THE EUROPEAN SOLAR TELESCOPE

Morten Franz and the EST-Team

ASTERIC DADI Technology Forum 5
Stasbourg, February 26th - 28th 2019

Leibniz-Institut für Sonnenphysik (KIS)

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- A flavor of solar data → Challenges for archiving and dissemination
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Upcoming Solar Telescopes

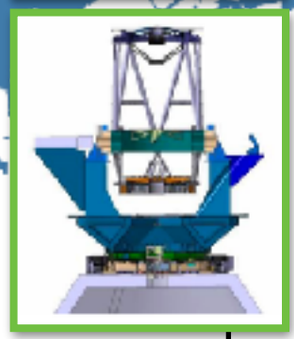
DKIST 2020

GST

EST 2027

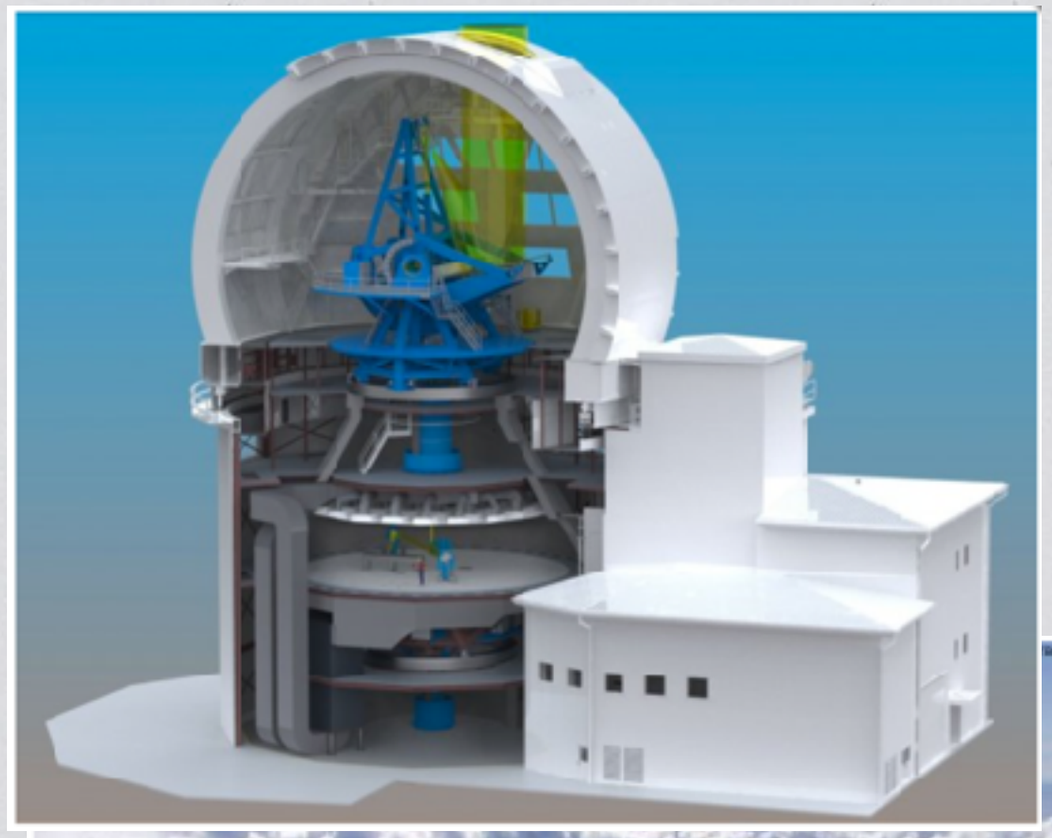
GREGOR, VTT, SST, Themis

Sayan Solar Telescope Coronograph



CGST 2030

Upcoming Solar Telescopes



DKIST
DANIEL K. INOUYE SOLAR TELESCOPE

Daniel K. Inouye Solar Telescope,
Hawaii, USA

Upcoming Solar Telescopes

Daniel K. Inouye Solar Telescope,
Hawaii, USA

UK and Germany are contributing to the DKIST project with detectors and the VTF 2D spectro-polarimeter

European access to observation and data

Upcoming Solar Telescopes

EAST
European Association for Solar Telescopes
(2006)

SOLARNET
(01/2019 — 12/2022)

EST

ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures
(02/2019 — 07/2022)

GREST
GETTING READY FOR EST
(06/2015 – 05/2018)

PRE-EST
(04/2017 – 03/2021)

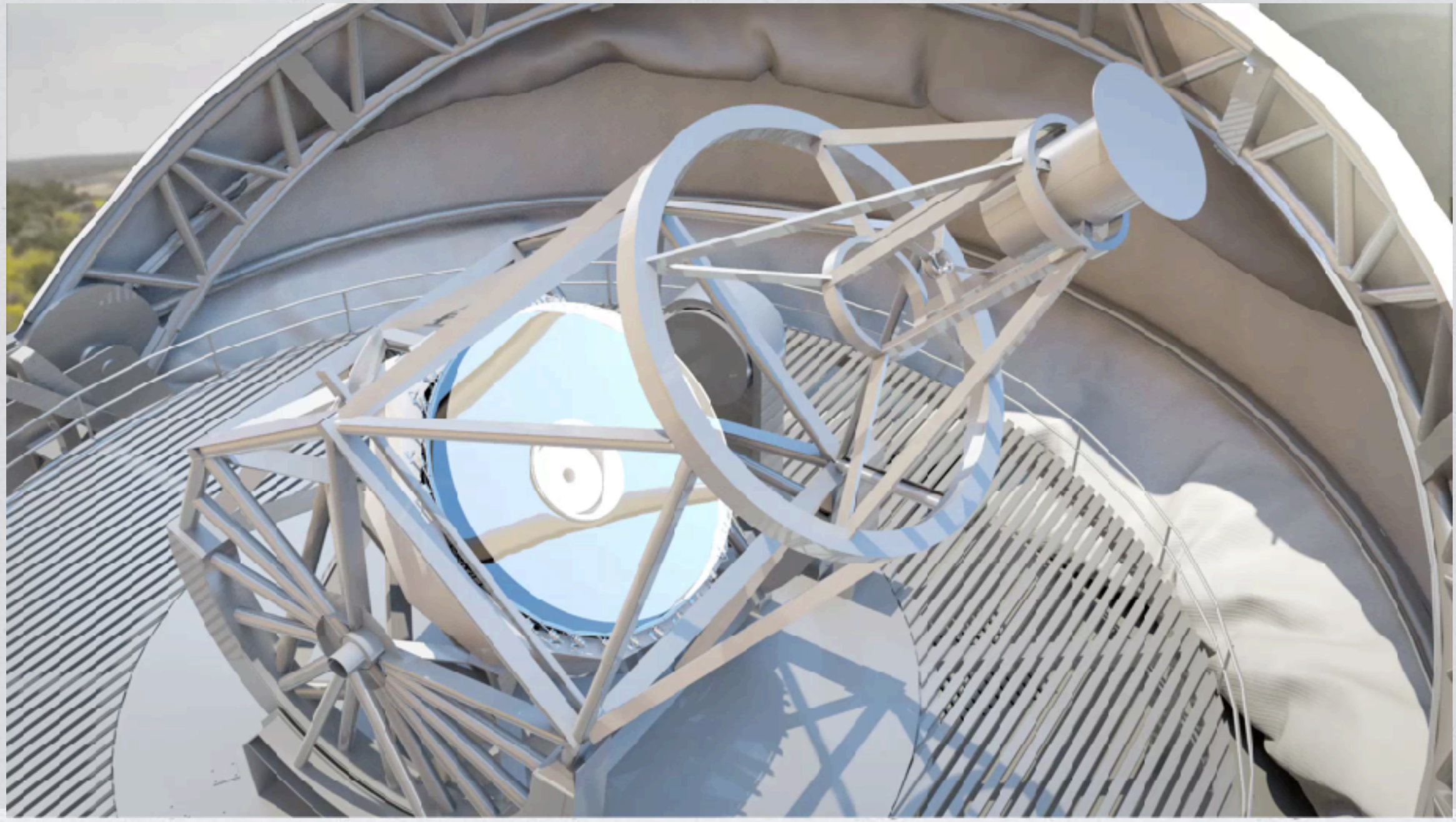
Asterics
Astronomy ESFRI & Research Infrastructure Cluster
(05/2018 — 04/2019)

SOLARNET
(04/2013 – 03/2017)

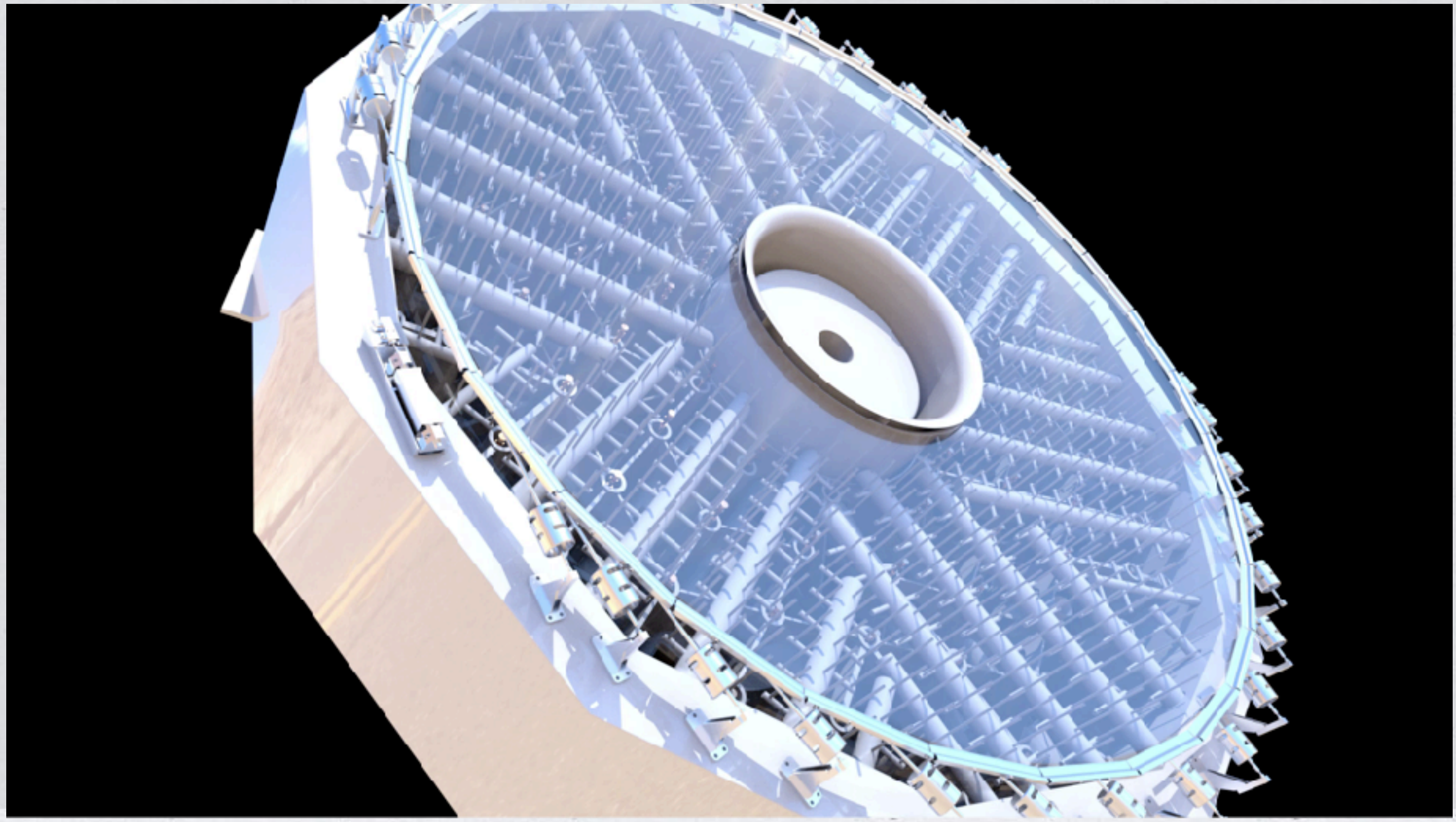
EST Design Study
(2008 - 2011)

EST

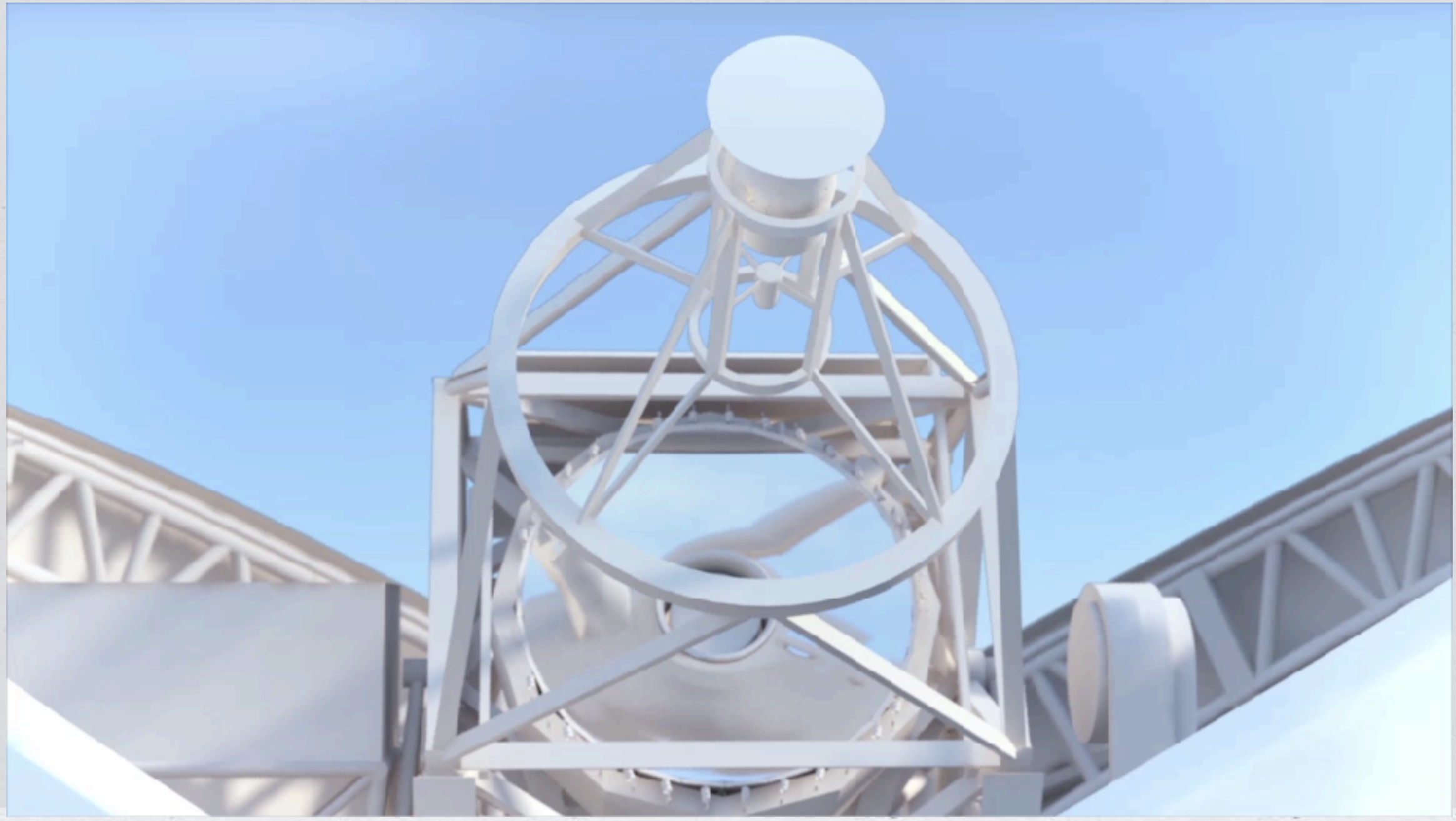
EST



EST



EST



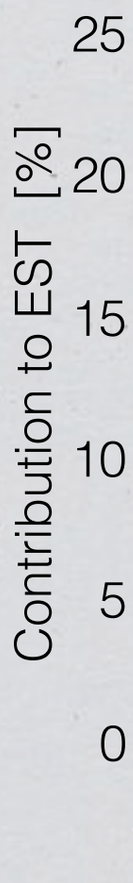
Upcoming Solar Telescopes

The *European Solar Telescope* (EST) is a 4m on-axis solar telescope. Its polarimetrically compensated design is optimized for high-resolution and multi-wavelength spectropolarimetric observation.

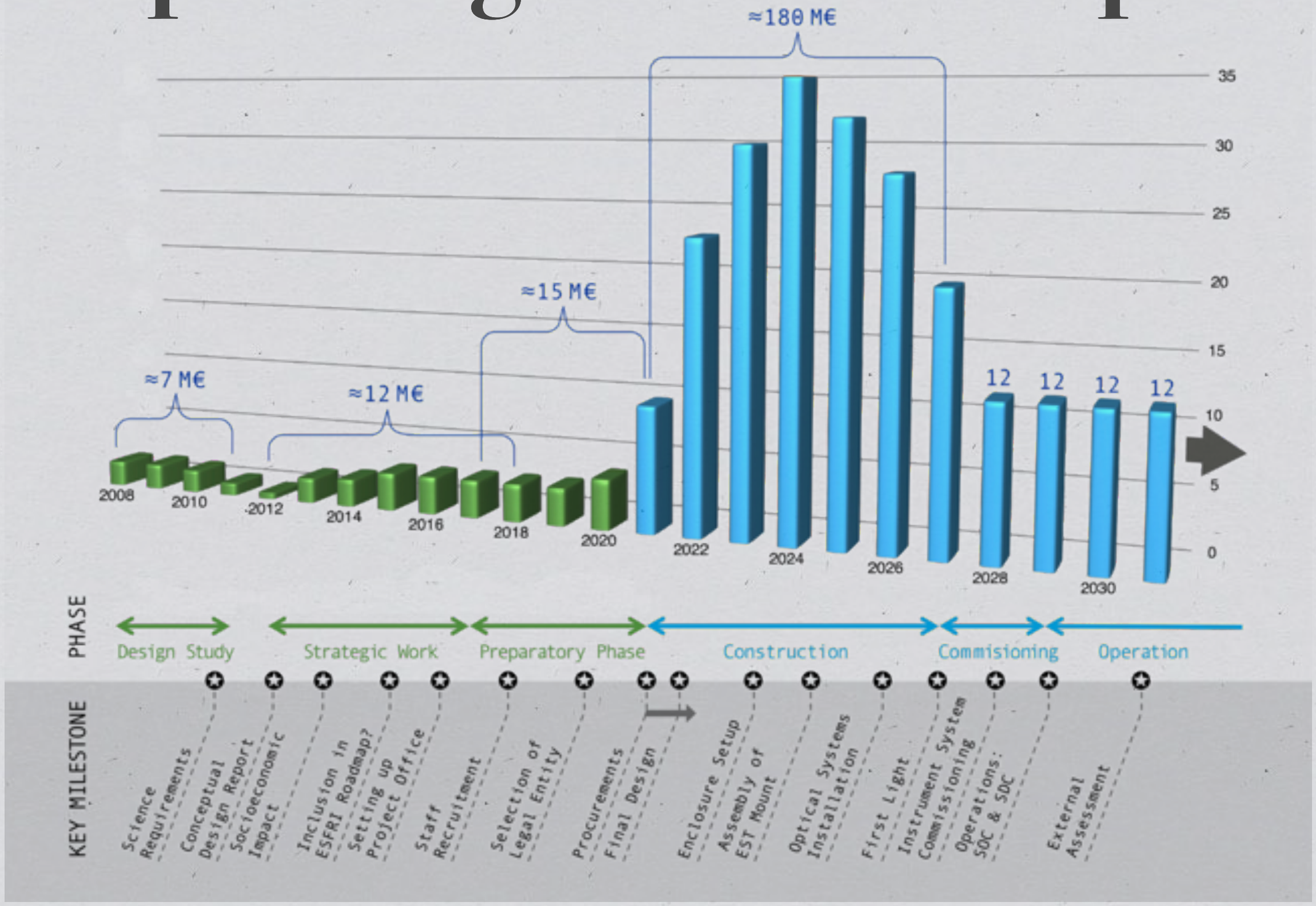
The EST project comprises 23 European institutions from 15 countries lead by IAC (Spain) and KIS (Germany).

EST became an ESFRI project when the road map was updated in 2016.

KIS joined the ASTERICS network in 2018 as a representative for the EST community. Within the ESCAPE initiative, EST is represented by four beneficiary institutes.

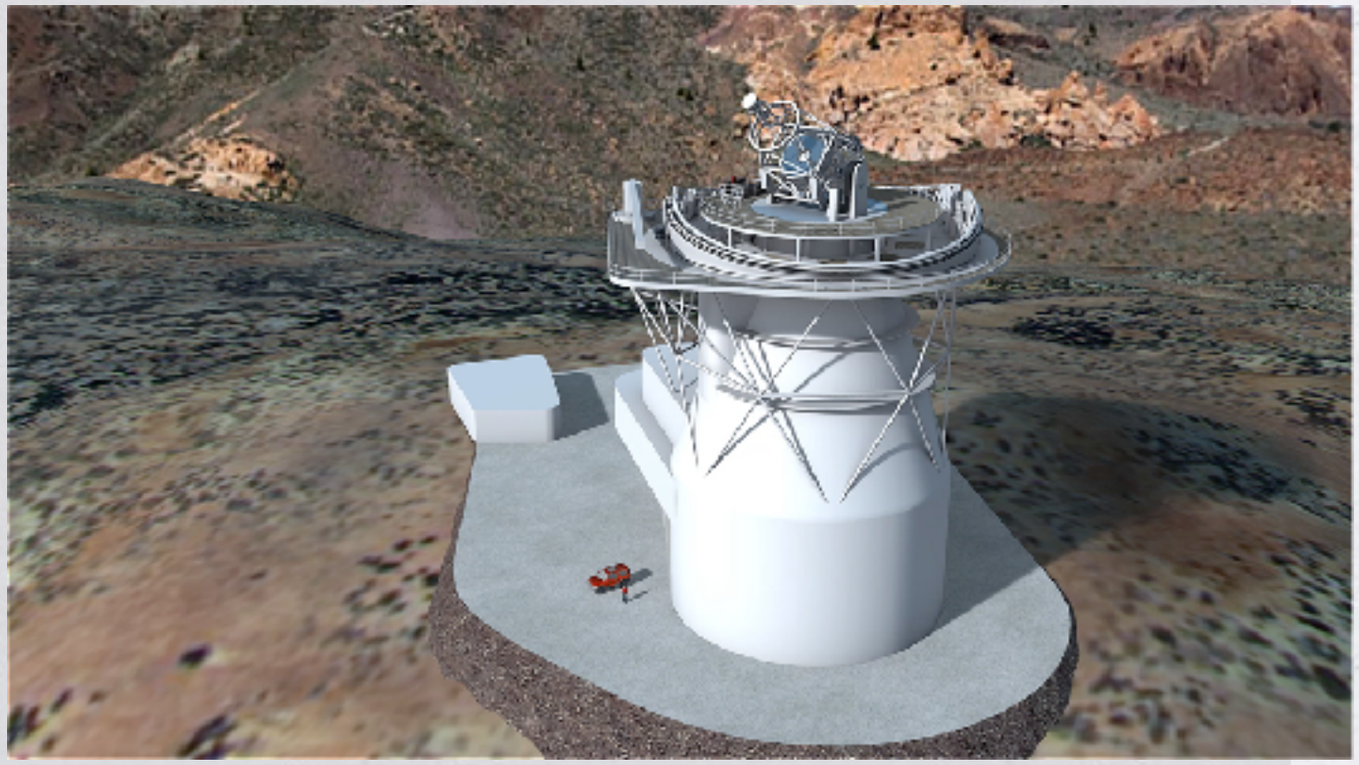


Upcoming Solar Telescopes



Upcoming Solar Telescopes

- Type: Single-sited
- Coordinating country: Spain
- Legal form: probably ERIC
- Funding
  - Spain: secured
  - Germany: pending; publication of the German roadmap delayed
  - Others: secured/pending on the confirmation of German roadmap
- Location
  - EST will be built on the Canary Islands
  - Headquarters will be at the Instituto de Astrofisica de Canarias, Tenerife, Spain



Upcoming Solar Telescopes

[...]
EST Science Data Center: EST SDC

Apart from the EST Telescope Operation and Science Centre on the Canary Islands, it is also planned to have the EST Science Data Centre in Germany, to provide data access and online services to the solar physics community. This center will provide a storage area to be accessed online through a data management system. Furthermore remote-observing facilities will be installed here.

Costs related to the installation of the telescope at the observatory form an integral part of the EST project budget. However, the construction or use of those spaces at sea-level and at mainland Europe for the EST TOSC and the EST SDC are planned to be covered by additional sources and agreements.
[...]

Online submission form: Research Infrastructure proposal to the 2016 ESFI Roadmap

Upcoming Solar Telescopes

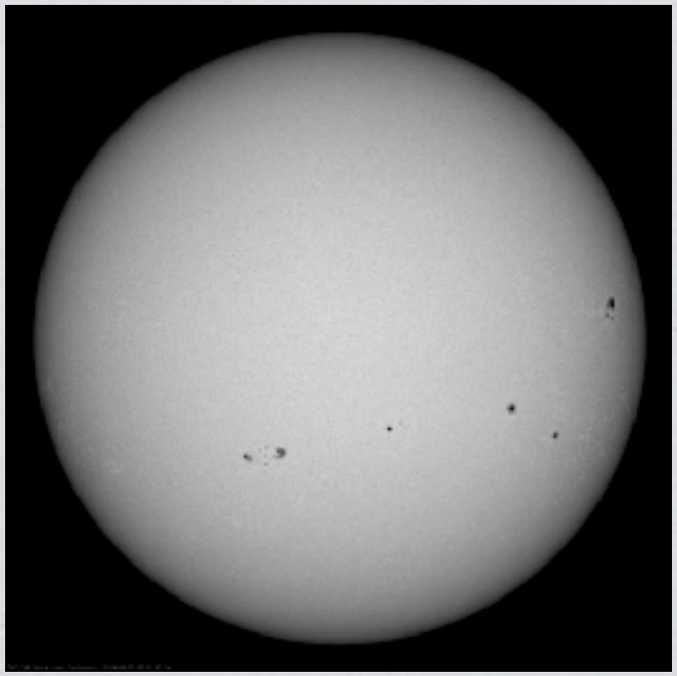
[...]
The EST Science Data Centre (EST SDC) will gather all expertise for producing EST science-ready data. Science-ready data will be moved or duplicated from the processing centre to the mainland Europe Virtual Observatory Compliant Data-Base (VOCDB). The SDC will be the nucleus of the scientific life of EST, where scientists are expected to come for a full data analysis and share results. If communication bandwidth allows, remote control of the infrastructure shall also be possible from the SDC. The SDC will also be in charge of the long-term data storage and the VO-diffusion of EST data. The VOCDB shall take charge of the interoperability with the VOCDB from other facilities.

The SDC shall have offices for specialized staff in data reduction and analysis and for visiting astronomers to work on, and get familiar with, the EST data. Computing and storage capacities will be enough to guarantee the successful handling of EST data to generate innovative results.

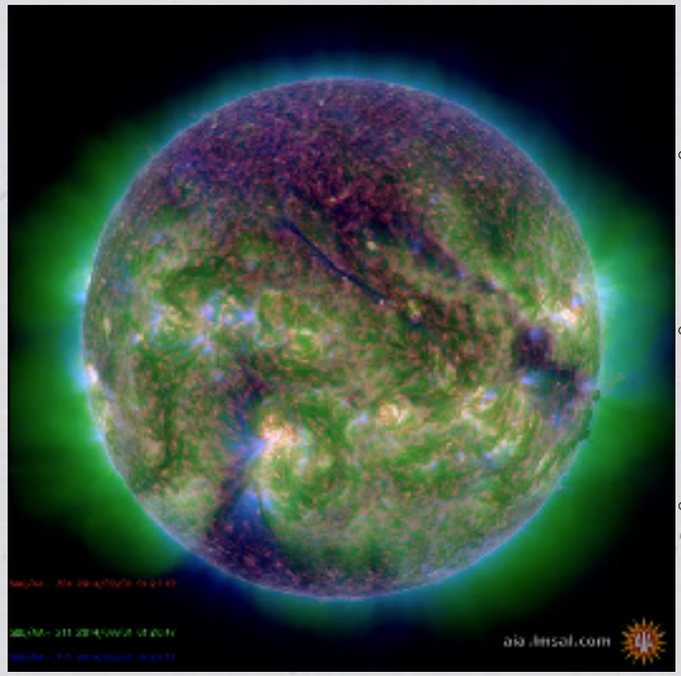
The SDC will organize special events to gather scientific visitors there to foster discussion forums and workshops based on EST data and results.
[...]

Online submission form: Research Infrastructure proposal to the 2016 ESFI Roadmap

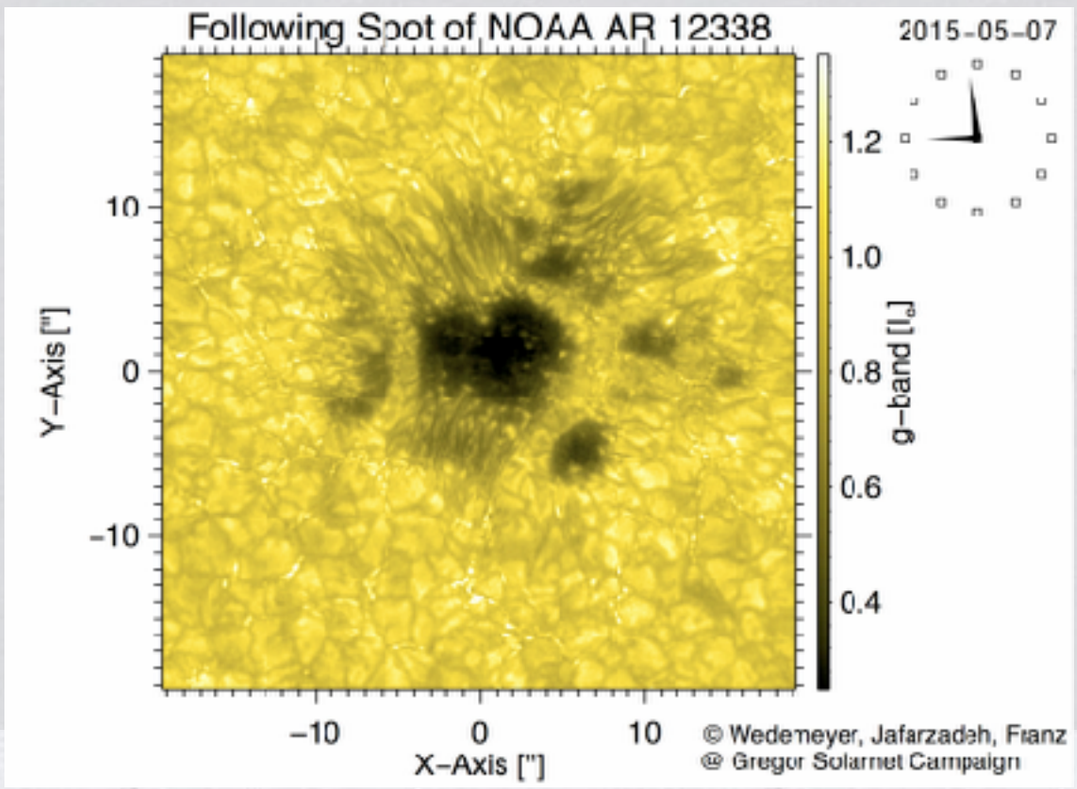
A Flavor of Solar Data

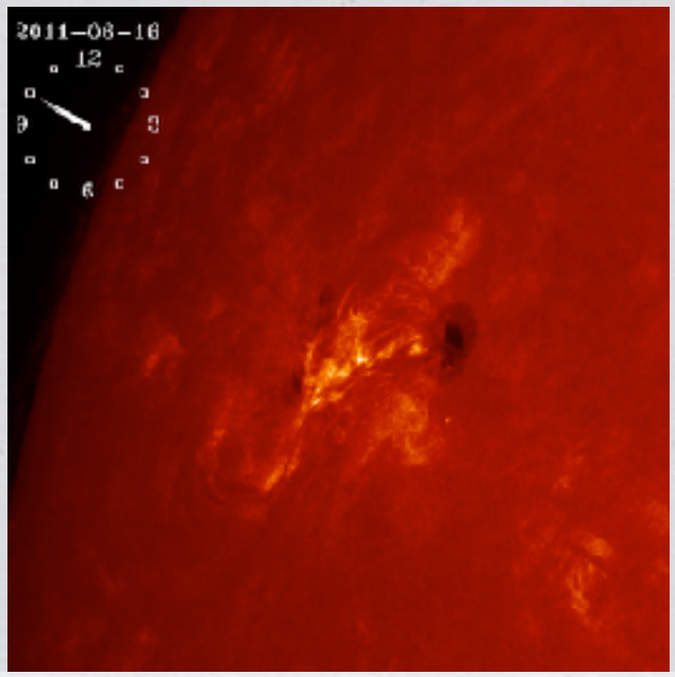


HMI 4500 Å @ SDO



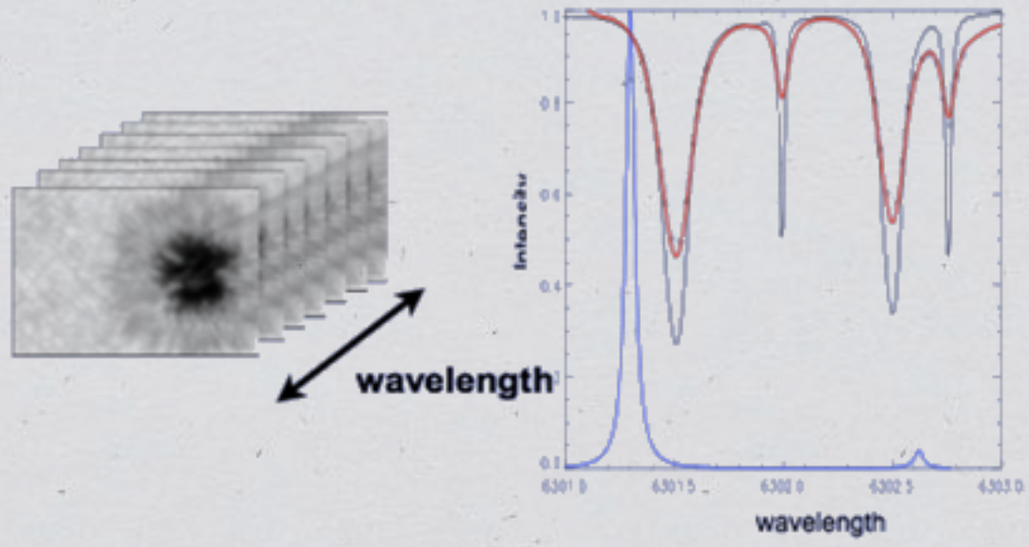
AIA 171 Å & 211 Å & 304 Å@ SDO

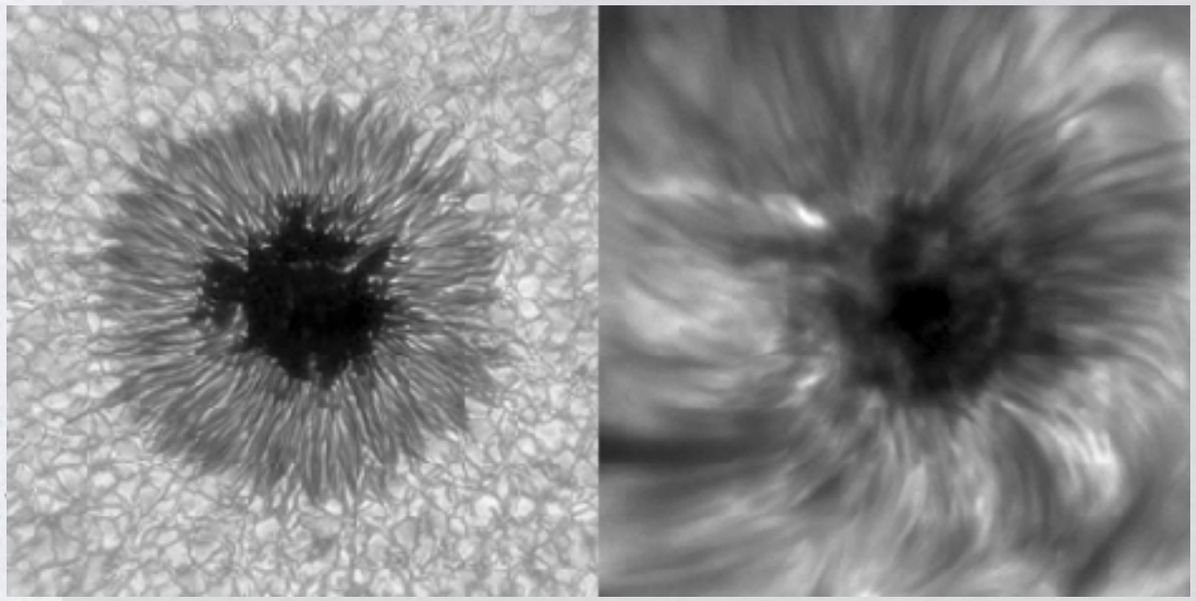


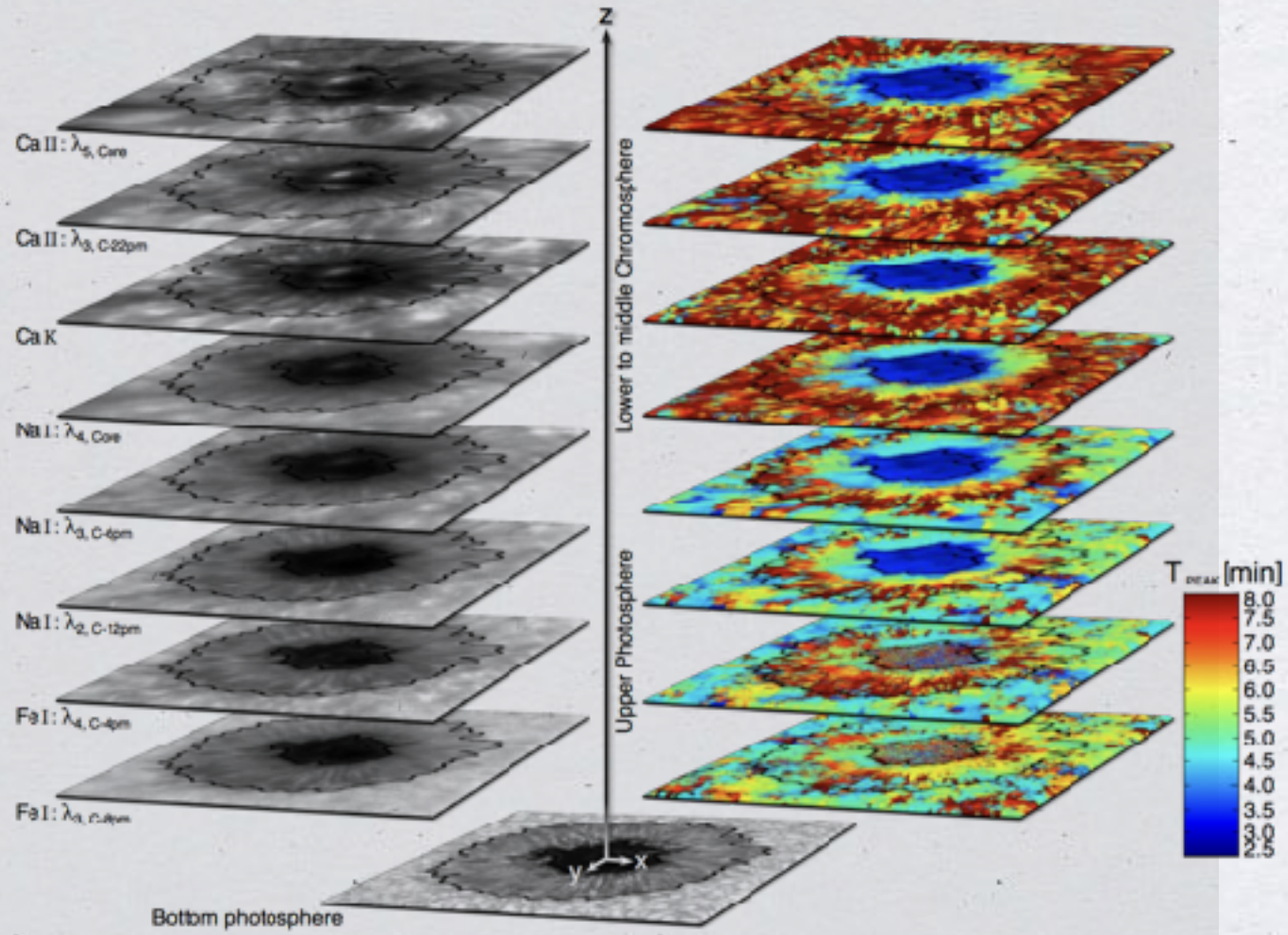


AIA 304 Å & AIA 4500 Å @ SDO

A Flavor of Solar Data

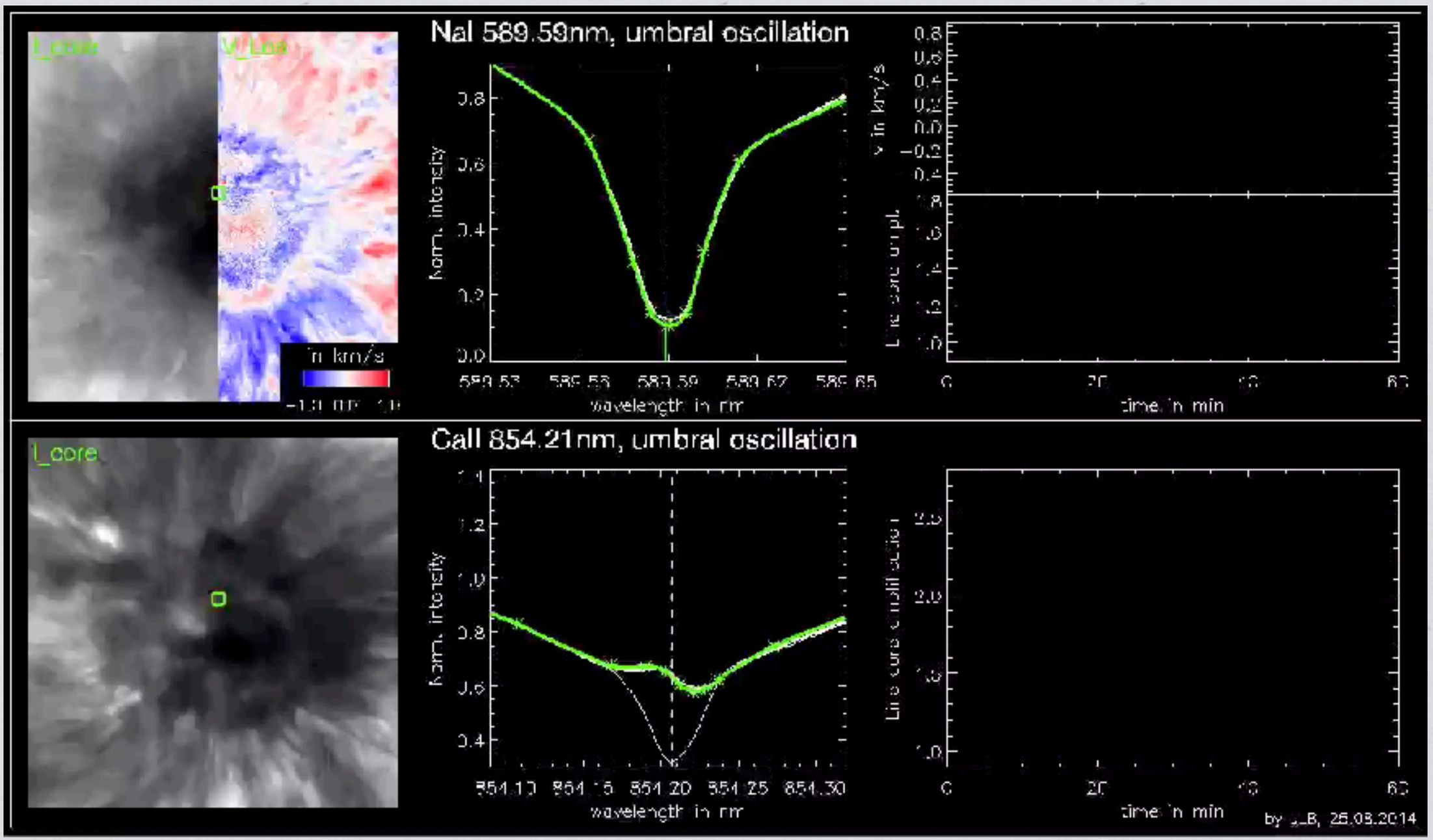






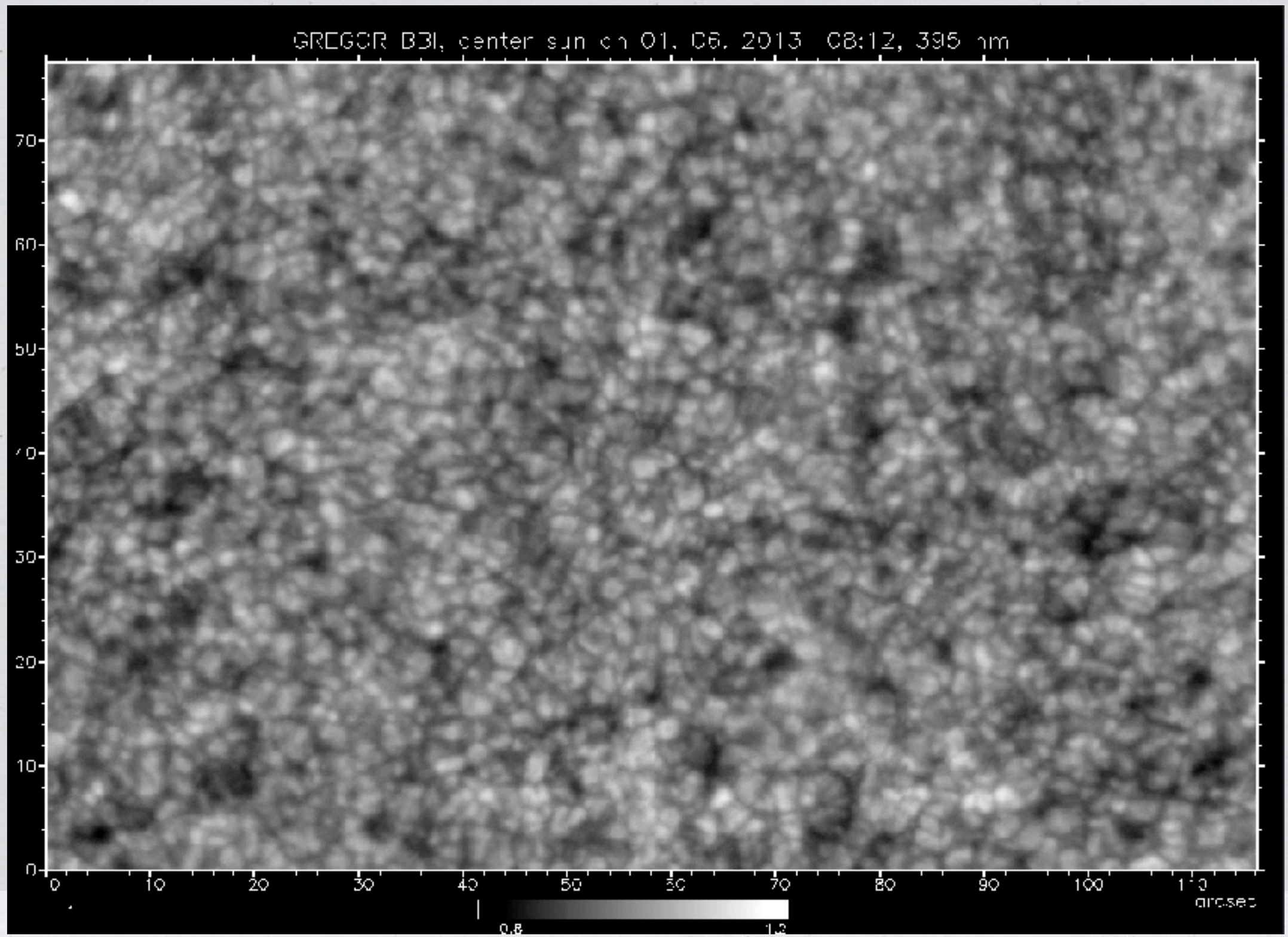
IBIS & ROSA@DST Löhner-Böttcher 2016

A Flavor of Solar Data



IBIS & ROSA@DST Löhner-Böttcher 2016

A Flavor of Solar Data



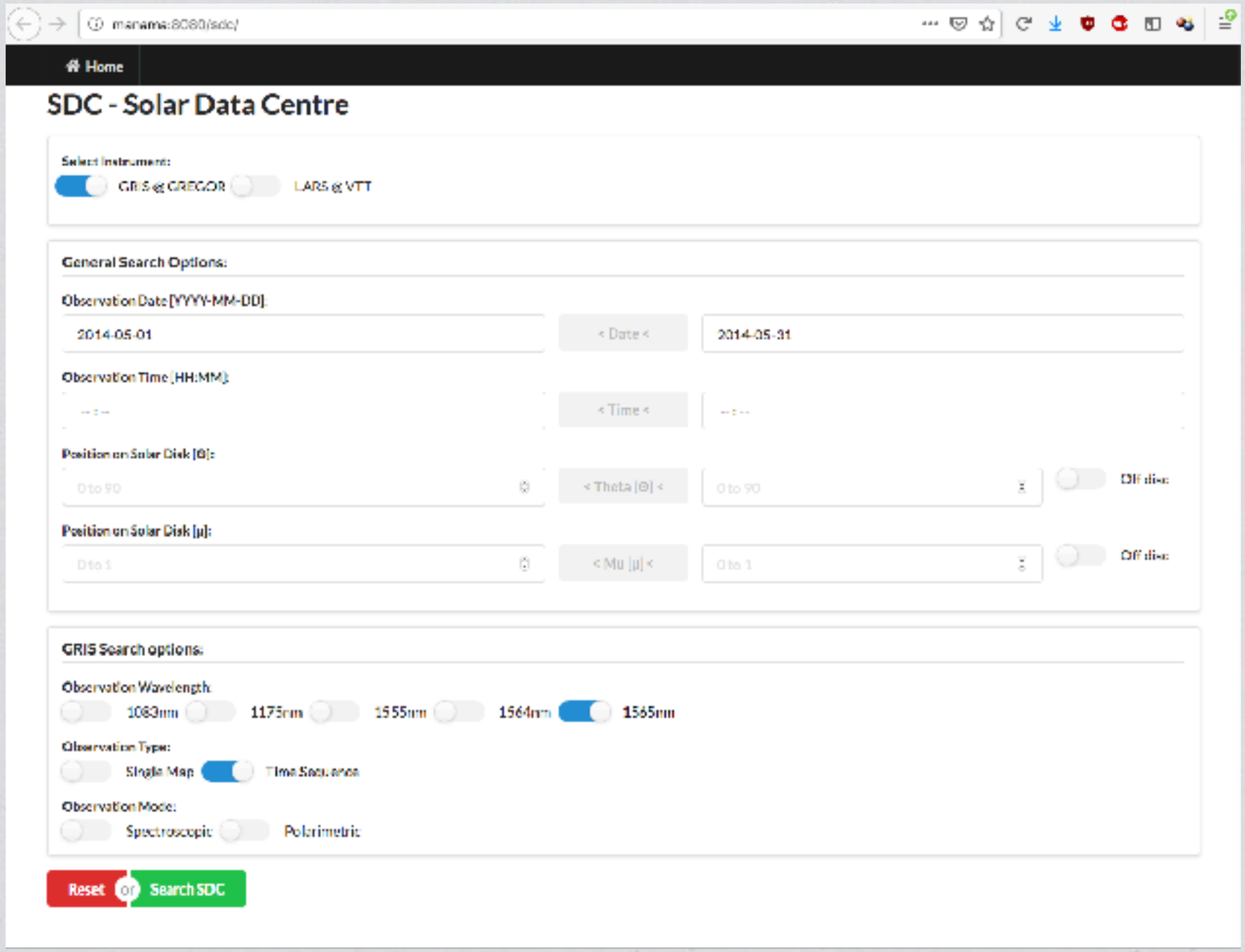
A Flavor of Solar Data

- Some characteristics of ground-based solar observation:
  - Varying atmospheric observing condition (seeing).
  - Target based (quiet Sun, sunspots, pores, plages, faculae, etc.) with a limited FOV. Pointing information become important.
  - Versatile and non-standardized observing modes as well as novel science (multi-wavelength, ...) make it difficult to unify data pipelines.
  - Upgrade might change the data characteristics for a given (upgraded) instrument.

The major challenge for the archiving and dissemination of ground-based solar observation is the inherent heterogeneity of the data

A Flavor of Solar Data

GRIS archive 2.0 (unofficial beta version)



Hederer, Schaffer, Franz 2018

A Flavor of Solar Data

GRIS archive 2.0 (unofficial beta version)

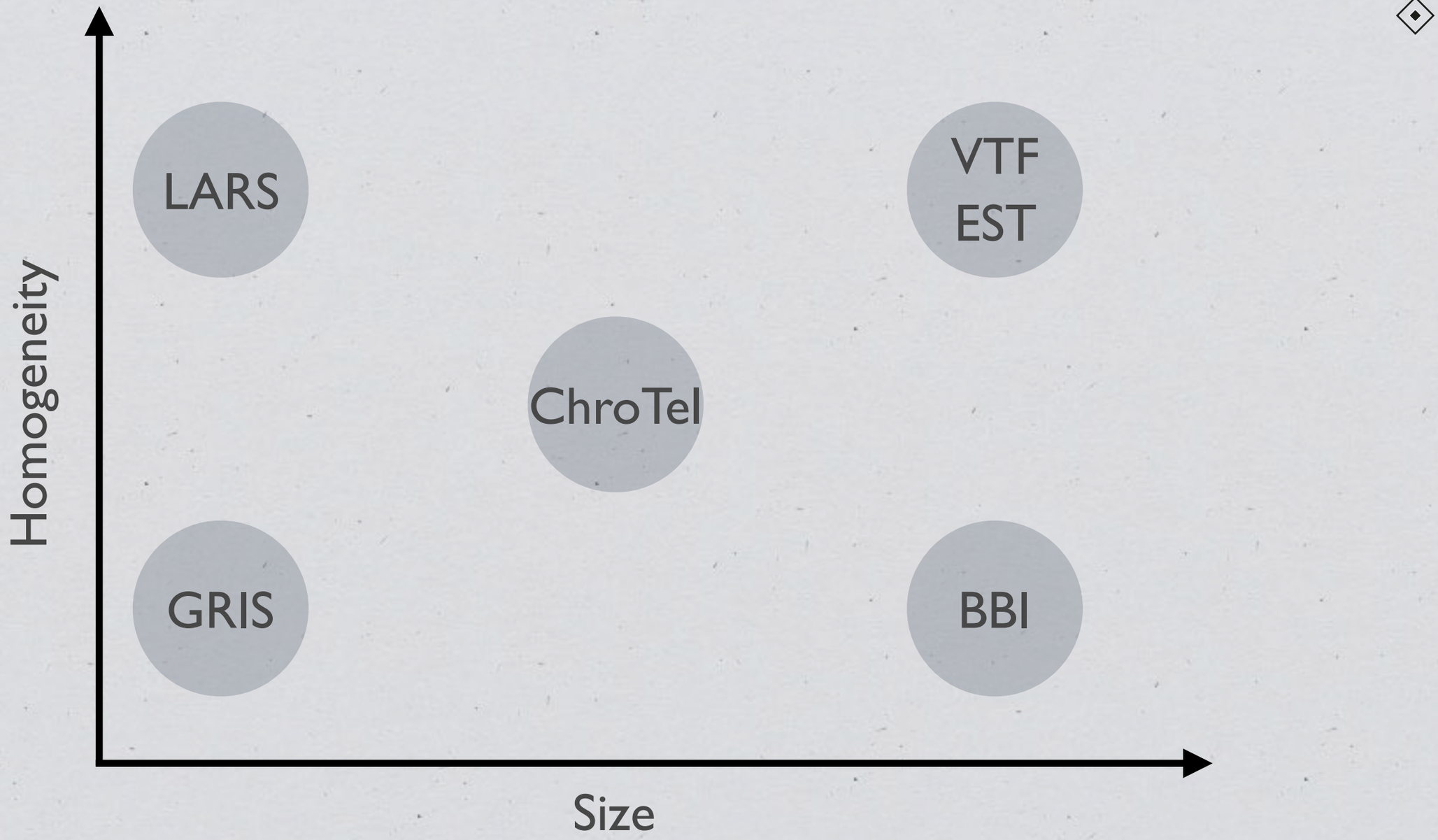
GREGOR Data Center

The result of your search:

No.	Date Obs	UT Start	UT End	λ [nm]	Scan Type	Mode	Exp. Time [ms]	FOV [arcsec]	Target	Solar X [arcsec]	Solar Y [arcsec]	ϑ [°]	Location	Map	Log File	LVL 0	LVL 1	LVL 2	Mark
1	2014-05-01	08:00:34.0	08:10:03.0	1565	Single Map	polar.	30.0	40,5	Filament/Prominence	-332	133	22,027	NO IMAGE AVAILABLE	TOTI TOTQ TOTU TOTV 01may14.001 1565 nm 08:00:34-08:10:09 UT 30.0 ms / 10 accum. # of steps: 106 x/ypos: -332" / 133"	D	O	O	O	
2	2014-05-01	08:26:27.0	08:44:26.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	8	-184	11,139			D	O	O	O	
3	2014-05-02	15:05:41.0	15:33:25.0	1565	Single Map	polar.	30.0	40,5	Filament/Prominence	-228	75	14,587			D	O	O	O	
4	2014-05-02	13:27:23.0	13:45:12.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	389	-153	26,01			D	O	O	O	
5	2014-05-02	11:35:12.0	11:53:00.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	-96	61	6,854			D	O	O	O	
6	2014-05-02	12:07:56.0	12:26:18.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	-168	151	13,71			D	O	O	O	
7	2014-05-02	14:16:47.0	14:32:14.0	1565	Single Map	polar.	30.0	40,5	Filament/Prominence	-213	104	14,401			D	O	O	O	

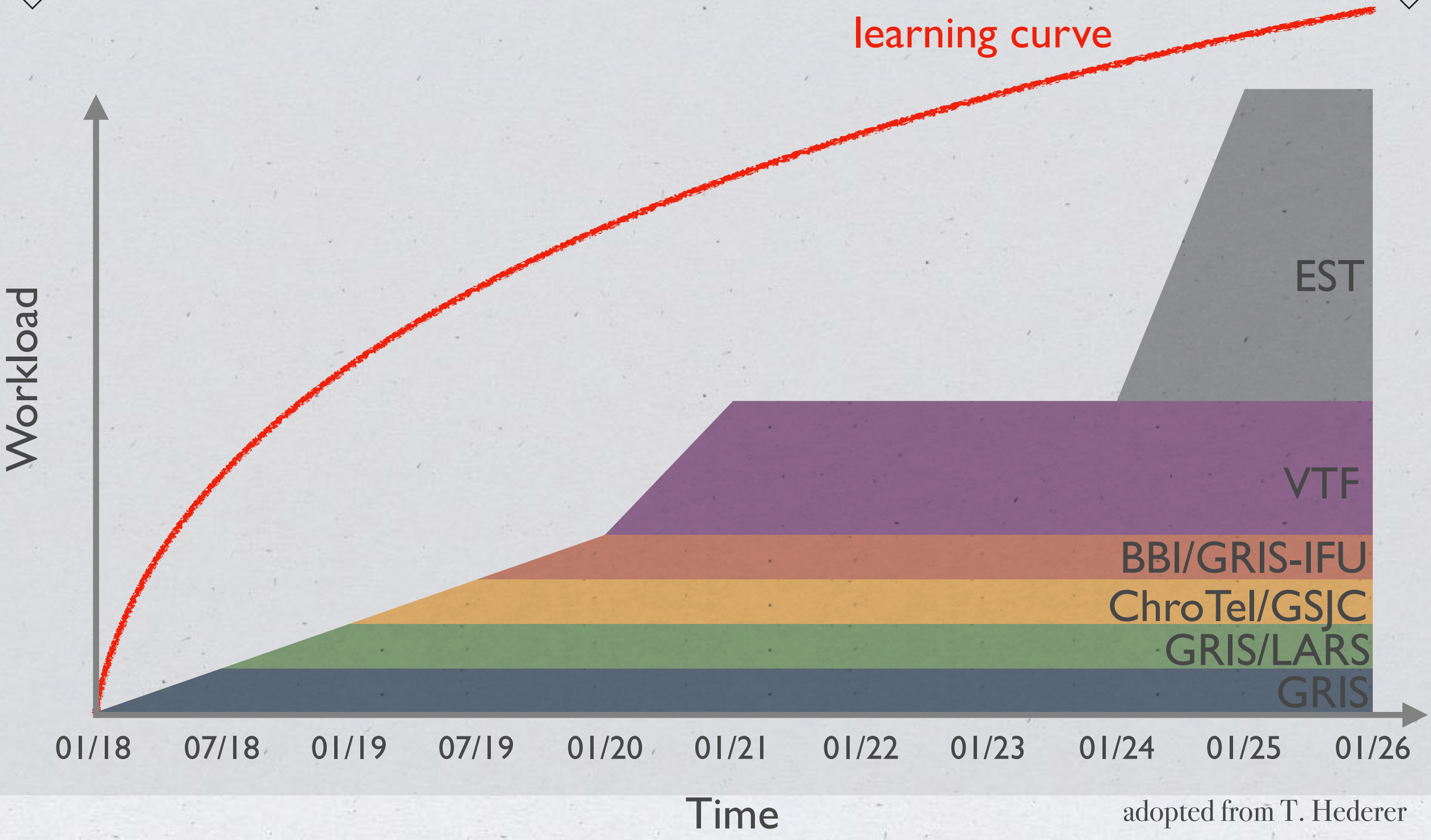
Hederer, Schaffer, Franz 2018

A Flavor of Solar Data



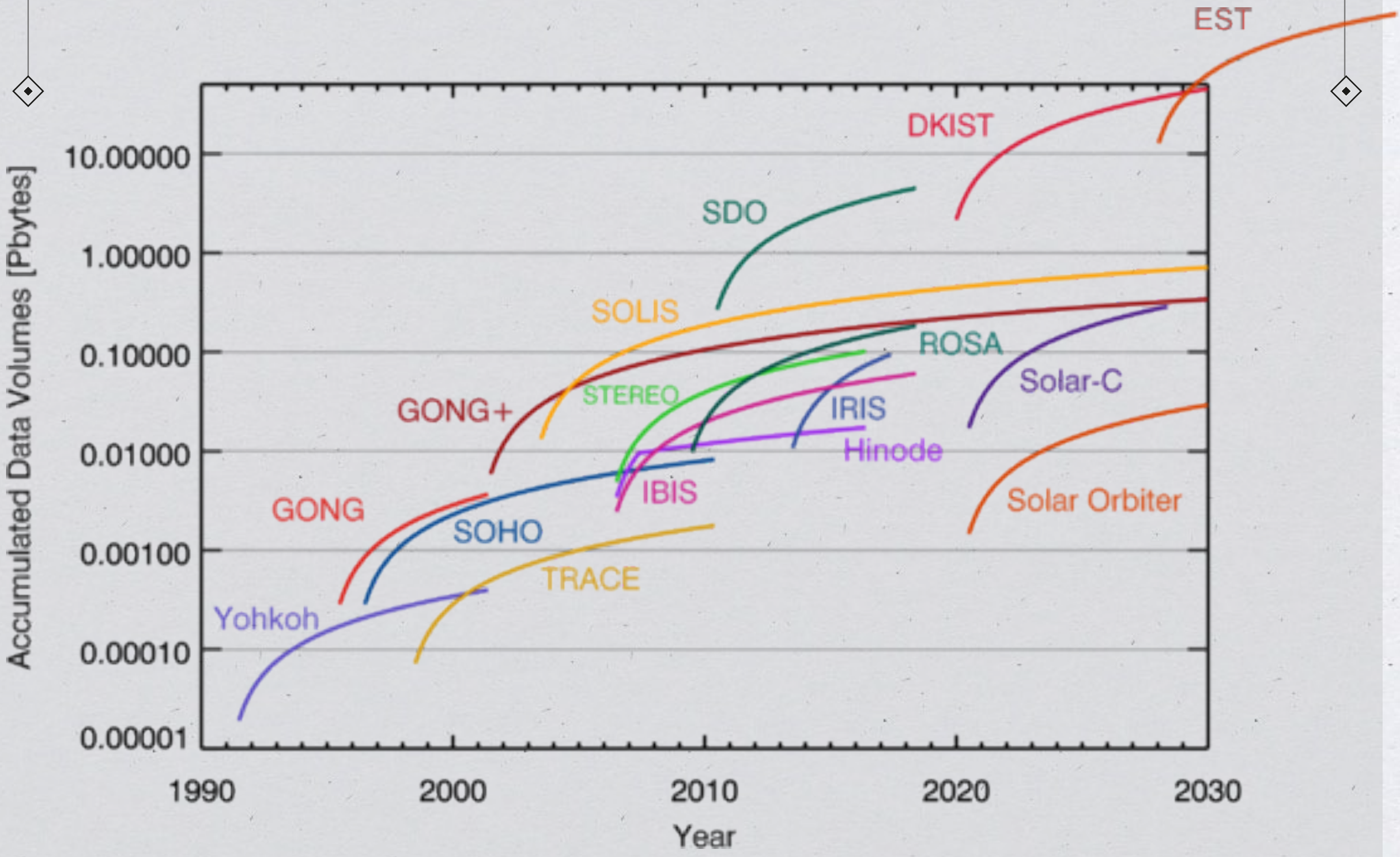
adopted from T. Hederer

A Flavor of Solar Data



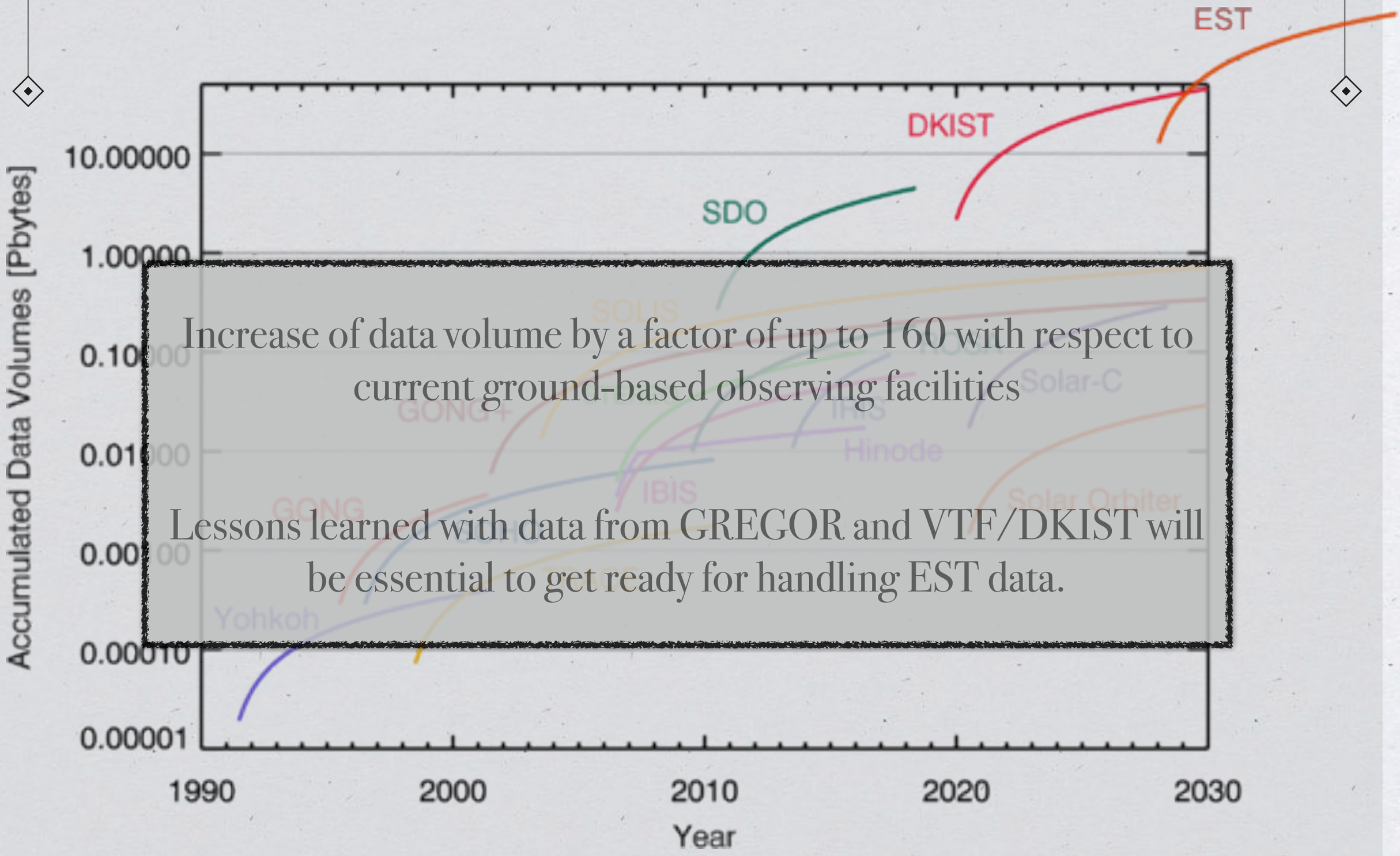
adopted from T. Hederer

A Flavor of Solar Data



adopted from K. Reardon

A Flavor of Solar Data



Increase of data volume by a factor of up to 160 with respect to current ground-based observing facilities

Lessons learned with data from GREGOR and VTF/DKIST will be essential to get ready for handling EST data.

adopted from K. Reardon

A Flavor of Solar Data

The size, the complexity, and the operational cost of the new generation of ground based solar telescopes require a paradigm change on how scientists obtain and work with observational data.

PI based data acquisition with data belonging to the observer. Individual calibration/reduction steps followed by a data evaluation of a small team of scientist.

Standardized observing runs performed by experienced (on site) observers. Data reduction via automatized pipelines and subsequent injection into online archives. Dissemination of open source data and higher level data products via the internet. Provision of data exploration, visualization and analysis tools.

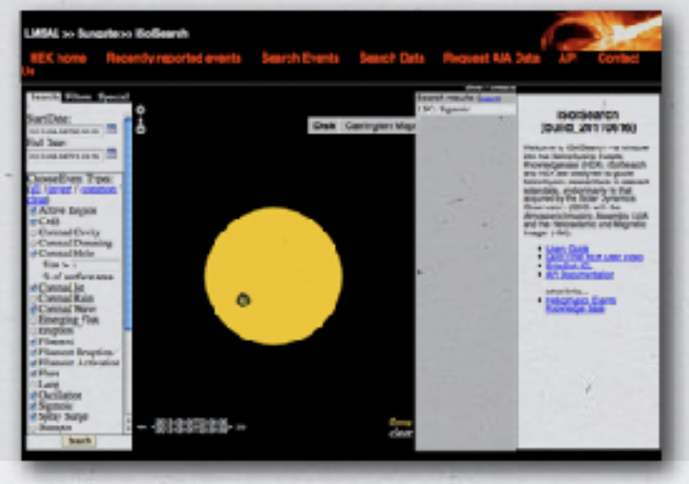
A Flavor of Solar Data

There is a need to make distribution and discovery of data as easy as possible, especially for ground based solar observation

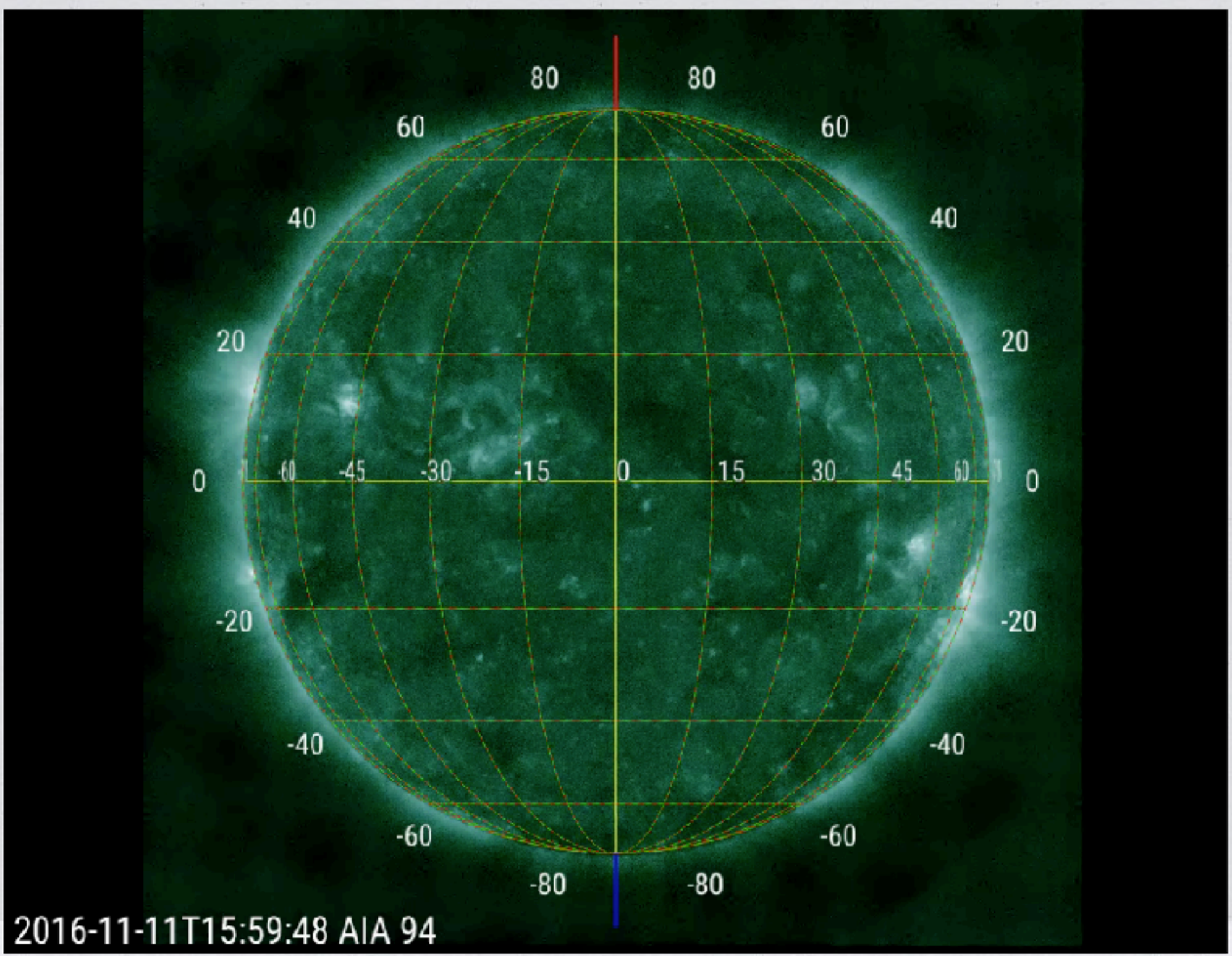
Data archives, e.g., VSO

Browsing tools, e.g., (j)Helioviewer

Event searching, e.g., HEK



A Flavor of Solar Data



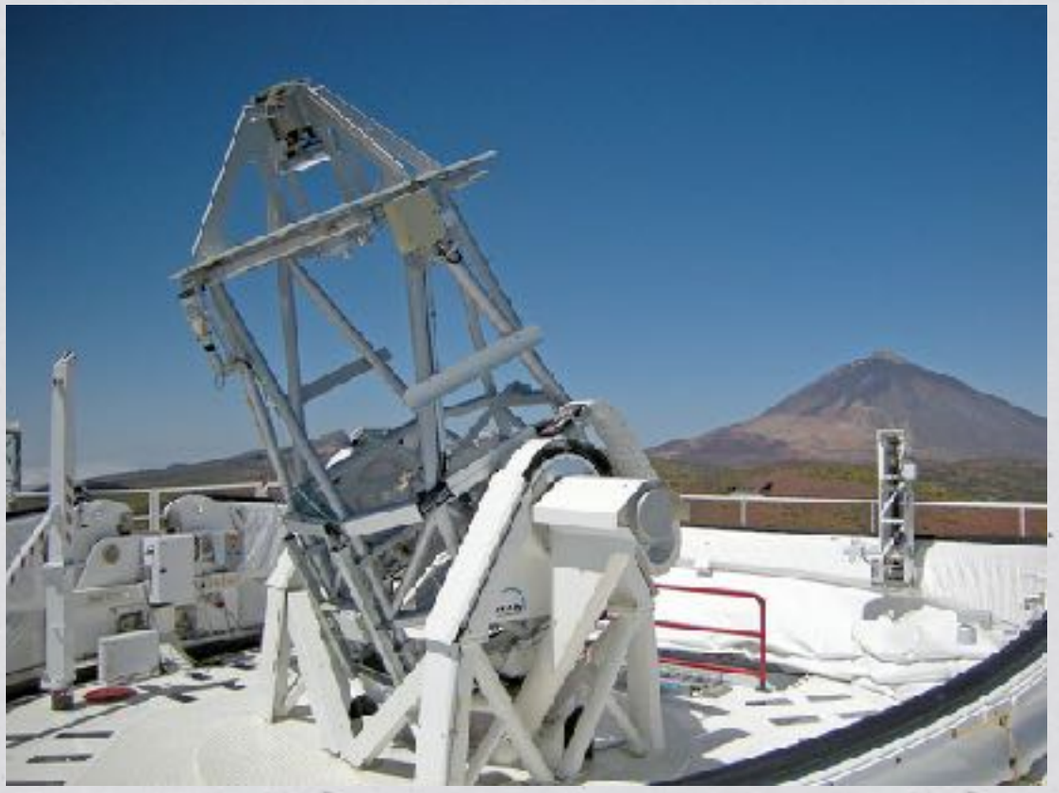
Royal Observatory of Belgium

Summary

* A new class of ground-based Solar Telescopes is on the horizon.
* Size and data volume of these telescopes require service mode observation and pre-defined standards for (meta)data.
* Challenges are the flexibility of the facilities and the subsequent heterogeneity of the data. Efforts to overcome these problems are undertaken, e.g. within the framework of the SOLARNET project.
* Adopting existing (meta)data standards from the astronomical community (IVOA) will be of great help for the solar community.

Acknowledgements

- Thomas Hederer
- Manolo Collados
- Peter Caligari
- Nazaret Bello Gonzalez
- Carl Schaffer
- Philip Lindner
- Christian Bethge
- Ikrima bin Saeed
- Alexander Bell
- Andreas Lagg
- Svetlana Berdyugina
- etc.



The 1.5-meter GREGOR solar telescope was built by a German consortium under the leadership of the Kiepenheuer-Institut für Sonnenphysik in Freiburg with the Leibniz-Institut für Astrophysik Potsdam, the Institut für Astrophysik Göttingen, and the Max-Planck-Institut für Sonnensystemforschung in Göttingen as partners, and with contributions by the Instituto de Astrofísica de Canarias and the Astronomical Institute of the Academy of Sciences of the Czech Republic.