

陽電子過剰の意味 Implications of the Positron Excess

井岡 邦仁 (KEK, Sokendai)

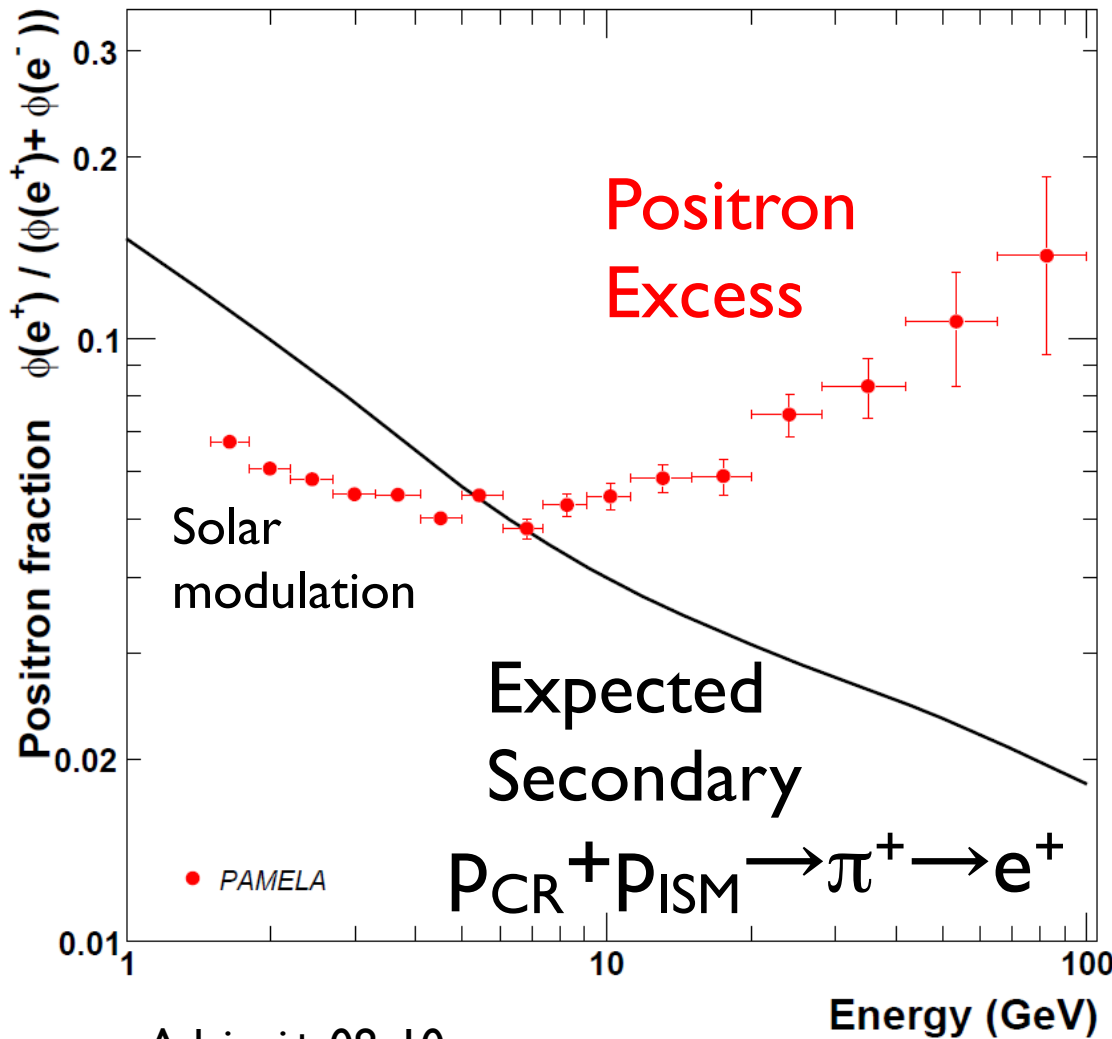


Contents

- Before AMS-02
- After AMS-02
- Future

PAMELA

Positron excess above the predicted secondary



⇒ New sources

– Dark Matter?

– Astrophysical?

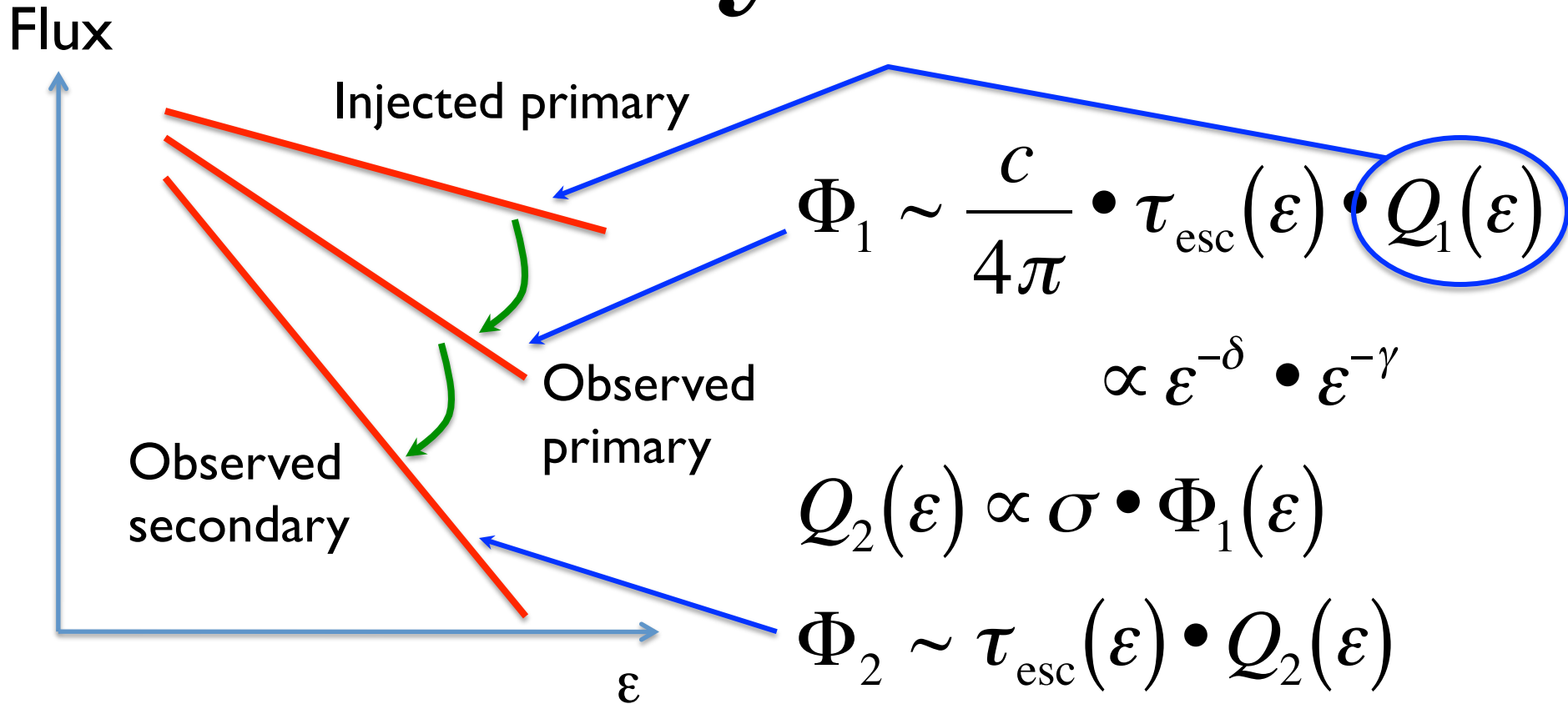
⇒ Many papers $> 10^3$



Jul 06 - Feb 08

151672 e-, 9430 e+

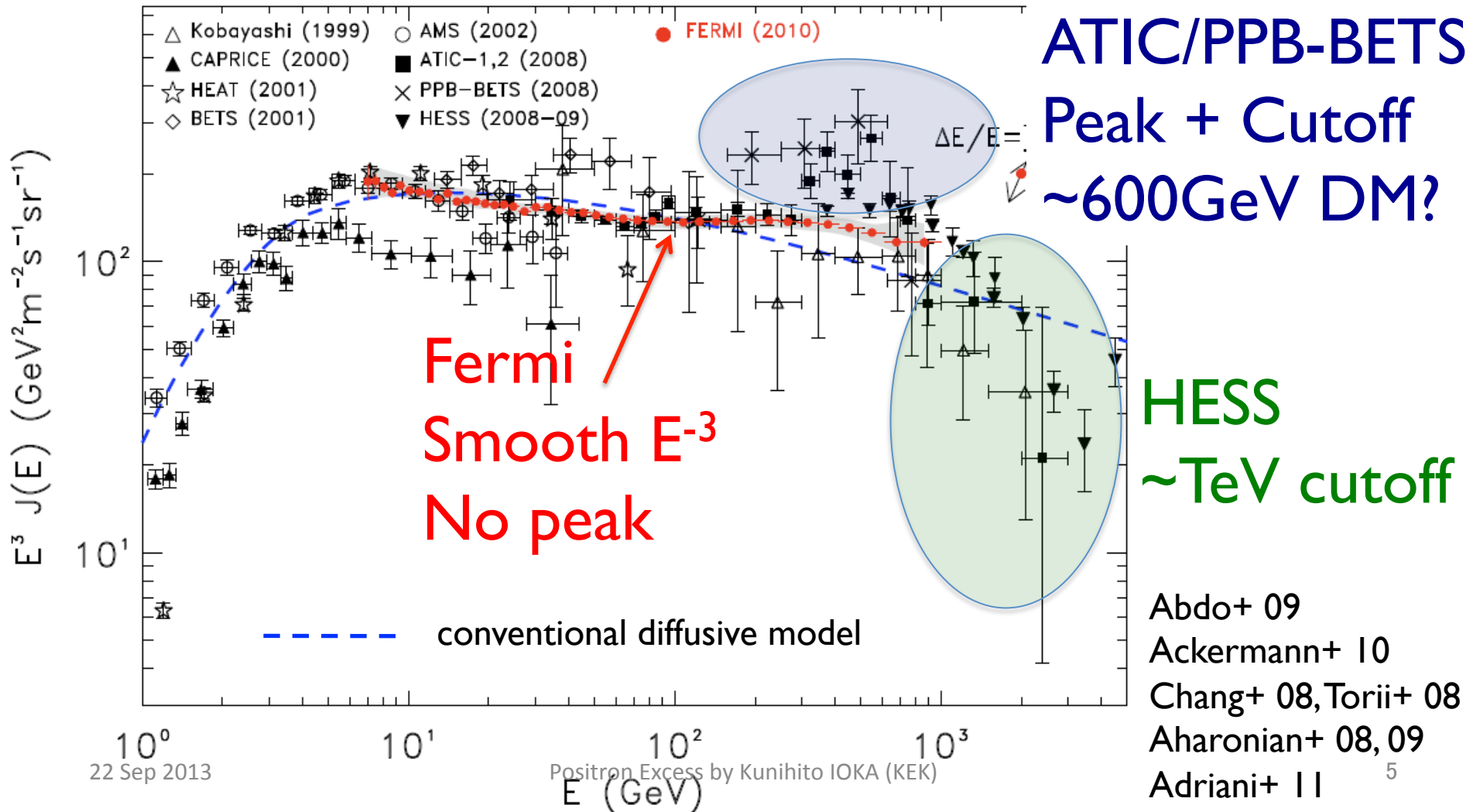
Secondary Positrons



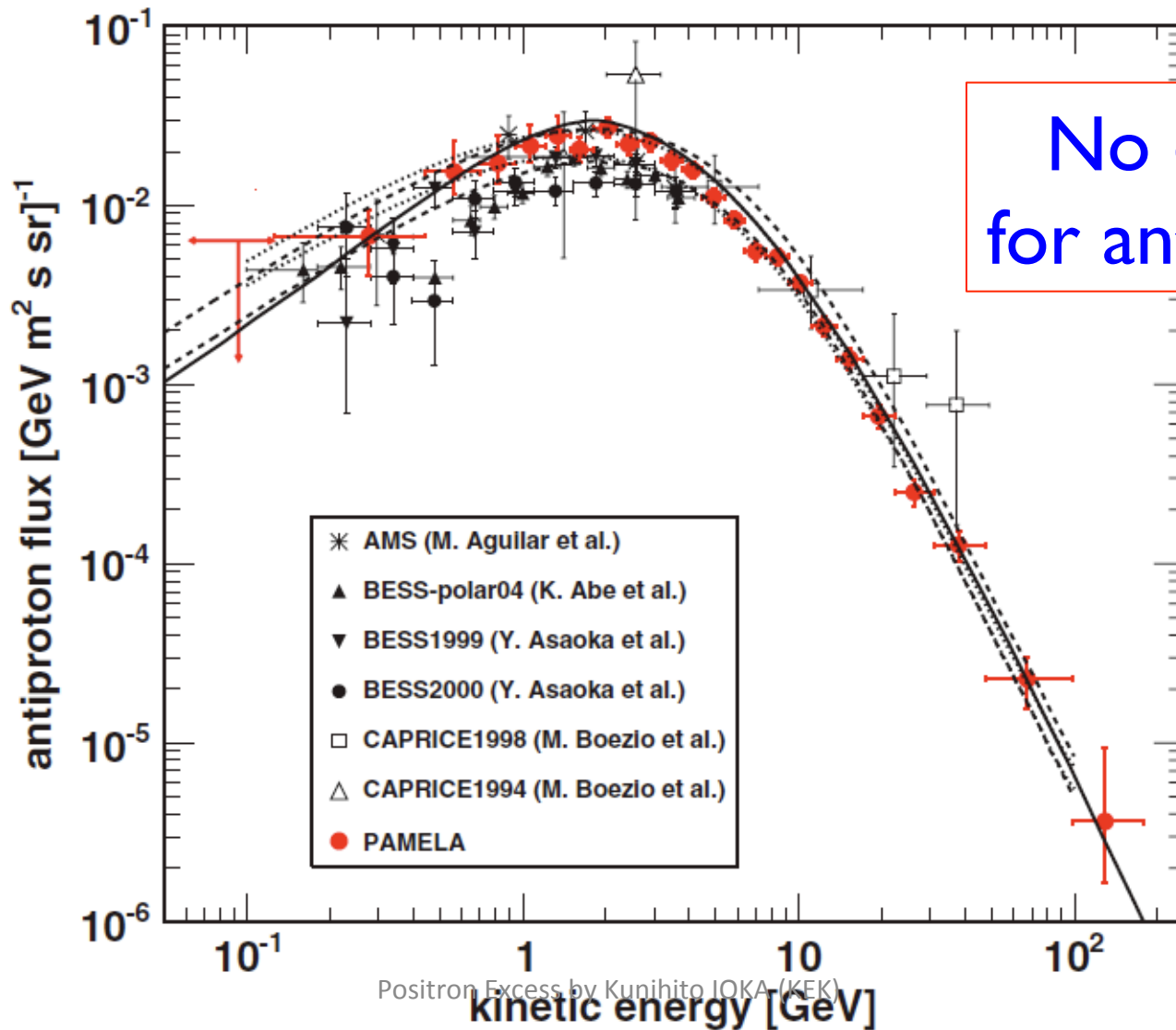
This is robust if
cooling/escape is faster
for higher energy

Cosmic-Ray Electron

An Excess also in ($e^+ + e^-$) Spectrum



Anti-Proton



Adriani+ 08,10

e^\pm Cooling

B

Our galaxy



We are here



e^\pm lose energy (cool)
via inverse Compton
and synchrotron

Positron source
 $d < \sim 1 \text{ kpc}$

$$\varepsilon_{\text{cut}} \sim \frac{1}{bt}, \quad b = \frac{4\sigma_T c}{3(mc^2)^2} \left(\frac{B^2}{8\pi} + U_\gamma \right)$$

e^\pm Propagation

$$\frac{\partial}{\partial t} f(t, \varepsilon_e, \vec{x}) = \underbrace{K(\varepsilon_e) \nabla^2 f}_{\text{Diffusion}} + \underbrace{\frac{\partial}{\partial \varepsilon_e} [b \varepsilon_e^2 f]}_{\text{Energy loss by IC \& synchro.}} + \underbrace{q(t, \varepsilon_e, \vec{x})}_{\text{Injection}}$$

$$b \sim 10^{-16} \text{ GeV}^{-1} \text{ s}^{-1}$$

$$K(\varepsilon_e) \sim 5.8 \times 10^{28} \text{ cm}^2 \text{ s}^{-1} \left(1 + \frac{\varepsilon_e}{4 \text{ GeV}} \right)^{1/3} \leftarrow \text{B/C ratio}$$

For a single burst with $q \propto \varepsilon_e^{-\alpha}$ Power law spectrum

$$f = \frac{q_0 \varepsilon_e^{-\alpha}}{\pi^{3/2} d_{diff}^3} (1 - bt\varepsilon_e)^{\alpha-2} e^{-(d/d_{diff})^2} \quad \text{Atoyan+ 95, Shen 70}$$

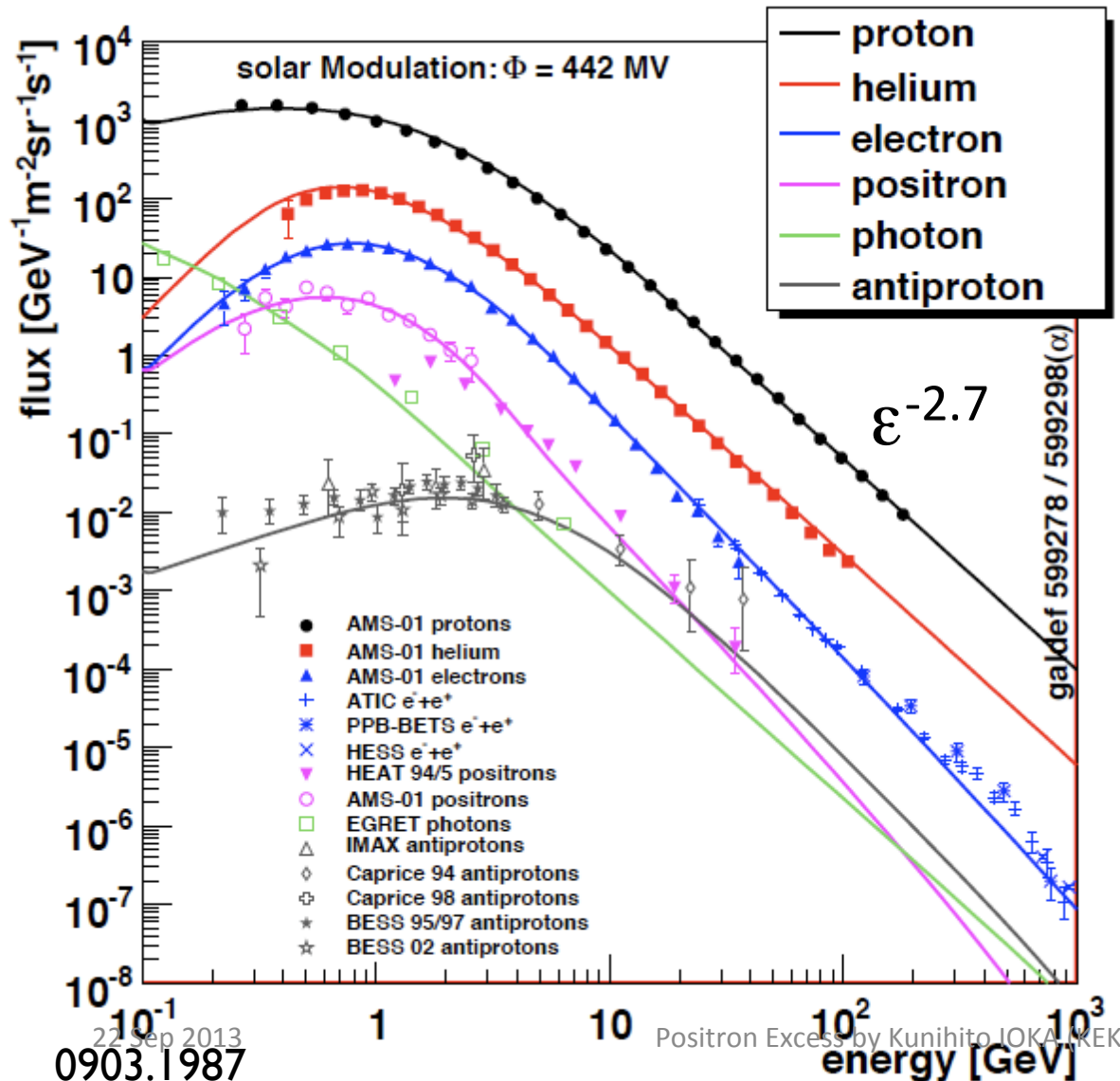
Spatially uniform over

Spectral cutoff

$$d_{diff}(t, \varepsilon_e) \sim 2 \left[\frac{K(\varepsilon_e) t}{\text{Positron Excess by Kunihito IOKA (KEK)}} \right]^{1/2}$$

$$\varepsilon_{cut} \sim \frac{1}{bt^8}$$

Energetics



U(proton)

$\sim 1 \text{ eV/cm}^3$

← Supernova remnants

U(electron)

$\sim 10^{-2} \text{ eV/cm}^3$

U(positron)

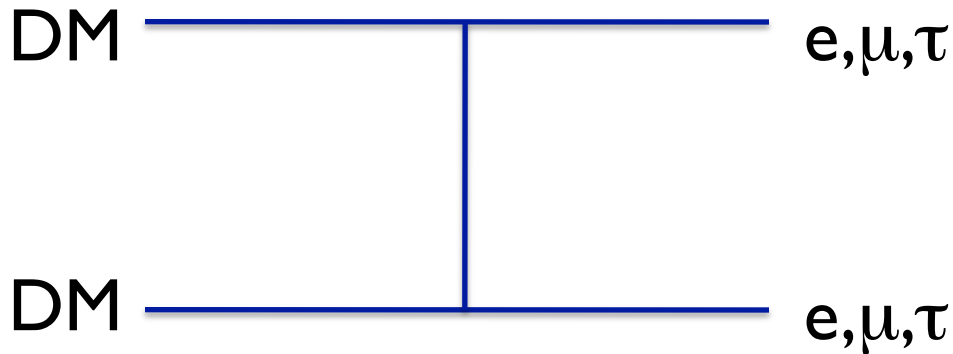
$\sim 10^{-3} \text{ eV/cm}^3$

$\sim 0.1\%$ of p

Even less @TeV

Dark Matter?

Annihilation



$$Q \sim n^2$$

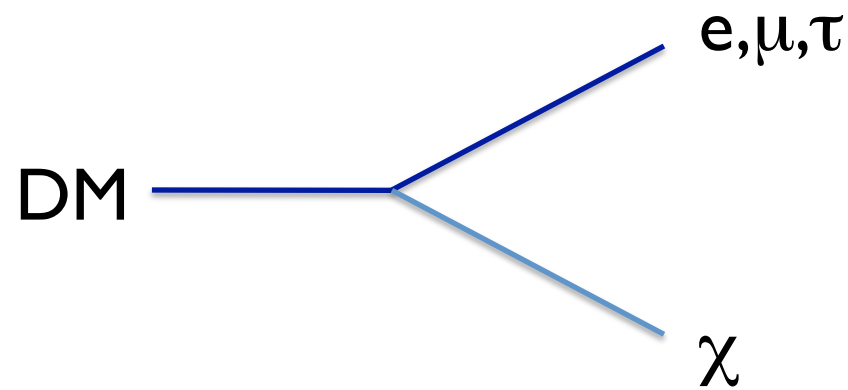
$$E_{\text{cut}} \sim m_{\text{DM}} \sim \text{TeV}$$

$$\langle \sigma v \rangle \sim 3 \times 10^{-24} \text{cm}^3/\text{s}$$

$$> 3 \times 10^{-26} \text{cm}^3/\text{s} \text{ (thermal)}$$

$$\text{boost factor} \sim 100$$

Decay



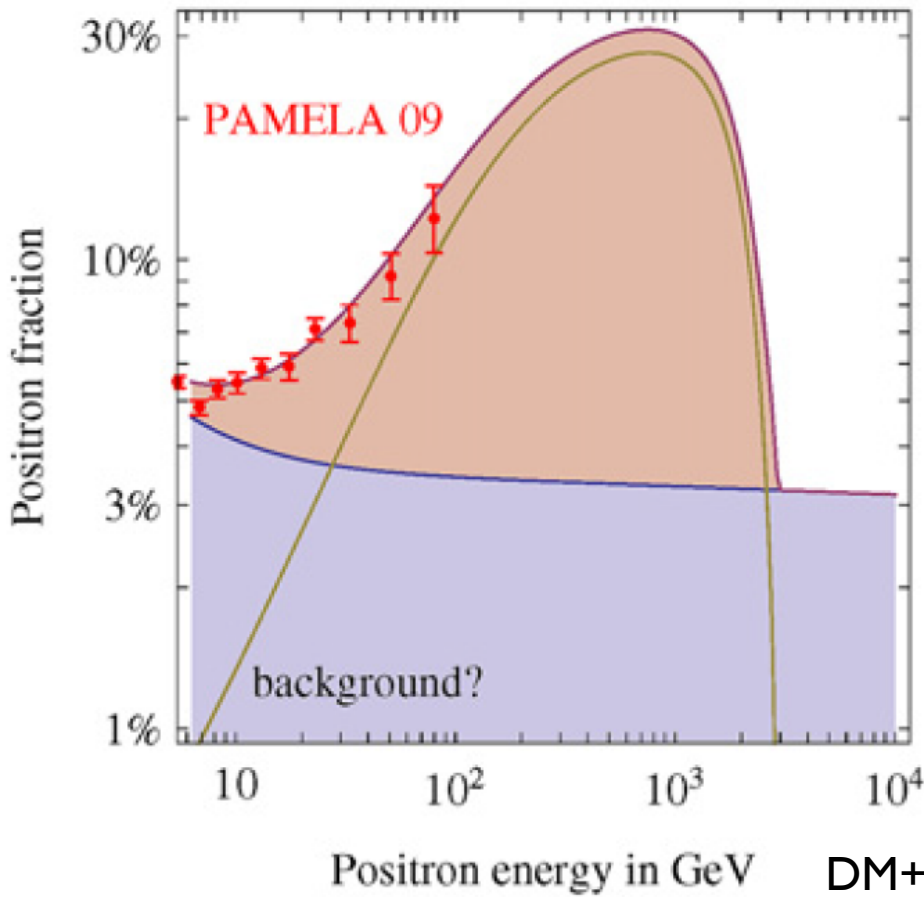
$$Q \sim n$$

$$E_{\text{cut}} \sim m_{\text{DM}}/2$$

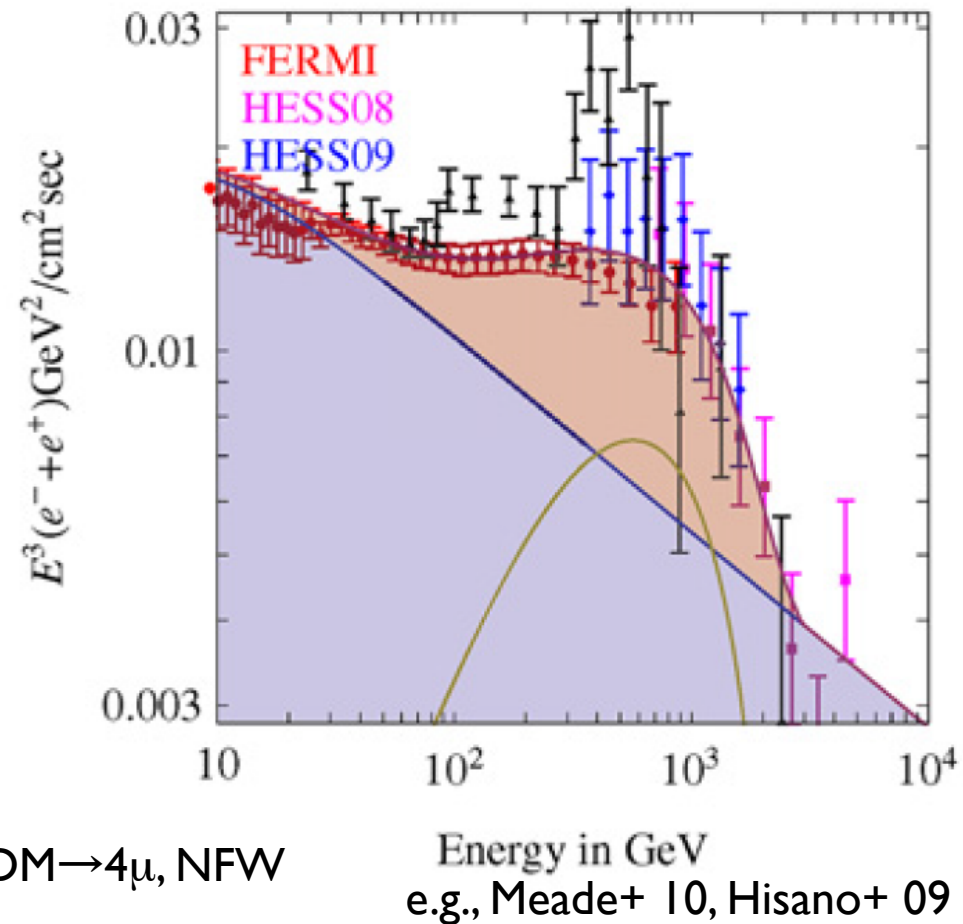
$$t_{\text{decay}} \sim 6 \times 10^{26} \text{sec} (> H^{-1})$$

Fitting

Positron



Electron



Both e^\pm can be fitted by the same model

Constraints on DM

- $DM(+DM) \rightarrow qq, WW, ee, \mu\mu, \tau\tau \rightarrow e, p\bar{a}r, \gamma, \nu$

- $p\bar{a}r \Rightarrow$ ~~hadron modes~~

- γ -ray

- Line, $\pi^0 2\gamma$, Compton,

- Final state radiation

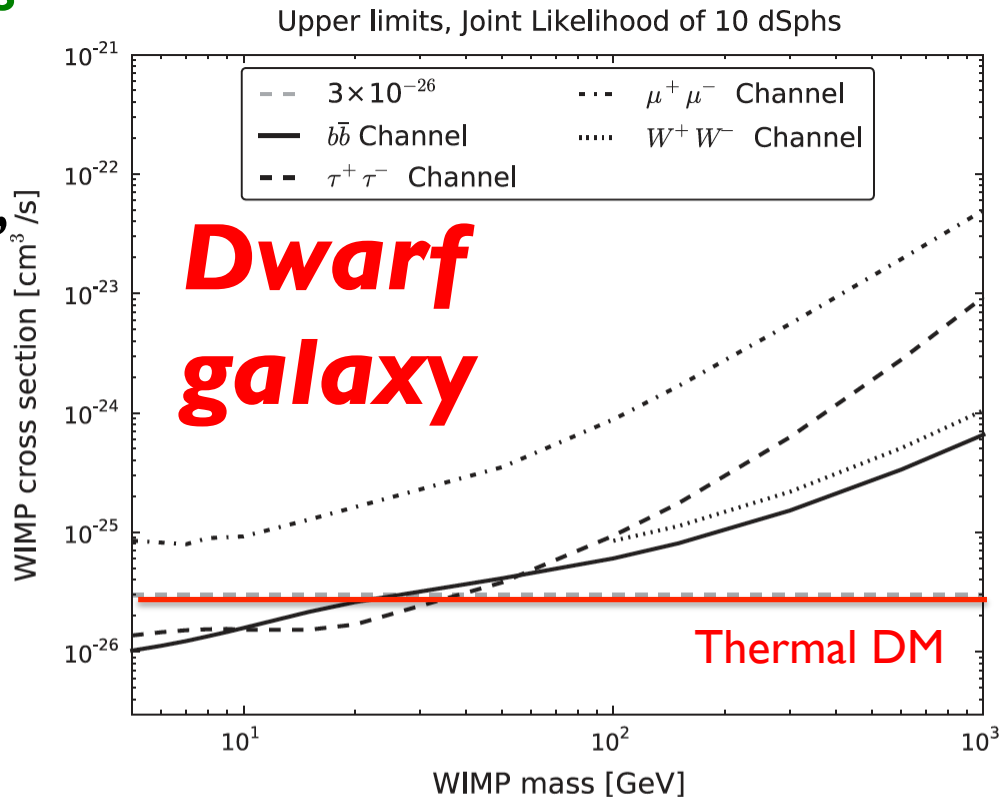
- GC, Dwarf, Cluster,

- Background

- ~~Cuspy DM profile~~

- Decay is OK

- Radio, ν , CMB, BBN, X



Ackermann+ II

Geringer-Sameth & Koushiappas II

Constraints on DM

- $DM(+DM) \rightarrow qq, WW, ee, \mu\mu, \tau\tau \rightarrow e, p\bar{p}, \gamma, \nu$

- $p\bar{p} \Rightarrow$ ~~hadron modes~~

- γ -ray

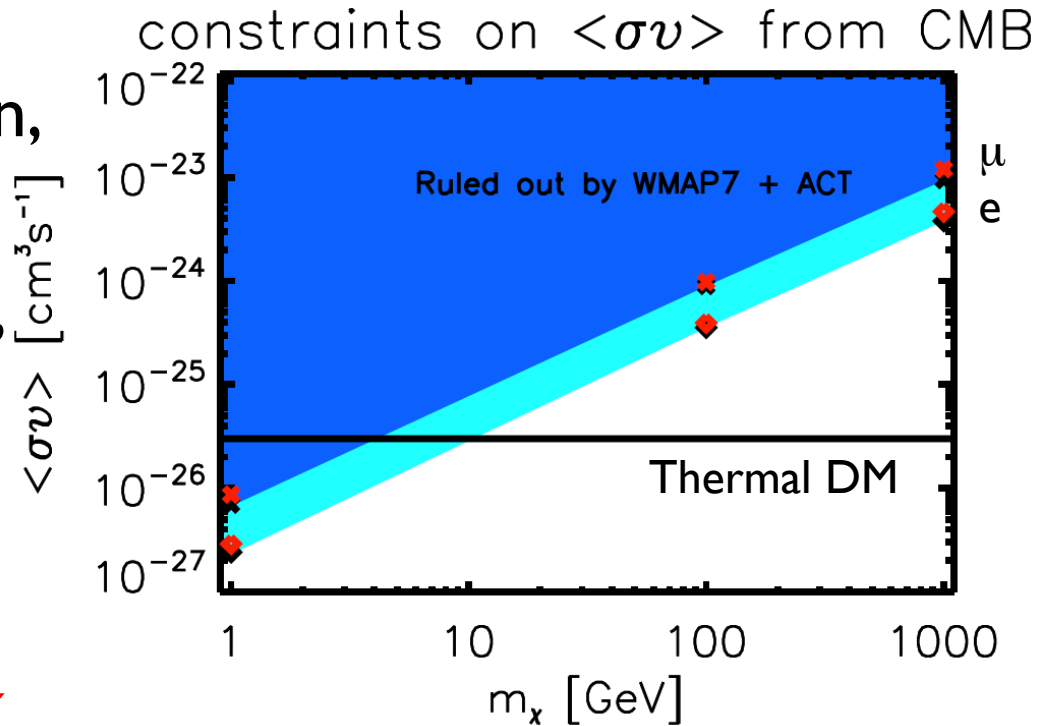
- Line, $\pi^0 2\gamma$, Compton, Final state radiation

- GC, Dwarf, Cluster, Background

- ~~Cuspy DM profile~~

- Decay is OK

- Radio, ν , CMB, BBN, X



Astrophysical Models

Pulsar

Supernova remnant

Microquasar

Gamma-ray burst

White dwarf pulsar

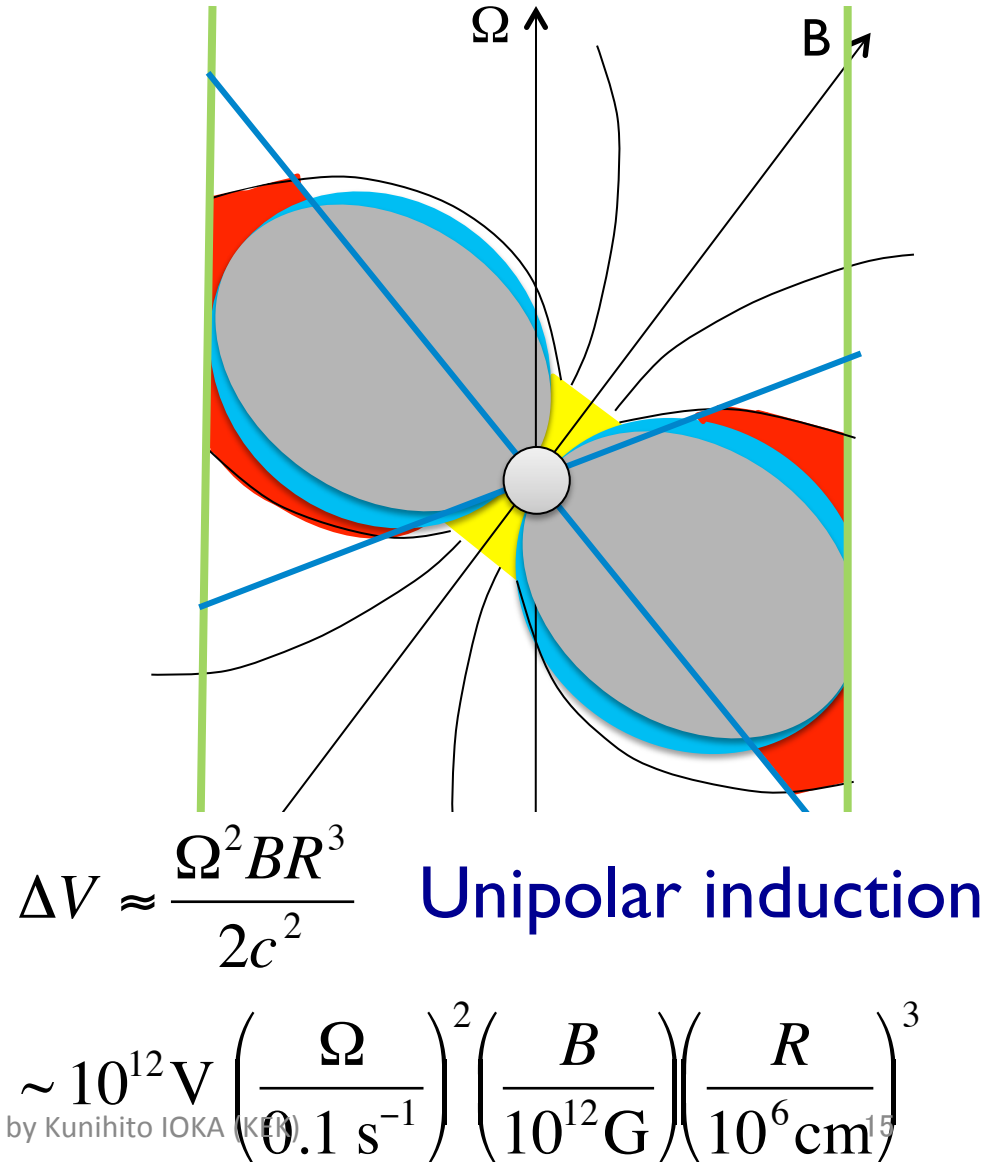
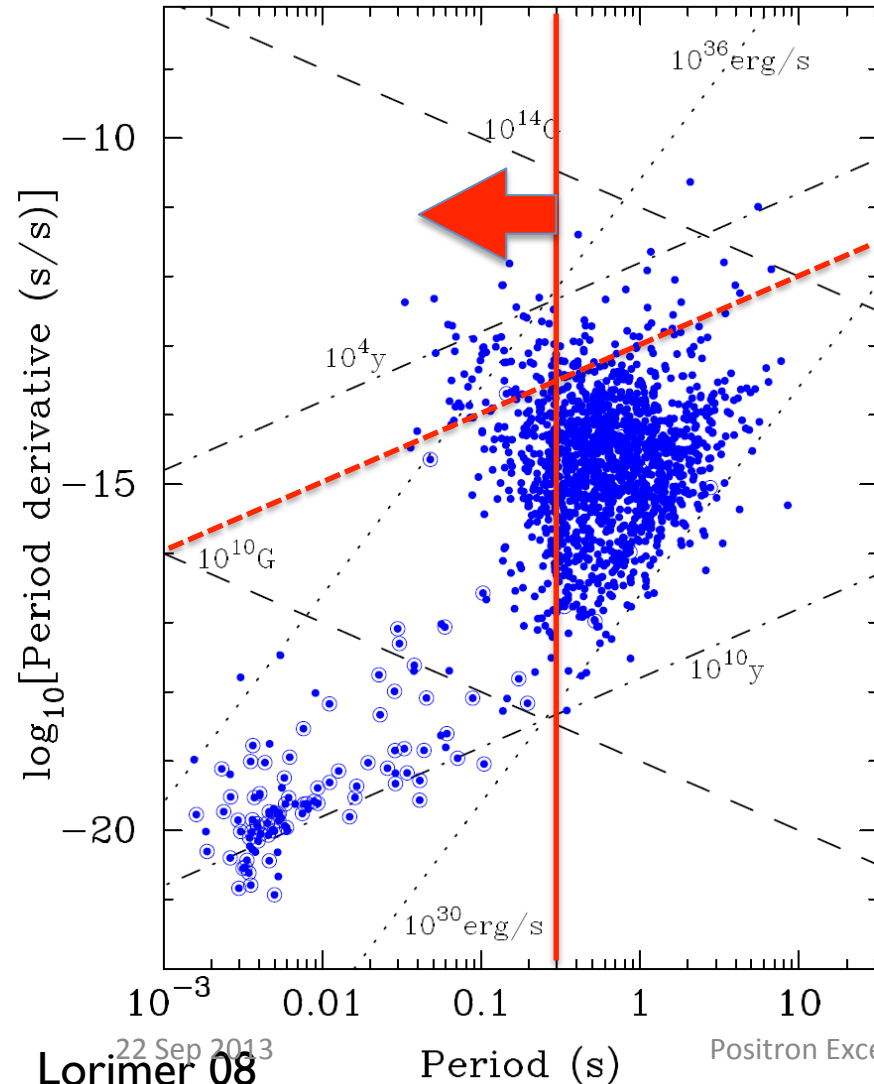
$$U_e \ll U_p \Rightarrow$$

$$E(e^\pm \text{ origin}) \ll E(\text{Supernova})$$

$$\frac{E_e}{\text{Supernova}} \sim \frac{U_e}{U_p} \frac{t_{esc}}{t_{cool}} E_{SN} \sim \frac{10^{47} \text{ erg}}{\text{Supernova}}$$

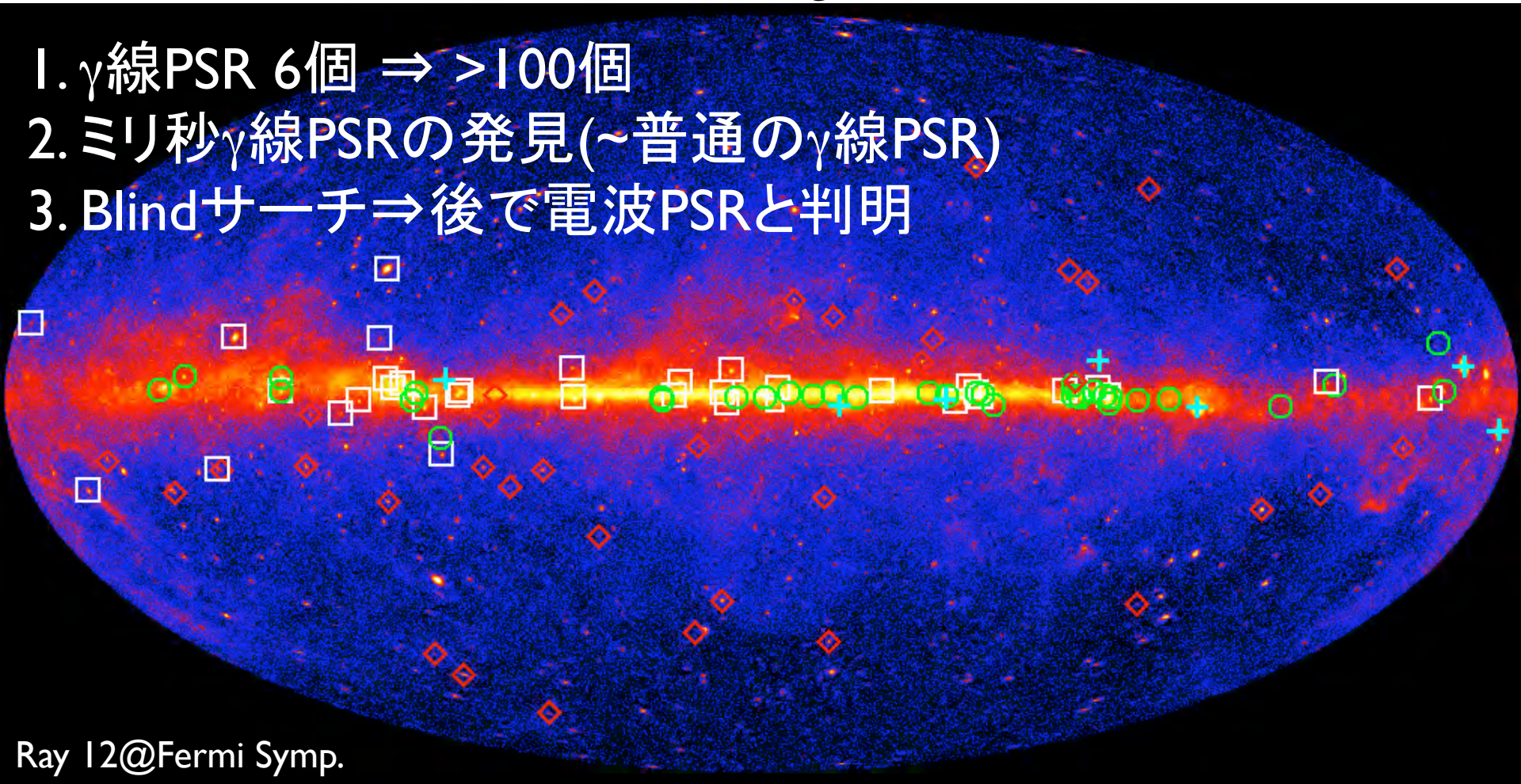
Pulsars

Goldreich & Julian 69



Gamma-Ray Pulsars

1. γ 線PSR 6個 \Rightarrow >100 個
2. ミリ秒 γ 線PSRの発見(\sim 普通の γ 線PSR)
3. Blindサーチ \Rightarrow 後で電波PSRと判明



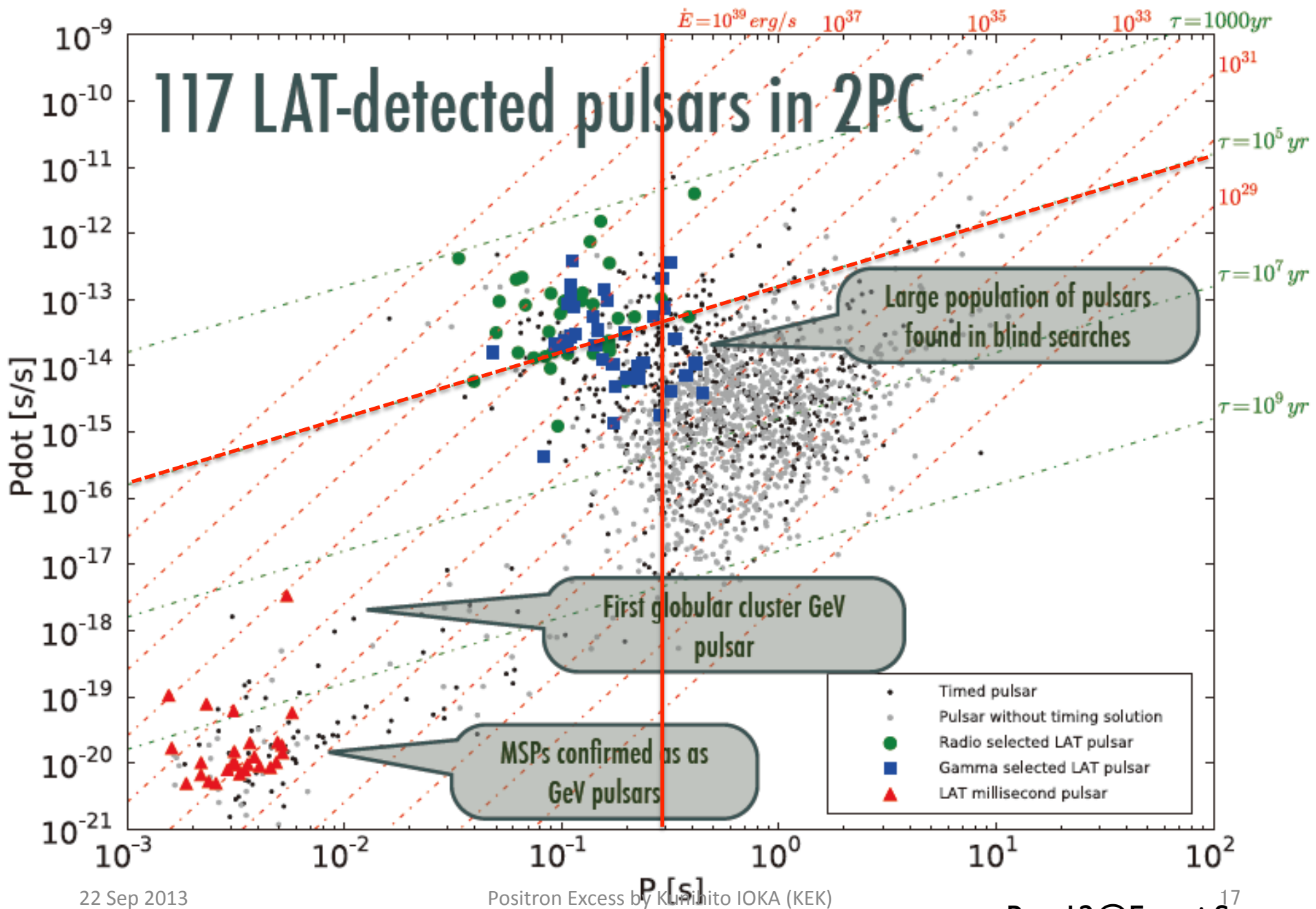
Ray 12@Fermi Symp.

Fermi satellite (LAT) has found **117 γ -ray pulsars**

22 Sep 2013

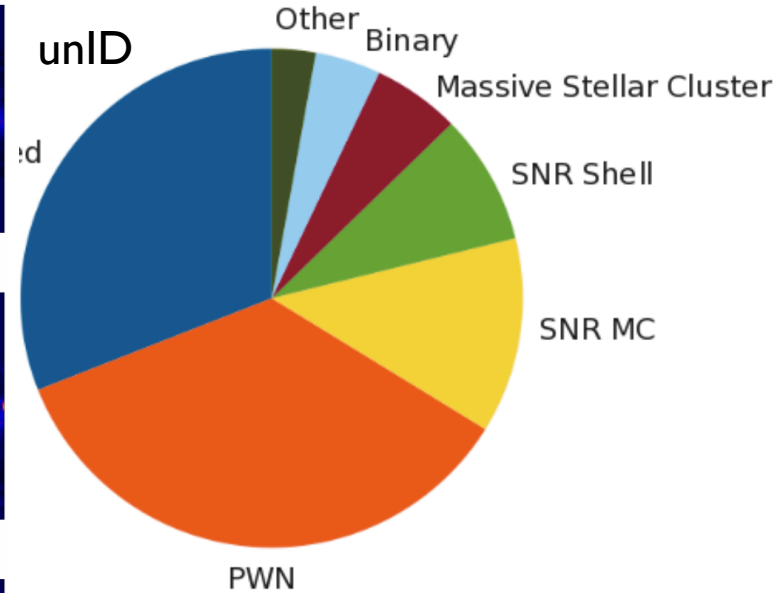
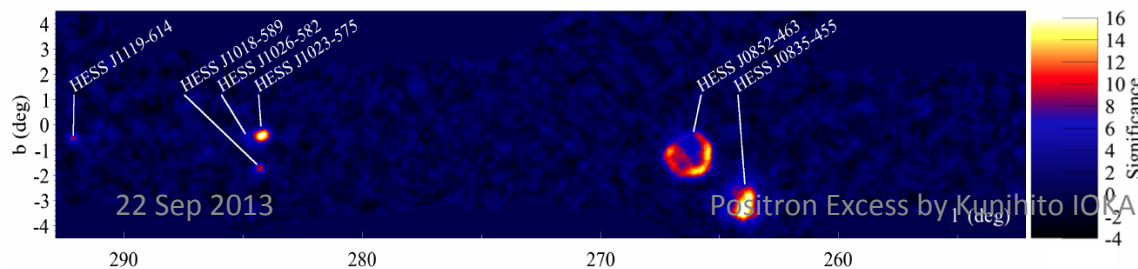
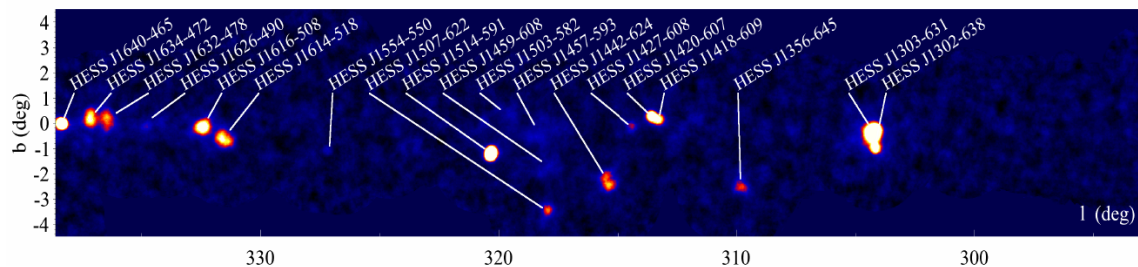
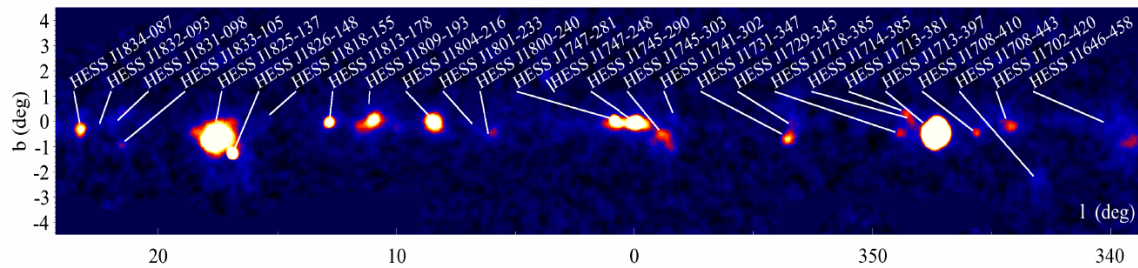
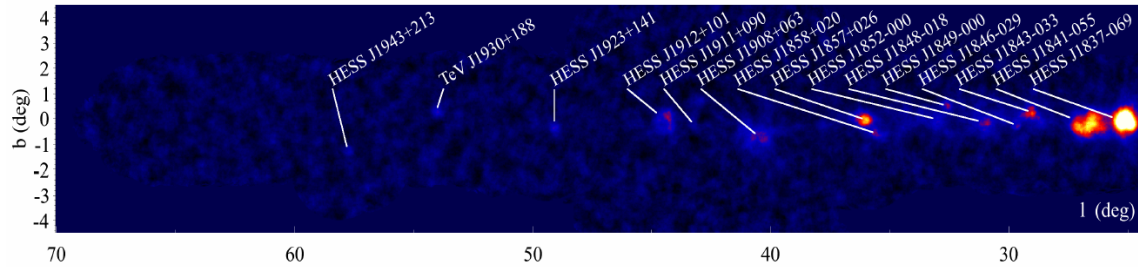
Positron Excess by Kunihito IOKA (KEK)

CGRO PSRs (+), young radio-selected (O), young gamma-selected (\square), MSPs (\diamond)¹⁶



TeV Gamma-Ray Sky

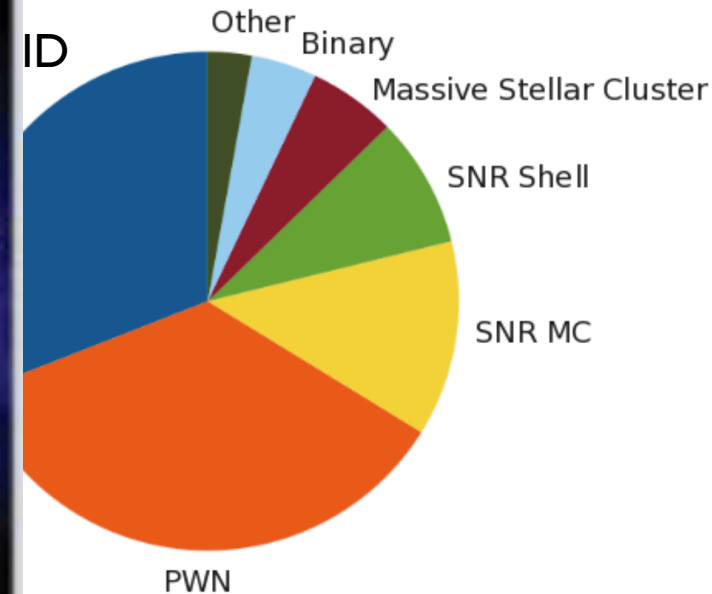
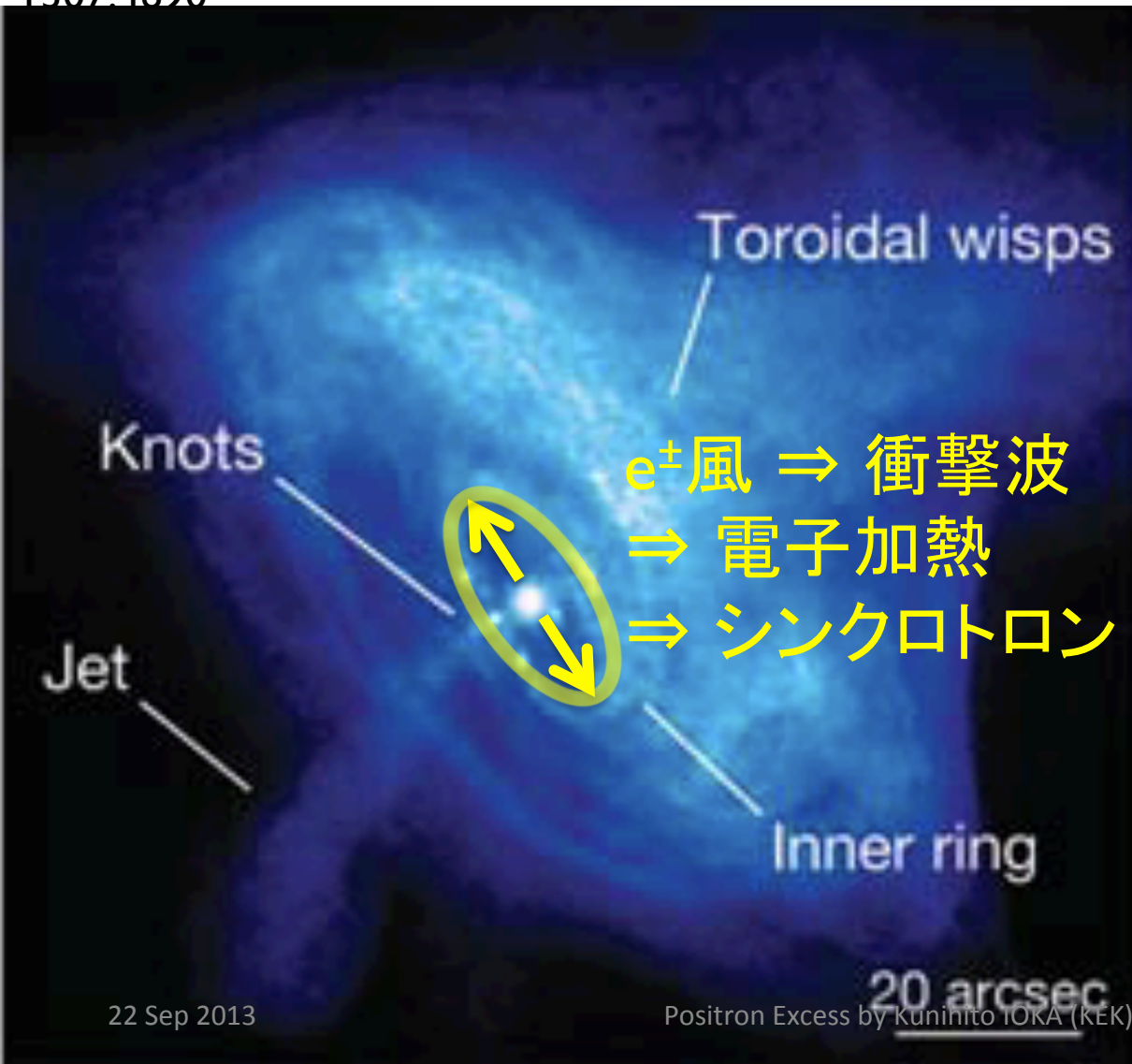
I 307.4690



**Pulsar
Wind Nebula
dominates
TeV γ -ray sky**

TeV Gamma-Ray Sky

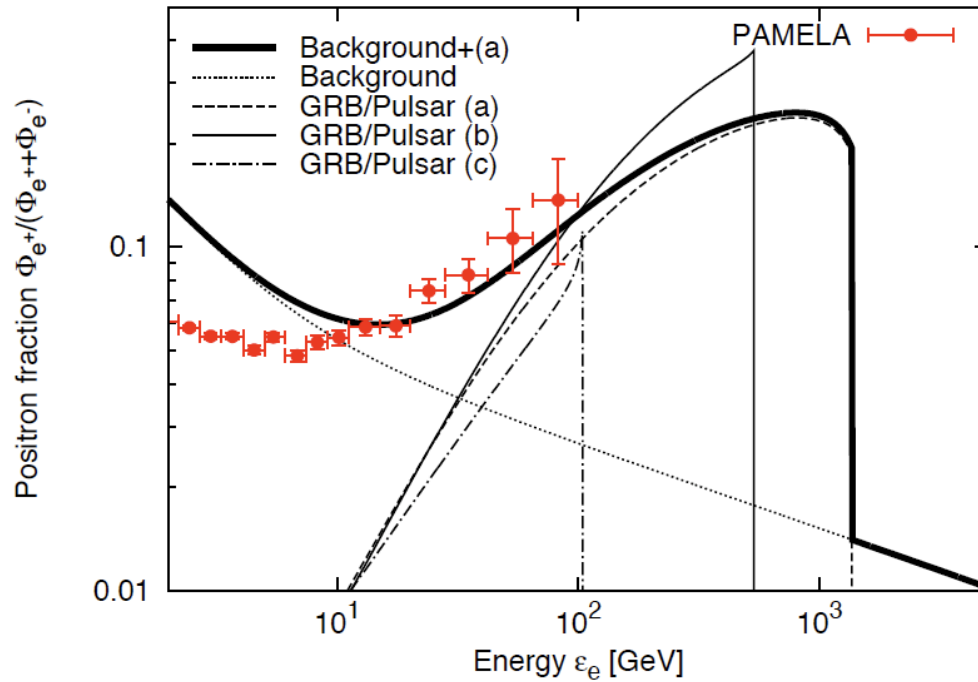
I307.4690



**Pulsar
Wind Nebula
dominates
TeV γ -ray sky**

Spectral Fitting

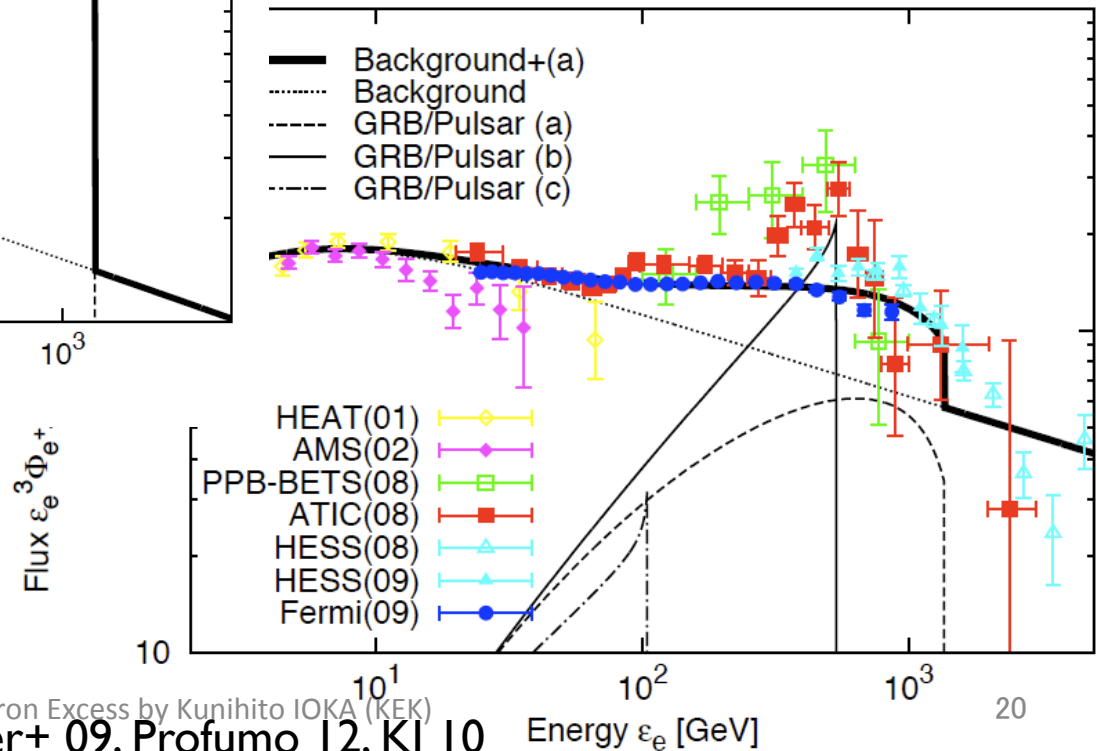
Positron



$d=1\text{kpc}$		
(a) Fiducial	(b) Harder	(c) Older
$0.9e50\text{ erg}$	$0.8e50\text{ erg}$	$3e50\text{ erg}$
$2e5\text{ yr}$	$5.6e5\text{ yr}$	$3e6\text{ yr}$
$\alpha=2.5$	$\alpha=1.8$	$\alpha=1.8$

Both e^\pm can be fitted by the same model

Electron

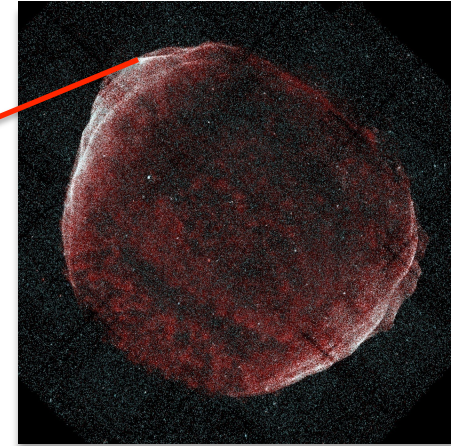
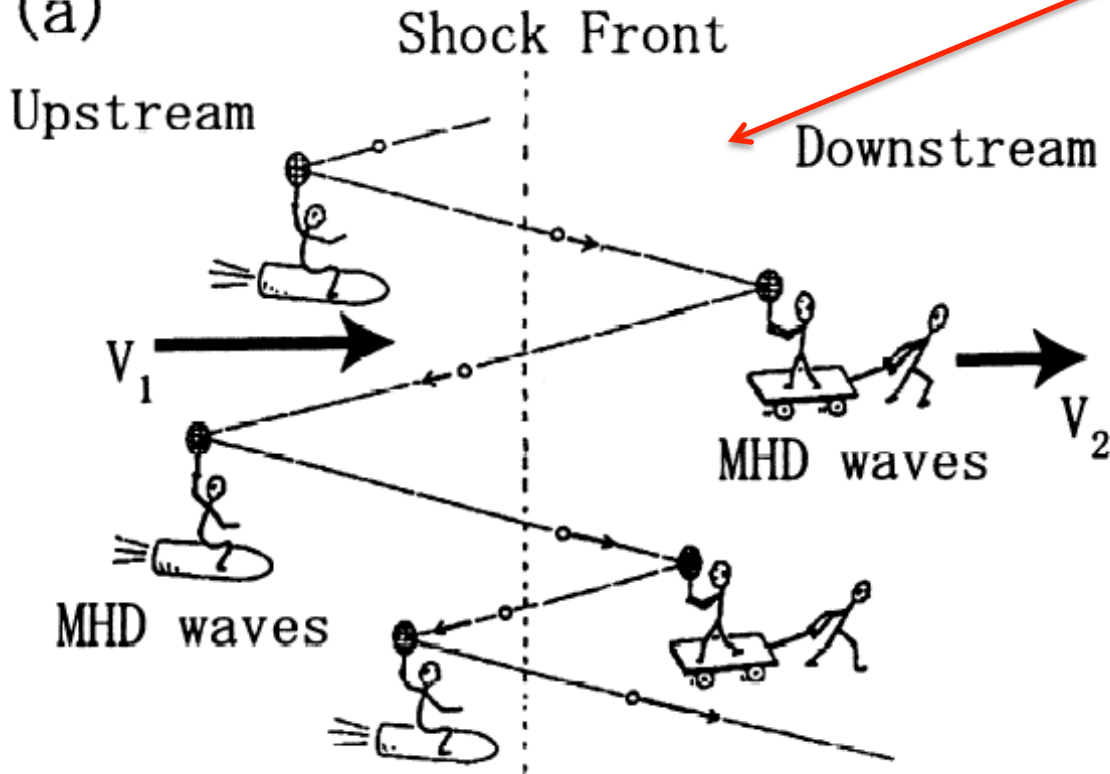


Positron Excess by Kunihito IOKA (KEK)
e.g. Hooper+ 09, Profumo 12, KI 10

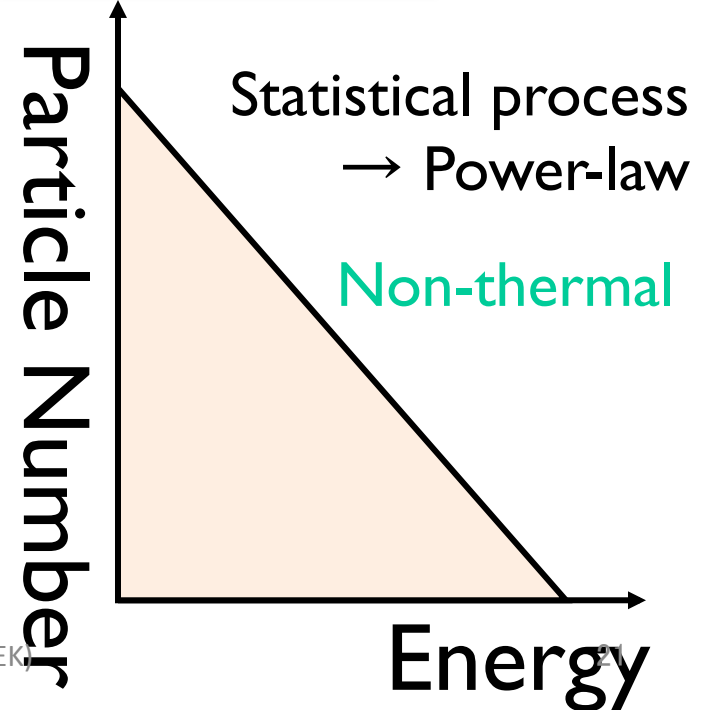
Supernova Remnant

Collisionless shock

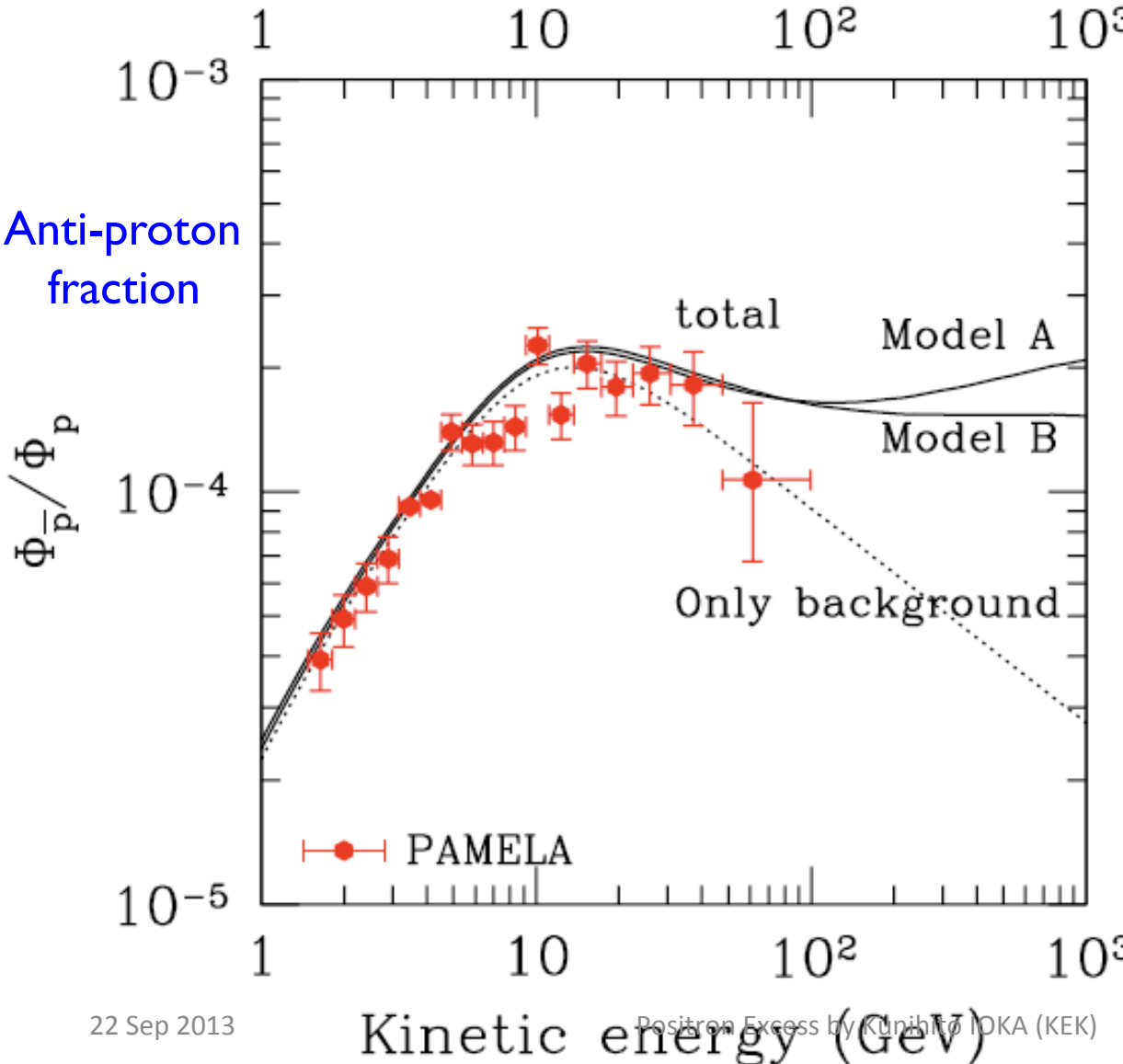
(a)



Diffusive shock acceleration
(Fermi acceleration)



Anti-Proton



SNR model:
 $pp \rightarrow \pi^+ \rightarrow e^+ e^-$
 (w/ surrounding)

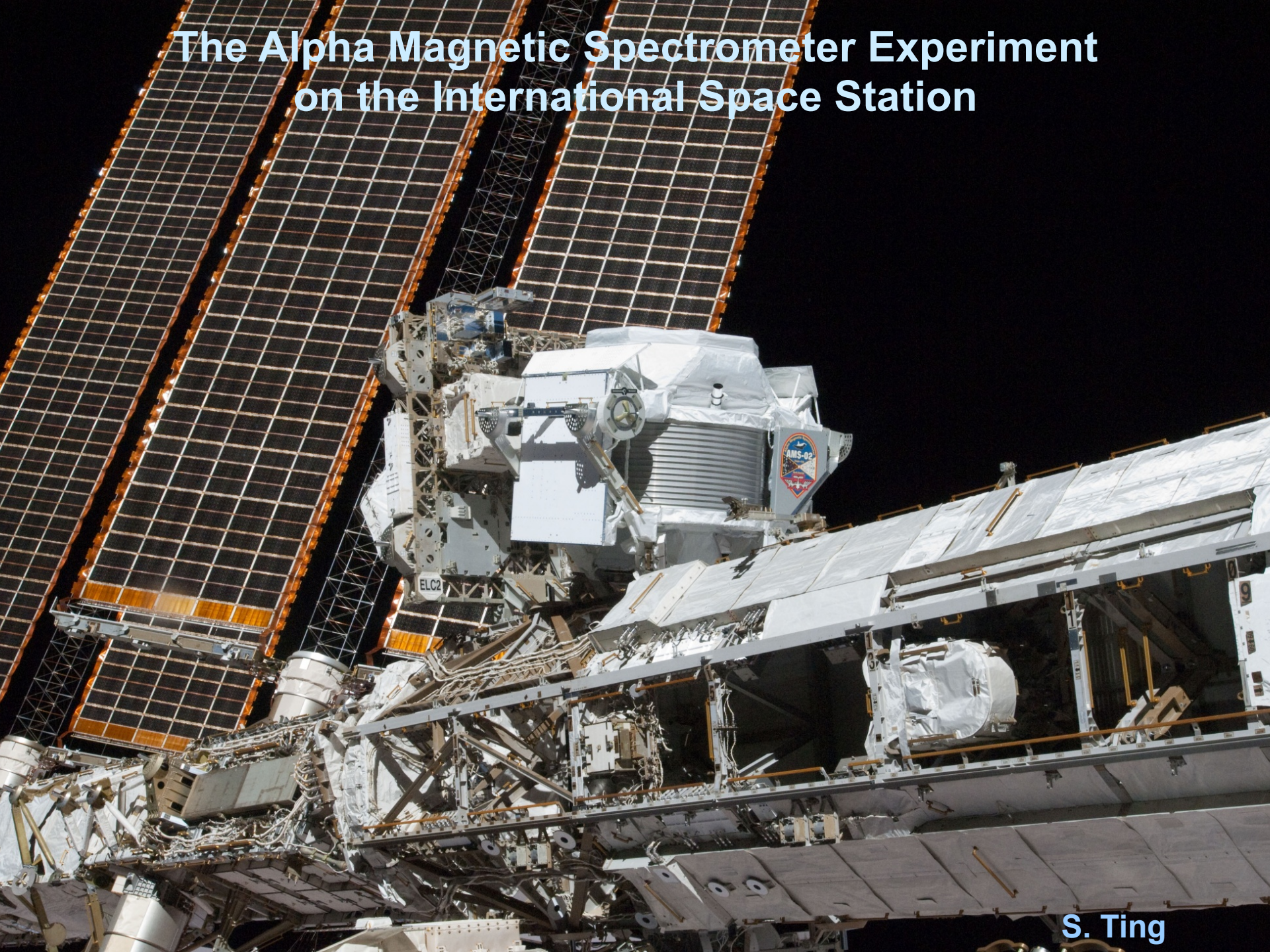
\Rightarrow Inevitably
 anti-proton
 excess above
 ~ 100 GeV

\Rightarrow AMS-02

Before AMS-02

- **e^\pm excesses, No $p\bar{p}$ excess**
- **Dark Matter**
 - can fit both e^\pm
 - constrained by other messengers
- **Astrophysical models**
 - can fit both e^\pm
 - Many models but pulsars are promising

The Alpha Magnetic Spectrometer Experiment on the International Space Station



S. Ting

2013.4.4. News Paper

2013年4月3日の晩にSamuel Ting氏の講演 次の朝の朝日新聞の一面



浦和学院が初V
選抜高校野球

北朝鮮は、巨匠バ、付近
なく、射撃や数段、強固に
搭載できる爆弾の量など、
詳しい性能はわかっていな

理論上、宇宙に大量の
と考えられている正体不
明の「暗黒物質」が、実際
に存在する可能性を示す痕
跡を、欧米やアジアの国際
研究グループが初め見付
けた。スイスで3日(日)
本時間4日未明)発表す
る。星や銀河の誕生の謎を
解き明かす一歩となる成果
だ。▼2面■「二ニニ」が
わからん」
現在の宇宙論では、暗黒
物質は宇宙の成分の約27
1を占めるとされる。ただ
光などの手がかりをばら
いたため確認が難しく、その
存在は宇宙最大の謎の一つ
だ。

暗黒物質の痕跡？確認 宇宙をつくる正体不明の成分

サミュエル・ティン米マ
サチューレット工科大学教
授を代表とするグループは
今回、国際宇宙探査機シ
ェン(シス)に取り付けた
アルファ磁気分光計(AM
S)とじつ装置を使い、電
子と逆のプラスの電気を帯
びた陽電子を観測した。陽
電子は、暗黒物質同士がぶ
つかって消滅する際に飛び
出すと考えられている。
陽電子の量とエネルギー
は、暗黒物質が存在すると
仮定した場合予測された
のとほぼ一致していること
を精度良く確認した。今後
解析でこの陽電子が暗黒
物質の痕跡かはかの発生源
の海域などでは禁止区域
を設定している。米国防
総省によれば、米軍は西太
平洋にシス(駆逐艦)「シ
ェン・シー・メイジャー」を派
遣した。(読者投稿)

互いの指先をのり家を人輪に駆け込み力押しで、
全国の自治体が判断を迫られそうだ。 7面

ダル、「あと1人」の難しさ
大リーグ・レンジャーズのダル
ビッシュ有投手が「あと1人」で完
全試合を逃した。似た経験をした
投手や元航空機機長、脳科学者に
聞いて「なぜ」を探った。 37面

復興 津波被災地かさ上げに遅れ
岩手、宮城、福島3県で津波被災地をかさ上
げて居住地にする地区は37カ所あるが、6割
で事業完了まで5年以上かかるとが分かっ
た。区画整理による私有地減少や津波への恐怖
から住民の合意づくりが遅れている。 39面

化粧の子カラ つまみつけの魔法 27面
志ん生風? 小林英雄の対談音源 37面
除染手当不払い「口止め拒んだら解雇」 38面

経済8.11面 囲碁・将棋14面
金融情報12.14.15面 小説34面
国際12.13面 科学34面
教育31面/生活27面 地域28.29面
スポーツ22.23.25面 TV・ラジオ32.33.40面

デジタル版「ネットと選挙」を特集
インターネットによる選挙運動が
参院選から解禁されます。特集ペ
ージ「ネットと選挙」で4日午前、衆
院での参选人質疑をツイッター・実況
します。http://t.asahi.com/abnu
www.asahi.com 専用窓口 0120-383-636(日・祝休み)

ニュースが わからん

あんらくぶっしつ こんせき
暗黒物質の「痕跡」
見つかったの?

宇宙の組成
通常の物質 4%
暗黒物質 23%
暗黒エネルギー 73%

ISSに取り付けられた検出器
国際宇宙探査機(シス)に取り付けられたアルファ磁気分光計(AMS)と宇宙線探査衛星(NASA)提供

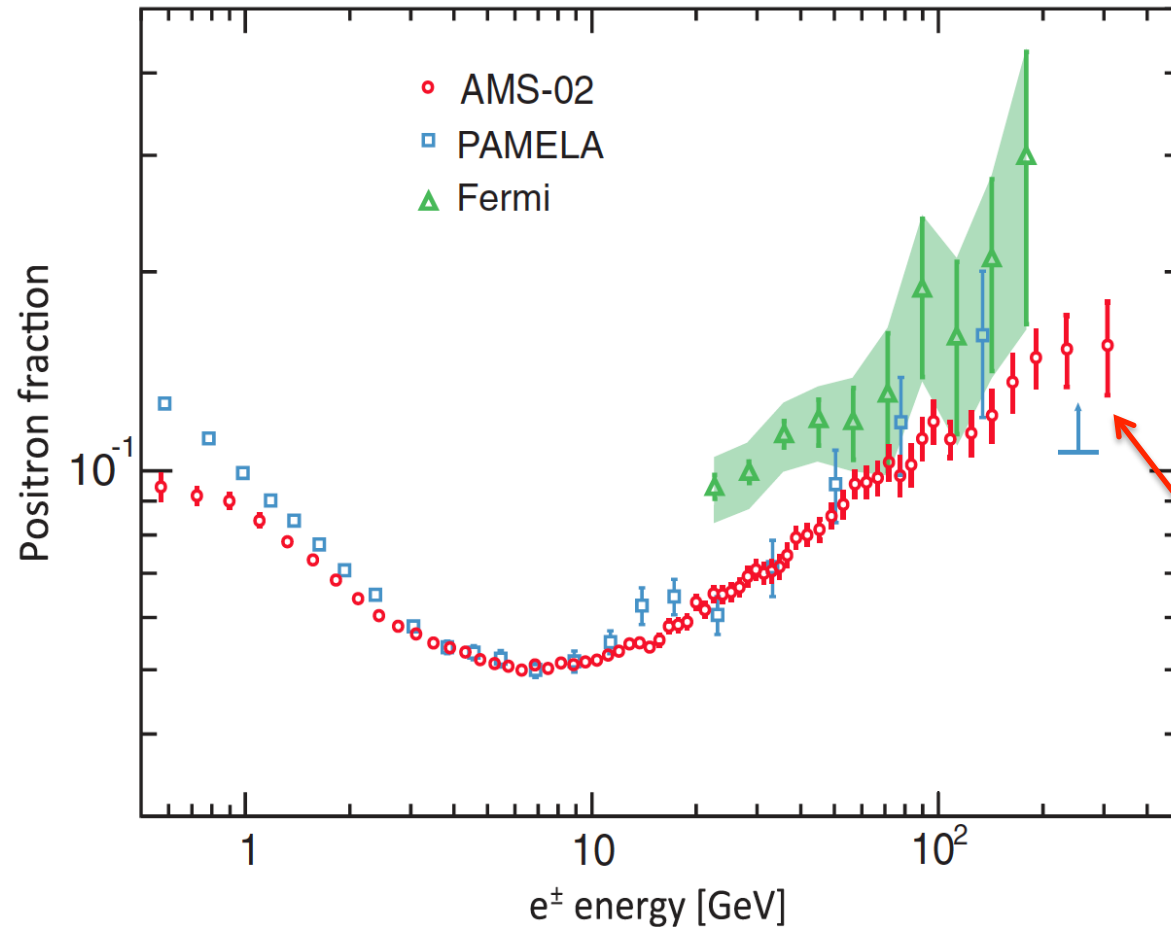
暗黒物質を探している主な装置
COMS(米国) LHC(仏・スイス国境)

XENON100(イタリア) XMASS(日本)

宇宙誕生のなごを解き明かす大きな一歩になるかもね
コブク郎「暗黒物質」
の痕跡が見つかったの?
A 暗黒物質同士がぶつ
かって生じたと思われる粒
子を、高度4000mを回る
国際宇宙探査機「シス」(I
SS)に取り付けた装置が
はそれ以外の「何か」か多
くを占めているらしいん
だ。例えば、たぐよんの天
体が集まって回転する銀河
の回転速度をうまく説明す
るには、銀河に重し「何
か」が必要があるんだ。
それが暗黒物質って
こと。
A そう。約80年前に提
唱されたときは信じられな
かった。暗黒物質のほかに
「ダークマター」もある。宇
宙膨張を緩め、ある時か
ら膨張が急激に遅くなる
らしいけど、それは暗黒エネ
ルギーのせいだと思われて
いる。この「ダークマター」
が存在が宇宙の9割以上を調
べていて、普通の物質は
4%に過ぎないと考えられ
ているんだ。
コ 普通の物質には影響
を身ないの?
A 暗黒物質は重い重力
によって宇宙を引っ張る
引き寄せて、星や銀河を形
作る。暗黒物質の量が分
かれば、現在の宇宙がどの
ままだって分かるはずだ。
だから、地球があるのも暗
黒物質のおかげかもね。
コ でも観測は難しいぞう
だね。
A はい。このように、暗黒
物質同士がぶつかった際に飛
び出す陽電子を観測する
ほか、地上でも岐阜県の
神岡鉱山にある検出器
「XMASS」などで暗黒
物質を直接見つけようとし
ている。欧州ではLHCとい
う巨大な加速器を使っ
て、暗黒物質の候補となる
粒子を作る研究も進めら
れている。(読者投稿)

完全にダークマターの話 一瞬、虚構新聞かと

AMS-02 New Points



1. High precision

2. Up to ~350 GeV

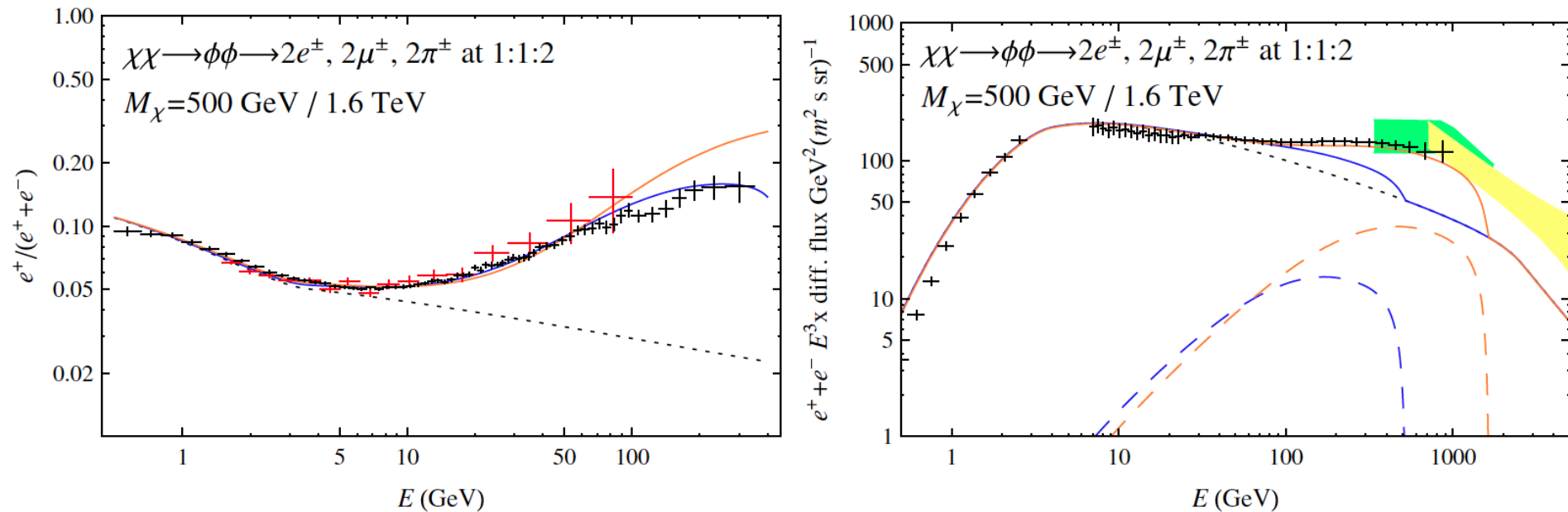
3. No fine structure

4. Slope declines

5. No anisotropy
 $\delta < 0.036$ (95%CL)

Tension with Fermi?

Slope declines \Rightarrow Does not fit Fermi data

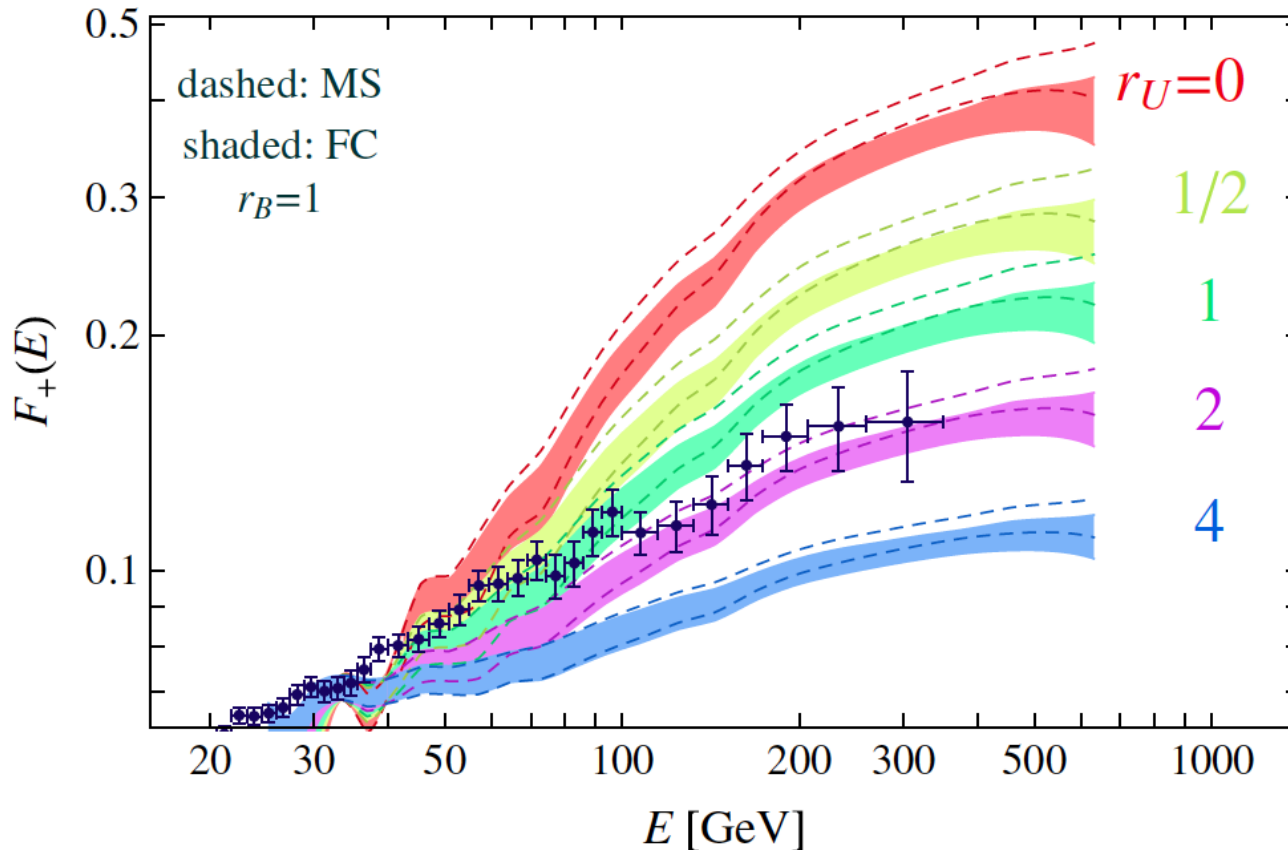


For both DM and pulsar models
Still within the Fermi systematics

Cholis & Hooper 13, Ibe+ 13
Yuan+ 13, Yuan & Bi 13
Masina & Sannino 13, Jin+ 13
De Simone+ 13, Feng+ 13
Gaggero & Maccione 13 27

Charge Asymmetry?

e^\pm source could produce $e^+ < e^-$?



$$r_U(E) \equiv \frac{\phi_{e^-}(E)}{\phi_{e^+}(E)}$$

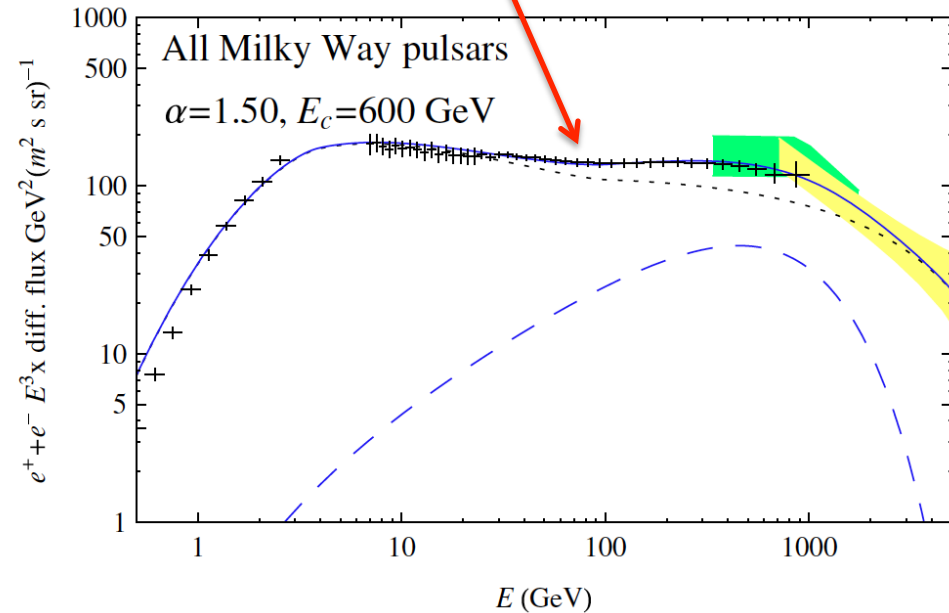
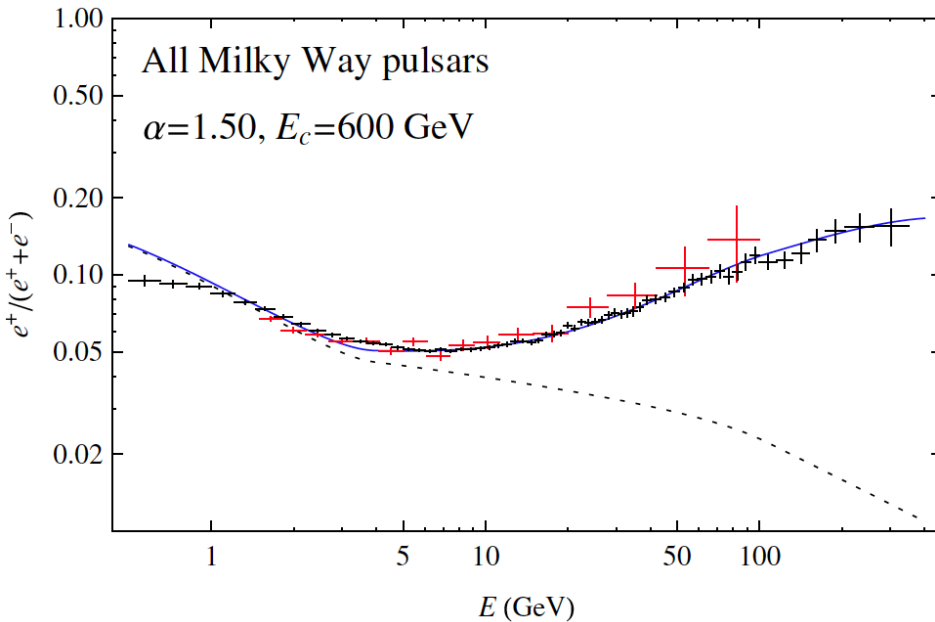
Asymmetric DM?
 e.g., $X \rightarrow e^- \mu^+$

Pulsar + SNR?

e^- Spectral Break?

Electron background may have a spectral break

$$\left\{ \begin{array}{ll} F \propto E_e^{-2.65} & \text{below 100 GeV} \\ F \propto E_e^{-2.3} & \text{above 100 GeV} \end{array} \right.$$



Cholis & Hooper 13, Yuan+ 13, Yuan & Bi 13, Feng+ 13

There WAS a motivation to consider such a break

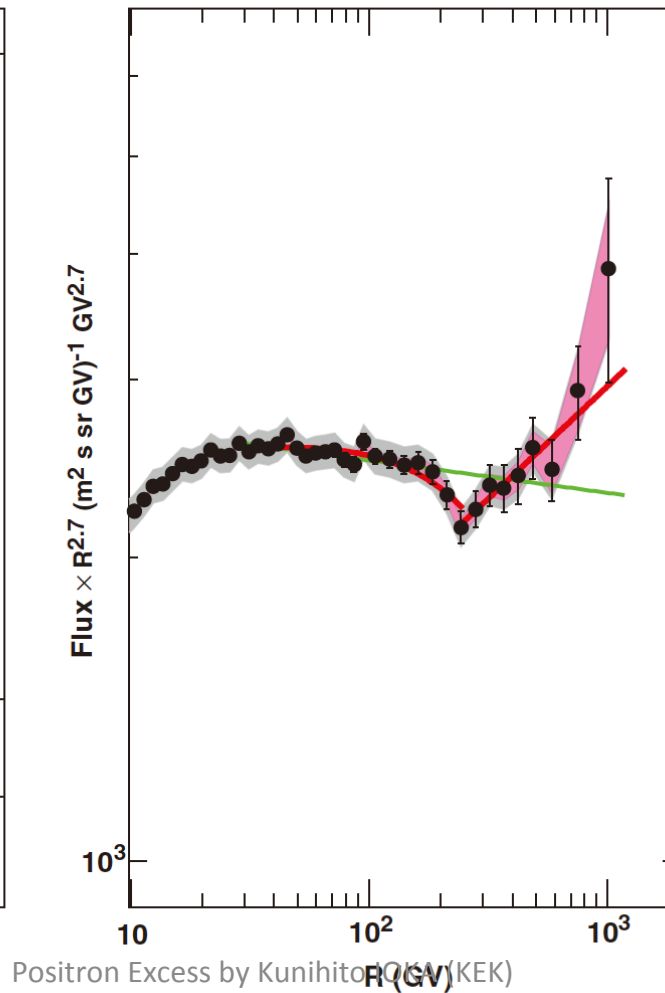
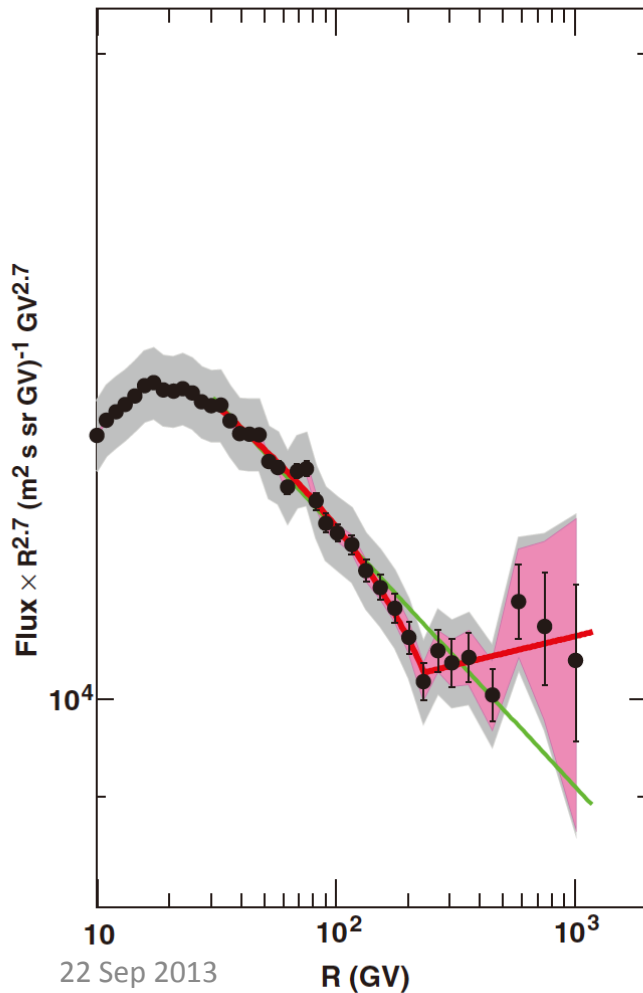
p & He Breaks

Proton

Helium

CREAM+ 10
PAMELA+ 11

p & He
⇒ Also e?



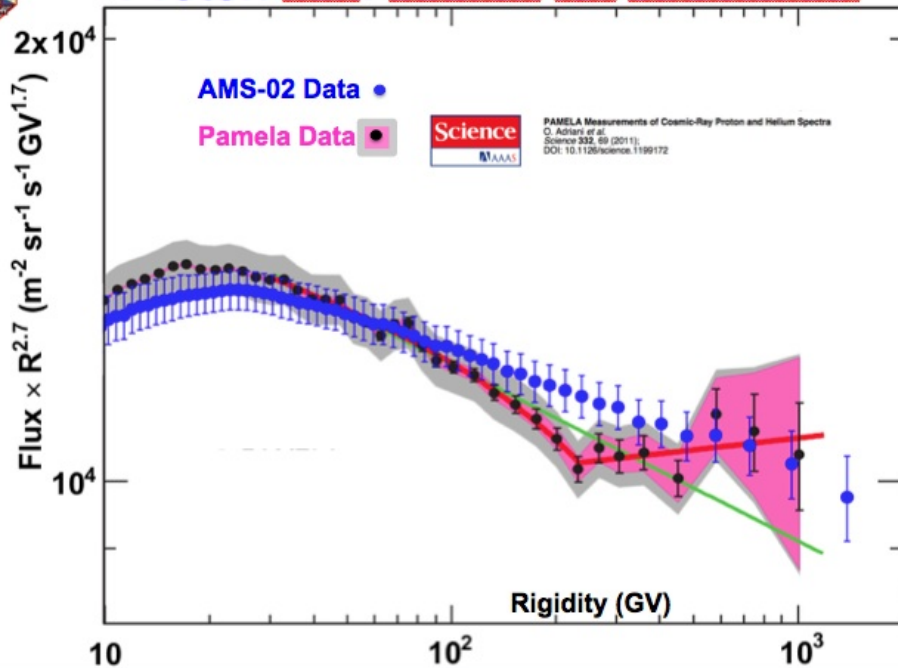
Index hardening
 $\Delta\gamma_p \sim 0.12 \pm 0.02$
 $\Delta\gamma_{He} \sim 0.16 \pm 0.02$

AMS-02: p & He

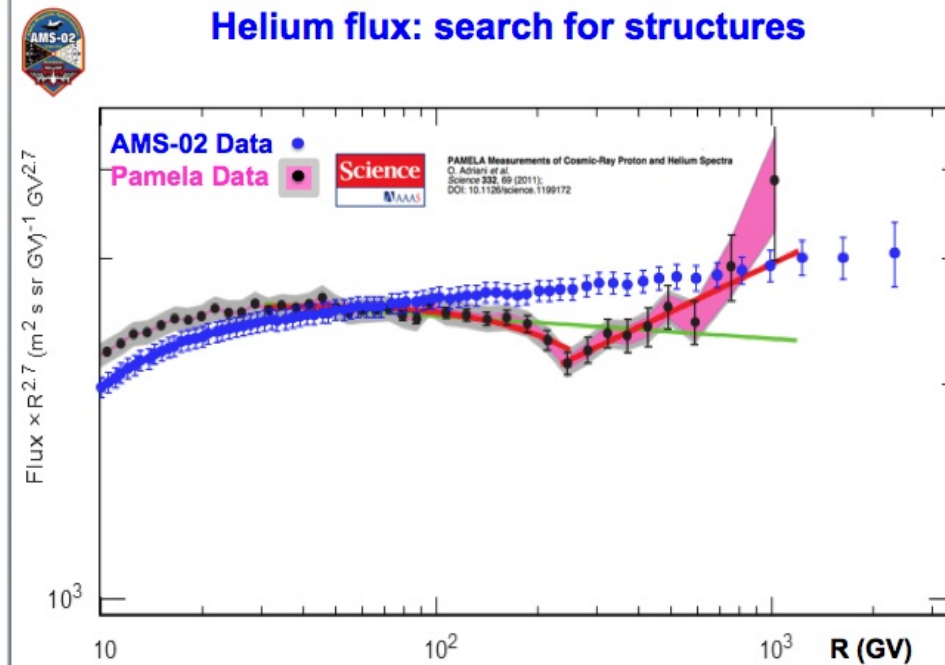
Spectral breaks disappear!

AMS-02, ICRC13

Proton flux: search for structures



Helium flux: search for structures

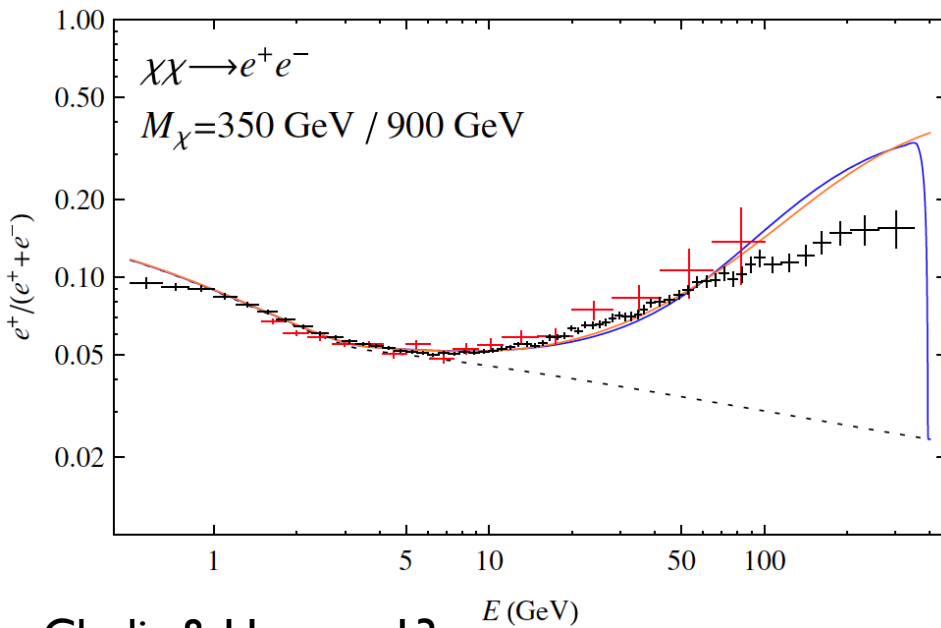


✓ He remains harder than p Ohira & KI 11

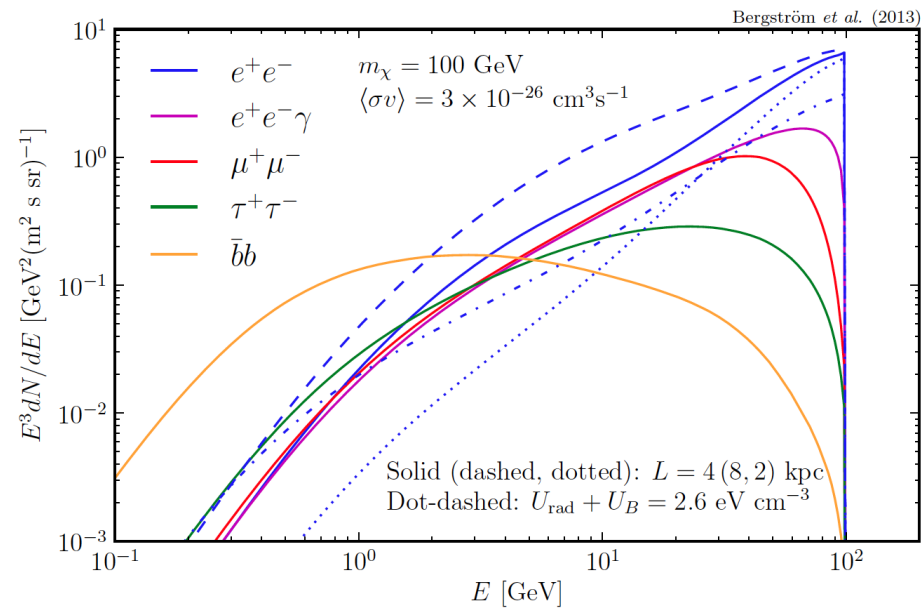
Stay tuned for e^- spectrum coming from AMS-02

Constraints on DM Models

Exclude ee and $\mu\mu$ channels



Cholis & Hooper 13

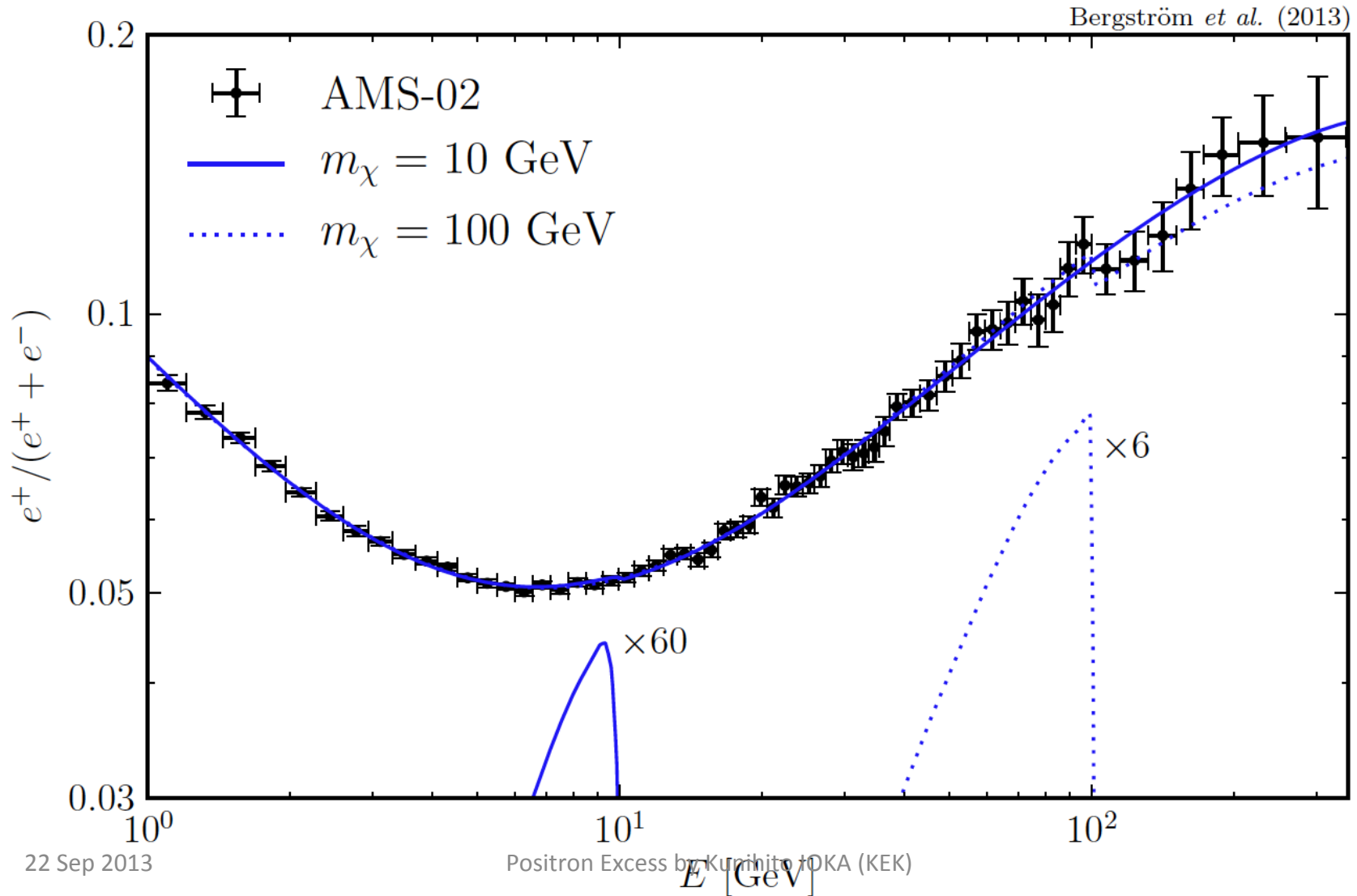


Bergstrom+ 13

Sharp spectrum does not fit

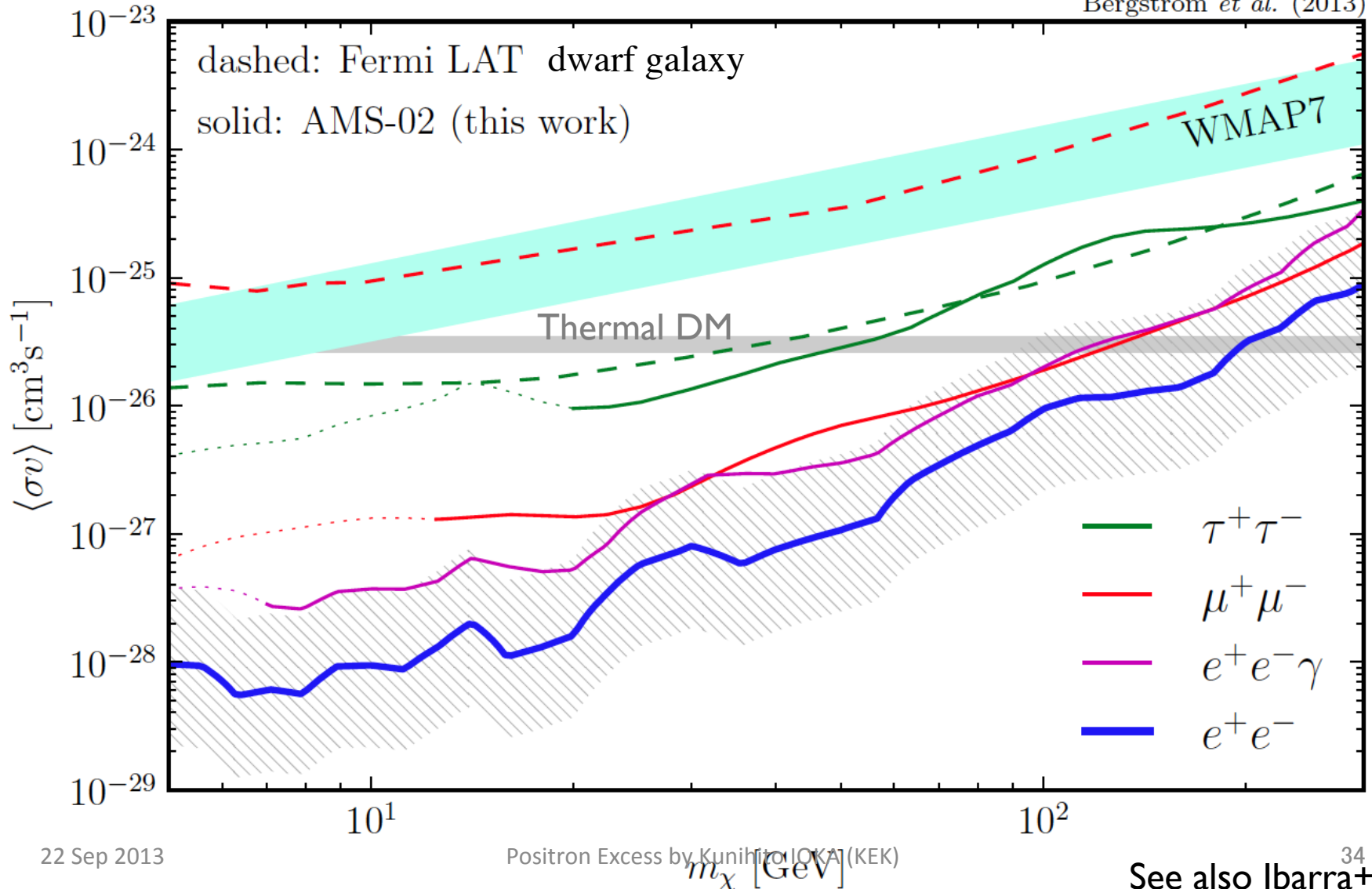
Allow, e.g., $\chi\chi \rightarrow \phi\phi \rightarrow 2e^\pm, 2\mu^\pm, 2\pi^\pm$ at 1:1:2

Limits on Cross Section



Limits on Cross Section

Bergström *et al.* (2013)



Dark Matter or Pulsar?

- Clues

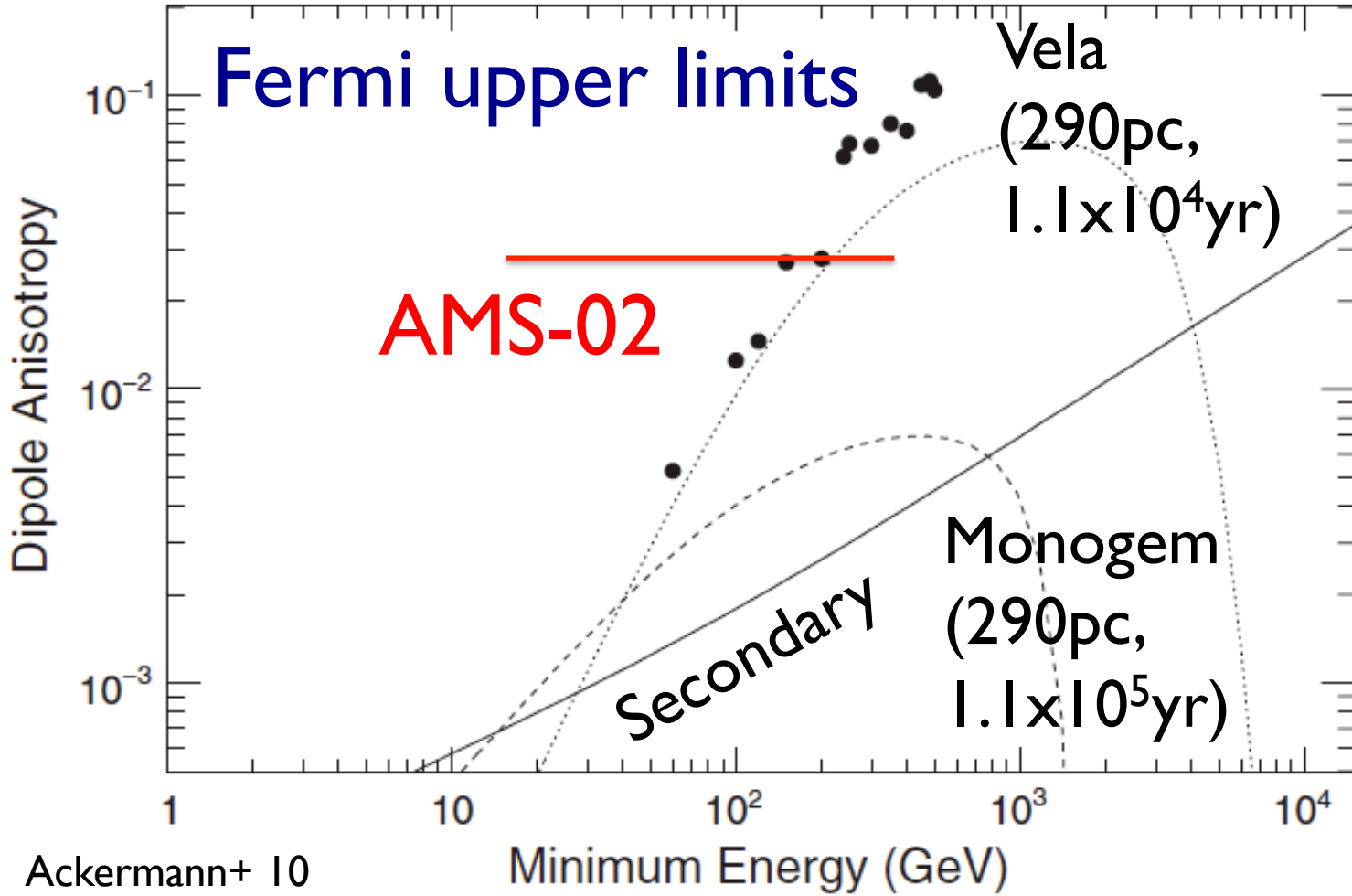
- Anisotropy

- Spectrum

- e^- , $pbar$, γ , other messengers

- Other possibility?

e⁻ Anisotropy: Pulsar



$$\delta = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

$$= \frac{3K|\nabla f|}{cf}$$

$$\sim \frac{3d}{2ct}$$

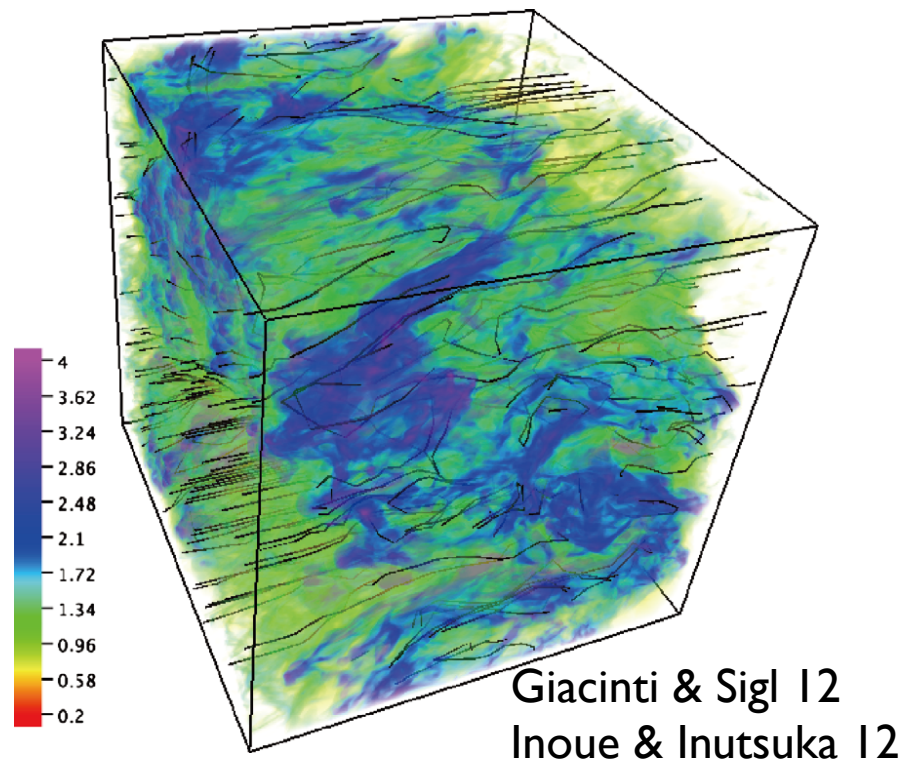
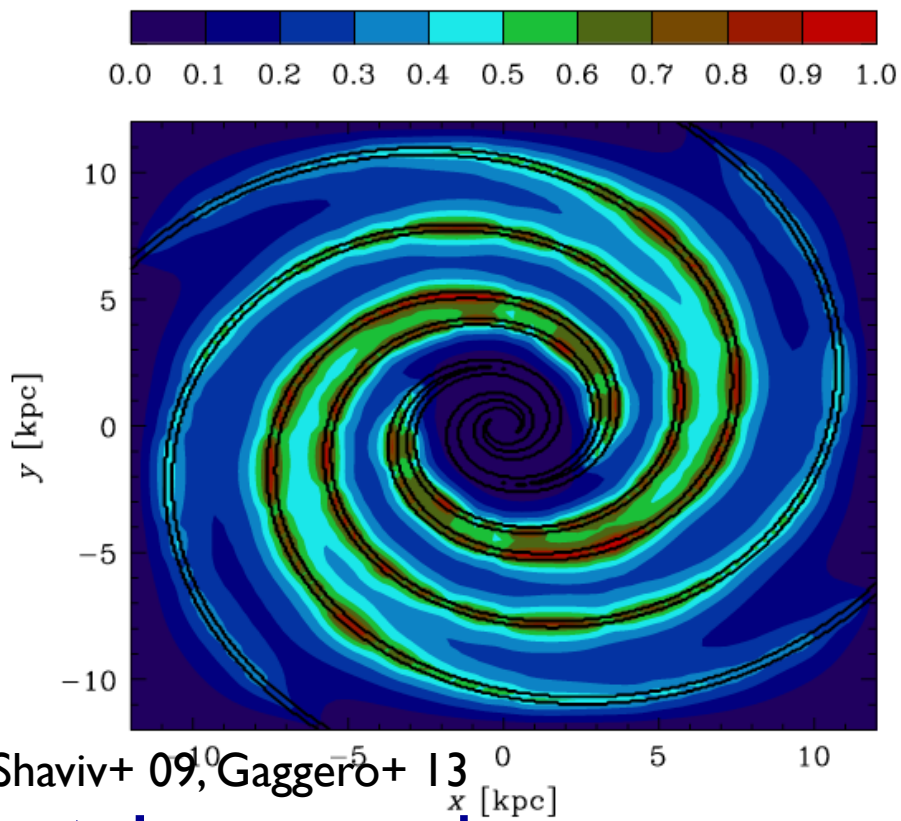
$\delta < 0.030$
(95%CL;
16-350 GeV)
by AMS-02

Limit $\propto t^{-1/2}$; For multiple sources, anisotropy \downarrow

Local Structures

Spiral distribution

Local B Turbulence

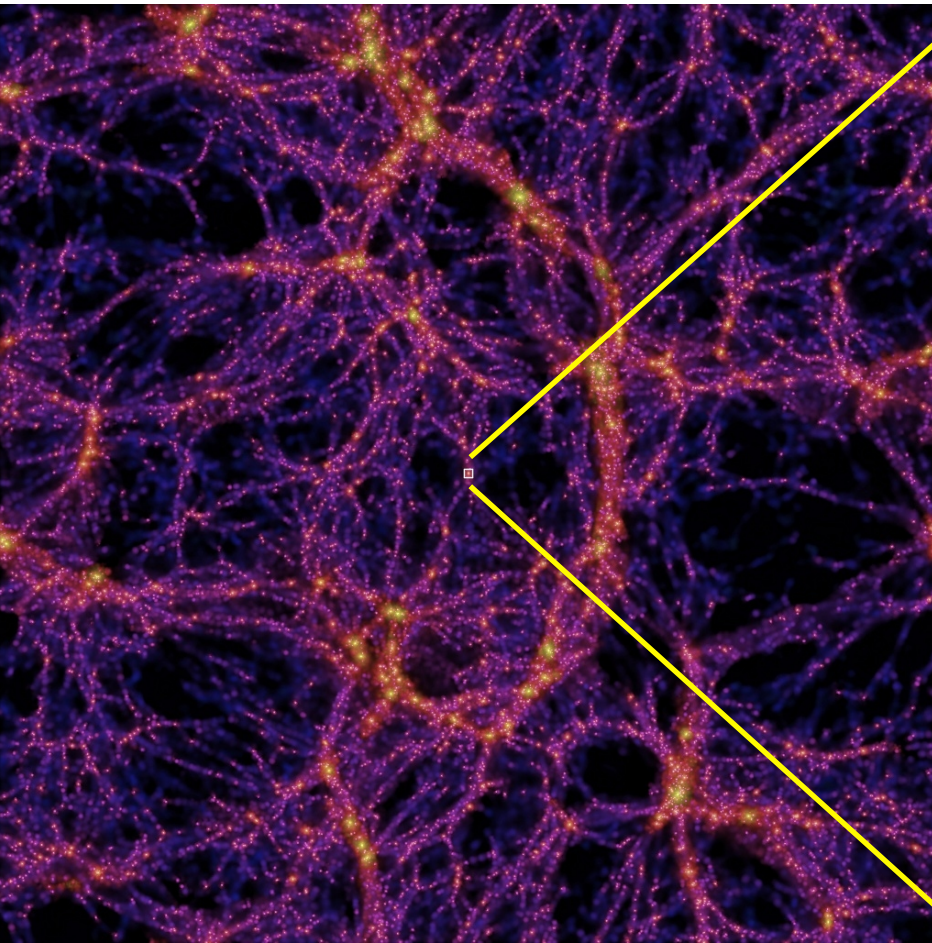


⇒ Less nearby sources

⇒ Less anisotropy

$$r_g(p) \approx \frac{p}{eZB} \approx 10^{-3} \text{ pc} \left(\frac{p/Z}{\text{TeV}} \right) \left(\frac{B}{\mu\text{G}} \right)^{-1}$$

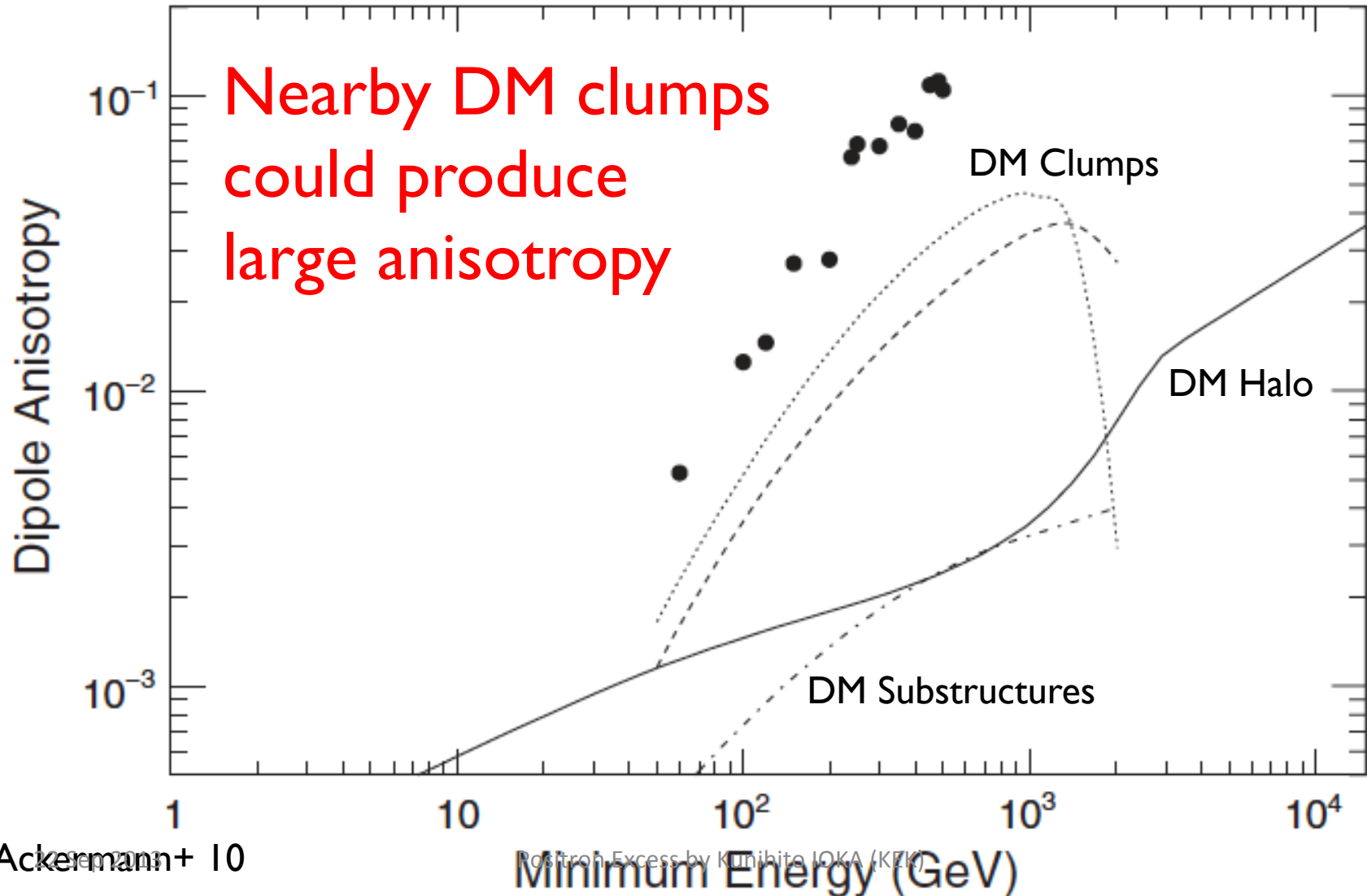
Dark Matter Structure



N-body Simulation

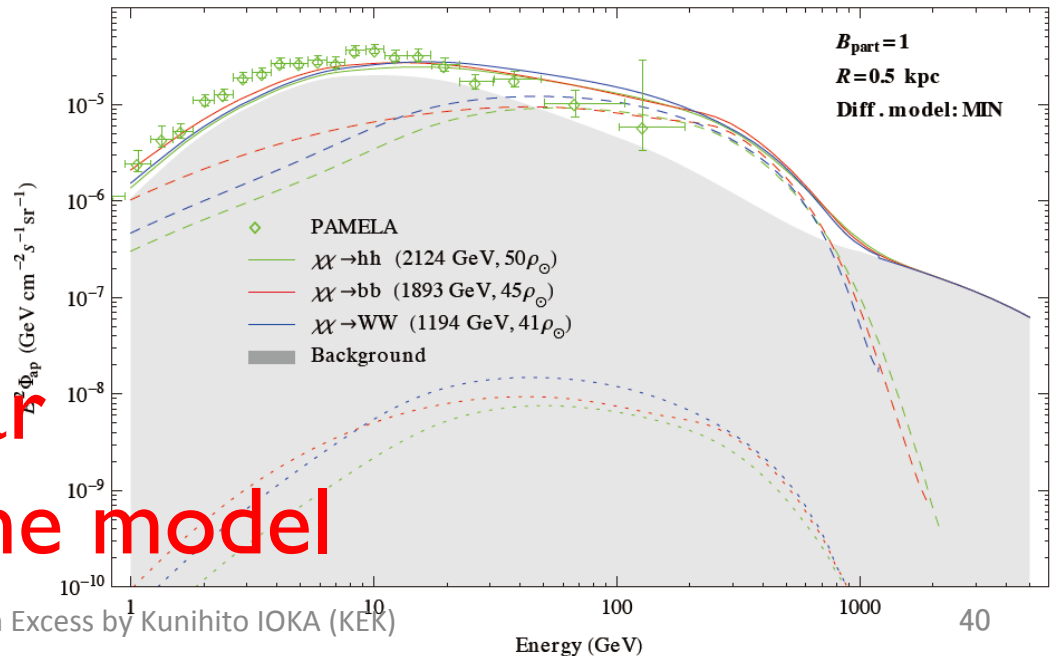
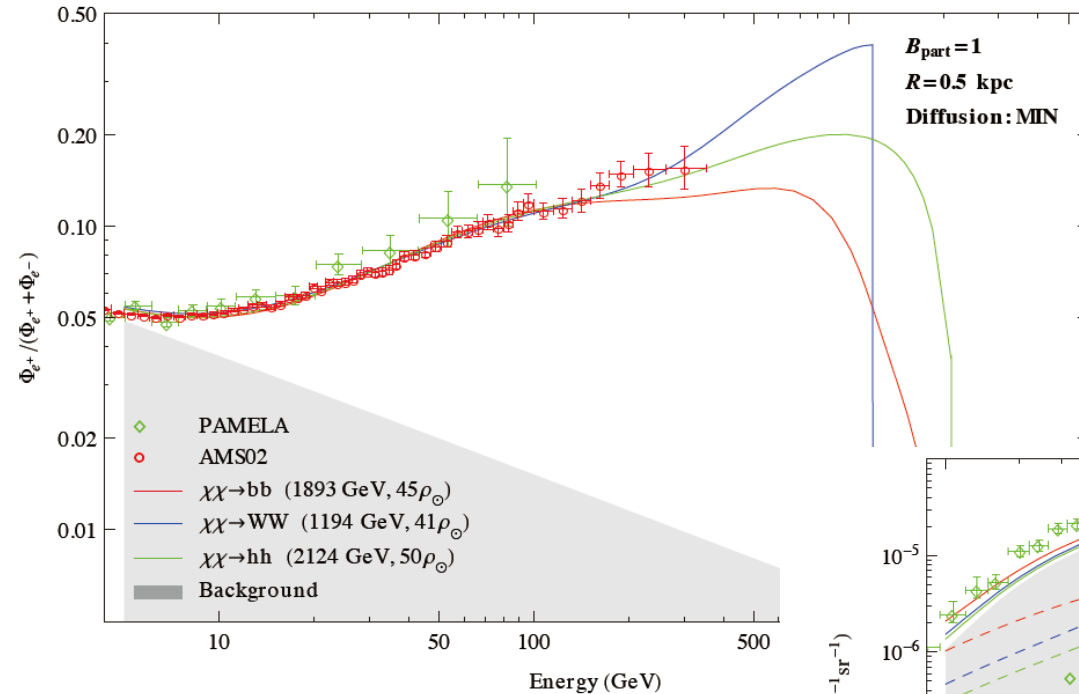
The Aquarius Project

e^- Anisotropy: Dark Matter



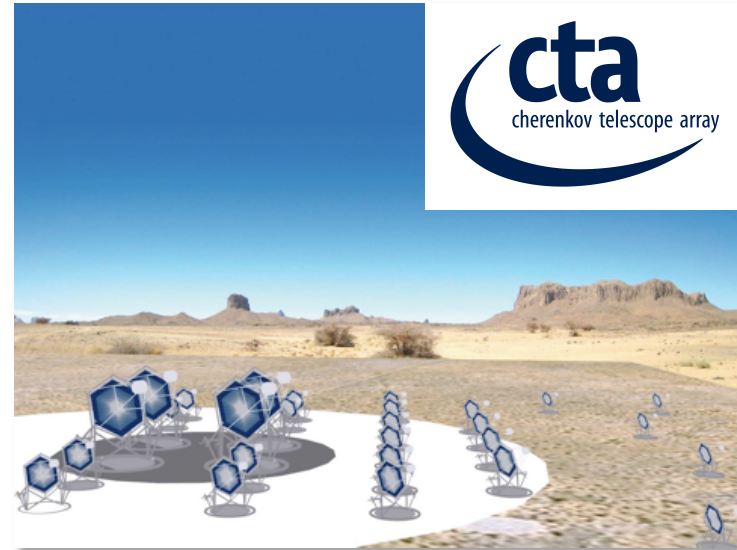
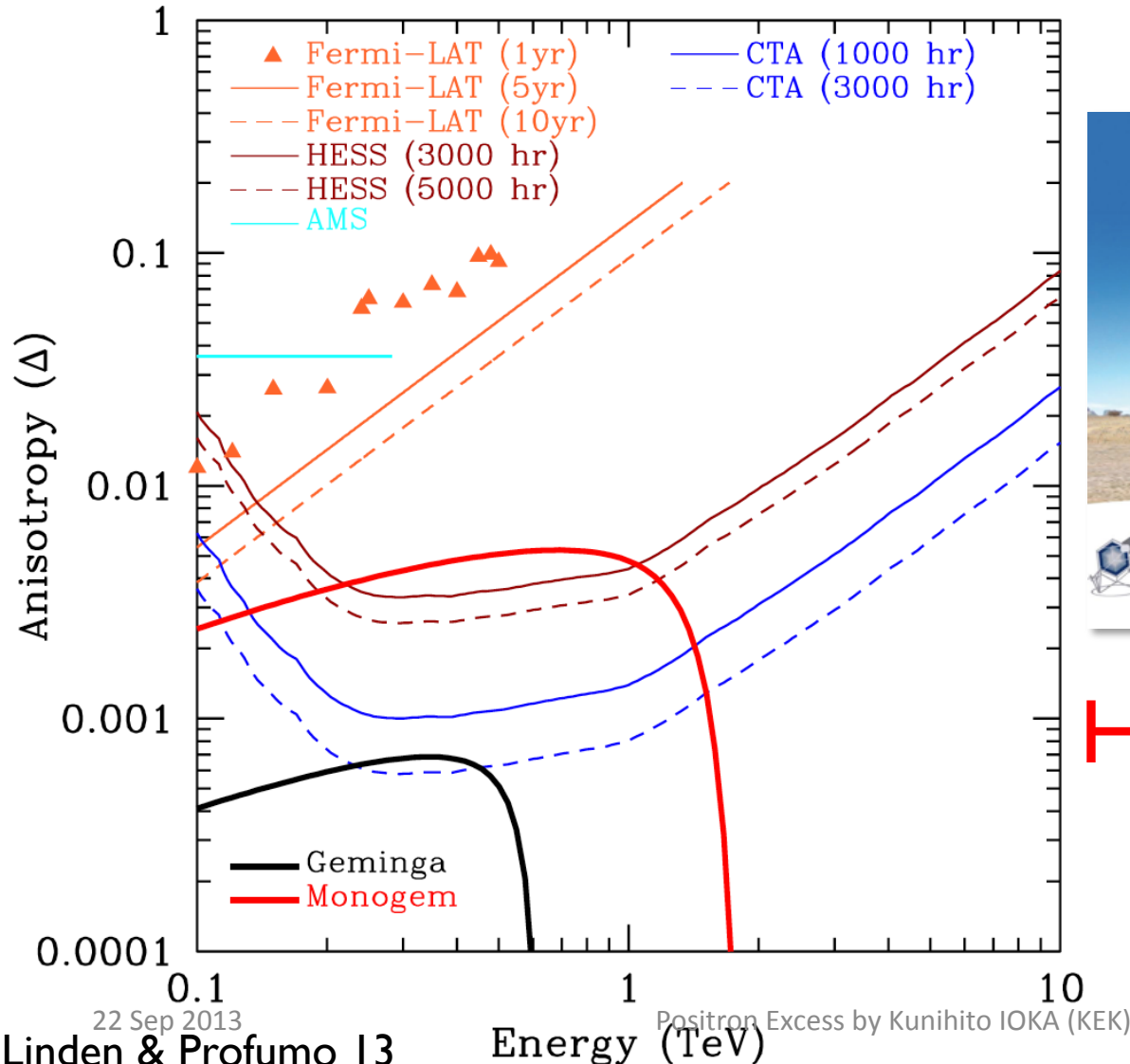
DM Over-Density

DM clump models
can use hadronic
modes to fit e^+/e^-



Consistent with pbar
AMS-02 pbar test the model

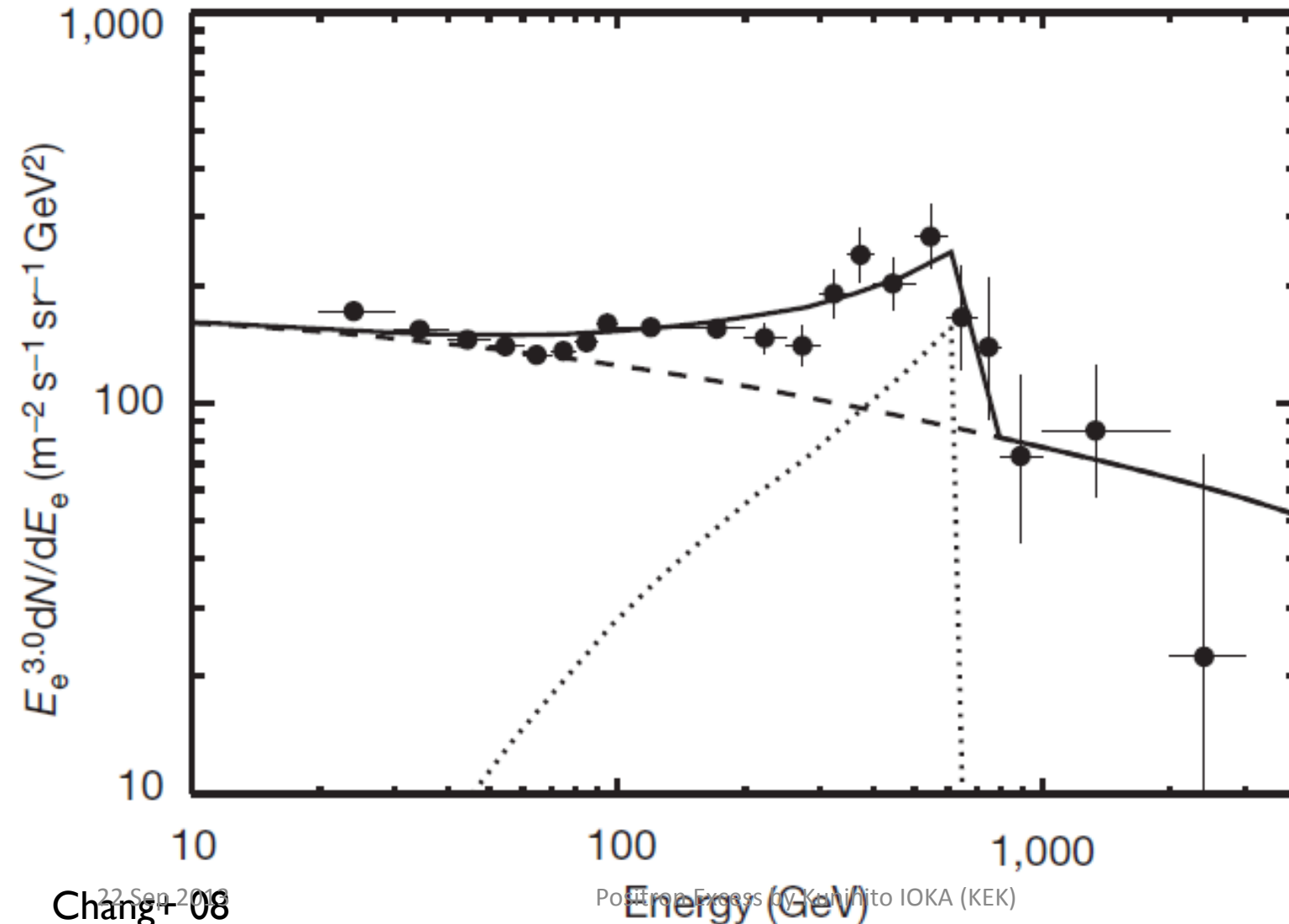
Future: CTA



Huge effective area

It may be difficult to control the systematics

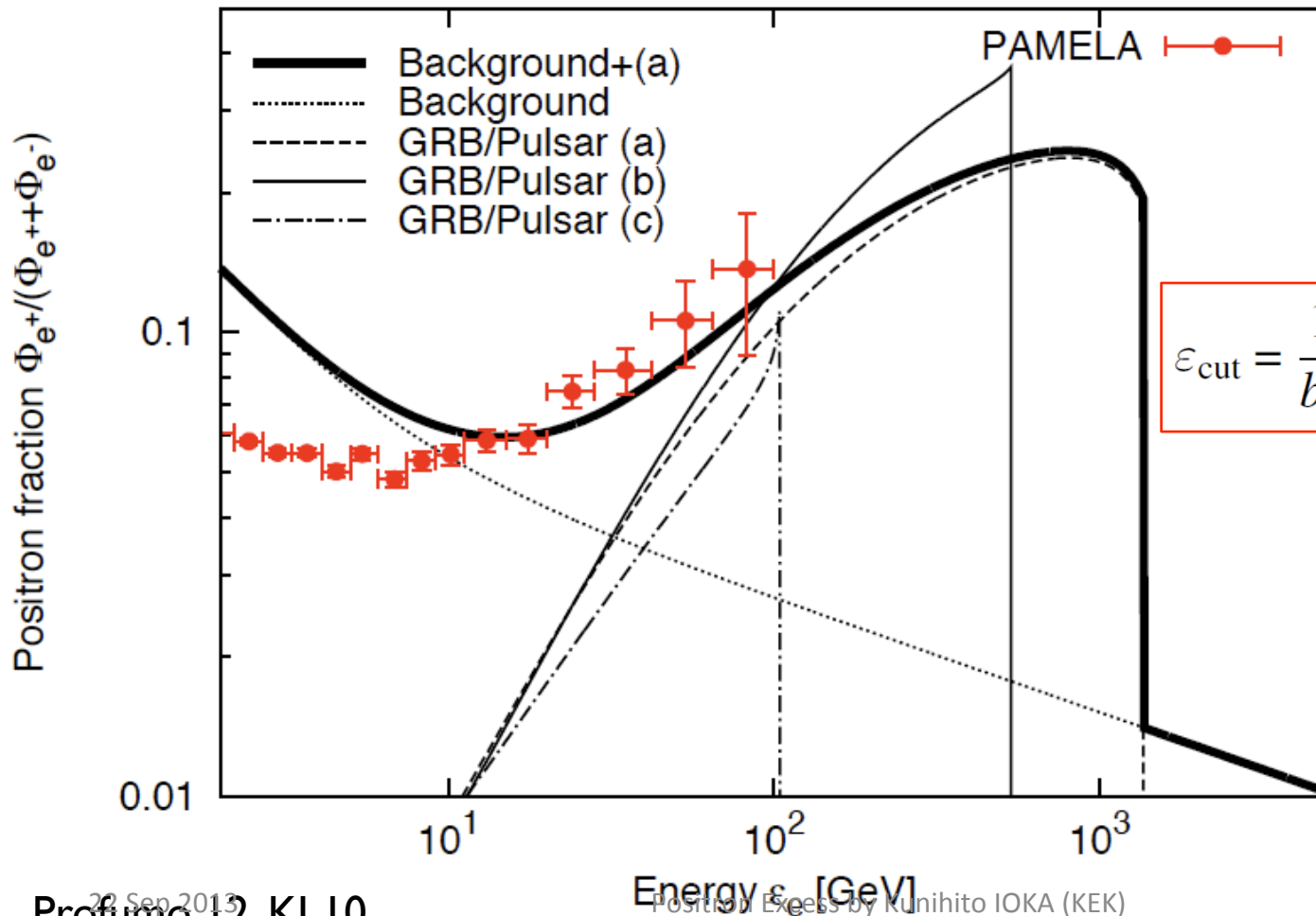
Spectrum



Peak +
Cutoff
= DM?

DM-like Pulsar

High-energy e^\pm lose energy by synch. & inv. Compton



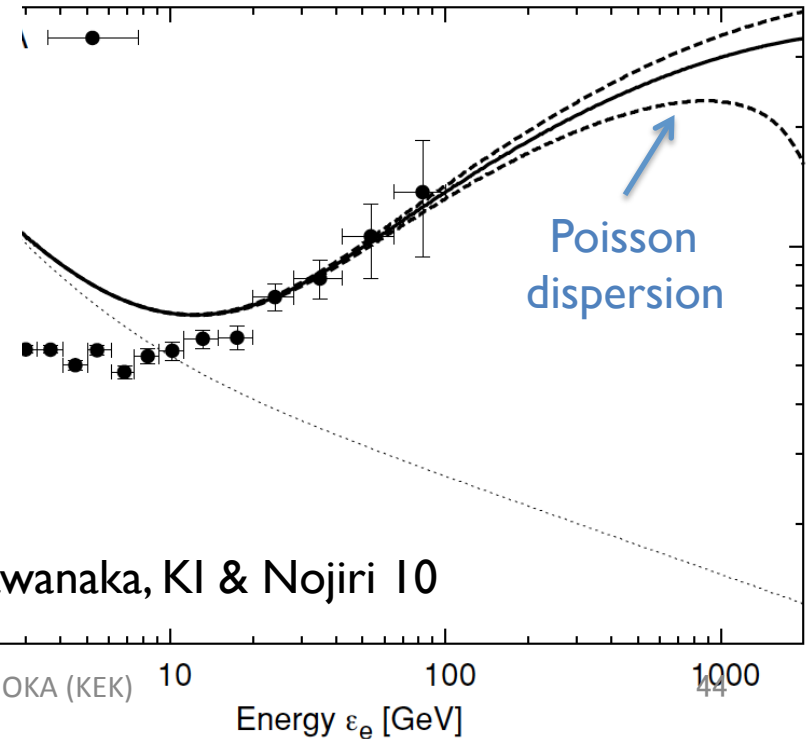
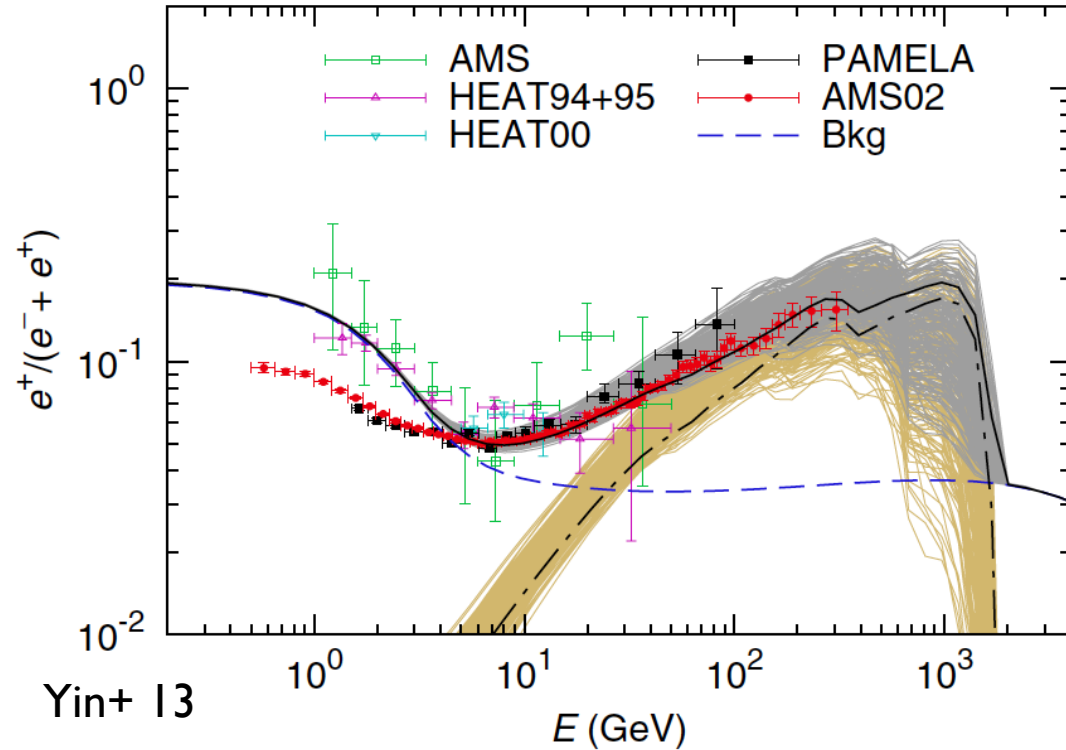
$$t_{cool} \propto \epsilon_e^{-1}$$

$$\epsilon_{cut} = \frac{1}{bt} \simeq 300 \left(\frac{10^6 \text{ yr}}{t_{age}} \right) \text{ GeV}$$

Cooling cutoff
mimics
DM cutoff

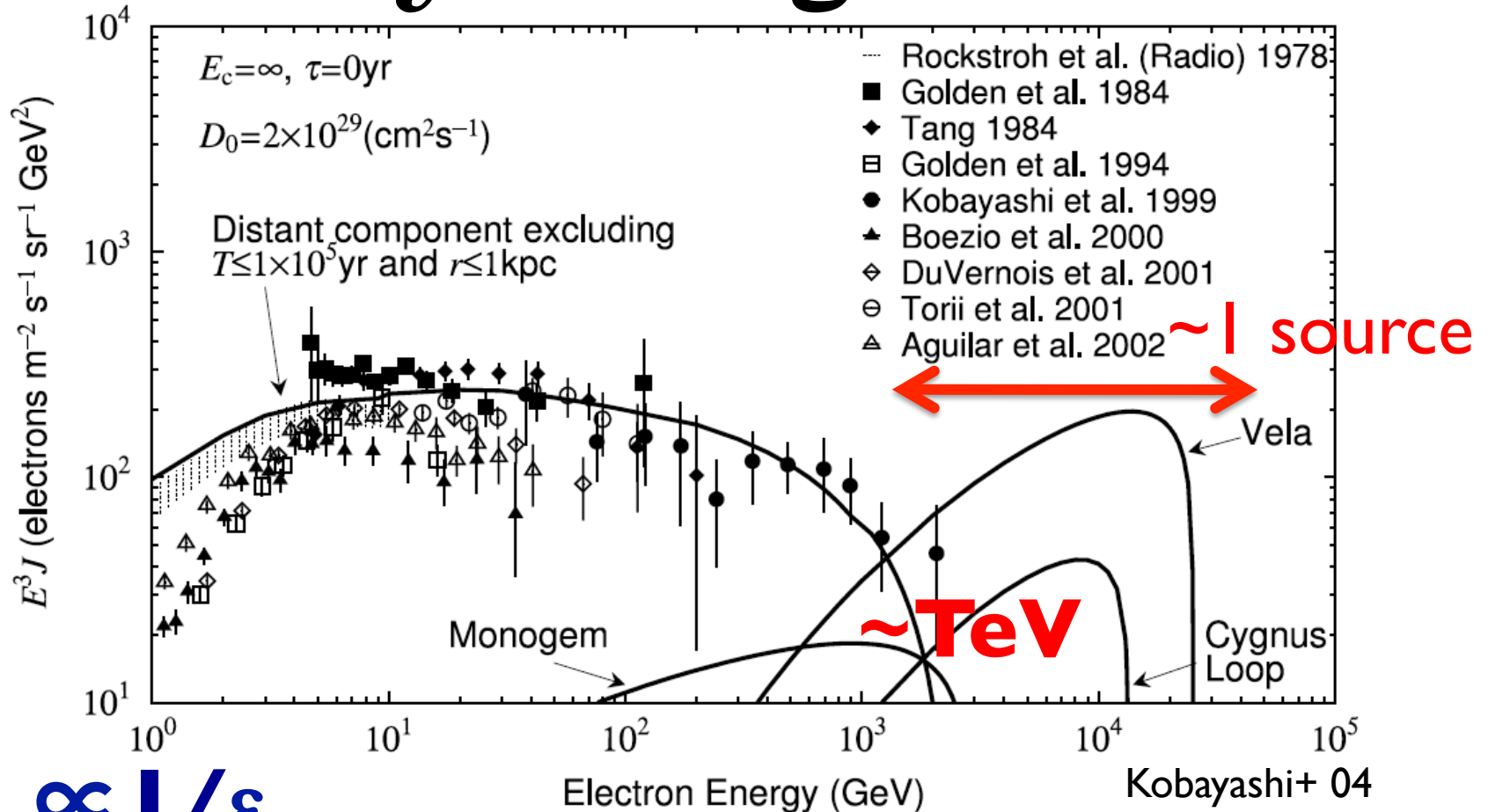
Spectrum: Fine Structure

Multiple pulsars
make fine structure



Large cosmic variance
at high energy

Nearby Young Source



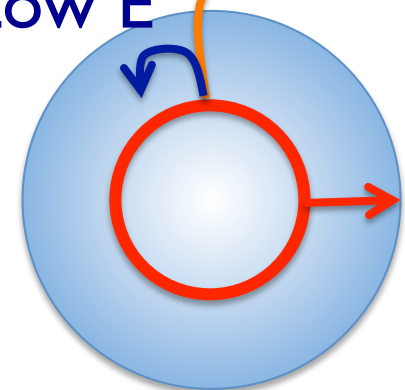
$$t_{\text{cool}} \propto I / \epsilon_e$$

$$N_{\text{PSR}}(\epsilon_e) \sim 6 \left(\frac{\epsilon_e}{\text{TeV}} \right)^{-5/3} \left(\frac{R}{0.7 \times 10^{-5} \text{ yr}^{-1} \text{ kpc}^{-2}} \right)$$

Line Spectrum by Pulsar?

High E

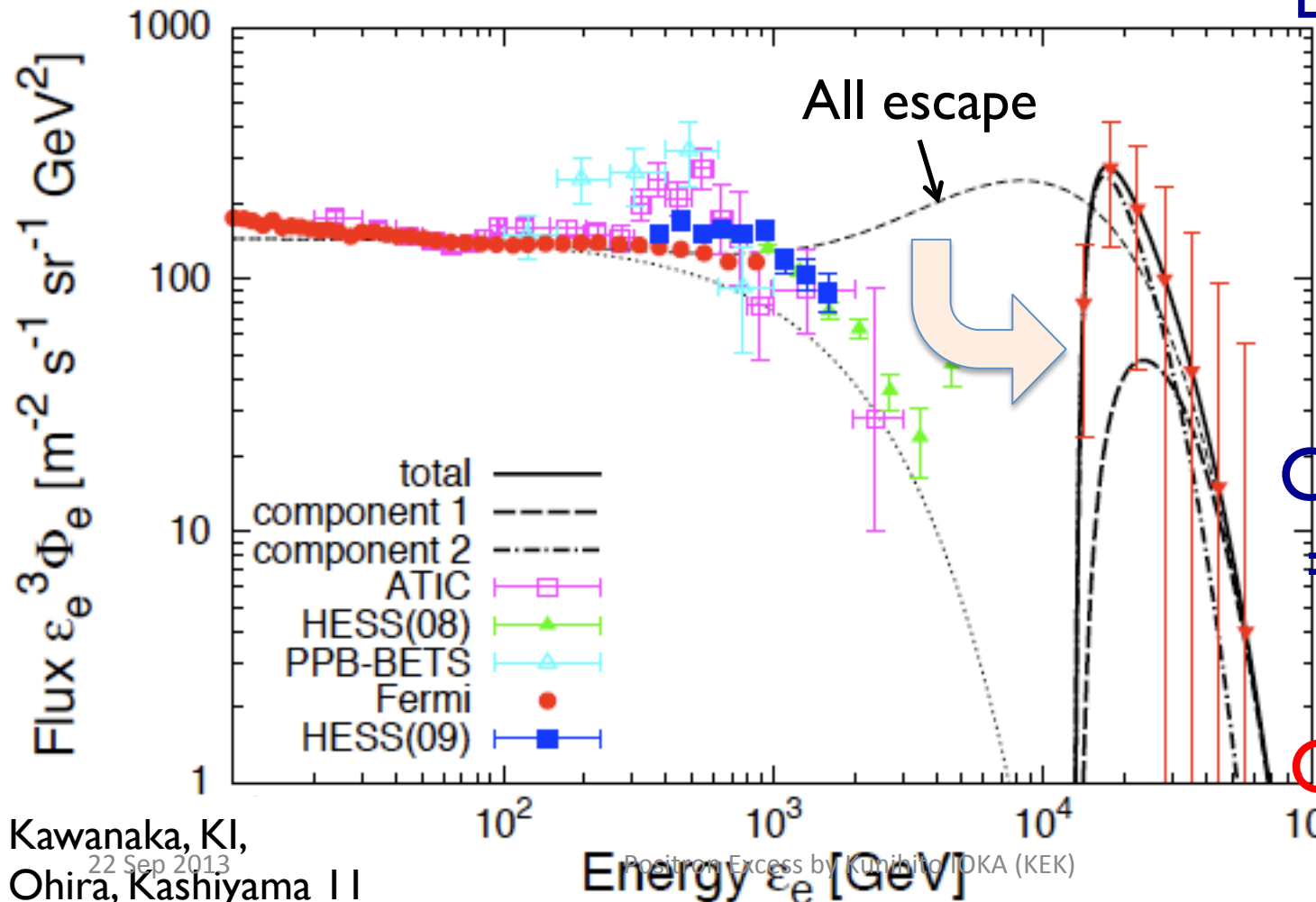
Low E



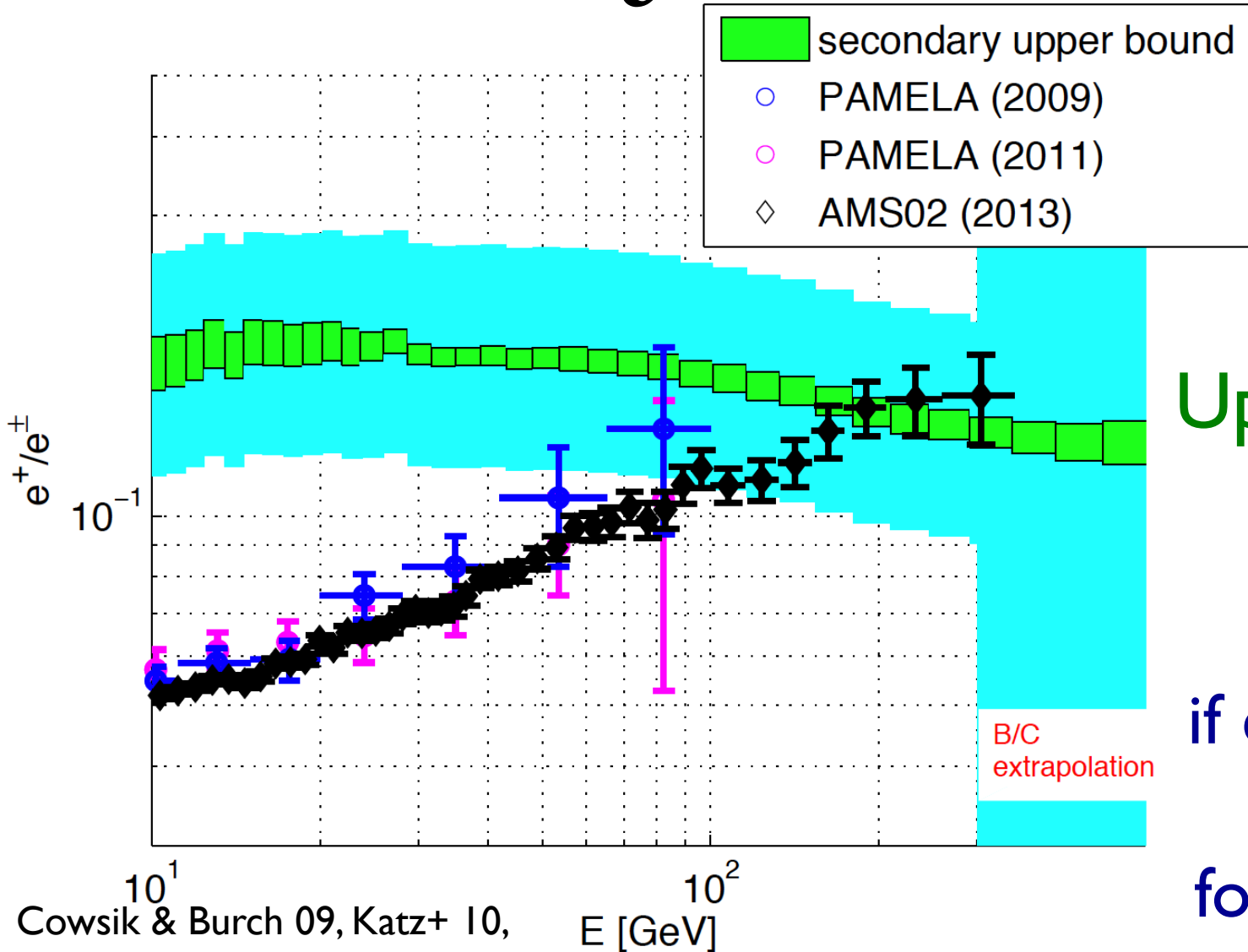
SNR w/ pulsar
Confinement
⇒ Low Ene.
cutoff

CTA, CALET
LHAASO

Nearby source (e.g., Vela) in TeV e window



Secondary e^+ still Viable?



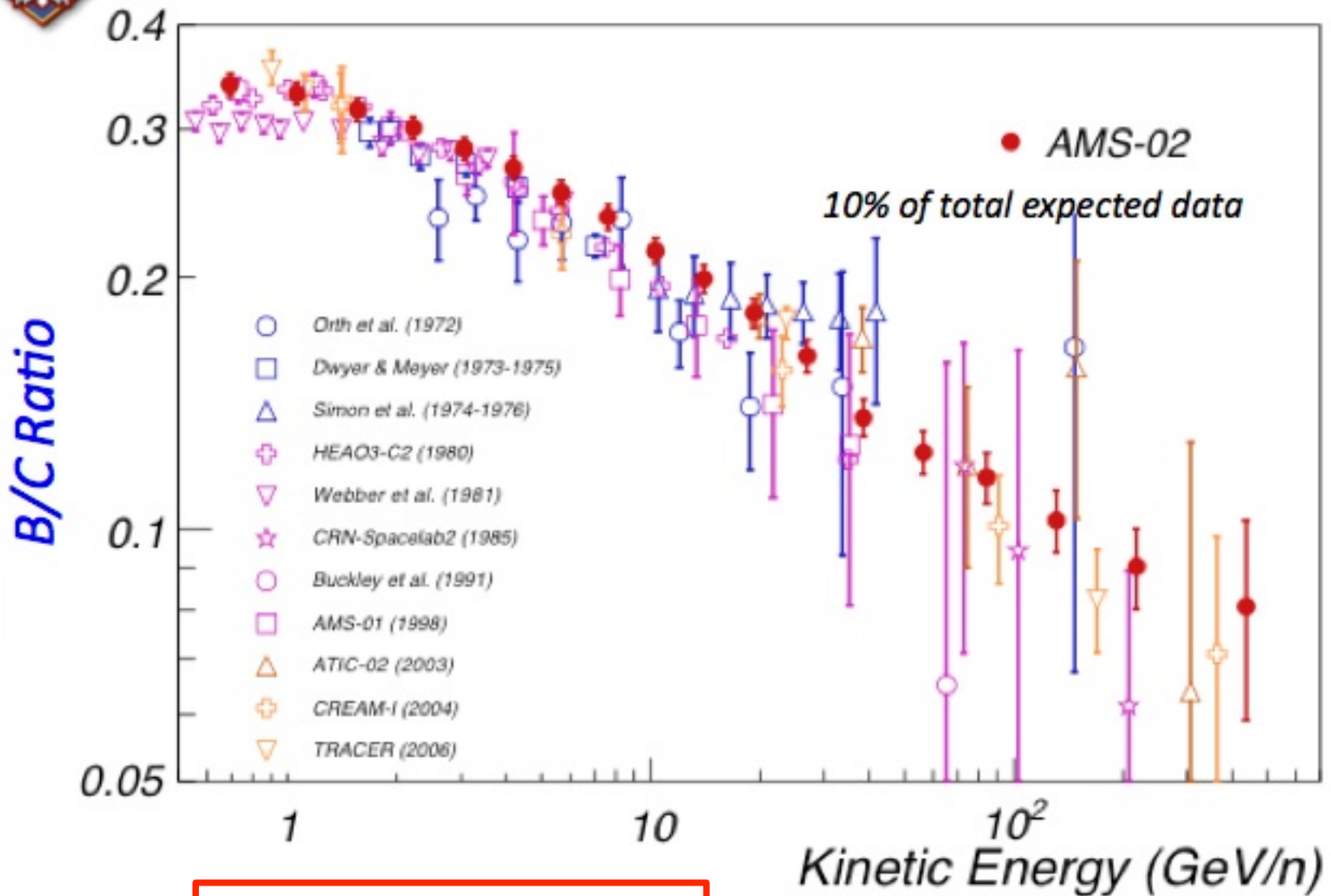
$$P_{CR} + P_{ISM} \rightarrow \pi^+ \rightarrow e^+$$

Upper Limits
by B/C

e^+/e^\pm rise
if escape time
is similar
for all energy



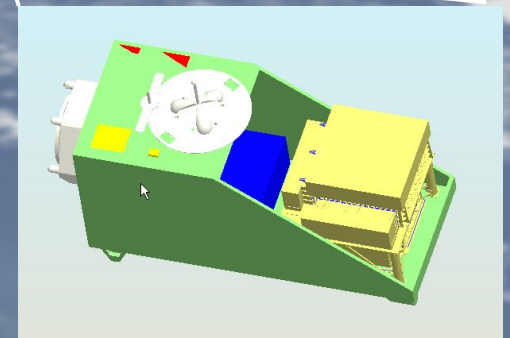
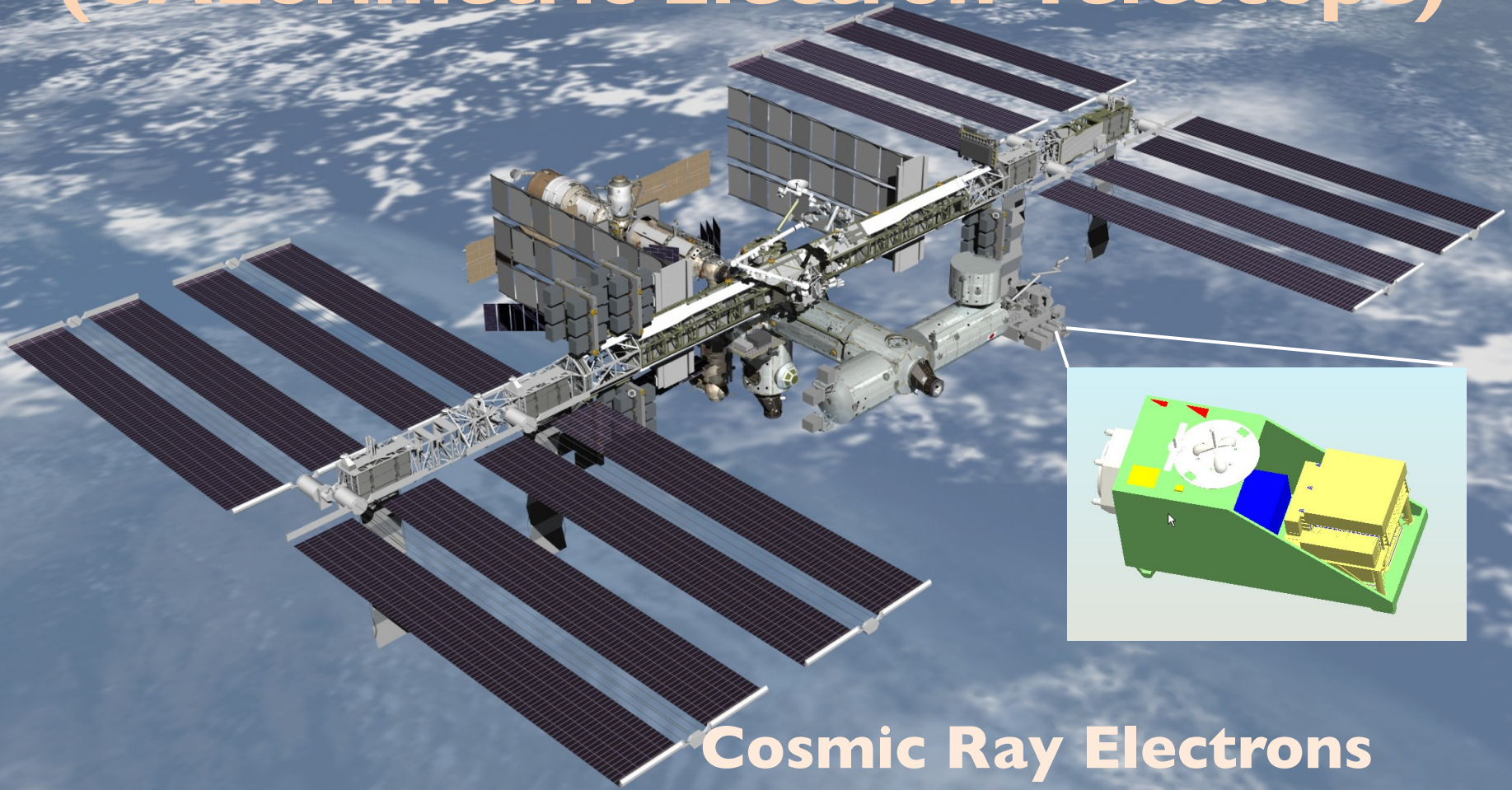
Boron-to-Carbon ratio compared with previous data



$$D(\varepsilon) \propto \varepsilon^{-0.2 \sim 0.3}$$

CALET

(CALorimetric Electron Telescope)



**Cosmic Ray Electrons
up to $\sim 10\text{TeV}$
w/ $\Delta E \sim$ a few % ($> 100\text{GeV}$)**

DAMPE

DArk Matter Particle Explore



China, Swiss, Italy
Launch 2015-2016
Total: 33 rad length

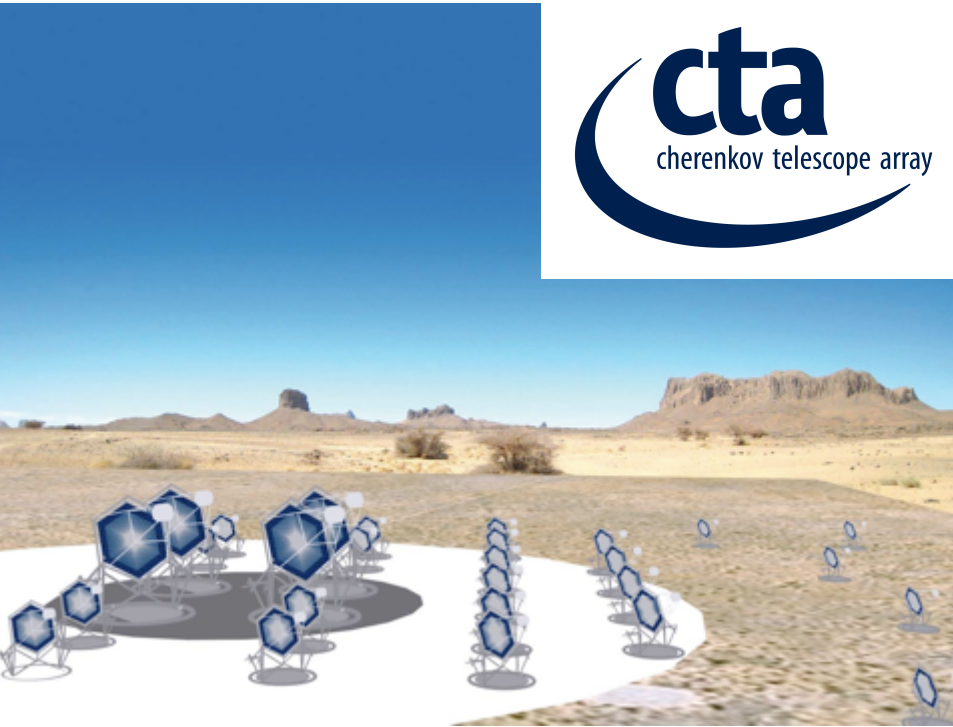
e, γ : 5 GeV-10 TeV
 $\Delta E = 1\% @ 800 \text{ GeV}$
0.3 m²

p : 100 GeV-100 TeV
 $\Delta E = 40\% @ 800 \text{ GeV}$
0.2 m²

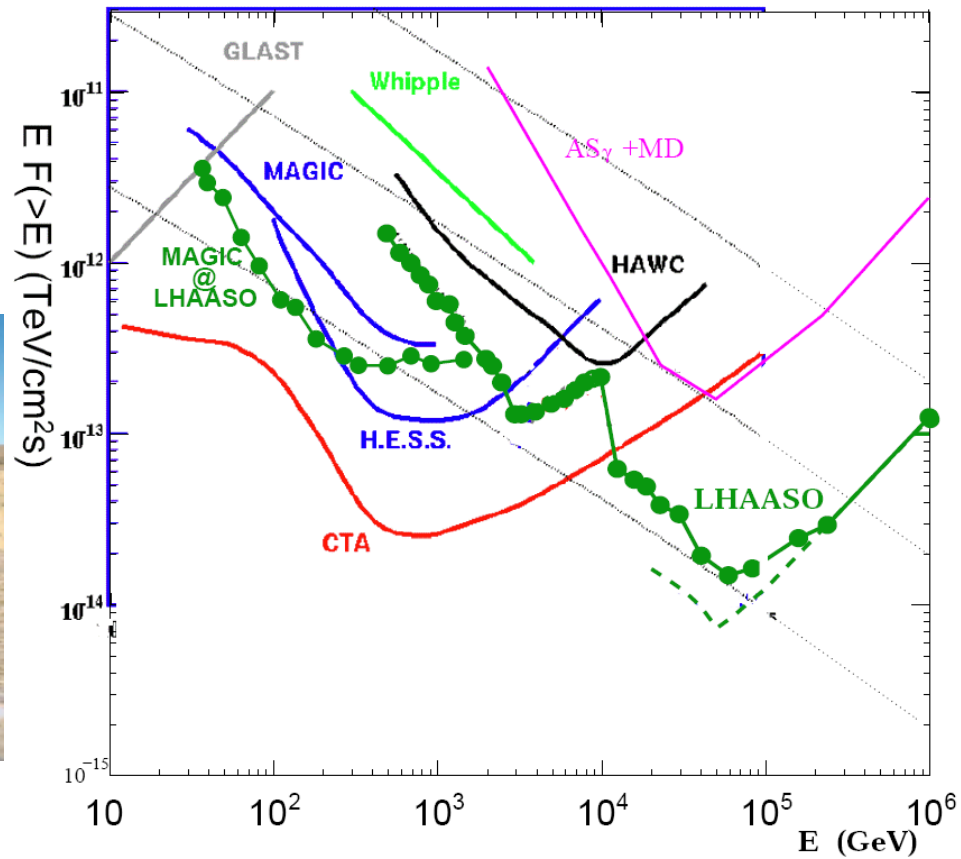
$\Delta\theta = 0.1^\circ @ 100 \text{ GeV}$

Air Shower

CTA



LHAASO



Summary

- **e^+ excess**

- DM or Pulsar (or SNR, 2ndary, ...)

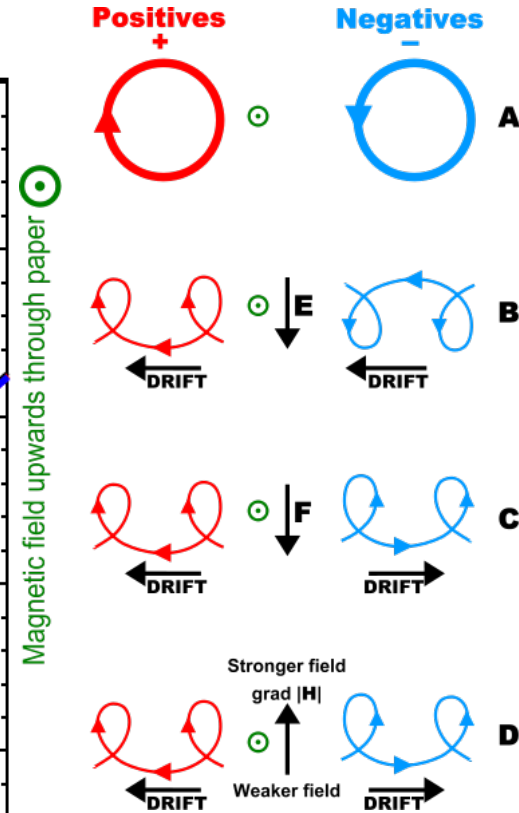
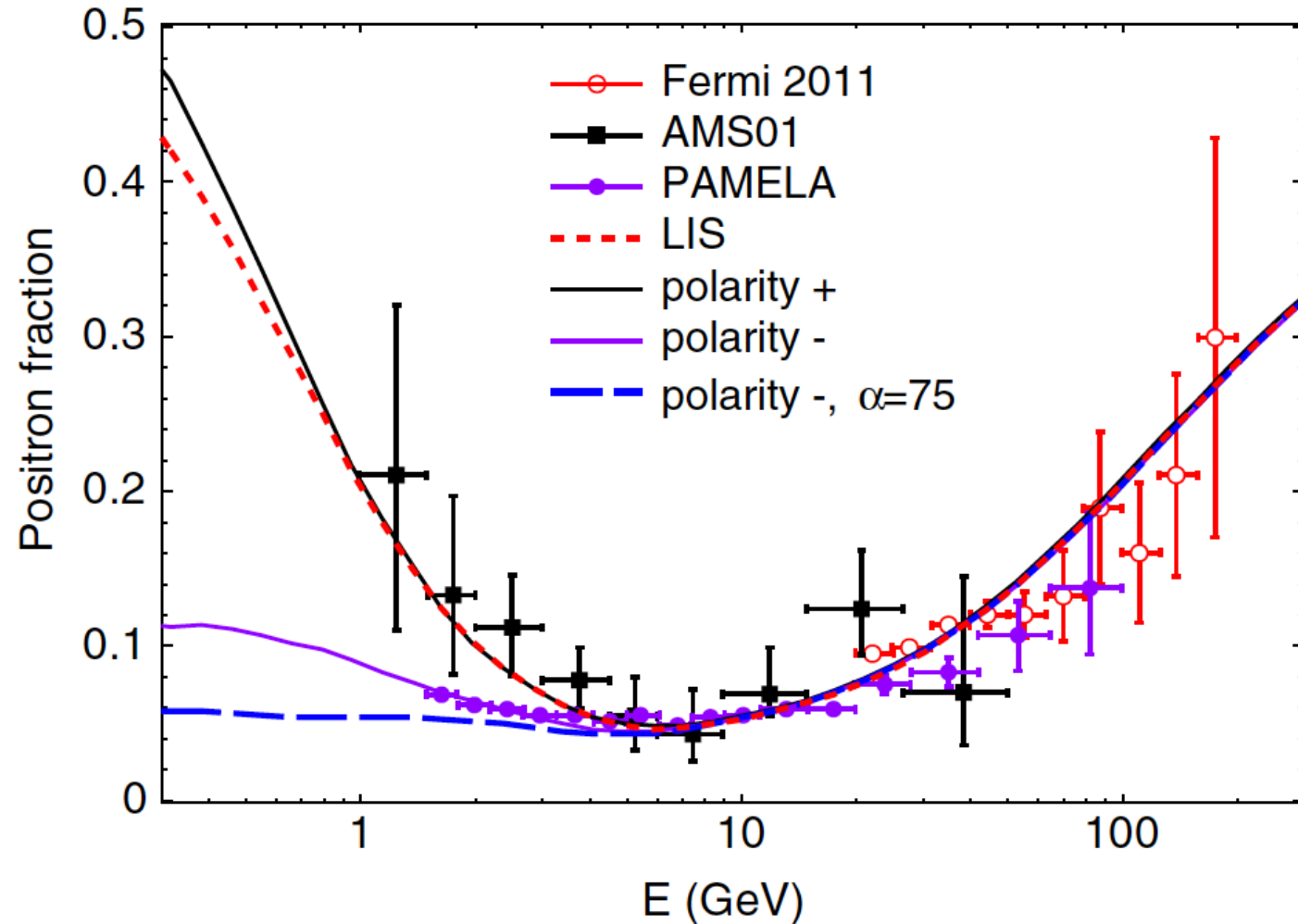
- **AMS-02**

- No fine structure, Declining Slope
- Tension with Fermi e^- ?

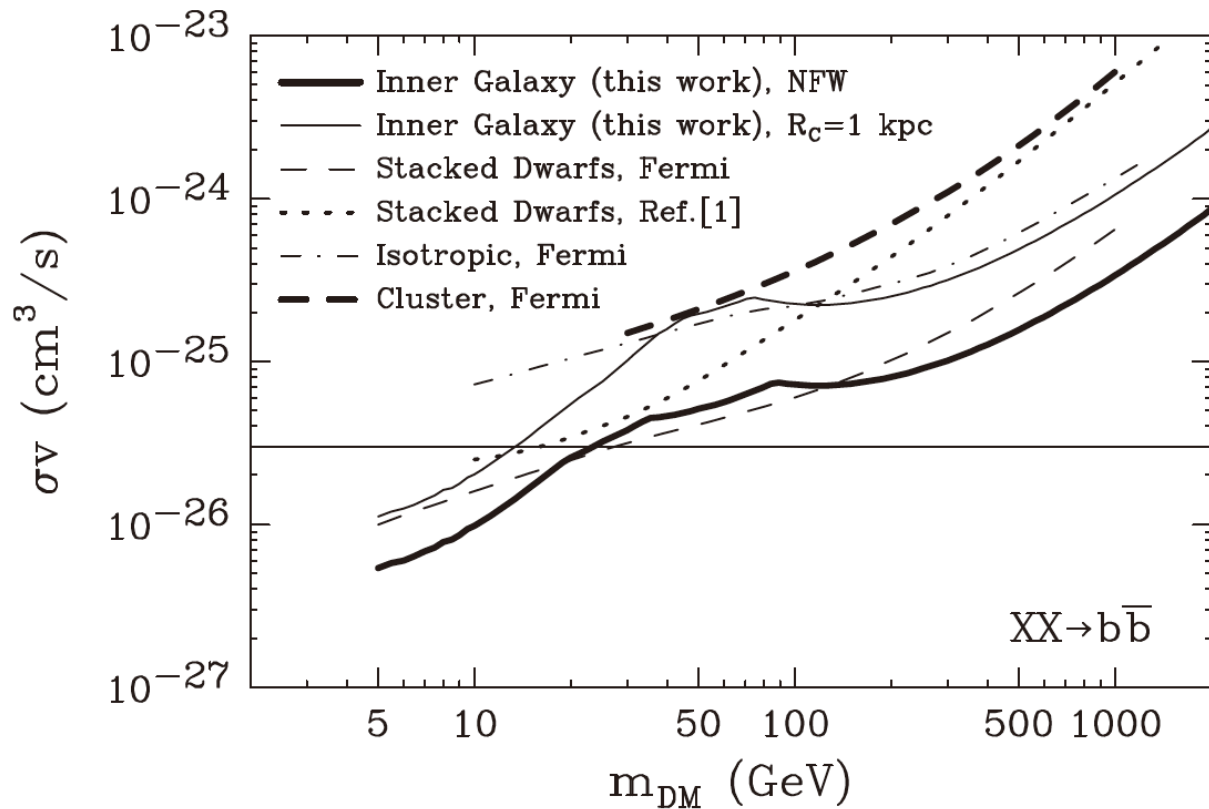
- **Future probes**

- Anisotropy, Spectrum, pbar, B/C, γ , others
- AMS-02, CALET, DAMPE, CTA, LHAASO

Charge Asymmetry @ $< 5 \text{ GeV}$



**B gradient
⇒ Drift**



Hooper+ 13

Fig. 14. A comparison of the upper limits on the dark matter annihilation cross section derived in this work to those from other gamma-ray observations. In particular, we show the constraints derived from the observations of dwarf spheroidal galaxies [1,2], the isotropic gamma-ray background [8], and from the Fornax galaxy cluster [3]. If we adopt an NFW halo profile (or an Einasto or contracted profile), the constraints derived from the Galactic Center are the most stringent. Only if the dark matter halo profile of the Milky Way has a significant core (while dwarf galaxies retain their cusps) are constraints from dwarfs more stringent. The constraints from the Galactic Center are, for all dark matter masses, more stringent than those reliably extracted from the isotropic gamma-ray background or from galaxy clusters.

ANTIPROTON AS PREDICTED

No excess for antiproton

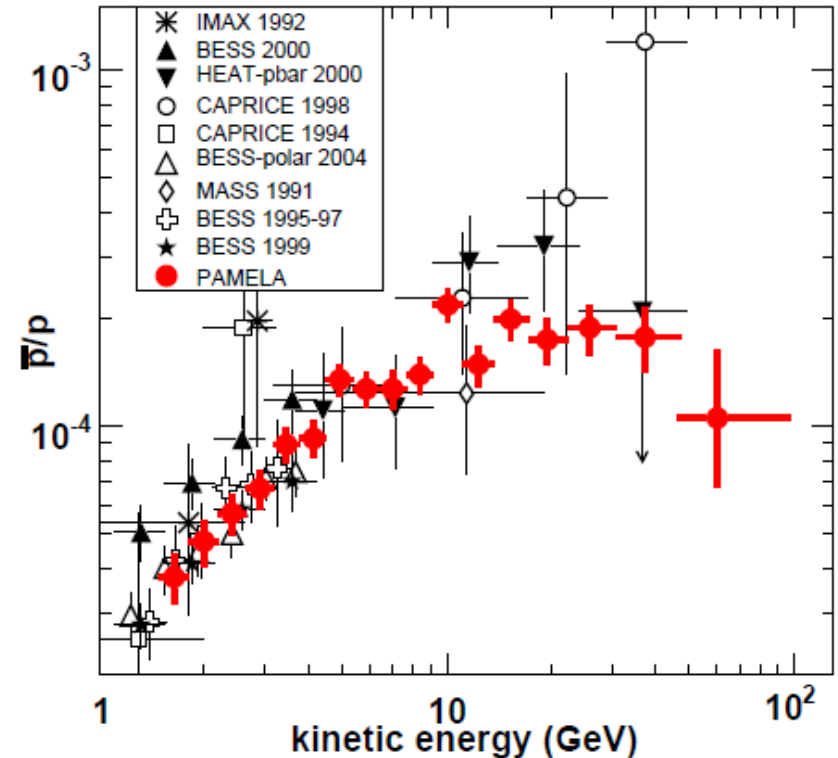
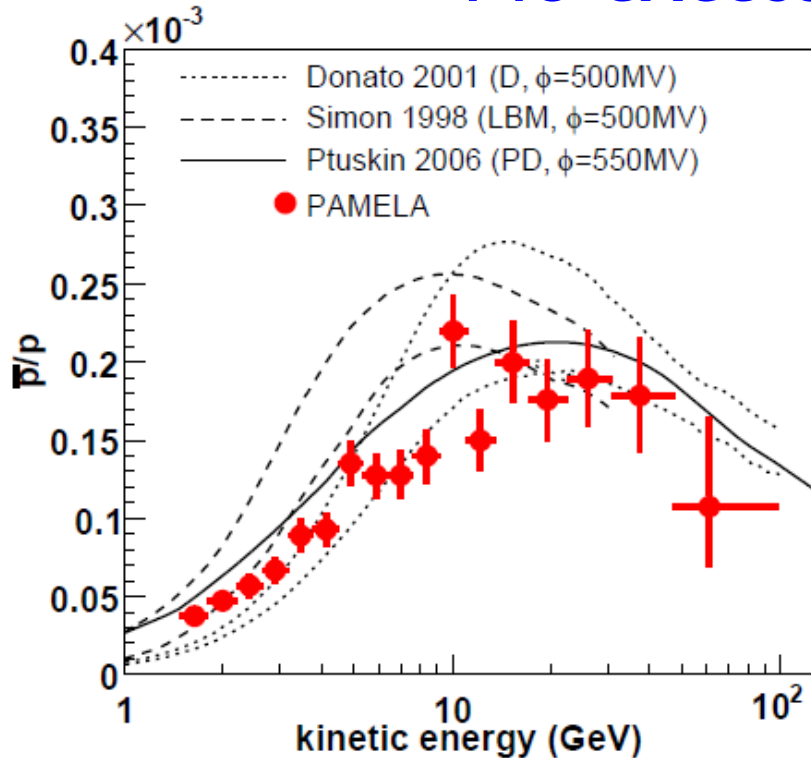
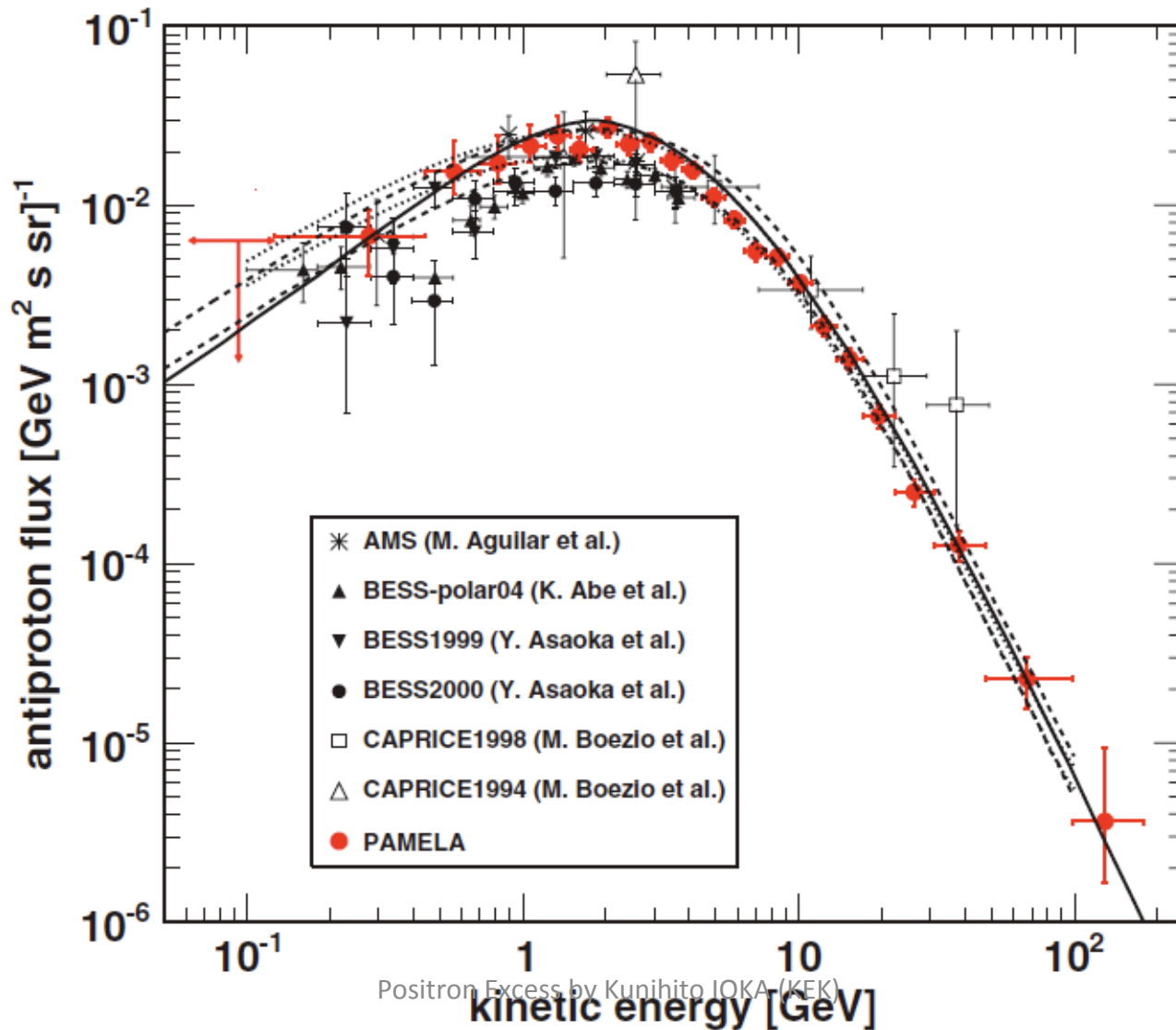


FIG. 3: The antiproton-to-proton flux ratio obtained in this work compared with theoretical calculations for a pure secondary production of antiprotons during the propagation of cosmic rays in the galaxy. The dashed lines show the upper and lower limits calculated by Simon et al. [17] for the standard Leaky Box Model, while the dotted lines show the limits from Donato et al. [18] for a Diffusion model. The solid line shows the calculation by Ptuskin et al. [19] for the case of a Plain Diffusion model. The curves were obtained using appropriate solar modulation parameters (indicated as ϕ) for the PAMELA data taking period.

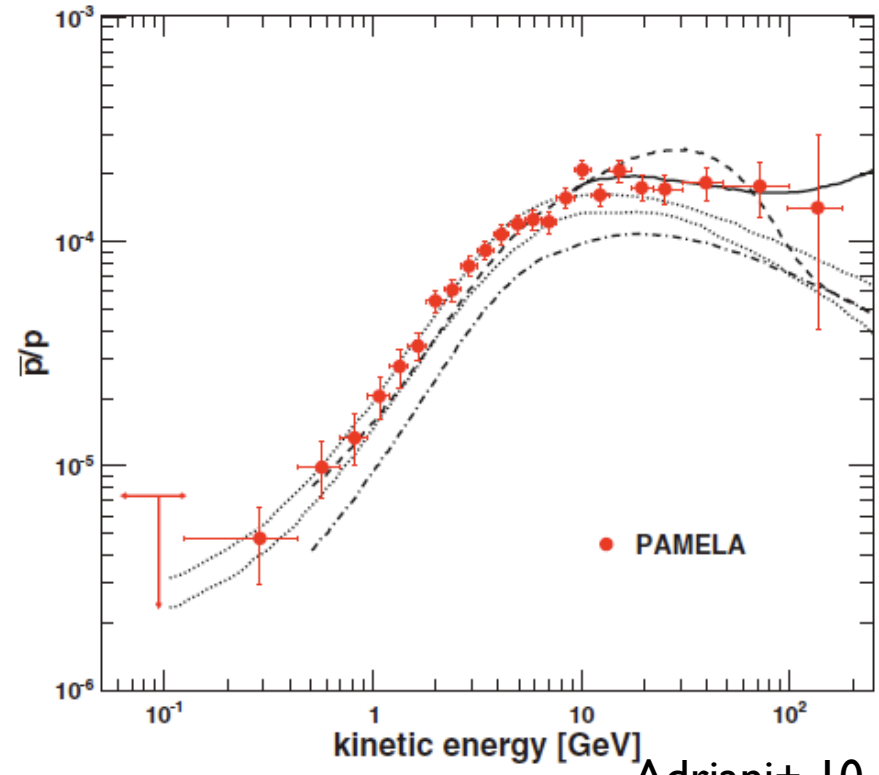
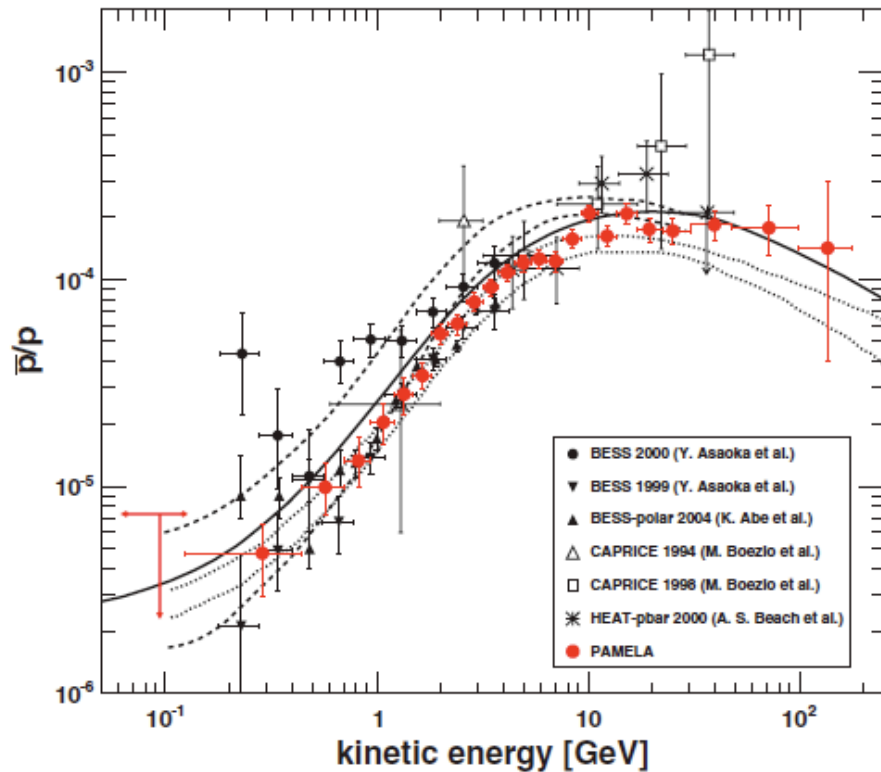
Adriani+(PAMELA) 08

PAMELA ANTI-PROTON



Adriani+ 10

PAMELA ANTI-PROTON

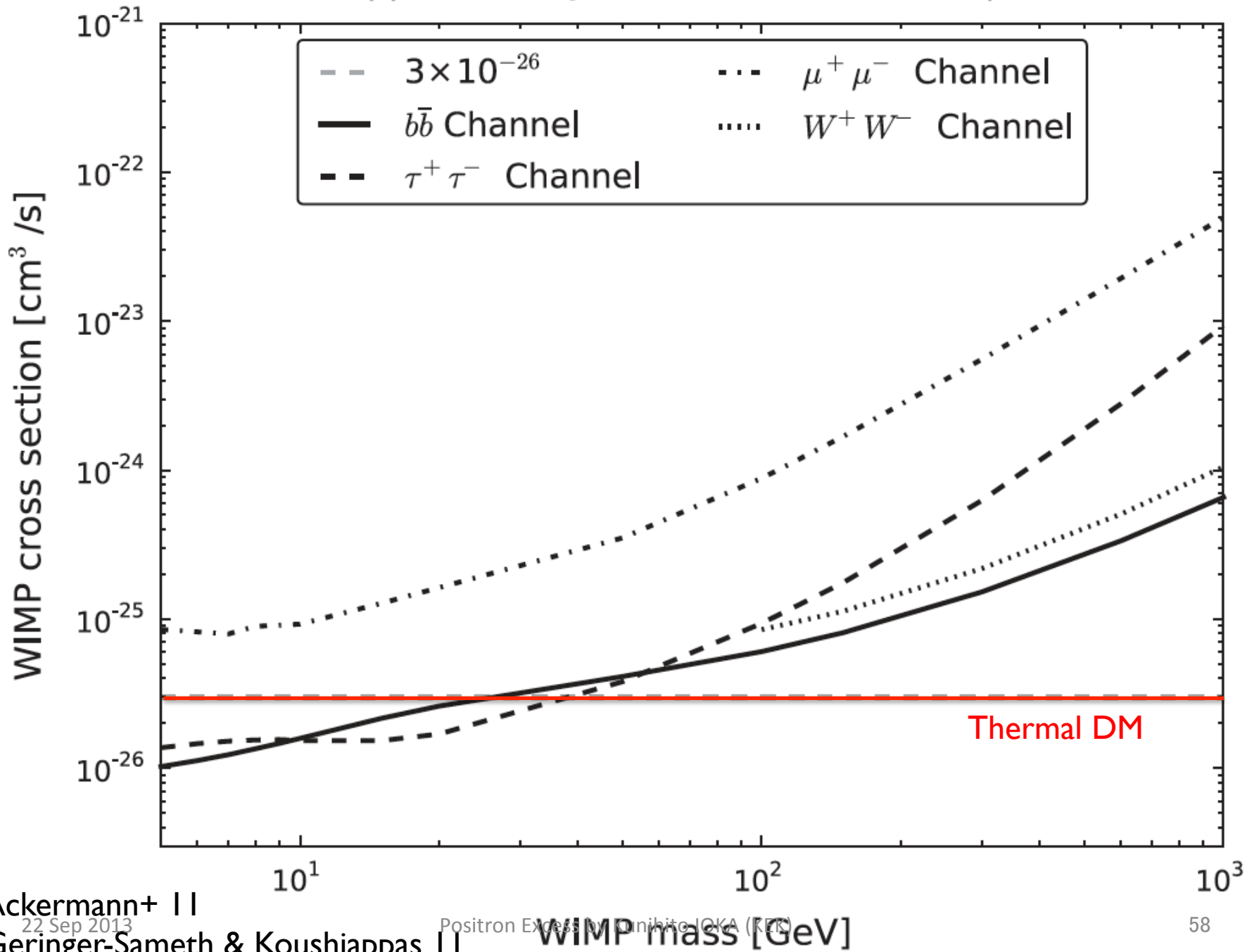


Adriani+ 10

FIG. 2 (color). The antiproton-to-proton flux ratio at the top of the payload obtained in this work compared with contemporary measurements [21–24,26] and theoretical calculations for a pure secondary production of antiprotons during the propagation of cosmic rays in the Galaxy. The dashed lines show the upper and lower limits calculated by Simon *et al.* [6] for the leaky box Model, while the dotted lines show the limits from Donato *et al.* [37] for a diffusion reacceleration with convection model. The

FIG. 3 (color). The antiproton-to-proton flux ratio at the top of the payload obtained in this work compared with theoretical calculations. The dotted lines show the upper and lower limits calculated for a pure secondary production of antiprotons during the propagation of cosmic rays in the Galaxy by Donato *et al.* [37] for a diffusion reacceleration with convection model. The dashed line is a calculation by Kane *et al.* [14] including both a primary antiproton component from annihilation of 180 GeV

Upper limits, Joint Likelihood of 10 dSphs



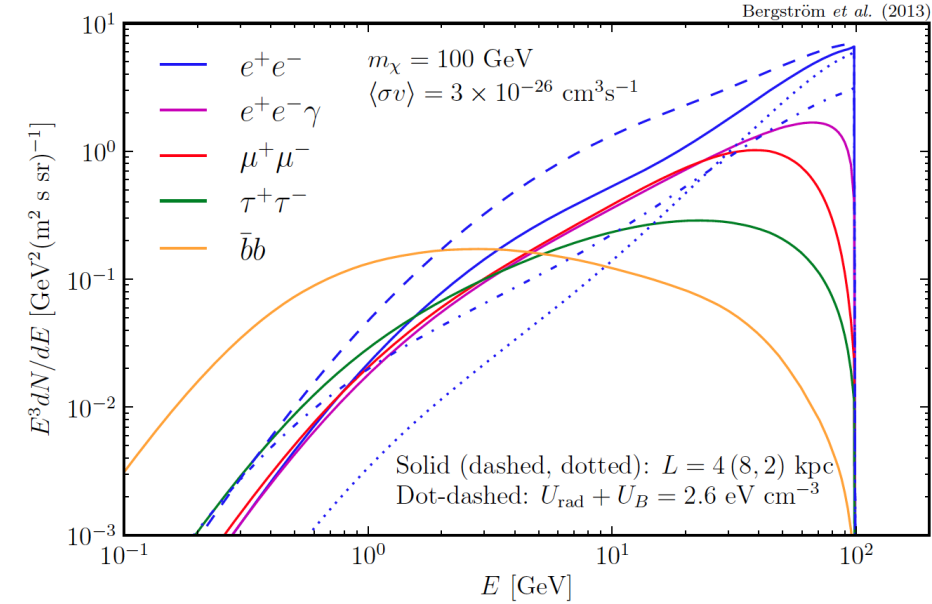


FIG. 1. The e^\pm spectrum from annihilating DM, after propagation, for different annihilation final states, assuming $\langle\sigma v\rangle = 3 \times 10^{-26} \text{ cm}^3 \text{ s}^{-1}$. Solid lines refer to reference diffusion zone ($L=4 \text{ kpc}$) and energy loss assumptions ($U_{\text{rad}} + U_B = 1.7 \text{ eV cm}^{-3}$). Dashed (dotted) lines show the effect of a different scale height $L=8$ (2) kpc. The dash-dotted line shows the impact of increasing the local radiation plus magnetic field density to $U_{\text{rad}} + U_B = 2.6 \text{ eV cm}^{-3}$.

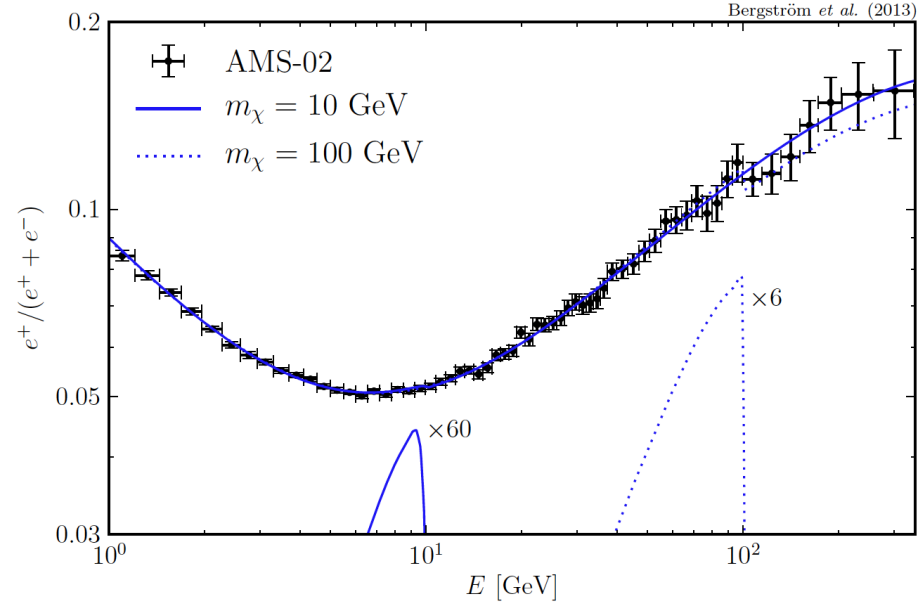
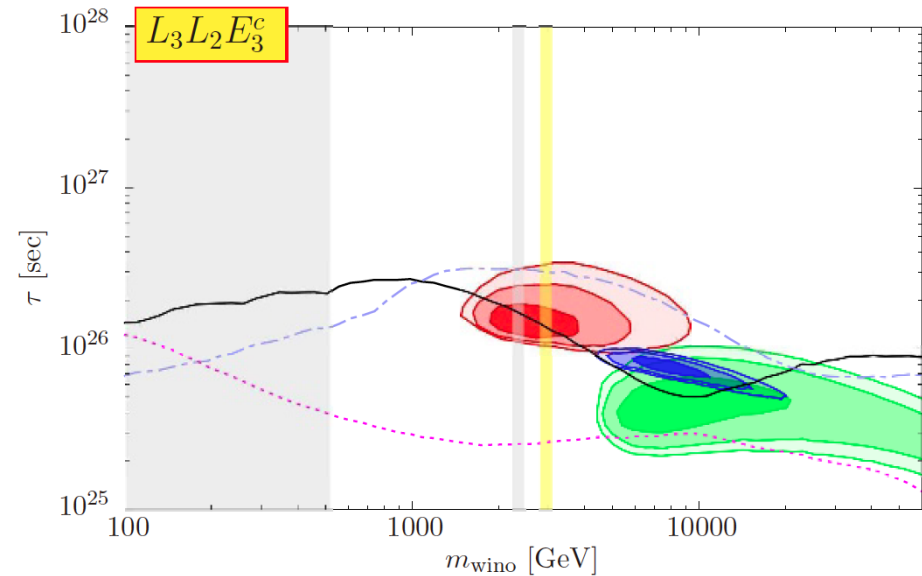
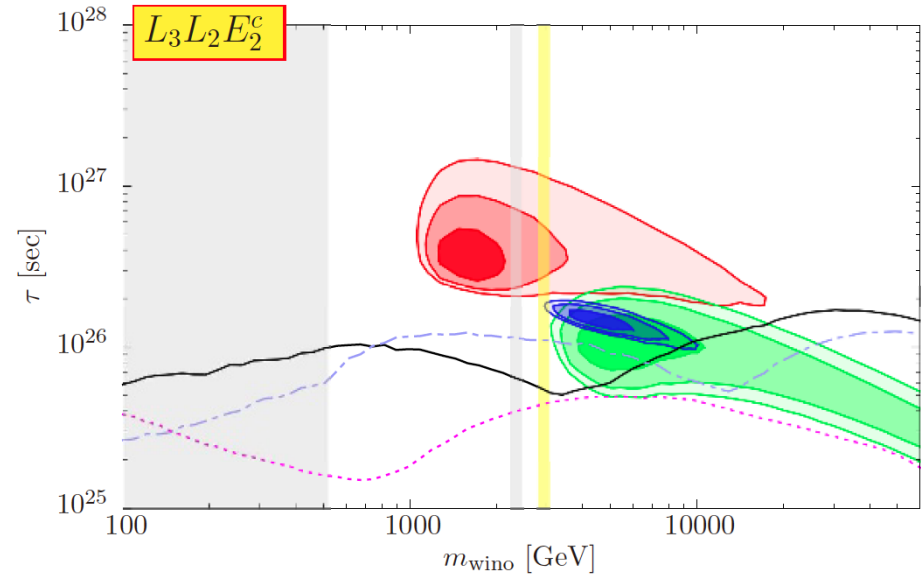
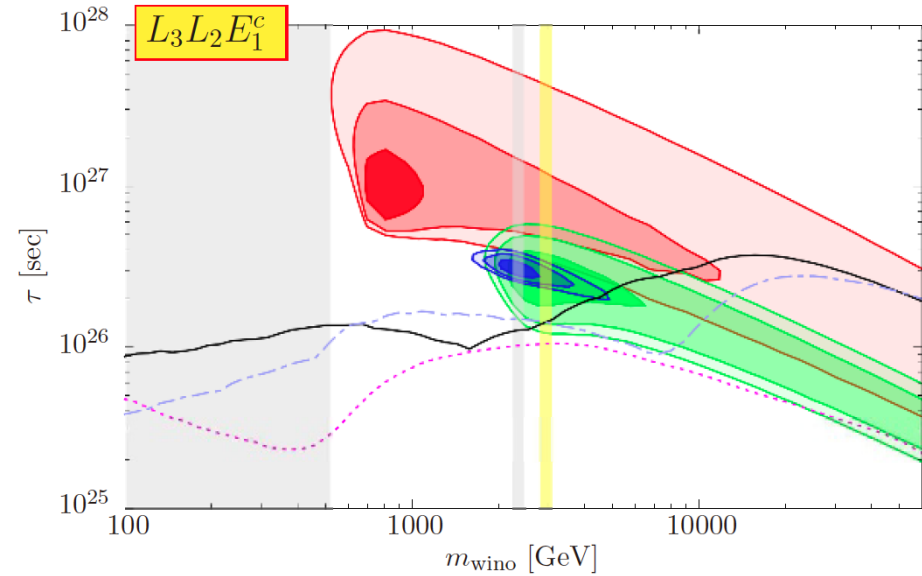
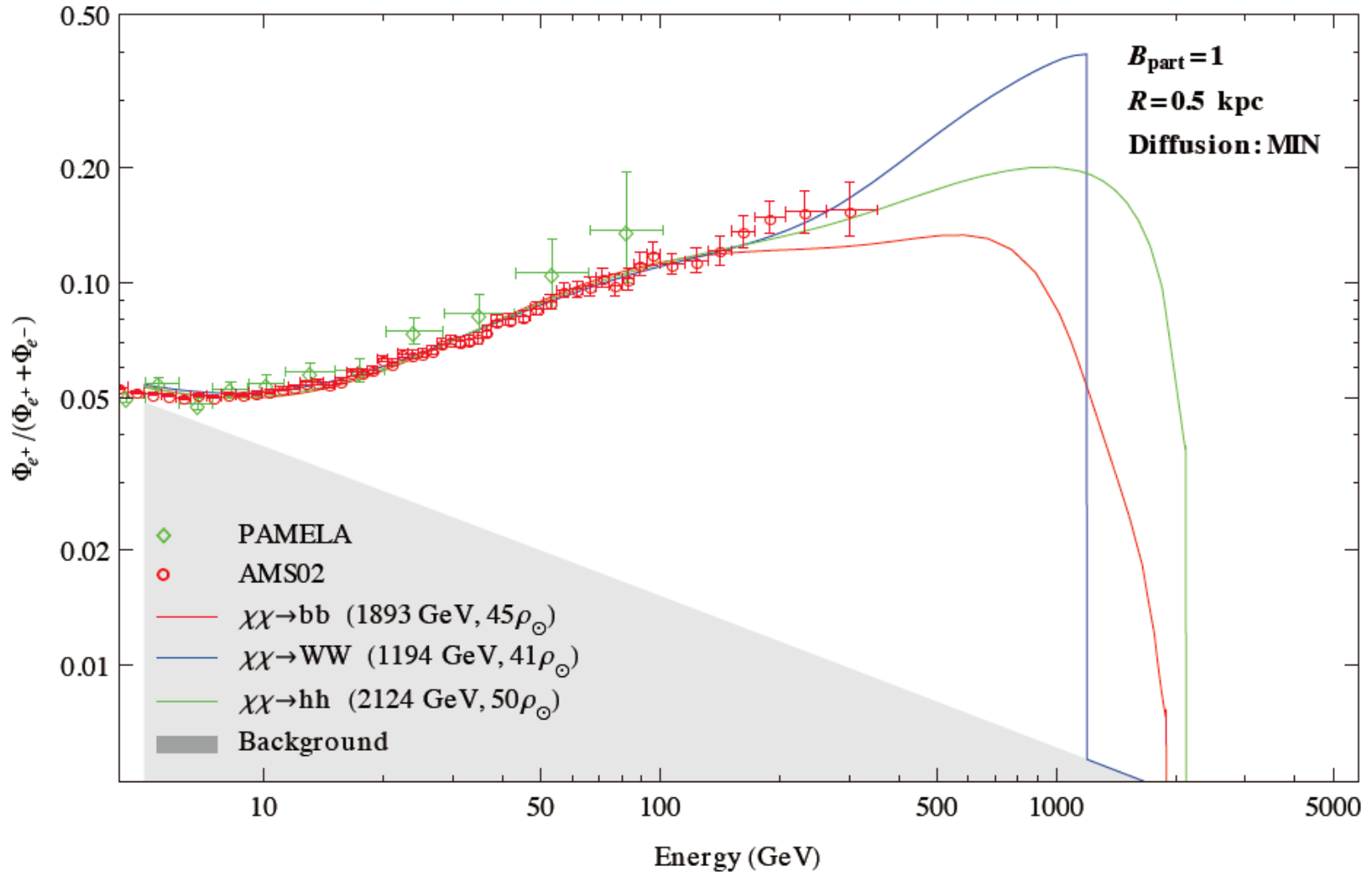


FIG. 2. The AMS positron fraction measurement [2] and background+signal fit for DM annihilating directly to e^+e^- , for $m_\chi = 10 \text{ GeV}$ and 100 GeV . The normalization of the DM signal in each case was chosen such that it is barely excluded at the 95% CL. For better visibility, the contribution from DM (lower lines) has been rescaled as indicated.

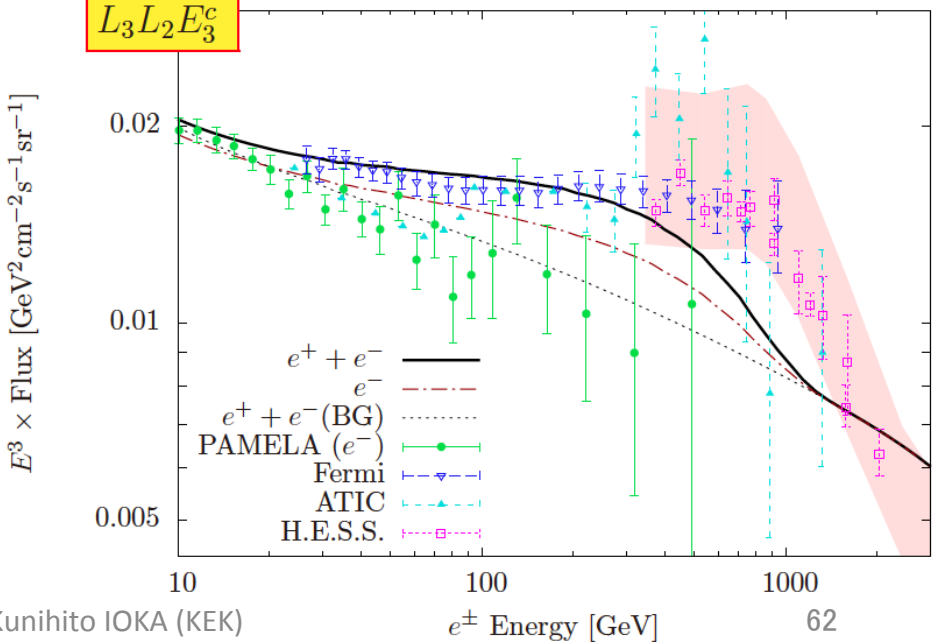
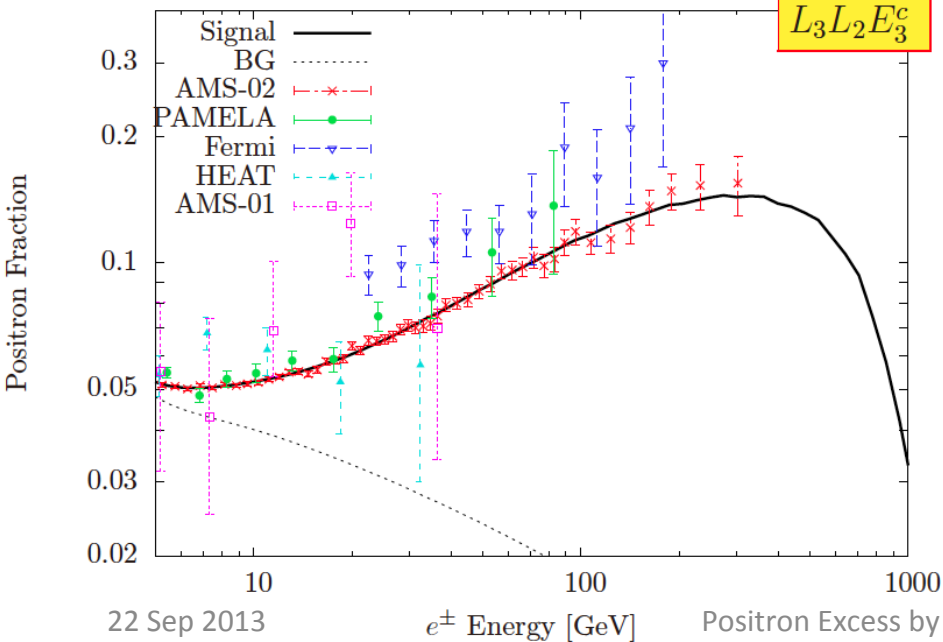


- $\Omega^{\text{thermal}} h^2 = 0.1$ █
- AMS-02 █
- Fermi █
- AMS-02 + Fermi █
- Fermi γ (Annihilation) █
- Fermi γ (Isotropic) █
- Fermi γ (All-GP+GC) - - -
- Fermi γ (Fornax) - - -

Local DM Over-Density



Ibe+ 13



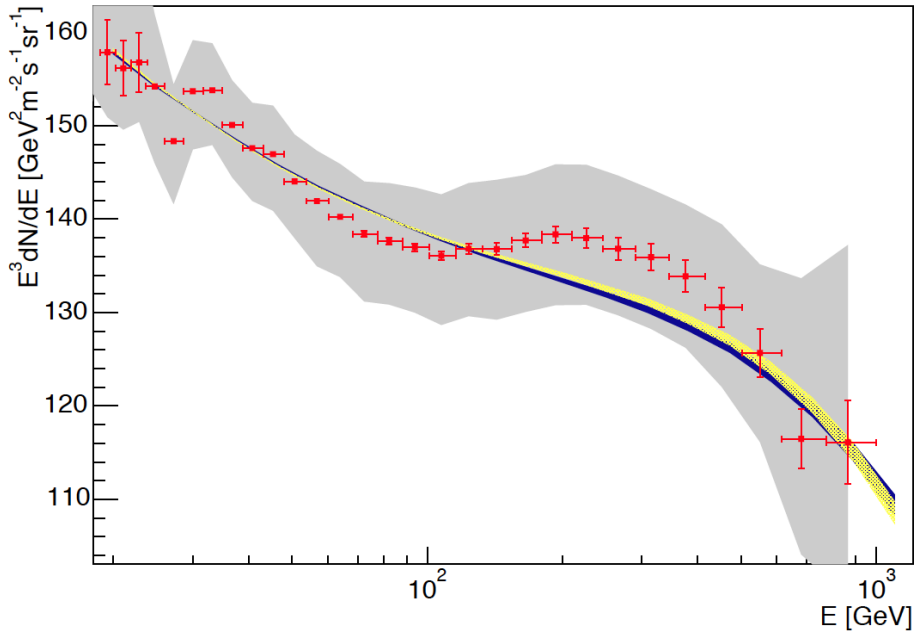


Figure 8. CRE spectrum for the best fit model derived combining AMS-02 and Fermi-LAT data. Red points are Fermi-LAT experimental data. The blue area represents our best-fit model, with its 68% uncertainty band. The yellow dotted area is instead for the best fit model assuming charge asymmetry. Error bars are statistical errors, while systematic errors correspond to the grey band.

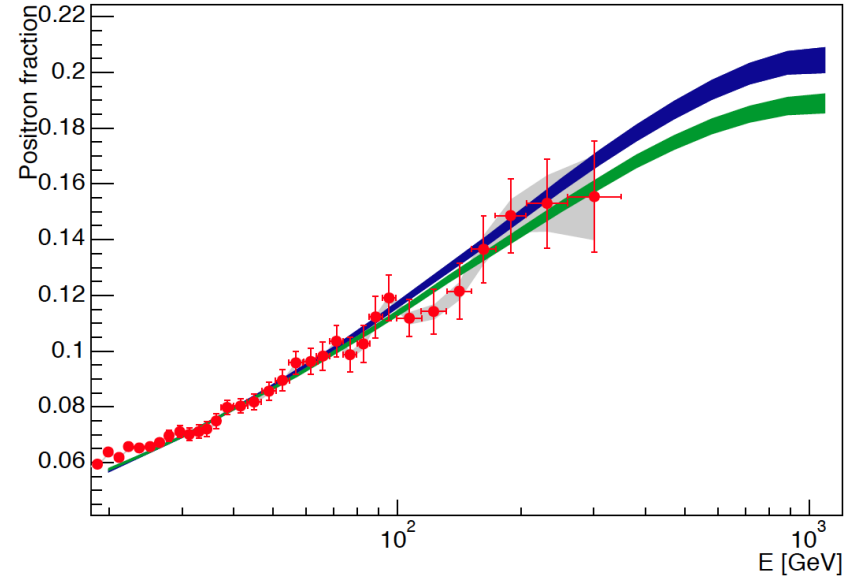
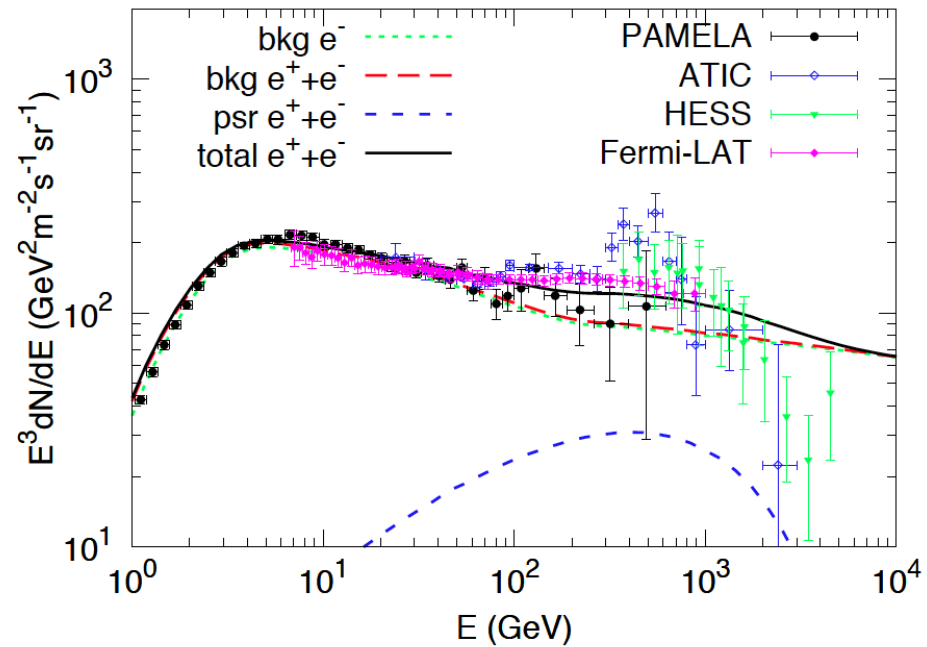
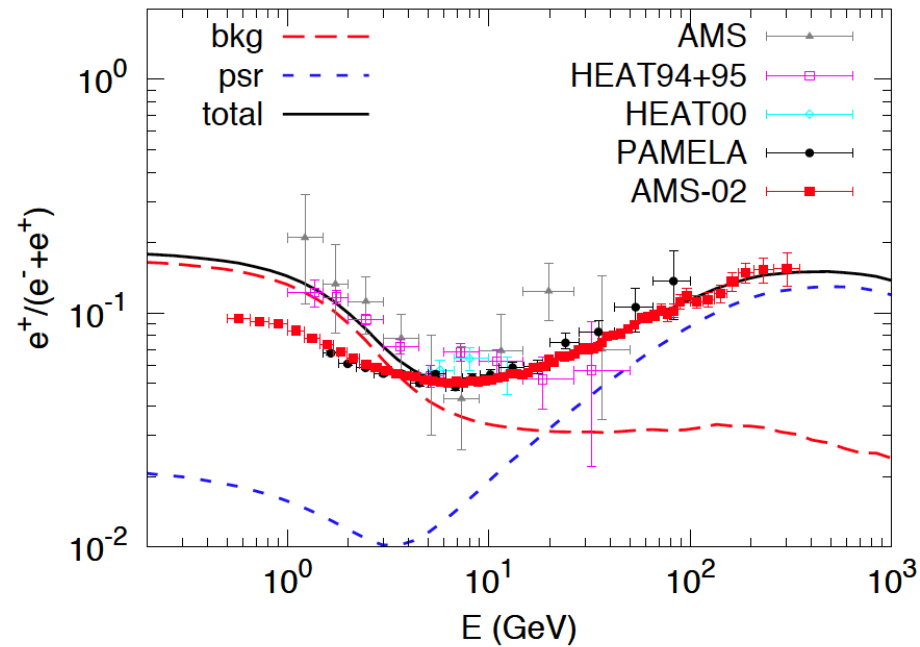


Figure 7. Positron fraction for the best fit model derived combining AMS-02 and Fermi-LAT data. Red points are AMS-02 experimental data. The blue area represents our best-fit model, with its 68% uncertainty band. The green area is instead for the best fit model assuming charge asymmetry. Error bars are statistical errors, while systematic errors correspond to the grey band.

Gaggero & Maccione 13

e- Spectral Break?



Yuan & Bi 13

