Solar-B X-ray Telescope (XRT)

R. Kano (NAOJ) and XRT Team
“Coronal Heating”
How are coronal structures heated?

Dynamics in Chromosphere & Corona
Magnetic Activities at Photosphere
Coronal Activities

EIS
SOT
XRT
Targets of XRT Observations

- Photosphere/Corona Coupling
  - Can a direct connection be established between coronal and photospheric events?

- Coronal Heating
  - How do coronal structures brighten?

- Coronal Loop Structures & Coronal Loop Heating

- Flare Energetics
  - What are the relations to the photospheric magnetic fields?

- CMEs, Jets and other coronal dynamical events
SXT Loops vs. EIT/TRACE Loops

SXT loops in active regions

Are they really different? Are they heated in a different way?

• We would like to observe all of the coronal plasma with a single telescope.
• However, we would like to distinguish between SXT loops and EIT/TRACE loops. (Importance of temperature diagnostics.)

SXT Loops vs. EIT/TRACE Loops

Do SXT loops have a dense plasma at the top?
Is it an apparent feature in a loop (by change of filling factor)?

- EIS can derive the coronal density with density-sensitive line pairs.
  (Importance of the coordinated observation between EIS and XRT.)

SXT loops in active regions
EIT Image

### Solar-B/XRT vs. Yohkoh/SXT

<table>
<thead>
<tr>
<th></th>
<th>Solar-B/XRT</th>
<th>Yohkoh/SXT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Optics</strong></td>
<td>Grazing Incidence</td>
<td>Grazing Incidence</td>
</tr>
<tr>
<td><strong>FOV</strong></td>
<td>34 arcmin</td>
<td>42 arcmin</td>
</tr>
<tr>
<td><strong>Pixel Size</strong></td>
<td>1 arcsec</td>
<td>2.5 arcsec</td>
</tr>
<tr>
<td><strong>PSF FWHM</strong></td>
<td>&lt;1 arcsec @ center</td>
<td>~ 3 arcsec</td>
</tr>
<tr>
<td><strong>Bandpass</strong></td>
<td>3 ~ 200Å</td>
<td>3 ~ 45Å</td>
</tr>
<tr>
<td><strong>Temp. Coverage</strong></td>
<td>1MK ~ 30MK</td>
<td>3MK ~ 30MK</td>
</tr>
<tr>
<td><strong>Time Cadence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Frame, Full-res.</td>
<td>min 9.5sec</td>
<td>256sec (Half Frame)</td>
</tr>
<tr>
<td></td>
<td>min 5.0sec</td>
<td>128sec</td>
</tr>
<tr>
<td></td>
<td>avg. 102sec</td>
<td></td>
</tr>
<tr>
<td>Partial Frame, Full-res.</td>
<td>min 2.0sec</td>
<td>8 sec in flare mode</td>
</tr>
<tr>
<td>(FOV = 300”~400”)</td>
<td>avg. 15sec</td>
<td>32 sec in Quiet mode</td>
</tr>
<tr>
<td>Other New Items</td>
<td>Pre-flare Buffer</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>Focus Mechanism</td>
<td></td>
</tr>
</tbody>
</table>
XRT characteristics

• Temperature Response
  – TRACE-like image and SXT-like image

• Field-of-View and Spatial Resolution
  – Focus Mechanism

• Observation control by MDP
  – Table Observation
  – Image Compression
  – Time Cadences
  – Preflare Buffer
X-ray Analysis Filters

- XRT has 9 X-ray analysis filters and a G-Band filter.

<table>
<thead>
<tr>
<th>Name</th>
<th>Metal</th>
<th>Metal Thickness</th>
<th>Substrate</th>
<th>Substrate Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin-Al/Mesh</td>
<td>Al</td>
<td>1600 Å</td>
<td>Mesh</td>
<td></td>
</tr>
<tr>
<td>Thin-Al/Poly</td>
<td>Al</td>
<td>1250 Å</td>
<td>Polyimide</td>
<td>2500 Å</td>
</tr>
<tr>
<td>C/Poly</td>
<td>C</td>
<td>6000 Å</td>
<td>Polyimide</td>
<td>2500 Å</td>
</tr>
<tr>
<td>Ti/Poly</td>
<td>Ti</td>
<td>3000 Å</td>
<td>Polyimide</td>
<td>2300 Å</td>
</tr>
<tr>
<td>Thin-Be</td>
<td>Be</td>
<td>9 µm</td>
<td>Mesh</td>
<td></td>
</tr>
<tr>
<td>Med-Al</td>
<td>Al</td>
<td>12.5 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Med-Be</td>
<td>Be</td>
<td>30 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thick-Al</td>
<td>Al</td>
<td>25 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thick-Be</td>
<td>Be</td>
<td>300 µm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2005/11/15 STEREO/Solar-B Workshop
XRT Temperature Response

TRACE-like

SXT-like

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Field of View (FOV)

• To point SOT at a certain target on the solar disk, we have to change Solar-B pointing. Therefore, XRT will not always observe the full solar disk.

• Many varieties of FOV size are available.

• Especially, for high-res.-observation, we recommend FOV= 1024”x1024” around CCD center.
Importance of Wide FOV

- Moreton waves tend to propagate along the global magnetic fields.
- X-ray waves also propagate with Moreton waves.
Field of View (FOV)

- To point SOT at a certain target on the solar disk, we have to change Solar-B pointing. Therefore, XRT will not always observe the full solar disk.

- Many varieties of FOV size are available.

- Especially, for high-res.-observation, we recommend FOV = 1024”x1024” around CCD center.
Aberration at Different Focus Pos.

(Only Geometrical Optics)

RMS=φ1"

Distance from the Center
Observation of XRT

XRT

Mission Data Processor

- Observation Tables

Autonomous Functions
- Exposure Control
- Region Selection
- Flare Detection

Image Compression

Pre-Flare Buffer

Data Recorder

2005/11/15
STEREO/Solar-B Workshop
Image Compression

• MDP can compress the image data. Observer selects the following options.
  – No compression
  – DPCM (lossless) compression
  – JPEG (lossy) compression
  • Q-factor = 98, 90, …, 65.
Typical Time Cadences

- typical data rate for XRT ~ 600 k pixel / min
  - ex.1: Continuous Observation for AR
    - AR FOV = 384” × 384”, 1”-res.
  - ex.2: High-Speed Observation for AR
    - AR FOV = 384” × 384”, 1”-res.
  - ex.3: Combination of Narrow and Wide FOV
    - Narrow FOV = 384” × 384”, 1”-res.
    - Wide FOV = 2048” × 2048”, 4”-res.
Pre-flare Observation

**SXT Image**

09:09:09UT

**Temp. Map**

09:20:37UT

09:27:01UT

09:30:31UT

09:32:35UT

**X-ray Total Intensity (10^6 DN/s)**

- Intensity
- Temperature

\[ \text{Start Time (20-Sep-97 09:08:00)} \]

**FOV = 256"x256", 1"-res.**

**Time Cadence = 10 ~ 20 sec for a filter pair**
Flare Observation

**XRT**
- Detect a flare.
- Report the location to all telescope.

**XRT Intensity**
- Switch the current observation to *Flare* one.
- Lock the Pre-Flare Buffer.
- *(There is a option not to switch to Flare observation.)*

**SOT**
- Switch the current observation to *Flare* one, if the flare location is in SOT-FOV.
- *(There is a option not to switch to Flare observation.)*

**EIS**
- Switch the current observation to *Flare* one, if the flare location is in EIS-FOV.
- *(There is a option not to switch to Flare observation.)*
# Solar-B/XRT vs. STEREO/EUVI

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<th>Solar-B/XRT</th>
<th>STEREO/EUVI</th>
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<tbody>
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<td>Grazing Incidence</td>
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<td><strong>FOV</strong></td>
<td>34 arcmin</td>
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</tr>
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<tr>
<td></td>
<td></td>
<td>Fe IX 171Å (1MK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fe XII 195Å (1.5MK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fe XIV 211Å (2MK)</td>
</tr>
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<td><strong>Temp. Coverage</strong></td>
<td>1MK ~ 30MK</td>
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<td></td>
</tr>
<tr>
<td>Full Frame, Full-res.</td>
<td>min 9.5sec</td>
<td>min 11sec in Fe IX avg. 20min</td>
</tr>
<tr>
<td>Full Frame, Half-res.</td>
<td>min 5.0sec avg. 102sec</td>
<td>min 4.75sec avg. 2.5min</td>
</tr>
<tr>
<td>Partial Frame, Full-res.</td>
<td>min 2.0sec avg. 15sec</td>
<td>(No Option?)</td>
</tr>
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<td>(FOV = 300”~400”)</td>
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Summary

• XRT has high sensitivity for low (1MK) temperature plasma, as well as high temperature plasma.
• XRT has the highest spatial resolution as GI imager. **Pixel Size = 1 arcsec**
• **Observation Tables** respond to various observations.
• **Autonomous functions** support XRT automatic operation.
• Observers can select types of **Image Compression**.
• **Built-in visible light optic** allows us to align XRT images with SOT images with sub-arcsec accuracy.