



# Reconstruction of Air Shower Events Measured by the Surface Detectors of the TAx4 Experiment

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For ICRC 2021 @ Berlin, Germany





# Telescope Array Collaboration

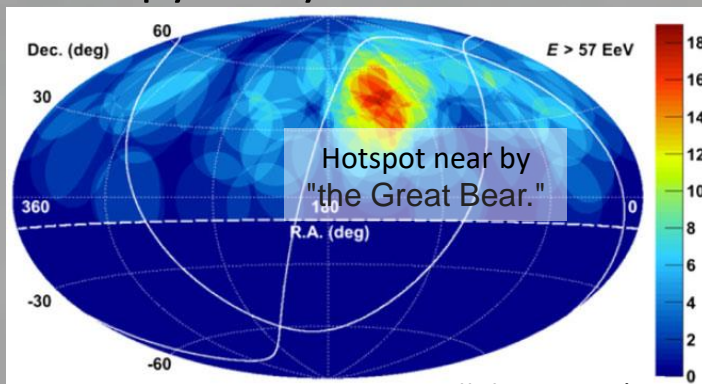
## Telescope Array Collaboration

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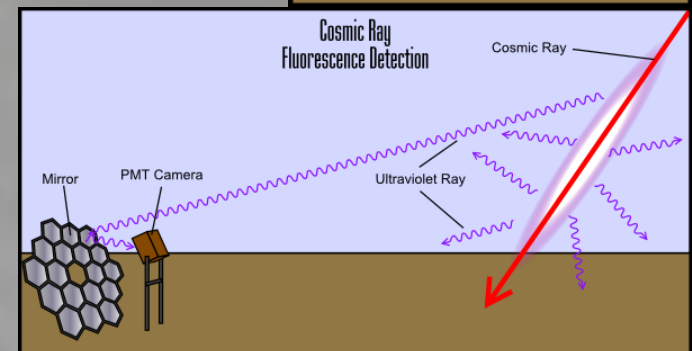
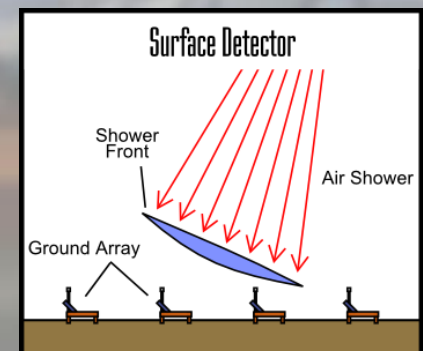


# Telescope Array

- To study Ultra-High Energy Cosmic Rays(UHECRs) from Extensive Air Showers
  - **Indirect measurement**
- TA experiment, the hybrid detection with two representative detection scheme
  - Surface Detector, detect secondary particles
  - Fluorescence Detector, detect UV
- Anisotropy study

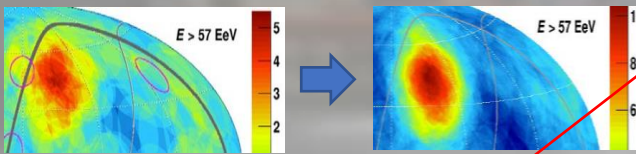


TA collaboration (2014)



# Telescope Array x 4

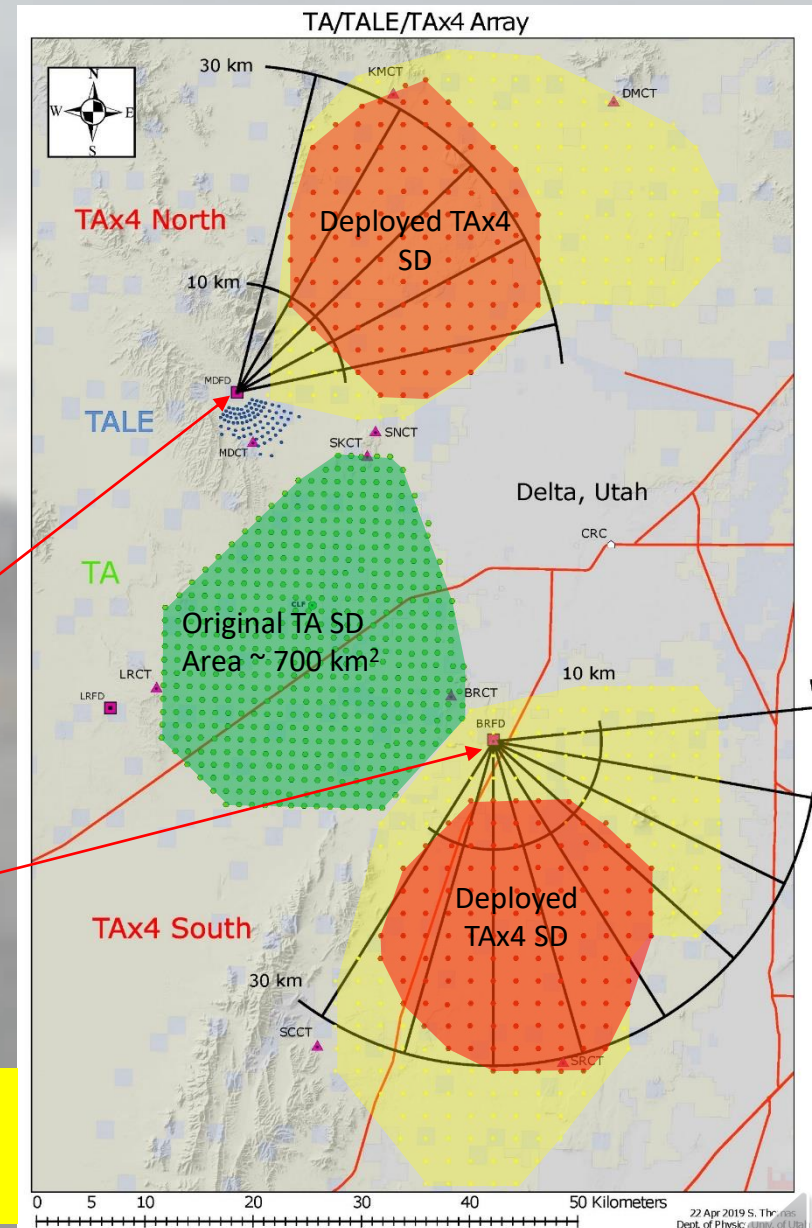
- To increase the statistics, **TAx4** is suggested as an extension of TA
  - Originally 4 times broader than TA
  - TA (~700km<sup>2</sup>)
  - > TA+TAx4 (~3,000km<sup>2</sup>)



Expected to improve significance

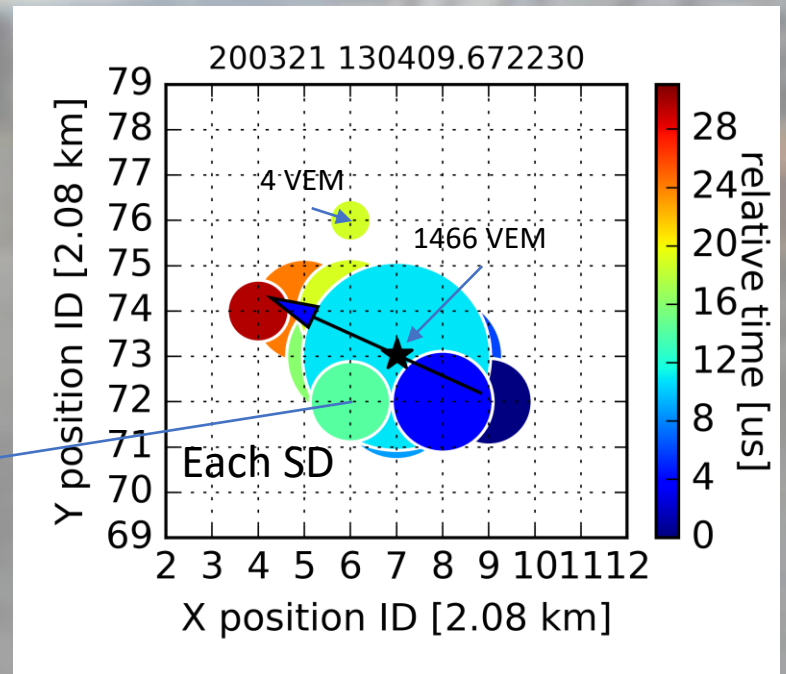
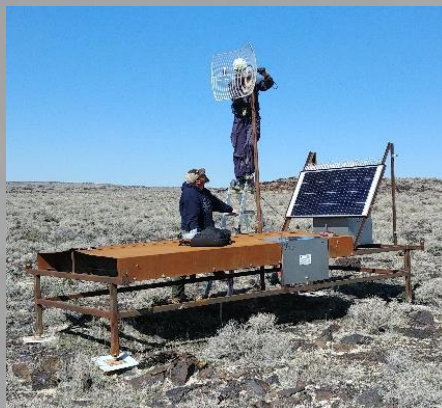
- 257 SD units had been deployed in early 2019 (Red points on the map)
- > **in total 1700 km<sup>2</sup>**
- 2 FD stations had been constructed (magenta squares)

Details about construction in talk ID 375, by E. Kido in this ICRC2021



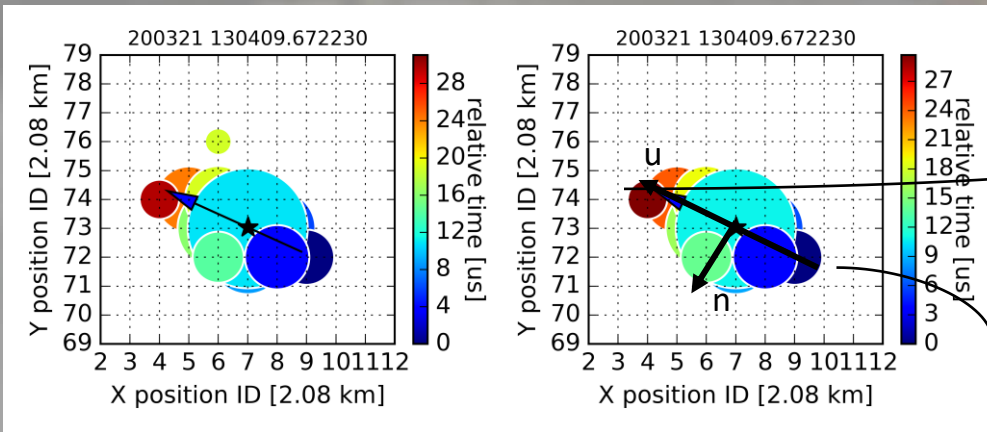
# Reconstruction procedure

- Example of signal from Surface Detectors
- 11 SDs triggered by 1 event
  - Area :  $\log(\text{Signal intensity})$
  - Color : relative time
  - VEM(Vertical Equivalent Muon)  
Signal intensity by single vertically hit muon



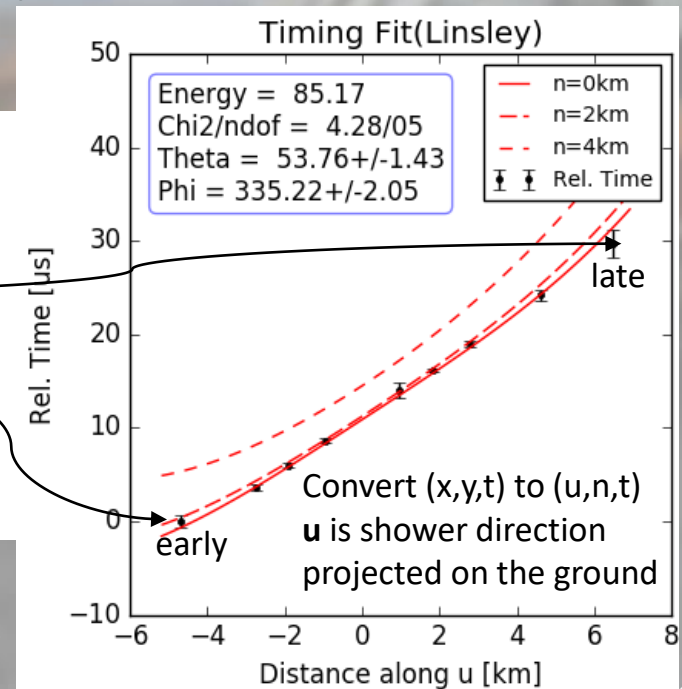
# Geometry Fit Result

- Example event at 200321.130409.672230
- All signals (left) and signals in S-T cluster (used in timing fit) by pattern recognition code (middle)
- Timing fit result (right)



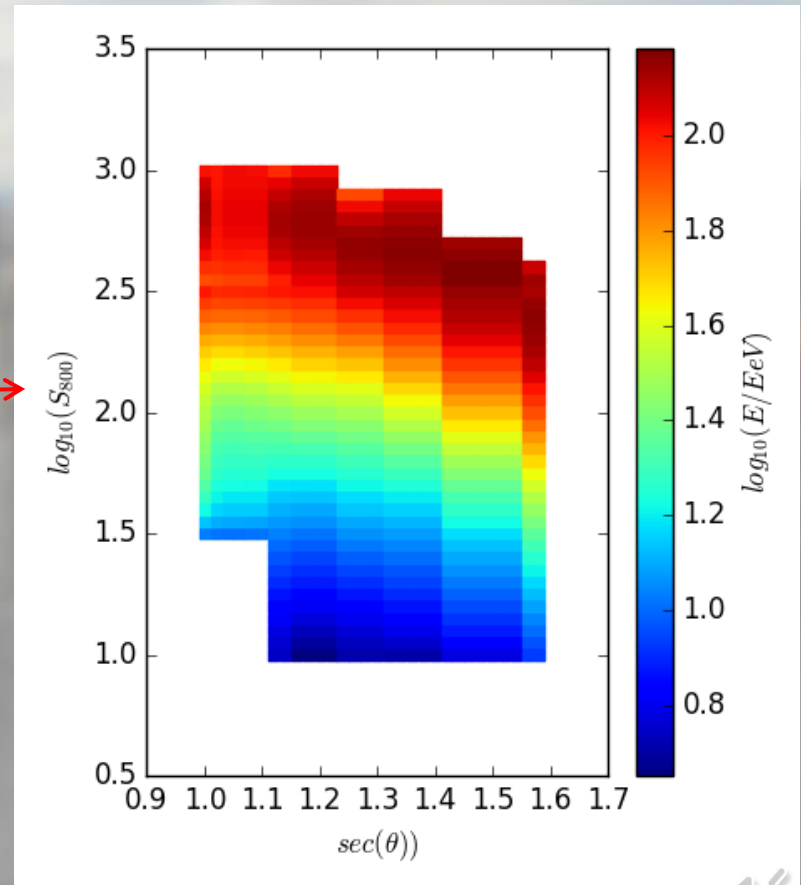
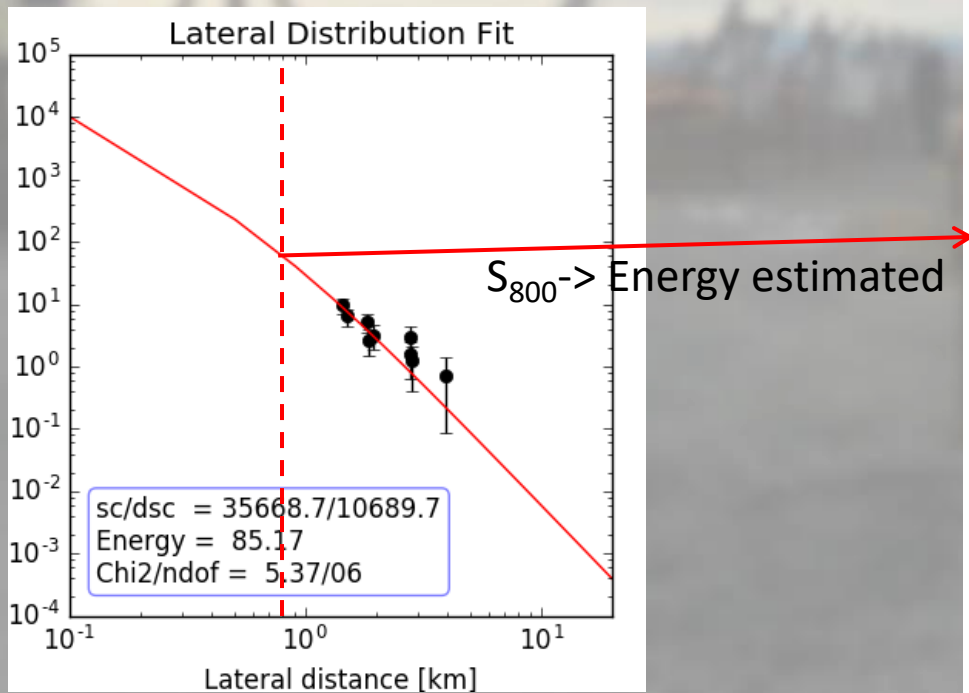
All signals

In S-T cluster  
(used during fitting)



Convert (x,y,t) to (u,n,t)  
u is shower direction  
projected on the ground

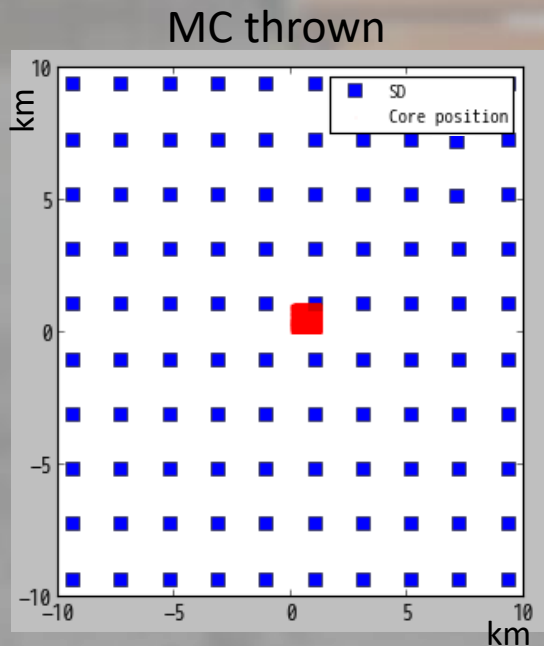
# Lateral Distribution Fit



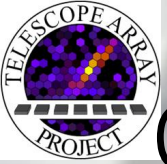


# MC Simulation

- AS generation: CORSIKA ver.7.3500
- Hadronic interaction model : QGSJETII-03
- 10x10 ideal grid array
- Primary proton assuming flux  $\sim E^{-3}$
- X, Y core location is 0~1 km (uniformly)
- Generated zenith angle  $< 60^\circ$





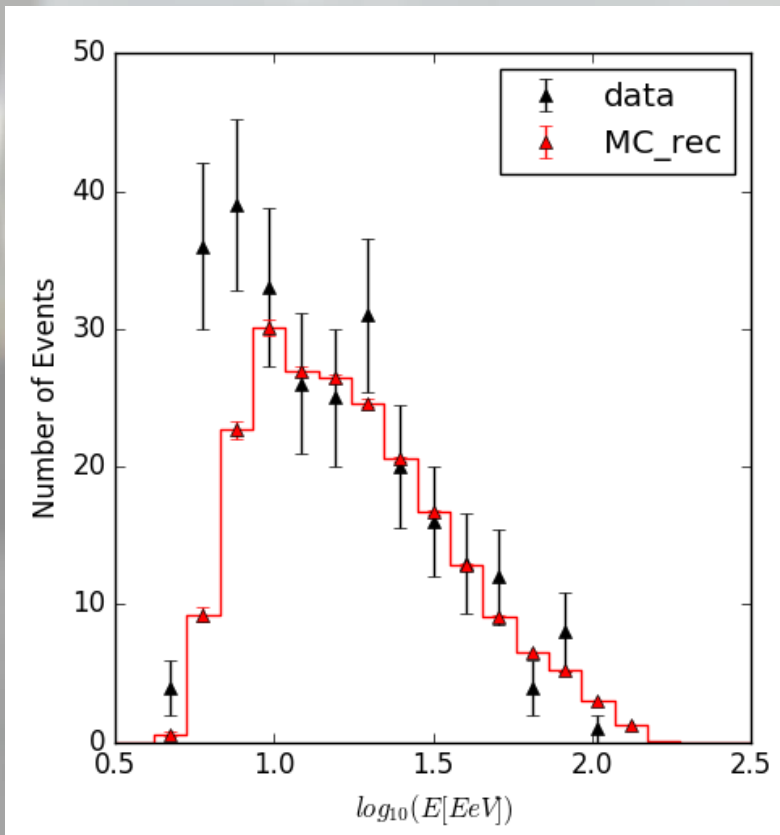


# Quality cuts

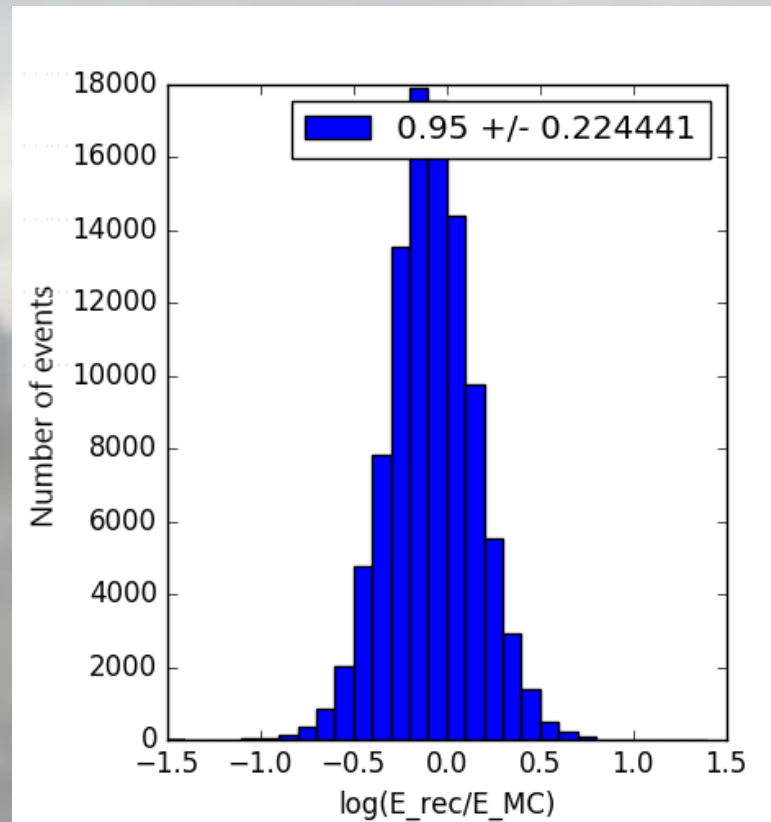
- To improve energy resolution and exclude misreconstructed events, five quality cuts is applied.
  - QC1:  $N_{SD} \geq 4$
  - QC2: Zenith angle  $< 55$  deg
  - QC3:  $\chi^2/ndof < 4$
  - QC4: Pointing direction error  $< 8$  deg
  - QC5:  $\sigma_{S800}/S800 < 0.5$



# Energy distribution with QC 5



Data: Nov. 1<sup>st</sup>, 2019. ~ Oct. 31<sup>st</sup>, 2020.



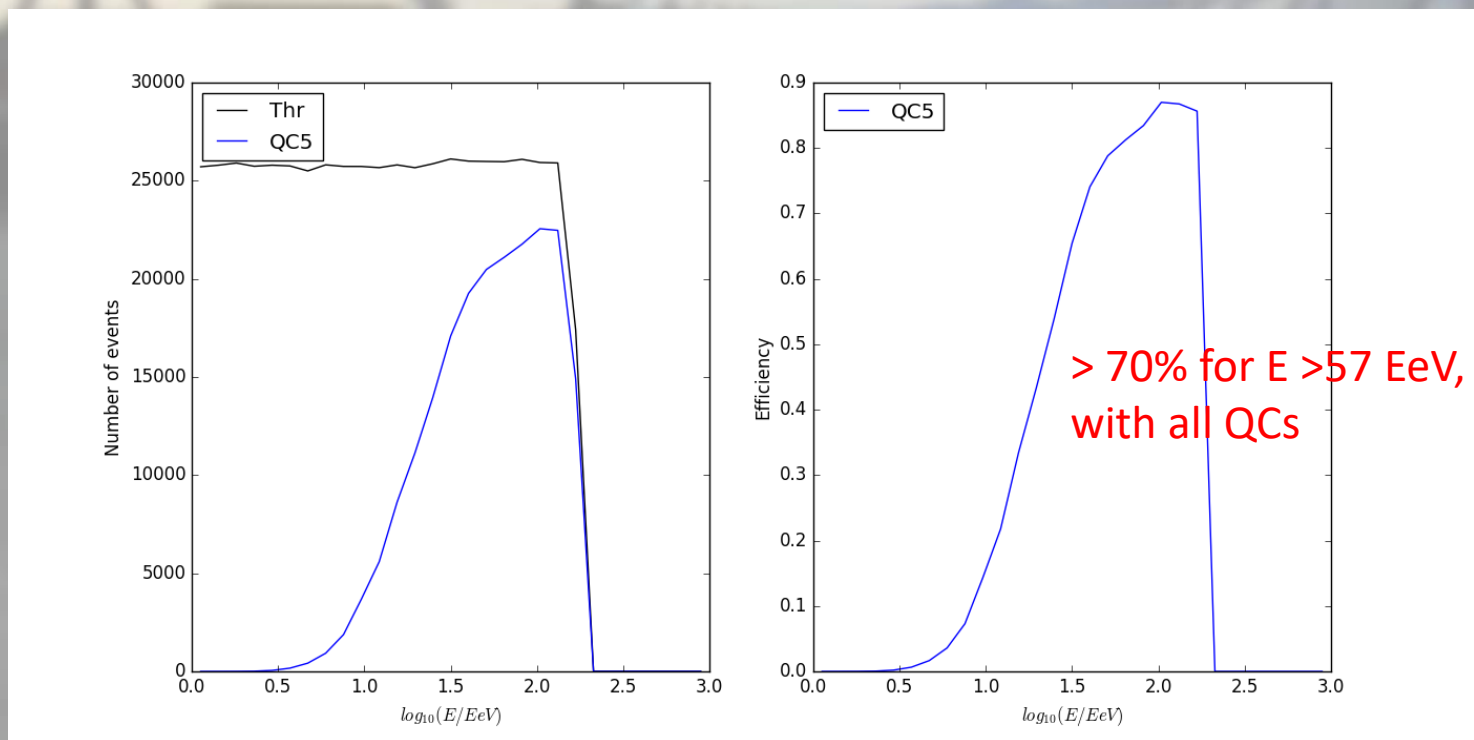
Energy resolution = RMS error of  $E_{rec}/E_{MC}$   
 -> 22.4% for  $E > 57 EeV$

✂ For the details of the MC/Data comparison, please see poster ID 890 by K. Fujisue



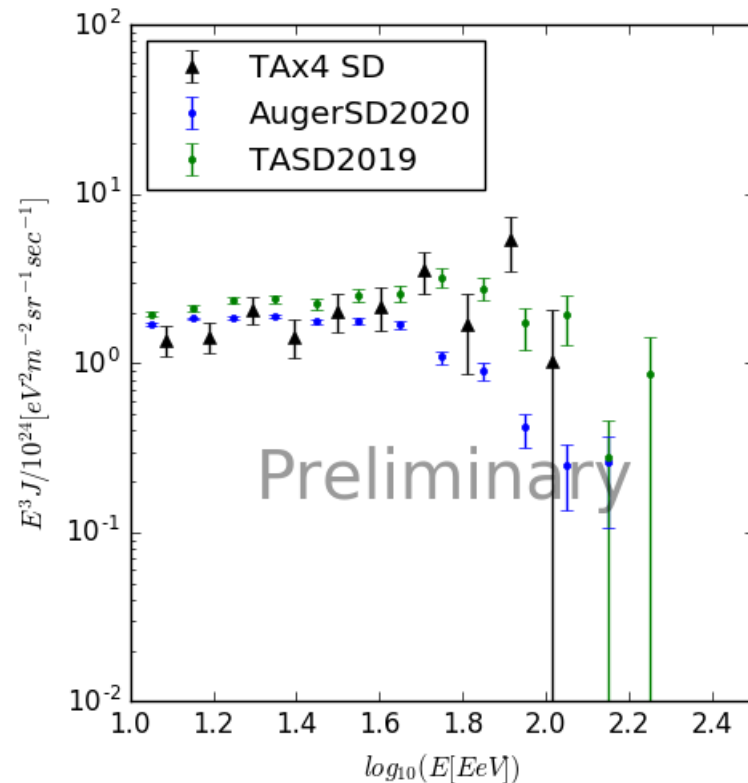
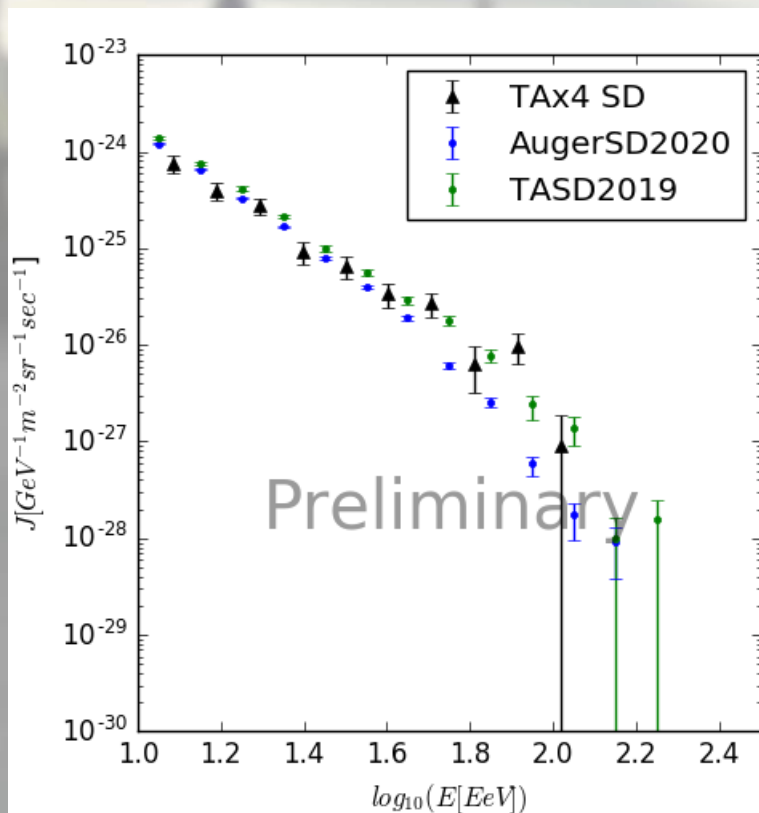
# Quality Cut Efficiency from thrown MC

- Left: The number of thrown (black) and passed QCs(blue)
- Right: Efficiency (passes QCs)



# Preliminary Spectrum by TAx4 SD

- $J(E)$  and  $E^3J(E)$  shown with recent other experiment data





# Summary

- TAx4 SD has successfully operated more than 1 year.
- Event reconstruction method of the TAx4 is developed by the experimental data and the MC simulation.
- The energy resolution of the TAx4 is estimated to be 22% above 57 EeV assuming that all SDs are available under the ideal condition.
- Preliminary energy spectrum measured by the TAx4 is overall consistent with previous works.





TA ALL MEETING@Pyeongchang, 2019, Korea

Thank you