XRT Instrument Capabilities

Ed DeLuca, Leon Golub & Jay Bookbinder SAO

Level 1 Science Requirements						
Торіс	Definition/Questions	General Instrument Impact (System drivers are boldfaced)				
Coronal Mass Ejections	 How are they triggered? What is their relation to the magnetic structures? What is the relation between large scale instabilities and the dynamics of small structures? 	High time resolutionHigh spatial resolutionLarge FOVBroad temperature coverage				
Coronal Heating	1.How do coronal structures brighten?2.What are the wave contributions?3. Do loop-loop interactions cause heating?	High time resolutionHigh spatial resolutionLarge FOVBroad temperature coverage				
Reconnection and Jets	 Where and how does reconnection occur? What are the relations to the local magnetic field? 	High time resolutionHigh spatial resolutionBroad temperature coverageCo-ordinated observing EIS/SOT				
Flare Energetics	 Where and how do flares occur? What are the relations to the local magnetic field? 	High time resolutionHigh spatial resolutionLarge FOVBroad temperature coverageHigh temperature responseLarge dynamic range				
Photospheric-Coronal Coupling	 Can a direct connection between coronal and photospheric events be established? How is energy transferred to the corona Does the photosphere determine coronal fine structure? 	High time resolution High spatial resolution Large FOV Broad temperature coverage Co-ordinated observing with SOT/EIS				

Other Level 1 Requirements						
Item	Description	Value				
Instrument Lifetime	Perform throughout the nominal Solar-B mission	3 years				
Instrument Weight		30 kg (TBR)				
Instrument Power		20 W (TBR)				
Support SOT/EIS	Coordinated Observing capability	S/W timing and coordination				

Requirement	Definition	Value	Primary	Determining Factor	Responsibility
•			Hardware	5	, ,
Exposure time	shutter open time (min)	4ms	Shutter	Flare brightness	SAO
	(max)	10sec		Quiescent corona	
Cadence	time between exposures	2 sec (reduced FOV)	Shutter/MDP	Flare variability	SAO/ISAS
T-range	limits of temperature coverage	6.1 < log T < 7.5	Coatings	coronal DEM	SAO
T-resolution	Temperature discrimination	log T = 0.2	F.P. Filters	transverse gradients	SAO
X-ray image resolution	50% encircled energy	2 arcsec	G.I. Mirror	moss size scales	SAO
Field of View	angular coverage of telescope	> 30 arcmin	G.I. Mirror	global variations	SAO
White Light Rejection	reduction of solar visible light at focal plane	>10**11	Filters	Lx/Lopt ratio	SAO
Data Rate	Maximum bit rate out of XRT	2.4 MB/sec	MDP	Flare mode observations	ISAS
Data Volume	Maximum daily data volume	60 MB/orbit	MDP	CME mode observations	ISAS
Spatial Co-alignment (X-ray to WL)	Align Xray to white light images	1 XRT pixel	Mirrror Assy		SAO
Spatial Co-alignment (X-ray to SOT or EIS)	Align Xray to white light images	1 XRT pixel	Structures		ISAS/SAO
Coordinated	Image start time coordination	0.1 second	MDP		ISAS/SAO
Observing					

Coordinated Observing Programs XRT

Ed DeLuca, Kathy Reeves & Harry Warren SAO

Emerging Flux Program

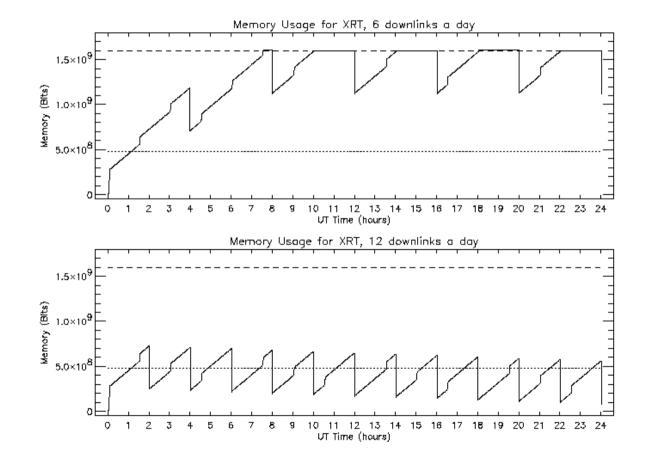
- Primary Instrument: XRT
- Science Goal: Understand the interaction of emerging magnetic flux with the existing coronal magnetic field. For example: Can we demonstrate that a jet is formed when a dipole of a certain size emerges near an existing arcade?

- Implementation:
 - Follow an active region as it crosses disk center (~1 week).
 - Use 768x768 FOV (13'x13') to cover an AR and surrounding area.
 - Use 3 filters to span the XRT temperature response.
 - Run at a fast enough cadence to follow coronal structures (100s based on TRACE experience).
 - Take white light images every 45 min (TBR) for context and alignment.

- Assumptions:
 - X-ray data compress to 3 bits/pixel.
 - White light data compress to 5 bits/pixel.
 - Filter move and settle time 1.2 s per step.
 - Shutter prep time 0.2 s
 - Parallel shift @ 10krows/s
 - Read time 512kpixels/s => 3.075 s to read 768x768 FOV.
 - Exposure times: 1s for filters 1 & 2; 3s for filter 3
- Question: Do we need more than a long and short exposure to cover the dynamic range?

- Data Rate:
 - 53 kBits/s Compressed data
- Duration:
 - 7 days per AR. Longer if FPP can provide useful data near the limb.

EFP On Board Storage



EFR as run timeline 6 downlinks

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HR	MIN		HR	MIN	
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0	2	CAL	12	0	EFR
0	7	Pointing:(800,200)	13	31	Pointing:(0,0)
0	9	EFR	13	33	SYNOPTIC
1	30	Pointing:(0,0)	13	34	Pointing:(800,200)
1	32	SYNOPTIC	13	37	EFR
1	33	Pointing:(800,200)	15	1	Pointing:(0,0)
1	35	EFR	15	3	SYNOPTIC
3	0	Pointing:(0,0)	15	5	Pointing:(800,200)
3	2	SYNOPTIC	15	7	EFR
3	4	Pointing:(800,200)	16	1	Download
3	6	EFR	16	1	EFR
4	0	Download	16	30	Pointing:(0,0)
4	0	EFR	16	32	SYNOPTIC
4	30	Pointing:(0,0)	16	33	Pointing:(800,200)
4	32	SYNOPTIC	16	35	EFR
4	34	Pointing:(800,200)	18	0	Pointing:(0,0)
4	36	EFR	18	2	SYNOPTIC
6	0	Pointing:(0,0)	18	4	Pointing:(800,200)
6	2	SYNOPTIC	18	6	EFR
6	4	Pointing:(800,200)	19	30	Pointing:(0,0)
6	6	EFR	19	32	SYNOPTIC
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7	36	EFR	20	1	EFR
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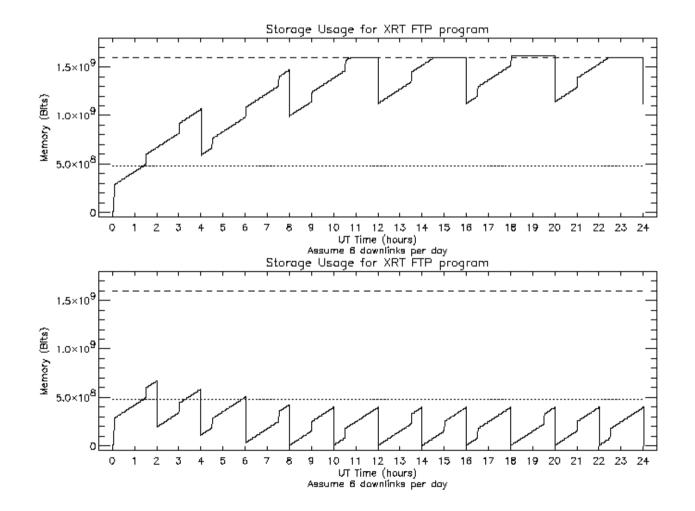
Flux Tube Physics

- Primary Instrument: FPP
- Science Goal: Study the coronal response to network and plage flux tube dynamics.
- Implementation:
 - Select FOV centered on FPP FOV
 - Use 3 filters to span the XRT temperature response
 - Use 256x256 FOV (4.3'x4.3') 33s cadence/set.
 - Use 1024x1024 FOV context every 5 min
 - Take white light images every 10 min.

Flux Tube Physics

- Data Rate: 41 kBits/s Compressed data
- Duration: TBD

FTP On Board Storage



FTP As Run Timeline

UT		Action	UT		Action
HR	MIN		HR	MIN	
0	0	Pointing:(0,0)	12	1	Download
0	2	CAL	12	1	FTP
0	7	FTP	13	30	SYNOPTIC
1	30	SYNOPTIC	13	32	FTP
1		FTP	14		Download
2		Download	14		FTP
2	0	FTP	15		SYNOPTIC
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3		FTP	16		Download
4		Download	16		FTP
4	0	FTP	16	30	SYNOPTIC
4		SYNOPTIC	16	31	FTP
4		FTP	18		Download
6	1	Download	18	1	FTP
6	1	FTP	19		SYNOPTIC
7		SYNOPTIC	19	32	FTP
7	32	FTP	20		Download
8		Download	20		FTP
8		FTP	21		SYNOPTIC
9		SYNOPTIC	21		FTP
9		FTP	22		Download
10		Download	22		FTP
10		FTP	22		SYNOPTIC
10	30	SYNOPTIC	22	31	FTP
10	31	FTP	24	1	Download

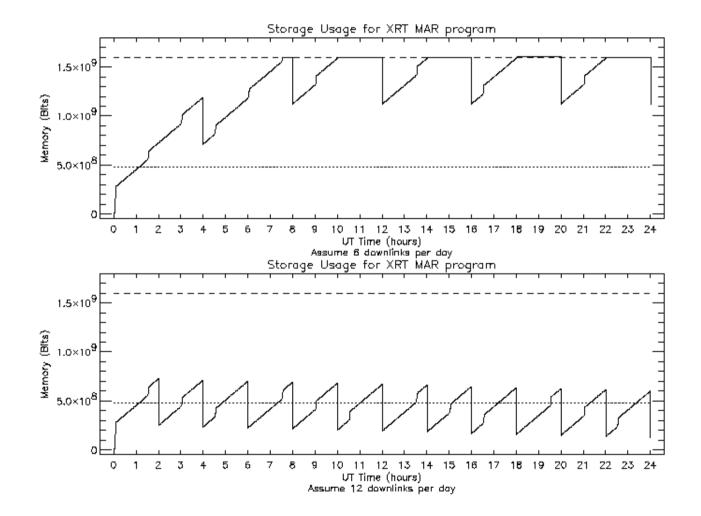
Medium Active Region Program

- Primary Instrument: EIS
- Science Goal: Flows, temperature and density diagnostics in an AR.
- Implementation:
 - Select FOV centered on EIS FOV
 - Use 3 filters to span the XRT temperature response
 - Use 512x512 FOV (8.5'x8.5') 60s cadence/set.
 - Use 768x768 FOV context every 5 min
 - Take white light images every 10 min

Medium Active Region Program

- Data Rate: 53 kBits/s Compressed data
- Duration: TBD

MAR On Board Storage



MAR as run timeline 12 downlinks

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XRT Synoptic Program

- Primary Instrument: XRT
- Science Goal: Produce a mission-long data base of the global evolution of the solar corona. Follow the large scale topological changes of the multi-thermal, fine scale coronal fields. Show the evolution of coronal holes, polar plumes and AR streamers over many rotations.

- Implementation:
 - Every 90 minutes, take long and short exposures at sun center in each of three filters that span the XRT temperature response.
 - Take a white light context image.
- Elapsed time: 90s of observing
- Data Rate:
 - Burst: 1082 kBits/s Compressed
 - Daily Avg: 13 kBits/s Compressed
- Duration: Mission Lifetime

XRT Calibration Program

- Primary Instrument: XRT
- Goal:
 - Establish a baseline of standard observations to detect changes in the sensitivity and performance of the telescope.

- Implementation:
 - Once per day (TBR)
 - Disk center
 - Long & Short exposures in each filter
 - Take white light image
 - Dark frames (not yet included in simulations)
 - Flat fields with WL (TBR)
- Elapsed Time: 6 minutes of observing w/o dark frames

- Data Rate
 - Burst: 940kBits/s Compressed
 - Daily Avg: 3 kBits/s Compressed
- Duration: Mission Lifetime