PIERRE AUGER OBSERVATORY

The AERA DAQ and GRAND scalability

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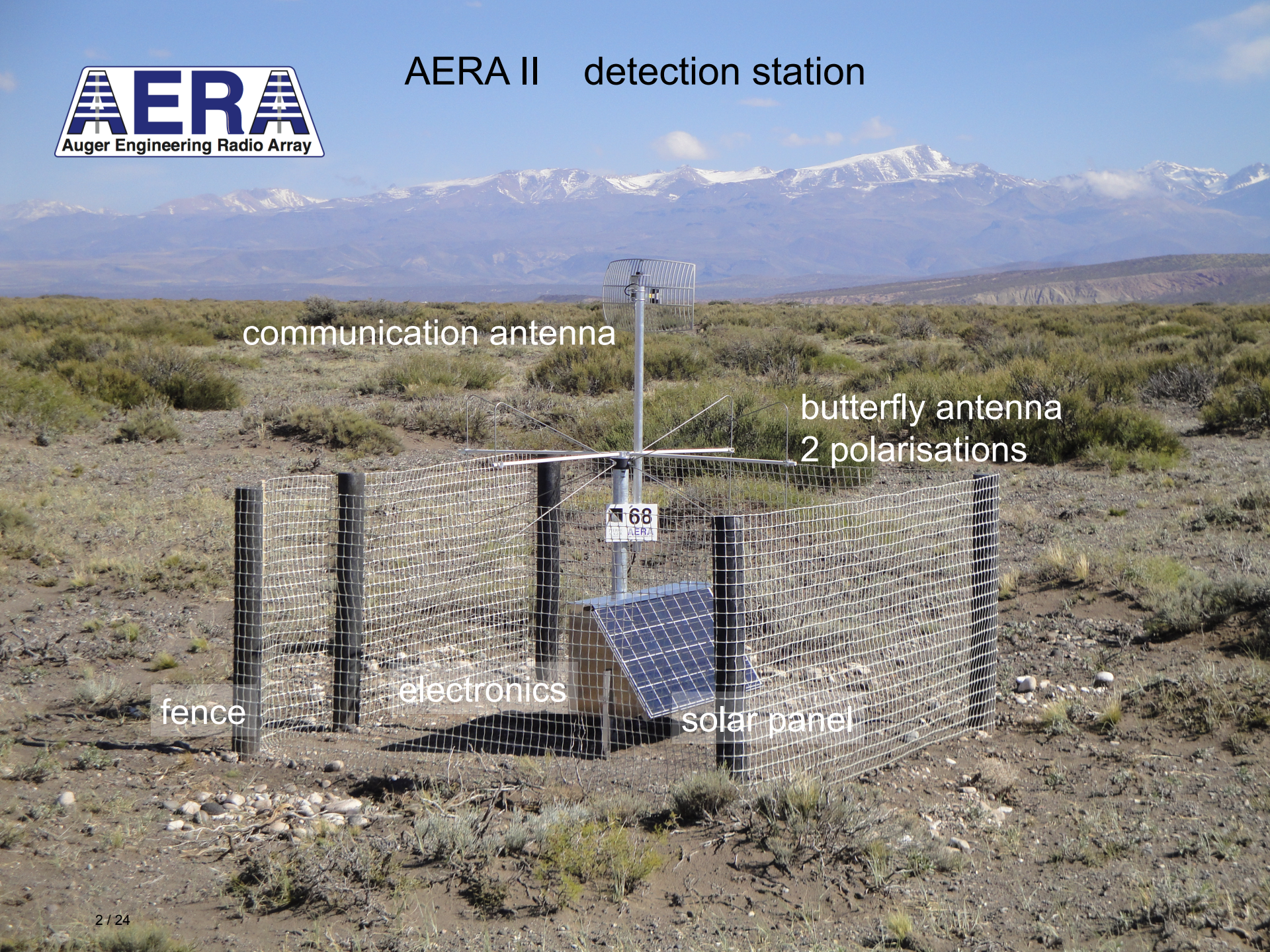
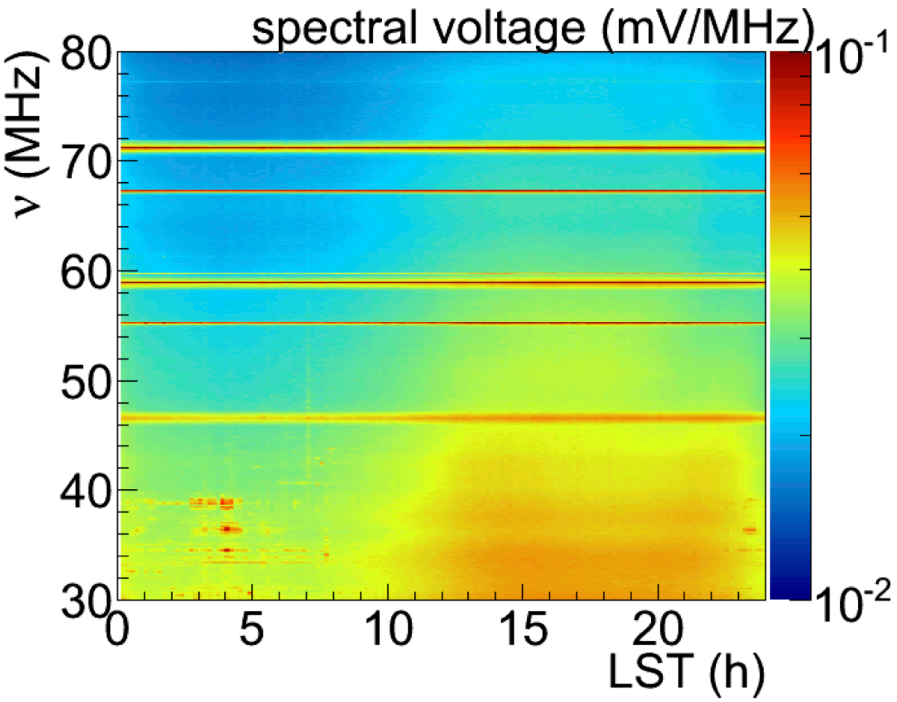
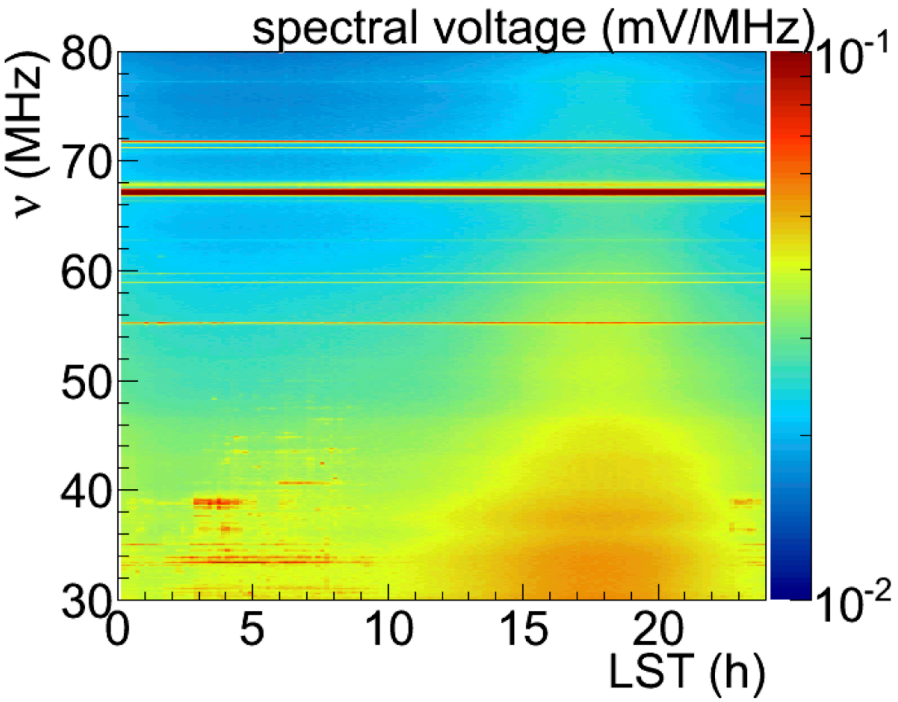
Nikhef/Radboud university Nijmegen

AERA II detection station

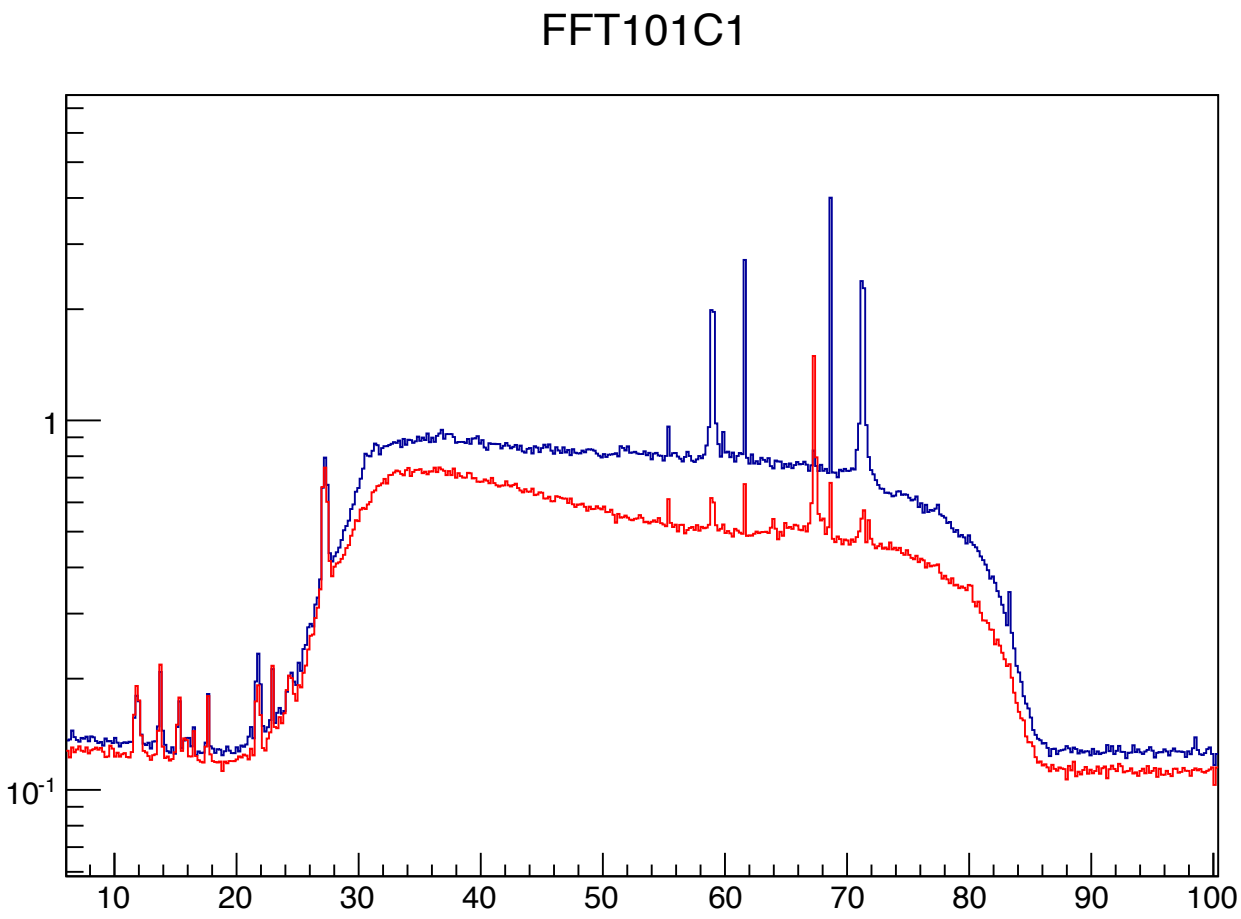


AERA Spectrum





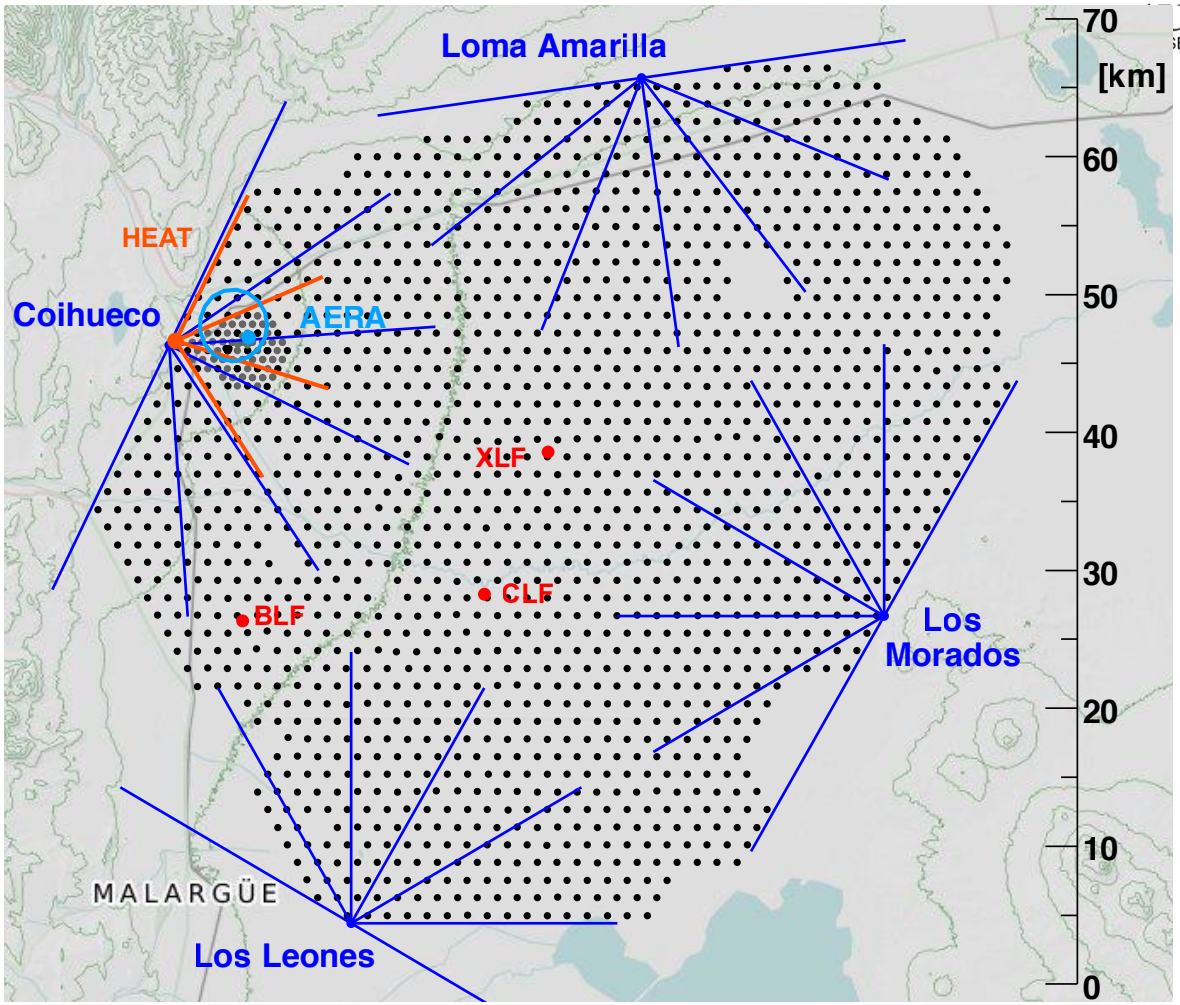
Noise in AERA



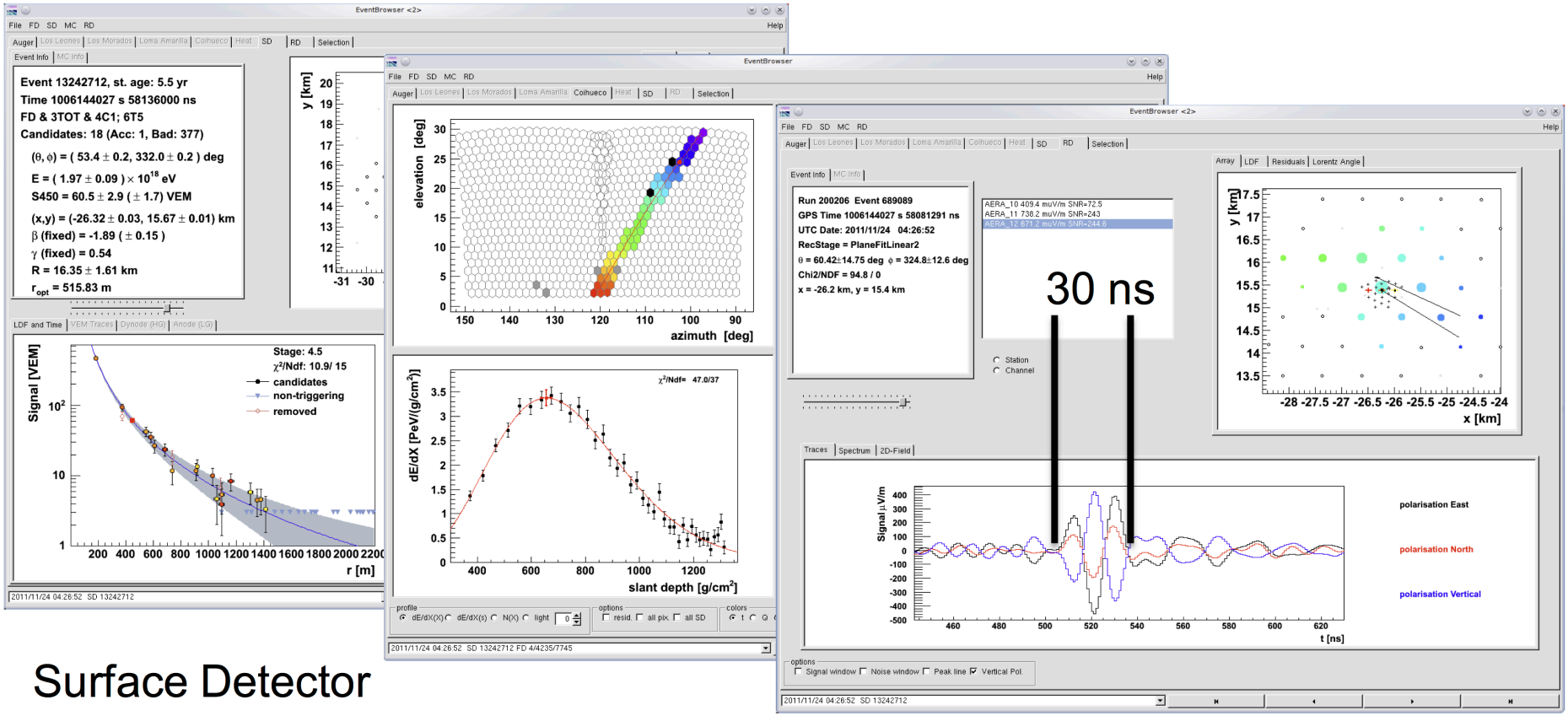
AERA in Auger

Currently 124 stations on 6 km^2 in the North-west site of Auger.

Extension to increase area to 13 km^2, using 25 additional stations planned for this year



First achievements of AERA



Surface Detector

Fluorescence Detector

Radio Detector

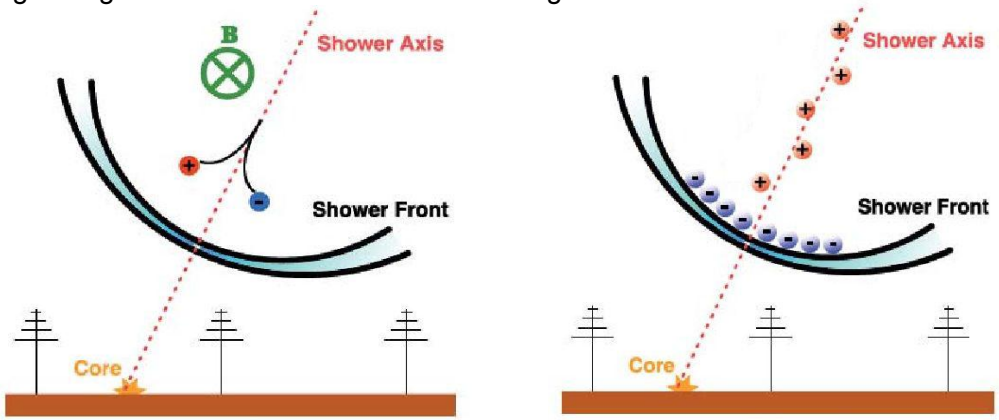
Full study of events measured with several techniques is carried out.

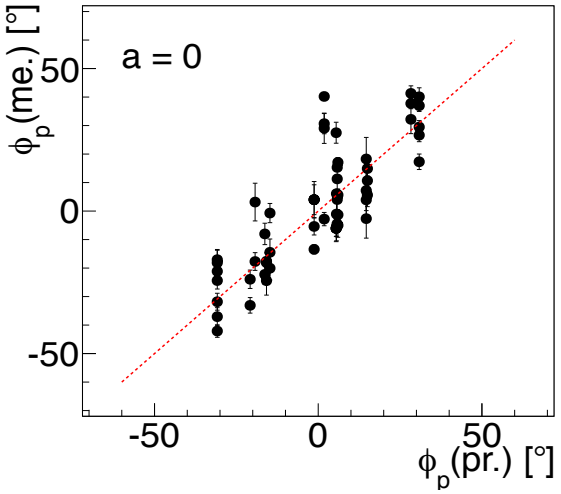
First achievements of AERA

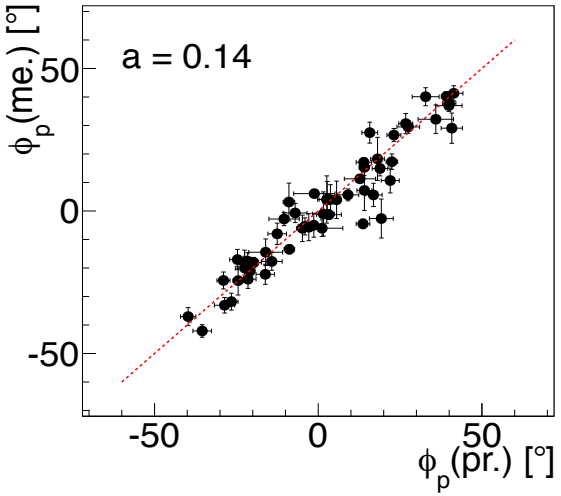
$$\vec{E} \sim \sin(\alpha) \cdot \vec{e}_{GM} + a \cdot \vec{e}_{CE}$$

geomagnetic emission

charge effect emission

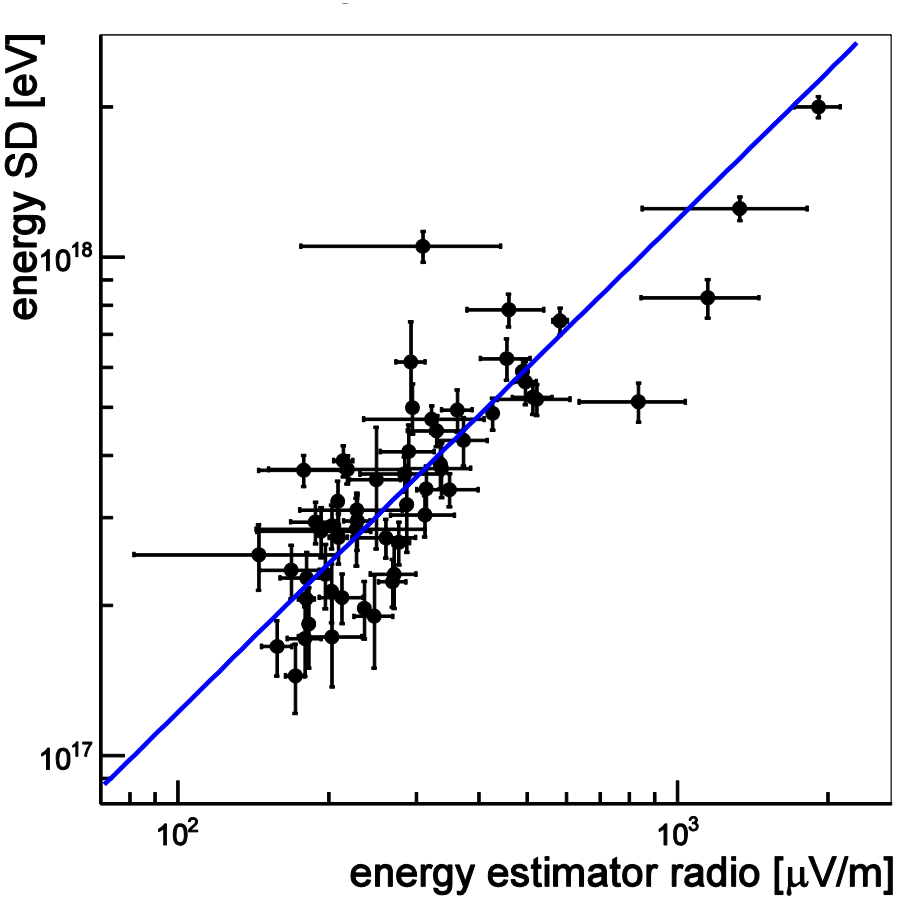






Polarization of the radio signal clearly indicates an effect of the net charge of the shower front.

First achievements of AERA



The amount of energy in radio at the surface correlates perfectly to the energy estimate of the Auger surface detectors. (paper in preparation)

Front-end hardware –Engineering emphasis differences

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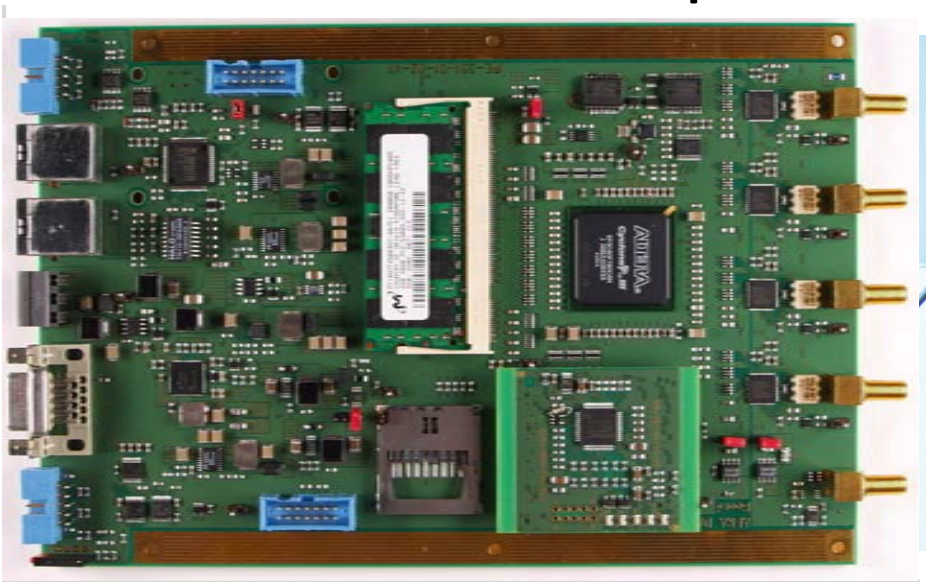
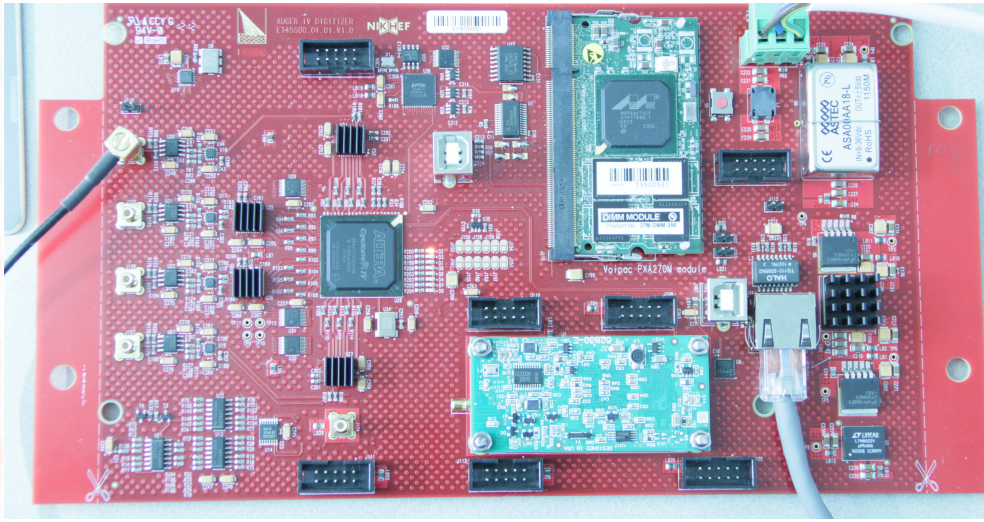
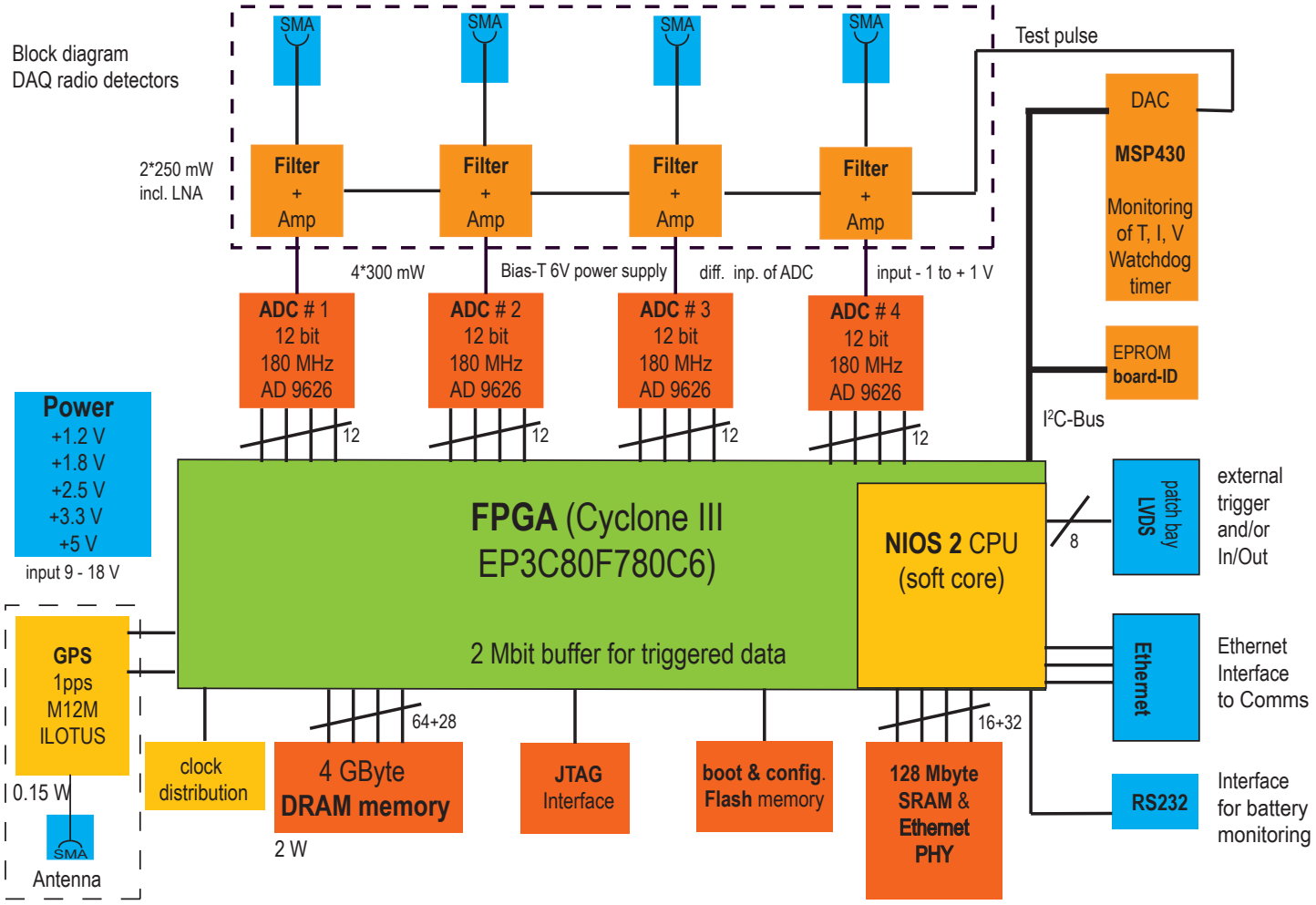




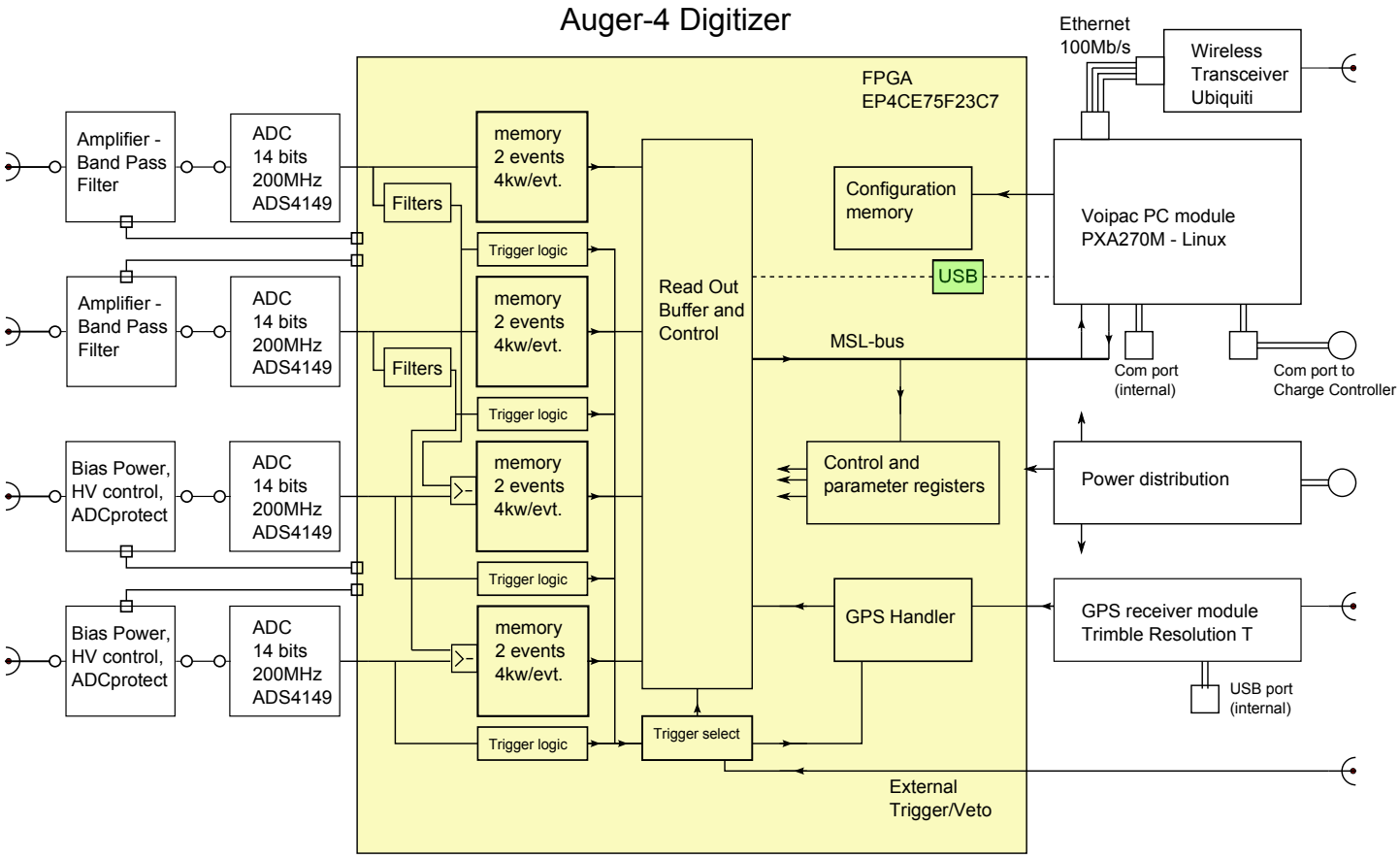
- Store 7 seconds of data (external trigger)
- Use sharp analogue filters (remove noise)
- Powerful FPGA (noise reduction/trigger)

- ARM-CPU (self trigger, storing triggered events)
- Filter designed to reduce dispersion (maintain signal)
- Power efficient FPGA (noise reduction/trigger)

Block Diagram A



Block Diagram B



5 GHz Commercial Wireless COMMS

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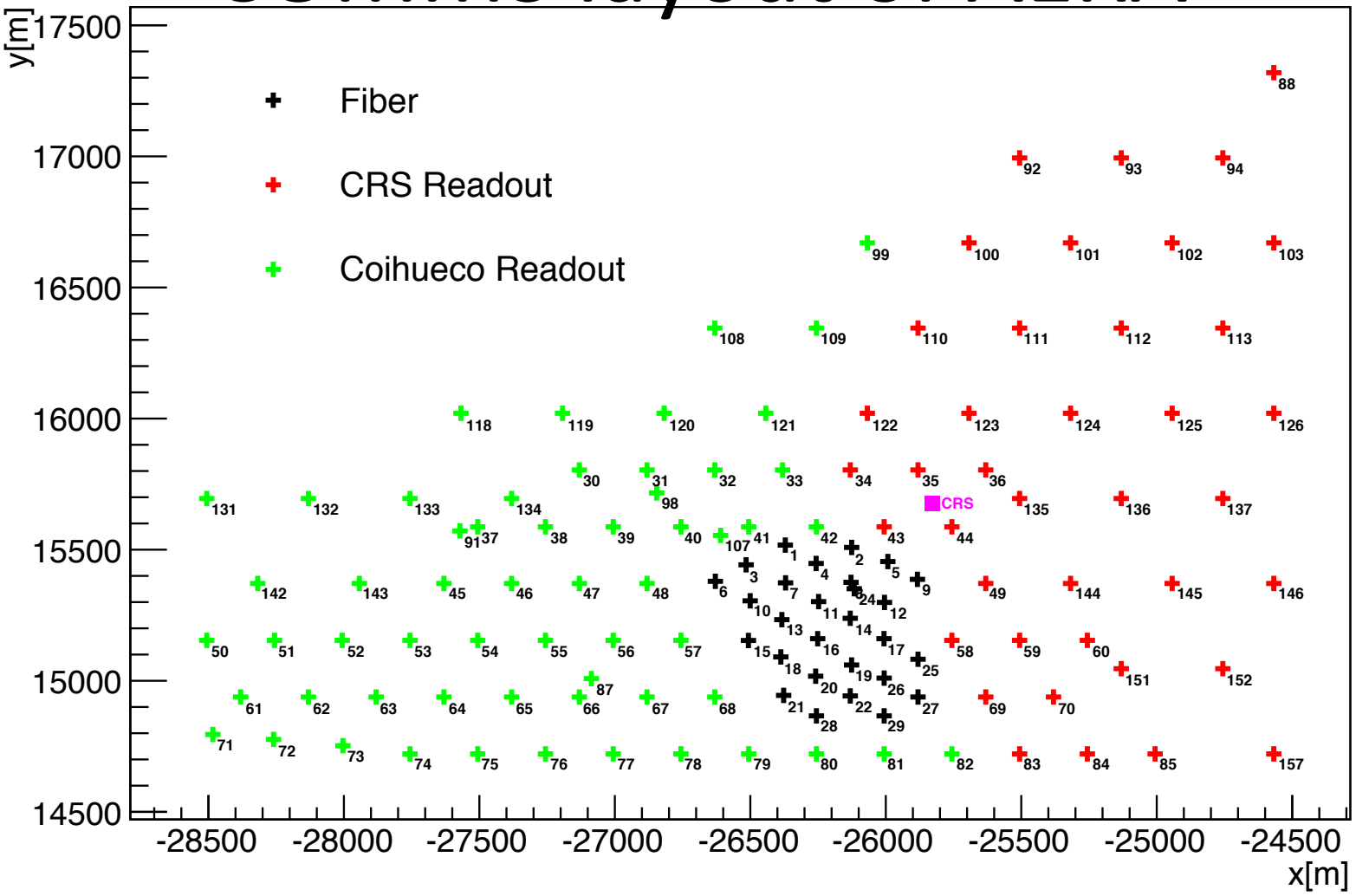
20 dBi 90° sector antenna +
Ubiquity 5 GHz Rocket M access point

Stations: 30 dBi parabolic dish antenna +
Ubiquity 5 GHz Bullet M subscriber unit

Tested up to 10 km

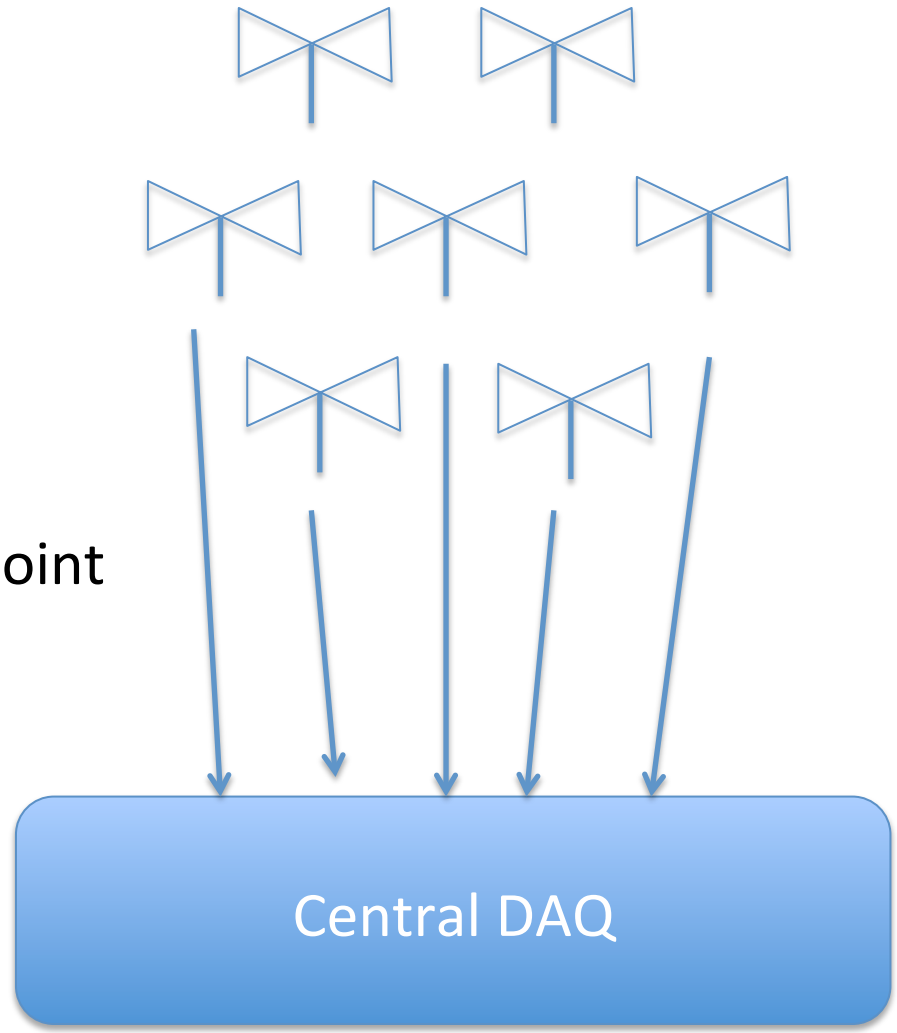
For 150 subscribers: two 40 MHz channels in 5 GHz band gives 2 Mbps per station, required ~0.5 Mbps

COMMS layout of AERA

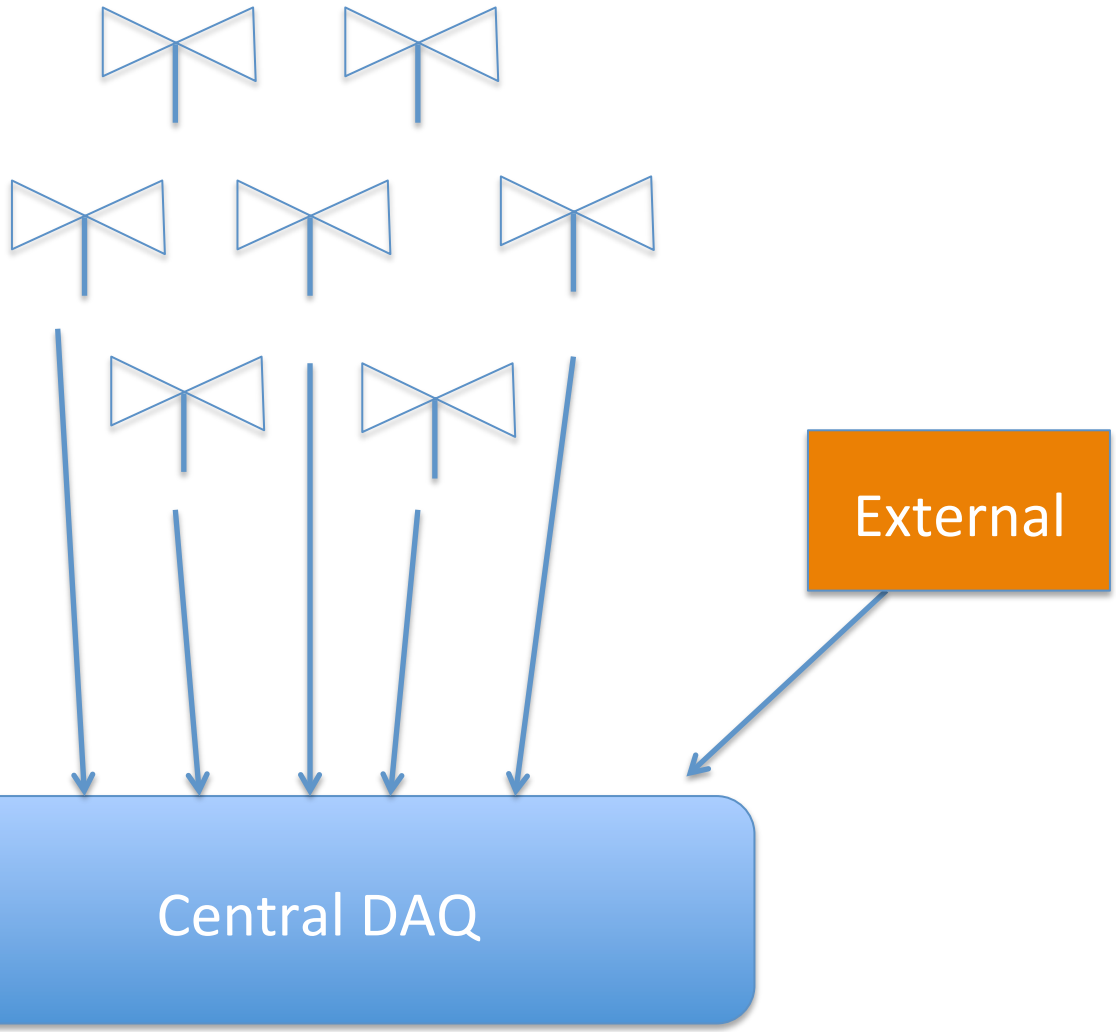


DAQ implementation

Point to multipoint



DAQ implementation



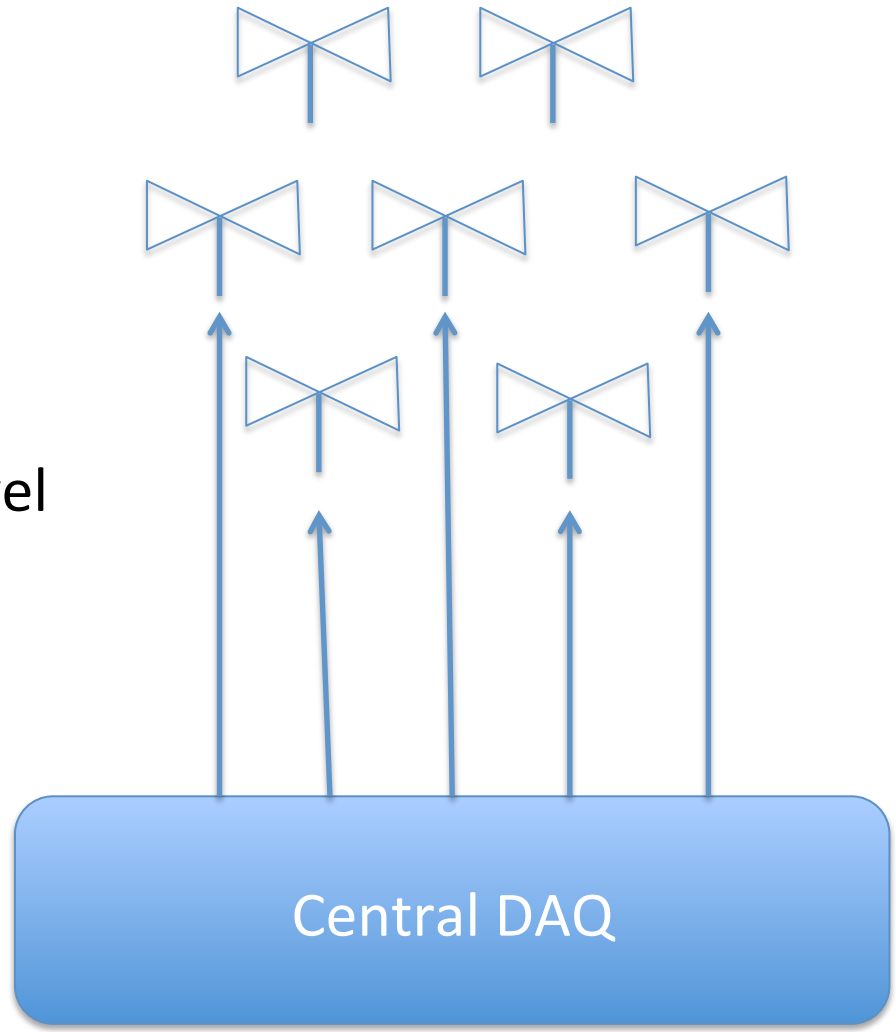
1a) Send timestamps from triggered events

1b) Receive external timestamps

DAQ implementation

2) Create high level trigger

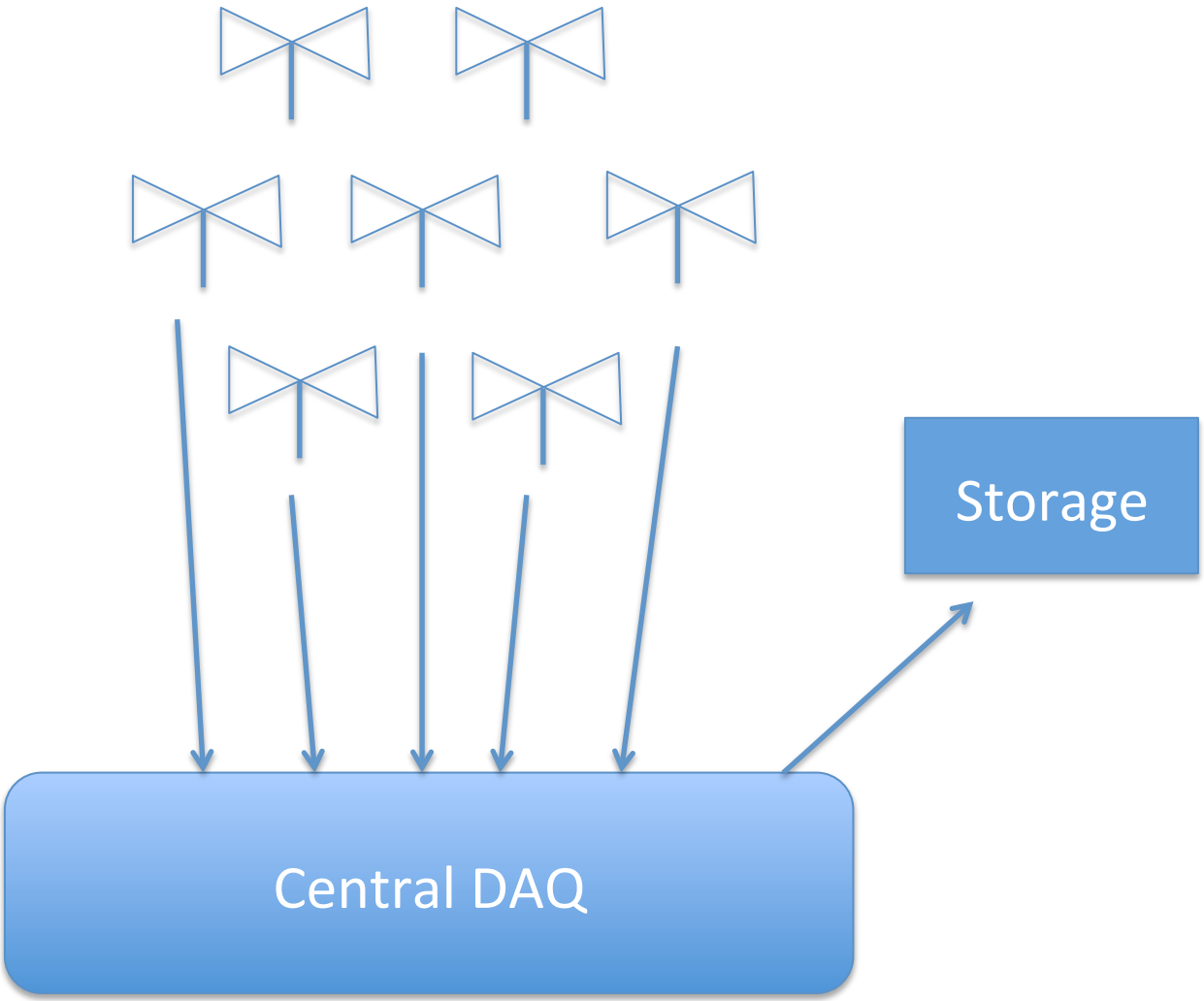
3) Request event fragments



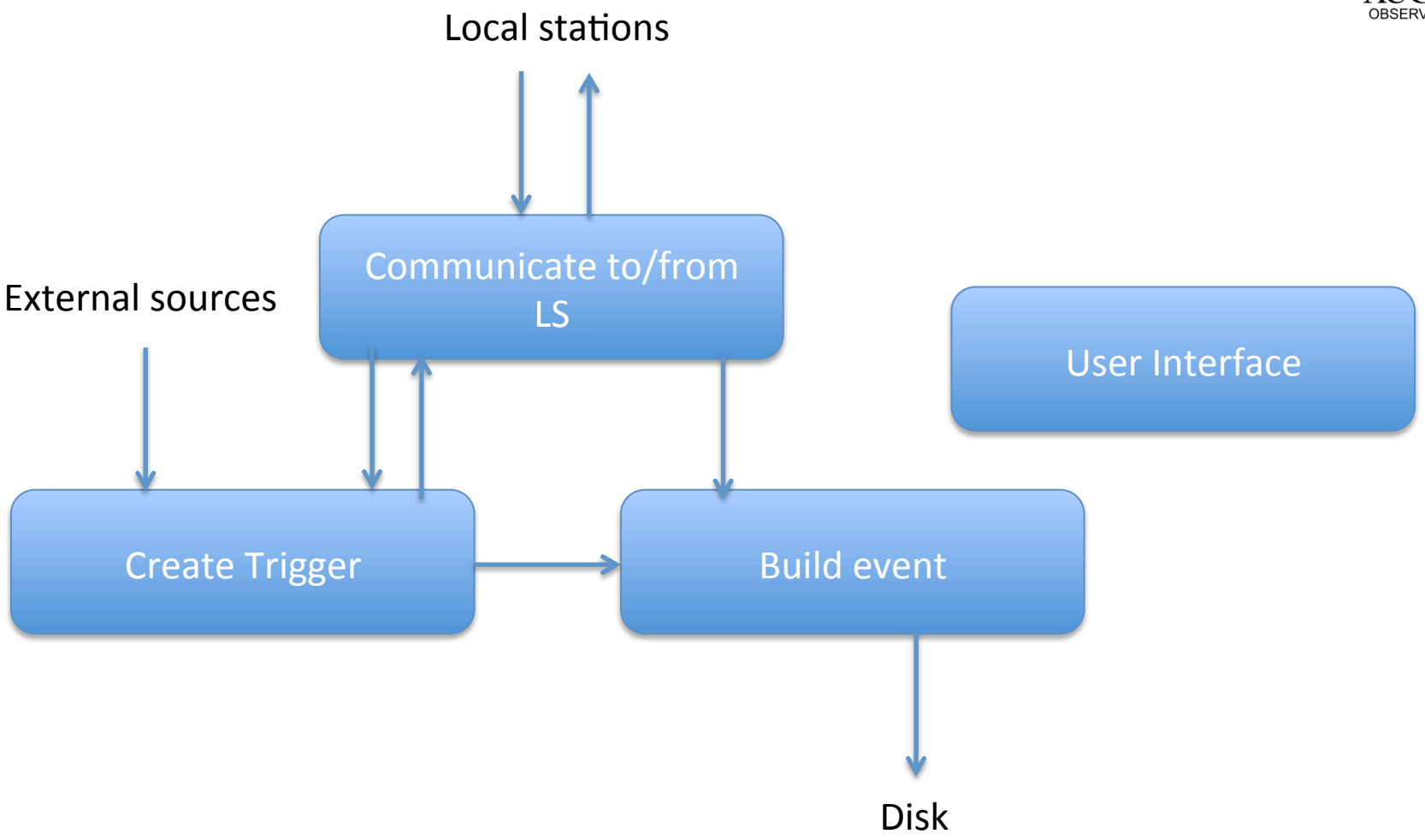
DAQ implementation

4) Build event

5) Write event



Core DAQ Software



Scalability AERA DAQ

- Online software
  - Single central trigger is limited
  - Division in segments needs worrying about boundaries
  - Sending timestamps forms a significant fraction of total used bandwidth
  - Trigger rate large array forms a challenge for eventbuilding

Scalability AERA DAQ

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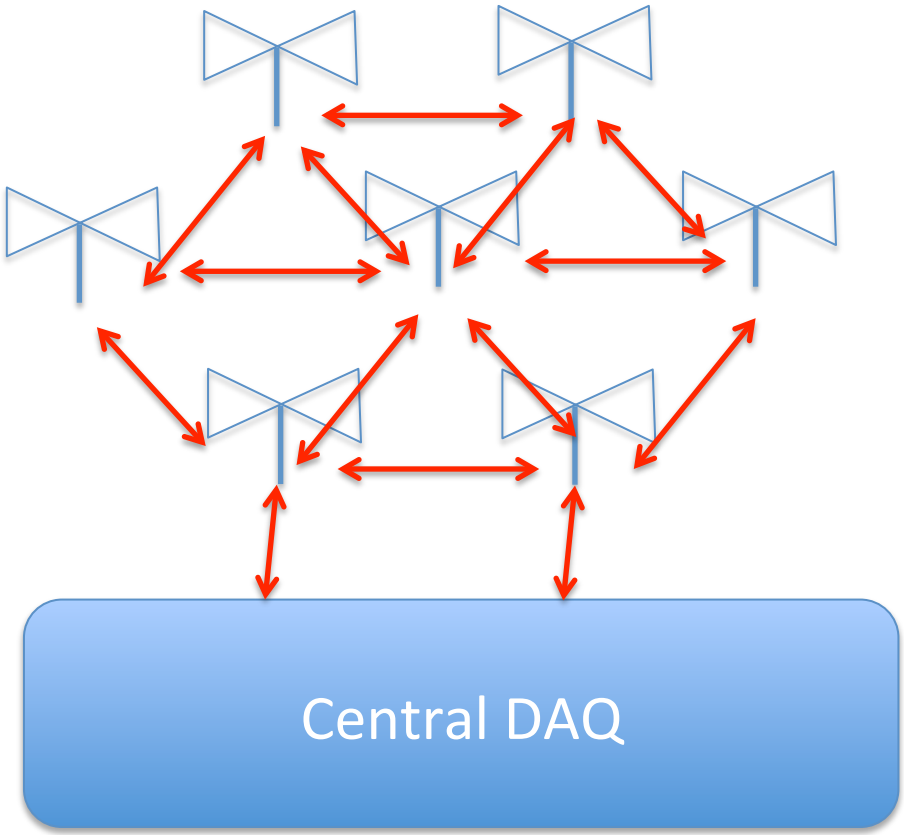
- COMMS system
  - High throughput commercial system works well
  - On board chip would decrease costs and power consumption
  - Point-multipoint solution might not scale to 90,000 units (maybe not even with many multipoints)
  - Mesh-like structure could enhance integrity of the network

Scalability Mesh-like structure

Every station communicates to nearest neighbors.

Provide many paths and short distance communications



Higher level triggering could be done in the field.

Central DAQ only needs to build event and perform monitoring tasks

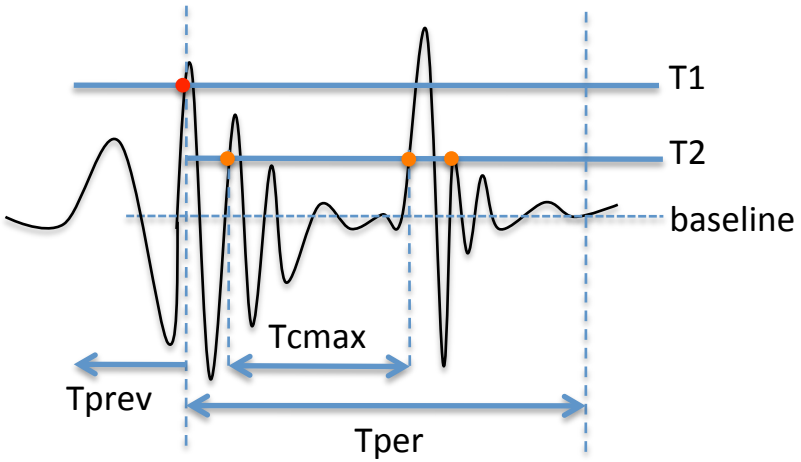
Scalability AERA DAQ

- Local Station Electronics
  - Two expensive general solutions.
  - R&D to improve self trigger needed for a GRAND-like setup
  - Simplification to a more focused version leading to simplified layout would be needed

Scalability - Self trigger

Now based upon:

- Rejection of multi-pulsed signal
- Removal of single-frequency noise
- Selection on pulse width



An additional selection based upon polarization and LDF could be added when direction and core position are known. → Requires reconstruction in the field

Summary

- AERA is making full use of its location in Auger to achieve its physics goals
- The front-end electronics of the AERA daq is universal and could be improved for a large radio array.
- The wireless configuration of AERA is with great difficulty scalable to GRAND sizes, an alternative has been shown
- Bottlenecks in the AERA DAQ software architecture make it difficult to port to GRAND scales. An alternative direction was provided