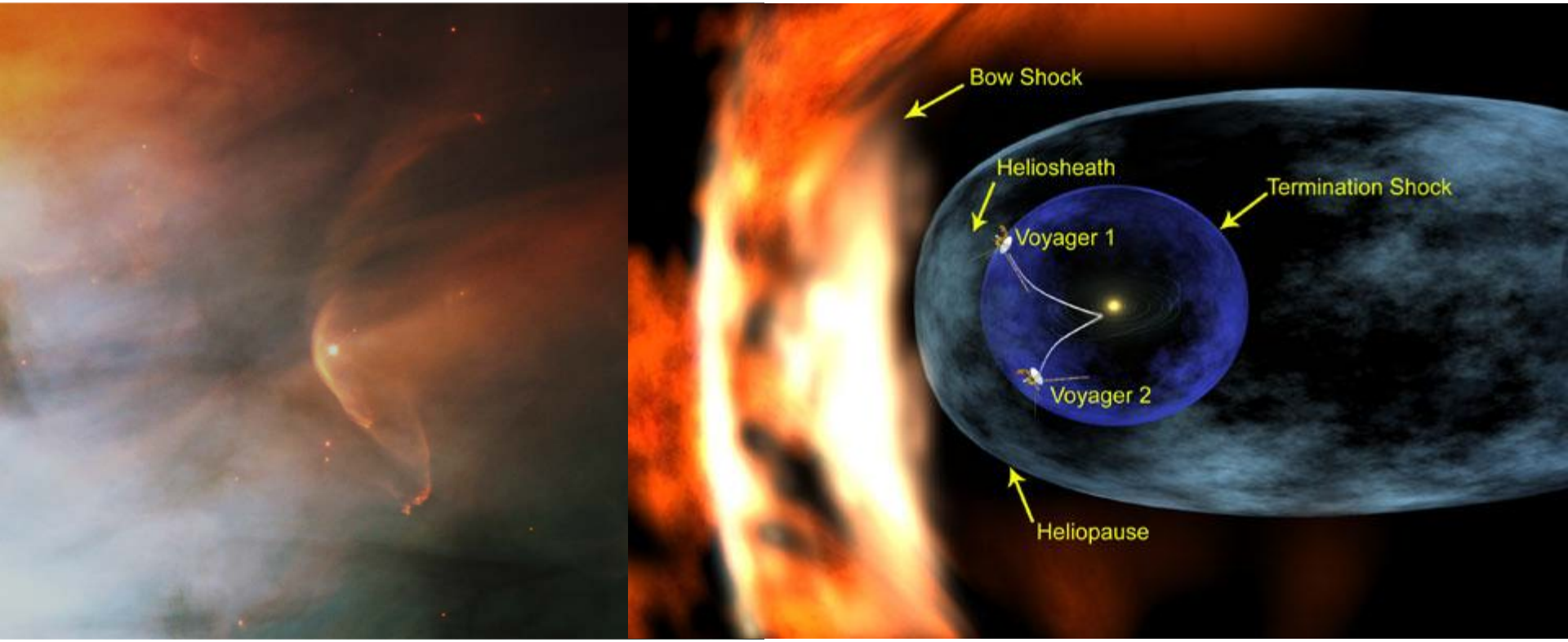
Solar Orbiter & RPW (Radio & Plasmas Waves) instrument Status

Joint RPW/FIELDS consortium Meeting,
6th November 2017, Meudon

Solar Orbiter – The mission to understand how the Sun creates and controls the Heliosphere



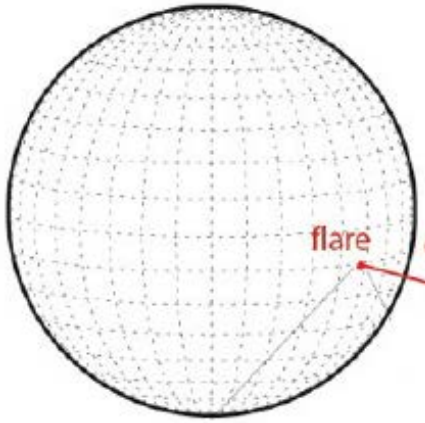
Courtesy Craig deForrest

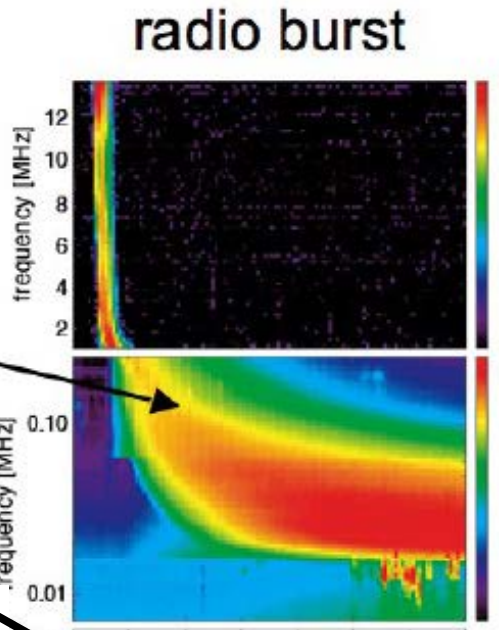


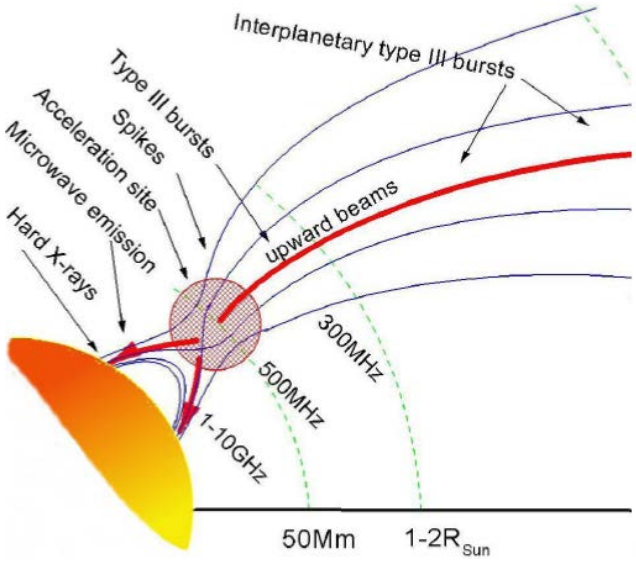
The top level science questions of the mission are

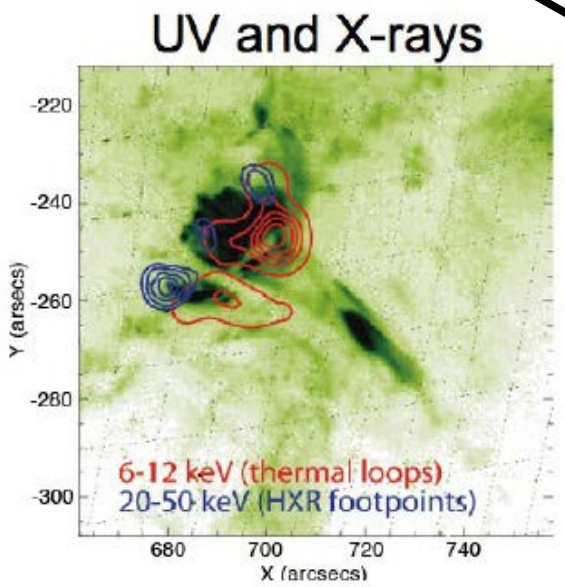
- What drives the solar wind and where does the coronal magnetic field originate from?
- How do solar transients drive heliospheric variability?
- How do solar eruptions produce energetic particle radiation that fills the heliosphere?
- How does the solar dynamo work and drive connections between the Sun and the heliosphere?

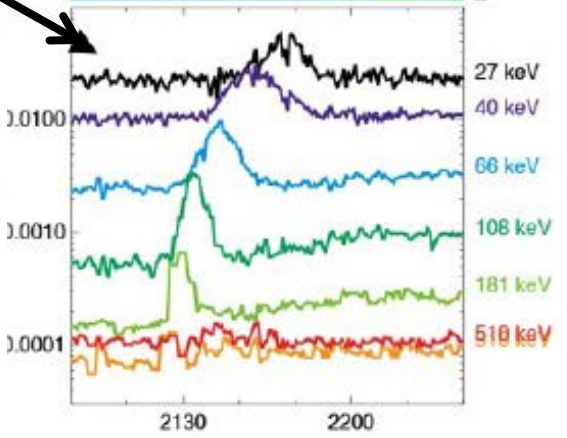
Solar Flares, escaping electrons & Radio Bursts







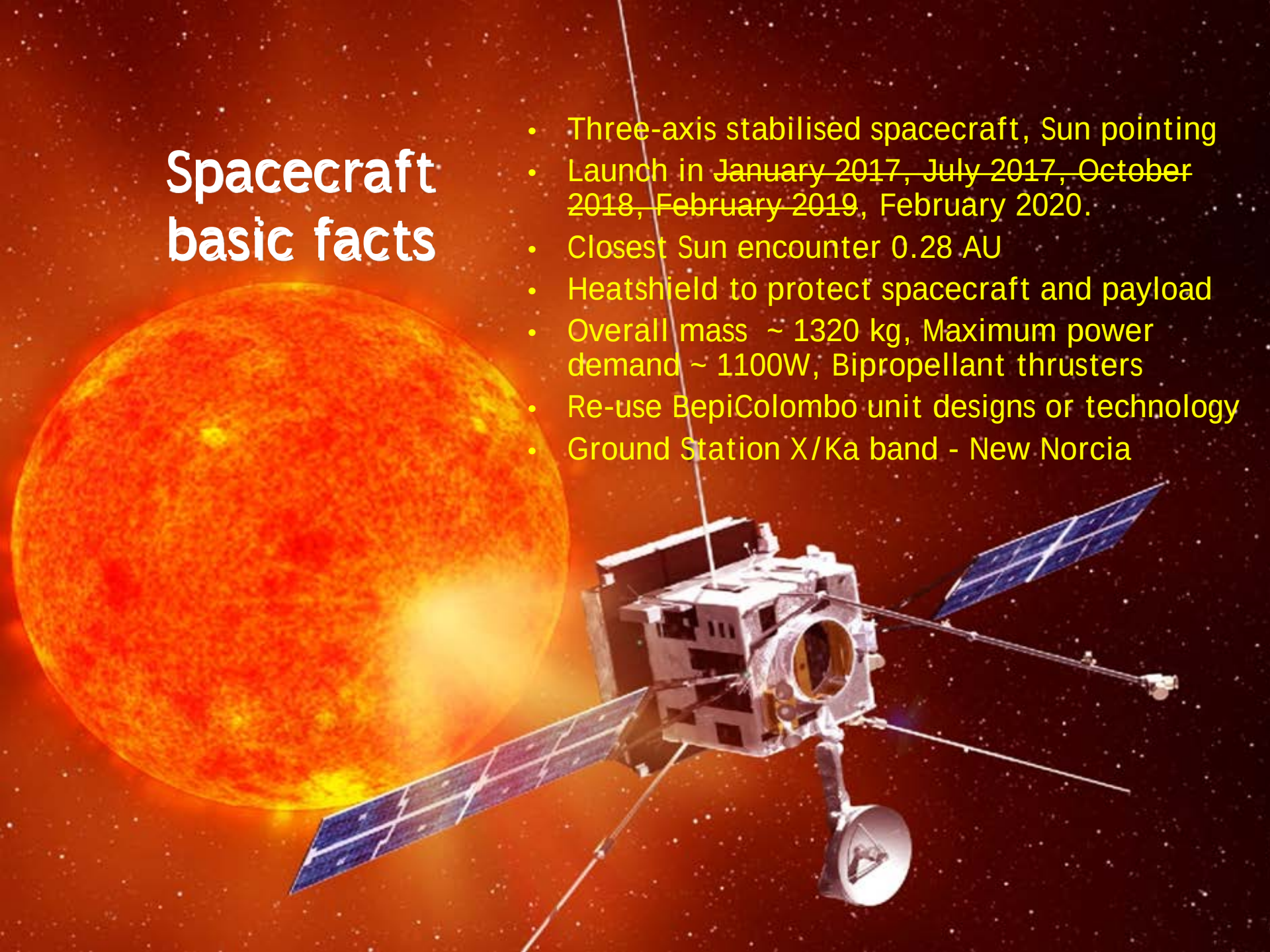


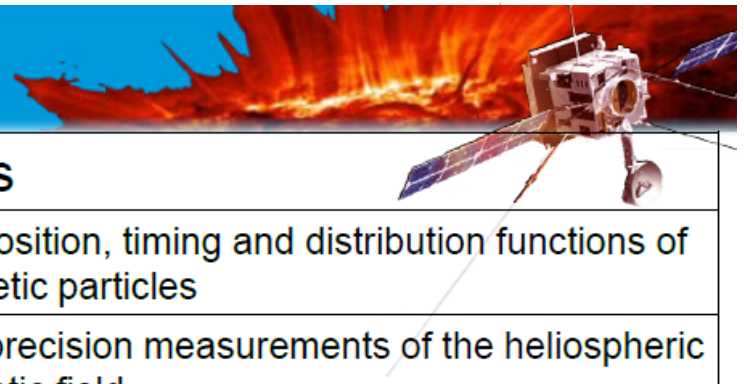


energetic electrons

Spacecraft basic facts

- Three-axis stabilised spacecraft, Sun pointing
- Launch in ~~January 2017, July 2017, October 2018, February 2019~~, February 2020.
- Closest Sun encounter 0.28 AU
- Heatshield to protect spacecraft and payload
- Overall mass ~ 1320 kg, Maximum power demand ~ 1100W, Bipropellant thrusters
- Re-use BepiColombo unit designs or technology
- Ground Station X/Ka band - New Norcia





Payload

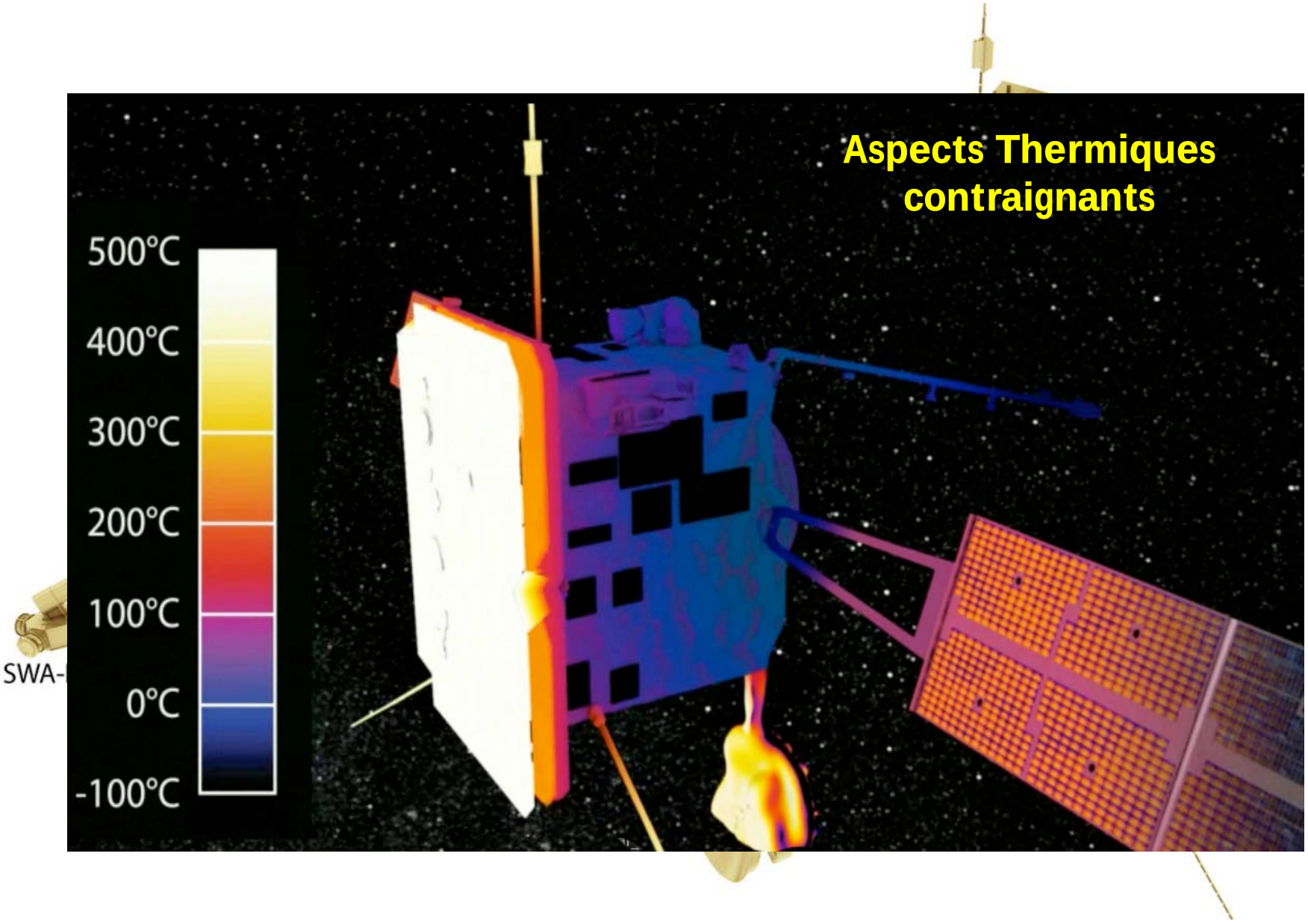
In-Situ Instruments

EPD	Energetic Particle Detector	J. Rodríguez- Pach	Composition, timing and distribution functions of energetic particles
MAG	Magnetometer	T. Horbury	High-precision measurements of the heliospheric magnetic field
RPW	Radio & Plasma Waves	M. Maksimovic	Electromagnetic and electrostatic waves, magnetic and electric fields at high time resolution
SWA	Solar Wind Analyser	C. Owen	Sampling protons, electrons and heavy ions in the solar wind

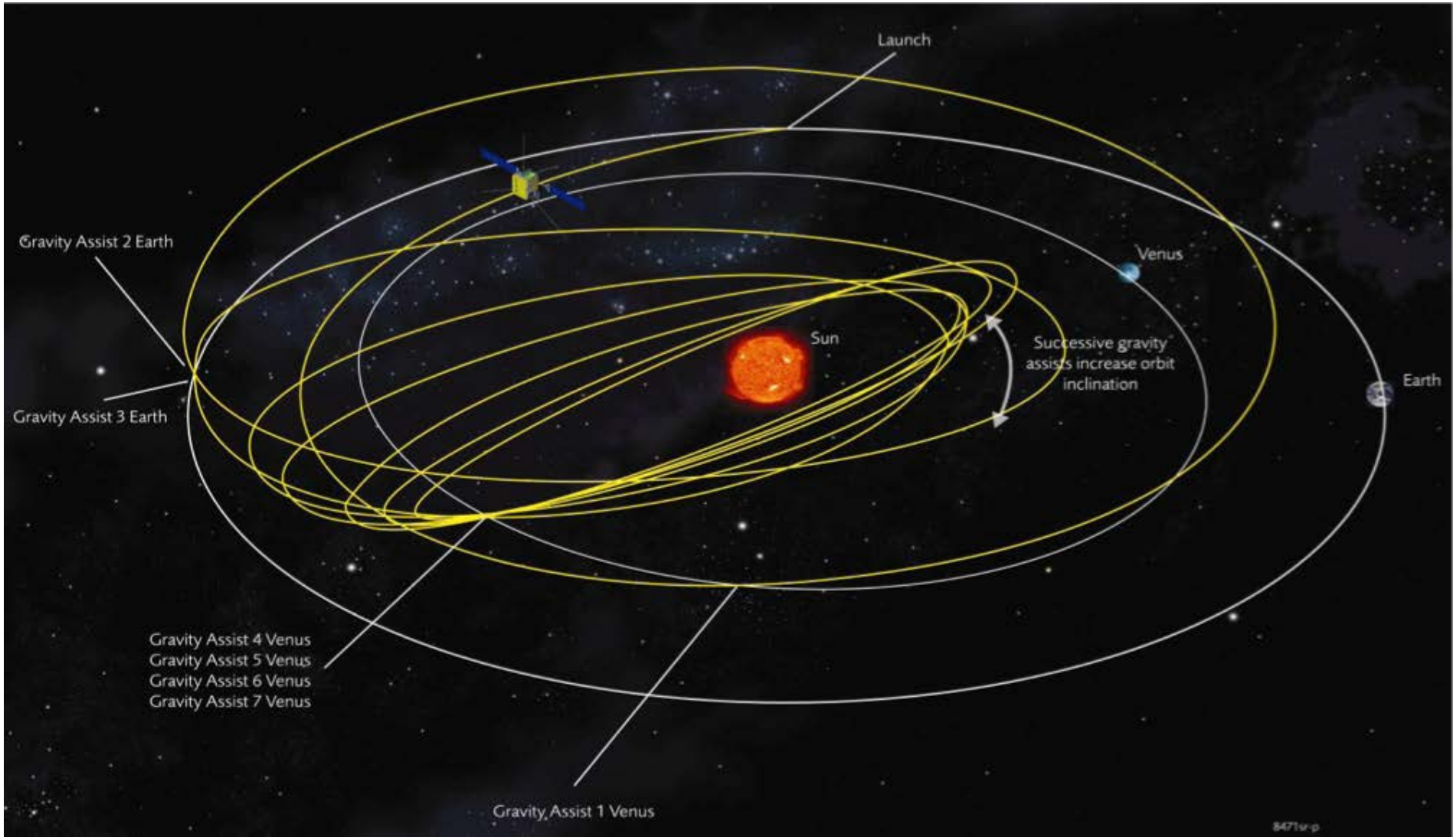
Remote-Sensing Instruments

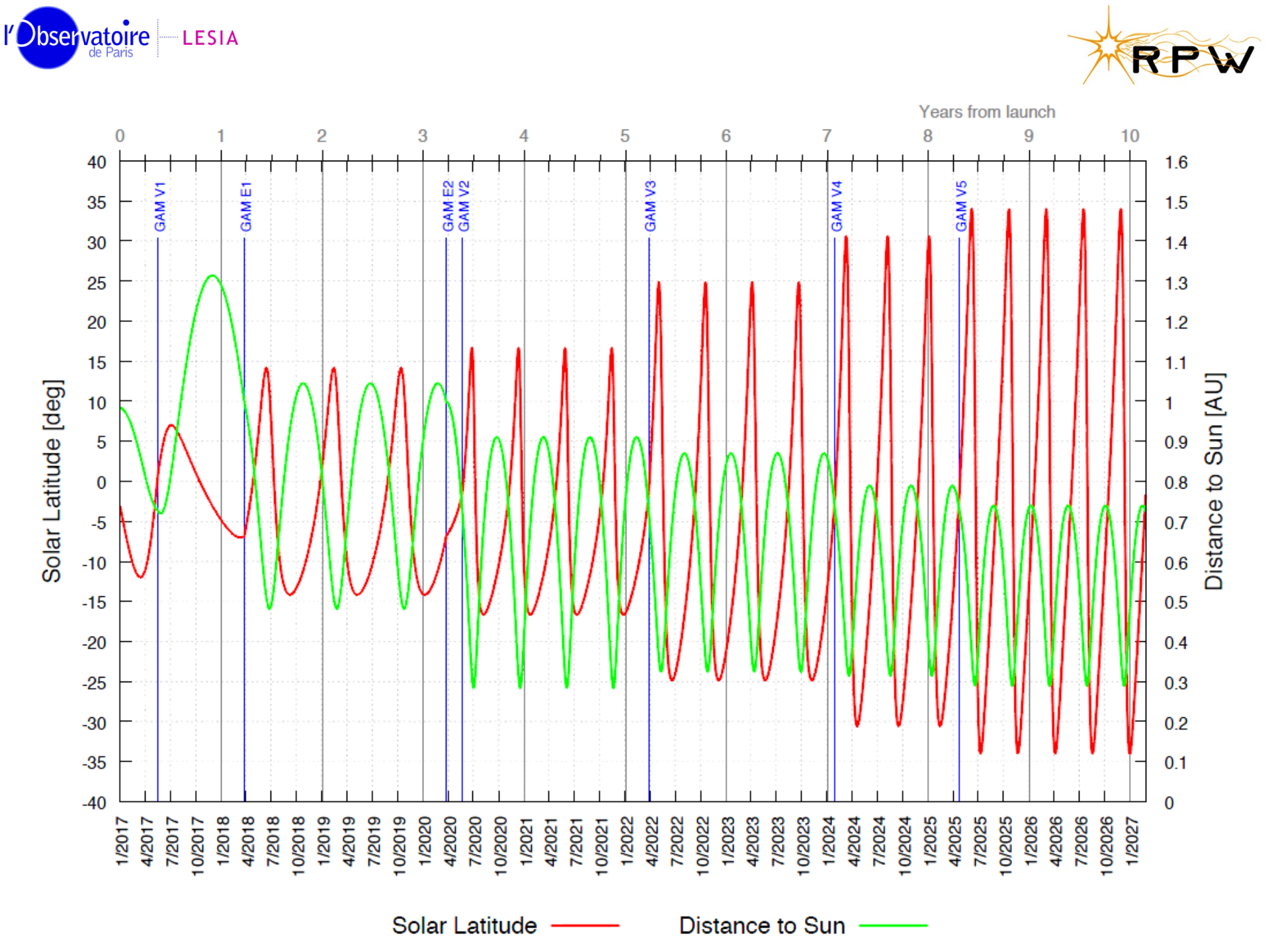
EUI	Extreme Ultraviolet Imager	P. Rochus	High-resolution and full-disk EUV imaging of the on-disk corona
METIS	Multi-Element Telescope for Imaging and Spectroscopy	E. Antonucci	Imaging and spectroscopy of the off-disk corona
PHI	Polarimetric & Helioseismic Imager	S. Solanki	High-resolution vector magnetic field, line-of-sight velocity in photosphere, visible imaging
SoloHI	Heliospheric Imager	R. Howard	Wide-field visible imaging of the solar off-disk corona
SPICE	Spectral Imaging of the Coronal Environment	European-led facili instrument	EUV spectroscopy of the solar disk and near-Sun corona
STIX	Spectrometer/Telescope for Imaging X-rays	S. Krucker	Imaging spectroscopy of solar X-ray emission

Disposition de la Charge Utile

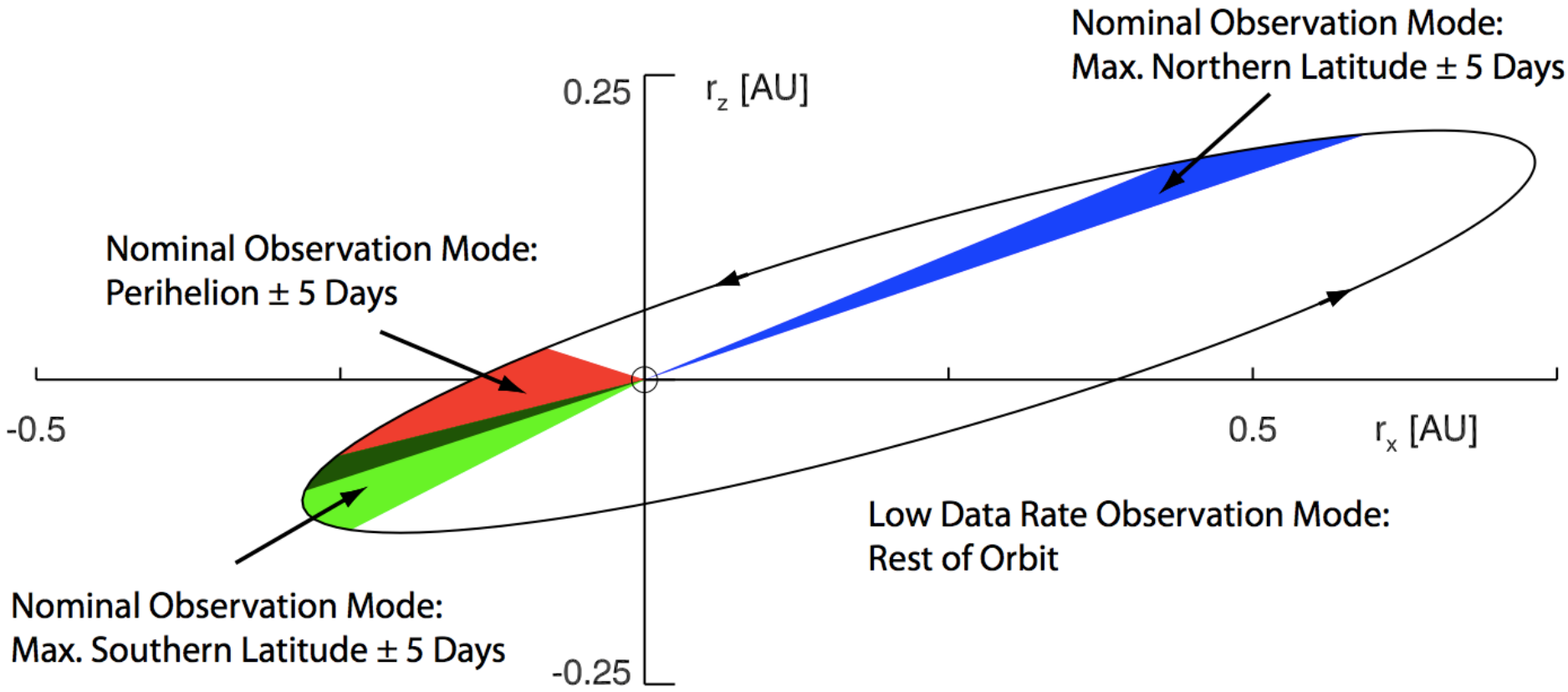


Mission Profile



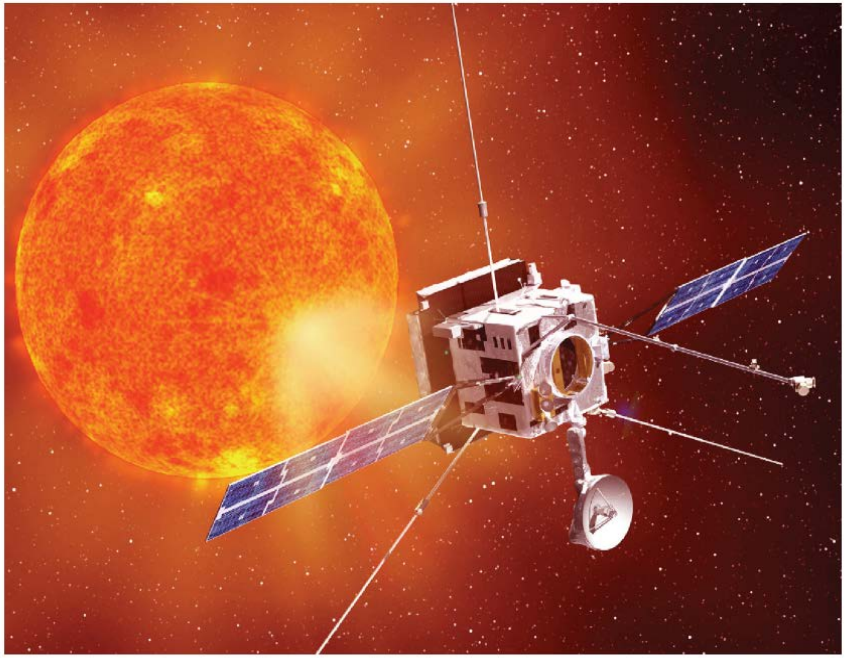

l'Observatoire de Paris
LESIA
RPW
Years from launch
0
1
2
3
4
5
6
7
8
9
10
GAM V1
GAM E1
GAM E2
GAM V2
GAM V3
GAM V4
GAM V5
Solar Latitude [deg]
Distance to Sun [AU]
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/2017
4/2017
7/2017
10/2017
1/2018
4/2018
7/2018
10/2018
1/2019
4/2019
7/2019
10/2019
1/2020
4/2020
7/2020
10/2020
1/2021
4/2021
7/2021
10/2021
1/2022
4/2022
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10/2022
1/2023
4/2023
7/2023
10/2023
1/2024
4/2024
7/2024
10/2024
1/2025
4/2025
7/2025
10/2025
1/2026
4/2026
7/2026
10/2026
1/2027
Solar Latitude
Distance to Sun

Observation modes



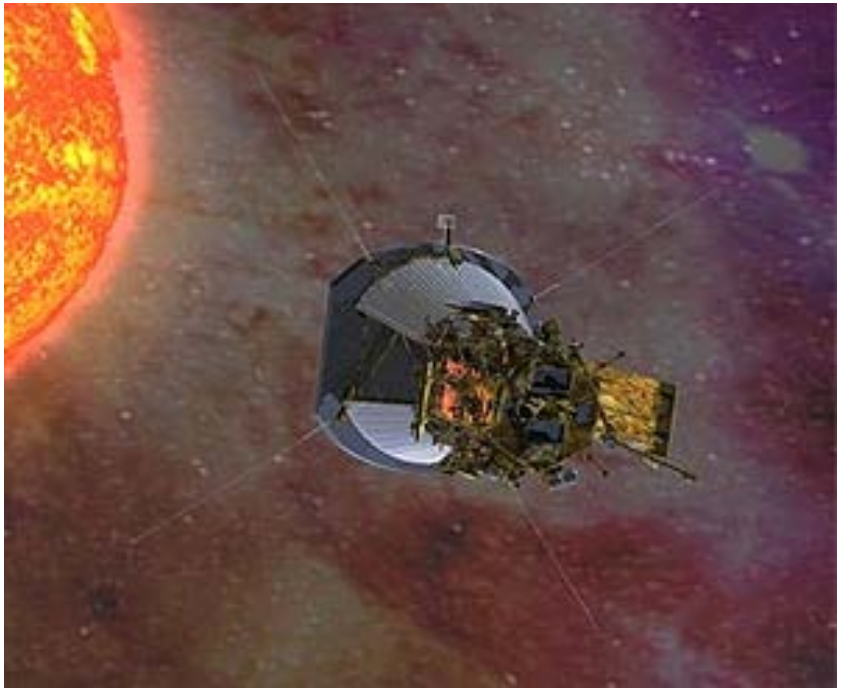
Solar Orbiter

Exploring the Sun-heliosphere connection



- ESA mission with NASA participation (launcher + two instruments)
- Up to 0.28 AU with dedicated in-situ & remote sensing instrumentation closest approach possible)
- Out of ecliptic observations
- 1st M-class ESA Cosmic Vision (Launch ~Oct. 2018)

Solar Probe Plus

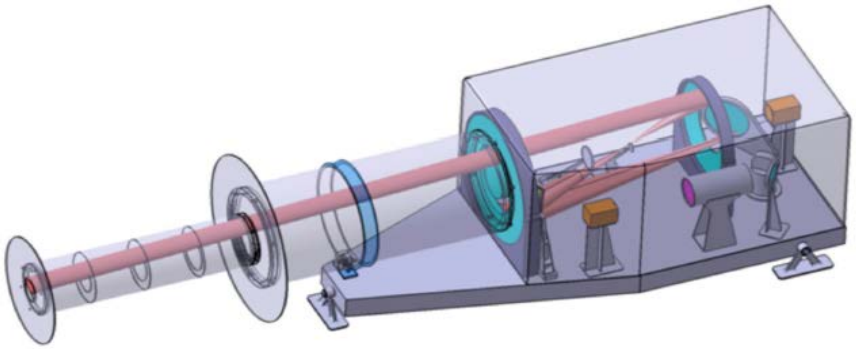


- 9.5 Rs to 30 RS : primary science
- Focussed in-situ instrumentation
- Remote sensing Heliospheric Imager to observe on the sides
- Launch ~ august 2018

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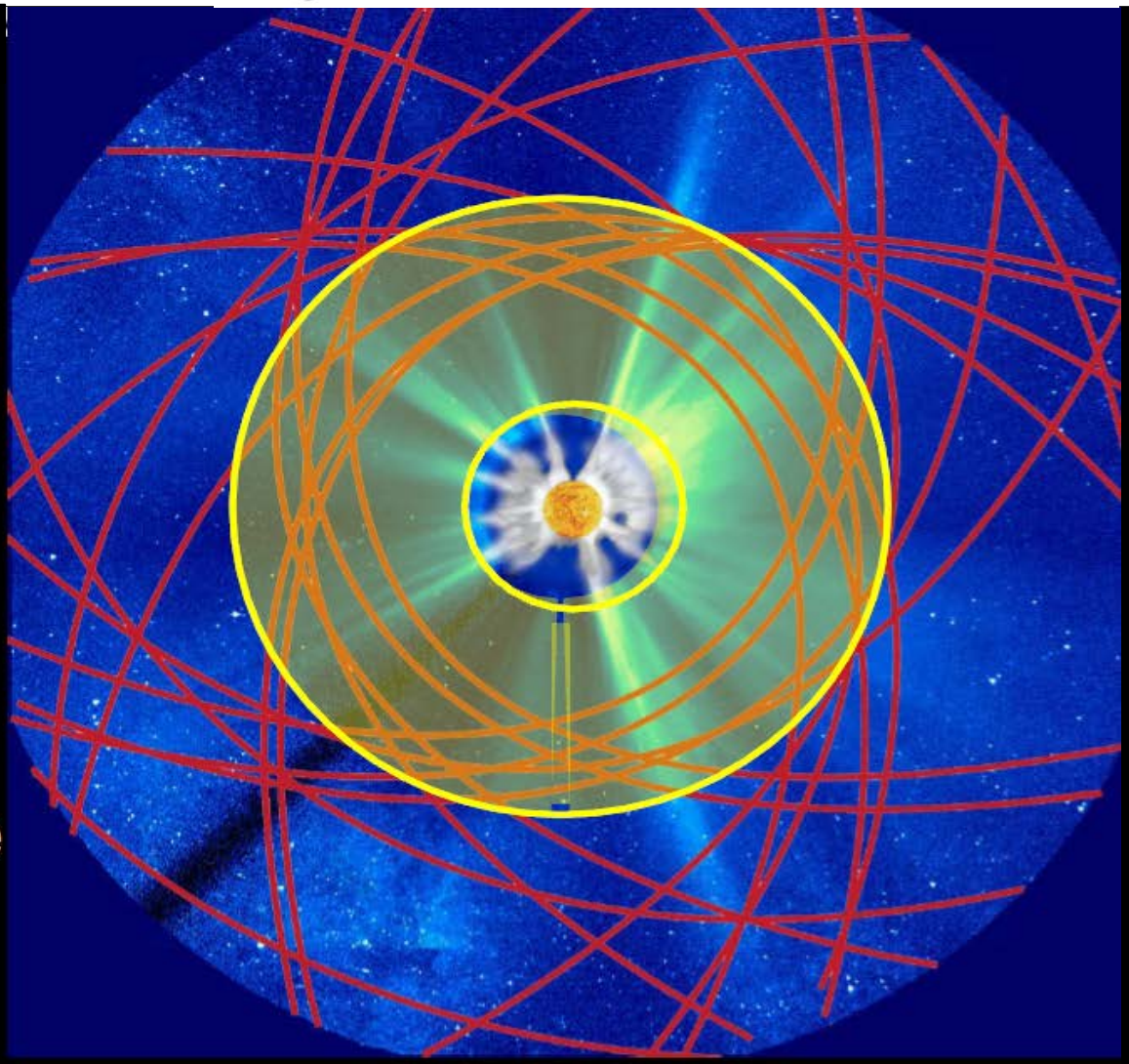
METIS UV & WL Coronagraph:

visible and UV (H I & He II) images of coronal structures out to 5.3 solar radii at 0.3 AU



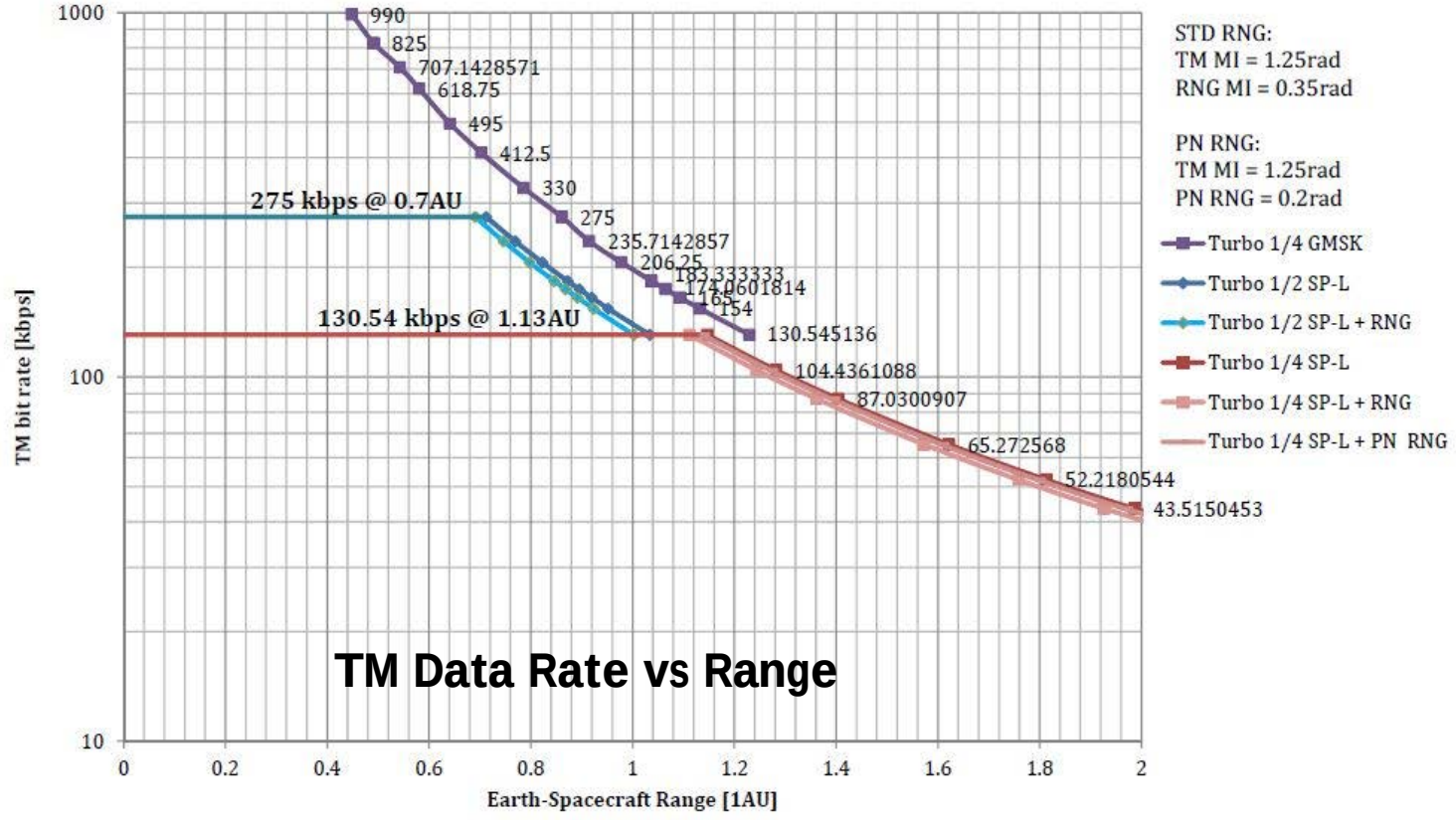
METIS field-of-view at 0.5 AU (yellow).

Solar Probe trajectory projected on the plane of the sky (red)



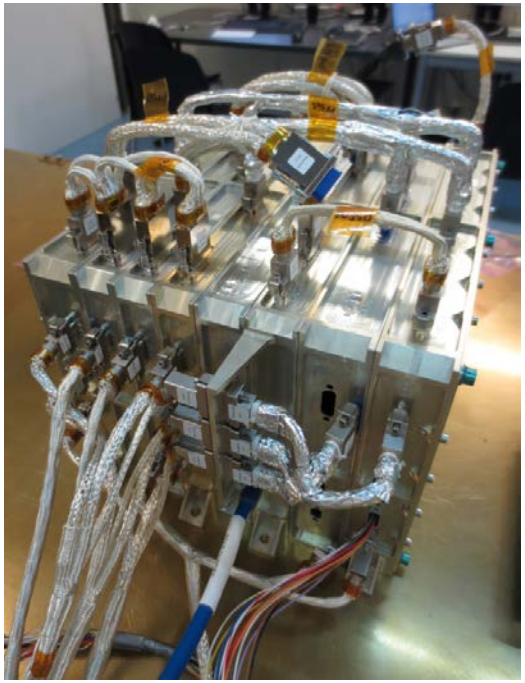
Telemetry Management

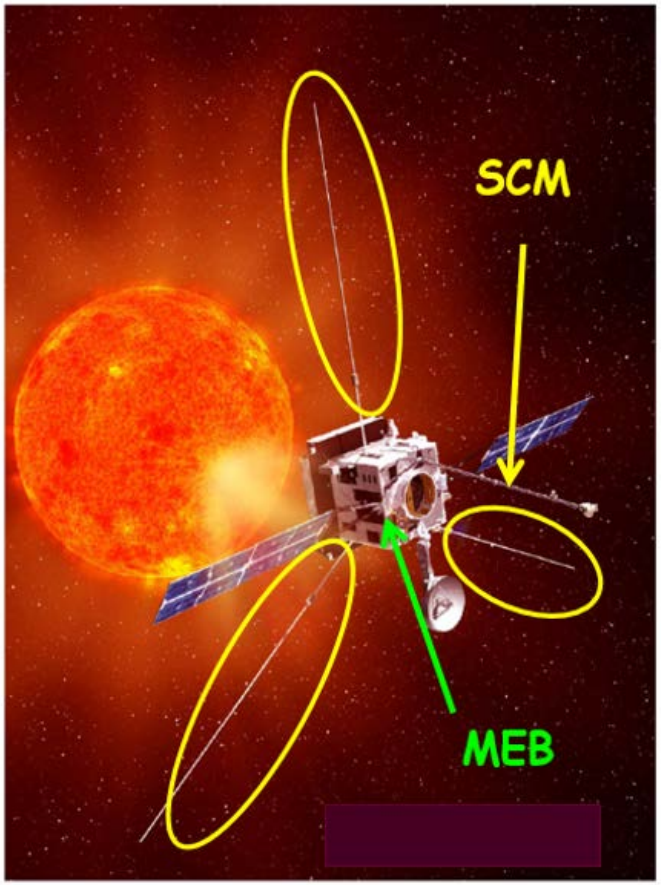
- 180 kbps for the 10 Instruments
- 2*500 Mo SSMM (Solid State Mass Memory) with a complex management
- 5 kbps pour RPW → shock & in-situ Type III detection

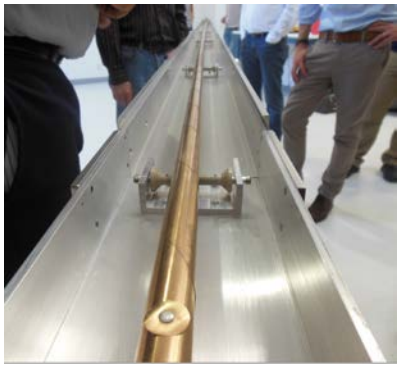


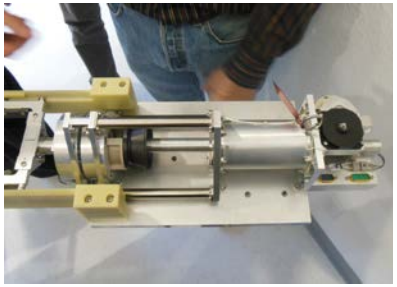
RPW : a brief overview







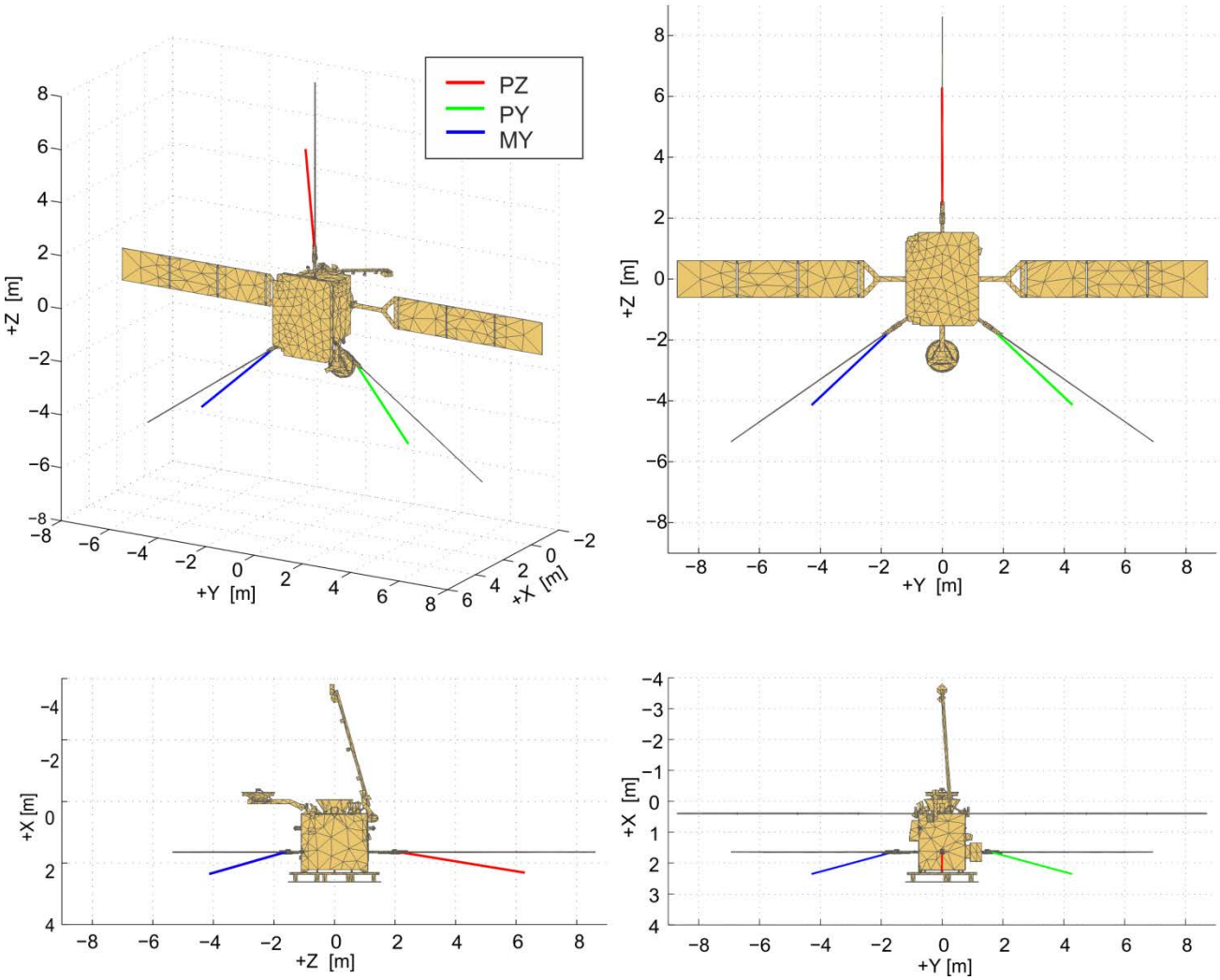








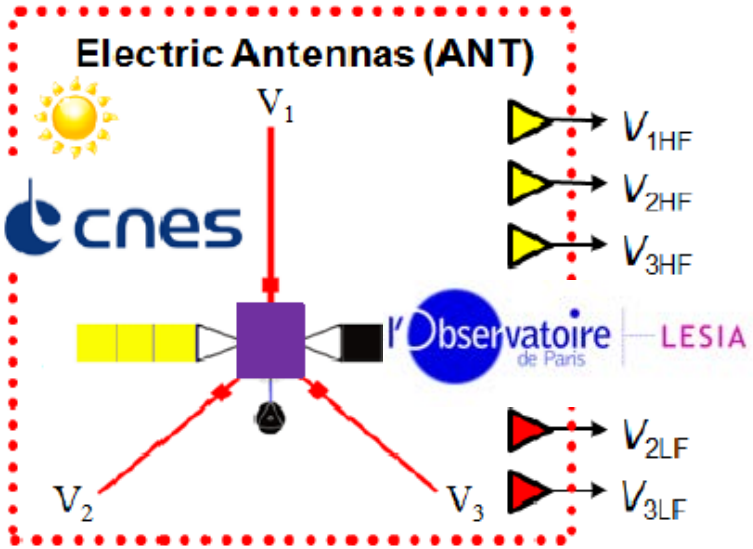
M. Panchenko

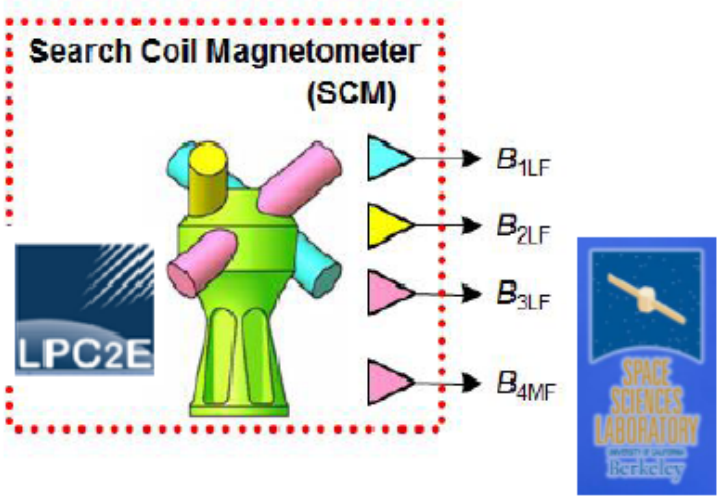


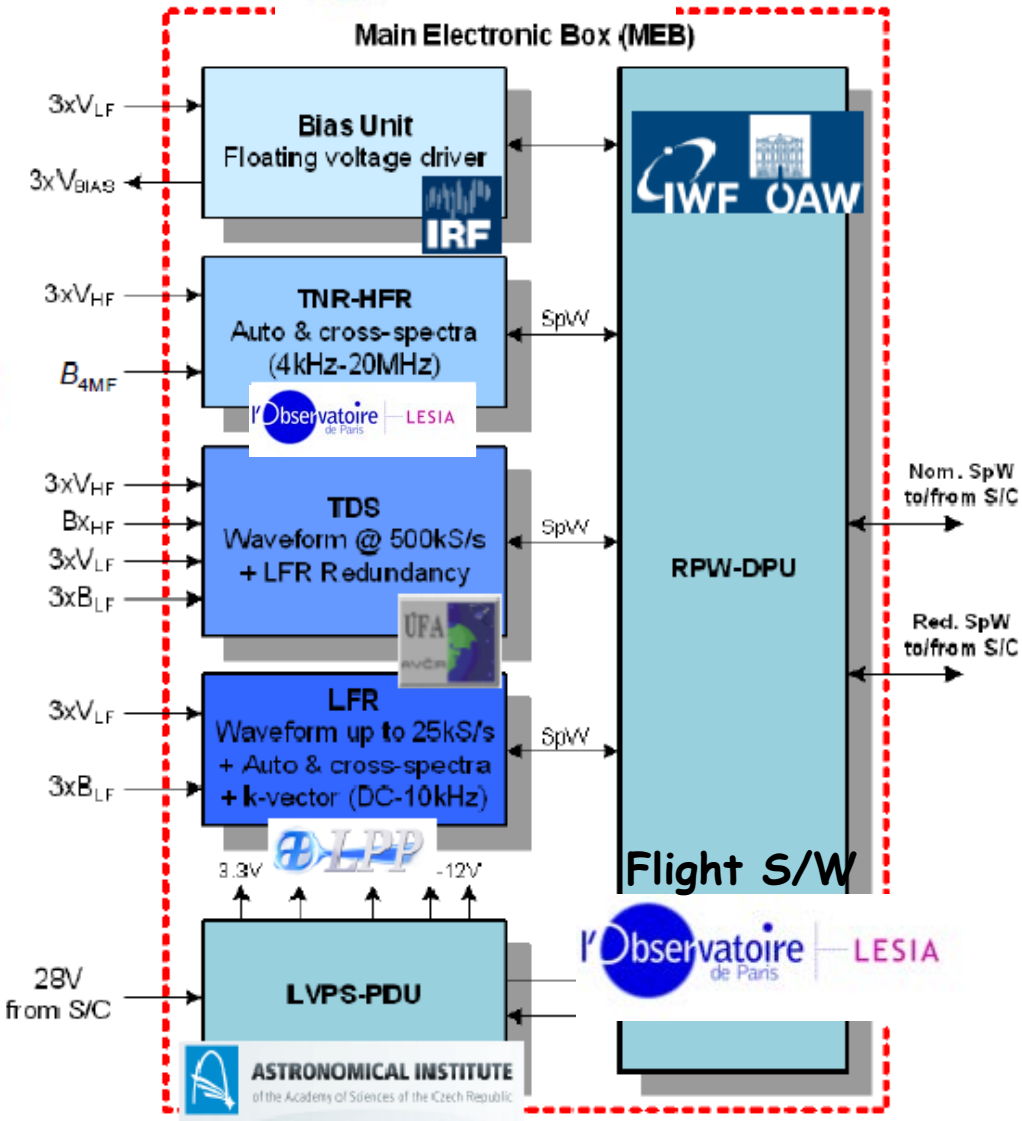
Effective length vectors at 300 kHz for a monopole configuration. Real antennas are given in black while the effective vectors are drawn in color. This gives an impression of the difference between mechanical and electrical quantities.

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RPW







DC Efield expertise & calibration, link to SPP

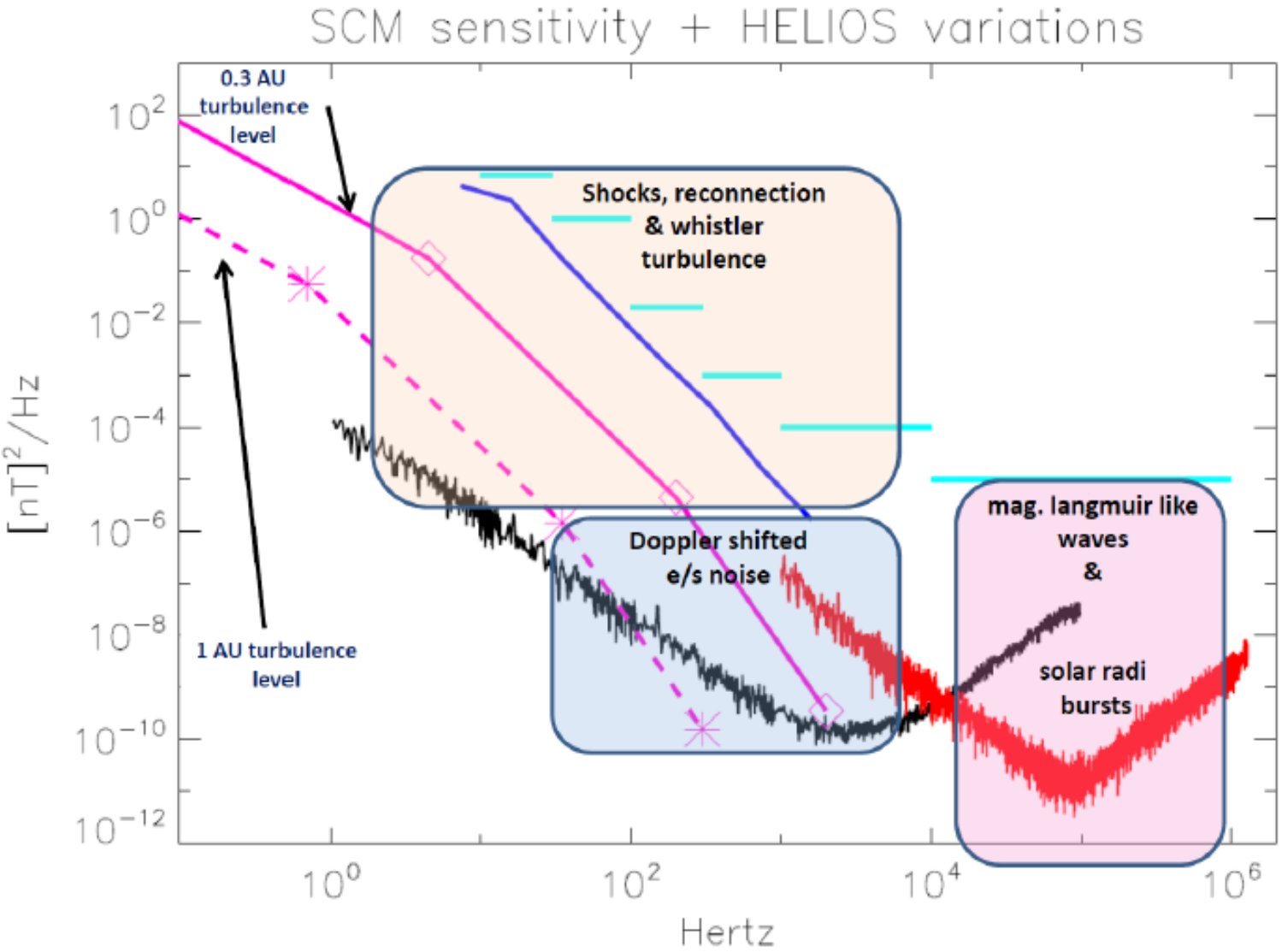
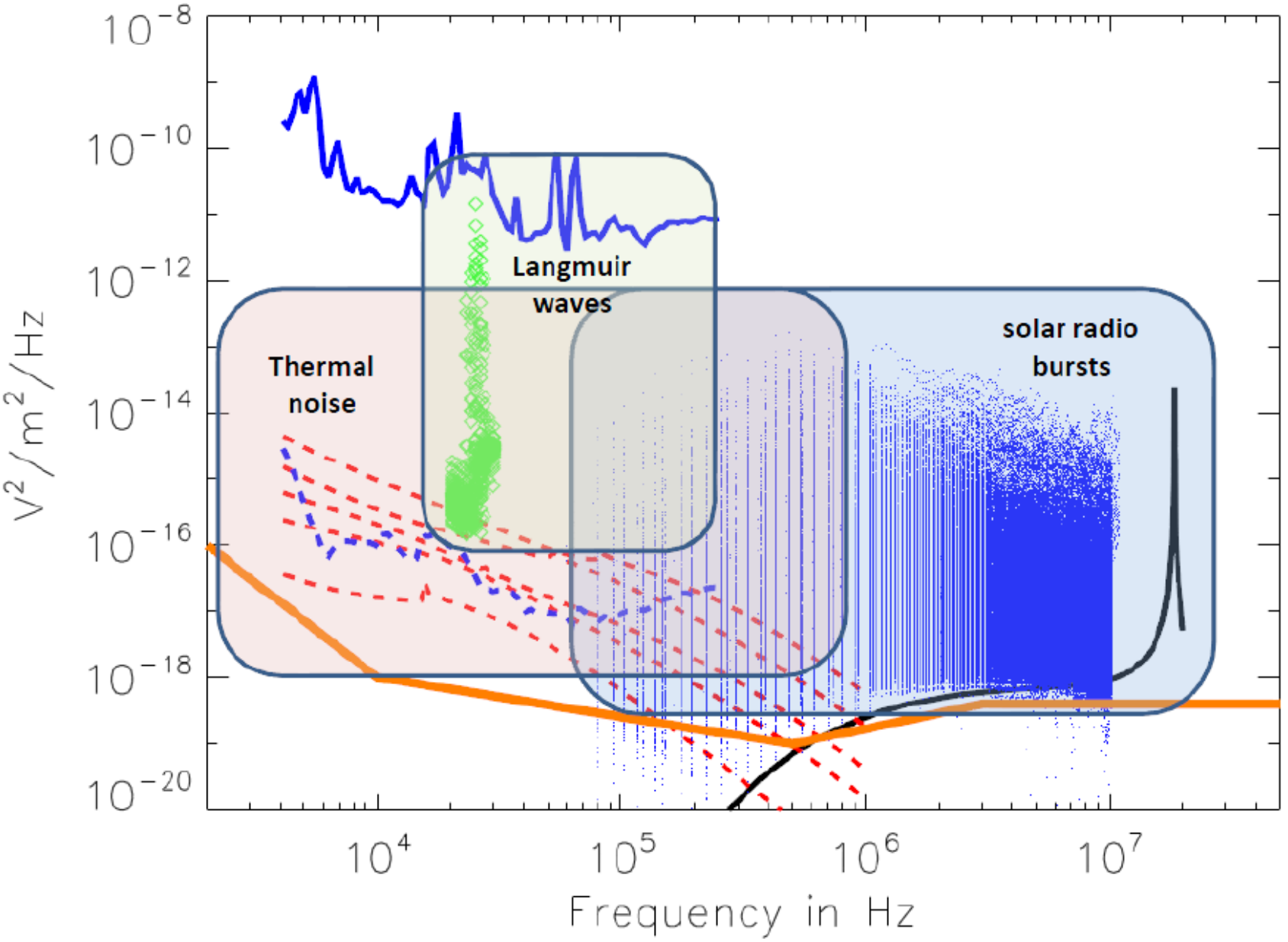
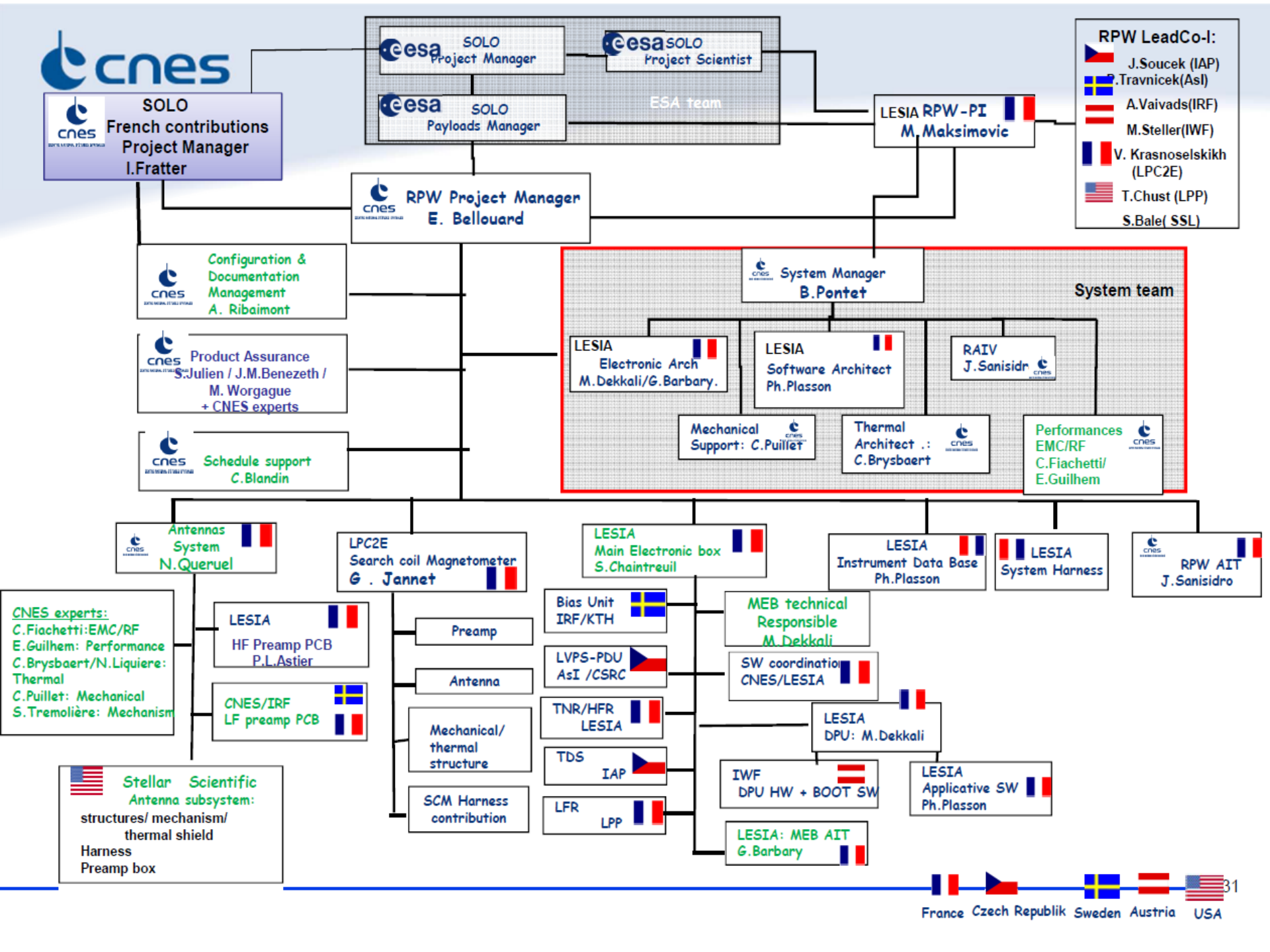


Figure 10: Magnetic field fluctuations of various natural phenomena that will be observed by the RPW instrument


Langmuir waves
Thermal noise
solar radio bursts
$V^2/m^2/Hz$
10^{-8}
10^{-10}
10^{-12}
10^{-14}
10^{-16}
10^{-18}
10^{-20}
10^4
10^5
10^6
10^7
Frequency in Hz


cnes
SOLO
French contributions
Project Manager
I.Fratter
esa SOLO Project Manager
esa SOLO Project Scientist
esa SOLO Payloads Manager
ESA team
LESIA RPW-PI
M. Maksimovic
RPW LeadCo-I:
J.Soucek (IAP)
P.Travnicek(Asl)
A.Vaivads(IRF)
M.Steller(IWF)
V. Krasnoselskikh (LPC2E)
T.Chust (LPP)
S.Bale(SSL)
RPW Project Manager
E. Bellouard
Configuration & Documentation Management
A. Ribaimont
Product Assurance
S.Julien / J.M.Benezeth / M. Worgague
+ CNES experts
Schedule support
C.Blandin
System Manager
B.Pontet
System team
LESIA
Electronic Arch
M.Dekkali/G.Barbary.
LESIA
Software Architect
Ph.Plasson
RAIV
J.Sanisidr
Mechanical Support: C.Puillet
Thermal Architect .: C.Brysbaert
Performances EMC/RF
C.Fiachetti/
E.Guilhem
Antennas System
N.Queruel
LPC2E
Search coil Magnetometer
G . Jannet
LESIA
Main Electronic box
S.Chaintreuil
LESIA
Instrument Data Base
Ph.Plasson
LESIA
System Harness
RPW AIT
J.Sanisidro
CNES experts:
C.Fiachetti:EMC/RF
E.Guilhem: Performance
C.Brysbaert/N.Liquiere: Thermal
C.Puillet: Mechanical
S.Tremolière: Mechanism
LESIA
HF Preamp PCB
P.L.Astier
CNES/IRF
LF preamp PCB
Preamp
Antenna
Mechanical/ thermal structure
SCM Harness contribution
Bias Unit
IRF/KTH
LVPS-PDU
AsI /CSRC
TNR/HFR
LESIA
TDS
IAP
LFR
LPP
MEB technical Responsible
M.Dekkali
SW coordination
CNES/LESIA
LESIA
DPU: M.Dekkali
IWF
DPU HW + BOOT SW
LESIA
Applicative SW
Ph.Plasson
LESIA: MEB AIT
G.Barbary
Stellar Scientific
Antenna subsystem:
structures/ mechanism/ thermal shield
Harness
Preamp box
France
Czech Republik
Sweden
Austria
USA

3 types of mode for 5.5 kbps

RPW operation mode	mode rate (kbit/s, uncompressed)	duty cycle min/day	# of events	duration of event (min)	%total
Normal Mode	6,46	1440			82,60%
Burst Mode	36,79	10			3,27%
Selected Burst Mode SBM1-Shocks	478,04	3	1 every 5 days 360 in 5 years	15	12,73%
Selected Burst Mode SBM2-In-situ Type III & LW	211,67	0,75	100 events in 10 years	30	1,41%

- Use of the service 20 MAG, SWA & EPD data in order to detect onboard SBM1 & SBM2 events
- These events will be stored on the S/C Solid State Mass Memory (SSMM)
- They will by retrieved by the ROC

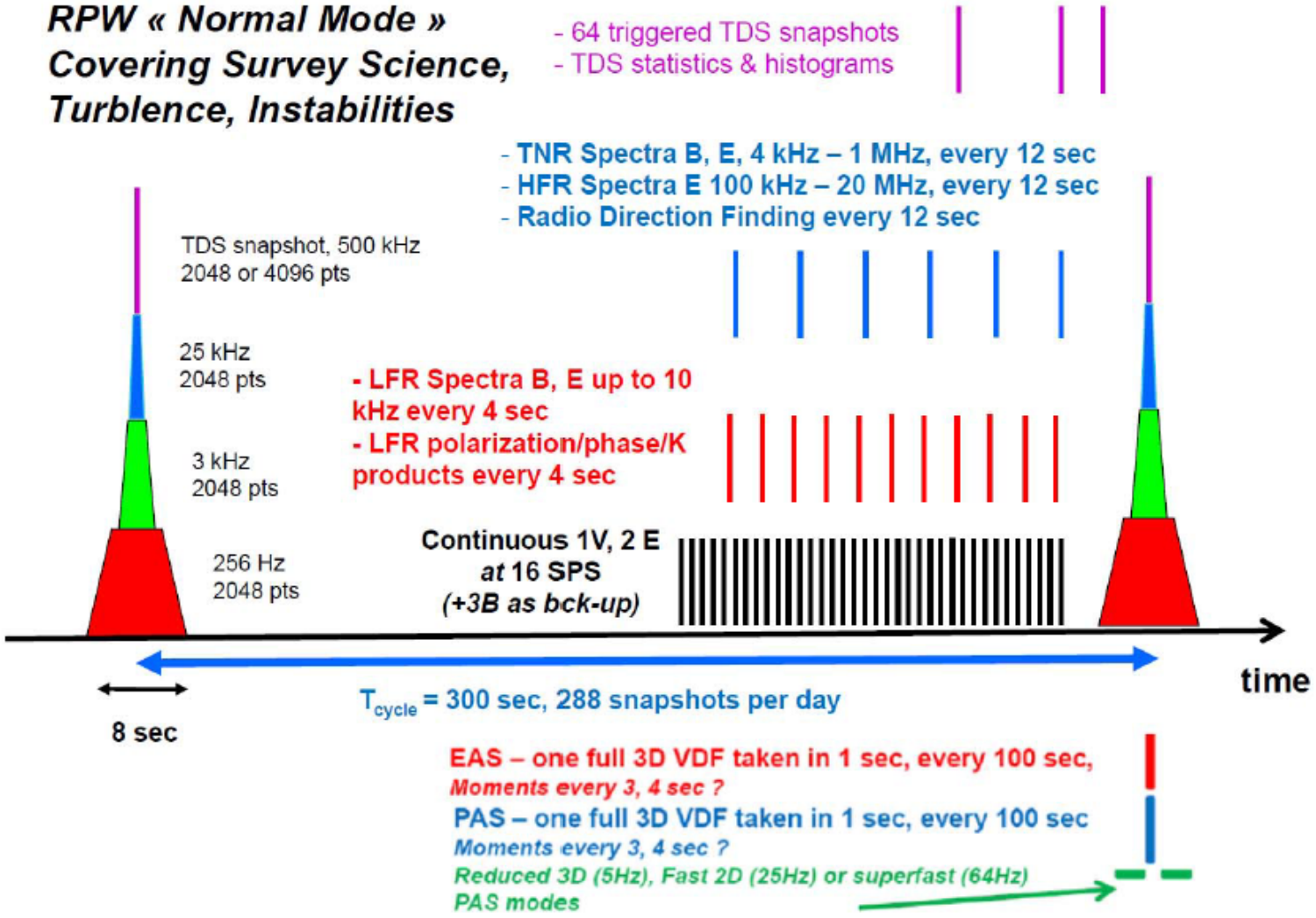


Figure 24 : Synoptic view of the RPW Normal mode

RPW Selected Burst Mode 1 (SBM1)

Shock crossing (~10 to 15 min., 1/5days)

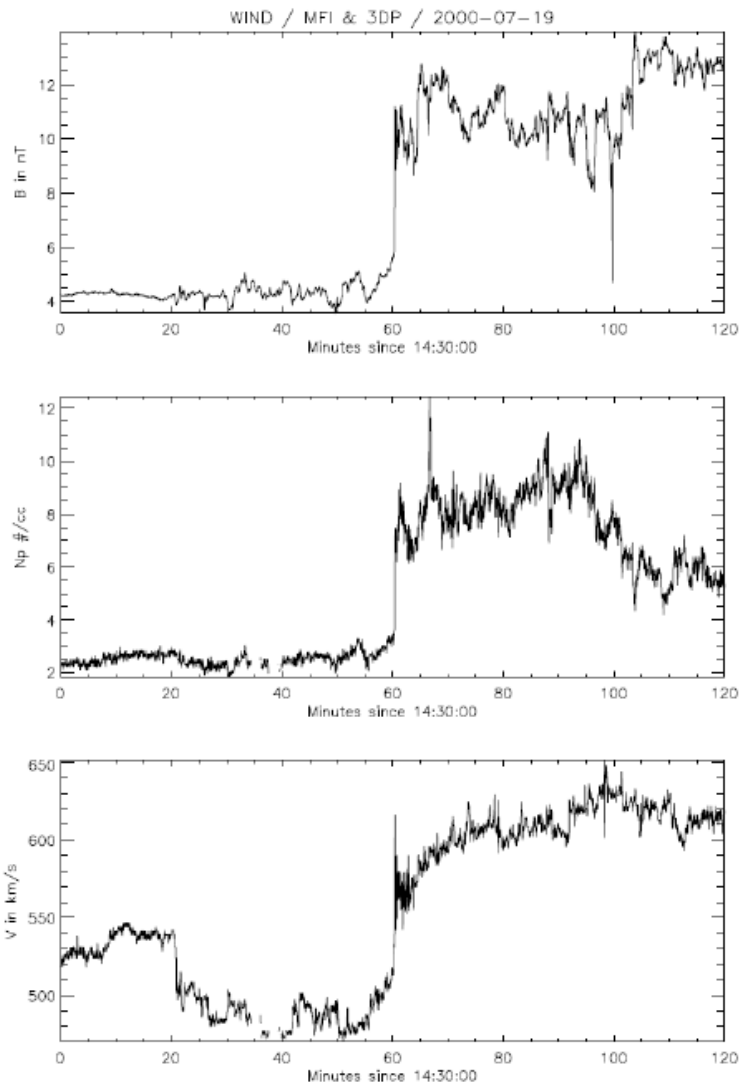
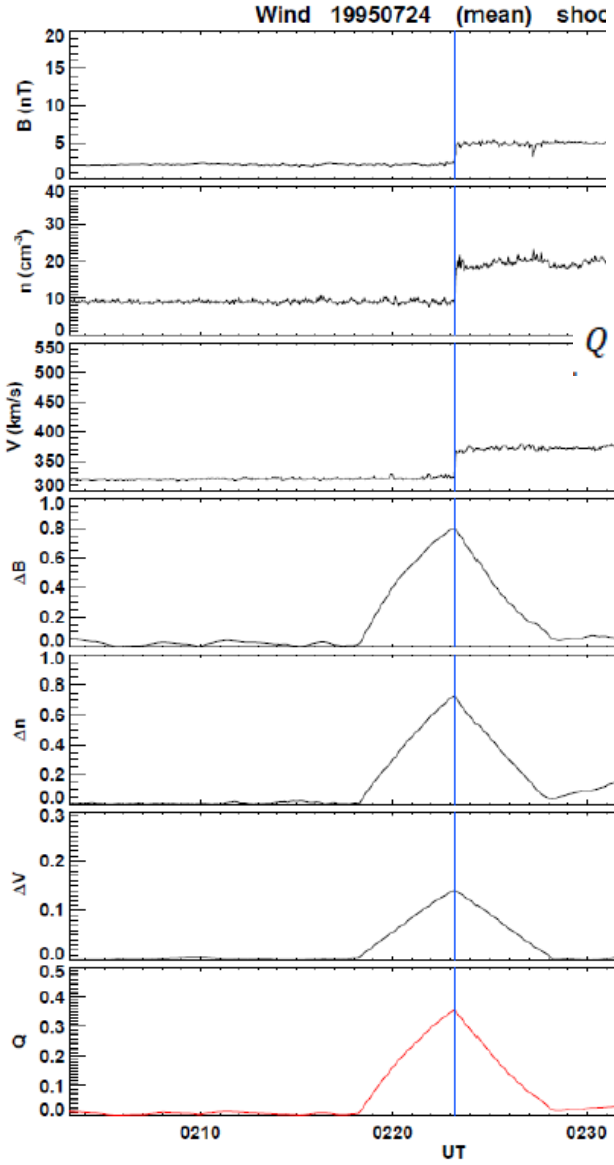


Figure 1 : Example of a quasi-perpendicular shock crossing by the WIND S/C.



$$\Delta B = \frac{2 \times |B_2 - B_1|}{B_1 + B_2}$$

$$\Delta Np = \frac{2 \times |Np_2 - Np_1|}{Np_1 + Np_2}$$

$$\Delta V = \frac{2 \times |V_2 - V_1|}{V_1 + V_2}$$

$$Q = \alpha \Delta B + \beta \Delta Np + \gamma \Delta V$$

$$\alpha + \beta + \gamma = 1$$

RPW Selected Burst Mode 2 (SBM2)

In-situ Type III (up to ~120 min., 100 to 150 total)

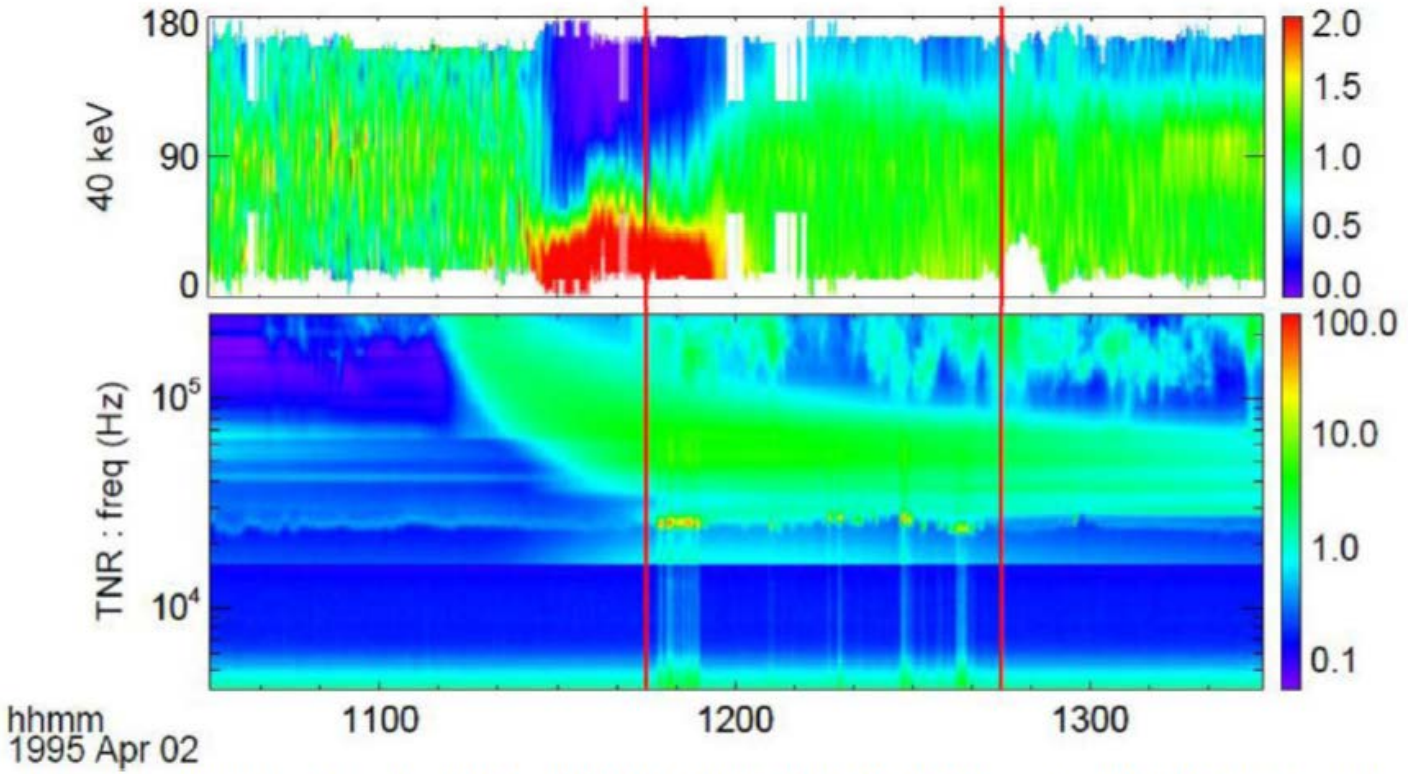
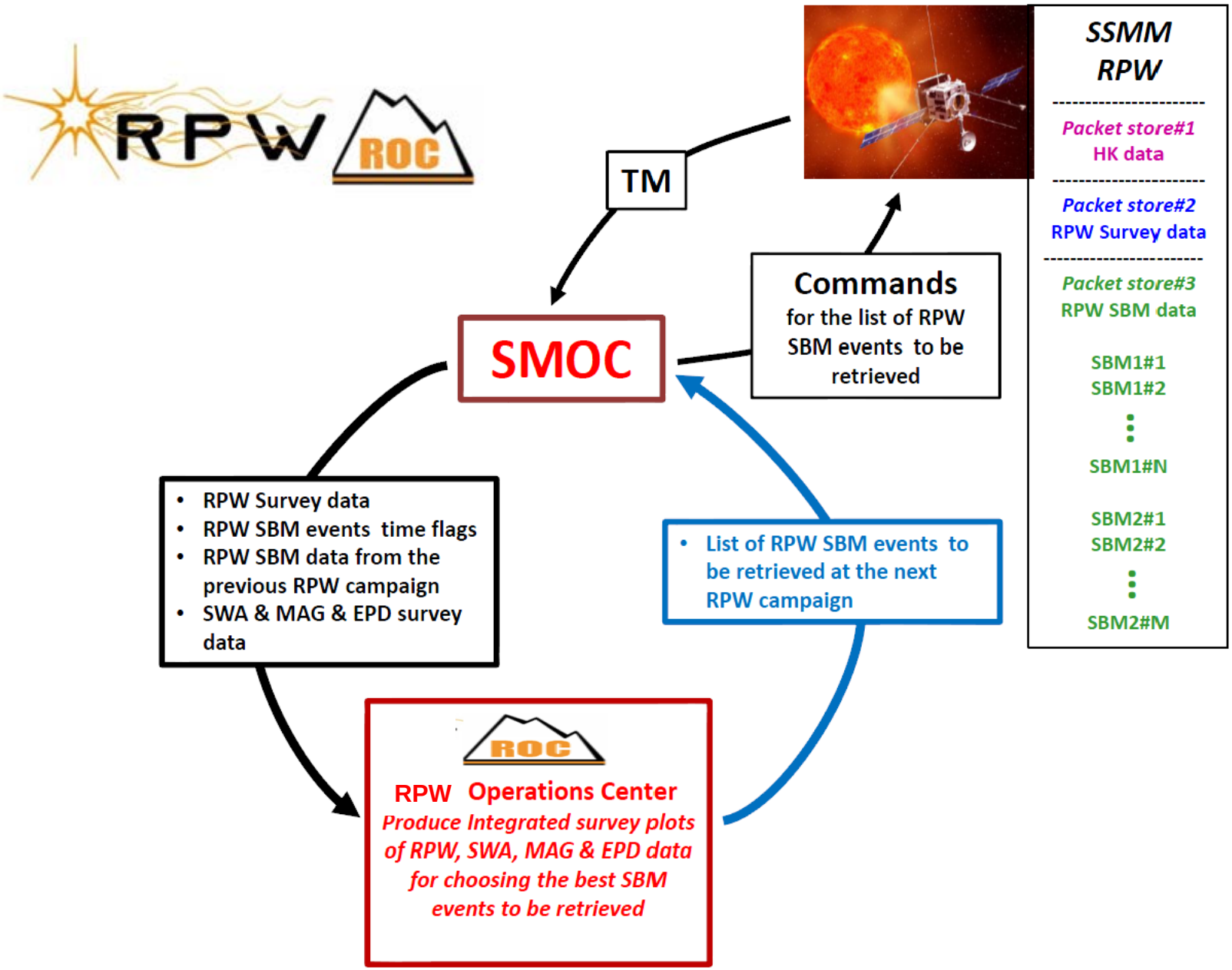


Figure 3 : Example of an in-situ Type III burst observed by the WIND spacecraft. The upper panel displays the anisotropy of the solar energetic electrons at 40 keV as a function of time and for different angles with respect to the mag field (between 0° & 180°). The red color corresponds to the anti-sunward electrons. The lower panel represents the TNR radio data of interest.


RPW
ROC
TM
SMOC
Commands
for the list of RPW SBM events to be retrieved
SSMM
RPW
Packet store#1
HK data
Packet store#2
RPW Survey data
Packet store#3
RPW SBM data
SBM1#1
SBM1#2
SBM1#N
SBM2#1
SBM2#2
SBM2#M
• RPW Survey data
• RPW SBM events time flags
• RPW SBM data from the previous RPW campaign
• SWA & MAG & EPD survey data
• List of RPW SBM events to be retrieved at the next RPW campaign
ROC
RPW Operations Center
Produce Integrated survey plots of RPW, SWA, MAG & EPD data for choosing the best SBM events to be retrieved

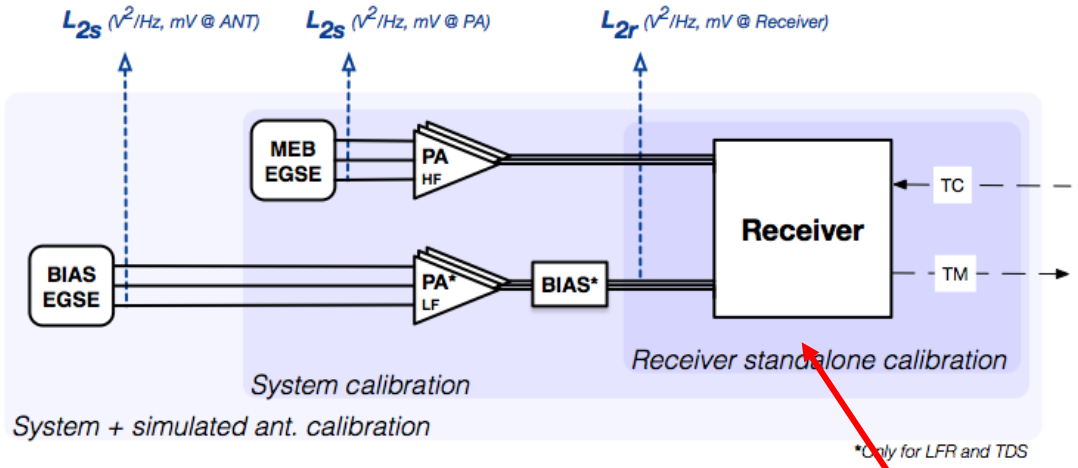
Data Levels:

L2 or Physical data

mV/m, V^2/Hz



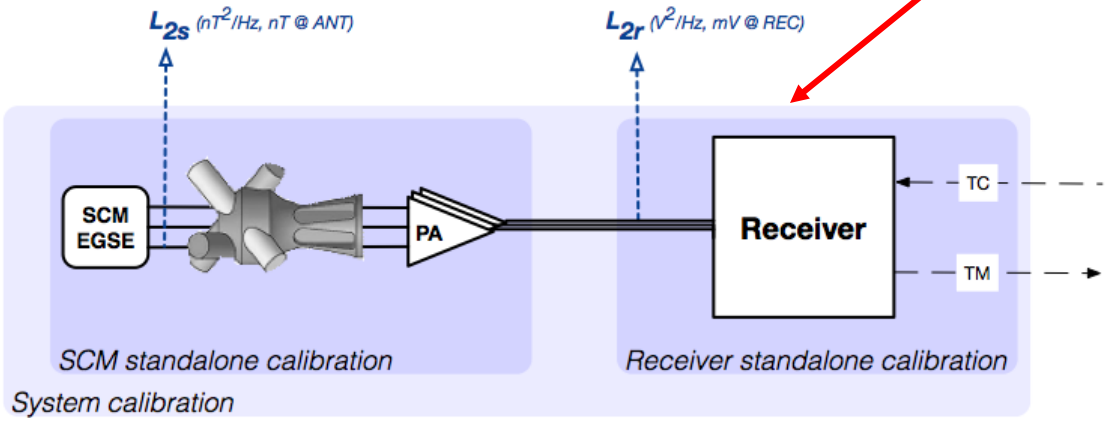
Electric data levels:



L1 data
In TM units

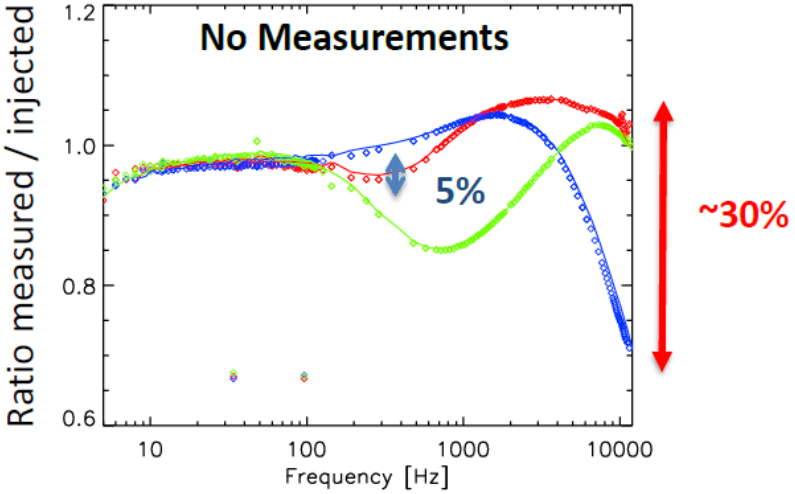
LFR, TDS TNR-HFR

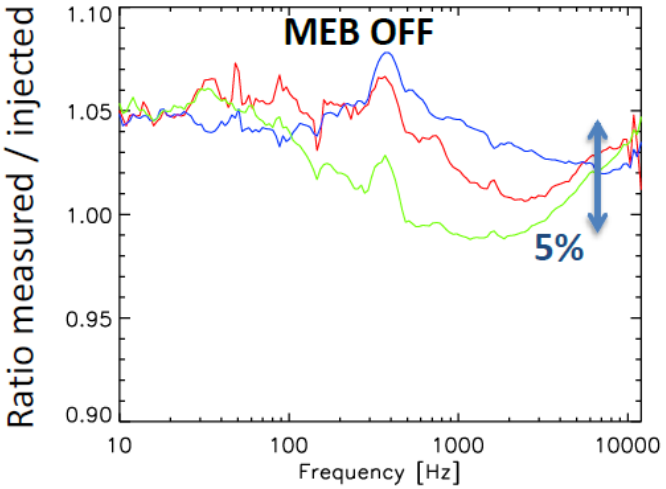
Magnetical data levels:

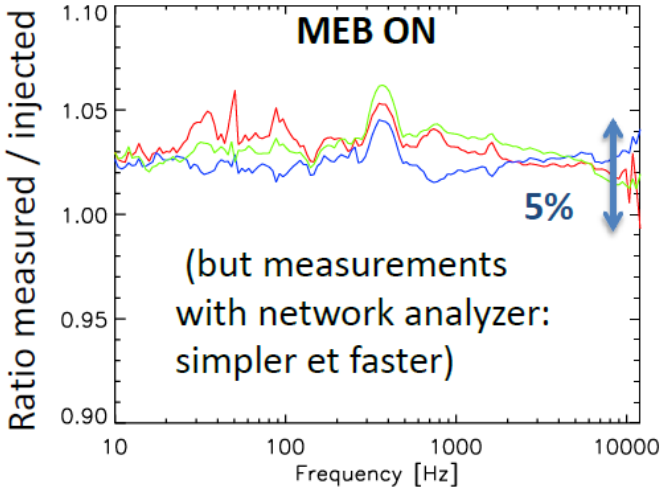


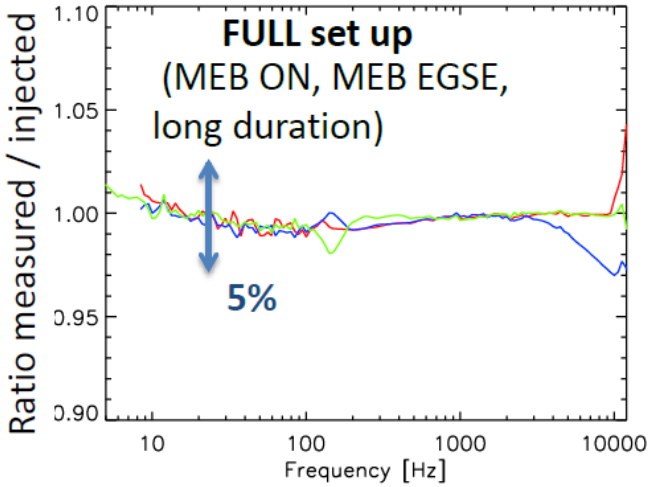
nT, nT^2/Hz

Why do we need to make measurements at Airbus with the MEB ON







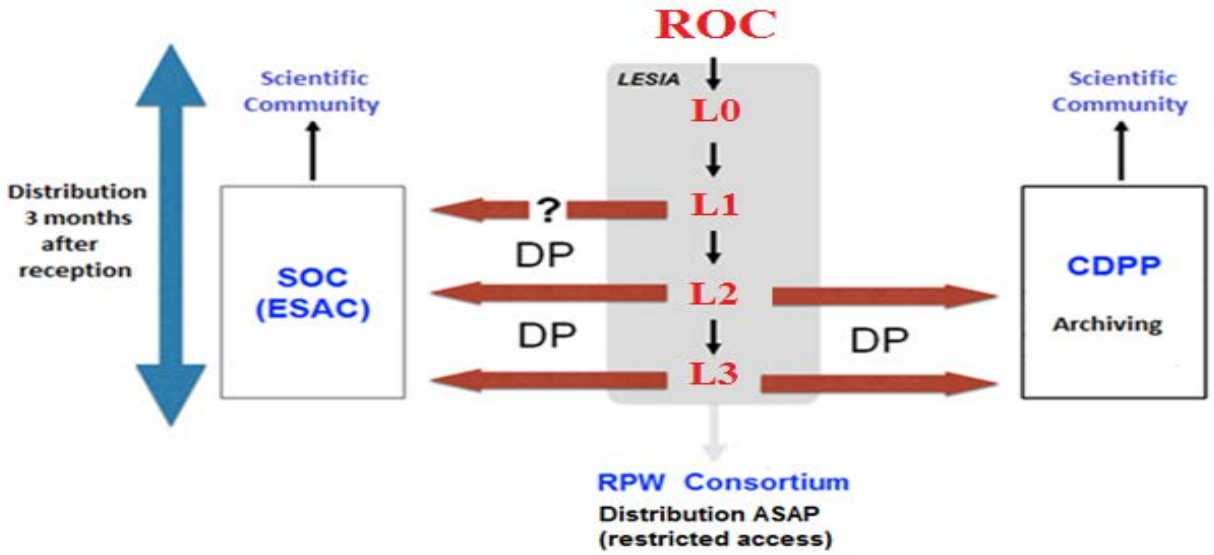


Data production responsibilities

Data Products (DP):

- *survey/sbm (CDF)*
- *summary plots*
- *geometry(antenna)(SPICE)*

+ Low Latency Pipeline
For RPW radio flux
@ 1 MHz



During Calibration

L0 → LESIA → L1 → BIAS, TDS, LFR & THR Teams → L2

After launch

L0 → LESIA → L1 → Softwares provided by the BIAS, TDS, LFR & THR Teams Data produced @ LESIA → L2

Summary

- The MEB has been delivered and is on the S/C (Full Fonctionnal Test or SFT maybe before X-mas)
- LVPS-PDU Spare June 2018 (Switch ?)
- The SCM Flight Spare will be delivered before end Nov, extra calibration needed with the MEB FM ON
- The antenna FM are finalized at Stellar Sci. Delivery Review Board in early January.
- Hope ADS UK can integrate the S/C some day …