ICRR INTER-UNIVERSITY AWARD
TELESCOPE ARRAY

John Matthews - University of Utah
Telescope Array Collaboration

21 Feb 2024

REPORTING FOR PI'S

- **John Matthews**: University of Utah – Institute for High Energy Astrophysics
- **Grigory Rubtsov**: Institute for Nuclear Research – RAS
- **Il Park**: Sungkyunkwan University
- **Anatoli Fedynich**: Academica Sinica – High-Energy Theory Group

TELESCOPE ARRAY

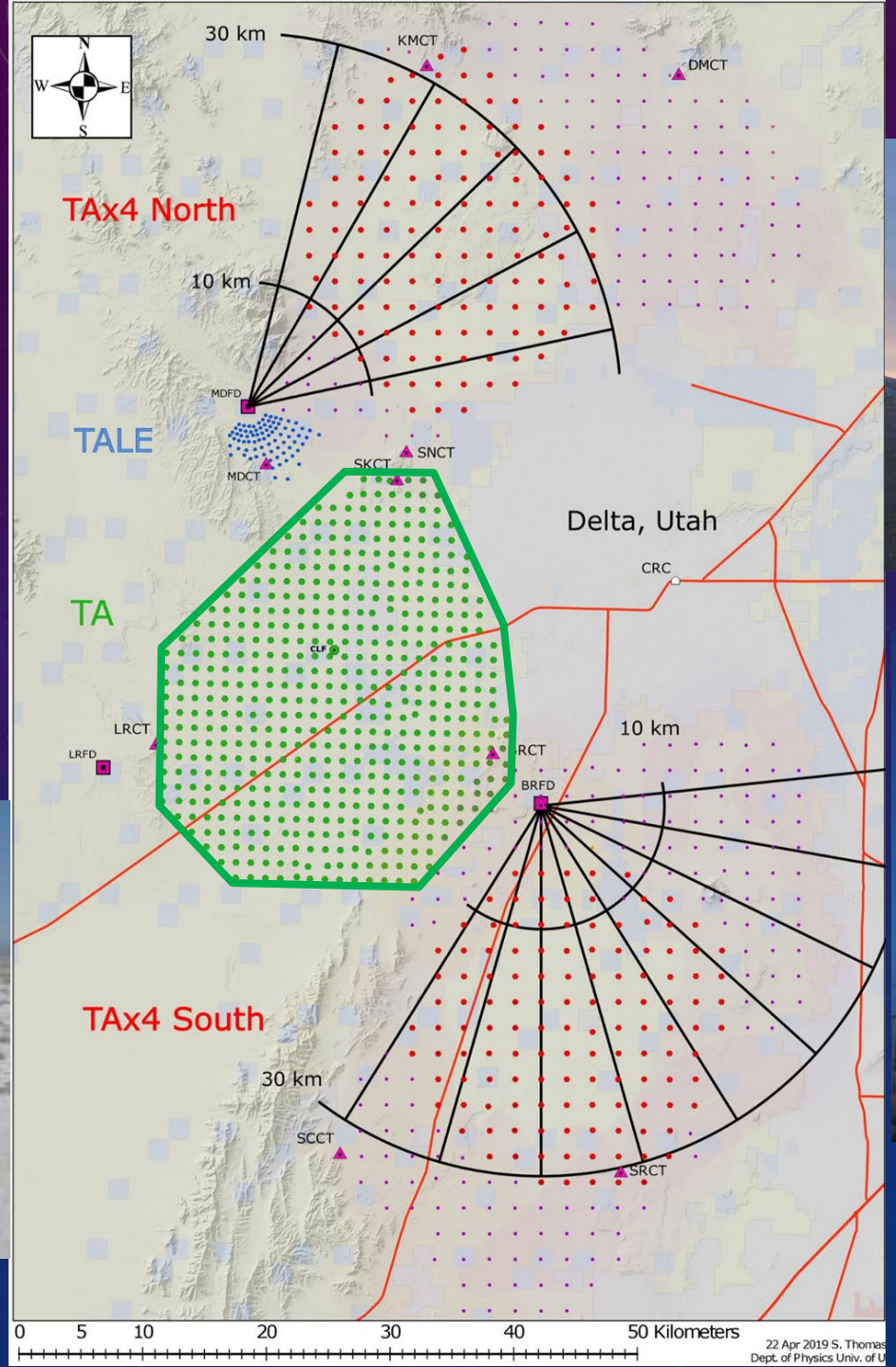
Telescope Array Detectors

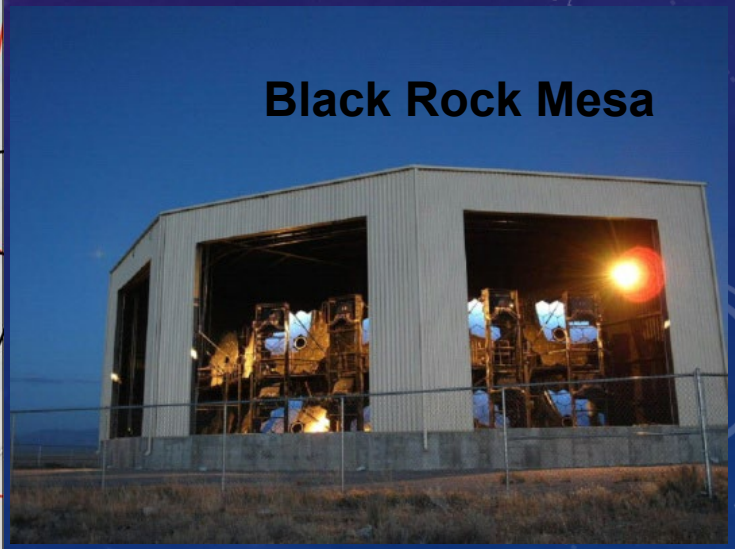
Surface Detector Array (3/2008)

- 507 Scintillator Counters
- 3 m^2 area
- 1.2 km spacing
- ~700 km^2

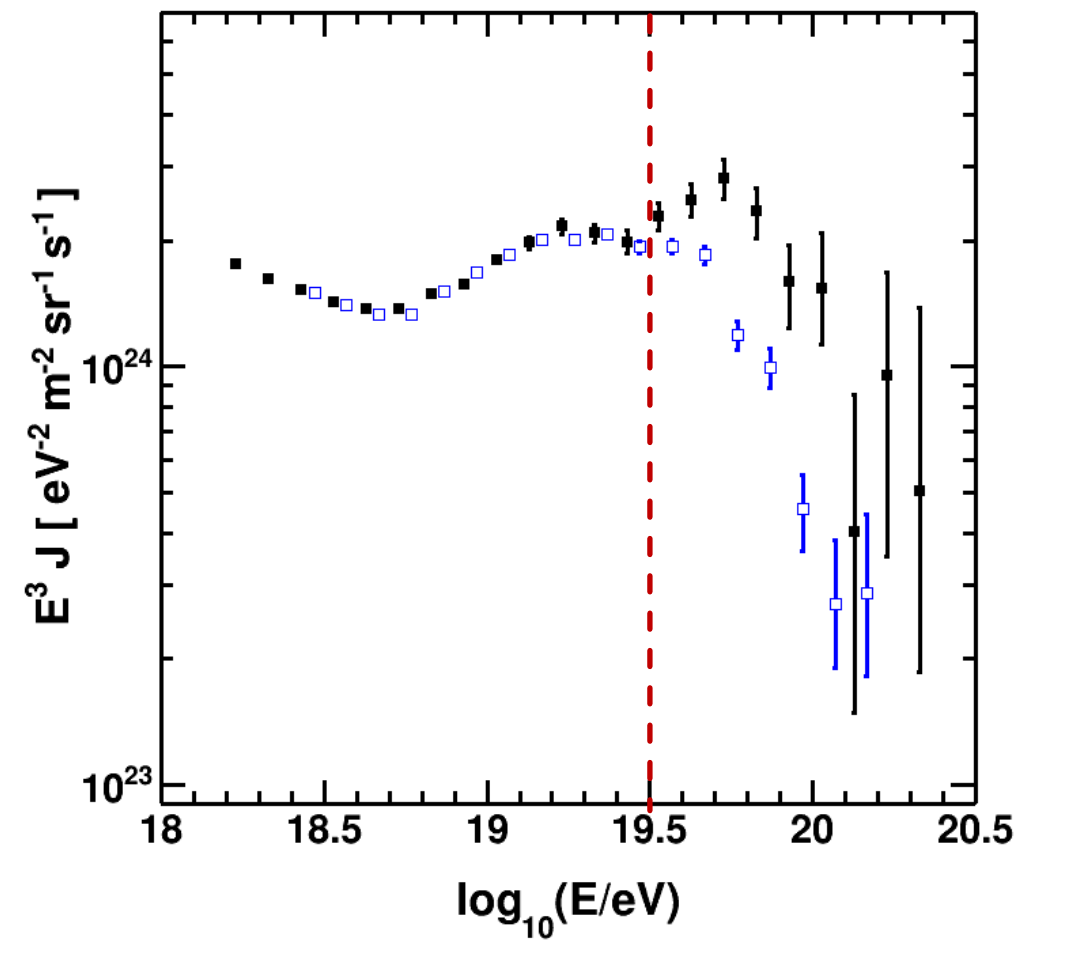
Fluorescence Telescopes (2007)

- 3 Stations
- 12–14 Telescopes ea
- 3˚–31˚ elevation
- FOV above SD Array



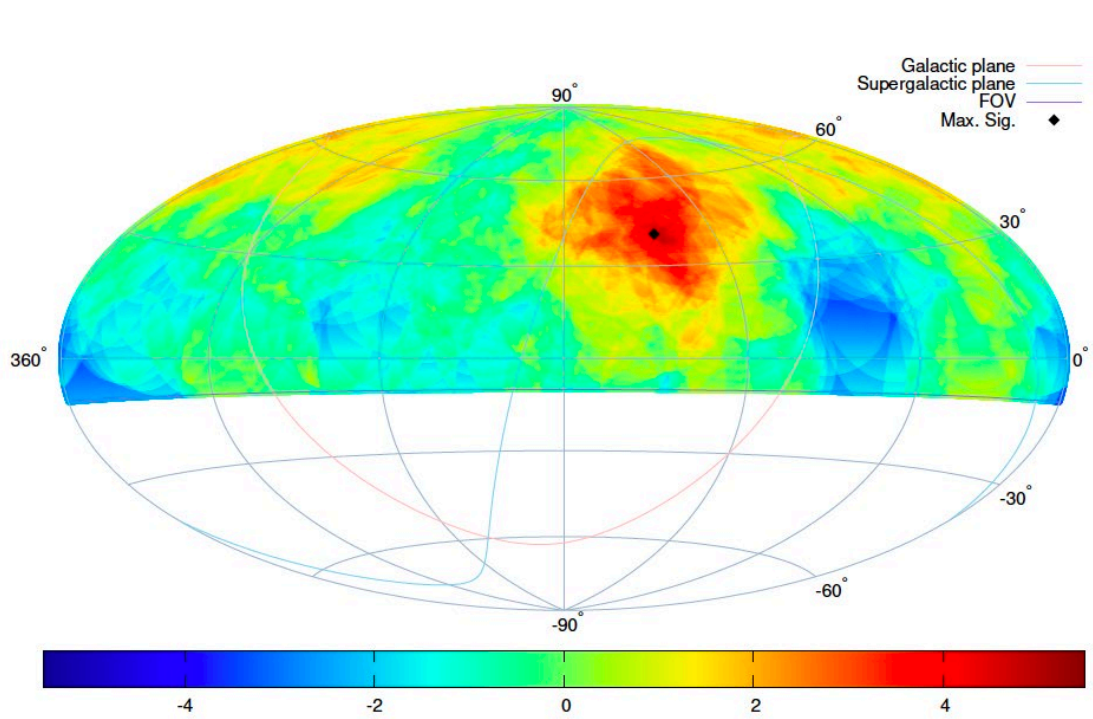


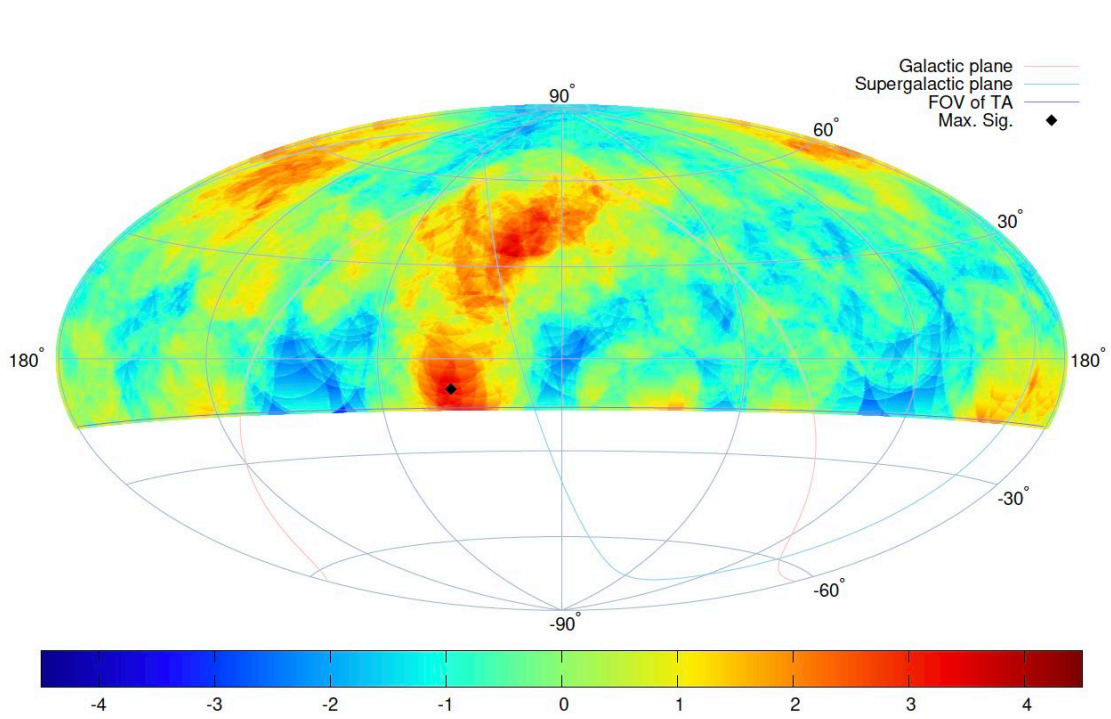
THE TELESCOPE ARRAY AND AUGER SPECTRA



- The spectrum difference between TA and Auger has long been a source of controversy – there was a ~9% difference in the normalization
- Shifting one or the other or both the spectra could be made to mostly agree
- Ogio-san and Fujita-san showed the difference is to be in the fluorescence yield and other constants used in setting the energy scales of both experiments.
- **However, a significant energy difference persists at $E > 10^{19.5}$ eV**

ANISOTROPY SIGNAL/EXCESS REGIONS IN TA DATA (14 YRS)



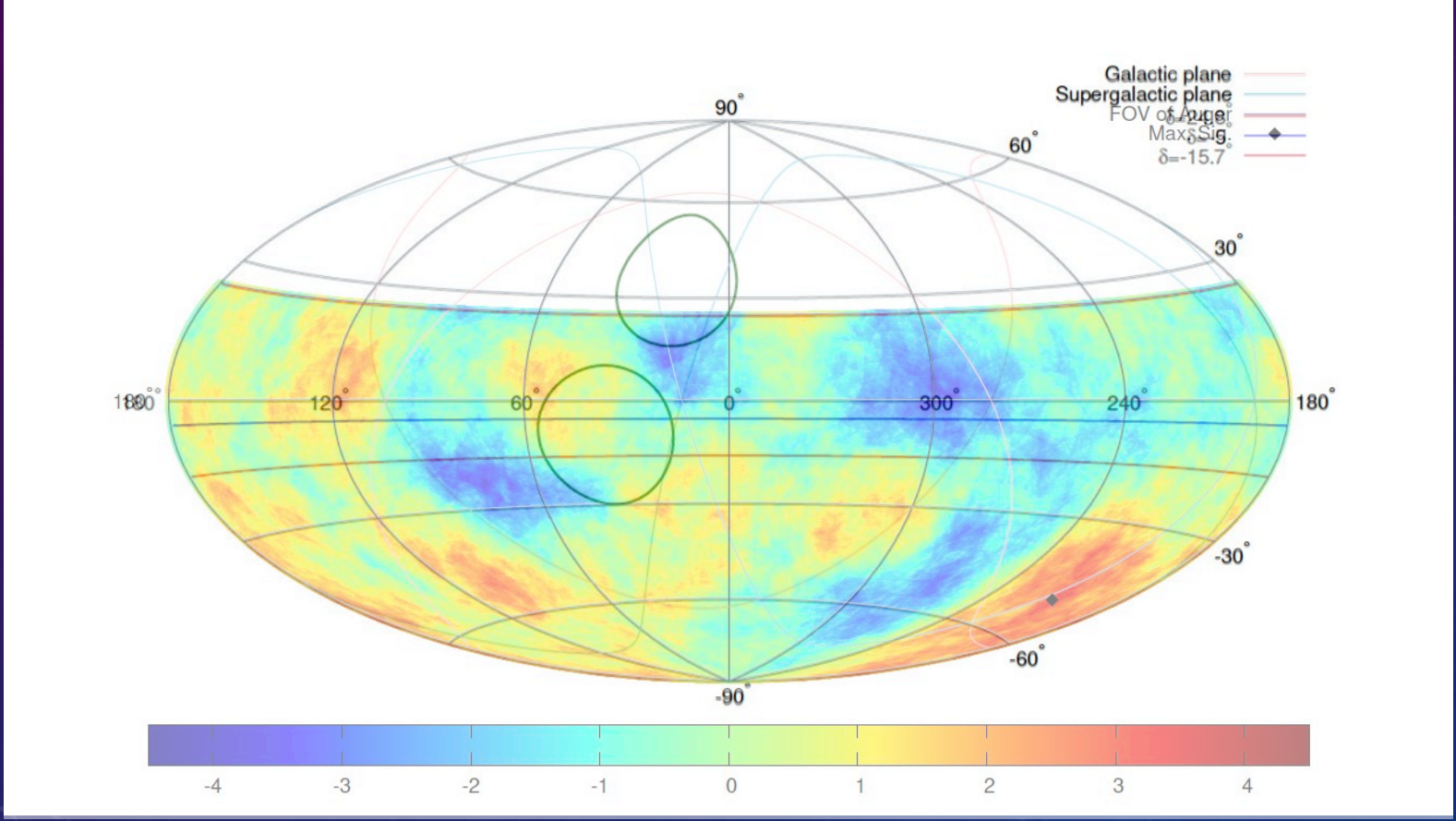


TA Hotspot
$E > 10^{19.75}$ eV
3.2σ post-trial

Perseus-Pisces SC
$E > 10^{19.6}$ eV
3.5σ post-trial

NGC 1068
$E > 10^{19.6}$ eV
3.7σ post-trial

THE AUGER FOV OBSERVES *PORTIONS* OF THE SKY WITH TA EXCESSES BUT SEES NO SIGN OF EXCESS IN ANY OF THEM



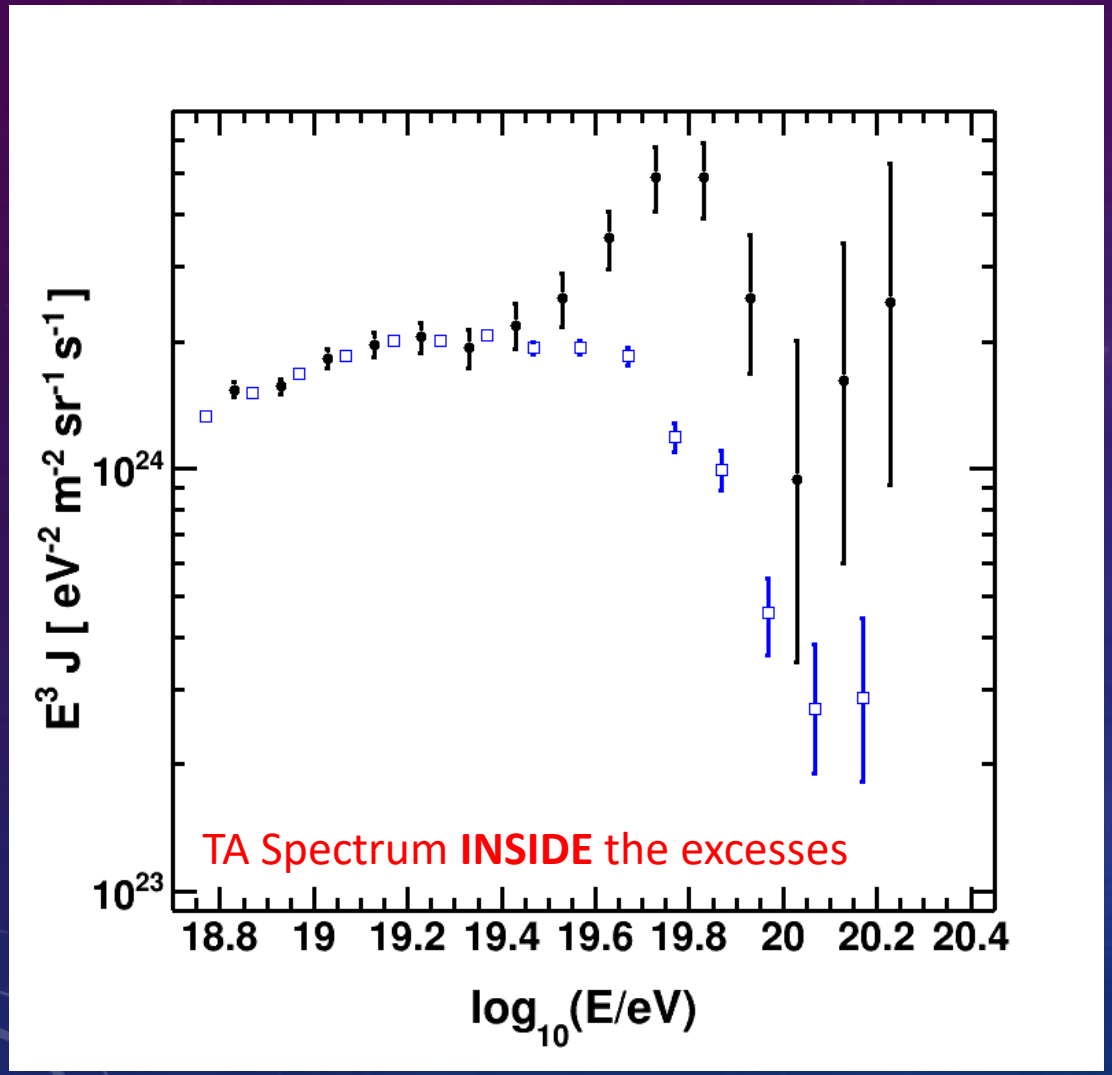
- Auger Data Observes
- TA HotSpot at – 1.0σ
- Perseus-Pisces at +0.1σ
- Auger does NOT see the whole HotSpot or PPSC region

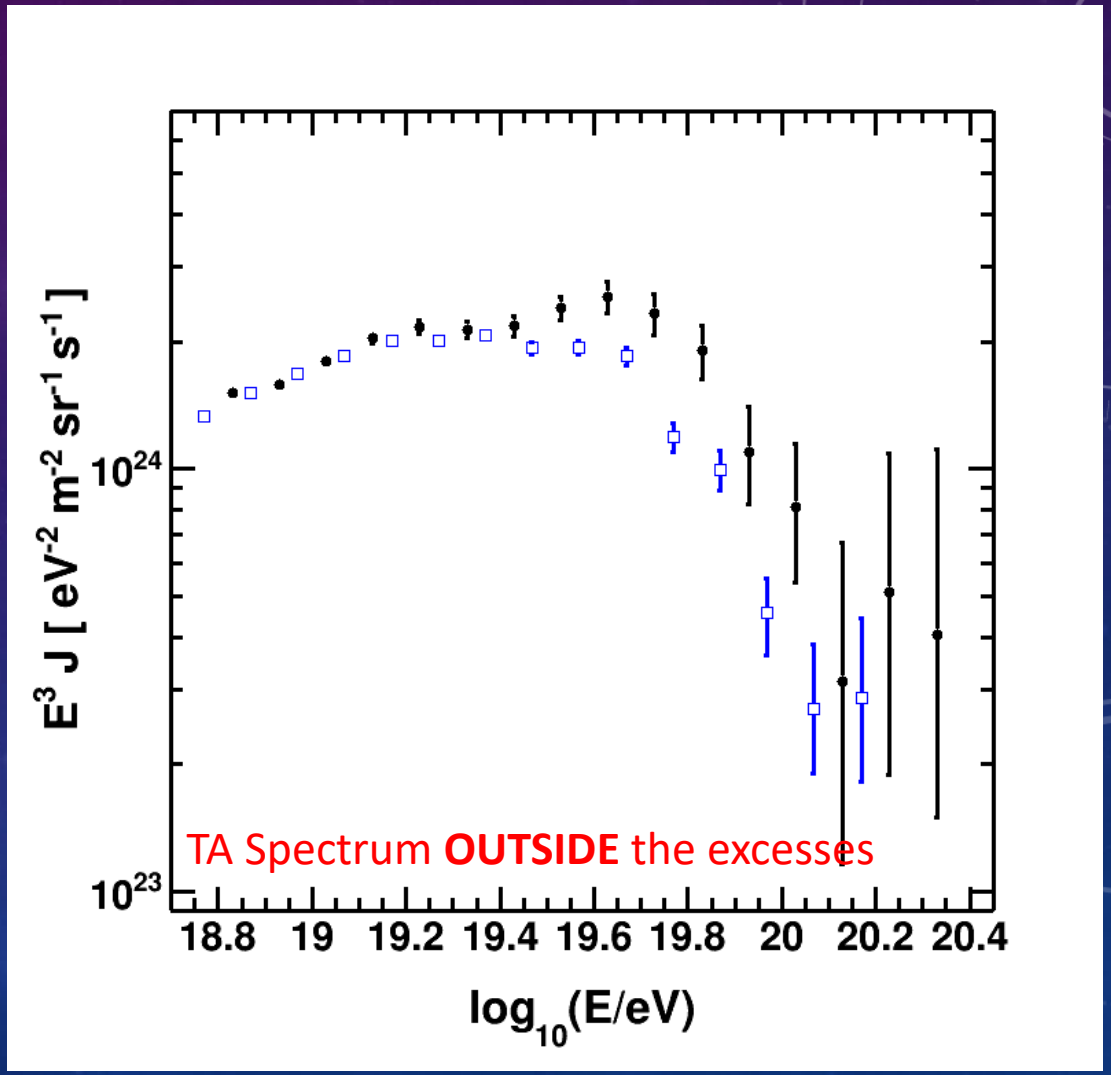
- Is the Telescope Array HotSpot (or any of these) a real source?

- **<u>Testing this is the main reason for building TAx4</u>**

Auger 17 yrs
E > 32 EeV (~$10^{19.5}$ eV)

MEANWHILE:


E^3 J [eV^{-2} m^{-2} sr^{-1} s^{-1}]
10^{24}
10^{23}
18.8 19 19.2 19.4 19.6 19.8 20 20.2 20.4
$\log_{10}$(E/eV)
TA Spectrum **INSIDE** the excesses

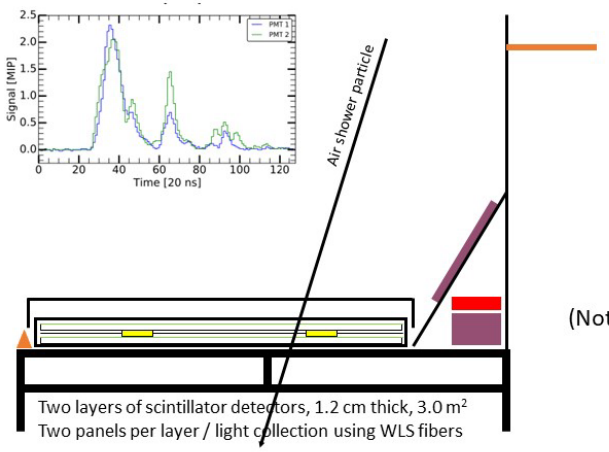

E^3 J [eV^{-2} m^{-2} sr^{-1} s^{-1}]
10^{24}
10^{23}
18.8 19 19.2 19.4 19.6 19.8 20 20.2 20.4
$\log_{10}$(E/eV)
TA Spectrum **OUTSIDE** the excesses

TELESCOPE ARRAY ALSO HOSTS A MINI-AUGER ARRAY

The Surface Detector, the statistical engine of both experimen

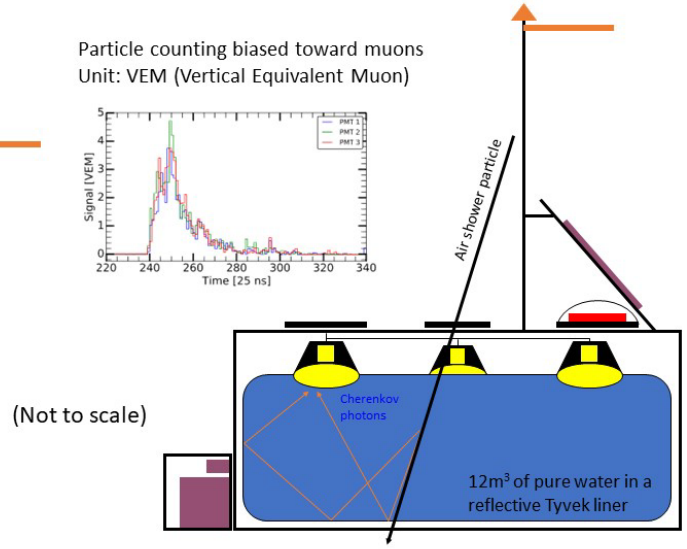
Telescope Array (Utah, USA)

Indiscriminate Particle counter
Unit: MIP (Minimum Ionizing Particle)



Pierre Auger Observatory (Mendoza Province, Argentina)

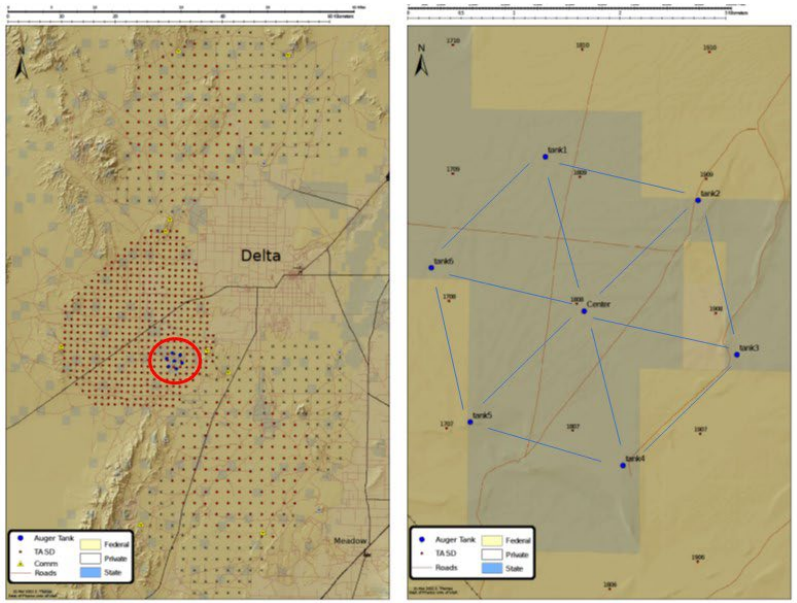
Particle counting biased toward muons
Unit: VEM (Vertical Equivalent Muon)



(Not to scale)

Fred Sarazin (Colorado School of Mines) on behalf ("Auger@TA")

Auger at TA



UofU (J.Matthews and S.Thomas) Arranged:

Site at TA selected (close to roads for water delivery)

- A unique site! SITLA land for faster approval procedure than BLM ✓
- Site staking ✓
- Cultural / environmental impact survey ✓
- Lease agreement ✓

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Coincident events will allow us to cross-check signals, calibrations, and lateral distributions
Auger scintillators to be added to the water tanks
The array is currently being commissioned

CENTER TRIPLE OF **AUGER@TA** – AUGER-N, AUGER-S, TA-SCINT

Project title: Ultra-high-energy cosmic-ray origin studies with the Telescope Array and TAx4 surface detector

Principal investigator:

Grigory I. Rubtsov, Institute for Nuclear Research of RAS

Project Number: 2023i-F-001

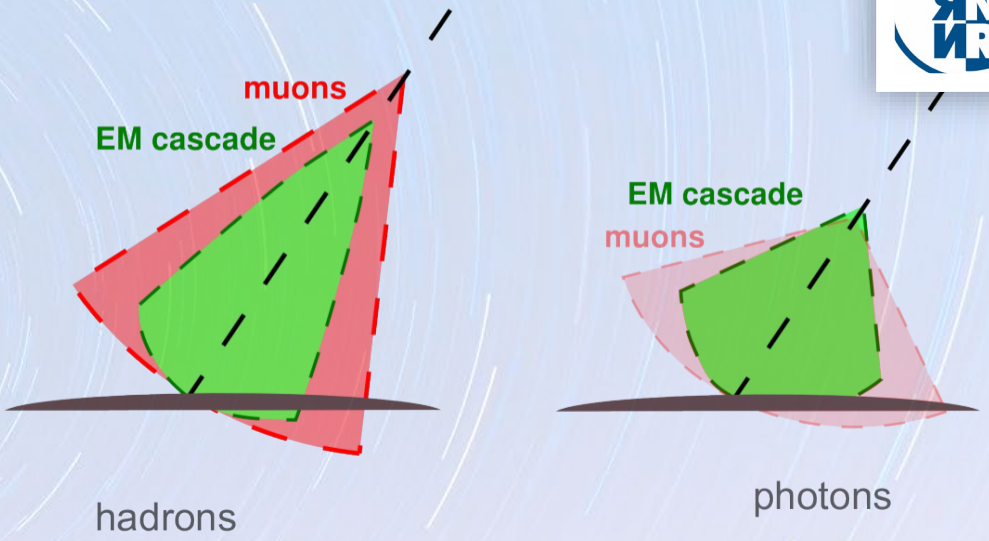
Allocated Research Fund

Total (Travel Expenses): 200,000 JPY

Research purpose:

Search for anisotropy and sources of cosmic rays, ultra-high-energy photons and neutrinos.

Search for ultra-high-energy photons with TA SD



Photon-induced showers:

- develop deeper in the atmosphere ⇒ arrive younger
- contain less muons ⇒ SD waveforms are less compressed

We use the neural-network classifier trained on both the

- **time-resolved waveforms**
- and derived features: front curvature, Area-over-peak, number of FADC signal peaks, $\chi^2/d.o.f.$, S_b

Neural network blocks:

- Spatial detectors bundle (geometrical features)
- Waveform with largest integral charge (signal specifics)
- Temporal detector bundle (overall information)
- Reconstruction parameters (high-level information)

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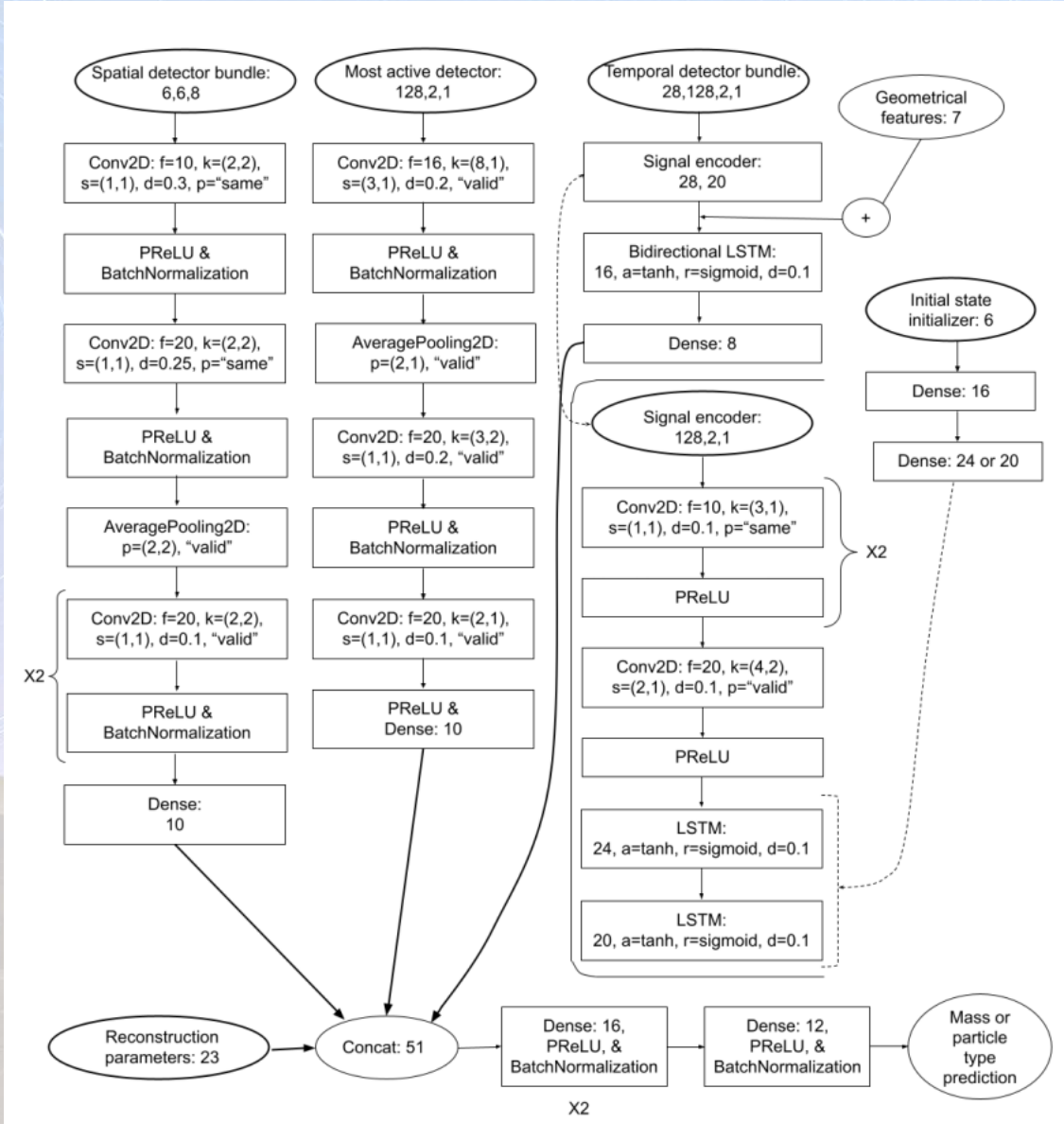
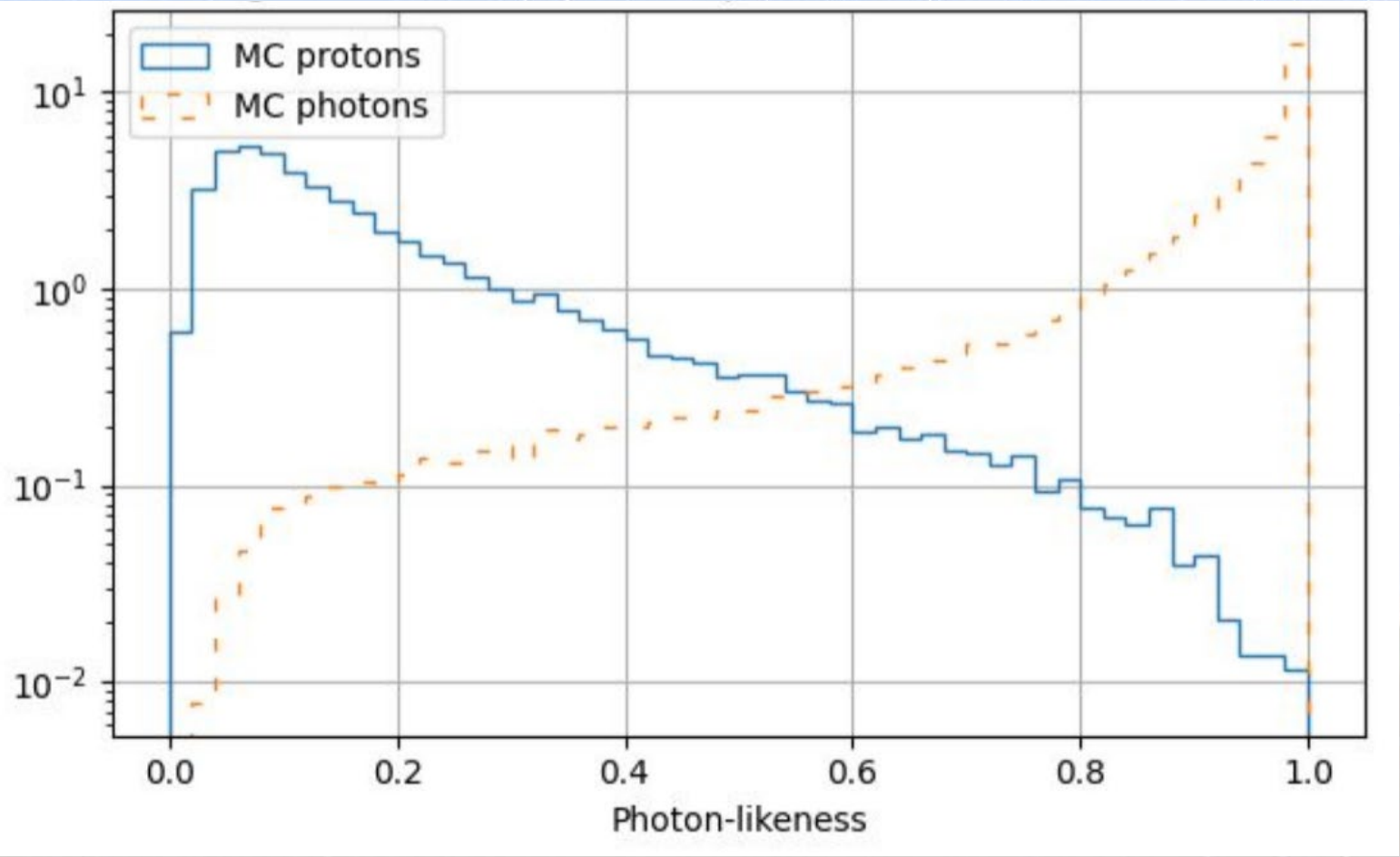
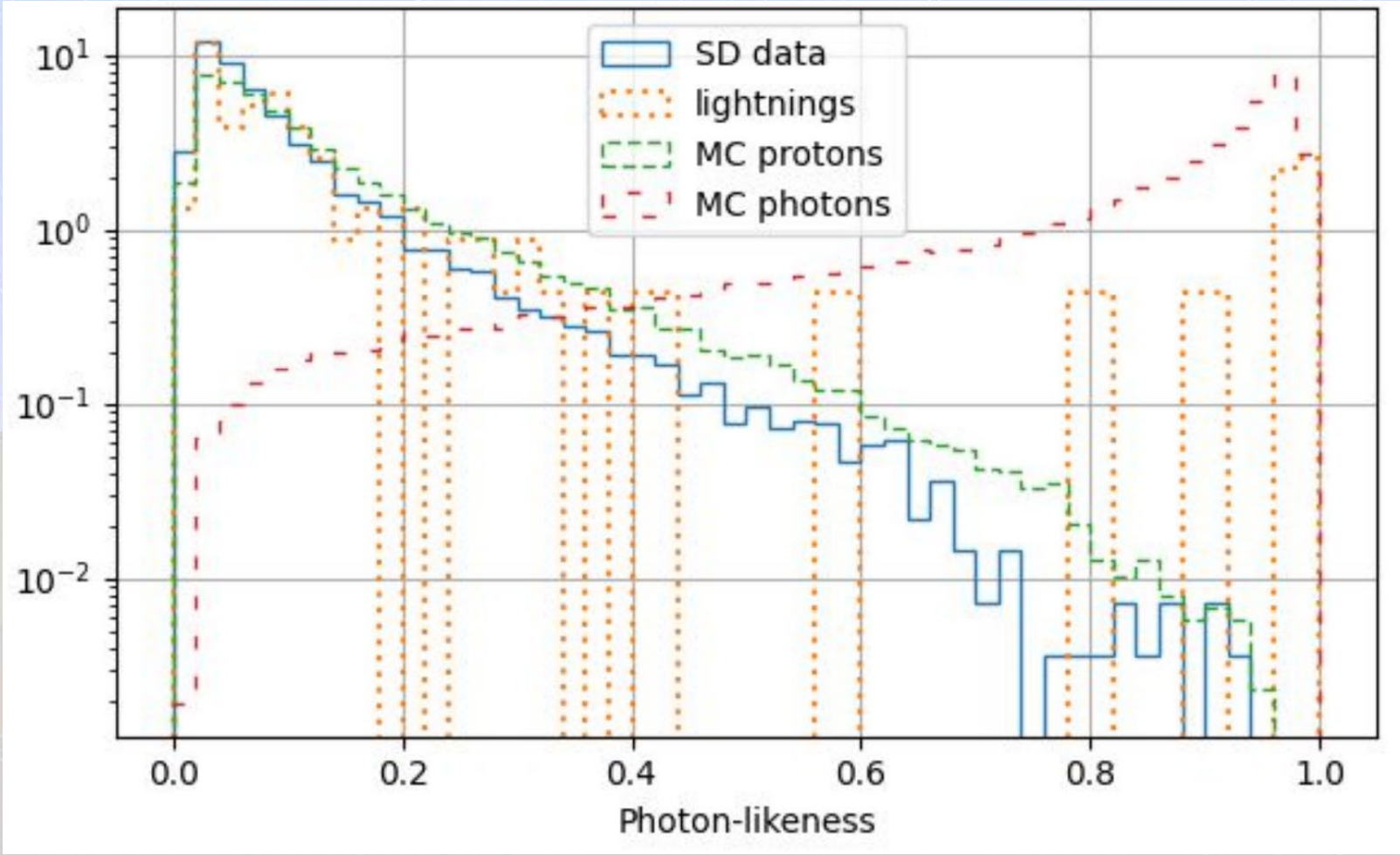


Neural network prediction on Monte-Carlo



Neural network prediction on data and Monte-Carlo



Telescope Array SD photon limits

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