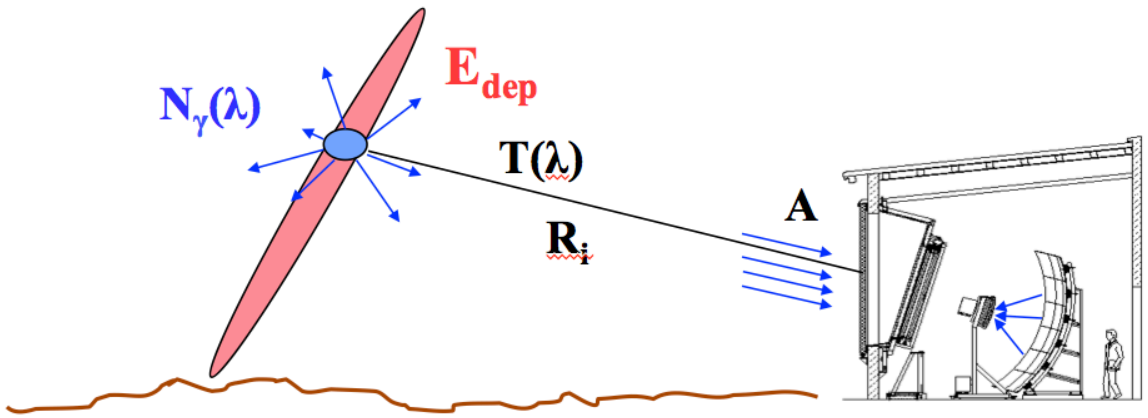
Gruppo Auger Roma “Tor Vergata”

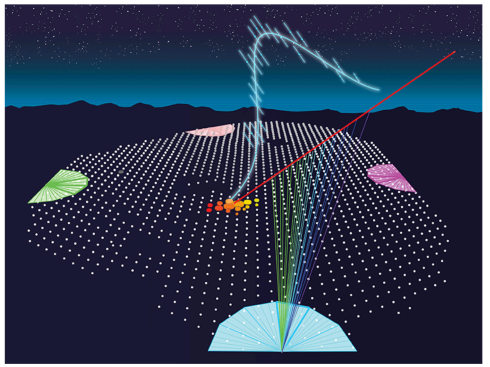
V. Verzi	Ricercatore INFN	80%
G. Salina	Primo Ricercatore INFN	50%
M. Feroci	Dirigente di Ricerca INAF	30%
G. Matthiae	Prof. ordinario	0%

G. Salina leader del *Calibration Analysis task*

V. Verzi leader del *Energy Spectrum task*
responsabile *FD camera PMTs*

Fluorescence events





FD databases

…

Event reconstruction

…

Energy scale

…

Advanced Data Summary Tree (ADST)

- databases
  - calibration: RM2, CT
  - aerosols: NA (CLF), TO (Elastic Lidar) and GSGC (Raman Lidar)
  - validations: all groups including LE

- FD event reconstruction: RM2 and LE
- SD energy calibration: RM2 and MI
- Long Term Performance: CT, GSGC, LE and RM2

- Data production - ADSTs hybrid events: LE

Leadership italiana – uso delle risorse del CNAF

Telescopes calibration

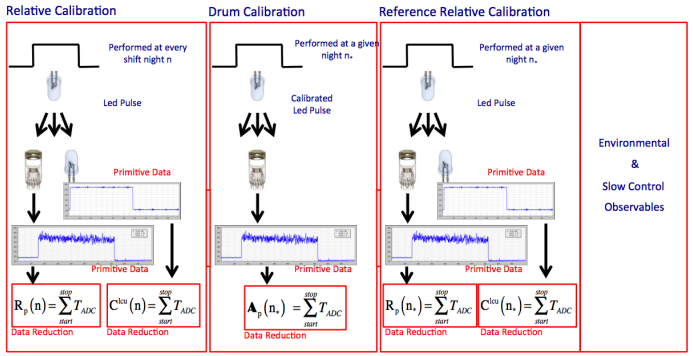
Gaetano S.

Automated procedure for the calibration of ≈ 12,000 PMTs

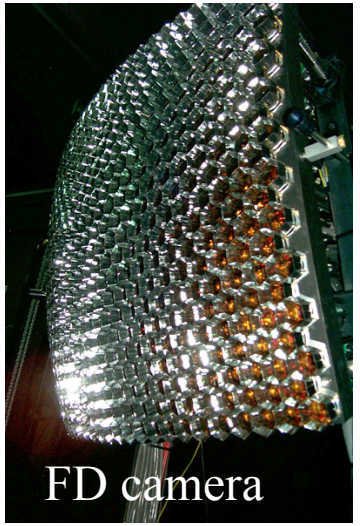
≈ 12,000 entries for each night of data taking → mysql database

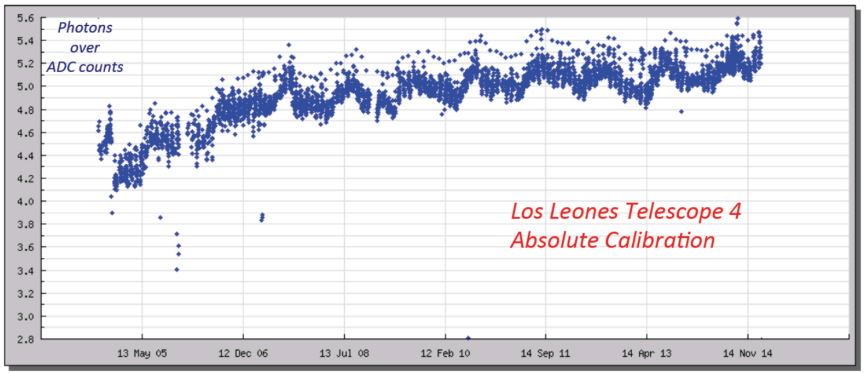
$$A_p(n) = C_p^{halo} \frac{C^{lcu}(n)}{C^{lcu}(n_*)} A_p(n_*) \frac{R_p(n_*)}{R_p(n)}$$

Absolute Calibration Constant $A_p(n)$
as FD Detector descriptor

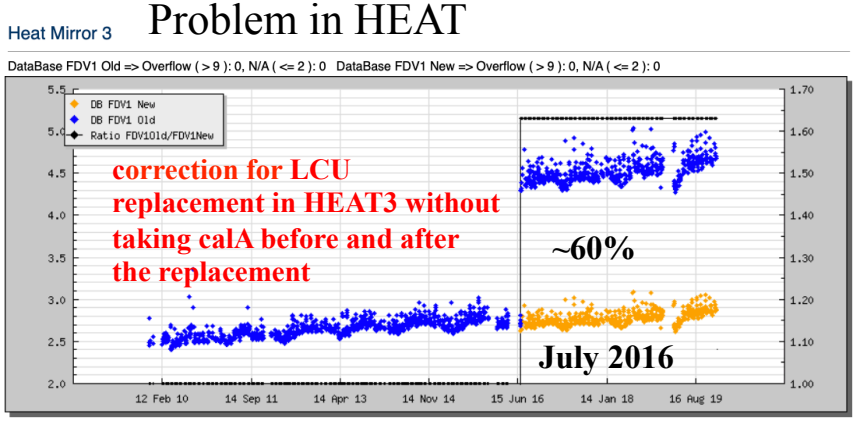


440 PMTs



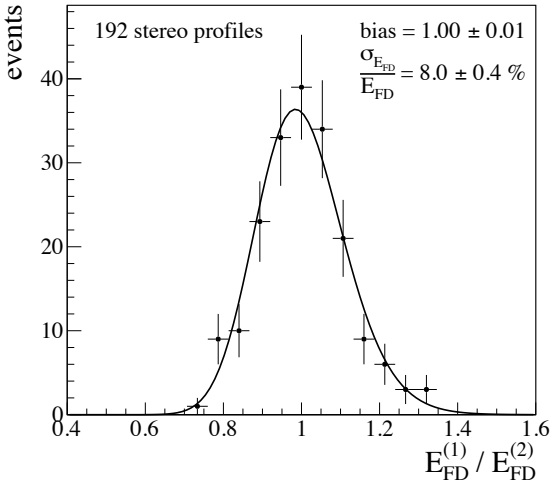


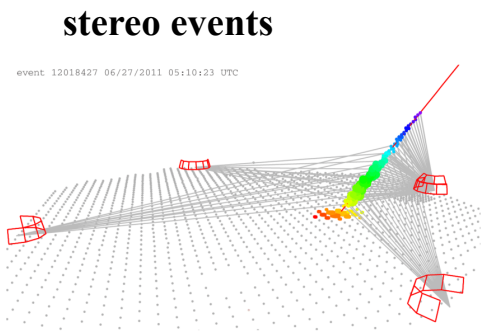
Problem in HEAT



Fluorescence events

Systematic uncertainties on the energy scale	
Absolute fluorescence yield	3.4%
Fluor. spectrum and quenching param.	1.1%
Sub total (Fluorescence yield - sec. 2)	**3.6%**
Aerosol optical depth	3%÷6%
Aerosol phase function	1%
Wavelength depend. of aerosol scatt.	0.5%
Atmospheric density profile	1%
Sub total (Atmosphere - sec. 3)	**3.4%÷6.2%**
Absolute FD calibration	9%
Nightly relative calibration	2%
Optical efficiency	3.5%
Sub total (FD calibration - sec. 4)	**9.9%**
Folding with point spread function	5%
Multiple scattering model	1%
Simulation bias	2%
Constraints in the Gaisser-Hillas fit	3.5% ÷ 1%
Sub total (FD profile rec. - sec. 5)	**6.5% ÷5.6%**
Invisible energy (sec. 6)	**3%÷1.5%**
Stat. error of the SD calib. fit (sec. 7)	**0.7%÷1.8%**
Stability of the energy scale (sec. 7)	**5%**
Total	**14%**



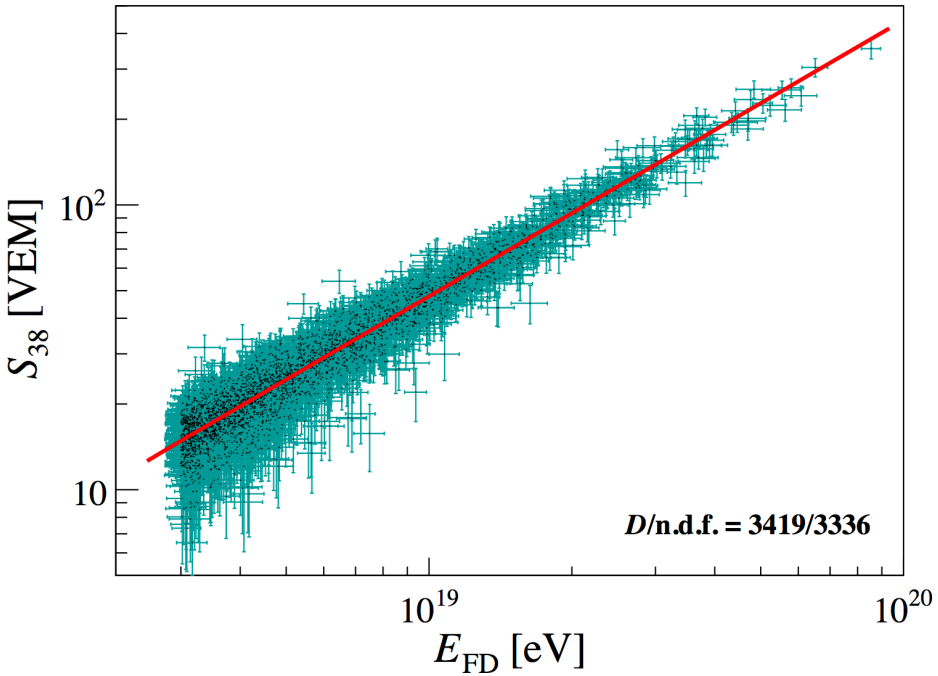


FD energy resolution	
Aerosol optical depth	1.2% – 3.8%
Horiz. uniform. of aerosols	1.6% – 5%
Molecular atmosphere	1%
Nightly relative calib.	1.3%
Time drift of FD energies	2.5%
Mismatch between telescopes	3.5%
Stat. error from geom. and GH fit	4.6% – 2.8%
Extrapolation of profile	2.2%
E_{inv} shower-to-shower fluc.	1.1% – 0.6%
E_{inv} mass uncertainty	2.4% – 0.3%
TOTAL	7.6% – 8.6%

Energy scale – ICRC 2013
Energy resolution – ICRC 2019

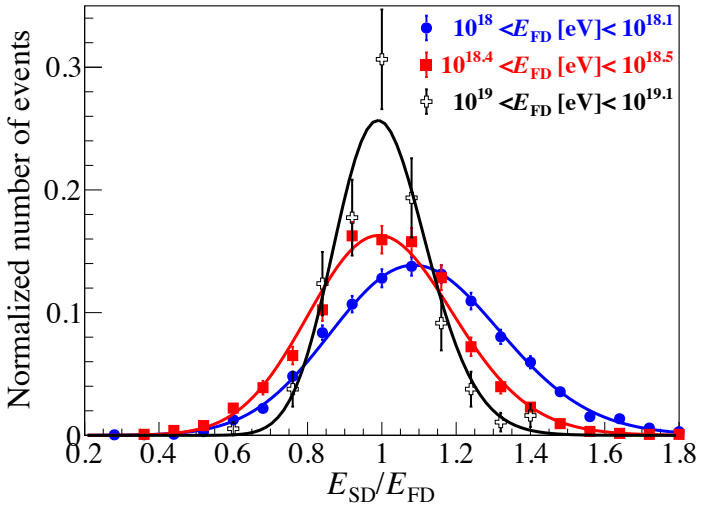
Calibration of SD events

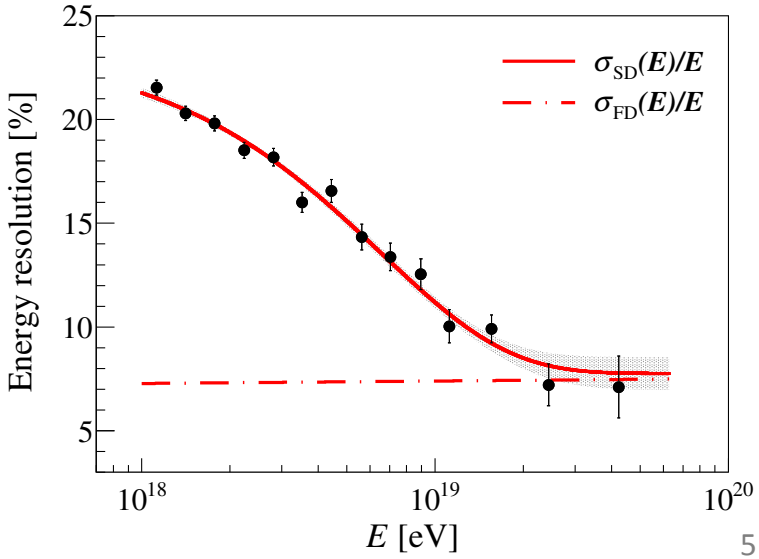
SD energy calibration



Phys. Rev. D 102, 062005 (2020)

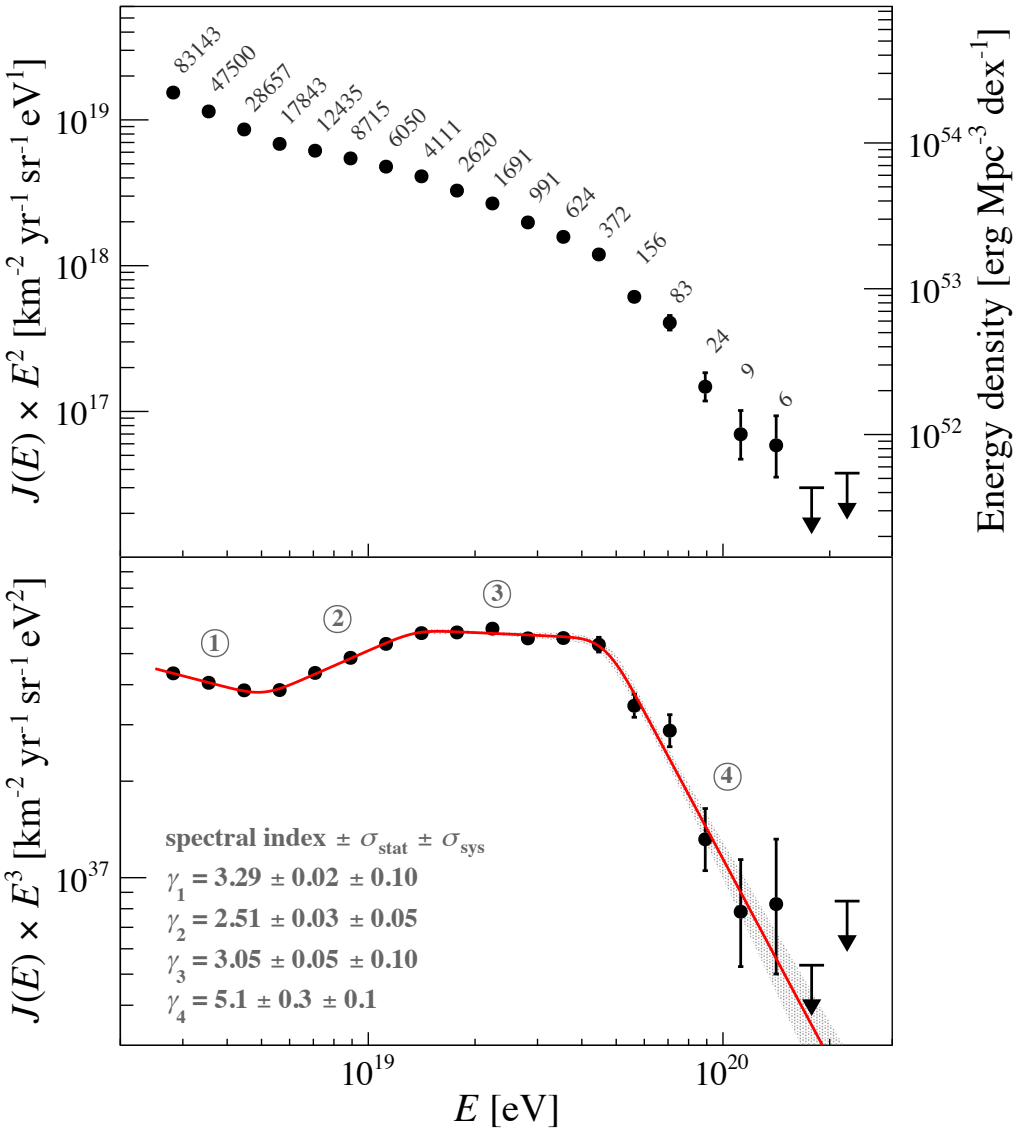
SD energy resolution





Energy spectrum

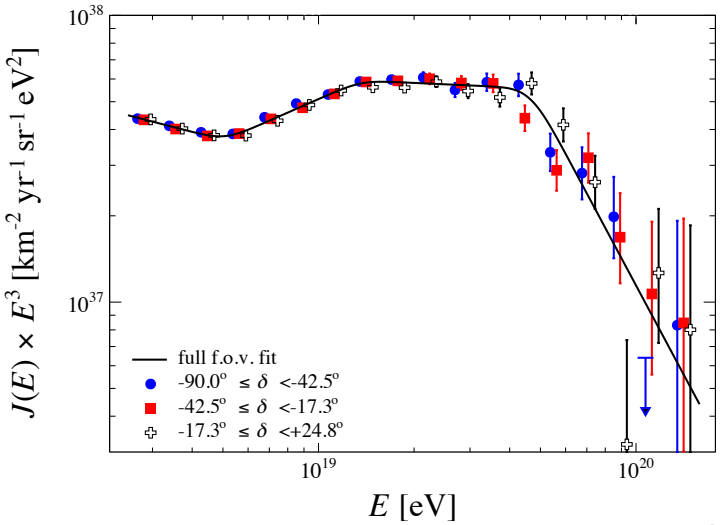
in collaboration with TO
(F. Fenu co-task leader)



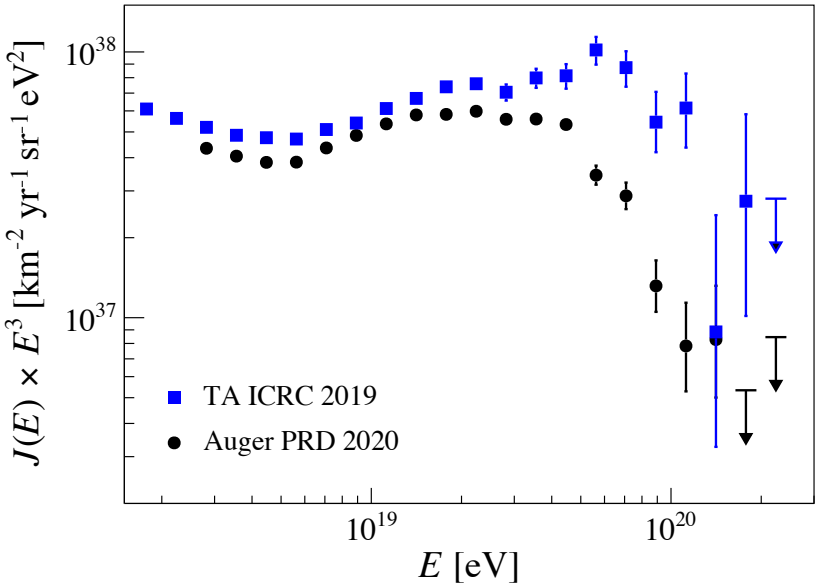
Phys. Rev. D 102, 062005 (2020)
Phys. Rev. Lett. 125, 121106 (2020)
Editors' suggestions & press-release

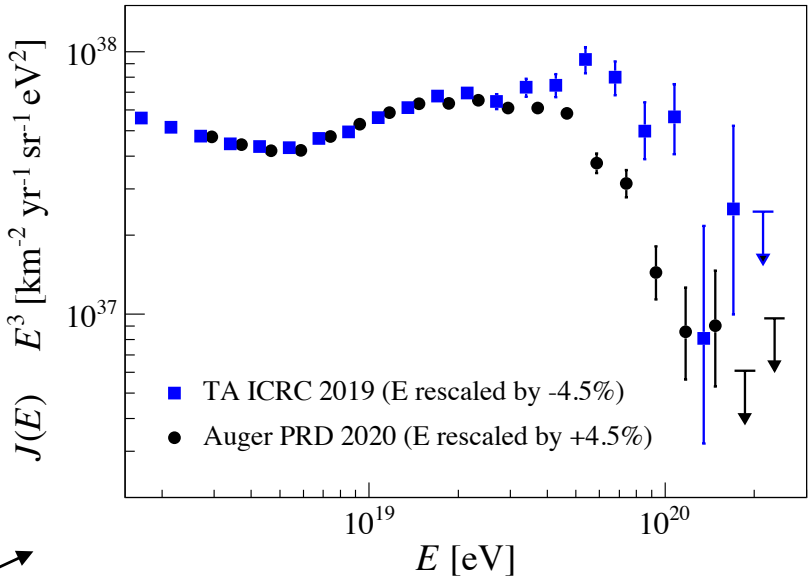
- ankle and suppression
- new feature at ≈ 10 EeV
- absence of declination dependence
- interpretation (TO)

<u>measurement free of assumptions on hadronic physics and the mass composition</u>

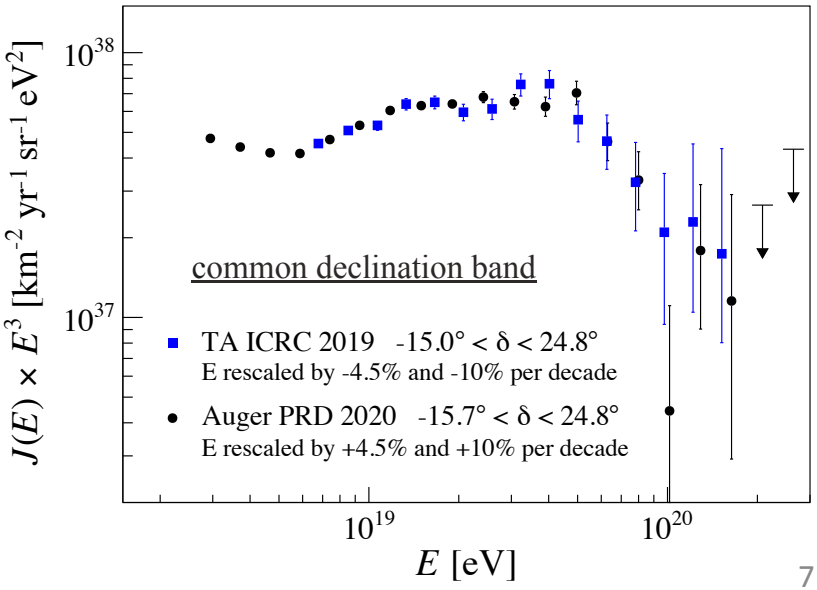


Auger vs Telescope Array





9% reduced to <5% once the same fluorescence yield and invisible energy model are used



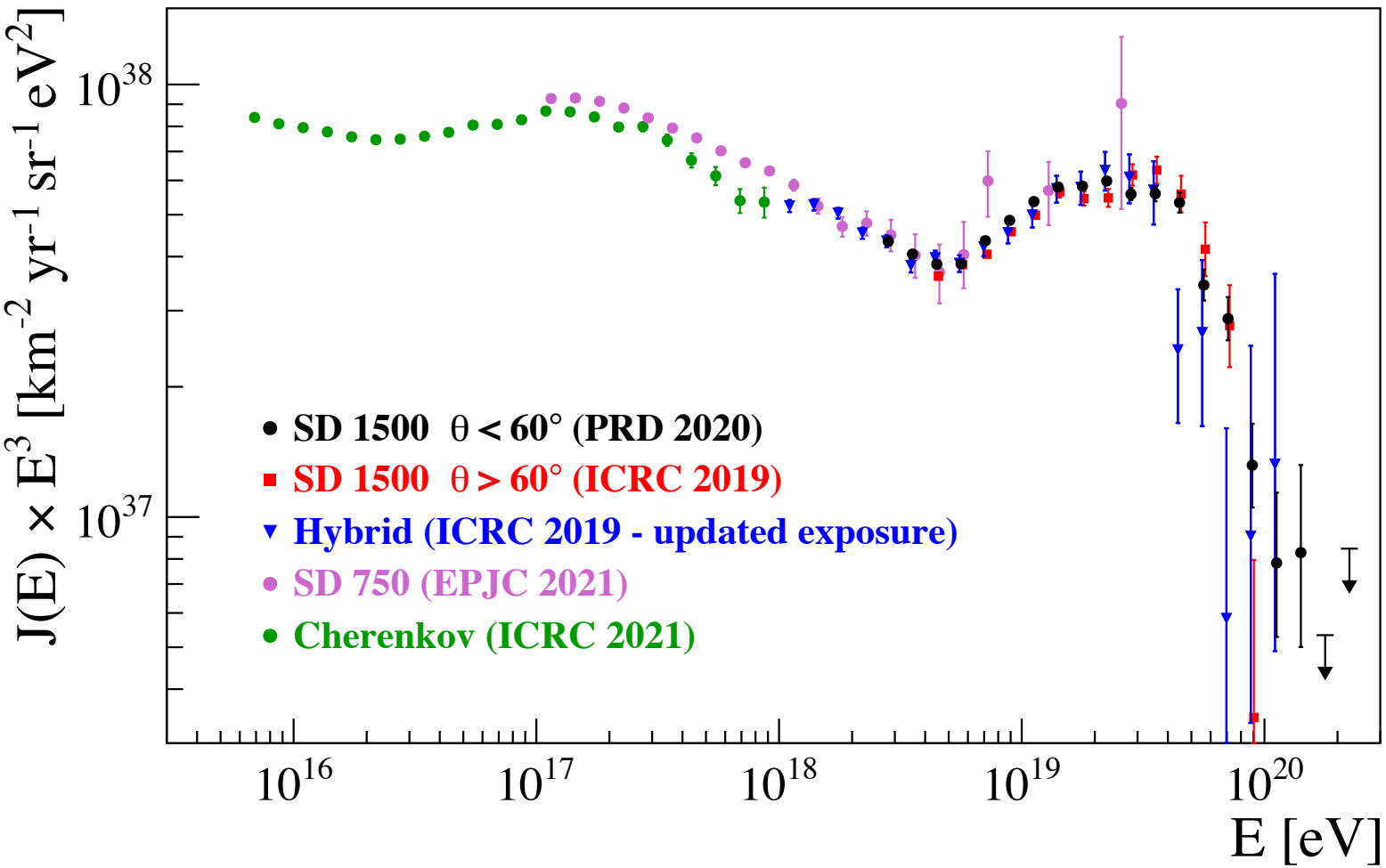
- excellent agreement around the "ankle"
- disagreement at highest energies significant (TA SD analysis?)

Joint WG – PoS (ICRC2021) 337
RM2 GSGC TO

Energy spectrum

in collaboration with TO
(F. Fenu co-task leader)

PoS (ICRC2021) 324

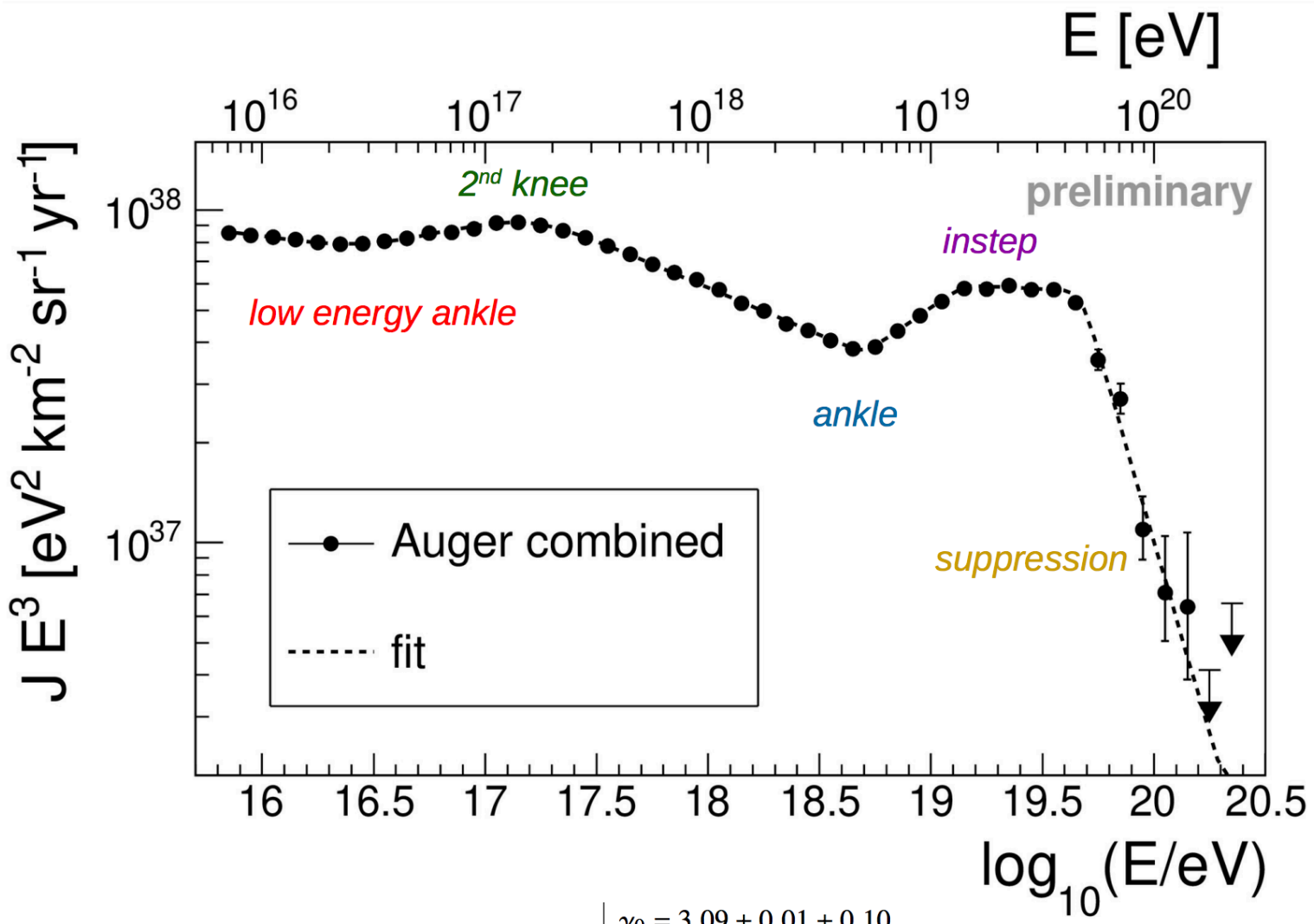


- Energy threshold lowered to 6×10^{15} eV
- Uncorrelated uncertainties (14% energy scale in common) important when comparing different measurements

Energy spectrum

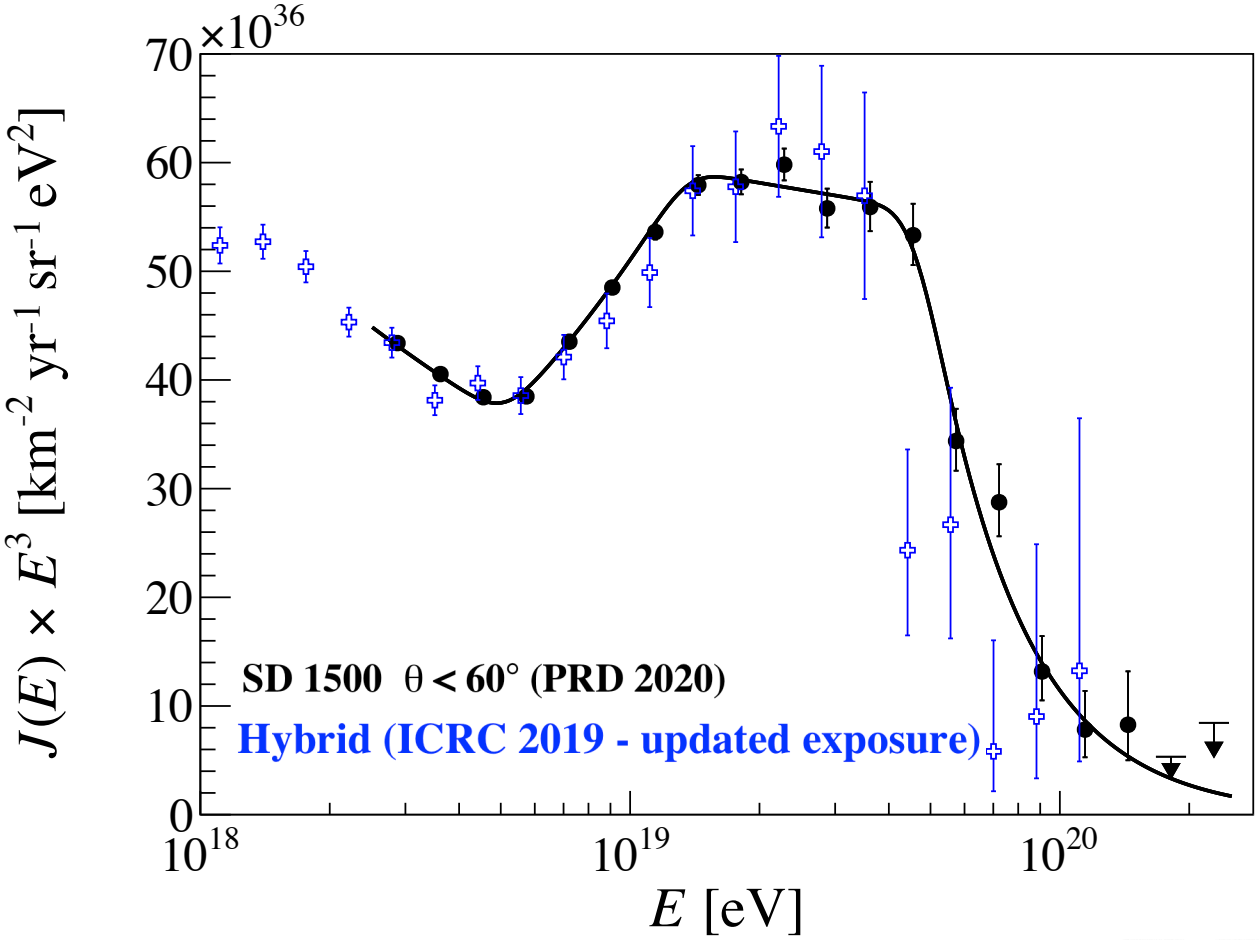
in collaboration with TO
(F. Fenu co-task leader)

PoS (ICRC2021) 324



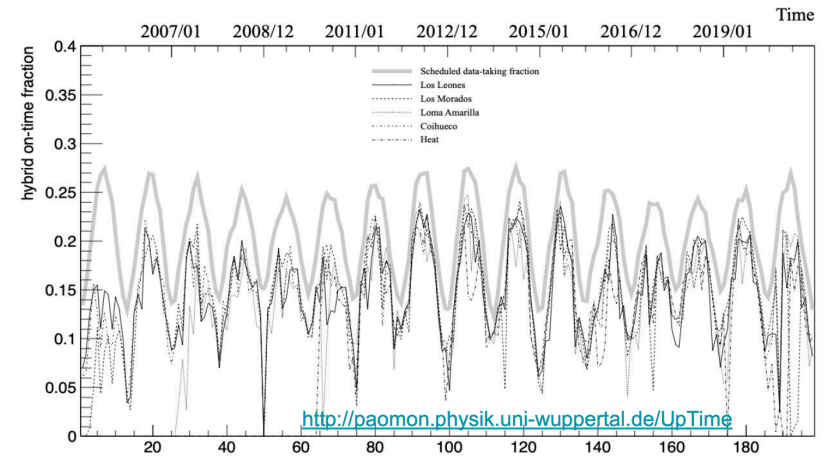
		$\gamma_0 = 3.09 \pm 0.01 \pm 0.10$
low energy ankle	$E_{01} = (2.8 \pm 0.3 \pm 0.4) \times 10^{16}$ eV	$\gamma_1 = 2.85 \pm 0.01 \pm 0.05$
2nd knee	$E_{12} = (1.58 \pm 0.05 \pm 0.2) \times 10^{17}$ eV	$\gamma_2 = 3.283 \pm 0.002 \pm 0.10$
ankle	$E_{23} = (5.0 \pm 0.1 \pm 0.8) \times 10^{18}$ eV	$\gamma_3 = 2.54 \pm 0.03 \pm 0.05$
instep	$E_{34} = (1.4 \pm 0.1 \pm 0.2) \times 10^{19}$ eV	$\gamma_4 = 3.03 \pm 0.05 \pm 0.10$
suppression	$E_{45} = (4.7 \pm 0.3 \pm 0.6) \times 10^{19}$ eV	$\gamma_5 = 5.3 \pm 0.3 \pm 0.1$

Hybrid spectrum



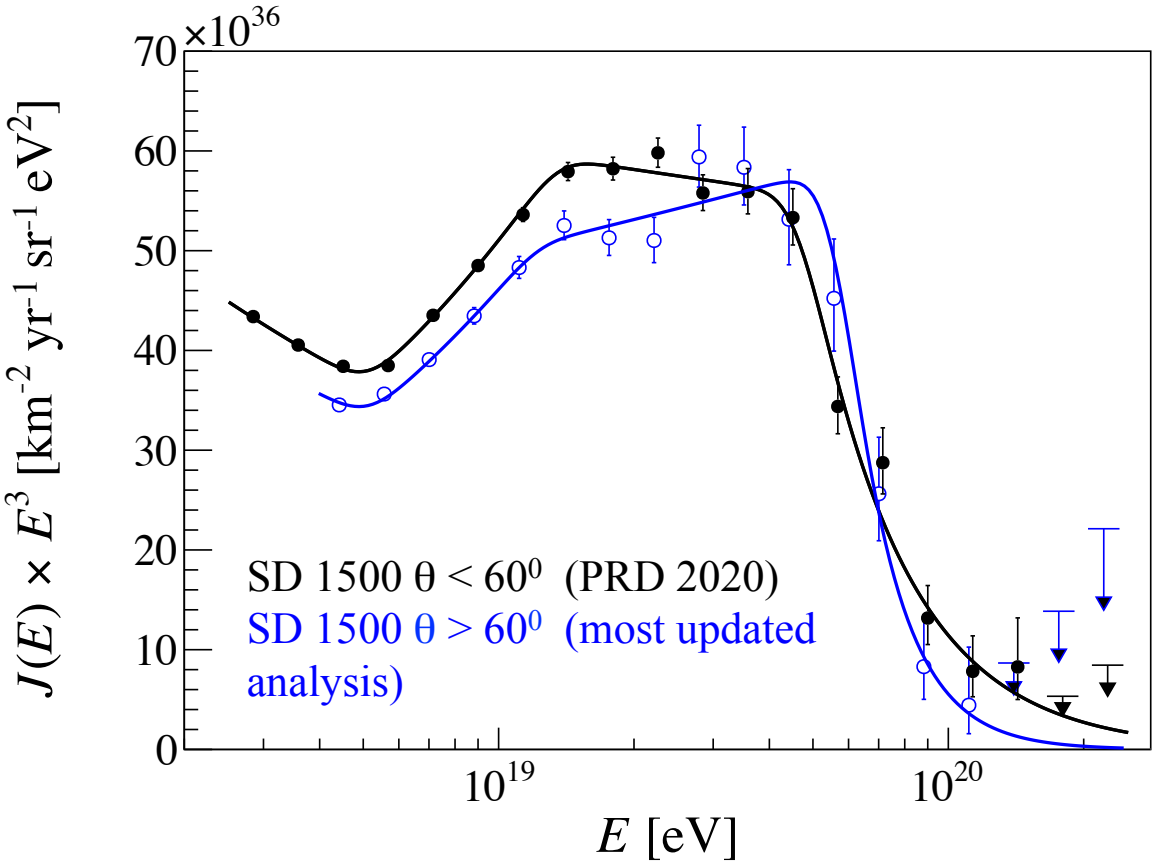
leadership italiana GSGC & LE

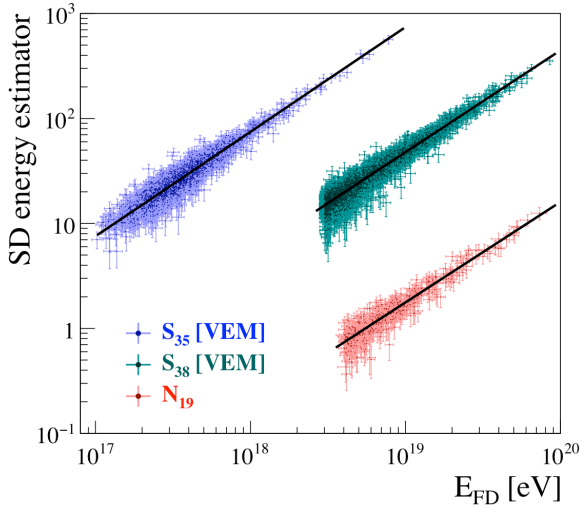
Hybrid exposure: time dependent simulation of the detector and atmosphere



(L.Perrone, J. Rautenberg, F.S.)

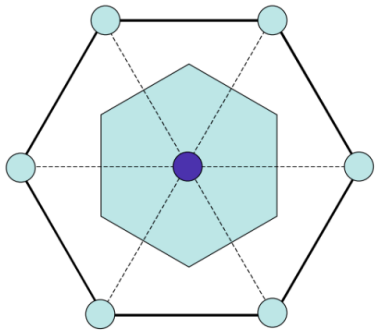
SD 1500 $\theta > 60^0$ spectrum



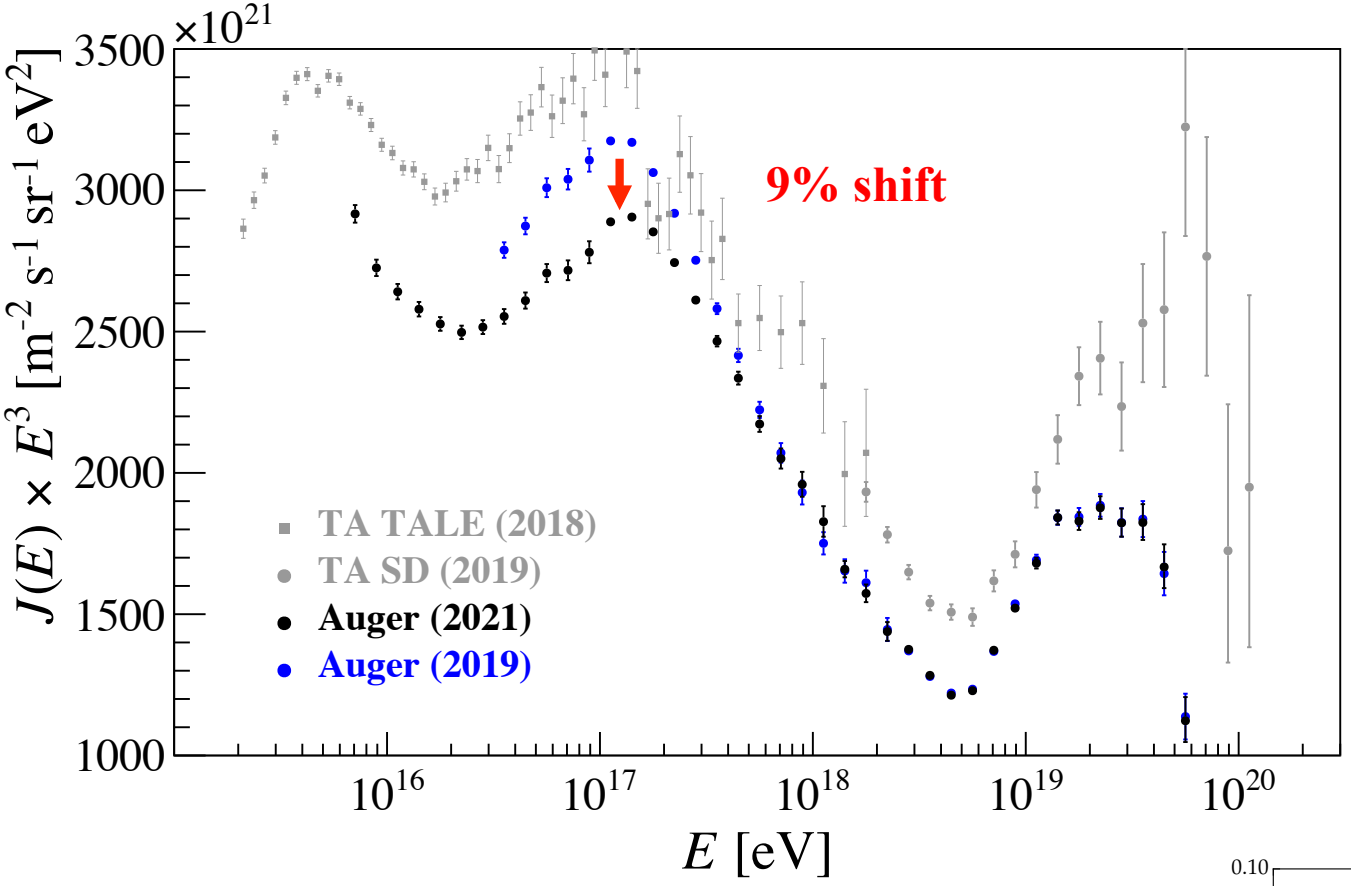


~9% offset in normalization?

- Fiducial trigger (MI)
  - $\theta < 60^0$ hottest tank
  - $\theta > 60^0$ reconstructed core ?
- Energy calibration
  - bias in mass composition of hybrid events $N_{19} \sim A^{0.1}$?

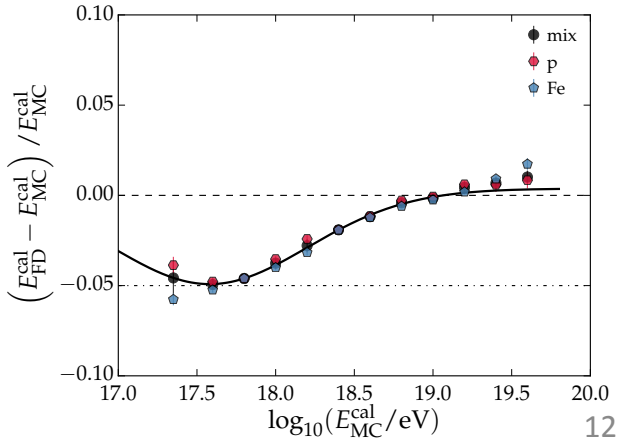


Extension to low energies

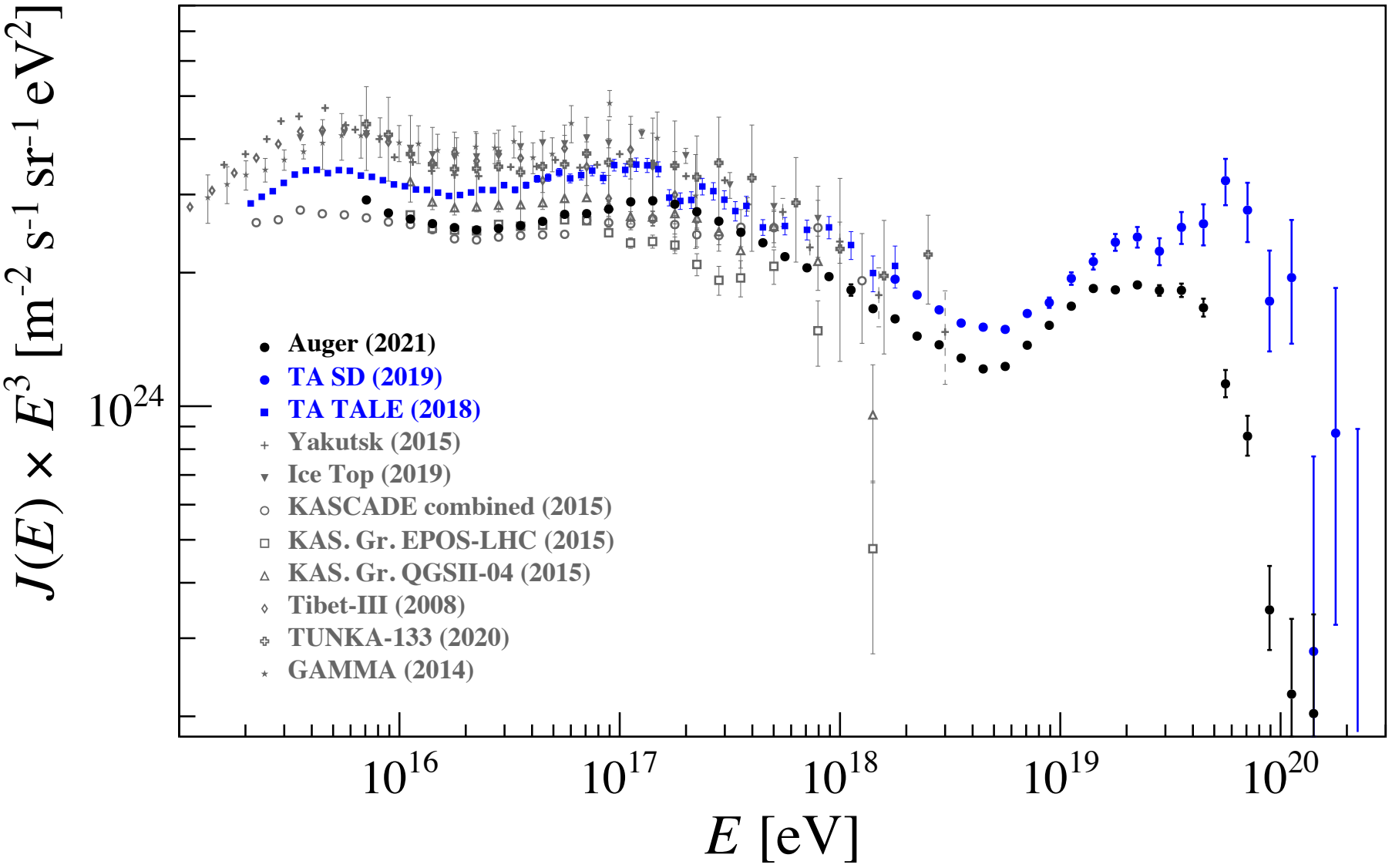


$$\frac{\Delta J}{J} \sim (\gamma - 1)\frac{\Delta E}{E}$$

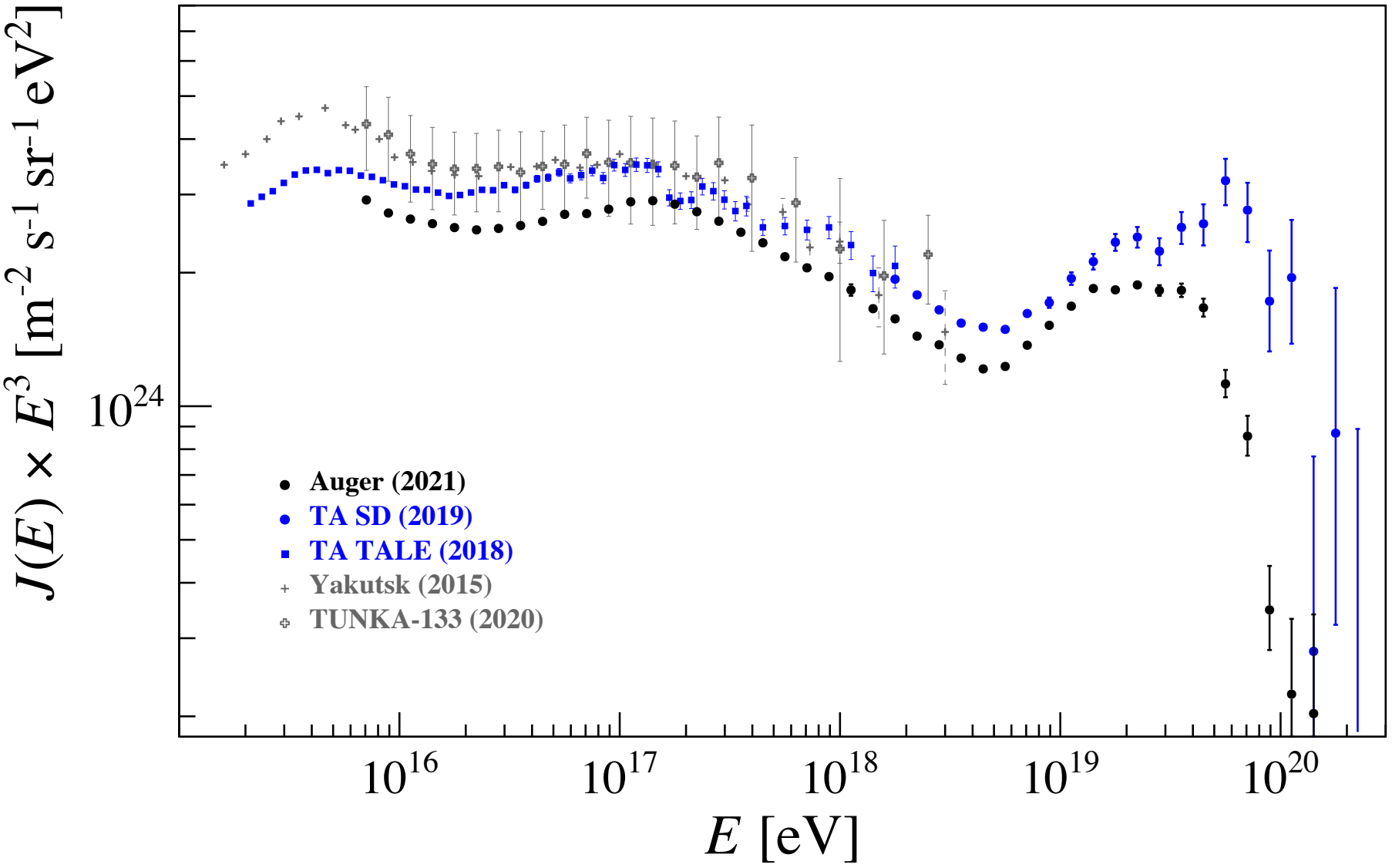
- HEAT absolute calibration updated using Night Sky Background (?)
- small bias in E_{cal} reconstruction at low energies?



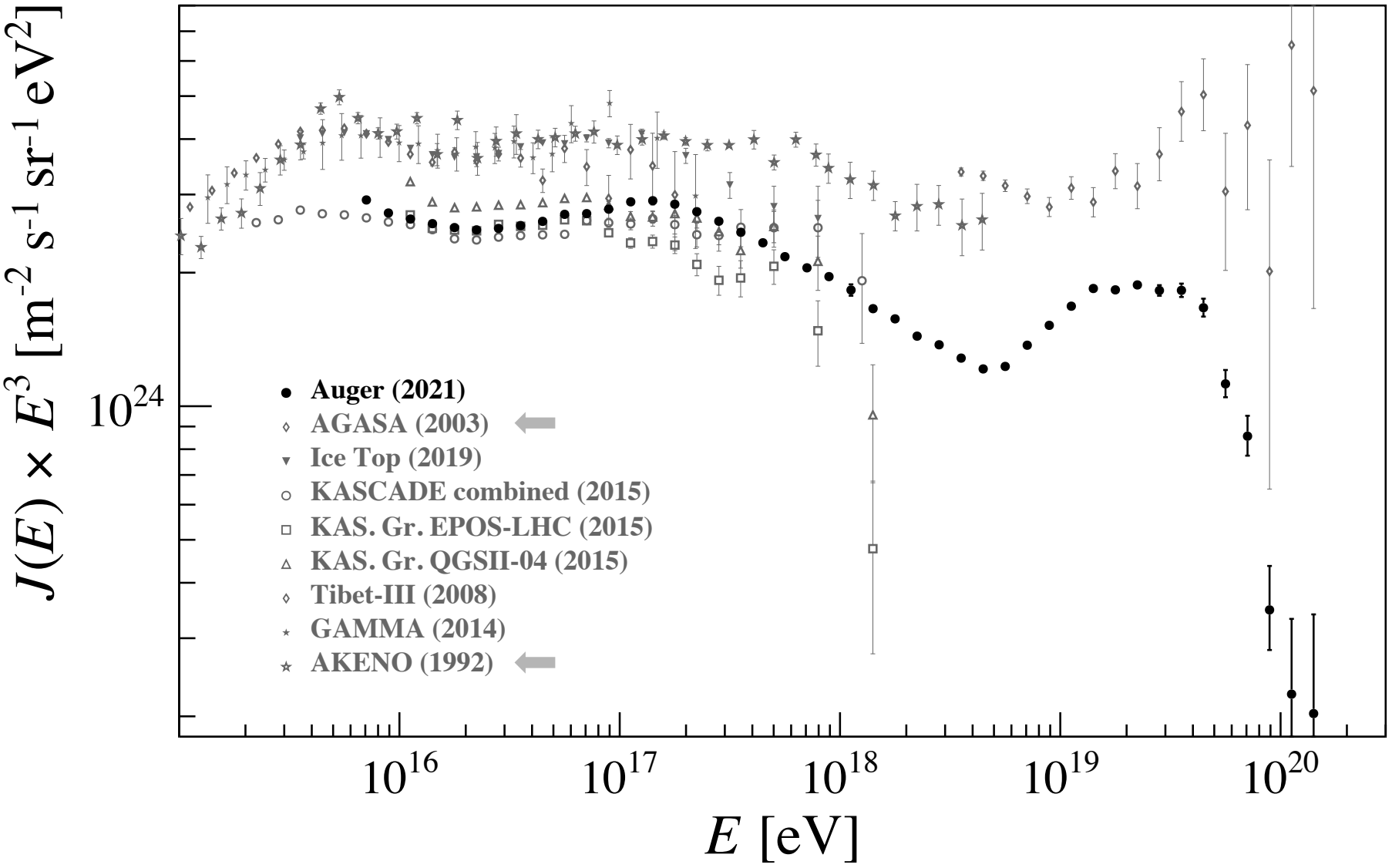
AUGER VS OTHER EXPERIMENTS



AUGER VS CALORIMETRIC EXPERIMENTS

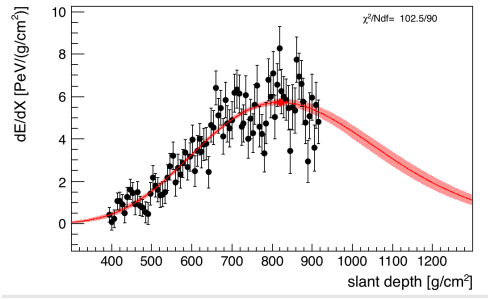


AUGER VS NON CALORIMETRIC EXPERIMENTS



ACTIVITIES IN THE NEAR FUTURE (Phase I)

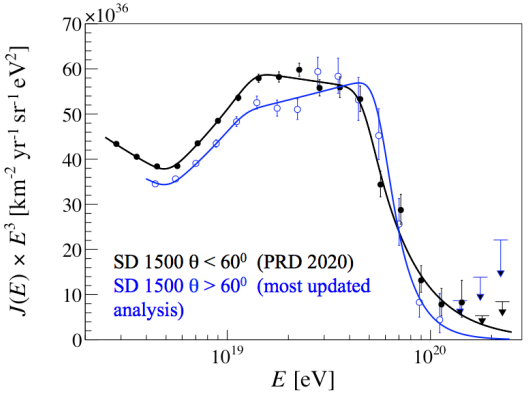
<u>important issues still to be fixed</u>



scrutinize constraint on $\frac{E_{cal}}{dE/dX_{max}}$

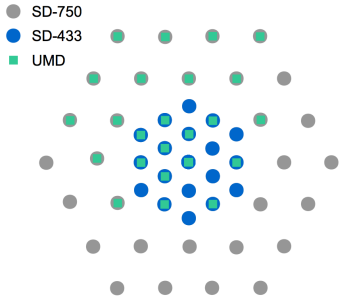
bias in X_{max} for very deep showers

inclined showers



HEAT absolute calibration

spectrum with 433 m array



<u>Pubblications</u>

- update of Hybrid spectrum
- update of SD 1500 θ > 60^0 (?)
- Cherenkov spectrum (difficult)
- combined spectrum

Richieste finanziarie

Capitolo	*Descrizione*	Parziali		Totale	
		Richiesta	SJ	Richieste	SJ
MISSIONI	1. Partecipazione alla conferenza UHECR con Telescope Array (due task leaders) leaders)Â§	3.00			
	2. Partecipazione responsabile gruppo a incontro con referee e incontri istituzionali responsabile nazionaleÂ§	2.00			
	3. Un turno di presa dati FDÂ§	4.00			
	4. Partecipazione a due meeting di collaborazione a Malargue (due task leaders)Â§	12.00		**21.00**	0.00
TRASPORTI	1. pese di trasporto per meeting e turni presa dati FDÂ§	3.00		**3.00**	0.00
INVENTARIO	1. Contributo per acquisto computer per analisi dati tipo Intel Core i9 8-core a 2,4GHz con 64 Gb di Ram e almeno 4 Tera di HD SSDÂ§	2.00		**2.00**	0.00
SPSERVIZI	1. CFÂ§	253.00		**253.00**	0.00