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Simulation of the propagation of ultra-high energy cosmic rays using SimProp software

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Content

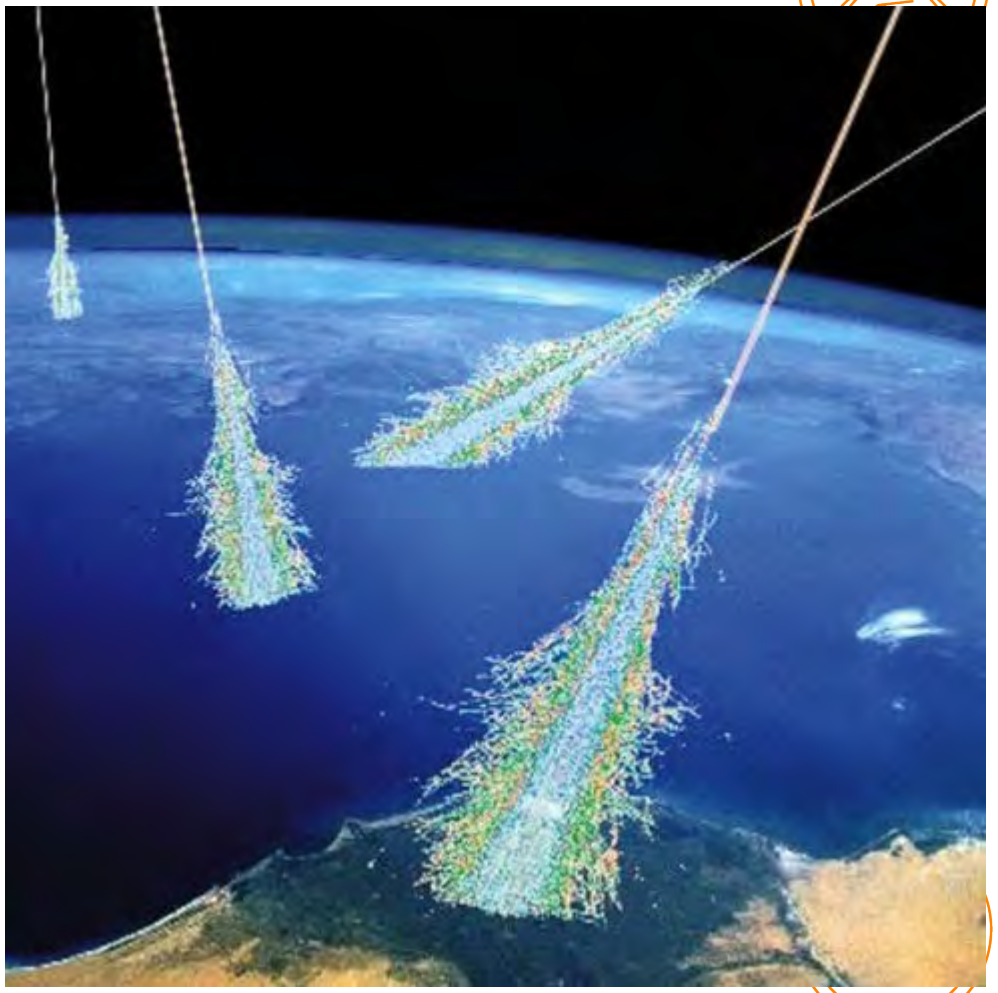
- Main characteristics of ultra-high energy cosmic rays (UHECRs) – energy spectrum, mass composition, propagation processes
- Simulation code *SimProp*
- Results of our work – evolution of $\langle \ln A_{Earth} \rangle$ and selection of simulations compatible with the shape of the energy spectrum measured by the Pierre Auger Observatory
- Summary

UHECRs and their main properties

Cosmic rays (CRs)

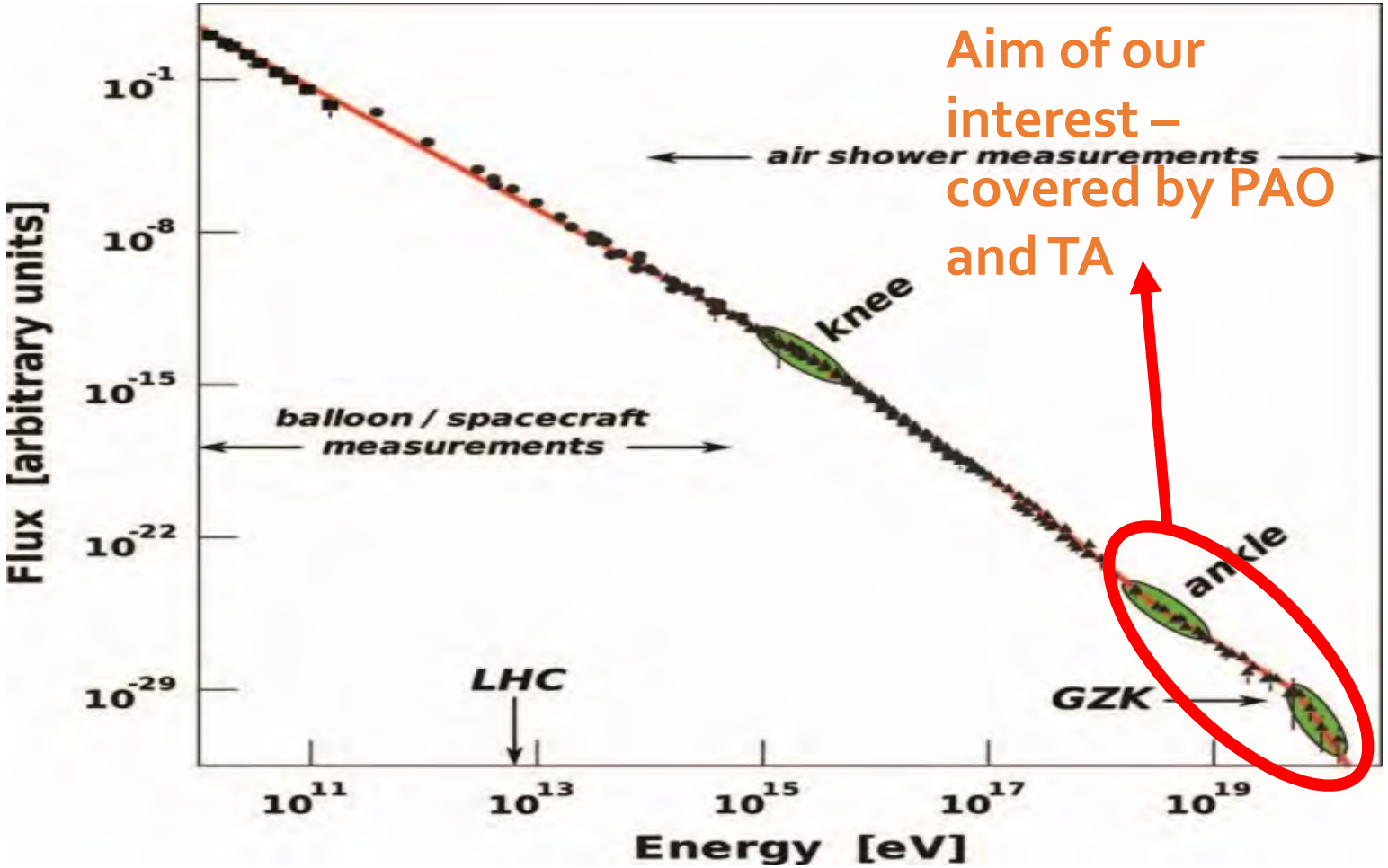
- Particles propagating through the Universe colliding with the Earth's atmosphere – mainly protons and nuclei of different elements
- Particles with sufficient energy (> 100 TeV) generate showers of secondary particles in the atmosphere
- Observations by arrays of surface detectors and fluorescence detectors

- At energies > 10^{18} eV – the Pierre Auger Observatory (PAO) and Telescope Array (TA)



Source: https://www.auger.org/index.php/cosmic-rays/cosmic-ray-mystery

Energy spectrum



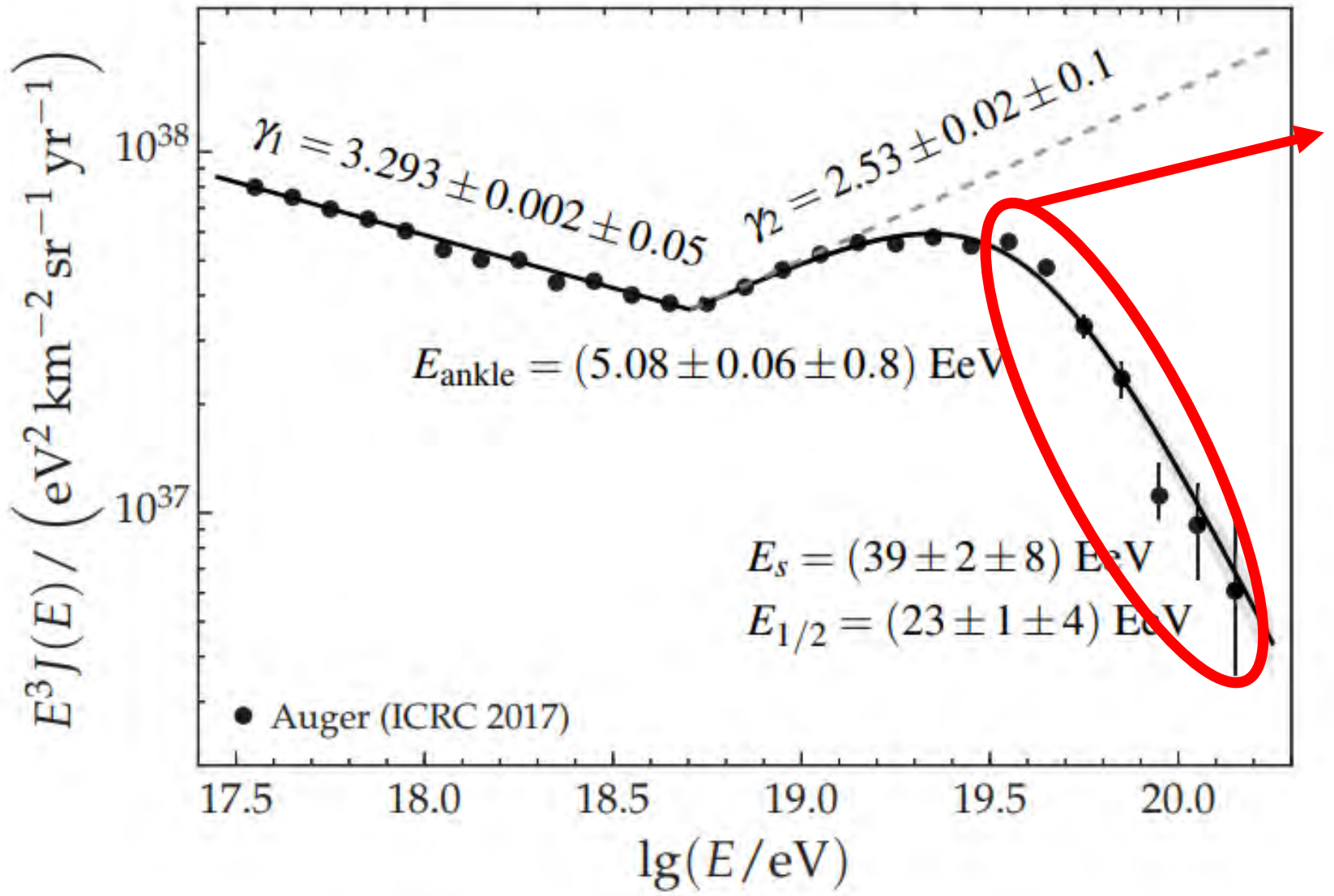
(Zavrtanik, 2010)

Energy spectrum

- Approximation by a simple power-law

$$J(E) \approx E^{-\gamma}$$

- γ – spectral index
- Regions where the spectral index changes
  - „knee" – steepening at $10^{15.6}$ eV (KASCADE Collaboration, 2005)
    - Below knee **γ ≈ 2.7 ± 0.01**
    - Above knee **γ ≈ 3.1 ± 0.07**
  - „ankle" – hardening of the spectrum, spectral index decreases at energies ≈ 3.10^{18} eV
  - suppression at the highest energies ≈ $10^{19.7}$ eV – usually „GZK" cutoff (**γ ≈ 4.8**)

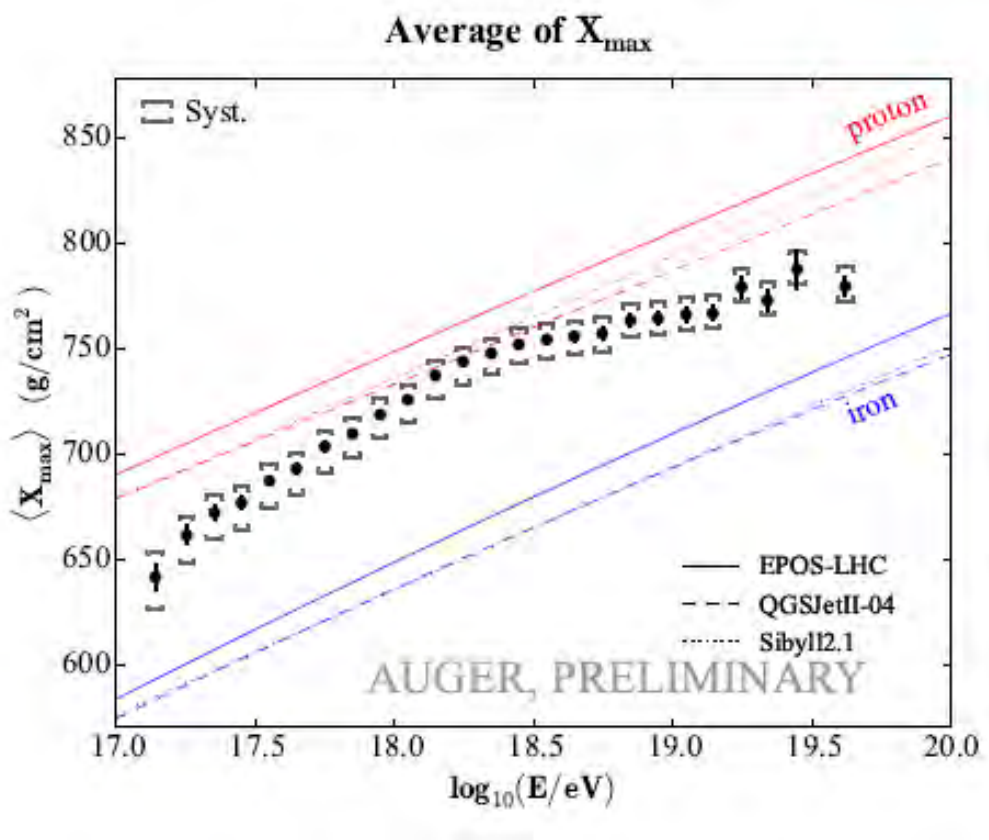


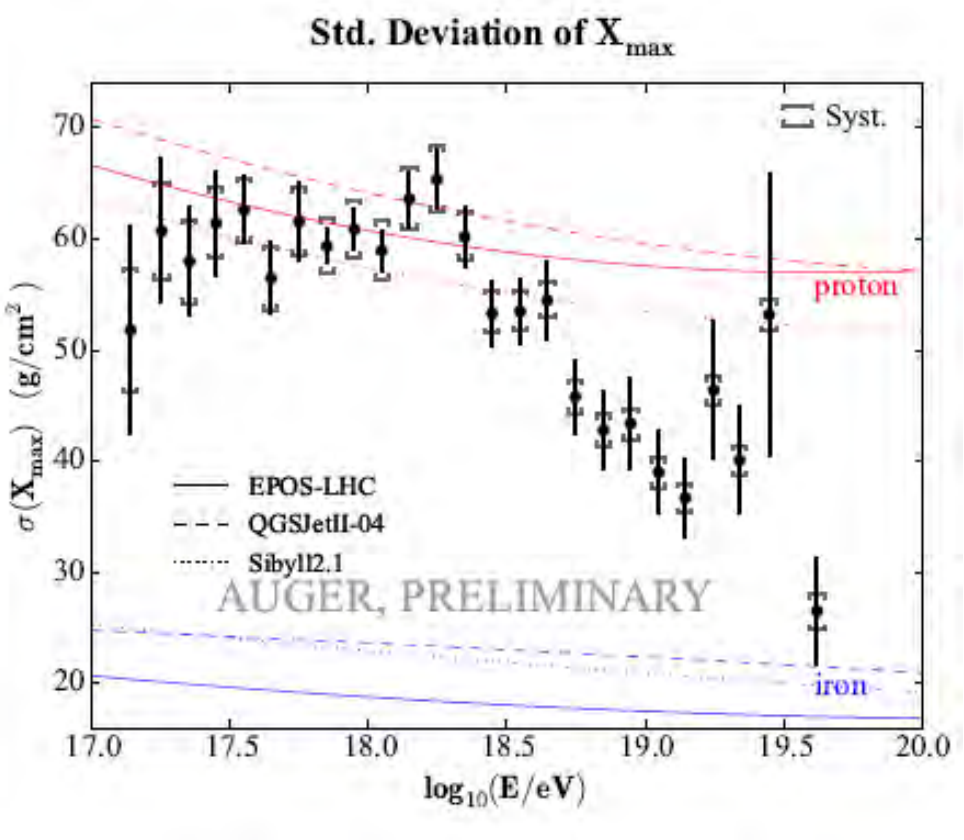
(Fenu for the Pierre Auger Collaboration, 2017)

Can be caused by a single source?

Mass composition of UHECRs

- - Measurements of X_{max}





$$X = \int_{\infty}^{h} \frac{\rho(l)}{cos\theta} dl$$

- $\rho(l)$ – the density of air at altitude l
- θ – zenith angle

- PAO measurements lighter
  - up to $10^{18.3}$ eV – composition becomes gradually
  - above $10^{18.3}$ eV – trend inverts, composition is getting heavier

Interaction processes

- Pair production

$$ {}^{A}_{Z}X + \gamma \longrightarrow {}^{A}_{Z}X + e^{+} + e^{-} $$

$$ E^{e^{\pm}}_{\mathrm{thres}} = \frac{m_e(m_X + m_e)}{\epsilon} \approx 4.8 \cdot 10^{17}\ A \left(\frac{\epsilon}{10^{-3}\ \mathrm{eV}}\right)^{-1} \mathrm{eV} $$

- Photo-pion production

$$ \mathrm{p} + \gamma \rightarrow \mathrm{p} + \pi^{0}, \qquad \mathrm{n} + \gamma \rightarrow \mathrm{n} + \pi^{0} $$

$$ \mathrm{p} + \gamma \rightarrow \mathrm{n} + \pi^{+}, \quad \text{and} \quad \mathrm{n} + \gamma \rightarrow \mathrm{p} + \pi^{-} $$

$$ E^{N,\pi}_{\mathrm{thres}} = \frac{m_\pi(m_N + m_\pi/2)}{2\epsilon} \approx 6.8 \cdot 10^{19} \left(\frac{\epsilon}{10^{-3}\ \mathrm{eV}}\right)^{-1} \mathrm{eV}\ , $$

- Photodisintegration

$$ {}^{A}Z + \gamma \rightarrow {}^{A-1}Z + \mathrm{n}, \qquad {}^{A}Z + \gamma \rightarrow {}^{A-1}(Z-1) + \mathrm{p} $$

$$ {}^{A}Z + \gamma \rightarrow {}^{A-4}(Z-2) + {}^{4}\mathrm{He}, \qquad \text{etc.} $$

- Several photodisintegration processes – giant dipole resonance, quasi-deuteron process and baryonic resonance

Other processes

- Adiabatic energy loss due to the expansion of the Universe

$$\left(-\frac{1}{E}\frac{\mathrm{d}E}{\mathrm{d}t}\right)_{\mathrm{ad}} = H(t) = H_0\sqrt{(1+z)^3\Omega_{\mathrm{m}} + \Omega_\Lambda}$$

- Decay of unstable particles
- Interaction with the magnetic fields – trajectories are curved

$$\left(\frac{r_L}{\mathrm{pc}}\right) = 1.1\left(\frac{E}{\mathrm{PeV}}\right)\left(\frac{\mu\mathrm{G}}{B}\right)\frac{1}{Z}$$

(Kuempel, 2014)

r_L – Larmor radius in pc

B – intensitiy of magnetic field in μG

E – energy in PeV

Z – charge of the particle

SimProp v2r4

- Monte Carlo code that simulate the propagation of UHECRs
- Written in C++
- Several options
- Output files in ROOT
- All previous processes implemented except of magnetic field deflection

Library of simulations

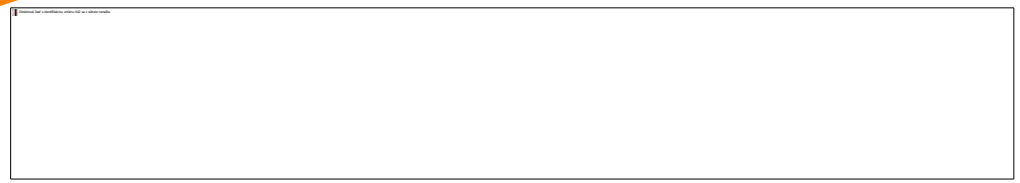
- Selection of a specific model of background fields – compatible with the reference model of PAO combined fit
    - Gilmore EBL model
    - PSB cross section
    - Decay of unstable particles – enabled
    - Photo-pion production – stochastic on CMB and EBL photons
    - Rigidity cutoff

- Propagation is rectilinear – magnetic fields not incorporated in *SimProp*
- We adopted a single-source scenario of extragalactic CRs at the specific distance and spectral index

- **Number of injected events – 10^5**
- **Injected nuclei – hydrogen ^{1}H, helium ^{4}He, carbon ^{12}C, oxygen ^{16}O, silicon ^{28}Si and iron ^{56}Fe**
- **Distance – 5, 50, 100 Mpc**
- **Injection energy – log(E/eV) = (19.0 – 21.0)**
- **Spectral index – 1, 1.5, 2, 2.5, 3**

Theoretically predicted range
$\gamma_{Source} = 1.0 - 2.2$

- Library reweighted according to the **rigidity cutoff R_{Cut}**



Library of simulations

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- **Number of injected eve…**
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- **Distance – 5, 50, 100 …**
- **Injection energy – log(E…**
- **Spectral index – 1, 1.5, 2,**

- Library reweighted accorfding to th…

rigidity cutoff R_{Cut}

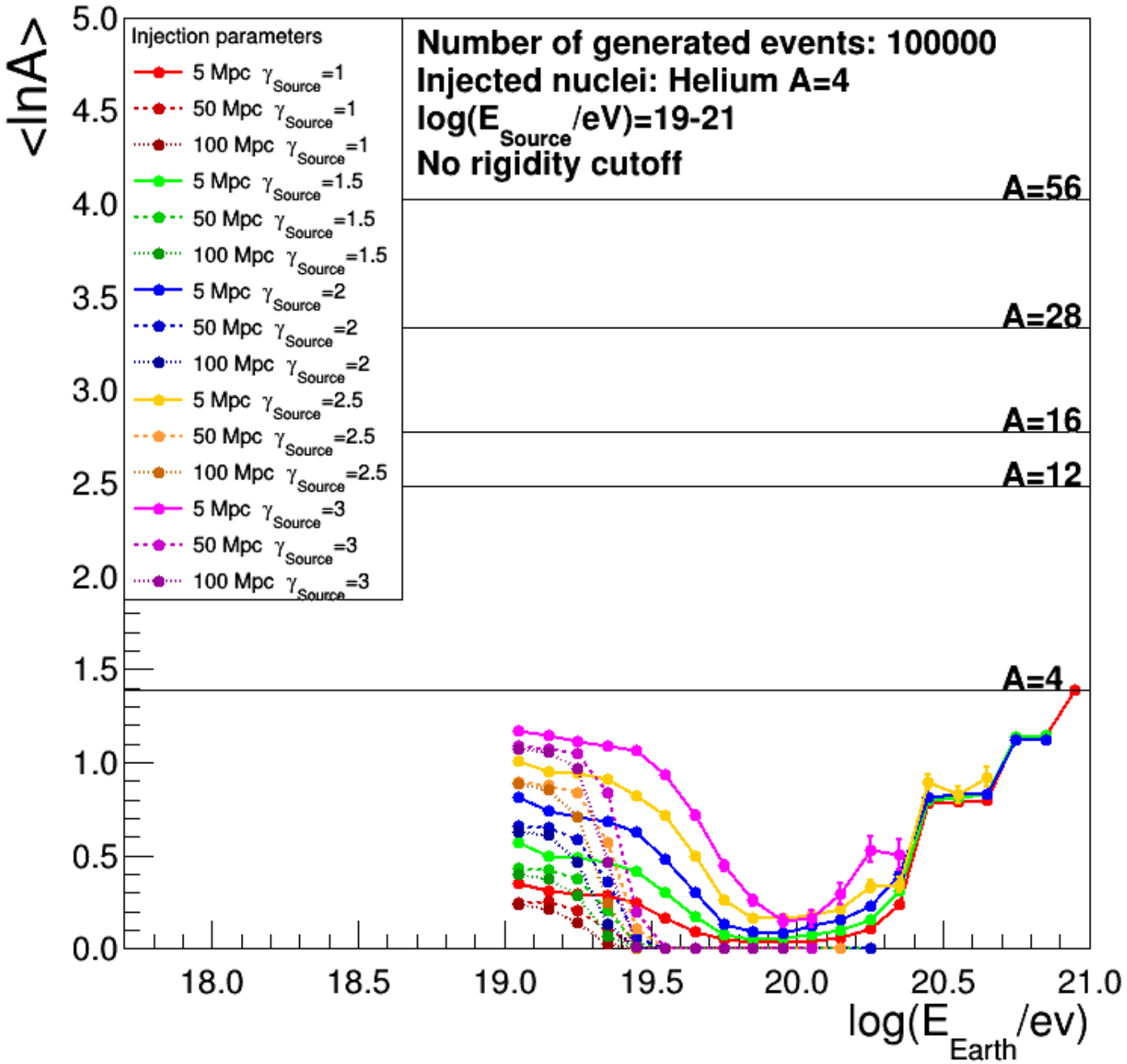
$Z_A R_{\mathrm{Cut}})$

$\ldots R_{\mathrm{Cut}}). \quad (E > Z_A R_{\mathrm{Cut}})$

These are the parameters of sources that were studied

1. Evolution of $\langle \ln A_{\text{Earth}} \rangle$

Helium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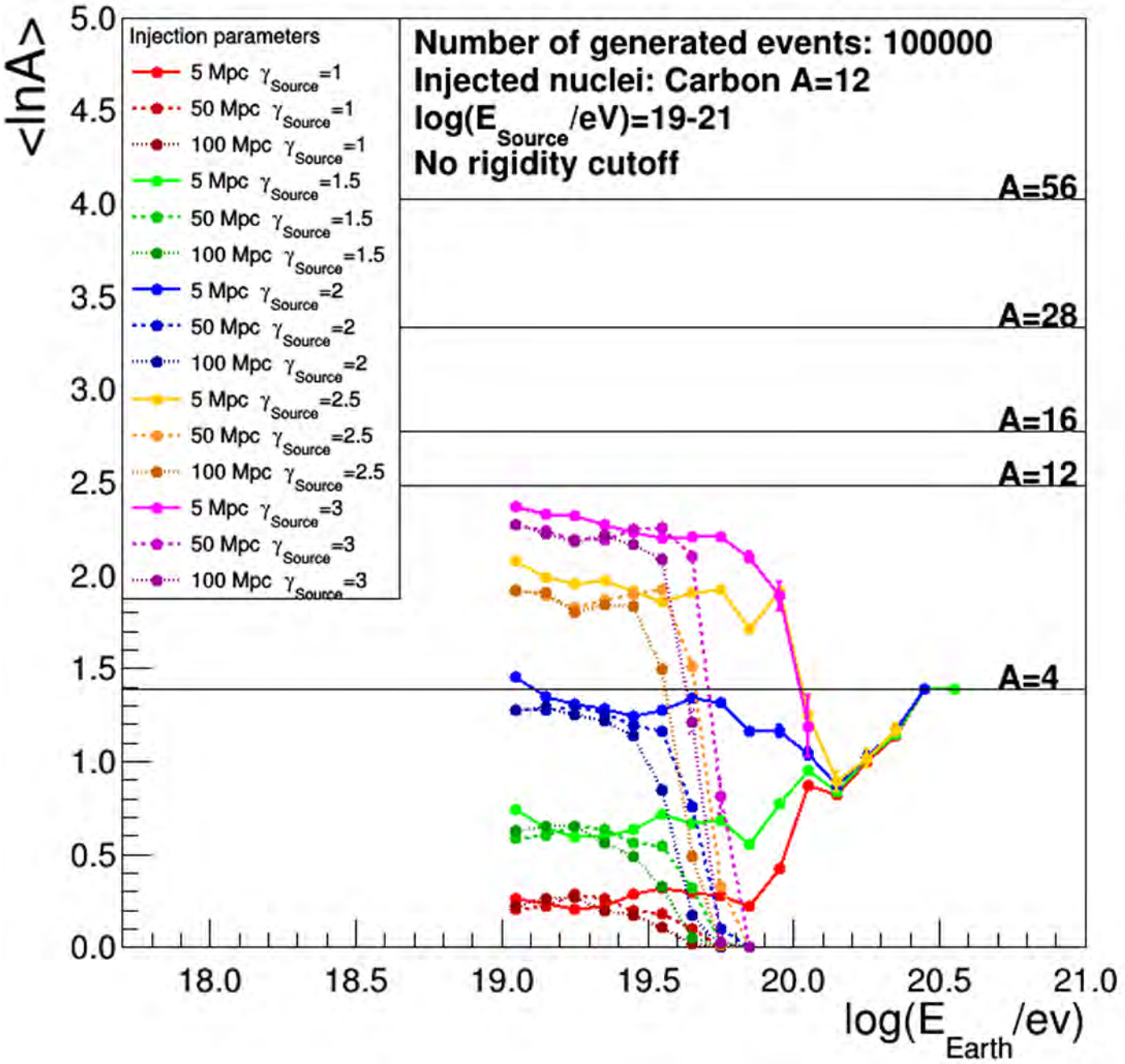
50 Mpc γSource=1
100 Mpc γSource=1
5 Mpc γSource=1.5
50 Mpc γSource=1.5
100 Mpc γSource=1.5
5 Mpc γSource=2
50 Mpc γSource=2
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Helium A=4
log(ESource/eV)=19-21
No rigidity cutoff
A=56
A=28
A=16
A=12
A=4
<lnA>
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0
log(EEarth/ev)

Carbon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5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Carbon A=12
log(ESource/eV)=19-21
No rigidity cutoff
A=56
A=28
A=16
A=12
A=4
<lnA>
log(EEarth/ev)
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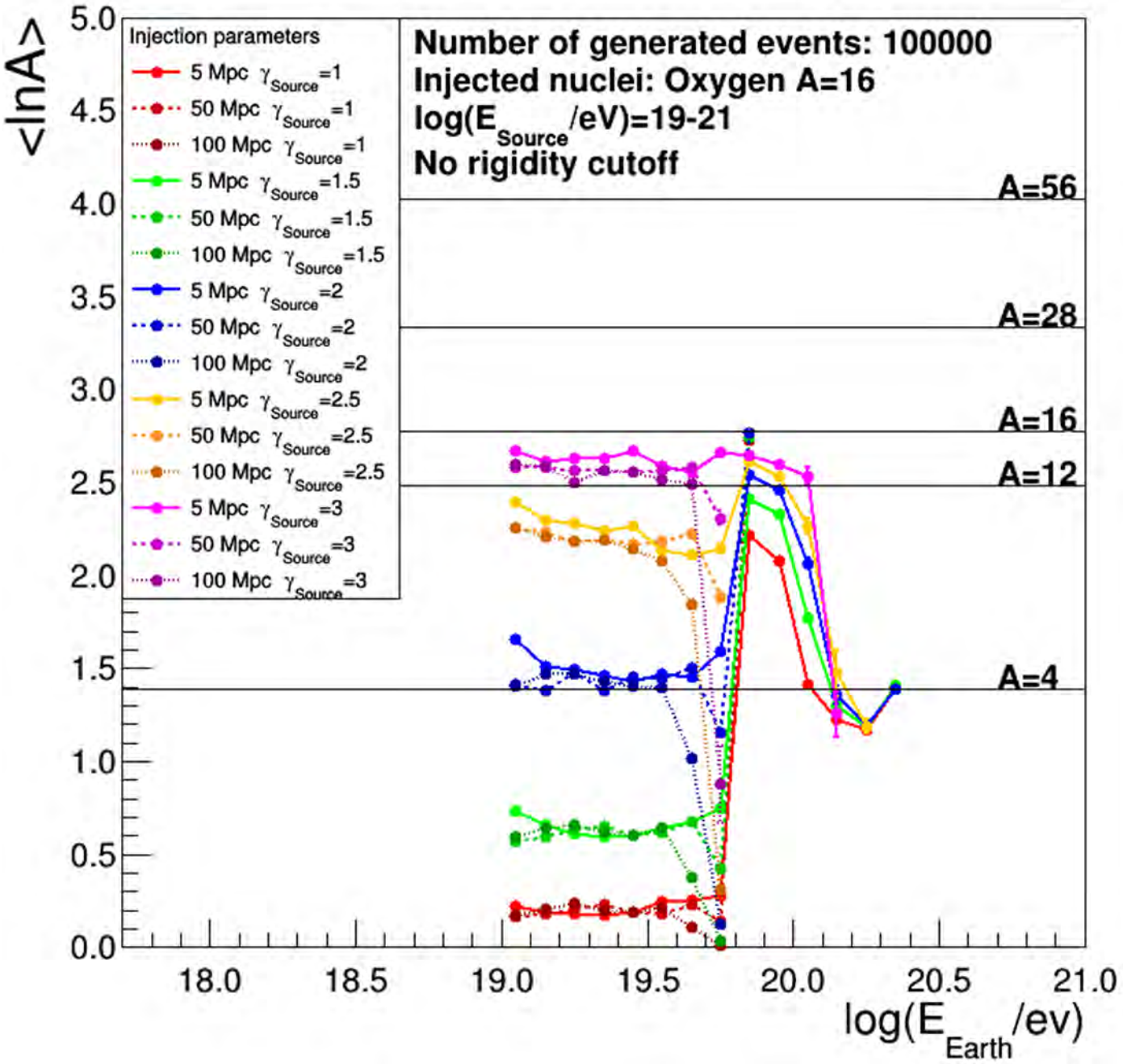
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0

Oxygen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50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
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100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Oxygen A=16
log(ESource/eV)=19-21
No rigidity cutoff
A=56
A=28
A=16
A=12
A=4
<lnA>
log(EEarth/ev)
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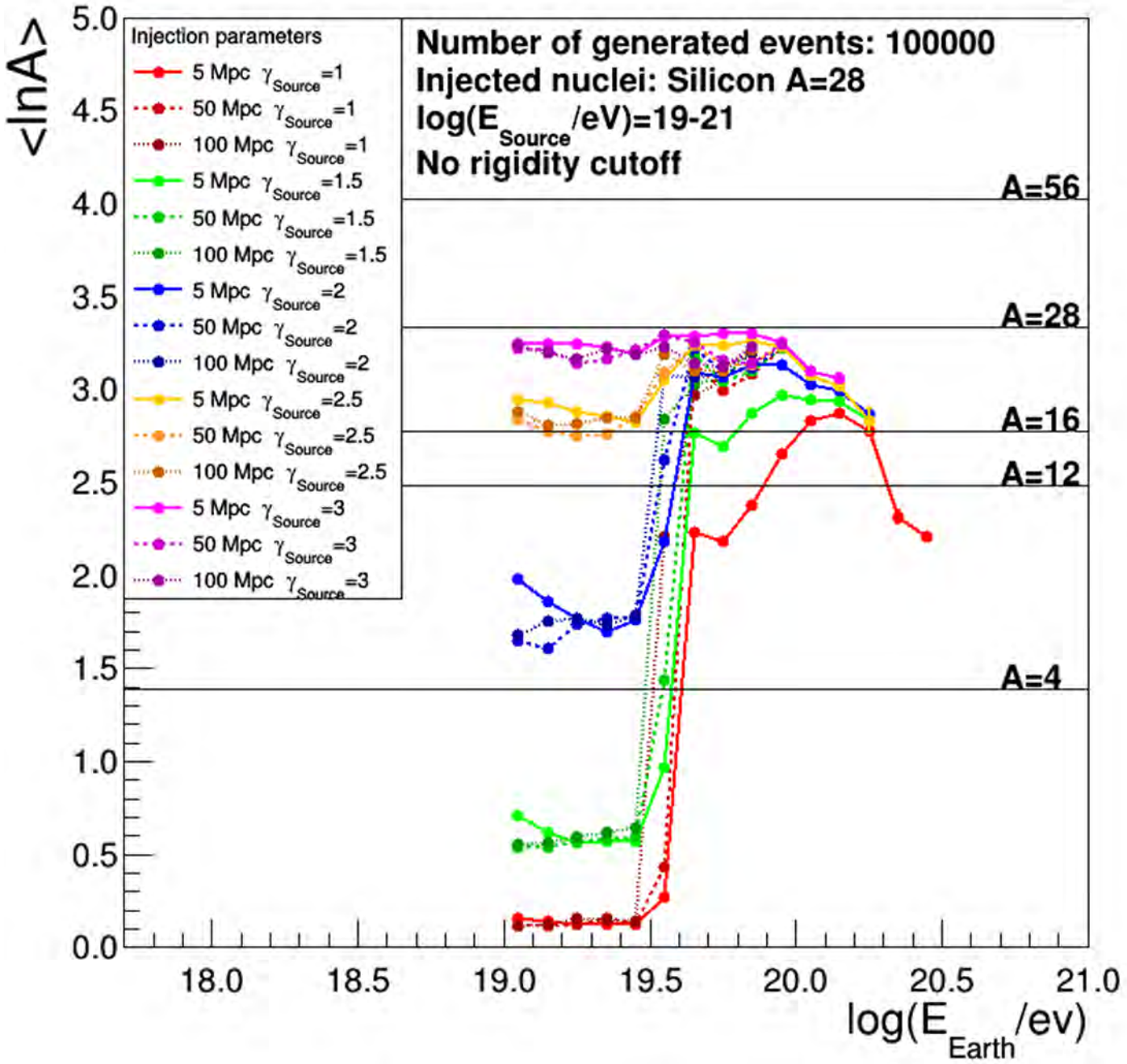
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0

Silicon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50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Silicon A=28
log(ESource/eV)=19-21
No rigidity cutoff
A=56
A=28
A=16
A=12
A=4
<lnA>
log(EEarth/ev)
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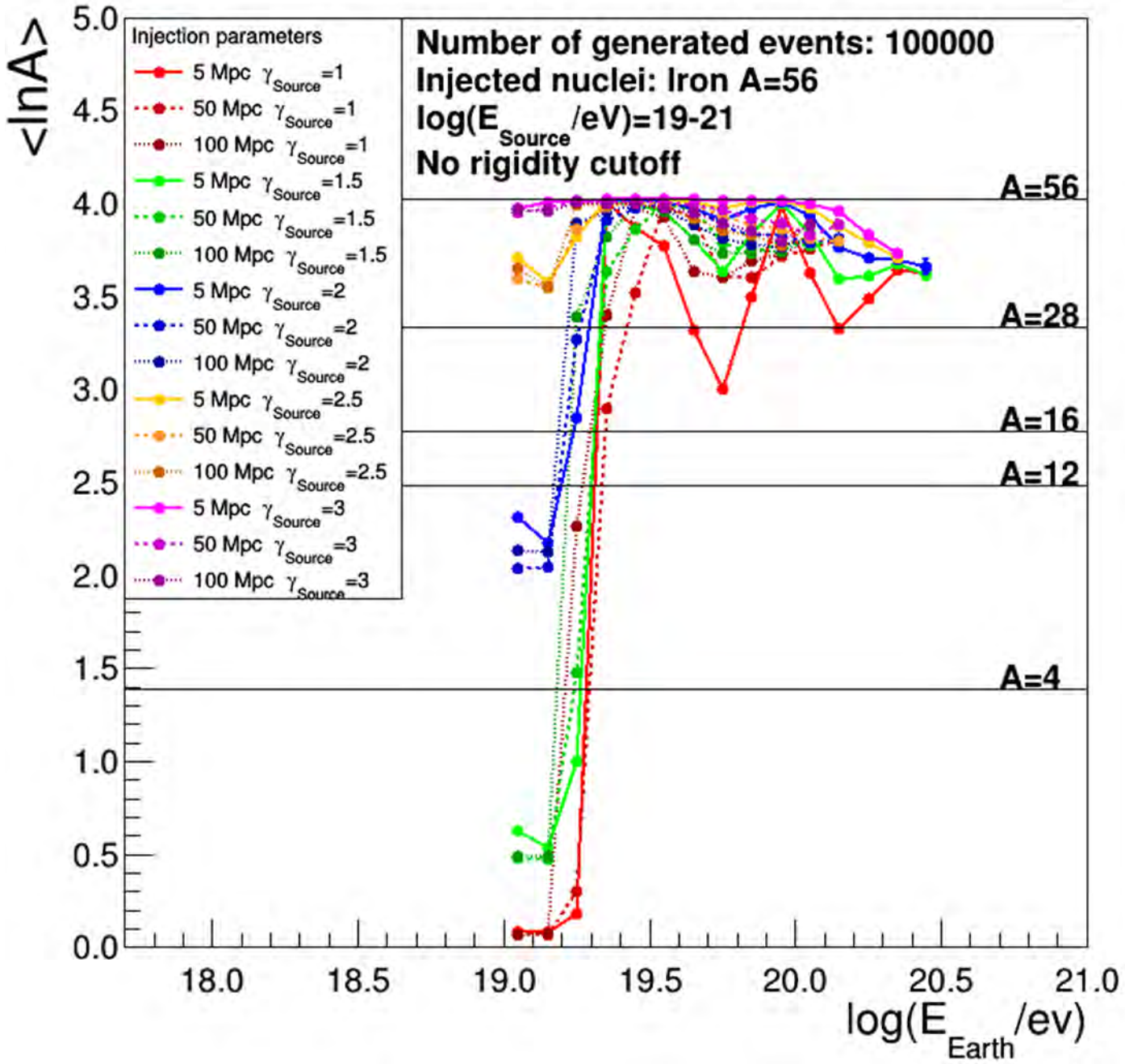
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0

Iron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No rigidity cutoff
A=56
A=28
A=16
A=12
A=4
<lnA>
log(EEarth/ev)
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4.5
4.0
3.5
3.0
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2.0
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18.0
18.5
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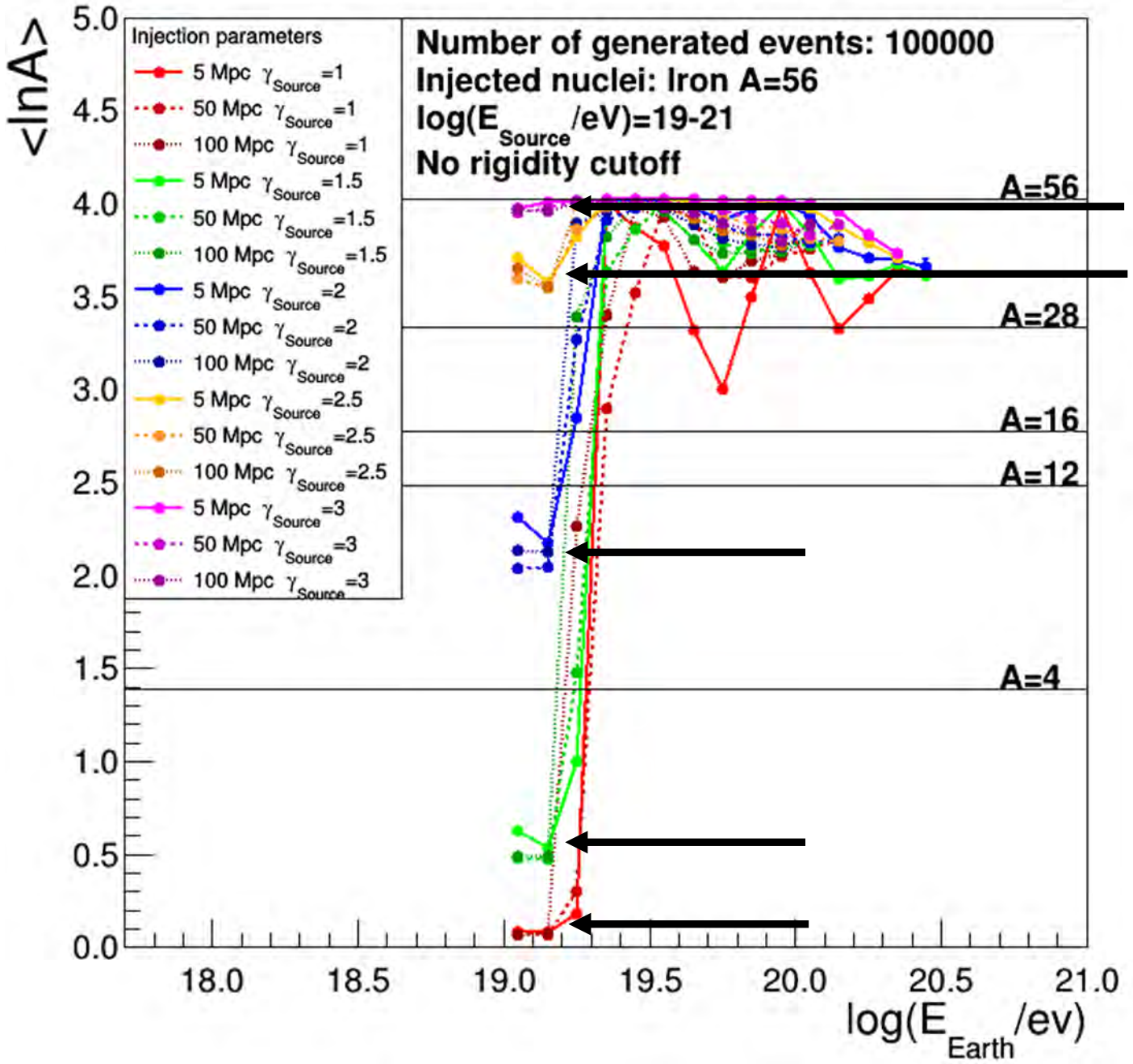
19.5
20.0
20.5
21.0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5 Mpc γSource=2
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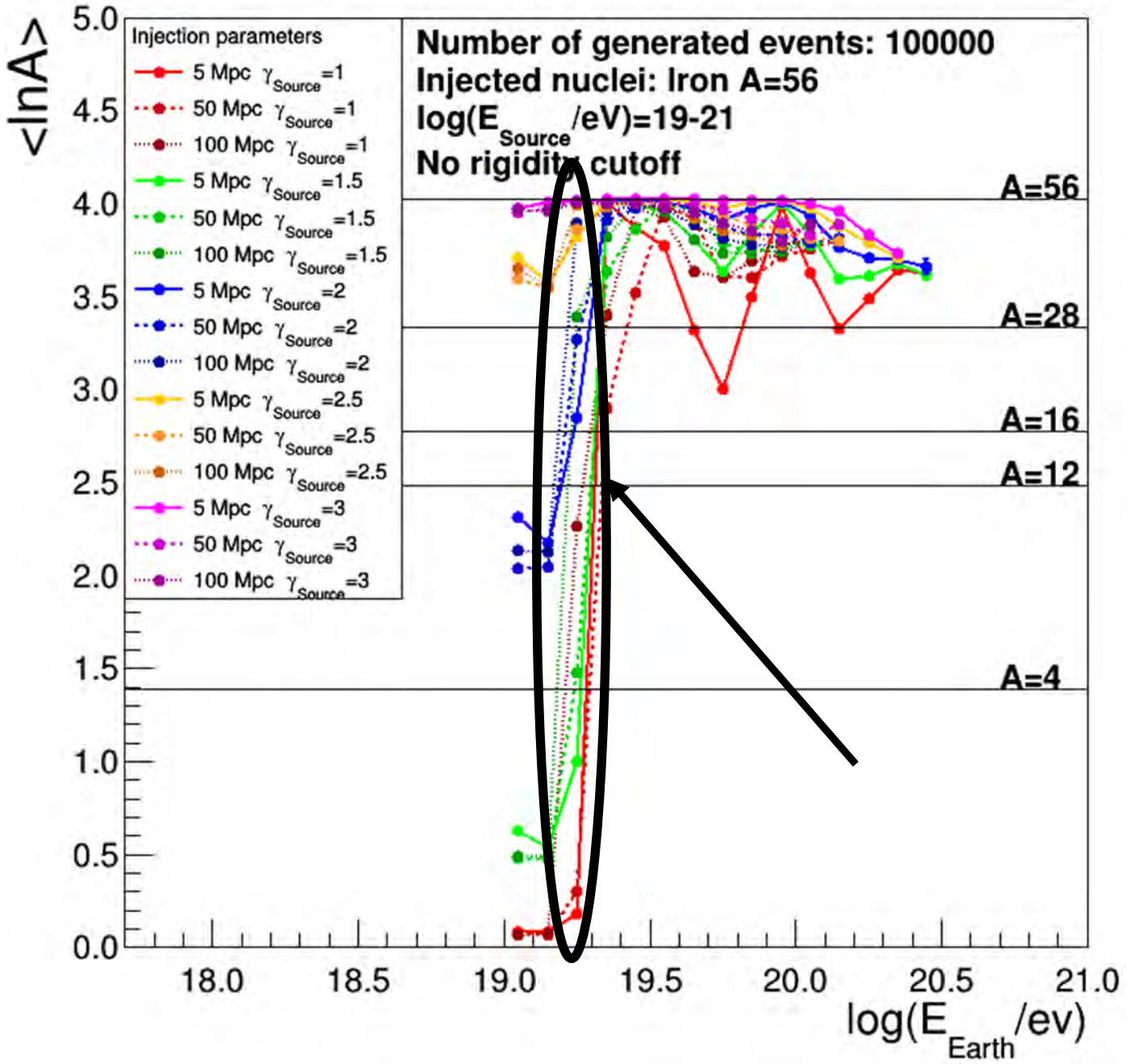
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Iron A=56
log(ESource/eV)=19-21
No rigidity cutoff
A=56
A=28
A=16
A=12
A=4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0
log(EEarth/ev)


Injection parameters
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50 Mpc γSource=2
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Iron A=56
log(ESource/eV)=19-21
No rigidity cutoff
A=56
A=28
A=16
A=12
A=4
<lnA>
log(EEarth/ev)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0

- A sharp increase at different energies for different elements
- Position of the increase

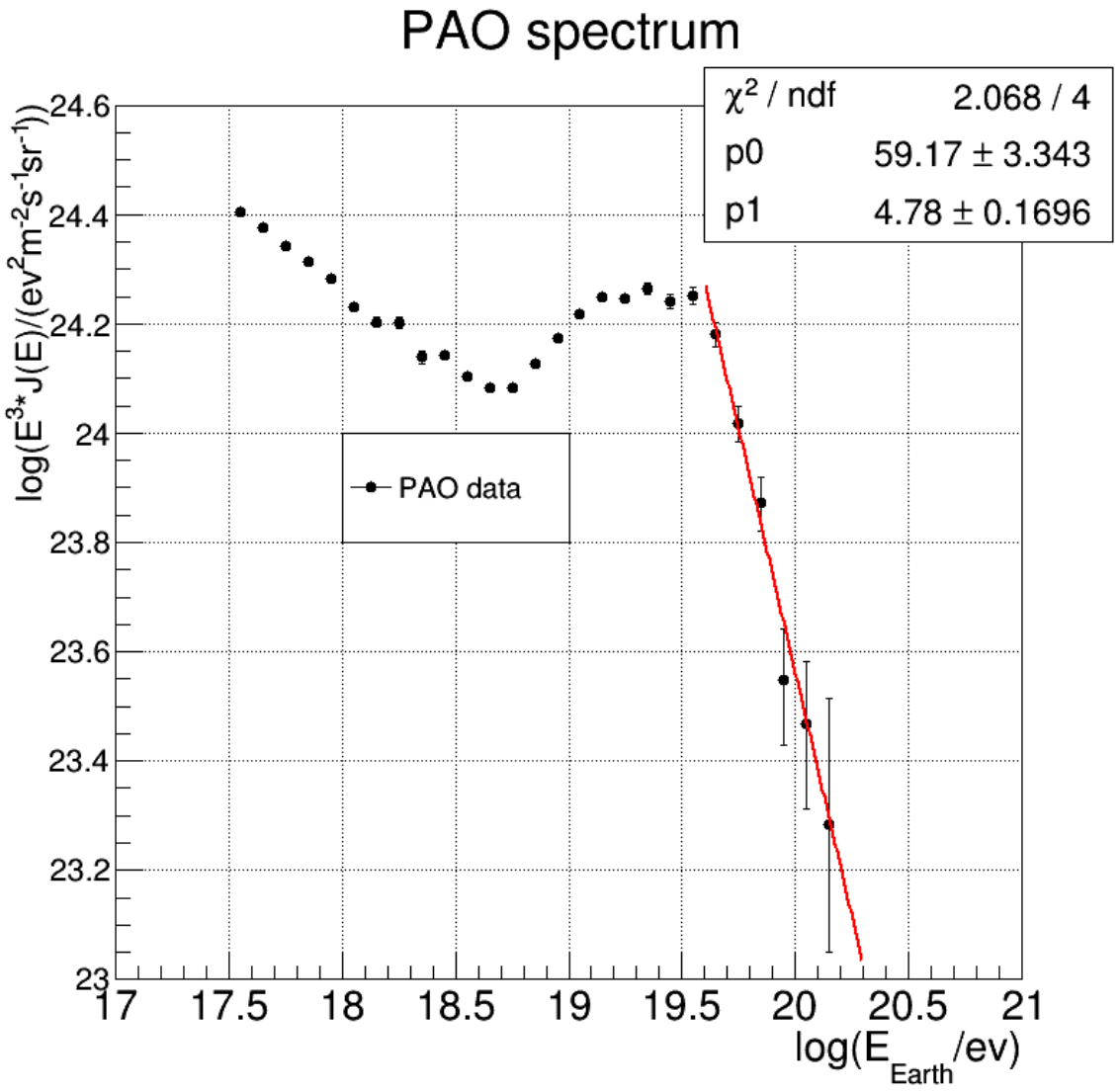
- Oxygen - $E_{Tr}^{O} \approx 10^{19.75}$ eV

- Iron - $E_{Tr}^{Fe} \approx 10^{19.15}$ eV

$$10^{19.75-19.15} \approx \frac{56}{16}$$

- Maximum energies of ejected protons depend on the nuclei type and their maximum energies
- However rigidity cutoff can smear the effect

2. Testing compatibility of our simulations with the PAO data



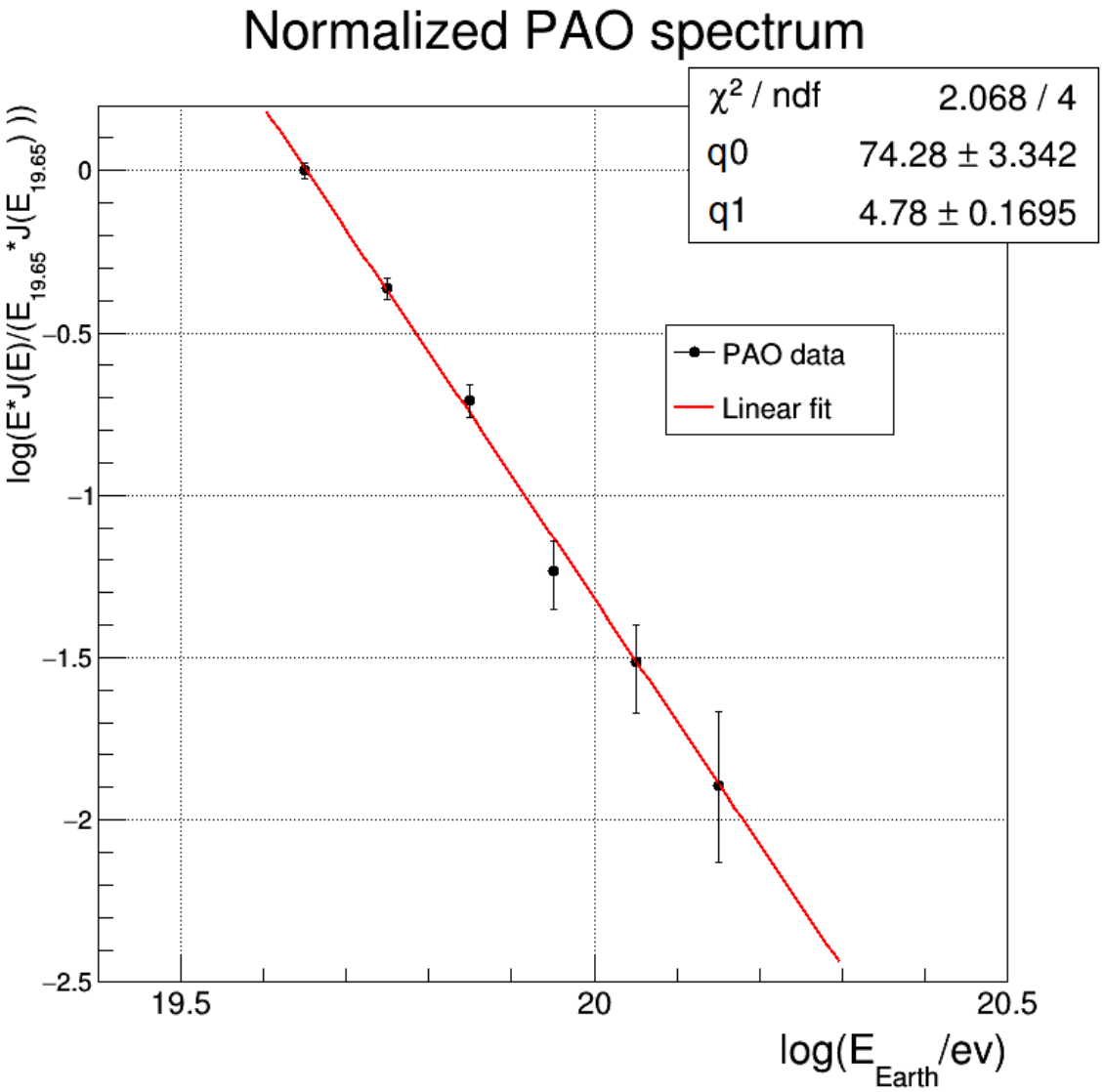
(Fenu for the Pierre Auger Collaboration, 2017)

Linear fit

$y = p0 - (p1 - 3) \times \log(E_{Earth}/eV)$

2. Testing compatibility of our simulations with the PAO data

- Normalization of PAO data to the value at energy $\log(E_{\text{Earth}}/\text{eV}) = 19.65$



Linear fit

$y = q0 - (q1 - 1) \times \log(E_{\text{Earth}}/\text{eV})$

Only the shape of the energy spectrum is what matters in the following analysis

2. Testing compatibility of our simulations with the PAO data

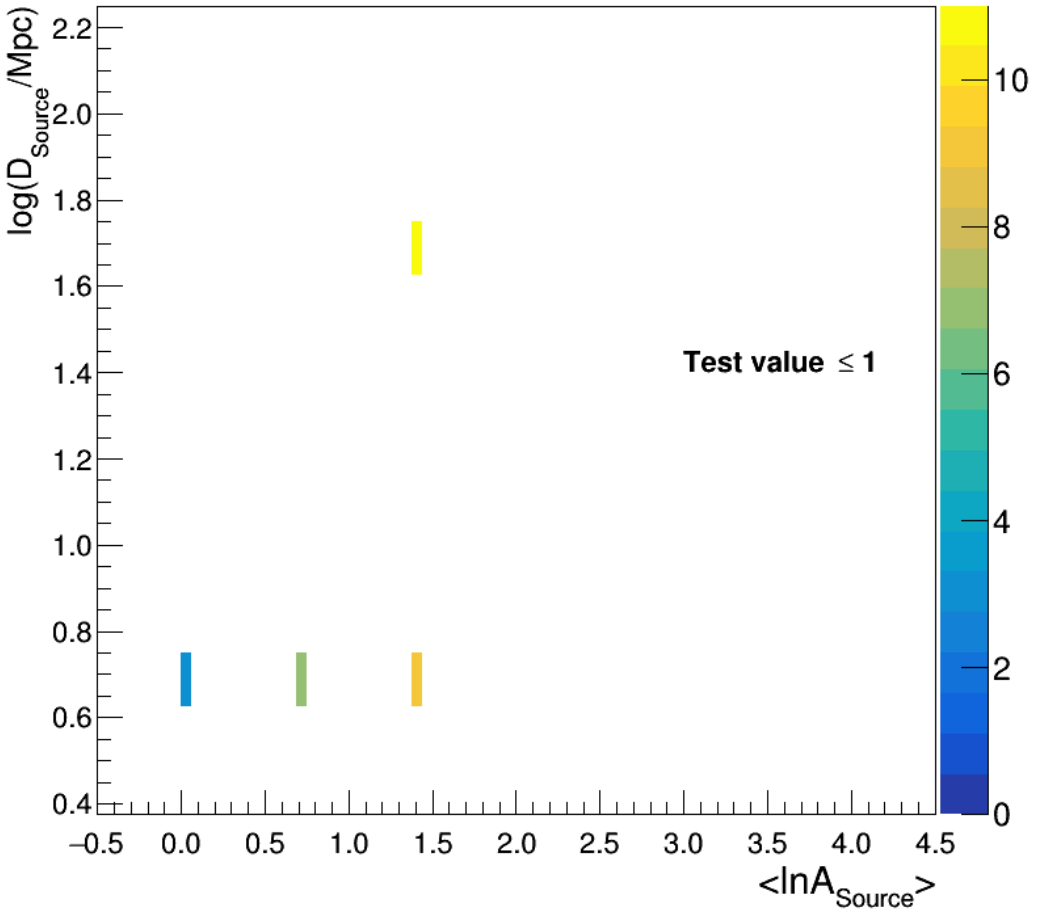
- Nuclei considered – hydrogen ^{1}H, helium ^{4}He, oxygen ^{16}O and iron ^{56}Fe
- Cutoff rigidity $\log(R_{Cut}/V) = (19.0 – 21.0)$ incremented by $\Delta\log(R_{Cut}/V) = 0.1$
- Mixed composition – combinations of different nuclei, equal fractions
    - „H" or „He" – pure composition
    - „H+He" – 50% of hydrogen and 50% of helium
- In total 4 free parameters – R_{Cut} , γ_{Source} , D_{source} , $\langle \ln A_{Source} \rangle$
- This represents 4725 different combinations

- Dispersion between the PAO datapoints and simulation datapoints represented by „Test value“

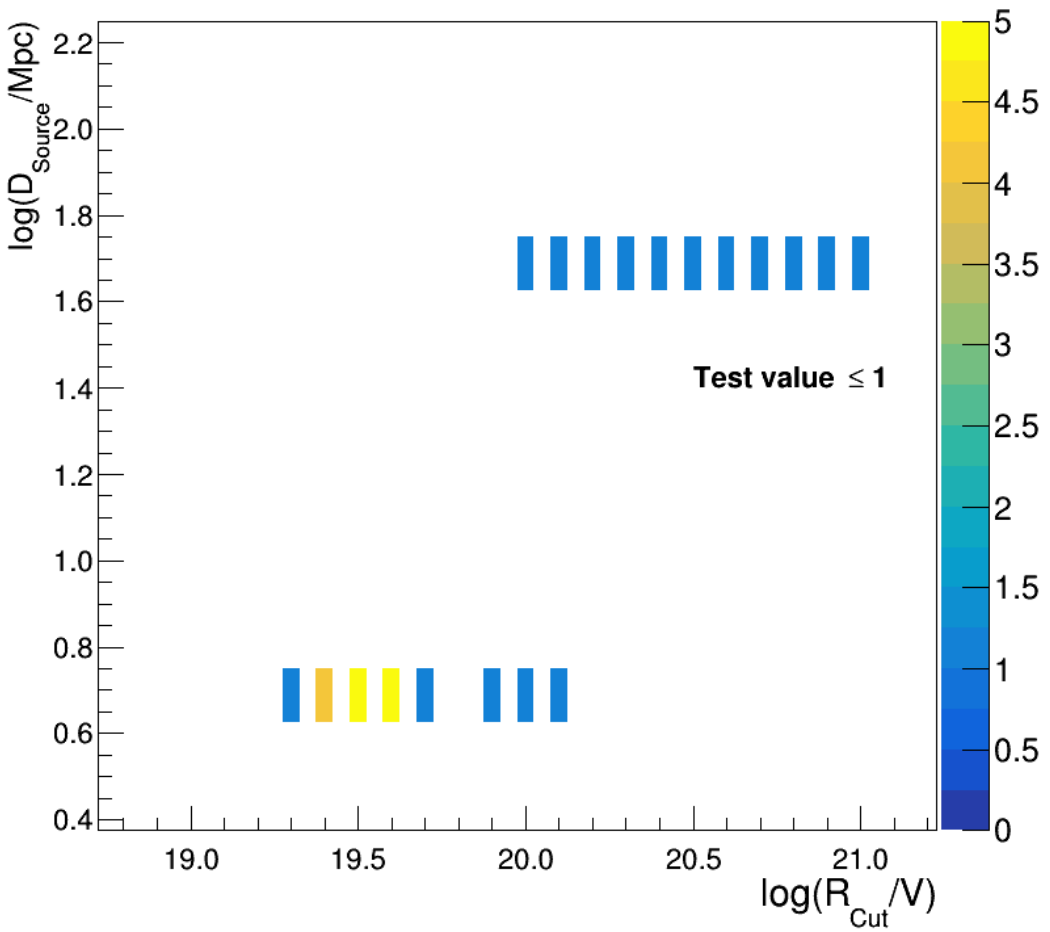
$$\boldsymbol{Test\ value} = \frac{\mathbf{1}}{\boldsymbol{n}} \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} \frac{\left| \boldsymbol{N_{P,i}} - \boldsymbol{N_{S,i}} \right|}{\sqrt{\boldsymbol{\sigma_{P,i}^2} + \boldsymbol{\sigma_{S,i}^2}}}$$

- where $N_{P,i}$ and $N_{S,i}$ are the values of PAO datapoint and simulated datapoint
- $\sigma_{N,i}$ and $\sigma_{S,i}$ are their uncertainties
- Simulation with **Test value ≤ 1 accepted** – 30 simulations satisfy this condition

Distance vs composition at source

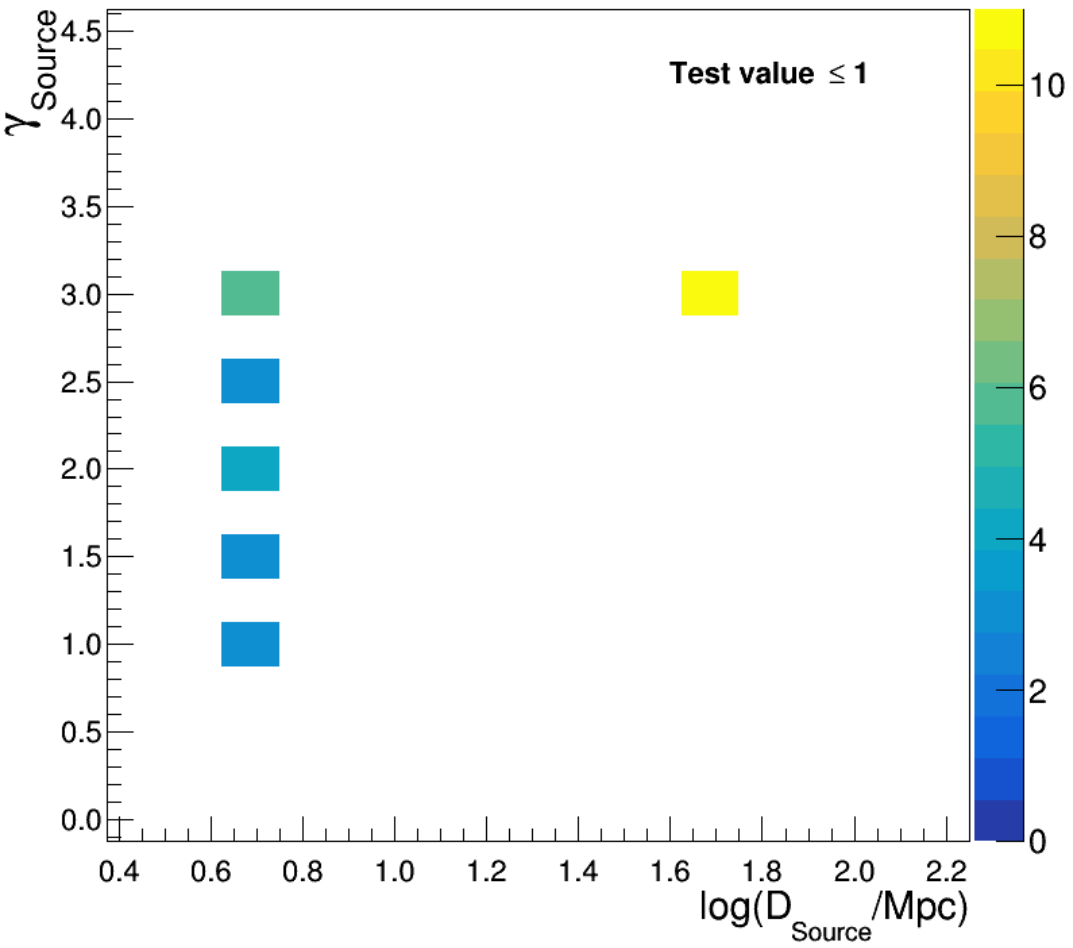


Distance vs cutoff rigidity

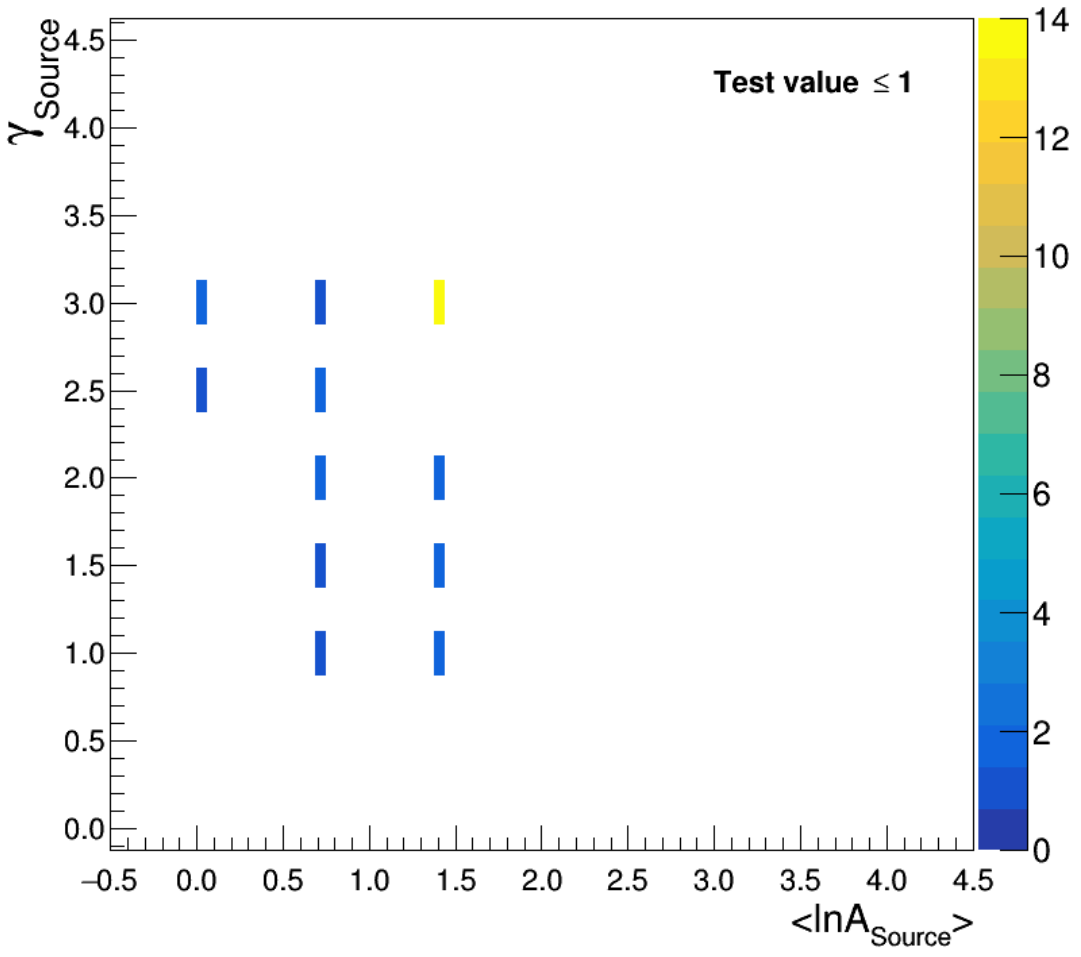


- PAO energy spectrum described by the sources with the light composition

Spectral index vs distance

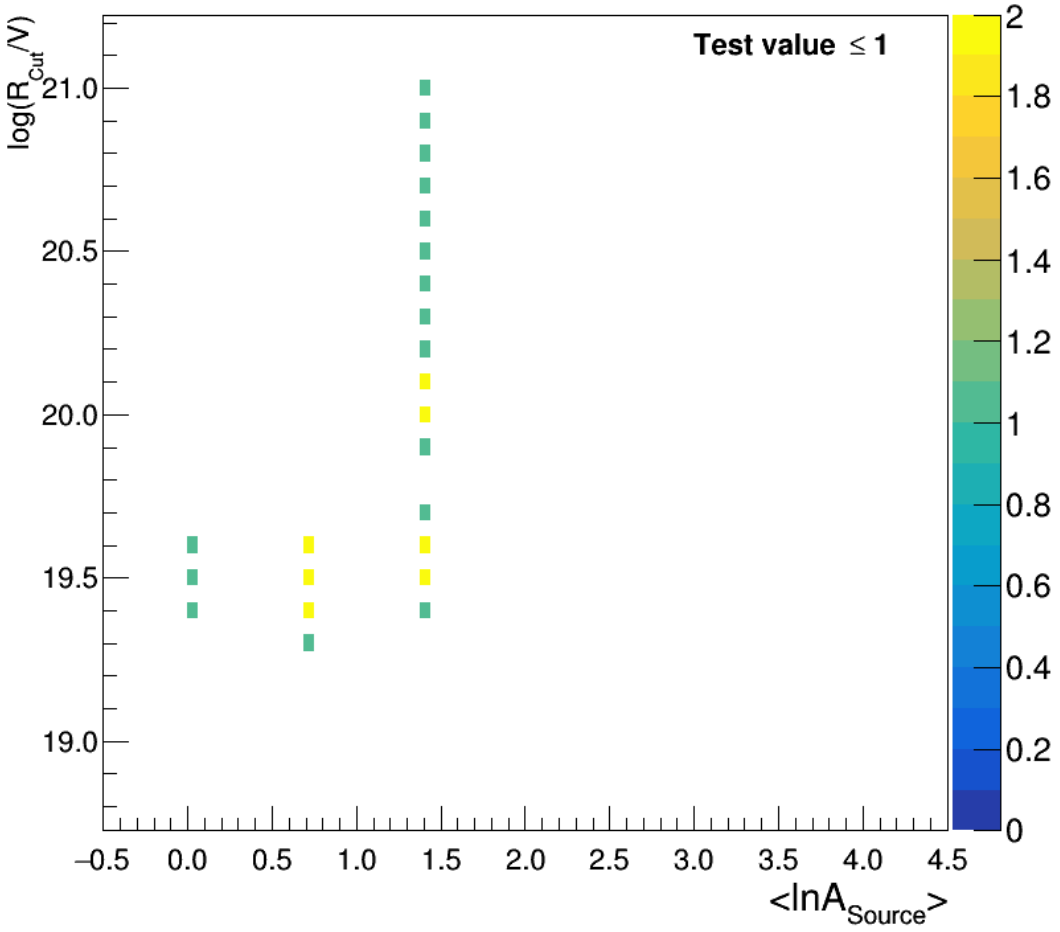


Spectral index vs primary mass composition

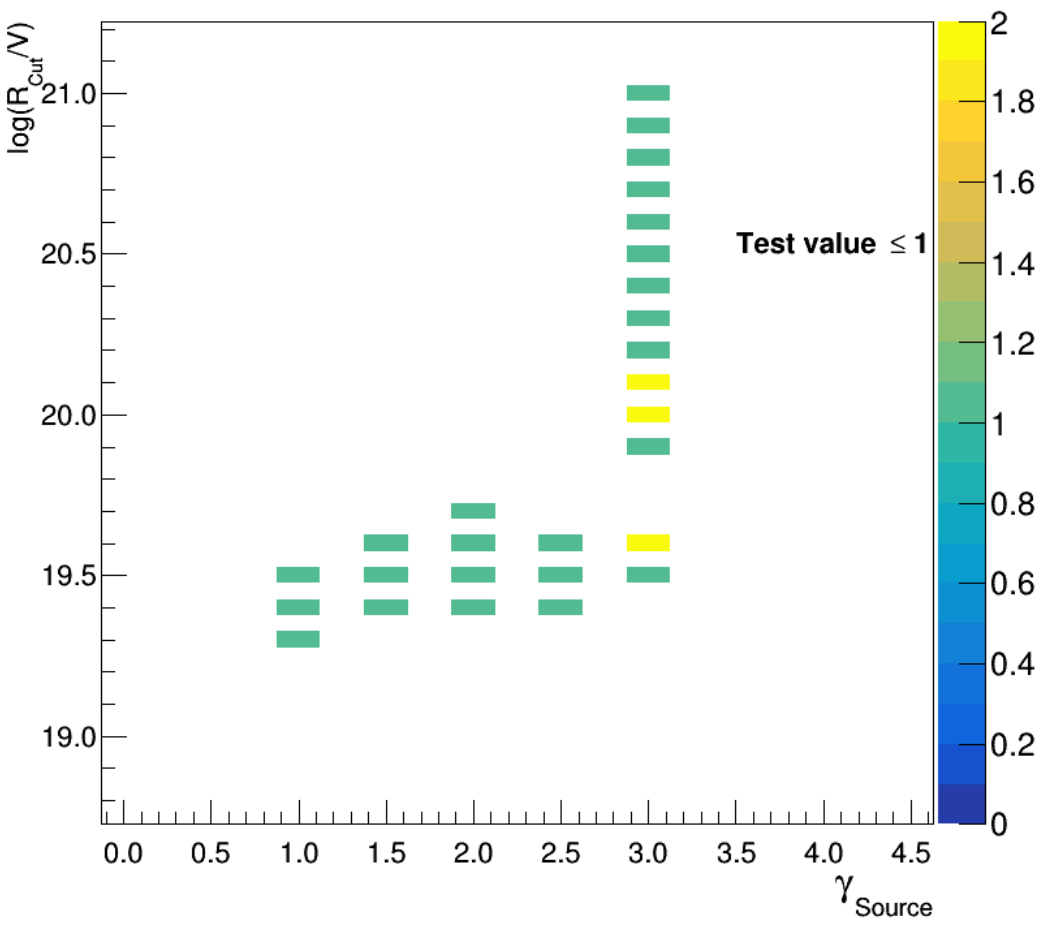


- Theoretically predicted indices are found for the closest sources

Cutoff rigidity vs primary mass composition



Cutoff rigidity vs spectral index



- Simulation with rigidities $\log(R_{Cut}/V) = 19.5$ passed our restrictions, considering $\gamma_{Source} = 1.0 - 2.2$

Summary

- Study of the evolution of $\langle \ln A_{\text{Earth}} \rangle$ - observation of the sharp increase, could be in future an indication of source features
- Study of the compatibility of the energy spectrum between measured data and simulations– sources with the light composition (similar to pure helium, pure hydrogen or the combination of both) were found to be able to describe the observed shape of the energy spectrum at the very end
- Considering spectral indices in the theoretical region 1.0 – 2.2, only sources with the rigidity cutoff of value $\approx 10^{19.5}$ V described the shape of the measured energy spectrum well. This is about one order of magnitude higher than the results of the combined fit of mass composition and energy spectrum by the Pierre Auger Observatory.

Thank you for your attention

reference model (SPG – EPOS-LHC)	main minimum		2nd minimum	
	best fit	average	best fit	average
$\mathcal{L}_0$ [10^{44} erg Mpc^{-3} yr^{-1}]	4.99		9.46*	
γ	$0.96^{+0.08}_{-0.13}$	0.93 ± 0.12	2.04 ± 0.01	$2.05^{+0.02}_{-0.04}$
$\log_{10}(R_{\rm cut}/{\rm V})$	$18.68^{+0.02}_{-0.04}$	18.66 ± 0.04	19.88 ± 0.02	19.86 ± 0.06
$f_{\rm H}(\%)$	0.0	$12.5^{+19.4}_{-12.5}$	0.0	$3.3^{+5.2}_{-3.3}$
$f_{\rm He}(\%)$	67.3	$58.6^{+12.6}_{-13.5}$	0.0	$3.6^{+6.1}_{-3.6}$
$f_{\rm N}(\%)$	28.1	$24.6^{+8.9}_{-9.1}$	79.8	$72.1^{+9.3}_{-10.6}$
$f_{\rm Si}(\%)$	4.6	$4.2^{+1.3}_{-1.3}$	20.2	$20.9^{+4.0}_{-3.9}$
$f_{\rm Fe}(\%)$	0.0		0.0	
D/n	174.4/119		235.7/119	
D (J), D $(X_{\rm max})$	13.3, 161.1		19.5, 216.2	
p	0.026		5×10^{-4}	

*From $E_{\rm min} = 10^{15}$ eV.

(The Pierre Auger Collaboration, 2017)

option	description	default
`-h`	prints the help and exits	none
`-s`	seed of the random number generator	65539
`-N`	number of events to be generated	100
`-A`	mass number of primary nuclei, $A_{\rm inj}$ (chosen at random for each event with `-A 0`)	56
`-e`	$\log_{10}(E_{\rm min}/{\rm eV})$, where $E_{\rm min}$ is the minimum injection energy	17
`-E`	$\log_{10}(E_{\rm max}/{\rm eV})$, where $E_{\rm max}$ is the maximum injection energy	21
`-g`	injection spectral index, γ	1
`-z`	minimum source redshift, $z_{\rm min}$	0
`-Z`	maximum source redshift, $z_{\rm max}$	1
`-r`	distance between sources, $L_{\rm s}$, in Mpc	0
`-L`	EBL model, see section	1
`-M`	photodisintegration model, see section	0
`-n`	nucleon ejection scaling factor (only with `-M 3` and `-M 4`)	1
`-a`	alpha-particle ejection scaling factor (only with `-M 3` and `-M 4`)	1
`-D`	beta decay: `0` disabled, all nuclei treated as their respective beta-decay stable isobars; `1` enabled, treated as instantaneous	1

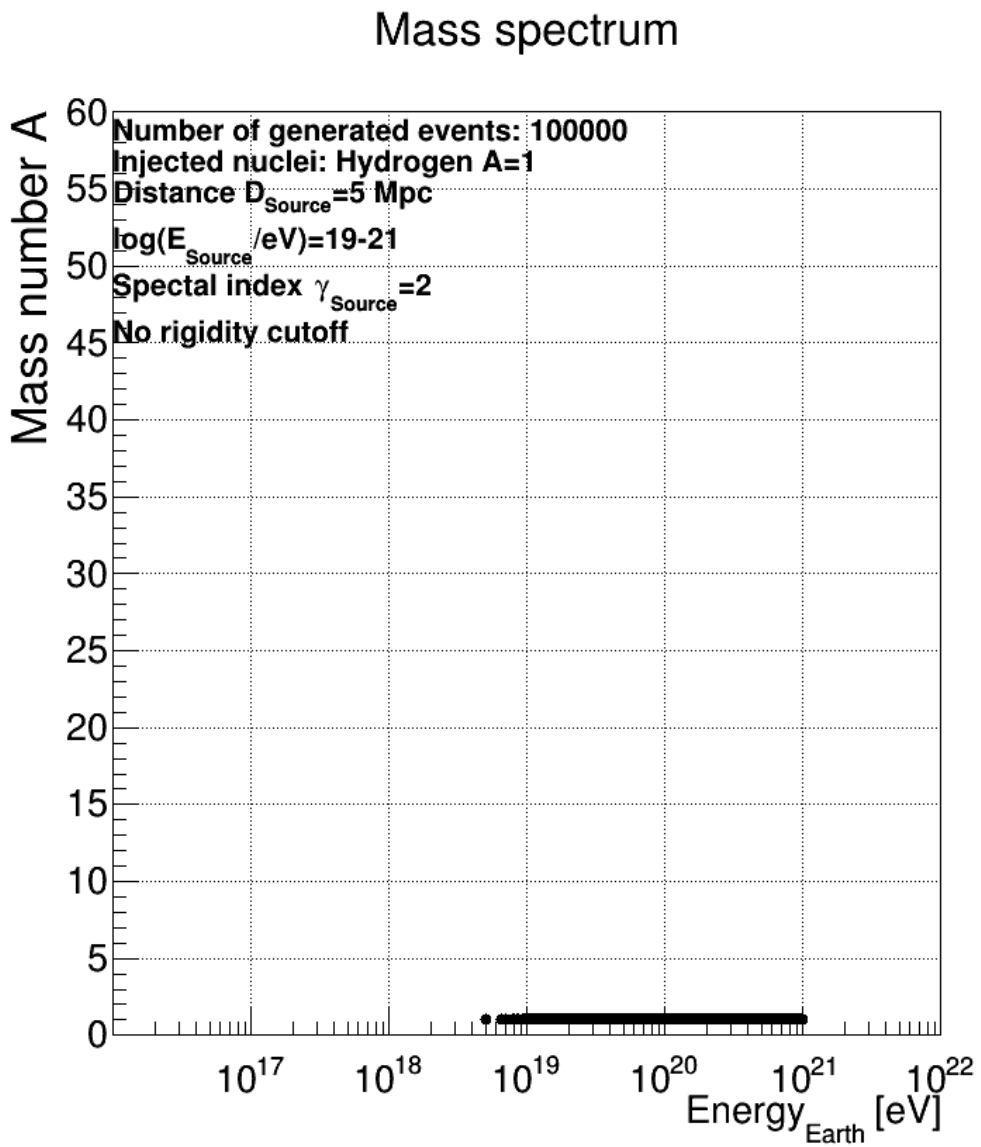
(Aloisio et al., 2017)

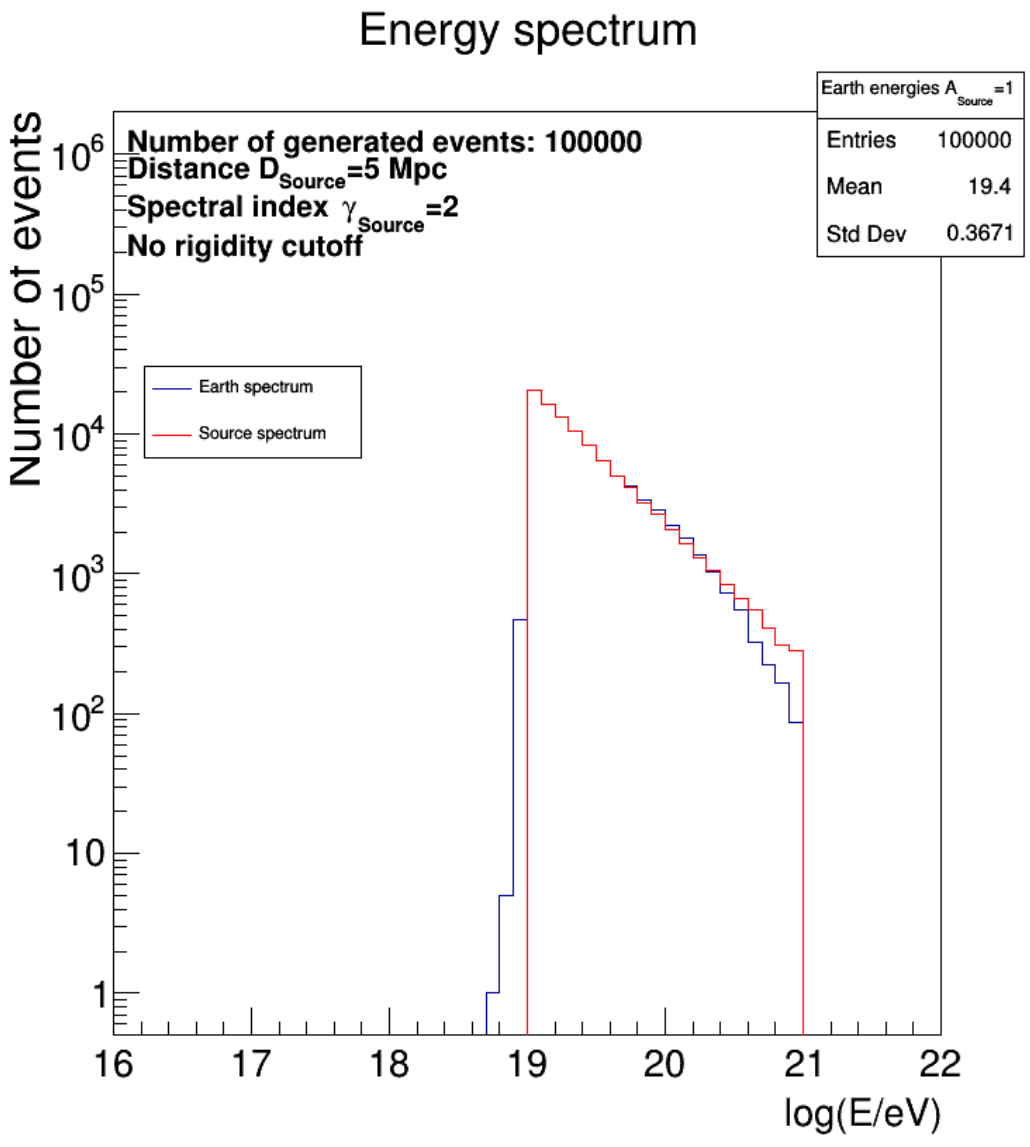
option	description	default
`-S`	treatment of pion production: `-1` continuous energy loss approximation for protons, neglected for other nuclei (as in *SimProp* v2r0); `0` continuous energy loss for both protons and other nuclei; `1` stochastic, on the CMB only; `2` stochastic, on both the CMB and the EBL	1
`-p`	electrons and positrons: `0` disregarded, `1` individually written to output file (warning: results in very large output files), `2` binned according to production redshift (by default $[10^{-4.0}, 10^{-3.8}), \ldots, [10^{+0.8}, 10^{+1.0})$, but can be changed in the file `src/Output.h` before compiling), `3` only total energy written	0
`-o`	output type (see below): `0` old (`nuc` and `ev` trees); `1` new (`summary` tree); `2` both	0

(Aloisio et al., 2017)

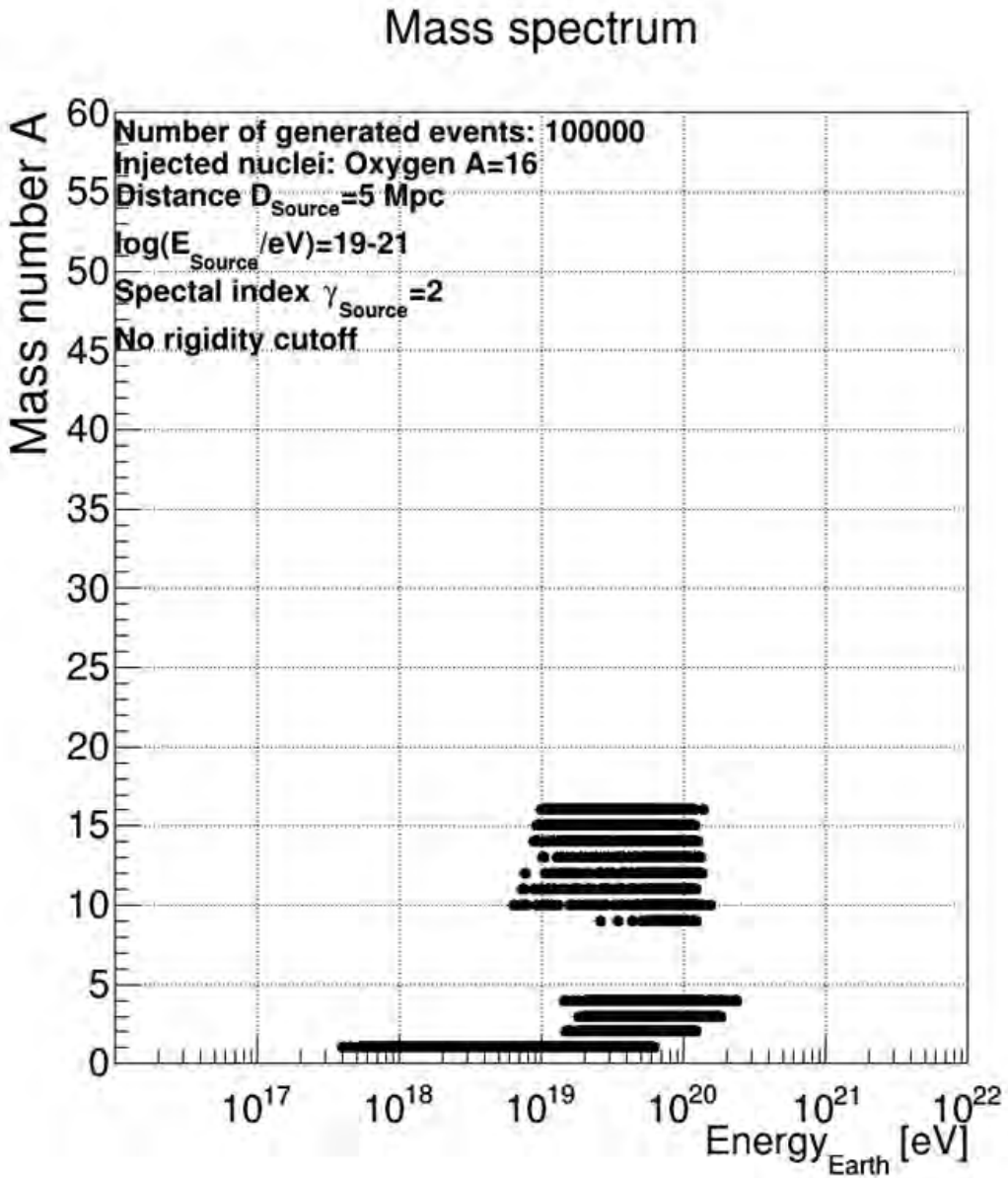
Analysis for close sources

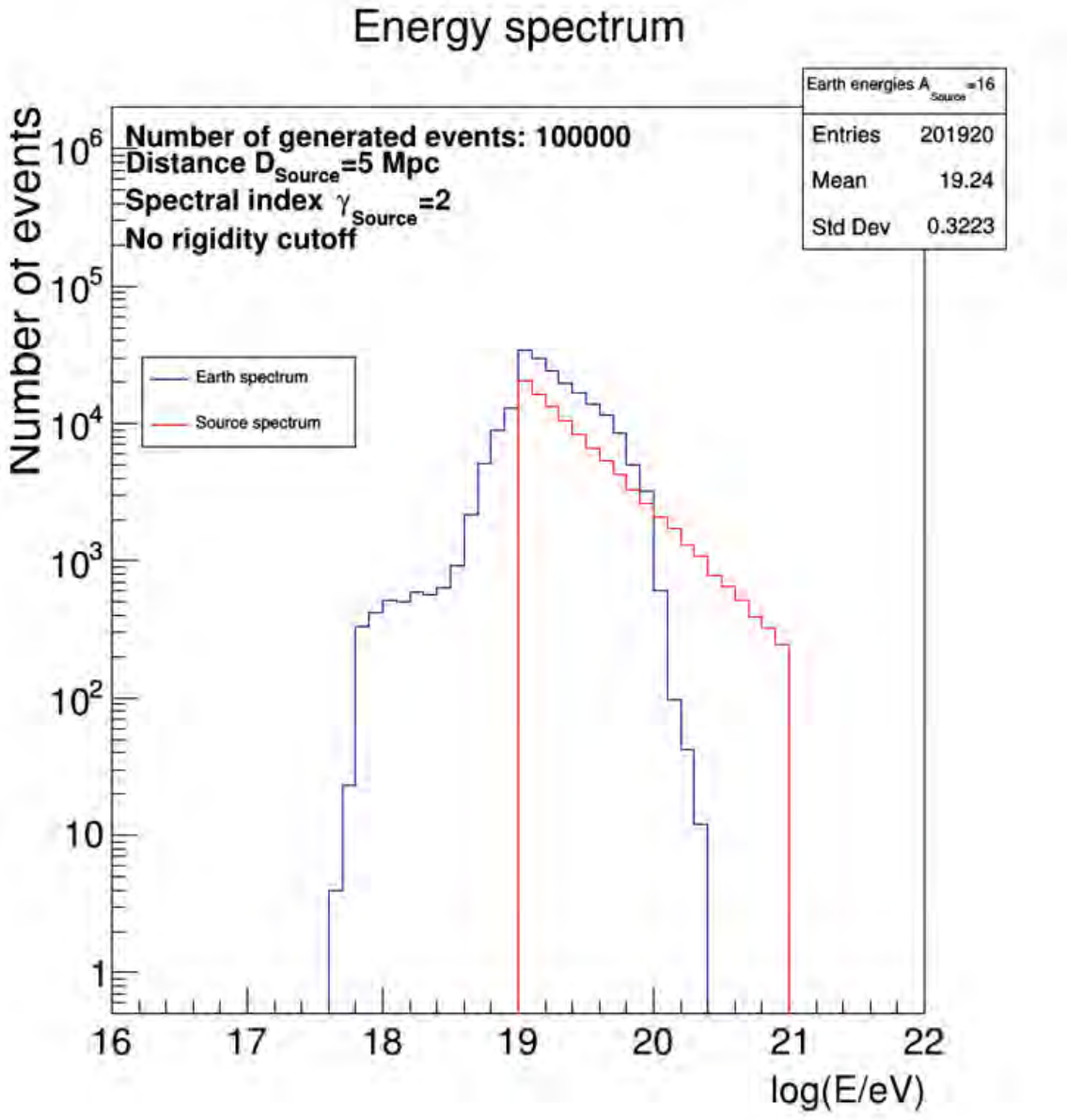
Hydrogen



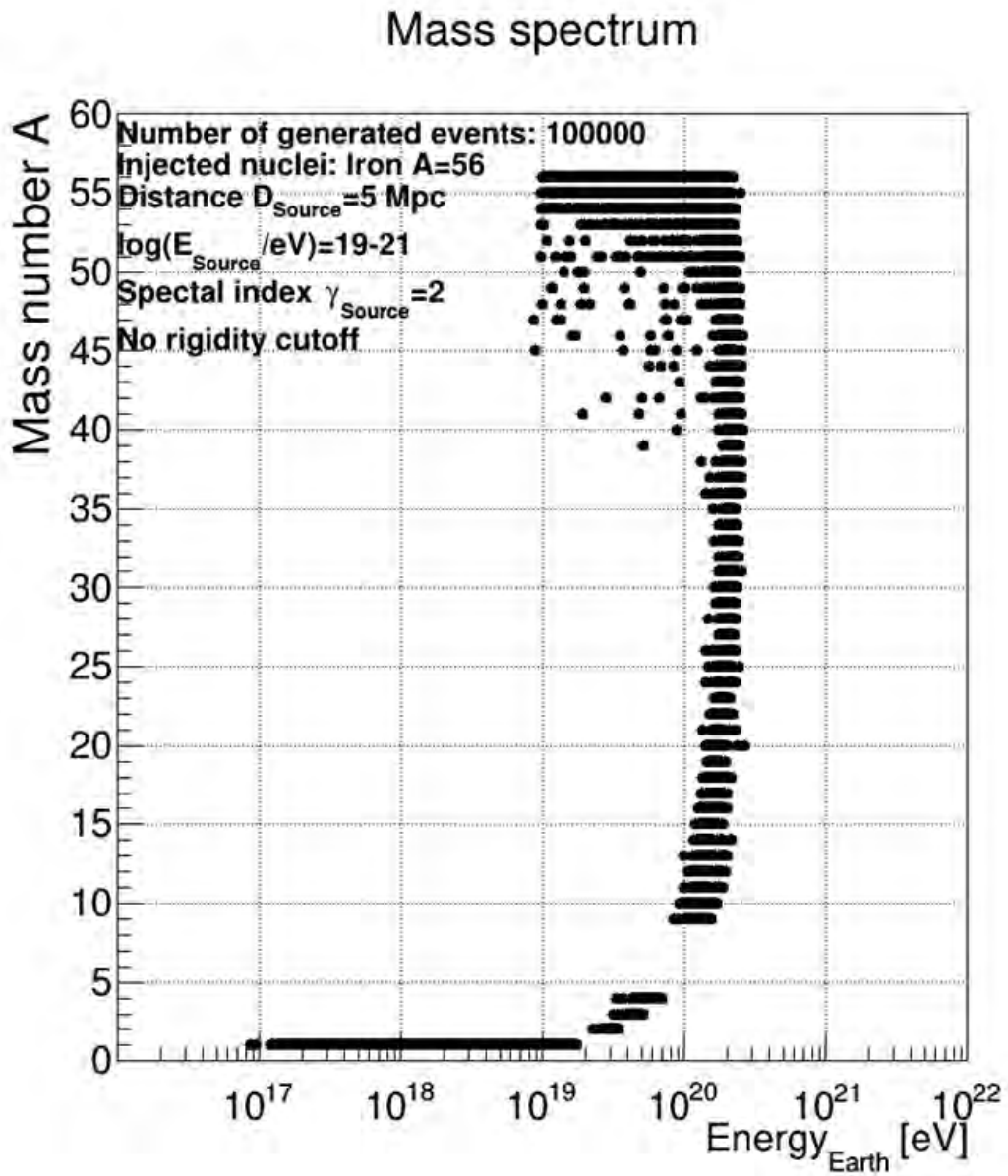


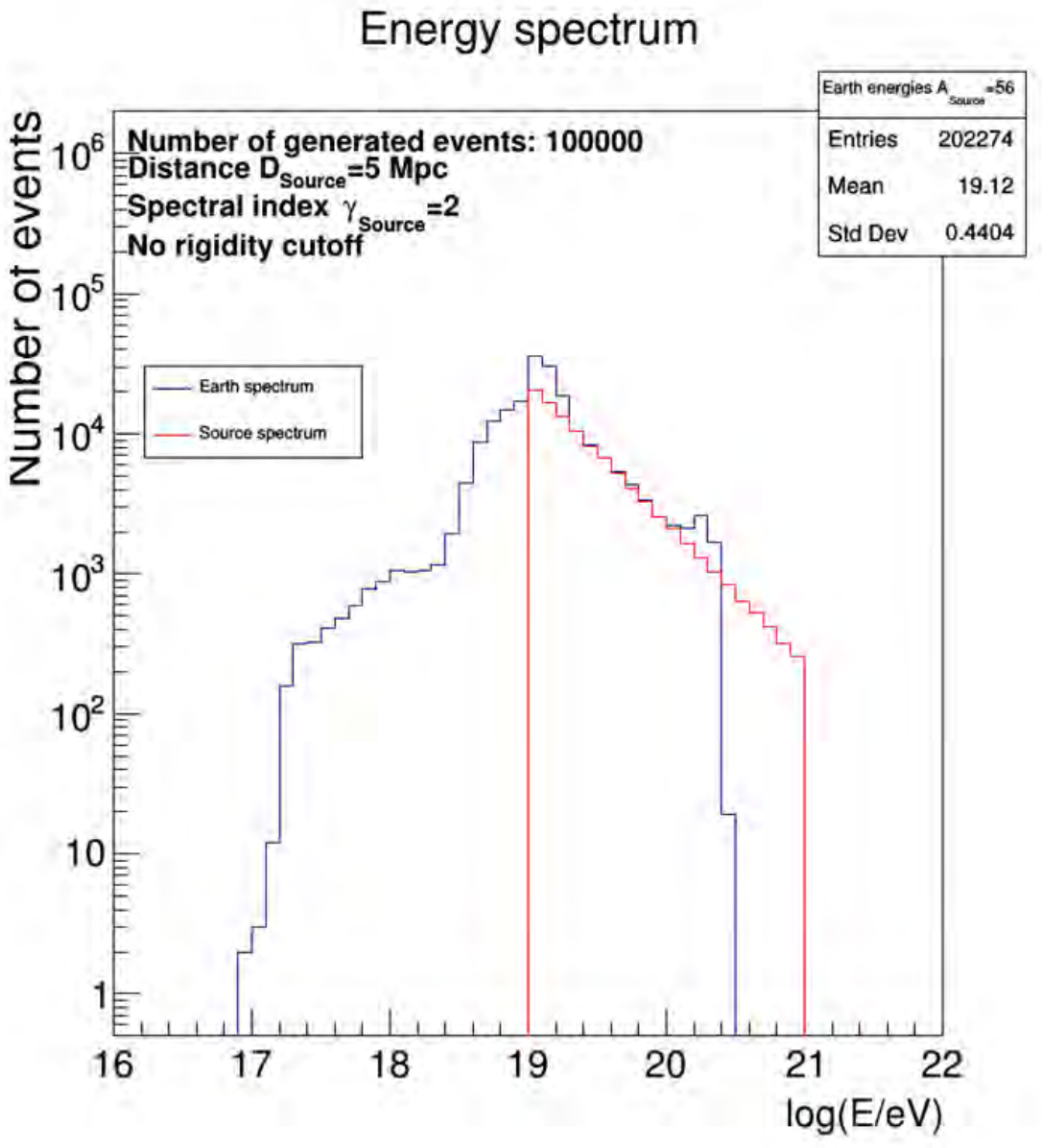
Oxygen

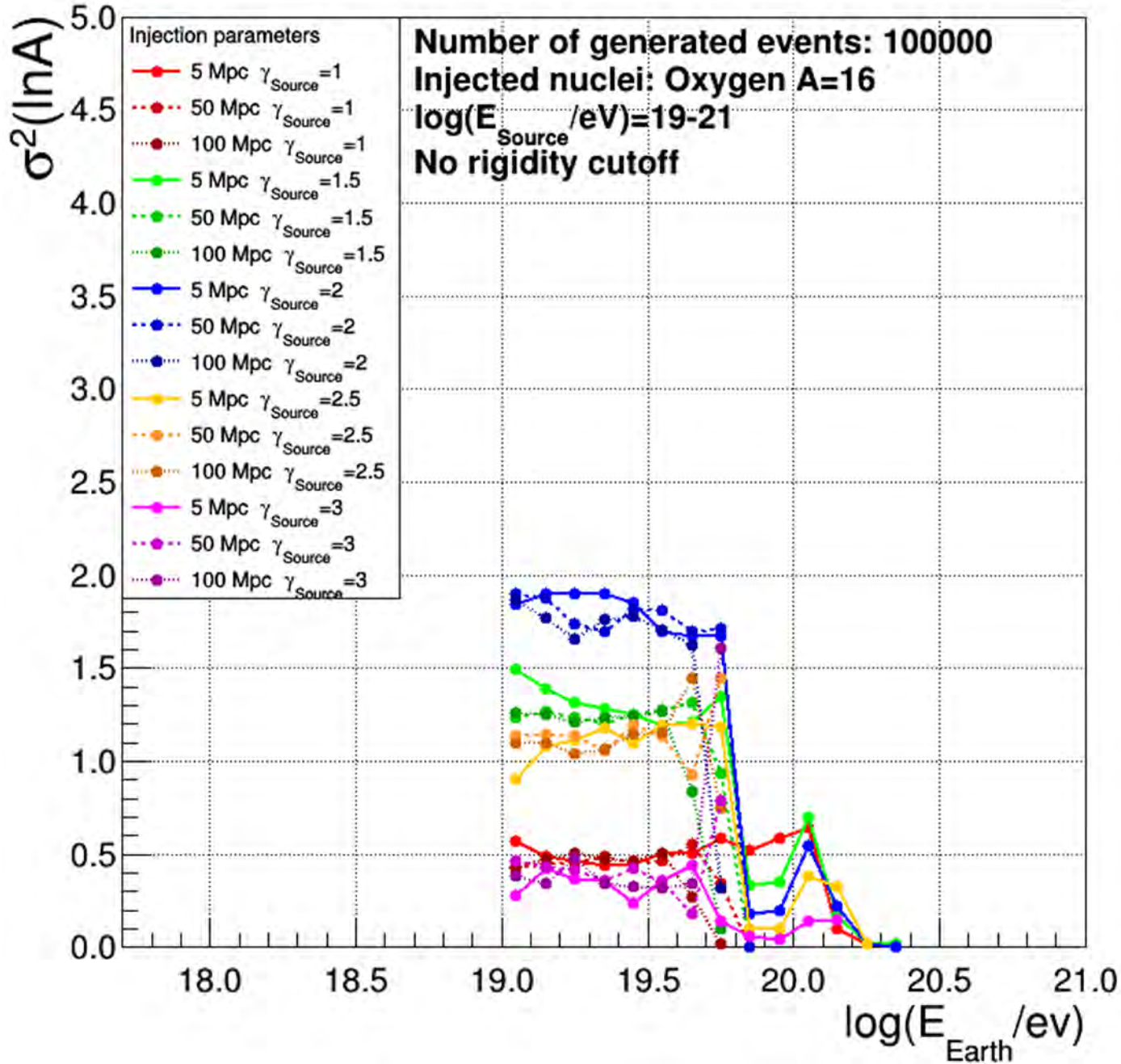

Mass spectrum
Number of generated events: 100000
Injected nuclei: Oxygen A=16
Distance D_Source=5 Mpc
log(E_Source/eV)=19-21
Spectal index γ_Source=2
No rigidity cutoff
Mass number A
Energy_Earth [eV]

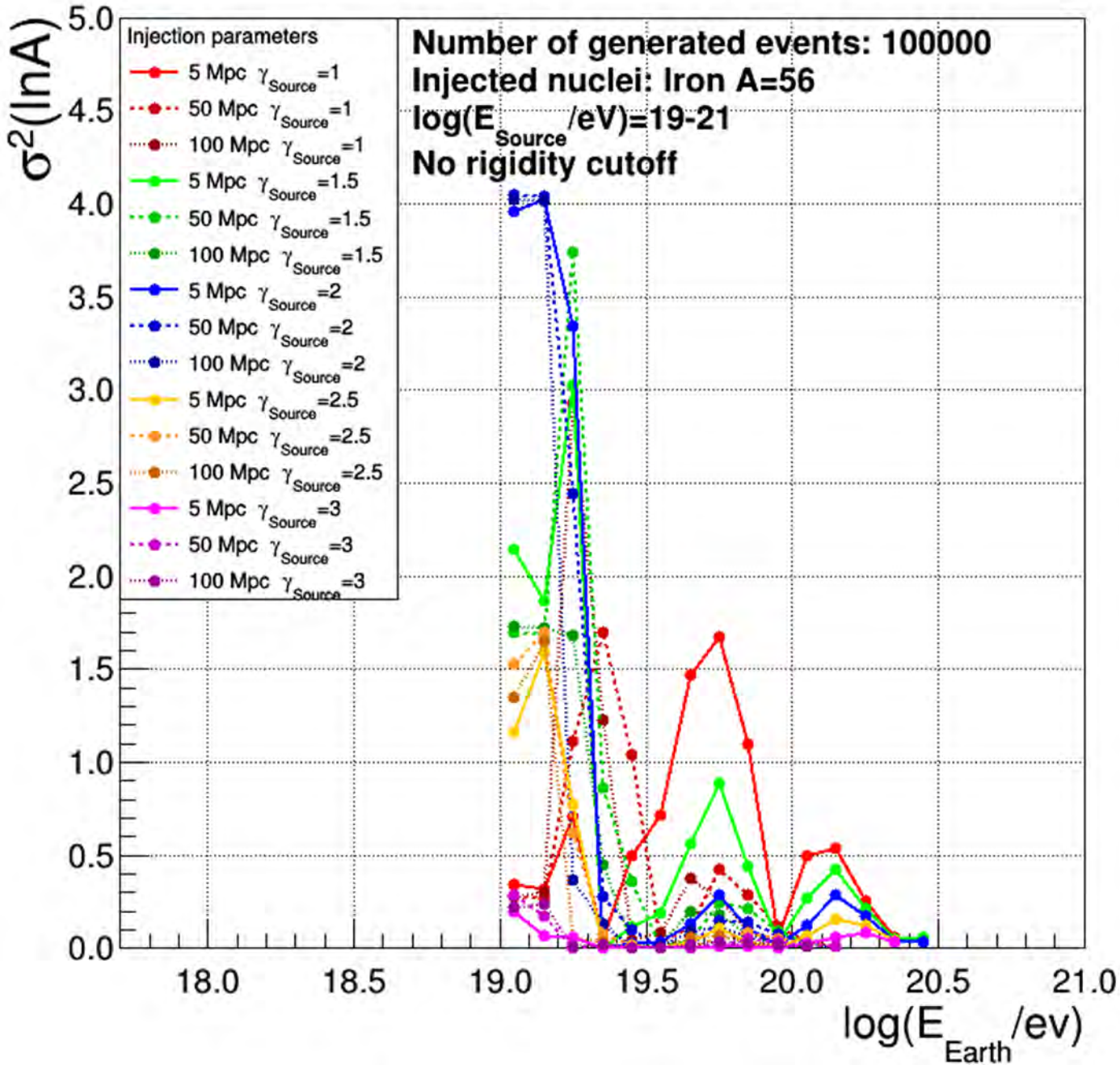

Energy spectrum
Number of generated events: 100000
Distance D_Source=5 Mpc
Spectral index γ_Source=2
No rigidity cutoff
Earth energies A_Source=16
Entries 201920
Mean 19.24
Std Dev 0.3223
Earth spectrum
Source spectrum
Number of events
log(E/eV)

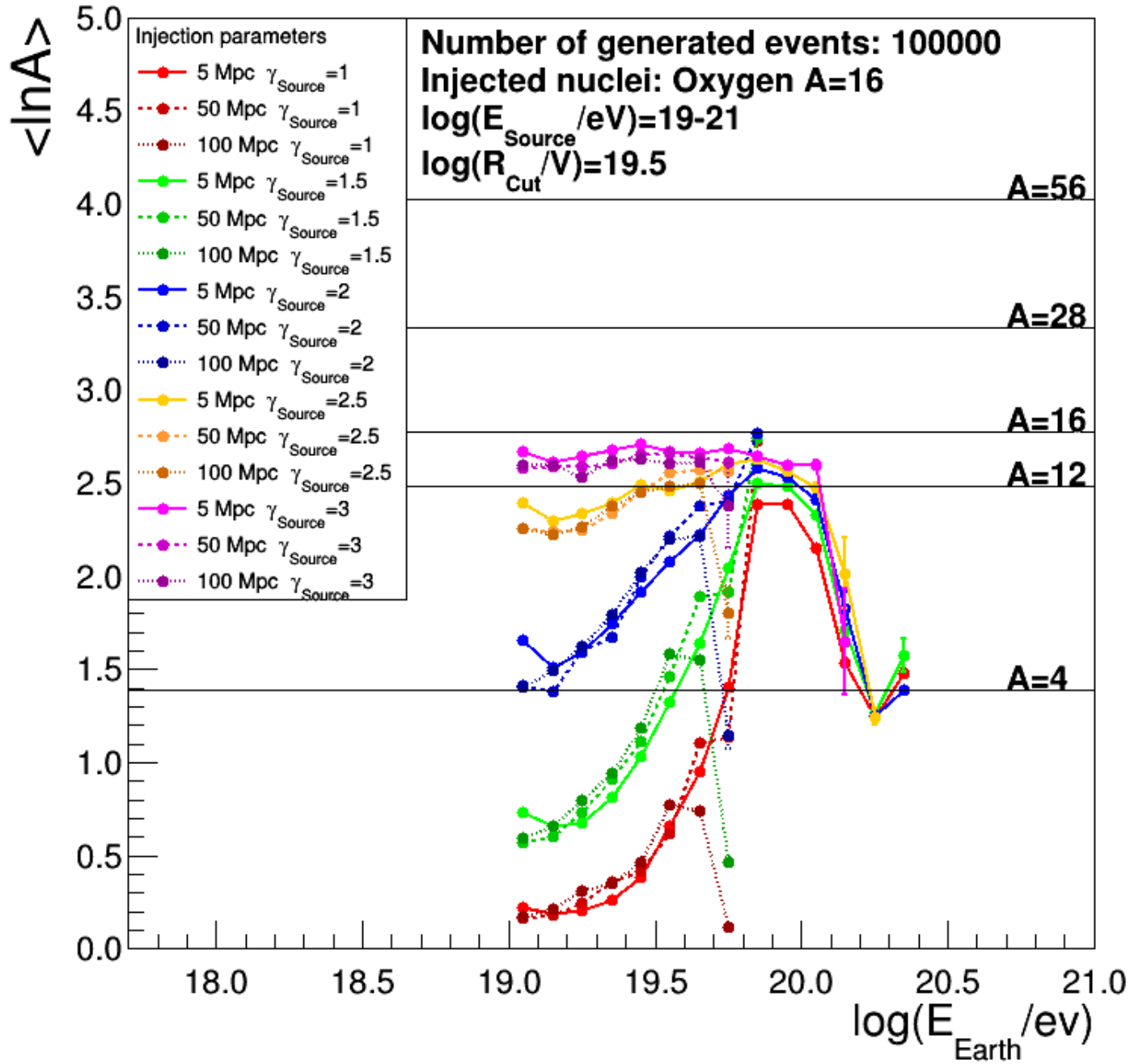
Iron

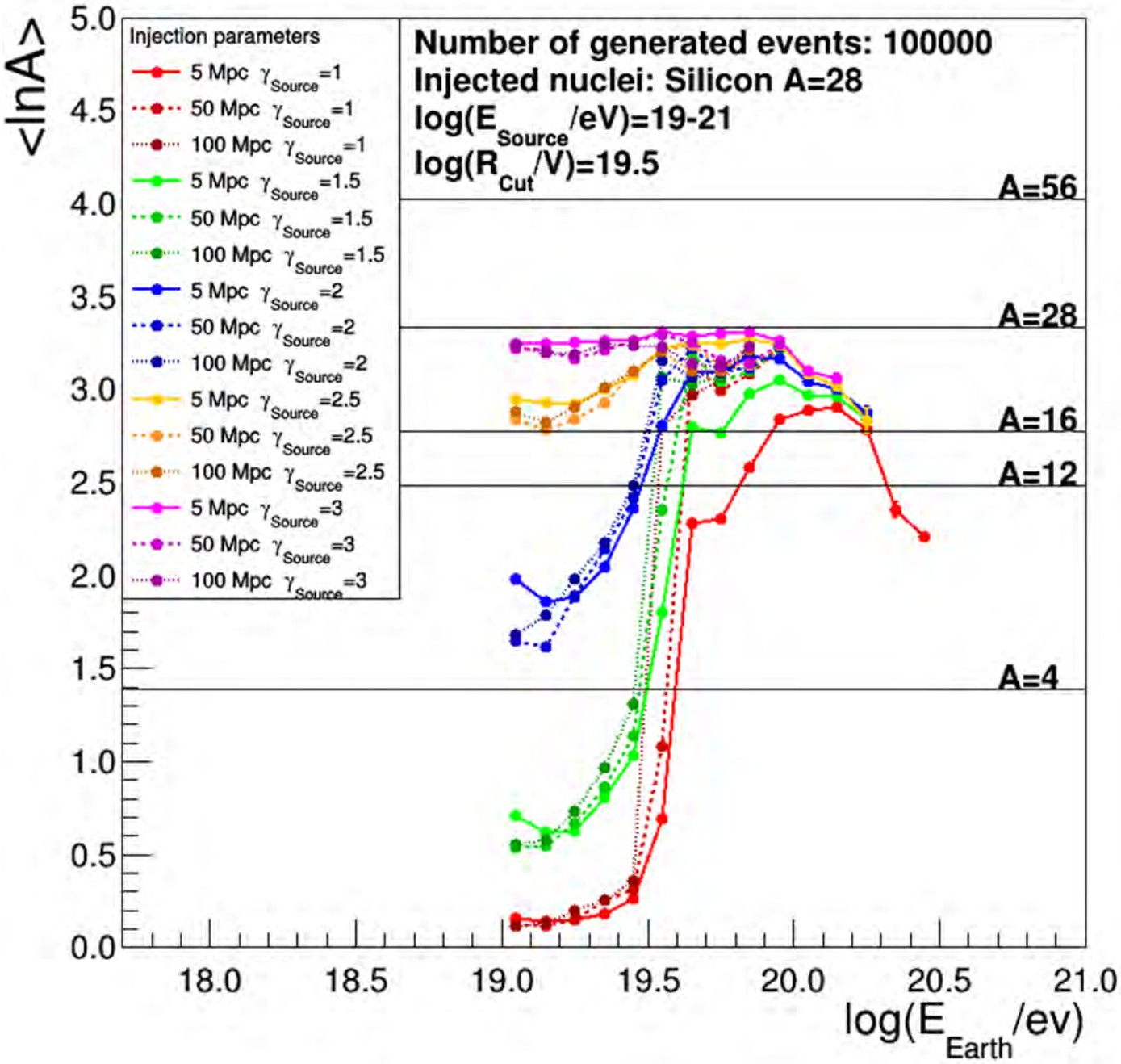

Mass spectrum
Number of generated events: 100000
Injected nuclei: Iron A=56
Distance D_Source=5 Mpc
log(E_Source/eV)=19-21
Spectal index γ_Source=2
No rigidity cutoff
Mass number A
Energy_Earth [eV]

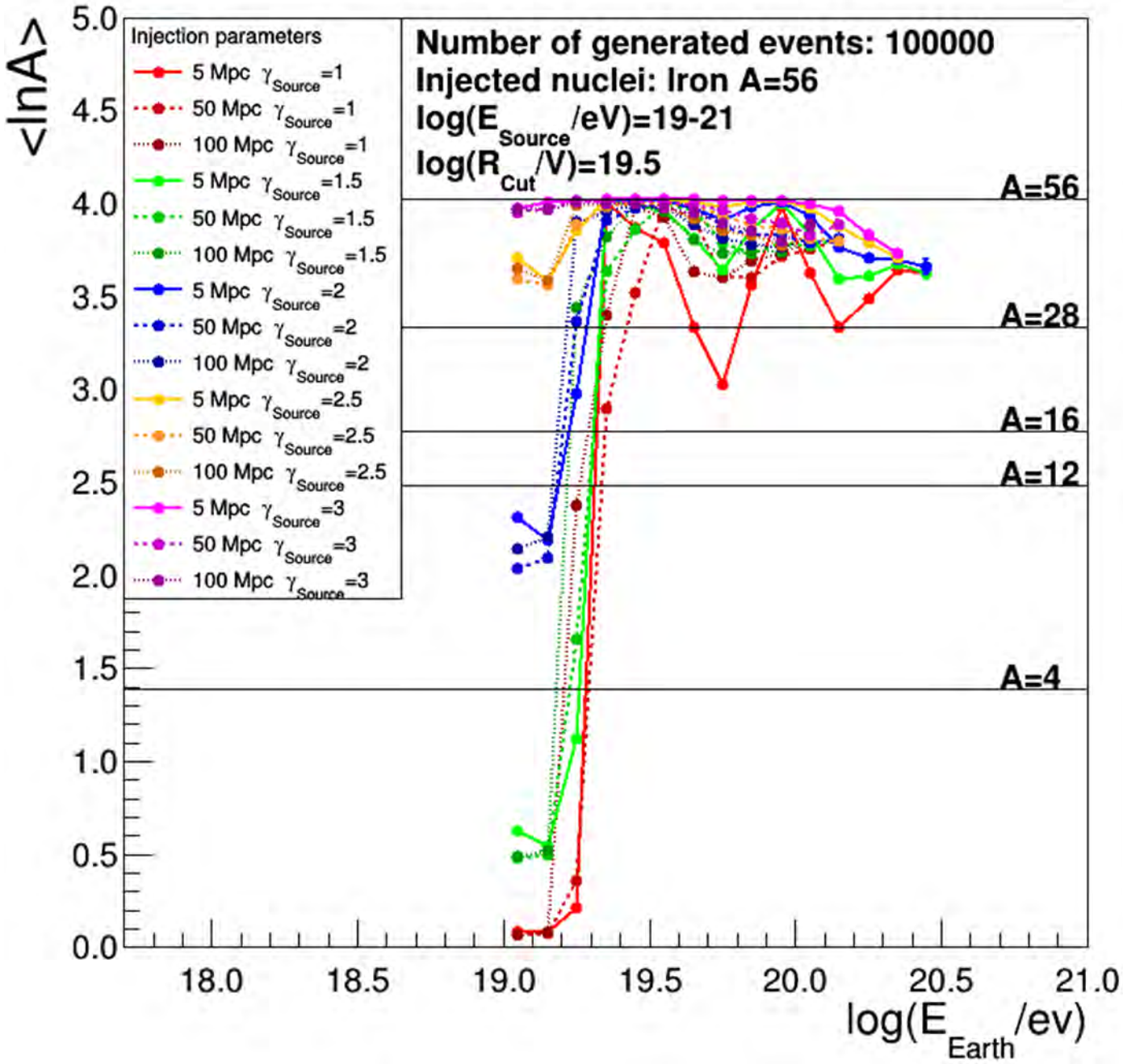

Energy spectrum
Earth energies A_Source=56
Entries 202274
Mean 19.12
Std Dev 0.4404
Number of generated events: 100000
Distance D_Source=5 Mpc
Spectral index γ_Source=2
No rigidity cutoff
Earth spectrum
Source spectrum
Number of events
log(E/eV)


Injection parameters
5 Mpc γSource=1
50 Mpc γSource=1
100 Mpc γSource=1
5 Mpc γSource=1.5
50 Mpc γSource=1.5
100 Mpc γSource=1.5
5 Mpc γSource=2
50 Mpc γSource=2
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Oxygen A=16
log(ESource/eV)=19-21
No rigidity cutoff
σ2(lnA)
log(EEarth/ev)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0

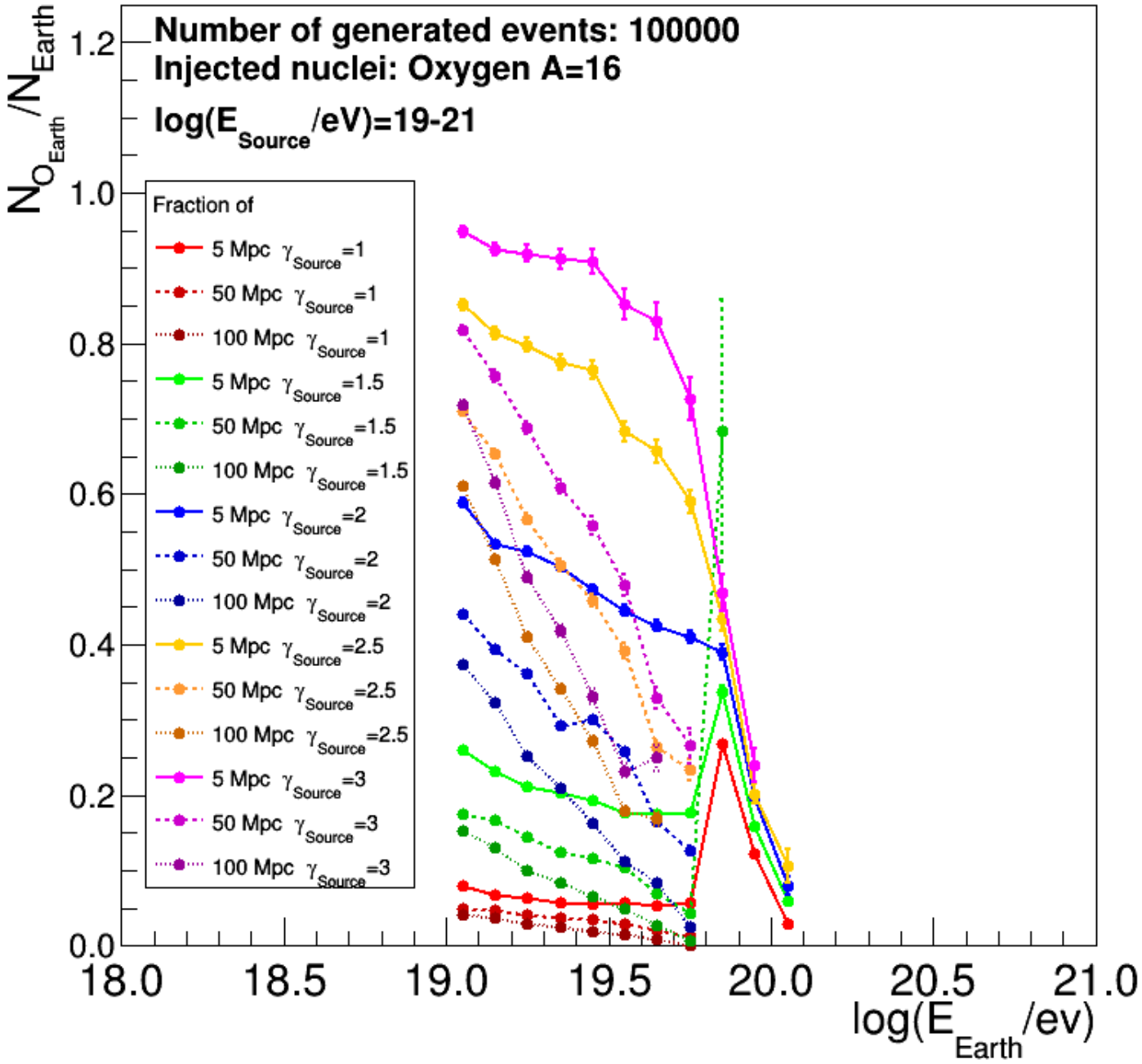

Injection parameters
5 Mpc γSource=1
50 Mpc γSource=1
100 Mpc γSource=1
5 Mpc γSource=1.5
50 Mpc γSource=1.5
100 Mpc γSource=1.5
5 Mpc γSource=2
50 Mpc γSource=2
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Iron A=56
log(ESource/eV)=19-21
No rigidity cutoff
σ2(lnA)
log(EEarth/ev)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0


<lnA>
Injection parameters
5 Mpc γSource=1
50 Mpc γSource=1
100 Mpc γSource=1
5 Mpc γSource=1.5
50 Mpc γSource=1.5
100 Mpc γSource=1.5
5 Mpc γSource=2
50 Mpc γSource=2
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Oxygen A=16
log(ESource/eV)=19-21
log(RCut/V)=19.5
A=56
A=28
A=16
A=12
A=4
log(EEarth/ev)

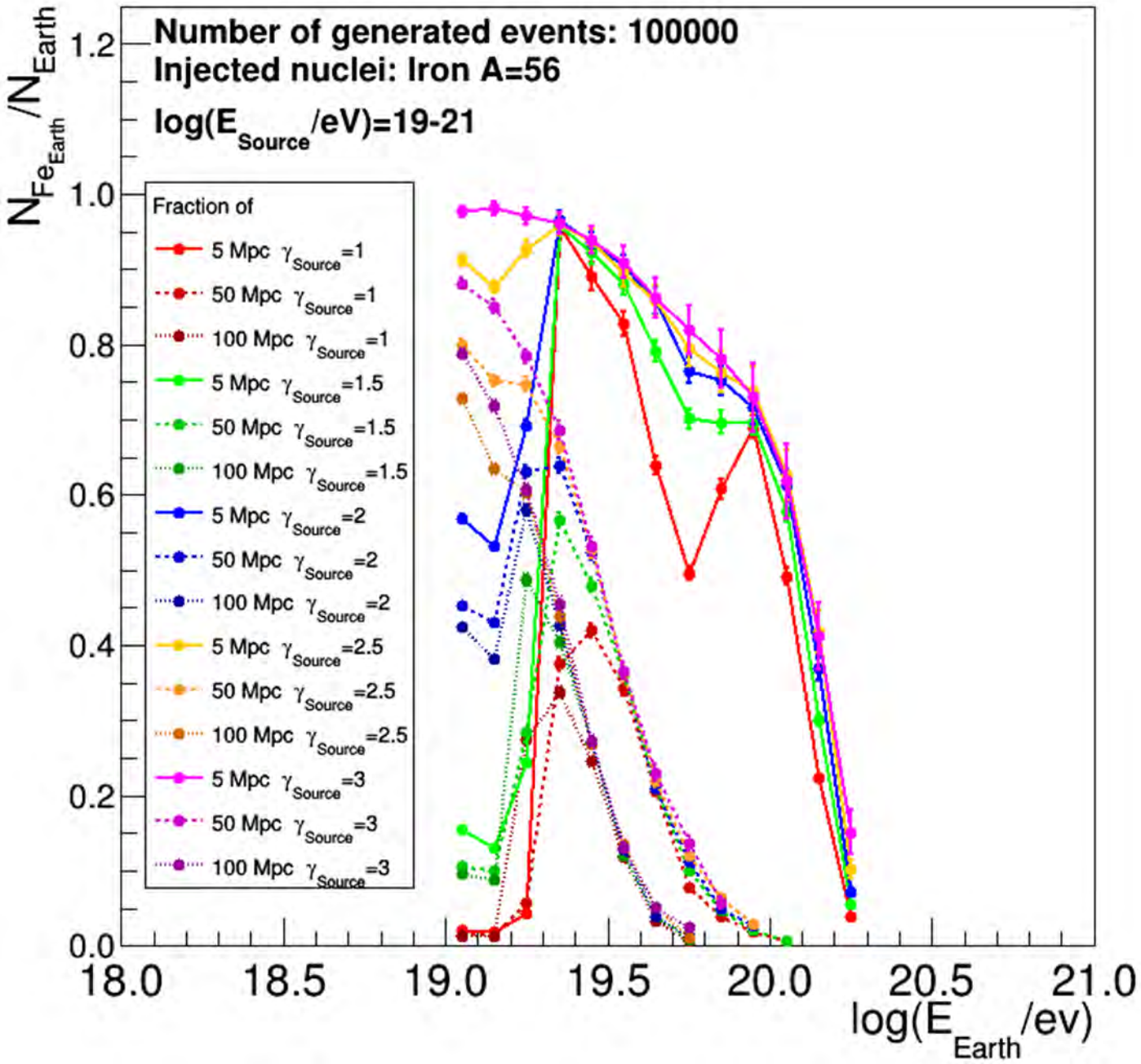

Injection parameters
5 Mpc γSource=1
50 Mpc γSource=1
100 Mpc γSource=1
5 Mpc γSource=1.5
50 Mpc γSource=1.5
100 Mpc γSource=1.5
5 Mpc γSource=2
50 Mpc γSource=2
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Silicon A=28
log(ESource/eV)=19-21
log(RCut/V)=19.5
A=56
A=28
A=16
A=12
A=4
<lnA>
log(EEarth/ev)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0


Injection parameters
5 Mpc γSource=1
50 Mpc γSource=1
100 Mpc γSource=1
5 Mpc γSource=1.5
50 Mpc γSource=1.5
100 Mpc γSource=1.5
5 Mpc γSource=2
50 Mpc γSource=2
100 Mpc γSource=2
5 Mpc γSource=2.5
50 Mpc γSource=2.5
100 Mpc γSource=2.5
5 Mpc γSource=3
50 Mpc γSource=3
100 Mpc γSource=3
Number of generated events: 100000
Injected nuclei: Iron A=56
log(ESource/eV)=19-21
log(RCut/V)=19.5
A=56
A=28
A=16
A=12
A=4
<lnA>
log(EEarth/ev)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
18.0
18.5
19.0
19.5
20.0
20.5
21.0

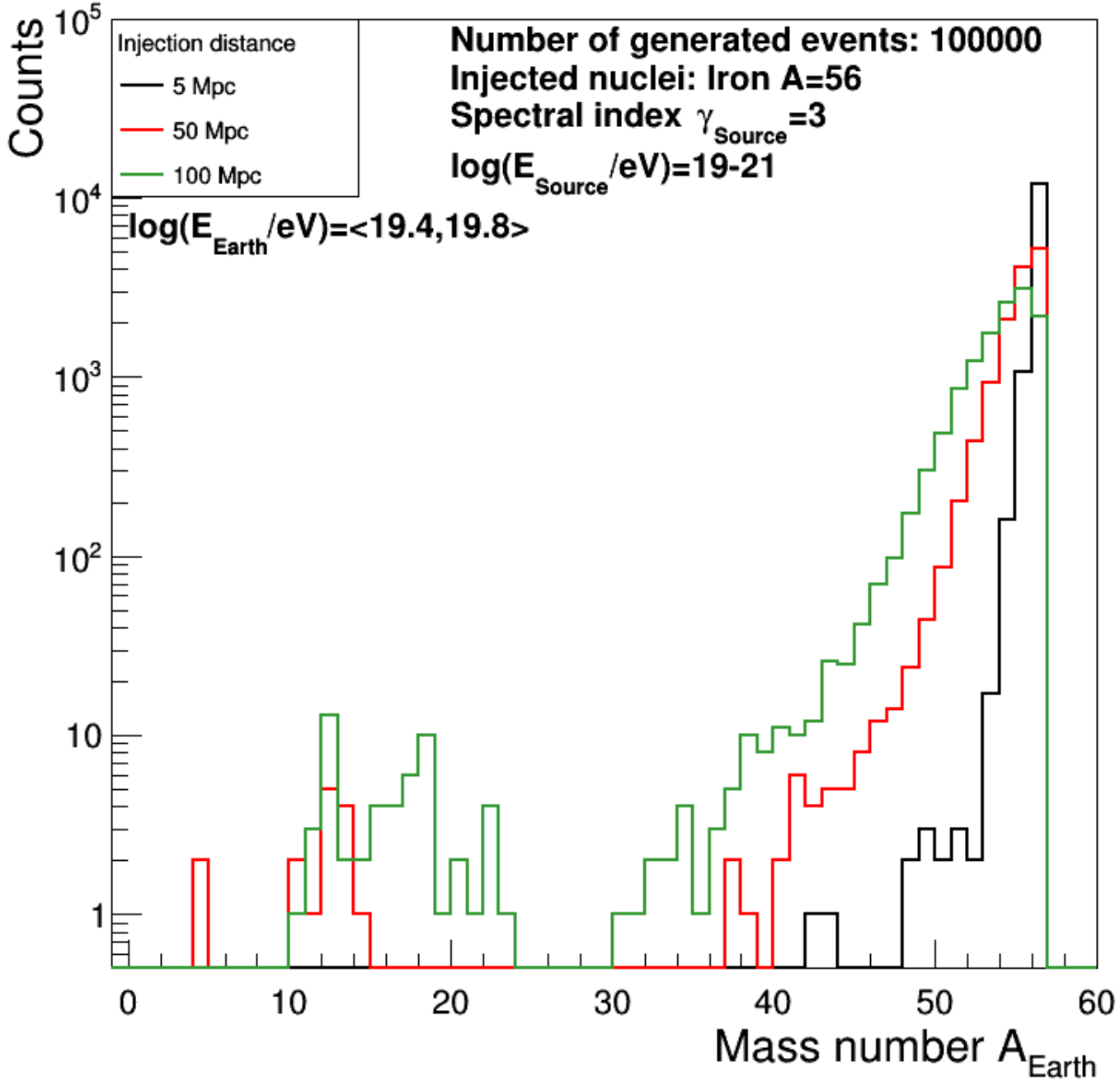
Fraction of oxygen nuclei on Earth



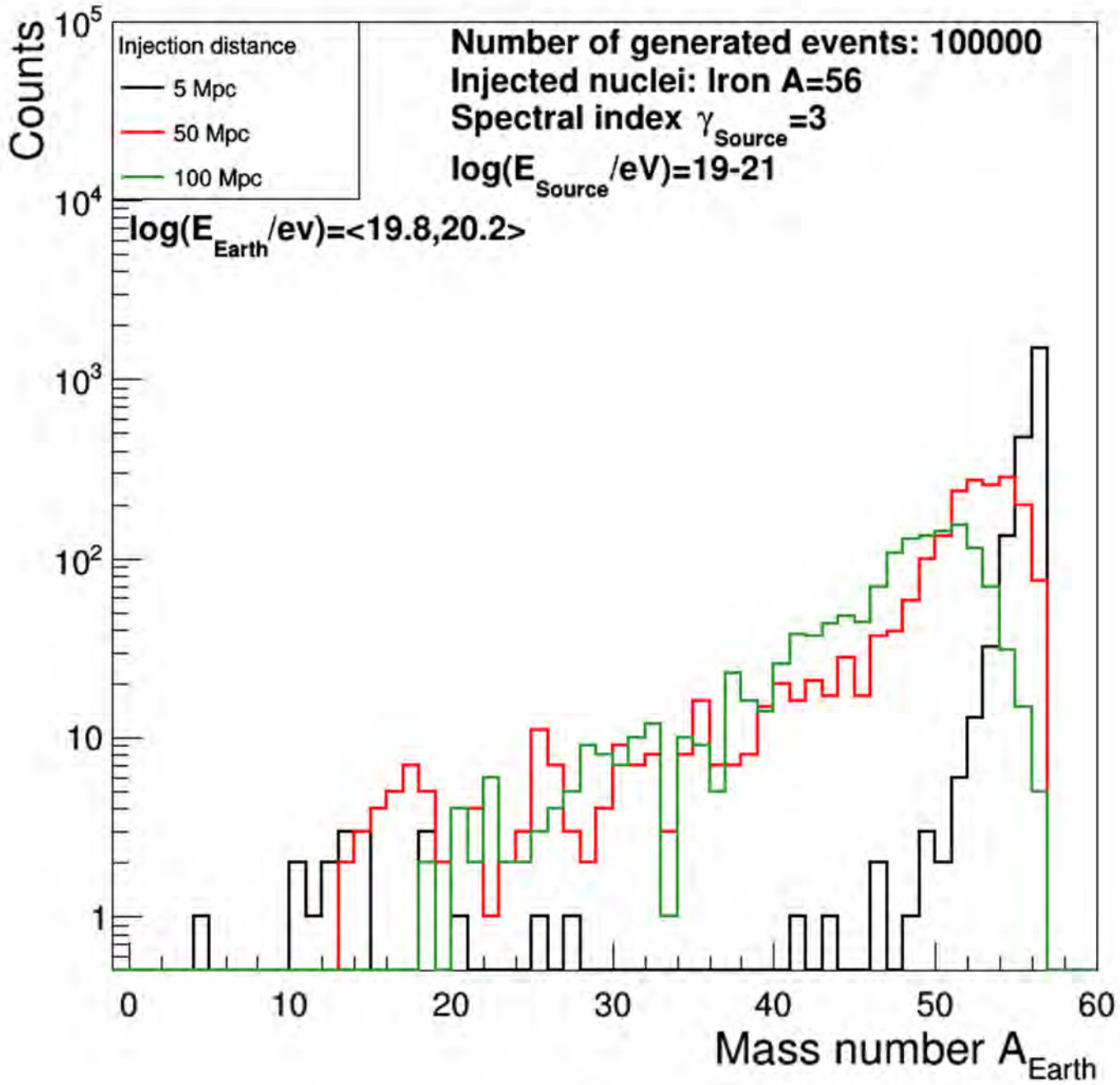
Fraction of iron nuclei on Earth



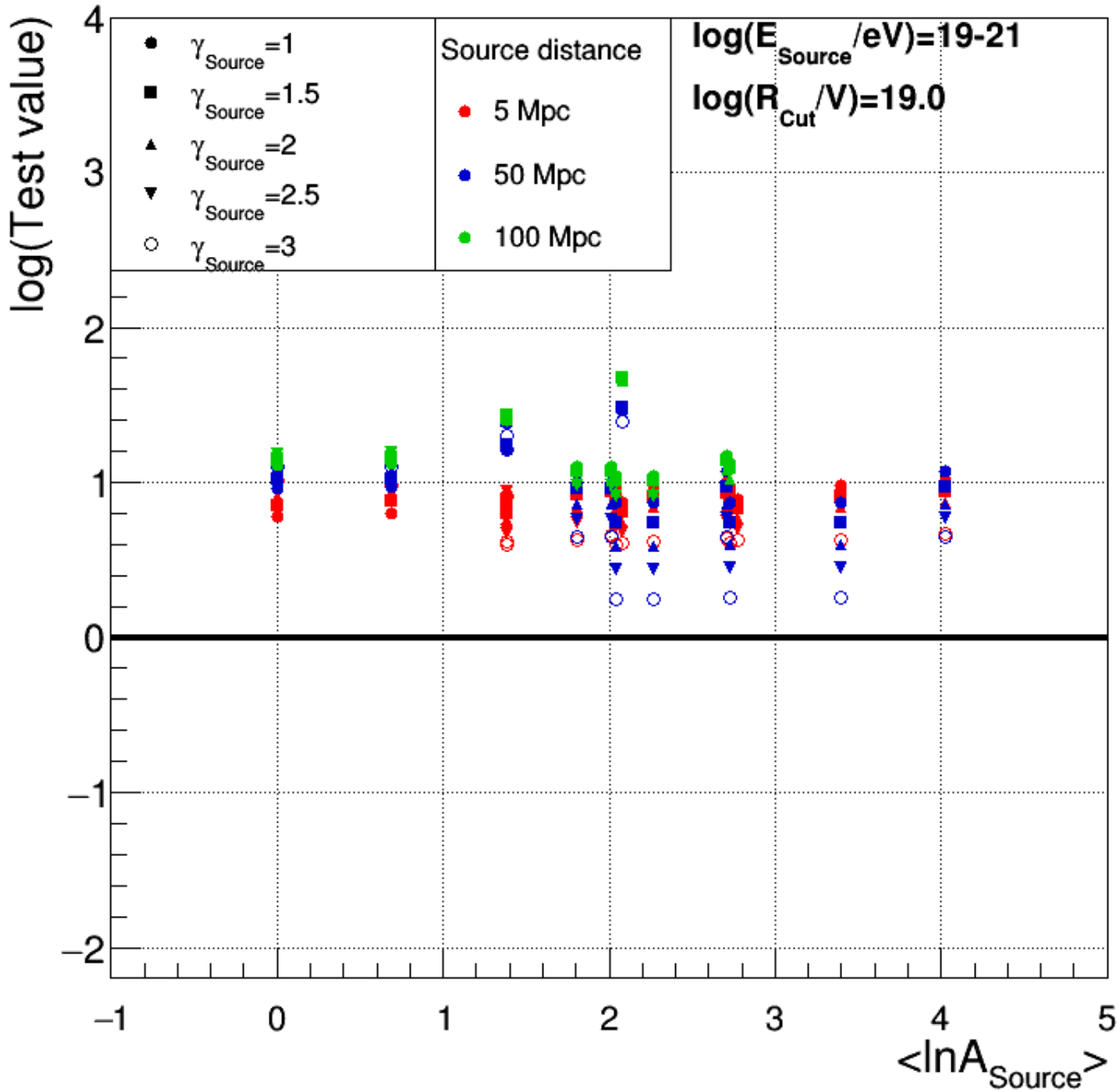
Distribution of mass number A

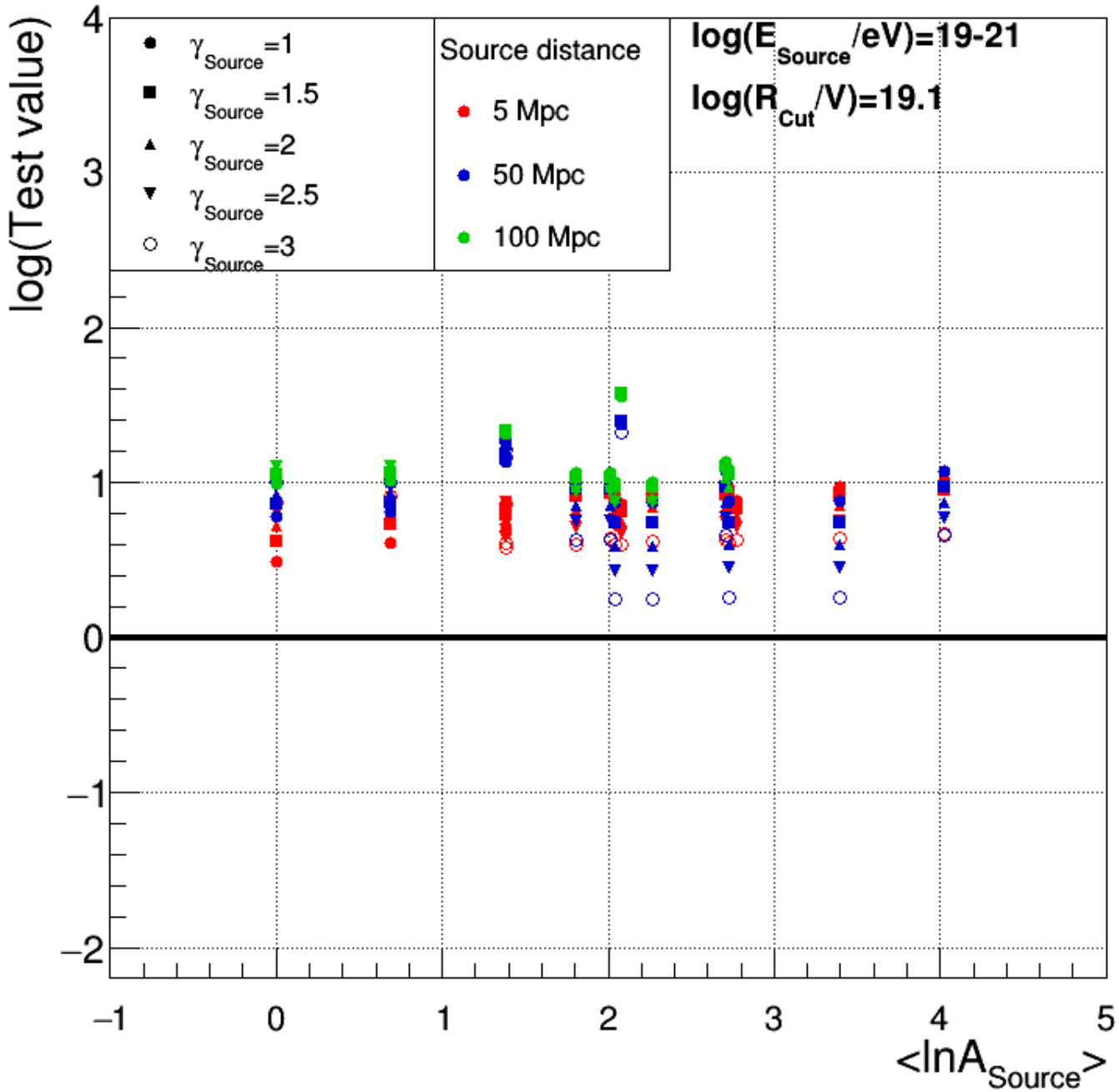


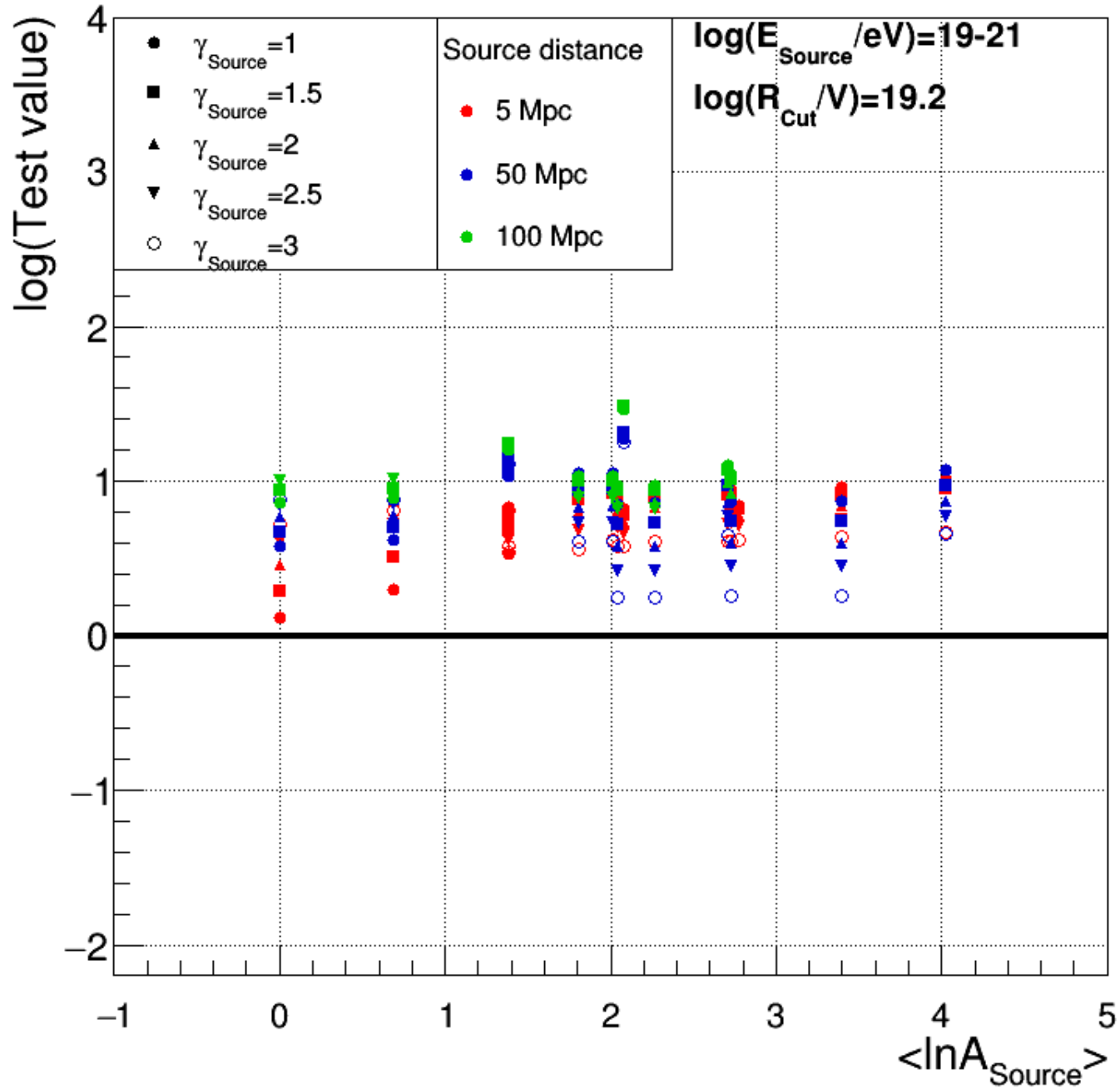
Distribution of mass number A

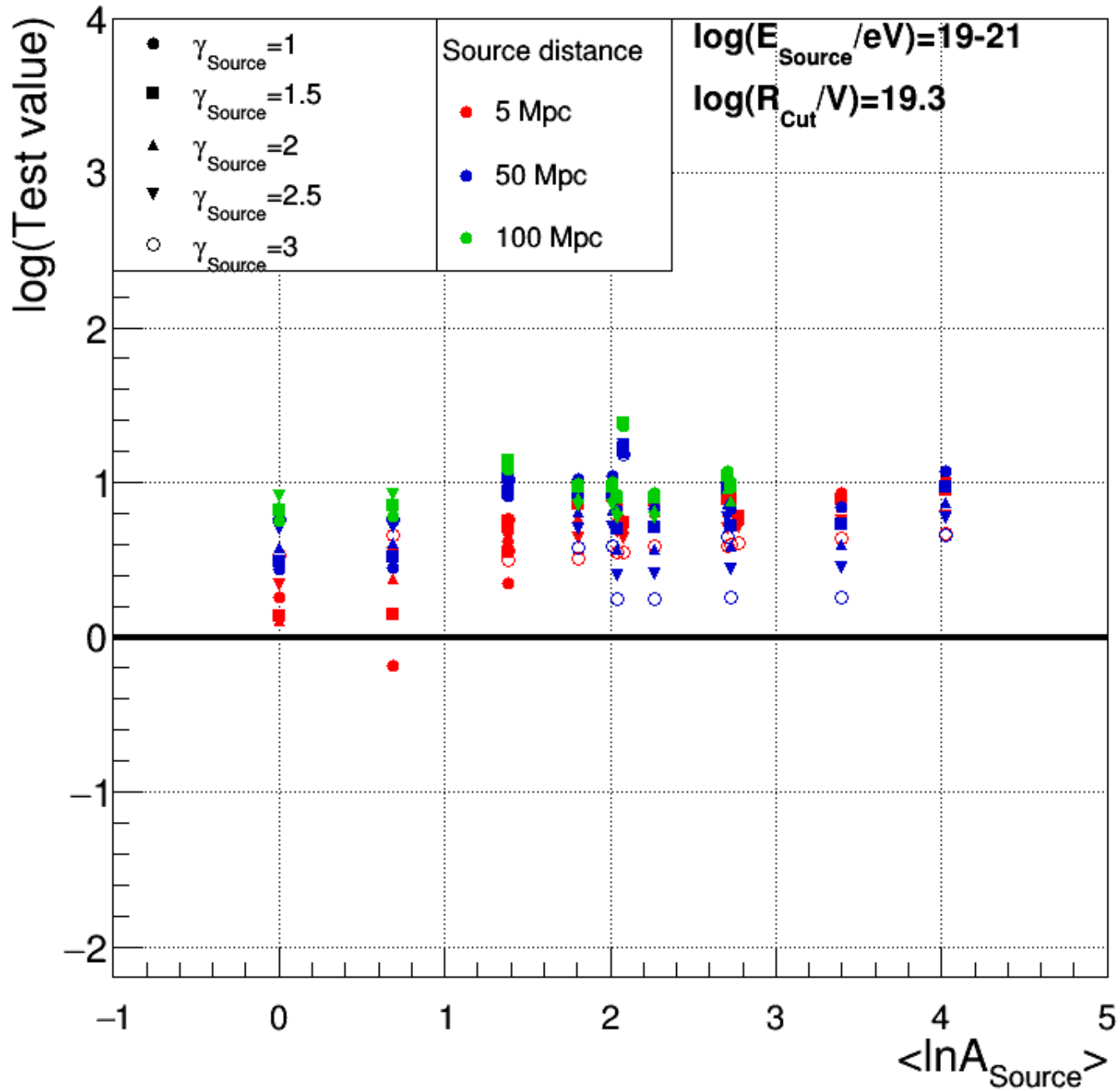


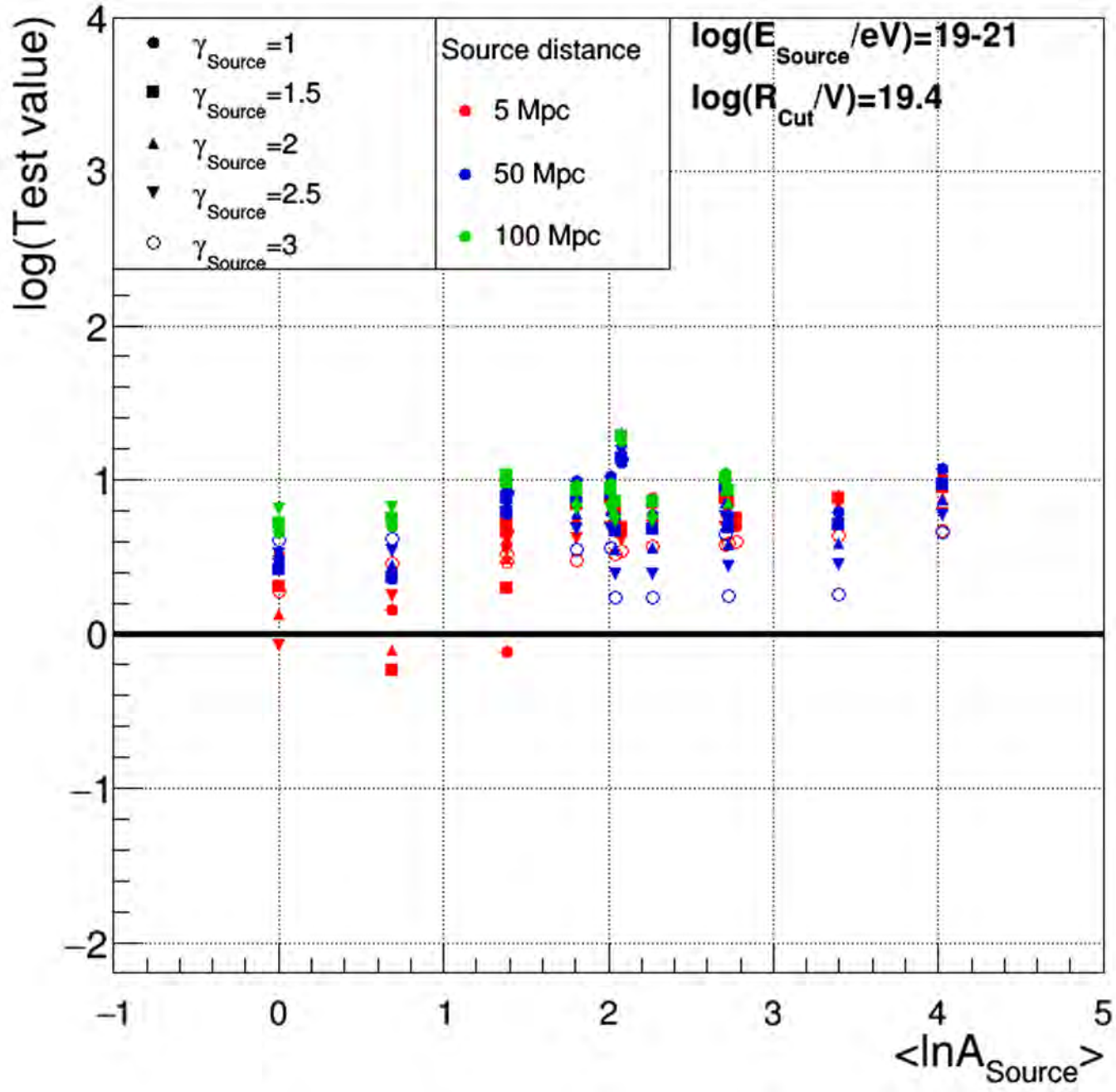
Combination	$<\ln A_{\mathrm{Source}}>$
H	0
He	1.386
O	2.773
Fe	4.025
H+He	0.693
H+O	1.386
H+Fe	2.013
He+O	2.079
He+Fe	2.706
O+Fe	3.399
H+He+O	1.386
H+He+Fe	1.804
H+O+Fe	2.266
He+O+Fe	2.728
H+He+O+Fe	2.046

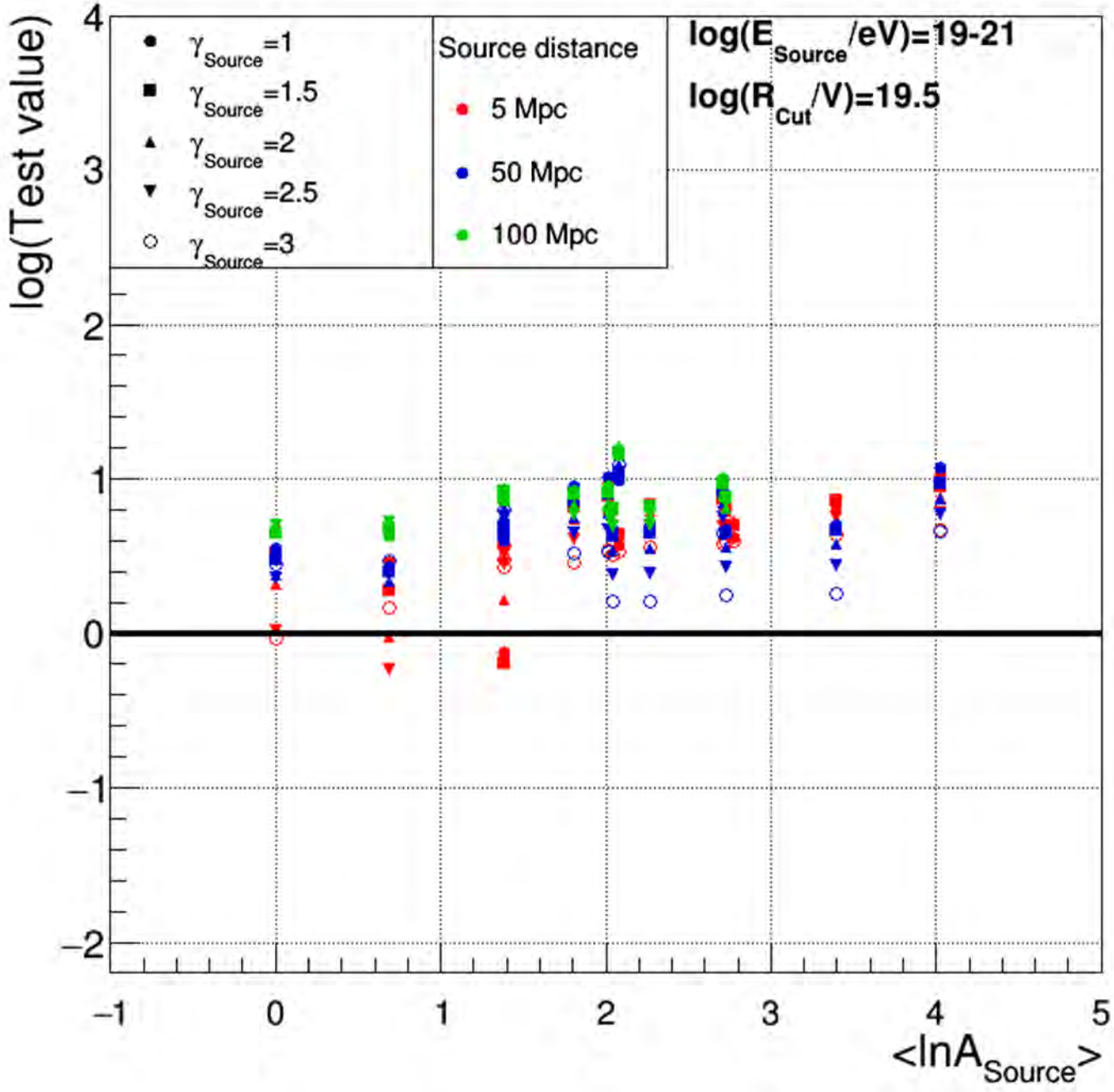

log(Test value)
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=19.0

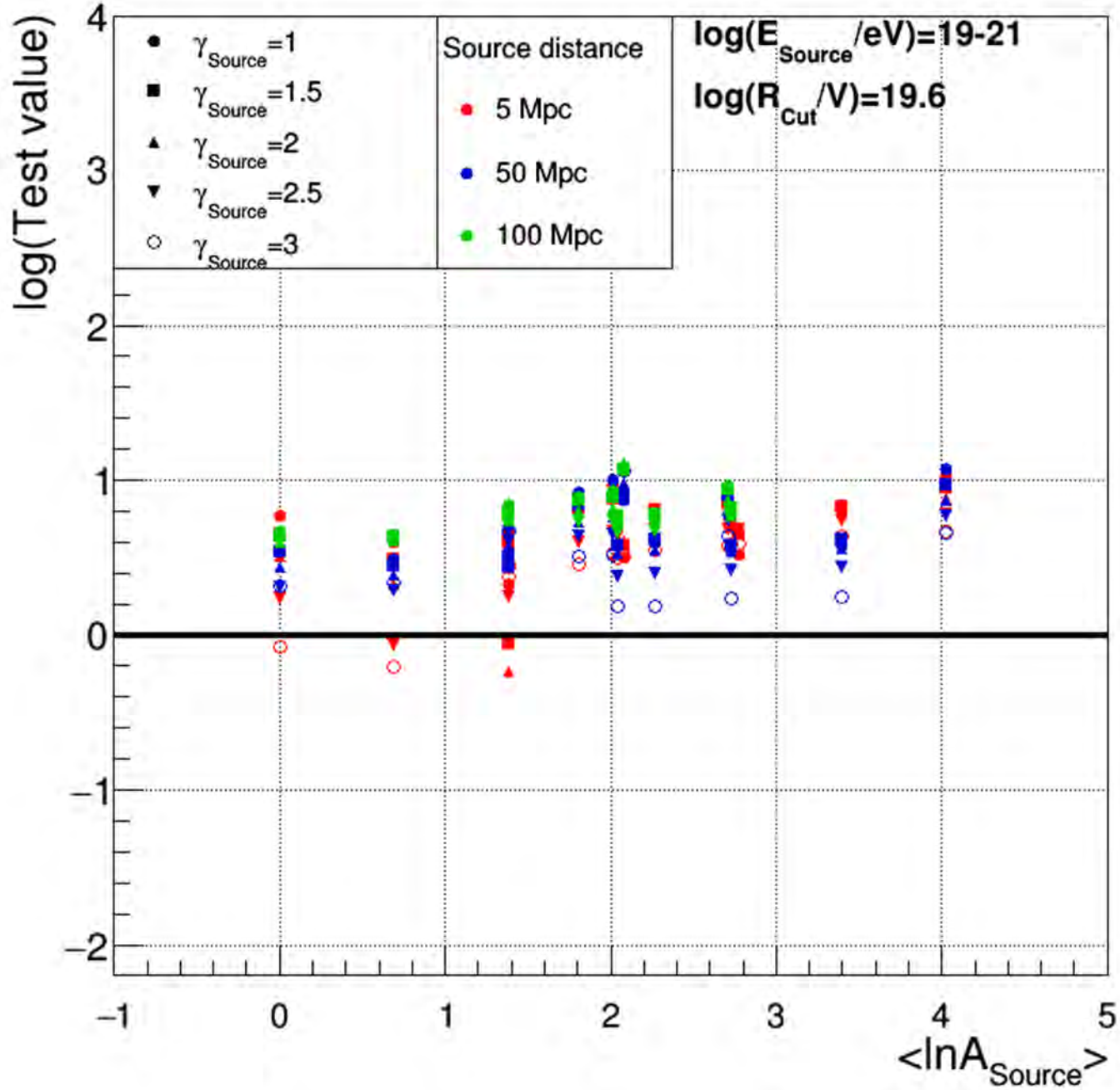

log(Test value)
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=19.1

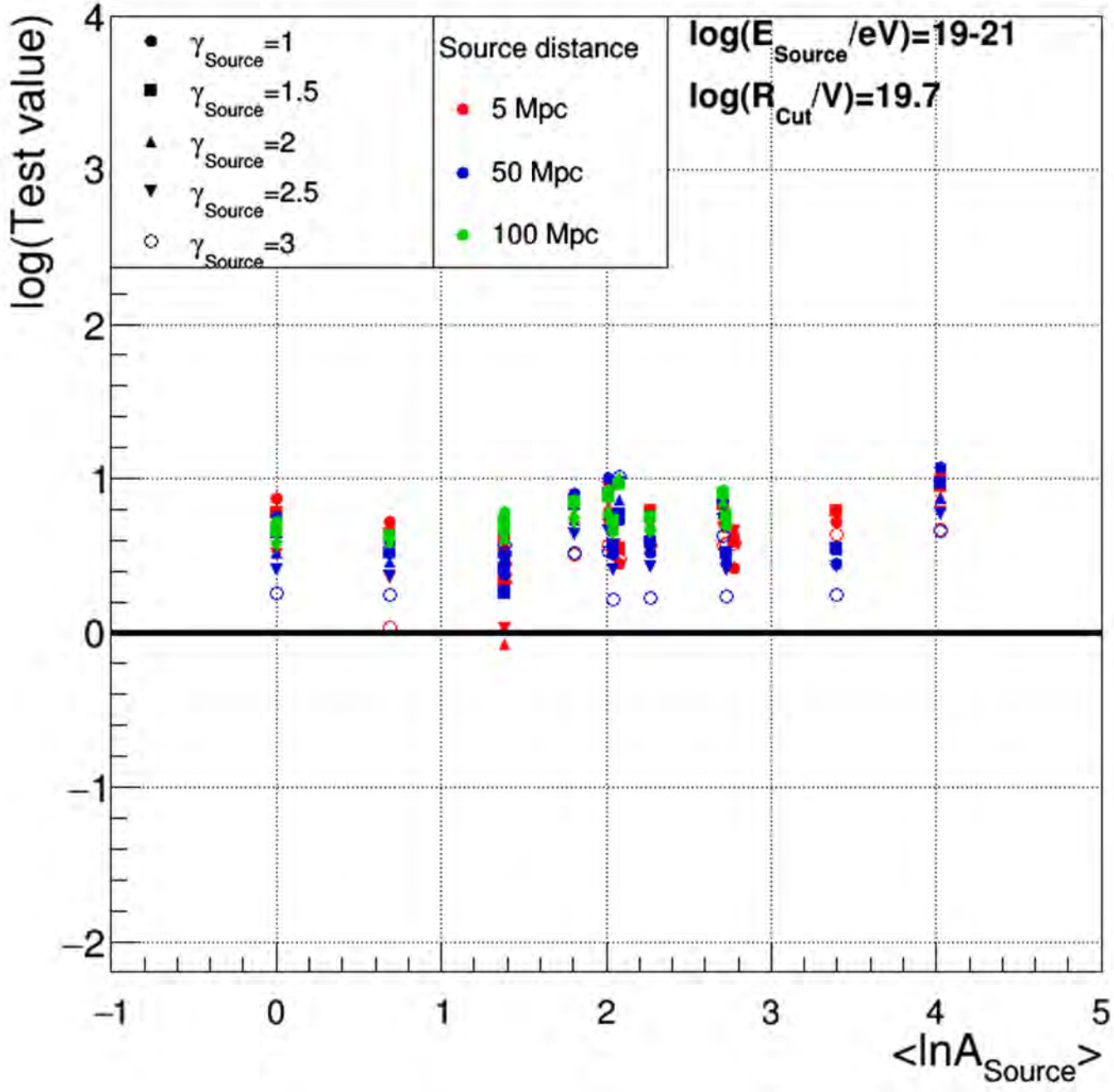

log(Test value)
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=19.2

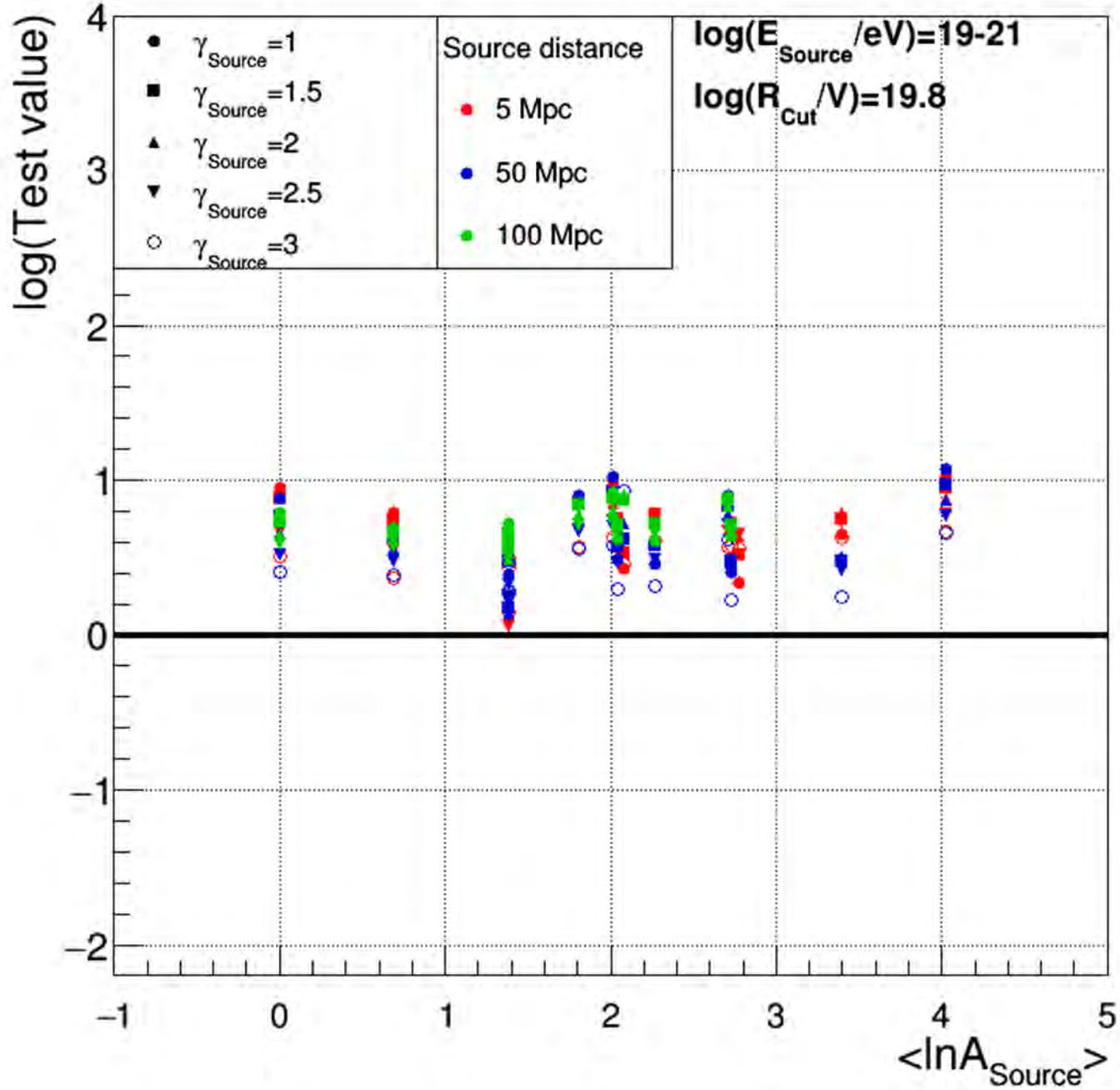

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=19.3
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5

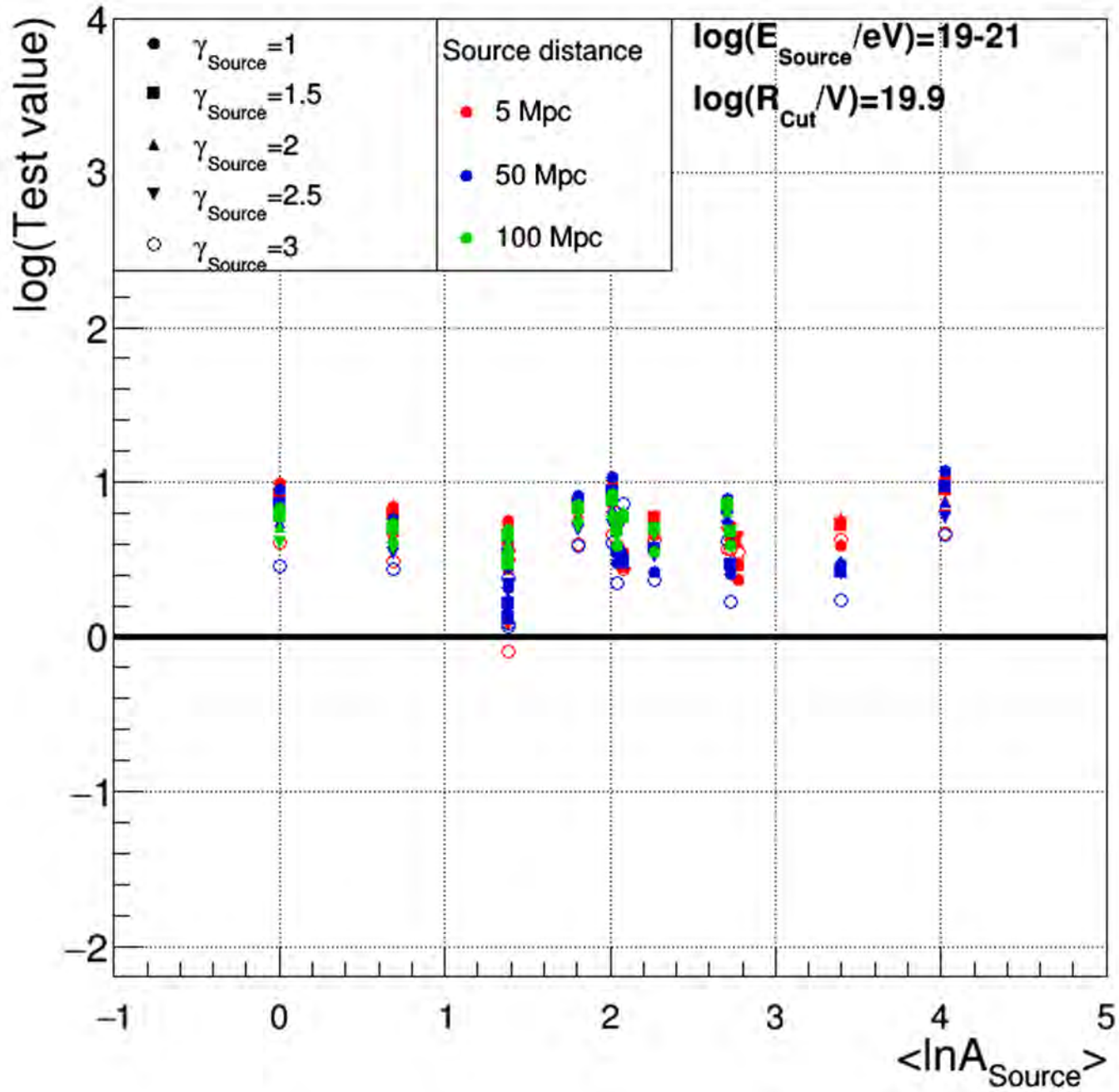

log(Test value)
γ_{Source}=1
γ_{Source}=1.5
γ_{Source}=2
γ_{Source}=2.5
γ_{Source}=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_{Source}/eV)=19-21
log(R_{Cut}/V)=19.4
<lnA$_{Source}$>
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5

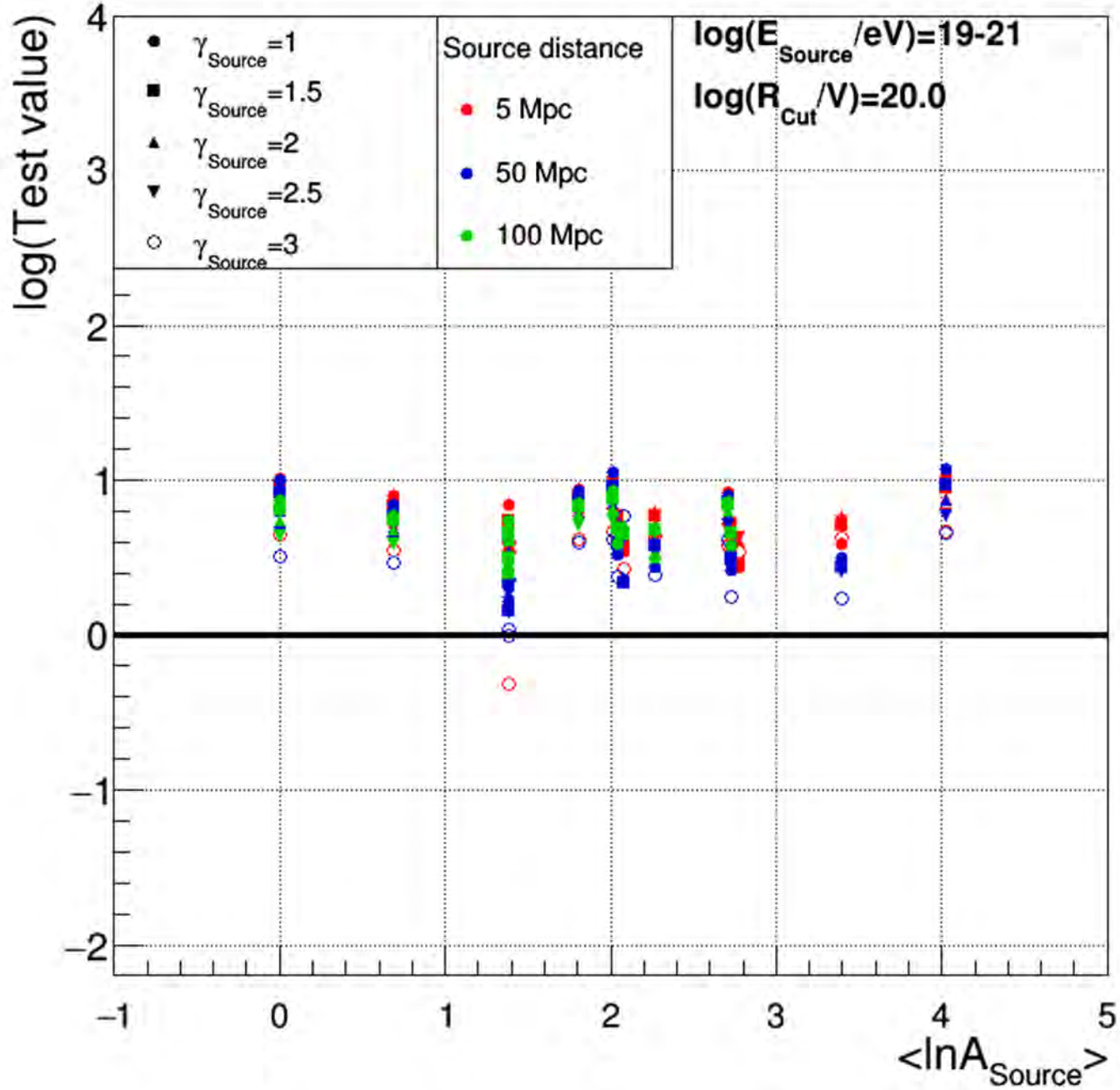

log(Test value)
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=19.5

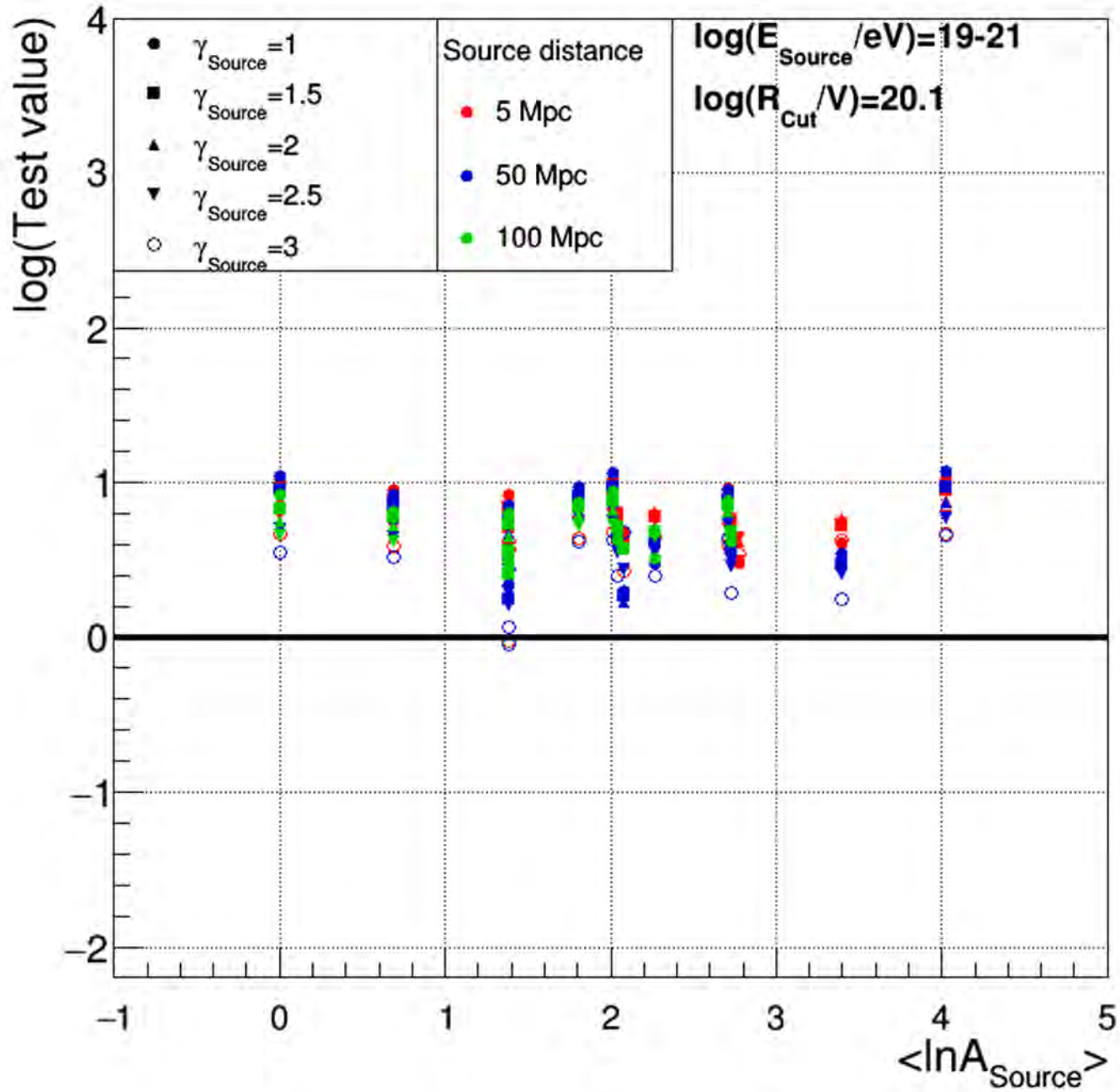

log(Test value)
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=19.6

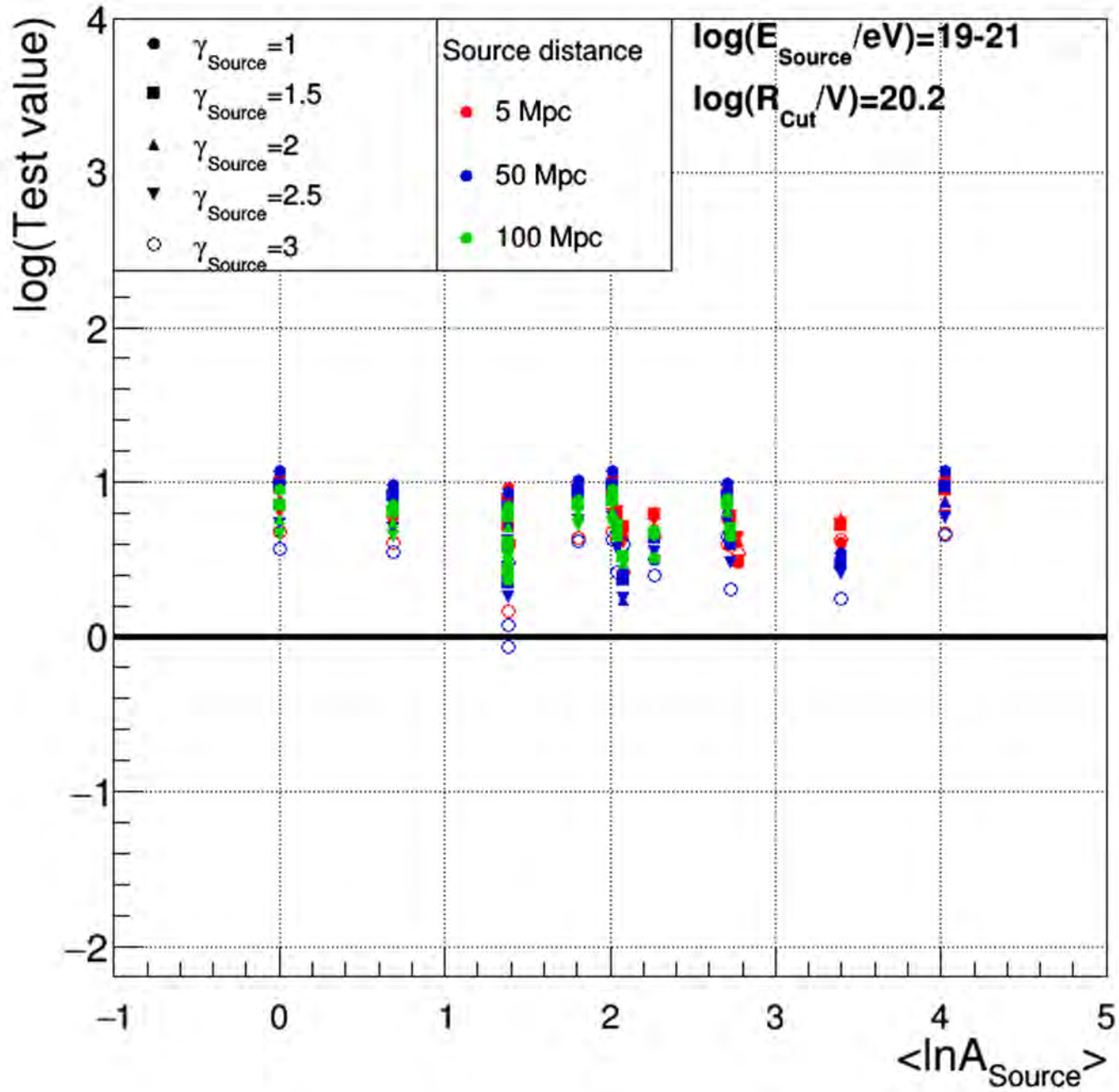

log(Test value)
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=19.7

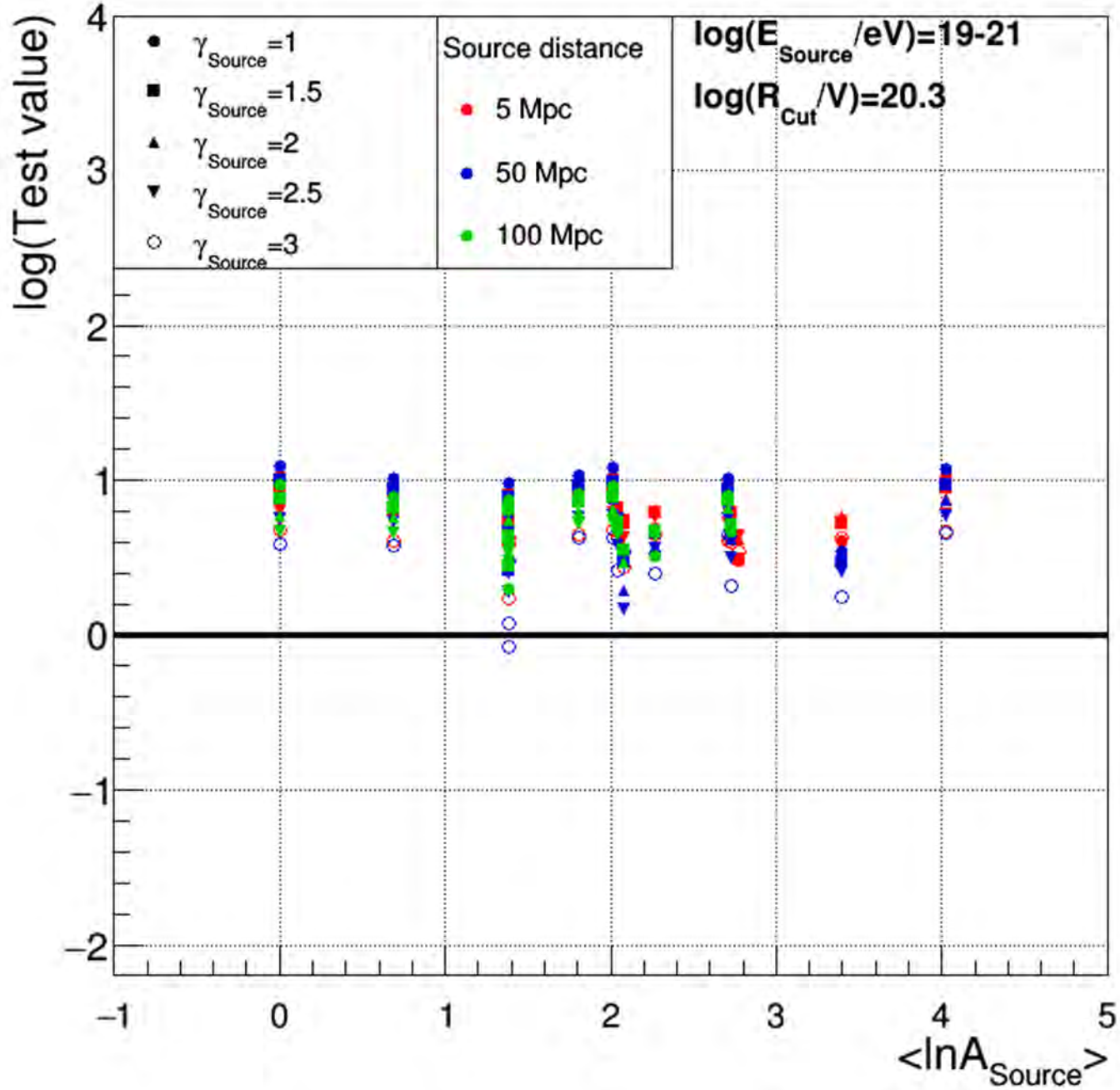

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=19.8
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc

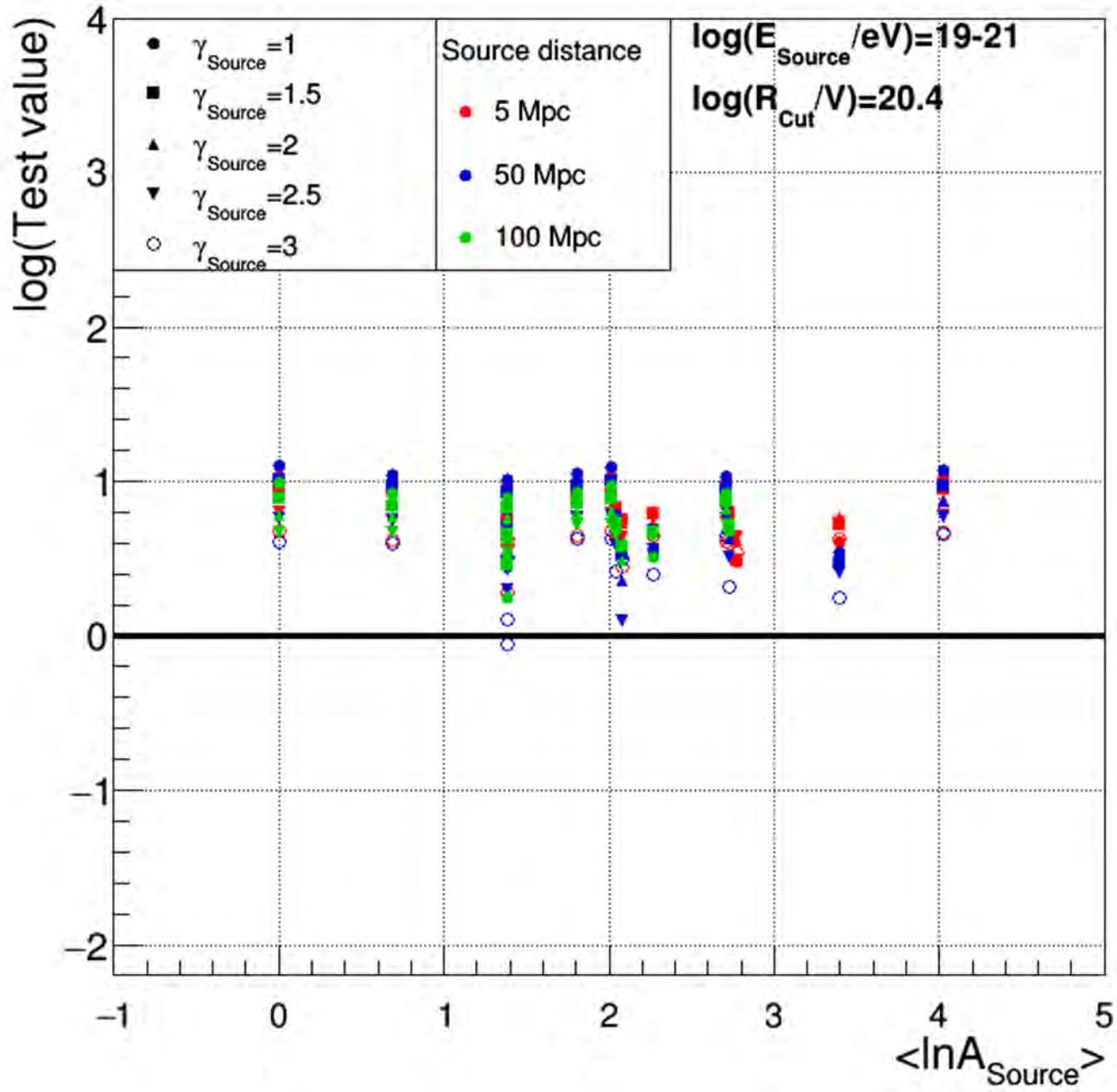

log(Test value)
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=19.9

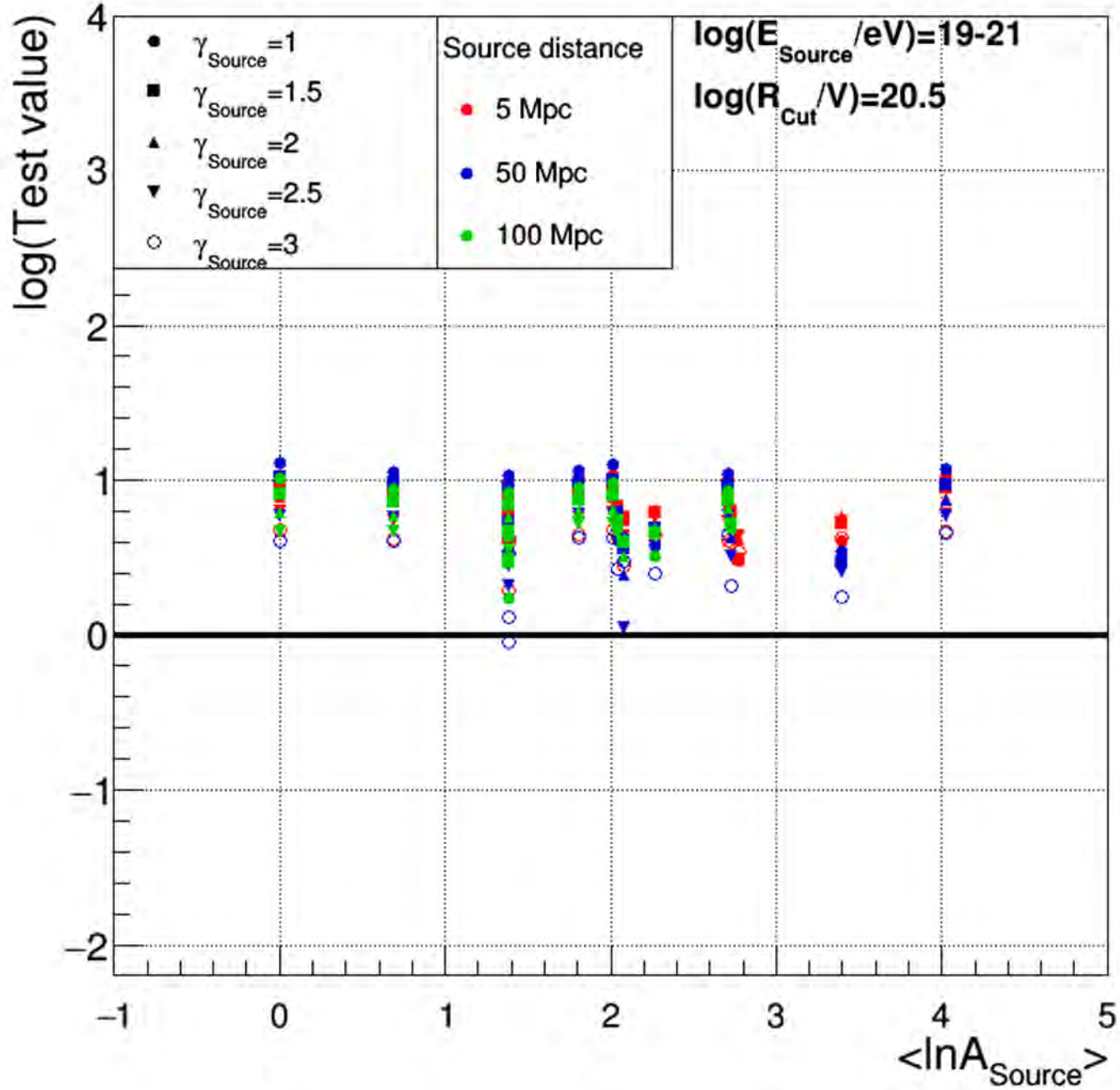

log(Test value)
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=20.0

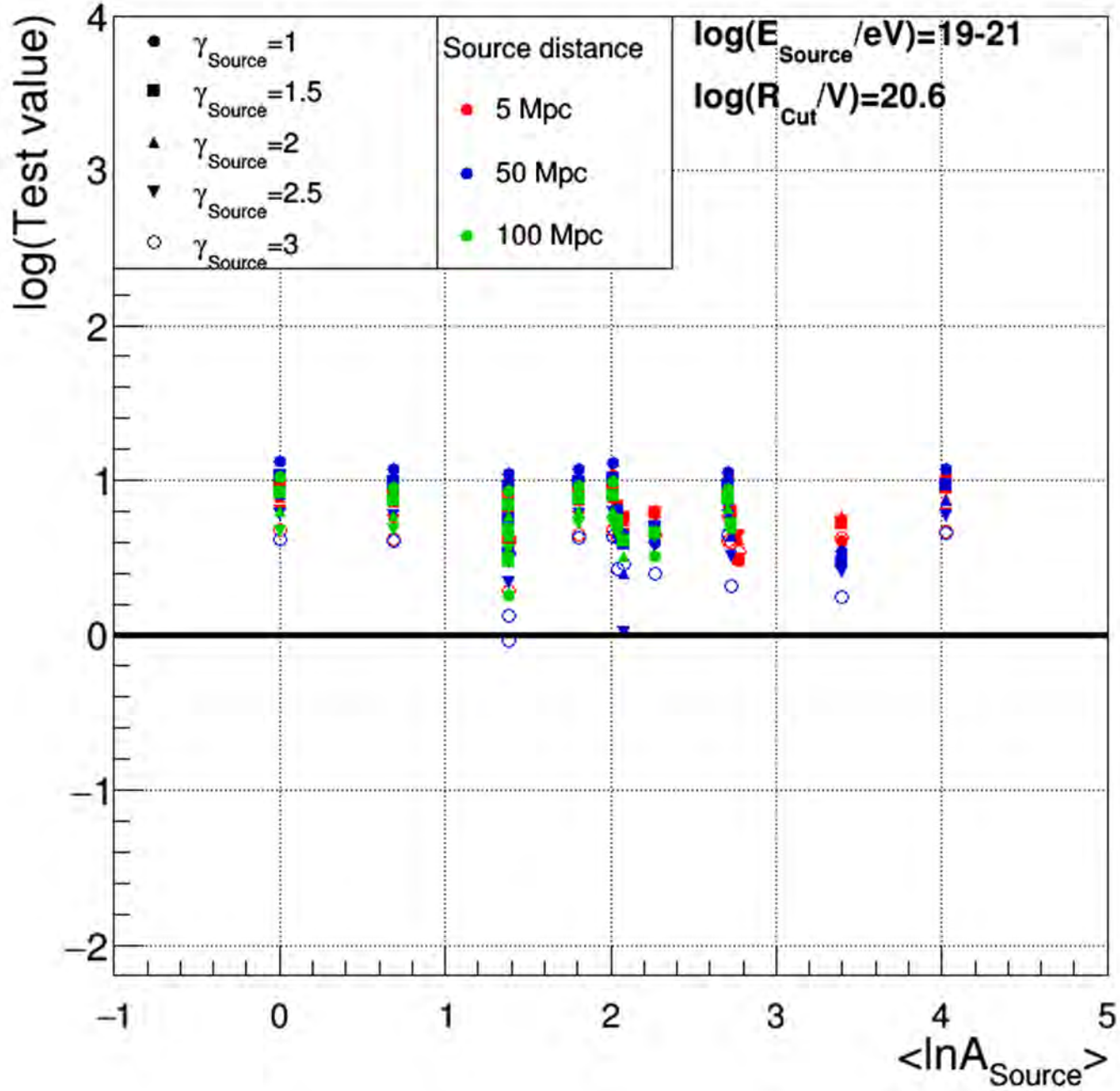

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=20.1
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc

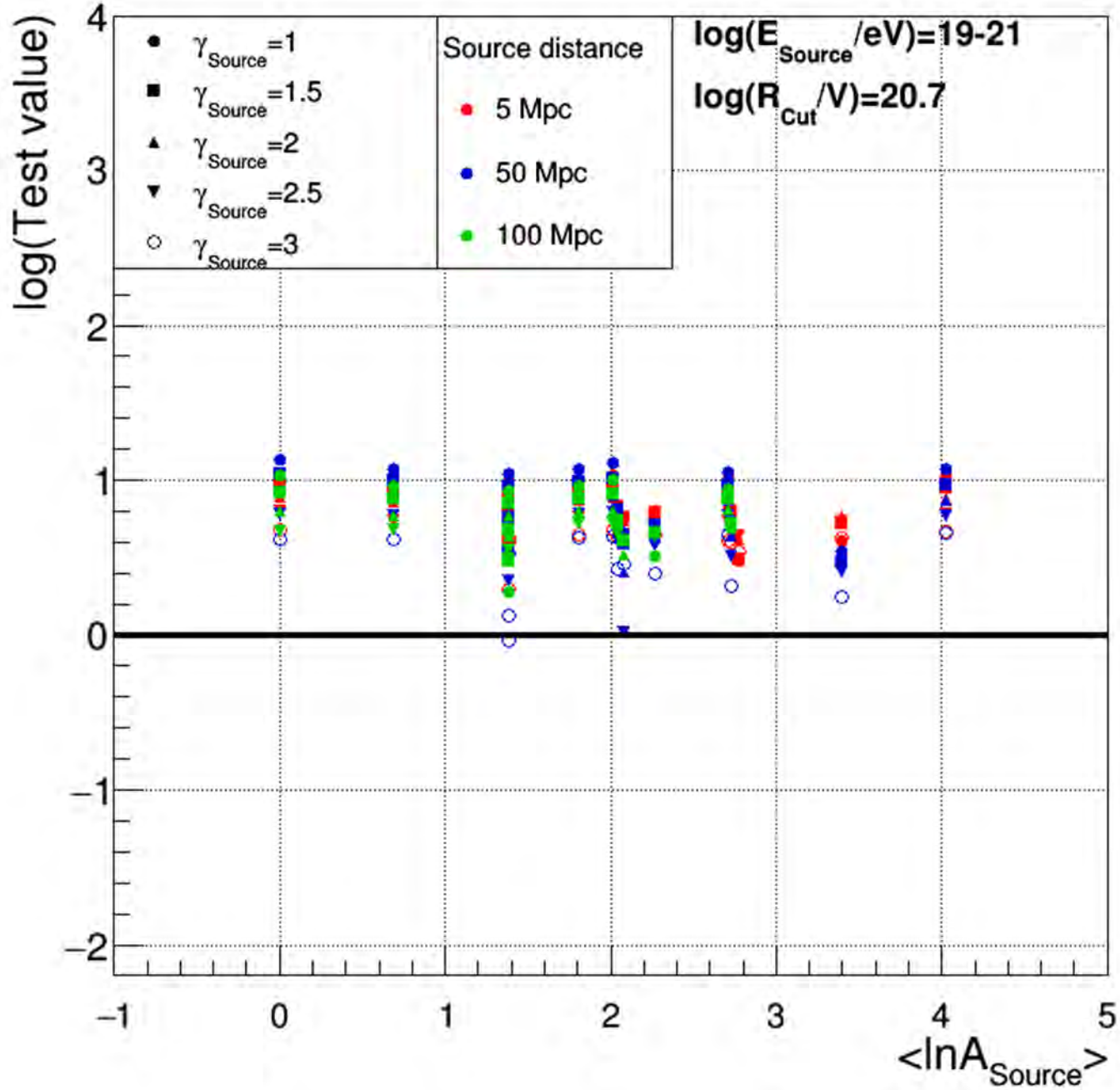

log(Test value)
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=20.2

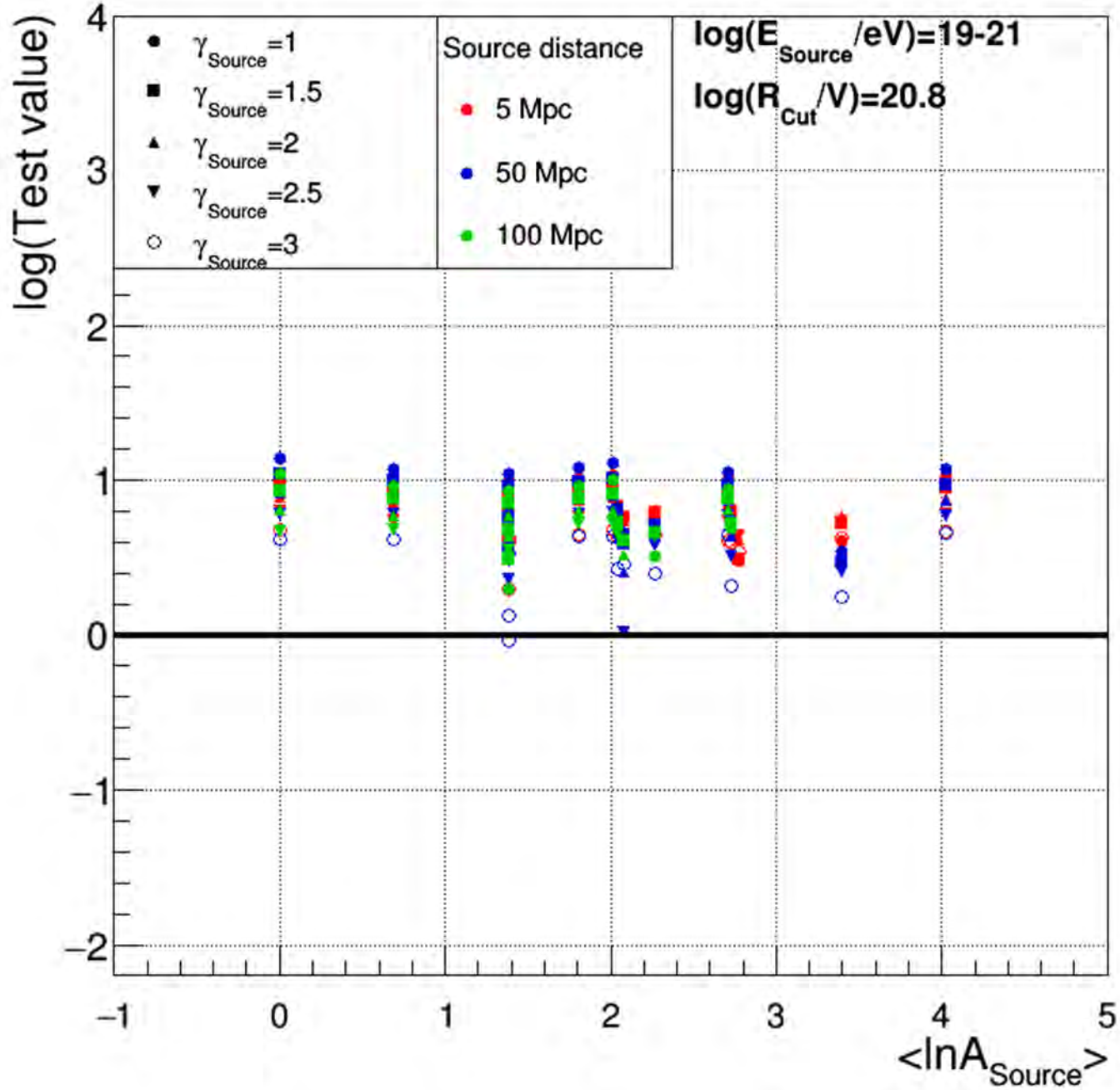

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=20.3
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5

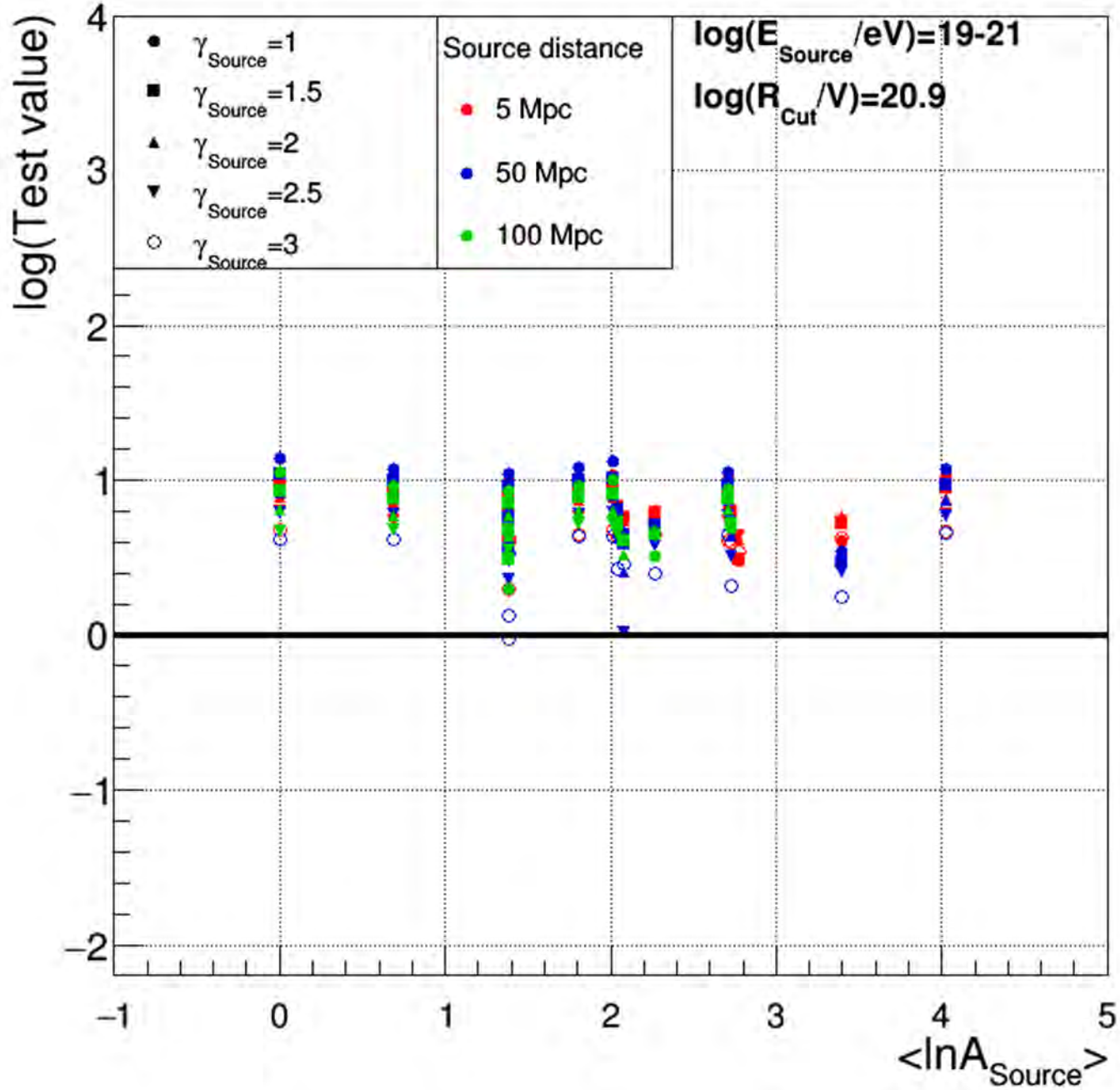

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=20.4
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5

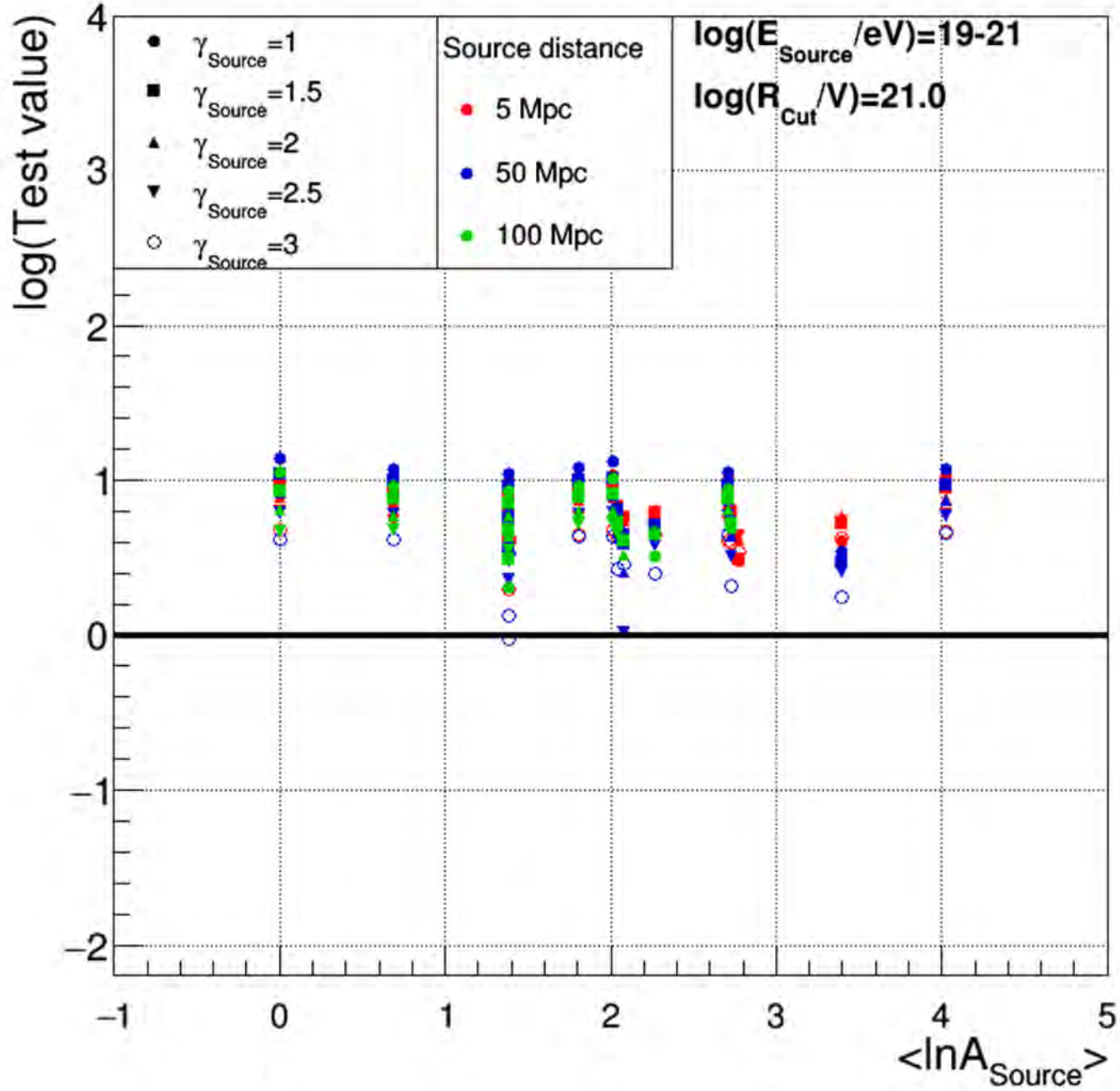

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=20.5
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc

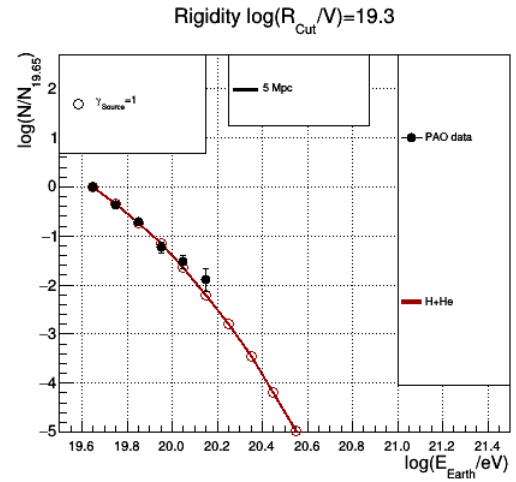

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=20.6
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc

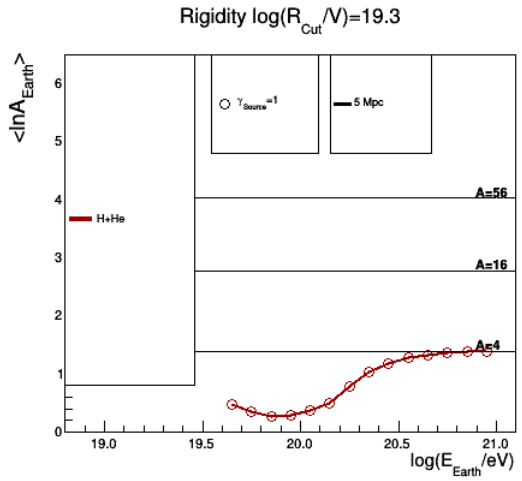

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=20.7
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5

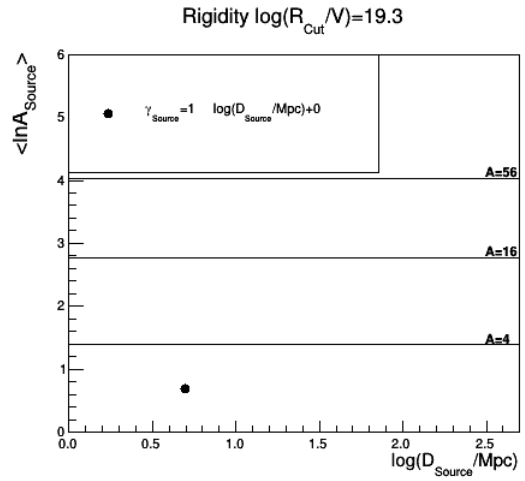

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=20.8
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
4
3
2
1
0
−1
−2
−1
0
1
2
3
4
5

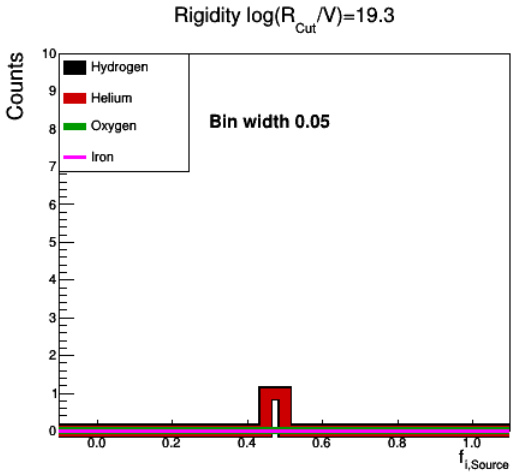

log(Test value)
<lnA_Source>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc
log(E_Source/eV)=19-21
log(R_Cut/V)=20.9

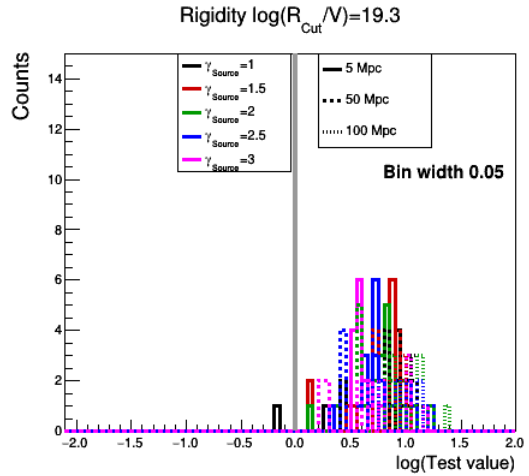

log(Test value)
<lnA_Source>
log(E_Source/eV)=19-21
log(R_Cut/V)=21.0
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
Source distance
5 Mpc
50 Mpc
100 Mpc

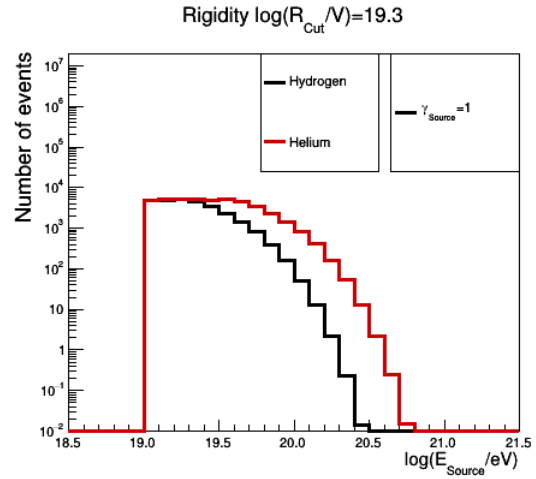

Rigidity log(R_Cut/V)=19.3
log(N/N_19.65)
γ_Source=1
5 Mpc
PAO data
H+He
log(E_Earth/eV)

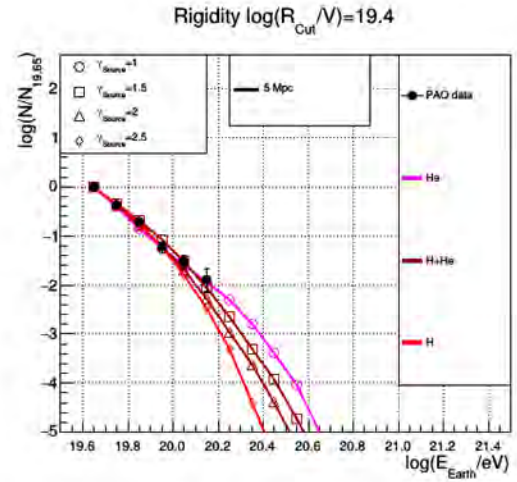

Rigidity log(R_Cut/V)=19.3
<lnA_Earth>
γ_Source=1
5 Mpc
H+He
A=56
A=16
A=4
log(E_Earth/eV)

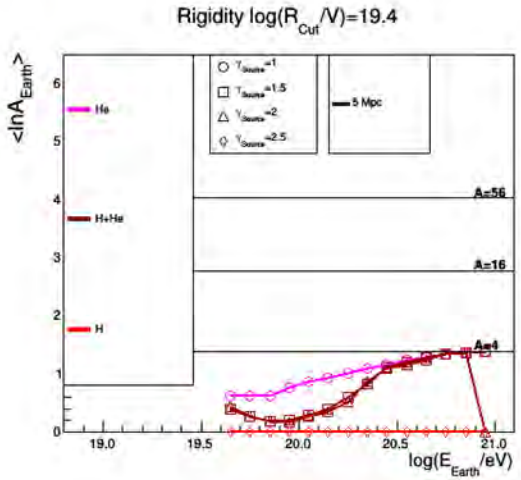

Rigidity log(R_Cut/V)=19.3
<lnA_Source>
γ_Source=1
log(D_Source/Mpc)+0
A=56
A=16
A=4
log(D_Source/Mpc)

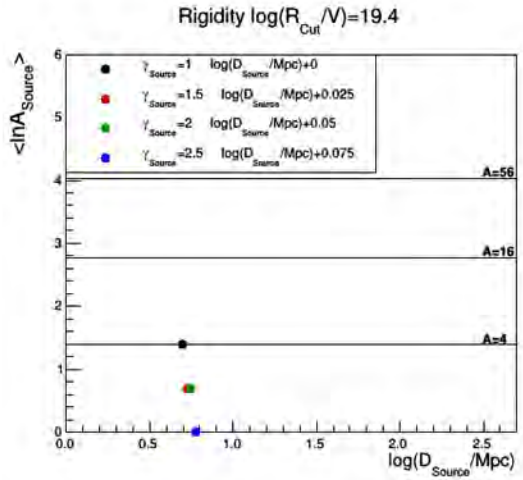

Rigidity log(R_Cut/V)=19.3
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

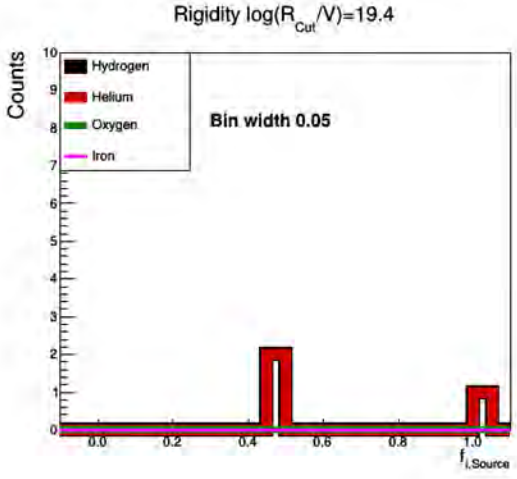

Rigidity log(R_Cut/V)=19.3
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

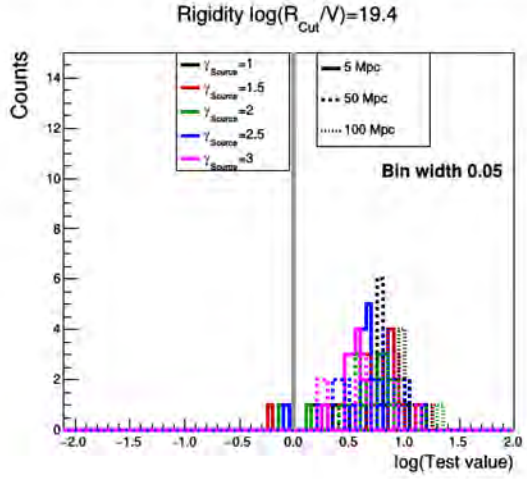

Rigidity log(R_Cut/V)=19.3
Number of events
Hydrogen
Helium
γ_Source=1
log(E_Source/eV)

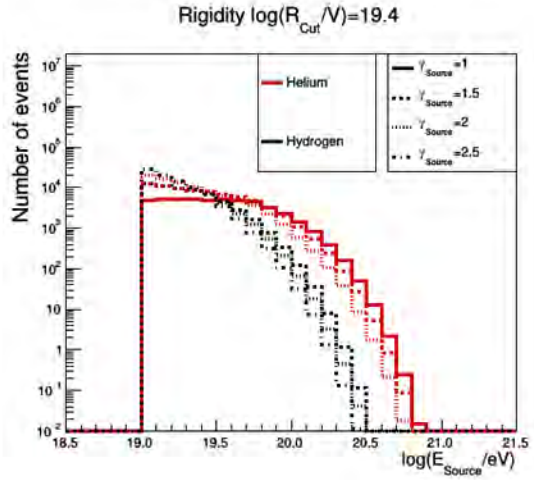

Rigidity log(R_Cut/V)=19.4
log(N/N_19.65)
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
5 Mpc
PAO data
He
H+He
H
log(E_Earth/eV)

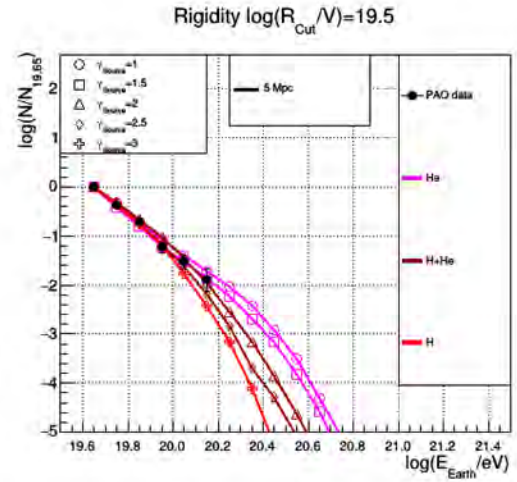

Rigidity log(R_Cut/V)=19.4
<lnA_Earth>
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
5 Mpc
He
H+He
H
A=56
A=16
A=4
log(E_Earth/eV)

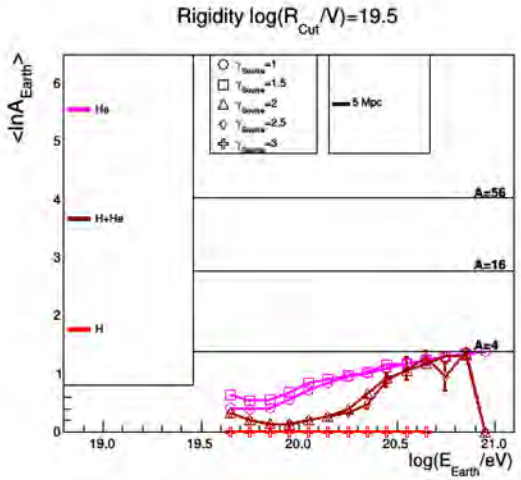

Rigidity log(R_Cut/V)=19.4
<lnA_Source>
γ_Source=1 log(D_Source/Mpc)+0
γ_Source=1.5 log(D_Source/Mpc)+0.025
γ_Source=2 log(D_Source/Mpc)+0.05
γ_Source=2.5 log(D_Source/Mpc)+0.075
A=56
A=16
A=4
log(D_Source/Mpc)

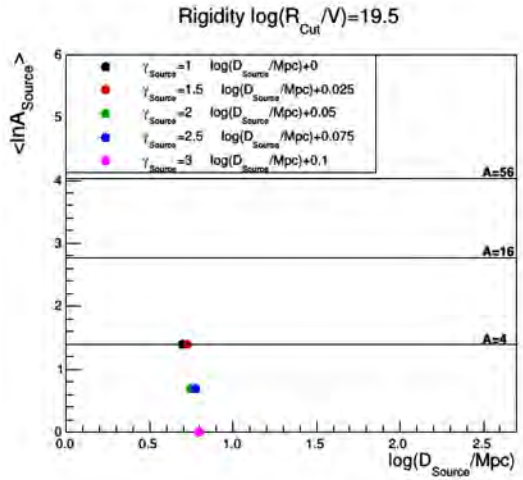

Rigidity log(R_Cut/V)=19.4
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

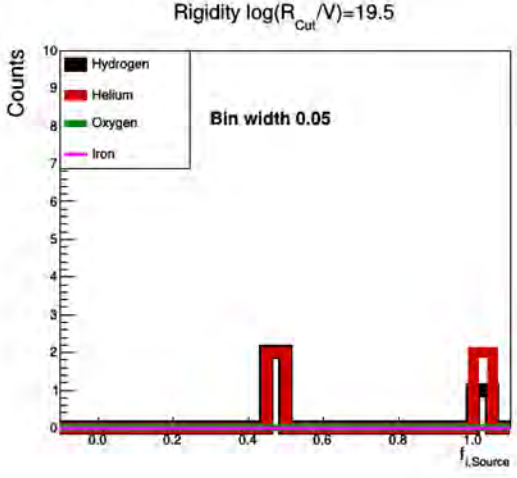

Rigidity log(R_Cut/V)=19.4
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

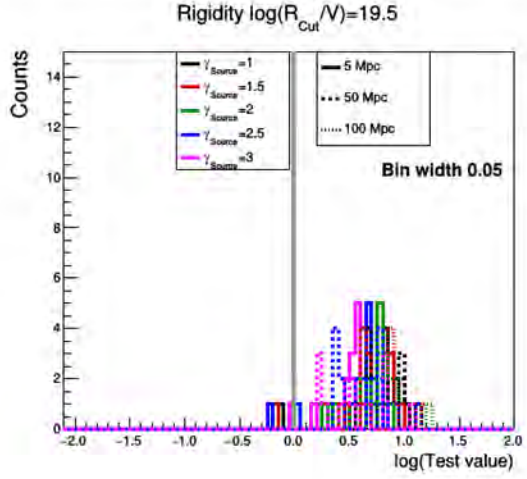

Rigidity log(R_Cut/V)=19.4
Number of events
Helium
Hydrogen
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
log(E_Source/eV)

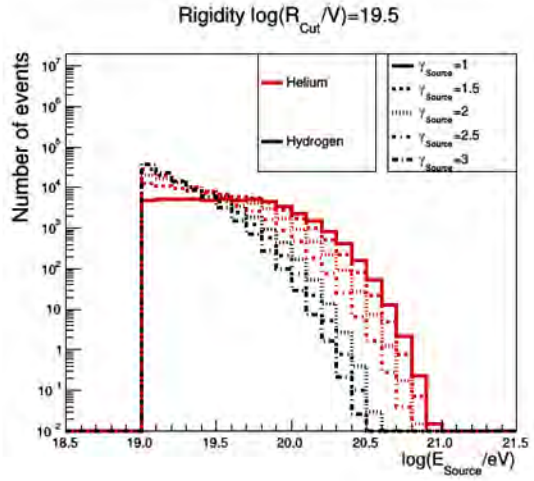

Rigidity log(R_Cut/V)=19.5
log(N/N_19.65)
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
PAO data
He
H+He
H
log(E_Earth/eV)

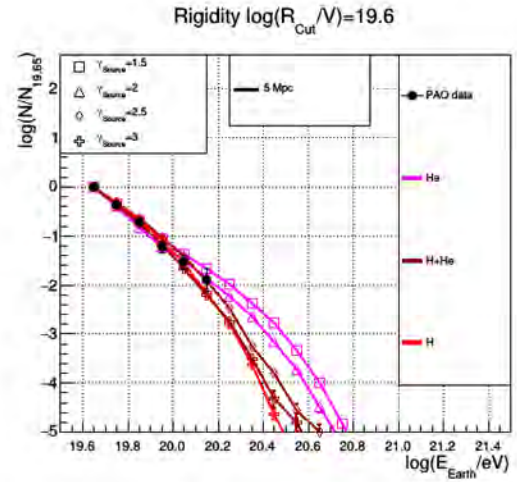

Rigidity log(R_Cut/V)=19.5
<lnA_Earth>
He
H+He
H
5 Mpc
A=56
A=16
A=4
log(E_Earth/eV)

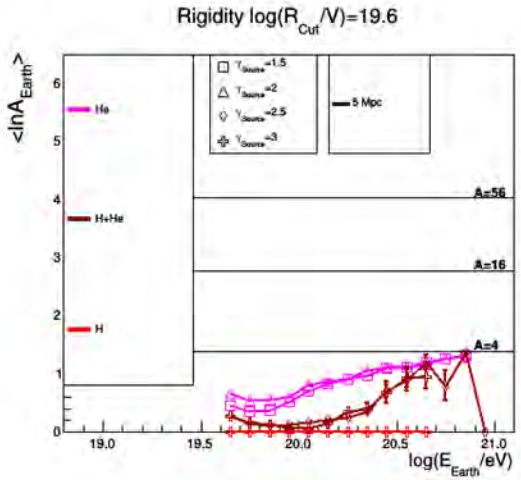

Rigidity log(R_Cut/V)=19.5
<lnA_Source>
γ_Source=1 log(D_Source/Mpc)+0
γ_Source=1.5 log(D_Source/Mpc)+0.025
γ_Source=2 log(D_Source/Mpc)+0.05
γ_Source=2.5 log(D_Source/Mpc)+0.075
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

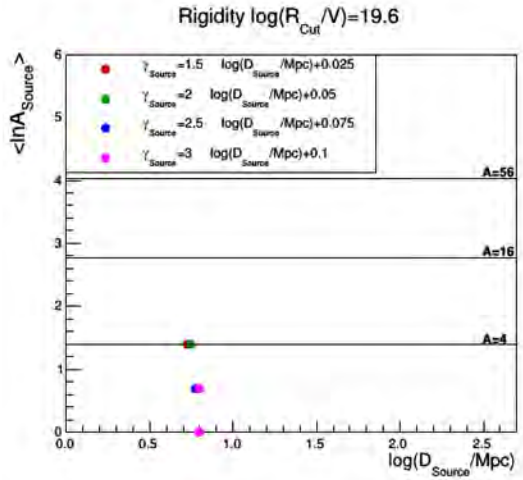

Rigidity log(R_Cut/V)=19.5
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

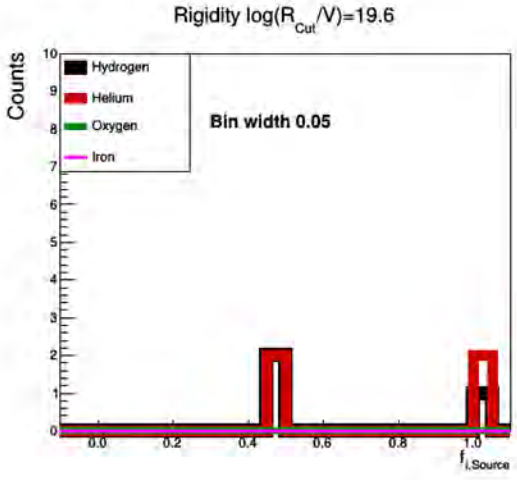

Rigidity log(R_Cut/V)=19.5
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

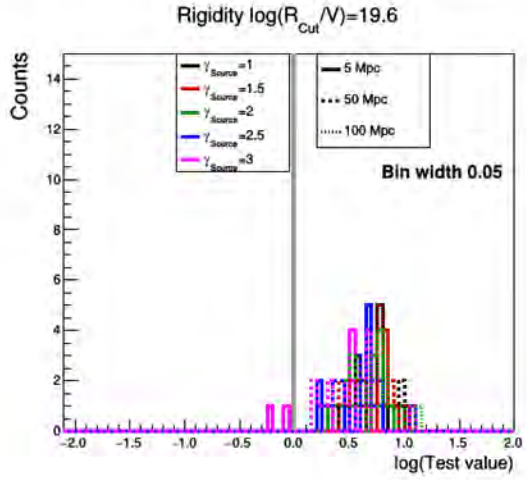

Rigidity log(R_Cut/V)=19.5
Number of events
Helium
Hydrogen
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
log(E_Source/eV)

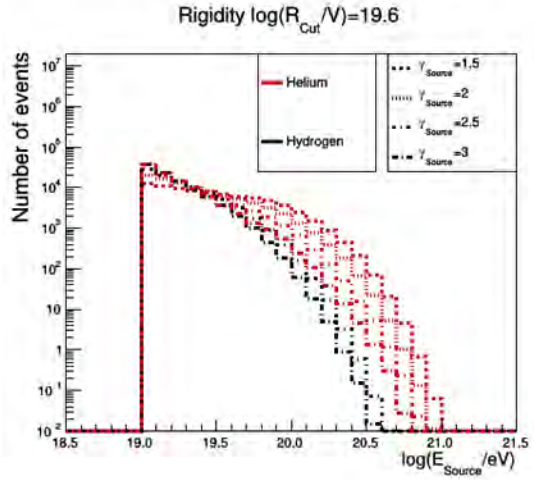

Rigidity log(R_Cut/V)=19.6
log(N/N_19.65)
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
PAO data
He
H+He
H
log(E_Earth/eV)

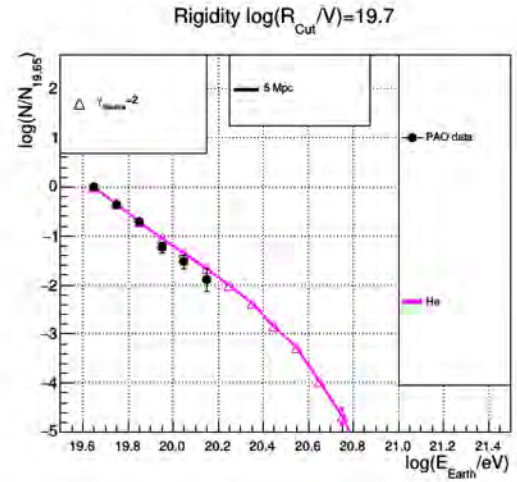

Rigidity log(R_Cut/V)=19.6
<lnA_Earth>
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
He
H+He
H
A=56
A=16
A=4
log(E_Earth/eV)

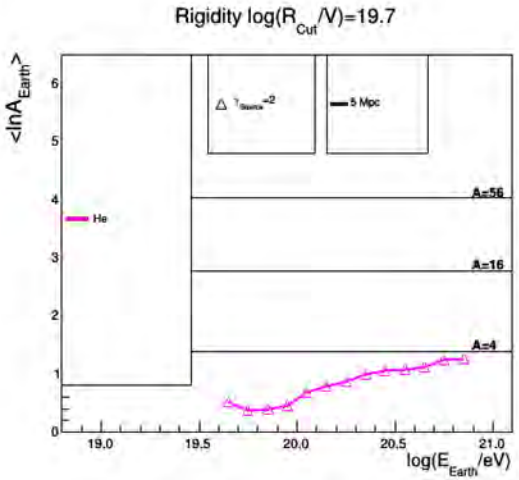

Rigidity log(R_Cut/V)=19.6
<lnA_Source>
γ_Source=1.5 log(D_Source/Mpc)+0.025
γ_Source=2 log(D_Source/Mpc)+0.05
γ_Source=2.5 log(D_Source/Mpc)+0.075
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

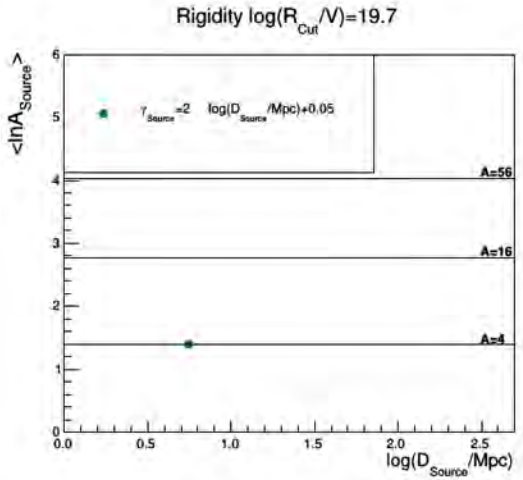

Rigidity log(R_Cut/V)=19.6
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

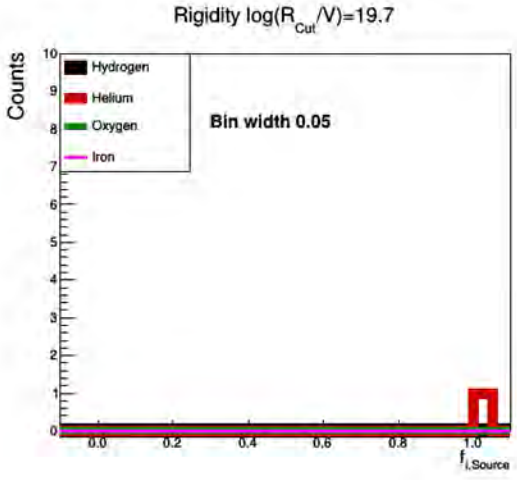

Rigidity log(R_Cut/V)=19.6
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

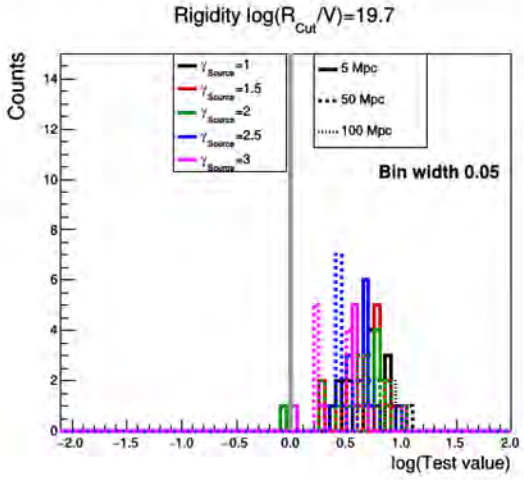

Rigidity log(R_Cut/V)=19.6
Number of events
Helium
Hydrogen
γ_Source=1,5
γ_Source=2
γ_Source=2.5
γ_Source=3
log(E_Source/eV)

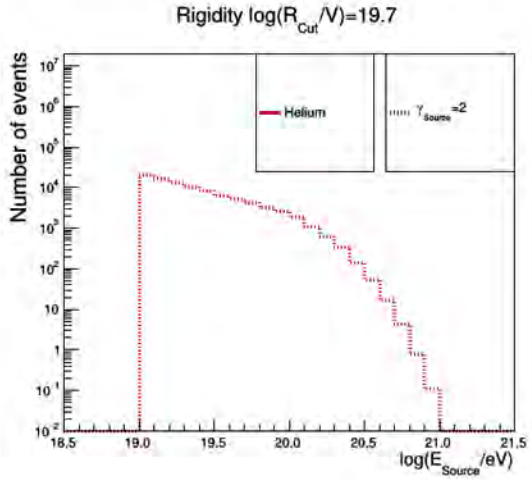

Rigidity log(R_Cut/V)=19.7
log(N/N_19.55)
γ_Source=2
5 Mpc
PAO data
He
log(E_Earth/eV)

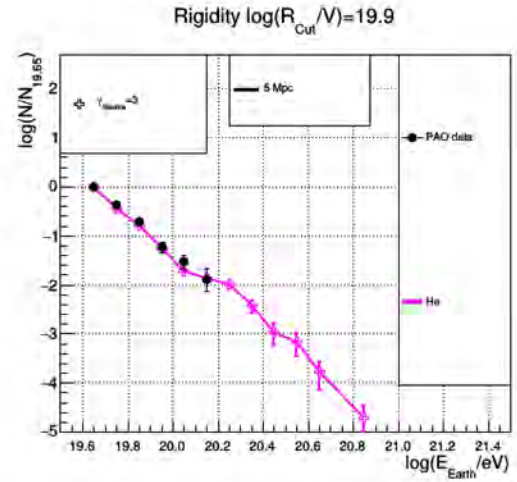

Rigidity log(R_Cut/V)=19.7
<lnA_Earth>
γ_Source=2
5 Mpc
He
A=56
A=16
A=4
log(E_Earth/eV)

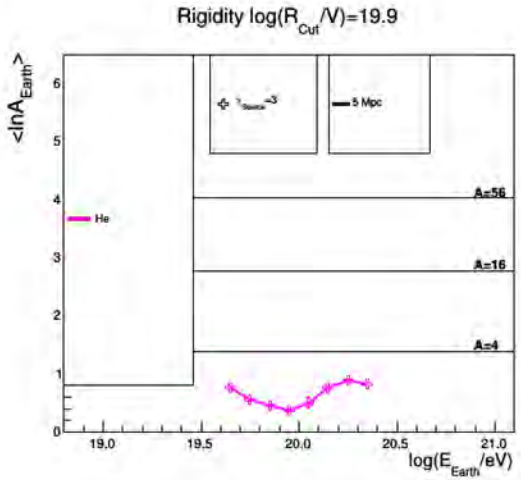

Rigidity log(R_Cut/V)=19.7
<lnA_Source>
γ_Source=2
log(D_Source/Mpc)+0.05
A=56
A=16
A=4
log(D_Source/Mpc)

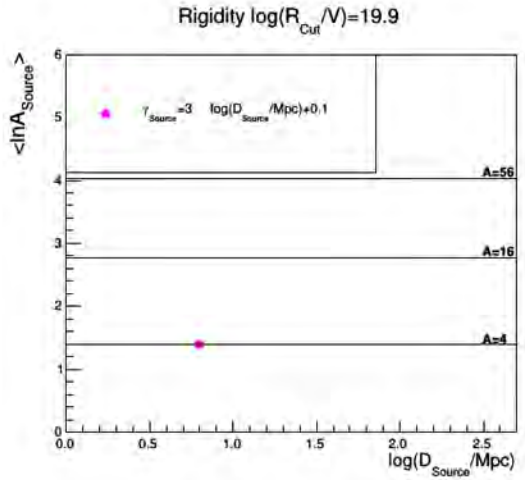

Rigidity log(R_Cut/V)=19.7
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

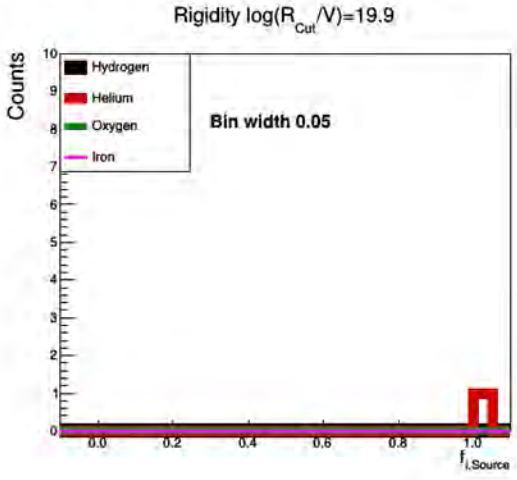

Rigidity log(R_Cut/V)=19.7
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

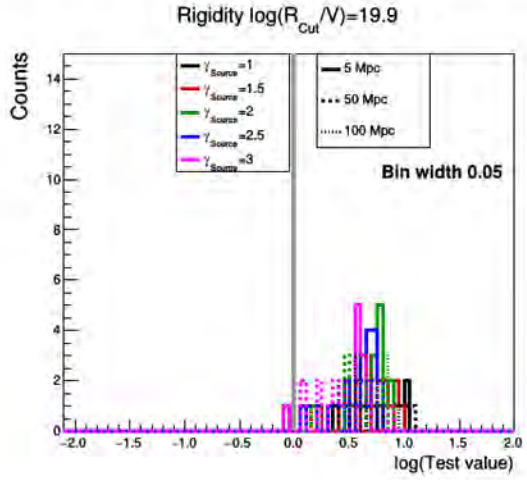

Rigidity log(R_Cut/V)=19.7
Number of events
Helium
γ_Source=2
log(E_Source/eV)

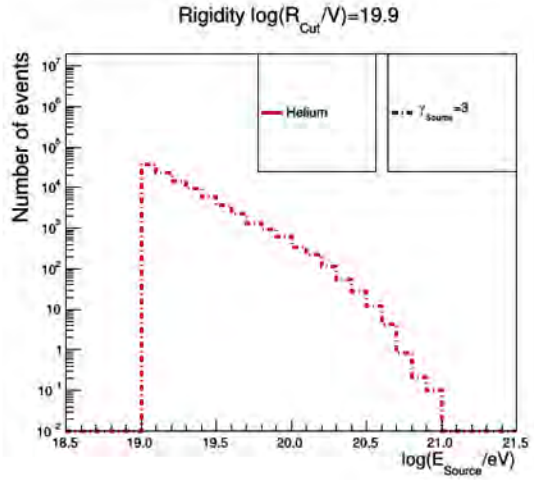

Rigidity log(R_Cut/V)=19.9
log(N/N_19.55)
γ_Source=3
5 Mpc
PAO data
He
log(E_Earth/eV)

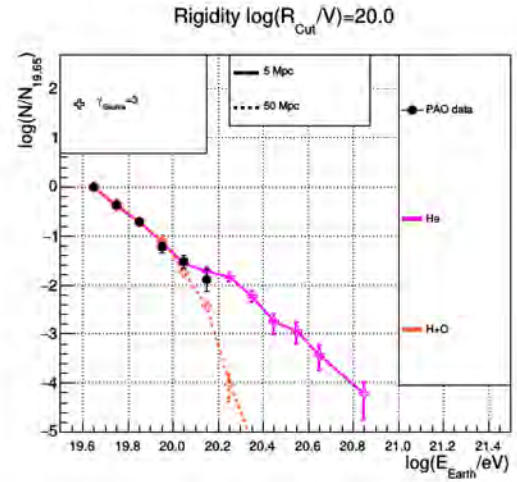

Rigidity log(R_Cut/V)=19.9
<lnA_Earth>
γ_Source=3
5 Mpc
He
A=56
A=16
A=4
log(E_Earth/eV)

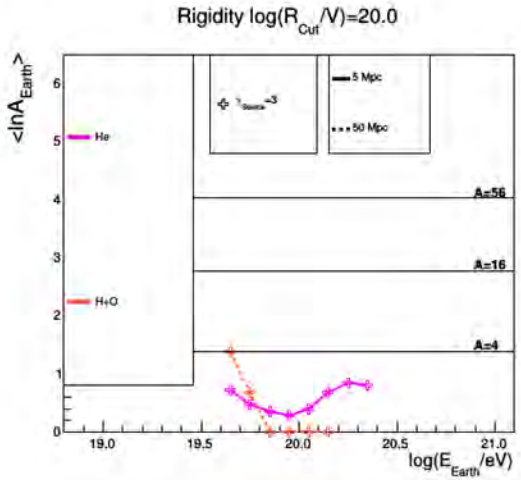

Rigidity log(R_Cut/V)=19.9
<lnA_Source>
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

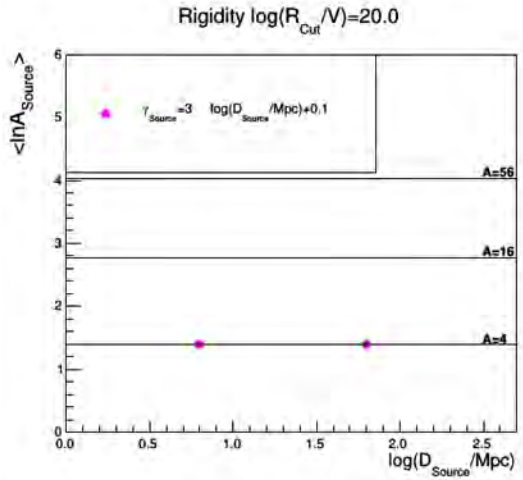

Rigidity log(R_Cut/V)=19.9
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

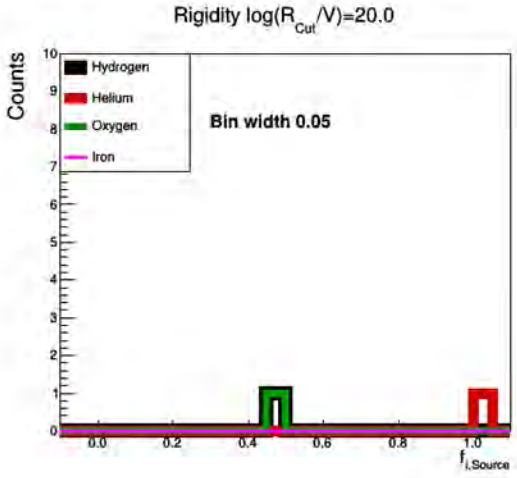

Rigidity log(R_Cut/V)=19.9
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

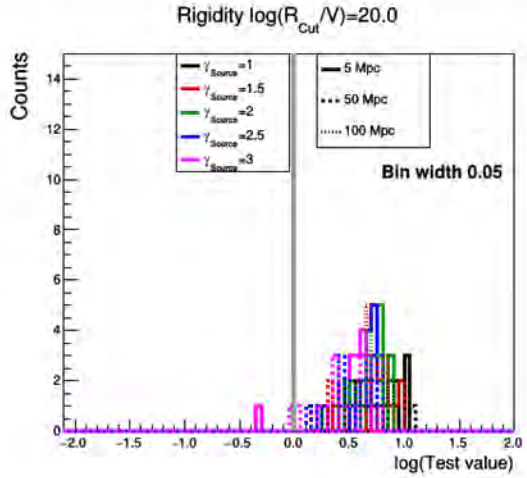

Rigidity log(R_Cut/V)=19.9
Number of events
Helium
γ_Source=3
log(E_Source/eV)

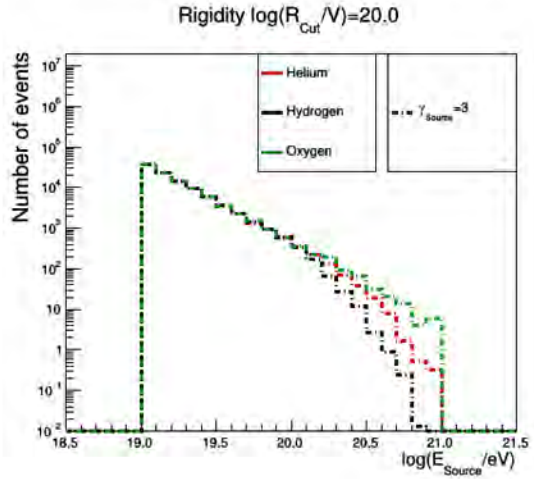

Rigidity log(R_Cut/V)=20.0
log(N/N_19.55)
γ_Source=3
5 Mpc
50 Mpc
PAO data
He
H+O
log(E_Earth/eV)

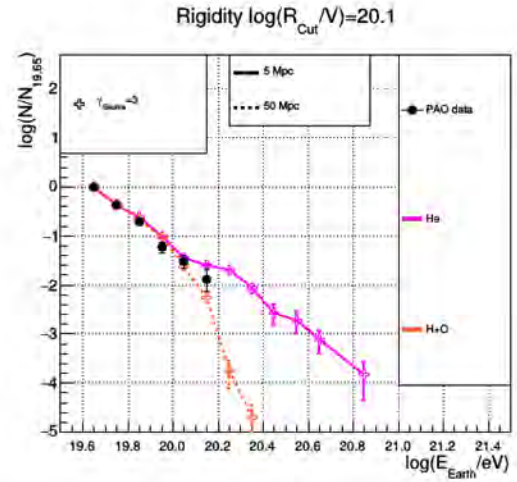

Rigidity log(R_Cut/V)=20.0
<lnA_Earth>
γ_Source=3
5 Mpc
50 Mpc
He
H+O
A=56
A=16
A=4
log(E_Earth/eV)

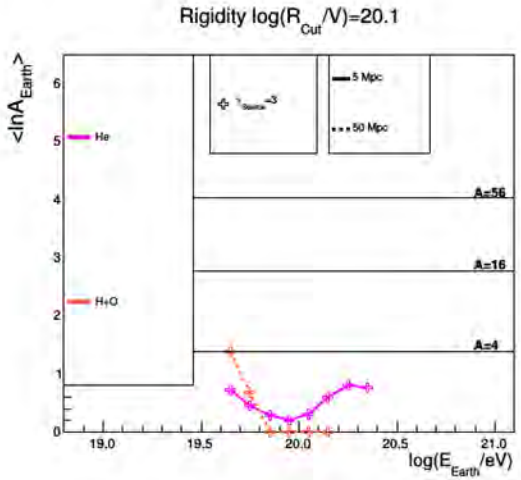

Rigidity log(R_Cut/V)=20.0
<lnA_Source>
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

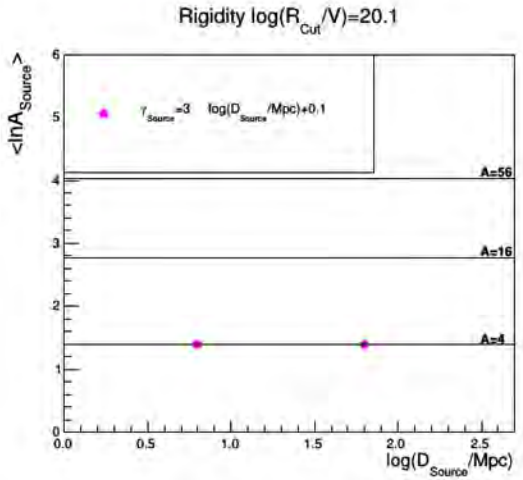

Rigidity log(R_Cut/V)=20.0
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

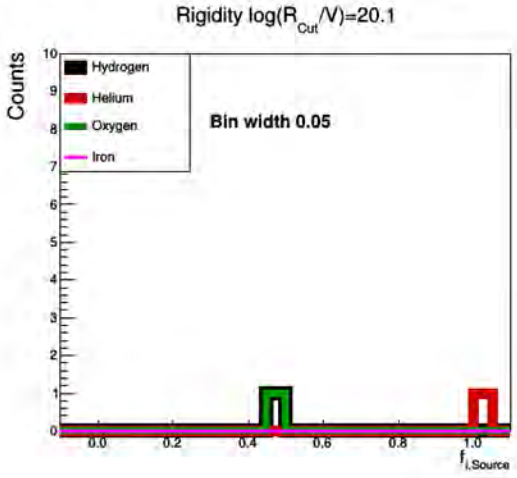

Rigidity log(R_Cut/V)=20.0
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

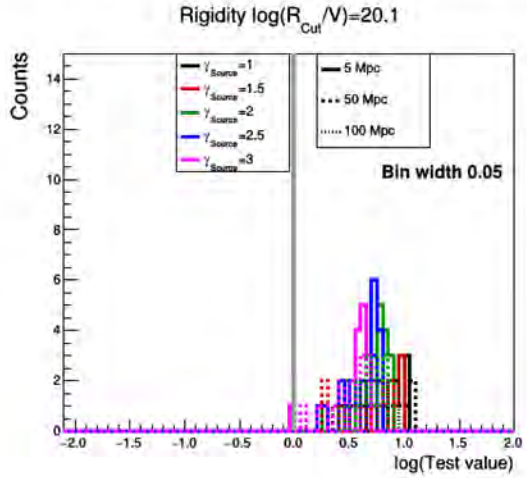

Rigidity log(R_Cut/V)=20.0
Number of events
Helium
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

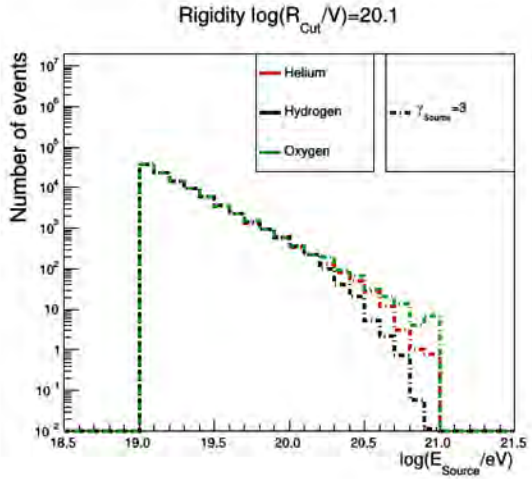

Rigidity log(R_Cut/V)=20.1
log(N/N_19.55)
5 Mpc
50 Mpc
PAO data
He
H+O
log(E_Earth/eV)

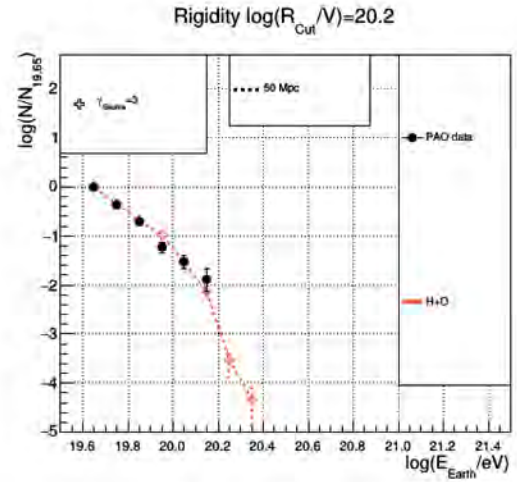

Rigidity log(R_Cut/V)=20.1
<lnA_Earth>
He
H+O
5 Mpc
50 Mpc
A=56
A=16
A=4
log(E_Earth/eV)

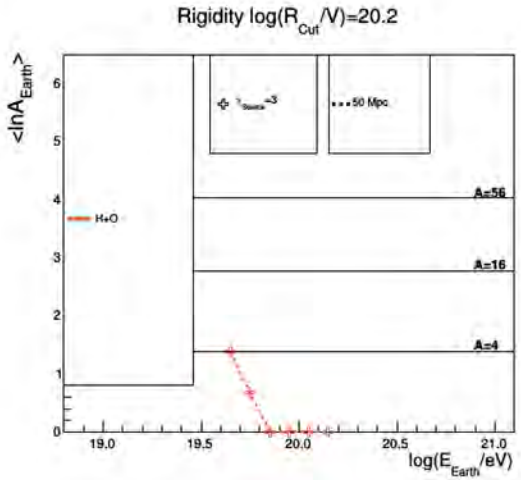

Rigidity log(R_Cut/V)=20.1
<lnA_Source>
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

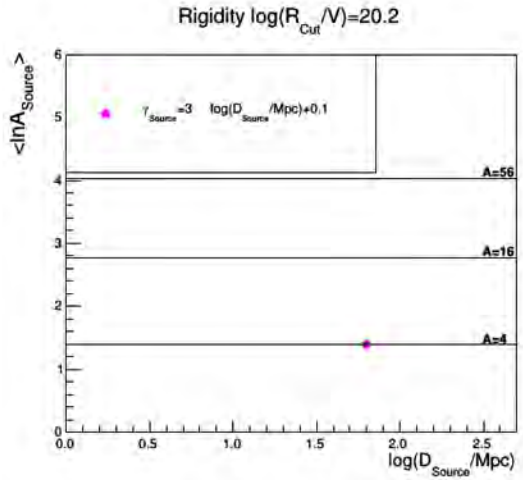

Rigidity log(R_Cut/V)=20.1
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

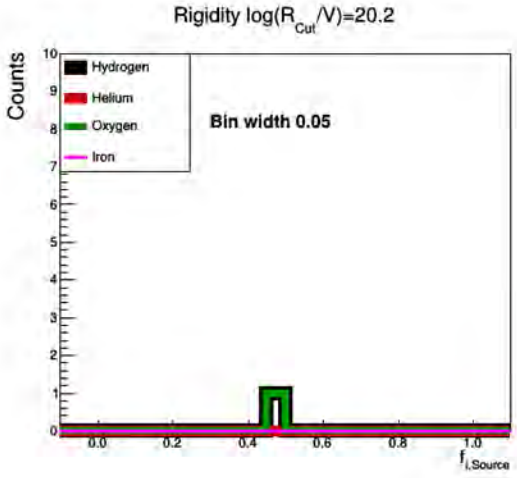

Rigidity log(R_Cut/V)=20.1
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

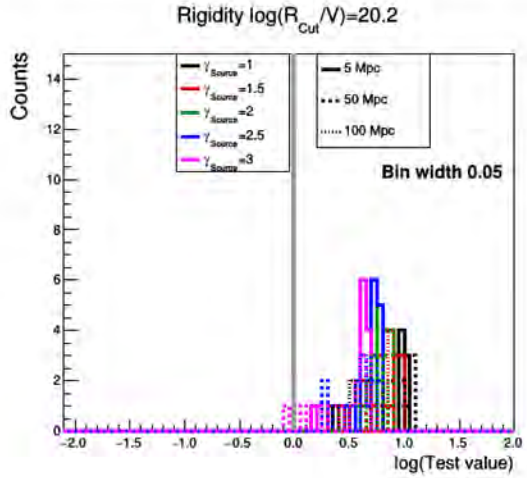

Rigidity log(R_Cut/V)=20.1
Number of events
Helium
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

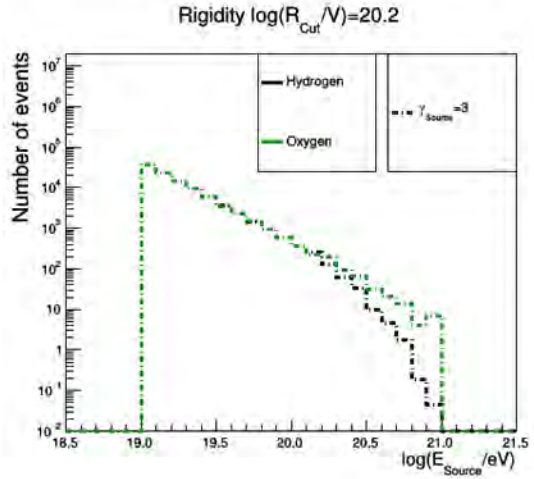

Rigidity log(R_Cut/V)=20.2
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

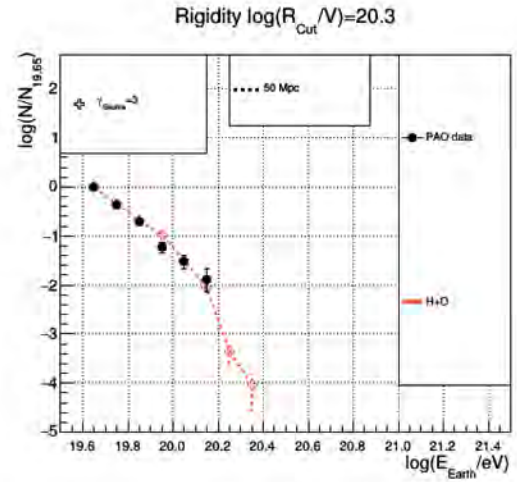

Rigidity log(R_Cut/V)=20.2
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

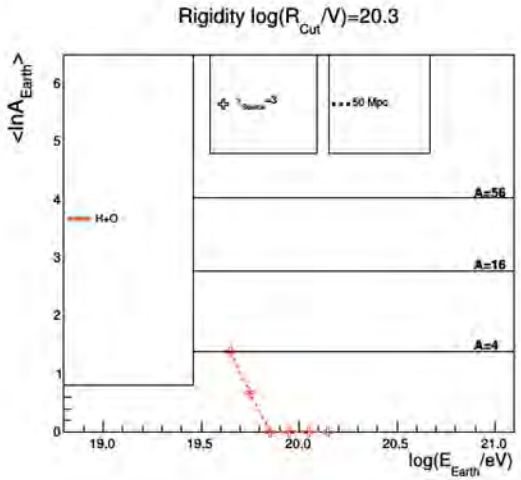

Rigidity log(R_Cut/V)=20.2
<lnA_Source>
γ_Source=3
log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

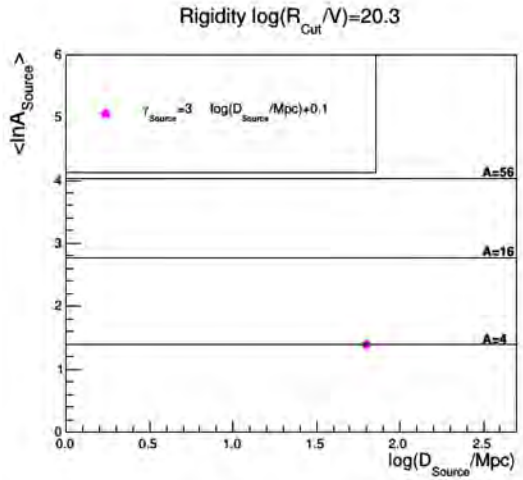

Rigidity log(R_Cut/V)=20.2
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

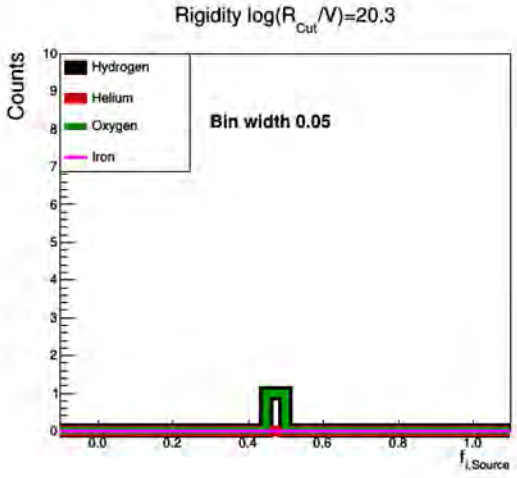

Rigidity log(R_Cut/V)=20.2
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

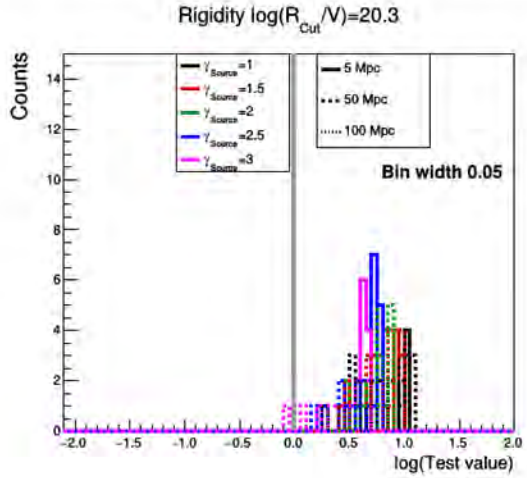

Rigidity log(R_Cut/V)=20.2
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

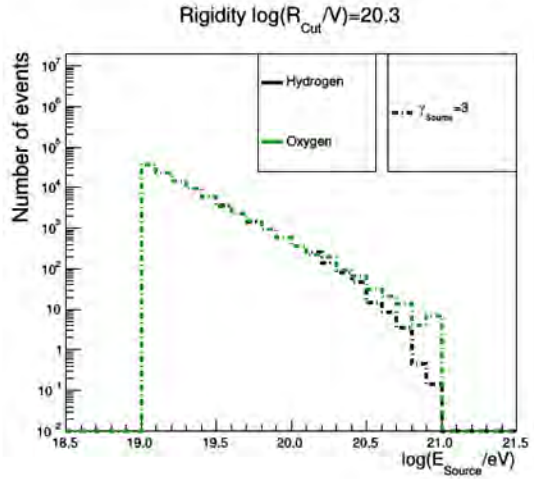

Rigidity log(R_Cut/V)=20.3
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

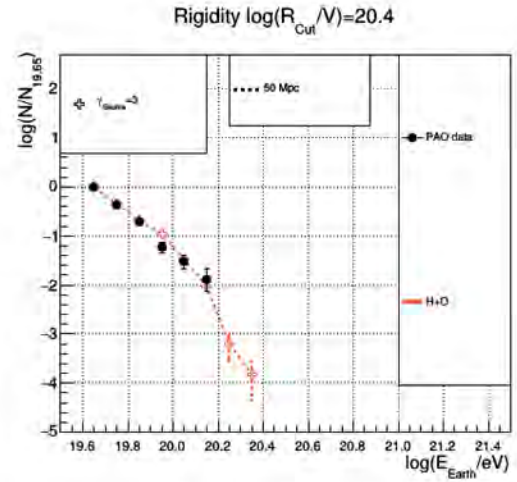

Rigidity log(R_Cut/V)=20.3
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

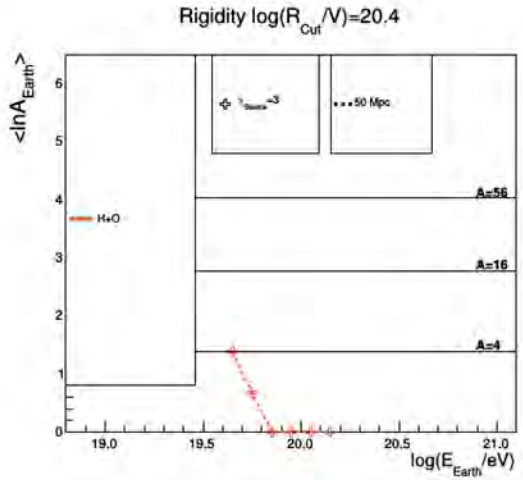

Rigidity log(R_Cut/V)=20.3
<lnA_Source>
γ_Source=3
log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

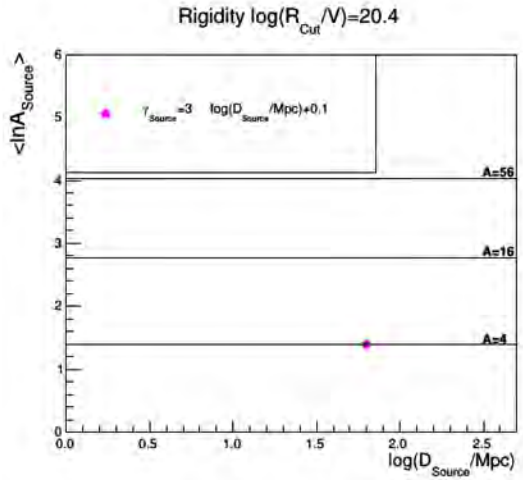

Rigidity log(R_Cut/V)=20.3
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

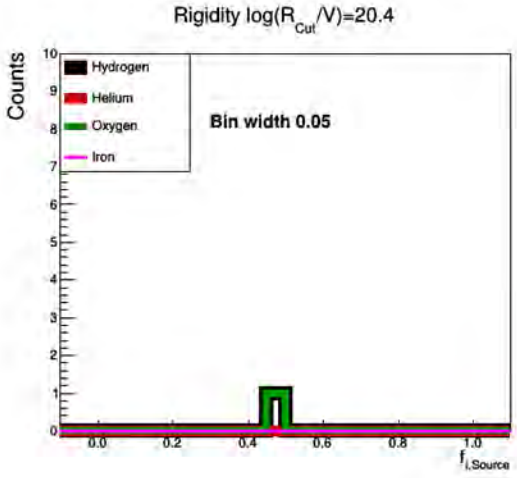

Rigidity log(R_Cut/V)=20.3
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

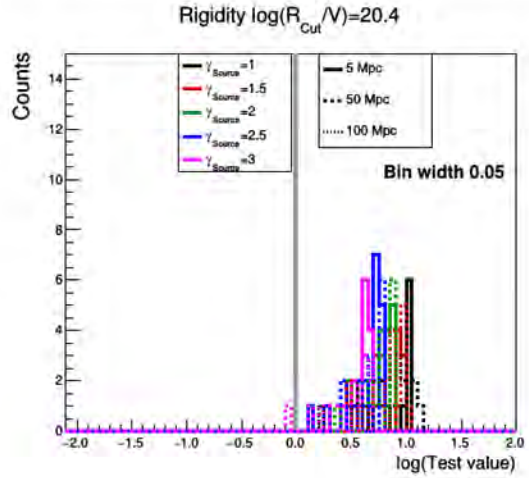

Rigidity log(R_Cut/V)=20.3
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

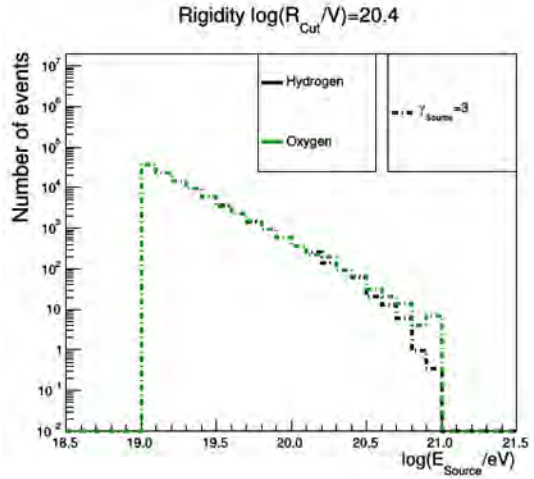

Rigidity log(R_Cut/V)=20.4
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

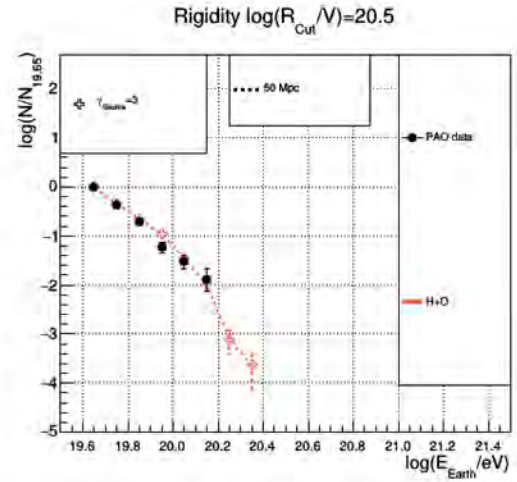

Rigidity log(R_Cut/V)=20.4
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

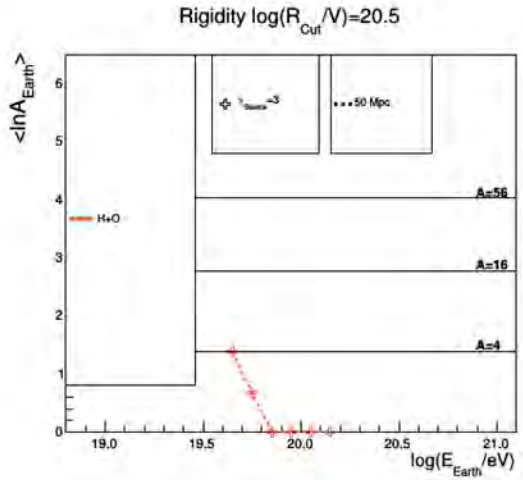

Rigidity log(R_Cut/V)=20.4
<lnA_Source>
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

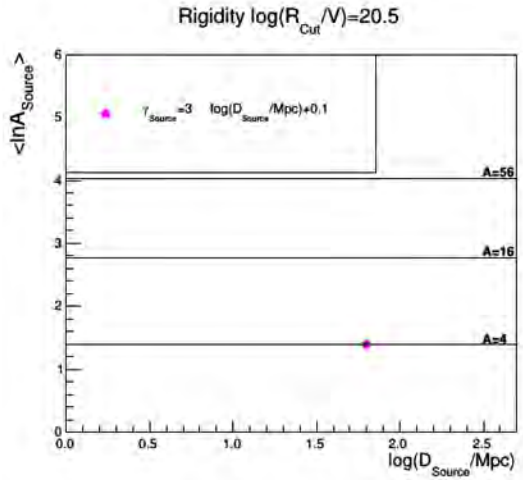

Rigidity log(R_Cut/V)=20.4
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

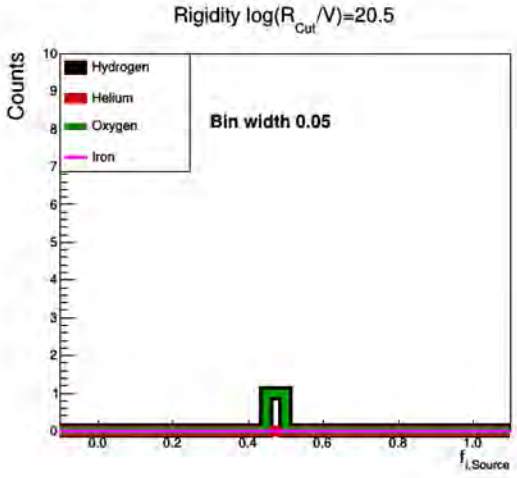

Rigidity log(R_Cut/V)=20.4
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

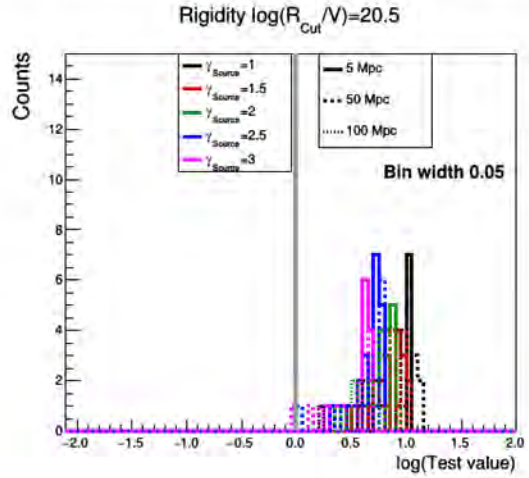

Rigidity log(R_Cut/V)=20.4
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

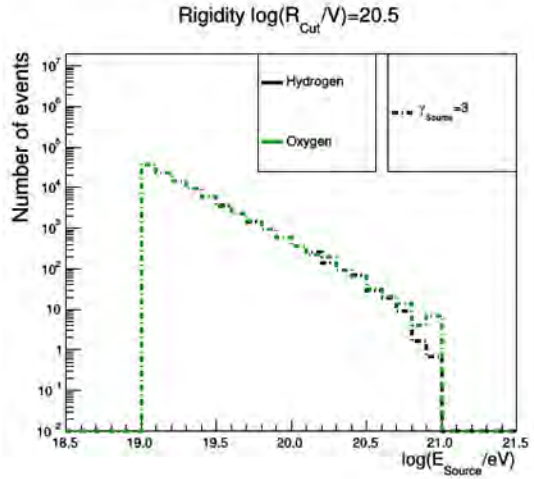

Rigidity log(R_Cut/V)=20.5
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

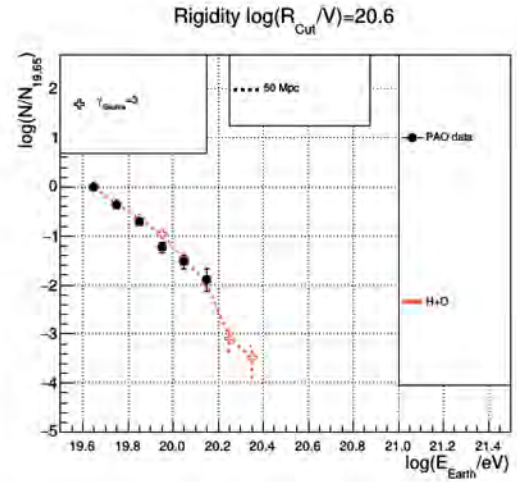

Rigidity log(R_Cut/V)=20.5
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

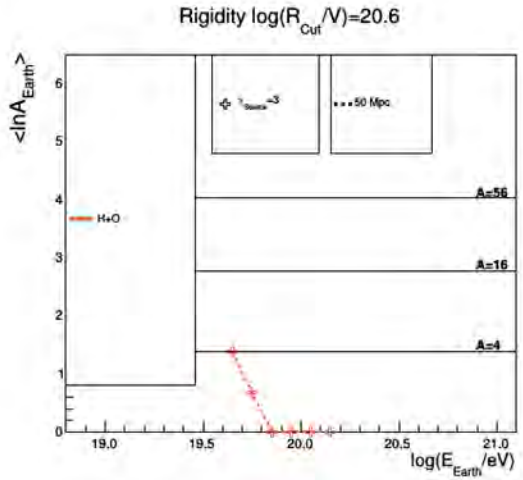

Rigidity log(R_Cut/V)=20.5
<lnA_Source>
γ_Source=3
log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

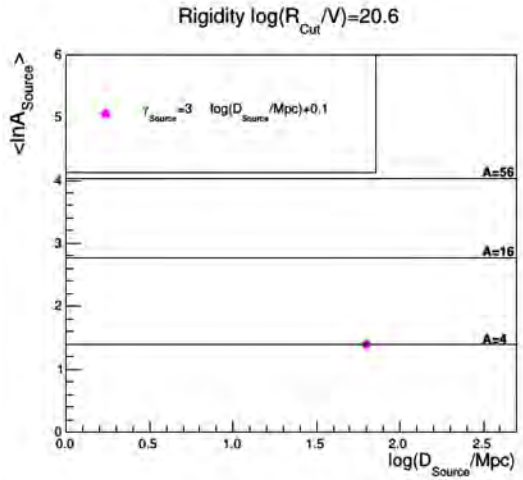

Rigidity log(R_Cut/V)=20.5
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

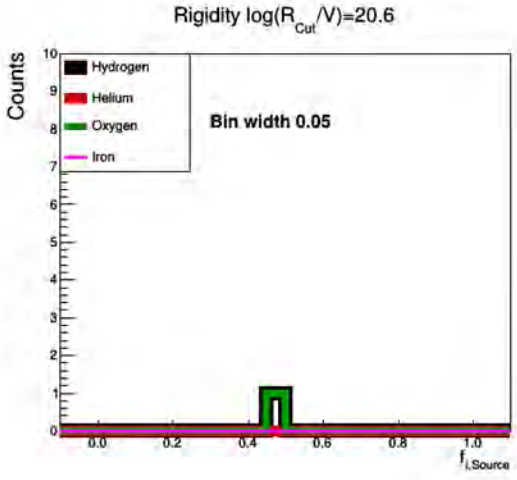

Rigidity log(R_Cut/V)=20.5
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

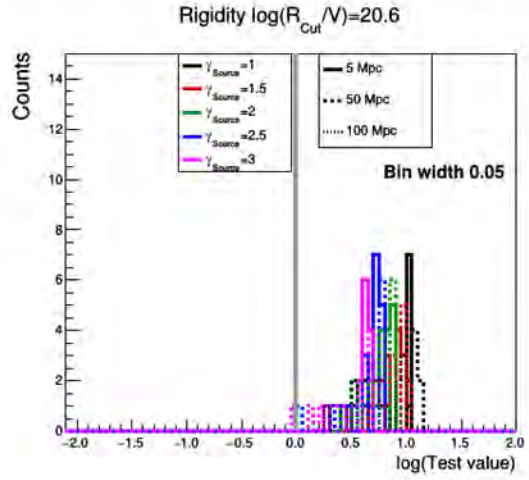

Rigidity log(R_Cut/V)=20.5
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

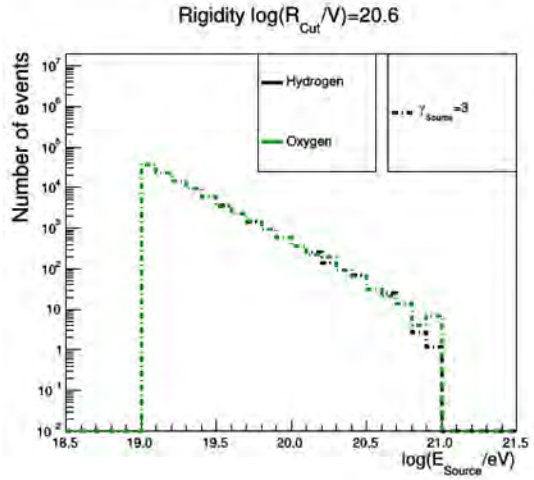

Rigidity log(R_Cut/V)=20.6
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

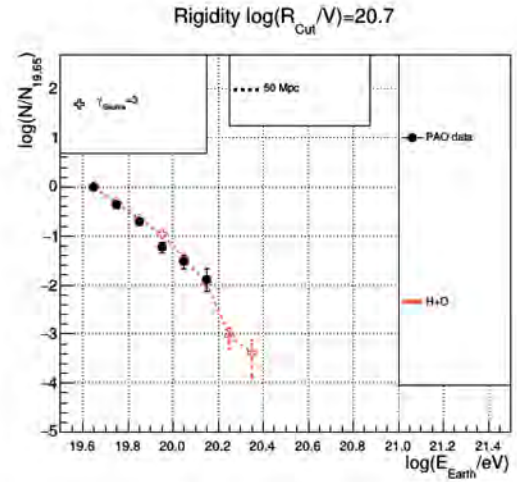

Rigidity log(R_Cut/V)=20.6
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

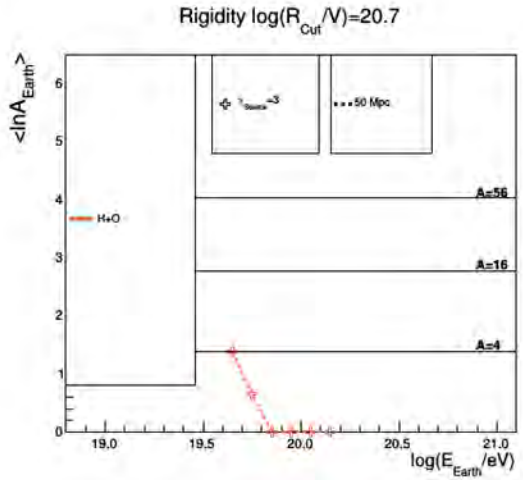

Rigidity log(R_Cut/V)=20.6
<lnA_Source>
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

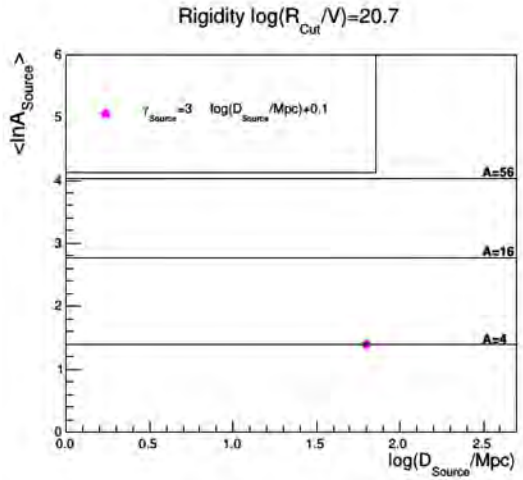

Rigidity log(R_Cut/V)=20.6
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

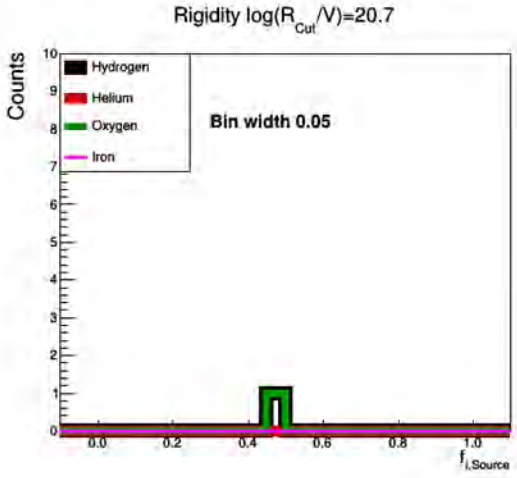

Rigidity log(R_Cut/V)=20.6
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

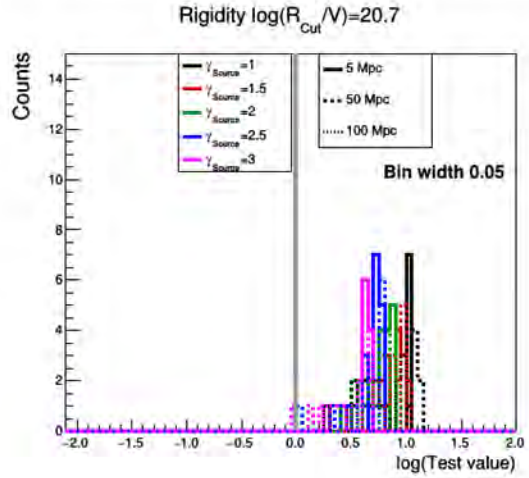

Rigidity log(R_Cut/V)=20.6
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

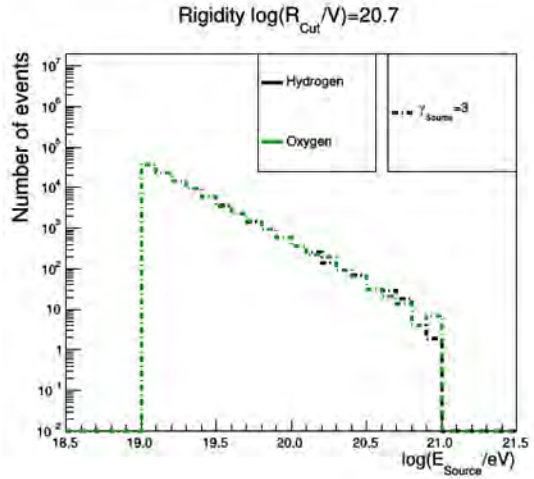

Rigidity log(R_Cut/V)=20.7
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

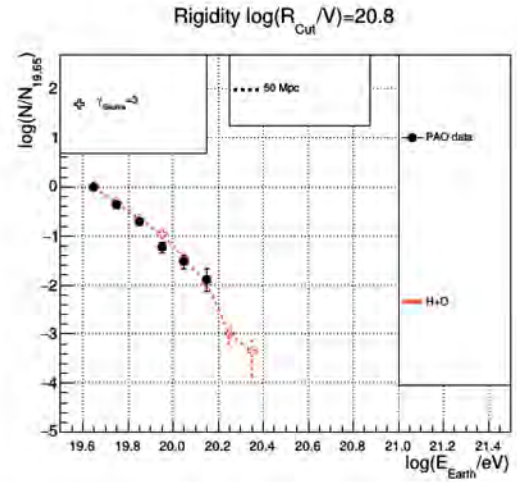

Rigidity log(R_Cut/V)=20.7
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

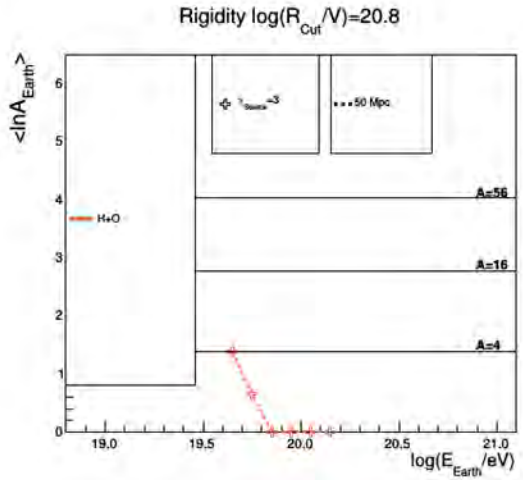

Rigidity log(R_Cut/V)=20.7
<lnA_Source>
γ_Source=3
log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

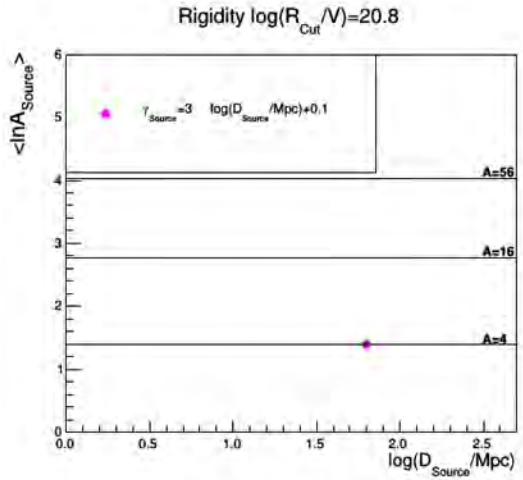

Rigidity log(R_Cut/V)=20.7
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

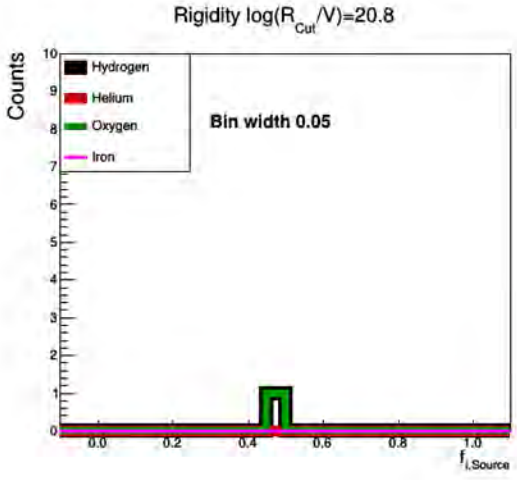

Rigidity log(R_Cut/V)=20.7
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

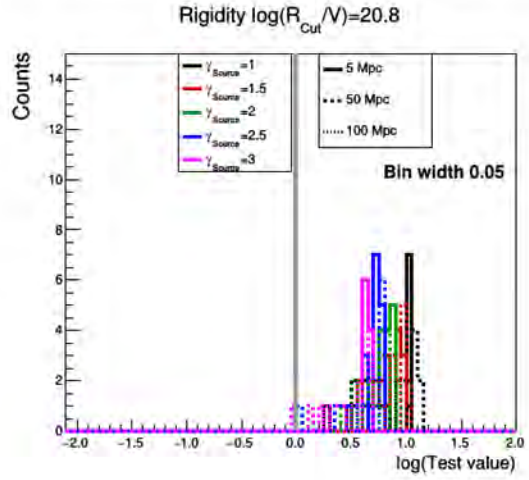

Rigidity log(R_Cut/V)=20.7
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

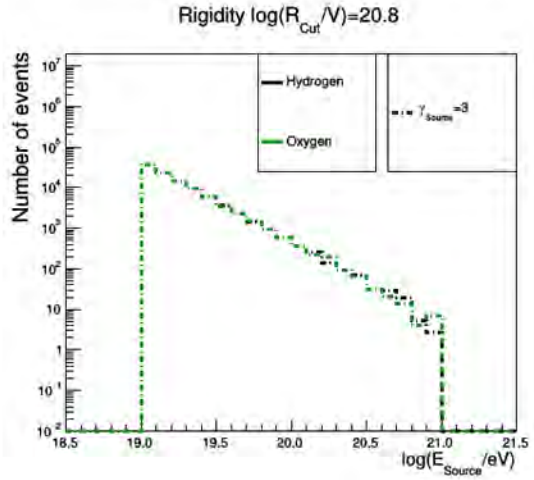

Rigidity log(R_Cut/V)=20.8
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

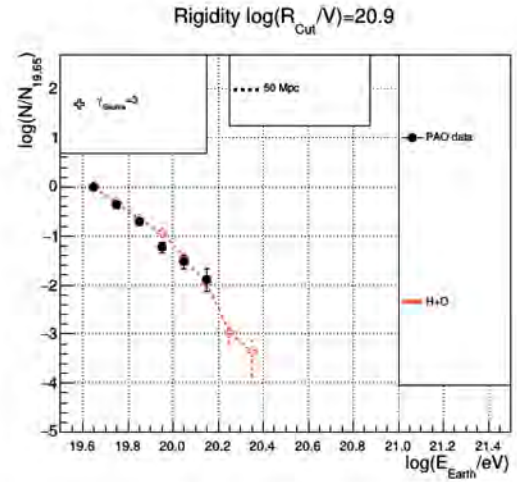

Rigidity log(R_Cut/V)=20.8
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

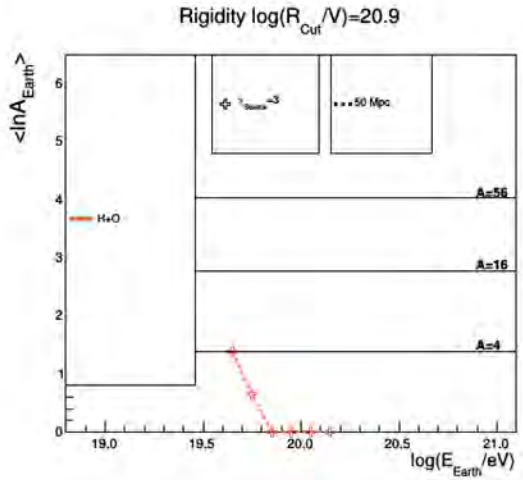

Rigidity log(R_Cut/V)=20.8
<lnA_Source>
γ_Source=3
log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

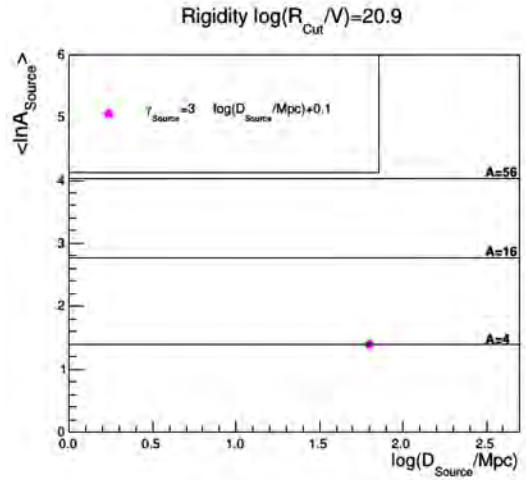

Rigidity log(R_Cut/V)=20.8
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

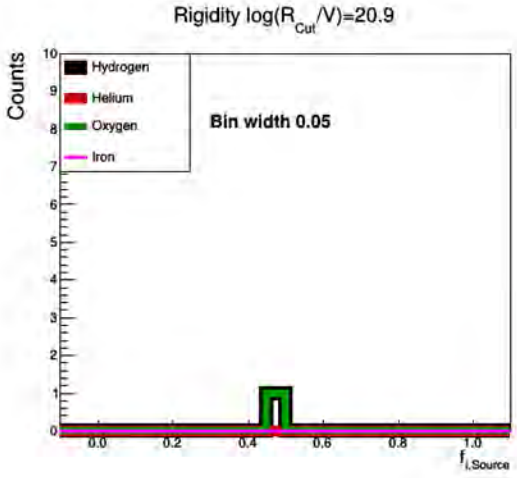

Rigidity log(R_Cut/V)=20.8
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

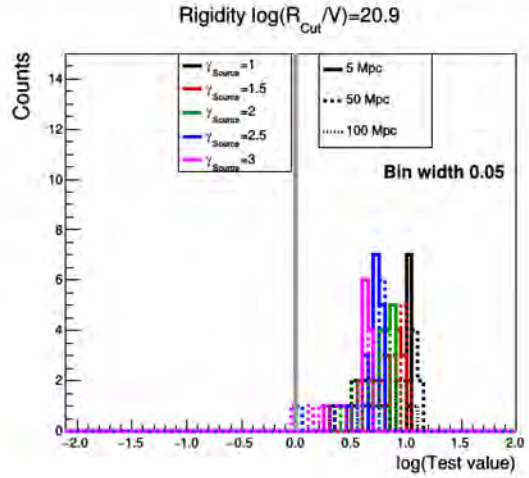

Rigidity log(R_Cut/V)=20.8
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

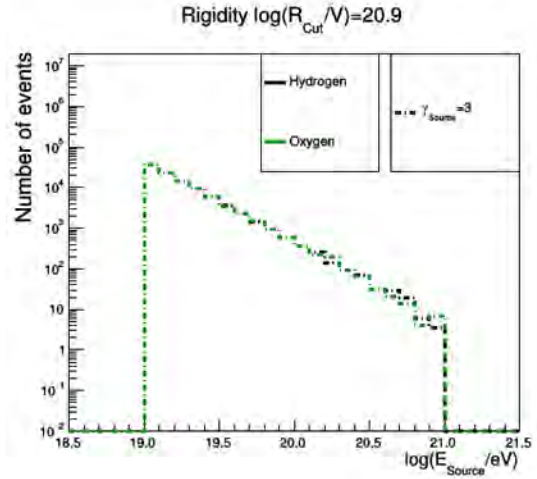

Rigidity log(R_Cut/V)=20.9
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)

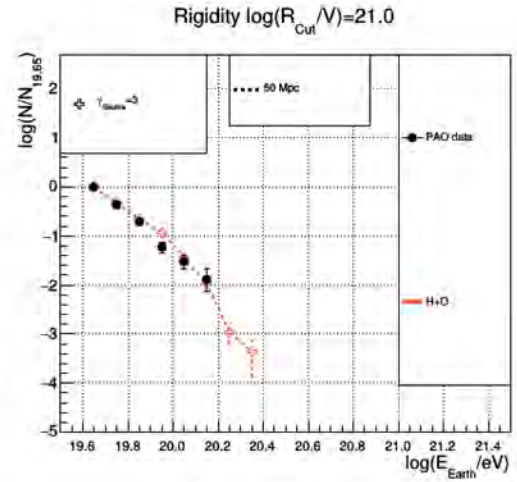

Rigidity log(R_Cut/V)=20.9
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)

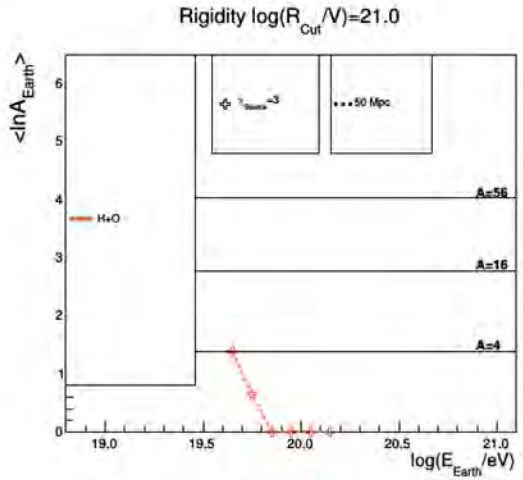

Rigidity log(R_Cut/V)=20.9
<lnA_Source>
γ_Source=3 log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)

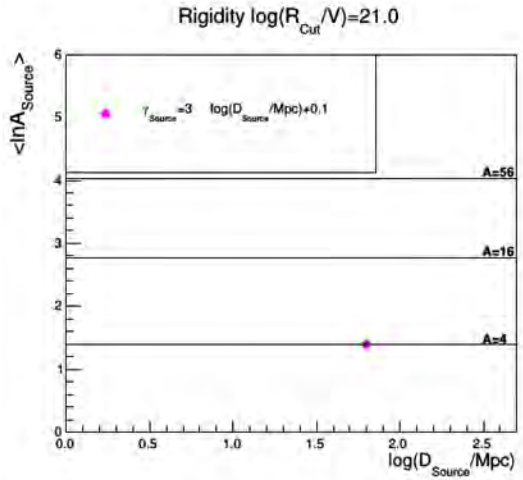

Rigidity log(R_Cut/V)=20.9
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source

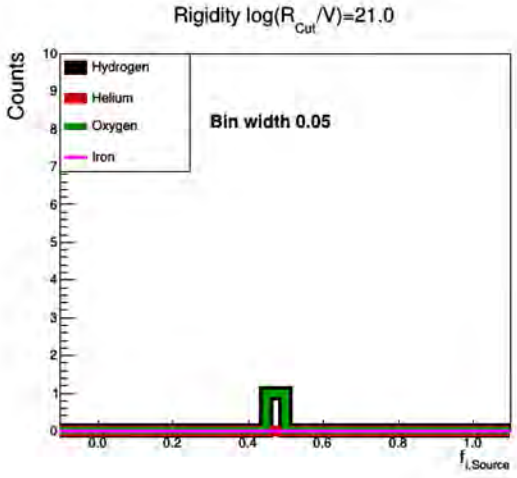

Rigidity log(R_Cut/V)=20.9
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)

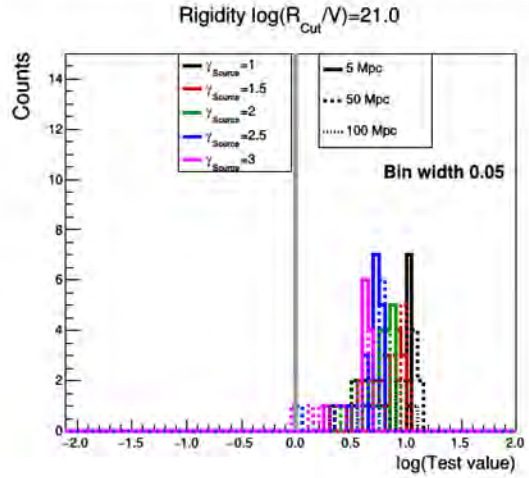

Rigidity log(R_Cut/V)=20.9
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)

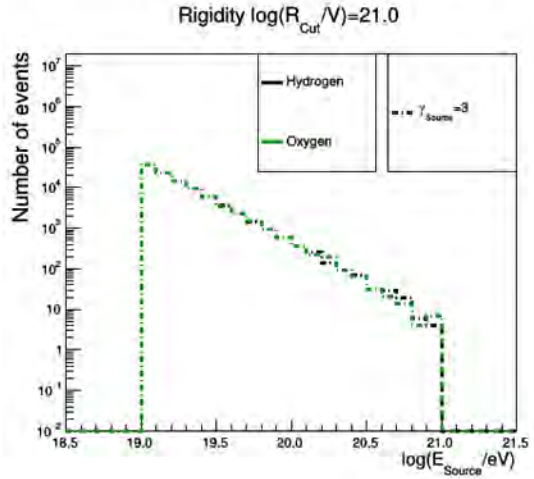

Rigidity log(R_Cut/V)=21.0
log(N/N_19.55)
γ_Source=3
50 Mpc
PAO data
H+O
log(E_Earth/eV)


Rigidity log(R_Cut/V)=21.0
<lnA_Earth>
γ_Source=3
50 Mpc
H+O
A=56
A=16
A=4
log(E_Earth/eV)


Rigidity log(R_Cut/V)=21.0
<lnA_Source>
γ_Source=3
log(D_Source/Mpc)+0.1
A=56
A=16
A=4
log(D_Source/Mpc)


Rigidity log(R_Cut/V)=21.0
Counts
Hydrogen
Helium
Oxygen
Iron
Bin width 0.05
f_i,Source


Rigidity log(R_Cut/V)=21.0
Counts
γ_Source=1
γ_Source=1.5
γ_Source=2
γ_Source=2.5
γ_Source=3
5 Mpc
50 Mpc
100 Mpc
Bin width 0.05
log(Test value)


Rigidity log(R_Cut/V)=21.0
Number of events
Hydrogen
Oxygen
γ_Source=3
log(E_Source/eV)