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Current status of the TAx4 surface detectors

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Pioneering Research

Outline

- Motivation
- Current status of the TAx4 experiment
- Future developments of the TAx4 experiment
- Summary

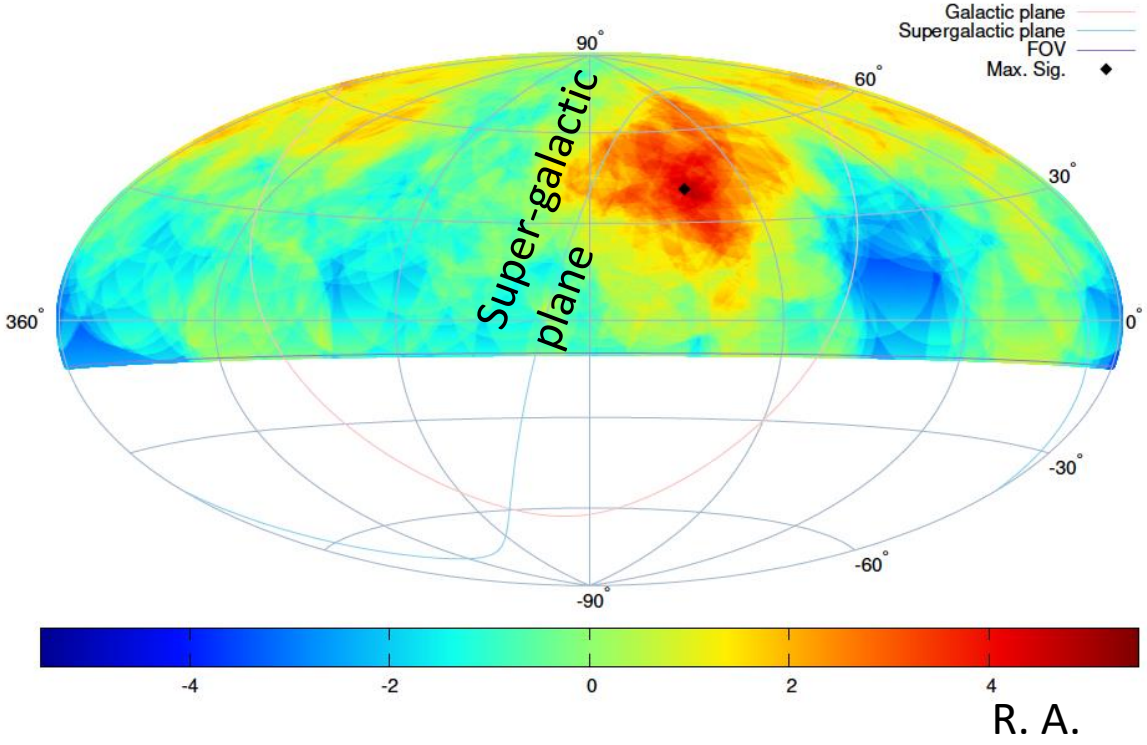
Anisotropy in the arrival directions

TA SD 14 years data

J.H. Kim
this conference

E > 57 EeV hotspot

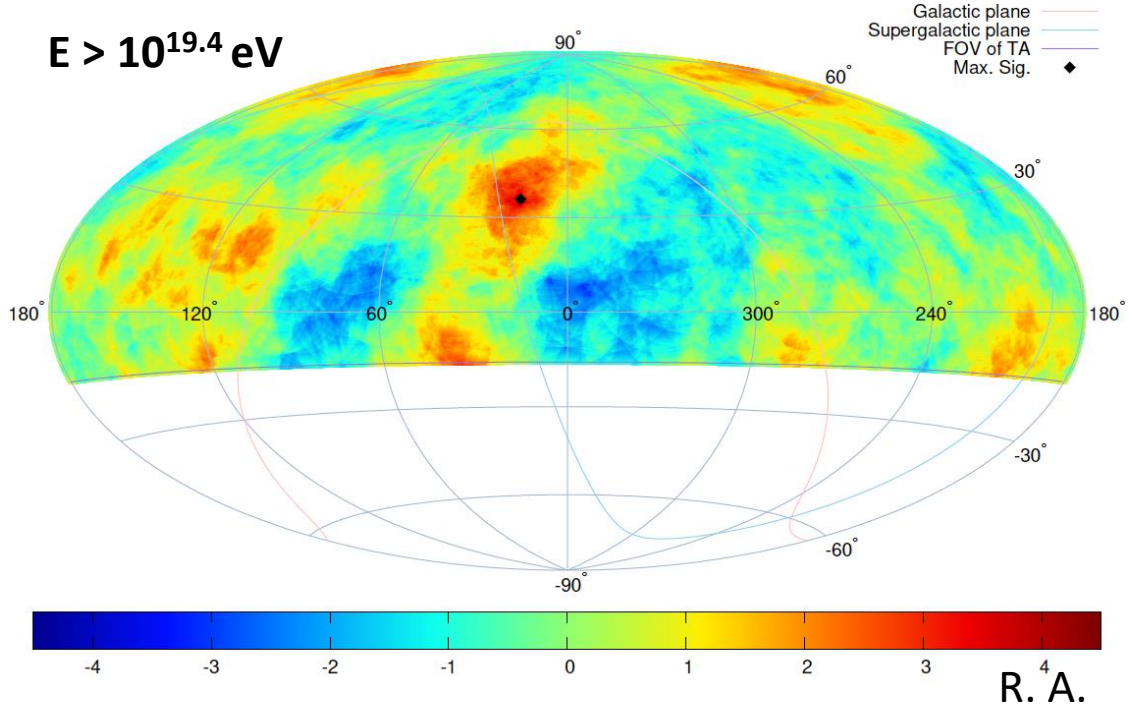
Significance map from isotropy expectation



Global significance: **3.2σ**

E > $10^{19.4, 19.5, 19.6}$eV new excess

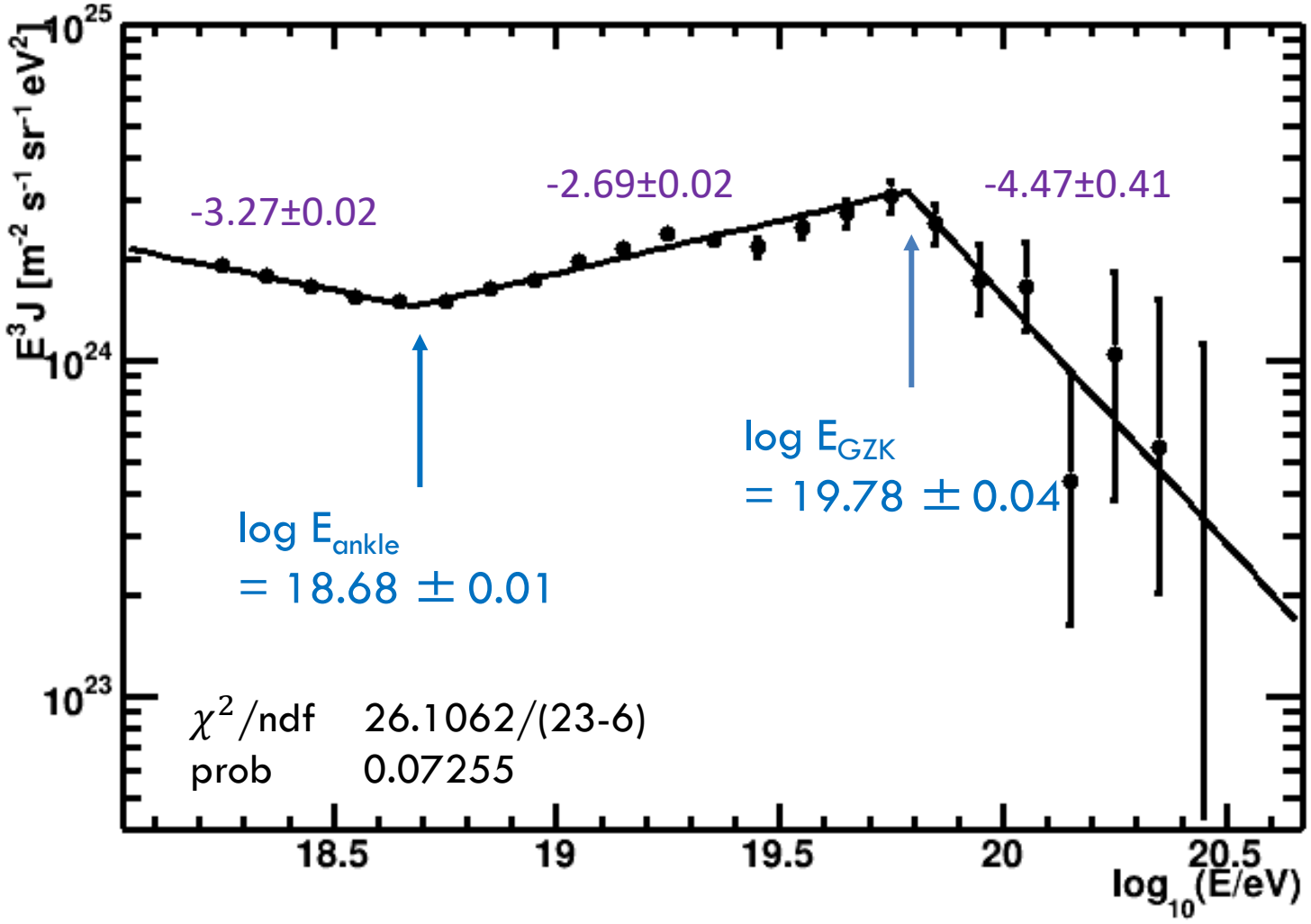
Significance map from isotropy expectation



3.2σ excess close to
Perseus-Pisces supercluster

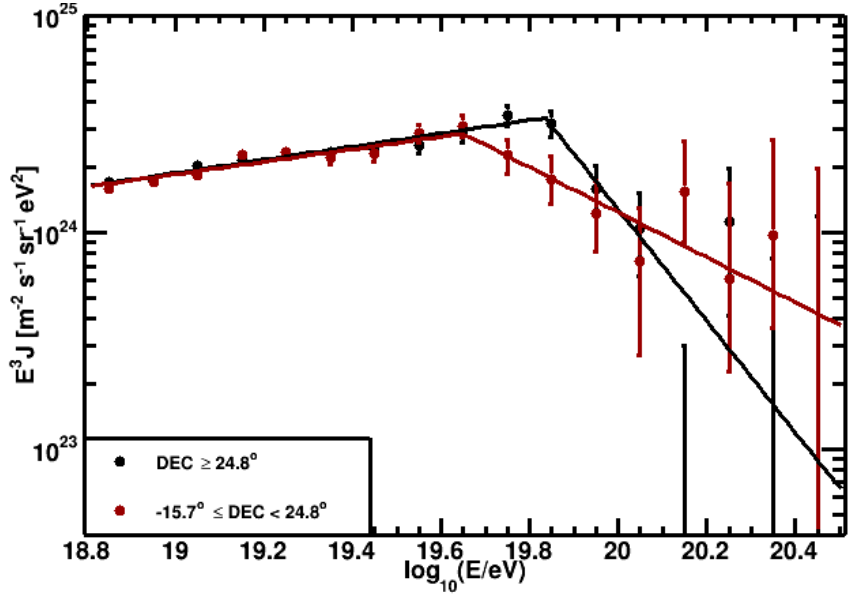
Declination dependence in the energy spectrum

TA SD 14 years data



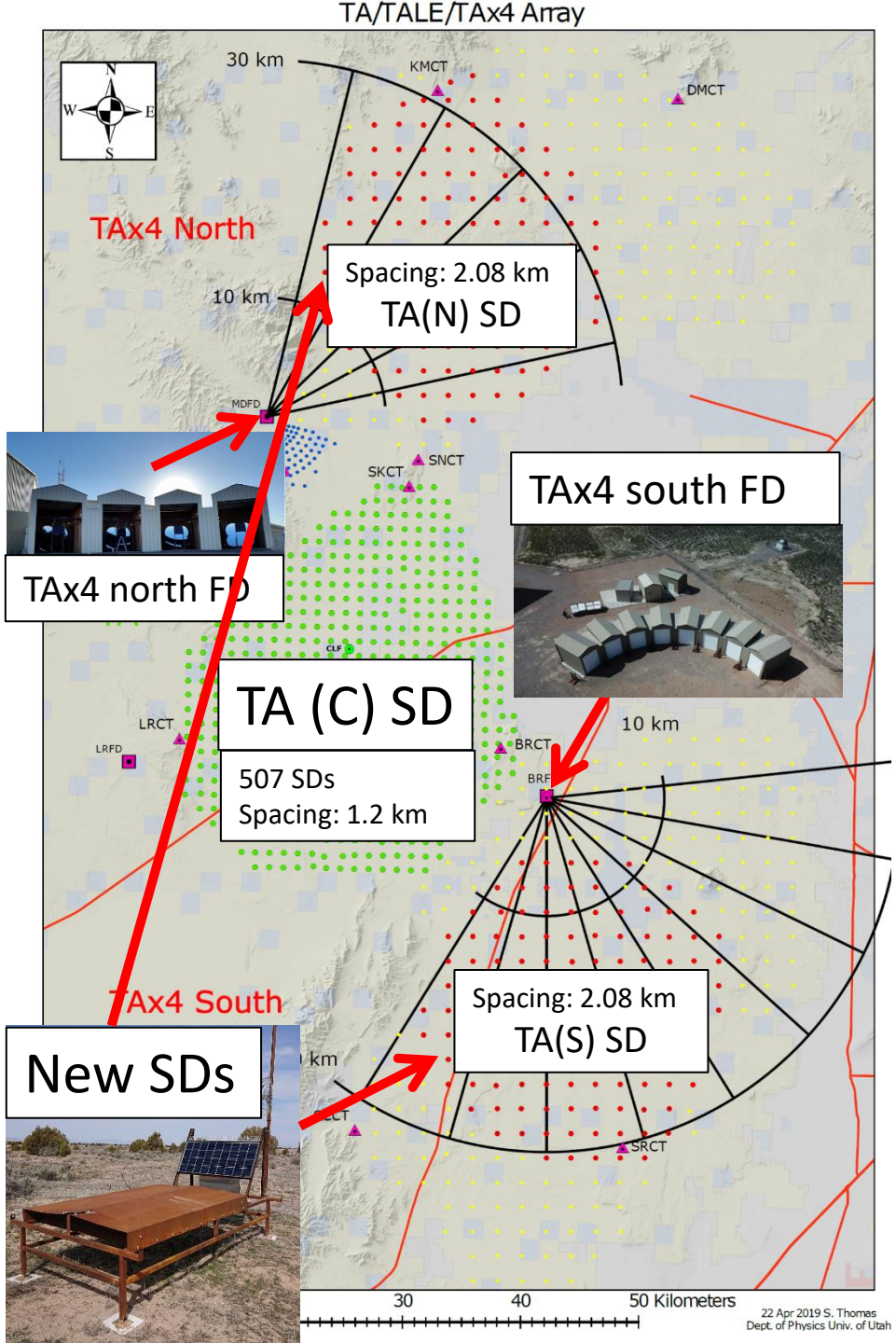
S. Ogio
this conference

Declination Dependence



- Differences in the cutoff energies
  - log(E/eV)=**19.84 ±0.02** for (24.8°–90°)
  - log(E/eV)=**19.65 ±0.03** for (-16°–24.8°)

The TAx4 experiment



In order to examine the implications of anisotropy at the highest energies obtained by TA, TAx4 was developed to accelerate the pace of data collection at the highest energies.

TA(C) 507 SDs (1.2 km spacing) continue to run from 2008.

500 new SDs with **2.08 km** spacing

New SDs (TA (N+S)) and TA (C) SDs totally cover

4 × TA SD detection area (~2800 km^2)

More than half of the new SDs (**257 SDs**) were deployed in 2019.

Deployed SDs are running stably from 2019 Nov.

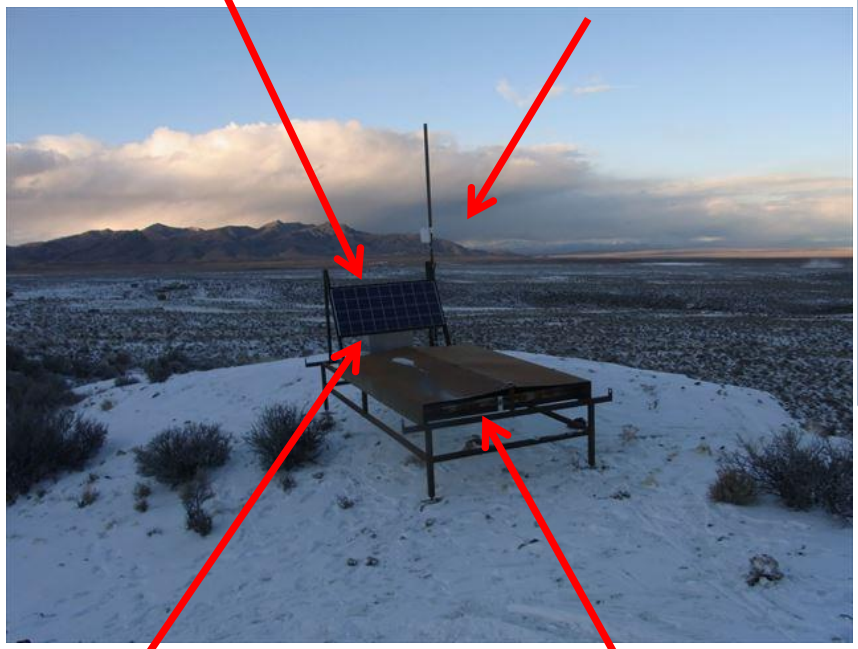
2 new Fluorescence Detector (FD) stations (4+8 HiRes Telescopes)

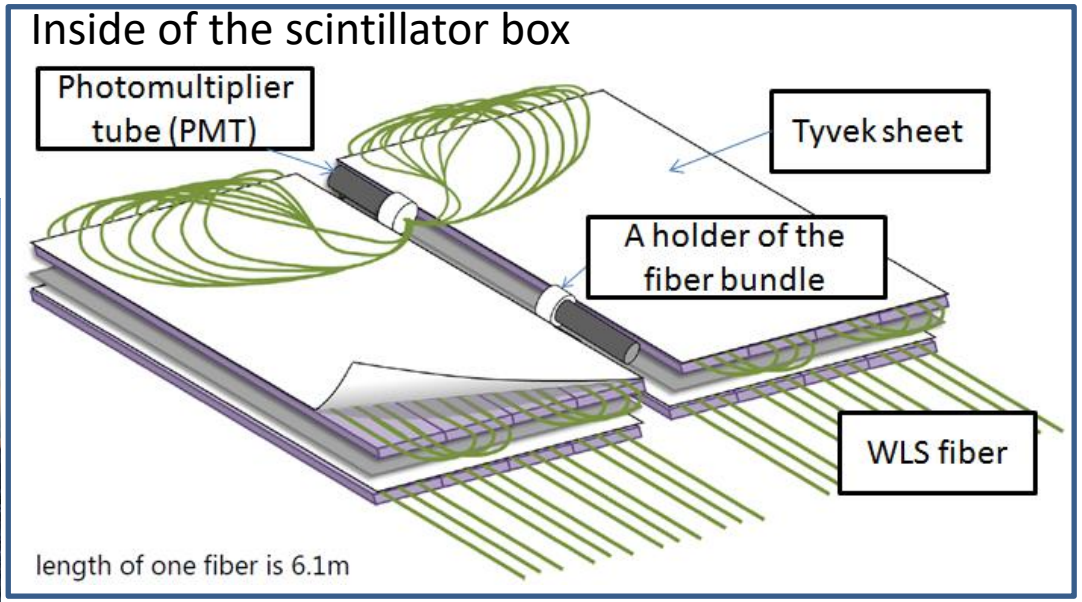
FD(north): stable run from 2018 Jun.

FD(south): stable run from 2020 Sep.

Construction of the new power line of the south FD station was finished in 2022 May for the stable operation.

Design of the TA northern (N) and southern (S) SDs





- **2 layers 3 m^2 1.2 cm thick plastic scintillators**

→ Calibration of signals using single muons

- Data acquisition from the communication towers using 2.4 GHz wireless communication (**Wi-Fi protocol**)

PMT and arrangement of WLF fibers was changed from TA SD for cost reduction and easier construction

Single peak: **23 p.e.** in average (～ **0.9 x TA SD**)

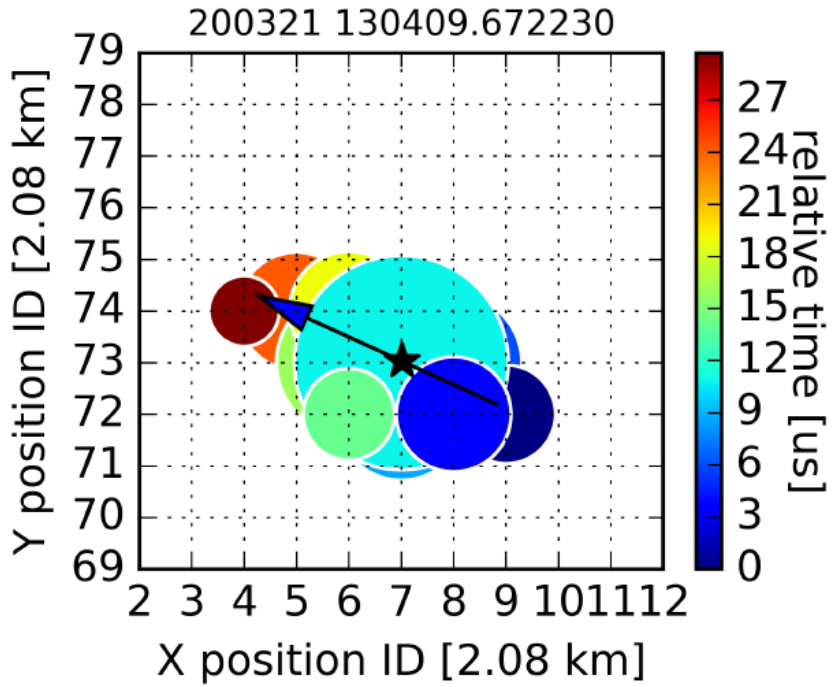
Non-uniformity: **< 15 %**

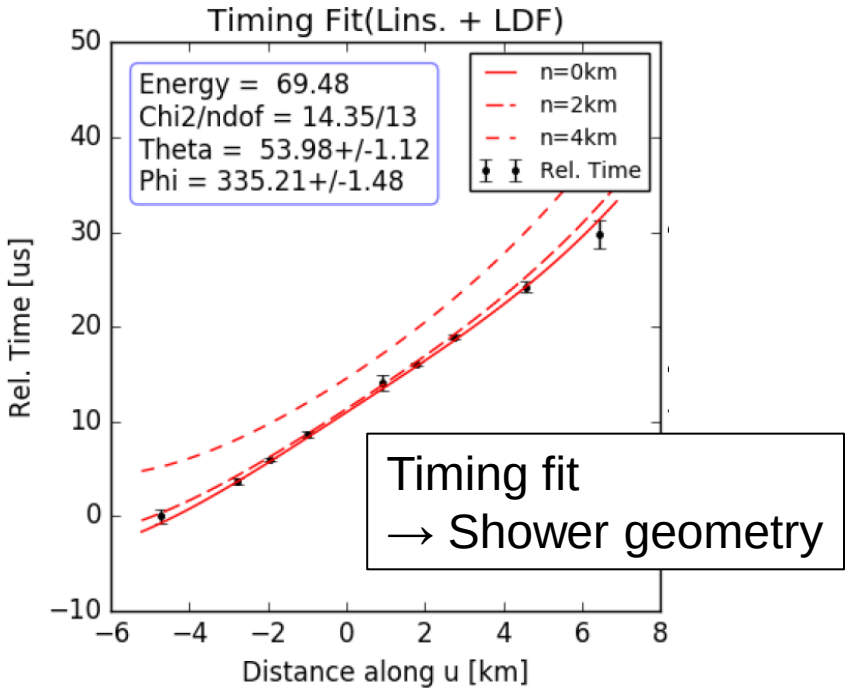
Pulse linearity: 50 mA (～**2 x TA SD**)

Operation of new SDs (TA (N+S))

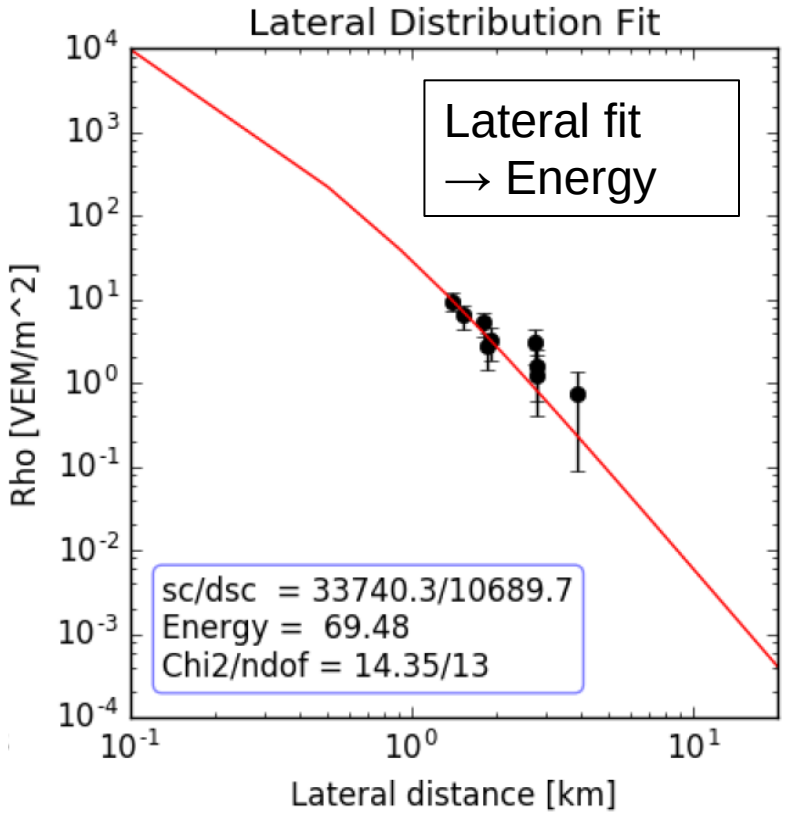
- SDs were maintained mainly by technical staff from the University of Utah and from the University of Tokyo in the situation of coronavirus from the end of 2019.
- Many collaborators visited the observation site to improve the signal strength of wireless communication for the data acquisition and solve some issues with the charge controller electronics in August → Issues of most of the SDs were solved.

Analysis with new SDs (2.08km spacing, 257 SDs)

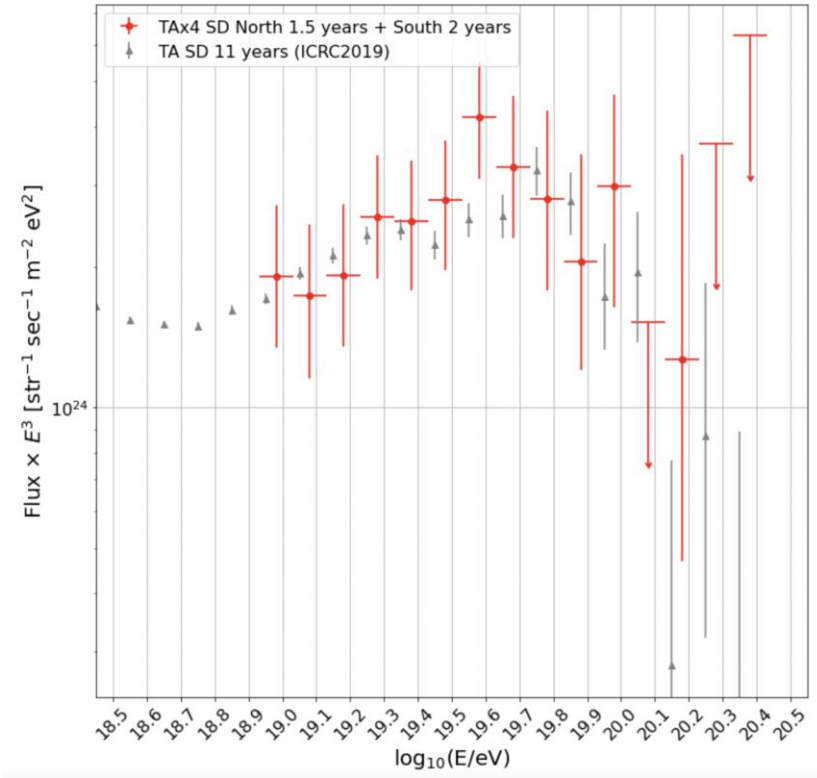




Timing fit
→ Shower geometry

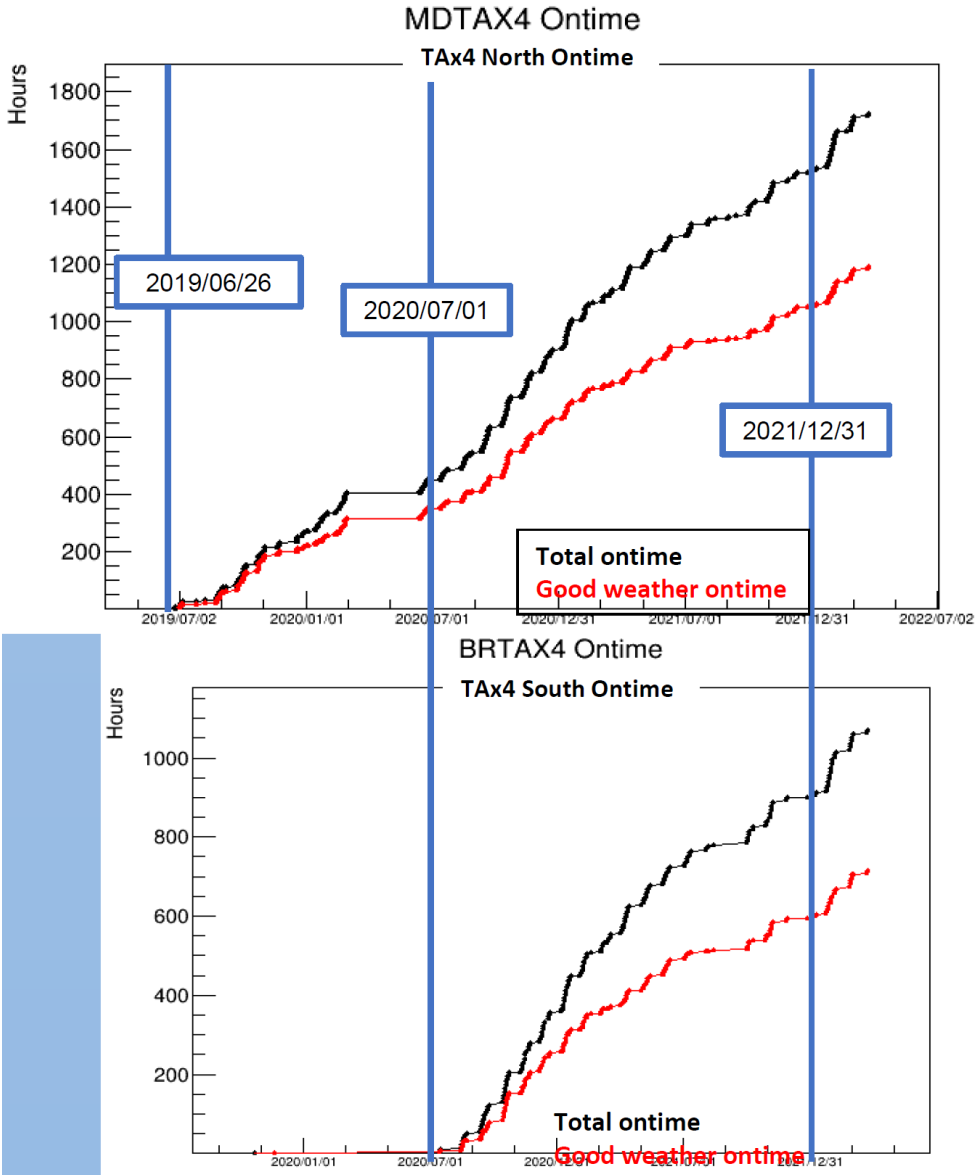


TAx4 SD 1.5-2 year data: 2019/11 –



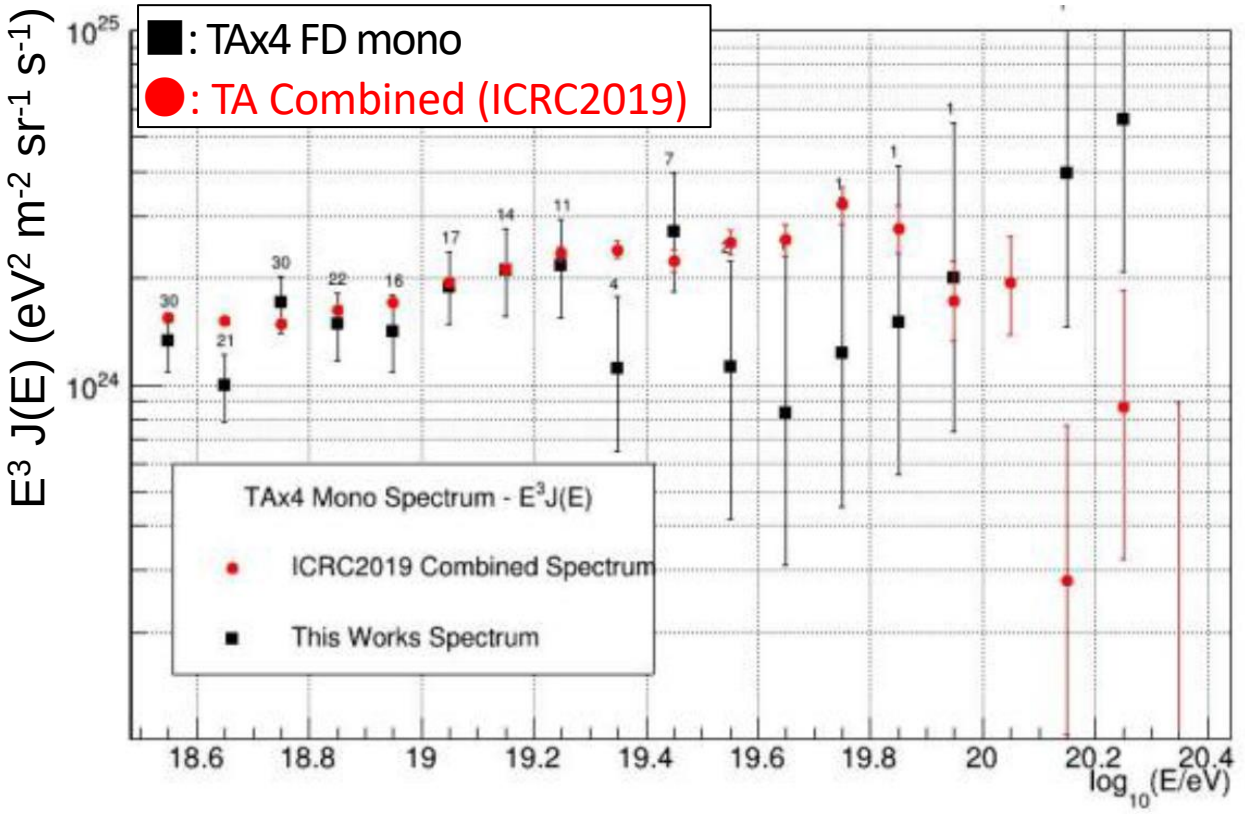
K. Fujisue
this conference

Monocular energy spectrum with new FDs

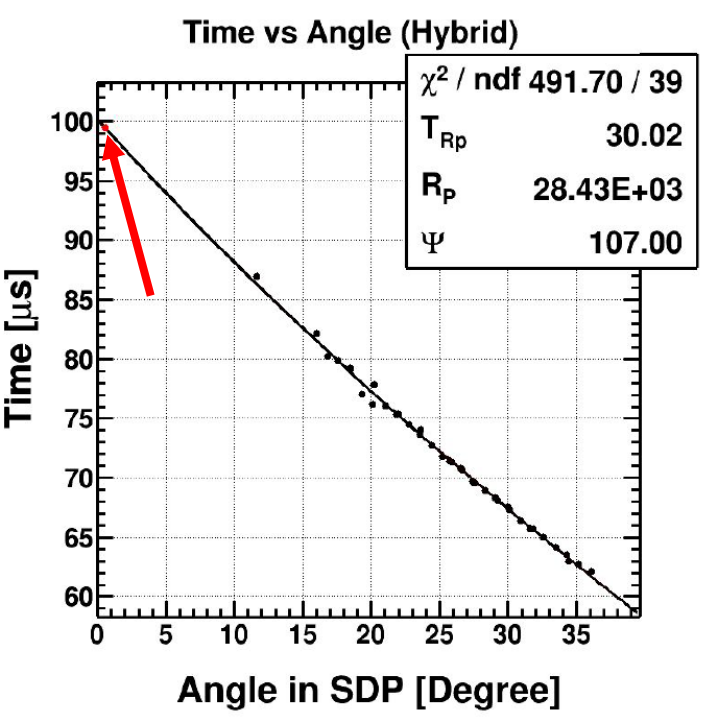


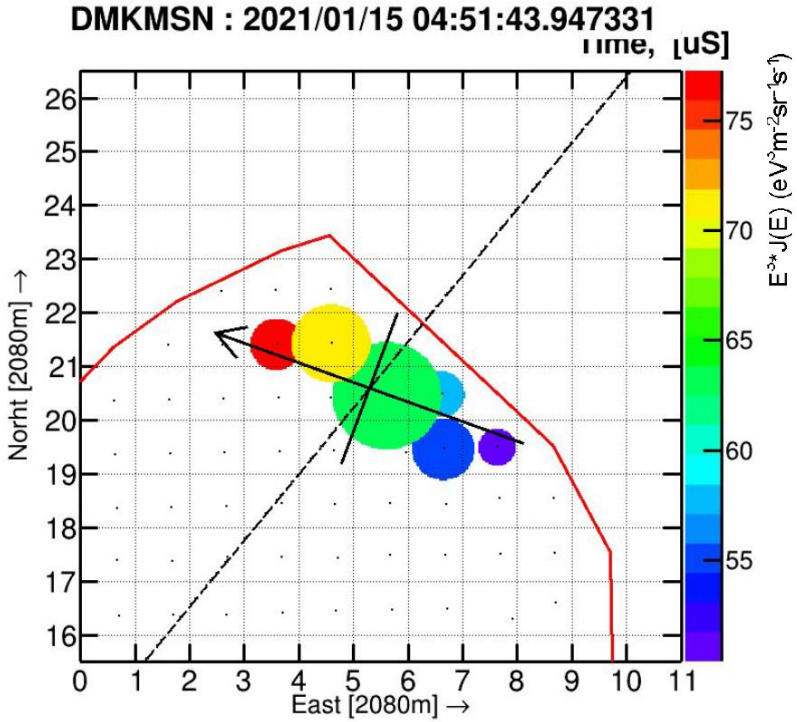
- 2019/06/26 –
- Energy resolution: ~20%
- Zenith angle resolution: ~3°
- All geometrical parameters get a reasonable agreement with MC simulations.

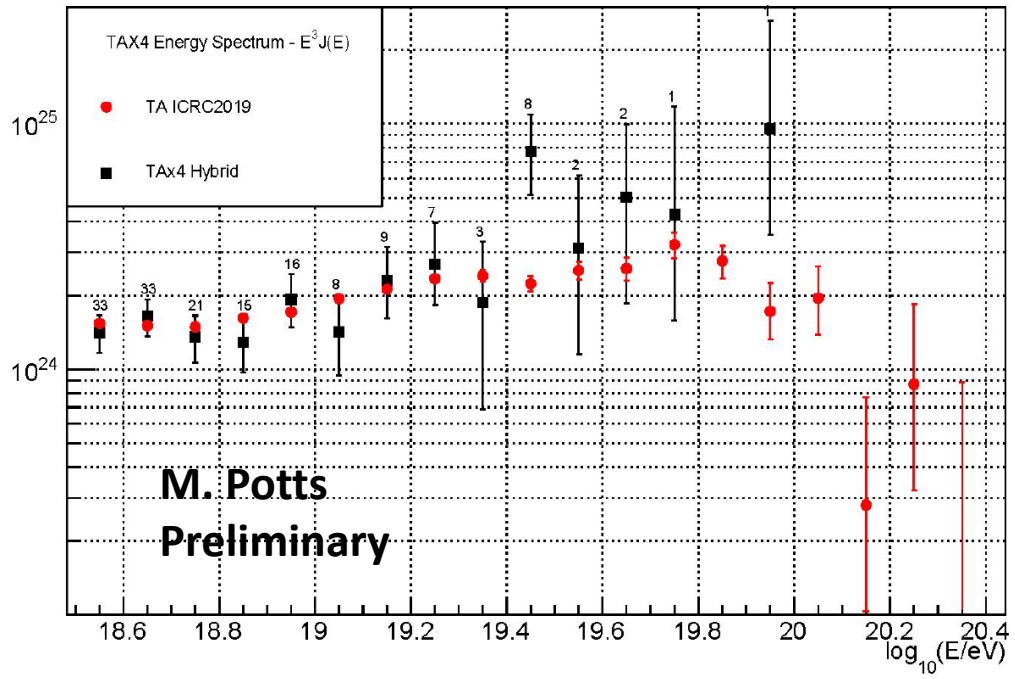
M. Potts this conference



Hybrid energy spectrum with new SDs and FDs





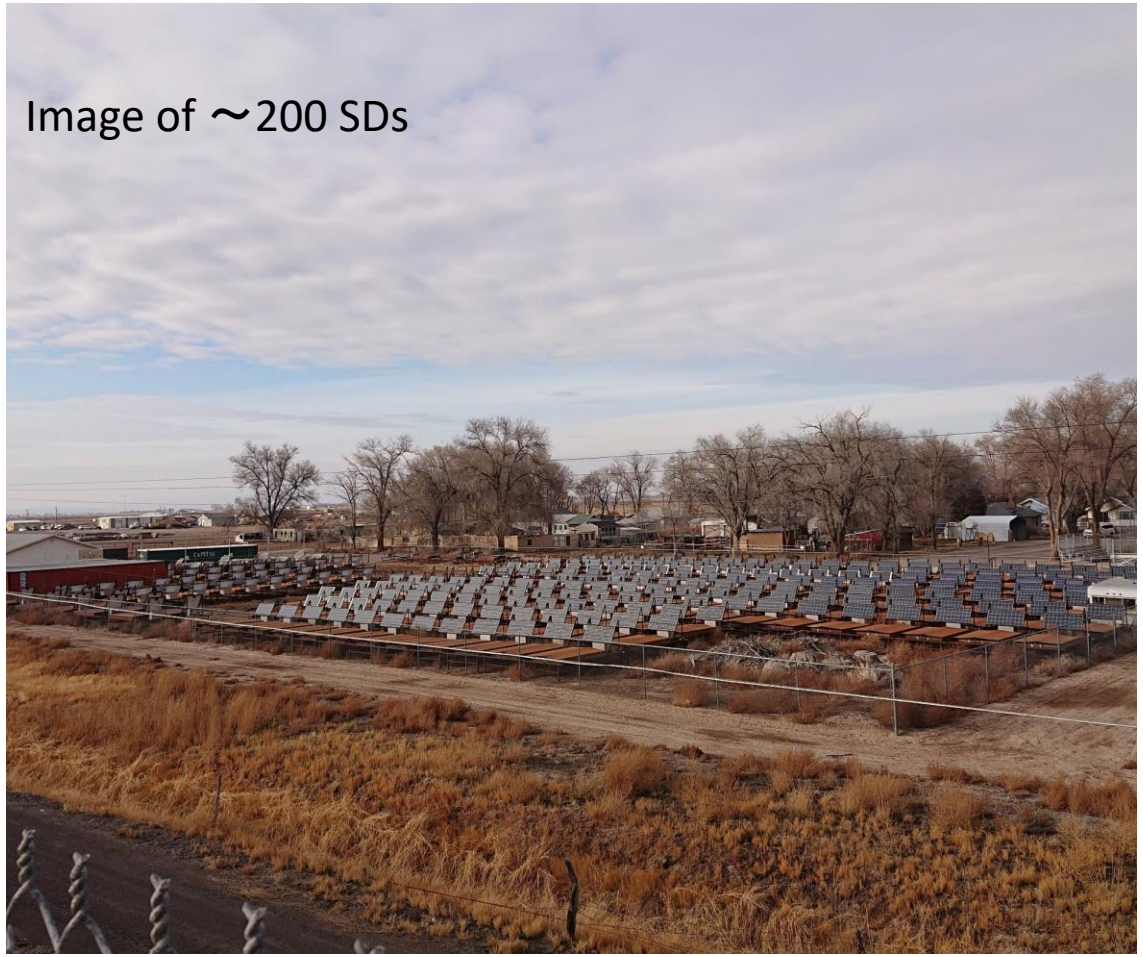


TAx4 SD trigger condition: ～30% efficiency at around 10 EeV

→ **Hybrid triggers** have been stably operated from **June 2020**.
FDs send the trigger timing to the communication towers of the SDs within +/- 128 usec time window.

→ **～3 × TA SDFD equivalent number of events** (E > 10 EeV) expected from the full TAx4

Future developments



- We plan to deploy the remaining 250 SDs to realize the full TAx4 coverage in 2023-2024.
- We will develop the analyses of anisotropies and compositions with new detectors.

Summary

- The TA experiment continue to observe UHECRs from 2008 with the largest detection area in the northern hemisphere.
- Arrival directions
  - **3.2σ** hotspot with E > **57** EeV was obtained using TASD 14 years data
  - **3.2σ** new excess with E > **$10^{19.4}$**eV was obtained using TASD 14 years data
- Energy Spectrum
  - Declination dependence in the energy spectrum was obtained using TASD 14 years data
- **Implications of anisotropy are being updated by the TA experiment.**
- Plan of the detectors of the TAx4 experiment:
  - **500 new** SDs with **2.08 km** spacing + TA SDs (1.2 km spacing) → Coverage of **4 × TA SDs ～2800 km^2**
  - **2 new** Fluorescence Detector (FD) stations (4+8 Telescopes)
- **257 new SDs** were deployed in 2019. The SDs are running stably since Nov. 2019.
- **New FDs were completed.** New north FD is running stably since Jun. 2018. New south FD is running stably since Sep. 2020.
- The extension of the SDs to the full coverage of TAx4 is scheduled for 2023 and 2024.
- Preliminary energy spectra were measured with new SDs, FDs, and SD FD hybrid.