



Radboud University



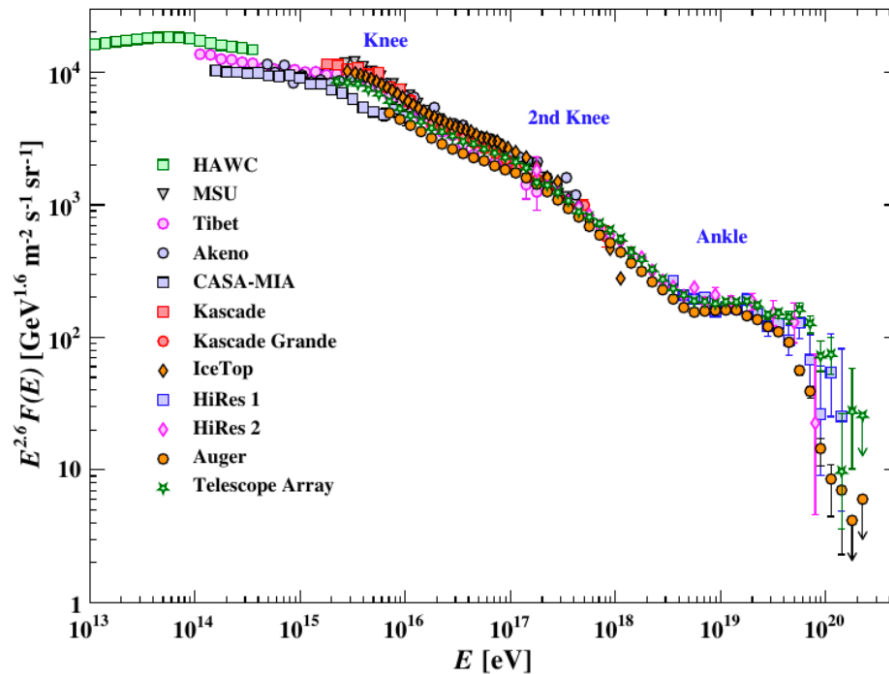
Nikhef

# AugerPrime Radio Detector

Mohit Saharan  
Nikhef Jamboree  
16 May 2023



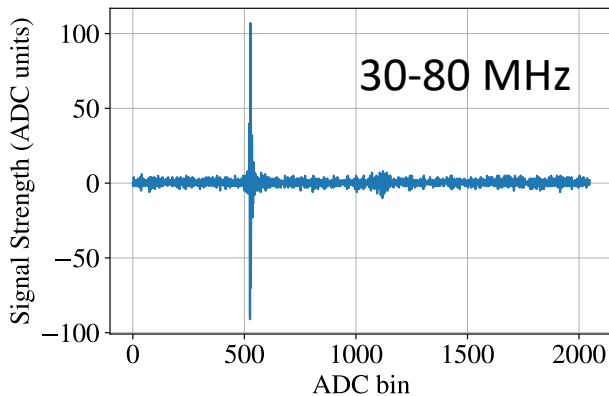
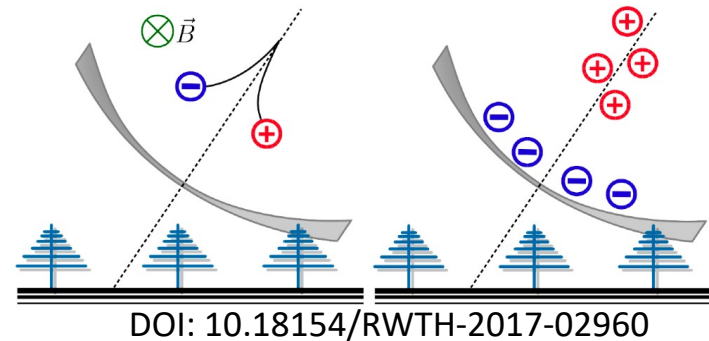
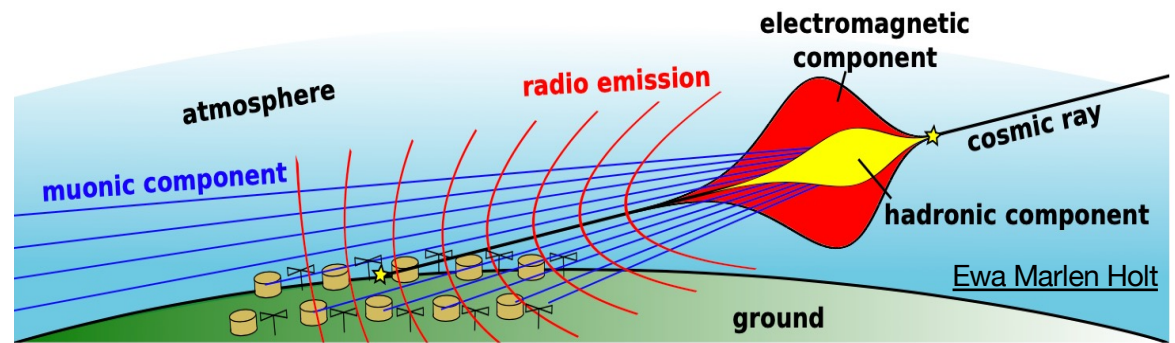
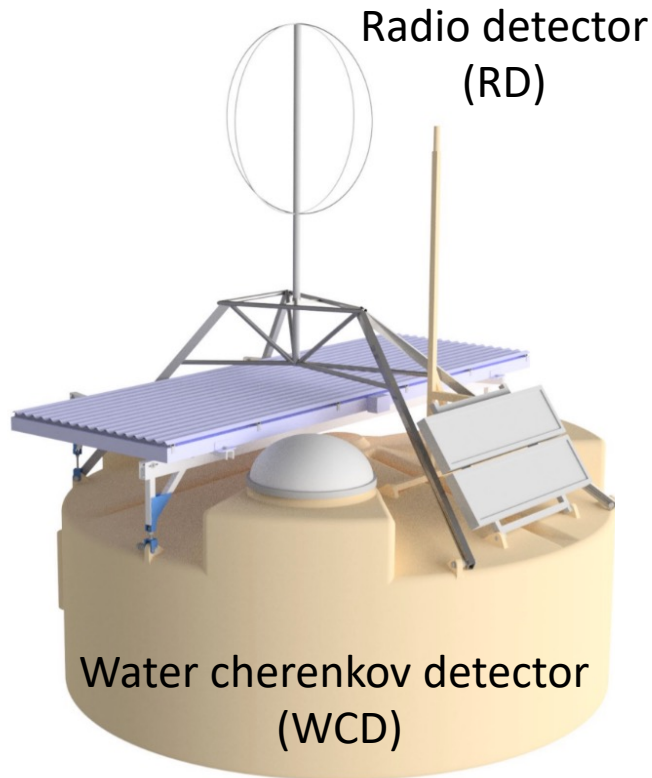
# Science goals of AugerPrime



PTEP 2020.8 (2020), p. 083C01

- Mass composition at the highest energies.
  - Flux suppression:
    - Due to interaction with  $\gamma_{CMB}$  or due to limited acceleration capacity of the sources?
- ∴ Constrain the ultra-high-energy neutrino and gamma-ray fluxes.

# AugerPrime Radio Detector



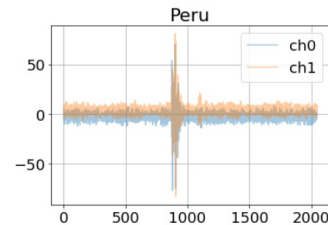
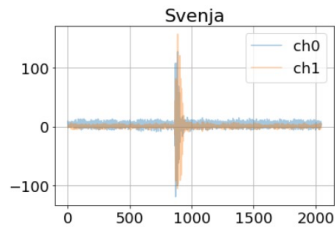
- Separate measurement of e/m and muonic component for  $\theta > 65^\circ$ 
  - Improves mass composition
  - Improves sensitivity to neutrinos and photons

# RD data

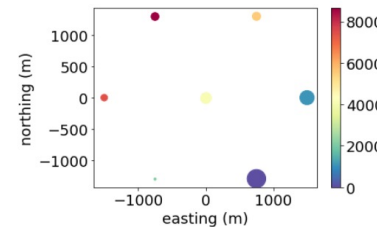
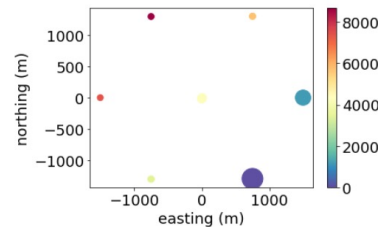
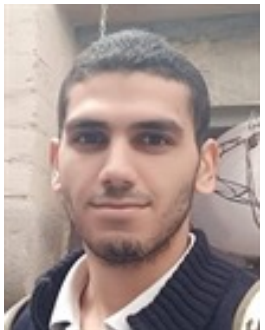
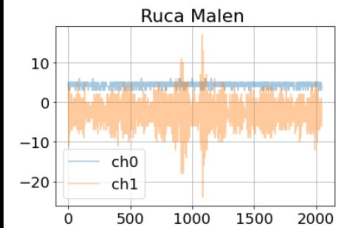
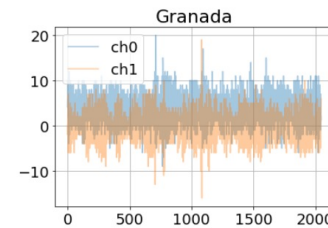
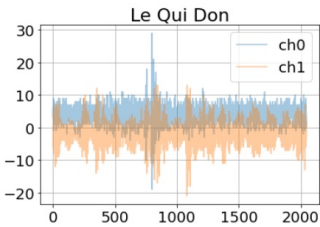
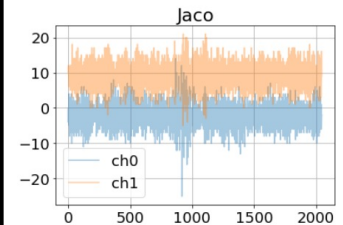
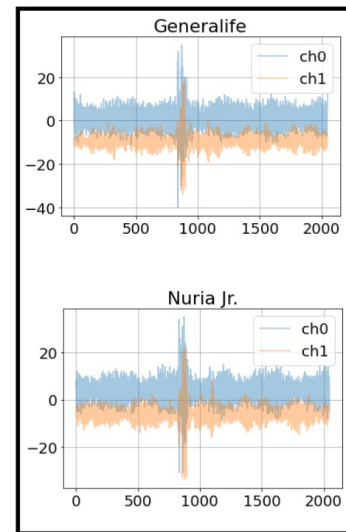
- An engineering array of 8 stations is measuring air-showers.



Biggest Event in March



Twin

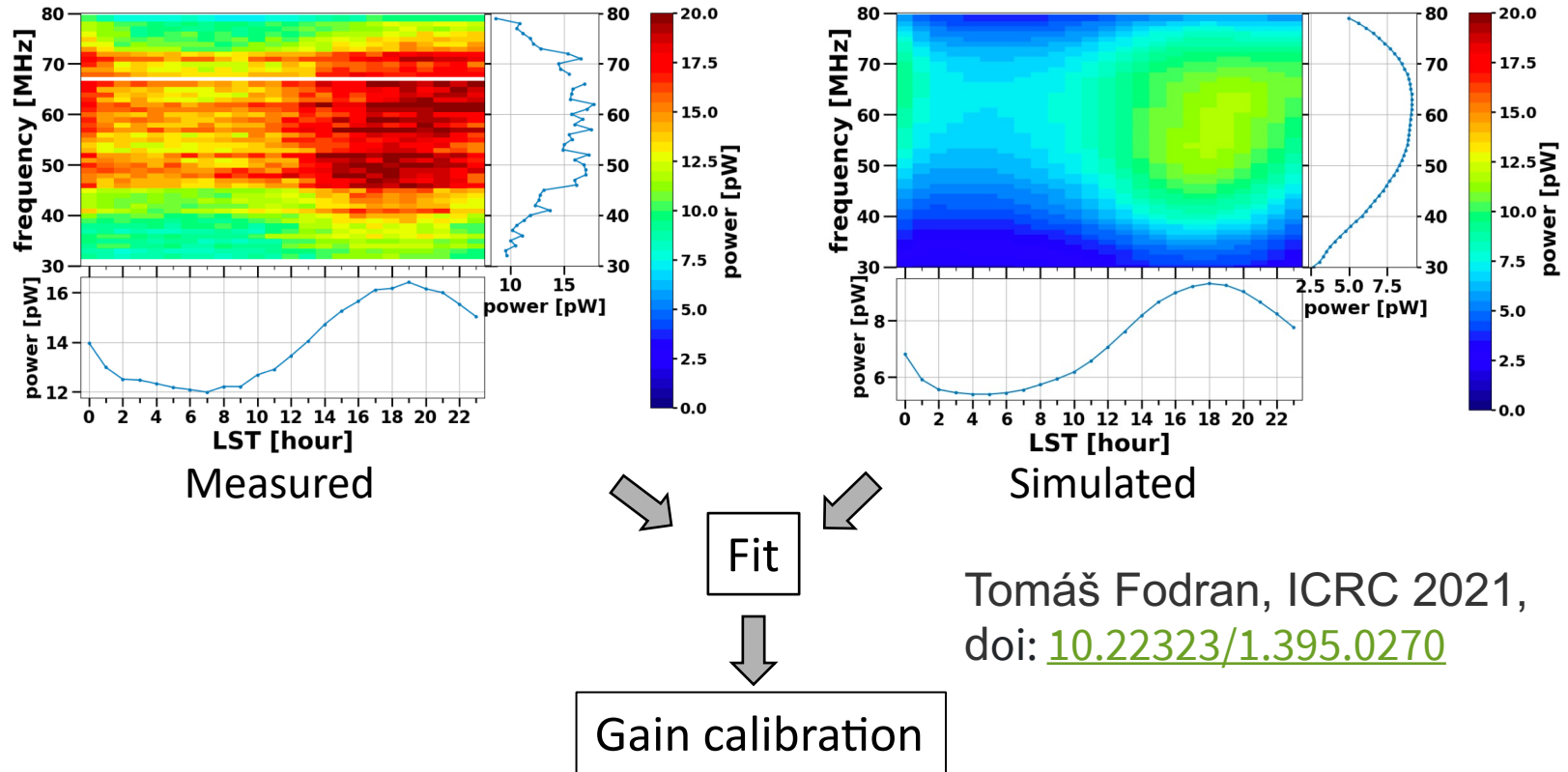


Harm Schoorlemmer

Mohamed Emam

# Absolute calibration of the RD

- Absolute calibration of the antennas using galactic diffuse emission.



- Effect of variations in antenna model geometry on energy reconstruction: < 5% (T. Fodran, ARENA 2022).

# Effect of temperature on the measured bg. noise

- Temperature correction to improve the absolute calibration.

Measured power

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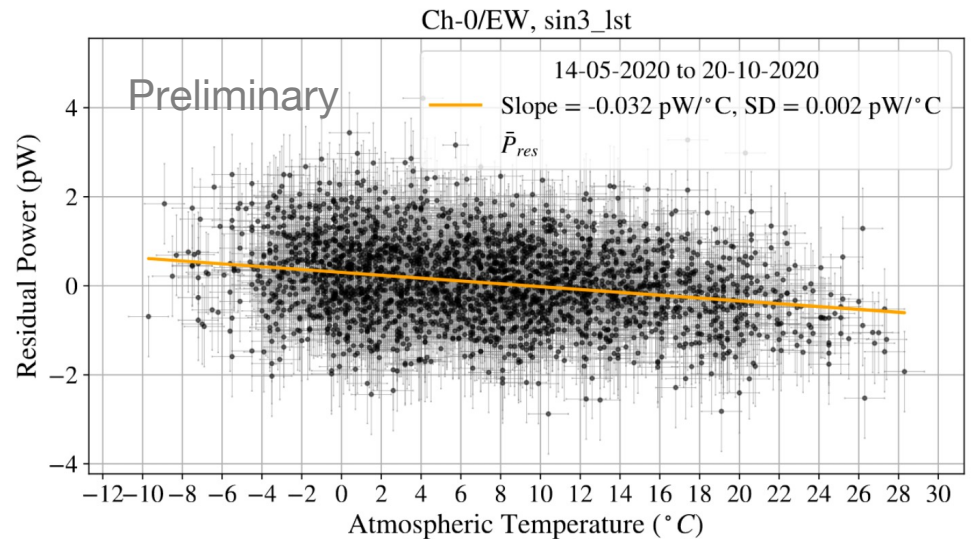
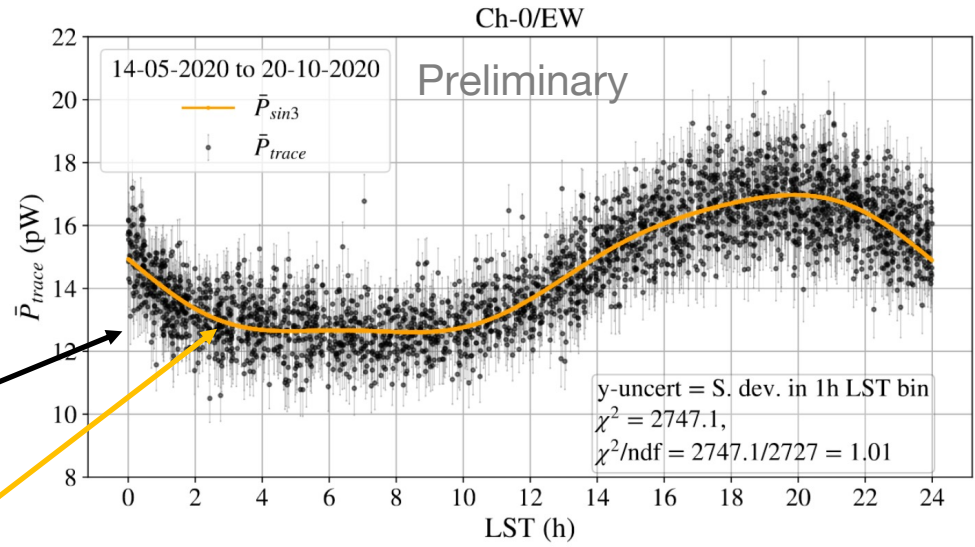
Fit to estimate the galactic contribution

=

Thermal contribution

~8 % variation in measured power for  $\Delta T = 30^\circ$

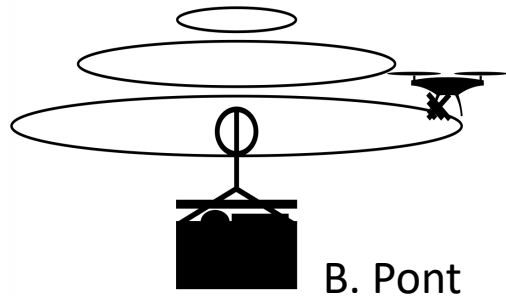
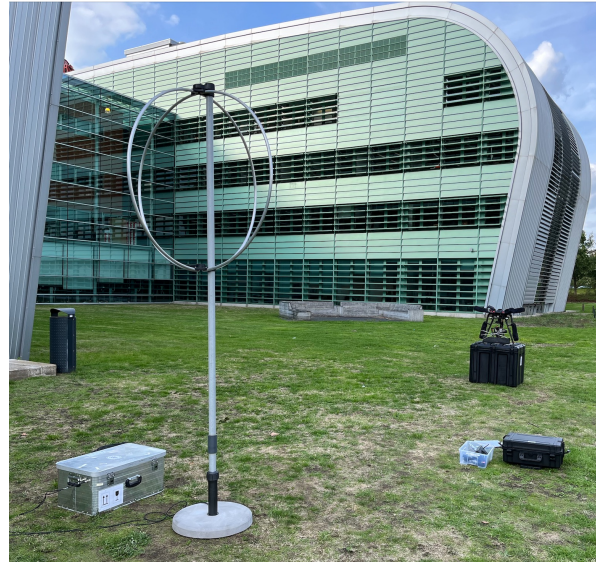
- Effect on calibration: to be studied.



Mohit Saharan, Cristina Galea, Sijbrand de Jong



# Directional calibration of the antenna response



B. Pont

- A portable setup was built at RU for readout- and flight tests.
- First campaign in 09/2022 postponed due to logistical issues.
- Full calibration this year.

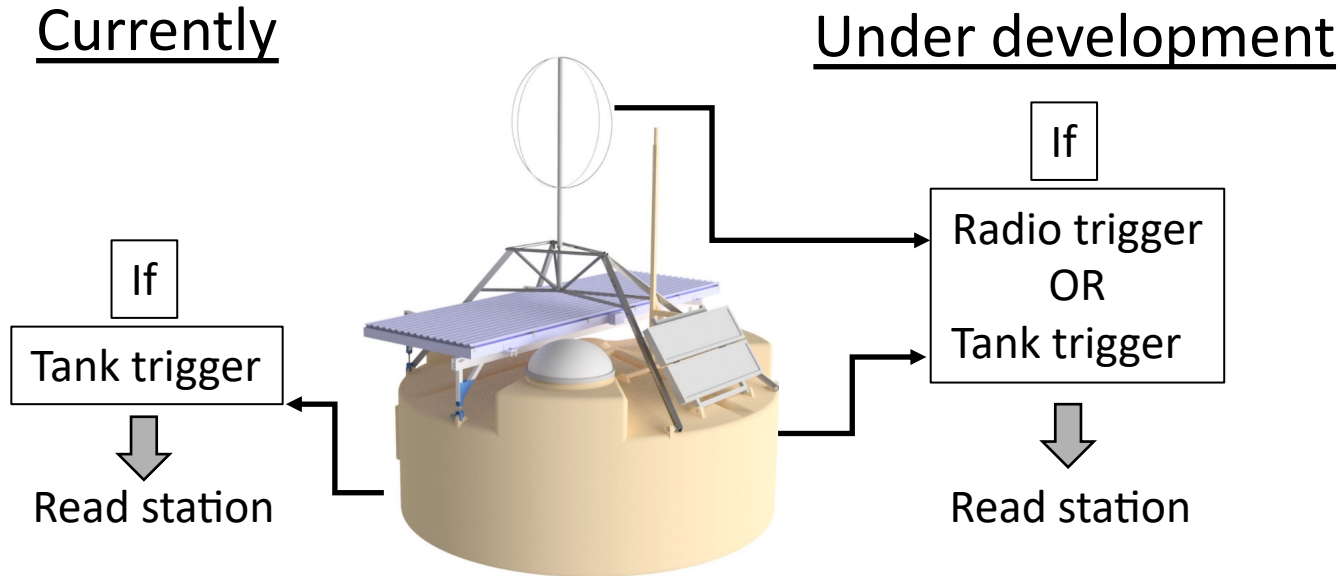
Bjarni Pont

Tomáš Fodran

Mohit (📷)

# RD self-trigger

Hardware experts



David Nitz  
(visiting)

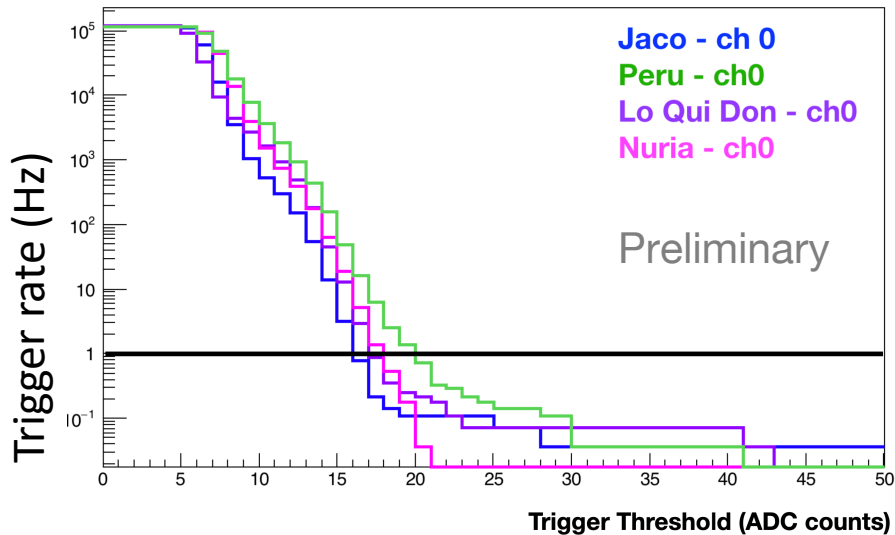


Sjoerd Timmer

- Threshold trigger
- Improved trigger efficiency for highly inclined  $\nu$  and  $\gamma$  showers.



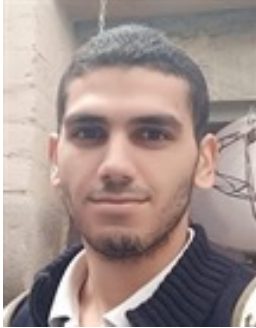
# RD self-trigger



Trigger rate studies by **Cristina Galea, et al.** using the background noise data recorded by **D. Nitz** in the field.

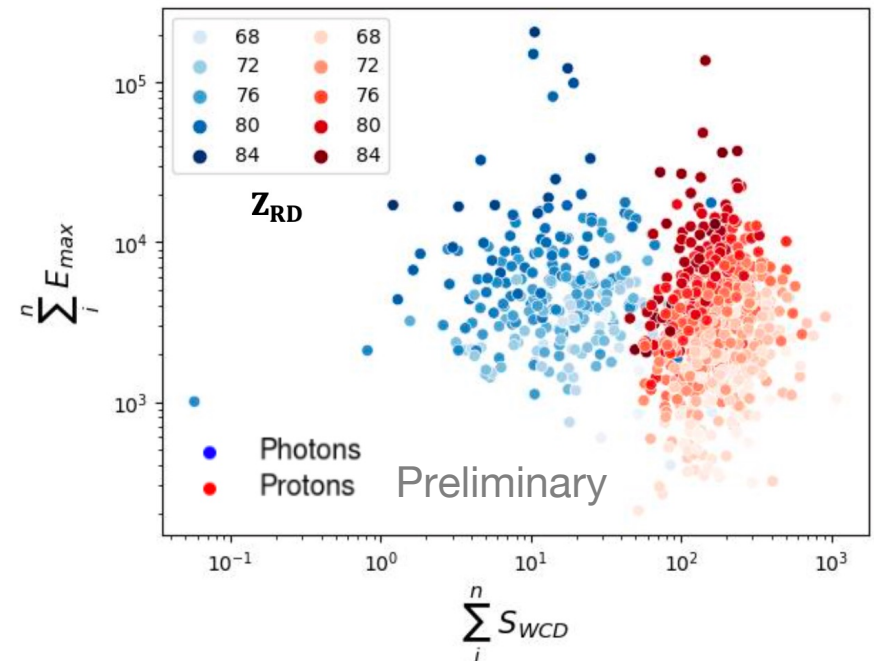
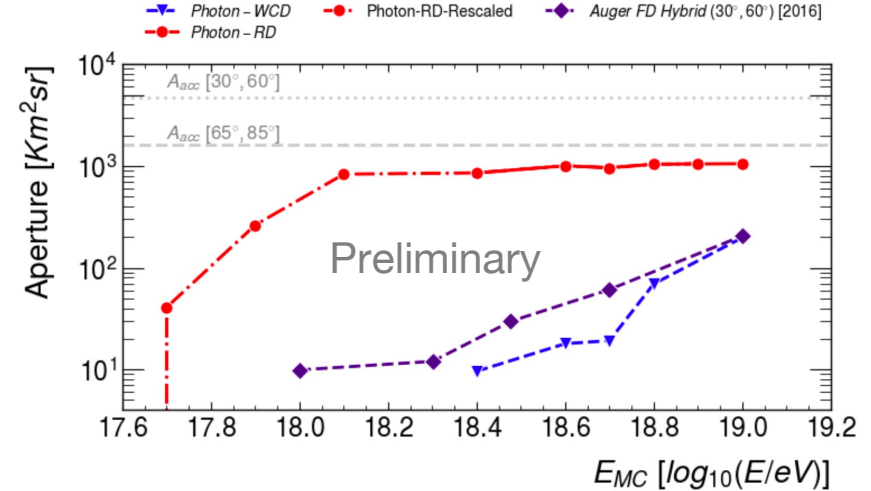
- Challenge: background (galaxy, environment), old hardware
- 09/2022 and 03/2023: **Tested in the field!**
- **Further tests soon.**

# UHE photons



**Mohamed Emam,**  
Harm Schoorlemmer,  
Sijbrand de Jong

- AugerPrime RD with self-trigger:  
up to 100x increase in aperture.
- RD crucial to identify photons  
against the background.

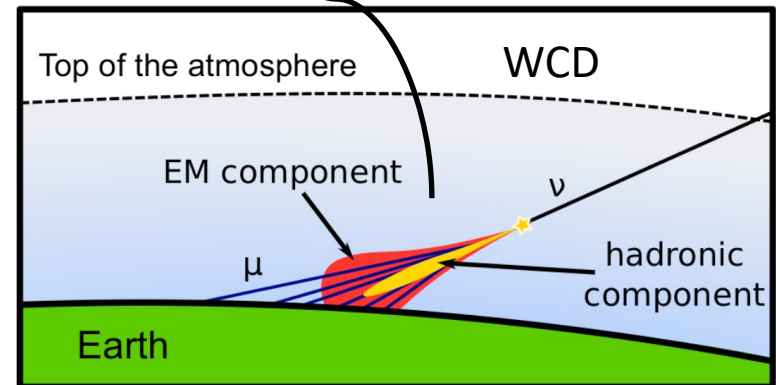
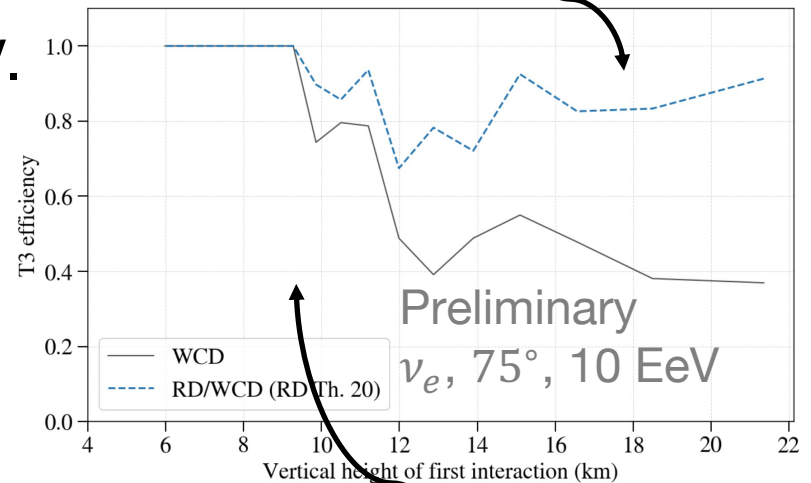
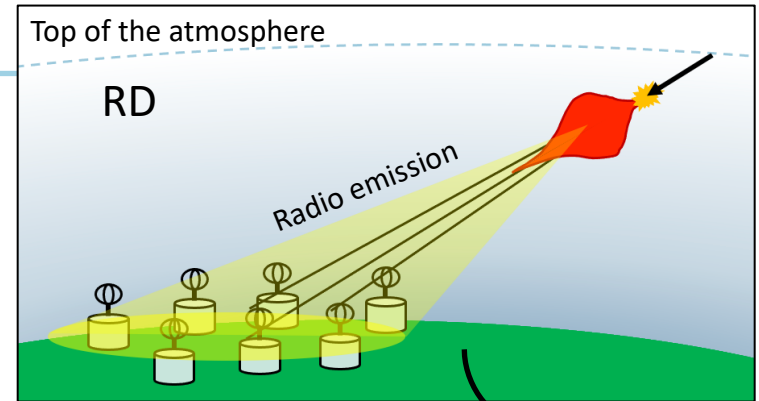


# UHE neutrinos



**Mohit Saharan,**  
Cristina Galea,  
Sijbrand de Jong

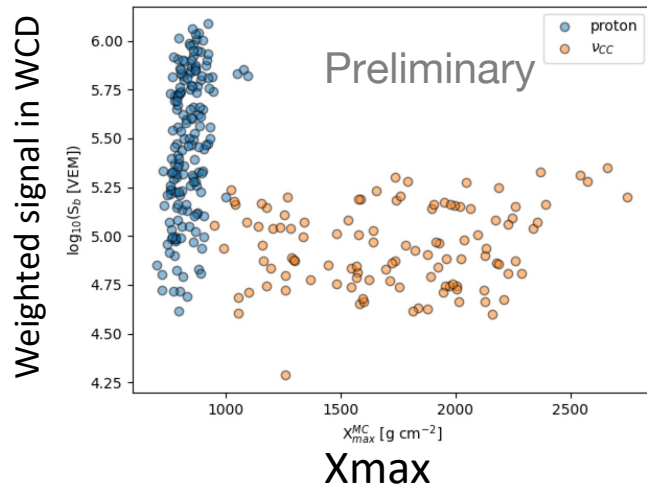
- Auger WCD sensitive to  $E_\nu > \sim 10^{17}$  eV.
- Stringent limits on  $\nu$  flux.
- RD will improve for distant showers with  $\theta \sim > 75^\circ$ .
- Ongoing: mass production of simulations
  - Challenge: CPU time
    - 1 shower can take from a few hours up to a few weeks!





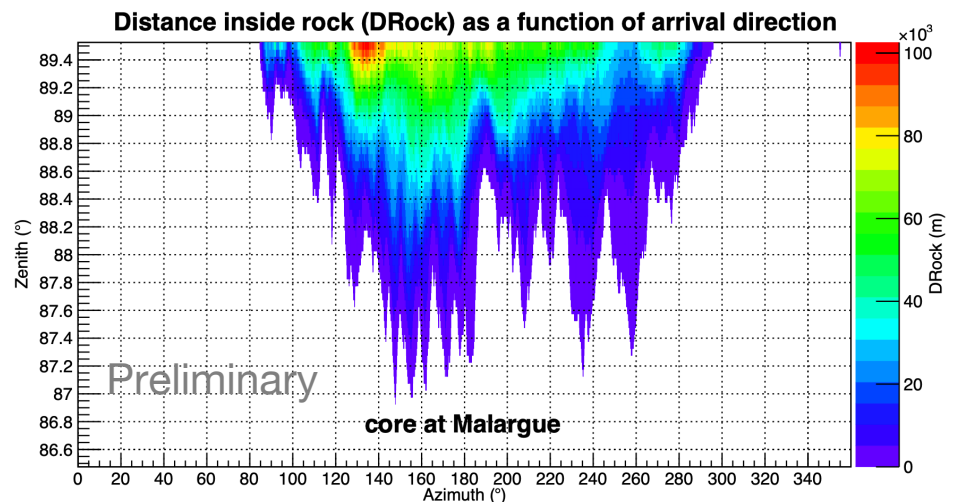
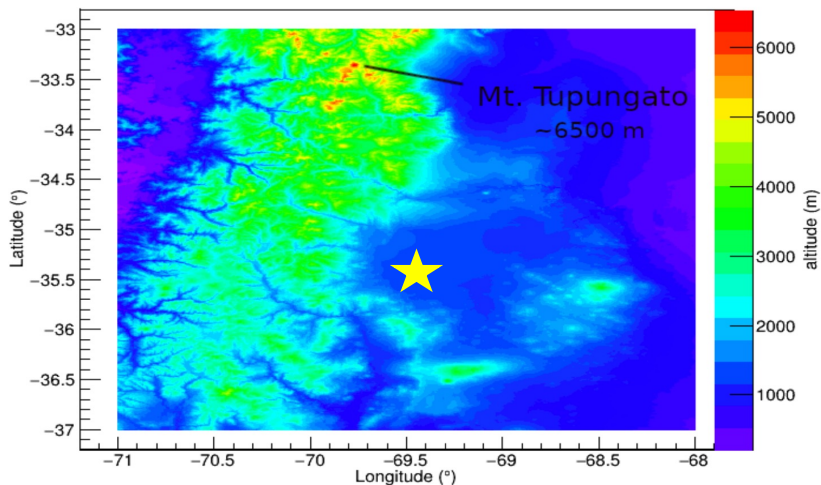
# UHE neutrinos

- **Ongoing:** RD/WCD observables to identify neutrino showers against bg.

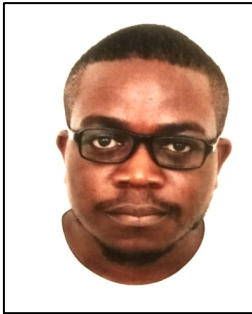


**Abha Khakurdikar,**  
Joerg Horandel

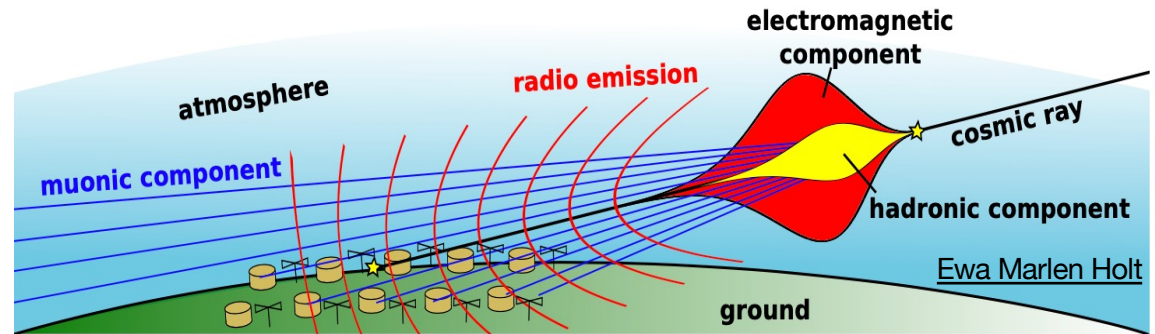
- **Ongoing:**  $\nu_{\tau}$  interacting in the mountains (Washington Carvalho, P.Doc)



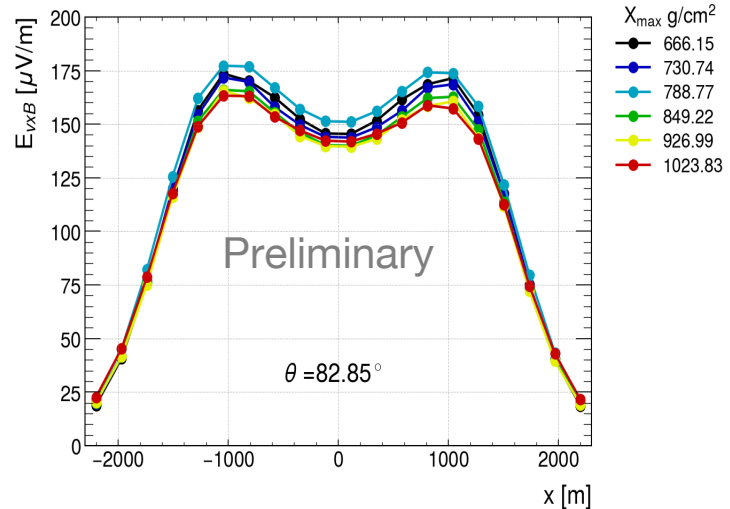
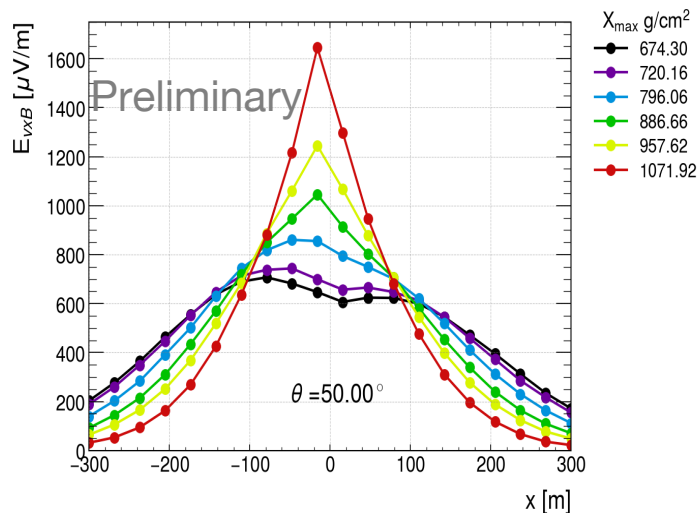
# Mass composition with AugerPrime RD



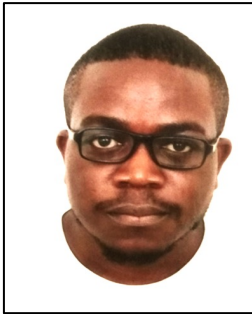
Anthony Bwembya,  
Harm Schoorlemmer,  
Charles Timmermans



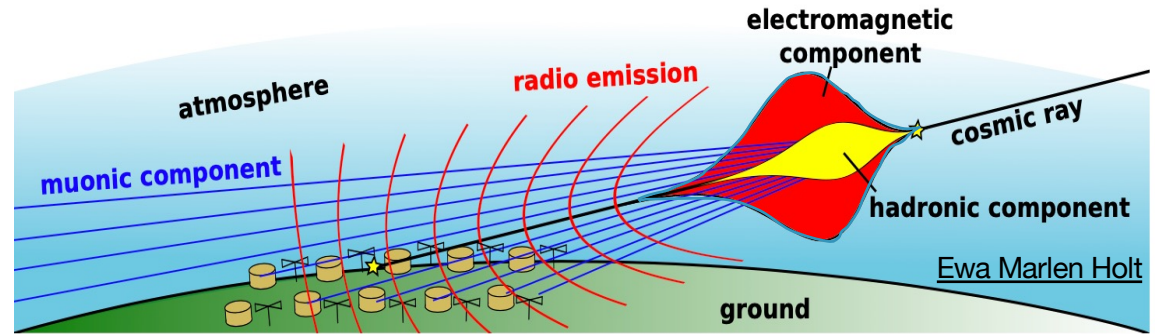
- $M_{primary}$ : encoded in  $X_{max}$  but conventional radio methods lack sensitivity for highly inclined showers.



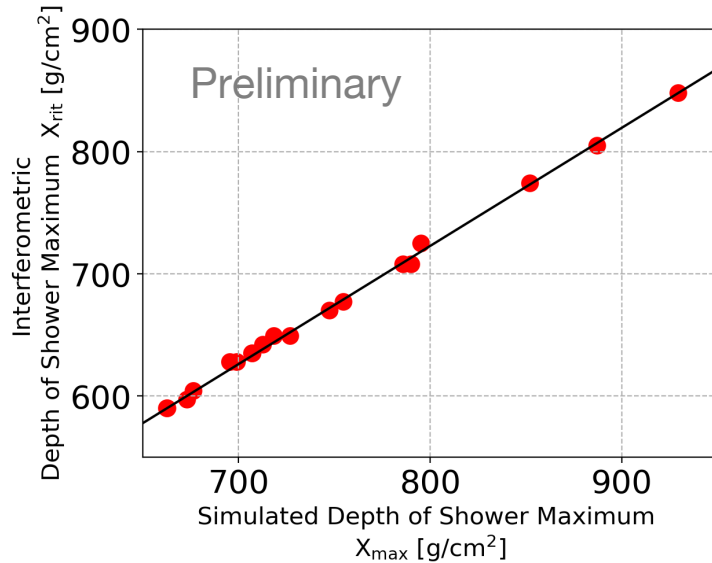
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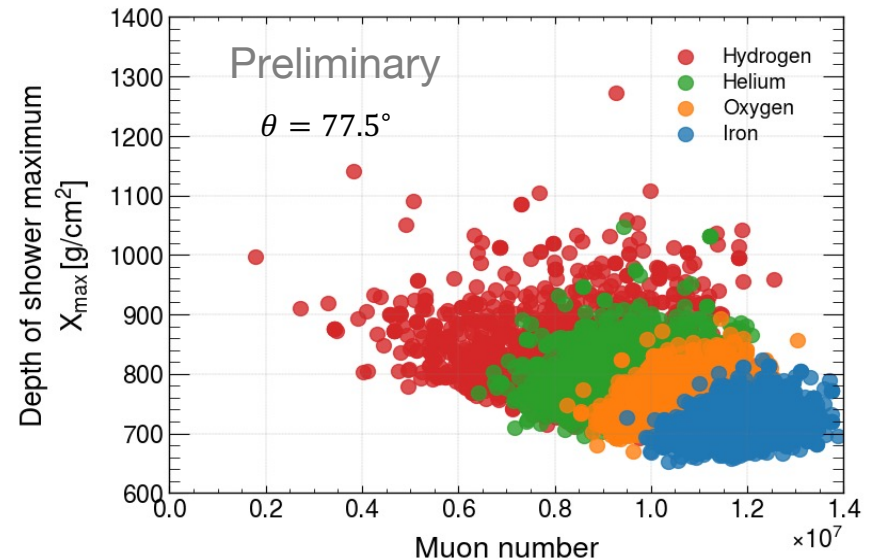
Anthony Bwembya,  
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- Radio interferometry for  $X_{max}$



- Particle identification using  $X_{max}$  and  $\#μ$





# Summary

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- AugerPrime RD will improve the mass composition of UHE CRs and the search for neutral particles.
- 8 stations are measuring air showers in the field.
- Absolute calibration: done!, directional calibration: this year.
- RD self-trigger is under development.
- RD self-trigger will improve the sensitivity to photons and neutrinos.
  - Up to 100x increase in aperture for photons.
  - Studies to quantify the enhancement for neutrinos are ongoing.
- Radio interferometry technique can improve the mass composition studies for highly inclined showers.