IMF Clock Angle Proxy and Mars global escape rate dynamics

Andrei Fedorov[1], Peter Budnik[1], Ronan Modolo[2], Rikku Jarvinen[3], Christian Mazelle[1]

1. IRAP Toulouse France
2. LATMOS Paris FRANCE
3. LASP, Boulder

Scientific objective: to study an induced magnetosphere dynamics and the planetary ions escape as a function of the solar activity (2008 – 2013 years)

"Political" objective: to publish a paper (papers?) BEFORE the first MAVEN data

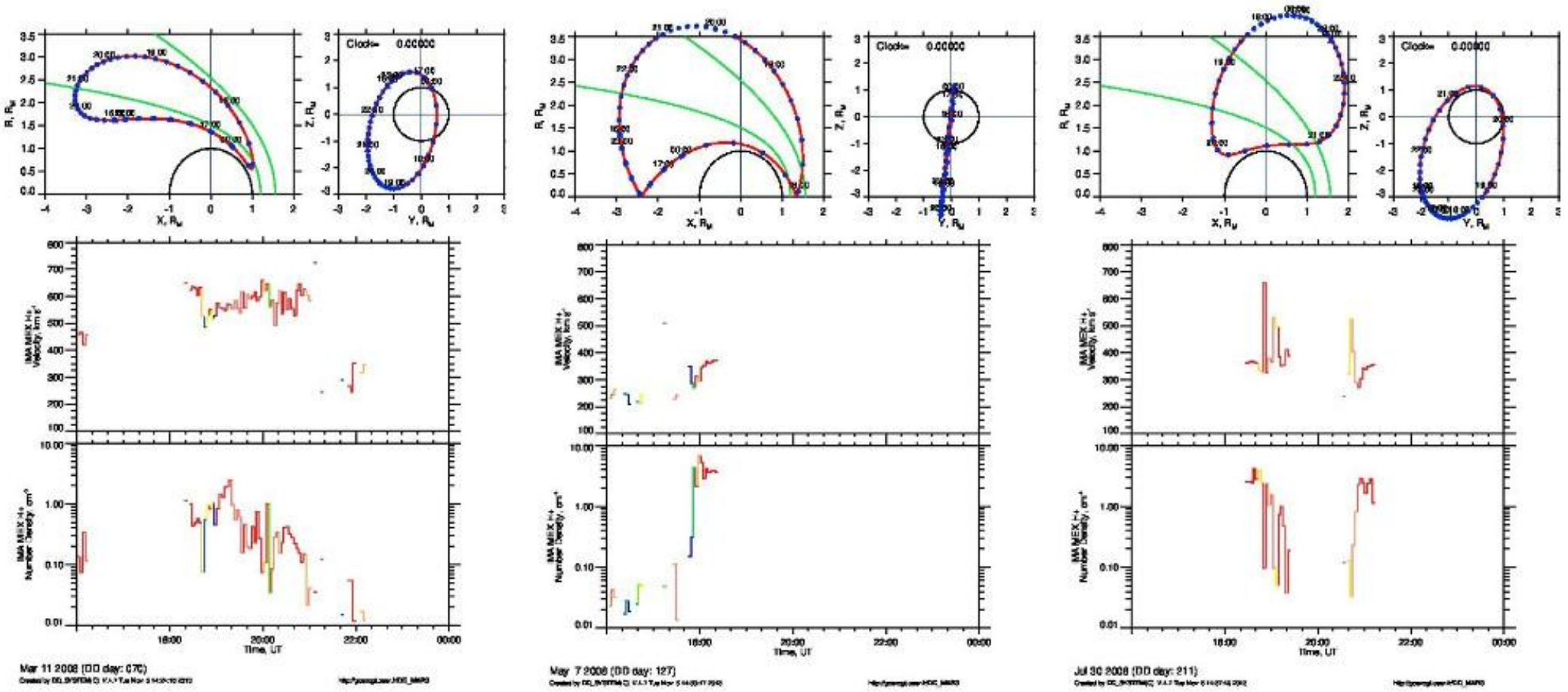
Technical tasks:

1. To select potential orbits of MEX for study
2. To obtain IMF clock angle proxy for maximal number of selected orbits.
3. To make season-by-season Martian magnetosphere statistics on the base of IMA (ASPERA-3, MEX)data

First technical task. Orbit selection

6500 orbits of 2008-2013 were inspected.

The criteria: There is plasma data, SW parameter can be obtained, the orbit is in the magnetosphere (as it is shoun in the image):



140 days = 400 orbits in one season when the orbit pass the planet magnetotatil

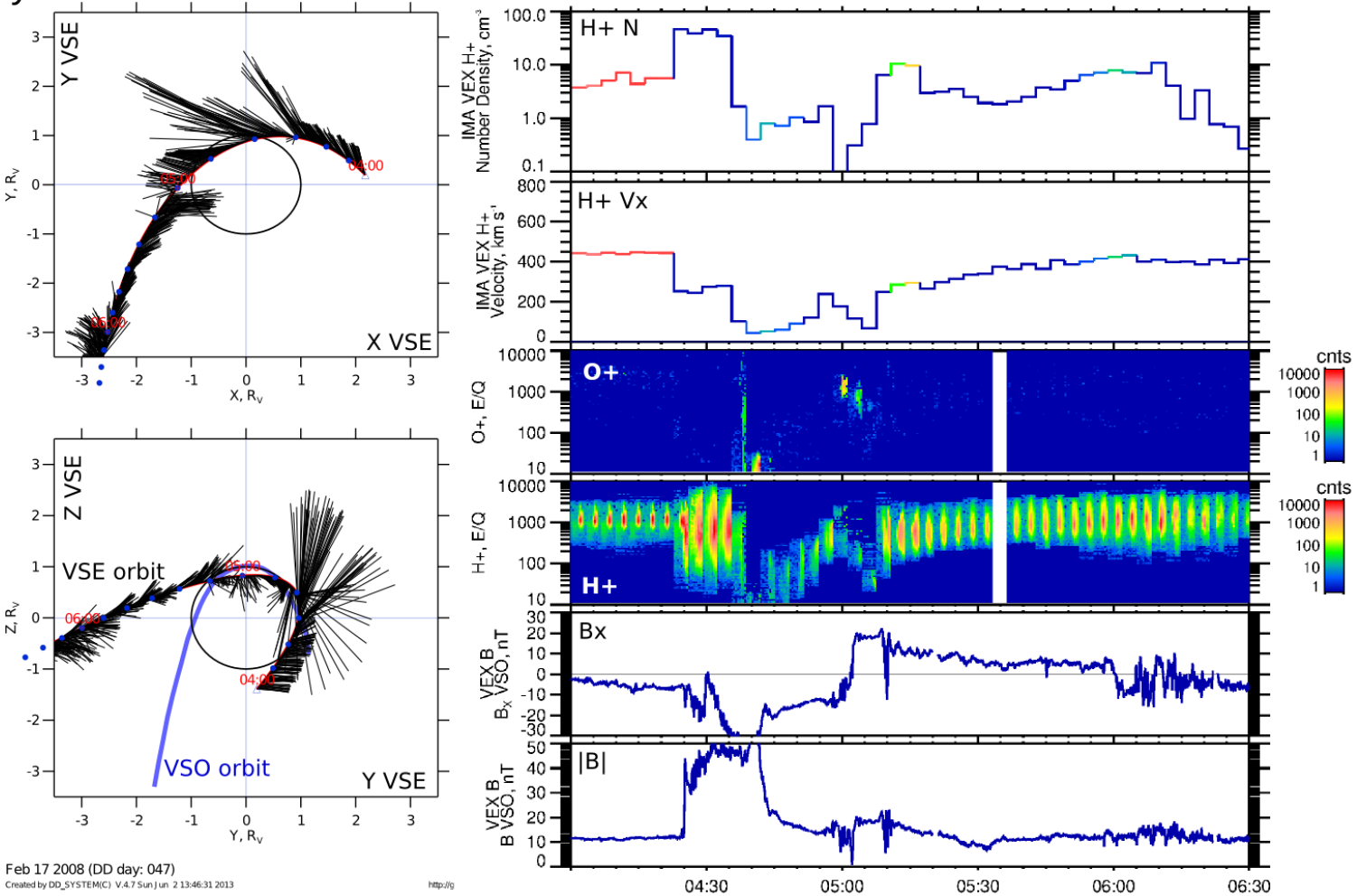
First technical task. Orbit selection

The result: A table as it is shown below. Then this table should be filled with IMF clock angle values

```
#*******************************************************************************************
#       orbit-list.2010000-2010090.txt
#       List of magnetosphere crossings with clock angle and SW moments
#       Prepared : Jan 2014
#       Clock angle added :
#*******************************************************************************************
# YYYYDDDHHMM   DDDHHMM   Clock  Model   Vsw     Nsw     Comments
#*******************************************************************************************
20100001720     0001940     0.0   ND    300.0   3.0
20100012050     0012310     0.0   ND    275.0   1.0
20100021040     0021300     0.0   ND    275.0   1.5
20100021730     0021950     0.0   ND    275.0   2.0
20100031420     0031630     0.0   ND    250.0   0.5
20100032110     0032330     0.0   ND    250.0   1.0
20100040400     0040620     0.0   ND    250.0   3.0
20100060420     0060640     0.0   ND    300.0   5.0
20100071450     0071700     0.0   ND    300.0   10.0
20100081130     0081350     0.0   ND    300.0   4.0
20100112220     0110030     0.0   ND    250.0   3.0
20100120520     0120730     0.0   ND    275.0   4.0
20100121900     0122110     0.0   ND    250.0   7.0
20100132240     0140050     0.0   ND    325.0   4.0
20100140530     0140750     0.0   ND    375.0   2.0
20100141230     0141440     0.0   ND    400.0   2.0
20100150220     0150420     0.0   ND    375.0   1.0
20100150910     0151120     0.0   ND    400.0   0.4
20100151610     0151810     0.0   ND    425.0   0.8
20100160550     0160800     0.0   ND    350.0   0.9
20100161250     0161450     0.0   ND    425.0   1.0
```

How to find a proper frame in case of VENUS (we have a magnetometer data)?

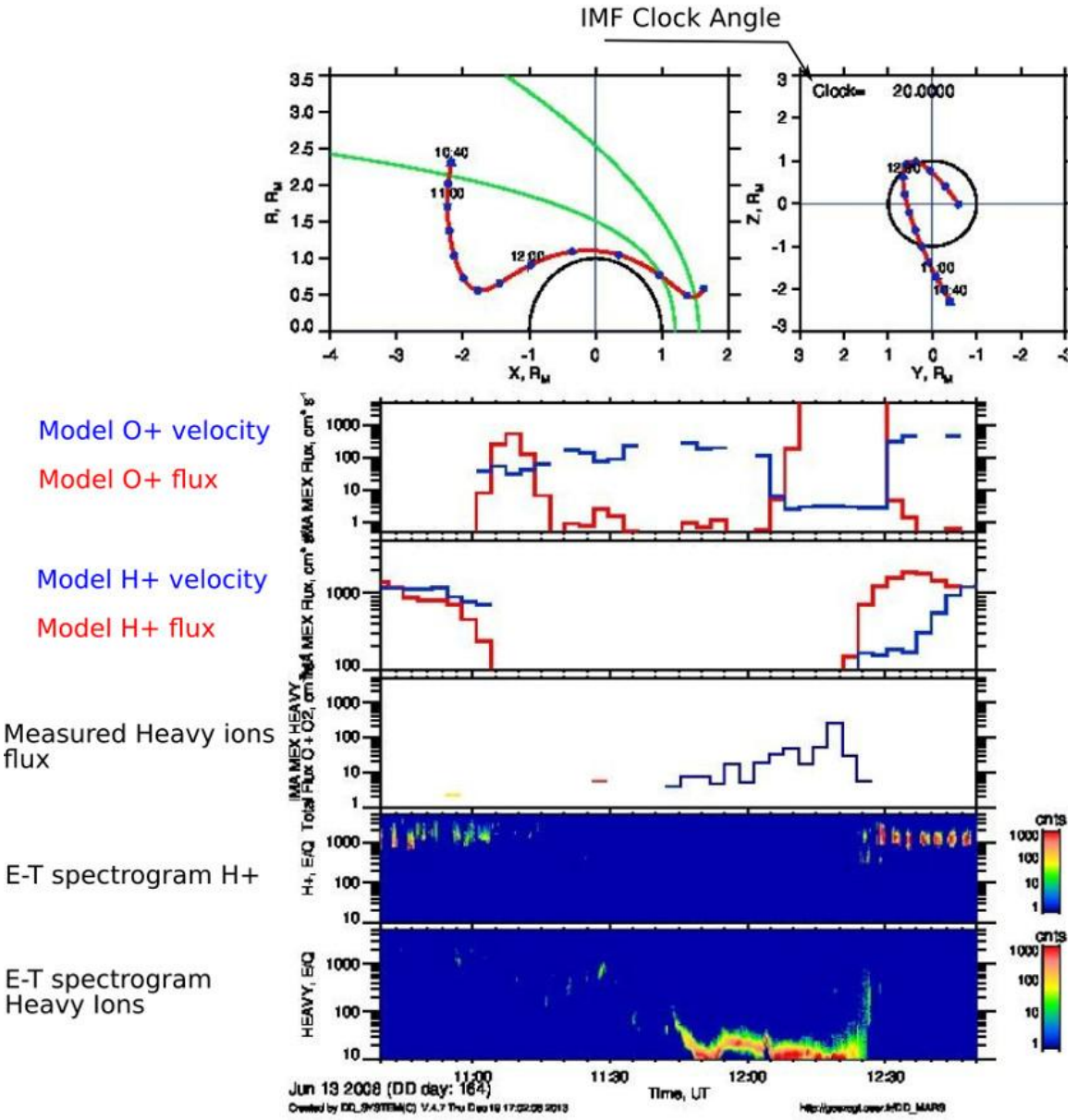
To make a statistics in the proper VSE frame we have to turn each orbit (or part of an orbit) according to the IMF clock angle (to put Z along –**V**x**B**) and aberration angle (to put X along solar wind velocity). Magnetic field data should show a IMF in YX plane and X reversing when S/C cross the XZ plane. At the same time the plasma data correspond to our imagination about induced magnetosphere structure. For instance the accelerated heavy ions beam at the current sheed in XZ plane.



How to Find the IMF clock angle with MEX data (no magnetometer)?

The idea is to compare the simulated data along the MEX orbit, varying the clock angle, with the real measurements.

For each possible IMF clock angle we make a special plot containing the orbit, turned according to IMF clock, corresponding model profiles (ion fluxes and ion velocities) and real measured data.

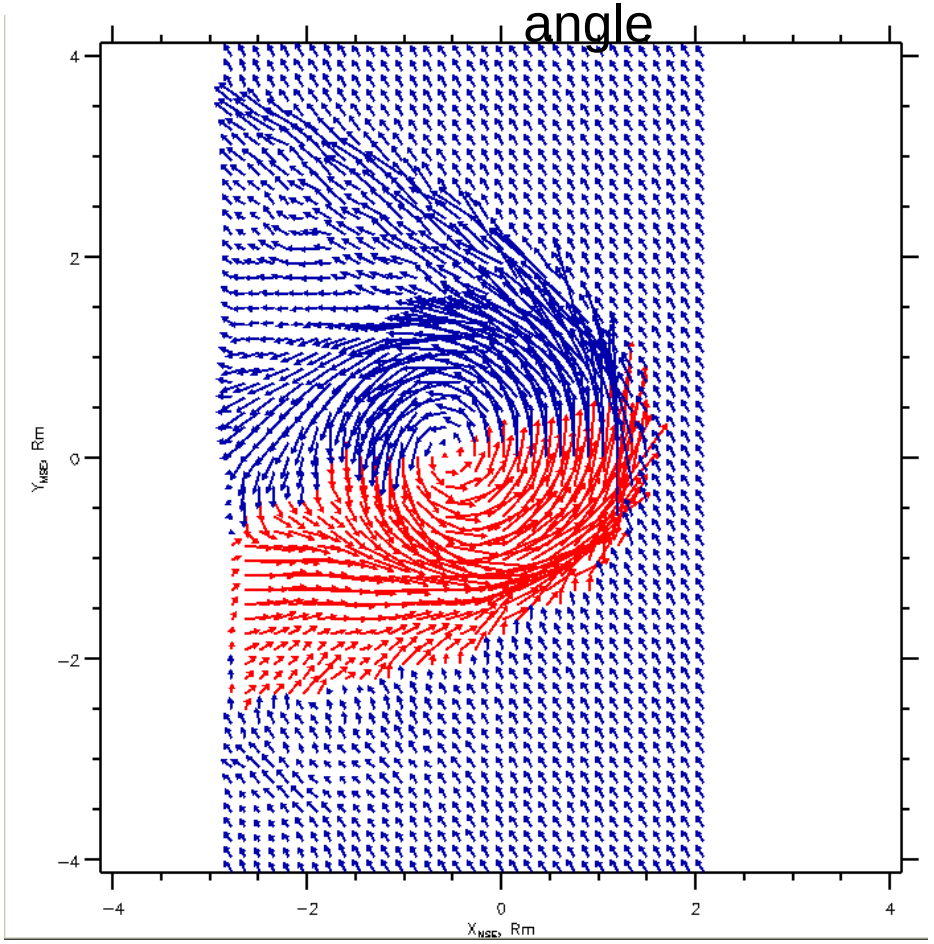


Four models have been used for comparison.

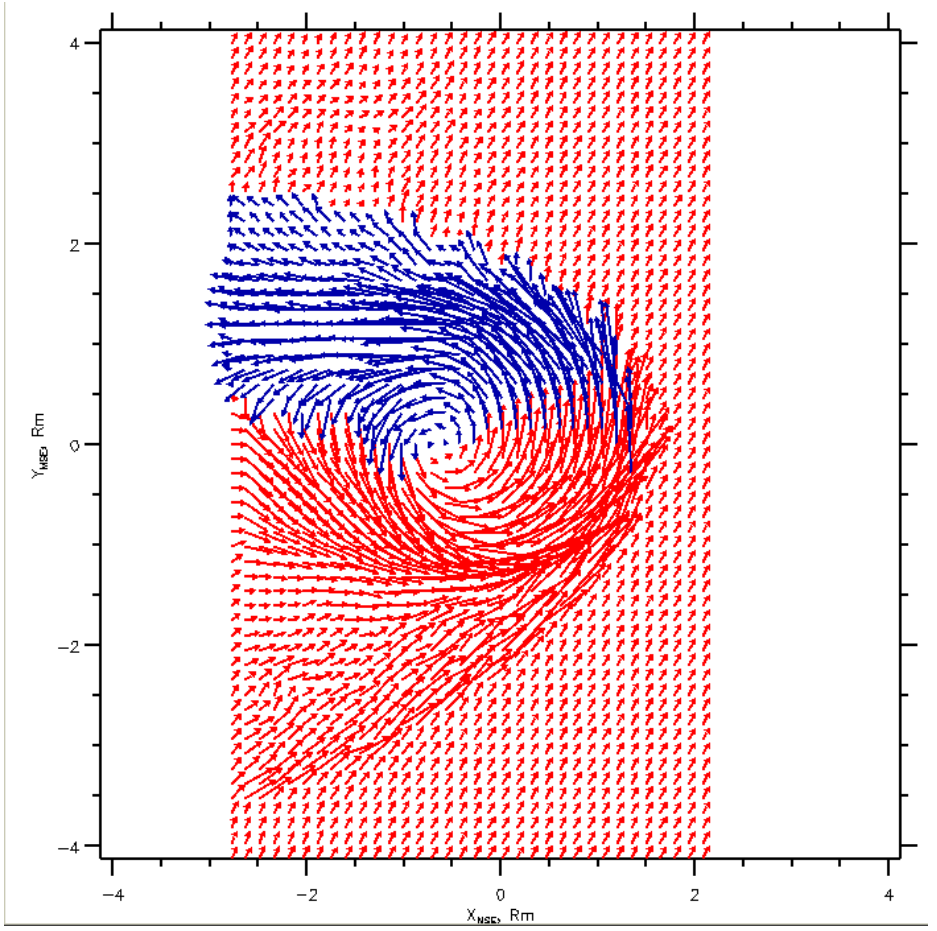
1 and 2 : Modolo for 40° and 140° spiral angle

Nsw = 3.15 cm-3
Vsw = 430 km/s
Tsw = 5.5 eV

40° spiral angle



140° spiral angle

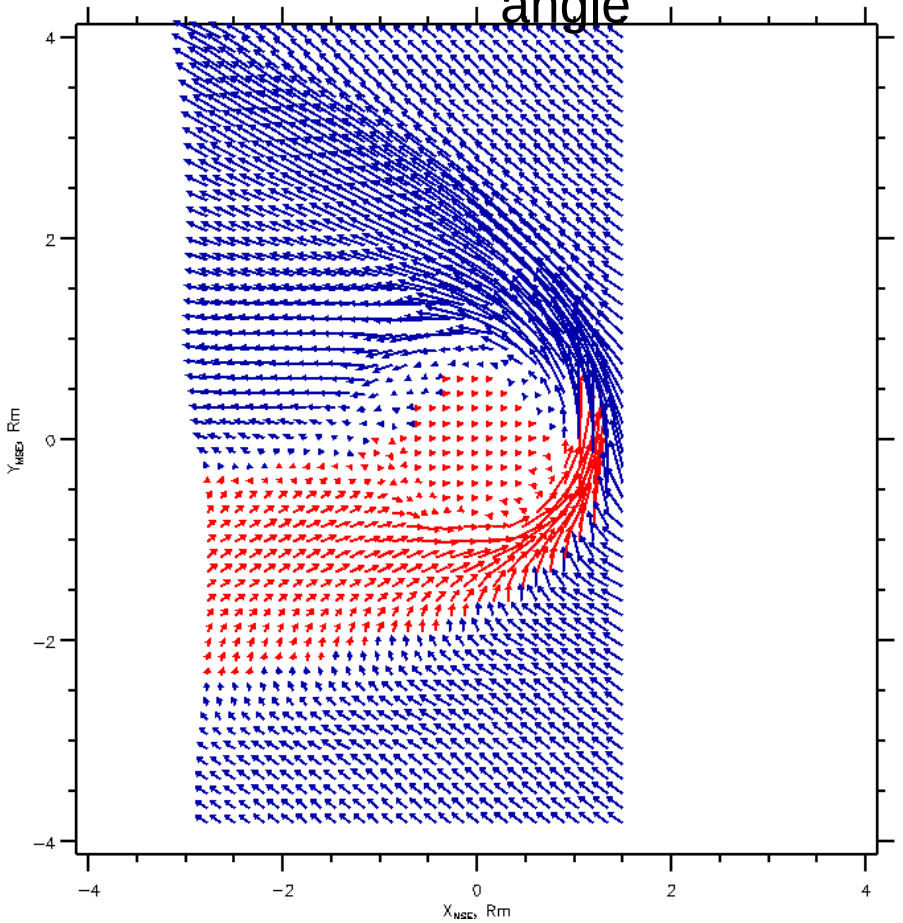


Four models have been used for comparison.

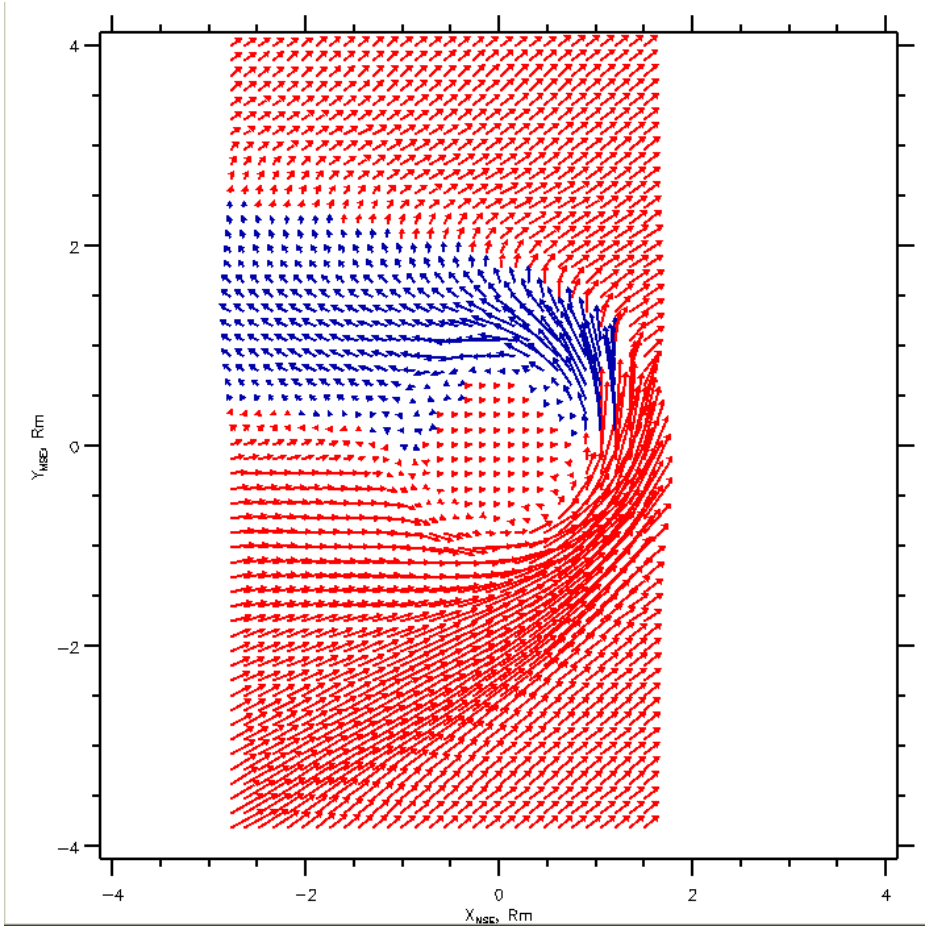
3 and 4 : Kallio for 40° and 140° spiral angle

Nsw = 3.15 cm-3
Vsw = 430 km/s
Tsw = 5.5 eV

40° spiral angle



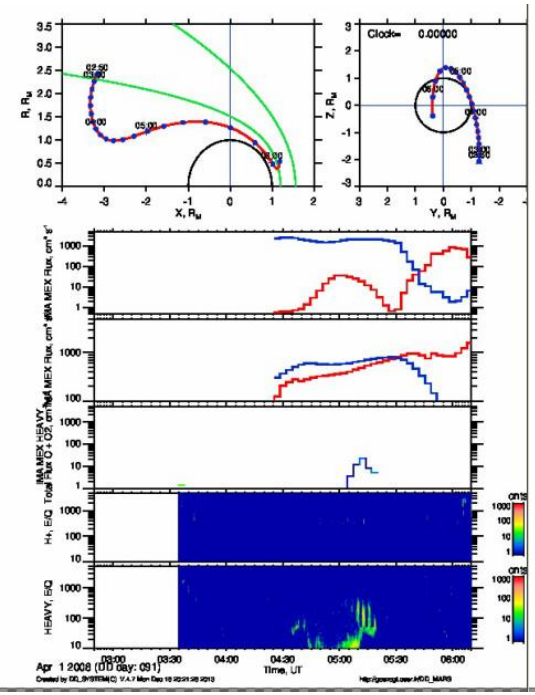
140° spiral angle



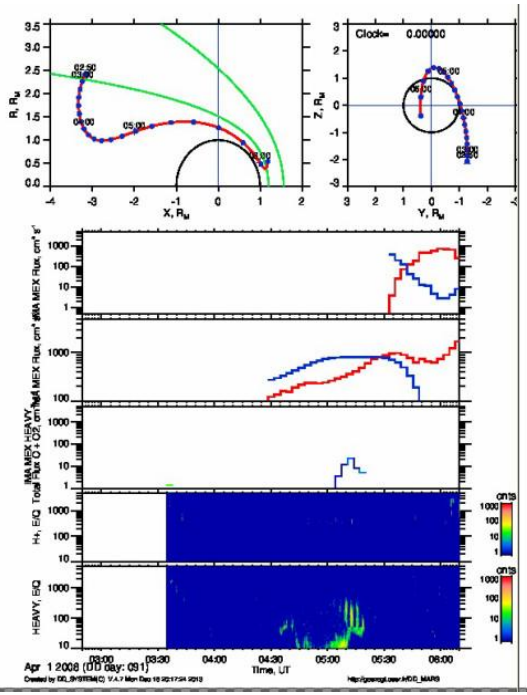
How to Fit the Measurements and the Model

See the following “movie” compilated from 22 slides

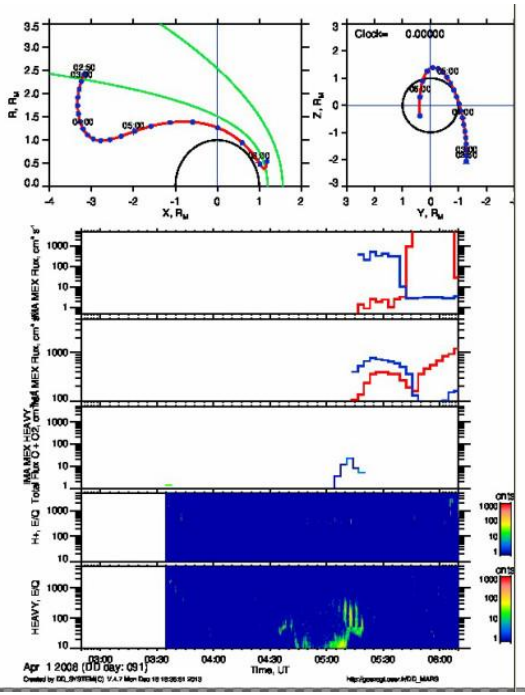
Kallio, 40˚



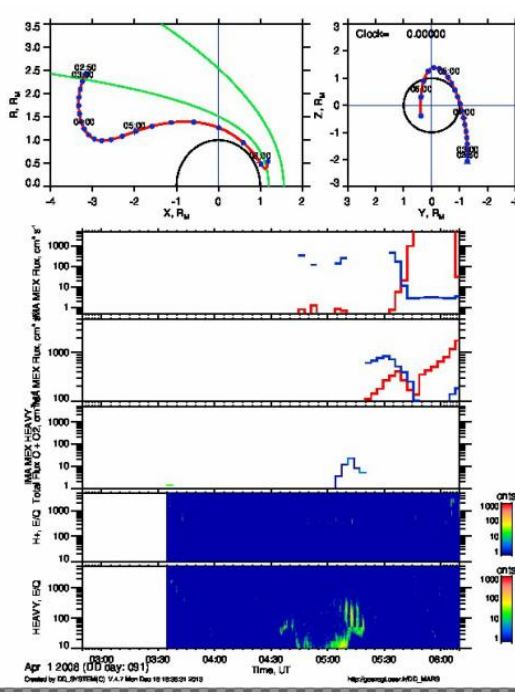
Kallio, 140˚



Modolo, 40˚

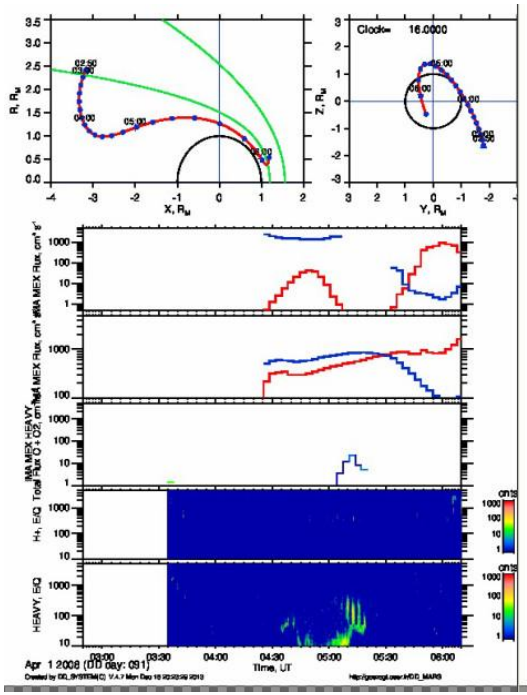


Modolo, 140˚

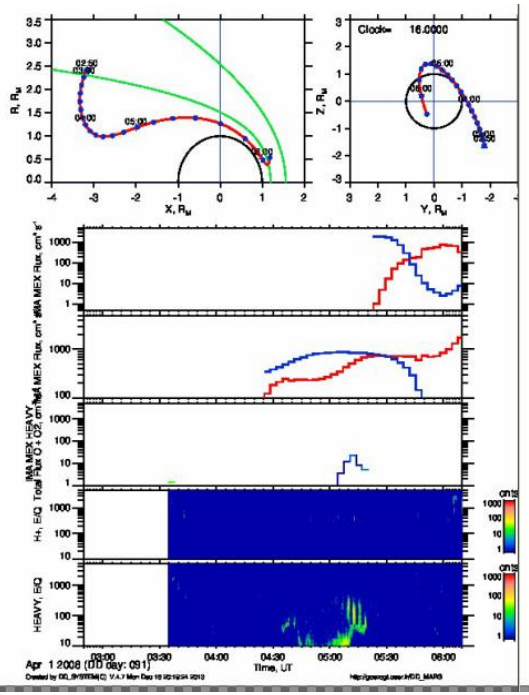


How to Fit the Measurements and the Model

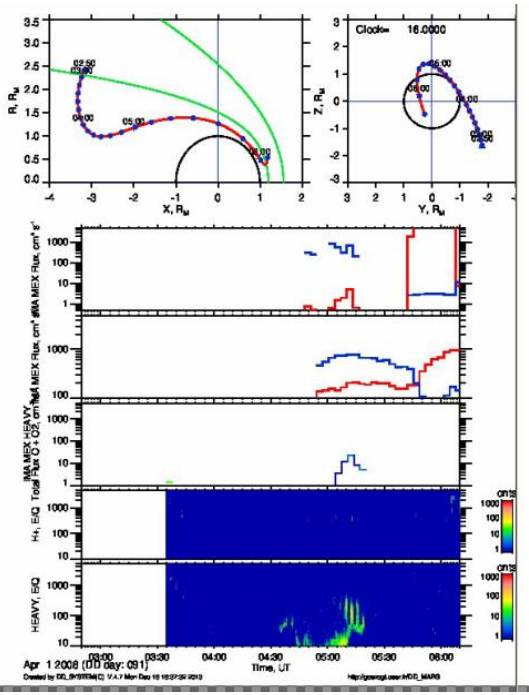
Kallio, 40˚



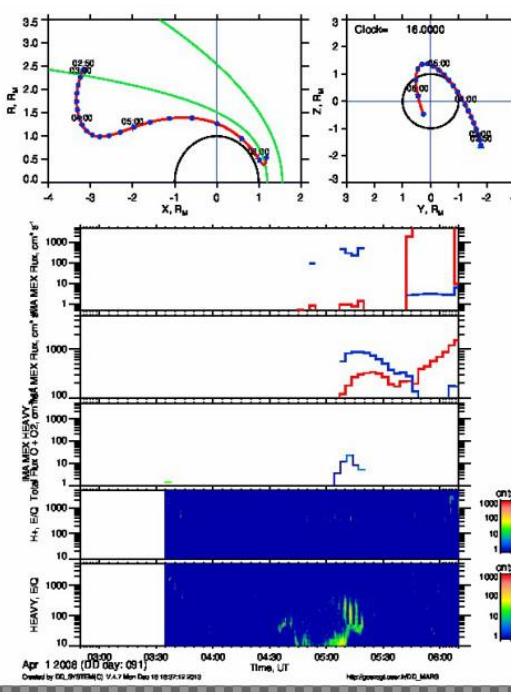
Kallio, 140˚



Modolo, 40˚



Modolo, 140˚



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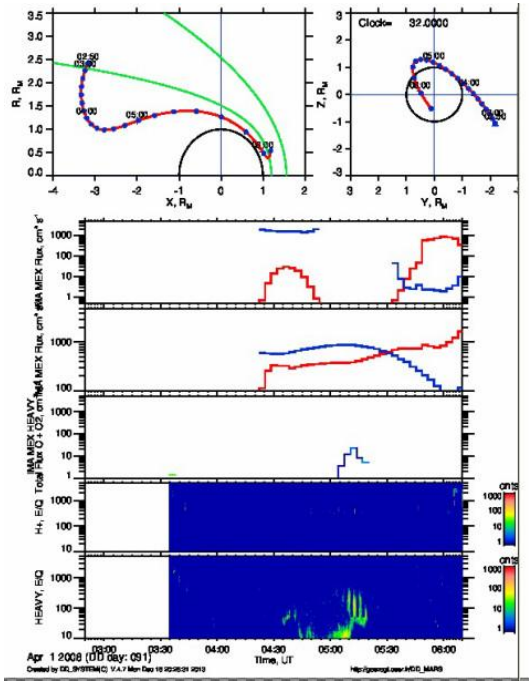
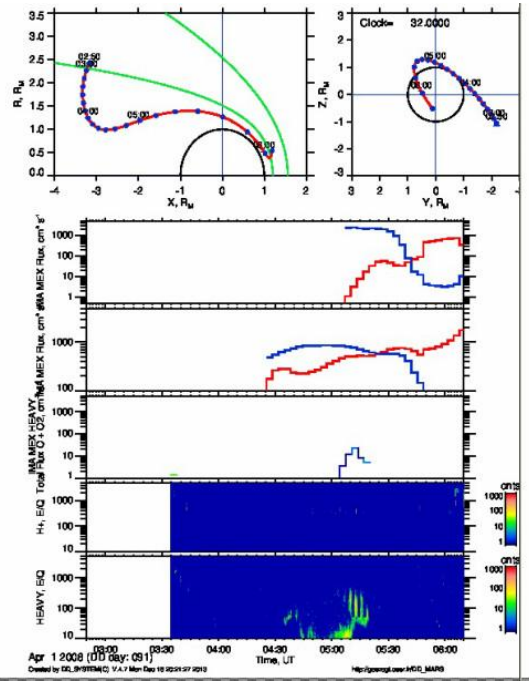
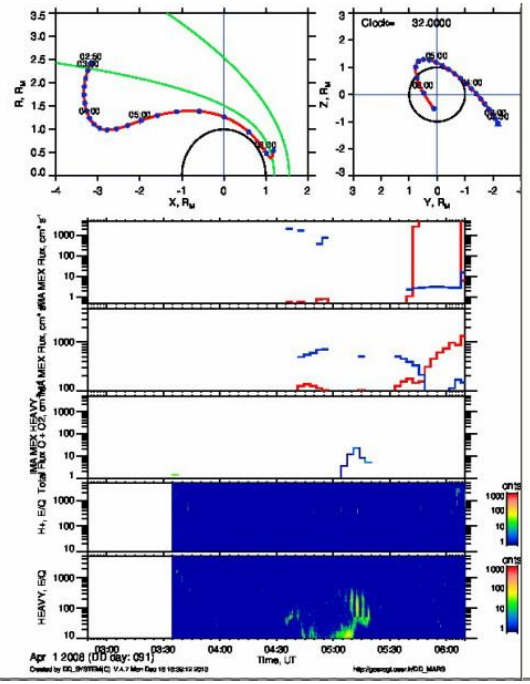
Kallio, 40˚



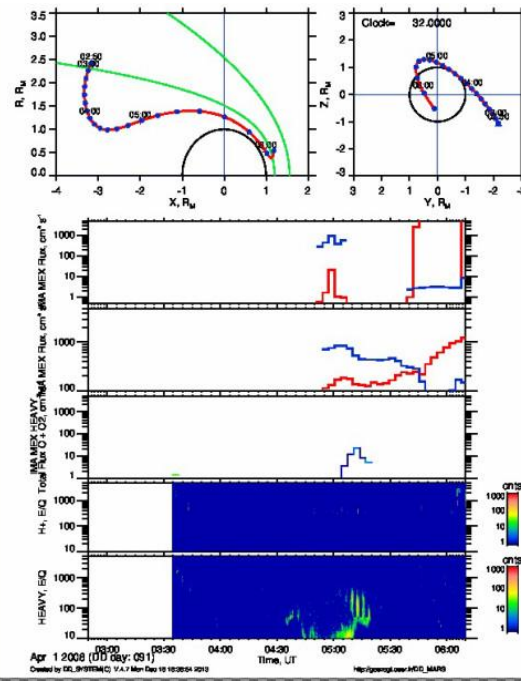
Kallio, 140˚



Modolo, 40˚

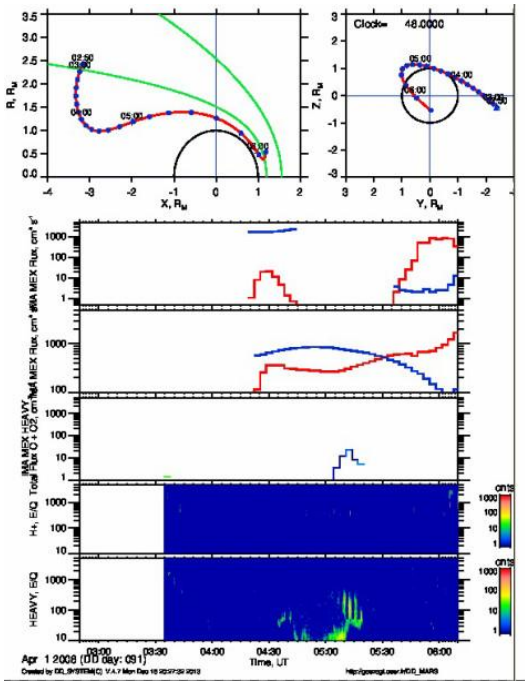


Modolo, 140˚

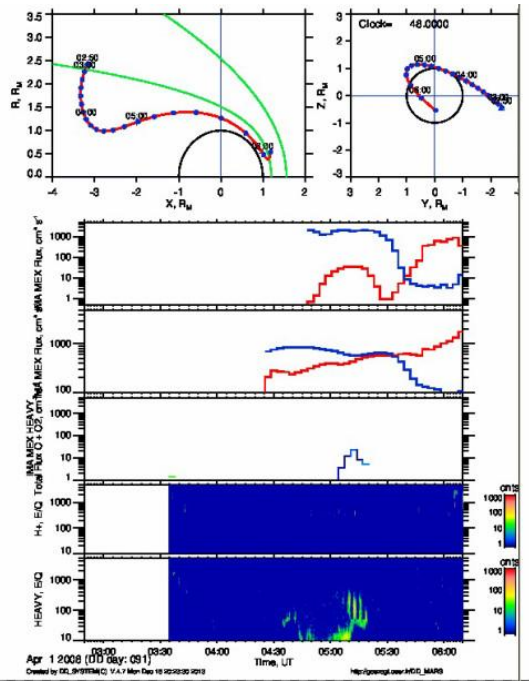


How to Fit the Measurements and the Model

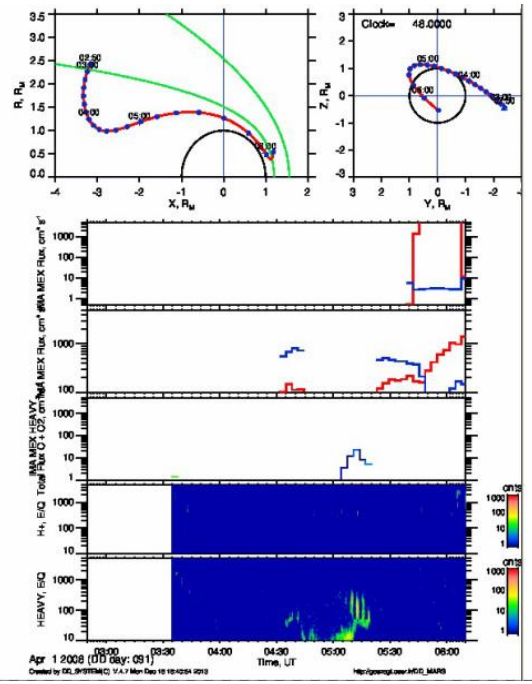
Kallio, 40°



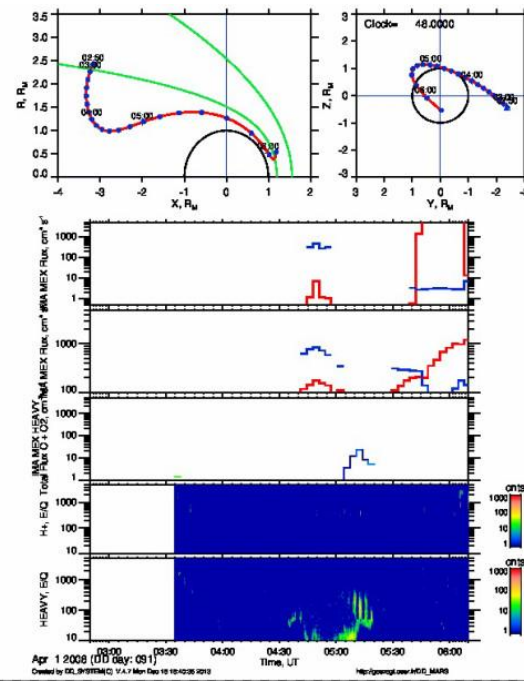
Kallio, 140°



Modolo, 40°

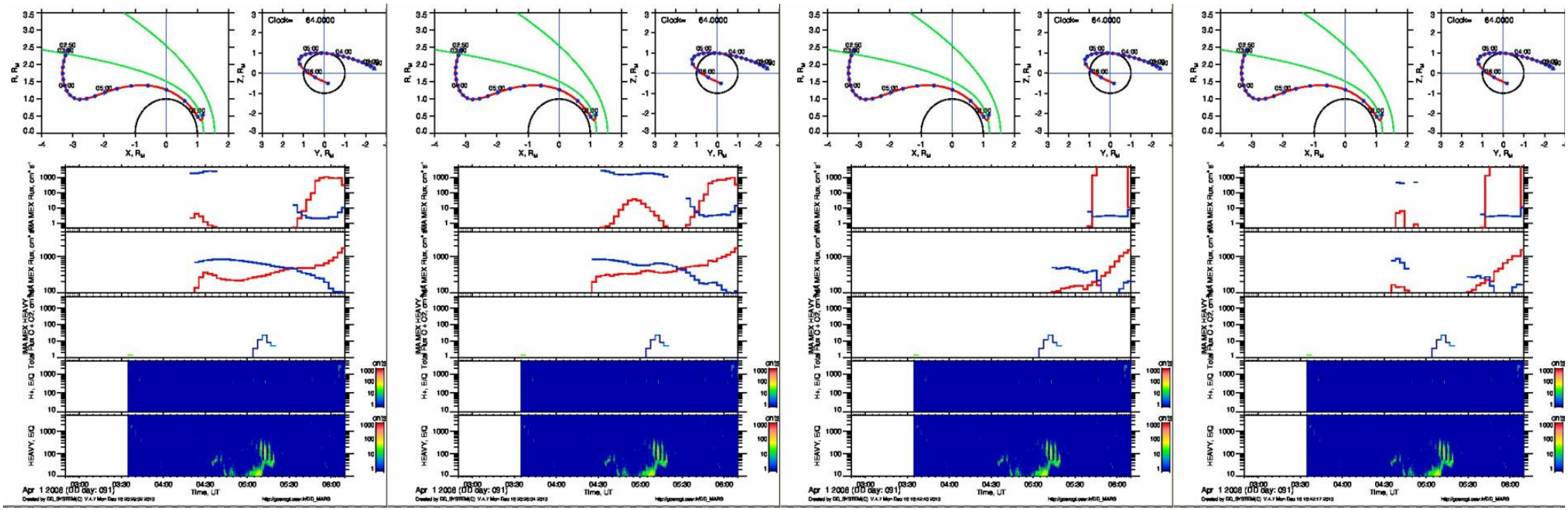


Modolo, 140°



How to Fit the Measurements and the Model

Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚



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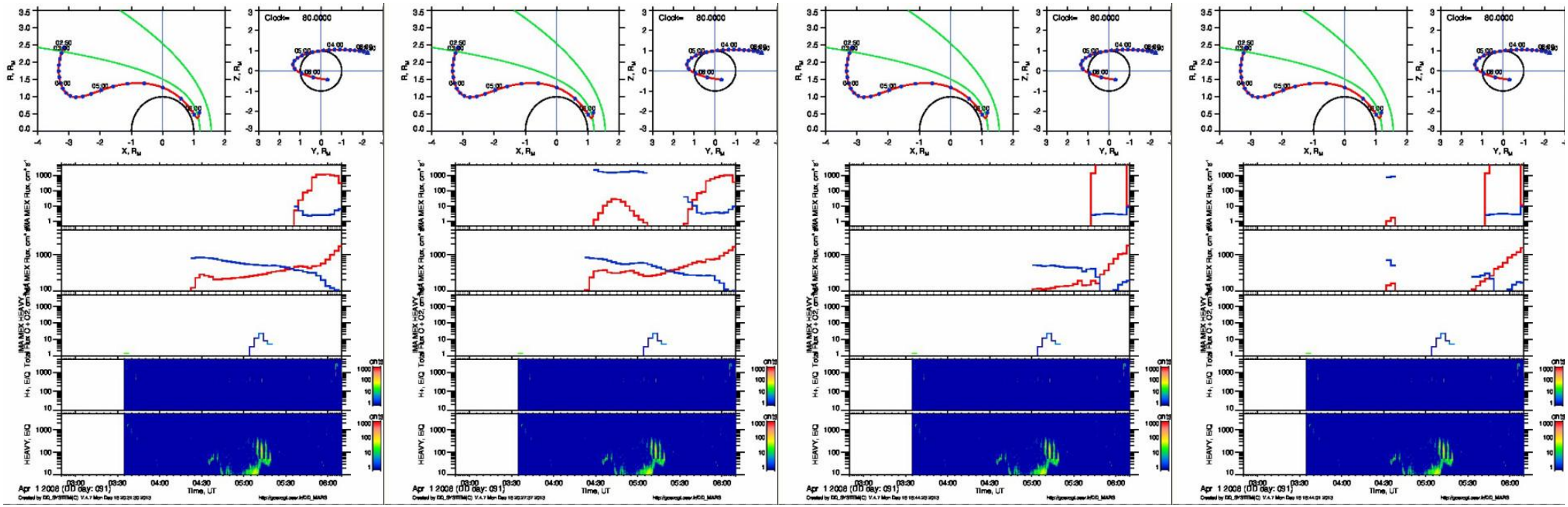
Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚



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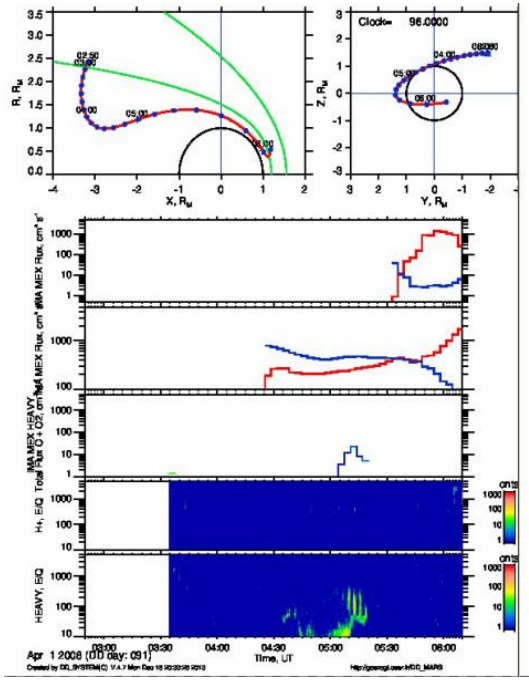
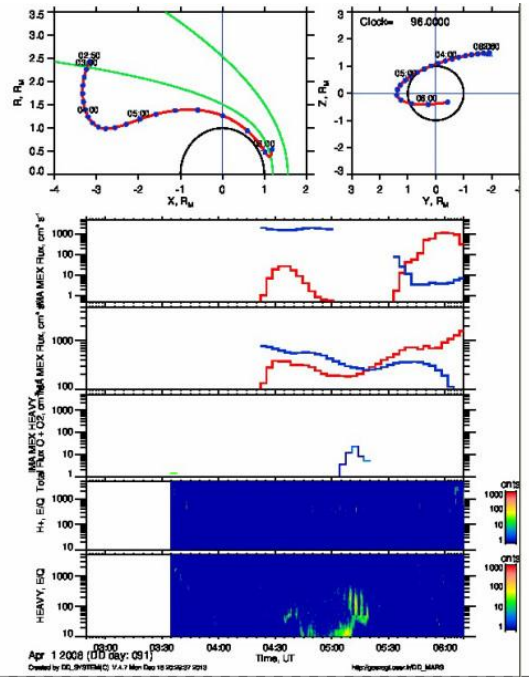
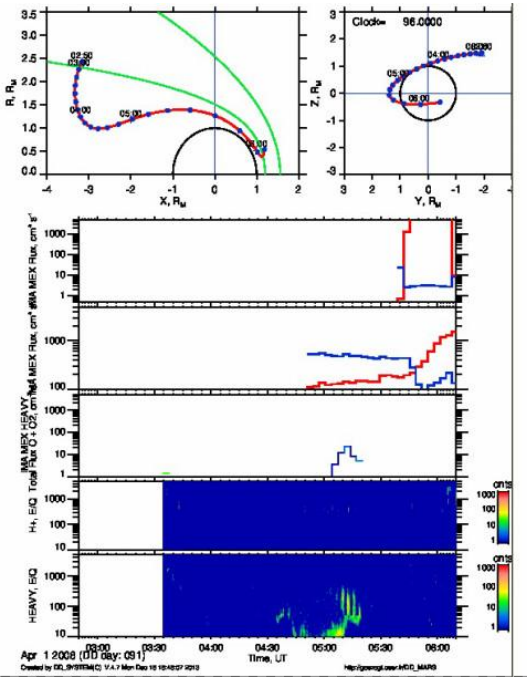
Kallio, 40˚



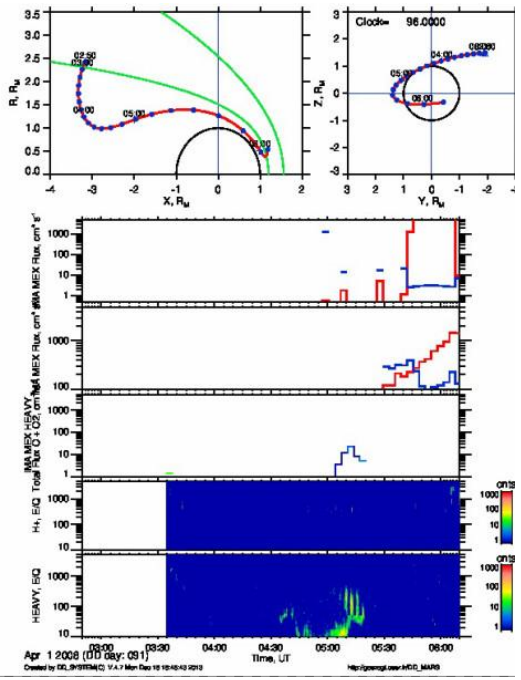
Kallio, 140˚



Modolo, 40˚

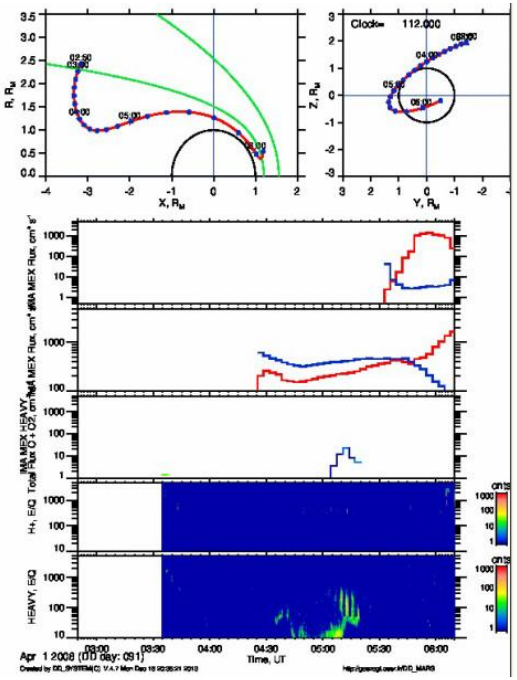


Modolo, 140˚

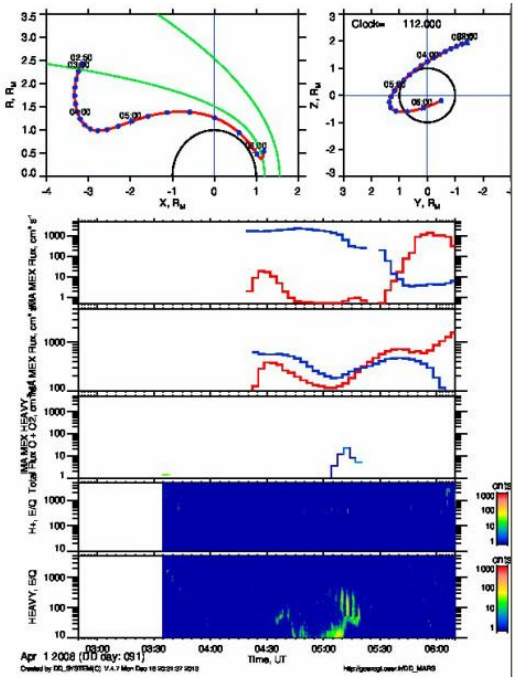


How to Fit the Measurements and the Model

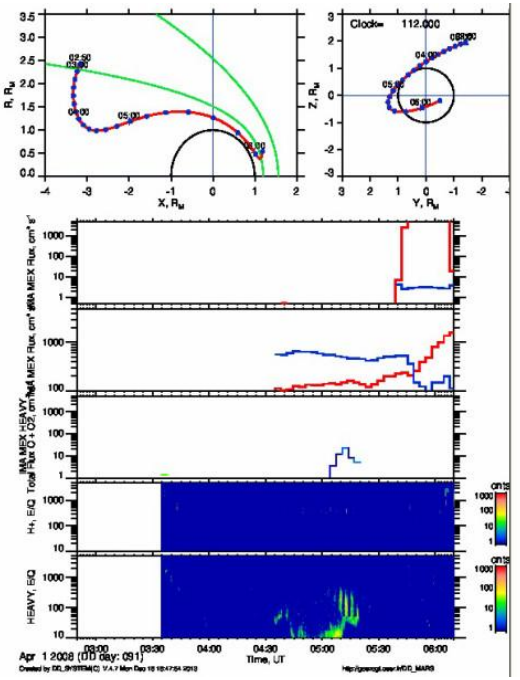
Kallio, 40˚



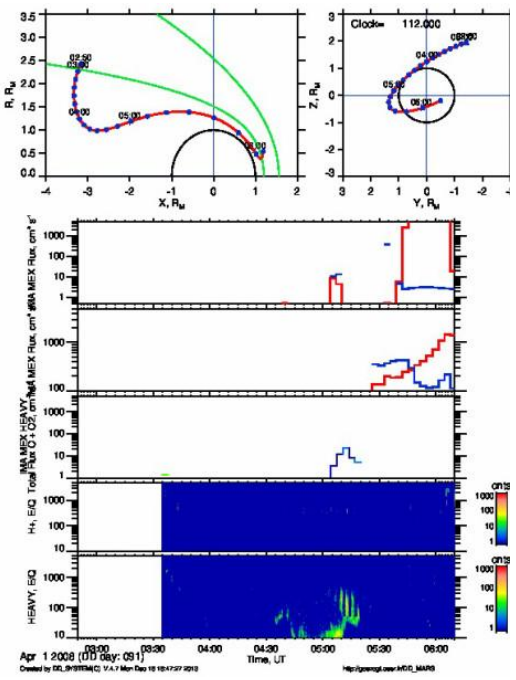
Kallio, 140˚



Modolo, 40˚

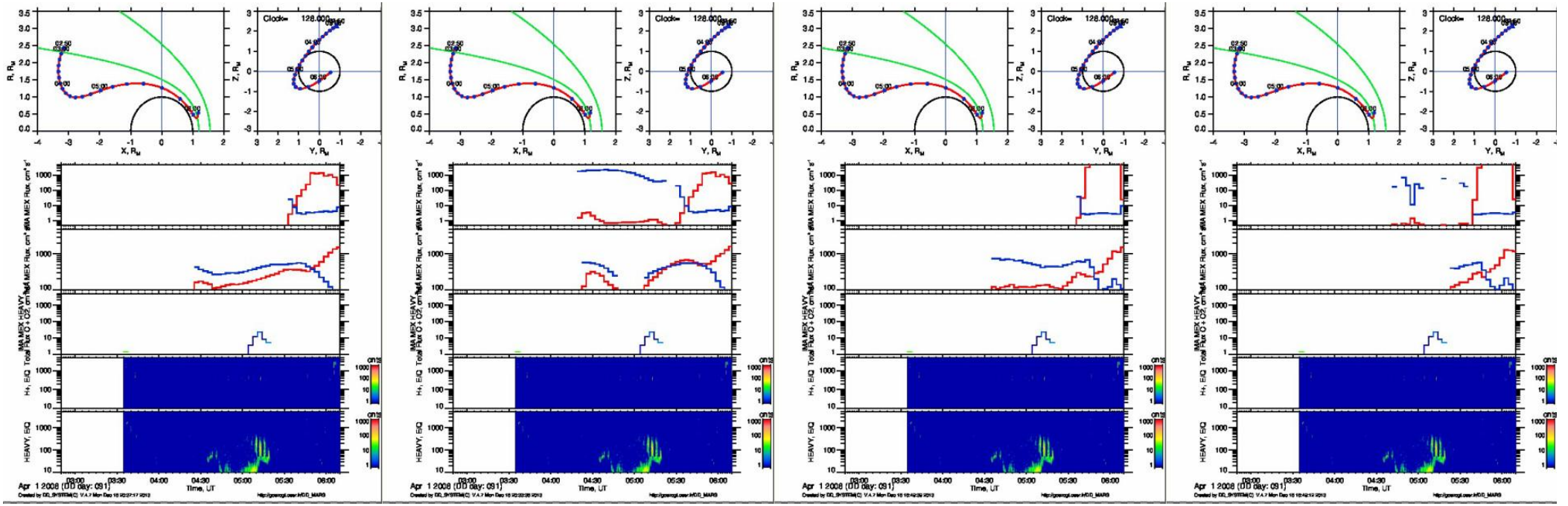


Modolo, 140˚



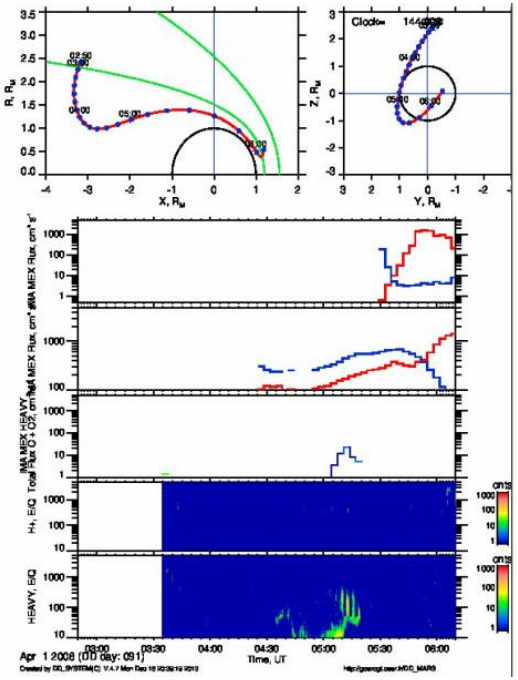
How to Fit the Measurements and the Model

Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚

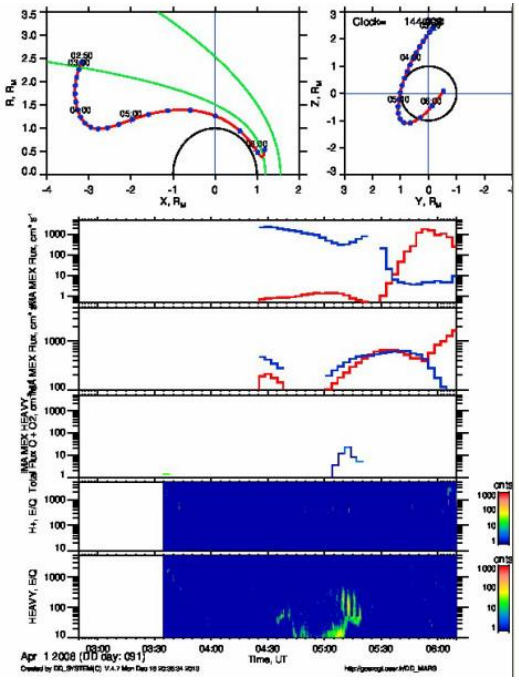


How to Fit the Measurements and the Model

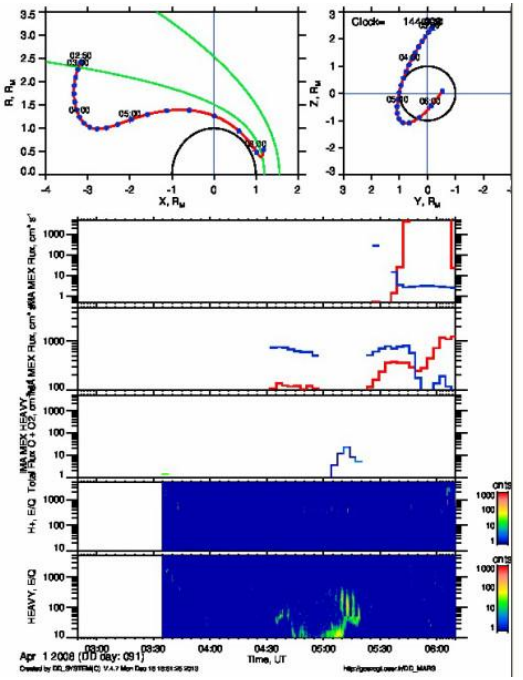
Kallio, 40˚



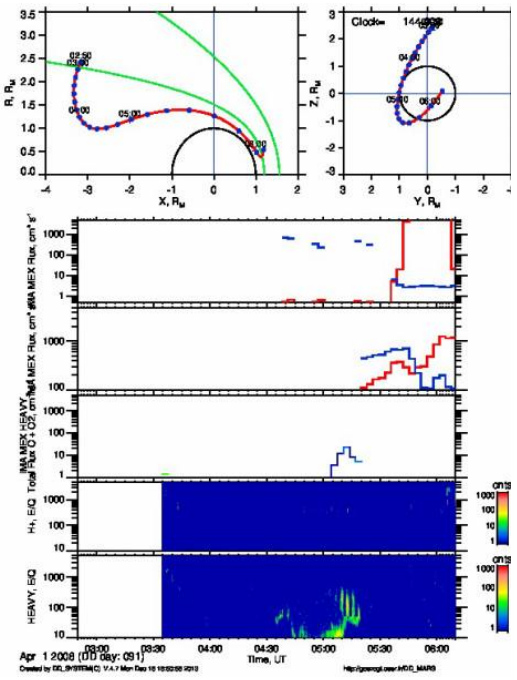
Kallio, 140˚



Modolo, 40˚

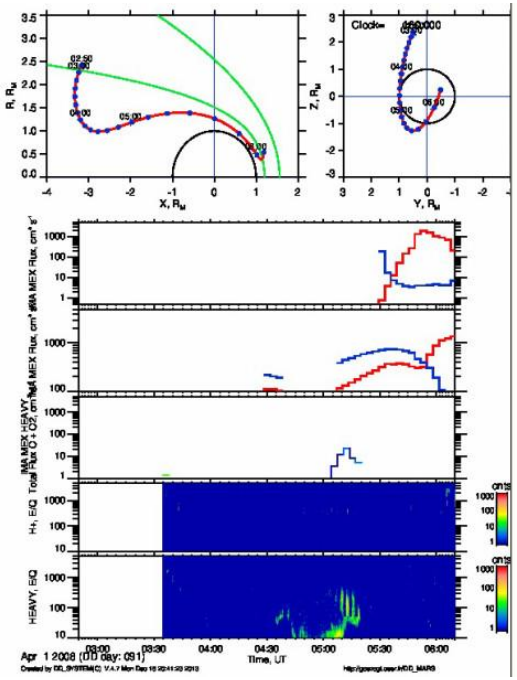


Modolo, 140˚

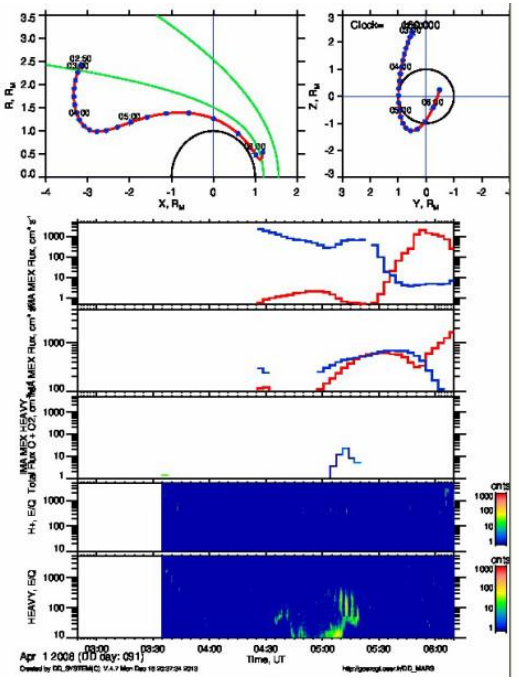


How to Fit the Measurements and the Model

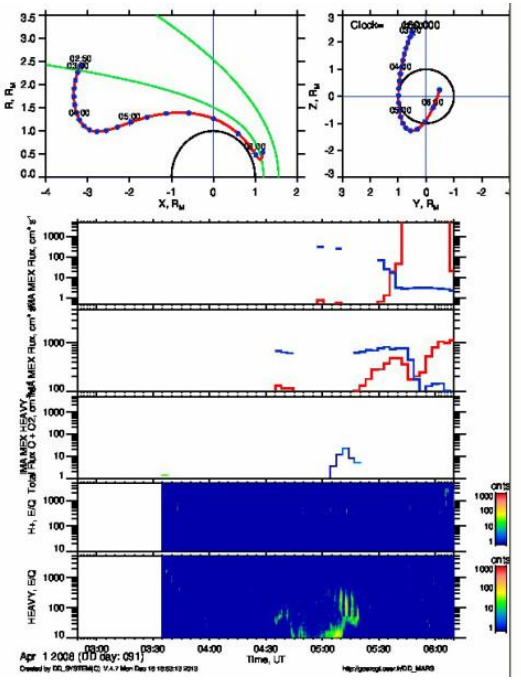
Kallio, 40˚



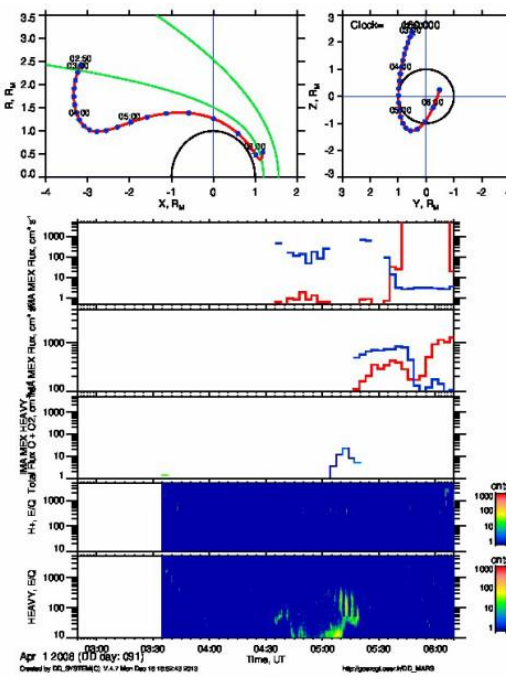
Kallio, 140˚



Modolo, 40˚

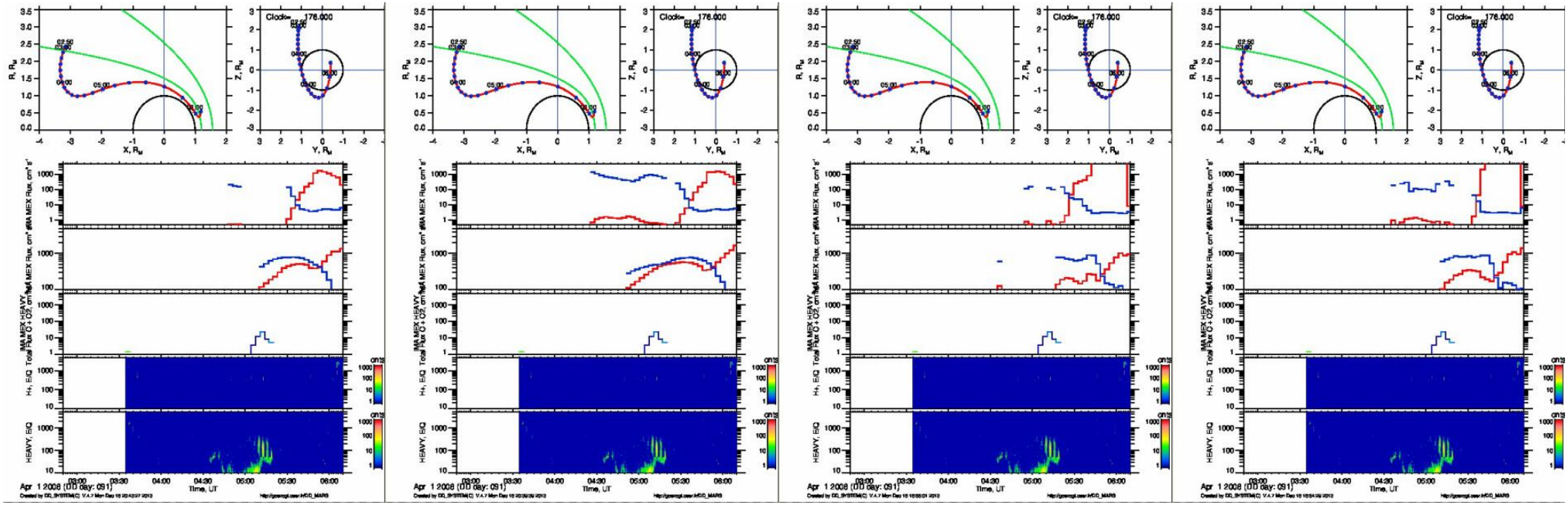


Modolo, 140˚



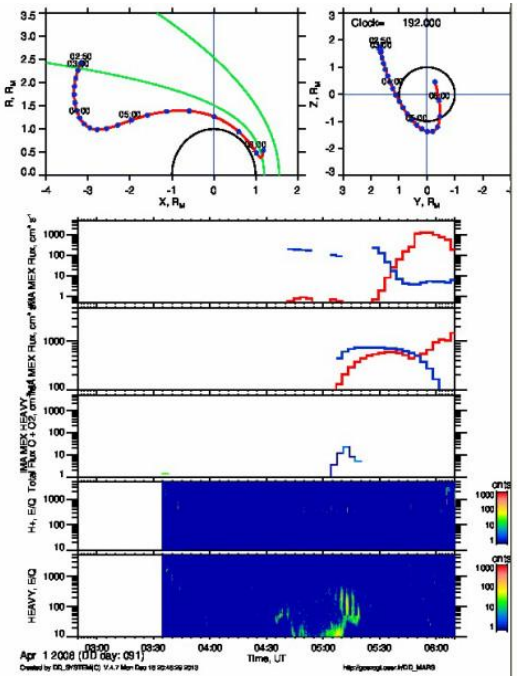
How to Fit the Measurements and the Model

Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚

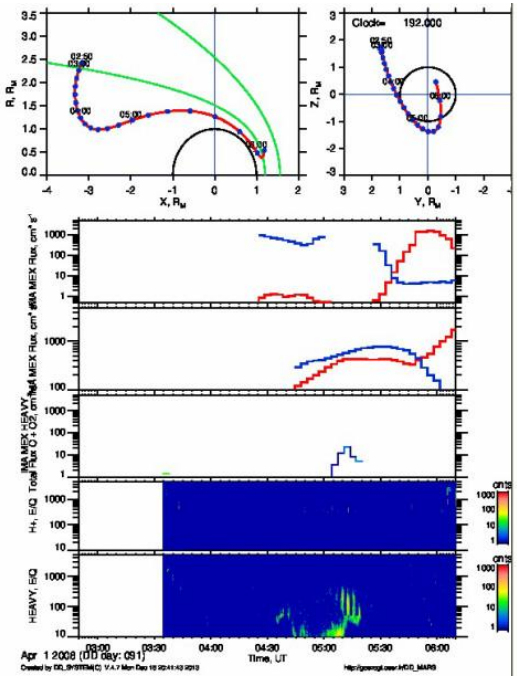


How to Fit the Measurements and the Model

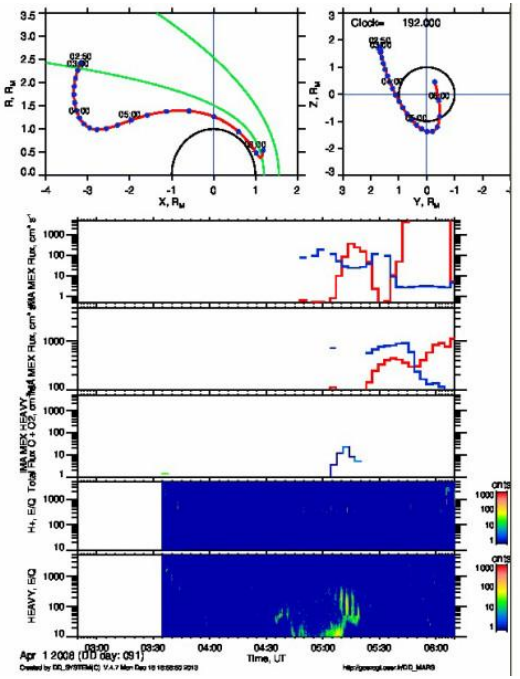
Kallio, 40˚



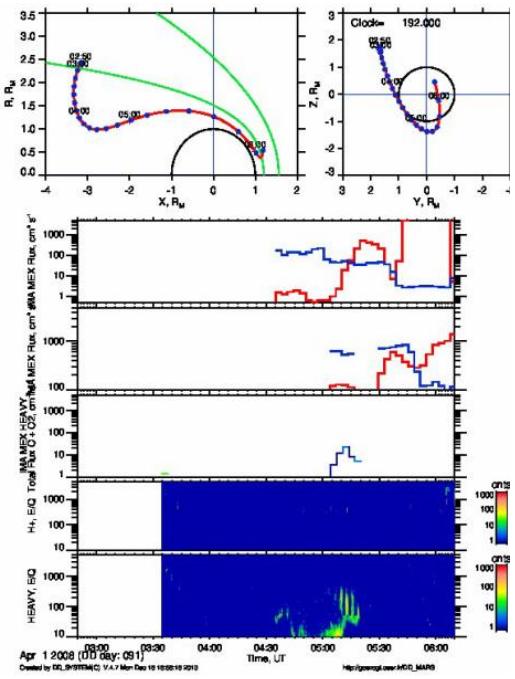
Kallio, 140˚



Modolo, 40˚

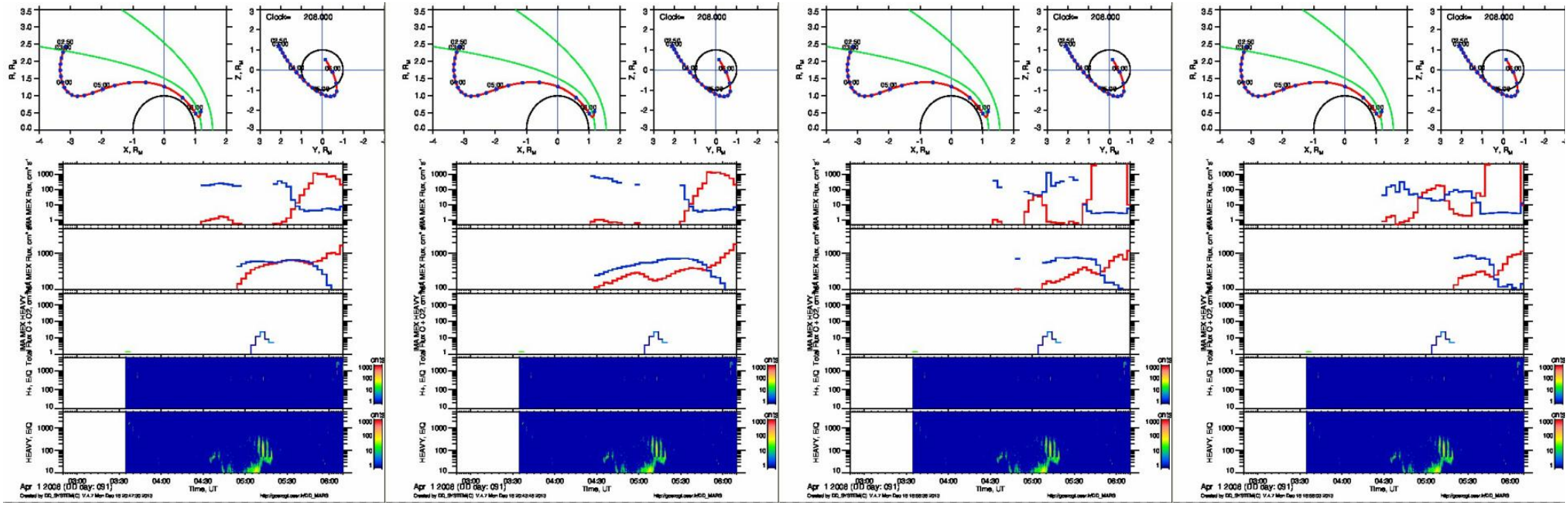


Modolo, 140˚



How to Fit the Measurements and the Model

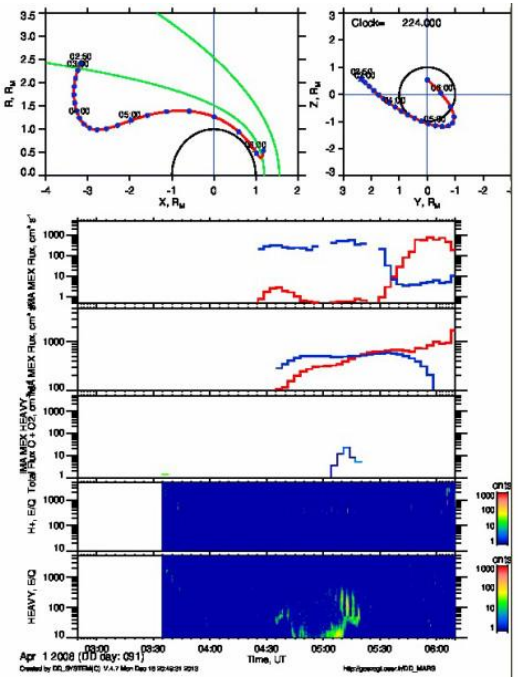
Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚



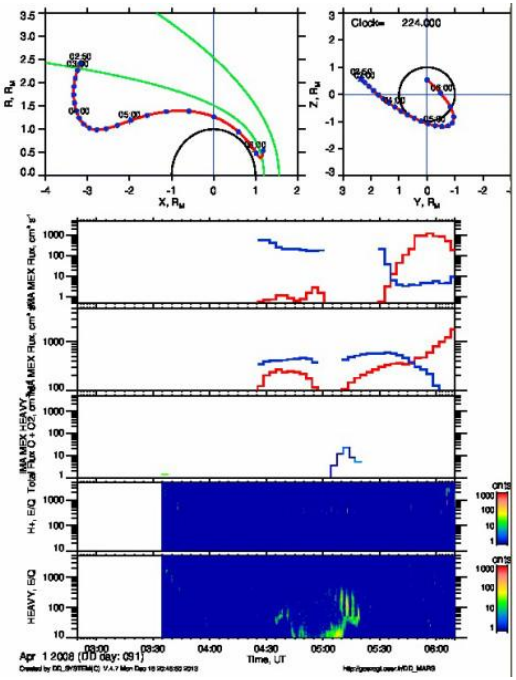
FOUND! Modolo, 40˚, Clock angle = 220˚

How to Fit the Measurements and the Model

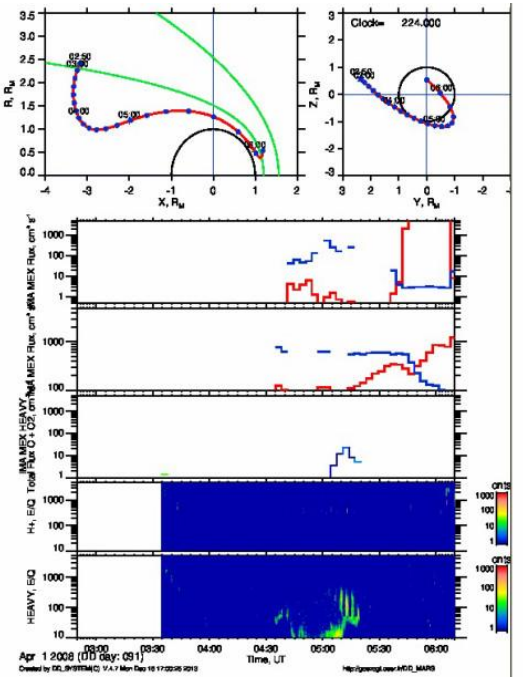
Kallio, 40˚



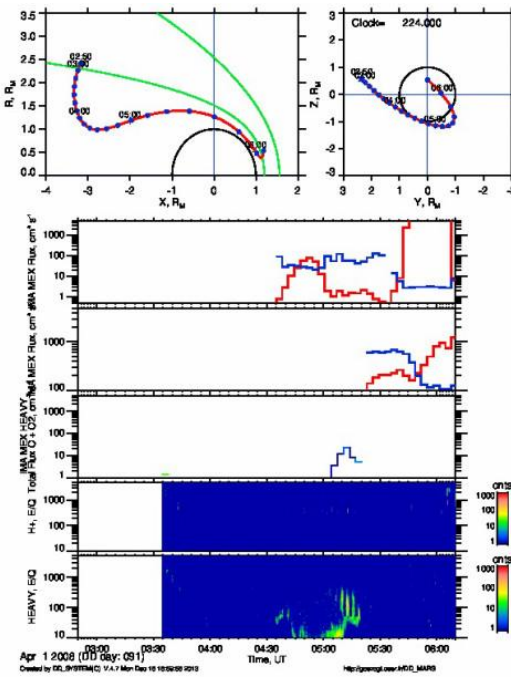
Kallio, 140˚



Modolo, 40˚

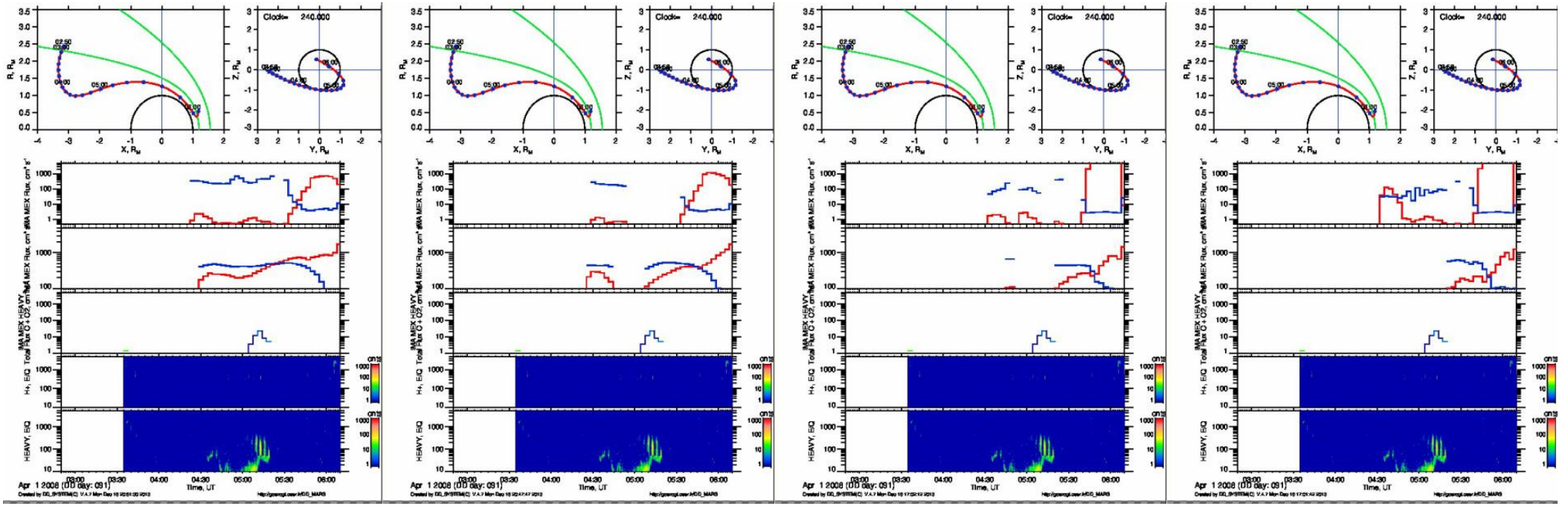


Modolo, 140˚



How to Fit the Measurements and the Model

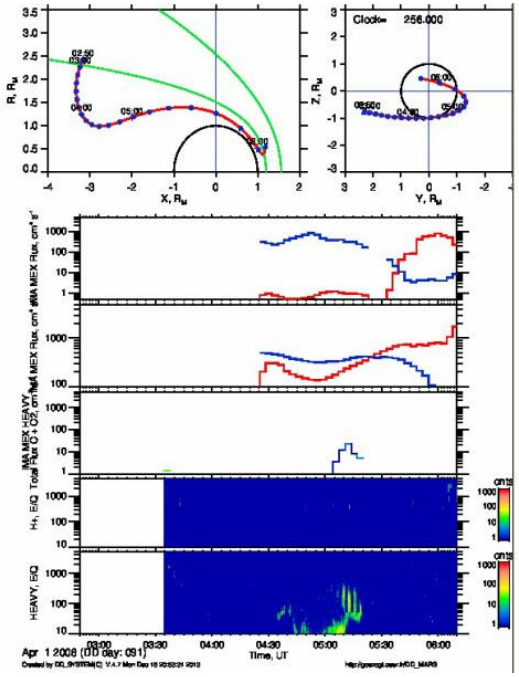
Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚



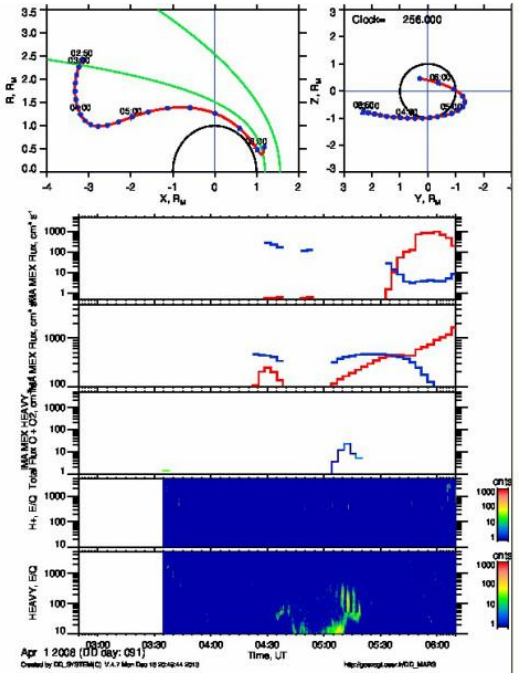
Another possibility: Kallio, 40˚ , Clock angle = 240˚

How to Fit the Measurements and the Model

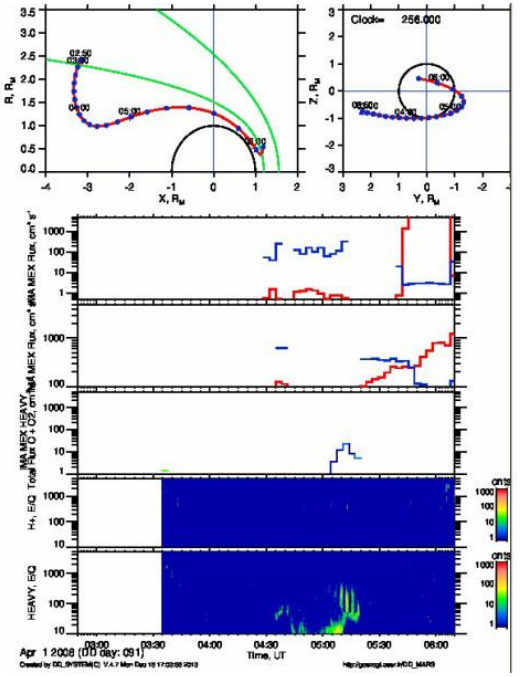
Kallio, 40˚



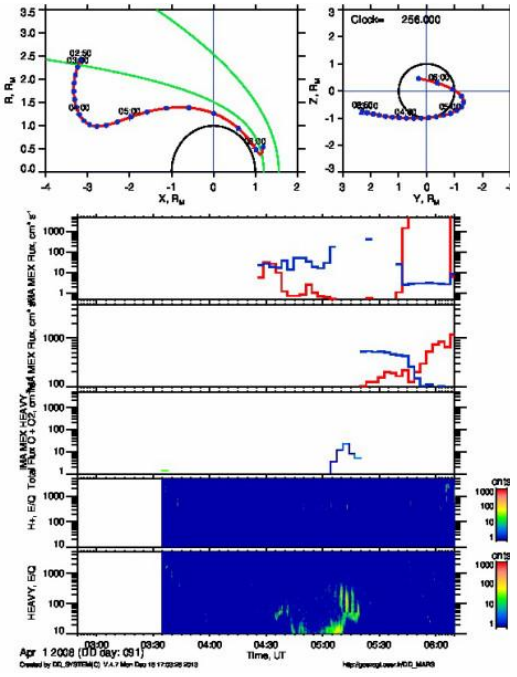
Kallio, 140˚



Modolo, 40˚

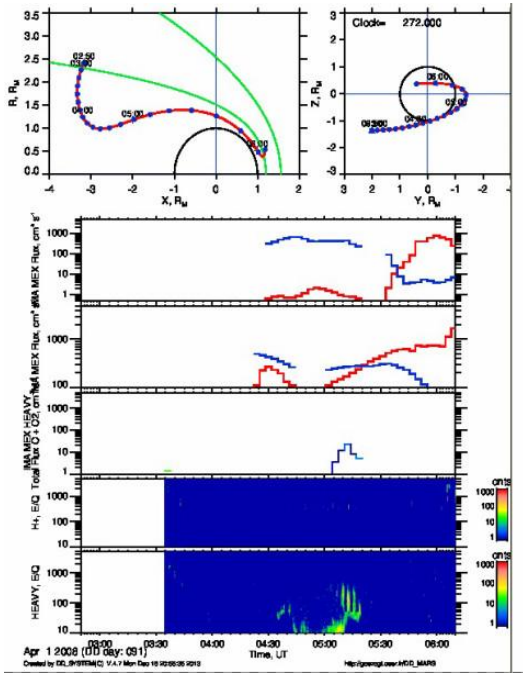


Modolo, 140˚

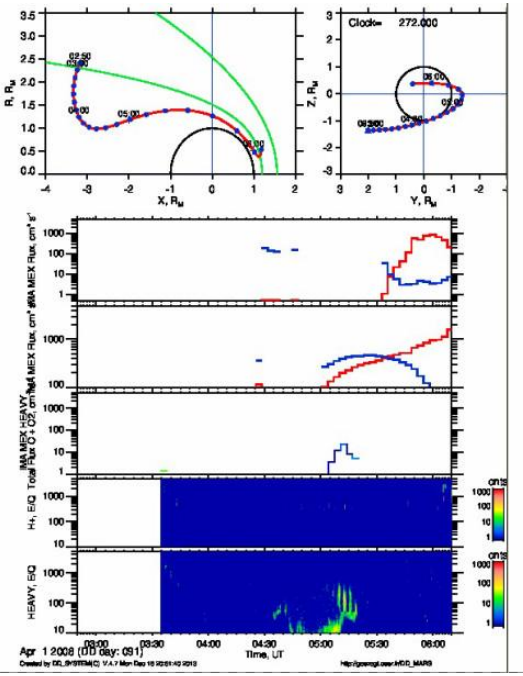


How to Fit the Measurements and the Model

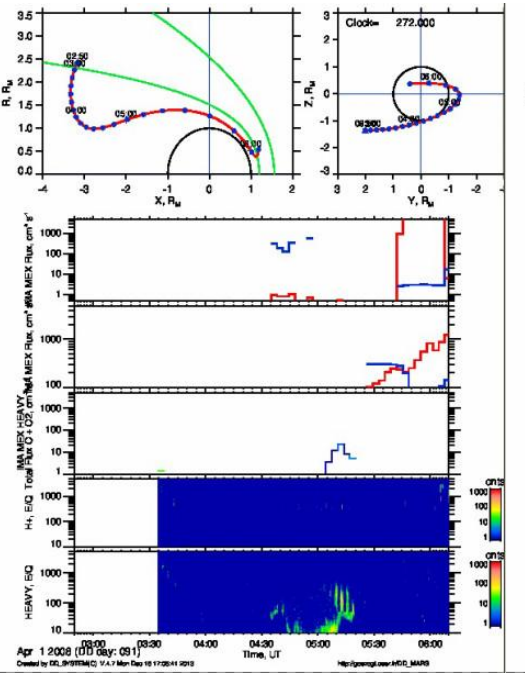
Kallio, 40˚



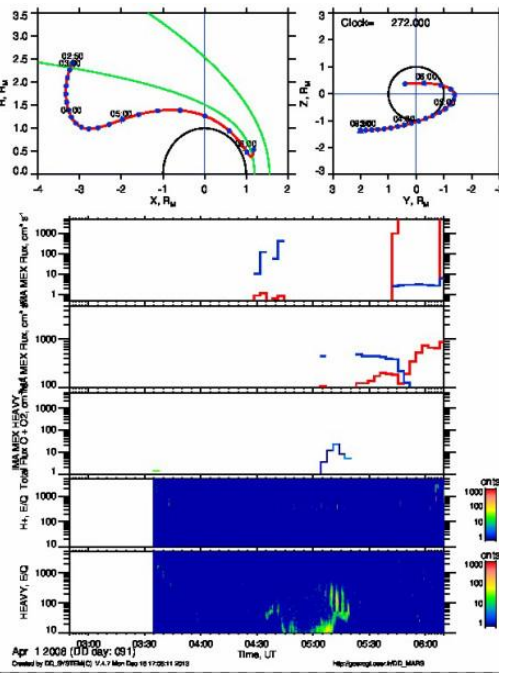
Kallio, 140˚



Modolo, 40˚

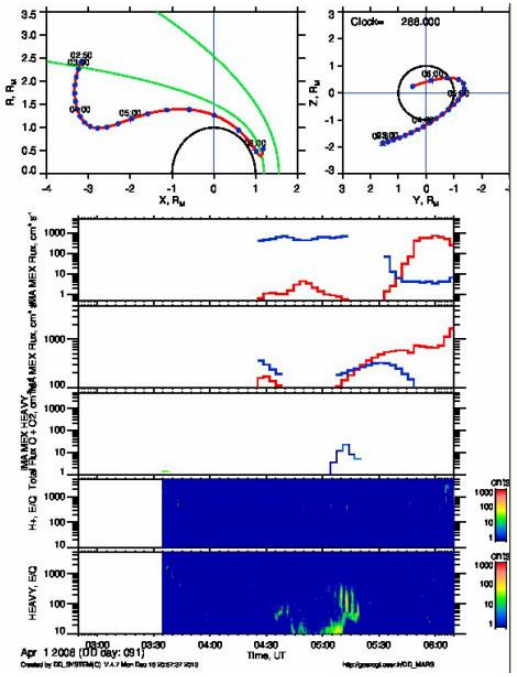


Modolo, 140˚

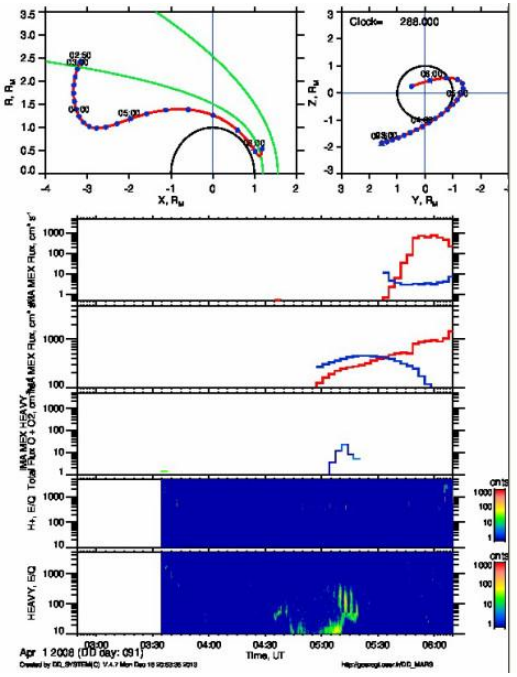


How to Fit the Measurements and the Model

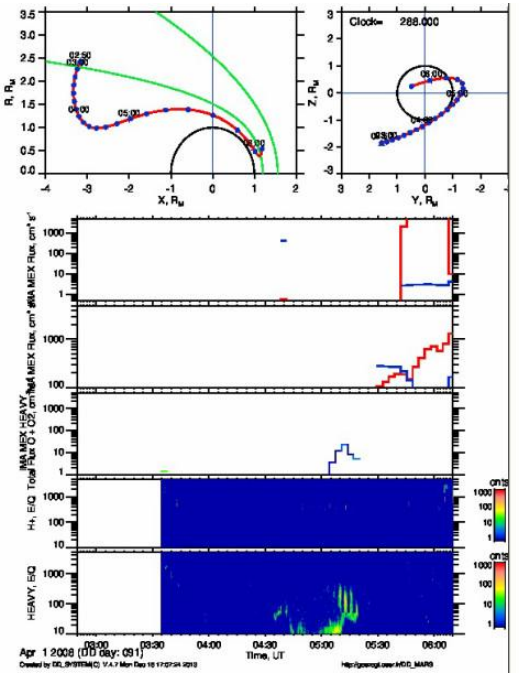
Kallio, 40˚



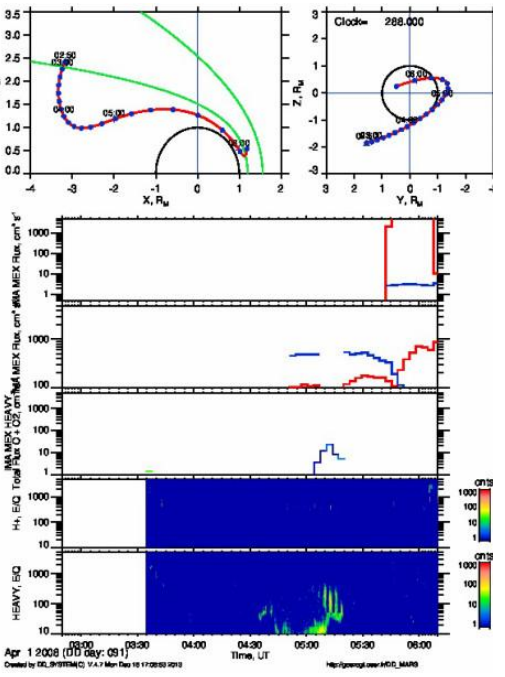
Kallio, 140˚



Modolo, 40˚

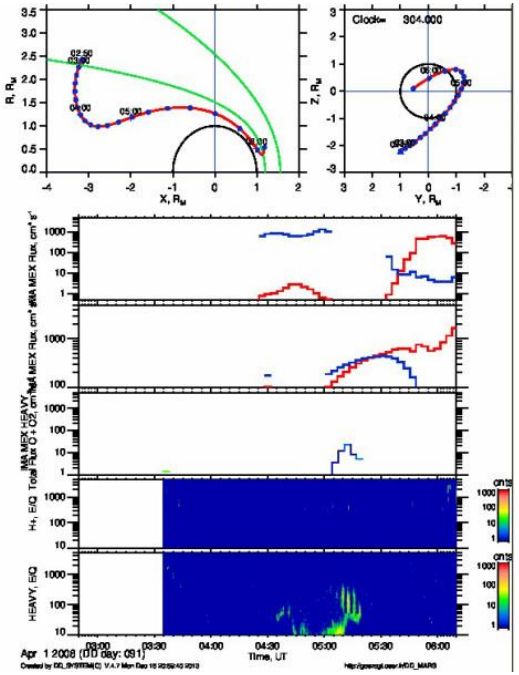


Modolo, 140˚

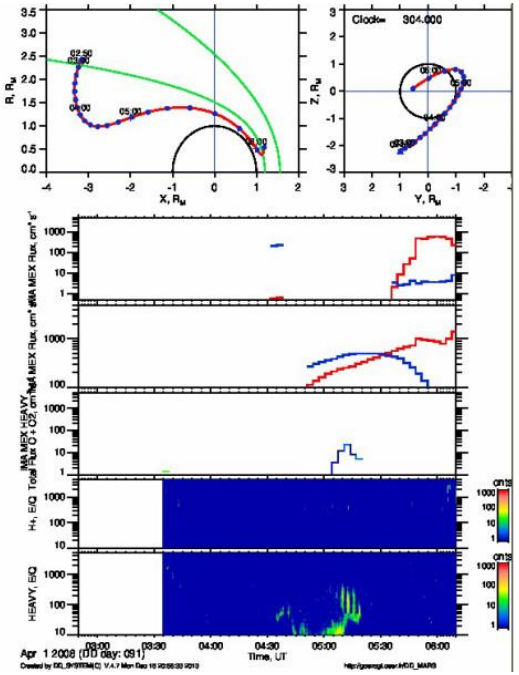


How to Fit the Measurements and the Model

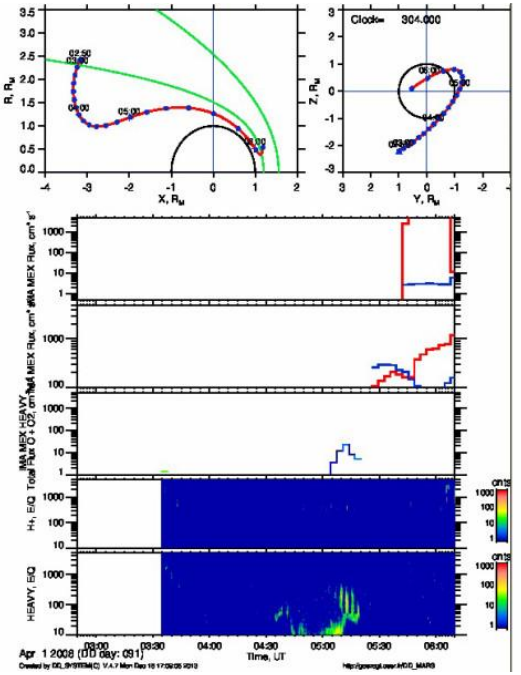
Kallio, 40˚



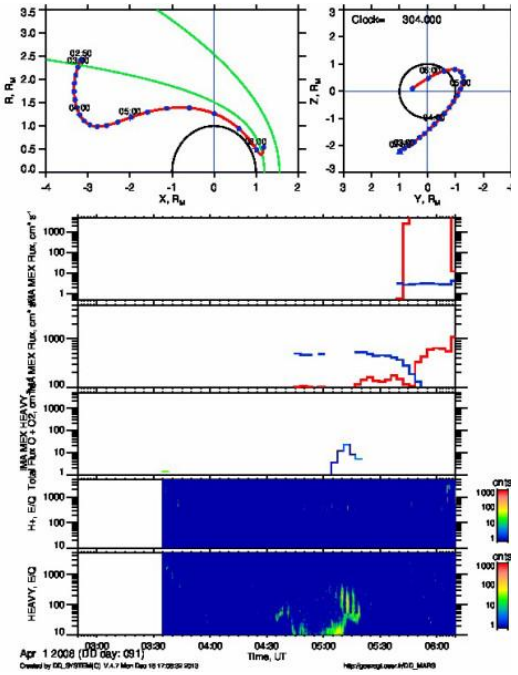
Kallio, 140˚



Modolo, 40˚

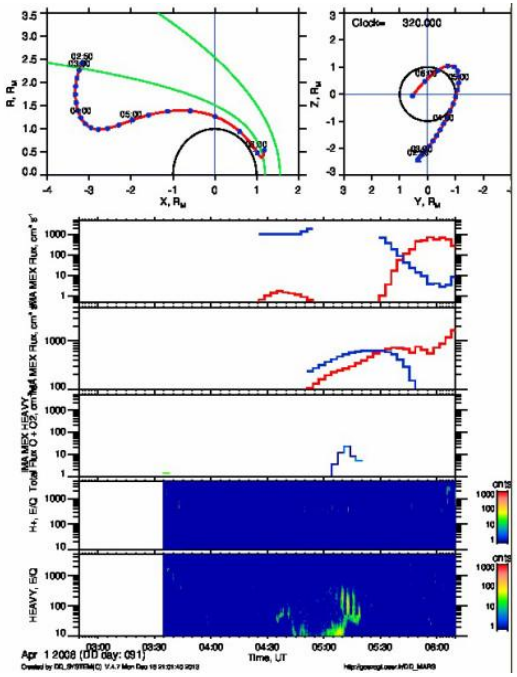


Modolo, 140˚

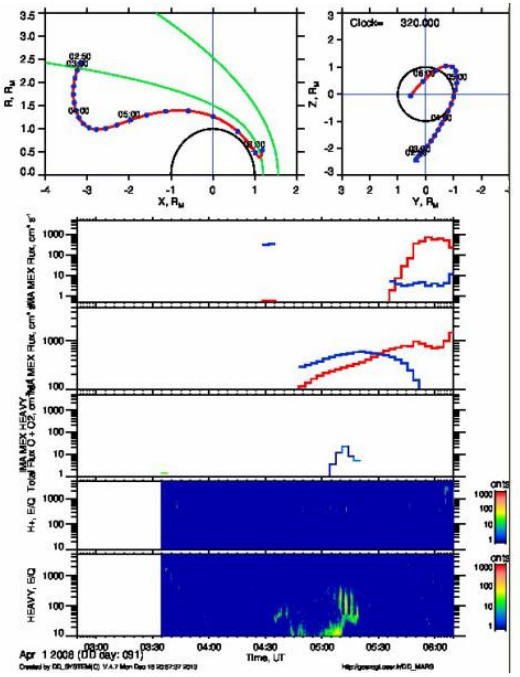


How to Fit the Measurements and the Model

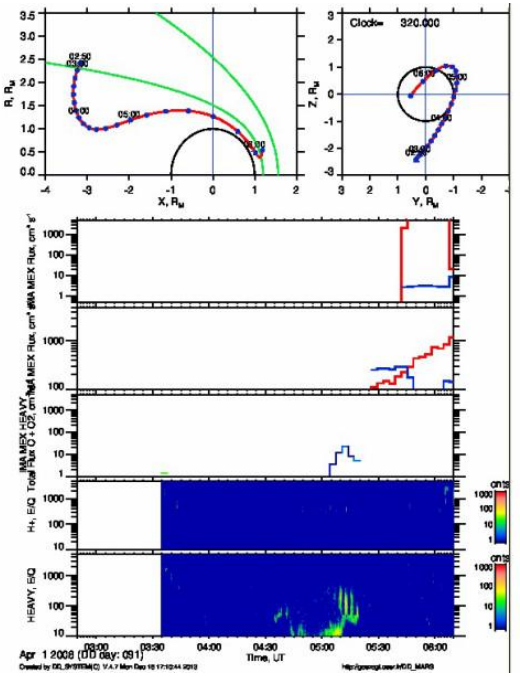
Kallio, 40˚



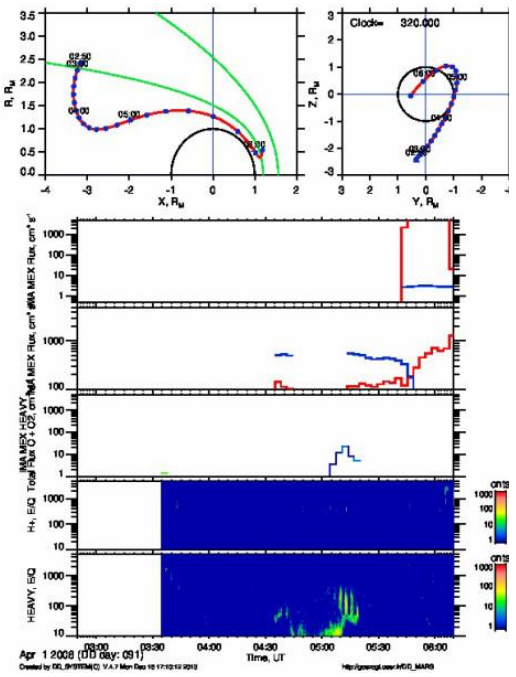
Kallio, 140˚



Modolo, 40˚

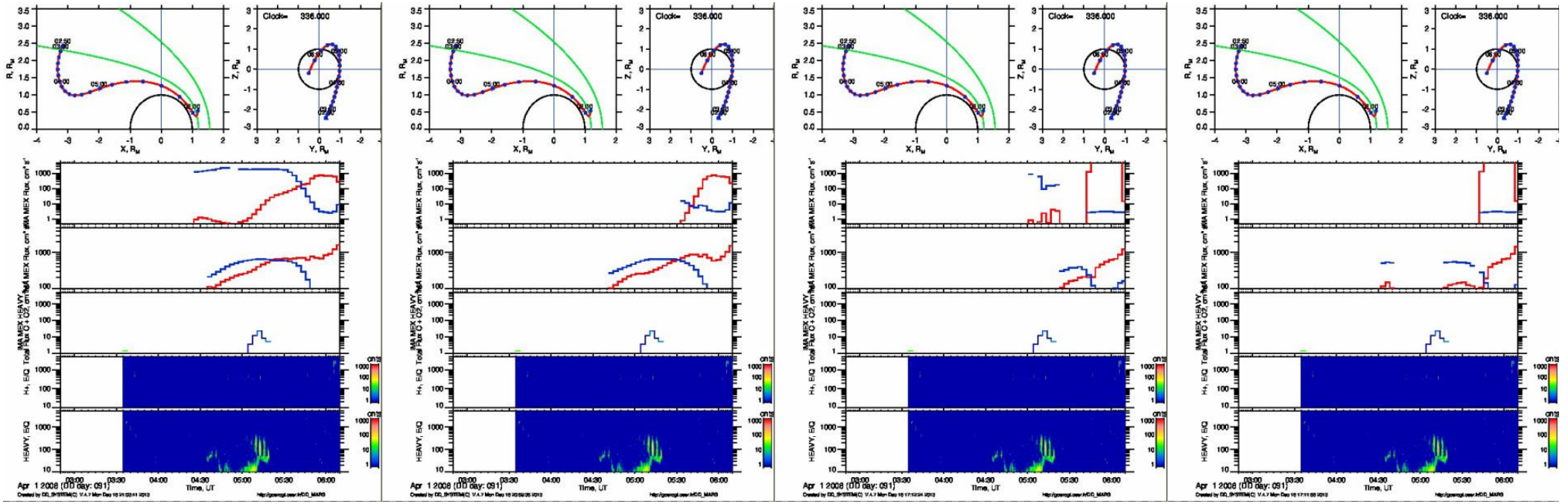


Modolo, 140˚



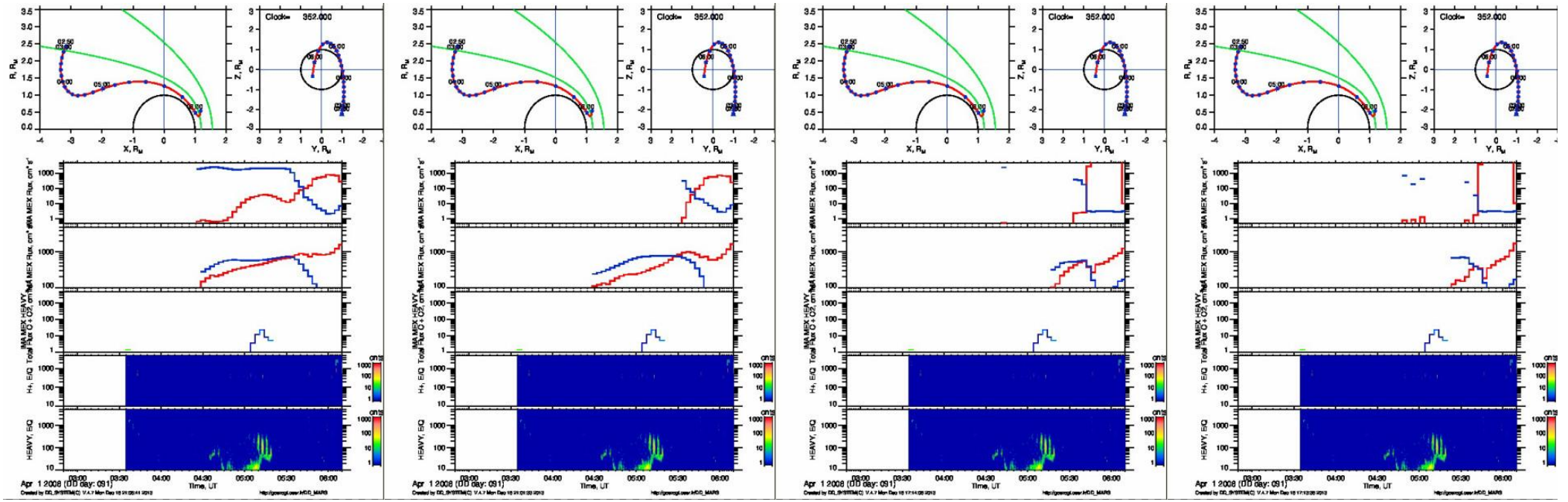
How to Fit the Measurements and the Model

Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚



How to Fit the Measurements and the Model

Kallio, 40˚ | Kallio, 140˚ | Modolo, 40˚ | Modolo, 140˚



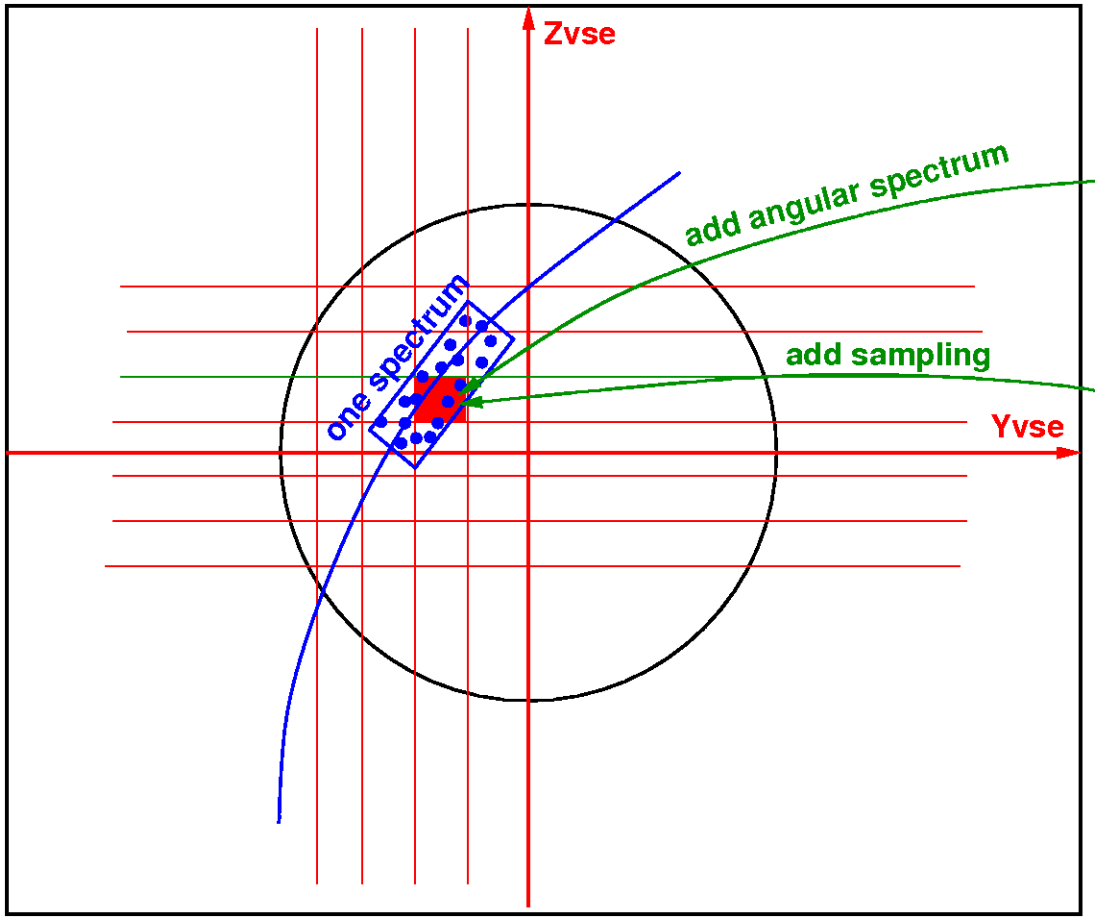
Second task. The result is in a complete table

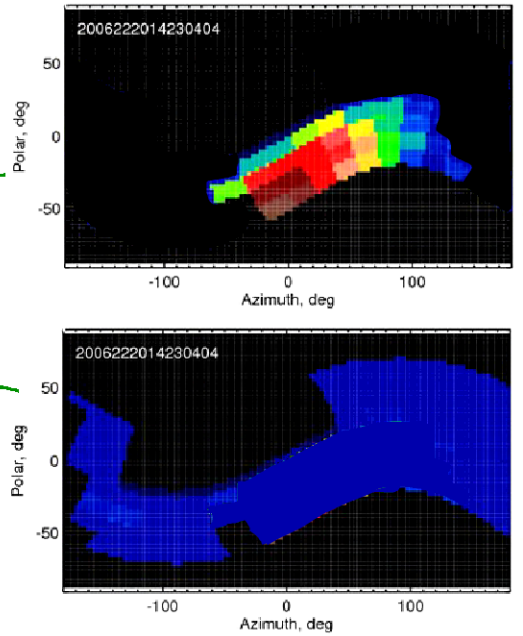
```
#*****************************************************************************
#       orbit-list.2008.txt
#       List of magnetosphere crossings with clock angle and SW moments
#       Prepared : Dec 2013
#       Clock angle added : 19 Jan 2014
#*****************************************************************************
# YYYYDDDHHMM   DDDHHMM Clock   Model   Vsw     Nsw     Comments (quality 0 5)
#*****************************************************************************
20080700030     0700350   10.0 m140    550.0   0.7       2
20080700720     0701040  270.0 m140    550.0   0.7       2
20080701420     0701740  240.0 m140    500.0   0.1       1
20080702050     0710030  270.0 m140    550.0   0.2       1
20080710350     0710710  180.0 k140    550.0   1.0       2
#20080711050    0711410    0.0   ND    525.0   0.4
20080711740     0712100  236.0 m140    450.0   0.1       5
20080720020     0720350  220.0 m140    500.0   0.5       4
20080720720     0721040  208.0 m140    500.0   1.0       4
20080721400     0721730   50.0 m140    500.0   0.6       4
20080722050     0730020  200.0 m040    500.0   0.1       3
20080730350     0730710  250.0 m040    475.0   0.3       4
20080731040     0731400  104.0 m140    500.0   0.4       3
```

It should be at least 5000 lines inside 2008 – 2013 time interval

How to accumulate multi-orbit statistics?

For instance we would like to integrate data in some X interval to make a YZ distribution. We divide YZ plane in Ny x Nz cells. In each cell we would like to accumulate an averaged velocity distribution. It is not so simple since the instrument FOV is limited and partially obscured.





The final statistics should seen like that (top : measurements, bottom : simulations)

X =[-2.5,-2.0] X =[-2.0,-1.5] X =[-1.5,-1.0]