The dependence of the peak velocities of HSS on the co-latitudes of their source CHs

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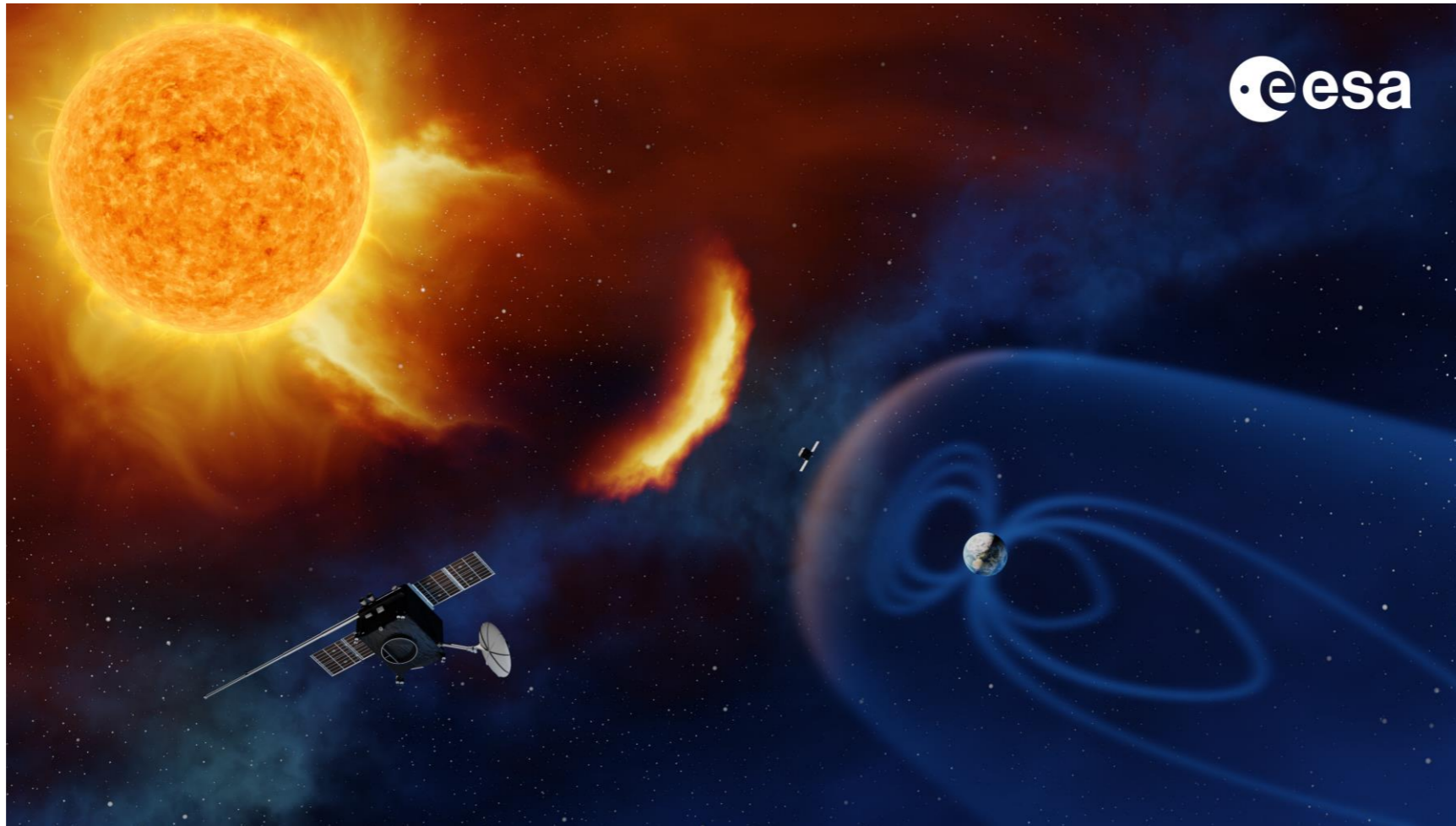
1: University of Graz, Austria
2: DTU Space, Denmark
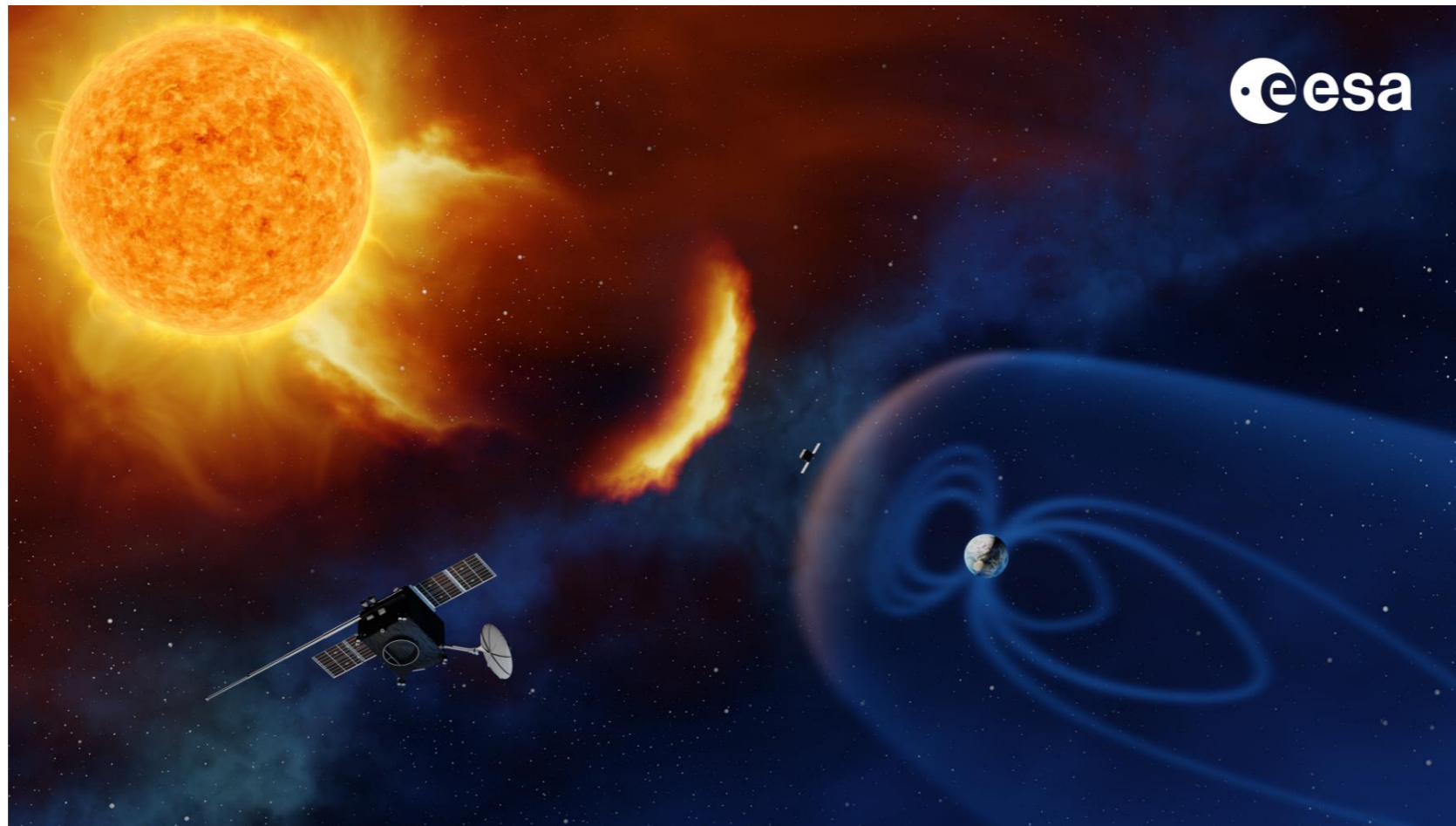3: Hvar Observatory, Croatia
4: University of Kiel, Germany

Why should we study high-speed streams?

➢ High-speed solar wind streams are the major source of minor to medium geomagnetic storms
➢ In addition, they pre-condition the interplanetary space for subsequent CMEs
  ➢ -> 30% of time, v_{sw} > 450 km/s
 -> higher velocity and earlier arrival time of CME

The latitudinal dependence

➤ A dependence of the properties measured on the position of the satellite within the HSS is well accepted
➤ But: almost no studies on the latitudinal dependence
➤ Still one of the big open issues

The latitudinal dependence
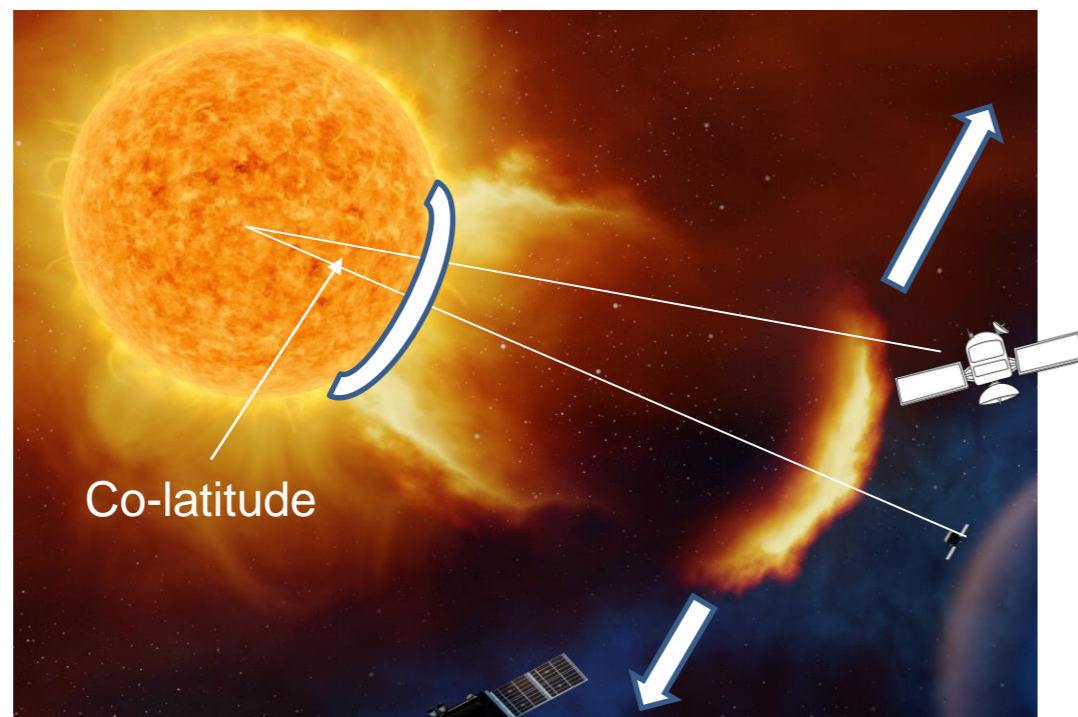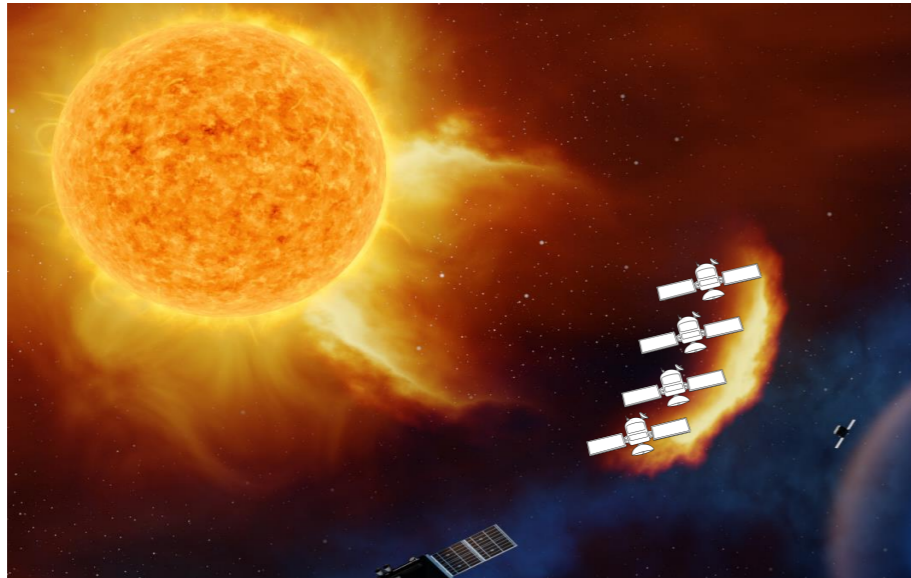
Co-latitude

➢ Create a dataset with many CHs/HSS to sample the latitudinal distribution
➢ But: works only of all HSS have similar distributions!
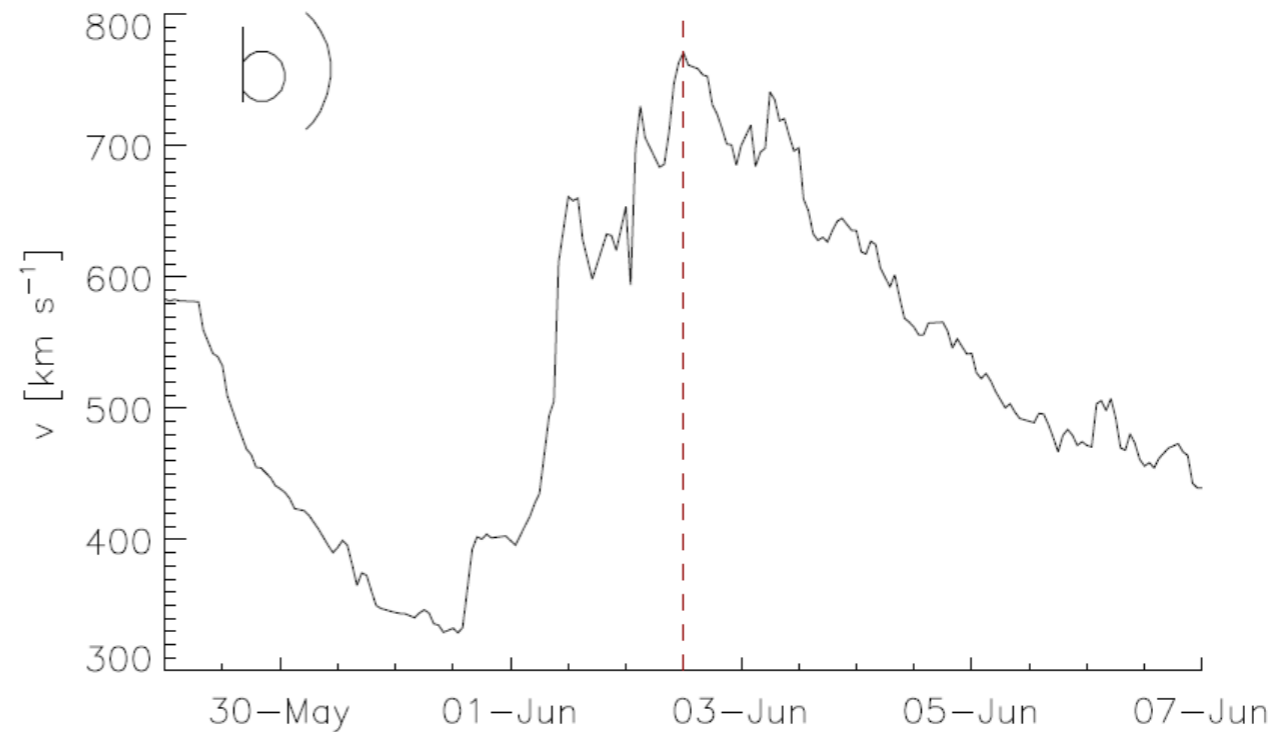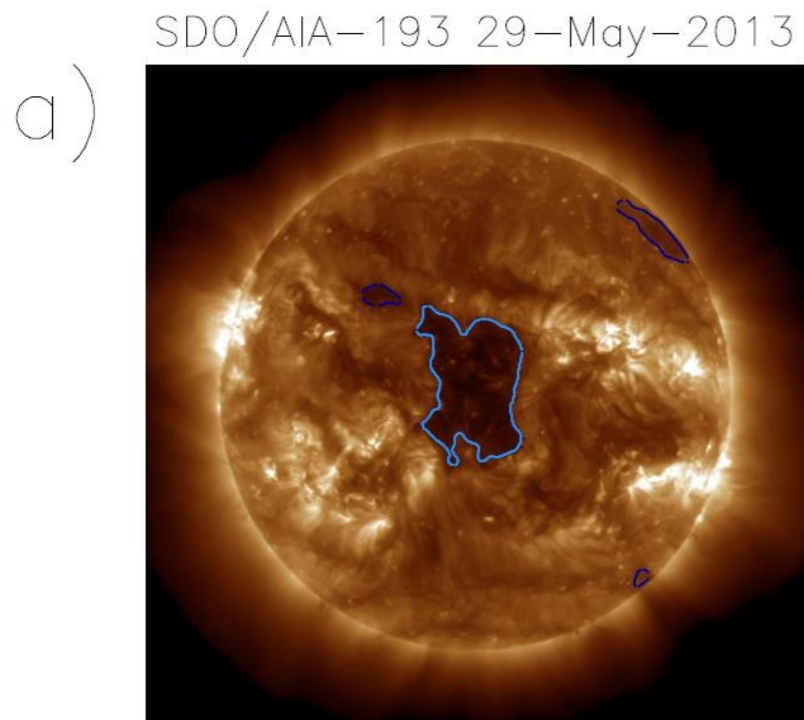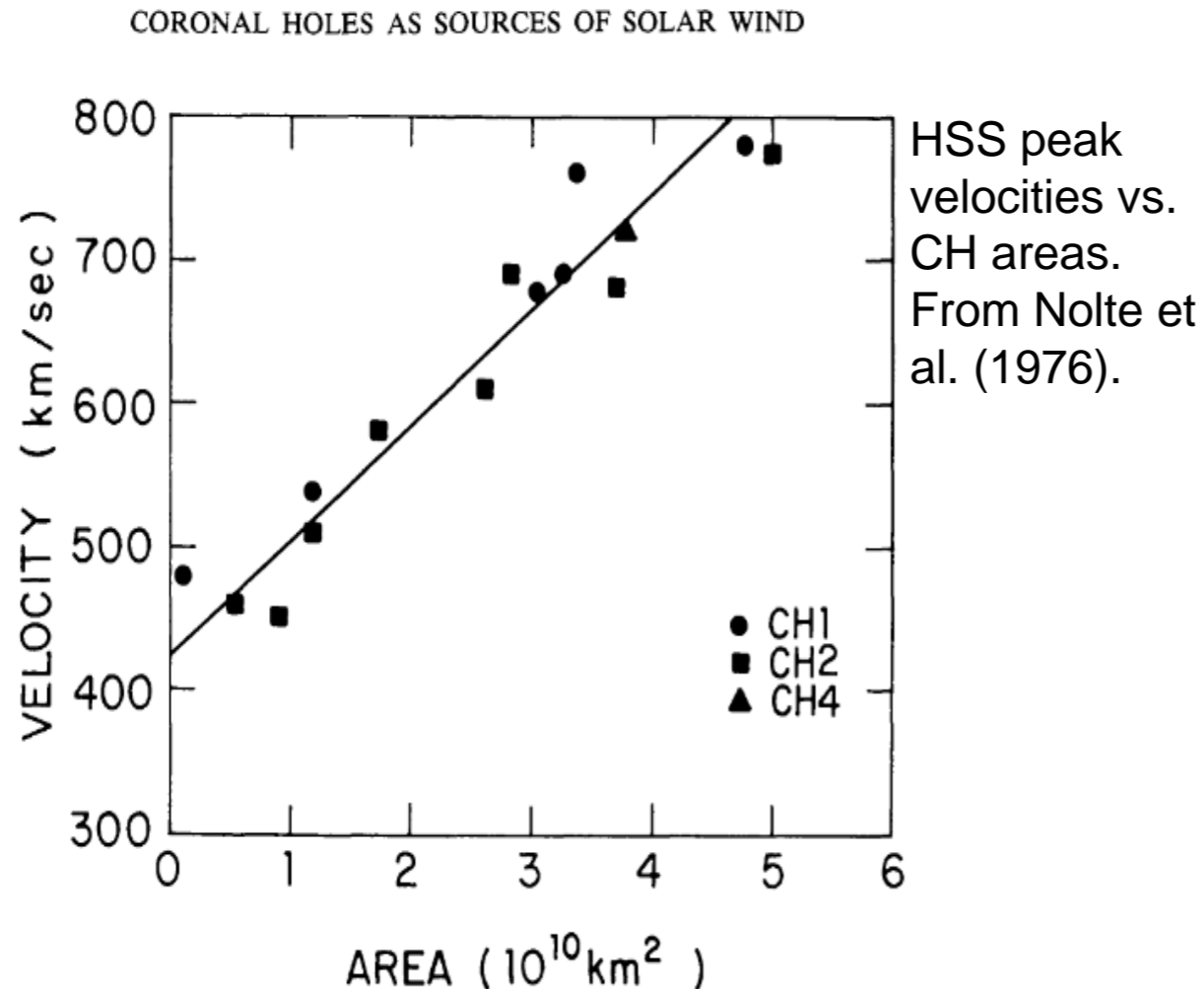
A first test: a case study on one CH/HSS
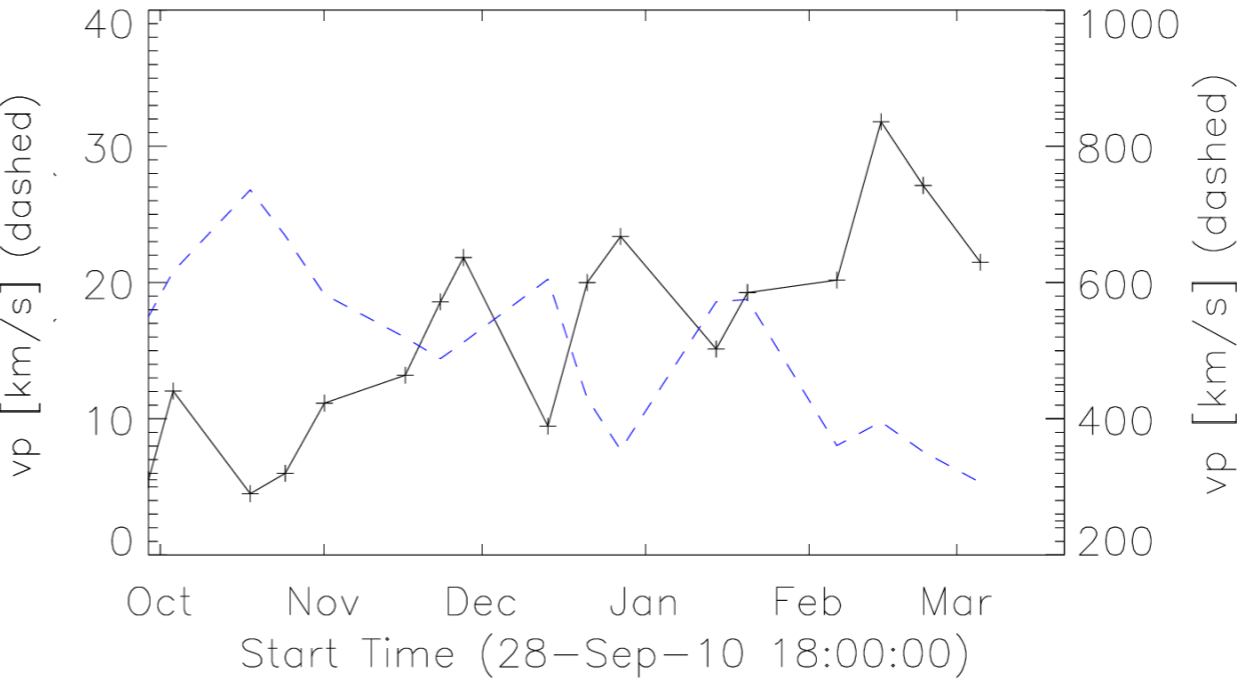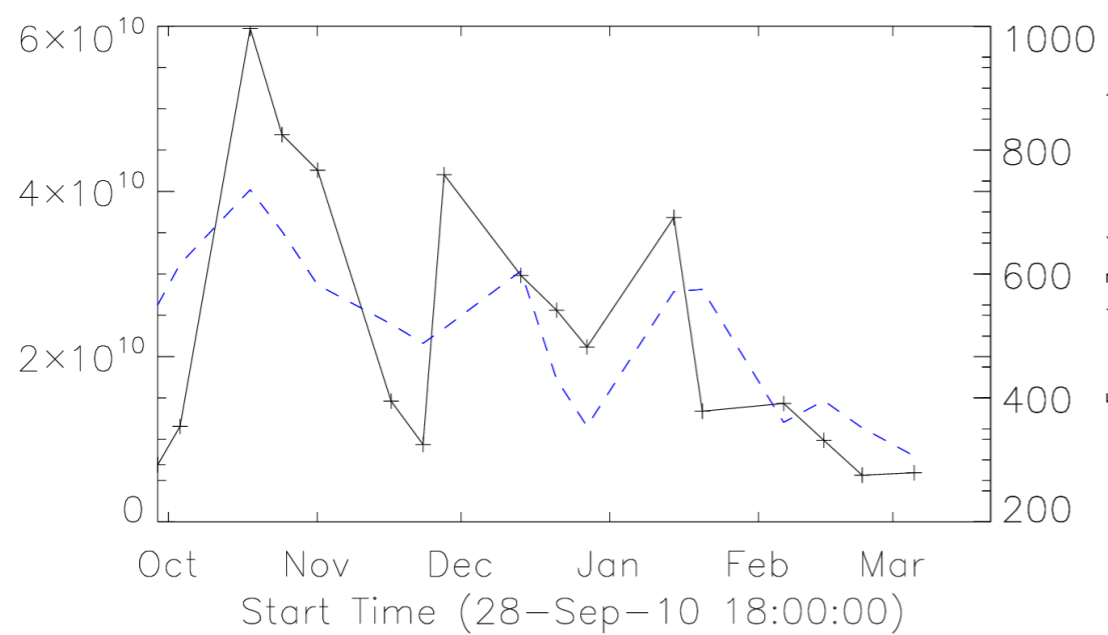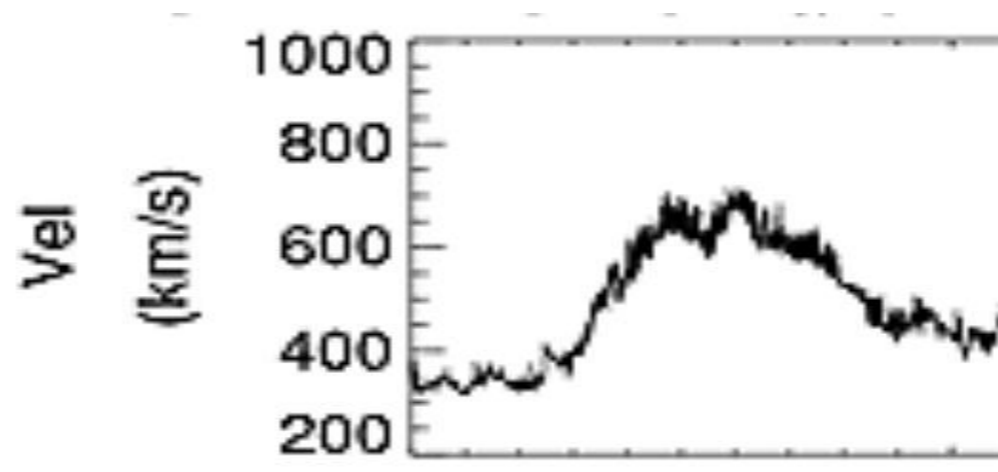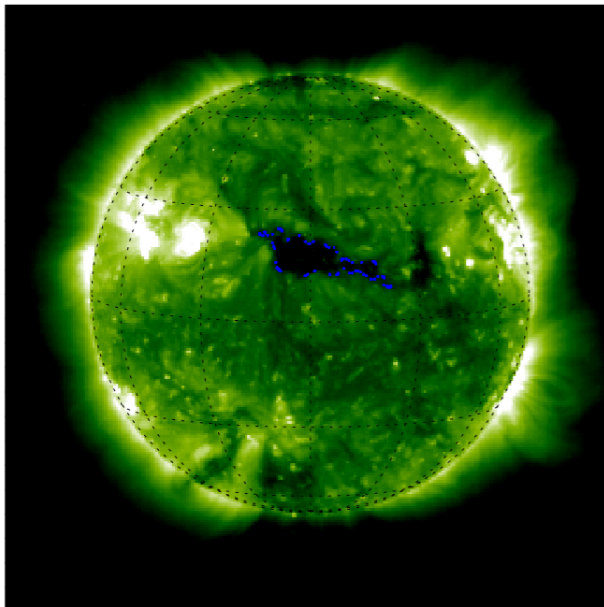
➢ Correlation of HSS peak velocity with CH area
➢ Anti-correlation with co-latitude!

Extending the dataset: 115 CHs/HSS

- CHs: SDO/AIA-193, STA+STB/EUVI-195
- HSS: ACE/SWEPAM, STA+STB/PLASTIC
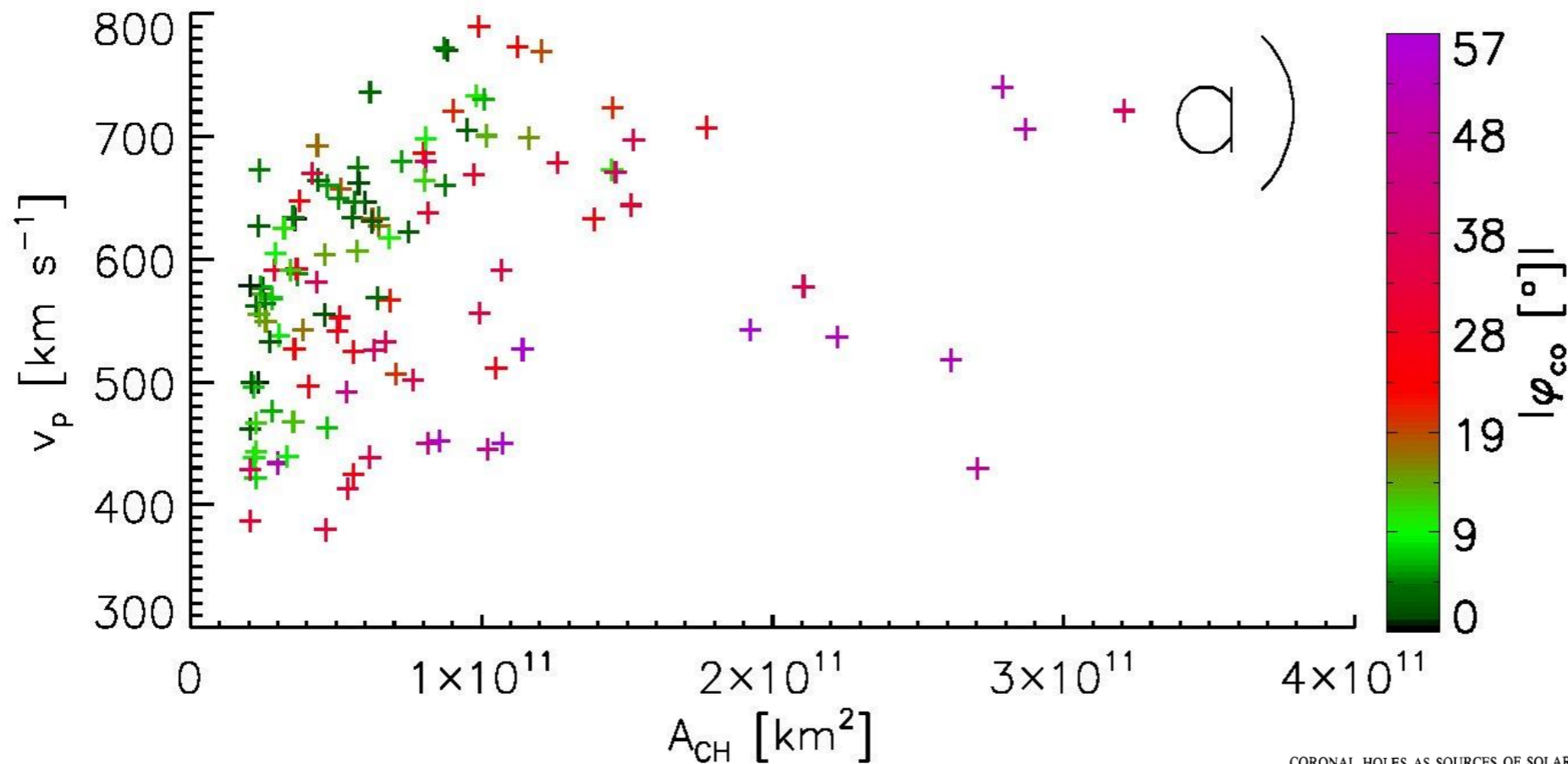- Only „clear" events!

Peak velocity – area relationship

CORONAL HOLES AS SOURCES OF SOLAR WIND

HSS peak velocities vs. CH areas. From Nolte et al. (1976).
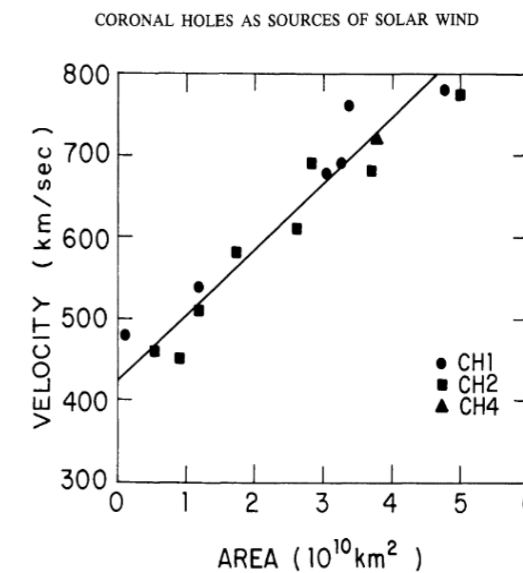
- ➢ Textbook events: Area – velocity relationship:
  velocity increase per area, (v-const) / A = const
- ➢ It is still not clear why the peak velocity of HSS is related with the area of CHs

Peak velocity – area relationship

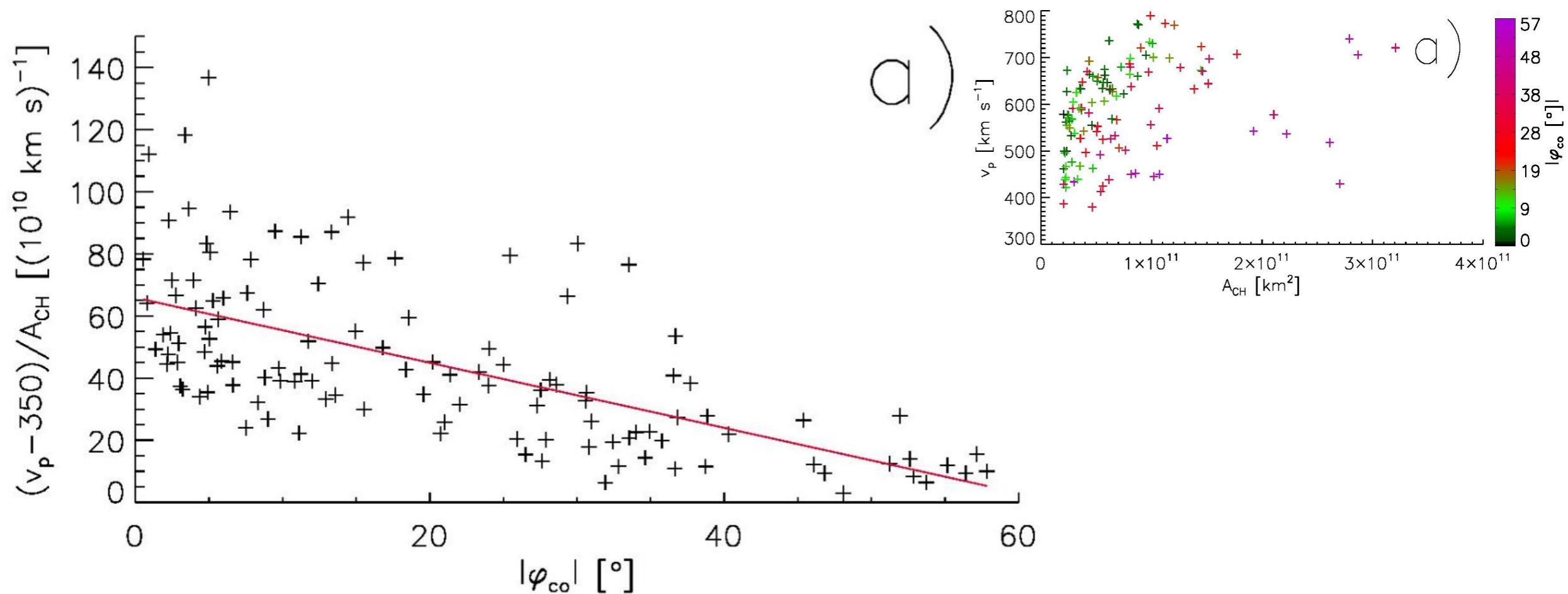$\triangleright$ (v-const) / A ≠ const!

$\triangleright$ (v-const) / A = f(φ_{co})

$\triangleright$ Largest v when satellite in the center of the HSS (φ_{co} = 0)

$\triangleright$ Co-latitude structures our data!

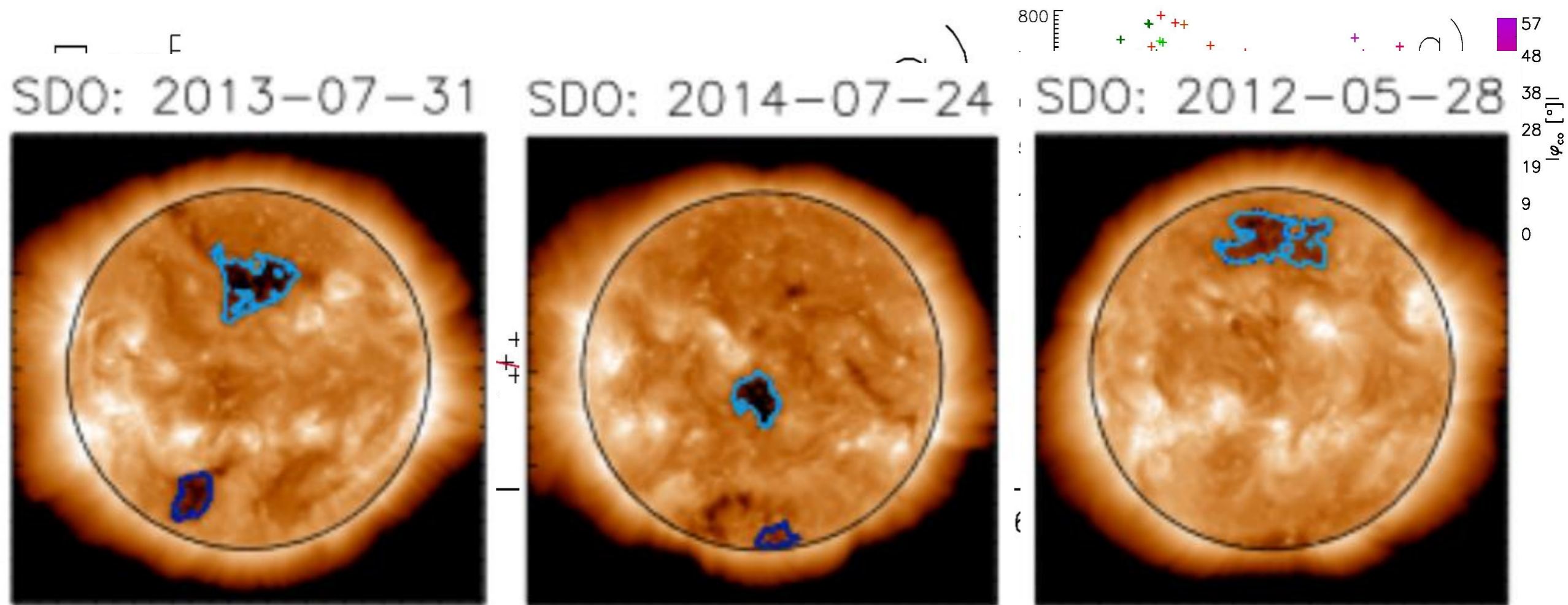From: HSS peak velocities vs. CH areas. From Nolte et al. (1976).

Velocity increase per area

- ➢ Plot $(v_p - v_{offset}) / A_{CH}$ vs φ_{co}
- ➢ Linearly decreasing with increasing φ_{co}
- ➢ $(v_p - v_{offset}) / A_{CH} = 0$ @ $\varphi_{co} \sim 60°$
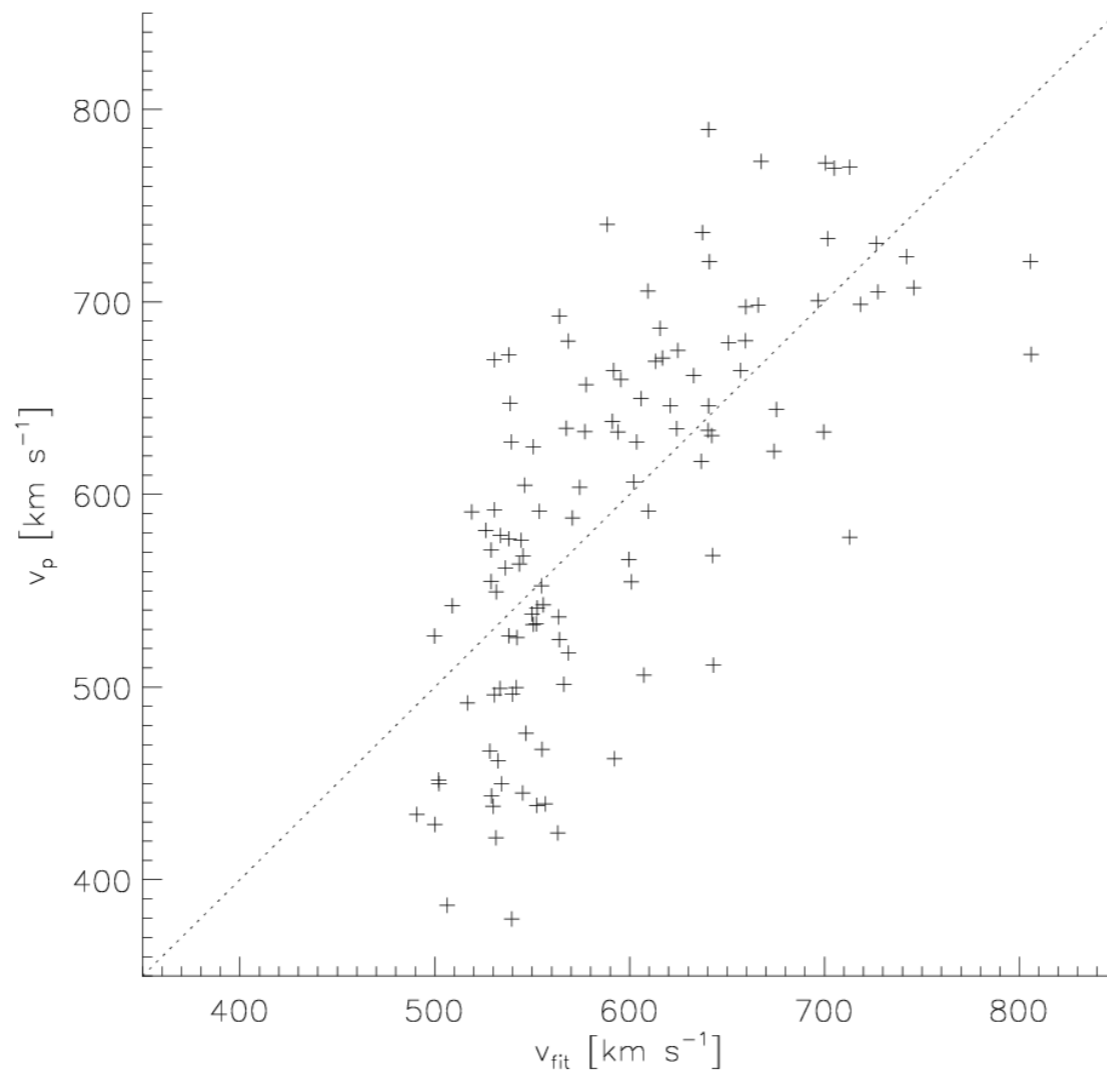- ➢ cc= 0.40 -> 0.72

Velocity increase per area

> ➤ Plot $(v_p - v_{offset}) / A_{CH}$ vs φ_{co}
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> ➤ $(v_p - v_{offset}) / A_{CH} = 0$ @ $\varphi_{co} \sim 60°$
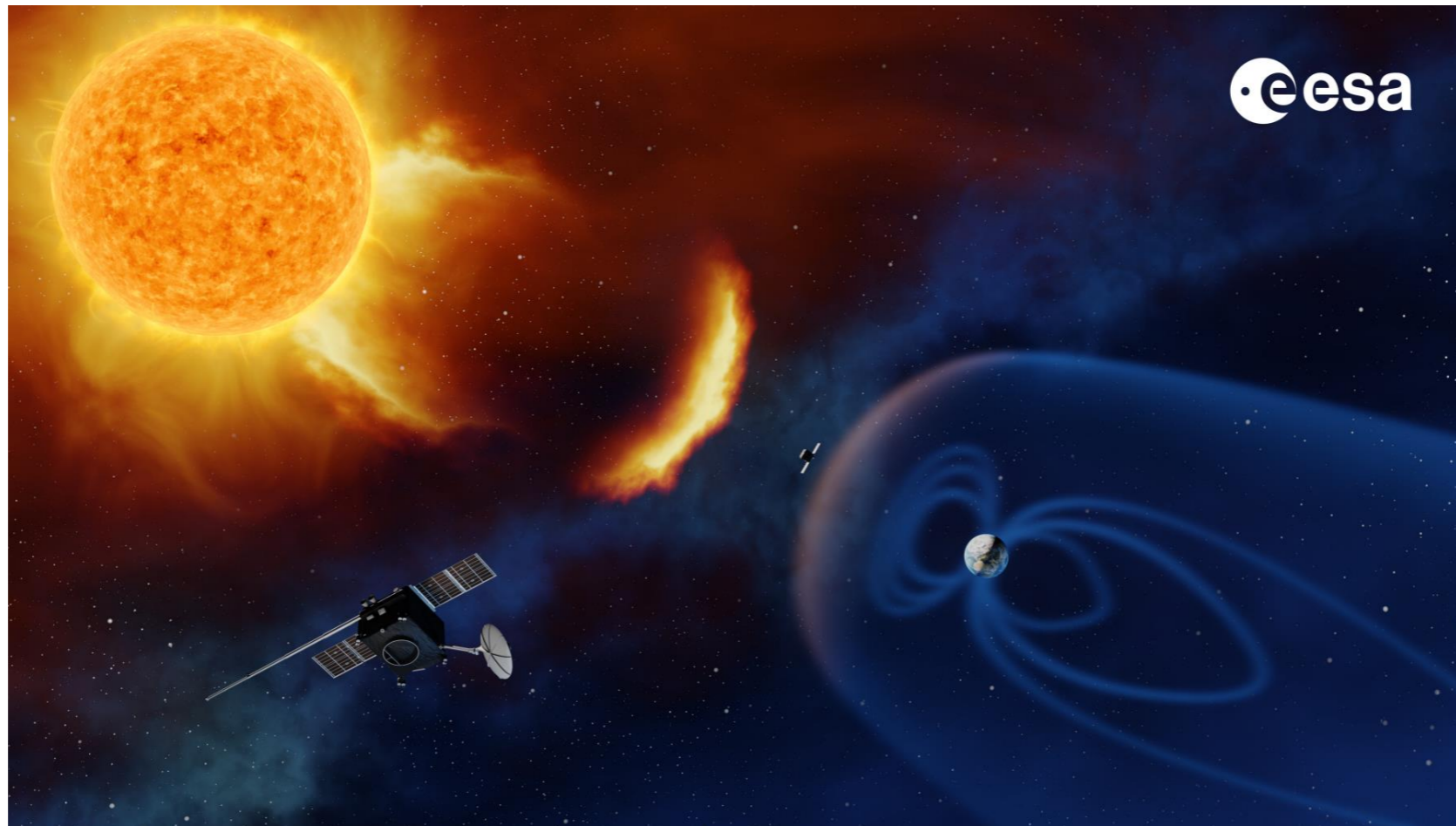> ➤ cc= 0.40 -> 0.72

Fitting the data

$$|v_{\text{fit}}[\text{km s}^{-1}] = 478 + (2.77 \cdot 10^{-9} \cdot A_{\text{CH}}[\text{km}^2])$$
$$\cdot (1 - |\varphi_{\text{co}}[^\circ]|/61.4)$$

Follows well the trend!

Geomagnetic Indices

- ➢ Velocity increas per coronal hole area decreases linearly from center of HSS to ist flanks
- ➢ Temperature is correlated, density anti-correlated to solar wind speed -> also a latitudinal dependence
- ➢ Magnetic field distribution?...
- ➢ Also geomagnetic consequences should be dependent on where the Earth is located within the HSS
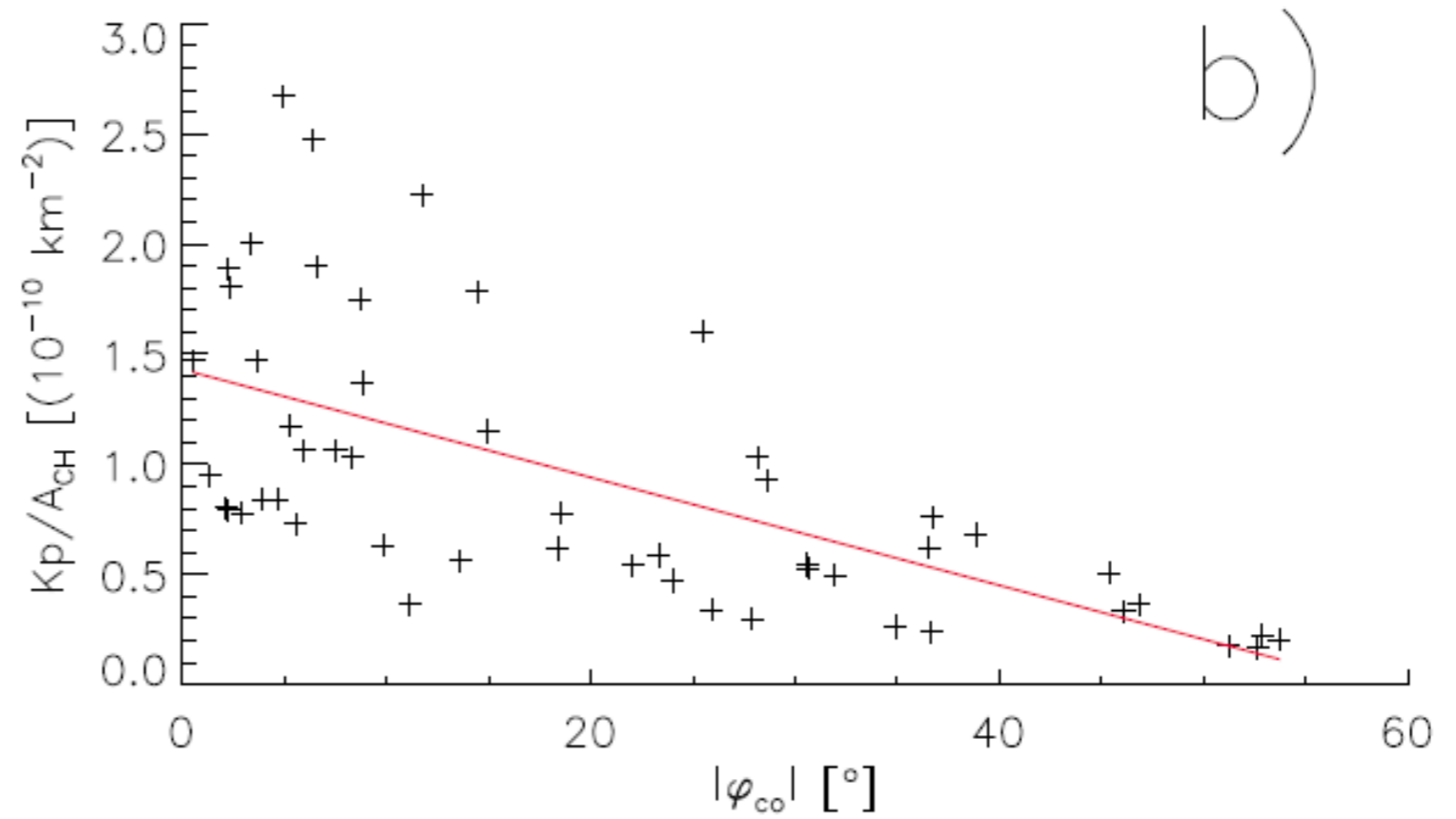
Kp index
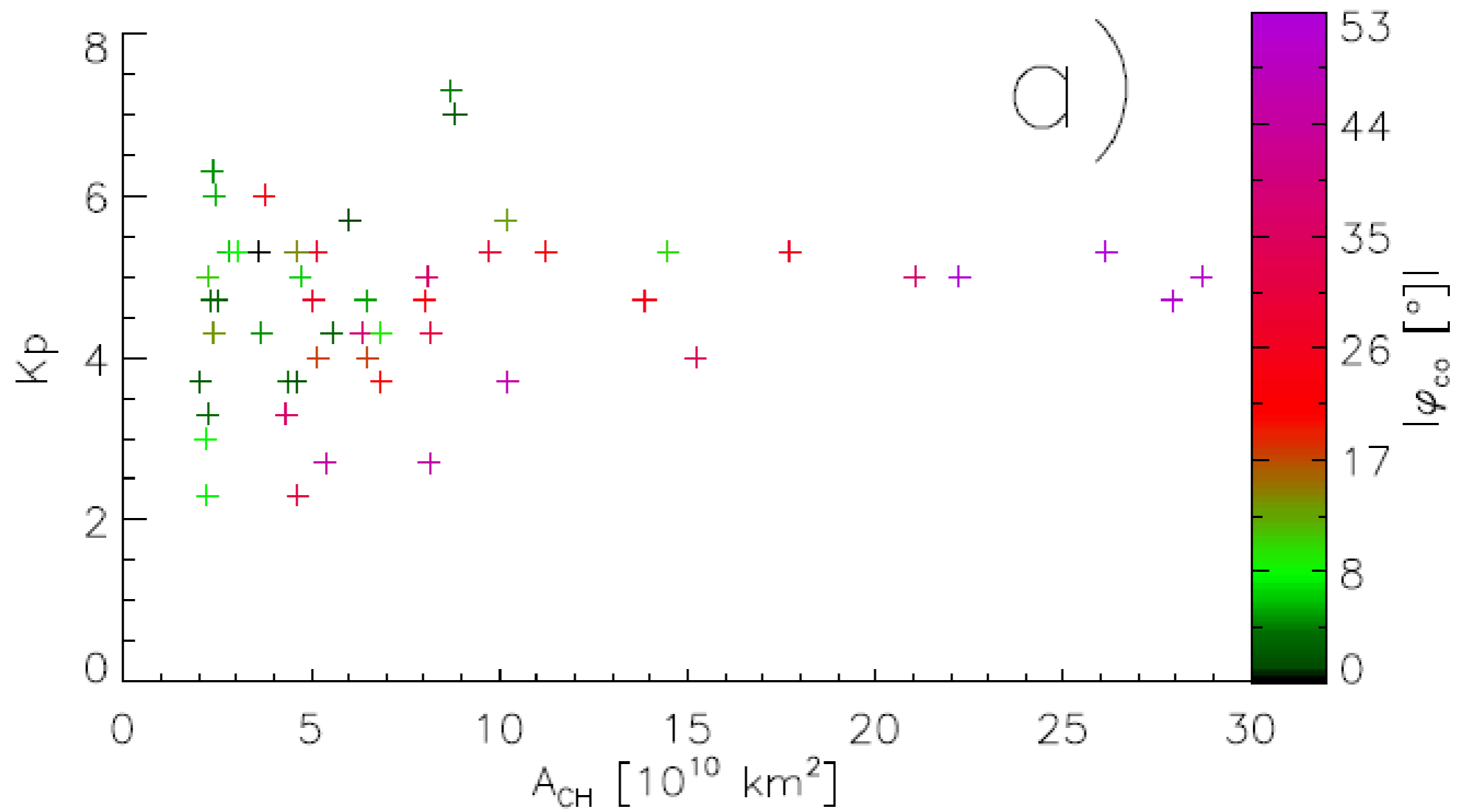
Kp index
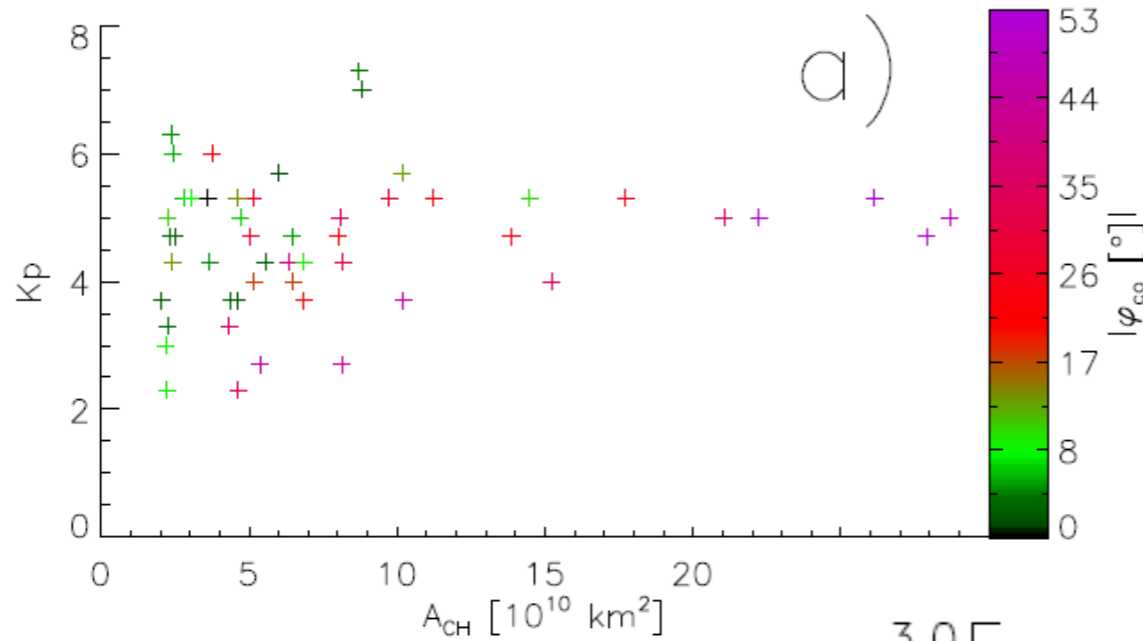
Analog dependencies for geomagnetic indices!

Summary:

➢ **Strong dependence of the peak velocity measured on the position of the measuring satellite within the HSS**

  ➢ increases cc from 0.40 to 0.72
  ➢ HSS arising from $\varphi_{co} > 60°$ have a high chance to not reach the ecliptic
  ➢ Forecast: co-latitude as input parameter

➢ **Shapes the interplanetary space.**
➢ **Pre-conditions the interplanetery space for subsequent CMEs.**

➢ **This is only one of many ways on how to investigate the co-latitudinal dependence.**
  We do not need to wait for Solar Orbiter, we have all the data we need to derive the latitudinal profile of HSS. Let's start.
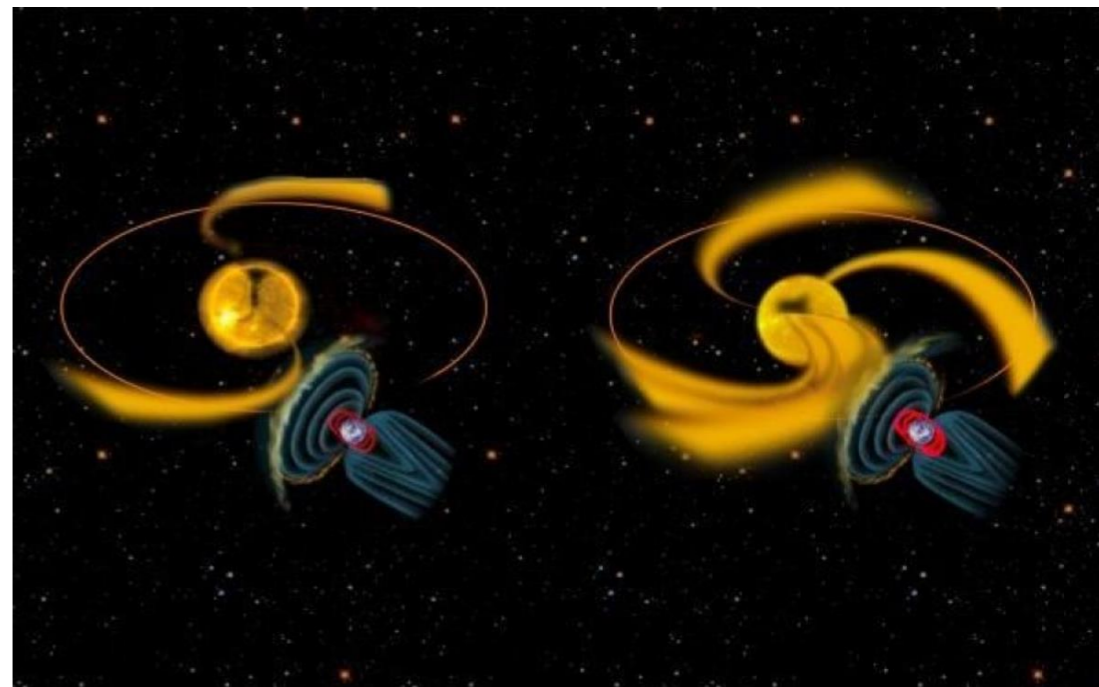
Extra slides

Velocity increase per area – only for $A_{CH} > 4*10^{10}$ km2
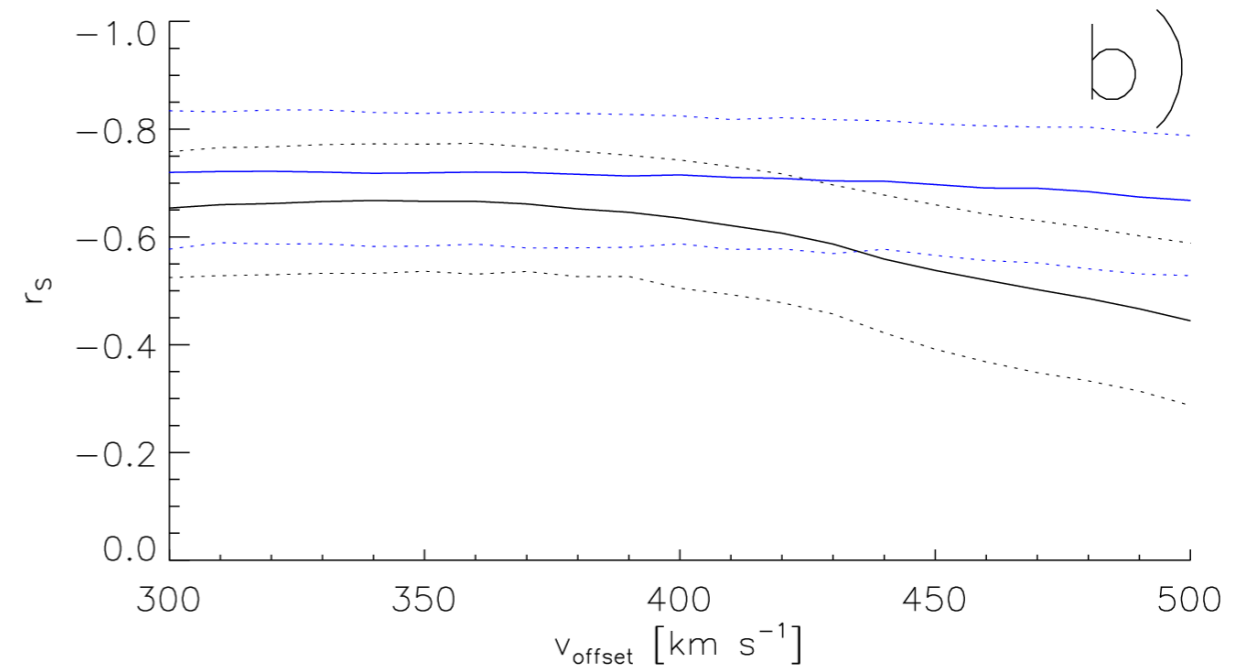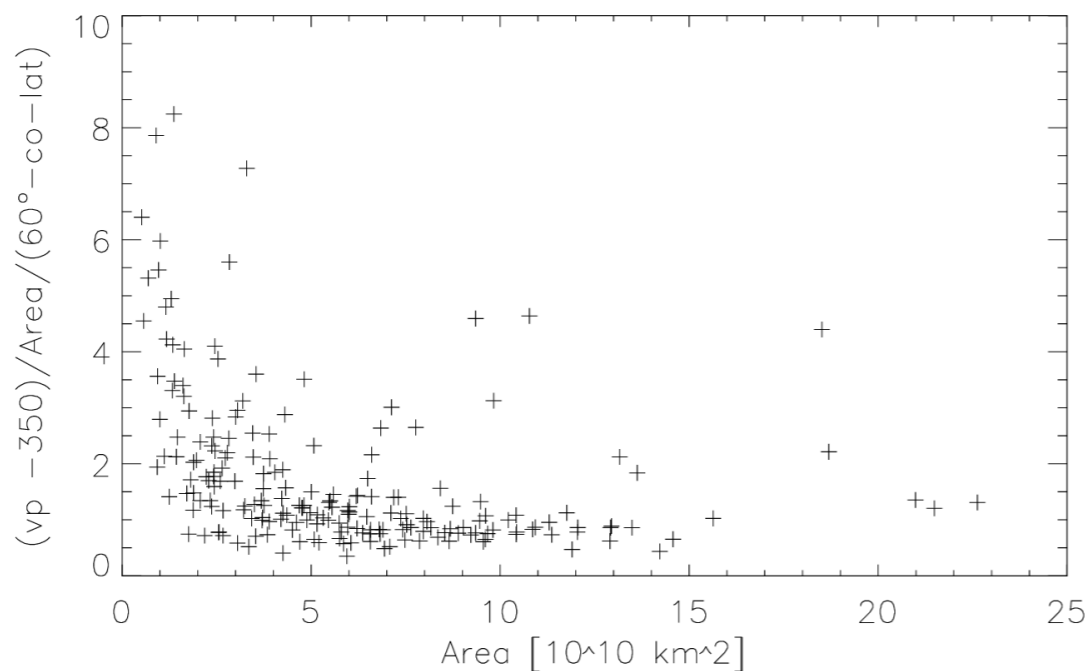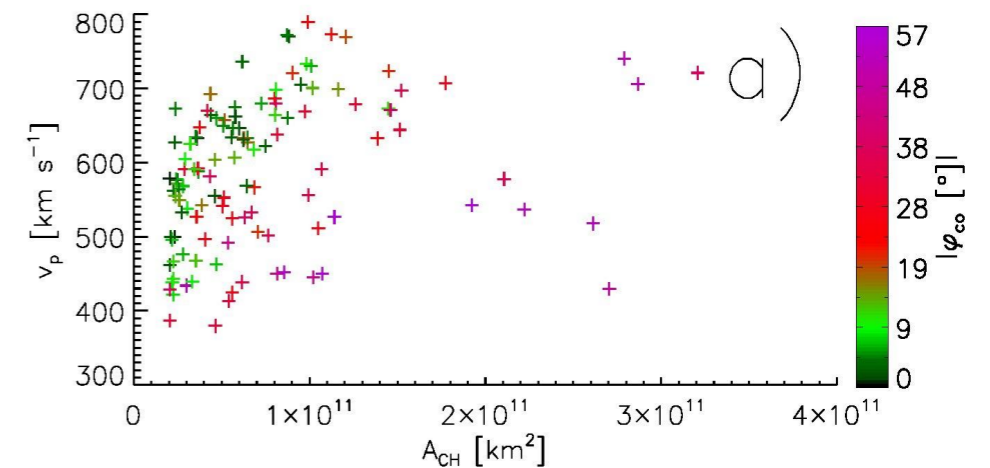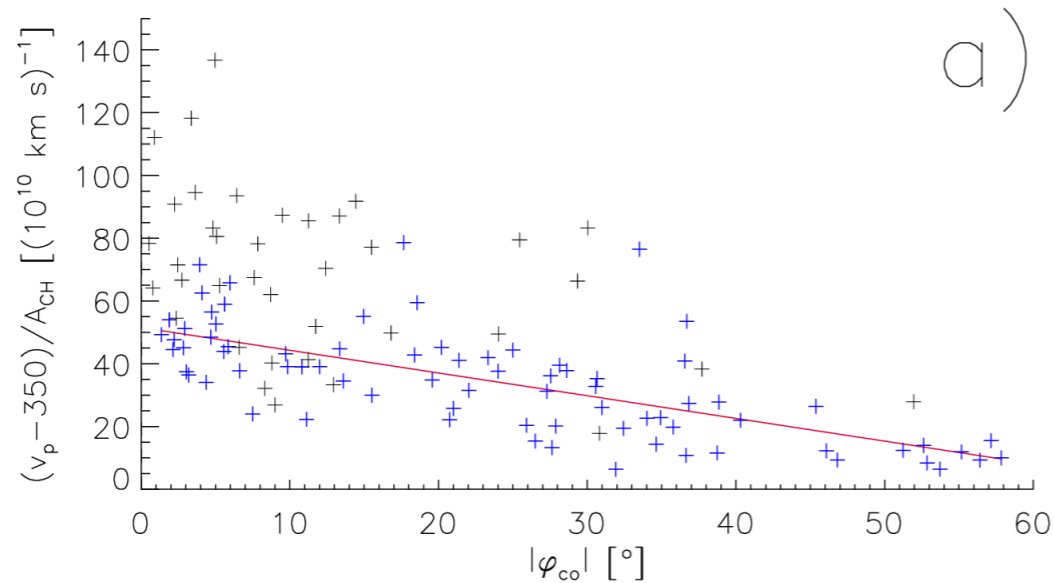
- ➢ Relationship changes for $A_{CH} > 4 * 10^{10}$ km^2
- ➢ High correlation for all offset velocities