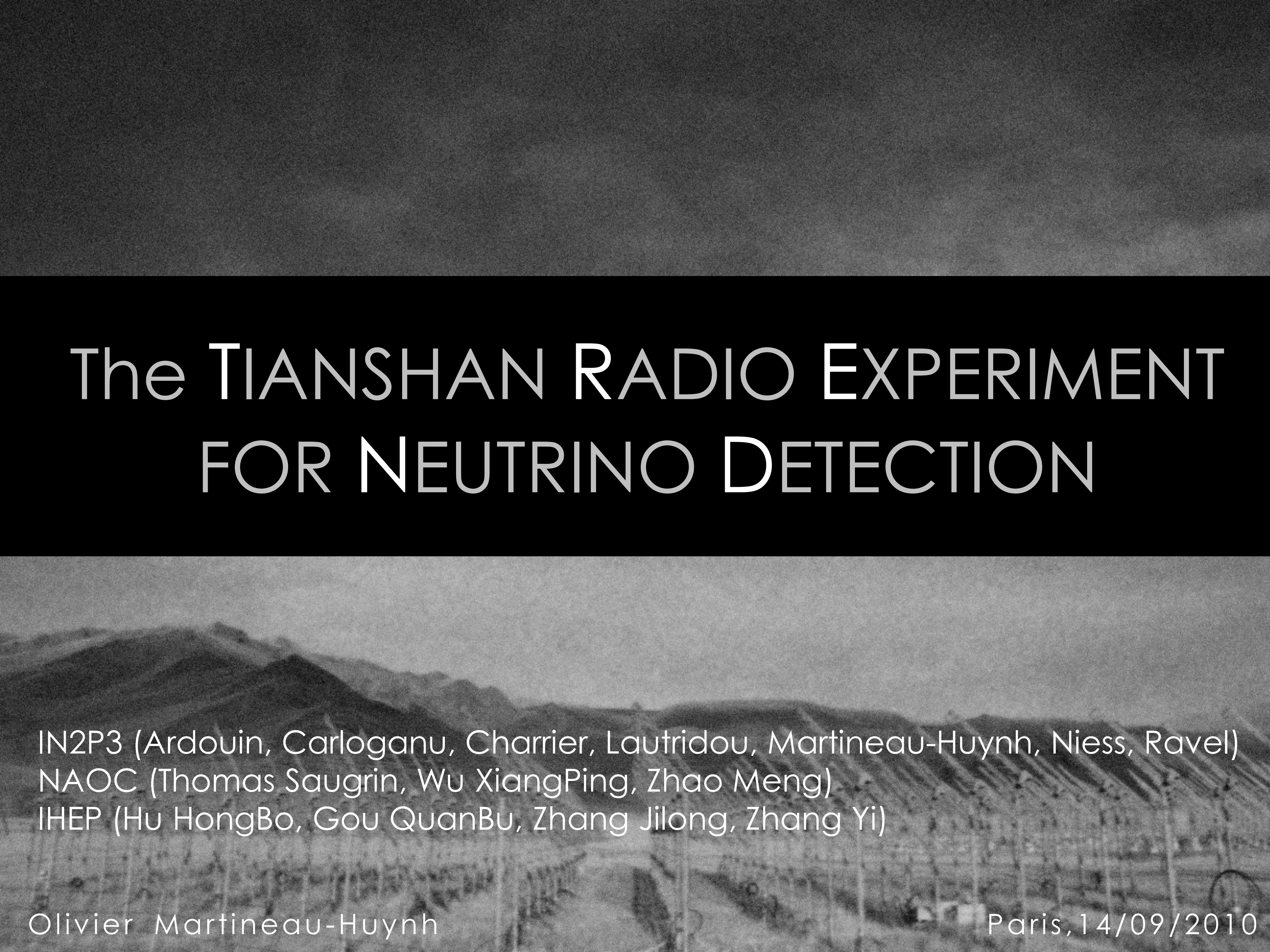


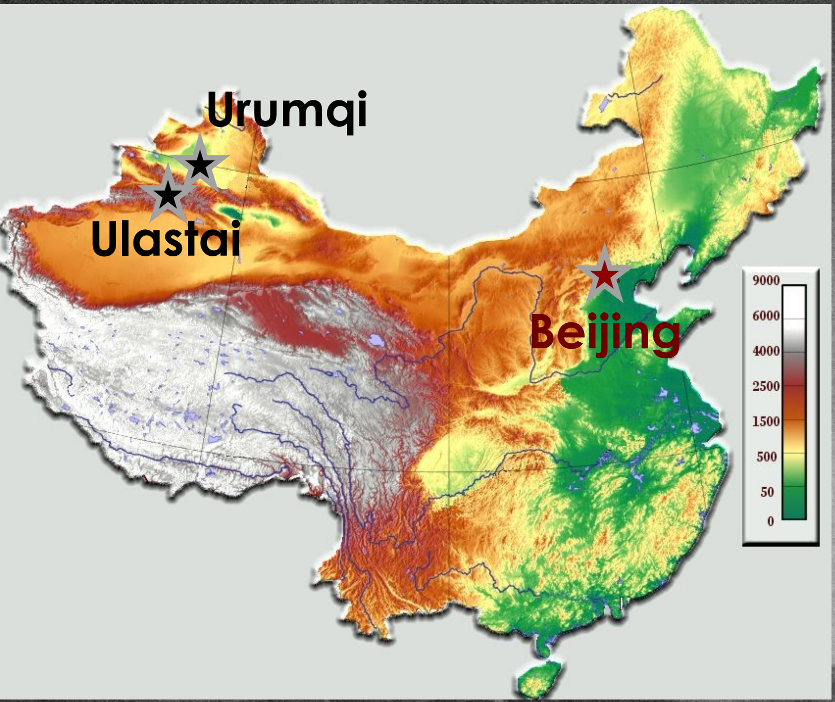
The TIANSHAN RADIO EXPERIMENT FOR NEUTRINO DETECTION

IN2P3 (Ardouin, Carloganu, Charrier, Lautridou, Martineau-Huynh, Niess, Ravel)
NAOC (Thomas Saugrin, Wu XiangPing, Zhao Meng)
IHEP (Hu HongBo, Gou QuanBu, Zhang Jilong, Zhang Yi)

Olivier Martineau-Huynh

Paris,14/09/2010

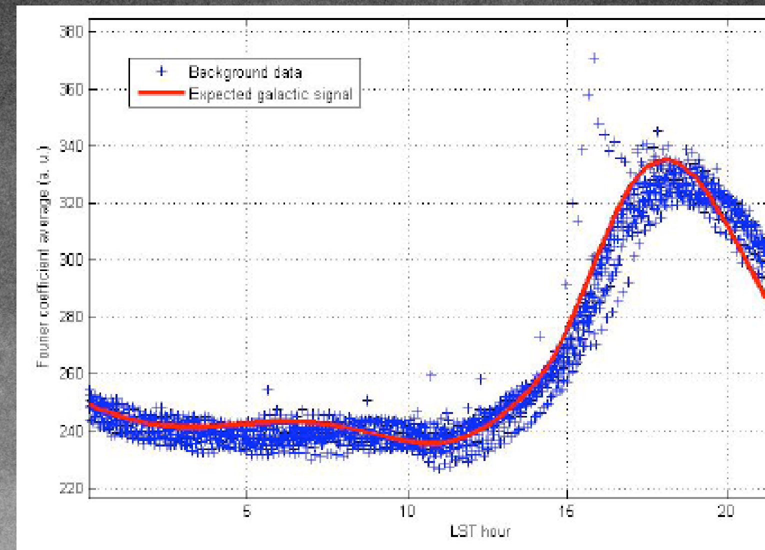
The TREND site

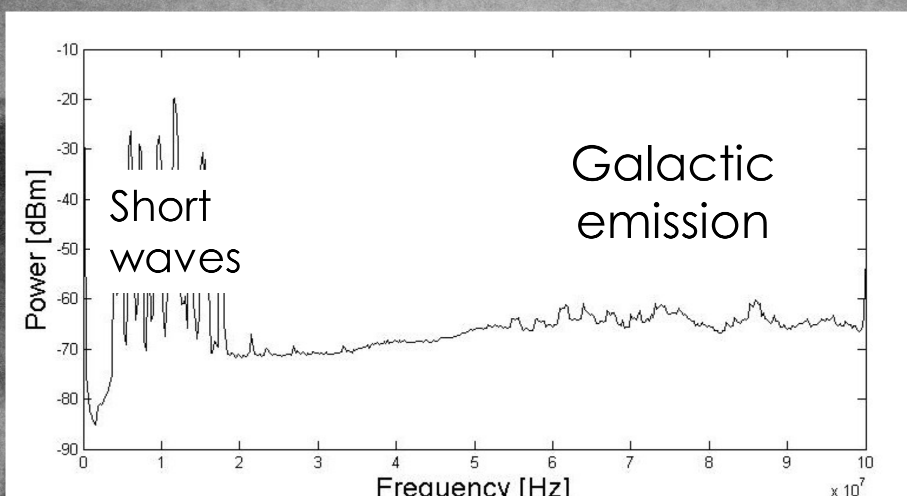


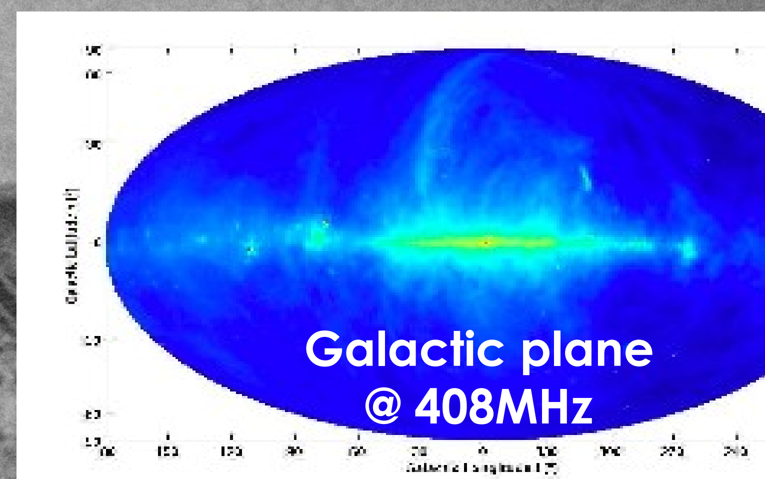
- Ulastai, Tianshan mountains,
  XinJiang autonomous province (2650m asl)

The electromagnetic environement

Extremely clean radio environement above 20MHz.







The 21cm array

a radio-interferometer for the study of the Epoch of Reionization (Wu XiangPing, NAOC)

127 log periodical antennas

x

80 pods

along

2 baselines

North

4 km

West

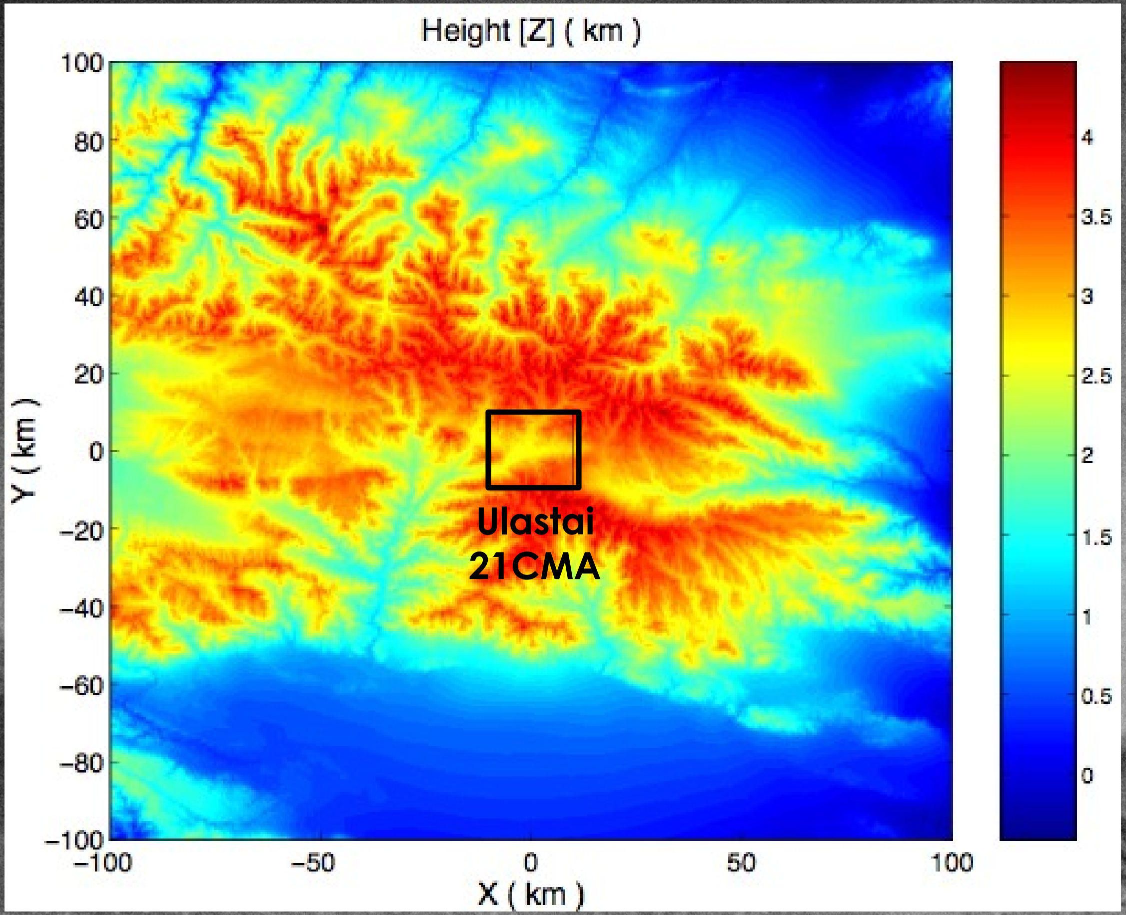
East

South

3 km

DAQ

The topology



- Detector at the cross point of 2 high altitude valleys.
- Surrounded by close (5-20 kms) and high (>4000m) mountains

The TREND project

- Take advantage of
  - elm environement
  - 21CMA infrastructures & staff
  - topology

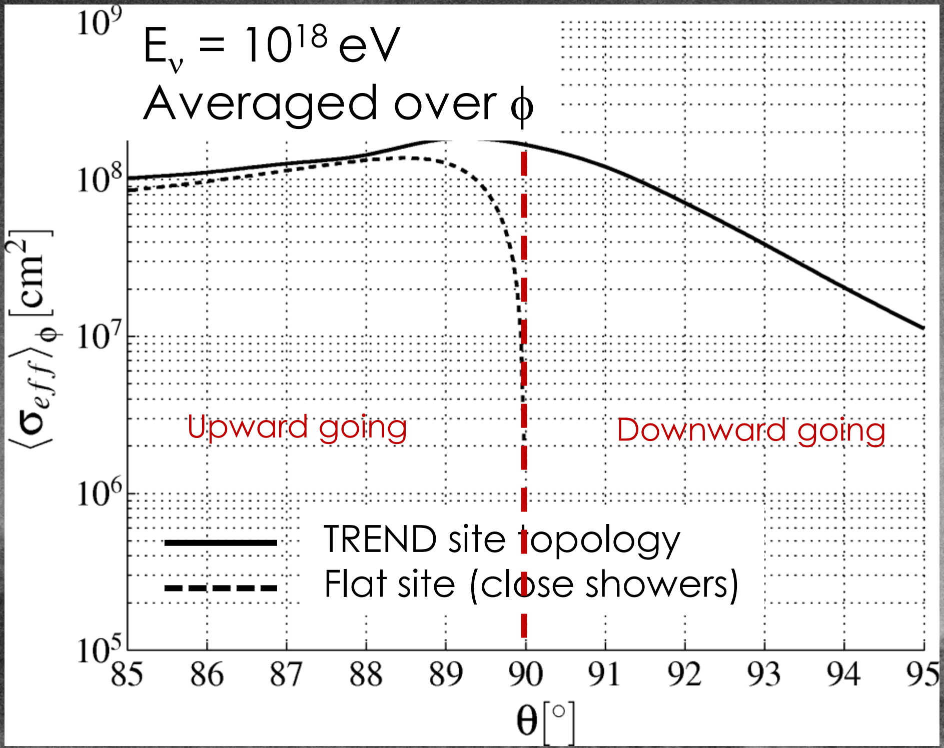
  to set up an **autonomous radio array aiming at UHE neutrino detection.**

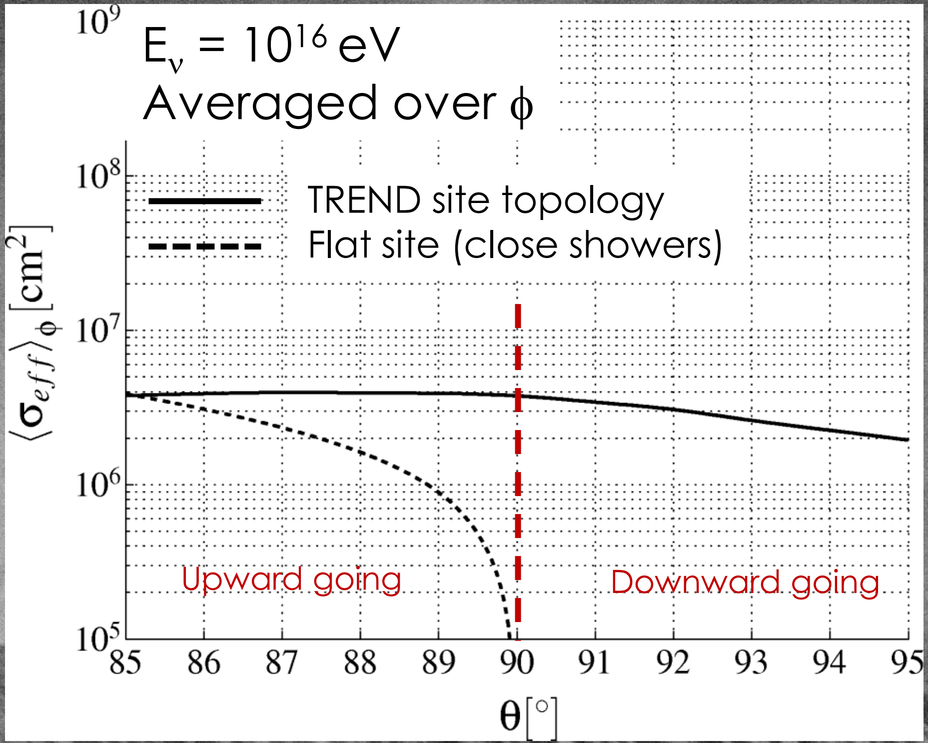
- Design baseline is 1 antenna connected to each pod (80 antennas over ~5km^2)… but evolution is possible!

Neutrino sensitivity simulation

- ν **DIS:**
  - Integrated cross sections (NC+CC) from **Gandhi *et al.*** (CTEQ4-DIS)
  - Inelasticity randomised with Pythia + CTEQ5d pdf.
- τ **propagation in rocks (energy loss + lifetime):**
  - τ photonuclear interactions coded in GEANT4 following **Dutta *et al.*** (dominant energy loss process for UHE τ's)
  - **Detailed simulations** of the τ energy loss in rocks **with GEANT4** for various τ initial energies $\Rightarrow$ **parametrization** of the τ energy loss and of the proper time **spectra** according to the distance d (0-60 km) and the initial energy, E_0.
  - **Hybrid Monte-Carlo scheme** for the τ propagation in rocks (energy loss, decay) according to the parametrization derived from GEANT4.
- τ **Decays**
  - Use Pythia + TAUOLA
- **No simulation for radio detection yet**
  - (Very optimistic) hypothesis of **100% efficiency** if :
    - **Decay point in direct view of detector**
    - **At least one pod (≡ 1 antenna) <1km from shower axis.**
    - **At least one pod (≡ 1 antenna) < 30° from τ decay point.**

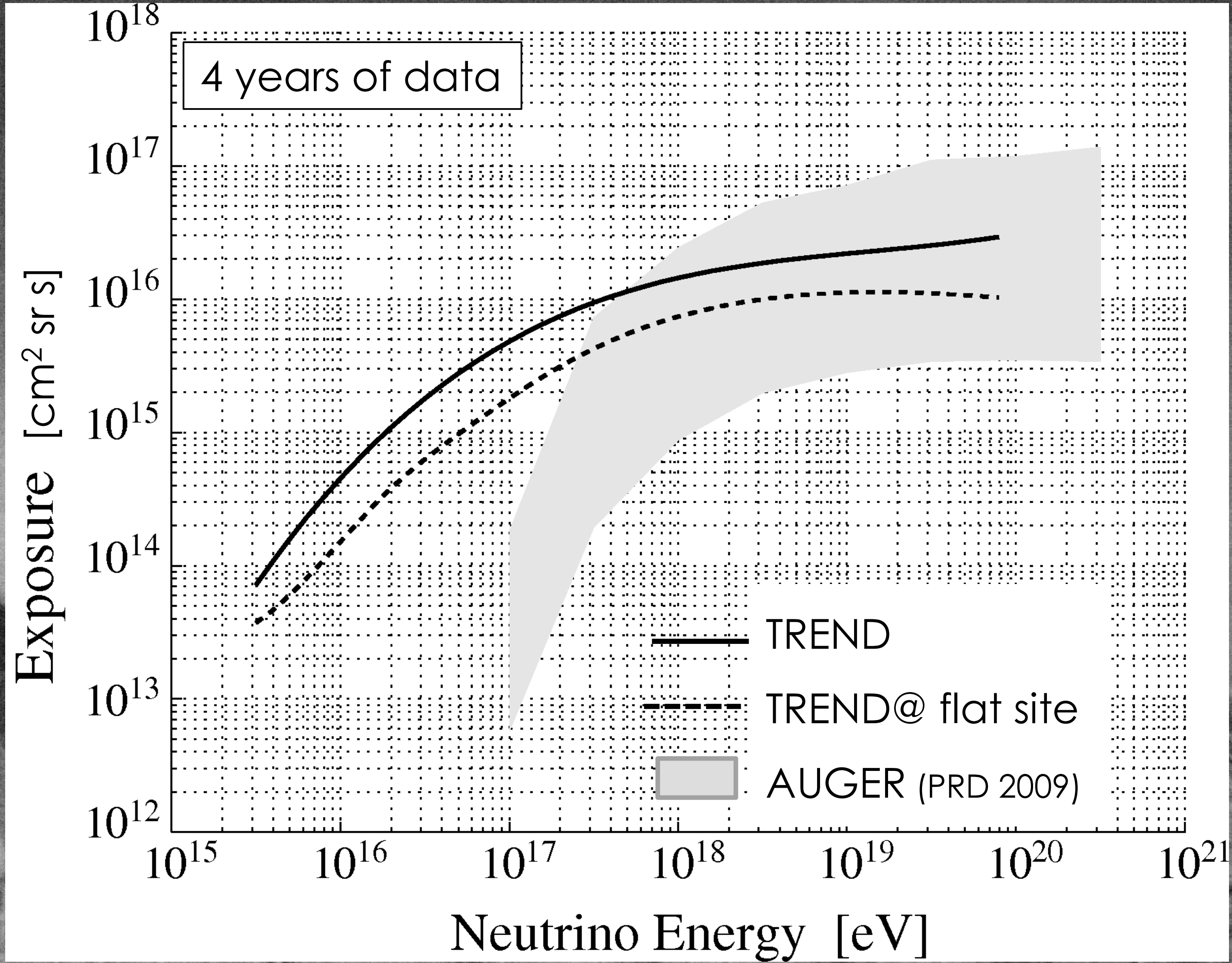
Cross sections





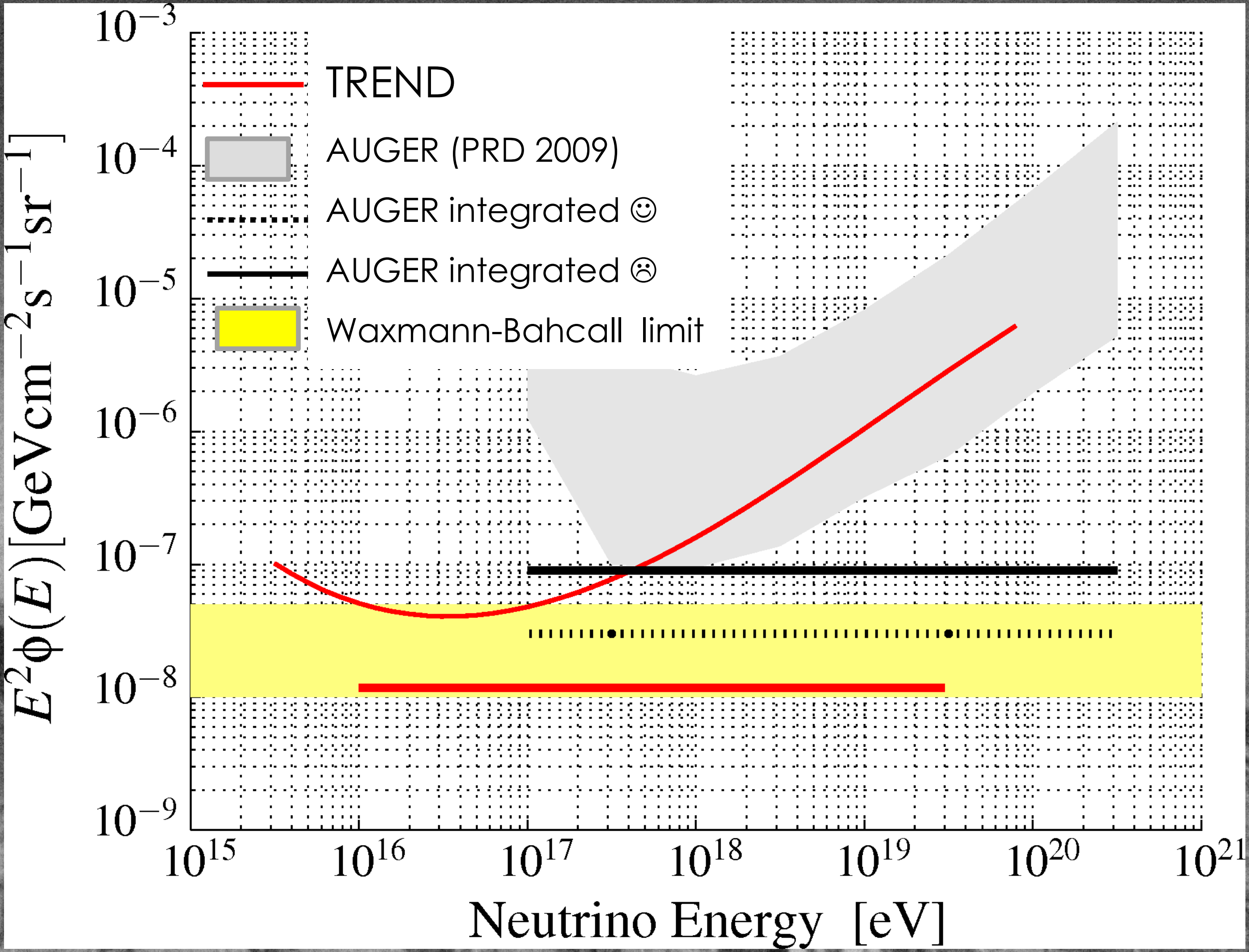
Exposure

Exposure obtained by integration over (θ,ϕ) of cross section $\sigma(E)$.



Flux limit

90%CL limit assuming flux $\phi=\phi_0/E^2$ and <u>no candidate within 4 years</u> <u>(& 0 background expected)</u>



Background rejection
requires a detailed study

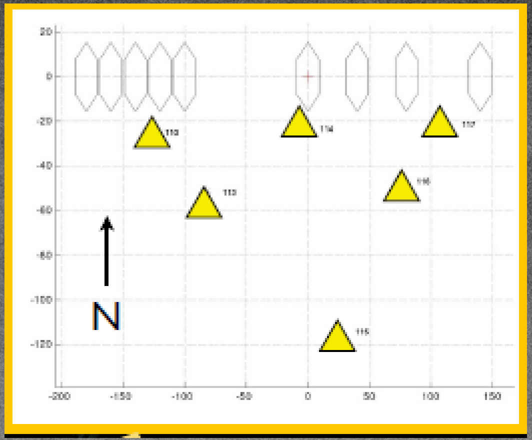
- Badly reconstructed «standard» CR showers
  - Mountain act as a **screen** for $\theta>75°$.

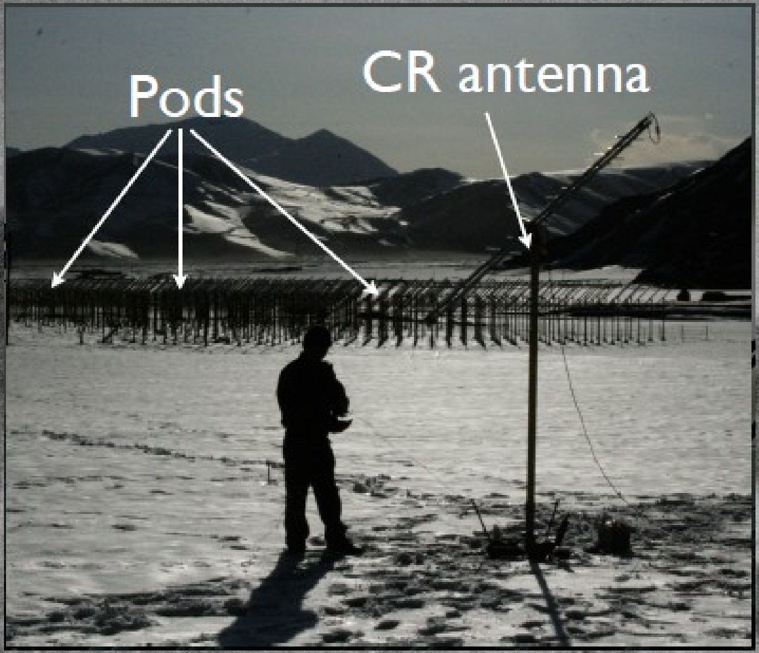
  ⇨ bkgnd events correspond to $\sim 5\sigma_\theta$ reconstruction error at least (with $\sigma_\theta \sim 3°$).

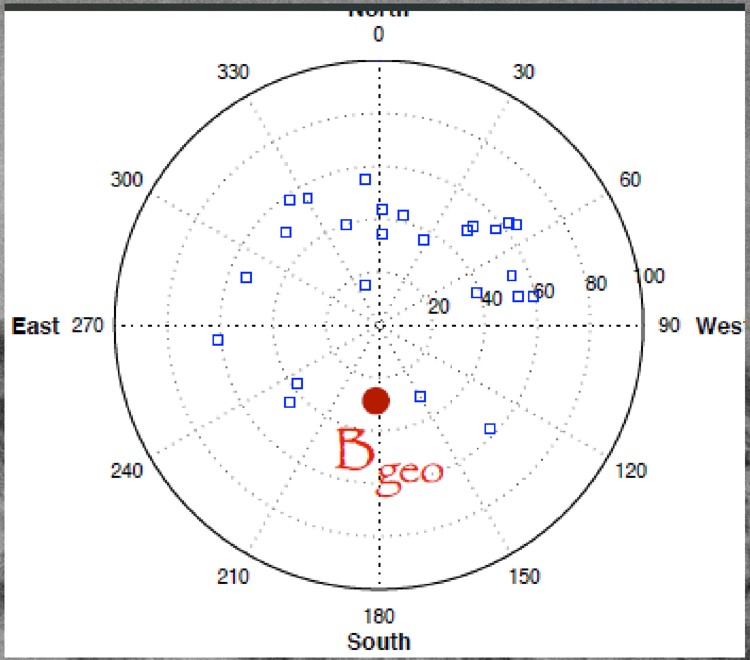
  Expected number: **few /year**.
  - Lateral profiles (young / old showers)
- Anthropic sources at ground level
  - Signal polarity (linear for CR showers)
  - Lateral profile reconstruction.

The TREND status

- 2009: 6 antennas protype
  - Test setup for principle validation.
  - 25 CR candidates detected.

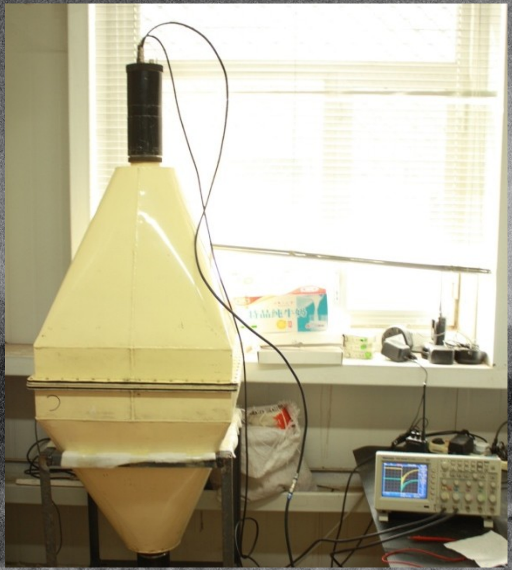


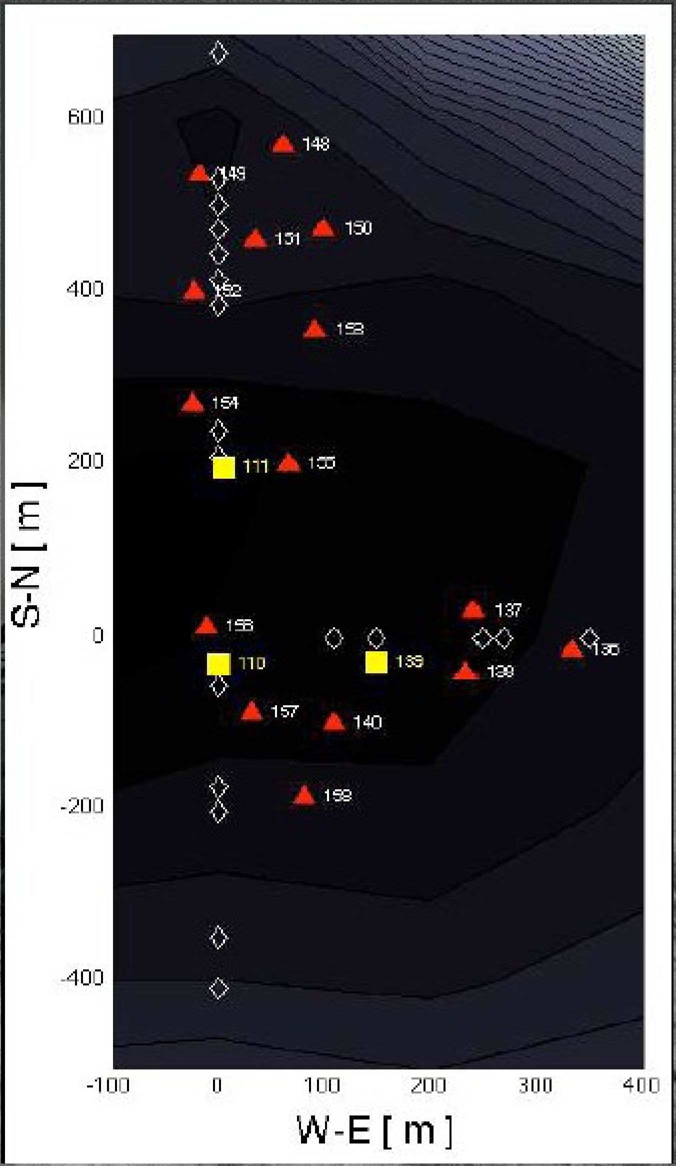




The TREND status

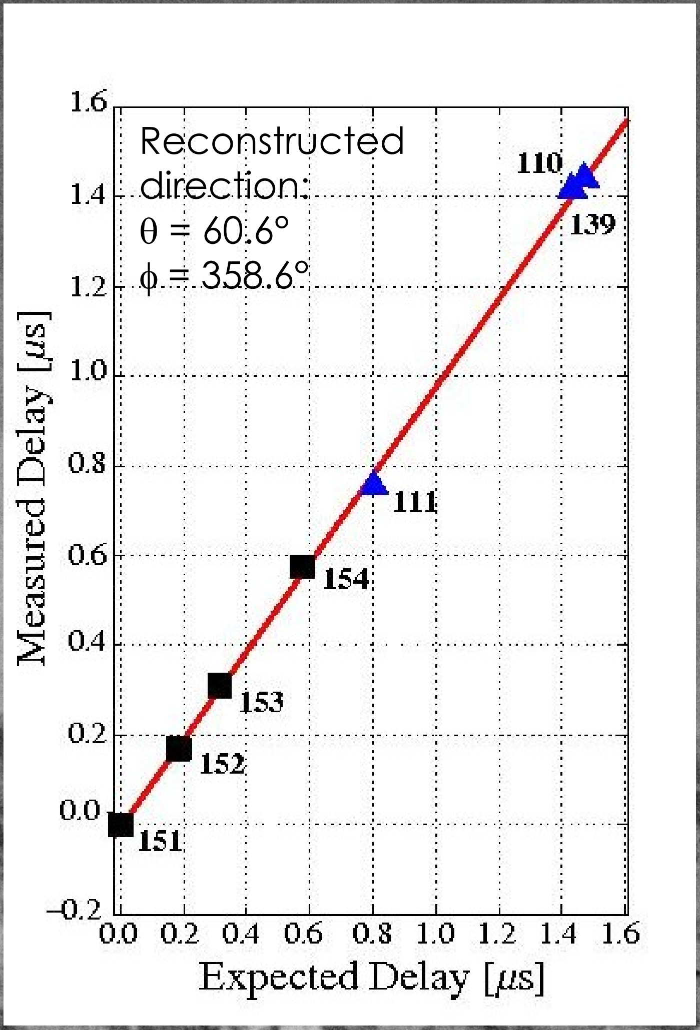
- March 2010: 15 antennas + 3 scintillators





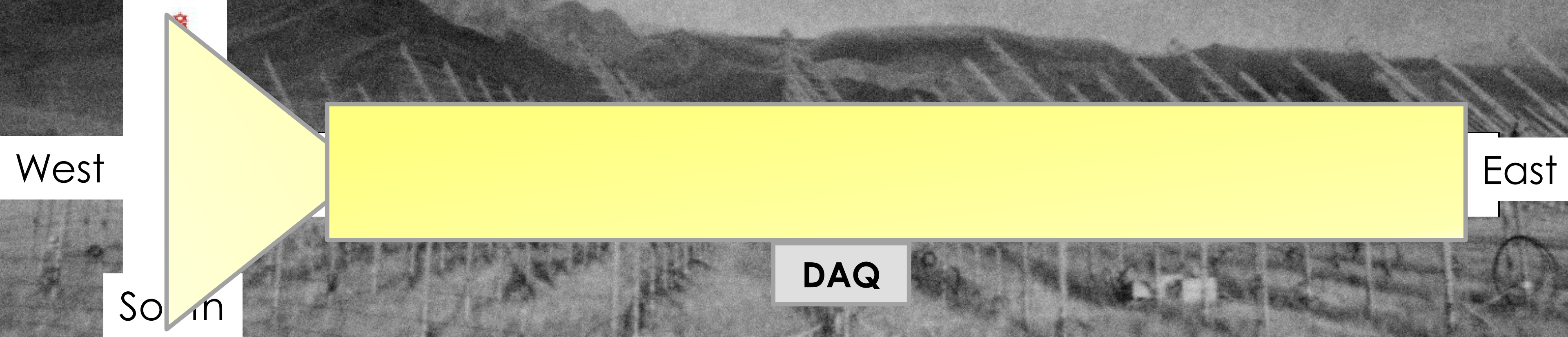
The TREND status

- March 2010: 15 antennas + 3 scintillators
  - Cosmic ray detection validation
  - Several coincidences with 4 antennas & scintillators within a week (April 2010).



The TREND status

- September 2010 : 50 antennas + 3 scintillators [in progress]
  - Total detector area: ~2 km^2
  - Improve detector/environment understanding
  - Study/develop background rejection
  - Acquire data on (inclined) CR showers



Conclusion

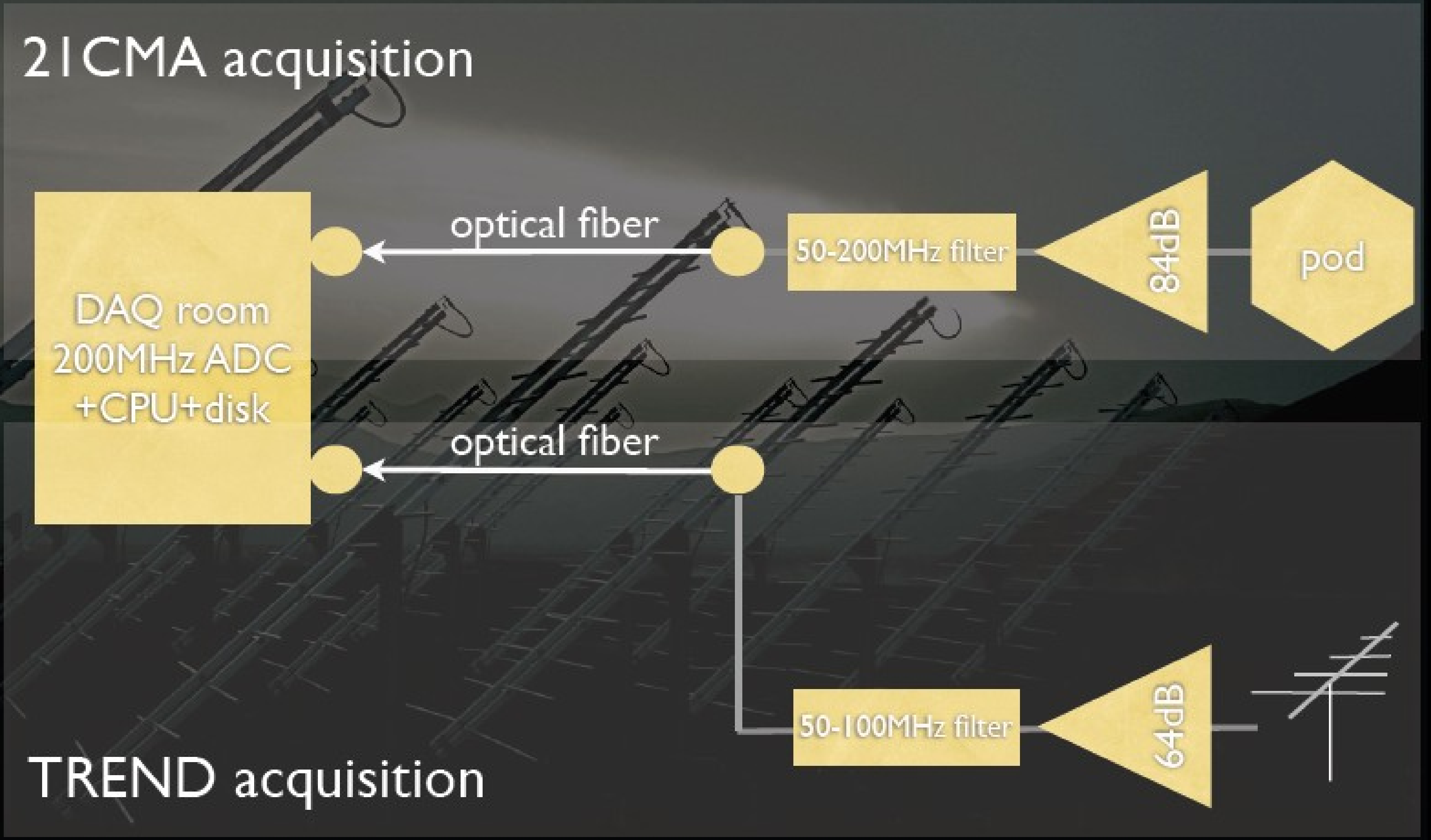
- TREND
  - 1rst demonstration of autonomous radio detection after 1½ year of work only.
  - Benefits from:
    - extremely favorable elm environement
    - extremely favorable topology
    - infrastructures & full support from 21CMA
    - Potentially a well adaptated techn
      (radio promising for inclin

to make it a poten petitive neutrino detector for $E_\nu>10^{16}$

Neutrino sensitivity estimations need to be refined (radio detection of inclined showers+bkgnd rejection)

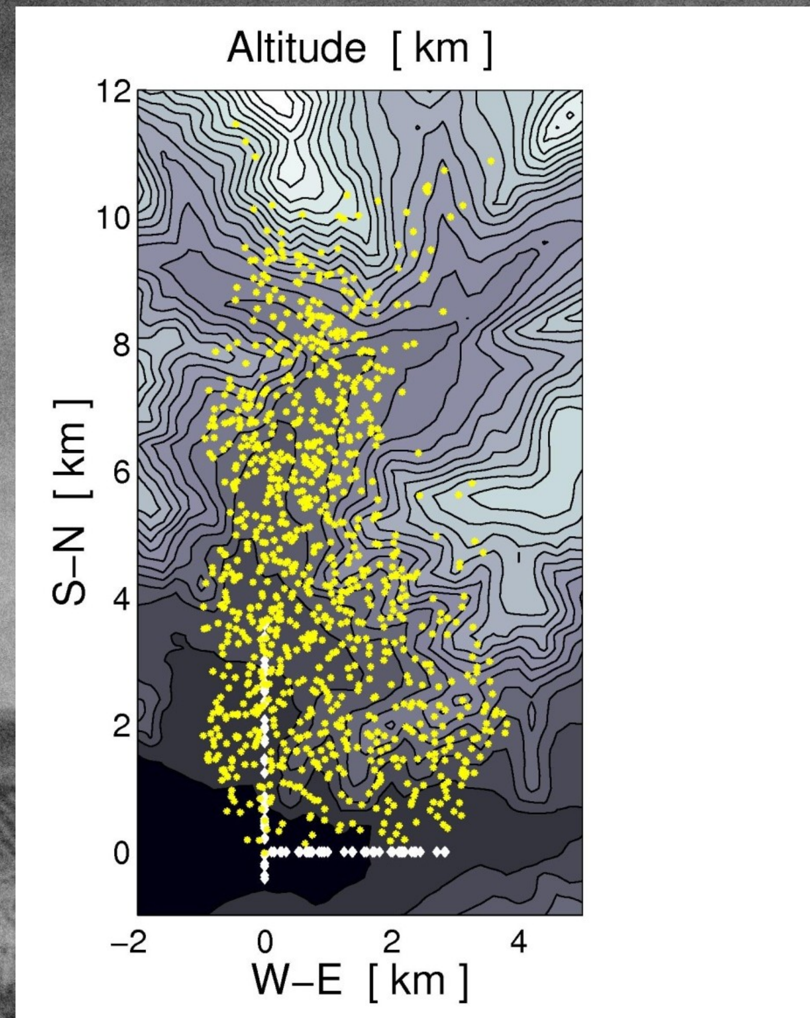

backup

TREND Prototype setup



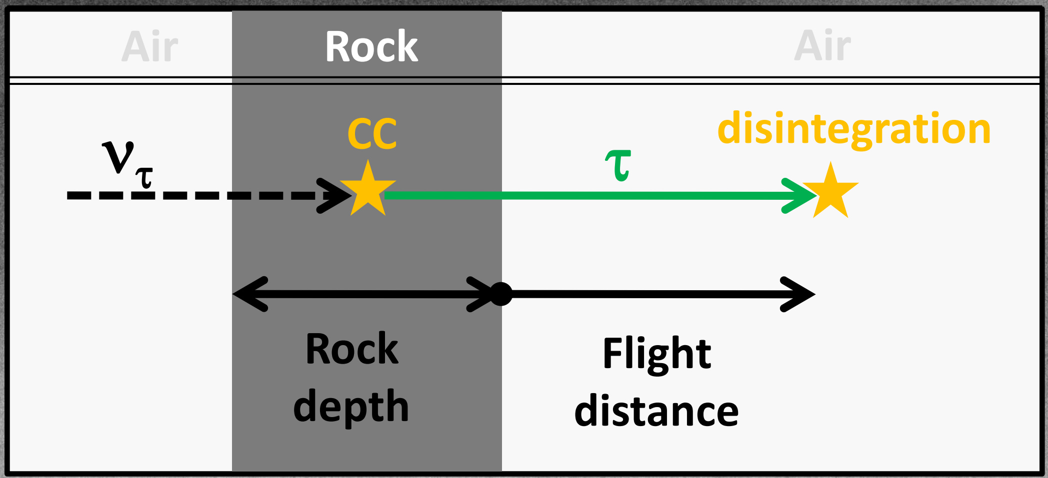
Trajectories

North incidence



Toy Experiment

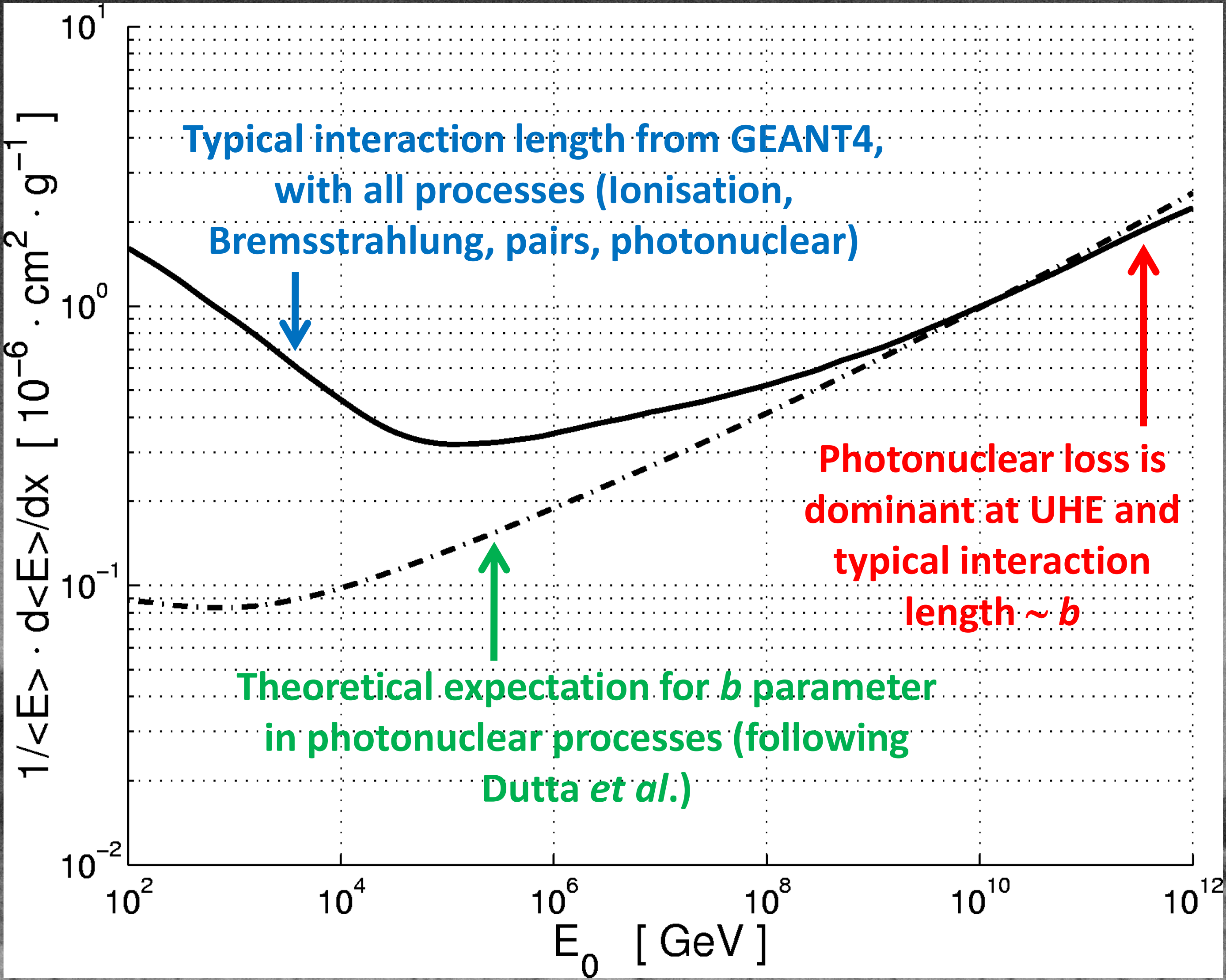
- Incoming ν_τ of energy E_ν normal to a rectangular wall of rocks.
- Look for τ's decaying in the air after the wall.



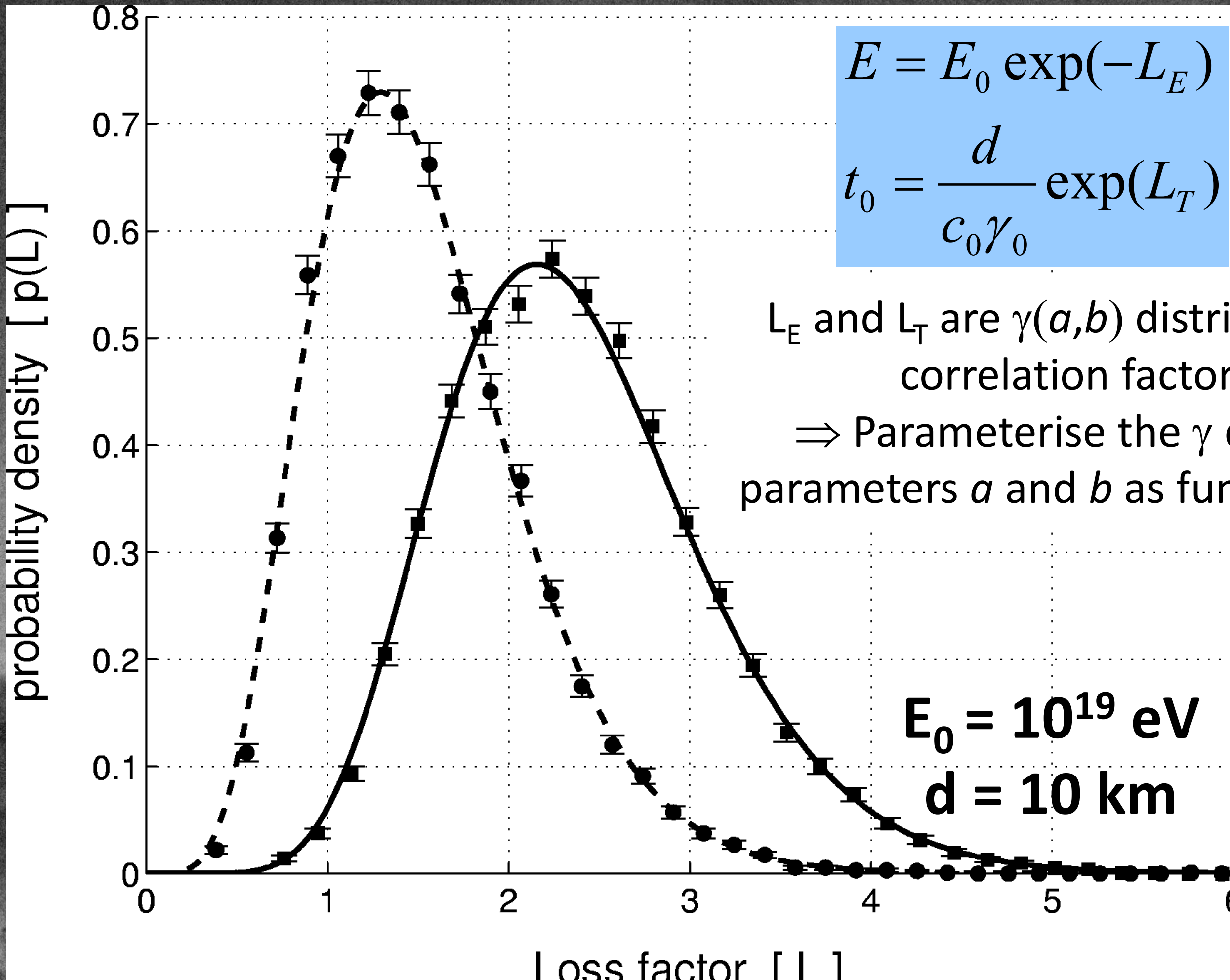
Compute

- The conversion efficiency to τ leptons decaying in the air.
- The energy spectrum of τ leptons at decay.
- The flight distance in the air of the decaying τ leptons.

GEANT4: τ Energy Loss



GEANT 4: τ Energy Loss and Proper Time Distributions



$$E = E_0 \exp(-L_E)$$

$$t_0 = \frac{d}{c_0 \gamma_0} \exp(L_T)$$

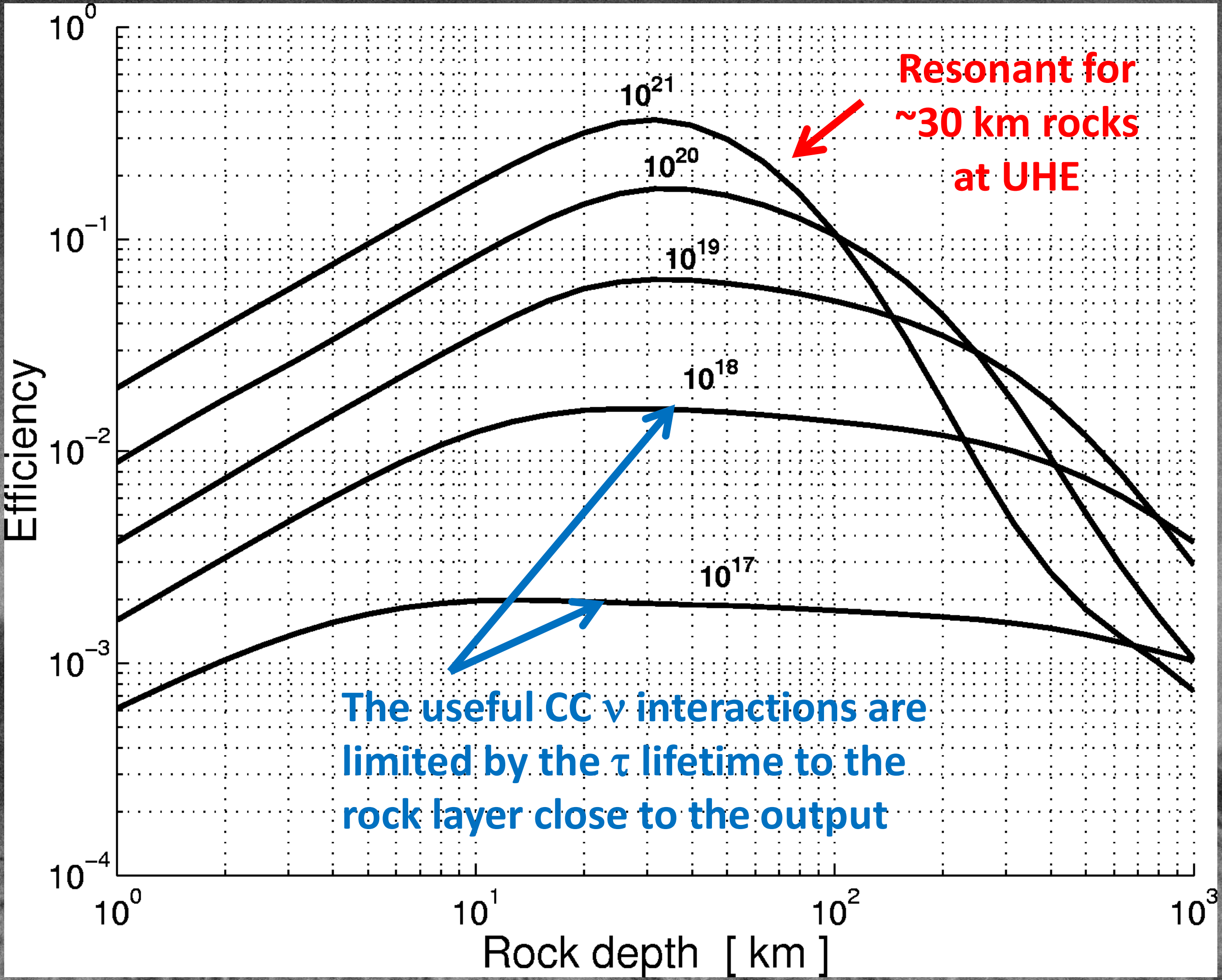
L_E and L_T are $\gamma(a,b)$ distributed with a correlation factor ~ 0.9

$\Rightarrow$ Parameterise the γ distribution parameters *a* and *b* as functions of E_0, d

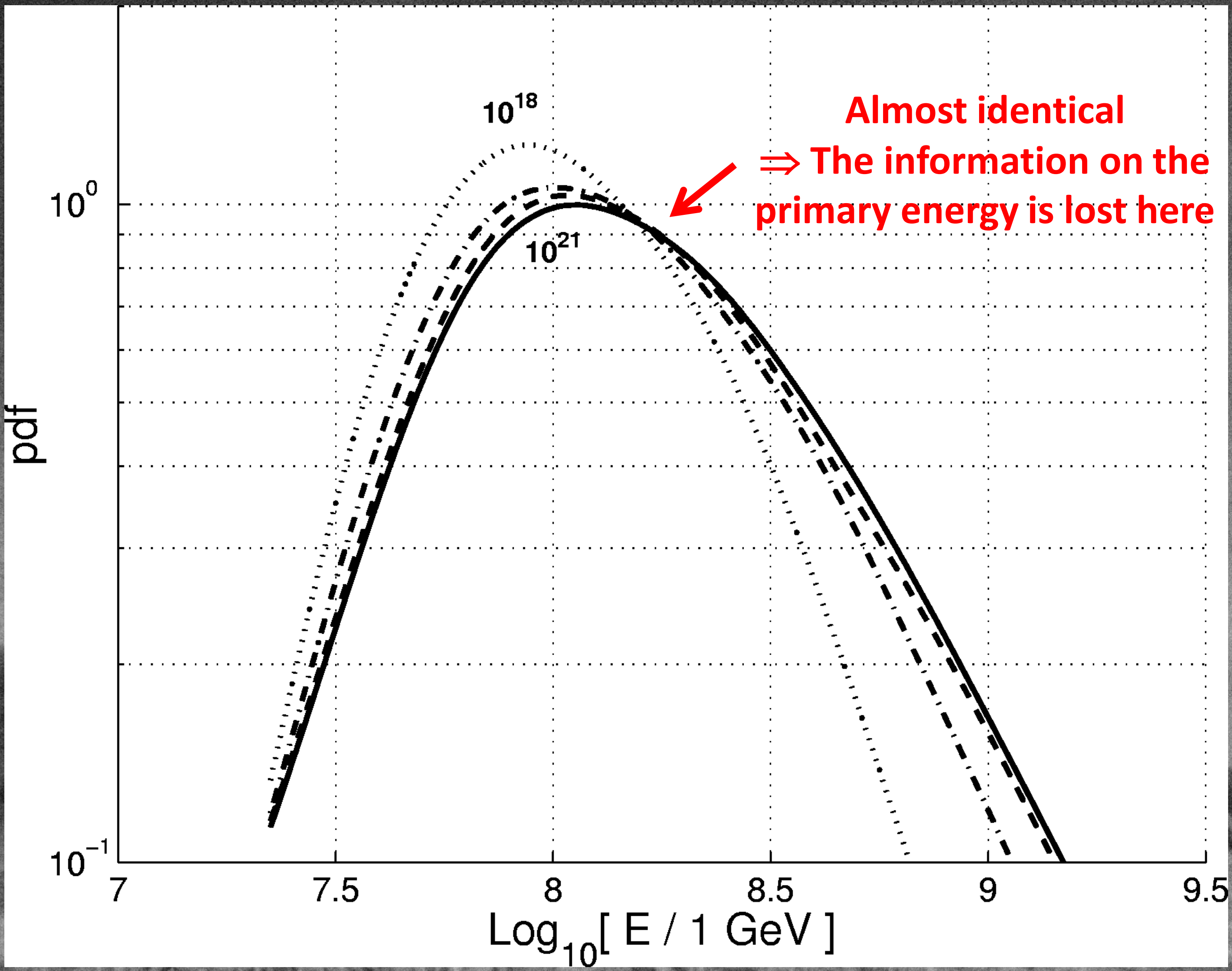
$E_0 = 10^{19}$ eV
d = 10 km

Conversion Efficiency as Rock Depth

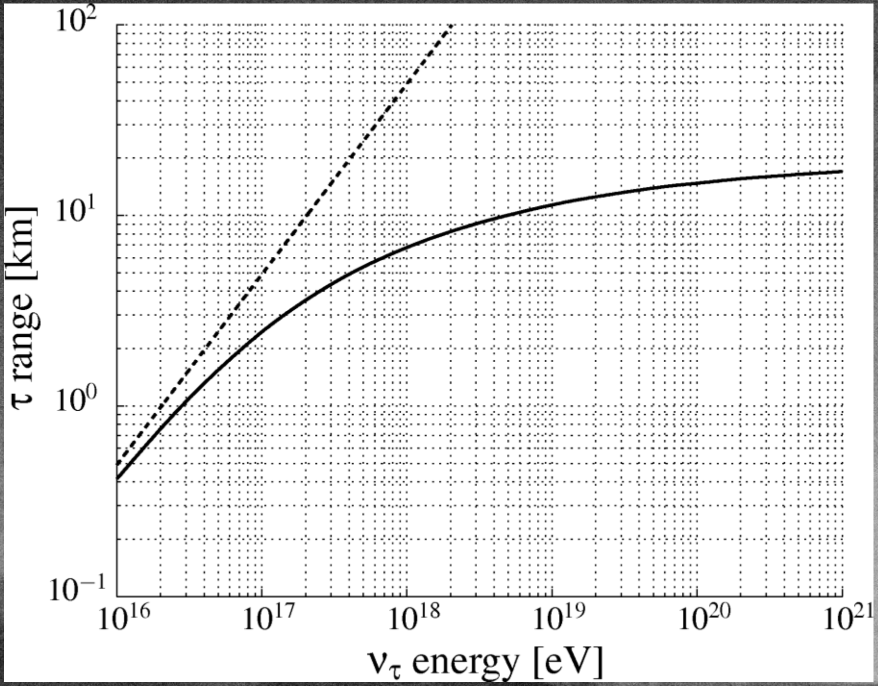
Trade to play between the stopping of the ν in the rocks and the escape of the τ out of the rocks.

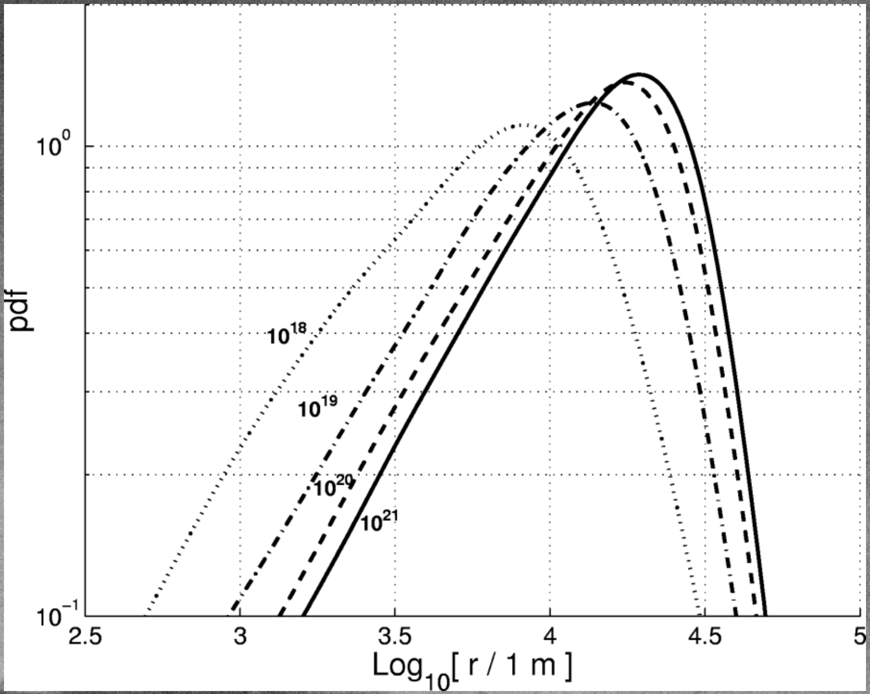


τ Energy Spectrum for 30 km Rocks



τ Flight Distance Spectrum for 30 km Rocks





Above 10^{18}eV, the flight distance only slightly increases with the primary energy.