XIT

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and Solar-C WG

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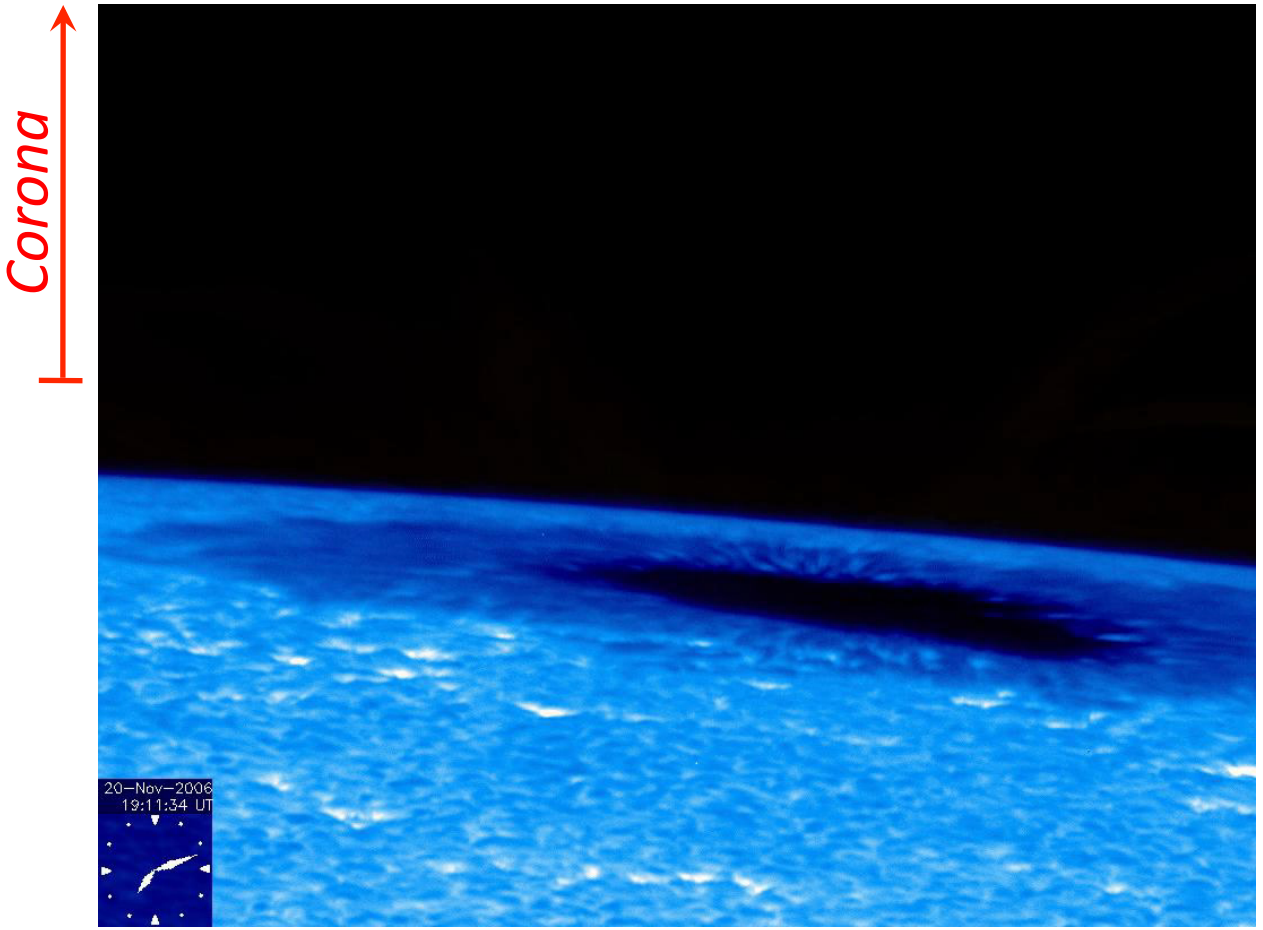
Solar-C Science Meeting

Key Hinode Observations Relevant to Solar-C

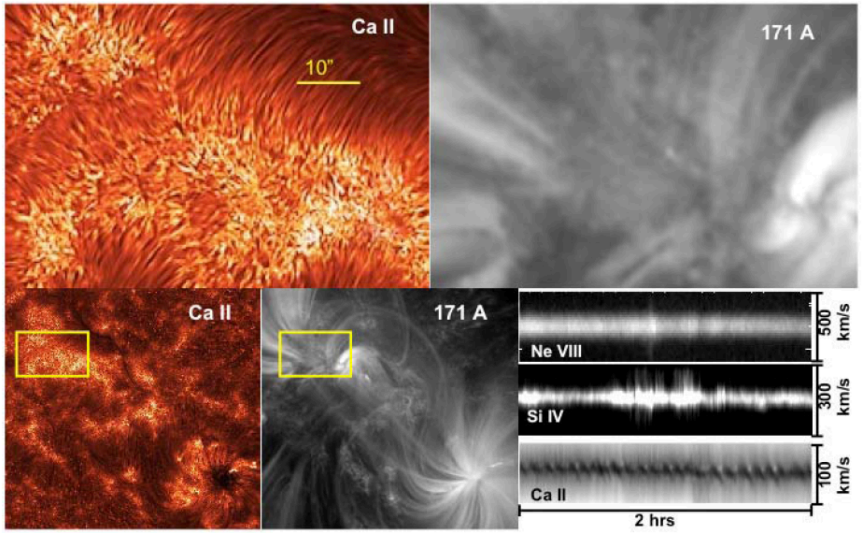
- Dynamic chromosphere, with activities protruding even into the corona.
  → Chromosphere may be playing a key role for the heating of the outer atmosphere.
  * Need of understanding vector magnetic field structure of the chromosphere.
- Possible sub-arcsec non-thermal events ongoing at the footpoints of coronal loops.
  → Contribution to coronal heating?



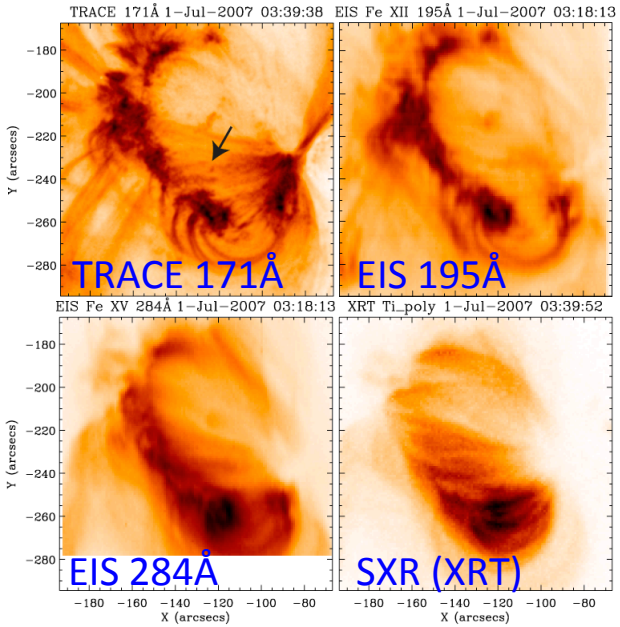
(Movie courtesy of Y. Katsukawa)

- Something crucial resides in angular scales within our reach in the chromosphere/ lower corona.
- Power of imaging spectroscopy.

Imaging Observation of the Corona



Causal connectivity between the base of the corona and the chromosphere/transition region with EUV-line images



Heating and activities of hot loops with broad-band soft X-ray images

Normal Incidence (Baseline)

Very-high-resolution with high-cadence imagery in EUV wavebands

Connectivity with lower atmosphere

Context information for EUVST

0.2-0.3" angular resolution (0.1"/pixel) with cadence <10 s for AR/FL

171, 94 and 304 (or 1548 UV) Å bands

Grazing Incidence (Optional)

Highest spatial-resolution soft X-ray imaging-spectroscopy

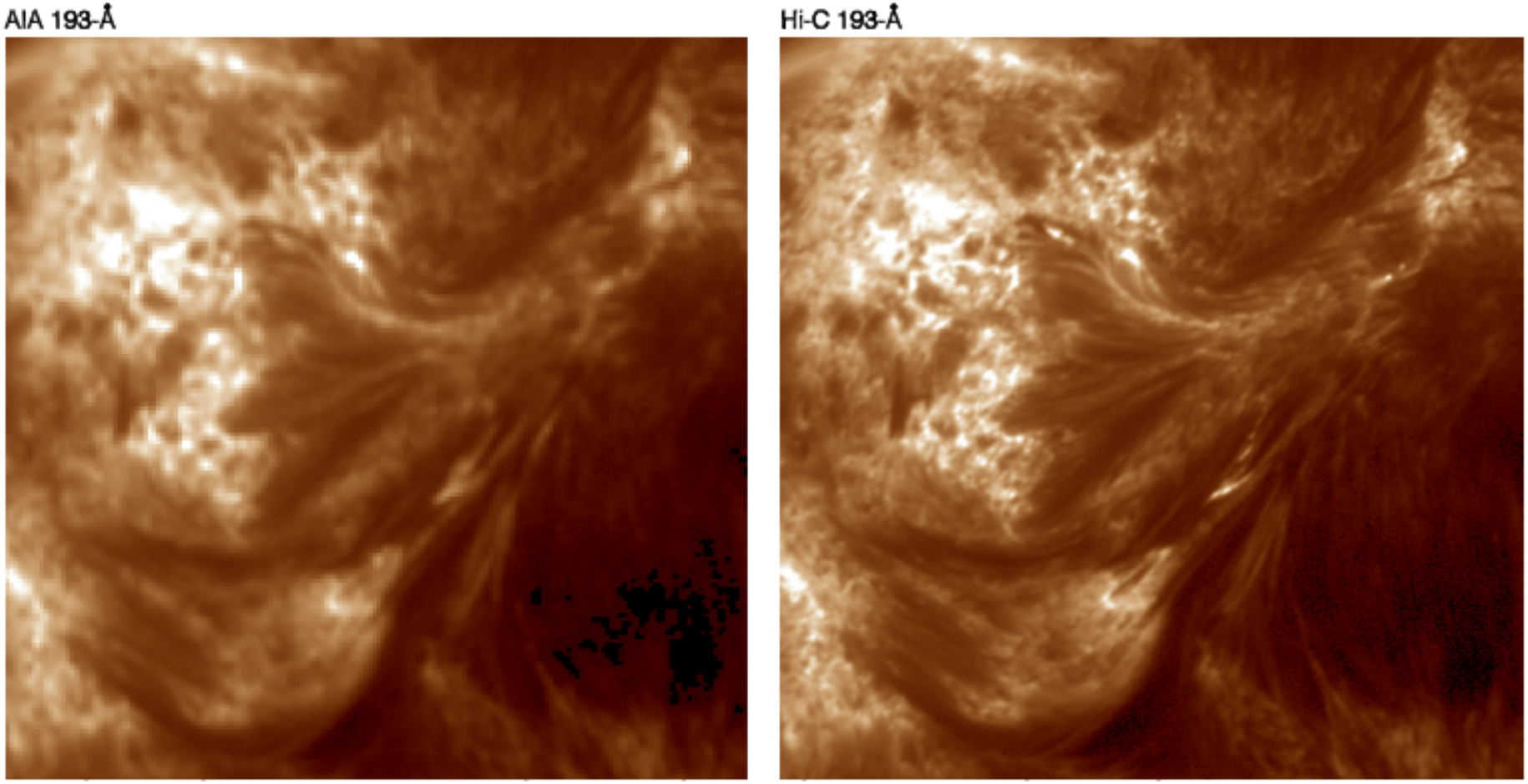
Photon-counting capability for reconnection structure etc.

~< 1" angular resolution (0.4-0.5"/pxl)

~0.5-10 keV energy range

Fine Structures in the Corona

Hi-C Experiment (July 2012)



AIA 0.6” pixel vs Hi-C 0.12” pixel

(Courtesy J. Cirtain)

Fine Structures in the Corona

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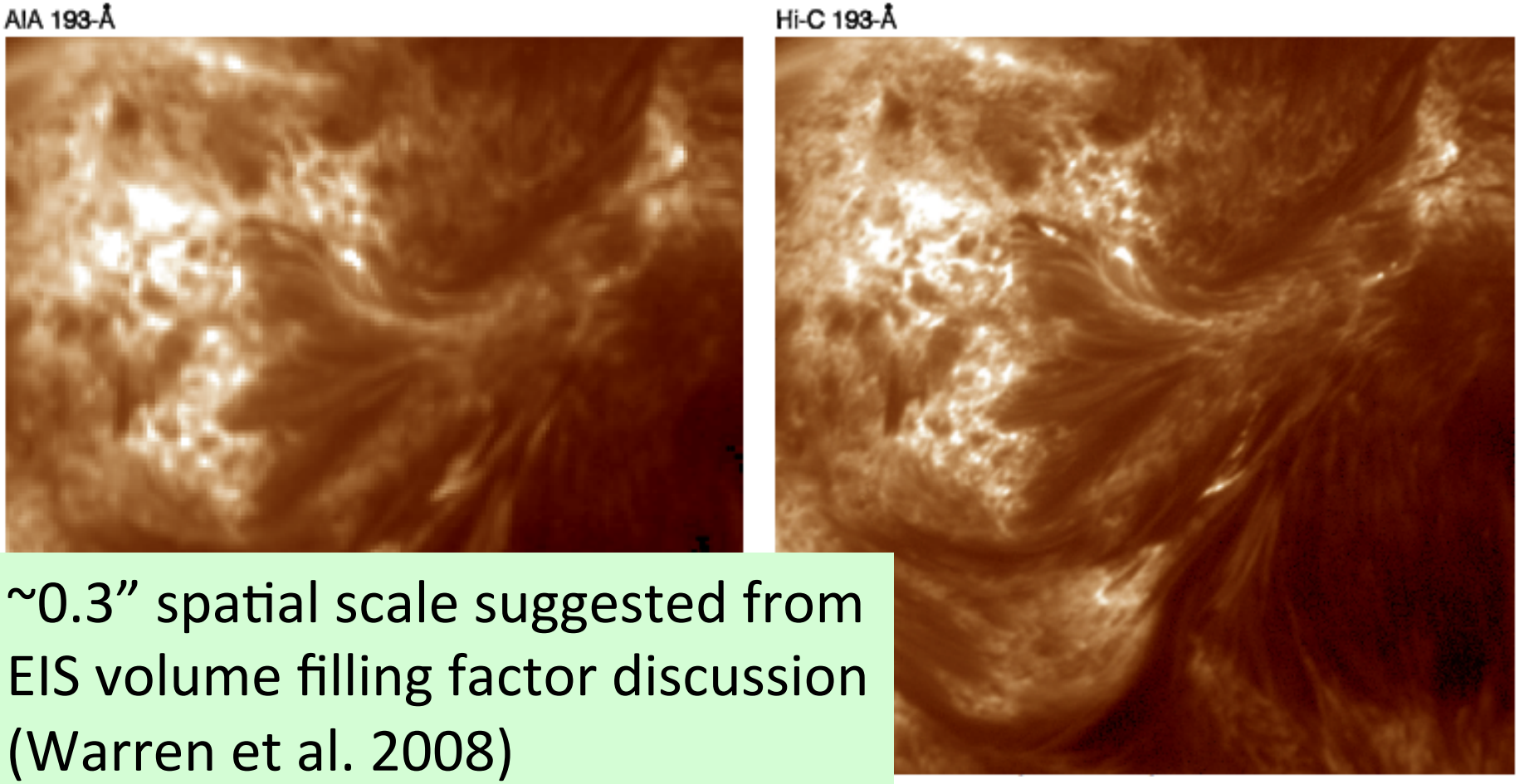

~0.3” spatial scale suggested from EIS volume filling factor discussion (Warren et al. 2008)

AIA 0.6” pixel vs Hi-C 0.12” pixel

(Courtesy J. Cirtain)

Science Cases of XIT-NI in the MPD (Pre-Release Version)

1. The fine-scale structure of coronal loops and the role of magnetic field line braiding in atmospheric heating
2. Heating mechanisms in the chromosphere and coronal footpoint regions
3. Alfvenic waves in the transition region and corona
4. The role of chromospheric jets in supplying hot plasma to the corona
5. Energy buildup and release in the solar corona: Measurement of free magnetic energy
6. Structure of prominences/filaments and their eruptions
7. Current sheet dynamics
8. Energy transfer in flares

Science Cases of XIT-NI in the MPD (Pre-Release Version)

Coronal heating

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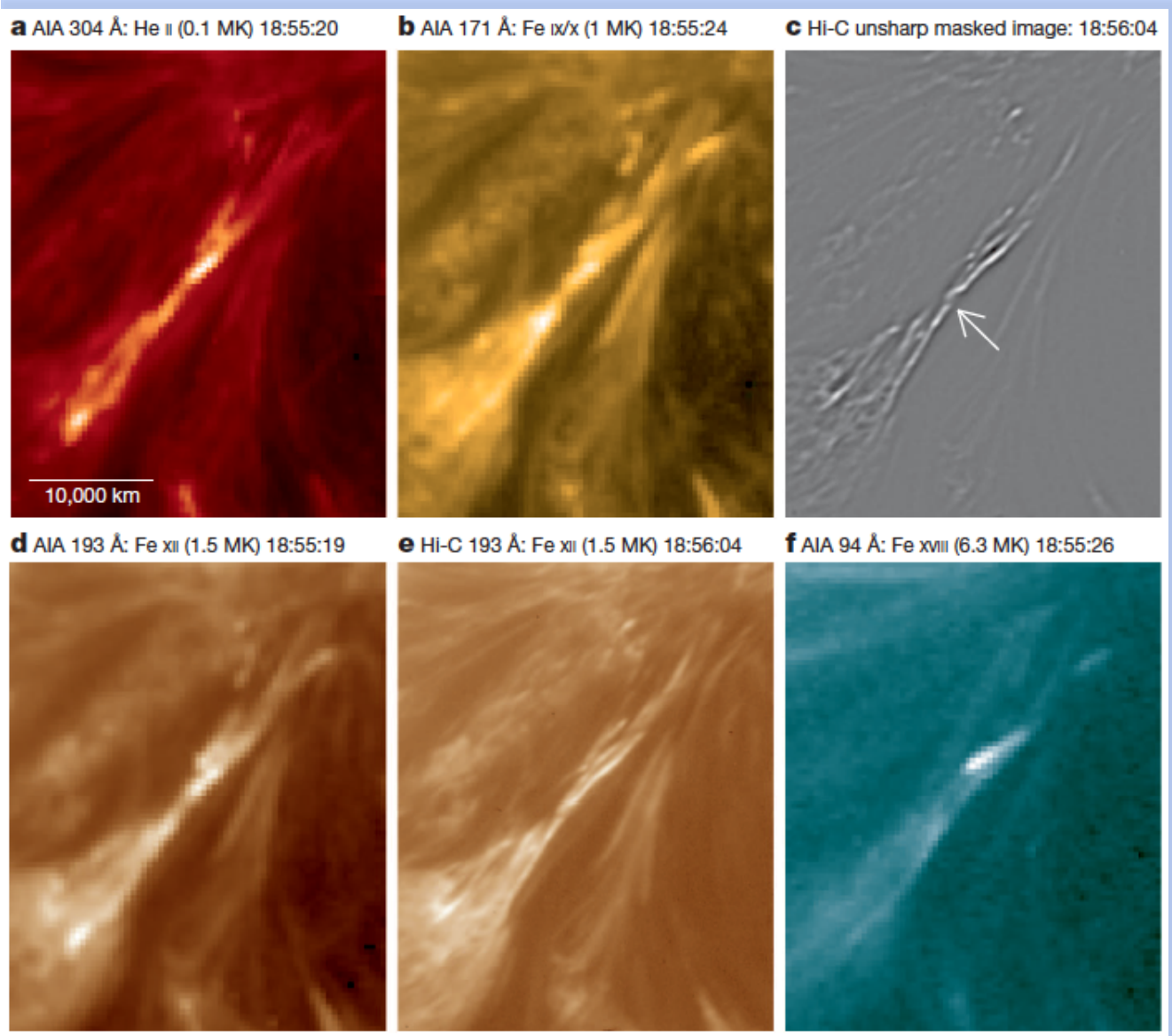
Dynamic activities

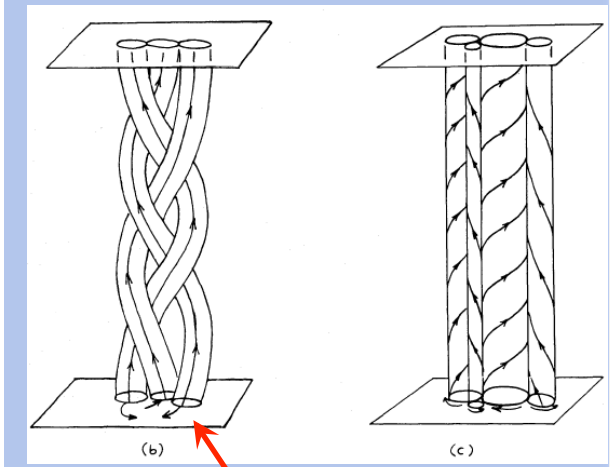
Fine-Scale Structure / Role of Braiding



(Cirtain et al. 2013)

Coronal heating by reconnection

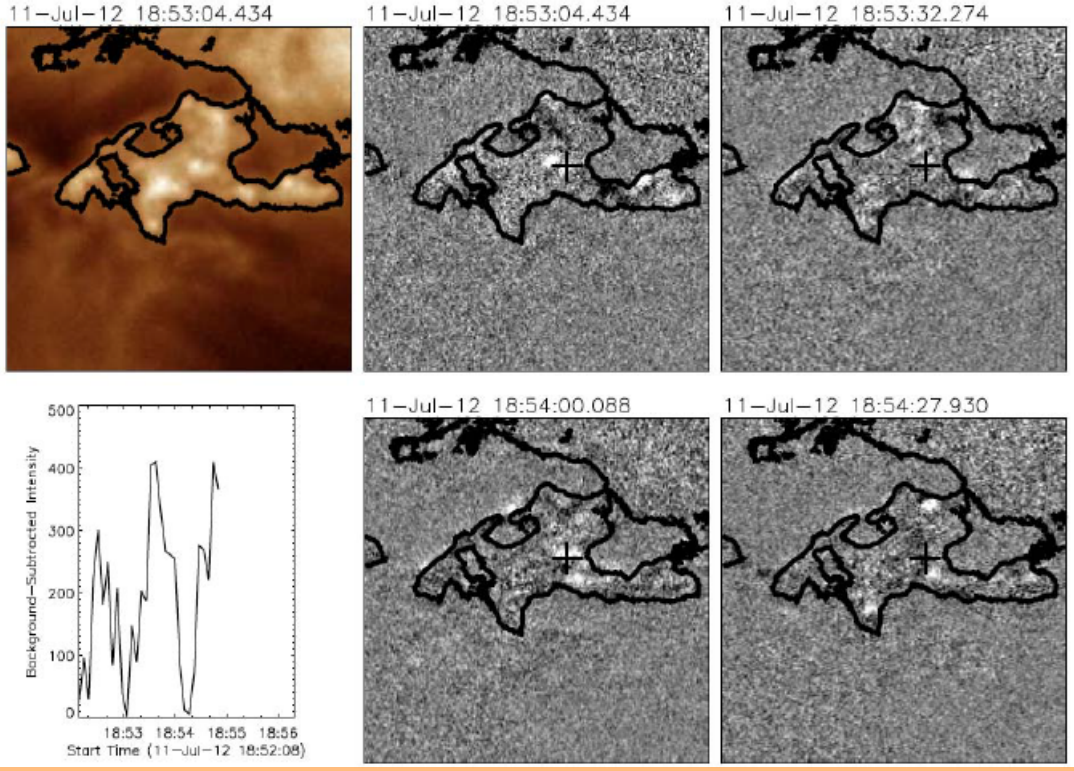
Braiding structure as a possible agent for coronal heating?

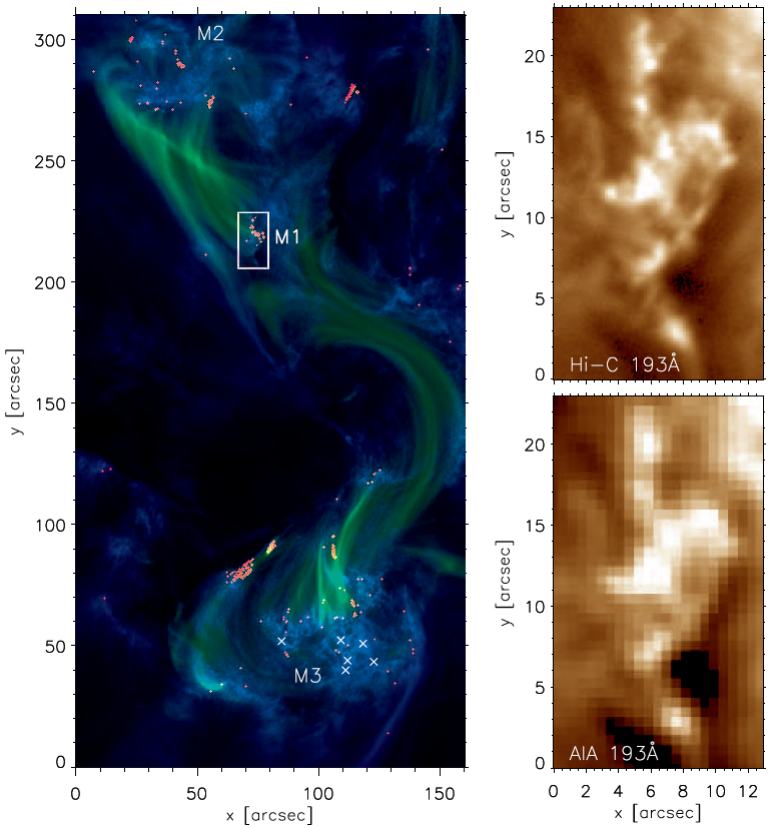


(Parker 1983)

Magneto-convective forcing? ← **SUVIT**

Moss Brightening to Infer Heating Timescale in the Corona





(Testa et al. 2013)

Nanoflare heating of the corona?

Thermal conduction timescale τ ~5 s

for E = 10^{24} erg, S = 2 x 10^{14} cm^2, T = 10 MK, L = 10^9 cm

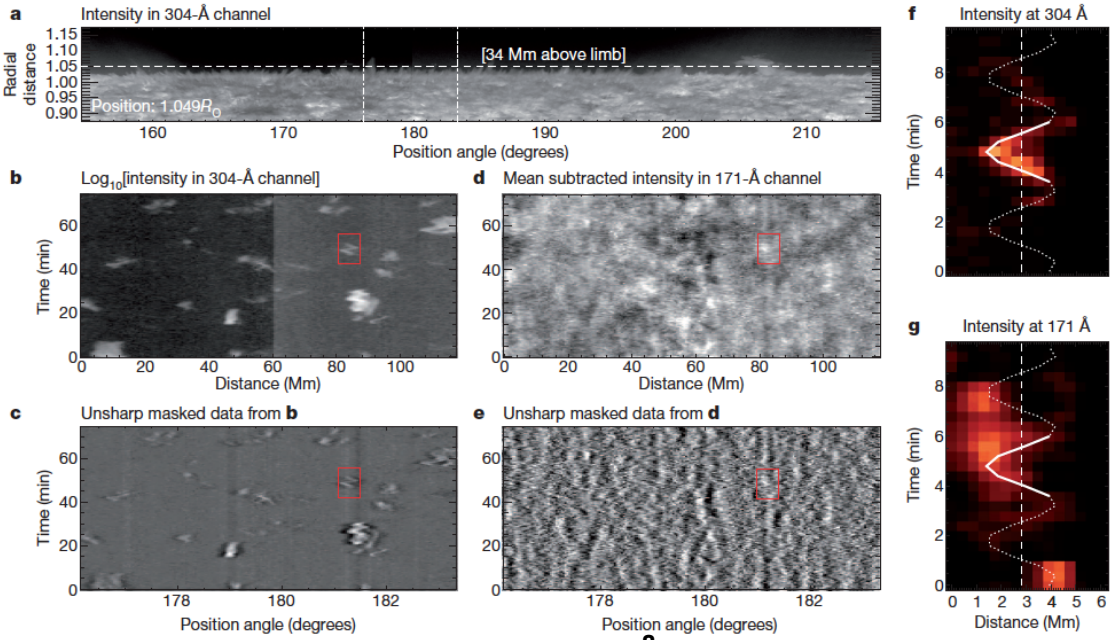
Hi-C observation with Δt = 5.5 s, $\Delta\theta$ = 0.25" started to detect impulsive brightening in the moss.

Alfvenic Waves in the TR and the Corona

Coronal heating by waves

Low frequency waves (P >~100 s) OK to heat QS & CH, but not likely to heat ARs

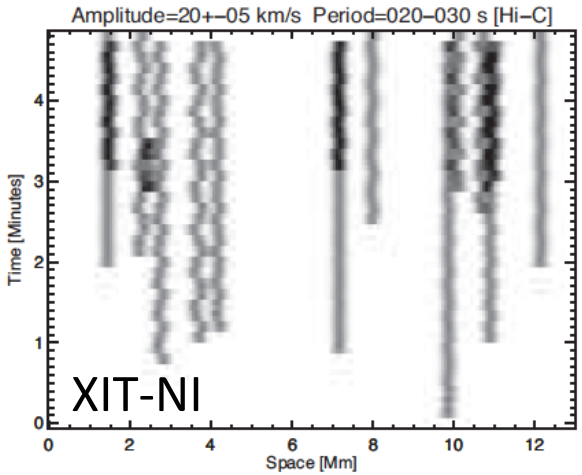
- Spatial resolution?
- How about higher frequency waves with P down to several second?

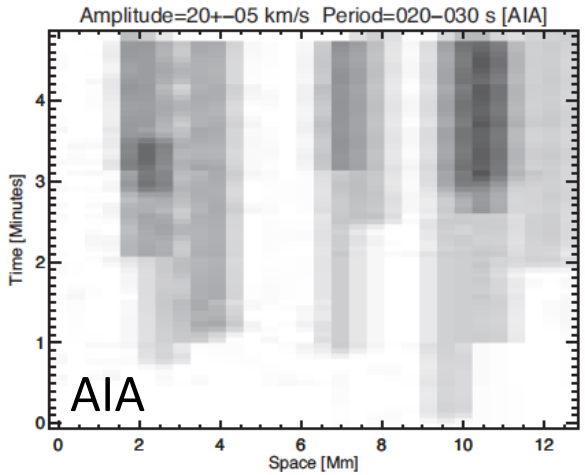


AIA 304 Å (McIntosh et al. 2011)

Wave detection capability: XIT vs AIA

Simulation with P = 20-30 s, δv = 20 km/s (± 5 km/s)

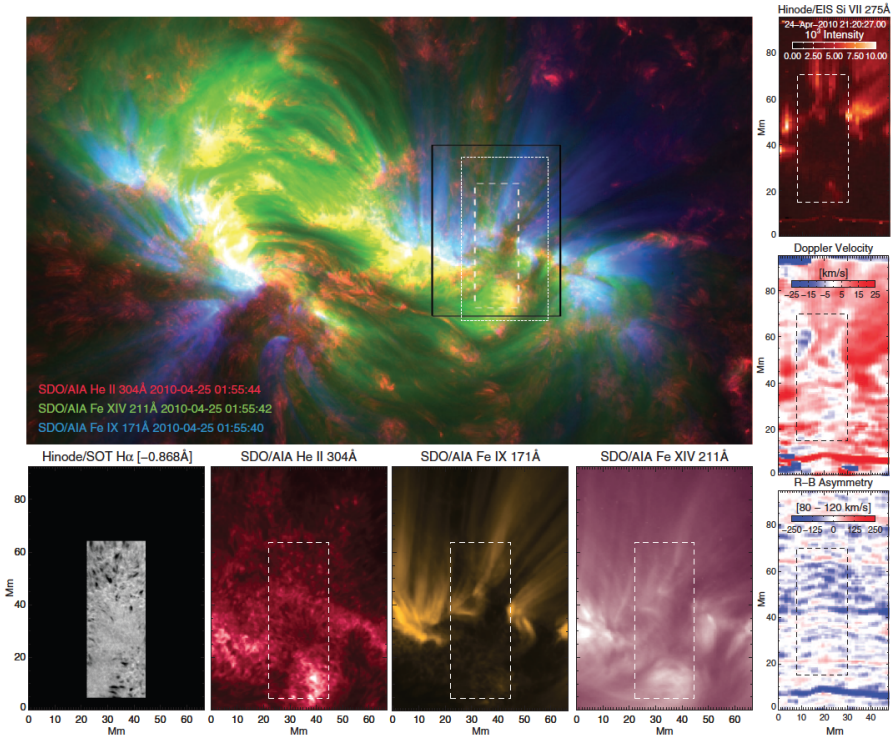




Low freq. power (~mHz):
Lateral oscillation ***with XIT***

High freq. power (~kHz):
Non-thermal broadening ***with EUVST***

Role of Chromospheric Spicles into the Corona



(**AIA 304, 171, 211 Å**; De Pontieu et al 2011)

Coronal counterpart of chromospheric spicules has only been marginally identified.

Neet to resolve:

- Spicule diameter < 0.5”
- Time scale 10-20 s

Mag. info. from SUVIT

Velocity info. from EUVST

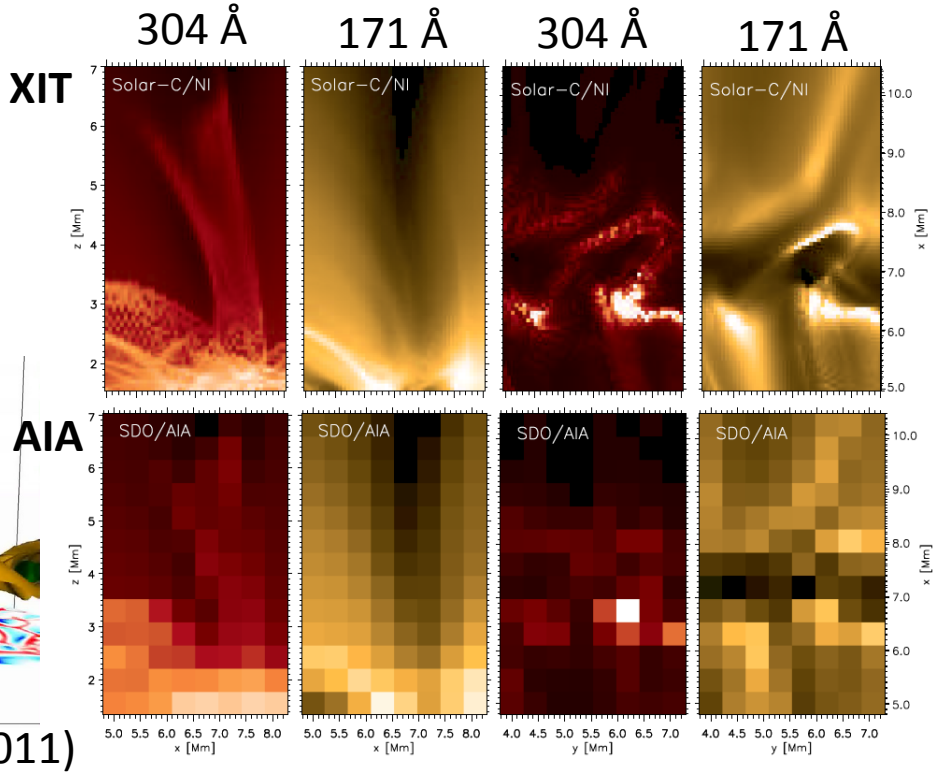
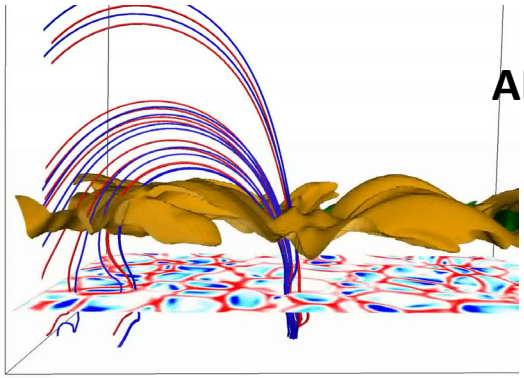


Image fine structures predicted by numerical simulations



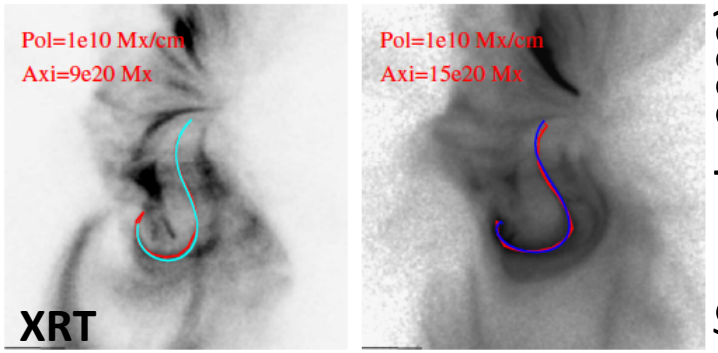
(Martinez-Sykora et al. 2011)

Measurement of free magnetic energy for energy buildup & release

Coronal magnetic field extrapolation by SUVIT

- Fine trace of coronal magnetic field (though thermally modulated) as the reference of NLFFF calculation
- Direct use in NLFFF calculation with flux-rope insertion method

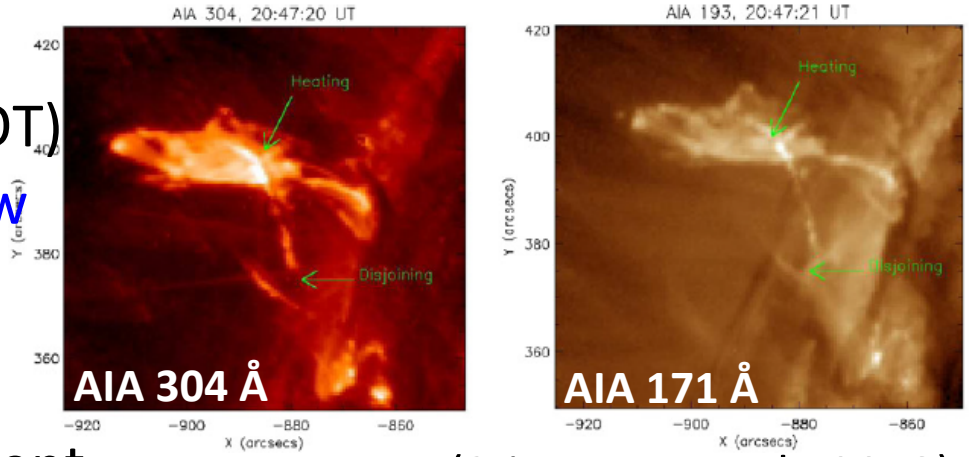
→ *Free energy buildup for flares*



(Su et al., 2009)

Structure of prominences and their eruptions

- Structure and dynamics at 0.2" scale in prominences present (SOT)
- Heating/dynamics at scales below AIA resolution



Strucutre: 304 Å, Heating: 171 Å

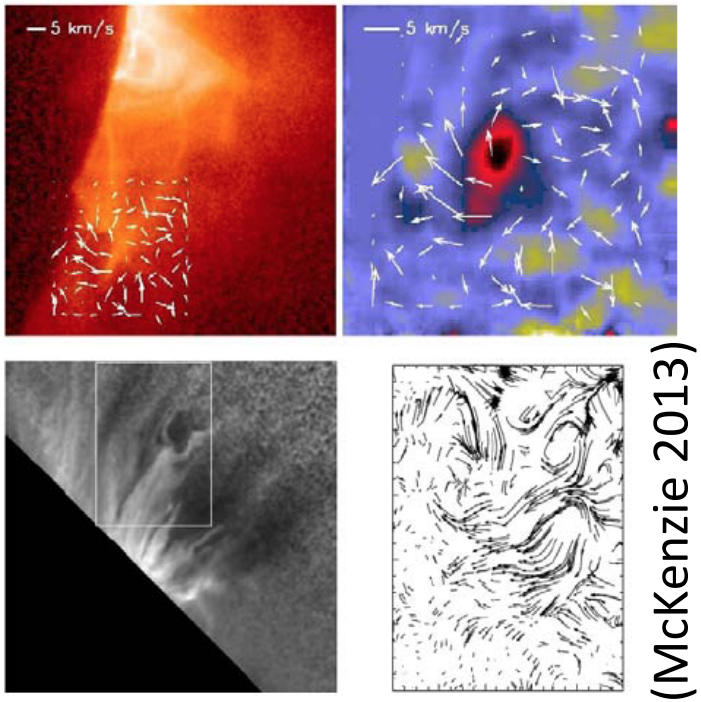
FOV: ~400"x400" to give entire extent

(Srivastava et al., 2013)

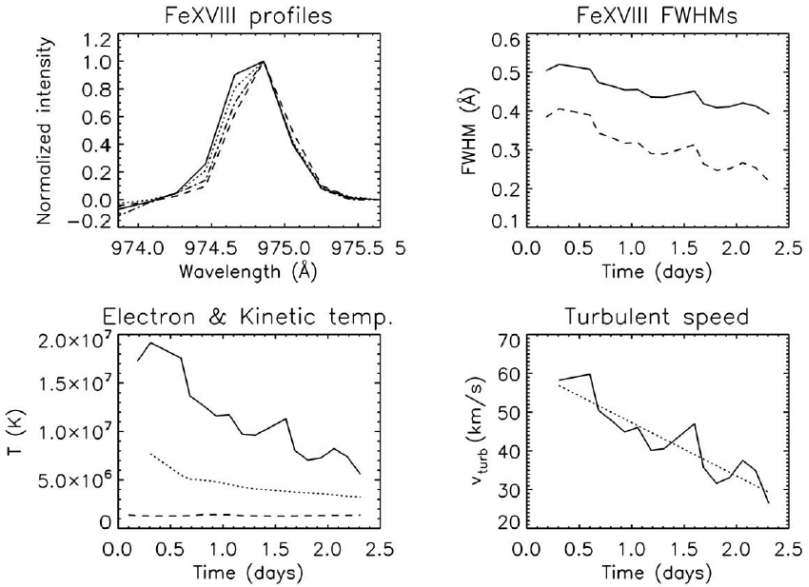
Current sheet dynamics

- Inefficient magnetic diffusion
  → **Slow reconnection**
- To make small length scale
  → <u>Turbulence</u> as a candidate to generate the small scale

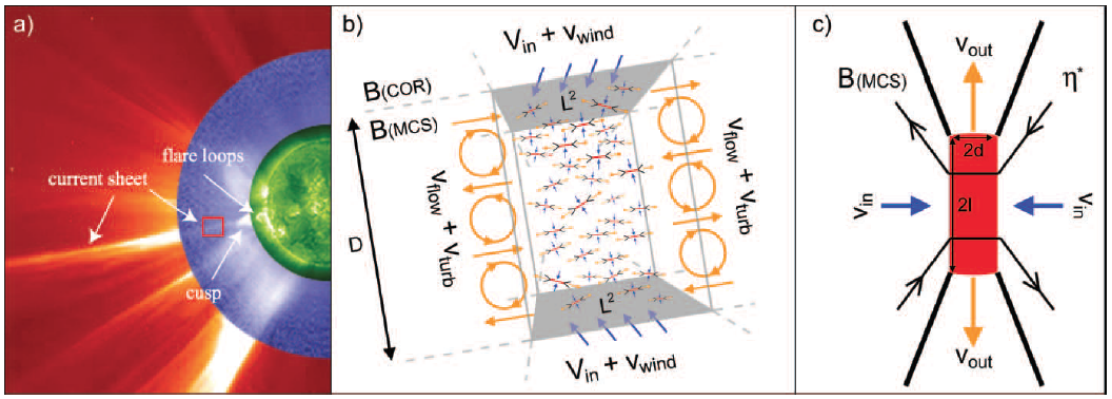
- CSs have been seen in **94**/131/193 Å
- Turbulence down to small spatial (≪1”) and temporal (a few seconds) scales



(McKenzie 2013)



UVCS detection of turbulence in post-CME current sheet (Bemporad 2008)



Preliminary Features of XIT-NI

Item	XIT-NI	EUVST
Telescope	32cmϕ primary mirror 3 sector coating (Ritchey-Chretien; ~4 m length) Tip-tilt control of the secondary	
Wavelength channel Temperature coverage	171 Å, 94 Å, and 304 Å (or UV band) (0.8MK / 1MK & 8MK(FL) / 0.05 MK) [some from 94/171/195/211/304/335Å]	
Spatial resolution	0.2" – 0.3" (0.1" pixel)	0.16" pixel
Exposure cadence	Exposure time : AR (<3 MK) – 1 s, FL – 0.1 s Cadence : typ. ~10 s (for AR <3 MK) max. 1-2 s AEC capability	Exposure time : AR – 1-5 s (w/ 0.33" spatial sampling)
Field of view	~400" x 400"	200" nominal > 300" extended
Data rate	std.: 1.3 Mbps (200" x 200"; 10 s) burst: 3.1 Mbps (100" x 100"; 1 s)	

Image
- Lower TR
- Lower corona
- Hot corona (with 1 MK)

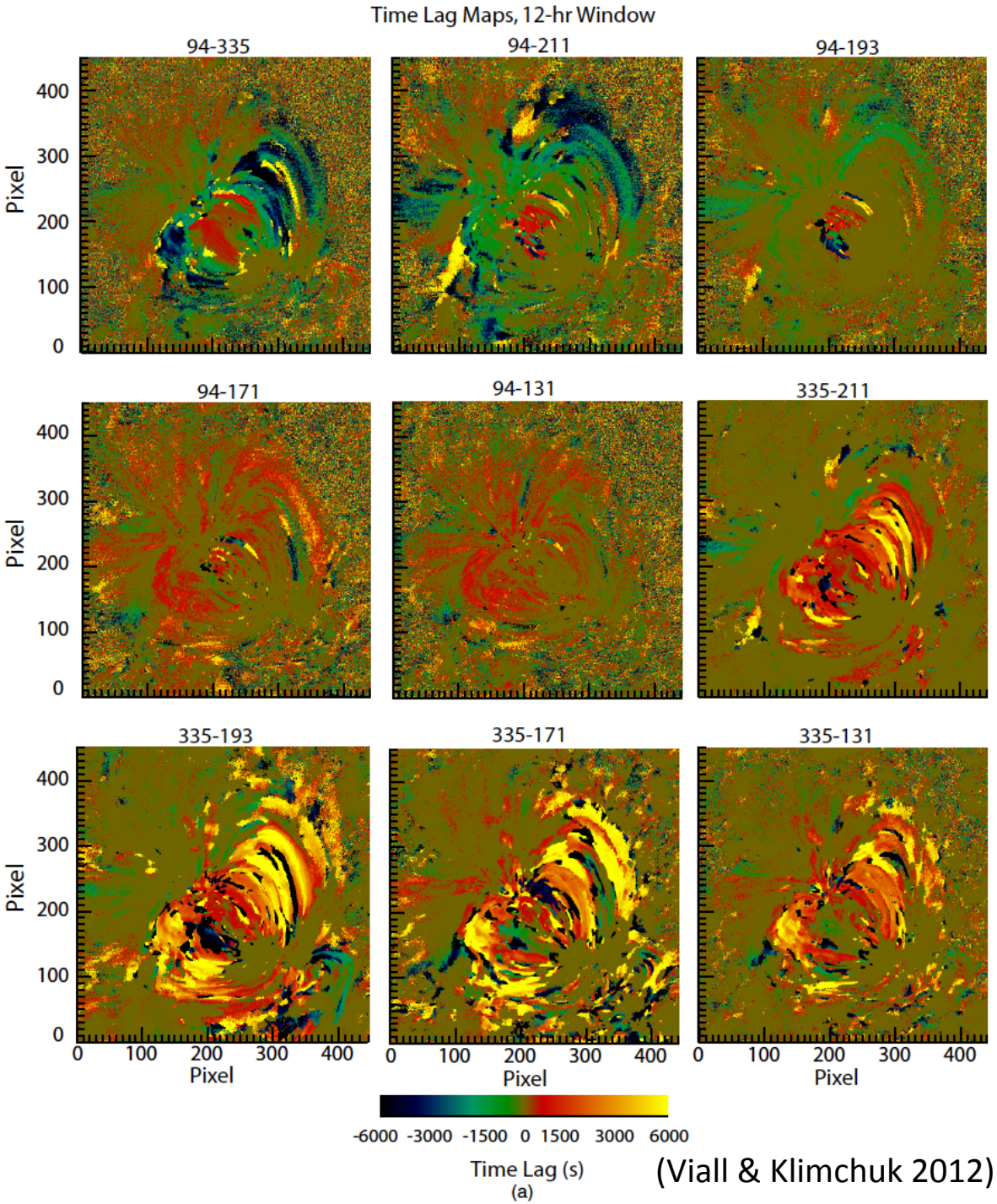
Provide context for EUVST

Line Candidates (Provisional)

Line	Target	Remark
304 Å	Imaging of lower TR (~0.1 MK); spicules and prominences • Fine magnetic structures in the TR • Alfvenic waves and their energetics in the TR • Chromospheric/TR spicules	Causal ch-co relationship in imagery with 304-171
171 Å	Imaging of lower corona (1 MK) • Fine magnetic structures (braiding/twist) of warm loops • Alfvenic waves and their energetics in the corona • Coronal counterpart signatures of chromospheric spicules	
94 Å	Imaging of high-temperature corona (>5 MK) • Fine magnetic structures (braiding/twist) of hot loops • Heating of hot loops	Heating of AR core and subsequent cooling down to warm loops

Line Cand

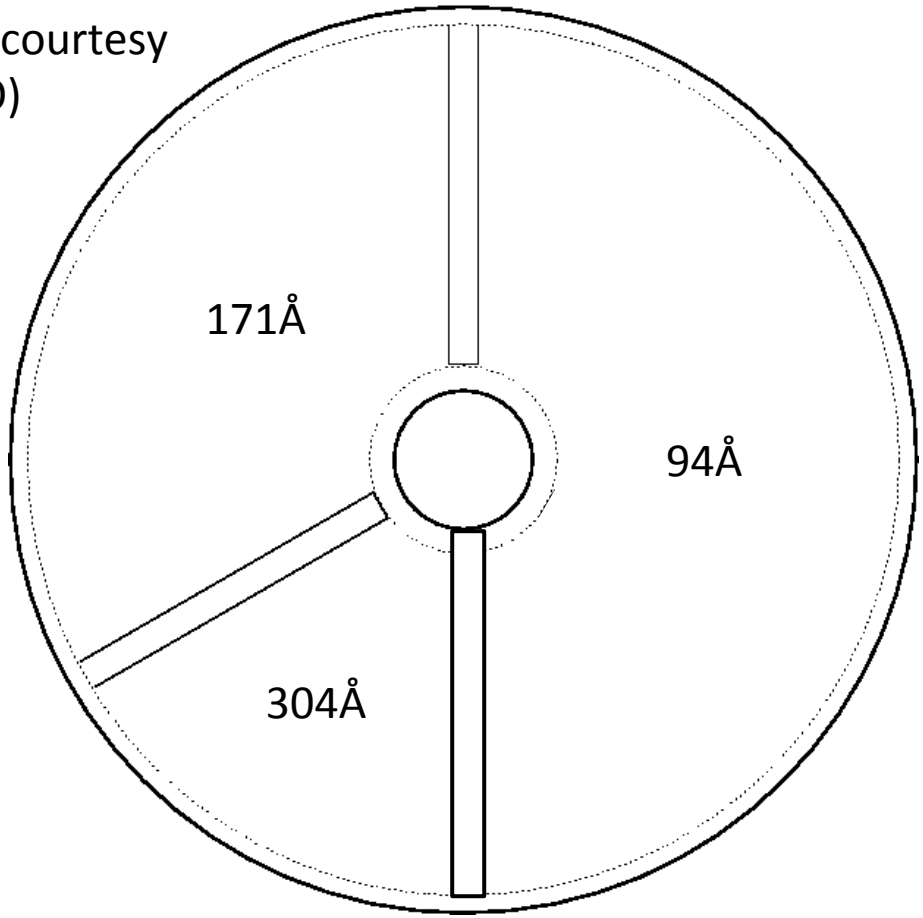
Line	Target
304 Å	Imaging of lower TR (• Fine magnetic struct • Alfvenic waves and t • Chromospheric/TR s
171 Å	Imaging of lower corc • Fine magnetic struct • Alfvenic waves and t • Coronal counterpart spicules
94 Å	Imaging of high-temp • Fine magnetic struct • Heating of hot loops

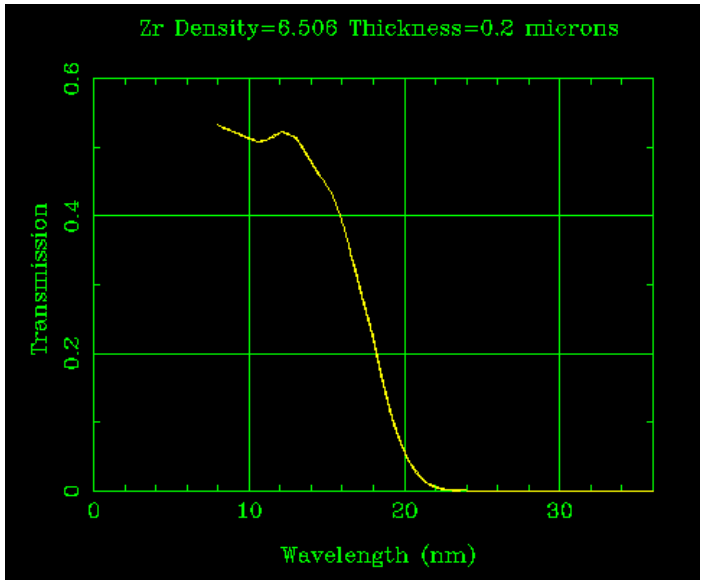


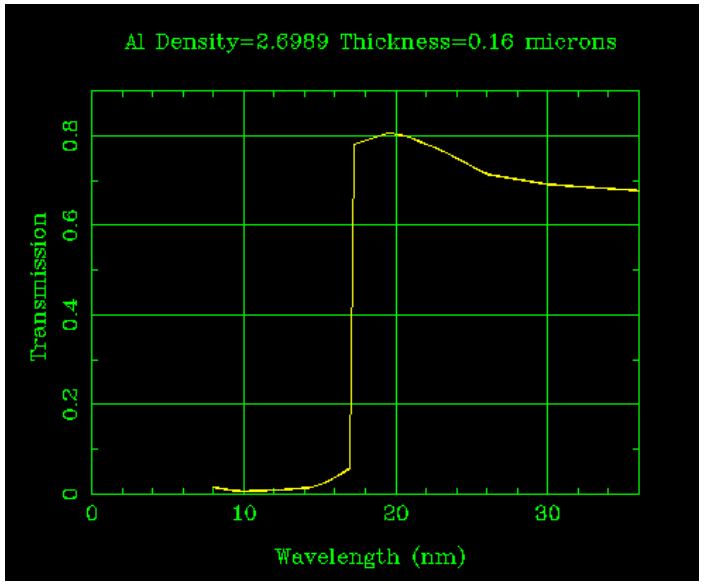
(Viall & Klimchuk 2012)

Three-Channel NI Layout

(Figure courtesy of SAO)





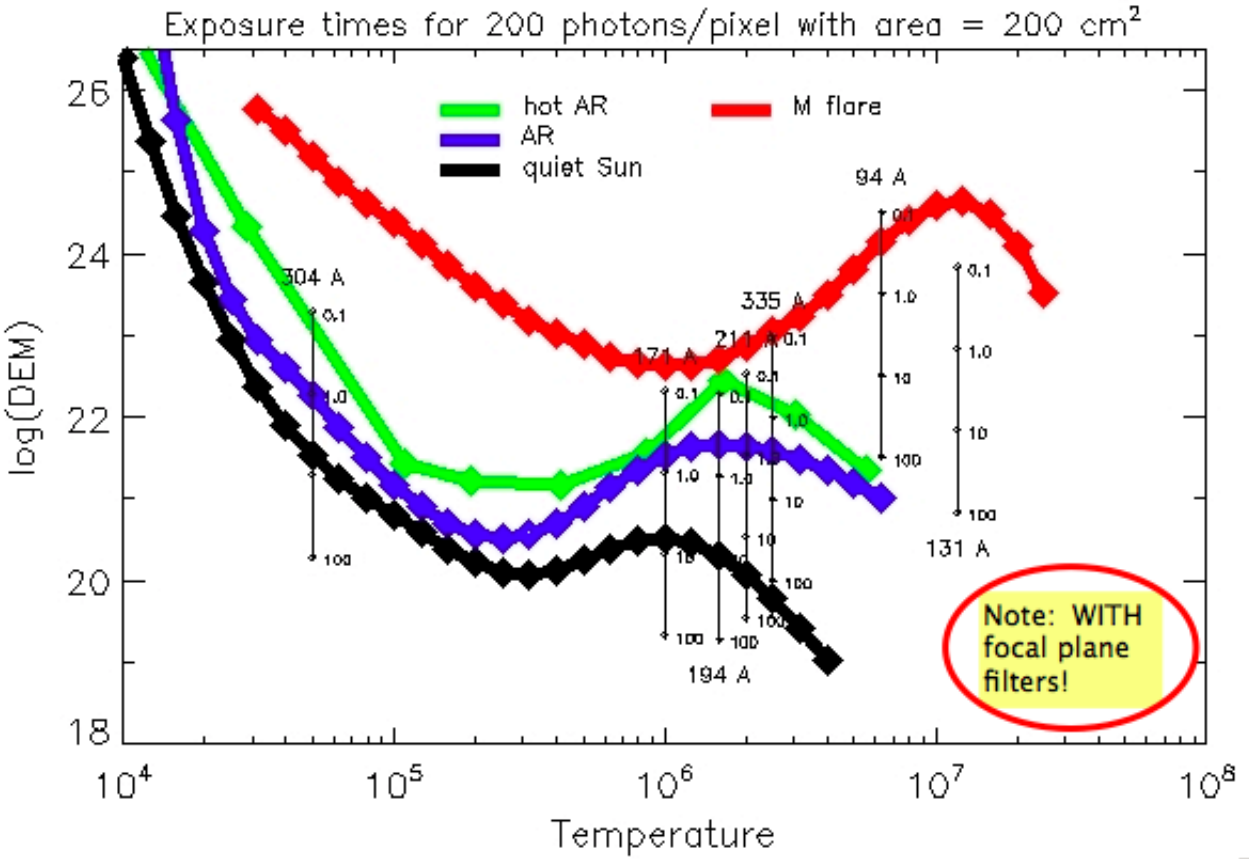


Primary: Φ32 cm, efl=16 m

Sector: $A_{geom} \approx$ 100, 200, 300 cm^2

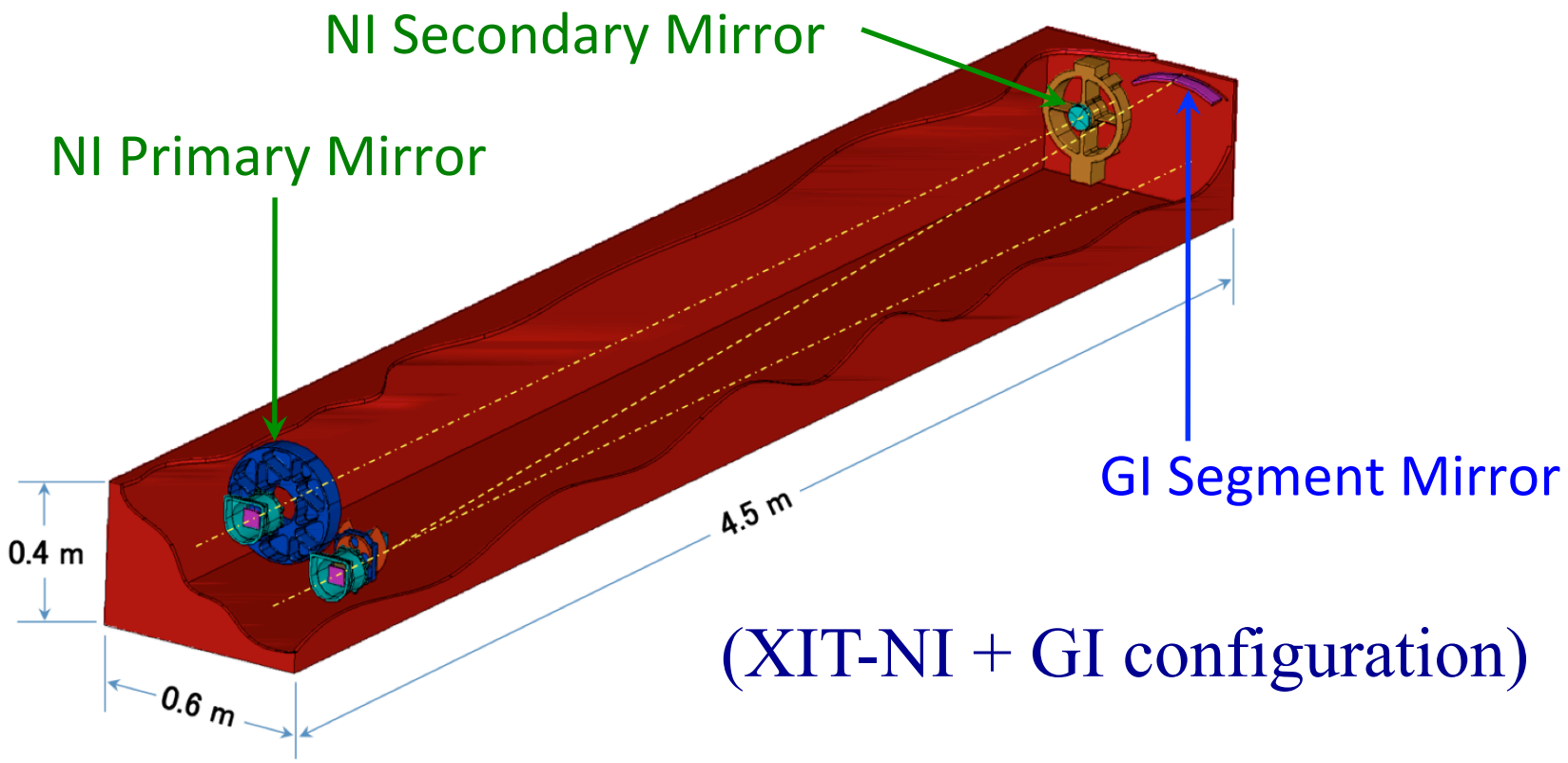
Channel selection via **focal plane filters!**

Issue(s)



- Exposure time for 94 Å very long (>1 min.) even for AR. Useful for brightenings, but what else?
- Other line possibilities?

Preliminary Outlook of the X/EUV Telescope



(XIT-NI + GI configuration)

Baseline 3 NI Channels:
94, 171, 304 Å (or 1548 Å)
Sector coating

Optional GI Channel:
Photon Counting in
0.5-10 keV

Scientific Requirements and Design Goal for XIT-GI

	Requirement	Design goal
Imaging-spectroscopic spatial resolution	~< 2”	1”-2”
Imaging- spectroscopic temporal resolution	~< 30 s	20 s – 10 s
Field of view	Photon-counting ~100” x 100” Photon-integration ~400” x 400”	Photon-counting >~100” x 100” Photon-integration >~400” x 400” (0.4”-0.5”/pixel)
Energy range	~0.5 – 10 keV	~0.5 – 10 keV
Energy resolution of the focal-plane array	Equivalent to CCD	CMOS-APS

Thank You!