



VHE emission at the cosmic gamma-ray horizon: Detection of quasar OP313 at redshift $z=0.997$ with LST-1

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Outline

- LST-1 overview
- Quasar OP 313
- Fermi-LAT monitoring
- LST-1 observations
- Very high energy (VHE) gamma-ray detection by LST-1
- Summary and outlook

LST-1

Large-Sized Telescope prototype of the future CTAO

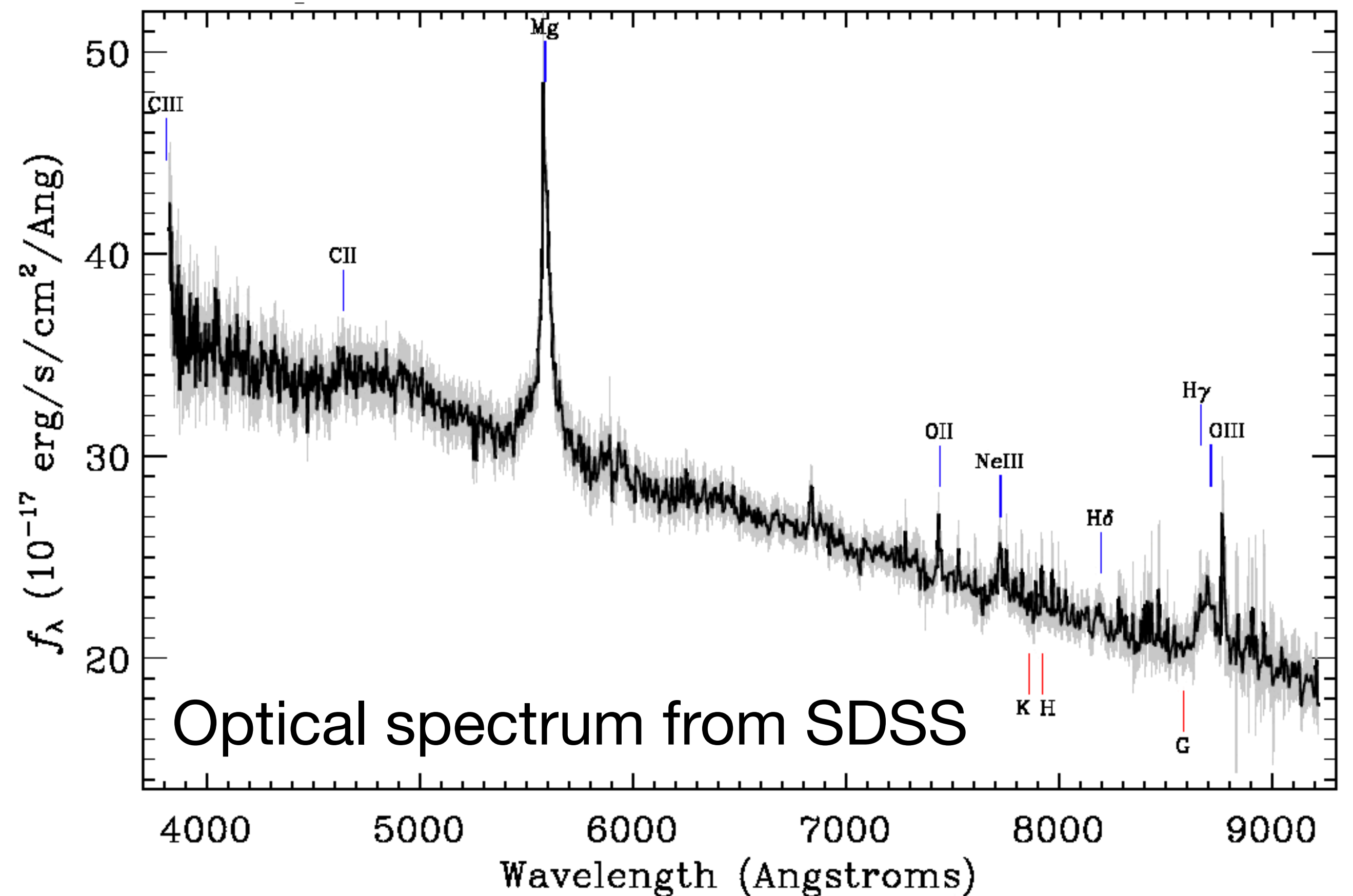
- Operating in **single-telescope mode** for several years
- Lowest **energy threshold** among current Cherenkov telescopes $\simeq 30 \text{ GeV}$ (*ApJ* 956 80)
- **Key for distant extragalactic sources**, whose VHE gamma-ray emission is strongly **attenuated** due to **extragalactic background light (EBL)** \rightarrow soft spectra
- Push the border of visible gamma-ray universe $z \gtrsim 1$ from ground-based telescopes



Credit: Tomohiro Inada

Quasar OP 313

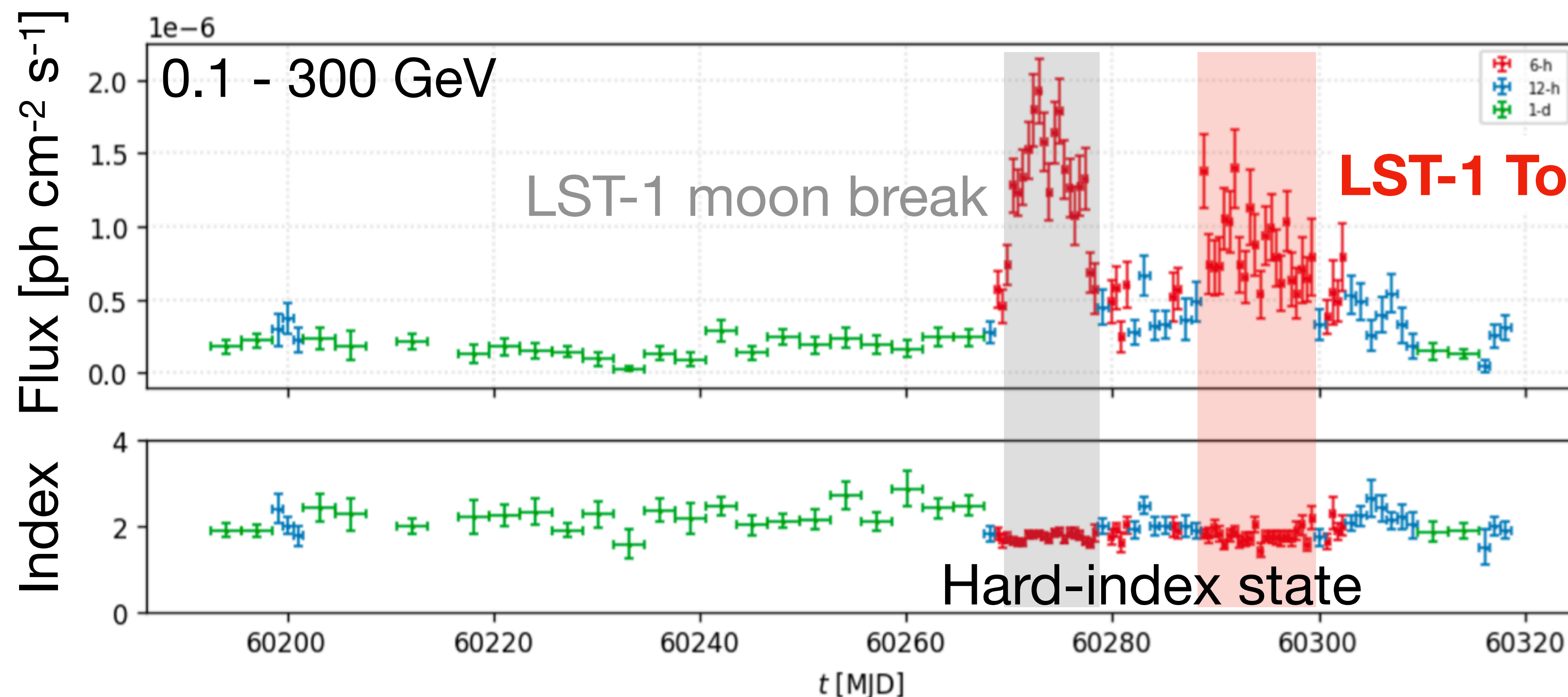
- **Flat-spectrum radio quasar (FSRQ)**
- **Not detected at VHE** before
- Only 9 VHE FSRQs were known
- **$z = 0.9973$** (Schneider et al., 2010)
- **Strong attenuation at VHE** (>100 GeV) due to **EBL**
- **Possible internal absorption of its gamma-ray emission**



Fermi-LAT monitoring

Flaring episodes since November 2023 (LST-1 moon break)

LST-1 ToO observations started on December 9th, 2023



LST-1 ToO observations

- Triggered by the high-flux state in Fermi-LAT (FlaapLUC)

Dates	Zenith angles	Effective time
9th to 18th, Dec 2023	> 30 deg	14.6 h
9th to 21st, Jan 2024	< 30 deg	4.5 h

- **Energy threshold $\simeq 40$ GeV** (from MC weighted with an OP313-like spectrum, 30-50 deg zenith angle)
- Data analysis with Istchain + Gammapy

First VHE detection of OP 313

- Detected with $> 5 \sigma$ (Li&Ma) after stacking data up to Dec 14th, 2023 (about 6 hours of data)
- ATel issued by LST-1 (#16381): 10th FSRQ detected in VHE gamma rays

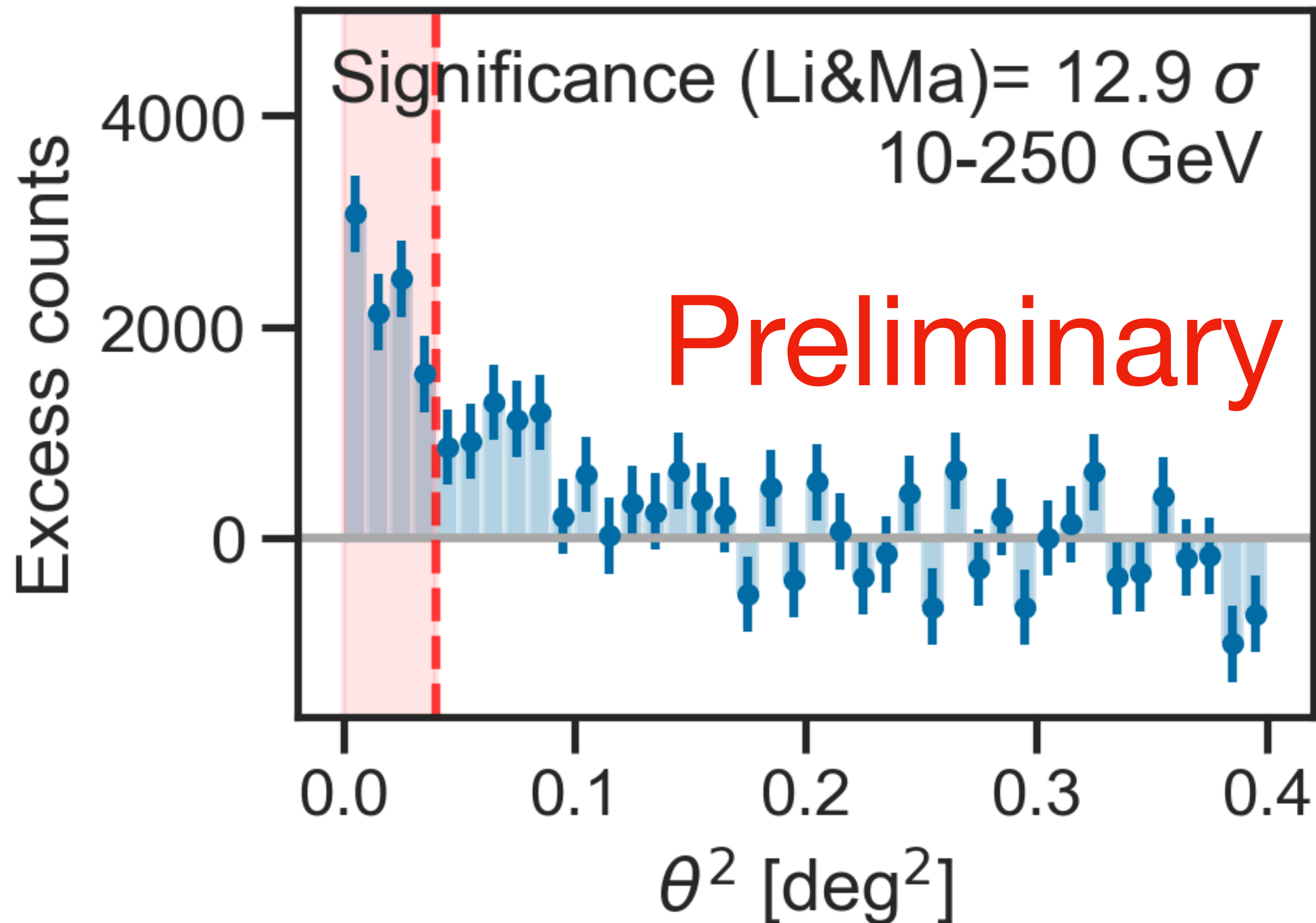
First detection of VHE gamma-ray emission from FSRQ OP 313 with LST-1

ATel #16381; **Juan Cortina (CIEMAT) for the CTAO LST collaboration**
on 15 Dec 2023; 14:31 UT

Credential Certification: Juan Cortina (Juan.Cortina@ciemmat.es)

Subjects: Gamma Ray, $>$ GeV, TeV, VHE, Request for Observations, AGN, Blazar,
Quasar

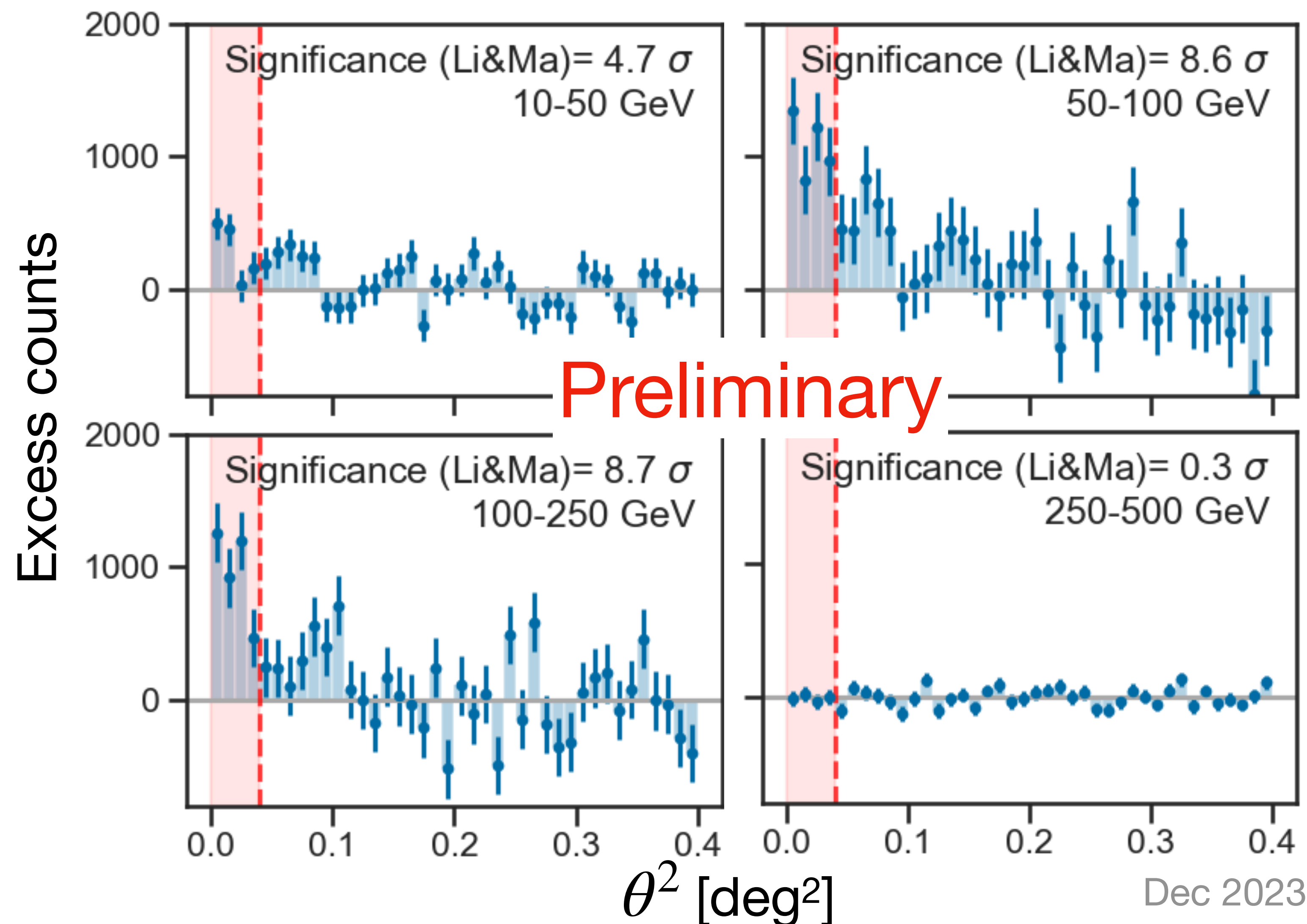
VHE detection of OP 313 by LST-1



- Staking all **December 2023** data (14.6 h), **significance (Li&Ma) $\simeq 13 \sigma$** below 250 GeV
- No detection at higher energies
- No significant detection in January 2024

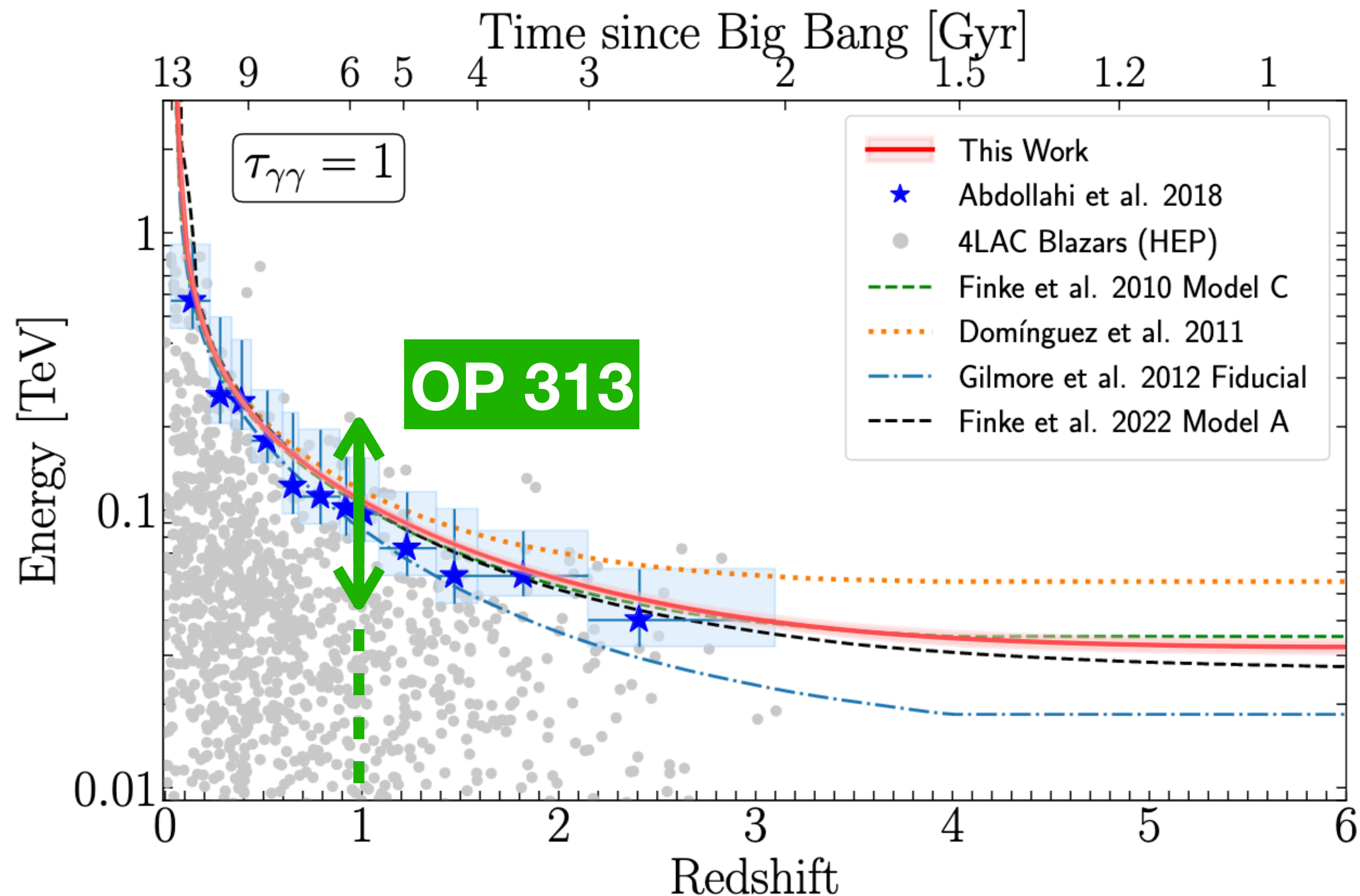
VHE detection of OP 313 by LST-1

- Calculated the gamma-ray excess in different energy bins
- VHE gamma-ray excess detected below **~250 GeV**
- Average **VHE flux (>100 GeV) of ~0.28 C.U.** in December 2023



Cosmic gamma-ray horizon

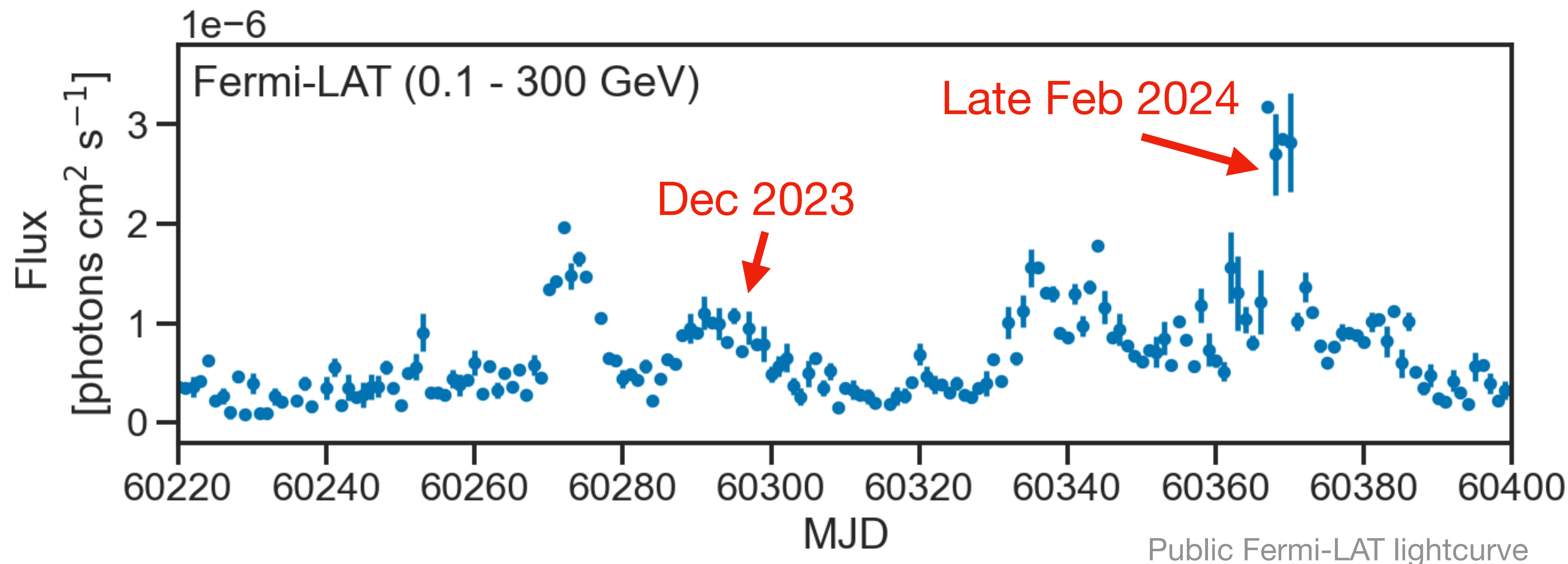
VHE gamma-ray emission from the cosmic gamma-ray horizon



Dominguez et al., 2024

Ongoing work

- **Keep monitoring OP 313 with LST-1** based on the flux state in Fermi-LAT
- **Multiwavelength follow-up observations**



Ongoing work

- **Keep monitoring OP 313 with LST-1** based on the flux state in Fermi-LAT
- **Multiwavelength follow-up observations**
- **Gamma-ray spectral energy distribution (SED):** joint fit of simultaneous LST-1 and Fermi-LAT data
 - **Constraint EBL models** at redshift $z \sim 1$
 - **Intrinsic cut-off in the spectrum?**
- **Broadband SED modeling**

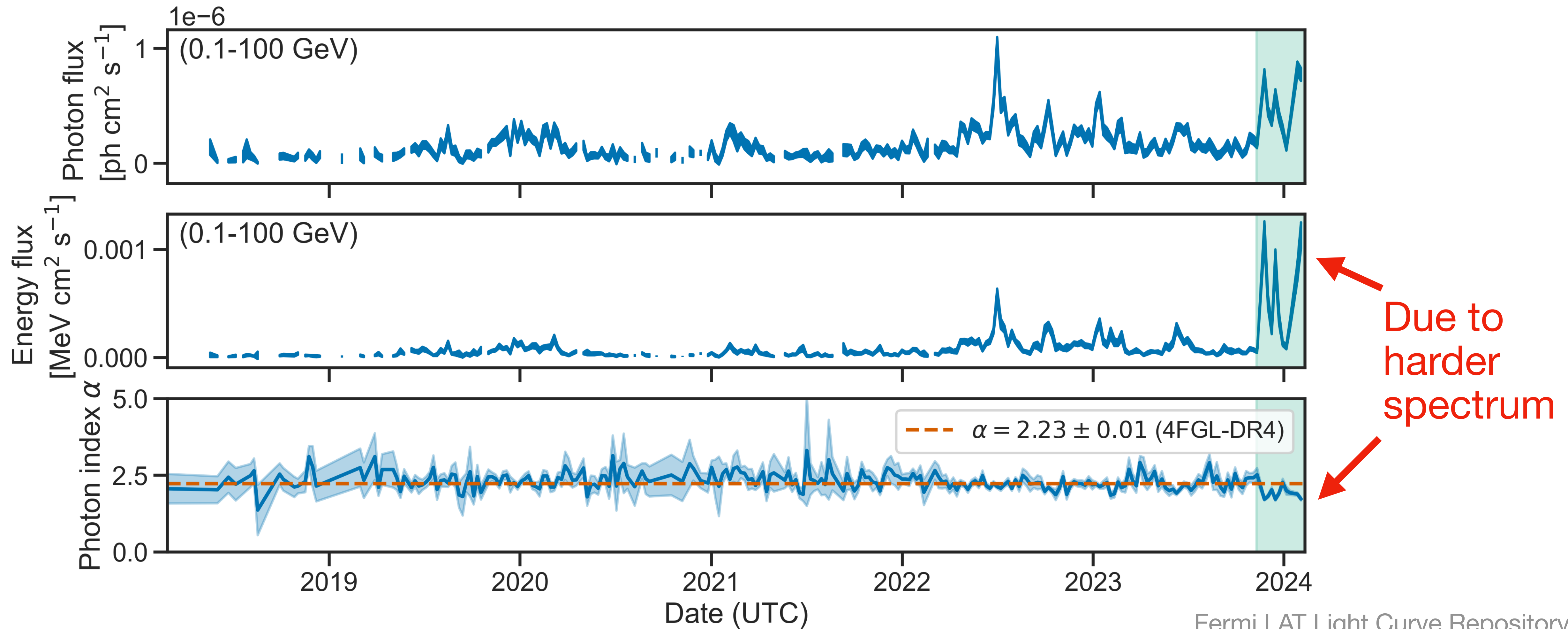
Summary and outlook

- High-flux state in the Fermi-LAT band triggered LST-1 ToO observations
- **First detection of VHE gamma-ray emission from quasar OP 313**
 - 10th FSRQ detected at VHE
 - **First *discovery* of LST-1 (ATel #16381)**
 - **Furthest VHE blazar ever detected ($z = 0.997$) and the second-most distant VHE source**
- **Spectral energy distribution modeling ongoing**
- Excellent source to **probe EBL models at $z \sim 1$**

Backup

Fermi-LAT monitoring

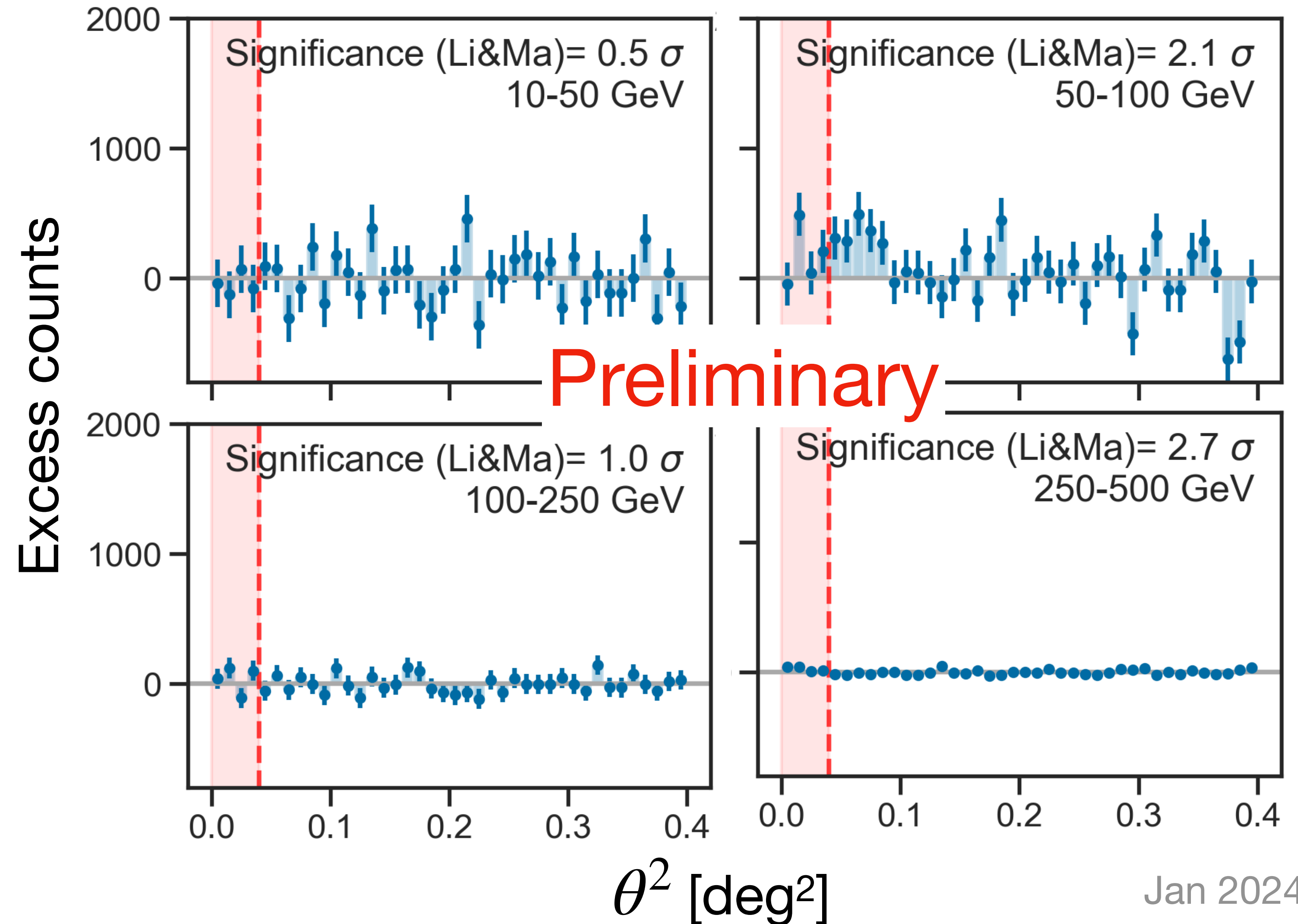
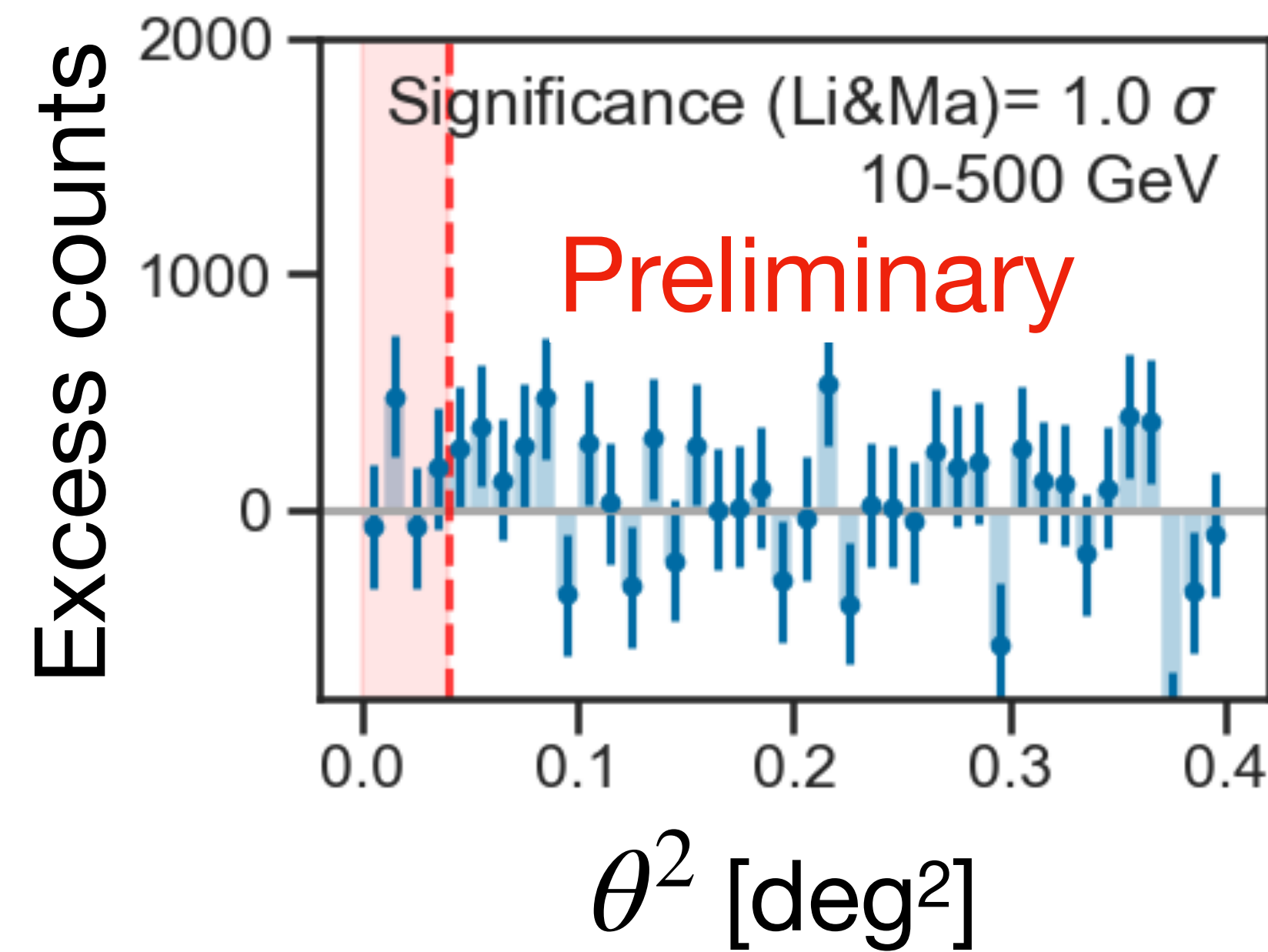
Most energetic flare to date



Fermi LAT Light Curve Repository

VHE detection of OP 313 by LST-1

No significant detection in January 2024



Jan 2024

Fermi-LAT recent monitoring

