Highly Squashed Expanding Flux-Tubes in a Quiescent Solar Active Region

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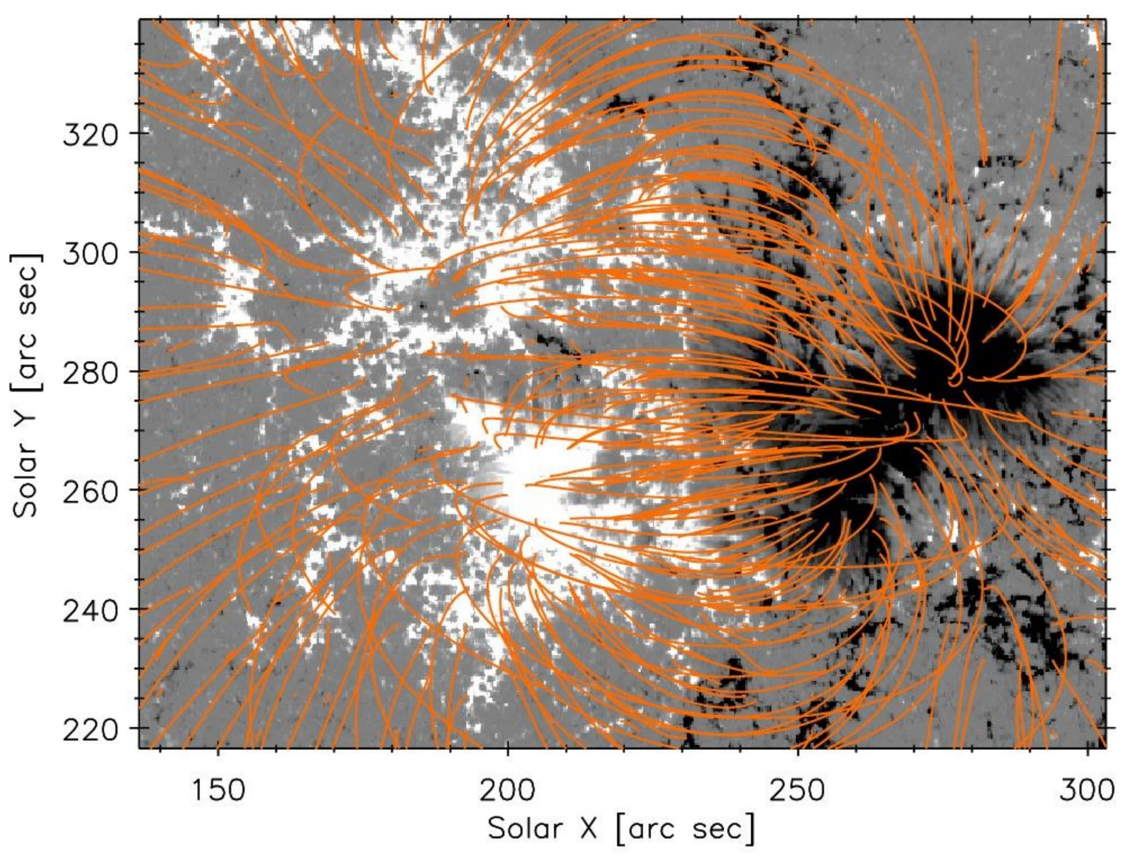
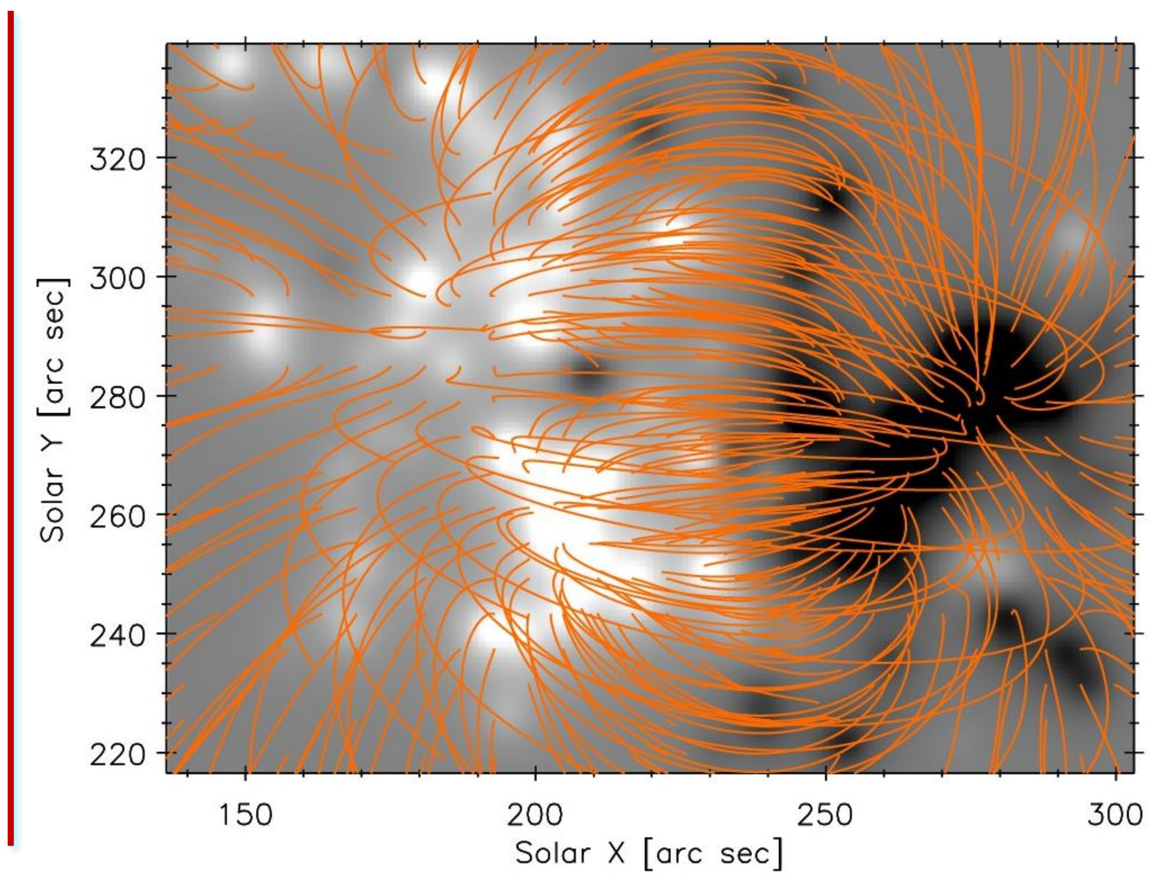
1. Potential Magnetic Field Extrapolation of the Active Region NOAA 11482

Extrapolation of a Hinode/SOT magnetogram

- **SOT/SP: 0.3" resolution**
- Large flux imbalance: trailing positive polarities contain 23% more magnetic flux than negative ones
- Potential magnetic field extrapolation since the AR is quiescent and non-flaring
- Direct extrapolation using Green's function method





Approximation by submerged magnetic charges

- 134 magnetic monopoles
- Approximation to the observed magnetogram
- Much **smoother** flux distribution **without any small-scale structure**
- Quick calculation of the potential magnetic field
- Magnetic field very similar to direct extrapolation

2. Spatial Structure of the Area Expansion Factor

Calculation of the area expansion factor Γ

- Trace a field line starting at every grid point in the 3D computational box (10^8 field lines!)
- The area expansion factor is determined as

$$\Gamma = (B_+ + B_-) / 2B_{apex}$$

where
$B_\pm$ – at footpoints and
B_{apex} – at field line apex

- **Γ is a global property of a field line**
- Γ is calculated only for field lines closed within the 3D box

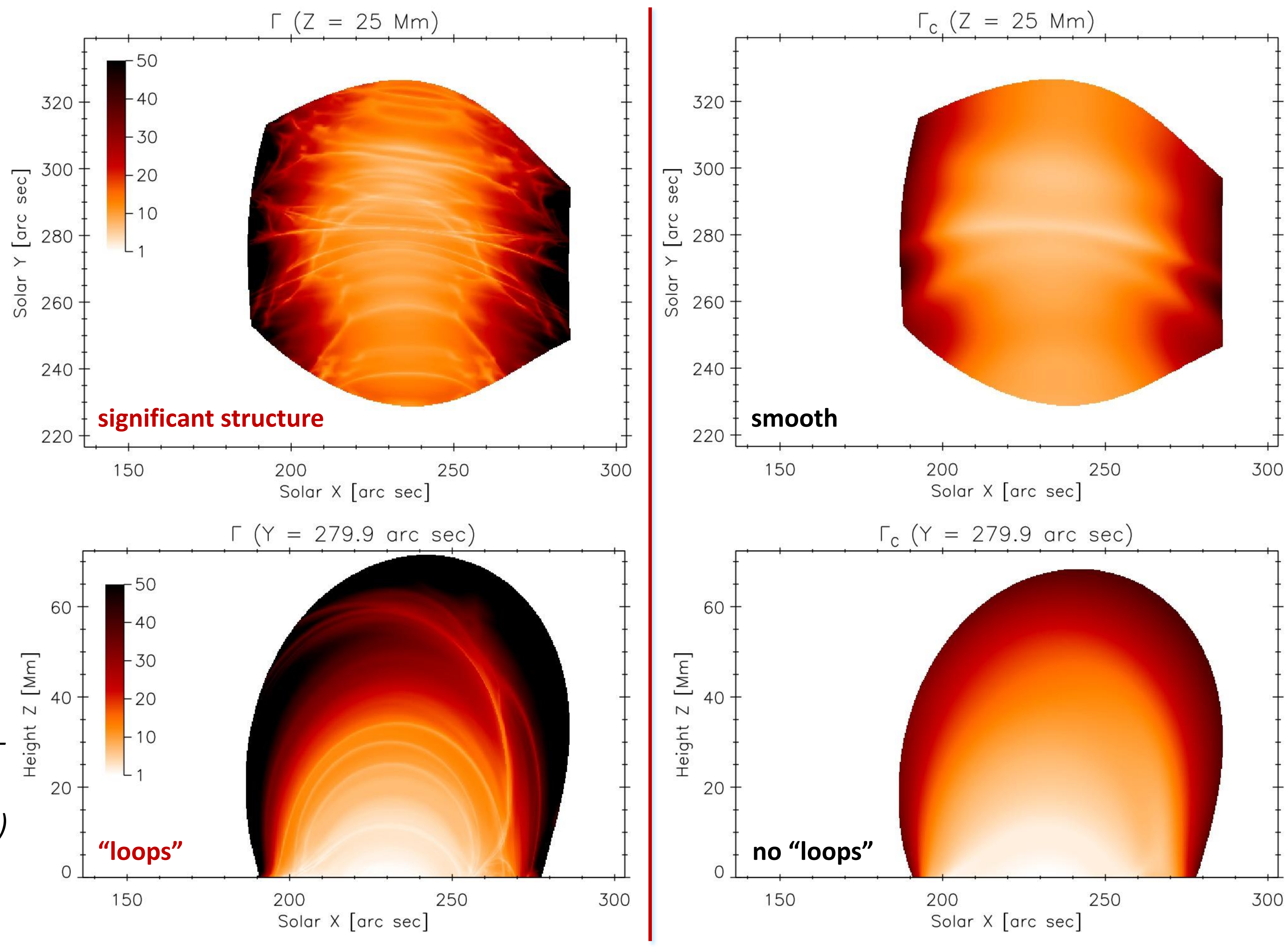


***Figure**: Spatial distribution of Γ at a constant height of Z = 25 Mm (first row) and at Solar Y = 280"*

The two extrapolations are very different

- **Significant structure** in the spatial distribution of Γ calculated from the high-resolution Hinode/SOT magnetogram
- **Little structure** in the spatial distribution of Γ_C calculated from the charges approximation

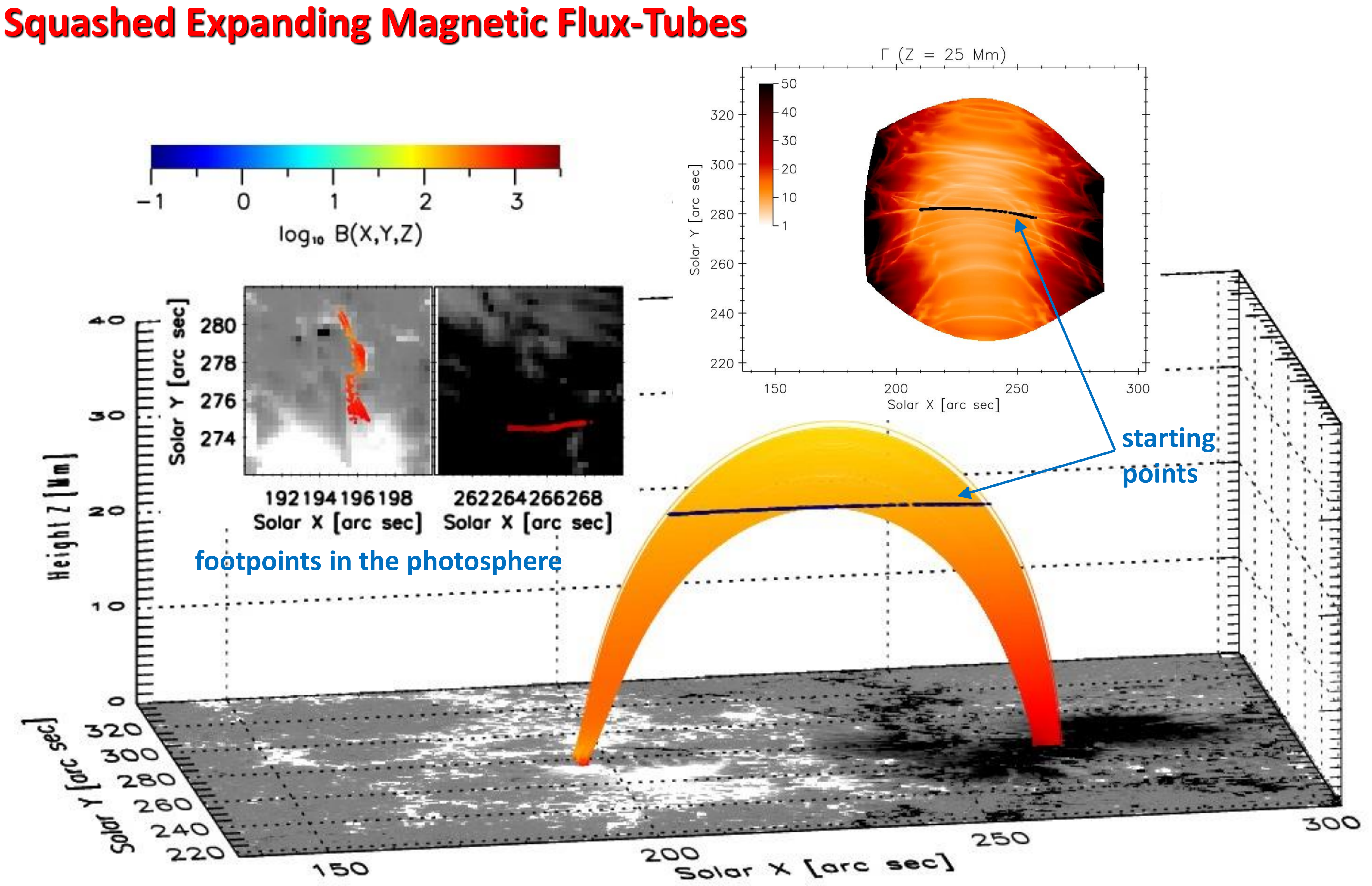
- **Local minima in Γ** correspond to **loop-like structures** in the vertical cut at Solar Y = 280"
- only several pixels wide
- embedded in a diffuse "background" characterized by higher Γ

- AR core: Γ < 5
- "Loops": Γ ≈ 5 – 25

3. Highly Squashed Expanding Magnetic Flux-Tubes

Example of an expanding loop-like flux-tube

- We selected starting points along one of the structures in the cut at Z = 25 Mm (see the inset)
- Integrated the field lines from these starting points
- An expanding flux-tube with a highly squashed cross-section is found: **Area expansion preferential in one direction**
- *"Linguine"* rather than *"spaghetti"*
- Apparent "twist" of π/2 due to connectivity mapping
- If the flux-tube is observed along the direction of expansion, it will appear non-expanding (see Malanushenko & Schrijver 2013, Astrophys. J., 775, 120)



The spatial structure in Γ

- can be a significant ingredient in structuring of the solar corona: The flux-tube expands less than the diffuse background
- leads to increased heating per particle in the squashed flux-tube, and also higher density compared to background

More details at: ***Dudík et al. 2014 (Astrophys. J., 796, 20)***

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