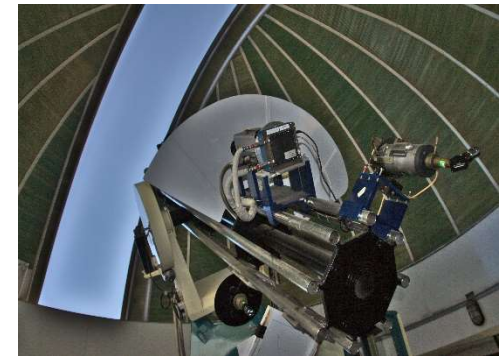


Recent advances of INAF telescopes for synoptic observations



**P. Romano¹, P. Costa¹, I. Ermolli², M. Falco¹, F. Giorgi², S.L. Guglielmino¹,
M. Murabito², M. Oliviero³, G. Viavattene²**

¹ INAF – Osservatorio Astrofisico di Catania

² INAF – Osservatorio Astronomico di Roma

³ INAF – Osservatorio Astronomico di Capodimonte

From our proposal....

WP8.3 Data recording and processing

These telescopes and data sets will be available for testing coordinated observations, merging of series, and producing higher level data products.

8.3.1 Lucky Imaging

As testbed and implementation platforms for the development of the Lucky Imaging methods, we will use the high-cadence full-disk observations of the Sun in H-alpha ...

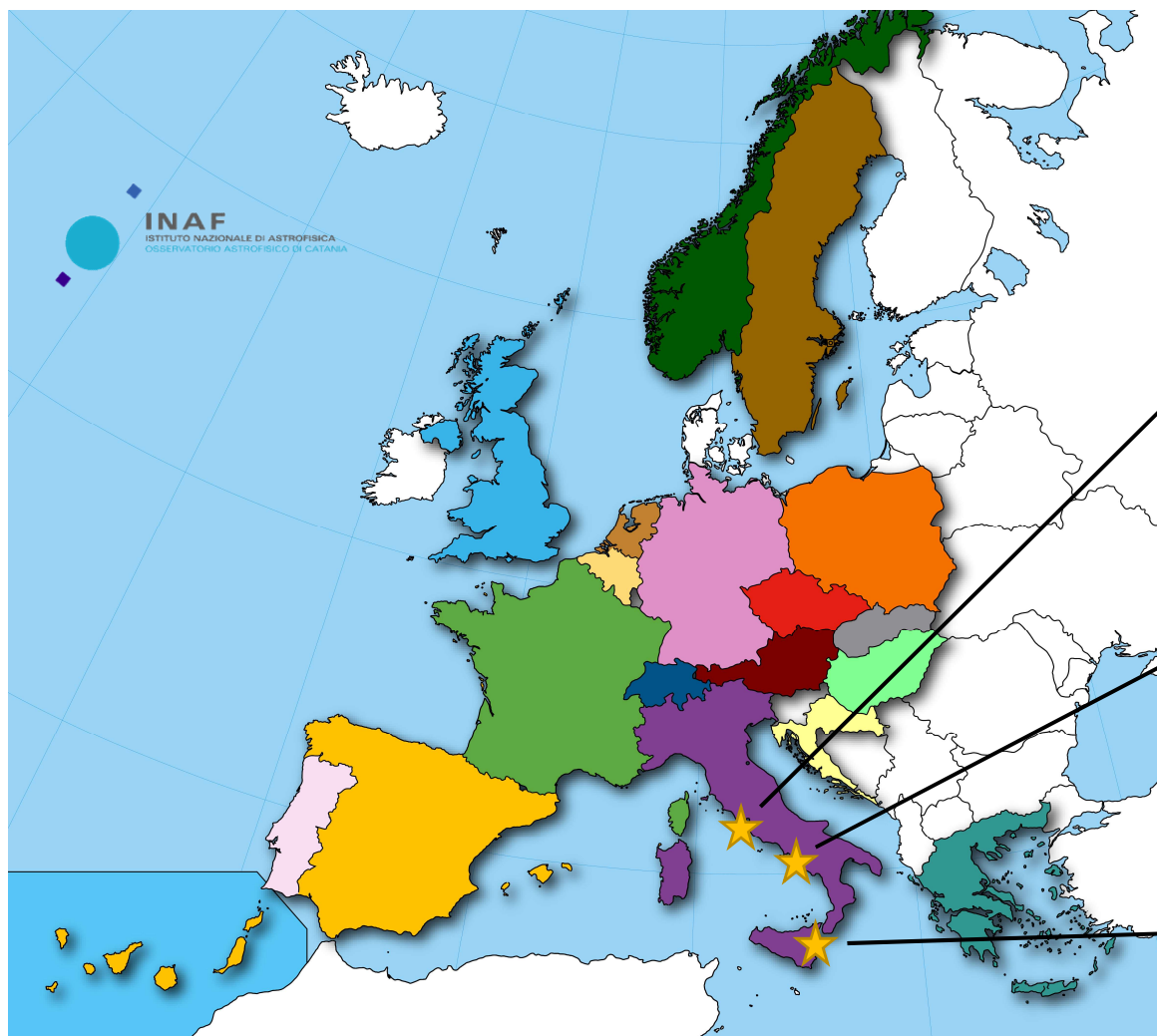
8.3.2 Data Calibration, Merging, and Inversion

Merging data from the various sites faces the problem of creating a coherent data set, while switching from one site to the other during the day.

8.3.3 Data Homogenization & Automatic Flare Detection

We aim at developing advanced algorithms to homogenize the data in time as well as across different network stations, with the main aim to provide continuous, unified and high-quality observing sequences, merging the data sets across the multi-station observations

INAF telescopes for synoptic observations



Rome-PSPT



Naples-VAMOS



Catania Solar Telescope

Rome - PSPT

Precision Solar Photometric Telescope

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

- Equipped with 6 narrow band interference filters (FWHM = 0.1 -1.2 nm)
- CCD camera 2k x 2k

Twin of the Mauna-Loa PSPT

MLSO-PSPT (2005 – 2015)

Rome-PSPT (1996 – present)



XEDAR camera – CCD THOMSON TH7899M 12 bit

Array size: 2048 x 2048 pixels

Pixel size: 12 μm

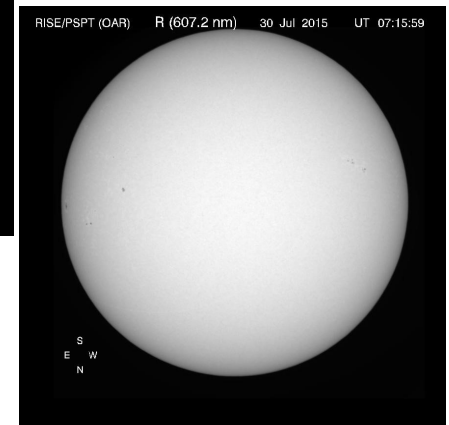
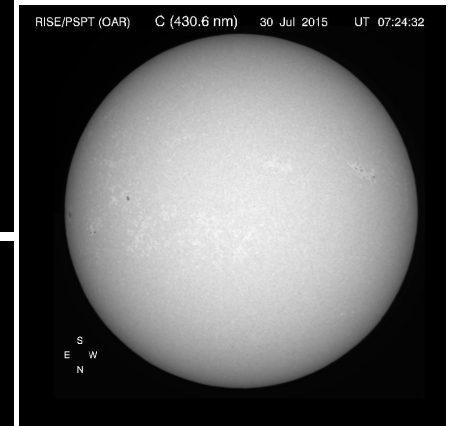
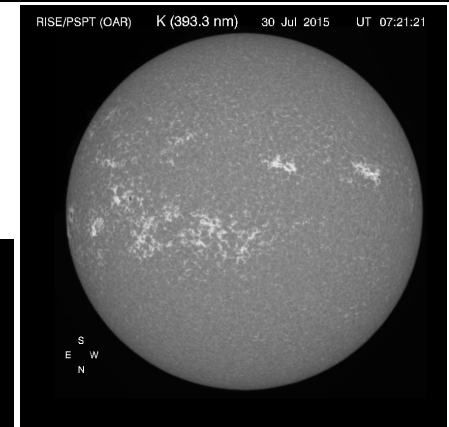
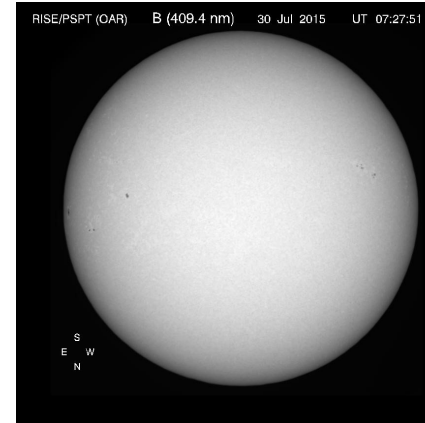
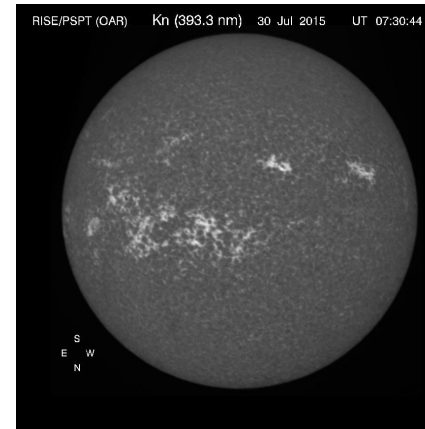
Noise: 35 e- RMS

Frame rate: 4 fps

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 arcsec

Observation time interval: from 8:00 to 13:00 CET,
cadence one/two images / day

Rome - PSPT data products



PSPT JPG Archive

[Home](#) [Archivio PSPT](#)

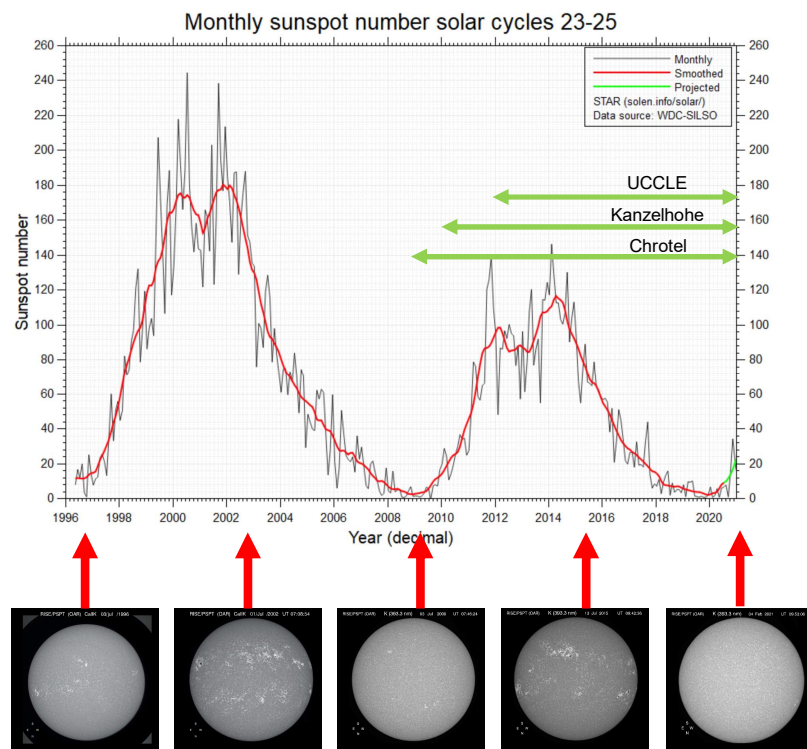
2021	1	13	R	https://drive.google.com/...	
2021	1	18	B	https://drive.google.com/...	
2021	1	18	C	https://drive.google.com/...	
2021	1	18	K	https://drive.google.com/...	
2021	1	18	KN	https://drive.google.com/...	
2021	1	18	R	https://drive.google.com/...	

Since 2020 access to data and archive compliant with new institute rules

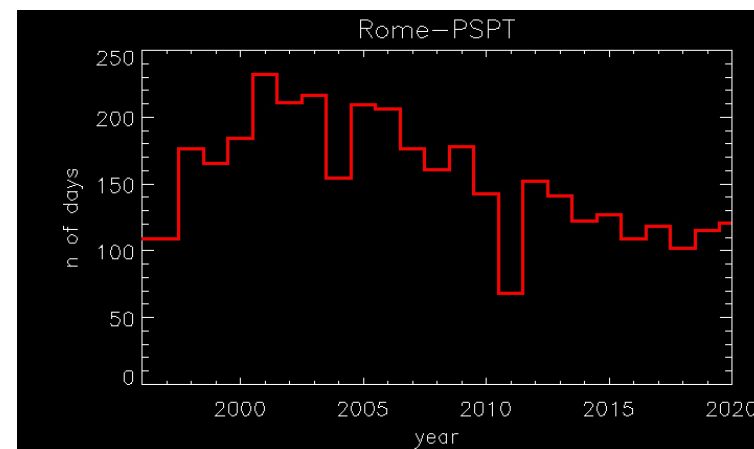
→ new interface

2020	2019	2018	2017	2016	2015
2014	2013	2012	2011	2010	2009
2008	2007	2006	2005	2004	2003
2002	2001	2000	1999	1998	1997

Rome - PSPT since 1996



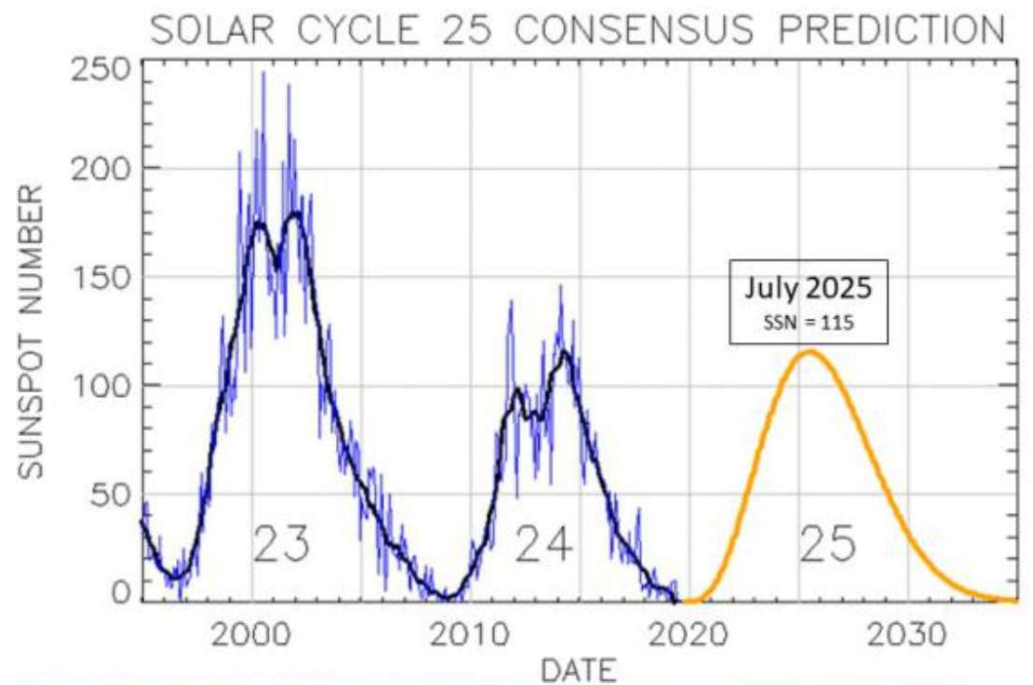
3804 observing days (Mon-Fri, 1 obs)
about 40 k images (calibrated)



Rome - PSPT refurbishment

Plans for

- Dome/telescope automation
- Control update (sw and hw)
- CCD (Apogee Alta U9000)
- Data format and hdr update
- New web page



Naples - VAMOS

Velocity And Magnetic Observations of the Sun

The VAMOS is capable of acquiring intensity, velocity, and magnetic field full-disk solar images in the K I D1 line at 7699 \AA , using two potassium vapor cells placed along the instrument optical path of a 0.25 m aperture telescope.

video cadence ($4''/\text{pixel}$)

4s cadence ($1.1''/\text{pixel}$)

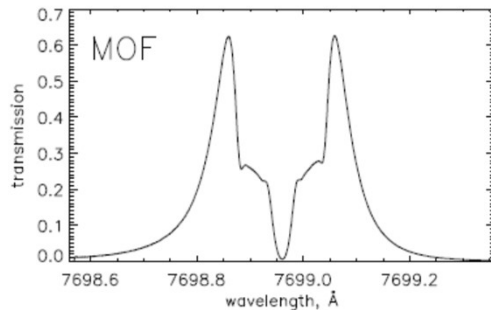


On a restricted solar area the instrument can reach $0.3''/\text{pixel}$.

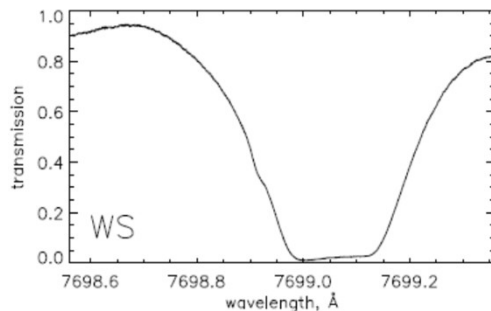
Naples - VAMOS

Velocity And Magnetic Observations of the Sun

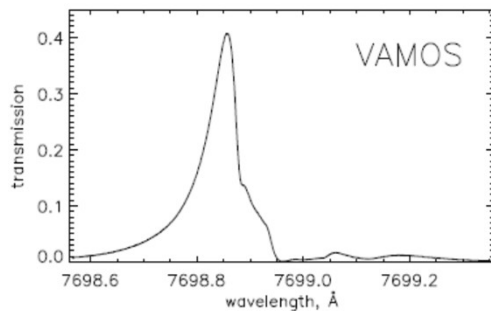
The VAMOS is based on the magneto-optical filter (MOF) technology.



- The first cell, called the MOF, transmits two peaks symmetric with respect to the K line center.



- The second cell, called the WS, absorbs alternatively the blue and red wings of the MOF bandpass.

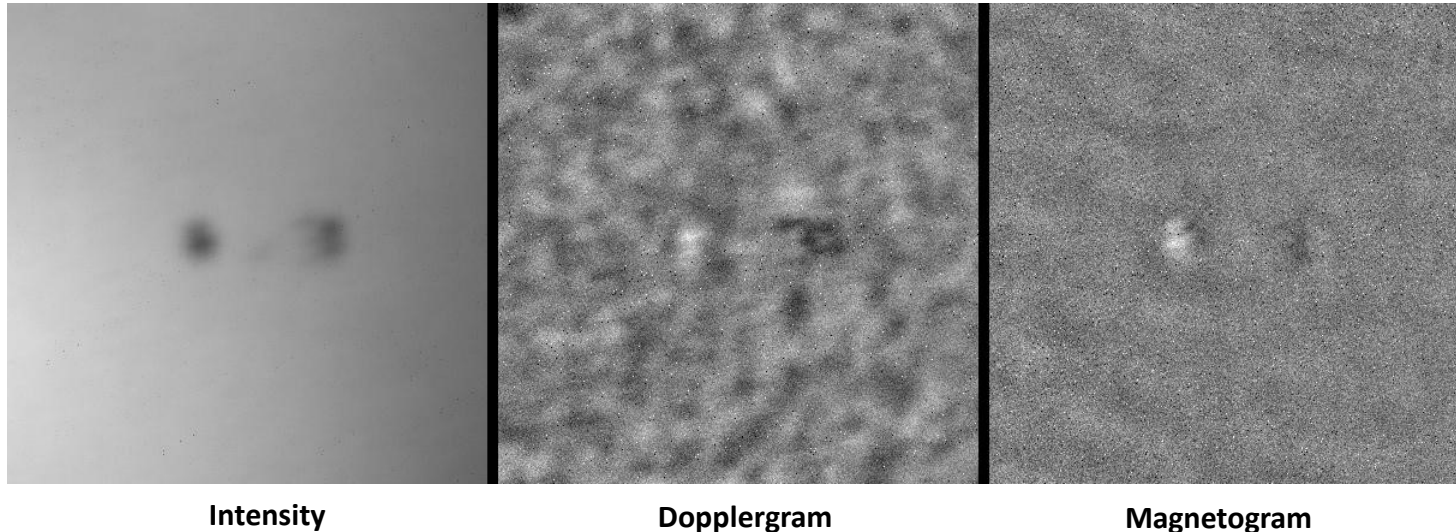


- Resulting blue VAMOS transmission.



VAMOS measurements

VAMOS – Naples 09-02-2018 09:18:00 UT

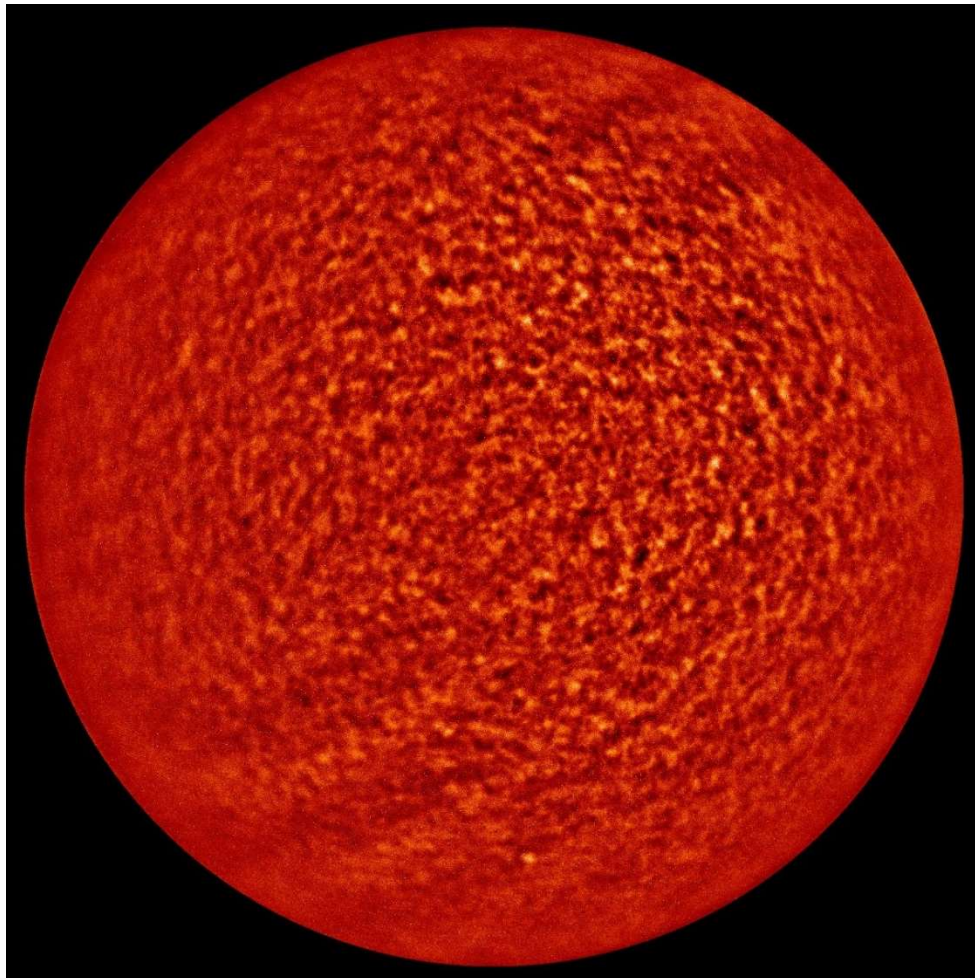


VAMOS intensity images and line-of-sight Doppler and magnetic field. The plotted area is 400"x400" near to solar limb. The small active structures have dimension of about 10".

The nominal resolution is 1.1"/pixel, but due to the weather conditions we had a seeing of about 5".

- Images: 4 sec integration time
- Doppler velocity: -200m/s and 200m/s, solar rotation removed
- Magnetic field: -300Gauss and +300Gauss

Doppler velocity measurements



2018-01-24 UT 15:12:00

Doppler residual line-of-sight velocity map after removing the solar rotation and offset velocities.

Spatial resolution 1,1"/pixel

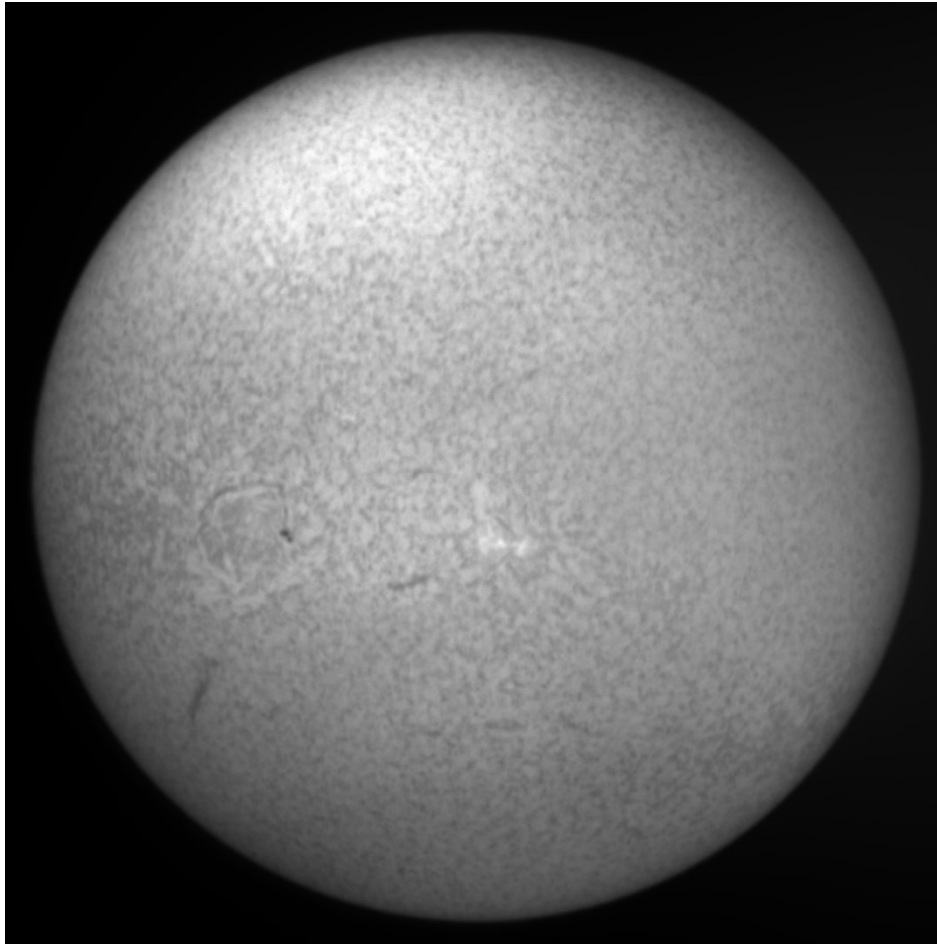


-300 m/s

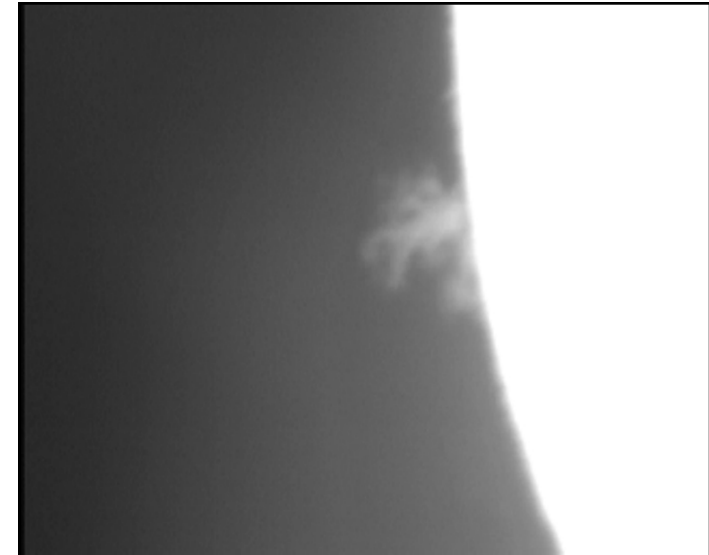
+300 m/s

Naples - VAMOS

Velocity And Magnetic Observations of the Sun



H α raw image (2016-05-08)
Spatial resolution = 0,7''/pixel



H α raw image (2015-03-04)
Spatial resolution 0,7''/pixel

Completed and ongoing activities

The VAMOS will be operated mostly for short observing campaigns devoted to specific scientific targets, and will be a calibration and reference instrument for a possible network of MOF based telescope.

TOPICS	STATE
Definition of the best optical set-up to acquire high spatial resolution solar images with the VAMOS	Completed
Definition of the best mechanical set-up system for the high resolution version of the VAMOS instrument	Completed
Definition of the technical specifications of the optical and mechanical elements to realize the VAMOS high spatial resolution version	Completed
Definition of the optical and mechanical elements for the optical connection between the VAMOS instrument and the solar telescope of the INAF-OAC. The telescope has 25cm aperture and 250cm focal length	Completed
Assembly of the new optical and mechanical parts	2021
Adjustment of the control electronics of the VAMOS MOF filters to the new opto-mechanical setup.	2021
Assembly of the VAMOS to the Coelostat	2021
Optical tests of the whole system and acquisition of images of the Sun in intensity for optical quality verification	2021
Acquisition of Dopplergrams and magnetograms to test the correct polarimetric functioning of the new setup	2021
Short observing campaigns for tests	2022
Development of the software for dopplergrams and magnetograms automatic acquisition and calibration	2022
Preliminary analysis of the acquired data	2022

Catania Solar Telescope

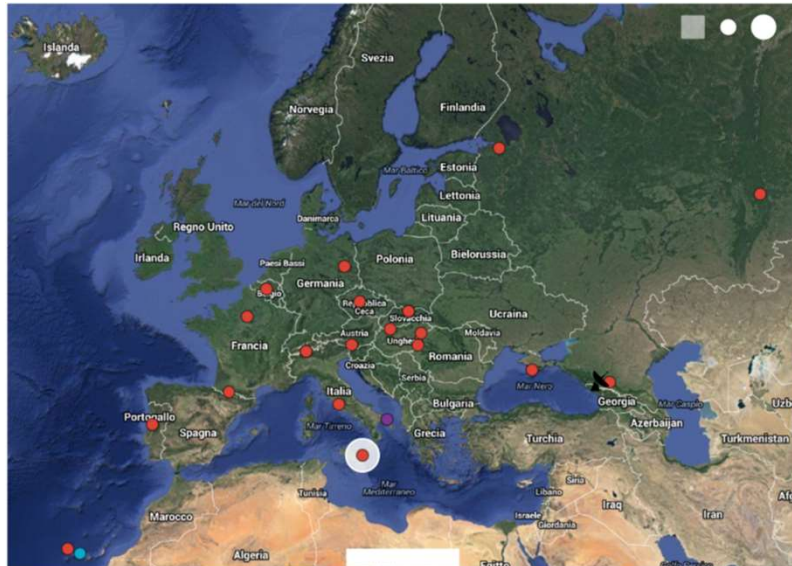
Solar observations of the photosphere and chromosphere have been carried out at the INAF - Catania Astrophysical Observatory in collaboration with the **University of Catania** since 1876, the year of its foundation.

Lat: $37^{\circ} 31' 43.71''$ N

Lon: $15^{\circ} 4' 17.38''$ E

h: ~ 35 m a.s.l.

Two observers: Pierfrancesco Costa and Mariachiara Falco



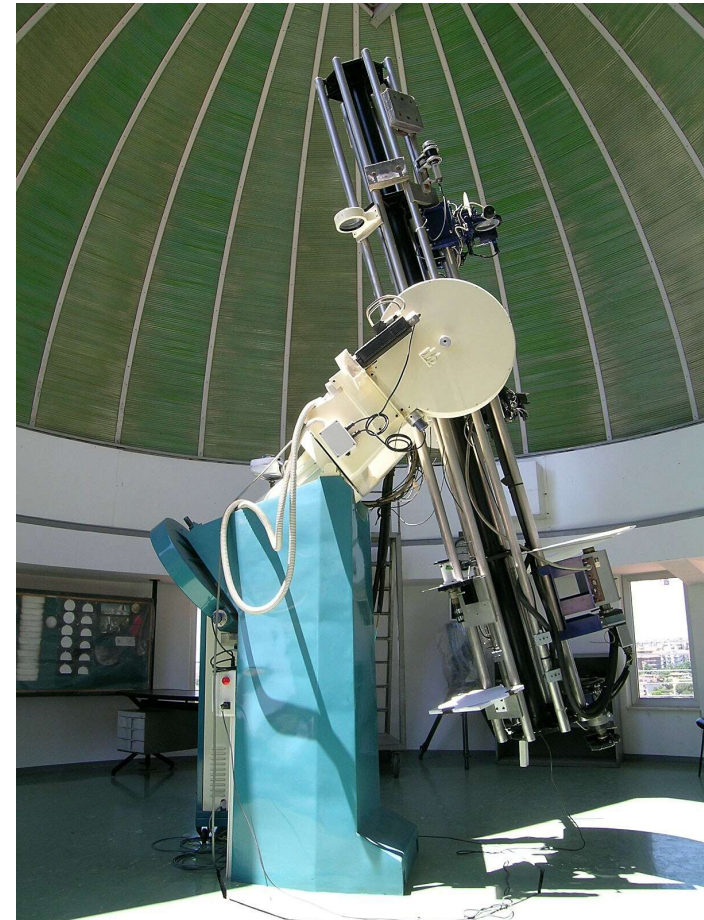
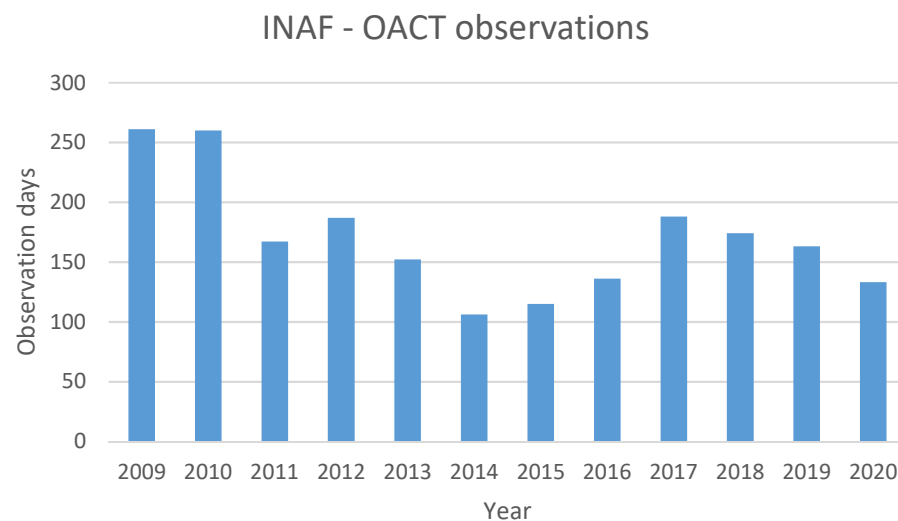
In average more than 320 days/year
are available for observations



Catania Solar Telescope

An equatorial spar which includes:

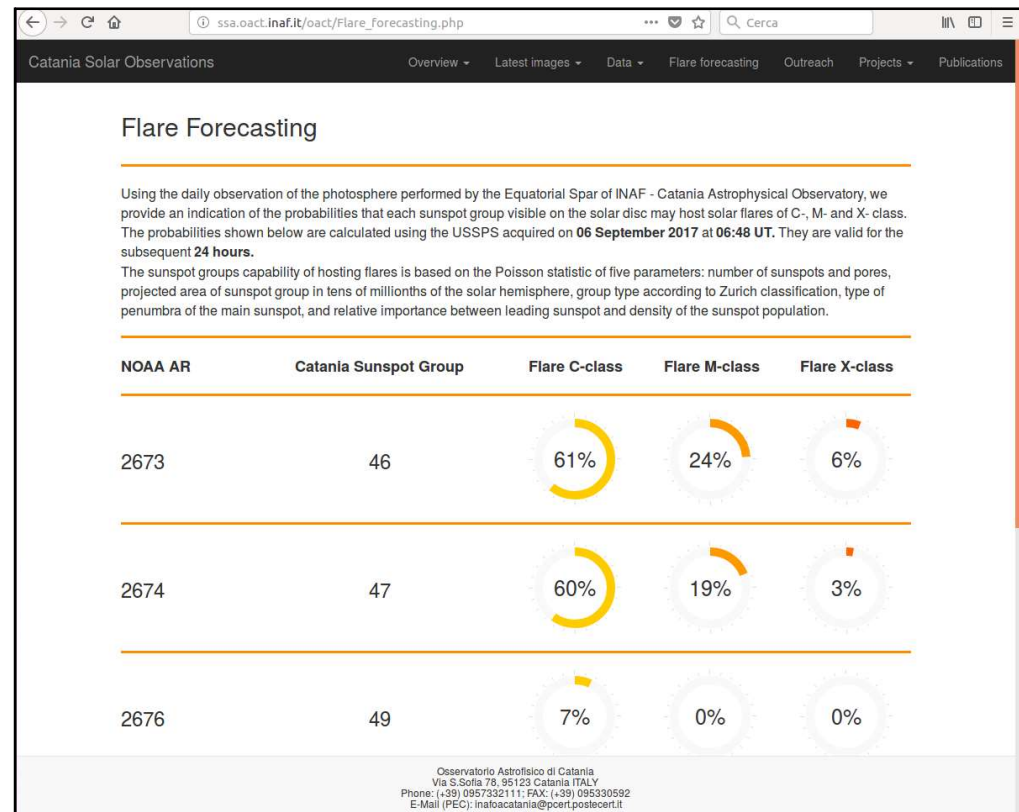
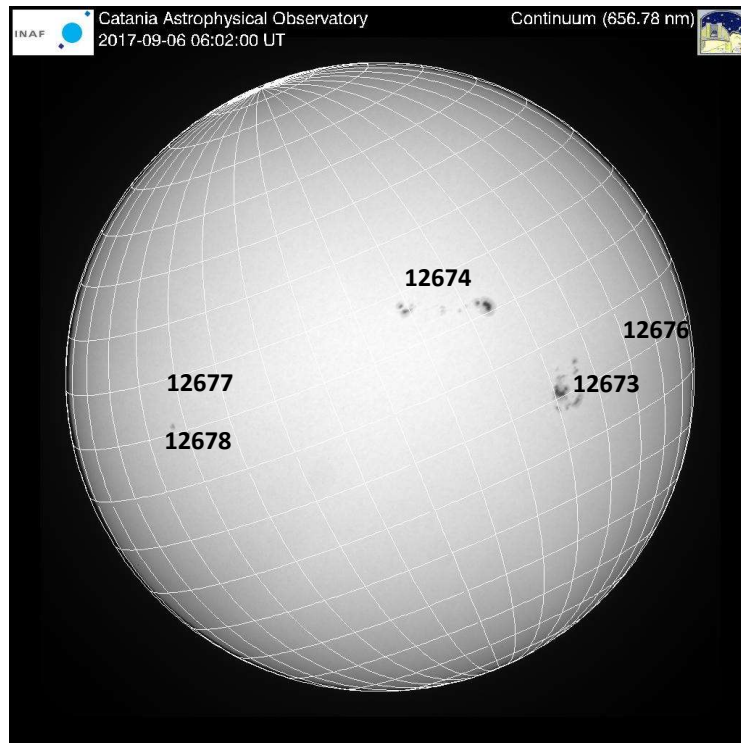
- a Cook refractor, used to make daily drawings of sunspot groups from visual observations;
- a 0.15 m refractor ($f=2230$ mm) with an H α Lyot filter for chromospheric and photospheric observations;
- a 0.15 m refractor ($f=2216$ mm)



<http://ssa.oact.inaf.it/oact/index.html>

Solar flare forecasting service – ESA Space Situational Awareness

When weather conditions permit, we provide daily an indication of the probabilities that each sunspot group visible on the solar disc may host solar flares of C1.0+, M1.0+ and X1.0+ class at: http://ssa.oact.inaf.it/oact/Flare_forecasting.php



For more details see Falco, M., Costa, P., Romano, P., JSWSC, 9, 22, 2019

Upgrade of the acquisition system

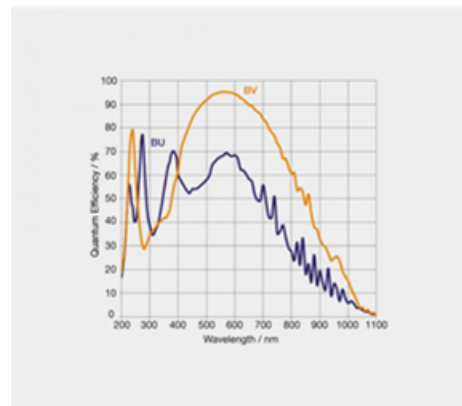
A CCD Camera Apogee Alta U9000-HC D09L

- Mechanical shutter
- Array size: 3096 x 3096 pixel
- Pixel size: 12 μm
- Digital resolution: 16 bit
- Noise: 12 e- RMS
- Dark current < 1.5 e-/pixel/s
- Frame rate: 15 s

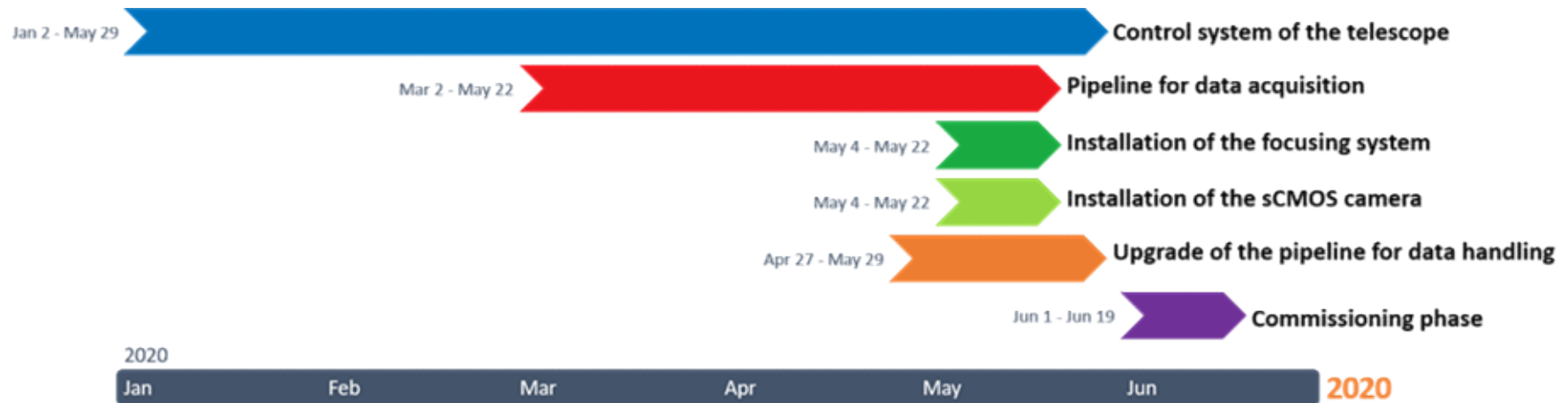


A back-illuminated sCMOS camera Andor Marana

- Rolling shutter
- Array size: 2048 x 2048 pixel
- Pixel size: 11 μm
- Digital resolution: 12/16 bit
- Dark current: 0.4 e-/pixel/s
- QE: 95%
- Frame rate: 24 fps at 16 bit
48 fps at 12 bit

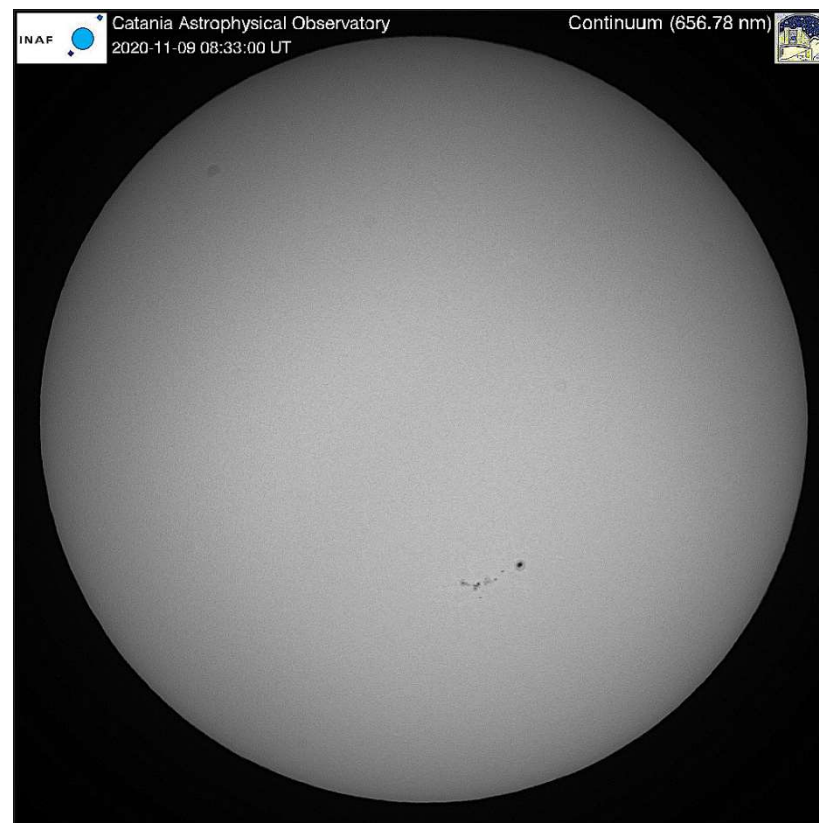
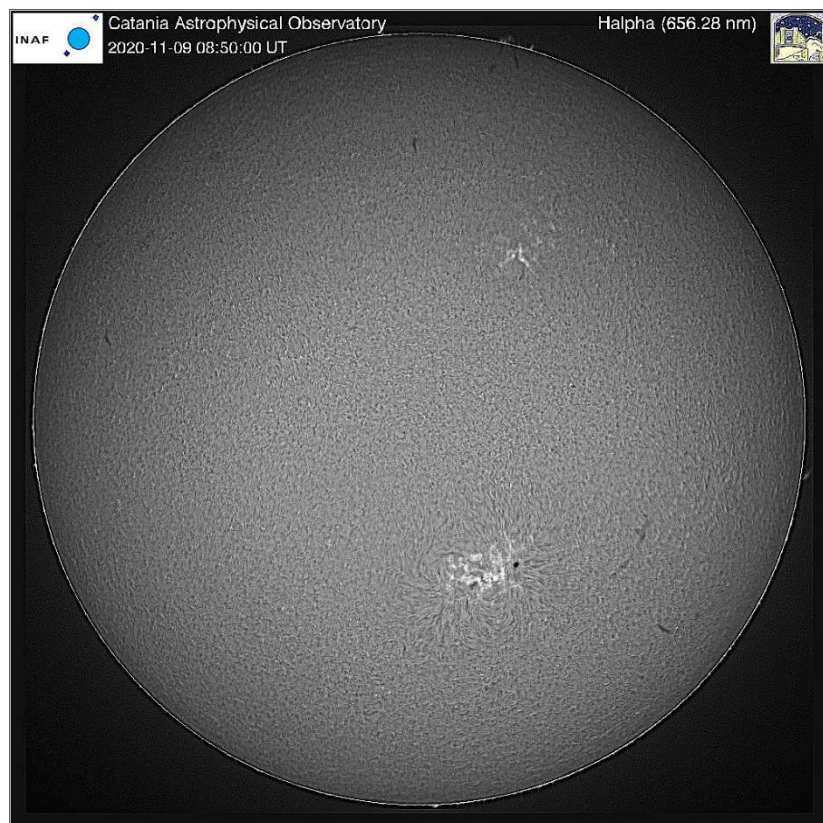


Upgrade of the acquisition system

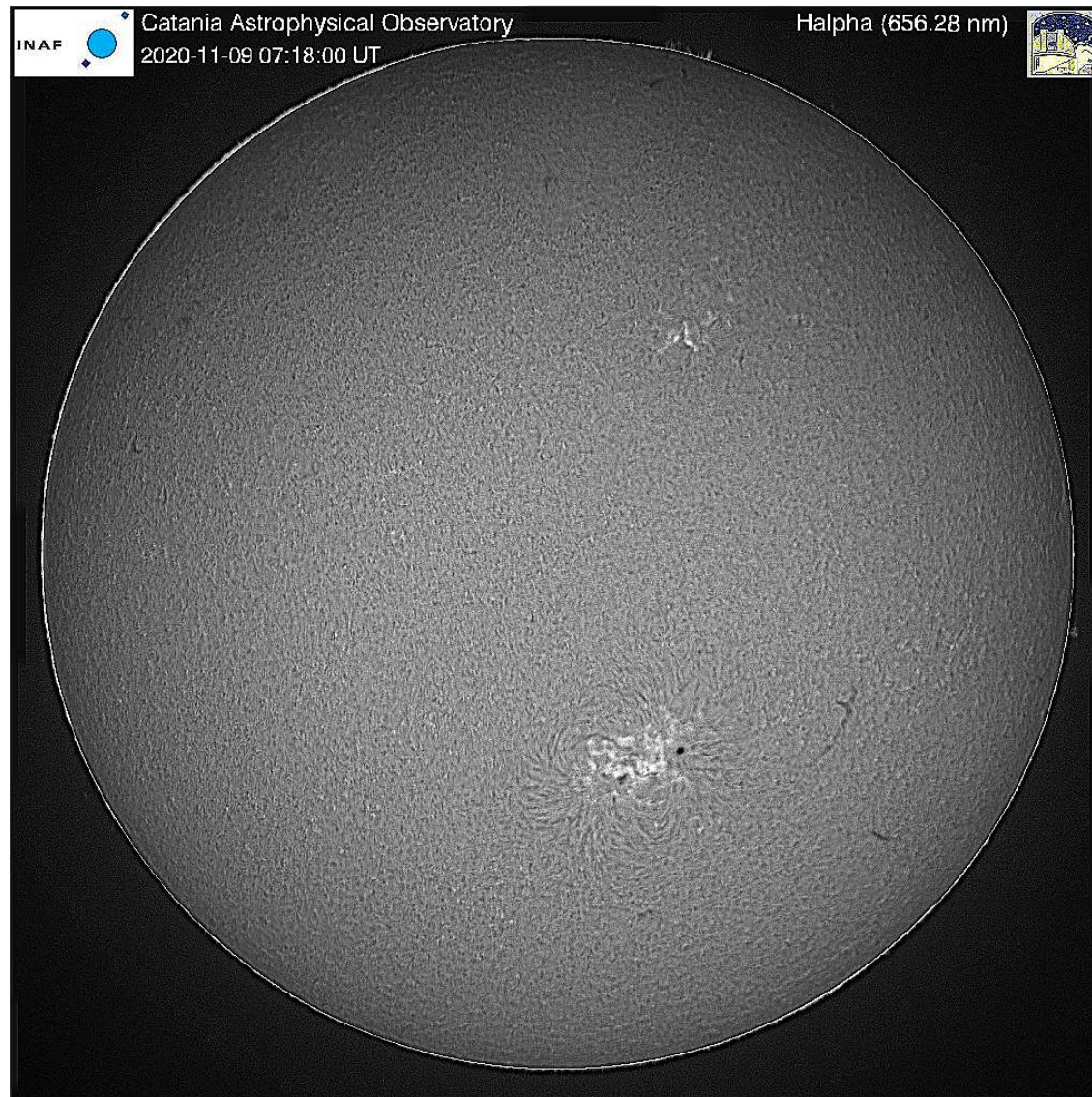


The enhancement plan focused on an increase of the acquisition rate of Halpha full disc images from about 1 image every 10 minutes to 1 image per minute, and on more aligned images characterization with standard FITS format (**same keywords of UNIGRAZ/KSO data**).

Upgrade of the acquisition system



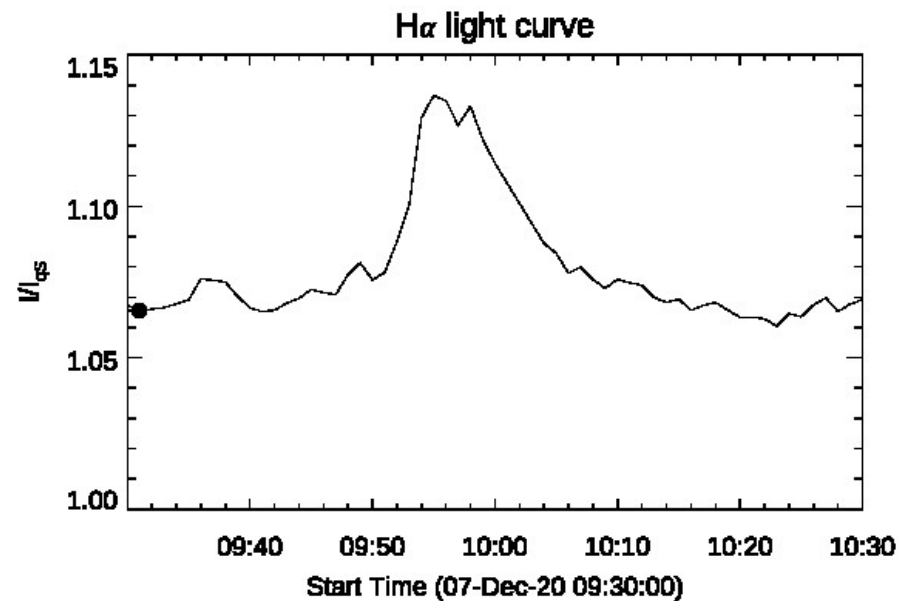
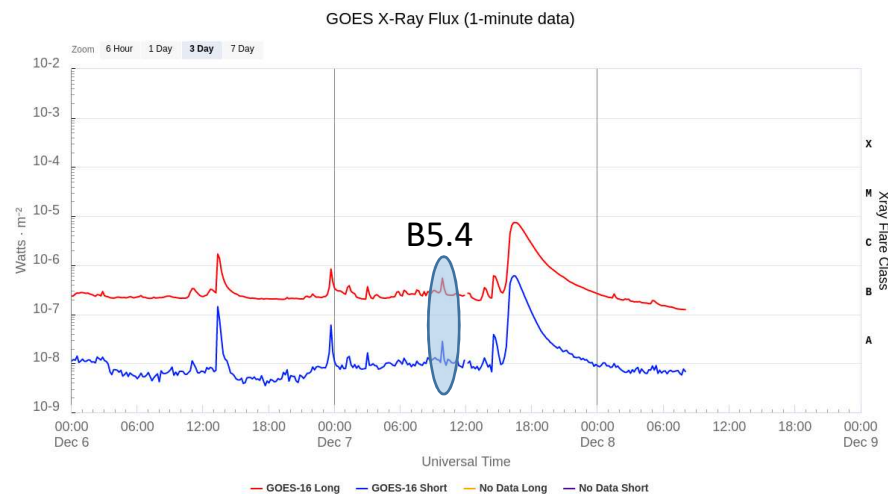
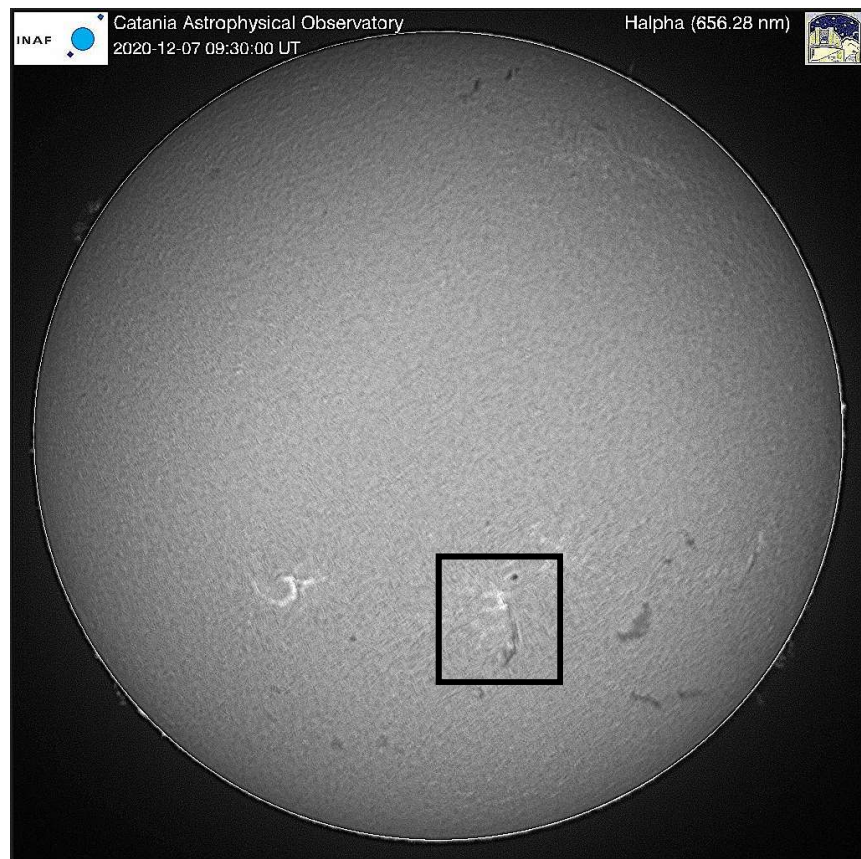
Lucky imaging technique...



Flare Detection

09:51 09:55 09:59 G16 XRA 1-8A B5.4

09:53 09:54 10:02 SVI FLA S25W04 SF NOAA 12790



Summary

Upgrades of the INAF telescopes for synoptic observations

Partecipation to the next coordinated observing campiagns

- Data marging
- Data homogenization
- Flare detection
- Lucky imaging

