Karlsruher Institut für Technologie

Auger Engineering Radio Array

AERA, the Auger Engineering Radio Array

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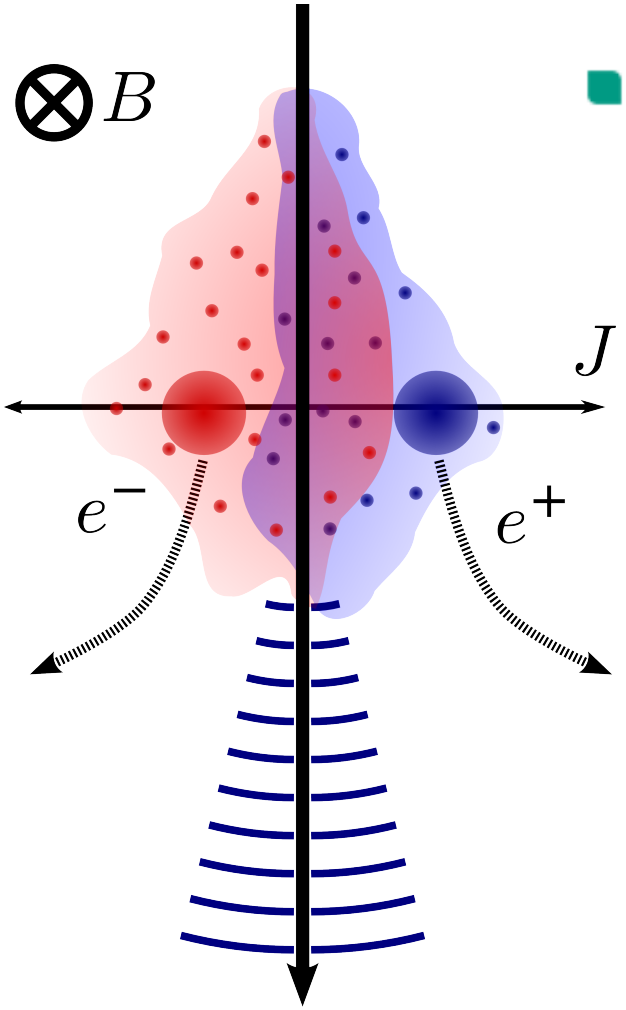
for the Pierre Auger Collaboration

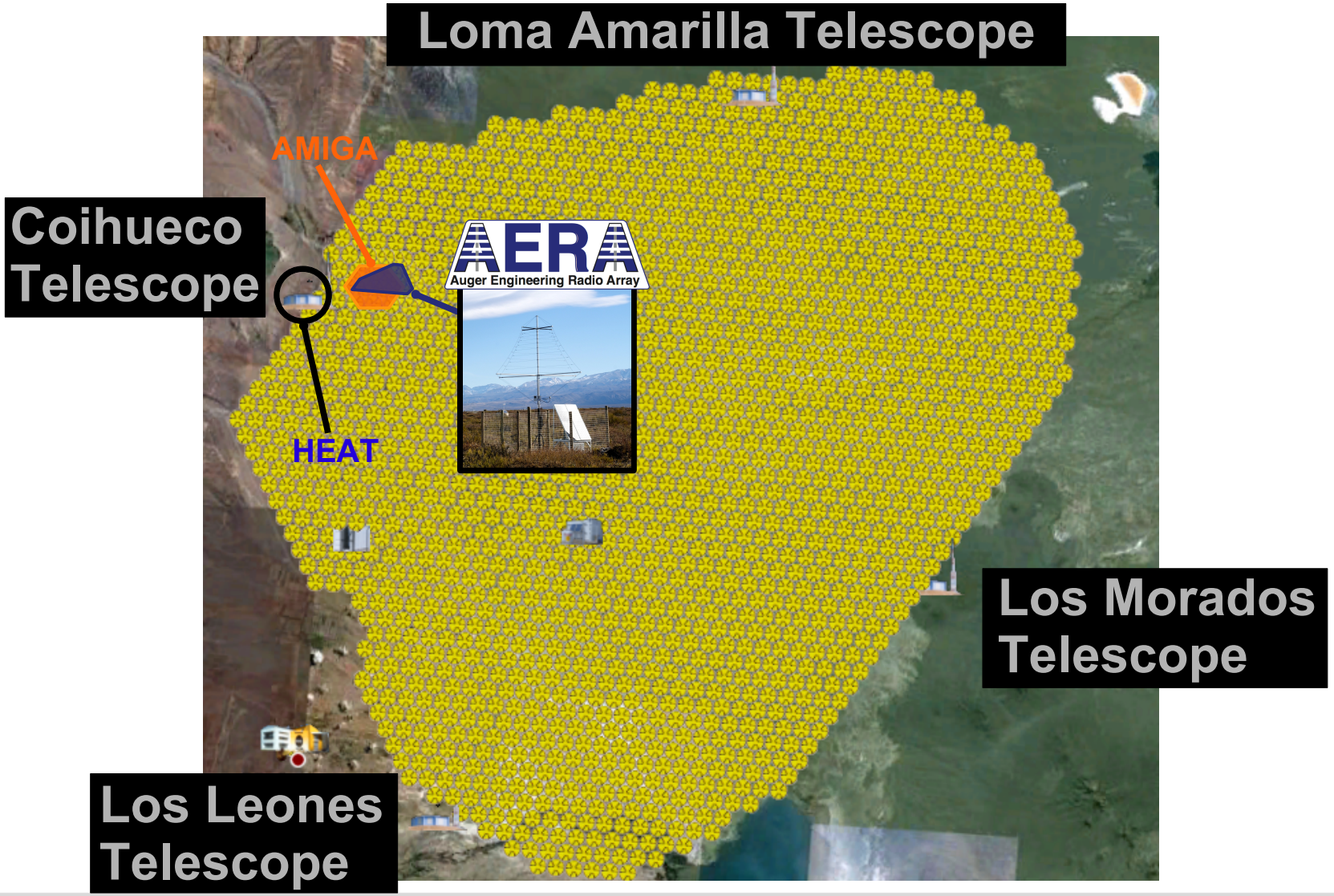
RICAP, ROMA 2011

Radio emission from extensive air showers

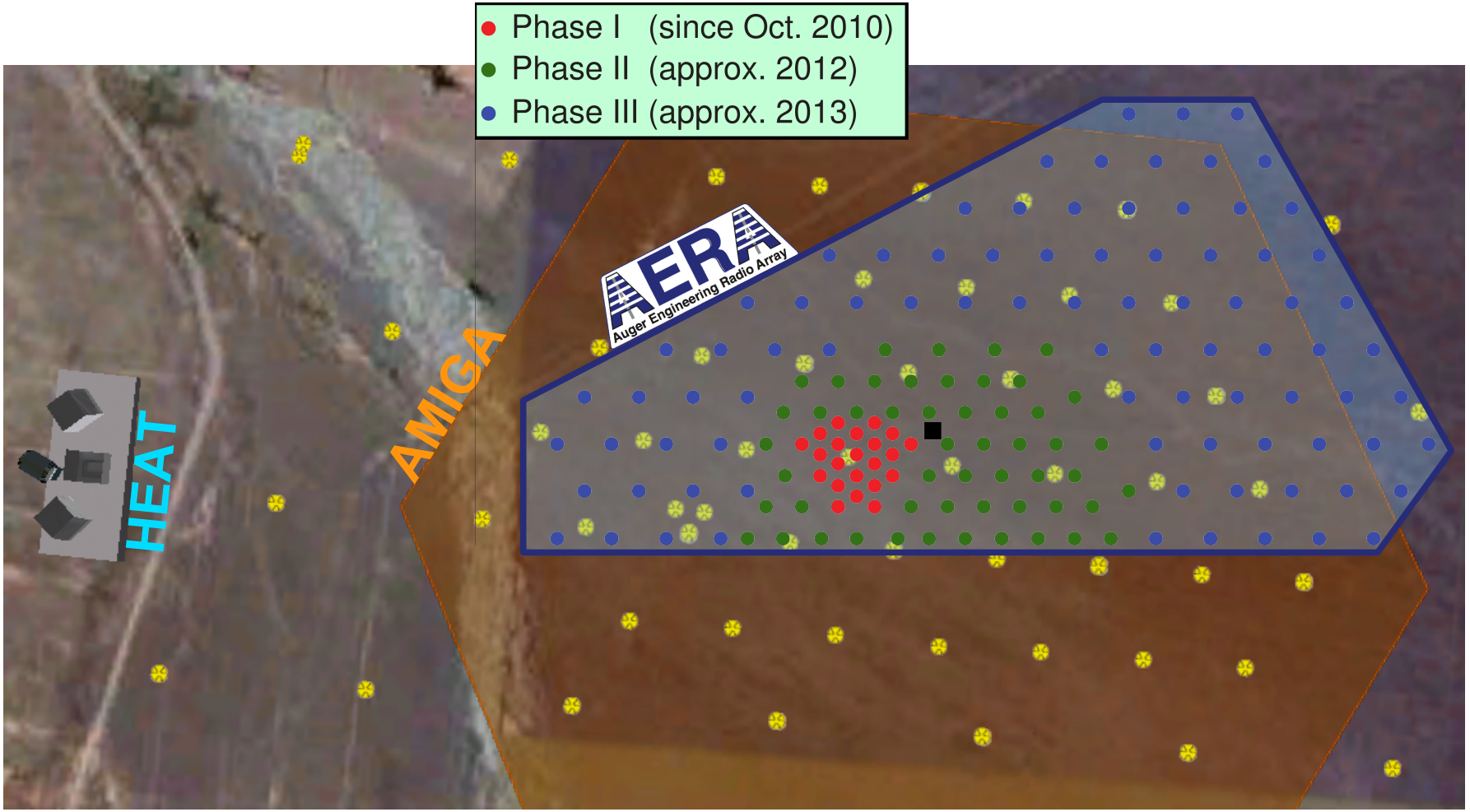


- extensive air showers emit pulsed radio signals:
  - Geomagnetic deflection of relativistic electrons and positrons
  - Time-variation of the number of charged particles and charge excess radiation
  - Coherent emission for frequency range below 100MHz
  - pulses with amplitude in μV/m range, duration up to 200 ns
  - 2 models describing the radio emissions: MGMR & REAS3

Extensions to the Pierre Auger Observatorium



AERA, HEAT & AMIGA location within the SD-Field

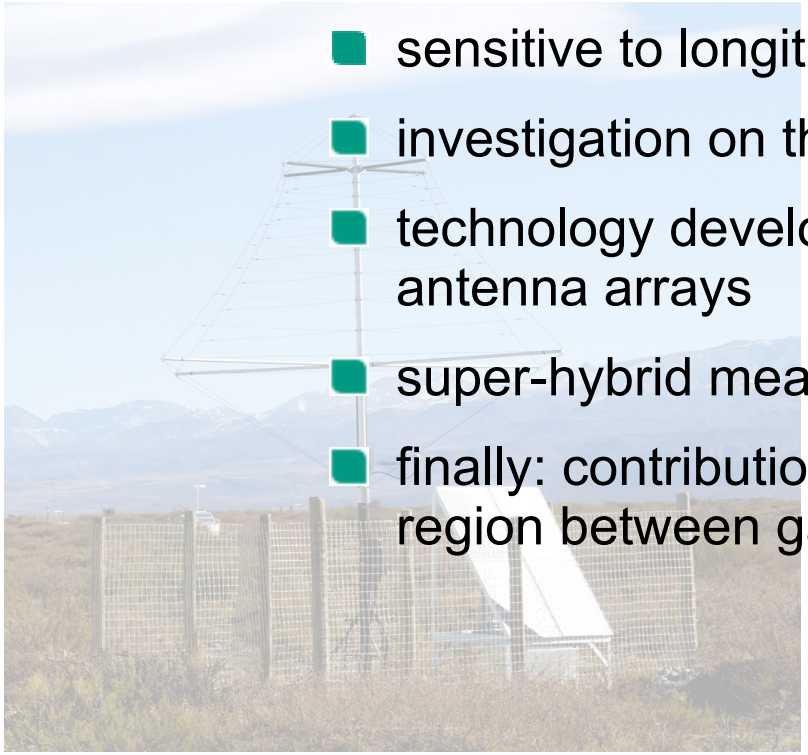


AERA – Auger Engineering Radio Array

- The AERA group of the Pierre Auger Collaboration

Why AERA?

- long-term measurements: ~95% duty cycle
- $\frac{signal}{noise} \propto (primary\ energy)^2$



- sensitive to longitudinal air shower development
- investigation on the emission mechanism
- technology development for next generation large scale antenna arrays
- super-hybrid measurements including RD, SD and FD
- finally: contribution to investigations on the transmission region between galactic and extra-galactic cosmic rays

AERA – components

- 21 (later 160) antenna stations
- central data acquisition & monitoring
  CRS, Central Radio Station
- power supply by solar panels (antennas & CRS)
- communication: Phase 1 – now wire / later wireless

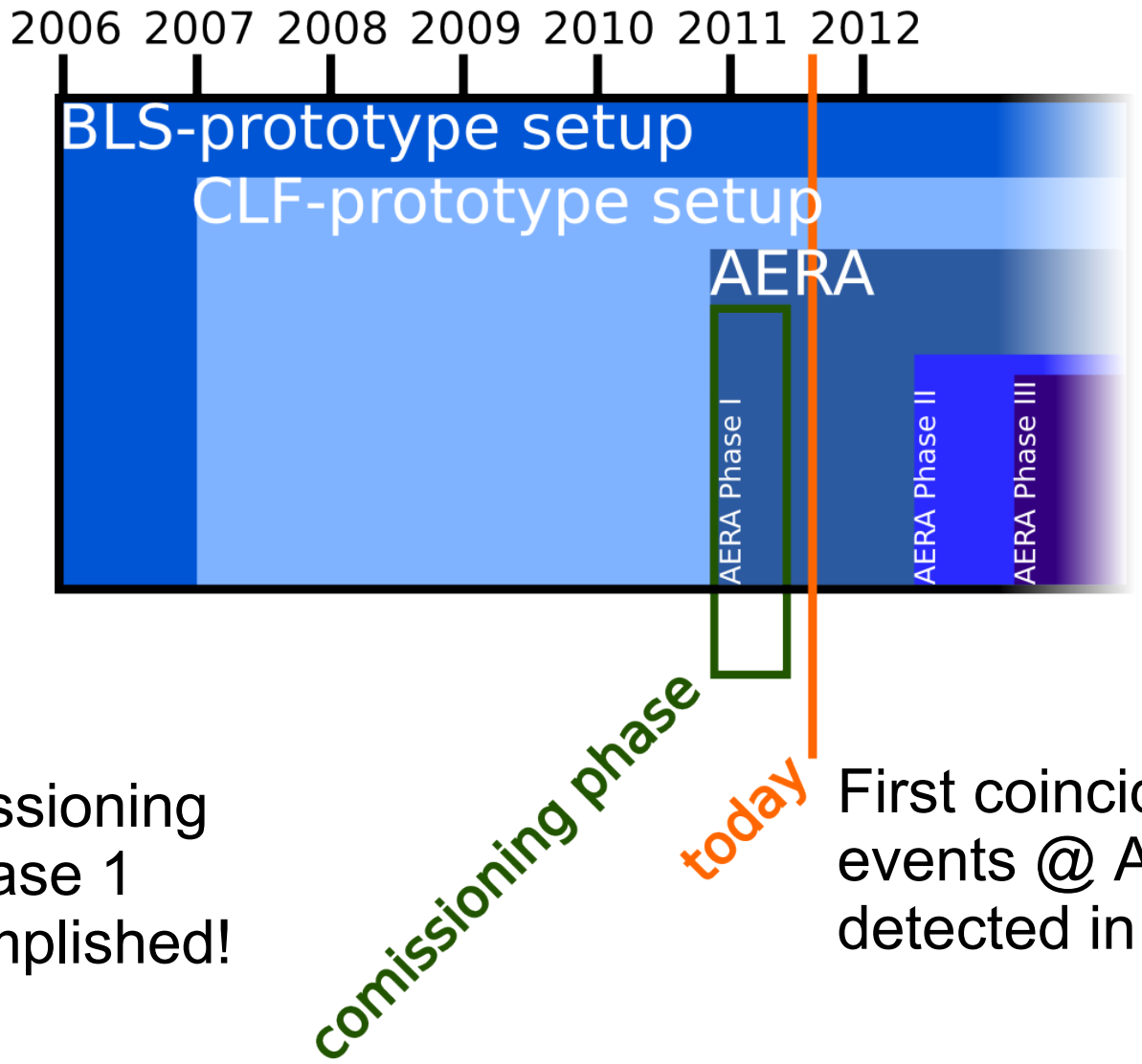
AERA – Auger Engineering Radio Array

- current data rate: 5-20 Hz
  expected data rate: 5000 radio events per year
- expected angular resolution: ~1.0°
- Trigger: self trigger (min. 2 stations) & random trigger (every 10s)
- Energy range:

Auger	above 10^{18} eV
Auger + HEAT & AMIGA	above 10^{17} eV
AERA	above 10^{17} eV

- super-hybrid analysis including FD, SD & RD are possible!

AERA – time line



Comissioning of Phase 1 accomplished!

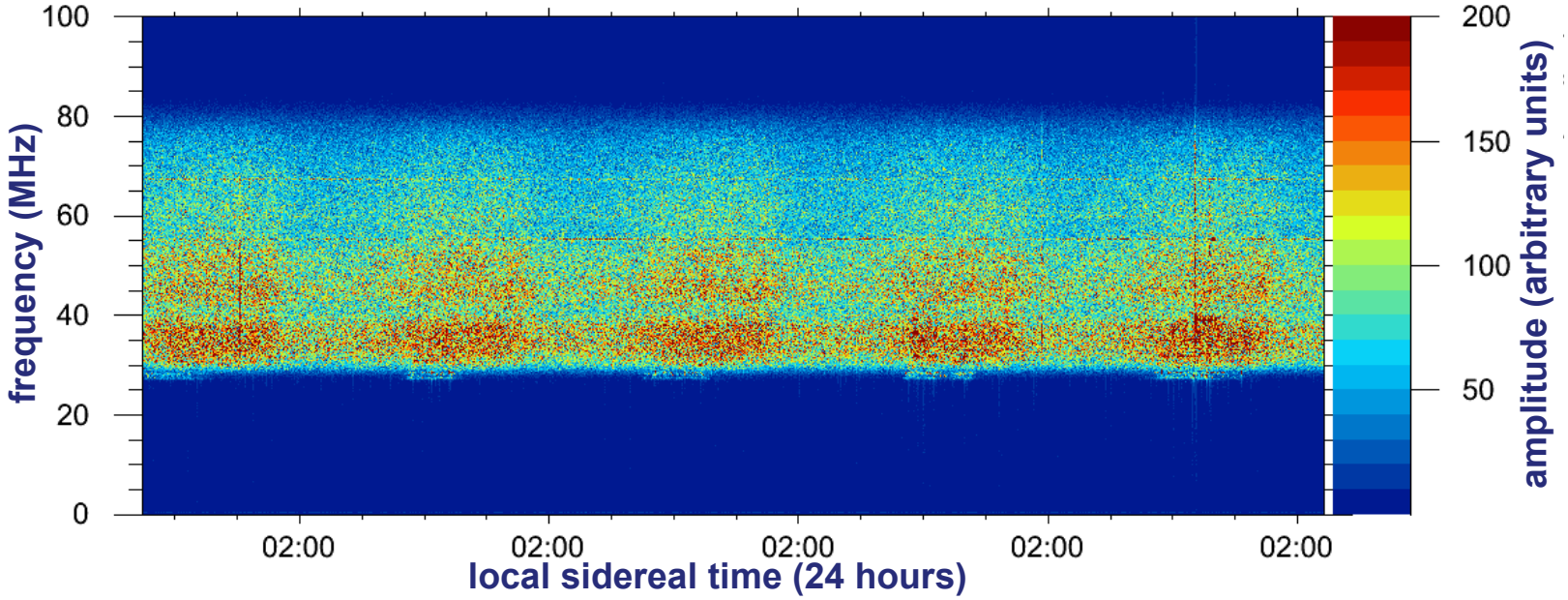
First coincident radio events @ AERA detected in April 2011!

OffLine: analysis software

- developed for SD & FD analysis of Auger-Data
- extended to analyse radio data of AERA & the prototype stations
- modular design, flexible and adjustable
- core components are available on request
- Nuclear Instruments and Methods A, 635 (2011), no. 1, 92-102

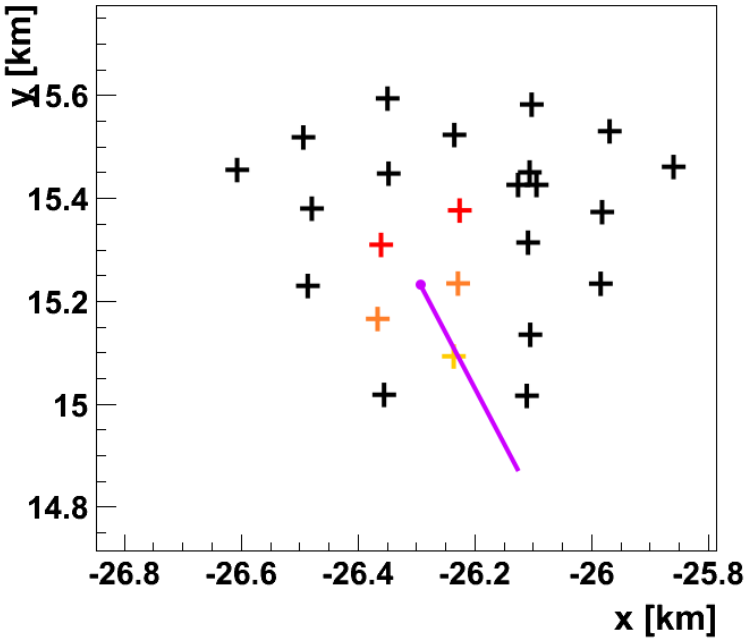
comissioning data at AERA

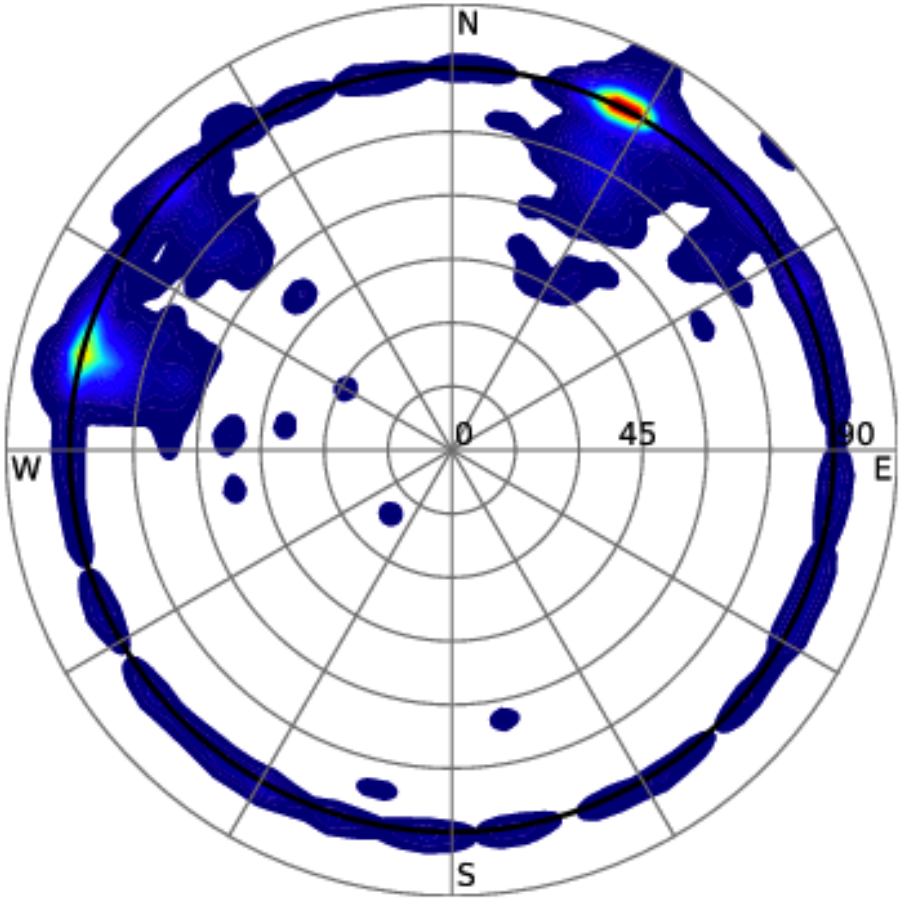
- comissioning data from October 2010 to March 2011
- study of noise sources at AERA



comissioning data at AERA

- incident direction distribution of comissioning events
  run duration: 4h



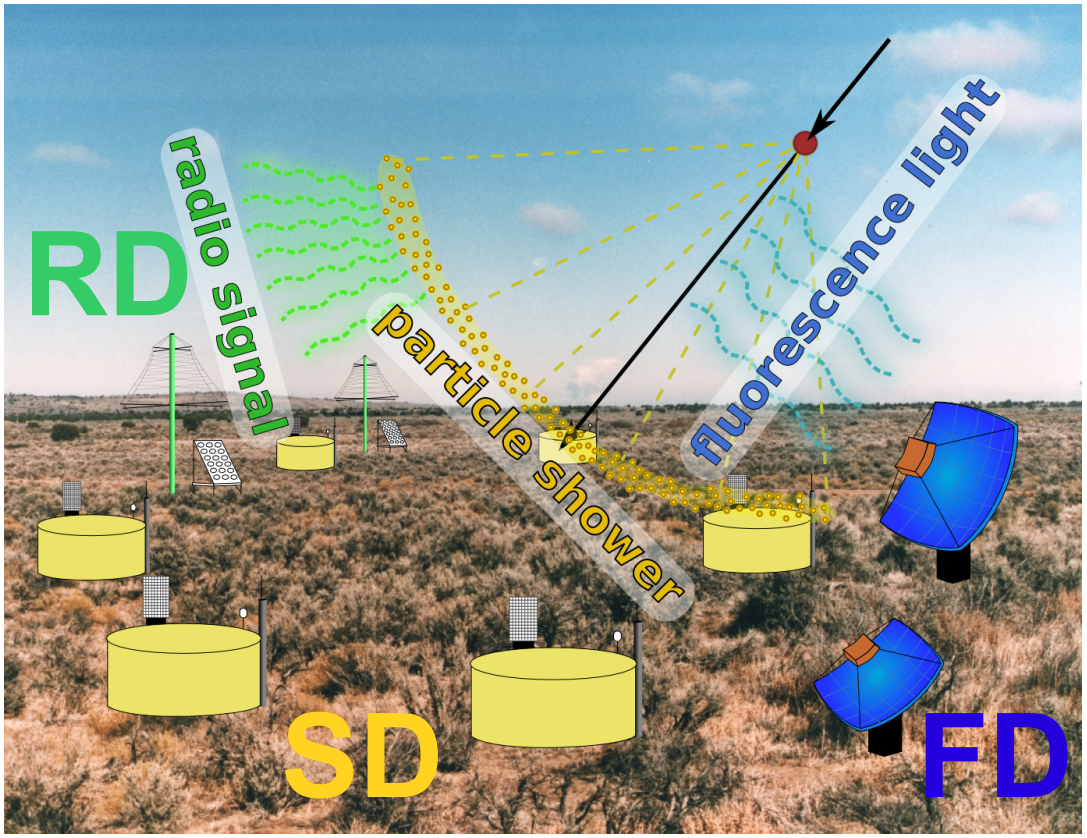


comissioning data at AERA

- RFI sources at the AERA site

AERA – super-hybrid analysis

- overlap of AMIGA, HEAT and AERA
- SD, FD & RD measurement of the same air shower!
- combined analysis of all 3 components

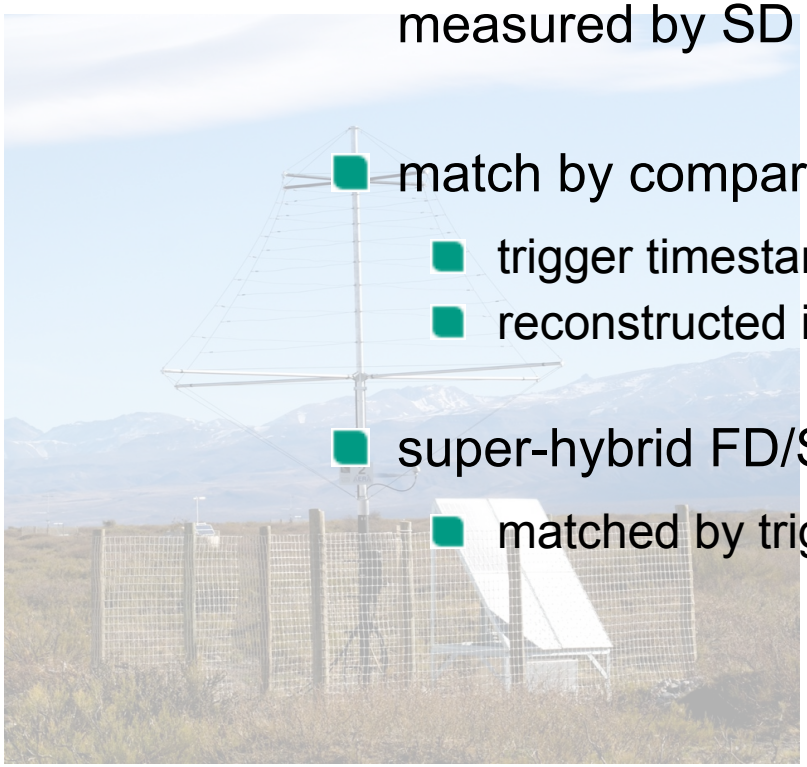


Advantages:

- High precision reconstructions
- combination of strengths of different methods (direction reconstruction)
- 1st step: coincidence search via timestamps & reconstructed directions

coincident search at AERA

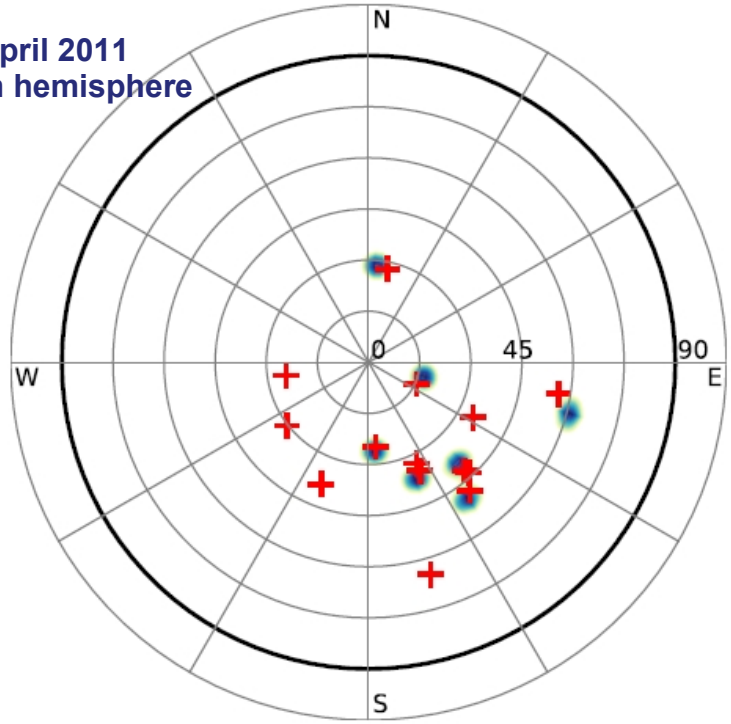
- first self triggered radio measurement in coincidence with SD in April 2011!
- 14 coincident events measured by SD & RD in April 2011
- match by comparison of
  - trigger timestamp
  - reconstructed incident direction (if # stations > 2)
- super-hybrid FD/SD/RD events allready detected
  - matched by trigger timestamp



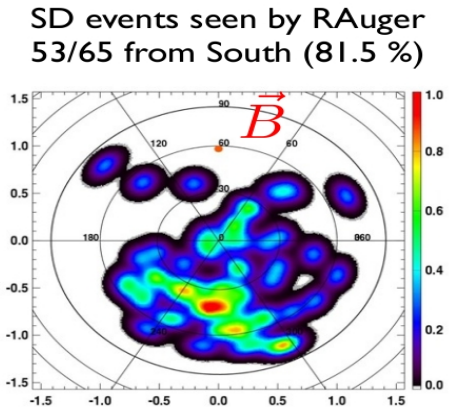
hybrid events at AERA

- incident direction of the 14 hybrid events:
- red cross: SD reconstructed direction
- blue dots: RD reconstructed direction
  (for 7 events only, >2 stations)

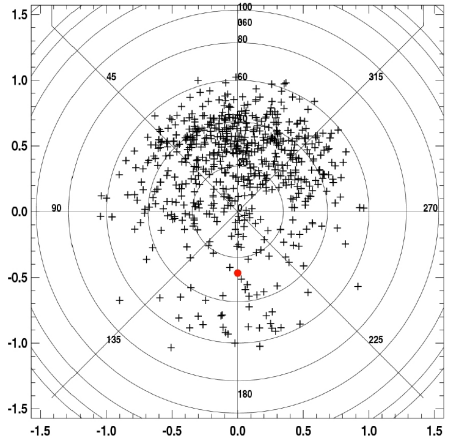
AERA, April 2011
southern hemisphere



Prototype setup @ the CLF,
southern hemisphere

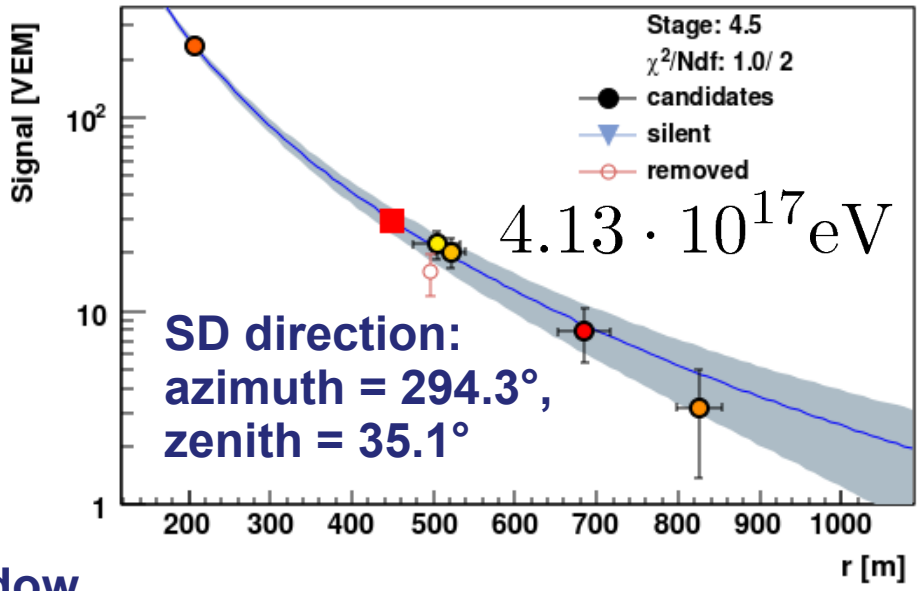


Codalema experiment, France
northern hemisphere

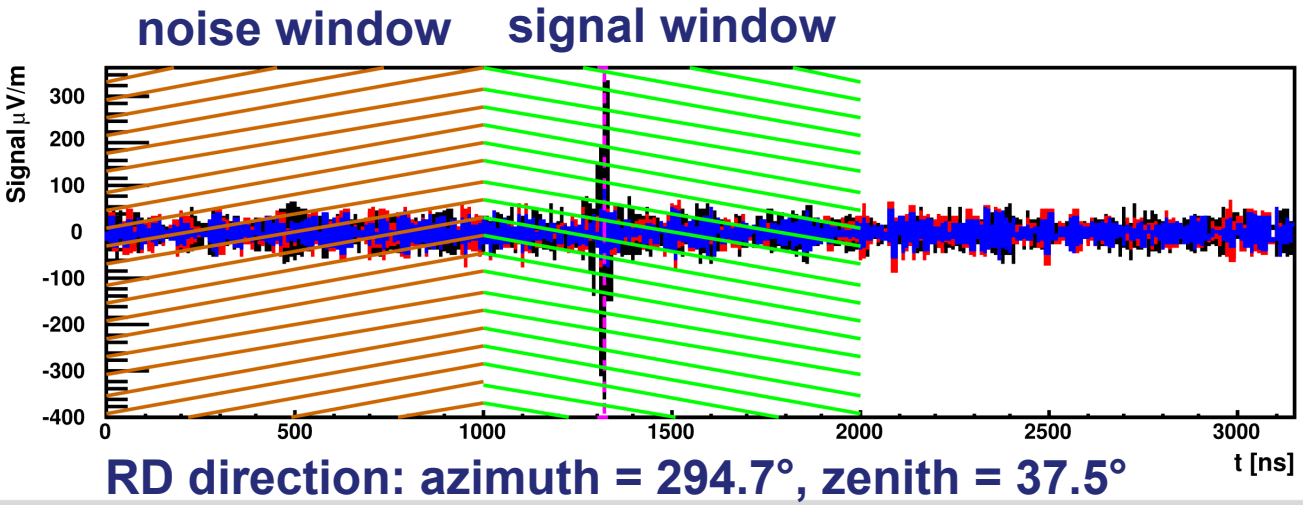


hybrid events at AERA

- measured on:
  April 16th 2011 – 14:09h
- 5 triggered radio stations

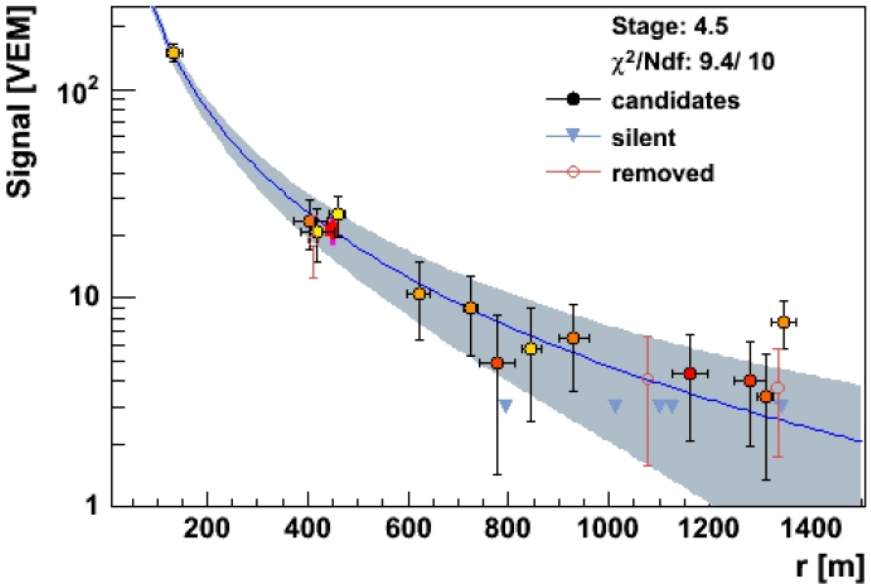


event 1039654, station 16

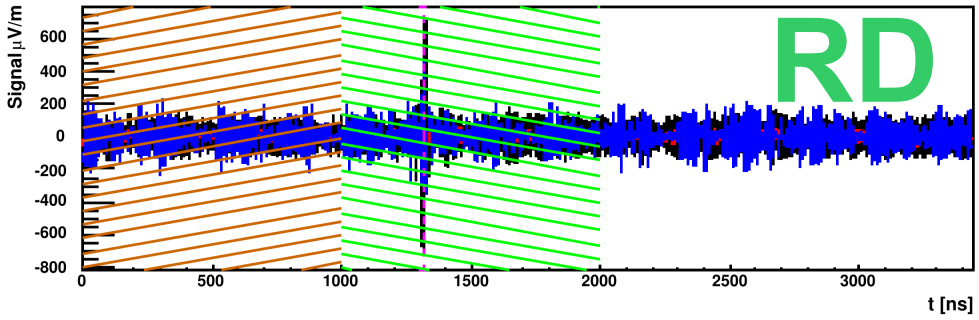


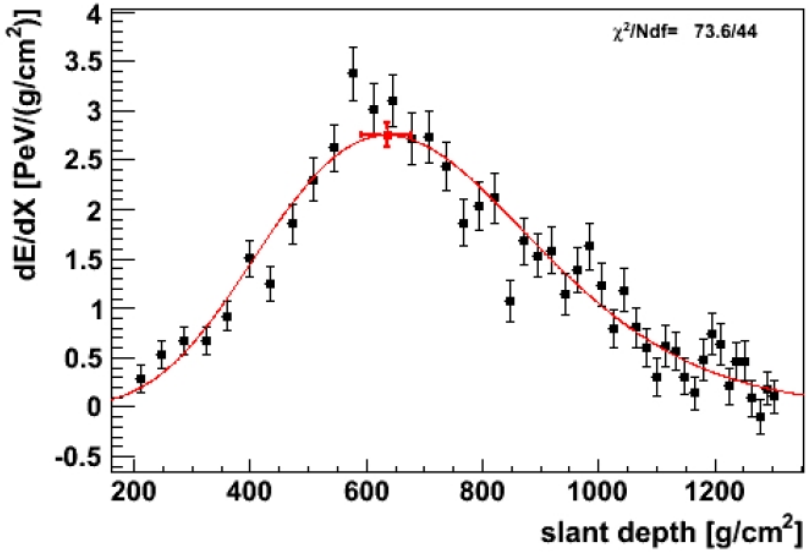
super-hybrid events at AERA

- RD/SD/FD coincident event
- 2 triggered radio stations
  → matched by timestamp
- Energy: $1.8 \cdot 10^{18}\mathrm{eV}$ (FD)
- Incident direction (FD):
  azimuth = 285.0°
  zenith = 63.0°



event 1362238, station 14

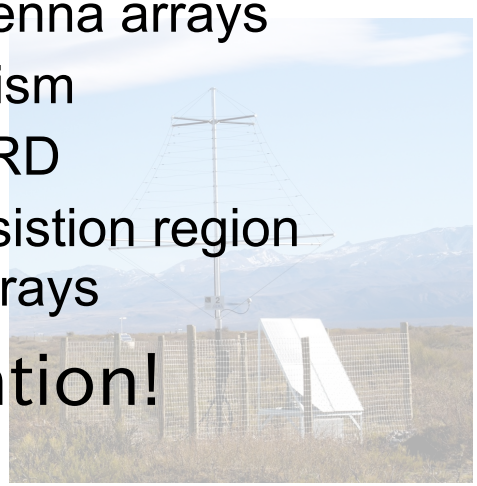




AERA – Auger Engineering Radio Array

- 21 antennas for phase 1 installed since November 2010
  extension to 160 antenna planned for 2012/2013
- Bandwidth: 30-80MHz, Energy range: above 10^{17} eV
- hybrid SD/RD events measured
- super-hybrid SD/FD/RD events measured

- Goals:
  - technology development for large scale antenna arrays
  - investigation on the radio emission mechanism
  - hybrid & super-hybrid analysis with SD/FD/RD
  - contributions to the investigation of the transition region between galactic and extra-galactic cosmic rays



Thank you for your attention!
??? Questions ???