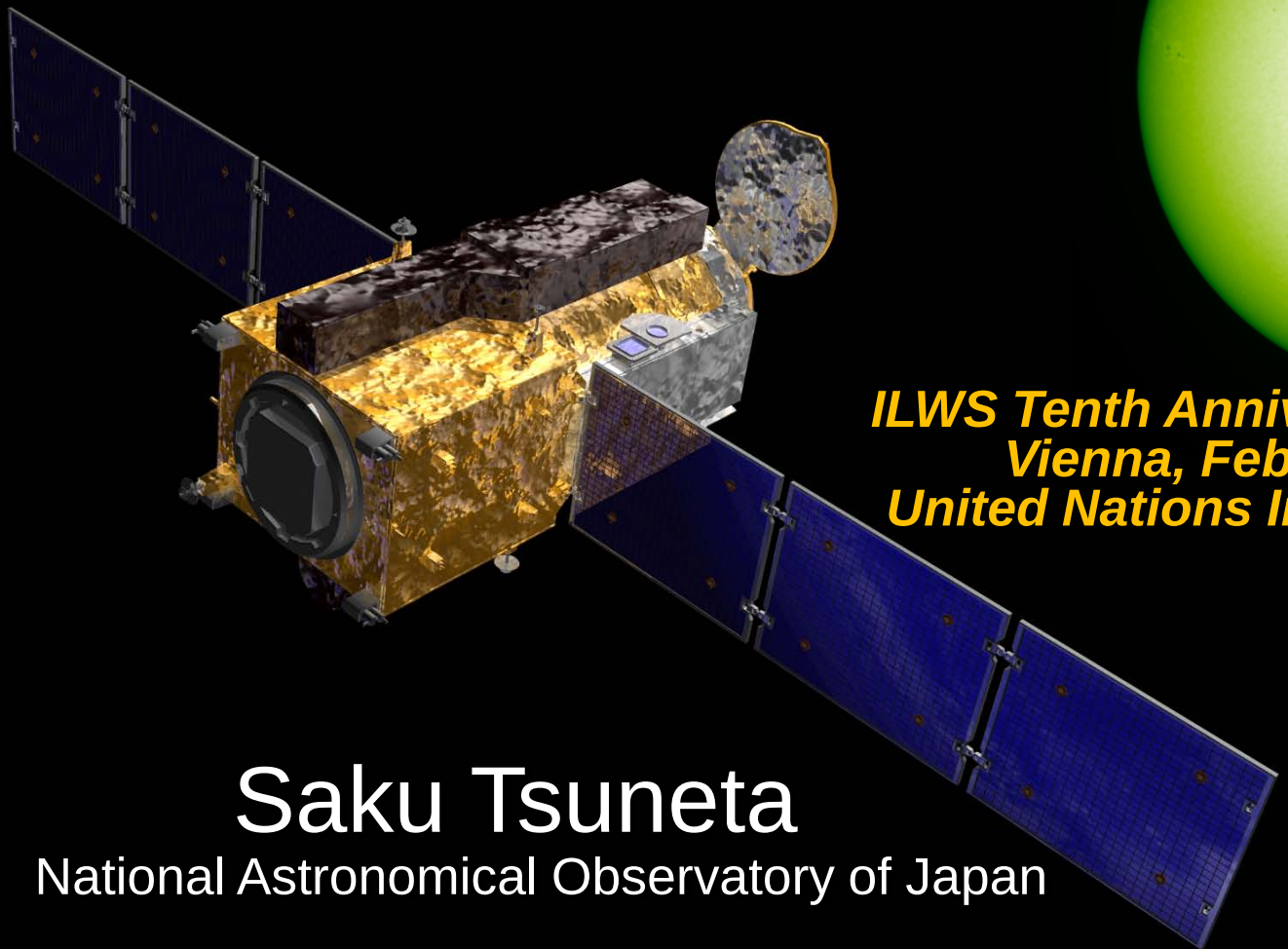
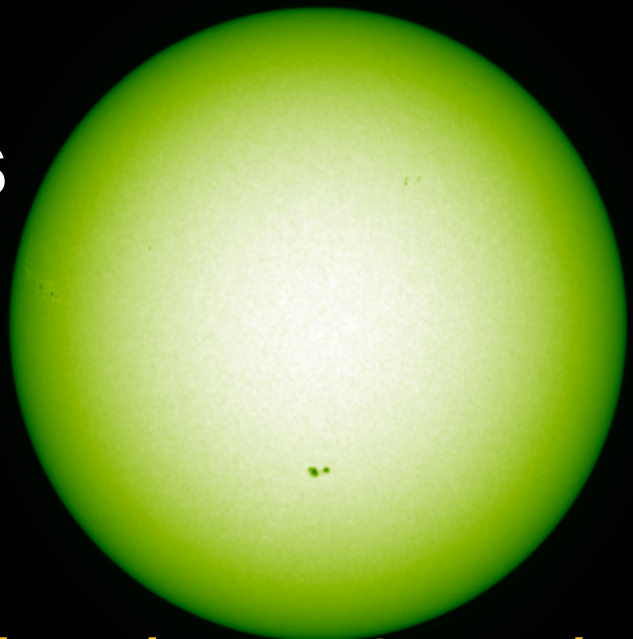
Panel: Future of ILWS - Challenges & opportunities for the next ten years

JAXA plan for solar and heliospheric observations





ILWS Tenth Anniversary Symposium
Vienna, February 14, 2013
United Nations International Centre

Saku Tsuneta
National Astronomical Observatory of Japan

Solar Missions

http://www.ilwsonline.org/tenthanniversary/

GOES

HINODE

PROBA-2

RHESSI

KORONAS -FOTON

SDO

SOHO

SOLAR ORBITER

ELEKTRO-L

PICARD

PROBA-3

SOLAR-C

TRACE

KUAFU

SOLAR PROBE+

SolACES

STEREO

INTERHELIOPROBE

Sunrise

2009 2012 2015 2018 2021

CNSA CSA ESA JAXA NASA USA (Other) RFSA Other

General tendency of solar physics missions in the coming 20 years

- Combination of high resolution and global imaging missions
- From mere imaging to spectroscopy and spectro-polarimetry
- More complete and simultaneous atmospheric coverage without temperature gap (with wider wavelength coverage)
- Toward out-of-ecliptic

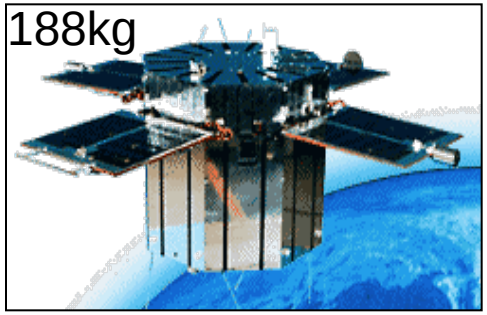
Solar physics in larger science context

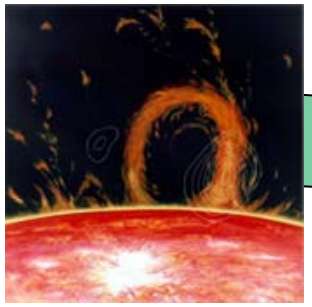
- From physical understanding to prediction
  - Space weather in terms of flares and CMEs
  - Space climate in terms of magnetic fields and cosmic rays, TSI, SSI (UV)
- More influence and integration to astrophysics and geo/planetary sciences
  - Common physics of magnetized plasma
    - Good example: magnetic reconnection
  - Sun and origin of life
    - Super-flares
    - Faint young sun paradox

Open issues in solar physics

- Internal structure of the Sun: differential rotation, meridional flow, turbulent diffusion, and tachocline
- Global and turbulent dynamo process
- 3D magnetic structure from photosphere through corona
- Chromospheric and coronal heating
- Prediction of solar flares
- Acceleration of fast solar wind
- Fundamental plasma processes in all layers of solar atmosphere
  - Propagation and dissipation of waves
  - Properties and roles of magnetic reconnection
- Solar activity and climate

Solar physics from space in Japan

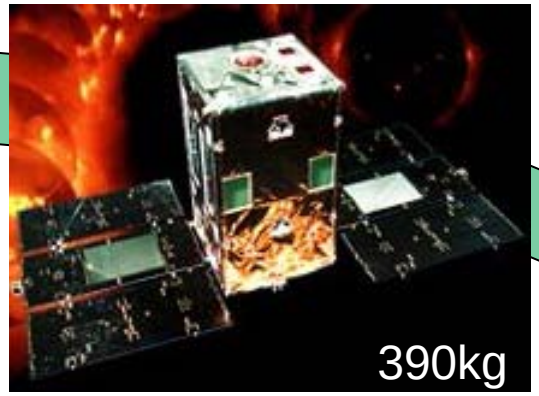


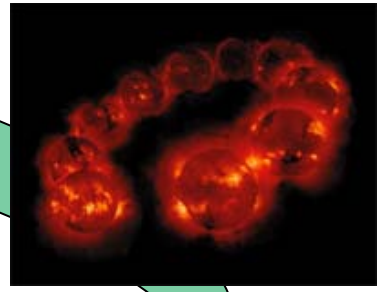


Hinotori/ASTRO-A（1981–1982）

Solar flare observations
in X & γ-rays

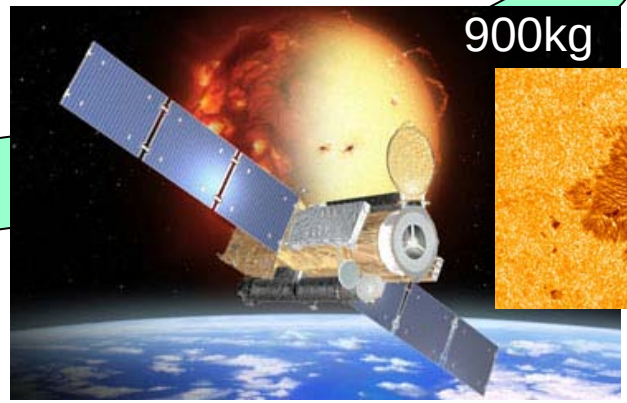
ISAS-NASA-UK Yohkoh/SOLAR-A

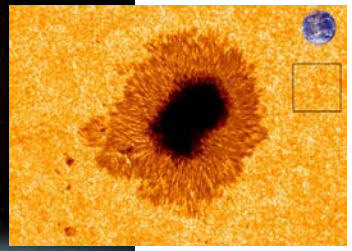




Hard X-ray Flares &
soft X-ray corona

ISAS-NASA-UK-ESA Hinode/SOLAR-B（2006–）





Photospheric magnetic fields

Solar physics from space

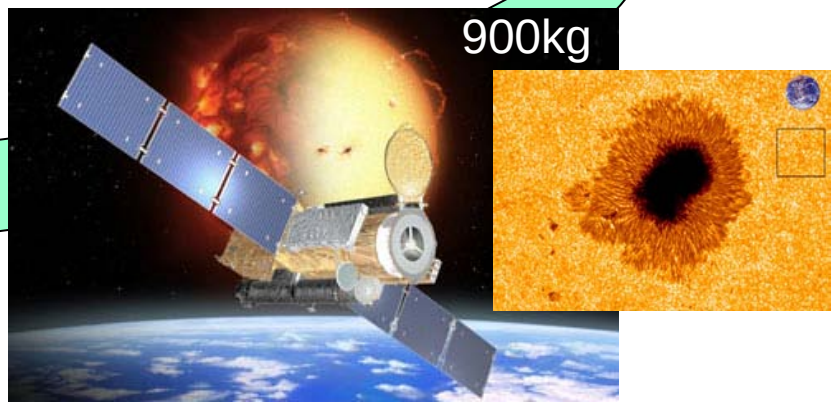
Open issues in solar physics

- ***Fundamental plasma processes (SOLARC)***
- ***Chromospheric and coronal heating (SOLAR-C)***
- ***Acceleration of fast solar wind (SOLAR-C)***
- ***Local dynamo process (SOLAR-C/D)***
- ***Internal structure and flow (SOLAR-D)***
- ***Global dynamo process (SOLAR-D)***

in X & γ rays

Hard X-ray flares &
soft X-ray corona

ISAS-NASA-UK-ESA Hinode/SOLAR-B（2006–）



Photospheric magnetic fields

SOLAR-C
Systems approach to understand solar and heliospheric magnetic activities and to develop algorithm for activity prediction

Solar-C concept

- ***Guiding principle*** is that ***small scale plasma processes*** associated with magnetic emergence, waves, shocks, and magnetic reconnection dictate the evolution of the global phenomena of the Sun and the heliosphere (and vice versa).
- Observations so far made indicate that observations of ***small scale*** structures and processes are within our reach.
- Hinode clearly showed that the ***combination of high spatial resolution and spectroscopy*** (including spectro-polarimetry) is a powerful tool for obtaining magnetic and plasma information.

Solar-C concept (continued)

- To establish magnetic connectivity in terms of both space and time from photosphere all the way to corona ***via 3 means***:
  - By ***direct measurement*** of the region plasma-beta <1 chromosphere
  - By computational ***extrapolation*** of coronal magnetic fields
  - By very high resolution ***EUV observations*** of corona
- This is inevitably achieved with **larger telescopes with highest possible throughput** for more photons and higher spatial resolution. High S/N is critical in order to retrieve information from spectral profiles.

Solar-C mission definition

Mission: ***to understand solar and heliospheric magnetic activities and to develop algorithm for solar activity prediction by understanding the magnetic coupling of convection zone-photosphere-chromosphere-transition region and corona***

Science cases:

1. ***3D-magnetic structure with neutral sheets***
2. ***Heating of chromosphere and corona***
3. ***Acceleration of fast solar wind***
4. ***Prediction of solar flares***
5. ***Fundamental plasma processes such as reconnection, waves, shocks, particle acceleration and turbulence***
6. ***Global and local dynamo***
7. ***Sun's influence to Earth climate***

Key requirements:

1. ***High spatial resolution to see more elemental structure inferred by Hinode***
2. ***High time resolution to freeze rapidly changing chromospheric phenomena***
3. ***Chromospheric magnetic observations***
4. ***Seamless spectroscopic imaging observations from photosphere to corona***
5. ***Wide FOV to connect local and global and to cover AR***

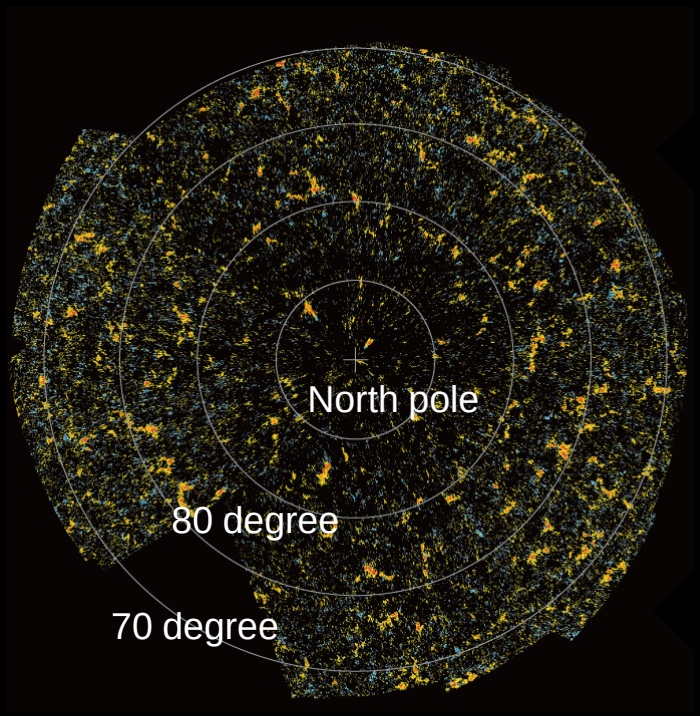
Imaging spectroscopy instruments:

X-ray/EUV: ultra-high resolution EUV telescopes with optional photon-countng telescope

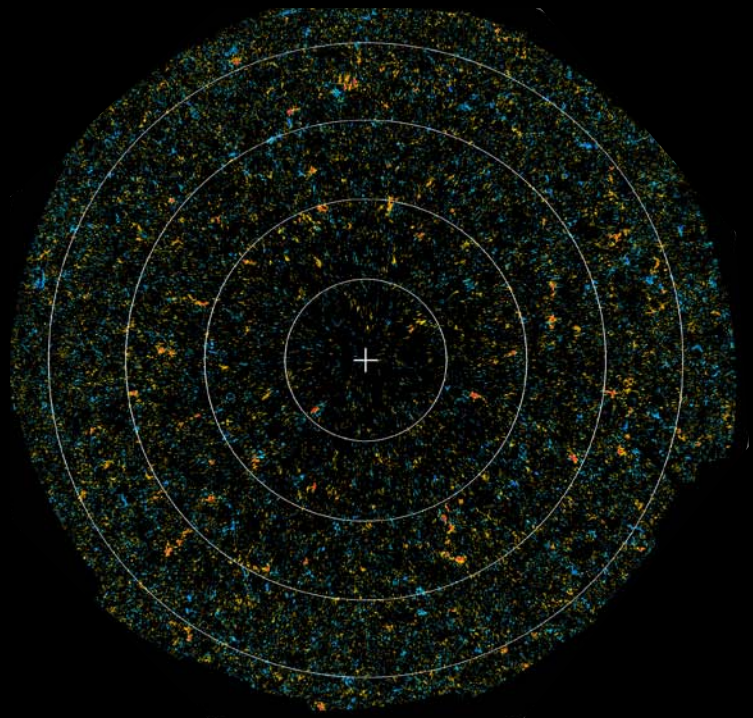
UV: high-throughput telescope x10 more sensitive with seamless coverage in temperature

Visible: 1.5m-class telescope to obtain 3D magnetic structure from photosphere to corona with x10 more photons, and x3 resolution with high cadence

Hinode observations on solar north pole



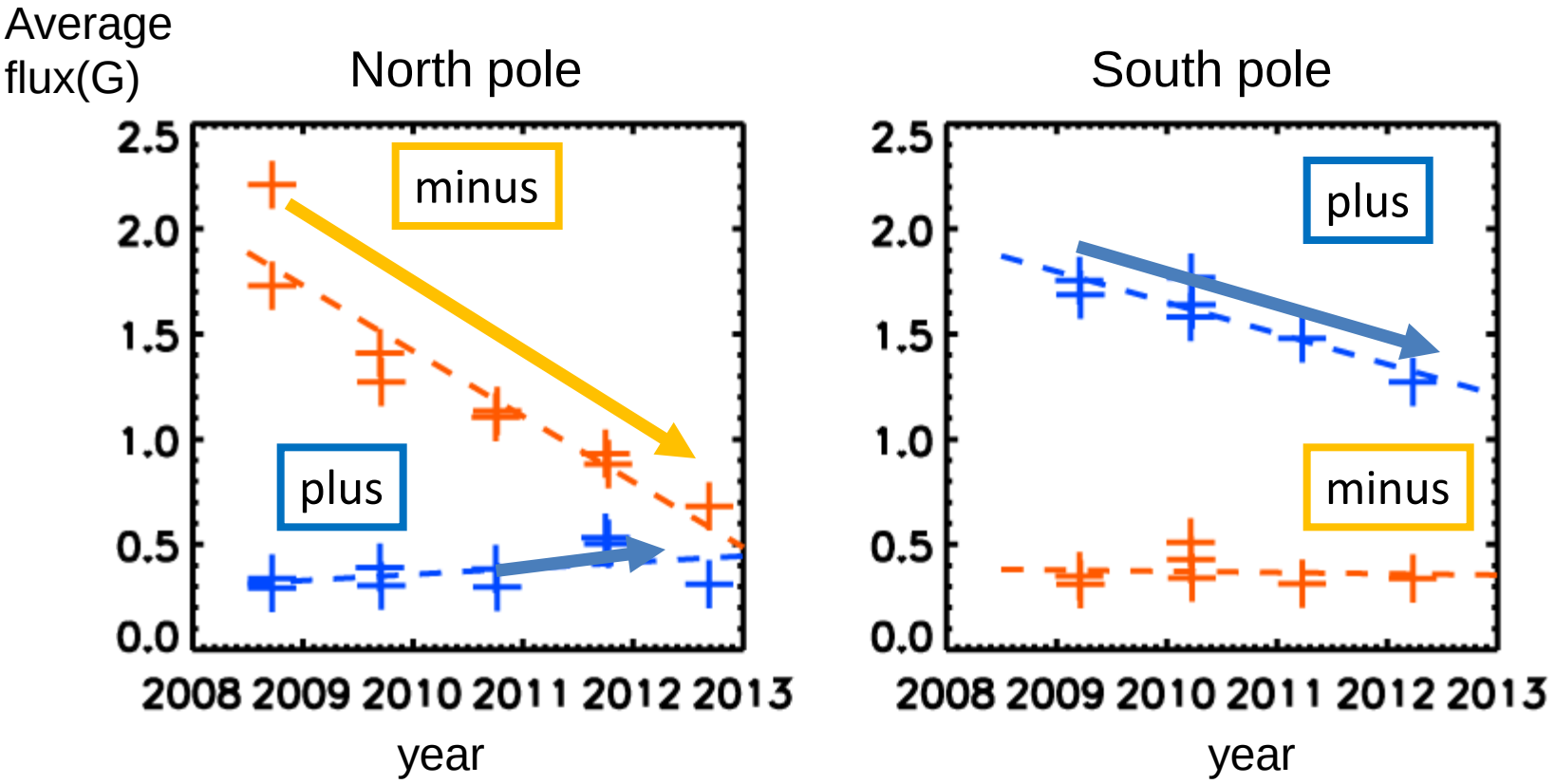
September 2007



September 2012

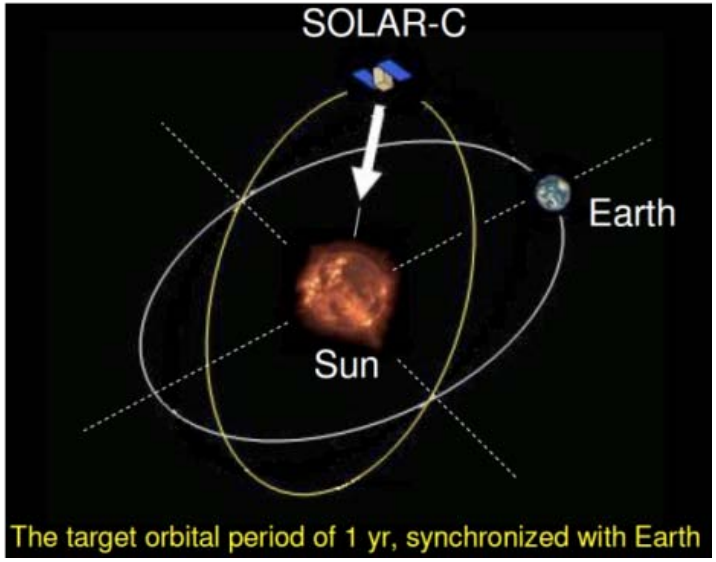
Tsuneta+08, Ito+ 10, Shiota+ 12

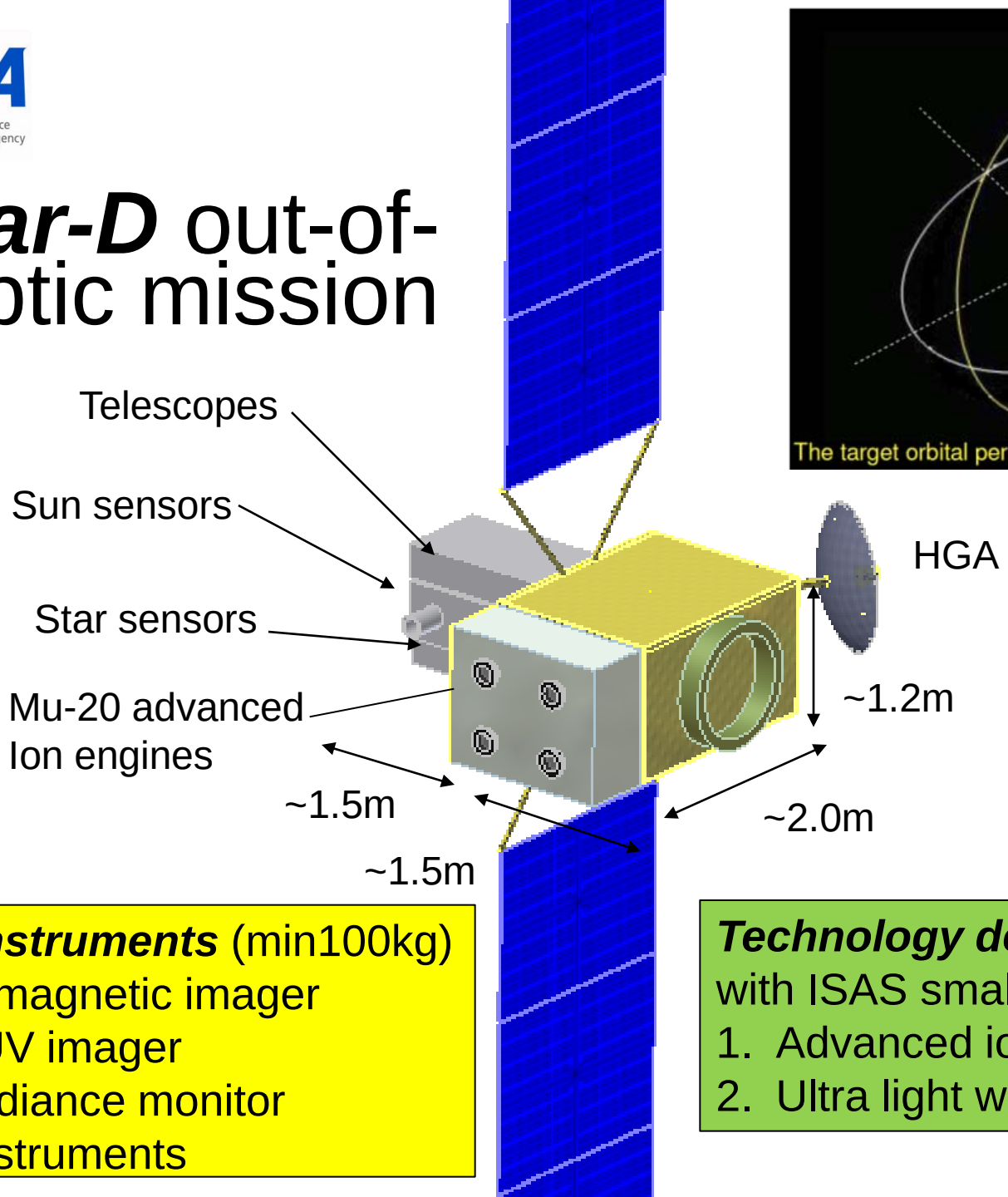
Hinode
magnetic flux in polar regions



- North pole: reversal going on
- South pole: stationary

Solar-D out-of-ecliptic mission

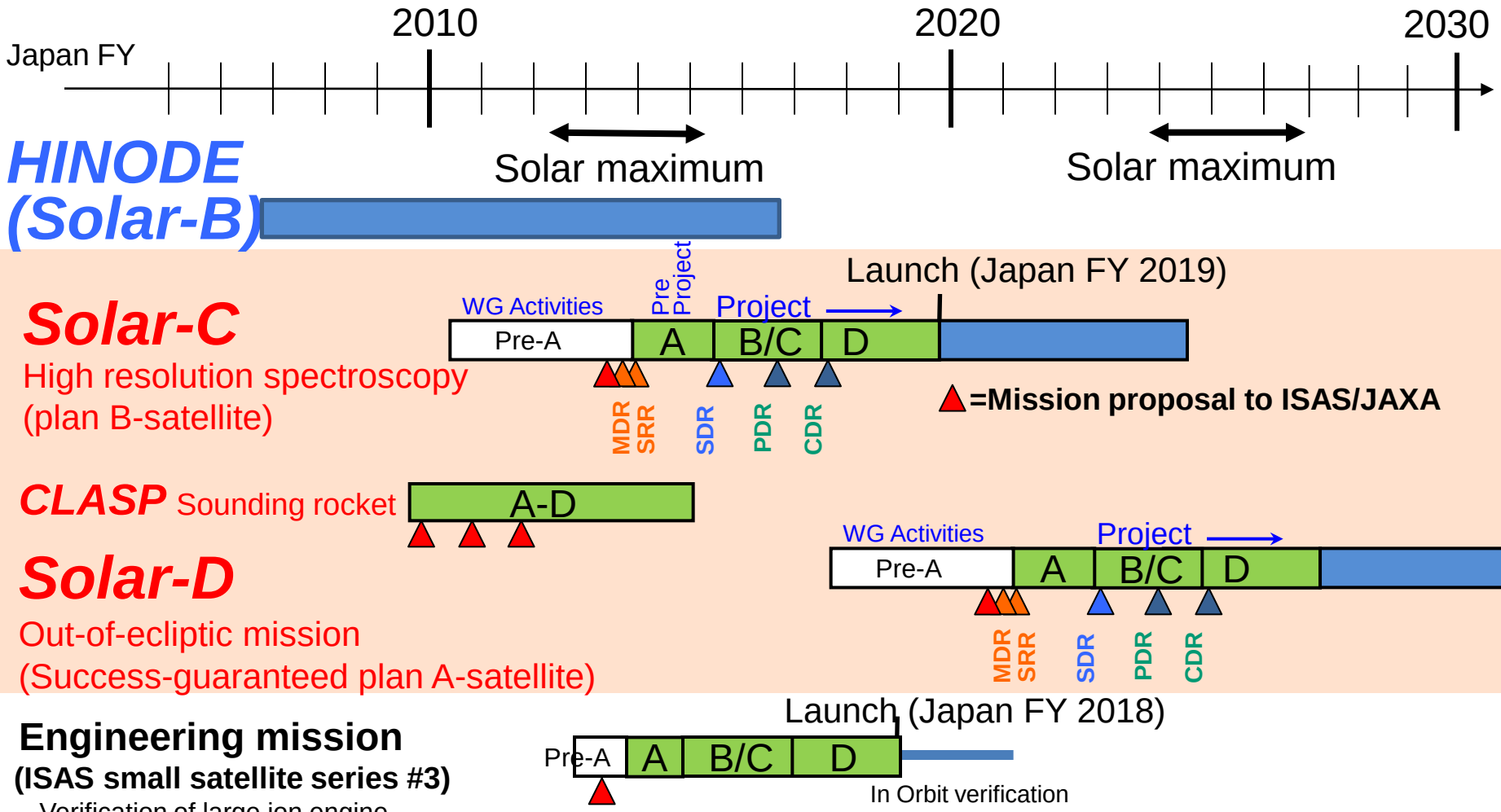




Model instruments (min100kg)
Doppler magnetic imager
X-ray/EUV imager
Total irradiance monitor
In-situ instruments

Technology development
with ISAS small satellite#3:
1. Advanced ion-engine
2. Ultra light weight solar paddle

Solar&helio physics roadmap 2011-2030: From SOLAR-C to SOLAR-D



Engineering mission
(ISAS small satellite series #3)
Verification of large ion engine and other technologies to be used for future deep space missions

Pre-A: Pre-Phase-A (WG activities)
A: Phase-A (R&D)
B/C: Phase-B/C (PM phase)
D: Phase-D (FM phase)

Rev. B: 12 Feb.2013
Rev. A: 11 March 2011

Summary

- Japan has been contributing to better understanding on the fundamental plasma processes taking place on the sun with 3 JAXA solar missions. We continue to do so with the proposed Solar-C mission.
- We recognize the importance of heliophysics in terms of its societal and environmental effects on Earth. We desire to contribute to ILWS activity with existing and planned JAXA missions.