



Giant Radio Array for Neutrino Detection

Sijbrand de Jong

On behalf of the GRAND Collaboration*

*Many thank to all GRAND members,
in particular Charles Timmermans

Take home:

will detect UHE ν

staged approach,

good progress on next step

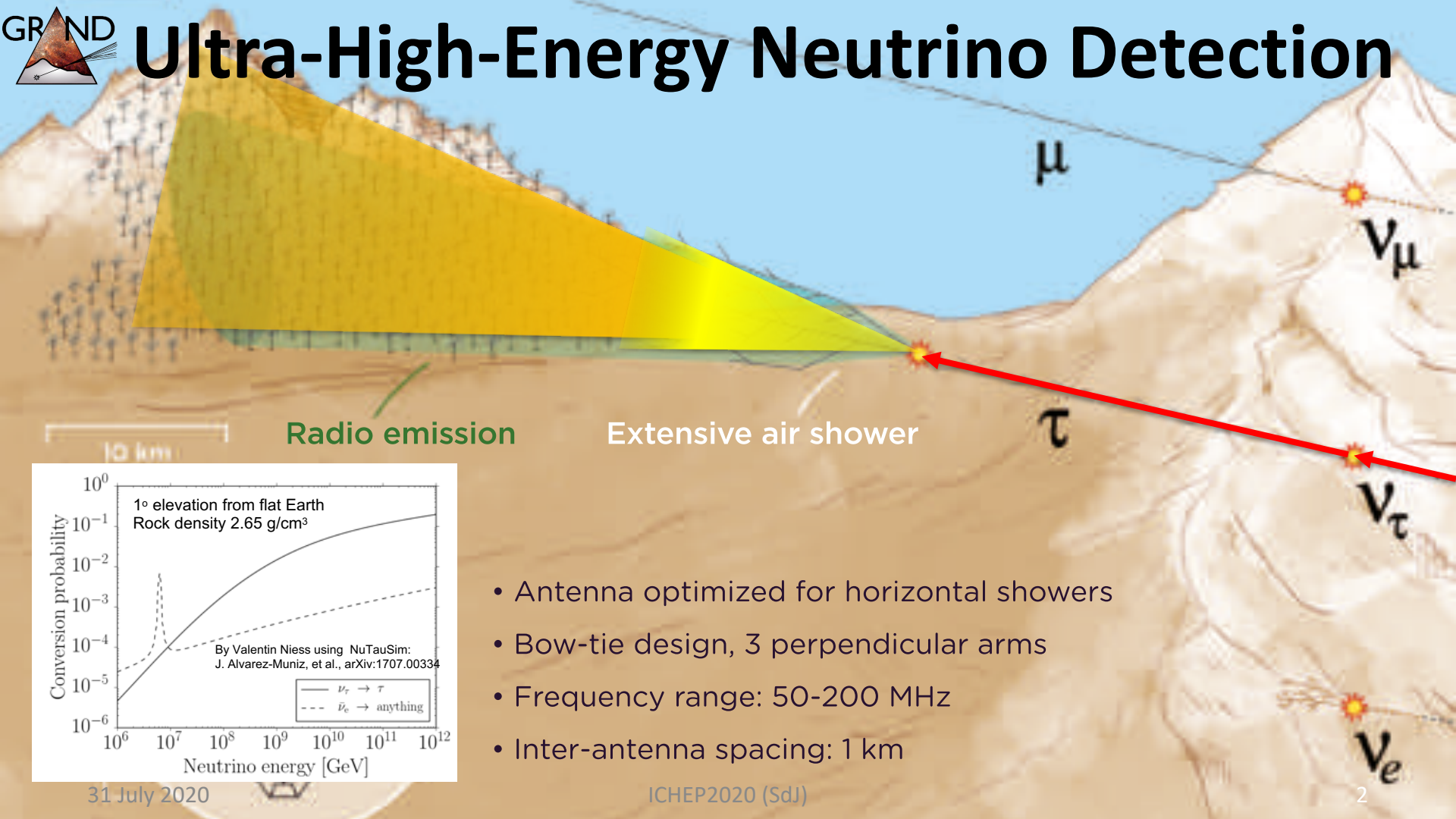
GRAND Proto300



31 July 2020

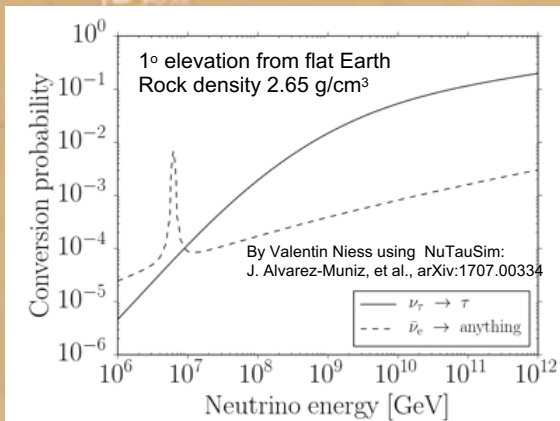
ICHEP2020 (SdJ)

Ultra-High-Energy Neutrino Detection



Radio emission

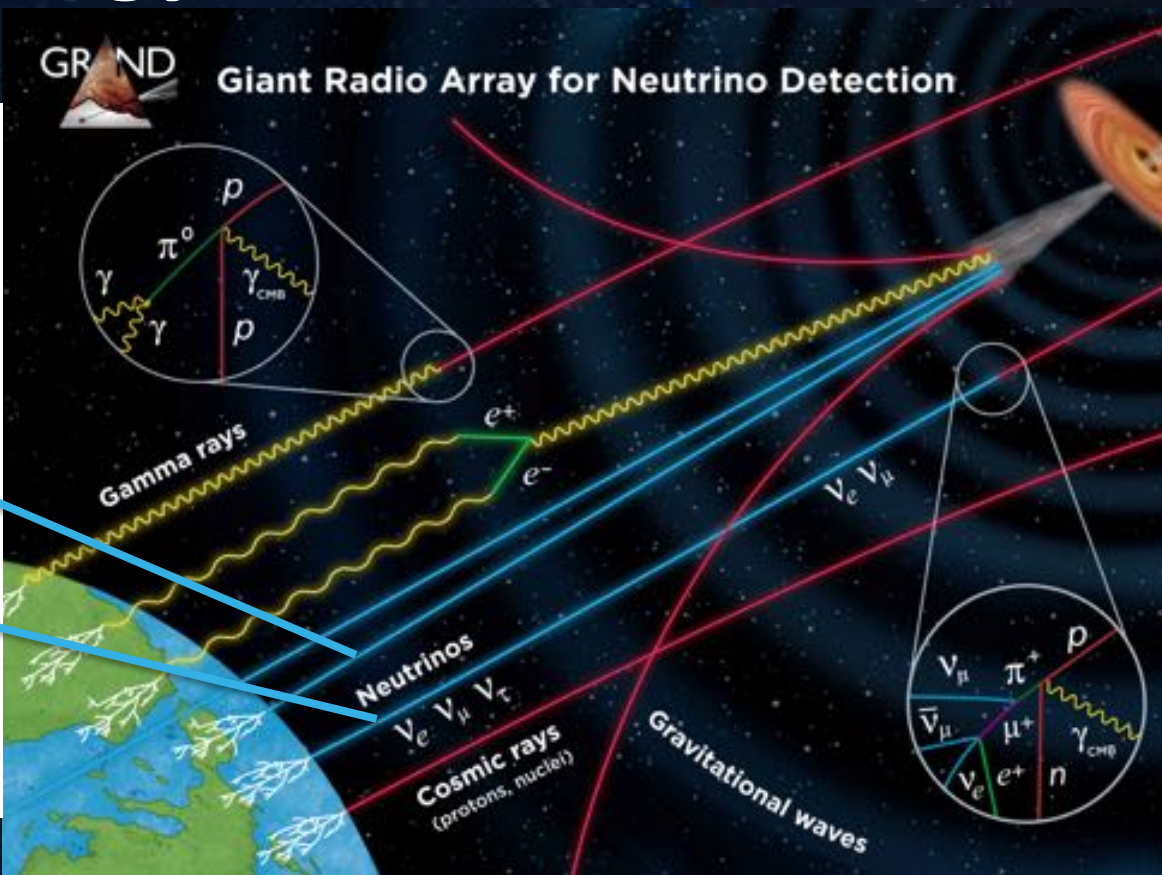
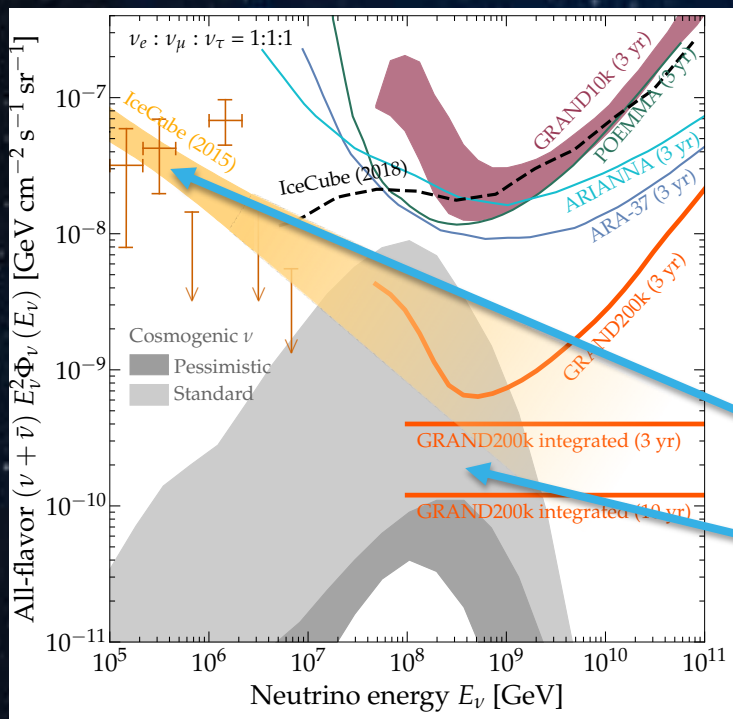
Extensive air shower



- Antenna optimized for horizontal showers
- Bow-tie design, 3 perpendicular arms
- Frequency range: 50-200 MHz
- Inter-antenna spacing: 1 km

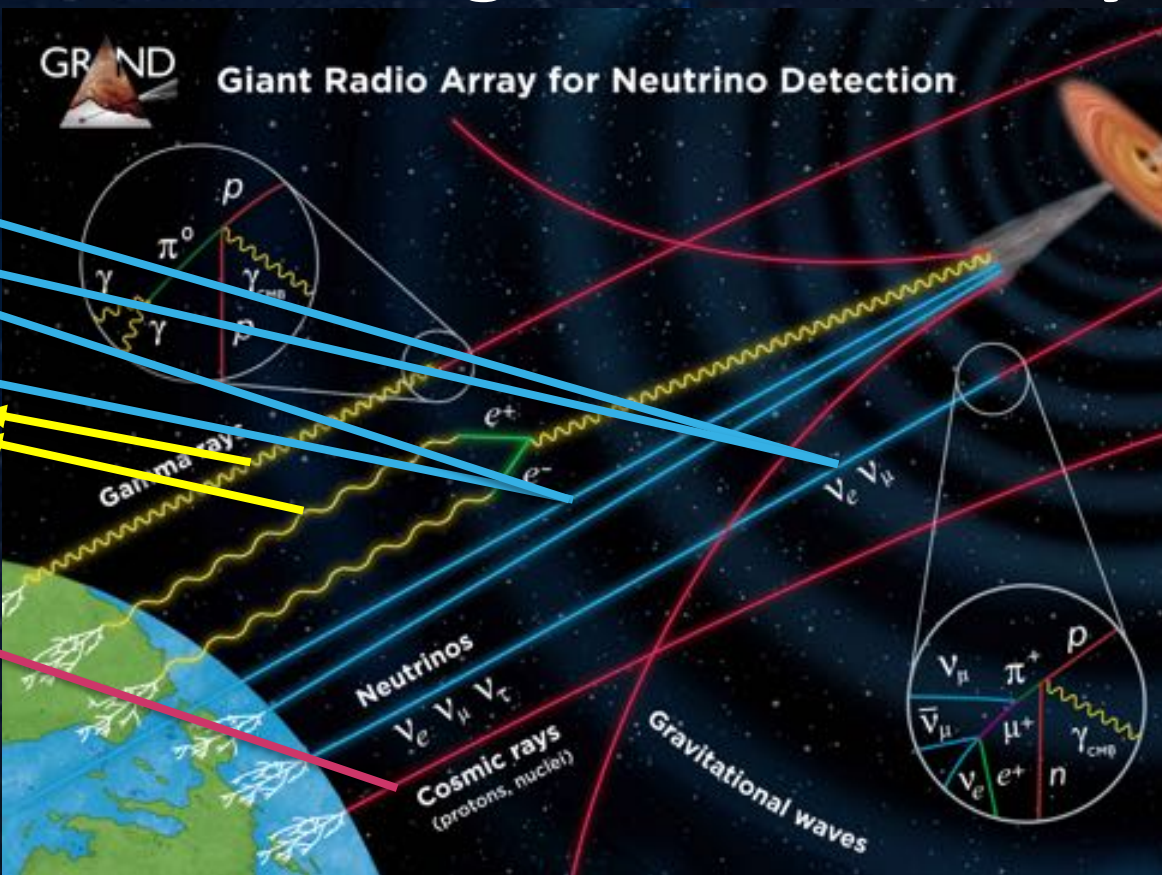
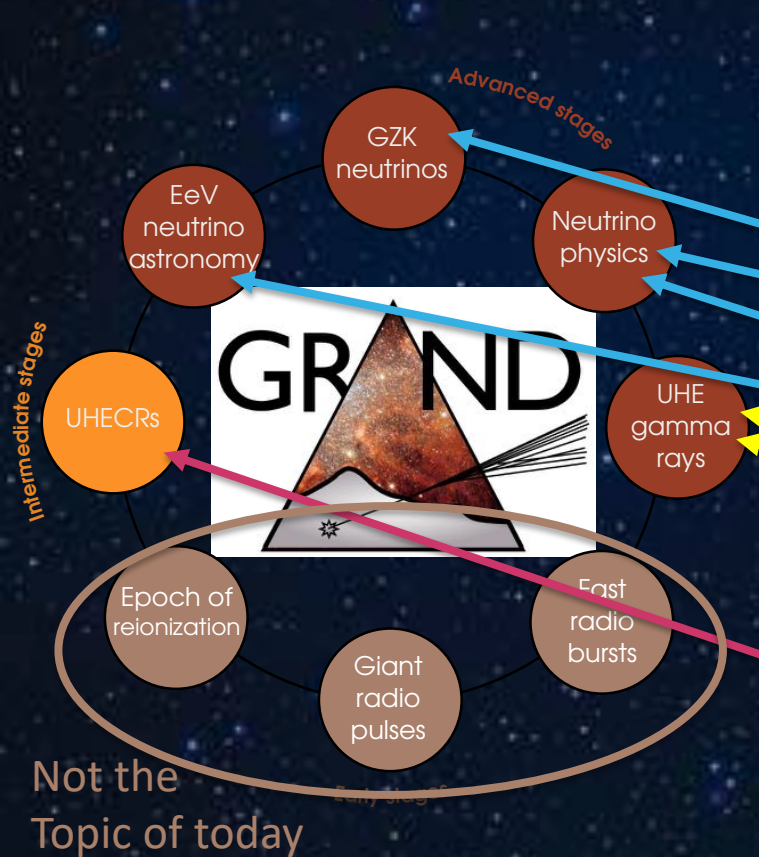


Ultra-High-Energy Neutrino Production





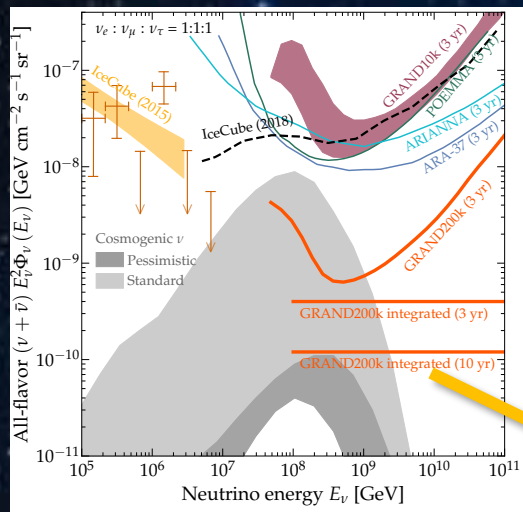
GRAND as multi-messenger observatory



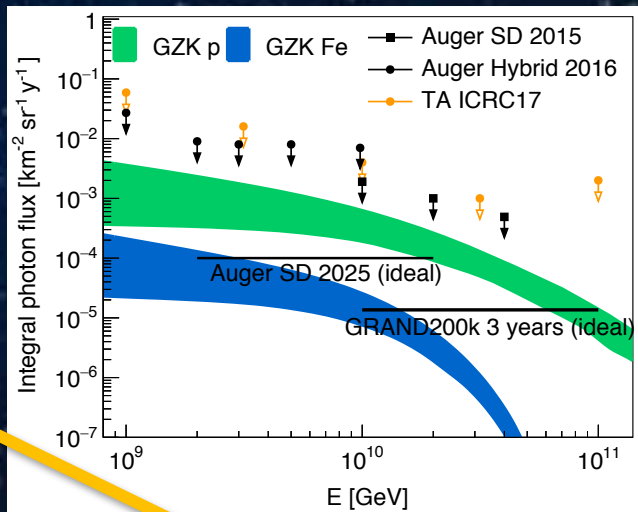


GRAND performance

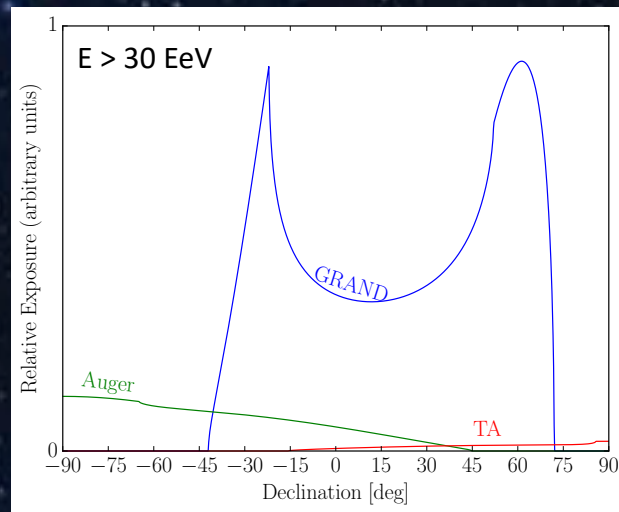
Ultra-high-energy Neutrinos



Photons



Cosmic Rays

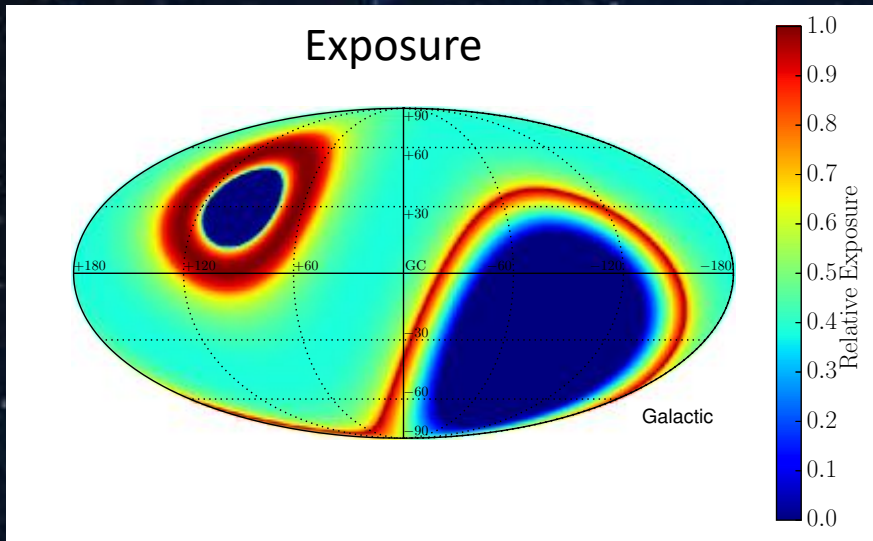


Total size determined by discovery of **UHE ν** for all standard models in about 10 years time
(No discovery : have to rethink our view of the universe)

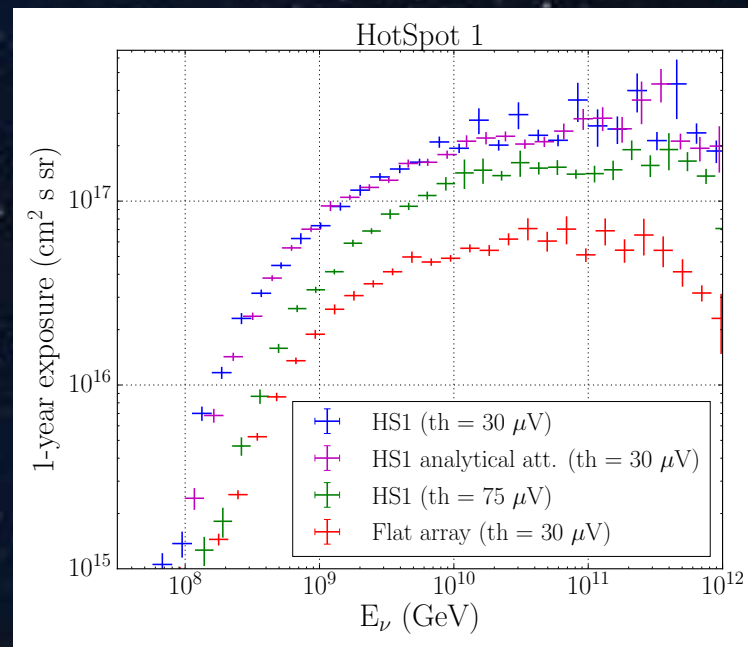
200 000 km²

(See white paper: Sci. China-Phys. Mech. Astron. 63 (2020) 219501, arxiv.org/abs/1810.09994)

GRAND sites



The first individual hotspot is a natural step in a roadmap capable of doing new astroparticle physics



Sky coverage 80% integrated over time,
but at any one time a limited ring/wedge
For full sky coverage at any time:
Need several locations: hotspots
Plan for 10-20 hotspots



GRAND Roadmap



GRAND Proto300 Station

Sensor antenna
3 polarisations

5 meter high
pole

Communication
antenna

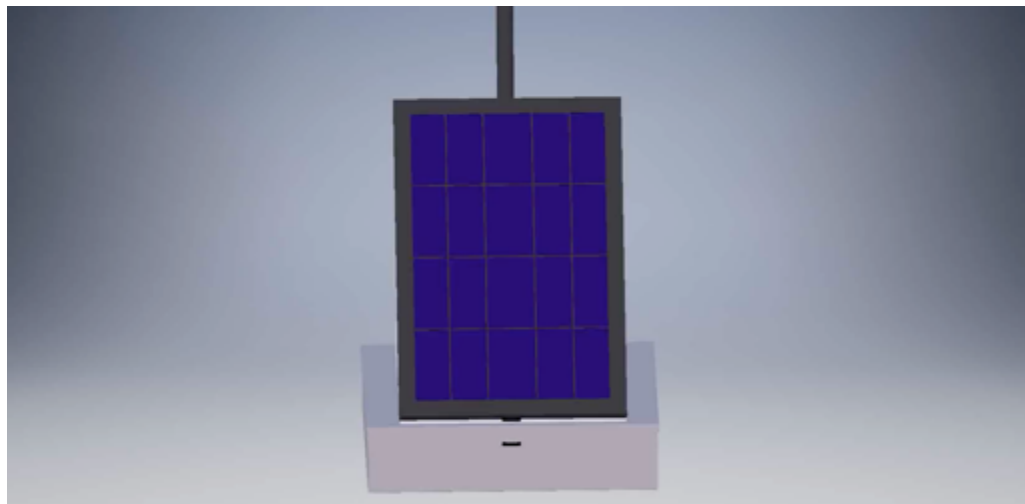
Inside box:

- battery
- electronics



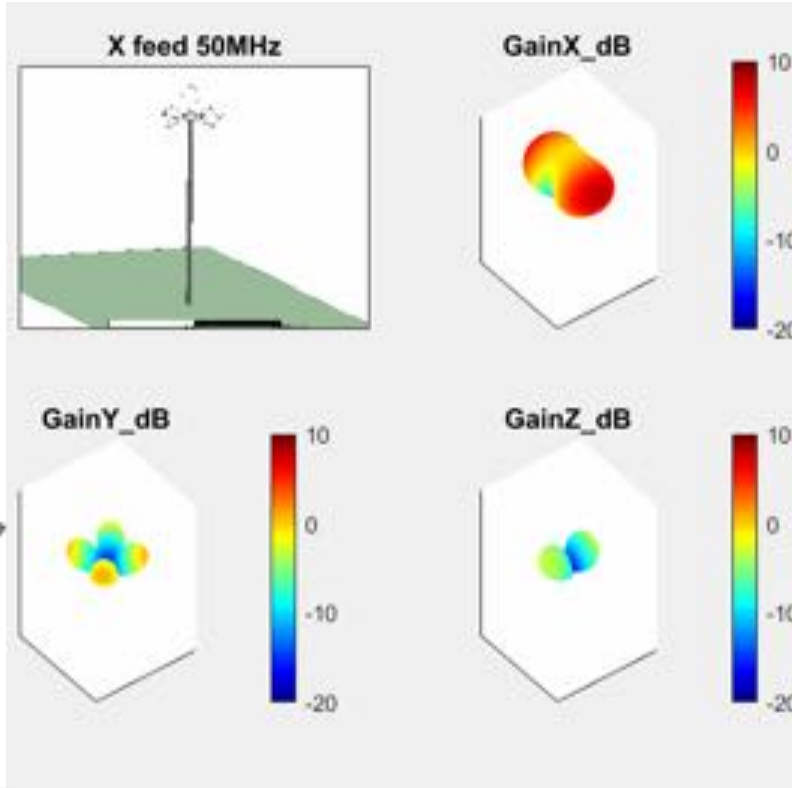
Sand/stone filled box

Solar panel



- Cheap and easy local manufacturing
- Easy to deploy
- Optimally accessible for tests & trails
- Intermediate step: final design needs to be cheaper

GRAND Proto300 Sensor Antenna

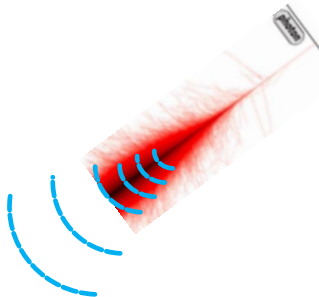


- Optimise for horizontal showers
- Butterfly to flatten frequency response
- Impedance matching to LNA
- Mounted on 5m high pole to limit
 - influence of ground reflections
 - solar panel/electronics box
- Mechanical stability
 - modest deformation by wind

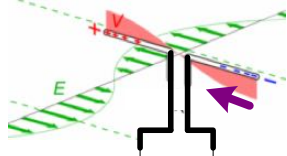


GRAND Proto300 Electronics

Radio Pulse
from EAS



Antenna



$$V_{OC} = \vec{l}(\theta, \varphi) \cdot \vec{E}(\theta, \varphi)$$

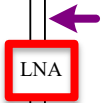
$$V_L = (Z_A / (Z_A + Z'_L)) V_{OC}$$

Transformer



Connect Cable(A)

Low noise
amplifier

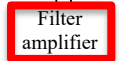


$$V_{LNA}^{in} = \frac{1}{\sqrt{r}} \frac{rZ_{LNA}^{in}}{Z_a + rZ_{LNA}^{in}} \frac{1 + \Gamma_{LNA-in} e^{\gamma_{ca} l_{ca}}}{e^{2\gamma_{ca} l_{ca}} - \Gamma_a \Gamma_{LNA-in}} V_{OC}$$

Connect Cable (B)

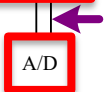
$$V_{LNA}^{out} = \frac{S_{21}^{LNA}}{1 + \Gamma_{LNA}^{in}} V_{LNA}^{in}$$

Filter amplifier



$$V_{FA}^{in} \approx e^{-\gamma_{cb} l_{cb}} V_{LNA}^{out}$$

Digitizer

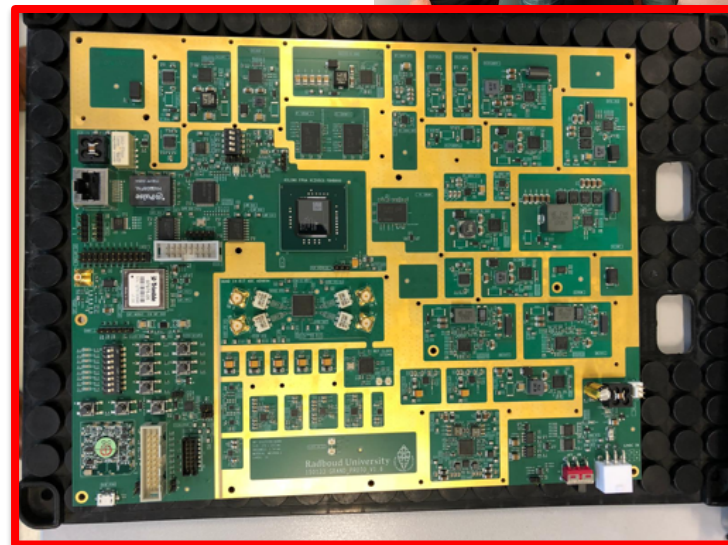
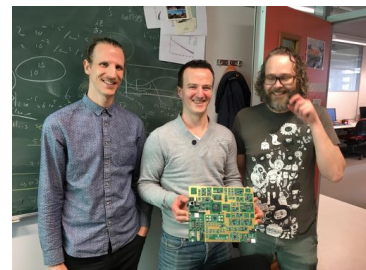


$$V_{FA}^{out} = S_{21}^{Filter} V_{FA}^{in}$$

31 July 2020



ICHEP2020 (SdJ)



10



GRAND Status

- Huge ground-based radio array ultra-high-energy neutrino, gamma, cosmic ray observatory
- Impressive versatile astroparticle and particle physics science case
- No-loose theorem for UHE tau neutrinos
- Roadmap for staged approach
- GRANDProto300 well underway, ready for production soon
- Open, lively and growing collaboration: More help welcome !