# LAGRANGE

## ESA's Space Weather Mission to L5

Stefan Kraft on behalf of the LAGRANGE team
*Mission Study Manager*
Space Weather Office
Space Safety Programme Office

21/11/2019

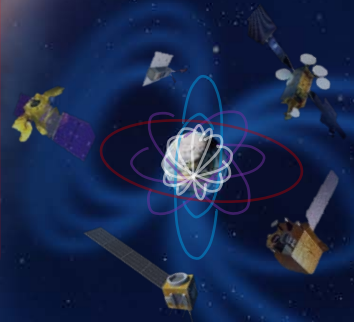
# Enhanced Space Weather Monitoring System

esa

## D3S
**(Distributed SWE Sensor System)**

Impact & State monitoring

**Hosted payloads**



## LAGRANGE Missions

L1

L5

Forecasting
&
Event detection

# Objectives of ESA's SWE Monitoring System

## Establish observational system that continuously monitors space weather

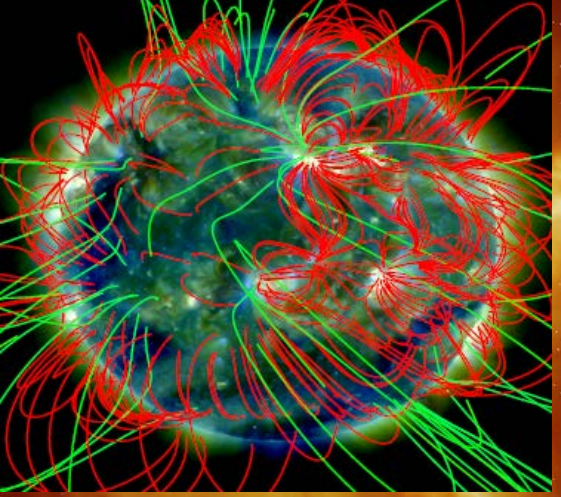
- From the Lagrangian points L1 and L5 (collaboration with US – NOAA/NASA, others …)
- In the proximity of the Earth (LEO, MEO, GEO)
- Ground based measurements

## Advantages of L5 position

- Monitoring of space between Earth and Sun from **a side view**
- Increases our visibility of the Sun to **2/3 of the Sun's surface**
- Activities on the Sun are seen about **4.5 days earlier** than from Earth

## Some specifics of an observatory at L5

- **Short latencies** (15 min to 1 h) and continuous operation (**24/7**) to keep track of changes
- High reliability (0.75 @ 7.5 years) and **high system availability** (99%)
- Requires the development approach of an operational mission
- **Science enabling** through observations and 'high data rate' when possible
- Good heritage from science missions (SOHO, STEREO, Solar Orbiter, Cluster, etc)
- First mission has the character of an Explorer (**first of its kind**)



EUV Imager (EUVI)

Single channel 19.5 nm

Photospheric Magnetic Field Imager (PMI)

Vector magnetograph (Zeeman line scanning)

Compact Coronagraph (CCOR)

~3 to 22 solar radii

Heliospheric Imager (HI)

4 to 70 degree

LAGRANGE (L5)

Remote/optical

In-situ

X-ray Flux Monitor (XFM)

Magnetometer (MAG)

Plasma Analyser (PLA)

Medium Energy Particle Spectrometer (MEPS)

Radiation Monitor (RM)

# Mission architecture

**Operation 5-10 years**

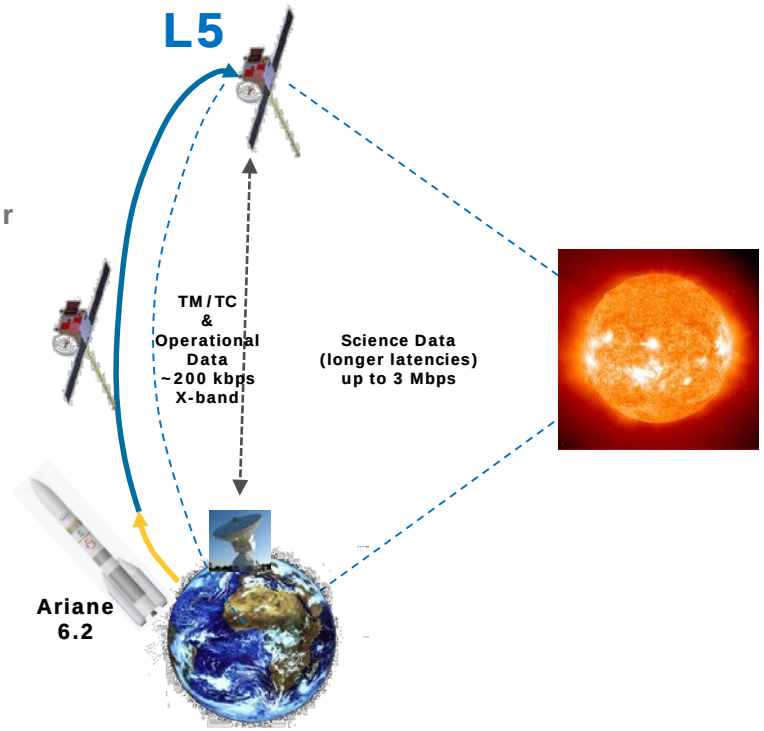
**Breaking manoeuvre**

**Operation during transfer**

**Transfer (14 or 26 m)**

**Commissioning**
S/C (1st month)
In-situ (2nd month)
Optical (4th month)

**Launch in 2025**
Direct injection

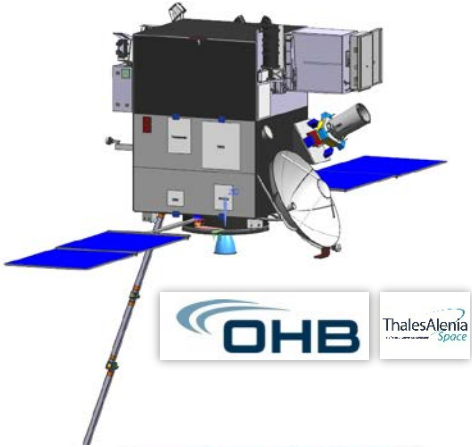


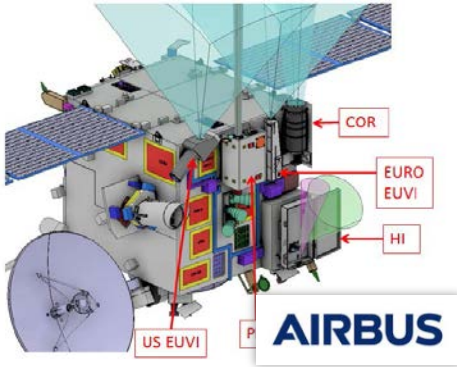

**24/7 operation using ESTRACK**

**Data transmission via flexible file based data handling**

# L5 space weather observatory key features

| Feature | Value | Comment |
|---|---|---|
| Mass, power | ~2 t wet mass, <1.5 kW | Propellant large fraction |
| Delta-v | Between ~1100 and 1800 m/s | One or two revolutions |
| Dimensions | 2.5 m x 2.5 m x 2.5 m | Medium sized S/C |
| Launcher | Ariane 6.2 | Single passenger |
| Instruments | 4 optical (200 kbps)<br>5 in-situ (10 kbps) | 120 kg, 200 W |
| Magnetic cleanliness | Optimised for magnetometer | ~5nT at sensor on boom |
| 'Silent' observations<br>3-axes-stabilised | Pointing stability | Imaging performance |
| Clean environment | Thruster configuration optimised for observations | Plasma measurements |
| Continuous observation | 24/7 - short latencies<br>(as short as 15 minutes) | Also during Carrington event – optimisation |
| Orbit | Lagrange Point 5 | 1 AU distance from Earth<br>~1.5 Mkm eccentricity |



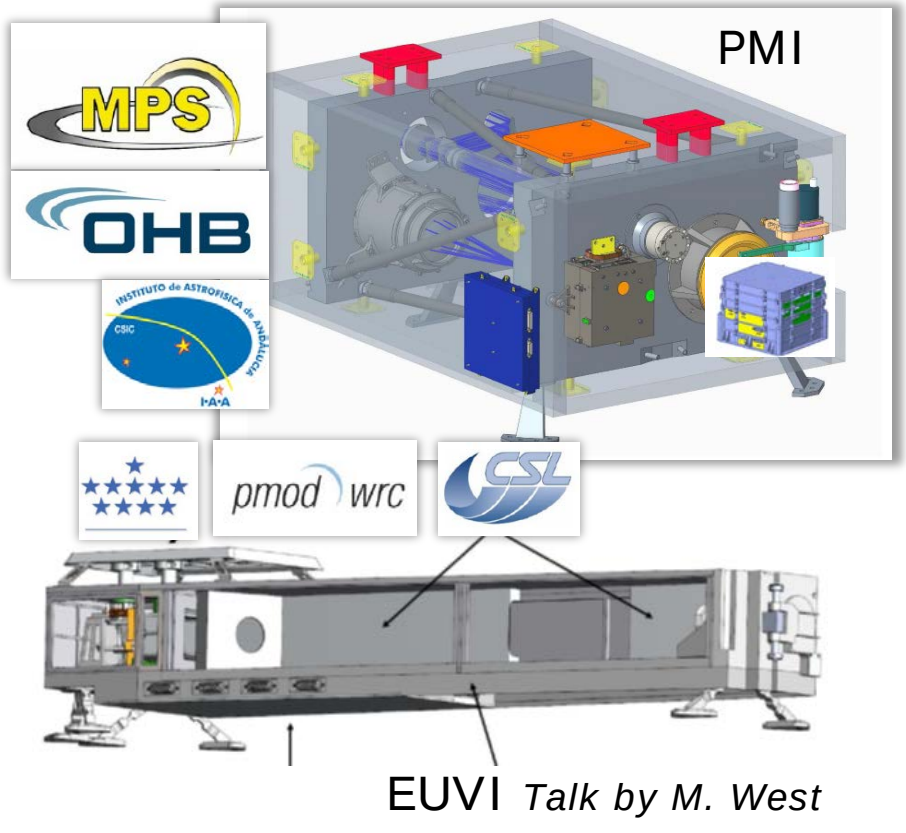



# LAGRANGE instruments

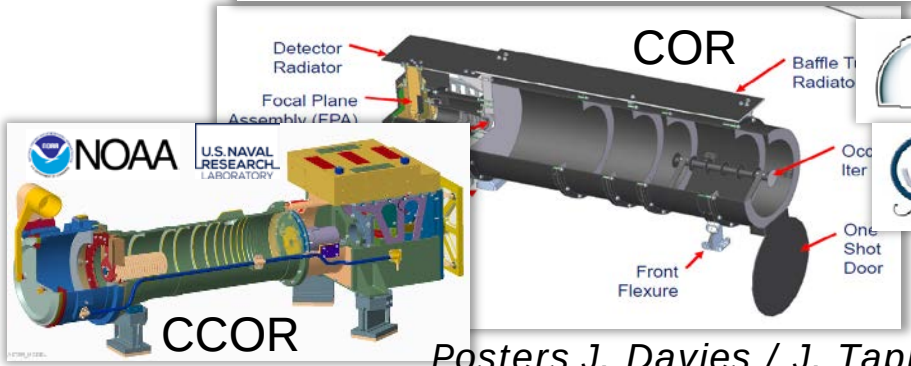
| Instrument | Observation | Utilisation | Performance (latency/cadence) |
|---|---|---|---|
| Photospheric Magnetic field Imager (PMI) | Vector magnetic field mapping of the solar photosphere | Evolving magnetic complexity: input into solar wind modelling and activity forecast | Range: +/-4 kG<br>Accuracy: 10 G, Zero 0.1G<br>1.2 arcsec / pixel, (40'/ 30') |
| EUV Imager (EUVI) | EUV solar disk imagery | Monitor solar active regions, coronal holes and on-disk signatures | 19.5 nm<br>1.6 arcsec / pixel, (15'/5') |
| Compact Coronagraph (CCOR) | Solar coronagraphy | Evolution and propagation of CMEs | 3 to 22 Solar Radii<br>1 arcmin / pixel, (15'/5') |
| Heliospheric Imager (HI) | Heliospheric imagery | | 4° to 70°, 2 arcmin / pixel, (50'/30') |
| Plasma Analyser (PLA) | Solar wind particle densities, temperatures and velocity | Solar wind monitoring, detection and characterisation of high-speed solar wind streams | ±22.5° x 45°, 5° angular<br>70 eV to 33 keV, (15'/1') |
| Medium Energy Particle Spectrometer (MEPS) | Medium energetic particles | | 30 kev/nuc up to 8 MeV/nuc (ions)<br>30 keV to 0.6 MeV(electroncs)<br>32/16 channels, 2x2 look directions, (15",1') |
| Magnetometer (MAG) | Interplanetary Magnetic Field vector-magnetic field | | Absolute accuracy 1 nT<br>(15'/1") |
| Radiation Monitor (RM) | Highly energetic particles | Solar energetic particle event detection and monitoring | 2 MeV to 1 GeV (p+, ions), directional<br>100 keV to 8 MeV (electrons), (15'/1') |
| X-ray Flux Monitor (XFM) | Solar disk integrated X-ray flux | Detection and categorisation of solar flares | 0.05 to 0.8 nm / 1.55 keV to 25 keV<br>512 channels, 400 eV @ 6 keV, (15'/1') |

# Remote Sensing Instruments

*Poster J. Davies*




*Talk by M. West*

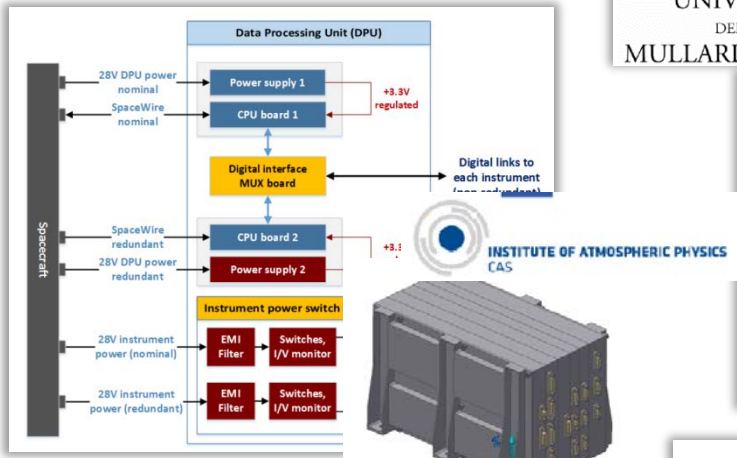

*Posters J. Davies / J. Tappin*

# In-situ Instruments

*Talk W. Hajdas*

PAUL SCHERRER INSTITUT PSI

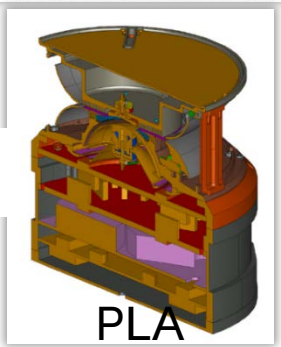
RM




UCLC

UNIVERSITY COLLEGE LONDON
DEPARTMENT OF SPACE & CLIMATE PHYSICS
MULLARD SPACE SCIENCE LABORATORY

UCL



PLA

*Talk*
*D. Kataria*
*Poster*
*J. Rae*

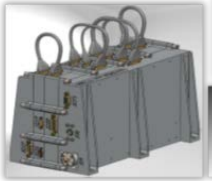
XFM

isaware

INSTITUTE OF ATMOSPHERIC PHYSICS CAS



MAG



ÖAW IWF

Imperial College London

MEPS

C A U
Kiel University
Christian-Albrechts-Universität zu Kiel

**Instrument to be procured individually**

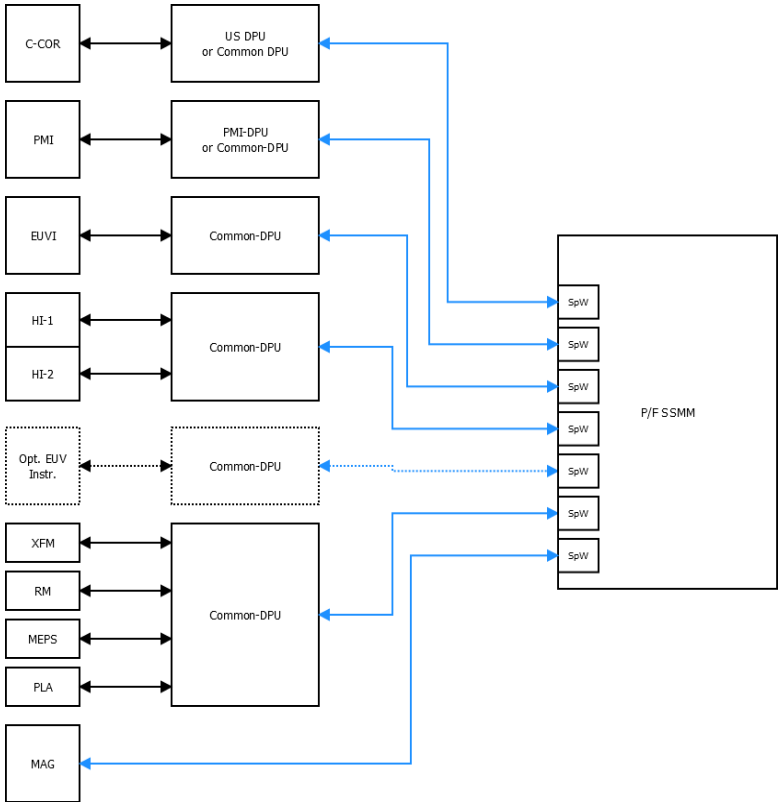
# Data Handling System

**Internal re-assessment performed at ESA**

**3 options recommended for further evaluation by industry**

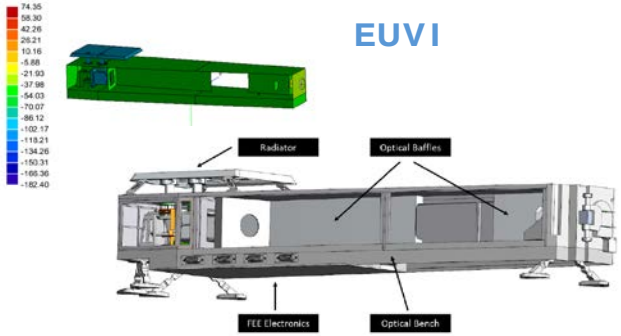
| Option | Description | Trade-off result | Comment |
|---|---|---|---|
| #1-A | Baseline configuration at ISRR (**IPCU - partially centralised**) | Recommended | Trade-off result from Phase 0/A study. |
| #3-A | **Common ICU+DPU** design for all remote sensing instruments, with no central processing function. | Recommended | Typical architecture used in Science missions (**JUICE evolution**). |
| #3-B | **Common I-CDPU** design for all remote sensing instruments and in-situ instrument suite, with a centralized unit for image processing and compression (e.g. OBC). | Recommended | As #3-A<br><br>Processing partly performed by platform |

**Distributed system anticipated**

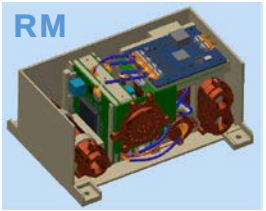


# Lagrange mission instrument status

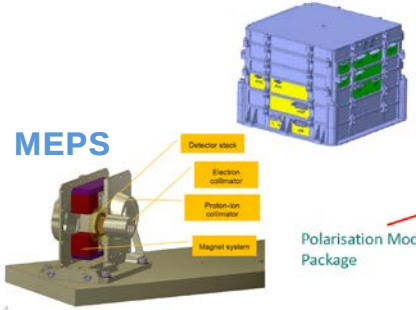
## EUVI



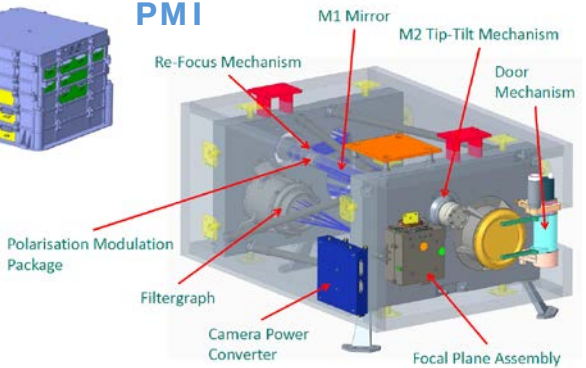

## RM



## MEPS

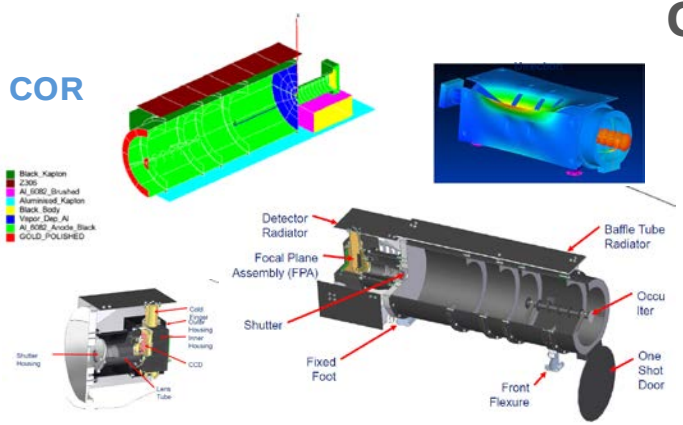



## PMI

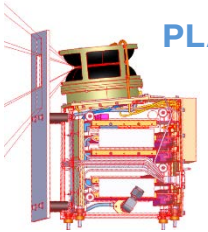



**Good progress in all design areas**

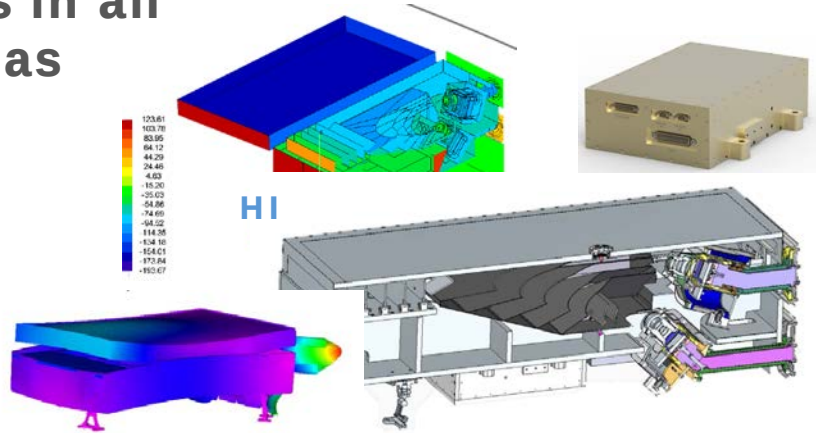
## COR



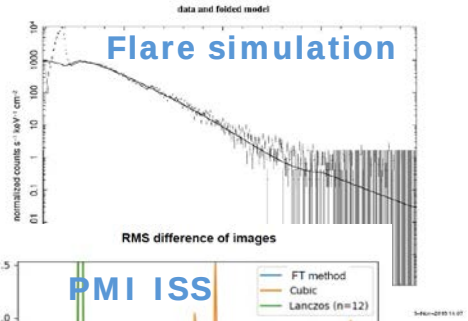

## PLA



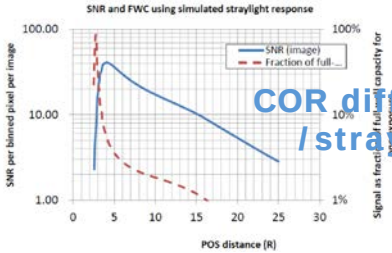
## HI



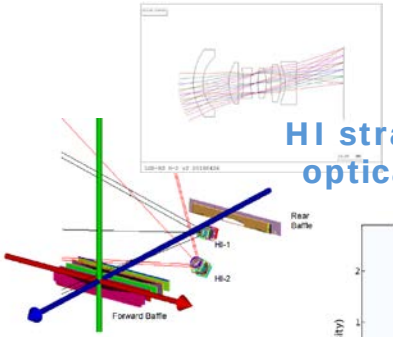
# Instruments performance status



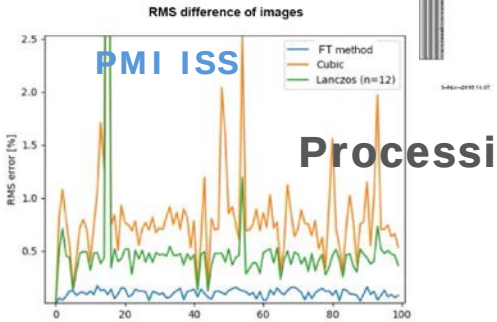

Flare simulation



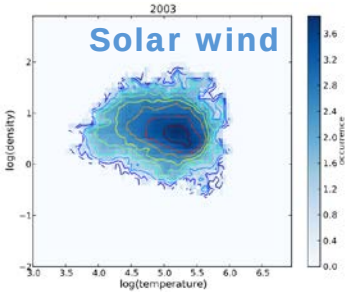

COR diffraction /straylight




HI straylight & optical model




PMI ISS



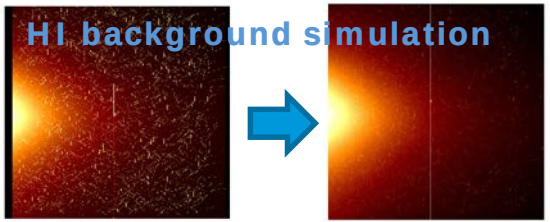

Solar wind

## Performance modelling

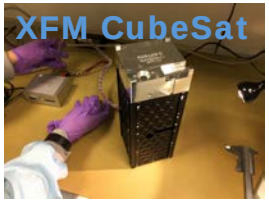
## Processing simulations & Requirements analysis

*Poster I. Grozea*

## First hardware coming

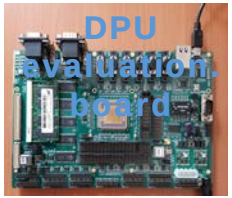


HI background simulation

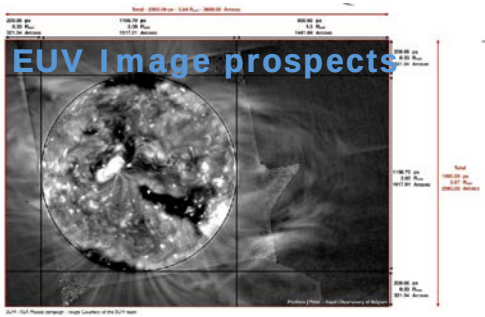


XFM CubeSat

MEPS detector

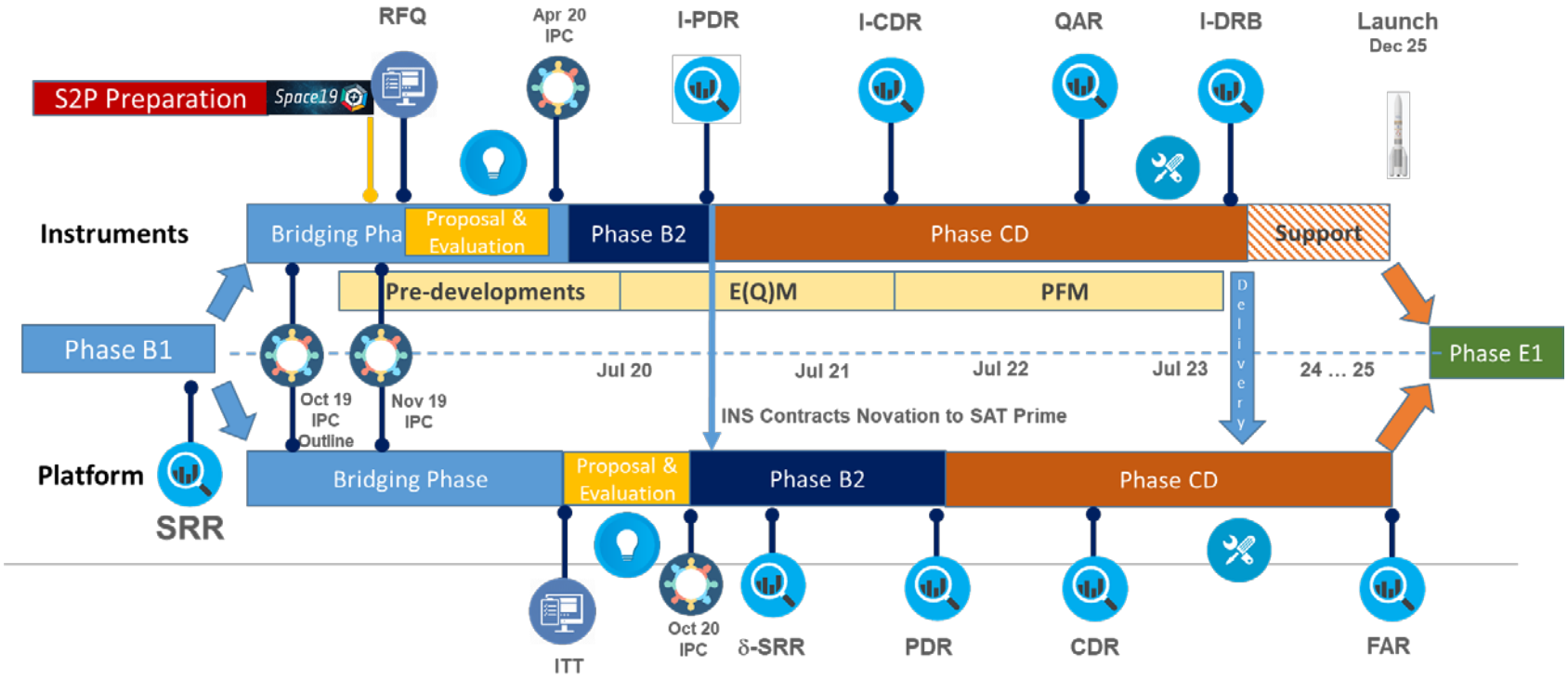


DPU evaluation board



EUV Image prospects

# LAGRANGE Mission development schedule



# THANK YOU

&

## ESA LAGRANGE Instruments Team:

F. Ratti (instrument coordination), I. Biswas (PMI, optical), S. Terzo (in-situ, MAG, PLA), A. Lupi (I/F), A. Baselga Mateo (EUVI/COR), A. Martinez Carou (Mechanisms), D. Rodgers (PLA), D. Steenari (DHS), G. Santin (RM, MEPS), J.P. Halain (EUVI/HI), J.P. Luntama (mission scientist), L. Visconti (cost), M. Solyga (thermal), N. Bozic (structures), P. Jiggens (environment), N. Nelms (detectors/FEE), R. Franco (E2ES), V. Favia (RAMS)

swe.ssa.esa.int

www.esa.int

# Other talks and posters

| | |
|---|---|
| The EUV Imager on Lagrange | *West, M et al. (talk)* |
| In-situ particle instruments for enhanced space-weather monitoring | *Kataria, D et al. (talk)* |
| Design, development and testing of the RADEM and NGRM instruments | *Hajdas, W et al. (talk)* |
| The Remote-Sensing Package for the Lagrange Mission | *Davies, J et al. (poster)* |
| The COR and HI Instruments for the Lagrange Mission | *Davies, J et al. (poster)* |
| Space weather monitoring of the in-situ environment from the Sun-Earth Lagrange points | *Rae, J et al. (poster)* |
| LGR-RS End to End Performance Simulator Architectural Design and First Results | *Grozea, I et al. (poster)* |