the giant radio array for neutrino detection (GRAND)

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primary goals: UHE neutrinos

secondary goals: cosmology & radioastronomy

epochs:
- Epoch of reionization
- Fast radio bursts
- Giant radio pulses

stages:
- Early stages
- Intermediate stages
- Advanced stages

GRAND

- GZK neutrinos
- Neutrino physics
- UHE gamma rays
- EeV neutrino astronomy
- UHECRs
A multi-messenger glimpse into the high-energy universe.
interactions of UHECRs with radiations fields and matter produce UHE neutrinos

**cosmogenic neutrinos**: produced during the intergalactic propagation of UHECRs via interactions

**source-produced neutrinos**: generated via interaction os UHECRs with the immediate vicinity of astrophysical objects

**cosmogenic neutrinos**

source evolution: \((1 + z)^m\)

- IceCube HESE 2015
- Auger 2015
- ARIANNA (3-yr)
- ARA (3-yr)
- GRAND (3-yr)
- GRAND (10-yr, integrated)

**source neutrinos**


- Clusters w. central sources
- GRB afterglow-ISM
- Newborn Pulsars
- GRB afterglow-wind
- Active Galactic Nuclei
- GRB afterglow-late prompt
Giant Radio Array for Neutrino Detection

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

Cosmic ray detection principle

Radio emission
Extensive air shower

Rafael Alves Batista | LASF4RI Symposium | July 10, 2020 | The Giant Radio Array for Neutrino Detection (GRAND)
annual geometric exposure for GRAND200k
‣ 300 detection units (radio antennas + surface detectors) over ~200 km² with denser infill array
‣ prospective site: QingHai province, China
‣ transition between galactic and extragalactic cosmic rays
‣ muon content of showers at $E \sim 10^{16.5} - 10^{18}$ eV
‣ cosmology: epoch of reionisation
transition between galactic and extragalactic cosmic rays

muon content of showers at $E \sim 10^{16.5} - 10^{18}$ eV

cosmology: epoch of reionisation
**GRAND Proto300**

2018

- Standalone radio array; test efficiency & background rejection
- 35 radio antennas, 21 scintillators
- 160k€, fully funded by NAOC+IHEP, deployment ongoing @ Ulastai

**GRAND Proto35**

2020

- Standalone radio array of very inclined showers ($\theta > 70^\circ$) from cosmic rays ($> 10^{16}$ eV)
- Ground array to do UHECR astro/hadronic physics

**GRAND 10k**

2025

- First GRAND subarray, sensitivity comparable to ARA/ARIANNA on similar time scale, allowing discovery of EeV neutrinos for optimistic fluxes
- 300 HorizonAntennas over 300 km²
- Fast DAQ (AERA + GRAND Proto35 analog stage)
- Solar panels (day use) + WiFi data transfer
- Ground array (à la HAWC/Auger)

**GRAND 200k**

203X

- First neutrino detection at $10^{18}$ eV and/or neutrino astronomy!
- 200,000 antennas over 200,000 km², ~20 hotspots of 10k antennas, possibly in different continents
- Industrial scale allows to cut down costs: 500€/unit $\rightarrow$ 200M€ in total

**Budget & stage**

- 1.3 M€ to be deployed in 2020

**Timeline**

- **Fully funded**
  - GRAND Proto300
  - GRAND Proto35
  - GRAND 10k
  - GRAND 200k
GRAND200k: ~20 arrays of ~10000 km² with all-sky coverage

expected timeline for completion: 2030s

radio detection: cheap and efficient way to detect air showers

science cases: ultra-high-energy cosmic particles, fundamental neutrino physics, cosmology, and radioastronomy

GRANDProto300: pathfinder for GRAND with a well-defined science case of its own

GP300 will start taking data within the next couple of years

major technical challenge: improve self-triggered detection rate