Influence of the Magnetic Decay Index Spatial Distribution on the Kinematics of the Solar Eruptive Prominence

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Outline

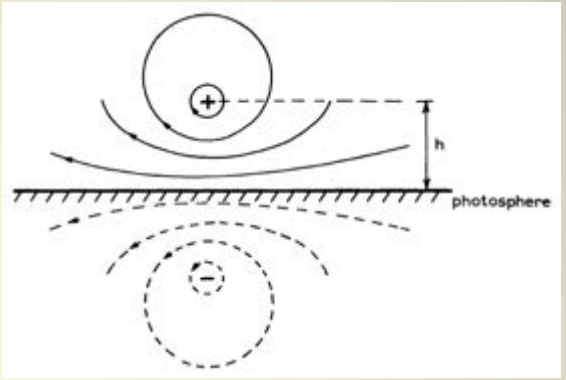
- Consider sequence of SDO/AIA images of an eruptive prominence prior and during its eruption in order to determine height of the prominence when it had lost the equilibrium

- Perform extrapolation of the coronal magnetic field

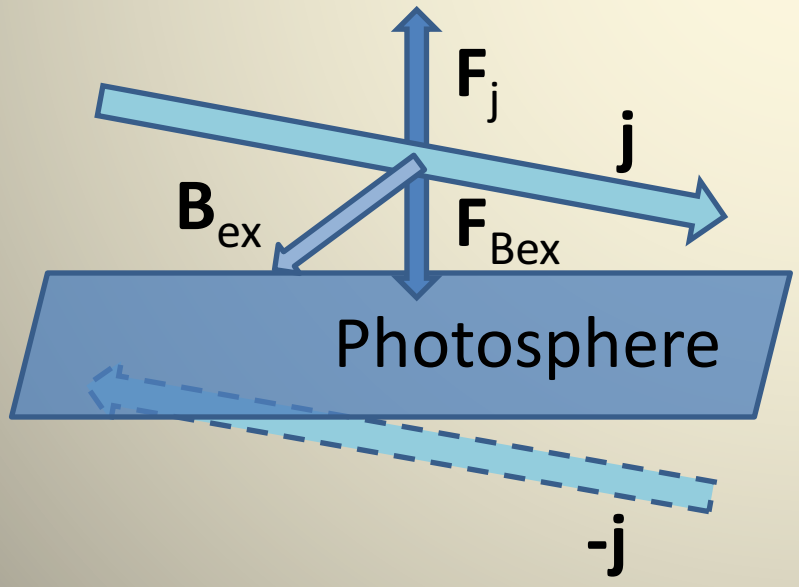
- Based on the obtained results investigate whether configuration of the coronal magnetic field could lead to the prominence eruption

Prominence equilibrium model

Kuperus, M. and M.A. Raadu, 1974, Astron&Astrophys., 31: 1189-193



Van Tend W. and M. Kuperus, 1978, Solar Phys., 59: 115-127



j – current density

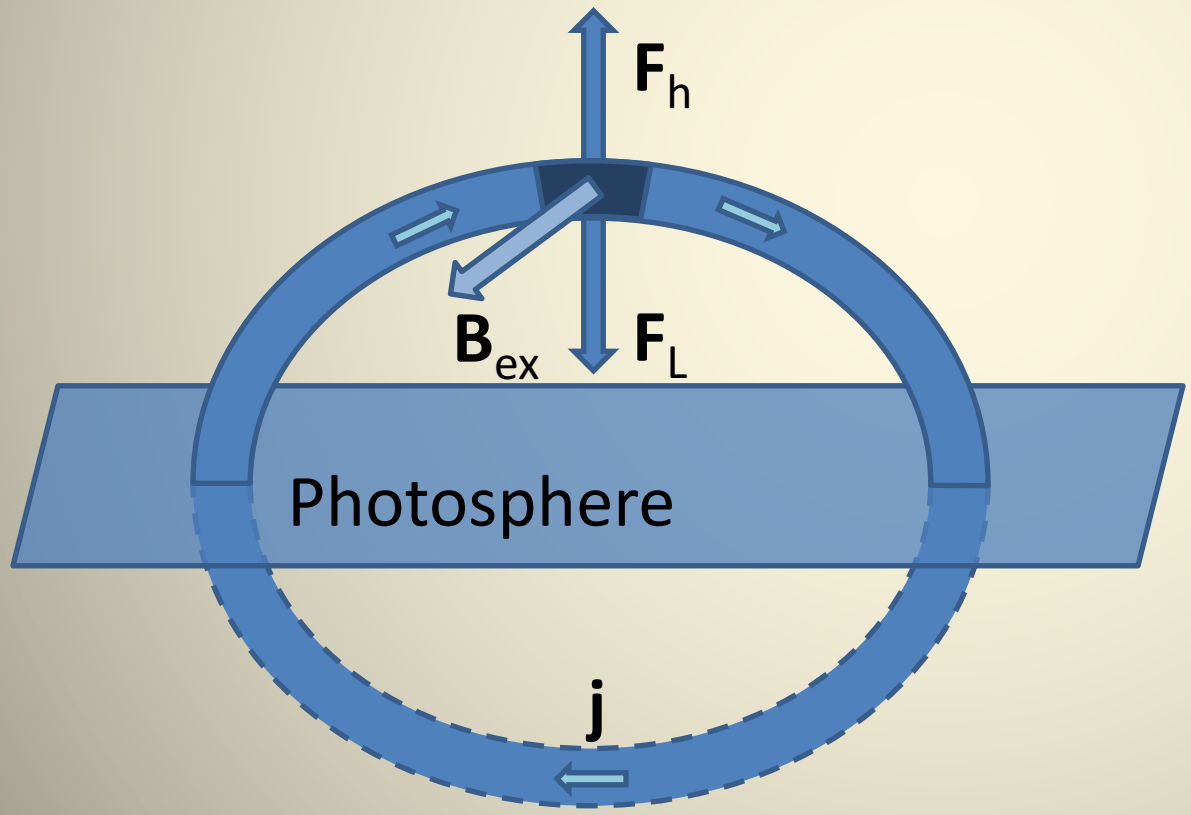
$\mathbf{F}_j$ – Lorentz force, produced by mirror current

$\mathbf{F}_{Bex}$ – Lorentz force, produced by external magnetic field

$\mathbf{B}_{ex}$ – external magnetic field

Torus instability

Kliem B. and T. Torok, 2006, Physical Review Letters, 96:255002-1 - 255002-4



j – current density

$\mathbf{F}_h$ – hoop force, self-induced by current

$\mathbf{F}_L$ – Lorentz force, produced by external magnetic field

$\mathbf{B}_{ex}$ – external magnetic field

Magnetic decay index

Van Tend W. and M. Kuperus, 1978, Solar Phys., 59: 115-127

Kliem B. and T Torok, 2006, Physical Review Letters, 96:255002-1 - 255002-4

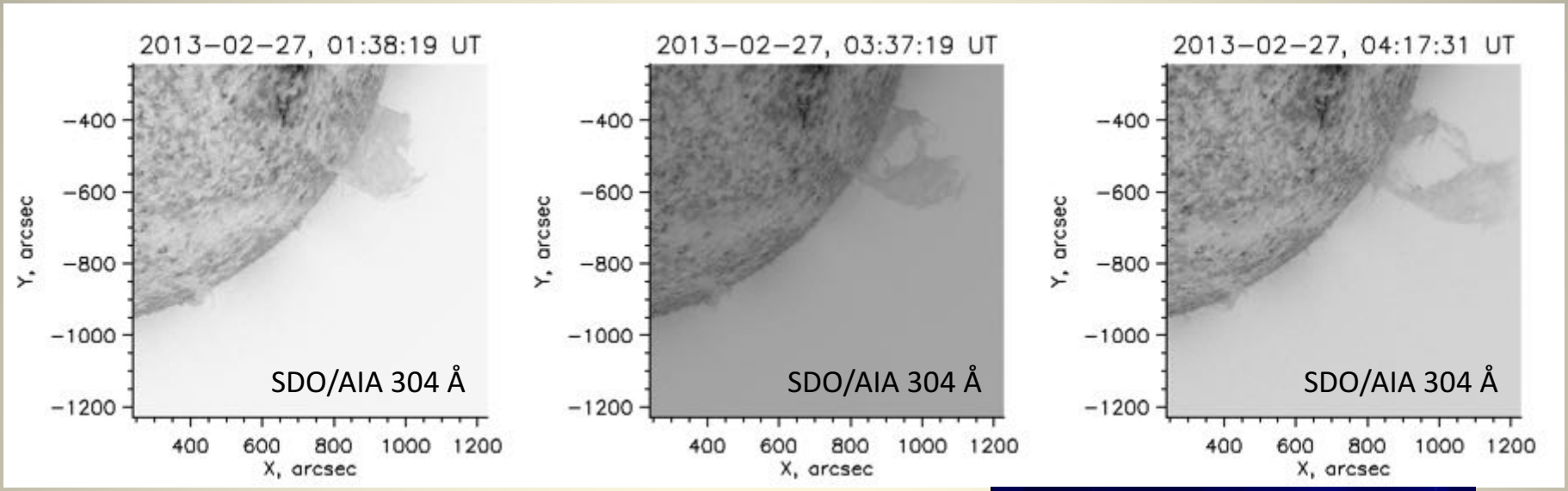
$$n = -\frac{\partial ln(\mathbf{B}_{ex})}{\partial ln(h)}$$

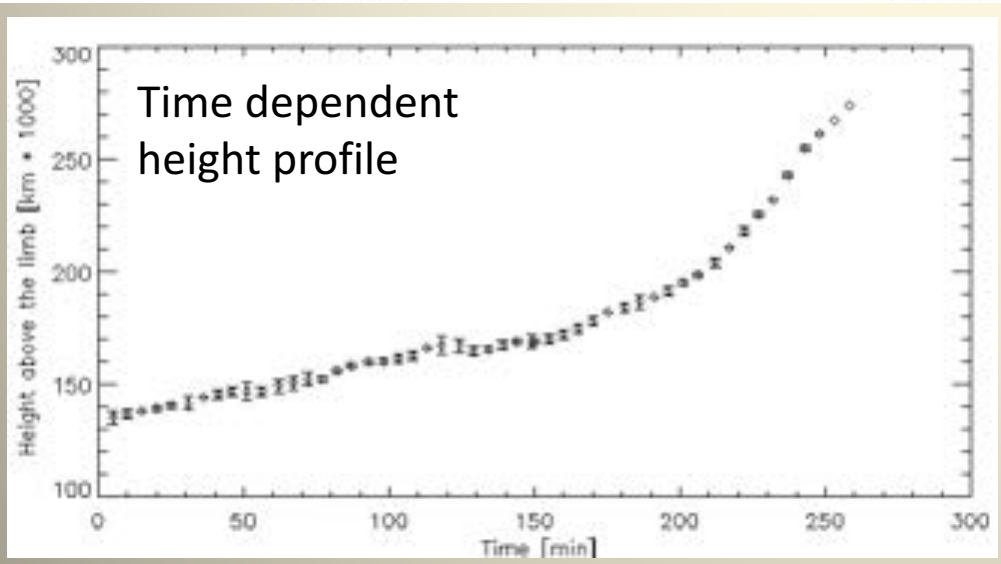
$\mathbf{B}_{ex}$ – external transverse magnetic field,
h – height above the photosphere

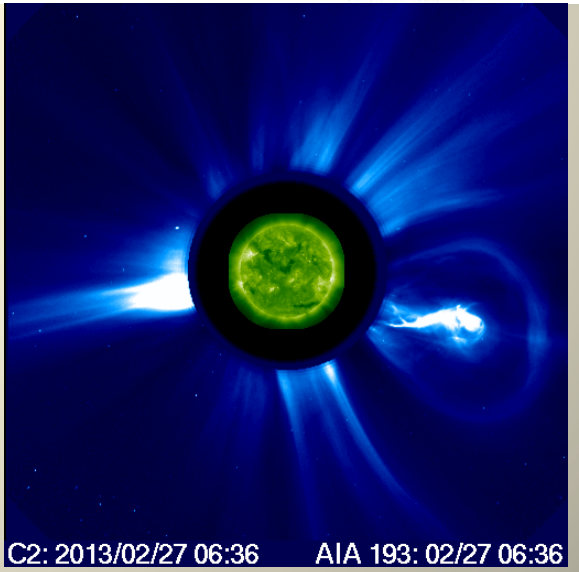
Critical values:

- n = **1** for a straight, linear electric current
- n = **1.5** for an electric current along curved axis (torus instability)

Eruptive prominence







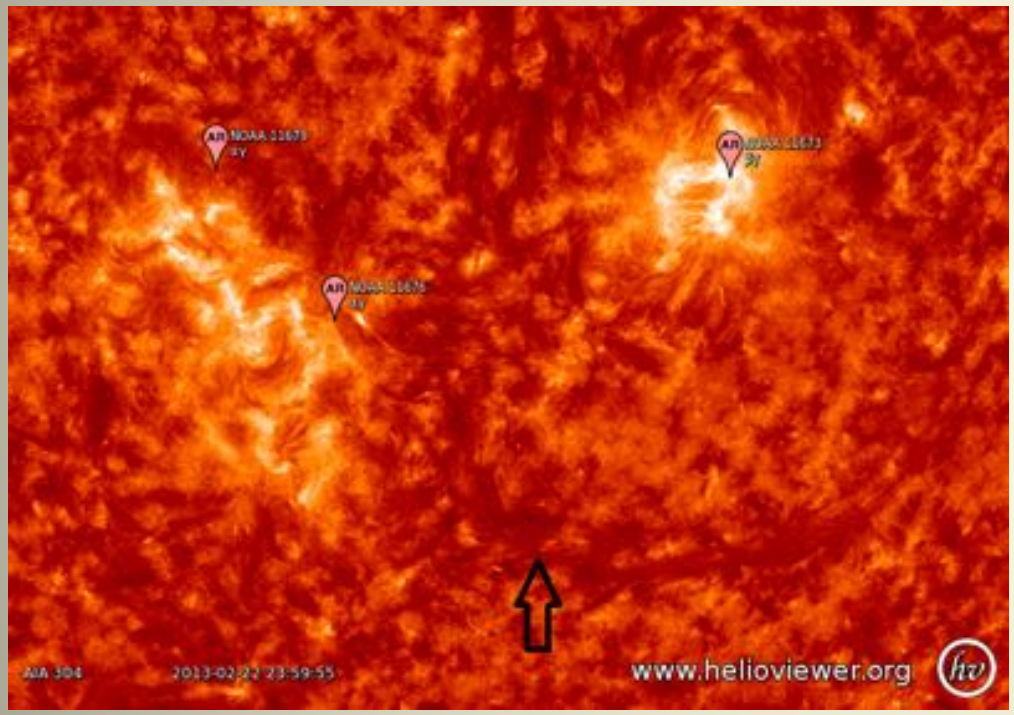
Magnetic field reconstruction

Green's function based potential extrapolation in spherical geometry.

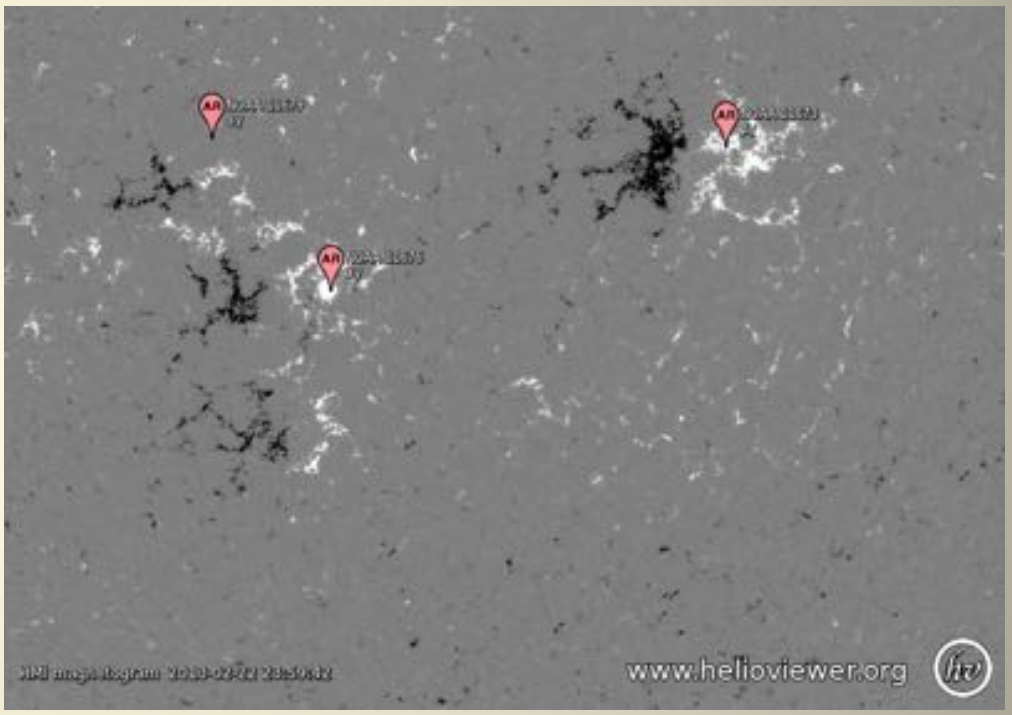
SDO/HMI vector magnetograms with resolved pi-ambiguity,
several days before the eruption.

Computational domain had sizes [**720** x **540** x **300**] *Mm*,
grid spatial resolution about **3** *Mm*.

Images by SDO, 23 February 0:00 UT

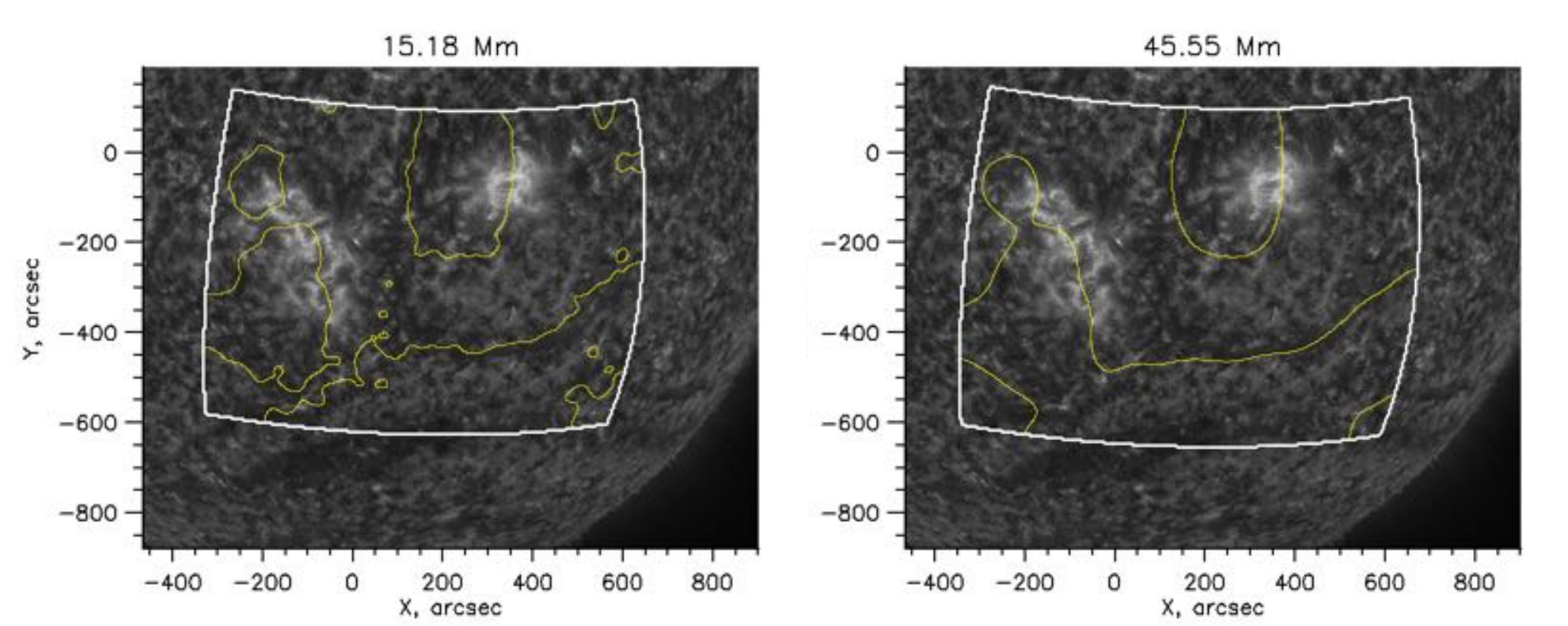


SDO/AIA 304 Å



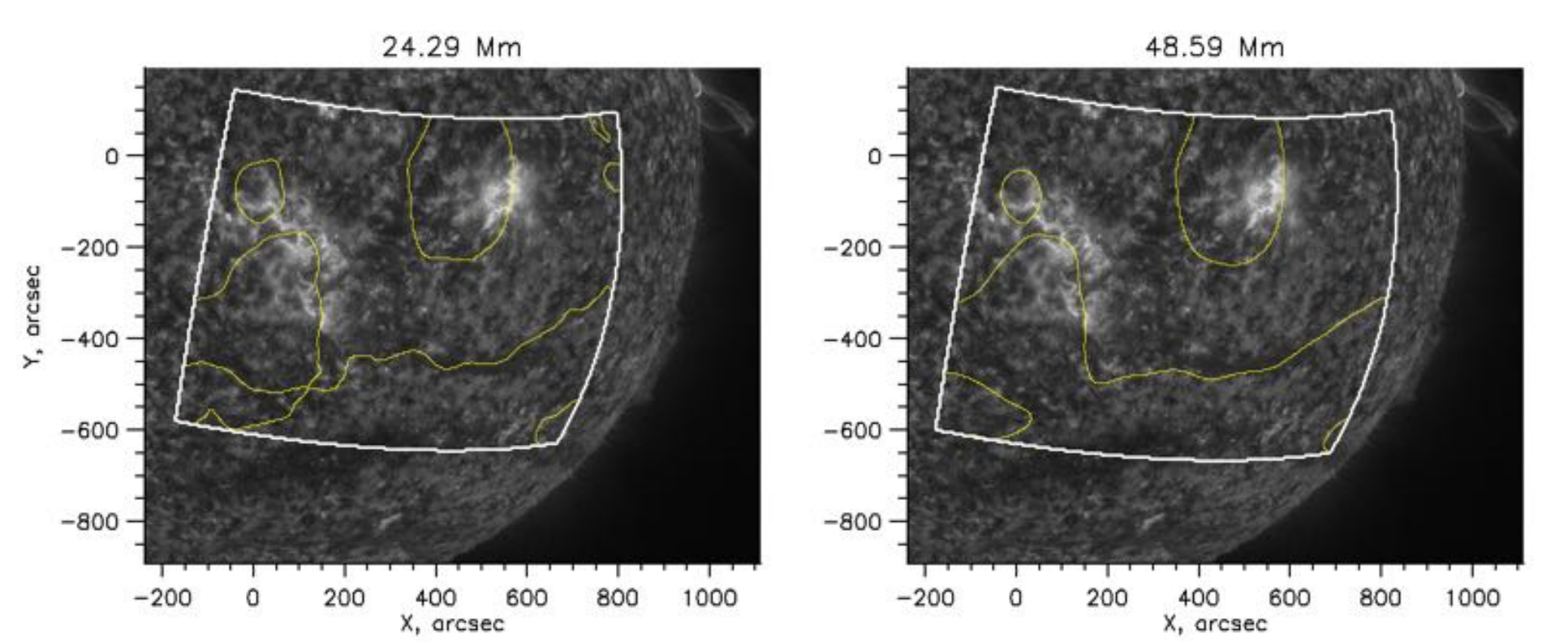
SDO/HMI line-of-sight magnetogram

Neutral line over HMI/AIA 304 Å image, 23 February 0:00 UT



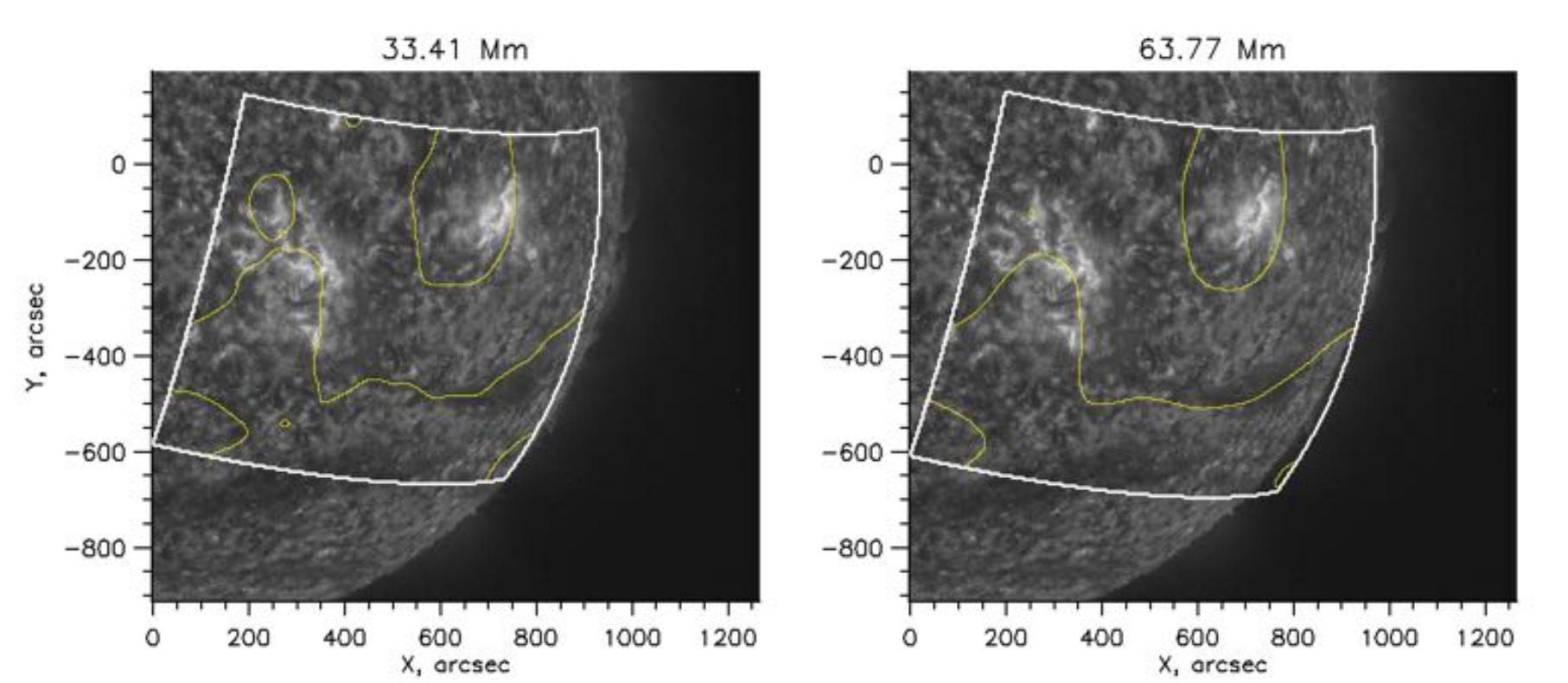
White contour – boundaries of the computational domain
Yellow contour – reconstructed neutral line

Neutral line over HMI/AIA 304 Å image, 24 February 0:00 UT



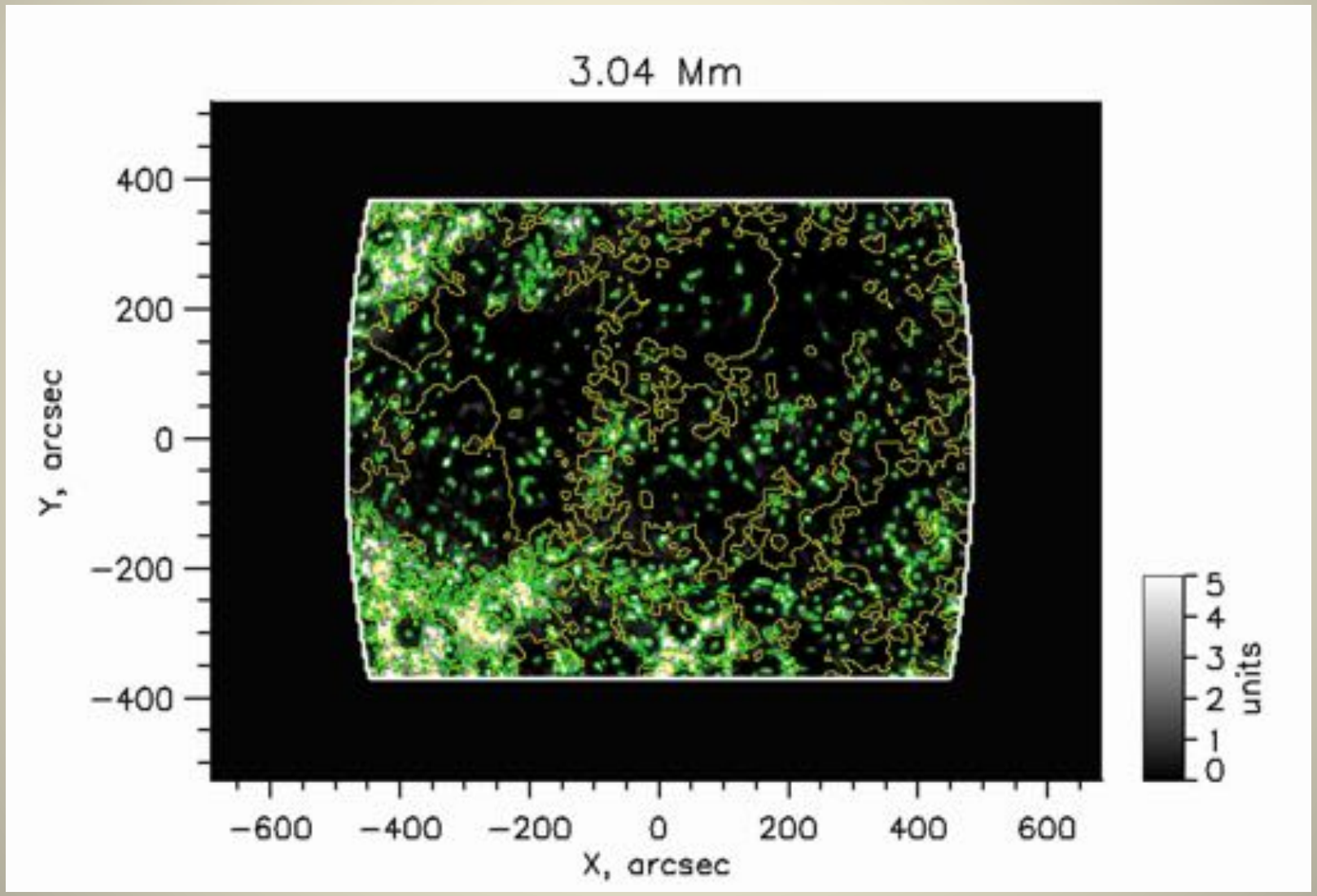
White contour – boundaries of the computational domain
Yellow contour – reconstructed neutral line

Neutral line over HMI/AIA 304 Å image, 25 February 0:00 UT

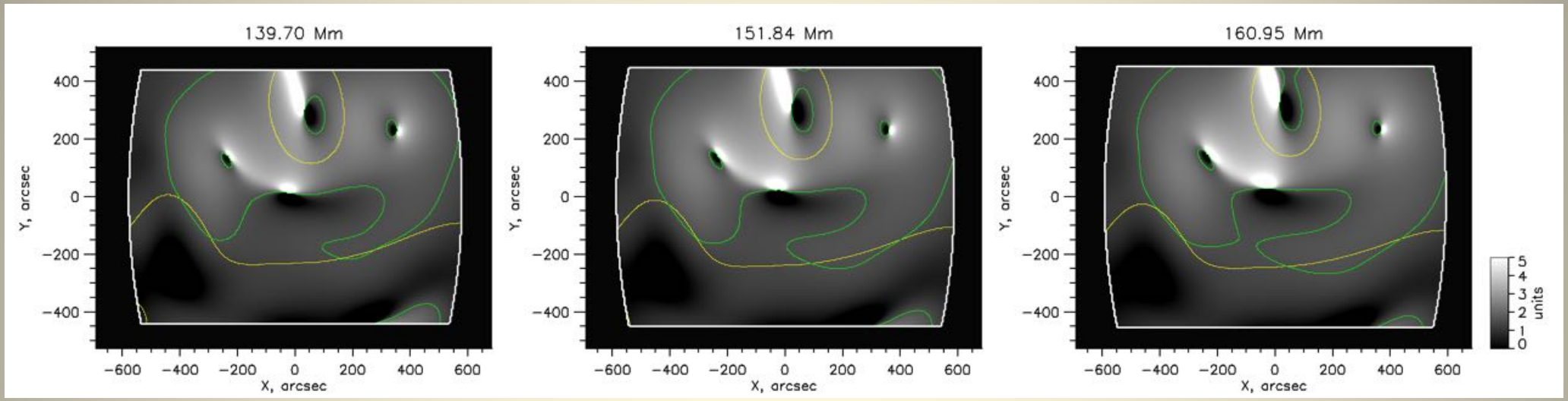


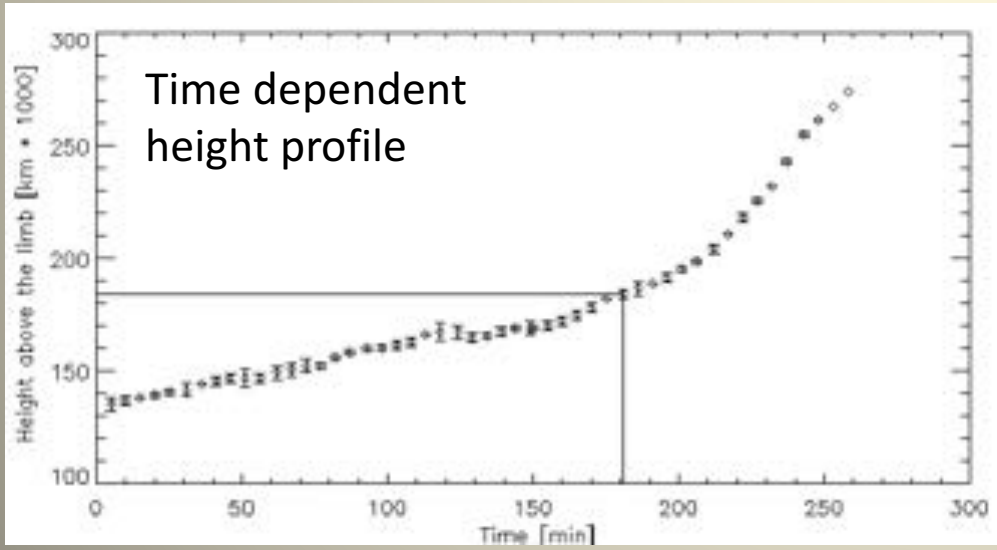
White contour – boundaries of the computational domain
Yellow contour – reconstructed neutral line

Magnetic decay index



Magnetic decay index, 25 February 0:00 UT



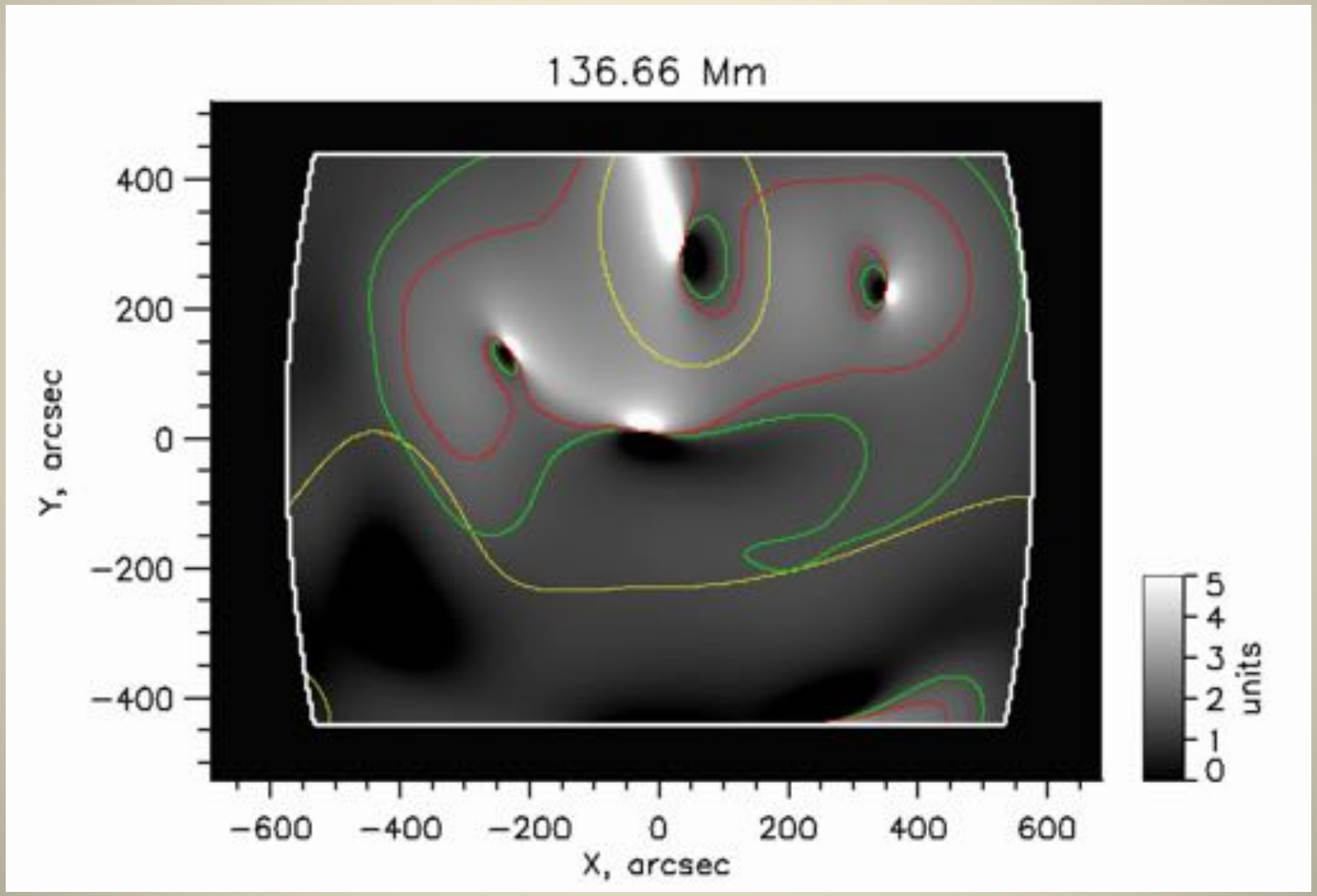


Green contour marks decay index level *n* = **1.5**

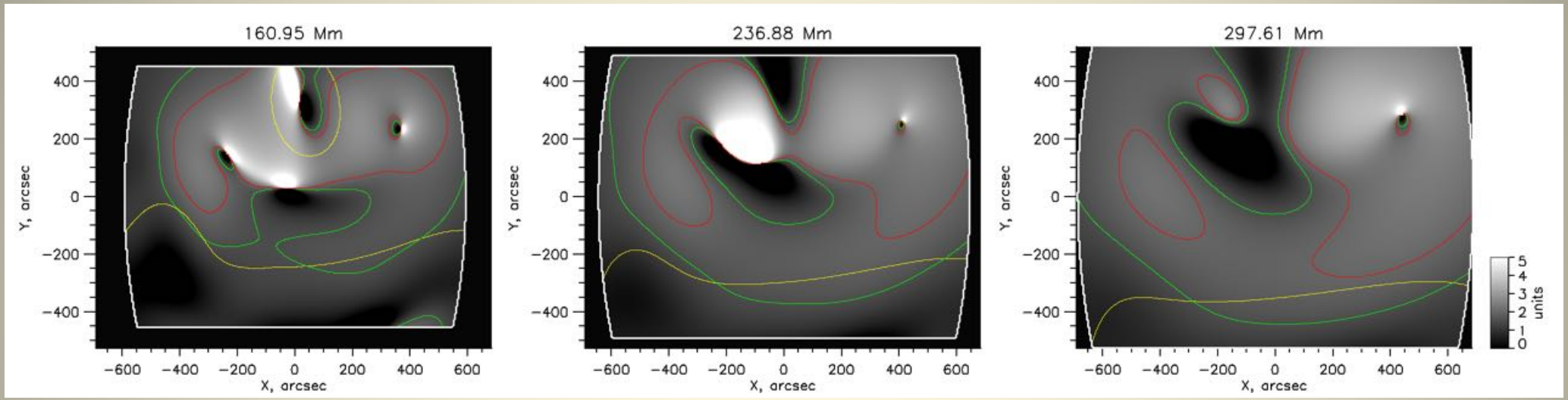
Acceleration started when apex of the prominence reached height of **180** – **190** *Mm*

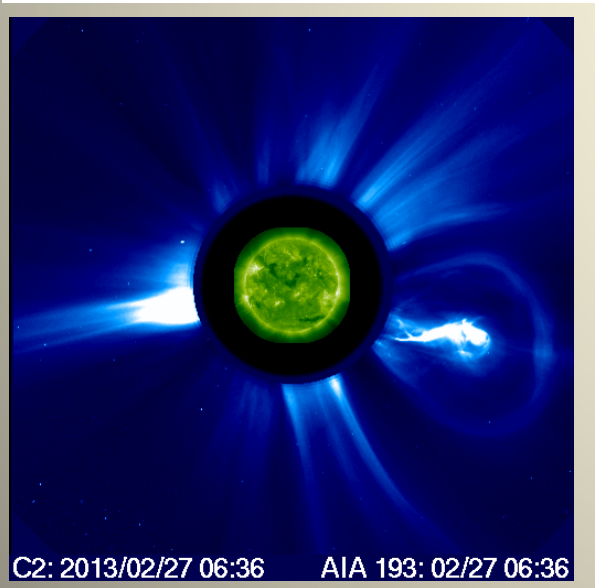
Transverse size of the prominence, estimated from SDO/AIA 304 Å image was up to **100** *Mm*

Magnetic decay index, higher altitudes



Magnetic decay index, 25 February 0:00 UT





Green contour marks decay index level n = **1.5**
Red contour marks decay index level n = **2.0**

Torok T. and B. Kliem, 2007, Astron. Nachr., 328, 8, 743-746

CME's acceleration depends on steepness of the field decrease.

http://cdaw.gsfc.nasa.gov/CME_list CME speed = **622.4** *km/s*

Conclusion

- Height of the prominence for several days before the eruption was estimated. It was found, that different parts of the prominence were located at different heights

- The height at which magnetic decay index reached critical value are in agreement with the height where prominence lost its equilibrium

- At higher altitudes magnetic field continues to decrease sufficiently rapidly, that is in agreement with average speed of the produced CME