Lyman-alpha Solar Telescope

inflight calibrations and data analysis guide

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Outline

ASO-S/LST payload and
relevant HI Lyα and 360nm observations

Inflight calibrations

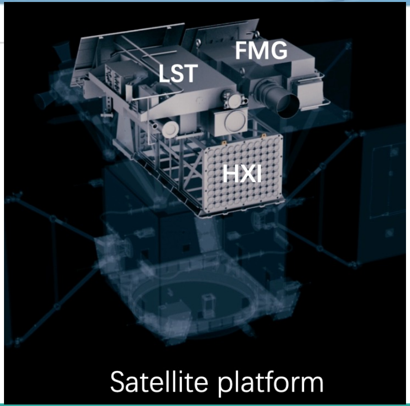
Data analysis guide

Lyman-alpha Solar Telescope (LST)

LST instruments

SCI: Solar Corona Imager
SDI: Solar Disk Imager
WST: White-light Solar Telescope

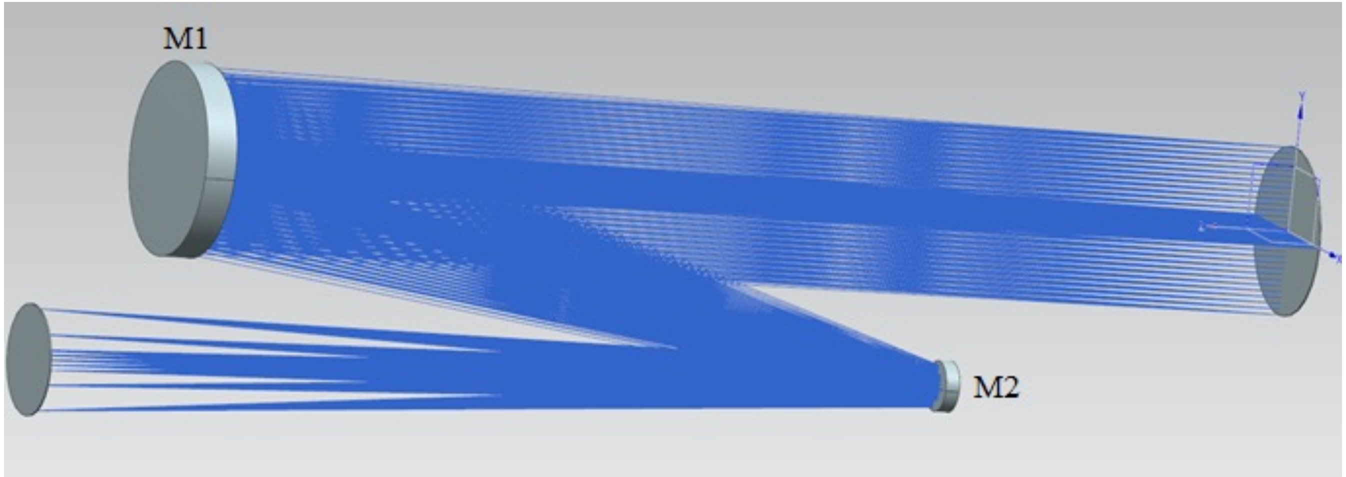
SCI does not work as expected. The reason is under investigation. However, it can sometimes observe eruptive prominences and CMEs in Lyα.



parameters	WST	SDI	SCIUV	SCIWL
waveband	360±2nm	121.6±4.5nm	122.6±3nm	700±32nm
FOV	0 – 1.2 Rs	0 – 1.2 Rs	1.1 - 2.5 Rs	1.1 - 2.5 Rs
Image size	4608×4608	4608×4608	2048×2048	2048×2048
cadence	routine (2min) burst (1s & 2s / 5s) user defined	routine (1min) burst (a few s/15s) user defined	Li+(2019), Chen+(2019) Feng+(2019) RAA	

Optical Design of SDI and WST

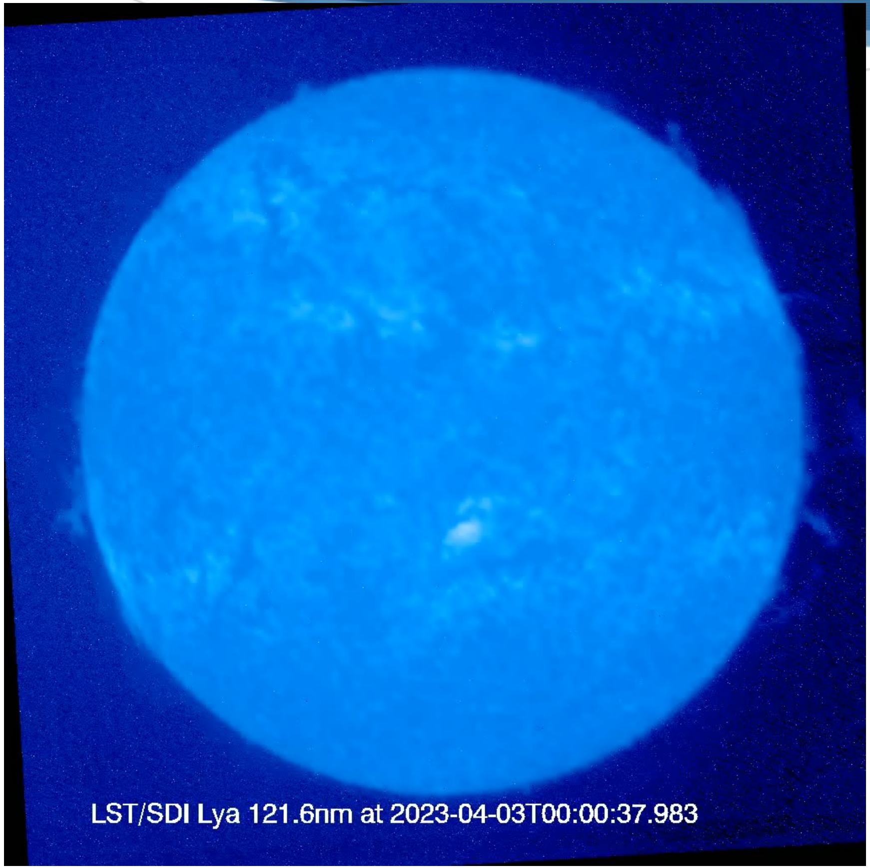
Off-axis Two-Mirror Reflective structure

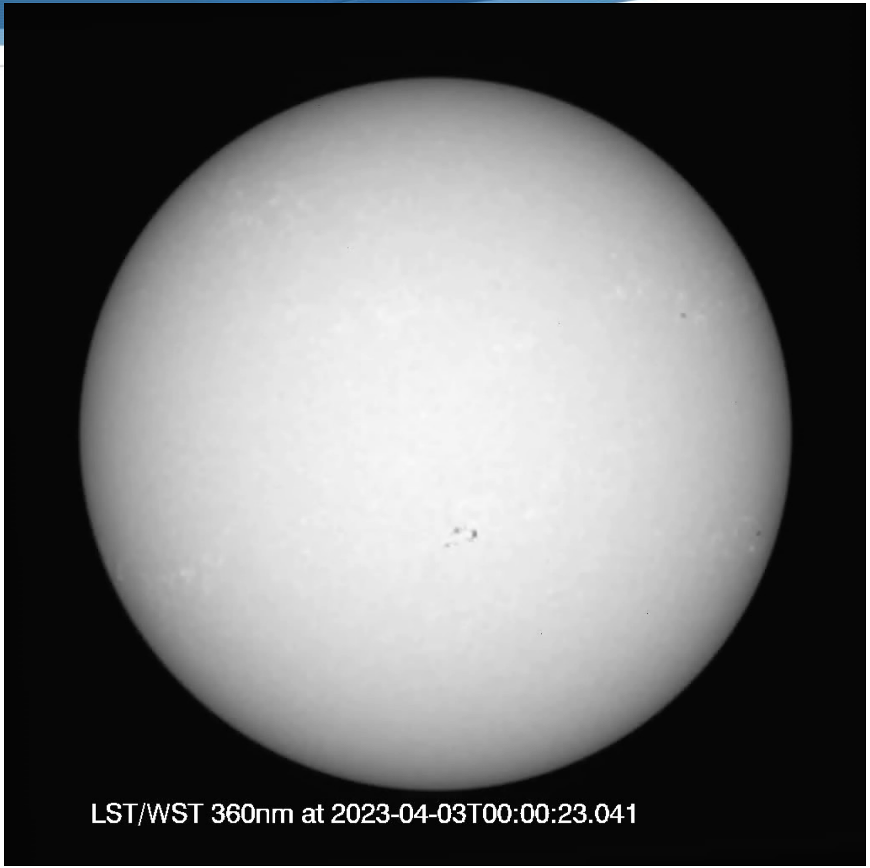


SDI:
Two Lyα filters from Acton at the entrance
One Lyα filter on the filter wheel before the detector

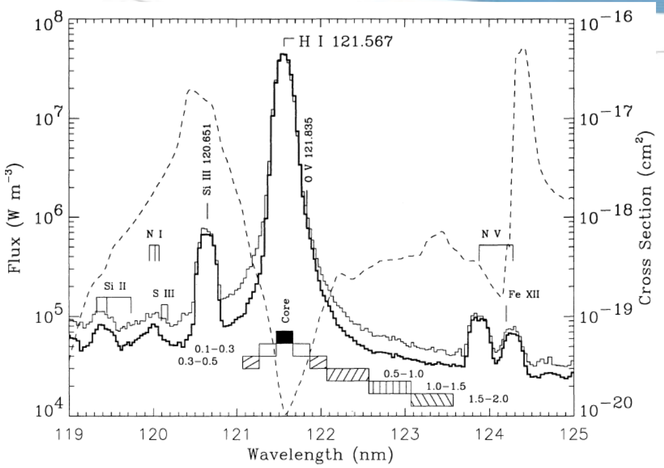
WST:
fused silica glass as incident window entrance

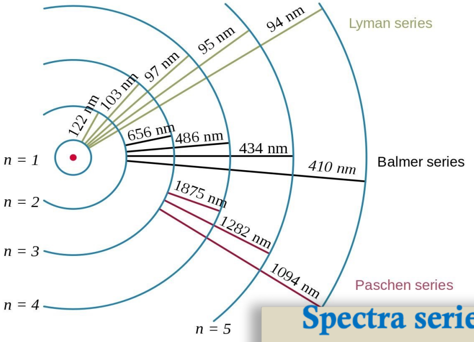
SDI and WST daily movies





SDI: H I Lyα line





Spectra series of Hydrogen atom

No. 4, 1981 QUIET SUN EUV BRIGHTNESS COMPONENTS 637

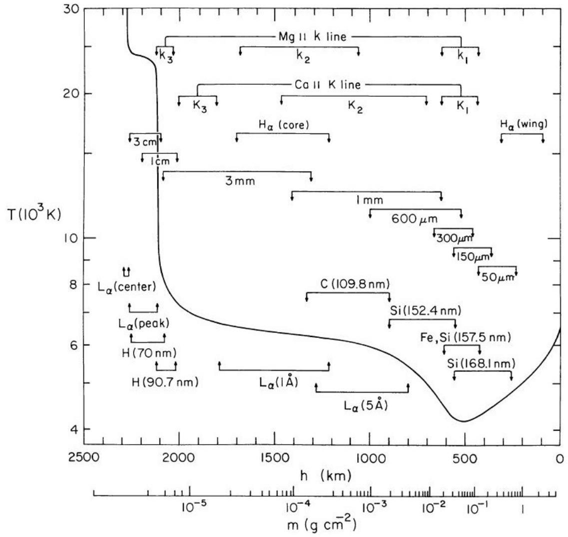
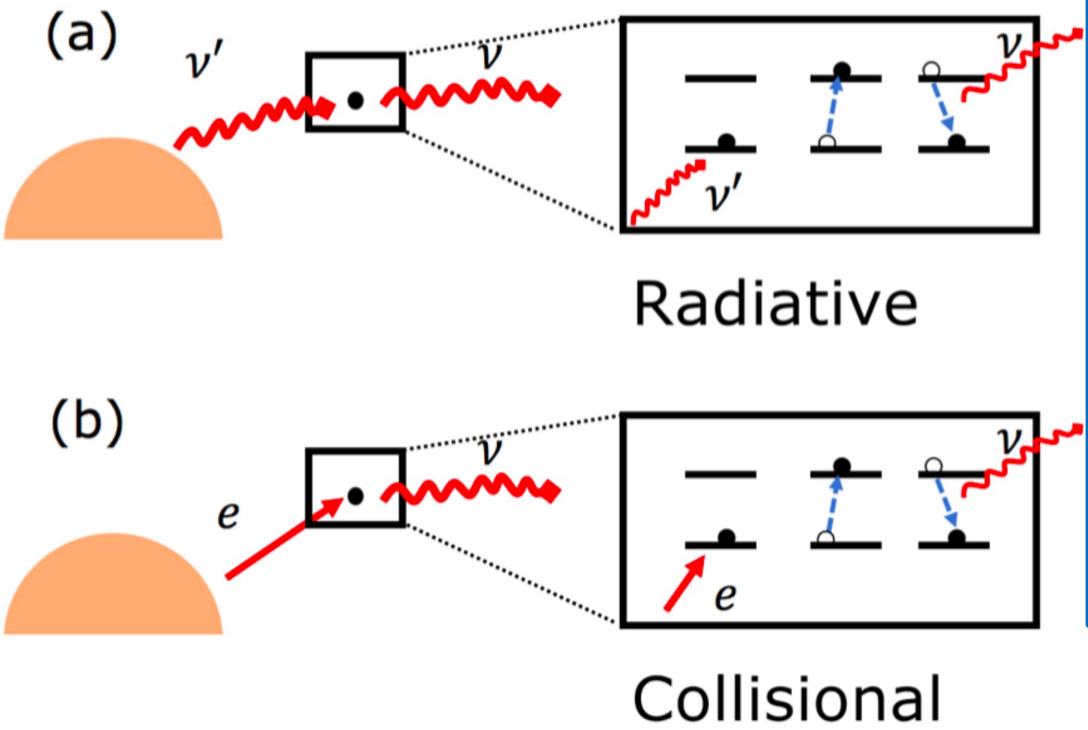


FIG. 1.—The average quiet-Sun temperature distribution derived from the EUV continuum, the Lα line, and other observations. The approximate depths where the various continua and lines originate are indicated.

Vernazza J.E., Avrett E.H., and Loeser R. The Solar Chromosphere. III. Models of the EUV Brightness Components of the Quiet Sun. The Astrophysical Journal Supplement Series, 45:635-725, 1981 April.

line wing : chromosphere (T~ a few kK)
line center: transition region (T~40000K)

H I Lyα emission at higher attitudes

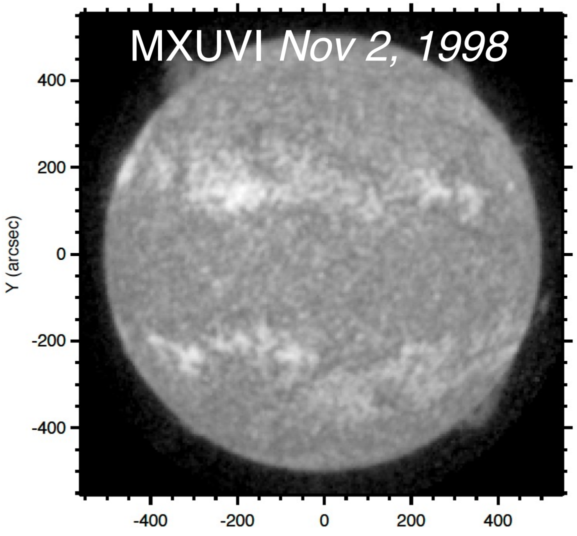


(a)Lyα radiative component:
Photo-excitation of the residual coronal neutral hydrogen atoms by the incident chromospheric Lyα emission (E-corona)

(b) Lyα collisional component:
Electron impact excitation of the residual coronal neutral hydrogen atoms (E-corona)

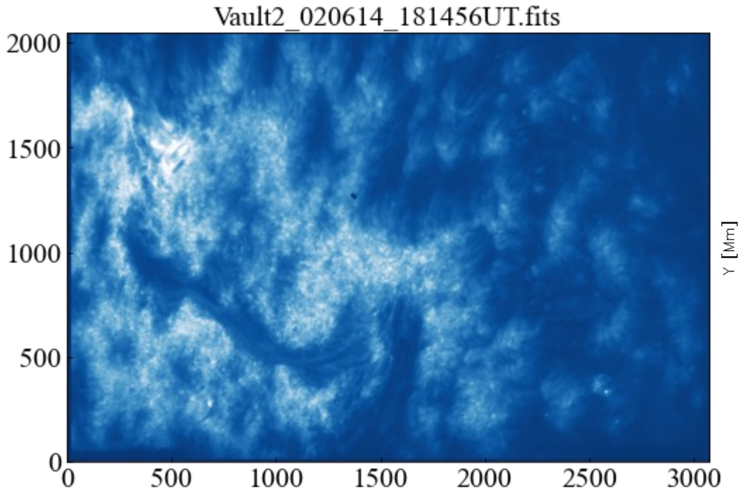
Imaging instruments observing in Lyα: disk imager

Rocket-borne MSSTA , MXUVI

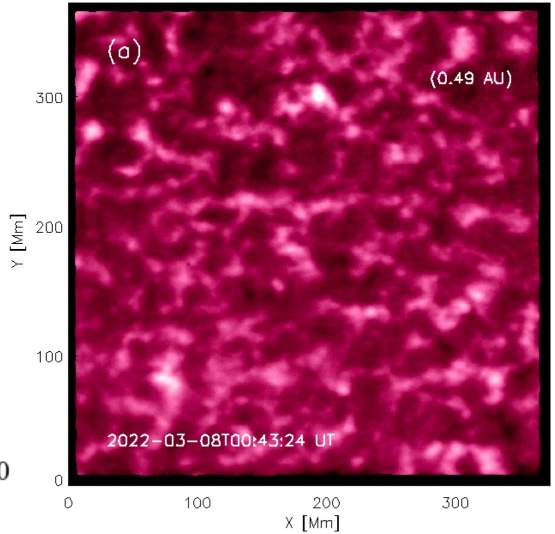


Gordino+(2022)

Rocket-borne VAULT

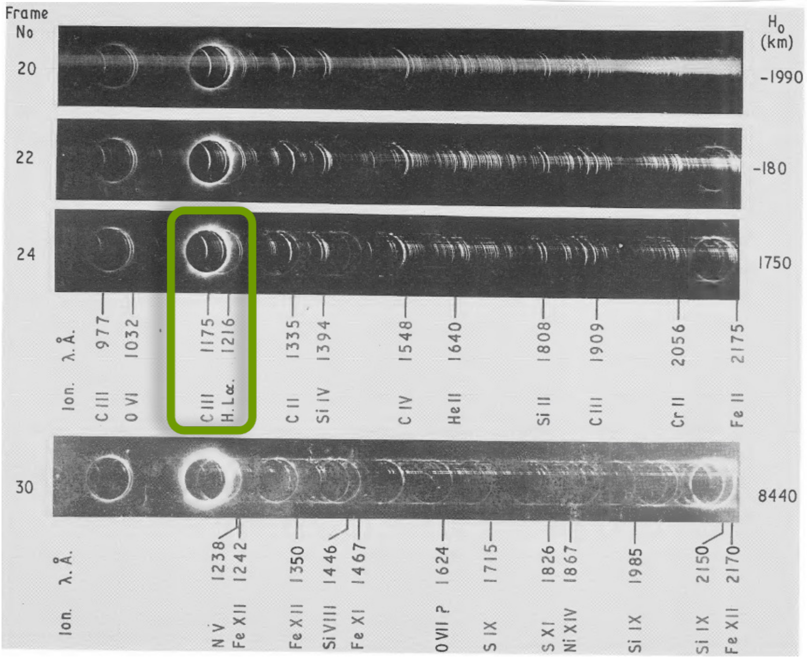


TRACE,
Solar Orbiter / EUILya

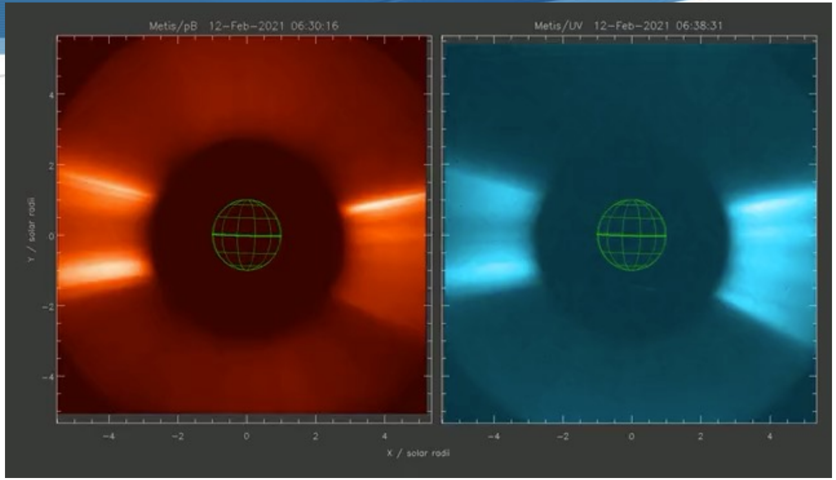


Berghmans+(2023)

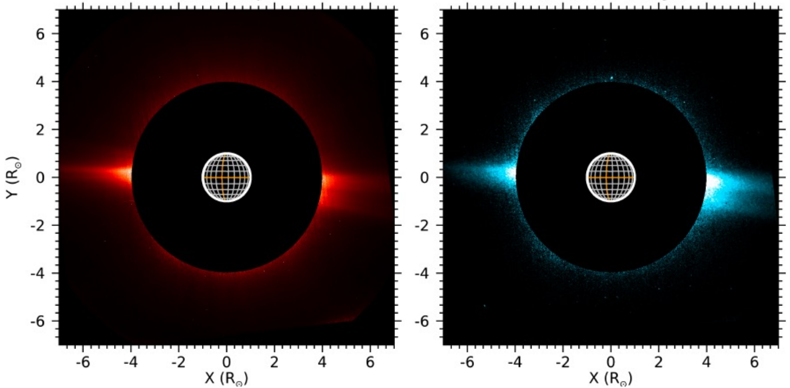
Imaging instruments observing in Lyα: coronagraph



Gabriel 1971 rocket observations

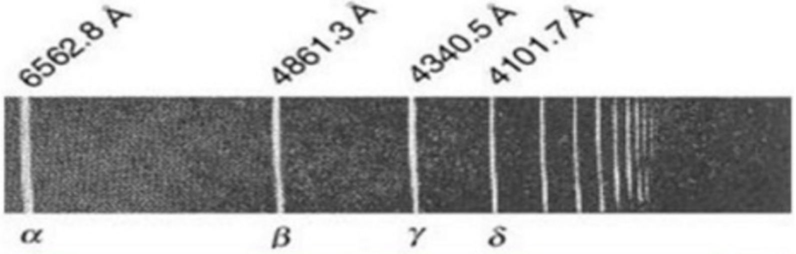


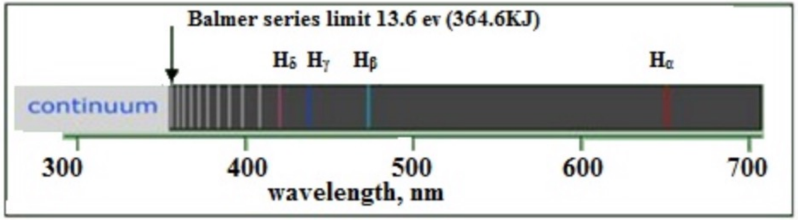
SolO/Metis: white light and Lyα corongraph



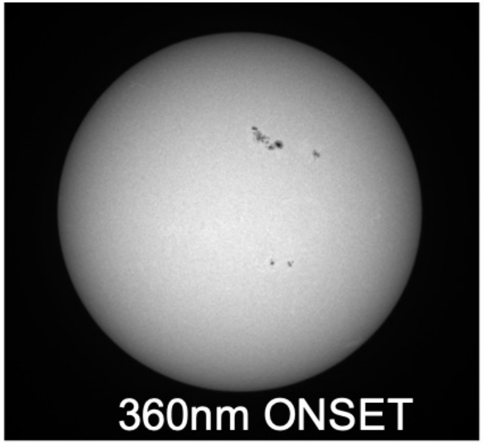
WST： 360nm

360nm is at the continuum of Balmer series

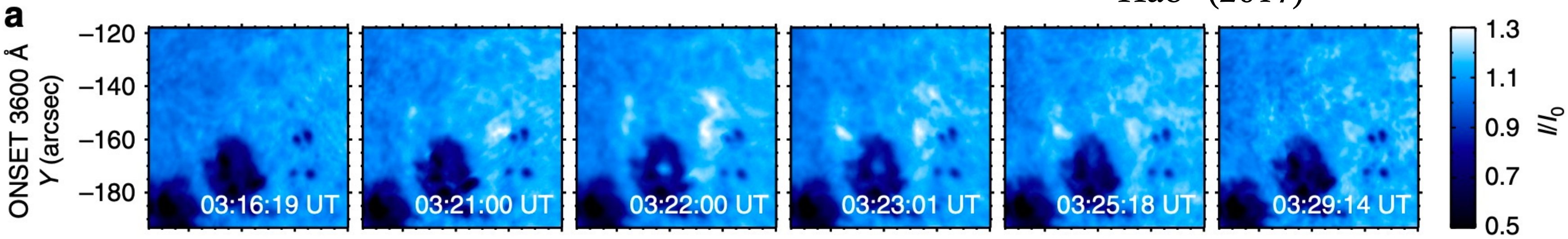




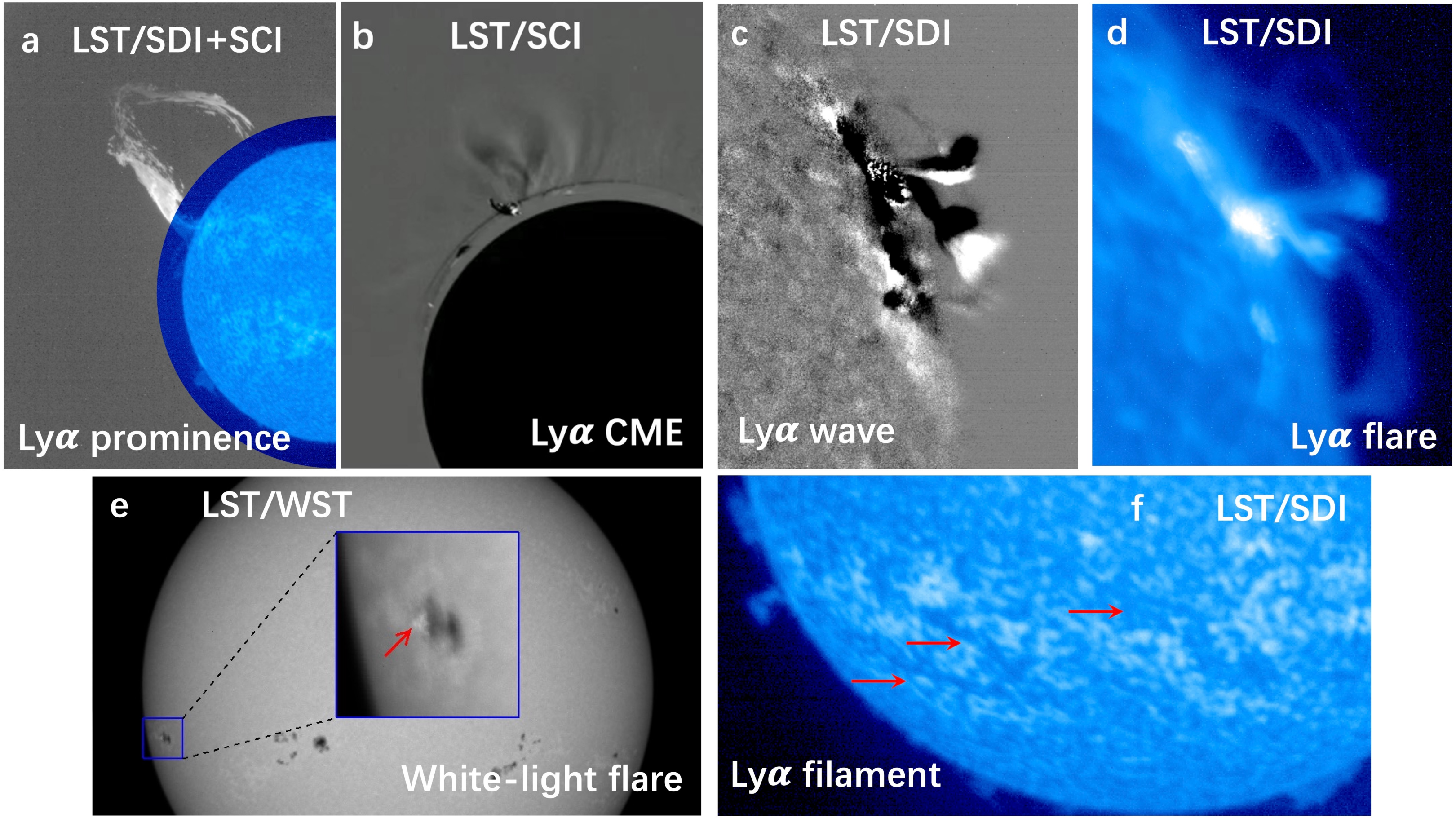
ONSET Ground-based observations



Hao+(2017)

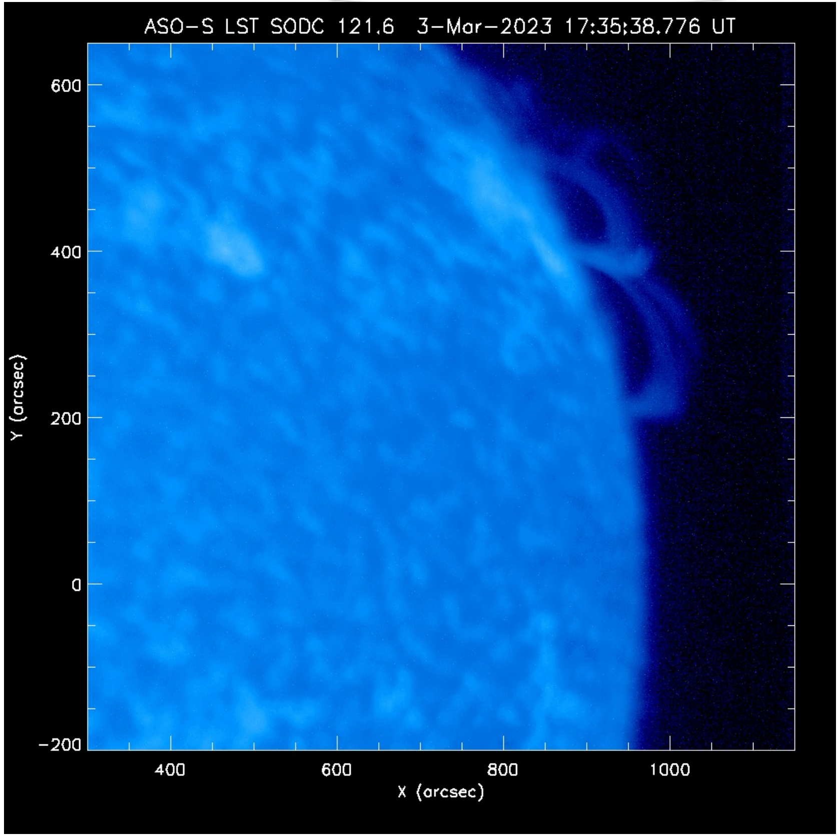


Gallery of LST observations

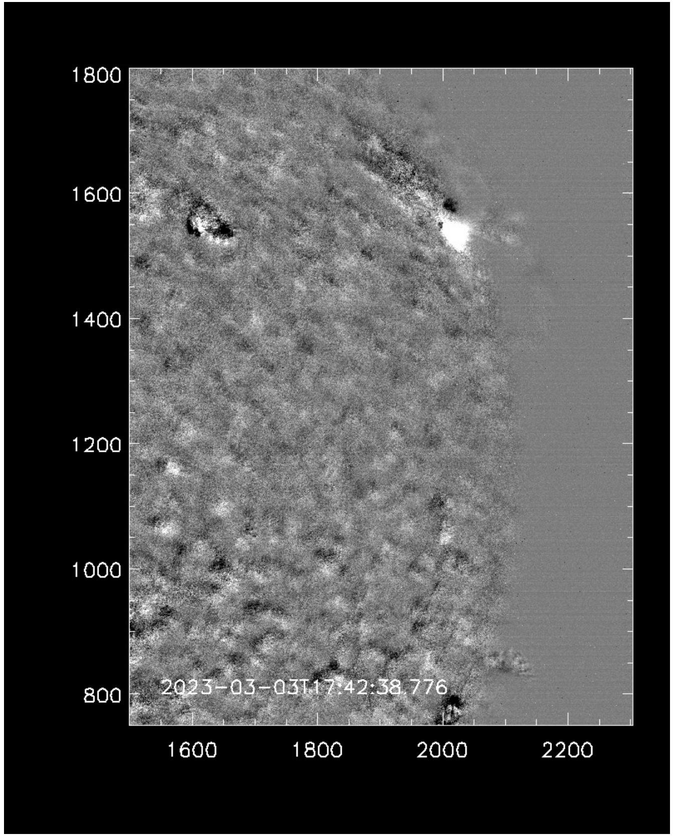


Movies of some eruptive events

X-class Flare

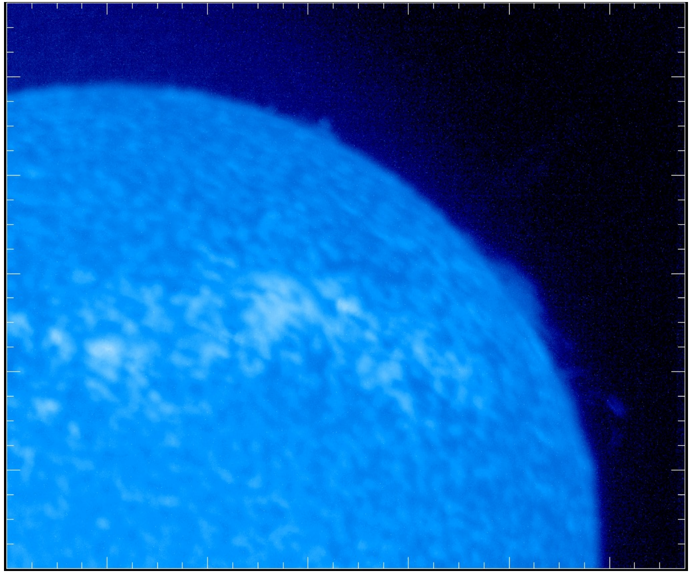


wave

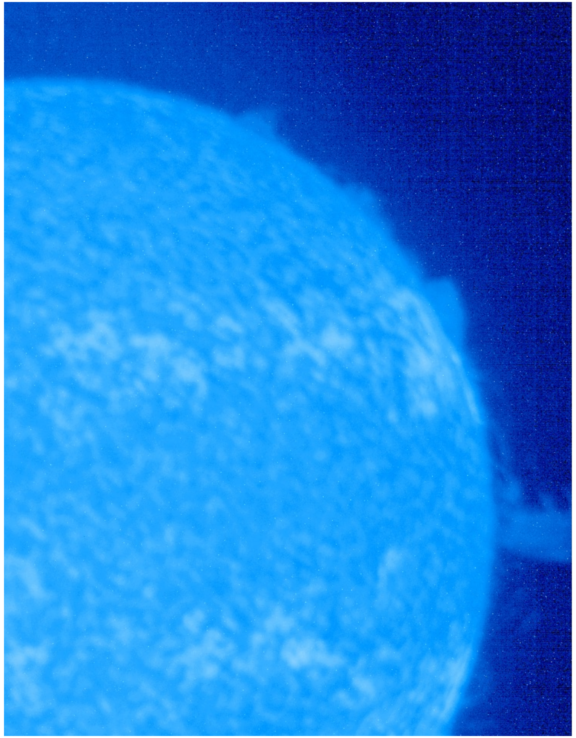


Movies of some eruptive events

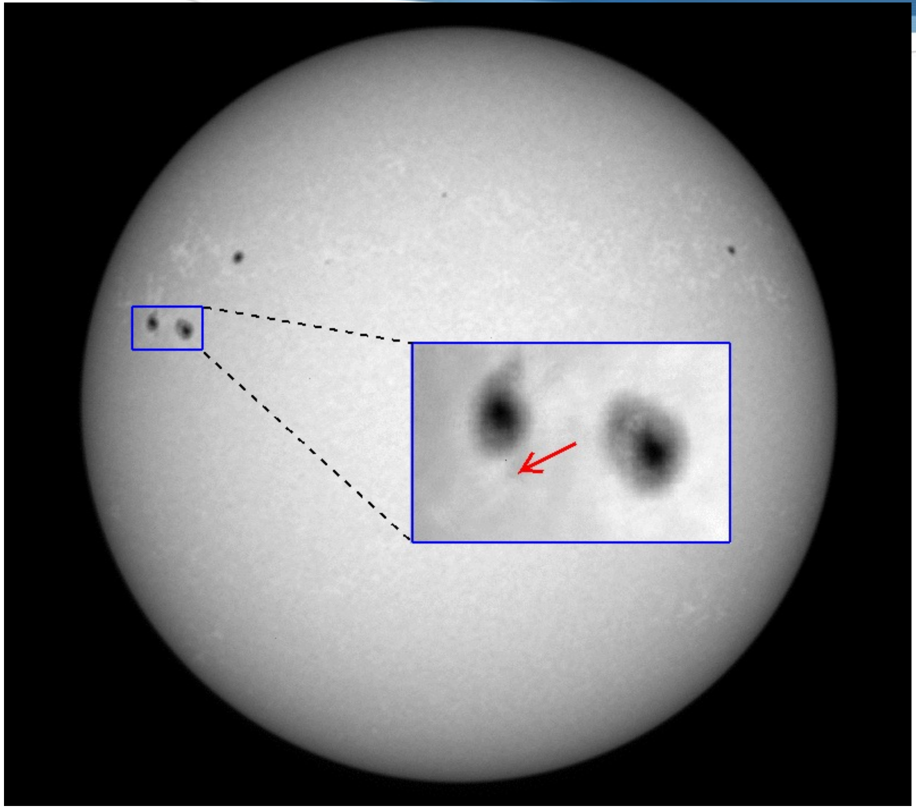
filament

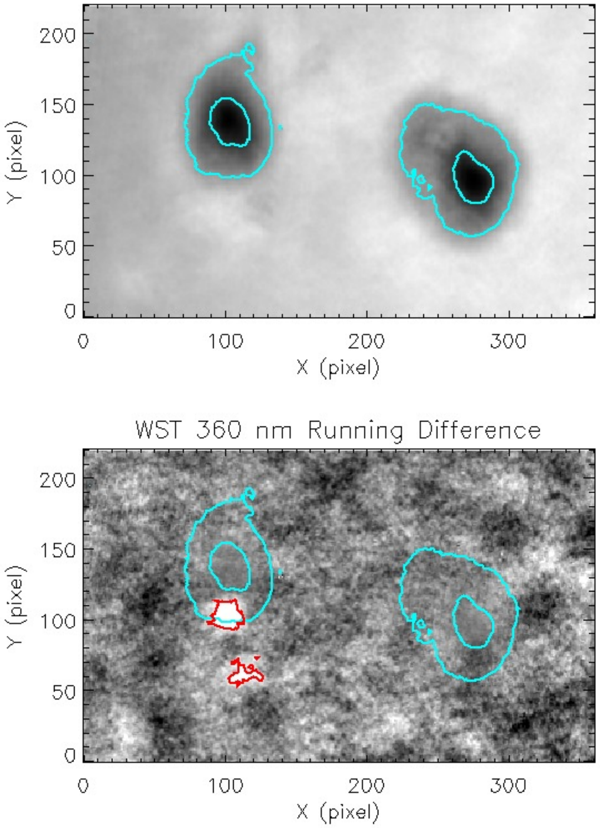


Prominence



Movies of some eruptive events



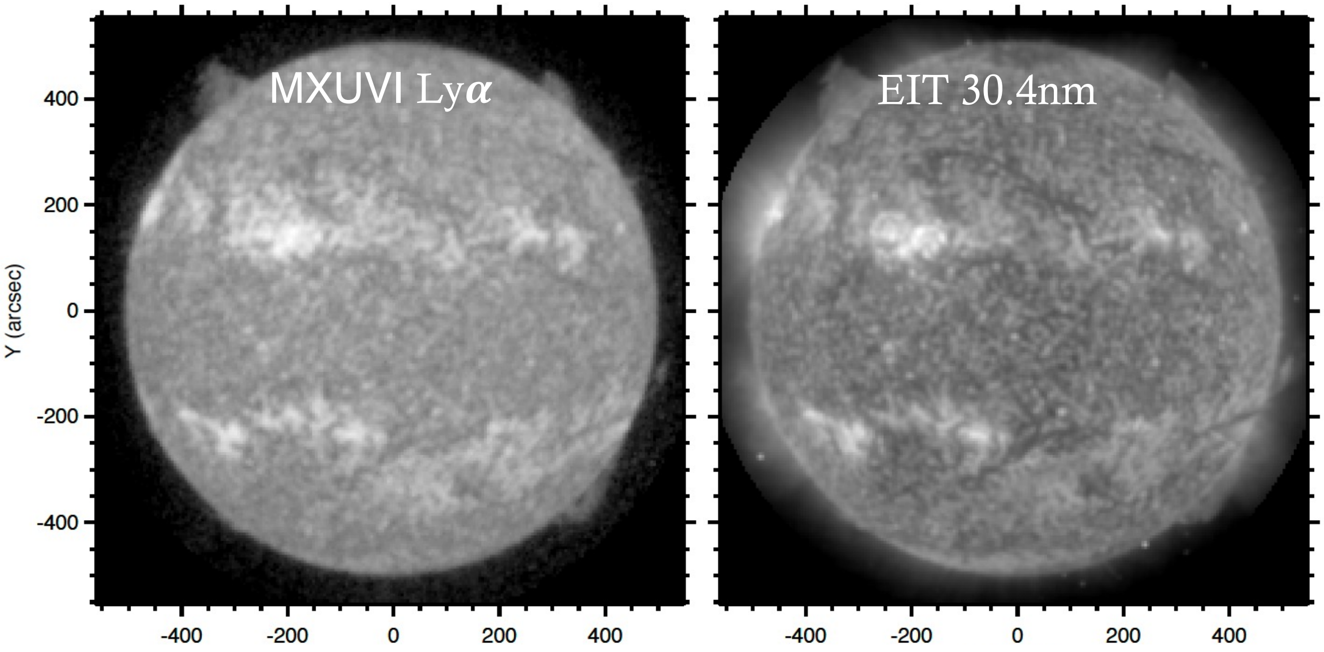


LST Scientific Objectives

– What is the relationship between solar flares, CMEs and eruptive prominences?
– What triggers solar flares and CMEs, and how do their parameters evolve during the eruptive process?
– What are the acceleration mechanisms of CMEs in the inner corona? What are their kinetic behaviors?
– How are shock waves formed and what favors the acceleration of solar energetic particles (SEPs) by shock waves?
– What are the physical properties and processes of white-light flares (WLFs)?

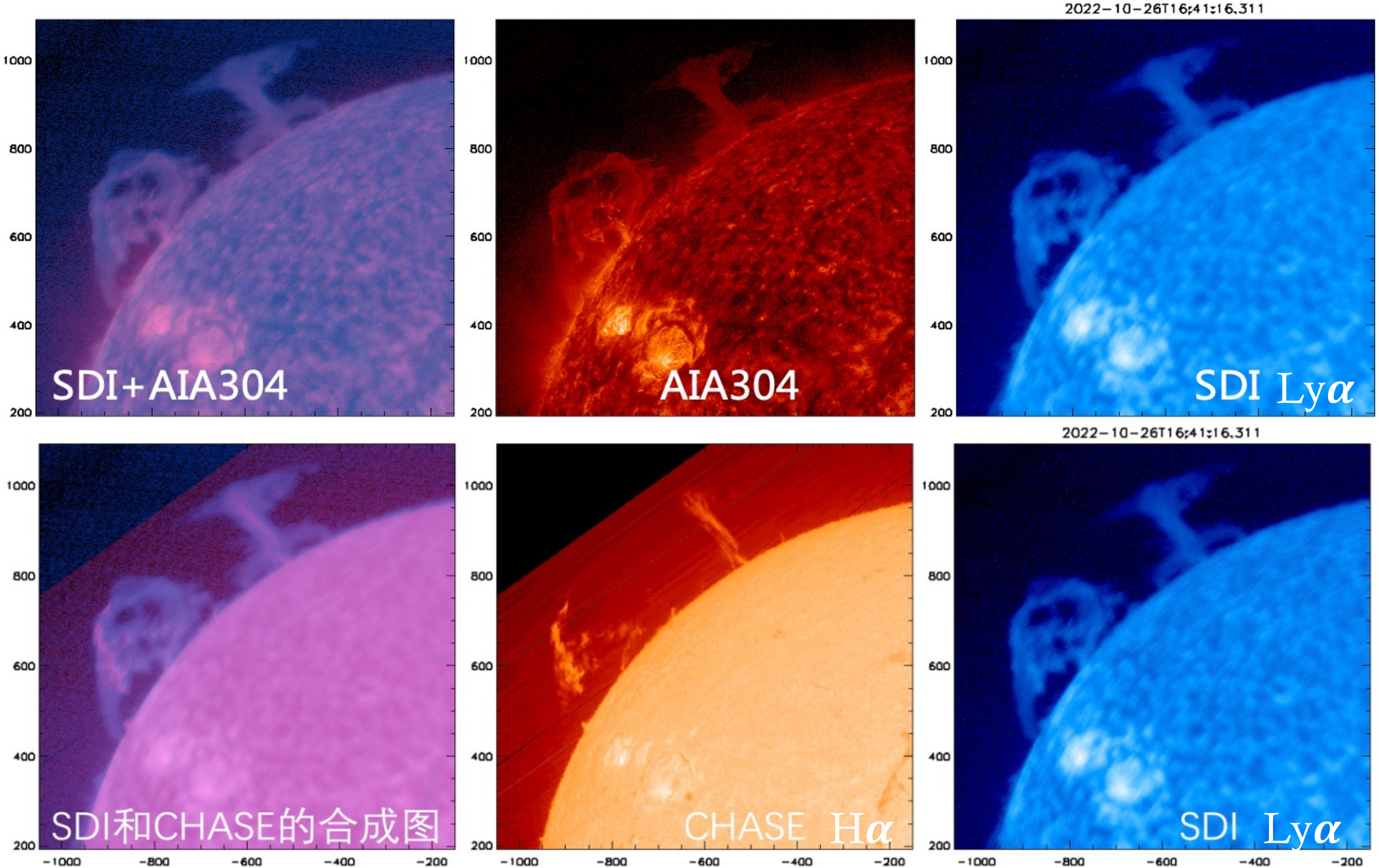
Lyα, Hα, and 30.4nm

rocket-borne MXUVI November 2, 1998

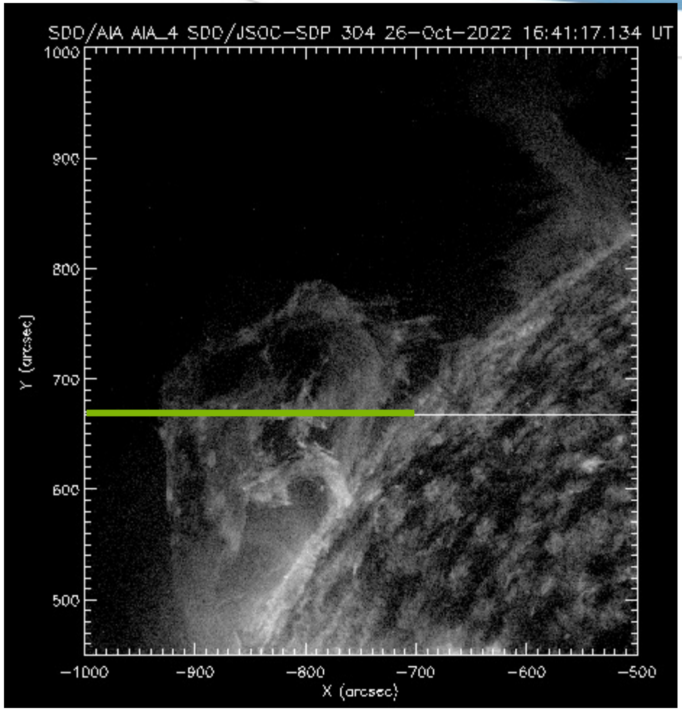


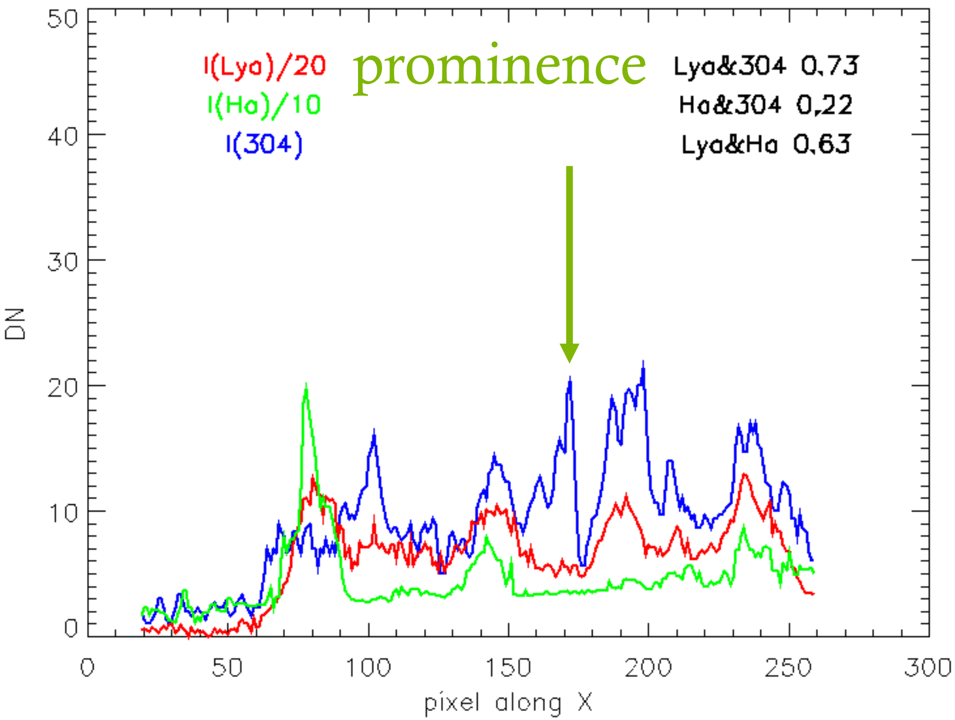
Gordino+(2022)

Lyα, Hα, and 30.4nm



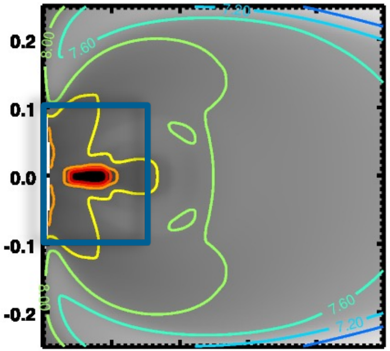
Lyα, Hα, and 30.4nm



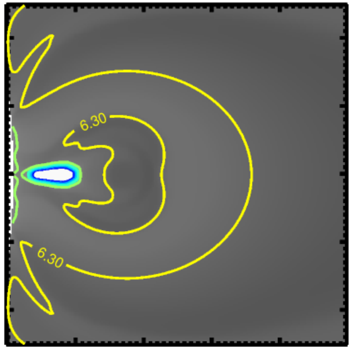


Prominences in Lyα – optically thick regime

POS electron density

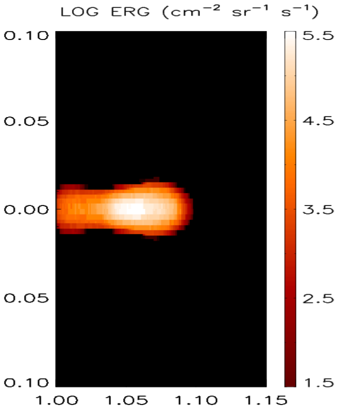


POS temperature

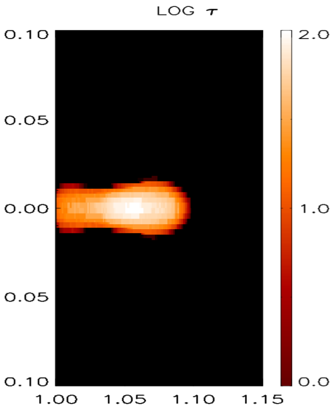


Zhao, Zhang+,2022

Lyα intensity

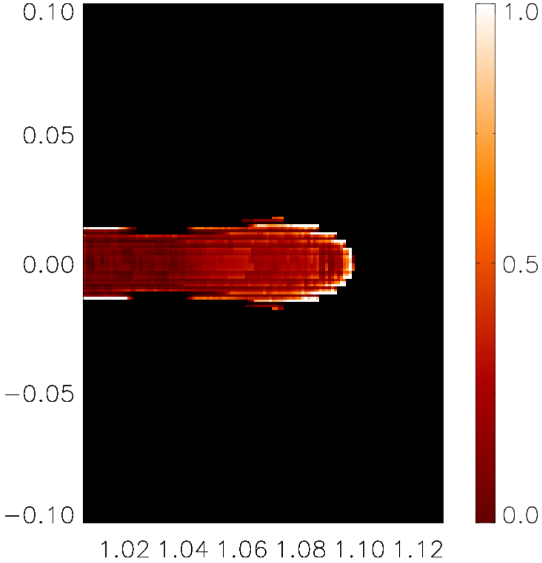


Optical thickness



I(opt. thick)

I(opt. thin)



1D NLTE radiative transfer code - PRODOP

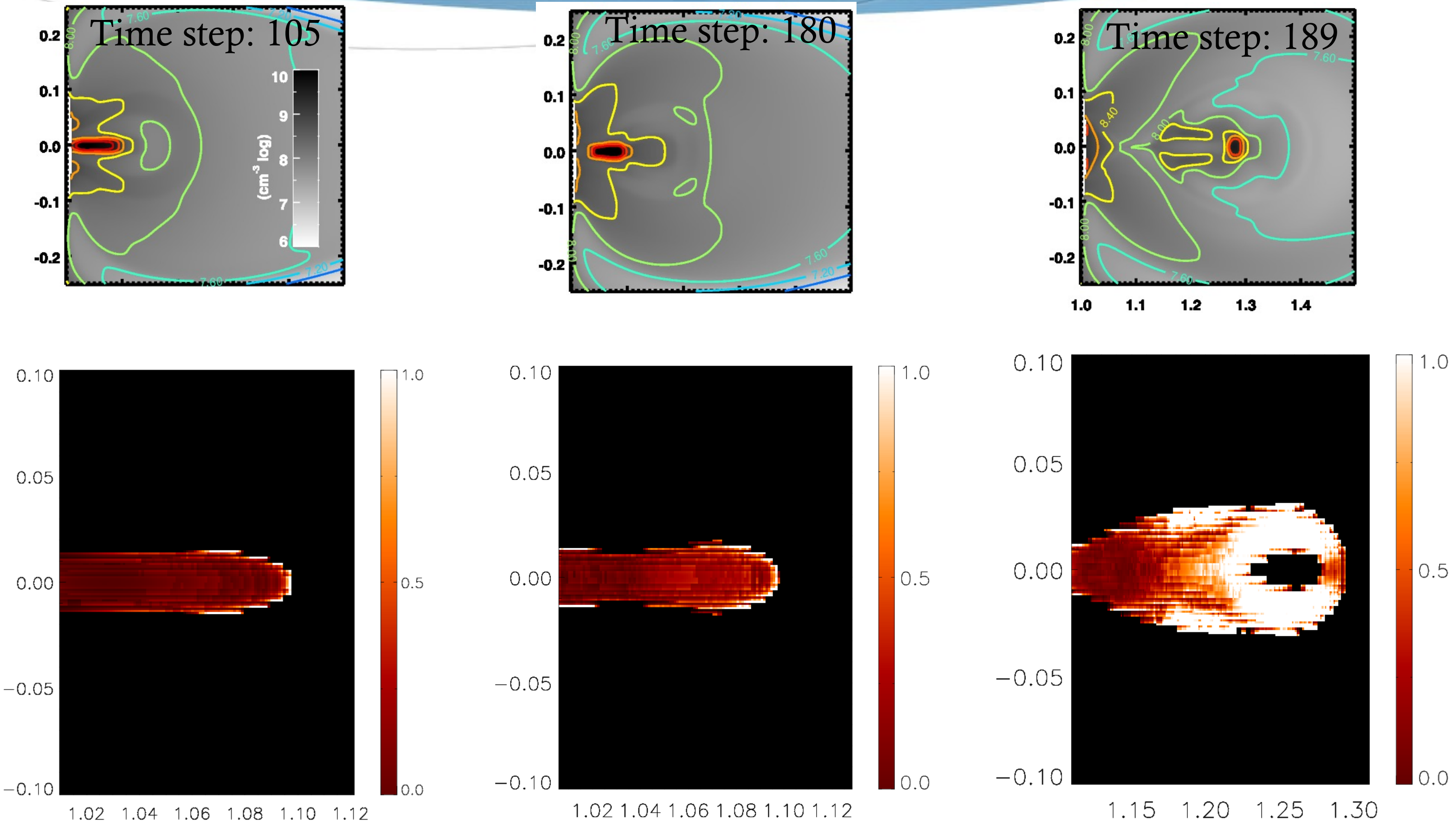
The Lyα line intensity and optical thickness are computed in the region with density larger than $1X10^{9}cm^{-3}$ and temperature less than 100 000K.

Prominences in Lyα – comparing optically thin and thick results

density

I(opt. thick)

I(opt. thin)



Outline

- **ASO-S/LST payload and relevant HI Lyα and 360nm observations**
- **Inflight calibrations**
- **Data analysis guide**

Progresses of inflight calibrations (SDI & WST)

1. Dark current model
2. Flat field
3. High dynamic range image: High gain & low gain image merging
4. Image stabilization system for SDI
5. Triggering of Burst mode and automatic exposure control (AEC)
6. Radiometric calibration: WST (done), SDI (not yet)
7. Optimal detector temperature to reduce the influence of the pollution for SDI
8. SCI: The inflight calibrations of SCI have not been regularly performed.

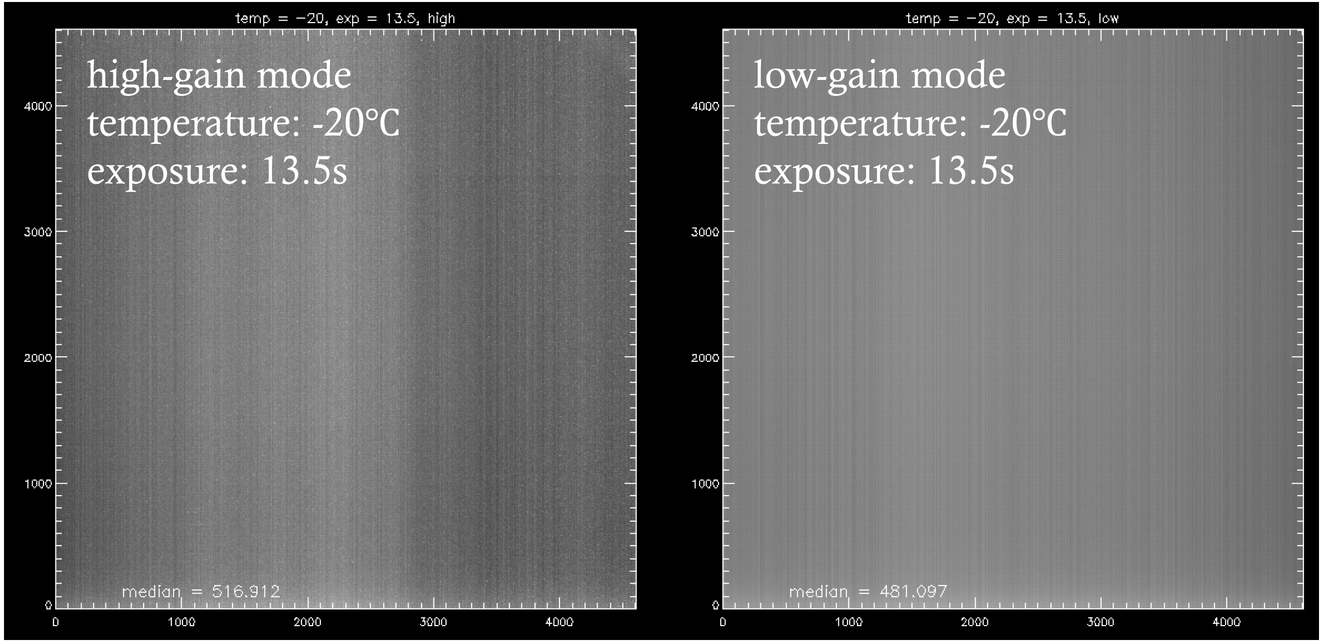
Dark current model

DC (Temperature, Texp)

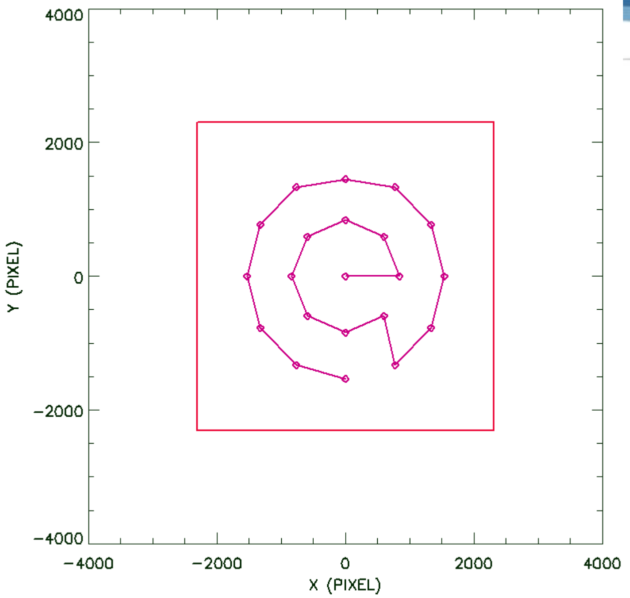
Dark current model as a function of detector temperature and exposure time

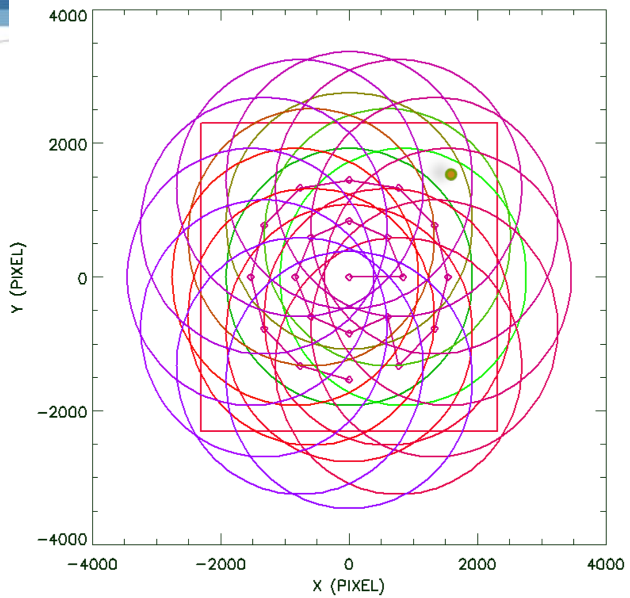
Detector temperature: 7 values in the range T±5°C

Exposure time: 30 values from the minimum exposure to 120s



KLL flat field: 21 satellite pointings



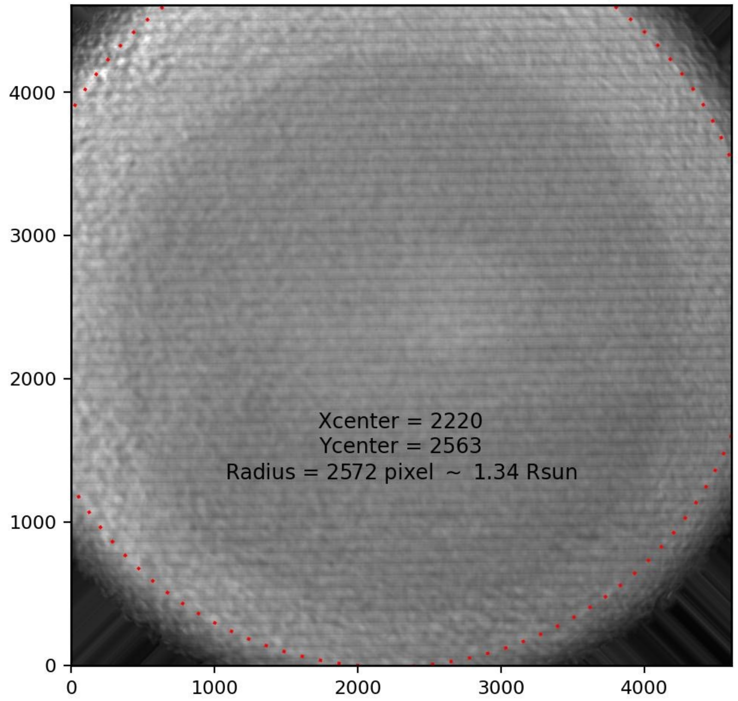


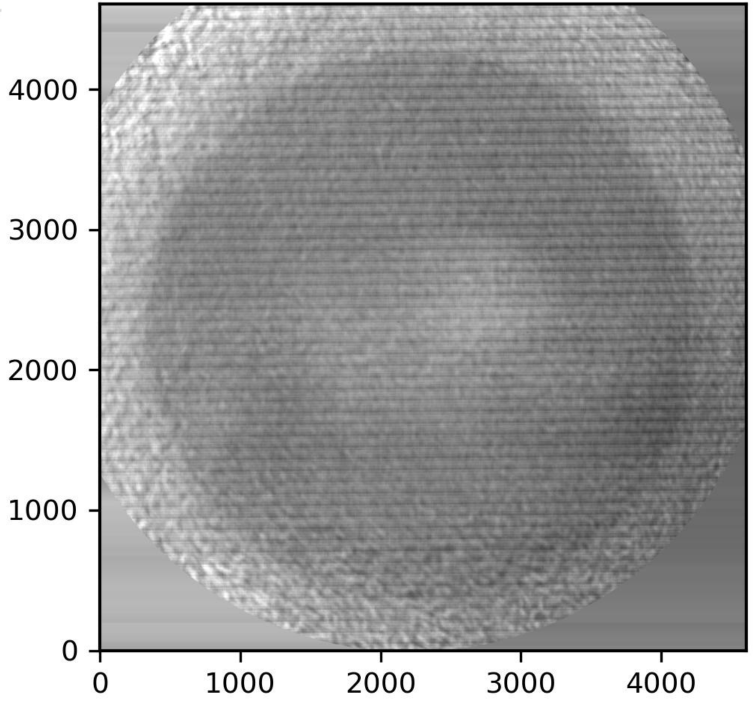
KLL(Kuhn, Lin, and Loranz, 1991) flat field:

For a given target, shifting of the satellite pointing makes the imaging of the same target are at different positions of the detector. Therefore, the difference in intensity reflect the difference in quantum efficiency.

Li+(2021)

KLL flat field: one example

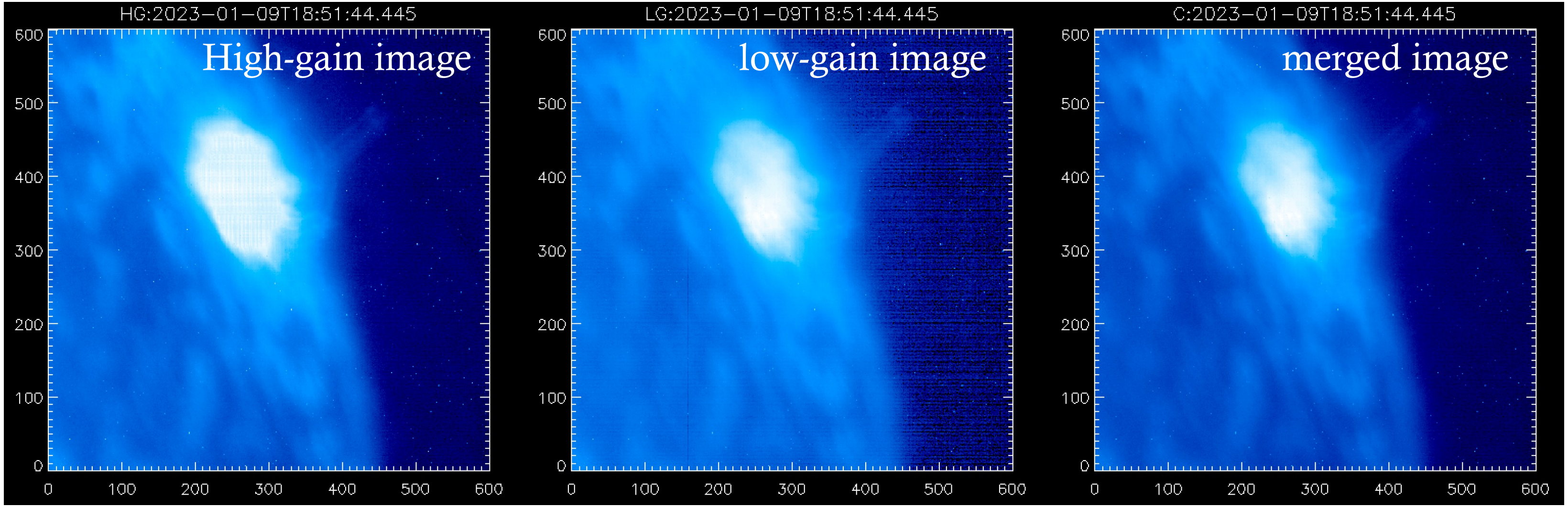




Effective field of view of SDI

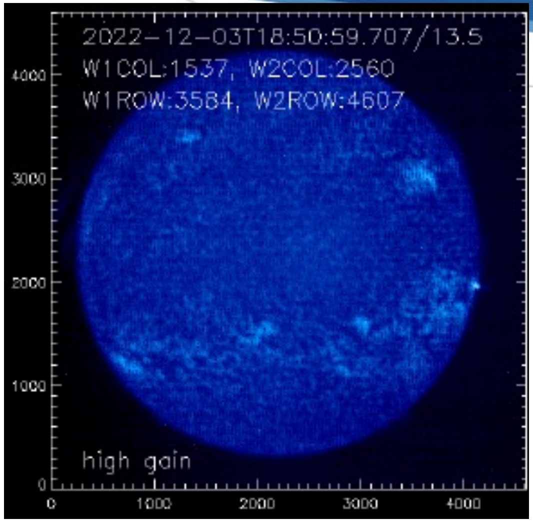
High dynamic range (HDR) imaging

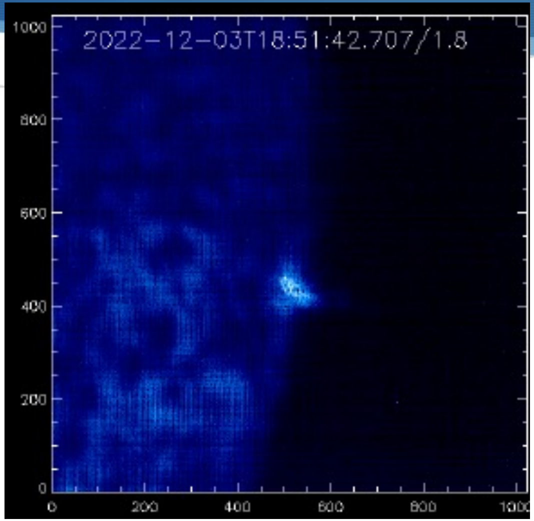
High-gain & low-gain image merging: to deal with the saturated regions in big flares



The saturated pixels in the high-gain image is replaced by the un-saturated pixels in the low-gain image

Onboard triggering and termination of burst mode

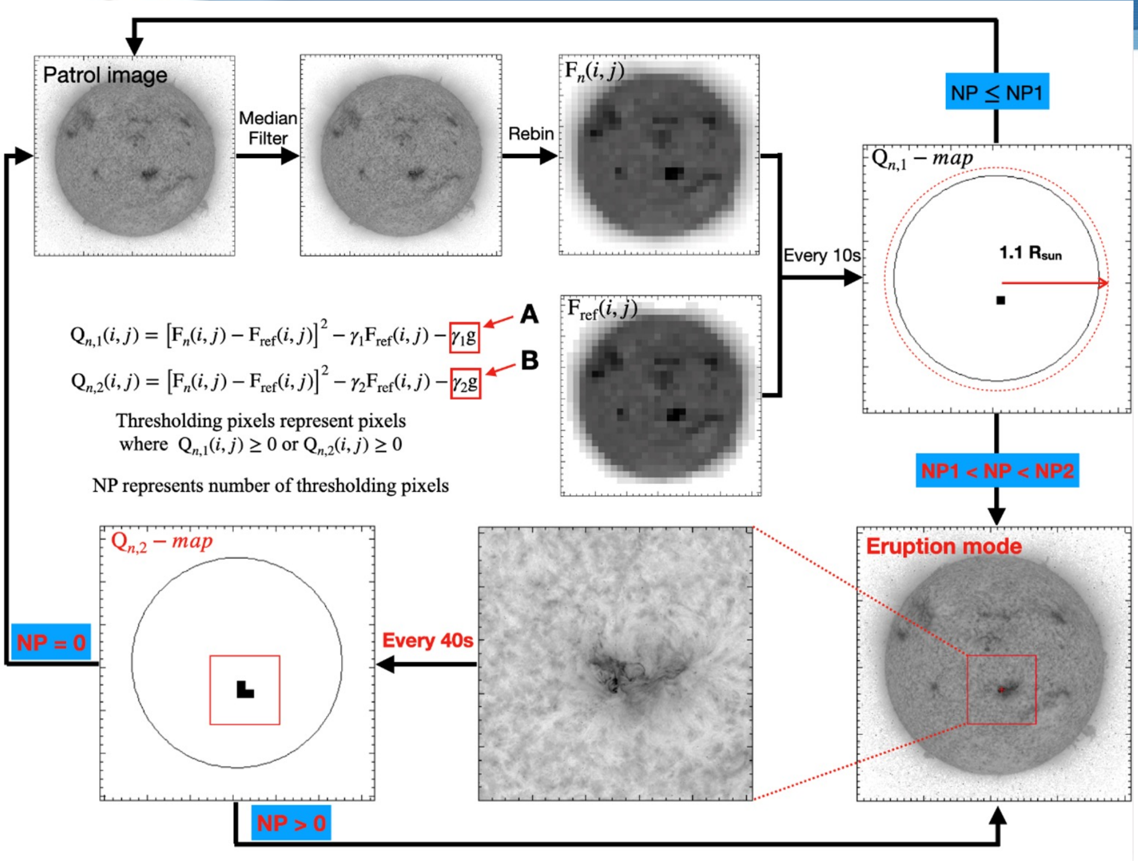




- Purpose: high time-cadence flare observations
- Automatic exposure control
- Need more tests to make it fully functionalized

	WST	SDI
cadence	routine : 2min burst triggered by SDI (1024*1024): 1s for the first 5mins & 2s for the second 5mins at maximum Burst triggered by HXI (4608*4608): 5s	routine (1min) burst triggered by SDI(1024*1024): a few s burst triggered by HXI(4608*4608): 15s

Onboard triggering and termination of burst mode



over-thresholding pixels: Intensity enhancement exceeds a given threshold

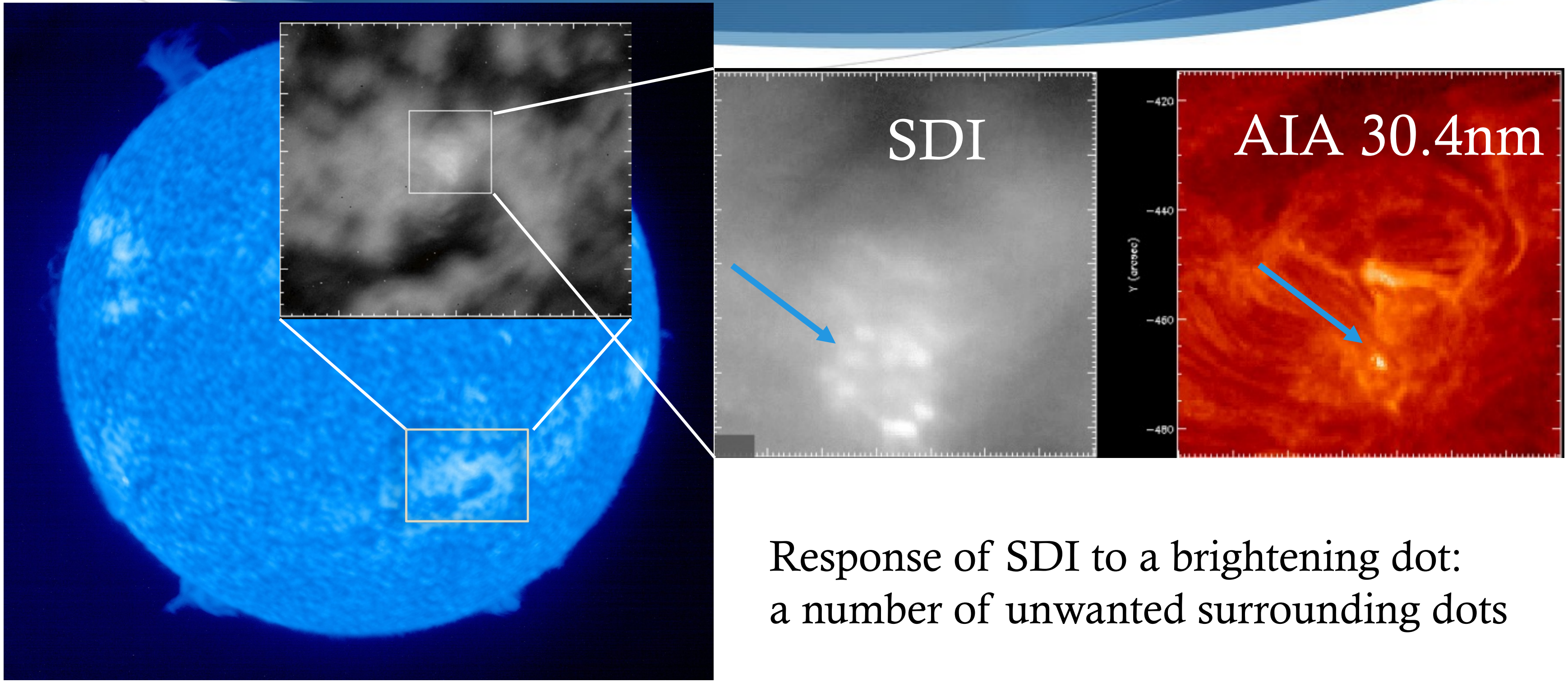
$$\gamma_n(i,j) = \frac{[F_n(i,j) - F_{ref}(i,j)]^2}{F_{ref}(i,j) + g},$$

$$\gamma_n(i,j) \geqslant \gamma_1$$

When over-thresholding pixels (NP) is NP1<NP<NP2, then the burst mode is triggered.

Lu+(2020)

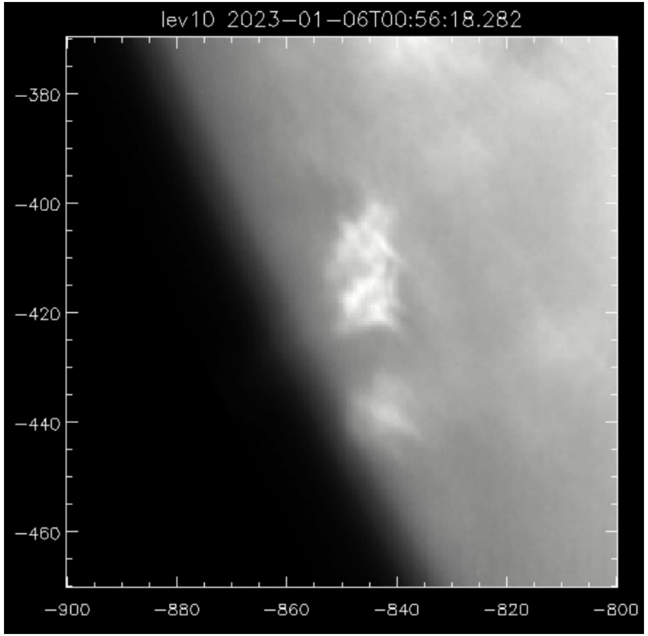
Instrumental artifacts



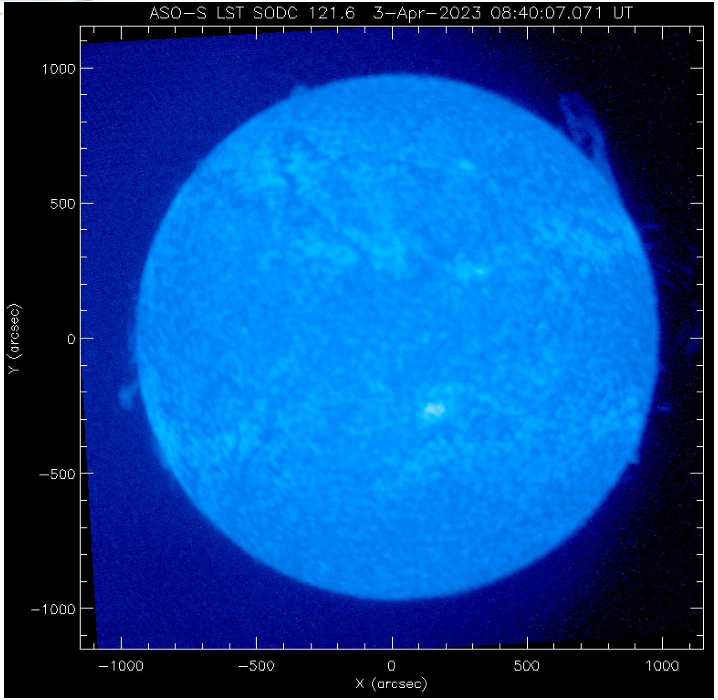
Response of SDI to a brightening dot:
a number of unwanted surrounding dots

Instrumental artifacts

WST: white-light flare



For strong white-light flares, there are extra horns due to the imperfect manufacturing of the reflective mirror.



SDI: east-west asymmetry beyond the limb

Outline

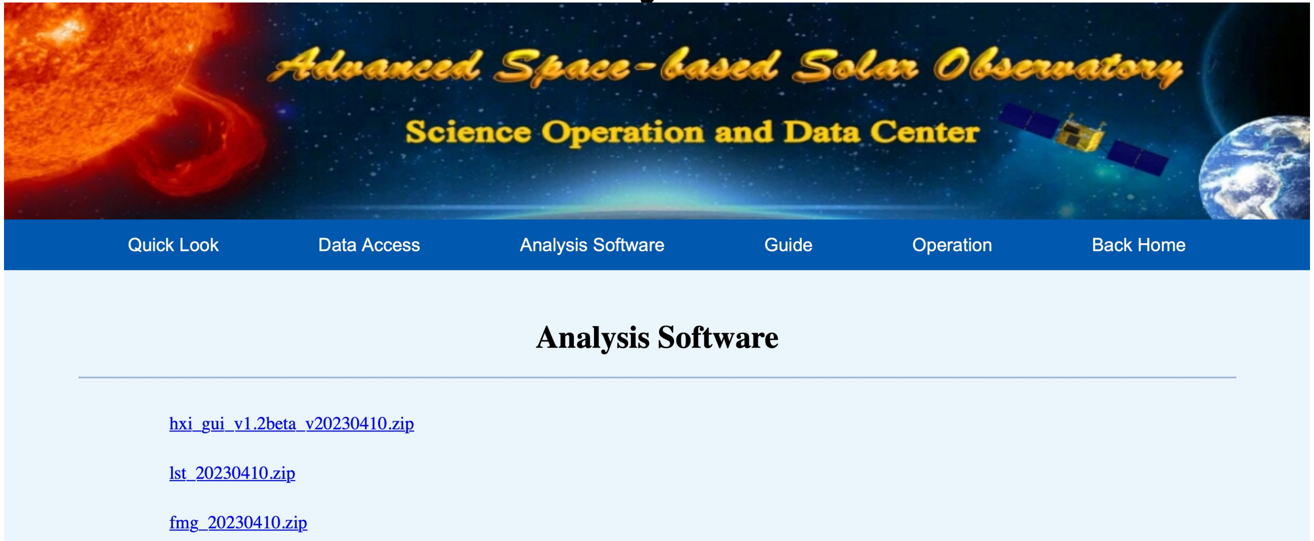
ASO-S/LST payload and relevant HI Lyα and 360nm observations

Inflight calibrations

Data analysis guide

Data analysis guide

1. Definition of LST data levels
2. Definition of LST fits header
3. LST data download
4. LST data analysis demos



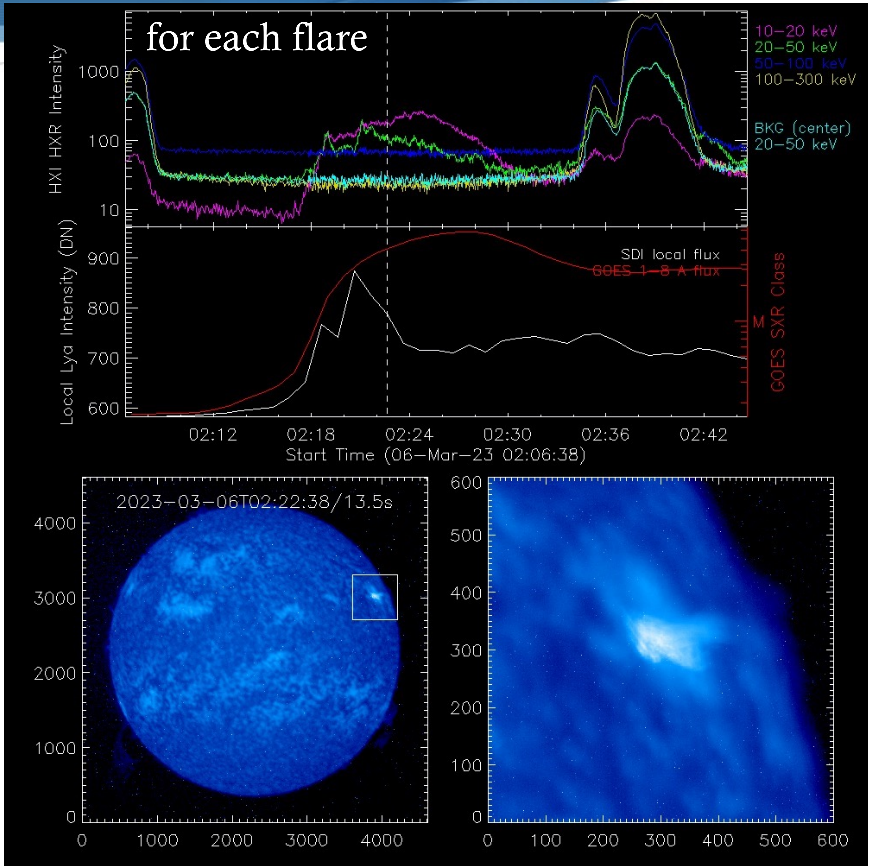
Definition of LST data levels (WST & SDI)

Level 0	**unpacking, verification, adding keywords, etc.**
Level 1 unit: DN	correcting dark current, flat field, merging high-gain and low-gain images to obtain a high-dynamic-range (HDR) image, indexing bad/missing/spike pixels;
Level 1.5 unit: DN	correcting bad/missing/spike pixels, Image registration (rotation, translation, scaling);
Level 2 unit: erg s^{-1} cm^{-2} sr^{-1}	radiometric calibration;
Level 2.5 unit: erg s^{-1} cm^{-2} sr^{-1}	correcting bad/missing/spike pixels; Image registration (rotation, translation, scaling)
quicklook	JPG images

Future Products: Lyα flare list

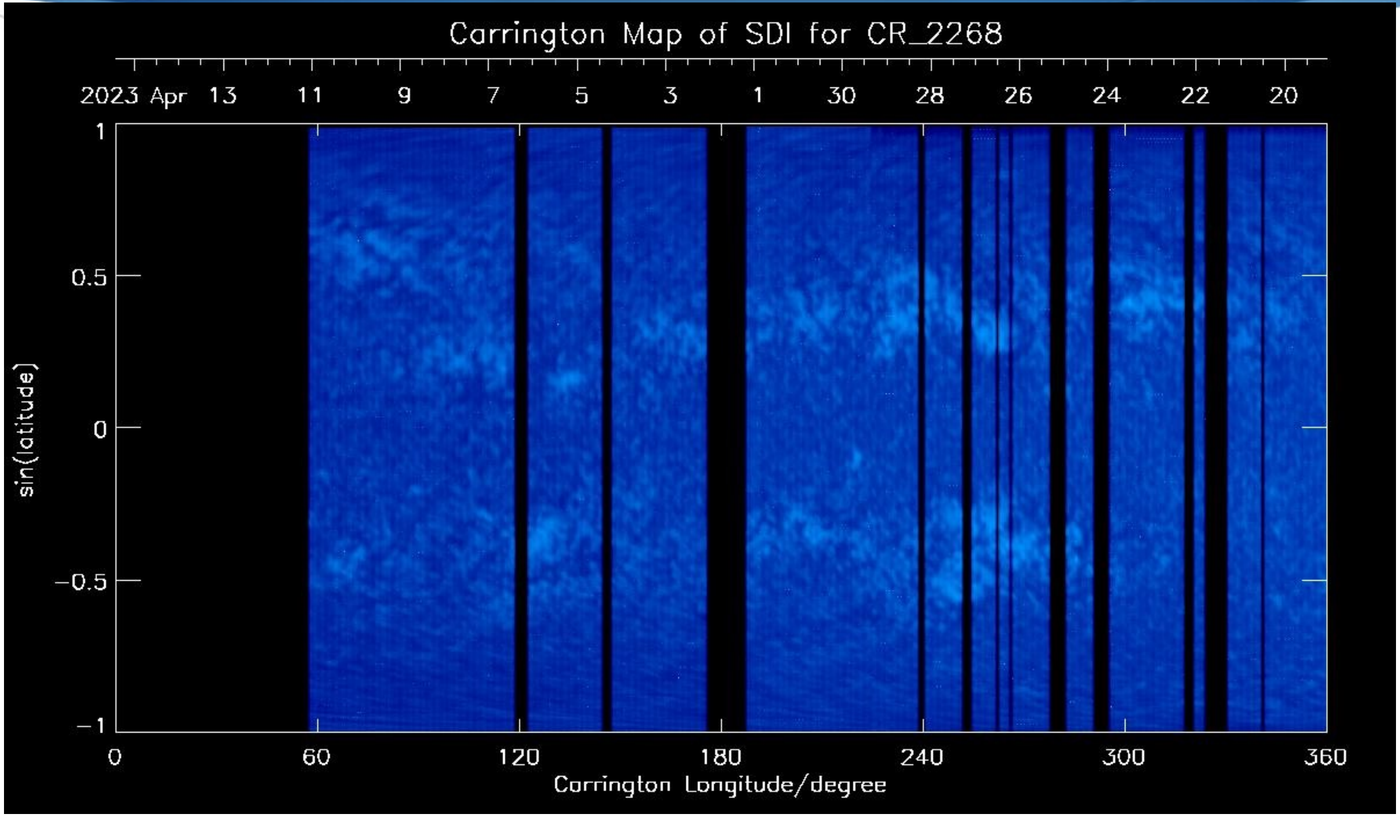
```
# N:        flare number
# DATE:     day of observation
# START:    start time, earliest indication of detection
# END:      end time, last indication of detection
# DUR:      duration of event in unit of minute
# Xpos:     pixel coordinates along horizontal (X) axis
# Ypos:     pixel coordinates along vertical (Y) axis
# Fpos:     heliographic coordinates of flare position
# SIGN:     maximum intensity increase relative to the background, in %
# CLASS:    the GOES class of the SXR flare
```

N	DATE	START	END	DUR(m)	Xpos	Ypos	Fpos	SIGN(%)	CLASS
1	2022-12-09	12:39:12	12:57:12	18.0	2240	1856	S13E02	2.8	C4.1
2	2022-12-09	13:26:12	13:40:12	14.0	4032	3136	N25W78	1.0	
3	2022-12-09	13:50:12	14:16:12	26.0	4032	3136	N25W78	1.5	C3.9
4	2022-12-09	18:02:12	18:06:12	4.0	4032	3264	N29W90	0.9	C1.5
5	2022-12-09	22:41:12	23:13:12	32.0	2112	1856	S13E06	3.5	C5.0
6	2022-12-10	01:14:12	01:45:12	31.0	1984	1472	S25E10	3.0	C1.3
7	2022-12-10	02:50:12	03:25:12	35.0	1984	1856	S13E10	2.6	
8	2022-12-10	10:21:12	10:37:12	16.0	1856	1344	S30E15	1.6	C4.7
9	2022-12-10	18:38:12	18:41:12	3.0	1088	2624	N09E39	1.0	
10	2022-12-10	20:15:12	20:27:12	12.0	832	2624	N09E50	0.8	C1.4
11	2022-12-10	20:40:12	21:03:12	23.0	1728	1344	S30E20	2.9	C4.8
12	2022-12-11	01:13:12	01:34:12	21.0	1472	1728	S17E27	1.0	
13	2022-12-11	09:13:12	09:26:12	13.0	576	1344	S29E90	8.2	
14	2022-12-11	11:30:12	11:52:12	22.0	576	2496	N05E63	7.2	C2.9
15	2022-12-11	15:46:12	15:49:12	3.0	576	2624	N09E64	1.2	C1.2
16	2022-12-12	00:55:12	00:59:12	4.0	576	2496	N05E63	1.3	C3.2
17	2022-12-12	08:11:12	08:15:12	4.0	448	2496	N05E73	0.8	
18	2022-12-12	09:24:12	09:29:12	5.0	960	1216	S34E56	1.8	C2.1
19	2022-12-12	15:05:12	15:20:12	15.0	3008	2880	N17W22	2.0	C3.0
20	2022-12-13	01:43:12	01:47:12	4.0	2240	1472	S26E02	0.5	C1.4
21	2022-12-13	05:40:12	05:58:12	18.0	2624	2752	N13W10	2.2	
22	2022-12-13	19:49:12	19:53:12	4.0	448	2624	N09E75	1.6	
23	2022-12-13	23:17:12	23:56:12	39.0	448	2624	N09E75	6.4	C2.9
24	2022-12-14	05:40:12	05:44:12	4.0	1088	2880	N17E40	0.7	
25	2022-12-14	07:33:12	07:55:12	22.0	1088	2752	N13E40	3.4	M2.4
26	2022-12-14	21:35:12	22:34:12	59.0	832	2752	N13E51	8.6	M1.3
27	2022-12-14	23:44:12	23:48:12	4.0	960	2880	N17E46	1.4	C7.3
28	2022-12-15	01:35:12	01:40:12	5.0	704	2752	N13E57	2.4	M1.6
29	2022-12-15	03:05:12	03:10:12	5.0	2752	3008	N20W14	1.4	C4.2
30	2022-12-15	05:21:12	05:41:12	20.0	832	2752	N13E51	1.4	C7.6
31	2022-12-15	06:58:12	07:19:12	21.0	832	2880	N17E52	3.9	M2.3
32	2022-12-15	07:56:12	08:28:12	32.0	832	2752	N13E51	2.7	M1.0



To be included: white-light flare (WST)

Future Products： preliminary carrington maps



The Carrington map can be used as the incident emission for the Lyα emission in the coronagraph field of view. However, due to various calibration activities, currently significant amount of data are missing.

Lyα radiation – radiative component

$$j_r = \frac{B_{12} h \lambda_0}{4\pi} n_i \int_{\Omega} p(\phi) d\Omega \int_0^{\infty} I_{ex}(\lambda - \delta\lambda) \Phi(\lambda, \vec{n}') d\lambda$$

the neutral hydrogen number density

scattering geometric function

Doppler dimming factor F_D

Scattering geometry

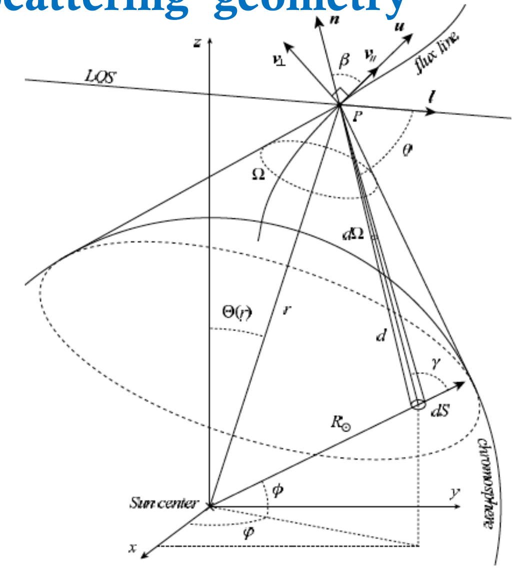
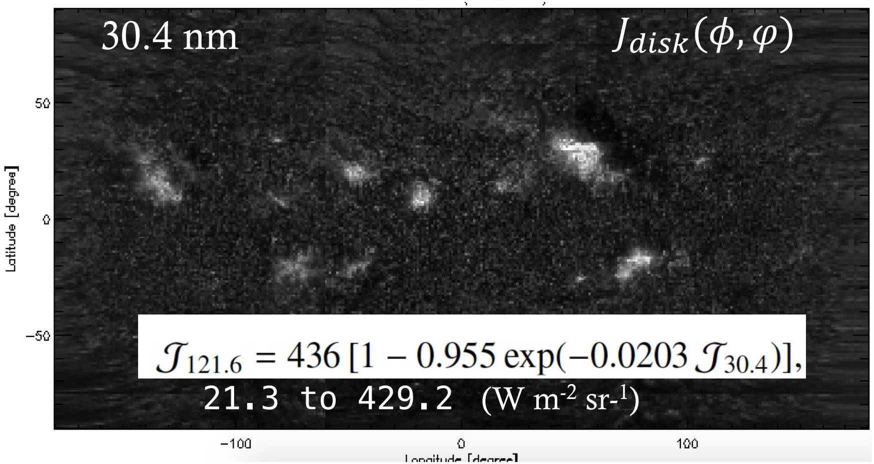


FIG. 1.—Geometry of the modeling of the resonantly scattered coronal Lyα radiation.

F. Auchere (2005)

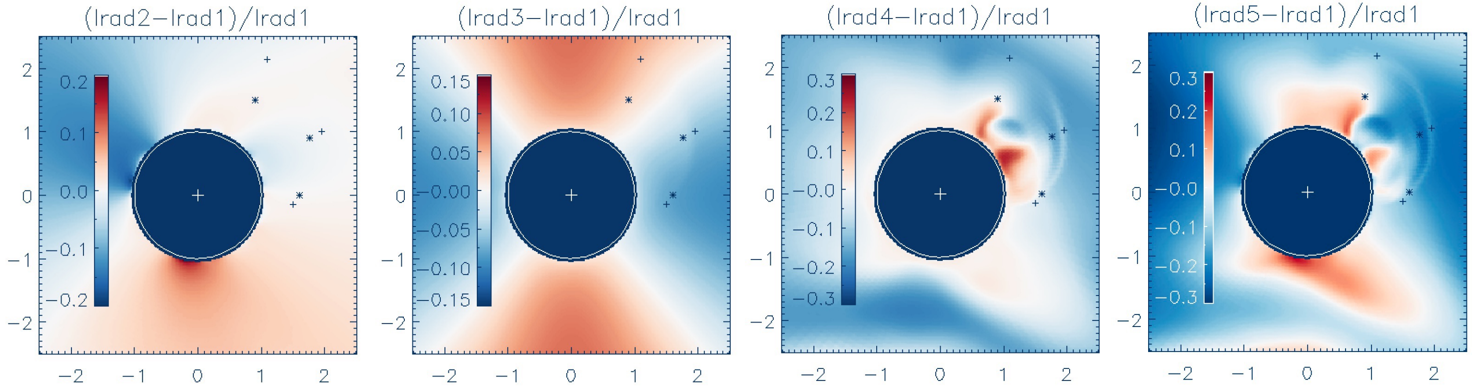
Nonuniform Lyα chromospheric radiation $I_{ex}(\lambda - \delta\lambda)$

An empirical relation between 30.4nm and Lyα radiation will be replaced by the observed **LST/SDI Carrington map in Lyα .**



Comparison of radiative component of Lyα intensity under different assumptions

	Irad1	Irad2	Irad3	Irad4	Irad5
nonuniform Lyα disk intensity	Y	uniform	Y	Y	uniform
detailed scattering geometry	Y	Y	Sun as a point source	Y	Sun as a point source
$T_p \neq T_e$	Y	Y	Y	$T = T_e = T_p$	$T = T_e = T_p$
Max uncertainty to Irad1	/	~15%	~10%	~25%	~30%



Ying+2023

Definition of LST fits header

#	Keyword	Type	Description	definition (Y)				archive (Y)				search (Y)				Comment
				L0	L1/ 1.5	L2.5(2)/3 .5(3)		L 0	L1/ 1.5	L2.5(2)/ 3.5		L0	L1/ 1.5	L2.5(2)/3 .5		
Basic Image Configuration Keywords and Information for Level 0 (Some are Level 1 as noted)																
1	NAXIS	Int2 (byte)	the number of axes of the overall image	Y	Y	Y	Y	Y	Y	Y	Y					
2	NAXIS1	Int2	the total number of pixels along axis 1 of overall image	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
3	NAXIS2	Int2	the total number of pixels along axis 2 of overall image	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
4	CAMERA	String	SCIUV, SCIWL, SDI, WST	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
5	FSN	Int4	Frame Serial Number (for lv3.5, maximum FSN of the polarization sequence)	Y	Y	Y	Y	Y	Y	Y	Y					
6	FILENAME	String	name of the fits file	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
7	APID	String	Image application ID	Y				Y								
8	NPACKETS	Int2	Number of packets in image	Y				Y								
9	NERRORS	Bool	decompression error (T: success, F: failure)	Y				Y								
10	HEADRERR	Bool	Header error in an image	Y				Y								
11	OVERFLOW	Bool	Image oversize with size exceeding naxis1*naxis2	Y				Y								
12	BZERO	Float	offset in stored_value, if applicable If missing, then assumed to be zero	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
13	BSCALE	Float	Phys_value = BZERO + BSCALE * Stored_value, if applicable. If missing, then assumed to be one	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
14	BUNIT	String	physical units of data	Y	Y	Y	Y	Y	Y	Y	Y					
15	BTYPE	String	a description of the content of the record/file	Y	Y	Y	Y	Y	Y	Y	Y					
16	SUM_COL	Int2	Number of summed columns	Y	Y	Y	Y	Y	Y	Y	Y					
17	SUM_ROW	Int2	Number of summed rows	Y	Y	Y	Y	Y	Y	Y	Y					
18	P1COL	Int2	starting pixel along column direction for CMOS readout, (0, P1COL-1) are underscan columns	Y	~~Y~~	~~Y~~	~~Y~~	Y	~~Y~~	~~Y~~	~~Y~~					
19	P2COL	Int2	ending pixel along column direction for CMOS readout, (P2COL+1, CMOS_COL_MAX) are overscan columns	Y	~~Y~~	~~Y~~	~~Y~~	Y	~~Y~~	~~Y~~	~~Y~~					

Document of the detailed definition of the LST fits header which includes 150+keywords will be uploaded to the ASO-S website.

LST data download: Data Archive

Data Archive

The ASO-S data policy can be found here.

The SDI data is between April 2, 2023 and April 3, 2023. The other data starts from April 1, 2023.

Start Time 04/02/2023 03:00 **End Time** 04/02/2023 04:00

HXI ?

Level Q1 ☐ Hourly Fits ☐ Hourly Png ☐ Data-production status Png

Level 1 ☐ Detector Data

FMG ?

Level ☐ 2-AR

Mode ☐ Routine ☐ User-defined Cadence s

LST ?

SDI Level ☑ 1 ☐ Background

SDI Mode ☑ Routine ☐ Burst-1024 ☐ Burst-4608 ☐ User-defined Cadence s

WST Level ☐ 1

WST Mode ☐ Routine ☐ Burst-1024 ☐ Burst-4608 ☐ User-defined Cadence s

Email: lfeng@pmo.ac.cn Search Tar and Download Data Reset

Result File Count : 60 Probable Size(KB) : 1361866 Request ID : 20230410182939184003

Data Export Status and Retrieval

Request ID : 20230410182939184003 Check Status Status : Ready

Link : http://172.17.90.231:8080/downloadPackFits/20230410/20230410182939184003.zip Download Link

	File Name	Download
1	sdi_lev10_20230402_030007.983_v01.fits.gz	download
2	sdi_lev10_20230402_030107.983_v01.fits.gz	download
3	sdi_lev10_20230402_030207.983_v01.fits.gz	download

LST data download: cutout sevice

Cutout Service

The SDI data is between April 2, 2023 and April 3, 2023. The other data starts from April 1, 2023.

Start Time 04/03/2023 07:30 **End Time** 04/03/2023 09:30

LST ?

SDI Level 1

Cadence(optional) User-defined Cadence s

WST Level 1

Cadence(optional) User-defined Cadence s

Cutout Xcenter (arcsec) 800 Ycenter (arcsec) 600 Xrange (arcsec) 600 Yrange (arcsec) 800

Tracking (optionalk) Reference Time:

Requirement The arcsec range for x-axis is between [-1150,1150]. Xrange>0, Xcenter-(Xrange/2)>=-1150, Xcenter+(Xrange/2)<=1150.

The arcsec range for y-axis is between [-1150,1150]. Yrange>0, Ycenter-(Yrange/2)>=-1150, Ycenter+(Yrange/2)<=1150.

Email: lfeng@pmo.ac.cn Search Submit Reset

Result

File Count : 120 Probable Size(KB) : 2648510 Request ID : 20230410181031551001

Data Export Status and Retrieval

Request ID : 20230410181031551001 Check Status Status : Ready

Link : http://172.17.90.231:8080/downloadCutout/20230410/20230410181031551001.tgz Download Link

LST data analysis tutorial

Two procedures that users often use:

IDL> read_lst, fn, ihdr, iimg

IDL> lst_prep, ihdr, iimg, ohdr, oimg

- IDL on linux, windows, Mac
- SolarSoftWare Dependence of the LST package: $SSW/gen/

```
pro read_lst, lstfiles, index, data, nodata=nodata, fitshead=fitshead
 ; ========================================================================
 ;+
 ; PROJECT:
 ;       ASO-S/LST
 ; NAME:
 ;       READ_LST
 ; PURPOSE:
 ;       Read LST FITS file(s) into 2D or 3D array
 ; INPUTS:
 ;       LSTFILES - LST FITS file(s) name to read
 ; KEYWORDS:
 ;       /NODATA  - Read in header(s) only, not data.
 ;       /FITSHEAD  - If set, output string index
 ; OUTPUTS:
 ;       INDEX   - Output the data header(s)
 ;       DATA    - 2D or 3D array of LST image(s)
 ; EXAMPLES:
 ;       IDL> read_lst, lstfiles, index, data [,/nodata] [,/fitshead]
 ; NOTES:
 ;       The input files must have the same size of data
 ;       if multiple data are read
 ; HISTORY:  2021-October-12; Written by lijw (njlijw@pmo.ac.cn)
 ; HISTORY:  2022-April-07  ; Readfits.pro is replaced with mreadfits.pro
 ; HISTORY:  2022-April-12  ; Default output structure index, and add keyword "fitshead
```

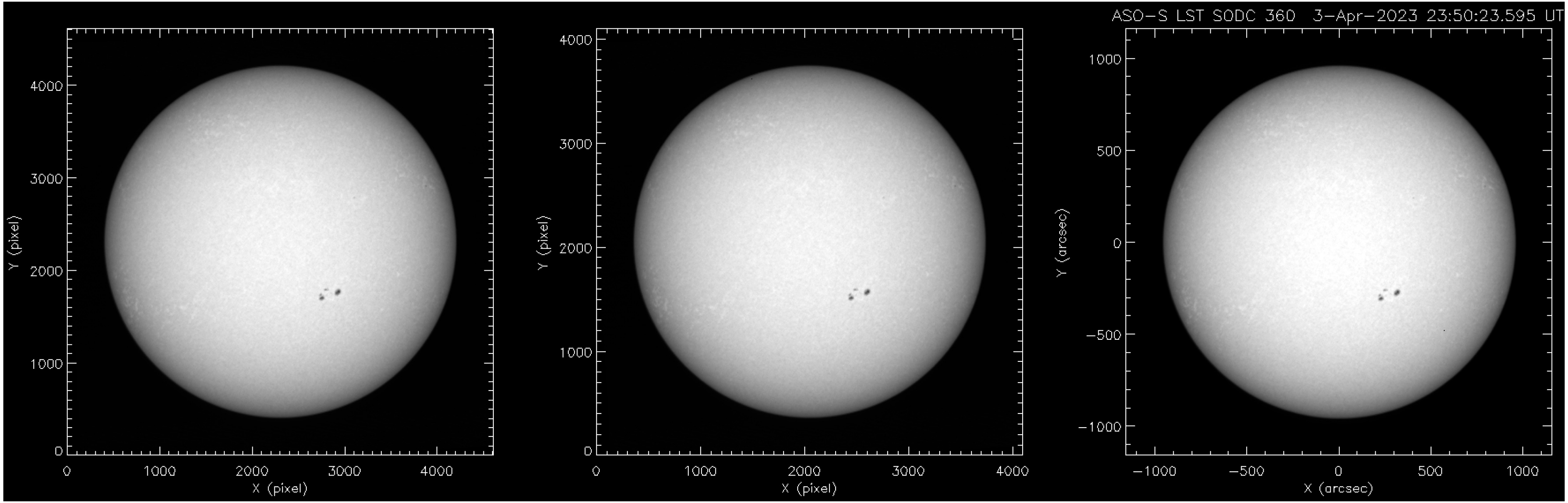
```
pro lst_prep, ihdr, iimg, ohdr, oimg, $
          bkgimg_on = bkgimg_on, bkg_hdr = bkg_hdr, bkg_dat = bkg_dat, $
          radcalib_on = radcalib_on, $
          fix_missing_off = fix_missing_off,  $
          despike_on = despike_on, la_cosmic = la_cosmic, $
          reg_off = reg_off, $
          outsize=outsize, $
          do_write_fits = do_write_fits, compress=compress, outdir = outdir, $
          status = status, quiet = quiet, _EXTRA=ex

 ;+
; NAME: LST_PREP
;
; PROJECT: ASO-S/LST
;
; PURPOSE: optional preprocessing steps of LST level 1 data including:
;          background subtraction (usually for full-disk images),
;          radiometric calibration,
;          fixing missing/bad pixels,
;          fixing cosmic-ray/spike pixels,
;          image registration (rotation, translation, scaling)
;
;          By default, 'lst_prep' fixes missing/bad pixels and does image registration.
;          If we want to do more, e.g., background substraction, radiometric calibration, despike,
;          please set /bkgimg_on, /radcalib_on, /despike_on, respectively.
```

LST data analysis tutorial: WST

```
file='/asos/data/wst/science/lev10/2023/04/03/wst_lev10_20230403_235023.595_v01.fits.gz'
read_lst, file, ihdr, iimg
lst_prep, ihdr, iimg, ohdr1, oimg1
lst_prep, ihdr, iimg, ohdr2, oimg2, outsize=4096 ;to work with e.g., SDO/HMI
;lst_prep, ihdr, iimg, ohdr2, oimg2, outsize=4096, /radcalib_on
index2map, ohdr2, oimg2, wstmap
window, 0, xsize=1800, ysize=600, retain=2
!p.multi=[0,3,1]
lst_lct, wavelnth = 3600, instr = 'wst', /load
plot_image, oimg1, dmin=0, dmax=8000, charsize=2., xtitle='X (pixel)', ytitle='Y (pixel)’
plot_image, oimg2, dmin=0, dmax=8000, charsize=2., xtitle='X (pixel)', ytitle='Y (pixel)'
plot_map, wstmap, dmin=0, dmax=8000, charsize=2.
```

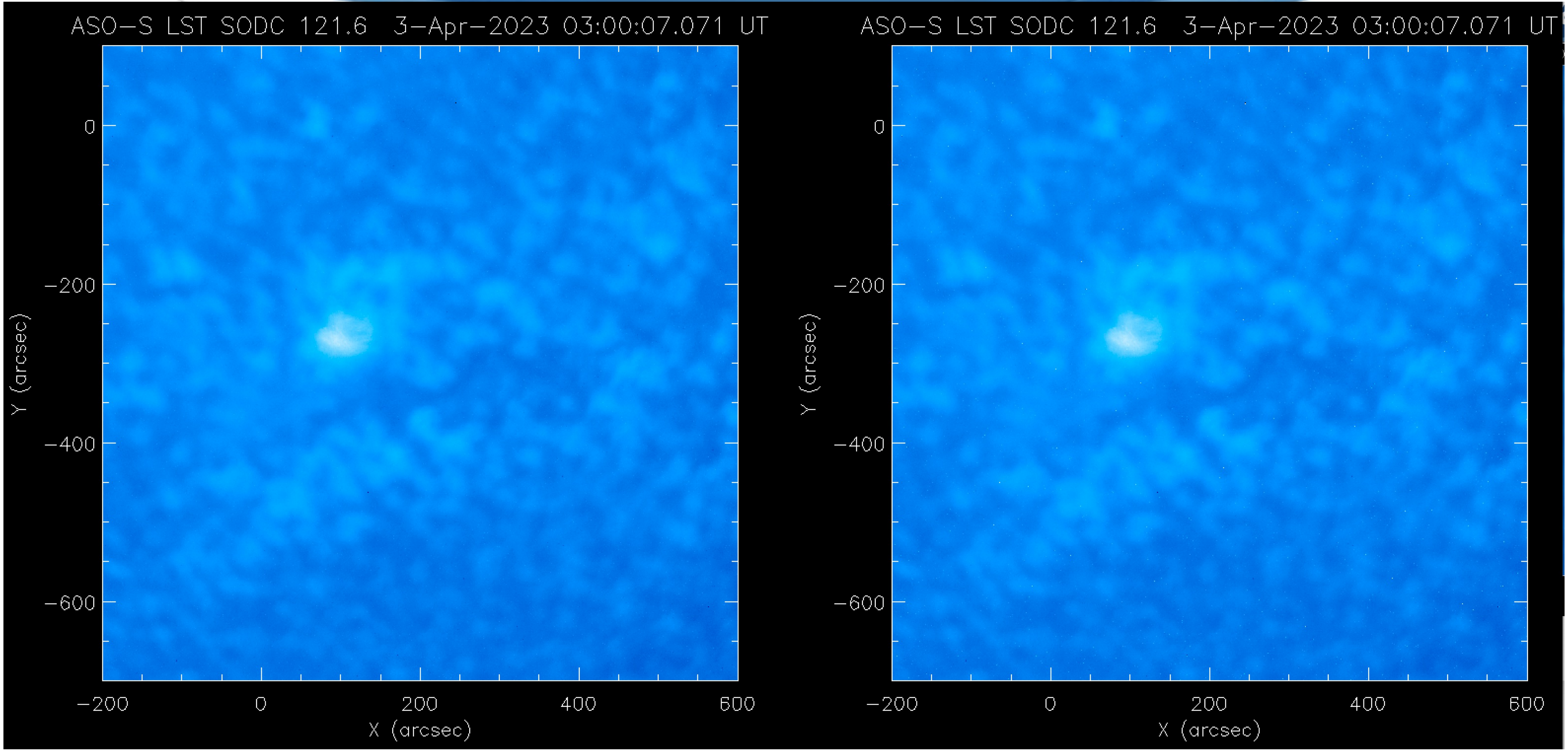
LST data analysis tutorial: WST



LST data analysis tutorial: SDI (cutout images)

```
fns=file_search('~/cutout/flare/sdi_lev10_20230403_030*cut.fits.gz')
read_lst, fns, ihdr, iimg ;dealing with a sequence of fits files
lst_prep, ihdr, iimg, ohdr1, oimg1, /despike_on, /la_cosmic, /reg_off
lst_prep, ihdr, iimg, ohdr2, oimg2, /reg_off
index2map, ohdr1[0], oimg1[*,*,0], sdimap1
index2map, ohdr2[0], oimg2[*,*,0], sdimap2
window, 0, xsize=1600, ysize=800, retain=2
!p.multi=[0,2,1]
lst_lct, wavelnth = 1216, instr = 'sdi', /load
plot_map, sdimap1, /log, dmin=20, dmax=14000, charsize=2.
plot_map, sdimap2, /log, dmin=20, dmax=14000, charsize=2.
```

LST data analysis tutorial: SDI (cutout images)

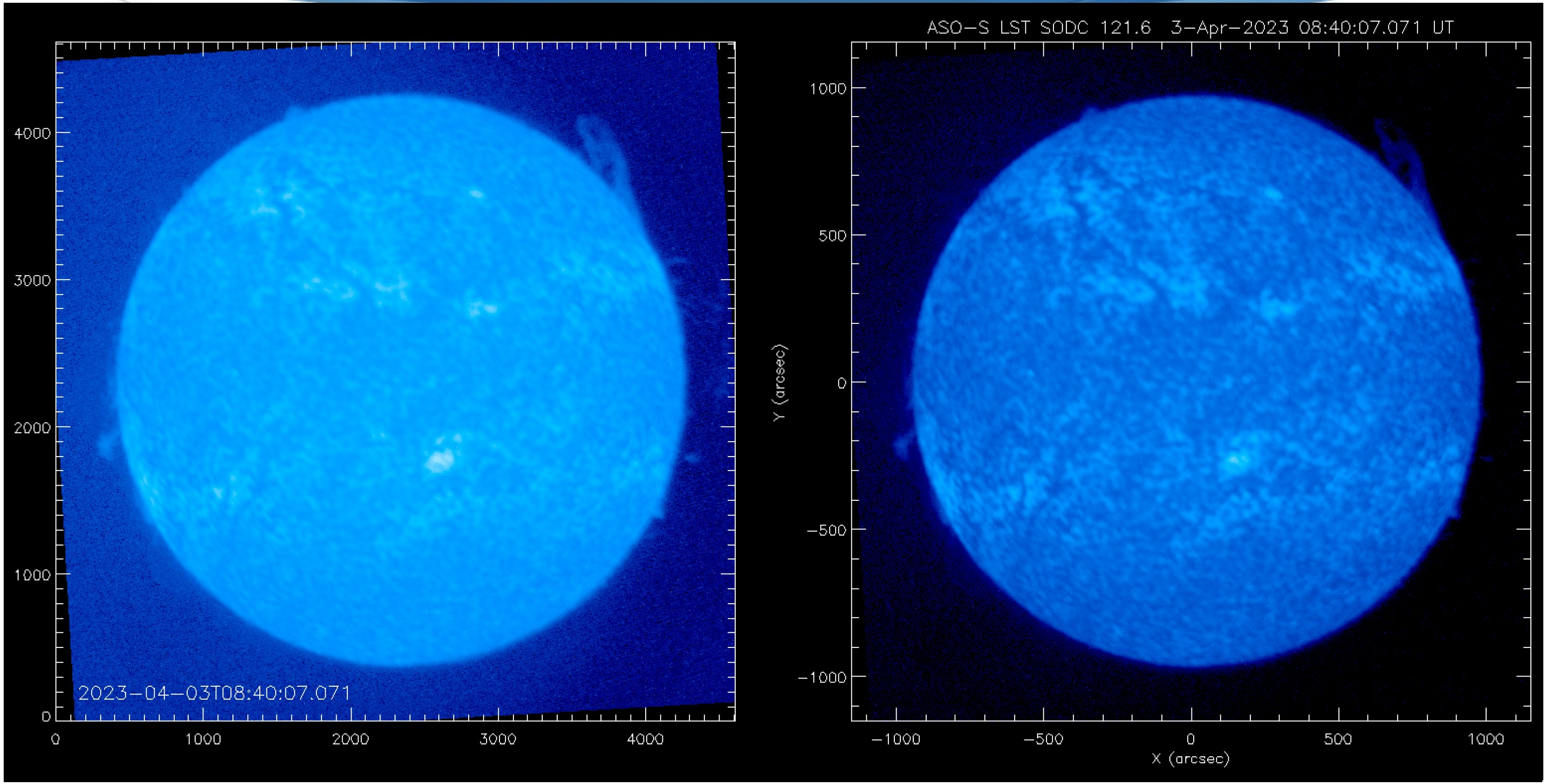


LST data analysis tutorial: SDI (full-disk images)

```
file='/asos/data/sdi/science/lev10/2023/04/03/sdi_lev10_20230403_084007.071_v01.fits.gz'
read_lst, file, ihdr, iimg
bkgfits = '/asos/data/sdi/bkg/2023/sdi_lev10_20230403_bkg_biweekly.fits.gz'
read_lst, bkgfits, bkg_hdr, bkg_dat
lst_prep, ihdr, iimg, ohdr, oimg, /bkgimg_on, bkg_hdr=bkg_hdr, bkg_dat=bkg_dat, /despike_on
index2map, ohdr, oimg, sdimap

window, 0, xsize=1600, ysize=800, retain=2
!p.multi=[0,2,1]
lst_lct, wavelnth = 1216, instr = 'sdi', /load
plot_image, alog10(oimg), min=0.5, max=4.1, charsize=1.5
xyouts, 150, 150, ohdr.date_obs, charsize=2.
plot_map, sdimap, /log, dmin=40, dmax=14000, charsize=1.5
```

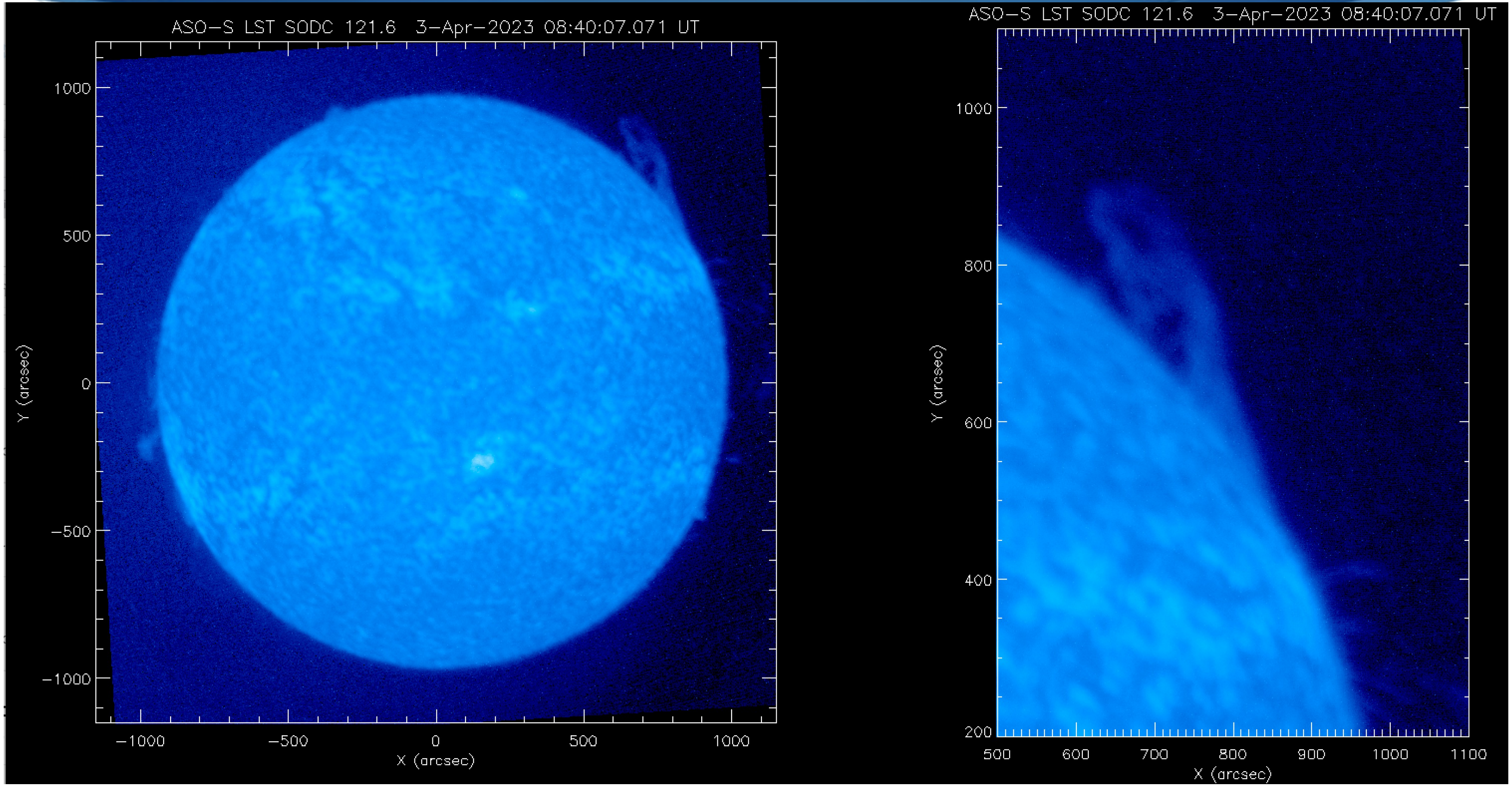
LST data analysis tutorial: SDI (full-disk images)



LST data analysis tutorial: SDI continue

```
index2map, ohdr, oimg, sdimap
sub_map,sdimap,smap, xrange=[500,1100],yrange=[200, 1100]
window, 0, xsize=1600, ysize=800, retain=2
!p.multi=[0,2,1]
lst_lct, wavelnth = 1216, instr = 'sdi', /load
plot_map, sdimap, /log, dmin=10, dmax=14000, charsize=1.5
plot_map, smap, /log, dmin=10, dmax=14000, charsize=1.5
```

LST data analysis tutorial: SDI continue



Summary

ASO-S/LST payload and relevant HI Lyα and 360nm observations

Inflight calibrations

Data analysis guide

Thank you. Your comments are very welcome!