

Systematically measuring the coronal magnetic field using “EIT waves”

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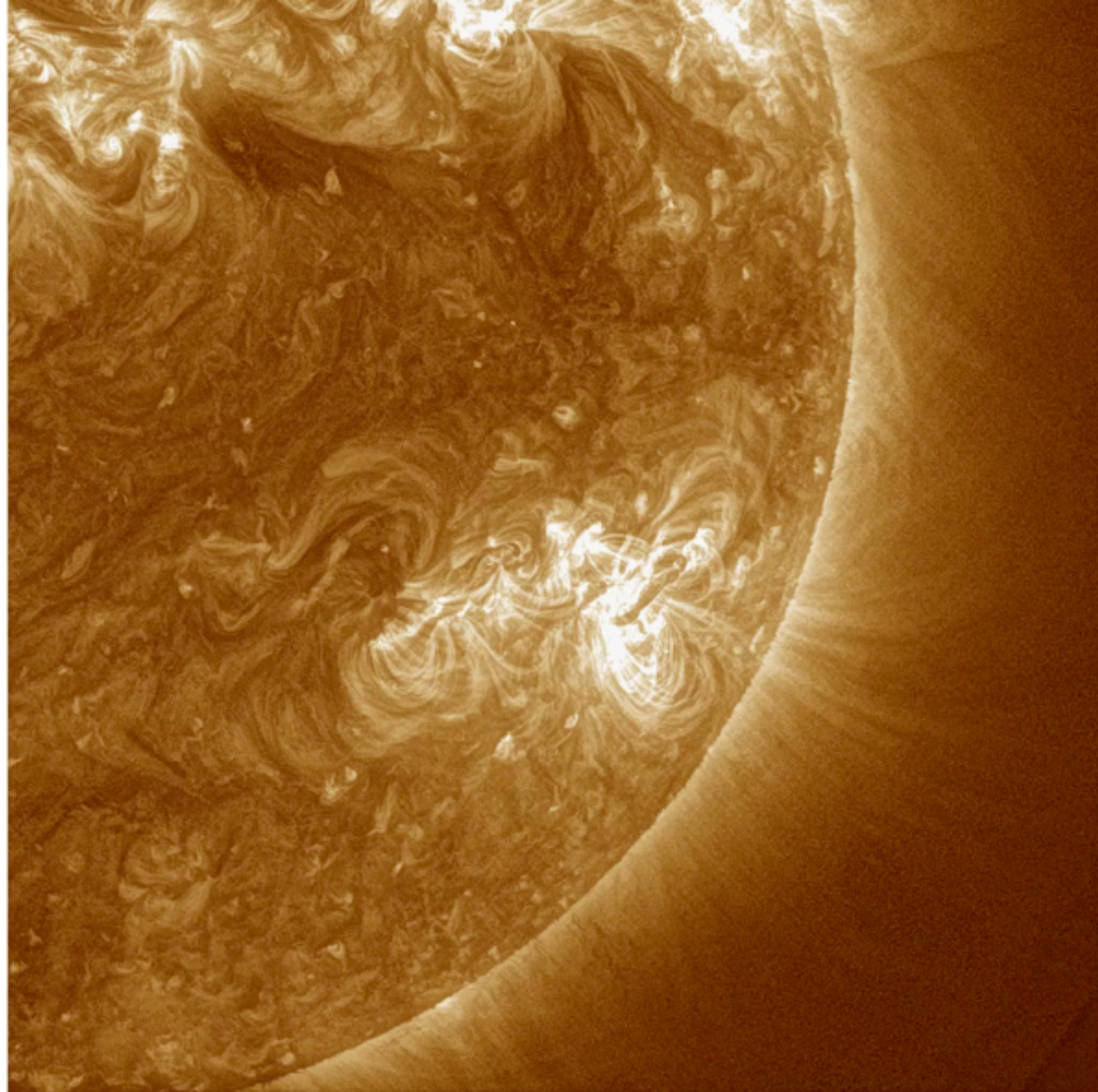
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**Now at Northumbria University*



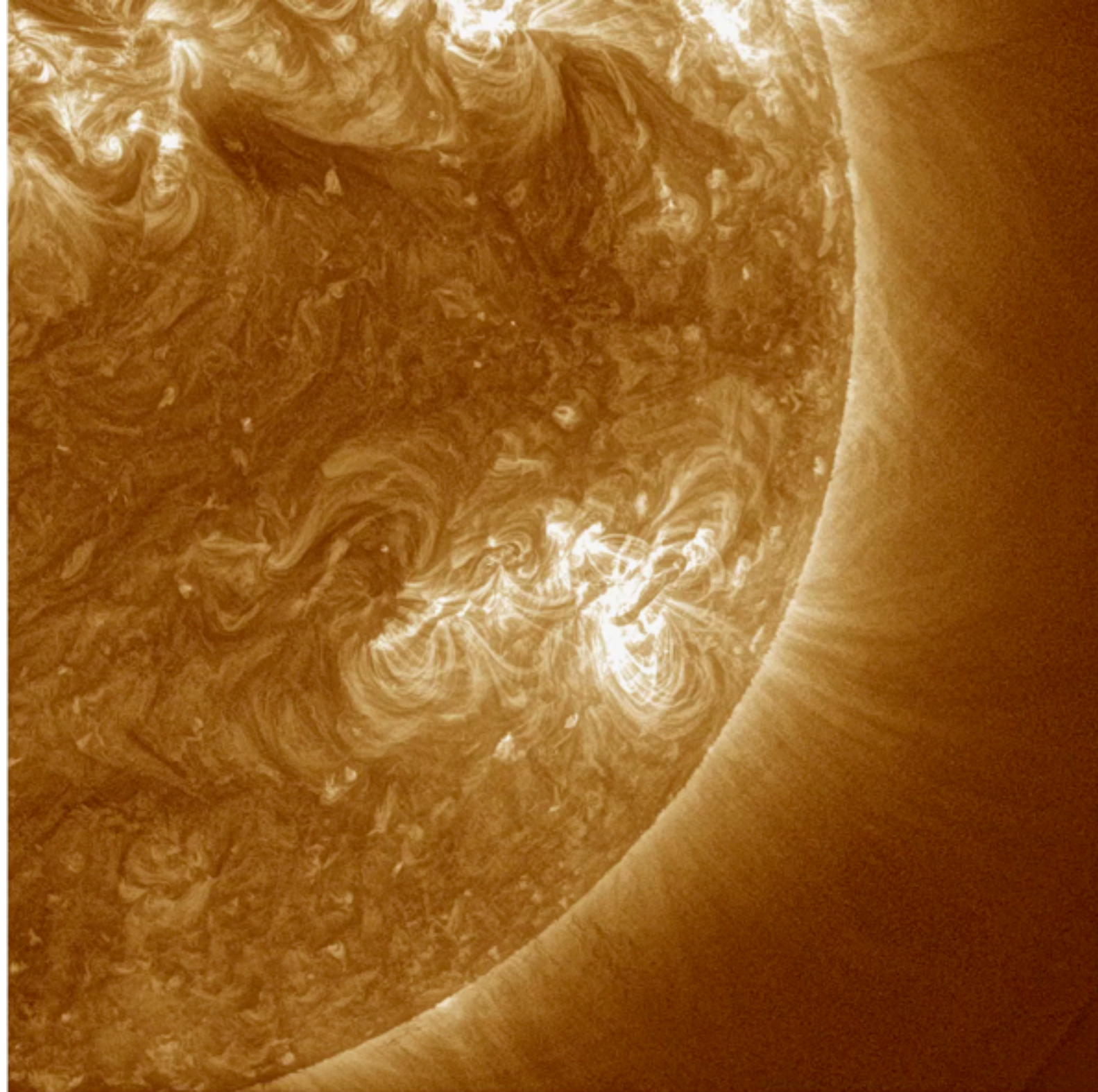
“EIT waves”

- First observed by *SOHO*/EIT
- Can traverse the Sun in less than an hour
- Originally interpreted as waves or magnetic field restructuring
- Strongly associated with coronal mass ejections
- Tend to avoid active regions and coronal holes
- $v \sim 600$ km/s (e.g., Nitta et al., 2013)



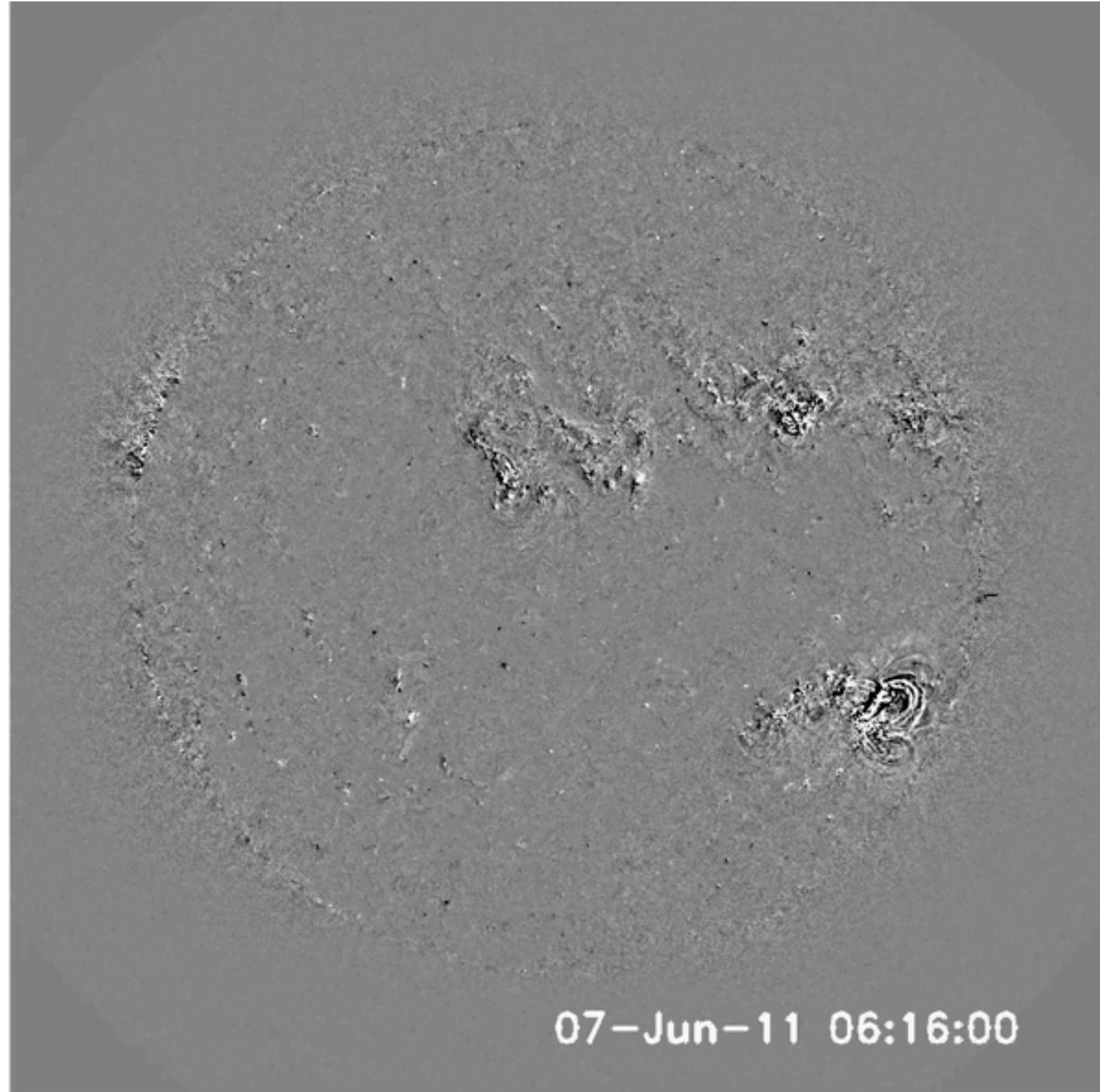
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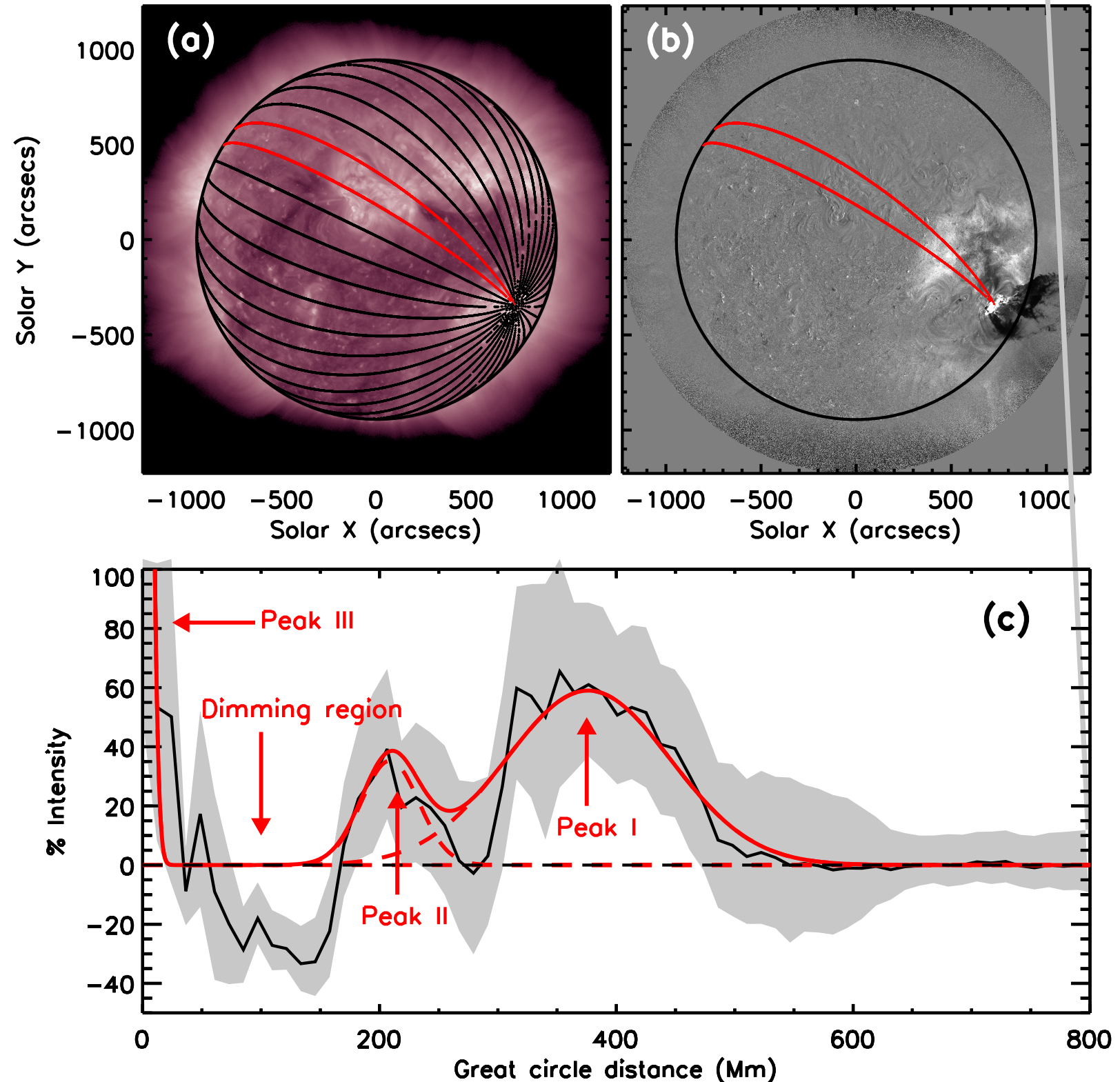
CorPITA

- Coronal Pulse Identification and Tracking Algorithm (Long et al., 2014)
- Designed to identify, track and analyse “EIT waves” using data from *SDO/AIA*
- Only requires position & start time
 - Data identified and downloaded as required
- Processes 10 minutes of observations
 - If no pulse identified, algorithm finishes
 - If pulse identified, processing continues until pulse no longer observed

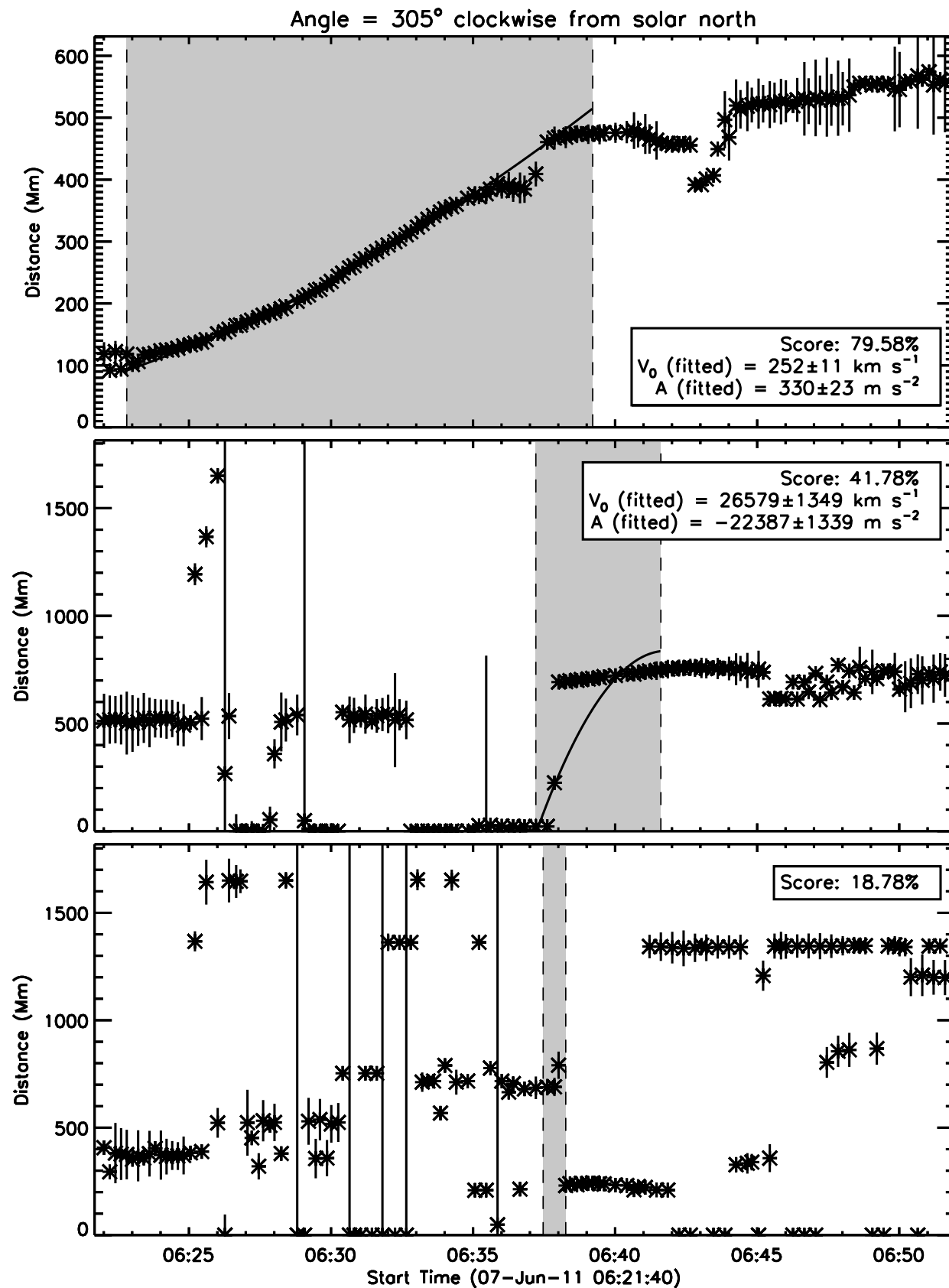
CorPITA

- Pulse identified using 360 arc sectors of 10° width offset by 1°
- Use intensity profiles from percentage base difference images to identify peaks

$$I(t) = \left(\frac{I_t - I_0}{I_0} \right) \times 100$$



CorPITA



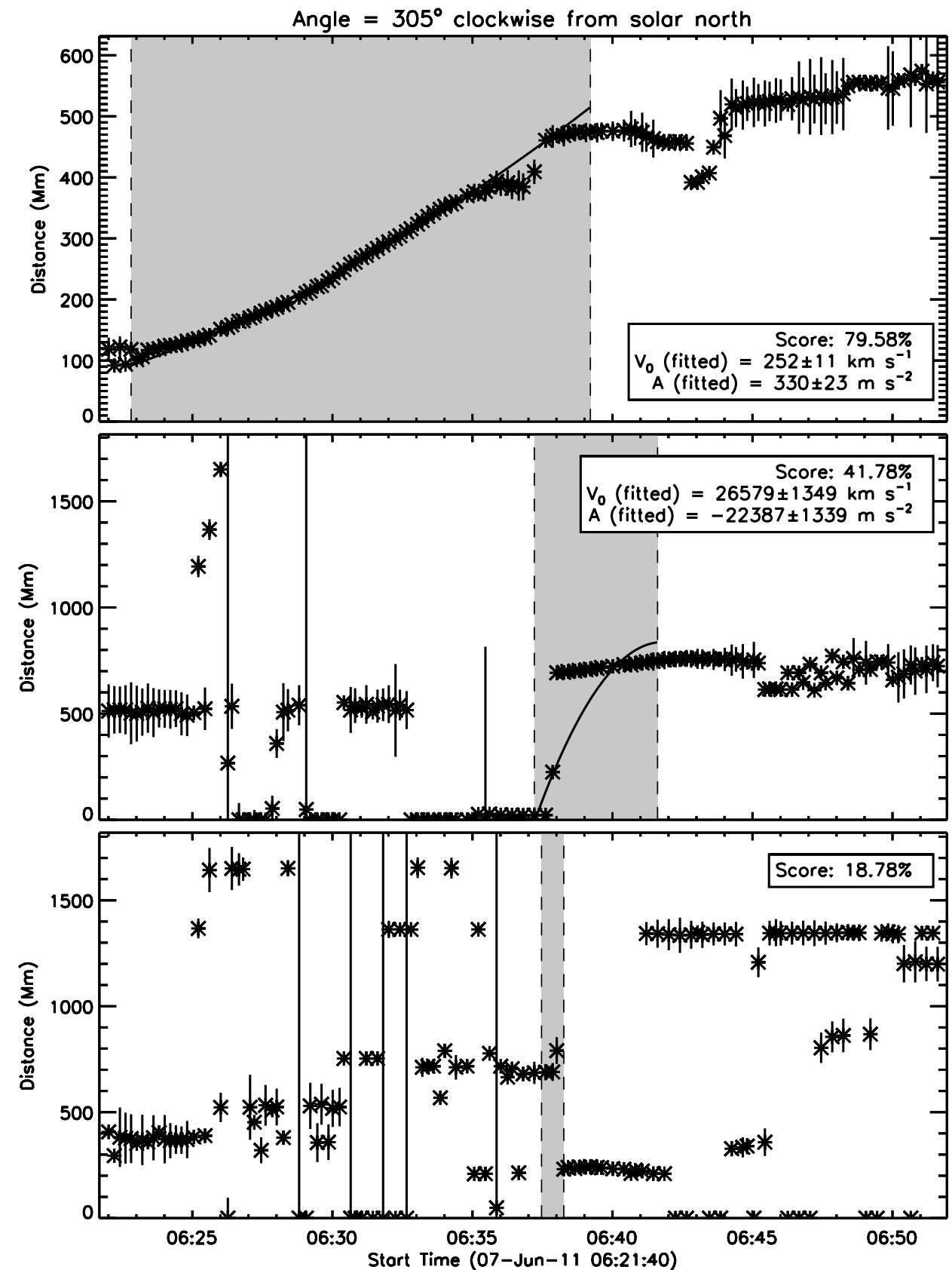
CorPITA

- Each peak scored to identify the pulse
- Score depends on:
 - Number of data points in selected section
 - Fitted velocity and acceleration
 - Relative error of points in selected section

$$\text{score} = \left[\left(\frac{1}{2} \times \frac{N_{\text{sector}}}{N_{\text{total}}} \right) + \frac{(v_{\text{score}} + a_{\text{score}} + \sigma_{\text{score}}^{\text{rel}})}{6} \right] \times 100$$

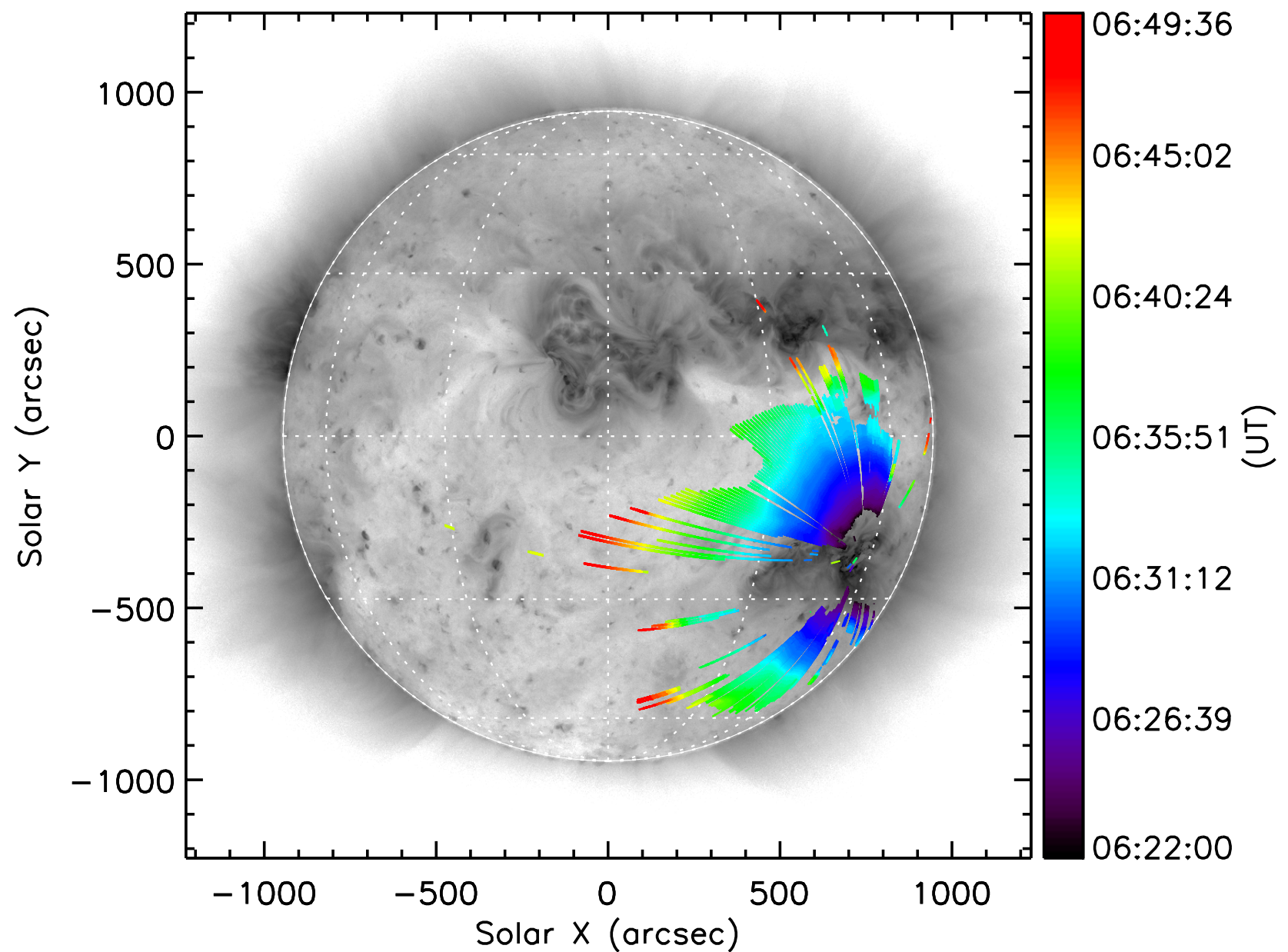
CorPITA

- Possible pulse detections scored
- Highest scoring arc most likely to be the pulse in that sector
- Each sector compared
 - If score greater than 60% then probably a pulse
- To confirm a positive identification..
 - Need >10 adjacent arcs with score >60%



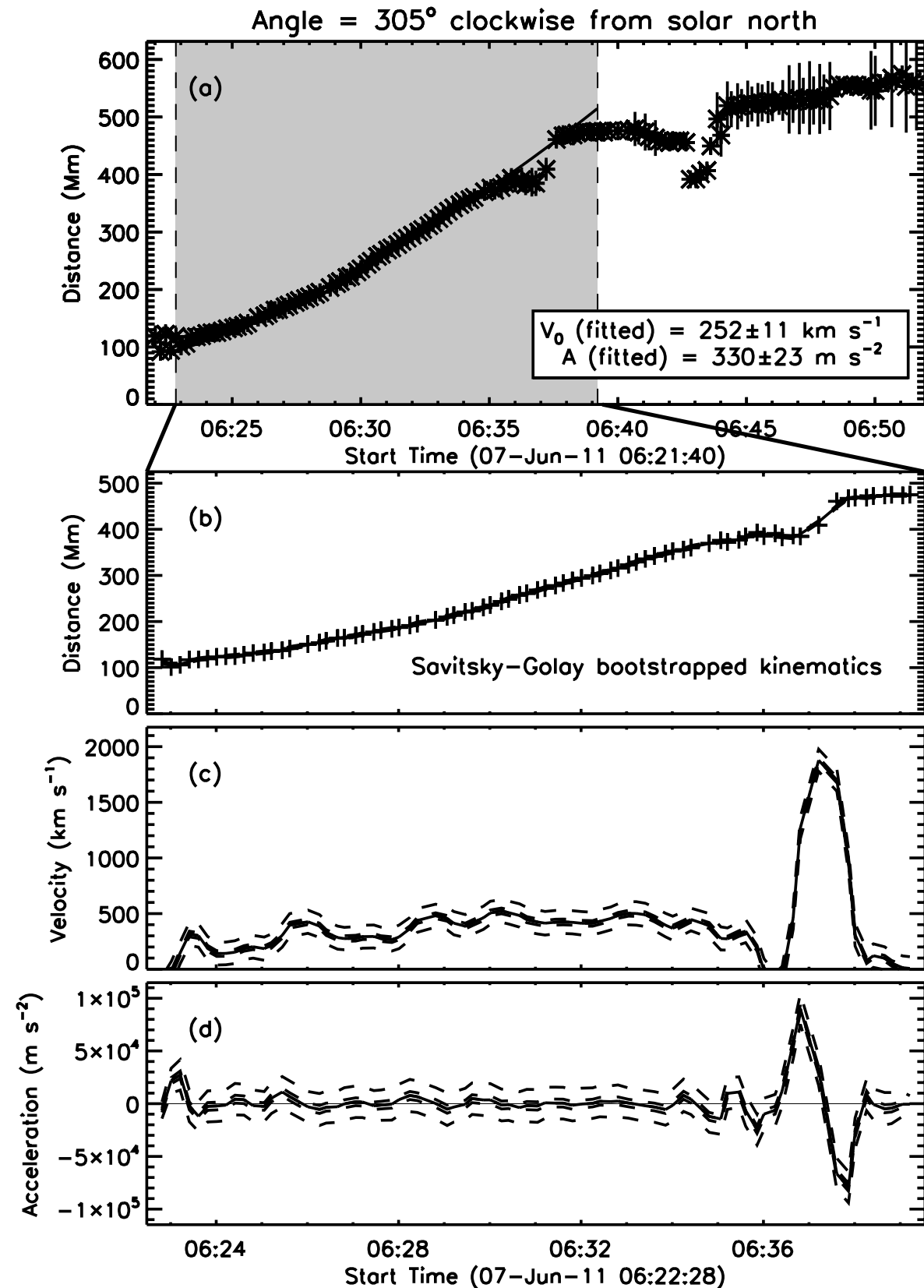
CorPITA

- Pulse position may then be tracked with time for each arc sector
- Can get fitted kinematics for each arc sector or derive kinematics (e.g., Byrne et al., 2013)

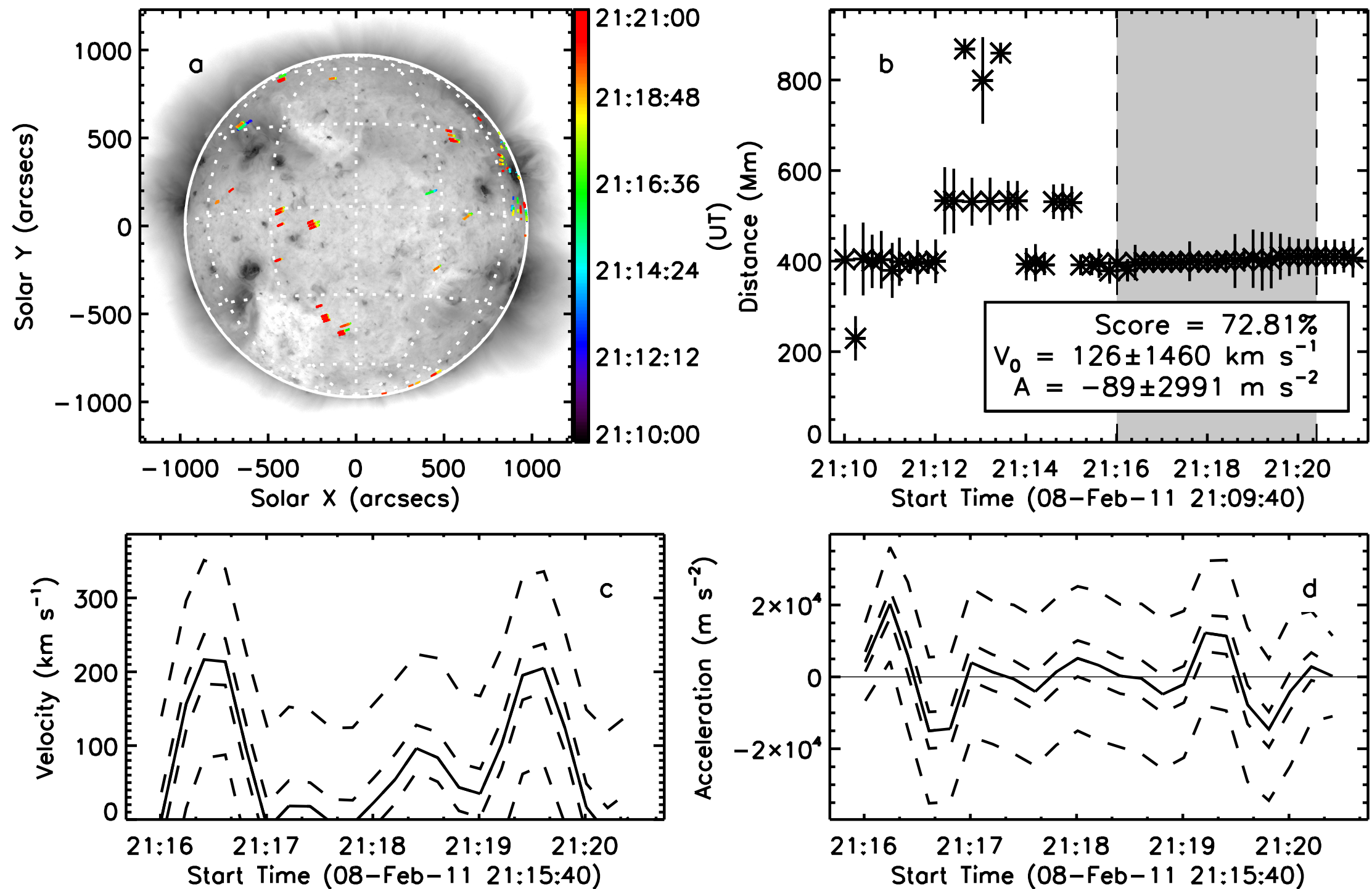


CorPITA

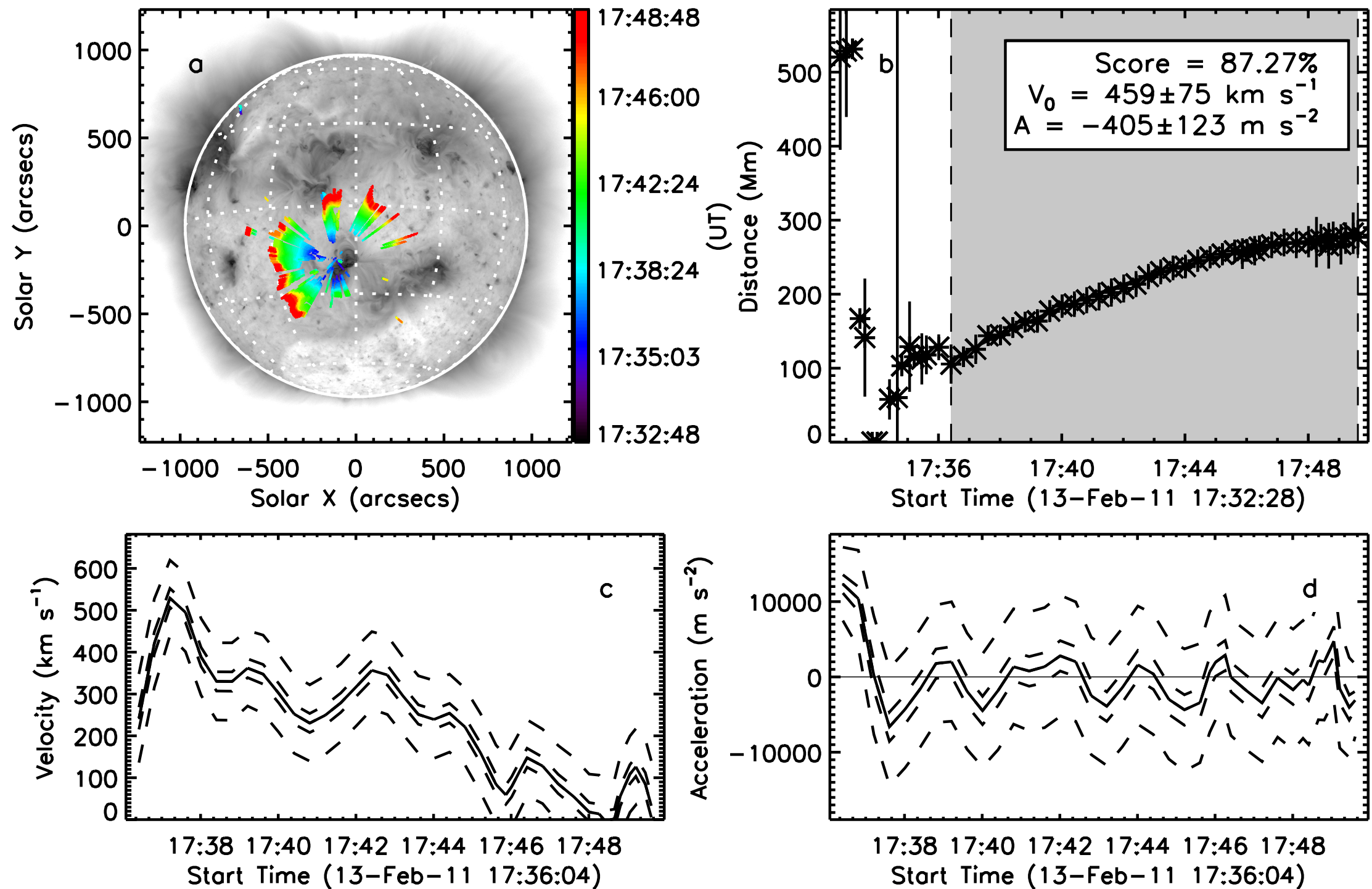
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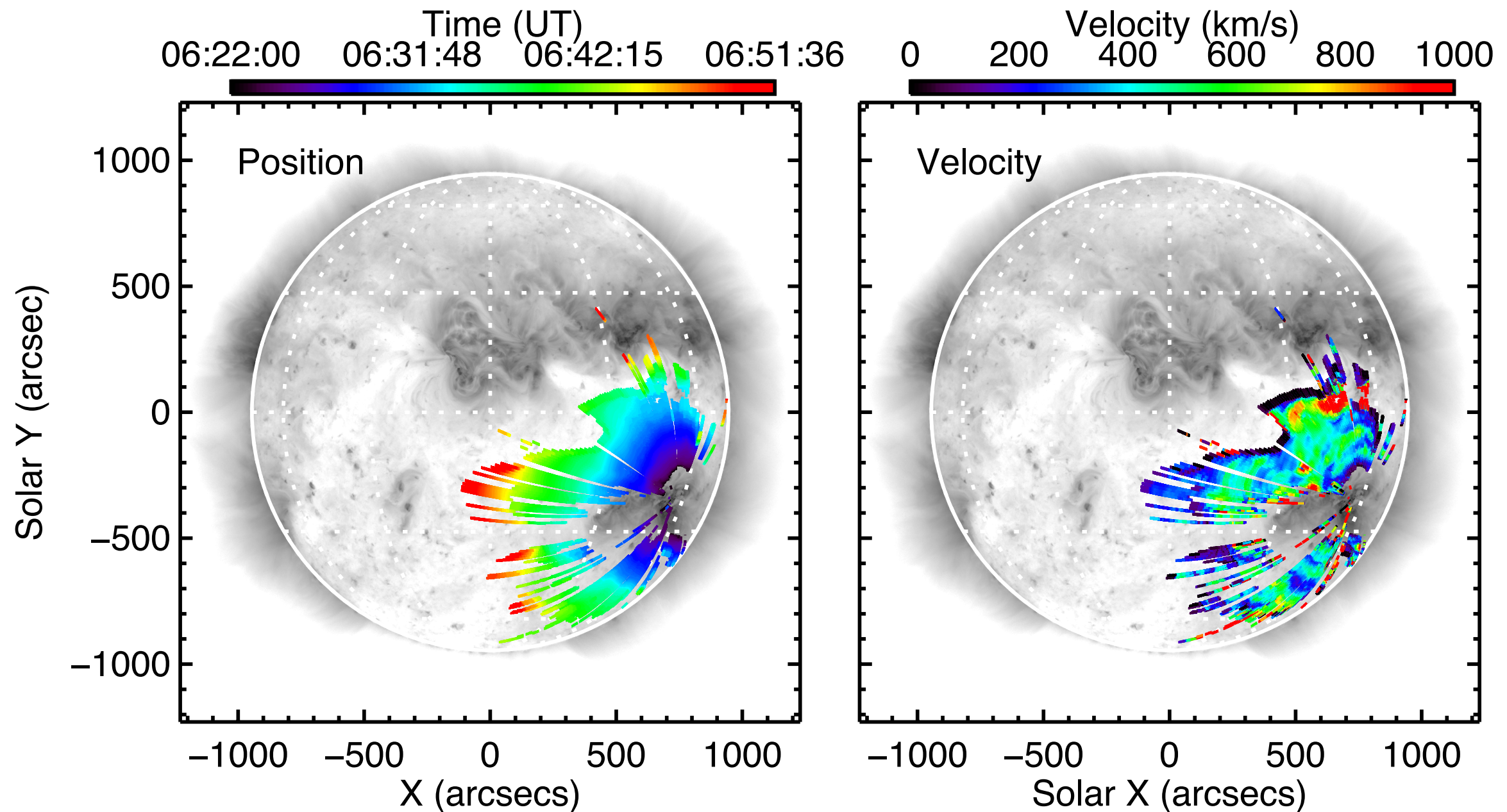
CorPITA



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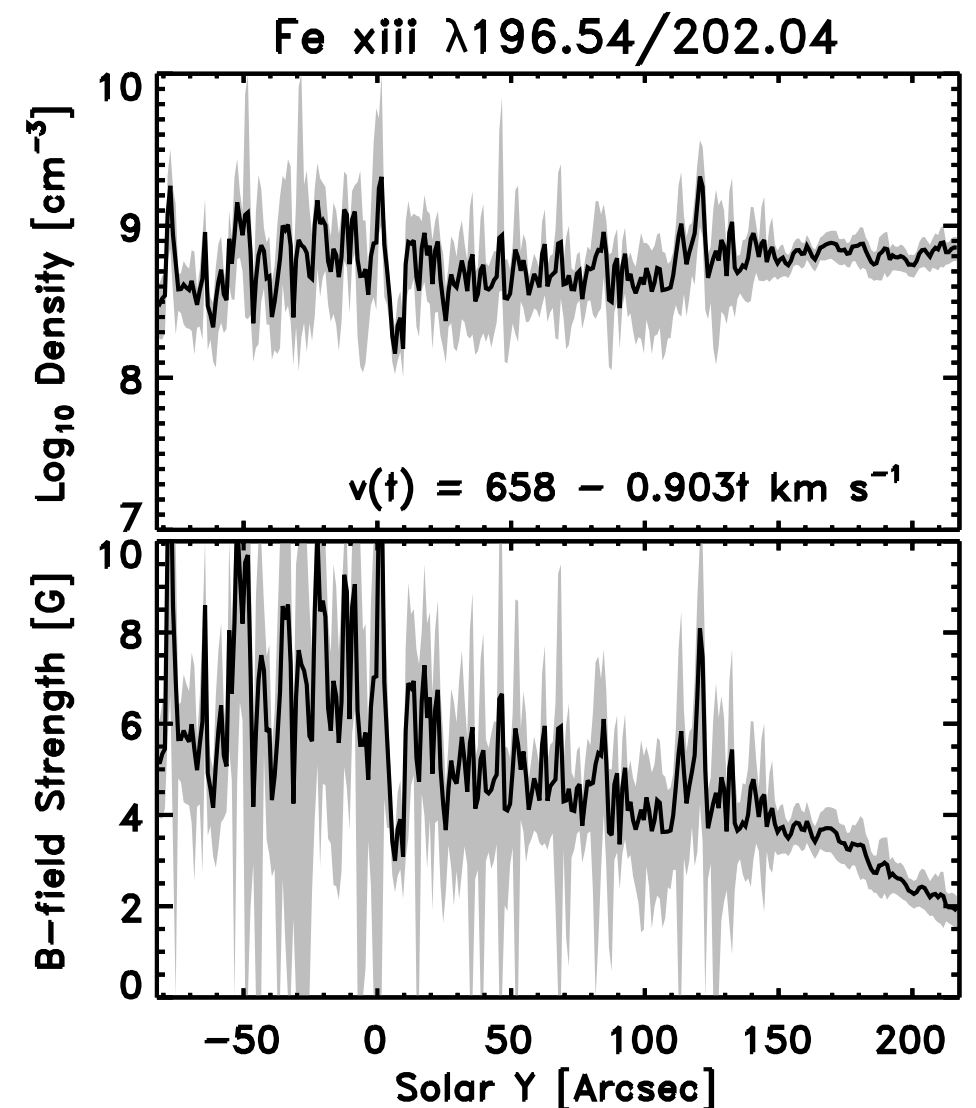
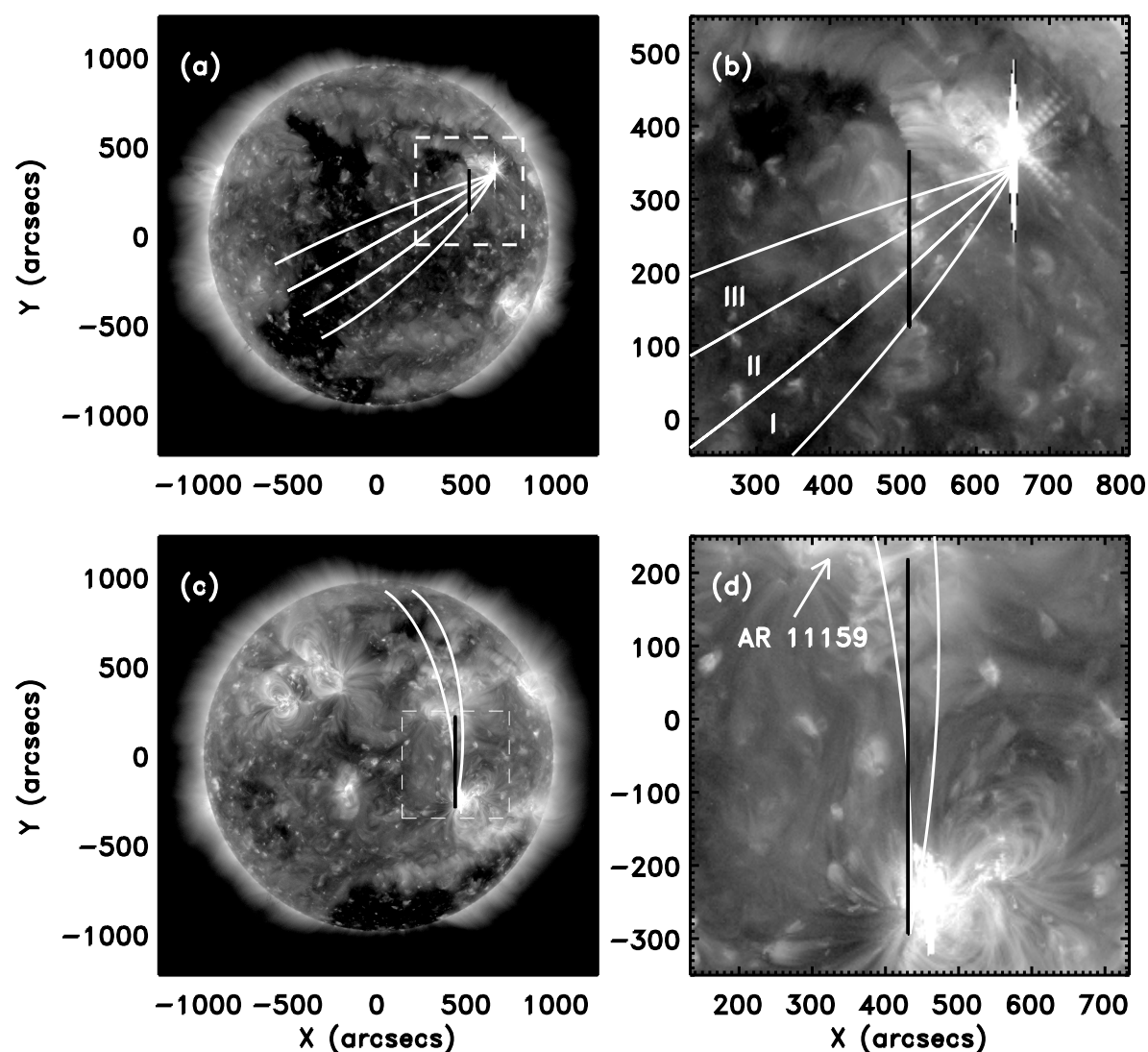
CorPITA



- Can examine variations in pulse kinematics using Savitsky-Golay approach with each arc sector

Coronal seismology

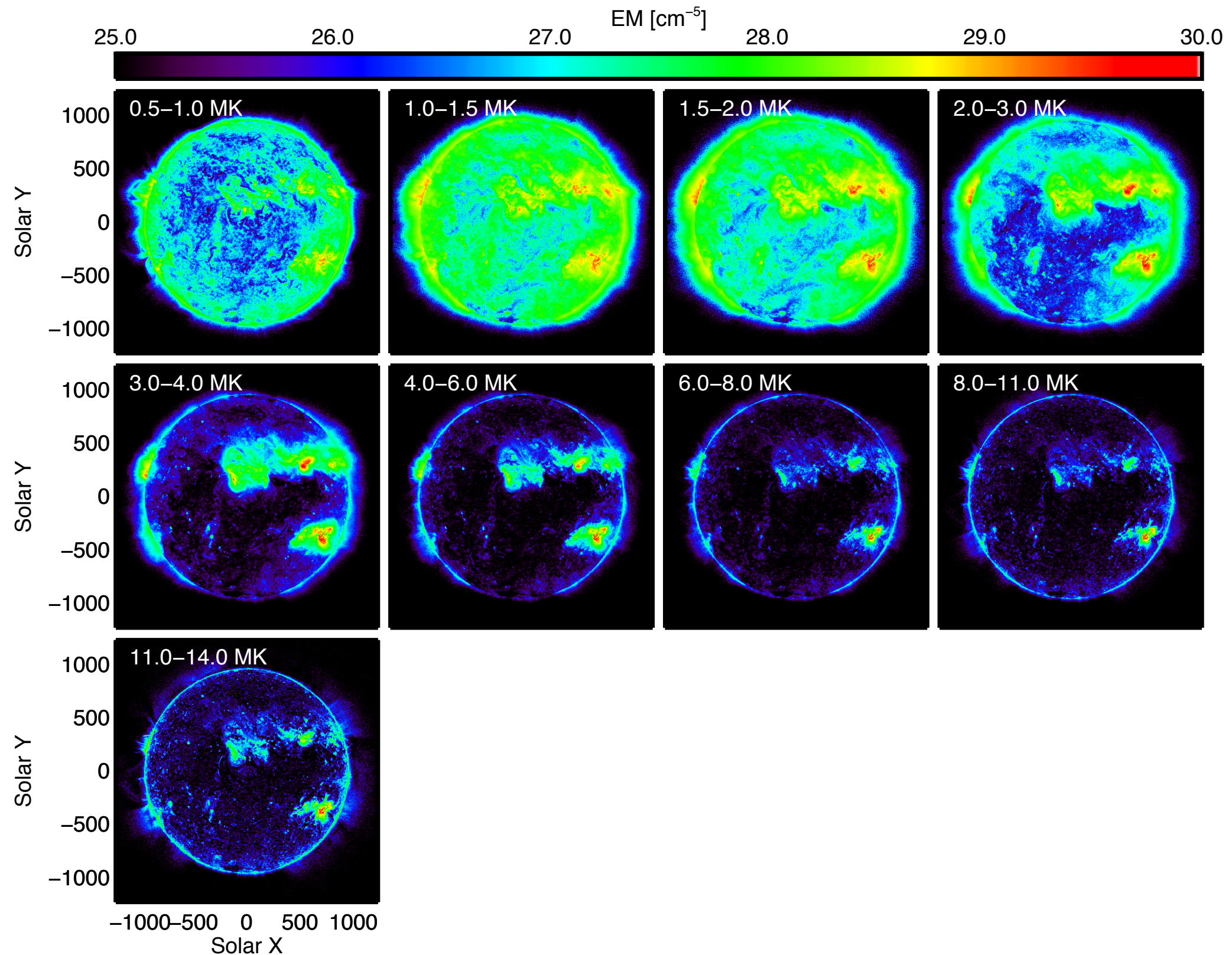
- “EIT waves” interpreted as fast-mode waves - kinematics affected by density and magnetic field strength
 - Difficult to measure magnetic field strength directly
 - Can measure density using spectrometers such as *Hinode*/EIS (e.g., West et al., 2011, Long et al., 2011, 2013)



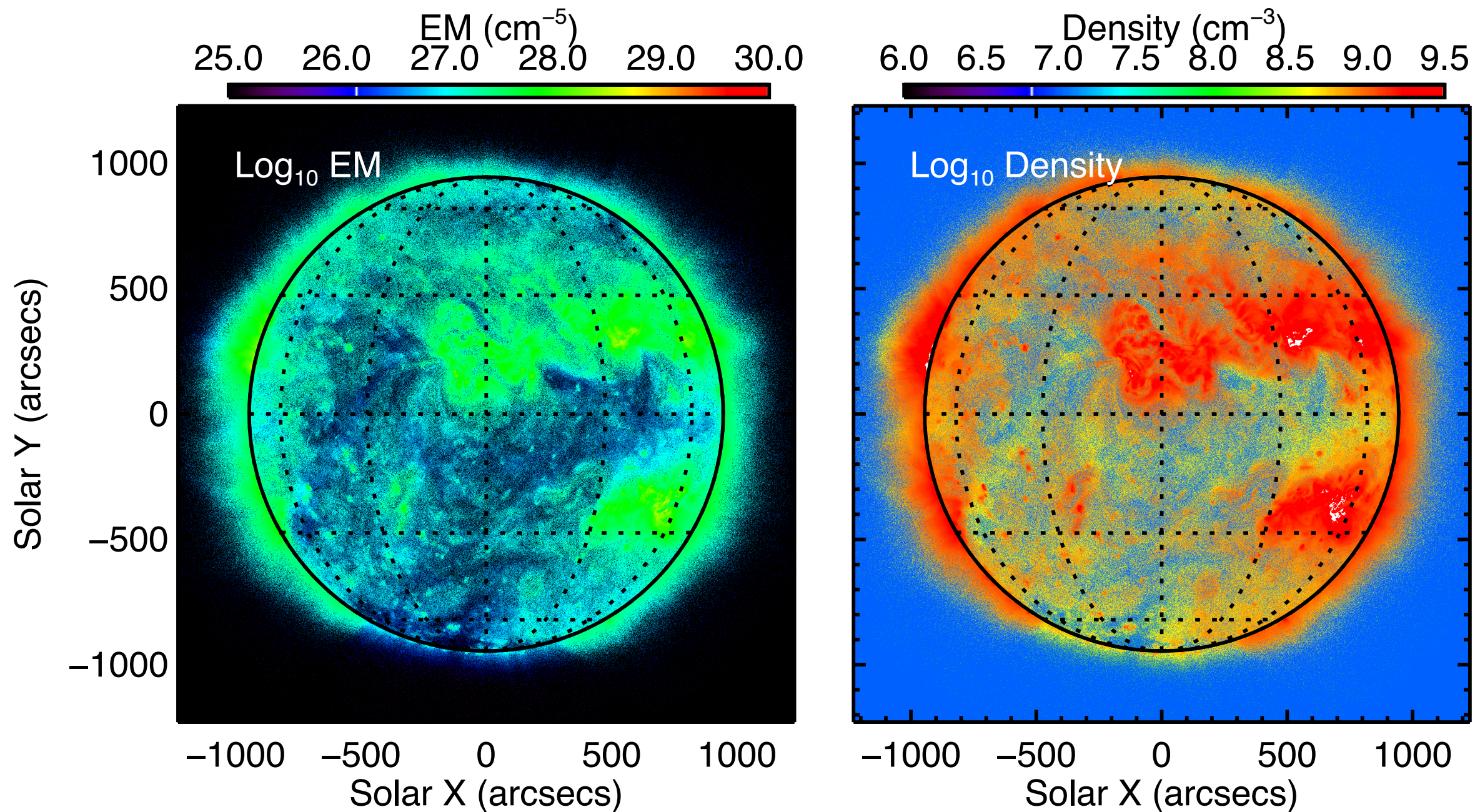
Coronal seismology

- Constrained by size and position of slit
- “EIT waves” are random events & difficult to predict direction
- Ideally want global density maps
- Can get global emission measure maps from SDO data using regularised inversion approach (Hannah & Kontar, 2012, 2013)

Coronal seismology



Coronal seismology



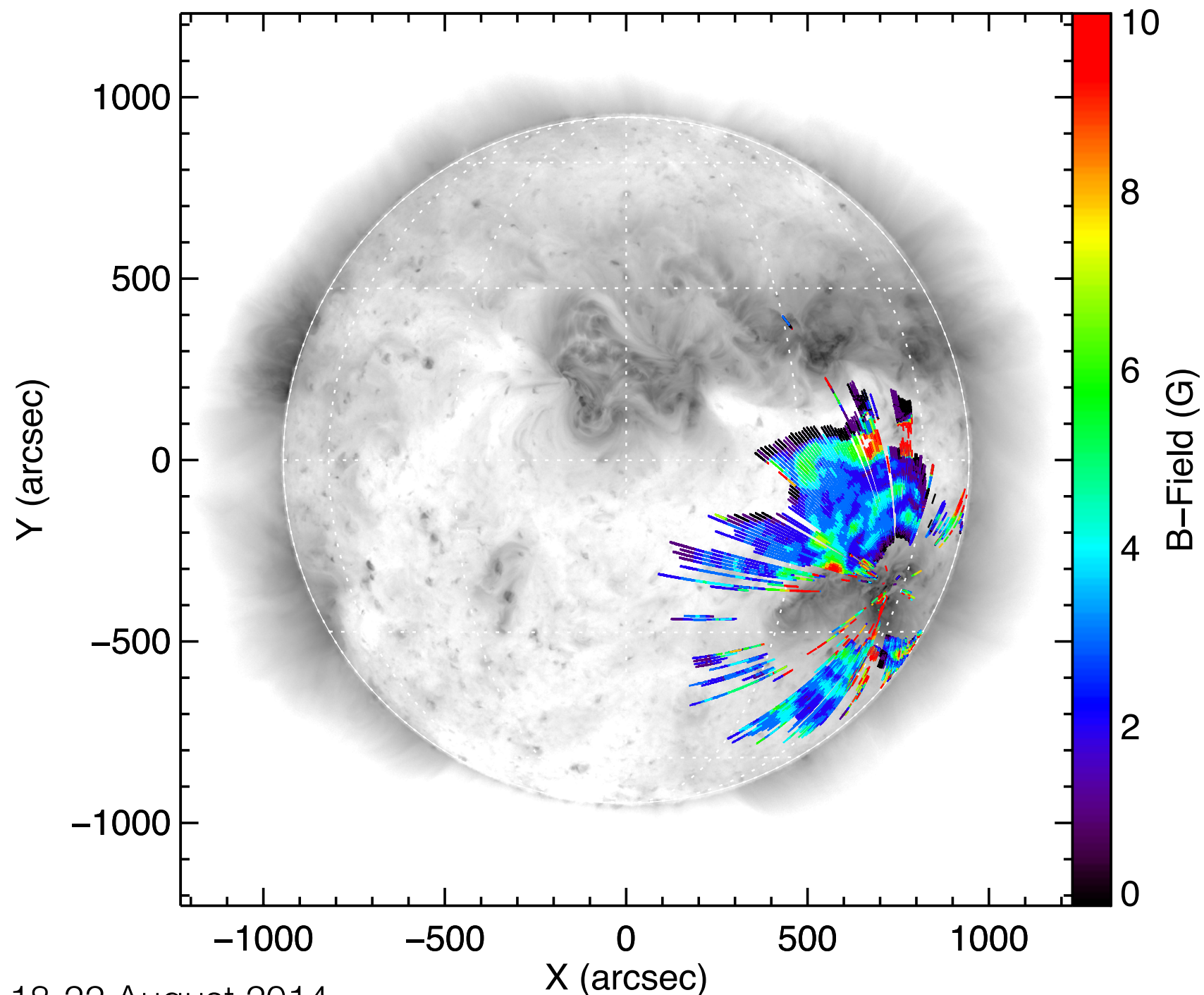
Can relate emission measure to density using scale height

Coronal seismology

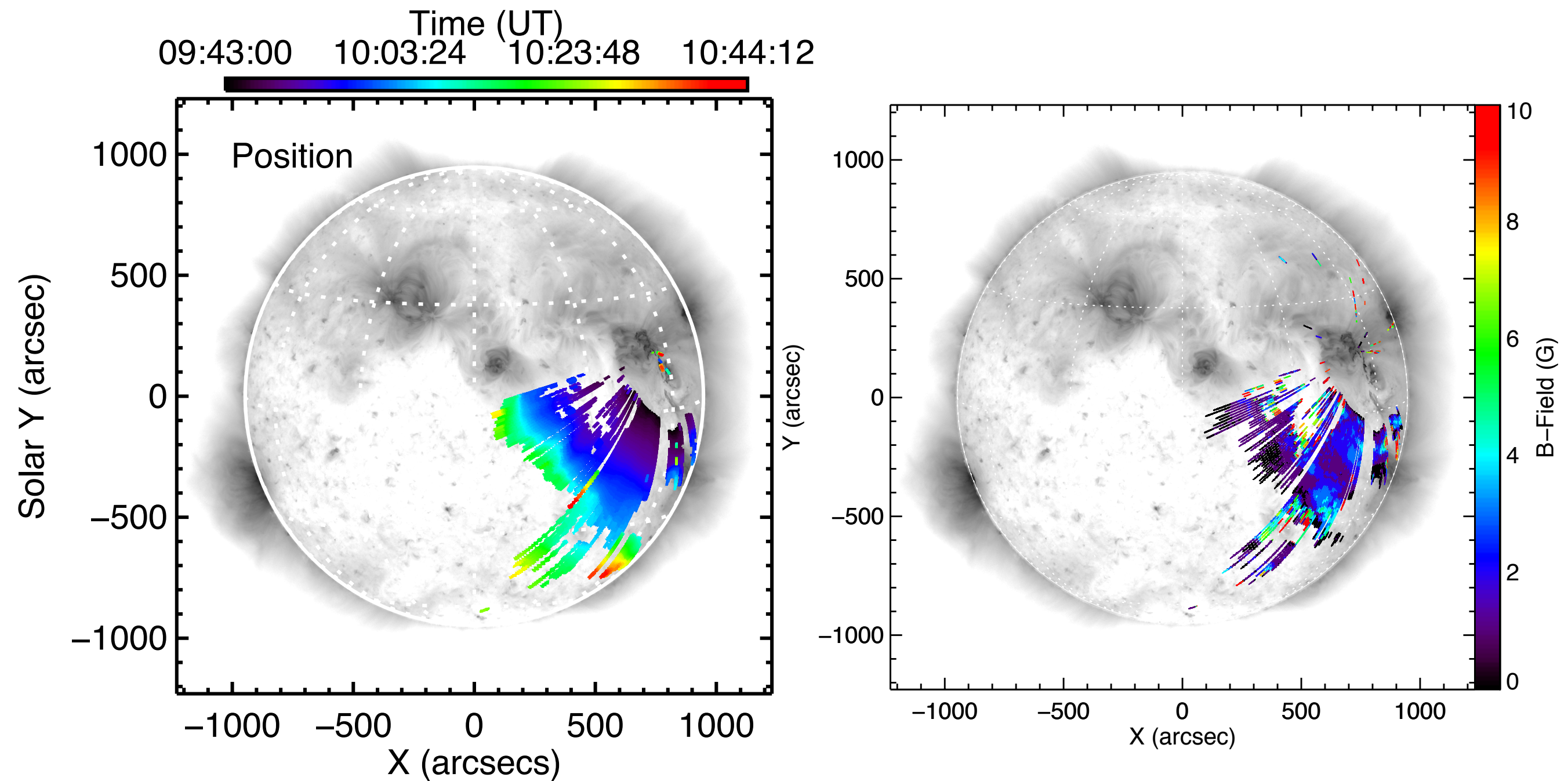
$$B = \sqrt{4\pi n(mv_{\text{fm}}^2 - \gamma k_{\text{B}}T)}$$

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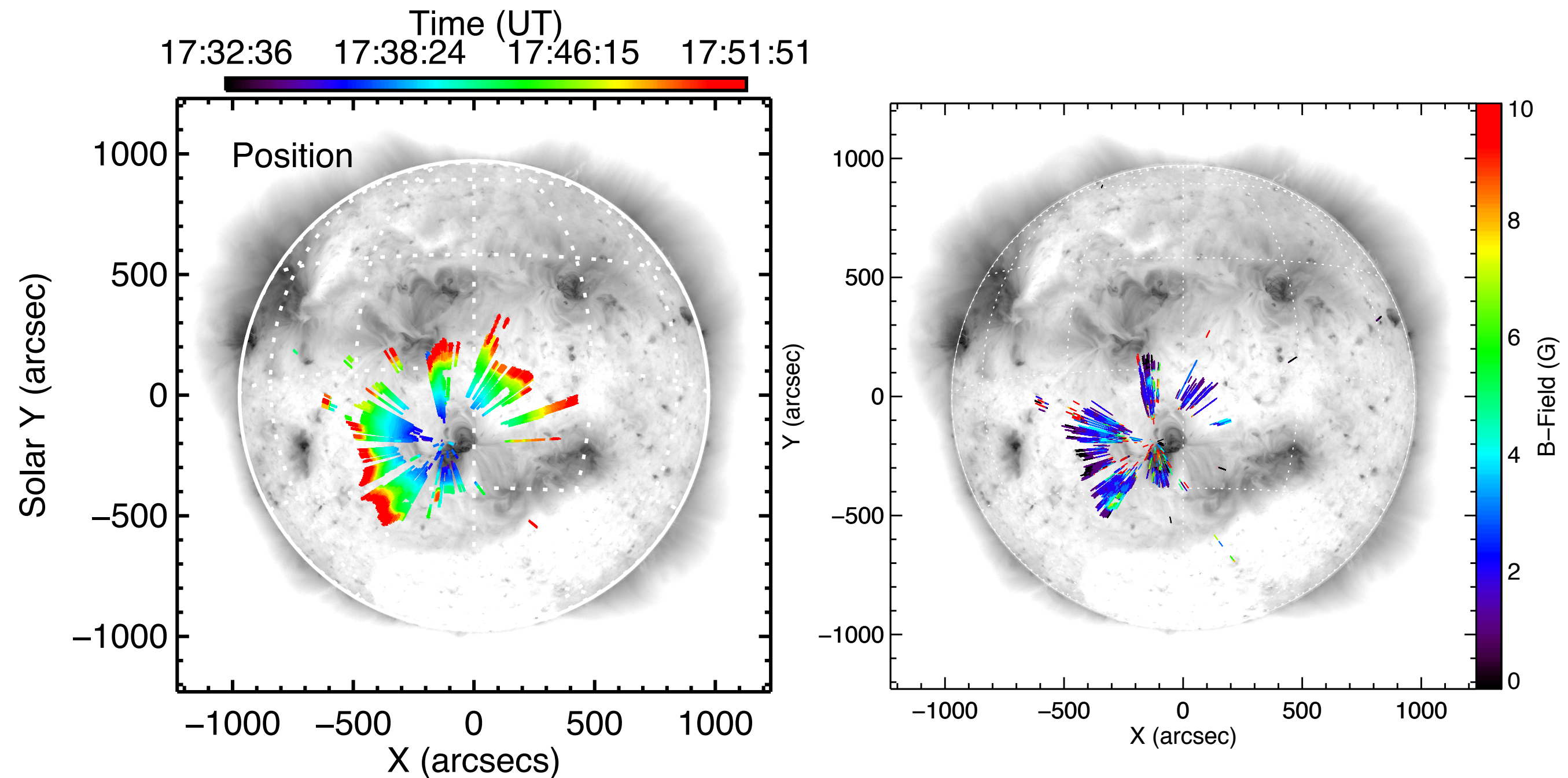


Systematic...



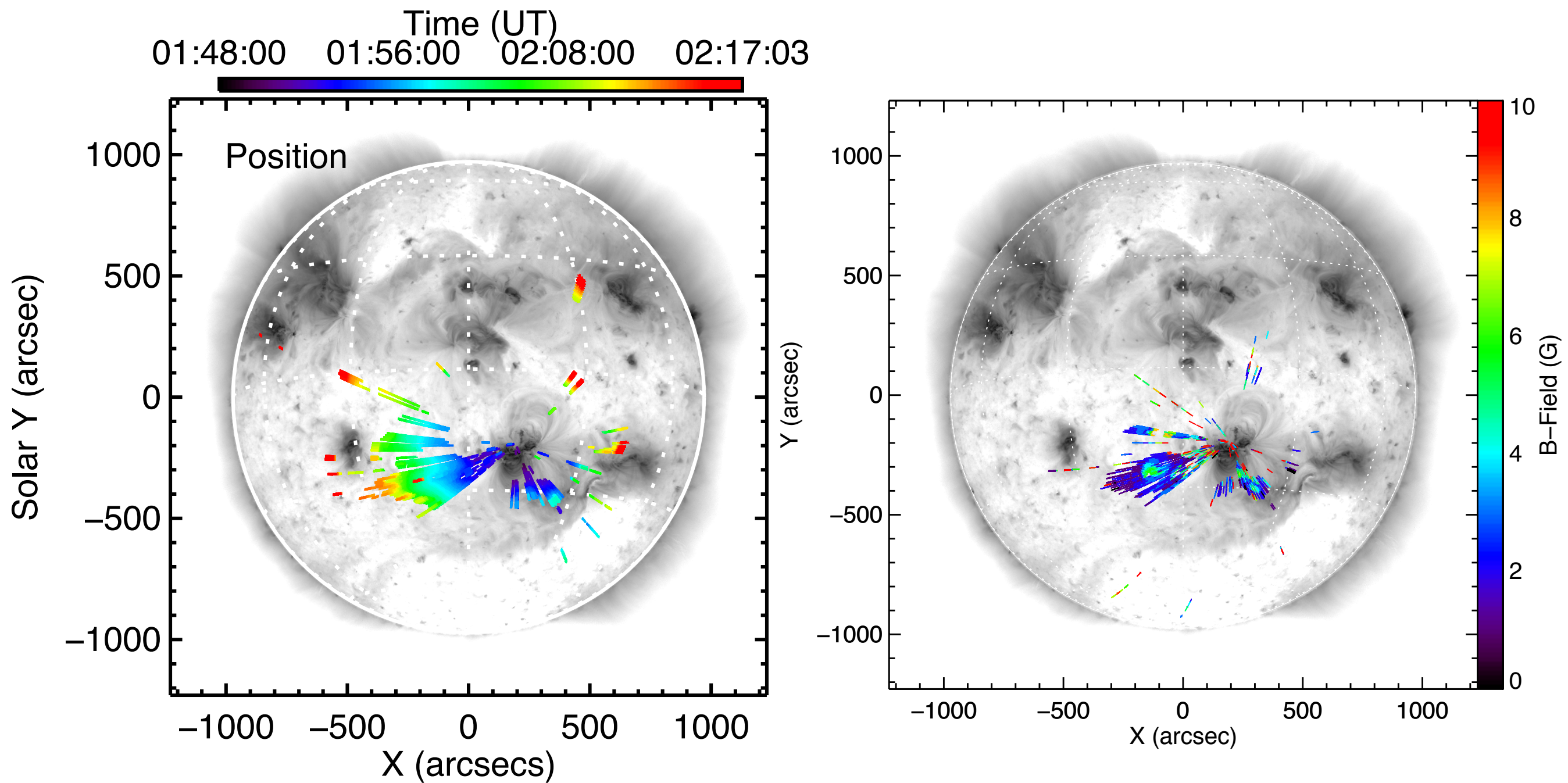
2010-08-14

Systematic...



2011-02-13

Systematic...



2011-02-15

Conclusions

- Automated algorithm for identifying, tracking and analysing “EIT waves”
 - CorPITA
 - Operational but output not online (yet!)
- Does a good job of tracking different events
- Can combine CorPITA with EM inversion technique to estimate magnetic field strength in the solar corona
 - Being compared against extrapolation models as we speak...