rijksuniversiteit groningen
Kernfysisch Versneller Instituut

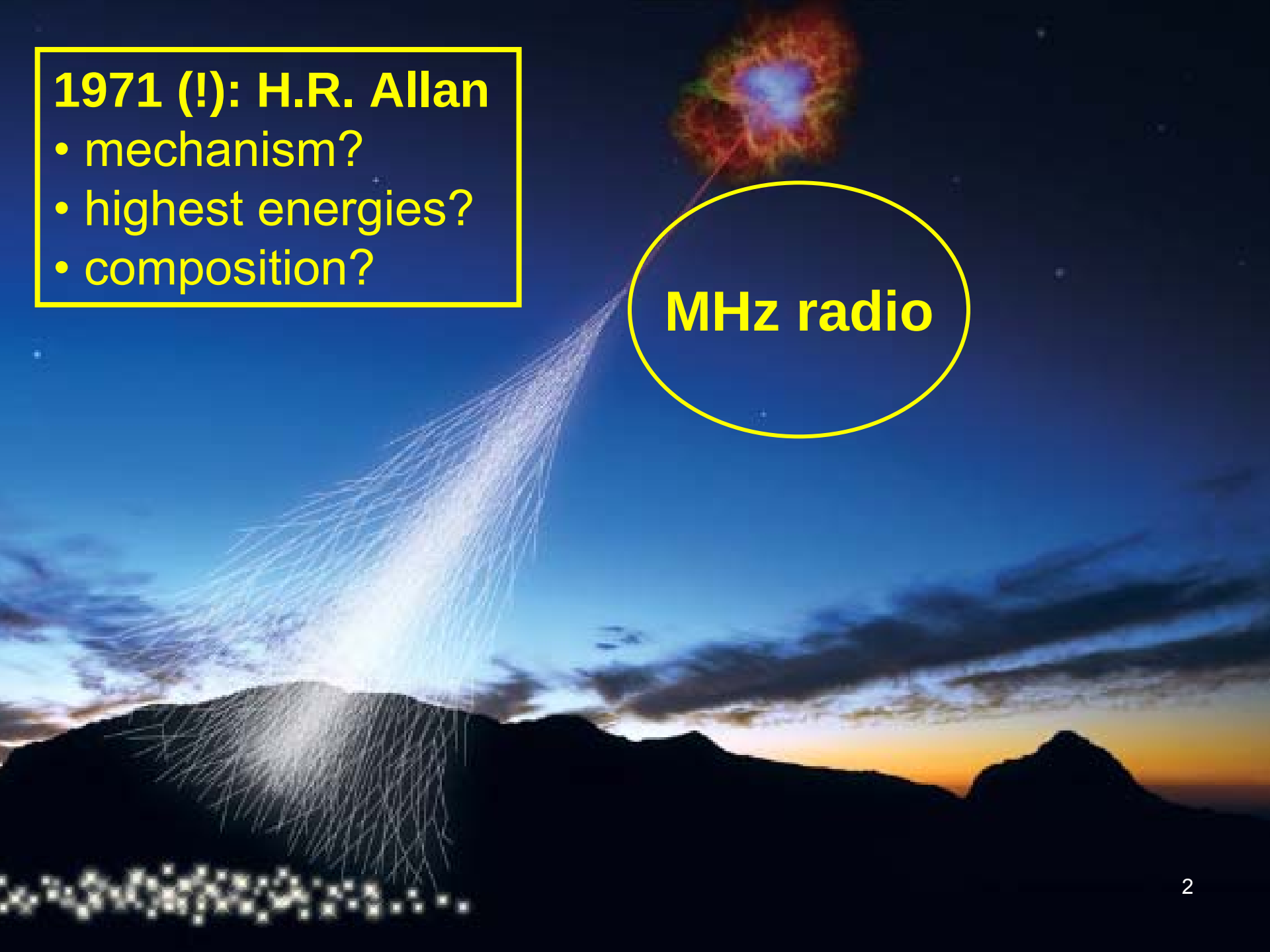
Results from and prospects for the

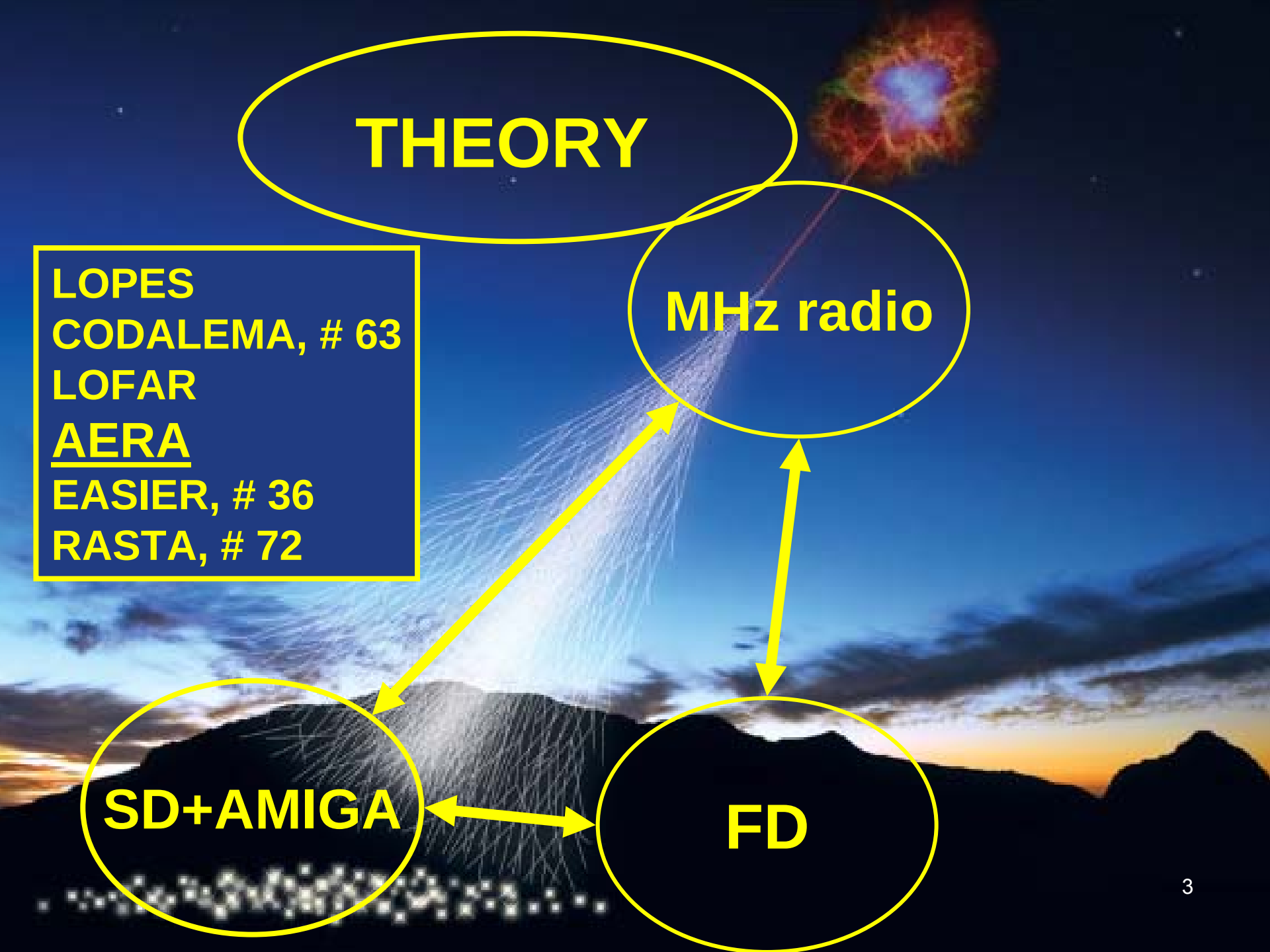
Auger Engineering Radio Array

Ad M. van den Berg
Kernfysisch Versneller Instituut
University of Groningen

UHECR 2012

International Symposium on Future Directions in UHECR Physics


1971 (!): H.R. Allan
• mechanism?
• highest energies?
• composition?
MHz radio


THEORY
LOPES
CODALEMA, # 63
LOFAR
AERA
EASIER, # 36
RASTA, # 72
MHz radio
SD+AMIGA
FD

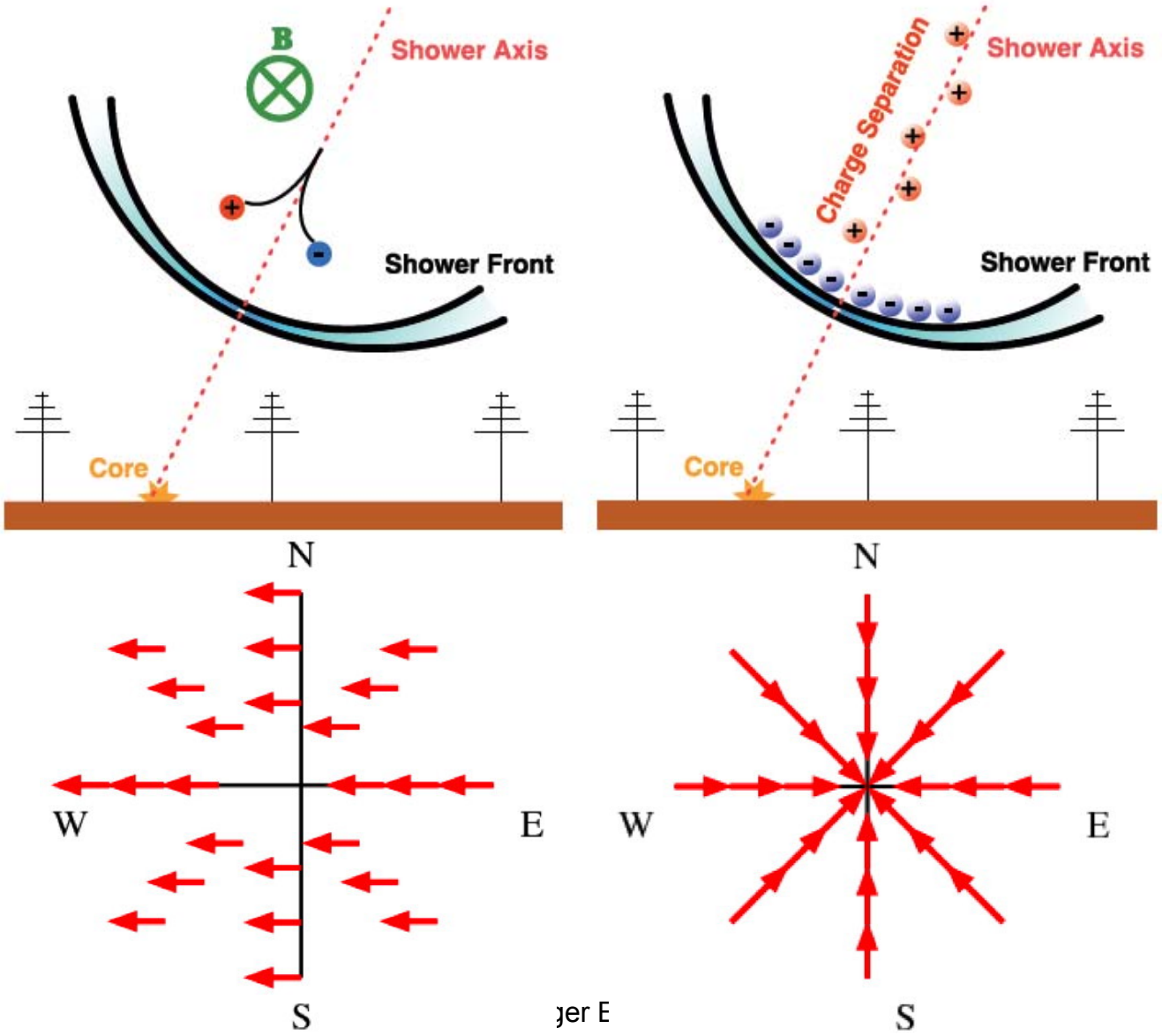
2009 – 2011: Mechanism

- Dominated by geomagnetic effect; v x B
- **Contributions from charge-excess at shower front**
- **Cherenkov beaming**

O. Scholten, # 30

Detailed measurements
- core positions
- signal polarization
- detector performance
- reconstruction of E vector

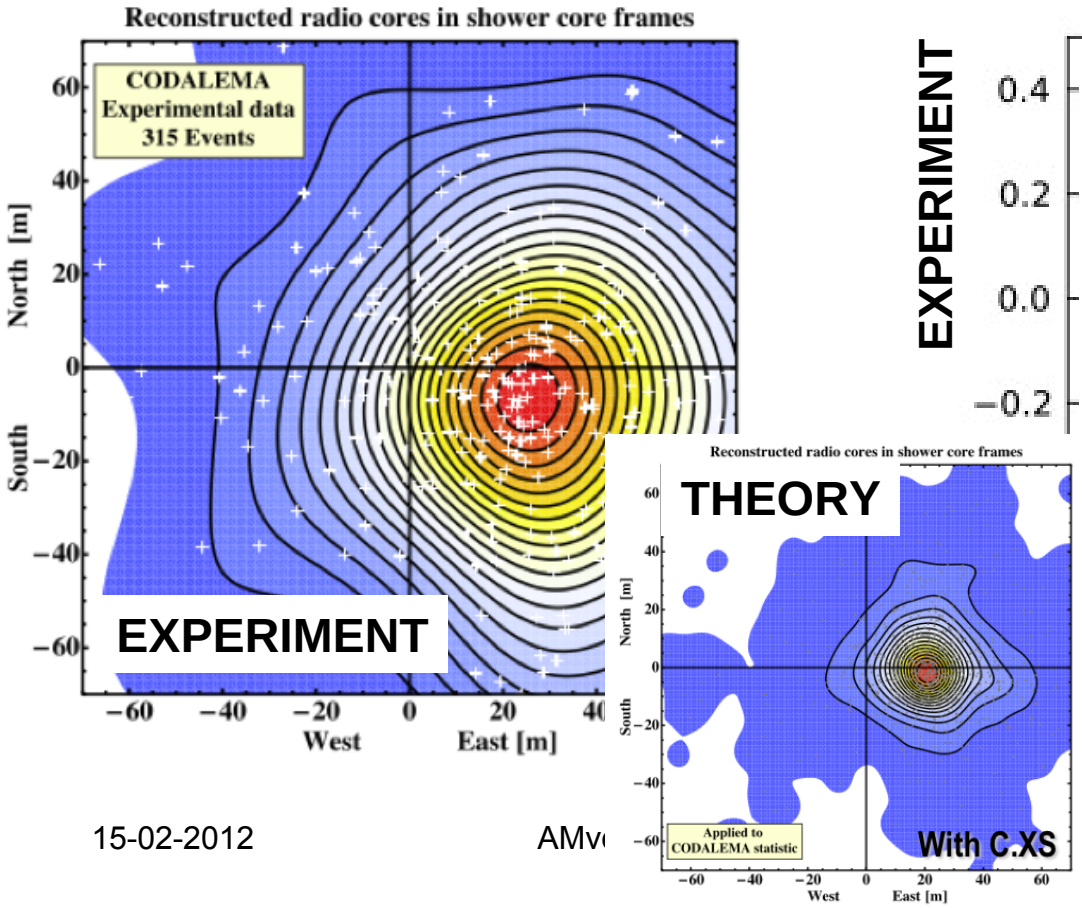
Improved models

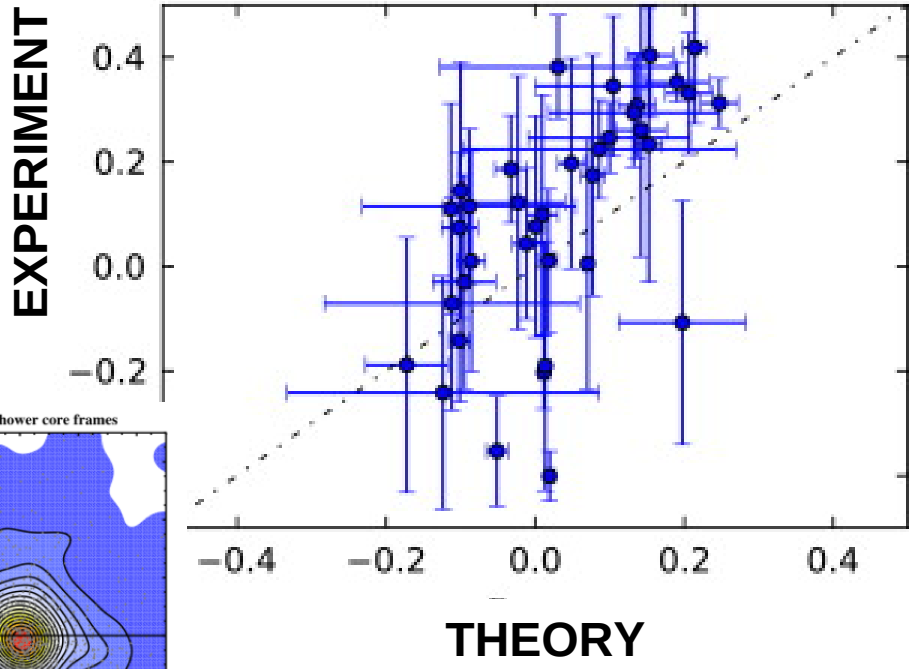

B
Shower Axis
Shower Front
Core
N
W
E
S
Charge Separation
Shower Axis
Shower Front
Core
N
W
E
S

Charge excess Exp. and Theory

displaced core position
CODALEMA: ICRC2011

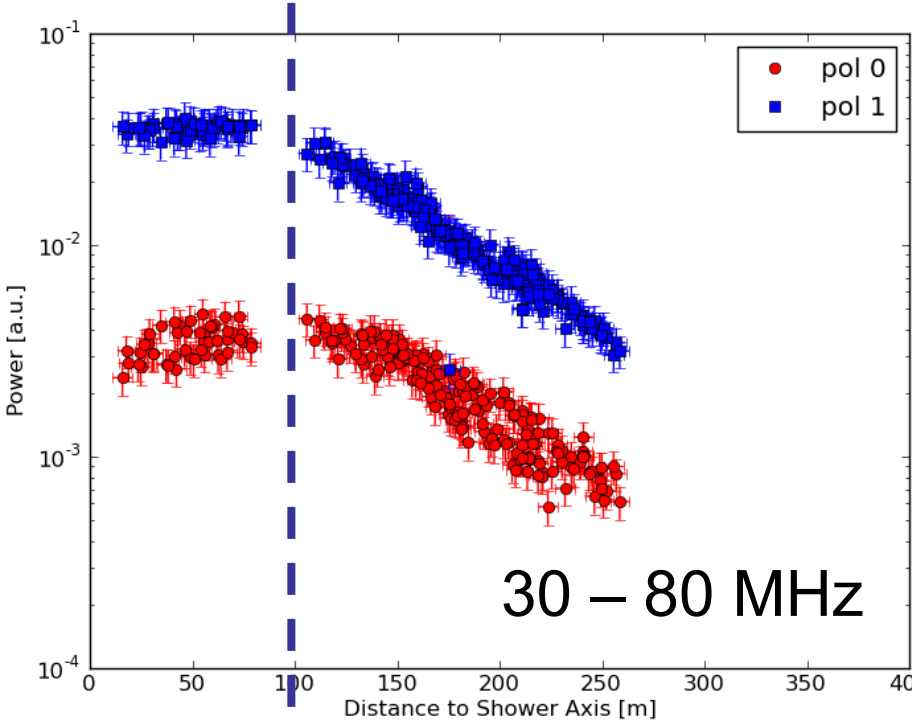
polarization analysis
Auger: ICRC2011 + ARENA2011





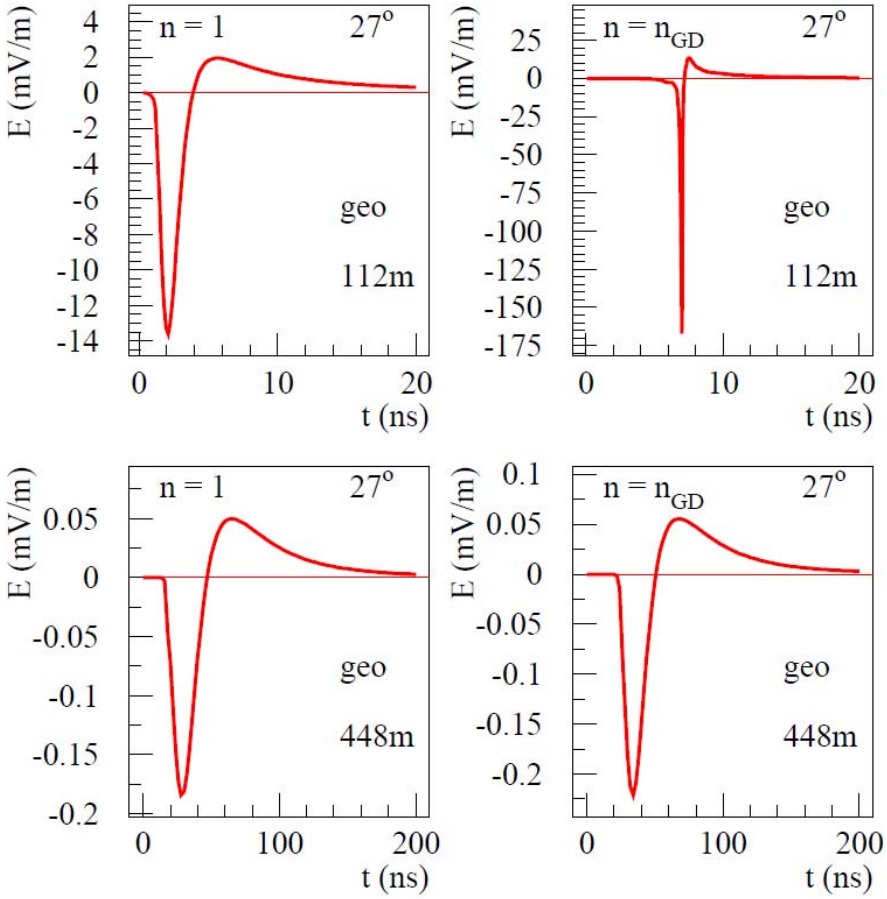
Cherenkov Exp. and Theory

Lateral Distribution Function
LOFAR: ICRC2011



O. Scholten, # 30

Lateral Distribution Function
K. Werner et al, arXiv



Emission

- Near shower core, high-frequency (Cherenkov)
  - LOFAR, ANITA, CROME??, EASIER??

R. Smida, # 68
S. Ogio, # 77
A. Lettesier-Selvon, # 36

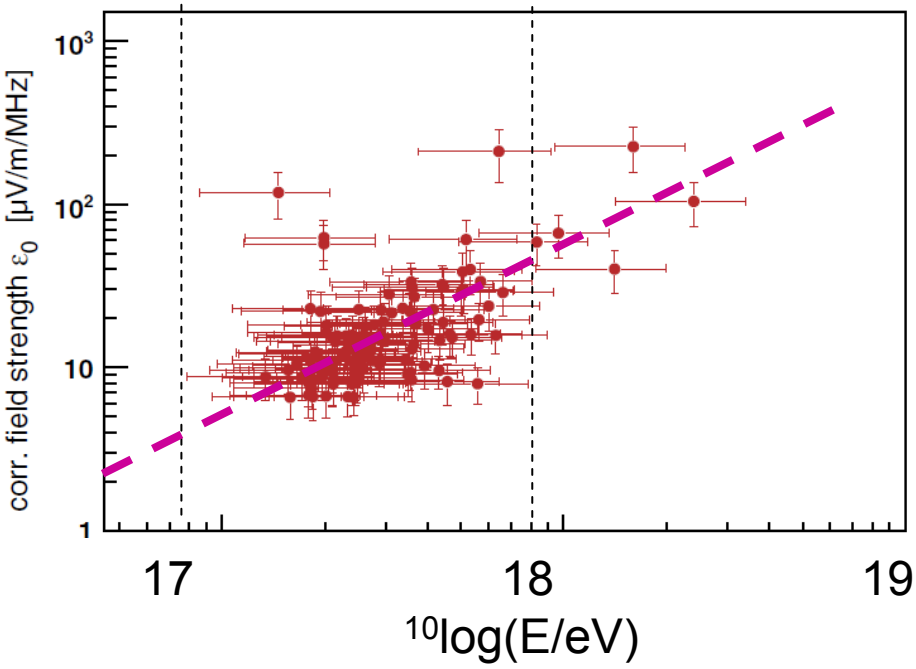
- Dominated by geomagnetic emission, fraction of charge excess

- Signal strength depends on
  - angle with respect to magnetic field
  - distance to shower axis and accepted band width (broad band)
  - **position of the observer with respect to core of the shower**

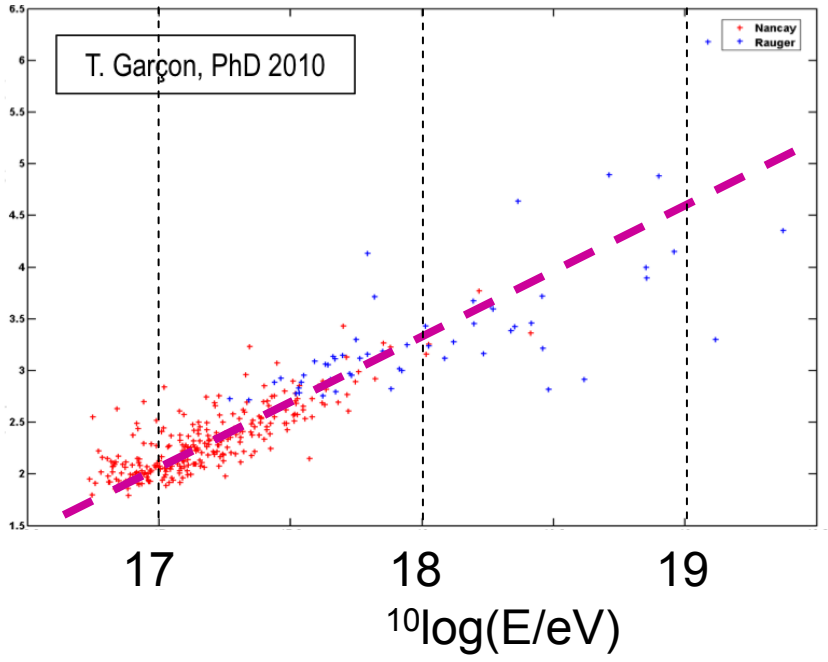
- Theoretical description has improved dramatically
  - different approaches: **Similar RESULTS !!**

Signal strength > 10^{18} eV

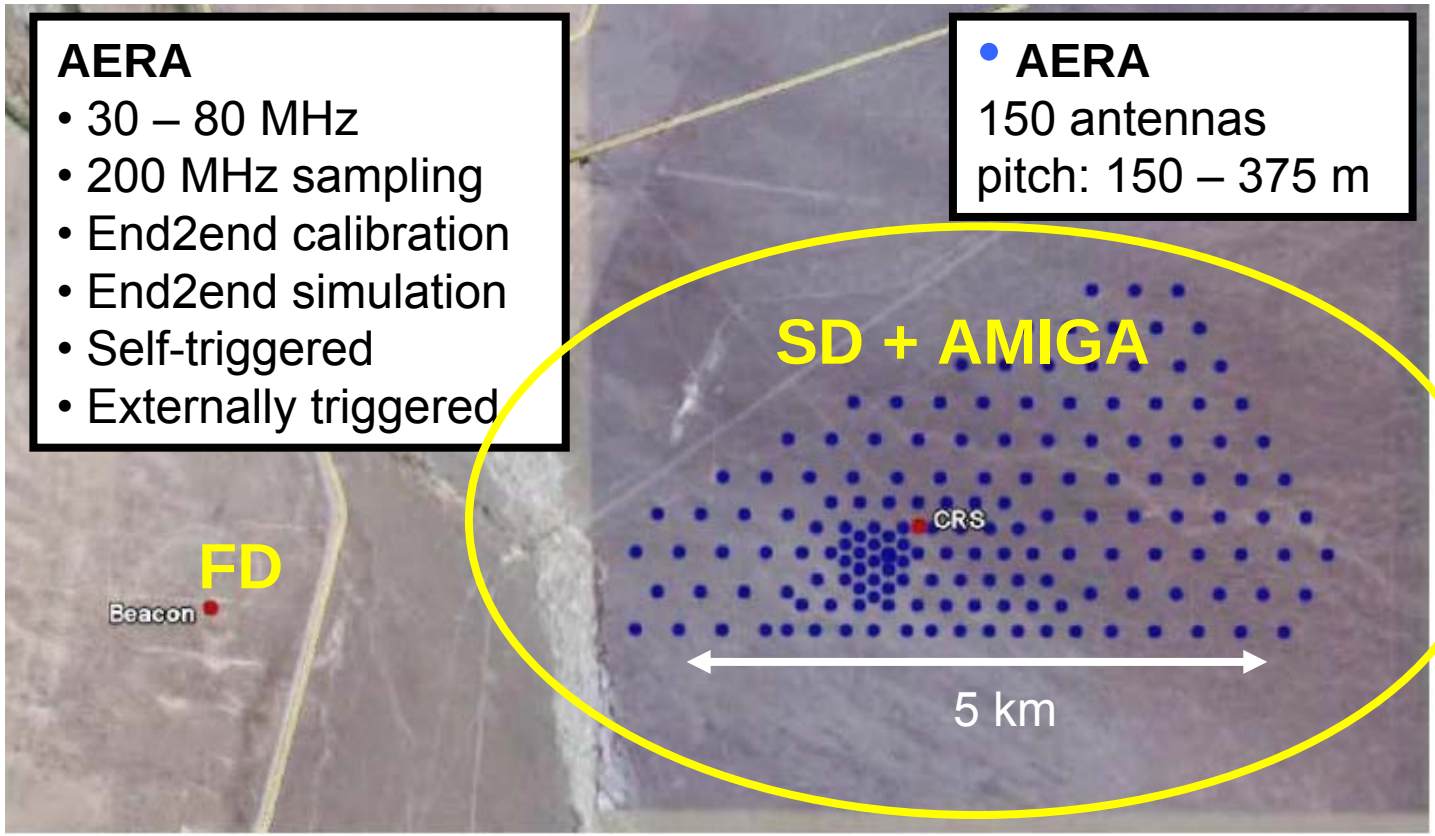
LOPES, 2010



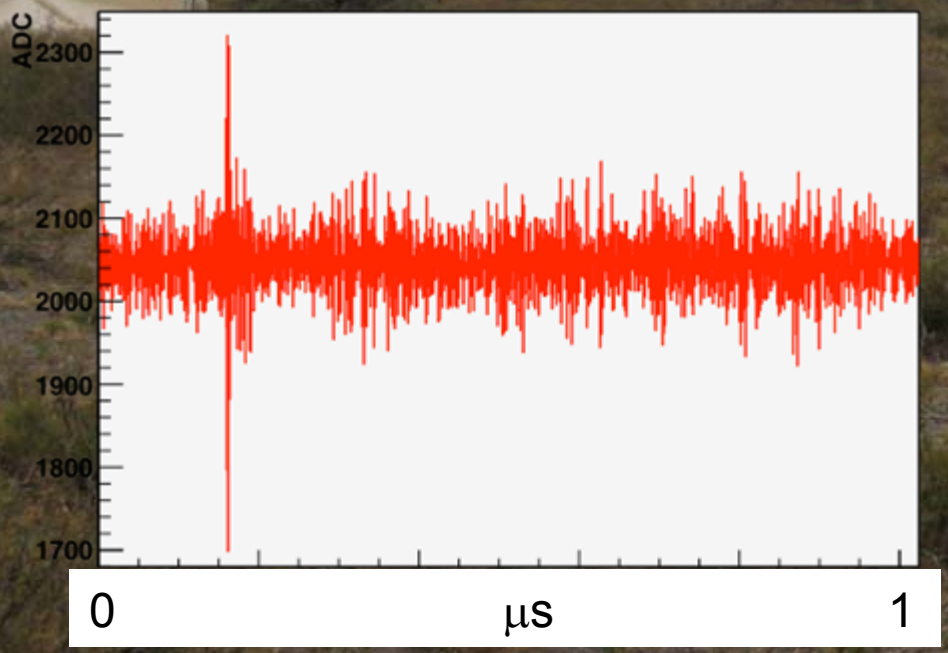
CODALEMA & Auger

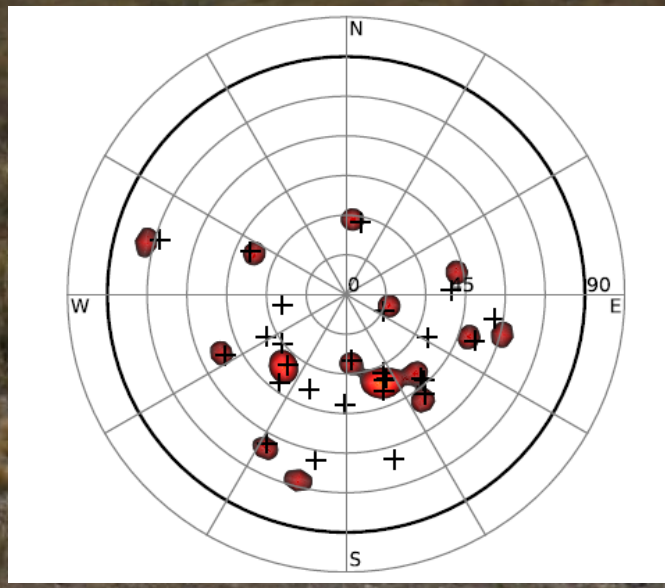


Auger Engineering Radio Array

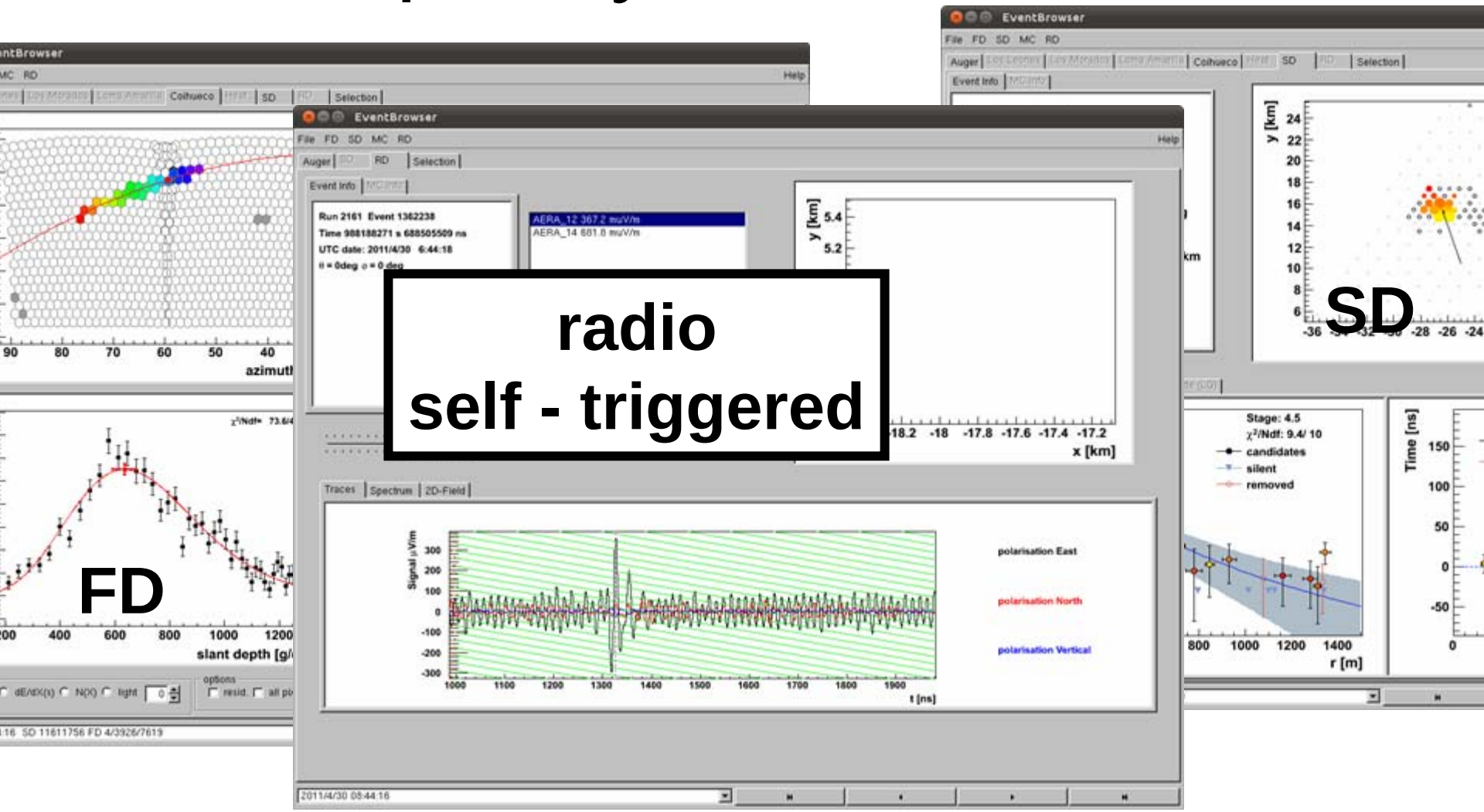


Self-triggered events





Super-hybrid detection



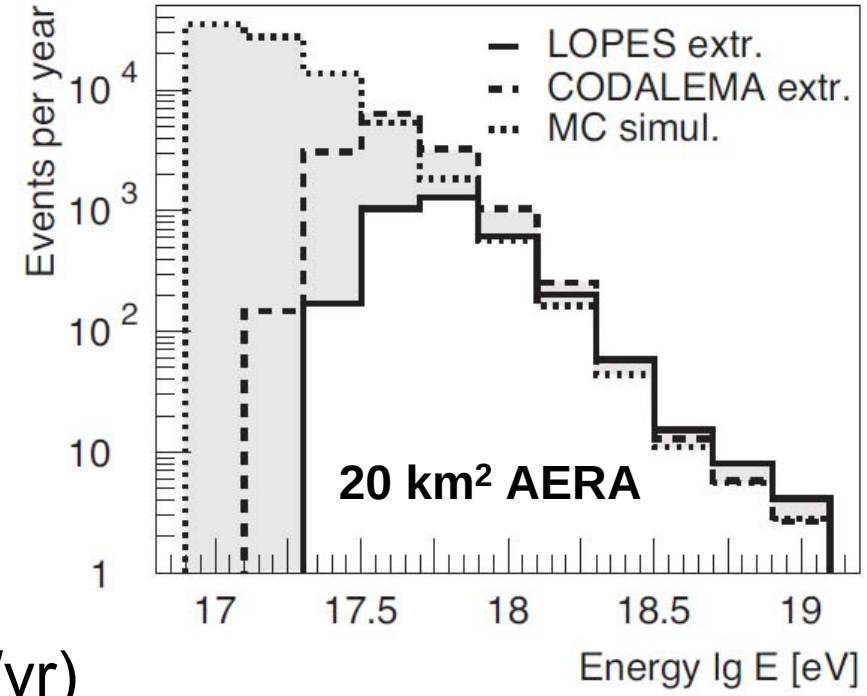
Composition and initial interactions

- **AERA + SD + FD + AMIGA: detailed investigation of air-shower physics, from the initial to the final stages of the air shower**

- Radio parameters for composition studies
  - pulse shape of the EM signal; high sampling rate
  - EM LDF; > 3 stations
  - shape of the EM shower front; > 3 stations (data from LOPES)

Next steps

- **2012 – 2013**
  - Determine sensitivity to composition: AERA 20 km^2
  - **17.3 < ^{10}log(E/eV) < 18.5**
- **2014 – 2018**
  - Increase to 300 km^2; 5 M€
  - **^{10}log(E/eV) > 19.0** (100 ev/yr)
  - pitch ~ 1000 m
  - GZK regime; **air-shower physics**



A. Haungs, # 63

2012: MHz detection

- mechanism !!
- highest energies !!
- composition??
- initial interactions ??

2014 Roadmap !!