

Science and possible instrumentation with Normal Incidence (NI) Imager for Plan B/SOLAR-C

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The Advantages of a NI Imager

- A Normal Incidence (NI) imager has the following advantages in comparison with a Grazing Incidence (GI) Imager.
 - **Higher spatial resolution (sub-arcsec)**
 - Enable to take roughly single-temperature images
 - It is also disadvantage because we need the large or plural mirrors if the telescope covers wide temperature range.
 - The length of a NI Tel. is shorter than a GI Tel.

The key point of the NI telescope for Plan B/SOLAR-C is the spatial resolution!!

How high spatial resolution do we need ?

- **TRACE Result** (Aschwanden & Nightingale, 2005)
 - If we define the elemental scale as a homogeneous temperature cross section, TRACE has already resolved the elemental structure (1000~2000 km) in corona.
 - They did not deny that there may be the fine structures in an isothermal loop.
- **EIS/Hinode result** (Warren, et al. 2008)
 - The volumetric filling factor of the coronal loop is 0.1.
 - It means that the actual width of an elemental structure is smaller than 230 km (0.3”).

The results indicate that **the spatial resolution of a NI telescope for SOLAR-C has to be smaller than 0.3”**.

(Note: The pixel size of AIA/SDO is the same as that of TRACE)

How high spatial resolution do we need ?

- Can we decide the target of the spatial resolution for the NI telescope from **the scientific point of view**?
- The answer is **“No”**.
 - The physical process of making the elemental scale in the coronal loop is unknown.
 - The width of the current sheet is “cm” scale.
 - The scale is not the realistic scale for the target of the telescope.

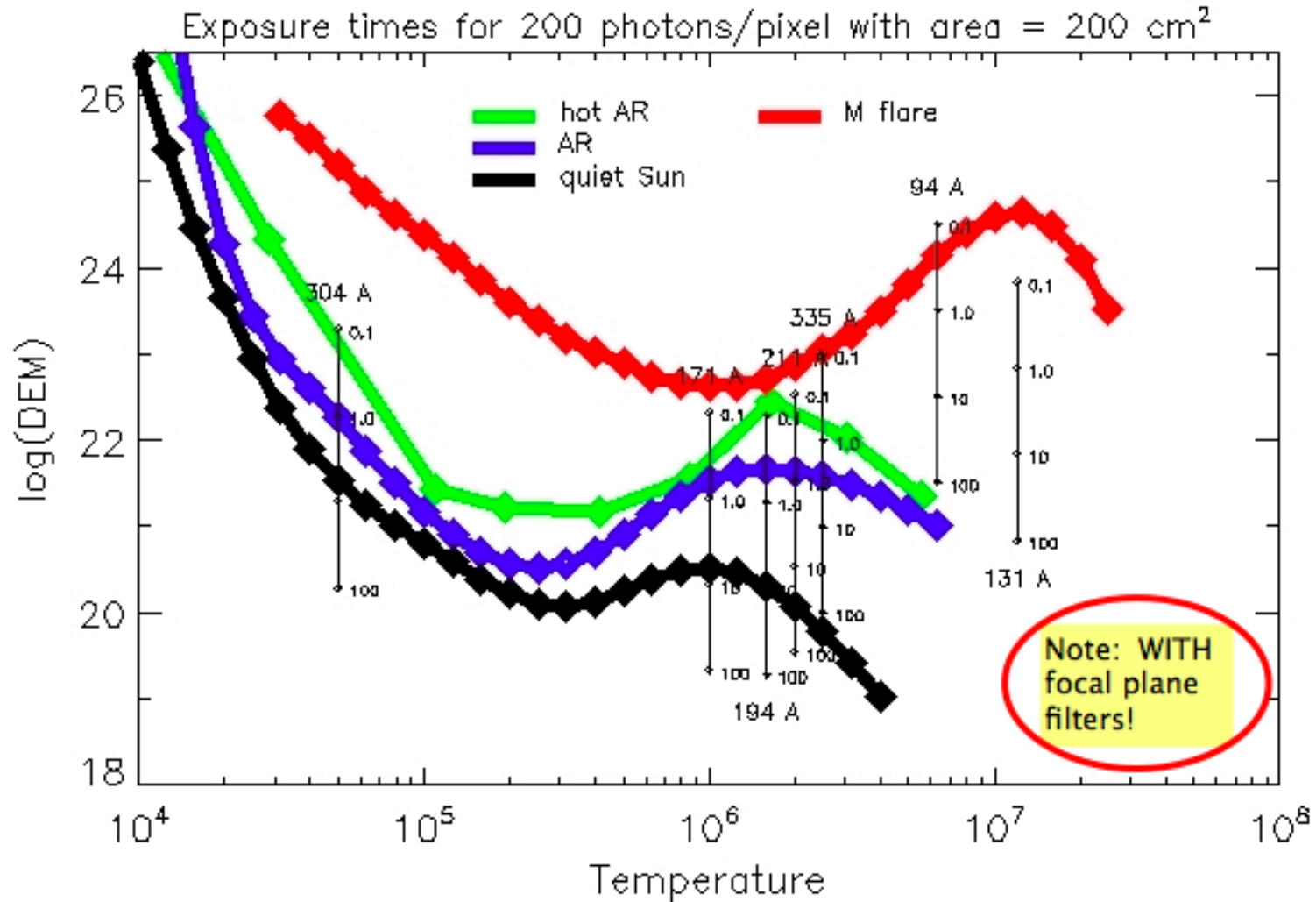
We discuss **what kind of subject become the science target, based on the possible NI Imager** for Plan-B/
SOLAR-C.

The baseline of the NI Imager for Plan-B/SOLAR-C

Spatial Resolution	0.2 arcsec (pixel size: 0.1)
Max. Time Cadence	< a few second for an active region.
Field of View	400 arcsec x 400 arcsec (cover an active region)
Line Selection (Candidates)	<4 lines is minimum> 171 Å, 194 Å, 304 Å, 465 Å (Ne VII), UV option (1550 Å) 131/133 Å (Fe VIII/Fe XXII), 335 Å, 94 Å (Fe XVIII), 211 Å. (The results of SDO will provide good guiding principles for the line selection.)
Number of Telescope	2 or 3 (2 channel per 1 telescope)
Geometry Area	200 cm ² per one line (If two lines are observed one mirror, the diameter of the primary mirror is 25 cm.)

Note: We do not perform the detail feasibility study of the telescope.

DEM-vs-exposure for 7 EUV channels *with* focal plane filters



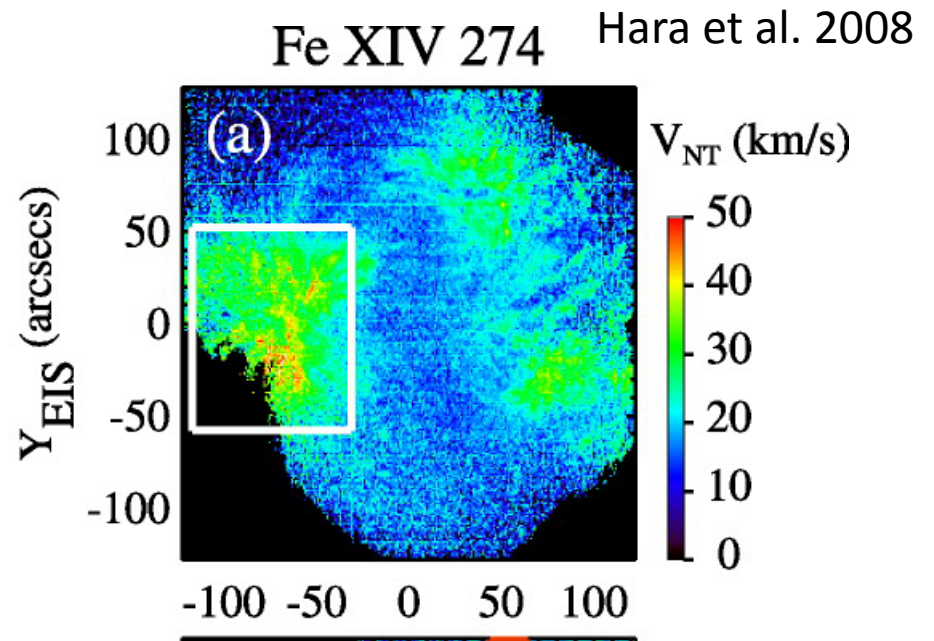
- The vertical bar shows necessary exposure time (in seconds) to yield a signal of 200 photons/pixel.

Science Goals of the NI Imager

- An elemental structure in solar corona
(It is already described.)
- Trace Energy flow
- Magnetic dispassion and reconnection
- Space Weather
- Particle acceleration
- Connection to heliosphere

Trace Energy Flow from Chromosphere to Corona

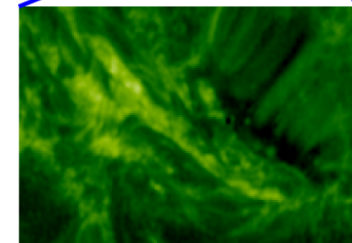
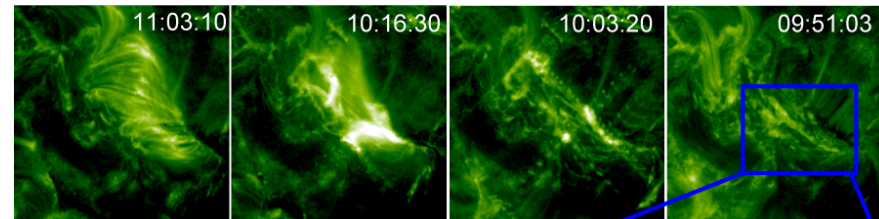
- EIS shows the upward flow / line broadening around the footpoints of coronal loops.
- In order to resolve the energy flow (wave, mass) from chromosphere to corona, NI Tel. observes the “moss” with the ultra-high resolution.



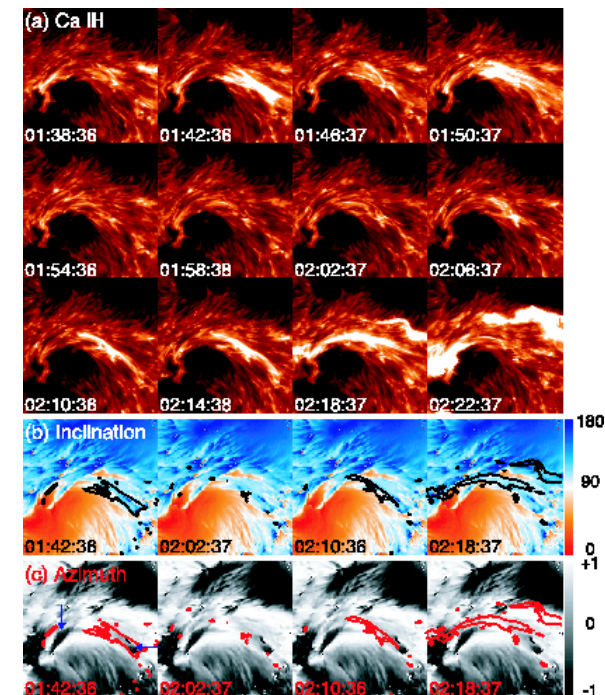
The cooperation with the EUV spectrograph is very important.

Energy Storage and Trigger of Flares

2001-Mar-29 X1.4 Flare



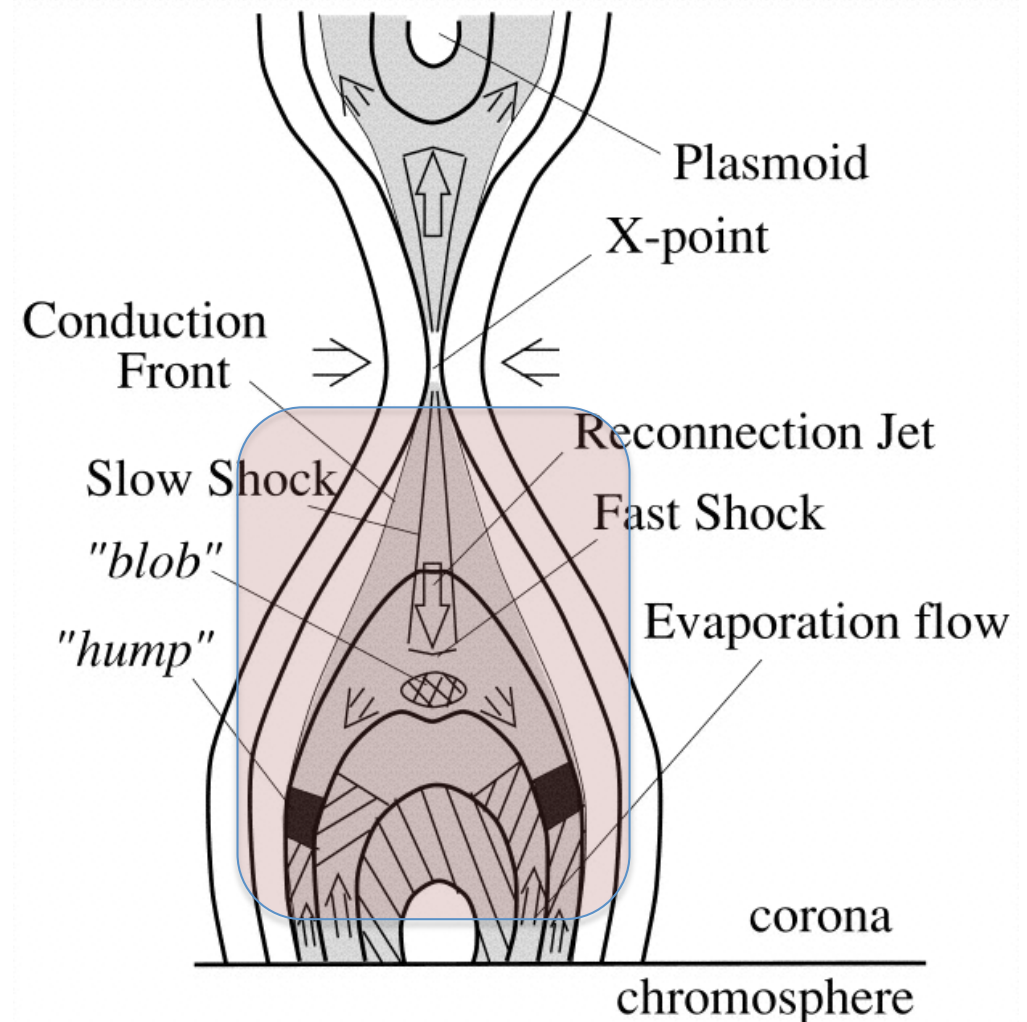
- Filaments/Sigmoid formation
 - Where does the flux rope come from?
 - From sub-surface? (Okamoto et al. 2009)
 - Construct in the corona?
- What is the trigger of the flare?
 - Small emerging flux?
 - Complex magnetic configuration? (Kubo et al. 2007)
- The theme connects to space weather study.



Magnetic Reconnection

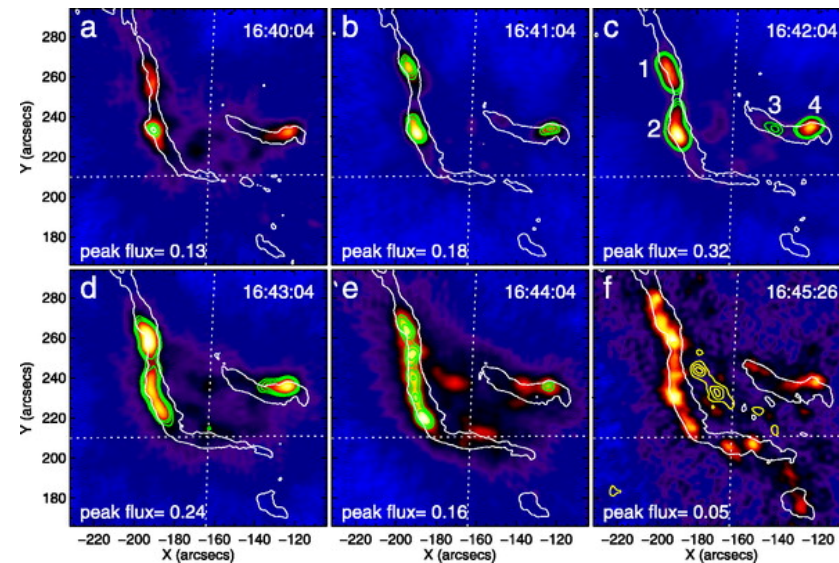
Yokoyama & Shibata 2000

- What are the thermal structure and the motion under the current sheet?
- Dynamics and heating process of the reconnected loops?
- For the themes we need a channel for the high temperature EUV lines.



Particle acceleration

- EUV/UV is emitted by non-thermal particles when the particles are bombarded to the TR/Chromosphere.
- The size of the EUV/UV kernels is small ($< 1''$)
- Observe EUV/UV kernels with high resolution and study the relation between acceleration sites and the coronal loops.

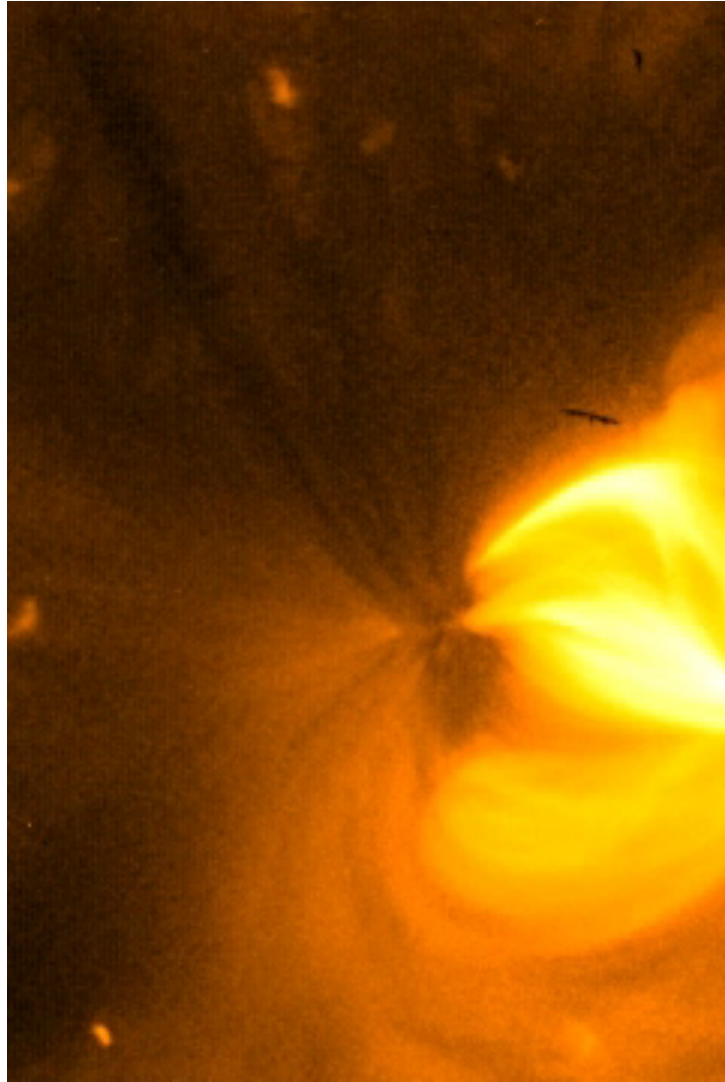


Note 1: The UV channel is better than the EUV channels.

Liu et al.

Note 2: If the optical telescope has the high time resolution,
the H alpha channel of the optical telescope is also useful for the target.

Connection to heliosphere



- Observe the footpoints of open fields that connect to the interplanetary space.
 - The origin of slow solar wind.
 - Origin of the plasma flow discovered by XRT/Hinode

Concerns about the NI Imager for Plan B/SOLAR-C (Shimojo's personal comments)

- If the NI Imager with **high spatial resolution** (0.2") is realized for SOLAR-C, we will be able **to open new window of coronal physics**. However, now, **we can not decide one main science goal** of the telescope, I think.
- The NI Imager becomes a **very powerful tool for understanding the physical processes** of the phenomena that are observed by the UV/EUV spectrograph. But, **it is unclear what we can obtain** the scientific result from only the image take with the NI imager.

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