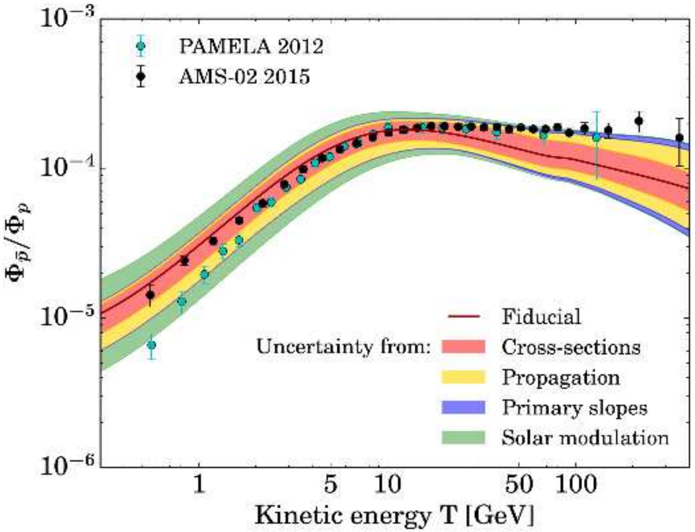
Outline of the talk

1. Introduction
   - Summary escape model & its approach
2. A recent nearby SN?
   - Anisotropy *[V.Savchenko, MK, D.Semikoz' 15]*
   - Antimatter fluxes *[MK, A.Nernov, D.Semikoz' 15]*
3. Antiproton production in hadronic collisions *[MK, I.Moskalenko, S.Ostapchenko '15]*
4. Conclusions

Uncertainties in $\bar{p}$ flux predicition

[Giesen et al. [1504.04276]]



CR propagation in the escape model

[*Giacinti, MK, Semikoz '14, '15*]

- Standard approach: diffusion as effective theory
  - effective parameters: not well constrained, often degenerated (D/h)
  - fast, but too simplistic: geometry uniform box, $D_{ij} = D\delta_{ij}$, etc,
- our approach: trajectories of individual CRs in GMF model
  - \+ adds info from RM + polarised synchrotron: $D = \mathrm{const} \to \boldsymbol{B}(\boldsymbol{x})$
  - \+ easy to include $n_{gas}(\boldsymbol{x})$ and $n_{src}(\boldsymbol{x}, t)$ (like spiral structure)
  - – computationally expansive

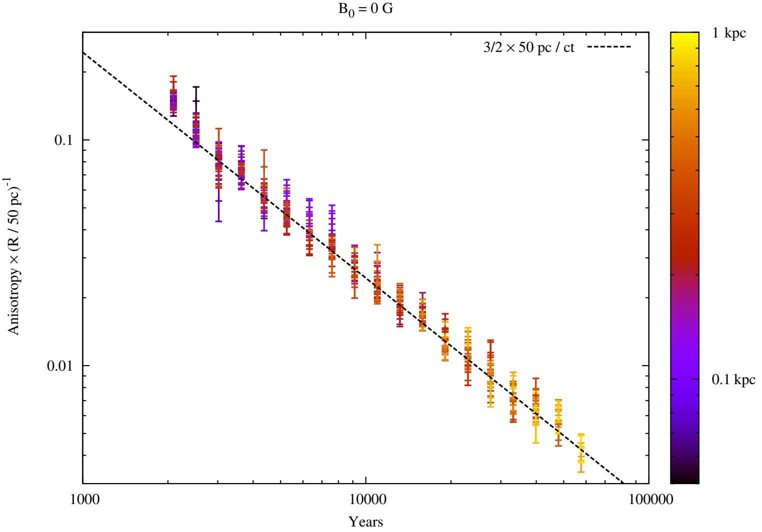
⇒ model reproduces all CR data from $\sim 200\,\mathrm{GeV}$ up 10^{18} eV

[*talk in VHE session*]

Anisotropy of a single source

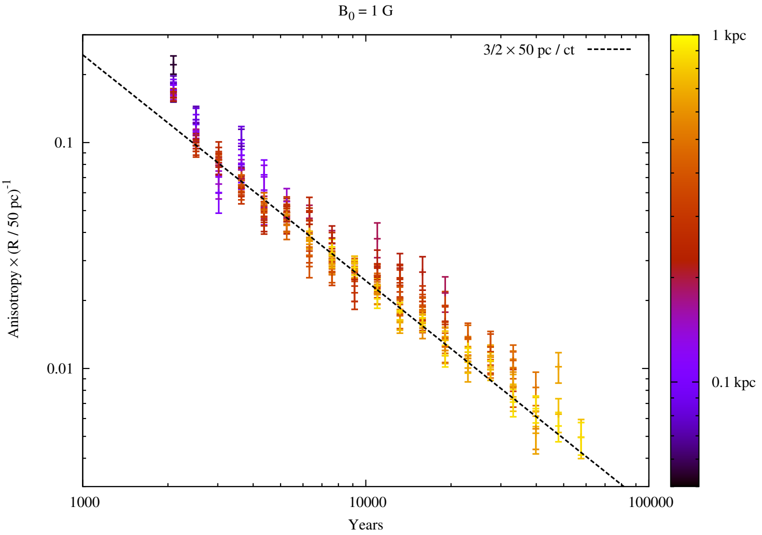
- if only turbulent field:
  diffusion = random walk = free quantum particle
- number density is Gaussian with $\sigma^2 = 4DT$
  $$\delta = \frac{3D}{c}\frac{\nabla n}{n} = \frac{3R}{2cT}$$
- what happens for general fields?

Anisotropy of a single source: only turbulent field



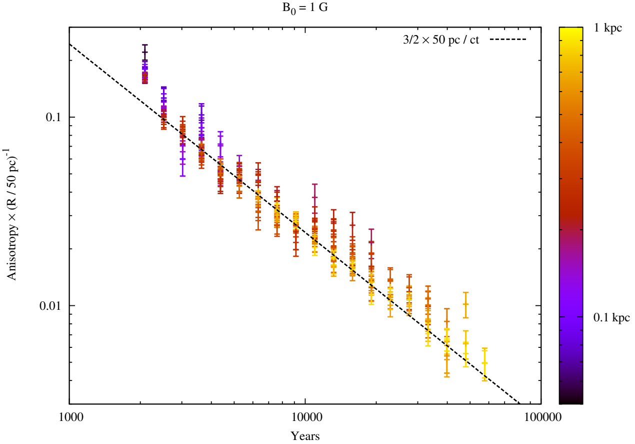
[Savchenko, MK, Semikoz '15]

Anisotropy of a single source: plus regular



[*Savchenko, MK, Semikoz '15*]

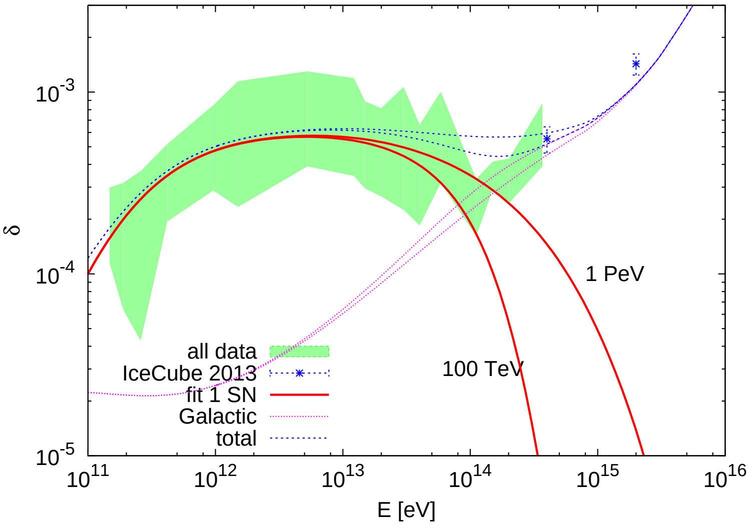
Anisotropy of a single source:



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

  $\Rightarrow$ no change in δ

Anisotropy of a single source:



[*Savchenko, MK, Semikoz '15*]

Single source: other signatures

- 2 Myr SN explains anomalous ^{60}Fe sediments [*Ellis+ '96*]

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  - $\bar{p}$ diffuse as $p \Rightarrow$ leads to constant $\bar{p}/p$ ratio
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  - e^+ flux is predicted
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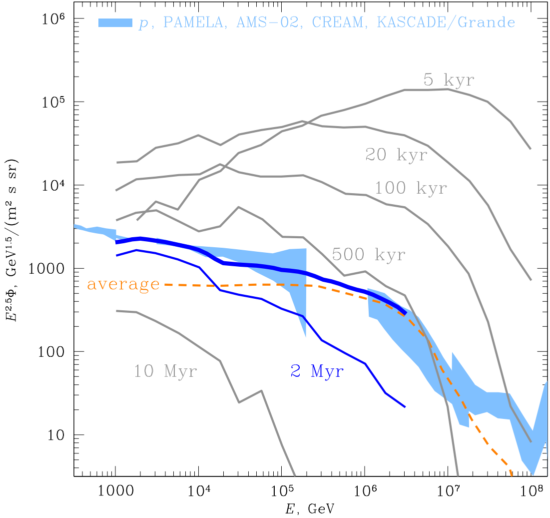
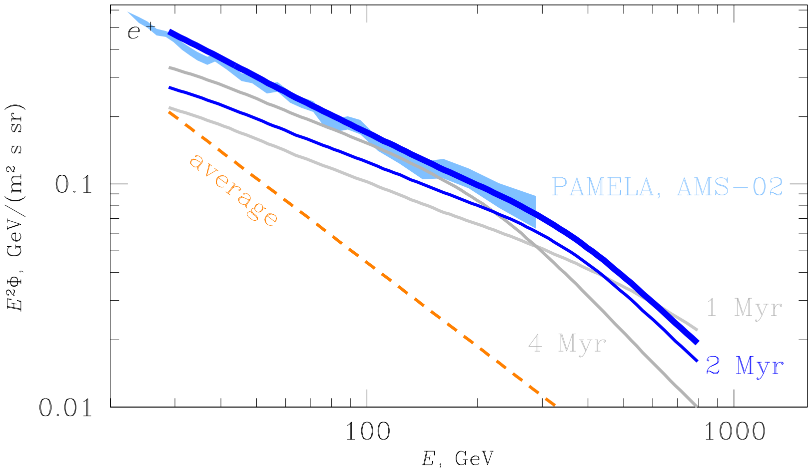
- may responsible for different slopes of local p and nuclei fluxes

Single source: proton flux



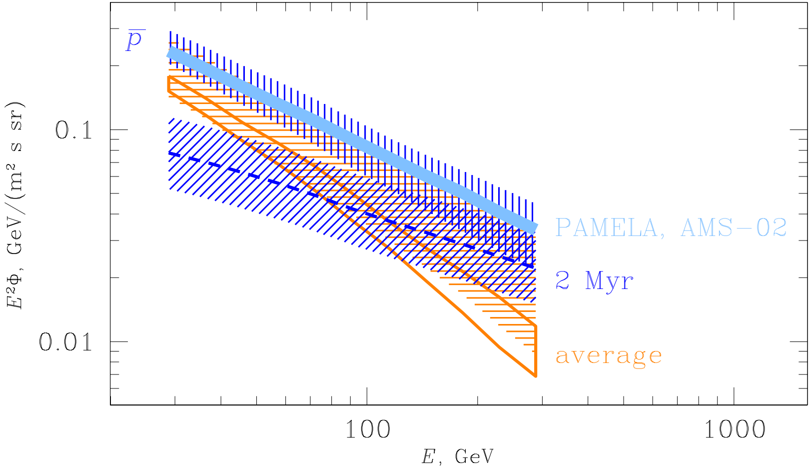
[*MK, Neronov, Semikoz '15*]

Single source: positrons



[*MK, Neronov, Semikoz '15*]

Single source: antiprotons



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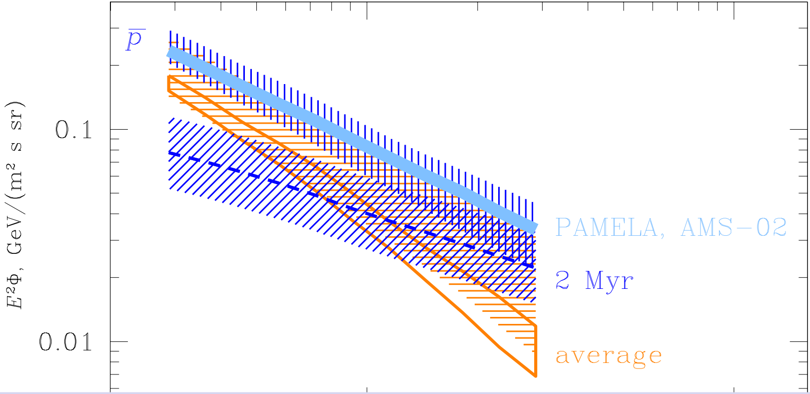

$\bar{p}$ flux = average + loc. source + DM

- DM is not needed, but how to constrain it best?

[*MK, Neronov, Semikoz '15*]

Fitting $\bar{p}$ production vs. modelling

- common problems:
  - low energies $\cong$ old exp. $\cong$ large, badly documented syst. errors
  - Ex.: some "pp" measurements are rescaled pA data
  - small Ω coverage, typically fixed angle
  - low E not covered
- fitting:
  - required extrapolation depends on quality of fit function
  - based on obsolet Ng&Tang parametrisations
- Simulations:
  - require models for soft interactions and hadronisation
  - models like QGSJet or EPOS calibrated on large data sets (SPS, Tevatron, LHC, Na49, . . . , CR)
  - consistent framework for pA, Ap and AA collisions

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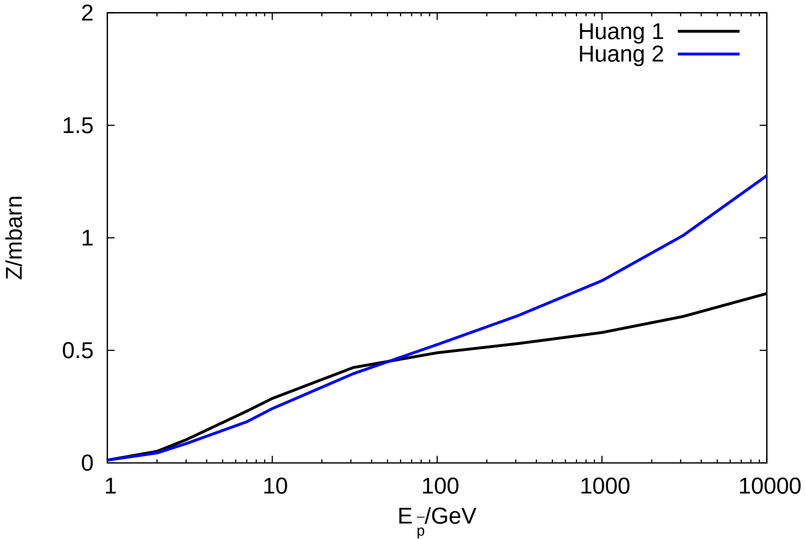
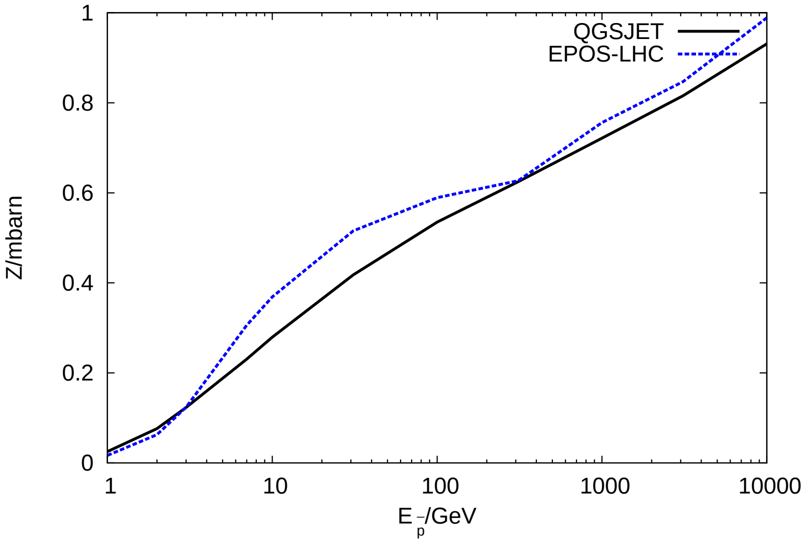
Fitting: Variation of Huang models ($\alpha = 2$)



Comparison of QCD models ($\alpha = 2$)



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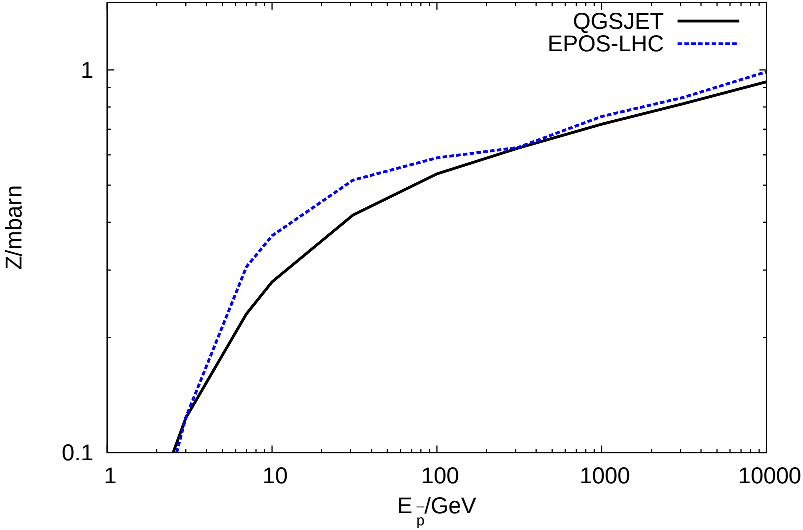
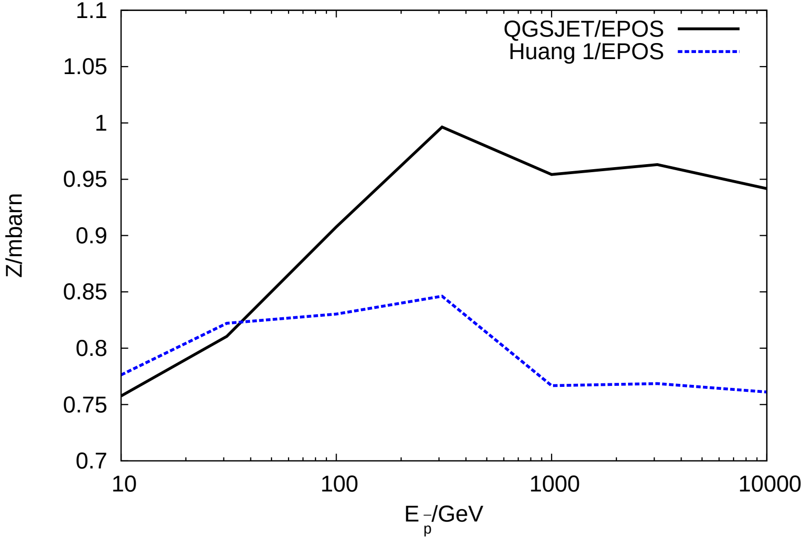
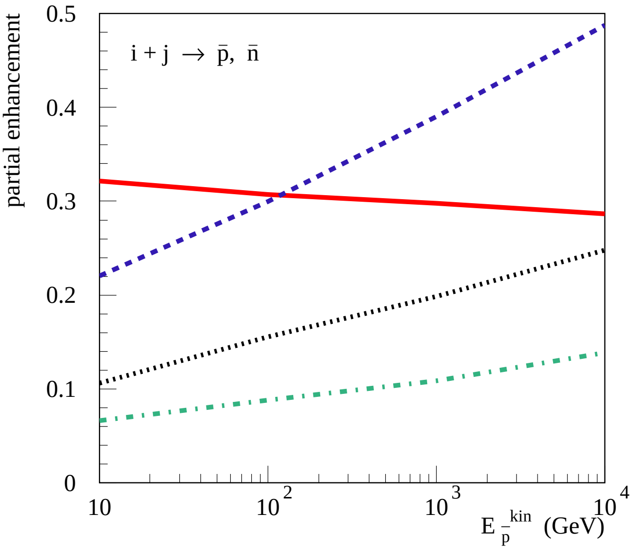


Ratios of Z-factors ($\alpha = 2$)



Nuclear enhancement: adding He ($\alpha = 2$)



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
   - consistent explanation of p, $\bar{p}$ and e^+ fluxes
   - explains γ flux $\propto E^{-2.5}$
   - consistent with ^{60}Fe and δ
3. Uncertainty in $\sigma(pp \to \bar{p})$:
   - $E_{\bar{p}} \gtrsim 100$ GeV: models agree within 15%
   - below: no improvement without no exp. data
   - parametrisations: $\varepsilon_{\rm nuc}$ adds additional uncertainty