



# The Temperature and Density of a Solar Flare Kernel Measured from Extreme-ultraviolet Lines of O IV

**Dr Peter Young**

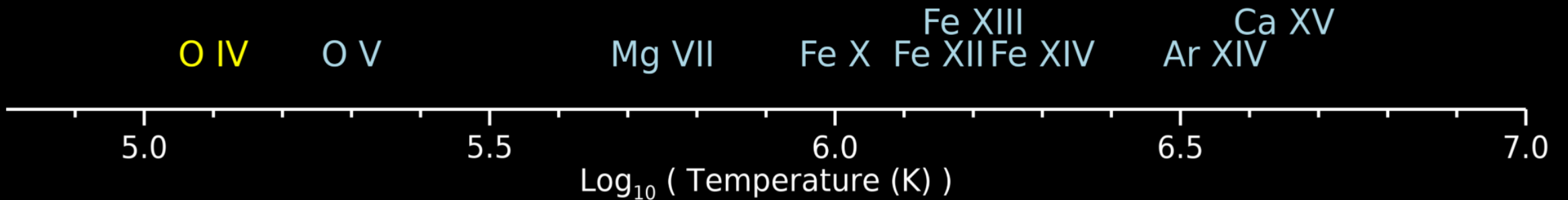
NASA Goddard Space Flight Center  
Northumbria University, UK

Young (2024, ApJ 966, 102)

O IV = oxygen 3+

# EIS density diagnostic ions are mostly coronal

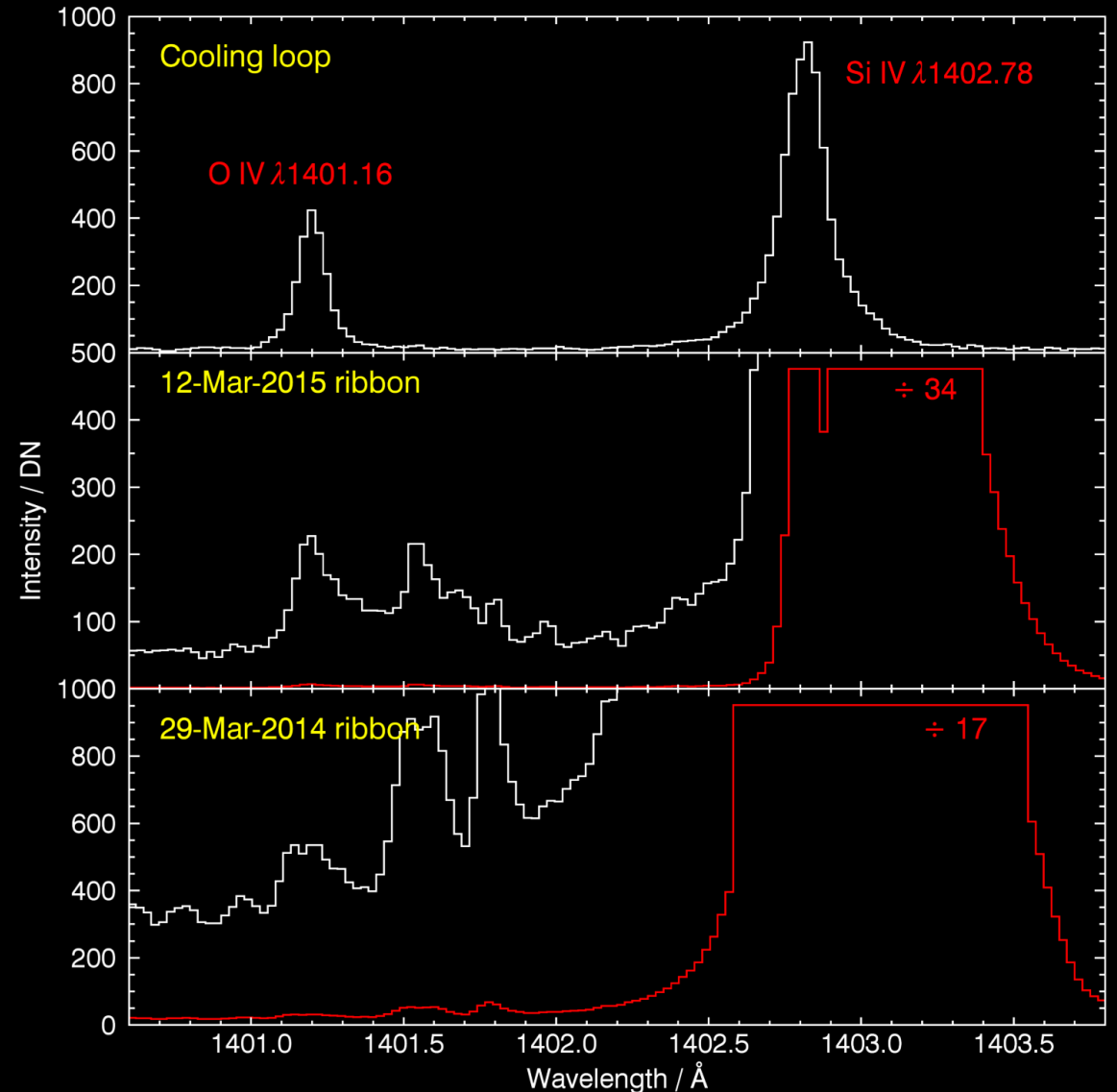
EIS: two wavelength bands of 170-212 Å and 246-292 Å



O IV has coolest density diagnostic accessible by EIS

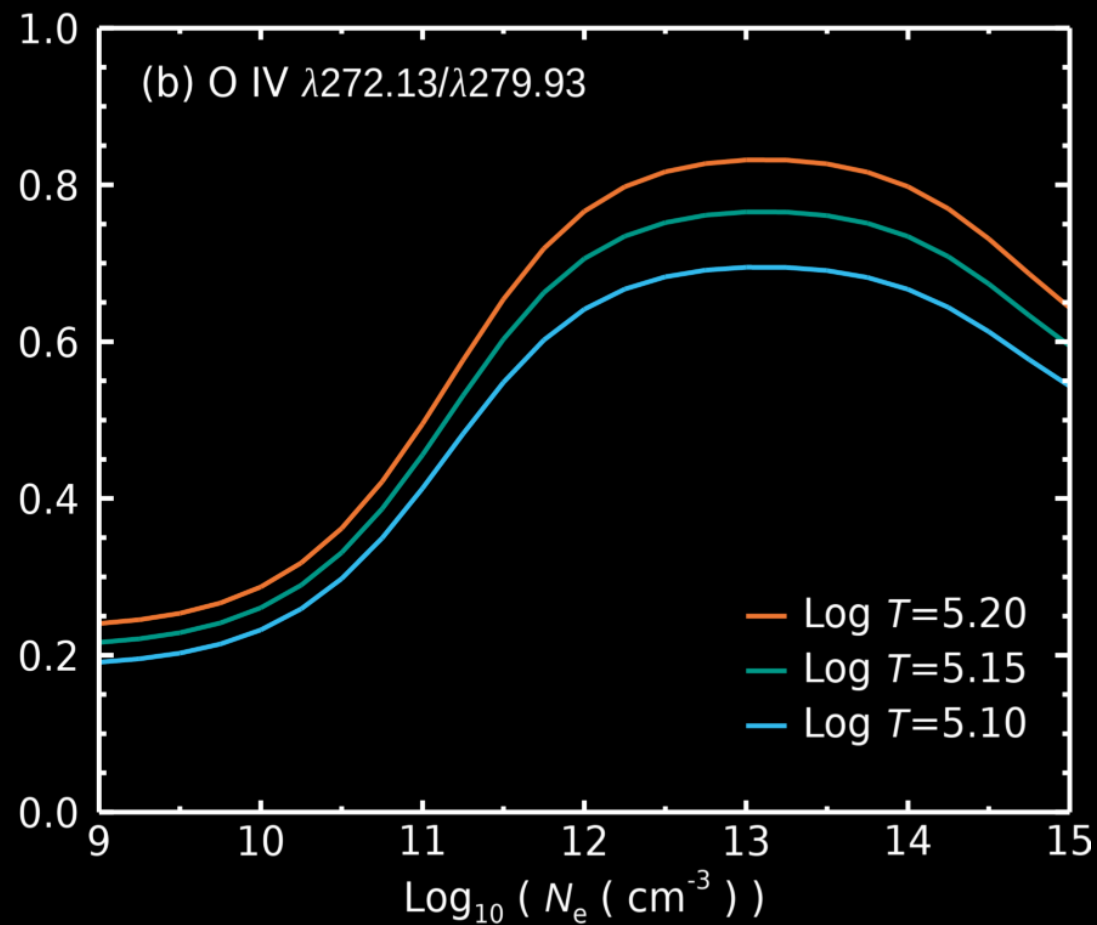
# IRIS O IV lines disappear at high density!

- The emitting levels are depopulated by electron collisions rather than radiative decay...so no emission lines!
- This doesn't happen for the EIS lines.



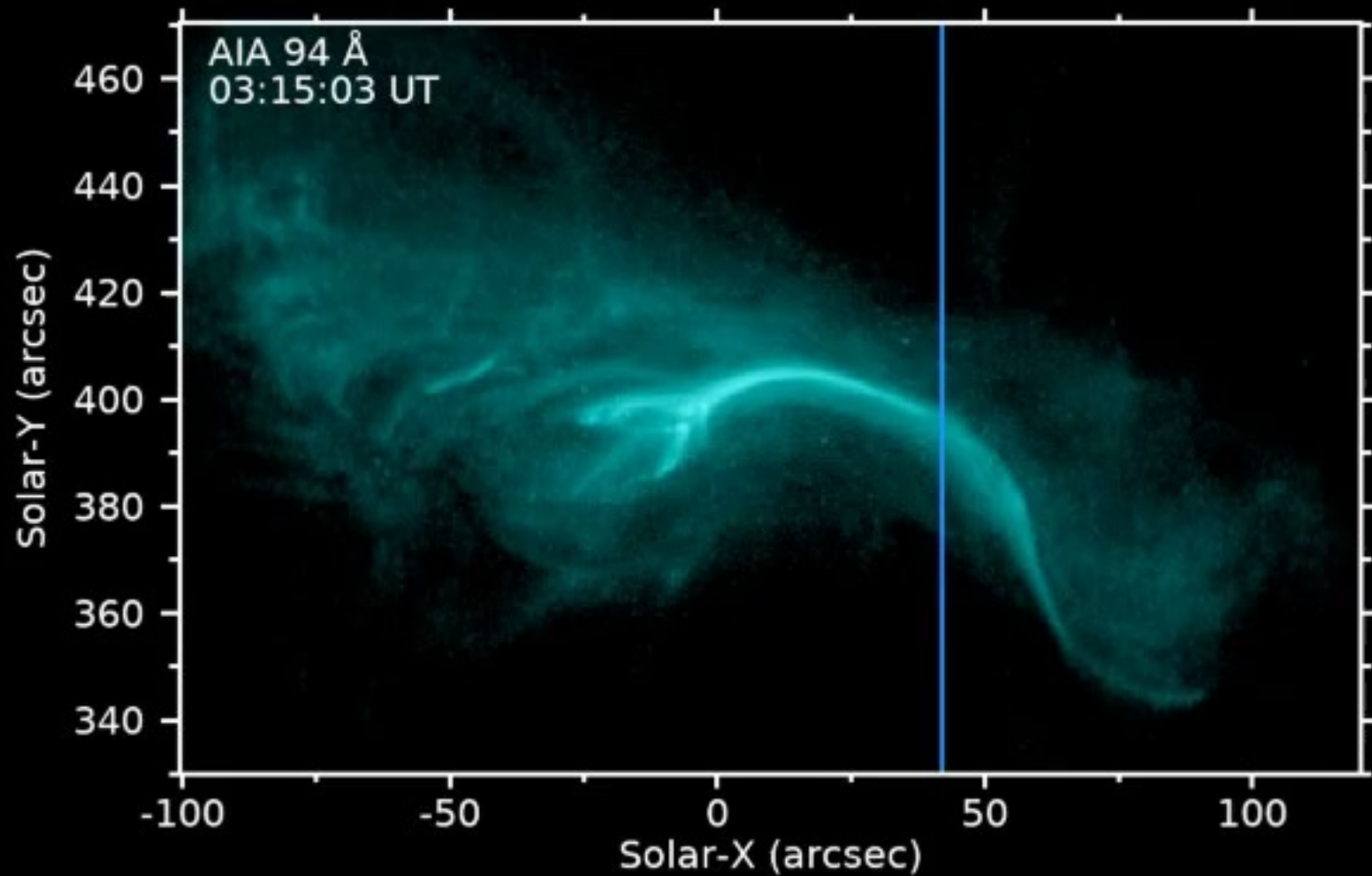
# Line ratio diagnostics

The  $\lambda 272/\lambda 279$  ratio shows some temperature sensitivity



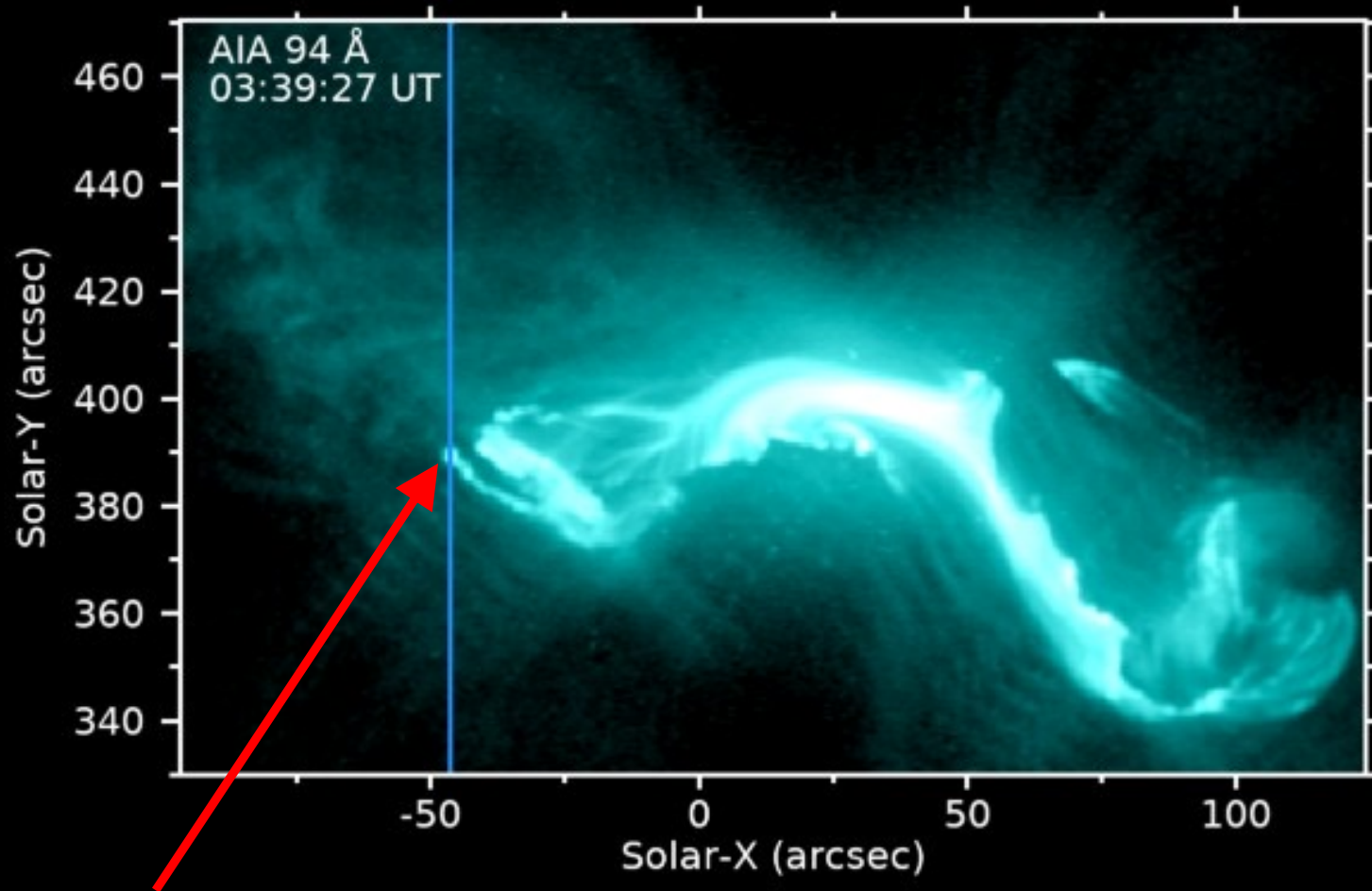
Atomic data from CHIANTI 10.1 (Del Zanna et al. 2013)

# M6 Flare, 9-Mar-2012: AIA 94 Movie with EIS Slit

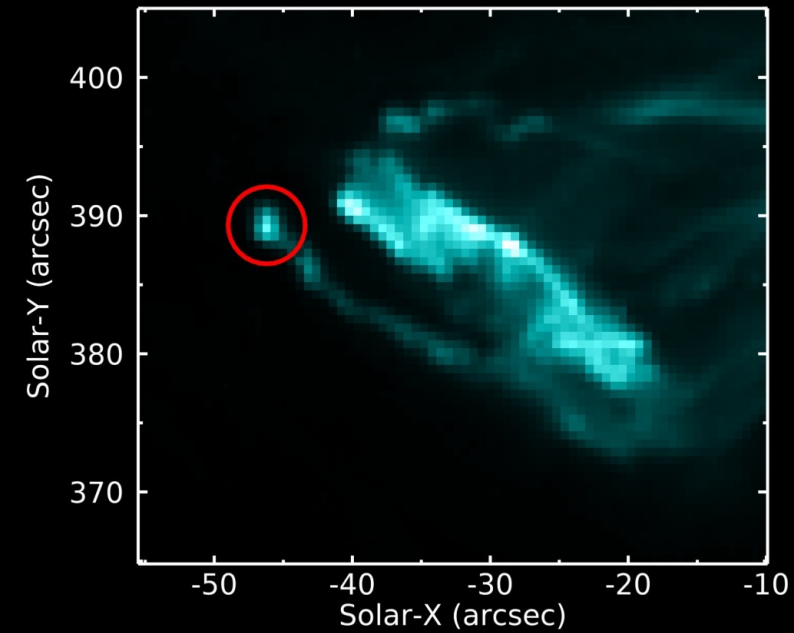


Blue line shows  
location of EIS slit

# Flare ribbon & kernel

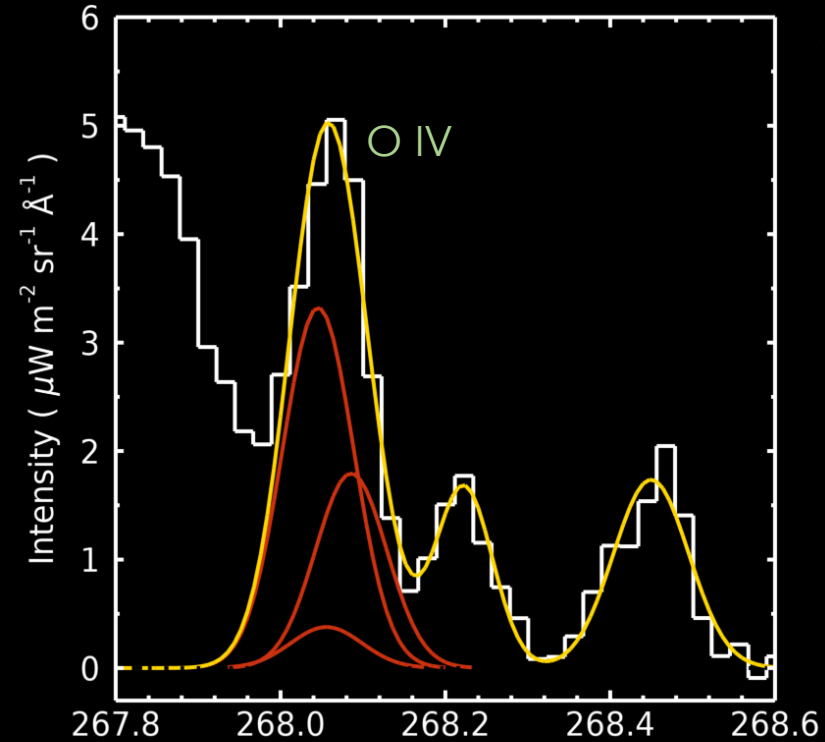


Slit captures a bright flare kernel within 1min of it appearing



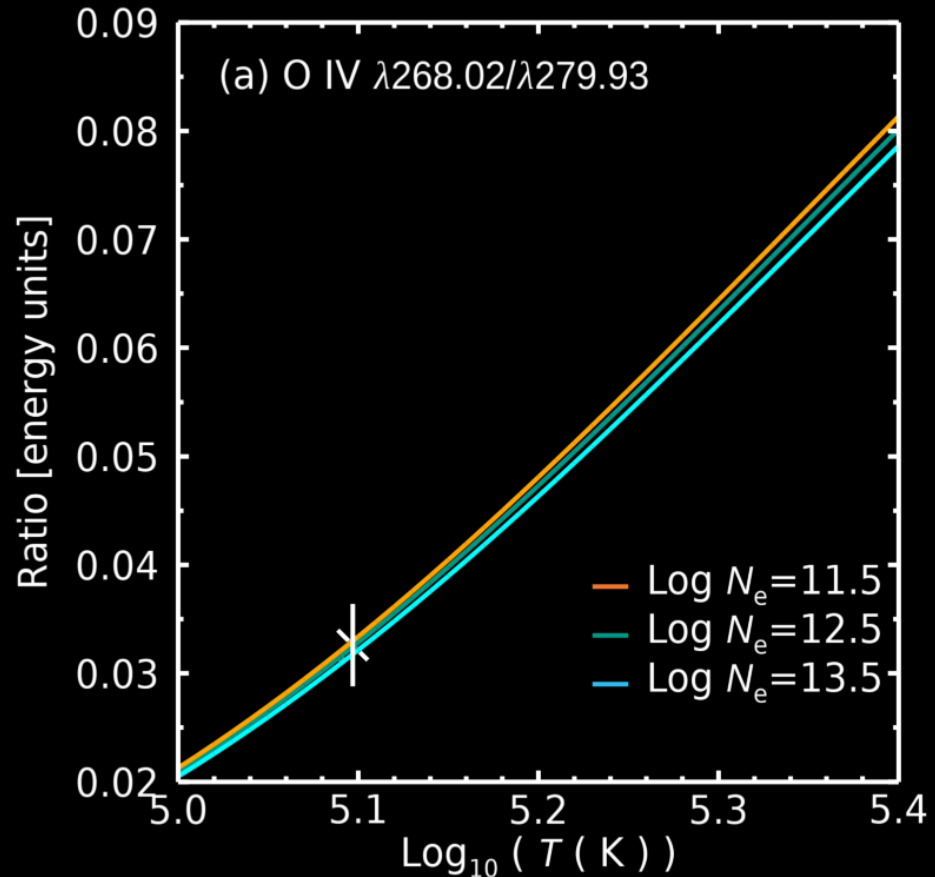
Linear scaling shows "kernel" is significantly brighter than rest of ribbon

# Line profiles & fitting

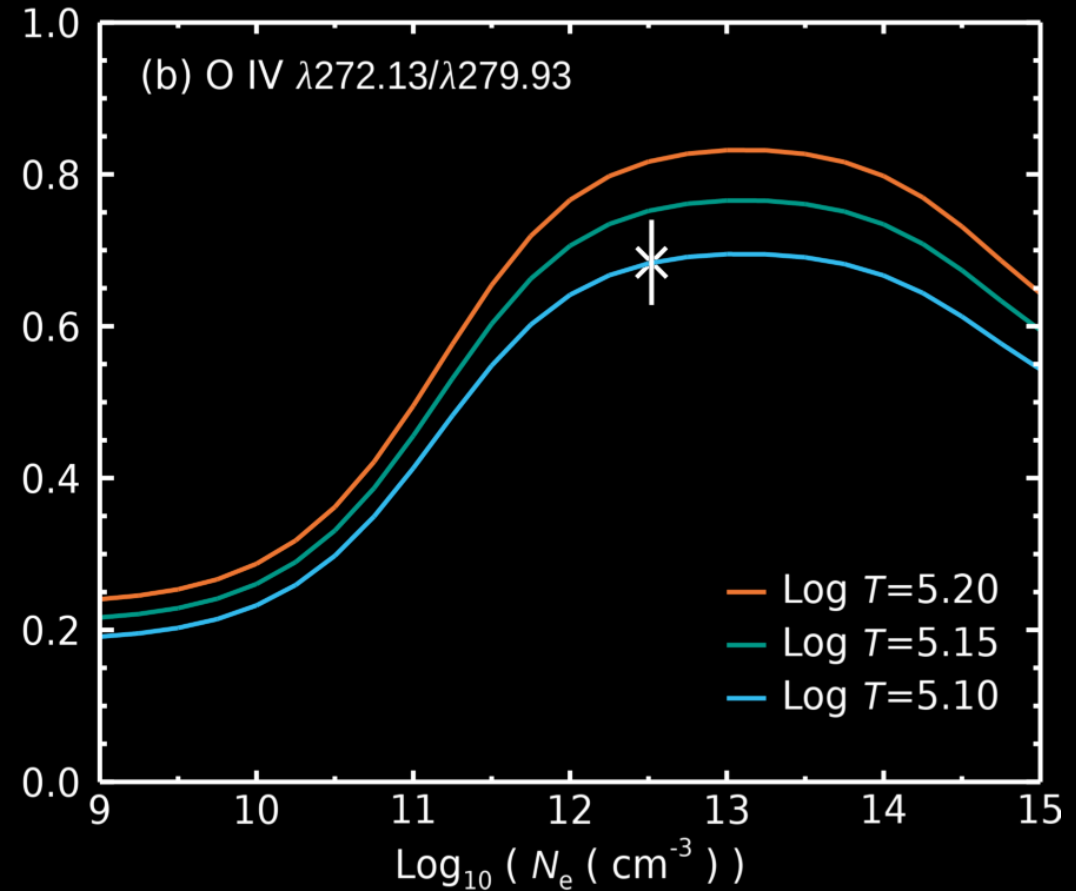


Three O IV components (red) at 268  $\text{\AA}$

# Diagnostic Results



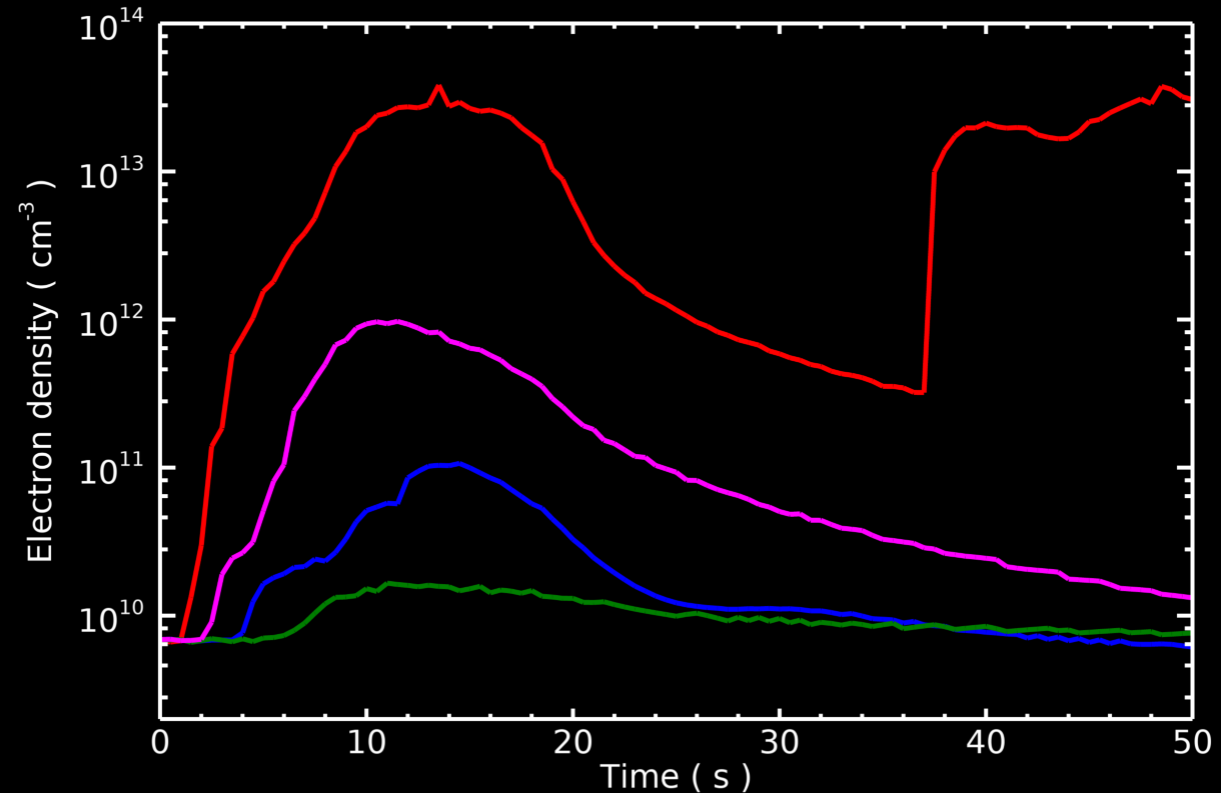
$$\text{Log} ( T / K ) = 5.10 \pm 0.04$$



$$\text{Log} ( N_e / \text{cm}^{-3} ) = 12.52^{+1.88}_{-0.62}$$

# Density: comparison with a flare model

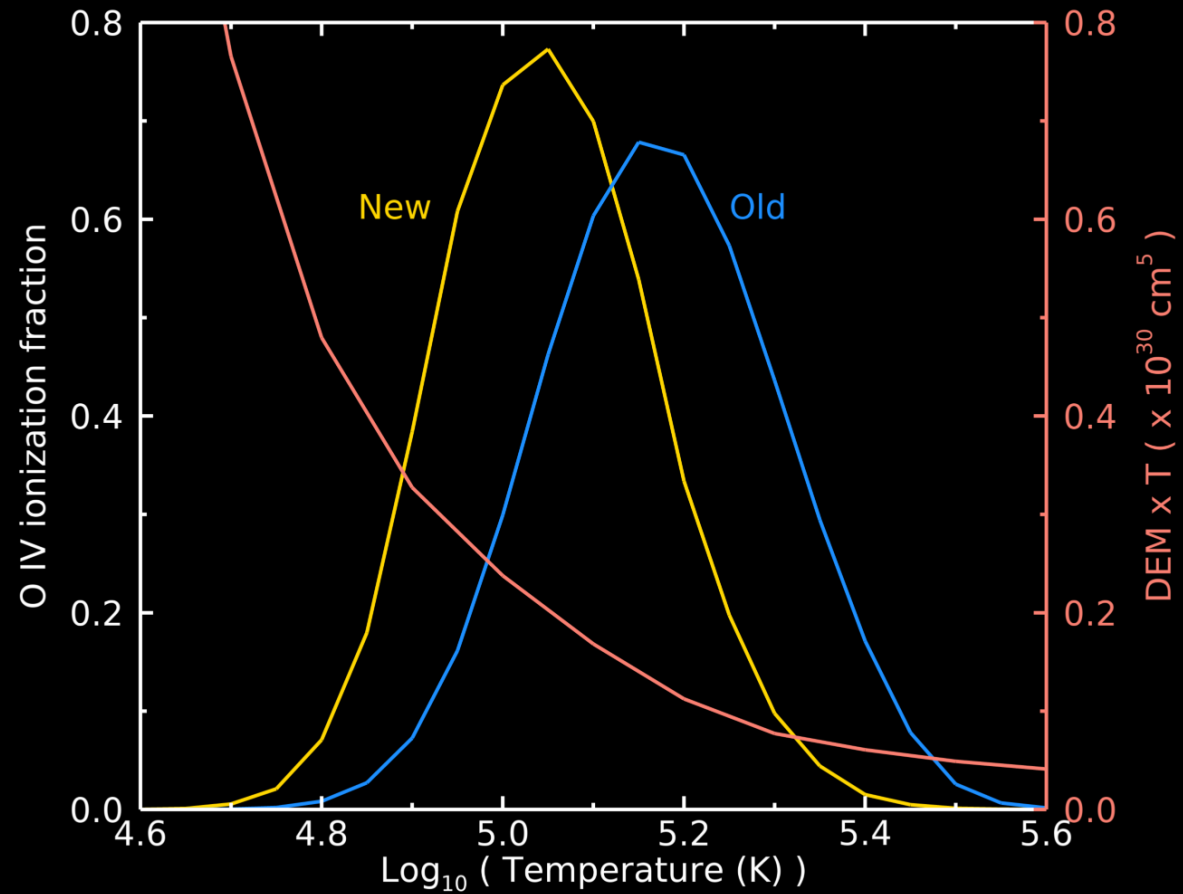
- F-CHROMA Project has database of RADYN flare models.
- RADYN models the response of chromosphere to flare heating in a 1D loop.
- Plot shows density variation for O IV plasma as function of time.
- Densities  $> 10^{12} \text{ cm}^{-3}$  obtained for largest energy input



Energies from  $3 \times 10^{10}$  (green) to  $1 \times 10^{12}$  (red)  $\text{erg cm}^{-2}$

# Temperature: consistent with new ionization models

- Temperature:  $\log T = 5.10 \pm 0.04$
- The lines' contribution functions peak at  $\log T \approx 5.25$  (CHIANTI)
- Can be explained by sloped DEM distribution and new ionization balance calculations (Dufresne et al. 2020)

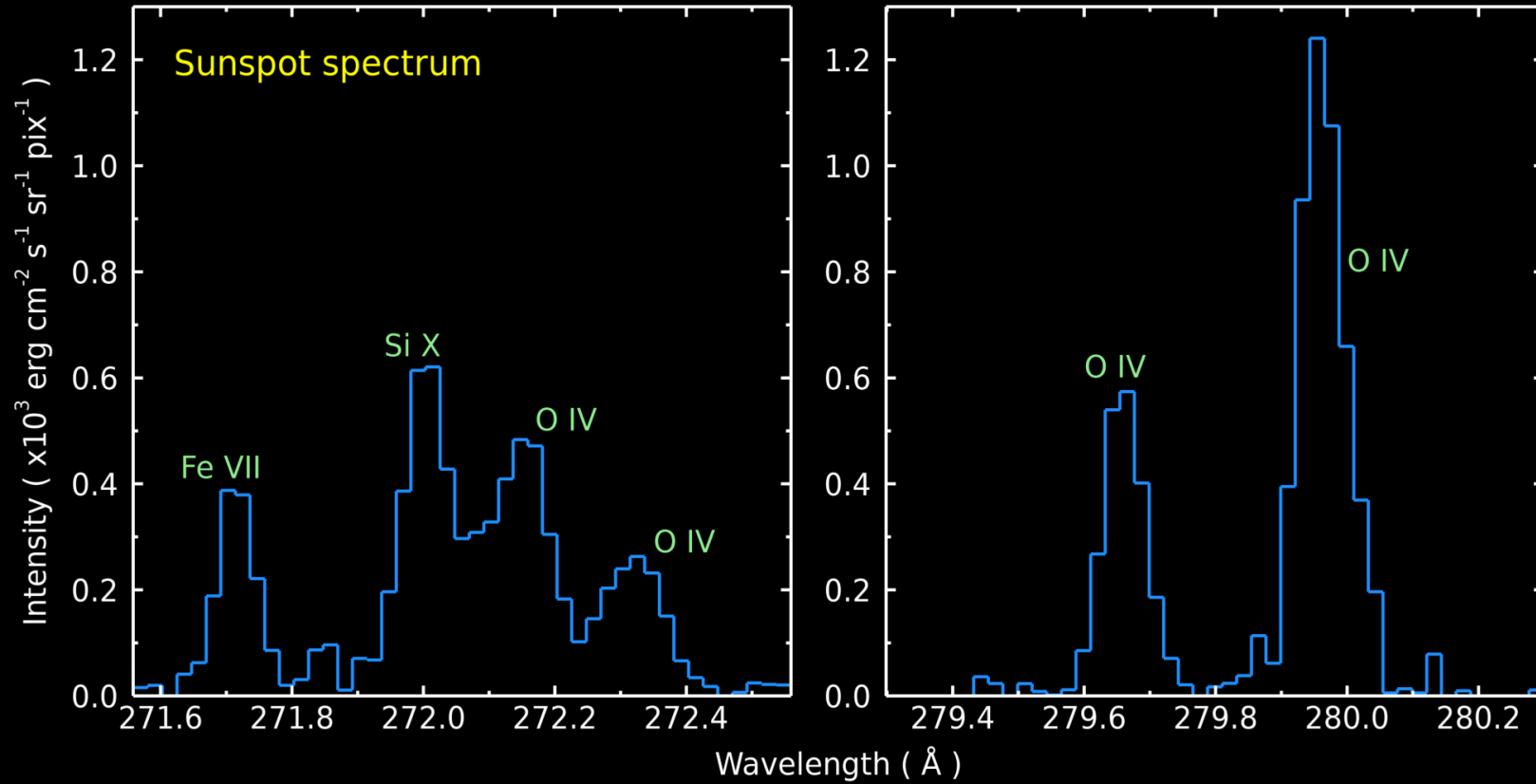


## Summary

- Previously unexplored line ratio diagnostics for O IV have been applied to EIS spectra of a flare kernel.
- Density:  $\log N_e = 12.52$  (upper limit 14.40; lower limit 11.90)
- Temperature:  $\log T = 5.10 \pm 0.04$
- Extends EIS diagnostic coverage to mid transition region

Young (2024, ApJ 966, 102)

# Application to sunspot loops



EIS sunspot  
observation  
20-May-2016

Density from O IV  $\lambda 272/\lambda 279 = 4.8 \times 10^{10} \text{ cm}^{-3}$

## MUSE: O IV diagnostic?

- If slits are suitably orientated, may be able to obtain a clean single-slit spectrum of a flare kernel.
- The O IV 272 Å and 279 Å lines should then be accessible in the 284 Å channel.

