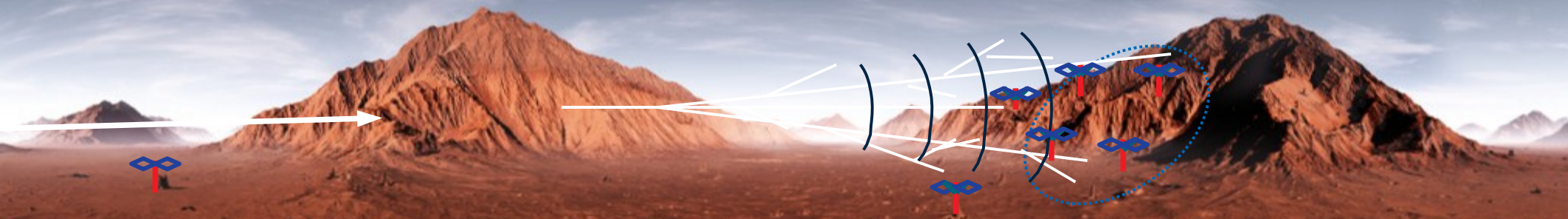
Optimization of CoREAS simulations for the GRAND project



Chao Zhang*, Tim Huege, Tanguy Pierog
for the GRAND Collaboration

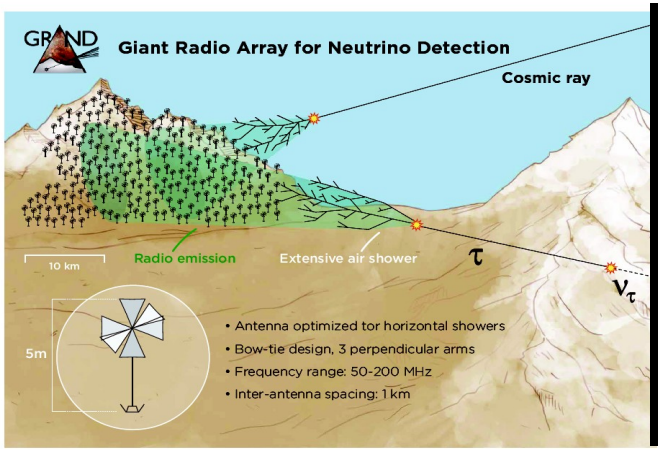
ONLINE
ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany
37th International
Cosmic Ray Conference
12–23 July 2021

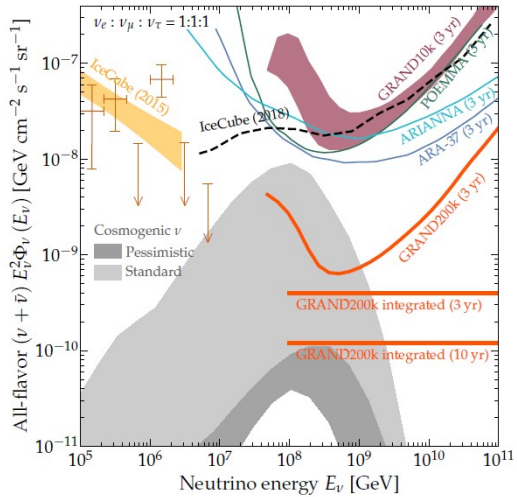
GRAND

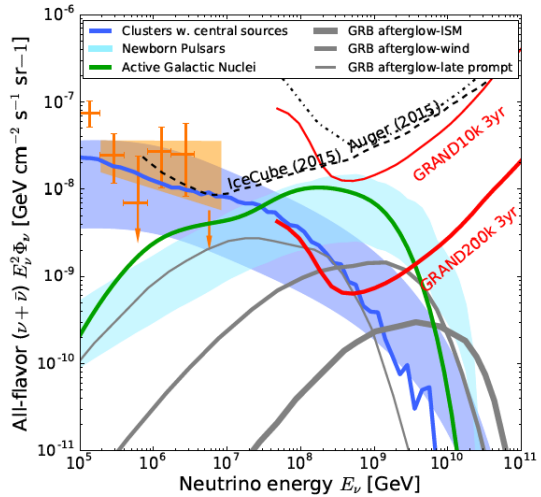
PEKING UNIVERSITY 1898

KIT Karlsruhe Institute of Technology

The GRAND project



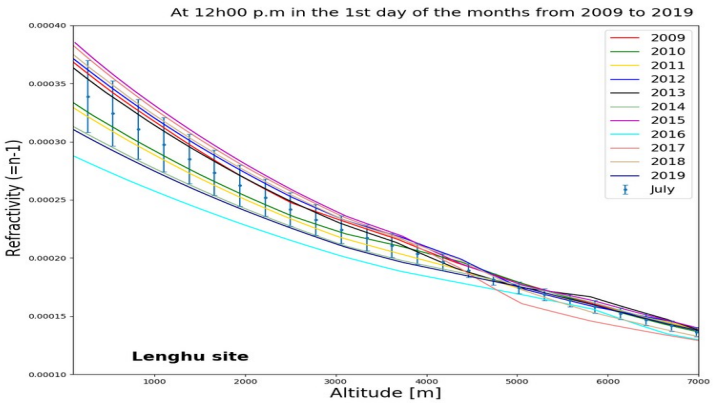


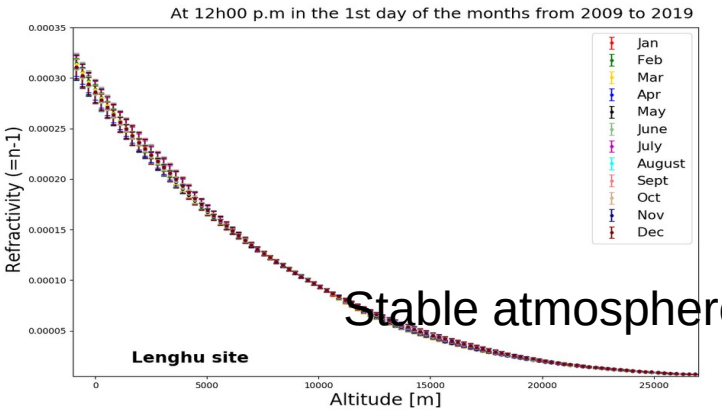


GRAND white paper 2018

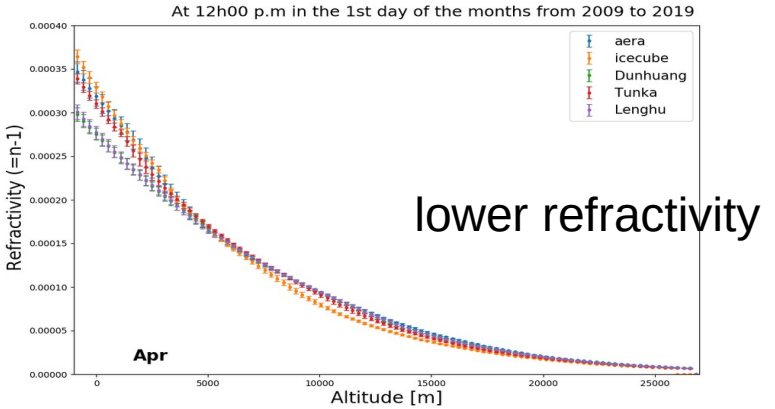
Karlsruhe Institute of Technology

1. Investigation of representative atmosphere for GP300 site

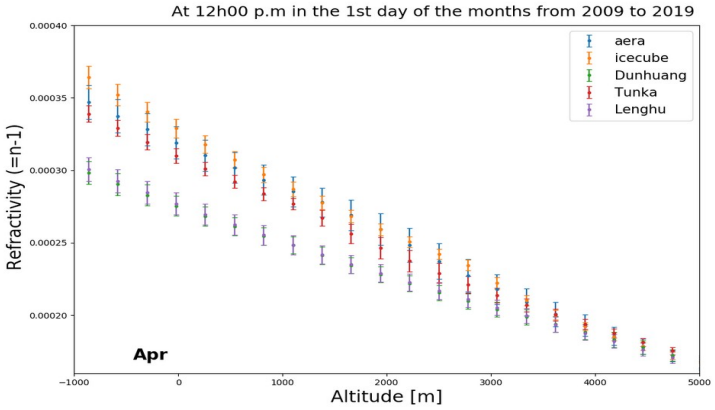




Stable atmosphere



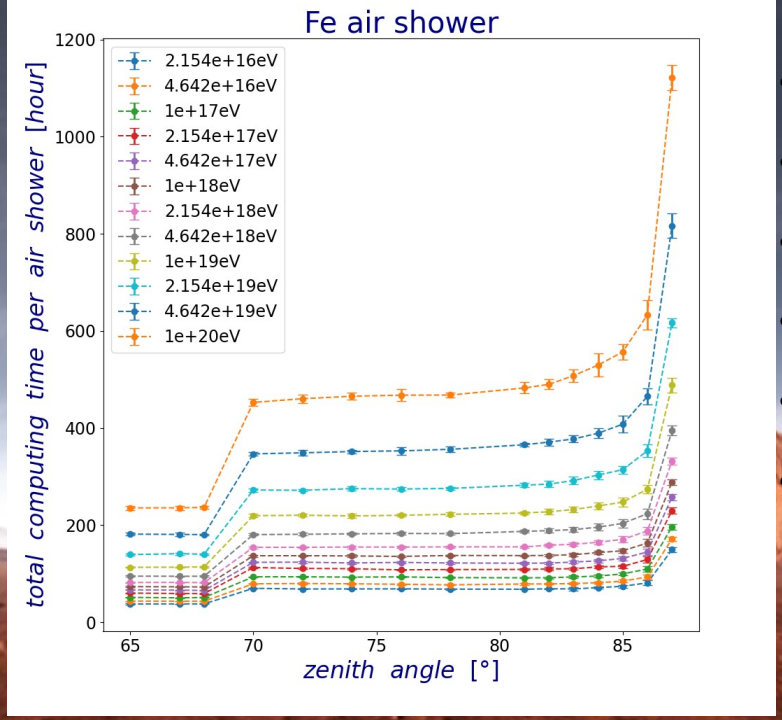
lower refractivity



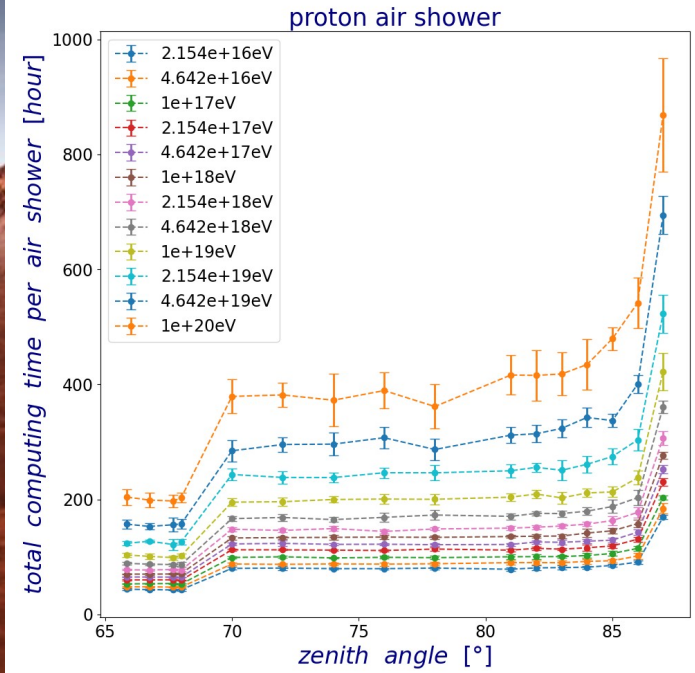
GDAS data analyzed with gdastool

Chao Zhang - chao.zhang@kit.edu

2. A CoREAS library for GRAND



- Energy: 12 bins from 2.154e+16 to 1e+20 eV.
- B field in Lenghu: {Bx,Bz}={26.927785,42.154416}mT
- Azimuth angle: {-180°,-135°,-90°,-45°,0°,45°,90°,135°}
- Zenith angle: 65° - 87°
- Thinning = 10^{-6}
- Work on bWunicluster



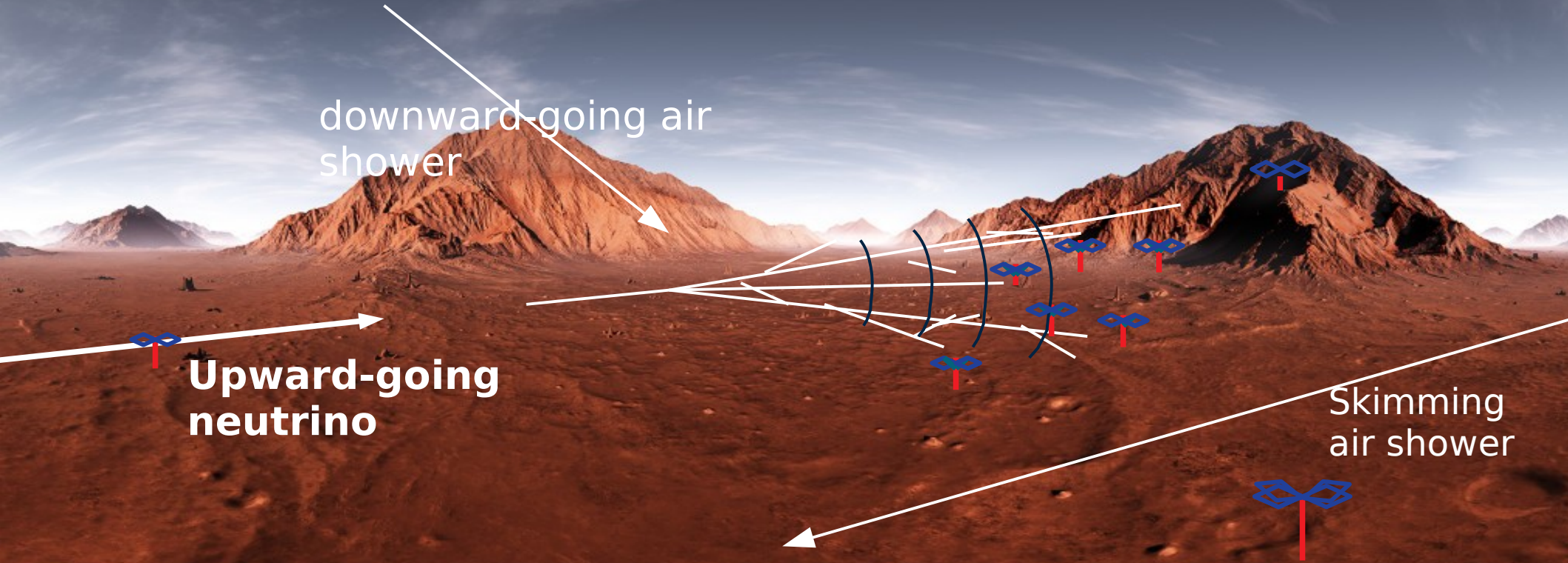
- Nodes=5, ntasks-per-node=20, time=12:00:00

  > 5012 air showers prepared until now (Proton and Iron)
- Simulated radio signal for 240 antennas (star-shaped pattern)
- Upward and skimming tested
- Neutrino library to be added later

Chao Zhang - chao.zhang@kit.edu

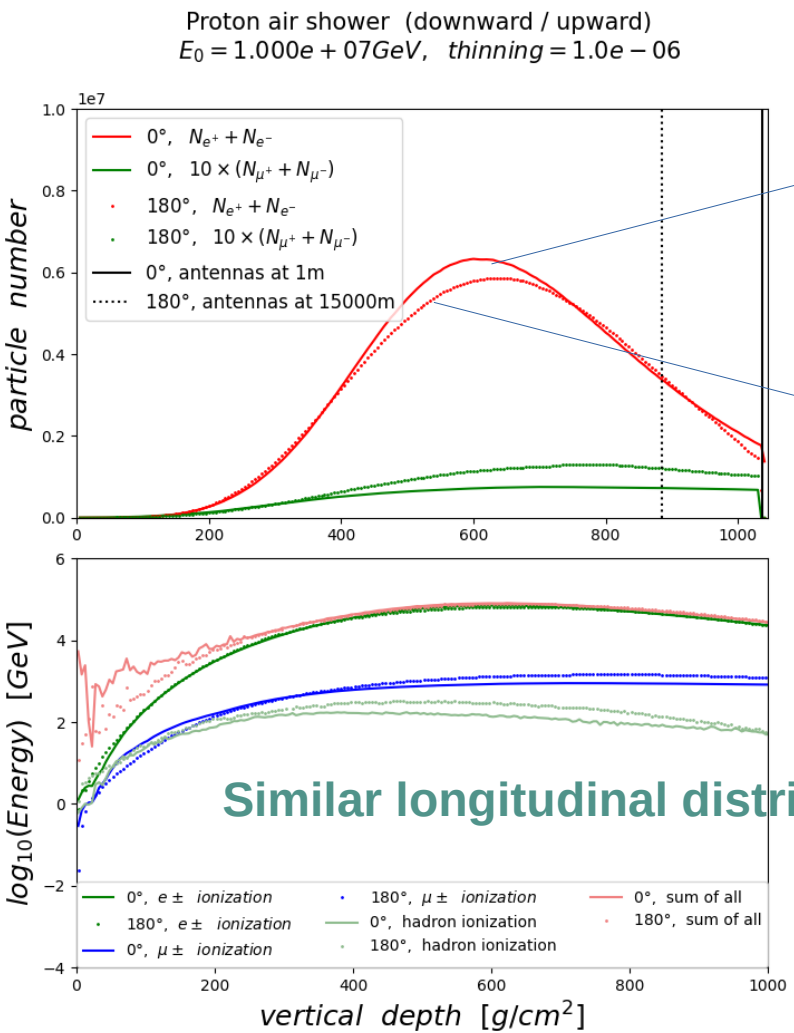
Karlsruhe Institute of Technology

3. Adaptation of CORSIKA7 for upward-going showers and its validation



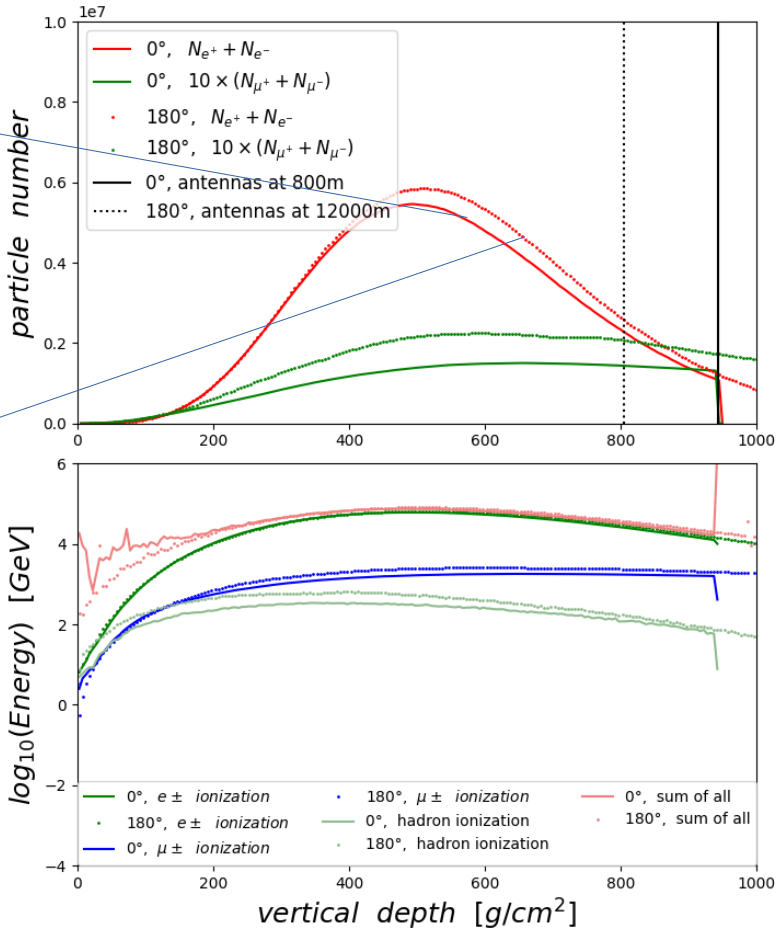
Chao Zhang - chao.zhang@kit.edu

Test a. Longitudinal distributions

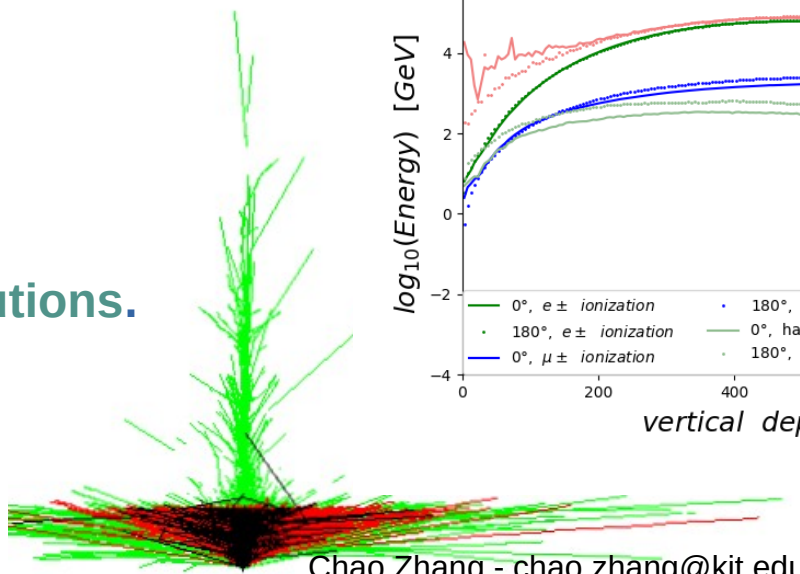


down

up



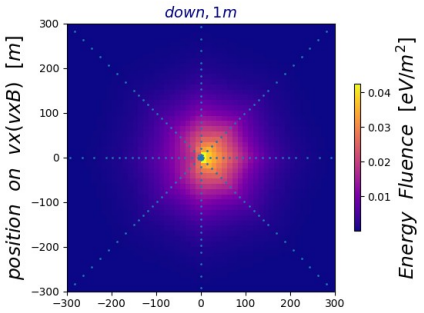
Similar longitudinal distributions.

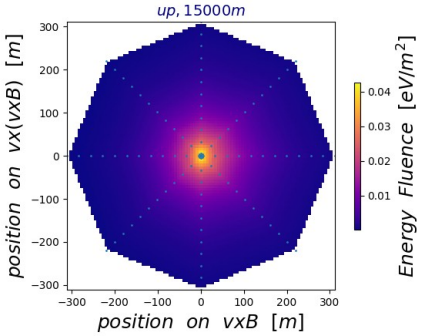


Chao Zhang - chao.zhang@kit.edu

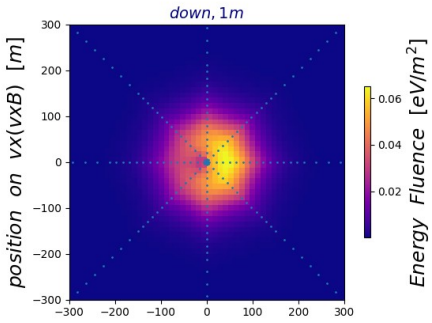
Karlsruhe Institute of Technology

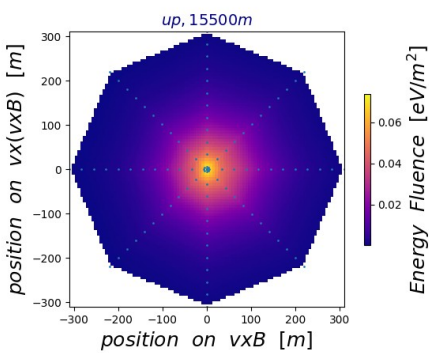
Test b. Energy fluence





30-80MHz

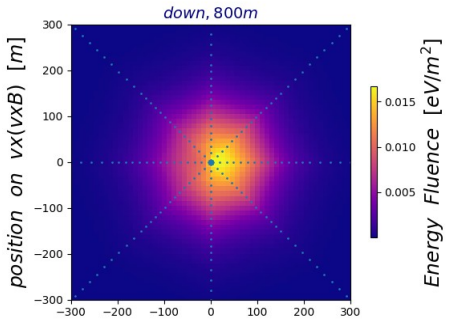


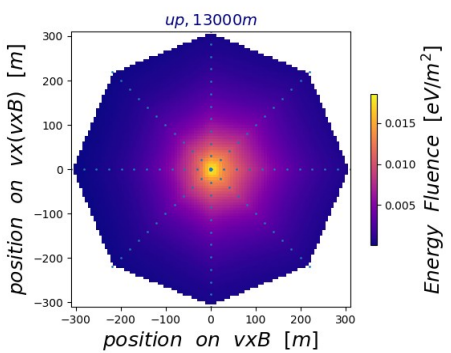


50-200MHz

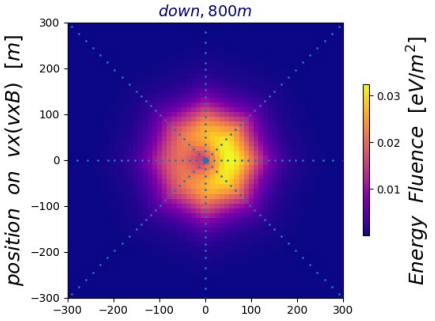
Proton air shower

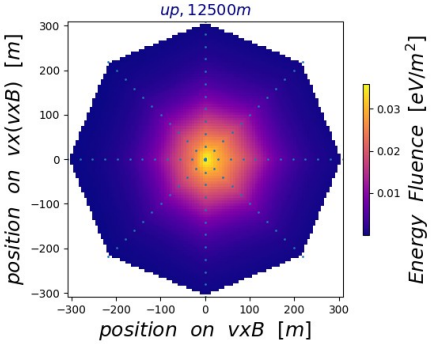
Similar radio footprints.





30-80MHz





50-200MHz

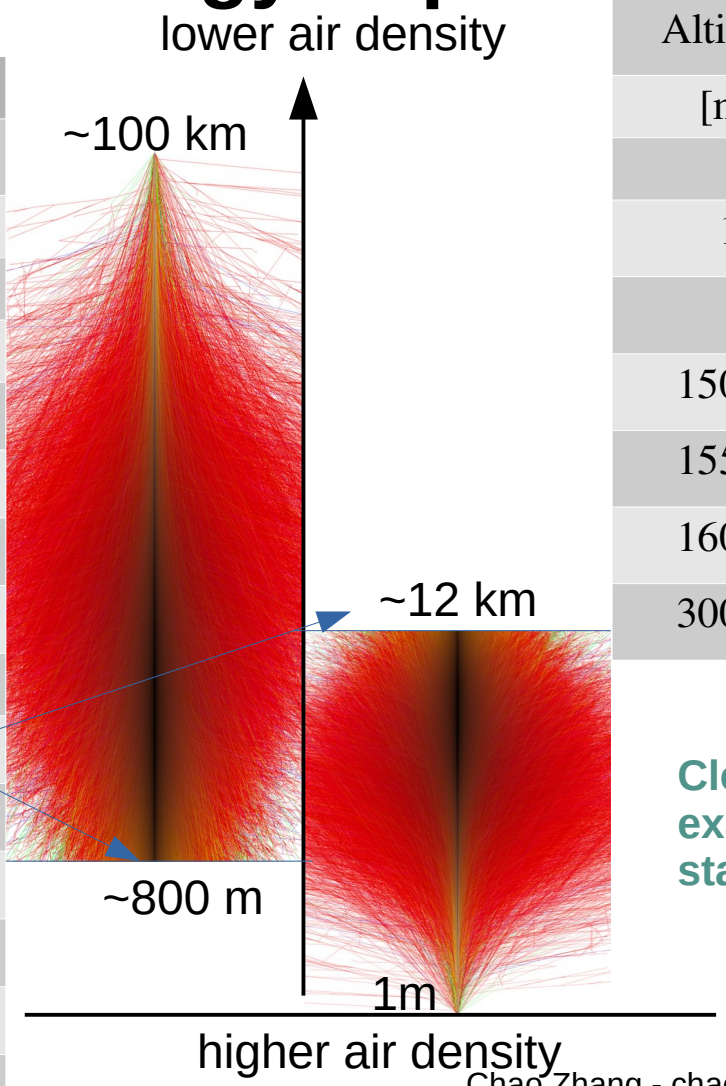
Iron air shower

Chao Zhang - chao.zhang@kit.edu

Karlsruhe Institute of Technology

Test c. Integral of energy deposit

Iron air shower		
Altitude [m]	E_{dep} [eV] 30-80 MHz	E_{dep} [eV] 50-200 MHz
Downward		
1	$8.195 \cdot 10^2$	$1.512 \cdot 10^3$
400	$8.117 \cdot 10^2$	$1.491 \cdot 10^3$
600	$8.111 \cdot 10^2$	$1.488 \cdot 10^3$
800	$7.970 \cdot 10^2$	$1.449 \cdot 10^3$
886	$7.513 \cdot 10^2$	$1.369 \cdot 10^3$
Upward		
11000	$7.127 \cdot 10^2$	$1.333 \cdot 10^3$
11500	$7.981 \cdot 10^2$	$1.522 \cdot 10^3$
12000	$7.834 \cdot 10^2$	$1.513 \cdot 10^3$
13000	$7.846 \cdot 10^2$	$1.537 \cdot 10^3$
15000	$8.247 \cdot 10^2$	$1.553 \cdot 10^3$
18000	$8.082 \cdot 10^2$	$1.513 \cdot 10^3$

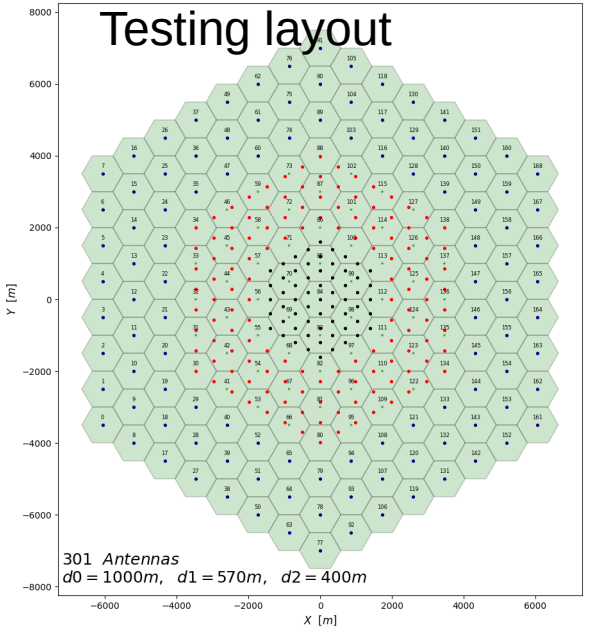


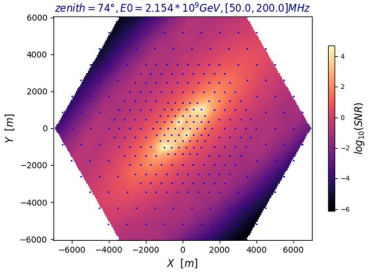
Proton air shower		
Altitude [m]	E_{dep} [eV] 30-80 MHz	E_{dep} [eV] 50-200 MHz
Downward		
1	$1.176 \cdot 10^3$	$2.238 \cdot 10^3$
Upward		
15000	$1.215 \cdot 10^3$	$2.420 \cdot 10^3$
15500	$1.225 \cdot 10^3$	$2.452 \cdot 10^3$
16000	$1.228 \cdot 10^3$	$2.470 \cdot 10^3$
30000	$1.098 \cdot 10^3$	$2.056 \cdot 10^3$

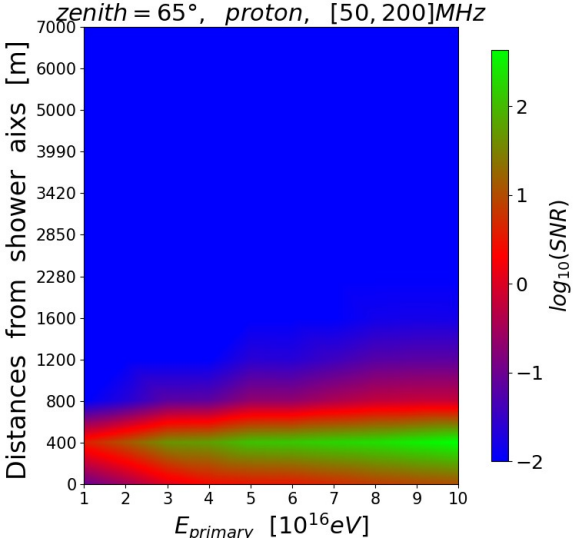
Close energy deposits (but not exactly the same) at comparable stages of air shower development.

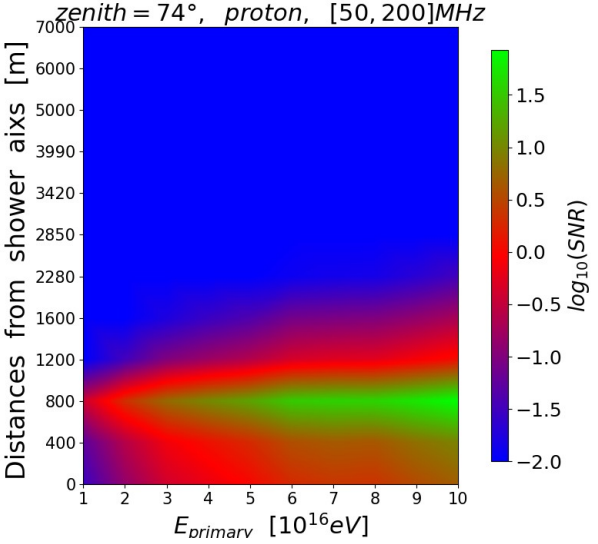
Chao Zhang - chao.zhang@kit.edu

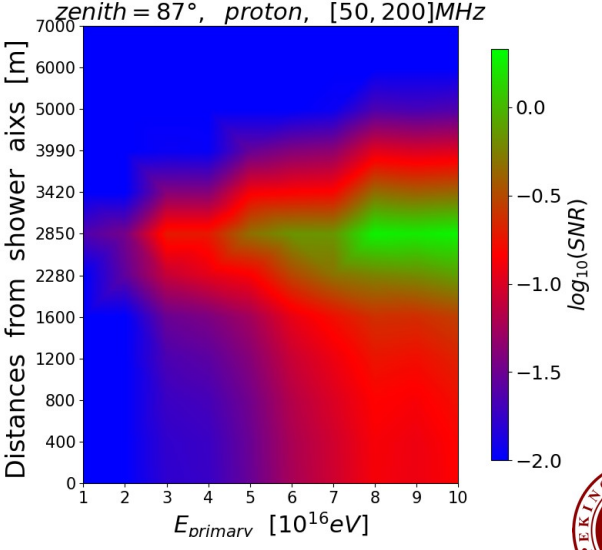
4. SNR analysis











$$SNR = \frac{S^2}{N^2}$$

S^2 → CoREAS-generated signal

N^2 → RMS, Galactic +Thermal

A. Balagopal et al. 2018

Chao Zhang - chao.zhang@kit.edu

Karlsruhe Institute of Technology

Conclusions

- 1. The GP300 site is located in a very stable atmosphere and the refractive index is on average lower than at other radio detection sites.
- 2. A library of down-going CoREAS-simulated air showers was created with the best knowledge of GRAND.
- 3. Testing methods in terms of particle and radio simulations have been developed and they validated the adapted version of CORSIKA7 for upward-going showers.
- 4. An SNR analysis using CoREAS shows that it will be very difficult to detect air showers below 10^{16} eV with the testing layout of GP300, but it might be possible if the zenith angle is not too large.

Thank you!