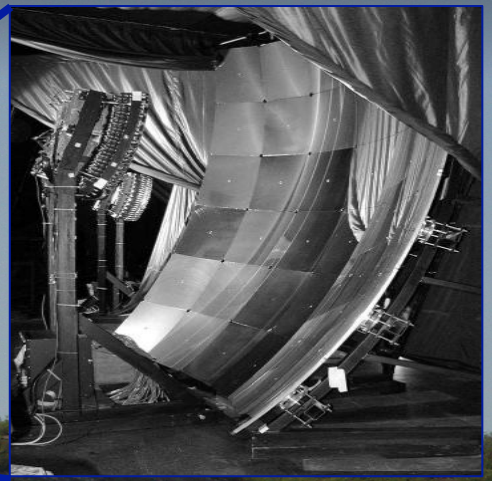
The Auger Experiment 2016

Nikhef
KVI-CART
NWO-E
IMAPP-RU

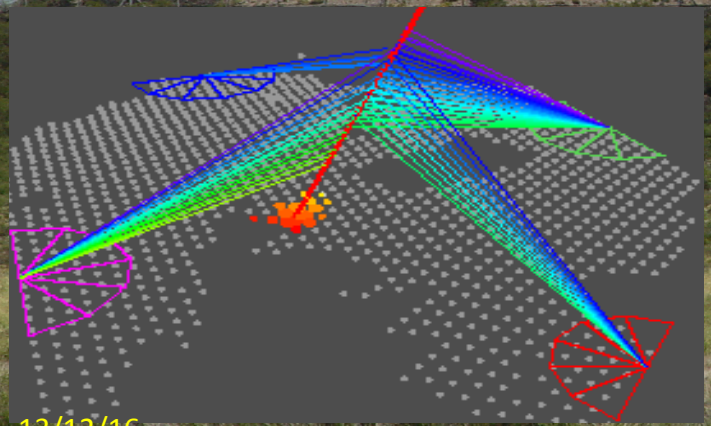
Sijbrand de Jong, Jörg Hörandel, Heino Falcke, Olaf Scholten, Ad van den Berg, Charles Timmermans, Arjen van Vliet, Fabrizia Canfora, Giuseppe de Mauro, Alexander Aab

The Pierre Auger Observatory

Aim: To measure properties of UHECR with unprecedented statistics and precision



*Fluorescence Detector **FD***



Hybrid detection

*Surface Detector **SD***

2016 Overview of Dutch PhDs in Auger

PhD defenses in 2016:

- Johannes Schulz: Reconstruction of Cosmic-Ray Properties from Radio Emission of Extensive Air Showers
- Stefan Jansen: Radio for the masses - Cosmic ray mass composition measurements in the radio frequency domain
- Stefano Messina: Extension to lower energies of the cosmic-ray energy window at the Pierre Auger Observatory
- Guus van Aar: On the nature and origin of ultra-high-energy cosmic rays

Still active:

- Alexander Aab (mid 2017)
- Giuseppe de Mauro (september 2018)
- Fabrizia Canfora (september 2019)

Pending Funding requests:

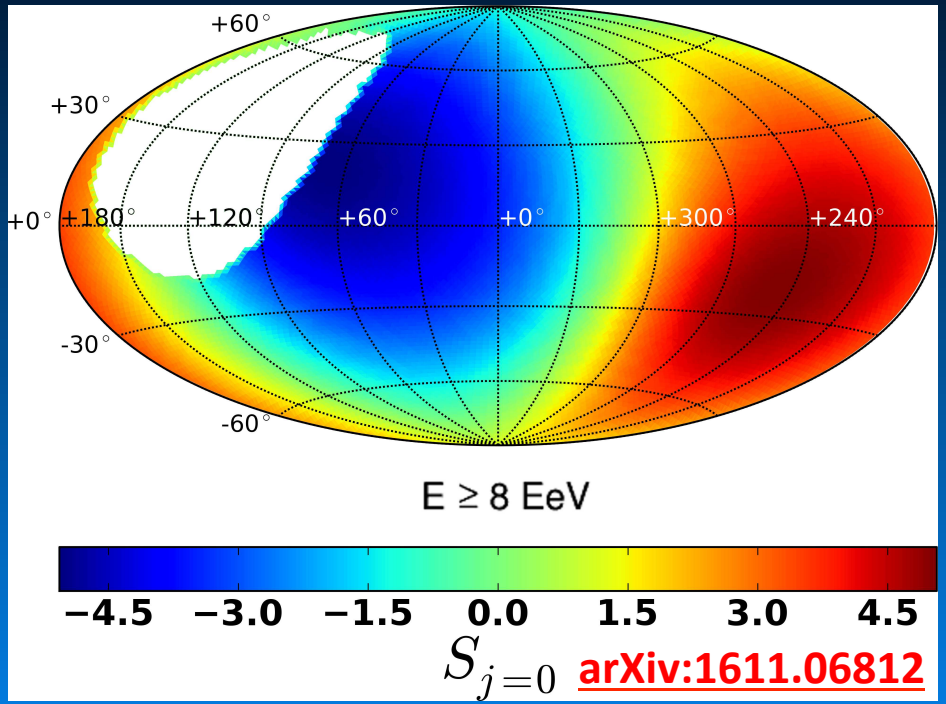
- ERC ADG S. J. de Jong (γ and υ with radio)
- ERC ADG J. Hörandel (radio@Auger)
- NWO-M J. Hörandel (Auger communications backbone upgrade)

2016 Physics Result: Anisotropy

Needlet analysis:

Hint for dipolar anisotropy above 8 EeV.

Probability to agree with isotropic distribution: 0.0008 %



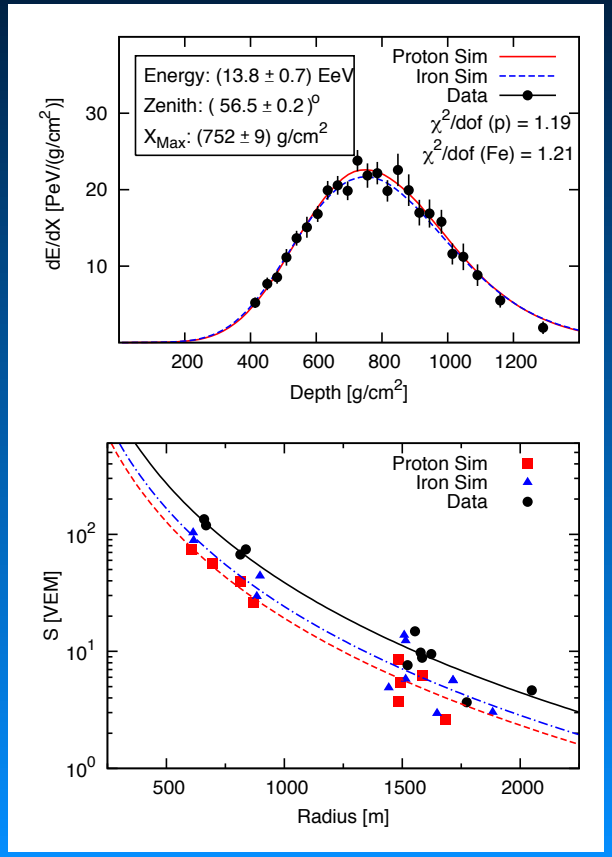
Interpretation: Gradient in extragalactic cosmic rays

But… the mechanism to create this is not evident

Combining particles and fluorescence

- FD and SD combined (hybrid) analyses:
  - Depth of shower maximum
  - Lateral distribution
  - Number of tanks

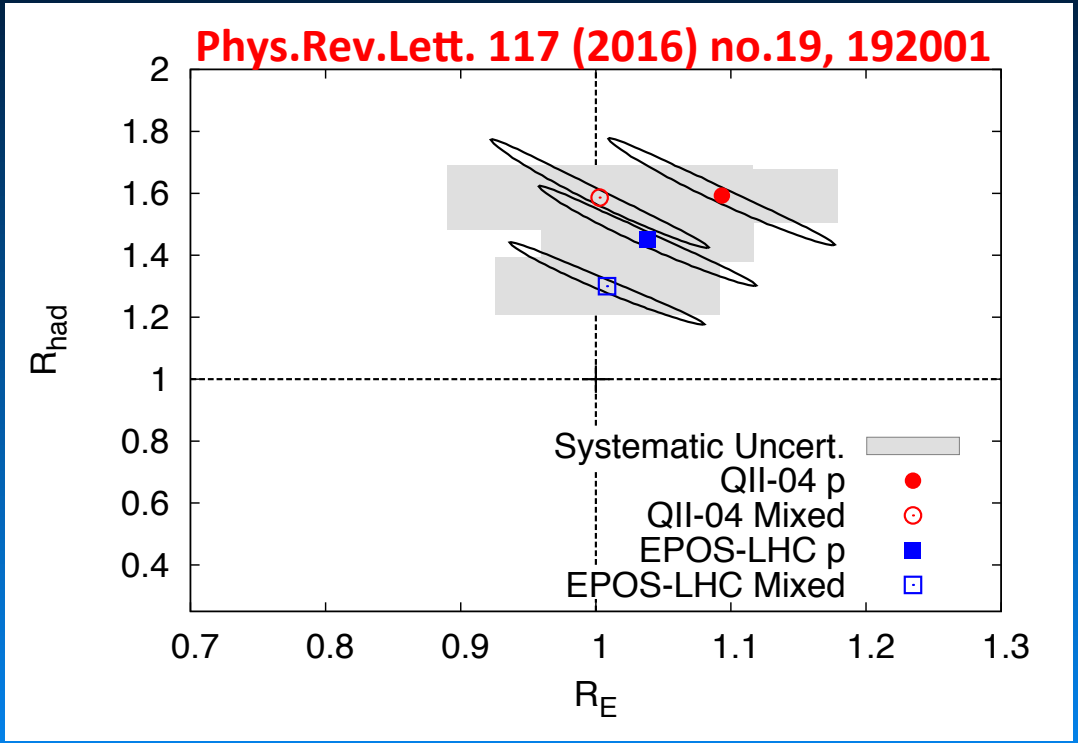
- Disadvantage: statistics
- Advantage: Event quality



Phys.Rev.Lett. 117 (2016) no.19, 192001

2016 Physics Result: Hadronic physics

Ratio of the measured to expected amount of energy in the hadronic part of the shower (SD)

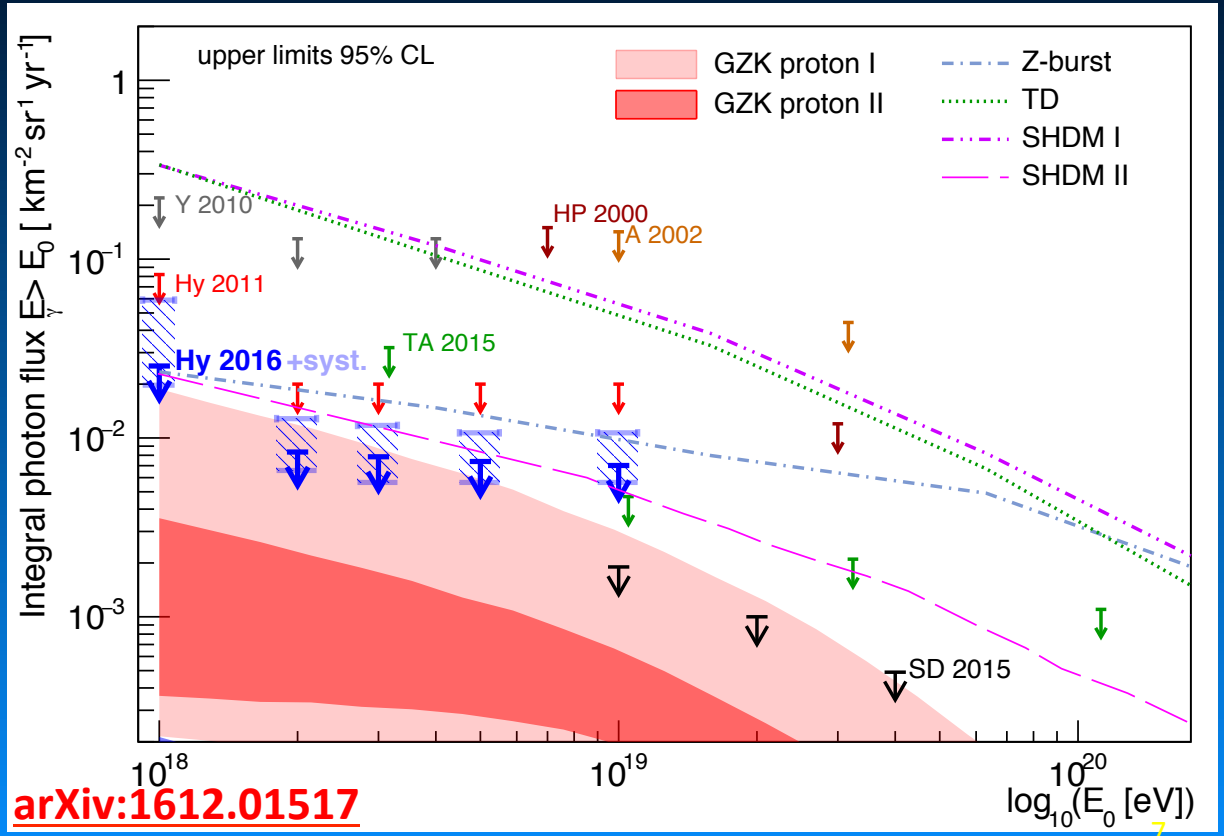


Ratio of the measured to expected amount of energy in the EM part of the shower (FD)

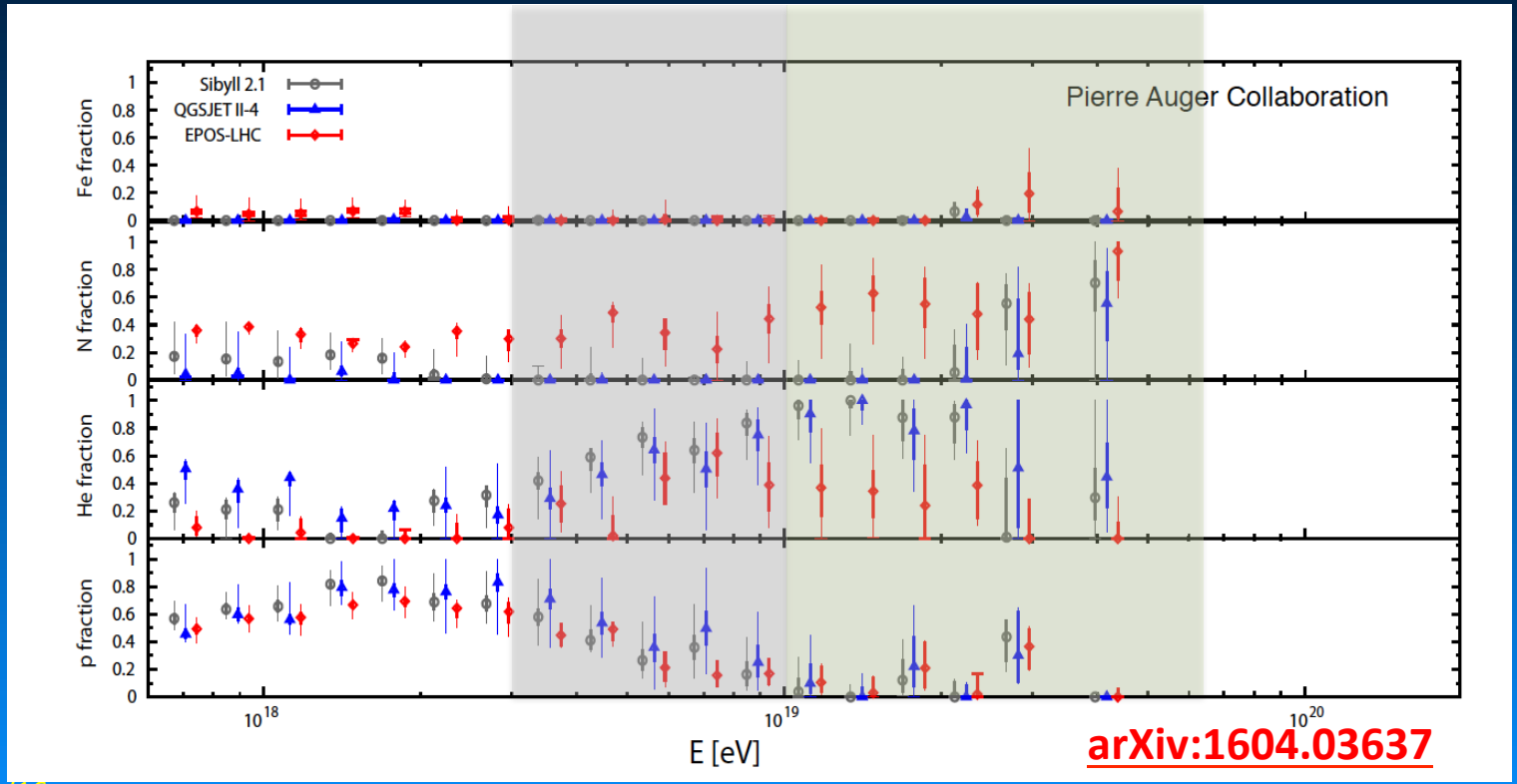
2016 Physics Result: Photon Limits

Photon expectations…

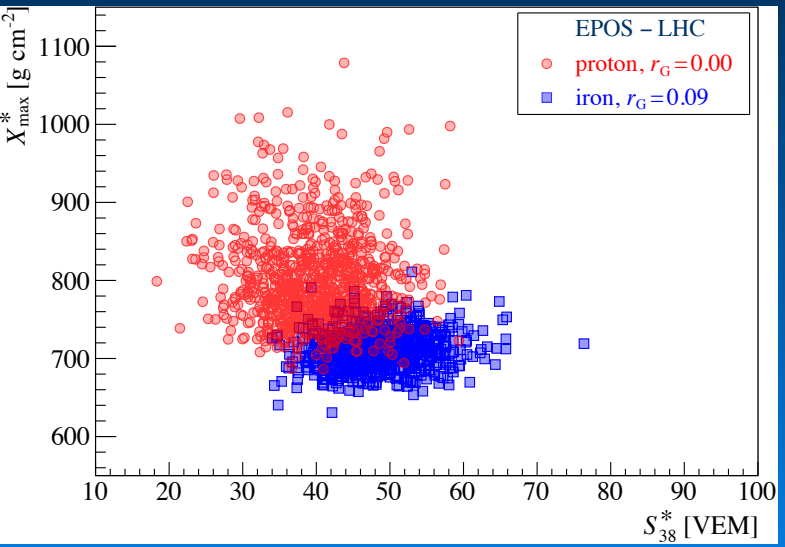
- Sources
- Cosmogenic

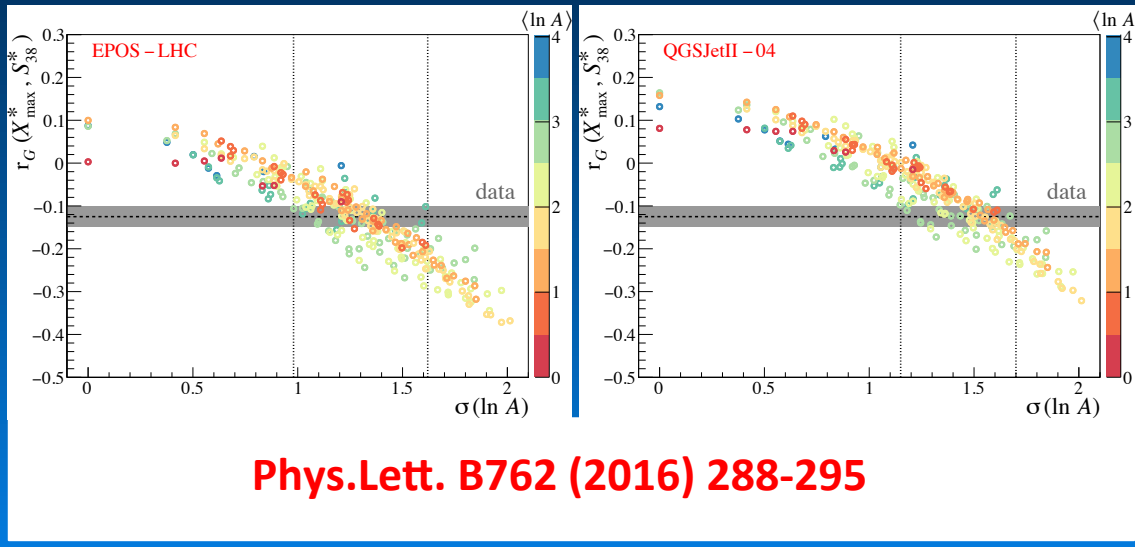


The Composition of Cosmic Rays



2016 Physics Result: Mixed composition at 3-10 EeV





Phys.Lett. B762 (2016) 288-295

Correlation SD and FD global parameters: Mixed composition

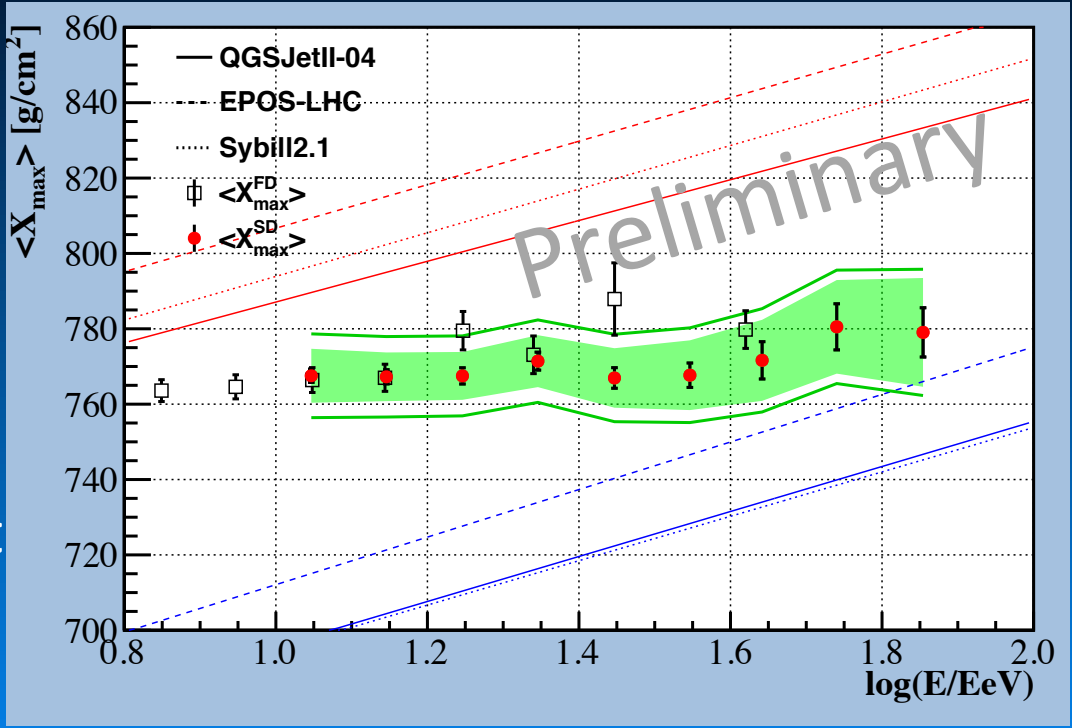
2016 Physics Result: Composition with SD

Thesis Guus van Aar:

Using hybrid events for calibrating SD information to Xmax

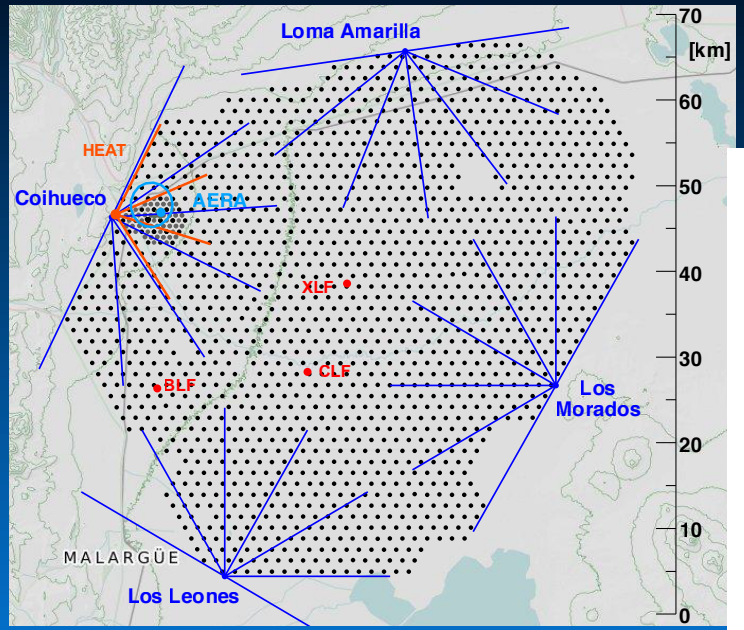
→Curvature of shower front

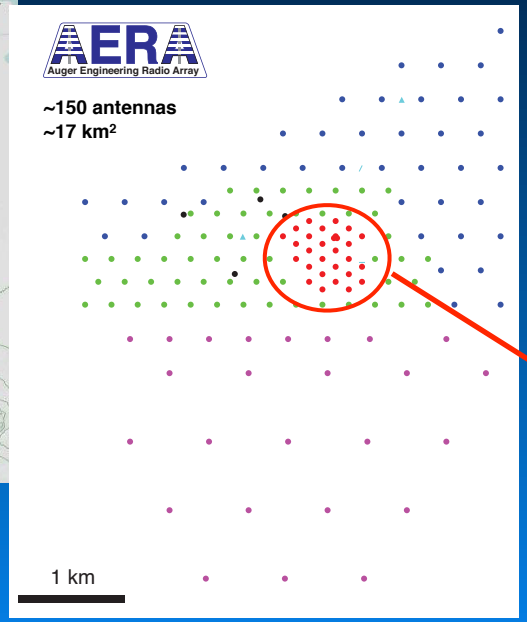
→ Risetime of signal



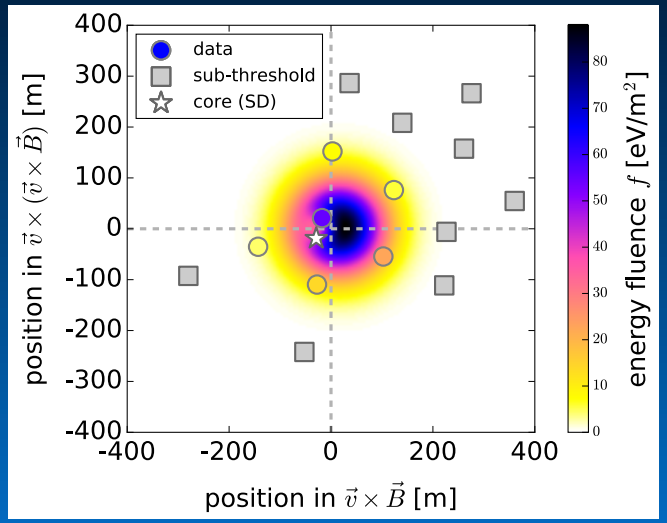
Model Independent!

The Auger Engineering Radio Array

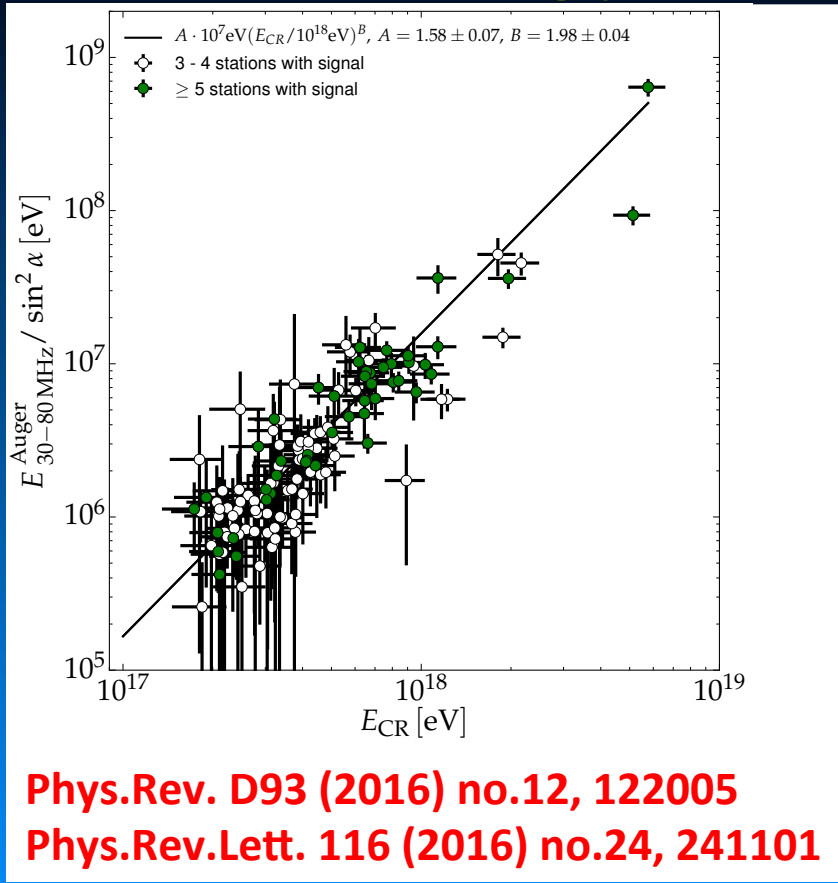




2016 Physics Results: Radio Energy

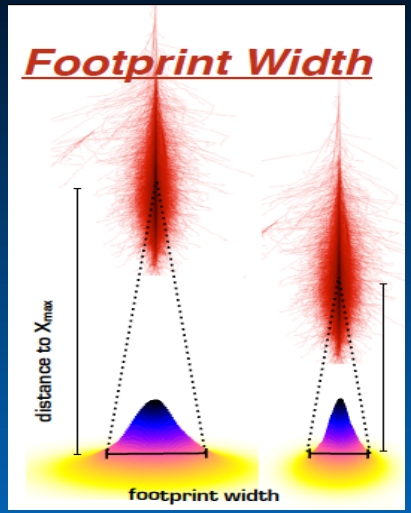


Comparing the total measured energy in radio at Earth to the SD energy measurement



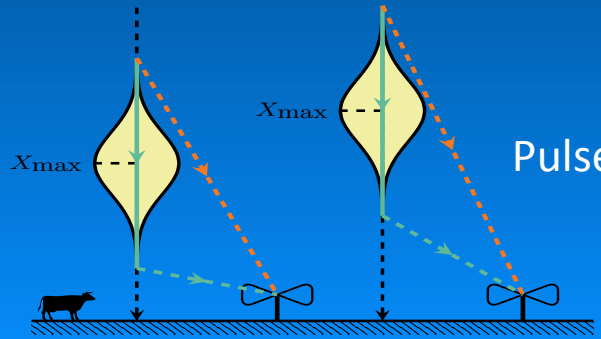
Phys.Rev. D93 (2016) no.12, 122005
Phys.Rev.Lett. 116 (2016) no.24, 241101

Radio Detection and Mass Composition



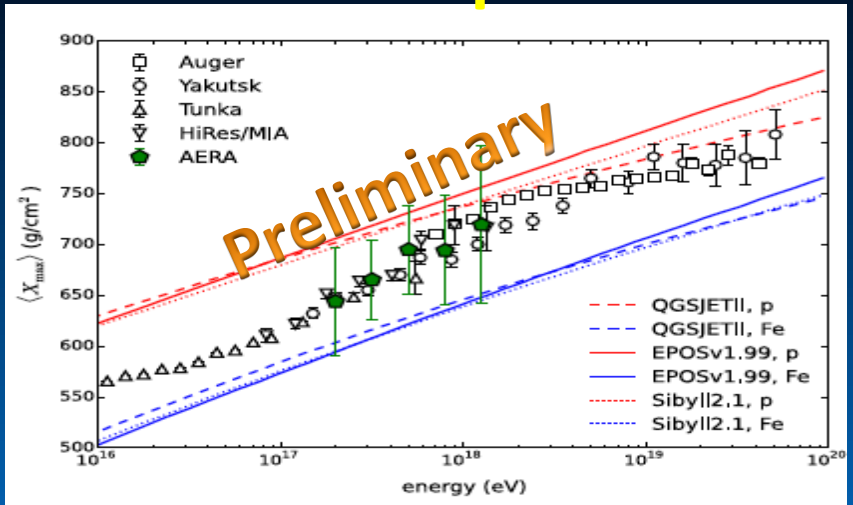
LDF shape→

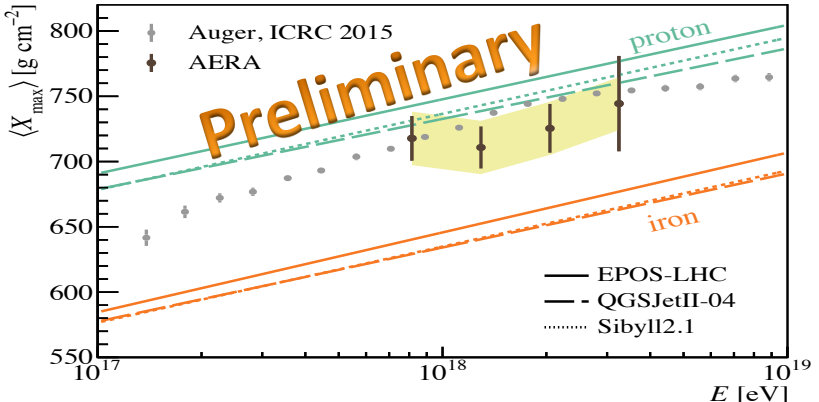
PhD Thesis J. Schulz



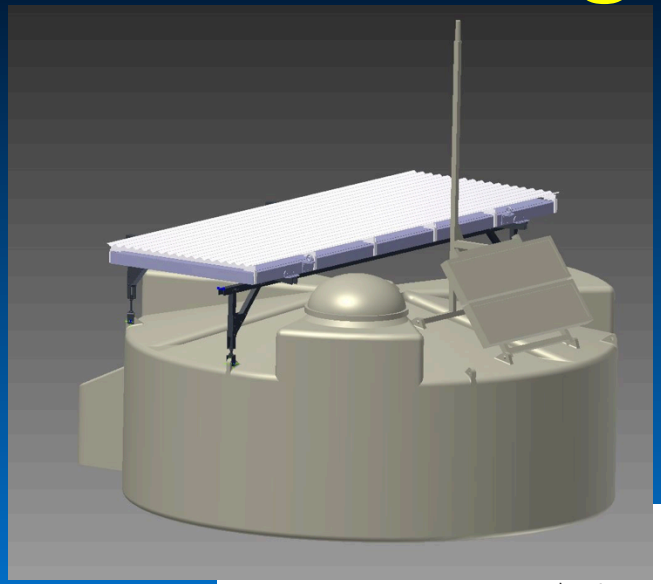
Pulse shape information →

PhD Thesis S. Jansen

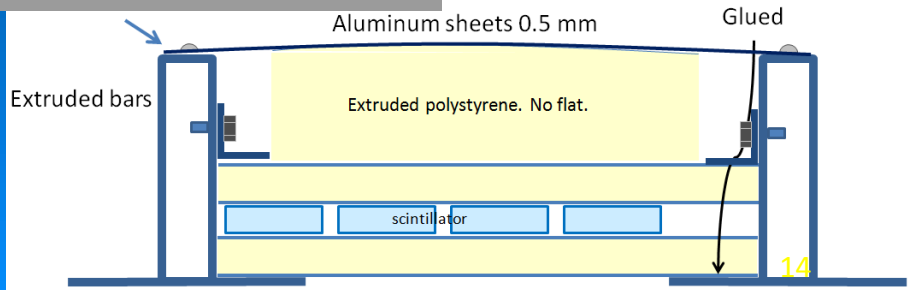




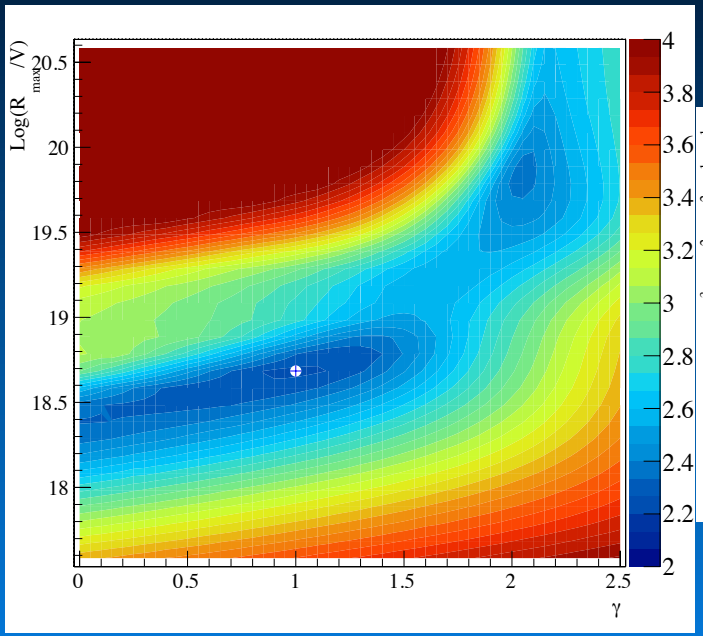
An upgraded detector: AugerPrime

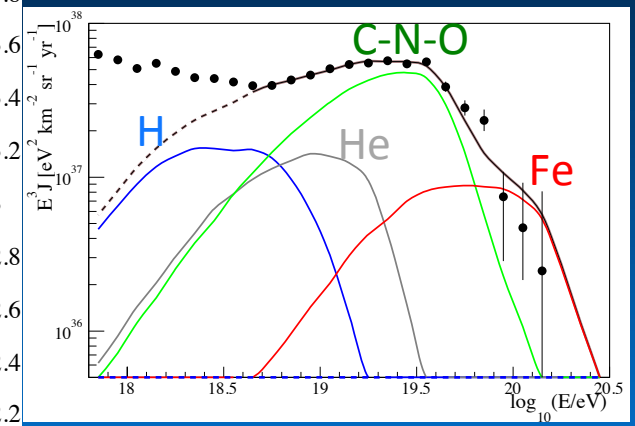


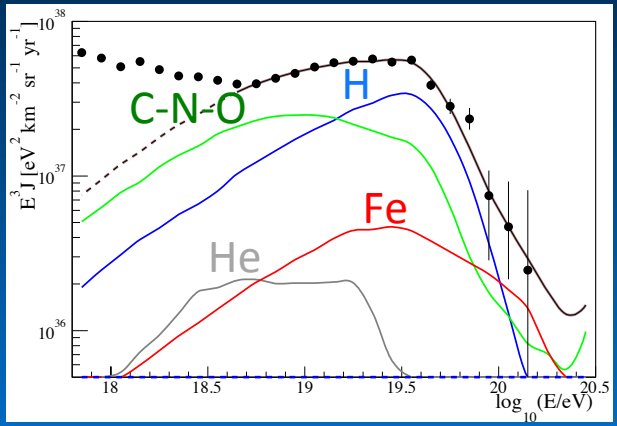
Auke Korporaal
Dimitri John
Arno Engels



Goals AugerPrime

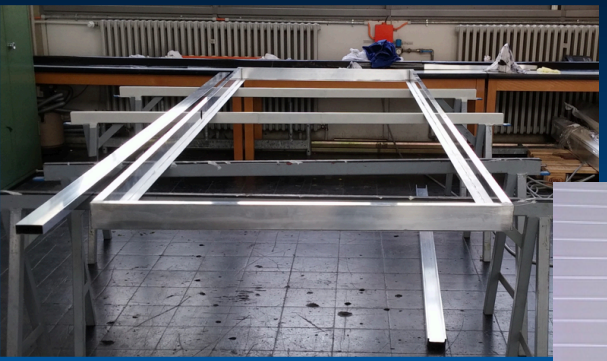


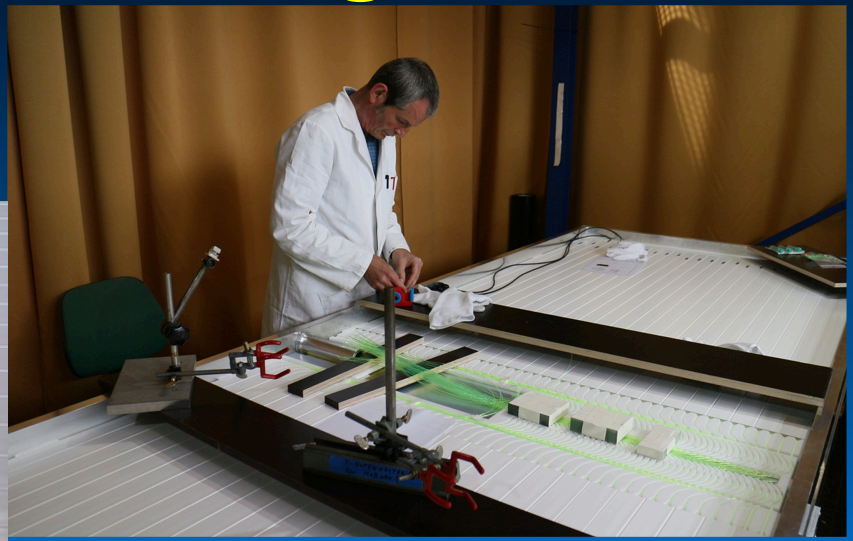


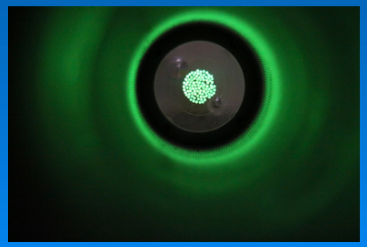


Distinguish scenario's

An upgraded detector: AugerPrime



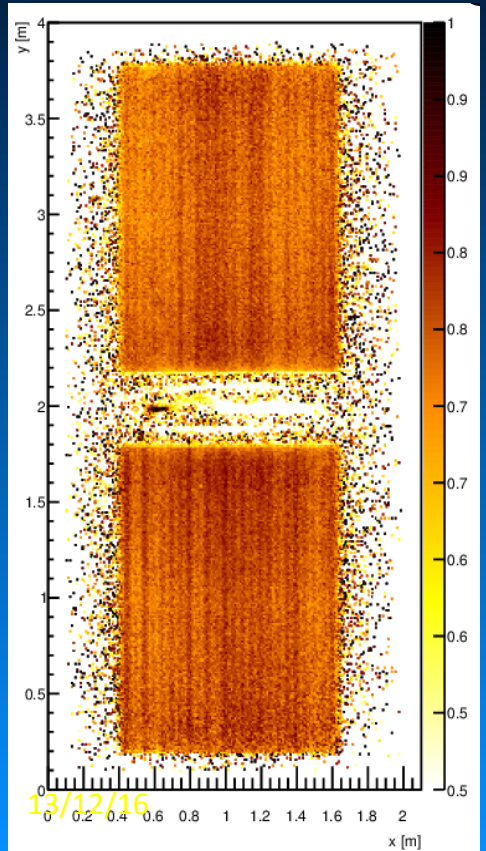




Production start: Summer 2017
Duration: 18 months

Ambition: produce our share (200-300) at Nikhef

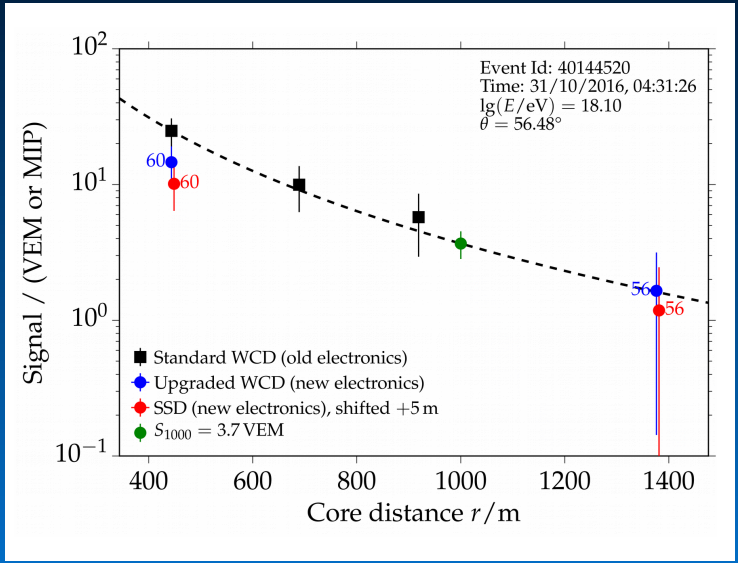
An upgraded detector: AugerPrime

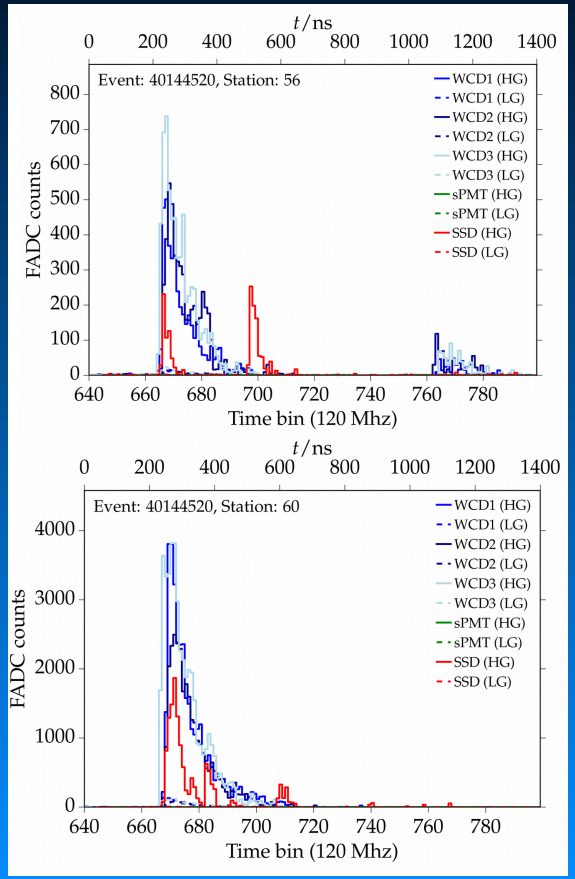


Efficiency test using muon telescope

An upgraded detector: AugerPrime

An upgraded detector: AugerPrime





120 MHz electronics, scintillator detector:
All works within the Auger infrastructure

Conclusion

- Auger had a very productive year

- Nikhef makes impact with a small group in
  - Radio (analysis) (JH, SdJ, OS, AvV, FC, CT)
  - SD composition analysis (AvV, AA, GdM, CT)
  - Upgrade (SdJ, CT)

- Field tests for the upgraded detector AugerPrime have successfully started