Deriving Physical Parameters of Auroral Event from Simultaneous Atomic and Molecular Emissions

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I. Introduction

Background

Red/Green lines are used to map auroral morphology, while Blue/UV molecular bands are typically used to monitor thermal changes[1].

The Opportunity

While auroral instruments generally favor bright but highly cross-contaminated UV bands, this study targets the unconventional Near-IR band which is fainter but provides a less complicated spectrum.

Project Overview

Goal: Quantify auroral energy input by monitoring precipitation depth and thermosphere heating.

Approach: Simultaneous spectral observations of OI (557.7, 630.0 nm) & $N_2^+M(2,0)$ (782-787 nm) using HiT&MIS

Location: Kiruna, Sweden

II. HiT&MIS

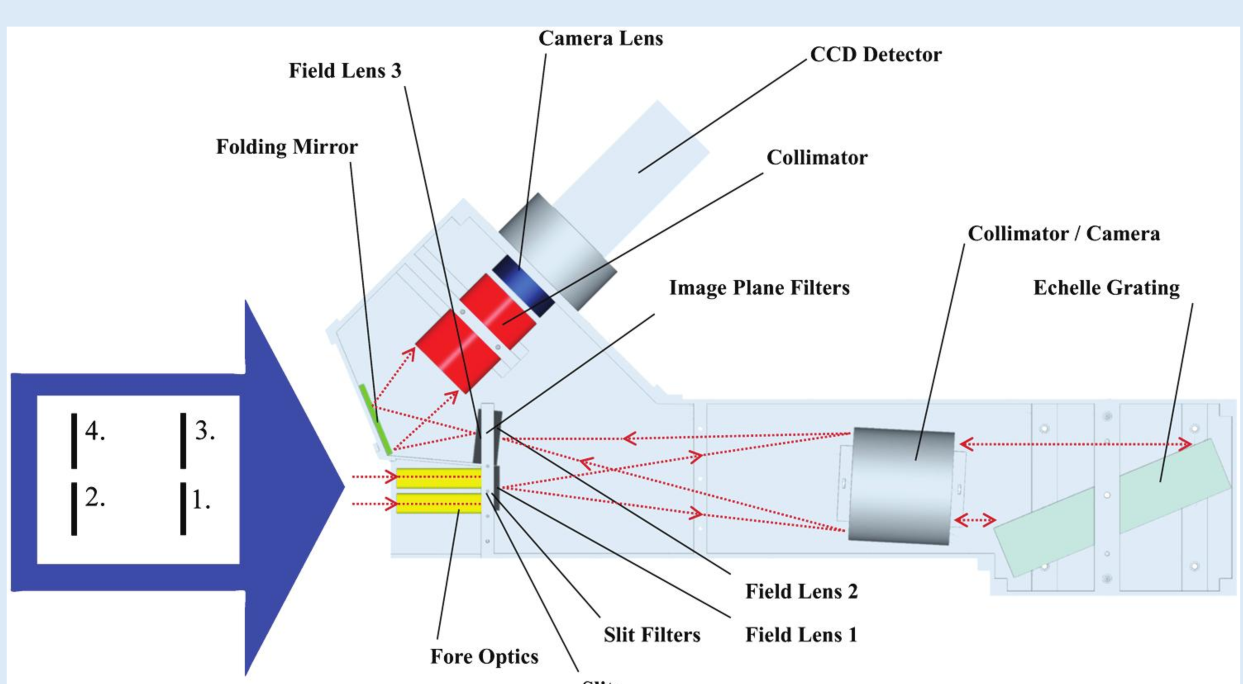
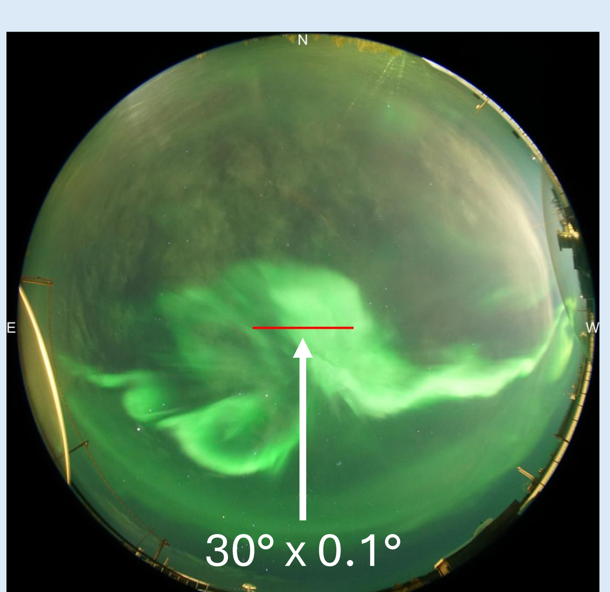


*Fig 1 : Schematic of **H**igh **T**hroughput **&** **M**ultislit **I**maging **S**pectrograph.*[2]



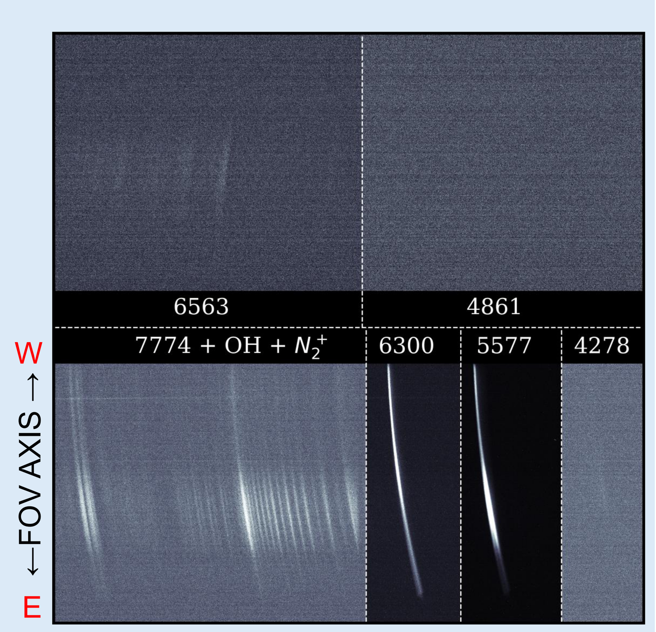


***Fig 2: Left**: HiT&MIS FOV(red line) overlaid on all-sky*[3] *image. **Right**: Raw normalized HiT&MIS frame from 2025-11-16 22:57 UTC.*

III. Observations

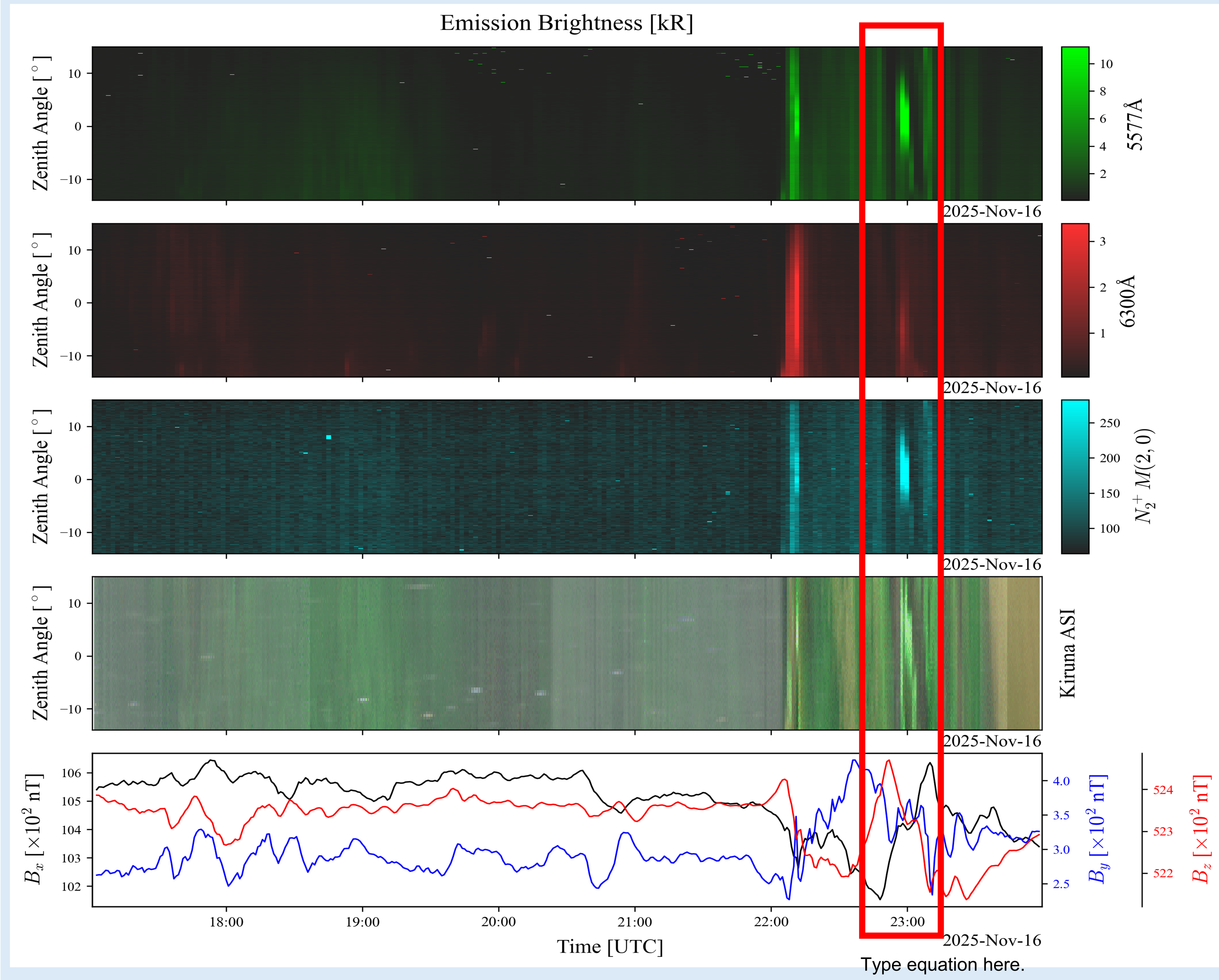


***Fig 3 :** Coordinated HiT&MIS, Kiruna All-Sky Imager*[3] *and Magnetometer*[4] *observations.*

Green (557.7nm) & $N_2^+M(2,0)$ track similarly because both emissions are driven by high energy electron-precipitation on low altitude, high-density regions

Red Line (630.0 nm) Behaves independently because it originates at much higher altitudes stimulated by lower energy precipitation.

Westward Electrojet Directly Overhead at ≈ 22:57:

B_x ↓ *lowest* = Max Current flow

B_y ↑↓= Current twisting & tilting

B_z − = Current Directly overhead

IV. Source Identification

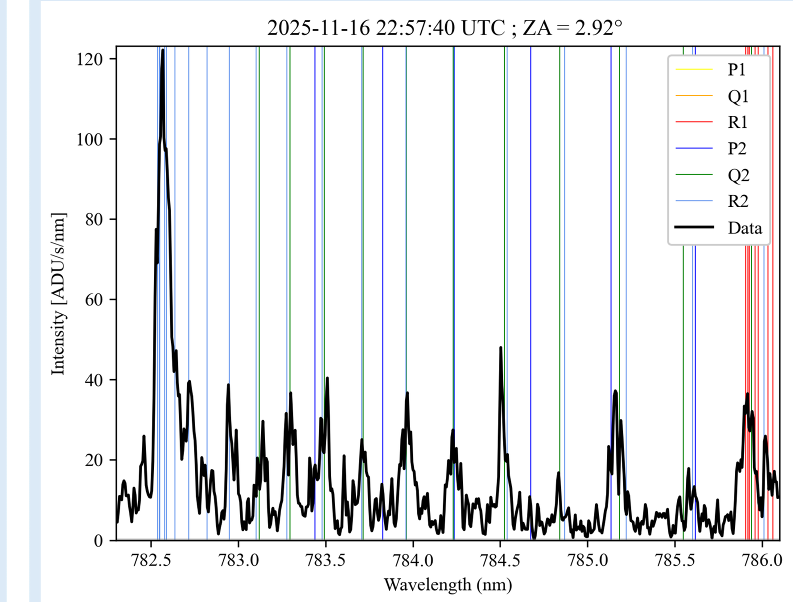


***Fig 4 :** HiT&MIS spectrum matched with theoretical line positions of N_2^+M (2,0) derived from Hill-Van Vleck equations*[5] *using known rotational constants to confirm the emission source*

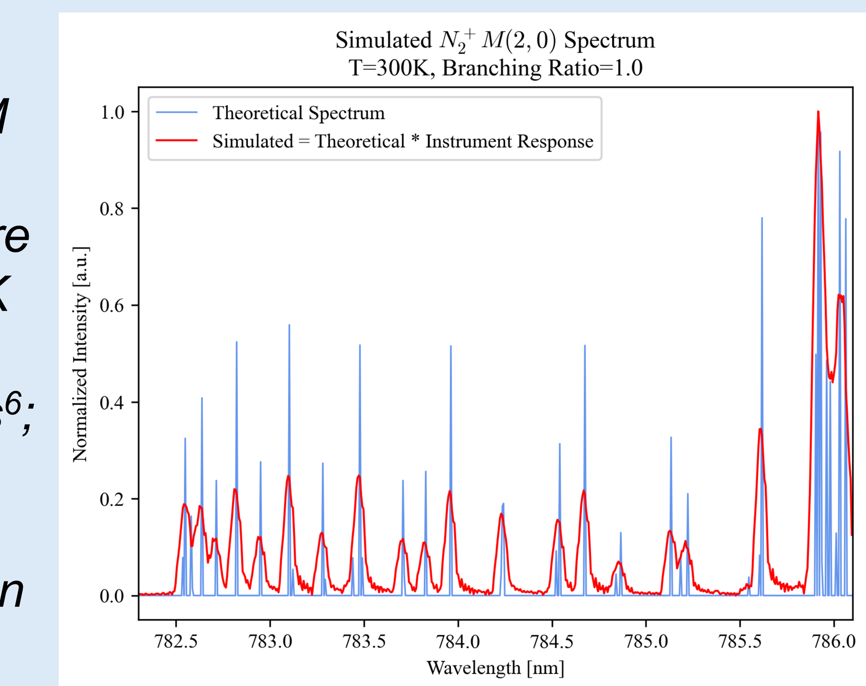


***Fig 5 :** Example theoretical N_2^+M (2,0) rotational line intensities are modeled at 300K using Honl-London formulas*[6]*; then convolved with instrument response function to simulate spectrum for fitting*

V. Retrieving Rotational Temperature from N_2^+M (2,0)

These plots demonstrate the retrieval process for a single zenith angle. The process will be scaled to all available spectra.

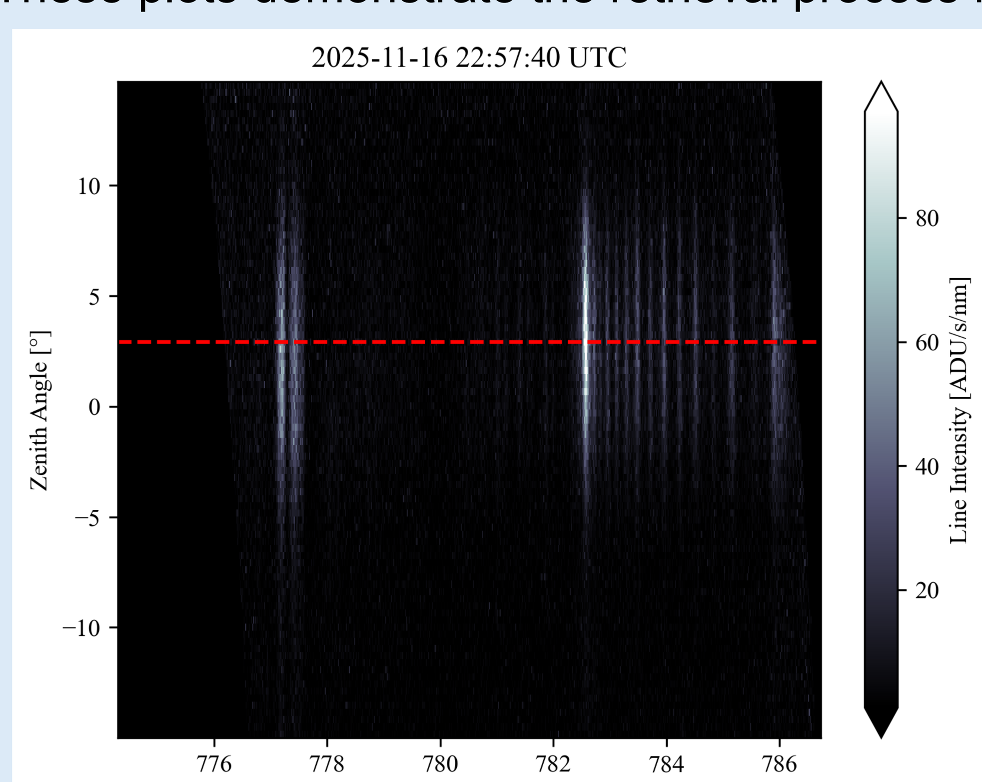
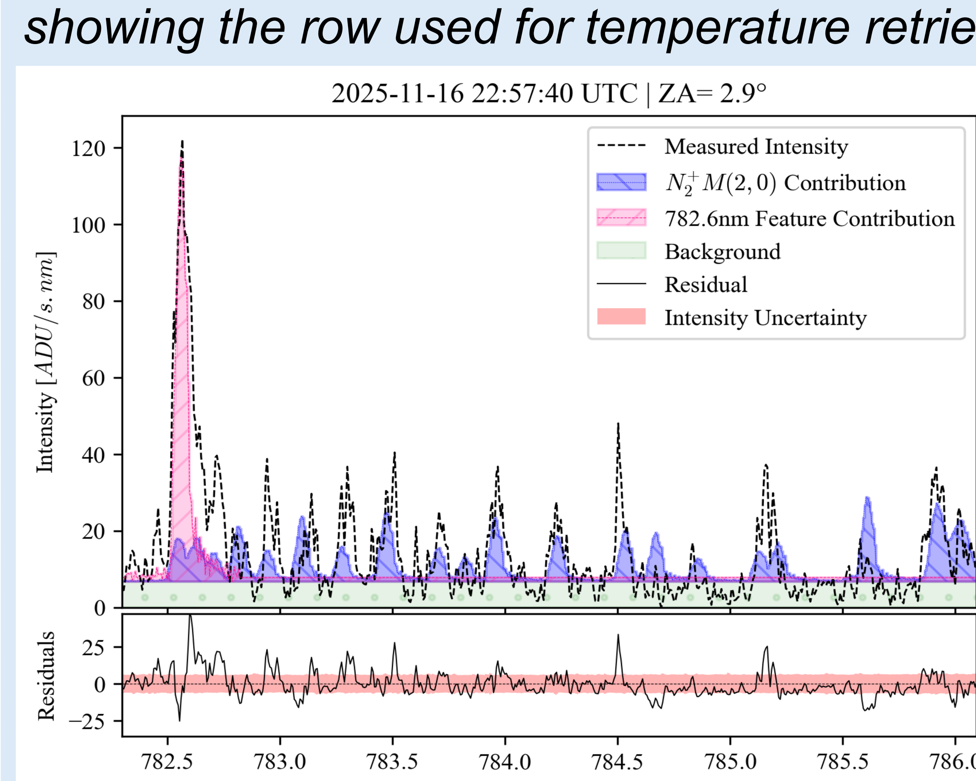


***Fig 6:** HiT&MIS frame with red dashed line showing the row used for temperature retrieval.*



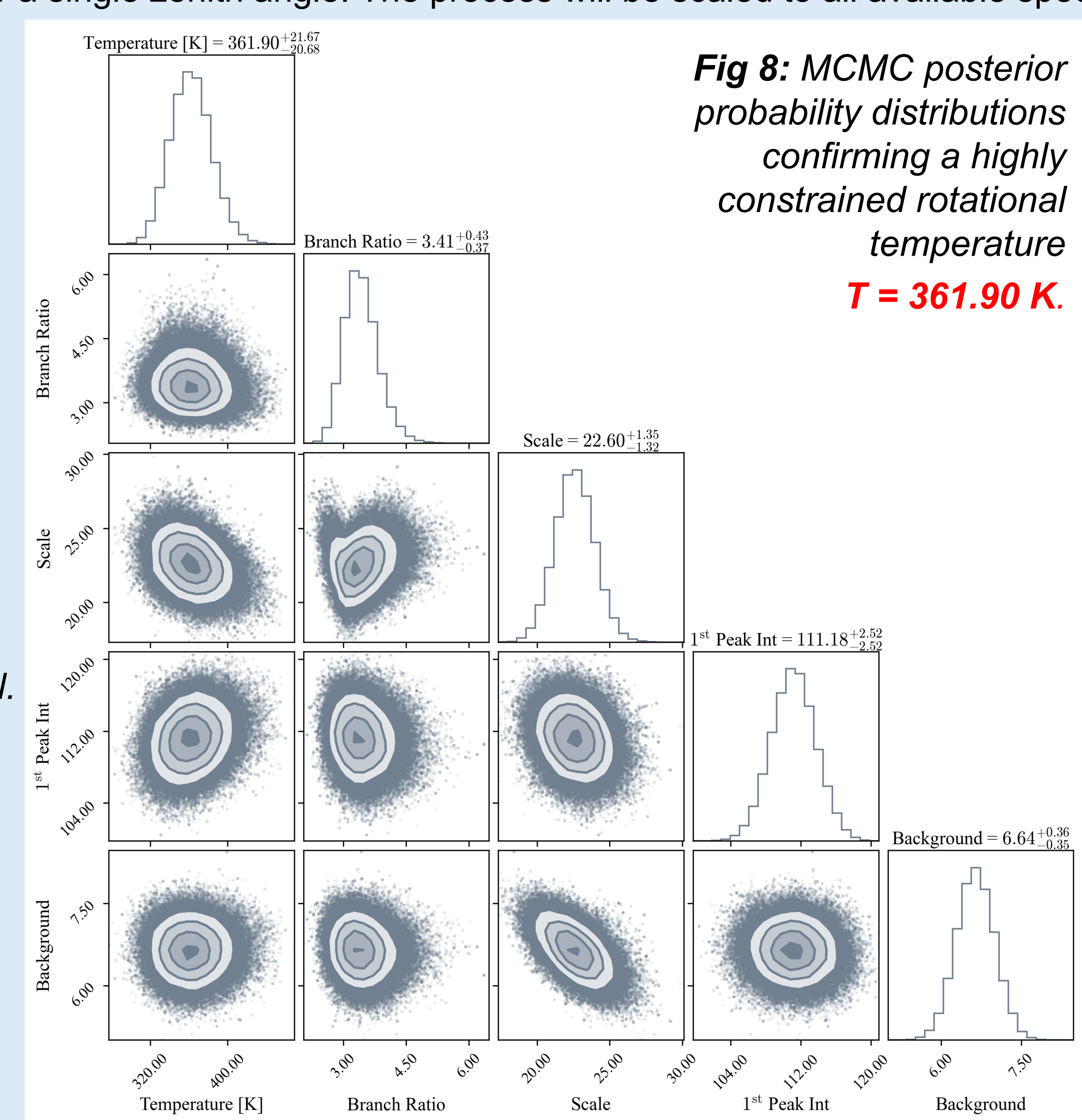


***Fig 8:** MCMC posterior probability distributions confirming a highly constrained rotational temperature*

***T = 361.90 K**.*

***Fig 7 Left:** Forward-modeled synthetic N_2^+M (2,0) profile fit against measured intensities and isolating the 782.6 nm contaminant line with average residual constrained within ~8% of peak values.*

VI. Next Steps

Optical Data from HiT&MIS

Green (557.7nm), Red (630.0 nm), N_2^+M (2,0)

Estimate Characteristic Energy

Map Temp to altitude proxy to find E_0

Modified GLOW Model

Fit particle flux (Q_0) for the given E_0

* Modification = extend GLOW to include N_2^+M (2,0)

Compare Against Ground Truth

Validate model-fit Q_0 and E_0 but comparing poxy measurements by other ground-based instruments

Track Evolution of Aurora Events

VII. References

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5. Hill, E., & Van Vleck, J. H. (1928). On the quantum mechanics of the rotational distortion... Phys. Rev., 32(2).
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