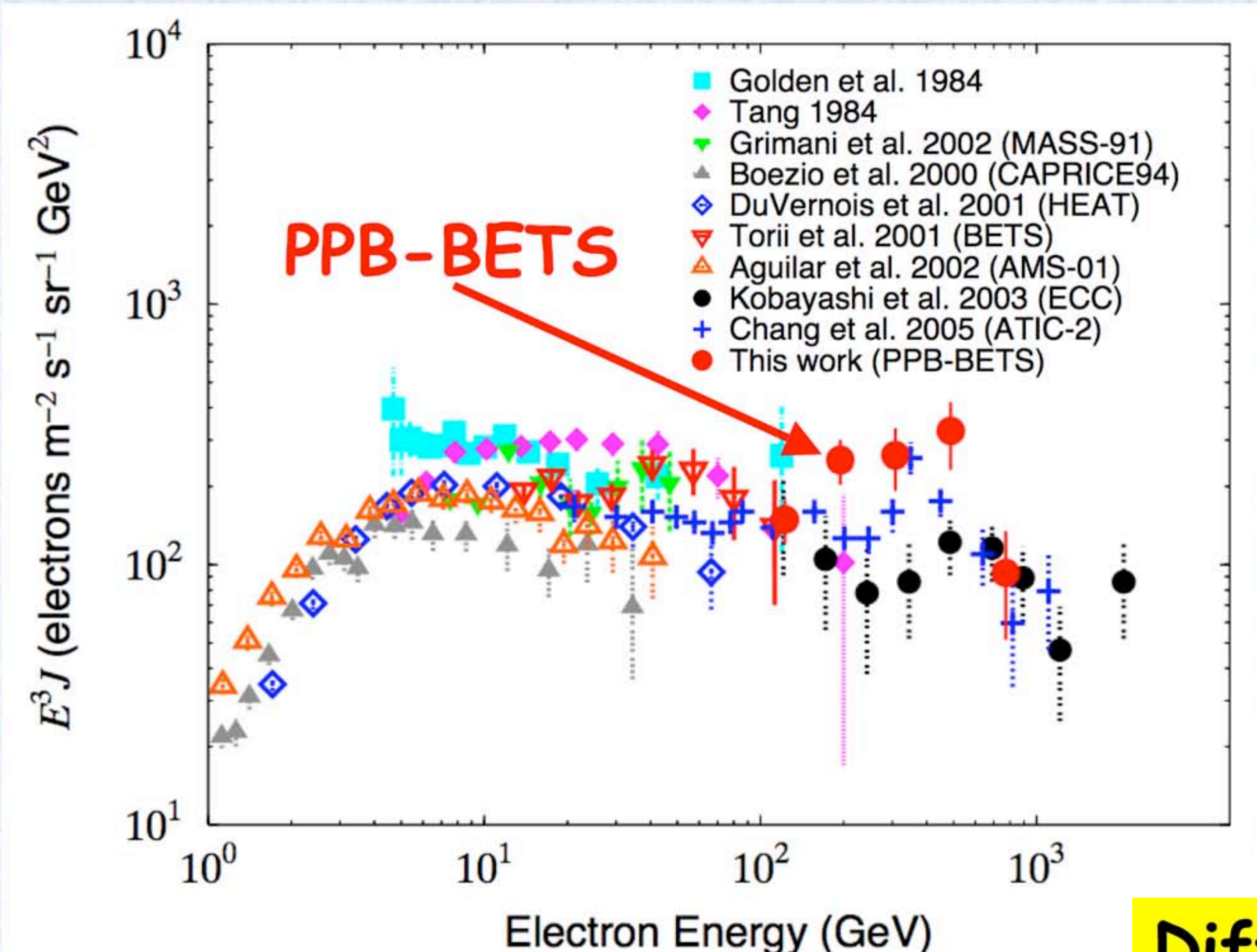
Expected limit
with next flight

POLAR PATROL BALLOON
PPB-BETS

13 days balloon flight in January 2004

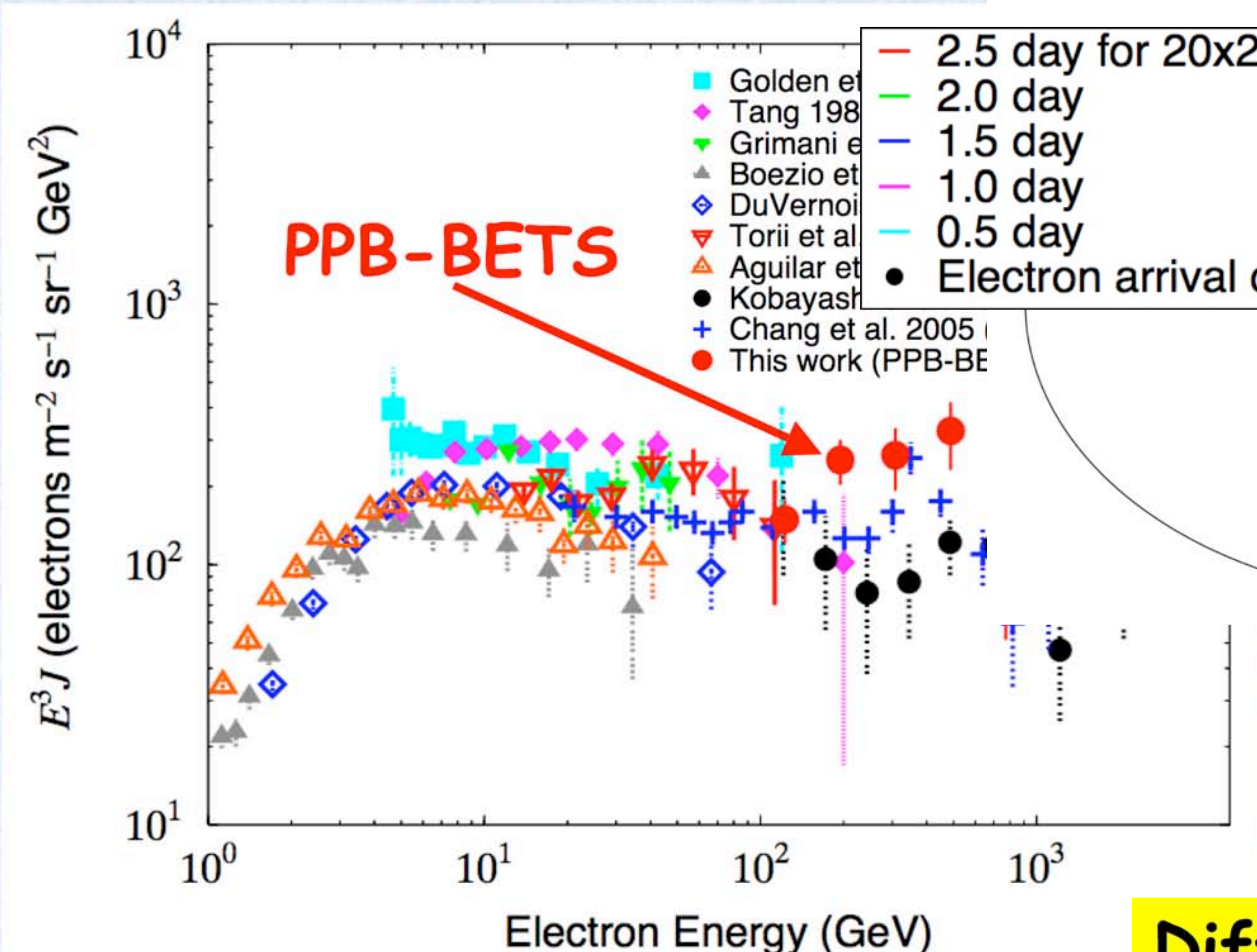


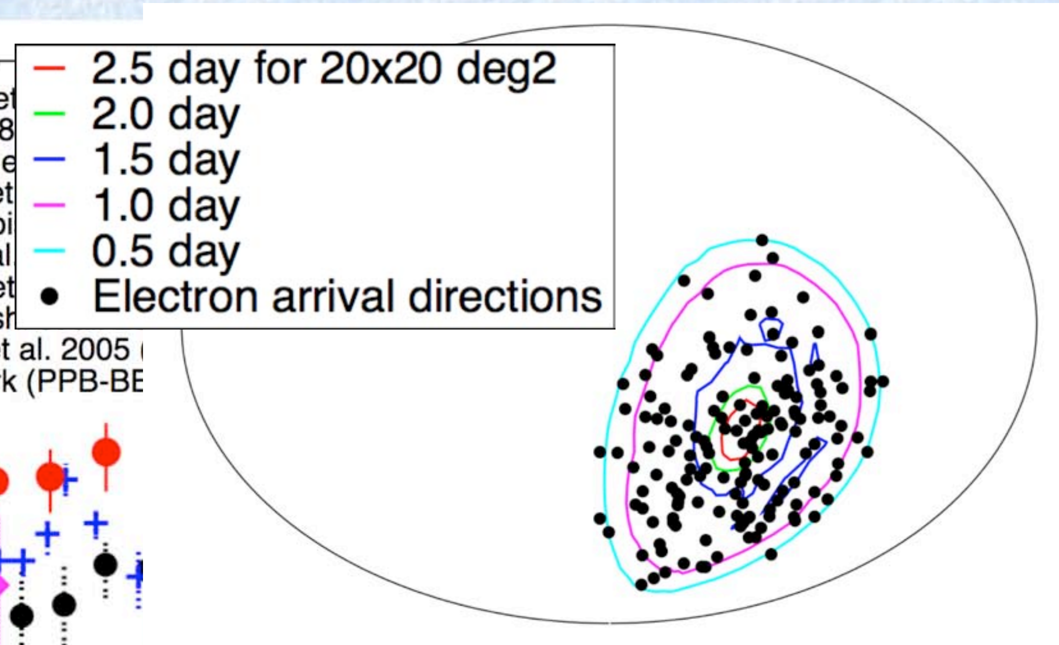
Main Results of PPB-BETS



Diffusion length during the loss Time: $[4D(E)T_{loss}]^{1/2}$=1-2 kpc

Main Results of PPB-BETS





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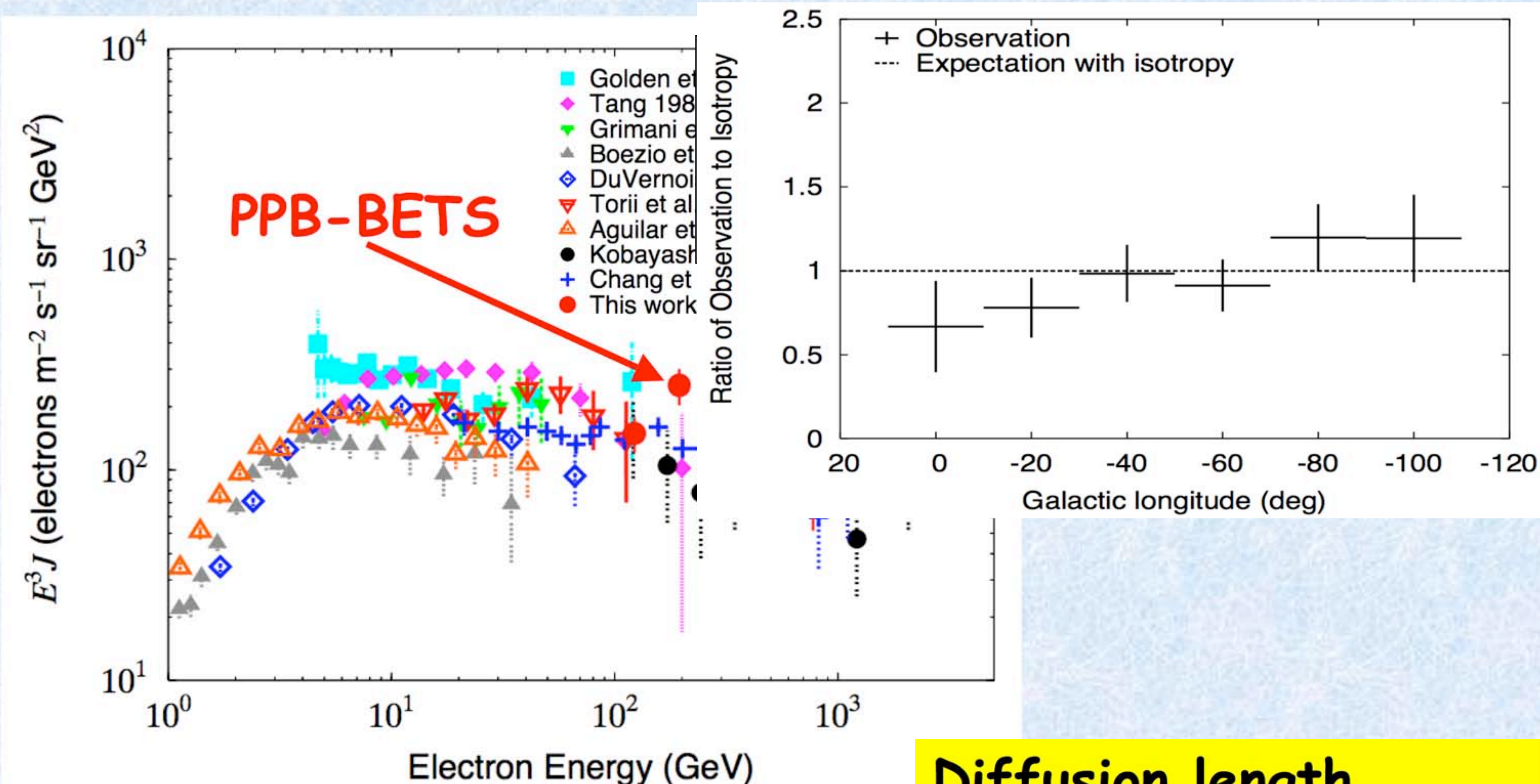

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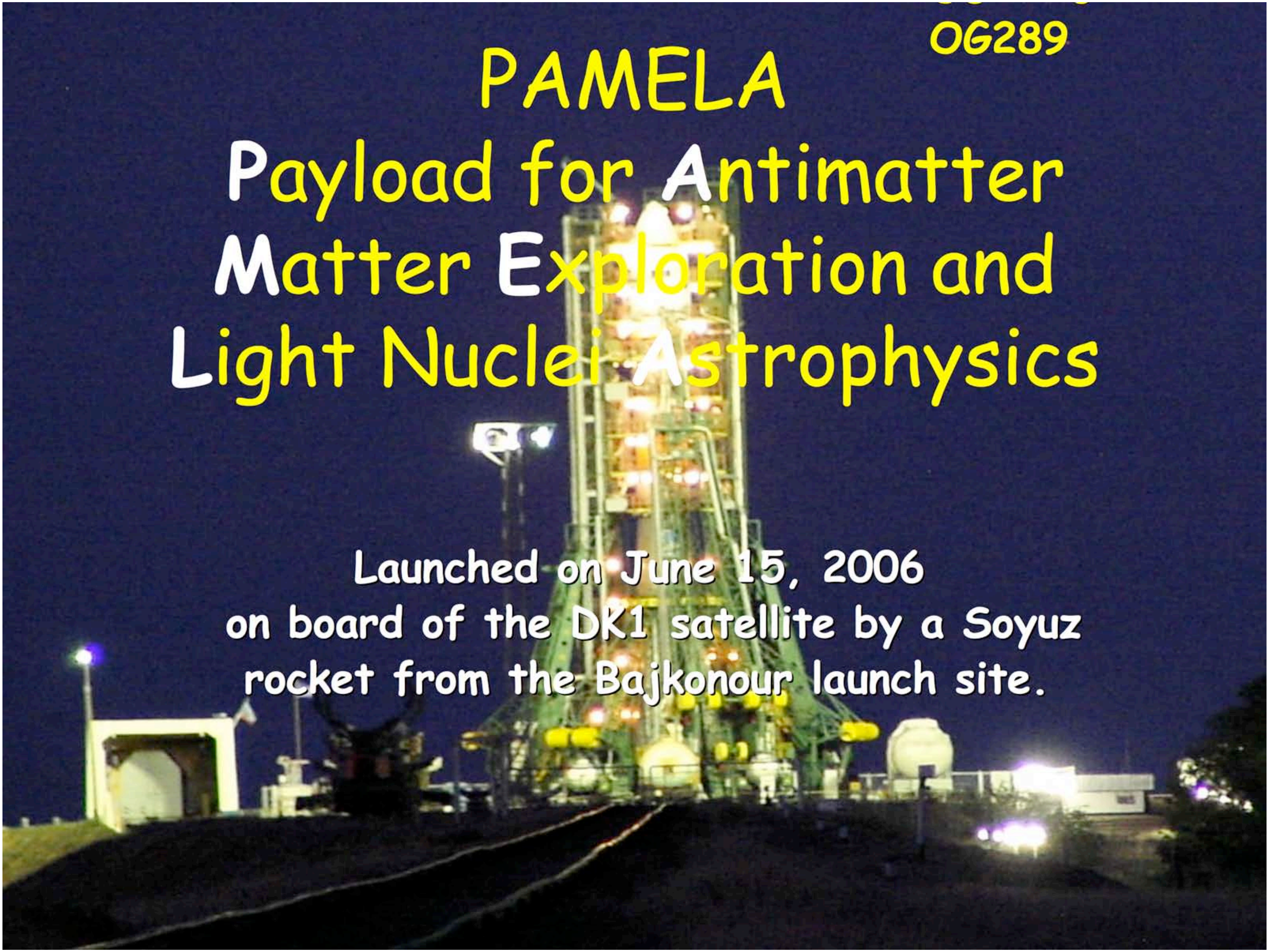
OG289
PAMELA
Payload for Antimatter
Matter Exploration and
Light Nuclei Astrophysics
Launched on June 15, 2006
on board of the DK1 satellite by a Soyuz
rocket from the Bajkonour launch site.

THE SCIENCE OF PAMELA

- Study of Galactic Cosmic Rays
- Dark matter signatures
- Anti-matter
- Search for exotic objects (e.g. Primordial BHs)
- Solar and Magnetospheric Physics

Expected Results…

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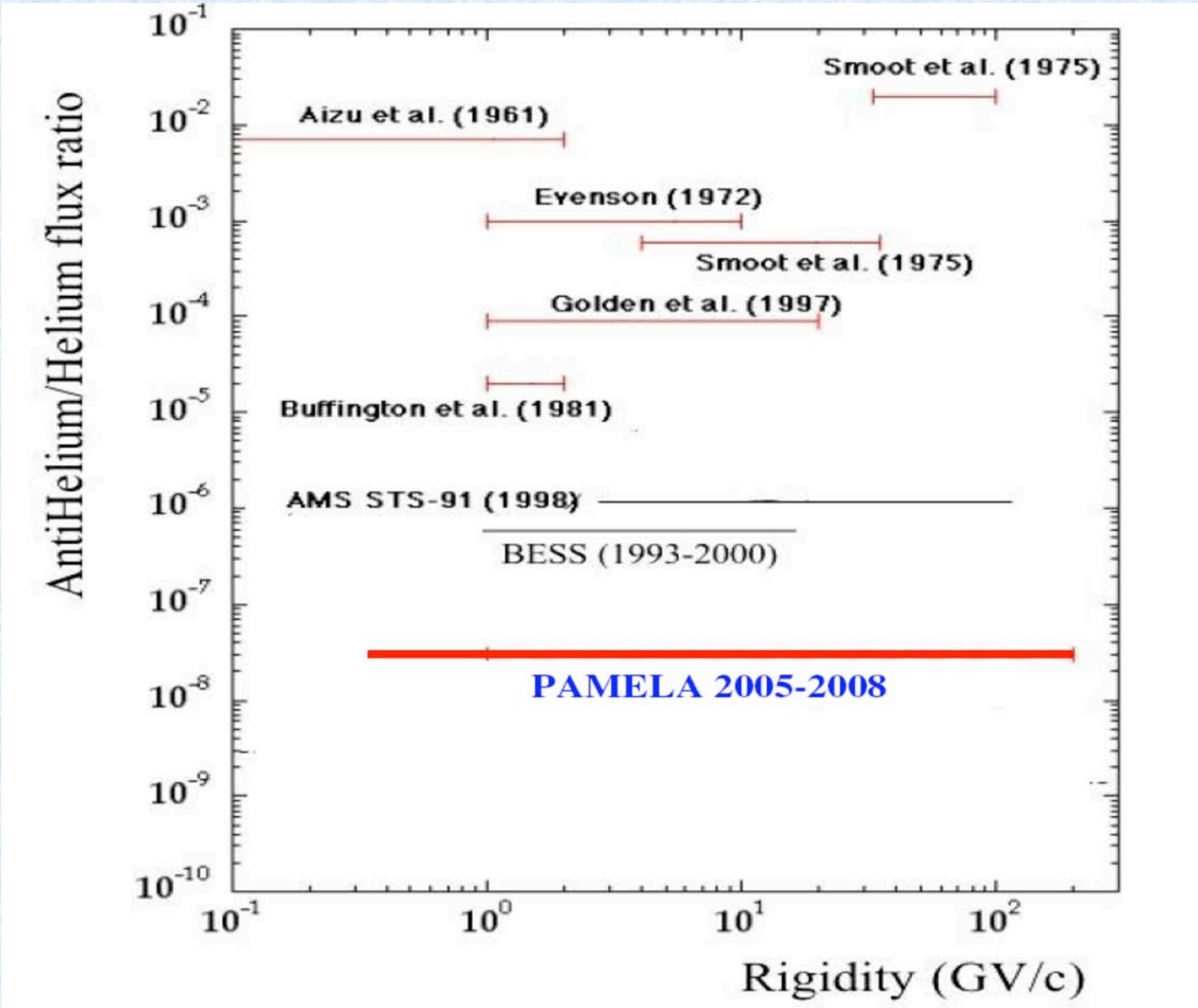
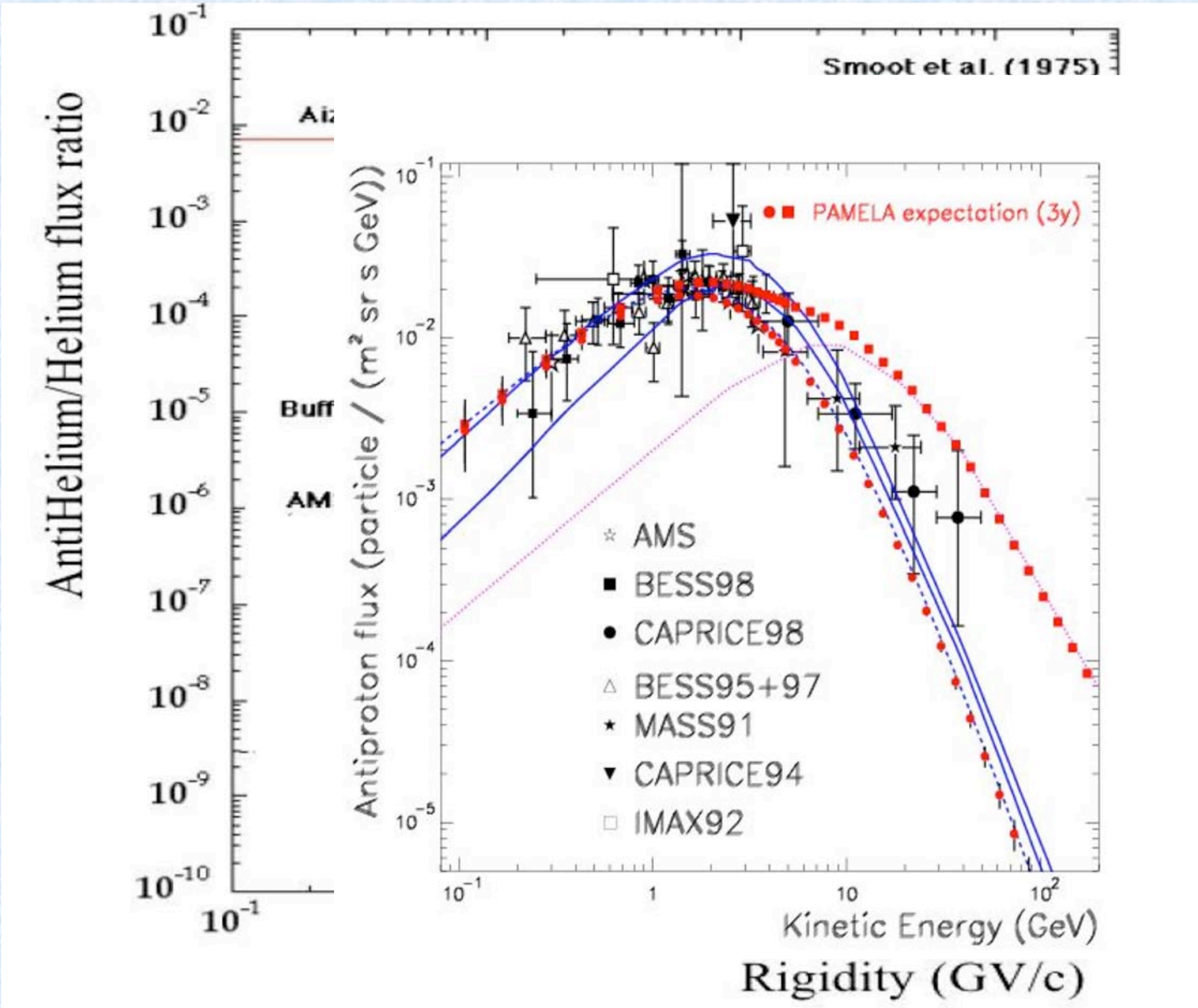
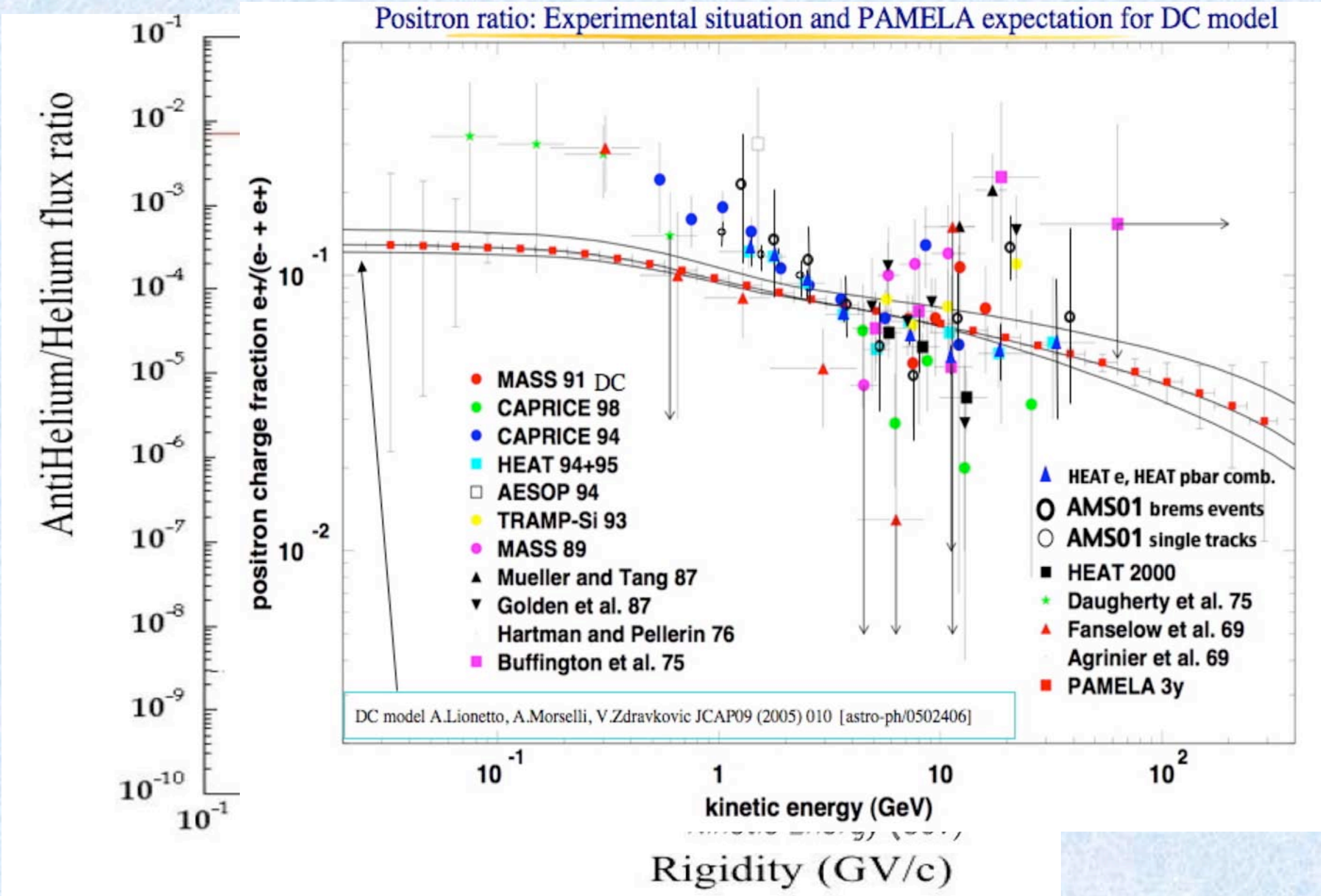


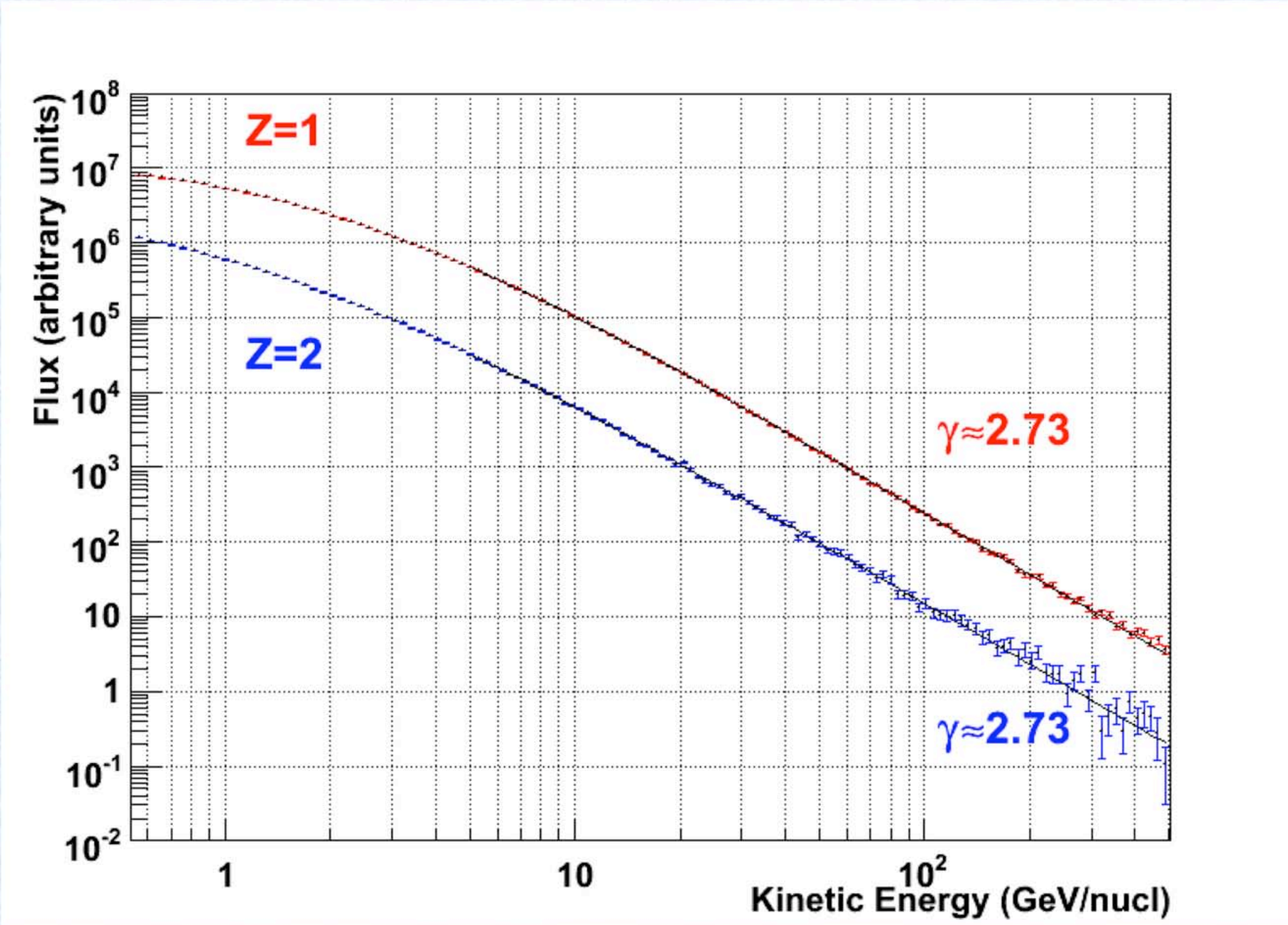
Expected Results…



Expected Results…



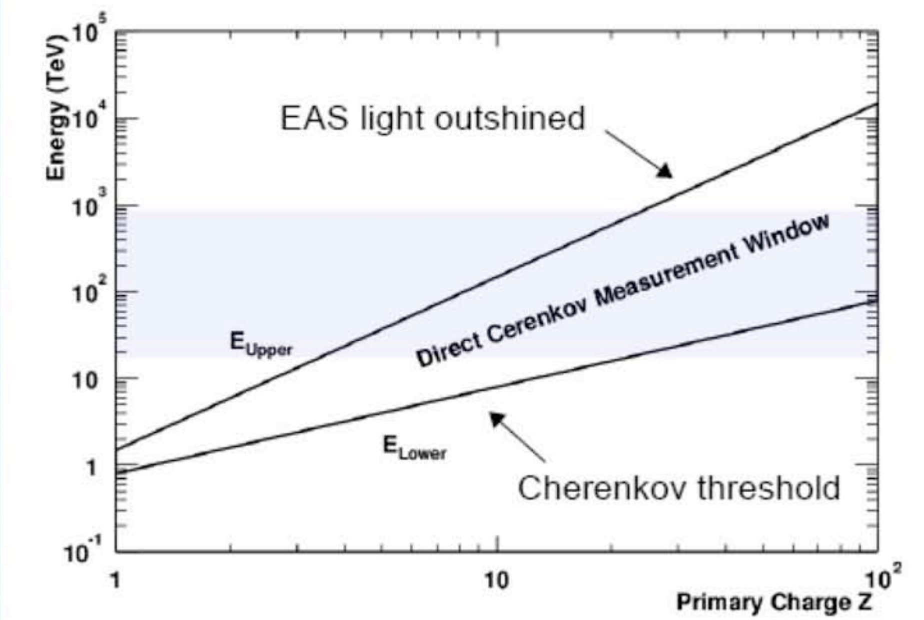
Already Preliminary Results!



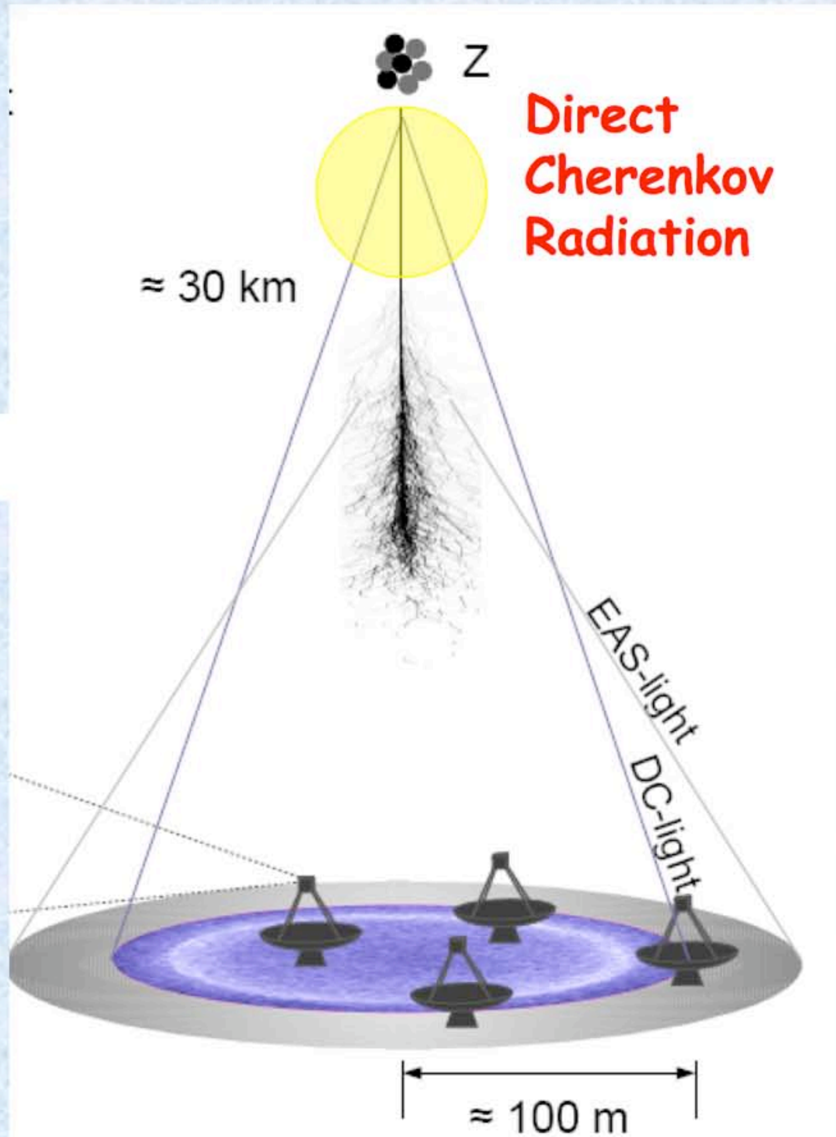
Gamma Ray Detector as a detector for CR nuclei

OG446

A beautiful idea by Kieda et al.

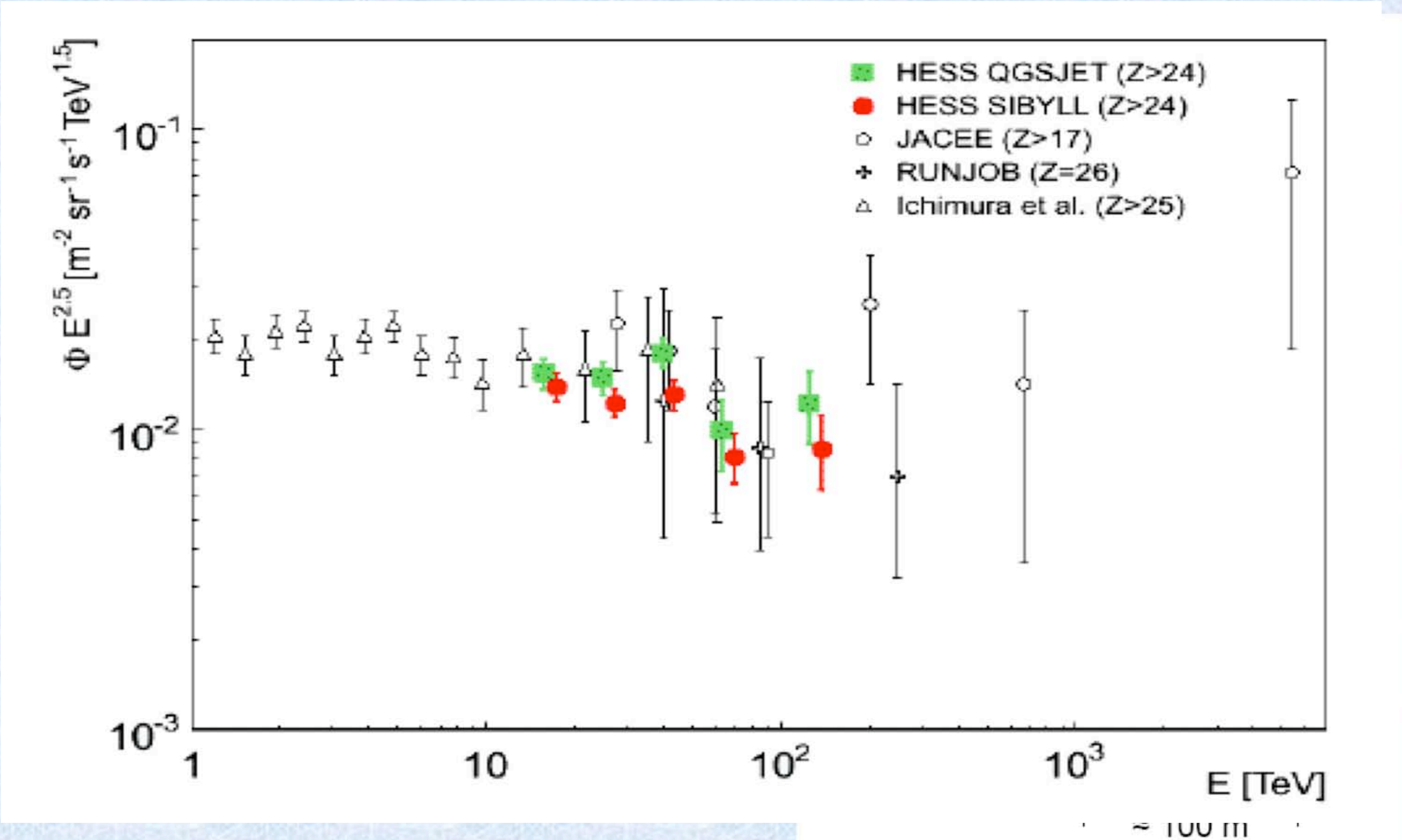


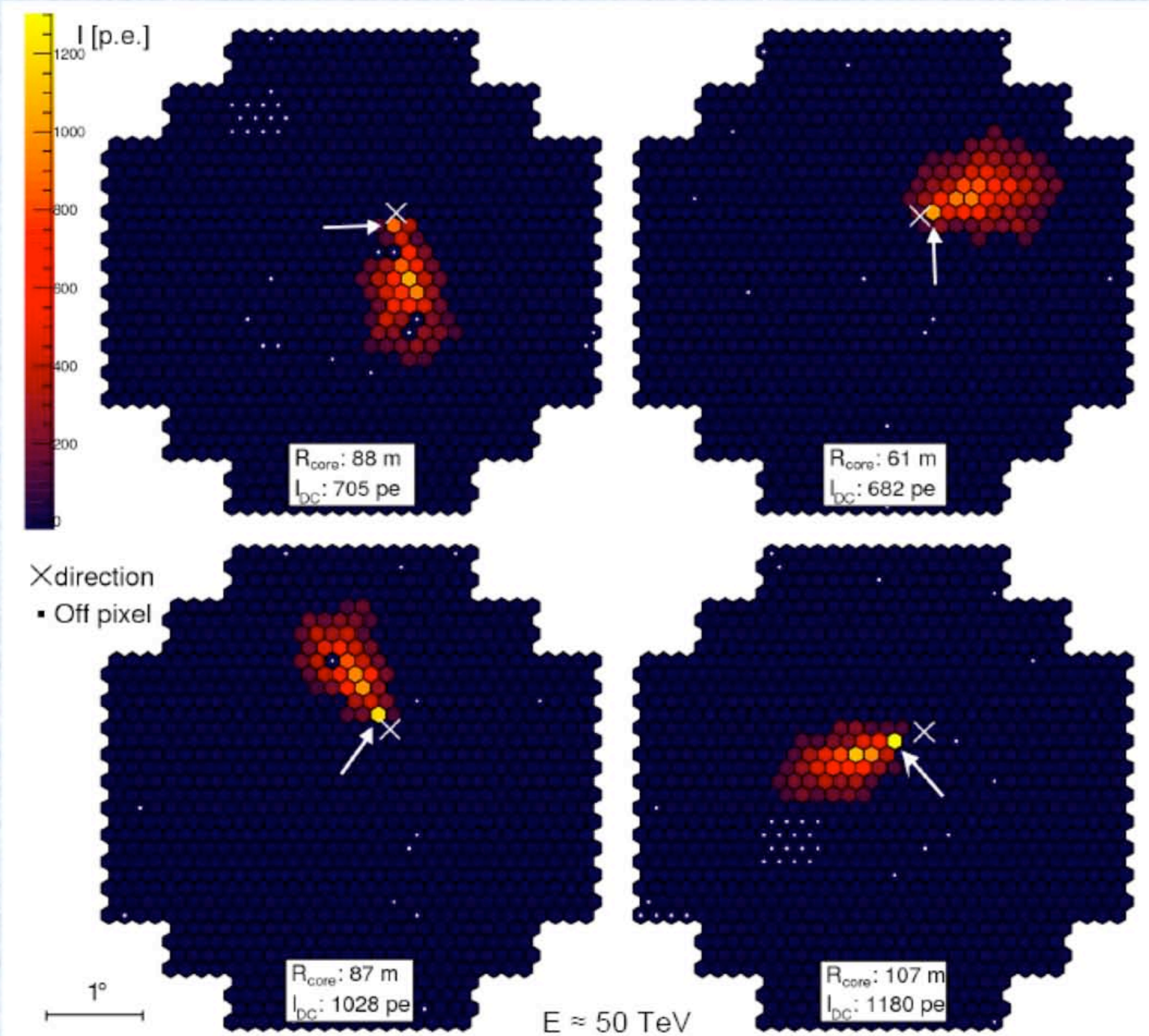
From D. Kieda Astroparticle Phys. 15, 287



Gamma Ray Detector as a detector for CR nuclei

OG446

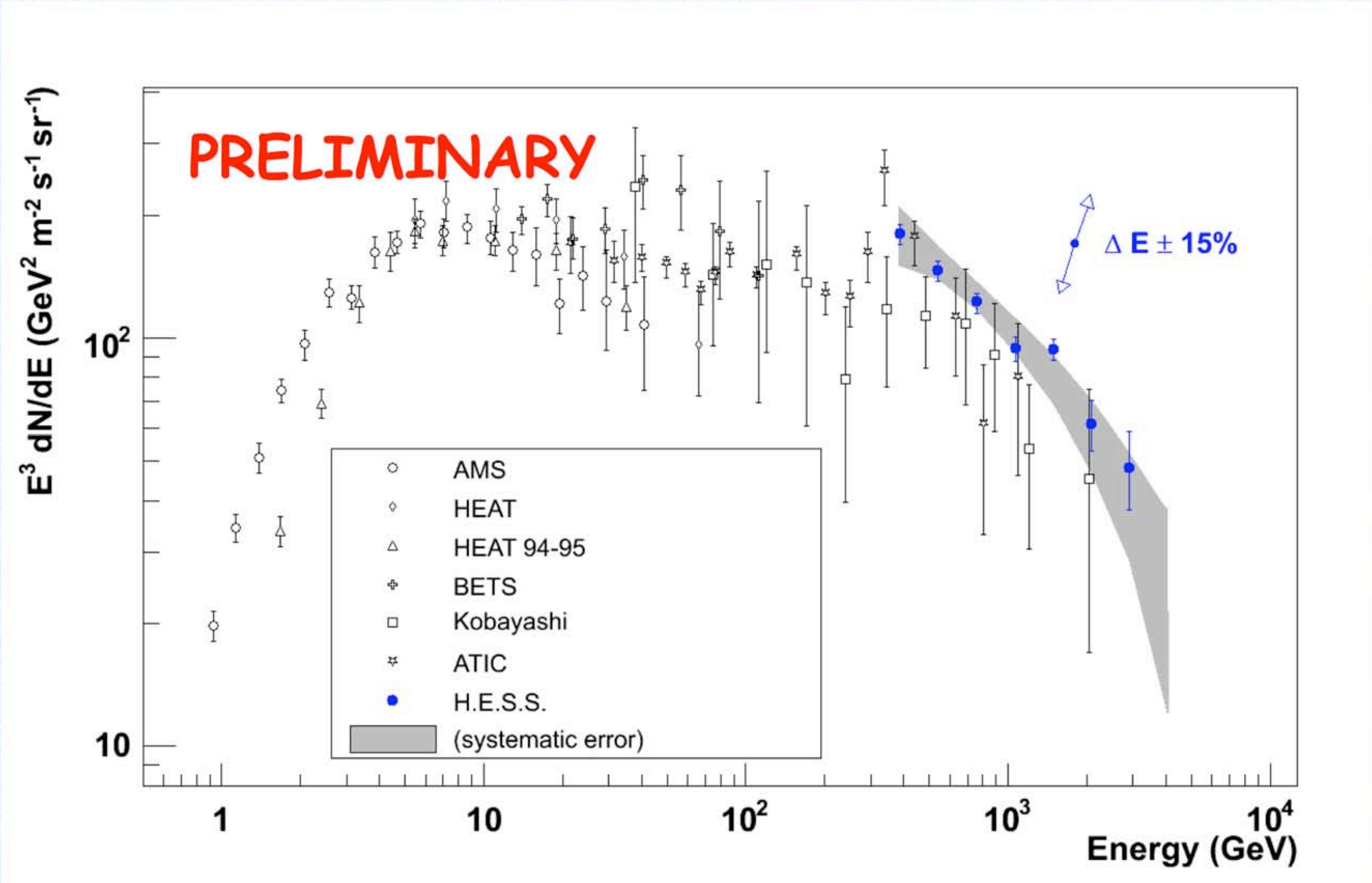




HESS
4 telescopes

A similar technique is being adopted in TrICE (Hays et al., OG1172), a dedicated instrument for Chemical composition in the TeV-PeV region

Electron Spectrum from HESS



The Analysis is still ongoing and the results could change

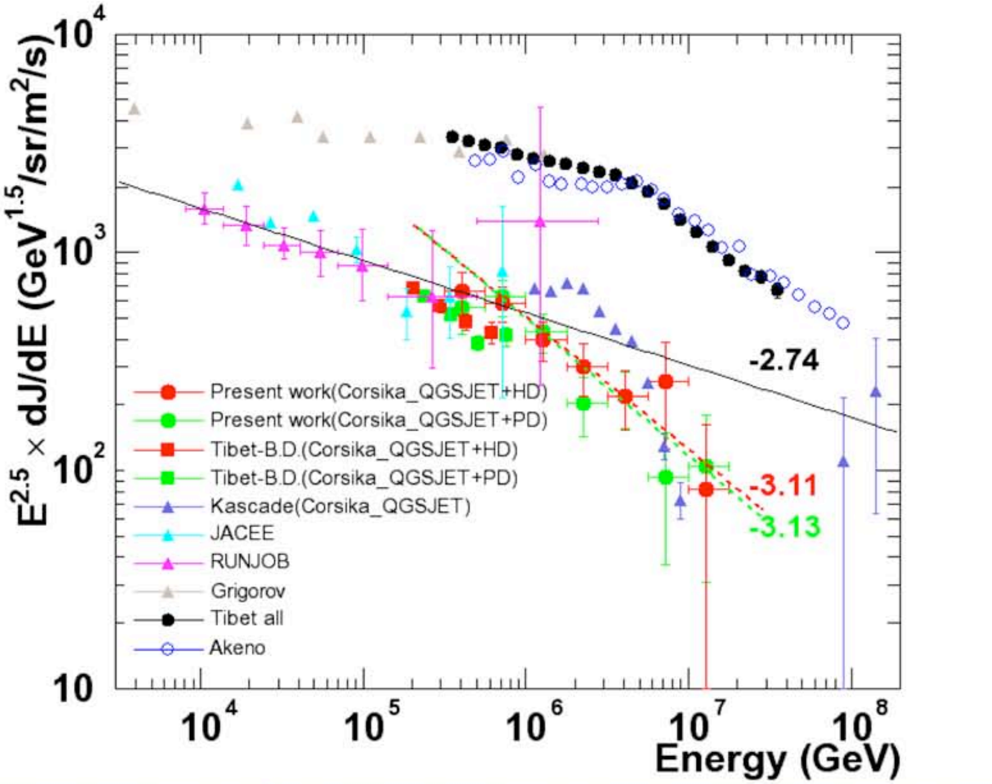
Uncertainty due to the hadronic models

Chemical Composition AROUND THE KNEE from the Tibet Array

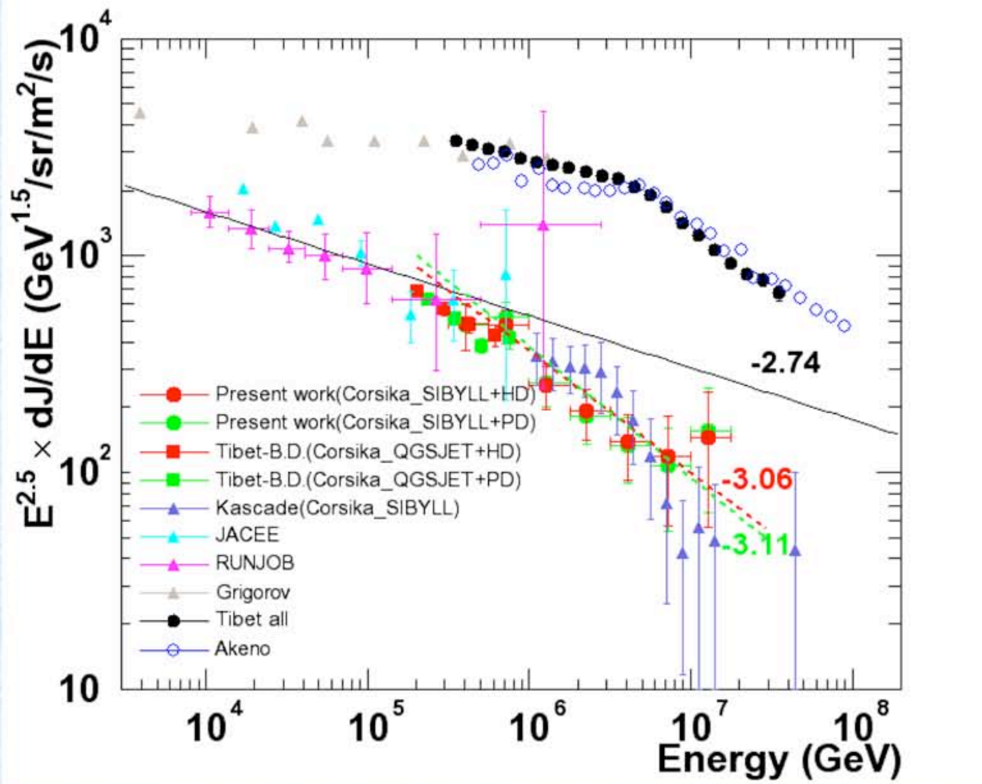
- MUCH MORE DISCUSSION ON THE TOPIC IN OTHER SESSIONS

Tibet Array: THE PROTON SPECTRUM

QGSJET

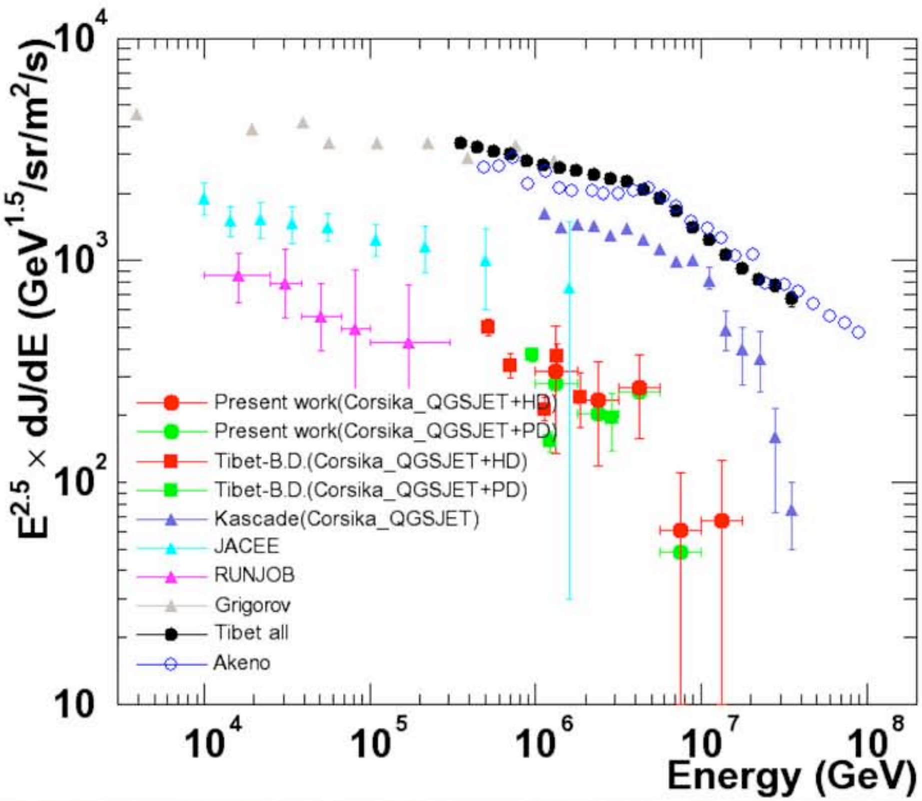


SIBYLL

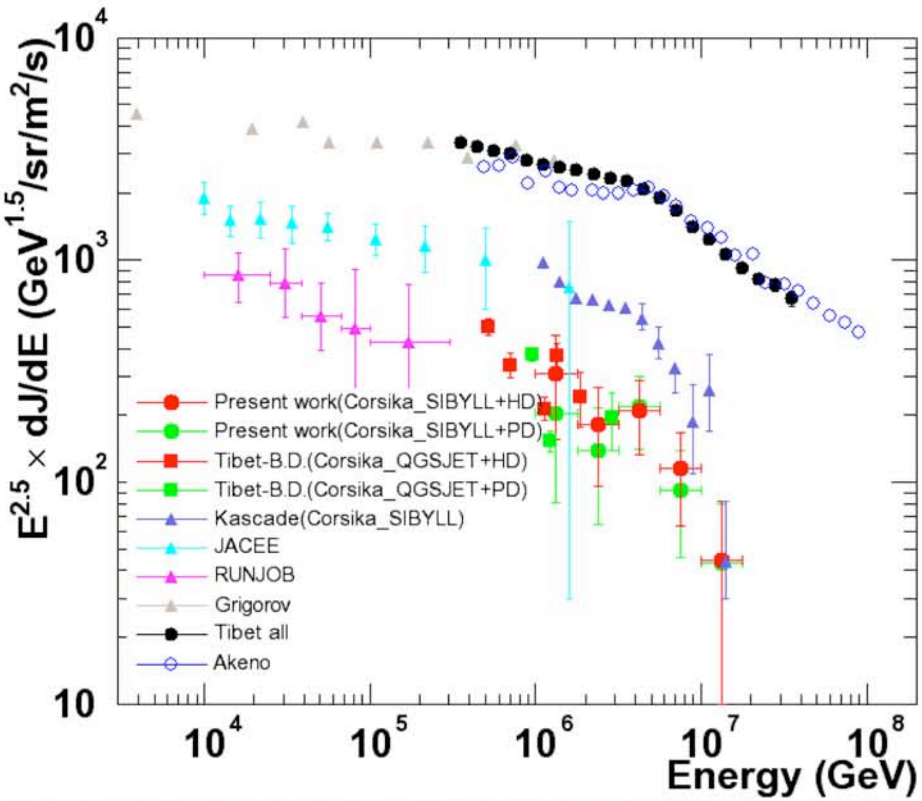


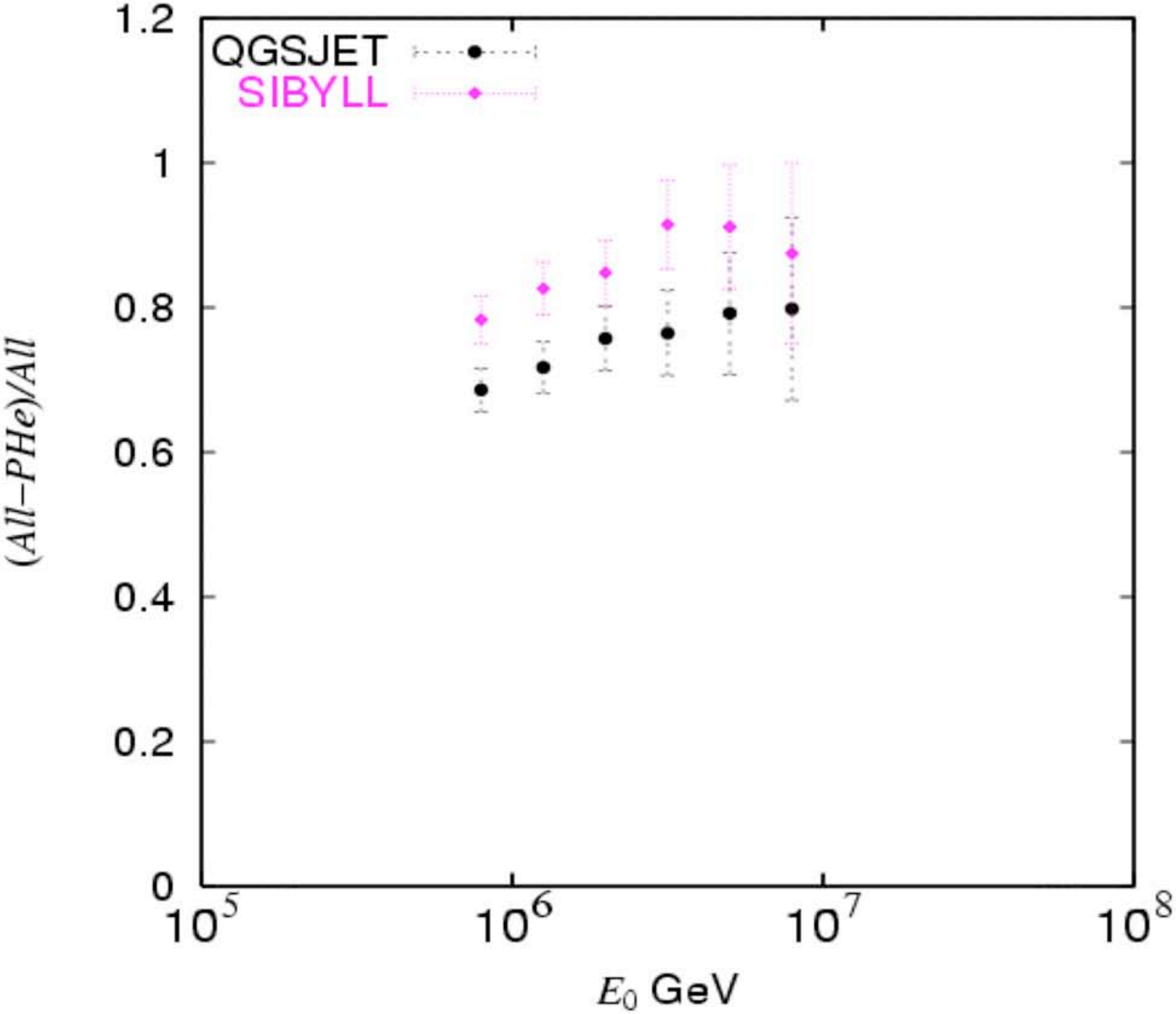
Tibet Array: THE HELIUM SPECTRUM

QGSJET

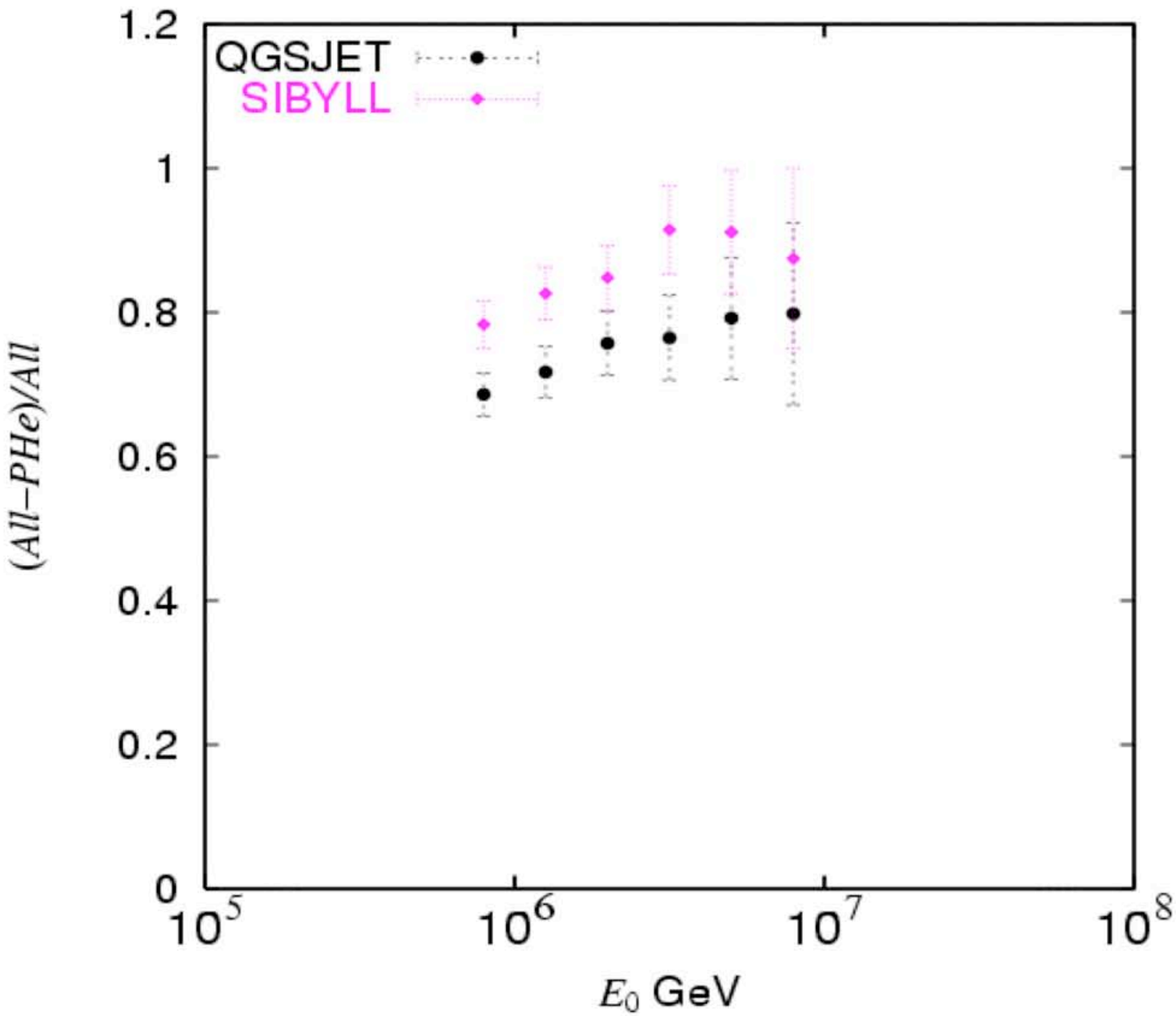


SIBYLL





QGSJET
SIBYLL
(All−PHe)/All
E_0 GeV
1.2
1
0.8
0.6
0.4
0.2
0
10^5
10^6
10^7
10^8



The fraction of Heavy elements

LET'S TRY TO PUT THESE FINDINGS IN THE RIGHT CONTEXT WITH THE HELP OF THE THEORY PAPERS PRESENTED IN THE SESSION …

I. Acceleration of CR's

II. Propagation of CR's in the Galaxy

III. Transition from Galactic to Extra-Galactic

IV. Secondary indicators of propagation (gamma rays, …)

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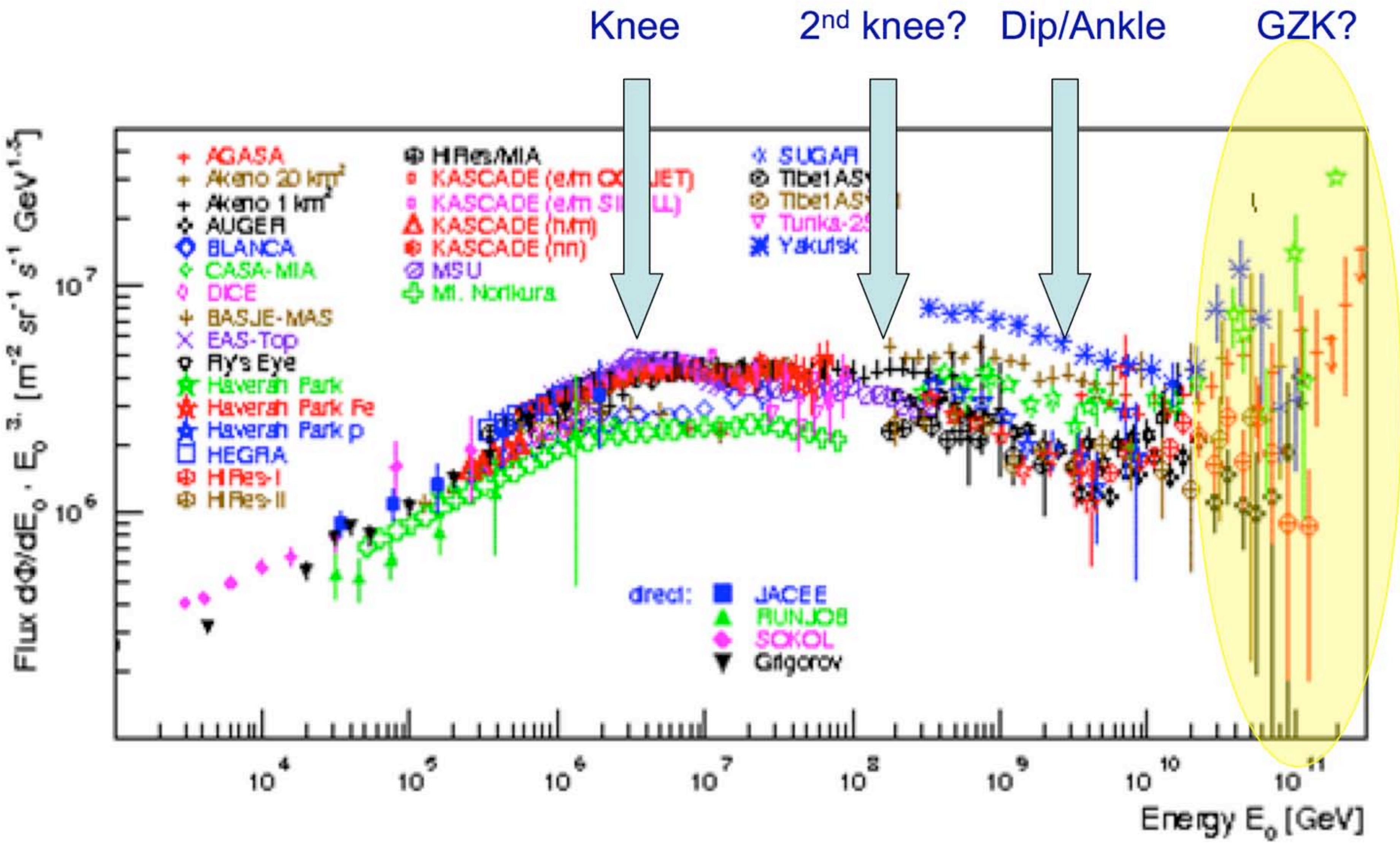
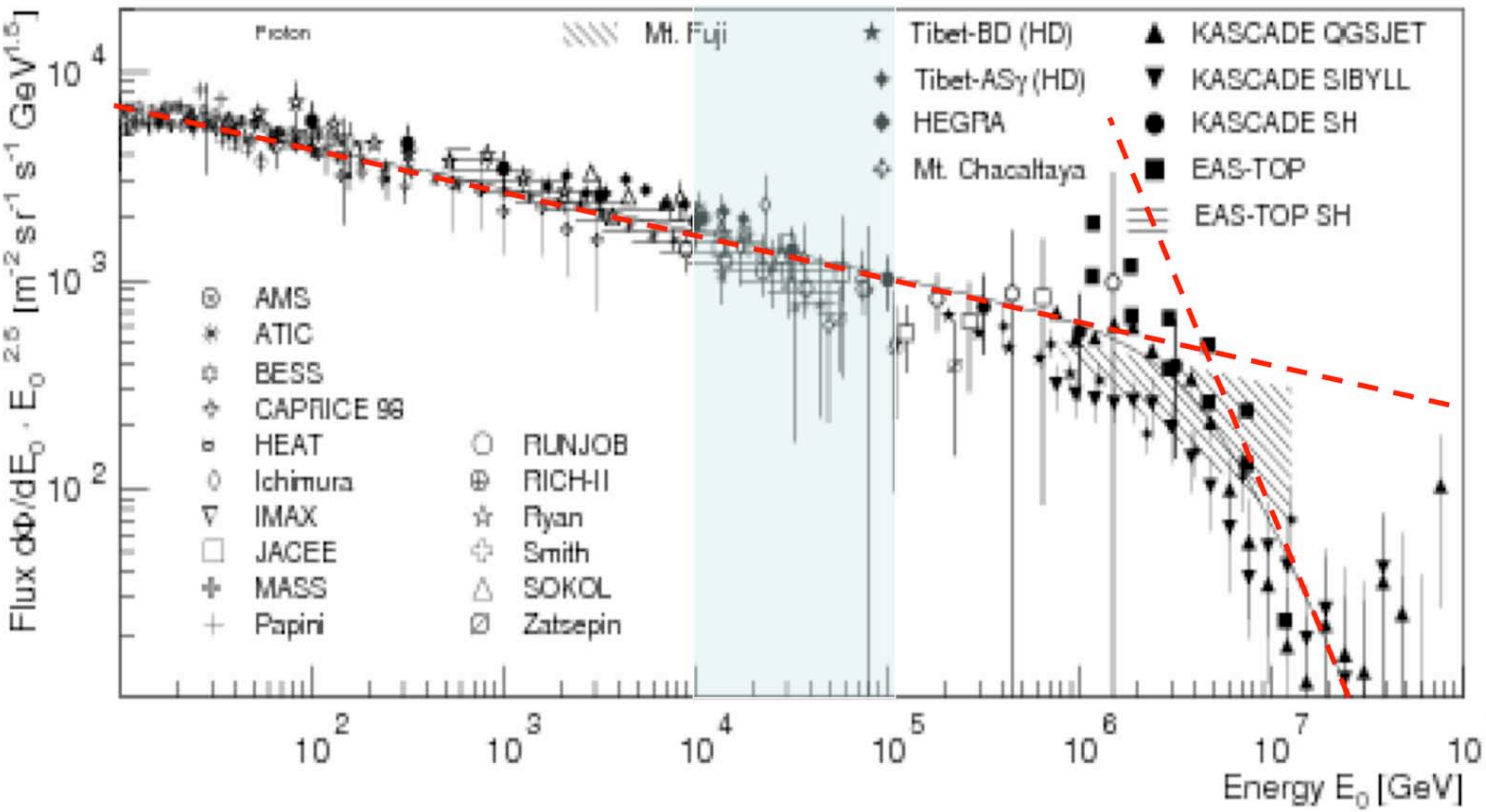
APOLOGIES HERE FOR INVADING OTHER SESSIONS, ESPECIALLY HE…BUT SOME ASPECTS CAN BE UNDERSTOOD ONLY BY LOOKING AT THE PROBLEM WITH A BIRD-EYE VIEW

ACCELERATION OF CR's



From the point of view of acceleration the most crucial issue is the spectrum of protons...IT'S THE BEST MEASURED!



Summary of the Supernova Remnant paradigm

- Cosmic Rays are accelerated by Fermi acceleration at SNR shocks
- Power laws of the type $E^{-\gamma}$ are usually assumed to be generated naturally, with slope around $\gamma=2$
- The spectra observed at the Earth are modified by diffusive propagation in the Galaxy

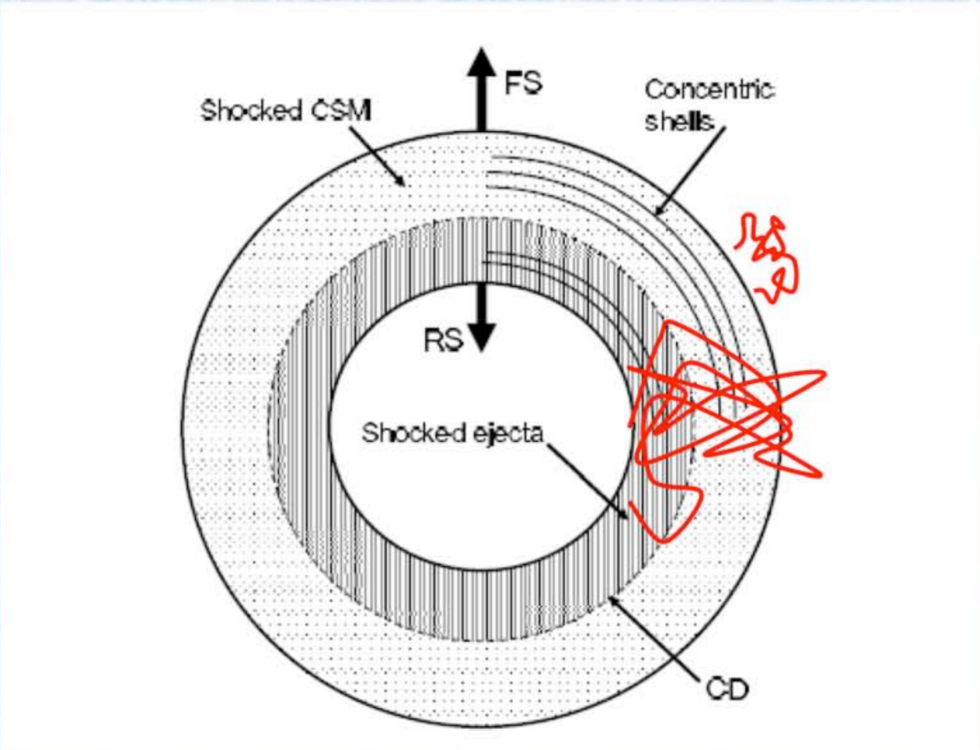
$$Q(E) = \frac{N(E)}{\tau_{escape}(E)} + \frac{N(E)}{\tau_{spall}(E)}$$

$$\tau_{escape}(E) \propto E^{-\delta}$$

When spallation losses (for nuclei) or nuclear losses (for protons) are negligible…

$$N(E) = Q(E)\tau_{escape}(E) \propto E^{-\gamma-\delta}$$

The Maximum Energy of Protons



UP DOWN

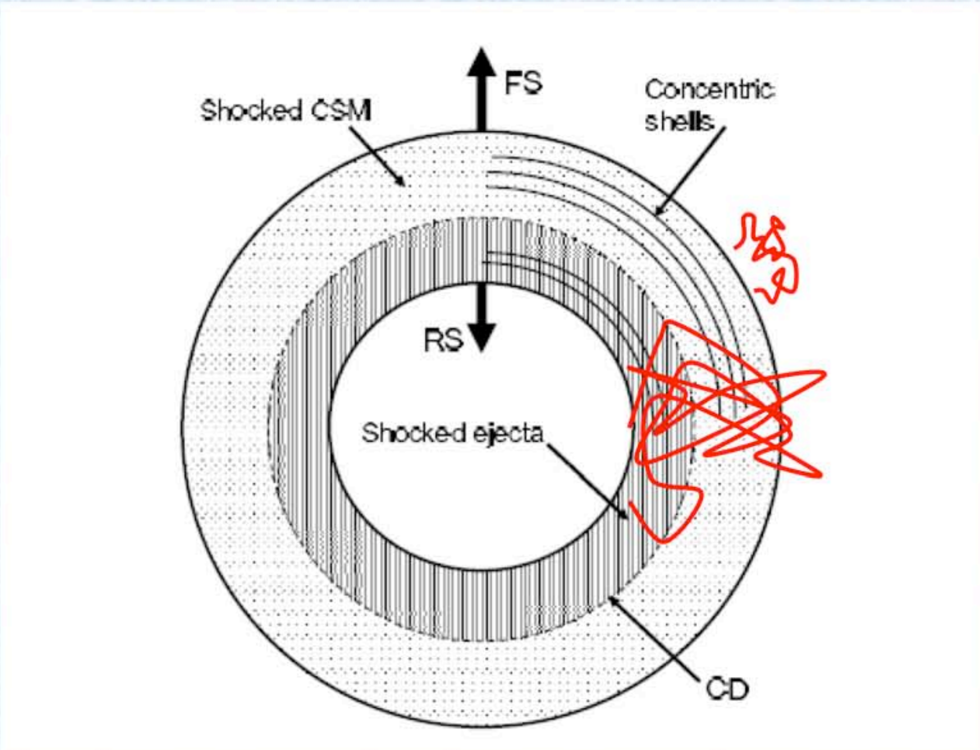
$$\hat{o}_{acc}(E) = \frac{3}{u_1 - u_2}\left[\frac{D_1(E)}{u_1} + \frac{D_2(E)}{u_2}\right]$$

IF ONE ADOPTS A DIFF COEFF INFERRED FROM B/C FOR THE ISM, say $D(E)=10^{28}\ E^{0.6}\ cm^2\ s^{-1}$ THE MAX ENERGY IS

1-10 GeV !!!

If the ISM field is put in the form of a Bohm diffusion, the Max energy evaluate by Lagage & Cesarsky (1983) is 10^4-10^5 GeV

The Maximum Energy of Protons



UP DOWN

$$\hat{o}_{acc}(E) = \frac{3}{u_1 - u_2}\left[\frac{D_1(E)}{u_1} + \frac{D_2(E)}{u_2}\right]$$

IF ONE ADOPTS A DIFF COEFF INFERRED FROM B/C FOR THE ISM, say $D(E)=10^{28}\ E^{0.6}\ cm^2\ s^{-1}$ THE MAX ENERGY IS

1-10 GeV !!!

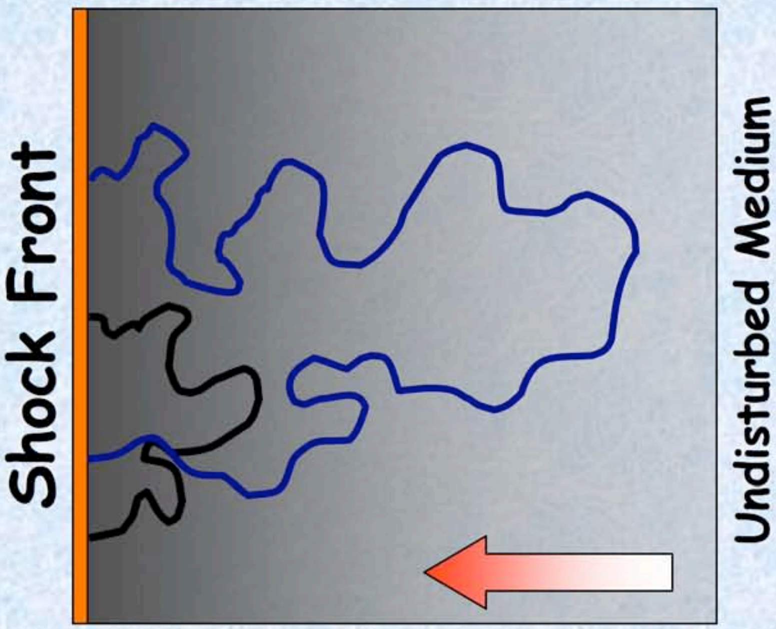
If the ISM field is put in the form of a Bohm diffusion, the Max energy evaluate by Lagage & Cesarsky (1983) is 10^4-10^5 GeV

1. **Strong dependence, at given B, on the D(E)**
2. **Magnetic field isotropization and amplification**

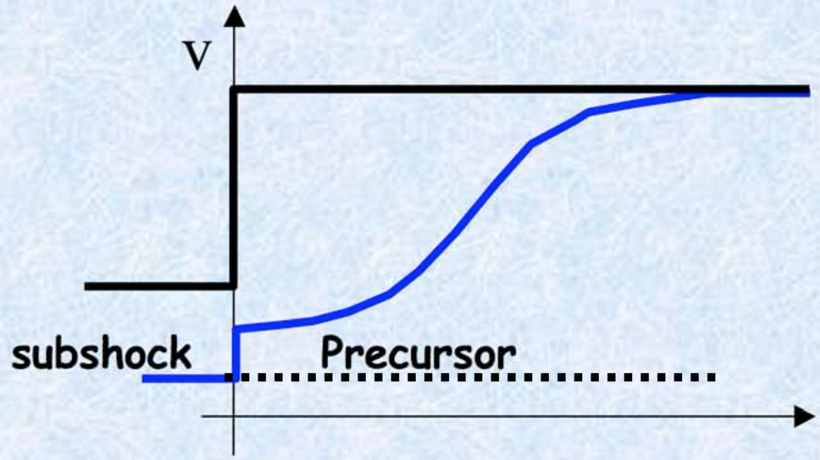
Developments in the Theory of Diffusive Shock Acceleration (DSA)

- NON LINEAR THEORY OF DSA (Analytical: PB&Amato, OG341; Numerical: Berezhko&Volk, OG111; Edmon,Jones & Kang, OG789)
- MAGNETIC FIELD AMPLIFICATION BY STREAMING INSTABILITY (PB&Amato, OG342; Niemiec&Pohl, OG1047)
- PHENOMENOLOGY OF SNR's IN THE CONTEXT OF NON LINEAR DSA (Berezhko et al., OG597,OG614)
- MHD MAGNETIC FIELD AMPLIFICATION, UNRELATED TO ACCELERATED PARTICLES, AT PERPENDICULAR SHOCKS (Jokipii&Giacalone, OG078)
- TIME DEPENDENT ACCELERATION AT MODIFIED SHOCKS (also multiple shocks) (Ferrand et al., OG995; Edmon et al., OG789)

Theory of nonlinear DSA



Berezhko & Volk, OG111
Blasi&Amato, OG341



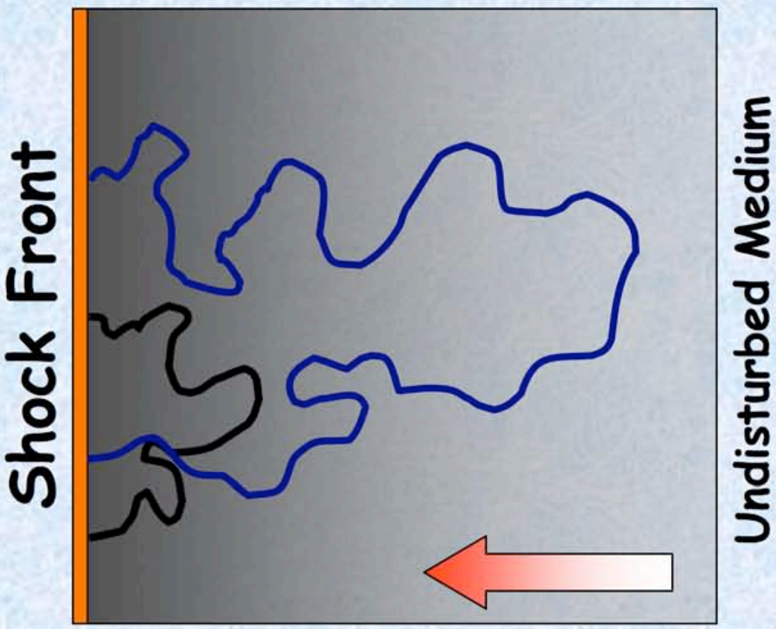
BASIC CONSEQUENCES:

1) Concave Spectra (steeper at low E and harder at high E)

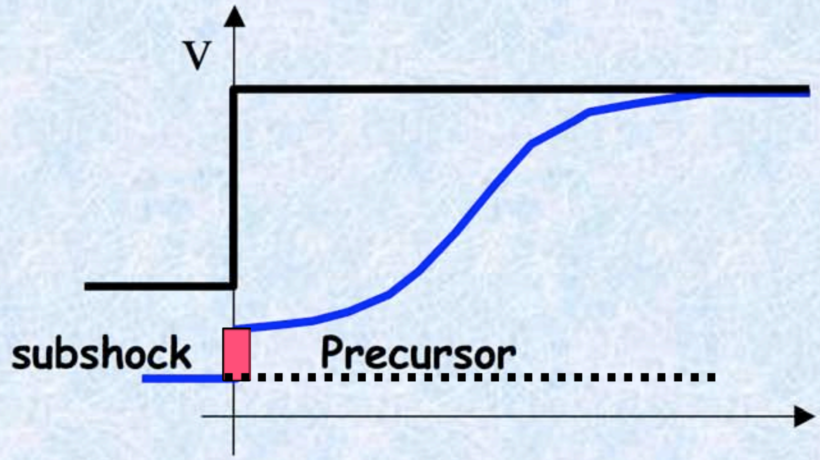
2) Suppression of thermal heating downstream of the shock

3) Large efficiency of conversion of ρu^2 into cosmic rays

Theory of nonlinear DSA



Berezhko & Volk, OG111
Blasi&Amato, OG341



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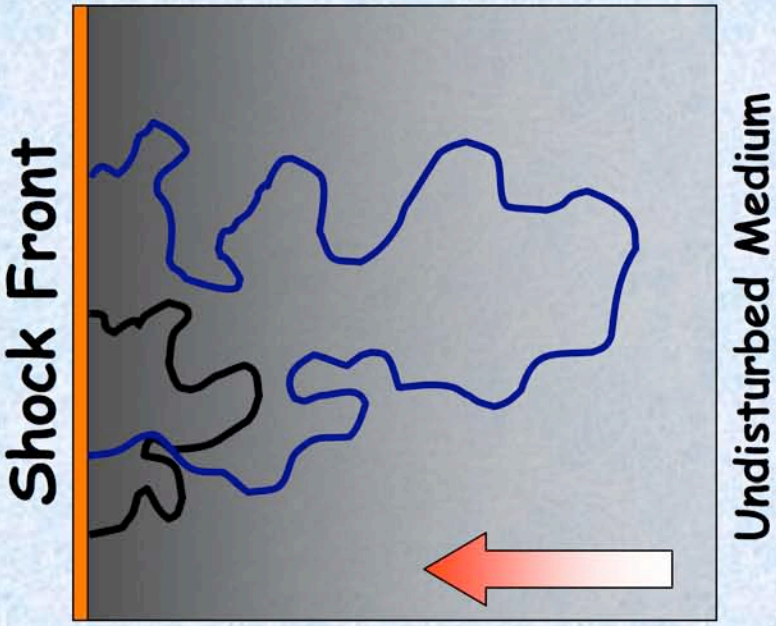

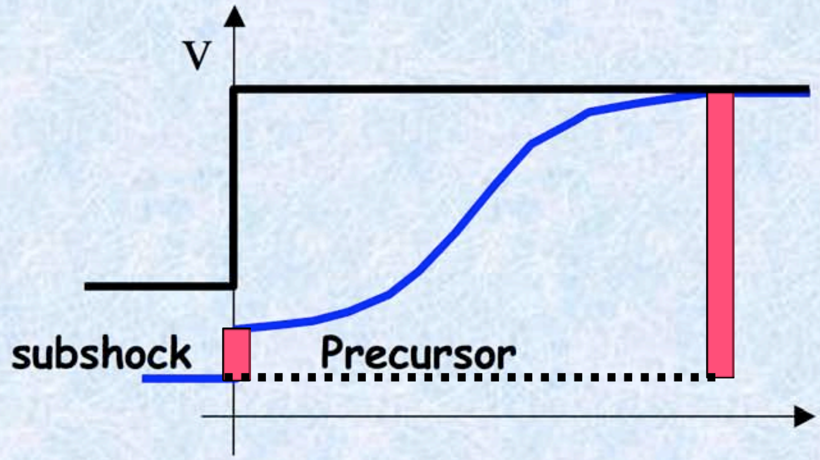

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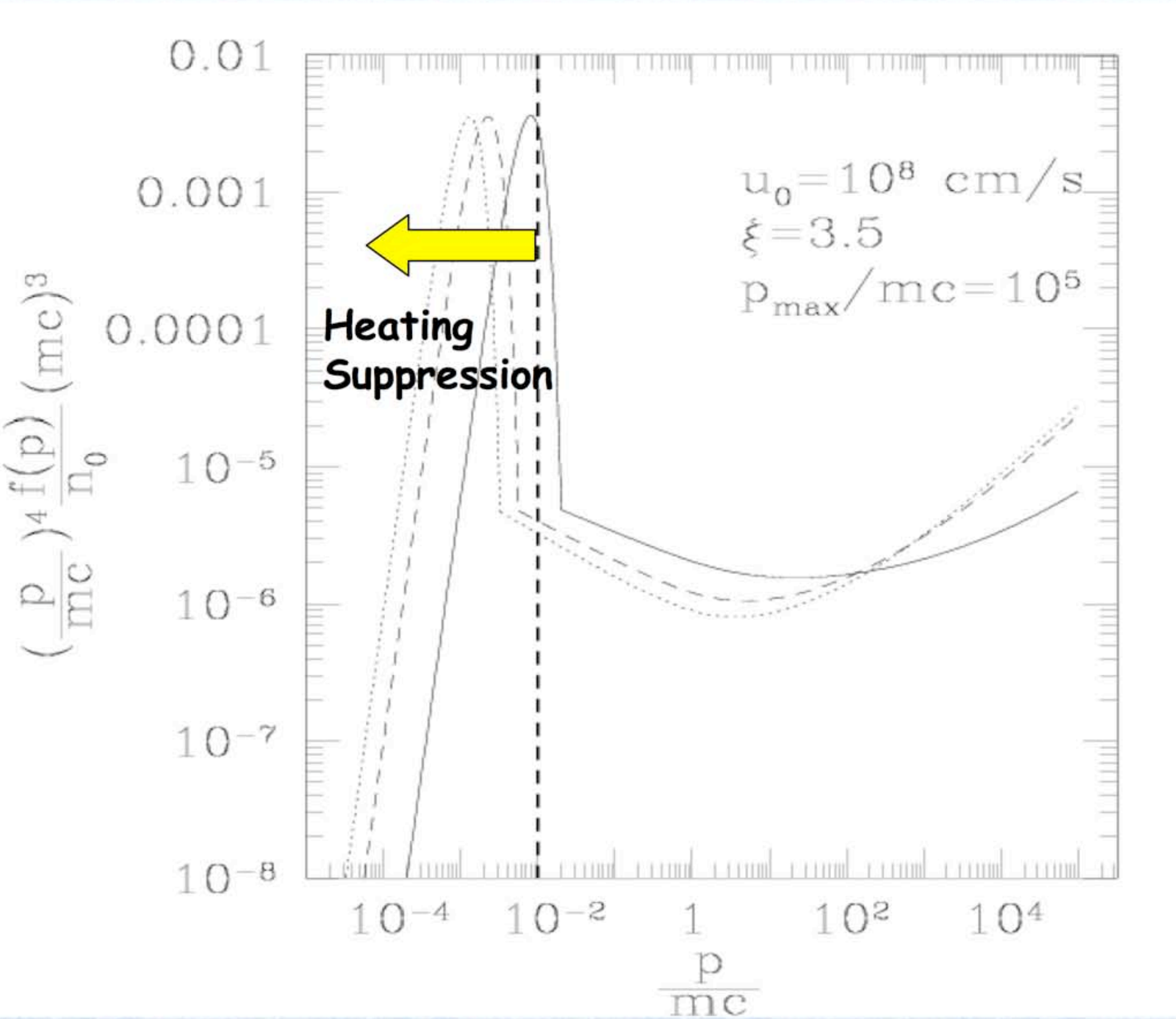
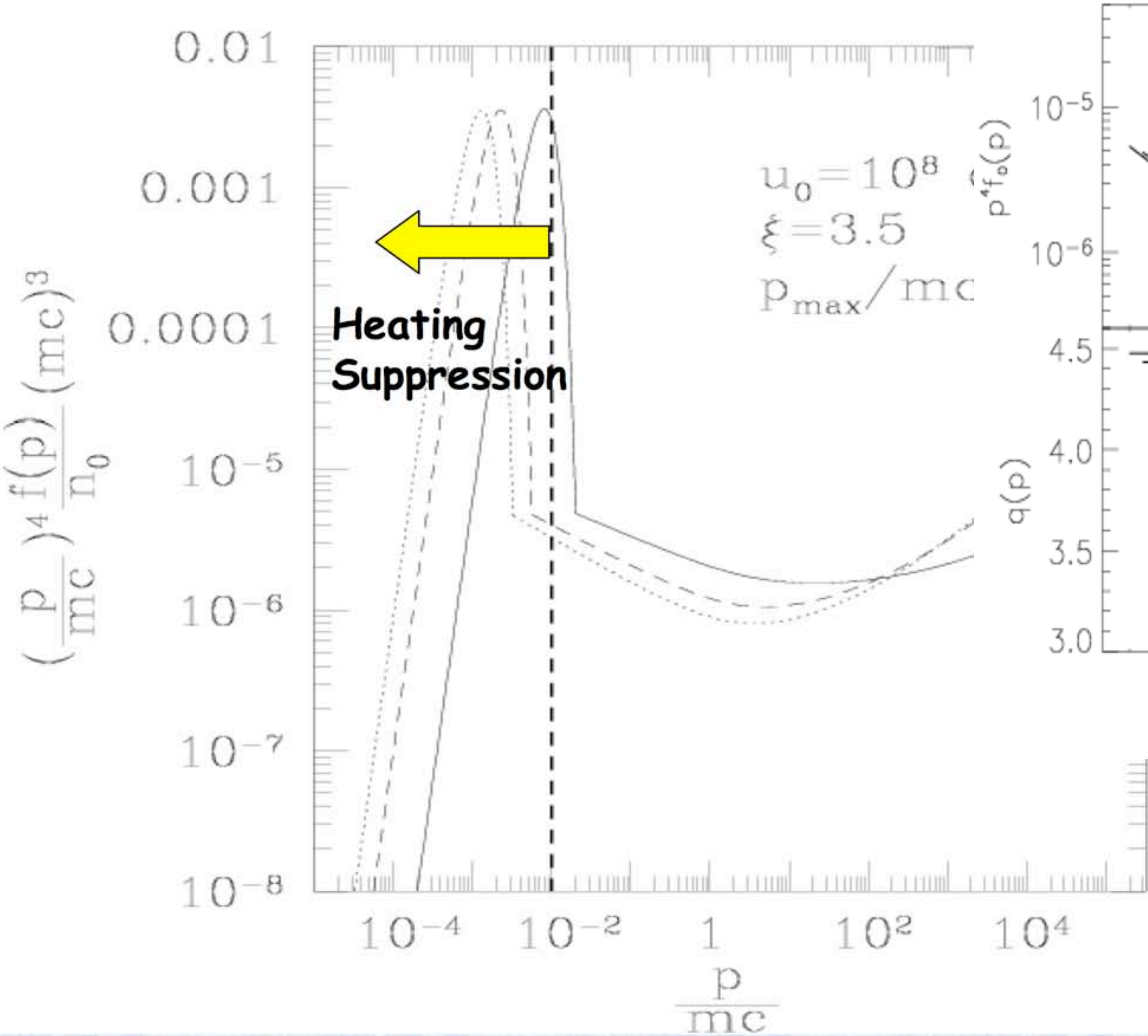
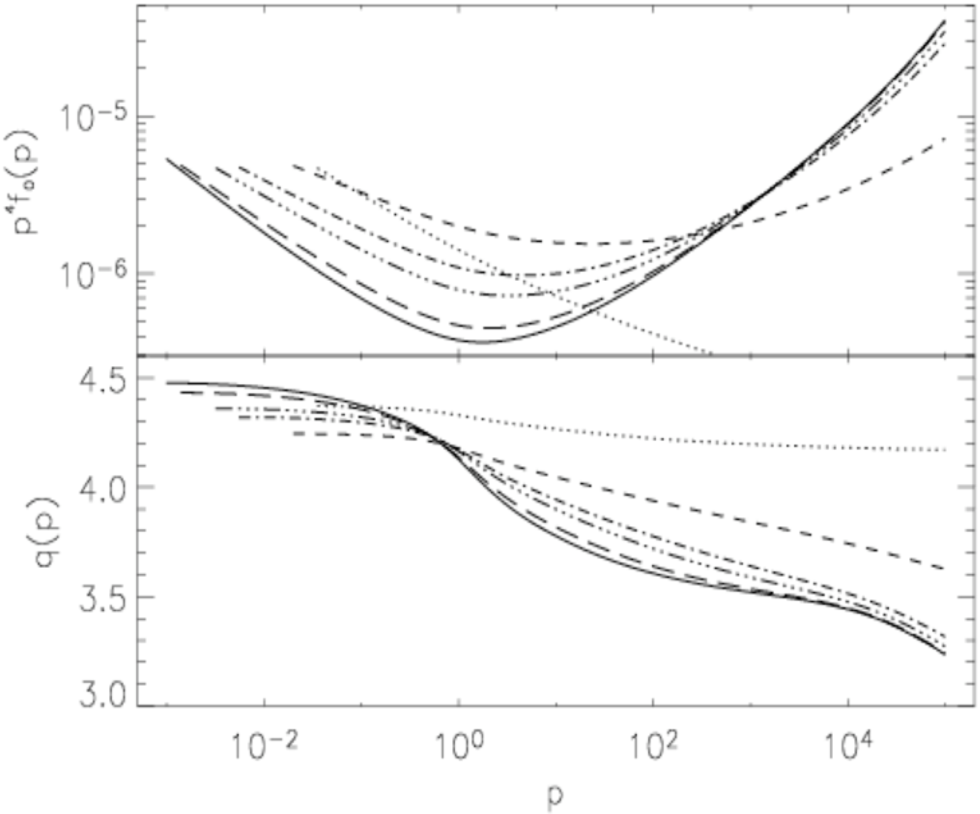
Concave Spectra



PB&Amato,OG341

Concave Spectra





PB&Amato,OG341

Delicate issues

- The so-called turbulent heating of the plasma upstream is crucial. If it is not included the spectra are too modified. Problem is that we only have phenomenological recipes to do it…unsettling

- In a non-linear system like this, each aspect influences all others in a complex way (concavity, max momentum, …)

- Diffusion coefficient?

MAGNETIC FIELD AMPLIFICATION

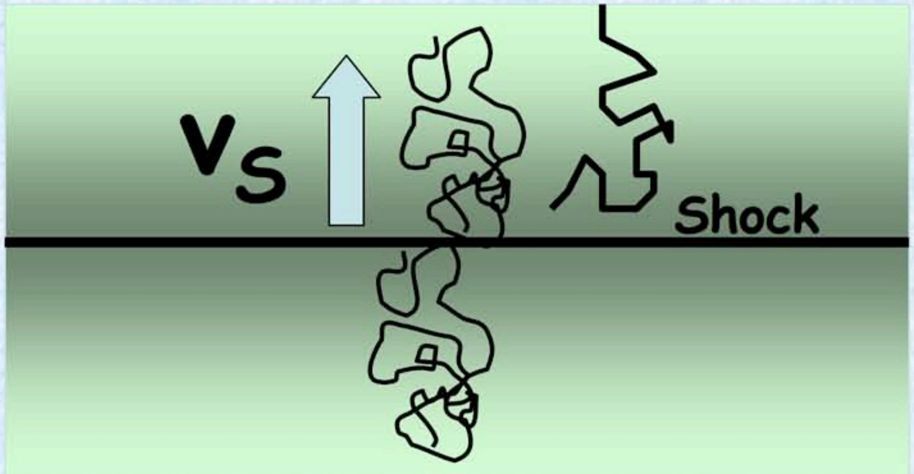
- **Resonant Streaming Instability** (Achterberg 1983, Zweibel 1978, Bell 1978)

- **Non-resonant Streaming Instability** (Bell 2004)

- **Firehose Instability** (Blandford & Achterberg)

- **MHD amplification** (Giacalone & Jokipii, OG78)

MAGNETIC FIELD AMPLIFICATION IN A NUTSHELL



$$\frac{dP_{CR}}{dt} = \frac{n_{CR}\, m\, \Gamma_{CR}\, (v_D - v_A)}{\tau}$$

RATE OF MOMENTUM LOST BY CR

BUT THIS MUST EQUAL THE RATE OF MOMENTUM GAIN BY THE WAVES

$$\frac{dP_W}{dt} = \gamma_W \frac{\delta B^2}{8\pi} \frac{1}{v_A}$$

GROWTH RATE OF WAVES

BY REQUIRING EQUILIBRIUM:

$$\boxed{\gamma_W = \frac{n_{CR}}{n_{gas}} \Omega_{cyc} \left(\frac{v_D - v_A}{v_A}\right)}$$

AMPLIFICATION '*a la BELL*'

- Bell (2004) proposed that the a "purely growing non-Alfvenic non-resonant mode" was to be found for a background plasma in MHD approximation

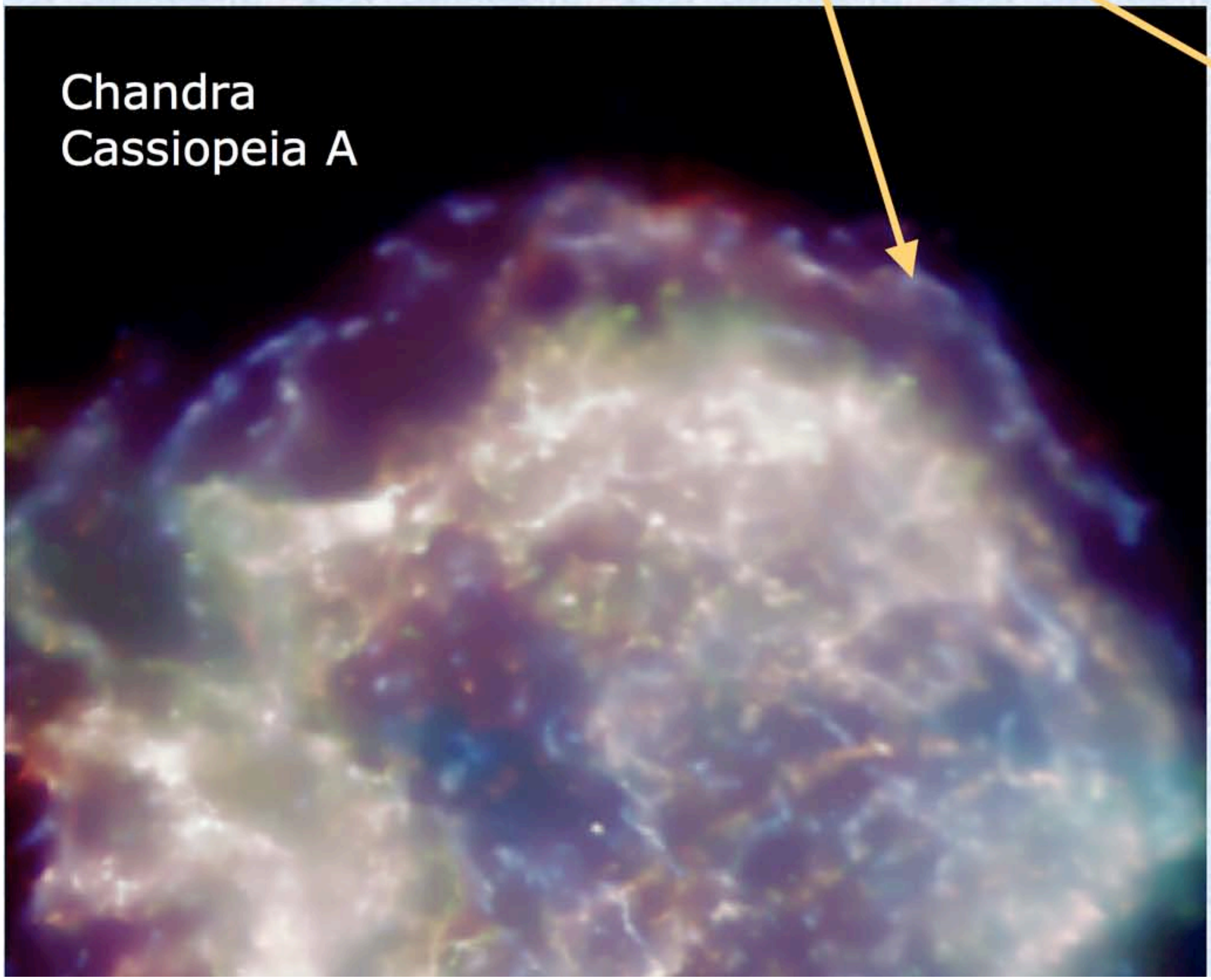
- This mode was calculated to lead to very fast growth of the waves and eventually saturate to levels that for a SNR would be $\delta B/B \sim 100-1000$

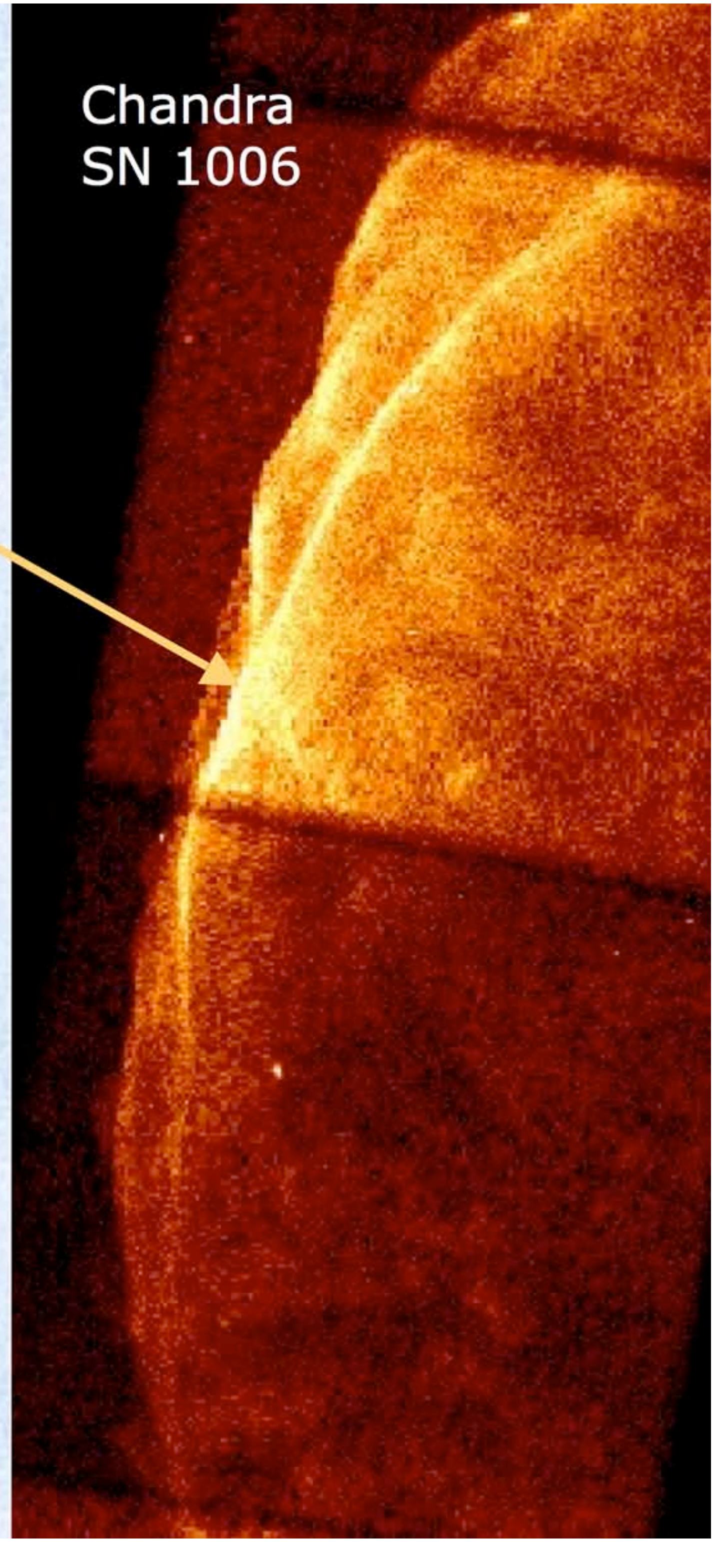
- This avenue was immediately recognized as a way to <u>reach the knee</u>

- But seems also required to explain X-ray observations of SNRs

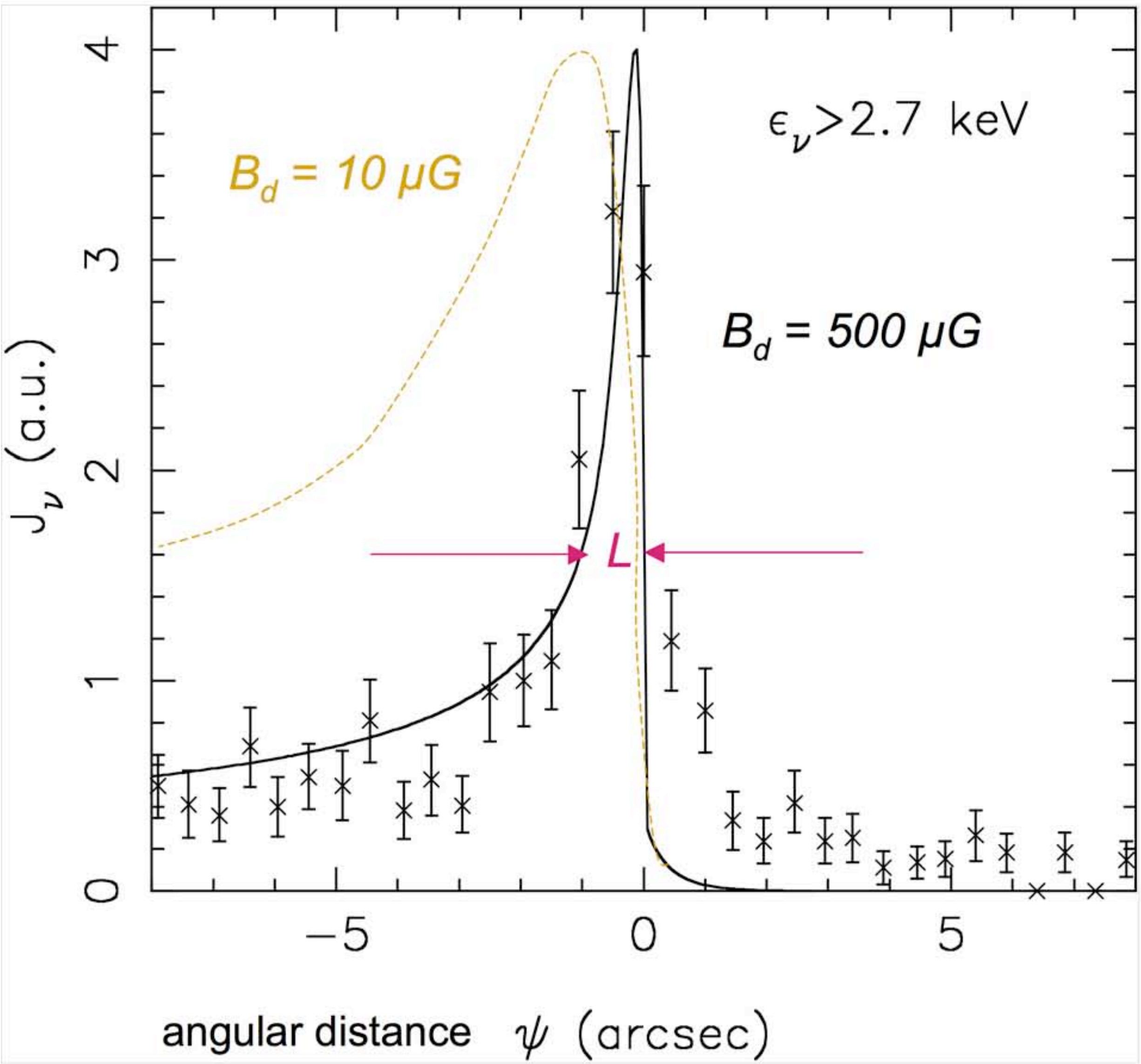
Filamentary structure of X-ray emission of young SNRs

Berezhko&Volk, OG111

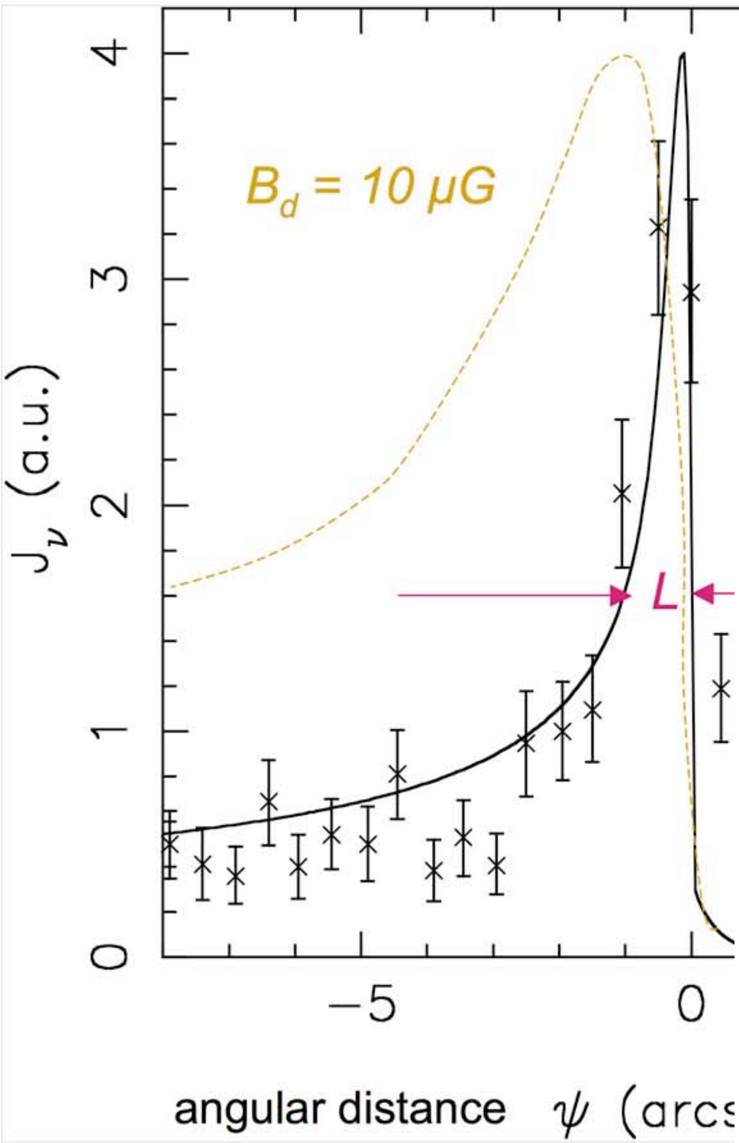


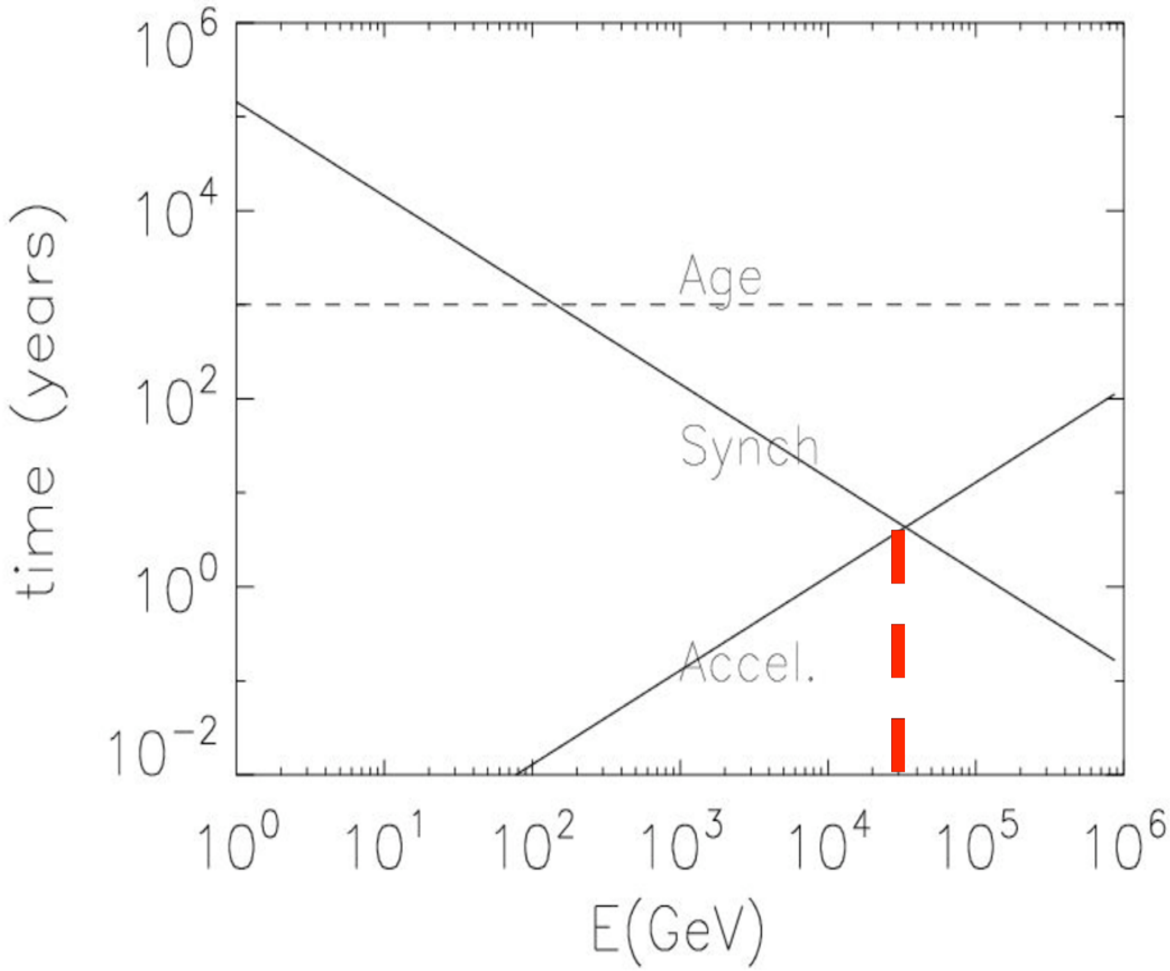


The X-ray gift…



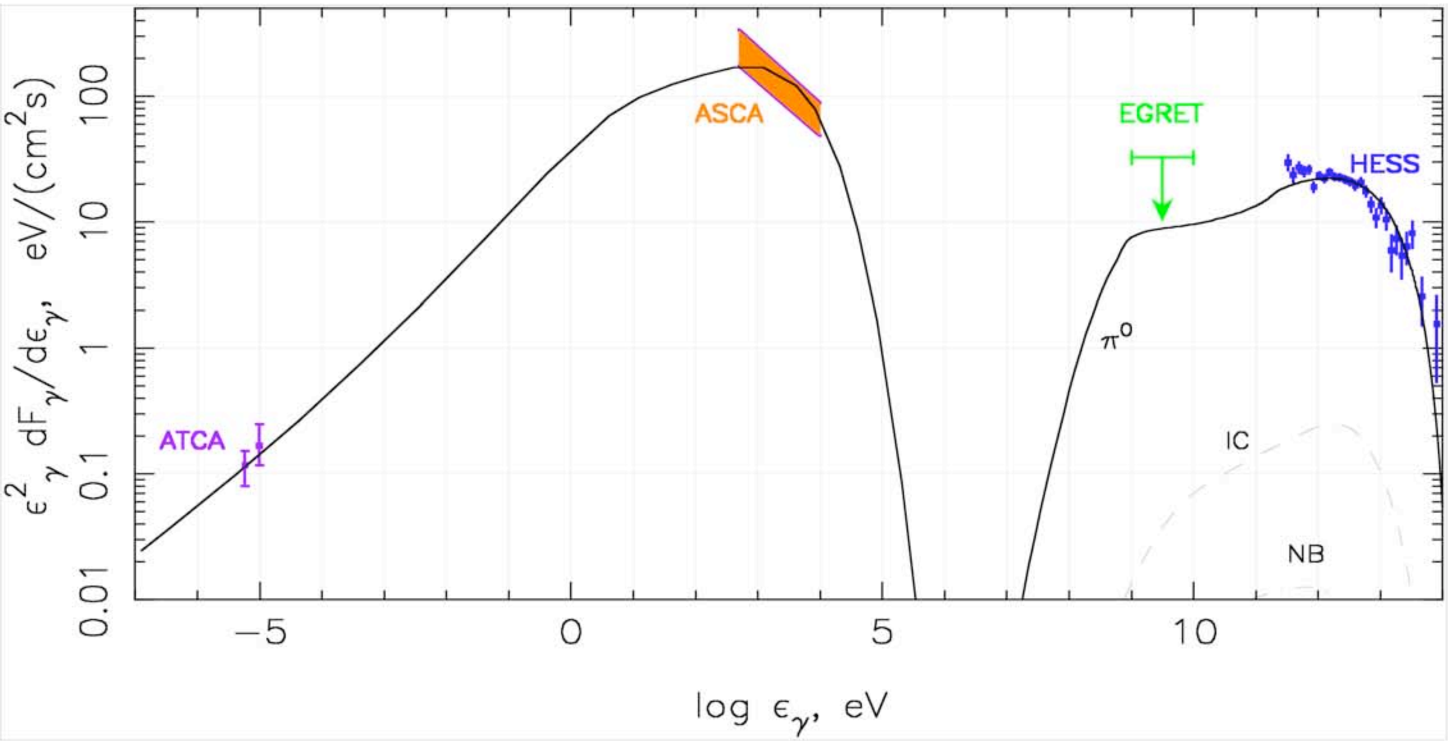
The X-ray gift…





Spatially integrated spectral energy distribution of RX J1713.7-3946

Theory: *Berezhko & Völk (2006)*



required interior magnetic field

B_d = 126 μG

THE PHYSICS IS IN THE CUTOFFS

BUT back to Acceleration…

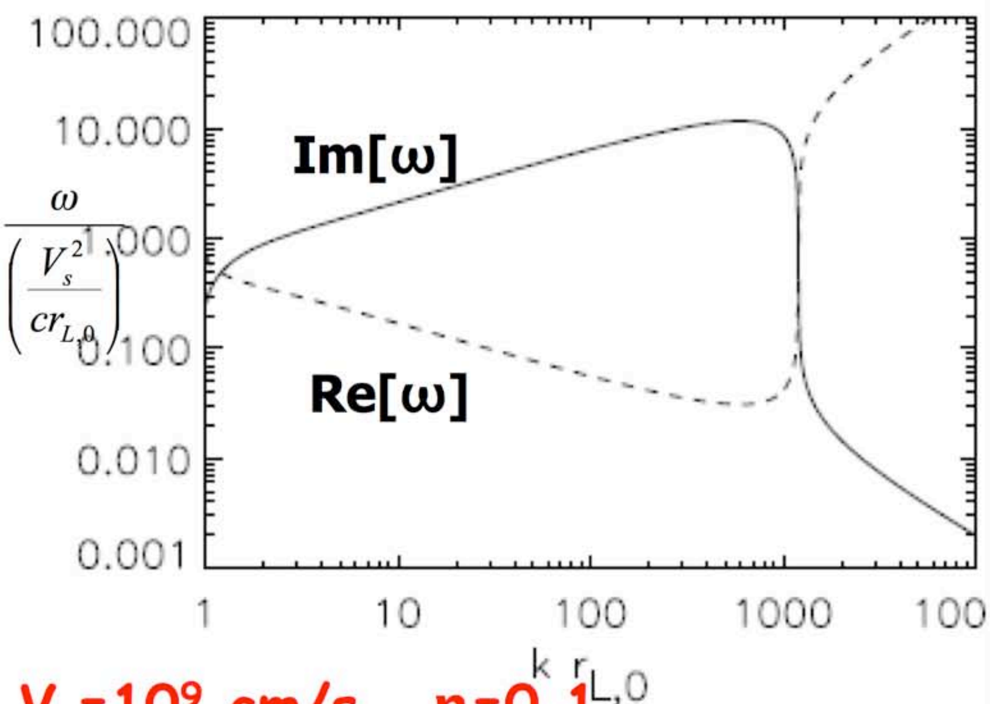
- In principle the previous arguments only show that there is magnetic field amplification, NOT that it is due to CR's

- The nature of the B-amplification 'a la Bell' needs to be investigated, both analytically and with PIC simulations (possibly with Hybrid simulations as well)

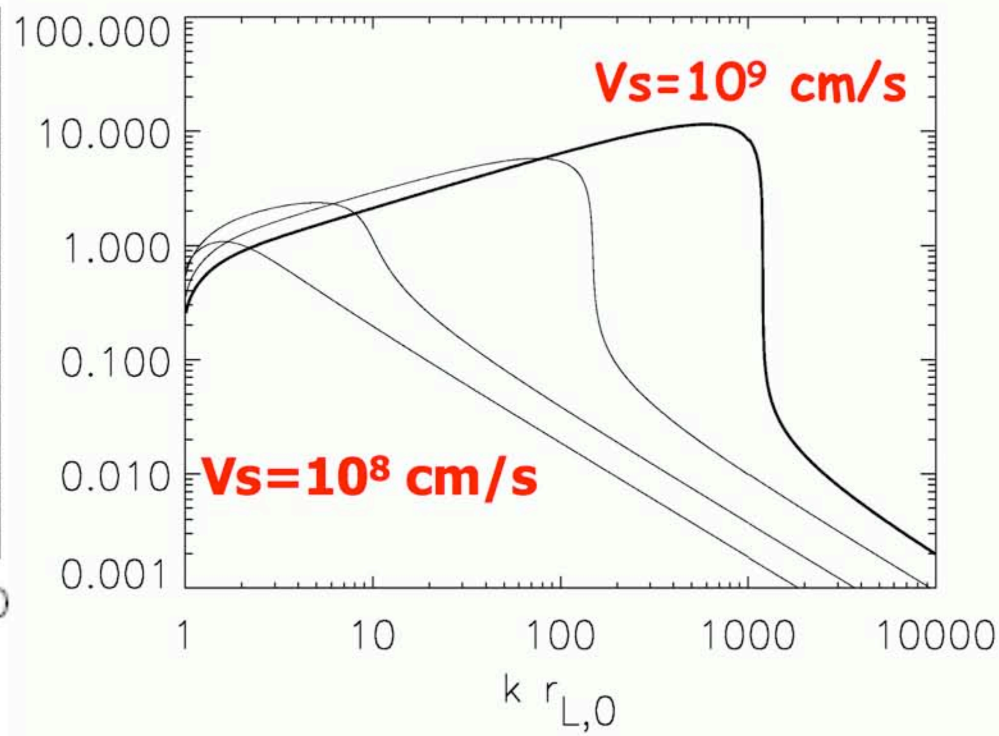
- Alternative B-field amplification can be proposed, but do they also imply efficient acceleration?

On the nature of the Bell instability

- PB & Amato (OG342) have shown that the instability is NOT a consequence of the MHD approximation: a kinetic approach leads to the same dispersion relation and the same modes



$V_s=10^9$ cm/s $\eta=0.1$



PIC Simulations (Niemiec & Pohl, OG1047) seem to NOT Confirm the growth found by Bell in 2004…More Investigations needed…

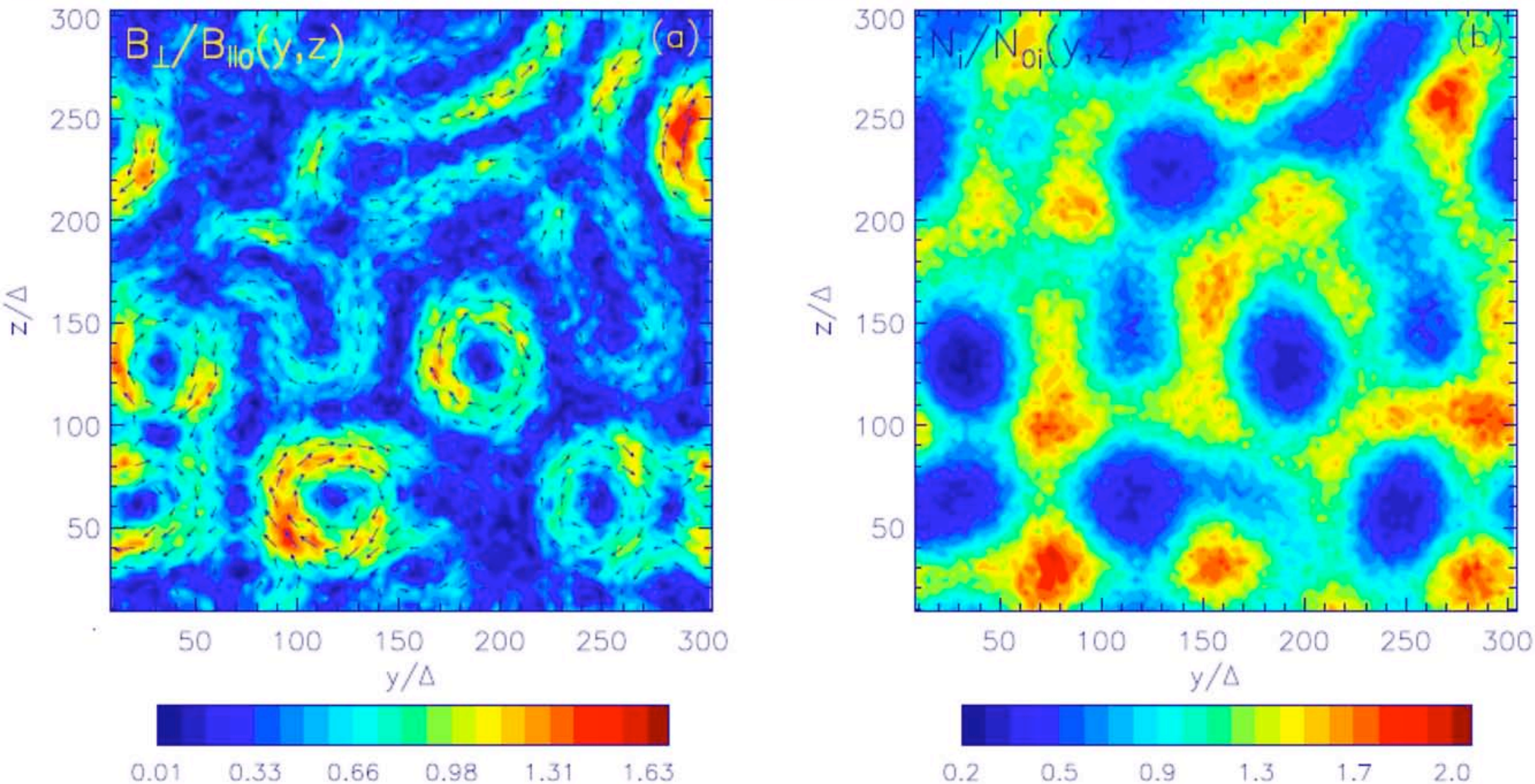
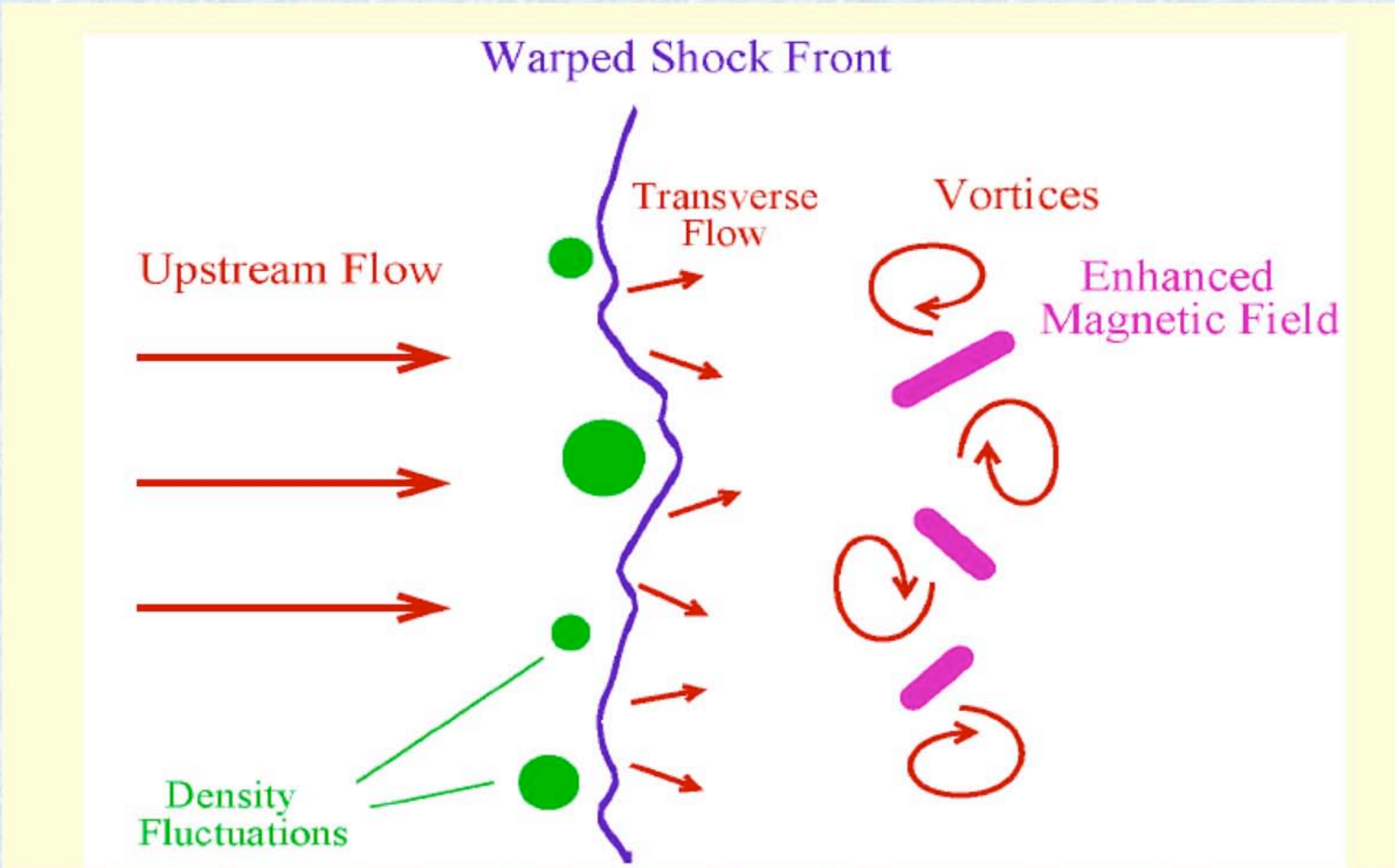


Figure 3: The magnitude and direction of the perpendicular magnetic field component $B_\perp = (B_y^2 + B_z^2)^{1/2}$ (a) and the ambient ion density N_i (b) in the plane perpendicular to the cosmic-ray ion drift direction at $x/\Delta = 500$ and $t \approx 10\gamma_{max}^{-1}$. $B_\perp$ is normalized to the amplitude of the homogeneous field $B_{\|0}$, and N_i to the initial ambient ions density. The electron distribution follows that of ambient ions.

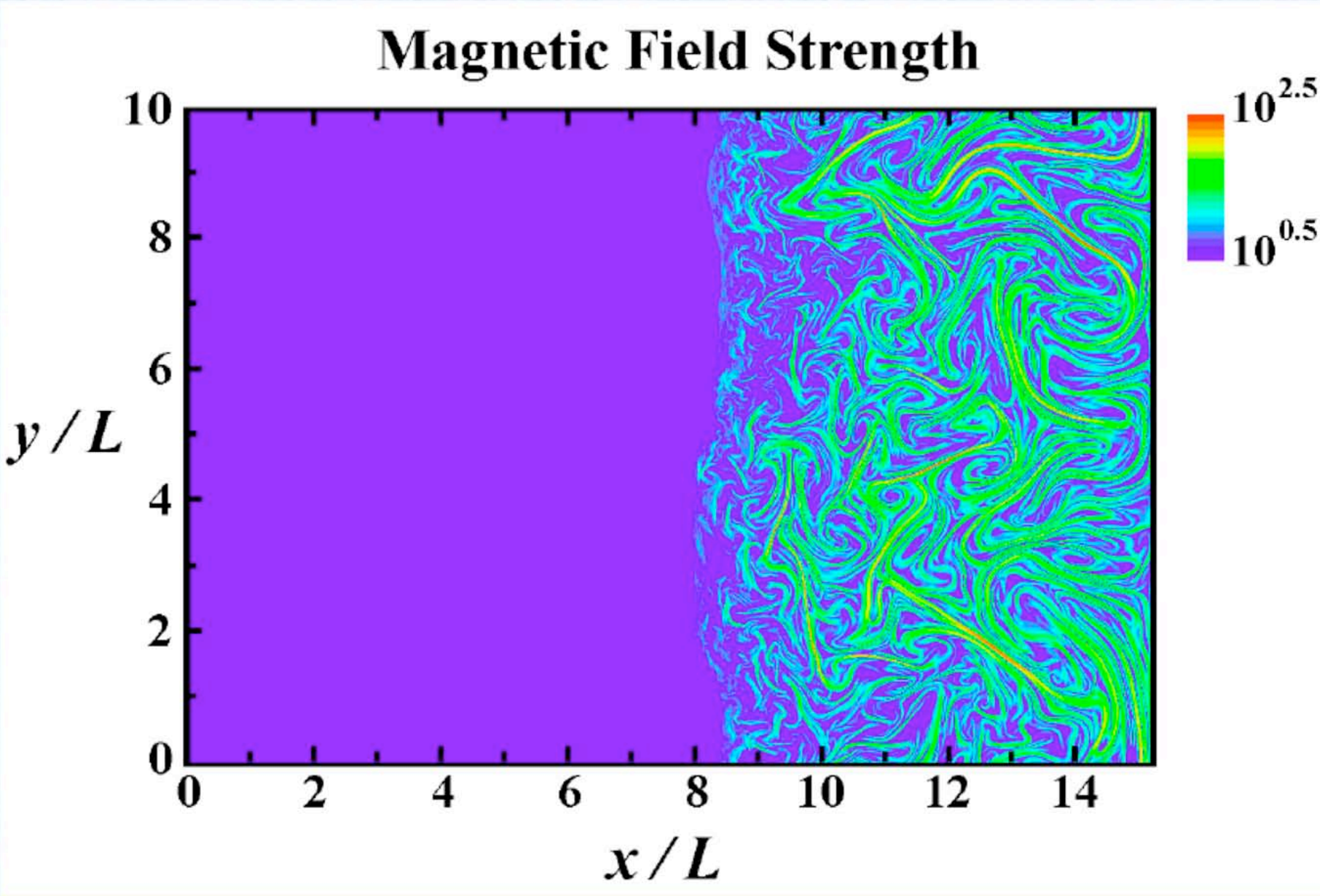
Giacalone & Jokipii, OG078

An alternative to Streaming Instability

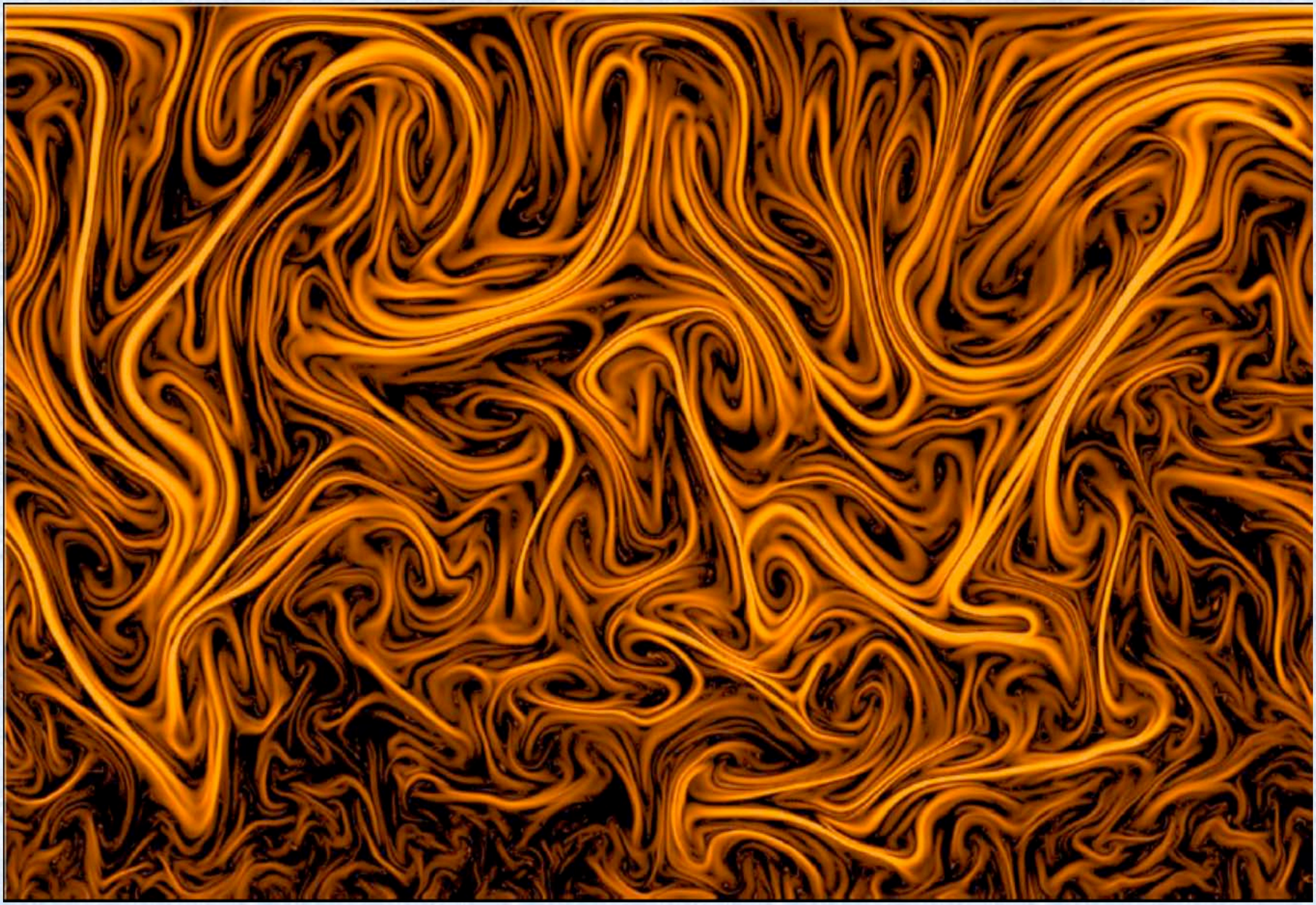


$$\frac{B_2^2}{8\pi} \simeq P_2 \simeq \rho_1 U_1^2 \simeq \frac{B_1^2}{8\pi} M_{A1}^2$$

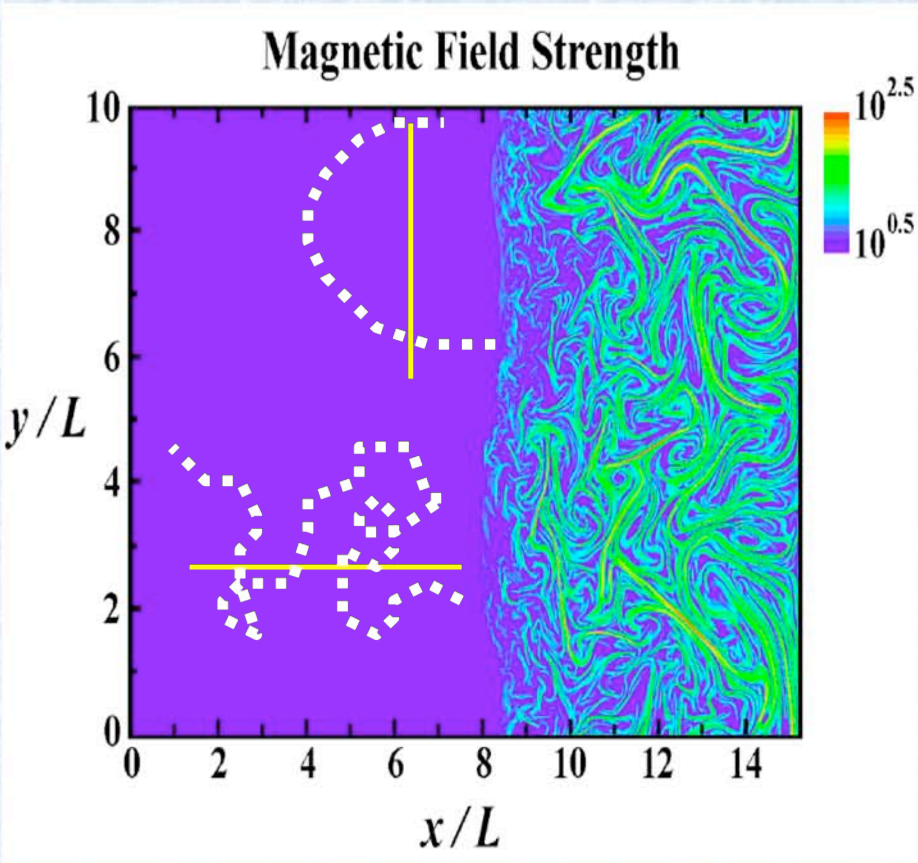
$$B_2 \simeq B_1 M_{A1}$$



Magnetic Field Strength
10
8
6
4
2
0
y / L
0
2
4
6
8
10
12
14
x / L
10^2.5
10^0.5



Does this accelerate particles too?



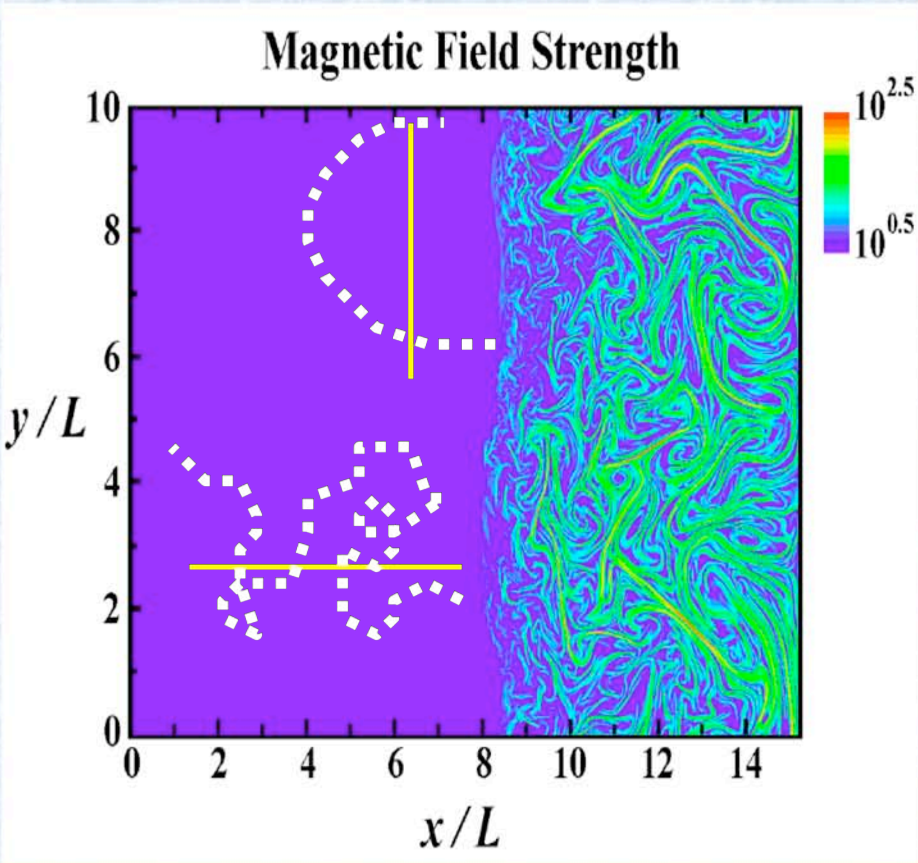
IF the upstream B-field is exactly perpendicular, then you do not even need Diffusion, it's a mirror…

BUT

If the field is NOT perp, then usual diffusion takes place and the acceleration time is then dominated by The upstream part, where NO amplification is present

$$\hat{o}_{acc}(E) = \frac{3}{u_1 - u_2}\left[\frac{D_1(E)}{u_1} + \frac{D_2(E)}{u_2}\right]$$

Does this accelerate particles too?



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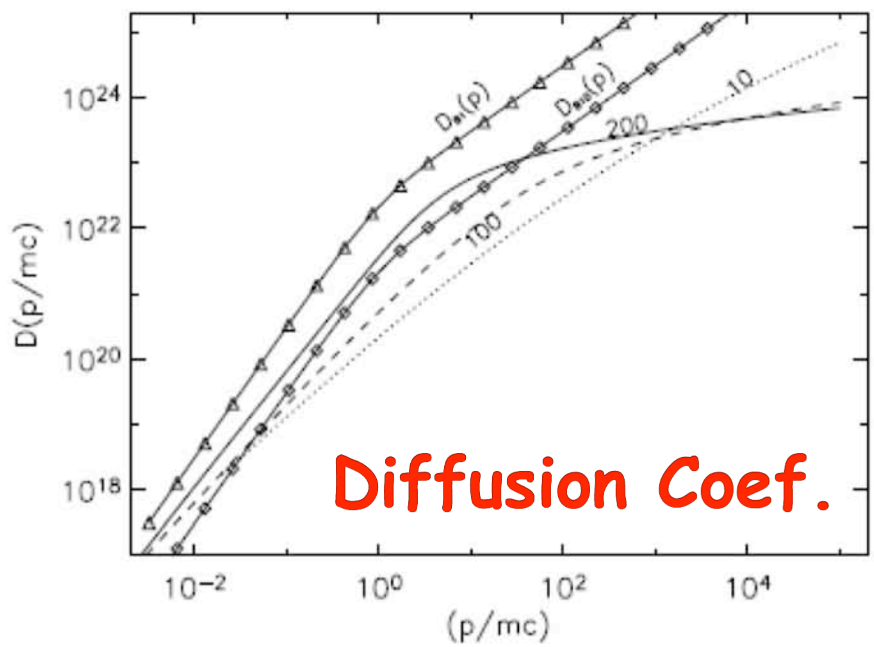
$$\hat{o}_{acc}(E) = \frac{3}{u_1 - u_2}\left[\frac{D_1(E)}{u_1} + \frac{D_2(E)}{u_2}\right]$$

PROBABLY THE STREAMING AMPLIFICATION AND THE TURBULENT ONE ARE BOTH PRESENT AND PLAY COMPLEMENTARY ROLES

Analytical approach to Non-linear DSA with self-generated magnetic field

- DSA can be followed through a semi-analytical kinetic approach
- The main limitation is the time independence
- The advantages over other techniques are numerous: it is fast and can be implemented in hydro-codes, contains the main physics
- It has been formulated in such a way that includes the self-generation of the B-field

PB&Amato,OG341



Spectra

Analytical approach to Non-linear DSA with self-generated magnetic field

- DSA can be followed through a semi-analytical kinetic approach
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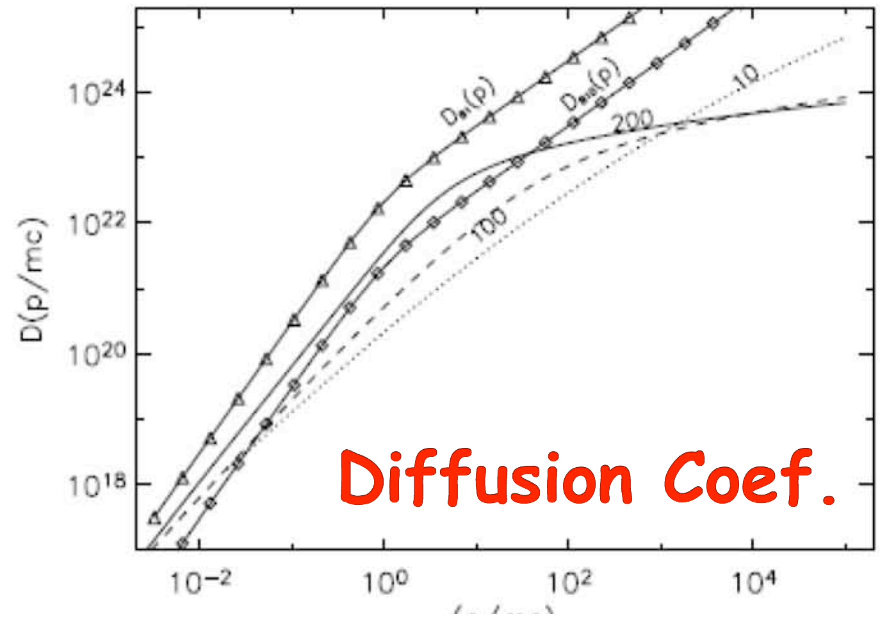
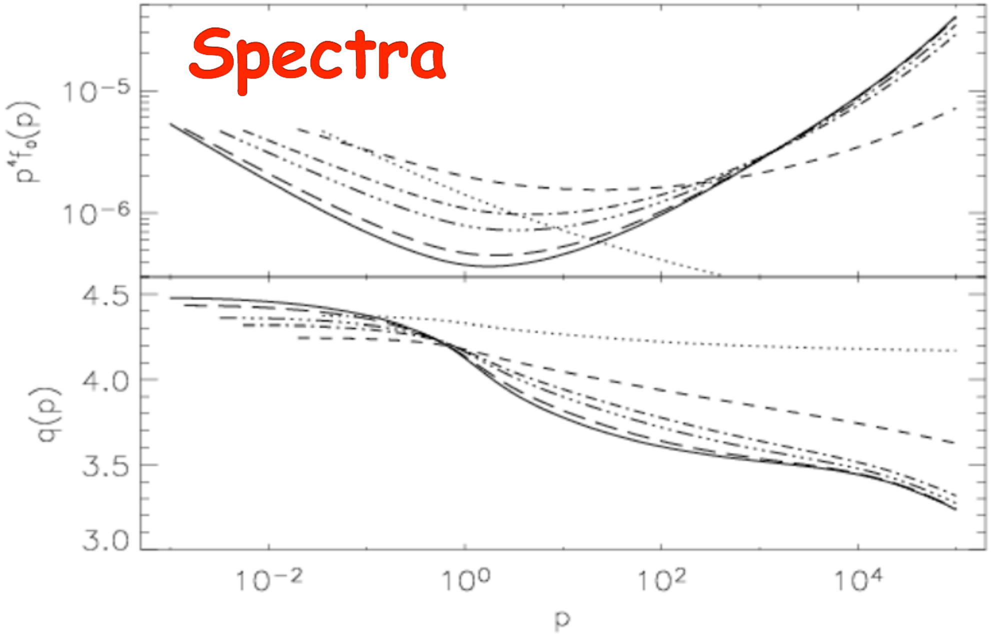
PB&Amato,OG341



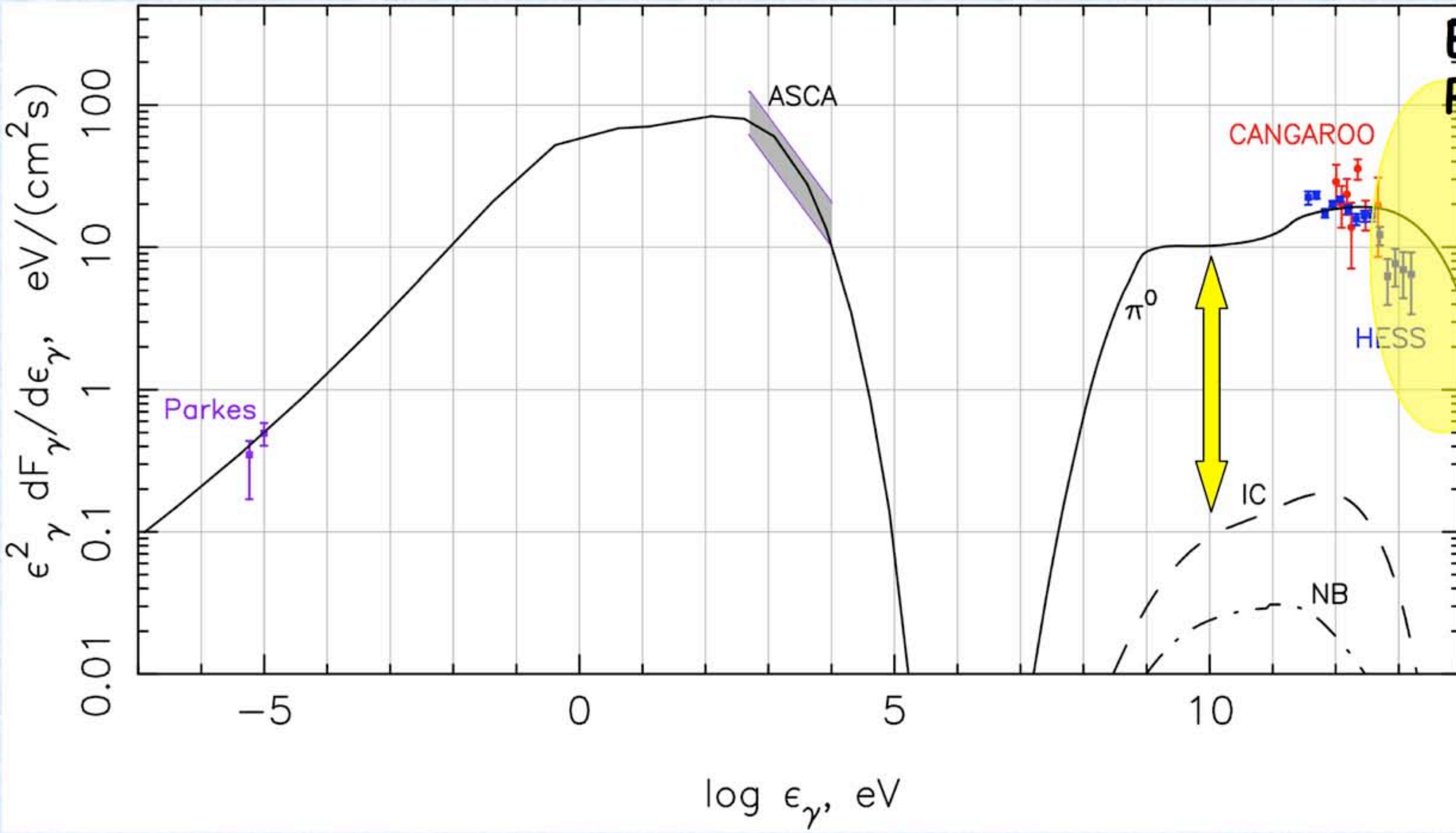


Maximum Energy

- With the amplified field inferred from X-rays, IF it is due to streaming instability (upstream) protons can reach the knee. Heavier elements will have Emax=Z*Emax,p
- This interpretation appears to be supported by multi-ν observations
- If the amplification occurs ONLY downstream, the increase in Emax is only mild
- In the context of non-linear DSA additional acceleration may take place because of scattering in the precursor gradient (Malkov OG759)

DSA applied to single sources

RX J0852.0-4622 (Vela Jr.)

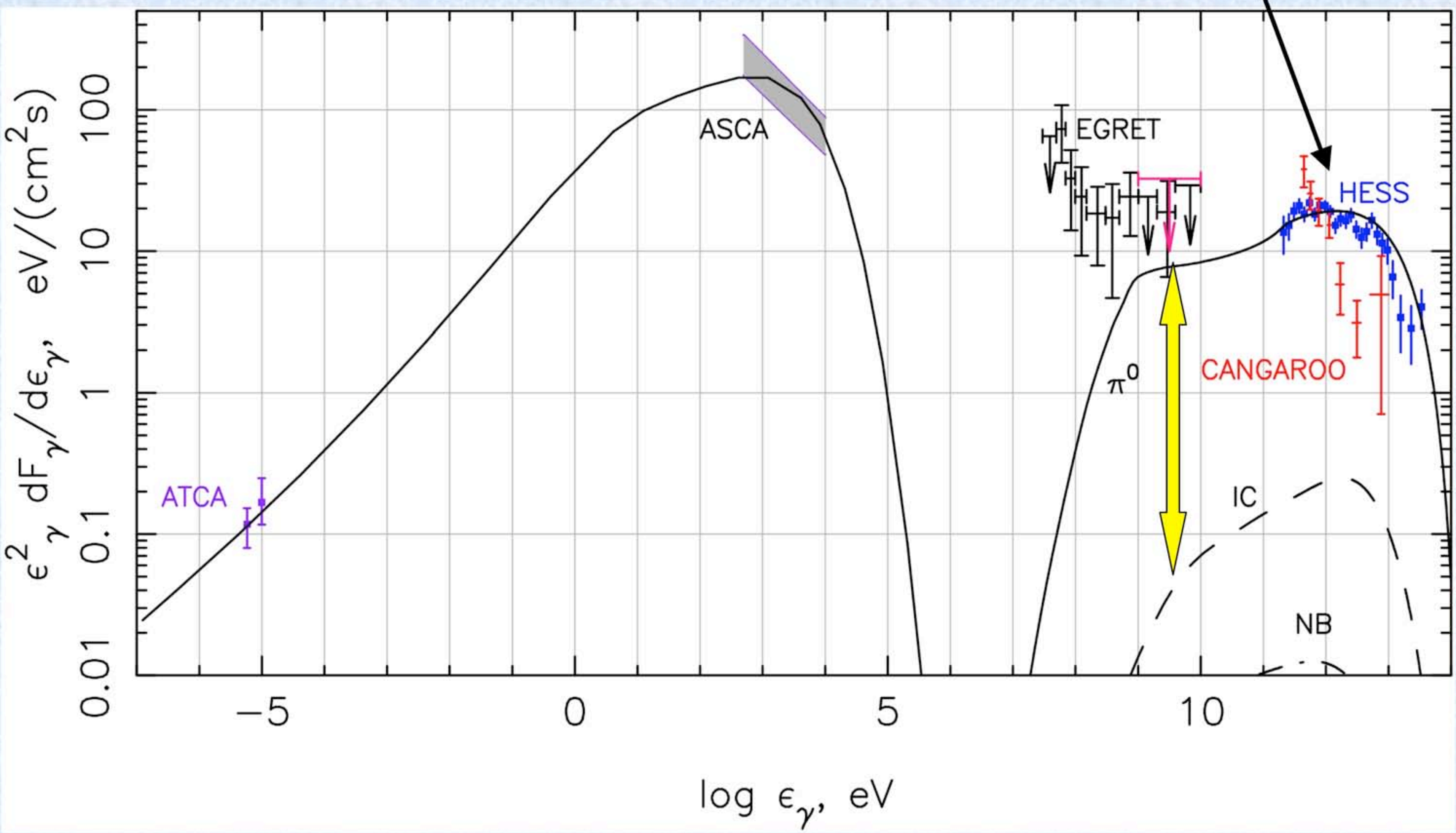


Berezhko, Pühlhofer & Völk, OG597

HADRONIC ORIGIN?

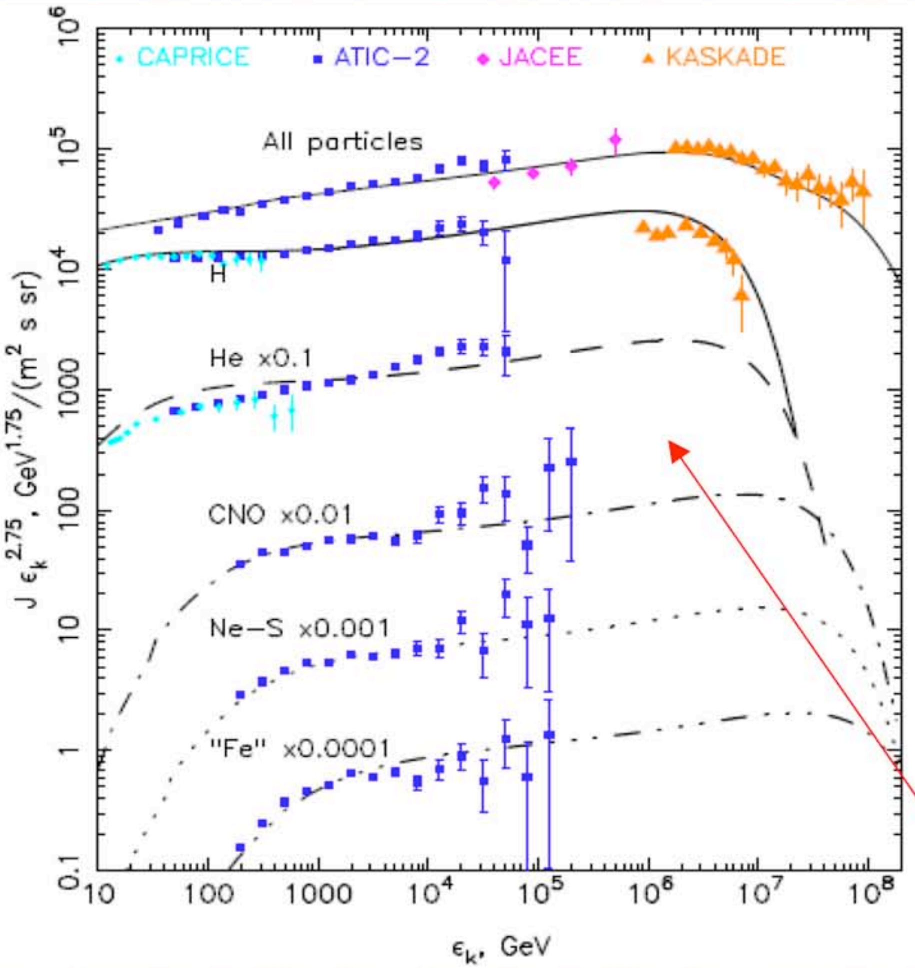
RX J1713.7-3946

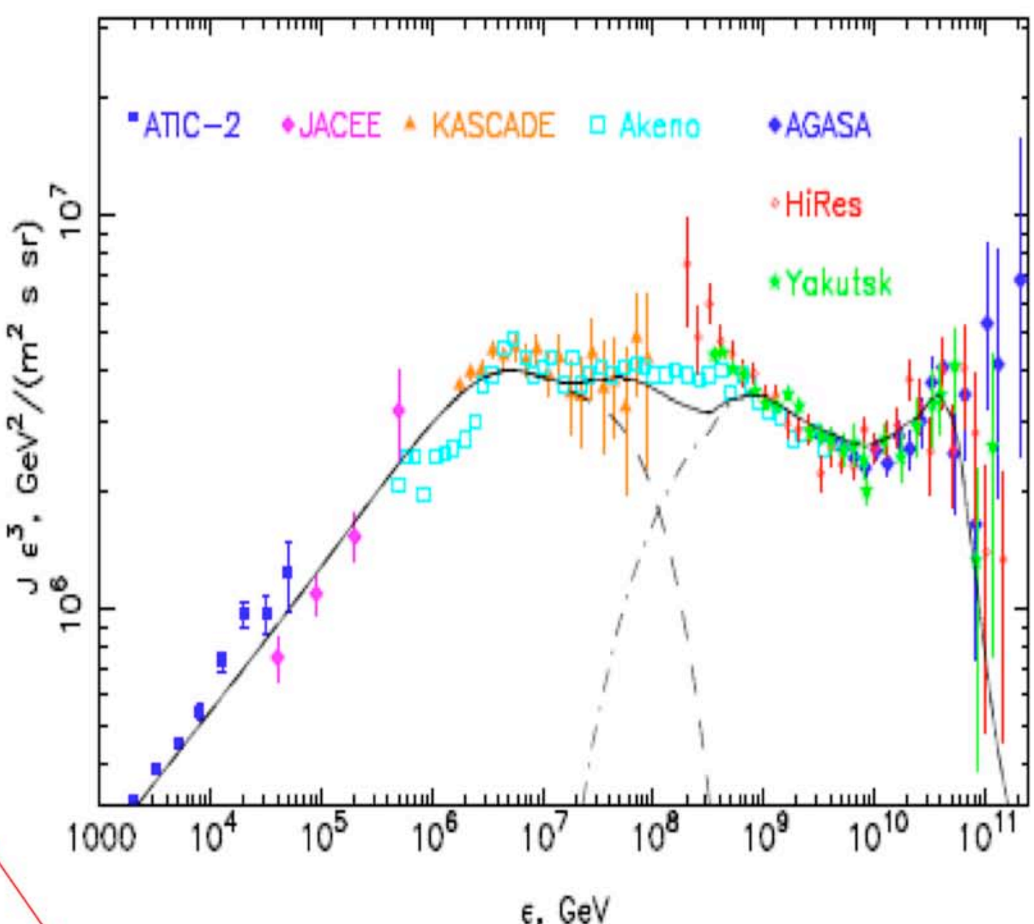
Berezhko & Völk, OG614



FROM THE SOURCE SPECTRA TO THE SPECTRUM OF **COSMIC RAYS**

THE CONVOLUTION PROBLEM: THE SPECTRUM OF CR's FROM SNR's





Berezhko&Volk, OG111

The fractions are fitted, not found from first principles, which would require knowing injection

MAIN IMPLICATIONS

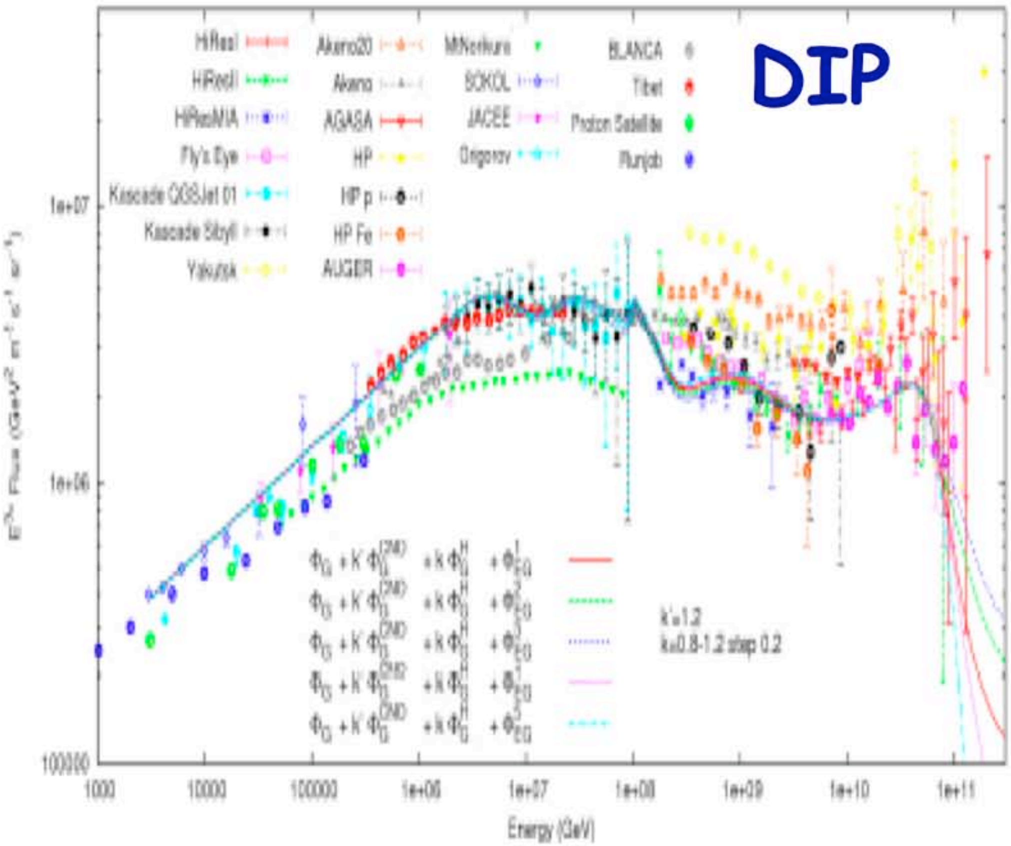
1) The Galactic component of CR in the standard model is expected to cut off around 10^{17} eV

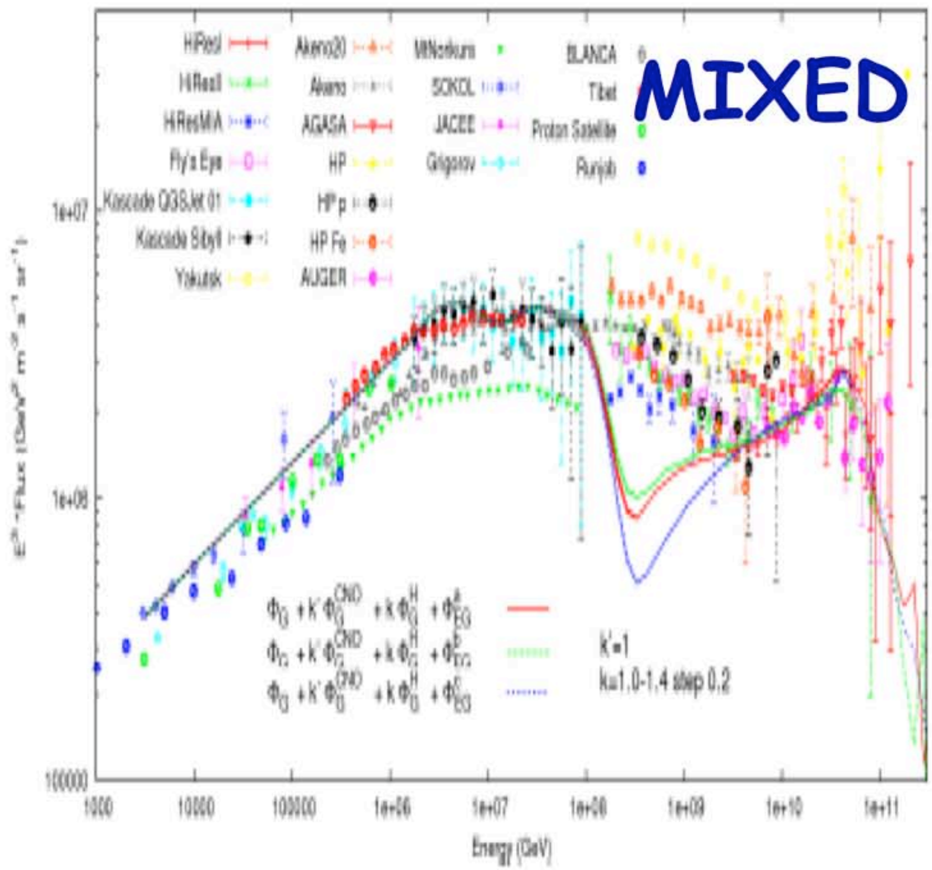
2) The dip scenario and the mixed composition scenario are compatible with this finding

3) The standard ankle scenario requires an additional component

4) The chemical composition in the transition region depends on dip vs mixed

Features in the Transition Region?





De Donato & Medina Tanco, OG1249 (Poster session)

PROPAGATION OF COSMIC RAYS

In the Galaxy…

- The Standard Model is based on diffusion of CR on a background of scattering waves

- Although the background waves may be generated by some unknown mechanism, there is the possibility that at least part of them is self-produced by CR

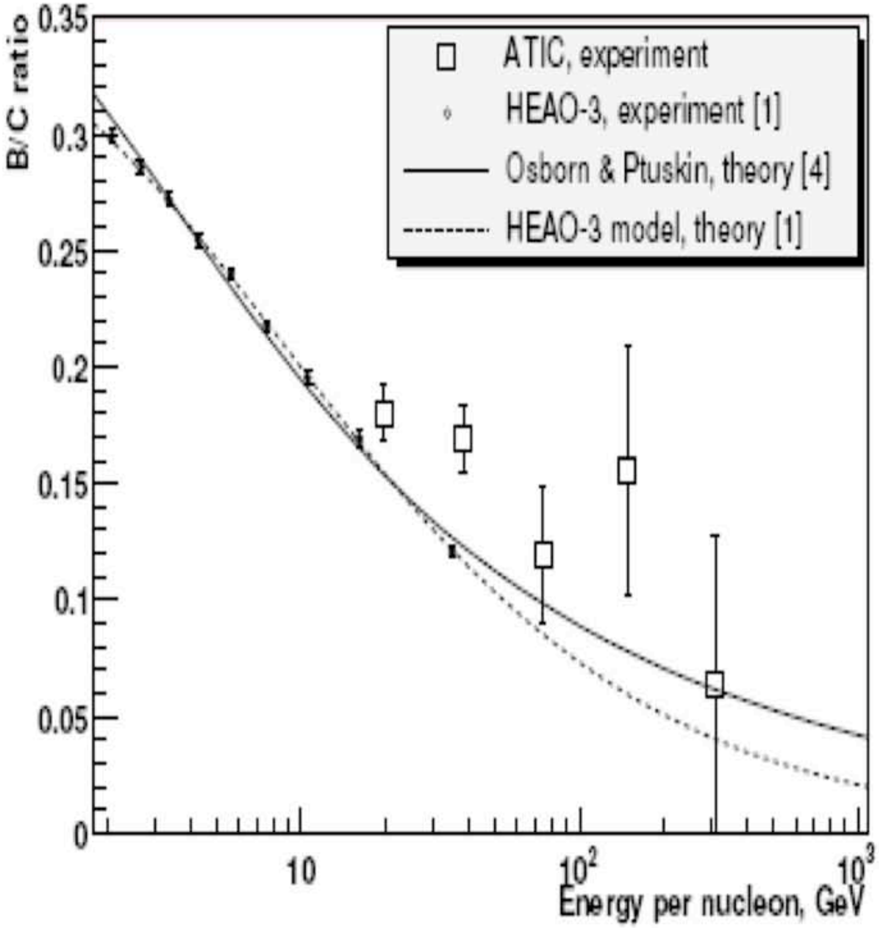
- The standard diffusion equation does not keep information on the ordered large scale field (spiral+halo)

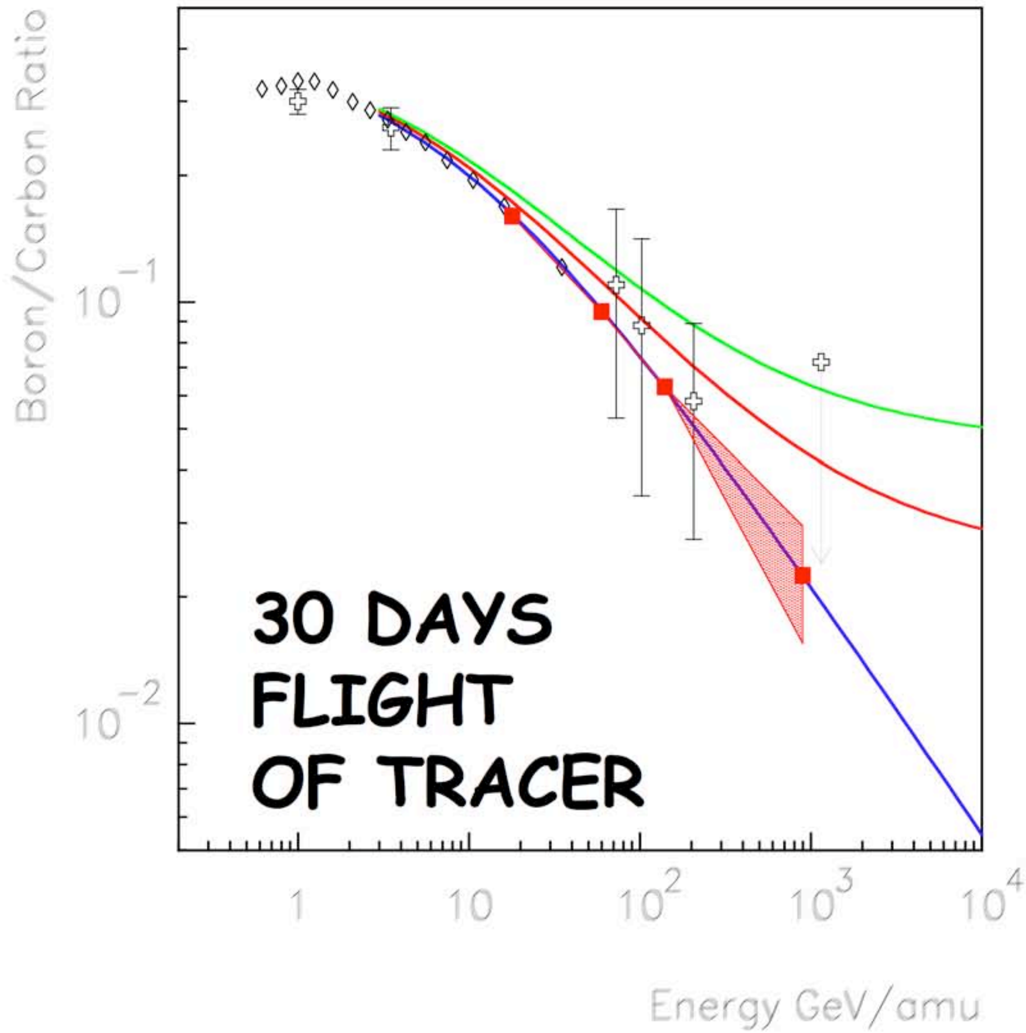
- The main uncertainty in these calculations is in our ignorance of both the ordered and turbulent B-fields

Approaches to Propagation

- DIFFUSION EQUATION
- LEAKY BOX IN VARIOUS VERSIONS
- NUMERICAL RANDOM WALKS
- ACTUAL NUMERICAL SIMULATION OF THE PROPAGATION

A CRUCIAL INPUT FROM OBSERVATIONS





WHY IS THIS IMPORTANT?

$$q_s(E) = n_p(E)\, Y\, \sigma\, n_{gas}\, c \propto E^{-\gamma}$$

$$n_s(E) = q_s(E)\tau_{conf}(E) \propto E^{-\gamma} E^{-\delta}$$

$$\frac{\text{Secondary}}{\text{Primary}} = \sigma\, Y\, n_{gas}\, c\,\tau_{conf}(E) \approx \frac{x(E)}{x_{nucl}} \qquad x_{nucl} \approx 50\ \mathrm{g\ cm^{-2}}$$

$$x(E) = n_{gas}\, m_p\, c\,\tau_{conf}(E) = n_{gas}\, m_p\, \lambda(E) \propto E^{-\delta}$$

IT IS A METHOD TO SINGLE OUT THE EFFECT OF PROPAGATION !

Unfortunately things may be more complex…

- …because, as we will see, the role of perpendicular diffusion, drifts, super(sub) diffusion may be important

- …because of the complex structure of the large scale magnetic field

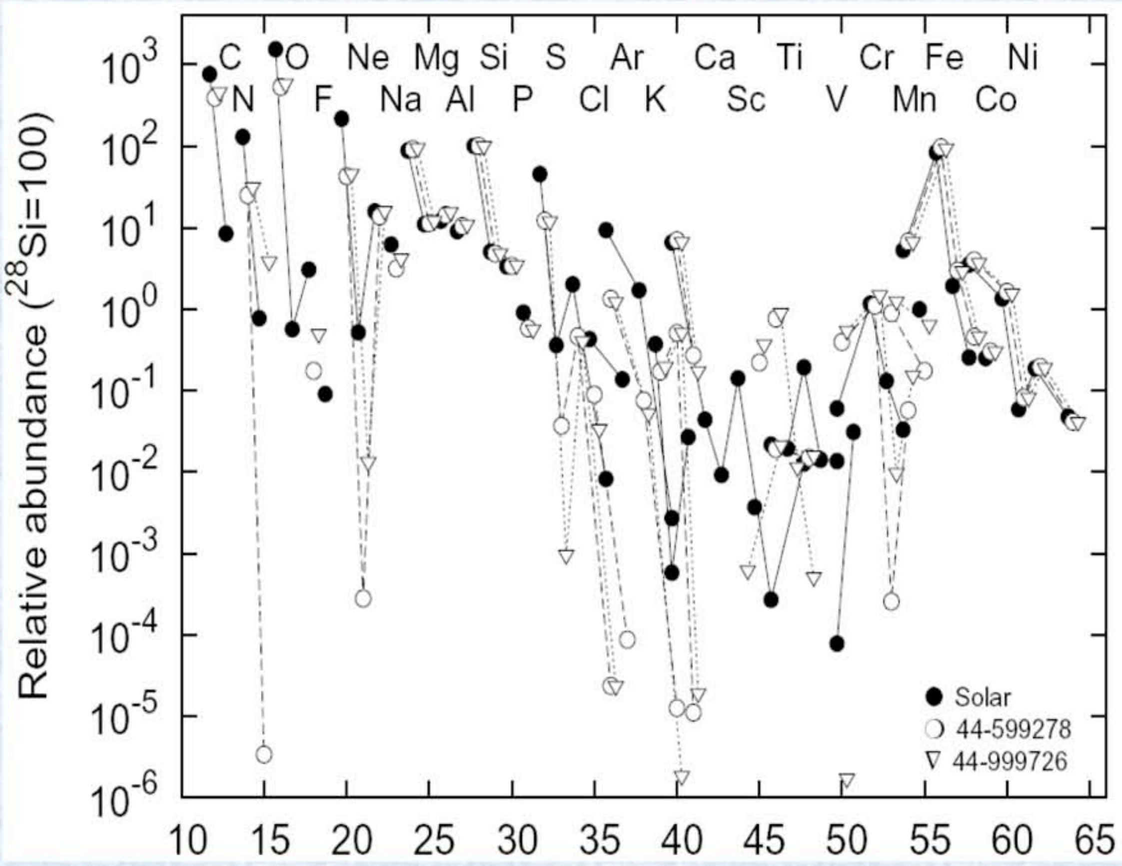
- …because the results of quasi-linear theory could be changed by weakly non-linear corrections (Shalchi & Schlickeiser, OG46)

- AND FINALLY BECAUSE DATA WOULD IMPLY TOO LARGE ANISOTROPY OF CR AT THE KNEE!

GALPROP

Strong, Moskalenko & Porter, OG738

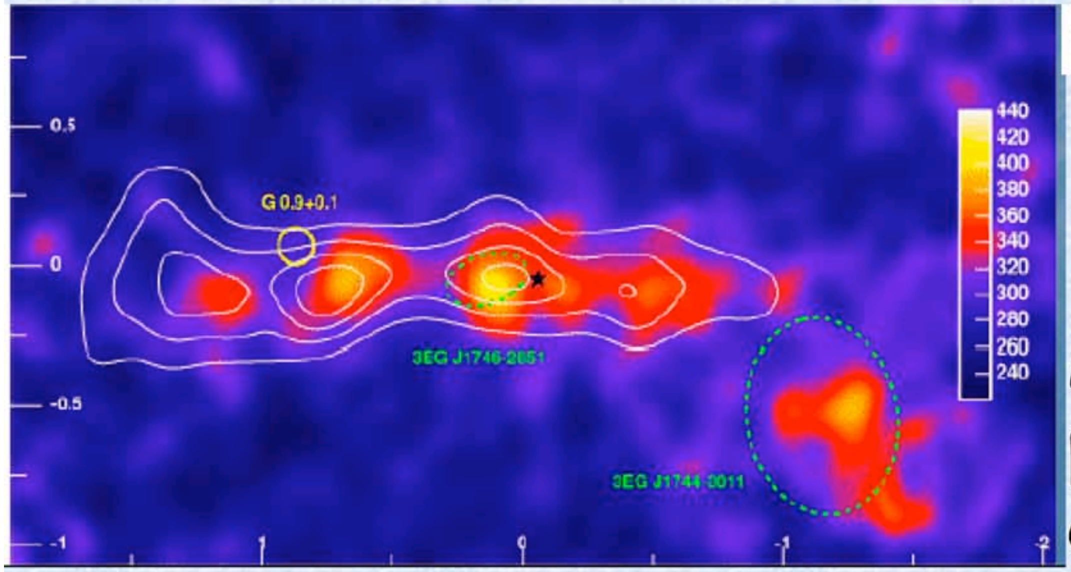
- GALPROP has become a useful tool to describe the diffusive propagation of CR in the Galaxy. It has many parameters that in principle you can fit to the data



Particularly useful to Introduce "realistic" Distributions of gas in The Galaxy and there Calculate the flux of Secondary radiations (gamma, radio, …)

NUMERICAL RANDOM WALKS…

There were a few attempts to "simulate" the propagation In a sort of phenomenological way (Dimitrakoudis et al., OG1127, Huang & Pohl, OG1087)



$$x_i(t_{n+1}) = x_i(t_n) + \Delta x_i = x_i(t_n) + \cos\alpha_i \overline{\Delta r}$$

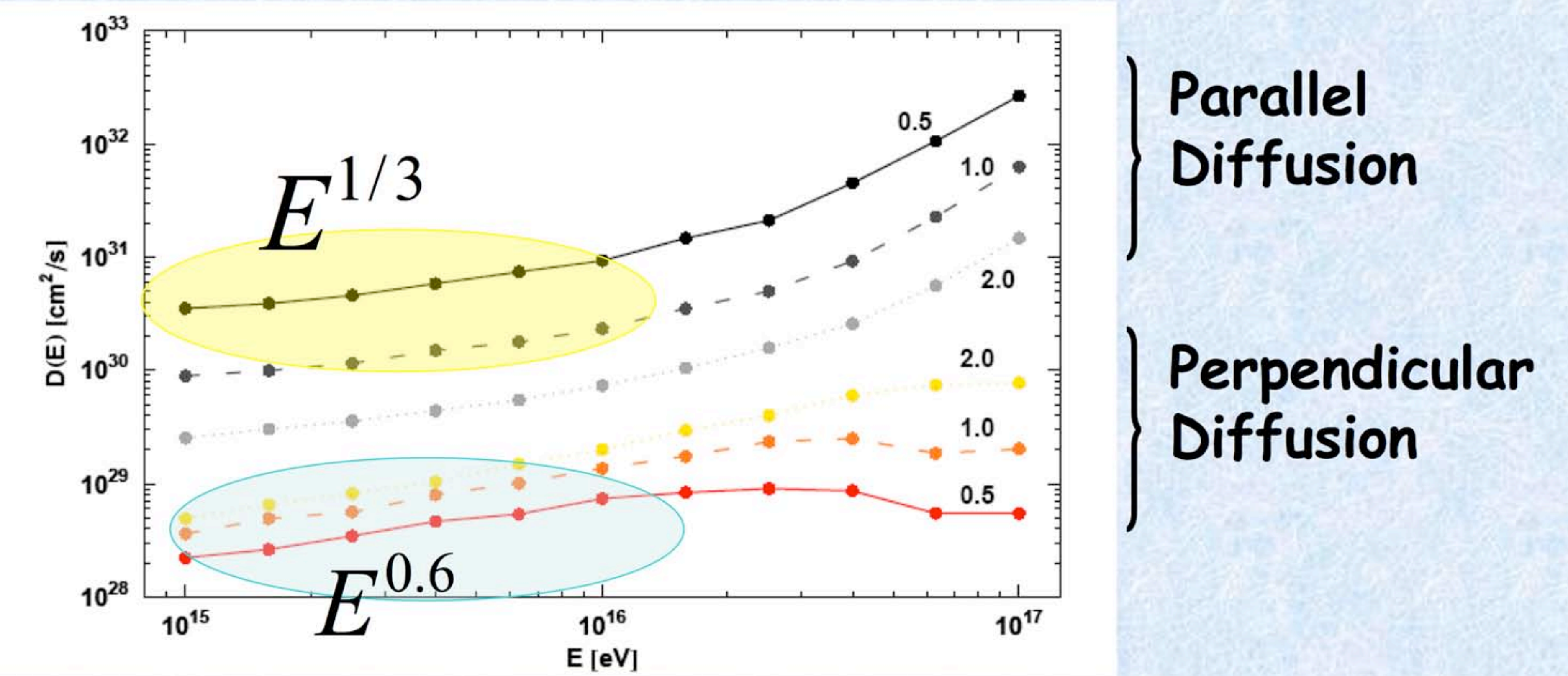
$$\overline{\Delta r} = \sqrt{6D(E)\Delta t}$$

Main motivation: treat the propagation in inhomogeneous cases

It is not really clear what one may gain with respect to the standard solution with finite differences.

SIMULATIONS

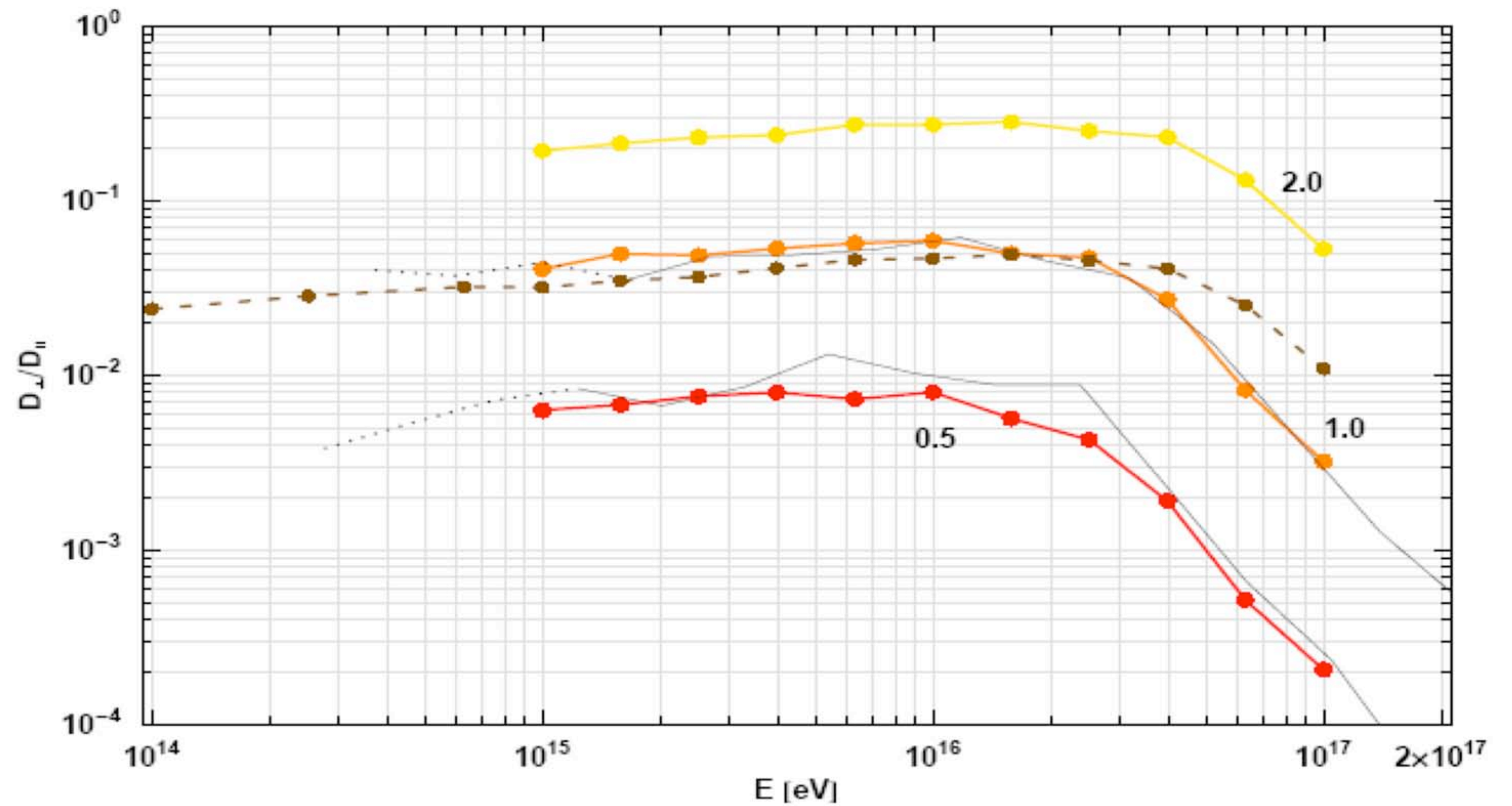
De Marco, PB & Stanev, OG736



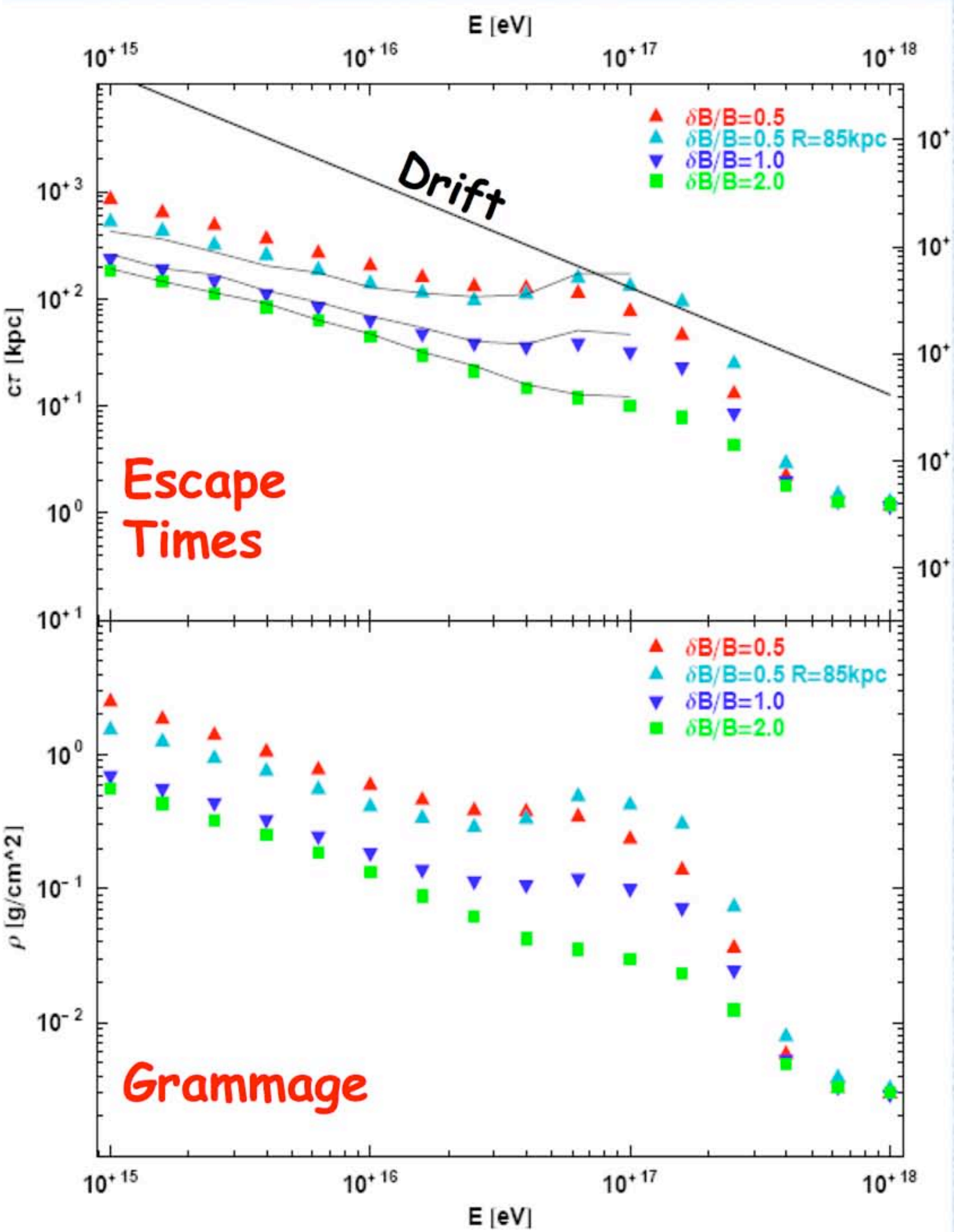
You can still DETERMINE the Diffusion coeff.
Assuming
$P(k) \sim k^{-5/3}$
(KOLMOGOROV)

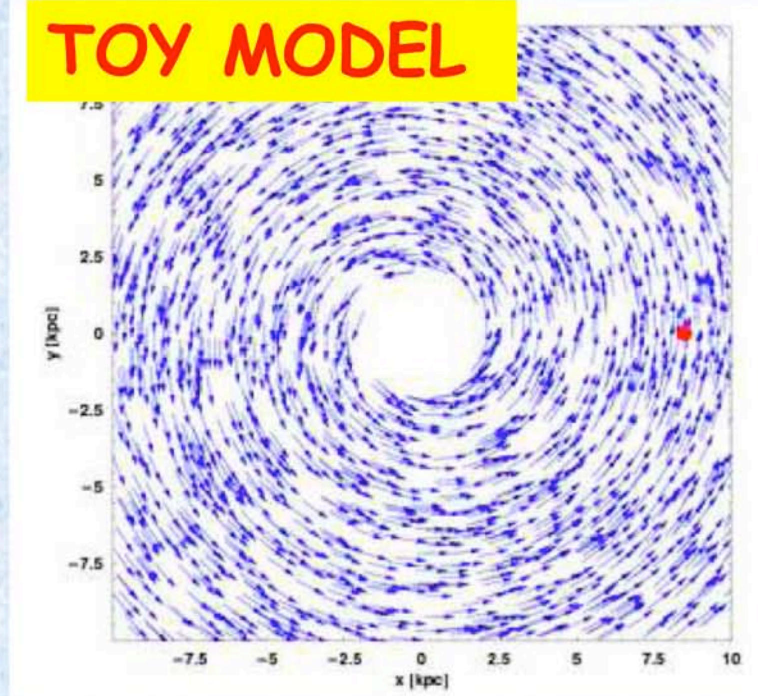
SIMULATIONS

De Marco, PB & Stanev, OG736



$P(k) \sim k^{-5/3}$
(KOLMOGOROV)





1. Perp diff dominant!
2. Escape times have slopes that reflect the PerpDiff
3. Drifts important
4. Escape time very large!
5. Extrapolation to lower E?
6. For a more "realistic" Galaxy the results are even more difficult to interpret (non diffusive effects…)

De Marco, PB & Stanev,

Disturbing ignorance of the Galactic Magnetic field

- Not only $\delta B/B$ is not known
- The size and separation of the spiral arms in terms of B-field is poorly known
- The behaviour of the B-field in the inter-arm region is poorly known
- The gradients along r and z are unknown
- The extension of the magnetized halo is basically inferred from diffusion of e and their radio emission

At least in the long run perspective, we might envision (rather bravely) to gather info on the Galactic field from:

1. Polarization of the CMB
2. Arrival direction distribution of UHECRs

Farrar, OG1271

CONCLUSIONS

- ✓ VERY IMPRESSIVE IMPROVEMENT IN THE QUALITY OF THE MEASUREMENTS

- ✓ WITHIN A FEW YEARS WE SHOULD BE ABLE TO MEASURE THE B/C RATIO WITH HIGH ACCURACY AT HIGH ENERGIES, WHERE THE DIFFERENCES MIGHT APPEAR…what about sub-Fe to Fe?

- ✓ MEASUREMENTS IN THE ELECTRON SPECTRUM MIGHT TELL US ABOUT NEARBY SOURCES, OR MORE LIKELY PUT LIMITS ON DIFFUSION

CONCLUSIONS...cont'd

- ✓ SIGNALS OF DARK MATTER ANNIHILATION, IF THEY EXIST, SHOULD BE DETECTABLE IN THE ANTIPROTON AND POSITRON SPECTRA
- ✓ THE SPECTRA OF ELEMENTS FROM P TO FE ARE EXPECTED TO BE MEASURED ACCURATELY UP TO THE KNEE IN THE ALL-PART. SPECTRUM IN BALLOON FLIGHTS
- ✓ NEITHER BALLOON FLIGHTS NOR SATELLITES WILL HOWEVER BE ABLE TO REACH THE KNEE IN THE SINGLE COMPONENTS!

CONCLUSIONS…cont'd

- ✓ MAY BE, IT IS WORTH THINKING ABOUT ULTRA-LONG DURATION BALLOON FLIGHTS FOR COVERING THE KNEE REGION AND BRIDGE THE TRANSITION TO GROUND ARRAYS
- ✓ THE GROUND ARRAYS WILL REMAIN CRUCIAL, WITH ALL TROUBLES ON EXTRACTING THE INFORMATION AND DEALING WITH HADRONIC MODELS (may be improvements from LHC?)
- ✓ BUT CRUCIAL ALSO TO REACH AS HIGH AS THE TRANSITION REGION (10^{17}-10^{18}eV)

CONCLUSIONS…cont'd

- ✓ ON THE SIDE OF ACCELERATION IN SNR, VERY IMPRESSIVE DEVELOPMENTS (NONLIN DSA AND B-FIELD AMPLIFICATION)… BUT ALSO LOTS OF THINGS WE ARE FAR FROM UNDERSTANDING, despite nice model fittings!

- ✓ MAJOR FINDINGS FROM X-RAY ASTRONOMY.

- ✓ FROM GAMMA RAY ASTRONOMY WE MAY GATHER INFORMATION ON THE CUTOFF ENERGY AND NATURE OF THE GAMMAS… HADRONIC ORIGIN???

- ✓ THE AMPLIFICATION OF THE FIELD IS NOT UNDERSTOOD…AND IT'S DIFFICULT TO KNOW HOW TO UNDERSTAND IT… BUT IT IS OBSERVED (downstream)

CONCLUSIONS…cont'd

- Major problems in understanding diffusion in the Galaxy. Simple models and codes can be fit to data but are they something more than tools?

- Numerical simulations in the Galactic field do not seem to confirm the expectations of a simple diffusion model: slopes and escape times are off

- An enthusiastic crowd of people are planning CR "telescopes" for the near and far future…more information is always the basics for future progress