

# Continuous Wide-Field Imaging of Venusian Aurora Using the Haleakalā T60 Telescope

Evidence for a new form of Venus aurora during quiet solar wind condition

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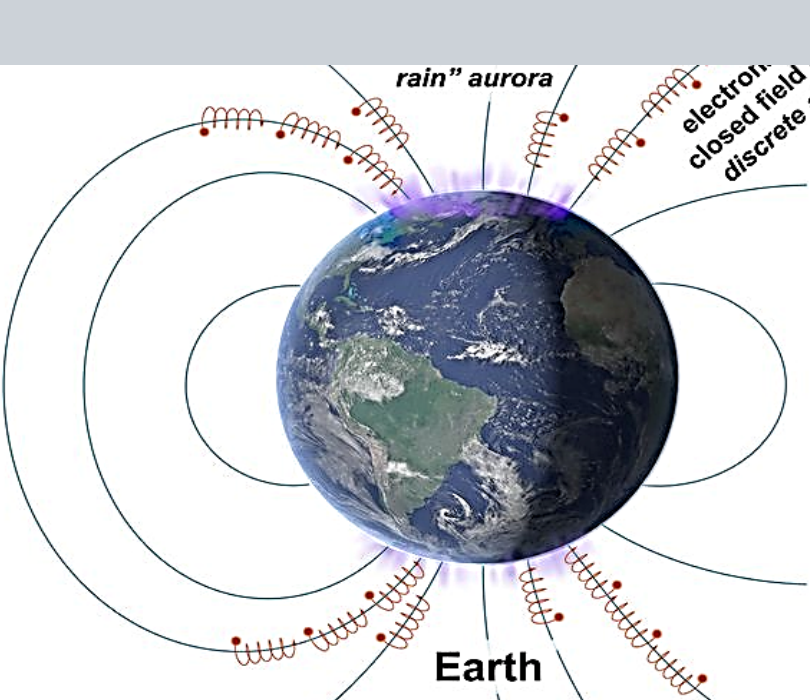
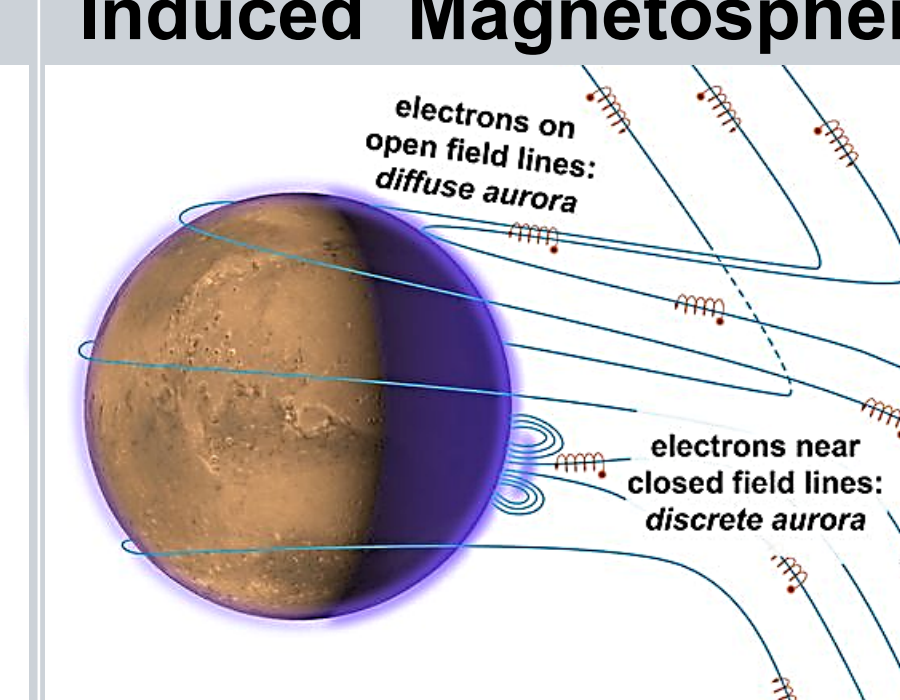
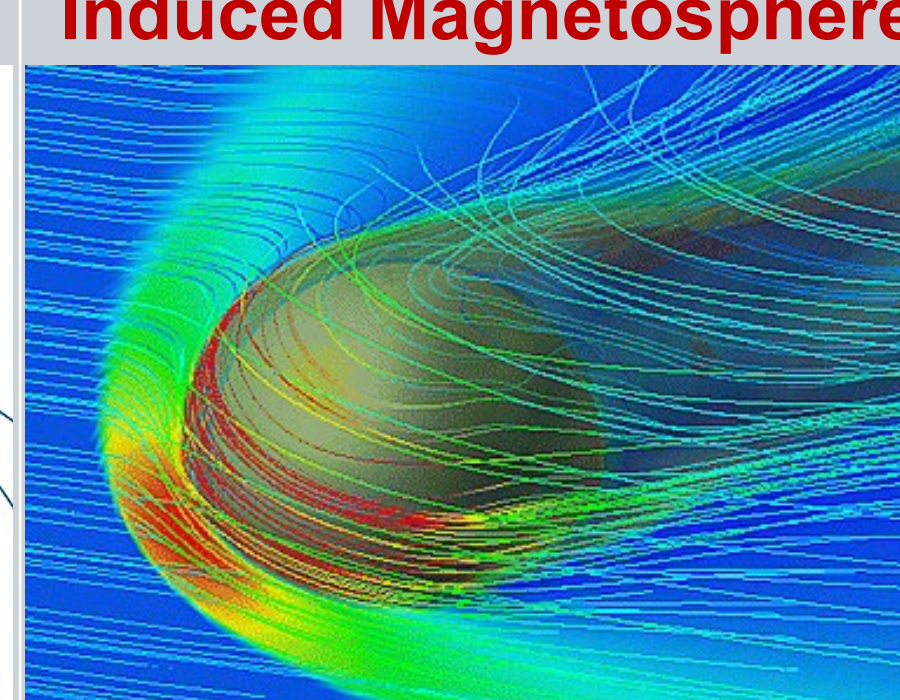
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## 1. Introduction

### Why Aurora?

Aurora traces energy input from the solar wind and energetic particles into planetary upper atmospheres. **Comparing different magnetic environments reveals how this energy is transported and deposited.**

### Aurora on Terrestrial Planets

Earth	Mars	Venus
<b>Dipole Field</b>	<b>Local crustal + Induced Magnetosphere</b>	<b>Only Induced Magnetosphere</b>
		
Fig1, Earth field (N. M. Schneider et al. 2015)	Fig2, Martian field (N. M. Schneider et al. 2015)	Fig3, Venusian field (N. Terada et al. 2009)
© Auroral observations are well established.	○ Auroral observations have been ambitious performed by MAVEN and EMM.	△ <b>Previous detections exist, but observations are still limited.</b>

### Observation of Venusian Aurora

#### Space-born observations

- Limited study by Pioneer Venus Orbiter.

#### Ground-based observations

- Limited chance for the inner planet near the Sun
- Strong contamination from dayside stray light
- Limited spatial coverage by narrow-slit observations in previous studies

#### What they found

- Detections were found only linked to major solar events

### Purpose in This Study

**To investigate how the aurorae with only an induced magnetosphere responds to solar activity through continuous wide-field observations of the Venusian aurora.**

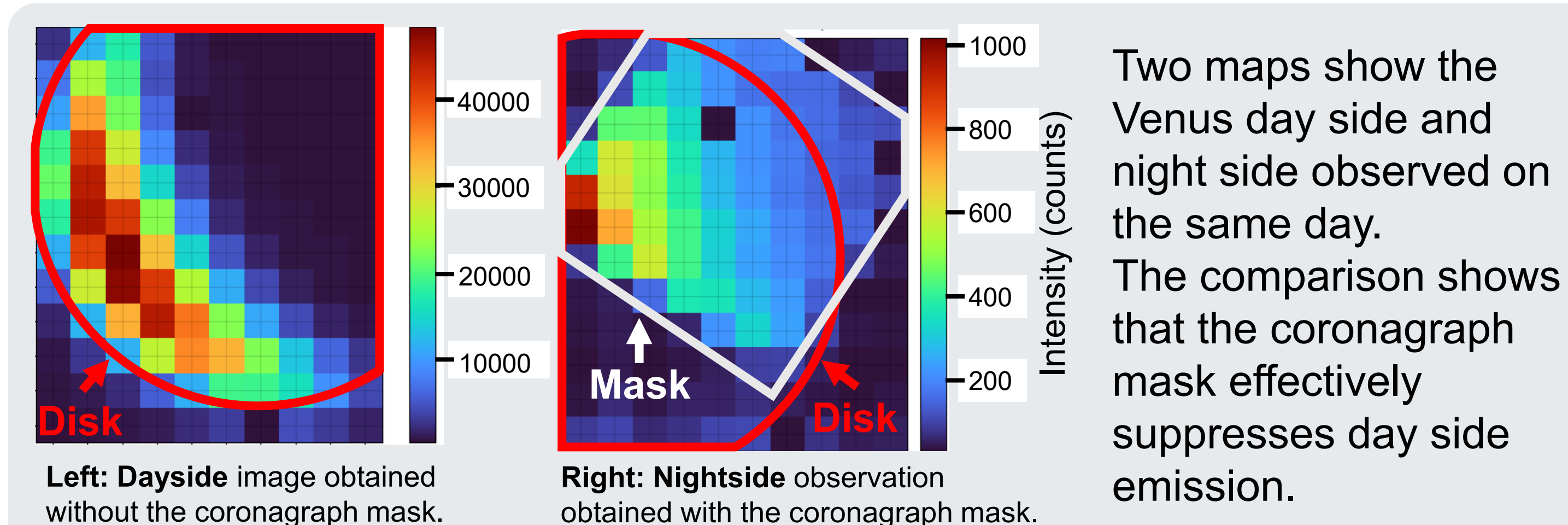
## 2. Methods

### T60 Telescope

Location	Haleakalā Observatory, Hawaii
Aperture	600 mm
Spectral Resolution	<b>R ≈ 60000 (0.0026 nm)</b>
Field of View	<b>30"×36" (10×12 segment)</b>
Light Suppression	<b>Coronagraph Mask</b>

- High spectral resolution** separates Doppler-shifted Venusian emission from terrestrial airglow (OI 557.7 nm).
- Wide-field fiber-array observations enable 2D mapping over a large area
- A coronagraph mask** reduces scattered dayside light.

### →Day side Light Suppression by the Coronagraph Mask



### Extended Observation Summary

Month	Observing Days	Datasets
February	15	61
May	24	53
June	27	75
July	17	60

- Observations were conducted in February and from May to July 2025.
- Multiple datasets were acquired on each observing day.**
- Data set corresponds a 20-minute nightside observation.

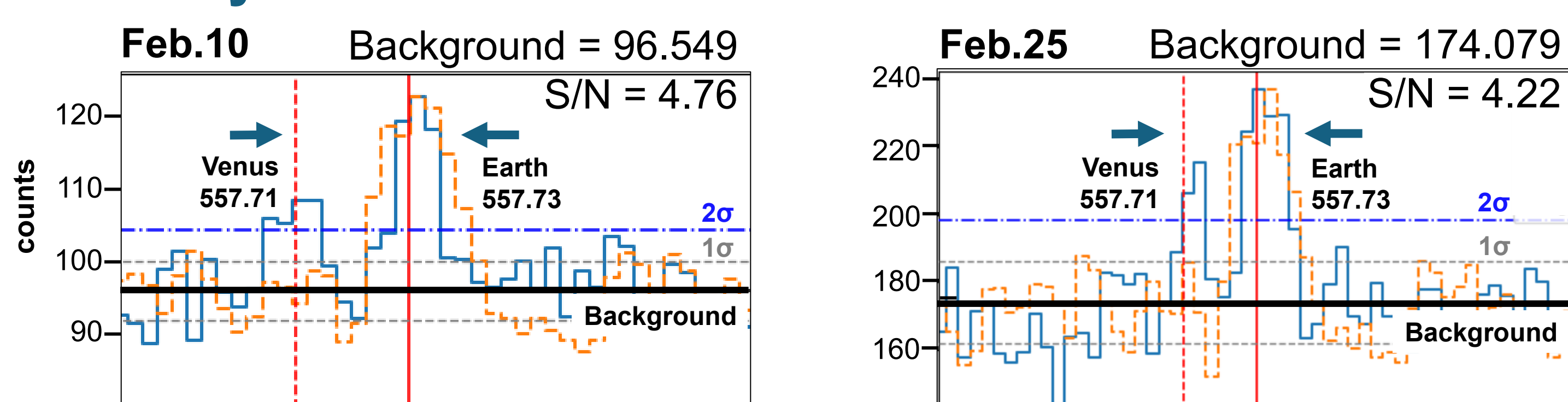
### Detection Criteria

$$S/N = \frac{\sum_{i=1}^3 (C_i - \mu)}{\sqrt{3} \times \sigma} > 3$$

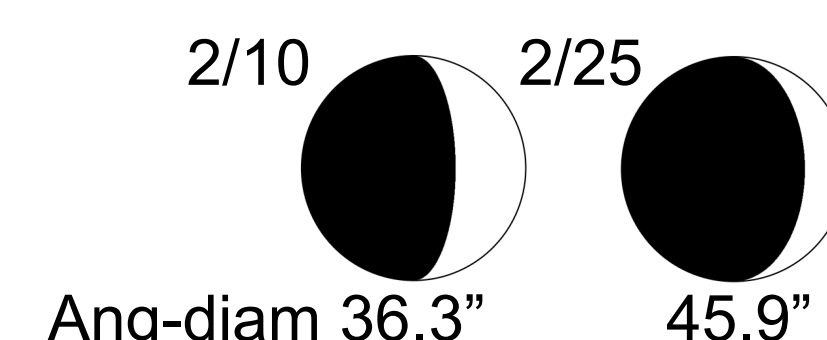
- Detection was defined as a 3-pixel integrated S/N > 3 around the target wavelength of 557.7 nm.

## 3. Results & Discussion

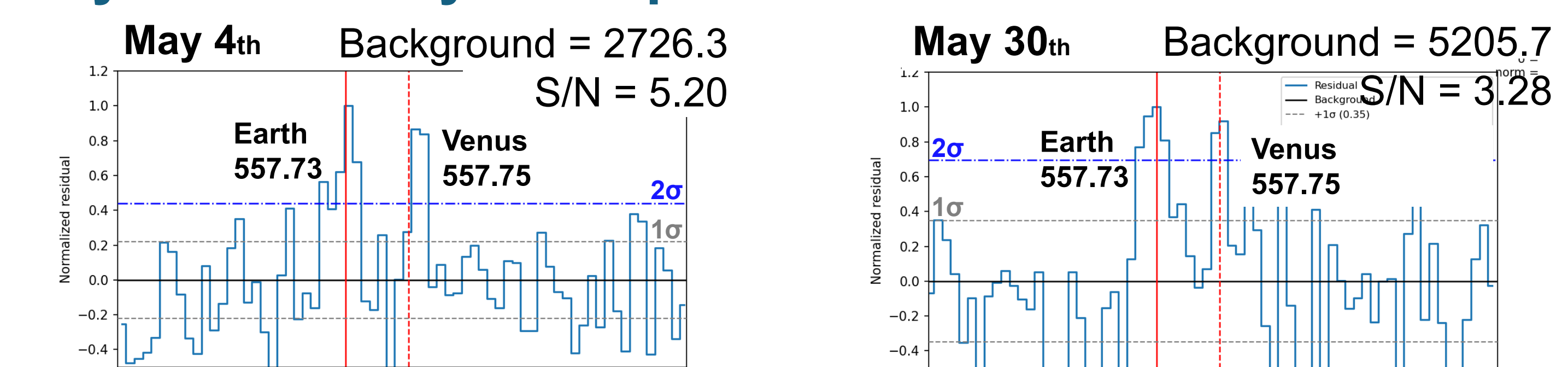
### February: Clear Detection



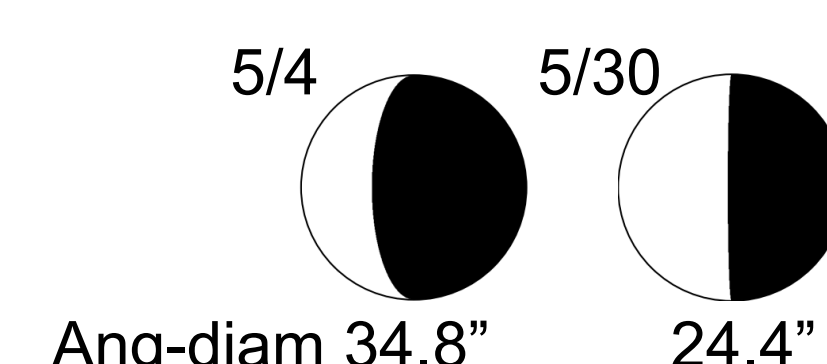
- Venusian auroral emission was detected on each observing day in February.
- The orange dashed line shows an example spectrum in which only the telluric airglow emission was detected.



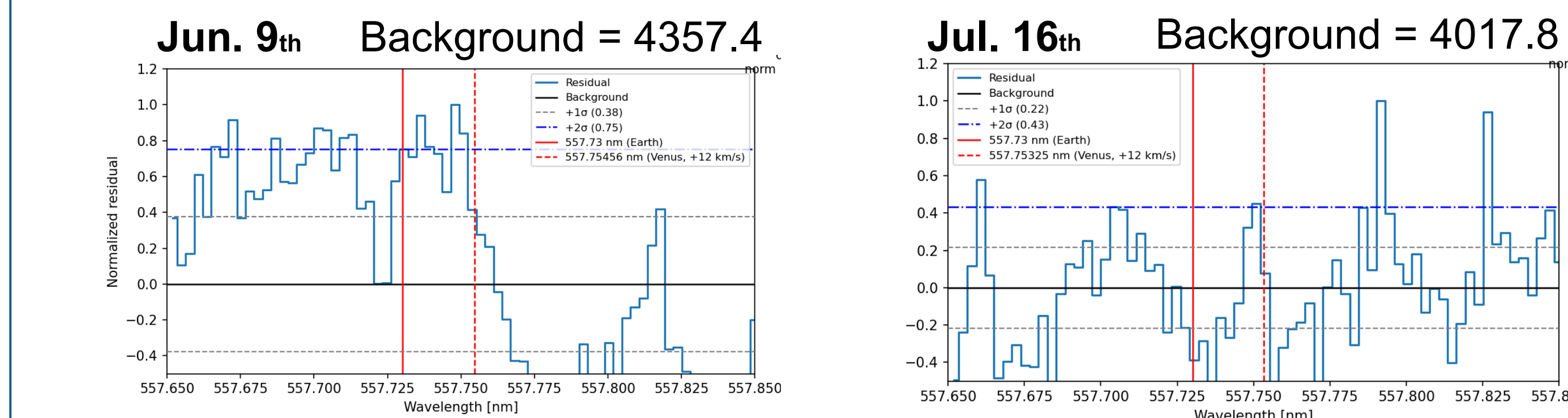
### May: Scaled Dayside-Spectrum Subtraction



- Unlike February, spectra in May were strongly affected by scattered dayside light.
- Venusian emission was detected after subtracting the scaled-dayside spectrum.



### June- July: Scaled Dayside-Spectrum Subtraction



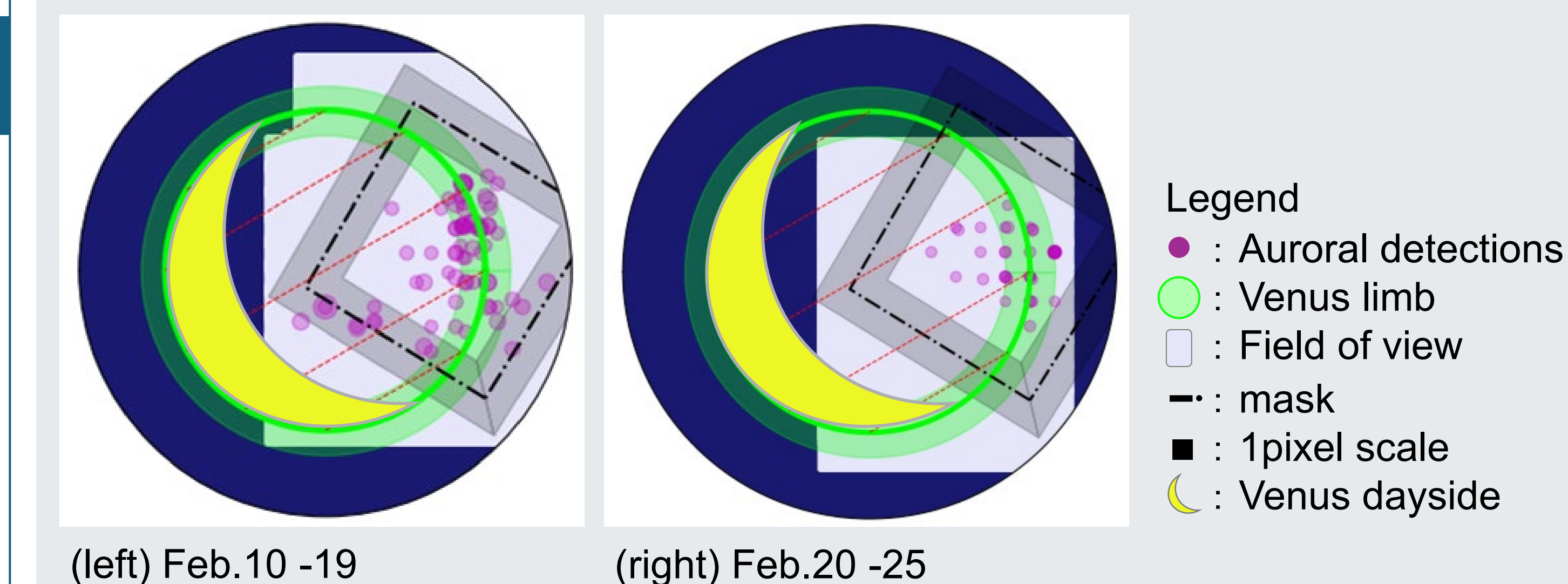
- As in May, the same scaled dayside-spectrum subtraction was applied to reduce strong dayside contamination.
- No reliable Venusian OI 557.7 nm emission was detected in June or July.

### Spatial Distribution: Possible New Form Aurora

#### Observed features

- Detected under **quiet solar conditions**
- Estimated intensity: **several tens of Rayleigh**
- Auroral emissions appeared over **a wide area of the nightside**.
- The emission is **not CME-driven**. It differs from previous studies.
- No clear geographic pattern was observed in the emission distribution. This resemble Martian non-crustal field patchy aurora. [Lillis+, 2022]

#### Auroral Detection Locations



Detections from February 10–19 were concentrated near the limb, while those from February 20–25 appeared more widely distributed. To characterize the spatial distribution, further statistical analysis of the May detections and additional observations are needed.

## 4. Summary

- We conducted continuous wide-field spectroscopic observations of Venus OI 557.7 nm emission using the T60 telescope.
- Auroral emissions were detected throughout the February campaign and were also identified in May through statistical processing.
- The detections under quiet solar conditions suggest a new-type aurora which different from previously reported.
- Continued observations are needed to characterize the spatial and temporal variability of the emission.