A large radio telescope dish is positioned in a desert landscape. The dish is a large, circular, black structure supported by a white, multi-legged base. In the background, there are large, brown, rounded mountains under a blue sky with some clouds. The foreground shows a flat, greenish-brown plain with some sparse vegetation.

# A Test for Coronal Thick Target Hard X-ray Emissions with Microwave Spectrum

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404.03

# Is the Collisionally Thick Target Model (CTTM) good for coronal HXR sources?

- Yes, if the column density is high enough to collisionally stop an electron beam within the coronal loop.

Veronig & Brown (2004) 2 homologous M-class flares, RHESSI 20-50 keV, the CTTM for coronal sources based on flare electron beam characteristics

Xu et al. (2008) photon energy dependent RHESSI source size

Guo et al. (2012-) electron energy dependent RHESSI source size  
cf.

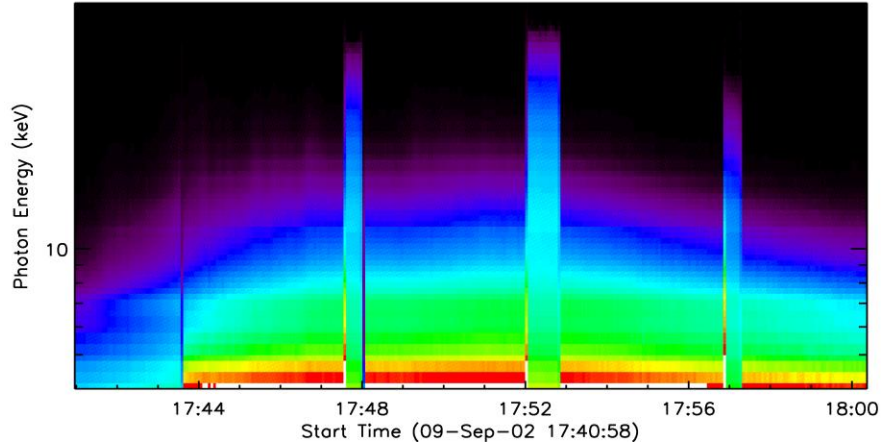
Masuda et al. (1994) Yohkoh the above-the-loop-top source 30-50 keV

Wheatland & Melrose (1995) Intermediate thick-thin target in corona

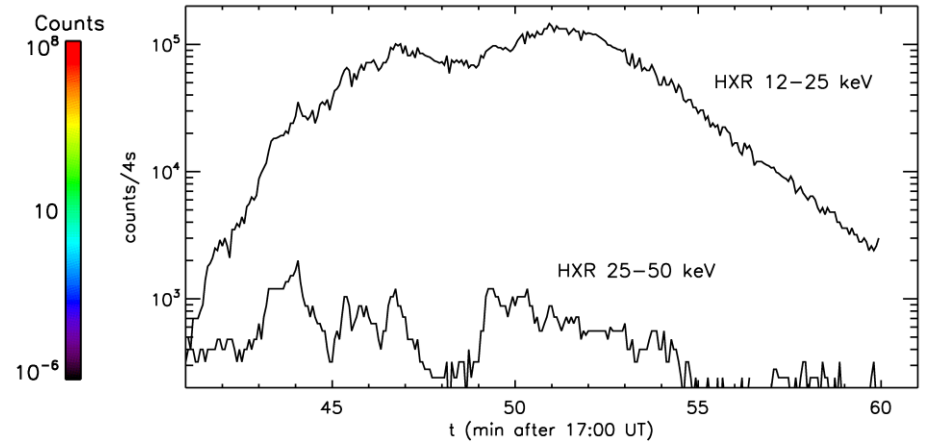
- Is there any independent tool for validating the coronal CTTM?
  - How about microwave observations?

# RHESSI and OVSA observations of the 2002/09/09 flare

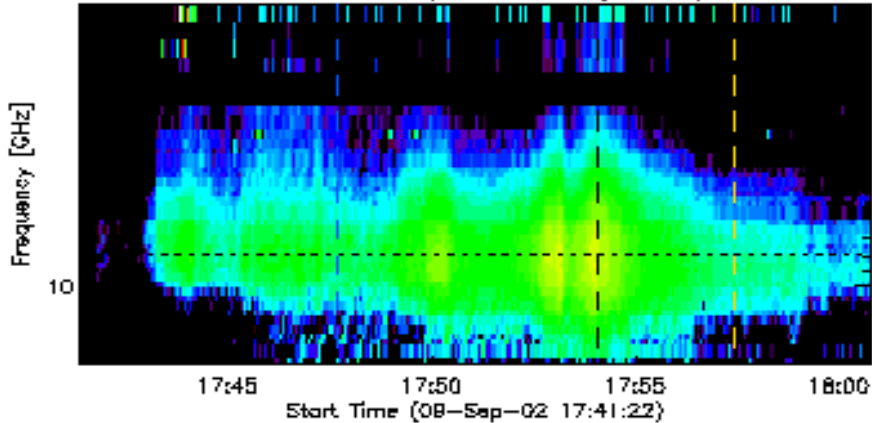
RHESSI counts rate (log scale)



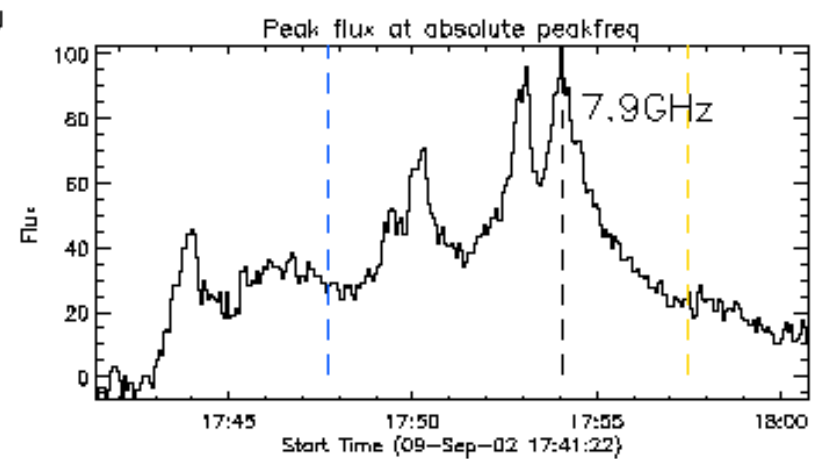
Lightcurves at two energy bands



Total Power Spectrum (Log scale)

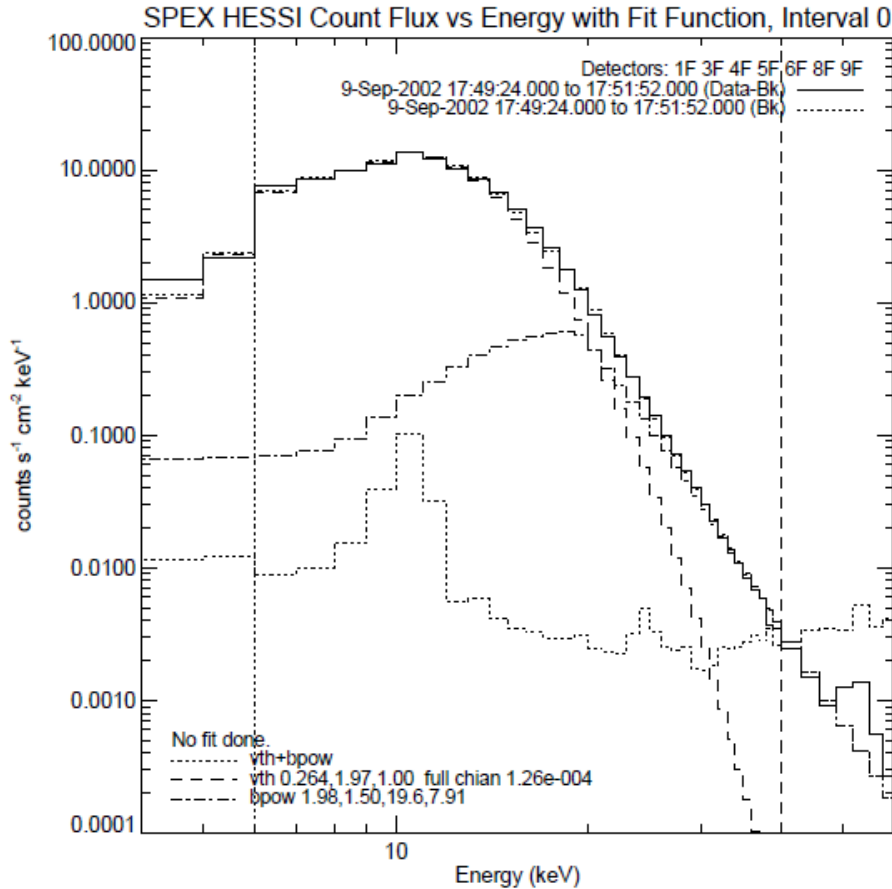


SFU



Both RHESSI and OVSA spectra indicate soft electron energy distribution.

# RHESSI spectrum vs. OVSA spectrum

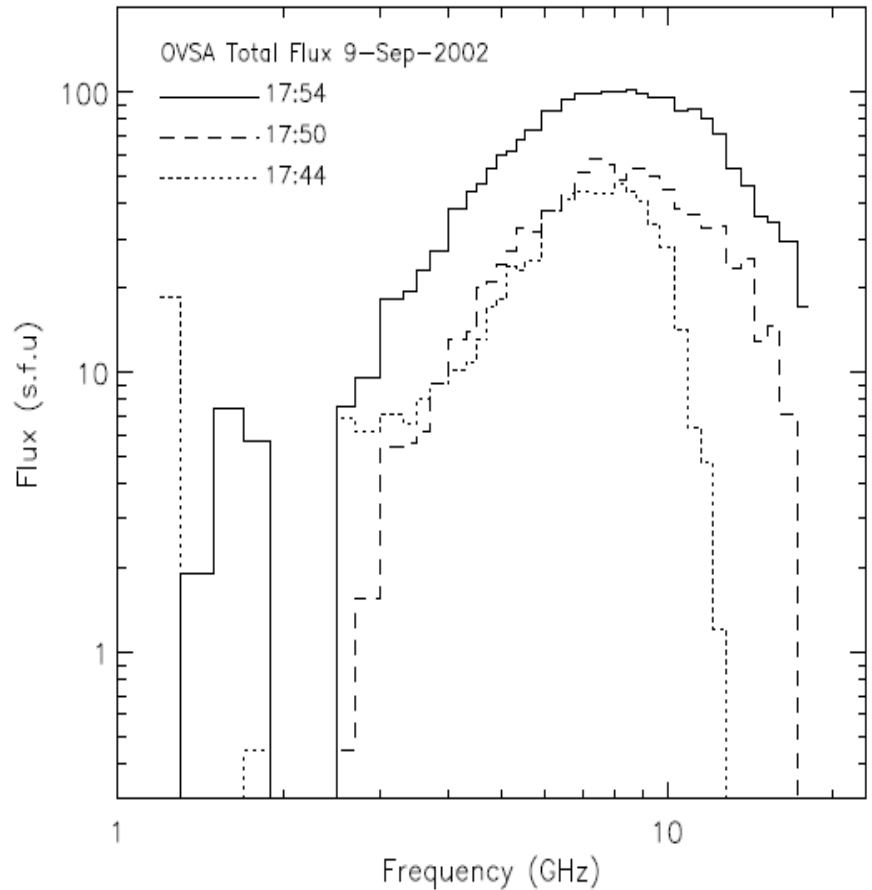


$$T = 1.97 \text{ keV}$$

$$\varepsilon_{\text{tr}} = 19.6 \text{ keV}$$

$$\gamma = 7.91$$

$$n = ?$$



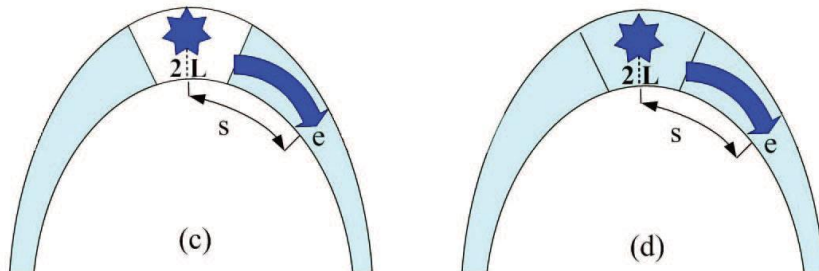
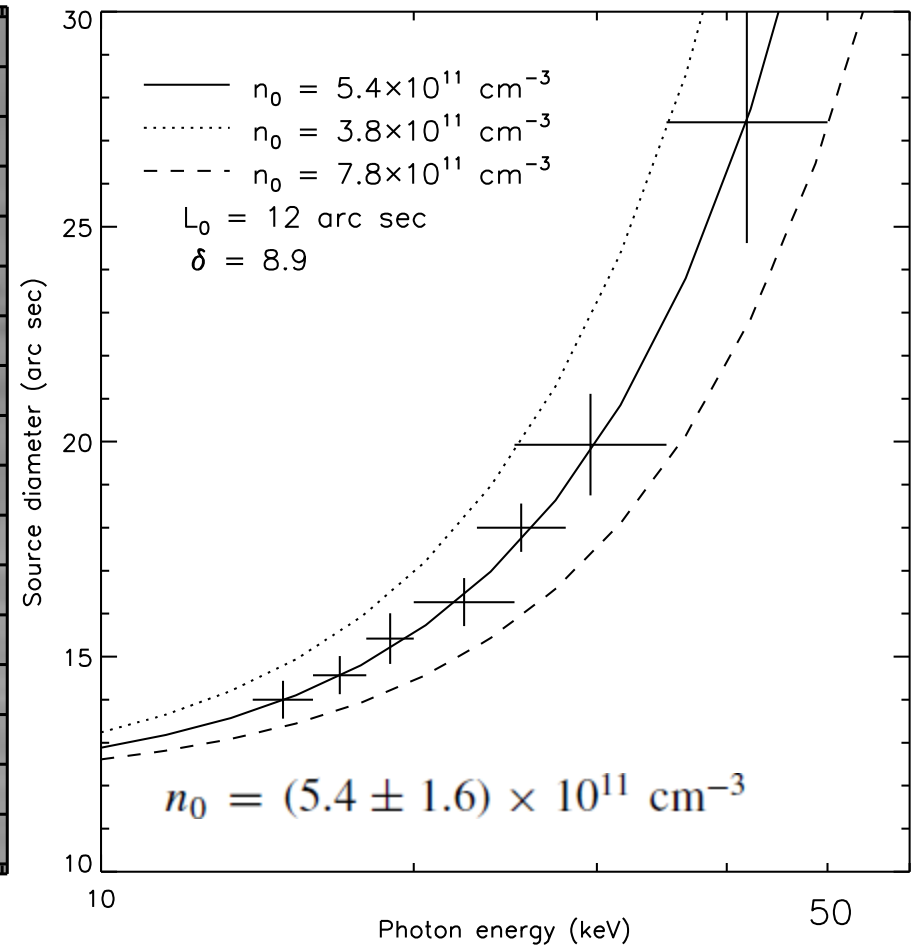
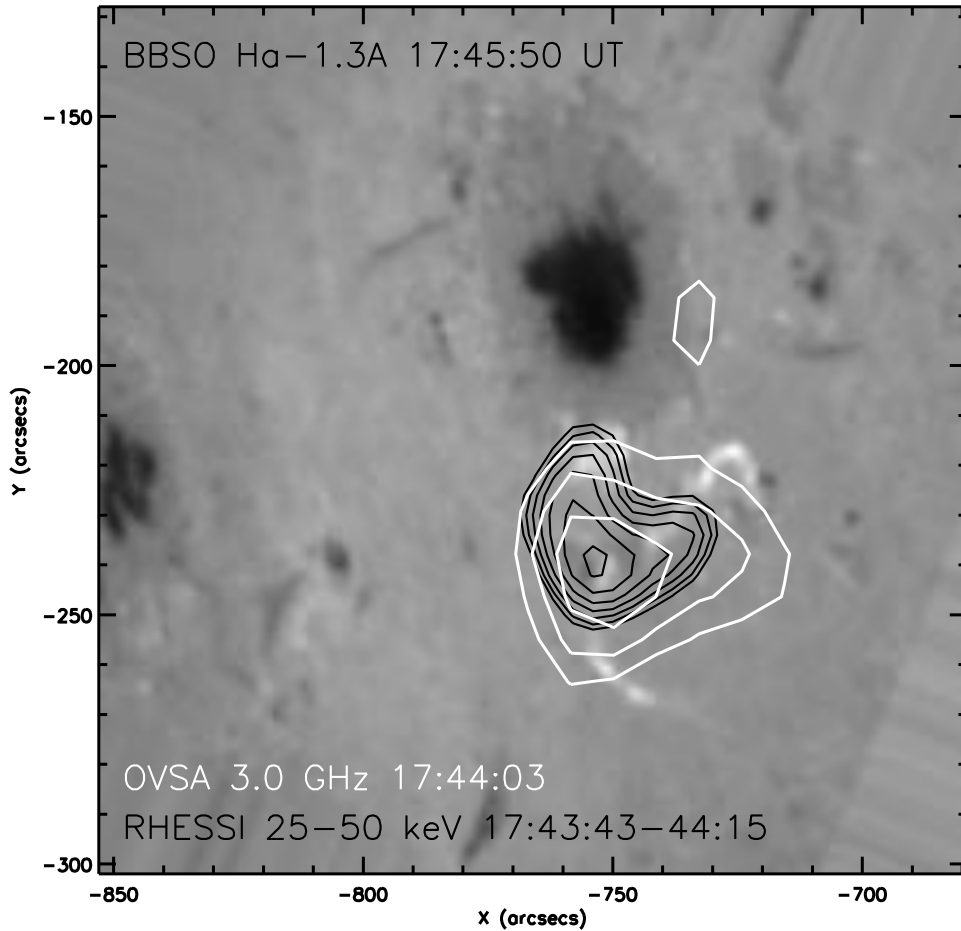
$$\delta = 8.9 \quad \text{from the high frequency slope}$$

$$n \leq 1 \times 10^{11} \text{ cm}^{-3} \quad \text{from the cut-off frequency}$$

$$T = ? \quad \text{from spectral modeling}$$

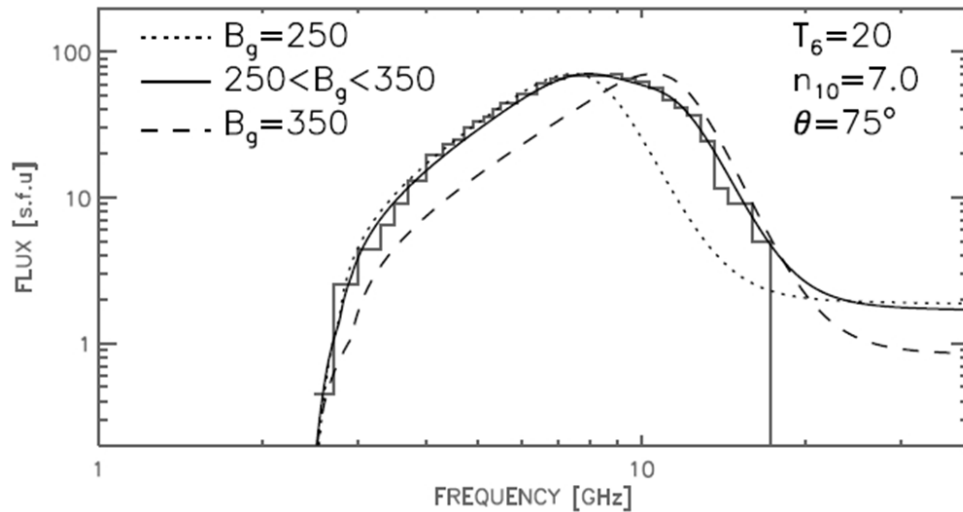
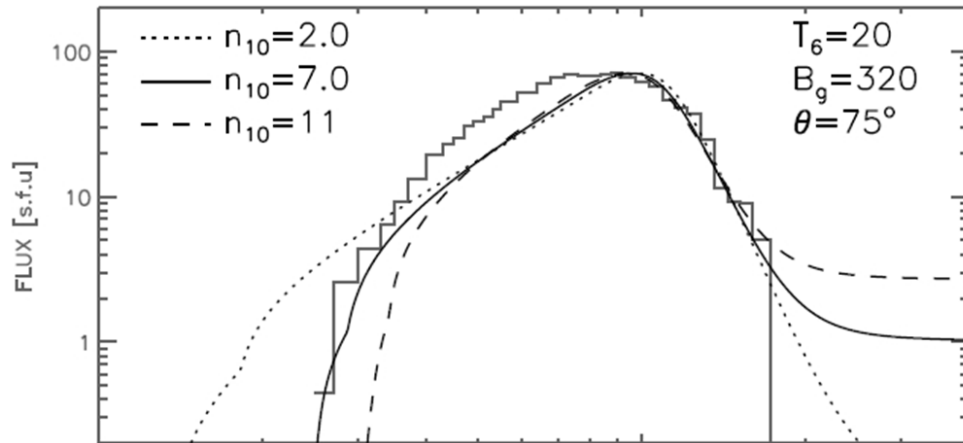
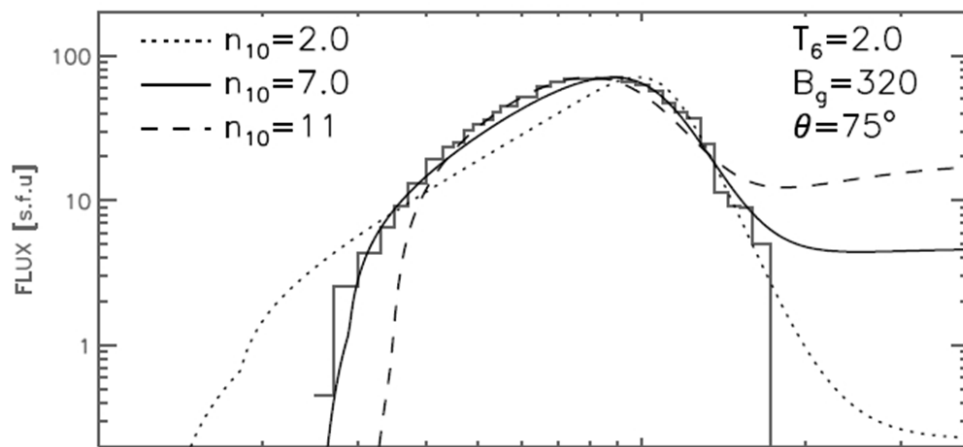
$$B = ? \quad \text{from spectral modeling}$$

# RHESSI imaging sequence and the density diagnostic under the CTTM



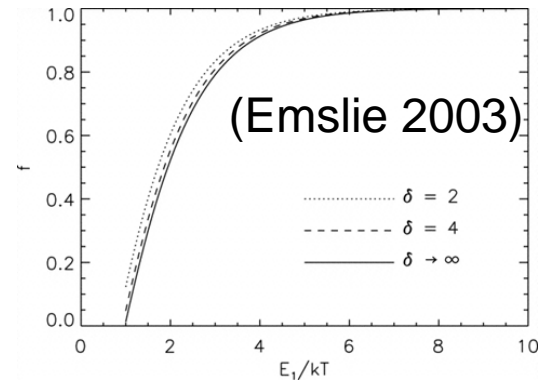
**Collisional models with an extended (c) tenuous and (d) dense acceleration regions. (From Xu et al. 2008)**

## Model Fits to OVSA Spectrum



$n \uparrow$ :  
 low frequency (LF) fluxes  $\downarrow$   
 high frequency (HF) fluxes  $\uparrow$

$T \uparrow$ :  
 HF fluxes  $\downarrow$   
 but  $E > 5kT$  for cold targets.



$T \uparrow$  causes some changes in the LF spectrum, and we need an inhomogeneous magnetic field distribution,  $250 \text{ G} < B < 350 \text{ G}$ .

# Summary

RHESSI HXR maps show energy dependent variation of source length, which can be explained by the CTTM over the coronal loop with  
 $n = 3 \times 10^{11} \text{ cm}^{-3}$   
 $L_0 = 12 \text{ arc sec}$

RHESSI spectrum gives  
 $T = 1.97 \times 10^7 \text{ K}$   
 $\gamma = 7.91$

OVSA microwave maps confirm the loop-top source.

OVSA microwave spectrum fitting with theoretical models gives

$$\delta = 8.9$$

$$n \leq 1 \times 10^{11} \text{ cm}^{-3}$$

$$T < 2 \times 10^7 \text{ K}$$

$$250 \text{ G} < B < 350 \text{ G.}$$

$$\Theta \approx 75^\circ$$

Both HXR and microwave spectra have some features that are sensitive to thermal plasma as well as nonthermal electrons.

Microwave observations can validate the CTTM and provide additional information based on the fundamental physics.

# Conclusion

1. Microwave spectrum has unusual density-sensitive features that become prominent at high thermal densities: the **Razin suppression and cut-offs** at low frequencies, and **free-free emission** at high frequencies.
2. These density-sensitive features of microwave spectrum may provide **complementary information and another physical insight into the CTTM** that HXR studies are largely based on.