Dipole anisotropies & local source

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with G.Giacinti, A.Nernov, V.Savchenko, D.Semikoz

Outline of the talk

1. Introduction
   - Propagation in magnetic fields
2. Dipole anisotropies – calculational approaches
   - diffusion approach
   - trajectory approach
3. Dipole anisotropy and the transition energy
4. Dipole anisotropy in the escape model
   - Anisotropy from background of all sources
   - Anisotropy of a single source
   - single source: other signatures
5. Conclusions

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Kolmogorov	$\alpha = 5/3$	$\Leftrightarrow$	$\beta = 1/3$
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- anisotropy $\delta_i = -3D_{ij}\nabla_i \ln(n)$

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  - known for bursting case
  - anisotropy [Lee '72, Blasi & Amato '12]

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- both:
  - only weak connection of $D_{ij}(\boldsymbol{x})$ to GMF
  - diffusion breaks down around the knee

Trajectory approach:

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- 2 methods used:
  - backward propagation à la Karakula
  - forward propagation for single sources

Anisotropy for Galactic sources

[*Giacinti et al. '11*]

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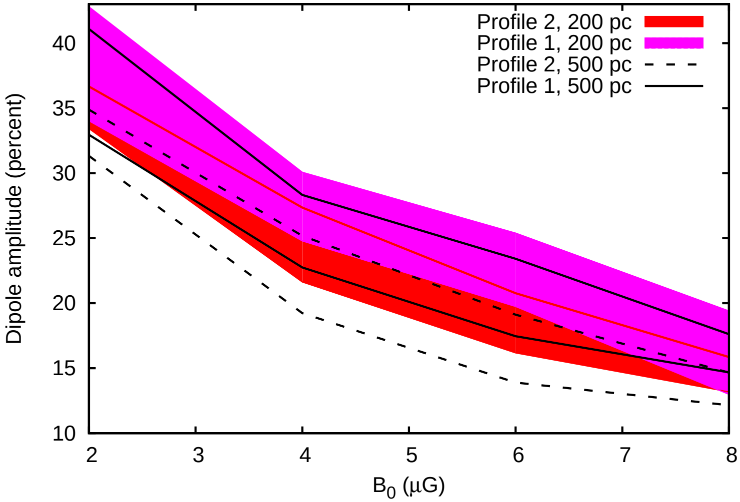
- backtrace $N = 10^4$ anti-particles injected with random direction $\hat{\boldsymbol{r}}$ from Earth
- weight $=$ path length in the source region
- dipole $d = 3N^{-1}\sum_i w_i \hat{\boldsymbol{r}}_i$

Anisotropy of protons at $E = 10^{18}$ eV – Kolmogorov



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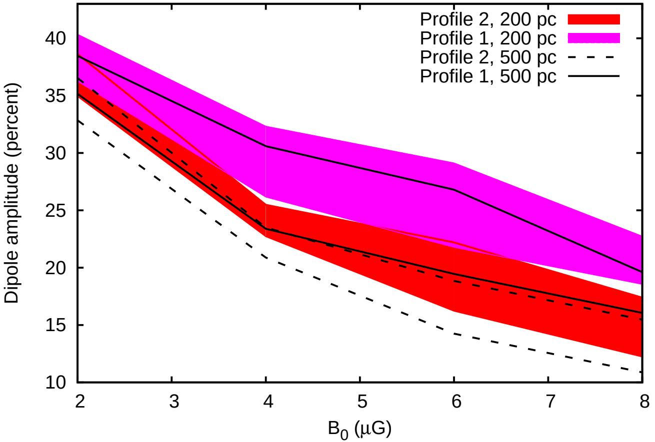

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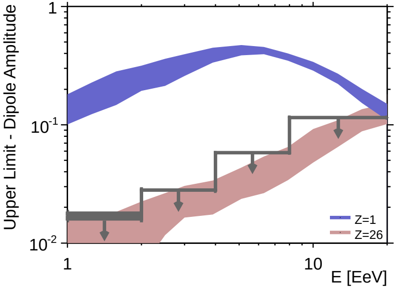
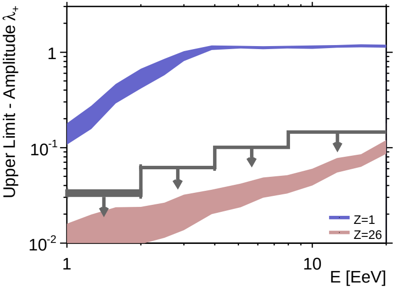
⇒ measuring protons at $E = 10^{18}$ eV means fixing transition energy

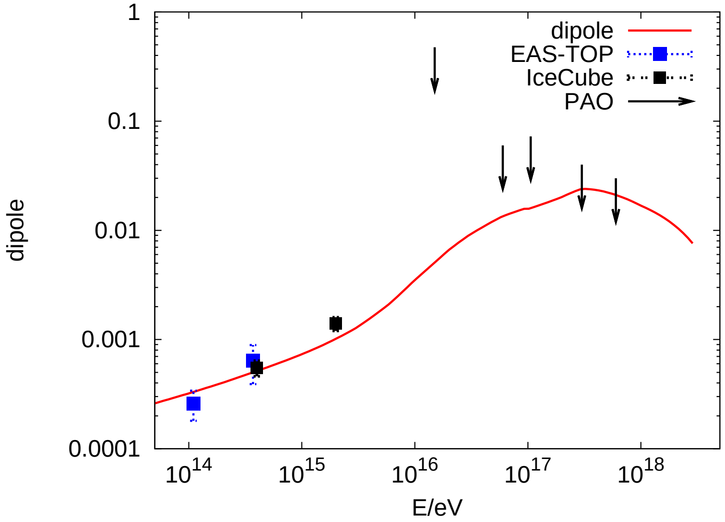
Updated PAO results:

- first 2-dim. analysis
- repeat Giacinti et al. analysis with more statistics:





Knee from CR escape: dipole anisotropy



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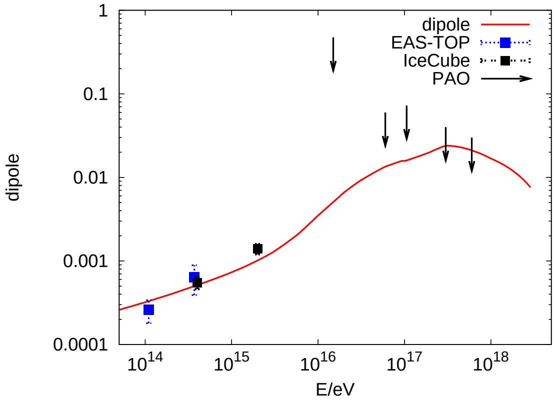

- assumes $D(E) \propto 1/X(E)$
- phase changes $10^{15} - 10^{18}$ eV.

Anisotropy of a single source

- if only turbulent field:
  diffusion = random walk = free quantum particle
- number density is Gaussian with $\sigma^2 = 4DT$
  $$\delta = \frac{3D}{c}\frac{\nabla n}{n} = \frac{3R}{2T}$$
- what happens for general fields?

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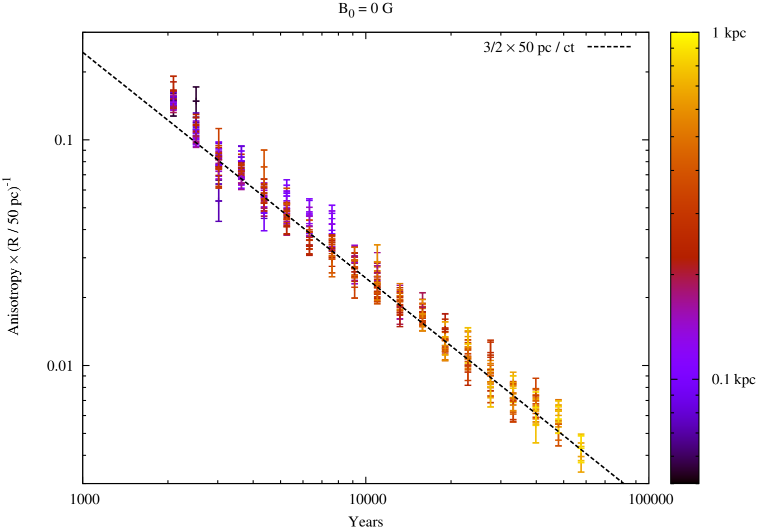
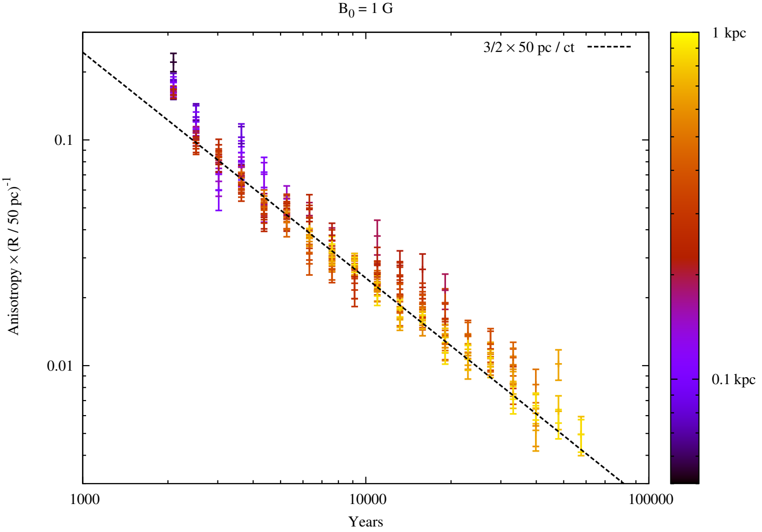


[Savchenko, MK, Semikoz '15]

Anisotropy of a single source: plus regular



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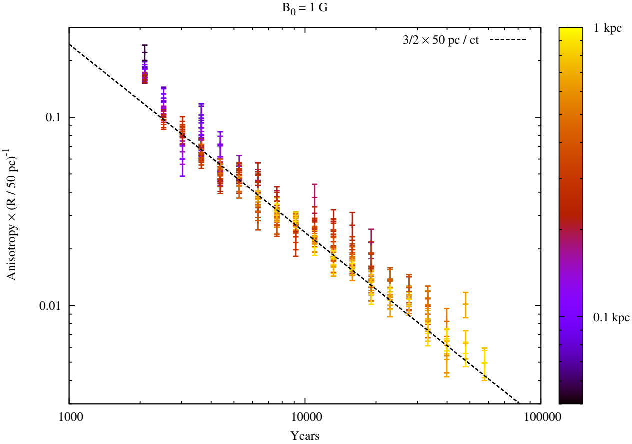

- regular field changes $n(\boldsymbol{x})$, but keeps it Gaussian

  $\Rightarrow$ no change in δ

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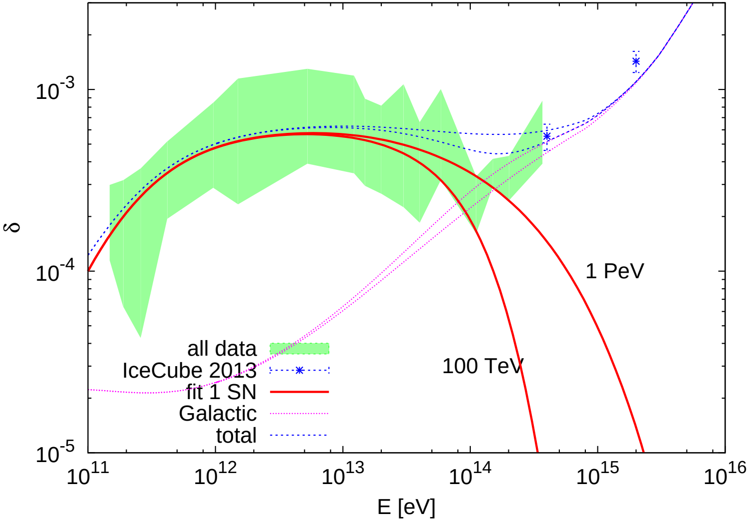

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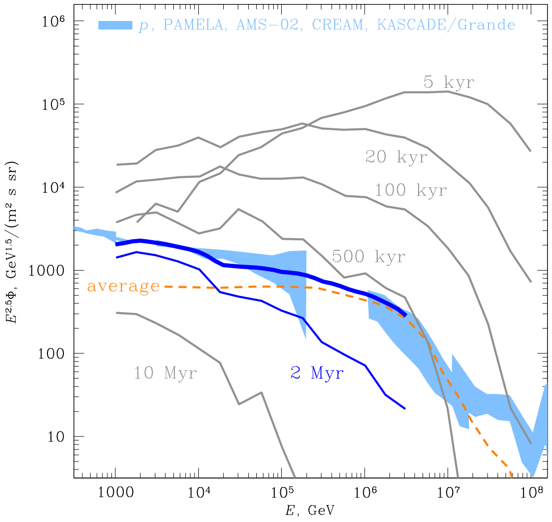
- may responsible for different slopes of local p and nuclei fluxes

Single source: proton flux



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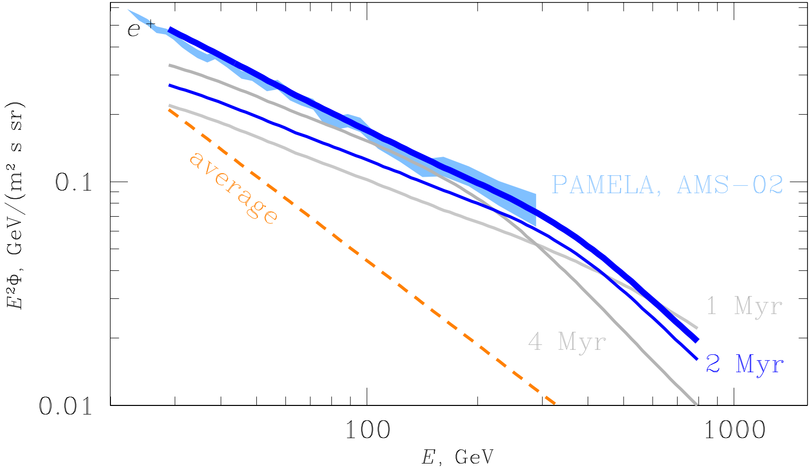
Single source: positrons



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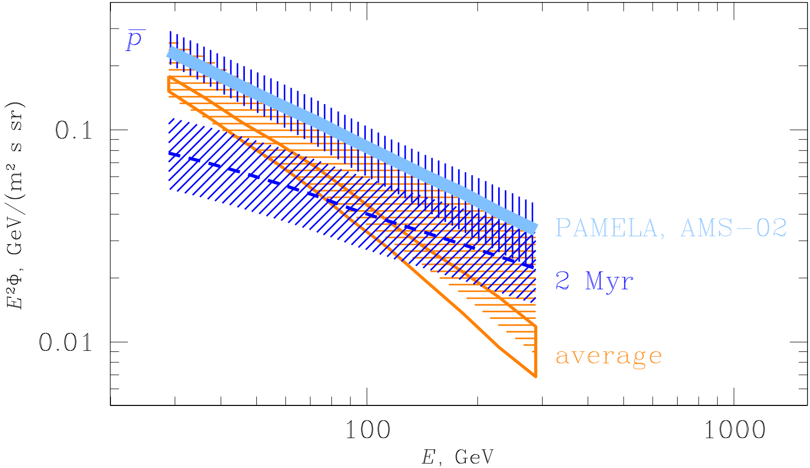
Single source: antiprotons



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Conclusions

1. Single source: anisotropy
   - dipole formula $\delta = 3R/2T$ holds universally in quasi-gaussian regime
   - plateau of δ points to dominance of single source
2. Single source: antimatter
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