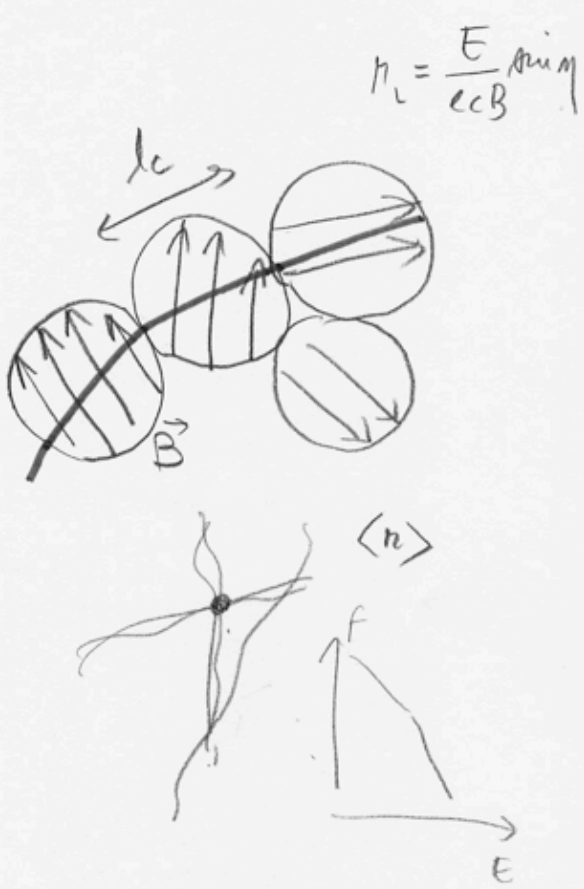
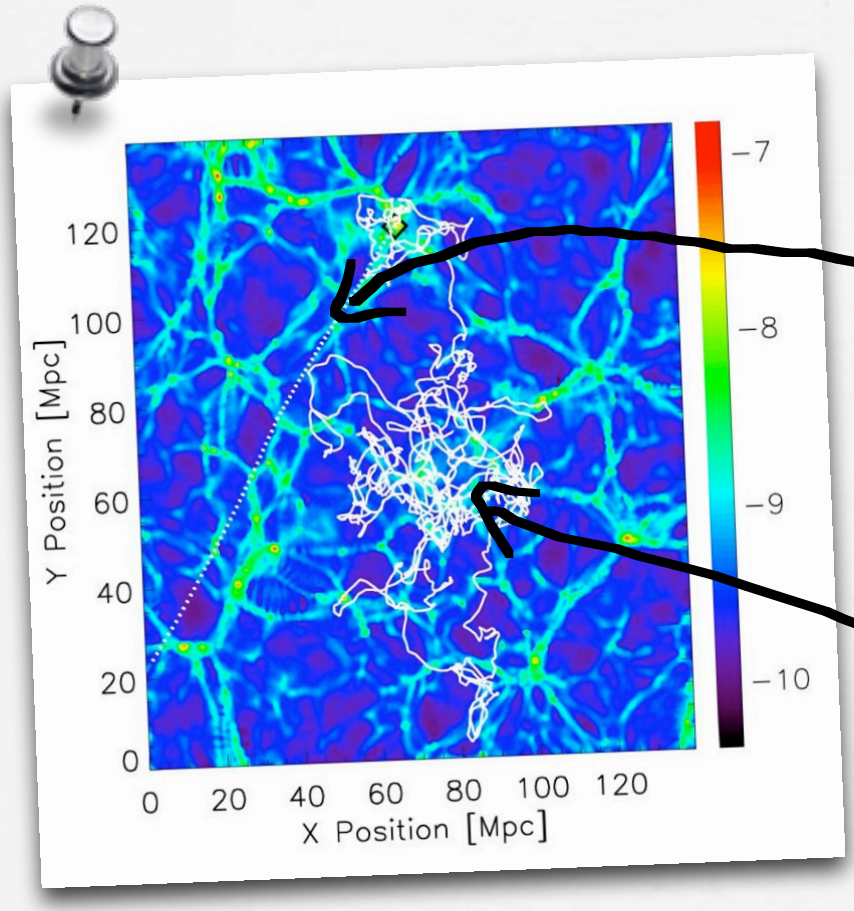




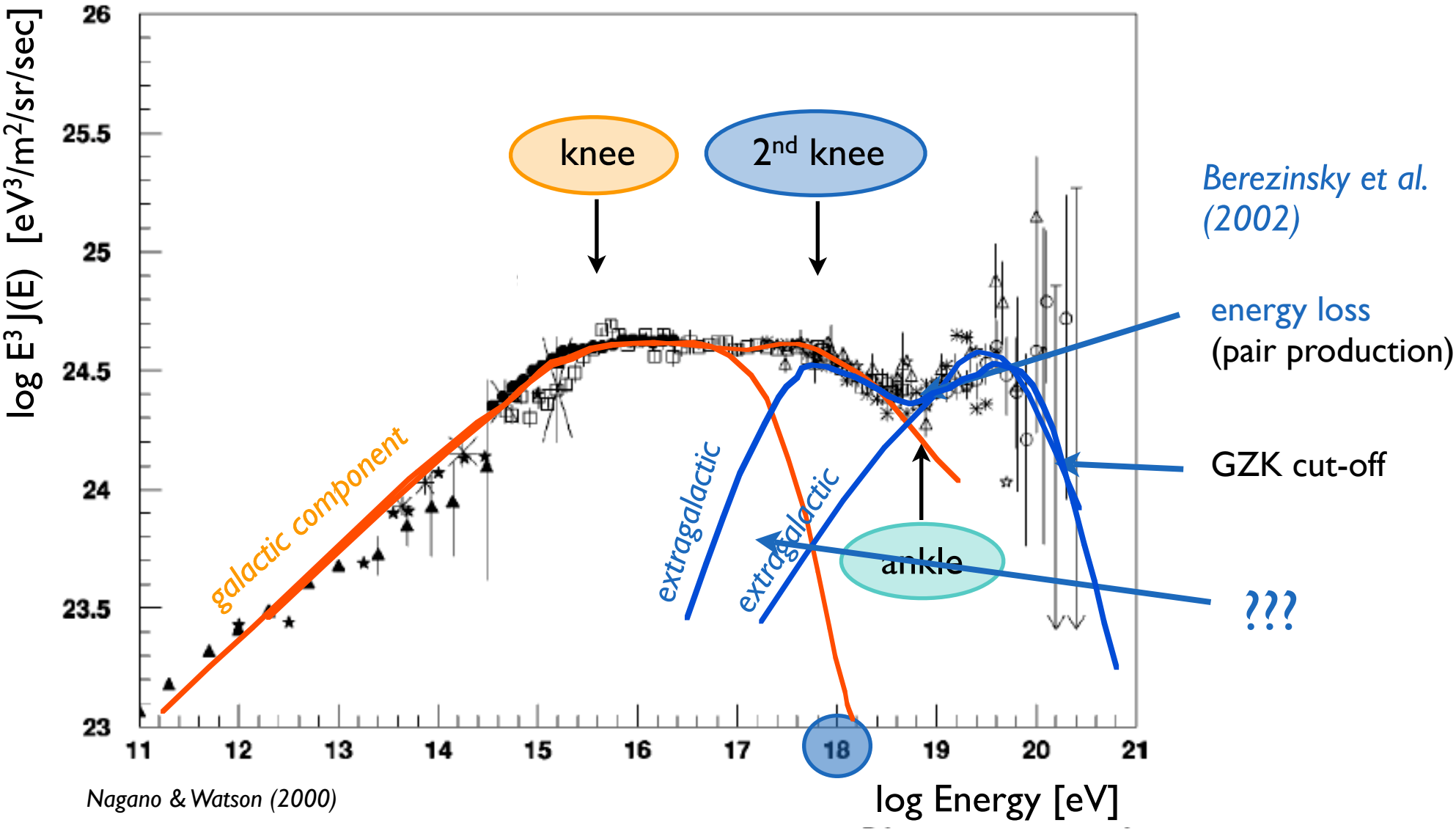
$E = 10^{19}$ eV

$E = 10^{17}$ eV

Inhomogeneous extragalactic magnetic fields and the second knee in the cosmic ray spectrum

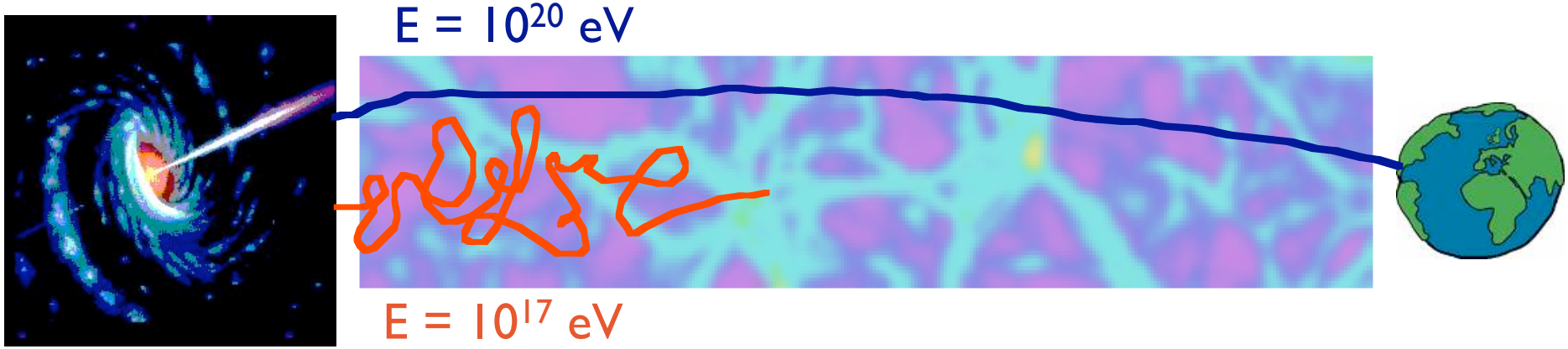
arXiv:0706.1891

Ultra high energy spectrum



Influence of extragalactic magnetic fields

Lemoine (2005), Aloisio & Berezinsky (2005)



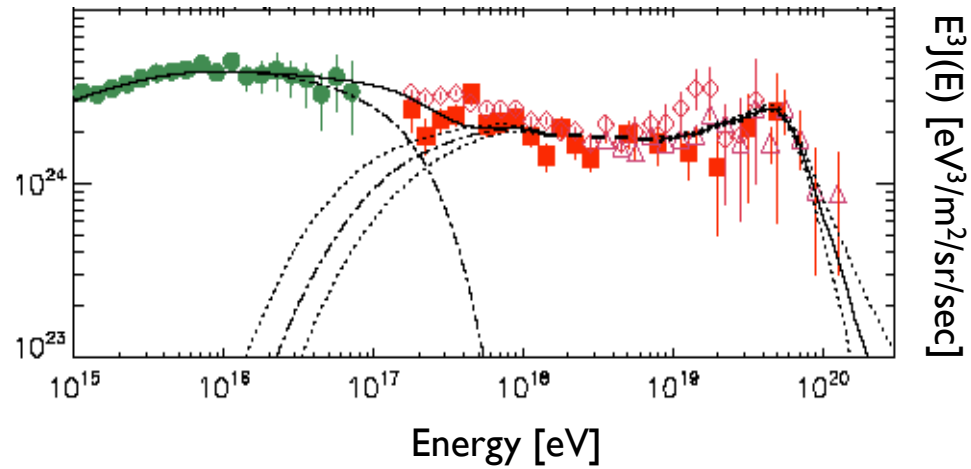
t_H = 14 Gyr

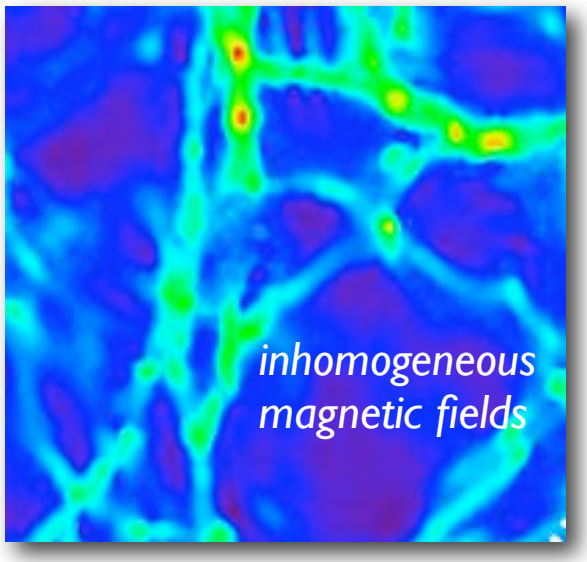
⇒ magnetic horizon effect

homogeneous magnetic fields

analytical calculations

Lemoine (2005),
Aloisio & Berezinsky (2005)





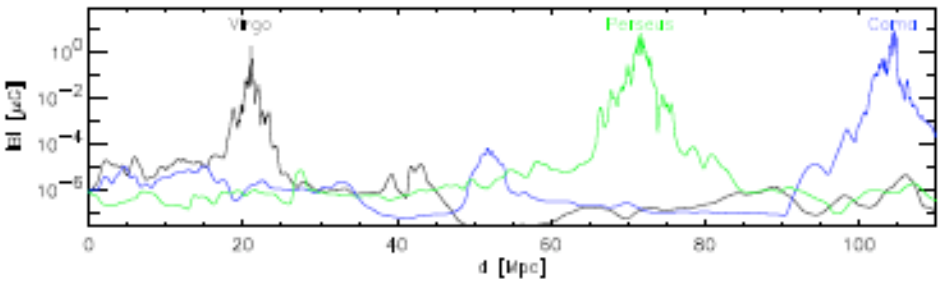
???

numerical simulations

Kotera & Lemoine (2007)
Sigl (2007)

magnetic field modeling

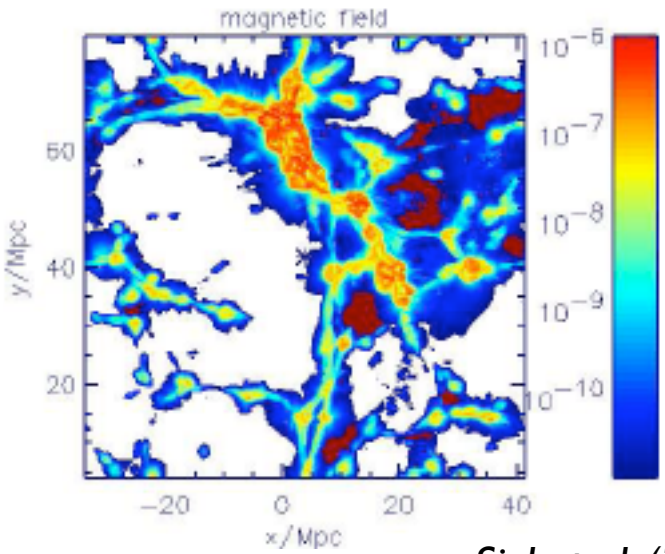
Dolag et al. (2004)



magnetic seed a high z

magnetic field evolved in a passive way

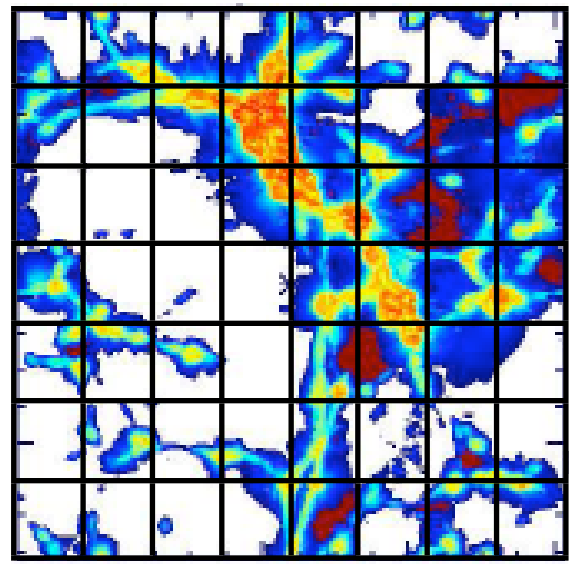
field scaled to reproduce observations in clusters



+ accretion shock waves

Sigl et al. (2004)

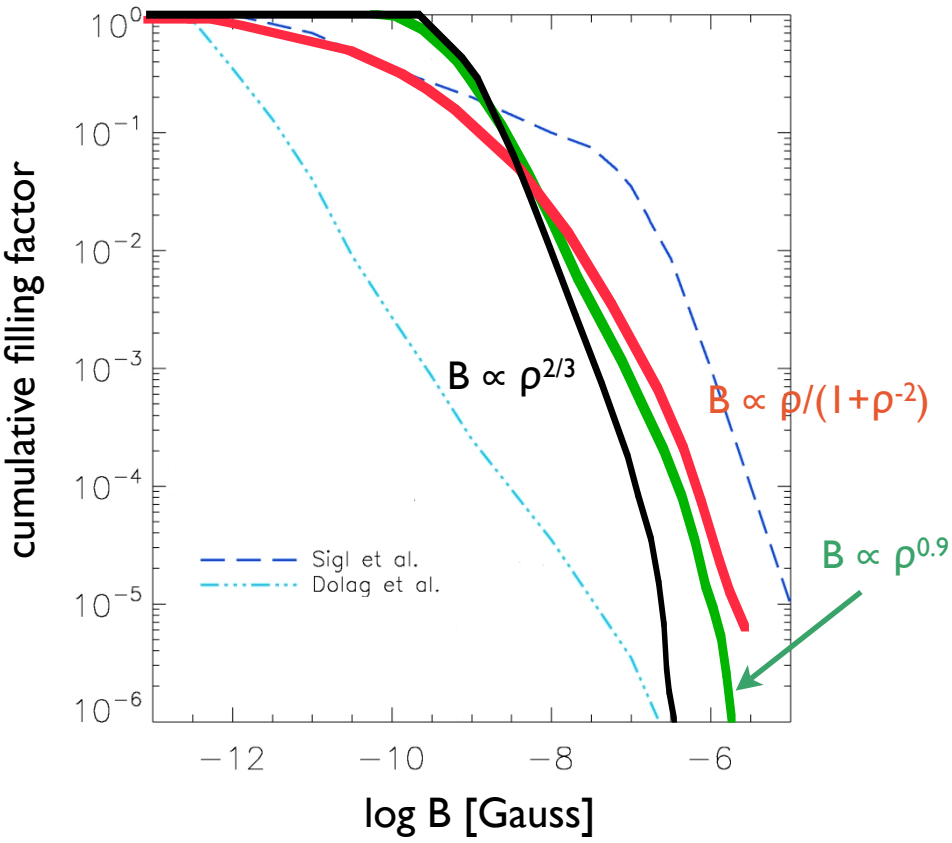
particle propagation

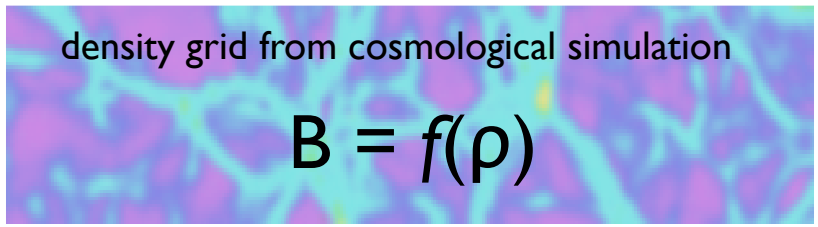


Monte Carlo method

direct integration of trajectory

magnetic field modeling





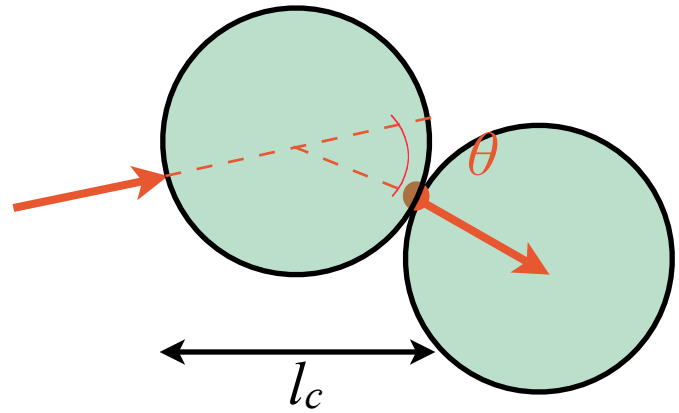
particle propagation

Problems with classical methods:

limited resolution *Casse et al. (2001)*

time consuming

Cellular propagation method:

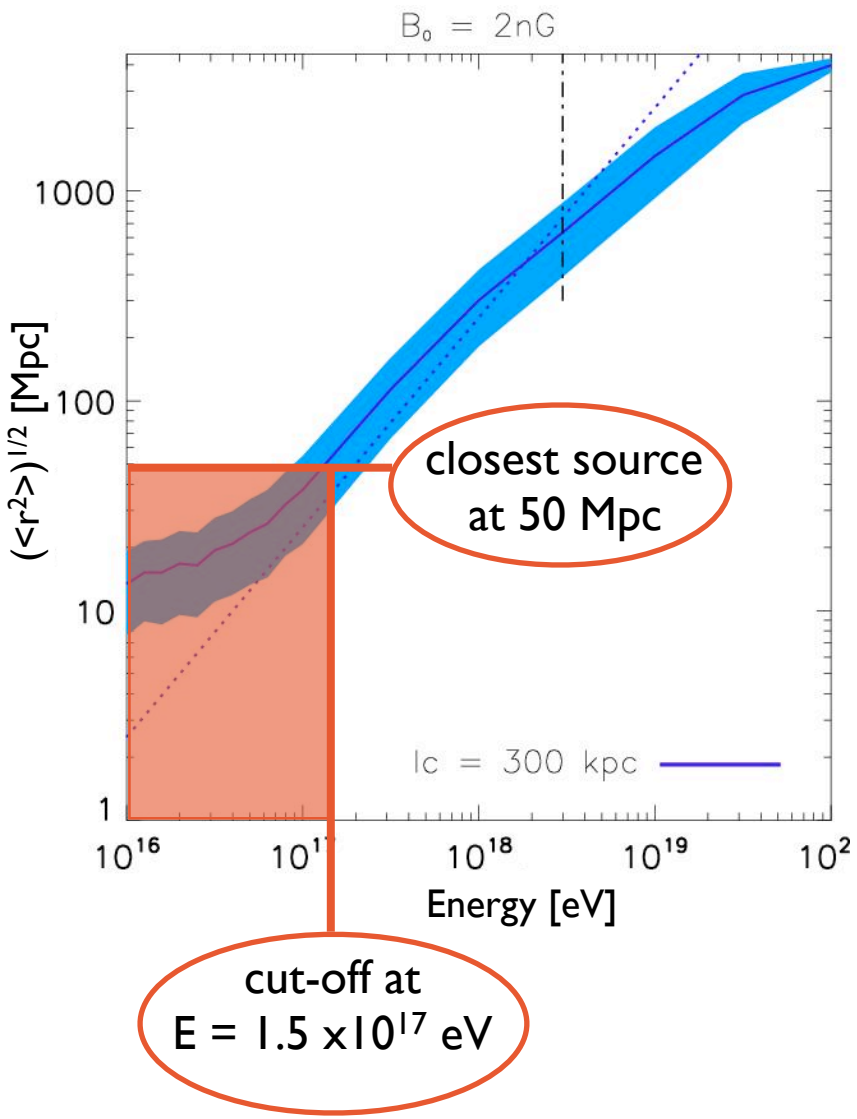


deflection angle sampled from a function $f(\theta, r_L/l_c)$

exiting time: $\tau = f(D, r_L/l_c)$

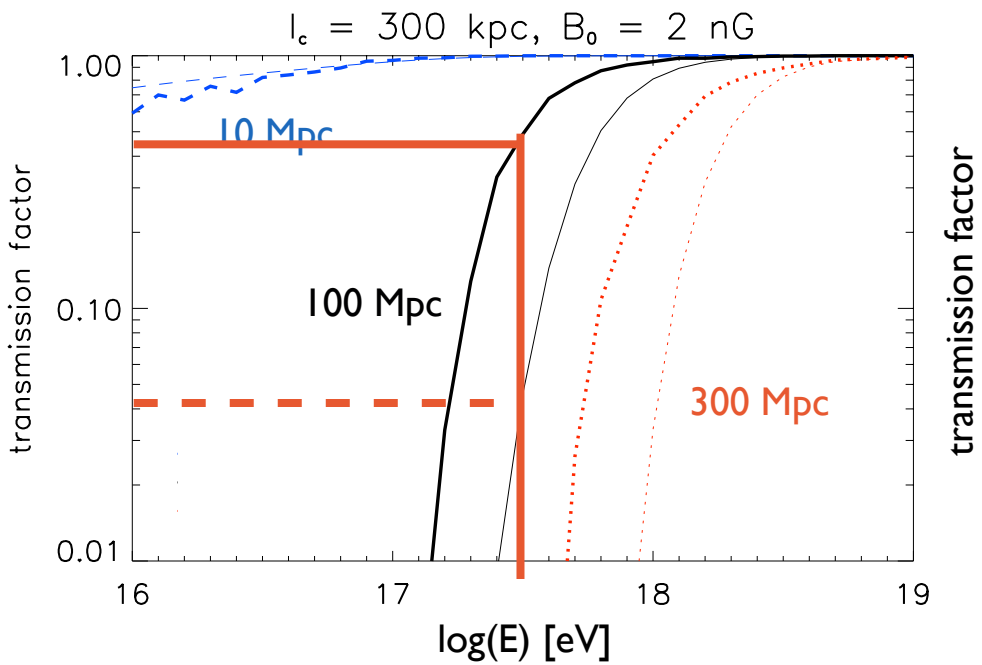
Existence of a magnetic horizon

distance traveled in a Hubble time



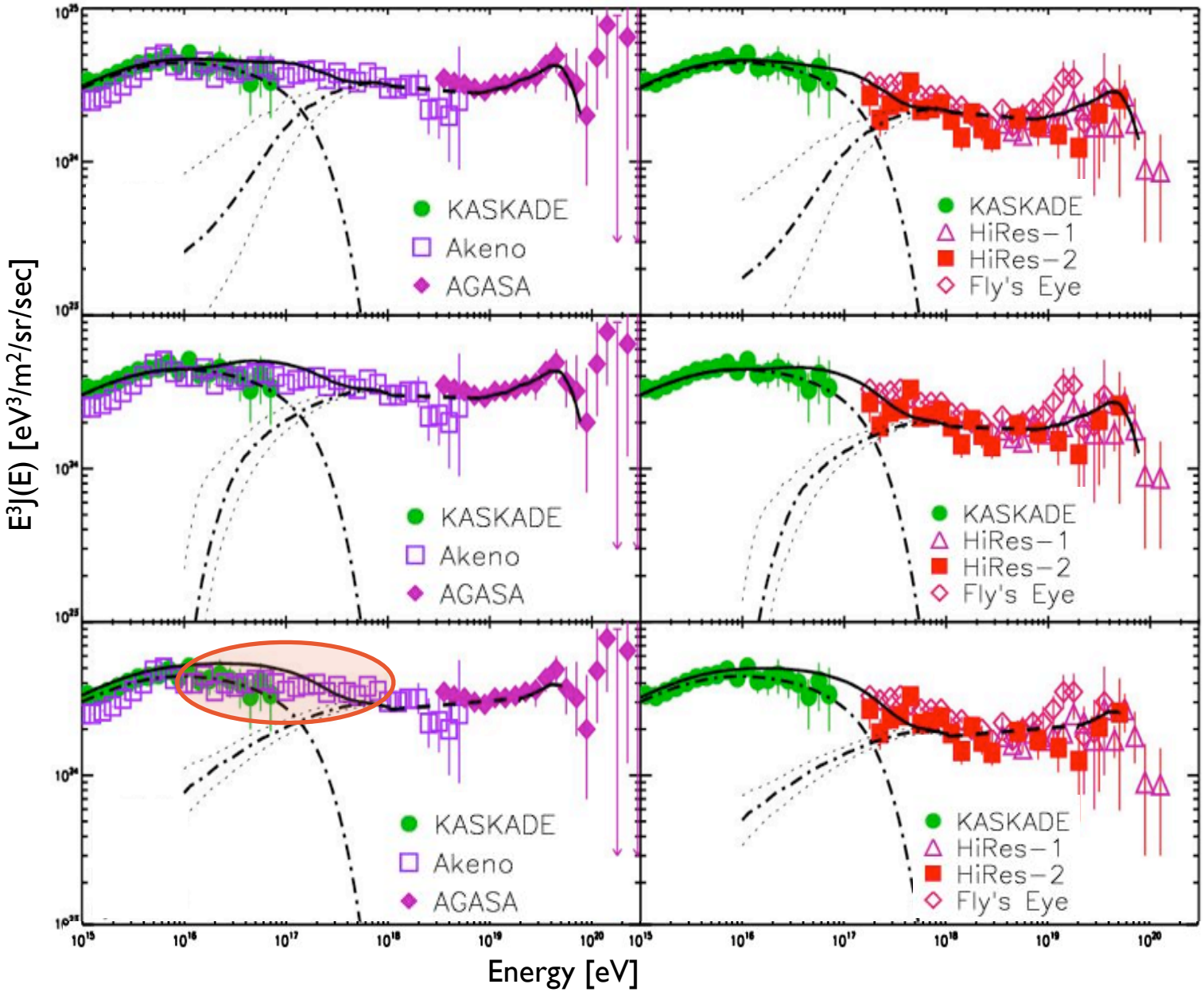
transmission factor

N that reached *d* / N emitted



thick lines: *inhomogeneous case*
thin lines: *homogeneous case*

Comparison with observed spectra



$B \propto \rho^{2/3}$

B_0 = 2 nG
l_c = 300 kpc
n_s = 10^{-5} Mpc^{-3}

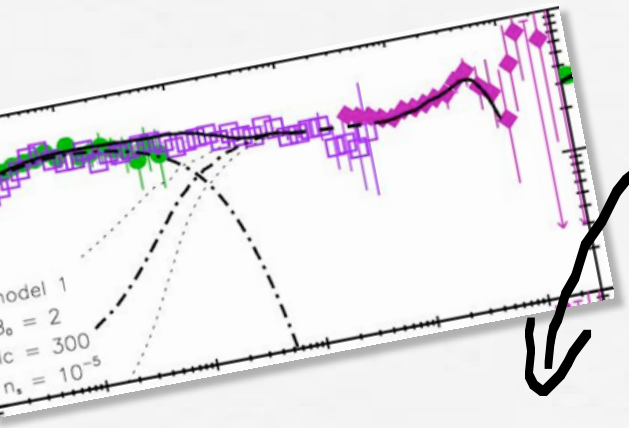
$B \propto \rho^{0.9}$

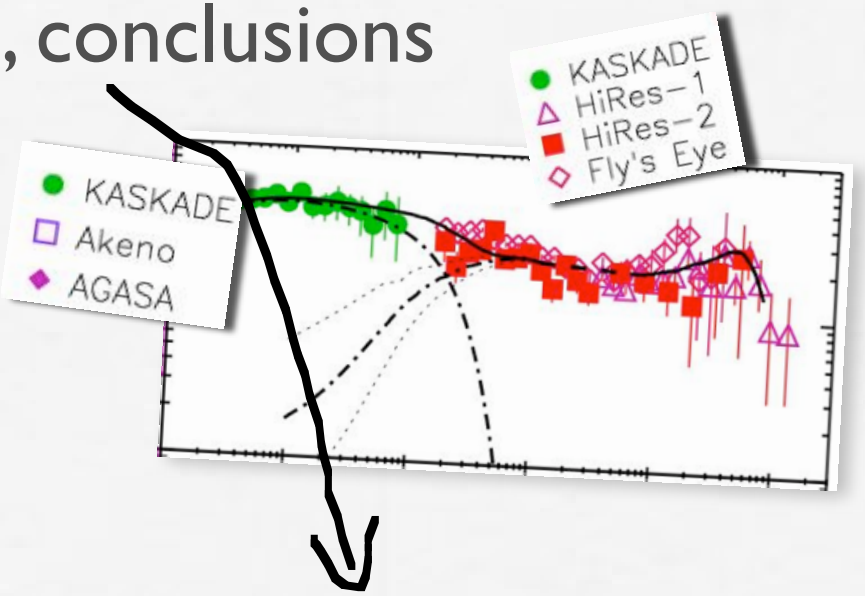
B_0 = 2 nG
l_c = 100 kpc
n_s = 10^{-5} Mpc^{-3}

$B \propto \rho/(1+\rho^{-2})$

B_0 = 2 nG
l_c = 30 kpc
n_s = 10^{-6} Mpc^{-3}

Other signatures, conclusions





Faraday RMs in our models:

median(RM) < 0.1 rad/m^2

(observations: RM < 5 rad/m^2)

Note: high variations in RMs according to the concentration of matter along the line of sight

Mean particle deflection angles:

moderate.

consistent with detection of counterparts at energies around GZK cut-off.

E = 10^{19} eV
B = 2 nG
lc = 300 kpc
d = 100 Mpc

models 1 & 2 $\theta \sim 3 - 5°$

model 3 $\theta \sim 8°$

- cut-off exists in inhomogeneous magnetic fields
- homogeneous/inhomogeneous cases quite different
- strong influence of B = f(ρ) models
- if voids unmagnetized, shallower cut-off → worse fit to observations
- → to be related to debate on metal enrichment of voids, origins of IGMF
- SKA, progress on superwinds, AUGER...