DE ZON

Petra Vanlommel
Solar-Terrestrial Centre of Excellence





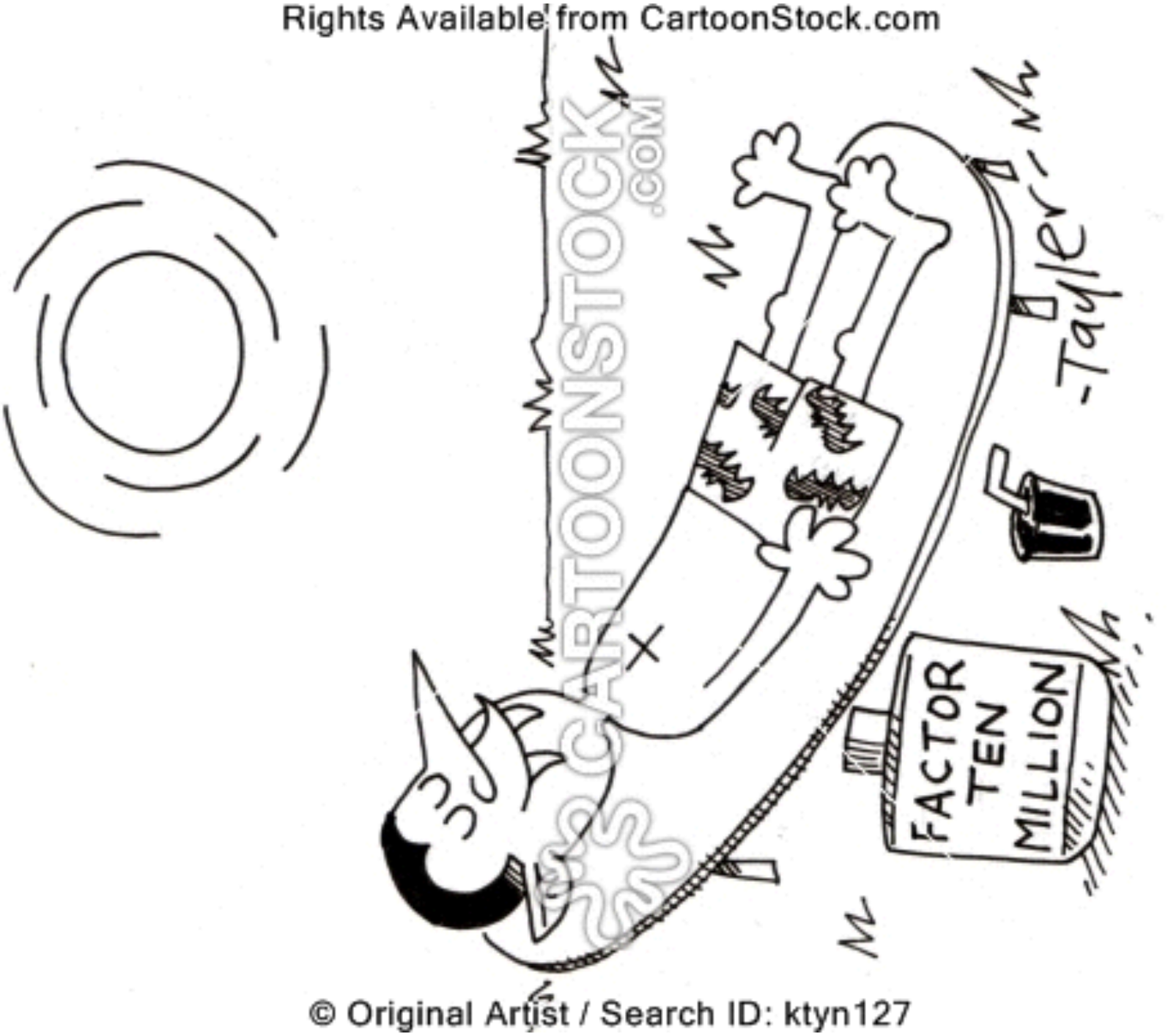
SUNLIGHT

Zonlicht bevat vele soorten licht en kleuren. Een regenboog geeft ons een voorsmaakje.




Het zonlicht geeft ons eveneens warmte.

Rights Available from CartoonStock.com



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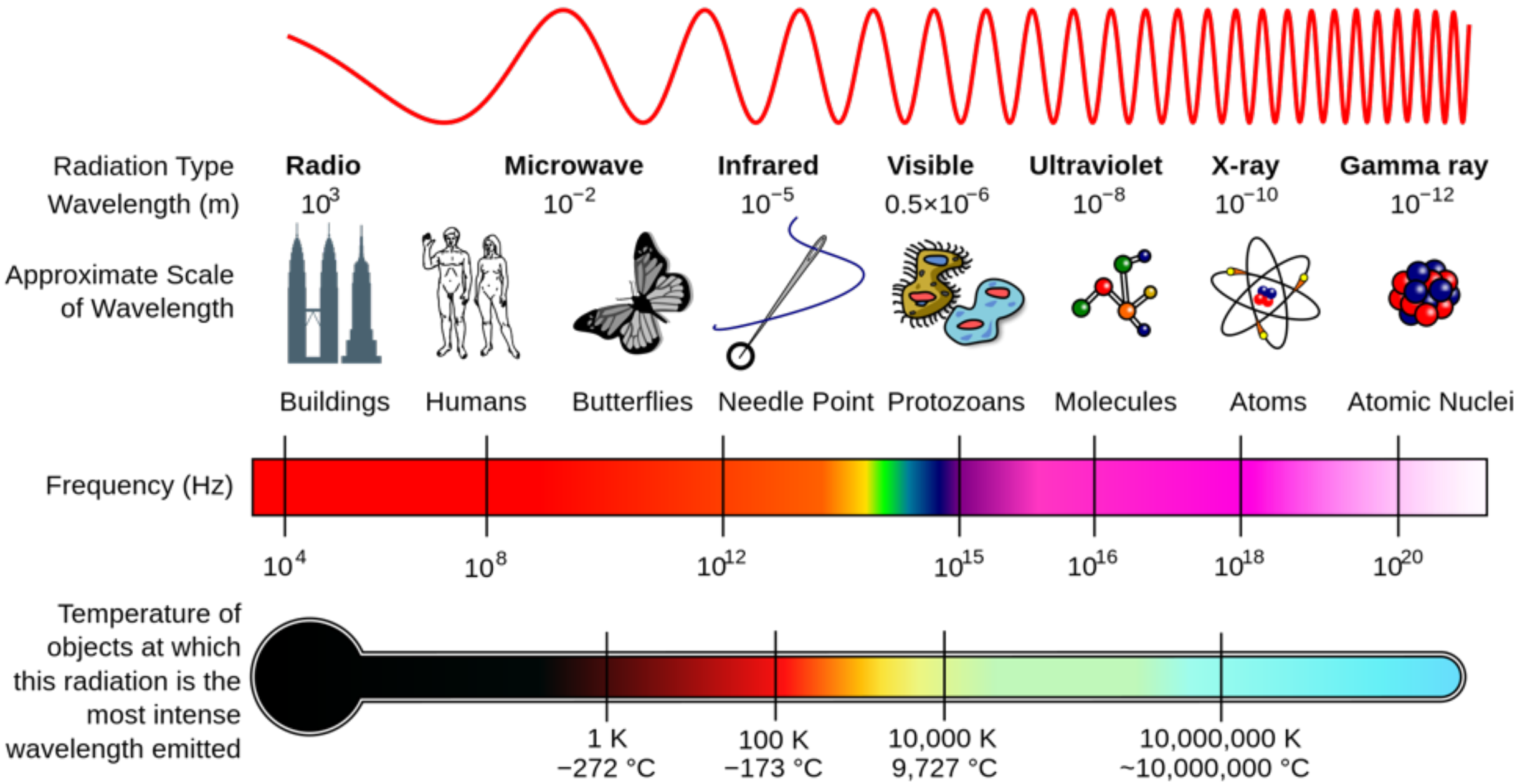
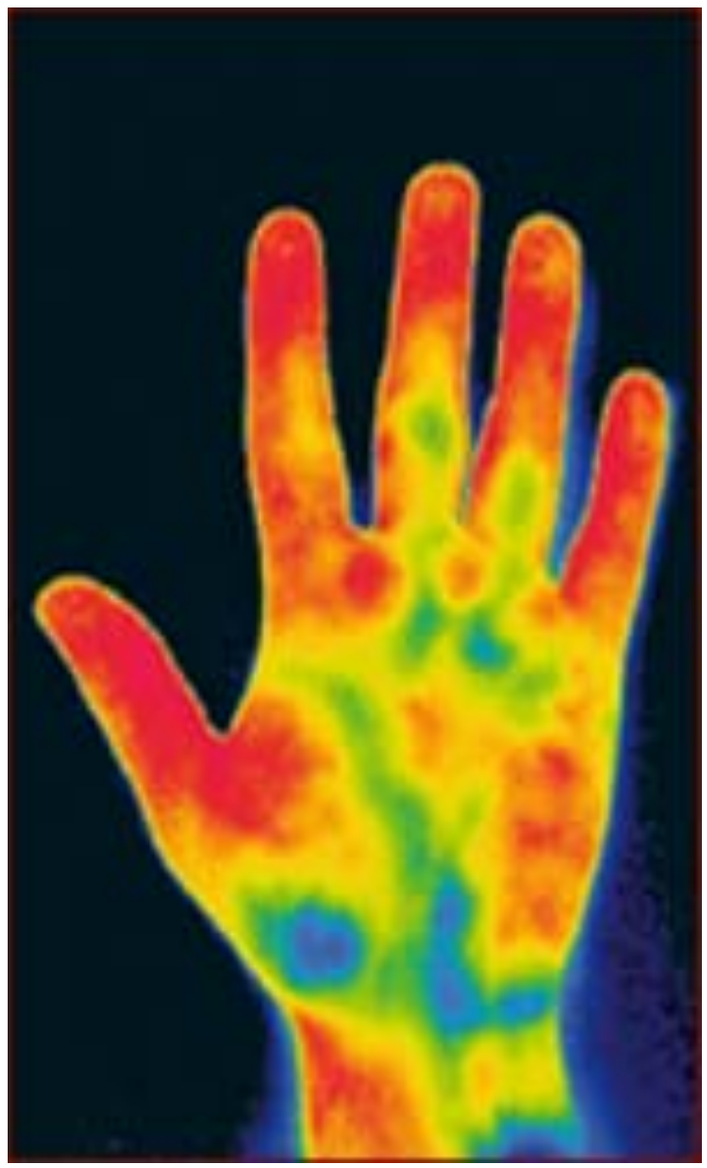
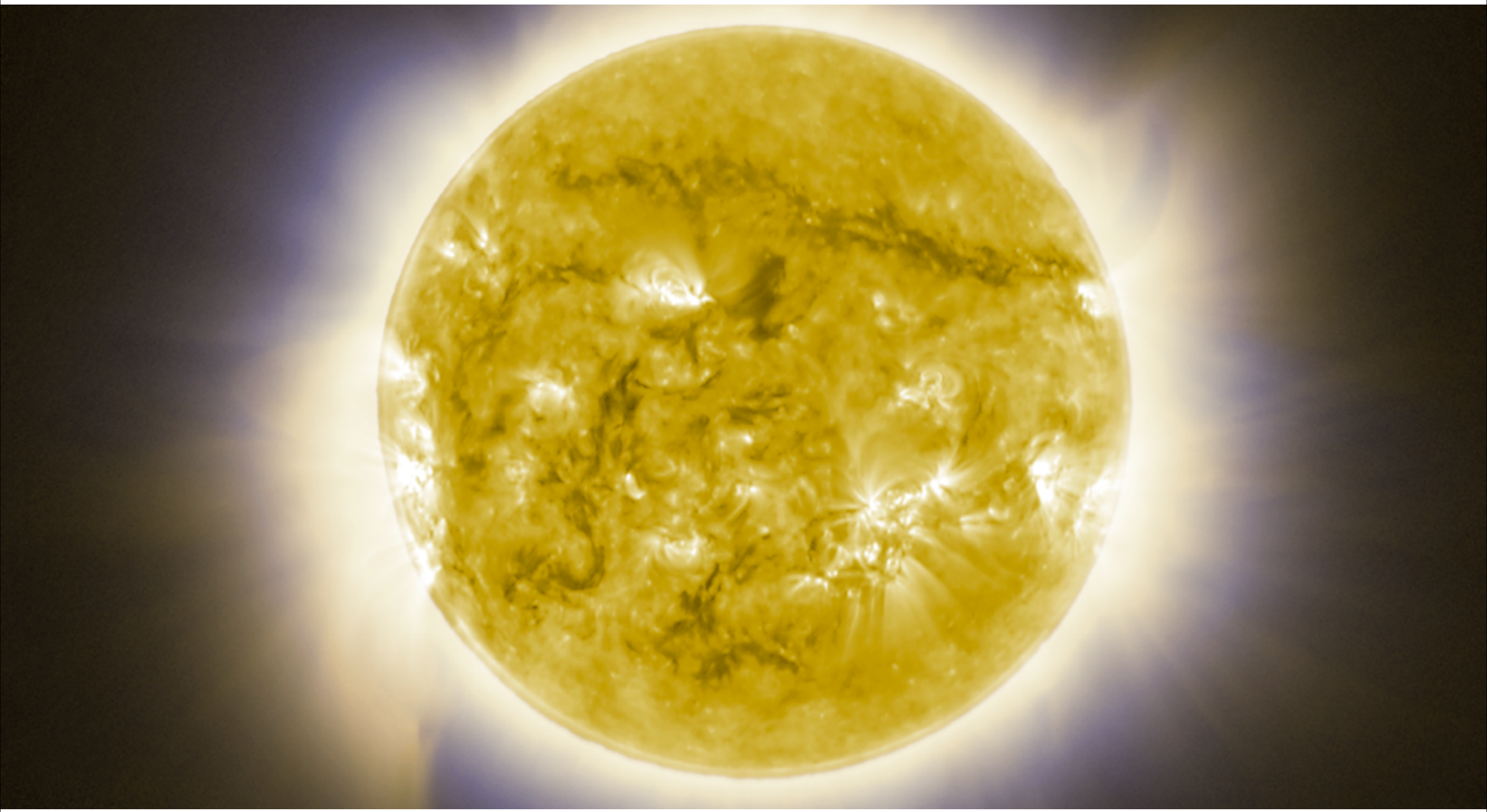

Radiation Type
Wavelength (m)
Approximate Scale of Wavelength
Radio
10^{3}
Microwave
10^{-2}
Infrared
10^{-5}
Visible
0.5×10^{-6}
Ultraviolet
10^{-8}
X-ray
10^{-10}
Gamma ray
10^{-12}
Buildings
Humans
Butterflies
Needle Point
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10^{4}
10^{8}
10^{12}
10^{15}
10^{16}
10^{18}
10^{20}
Temperature of objects at which this radiation is the most intense wavelength emitted
1 K
−272 °C
100 K
−173 °C
10,000 K
9,727 °C
10,000,000 K
~10,000,000 °C

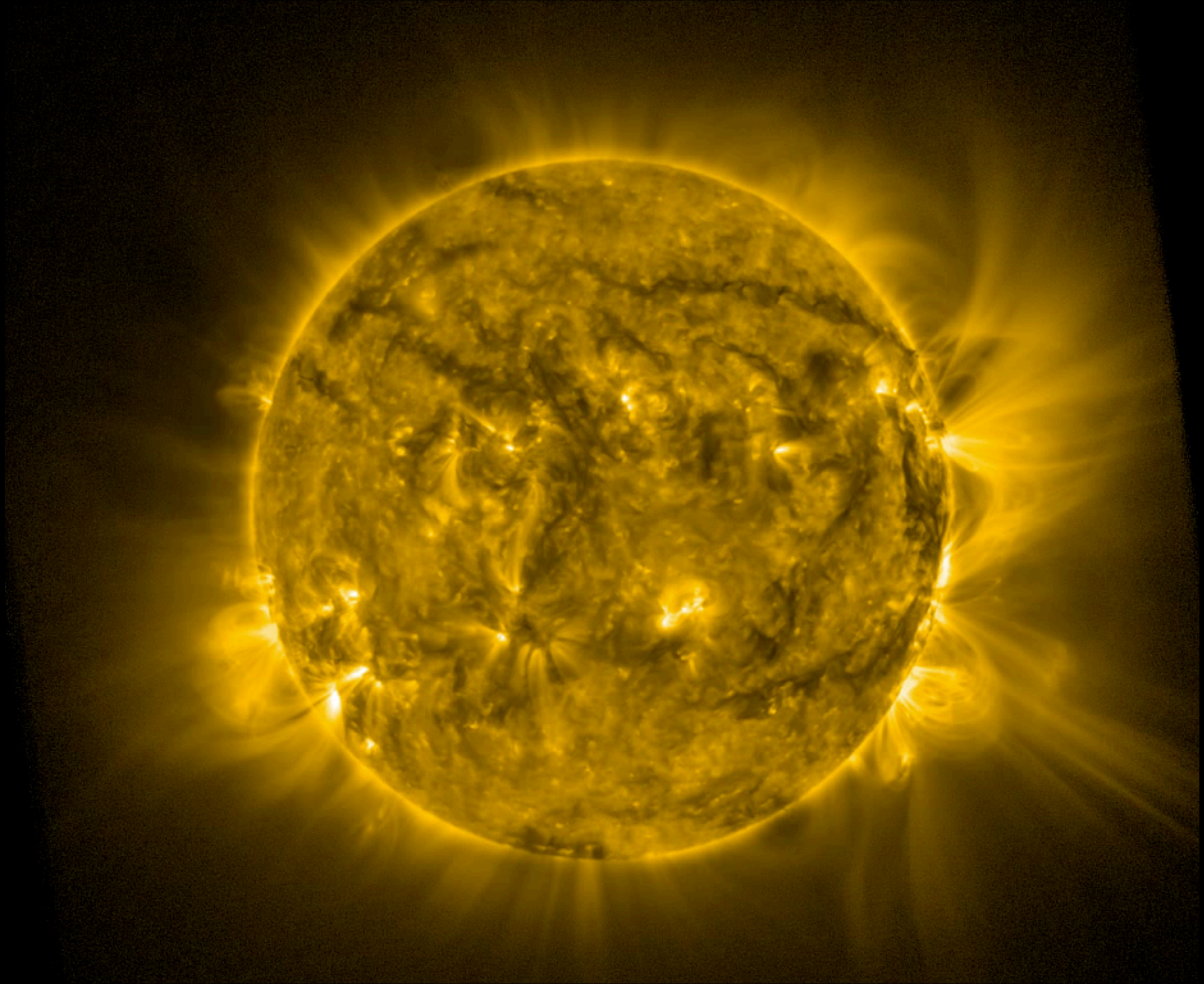






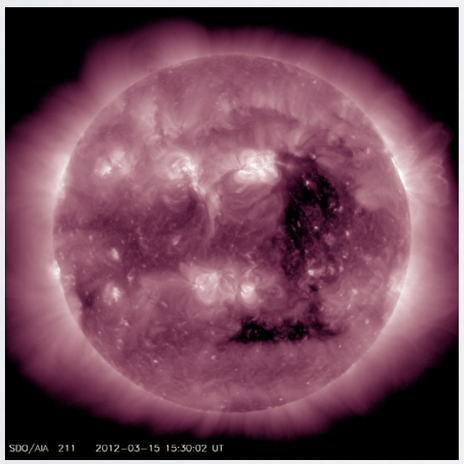

01206_230008

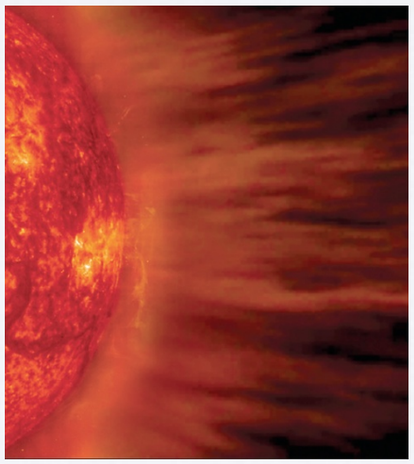


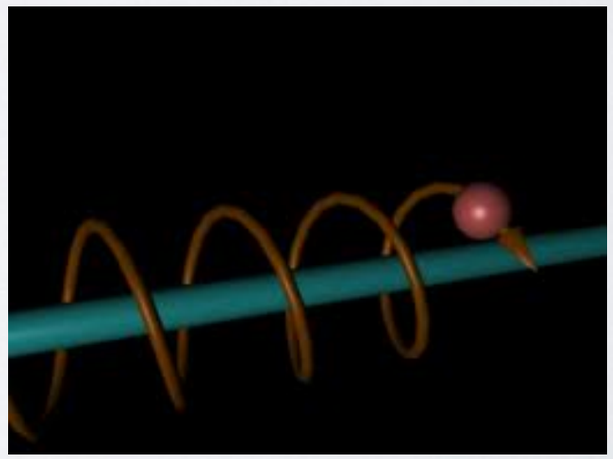


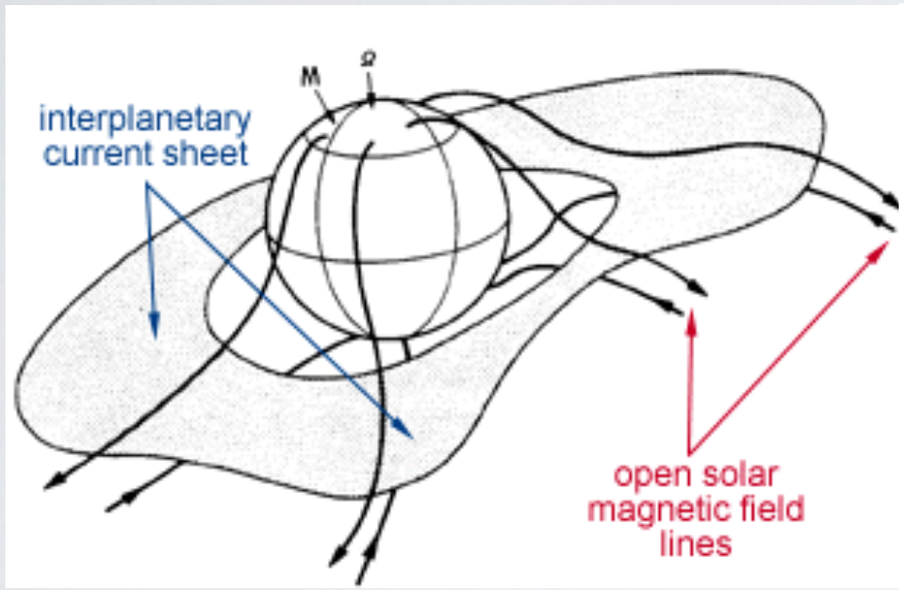
THE SUN LOSES ENERGY
SPACE CLIMATE

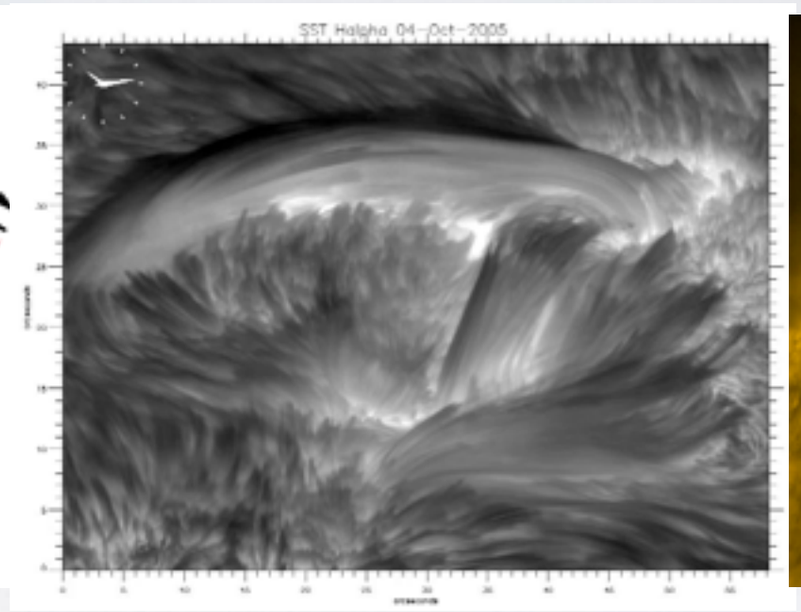
Light	Mass	Particles

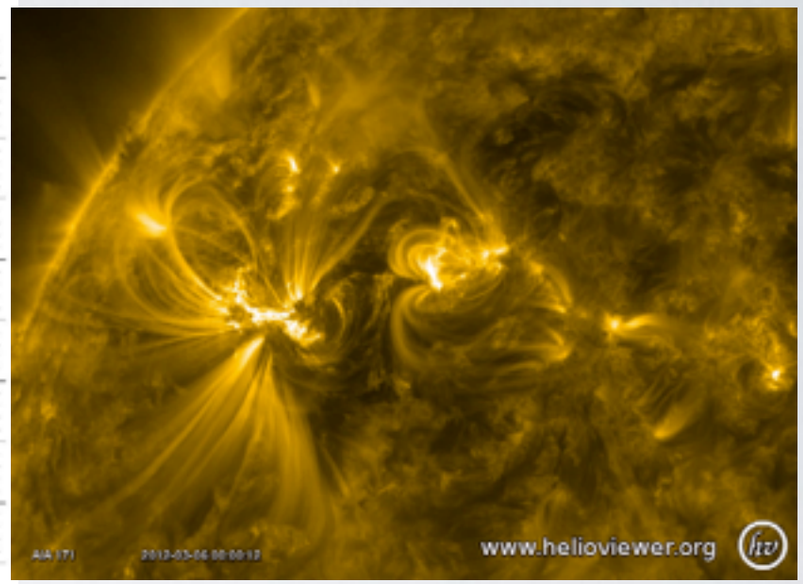







interplanetary
current sheet
open solar
magnetic field
lines


SST Halpha 04-Oct-2005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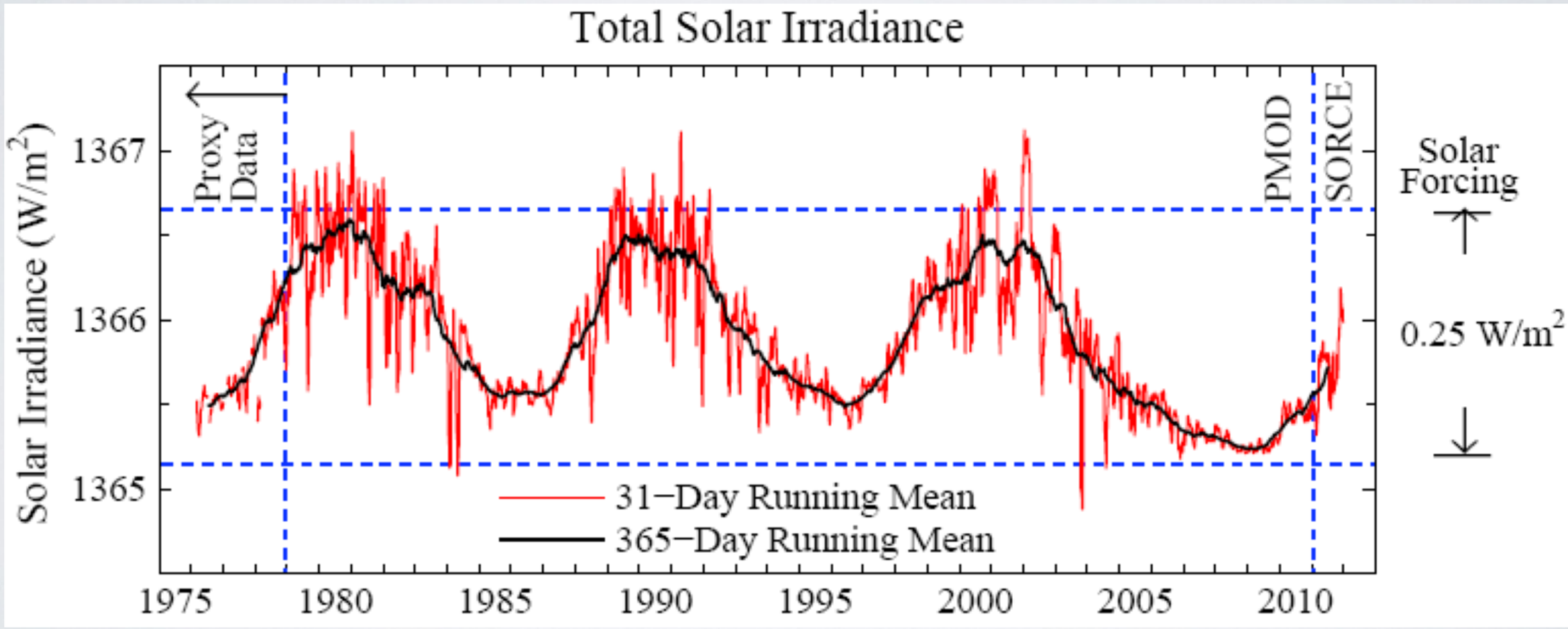
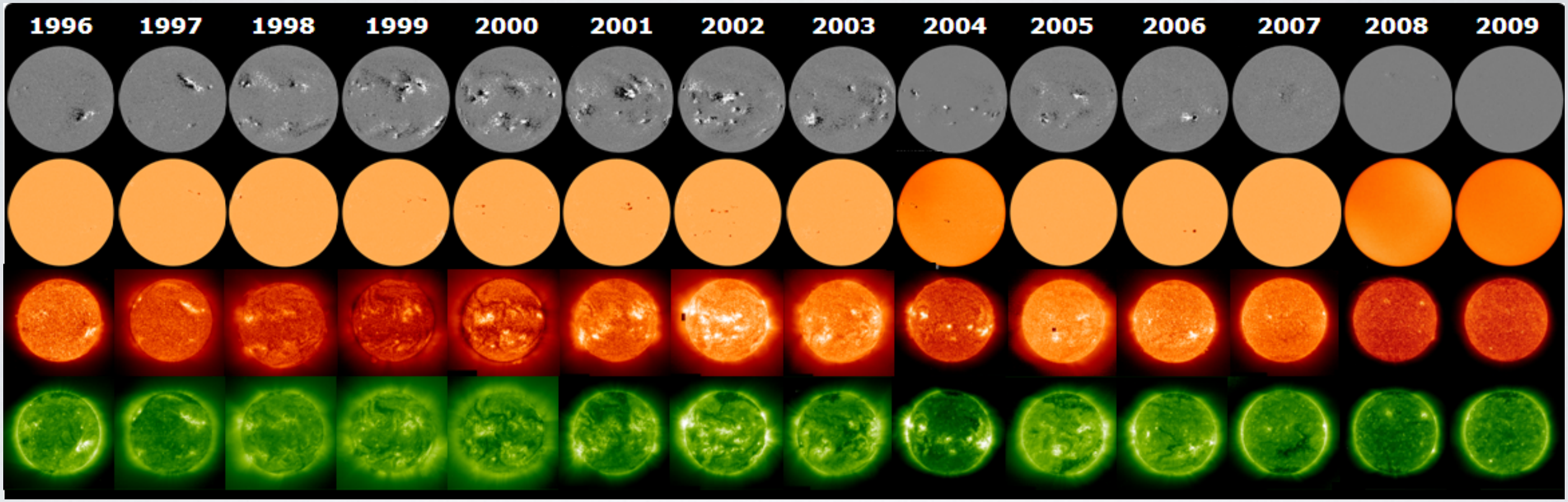
MAGNETISME

ZONNECYCLUS




1996
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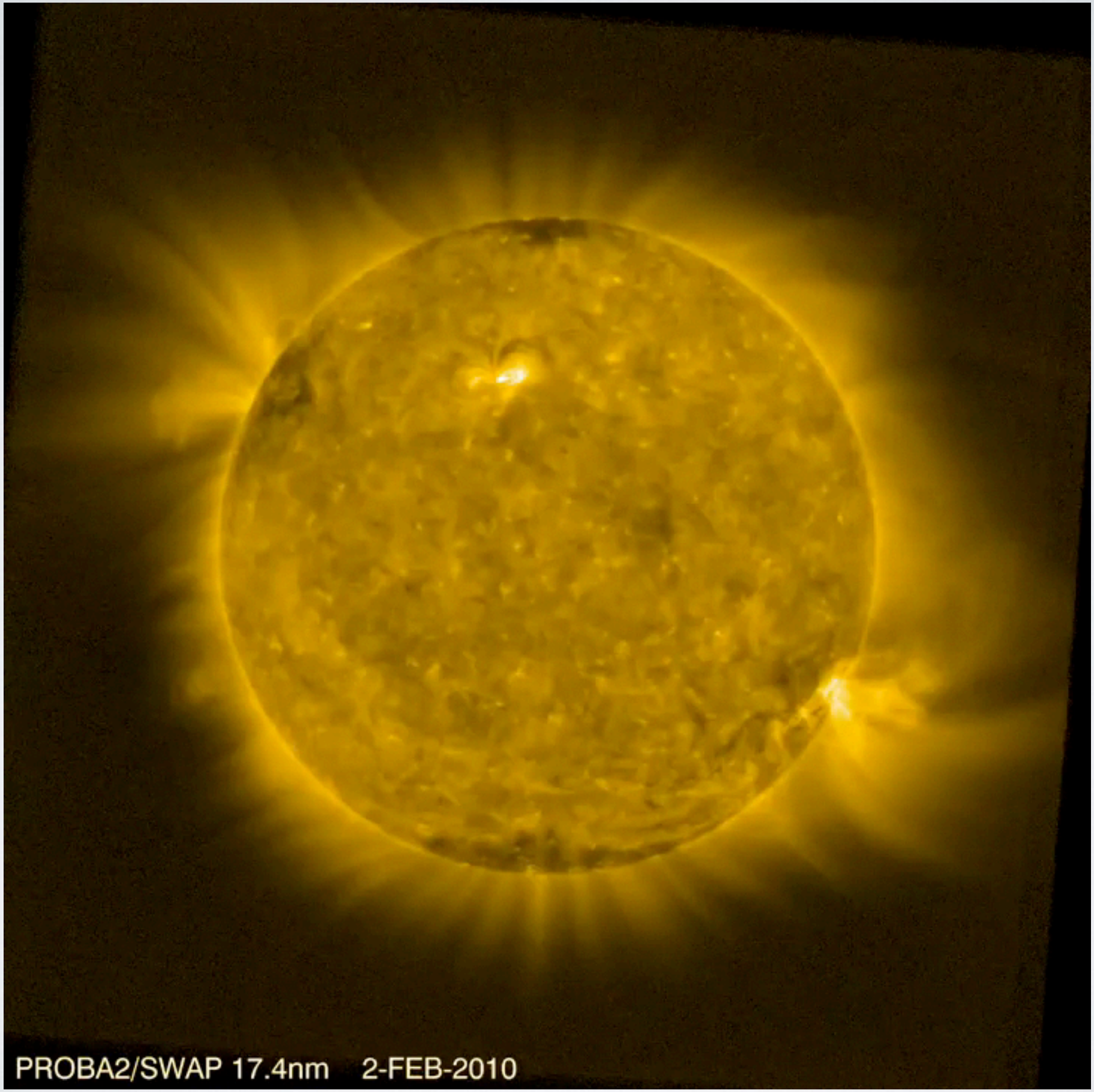
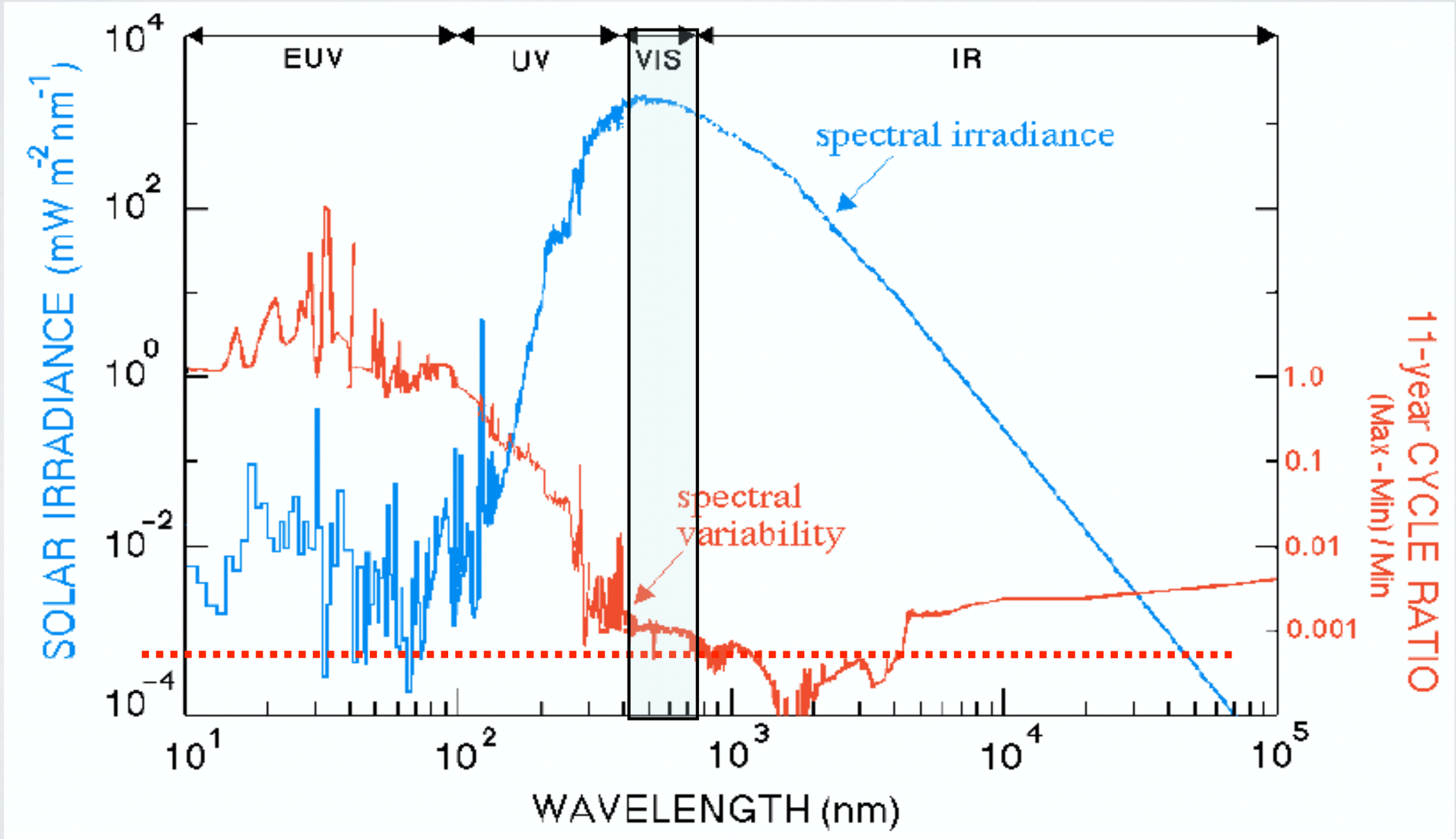

PROBA2/SWAP 17.4nm 2-FEB-2010

VARIATIE LICHTKRACHT/ GOLFLENGTE



Dipool is zichtbaar tijdens zonneminimum

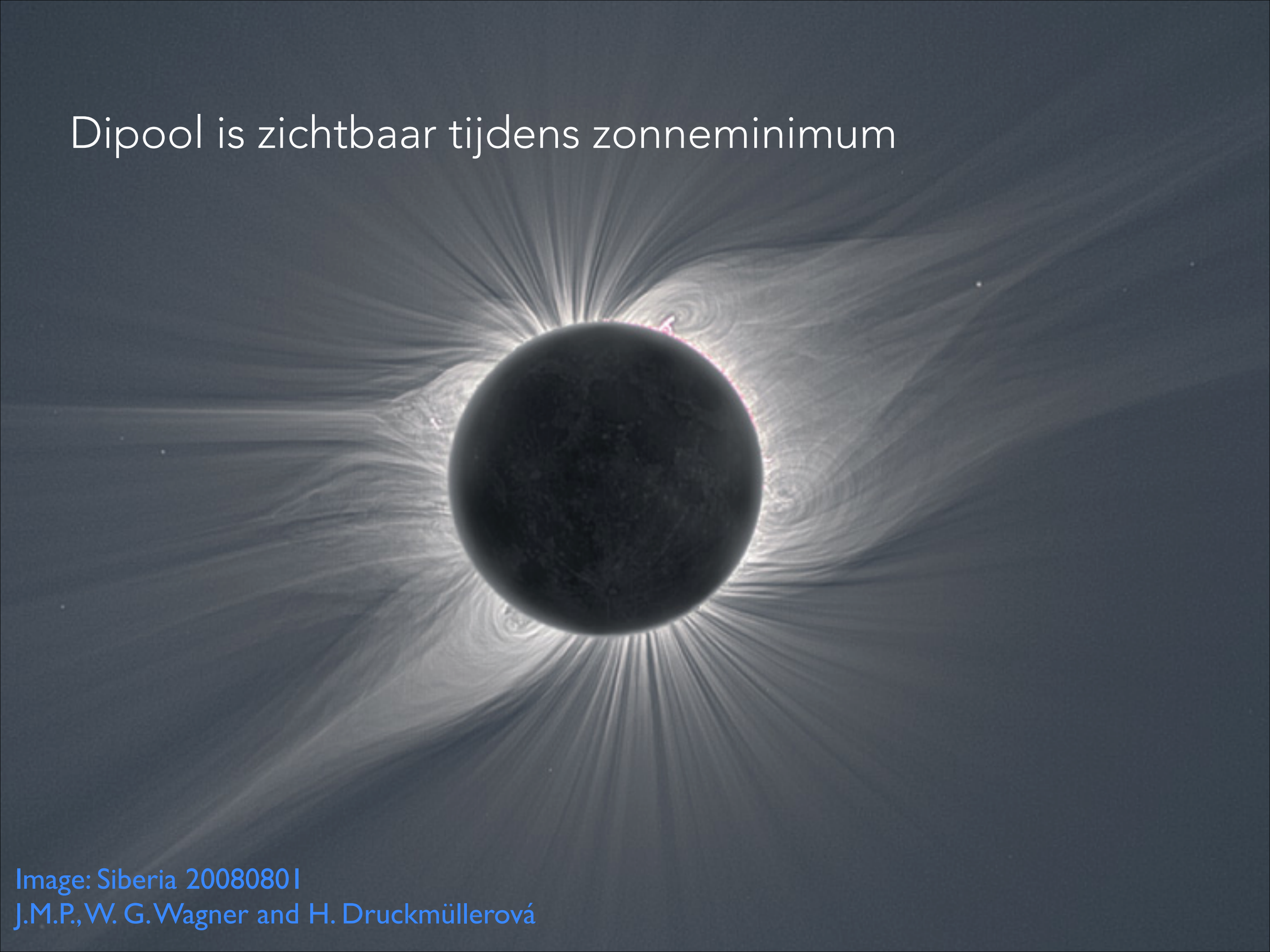


Image: Siberia 20080801
J.M.P., W. G. Wagner and H. Druckmüllerová

Dipool is minder zichtbaar tijdens zonnemaximum.

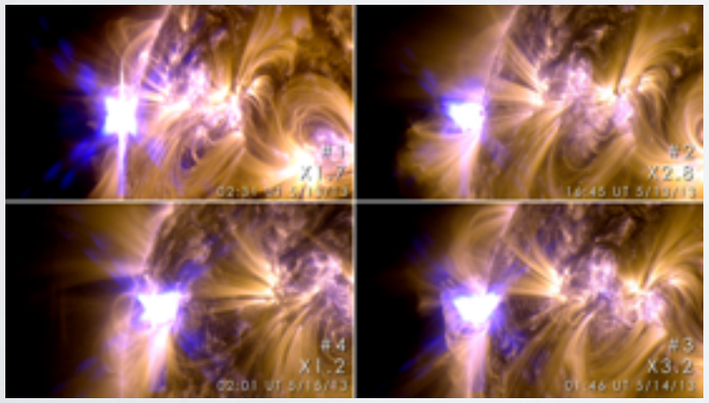


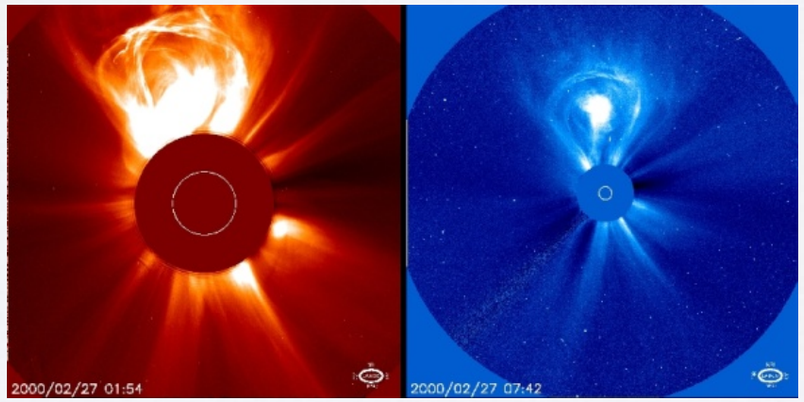
SPACE WEATHER

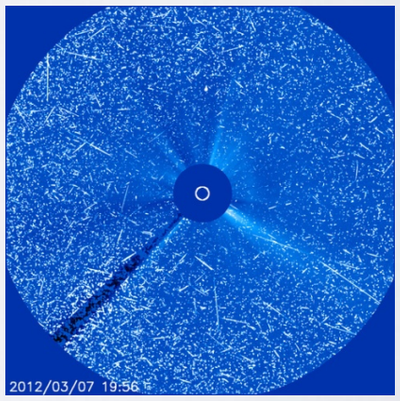
Zonnevlammen

Wolken

Proton storm

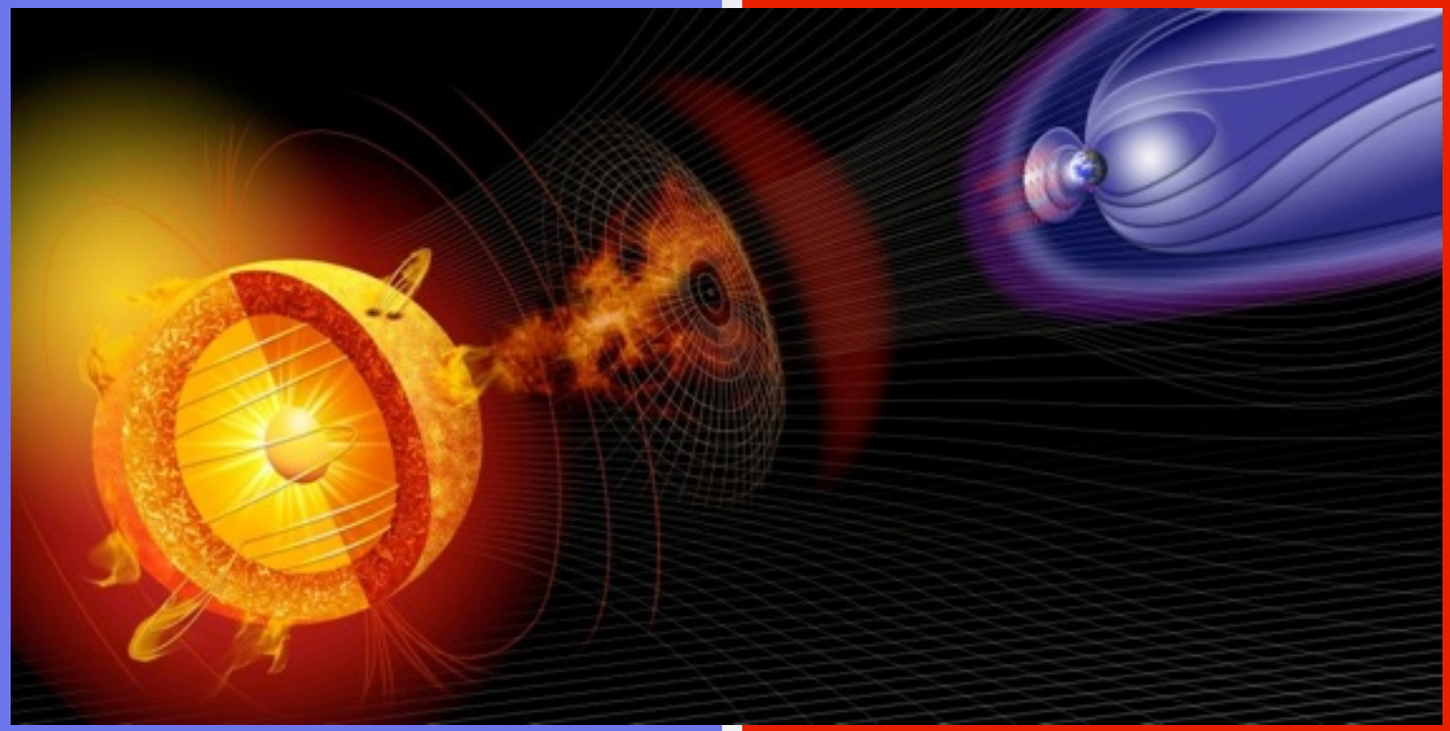


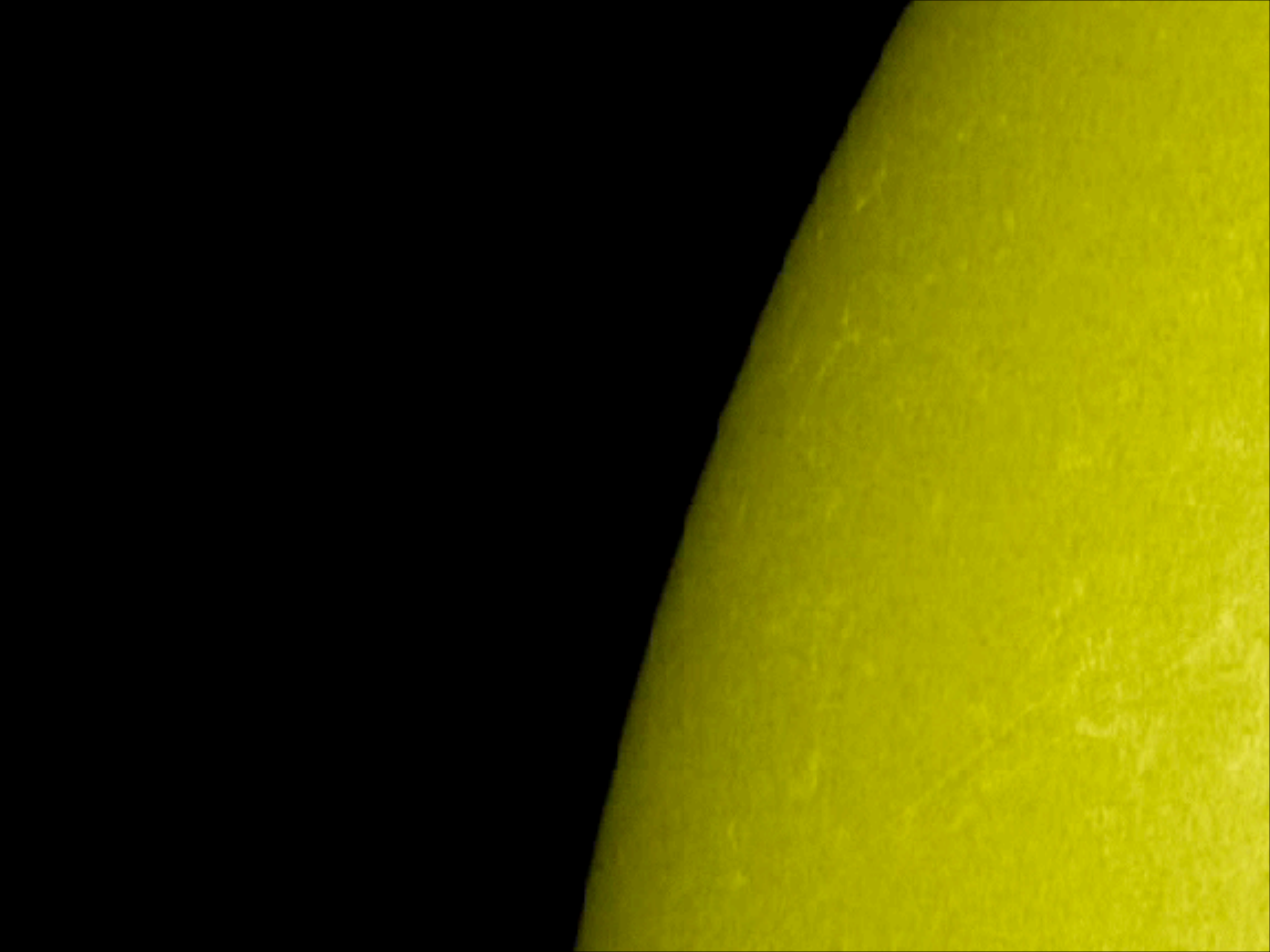




Het aardmagnetisch schild beschermt ons tegen de zonnewind en ruimtewolken.
De aardatmosfeer beschermt ons tegen straling en lichtstormen








AIA 131
2014-02-25 00:00:32
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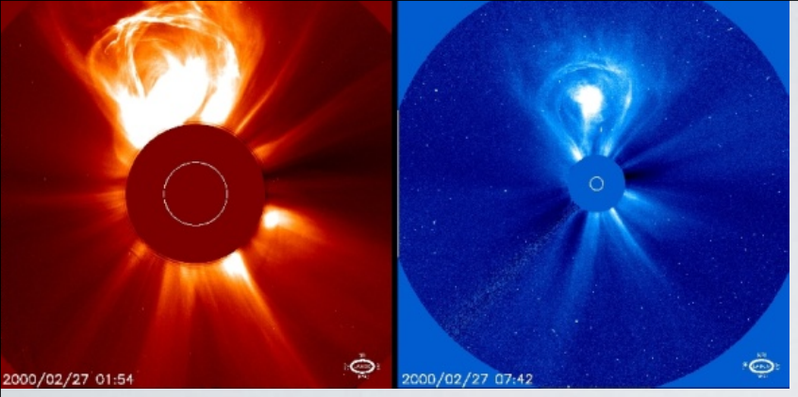


GEVOLGEN

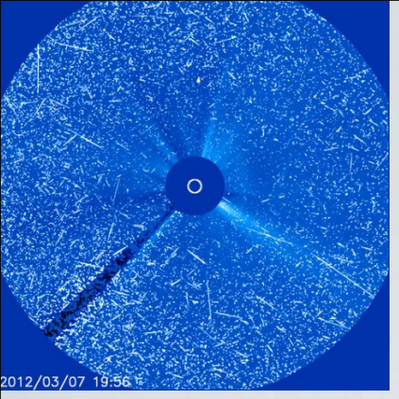
- GIC
- GNSS
- Aurora
- Drag on satellites





Malmö Blackout - Oct 30, 2004

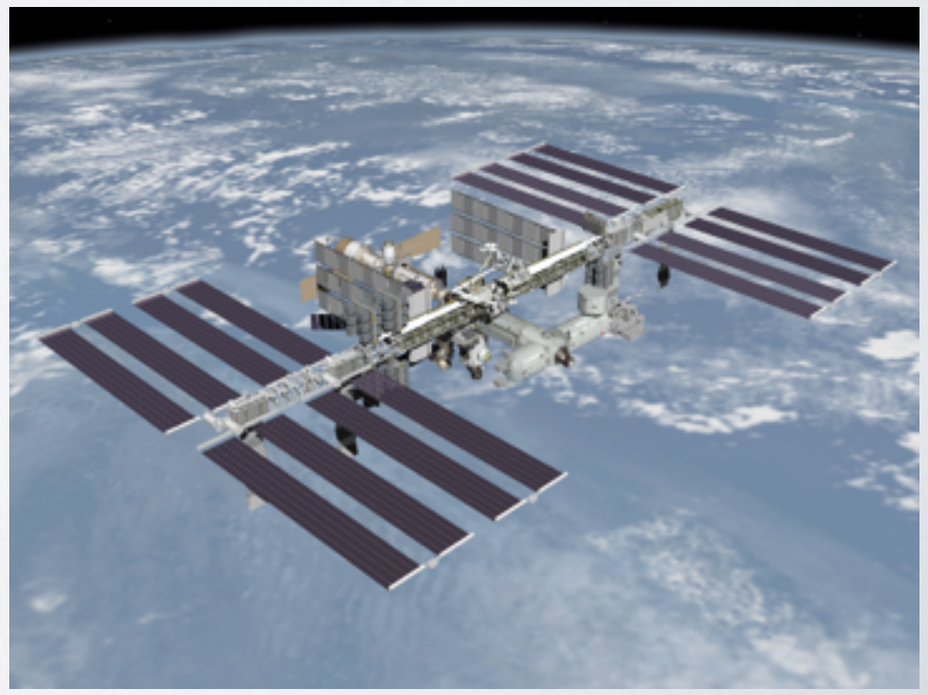
- About 50 000 customer were without electricity in Malmö, Sweden for 20-50 minutes
- First known power grid blackout due to GIC in Europe
- An overcurrent relay was too sensitive to the third harmonic of 50 hZ. It has been replaced by a less sensitive relay later.

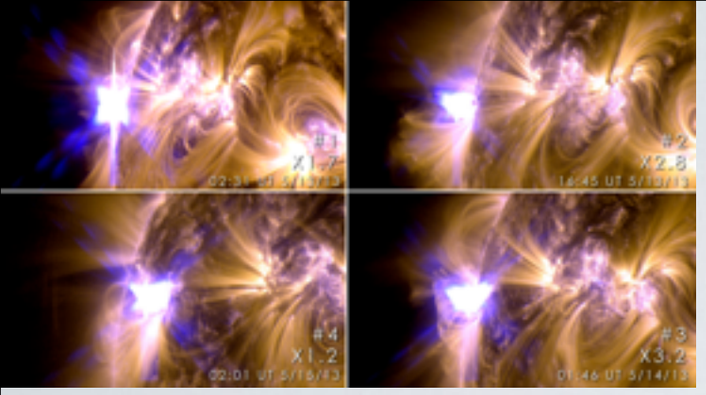


GEVOLGEN



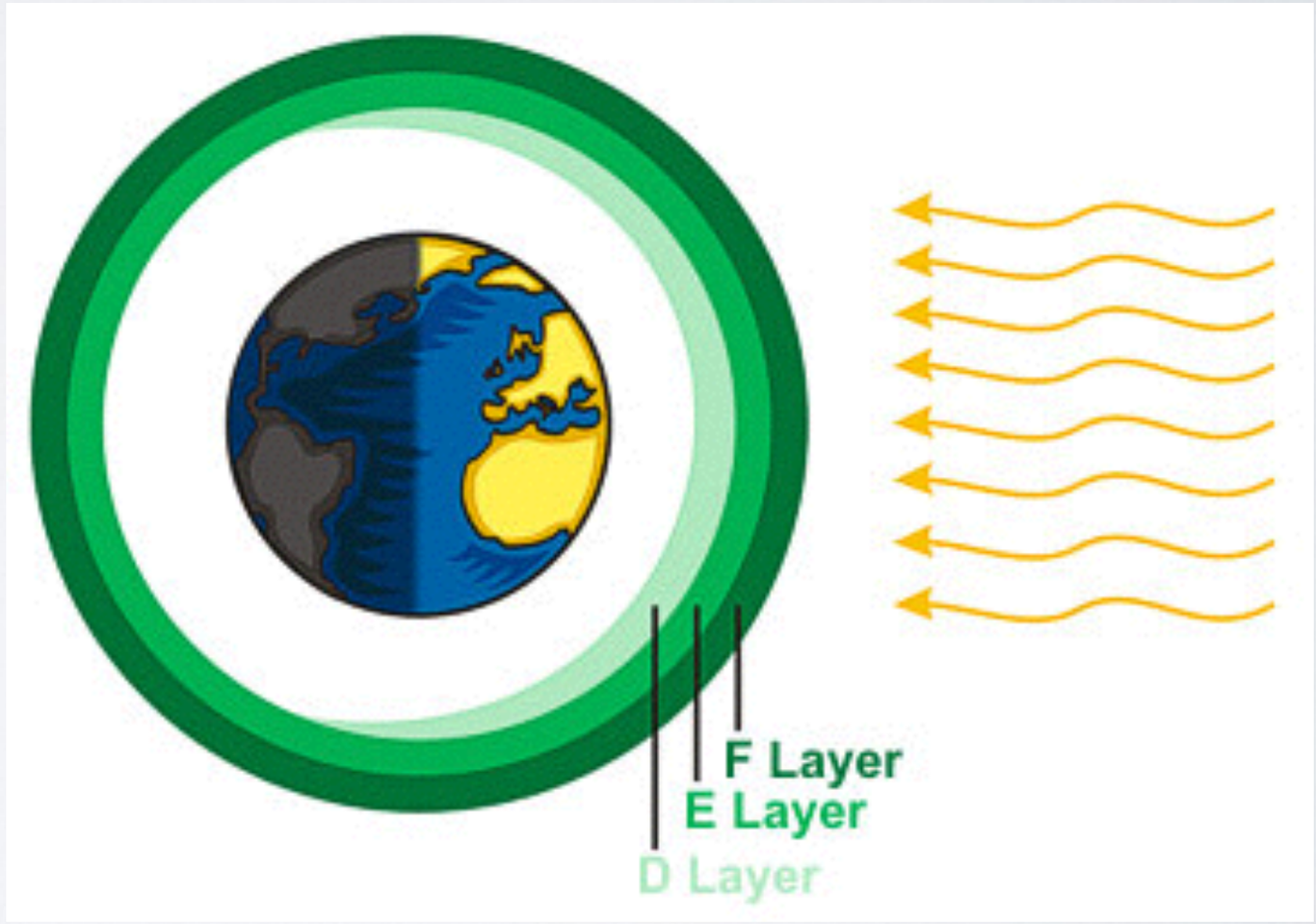
- Polar flights
- Astronauts
- Electronics
- Satellites: anomalies/loss



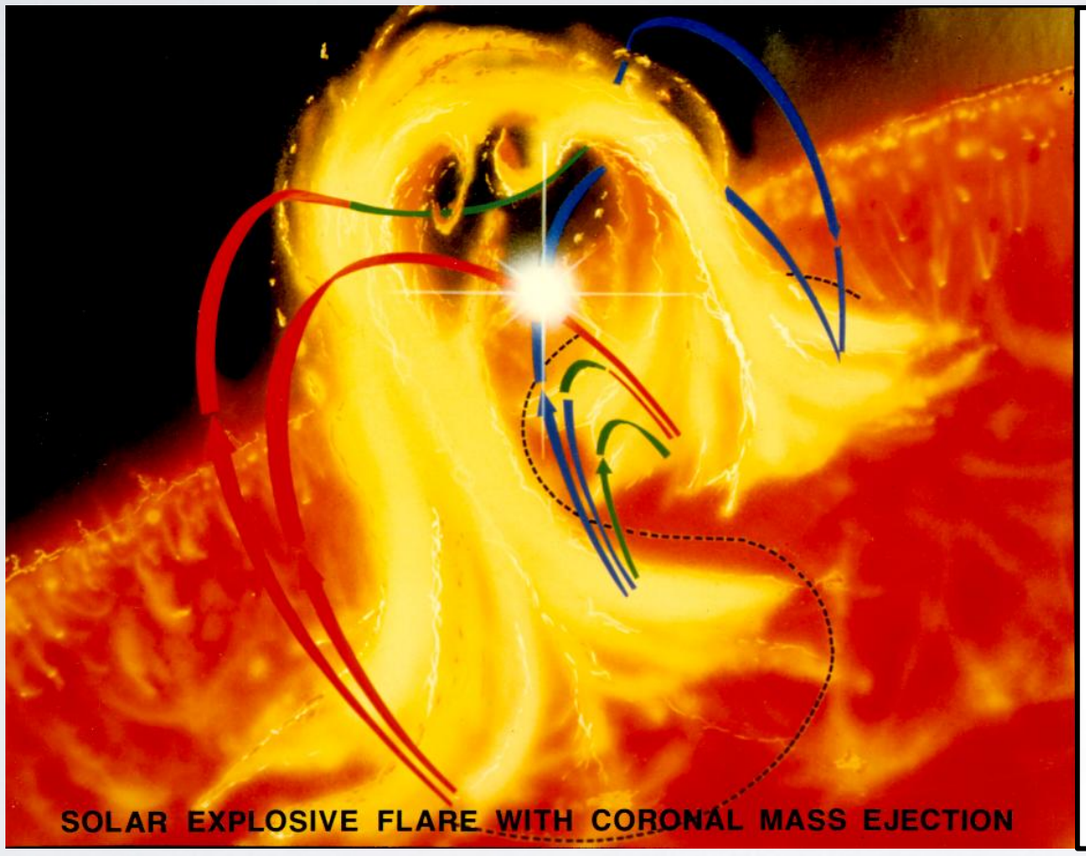


GEVOLGEN

- GNSS
- Radio communication
- Drag on satellites



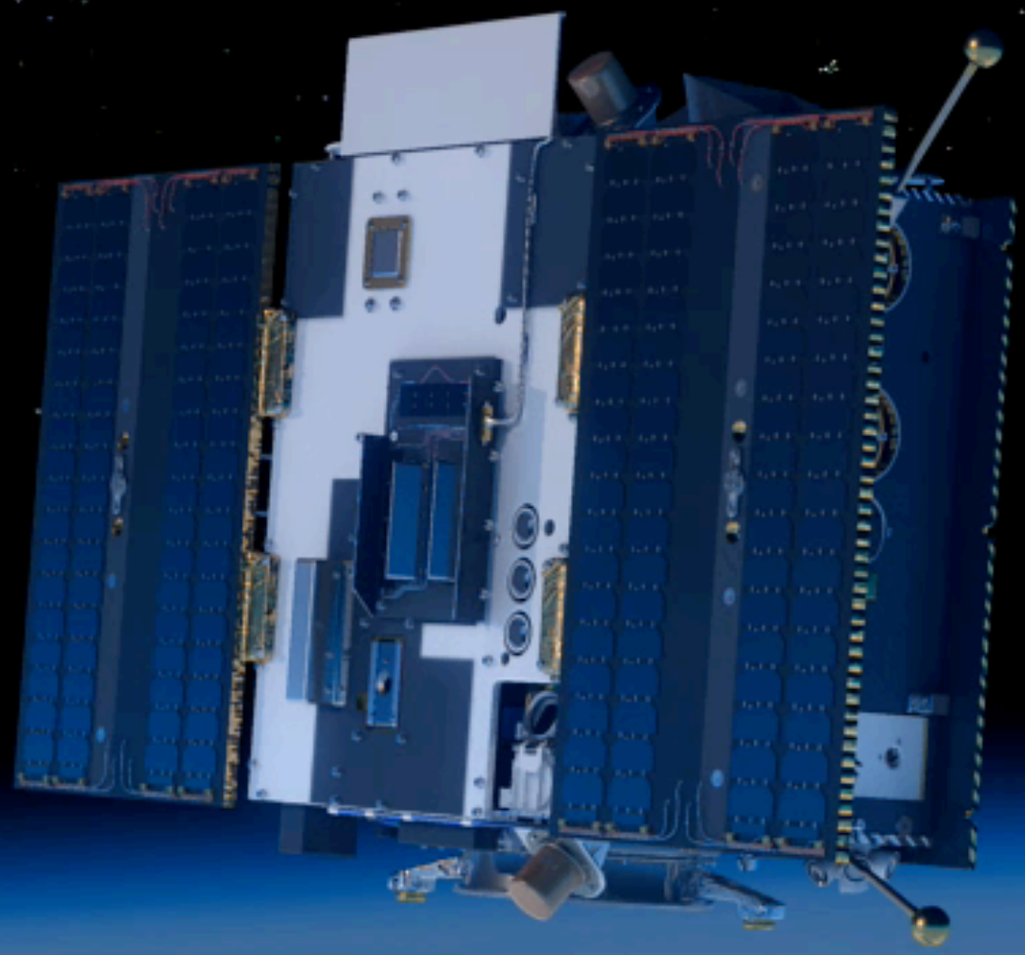
ONS ANTWOORD





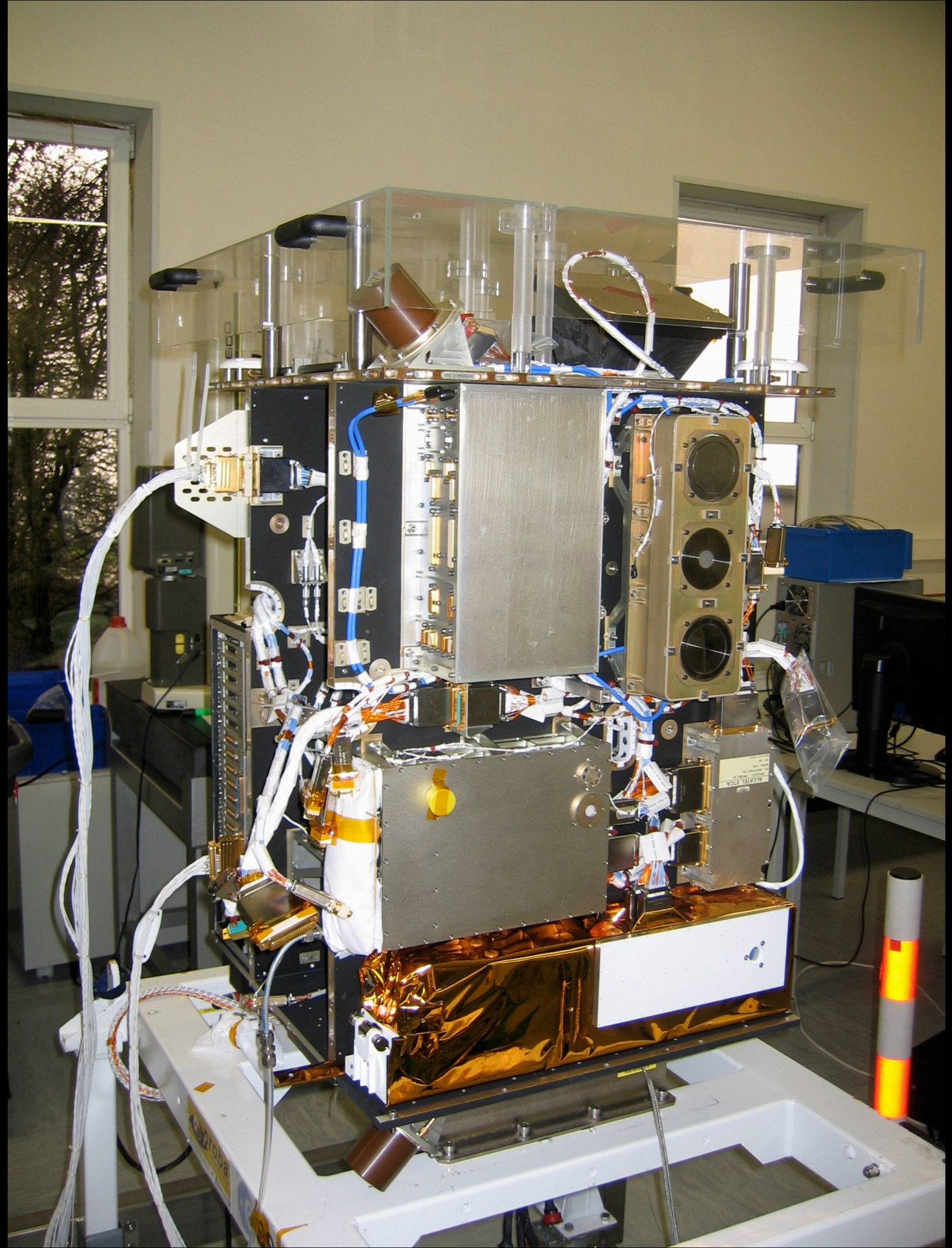
science - forecast - engineering

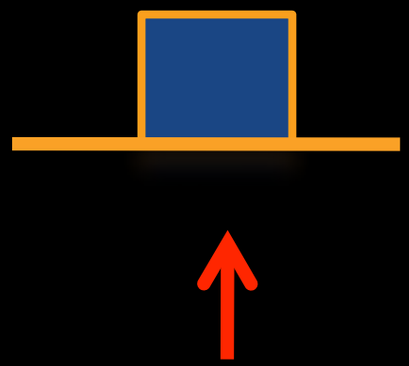
PROBA2, gebouwd in België
Instrumentenbeheer vanuit Brussel



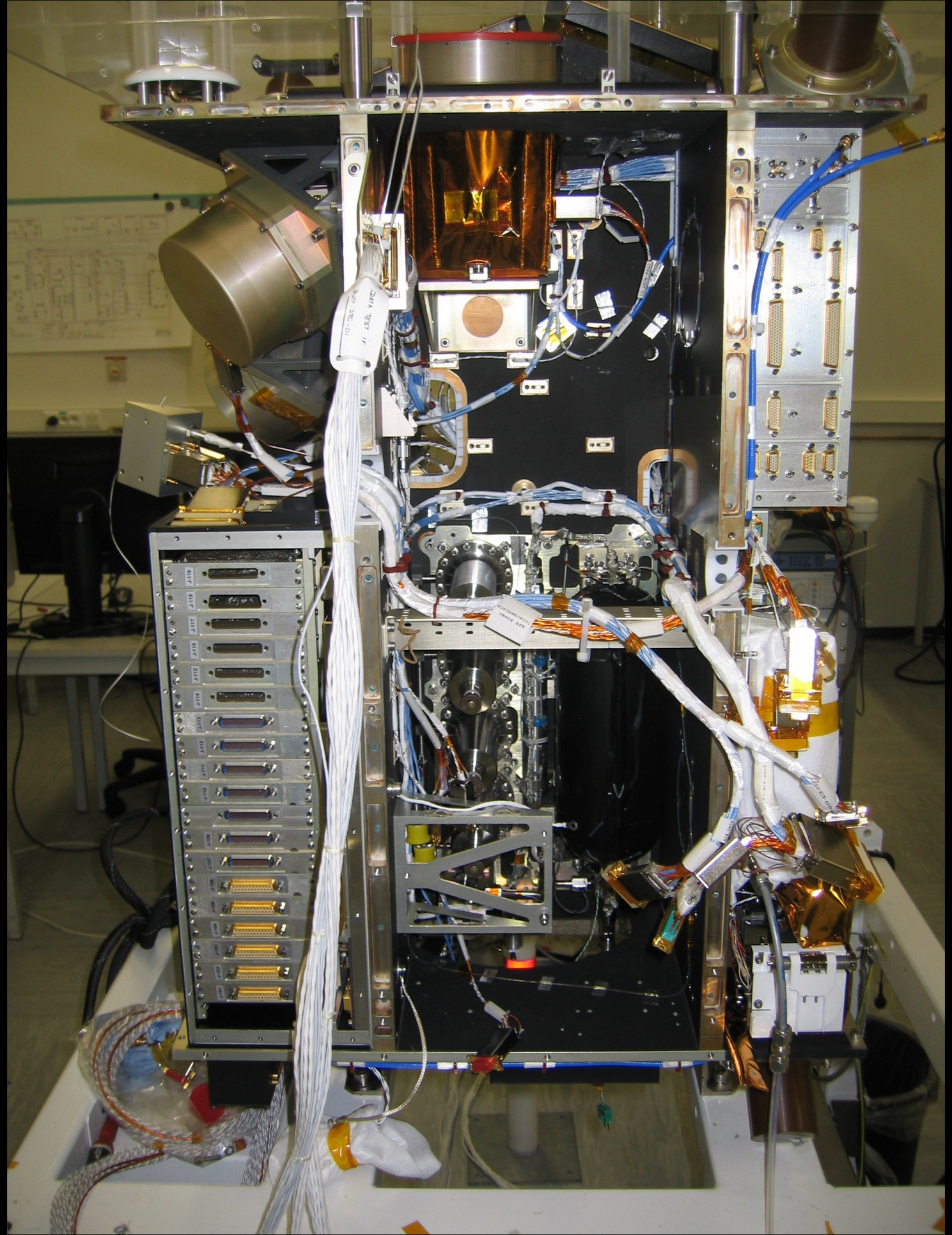




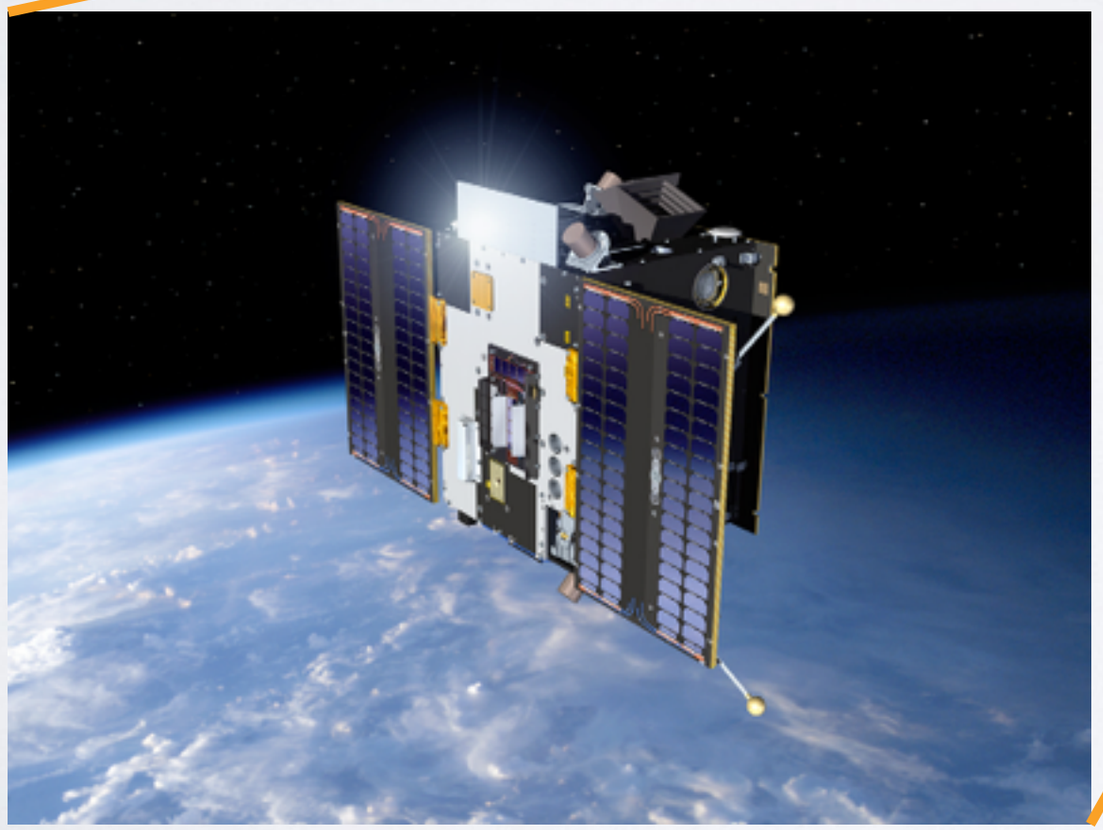


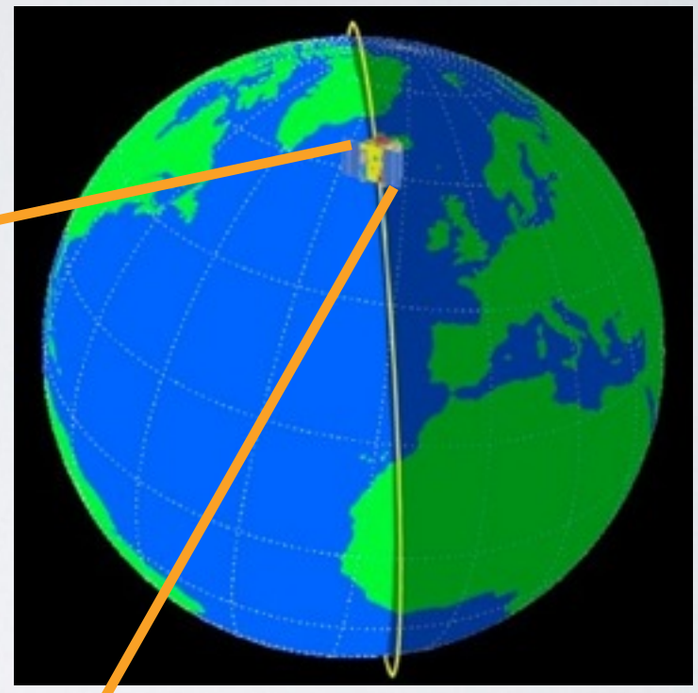






PROBA2

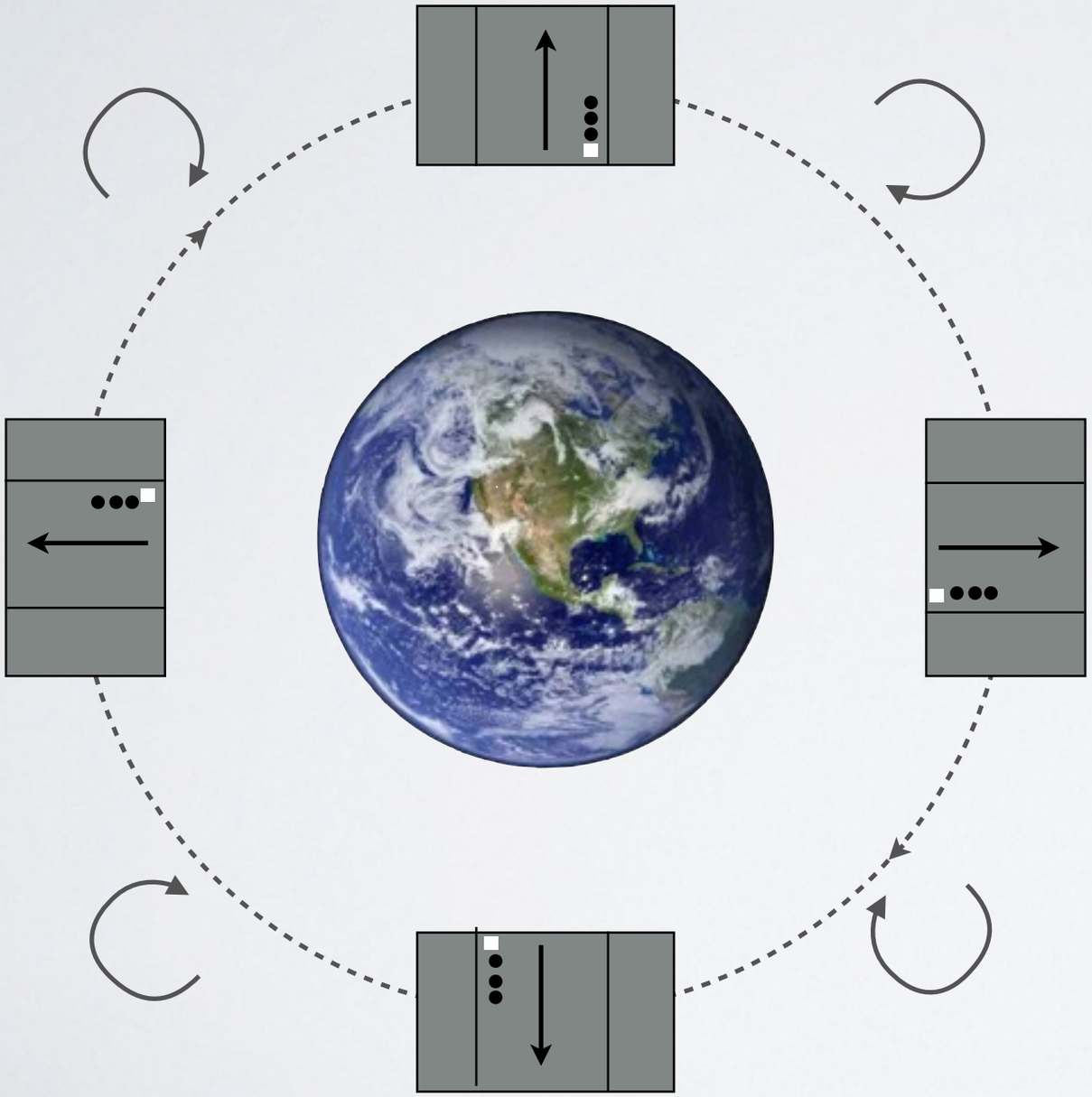


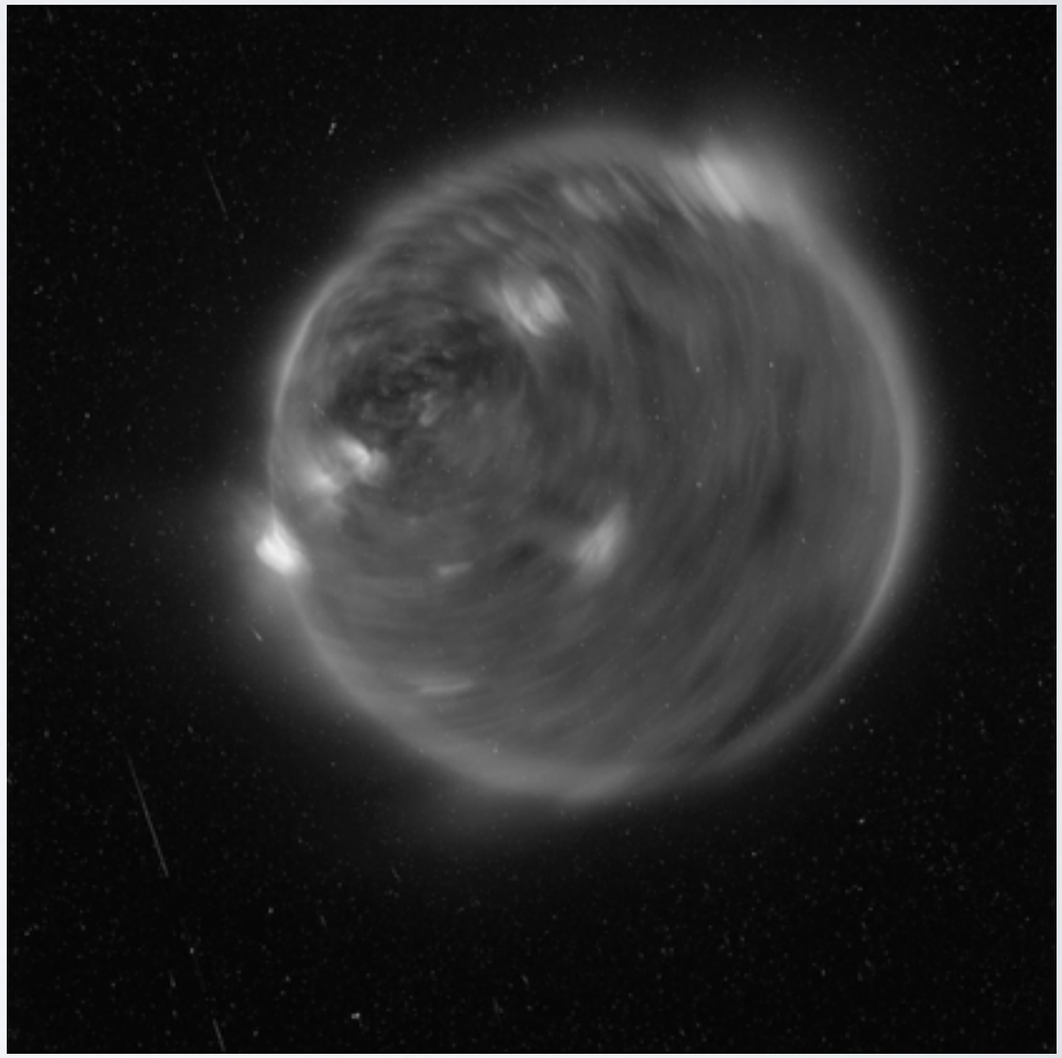


725 km hoogte

zon-synchrone baan
("dawn-dusk")

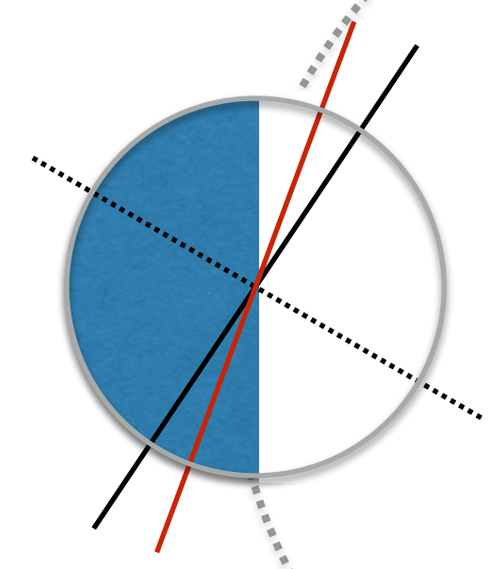
PROBA2 IN ZIJN BAAN





de hoek tussen de PROBA2 baan en de rotatie-as van de aarde is 8 graden

hoek tussen de rotatieas en lijn loodrecht op ecliptica is 23 graden



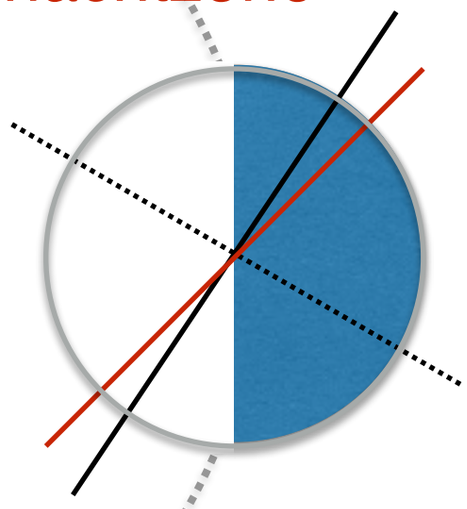
zomer

23-8 = 15 graden in de nachtzone

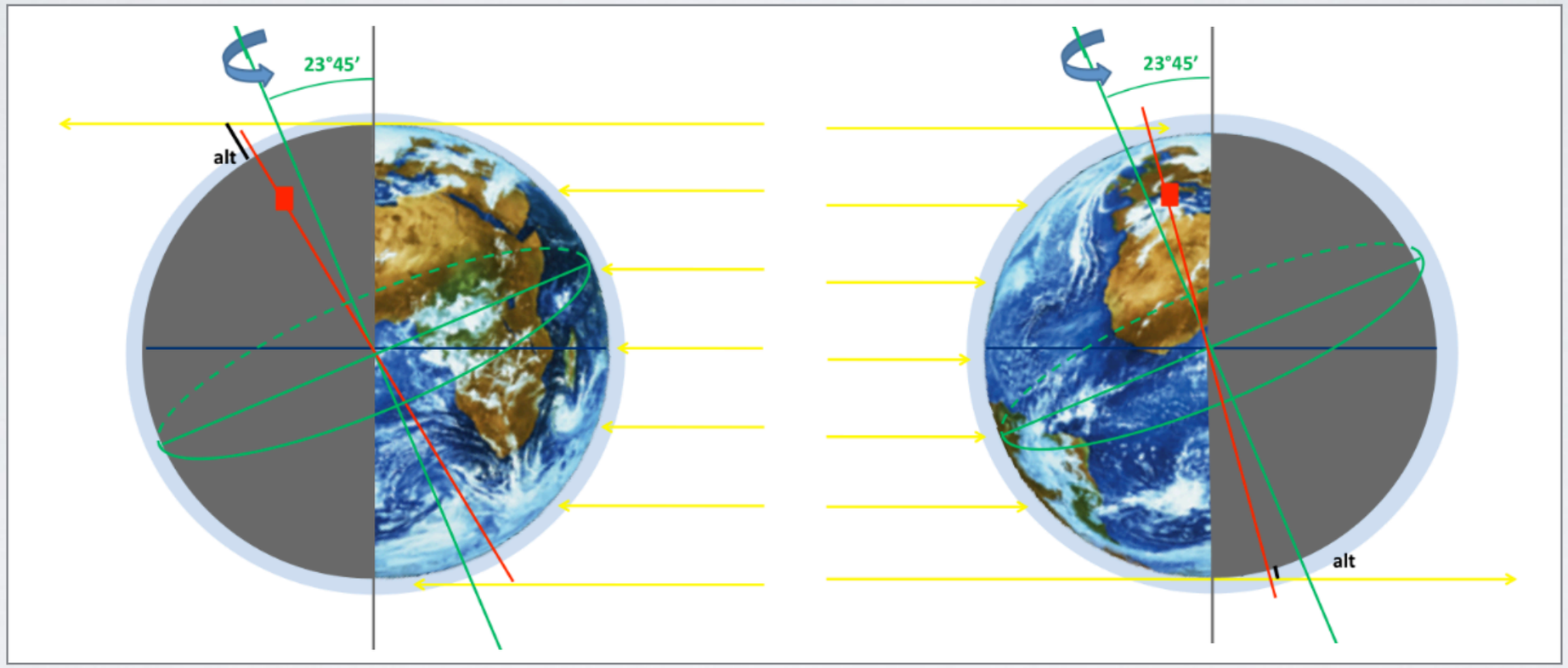


winter

23+8 = 32 graden in de nachtzone



ECLIPSSEIZOEN



2012 Nov 13 10:00:00 UTC
10000×langzamer

Aarde

Afstand: 25.513 km
Straal: 6.378,1 km
Observeerbare diameter: 23° 04' 26,1"
Fasehoek: 27,5°



Snelheid: 0,00000 m/s

Achtervolg Aarde
Zichtbaar veld:50° 00' 0,0" (

PROBA2/SWAP 174 Å

2012-04-16 18:28:24 SDO/AIA 171 Å

R_{Sun} 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6

ZONNEATMOSFEER

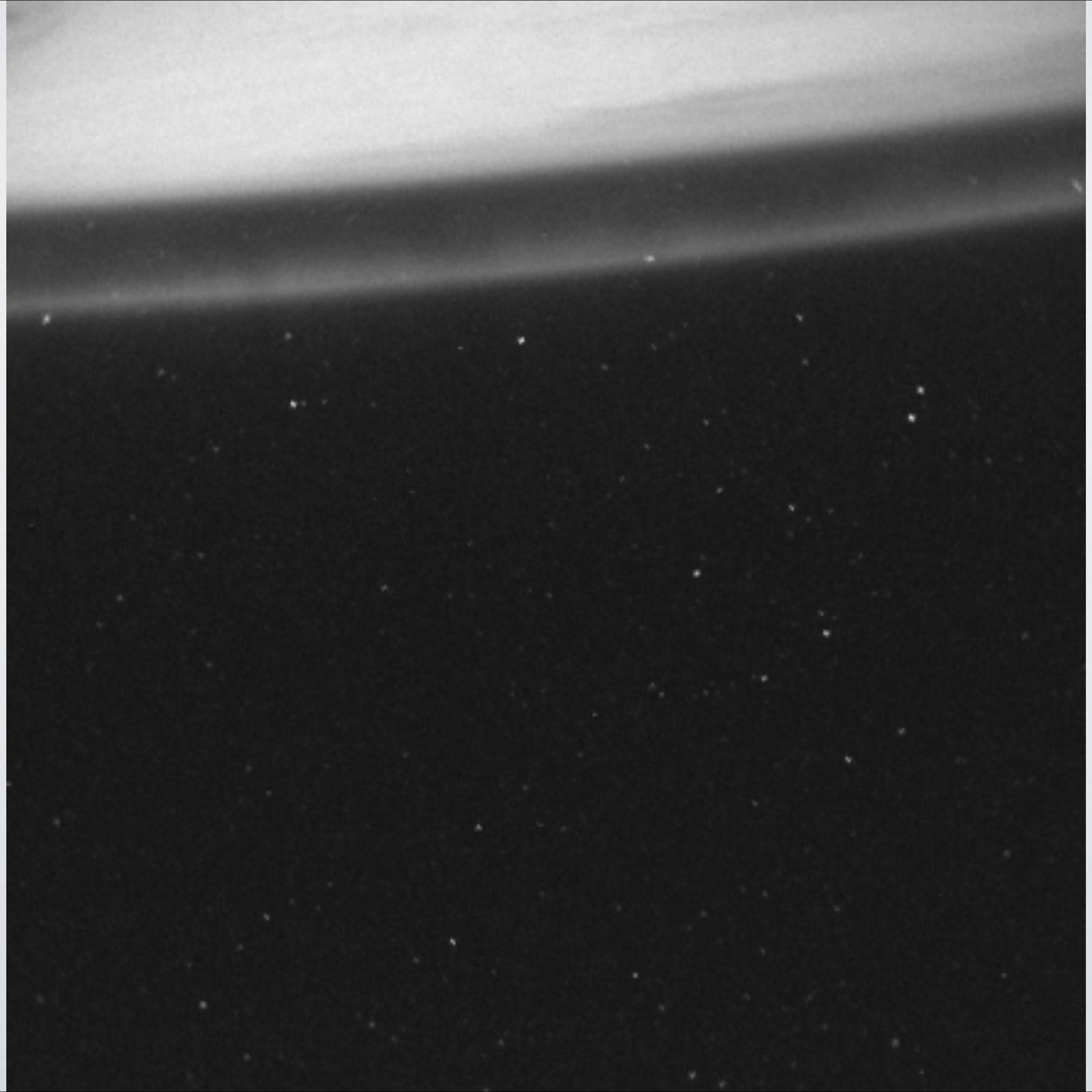


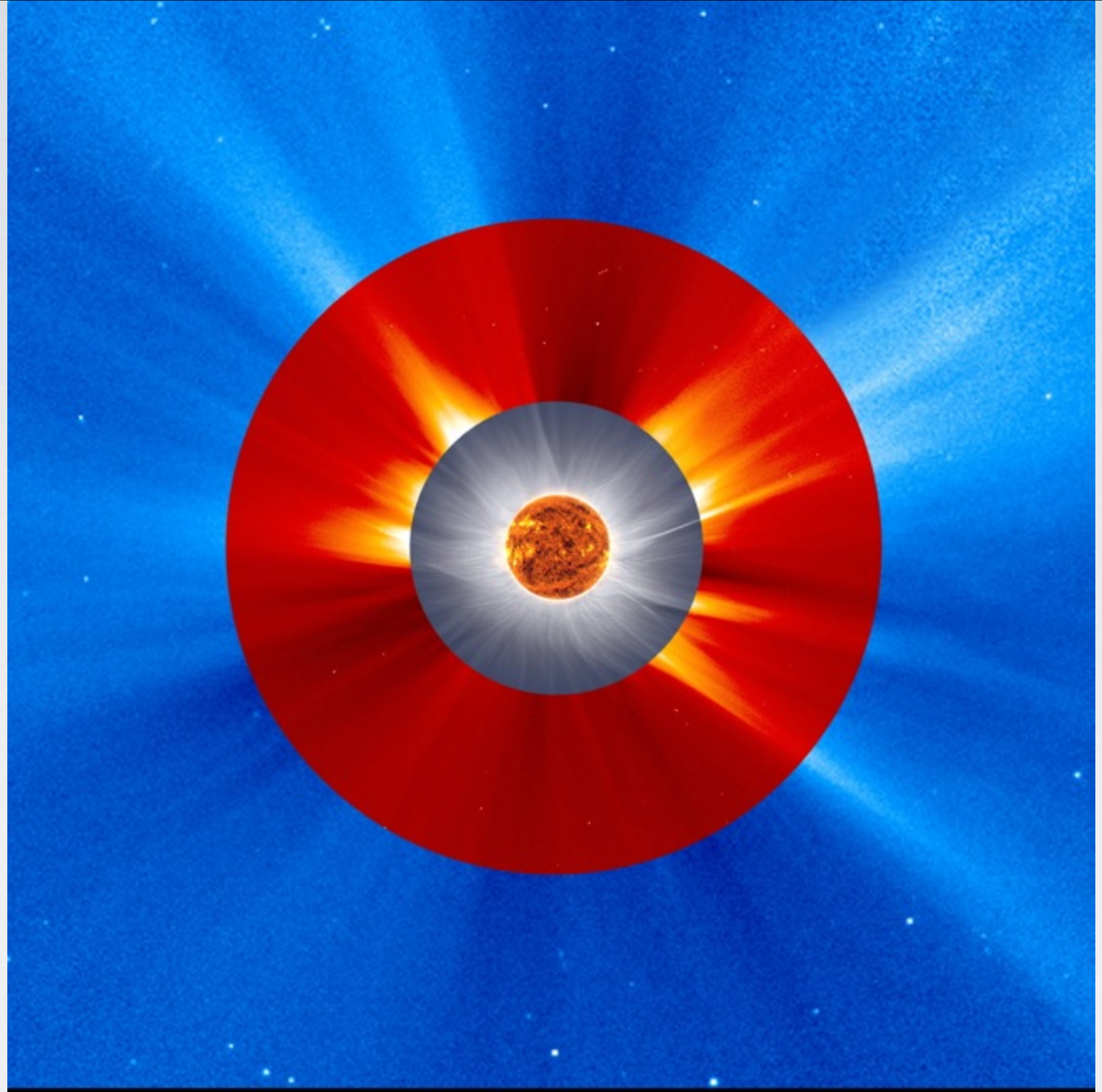
Image: Siberia 20080801
J.M.P., W. G. Wagner and H. Druckmüllerová

The atmosphere of the Sun is bigger than the Sun!



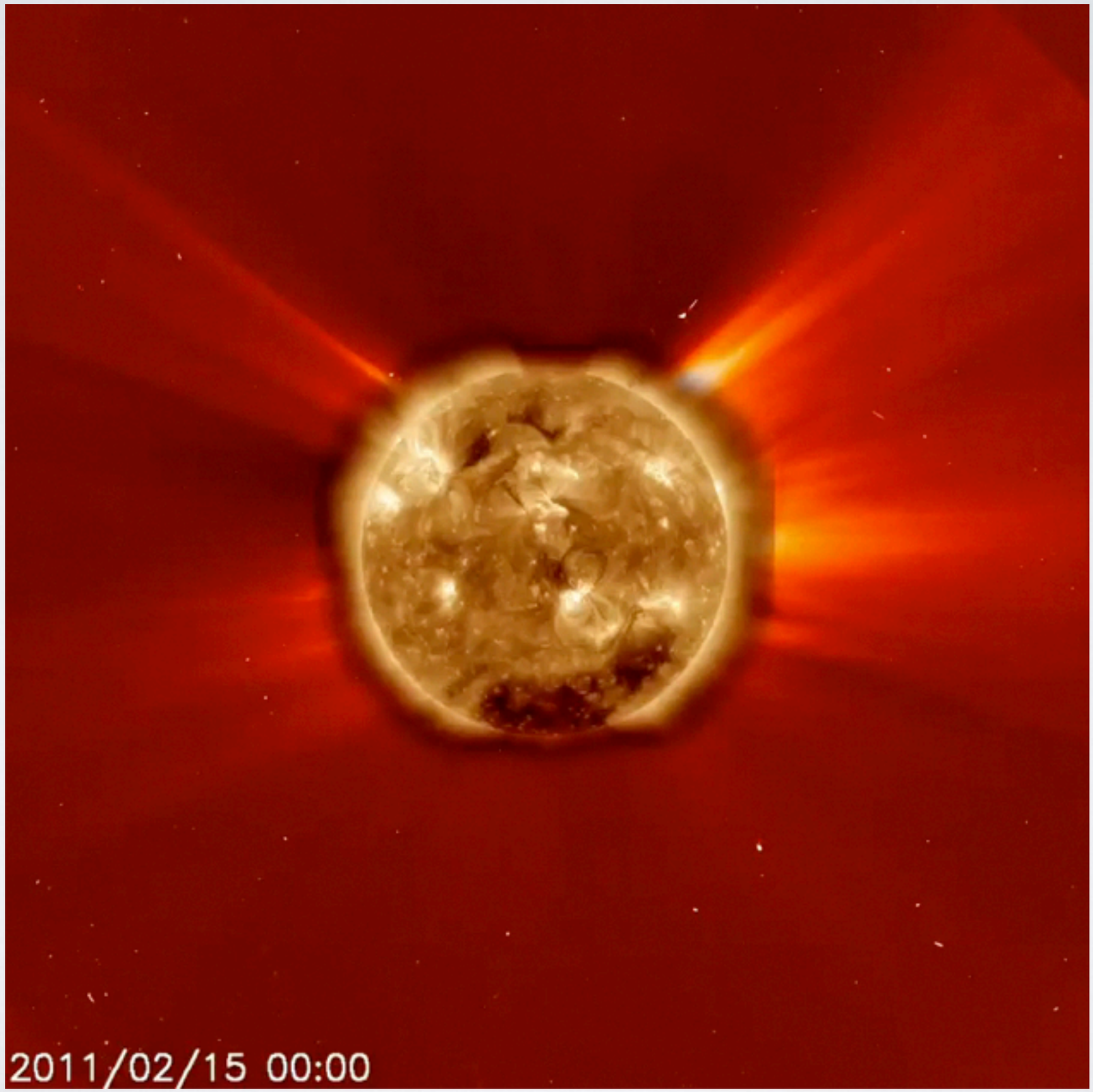
Image: Siberia 20080801
J.M.P., W. G. Wagner and H. Druckmüllerová



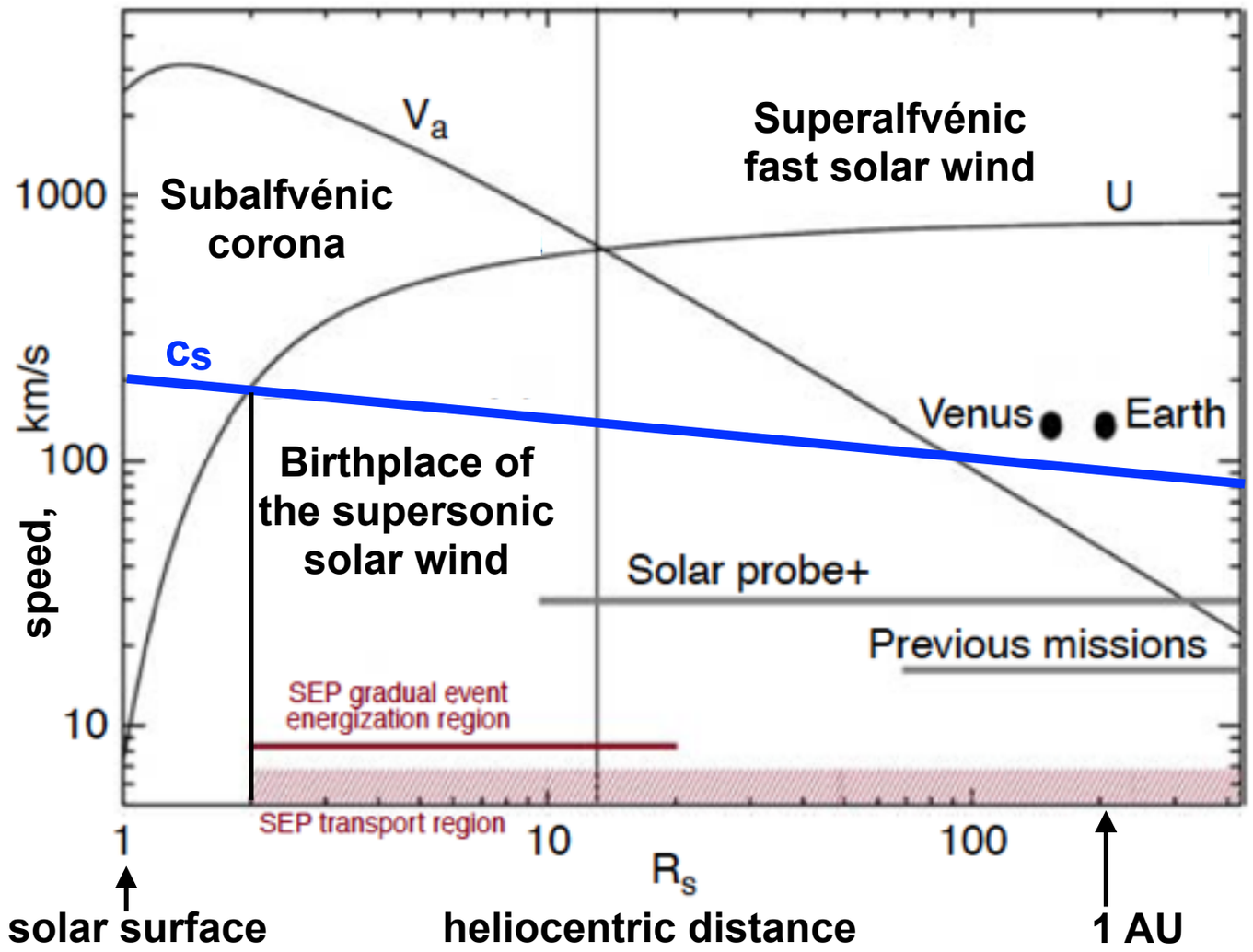


4-33 solar radii with LASCO-C3 instrument in white light, SOHO, ESA/NASA
2-6 solar radii with LASCO-C2 instrument in white light, SOHO, ESA/NASA
1-3 solar radii with ground-based images from: Adventdalen, Longyearbyen, Svalbard, Norway (K. Gazeas)
Solar disk in extreme ultraviolet light (30.4 nm), SDO/AIA, NASA
Solar disk in extreme ultraviolet light (17.4 nm), PROBA2/SWAP, ESA/ROB

HALO CME



INNER SOLAR CORONA



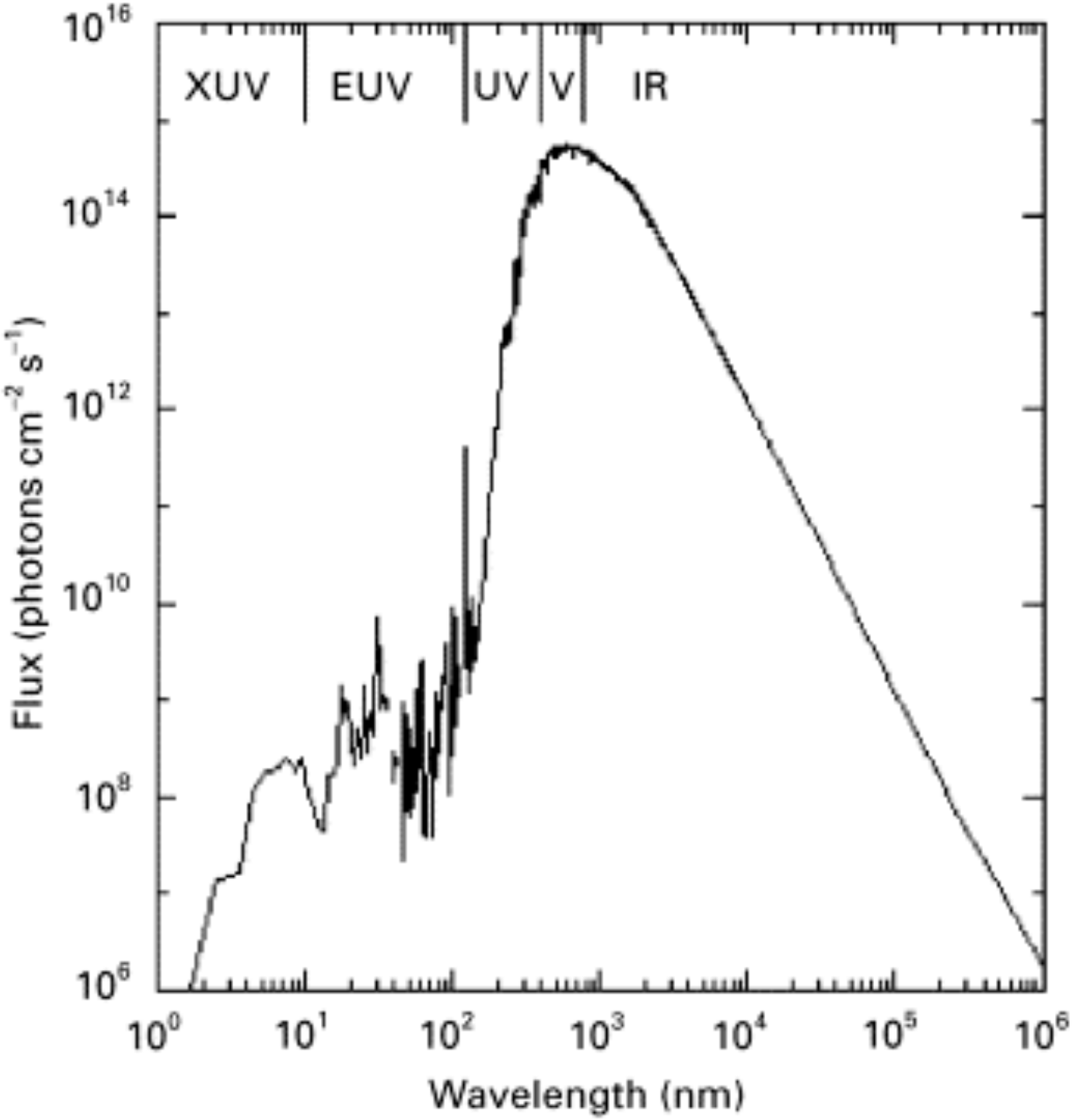
The solar wind becomes supersonic around 2-3 $R_\odot$ from the center of the Sun.

CMEs are also accelerated in this region.

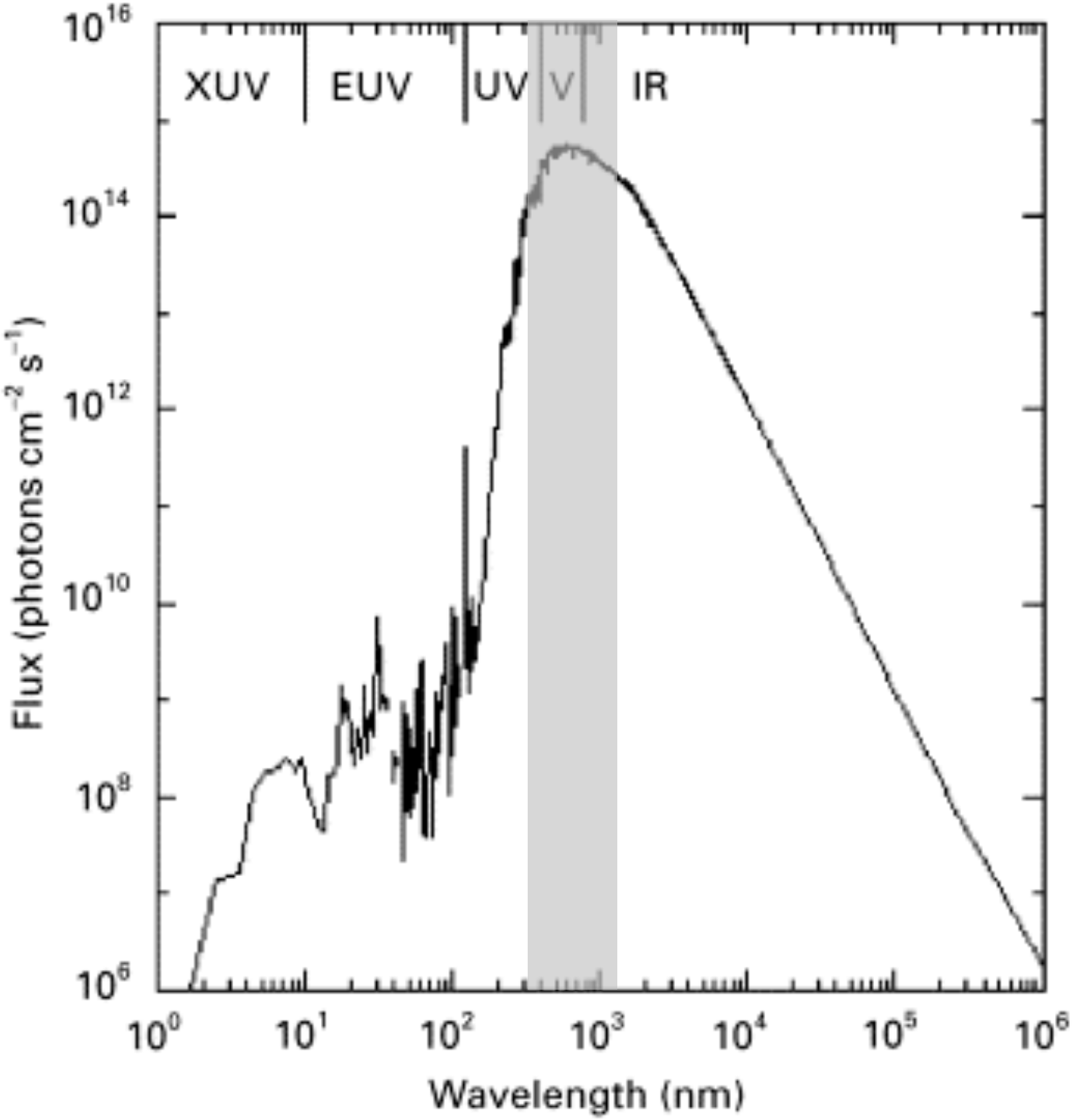
OBSERVEREN VAN DE ZONNECORONA

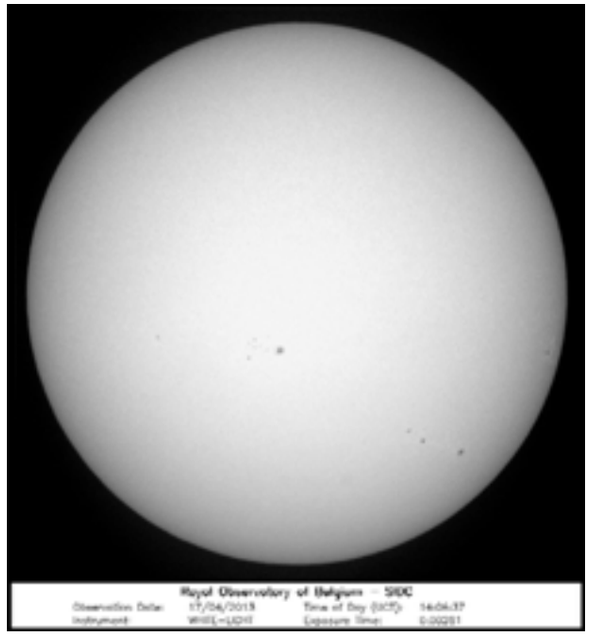
- wait for the next total solar eclipse
- get rid of the bright visible disk by blocking it off by an occultor
- get rid of the bright visible disk by looking at corona-light (EUV & X-rays) only
- fly into it and measure it locally

EUV imagers



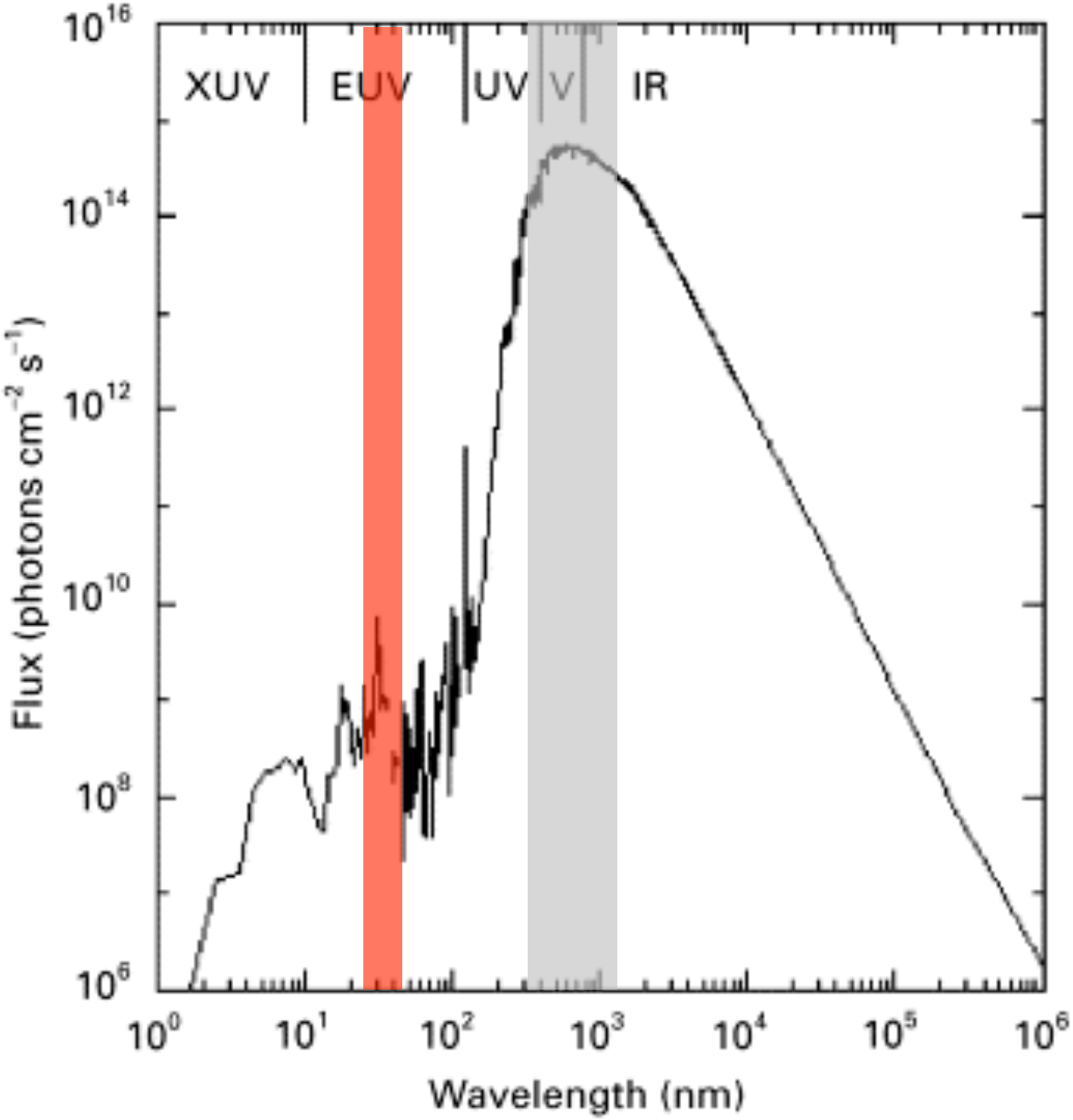
SOLAR2000, Tobiska 2000

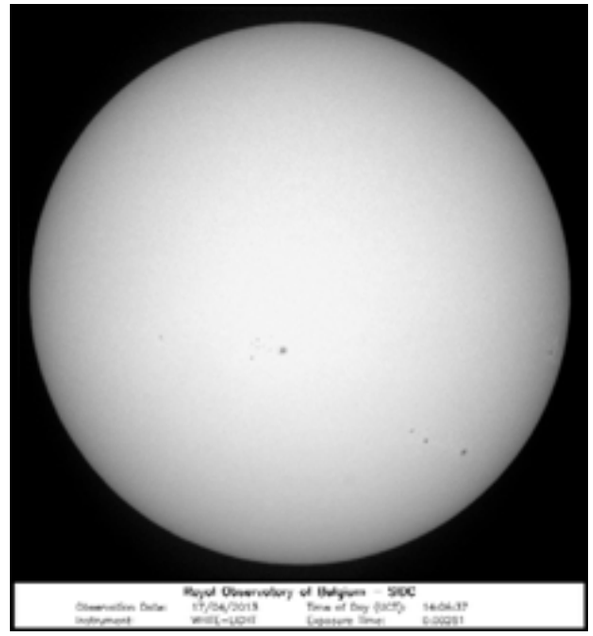




5700K

SOLAR2000, Tobiska 2000





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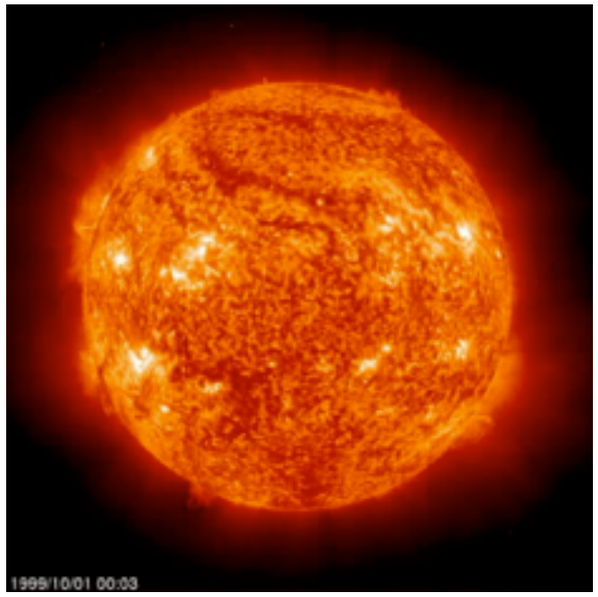

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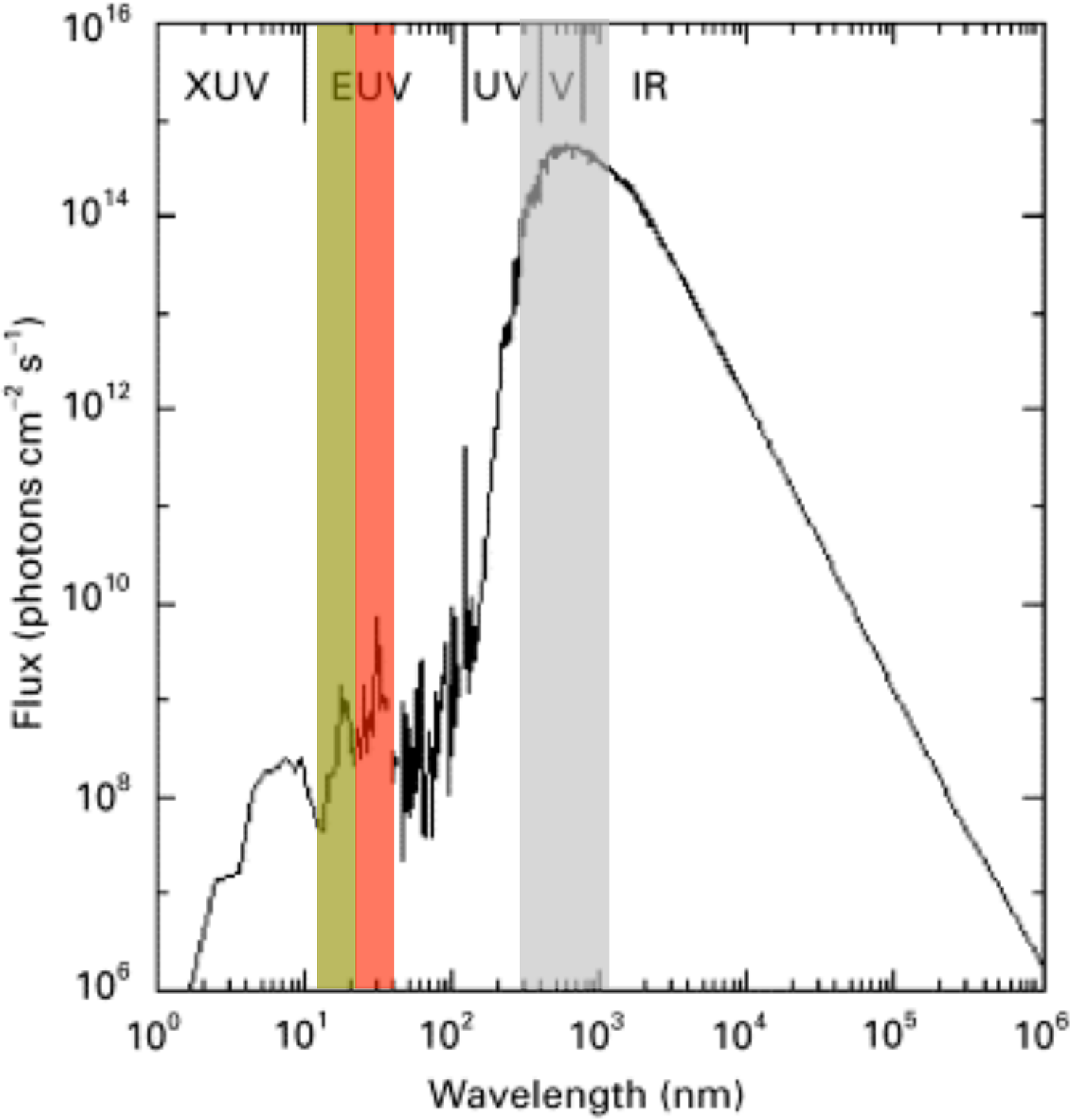
[SOLAR2000, Tobiska 2000]



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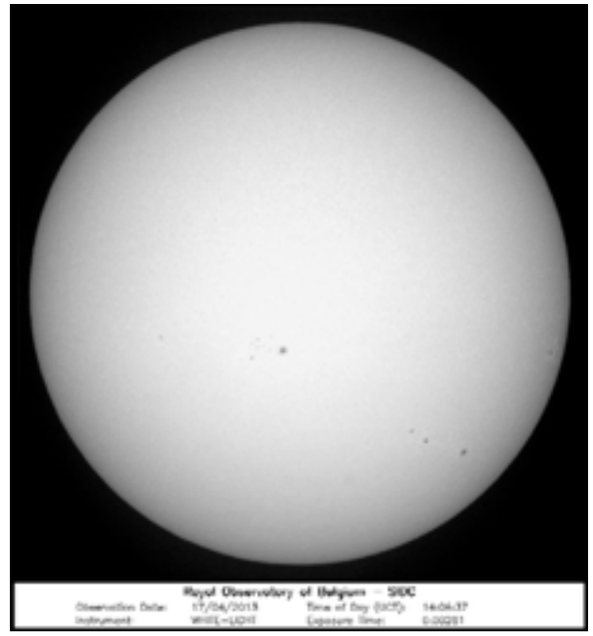
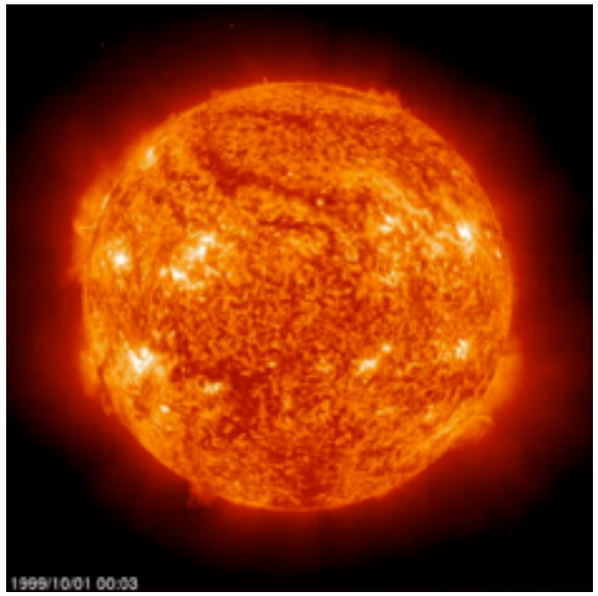
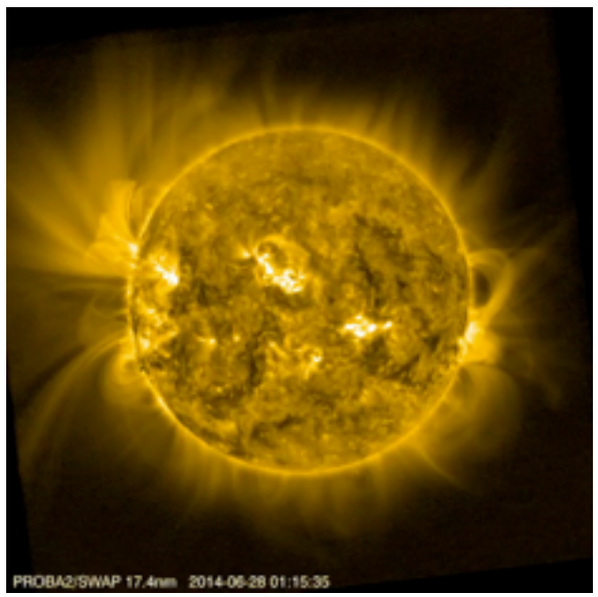


5700K



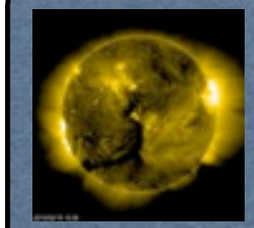
80000K



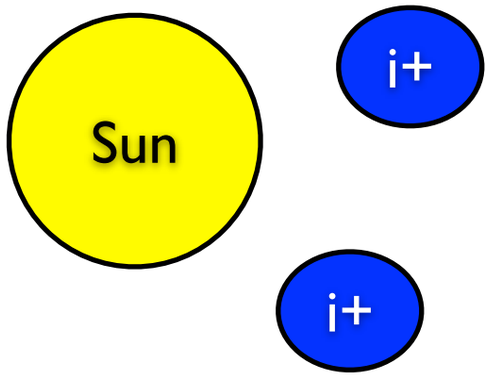
few MK

Sun

filter for EUV
only specific T
visible



EUV
telescope



collected light is emitted by ions ~ (density)^2

filter for EUV only specific T visible



collected light is emitted by ions ~ (density)^2

Sun

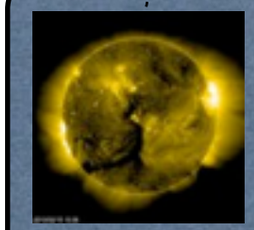
i+

i+

All emission along the line of sight is summed up equally

i+

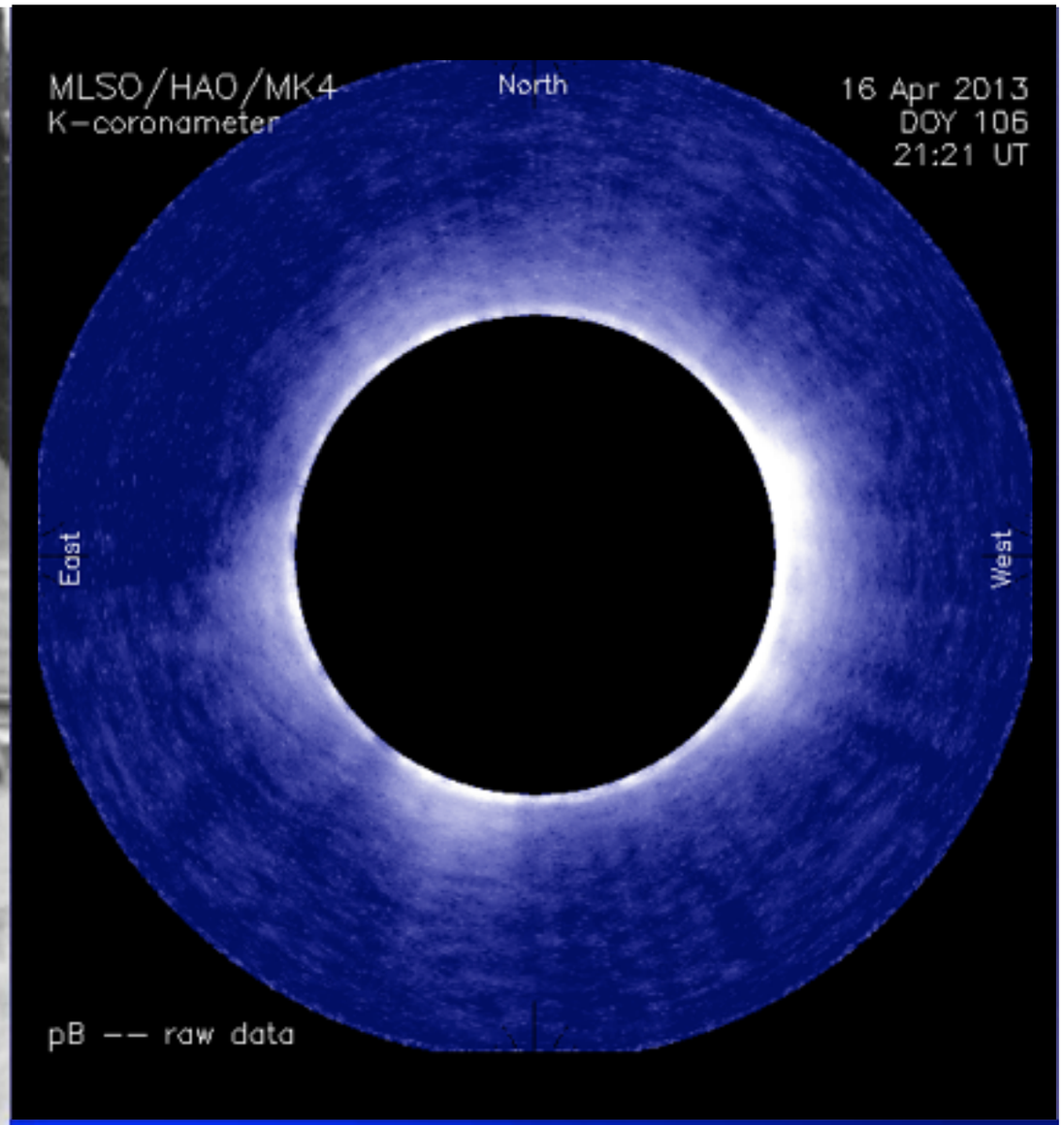
filter for EUV only specific T visible



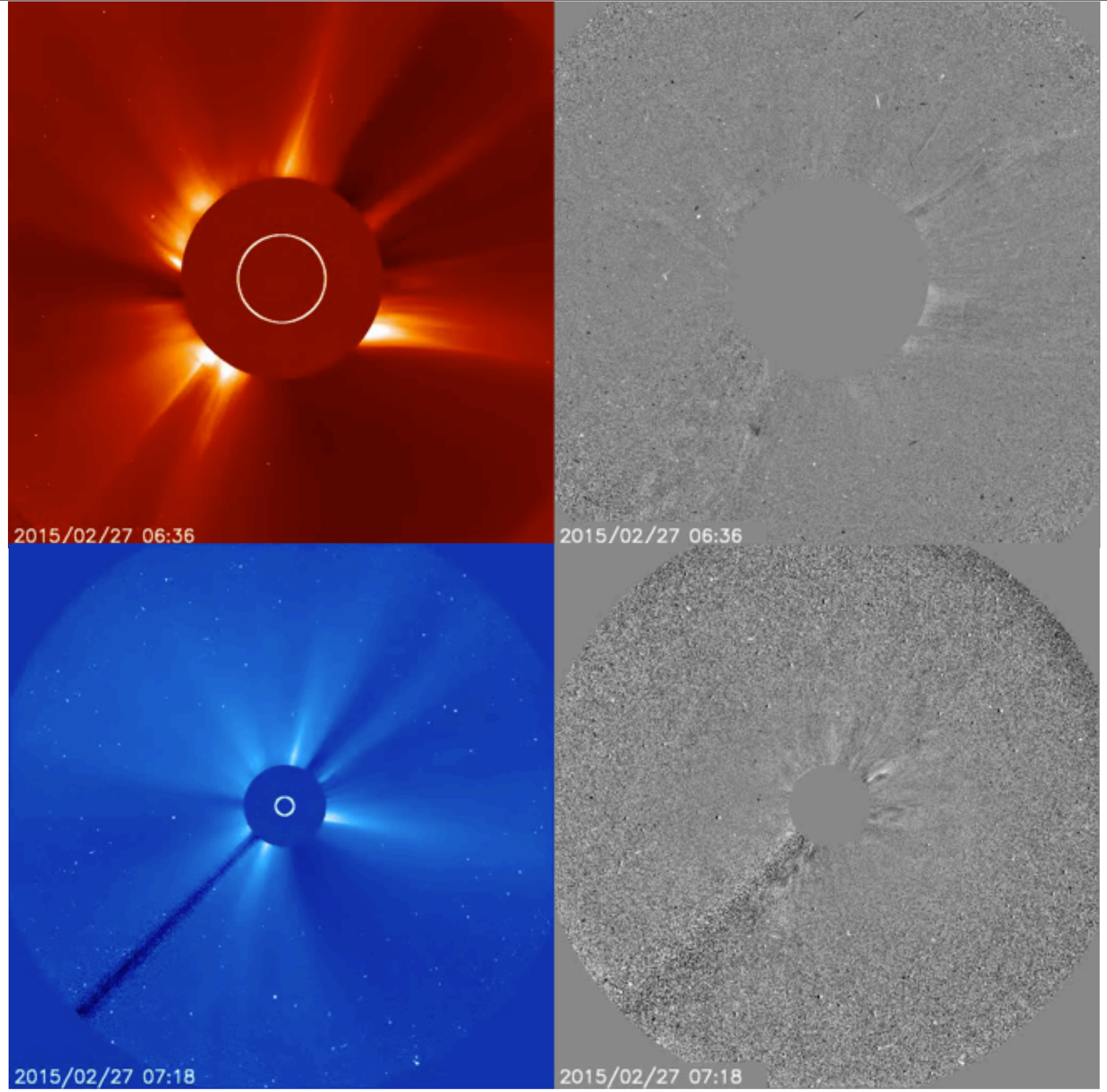
EUV telescope

coronagraphs





Bernard Lyot, 1939, at Pic du Midi
French Astronomer
Inventor of the Coronagraph



SOHO / LASCO c2&c3 running difference

collected light is emitted by ions ~ (density)^2

Sun

i+

i+

All emission along the line of sight is summed up equally

i+

filter for EUV only specific T visible

EUV telescope

Sun

occulter

visible light

Corona-graph

collected light is emitted by ions
~ (density)^2

Sun

i+

i+

All emission along the line of sight is summed up equally

i+

filter for EUV only specific T visible

EUV telescope

collected light is refracted on electrons ~(density)

Sun

e-

occulter

visible light

Corona-graph

collected light is emitted by ions ~ (density)^2

Sun

i+

i+

All emission along the line of sight is summed up equally

i+

filter for EUV only specific T visible

EUV telescope

e-

e-

e-

Sun

collected light is refracted on electrons ~(density)

e-

occulter

visible light

Corona-graph

collected light is emitted by ions ~ (density)^2

Sun

i+

i+

All emission along the line of sight is summed up equally

i+

filter for EUV only specific T visible

EUV telescope

e-

e-

Sun

collected light is refracted on electrons ~(density)

e-

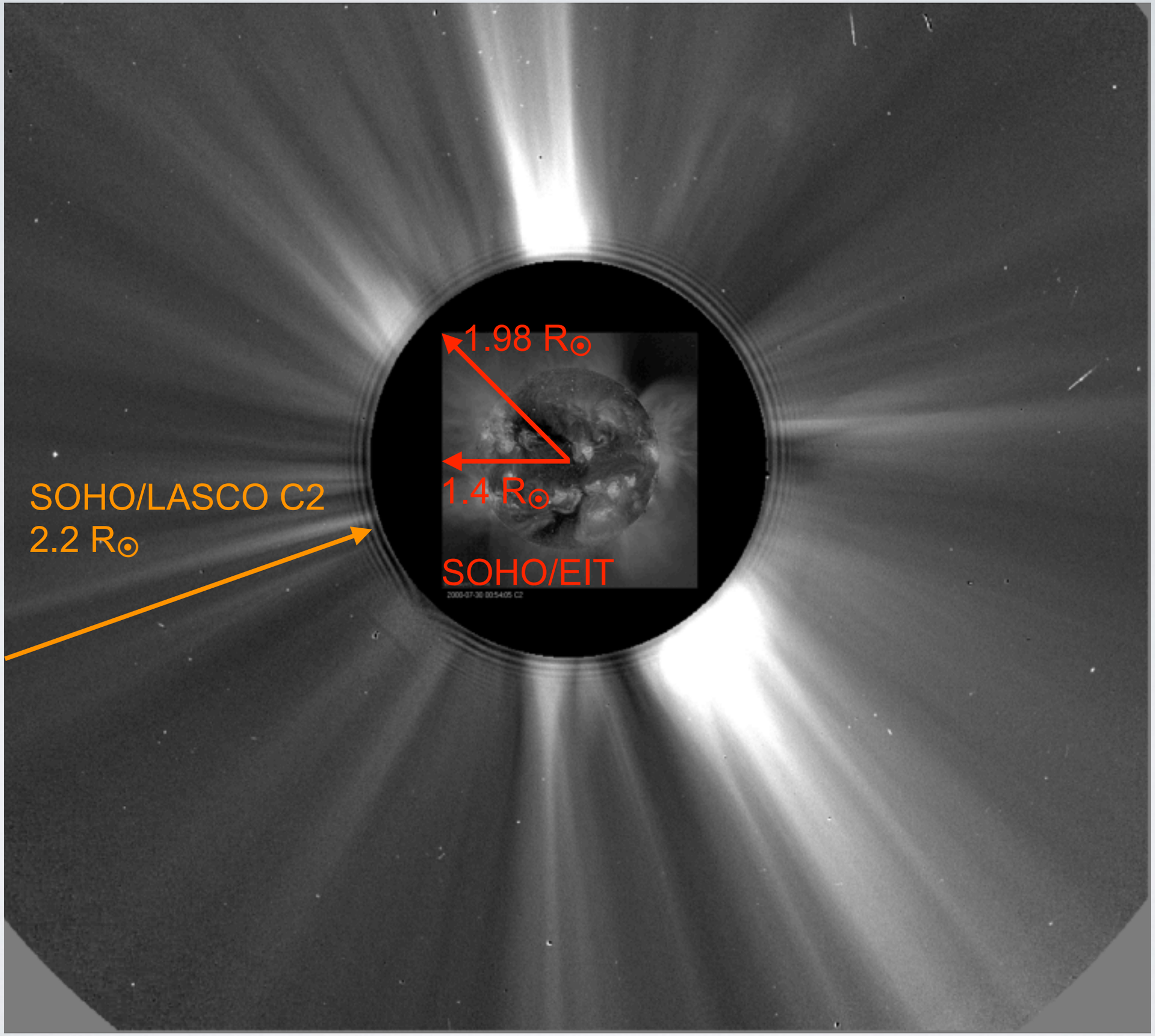
e-

All emission along the line of sight is summed up but not equally

occulter

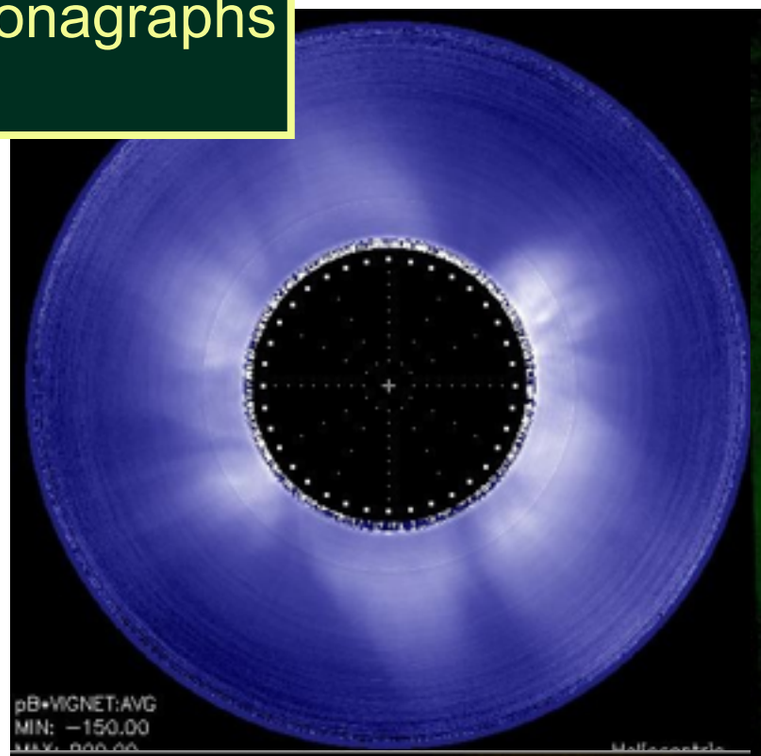
visible light

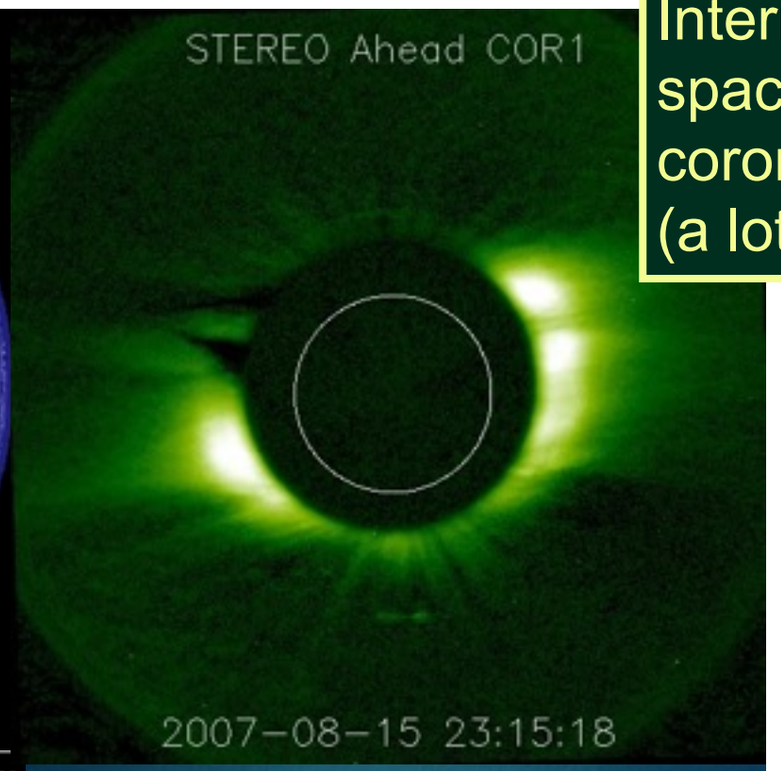
Corona-graph


1.98 R⊙
1.4 R⊙
SOHO/EIT
SOHO/LASCO C2
2.2 R⊙

BEPERKINGEN

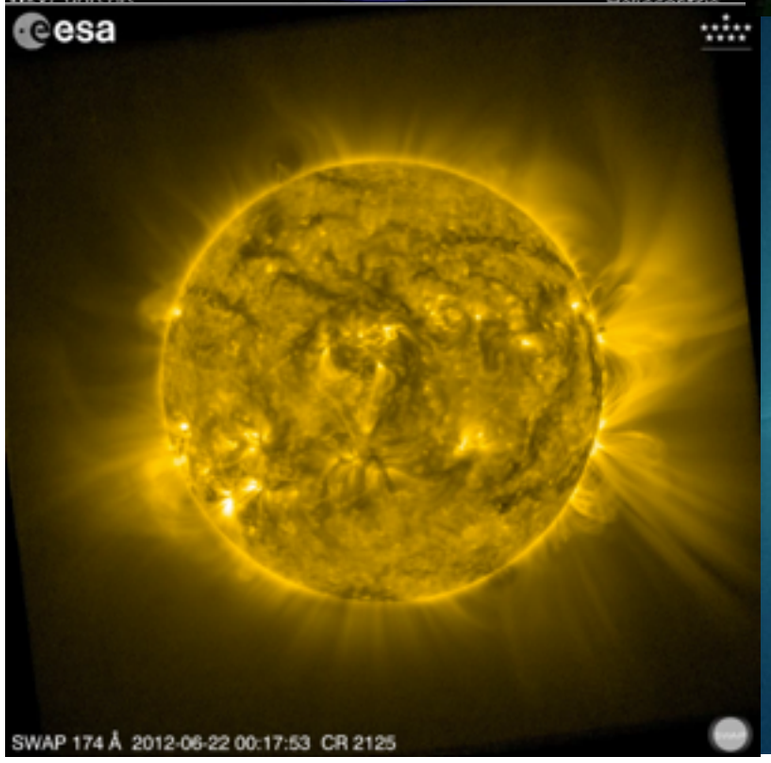
Ground-based coronagraphs
(a lot of straylight)

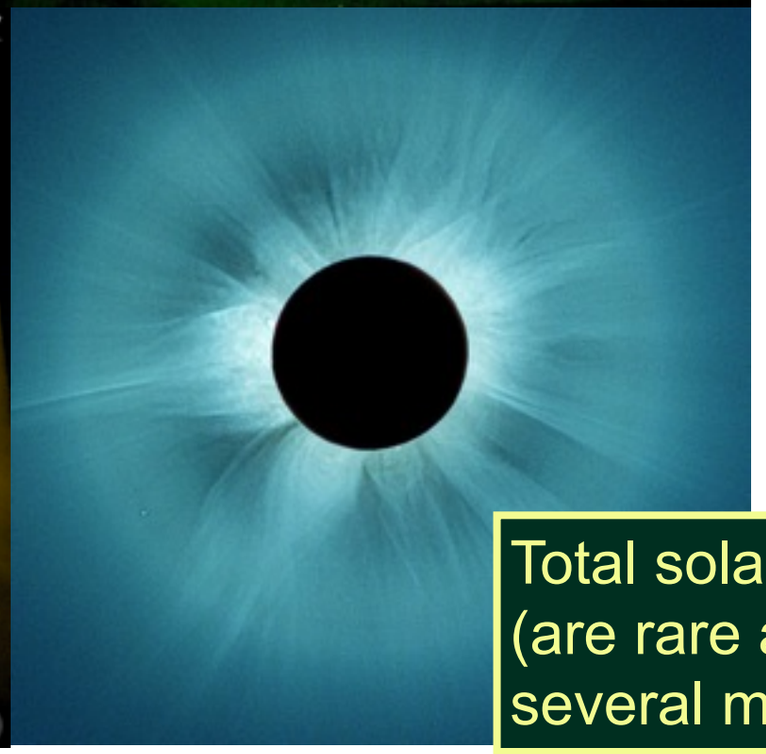




Internally occulted
space-borne
coronagraphs
(a lot of straylight)

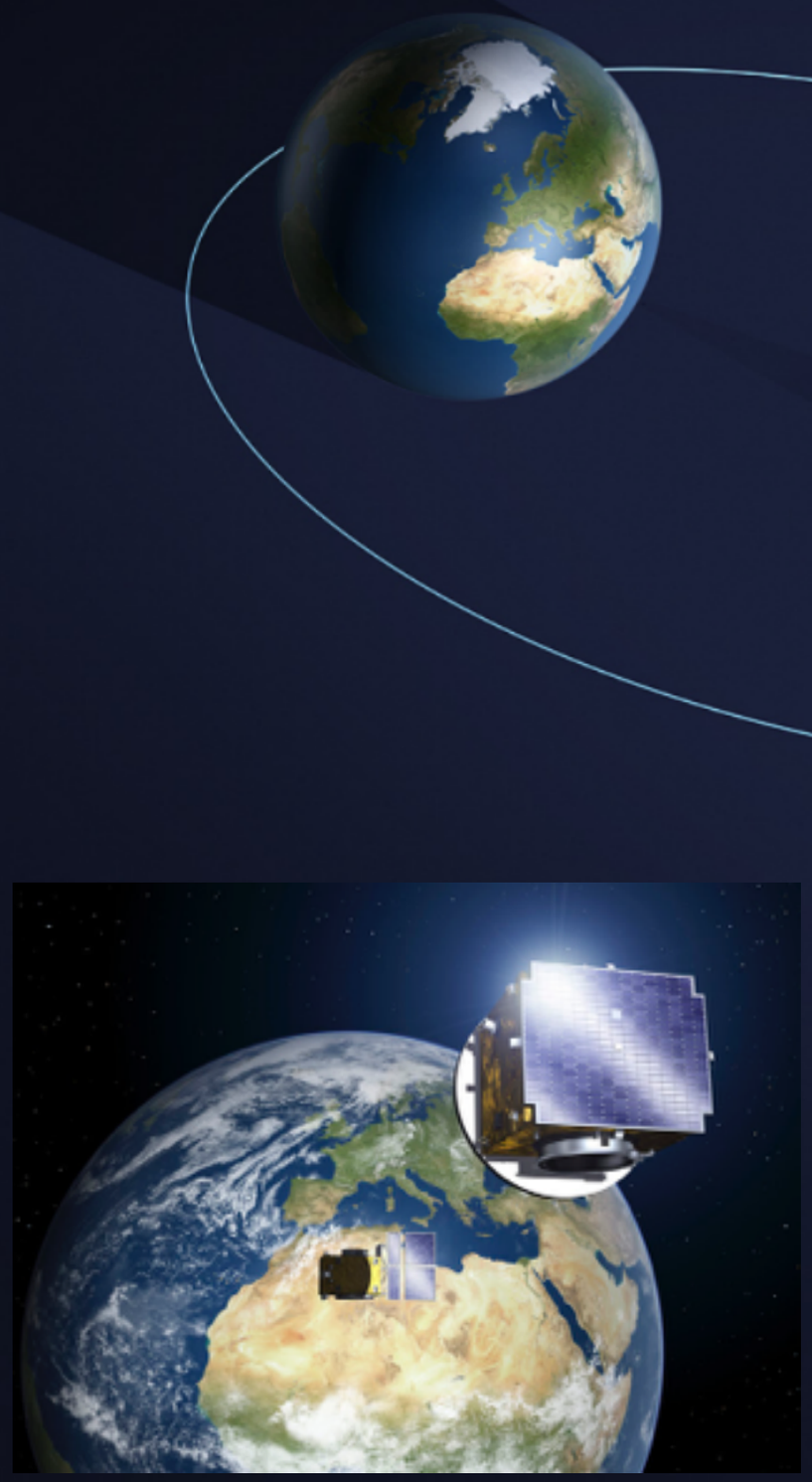
Wide field-of-view
EUV imagers
(very long
exposure times)



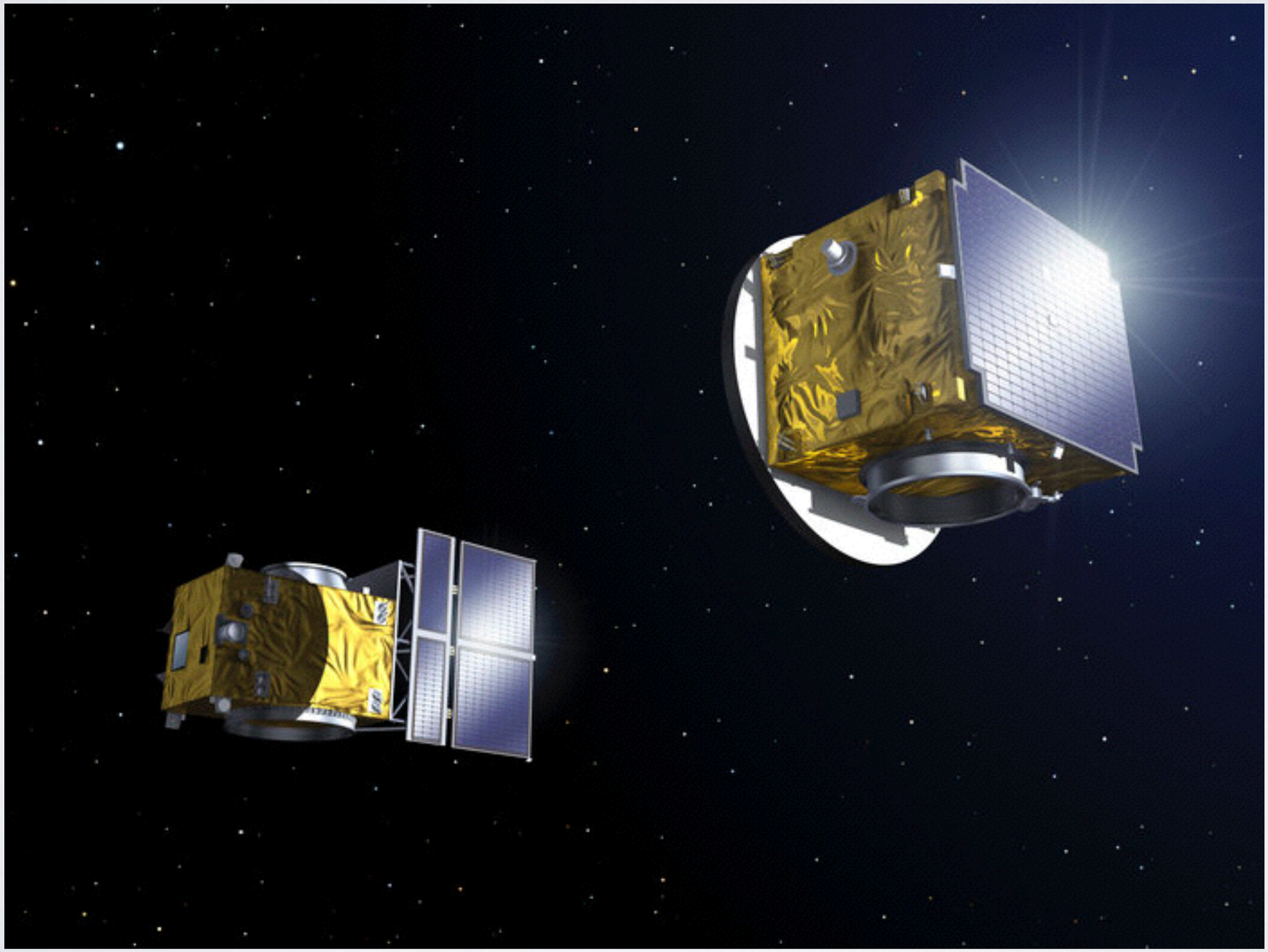


Total solar eclipses
(are rare and last only
several minutes)

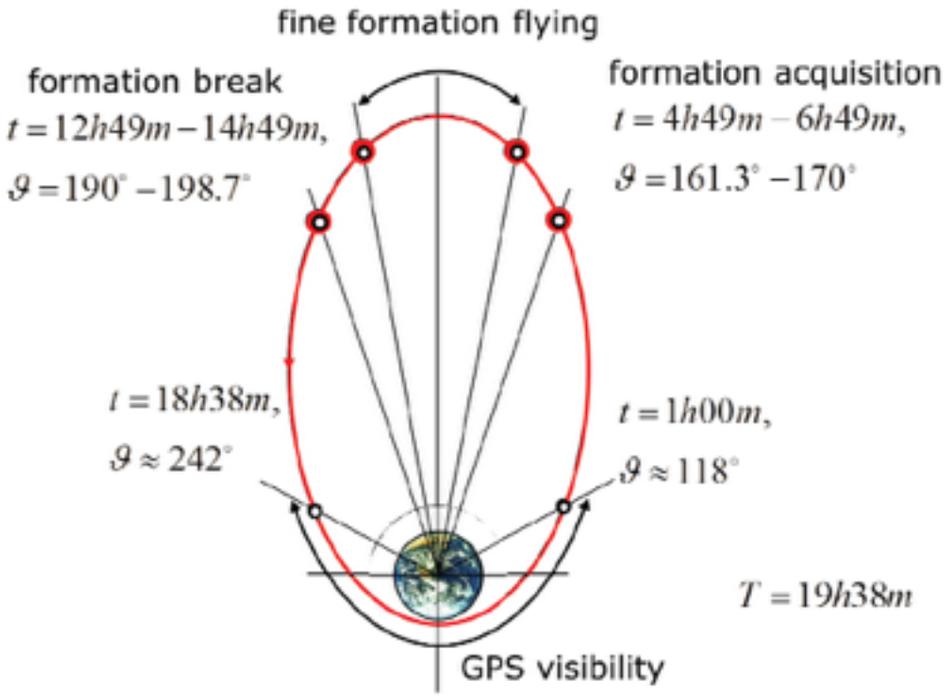
PROBA 3

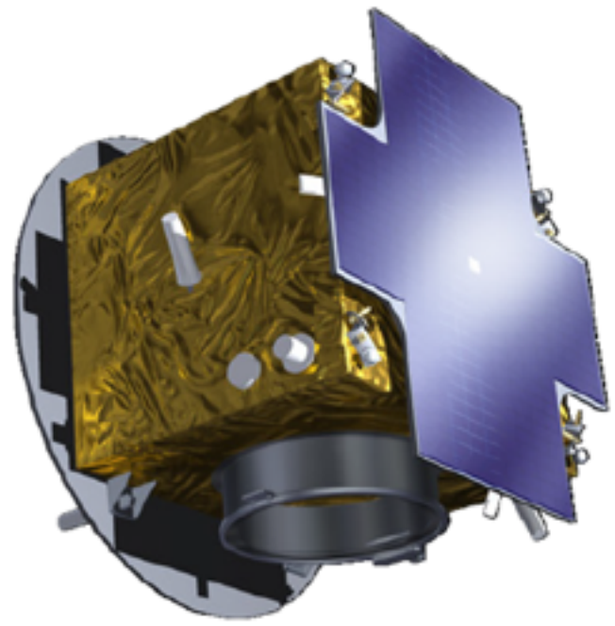


FORMATIEVLUCHT

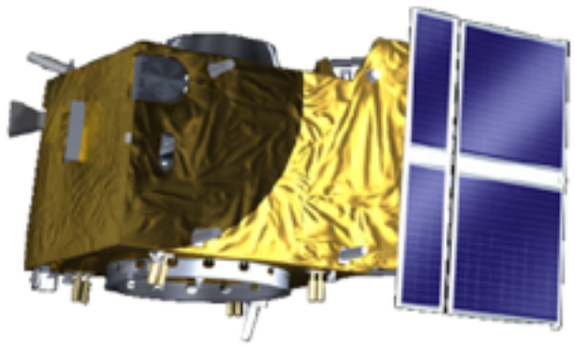


THE ULTIMATE CORONAGRAPH





towards the Sun



- The formation flying is maintained over 6 hours in every 20-hour orbit: *around a factor 100 improvement* in the duration of uninterrupted observations in comparison with a total eclipse.

- A technological challenge: the distance between the spacecraft is 150 m, and the accuracy of their positioning should be around a few millimeters!

2018

