



# Premieres observations simultanees d'ions et d'electrons de faible energie sur Mercure lors du premier survol de BepiColombo

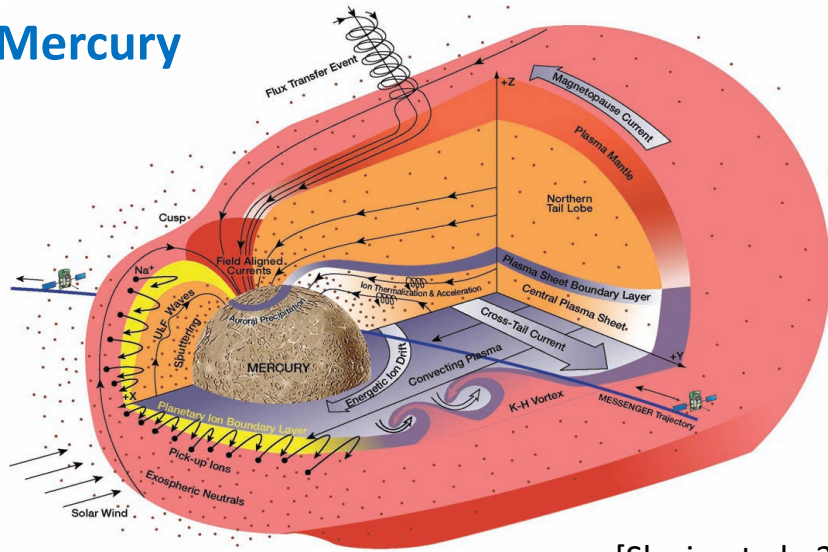
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A. Fedorov, E. Penou, A. Barthe, J.-A. Sauvaud, B. Katra, S. Matsuda, G. Murakami

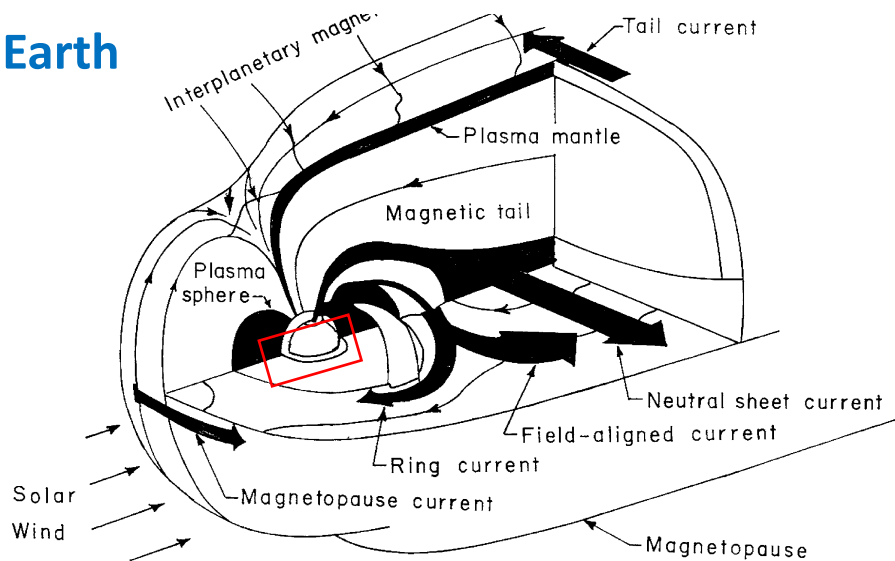
# Mercury's magnetosphere

## Mercury



[Slavin et al., 2008]

## Earth



[Singh et al., 2004]

**Weak intrinsic magnetic field at Mercury  
(200 nT at Mercury's surface  $\leq$  1% of Earth)**



**Harsh solar wind condition  
(larger dynamic pressure/lower Alfvén Mach number)**



**Smaller but dynamic magnetosphere  
~ 5% of Earth's magnetosphere  
Dungey cycle : a few minutes**

**Different coupling system  
Earth : SW - magnetosphere – ionosphere  
Mercury : SW - magnetosphere – exosphere - surface**

# Past observations and their discovery

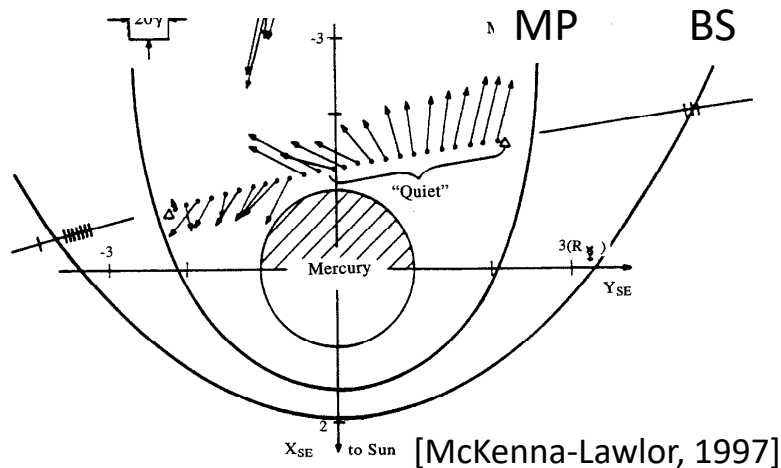
## Mariner 10

### Basic information

- 3 Mercury flybys (1974 – 1975)
- Electron & Ion detector, Magnetometer

### Discovery

- Global intrinsic magnetic field at Mercury [Ness et al., 1974]
- Ongoing plasma activity like Earth [Ogilvie et al., 1977; Slavin et al., 1996; Fairfield and Behannon, 1976]



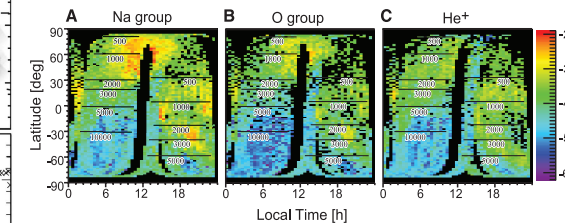
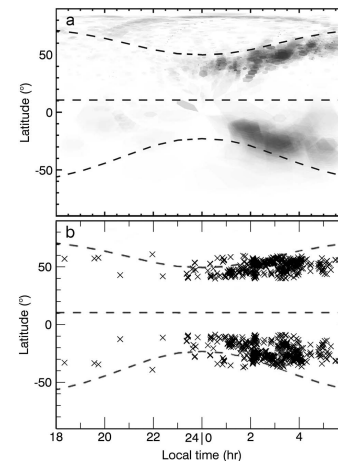
## MESSENGER

### Basic information

- Main purpose : geology, surface composition, magnetic field
- In the orbit from March 2011 to April 2015
- Electron & Ion detector, Magnetometer

### Discovery

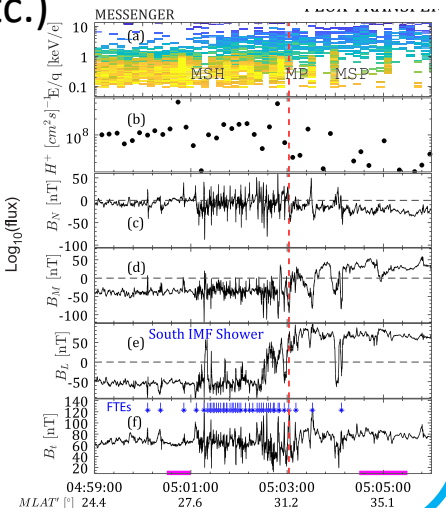
- 20% of dipole shift & more precise magnetic moment
- Ion distribution in the magnetosphere
- Ongoing plasma activities (dipolarization, KH waves, reconnection etc.)



[Zurbuchen et al., 2011]

Dewey et al., 2017

[Sun et al., 2020]



# BepiColombo mission

## The Europe's / Japan's first mission to Mercury

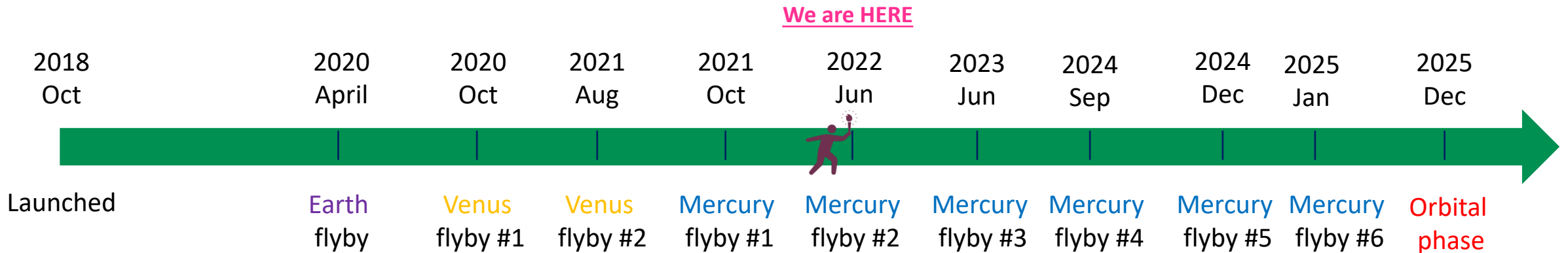
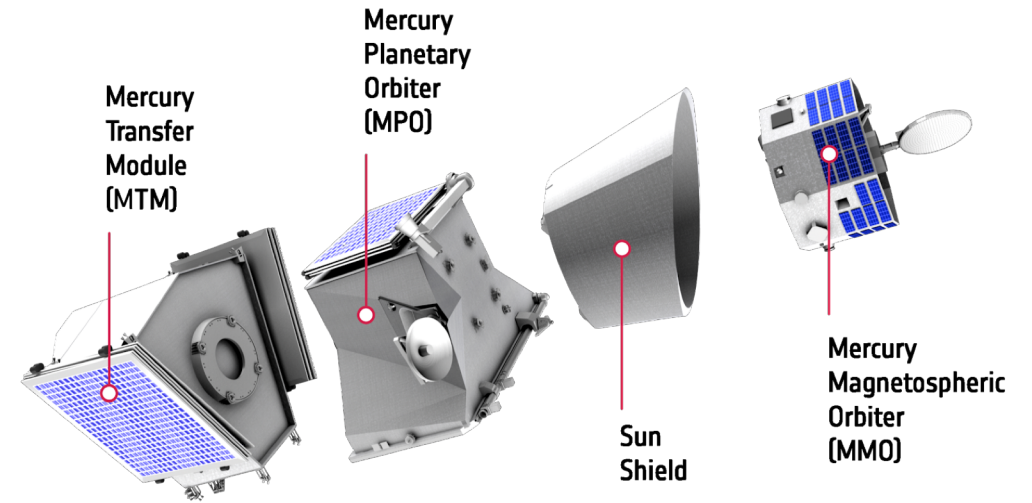
### Two Spacecraft:

Mio: Mercury Magnetospheric Orbiter (led by JAXA)

- Instruments to observe Mercury's plasma environment

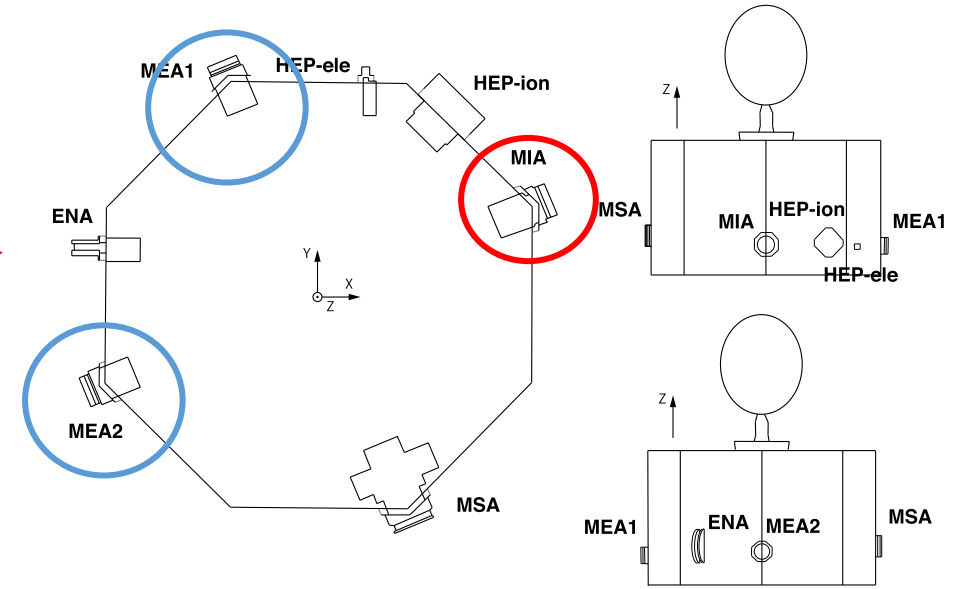
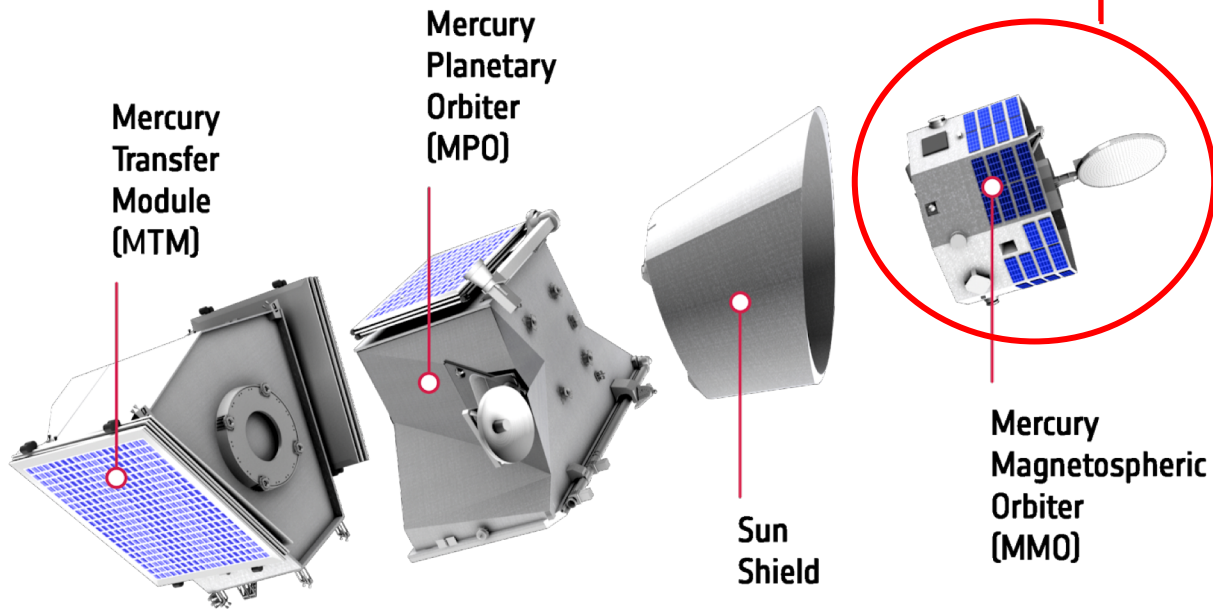
MPO: Mercury Planetary Orbiter (led by ESA)

- Instruments to observe surface, composition, plasma.



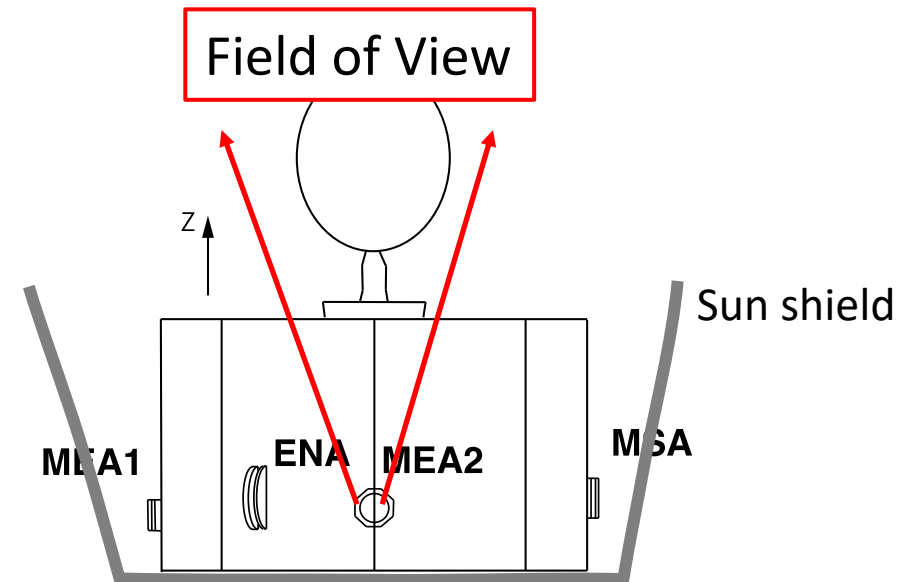
# BepiColombo – MEA & MIA /MPPE

Mercury Electron Analyzer (MEA) — MEA1 & MEA2  
 Mercury Ion Analyzer (MIA)

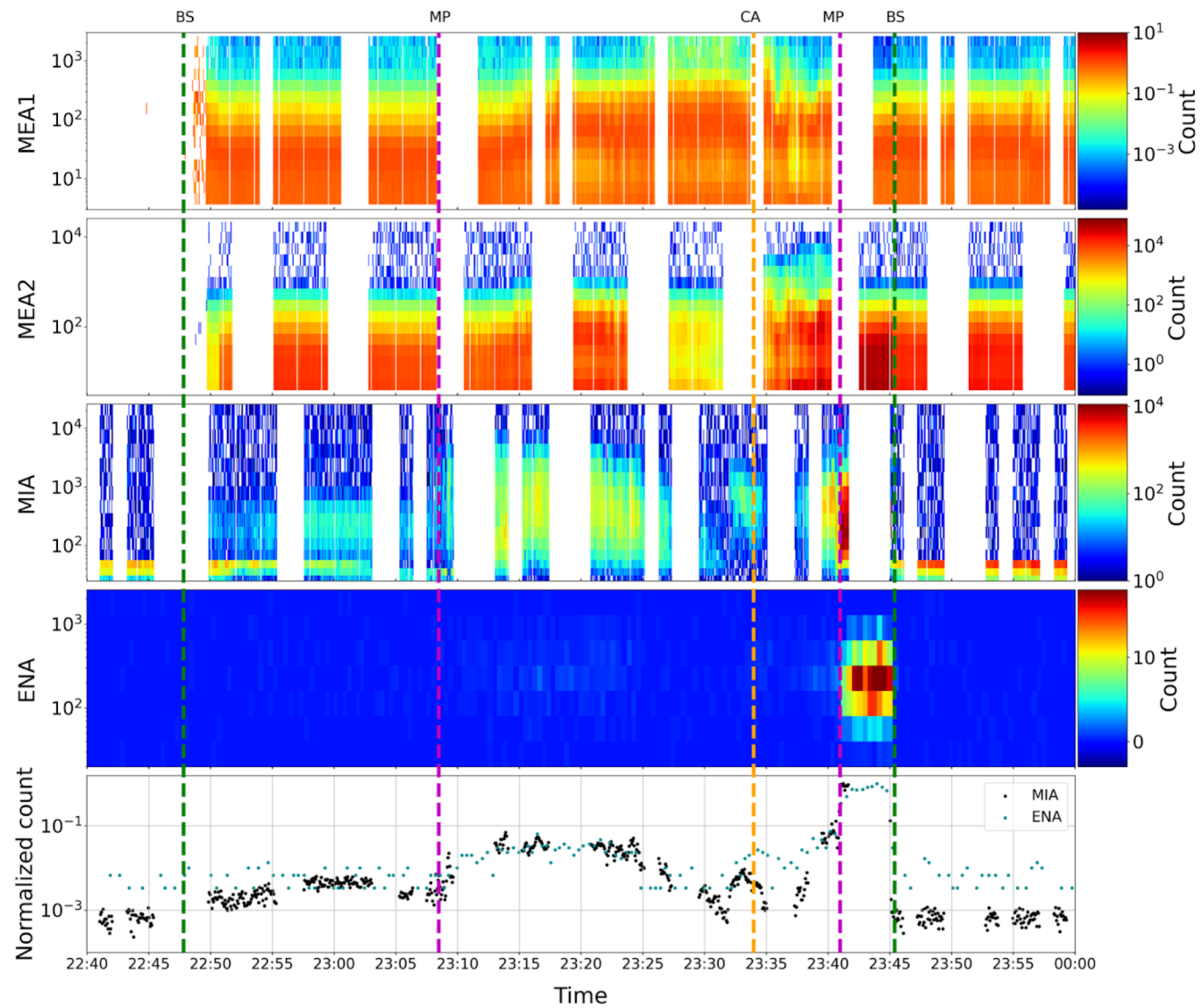
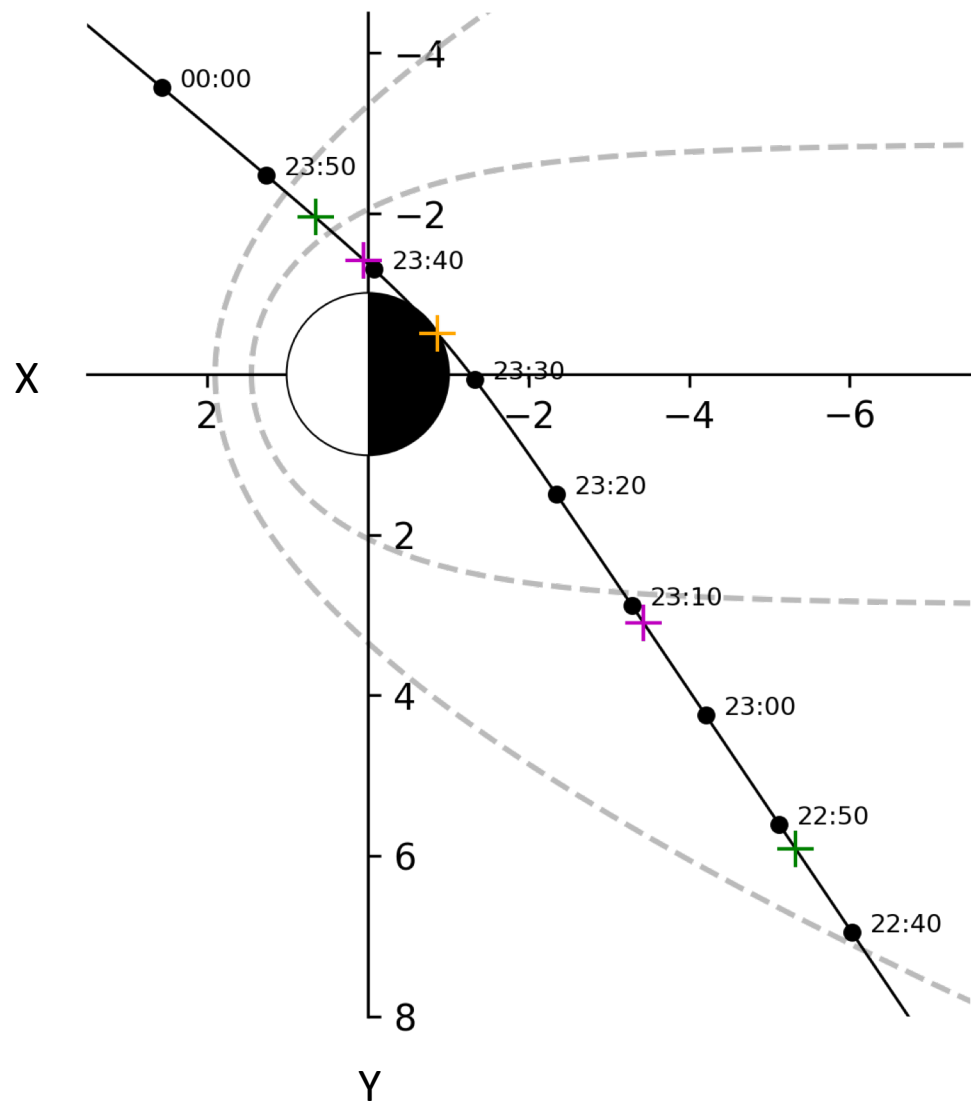


[Saito et al., 2021]

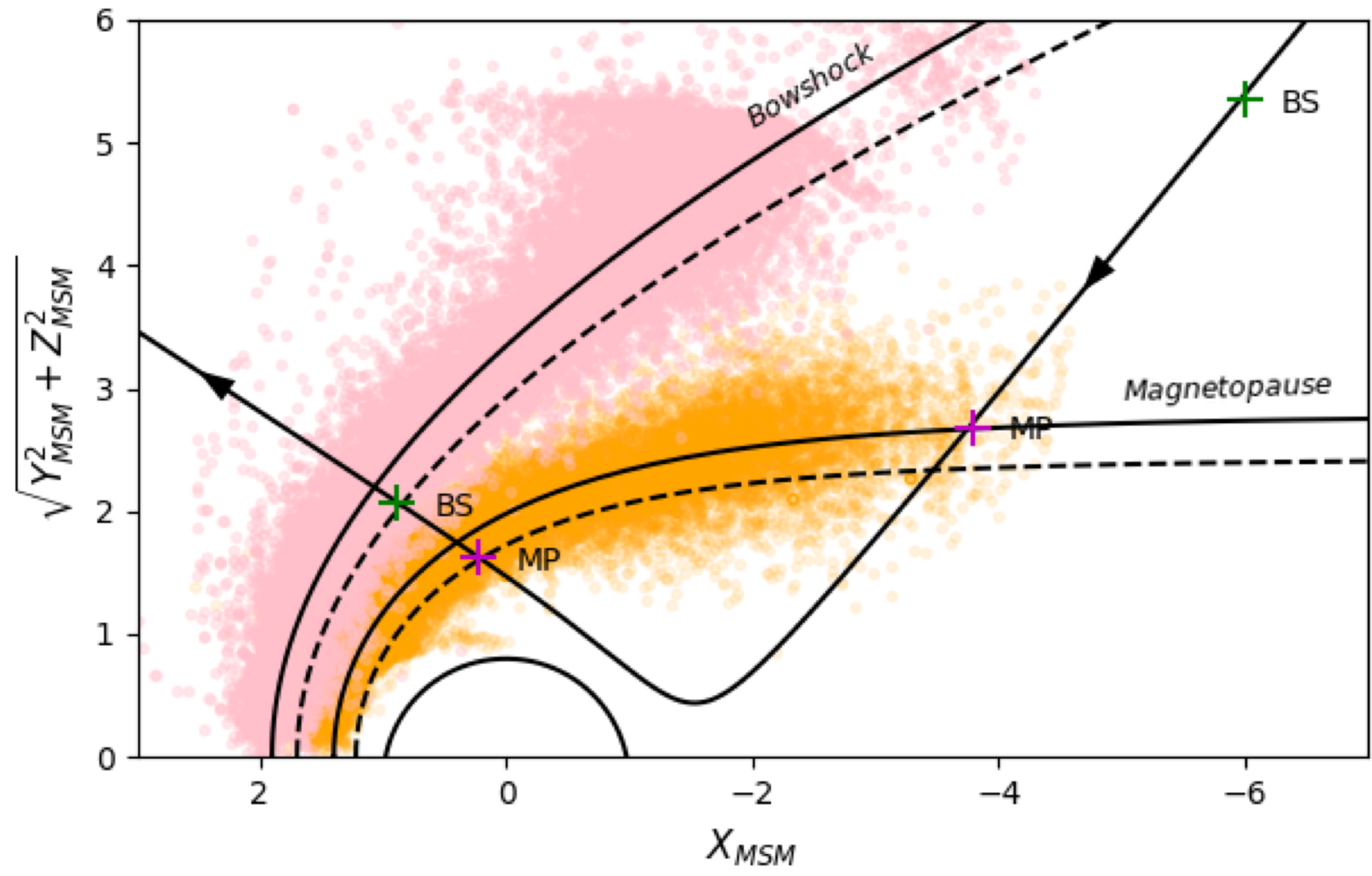
**Limited FOV for MPPE due to Sun shield:**  
 Only electrons can be measured in the solar wind  
 Ion data can be obtained during planetary flybys



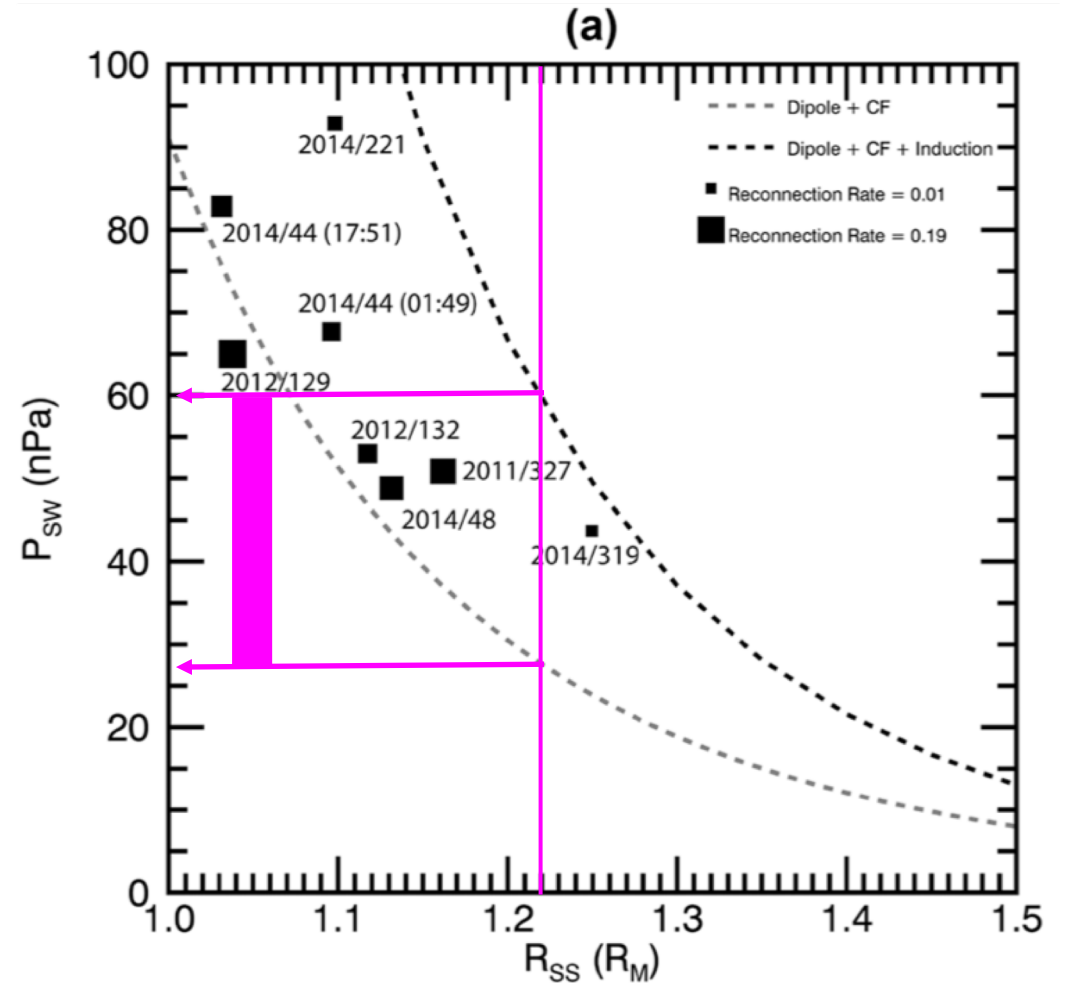
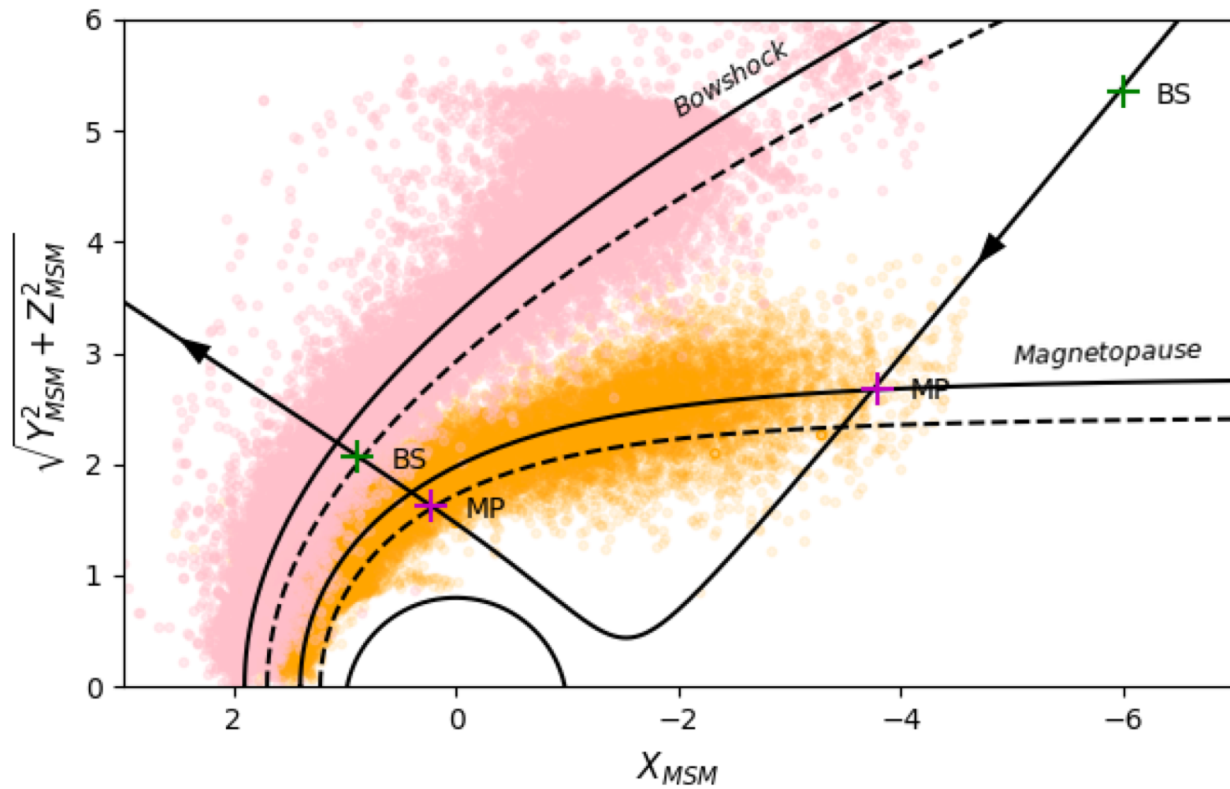
# Overview of MPPE observation



# Shock crossings with respect to previous observations



# Shock crossings with respect to MESSENGER

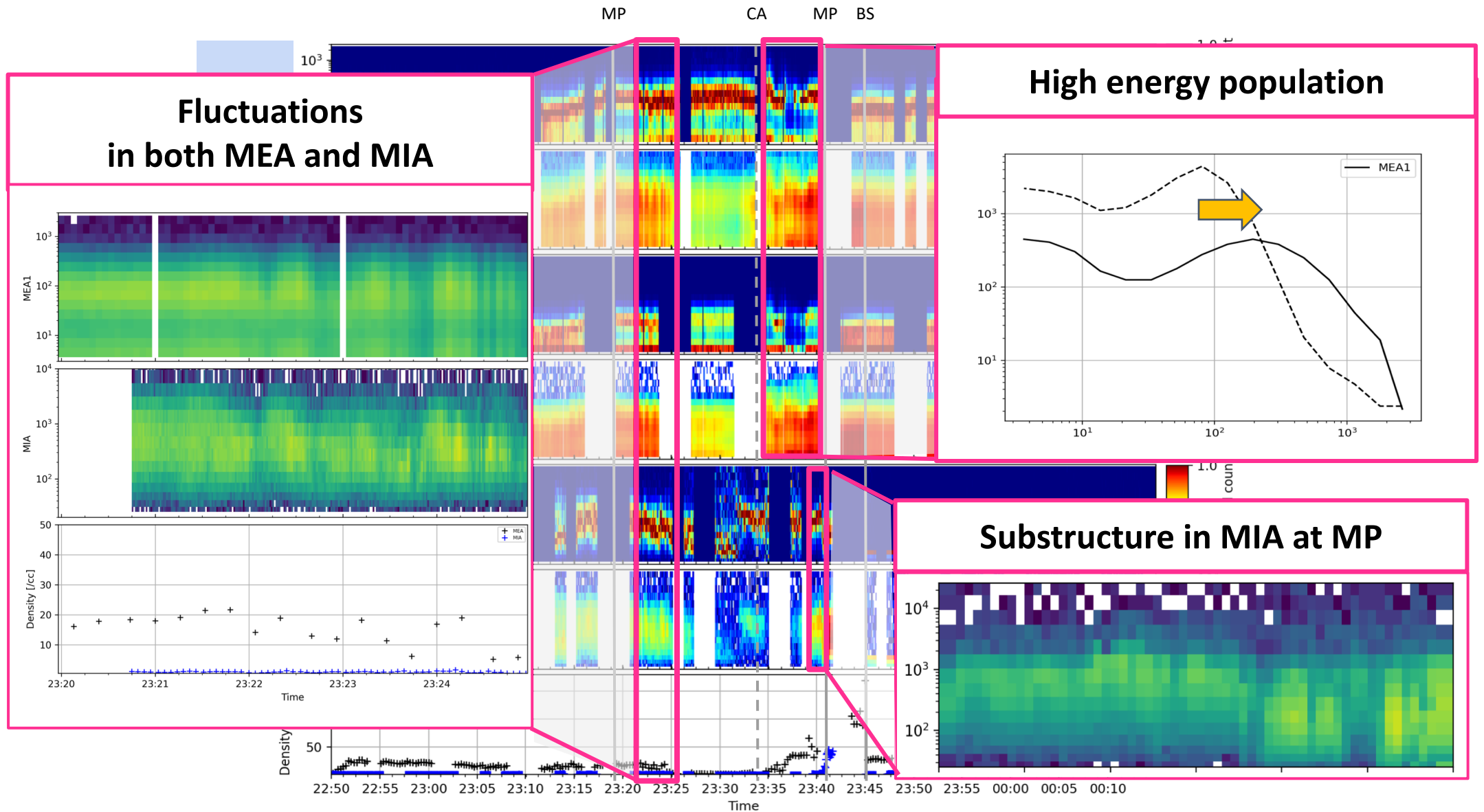


MP nose distance

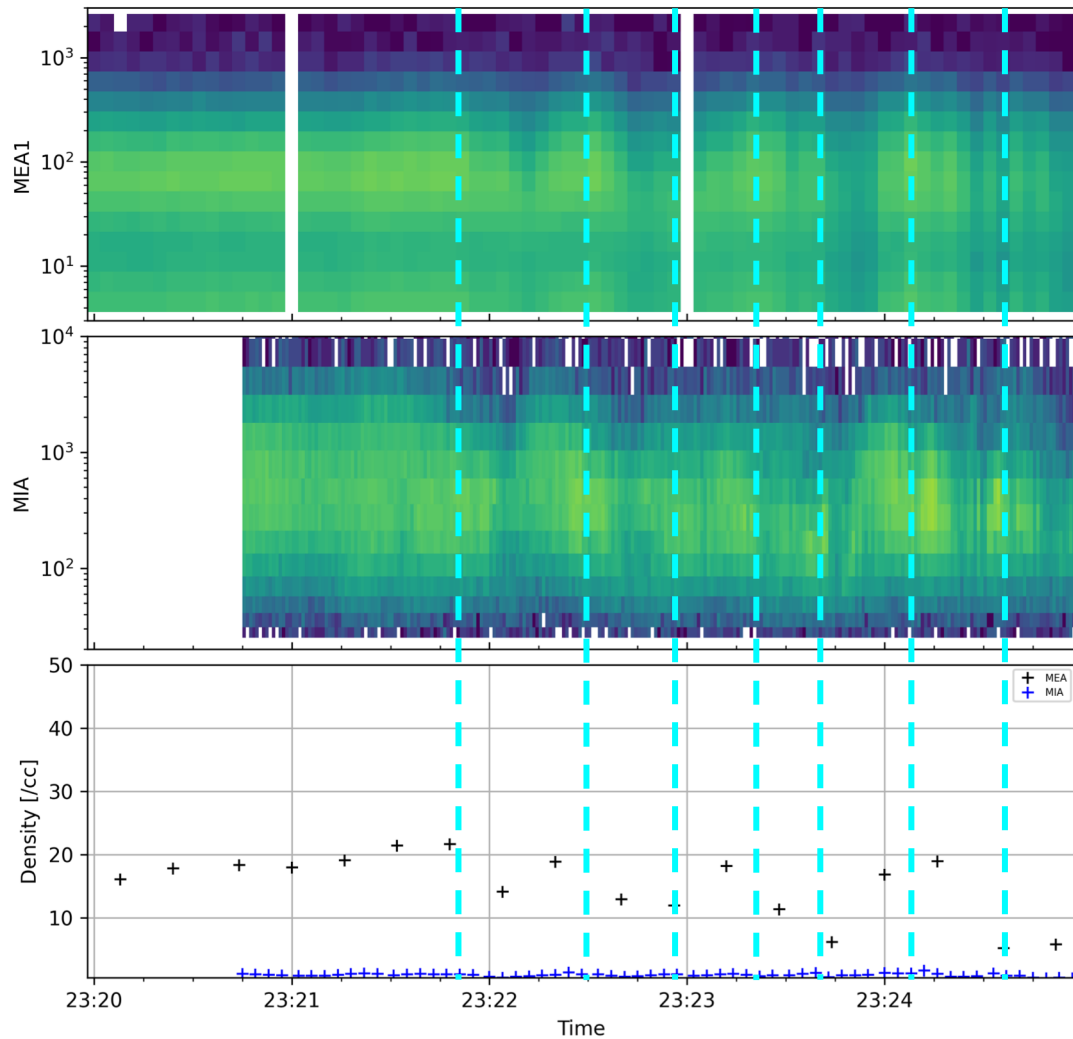
BS nose distance: 1.67  $R_M$   
 MP nose distance: 1.22  $R_M$   
 Estimated dynamic pressure : 28 ~ 60 nPa  
 (e.g., average dynamic pressure by MESSENGER: ~ 10 nPa )



# Interesting signatures in MEA and MIA



# Fluctuations in the dusk

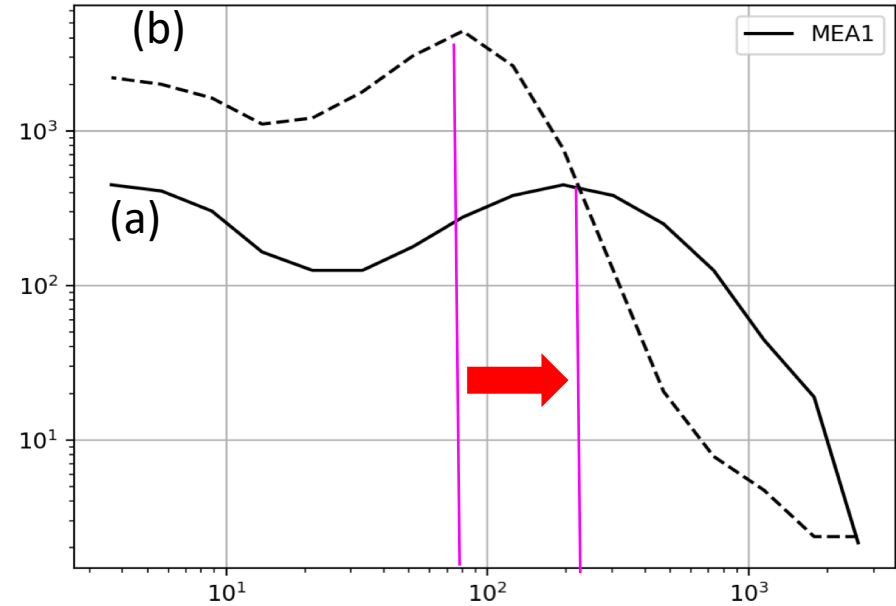
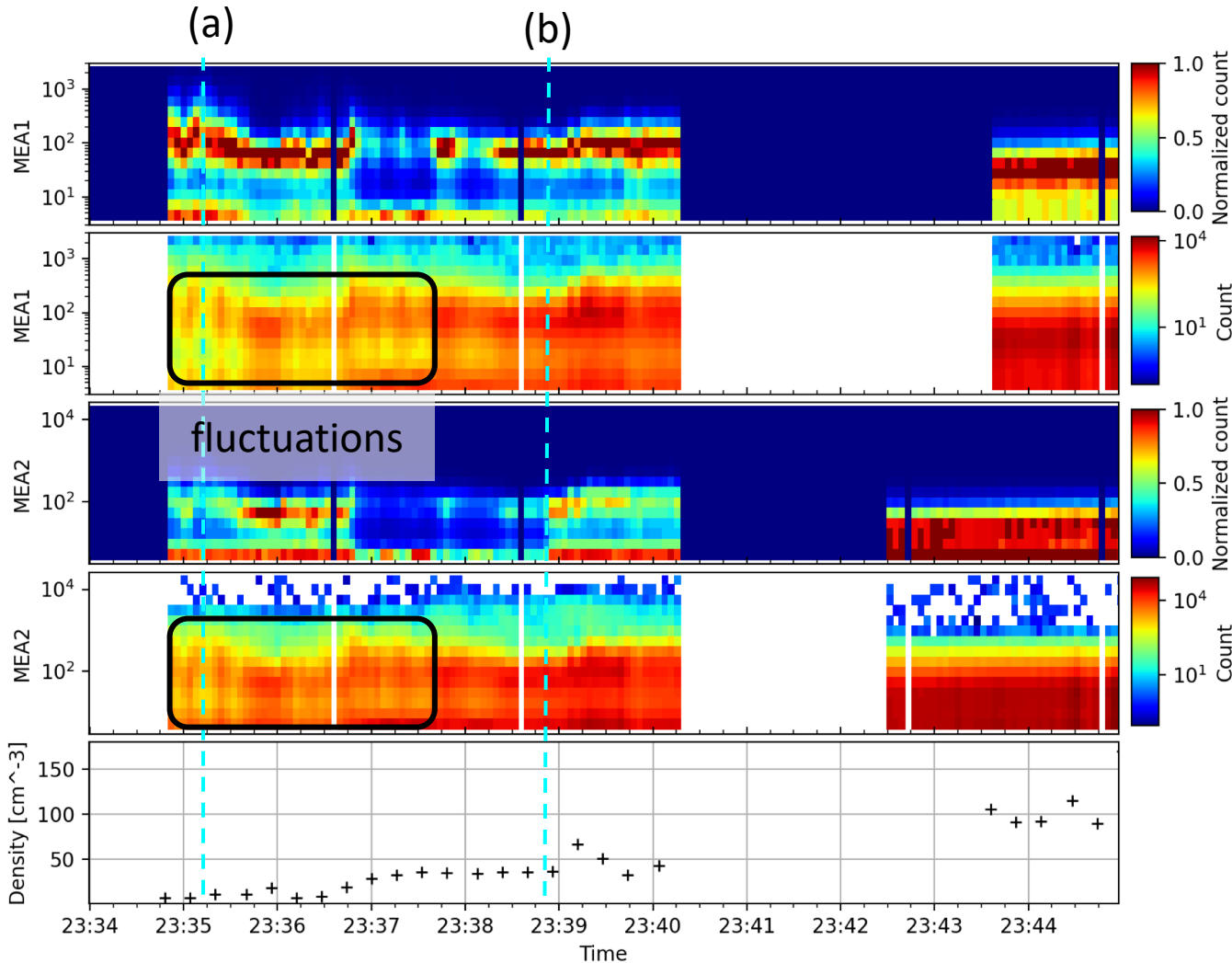


	frequency/period	Observed region	electrons	ions
This event	15 - 30 sec	Dusk, inside MSP	O	O
KH	0.01 - 0.05 Hz (20 - 100 sec)	Mostly dusk	-	O
ULF	0.025 - 0.1 Hz (10 - 40 sec)	dusk	-	?
ULF	0.02 - 0.04 Hz (25 - 50 sec)	dawn	-	?

[ex. Gershman et al., 2015, James et al., 2016; 2018, Liljeblad and Karlsson, 2017]

ULF would be the best candidate  
To be further investigated with MPOMAG

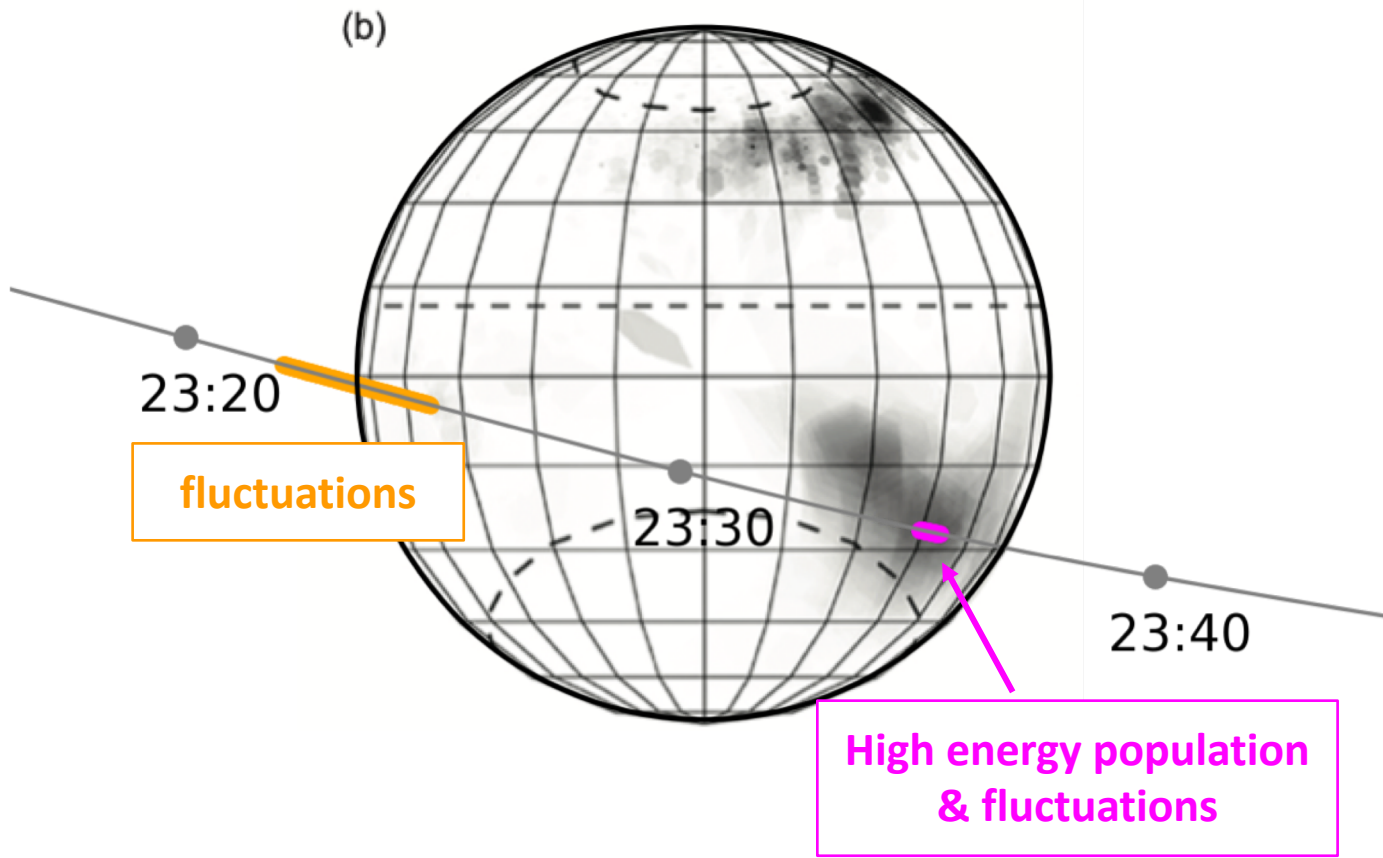
# High energy population and Fluctuations in the dawn



Energy peak : 80 eV  $\rightarrow$  200-300 eV  
Counts : higher  $\rightarrow$  lower (by factor of  $\sim 5$ )

Electrons are significantly accelerated there  
Associated with fluctuations?  
Wave-particle interactions?

# Structures along the trajectory



[Lindsay et al., 2016]

- X-ray aurora [Lindsay et al., 2016]  
Electron > a few keV
- Energetic electron and its footprint [Dewey et al., 2017]  
Electron > 300 keV

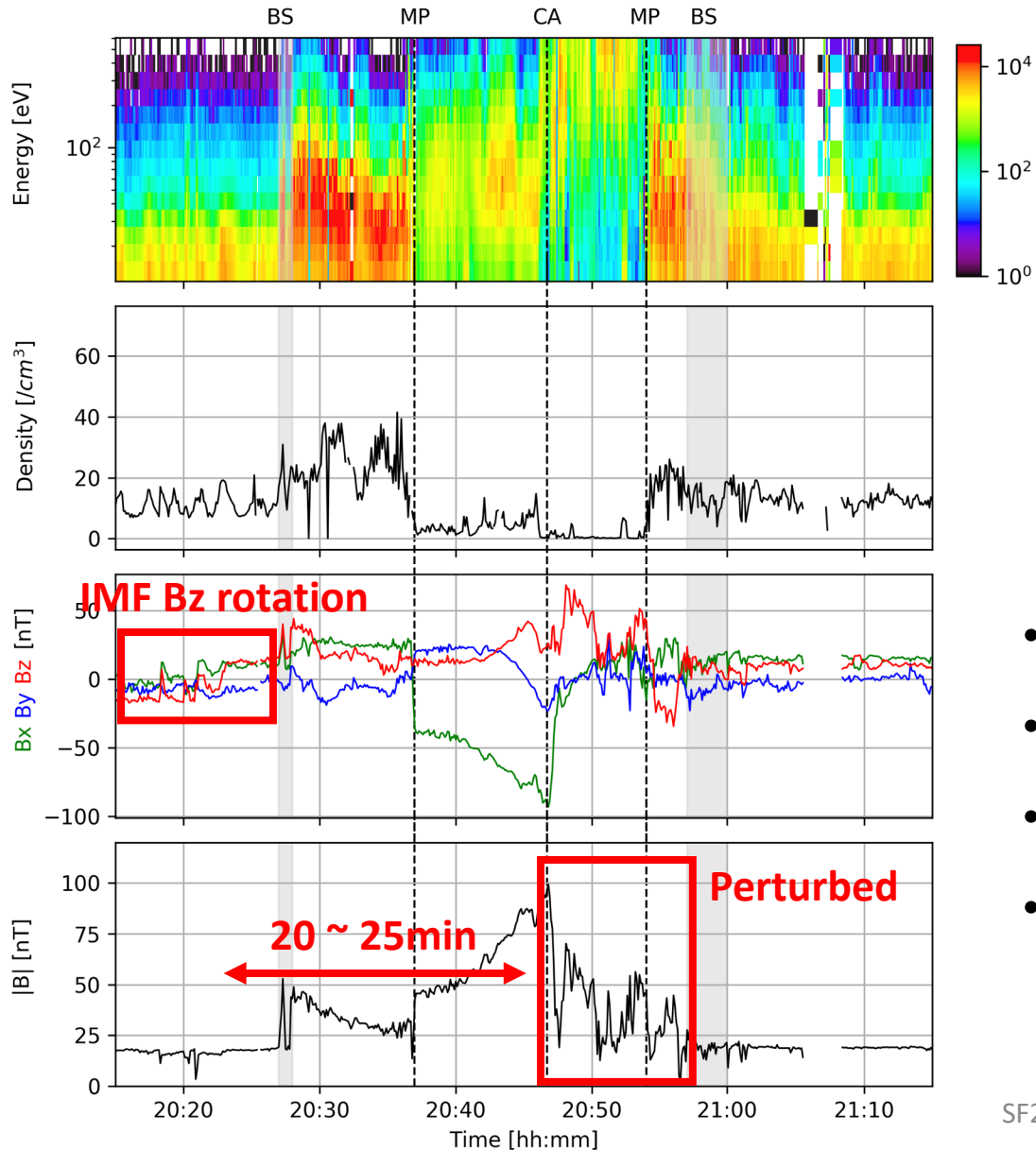


MEA : a few hundreds of eV

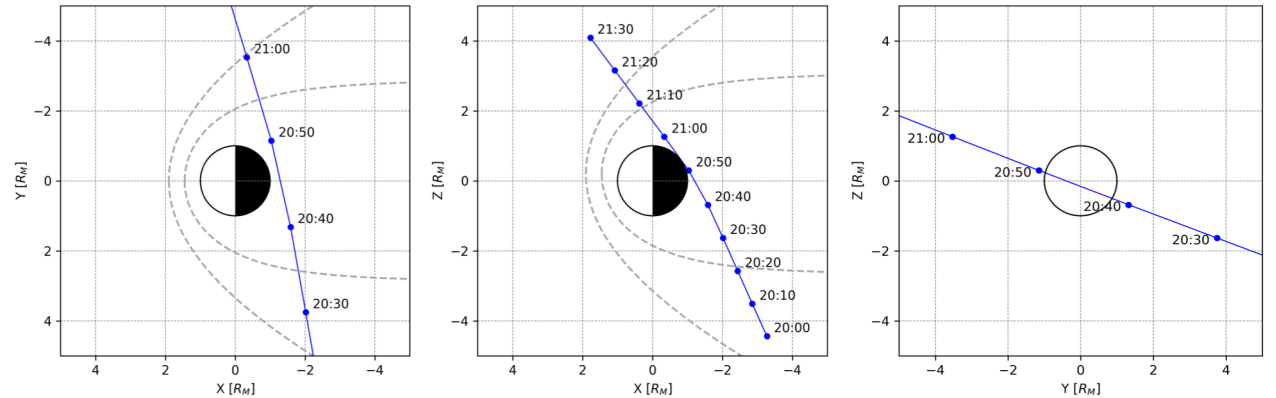
Too low energy to discuss electron precipitation?  
But energy is still higher than other region!

Superimposed trajectory is not magnetically connected to the planet

# Support from simulations: Mariner-10 Mercury 1<sup>st</sup> flyby observation



Orbit : southern dusk → northern dawn

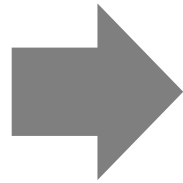
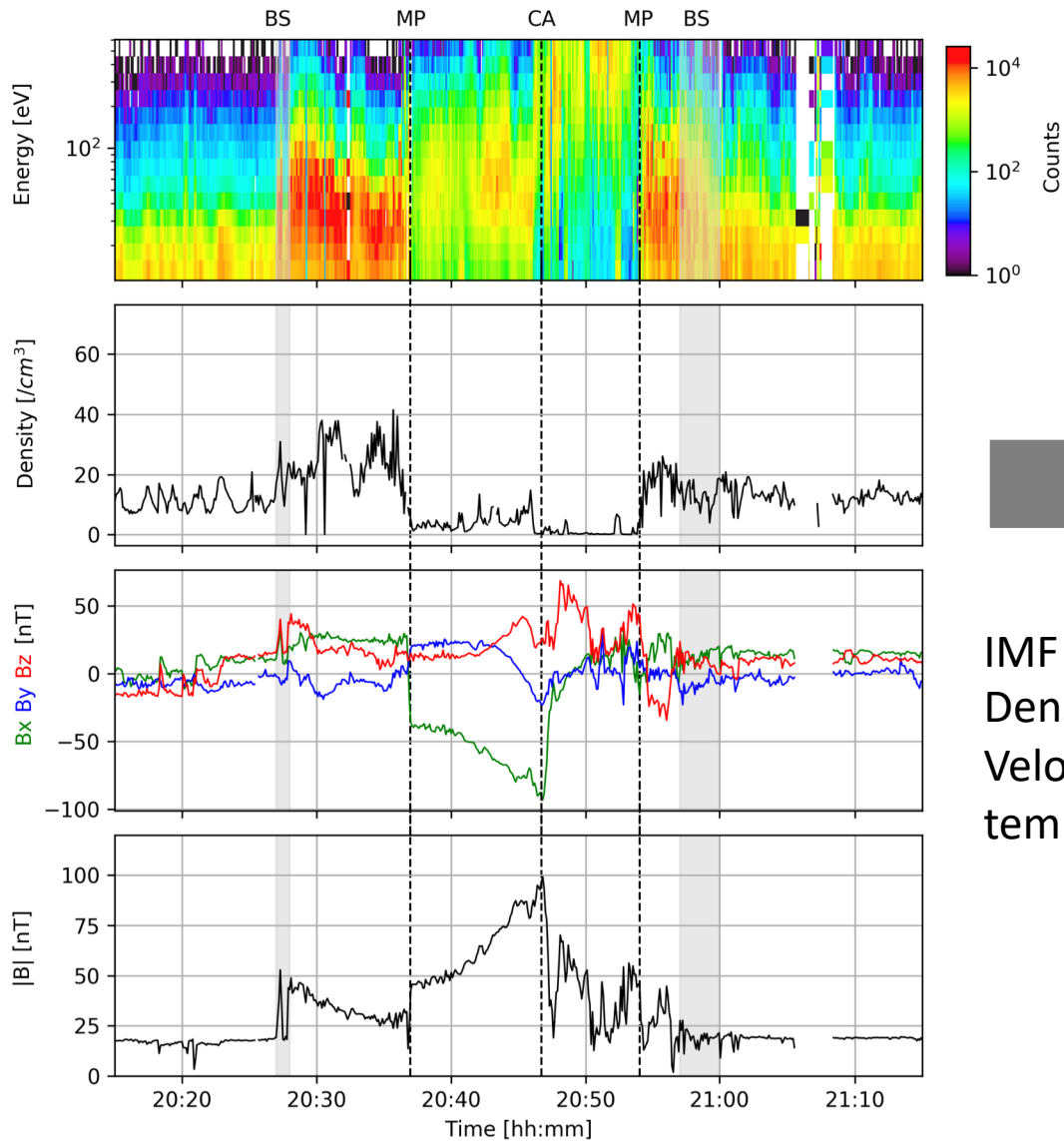


## Findings from previous studies :

- It took less than an hour to traverse the magnetosphere
- Clear shock crossings in both inbound & outbound
- Cold & Hot electron components
- Two parts in the magnetic field – quiet and perturbed  
Due to the IMF rotation ?  
Spacecraft observed its signature ~ 25 min after .. Reasonable?

# Support from simulations (Ex. Mariner-10)

## Plasma observations from Mariner-10

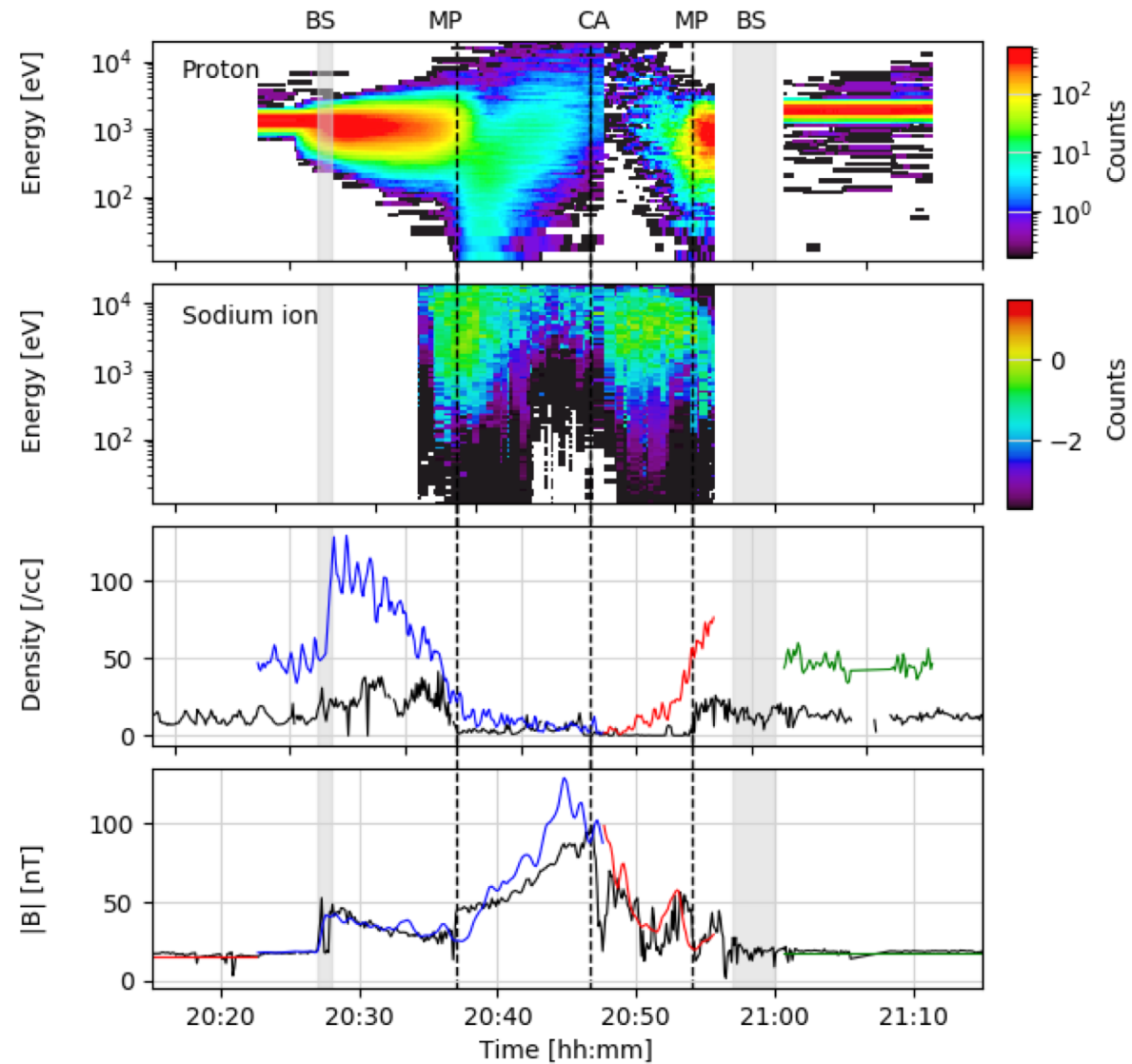


IMF  
Density  
Velocity  
temperature

LatHyS

LIZE

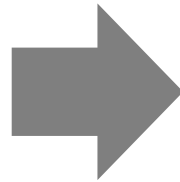
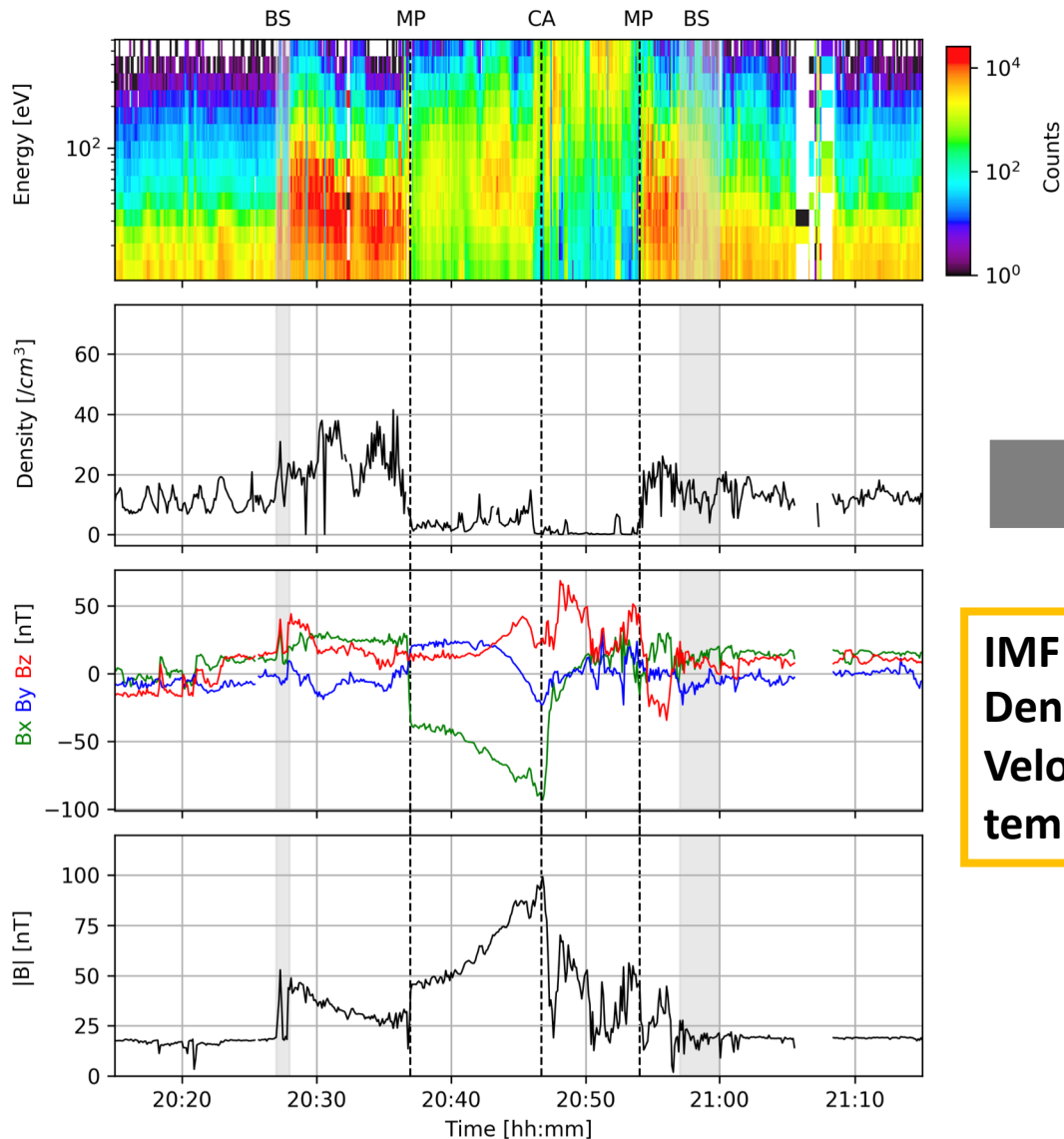
## Virtual sampling in LatHyS



# Support from simulations (Ex. Mariner-10)

# Comparison with real data for both plasma and field Understanding the variation in the data

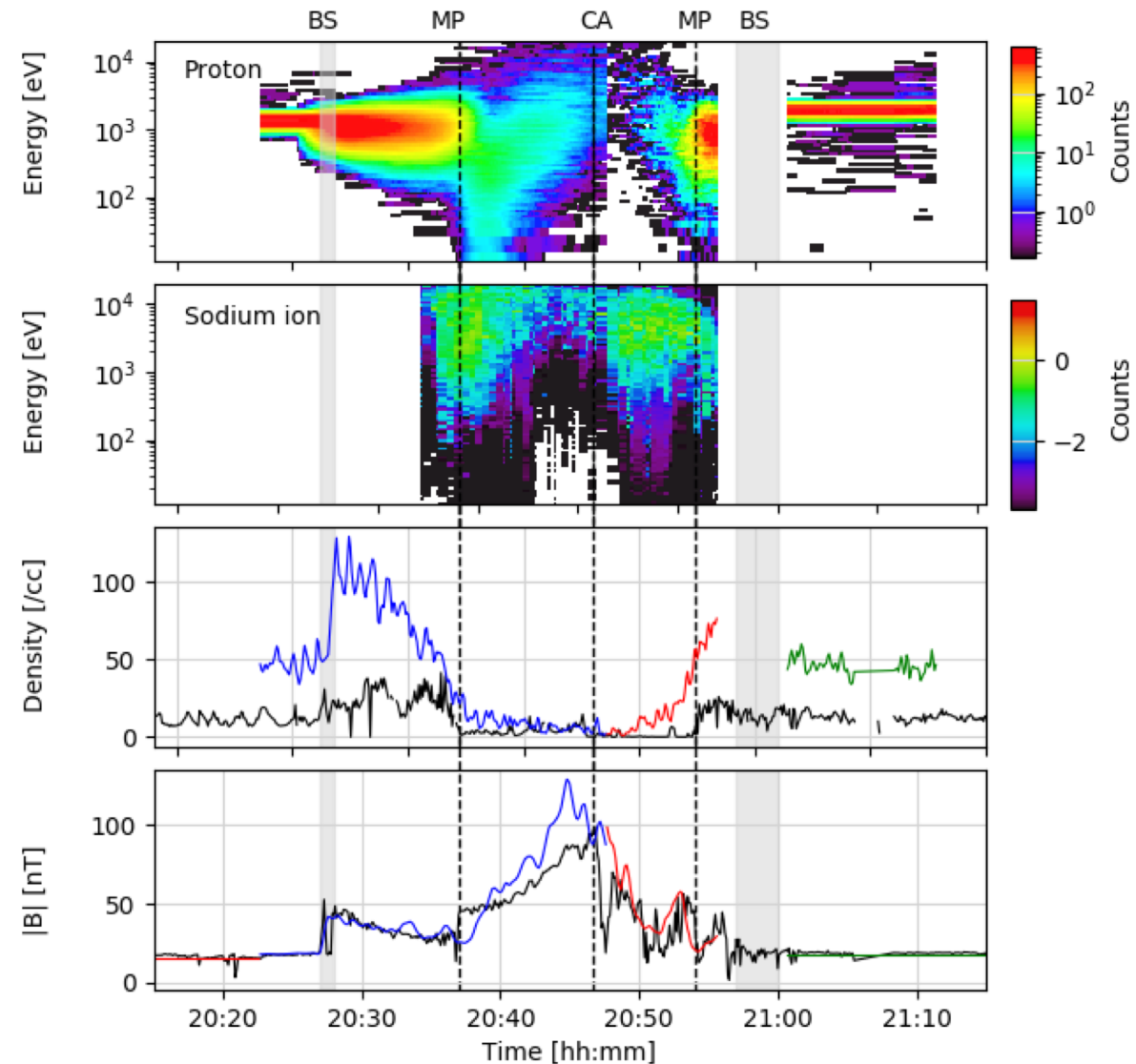
### Plasma observations from Mariner-10



**IMF  
Density  
Velocity  
temperature**

LatHyS  
LIZE

### Virtual sampling in LatHyS



## Summary

- BepiColombo has successfully conducted some planetary flybys (Earth, Venus x2, and Mercury)
- Mercury flyby #1:
  - First simultaneous observation of low energy electrons and ions has been conducted
  - Data gaps but clear shock crossings : a bit compressed magnetosphere
  - Interesting signatures in both MEA and MIA :  
fluctuations, substructures, high-energy component
- Support from simulations:
  - Powerful tool to understand the physics there
  - Important to get the magnetic field data ... but not ready! To be done.

**Next Mercury flyby is planned for the 23rd of June – Stay Tuned!**