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# Status and prospects of the TAx4 experiment

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### Outline

- Motivation
- Configuration of Detectors
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20 deg. from each events are counted. Global significance:  $3.4\sigma (0.037\%)$ 









## Configuration of Detectors

To study more about the highest energies and clarify the implication obtained by TA

500 new SDs with 2.08 km spacing

and TA SDs cover

4 × TA SD detection area (~3000 km<sup>2</sup>)

Construction is ongoing.

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

First light was observed by north FD station Construction of south FD station is ongoing.

### Design of SDs



Inside of the scintillator box Photomultiplier tube (PMT) A holder of the fiber bundle WLS fiber length of one fiber is 6.1m

- 2 layers 3 m<sup>2</sup> 1.2 cm thick plastic scintillators
- $\rightarrow$  Calibration of signals using single muon
- DAQ with 2.4 GHz wireless communication

Stainless steel box for the electronics and a battery Scintillator box

PMT: Hamamatsu R8619 (PMTs in TA SD: ET9124)

- Quantum efficiency ~20 % at 500 nm (~10% ET9124)
- Pulse linearity ~50 mA (25 mA ET9124)
- →Arrangement of WLF fibers was changed Total length of fibers ~33% of TA SD

### Quality Check of SDs

Position dependence of single peak of typical SD (average: 1) using 15cmx15cm trigger probe



Mean value of the Gaussian obtained by fitting ADC distribution of **pedestal run** 

Single peak of all SDs: Ave: 21 p.e. (photo electrons) RMS: 4 p.e. (~1/2 TA SD) 10 SDs were picked up and checked: Non-uniformity < 15%

#### **Quality Check of SDs**



#### **Expectation of SD Array**

1 10 EeV 0.9 57 EeV 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 Trig. eff. 0 -0.5 0 0.5 2 1.5 2.5 log<sub>10</sub>(Energy<sub>sim</sub> (EeV))

**Reconstruction efficiency** 

SD array: square grid with 2.08 km spacing E > 57 EeV:

- Reconstruction efficiency > 95%
- Angular resolution: 2.2°
- Energy resolution:  $\sim$ 25%

#### **Construction of SDs**



Transport scintillator boxes 9 Construction was started in 2015.

Utah

260 SDs will be ready for the deployment early next year!

#### **Construction of SDs Next Year**

- Deploy SDs with helicopters.
- Communication towers will be constructed.
- Communication b/w SDs and comm. tower will be tuned.
- $\rightarrow$  start DAQ from SDs!

Pictures below: deployment of TALE SDs last year.





#### Location of North FD Station





#### **Construction of North FD Station**



#### Feb. 16<sup>th</sup>, 2018 First light was observed.

(camera 28: Xe Flasher)



#### South FD Station



South FD station is also being constructed.

#### **Expectation of Hotspot**





Independent  $\sim$ 40 events with E > 57 EeV are expected at the hotspot from  $\sim$ 2.5 years of full operation of TAx4 SD

#### **Expectation of Spectrum Anisotropy**



- 7 years TA SD equivalent energy spectrum with E > 57 EeV are also expected from  $\sim$ 2 years of full operation of TAx4 SD.
- Xmax at the highest energies will be also measured.
- $\sim$ **3**  $\times$  TA SDFD hybrid equivalent data will be obtained by the full TAx4.

#### For More Improvement



### Summary

- Implications on anisotropy were obtained by the TA experiment.
- Configuration of TAx4:
  - 500 new SDs with 2.08 km spacing + TA SDs  $\rightarrow$  Coverage of 4  $\times$  TA SDs  $\sim$  3000 km<sup>2</sup>
  - 2 new Fluorescence Detector (FD) stations (4+8 HiRes Telescopes)
- Reconstructed efficiency of SD array is expected to be more than 95% for E > 57 EeV.
- The construction of the TAx4 experiment is ongoing.
  - Uniform and better quality of SDs were checked.
  - More than half of new SD array will be deployed early next year.
  - First light was observed by north TAx4 FD station and south TAx4 FD is now being constructed.
- Hotspot and spectrum anisotropy with E > 57 EeV will be studied with  $\sim$ 4 × TA SD equivalent statistics if the full operation is started.
- Xmax:  $\sim$  **3** × TA SDFD equivalent events will be expected at the highest energies. Same quality as TA FDSD hybrid would be expected.
- We are trying to implement lower energy threshold by changing trigger condition.

#### Prospects of energy spectrum



• Energy spectrum: more detailed spectrum shape at the highest energies with  $\sim$  21 TA SD equivalent years data

#### MC simulation for hybrid events

- Analysis for the TALE upper FoV are applied for the simulation for north TAx4.
- MC generated area is  $30[\text{km}] \times 30[\text{km}] \times \pi / 4$  for  $10^{18.5}$  eV,

 $40[\text{km}] \times 40[\text{km}] \times \pi / 4$  for  $10^{19}$  and  $10^{19.5}$  eV and  $50[\text{km}] \times 50[\text{km}] \times \pi / 4$  for  $10^{20}$  eV

Zenith angle < 60 deg.



Fujita

#### **Examples of Energy Spectra**



### Expected significance of the hotspot considering energy resolution effect

