

combined analysis of the
spectrum and
anisotropies of UHECRs

Daniel De Marco

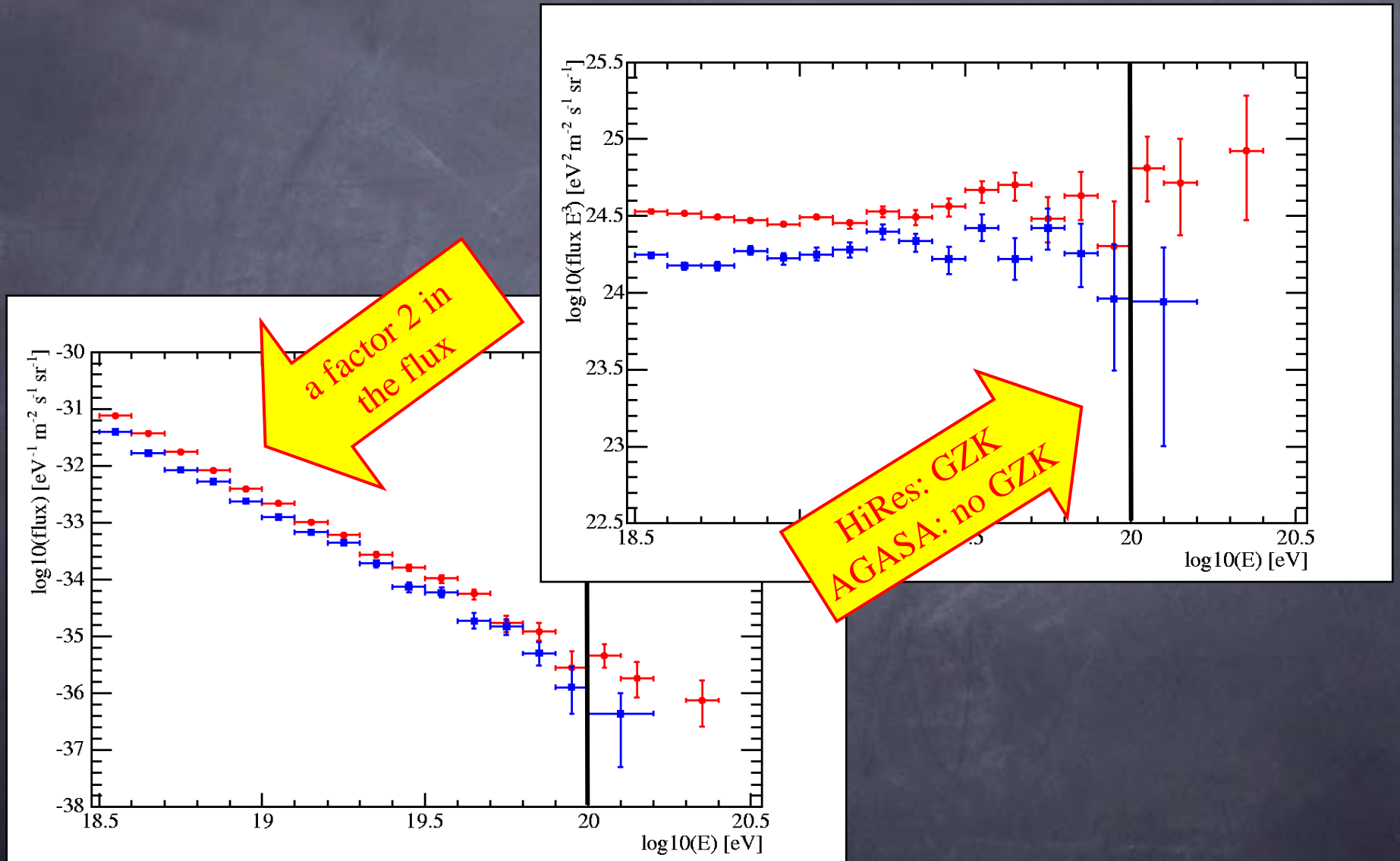
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University of Delaware

plan

AGASA vs HiRes

AGASA: spectrum vs ssa
expectations for Auger

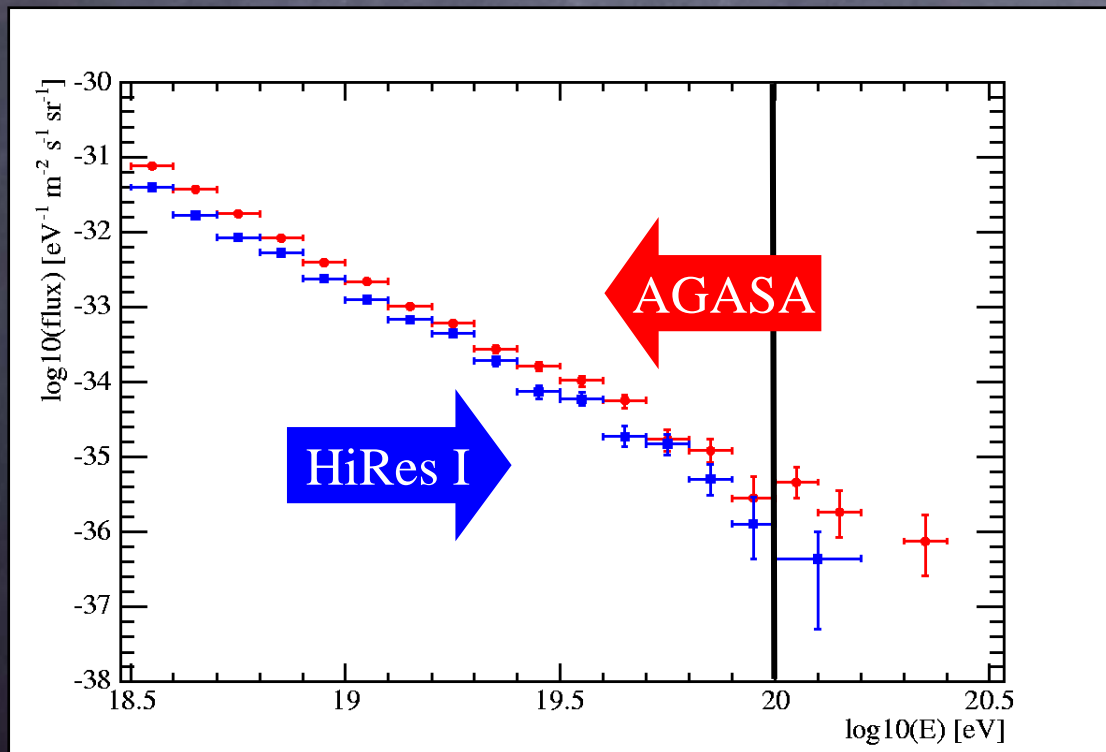
AGASA & HiRes



systematic errors (?)

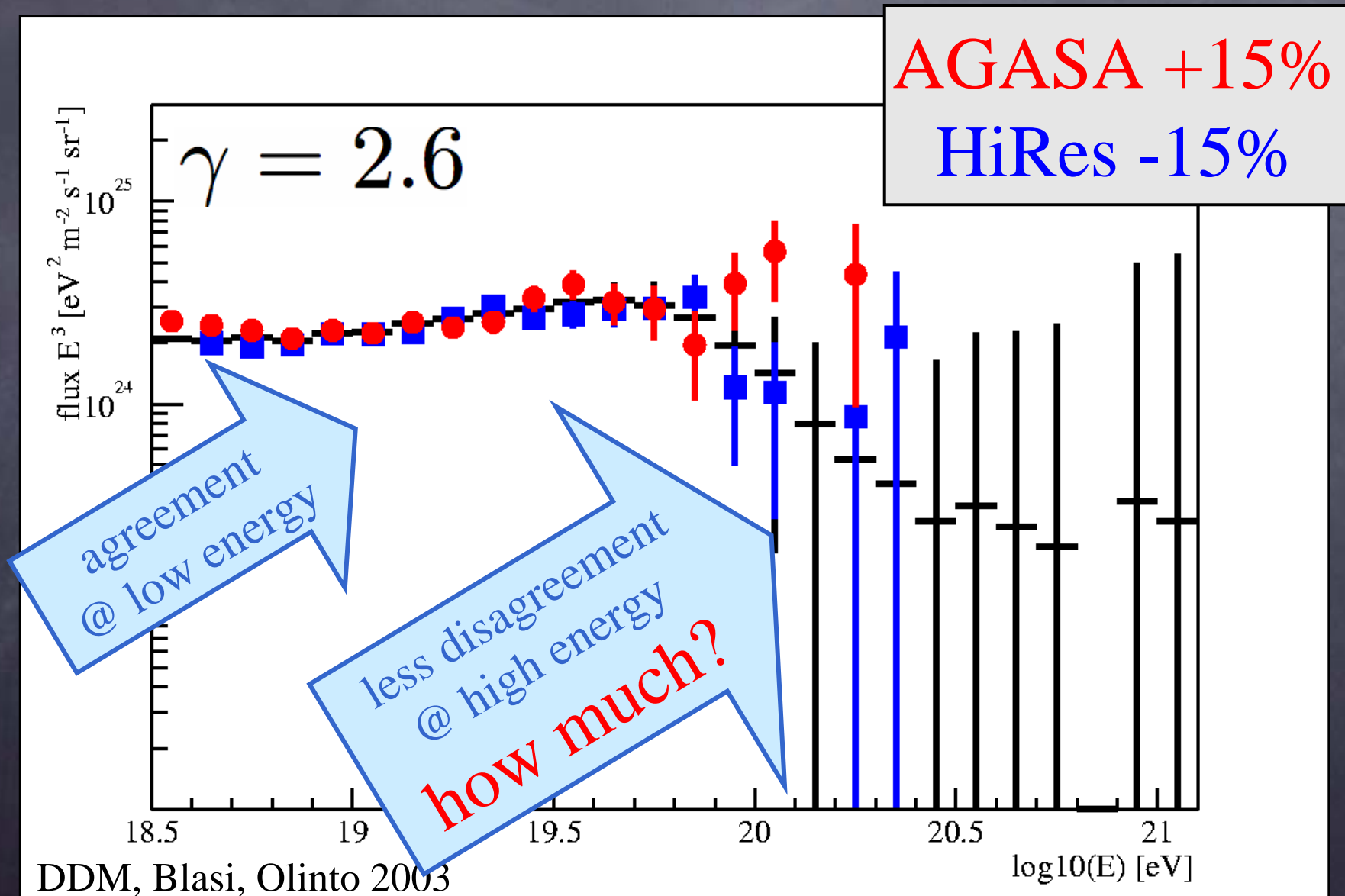
systematic errors may be the explanation (at low energy)

a factor 2 in the flux can be accounted for with a systematic error in the energy determination of about 30%



15% within limits allowed by both collaborations

systematic errors (?)

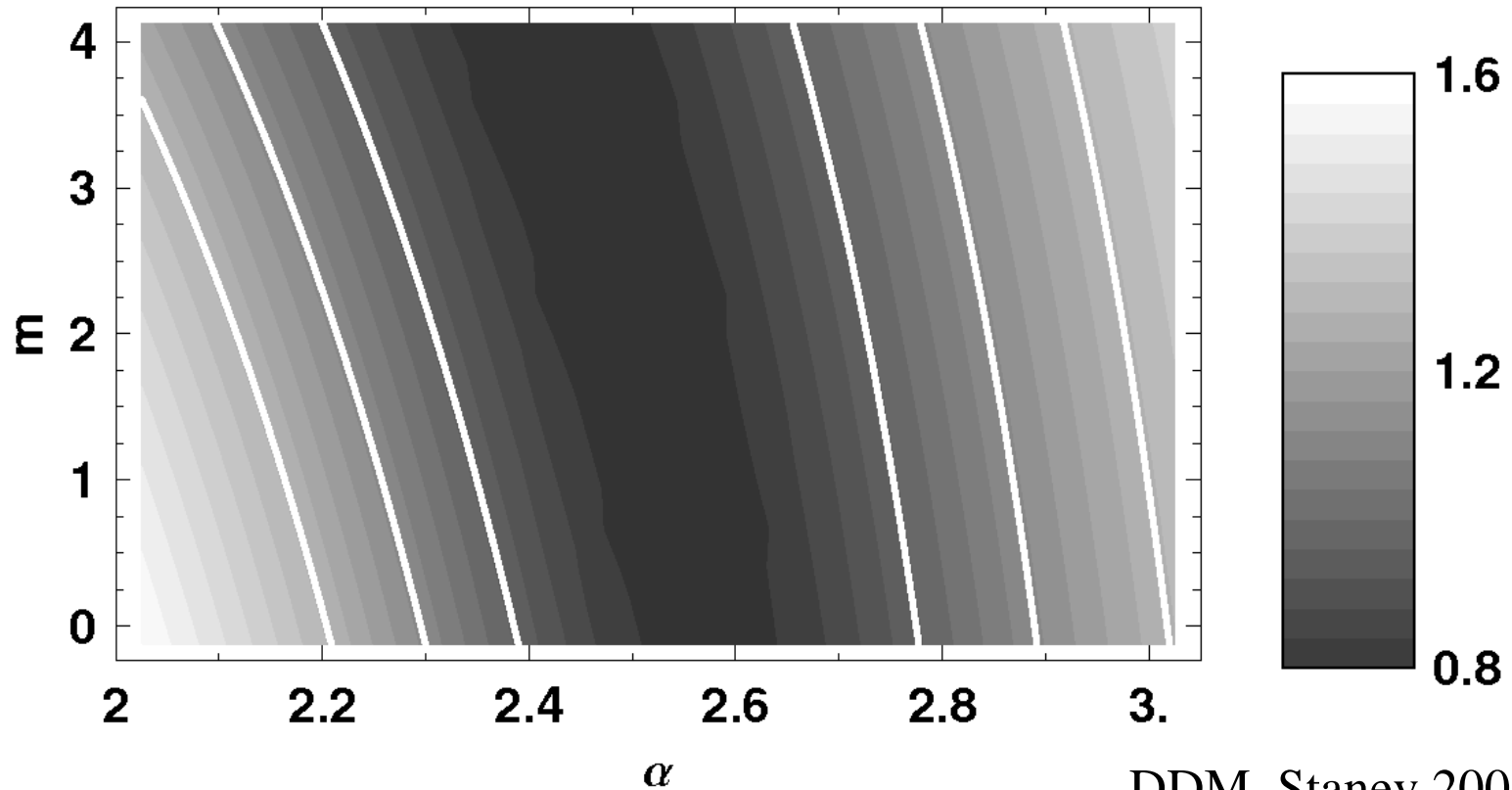


fit uncertainties

fit to shifted data in the range 10^{19} eV to 10^{20} eV

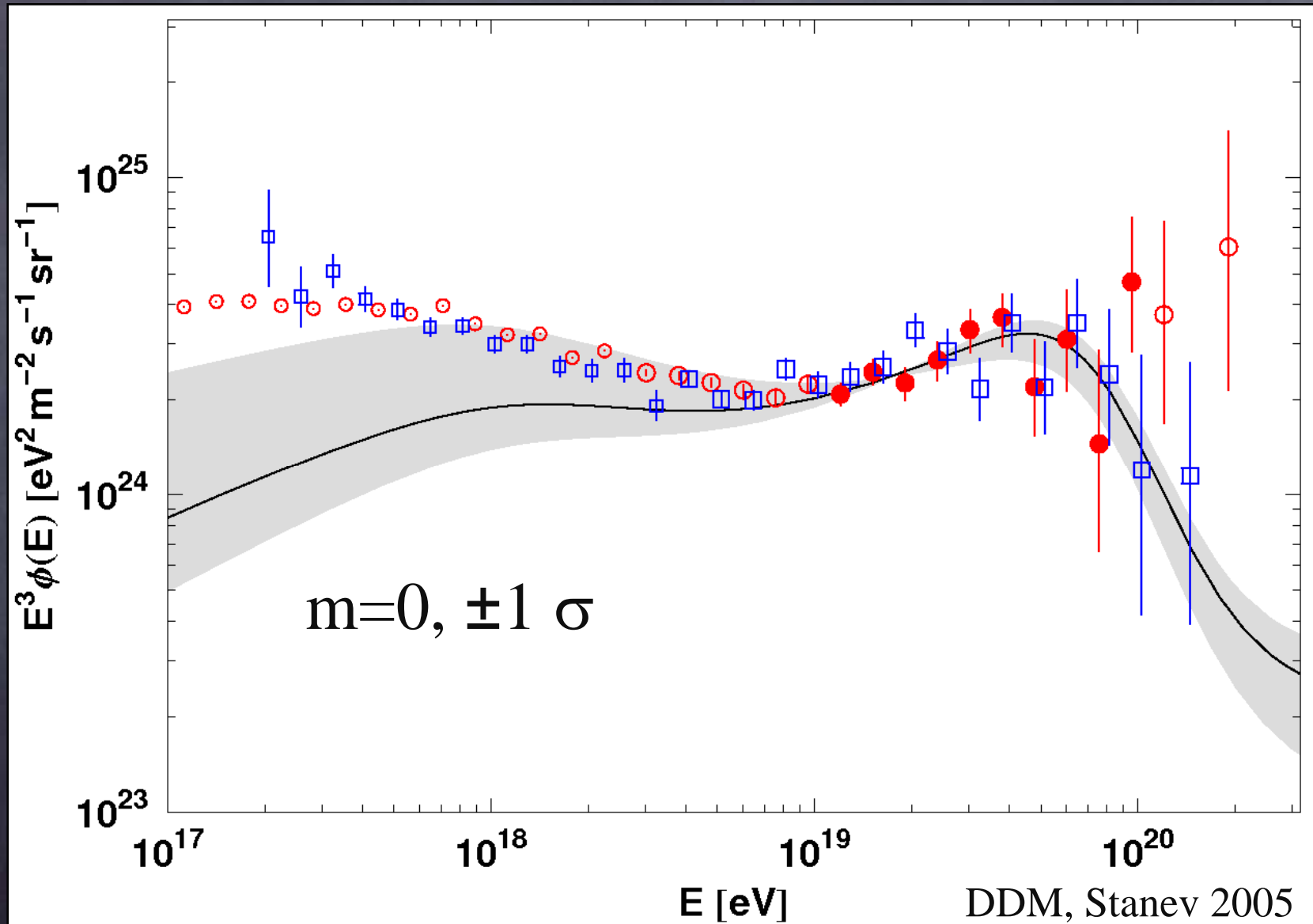
proton propagation

$\log_{10}\chi^2$

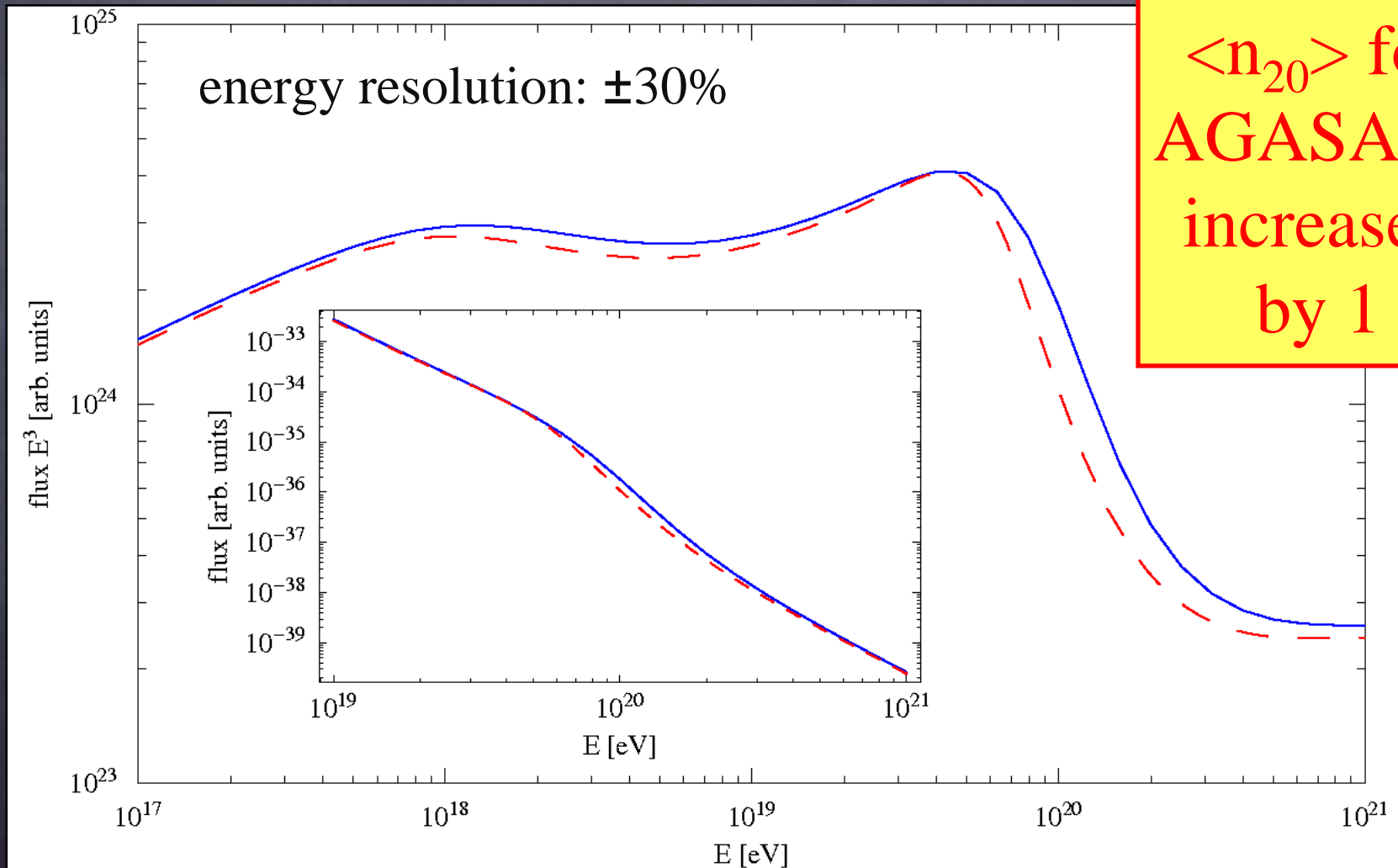


DDM, Stanev 2005

fit uncertainties



statistical error in the energy reconstruction



$\langle n_{20} \rangle$ for
AGASA is
increased
by 1

high energy: AGASA

we simulated 30000 realizations of the AGASA statistics above $4 \cdot 10^{19}$ eV (72 events) and we counted the number of events with energy above 10^{20} eV.

18 realizations produced 11 or more events above 10^{20} eV

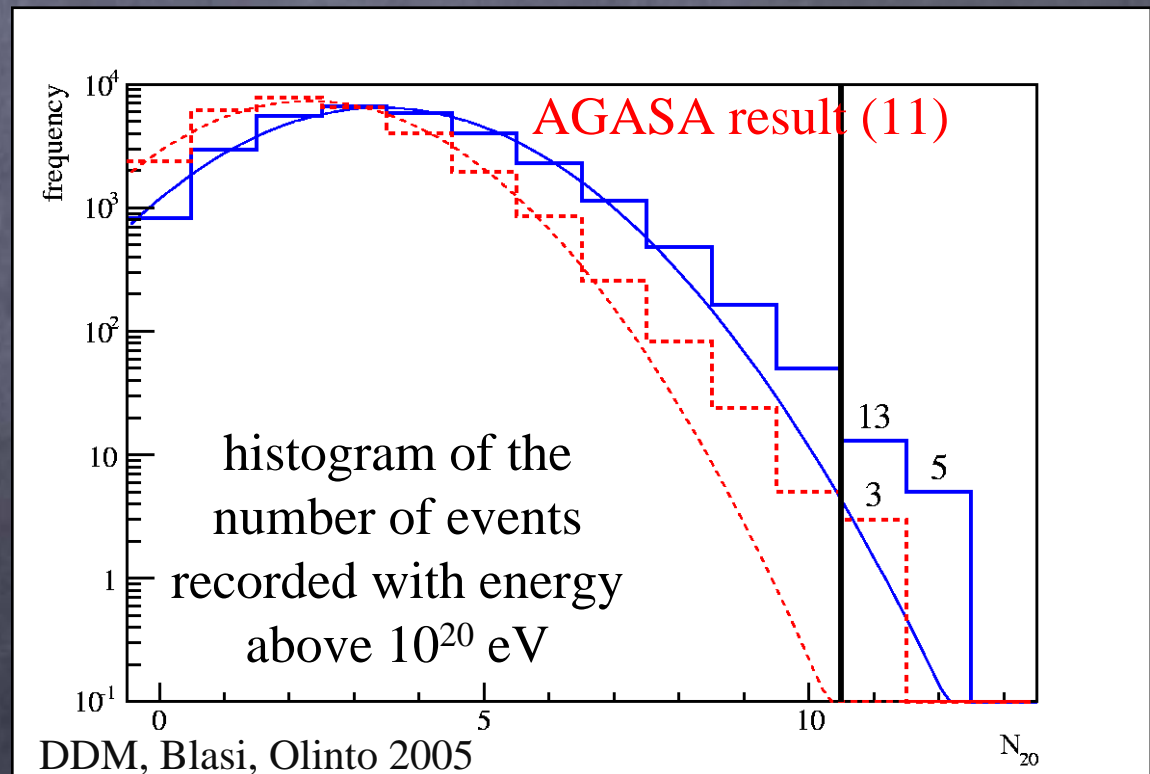
probab.: $6 \cdot 10^{-4}$ — 3.2σ

the same procedure applied to the AGASA-15% statistics resulted in a probability of

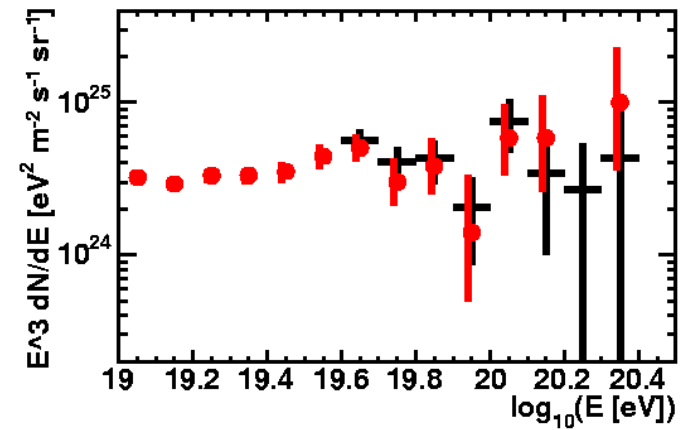
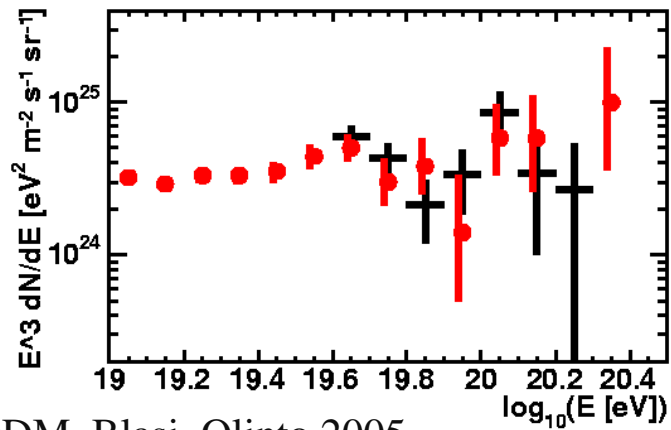
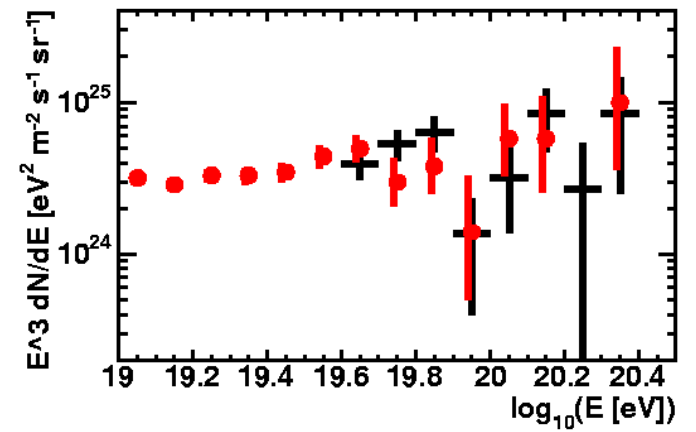
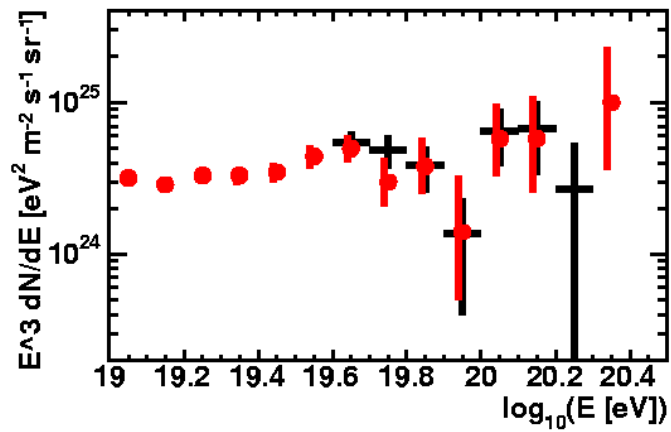
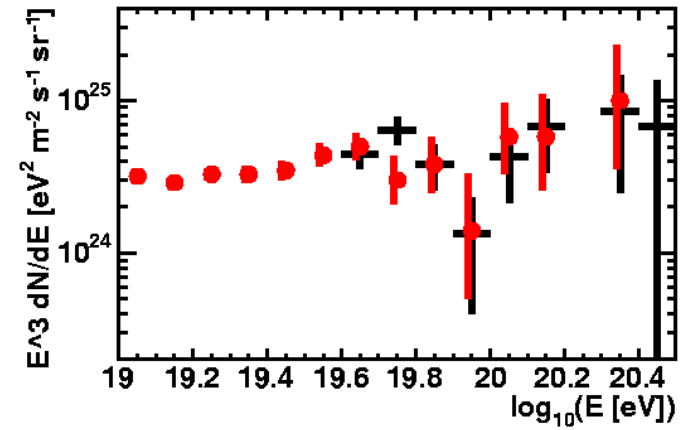
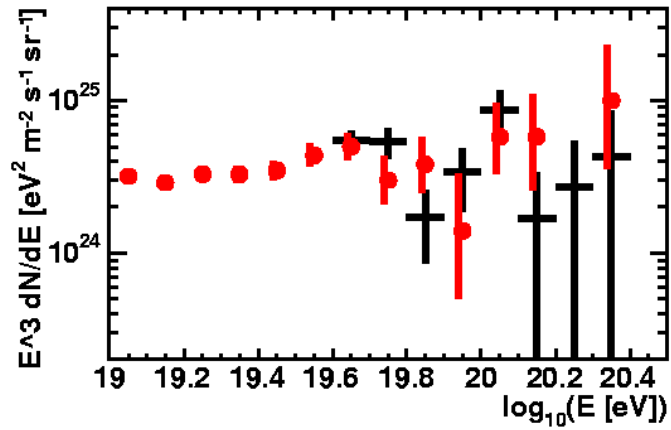
about 1% — 2.3σ

accounting for the sys. errors, the AGASA result doesn't have a high statistical significance

propagation simulation ($\gamma=2.6$)
GZK suppression



some AGASA spectra



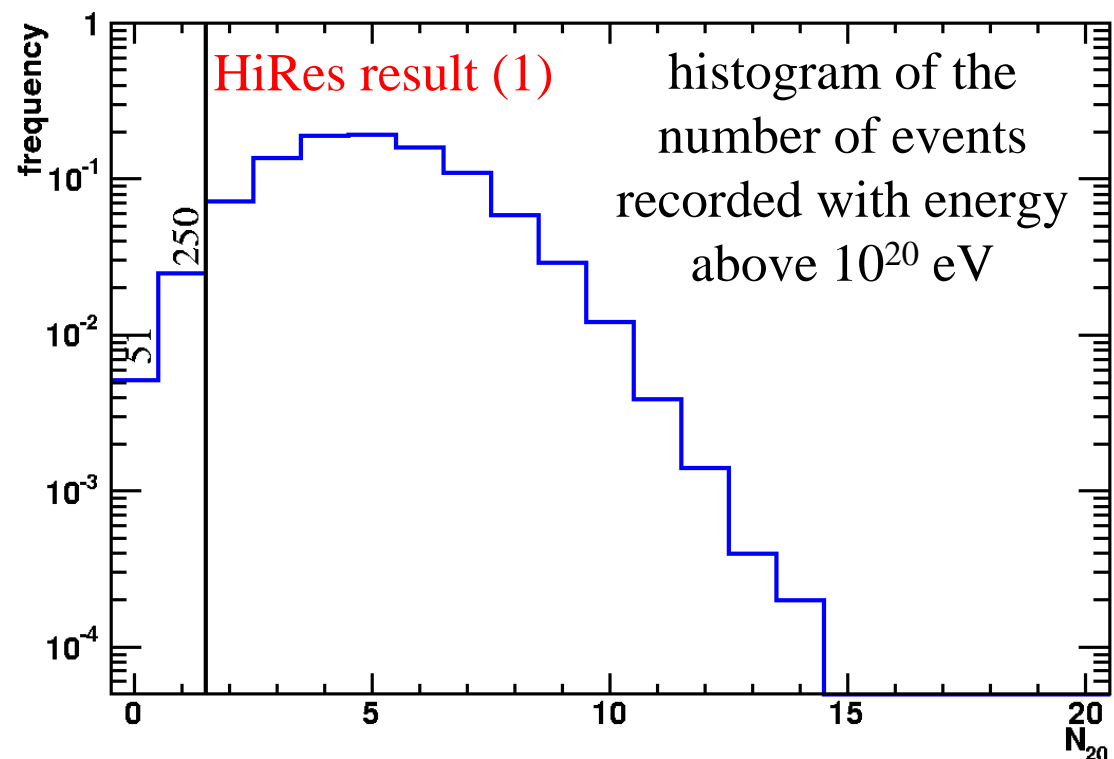
high energy: HiRes

we simulated 10000 realizations of the HiRes statistics above $4 \cdot 10^{19}$ eV (27 events) and we counted the number of events with energy above 10^{20} eV.

no propagation, we used as template the AGASA measured spectrum, but for the HiRes statistics

301 realizations
produced 1 or less events
above 10^{20} eV
prob.: **3% — 2σ**

the HiRes result as well does not have a high statistical significance



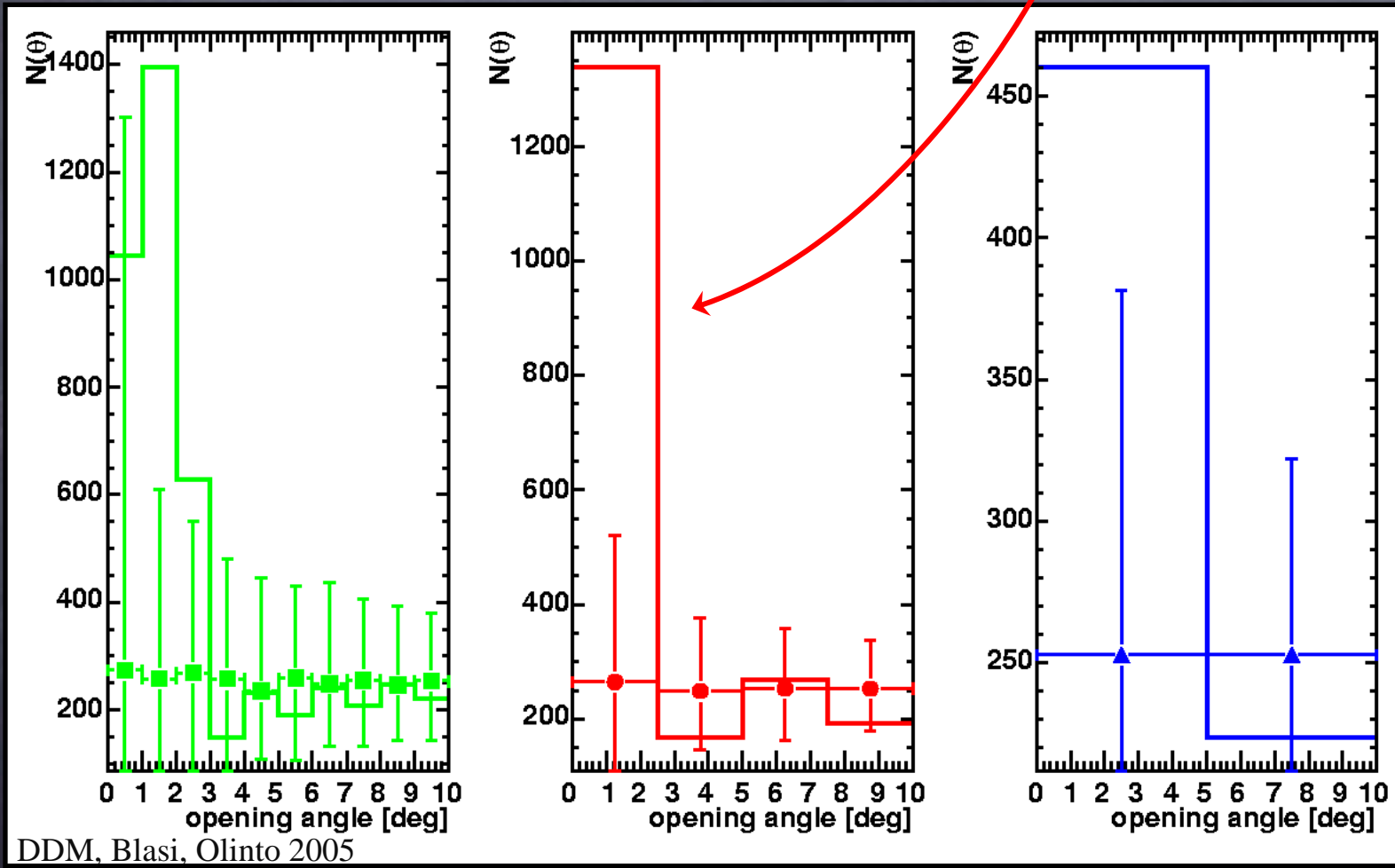
no strong discrepancy
between AGASA and
HiRes spectra

Small Scale Anisotropies: what can they tell us?

simulation of the propagation from
astrophysical point sources

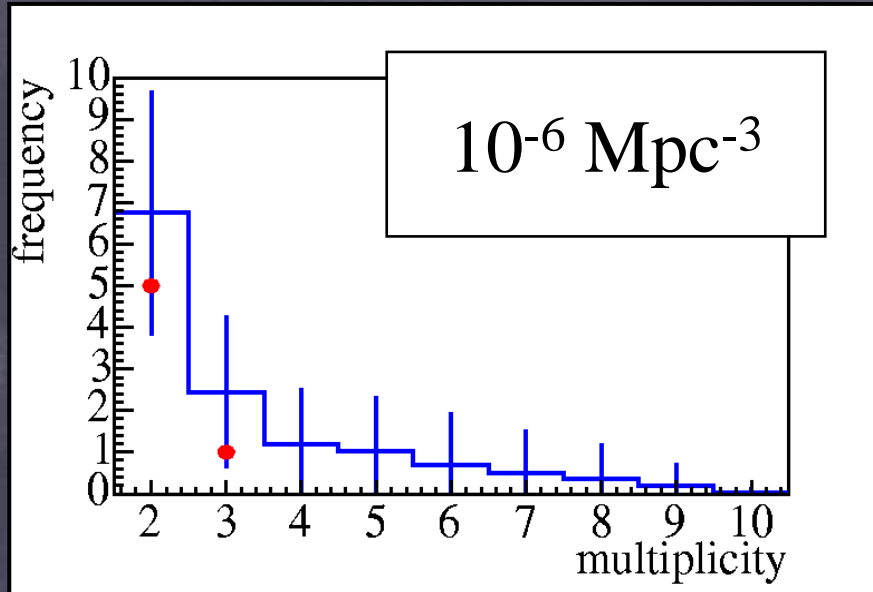
AGASA 2pcf

point sources (?)

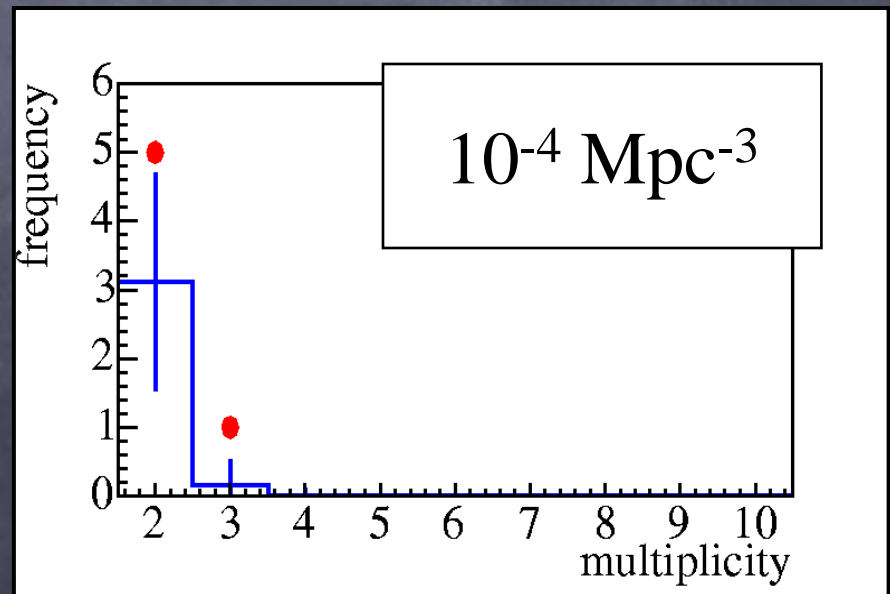
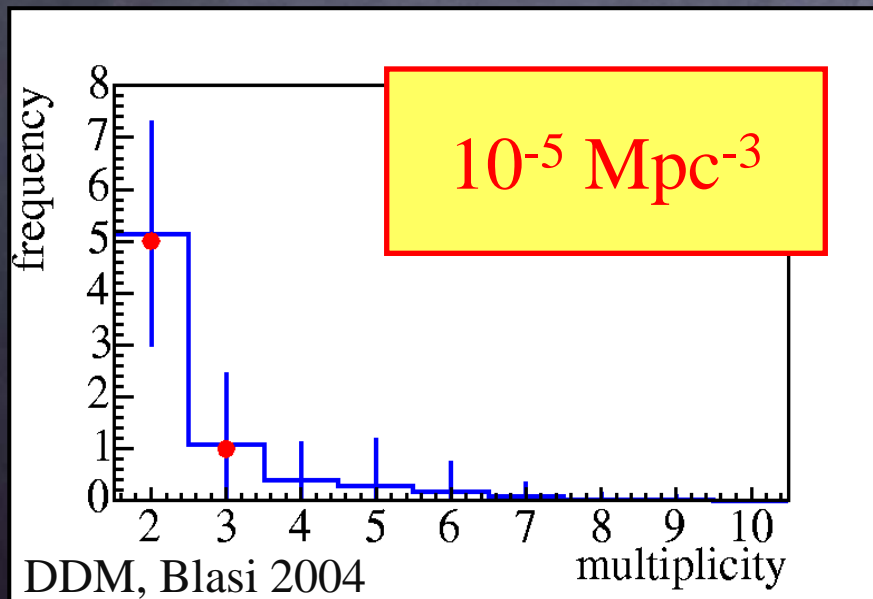


see also Finley and Westerhoff 2003

AGASA multiplets



$B \sim < 10^{-10}$ G **resol. = 2.5°**
 $\gamma = 2.6$ $m = 0$
 $E > 4 \cdot 10^{19}$ eV - 57 events



sources characteristics

$$\square L_{\text{CR}} = 6 \cdot 10^{44} \text{ erg/yr/Mpc}^3 \quad (E > 10^{19} \text{ eV} - \text{from spectrum fits})$$

$$n_0 = 10^{-5} \text{ Mpc}^{-3} \quad (\text{from ssa})$$

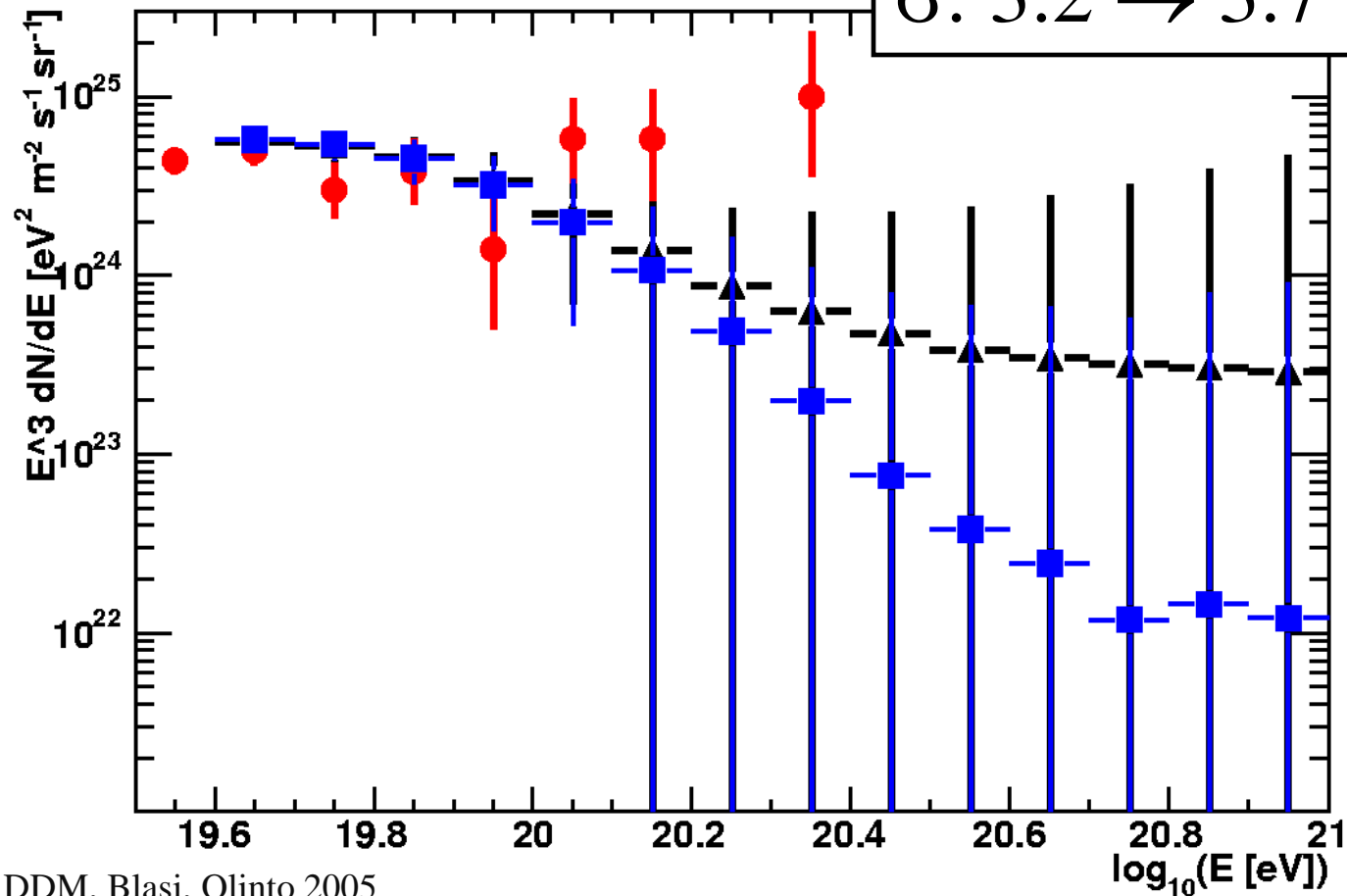
$$L_{\text{src}} = 2 \cdot 10^{42} \text{ erg/s} \quad (E > 10^{19} \text{ eV})$$

are these ssa for real?

- the significance of the AGASA result is not clear
 - HiRes doesn't see them
 - some internal inconsistency

AGASA spectrum discrete sources

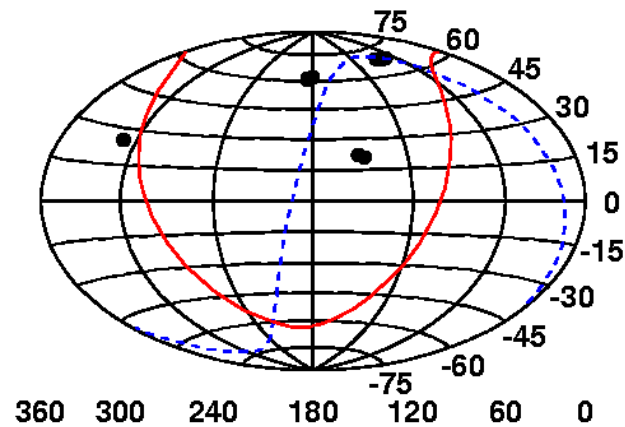
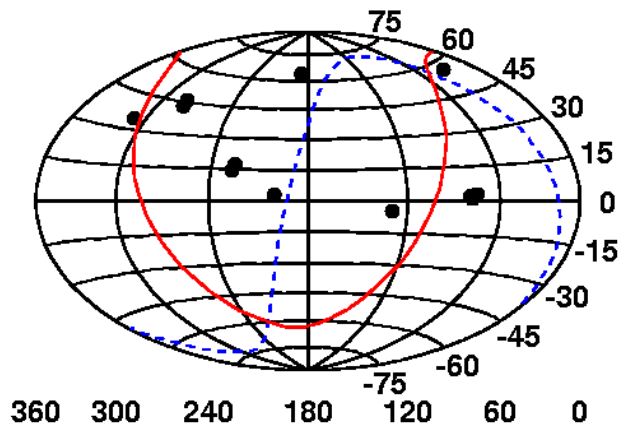
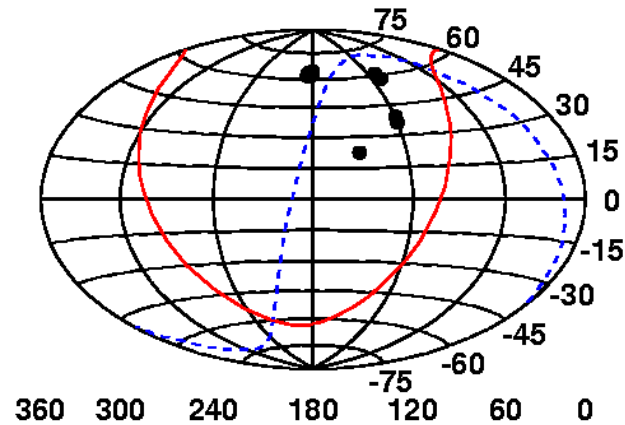
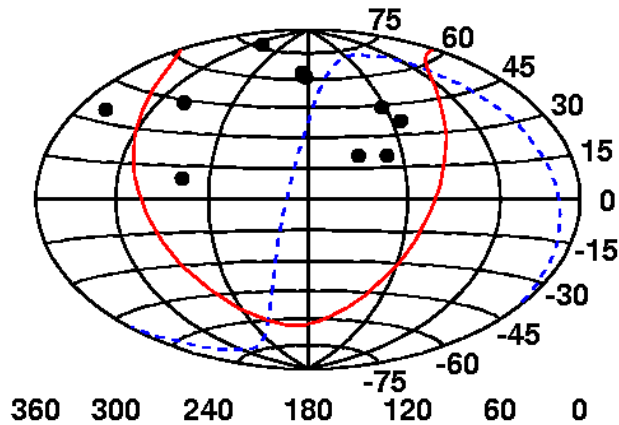
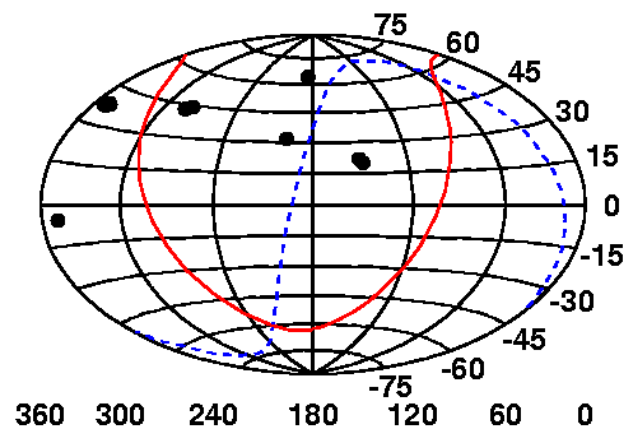
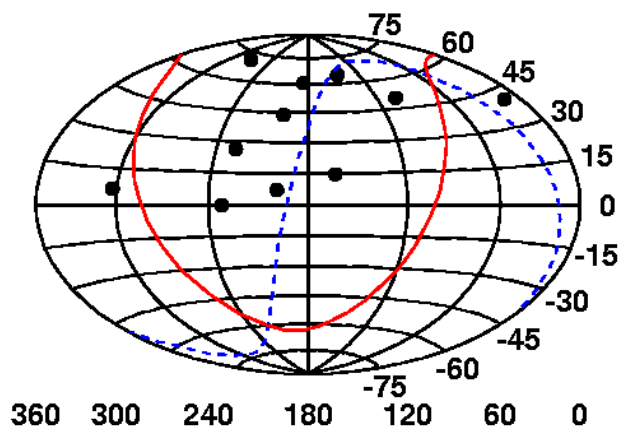
P: $6 \cdot 10^{-4} \rightarrow 2 \cdot 10^{-4}$
 σ : $3.2 \rightarrow 3.7$



DDM, Blasi, Olinto 2005

$P \sim 2 \cdot 10^{-5}$

arrival directions



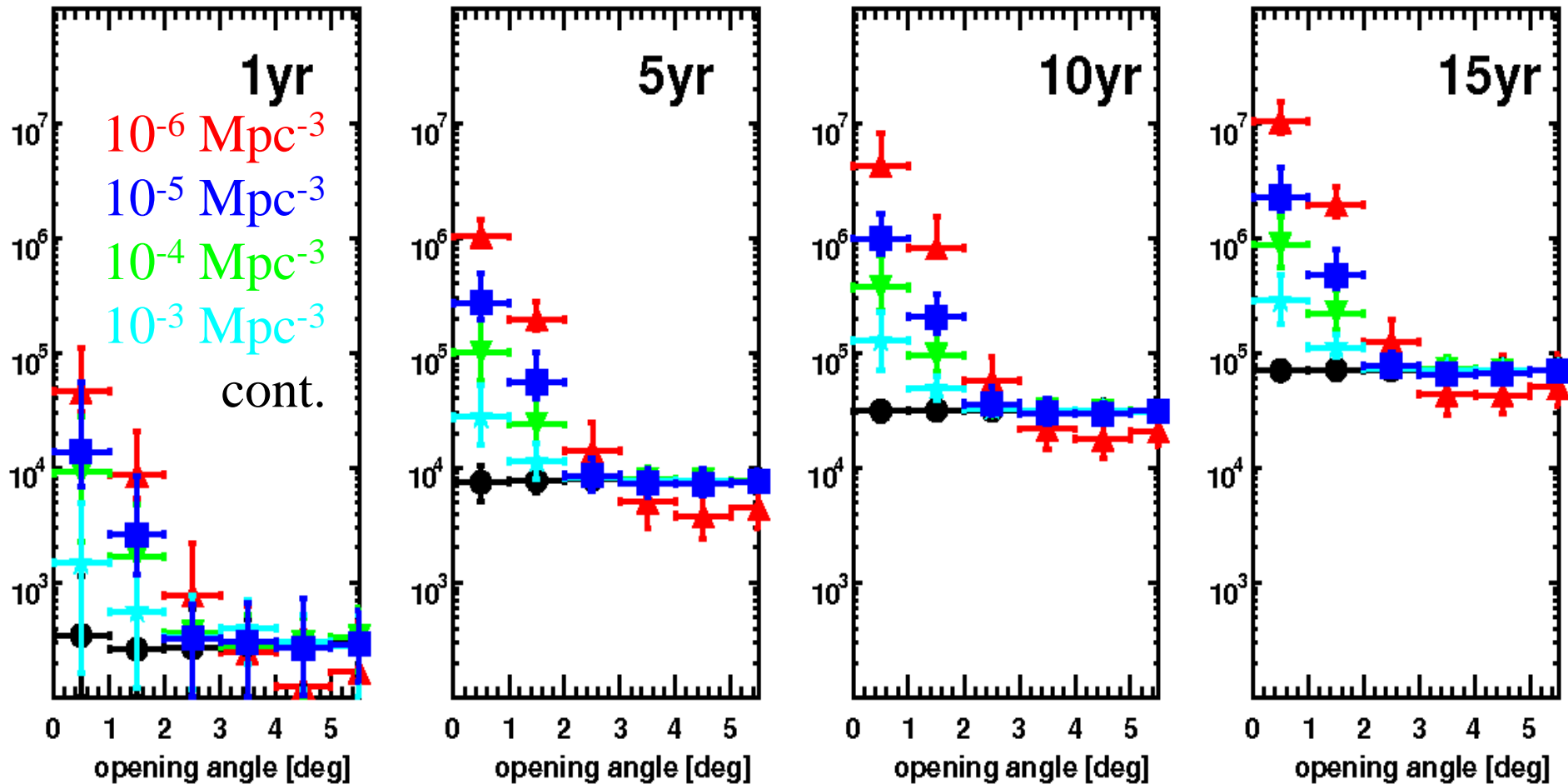
both the ssa and the spectrum
measurement need more statistics
to be
conclusive and reliable

Auger 2pcf

$E > 4 \cdot 10^{19}$ eV

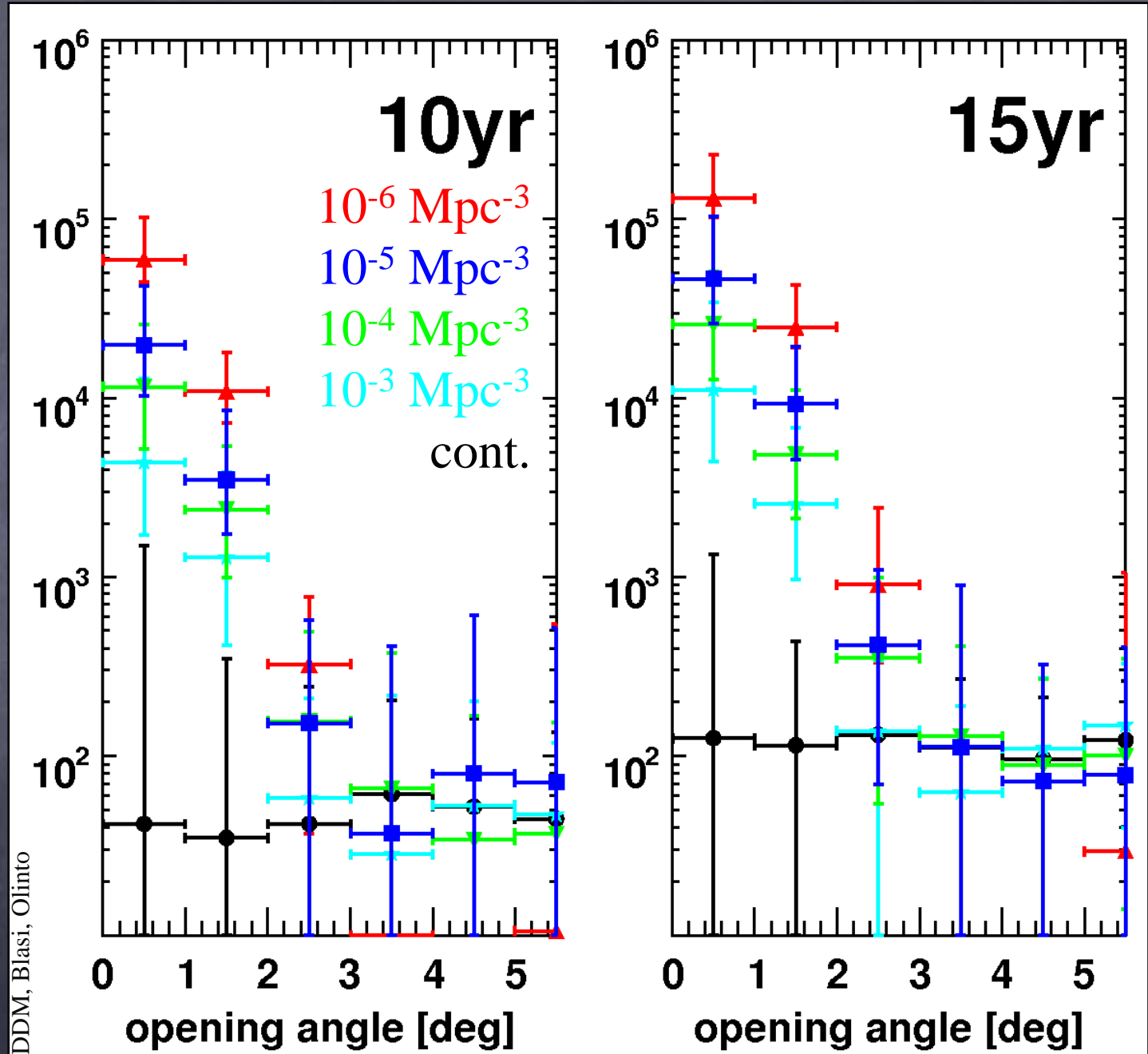
$$d_{\min} = (2\sqrt[3]{\rho})^{-1}$$

DDM, Blasi, Olinto

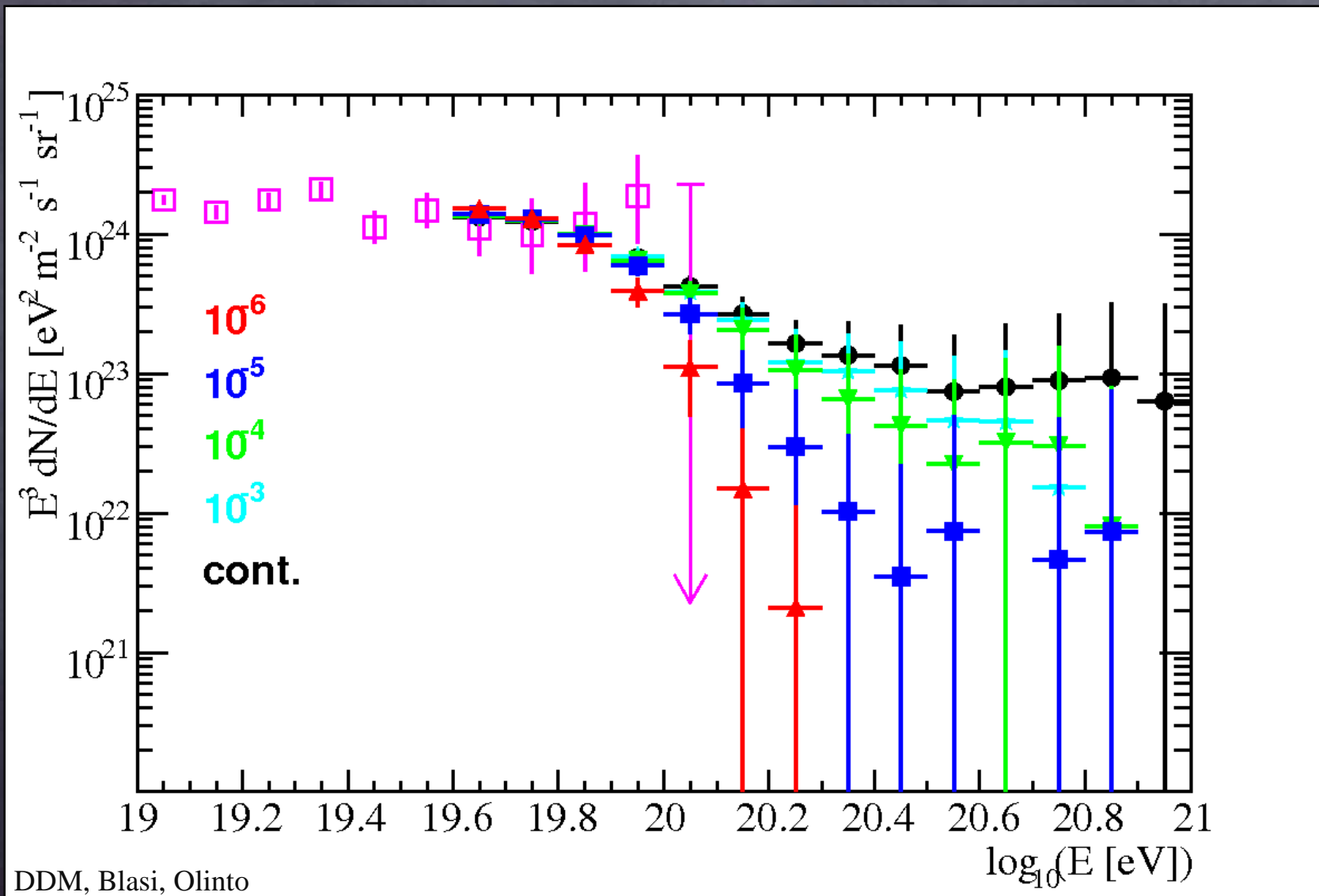


Auger
2pcf
 $E > 10^{20}$ eV

$$d_{\min} = (2\sqrt[3]{\rho})^{-1}$$



Auger spectrum $d_{\min} = (2\sqrt[3]{\rho})^{-1}$



DDM, Blasi, Olinto

conclusions

- AGASA & HiRes: statistics too low to reach conclusions on spectrum & ssa
- m & γ degeneracy: we need good composition measurements or other method to determine where the galactic CRs end (ex: anisotropy)
- Auger should be able to shed light on some of these issues

Auger ICRC spectrum

