INSTRUMENTATION AND DATA AVAILABLE TO SOLARNET

Ilaria Ermolli

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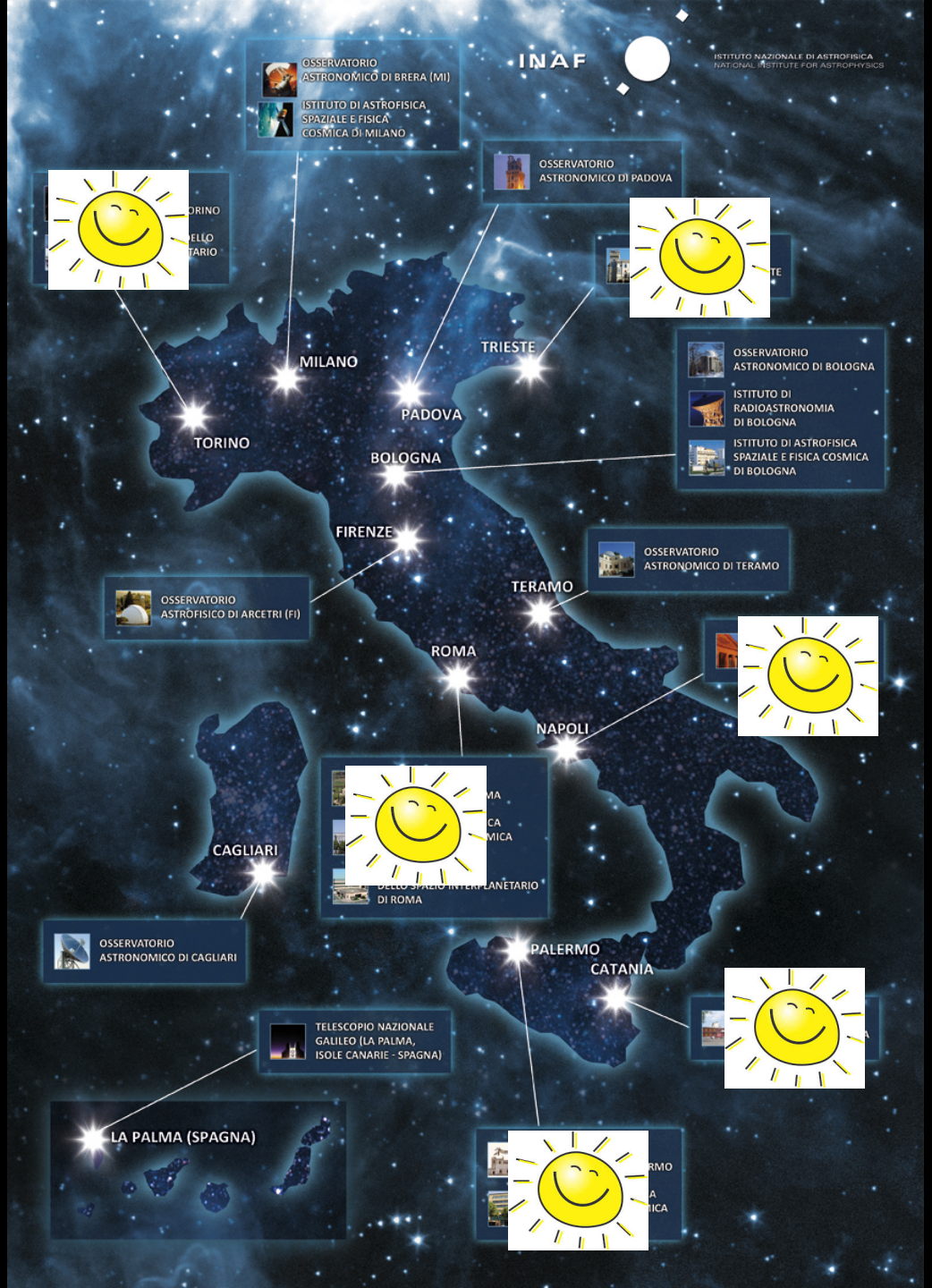
National Institute for Astrophysics

17 institutes
12 cities
1400 staff

TNG LaPalma
LBT Arizona

Solar Physics
at INAF

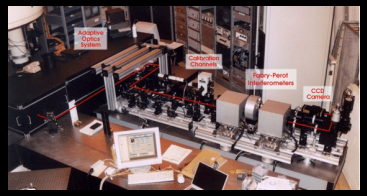
6/17 institutes
6/12 cities



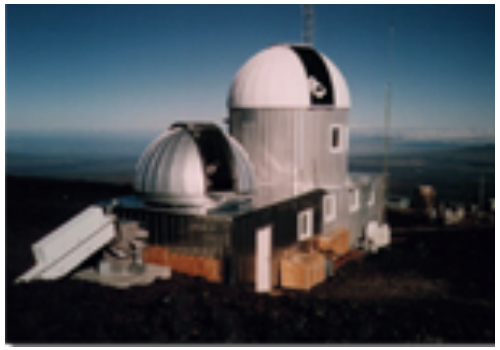
Solar Physics at INAF

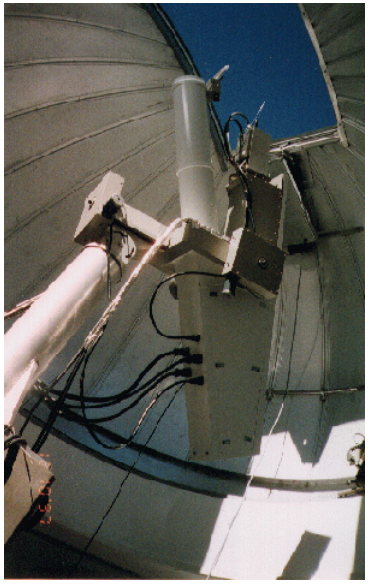
3 optical tel. (3/6 cities)

IBIS



Rome-PSPT
Precision Solar Photometric Telescope





Provides multi-band full-disk observations of the Sun on a continuous basis (spatial resolution 1 arcsec per pixel, photometric accuracy 0.1%) ideal for studying:

- Photometric properties of solar features
- Irradiance changes

→ **SPRING SCIENCE TOPICS:**

- Solar awareness
- Synoptic magnetic fields

[Ermolli et al. 1998, 2003, 2007]

Rome-PSPT
Precision Solar Photometric Telescope

A 0.15m achromatic-doublet (f=2.3m), low-scattered light, refractor telescope designed for synoptic observations

- equipped with 6 narrow band interference filters (FWHM = 0.1 − 1.2 nm)
- CCD camera 2kx2k

Twin of the Mauna-Loa PSPT

MLSO-PSPT (2005 – 2015)

Rome-PSPT (1996 – present)

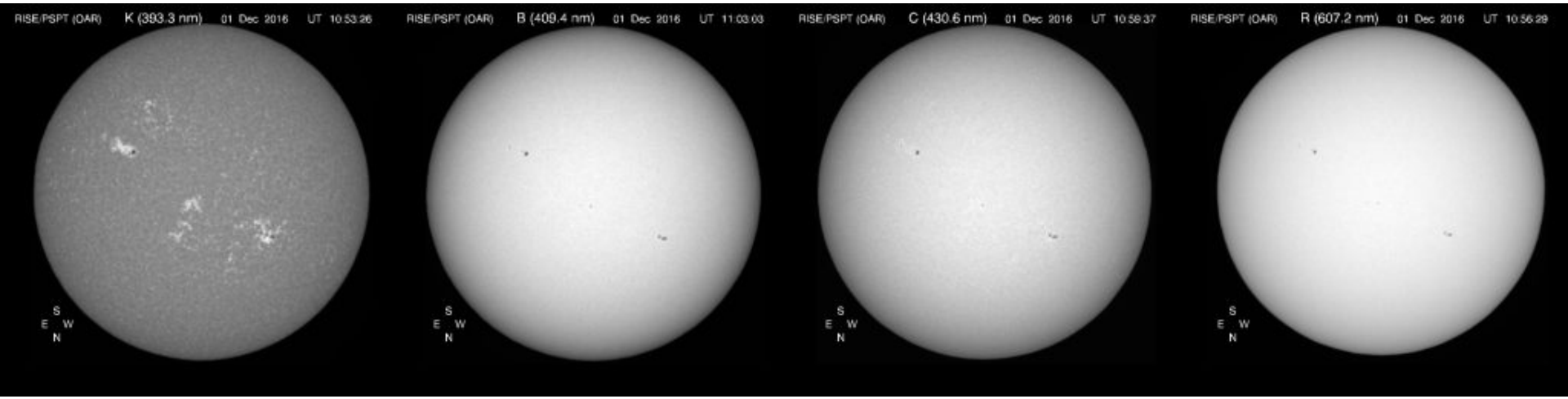
XEDAR camera – CCD THOMSON TH7899M 12bit

array size: 2048x2048 pixels **noise**: 35 e^- RMS

pixel size: 12 µm **rate** 4 frames/s

Rome-PSPT data products

- **Full-disk images taken at 5 spectral bands**
  - **Ca II K @ 393.2 ± 0.25 nm**
  - **Ca II K @ 393.3 ± 0.11 nm**
  - **G band = 430.7 ± 1.2 nm**
  - **Blue cont. = 409.4 ± 0.27 nm**
  - **(also Green cont. = 535.7 ± 0.5 nm)**
  - **Red cont. = 606.9 ± 0.45 nm**
  - spatial resolution: 2"
  - observation time interval: from 8:00 to 13:00 CET, cadence one/two images/day

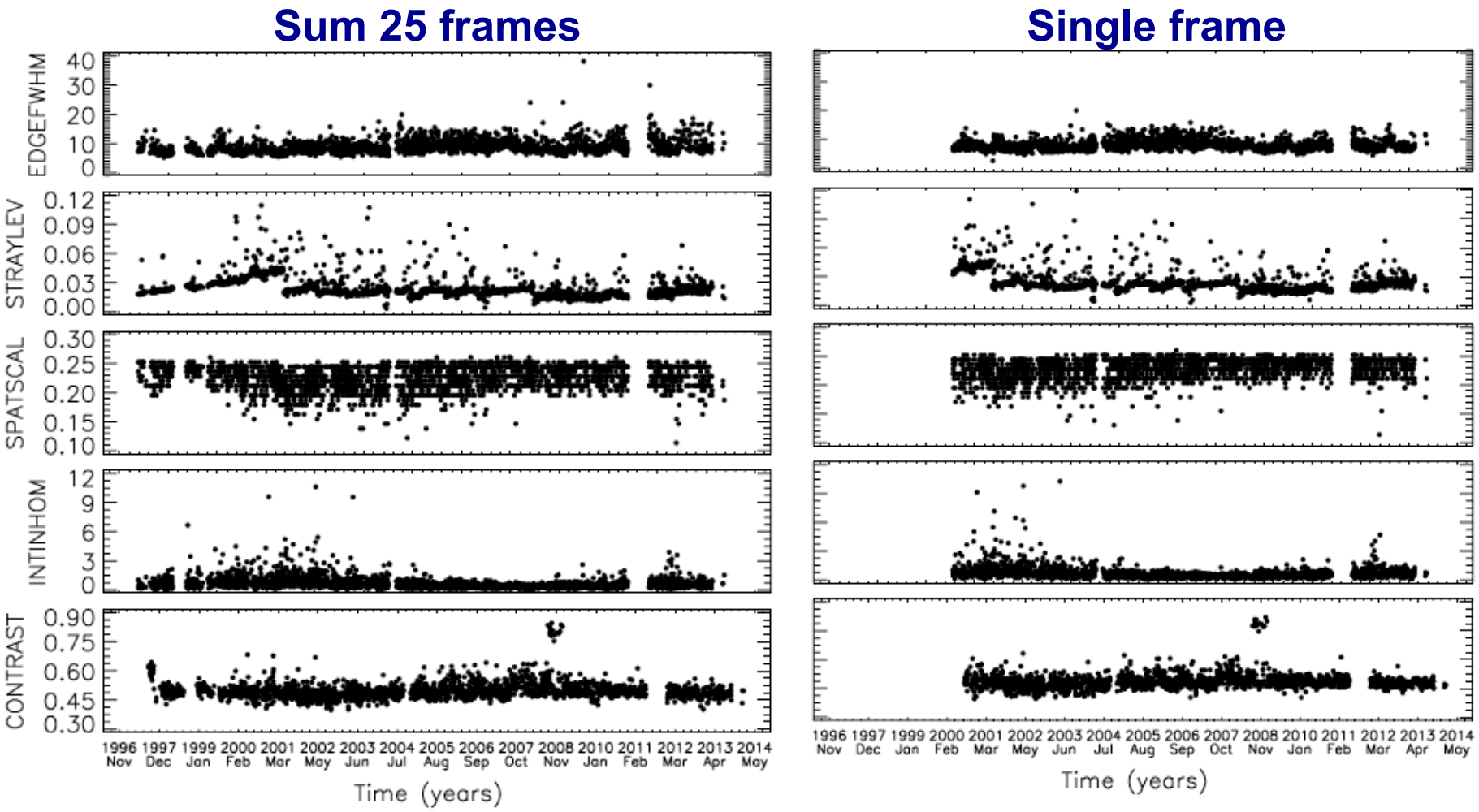


Rome-PSPT image processing: image quality evaluation

To evaluate both **data contents and homogeneity in time**, we measure the following quantities in each image:

- Level of **geometrical distortions** (limb width)
- Level **of large-scale inhomogeneities** (intensity along disk annuli)
- Level of **stray-light degradations** on the images (aureola intensity)
- **Spatial resolution** (FFT) and
- **Contrast** on the solar disk.

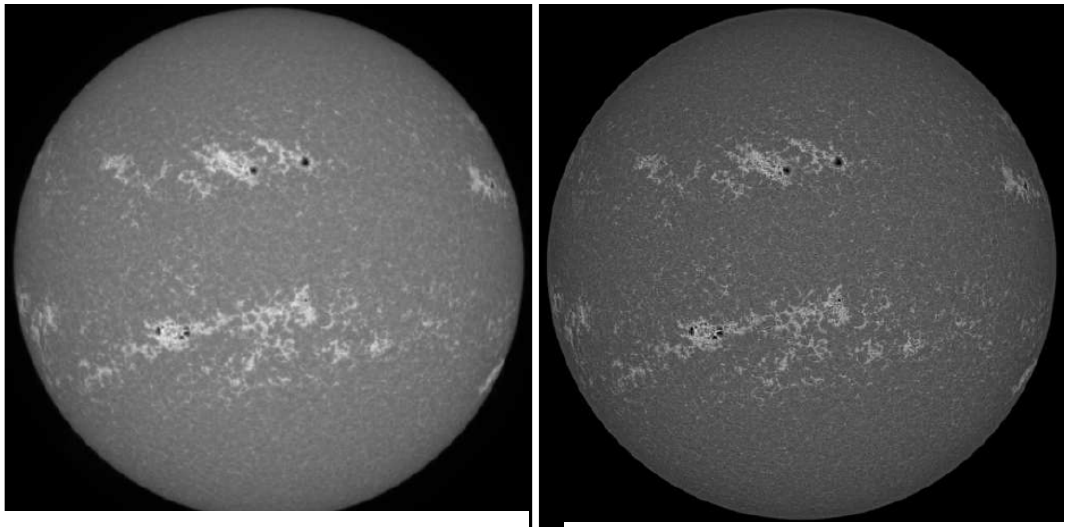
Rome-PSPT image processing: image quality evaluation

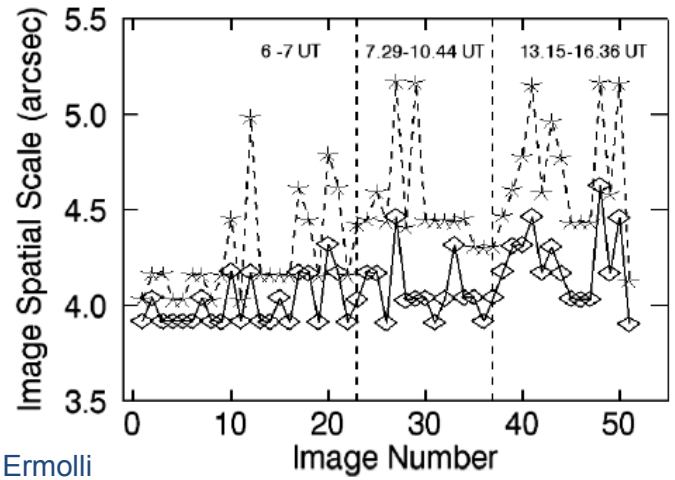


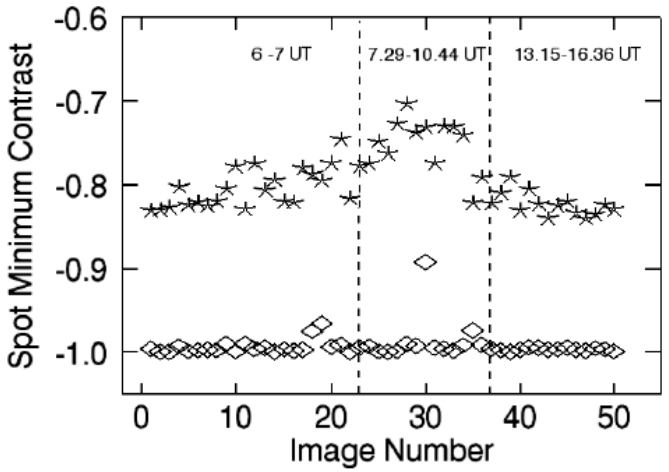
Rome-PSPT image processing: Restoring seeing effects

Estimation of the PSF, Image deconvolution

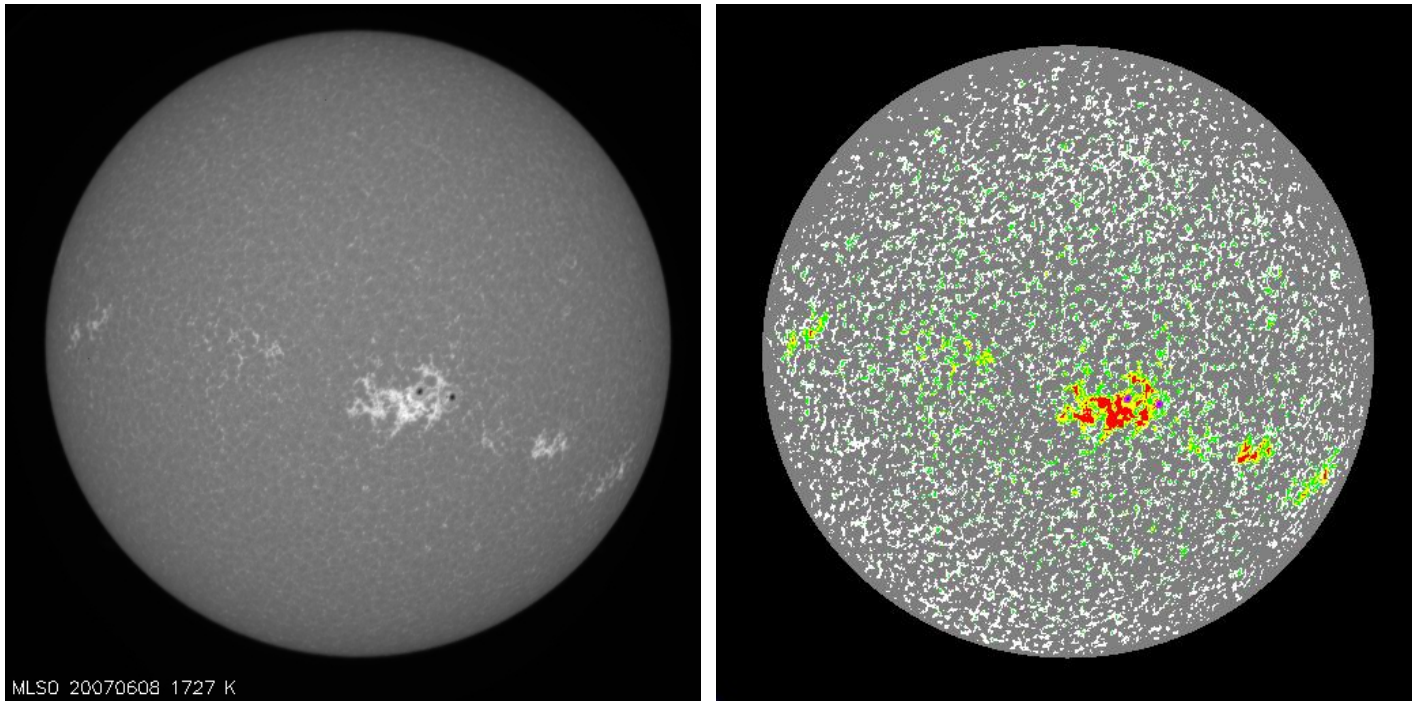
[Criscuoli and Ermolli 2008]







Rome-PSPT image processing: CLV compensation, Image segmentation



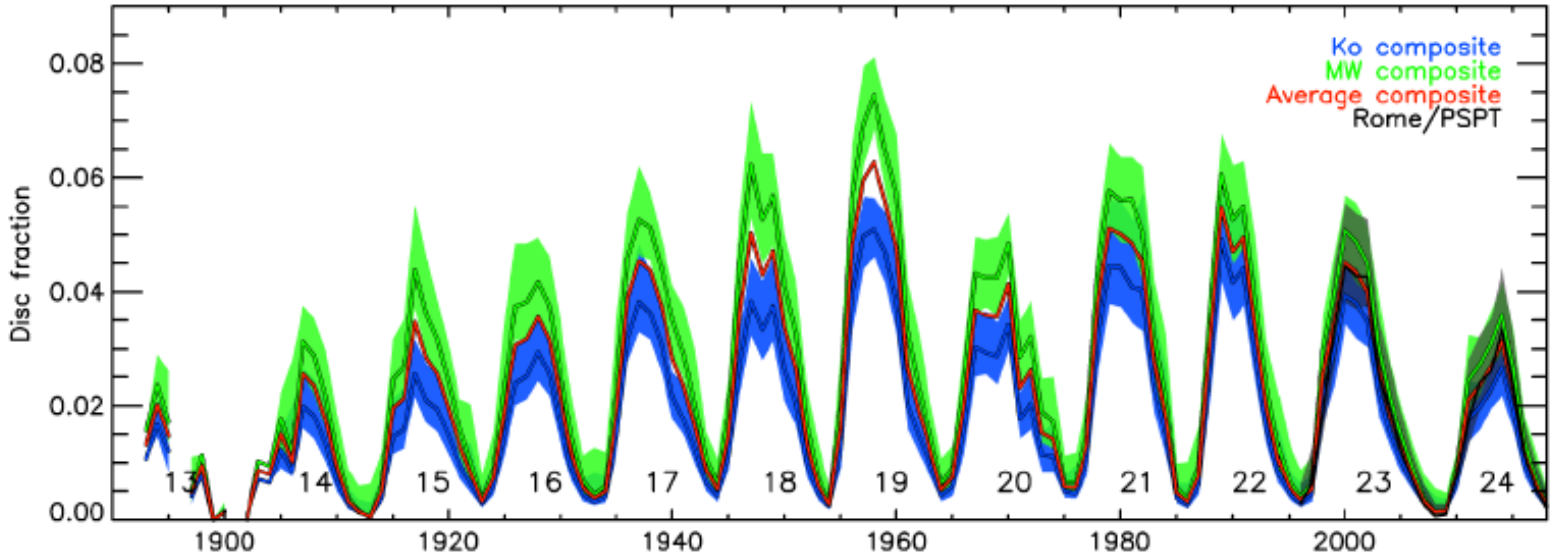
Class	Solar feature	Atmosphere model
B	quiet Sun	model B, VAL3-C, FAL3-C, FA-06
D	network	model D, FAL3-F
F	enhanced network	model F
H	plage	model H, model F, FAL3-F, FAL3-P
P	bright plage	model P
S	umbra	–
R	penumbra	–

[Ermolli et al. 2010]

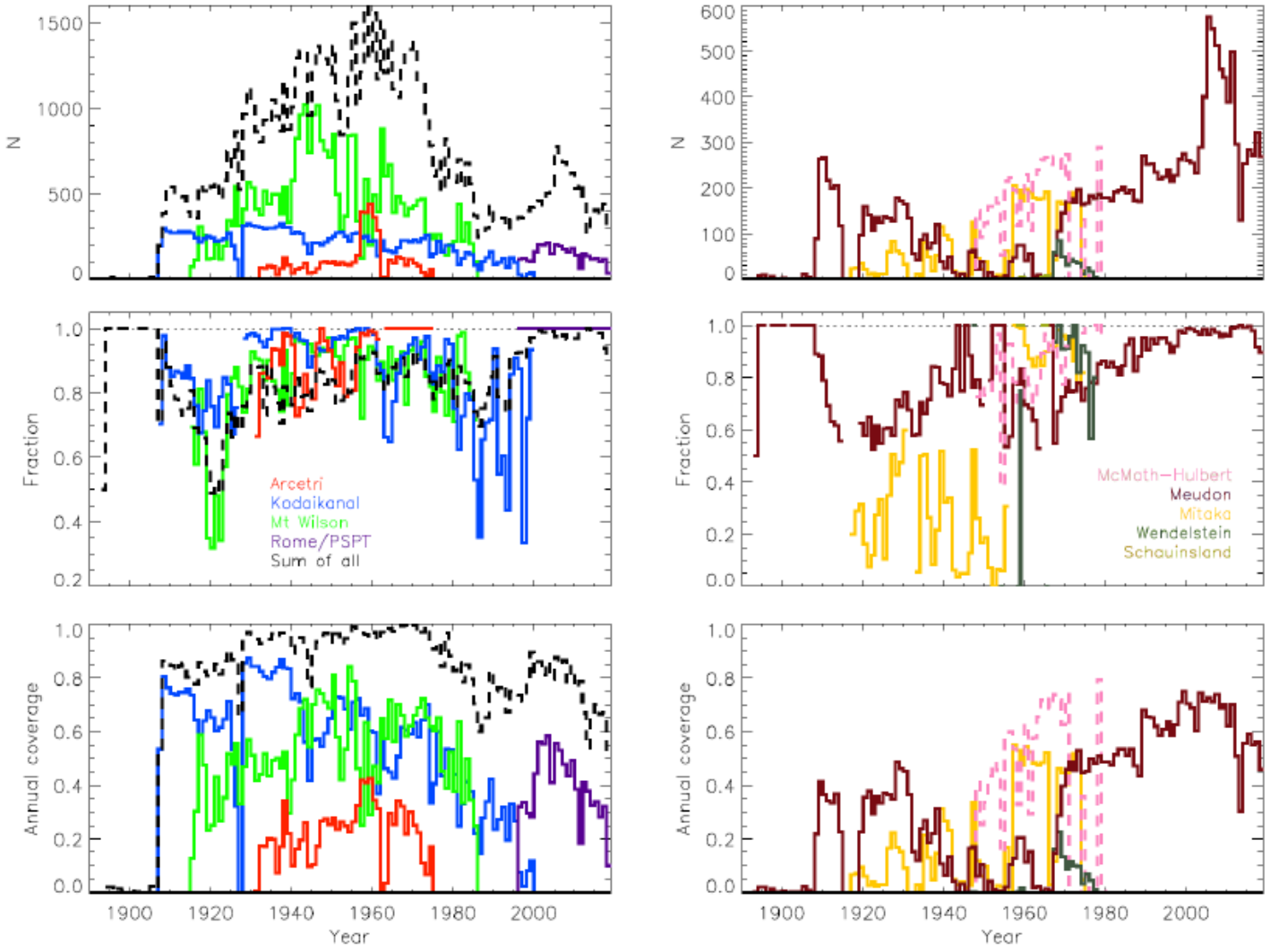
Rome-PSPT : homogenization of different series

[Chatizistergos et al. 2018, 2019]

Observatory	Abbreviation	Years	Images		SW	Disc size	Data type	Pixel scale
			Total	Used	[Å]	[mm]	[bit]	["/pixel]
Arcetri	Ar	1931–1974	5133	4825	0.3	65	16	2.4
Kodaikanal[a]	Ko	1907–1999	22158	19291	0.5	60	8	1.3
McMath-Hulbert	MM	1948–1979	5912	4911	0.1	-	8	3.5
Meudon	Me	1893–2018[b]	20986	17605	0.15	65	16	0.9–11[c]
Mitaka	Mi	1917–1974	8585	4193	0.5	variable	16[d]	0.9, 0.7[e]
Mount Wilson	MW	1915–1985	36340	31430	0.2	50	16	2.7
Rome	Rome/PSPT	1996–2018	3292	3292	2.5	~ 27	16	2[f]
Schauinsland	Sc	1958–1965[g]	18	18	-	variable	16	1.7, 2.6[h]
Wendelstein	WS	1947–1977[g]	452	407	-	variable	16	1.7, 2.6[h]



About annual coverage…



[Chatizistergos et al. 2019]

Rome-PSPT : future steps

A **2 solar-cycle old instrument**:

Control update (sw and hw)

CCD (???)

data format and update hdr keywords

Further **work to merge observations from different sites**:

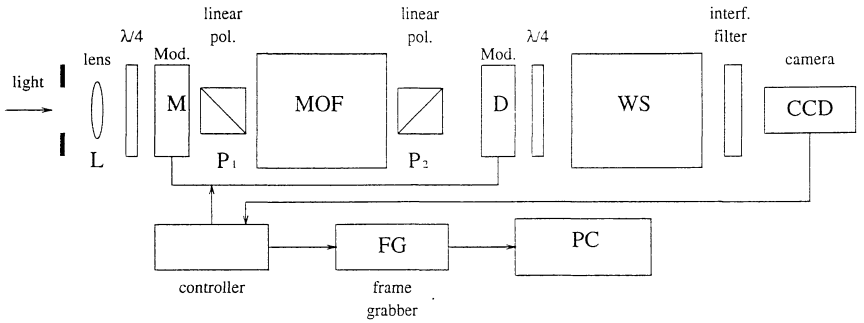
Inter-comparison of results from modern observations (image quality, image content)

Merging of results from historical and modern observations (scaling vs AL)

VAMOS

Velocity and Magnetic Observations of the Sun

[Severino et al. 2001]



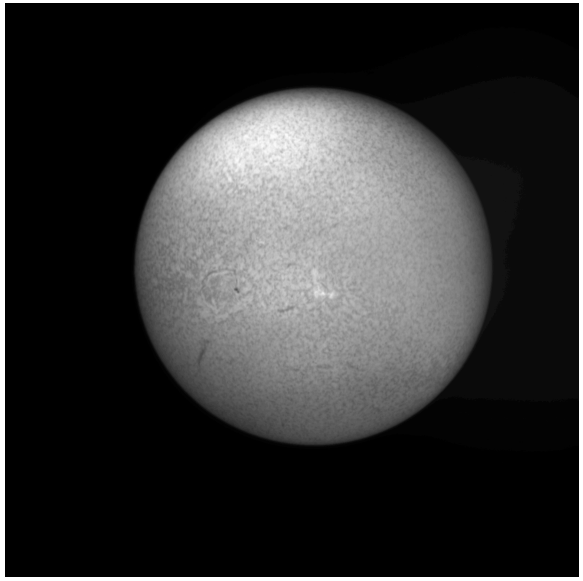
Since 2015
Coelostat (30 cm) – 245 cm lens (flenght 250 cm)
Diffraction limit 0.6” at 600 nm
Halpha filter 0.5 A
VAMOS
2x CCD 4kx4k
-> 1"/pixel scale, 5 s cadence

Telescope (40 cm)
Best time resolution 1 image/160 ms
Doppler velocity resolution : 10 m/s
Magnetic field range: 20-2500 G
Diffraction limit 0.6” at 600 nm
Halpha filter 0.5 A 0.6”/pixel
CCD 800x400
-> 6"/pixel scale, 1 min cadence

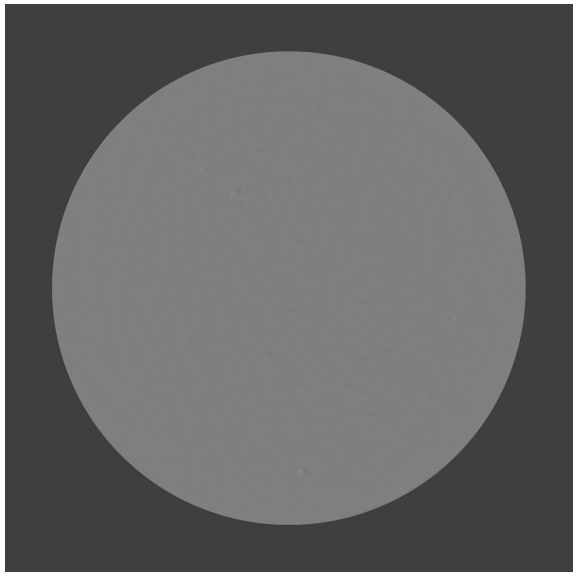
Regular observations 1999-2005, 2009-2010

VAMOS data products

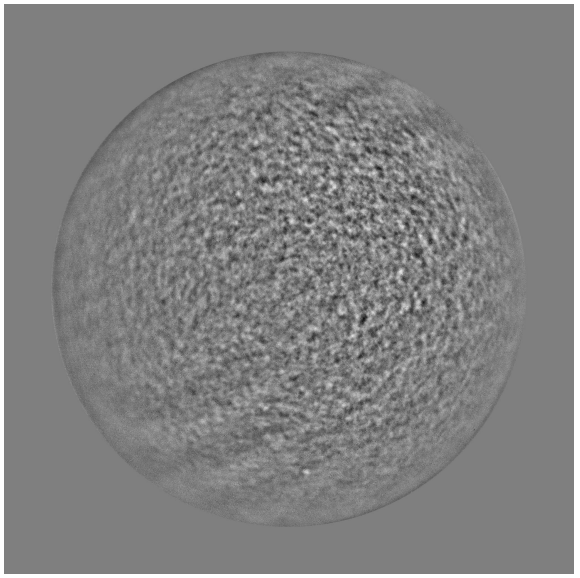
Halpha



Magnetogram



Dopplergram



→ **SPRING SCIENCE TOPICS:**

- Synoptic magnetic fields
- Synoptic velocity fields
- Transient events

FUTURE STEPS:

Finalization (optical components, coelostat motors)

Software and electronics necessary to automate

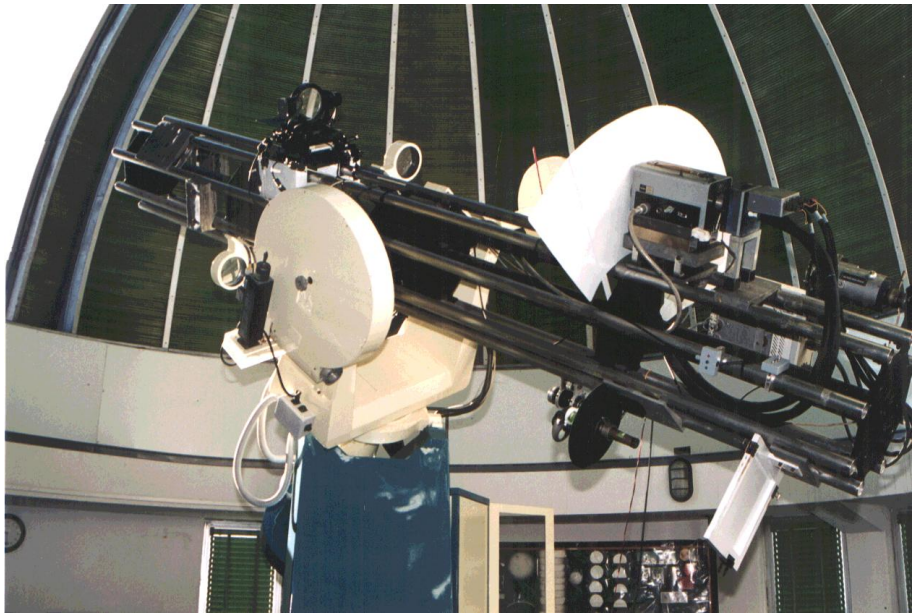
Data calibration, Regular observations

EQUATORIAL SPAR CATANIA

→ Francesca's talk later today

→ **SPRING SCIENCE TOPICS:**

- Solar awareness
- Synoptic magnetic fields
- Transient events



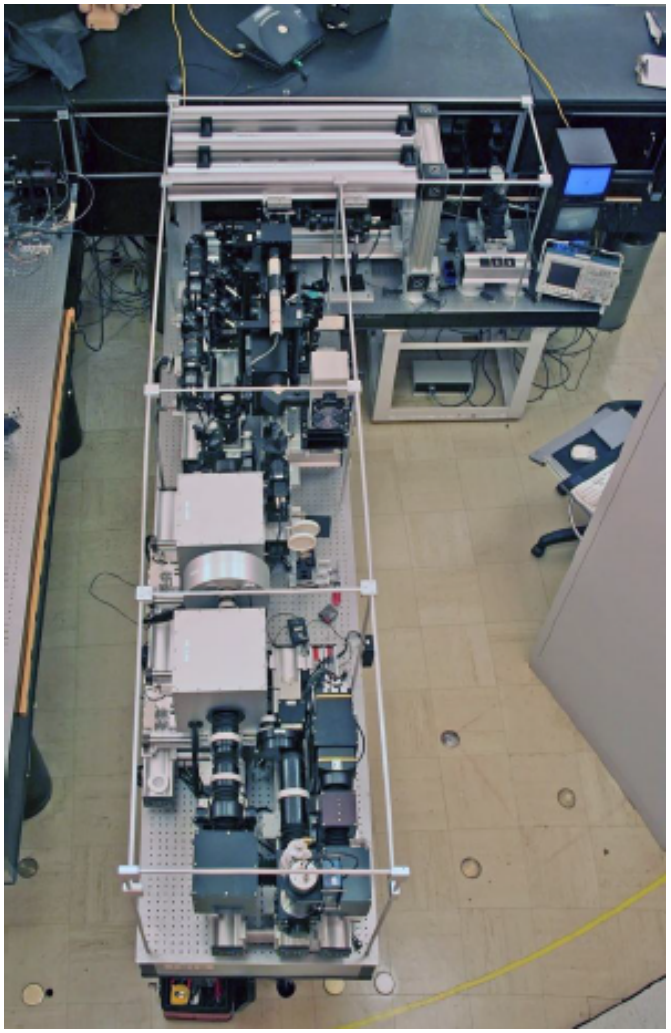
IBIS

Interferometric Bidimensional Spectrometer

High cadence, dual interferometer imaging spectropolarimeter. By means of precise piezo-electric tuning, IBIS can **rapidly and reliably scan selected spectral line**s.

Main components: **2 x Fabry Perot** interferometers, **50-mm in diameter**, used in series in a **collimated mount;** coating optimized for the **550-860 nm spectral** range, **spectral resolution > 200,000 over the whole interval**; this corresponds to a **FWHM** of the instrumental profile of **20-45 mÅ**, depending on wavelength.

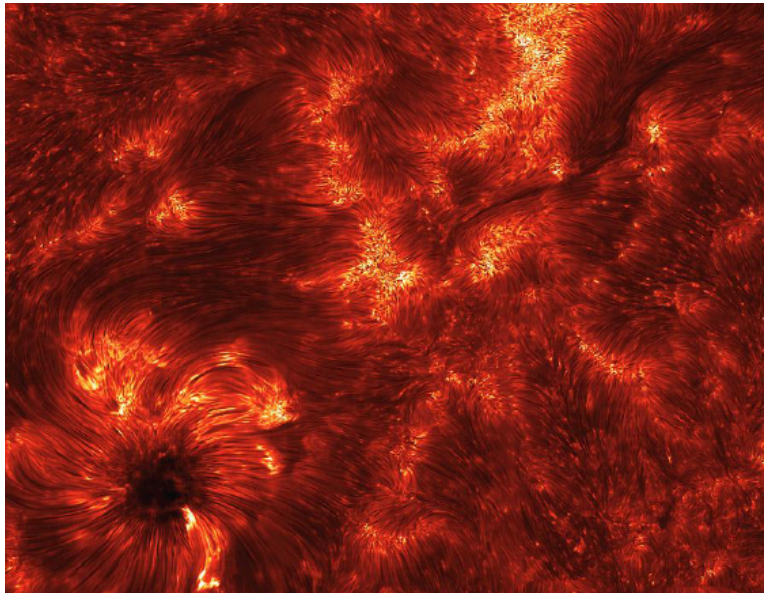
FoV about 95" in diameter, **pixel size is 0.098" x 0.098"** and the diffraction limit at 600 nm is ~0.2", short exposures, **approx 25 ms**, fast acquisition system achieves **8-14 frames/sec.**



[Cavallini 2006]

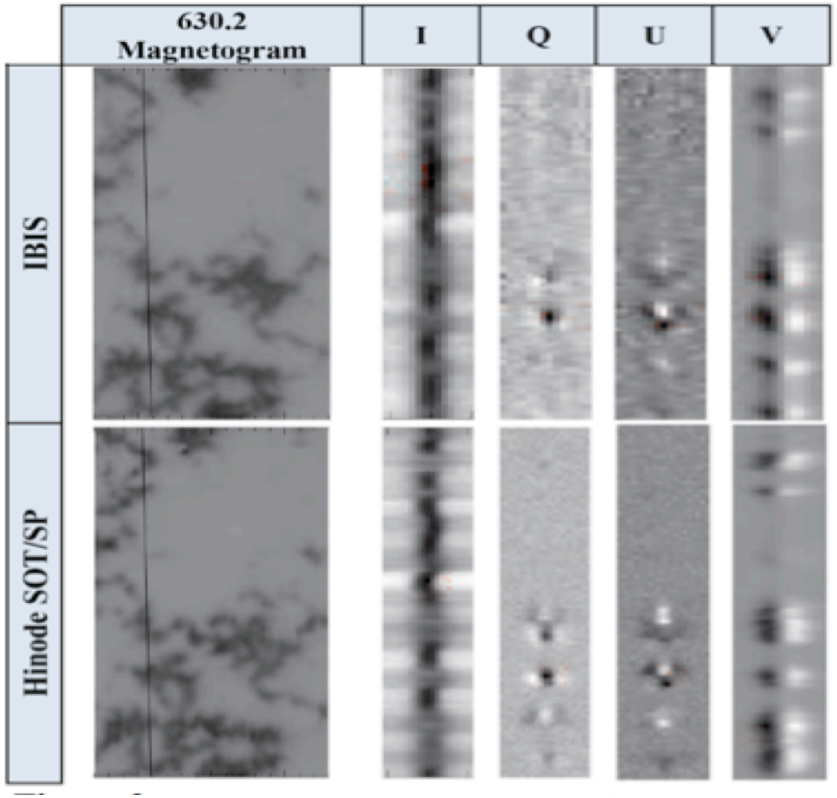
IBIS

Interferometric Bidimensional Spectrometer



[Cauzzi et al. 2008]

IBIS can function in spectropolarimetric mode by modulating the incoming light with a pair of nematic **liquid crystal variable retarders** placed ahead of the instrument.

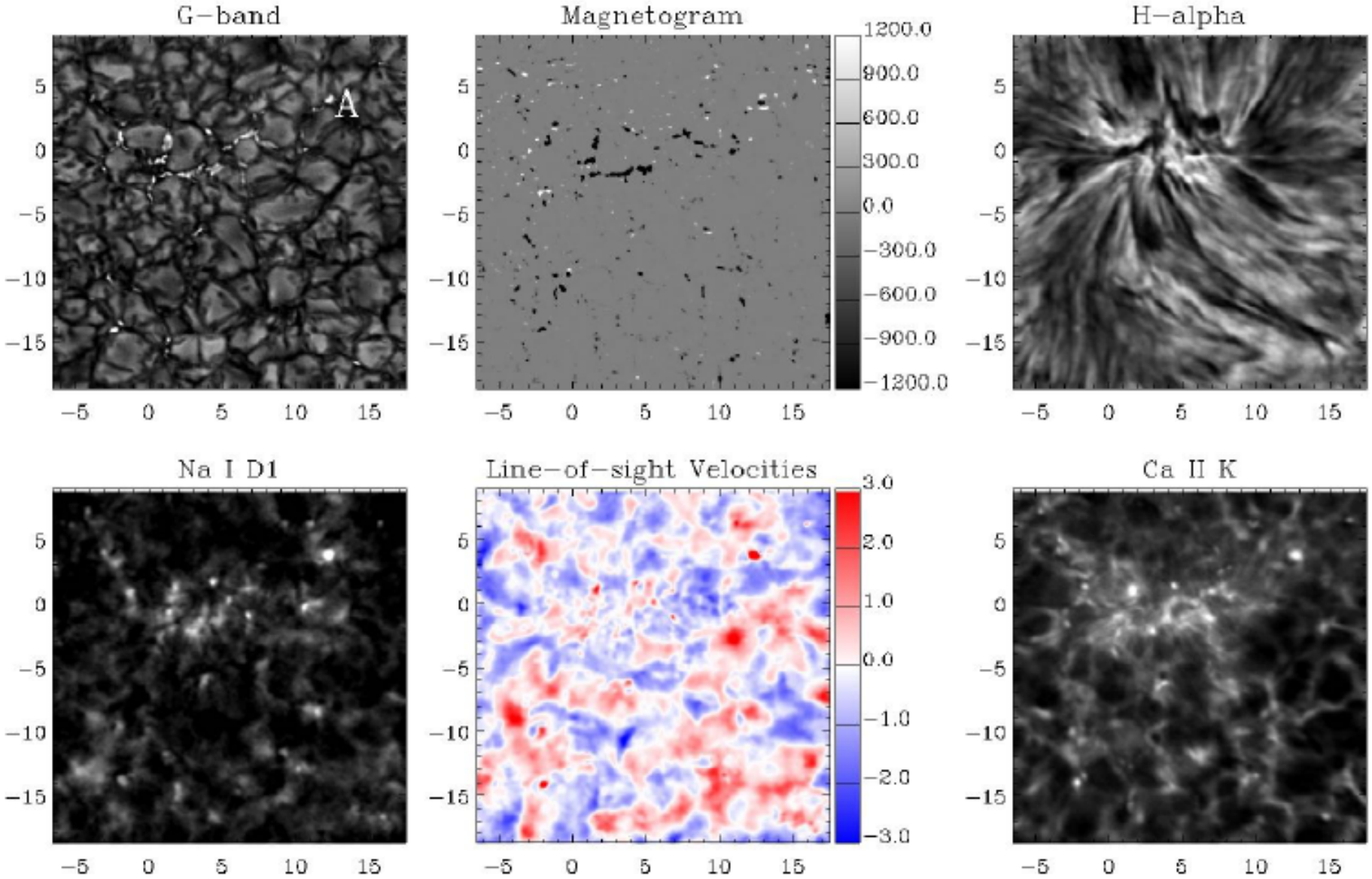


[Judge et al. 2010]

→ **SPRING SCIENCE TOPICS:**

- Synoptic magnetic fields
- Synoptic velocity fields
- Transient events
- Solar awareness

IBIS data products



IBIS data products : IBIS-A

IBIS(A)rchive

ibis.oa-roma.inaf.it/IBISA

ibis.oa-roma

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(Webpage optimized for fullscreen view)

IBIS-A: The IBIS data Archive

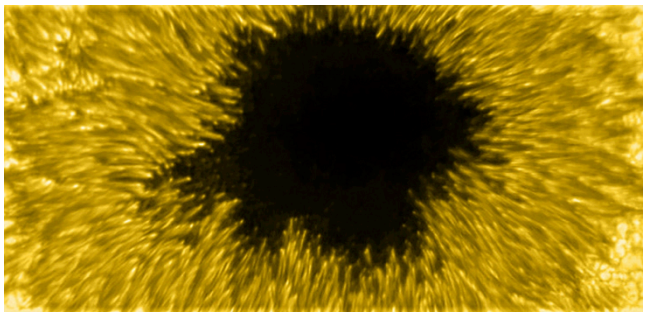
The IBIS data Archive (IBIS-A) contains data acquired with IBIS (Interferometric Bidimensional Spectropolarimeter), an imaging spectro-polarimeter based on a dual Fabry-Perot interferometric system (Cavallini 2006). IBIS allows spectropolarimetric observations of the solar photosphere and chromosphere at high spatial (pixel scale of 0.09 arcsec), spectral (> 200000), and temporal resolution (8-15 fps). Read more...

IBIS has been built by the INAF (Italian National Institute for Astrophysics) at the Arcetri Astrophysical Observatory, with the support of the Dept. of Physics and Astronomy of the University of Florence, and the Dept. of Physics of the University of Rome Tor Vergata, and installed in June 2003 at the Dunn Solar Telescope of the US National Solar Observatory in Sunspot, New Mexico. Read more...

The IBIS-A has been designed to realize the storage, the management, and the retrieval of the IBIS data. Currently, IBIS-A includes 7.7 TB of data taken during 8 observing campaigns carried out from 2012 to 2016 on 39 days. Read more...

Search data in IBIS-A :

The IBIS-A is realised in the framework of the FP7 SOLARNET3 High-resolution Solar Physics Network that aims at integrating the major European infrastructures in the field of high-resolution solar physics, as a step towards the realisation of the 4m EST (European Solar Telescope, Collados et al. 2010, 2013).



A sharp view of the Sun obtained with the IBIS at the NSO/Dunn Solar Telescope (New Mexico, USA).
The image shows remarkable details of the large sunspot seen in AR NOAA 12546 near the central meridian [S07W07].
Observer: Marco Stangalini (INAF) et al.
Image processing: Fabrizio Giorgi (INAF)
Wavelength: Fe I 617.3 nm line (continuum)
Date: 20 May 2016, 13:53 UT

23.5 TB of data taken during 21 observing campaigns
carried out from 2012 to 2018 on 115 days

IBIS past, present and near future

Installed at the Dunn Solar Telescope of the National Solar Observatory in Sunspot on June 2003, IBIS will soon be disassembled and shipped back to Italy for maintenance and updates in the perspective of relocating it at the Teide Observatory.

CONCLUSIONS

AVAILABLE TO THE PROJECT

Instrumentation : Rome-PSPT, VAMOS, Eq.-spar Catania, (N)IBIS

Data : full-disc filtergrams (Ca II K to K: 393 -770 nm range), dopplergrams, magnetograms
High-resolution Full-Stokes measurements 550-860 nm spectral range

Methods : full-disc (calibration, restoring, image quality, CLV, segmentation, merging)
High-resolution (calibration, restoring, inversion)

INAF CONTRIBUTION TO THE PROJECT

D8.3 Design For Post-focus Instrumentation
Prototyping: opto-mechanical design (N-IBIS), control (N-IBIS, PSPT), operation

D8.6 Software For Stokes Inversion

D8.8 Software For Data Calibration, Merging
Data series to test the new methods developed by the project

D8.9 Report On Rational And Results Of The Data Homogenization And Multi-instrument Flare Detection

D8.10 Report On Data Homogenization Of Spring Prototype Data
Inter-comparison of results from other methods

THANKS!

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