



# Solar Energetic Emission and Particles Explorer (SEEPE)

Siming Liu

Purple Mountain Observatory

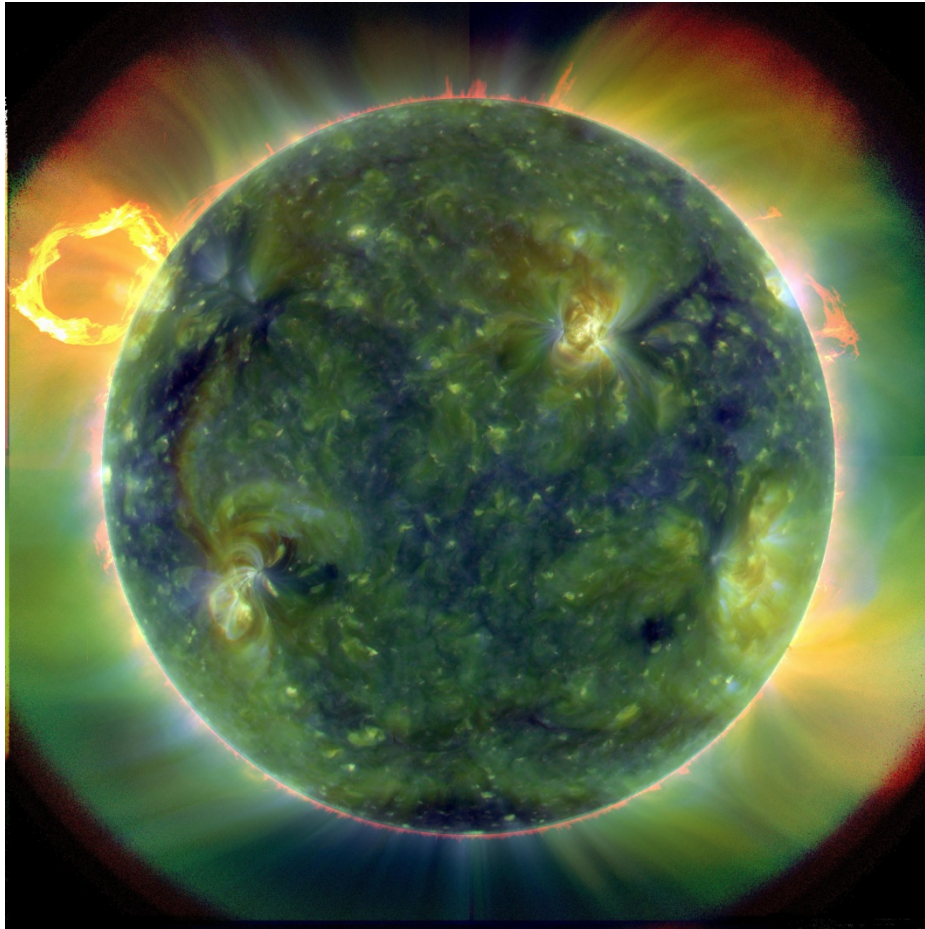
Paolo Soffitta, IAPS/INAF

Ronaldo Bellazzini, INFN-Pisa

Robert Wimmer-Schweingruber, CAU Kiel



# Scientific Motivation



**Solar Magnetic Fields**



**Magnetic Reconnection**



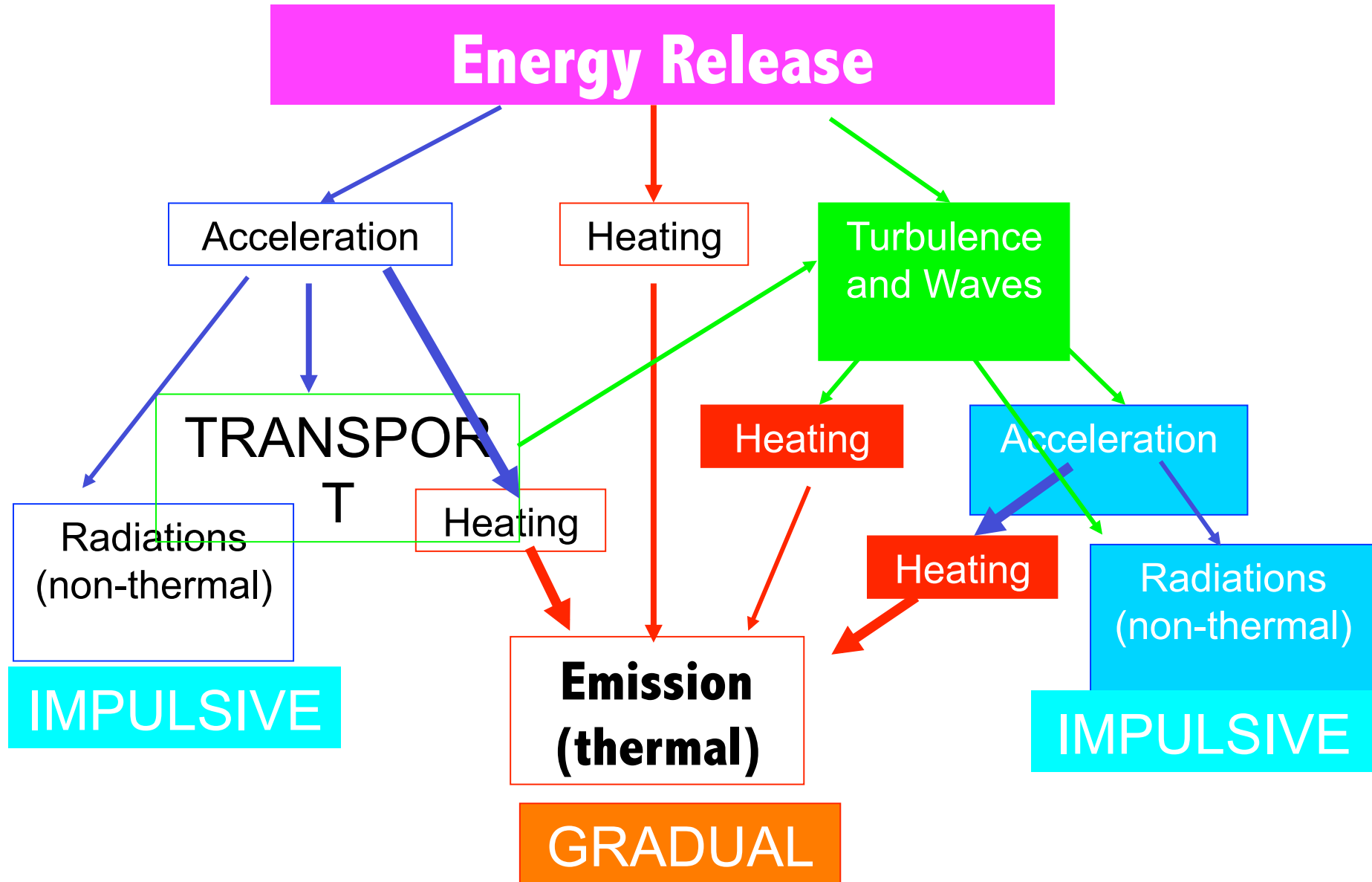
**Flare, CME, Solar Wind**



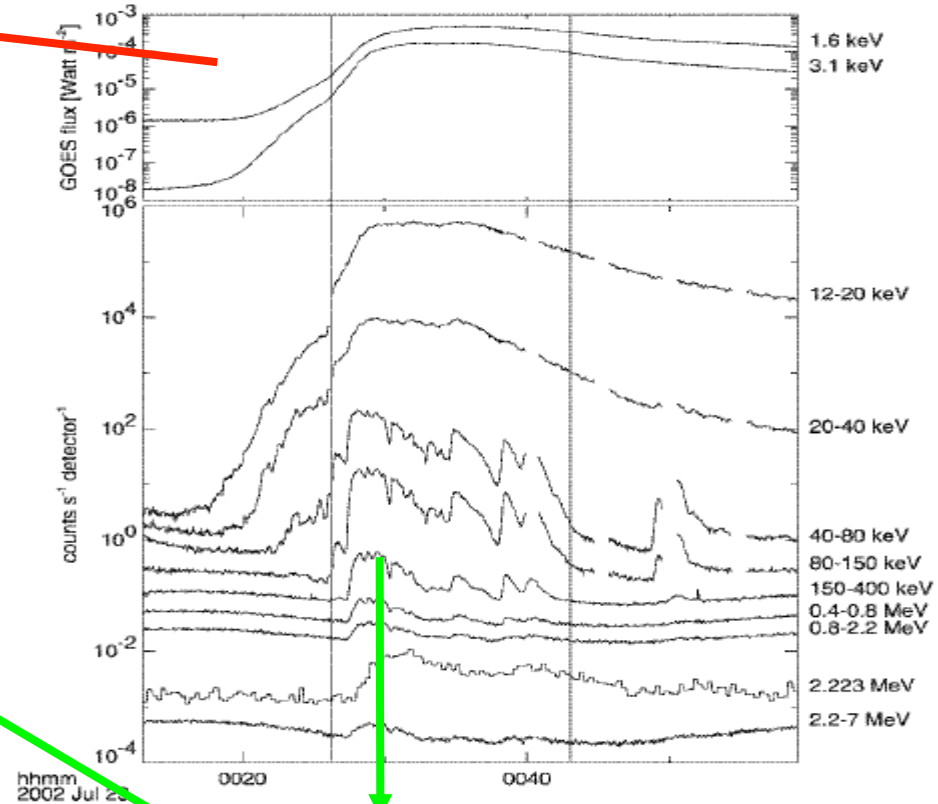
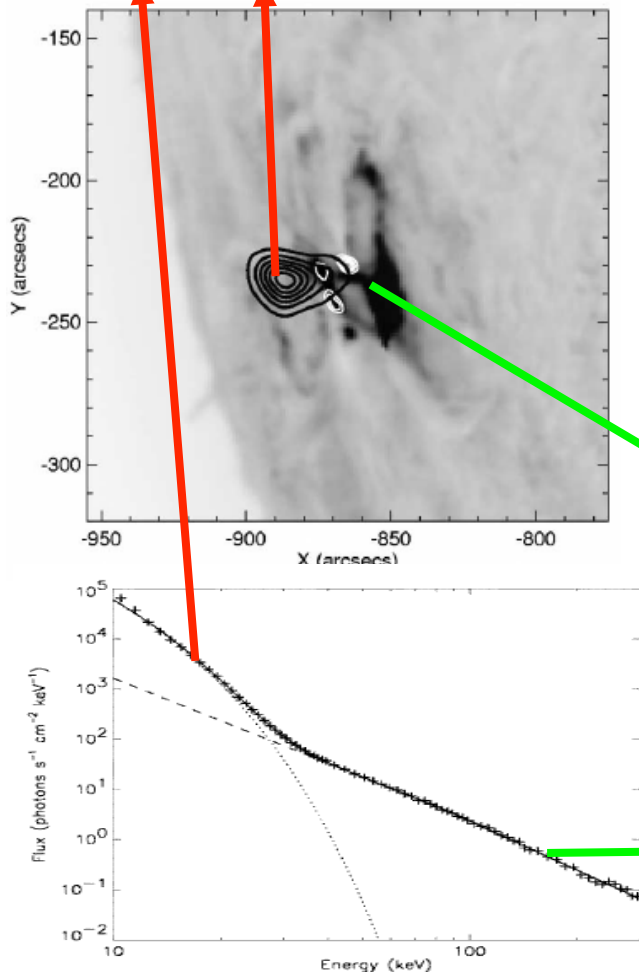
**Space Weather**



# Scientific Motivation



Low-energy: Gradual Thermal  
Coronal Source



**High-Energy: Impulsive  
Non-thermal  
Chromospheric  
Footpoints**



# Scientific Aim

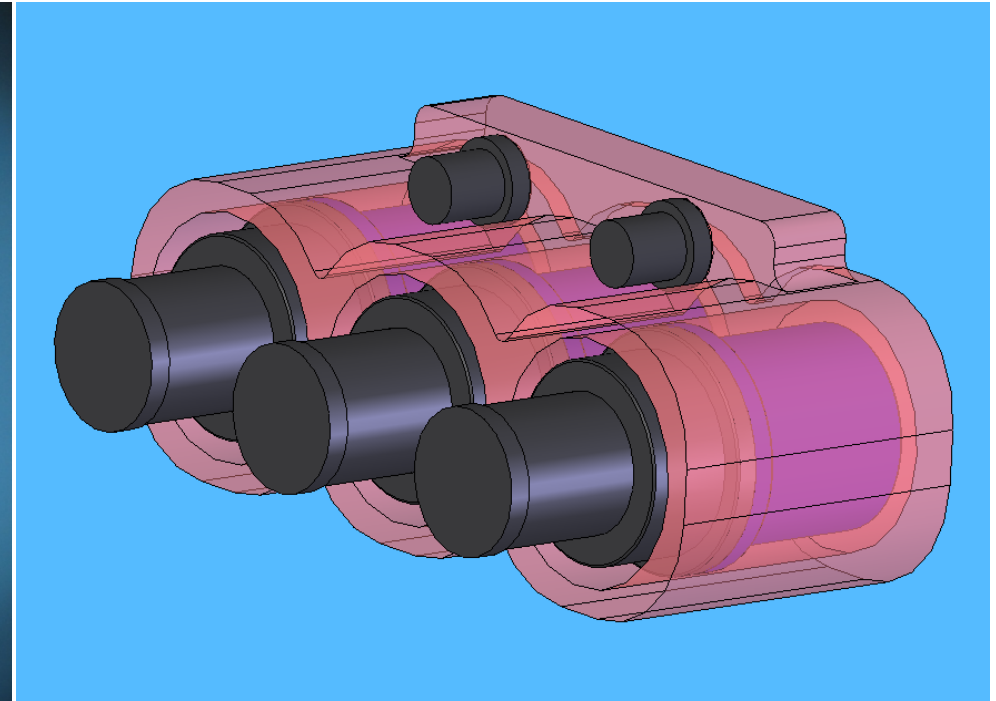


**To explore the magnetic **energy release** and consequent **plasma heating** and **particle acceleration** in the solar atmosphere by distinguishing the thermal and the non-thermal emission component:**

	Thermal	Non-thermal
Temporal	Gradual	Impulsive
Spectral	Exponential	Power-Law
Polarization	Isotropic	Polarized
Transport	Local	Global



# Scientific Payload



## High Energy Band Spectrometer (HEBS)

Size	362×349×172.5mm
Weight	20.5 kg
Power	20 W
Energy Range	10keV - 600MeV
Energy Resolution	3%@662keV





# Scientific Payload

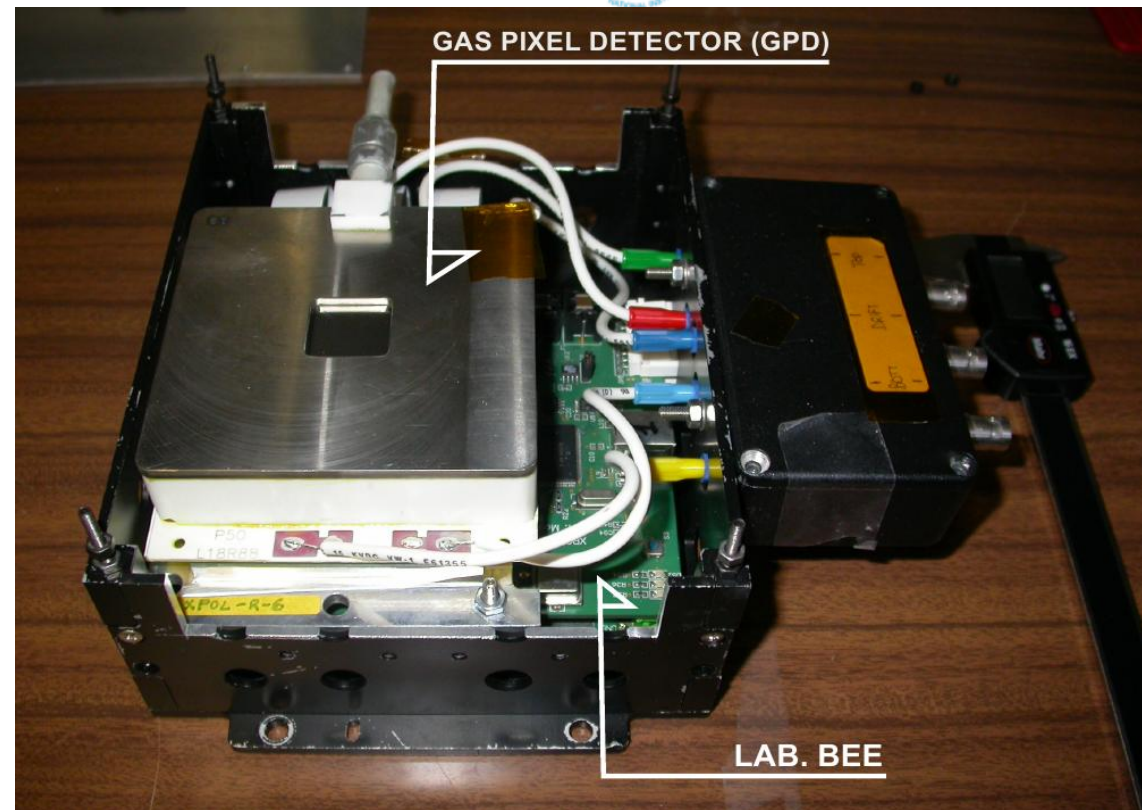


## A solar flares X-ray polarimeter

S. Fabiani<sup>1,3</sup>, R. Bellazzini<sup>2</sup>, F. Berrilli<sup>3</sup>, A. Brez<sup>2</sup>, E. Costa<sup>1</sup>, F. Muleri<sup>1</sup>,  
M. Pinchera<sup>2</sup>, A. Rubini<sup>1</sup>, P. Soffitta<sup>1</sup>, and G. Spandre<sup>2</sup>

$$MDP = \frac{4.29}{\mu \cdot R} \cdot \sqrt{\frac{R + B}{T}}$$

Flare Class	MDP (%)	Integration Time (s)
X10	0.6	748
X5.1	1.3	989
X1.2	4.8	239
M5.2	6.6	489
M1	46.4	128

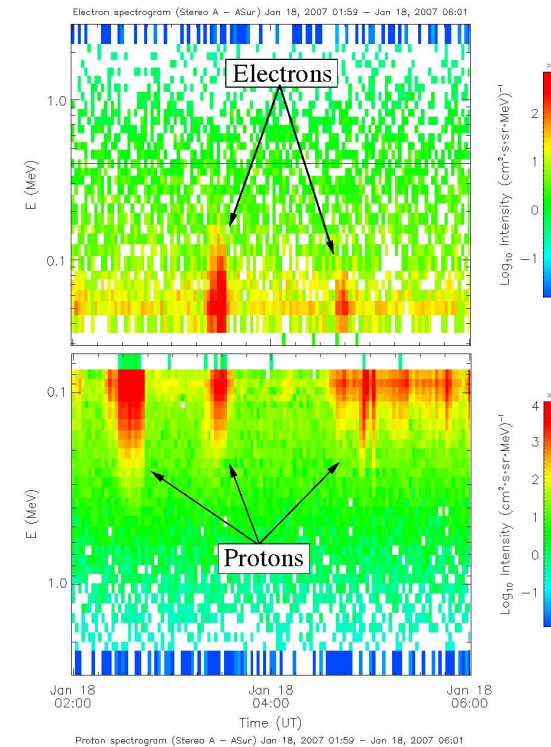
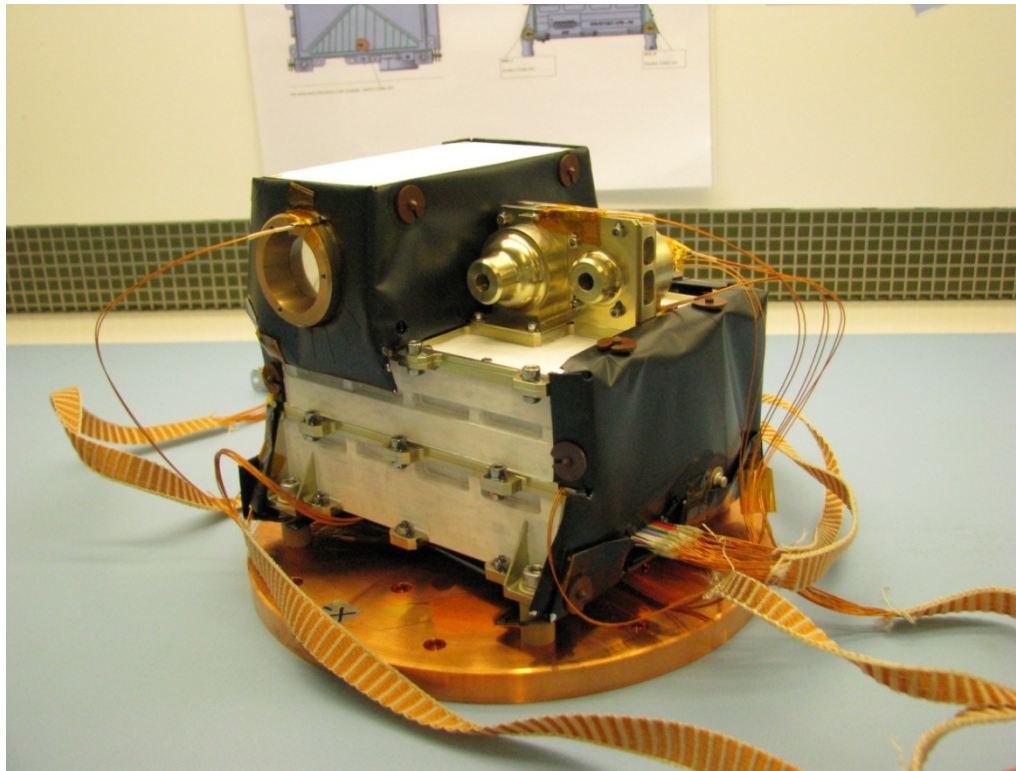


## X-ray Polarimeter (**Polarization**)

Weight	16 kg
Power	25 W
Energy Range	10-35keV(for non-thermal bremsstrahlung)



# Scientific Payload



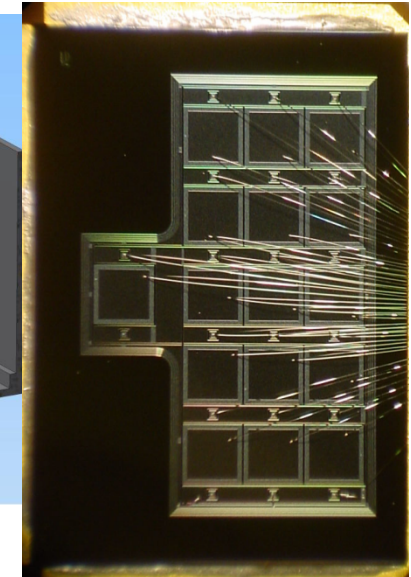
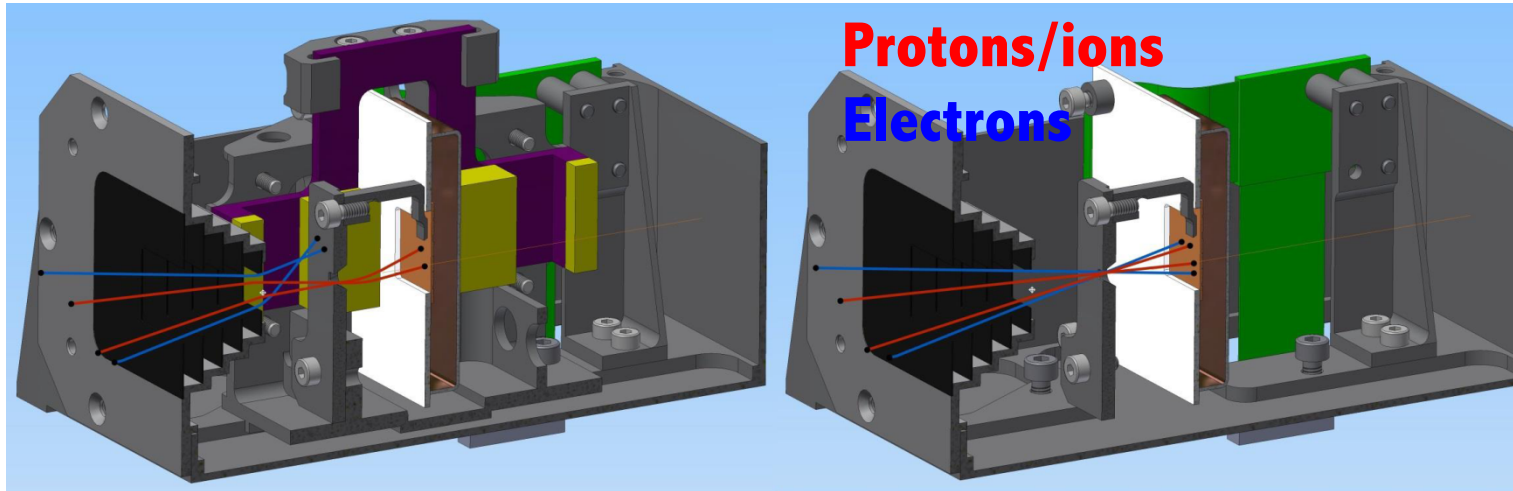
## Electron-Proton and High-Energy Telescopes (**Transport**) (EPT-HET)

Mass	2.5 kg
Power	5 W
Energy Range	Electrons: 20 keV – 30 MeV Protons: 20 keV – 100 MeV Heavy ions: ~10 MeV/nuc – ~200 MeV/nuc (species dependent)
Time Resolution	10s (species dependent)



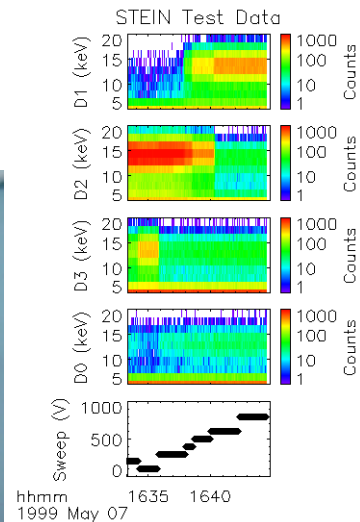
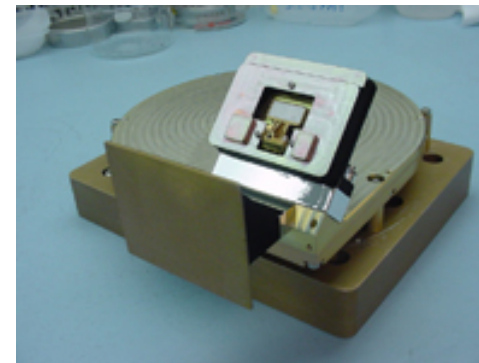


# Scientific Payload



## Supra-Thermal Electrons & Protons (STEP) (Transport, Local Acceleration)

Mass	2.5 kg
Power	5 W
Energy Range	Electrons: 2 keV – 100 keV Protons: 3 keV – 100 keV
Time Resolution	10s (species dependent)





# SEEPE



High Energy Band Spectrometer(HEBS)	
Size	362×349×172.5mm
Weight	20.5 kg
Power	W
Telemetry	2 GB/day
Energy Range	10keV - 600MeV
Energy Resolution	3% <sub>@662keV</sub>
Temporal Resolution	1s(quiescent),32ms (flare-mode)
Effective Area	>60cm <sup>2</sup> <sub>@1MeV</sub>
Sensitivity (300keV-10MeV)	Better than 3X10 <sup>-3</sup> photos/cm <sup>2</sup> /s

X-ray Polarimeter (Gas Pixel Detectors)	
Weight	16 kg
Power	25 W
Energy Range	10-35keV(for non-thermal bremsstrahlung)
Mass Memory	

Electron and Ion Detectors		
	EPT-HET	STEP
Mass	2.5 kg	2.5 kg
Power	5 W	5 W
Telemetry	1.5 kbps	1 kbps
Energy Range	Electrons: 20 keV – 30 MeV Protons: 20 keV – 100 MeV Heavy ions: ~10 MeV/nuc – ~200 MeV/ nuc (species dependent)	Electrons: 2 keV – 100 keV Ions: 3 keV – 100 keV
Time Resolution	10s (species dependent)	10s
Geometry Factor [cm <sup>2</sup> sr]	EPT: 2 x 0.01 HET: 3 x 0.21 (protons) HET: 2 x 0.26 (heavy ions)	2 x 1.7 10 <sup>-4</sup> or 2 x 7.5 10 <sup>-3</sup>

**Total:**  
**41.5 kg**  
**55 W**



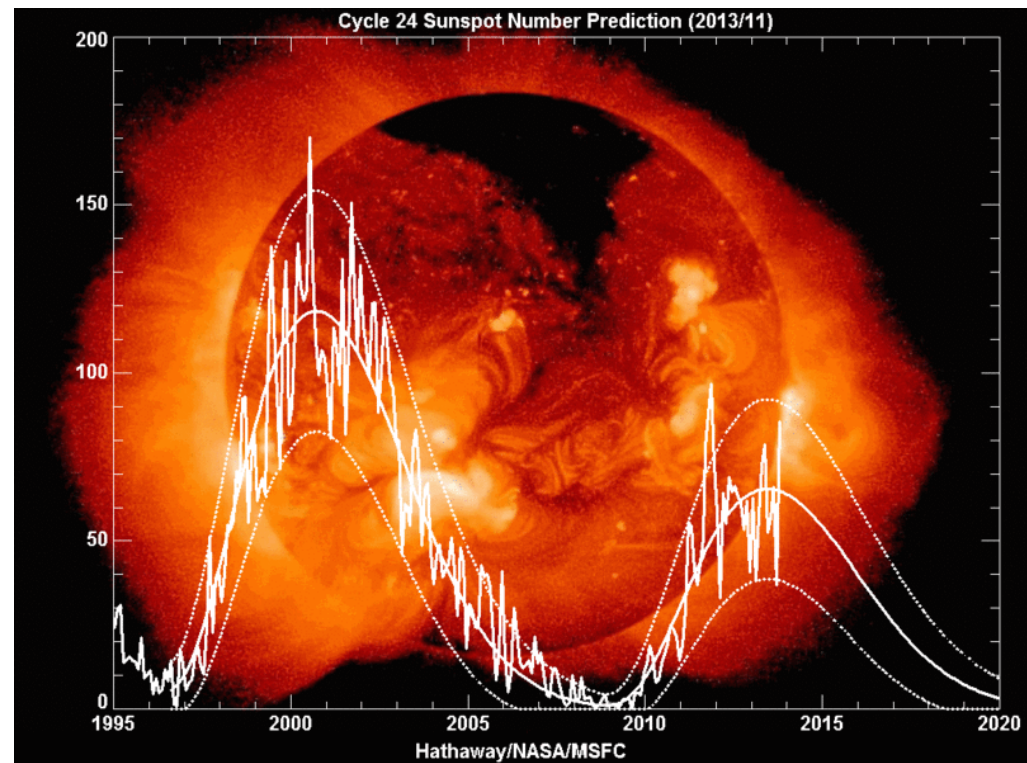
# SEEPE



## Schedule

- Mission selection: 2014-2015
- Study phase: 2016-2017
- Implementation phase: 2018-2021
- Launch: 2021

**The next solar  
cycle starts near  
2021!**

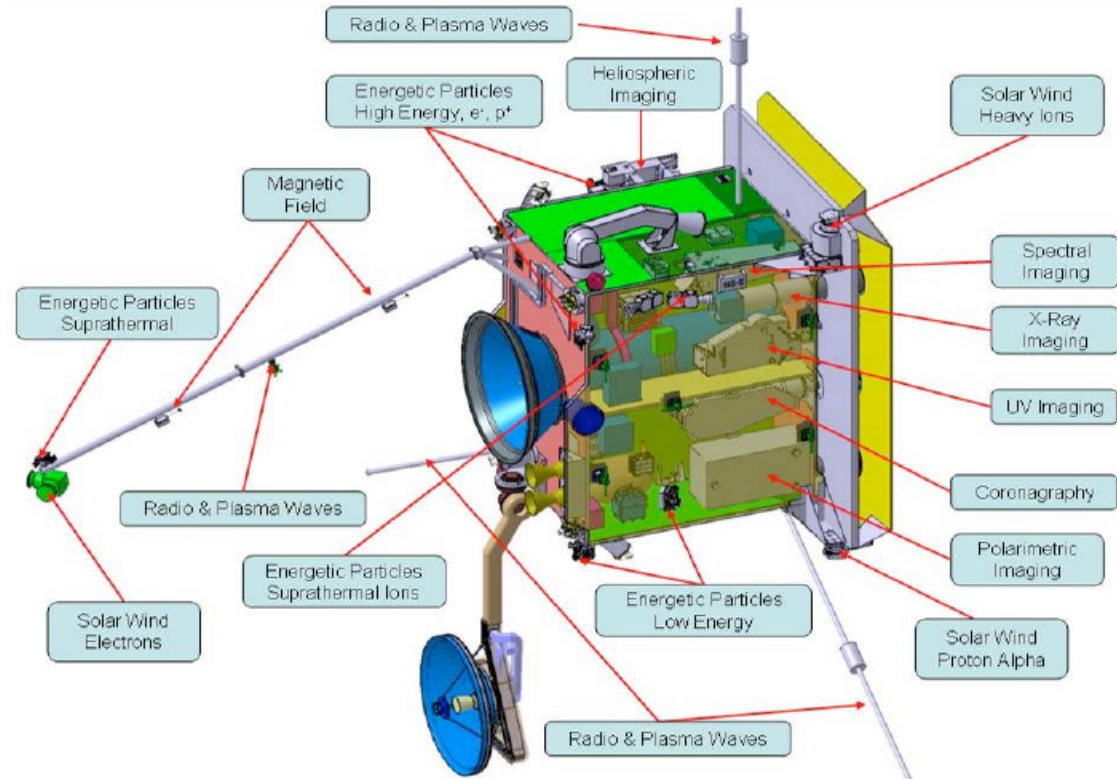




# Complementary Missions



- SDO (2010- )
- IRIS (2013- )  
Magnetic Fields.  
Thermal Emission.
- Solar Orbiter
- Solar Probe +  
(~2018- )  
<0.3 AU.



STIX: X-ray Images; EPD: electrons, protons, ions.

Solar Wind Electrons Alphas and Protons Investigation.

- Advanced Solar Obs. (2020-) 1.0AU, X-ray Imager.





# Complementary Observations



- Radio

**Gyro-synchrotron and Bremsstrahlung**

**Magnetic Fields, Energetic Electron Beams**

- H $\alpha$

Irradiation by X-ray and Heating by energetic particles

- Optical (ATST)

**Energetics of thermal and non-thermal particles**





# Team



## Science and Data Analysis:

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**Purple Mountain Observatory, CAS, China**

**Valentina Zharkova**

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## High Energy Band Spectrometer:

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**Purple Mountain Observatory, China**

## X-ray Polarimeter:

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**Michele Pinchera, Gloria Spandre (INFN-Pisa)**

## Electron-Proton and High Energy Telescopes and STEP:

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# Summary



Solar Energetic Emission and Particles Explorer (SEEPE) is a timely mission suitable for the ESA and CAS joint scientific space mission:

- 1) The proposed mission meets the boundary conditions and draws on expertise in both China and Europe;
- 2) The scheduled launch time matches the onset of the next (25<sup>th</sup>) solar cycle;
- 3) It is highly complementary to the ESA's Solar Orbiter, NASA's Solar Probe Plus, CAS's ASO missions for the 25<sup>th</sup> solar cycle;
- 4) The timing, spectral, polarization, and energetic particles observations of the solar activity, in coordination with other ground and space based observations, will help to reveal how the space weather is driven by the Sun.