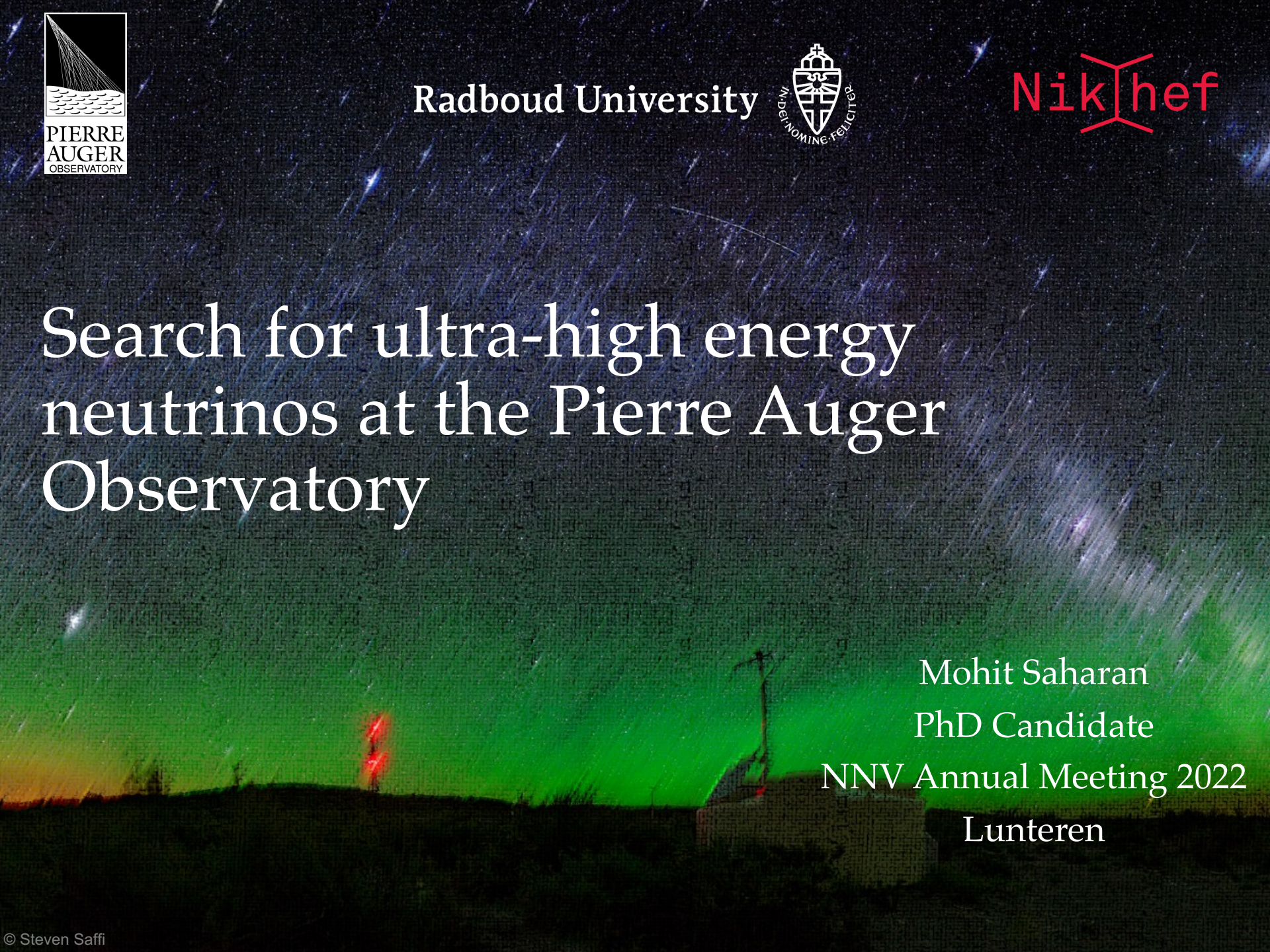


Search for ultra-high energy neutrinos at the Pierre Auger Observatory

Mohit Saharan
PhD Candidate

NNV Annual Meeting 2022
Lunteren

UHE neutrinos: $E \geq 10^{18}$ eV

- How are they produced?

Mohit Saharan (m.saharan@science.ru.nl)

UHE neutrinos: $E \geq 10^{18}$ eV

- How are they produced?

Cosmogenic neutrinos

Proton or heavier nuclei + cosmic microwave background photons

$\rightarrow \nu_e : \nu_\mu : \nu_\tau = 1:2:0$ (source) $\rightarrow 1:1:1$ (Earth)

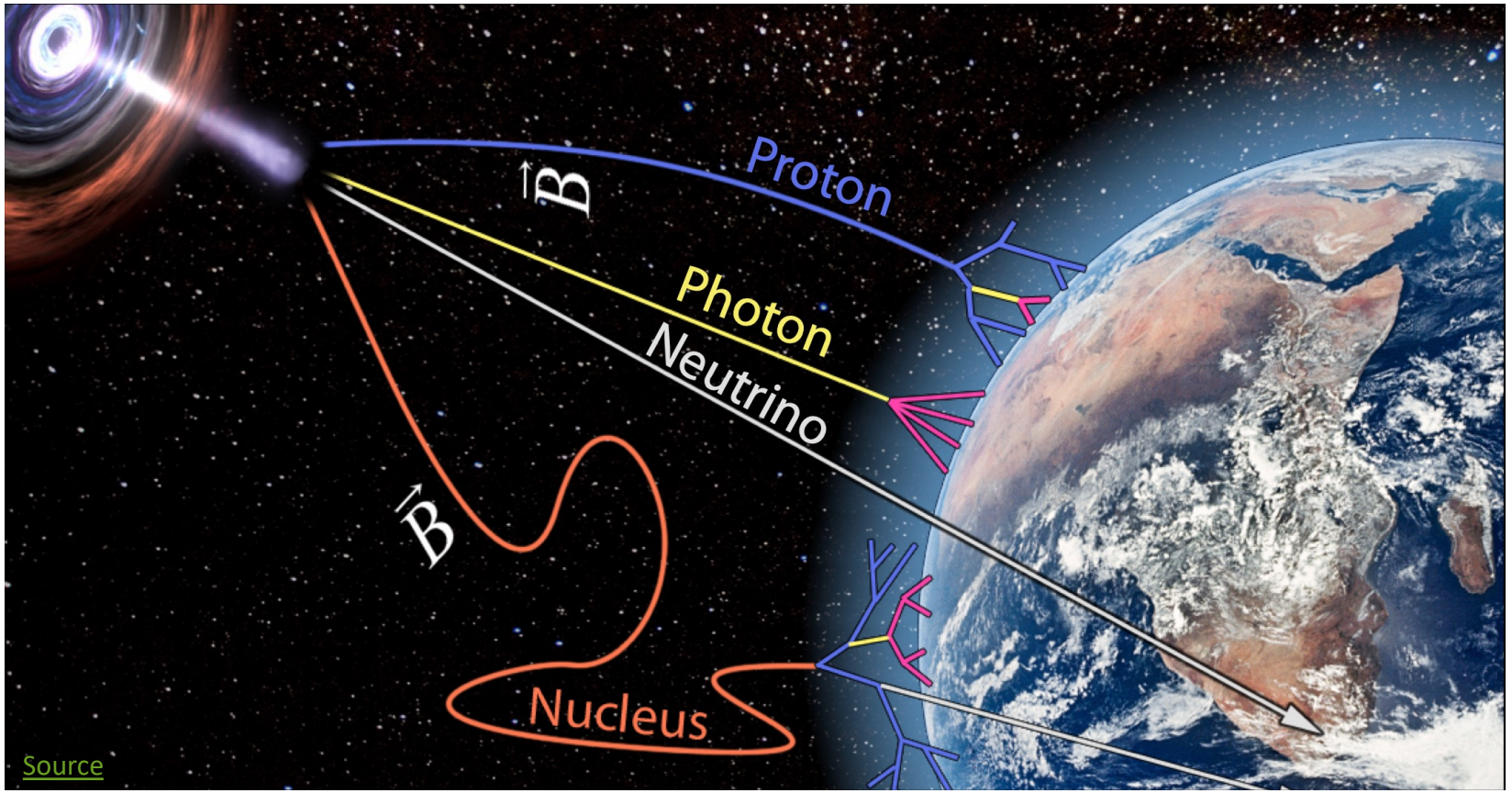
Astrophysical neutrinos

- Active galactic nuclei
- Gamma ray bursts
- …

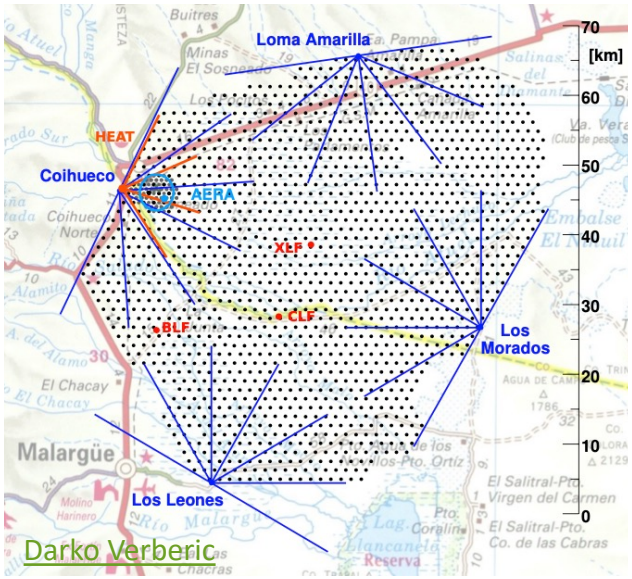
Ref: PHYSICAL REVIEW D 91, 092008

How do they reach us?

- Emitted from the sources among other charged particles (cosmic rays)



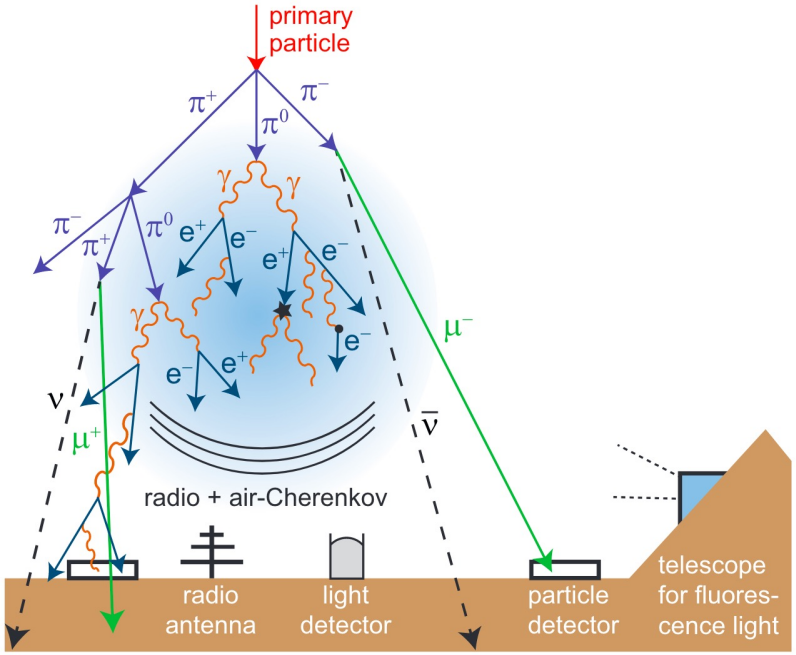
Pierre Auger Observatory



Darko Verberic


Source

- World's largest cosmic ray detector array in Argentina
- 1.5 km spaced Water Cherenkov Detector (WCD) array
- Area ~ 3000 km^2



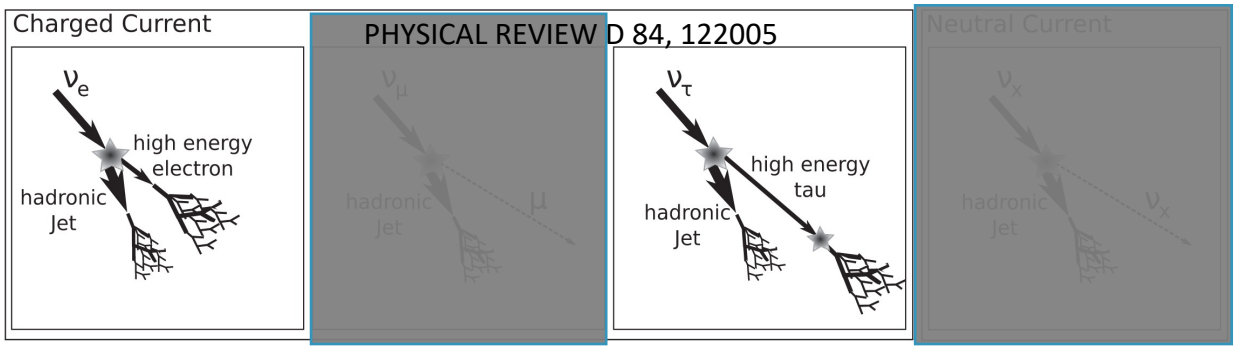
Marvin Gottowik

Why are UHE neutrinos interesting?

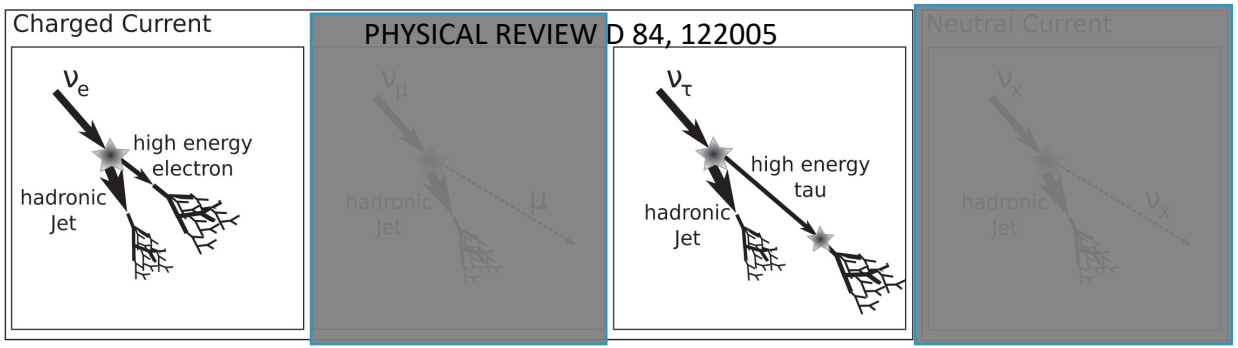
100 years since the discovery of cosmic rays and we still don't know:

- Which astrophysical objects produce UHE cosmic rays?
- How do they accelerate these particles to such high energies?
- What are cosmic rays made of at the highest energies?
  - Are they light, e.g. protons?
  - Are they heavy, e.g. iron?
- …
- UHE neutrinos can help us find the answer to these long-standing questions.

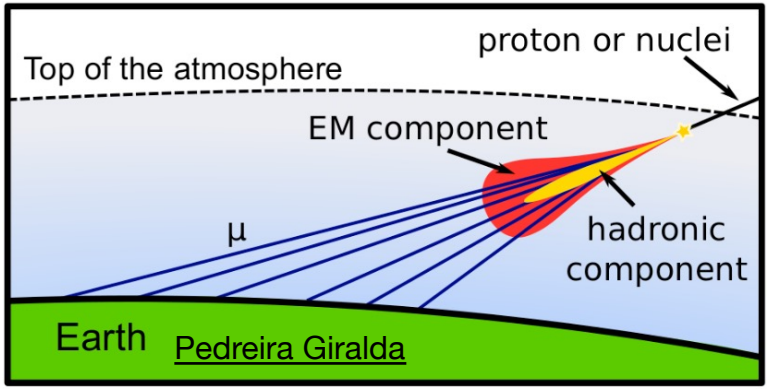
Measurement of neutrino showers at Auger

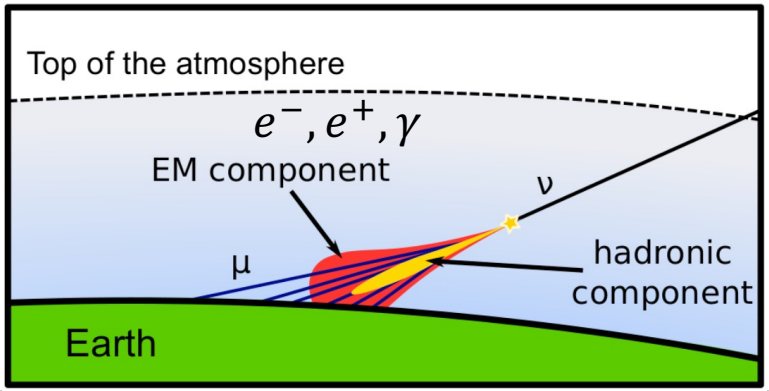


Measurement of neutrino showers at Auger



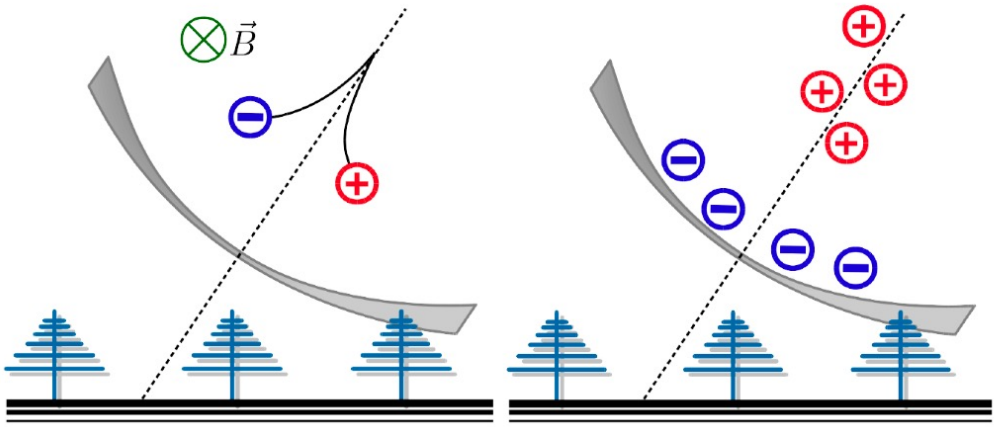
- Auger WCD sensitive to neutrinos with E $> 10^{17}$ eV
- Identification using the EM component
- No neutrino detected so far but stringent upper limits on neutrino flux
- Room for improvement?
  - Sensitivity to distant showers



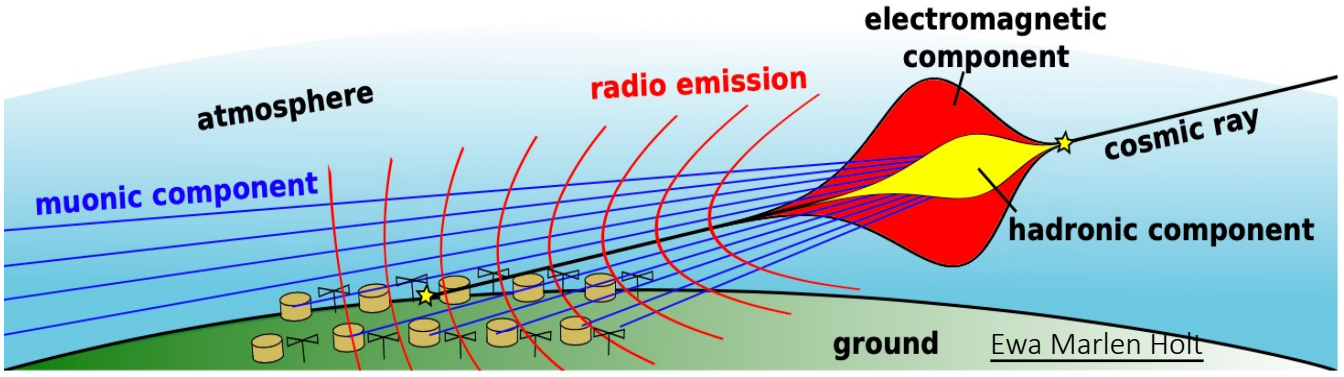


Radio emission from air showers

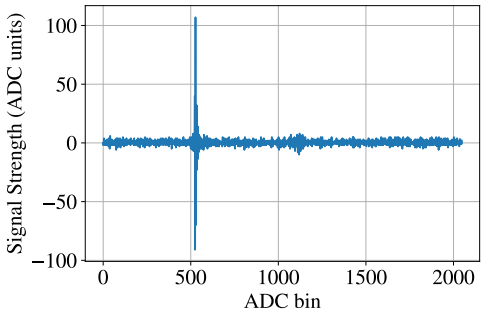
- Ionisation of air due to the motion of fast-moving highly energetic particles
- Change in currents → radio waves
- Travels ~ unattenuated → sensitivity to distant showers

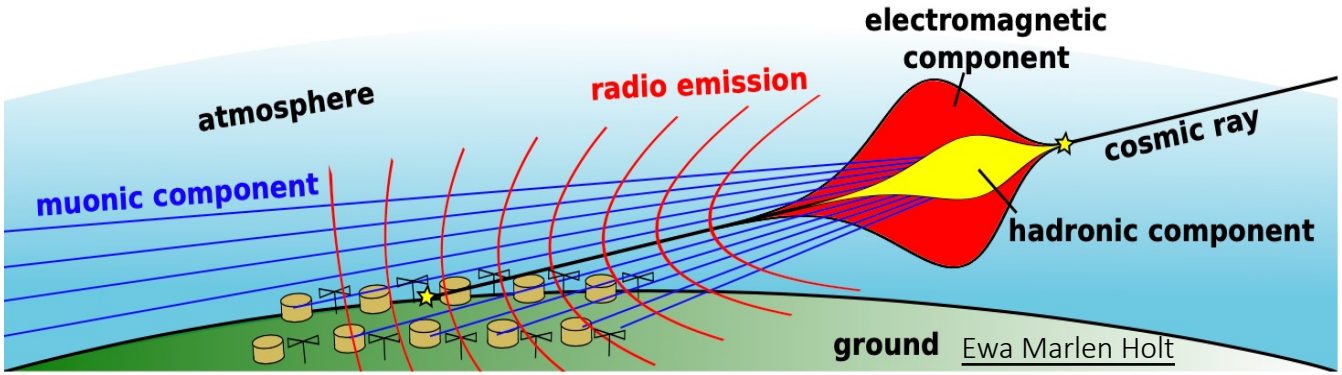


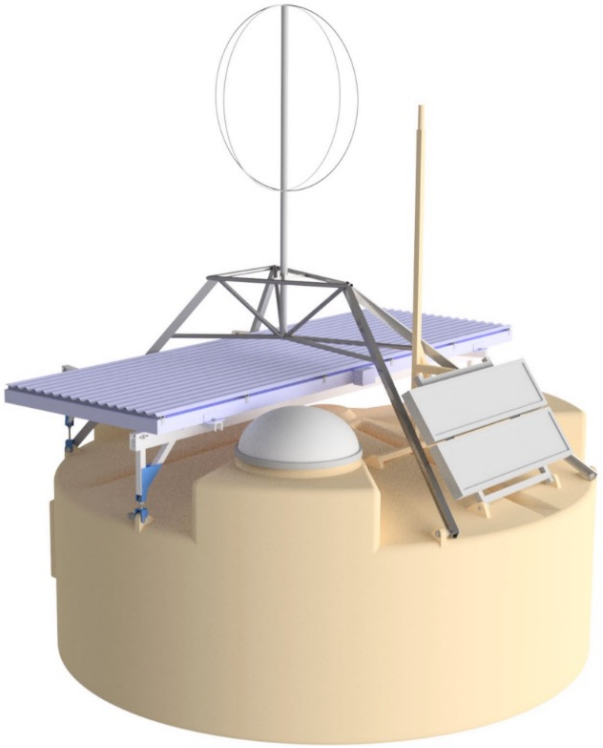
DOI: 10.18154/RWTH-2017-02960



The AugerPrime Radio Upgrade







- Deployment in progress
- 7 Stations active in the field since 3 years
- Upgrade of all 1660 stations
- World's largest radio detector array
- Improved sensitivity to highly inclined cosmic ray and neutrino showers.

RD self-trigger

Concept

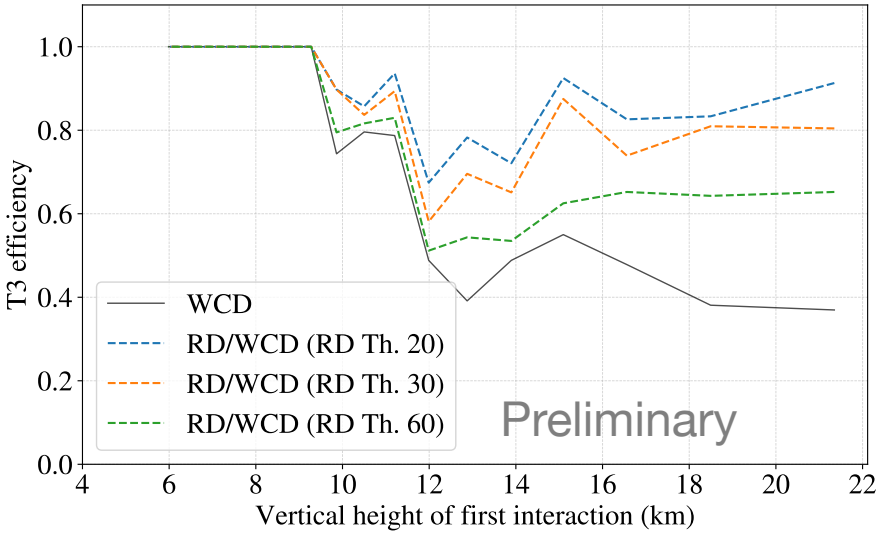
- If Radio signal > Threshold in either polarisation → RD trigger
- Combine with WCD or RD triggers from neighbouring stations
- If a trigger cluster (T3) → Save the event to the disk

Development

- Still in very early phase
- First set of workable parameters available; need further optimisation
- Likely a test of radio trigger in the field this month

Trigger efficiency for ν_e

- Preliminary tests show significant increase in trigger efficiency for distant neutrino shower simulations.
- A long way to go for new limits
  - Tests for other energies, zeniths, flavours…
  - New identification criteria
  - Implementation in hardware
  - Data collection
  - Search



Summary

- UHE neutrinos can help answer long-standing questions about the nature of cosmic rays.
- Auger, the world's largest cosmic ray detector array, is sensitive to neutrinos at highest energies with E > 10^{17} eV.
- No neutrinos detected so far but stringent limits.
- The AugerPrime Radio Detector upgrade is expected to increase the sensitivity of Auger Observatory towards UHE neutrinos.
- The AugerPrime RD deployment is in progress.
- RD self-trigger is under development.
- Preliminary tests show significant improvement in trigger efficiency for distant neutrino shower simulations.
- First test in the field this month but it's a long way to go for new limits.