

Nuove opportunità di collaborazione e nuove
sfide per la Fisica Solare ed eliosferica in
INAF

New Opportunities for Collaboration and
New Challenges In Solar and Heliospheric
Physics in INAF

Ilaria Ermolli

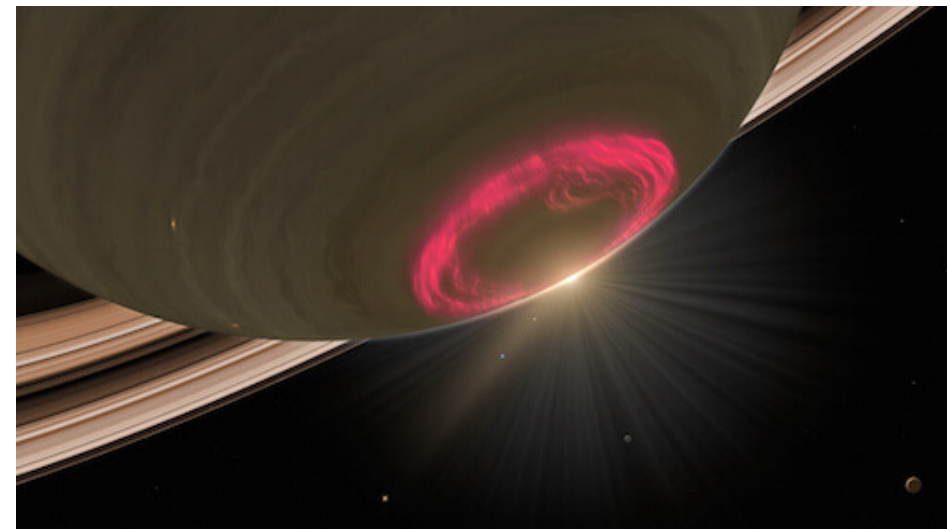
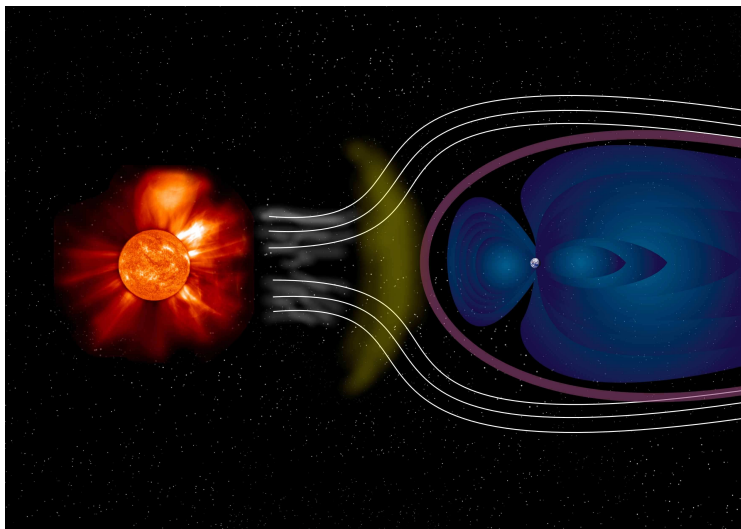
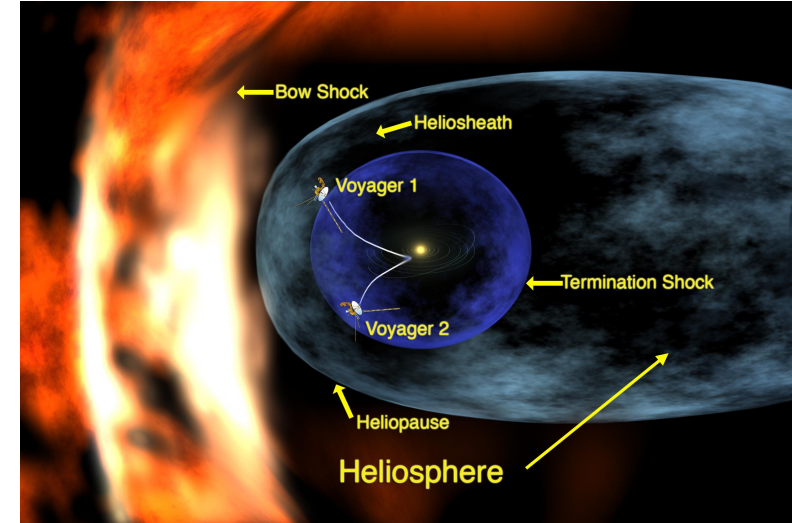
OAR - Osservatorio Astronomico di Roma

Vincenzo Andretta

OAC - Osservatorio Astronomico di Capodimonte, Napoli

The domain of Solar & Heliospheric Physics

From the Sun's interior, through the solar atmosphere and wind, up to the interstellar medium, and the effects of the Sun and of its wind on planets and other objects of the solar system

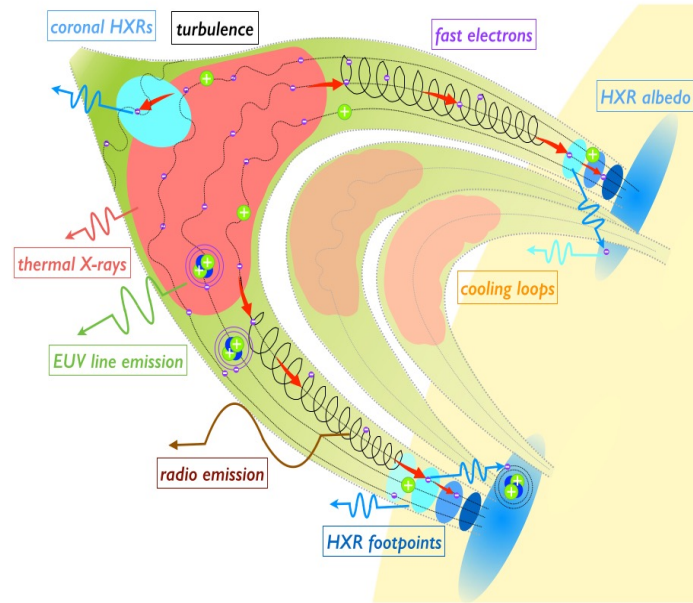
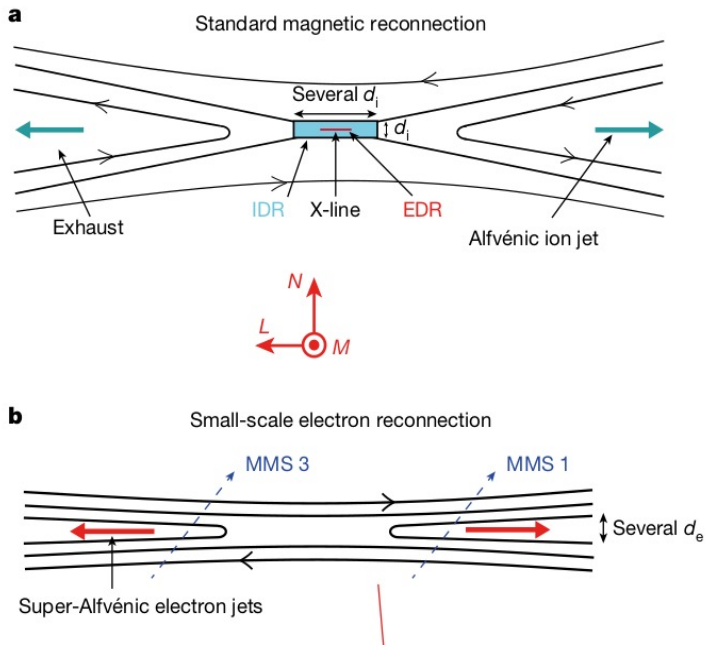


Methods and Challenges of the domain

- **Multi-messenger science:** radiation and particles, from neutrinos to in-situ measurements
- **Wide observational coverage:**
 - **Multi-wavelength:**
 - The entire electromagnetic spectrum: $\gamma \rightarrow X \rightarrow VUV \rightarrow UV/V \rightarrow IR \rightarrow \text{radio}$
 - **Multi-scale:**
 - From unresolved (Sun-as-a-star) to high spatial, high cadence observations (fundamental plasma and kinetic processes at small scales)
 - **Multi-(view)point:**
 - Observation from multiple observatories and instruments scattered in the solar system, often combining remote-sensing and in-situ
- **Modelling** is an integral part of the interpretation of the observations
- **Big data, advanced software, technological challenges** to acquire, analyse, and model the data

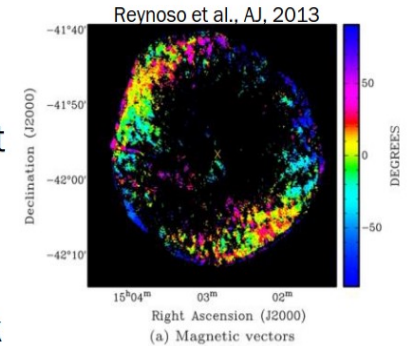
A complete, complex, dynamic system

a) The Sun and the Heliosphere as **astrophysical laboratories** (plasma physics, but not only)

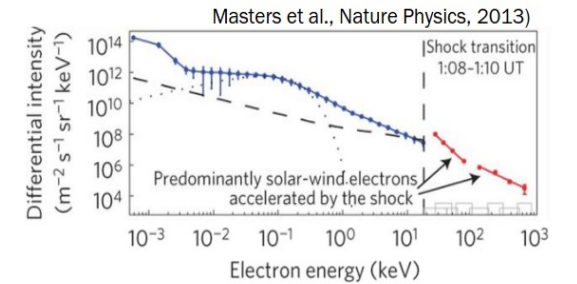


Relativistic electron acceleration at quasi-parallel shocks

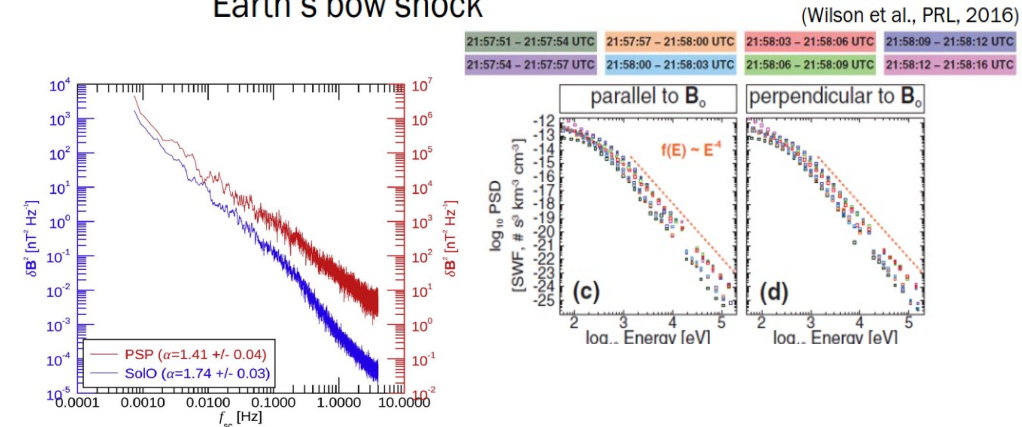
Supernova remnant shock



Saturn's bow shock

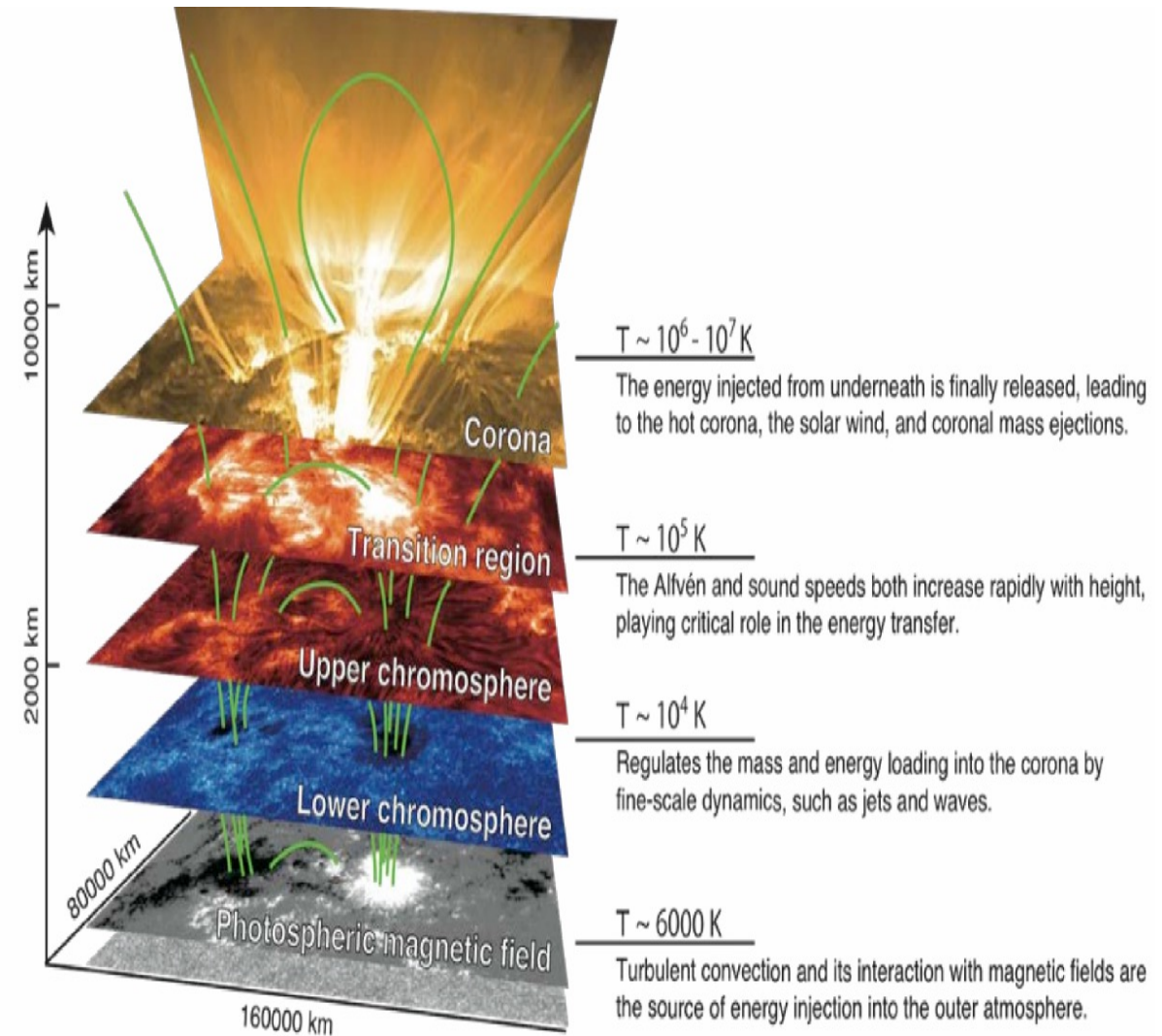
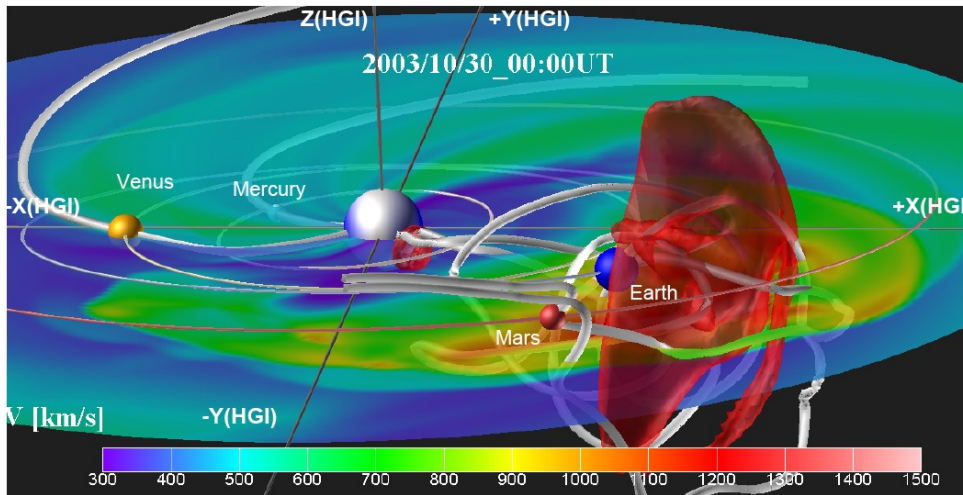


Earth's bow shock



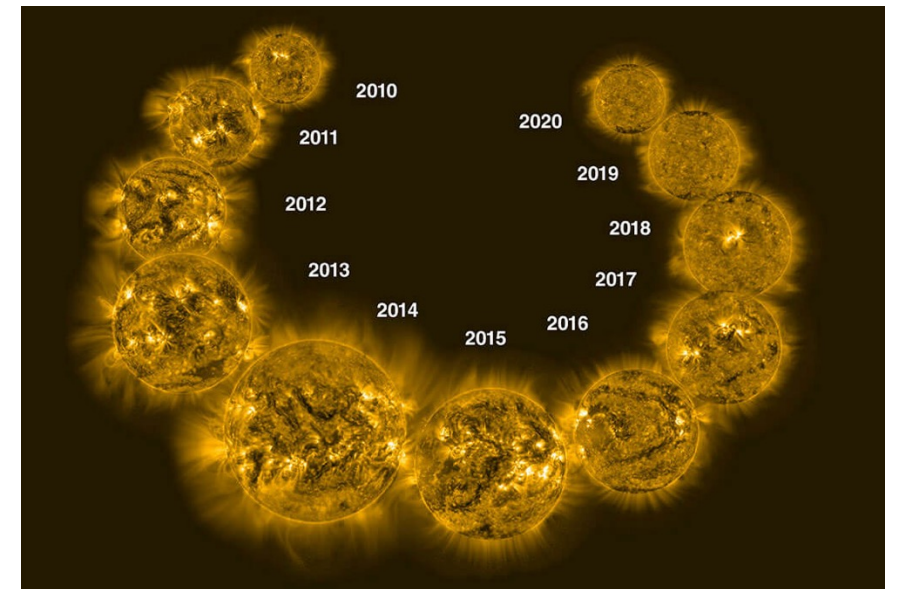
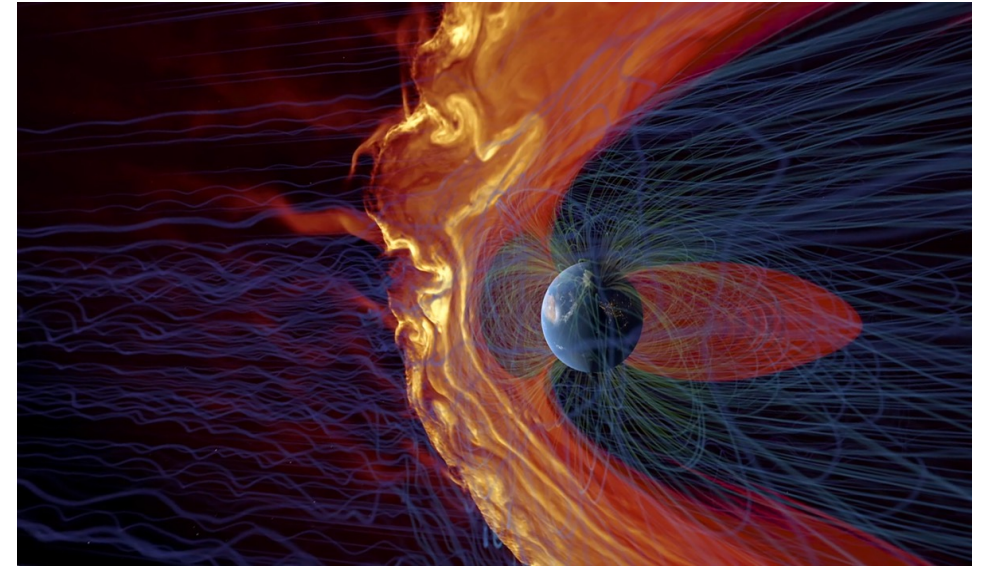
A complete, complex, dynamic system

- a) The Sun and the Heliosphere as **astrophysical laboratories** (plasma physics, but not only)
- b) Study of the **transfer of matter and energy** from the solar interior to the interstellar medium



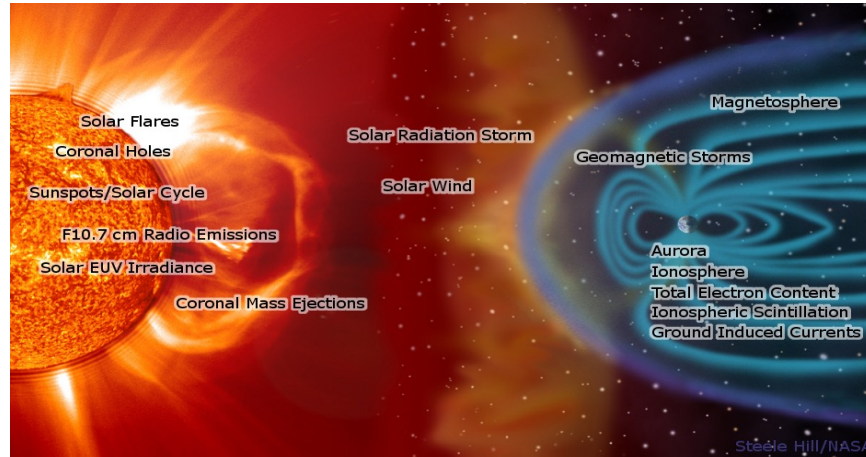
A complete, complex, dynamic system

- a) The Sun and the Heliosphere as astrophysical laboratories (plasma physics, but not only)
- b) Study of the transfer of matter and energy from the solar interior to the interstellar medium
- c) The **Sun-as-a-star**, and **effects of the Sun on planets** and their environments



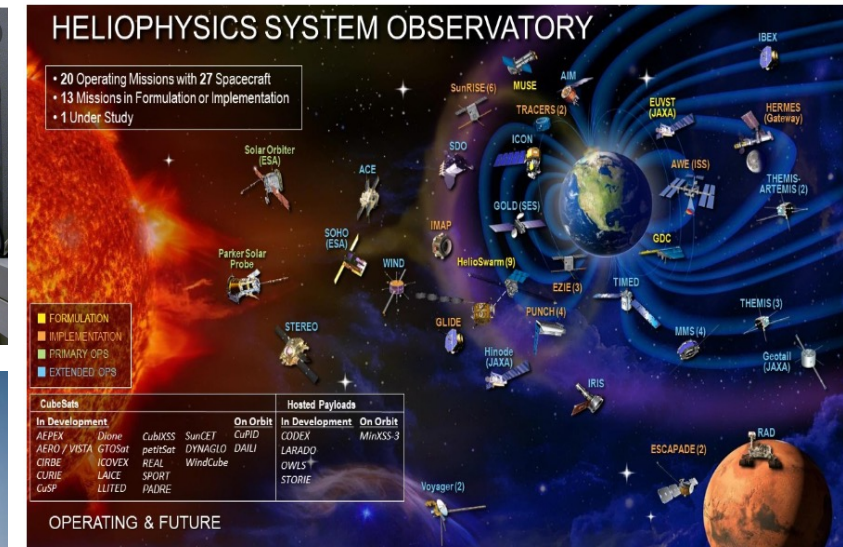
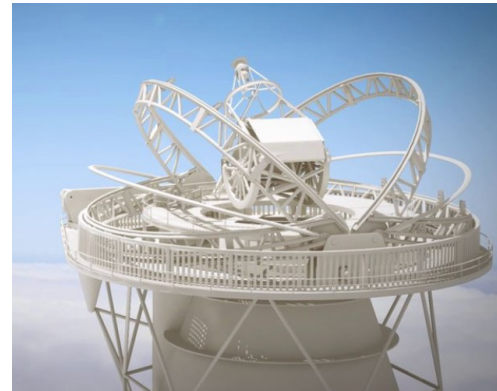
A complete, complex, dynamic system

- The Sun and the Heliosphere as **astrophysical laboratories** (plasma physics, but not only)
- Study of the **transfer of matter and energy** from the solar interior to the interstellar medium
- The **Sun-as-a-star**, and **effects of the Sun on planets** and their environments
- Relevance for the society**



A complete, complex, dynamic system

- a) The Sun and the Heliosphere as **astrophysical laboratories** (plasma physics, but not only)
- b) Study of the **transfer of matter and energy** from the solar interior to the interstellar medium
- c) **The Sun-as-a-star**, and effects of the Sun on planets and their environments
- d) **Relevance for the society**
- e) **Technological strives & Big data**



Vision & Priorities

INAF Strategic Vision

June 2019

INAF Strategic Vision

2019-2029

Introduction

Astronomy is arguably the oldest of the natural sciences. Over the course of human civilization, the sky has provided the means to measure time and the succession of the seasons, to guide the traveler, to understand our place in the Universe. Astronomical knowledge was remarkably advanced in Babylon, Egypt and China thousands of years ago and developed through the centuries with Aristarcos and Tolomeus in Greece and Copernicus, Kepler and Galileo in Europe. It was in Italy with Galileo Galilei at the beginning of the 17th century that Astronomy and Physics were united, deriving mathematical predictions of celestial motions from assumed physical causes.



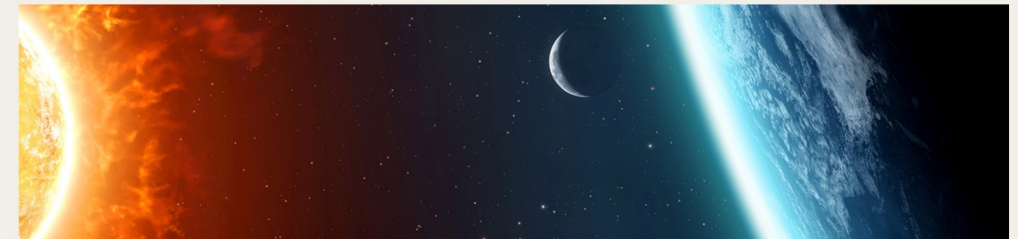
NATIONAL ACADEMIES

Sciences
Engineering
Medicine

SEARCH Q
About Us Events Our Work Publications Topics Engagement Opportunities

Decadal Survey for Solar and Space Physics (Heliophysics) 2024-2033

SHARE f t in x



SCIENCE MISSIONS EUROPEAN SPACE AGENCY SCIENCE & TECHNOLOGY SIGN IN

voyage 2050



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- Workshop programme
- White Papers

VOYAGE 2050
LONG-TERM PLANNING OF THE ESA SCIENCE PROGRAMME

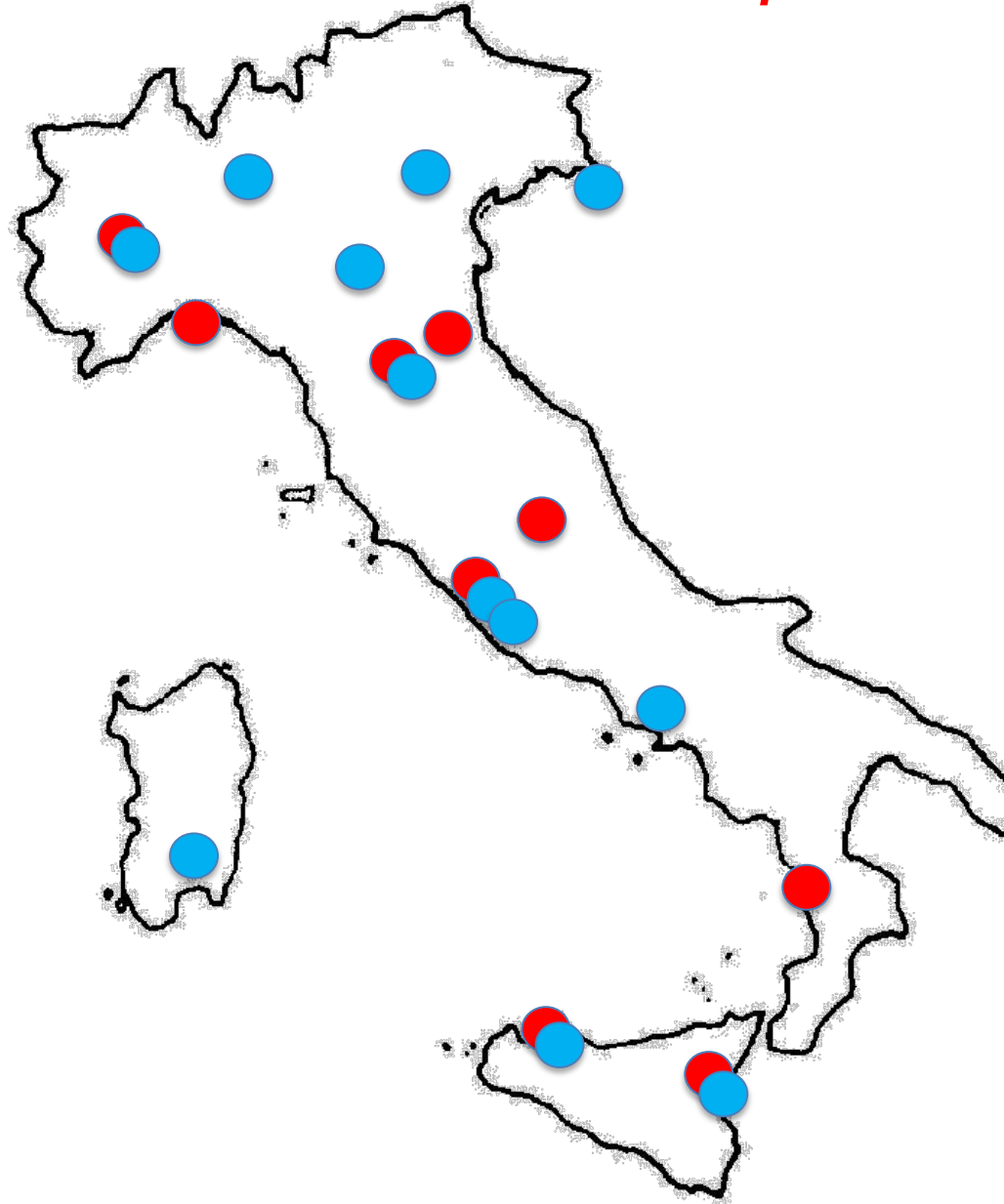
Major open questions

INAF DVS 2019-2029

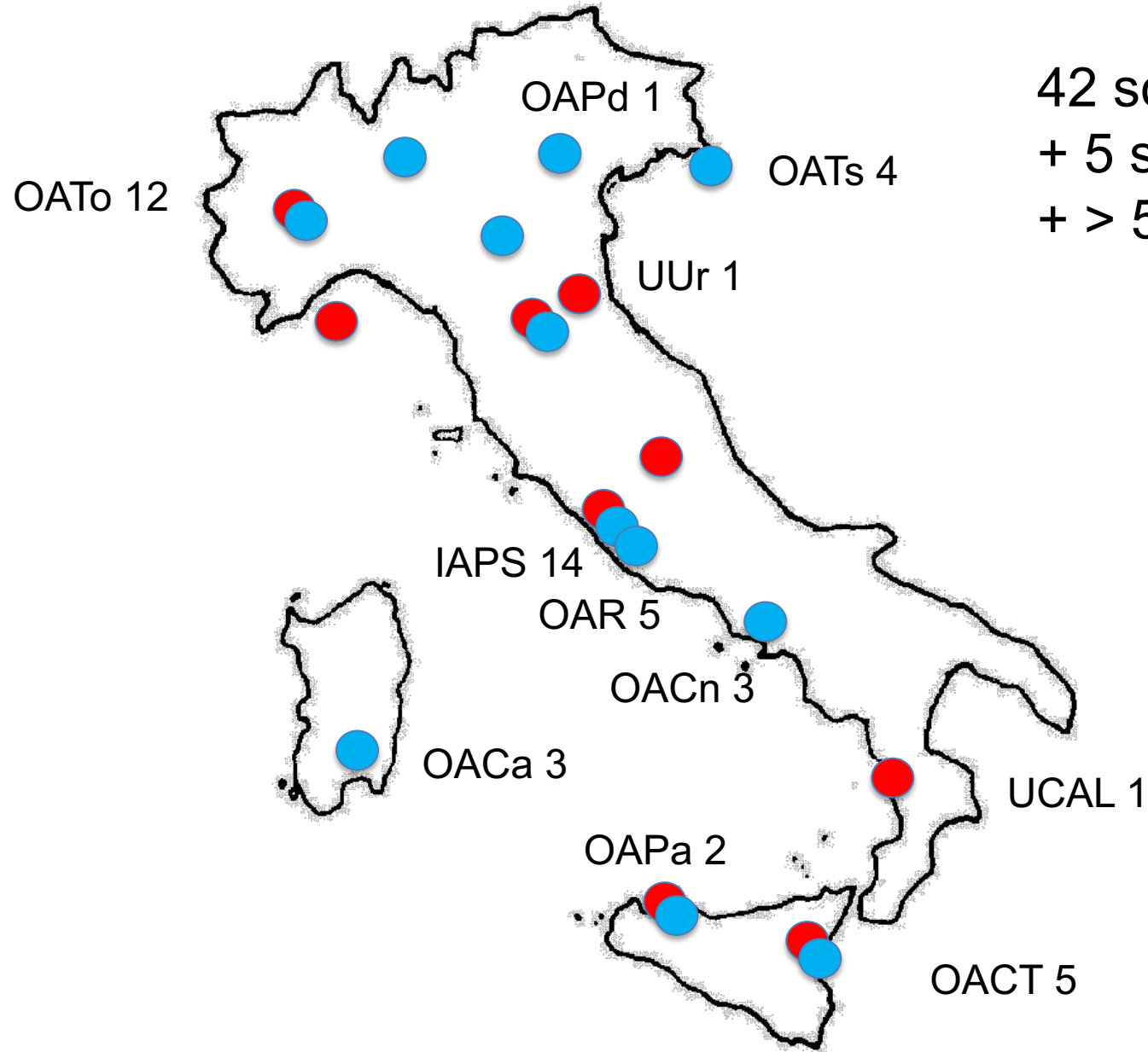
- 1. How does the Sun give origin to the heliosphere and control its evolution? How does the Solar System evolve in relation with the parent star and interplanetary medium?***
 - How is the solar magnetic field produced? What is the role of turbulent magneto-convection in the mechanisms giving origin to the solar dynamics and variability?*
 - What are the physical mechanisms regulating the heating of astrophysical plasmas and acceleration of high-energy particles?*
 - Which processes are active today in the interaction between the interplanetary medium and the bodies surface and environment, and/or played a role in the early history of the Solar System?*
- 2. Which is the influence of the Sun and the radiation environments on the human activities and on life?***
 - Which are the particle radiation and electromagnetic fields dynamics in the planetary environment (with focus on the Earth)? And how are they driven by external agents (space weather)?*
 - How can the space weather be monitored and forecasted?*

*The Physics of the Sun and Heliosphere
at INAF and Italy*

RSN3 Sun & Heliosphere



Schede INAF vs Groups



42 schede RSN3 primary
+ 5 schede RSN* primary
+ > 5 activities unreported

Main topics

17+0+1 schede
4 instrum
8 single group

*The Sun and The Heliosphere as Astrophysical
Laboratories*

EST-0, EUVST,
Helios-0/1/2,
HELIOS-SWE,
IBIS 2.0, Metis,
MHDcorloops,
MHYSA,
MOSAIC, SPIRiT,
SUSPE-0/1/2/3,
SWM

Main topics

17+0+1 schede
4 instrum
8 single group

The Sun and The Heliosphere as Astrophysical Laboratories

18+1+1 schede
6 instrum
6 single group

Transfer of matter and energy from the Sun through the heliosphere

EST-0, EUVST,
Helios-0/1/2,
HELIOS-SWE,
IBIS 2.0, Metis,
MHDcorloops,
MHYSA,
MOSAIC,
SCORE,
SunDish,
SUSPE-0/1/2,
XUVSun,
Active Star
(RSN2)

Main topics

17+0+1 schede
4 instrum
8 single group

The Sun and The Heliosphere as Astrophysical Laboratories

18+1+1 schede
6 instrum
6 single group

Transfer of matter and energy from the Sun through the heliosphere

9+3+2 schede
2 instrum
2 single group

The Sun-as-a-star, effects on planets and their environments

EST, Helios-0/1/2, MHYSA, MOSAIC, SERENA, SUSPE-3, VARSOL, ActiveStar (RSN2), LOCNES (RSN2), The StellaR PAth (RSN2), SW&SC techniques applied to solar-type stars, CR in the heliosphere

Main topics

17+0+1 schede
4 instrum
8 single group

The Sun and The Heliosphere as Astrophysical Laboratories

18+1+1 schede
6 instrum
6 single group

Transfer of matter and energy from the Sun through the heliosphere

9+3+2 schede
2 instrum
2 single group

The Sun-as-a-star, effects on planets and their environments

18+1+3 schede
7+3 instrum
10+3 single group

Services and Relevance for the society

ASPIS, CAESAR, CEI6, CoSD, ESCAPE, EST, HELIOS-SWE, HENON, MoonSWA, MOSE-Solaris, SPIRiT, SunDish, SVIRCO, SWELTO, SWESNET, SWM, SWS, VARSOL, LOFAR-IT, CUBE (CME Catcher Carousel), TSRWC (Trieste Solar Radio Weather Centre), RSRWC (Rende Solar Radio Weather Centre)

Main topics

17+0+1 schede
4 instrum
8 single group

The Sun and The Heliosphere as Astrophysical Laboratories

18+1+1 schede
6 instrum
6 single group

Transfer of matter and energy from the Sun through the heliosphere

9+3+2 schede
2 instrum
2 single group

The Sun-as-a-star, effects on planets and their environments

18+1+3 schede
7+3 instrum
10+3 single group

Services and Relevance for the society

25+3+3 schede
7+3 single group

Development of instrumentation & data archives

ASPIS, CAESAR, CaTS, ESCAPE, EST, EUVST, Helios-1, HENON, IBIS 2.0, IBIS-A, Metis, MOSE-Solaris, PRE-EST, PROBA-3, SailCor, SCORE, SERENA, SOLARNET, SP4GATEWAY, SunDish, SVIRCO, SWESNET, SWS, VAMOS, VARSOL, LOCNES, LOFAR-IT, PlasmaLab4Space (RSN2), CUBE (CME Catcher Carousel), TSRWC (Trieste Solar Radio Weather Centre), RSRWC (Rende Solar Radio Weather Centre)

Funding



SO/METIS, SO/SWA, BC/SERENA
HELIOS, SUSPE, ASPIS, CAESAR
SOLAR-C/EUVST



PROBA3, HENON, CUBE
SWESNET



EST, PRE-EST, SOLARNET, IBIS-A



PRIN-MUR,
PNRA,
Regioni,
Ministeri, etc

CEI6, SPIRiT, CoSD, SOLARIS, ESCAPE, LOFAR-It



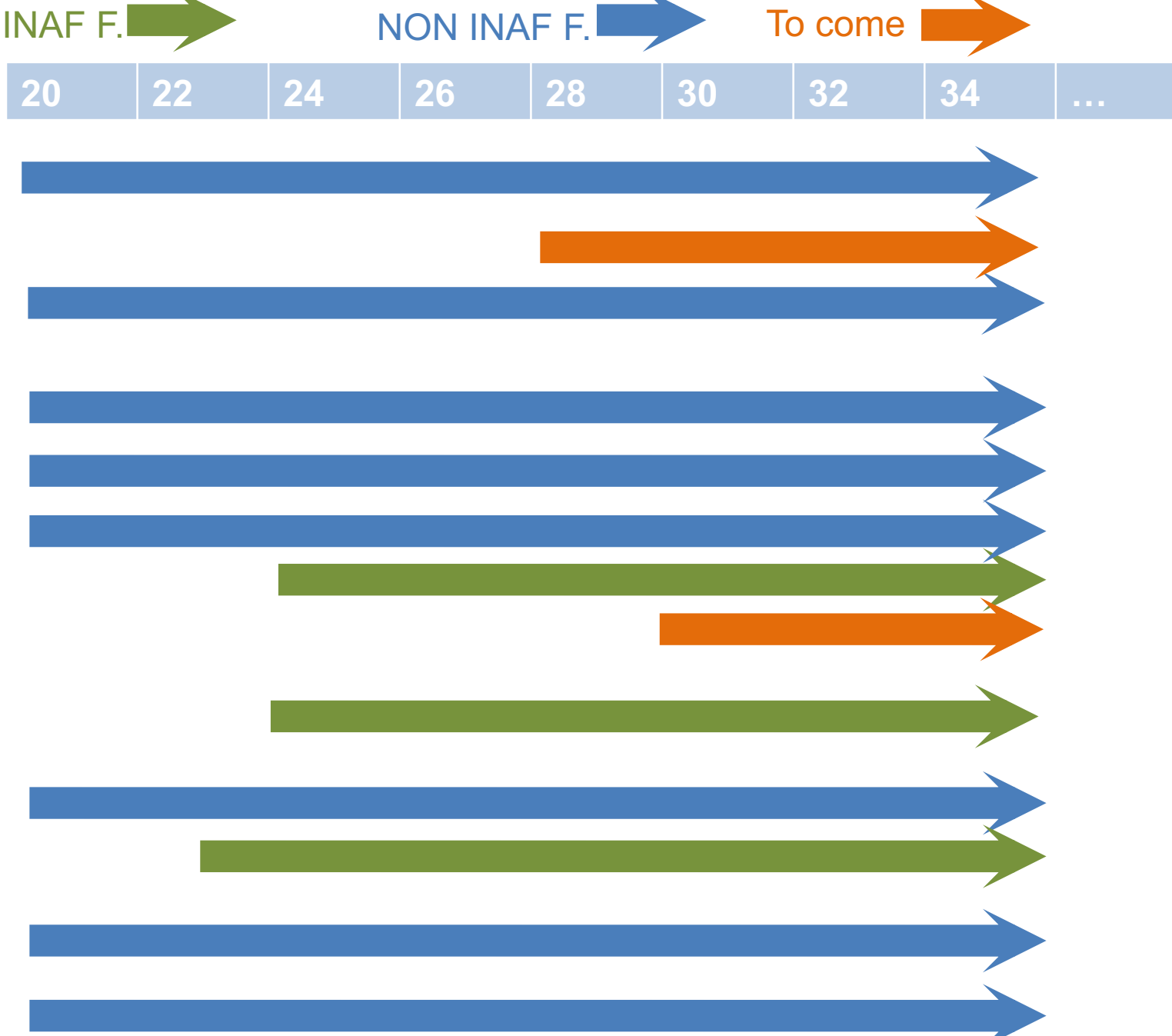
PRIN, FFO, etc

SVIRCO, SunDish, TSRWC, ReRWC, SWELTO, IBIS 2.0

Current and future

Facilities

- γ -X: Fermi, SO-STIX
- UV: Solar-C EUVST, SO-METIS
- ViS/NIR: HINODE/SDO/IRIS, DKIST/1-m class, Full-disk@INAF, IBIS 2.0, EST
- IR: LOCNES
- Radio: ALMA/LOFAR, Radio@INAF
- Particles: BC/PSP/SO-SWA, CoSD/....



Challenges

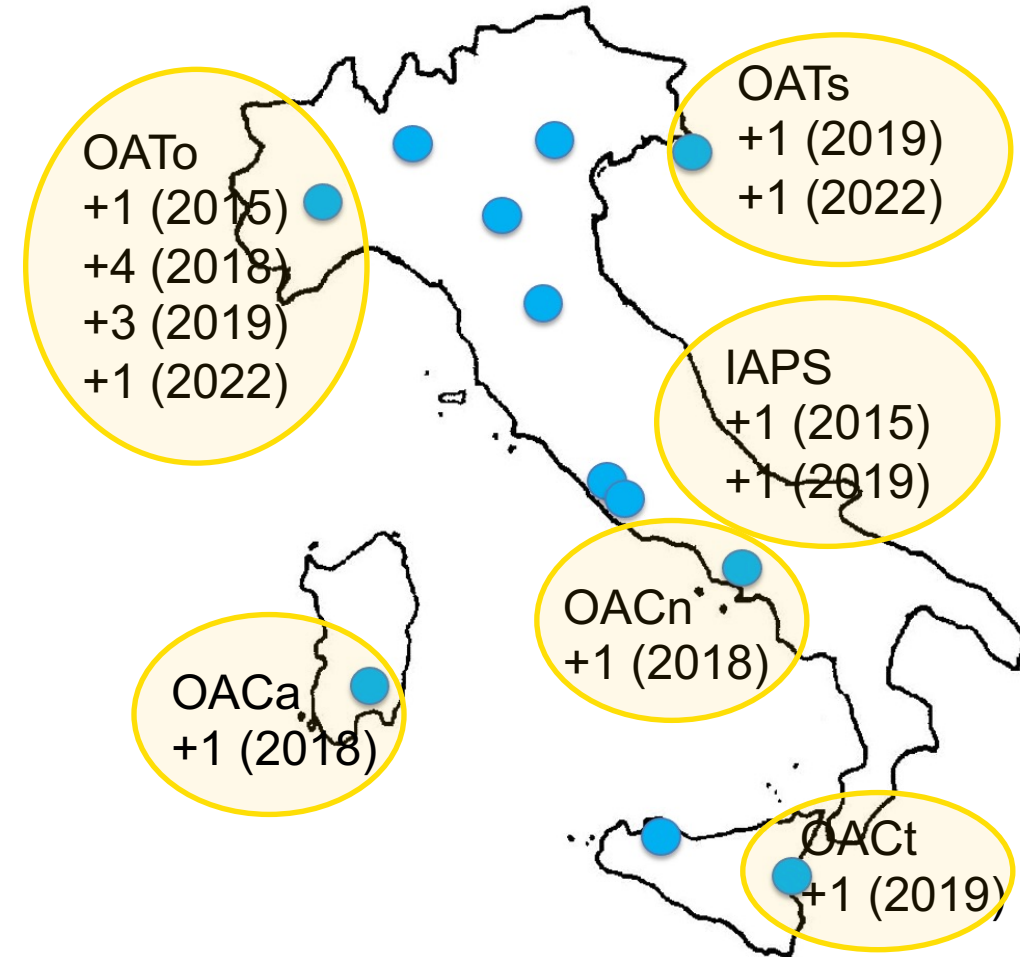
- a) **Precise workings of the solar dynamo** → getting a polar view of the magnetic field and flows to constrain dynamo models.
- b) **Generation of the solar atmosphere** → building a complete 3D picture of the magnetic field from the visible solar surface to the corona.
- c) **Origin of solar flares, coronal mass ejections, and other instabilities** → uncovering the thermal, dynamic, and magnetic properties of the Sun's plasma at high spatial and temporal resolution and the atmospheric coupling.
- d) **Accurate forecast of the upper atmospheric responses to Space Weather events for the Earth, other planets and bodies** → monitoring the solar atmosphere, solar wind, magnetosphere, and ionosphere-thermosphere.

Criticalities

- **Several projects** involve **only few researchers**, with tenuous connection to the wider community and **minimal INAF institutional involvement**
- **Significant depletion of human resources** over the past decade (few new 3rd-lev positions, very few 1st-2nd lev positions)
- **Under-represented @ MM**
- **Often limited access to PhD/Master students**

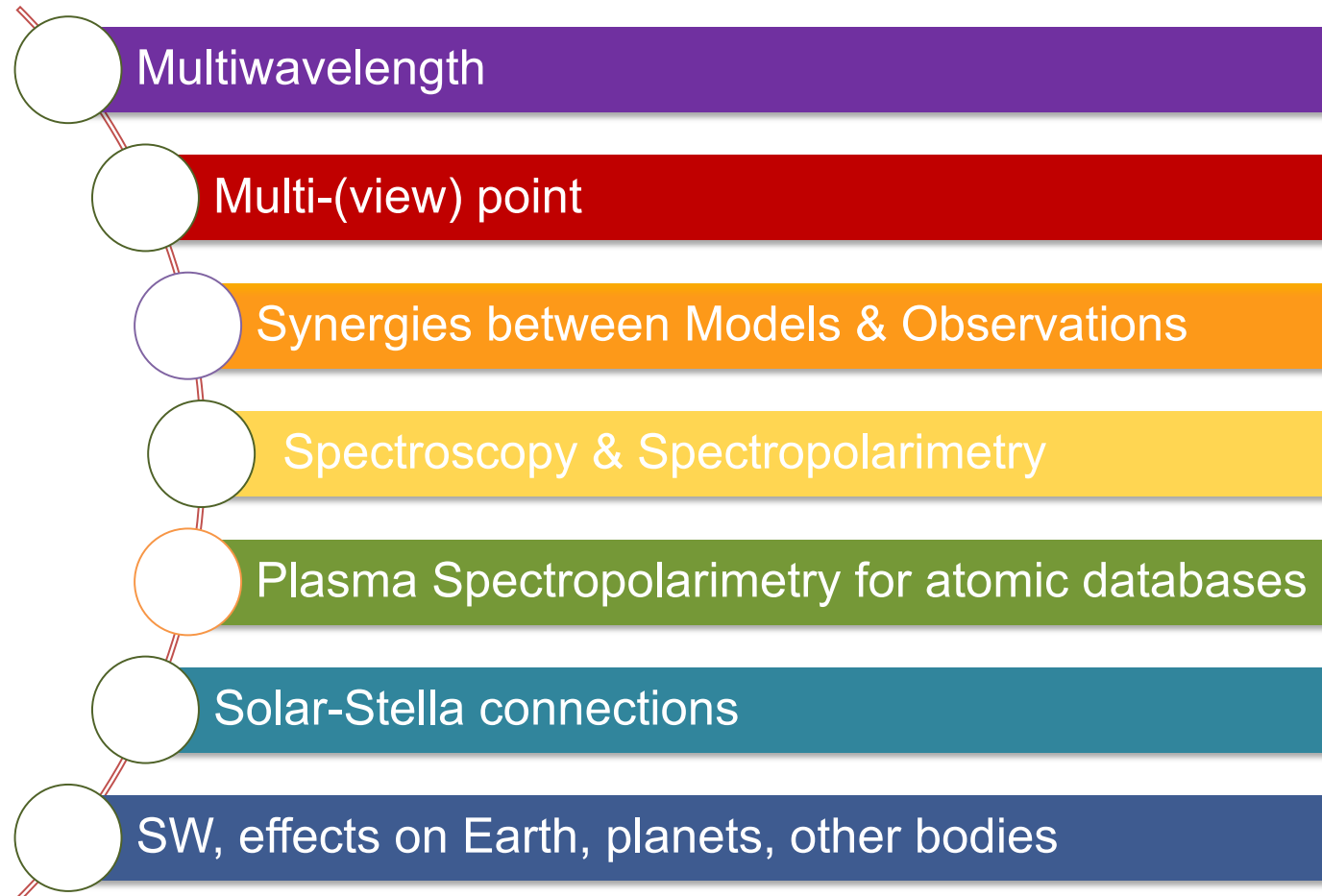
Criticalities

- **Limited synergies between different groups**
- (1998, 2000, 2002, --2016, 2019)
- **Critical mass**
 - Several retirements
 - Few new positions



New opportunities

Foster collaborations (e. g. ASI Topical Teams, CAESAR, etc)



New opportunities

- **1 of 1** Theory-grant (Bemporad) & **6 of 20** Mini-grant (Simonetti, Alberti, Frassati, Benella, **Marassi**, Andretta)
- Space Weather (SWScience, PNRR, INAF obs & model assets, etc.)
- New missions under development or proposed
 - (**SOLAR-C**, CUBE, VIGIL, SPARK, FireFly, etc.)
- **ESFRI EST**
- **Consolidation of individual** schede/local projects
- **Register activities** unreported in schede

Thanks

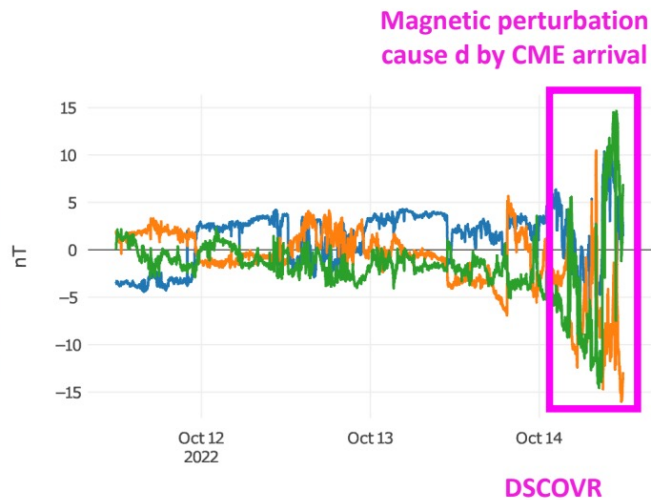
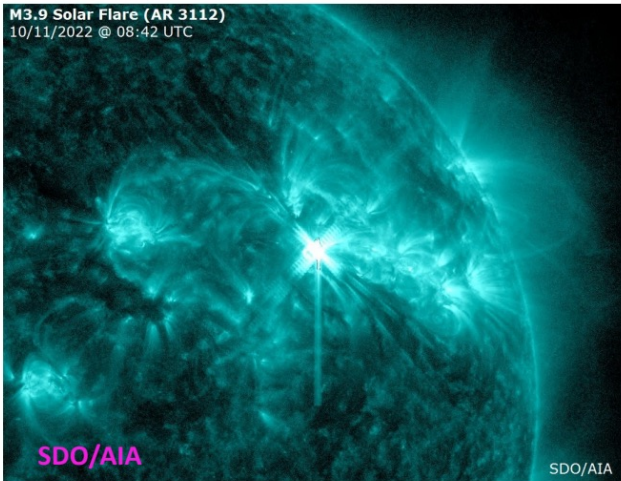
Time for discussion!

Flare bulletin

<https://drive.google.com/drive/folders/1WbA1ccVYyAW-CtYyjs3WudN3-YnT30r7?usp=sharing>

Focus: M-flares and geoeffective CMEs

11/10/22, M3.9 flare from AR 3112 at 08:42UTC



7 M-class flares this week which caused minor radio blackouts (R1)
M-flares from October 11 were associated with CMEs that reached the Earth on October 14
As a result Kp index reached 4 over the past few hours (moderate geomagnetic activity)



WEEKLY FLARE BULLETIN
07/10/2022 -- 14/10/2022
Contact: barbara.perrin@cea.fr

Interesting configurations

