

# **Using CAVMORPH and FORWARD to predict X-Ray emission of hot cavity cores**

**Kathy Reeves, Harvard-Smithsonian Center  
for Astrophysics**

**...with thanks to the ISSI Cavities Team**

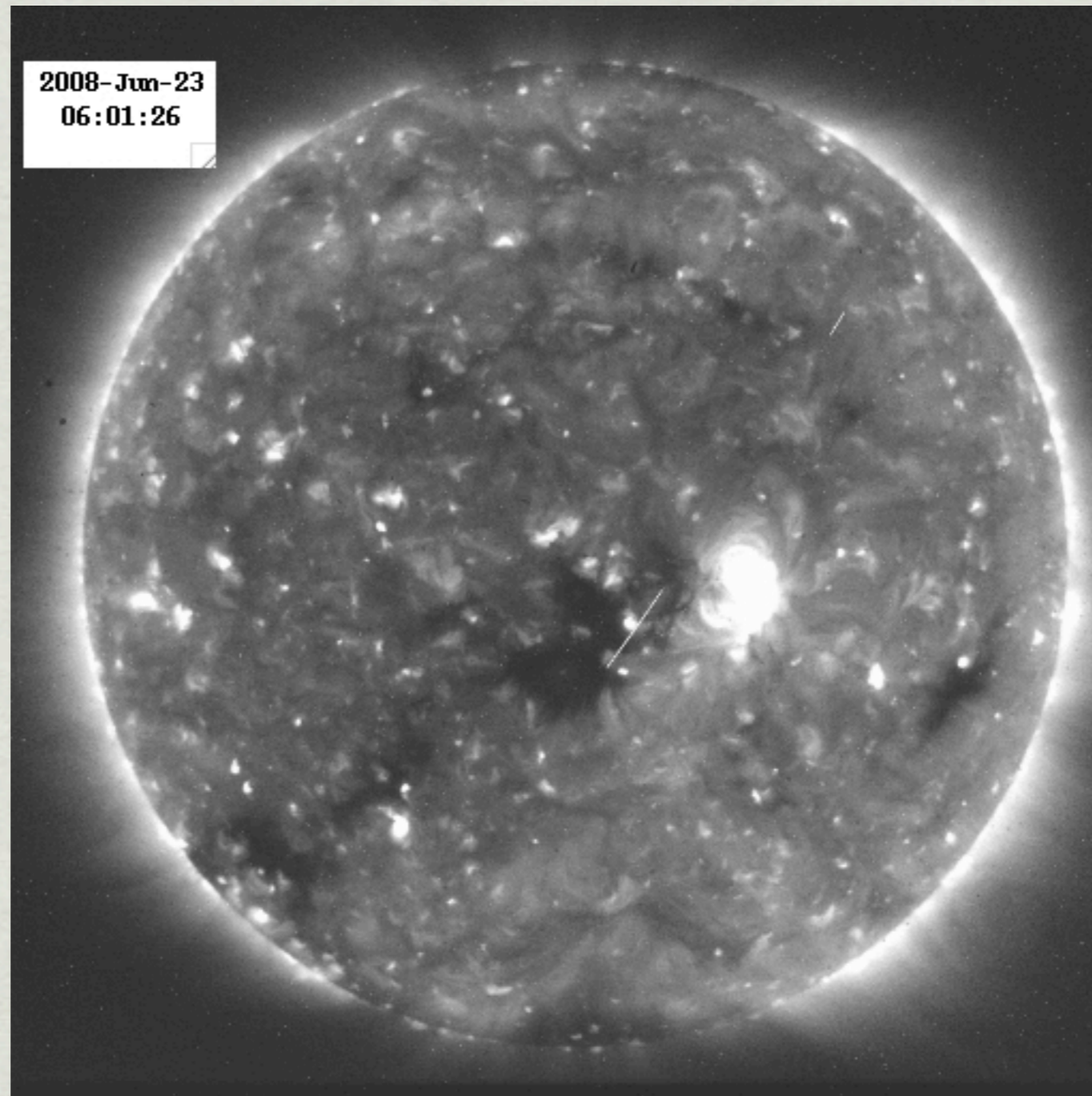


# Hinode XRT





# Summer 2008 cavity



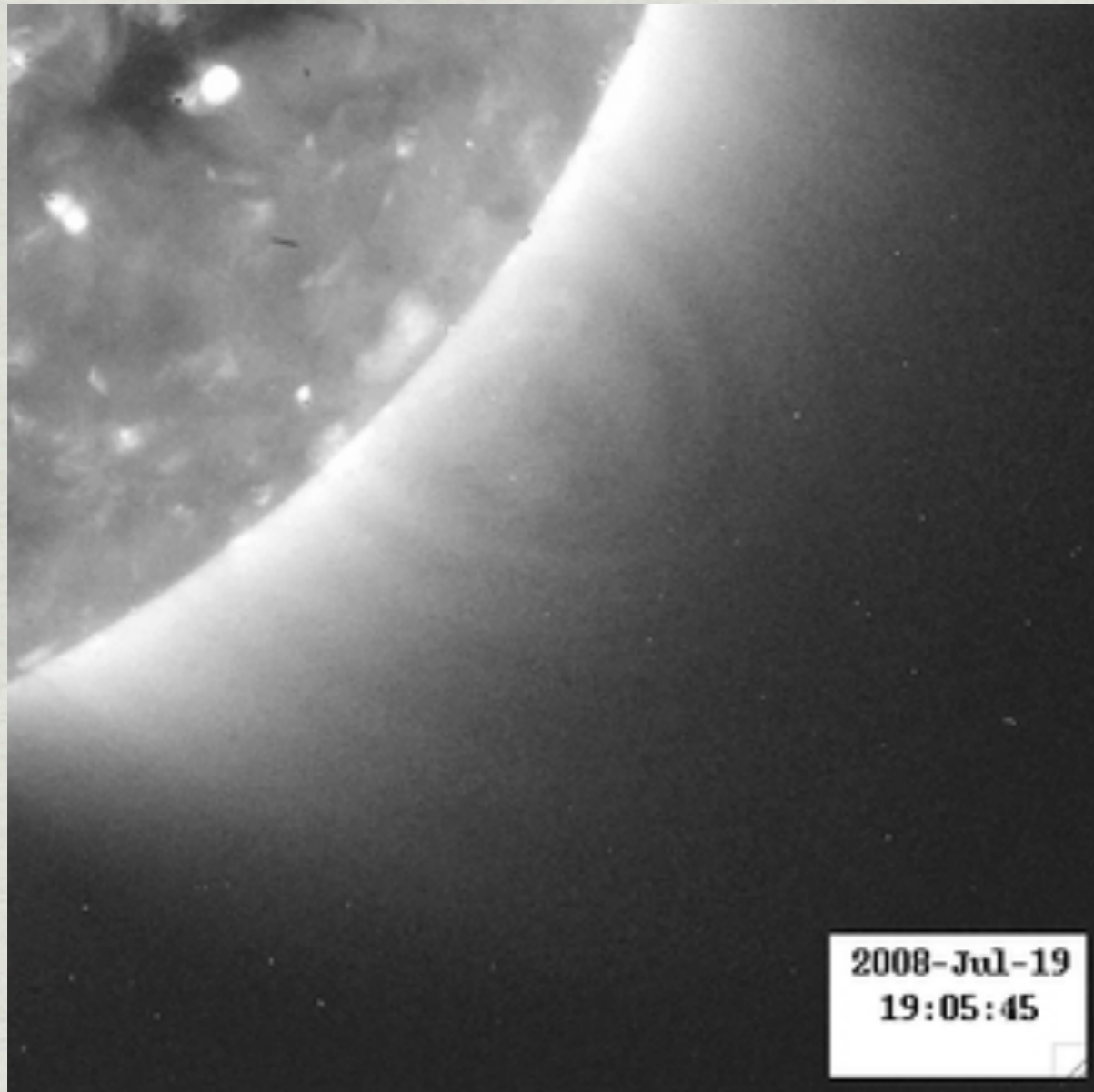


# XRT cavity observing program

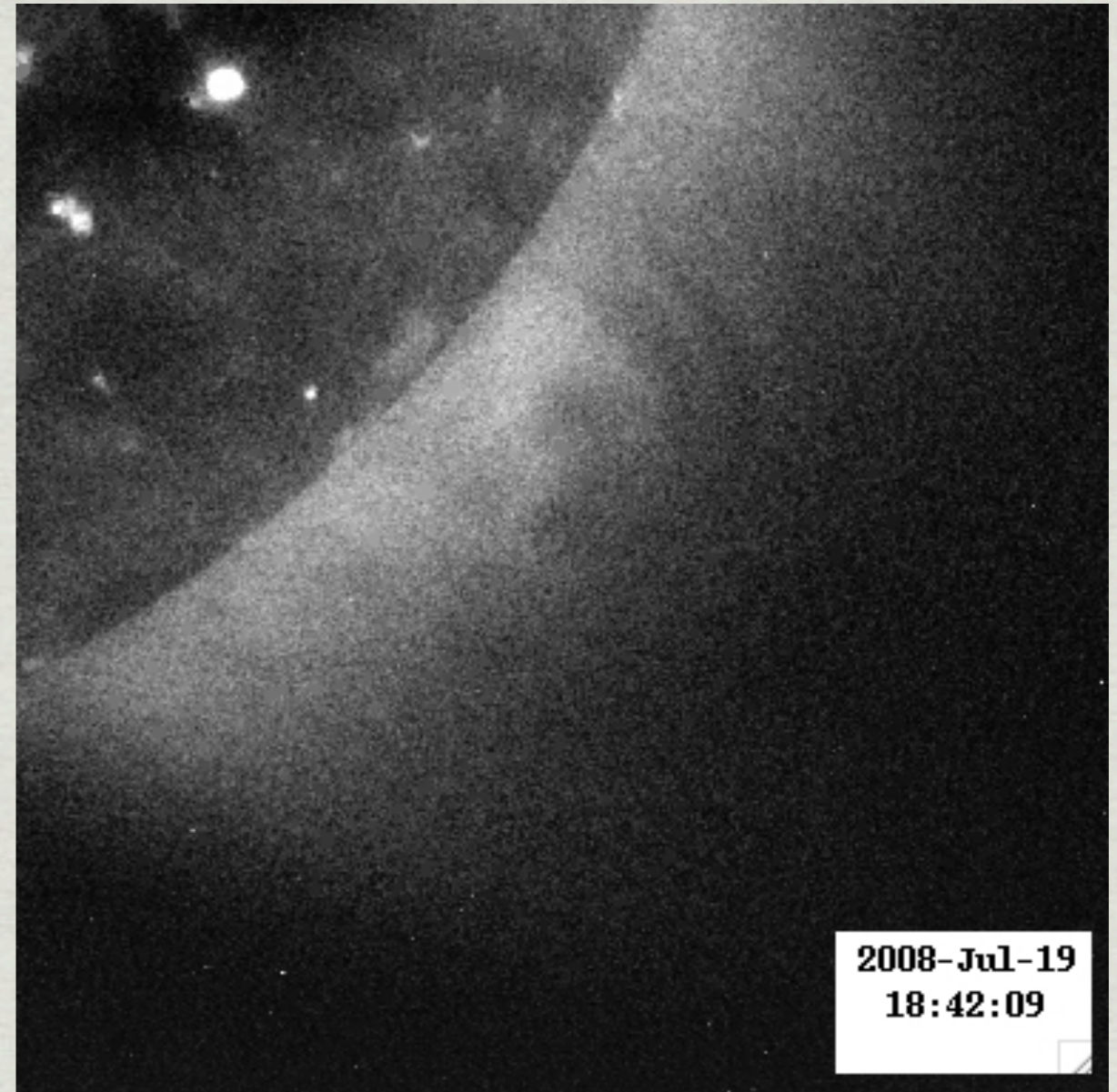
- \* Three filters - Al-poly (coolest), Ti-poly (middle) and Thin Be (hottest)
- \* 768"x768" field of view
- \* 2x2 binning (~2" pixels)
- \* Long exposure times (12 - 65 sec)
- \* Lossless compression



# XRT data



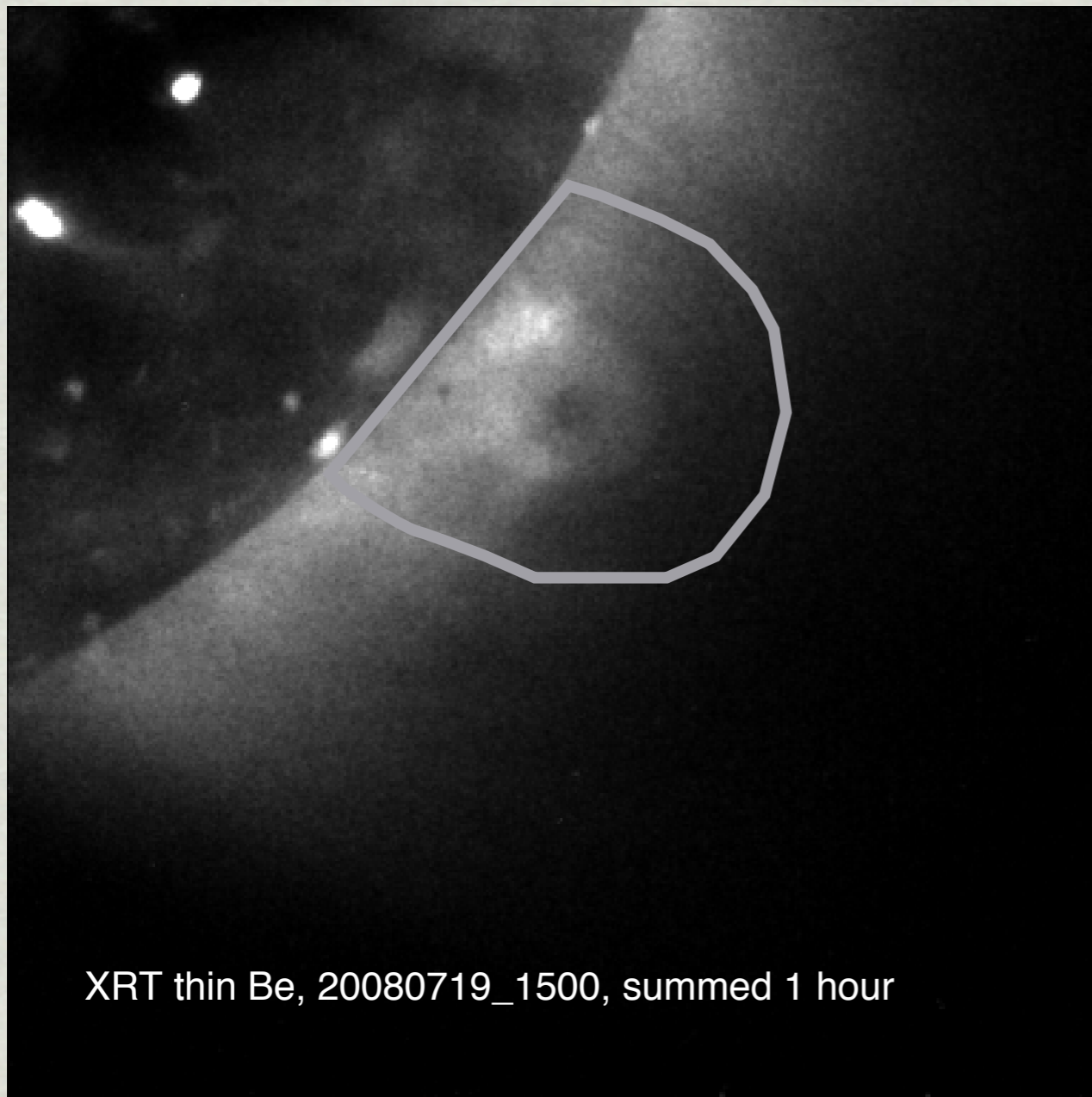
**TI-POLY FILTER  
(COOLER)**



**THIN-BE FILTER  
(HOTTER)**



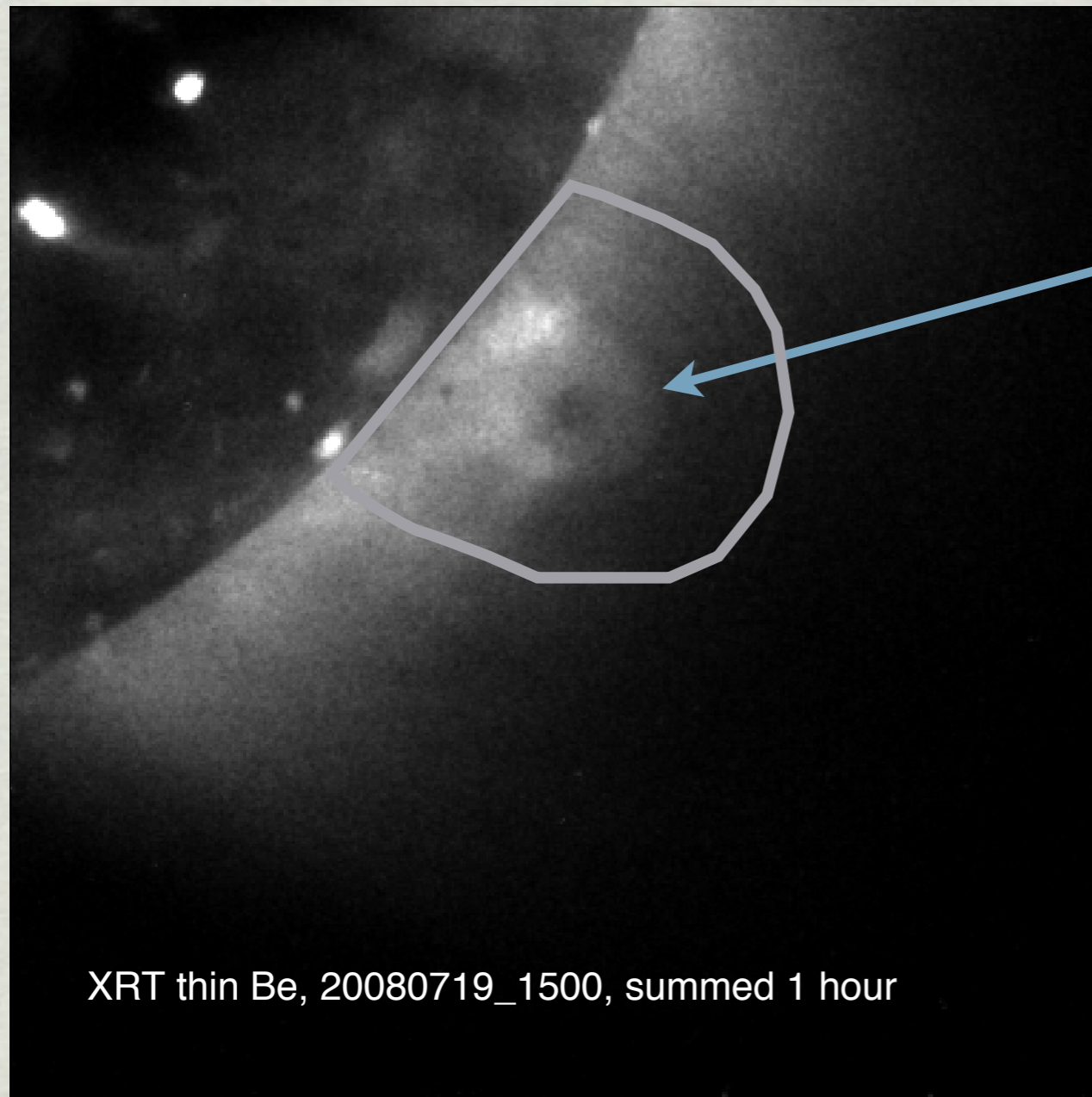
# Cavity structure



XRT thin Be, 20080719\_1500, summed 1 hour

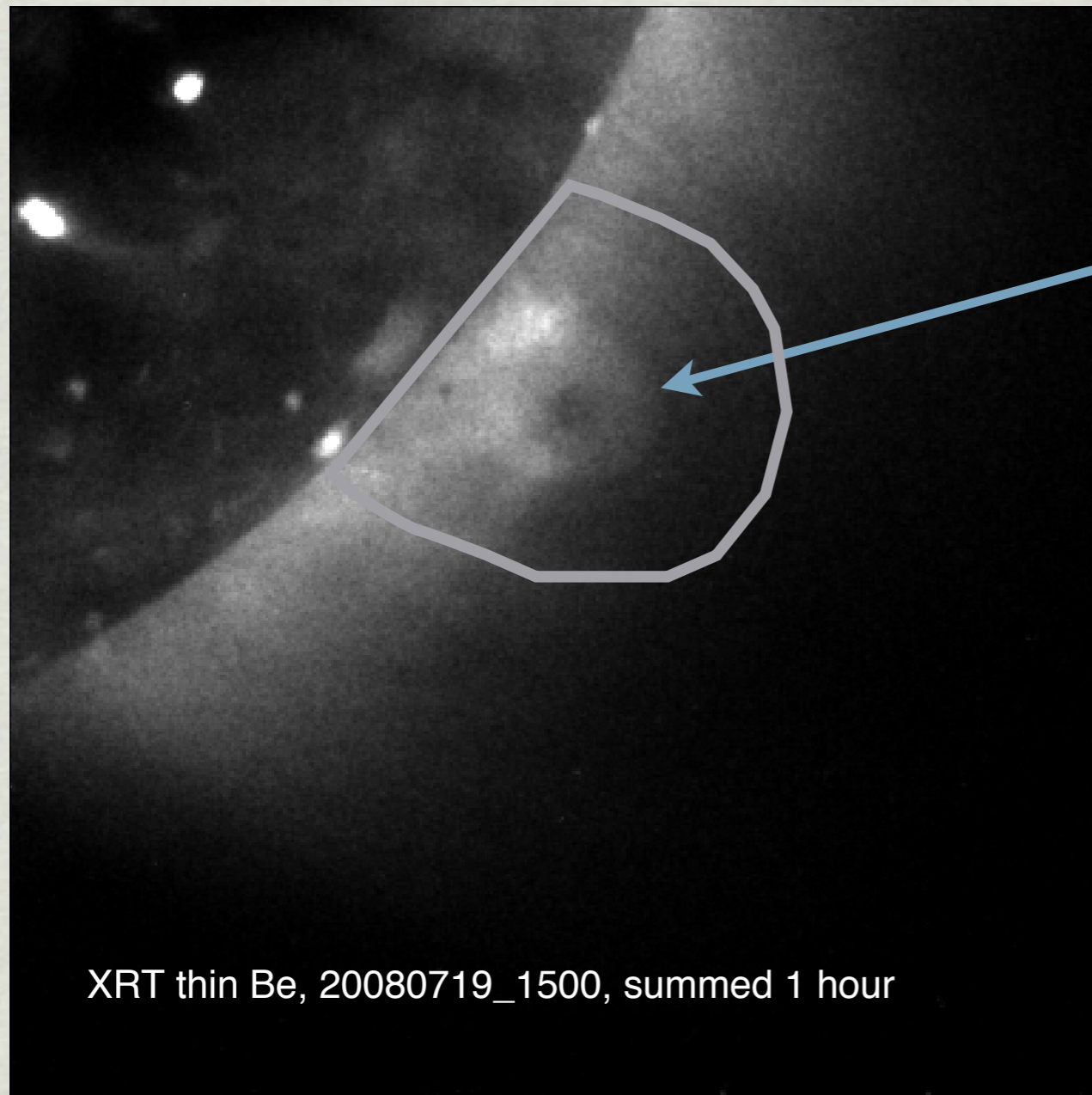


# Cavity structure





# Cavity structure

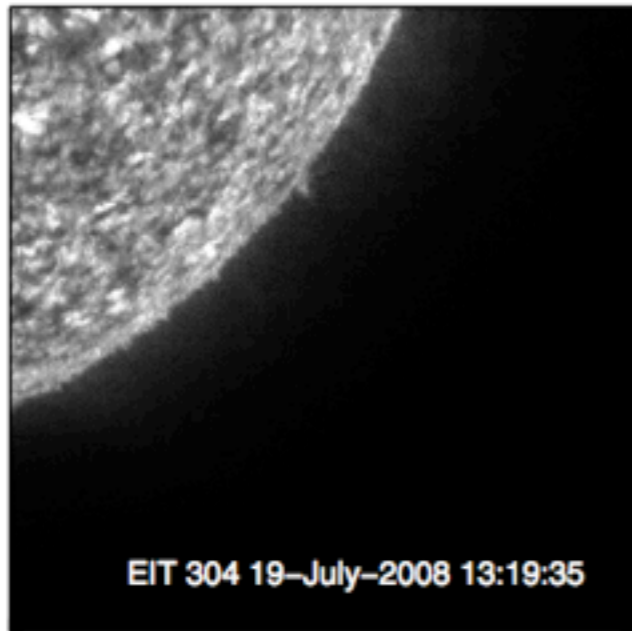


## CHEWY NOUGAT

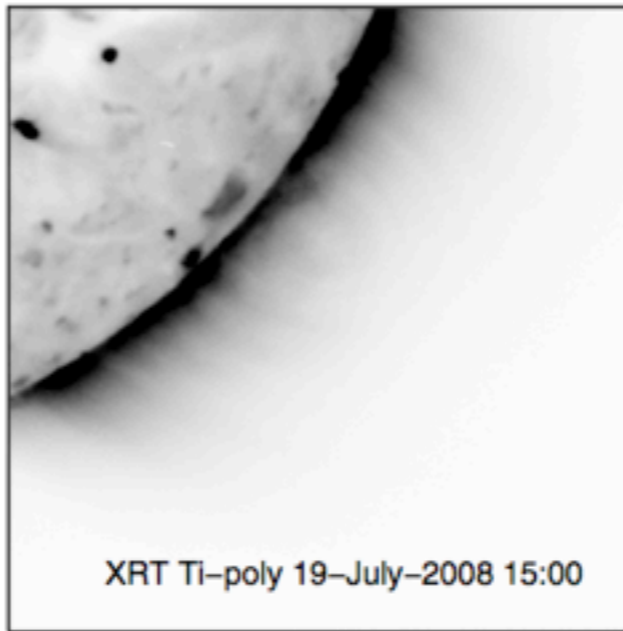


(HOT, BIGHT FILAMENT  
CAVITY CORE - SEE  
HUDSON ET AL. 1999)

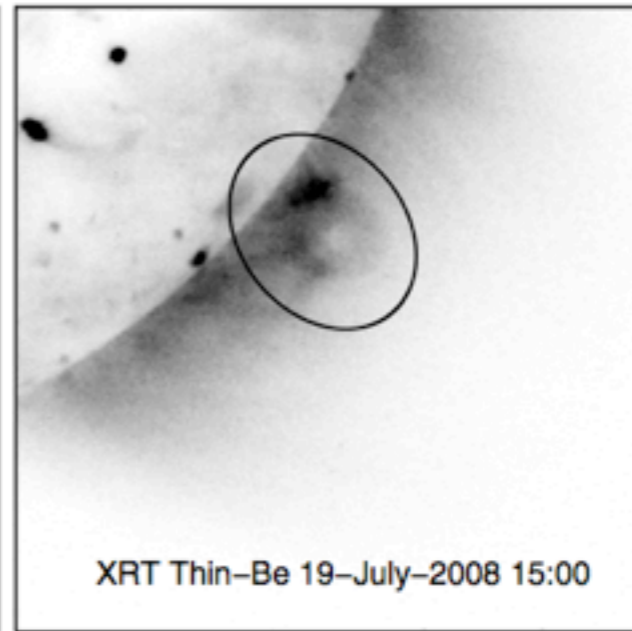




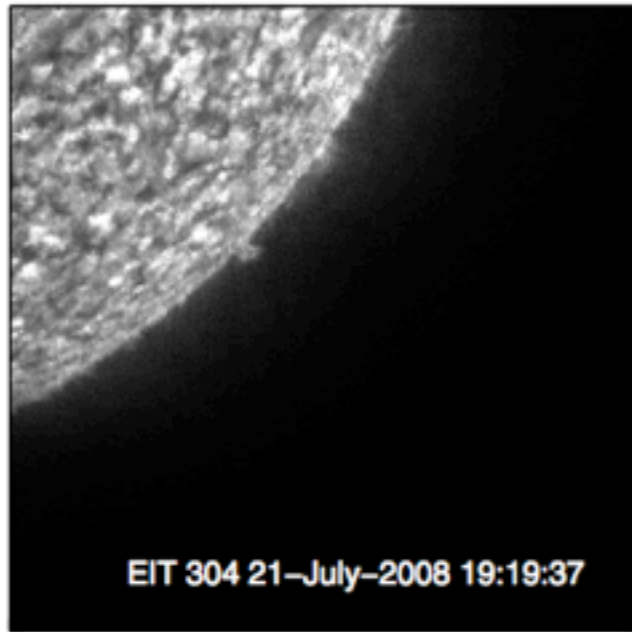
EIT 304 19-July-2008 13:19:35



XRT Ti-poly 19-July-2008 15:00



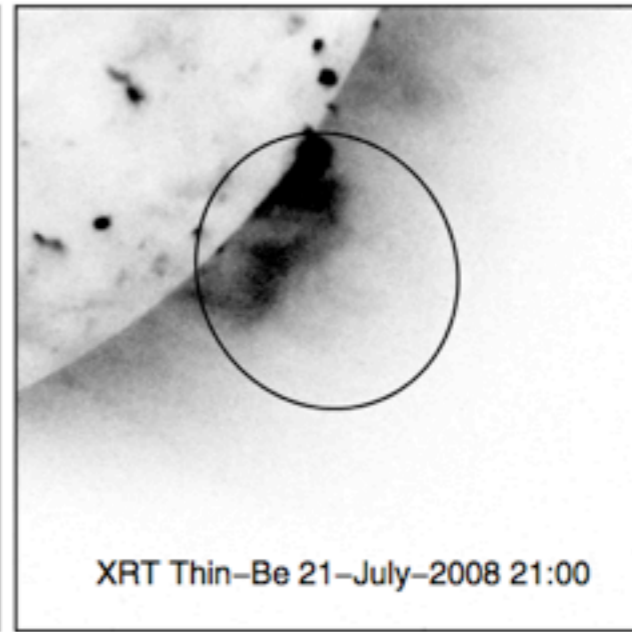
XRT Thin-Be 19-July-2008 15:00



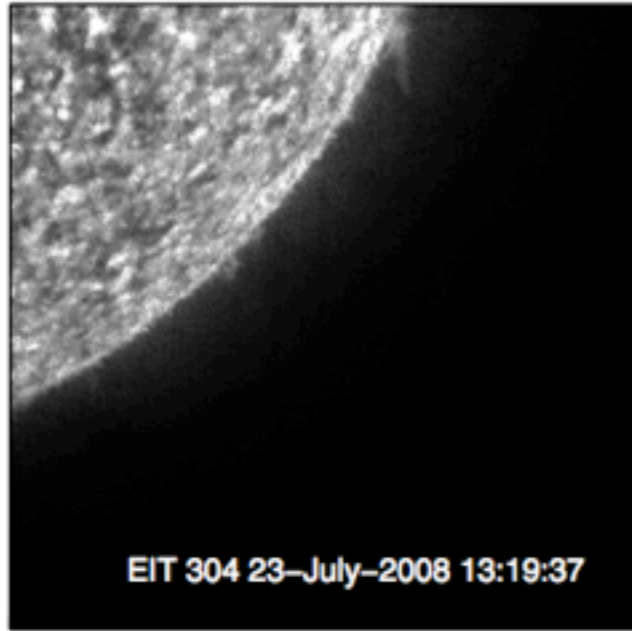
EIT 304 21-July-2008 19:19:37



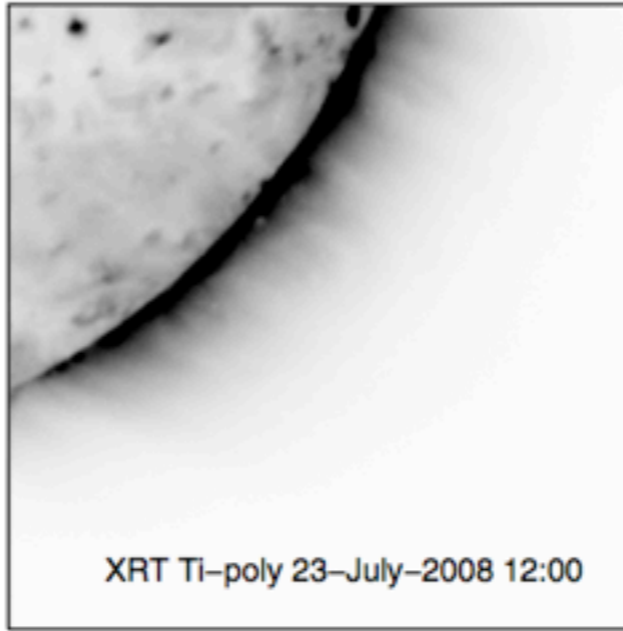
XRT Ti-poly 21-July-2008 21:00



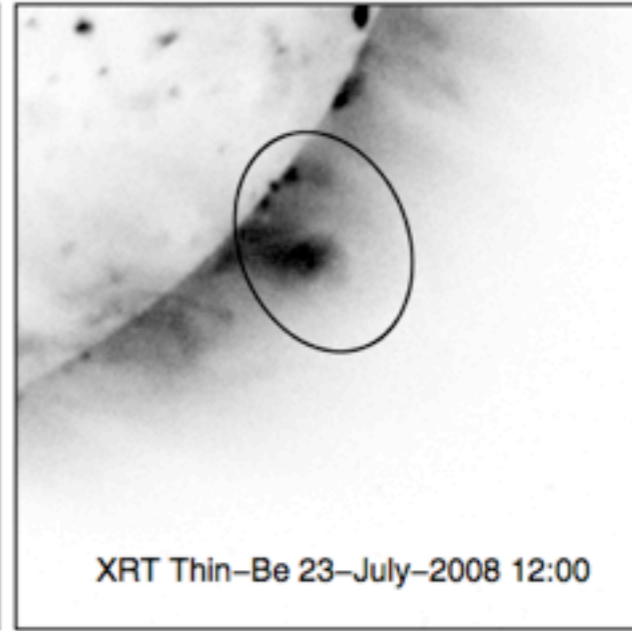
XRT Thin-Be 21-July-2008 21:00



EIT 304 23-July-2008 13:19:37



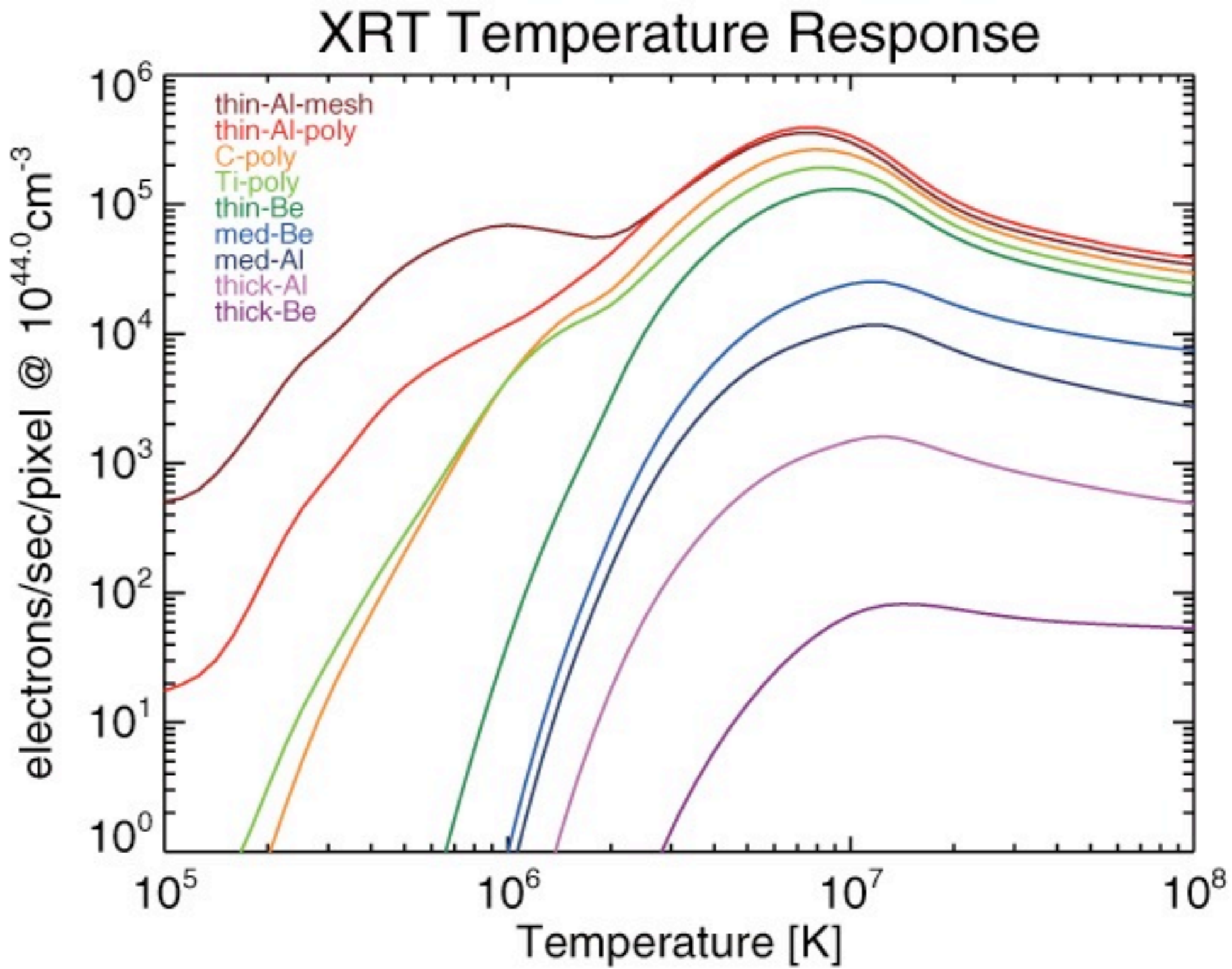
XRT Ti-poly 23-July-2008 12:00



XRT Thin-Be 23-July-2008 12:00

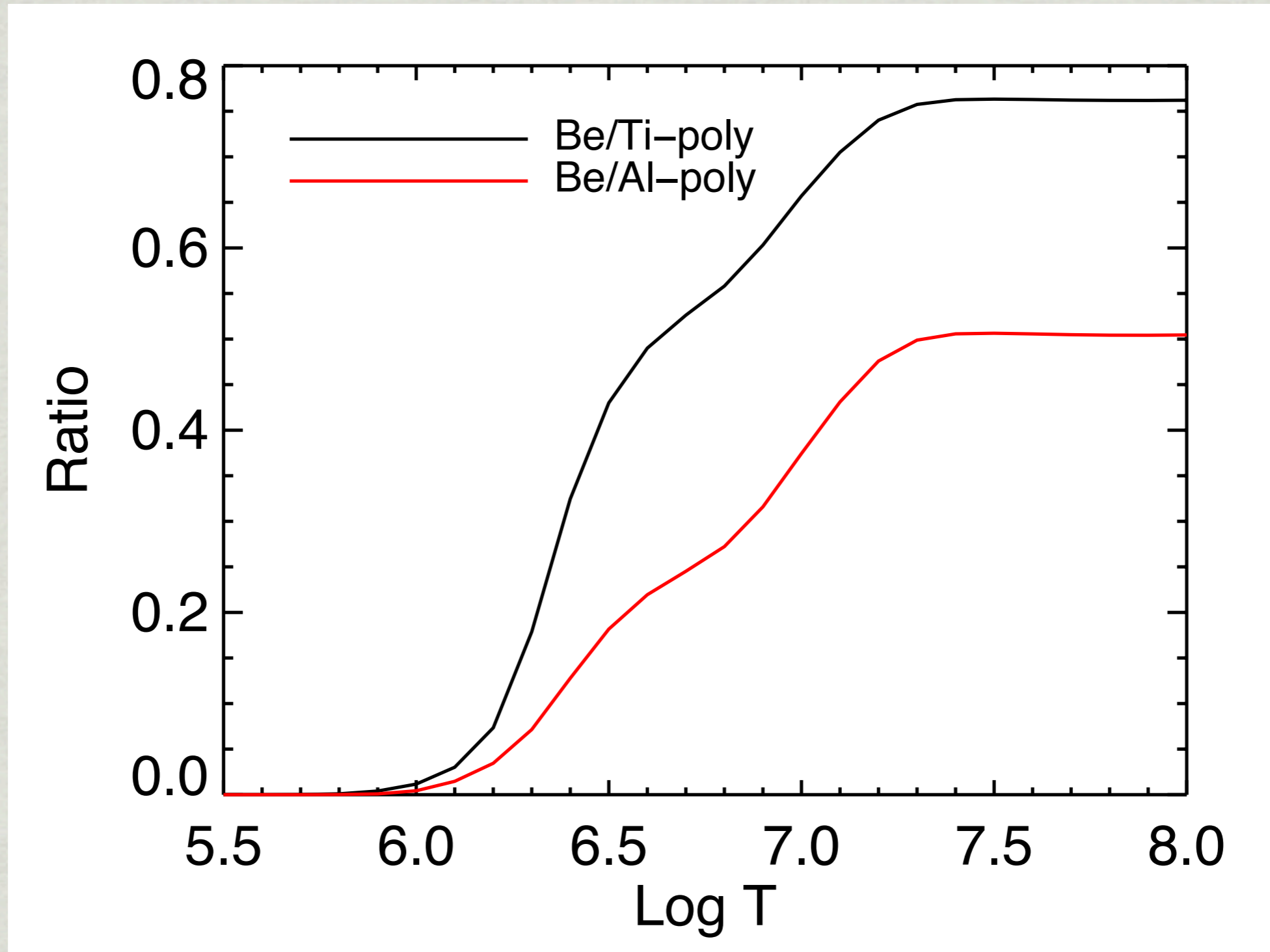


# XRT X-ray filters



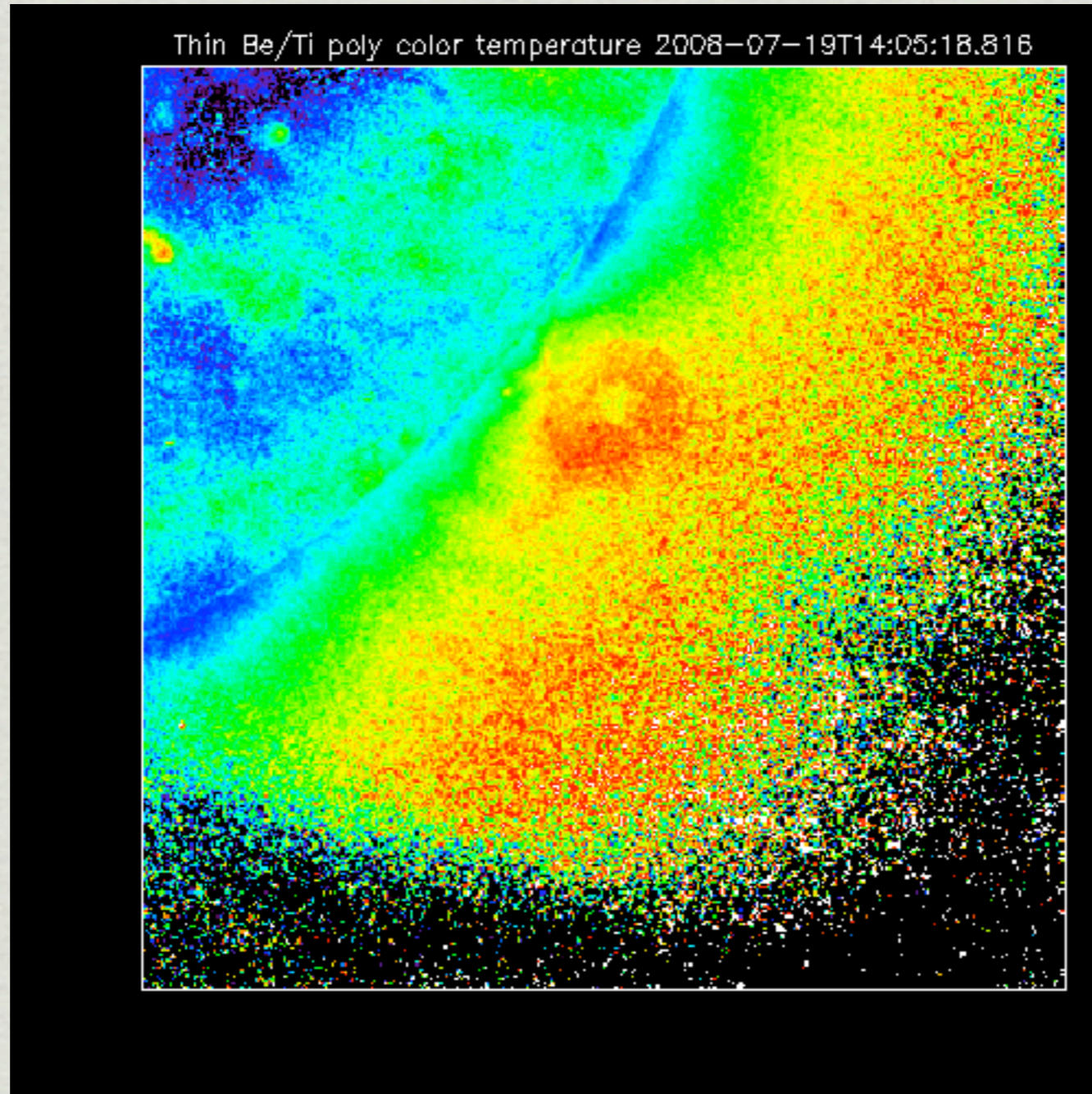


# Temperature ratios

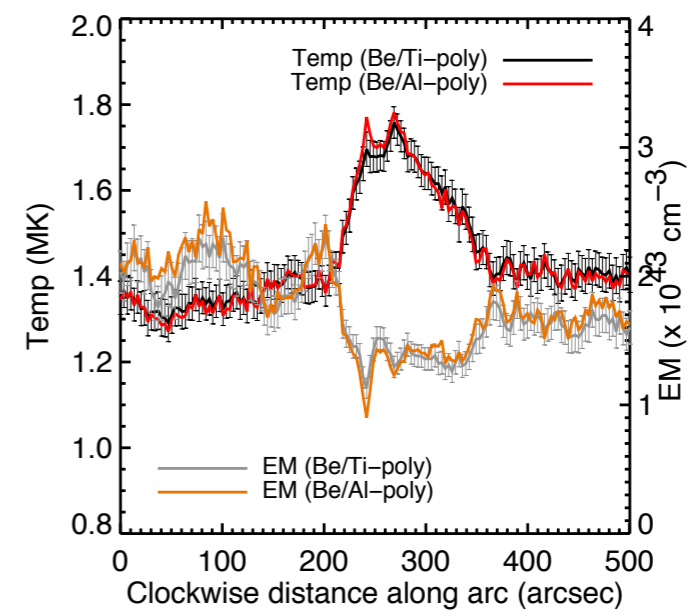
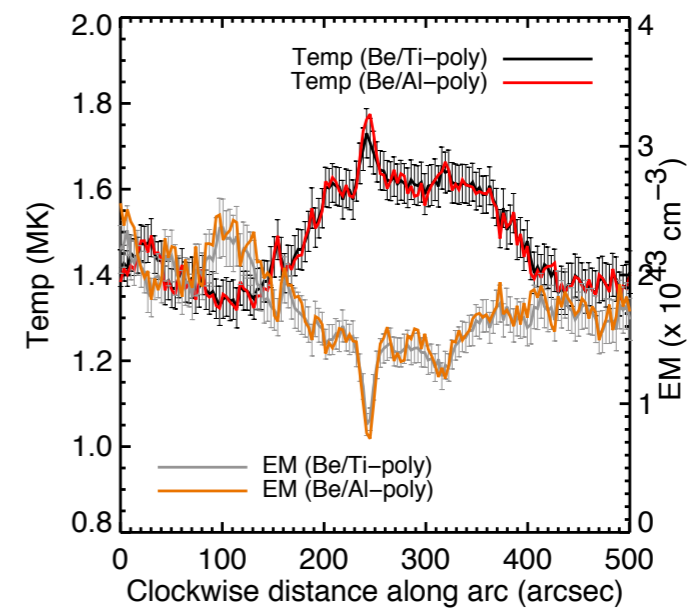
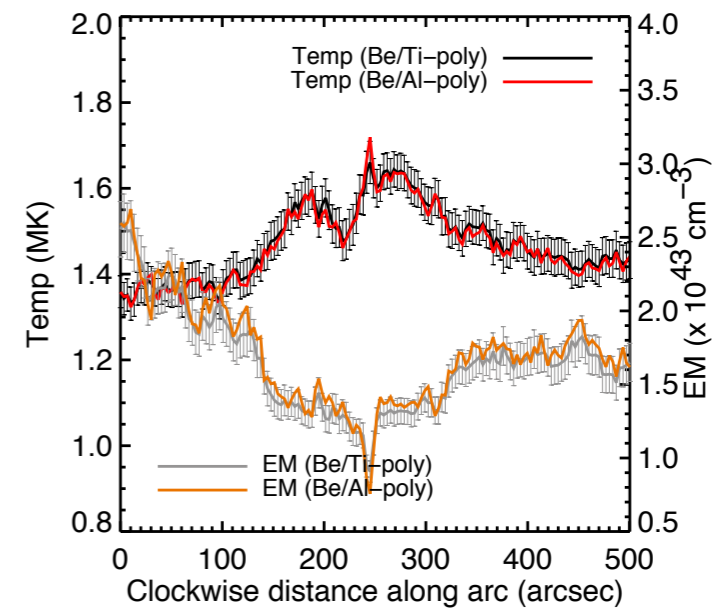
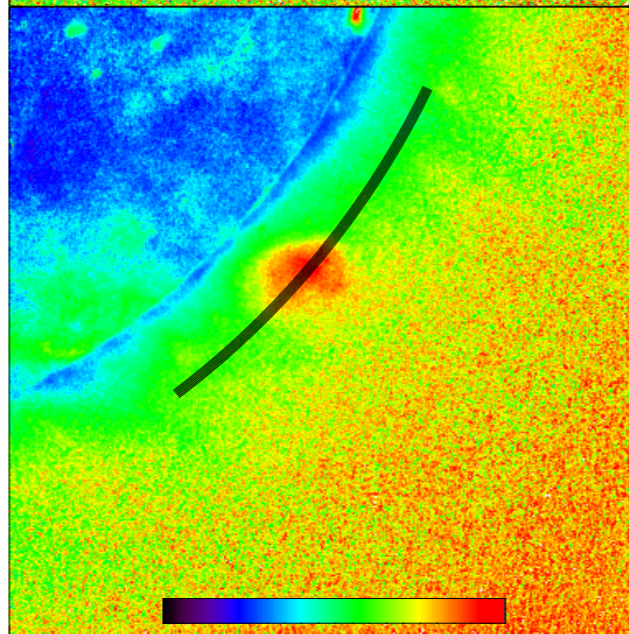
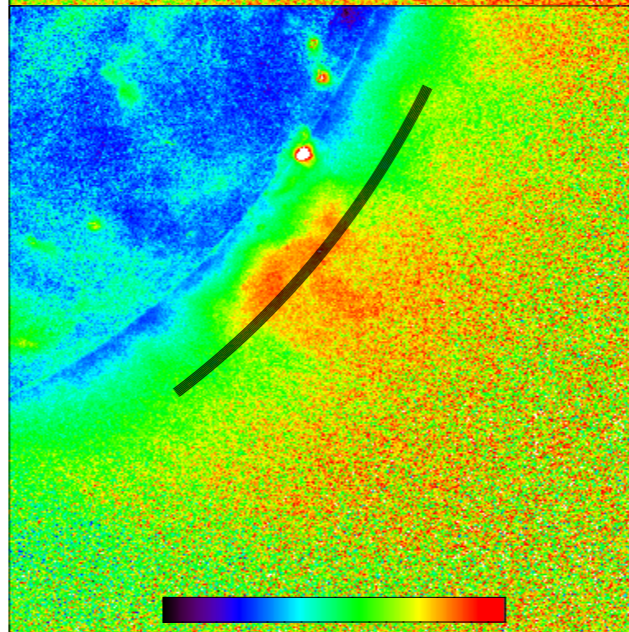
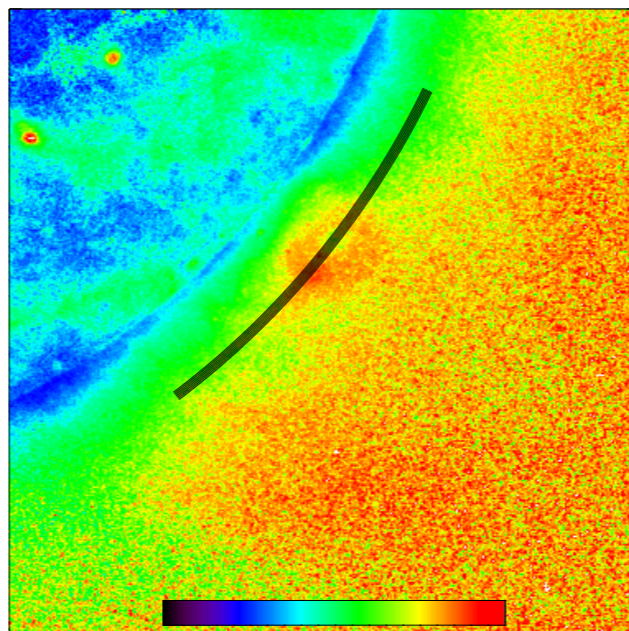
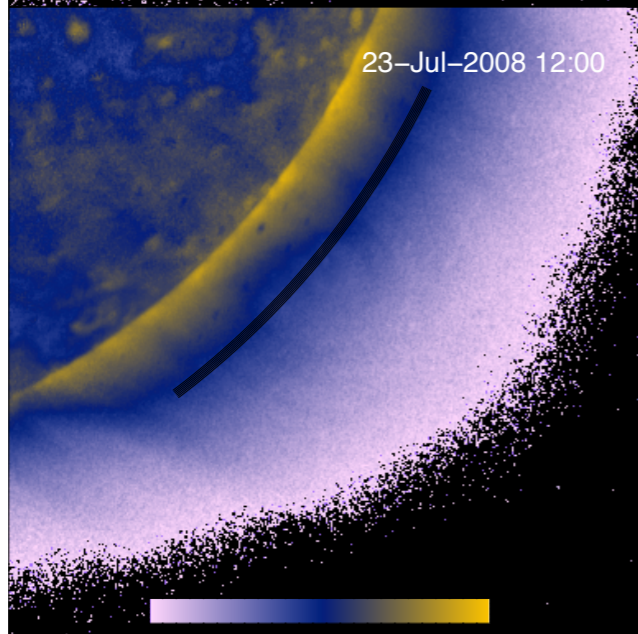
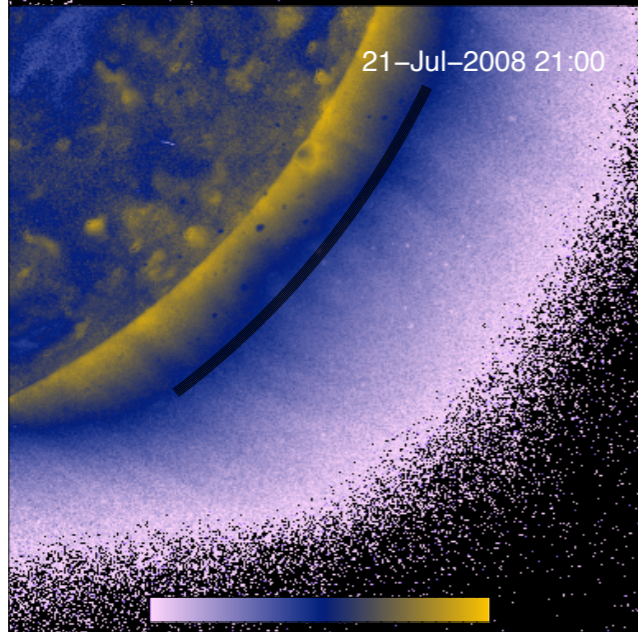
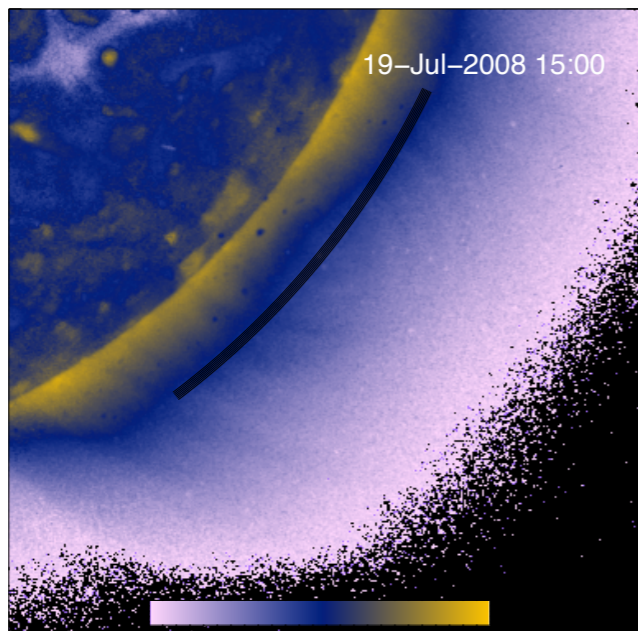




# Temperature movie



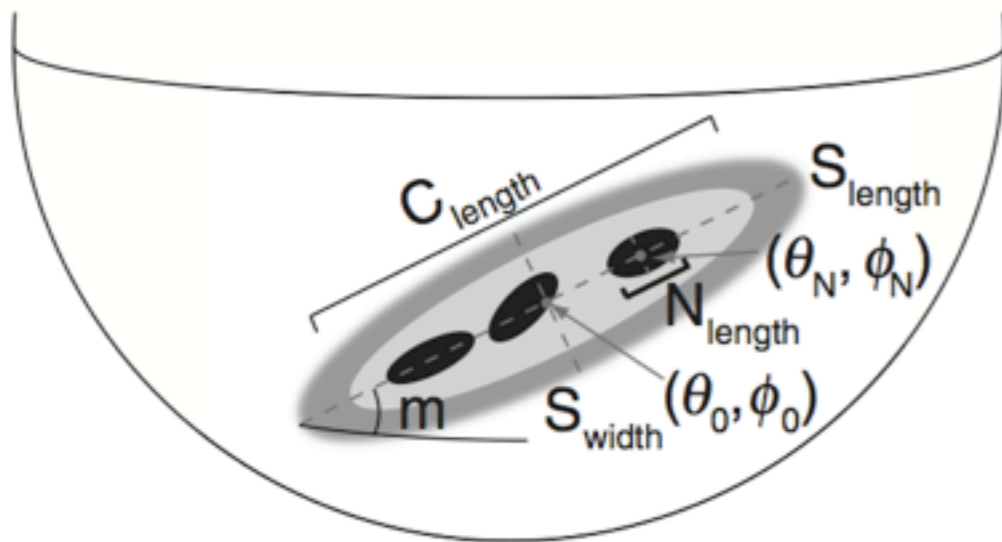






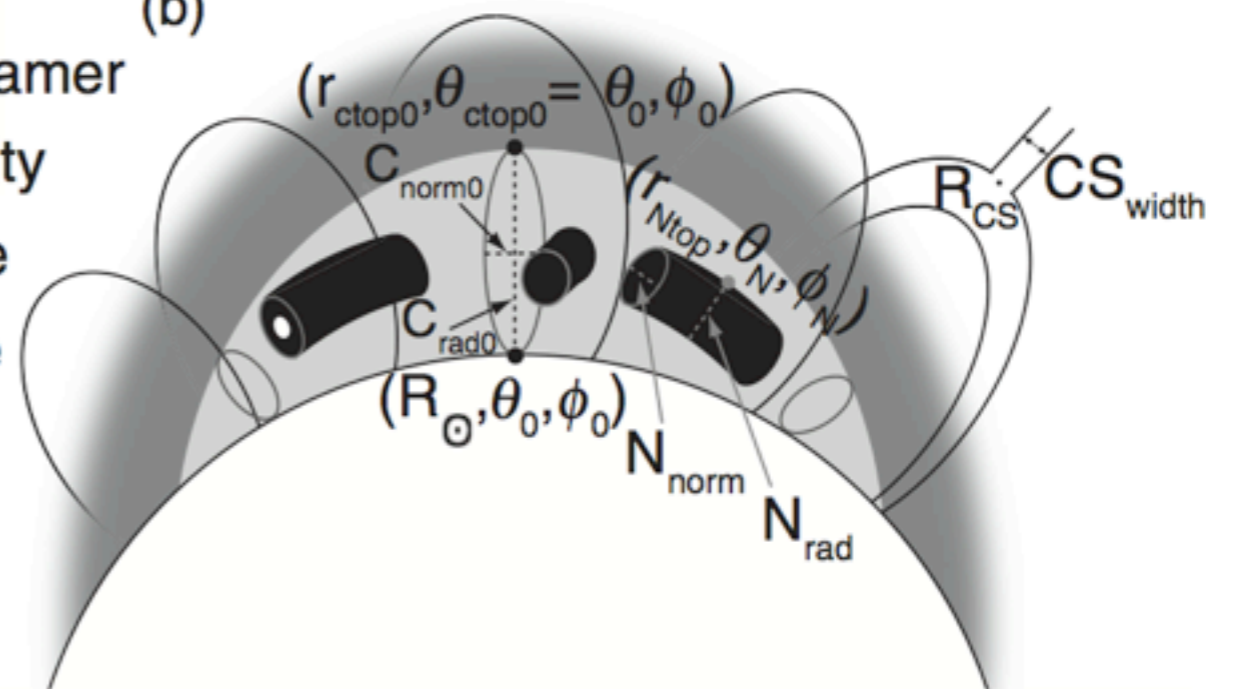
# CAVMORPH model

(a) Viewpoint for panel b) view



- Streamer
- Cavity
- Core
- Hole

(b)





# Model parameters

**Table 1**  
Geometrical Parameters for the Streamer and Cavity in the  
Morphological Model

Quantity	Parameter	Value
Streamer central colatitude	$\theta_0$	$131^\circ 41 \pm 3.27$
Streamer central Carrington longitude	$\phi_0$	$252.29 \pm 0.52$
Angle of streamer axis to equator	$m$	$2^\circ 6$
Tilt of streamer height axis vs. radial	$\alpha$	$0^\circ$
Streamer half-width at photosphere	$S_{\text{width}}$	$40^\circ$
Streamer half-length at photosphere	$S_{\text{length}}$	$100^\circ$
Streamer current sheet height	$R_{\text{cs}}$	$2.5 R_\odot$
Streamer current sheet half-width	$C S_{\text{width}}$	$3^\circ$
Cavity top radius at $\phi_0$	$r_{\text{ctop}_0}$	$1.33 R_\odot \pm 0.005$
Cavity top colatitude at $\phi_0$	$\theta_{\text{ctop}_0}$	$131^\circ 69 \pm 1.78$
Cavity height at $\phi_0$	$C_{\text{rad}_0}$	$0.331 R_\odot \pm 0.005$
Cavity width at $\phi_0$	$C_{\text{norm}_0}$	$0.296 R_\odot \pm 0.005$
Cavity half-length	$C_{\text{length}}$	$35^\circ \pm 2$



# Model parameters

**Table 2**  
Geometrical and Thermodynamic Parameters for the Cavity Cores Used in the Morphological Model

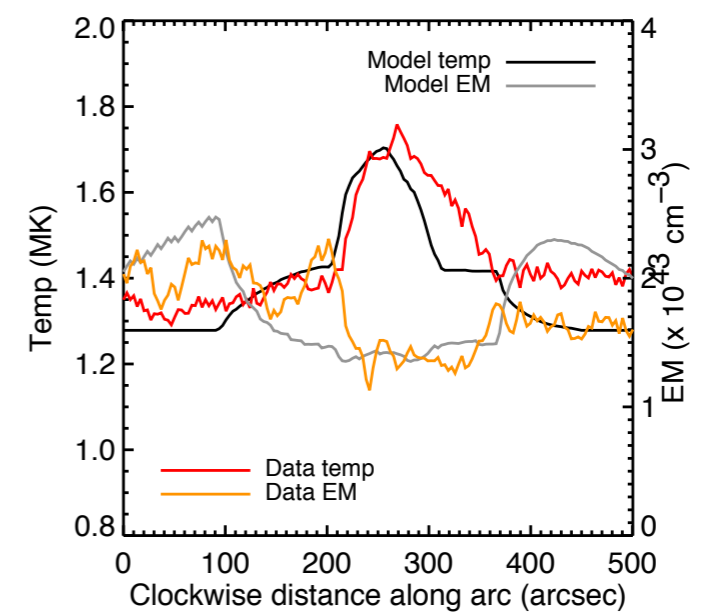
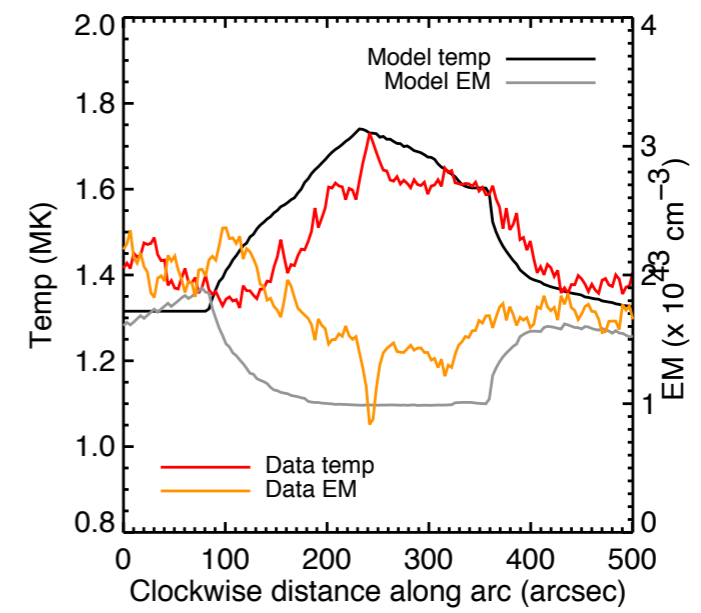
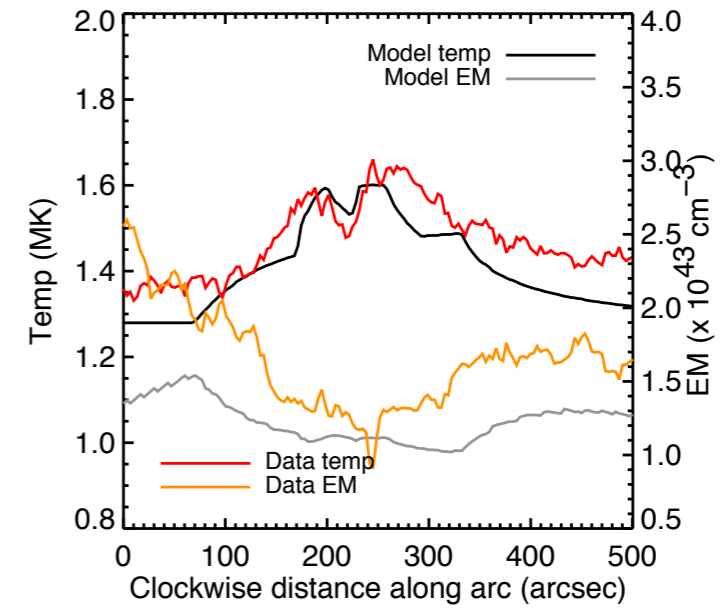
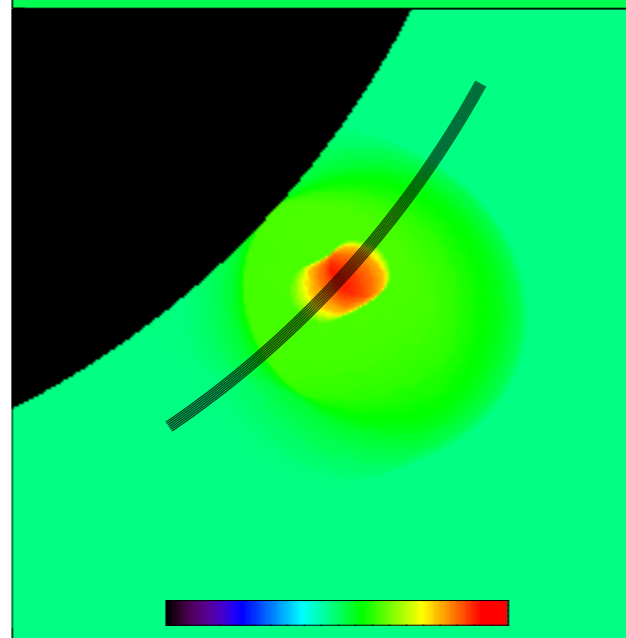
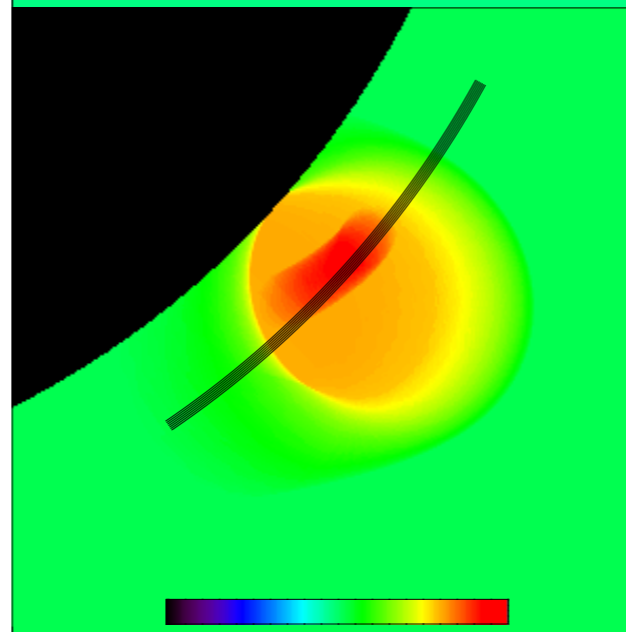
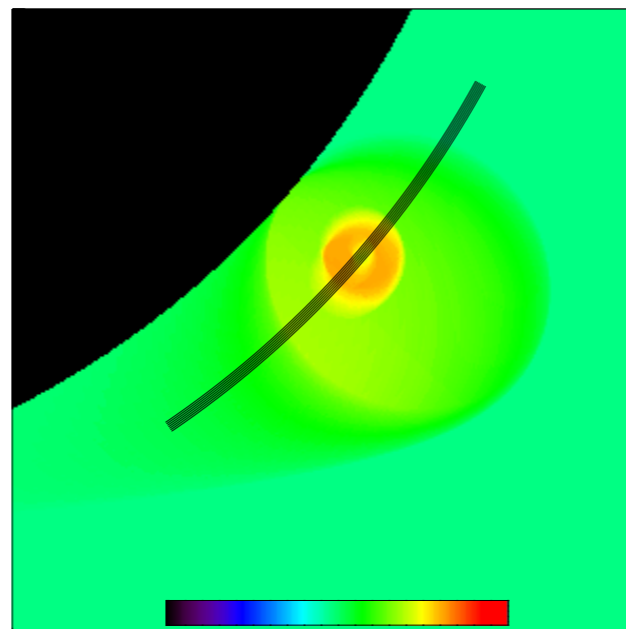
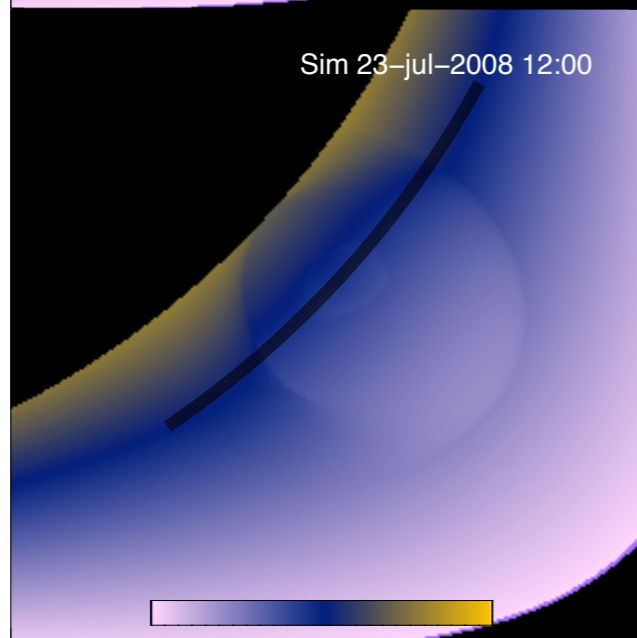
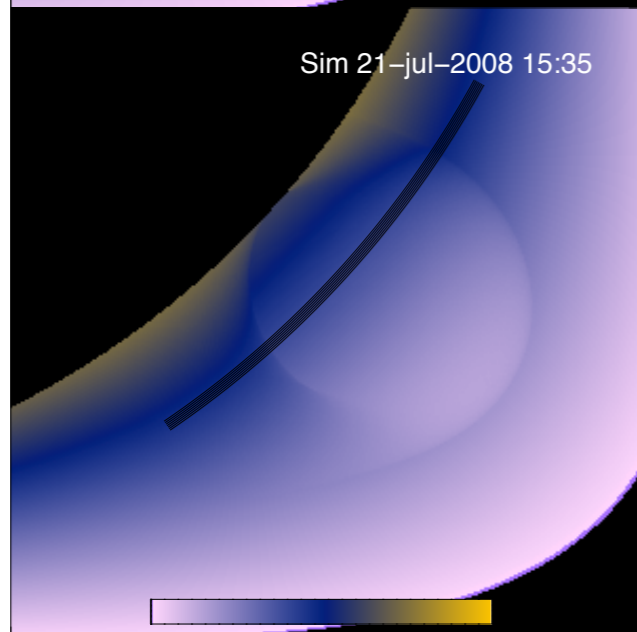
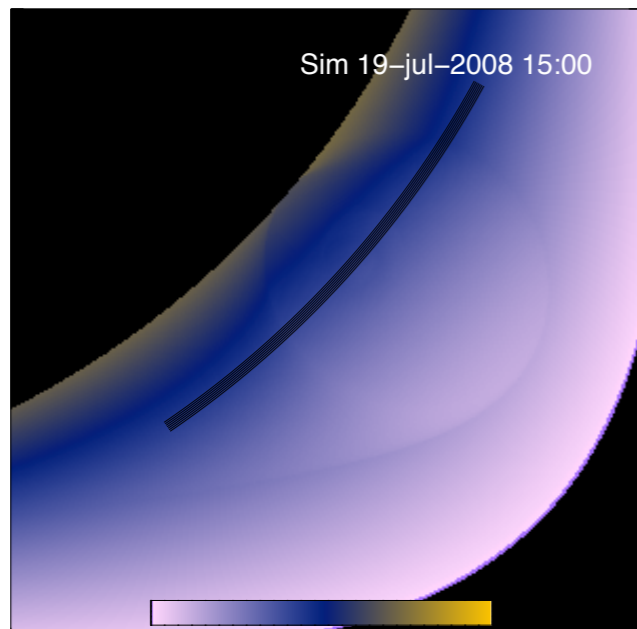
Quantity	Parameter	2008 Jul 19	2008 Jul 21	2008 Jul 23
Angle of core to equator	$m_N$	2:6	10°	2:6
Core central Carrington longitude	$\phi_N$	282	242	230
Core top radius at $\phi_N$	$r_{Ntop}$	1.16 $R_\odot$	1.13 $R_\odot$	1.15 $R_\odot$
Core top colatitude at $\phi_N$	$\theta_{Ntop}$	131:4	131:4	131:4
Core height at $\phi_N$	$N_{rad}$	0.09 $R_\odot$	0.06 $R_\odot$	0.07 $R_\odot$
Core width at $\phi_N$	$N_{norm}$	0.09 $R_\odot$	0.07 $R_\odot$	0.06 $R_\odot$
Core half-length	$N_{length}$	20°	20°	15°
Percent of core occupied by “hole”		30%	0%	0%
Temperature of cavity		1.6 MK	1.65 MK	1.5 MK
Temperature of rim		1.3 MK	1.35 MK	1.3 MK
Temperature of core		1.75 MK	1.70 MK	2.0 MK
Core density scale factor <sup>a</sup>		1.2	1.8	1.2

**Note.** <sup>a</sup> The core density is the scale factor times the cavity density.



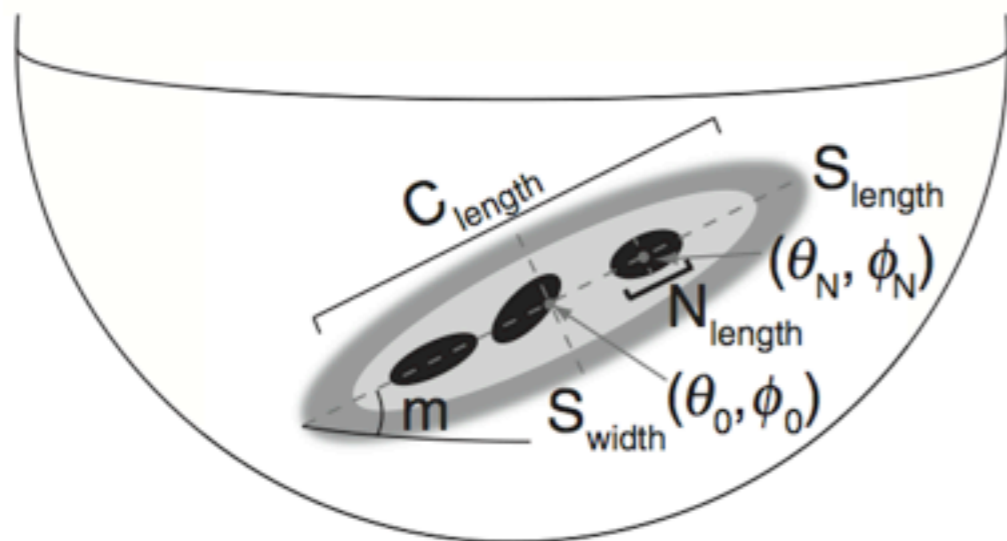
And now use FORWARD...





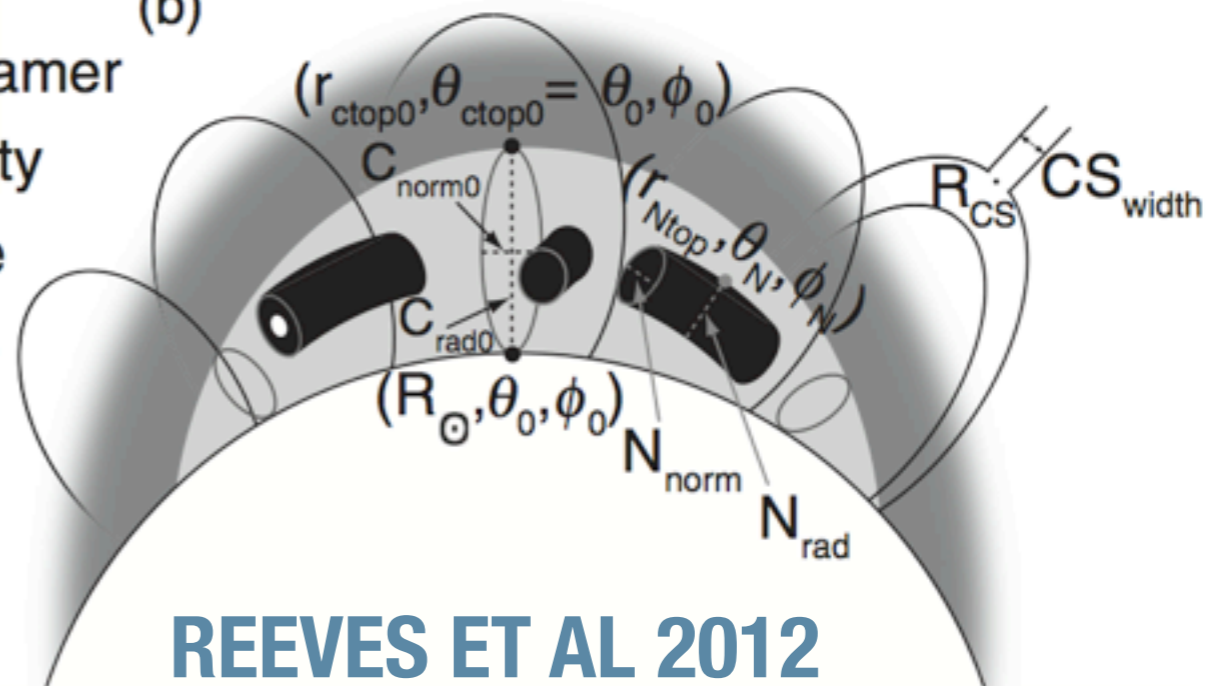


(a) Viewpoint for panel b) view



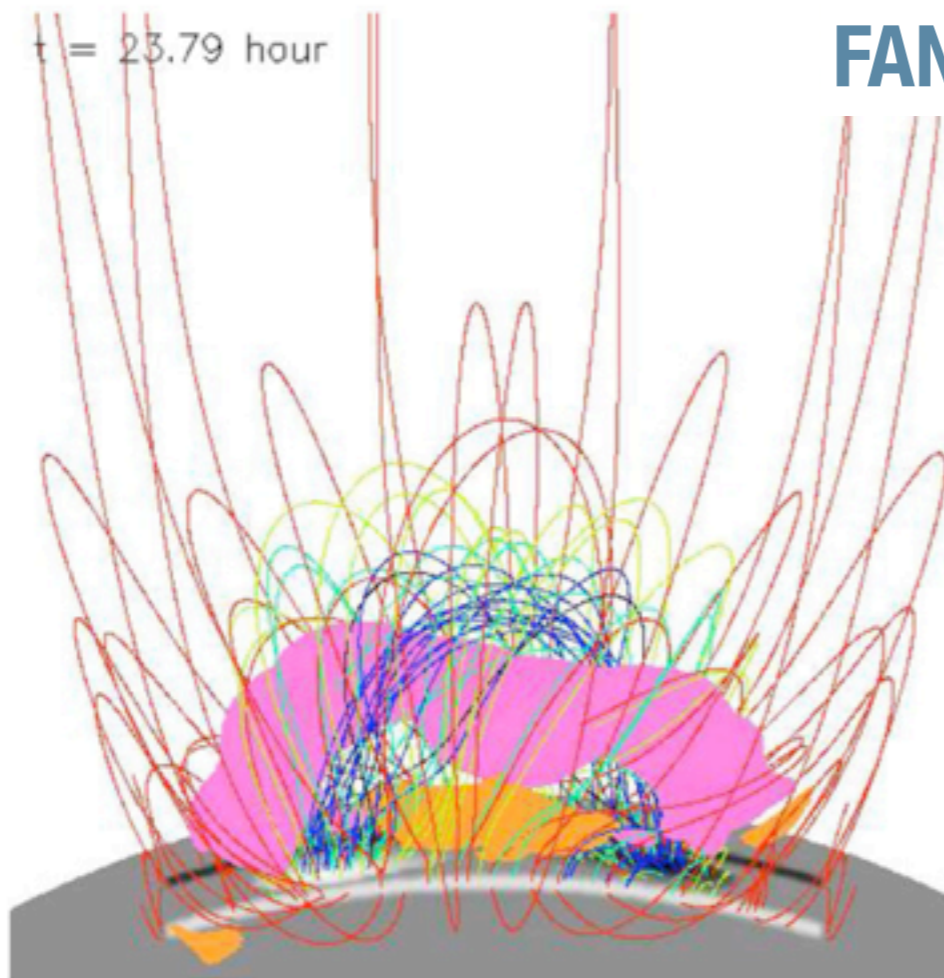
- Streamer
- Cavity
- Core
- Hole

(b)

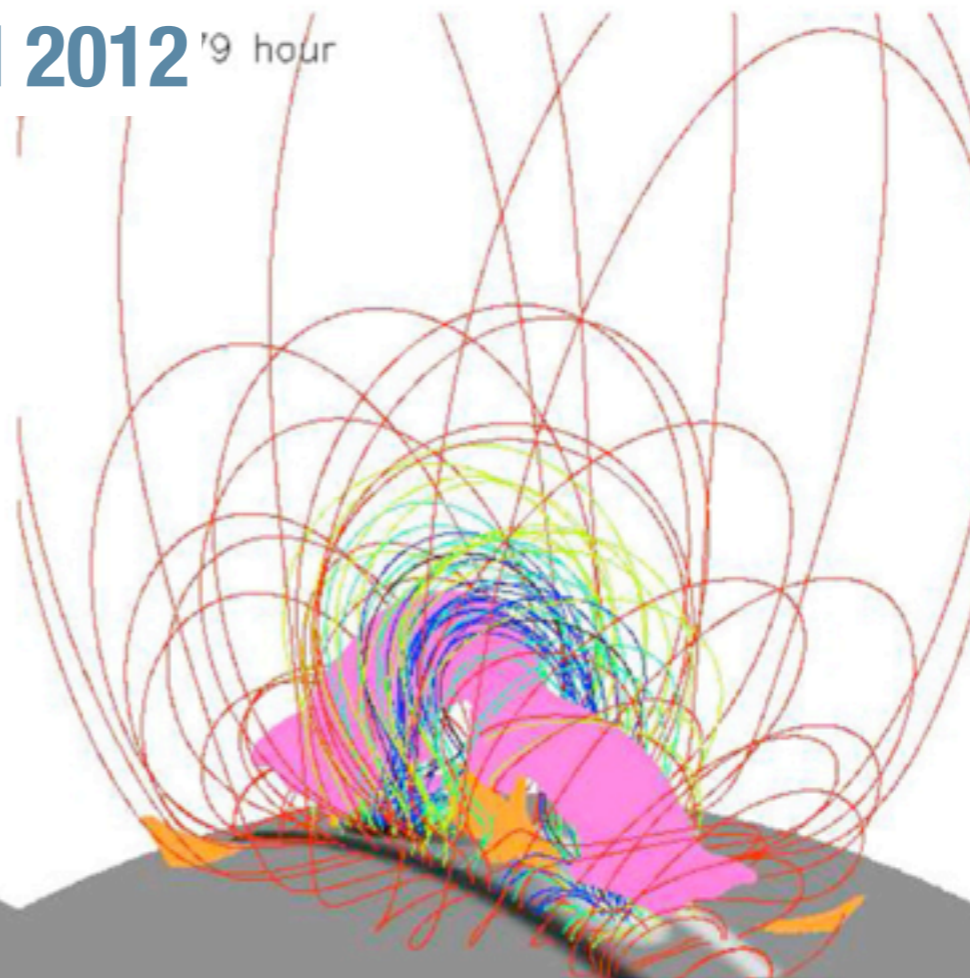


REEVES ET AL 2012

$t = 23.79$  hour



FAN 2012 '9 hour





# Conclusions

- \* XRT observations show hot cavity cores with low emission measures.
- \* We can do a reasonable job of modeling the observations with CAVMORPH + FORWARD.
- \* Nougat substructures could be indicative of hot field lines as in Fan 2012.
- \* More work needs to be done to explain magnetic field structure that causes the ring shaped nougat.