Radiative Hydrodynamic Modelling Of The Lyman Continuum During Solar Flares

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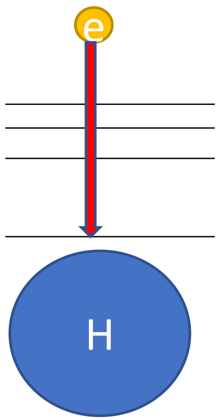
The Lyman Continuum (LyC)



- Free-bound transition of electrons to n=1 of an ambient hydrogen nuclei
- Recombination edge at 911.12Å
- In Quiet Sun LyC forms in the chromosphere and is in NLTE (Machado & Noyes 1978)
- LyC can be used to the determine the plasma conditions in the chromosphere (Noyes & Kalkofen 1970)
- EVE onboard SDO is currently the only mission providing solar LyC observations

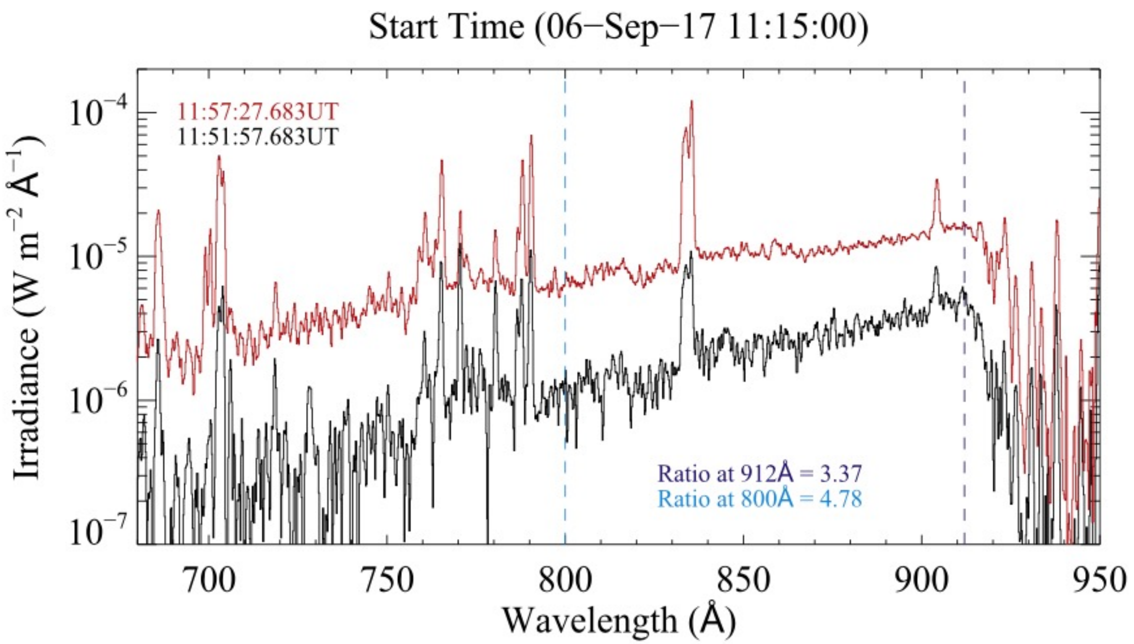
$$I = \frac{B(T_c)}{b_1}$$

Planck function → B

Colour temperature → T_c

Intensity → I

Departure coefficient (n1/n1*) → b_1

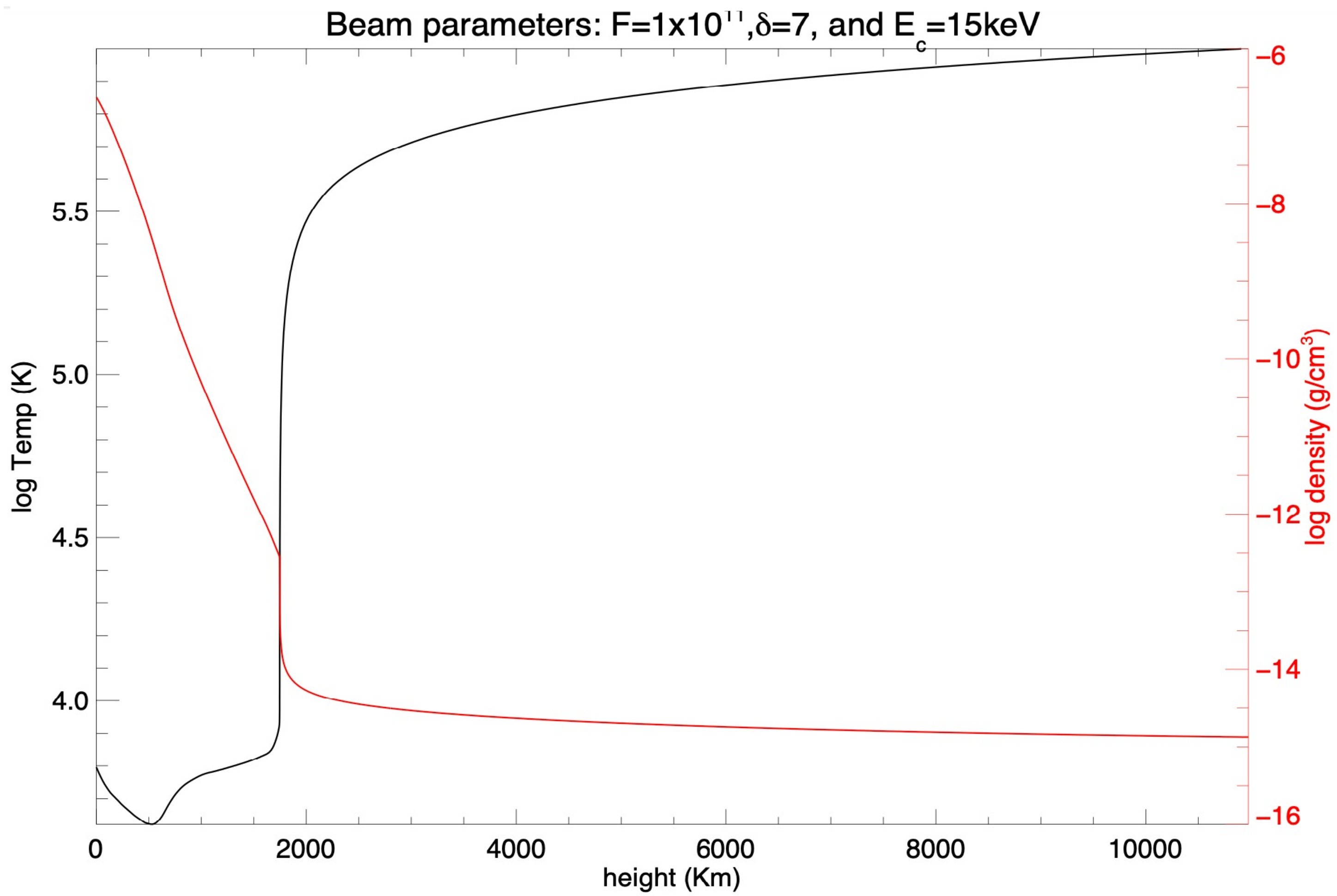


Credit: Machado, Milligan & Simões (2018)

RADYN & the F-CHROMA grid

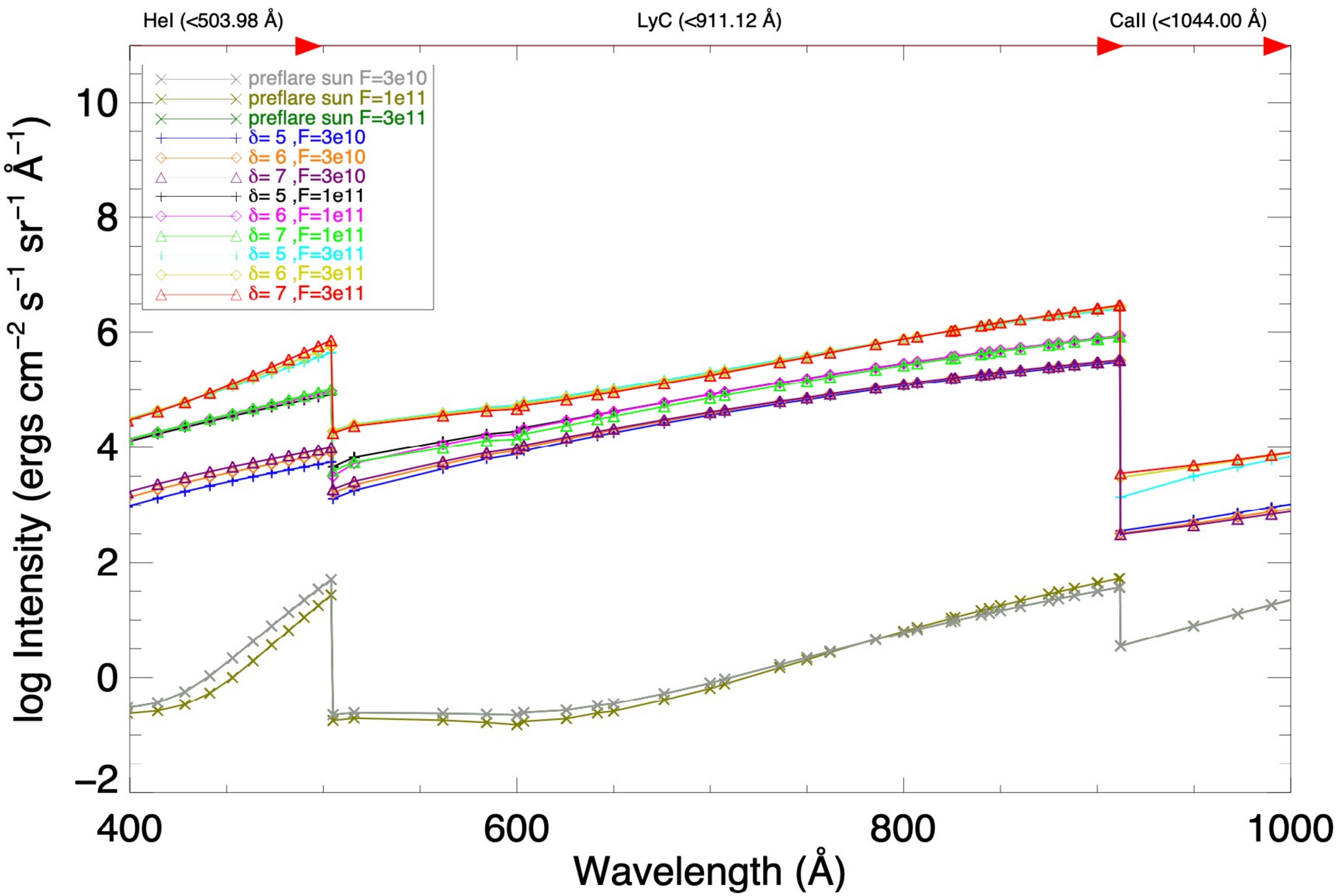
Credit: Mclaughlin et al. in preparation

- 1d radiative-hydrodynamic code with adaptive mesh grid (Carlson & Stein 1992)
- Models the atmospheric response to the injection of a nonthermal particle beam
- F-CHROMA grid of 72 models generated for a range of beam parameters
  1. Electron flux density ($3x10^{10}$, $1x10^{11}$, and $3x10^{11}$ erg cm^{-2} s^{-1})
  2. Low Energy cut off (20keV)
  3. Spectral index (5,6, and 7)



LyC Spectra from RADYN

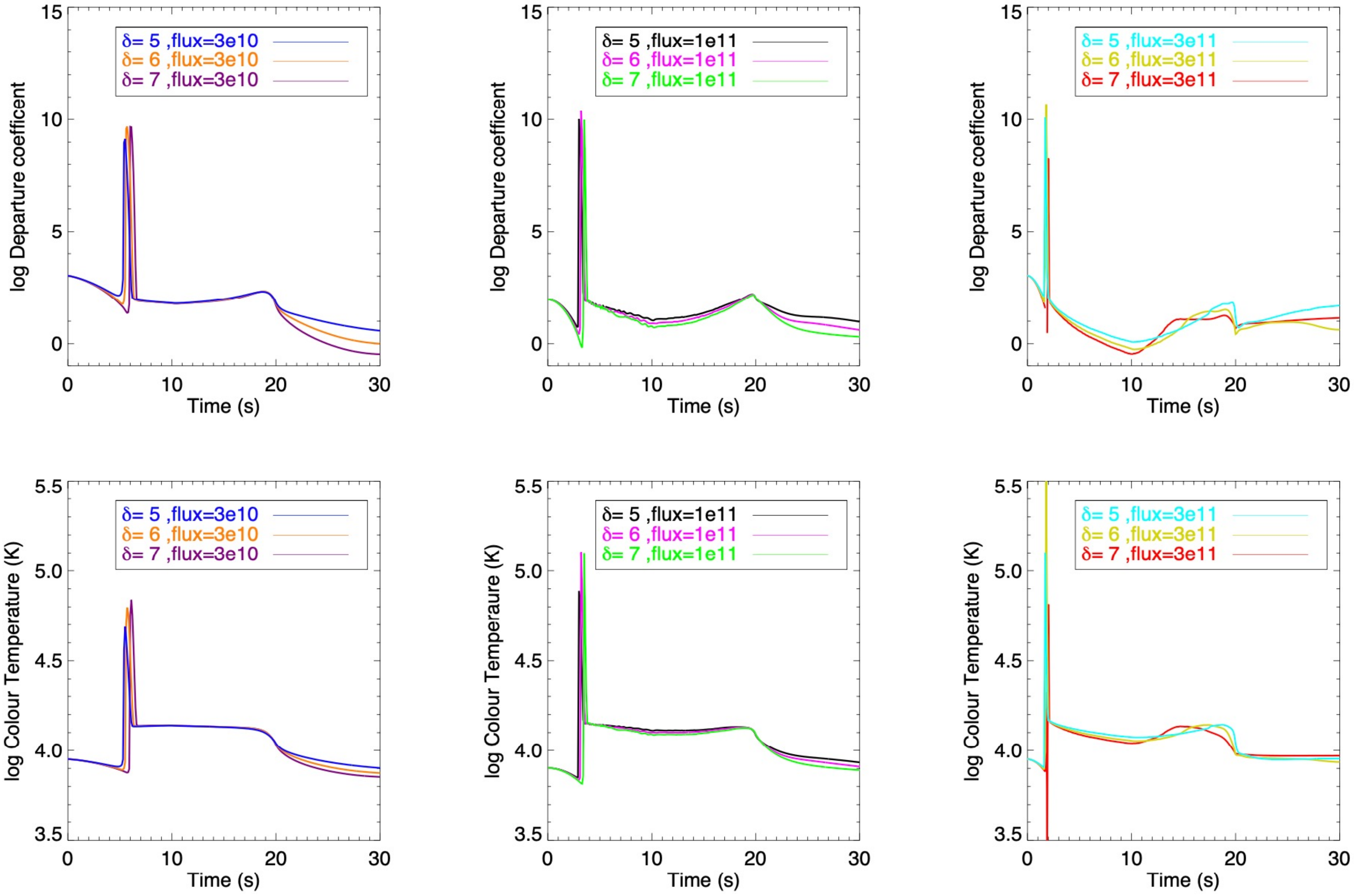
- The LyC intensity is greatly enhanced by the flux of the nonthermal electron beam
- Can apply Eddington-Barbier approximation to determine b_1 and T_c from the spectra



Credit: Mclaughlin et al. in prepara

Colour Temperature and Departure coefficient

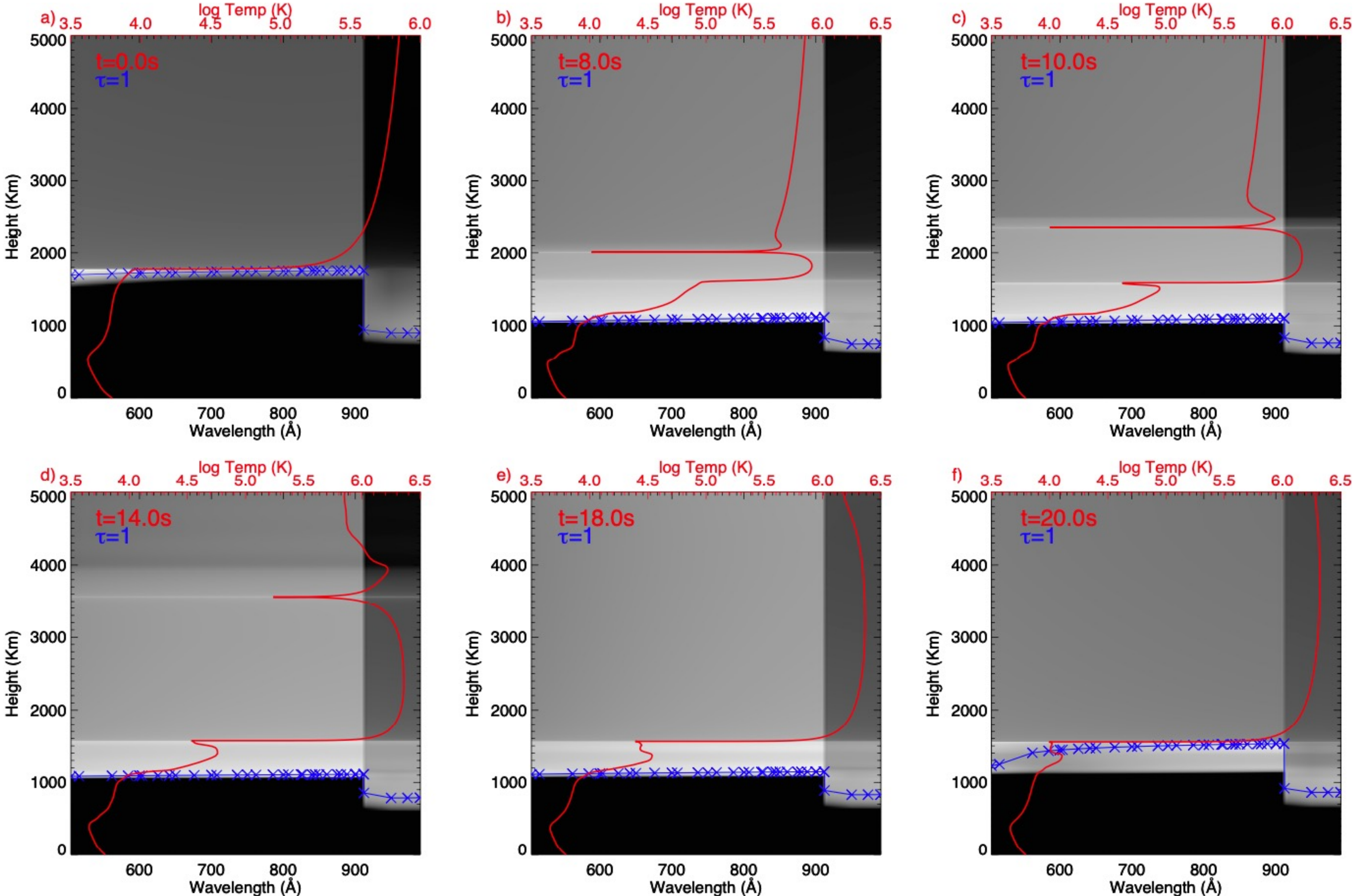
- Eddington-Barbier approximation applied from 515.9 to 911.3Å
- b_1 generally decreases from 10^{2-3} to approximately unity
- T_c generally increased from $10^{3.9}$ to $10^{4.2-4.3}$
- Clear spikes in T_c and b_1 in all models



Credit: Mclaughlin et al. in preparation

LyC contribution function (3e11 δ5 20keV)

- T=0s LyC is optically thick and formed in the transition region
- During beam heating the optically thick component moves deeper into the chromosphere
- Two optically thin components formed at a higher altitude due to chromospheric evaporation and condensation



Credit: Mclaughlin et al. in preparation

Conclusions:

- In the **Quiet Sun LyC is optically thick in NLTE** forming at the base of the transition region

- During Solar flares, LyC has an **optically thick component formed deeper in the chromosphere** compared to the Quiet Sun and is approximately **in LTE**

- As the **optically thick** component can be assumed to be **in LTE $T_c \approx T_e$**

- There are **optically thin components to LyC** formed **due to chromospheric evaporation and condensation**