Session 8. Next Generation Solar Physics Mission special session (17:35-18:40)

- Purpose: Share the latest status among the community

1. The NGSPM-SOT report and Japanese contributions to the NGSPM T. Shimizu (JAXA)
2. US contributions to the NGSPM

   D. McKenzie (NASA)
3. Questions and discussions

Session 8. NGSPM splinter session

Wednesday, 12 September from 17:50 to 18:50

Purpose: Understand the mission plans and consider coordination among the missions to achieve NGSPM science goals.

1. Solar-C_EUVST S. Imada, H. Warren
2. MUSE T. Tarbell
3. FOXSI H. Hudson
4. PhOENiX S. Ishikawa
5. Discussions for coordination led by D. McKenzie

The NGSPM-SOT report and Japanese contributions to the NGSPM concept

Hinode 12
10-13 September 2018
@Granada, Spain

Toshifumi SHIMIZU
ISAS/JAXA, Japan
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Next Generation Solar Physics Mission – Science Objectives Team (NGSPM-SOT)

- A study team was formed as a means of improving international coordination in solar physics, and developing a multilateral solar physics mission concept for the next decade.
  - Motivated by the original Solar-C situation happened in 2015.
- This advisory team was chartered by NASA, JAXA, and ESA in June 2016.
- Developed and documented scientific objectives and priorities for an NGSPM concept
  - within the resources and framework by the agencies.
  - with community inputs, via white papers
- The NGSPM-SOT final report was delivered to the agencies in July 2017.

http://hinode.nao.ac.jp/SOLAR-C/SOLAR-C/Documents/NGSPM_report_170731.pdf

NGSPM-SOT members

NASA appointed Members

- David McKenzie, NASA, Marshall Space Flight Center
- Ted Tarbell, Lockheed Martin Solar and Astrophysics Laboratory
- John Raymond, Smithsonian Astrophysical Observatory
- Sarah Gibson, High-Altitude Observatory

ESA appointed Members

- Luis Ramon Bellot Rubio - Instituto de Astrofisica de Andalucia, Spain
- Mats Carlsson - UiO Institute of Theoretical Astrophysics, Norway
- Lyndsay Fletcher - University of Glasgow, UK
- Sami Solanki - Max-Planck-Institut für Sonnensystemforschung, Germany

JAXA appointed Members

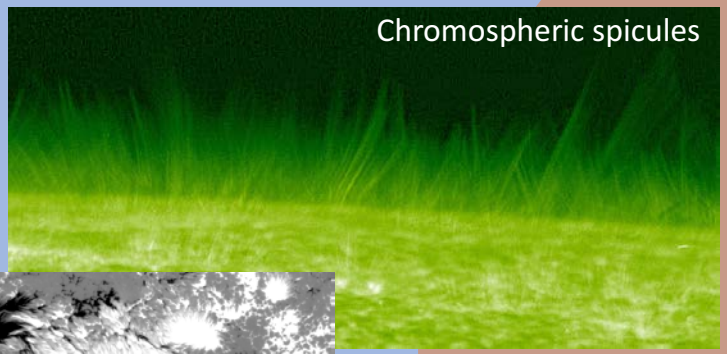
- Kiyoshi Ichimoto, Kyoto University/NAOJ
- Kanya Kusano, Nagoya University
- Hirohisa Hara, NAOJ
- Toshifumi Shimizu, ISAS/JAXA, team chair

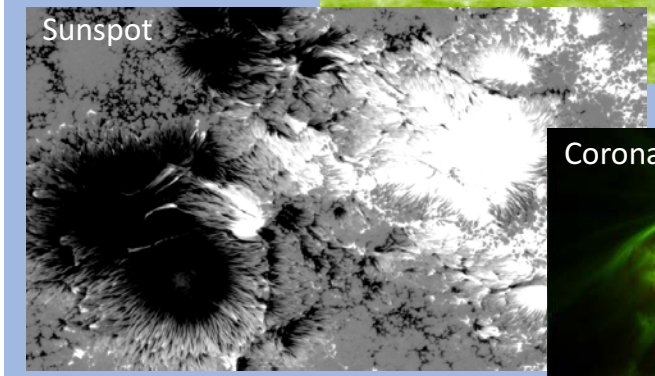
Experts added later for assessing helioseismology related objectives

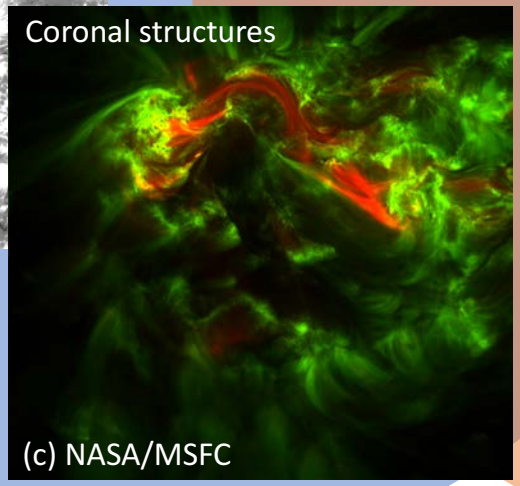
- Laurent Gizon, Max-Planck-Institut für Sonnensystemforschung, Germany
- Takashi Sekii, NAOJ

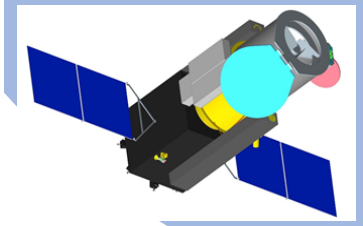
Two venues of scientific objectives

Physical mechanisms
on elemental (small) scales



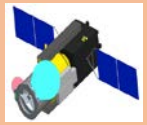




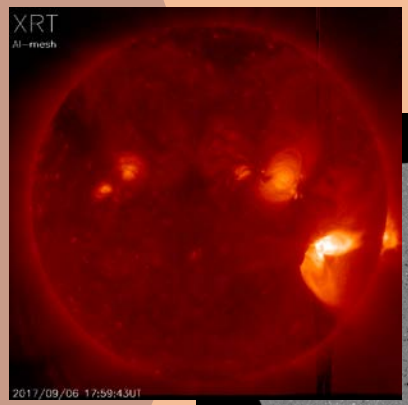


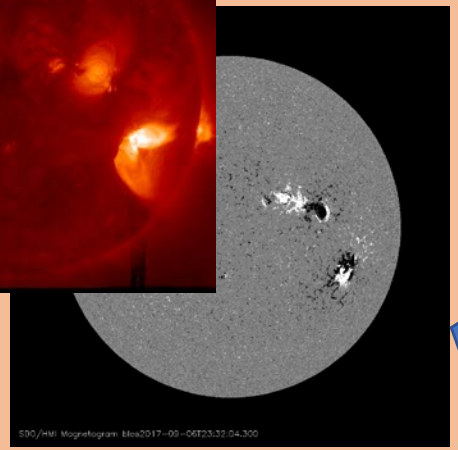
→ *Probing beyond the current resolution*
chosen for near-term NGSPM

Global-scale processes
affecting/involving large
fractions of atmosphere



From high latitude





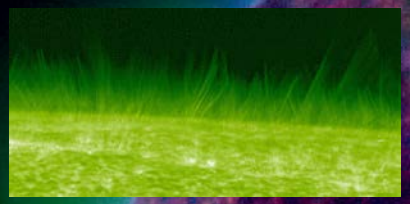
Away from Sun-Earth line

→ *Global, multi-vantage observations*

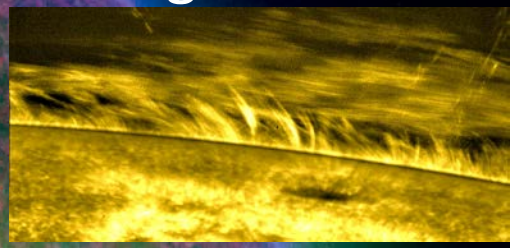
I. Formation mechanisms of the hot and dynamic outer solar atmosphere

I-5. Sources of solar wind

I-1. Formation of chromospheric fine-scale structures & influence

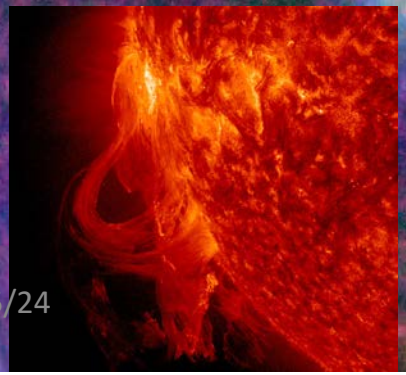


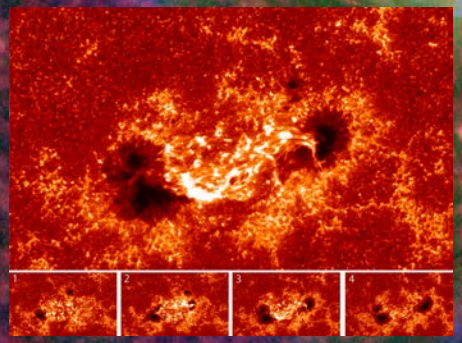
I-2. Test nanoflare heating
I-3. Test wave heating



I-4. Role of flux emergence in heating

I-6. Formation of prominences





II. Mechanisms of large-scale solar eruptions and fundations for prediction

II-1. Measure energy build-up

II-5. Formation of sunspots

II-2. Identify the trigger mechanism

II-4. Processes of fast magnetic reconnection

II-6. Particle acceleration and flare energy transport

II-3. Evolution & propagation of CME

III. Mechanisms driving the solar cycle and irradiance variation

III-1. Flow structures in the convection zone

III-2. Locate & trace global magnetic flux

III-3. Quantify turbulence in the dynamo

III-4. Mechanism of irradiance variations

III-5. Explore the deep internal structure

For these key objectives, transformative progress would be made possible with "global" observations from sustained, vantage points away from the Earth-Sun line

But implementation schemes likely exceed the resources available for a NGSPM on the timescale of the next decade.

Physical mechanisms on elemental scales

- In many sub-objectives in objectives I and II, progress will be substantially benefit from observations with increased resolution.
- A higher-resolution focus for NGSPM will be rich scientifically with game-changing discoveries, as shown by the results of recent high-resolution investigations as Hi-C rocket, IRIS and Hinode.
- Based on the resources that are likely to be available in the near term, **the SOT recommends** the path for the Next Generation mission should be **probing elemental-scale processes, using highest-ever resolution**.

Notional instrument set for elemental science

- A minimum set of instruments with which NGSPM can address the greatest number of sub-objectives and maximize the science return of the mission.

Higher priority of instruments in order from the top

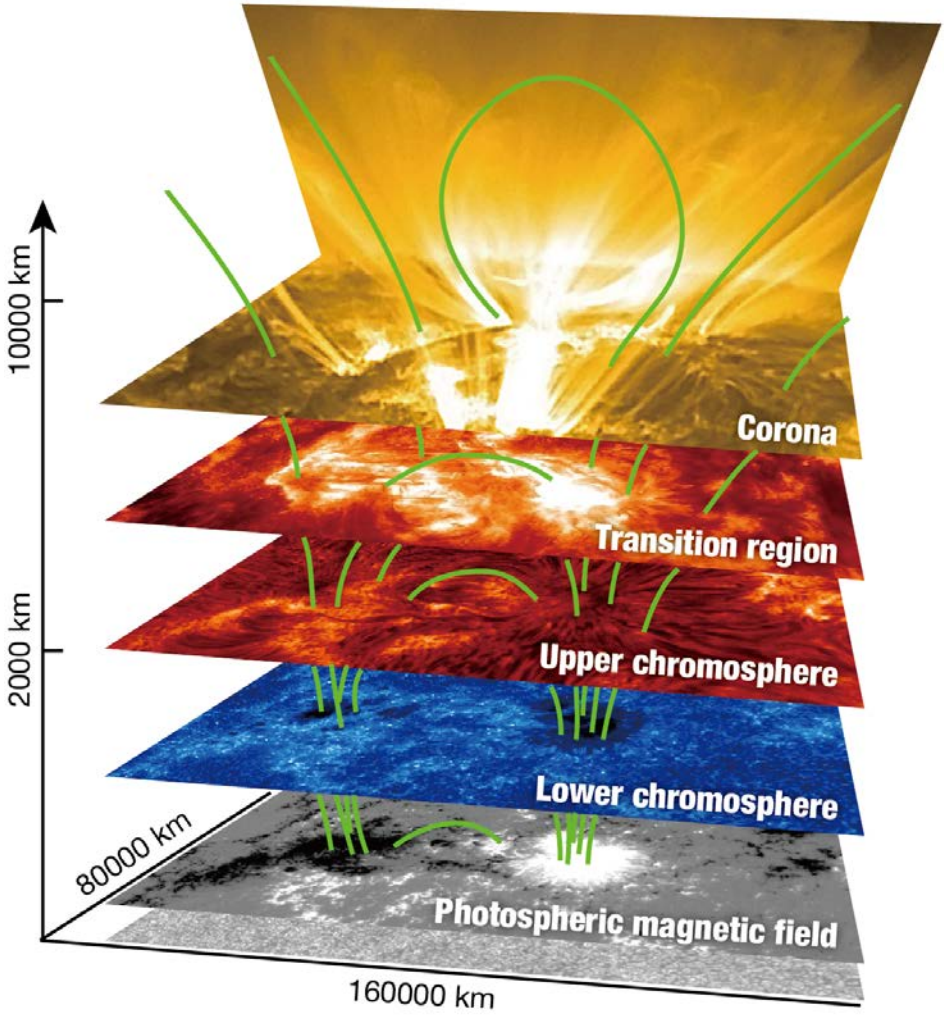
0.3” coronal/TR spectrograph (T-9)

seamless plasma diagnostics through the atmosphere

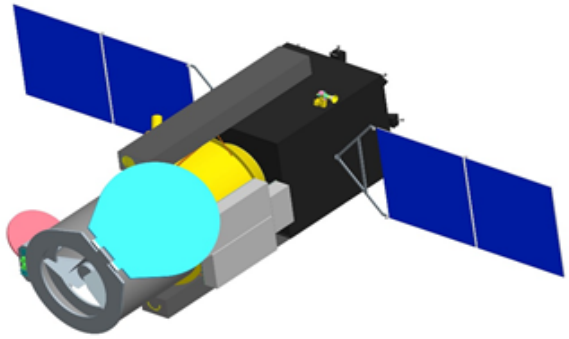
0.2”-0.6” coronal imager (T-7)

0.1” – 0.3” chromospheric imager and magnetograph (T-4)
0.1” photospheric magnetograph (T-1)
0.1” chromospheric spectrograph (T-5)

Magnetic and velocity fields at chromosphere



Mission concepts



1. Large mission design

- 3 instruments (T-09, T07, and T-01/04/05) on a single platform.
- Opportunity: JAXA strategic Large mission (戦略的中型)
- Significant scientific and operational advantages: launch & operations simultaneously and integrated, instrument design optimized, save the total costs
- Not easy to start the project.

2. Constellation of small/med-class missions

- To form a constellation of satellites to realize 3 instruments (T-09, T07, and T-01/04/05).
- Opportunity: JAXA Epsilon (公募型小型), NASA SMEX/MIDEX
- Increase the possibility that some of the instruments are launched as early as possible.
- Scientific synergy limited unless significant overlap in observing time of the missions

JAXA opportunities

2010 2020 2030

Strategic Large Missions (300M$ class) for JAXA-led flagship science mission with HIIA /III vehicle (3 in ten years)

Hitomi (2016)

XRISM - Hitomi revival(2020)

#1: MMX - Phobos/Deimos (2024)

#2: LiteBIRD, Solar-Sail, ~~(Solar-C)~~ (2027)

#3: SPICA (2029)

No 2nd opportunity of proposal for #2: April 2018

Competitively-chosen medium-sized focused missions (<150M$ class) with Epsilon rocket (every 2 year)

Note: 1$= 100 yen

Hisaki(2013)

Arase (2016)

#1: SLIM(2020)

#2: Destiny+(2022)

#3(2024)
#4 (2026)

NGSPM T-09 (S-C_EUVST)

#3 (2nd) for 2024 and #4(1st) for 2026 launch

Missions of opportunity for foreign agency-led missions (10M$/year)

Including competitively-chosen small-sized missions (sounding rockets, balloons)

BepiColombo (ESA, 2018)

JUICE (ESA, 2022)

WFIRST(NASA, 2025)

ATHENA(ESA, 2028)

NASA NewFrontiers2016

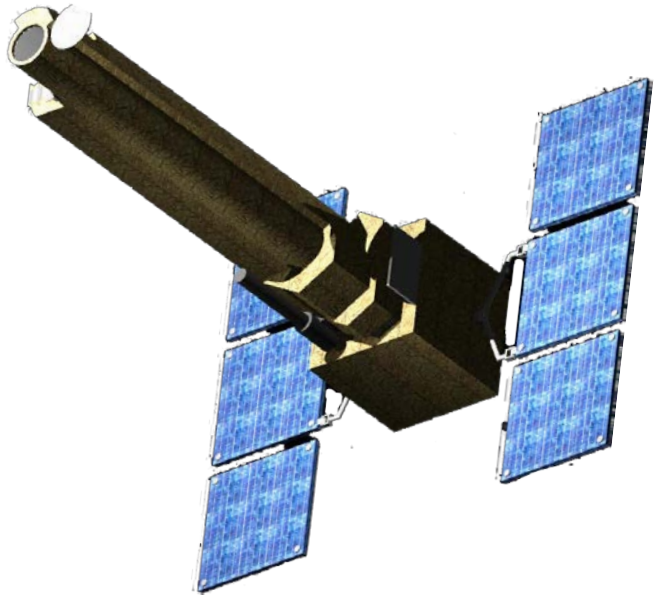
Solar-C_EUVST

EUV High-Throughput Spectroscopic Telescope

- Corresponding to 0.3” coronal/TR spectrograph (T-9)
- Science objectives: (1) To understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind, and (II) to understand how the solar atmosphere becomes unstable and release the energy.

An EUV coronal/TR spectrograph to measure how mass and energy are transferred through the atmosphere

- Seamless temperature coverage from chromosphere to corona and flare plasma (17-128nm)
- High spatial resolution (0.4”)
- High-throughput, much improved temporal resolution (0.5-10s).



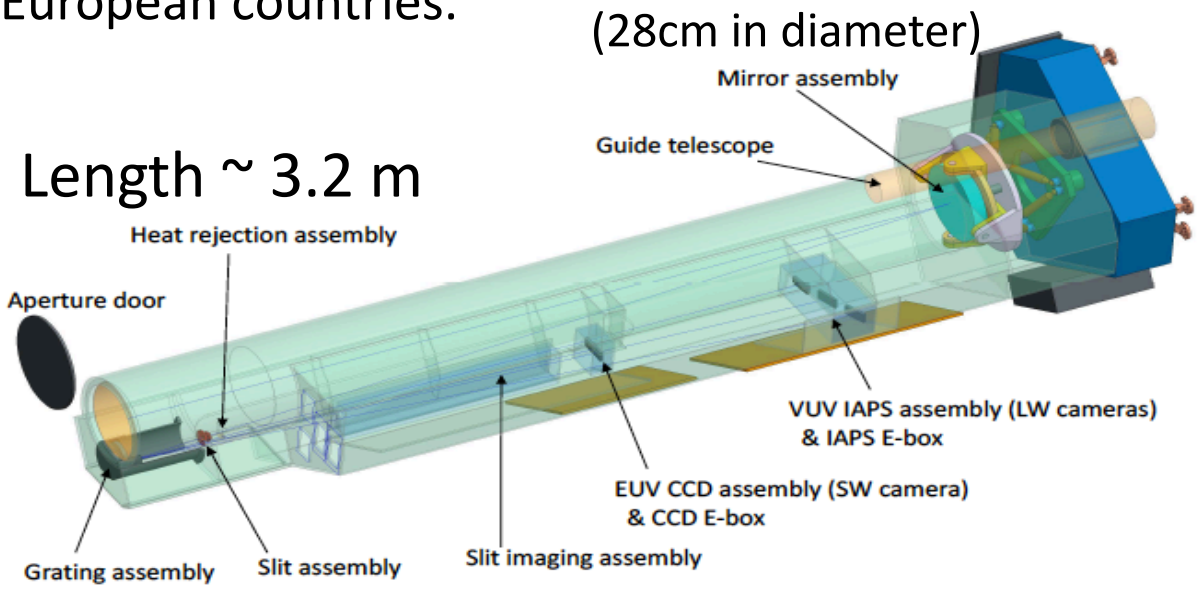
Solar-C_EUVST
EUV High-Throughput Spectroscopic Telescope

- This mission concept proposal was submitted to a JAXA call for competitive M-class mission candidates this January.
  - One of 6 submitted proposals
- down-selected to proceed to the next study phase!
- Final down-selection for slot #3 (FY24 launch) by Dec 2019
  - S-JASMINE …. Astrometry, down-selected in 2016
  - Solar-C_EUVST
  - HiZ-GUNDAM … gamma-ray bursts for star formation history in early universe and electromagnetic wave couterparts of gravitational wave sources, down-selected with S-C_EUVST

Solar-C_EUVST

EUV High-Throughput Spectroscopic Telescope

- JAXA: EUVST unit structure and mirror assembly, spacecraft bus, rocket vehicle and managing the overall development program.
- The EUVST instrument will be developed as an international collaboration among Japan, US, and European countries.



- For details, science talks by Shin Imada & Harry Warren tomorrow.

Notional instrument set for elemental science

EUVST with good spectroscopic capabilities and MUSE with high temporal resolution in their high spatial (0.4”) resolution has significant synergy, according to the NGSPM-SOT report.

Higher priority of instruments in order from the top

0.3” coronal/TR spectrograph (T-9)

seamless plasma diagnostics through the atmosphere

0.2”-0.6” coronal imager (T-7)

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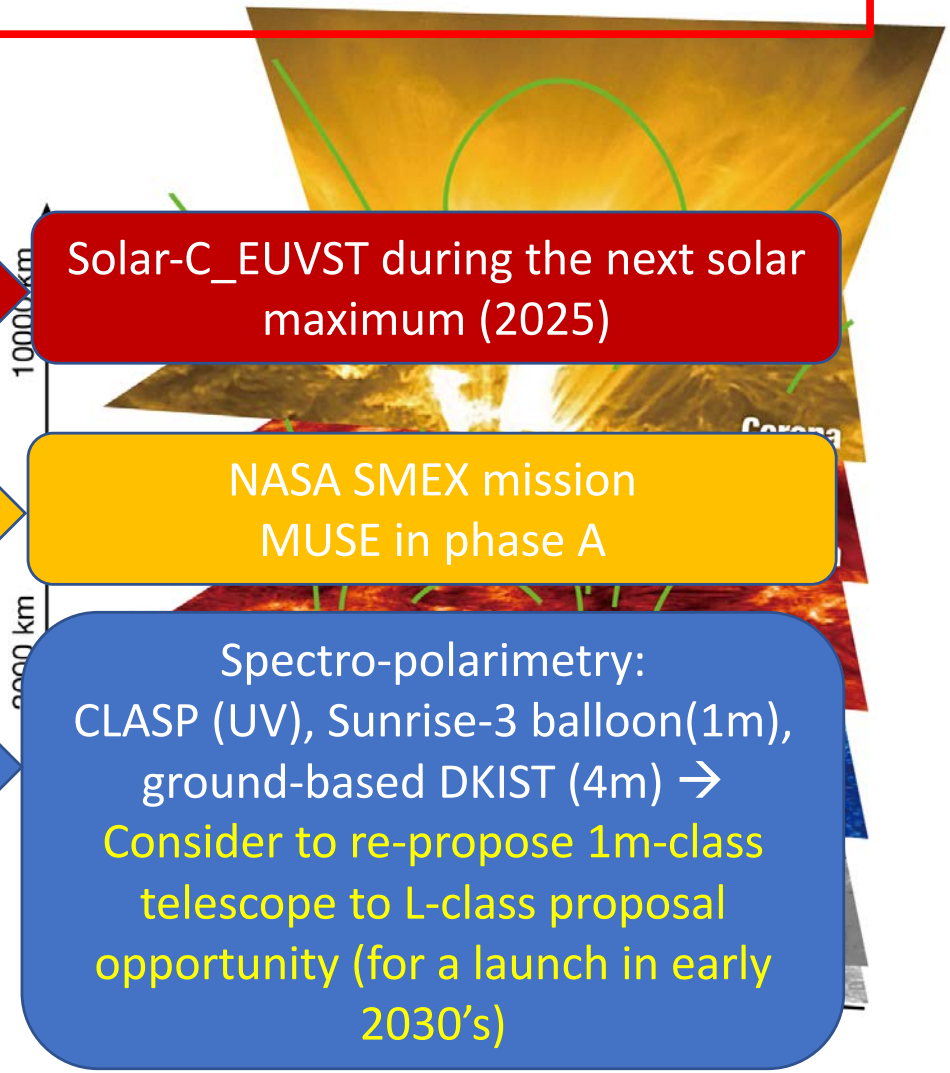

Solar-C_EUVST during the next solar maximum (2025)

NASA SMEX mission
MUSE in phase A

Spectro-polarimetry:
CLASP (UV), Sunrise-3 balloon(1m), ground-based DKIST (4m) →
Consider to re-propose 1m-class telescope to L-class proposal opportunity (for a launch in early 2030’s)

Possible additional instruments for NGSPM

- Next-highest priority instrument for elemental-scale science objectives
  - Addition of T-10 (high-energy spectroscopic imager)
  - Non-thermal and superhot emissions in flares and nanoflare heating.
- Two proposed missions
  - FOXSI in phase A study for NASA SMEX
  - PhoENiX (Physics of Energetic and Non-thermal Plasmas in the X-region) concept proposal … not selected in 2018, but would propose again for #4 & #5 (2026/2028)

These missions provide non-thermal information and would complement Solar-C_EUVST, although lower spatial resolution.

Summary

- Next generation solar physics mission(s) are eagerly wanted in middle 2020s.
- The NGSPM-SOT report to JAXA, NASA and ESA
  http://hinode.nao.ac.jp/SOLAR-C/SOLAR-C/Documents/NGSPM_report_170731.pdf
  - Science priorities are given to understanding of physical mechanisms on elemental (small) scales
  - Recommended three instruments (T-9, T-7, T-4/1/5 in order) as the highest priority.
- Ongoing efforts at JAXA and NASA are investigating how near term competitive missions may form a constellation to address science goals of NGSPM.
  - Japan-led Solar-C_EUVST as T-9.
- T-4/1/5
  - Ground-based large telescopes (DKIST, EST etc)