A study on energy budget of Io Plasma Torus based on the EUV spectroscopic observation

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Purpose of this study

HISAKI satellite observed the transient brightening of IPT about 10 hours after the brightening of aurora(Yoshikawa et al., 2016).

<u>What causes the event?</u>
<u>Hot electrons transport?</u>

→To find out it, we used the method called “spectral diagnosis” to the data obtained by HISAKI.

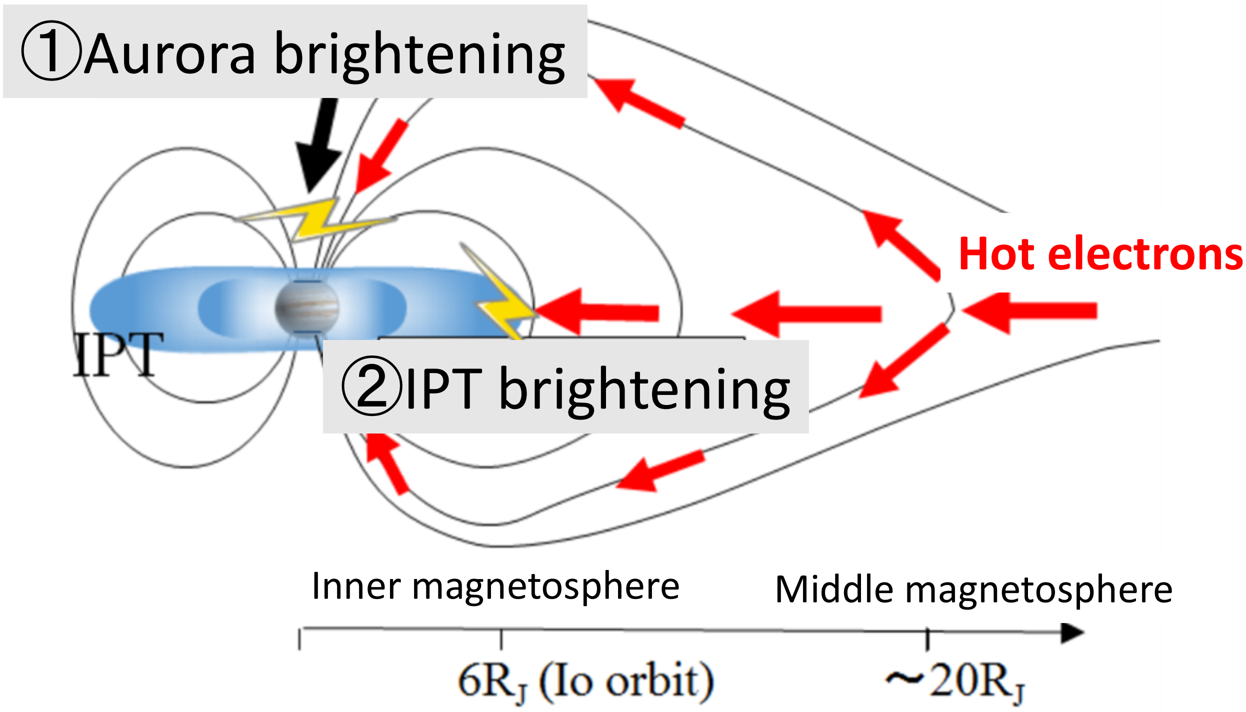


Fig. Schematic view of the brightening event

Principle of the spectral diagnosis

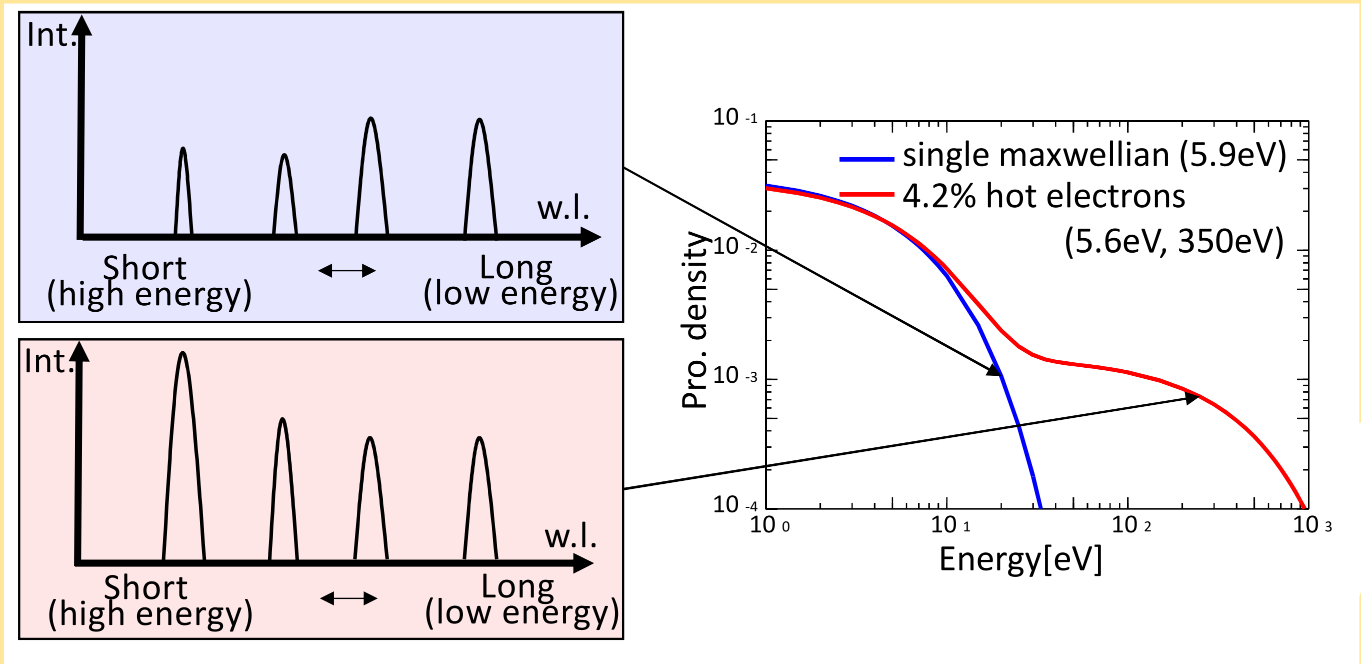


Fig. Schematic view of the relation between line intensities and hot electrons

- Ion densities affect the line intensity **regardless of the wavelength**.
- The amount of hot electrons affect the line intensities of **short wavelength**.

➡ The ion densities and the electron density distribution can be deduced remotely by using spectrum.

Procedure

1. To calculate the spectrum using the input parameters (ion densities and electron density distribution).

$$I(\lambda_{ji}) = \frac{1}{4\pi} \int N_j A_{ji} dl \ [\text{photons/cm}^2\text{/sr/sec}]$$

N_j : Density of ion in the energy level of "j"

A_{ji} : Natural transitions

$\int dl$: Integration along the line of sight

Balanced equation between energy levels:

$$\begin{pmatrix} \alpha_{11} & \alpha_{21} & \alpha_{31} & \alpha_{41} & \cdot \\ \alpha_{12} & \alpha_{22} & \alpha_{32} & \cdot & \cdot \\ \alpha_{13} & \alpha_{23} & \cdot & \cdot & \\ \alpha_{14} & \cdot & \cdot & & \\ \cdot & \cdot & & & \end{pmatrix} \begin{pmatrix} N_1 \\ N_2 \\ \cdot \\ \cdot \\ \cdot \end{pmatrix} = \mathbf{0}$$

Natural transitions

Collisional cross section

$$\alpha_{ij} = A_{ij} + N_e \int_0^\infty \widehat{g_e} v \sigma_e dv$$

Registered in CHIANTI atomic database

※$\widehat{g_e}$: Electron density distribution

2. To determine the best-fit input parameters by χ2 fitting to the spectrum obtained by HISAKI.

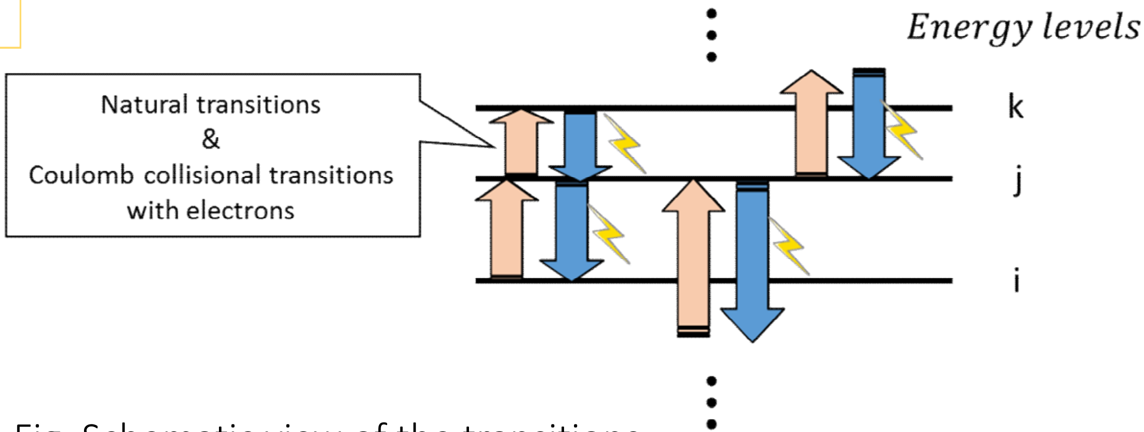
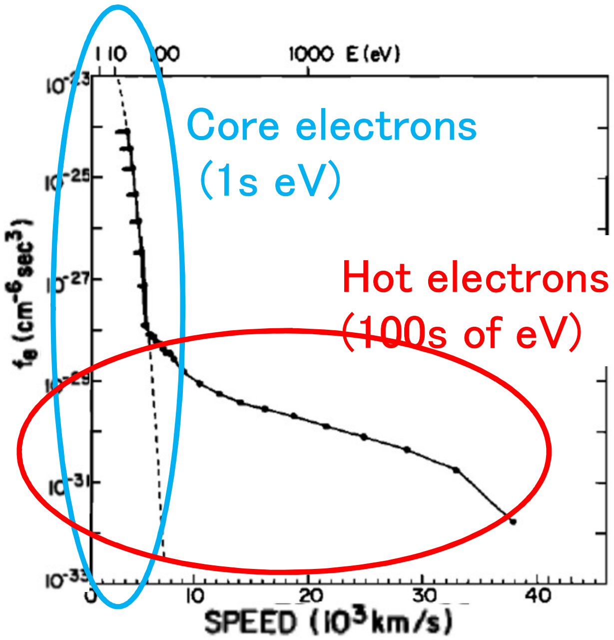


Fig. Schematic view of the transitions

Parameters

In this study, 6 parameters are deduced by the spectral diagnosis.

- Electron densities & temperature(T_{core}, N_{core}, N_{hot})
- Ion densities(N_{S^+}, $N_{S^{2+}}$, $N_{S^{3+}}$)
  - The electron density distribution is assumed as the sum of 2 maxwellians(Sccuder et al., 1981).
  - T_{hot} is fixed to 600 eV(Sccuder et al., 1981).
  - The densities of oxygen ions are fixed because the data obtained by HISAKI is contaminated by geocorona.
  - The charge neutral is assumed.

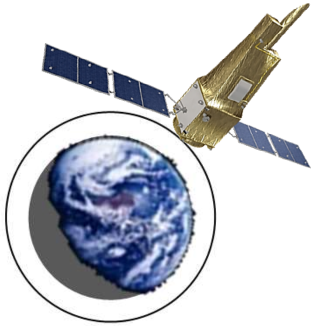


The electron density distribution (5.5 Rj from Jupiter, obtained by Voyager(Scudder et al., 1981))

N_O^{+}/N_S^{2+}	1.0
N_O^{2+}/N_S^{2+}	0.1

Density ratios obtained from Cassini's data

Data set (obtained by HISAKI)



・Spatial bins were summed over 3 RJ for the spectra from 5 to 8 RJ.

・The orbit-averaged data were integrated over 20 hours to remove the known periodic variation and to improve the signal to noise ratio.

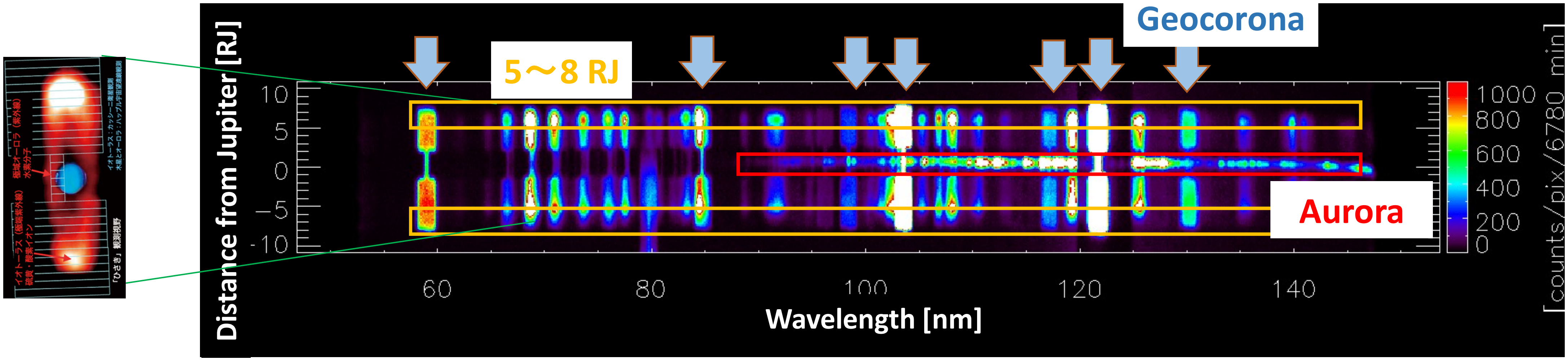


Fig. The spectral image obtained by integrating the HISAKI data.

Data set

The data obtained on from 5th, March, 2015 to 10th ,March, 2015 were applied. **The greatest brightening** within HISAKI's observation occurred in the period.

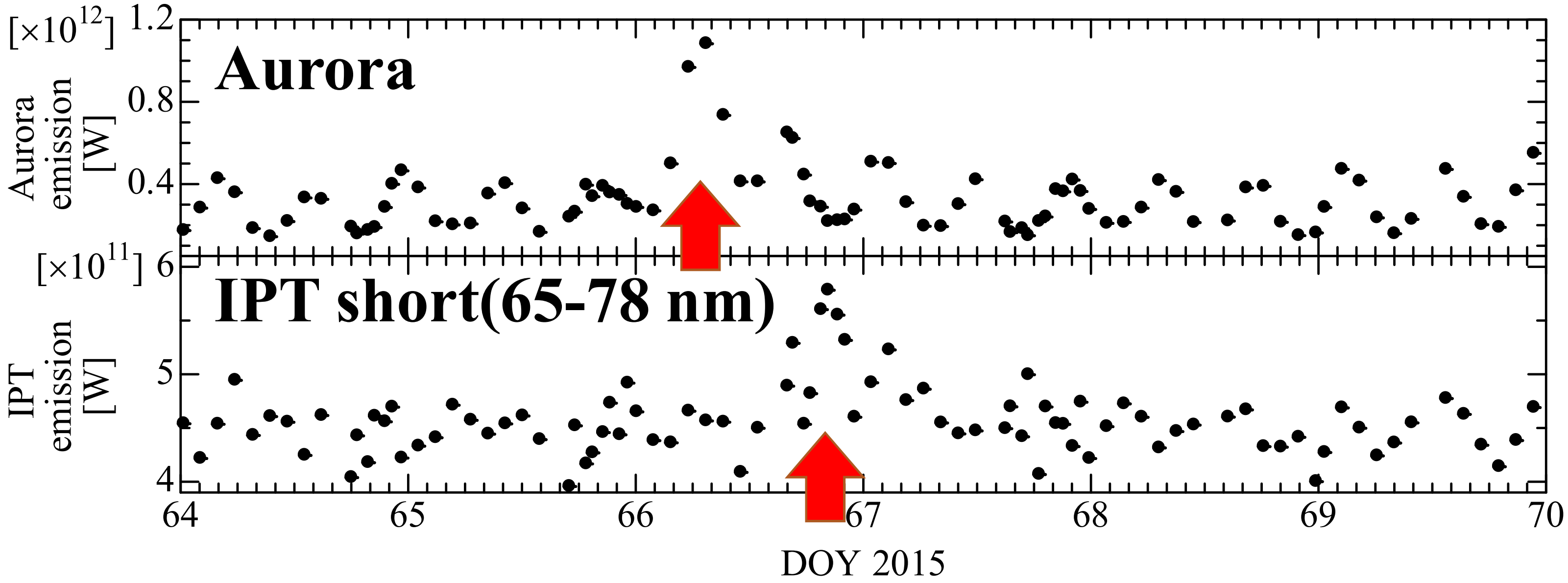
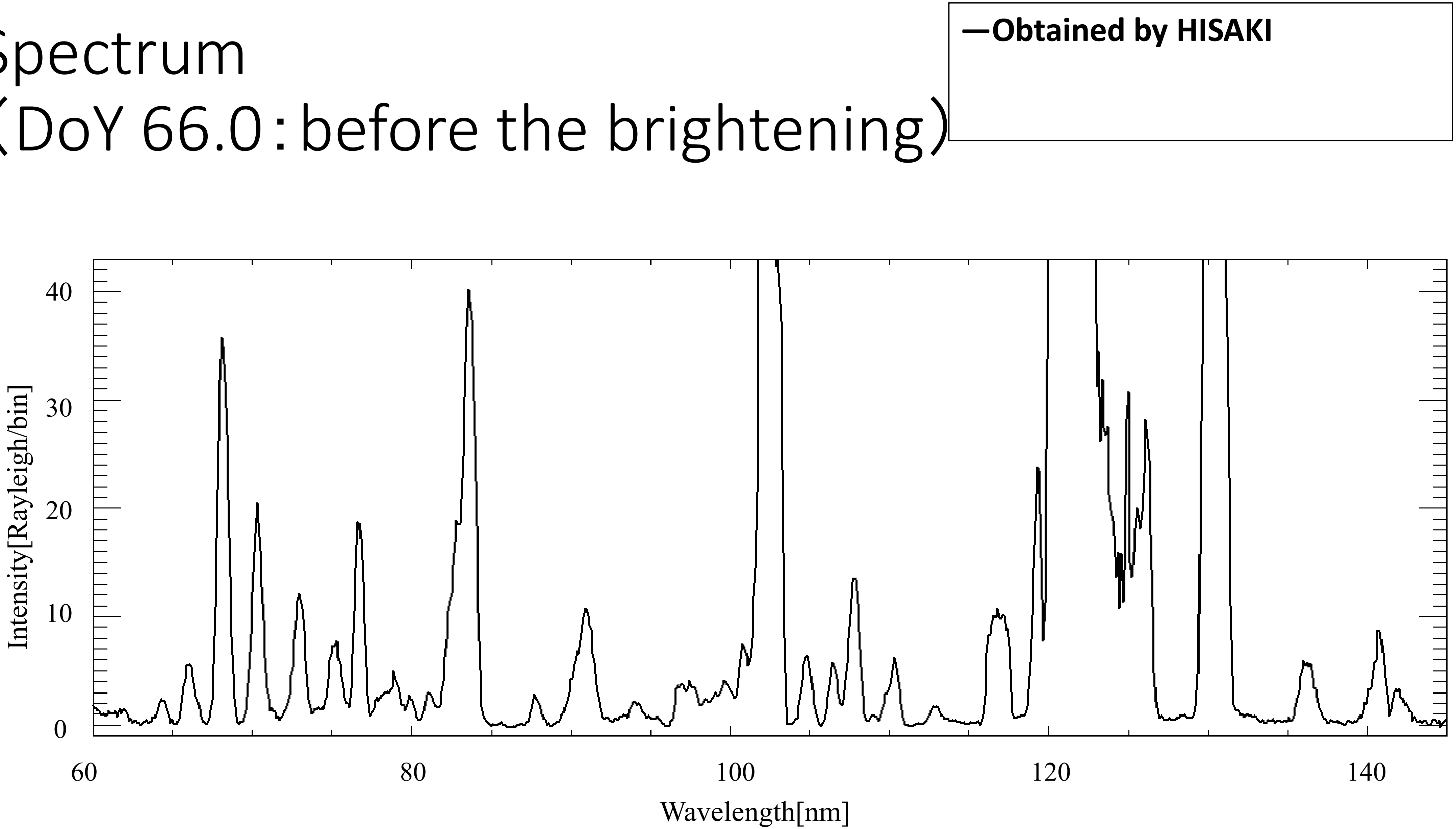
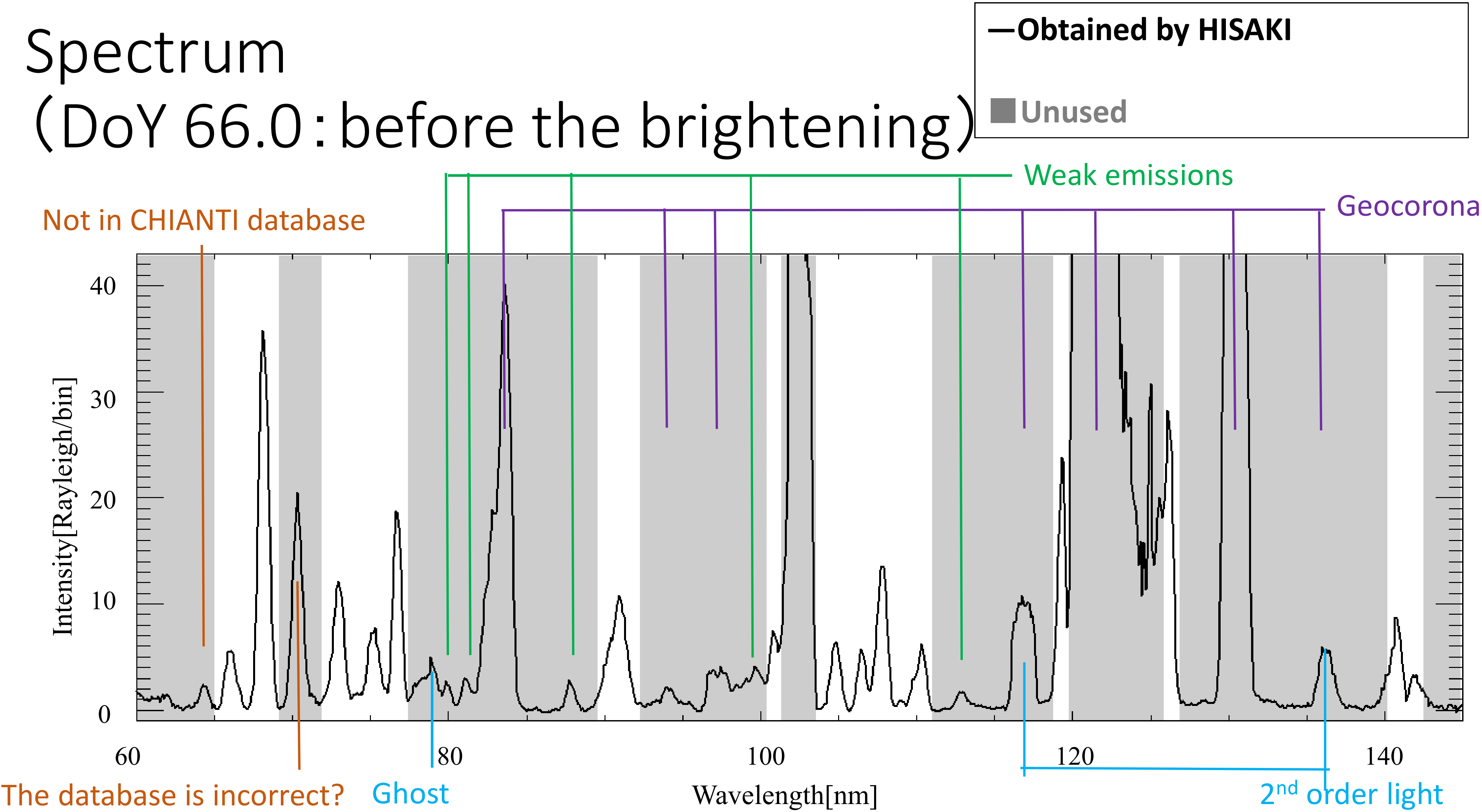


Fig.(a) Time variations of the auroral emission (b) Time variations of IPT emission

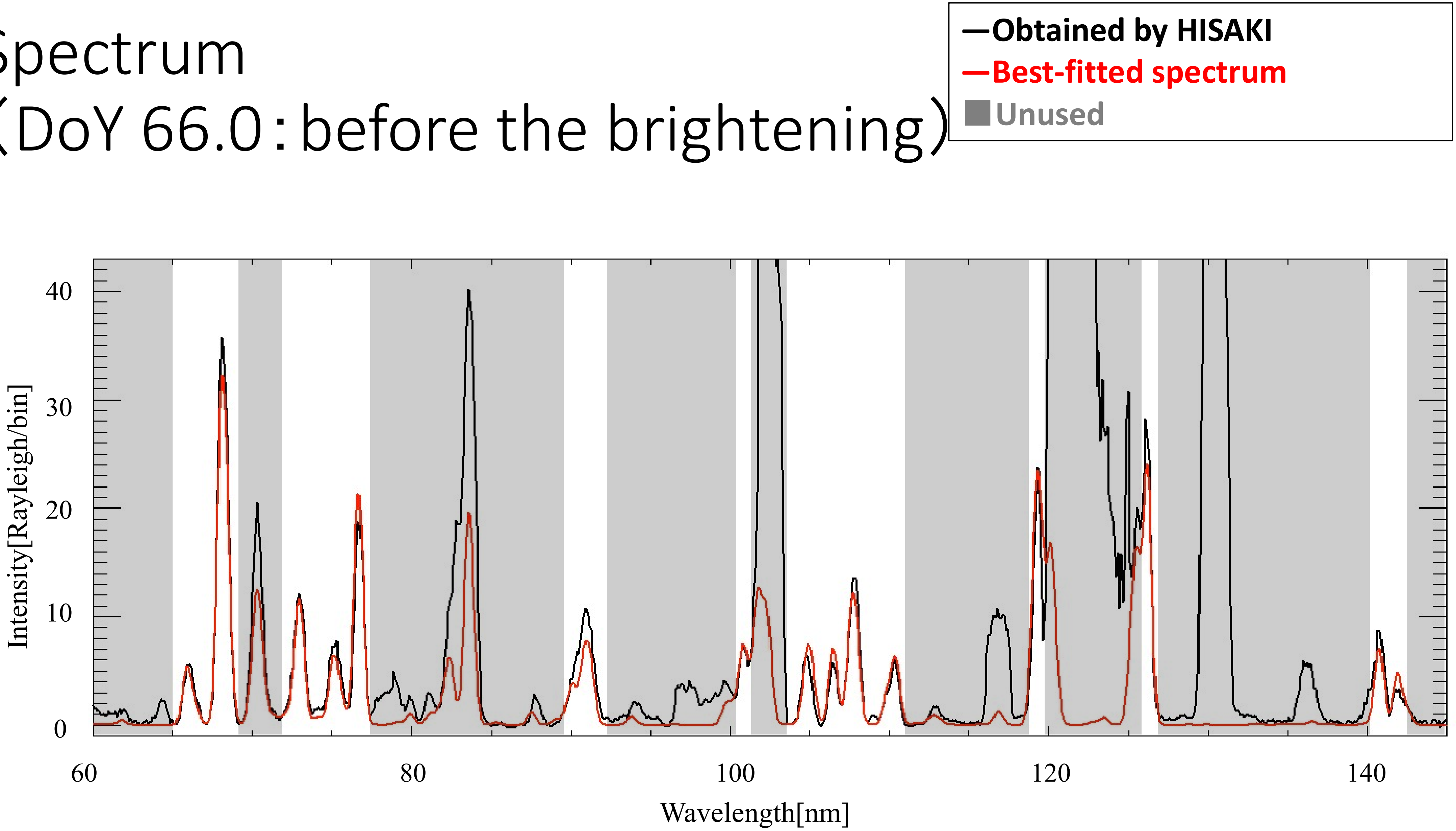
Spectrum
（DoY 66.0：before the brightening）



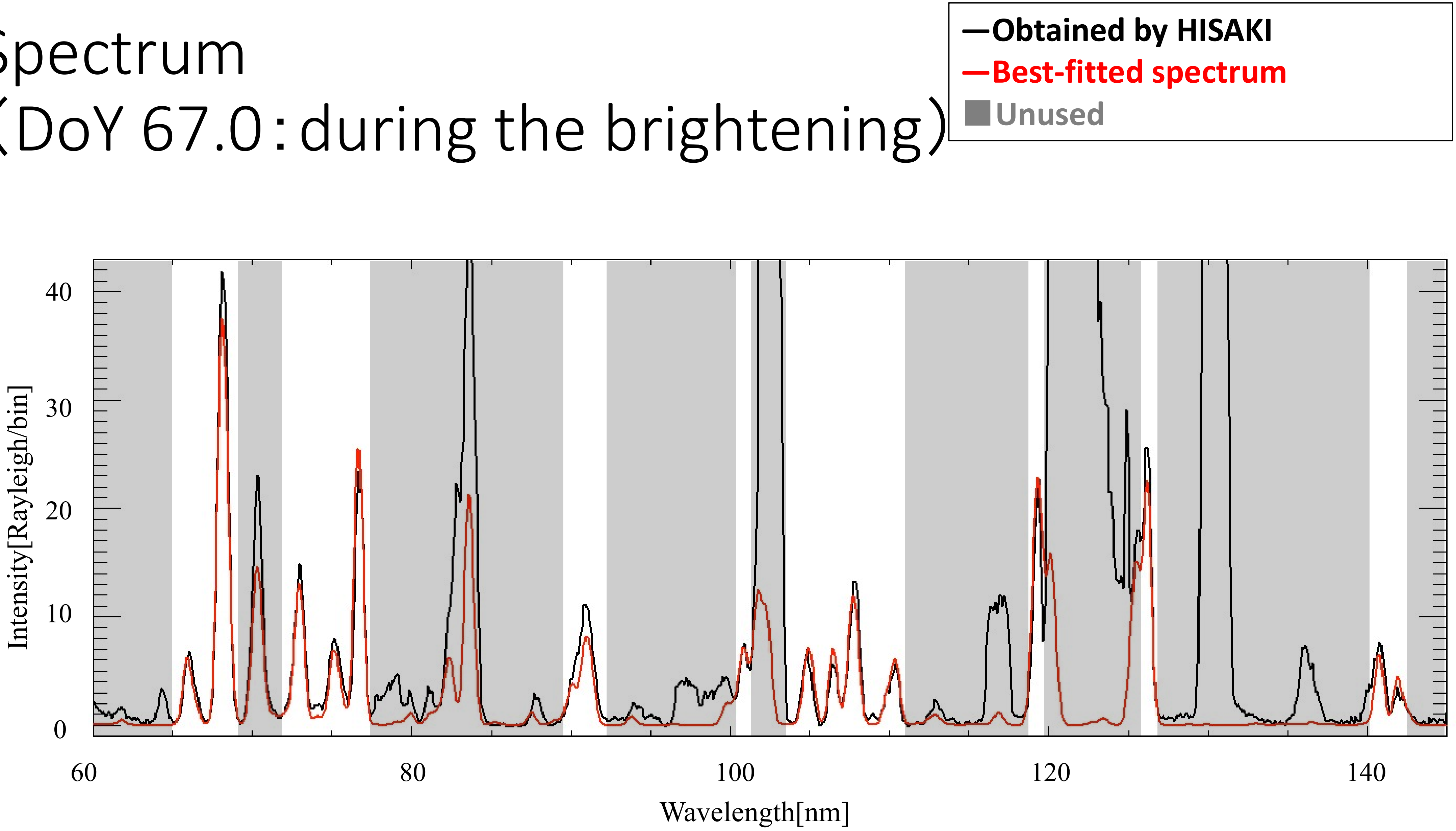
Spectrum
（DoY 66.0：before the brightening）



Spectrum
（DoY 66.0：before the brightening）

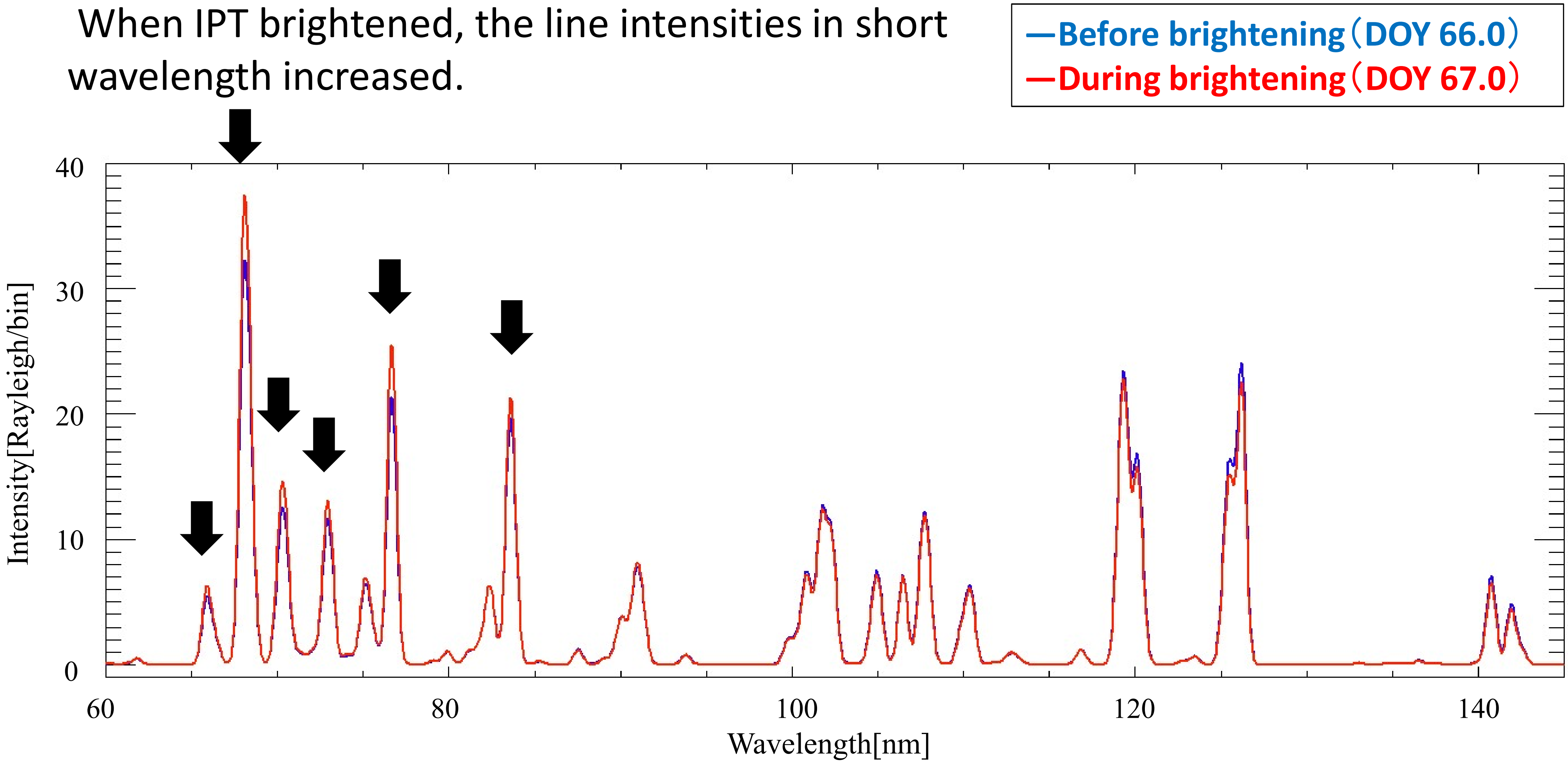


Spectrum (DoY 67.0：during the brightening)



Change in the spectrum during the brightening

When IPT brightened, the line intensities in short wavelength increased.



Results(1)

<u>The increase in hot electron density is confirmed.</u>

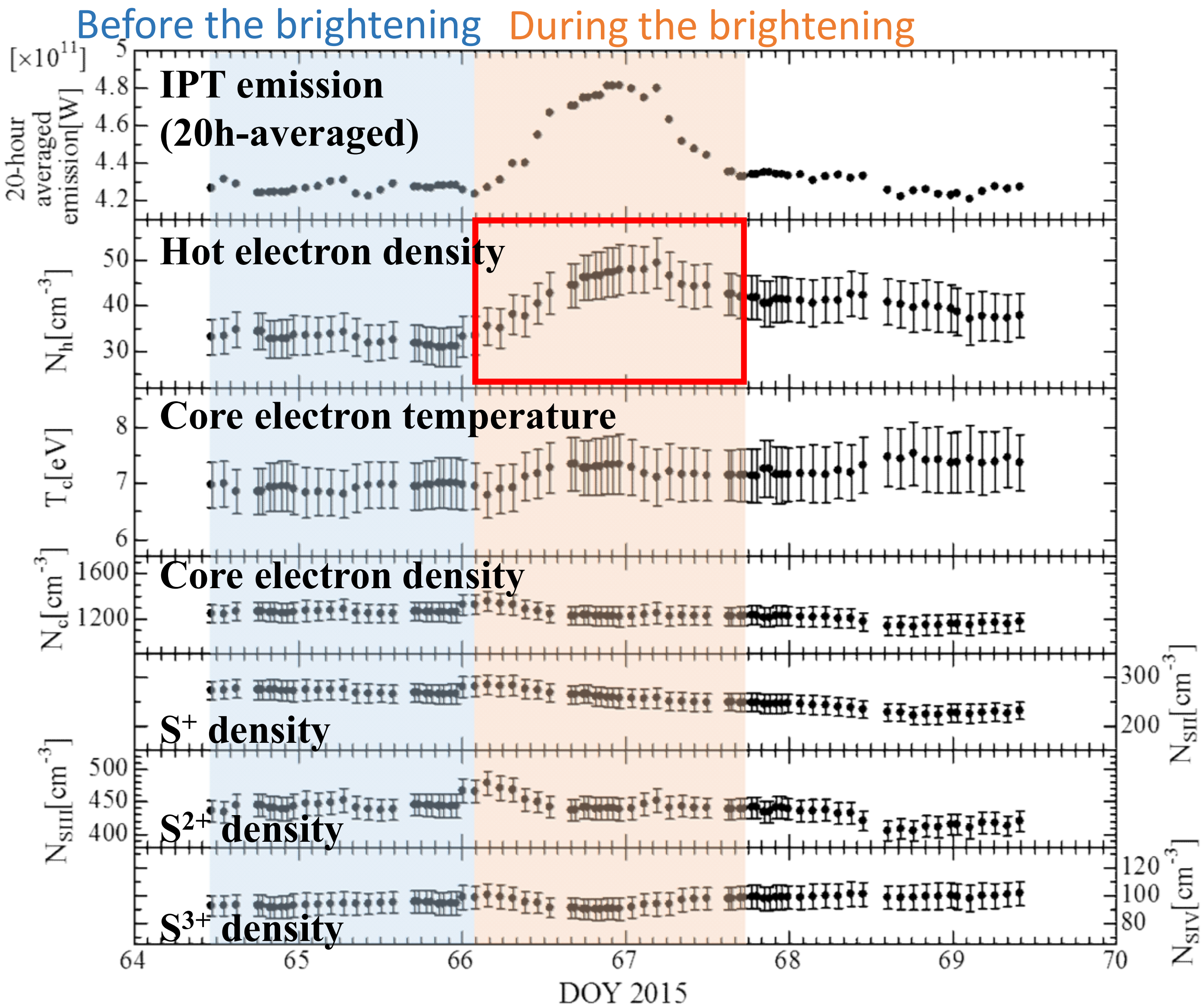


Fig. Time variation of 20 hours-running-averaged IPT emission, hot electron density, core electron temperature, core electron density, densities of sulfur ions.

The contribution of hot electrons to IPT emissions

By using the results of the spectral diagnosis and CHIANTI atomic database, we distinguished the emissions generated by hot electrons and core electrons.

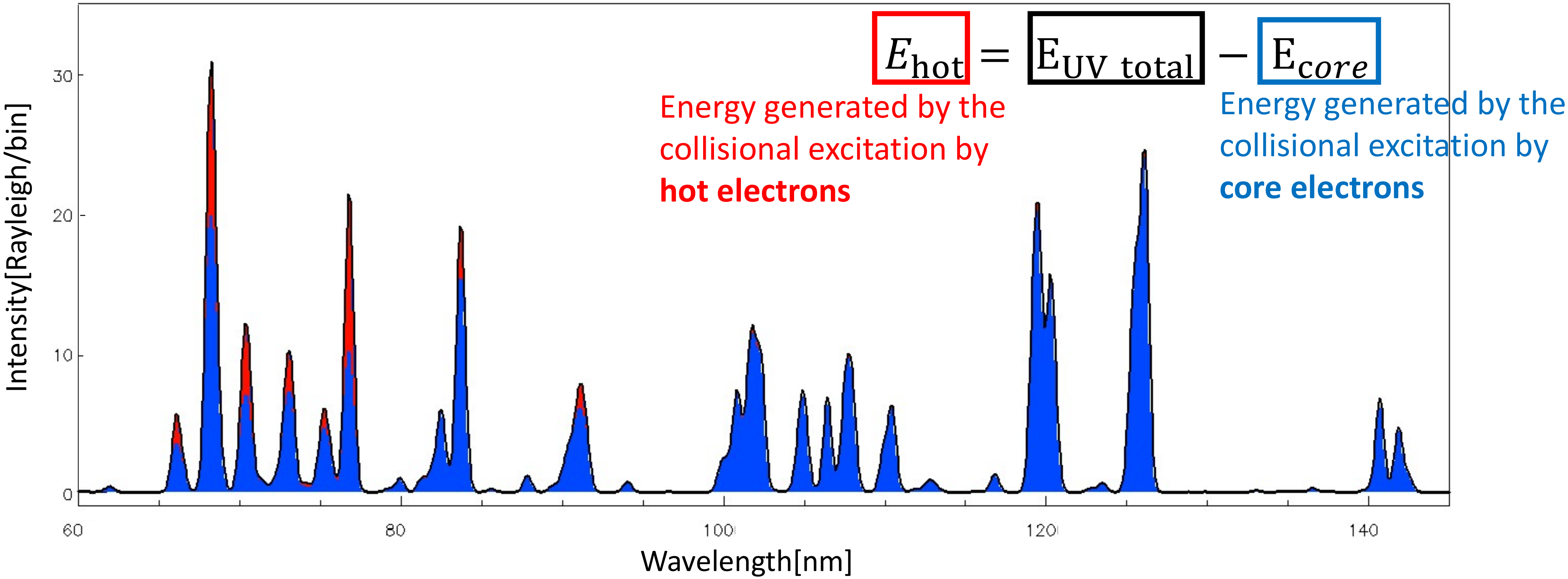


Fig. Schematic view of the emissions generated by core/hot electrons

Results(2)

The increase in the contribution of hot electrons is confirmed.

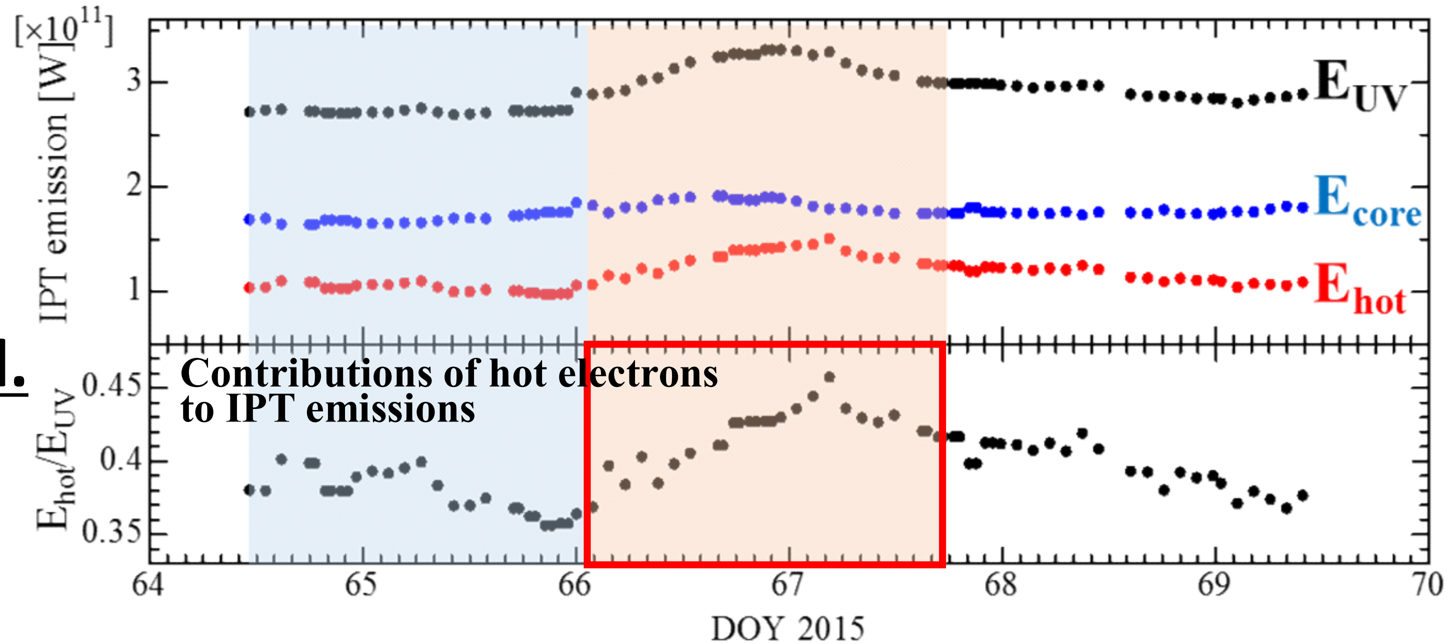
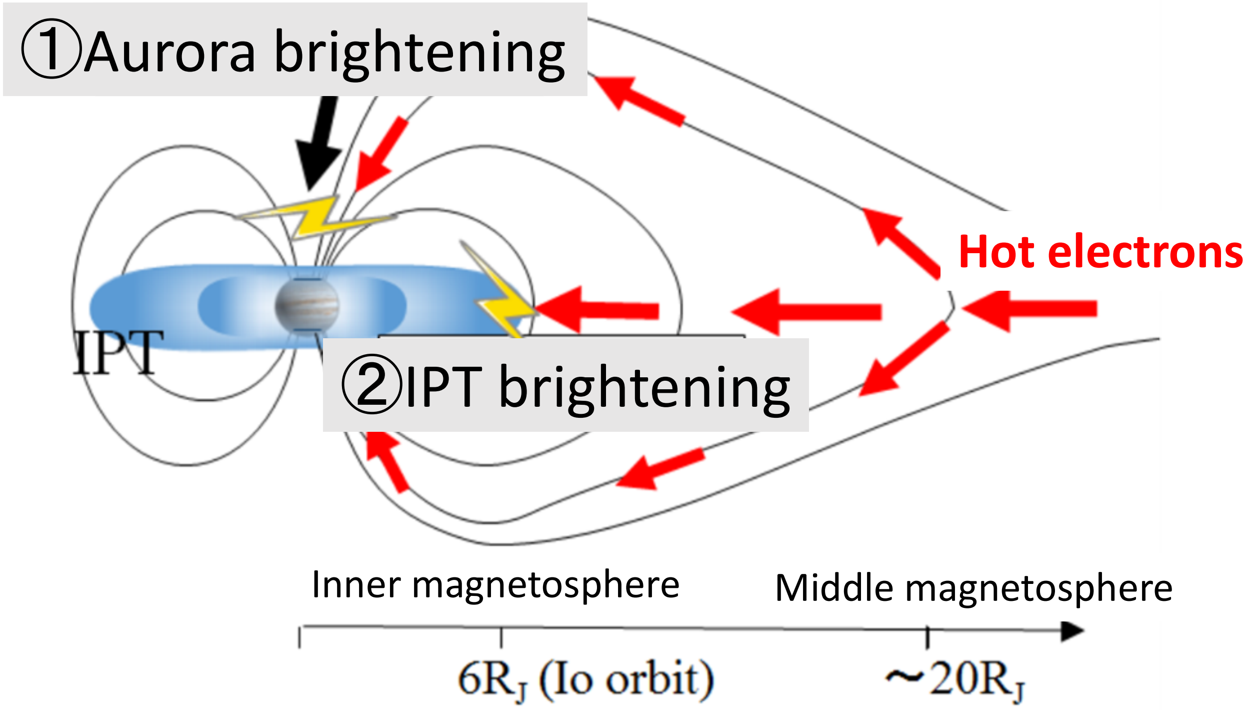


Fig.(upper) Time variations of IPT emission generated by core/hot electrons and sum of them.(lower) Time variations of the contribution of hot electrons to IPT emissions.

Conclusions

The increase in **hot electron density** and **the contribution of hot electrons to the IPT emission** during the IPT brightening is confirmed.

→This result suggests that the brightening was caused by **the injection of hot electrons.**



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