SOLAR WIND DYNAMICS NEAR 67P/CHURYUMOV-GERASIMENKO

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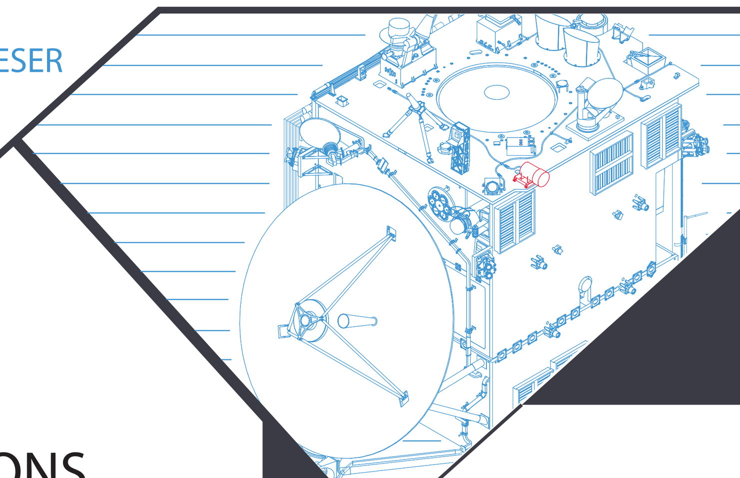


0 THE TOPIC

The interaction between the solar wind and a comet atmosphere.

1 THE QUESTIONS

What is the solar wind dynamics near 67P/CG?

How does this dynamics evolve with decreasing heliocentric distances?

How can we bring together observations and models?

2 COMETS

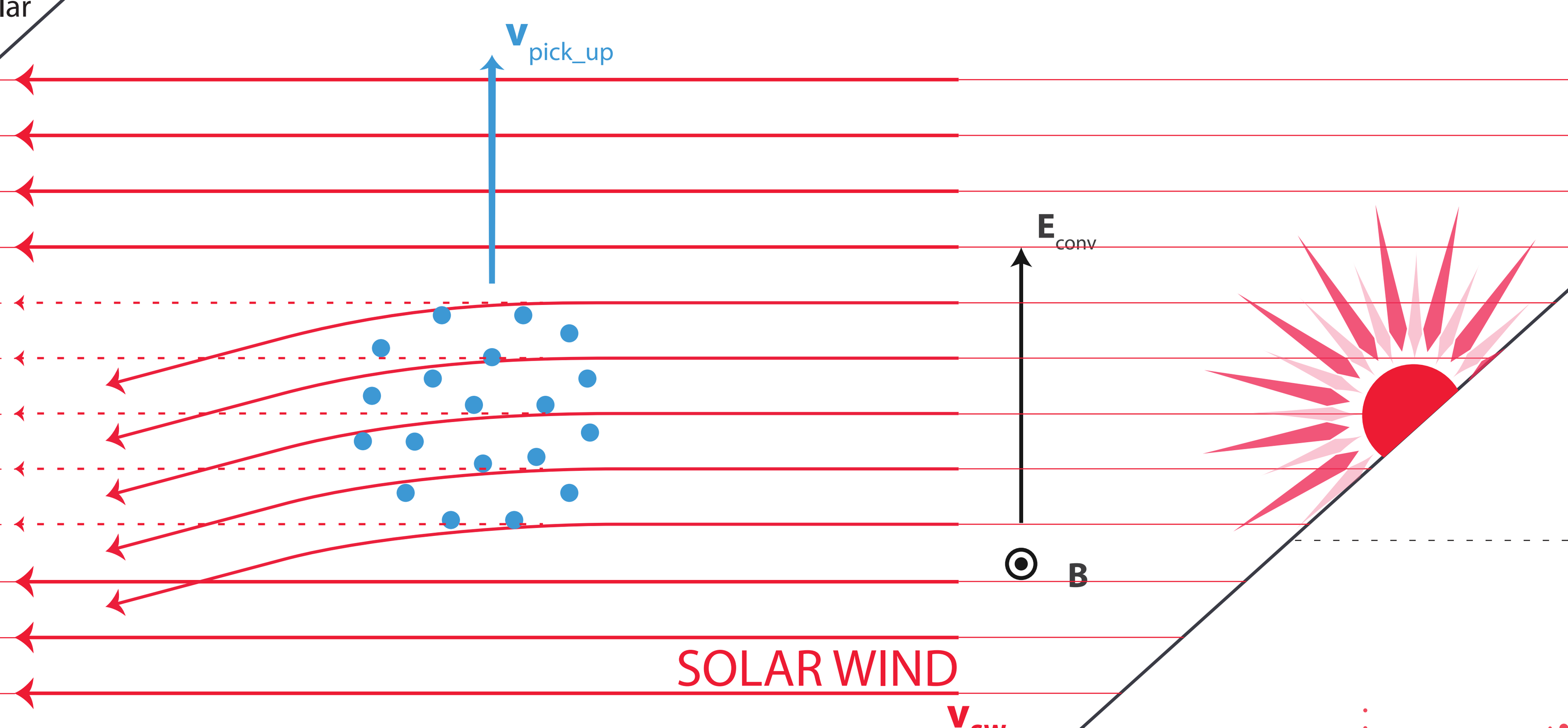
At aphelion: an atmosphere-less body of a few kilometers, interacting directly with the solar wind.

At perihelion: one of the biggest obstacles for the solar wind in the solar system.

What happens in-between?

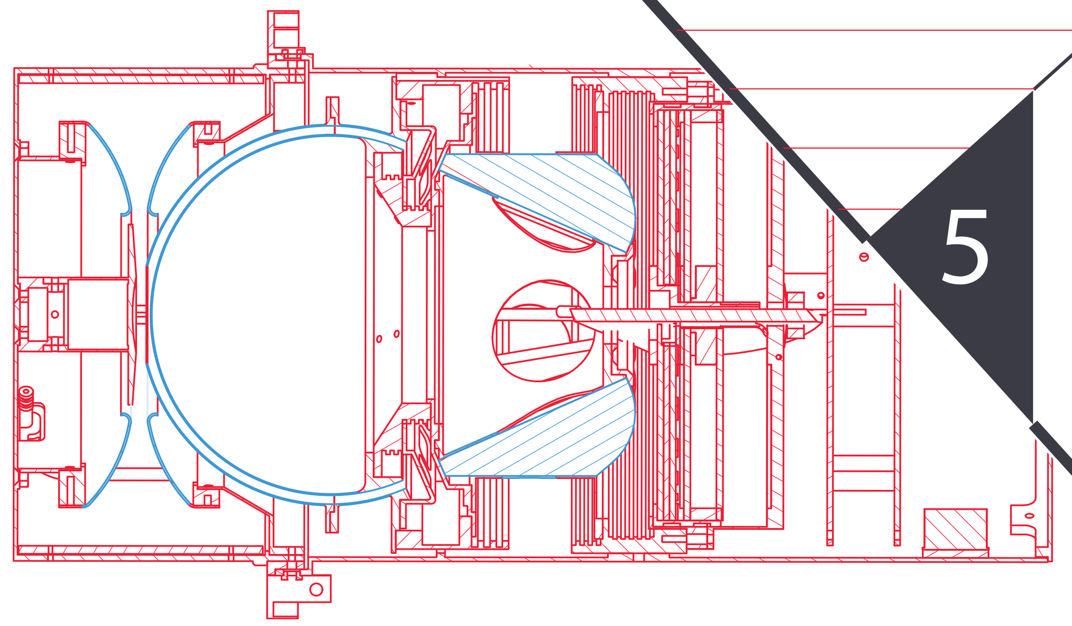
3 HOW DOES IT START? MASS LOADING AT LOW ACTIVITY

At low activity, or at large heliocentric distances, cometary particles are ionized within the initially undisturbed solar wind. These new born ions are accelerated by the convective electric field of the solar wind. Energy and momentum are there transferred from the solar wind to the coma. We expect to see the solar wind deflected and slowed down (see figure below). Here, we focus on deflection, which is a more straightforward value to measure. In contrast, we don't have direct measurement of the upstream solar wind velocity, and deceleration is thus more complex to estimate.

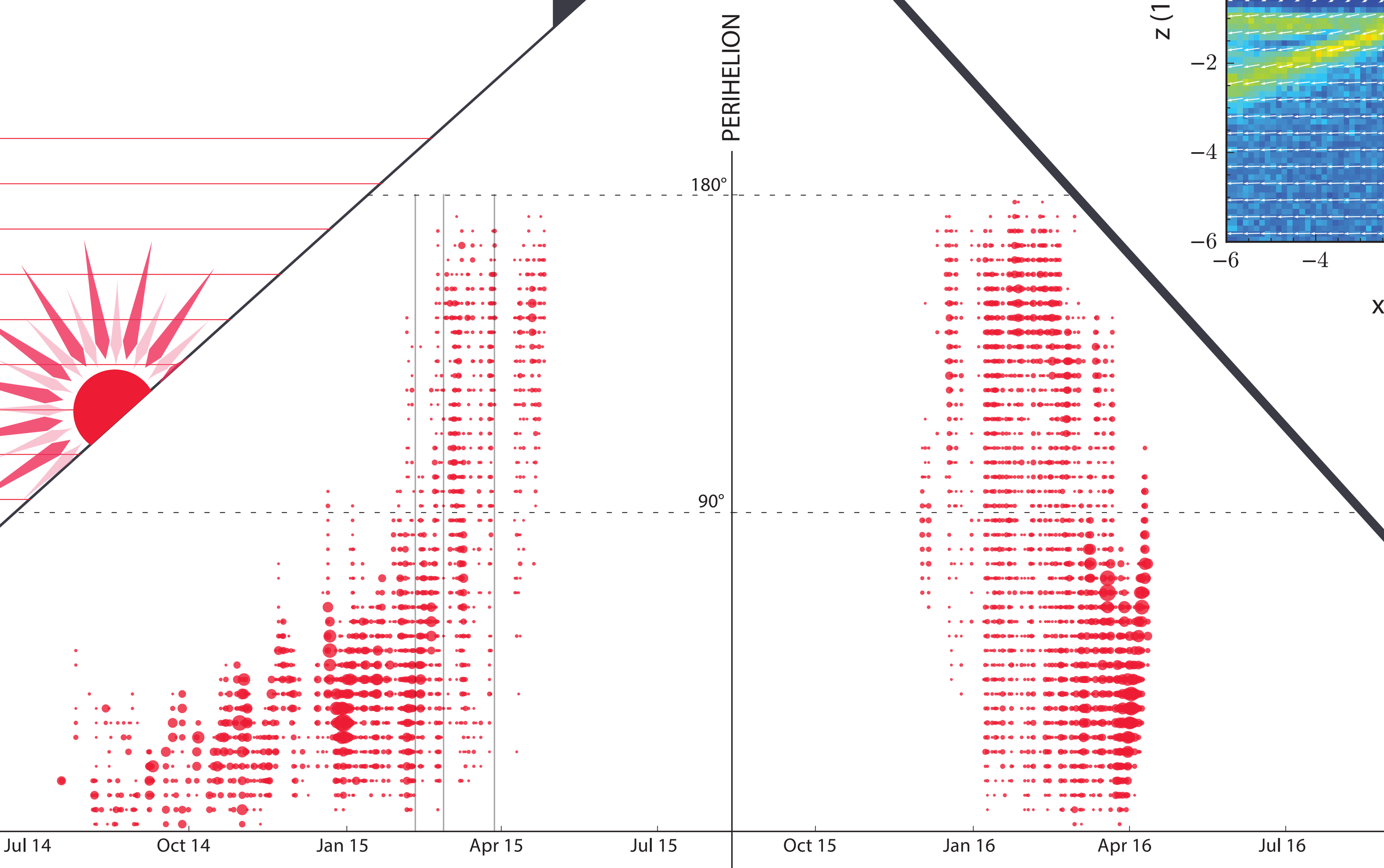


4 METHOD

We measure the deflection and the deceleration of the solar wind protons, using the ion spectrometer RPC-ICA (the Ion Composition Analyzer, part of the Rosetta Plasma Consortium).



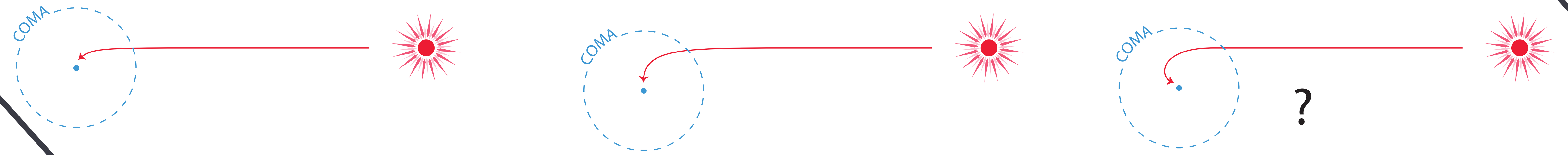
5 DEFLECTION - DATA



Yes, it is observed! Reaching values of 90°, to later get close to 180°. For a while, solar wind is not observed close to the nucleus. It comes back after perihelion, when heliocentric distances increase.

How do we understand the measurements:

What does the complete picture looks like?
We only have a single-point measurment:
we need a model!



DEFLECTION - MODELS

SIMPLISTIC MODEL - a first attempt to visualize the solar wind flow. A force is applied on the protons:

$$|\mathbf{F}| = a/r^2,\ a \in \mathbb{R}$$

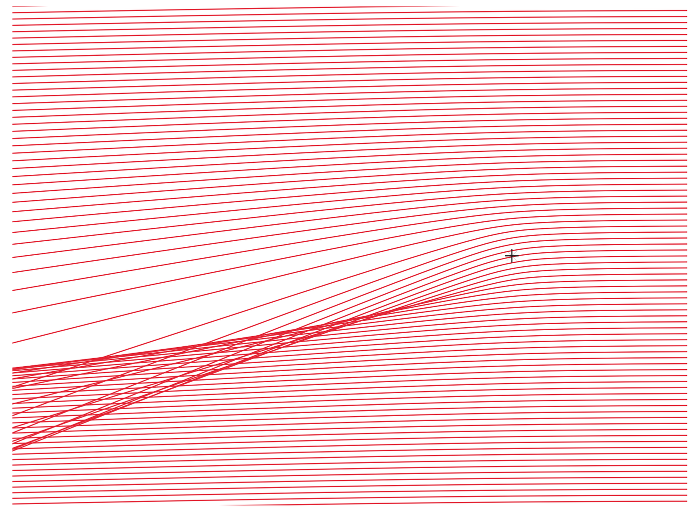
and **F** orthogonal to $\mathbf{v}_{proton}$

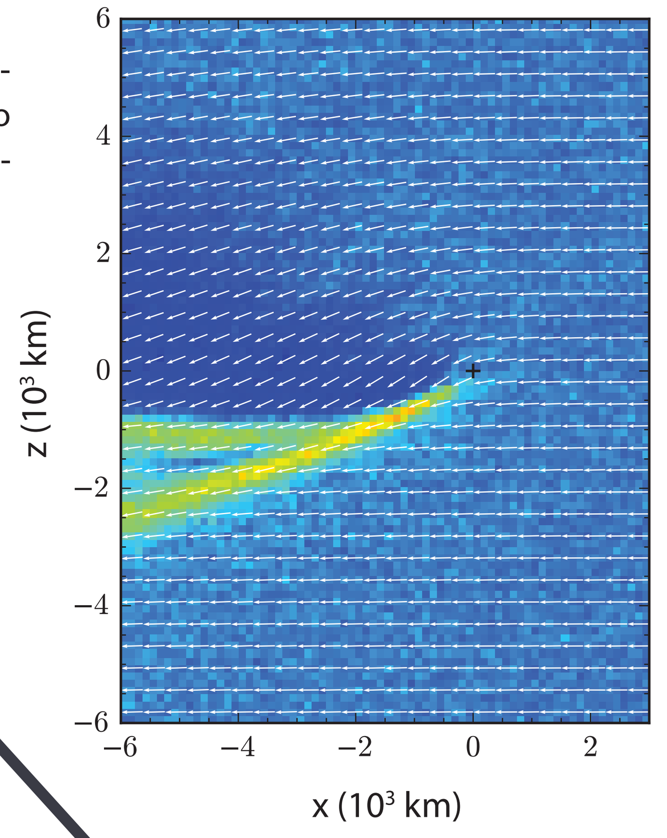
$$\mathbf{a} = m\,.\,\mathbf{F}$$

This way, the solar wind is only deflected and does not lose energy.

HYBRID MODEL - ions as particles, electrons as massless fluid. No gravity, no solid obstacle, no transfer of momentum by collision.

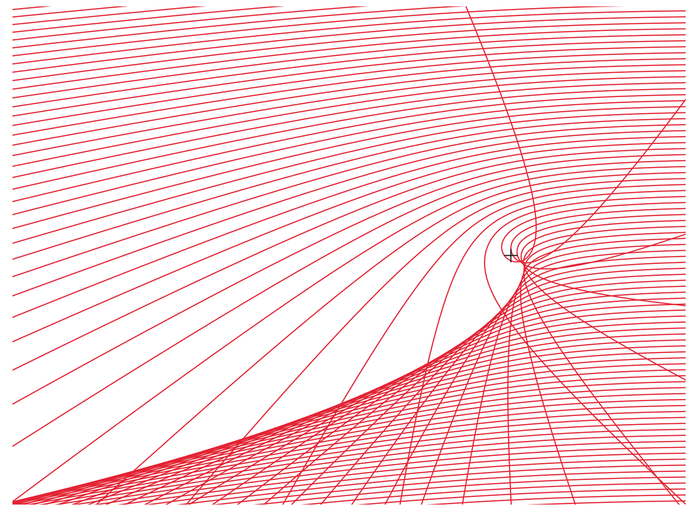
2.35 AU

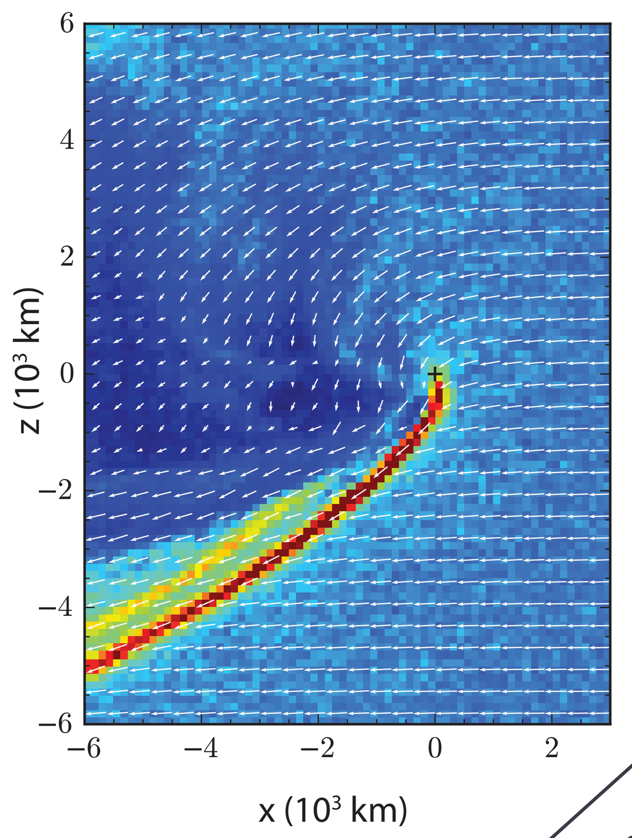




2.35 AU

2.00 AU





2.00 AU

Both models give deflection up to 180°, close to the nucleus, for the 2.0AU (Astronomical Unit) case.

The simplistic model, even though not including any loss of energy for the protons, gives a surprisingly good agreement with the much more complex and complete hybrid model, in terms of topology of the flow. The red lines in the simplistic model are the flow lines, to be compared with the white arrows in the hybrid model results. The density of red flow lines also gives a feeling concerning the solar wind density, given with the color scale in the hybrid model results.

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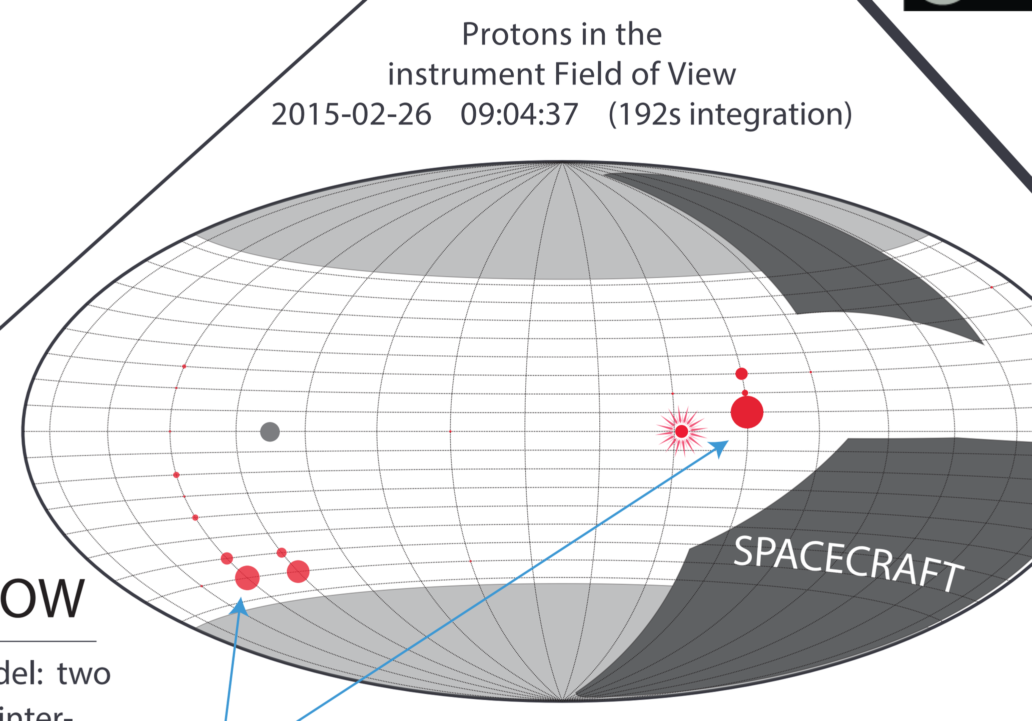
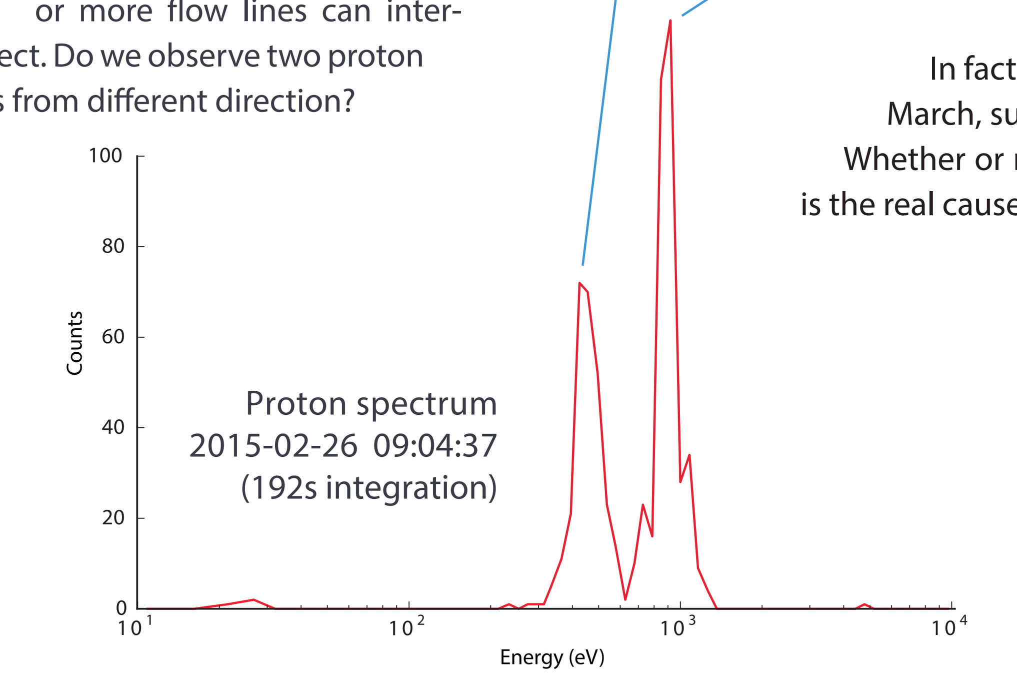
7 DOUBLE FLOW

In the simplistic model: two or more flow lines can intersect. Do we observe two proton flows from different direction?





In fact, for a period covering February and March, such a double flow is often observed. Whether or not such a geometrical explanation is the real cause for it is yet to be determined.

8 SUMMARY

Data show a largely disturbed solar wind, in terms of deflection.

Models are consistent with this observed deflection. One can see that the region where momentum is exchanged is extremely local, close to the nucleus. Although local, it affects largely the downstream solar wind flow, when undisturbed solar wind and deflected solar wind are intersecting.

The solar wind does not loose much energy.