ESPM 16

Hydrodynamic modeling of coronal loops reconstructed tomographically

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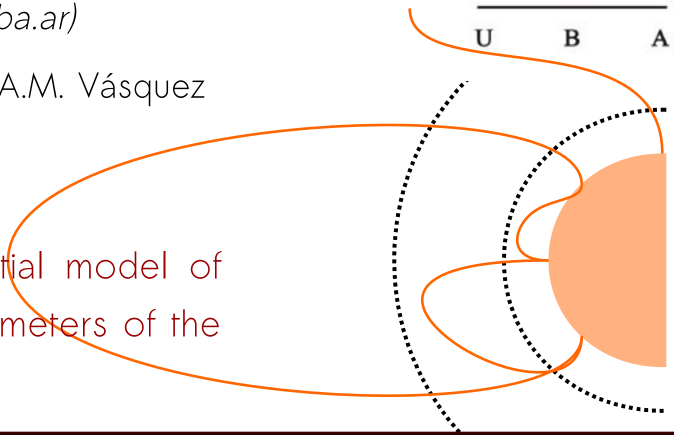
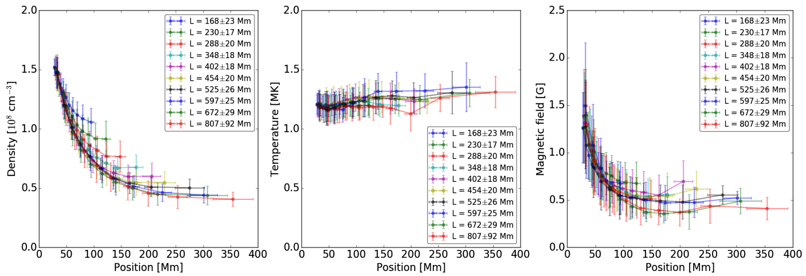


Coronal loops observation

Differential emission measure tomography, combined with a global potential model of coronal magnetic field (DEMT-PFSS), allows us to characterize physical parameters of the coronal plasma along reconstructed loops.

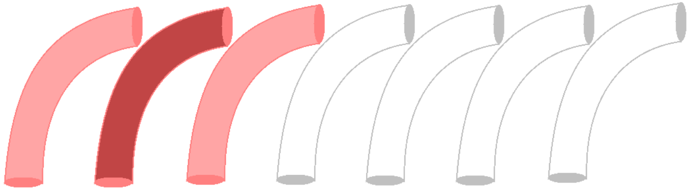


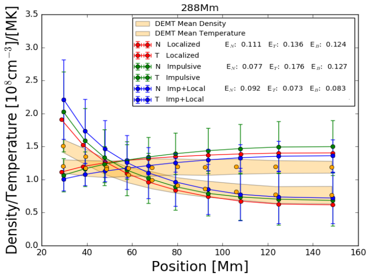
Quiet sun typical loop legs

We statistically analyze the thermodynamic properties of coronal loops by finding "typical" loops for different length ranges.

Hydrodynamic modeling

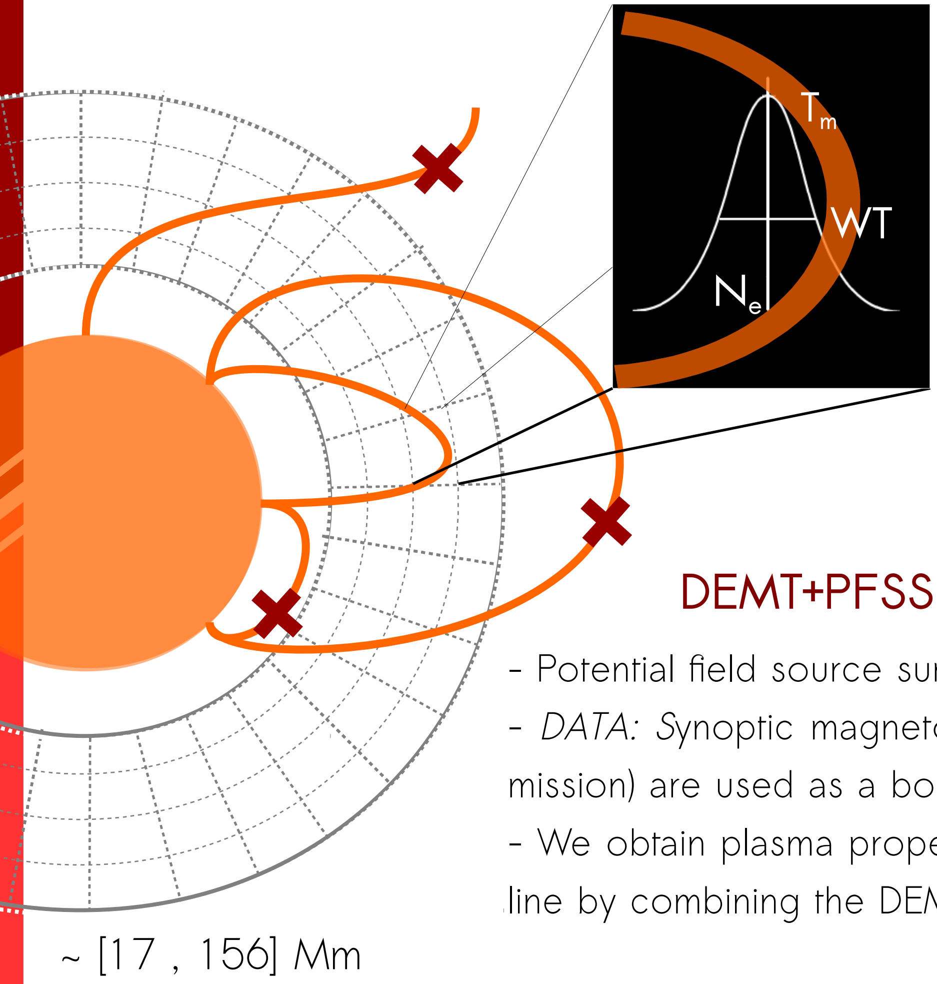
We compare typical loops with a HD model for constant and impulsive heating regimes.





Coronal loops observations

Frazin et al. 2009

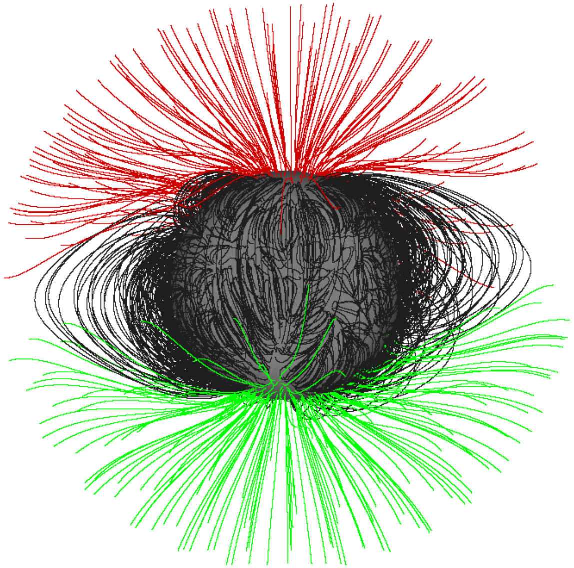


DEMT:

- Spherical grid from ~17Mm to ~156Mm.
- Local Differential Emission Measure (LDEM) in each voxel.
- Tm, Ne and WT are obtained by computing the LDEM moments.
- *DATA*: We reconstructed Carrington rotation CR2082 with EUV images obtained with the EUVI telescope (STEREO mission).

DEMT+PFSS:

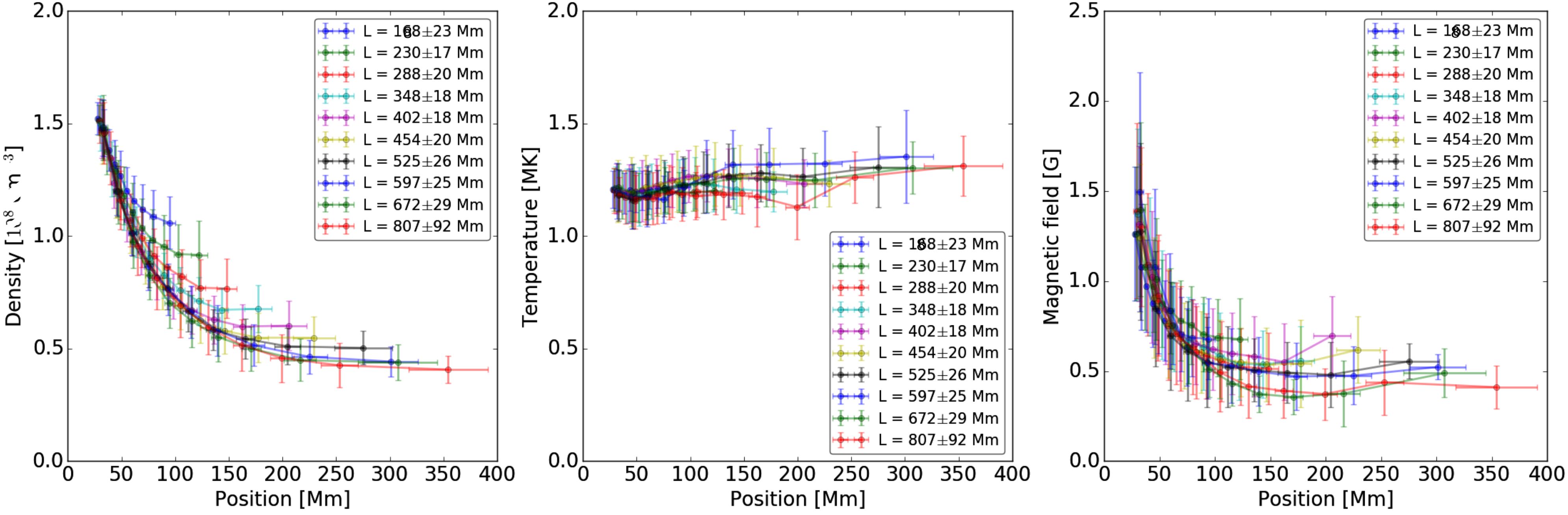
- Potential field source surface (PFSS).
- *DATA:* Synoptic magnetogram obtained with HMI (SDO mission) are used as a boundary condition.
- We obtain plasma properties along each magnetic field line by combining the DEMT results and the PFSS model.



- We only studied closed loops within tomographic limits (~16000 loops).

Quiet sun typical loop legs

- 10 length bins, each containing with ~1600 loops
- We construct "typical" loop leg profiles for each length bin by computing the mean density, temperature and magnetic field at 10 mean positions along the leg.



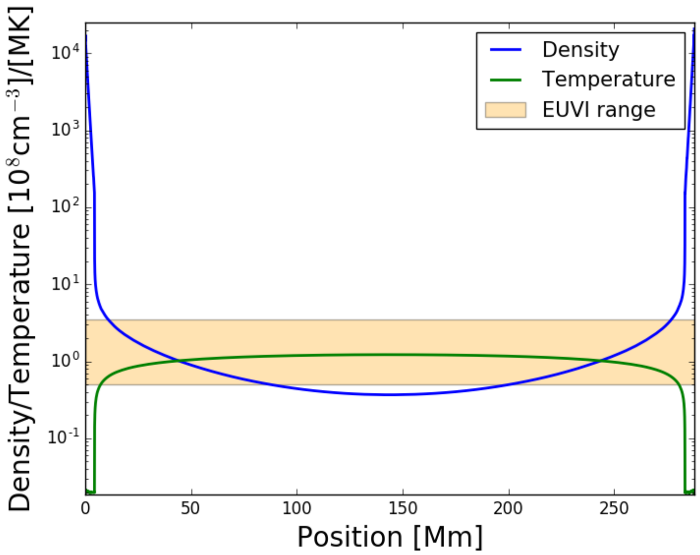
We found a similar behavior for all the typical loops in density (N), temperature (T) and magnetic field (B). There is a substantial variation in the N and B profiles and very little in T profiles. Loops can be considered approximately isothermal.

Hydrodynamic modeling

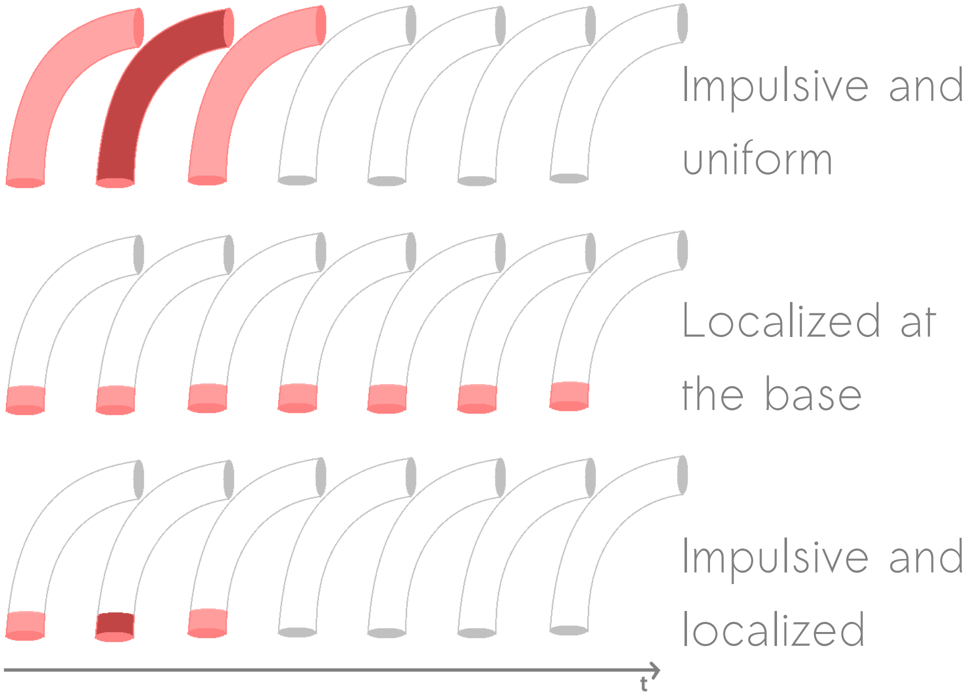
Bradshaw et al. 2013

HYDRAD solves the hydrodynamic equations assuming symmetrical and semicircular loops with variable gravitational acceleration along them. Boundary conditions and input parameters:

- Loop length: set with the length of typical loop legs
- Density and temperature at the interface between the chromosphere and the transition region: set as 10^{10} cm^{-3} and 20000K respectively.
- Chromospheric depth: 5 Mm.
- Loop heating regime:



Typical HYDRAD profiles of density and temperature



Hydrodynamic modeling

We compare the 10 DEMT typical loop leg profiles with HYDRAD profiles obtained with the three described heating mechanism.

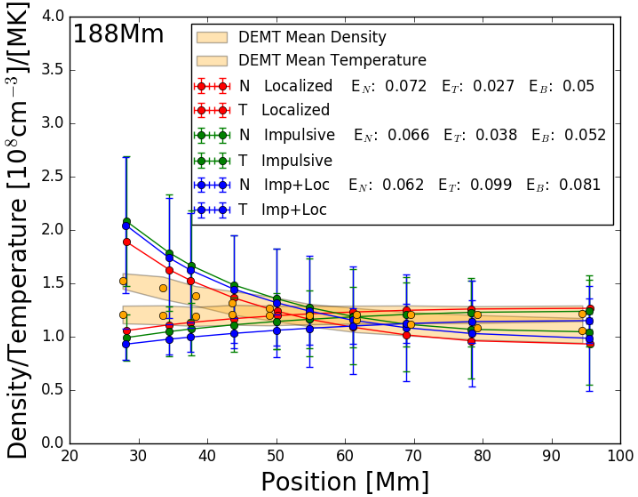
We compare quantitatively DEMT and HYDRAD profiles by defining an error:

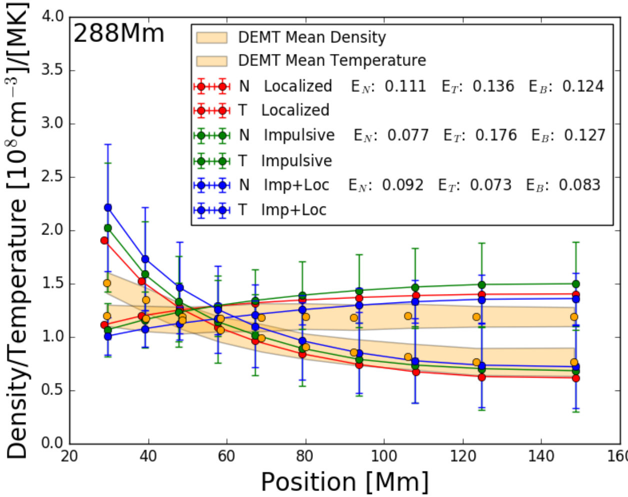
$$E_{N,T} = \mathrm{mean}\left(\frac{|\,HYDRAD_{N,T} - DEMT_{N,T}\,|}{DEMT_{N,T}}\right)$$

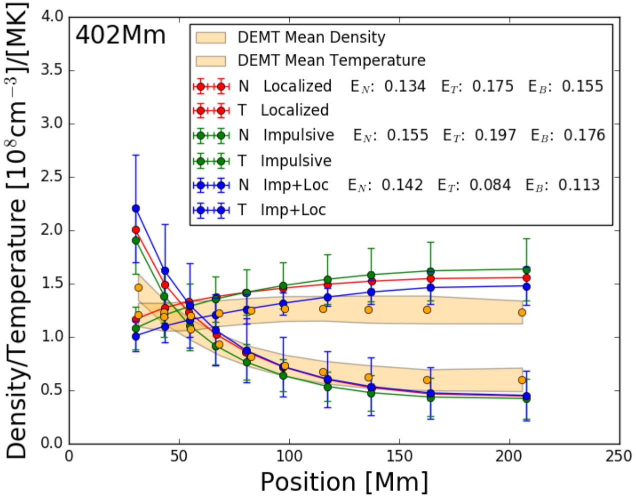
$$E_M = \mathrm{mean}(E_N\,,\ E_T)$$

Best fit	L [Mm]	Dur [s] (*)	E[$ergcm^{-3}s^{-1}$]	Evol [s](**)	E_N	E_T	E_M
Localized	188	9600	0,0003	400	0,06	0,04	0,05
Imp+Local	230	200	0,007	9600	0,08	0,02	0,05
Imp+Local	288	200	0,01	9600	0,10	0,08	0,09
Imp+Local	348	200	0,01	9600	0,11	0,09	0,10
Imp+Local	402	300	0,007	9700	0,14	0,07	0,11
Imp+Local	454	300	0,007	9700	0,15	0,09	0,12
Imp+Local	525	300	0,007	9700	0,24	0,10	0,17
Imp+Local	597	300	0,007	9700	0,28	0,09	0,19
Imp+Local	672	300	0,007	9700	0,28	0,13	0,20
Imp+Local	807	300	0,007	9700	0,43	0,24	0,34

(*) Dur = Heating duration (**) Evol = integrated evolution







Example of comparison between HYDRAD and DEMT profiles for loop length of 188, 288 and 402Mm

Conclusions

- Using DEMT+PFSS technique we obtained 10 typical loops that represent statistically the quiescent corona.
- Typical loop legs: Quasi-isothermal and with deceasing density and magnetic field profiles as expected.
- We modeled the 10 typical loop legs with the 1D HD model HYDRAD, using three different heating regimes.
- As a result of the comparison, the error for shorter loops is less than 15% in both, density and temperature.
- Longer loops cannot be correctly modeled possibly because they widely depart from a semi-circular geometry.
- We found that localized (both, impulsive and constant) heating at the coronal base is the best scenario to reproduce the reconstructed properties of quiet-sun coronal loops.

Future work

- Add to our models variations on the loop cross section and inclination angle.
- Explorethe development of thermal non-equilibrium (TNE) in quiet-sun loops.