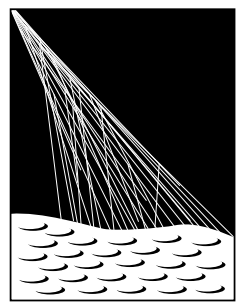
Declination and spectral feature studies

Auger - Telescope Array Workshop

Daniela Mockler[1]

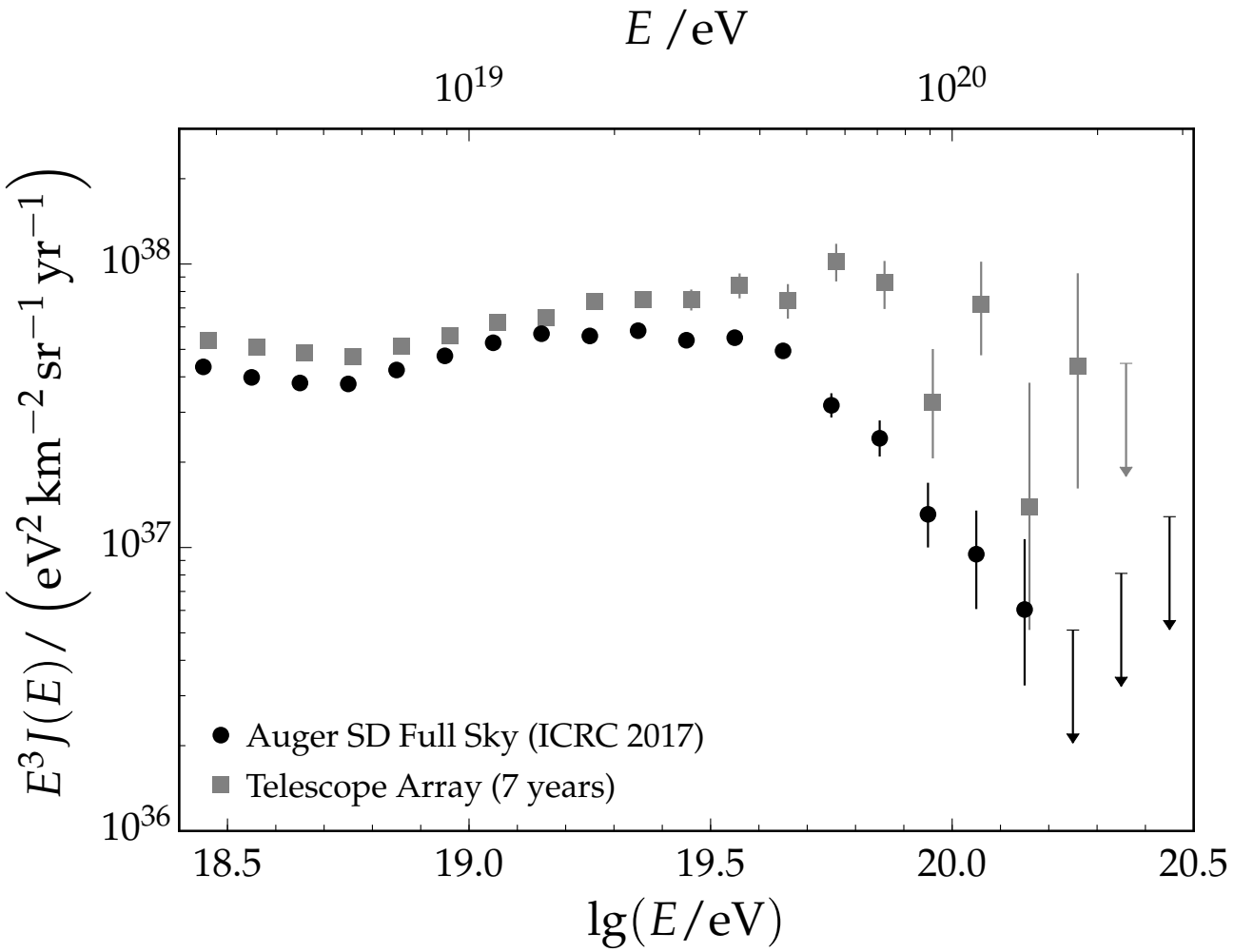
October 12, 2017



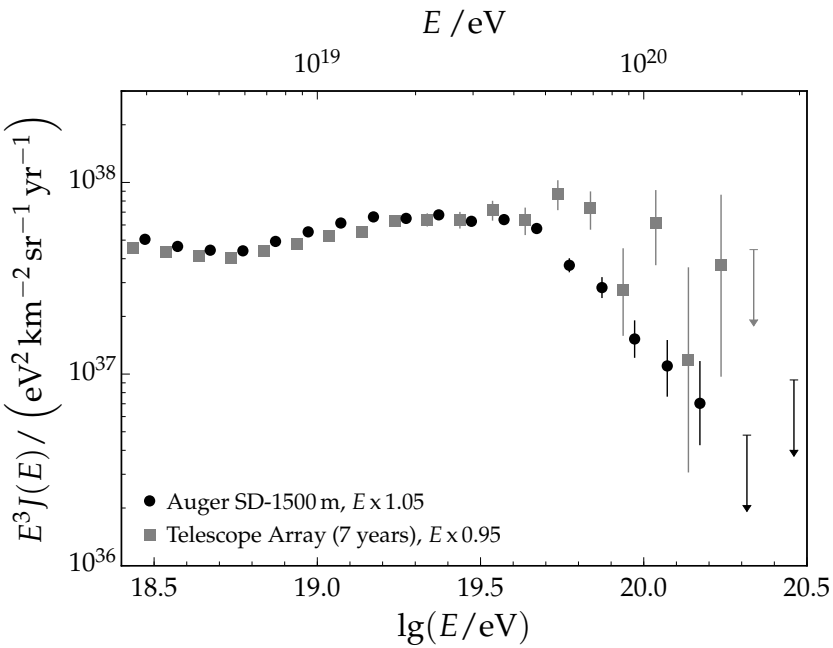
PIERRE
AUGER
OBSERVATORY

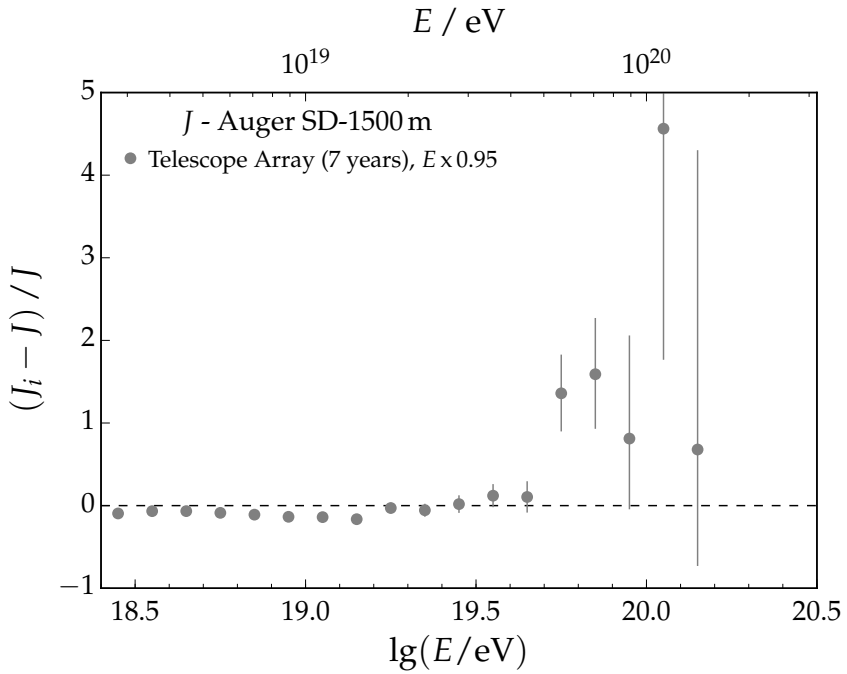
[1]Karlsruhe Institute of Technology, Institute for experimental particle physics

Spectra

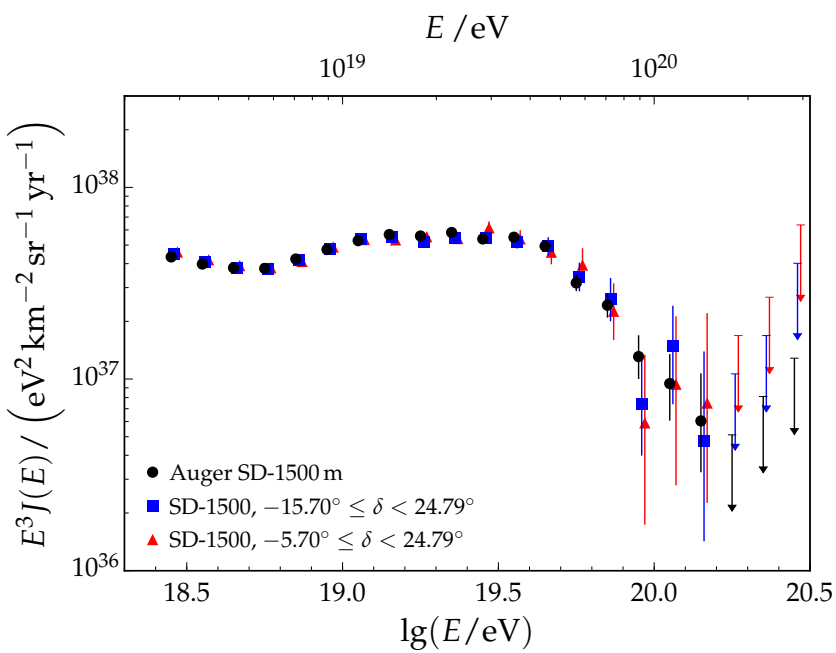

E /eV
10^{19}
10^{20}
$E^3 J(E)$ / $\left(\mathrm{eV}^2\,\mathrm{km}^{-2}\,\mathrm{sr}^{-1}\,\mathrm{yr}^{-1}\right)$
10^{38}
10^{37}
10^{36}
Auger SD Full Sky (ICRC 2017)
Telescope Array (7 years)
18.5
19.0
19.5
20.0
20.5
$\lg(E/\mathrm{eV})$

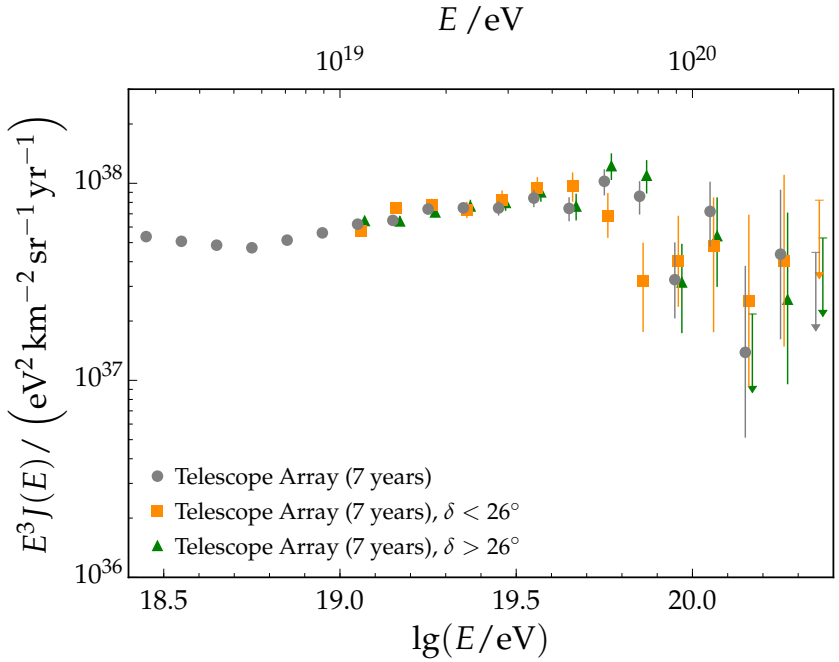
Spectra - rescaled





Spectra in different declination intervals





Fits to the flux

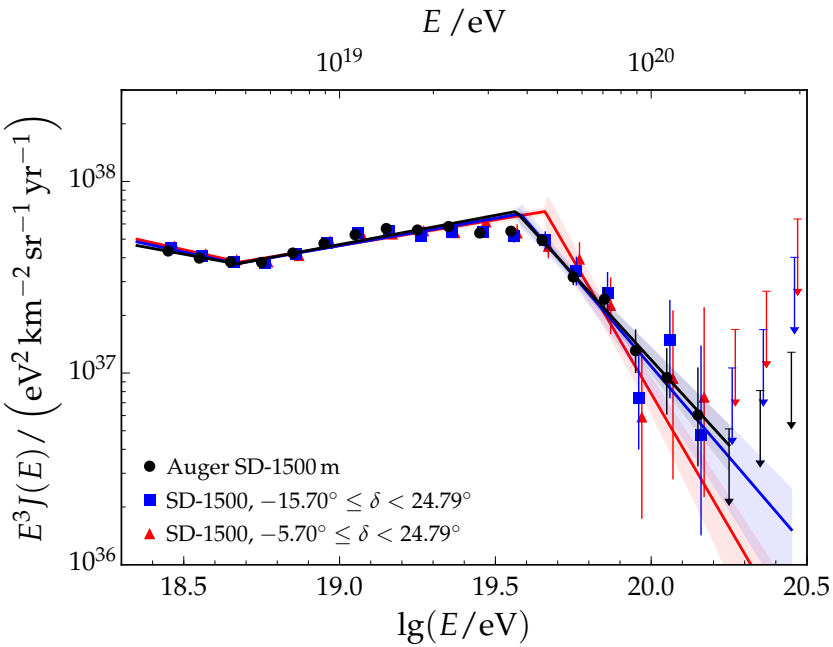
- Perform fits to the unfolded spetra using two different models
  - three connected power laws E^{γ_1}, E^{γ_2} and E^{γ_3} with hard breaks at E_{ankle} and E_{break}
  - hard ankle and smooth suppression

    $J(E < E_{\text{ankle}}) = J_0 \left(\frac{E}{E_{\text{ankle}}}\right)^{\gamma_1}$

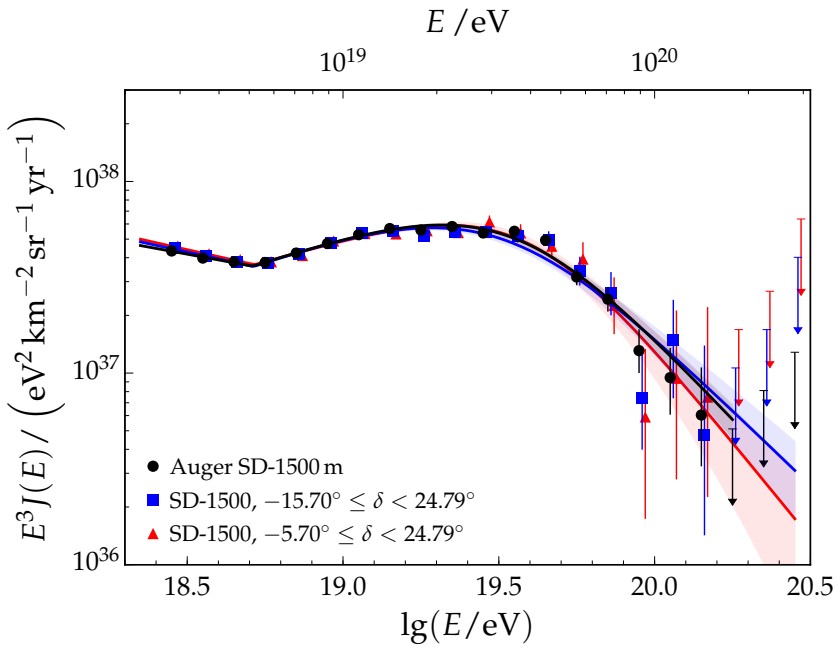
    $J(E > E_{\text{ankle}}) = J_0 \left(\frac{E}{E_{\text{ankle}}}\right)^{\gamma_2} \left[1 + \left(\frac{E_{\text{ankle}}}{E_{1/2}}\right)^{\Delta\gamma}\right] \left[1 + \left(\frac{E}{E_{1/2}}\right)\right]^{-1}$
- All spectra fits are χ^2-fits

Fit results for Auger spectra

hard

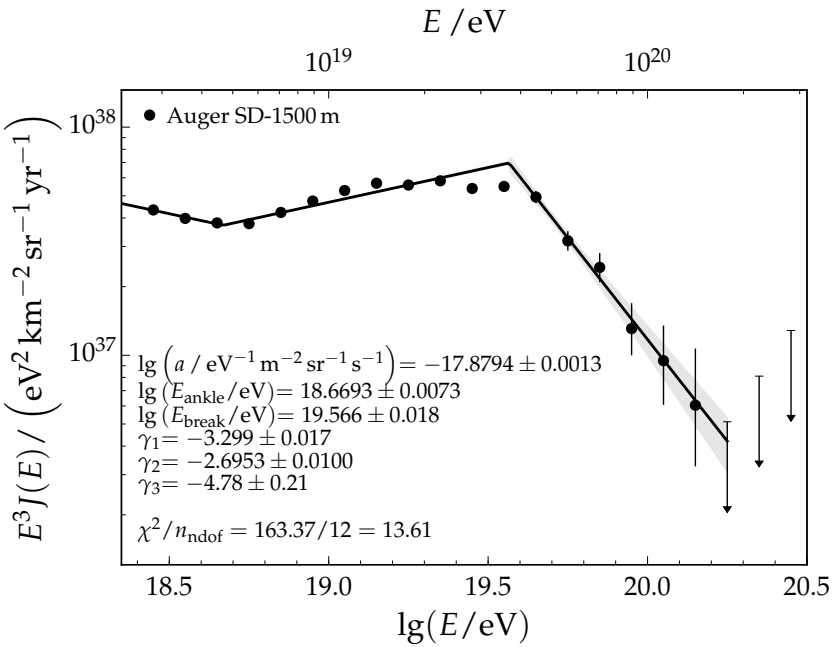


smooth



Fit results for Auger spectra

hard



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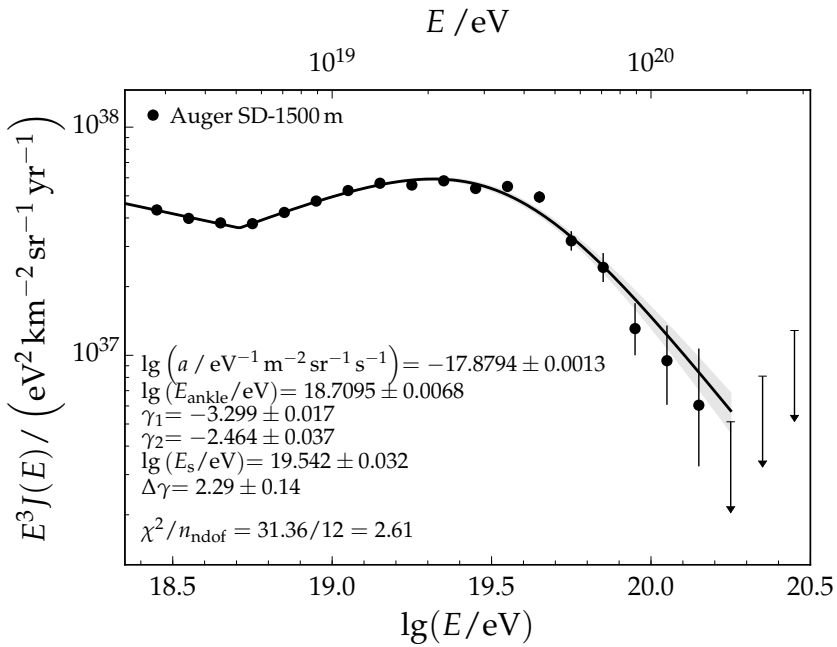
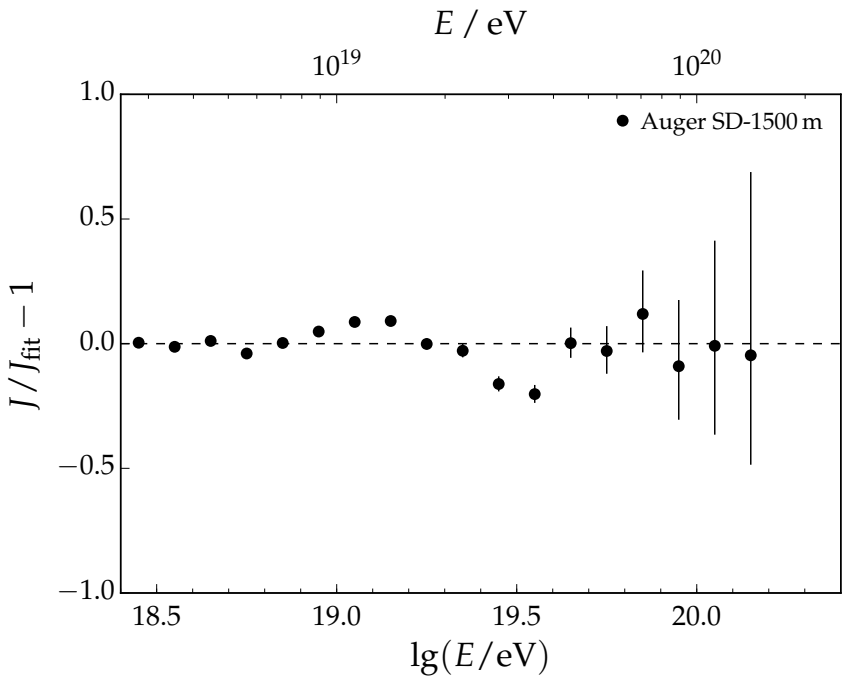


Fit quality - Auger

hard



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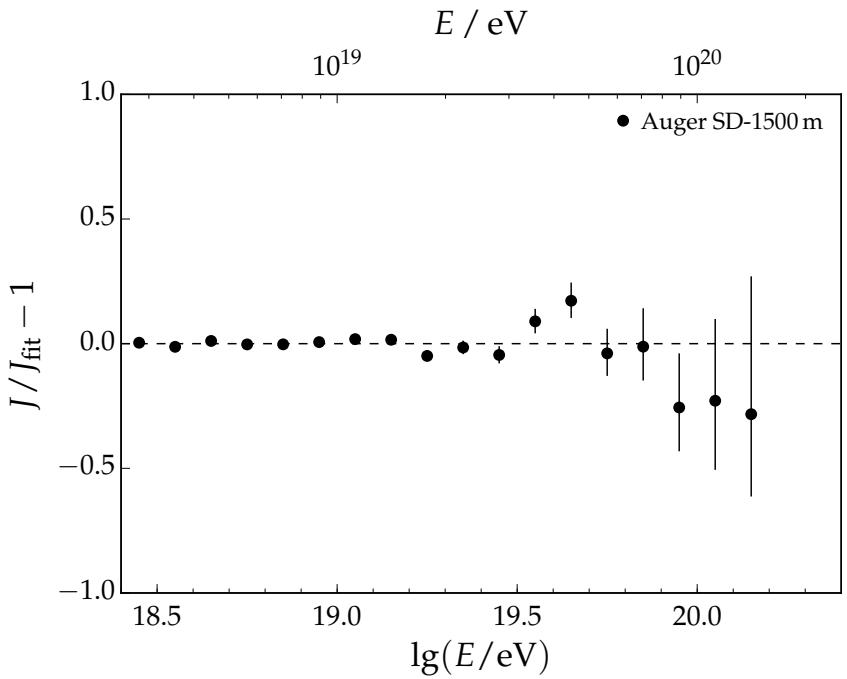
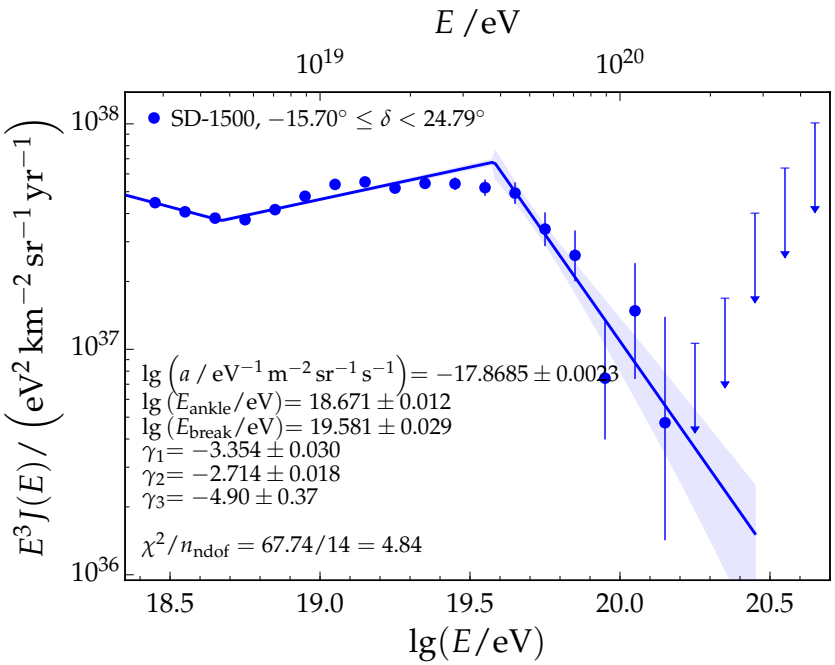


Fit results for Auger spectra - $[-15.7°, 24.8°]$

hard



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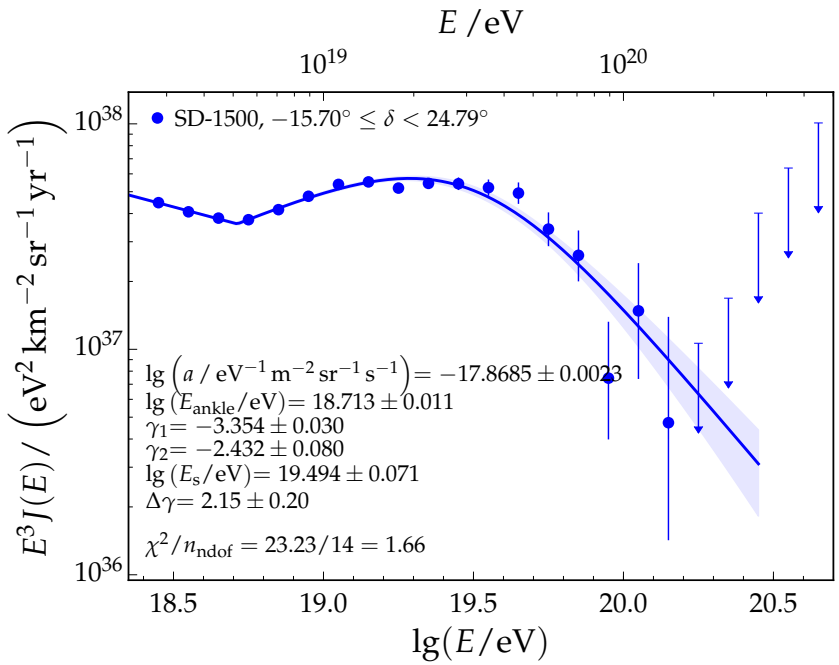
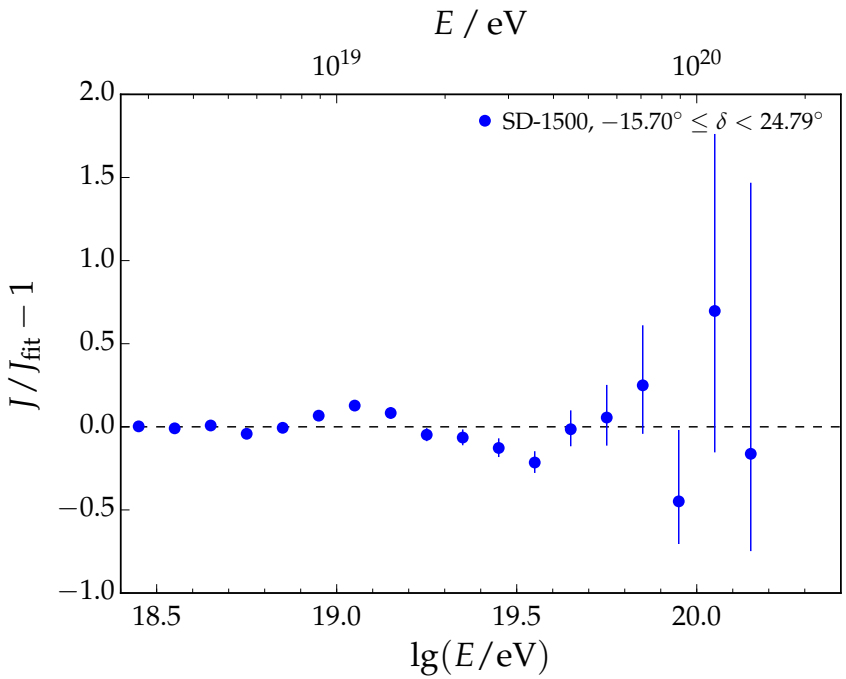


Residuals for Auger - $[-15.7°, 24.8°]$

hard



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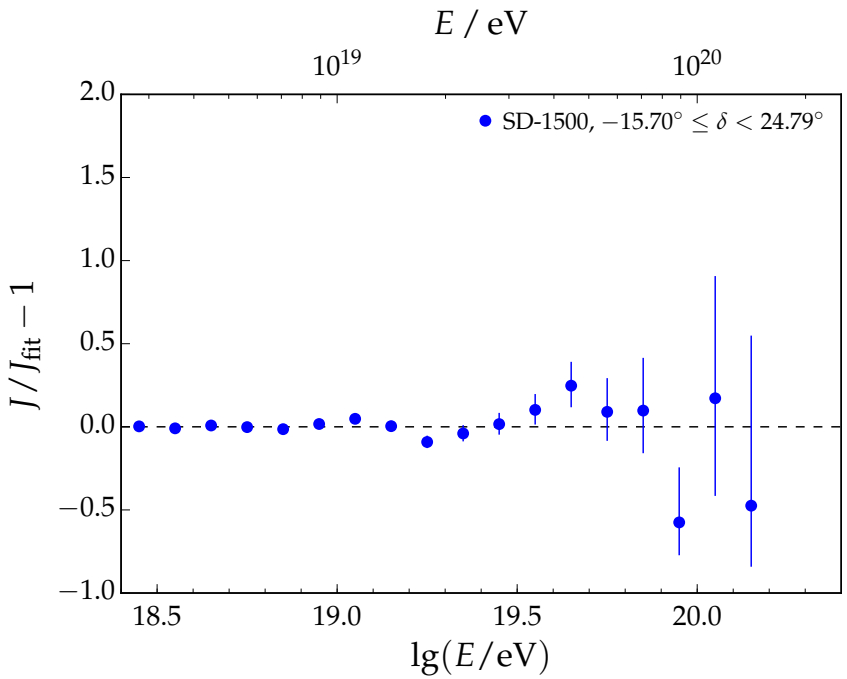
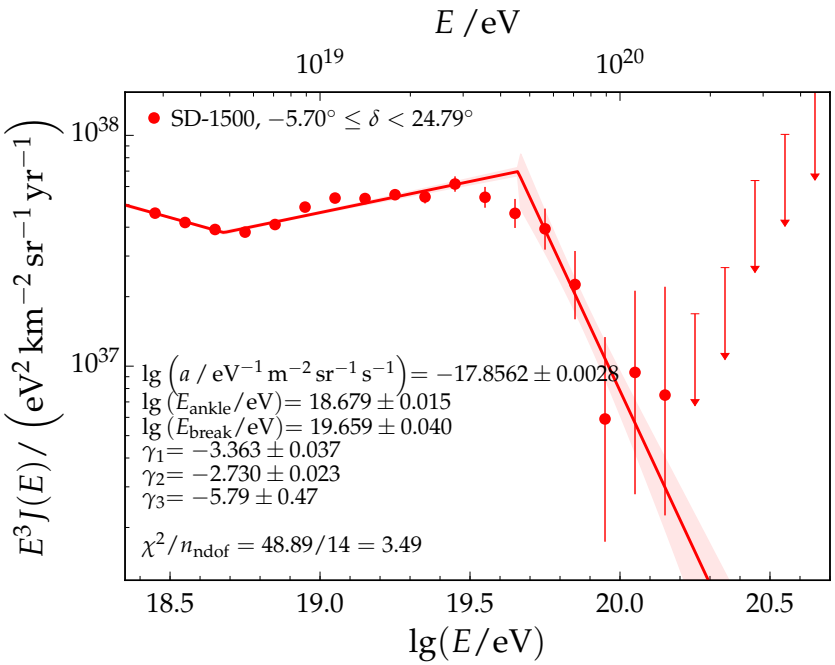


Fit results for Auger spectra - $[-5.7°, 24.8°]$

hard



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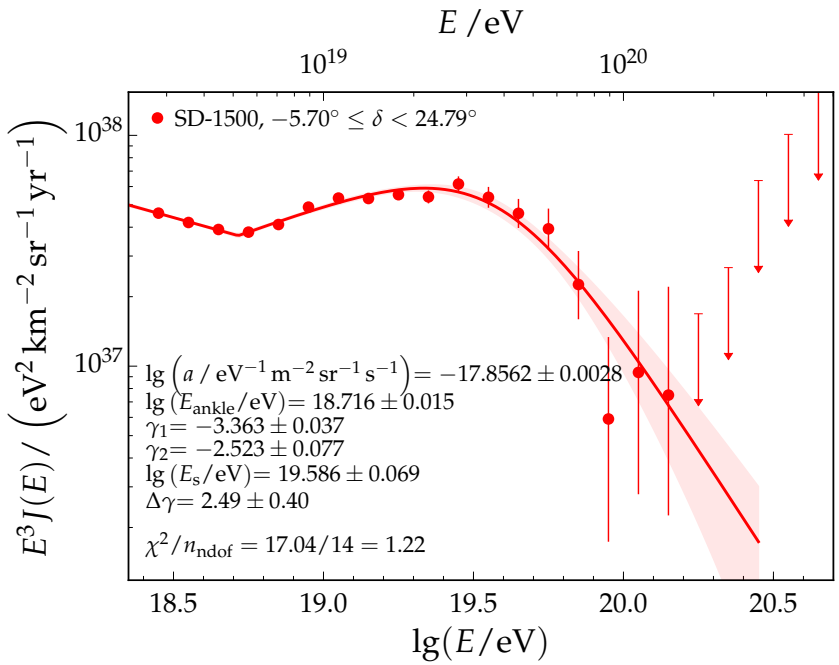
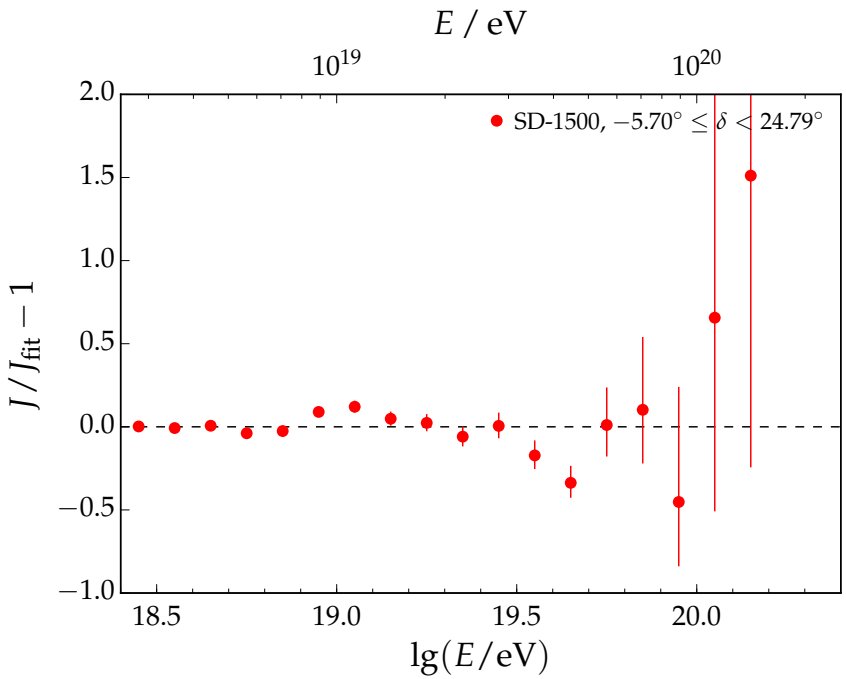


Residuals for Auger - $[-5.7°, 24.8°]$

hard



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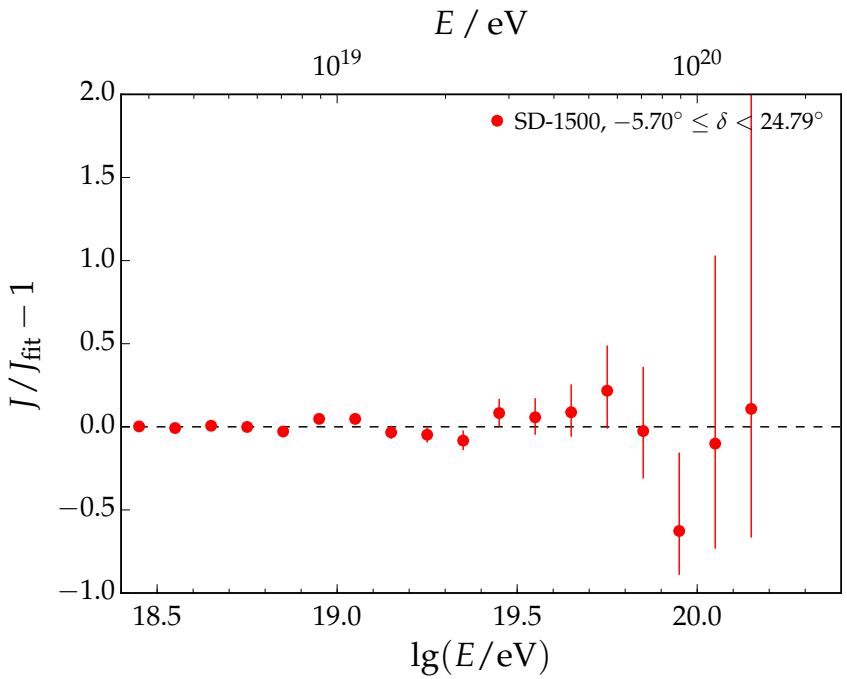
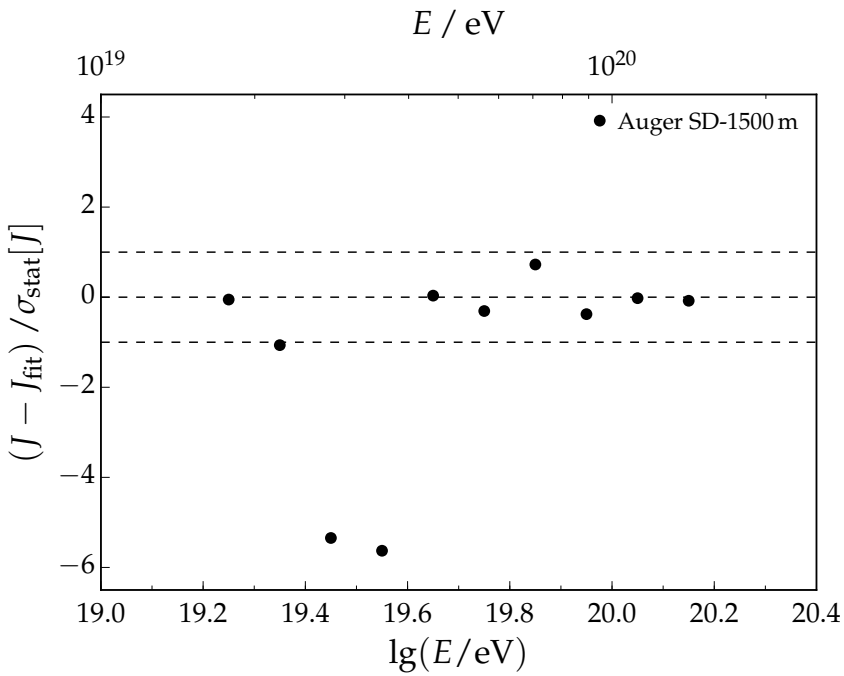


Residuals - Auger

hard



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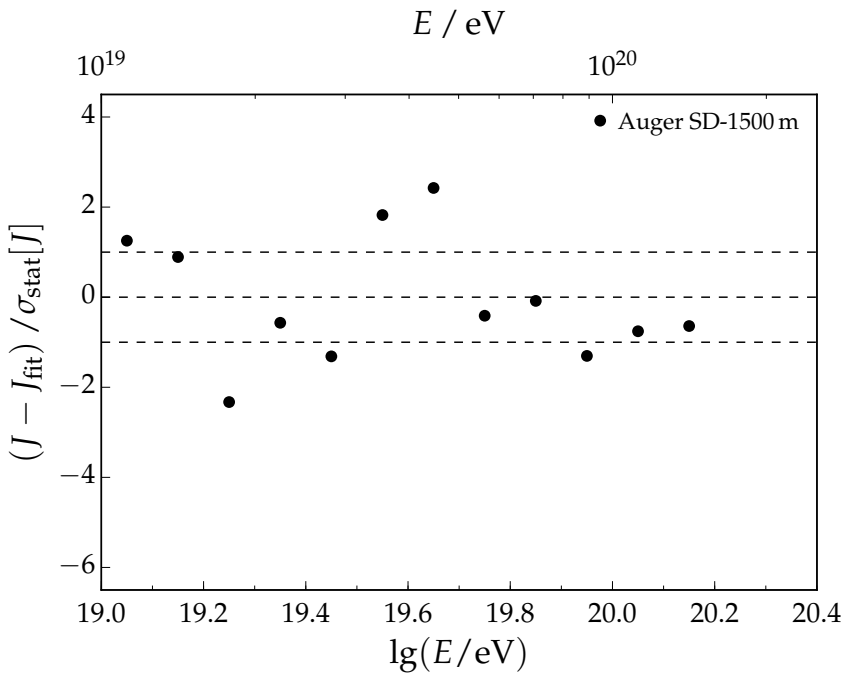
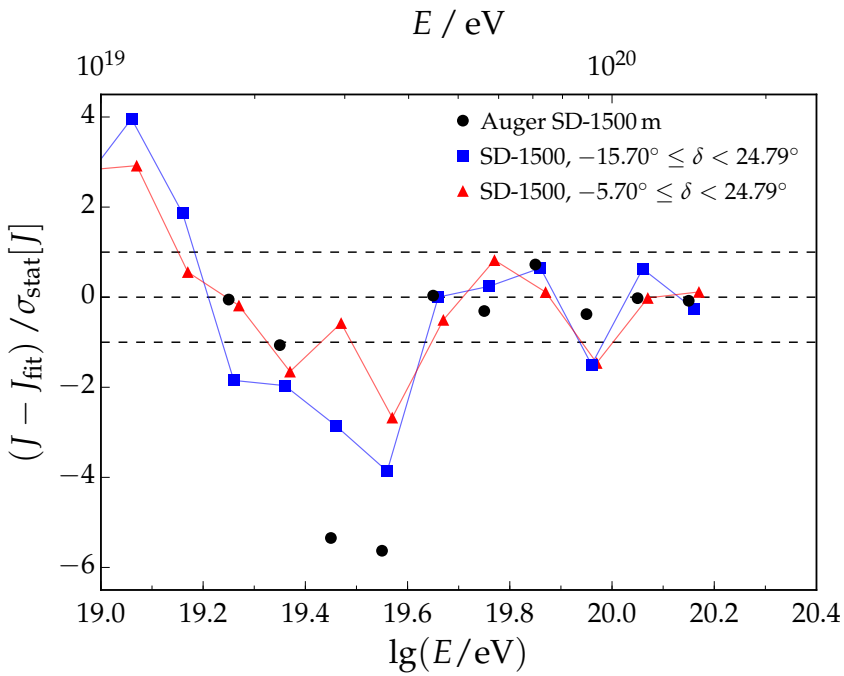


Residuals - Auger

hard



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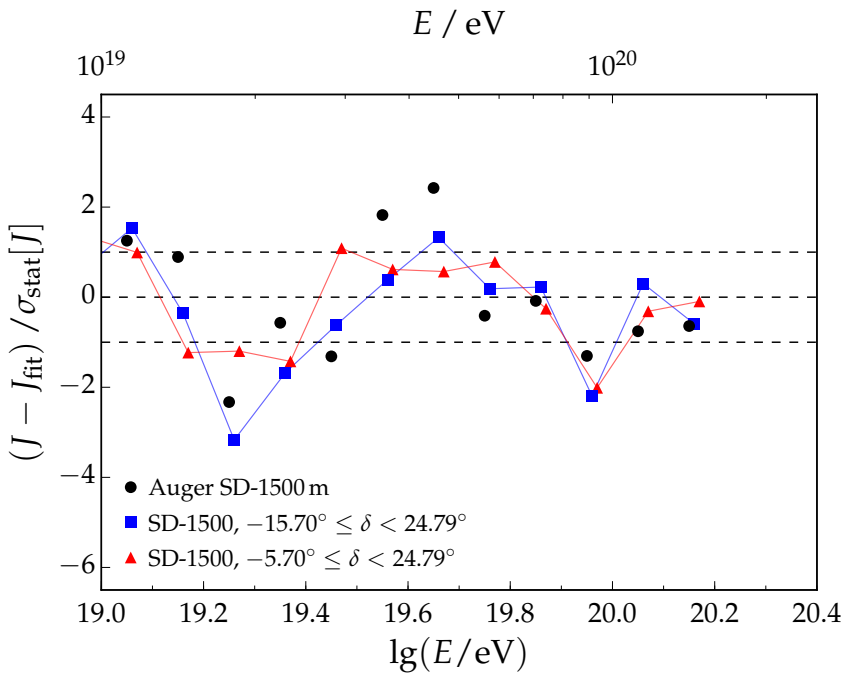
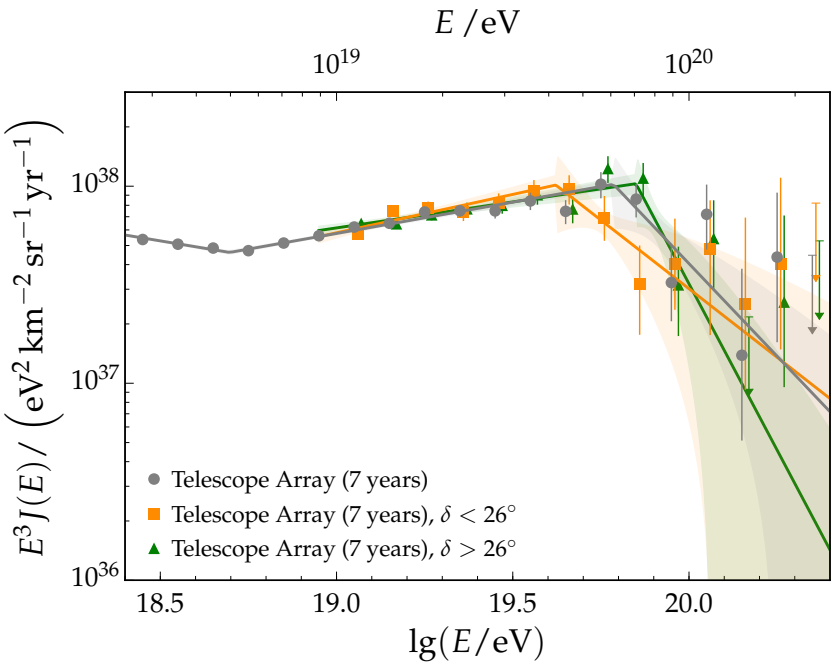


Fits results for the TA spectra

hard



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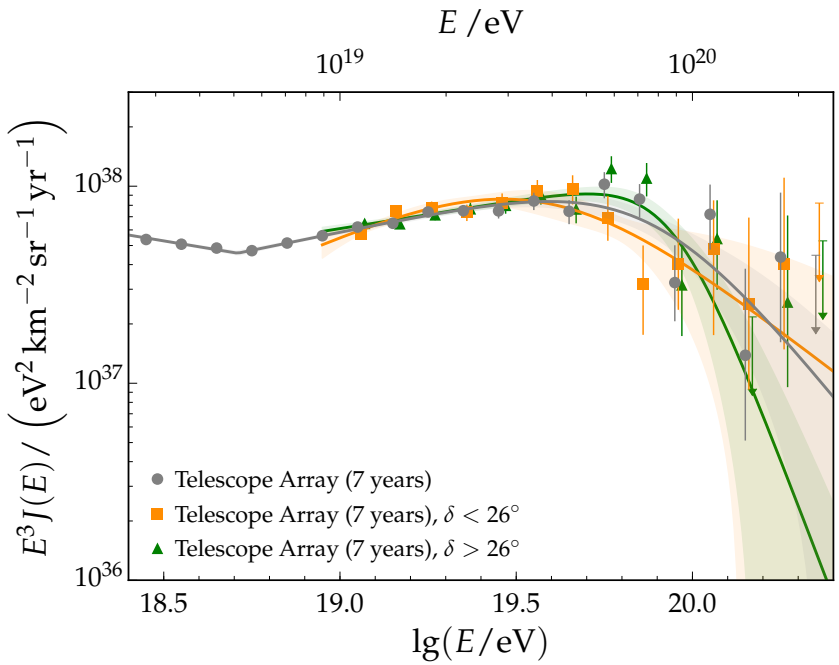
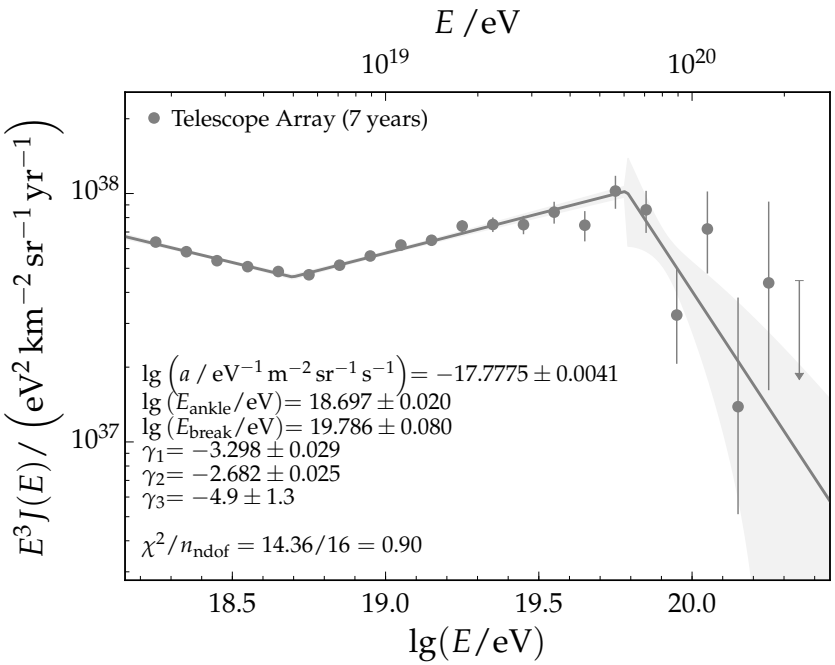


Fit results for Telescope Array

hard



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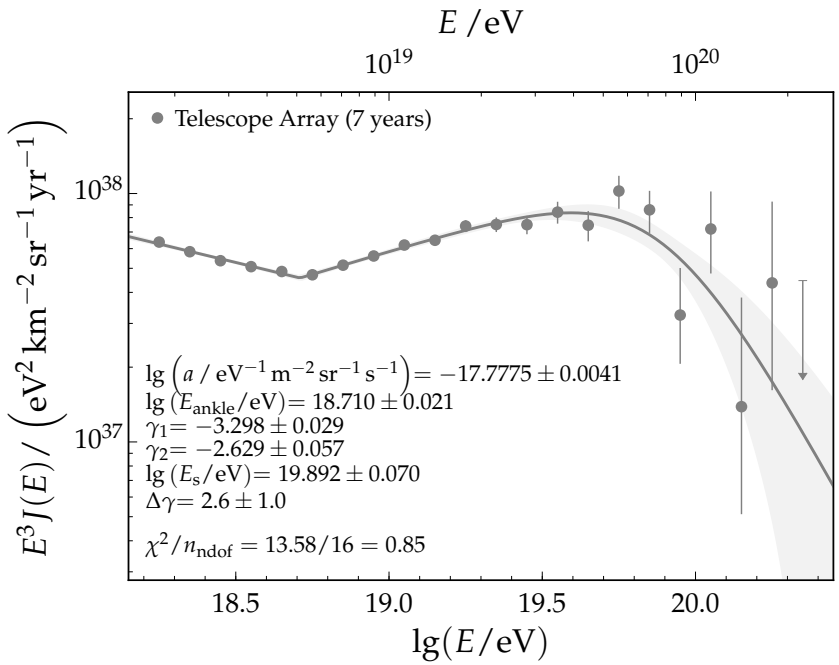
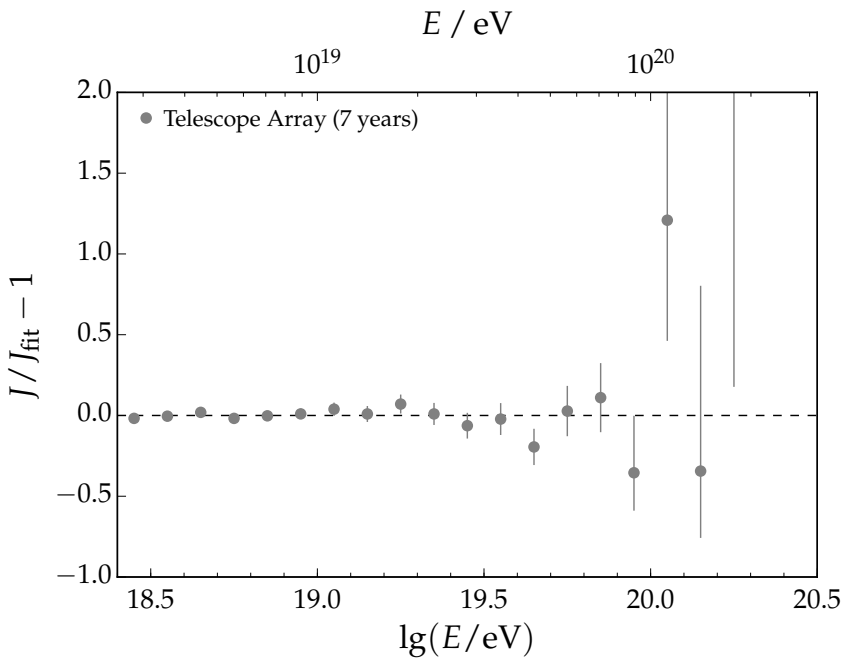


Fit quality - Telescope Array

hard



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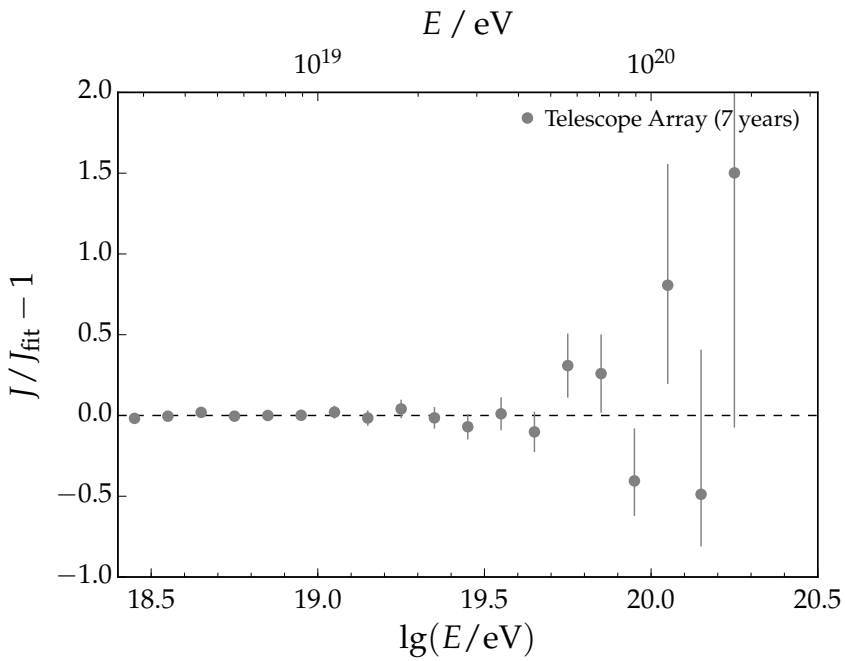
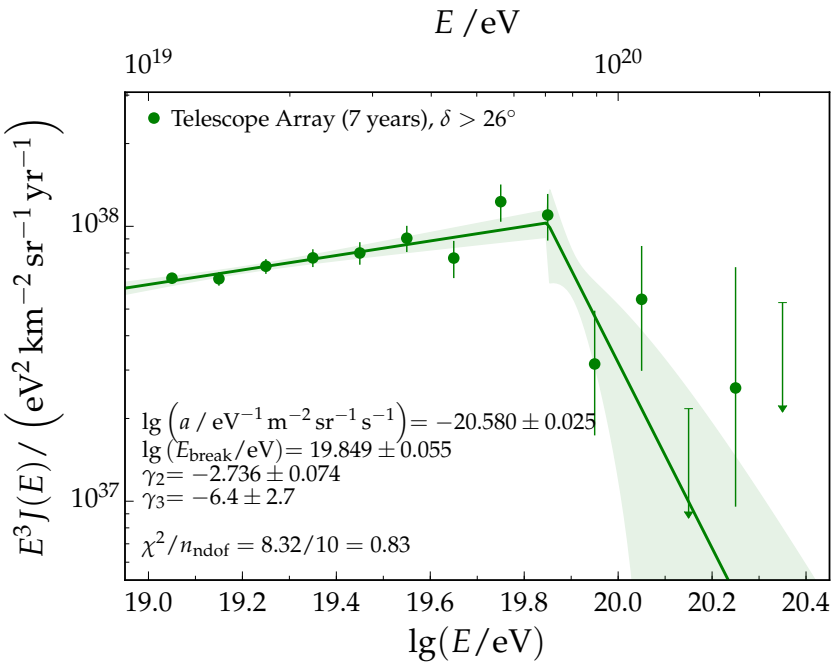


Fit results for Telescope Array - $\delta > 26°$

hard



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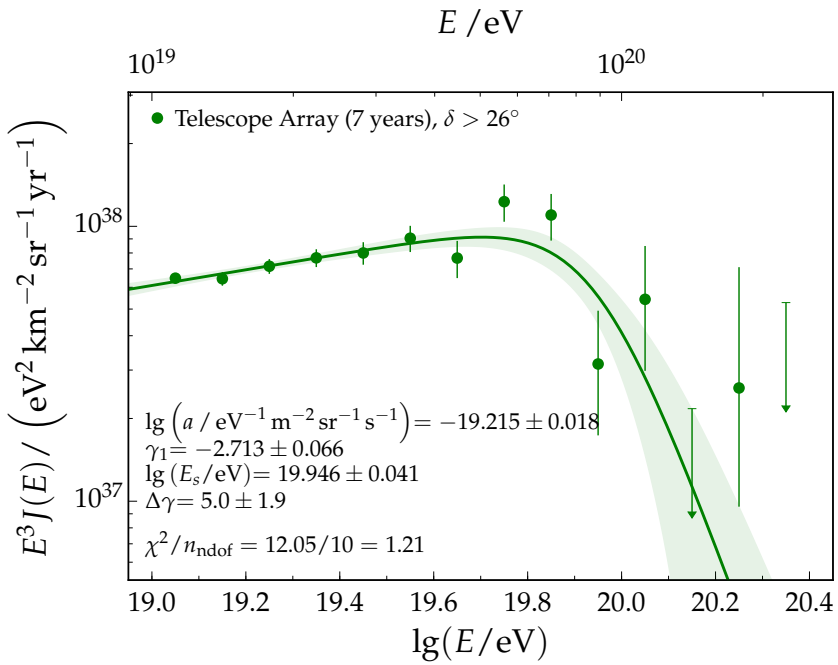
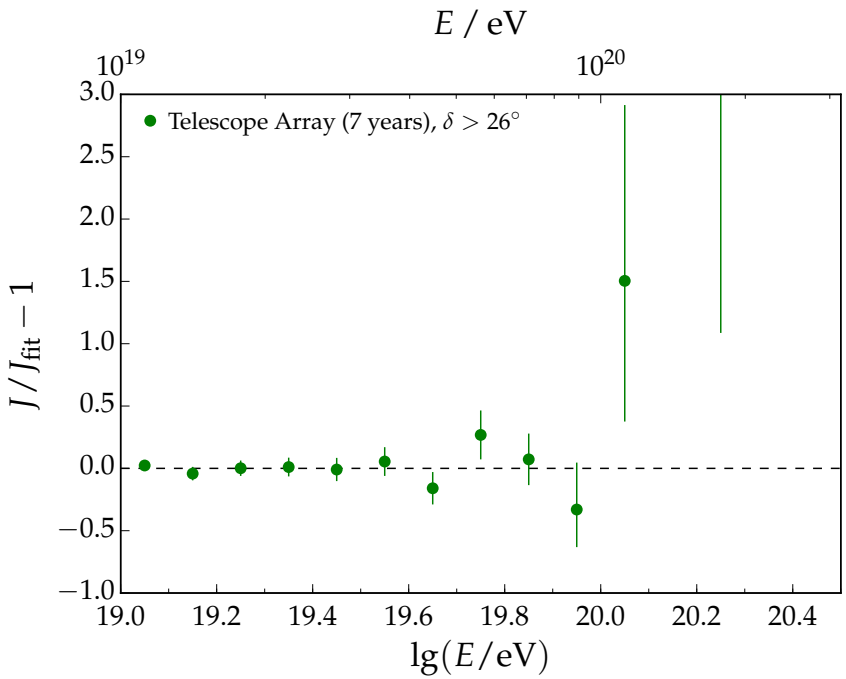


Residuals for Telescope Array - $\delta > 26°$

hard



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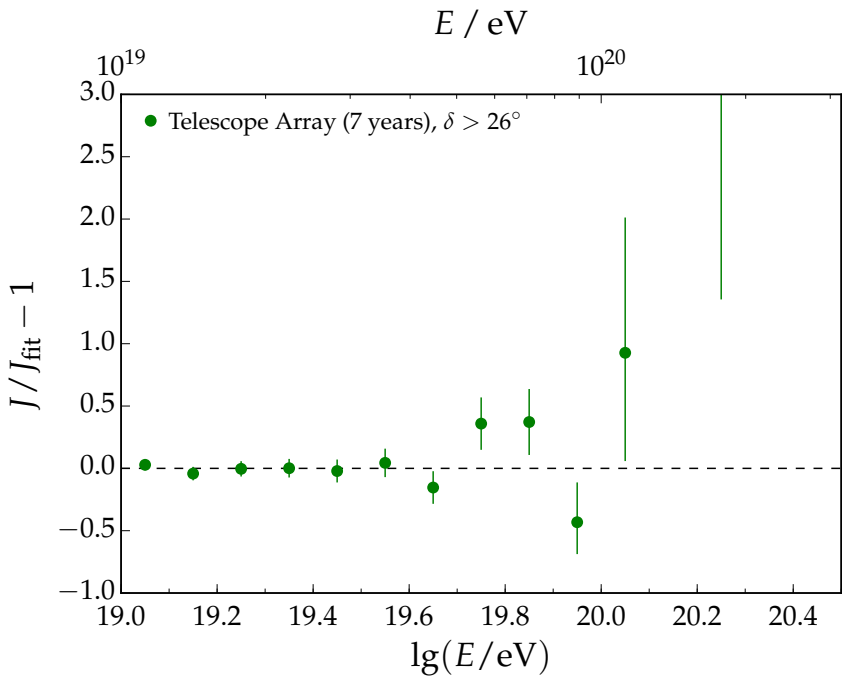
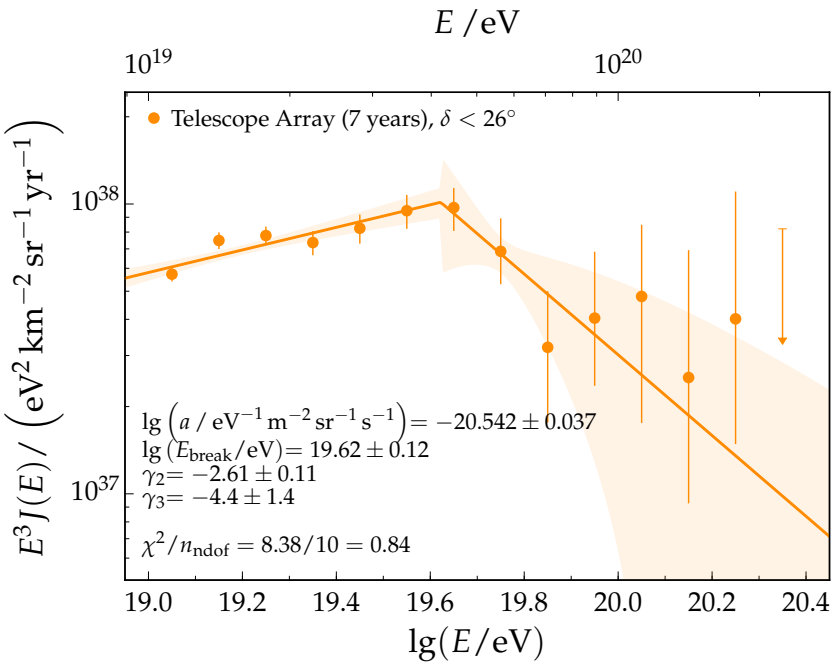


Fit results for Telescope Array - $\delta < 26°$

hard



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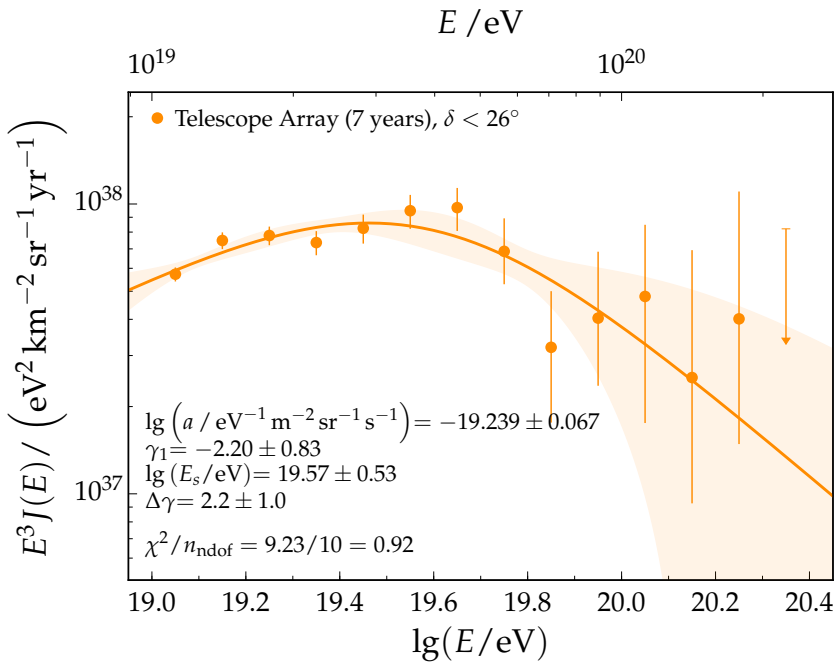
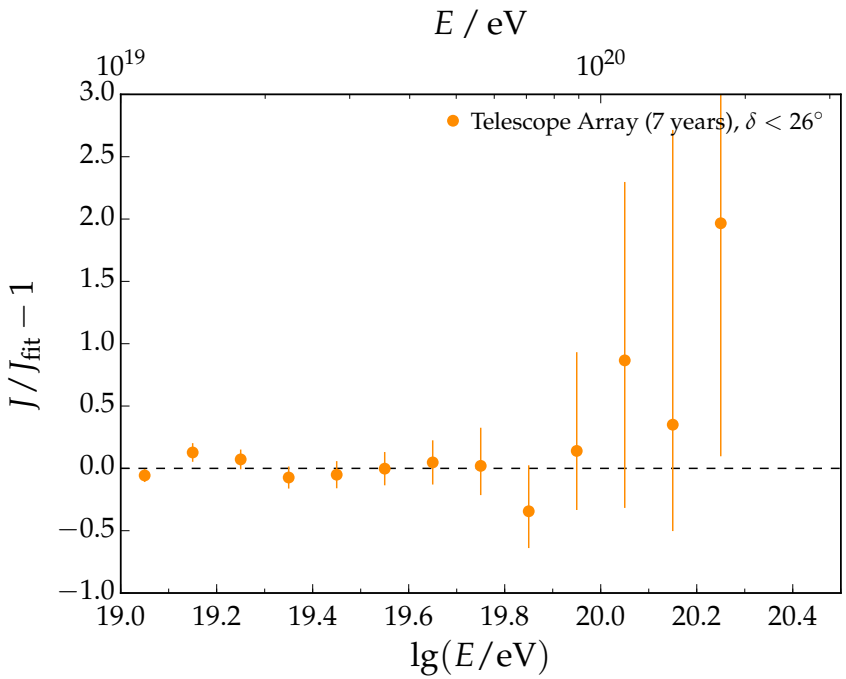


Residuals for Telescope Array - $\delta < 26°$

hard



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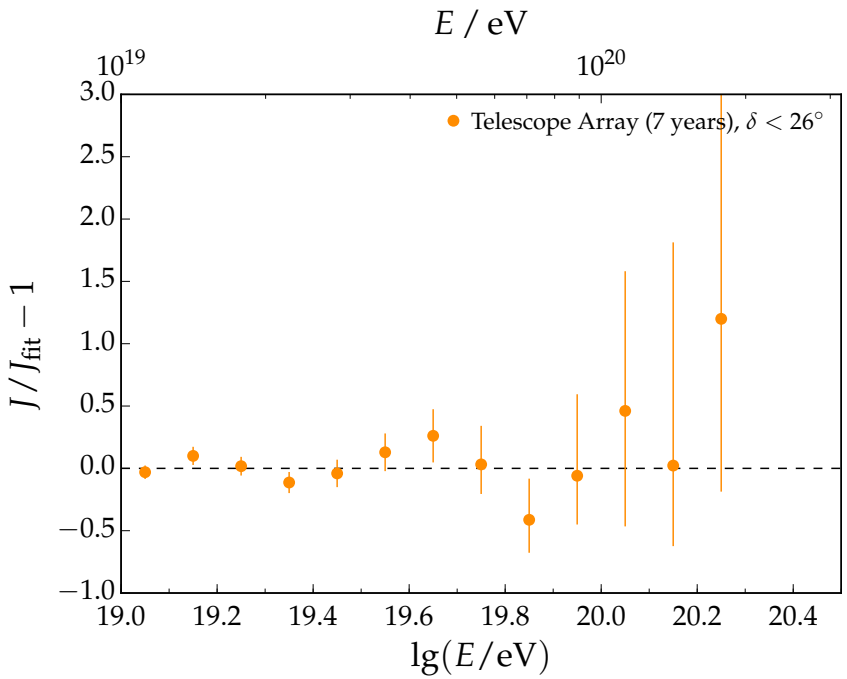
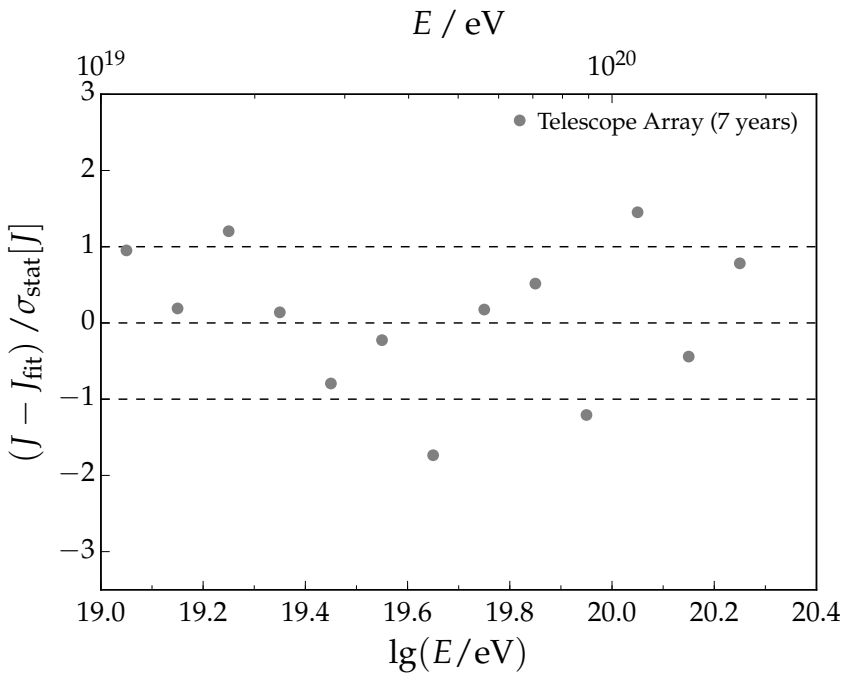


Residuals - Telescope Array

hard



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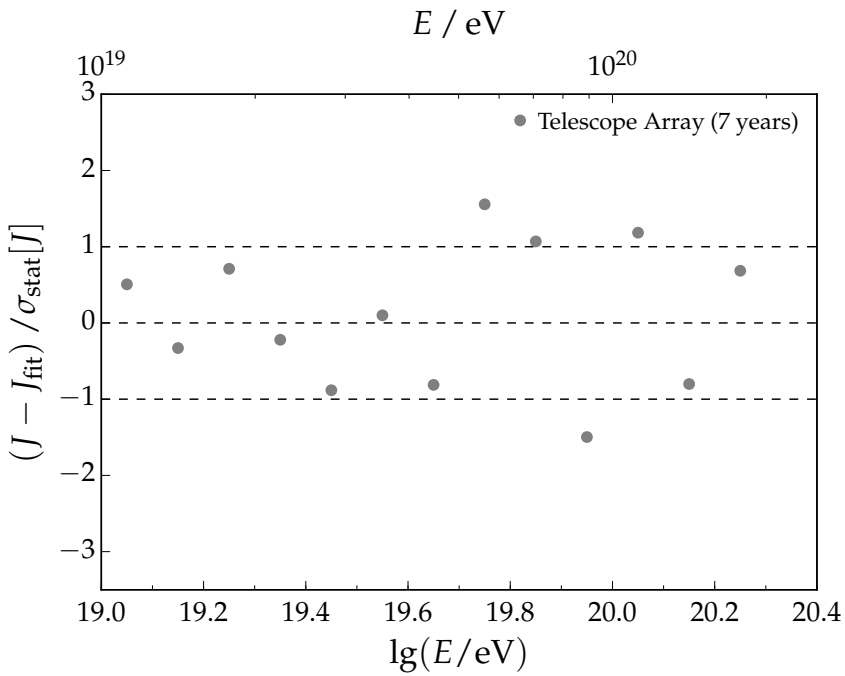
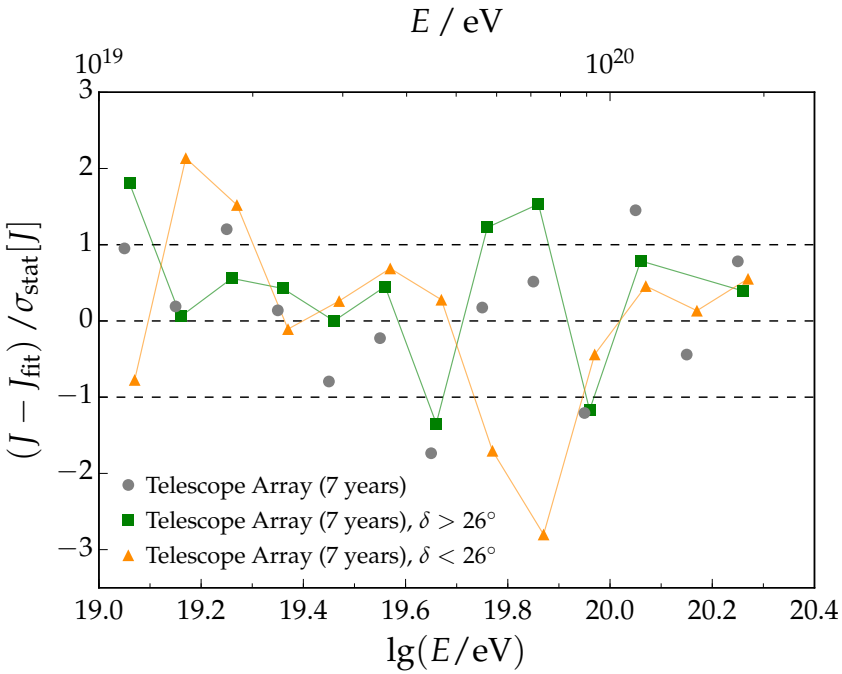


Residuals - Telescope Array

hard



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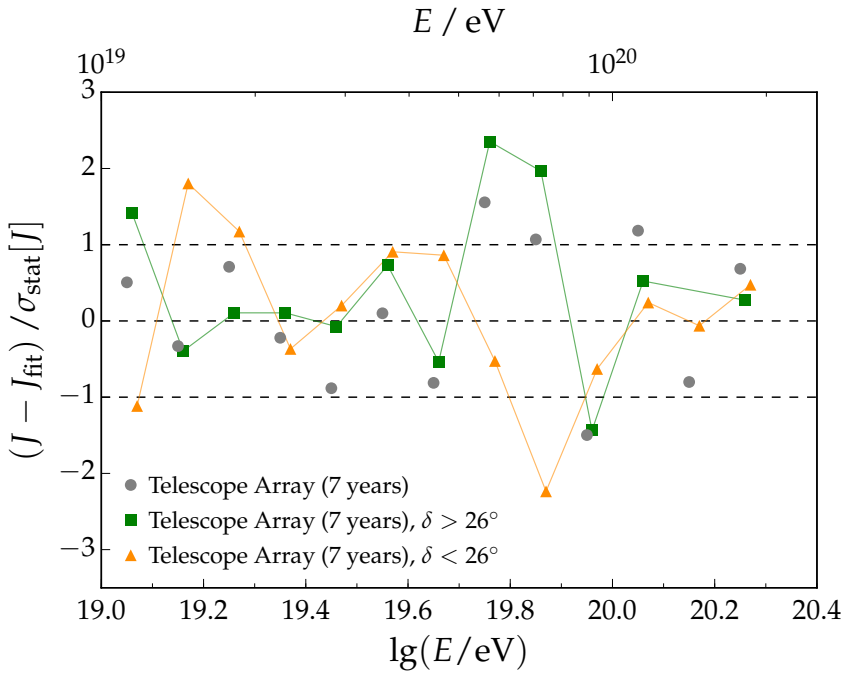
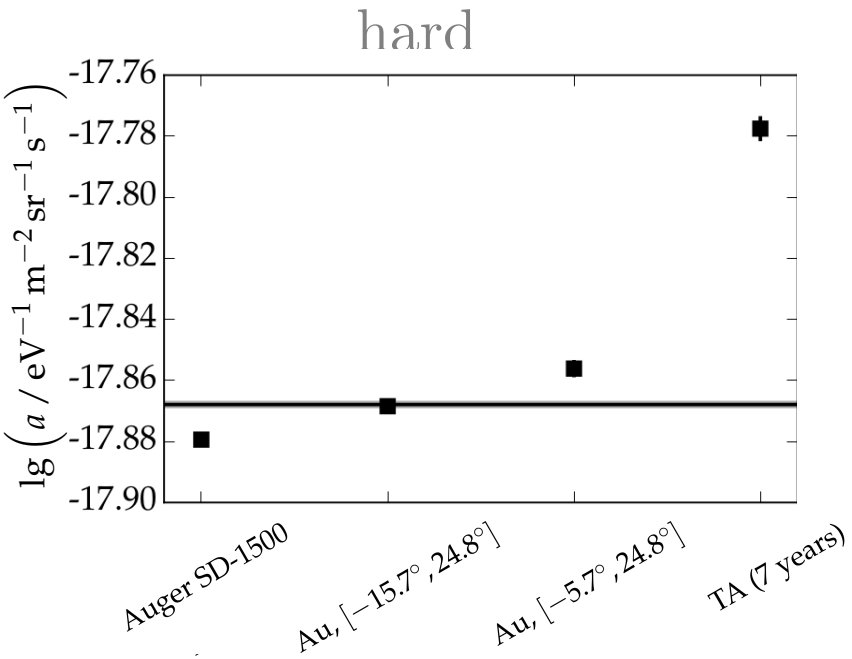
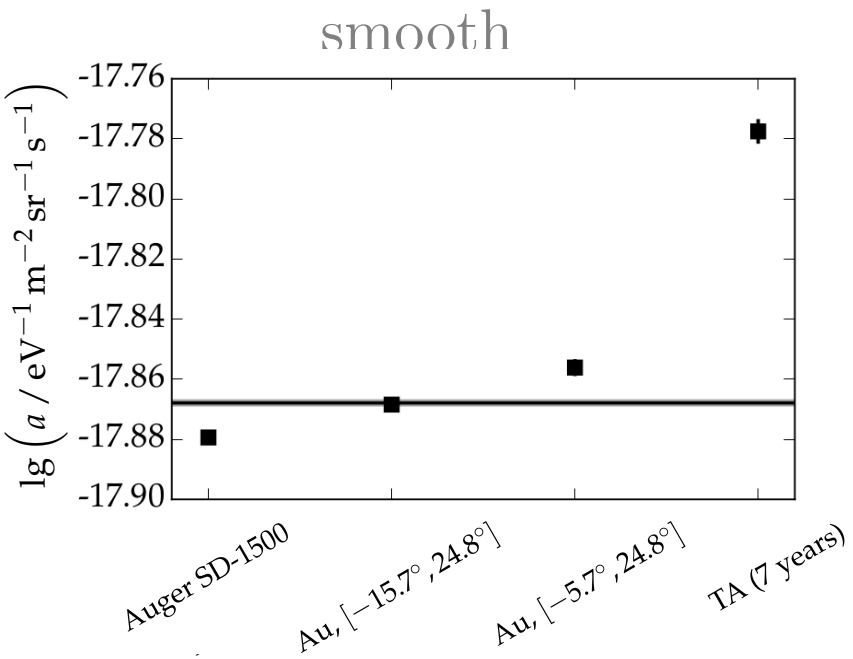


- TA total spectrum up to 45°
  → how does it look like for TA $< 55°$

Fit parameters

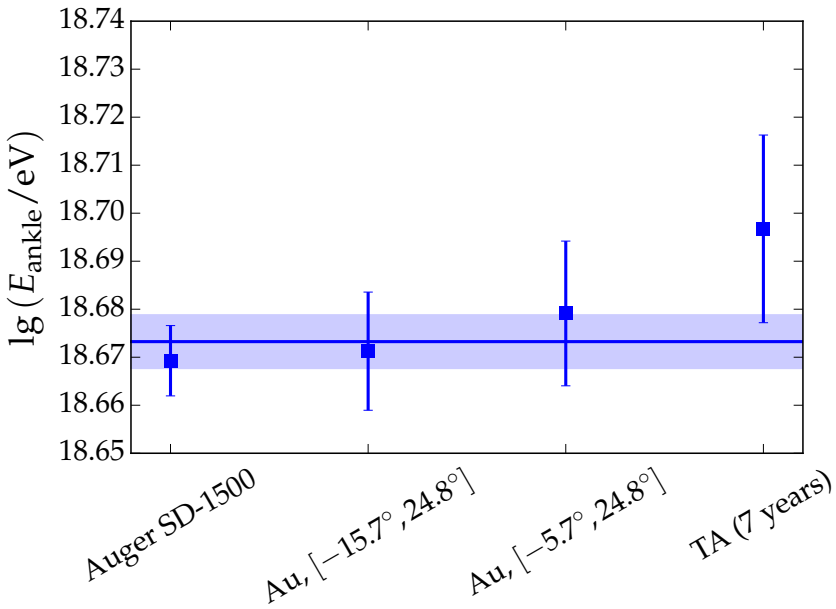
Fit parameters - overall normalization





Fit parameters - position of the ankle

hard



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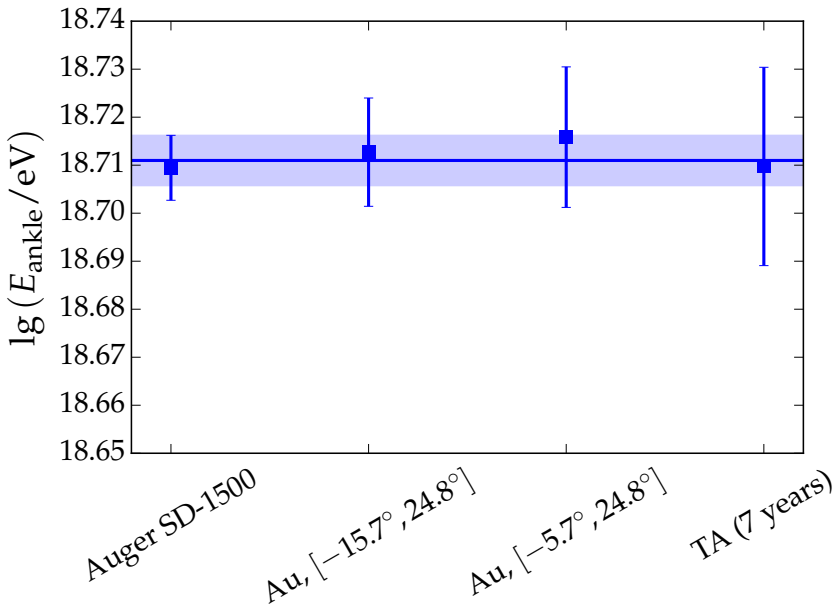
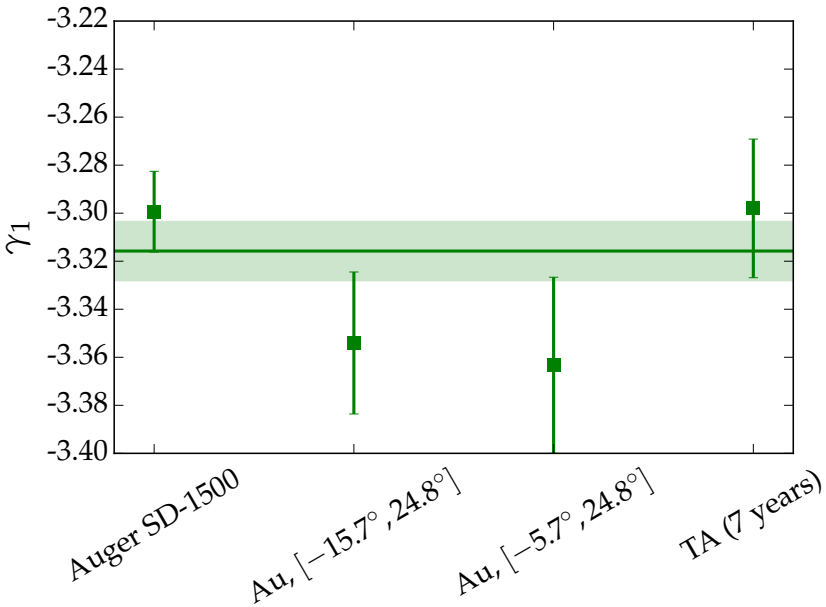


Fit parameters - spectral index prior to the ankle

hard



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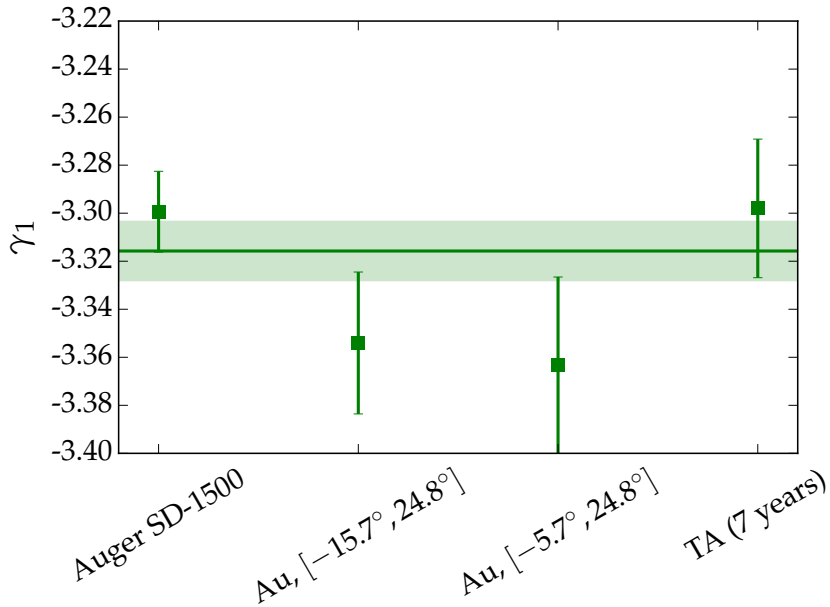
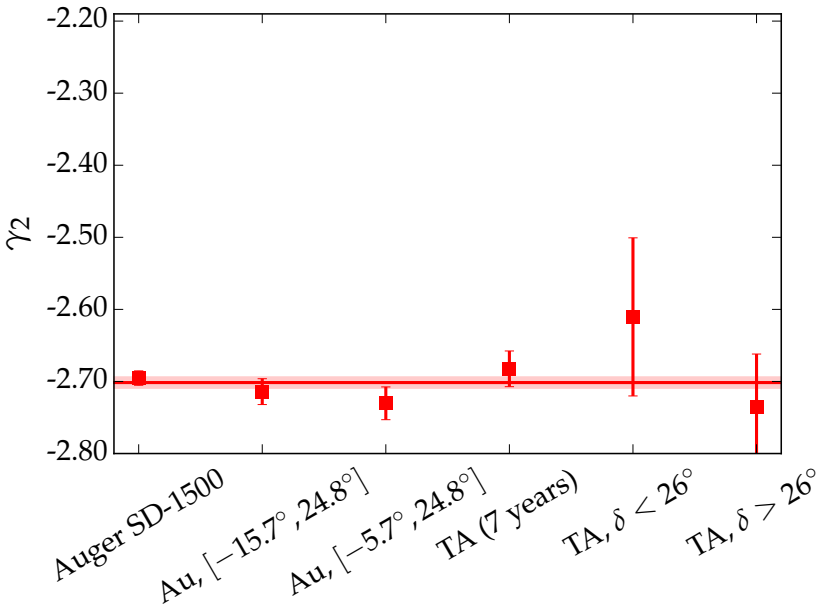


Fit parameters - spectral index after the ankle

hard



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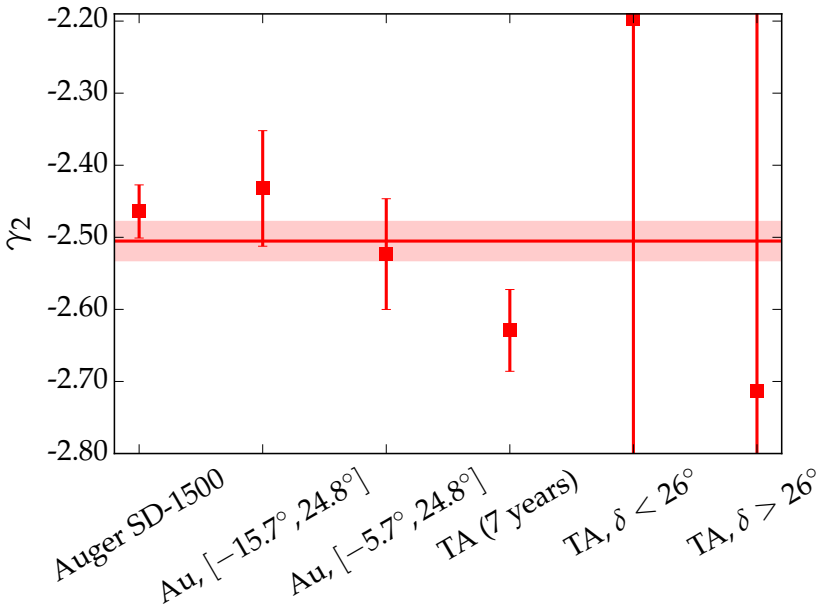
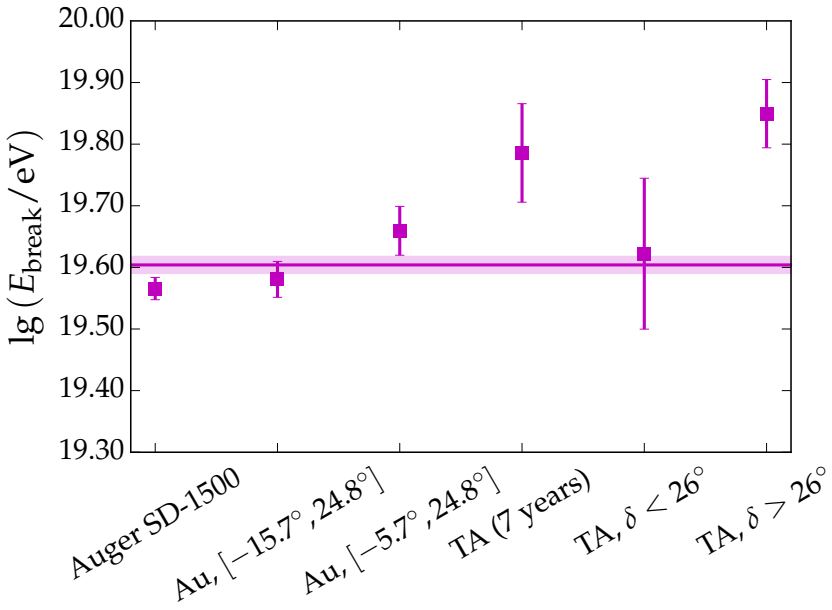


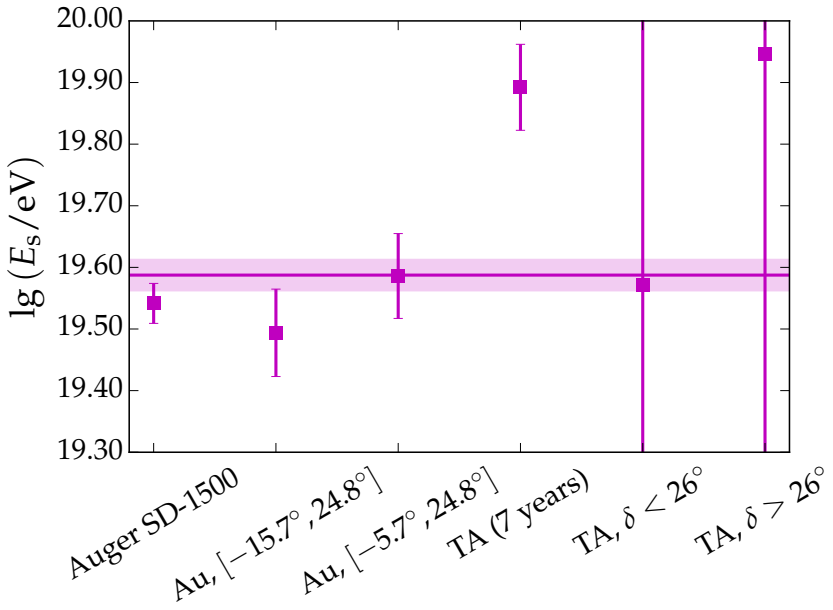
Fit parameters

- Position of E_{break} and $E_{1/2}$ respectively

hard



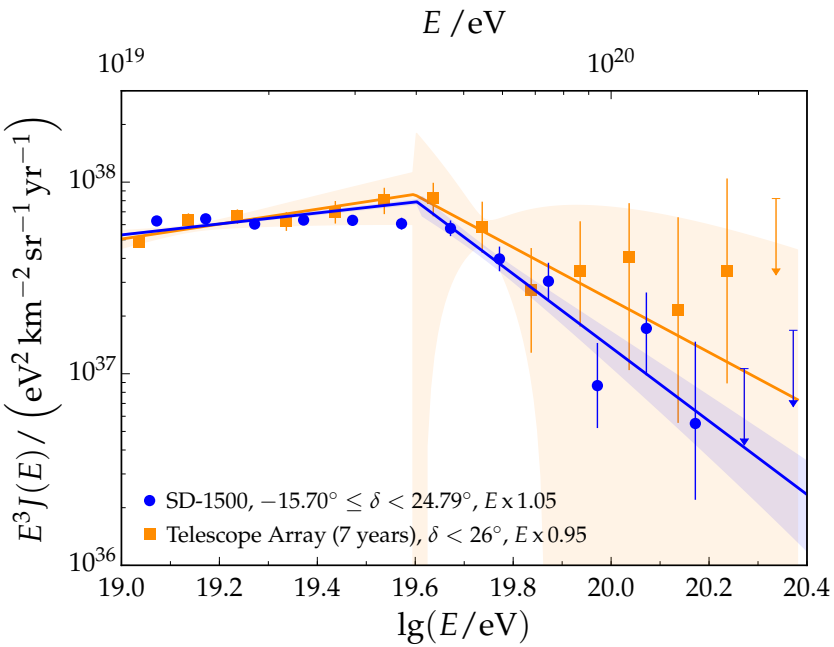
smooth



Auger $[-15.7°, 24.8°]$ vs TA $(\delta < 26°)$

- Common declination band
- Energies rescaled by 5.2%

hard



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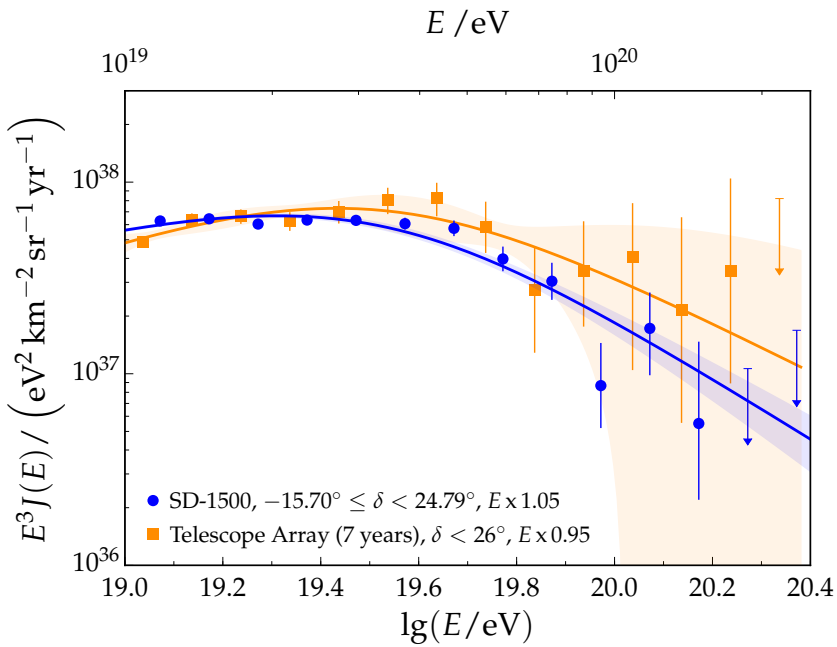
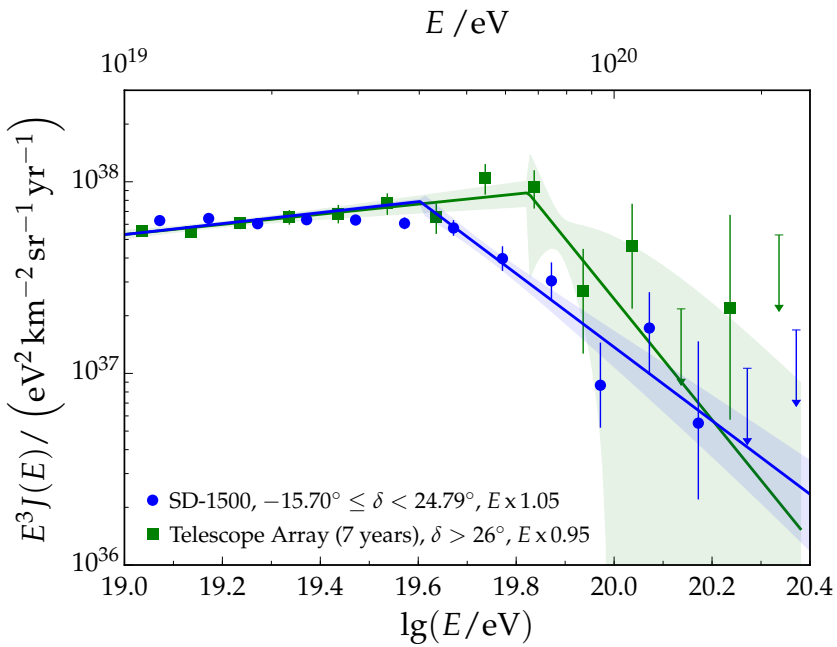


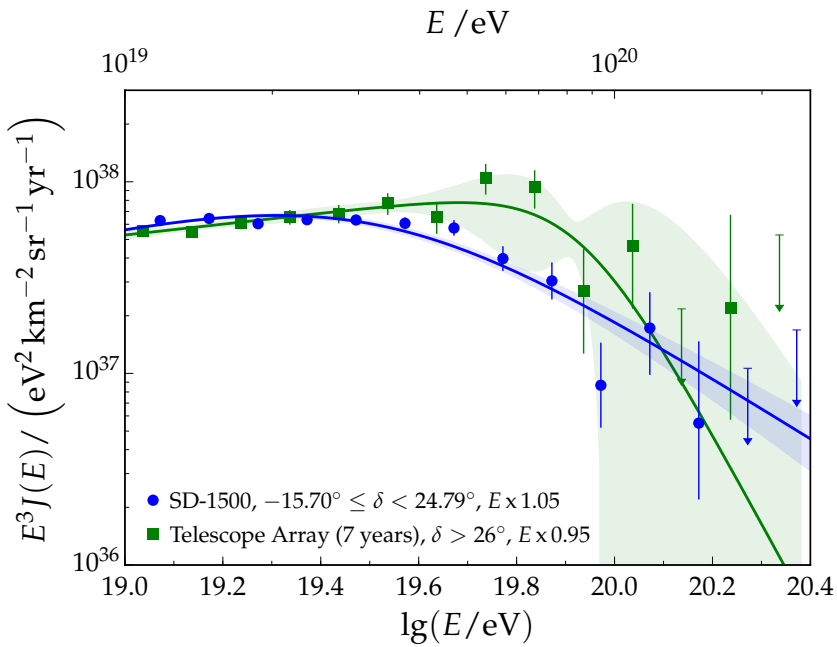
Auger $[-15.7°, 24.8°]$ vs TA ($\delta > 26°$)

- Energies rescaled by 5.2%

hard



smooth

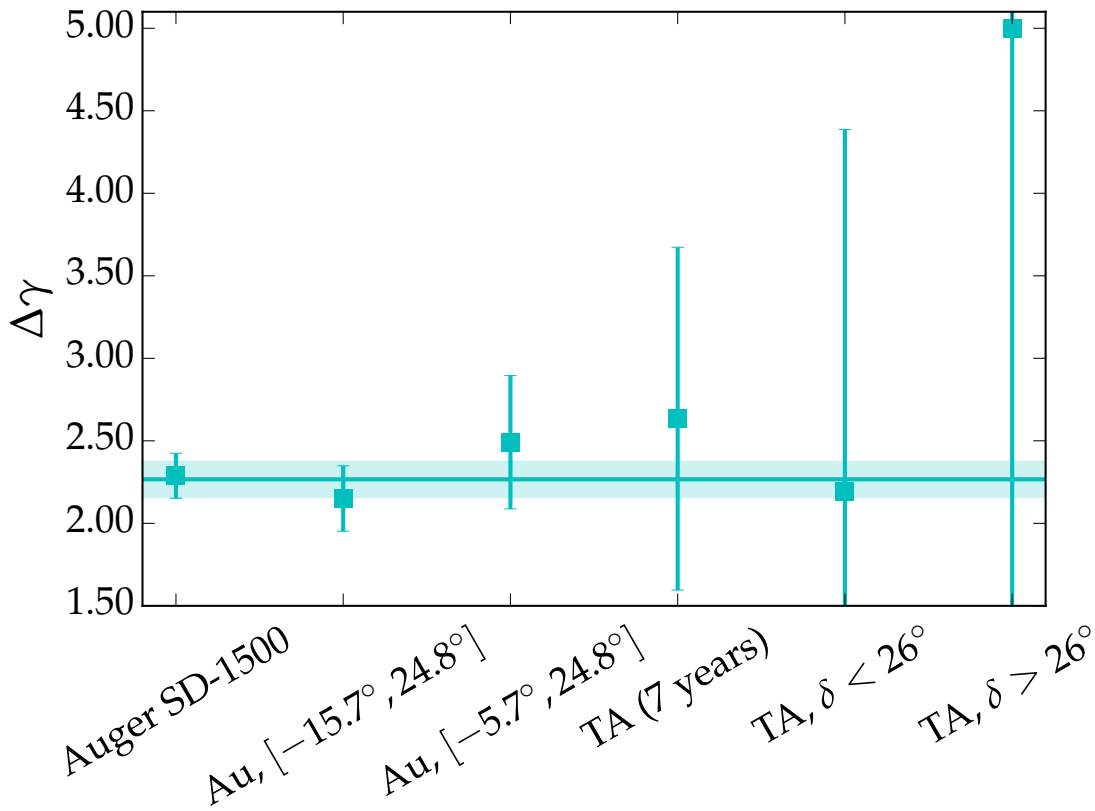


Summary

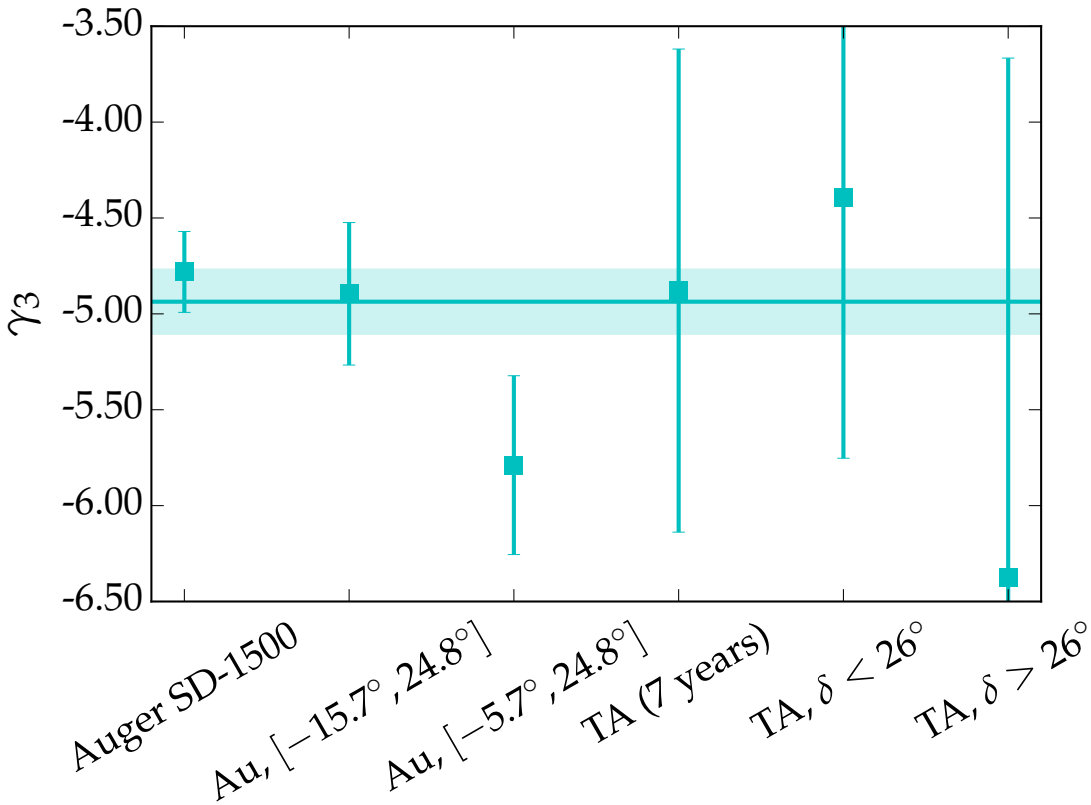
- Auger spectra better described by model with hard ankle and smooth suppression
- TA well described by three power laws
  $\rightarrow$ however, also smooth model fits well in case of the total spectrum
- TA spectrum has higher cut-off energy
- Cut-off energies compatible in common declination band
  $\rightarrow$ higher cut-off energy in northern declination band of TA $\rightarrow$ how does this develop with increasing statistics?
- residuals reveal more details
- show differences in the shape

Back-up

Fit parameters - increment of the spectral index after the suppression

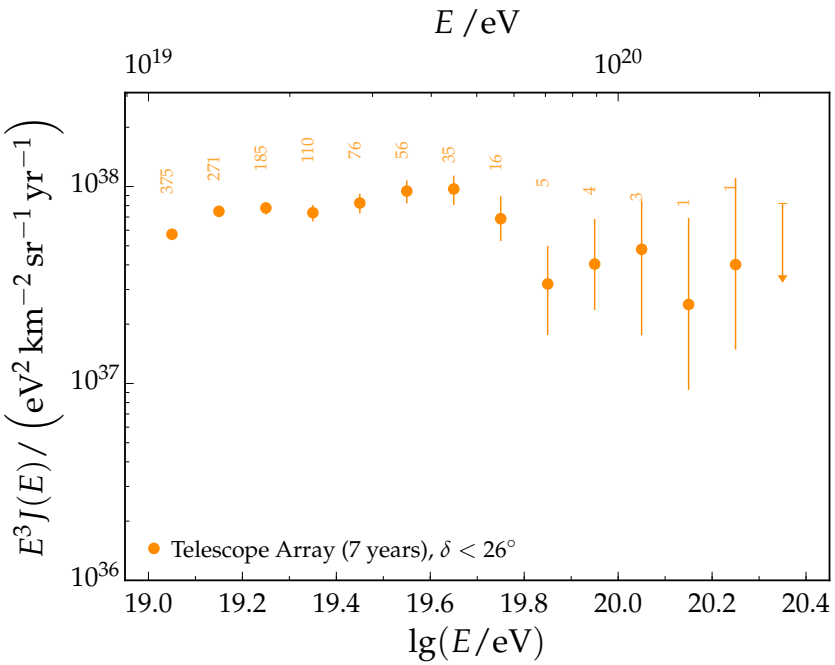


Fit parameters - spectral index after the suppression for hard model

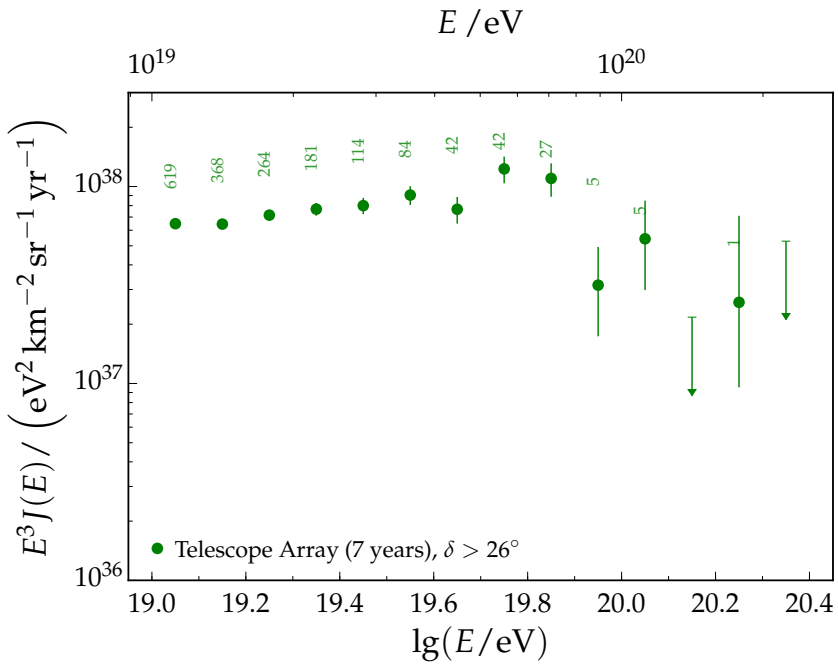


Telescope Array - declination spectra

$\delta < 26°$



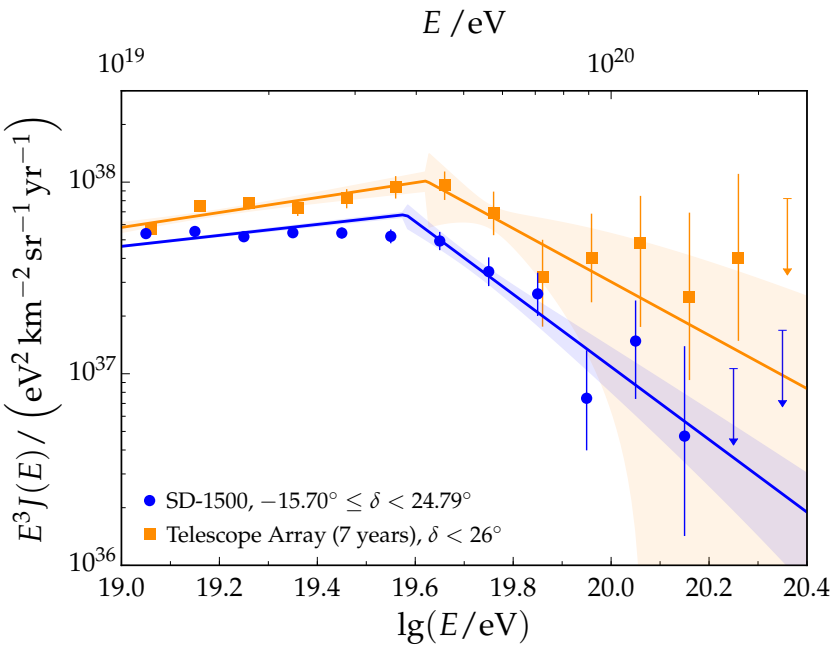
$\delta > 26°$



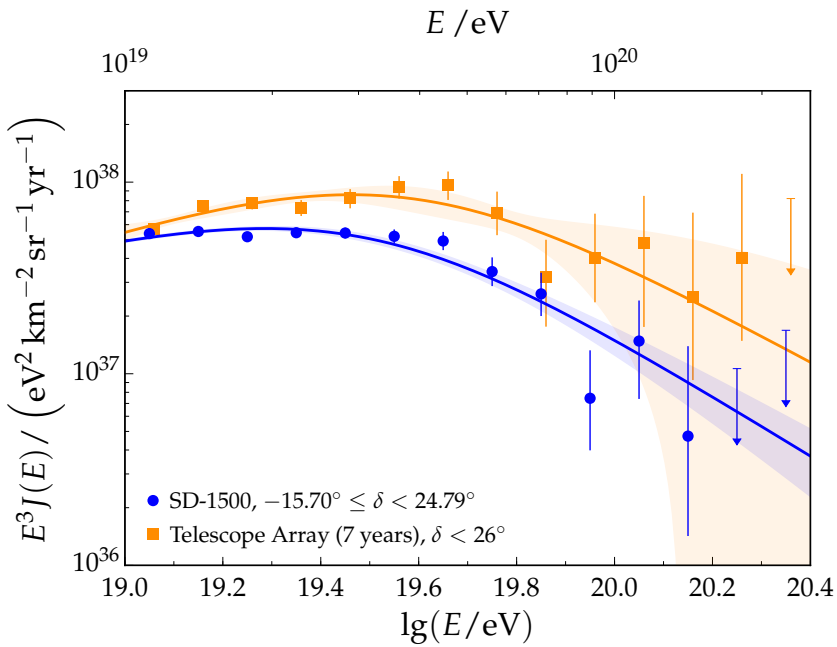
Auger $[-15.7°, 24.8°]$ vs TA $(\delta < 26°)$

- Common declination band
- No scaling

hard



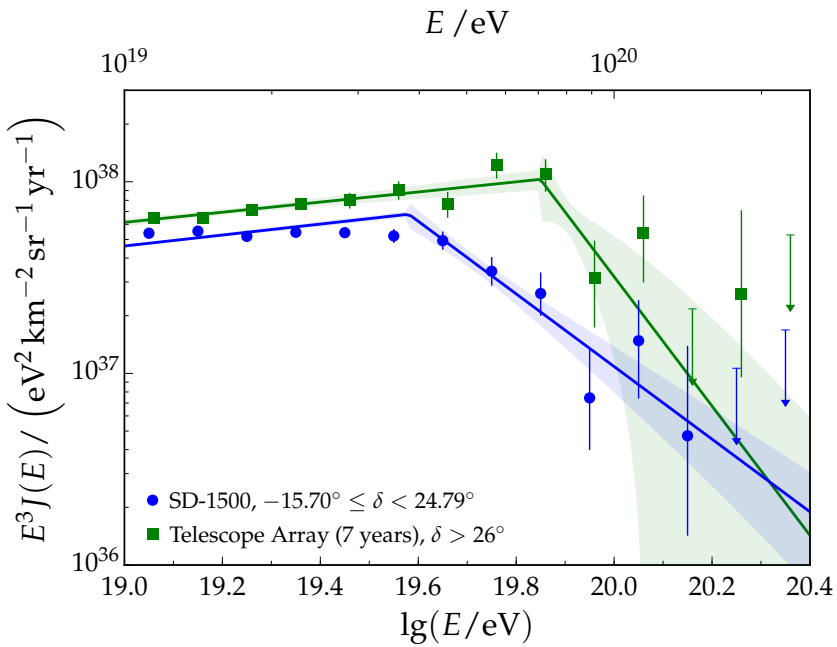
smooth



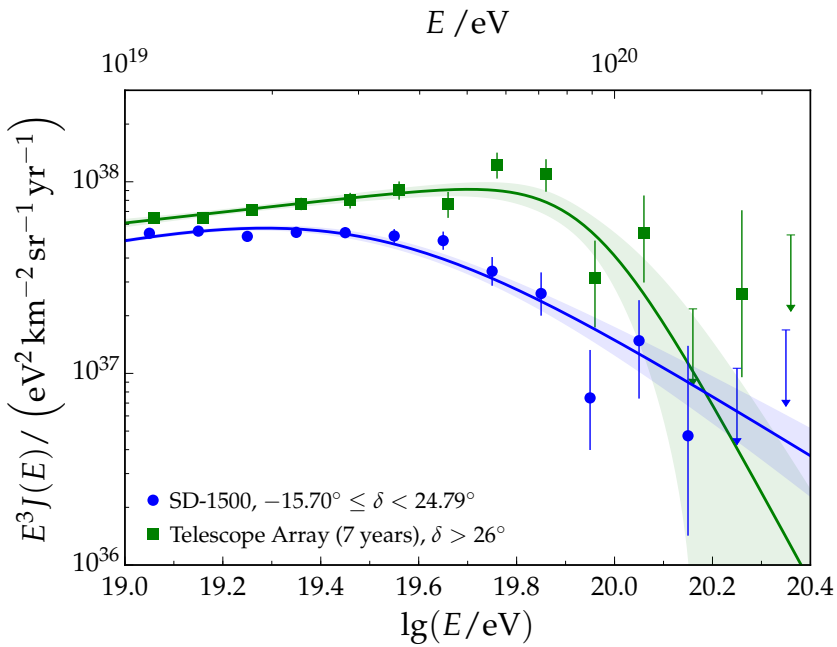
Auger $[-15.7°, 24.8°]$ vs TA $(\delta > 26°)$

- No scaling

hard

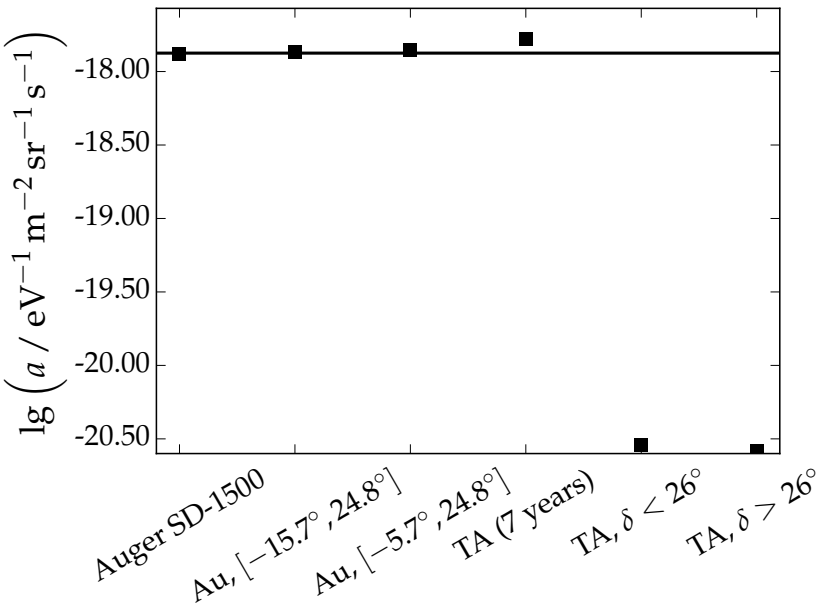


smooth



Fit parameters - overall normalization

hard



smooth