Auger@TA:
Deploying an independent Pierre Auger Observatory SD array at the Telescope Array Project

UHECR 2022

L'Aquila, Tuesday, October 4th

S. Mayotte
for the Auger@TA working group
smayotte@mines.edu

PIERRE AUGER OBSERVATORY

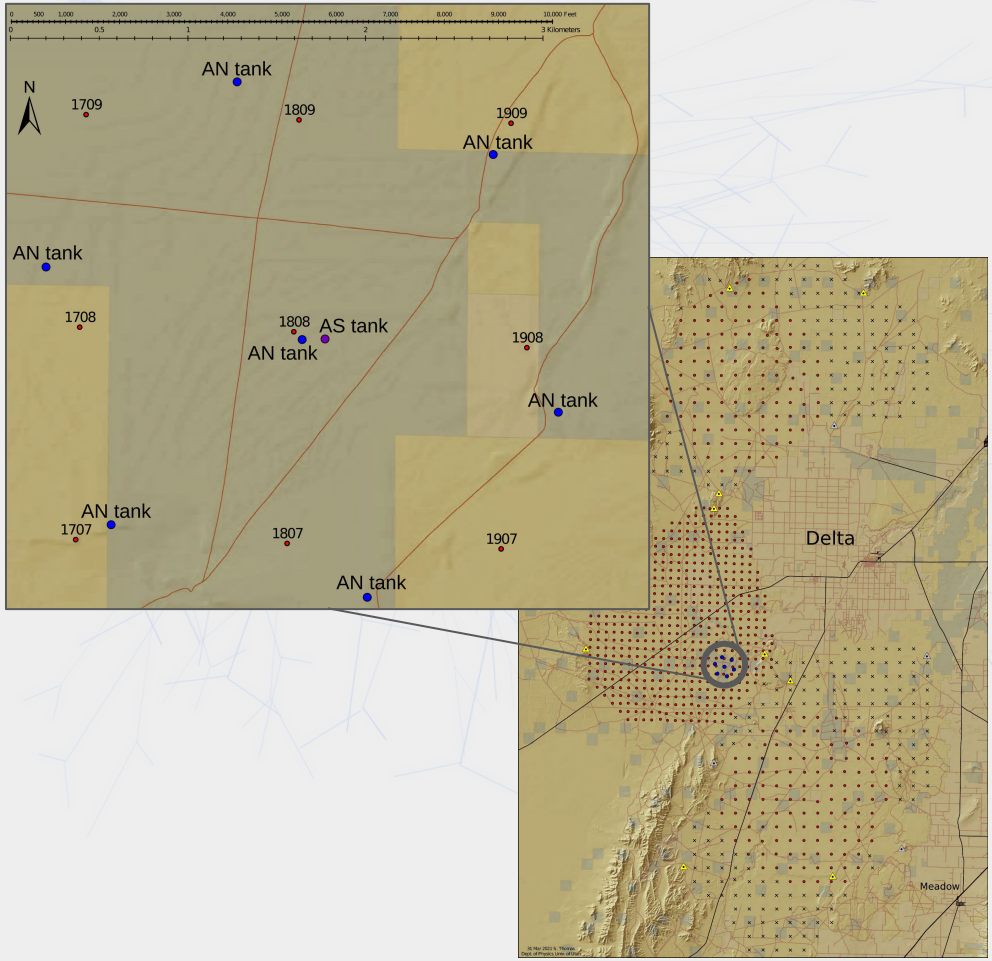
TELESCOPE ARRAY PROJECT

COLORADO SCHOOL OF MINES

The Auger@TA Working Group and Contributors

T. Arnold (Delta), A. Baum (Delta), C. Covault (CWRU), T. Fujii (KyotoU), S. Im (CWRU), R. James (CWRU), J. Johnsen (Mines), K.H. Kampert (BUW), H. Kern (KIT), J. Matthews (UU), S. Mayotte (Mines), E. Mayotte (Mines), S. Quinn (CWRU), J. Rautenberg (BUW), M. Roth (KIT), H. Sagawa (ICRR), T. Sako (ICRR), F. Sarazin (Mines), R. Sato (Malargüe), D. Schmidt (KIT), R. Takeishi (ICRR), S. Thomas (UU), G. Wörner (KIT)

Auger@TA Overview

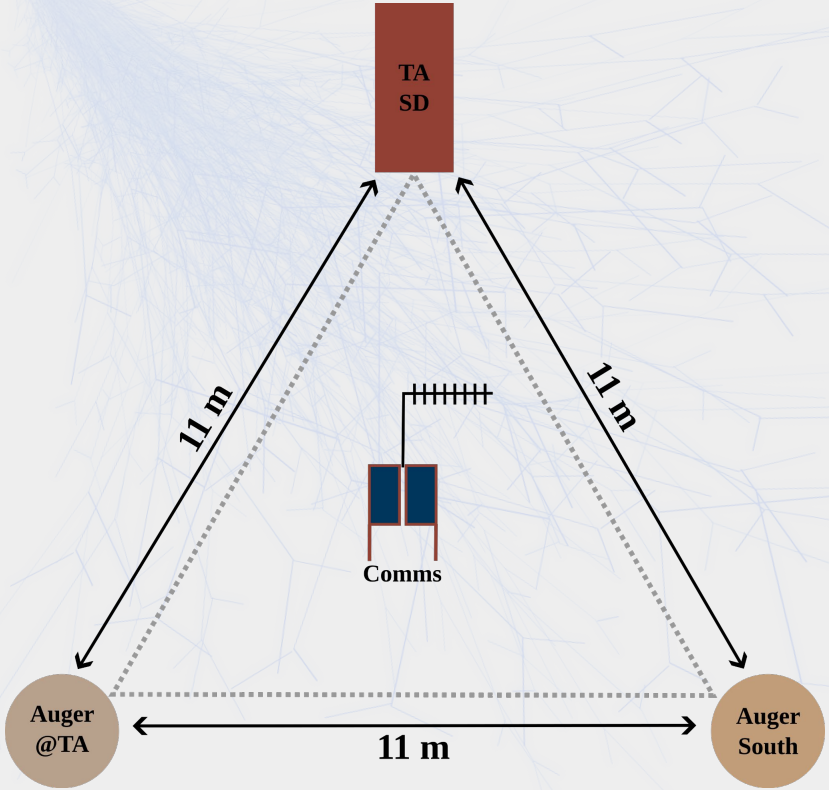


Cross-calibration of Auger and TA with an Auger-like SD Array consisting of 8 stations:

- Deployment in south-east corner of TA array
  - 7 Auger@TA (1 PMT) station (full hexagon)
  - 1 Auger South (3 PMT) station (in center)
- Fully independent trigger and measurements

➡ Feature: Auger@TA / Auger South / TA triplet

Auger@TA Overview

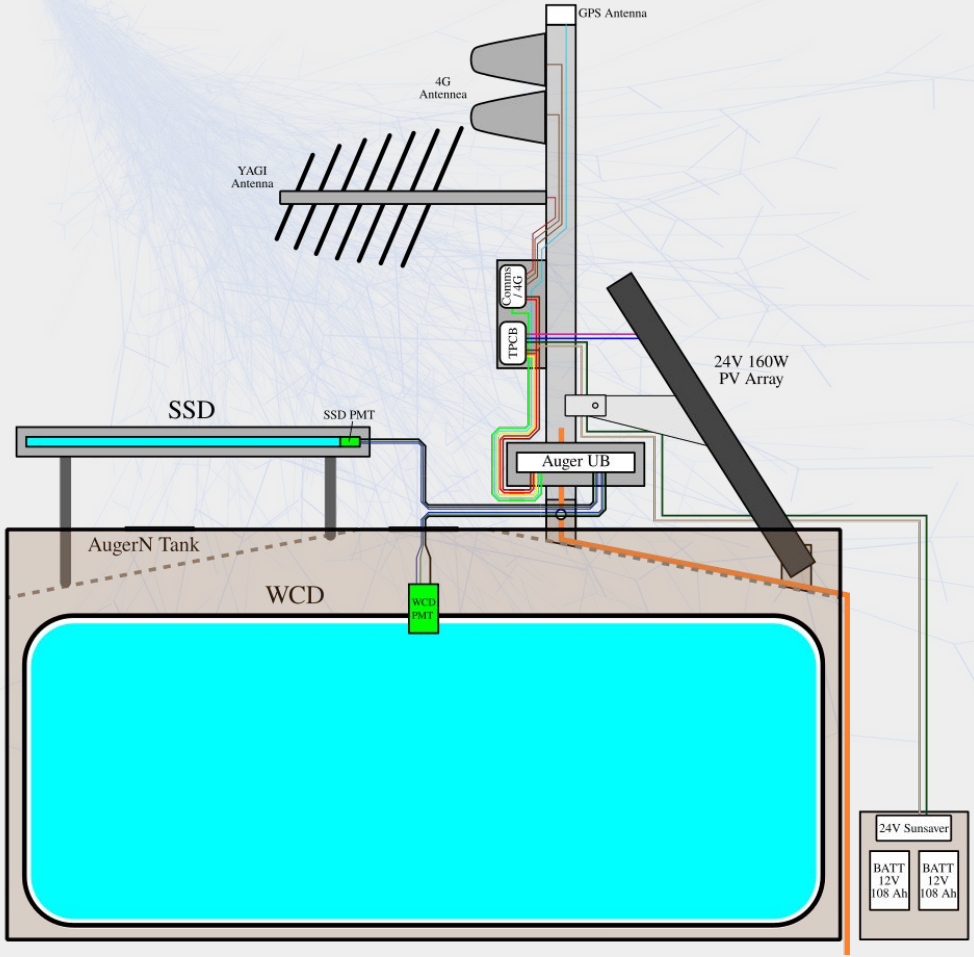


Cross-calibration of Auger and TA with an Auger-like SD Array consisting of 8 stations:

- Deployment in south-east corner of TA array
  - 7 Auger@TA (1 PMT) station (full hexagon)
  - 1 Auger South (3 PMT) station (in center)
- Fully independent trigger and measurements

➡ Feature: Auger@TA / Auger South / TA triplet

The Auger@TA Station



Design and implementation

- Retrofit of AugerNorth hardware with standard Auger components
  - Prototype AugerN tank shell
  - Single central WCD PMT with Auger base
  - Auger UB and TPCB
- Thanks to efforts of KIT/BUW an SSD will be mounted on every station
  - SSDs assembled by KIT from spare material
  - 8 new SSD supports by KIT
  - PMTs + Bases from BUW
  - SSD to UB cables from Malargüe
- Upgraded solar power system 24V/160W/216Ah
- Internet connectivity via 4G cell network/modem
- Local comms via YAGI 2-way communication
- Independent trigger and DAQ at central station

Auger@TA Motivation and Goals

- **Cross-calibration of TA SD, Auger-like WCD, and Auger SSD responses to real showers**
  - Analyze trigger efficiency, zenith dependence, and shower component dependent systematic differences between Auger and TA detectors
  - Potentially simulate TA@Auger using AugerPrime SSDs cross-calibrated with TA responses

- **Make fully independent flux measurement with self-triggering Auger-like array at TA site**
  - Directly compare flux at energies around the ankle
  - Look for systematic differences in reconstruction and trigger rate between Auger-like and TA arrays
  - Test nature of 9% spectral scale difference between Auger and TA

- **Limited high-energy events may provide opportunity to test nature of the difference in flux suppression kick-in**

Deployment:
19.09. - 30.09.

Auger@TA Deployment: 1st week

- Assembly of SSDs
- Decommission of Auger@TA phase I for re-deployment
- Inflate and inspect liners
- Clean, inspect and repair PMTs
- Prepare stations for setting of PMTs
- Organize logistics

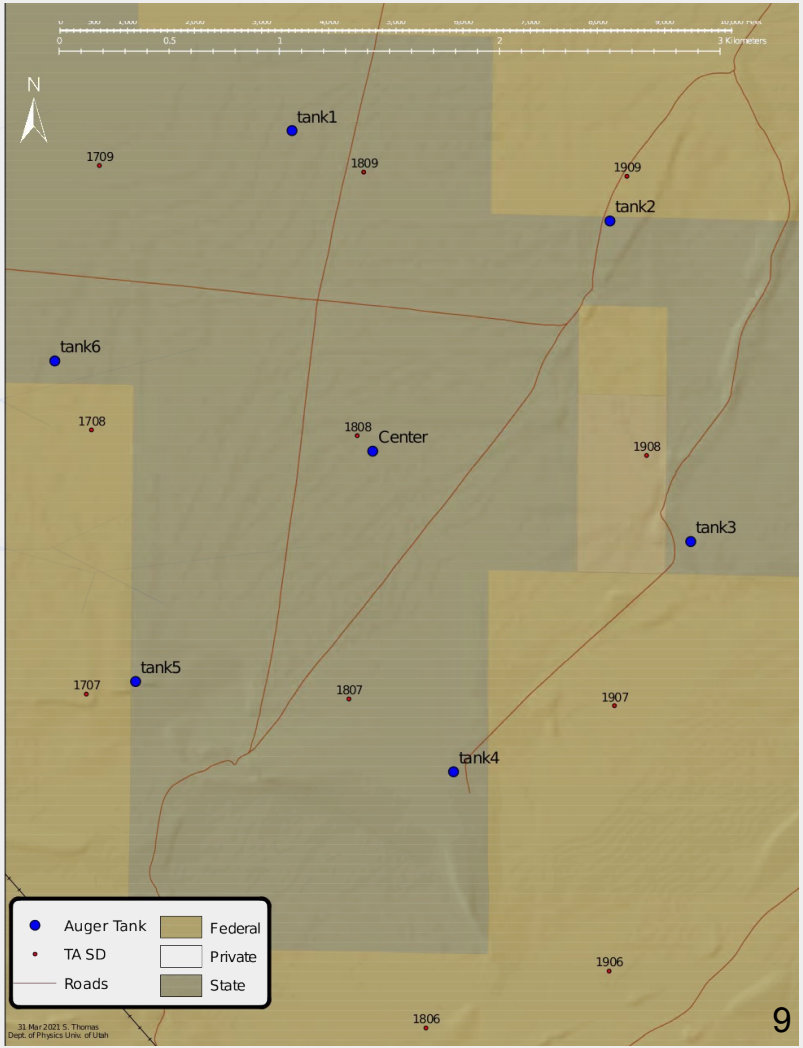
Auger@TA Deployment: Plan & Changes

Until 22.09.2022:
Federal/State Regulations affected sites

- **Motorized vehicles were not allowed off roads:**
  - Travel by foot and pulled wagon
  - Helicopter Skycrane
- **Strict wildlife protections January to August**
  - Deployment planned for late September
- **Archeological survey of each tank site performed**

Deployment Plan

- **4 teams (3 in array, 1 staging area) + Helicopter**
  - Array teams receive payload + make min install
- **Helicopter Skycrane, two flights per tank site:**
  1) WCD + Inflated Liner (PMT in) + SSD frame
  2) SSD + Mast/Solar Power + Components
- **Water delivery shortly after heli deployment**
- **Station commissioning over following week**



Auger@TA Deployment: Plan & Changes

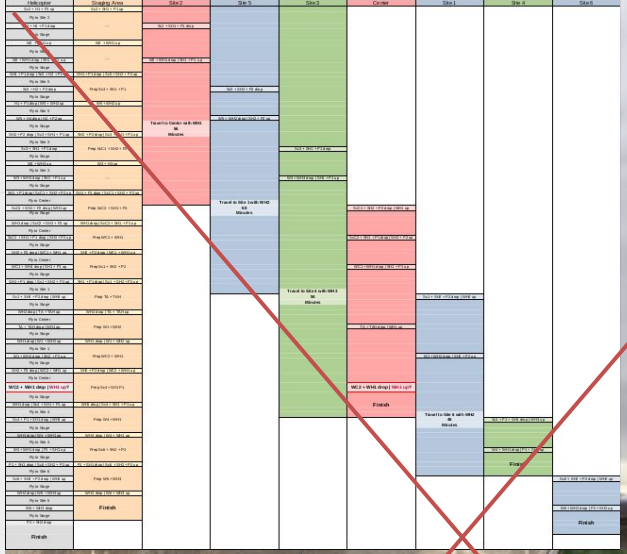
Until 22.09.2022:

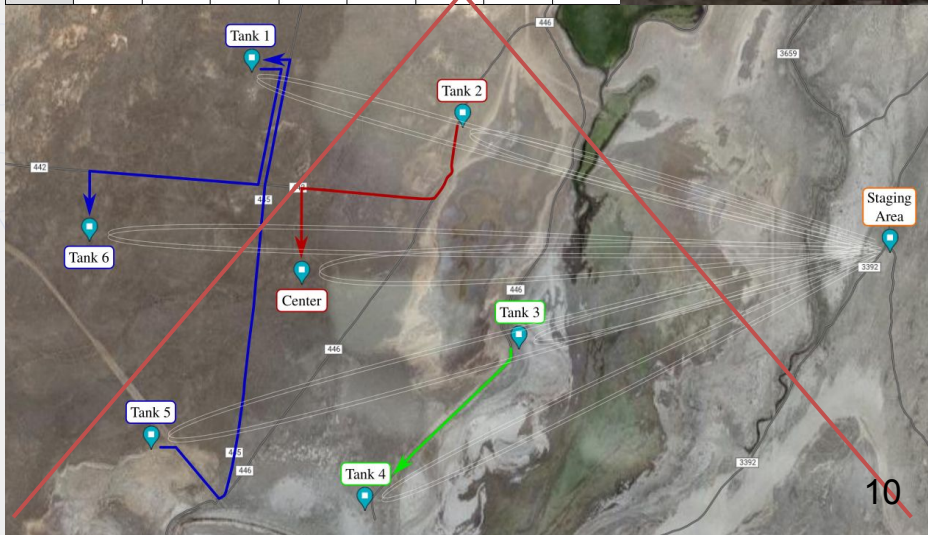
Federal/State Regulations affected sites

- **Motorized vehicles were not allowed off roads:**
  - Travel by foot and pulled wagon
  - Helicopter Skycrane
- **Strict wildlife protections January to August**
  - Deployment planned for late September
- **Archeological survey of each tank site performed**

Deployment Plan

- **4 teams (3 in array, 1 staging area) + Helicopter**
  - Array teams receive payload + make min install
- **Helicopter Skycrane, two flights per tank site:**
  1) WCD + Inflated Liner (PMT in) + SSD frame
  2) SSD + Mast/Solar Power + Components
- **Water delivery shortly after heli deployment**
- **Station commissioning over following week**





Auger@TA Deployment: Plan & Changes

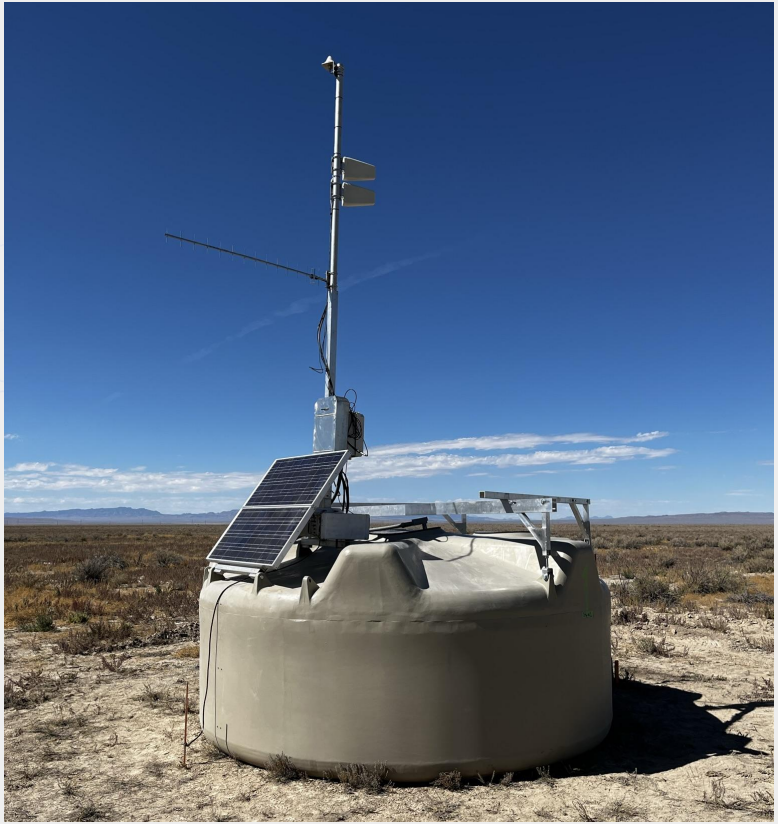
New Deployment Plan

- **Instead of helicopter skycrane deploy tanks via truck**
  - Deploy as many tanks per day as possible
  - Alternate with component drop-off for commissioning
- **Water delivery happening over next week**
- **SSD + PMT deployment later this year**
- **Final comms deployment as soon as components are available**

Auger@TA Deployment: In the field

Auger@TA Deployment: Current Status

Site	Station deployed	Components commissioned	Electronics deployed	SSD deployed
CN	✓	✓	✓	✗
CS	✓	✓	✗	✗
CT	✓	✓	✗	✗
1	✓	✓	✓	✗
2	✓	✓	✗	✗
3	✓	✓	✓	✗
4	✓	✓	✓	✗
5	✓	✓	✓	✗
6	✓	✓	✓	✗
Comms	✓	✓	✓	–



Simulation Status
&
Expected Performance

Simulation Status & Quality Cuts

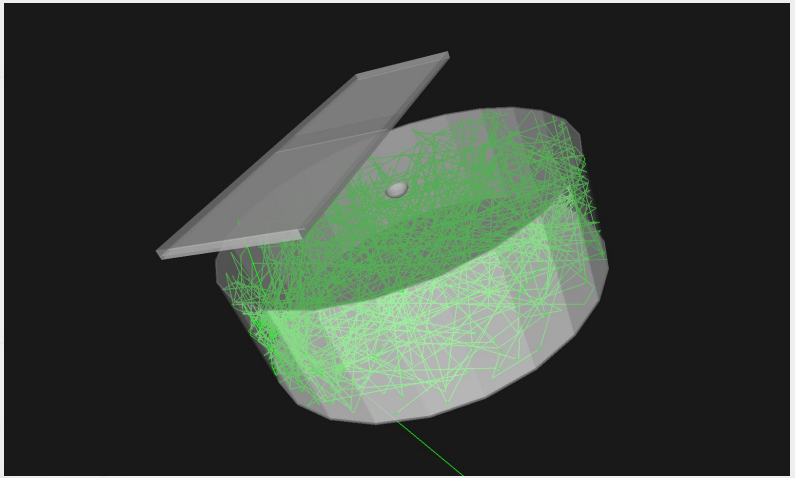
Simulation status

- Auger@TA detector simulation with Offline in place
- Napoli/praha CORSIKA showers in range

$$E_{MC} \in 18.0 - 19.0 \log_{10}(E/eV)$$

- Throw in 5 x 5 km square around central hexagon for Single Hexagon and Full Auger Array
- Same random seeds/shower for each generated event for each detector configuration

➡ Allows 1:1 comparison

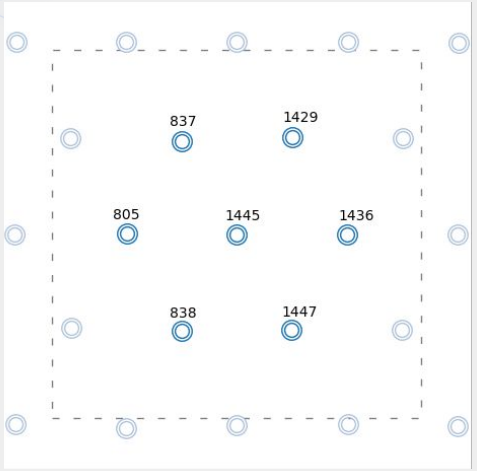


Necessary quality cuts for future analysis

- Events falling outside of Hexagon under-reconstruct energy w.r.t. Full Auger Array
- Events falling on hexagon border over-reconstruct energy w.r.t. Full Auger Array

➡ Optimized cut on shower core distance to central station

$$R_{center} \leq 1125m$$



Simulation Status & Quality Cuts

Simulation status

- Auger@TA detector simulation with Offline in place
- Napoli/praha CORSIKA showers in range

  $E_{MC} \in 18.0 - 19.0 \log_{10}(E/eV)$
- Throw in 5 x 5 km square around central hexagon for Single Hexagon and Full Auger Array
- Same random seeds/shower for each generated event for each detector configuration

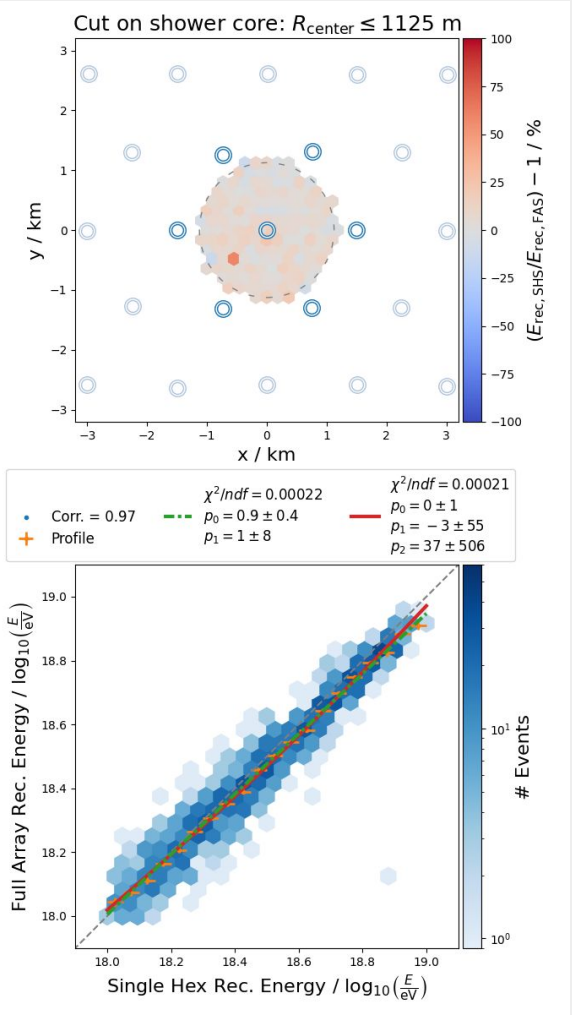
  ➡ Allows 1:1 comparison

Necessary quality cuts for future analysis

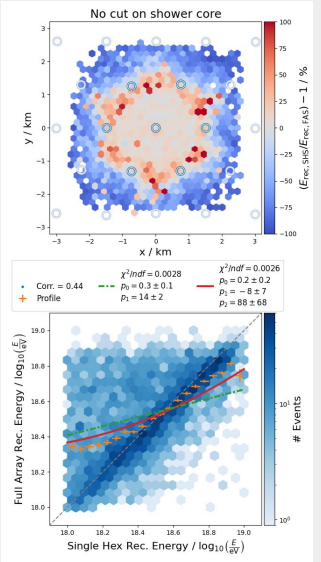
- Events falling outside of Hexagon under-reconstruct energy w.r.t. Full Auger Array
- Events falling on hexagon border over-reconstruct energy w.r.t. Full Auger Array

➡ Optimized cut on shower core distance to central station

$R_{center} \leq 1125$m



Uncut



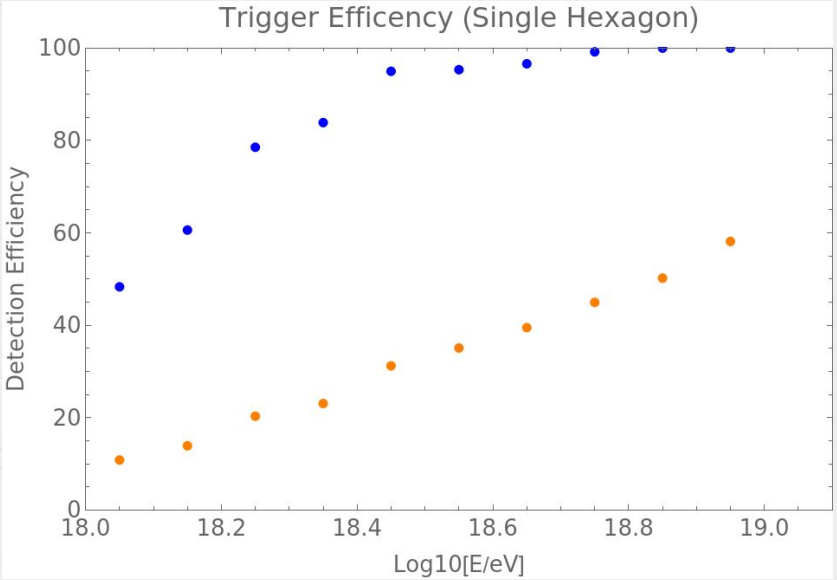
Single Hexagon Trigger Efficiency and Projected Event Rate

- Calculate trigger efficiency of Single Hexagon array for each energy bin for
  - Full 5 x 5 km square
  - Events falling inside 1.125km circle (high quality)

  ➡ Fully efficient around the ankle
- Calculate expected event rate for each case

  ➡ Expected event rate: ~120 high quality events/yr with E > 1 EeV

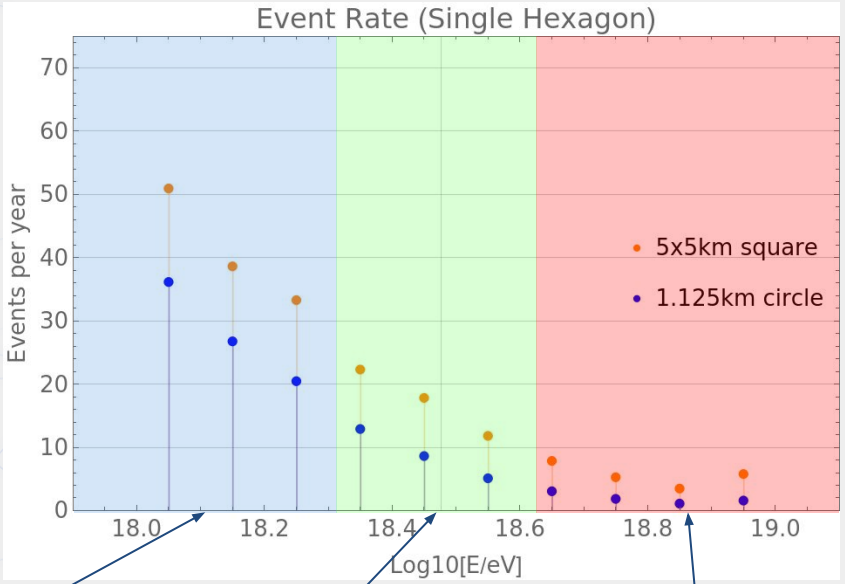
Area	Events per year
5x5 km	197
R ≤ 1.125 km	117



Single Hexagon Trigger Efficiency and Projected Event Rate

- Calculate trigger efficiency of Single Hexagon array for each energy bin for
  - Full 5 x 5 km square
  - Events falling inside 1.125km circle (high quality)
  - ➡ Fully efficient around the ankle
- Calculate expected event rate for each case
  - ➡ Expected event rate: ~120 high quality events/yr with E > 1 EeV

Area	Events per year
5x5 km	197
R ≤ 1.125 km	117



low *E* station by station cross-calibration

direct comparison of Northern flux with Auger-like and TA arrays

investigation of energy-dependent station response differences

Thank you!
Questions?