MASC:
MAGNETIC ACTIVITY OF THE SOLAR CORONA

Hui Li, Weiqun Gan, Jian Wu,
Jingwei Li, Qiusheng Du - *Purple Mountain Obs, Nanjing, China*

Cheng Fang, Yang Guo - *Nanjing University, Nanjing, China*

Xin Meng - *National Space Science Center, China*

Haiying Zhang – *Nanjing Institute of Atronomical Optics & Technology, China*

Frédéric Auchère, Jean-Claude Vial - *Institut d'Astrophysique Spatiale, France*

Silvano Fineschi - *INAF-Osservatorio Astrofisico di Torino, Italy*

Marco Romoli, Federico Landini - *University of Florence, Italy*

Petr Heinzel - *Astronomical Institute of the Academy of Sciences of the Czech Republic*

Hardi Peter - *Max-Planck-Institut für Sonnensystem-forschung, Germany*

Andrei Zhukov, Susanna Parenti - *Royal Observatory of Belgium, Belgium*

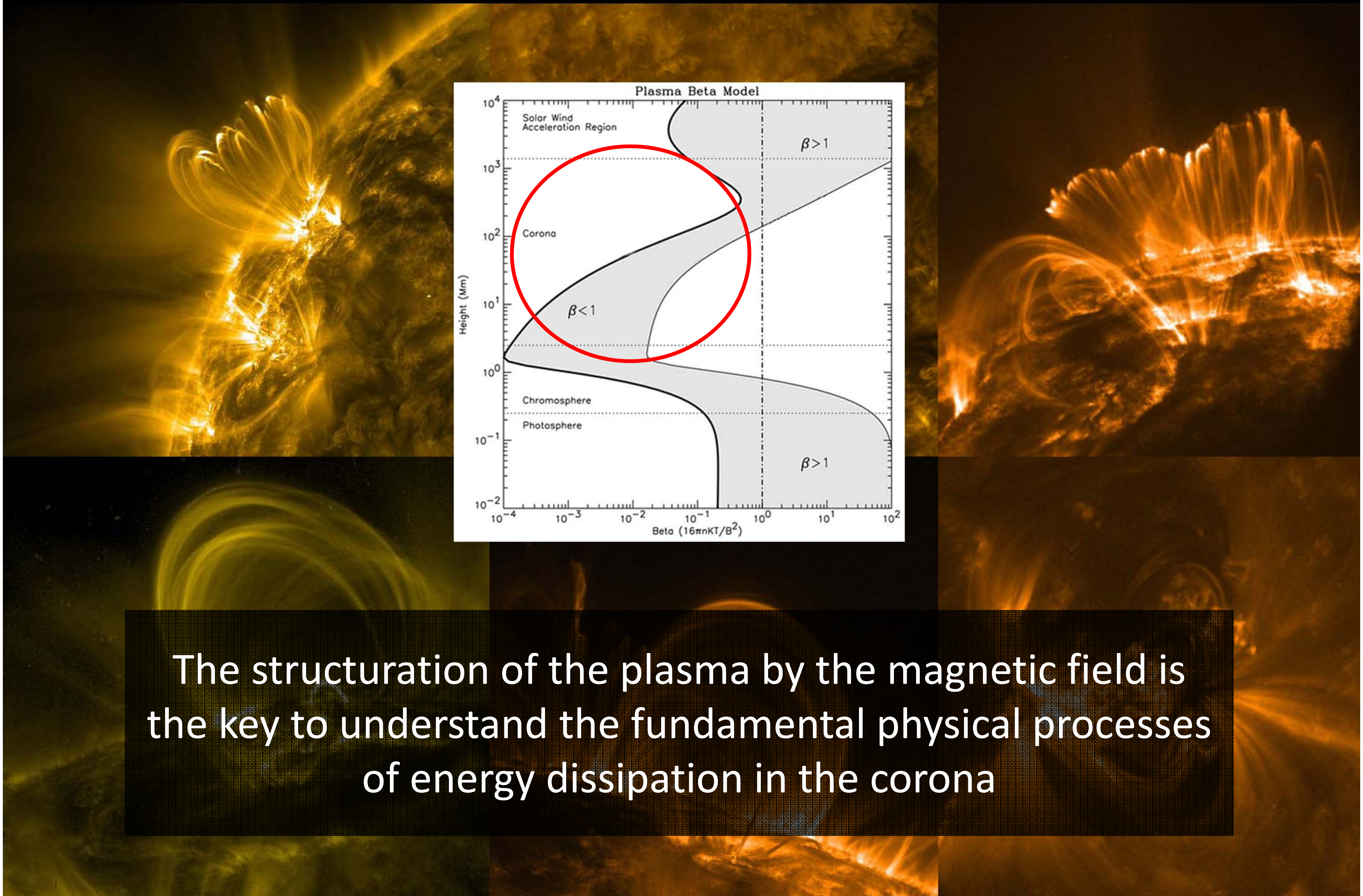
Pierre Rochus – *Centre Spatial de Liège, Belgium*

Manolis Georgoulis - *Academy of Athens, Greece*

Thanassis Katsianis - *National Observatory of Athens, Greece*

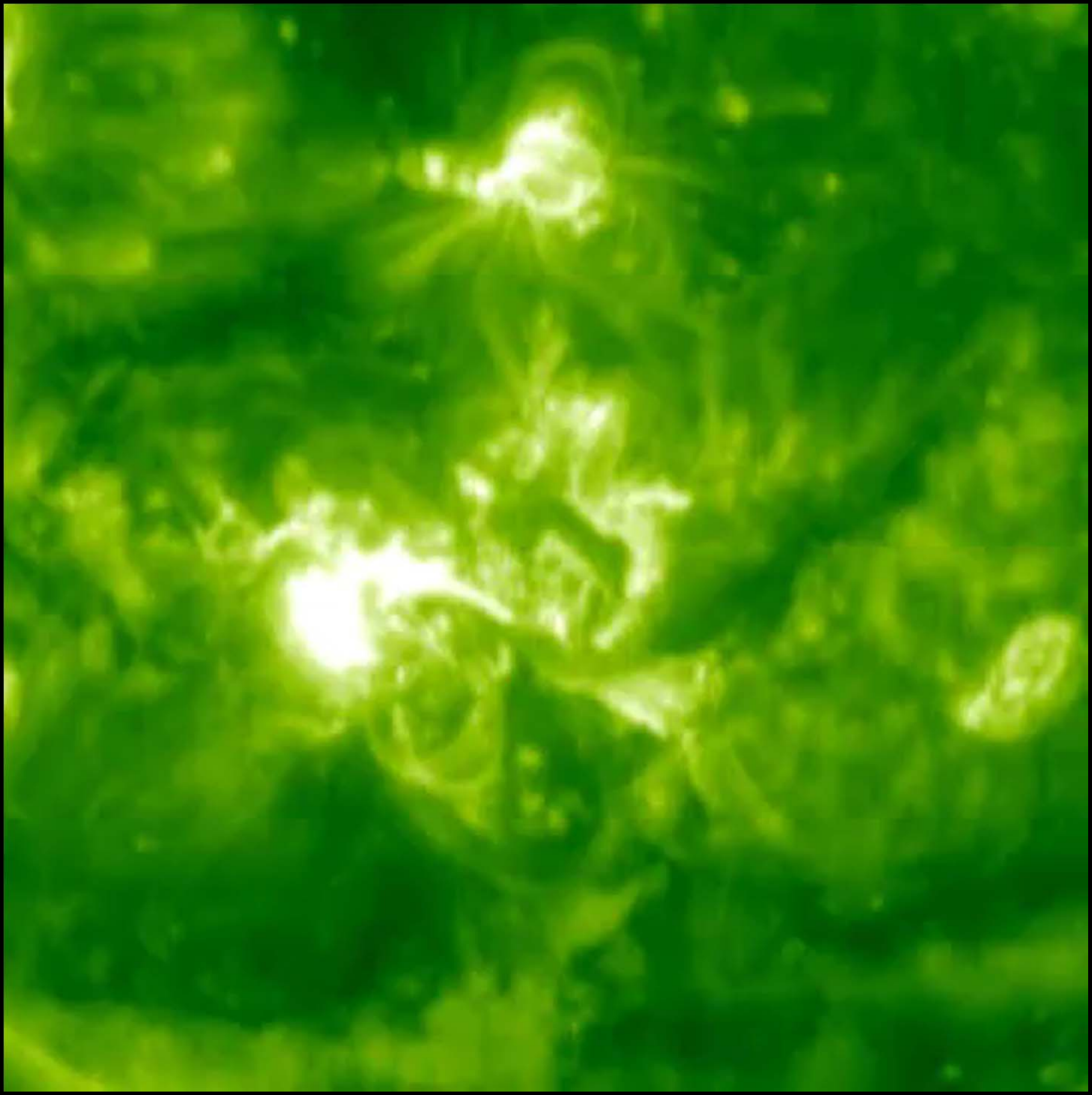
Spiros Patsourakos - *University of Ioannina, Greece*

The magnetic field shapes the solar corona



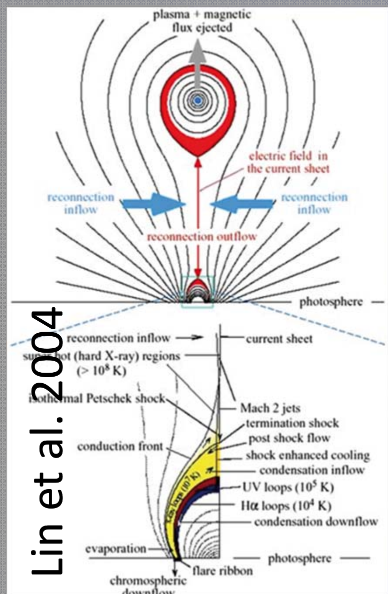
The structuration of the plasma by the magnetic field is the key to understand the fundamental physical processes of energy dissipation in the corona

The magnetic field drives coronal dynamics

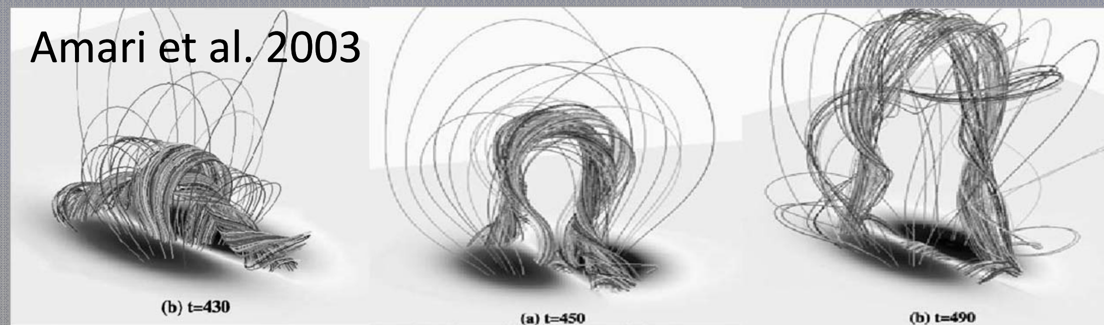


Magnetic restructuring and instabilities

Many models of the flare / CME process



Lin et al. 2004



Amari et al. 2003

What is the true field topology & strength?

But… How is the magnetic energy stored ?

What triggers the instability ?

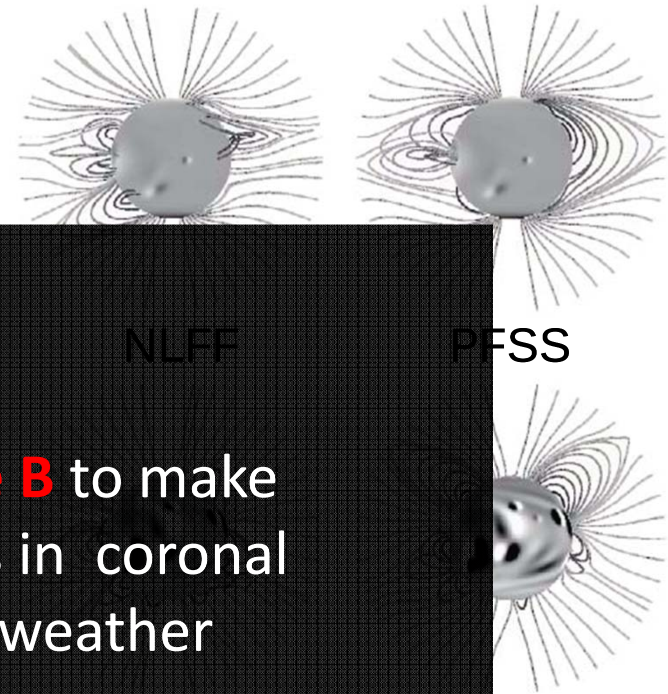
The coronal magnetic field is the key to understanding coronal dynamics … and space weather !

FESTIVAL

SECCHI

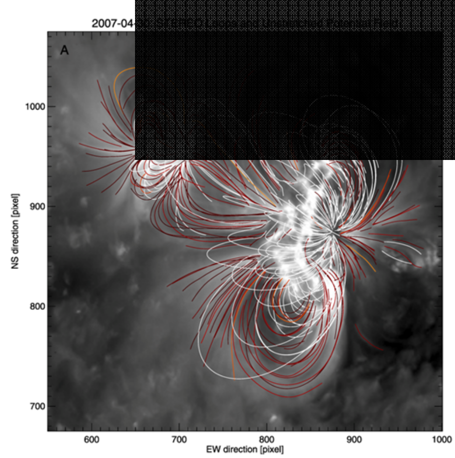
Coronal B is known mainly from *photospheric* extrapolations

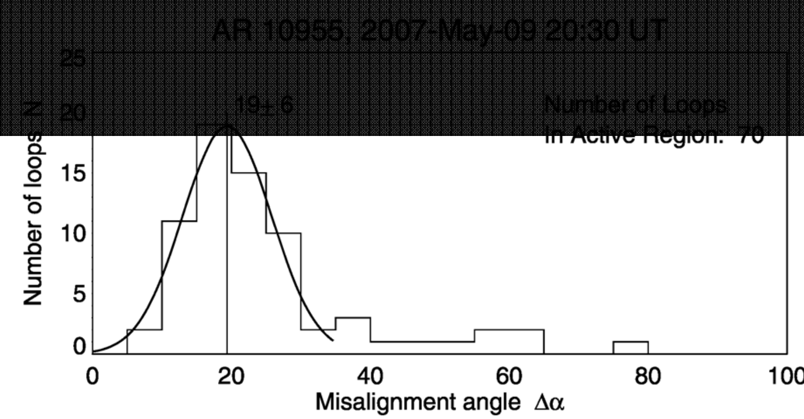
- The extrapolated field is strongly model-dependent.
- The extrapolated field is static
- Realistic extrapolations also require difficult horizontal photospheric field measurements
- The extrapolated fie[illegible] reproduce the complexity of the solar corona



Yeates et al. 2010

We **need** to **measure B** to make significant progresses in coronal physics and space weather





DeRosa et al. 2009

MASC: Magnetic Activity of the Solar Corona

MASC is aimed at understanding dynamic plasma processes in the solar corona using unprecedented space-borne measurements of the coronal magnetic field.

The top-level scientific objectives are

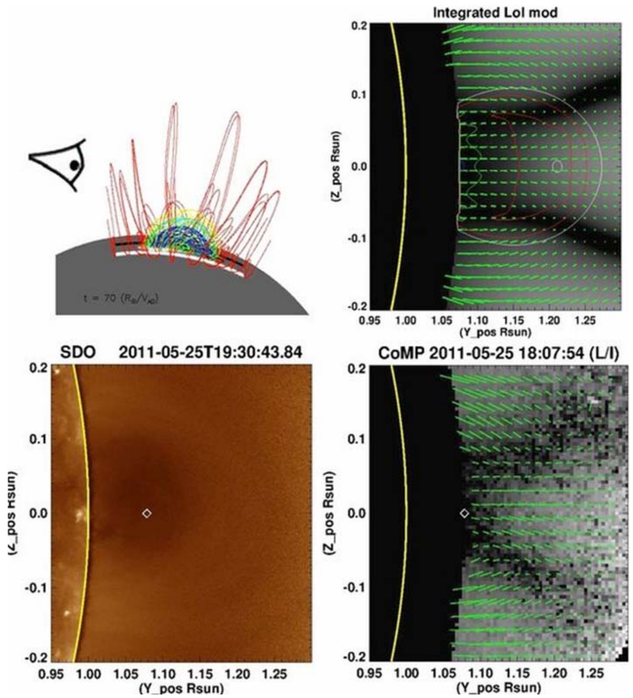
1. What is the global magnetic field configuration in the corona?
2. What is the role of the magnetic field in the triggering of flares and CMEs?
3. What is the link between magnetic configuration and energy release?

To fulfill these objectives, we need

1. High cadence high spectral resolution X-ray spectra of the eruptions
2. High cadence high spatial resolution EUV imaging of the source regions
3. Measurements of the coronal magnetic field

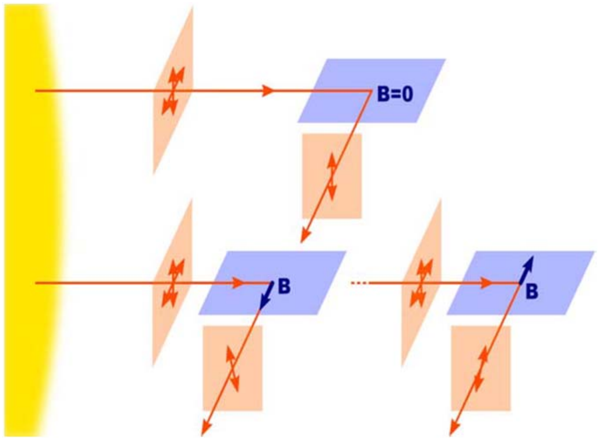
How to measure the magnetic field magnitude & topology?

- **Zeeman effect**
  - Compared to photospheric conditions
    - $B_{corona} \searrow$, Zeeman splitting $\searrow$
    - $T_{corona} \nearrow$, Line width $\nearrow$
  - Limited to strong fields above Active Regions



Bak et al. 2013

- **Hanle effect !**
  - Modification of the linearly polarized scattered radiation by the magnetic field
  - Sensitive to weaker fields
  - Successful in prominences (Bommier et al. 1994)

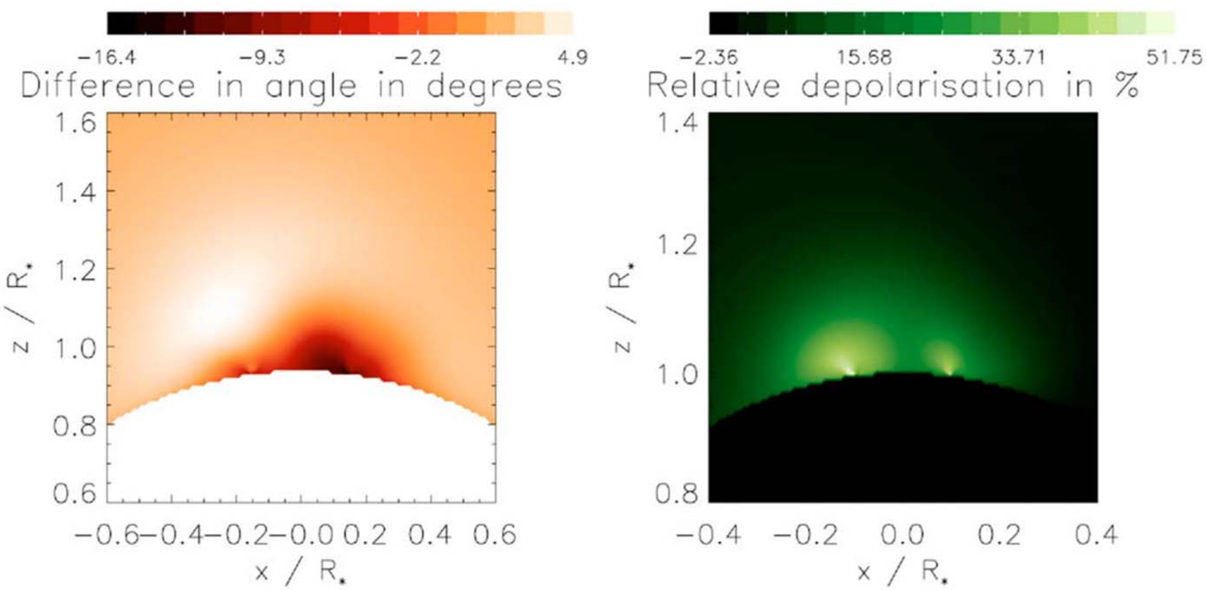


Trujillo Bueno et al. 2005

Hanle effect for the H Lyman series

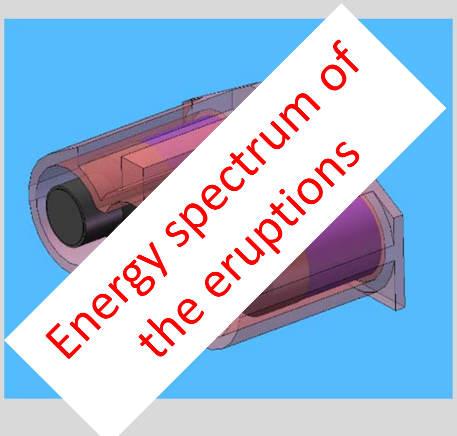
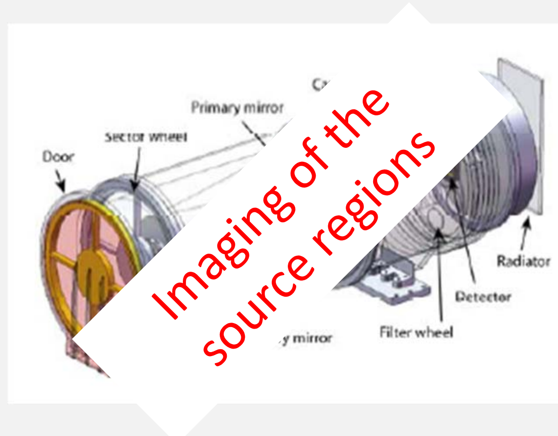
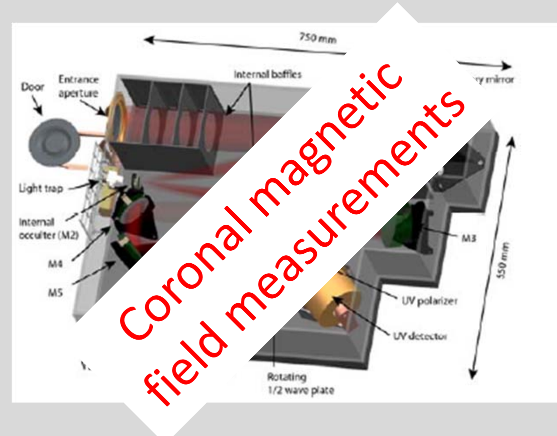
- **The Hanle effect is sensitive to much weaker fields than the Zeeman effect**
  - [5, 500] G for H I Ly-α (1216 Å)
  - [1, 160] G for H I Ly-β (1026 Å)
  - [0.5, 70] G for H I Ly-γ (992 Å)

- **Lyman α is the prime candidate for the first measurements**
  - Strongest coronal UV line
  - The physics is well understood (e.g. Bommier & Sahal-Bréchot 1982)
  - The technology is available
  - Strong expected signal (e.g. Derouich et al. 2010)



Khan & Landi degl'Innocenti 2011

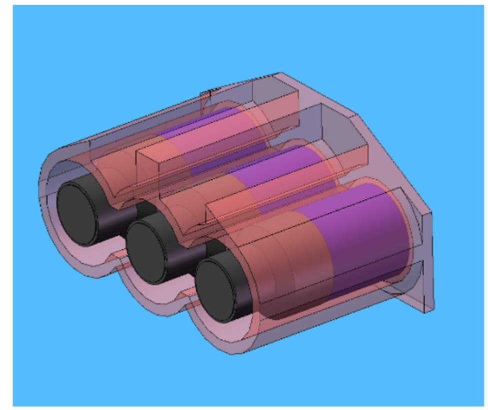
The MASC payload

HXR spectrometer (HESP)	UV/EUV Imager (WIFI)	Coronagraph (MAGIC)
 Energy spectrum of the eruptions	 Imaging of the source regions	 Coronal magnetic field measurements
	 	 

Payload: High Energy Spectrometer (HESP)

Measurements: energy spectra of the eruptions

Main characteristics



- E range: 20 keV – 600 MeV
- Resolution: 3.6%@662keV
- Cadence 1 to 4 s (down to 32ms)
- Mass: 20 kg
- Power: 20 W
- Volume: 31 x 23 x 16 cm^3

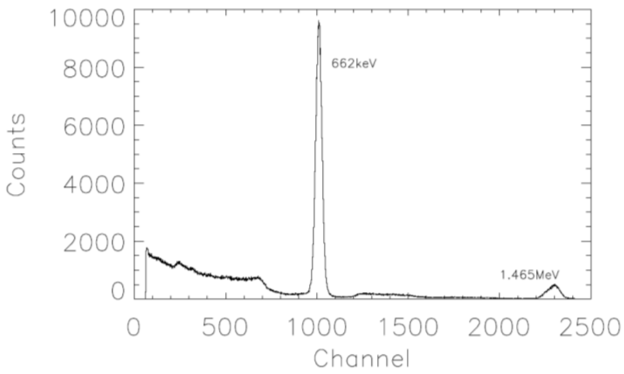
Consortium



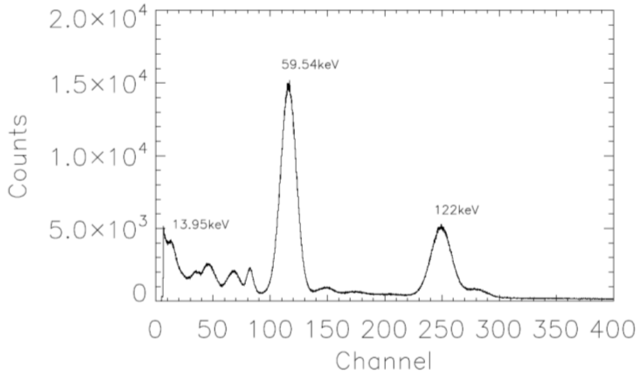
- PMO: Management, structure, electronics, PA/QA, AIT/AIV
- NIAOT: Structure
- NJU, NSSC: flight software

HESP status

~3.6% @ 662 keV



Response down to 10 keV



- Preliminary structure and electronic design completed
- Bought one 2 inches LaBr3 crystal
- **Prototype (1 channel)** finished and tested with electronics
- LaBr3 crystal tested as a scintillator for space observation on GRS/CE-2 of CLEP

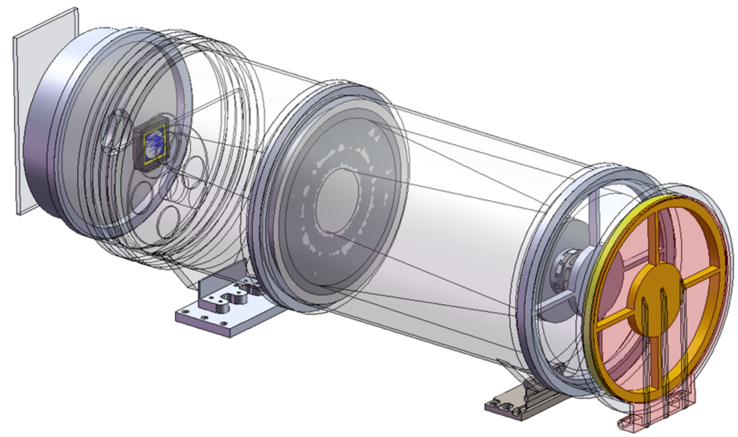
TRL 6-7

Payload: Wide Field Imager (WiFI)

Measurements: dynamics, morphology, electron temperature

Main characteristics

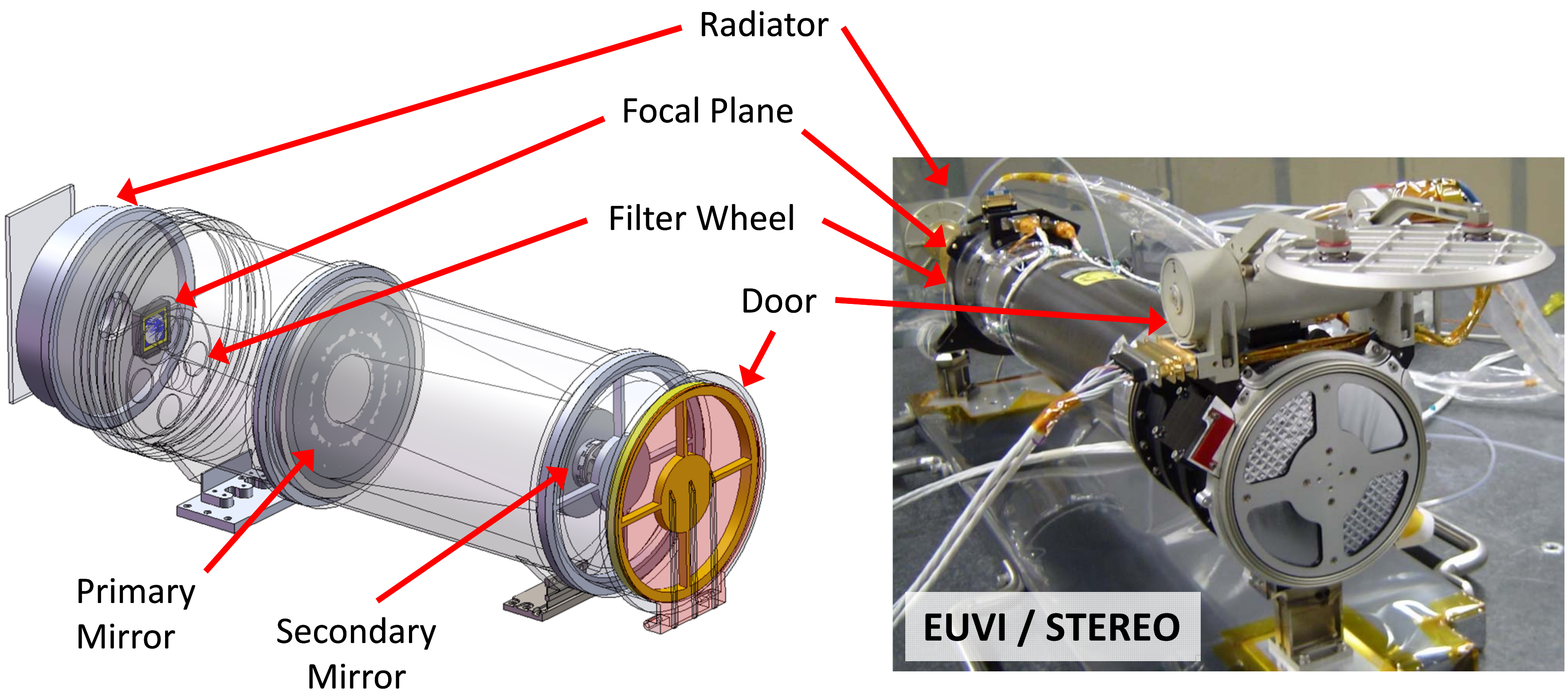
- Field of view: 0 to 3 Rs
- Passbands: 13.1, 17.1, 19.5 nm, Lyman α
- Cadence: 1 to 7 min
- Resolution: 2.8’’ (2048 × 2048)
- Mass: 15 kg
- Power: 10 W
- Volume: 75 x 28 x 22 cm^3



Consortium

- Management, structure, cameras, electronics, PA/QA, AIT/AIV
- Door
- Filter wheel
- Flight software
- EUV optics
- Possible contributions from China

WiFI status



- Telescope design similar to EIT/SOHO, EUVI / STEREO
- Consortium heritage: EIT, EUVI, SWAP/Proba 2, EUI/Solar Orbiter, etc.

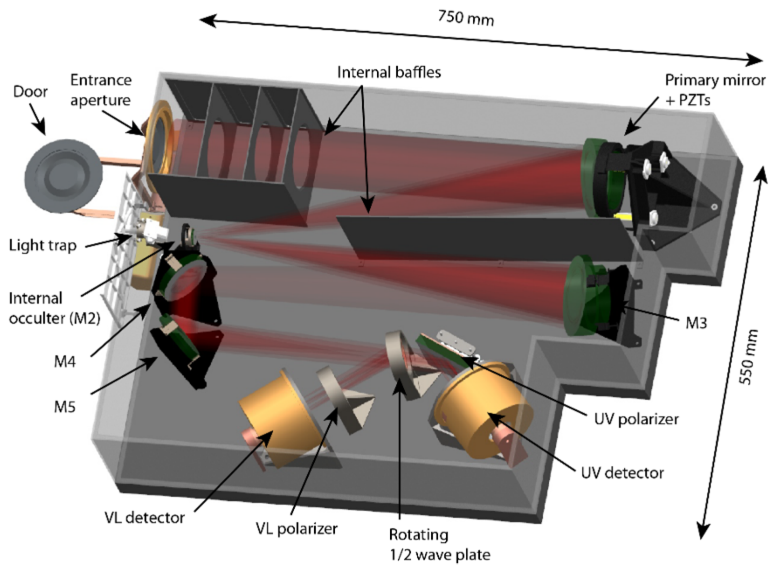
TRL > 7

Payload: Magnetic Imaging of the Corona (MagIC)

Measurements: magnetic field, electron density & Hydrogen outflow velocity

Main characteristics

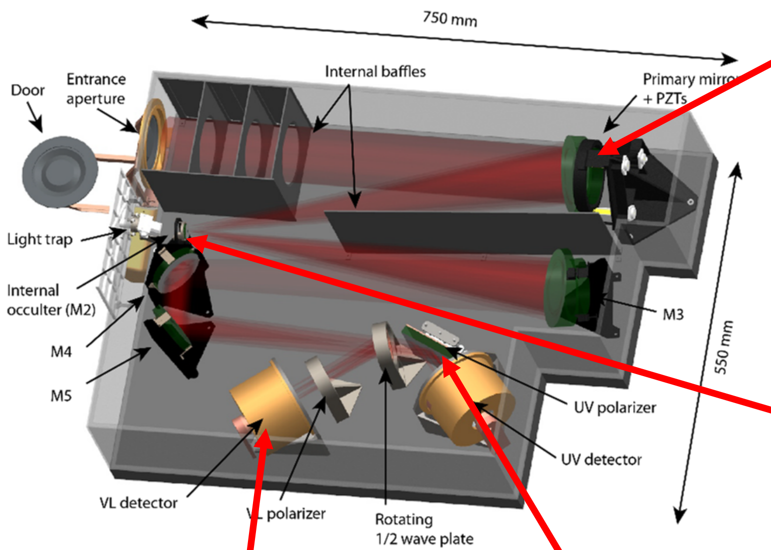
- Field of view: 1.15 to 3 Rs
- Passbands: Visible light & Lyman α
- Linear polarization in VL & Lyman α
- Cadence: 2 min
- Resolution: 2.8’’ (2048 × 2048)
- Mass: 26 kg
- Power: 20 W
- Volume: 75 x 55 x 20 cm^3

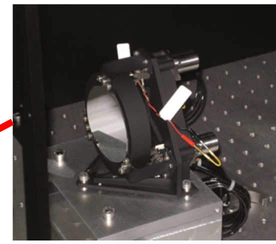


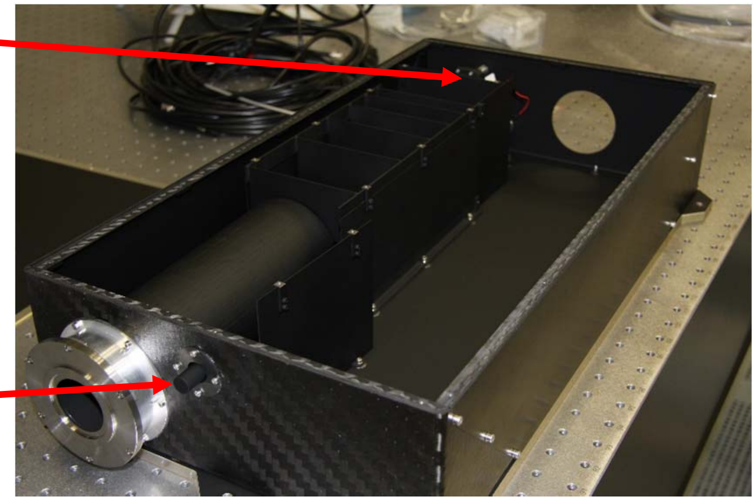
Consortium

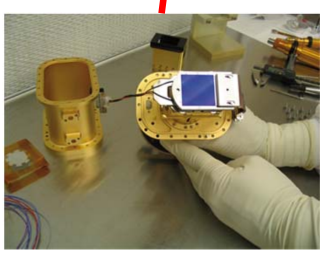
- Management, optics, structure, PA/QA, AIT/AIV
- Door
- Stray light analysis, polarizers
- Flight software
- Cameras, electronics
- Possible contributions from China

MagIC status





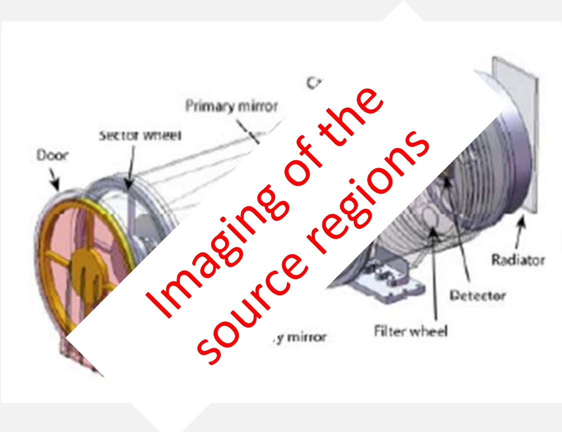
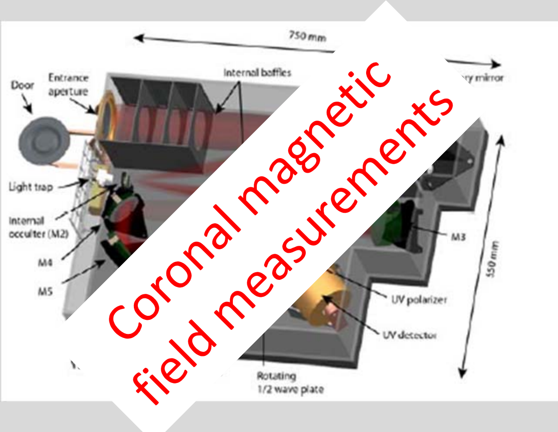




- Developments since 2000+: LYOT/SMESE, ECLIPSE, SIGMA, etc.
- All critical components (mirrors, polarizers, detectors) have benefited from CNES R&Ts
- Stray light levels validated on a mock-up

TRL >6

MASC payload summary

HXR spectrometer (HESP)	UV/EUV Imager (WiFI)	Coronagraph (MagIC)
		
- E range: **20** keV – 600 MeV - Resolution: 3.6%@662keV - Cadence 1 to 4 s - Mass: 20 kg - Power: 20 W - Volume: 31 x 23 x 16 cm^3	- Disk & corona up to 3Rs - Lyman α + 3 EUV bands - Cadence up to 1 sec - Mass: 15 kg - Power: 10 W - Volume: 75 x 28 x 22 cm^3	- Coronagraph 1.15 – 3 Rs - Visible light & Lyman α - Cadence up to 2 min - Mass: 26 kg - Power: 20 W - Volume: 75 x 55 x 20 cm^3

- Developments since 2000+: SMESE, ECLIPSE, SIGMA, etc.
- Strong heritage: SOHO/EIT, EUVI/STEREO, LYOT/SMESE, etc.
- Meets the mission constraints

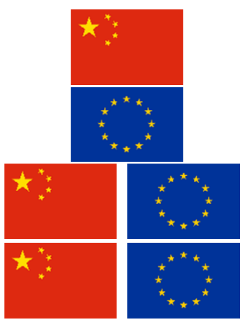
TRL 6 to 9

MASC mission overview

Requirements

- (Quasi)-continuous view of the Sun
- ~4 Mbit/s telemetry (High resolution, high cadence)
- Dawn-dusk SSO or geo-synchronous orbit
- Launch in 2021, three year nominal mission

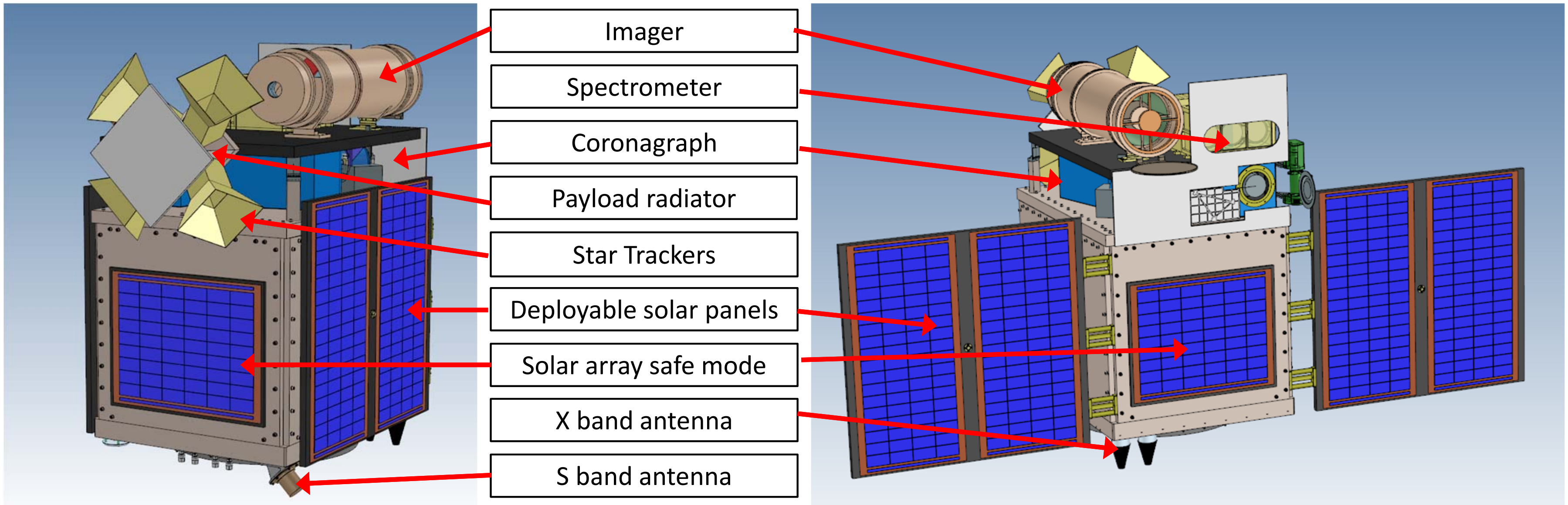
Implementation



- Chinese launch, dedicated or possibly as a piggy back payload
- European platform (Proba, Myriad Evo, etc.)
- Dual ground segment
- Joint science operations center

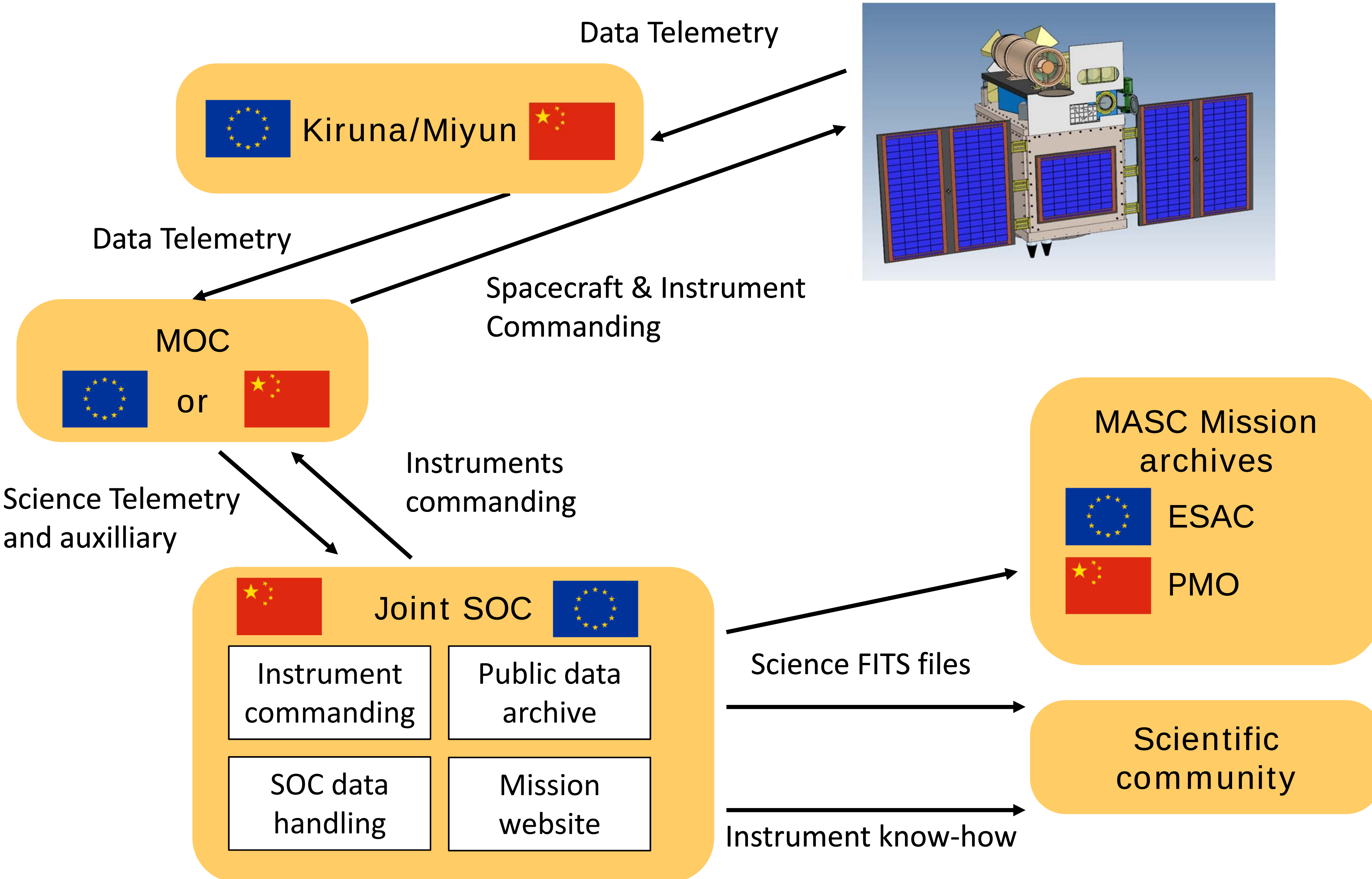
Accommodation Study

- Based on the PROBA series of platforms (TRL ≥ 8)
- PROBA is being ''ITAR freed''
- Total S/C mass: ~250 kg (including payload)



- Confirms previous analyses: the concept is mature and fits a small mission
  - SMESE Franco / Chinese project phase A study (2006-2008)
  - SIGMA shortlisted for ESA's small missions (2012)

Joint ground segment



Conclusions

- A mission dedicated to the understanding and quantification of solar coronal magnetism is bound to emerge
  - The proposed measurements are clearly identified by the community as key elements that can lead to major breakthroughs in heliophysics and space weather
  - A stream of proposals:
    - SMESE (France/China microsat, 2006-2008), COMPASS (ESA M-class, 2007), SolMeX (ESA M-class 2010), SIGMA (ESA S-class 2012), …
- MASC
  - CAS & ESA can be the first to make these pioneering measurements !
- Payload is mature, has a strong heritage & fits on a small mission platform
- Let's do it !