

WP 50.1: Innovative Tools for Data Handling – Data Reduction Pipelines

Lead Institution: **Stockholms universitet (SU)**

Participants: **Instituto de Astrofísica de Canarias (IAC), Kiepenheuer-Institut für Sonnenphysik (KIS), Centre national de la recherche scientifique (CNRS), Universitetet i Oslo (UiO), Leibniz-Institut für Astrophysik Potsdam (AIP), The Queen's University of Belfast (QUB)**

Authors
SU (CRISP, TRIPPEL, CHROMIS)
 Dan Kiselman (presenting)
 Jaime de la Cruz Rodríguez
 Mats Löfdahl
 Tomas Hillberg

AIP (GFPI, HiFI)
 Carsten Denker
 Andrea Diercke
 Horst Balthasar
 Meetu Verma
 Sergio Gonzalez Manrique
 Christoph Kuckein

UiO (metadata recommendations)
 Stein Vidar Haugan
 Mats Carlsson
 Terje Fredvik

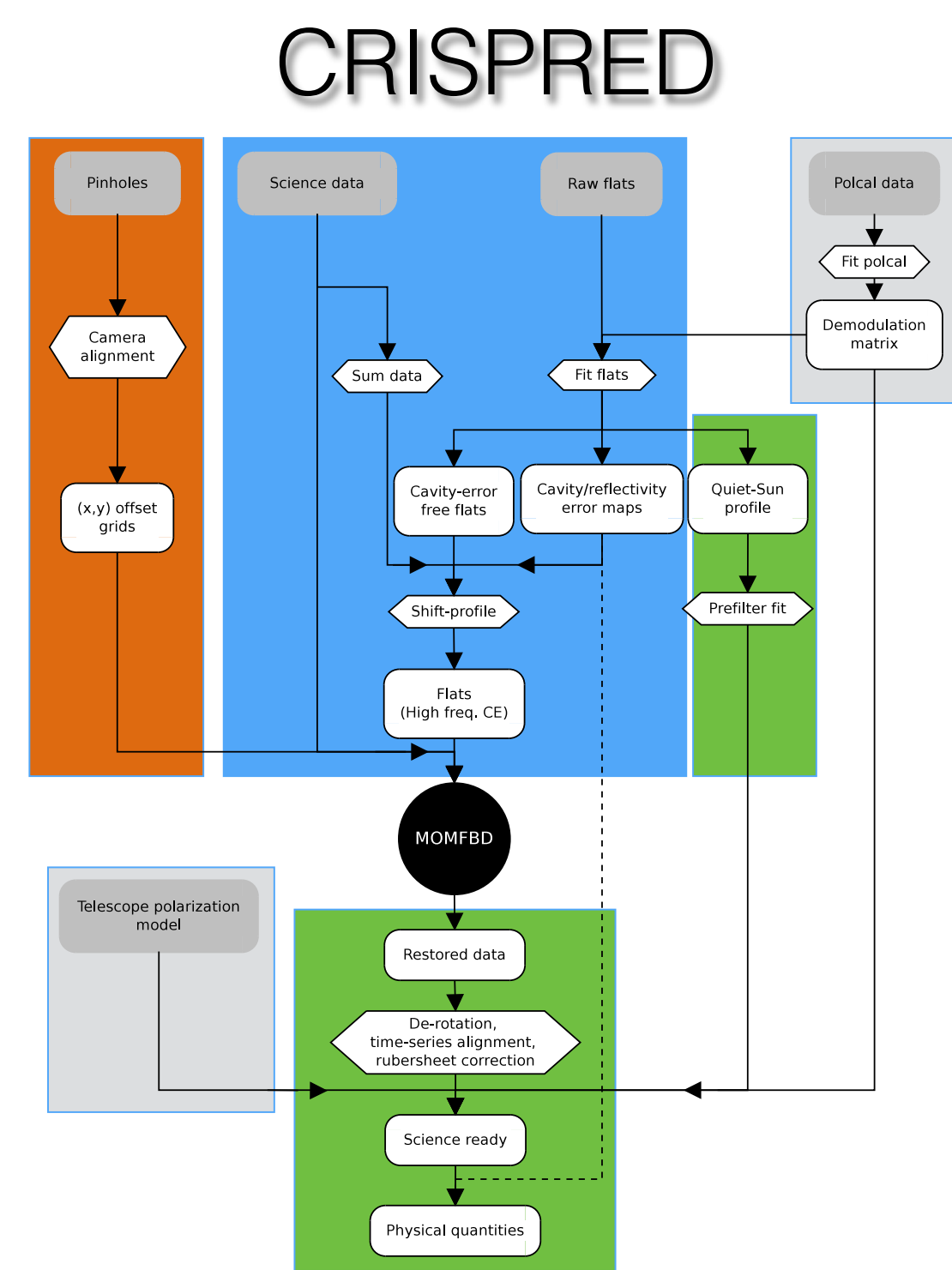
CNRS (TUNIS, MTR)
 Bernard Gelly

KIS (TESOS, LARS)
 Nazaret Bello-Gonzalez
 Johannes Löhner-Böttcher

IAC (GRIS)
 Manolo Collados

QUB (ROSA)
 Peter Keys

INAF (IBIS)
 Ilaria Ermolli
 Gianna Cauzzi
 Fabrizio Giorgi



Flow chart for the **CRISPRED** pipeline developed to reduce **SST/CRISP** data. Published by de la Cruz Rodríguez et al. (A&A, 573, 40, 2015).

Visit the **SOLARNET Solar Virtual Observatory prototype** which was developed in SOLARNET WP50.2: <http://solarnet.oma.be>

Listen to the presentation of Robbe Vansintjan – the final talk of SOLARNET IV!

Data pipelines have been developed for **twelve European instruments** on **five solar telescopes** situated on La Palma, Tenerife, and Sacramento Peak.

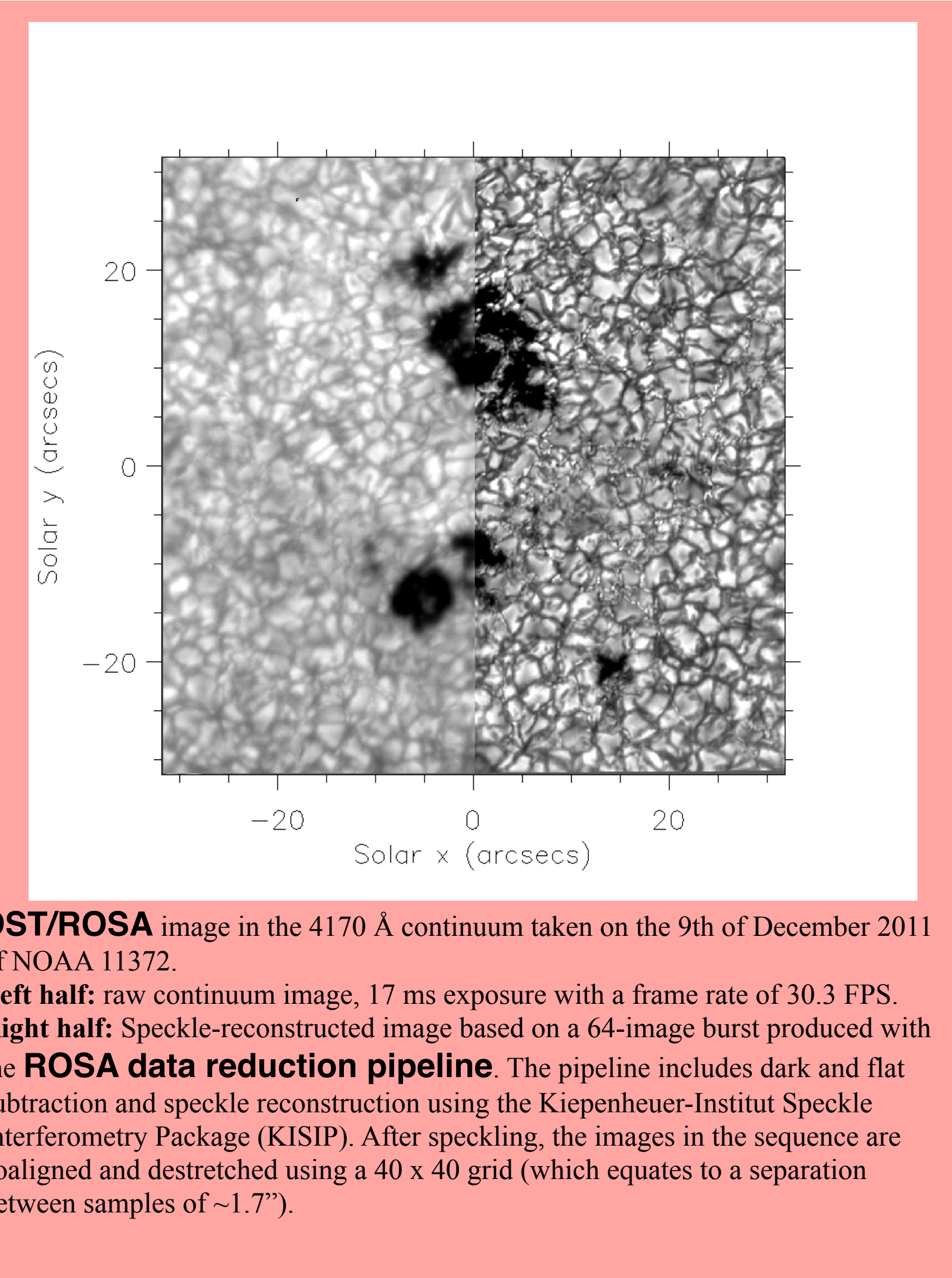
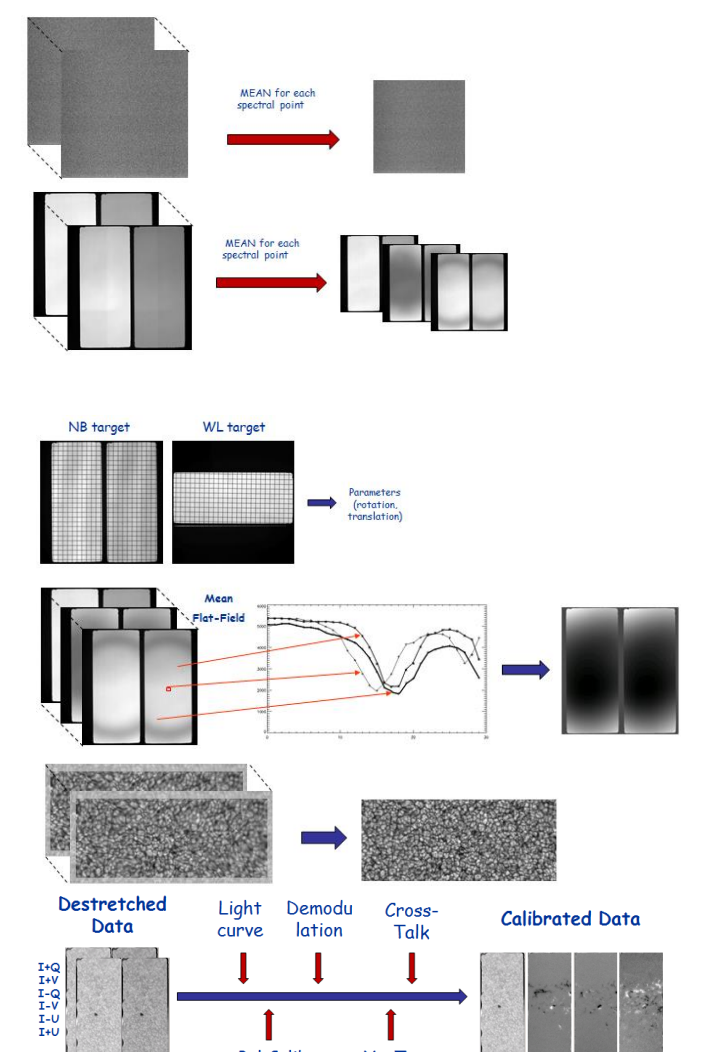
An important goal is that the pipelines should have standard data products, including metadata, that can easily be incorporated in virtual observatories.

Below we present a table summarising the pipelines, surrounded by illustrations. We also display the recommendations for metadata.

Telescope	Instrument	Instrument type	Responsible partner	Pipeline exists	Pipeline name	Distribution
GREGOR	GRIS	Grating-based spectropolarimeter for the IR	KIS	YES	GRIS	download
GREGOR	HiFI	Blue imager	AIP	YES	sTools	svn
GREGOR	GFPI	FPI-based imaging spectropolarimeter, 530-860 nm (pol 580-660 nm)	AIP	YES	sTools	svn
SST	CRISP	FPI-based imaging spectropolarimeter, 510-860 nm	SU	YES	CRISPRED	git
SST	CHROMIS	FPI-based imaging spectrometer, 380-500 nm	SU	YES	CHROMISRED	git coming soon
SST	TRIPPEL	Grating spectrograph	SU	YES	specred	request
VTT	LARS	Spectrograph with laser comb	KIS	YES	larsrdc	git
VTT	TESOS	FPI-based imaging spectropolarimeter	KIS	YES	CASSDA GUI TESOS	git
DST	ROSA	Multi-band imager at high cadence	QUB	YES	ROSA data reduction pipeline	http
DST	IBIS	FPI-based imaging spectropolarimeter	INAF	YES	lbis lib	http
THEMIS	TUNIS	Imaging spectropolarimeter	CNRS	YES	Tunvision	download
THEMIS	MTR	Multiwavelength spectropolarimeter	CNRS	YES	SQUV	download

IBIS PIPELINE

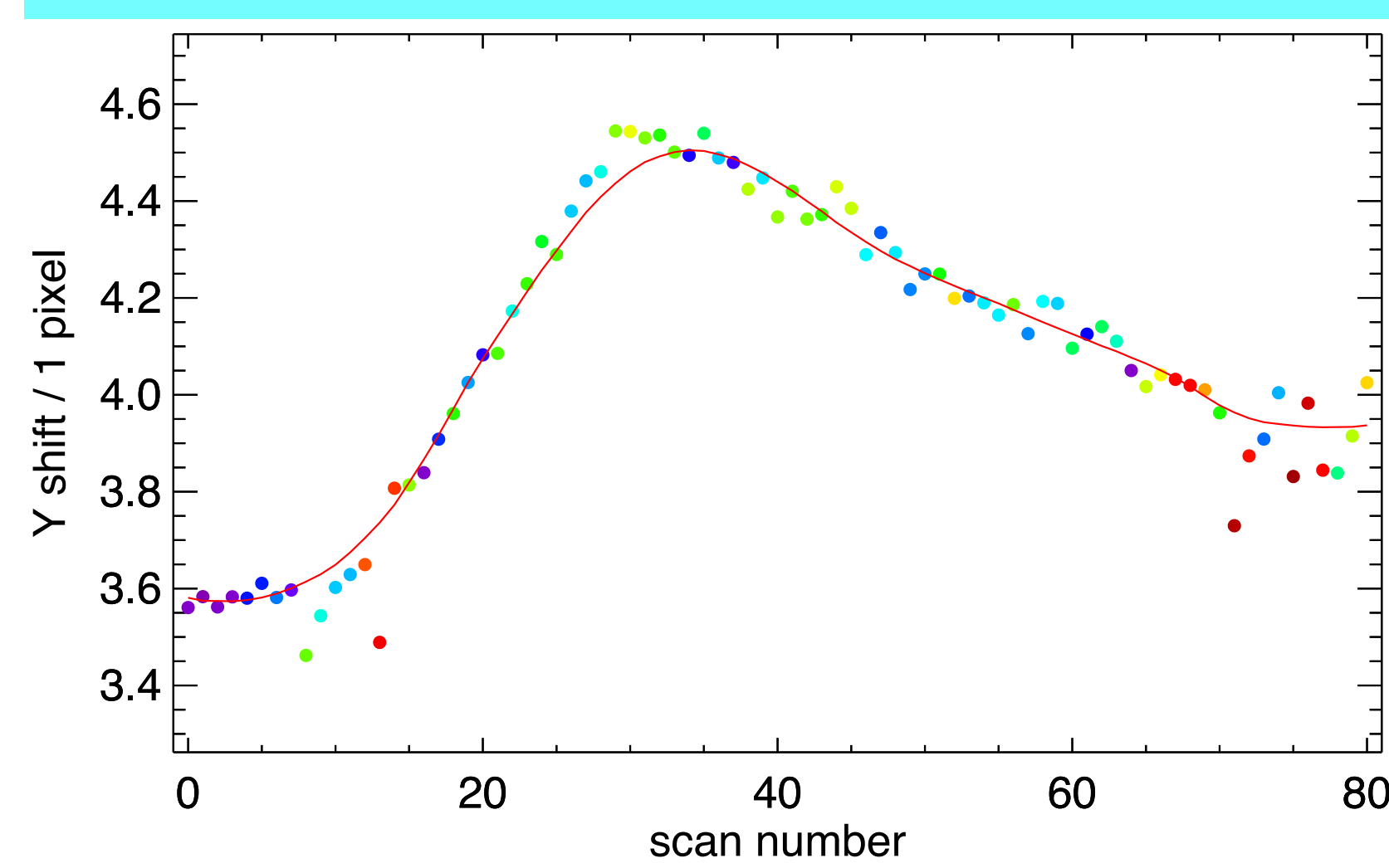
- DARK CURRENT
- FLAT FIELD
- FILTER TRANSMISSION
- ALIGNEMENT
- BLUESHIFT
- MOMFBD
- Polarimetric calibration



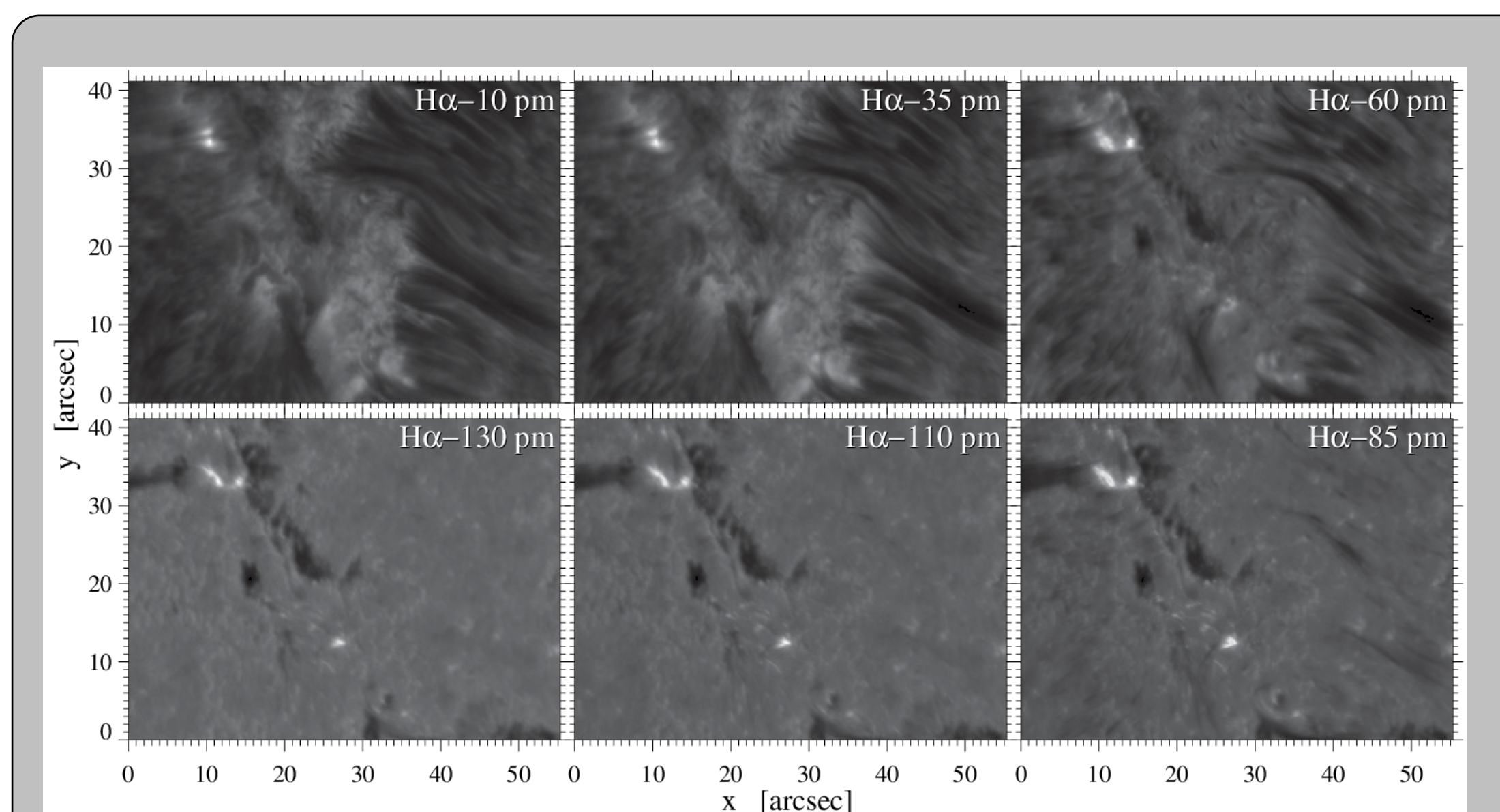
DST/ROSA image in the 4170 Å continuum taken on the 9th of December 2011 of NOAA 11372.

Left half: raw continuum image, 17 ms exposure with a frame rate of 30.3 FPS. **Right half:** Speckle-reconstructed image based on a 64-image burst produced with the **ROSA data reduction pipeline**. The pipeline includes dark and flat subtraction and speckle reconstruction using the Kiepenheuer-Institut Speckle Interferometry Package (KISIP). After speckling, the images in the sequence are co-aligned and destretched using a 40 x 40 grid (which equates to a separation between samples of ~1.7").

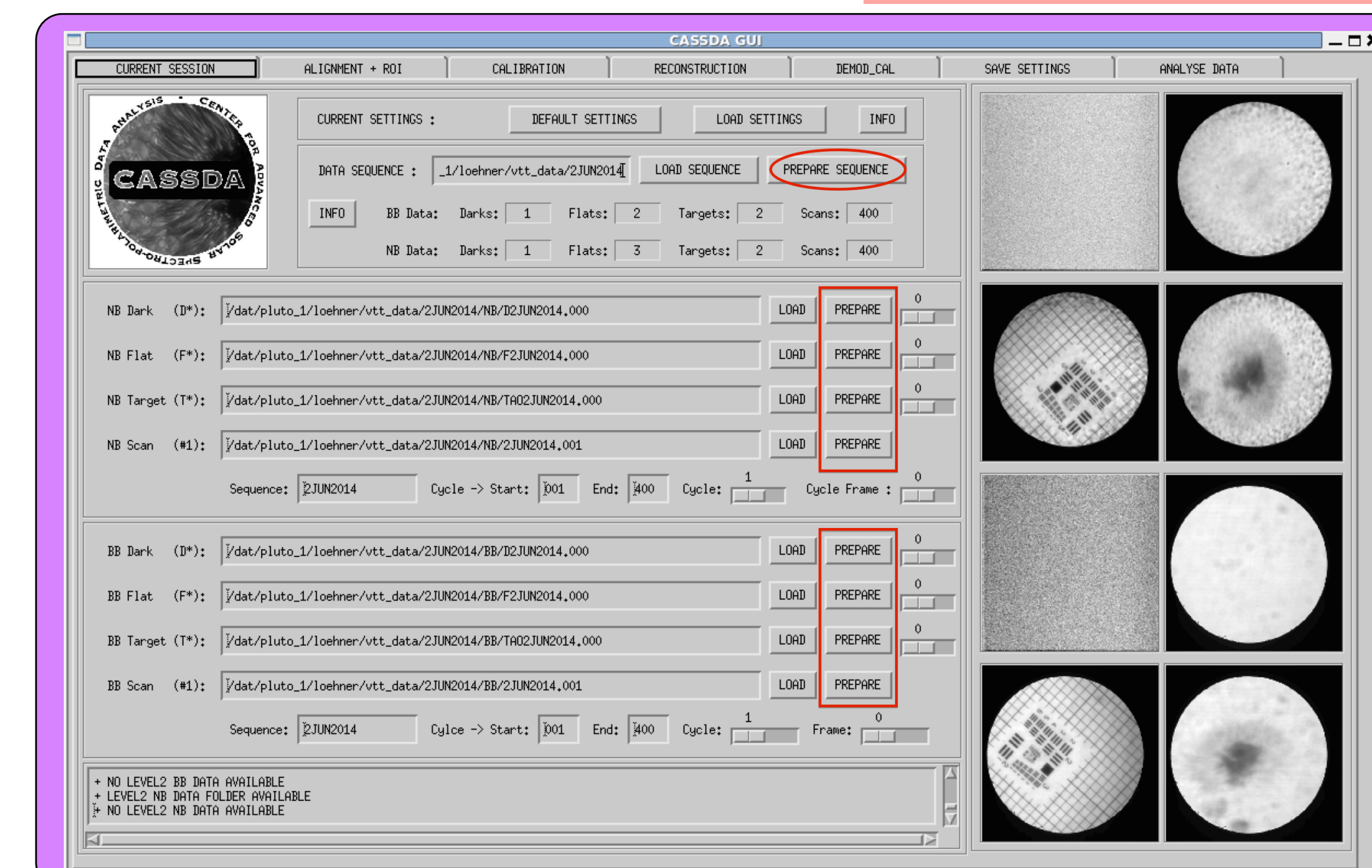
High-precision coalignment between the **SST/CHROMIS** wideband and narrowband cameras is essential for image reconstruction and science interpretation. Empirically we find a wavelength-dependent, time-variable alignment difference consisting of two components: one depending on differential atmospheric refraction and one on internal telescope temperature changes. This is measured accurately with cross-correlation between narrowband continuum and wideband images. The plot shows the resulting shifts between 395 nm and 399 nm. The shifts for all wavelengths in a scan are then calculated with linear inter/extrapolation. (The shifts are much smaller in the longer wavelengths observed with CRISP).



Diagnostic plot automatically produced by the **CHROMISRED** pipeline for **SST/CHROMIS** data. **Dots:** Measured continuum/wideband Y-shifts, colours represent RMS contrast (blue=high, red=low). **Line:** Smoothed Y-shifts used for alignment. 81 scans collected in 22 minutes between 09:06:33 and 09:28:55 on 2016-09-14. One pixel corresponds to 0".0379.



H- α filtergrams acquired with **GREGOR/GFPI** on 2014 August 13. Images were reduced with the **sTools** pipeline (see separate poster by Kuckein et al.) developed at the Leibniz Institute for Astrophysics (AIP) and restored with Multi-Object Multi-Frame Blind Deconvolution (MOMFBD).



The user interface for the **CASSDA GUI** for **TESOS**. (Löhner-Böttcher 2016, PhD Thesis)

METADATA

SOLARNET WP20.3 has issued recommendations for how metadata should be specified in science data files, which FITS keywords to use and which not to use. The purpose is to facilitate searching in archived data, as well as scientific interpretation. Following the recommendations is necessary for the data to be searchable from a future virtual solar observatory.