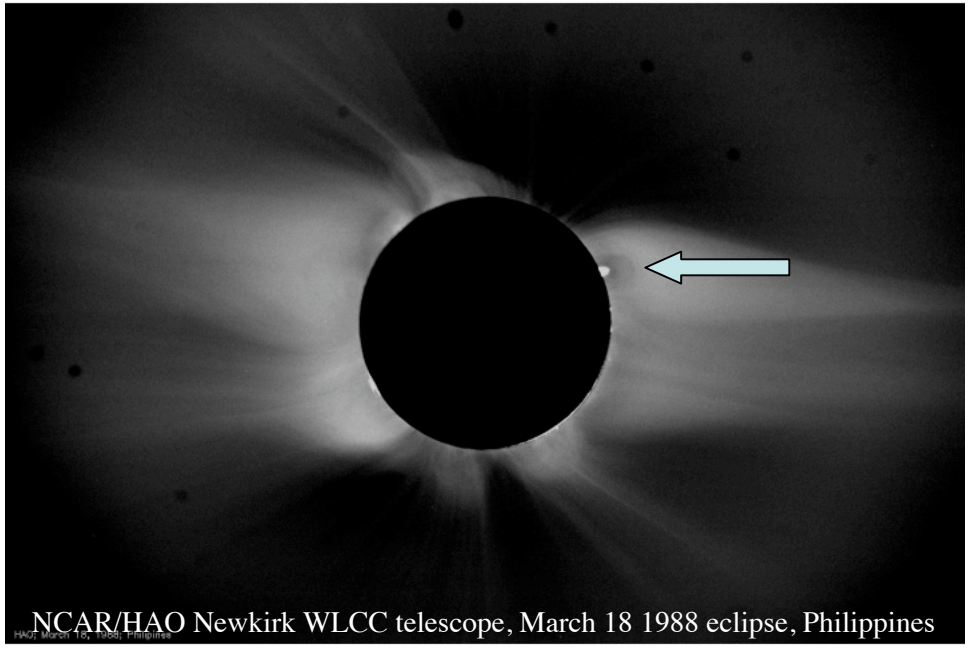
Coronal filament cavities: why there is a there there and what to do about it



Sarah Gibson

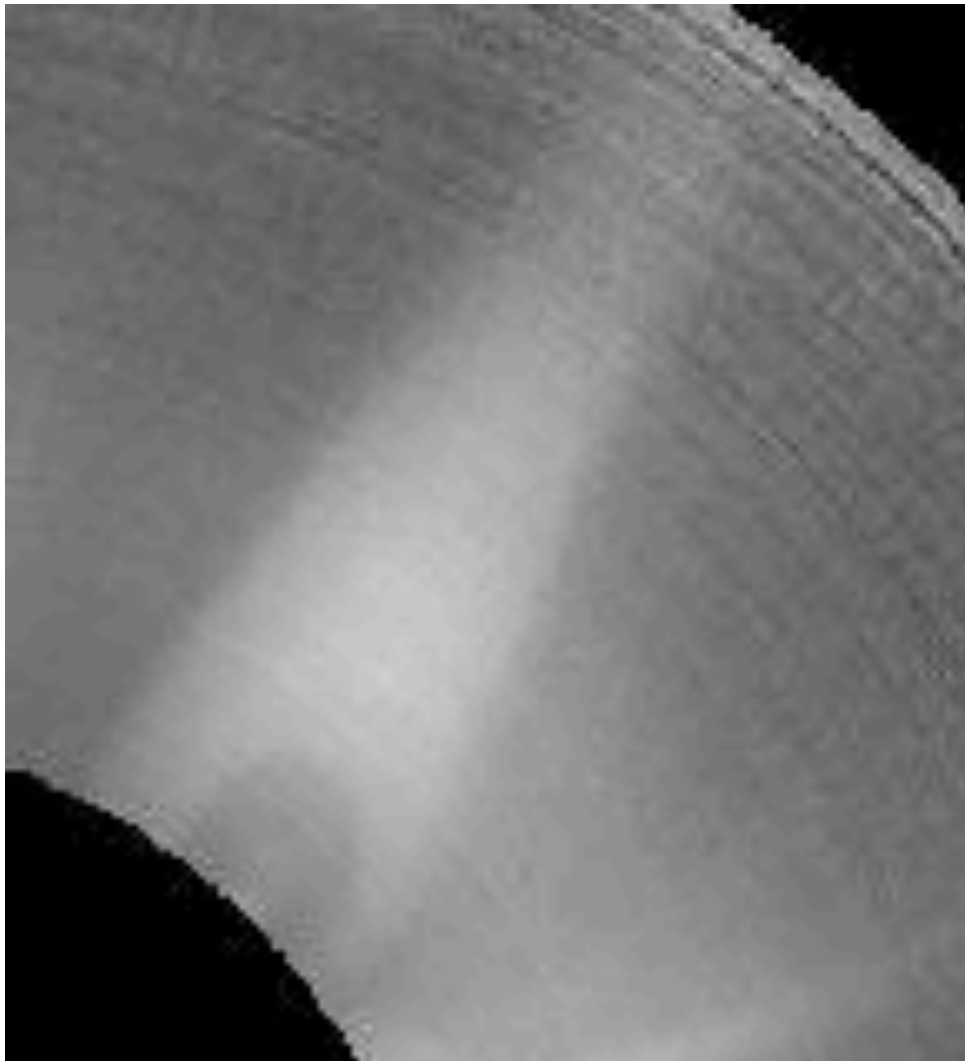
Jim Fuller, Giuliana de Toma, and Yuhong Fan

Problem: quantitative interpretation of cavities is complicated by the potential for projection of non-cavity plasma along the line of sight

Our solution: use geometric arguments to establish cases where non-cavity contributions are minimal, and include them as model uncertainties

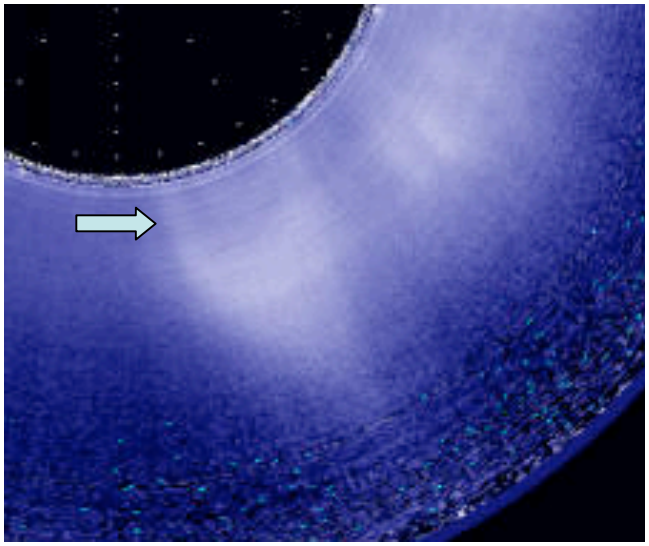
Talk outline

- Background/Motivation
- Model geometry
- Calculating density, temperature
- Implications for emission cavities
- Implications for magnetic field
- Conclusions

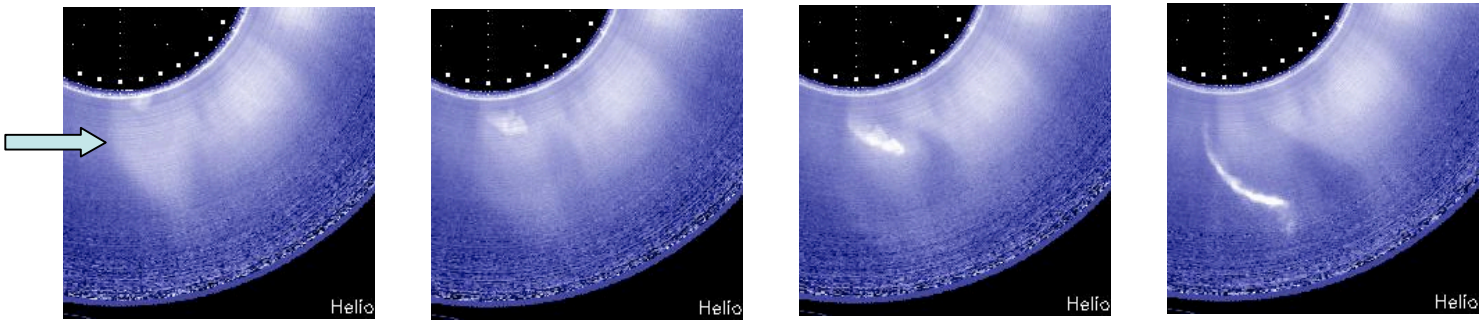


Background: cavity --> CME

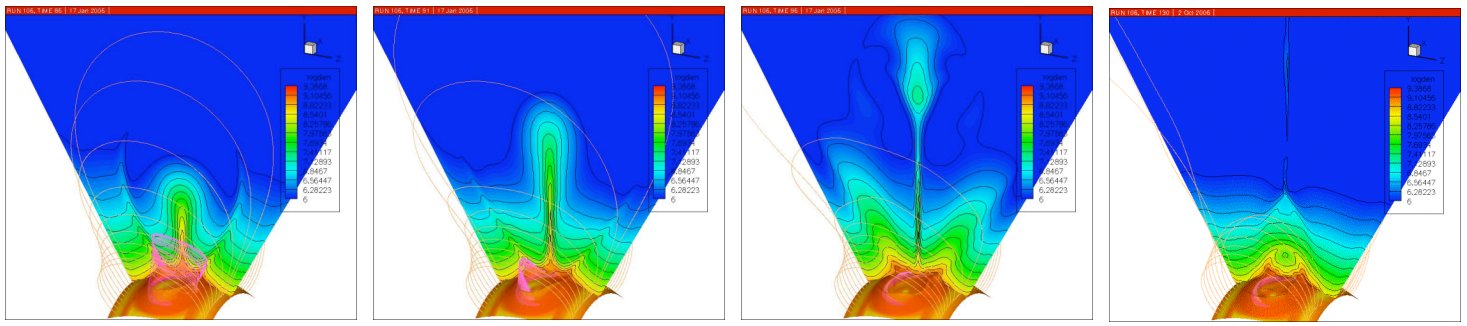
- Cavites are known to be CME precursors
- Highly suggestive of flux rope topology



Quiescent cavity: November 18, 1999



CME eruption of cavity: November 19, 1999



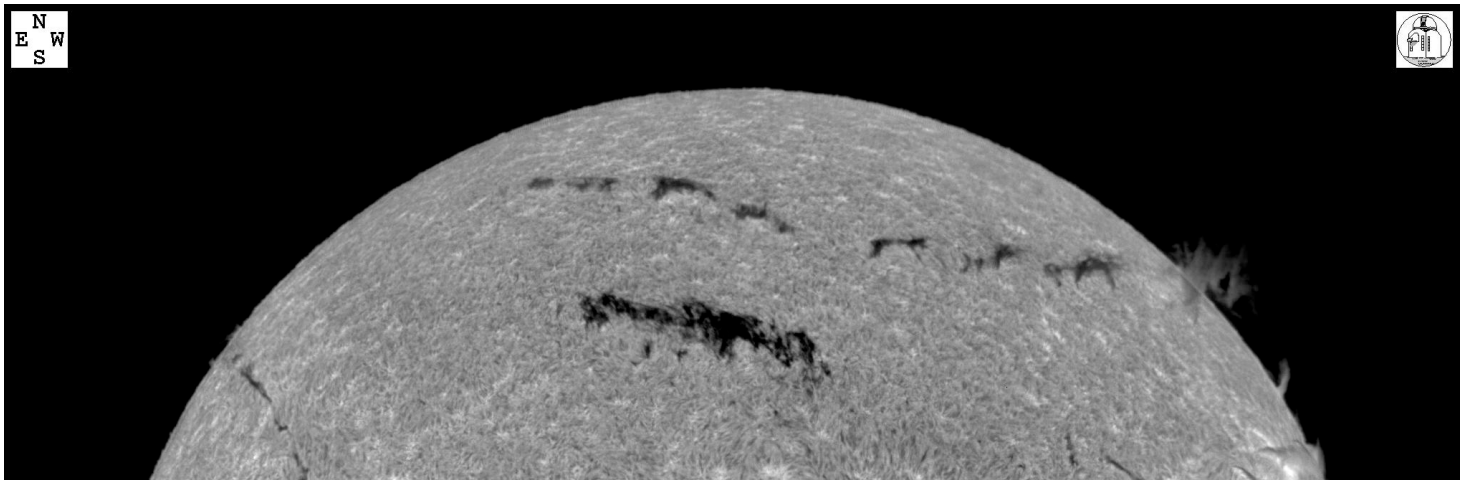
CME eruption of cavity: flux rope model ***(Gibson and Fan, 2006)***

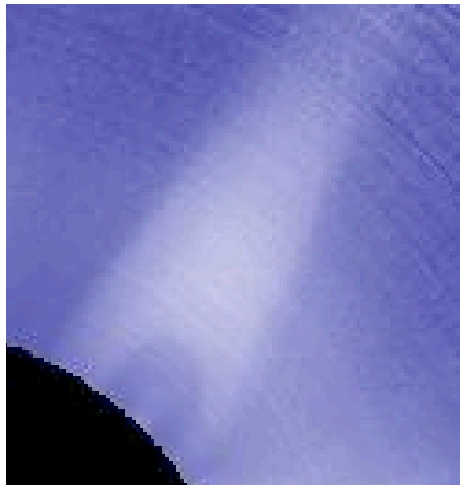
Background: cavities as filament channels

As early as eclipse of Jan 22, 1898, white light observations have demonstrated the presence of non-eruptive 3-part structures: prominence/cavity/helmet

- **Prominence cavity = filament channel viewed at limb:**

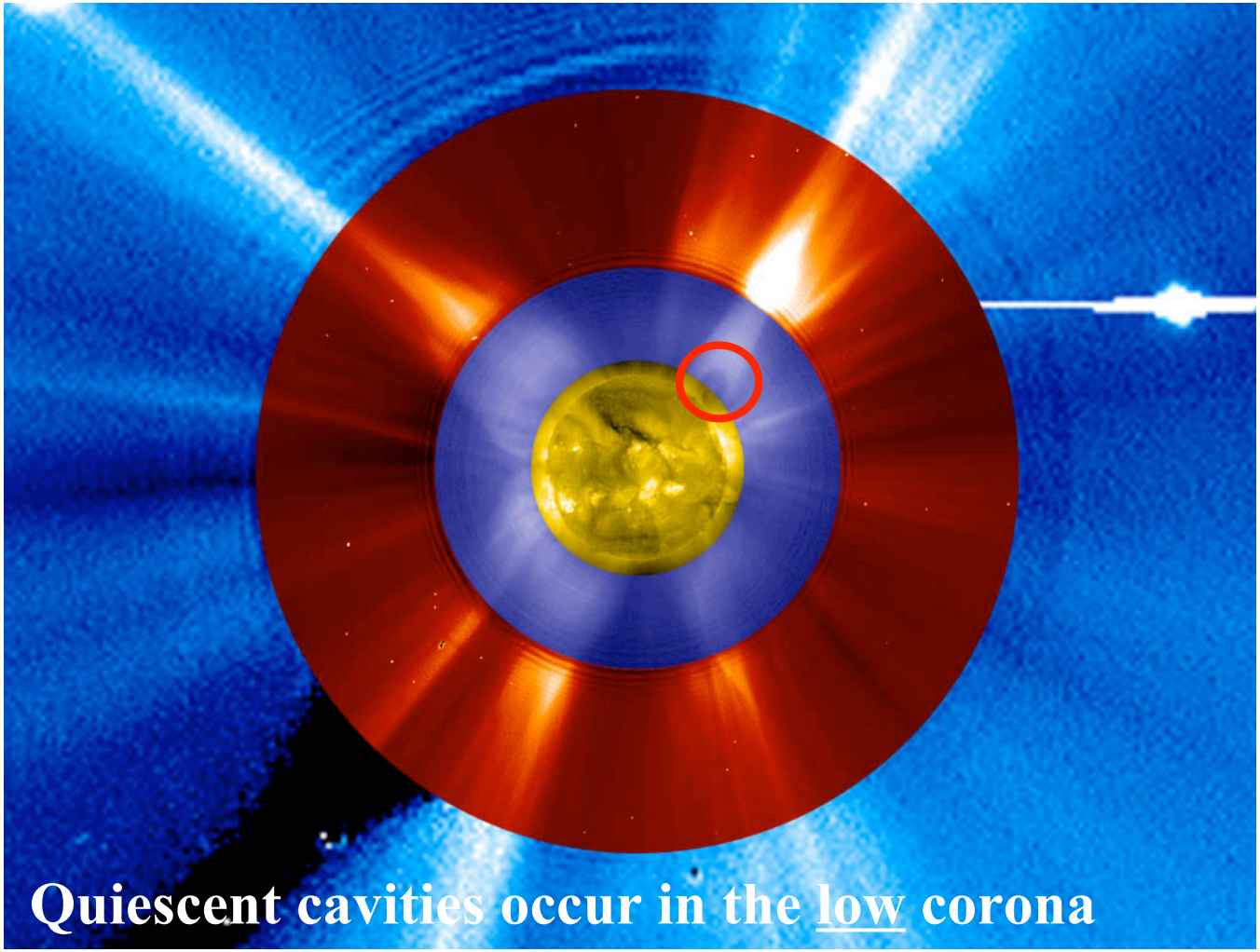
ubiquitous…





Background: cavities as filament channels

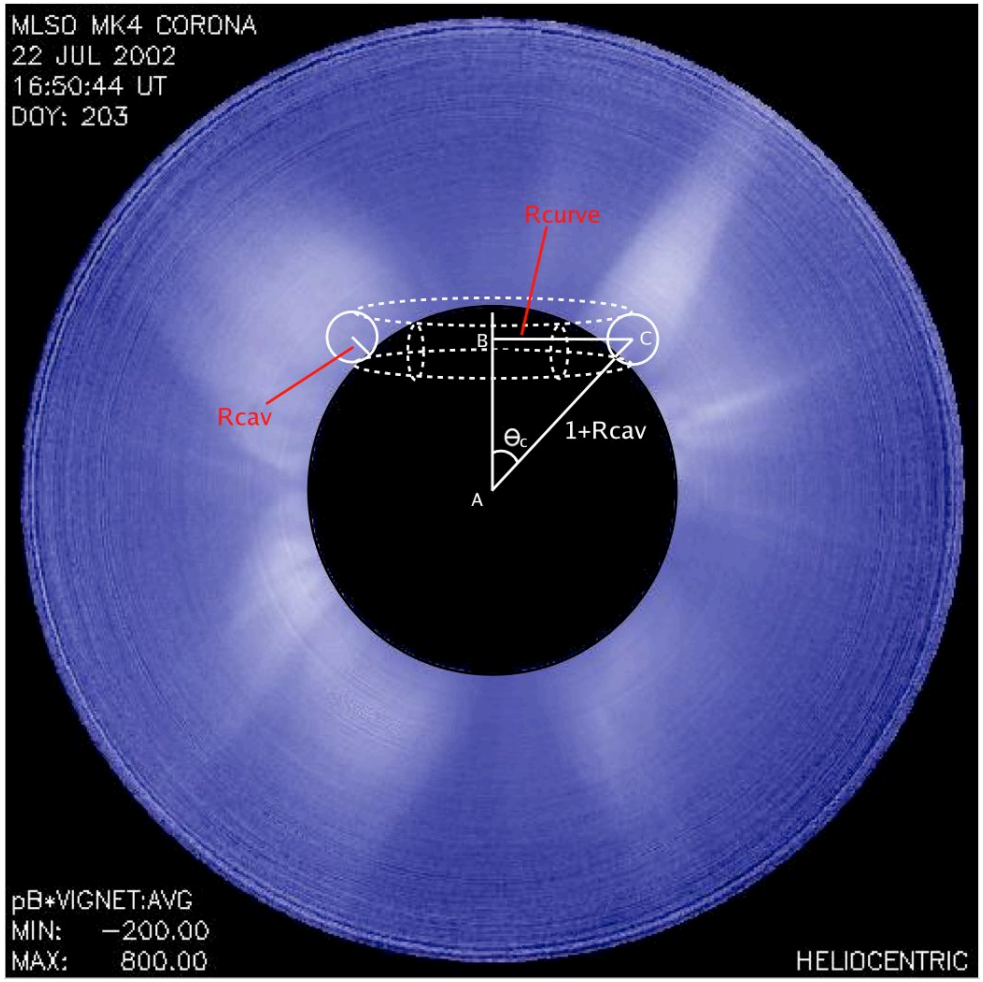
…But low-lying!

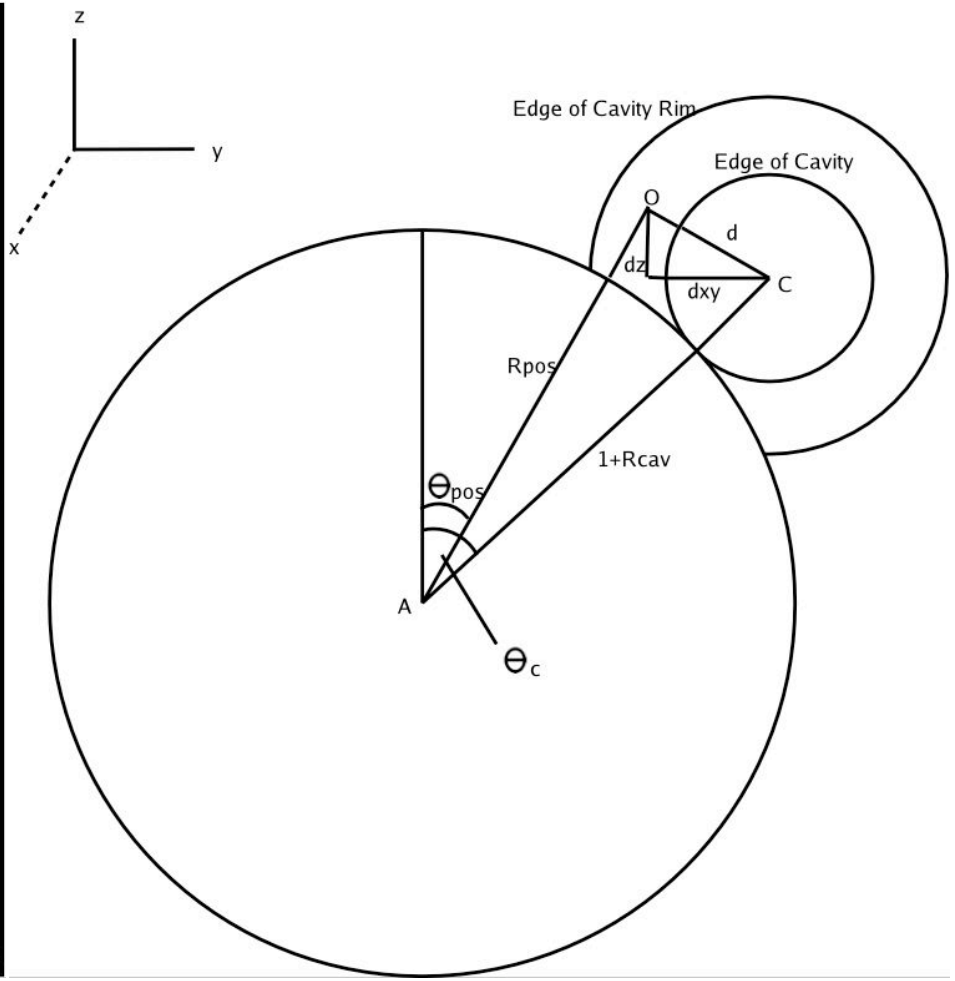


Innermost to outermost: EIT 284, Mark IV, Lasco C2, Lasco C3

Model geometry: Cavity as axisymmetric “tunnel”

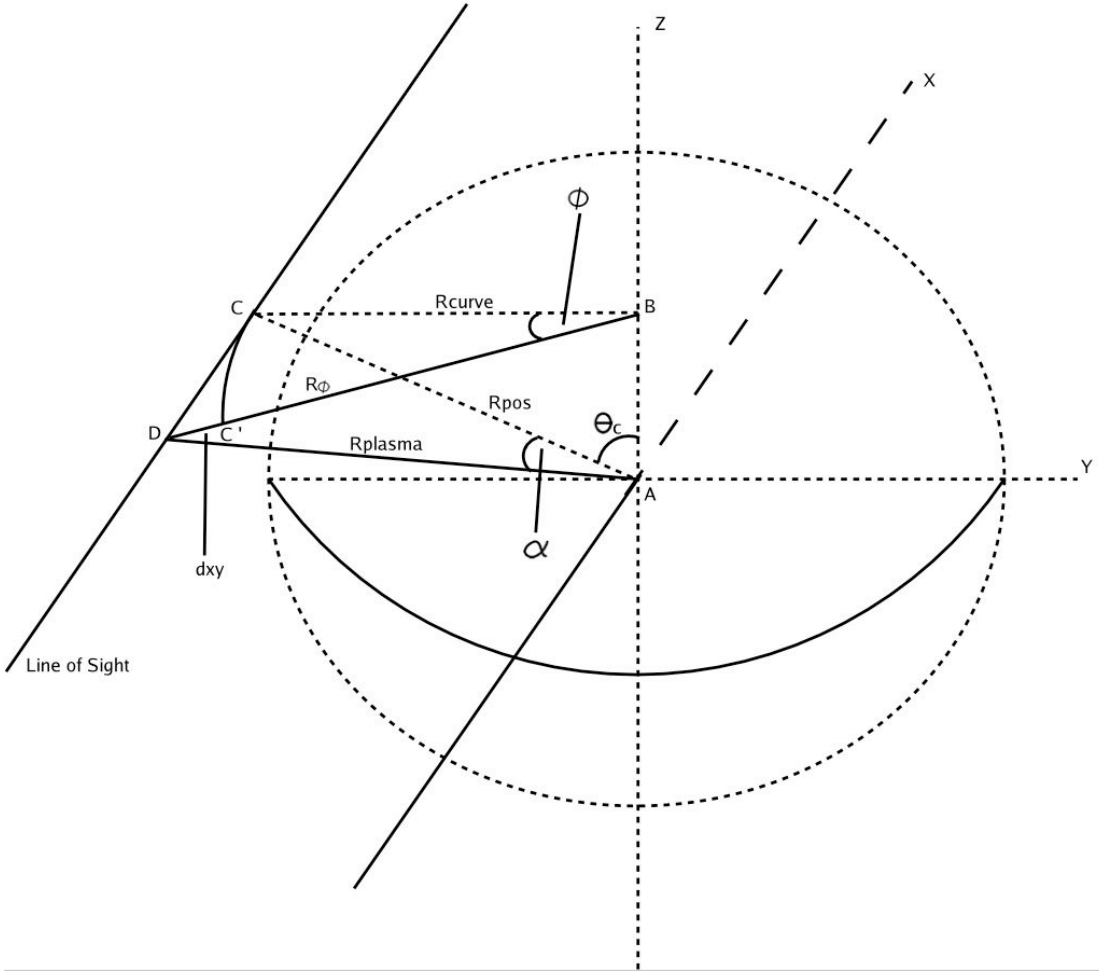
- Matches observations of polar crown filaments (PCFs)
- Cavity rim as denser surrounding tunnel

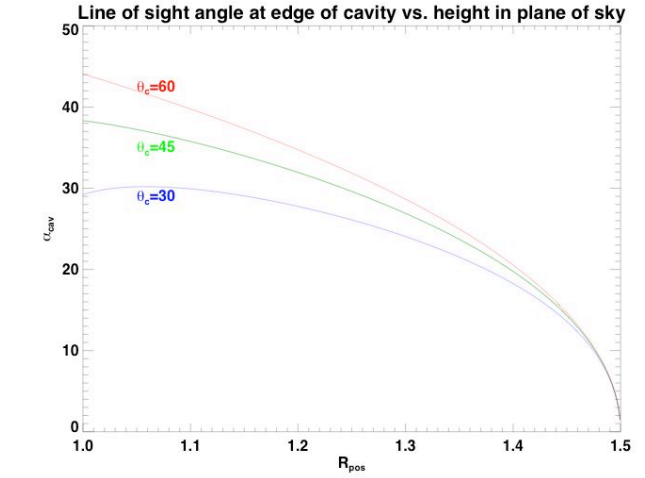


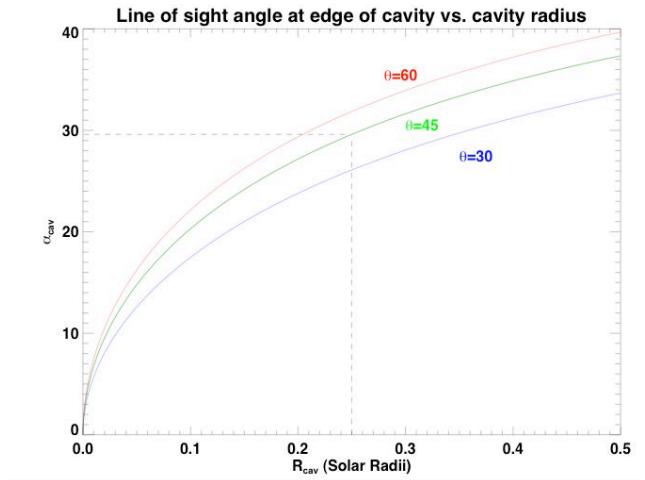


Model geometry:
Best cavities for avoiding cavity <u>rim</u> projection

- Better for lower plane-of-sky heights
- Better for big cavities, nearer equator (less curvature)

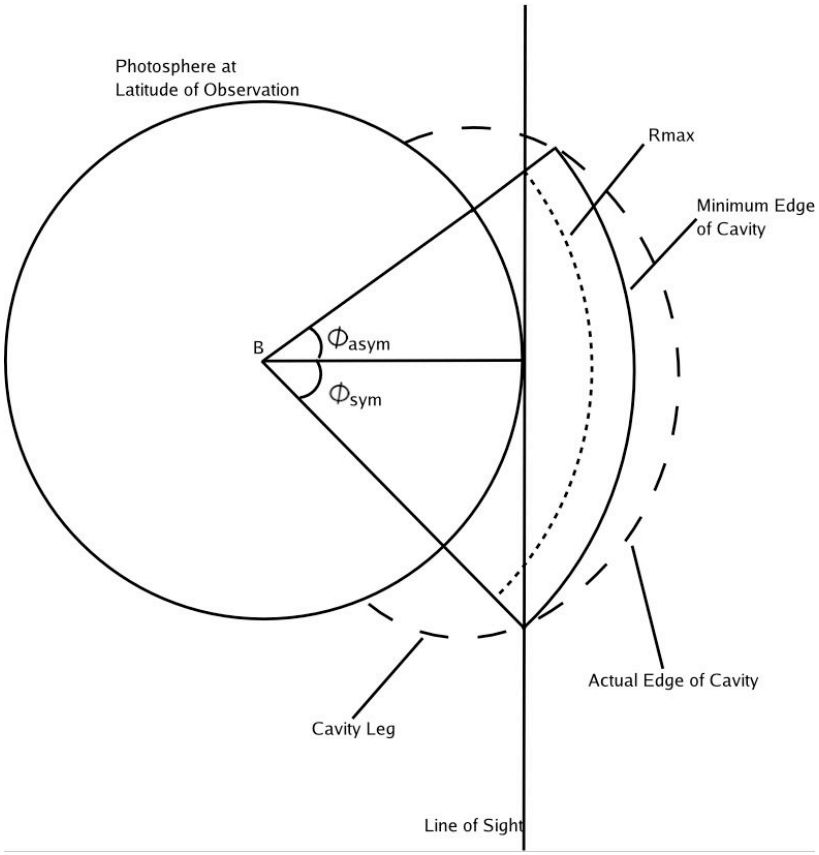






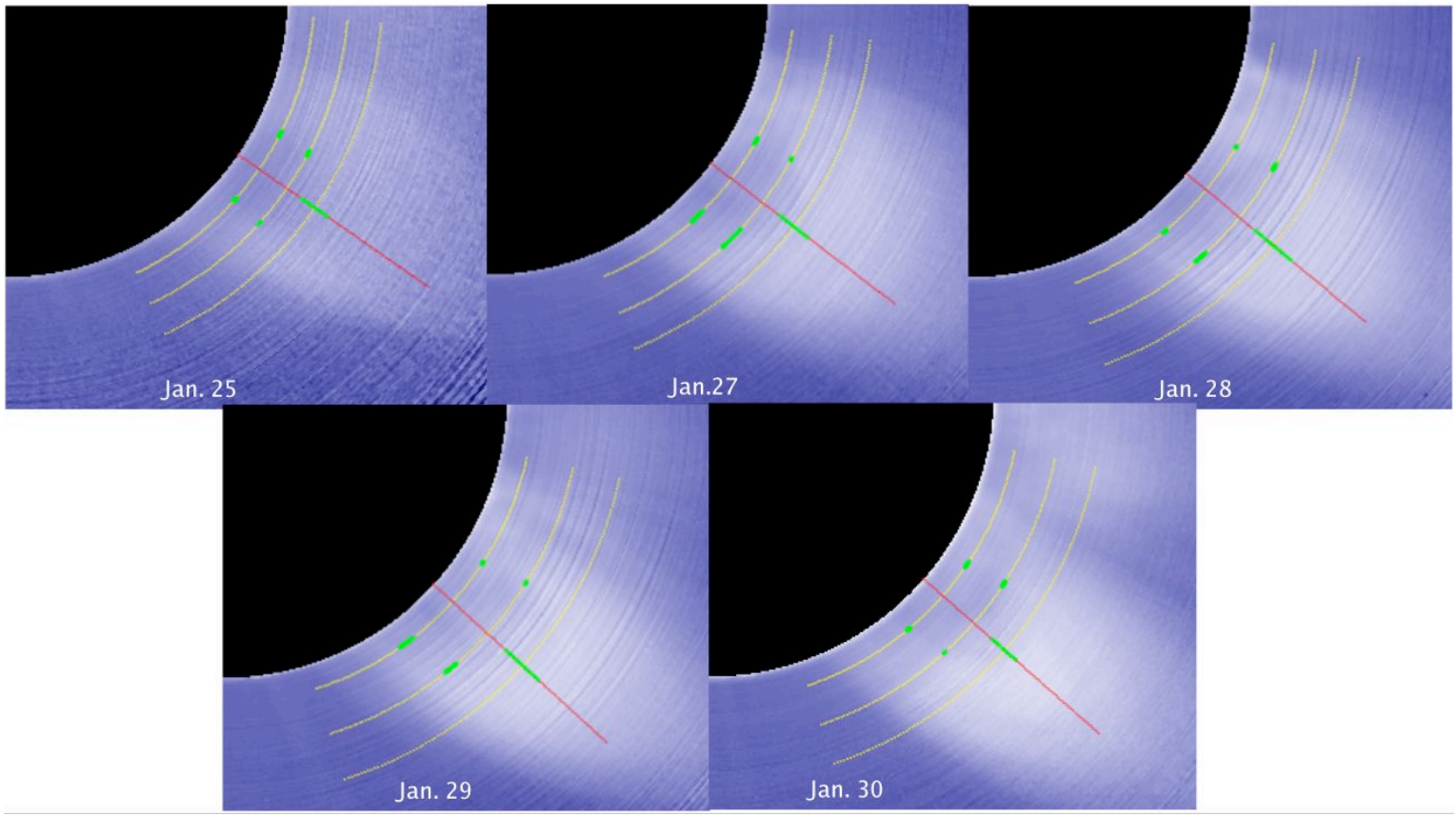
Model geometry:
Best cavities for avoiding cavity <u>legs</u> projection

- Only needs to be a torus for as long as line of sight passes through
- Better for higher plane-of-sky heights
- Better for small cavities (more curvature)



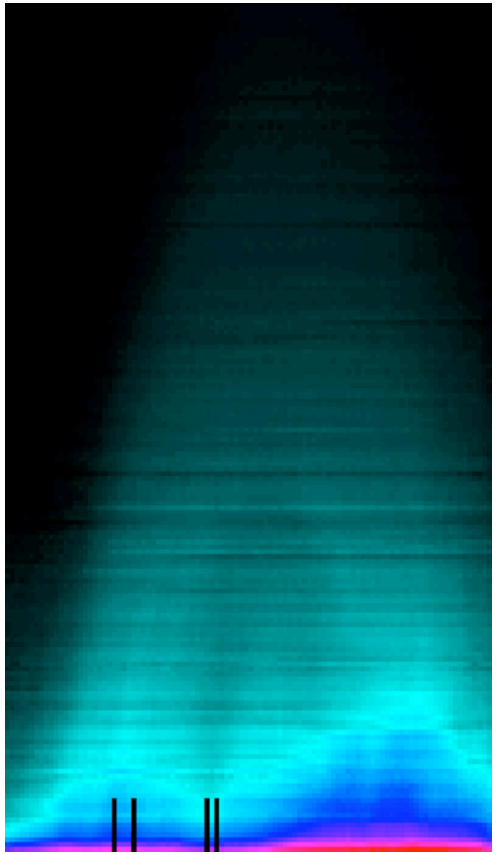
White light cavity that meets criteria: (Jan 25-31, 2006)

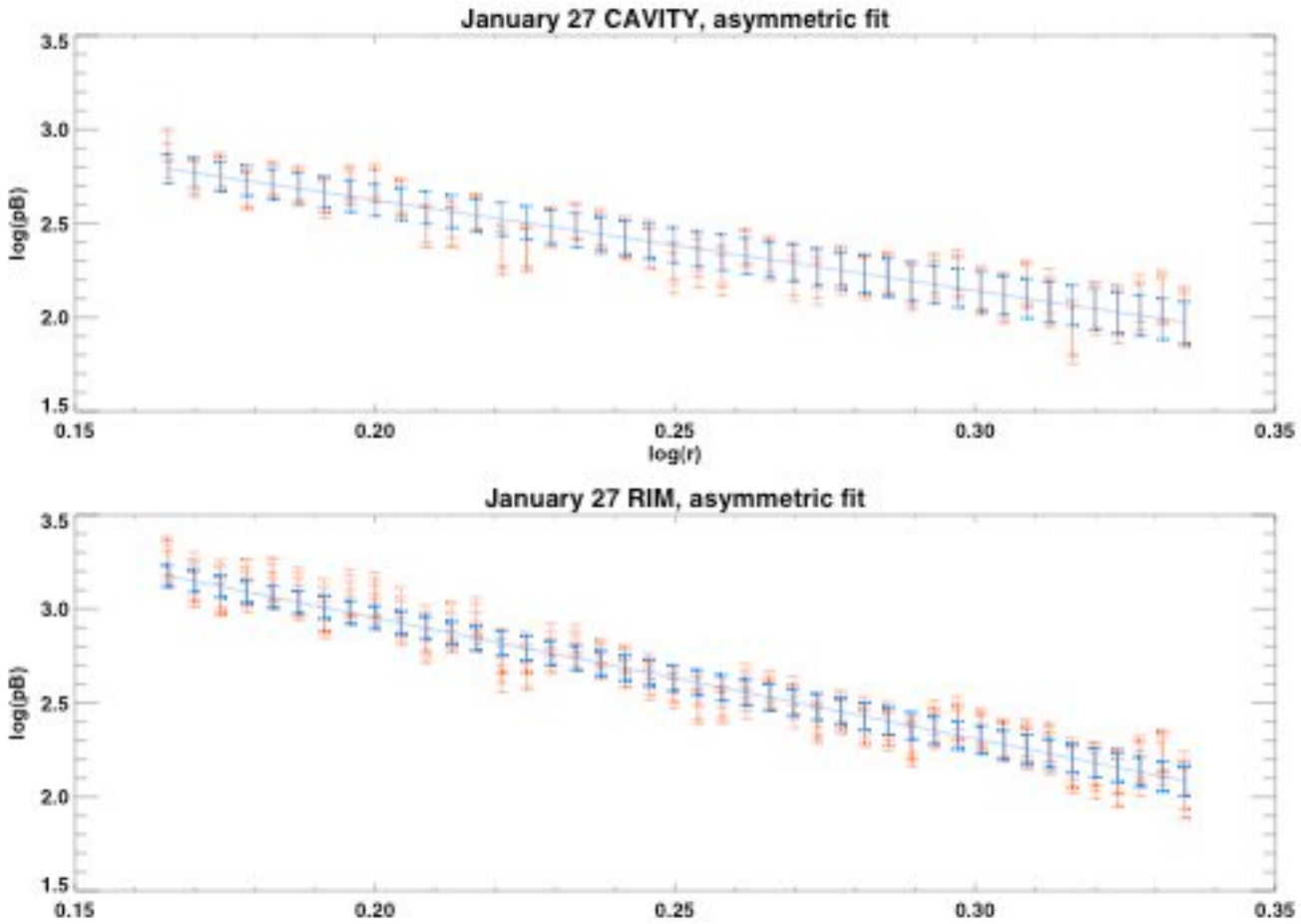
- Big enough (radius) for minimal rim projection
- Long-lived enough (longitudinal extent) for minimal leg projection



Rim vs. Cavity profiles

- Include departure from axisymmetry as error bars
- Fit linear power law for polarized brightness vs. height



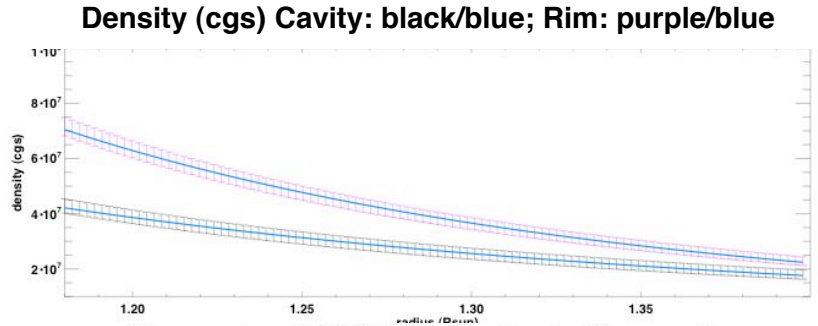


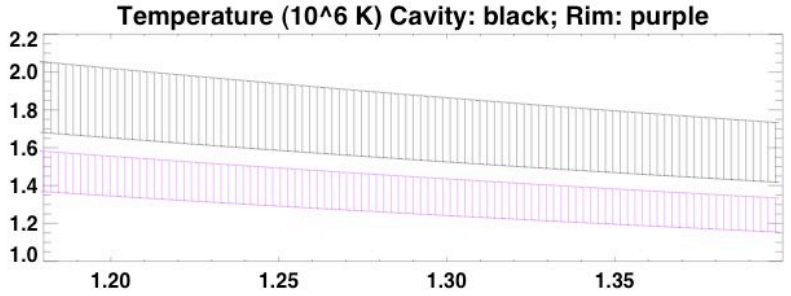
Density, temperature and pressure

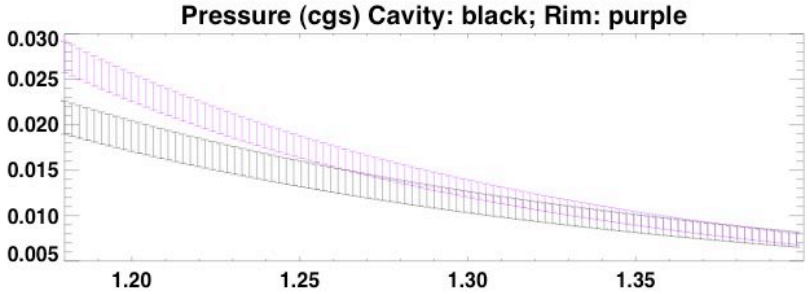
- Fit van de Hulst inversion to pB profiles to obtain density profiles
- Assumed polytropic and solved for ``hydrostatic'' temperature and pressure

RESULTS

- Density smaller in cavity (as much as 40%), but flatter profile vs. height than rim
- Cavity 21% hotter than rim! (but be careful…)
- Pressure still smaller in cavity, and profile flatter than rim

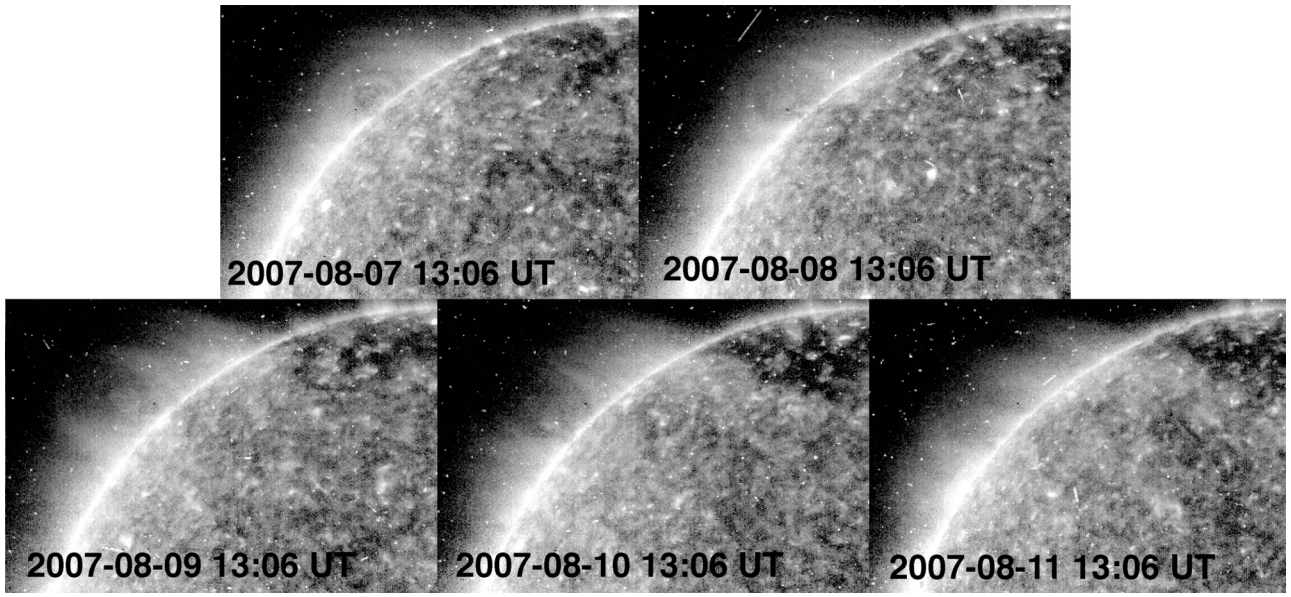






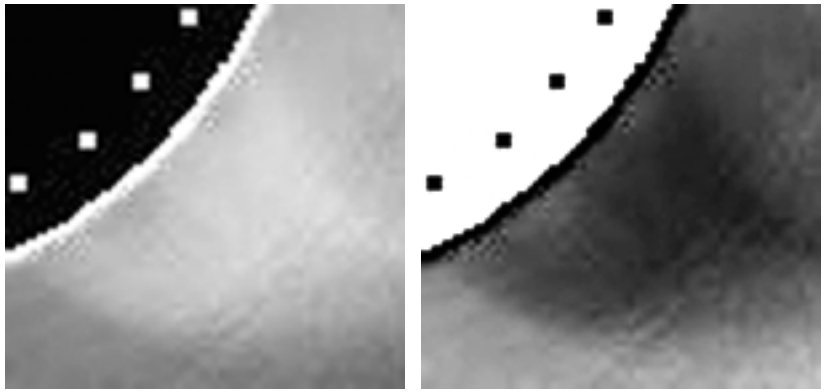
Implications for emission cavity

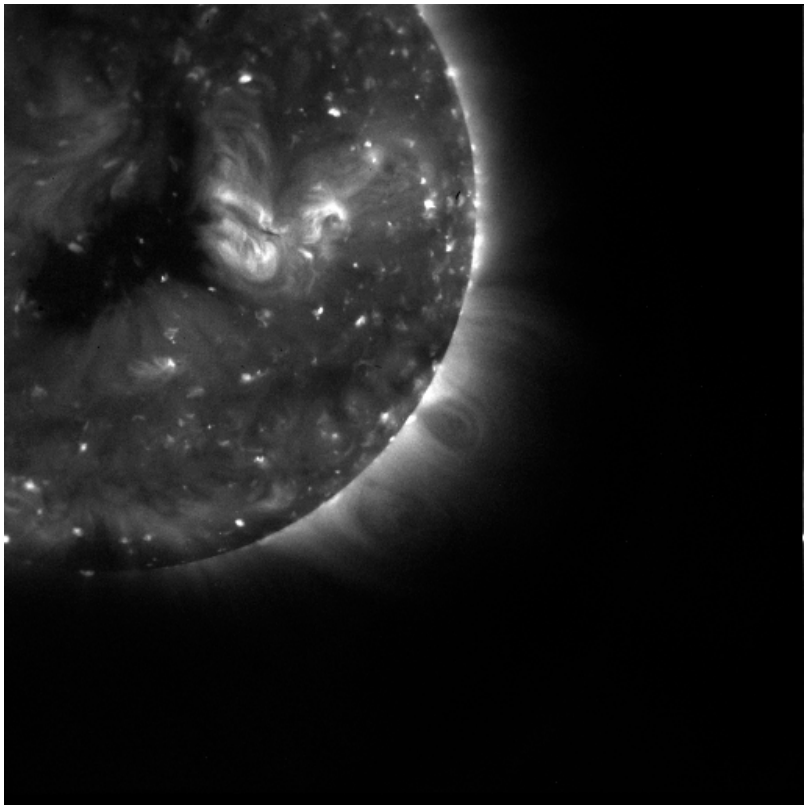
- Independent temperature diagnostics needed
- Geometry of model can also be used for emission cavities
  - Rim projection not a problem: rim at heights where no emission (note cavity has no top on August 9-10
  - Cavity axisymmetric enough so legs not a problem either for August 9
- Temperature diagnostics have been taken for this cavity in IHY filament/cavity campaign! (SOHO/CDS, Hinode/EIS)



Implications for emission cavity

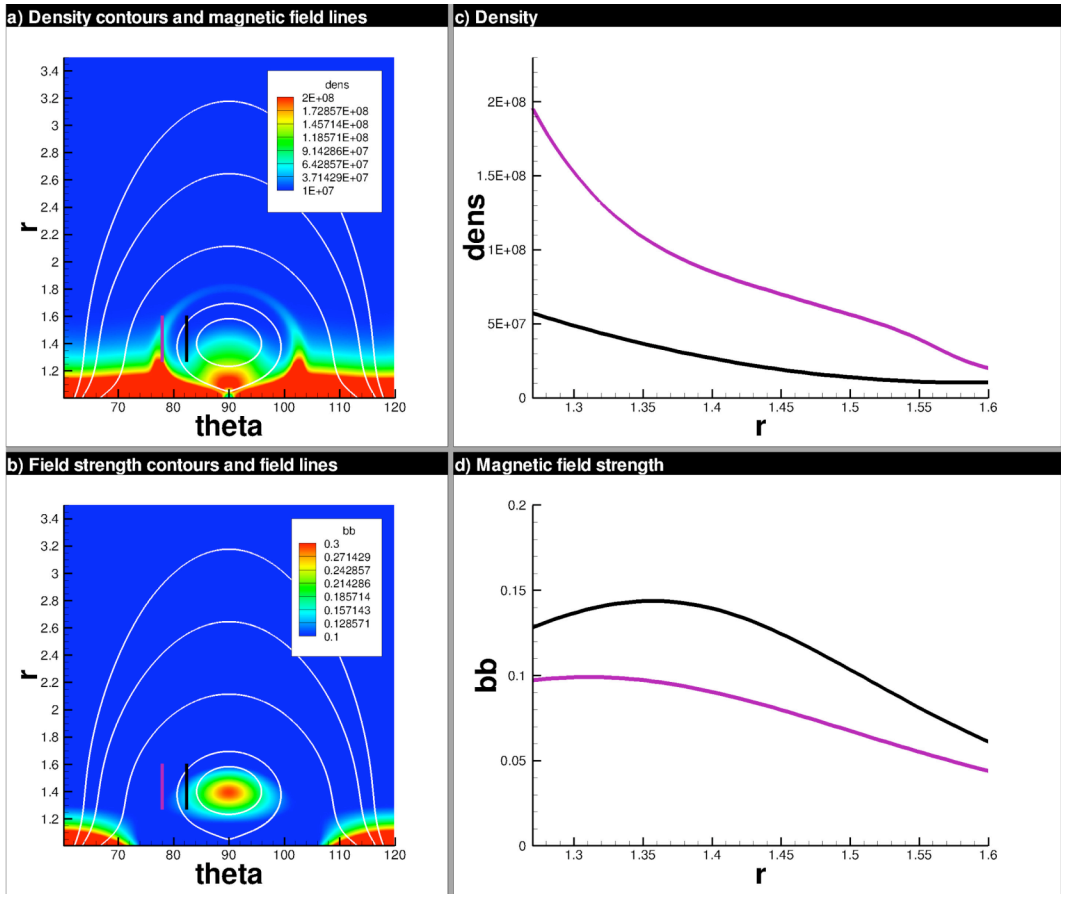
- When cavities well-resolved in emission, minimal overlap with white light
- Could use emission observations at the base of large white light cavity, but then substructure an issue
- IHY cavity about as good-sized as could be hoped for overlap of analysis
- Eclipse would be ideal!





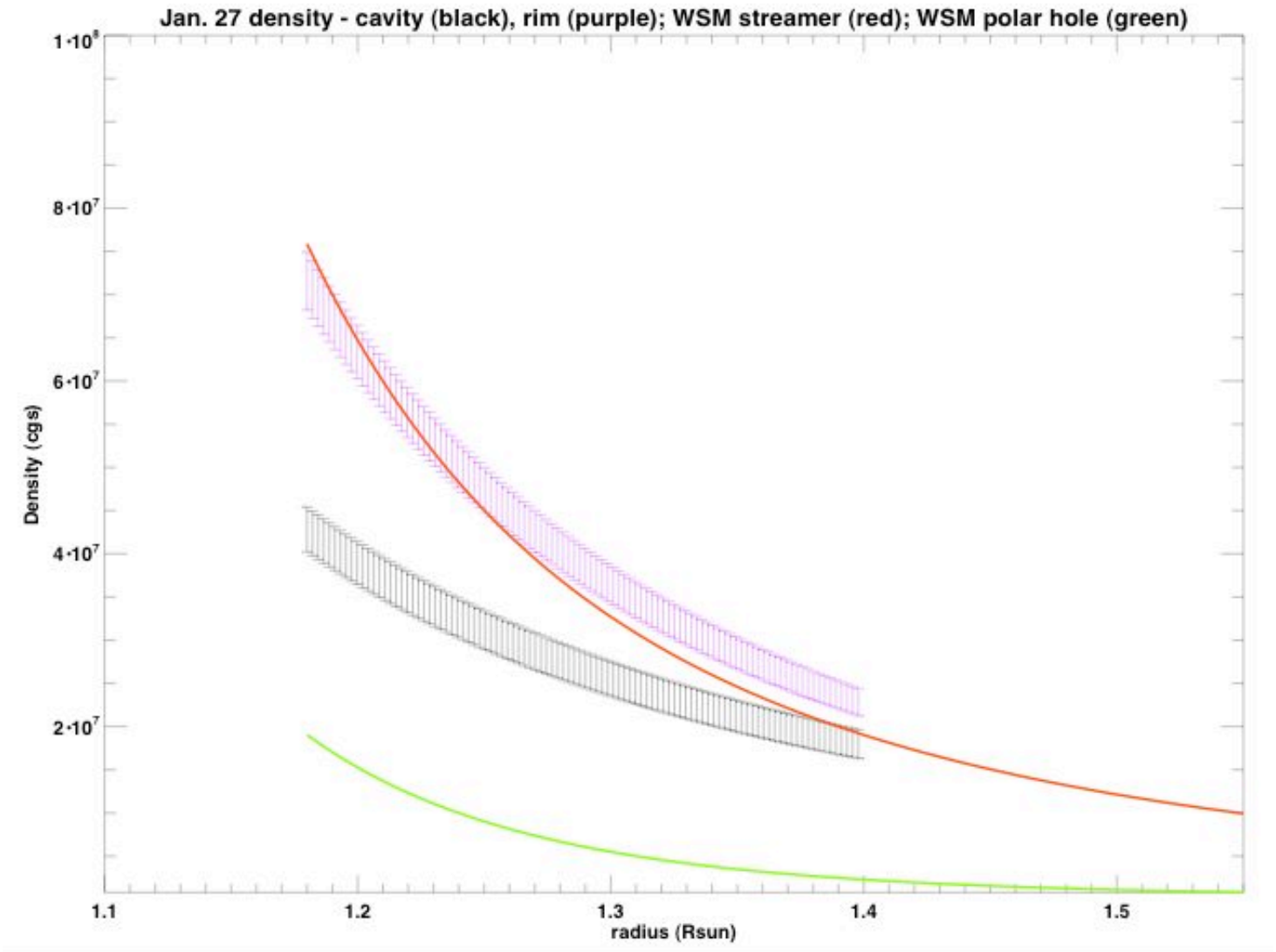
Implications for magnetic field

- Axisymmetric flux rope model (*Fan and Gibson, 2006*)
- Flat density profile in cavity vs. rim:
  - Total pressure continuity: gas pressure decrease across boundary compensated for by magnetic pressure increase
  - DeltaP/P maximum at flux surface nearest flux rope axis, then decrease with height



There <u>is</u> a there there!

- Cavity density double or more than coronal hole density



Conclusions

- Unobservable? No!
  - Projection effects of unrelated material can be dealt with
  - Cavity plasma significantly denser than corona hole

- Assuming a polytropic profile, found that cavity hotter than rim
  - Needs independent confirmation from temperature line diagnostics

- Flat density profile consistent with magnetic flux rope model
  - Observations of cavity rising, getting more sharply defined in the 24 hours before a CME: possible indicator of magnetic energy reaching a critical threshold for eruption?