Insights on 3D kinematics of Coronal Mass Ejections in the inner corona.

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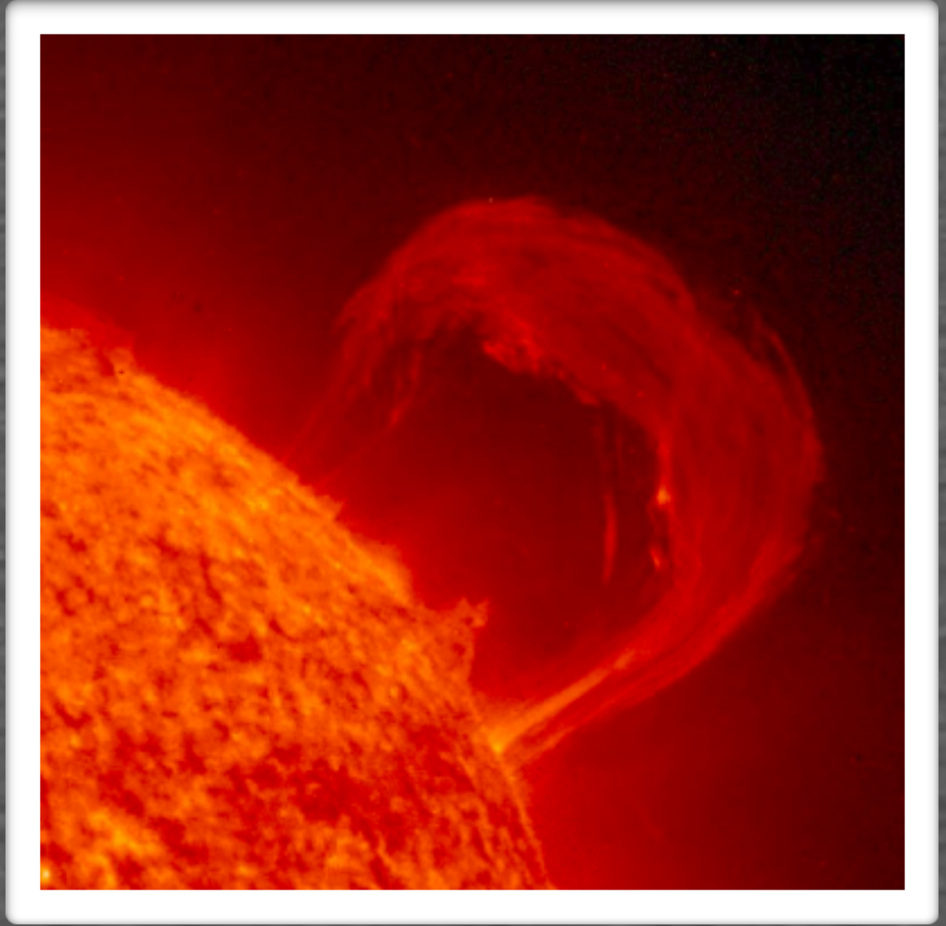
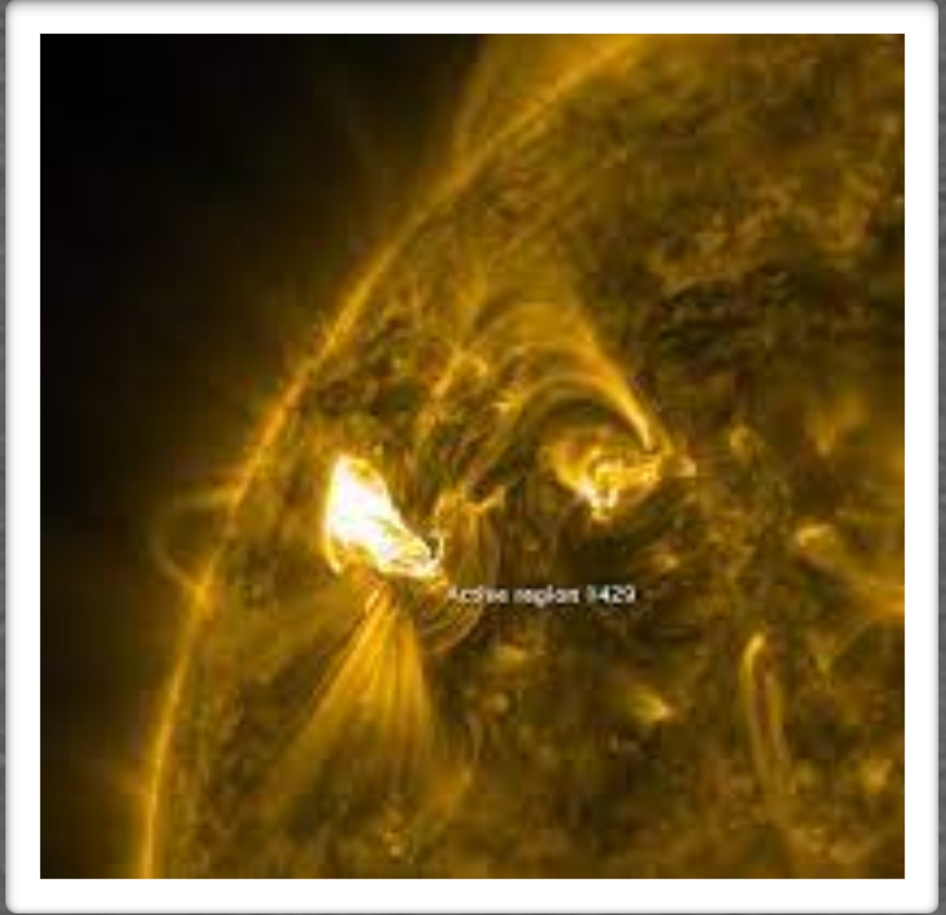
Working Method :

STEP 1 -> 59 CMEs are selected from the CDAW cataloge, which were observed between 2007 to 2012

STEP 2 -> The source regions of all these CMEs were identified, and the identified sources were classified into 3 categories :



Quiescent prominences (PEs)



Active Regions (ARs)

The source regions of all 59 CMEs were identified using back projection. The identified sources were classified into 3 classes :

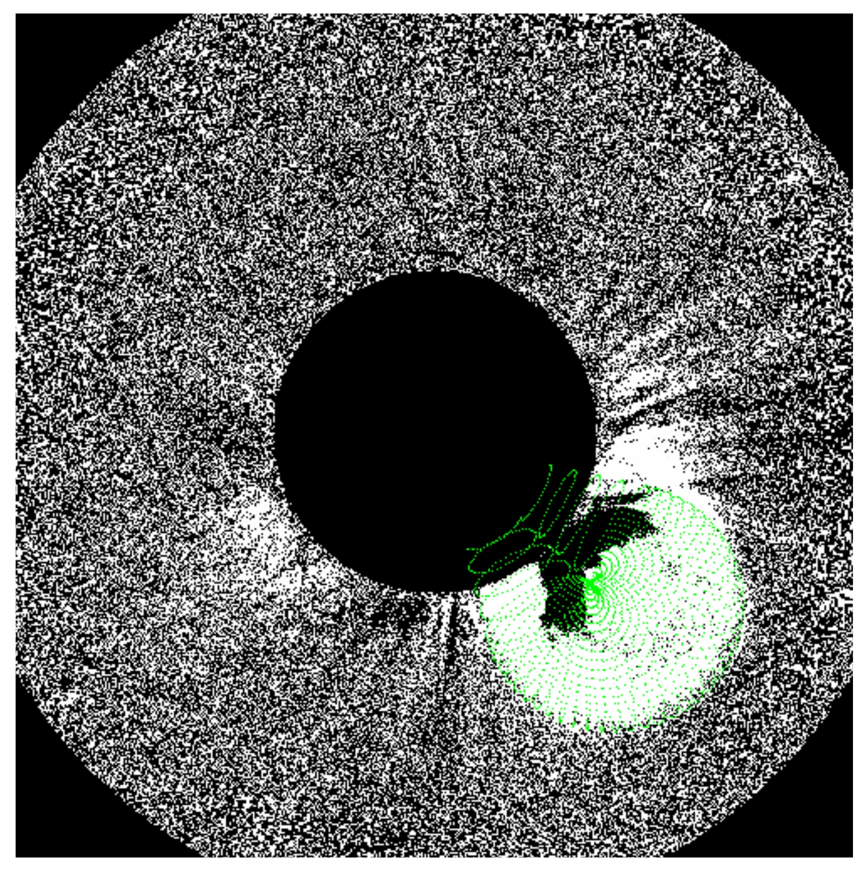
ARs - 20/59

PEs - 20/59

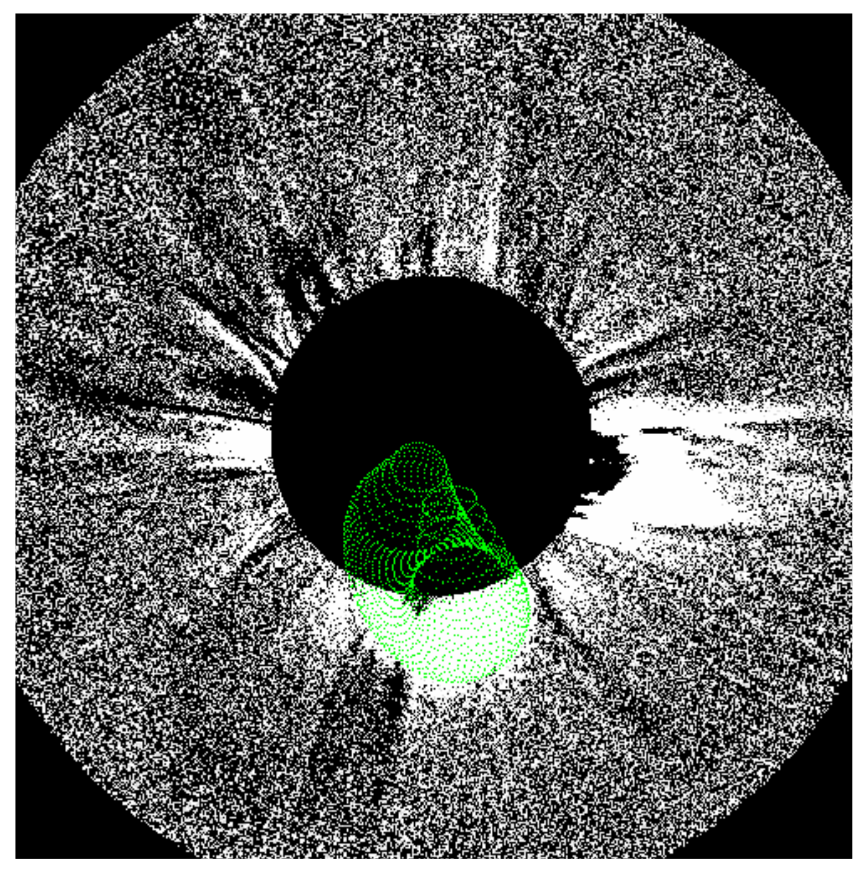
APs - 19/59

Active Prominences (APs) : PEs with foot-point(s) connected to ARs

STEP 3 -> The CMEs were fitted with the GCS model (Thernesien et al. 2009) in the COR-1 and COR-2 field of view (1.5-14 R) to study their 3D evolution in the inner and outer corona..



STEREO - A / COR - 1



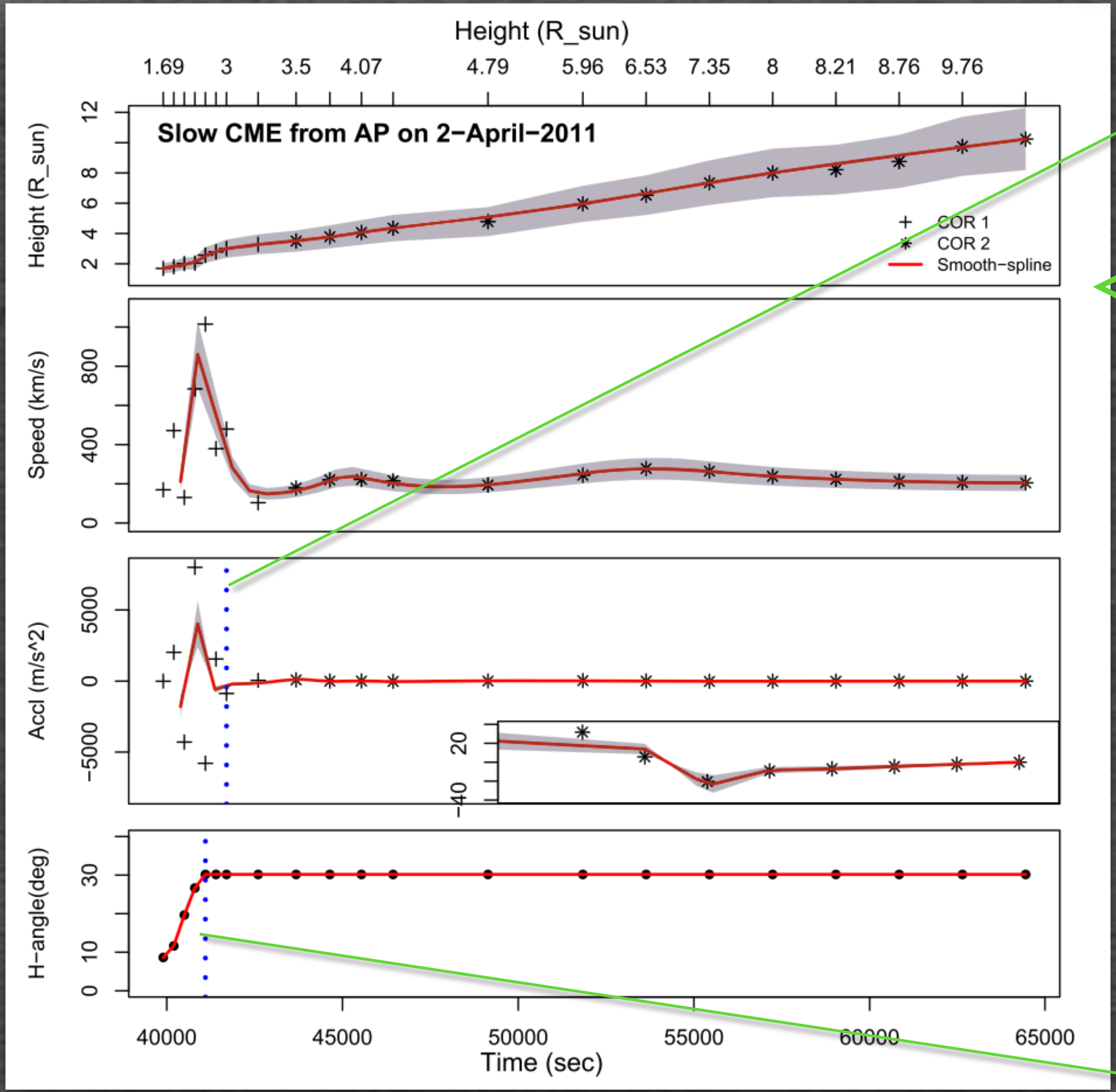
STEREO - B / COR - 1

STEP 4 -> The fitted GCS parameters are recorded for a time sequence of evolution for every event for further study

Table 1
GCS Model Parameters of All the CMEs

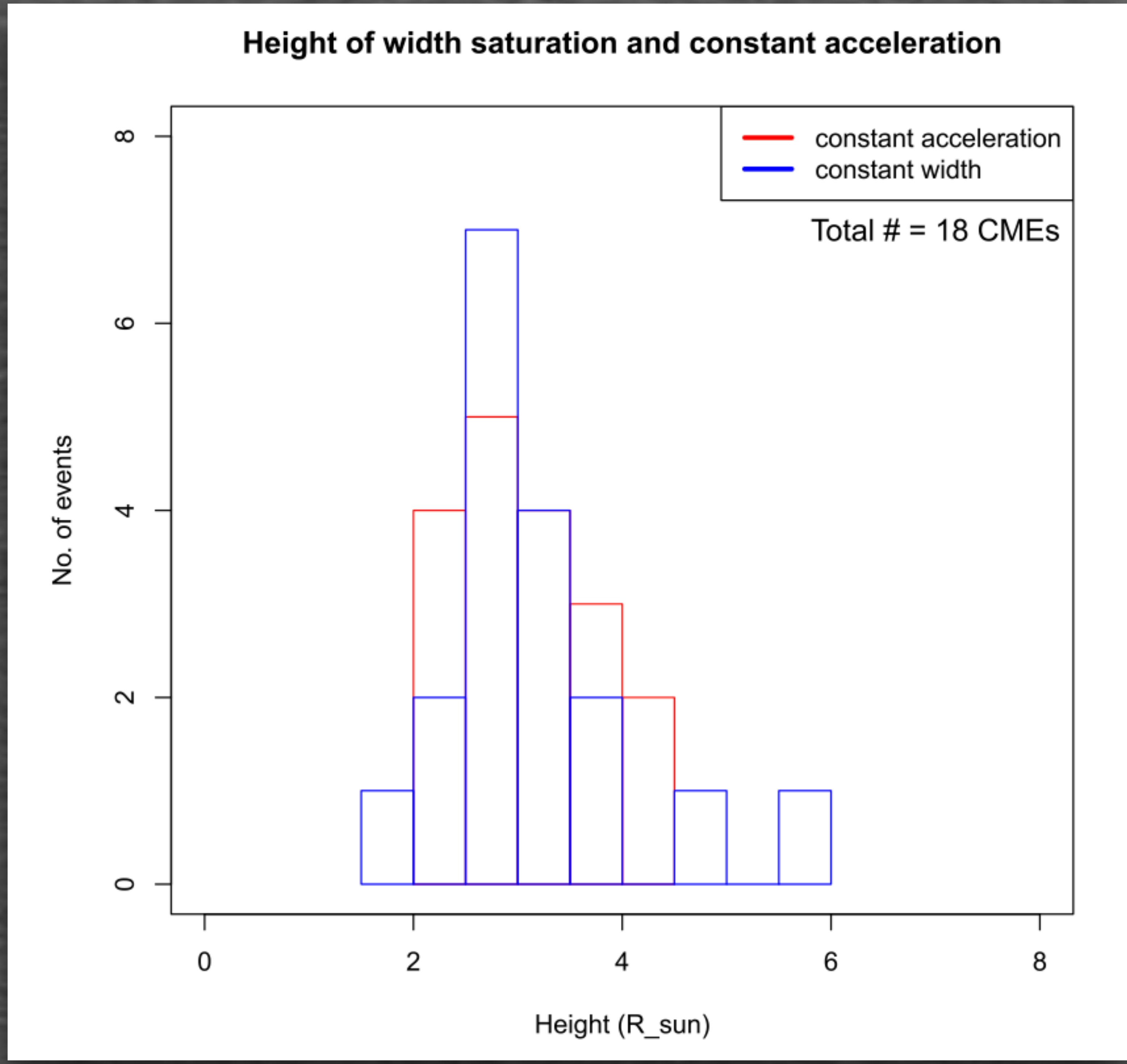
Date	Time (hh:mm:ss)	Source Region	Height (h) ($R_\odot$)	Longitude (ϕ) (deg)	Latitude (θ) (deg)	Tilt angle (γ) (deg)	Aspect ratio (k)	Half-angle (α) (deg)	V_{CDAW} (km s^{-1})	V_{GCS} (km s^{-1})
2007 May 9	02:00:00	AR	3.36	69	3.9	–	0.33	0	264	277
2008 Mar 25	19:20:00	AR	3.36	188	−15	69	0.17	12	1103	1074
2008 Mar 26	10:52:22	AR	3.71	1	−5	2	0.21	4	163	241
2008 Apr 5	16:15:00	PE	3.35	258	0	−65	0.13	14	962	994
2008 Apr 9	10:45:00	AP	3.22	193	−21	2	0.12	8	650	543

Results:Width and acceleration unification of CMEs in inner corona : Observational evidence of Lorentz force imprints



The h-t, v-t, a-t and width-time profiles of an impulsive CME.

The dotted lines in 3rd and 4th panel marks the height at which impulsive acceleration phase and rapid width expansion phase ceases !!
These two heights were recorded for different events and they are plotted on the right side.
The observational evidence that the imprint of Lorentz force stays dominant till 2.5-3R.

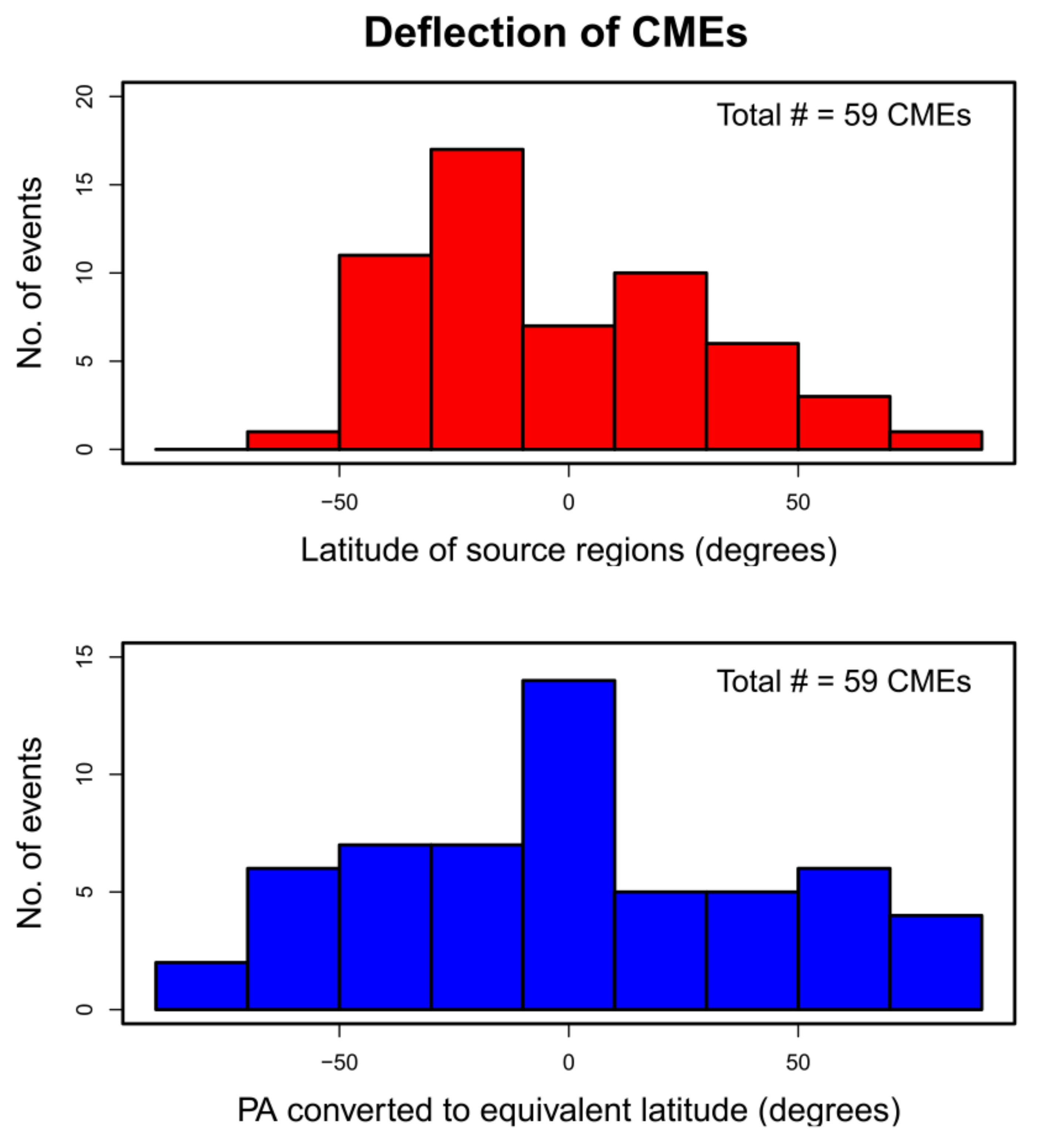


Statistically, both the distributions for most CMEs peak around 2.5-3 R. Thus showing the influence of Lorentz force on 3D kinematics stays dominant till 2.5-3R.

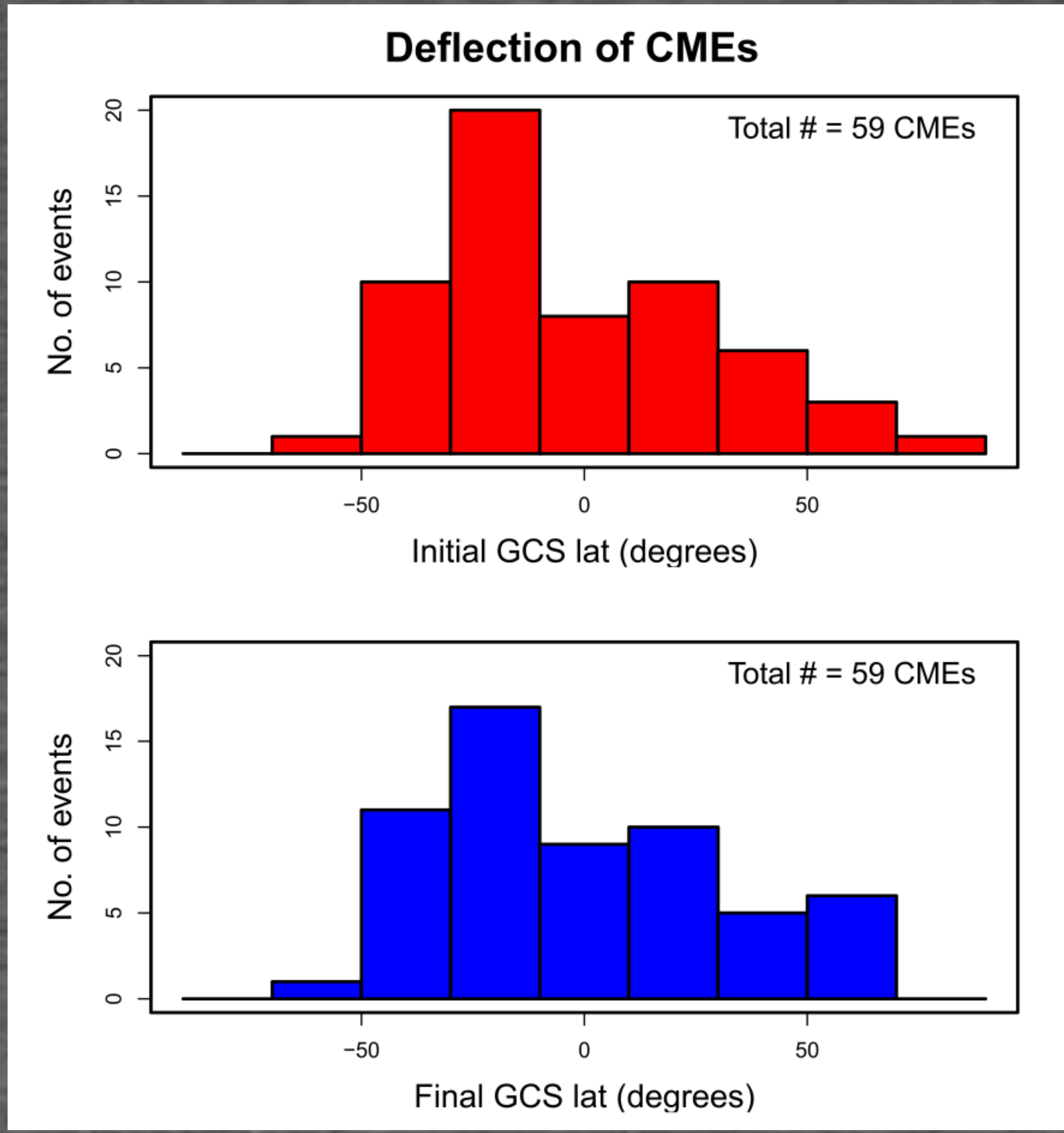
Take home message : Width expansion and radial acceleration profiles in 3D are veritable manifestation of the same Lorentz force.

Results : The fine line between study of 2D and 3D deflection of CMEs

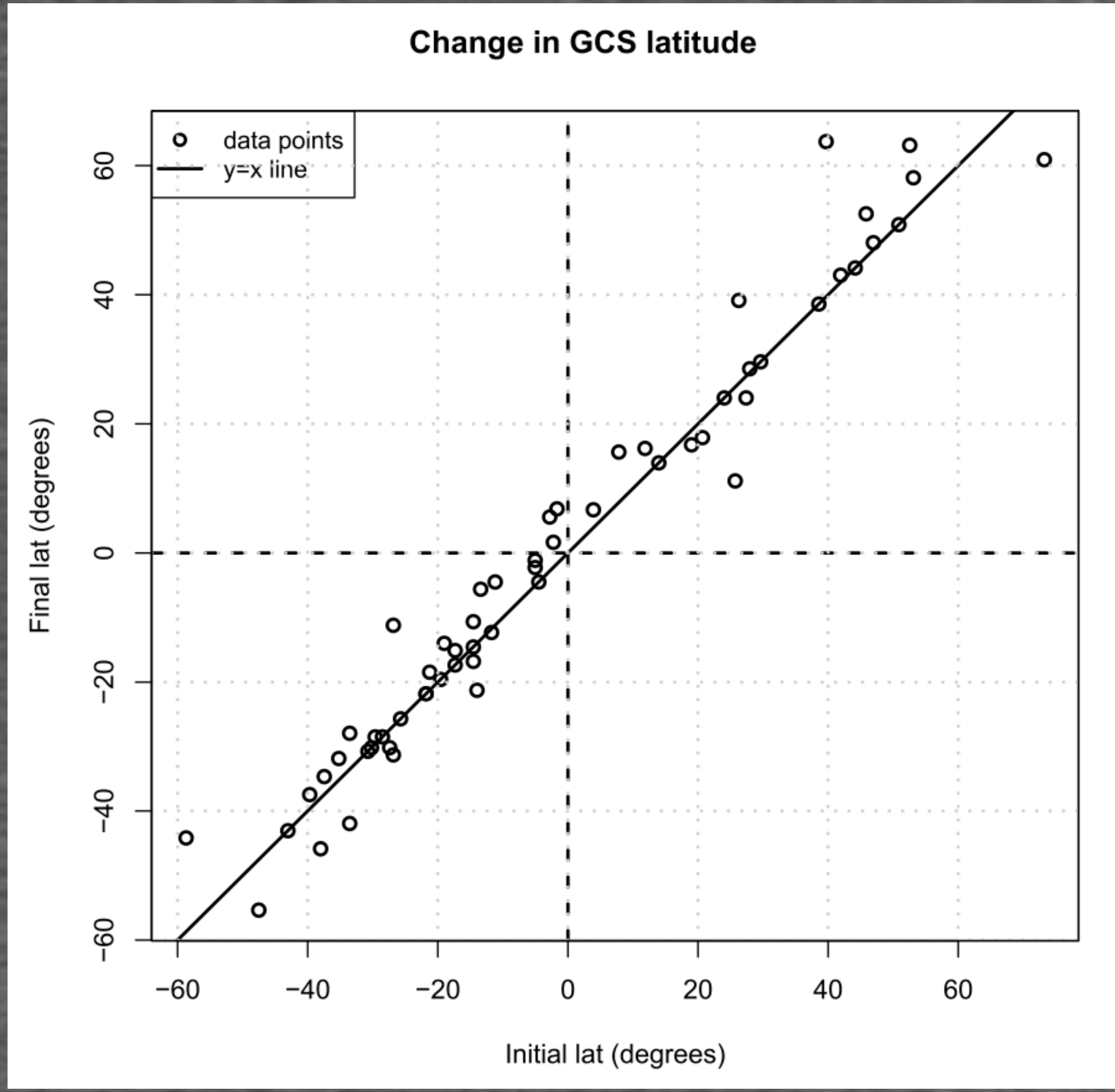
STEP 1 : Bi-modal distribution of CME source latitudes and uni-modal distribution of CME position angle equivalent latitudes -> imply equatorward deflections



STEP 2 : Bi-modal distribution of true GCS latitude for both initial and final values do not show deflection signatures !! WHY ??



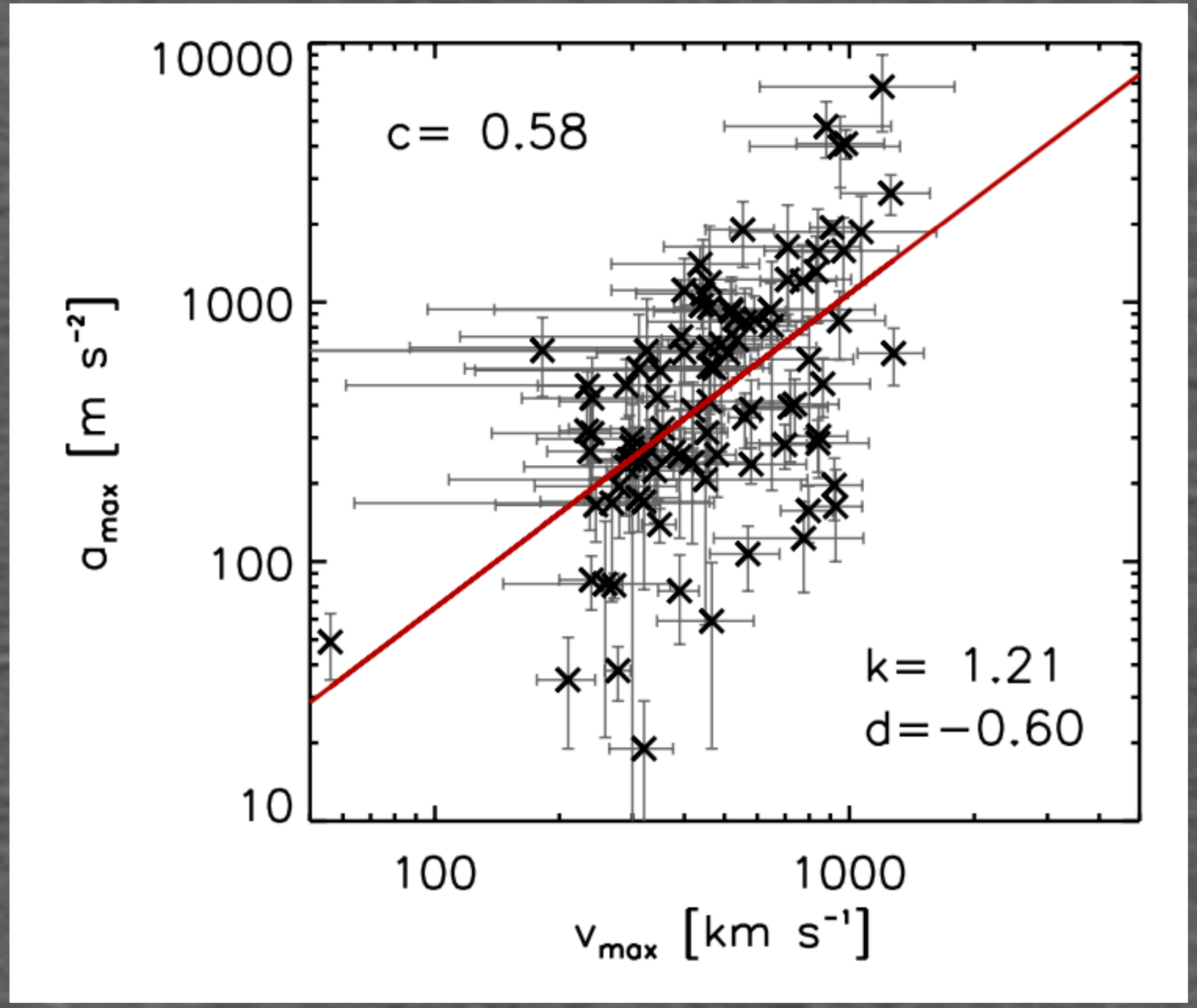
STEP 2 : GCS final versus initial latitudes show magnitude of deflections are much smaller and hence their apparent position angles mislead conclusions



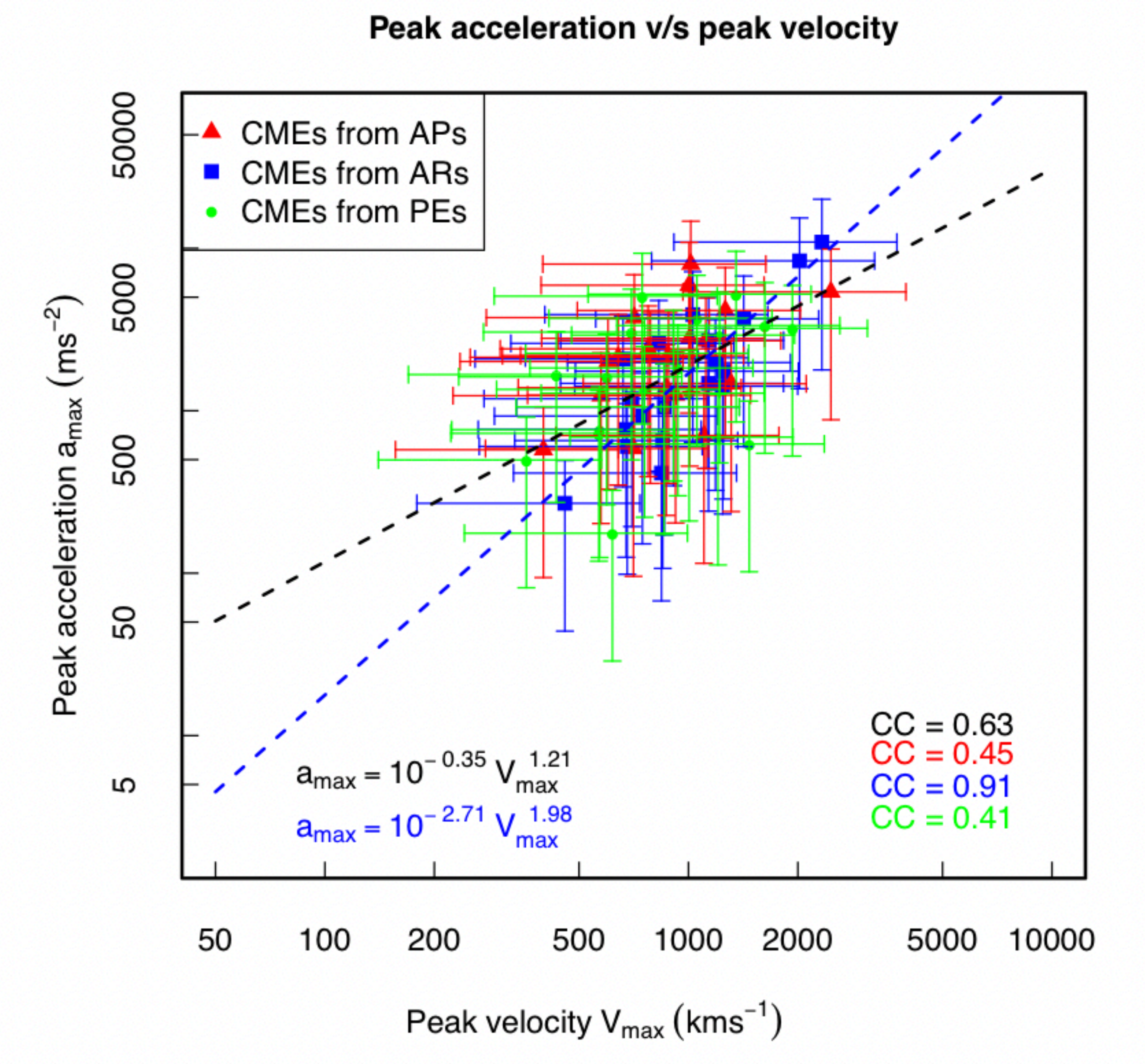
Take home message : Old method of using latitude - position angle distributions do not provide conclusive evidence on true deflections and thus can be highly misleading !!

Results : Coupling of knematics in inner and outer corona

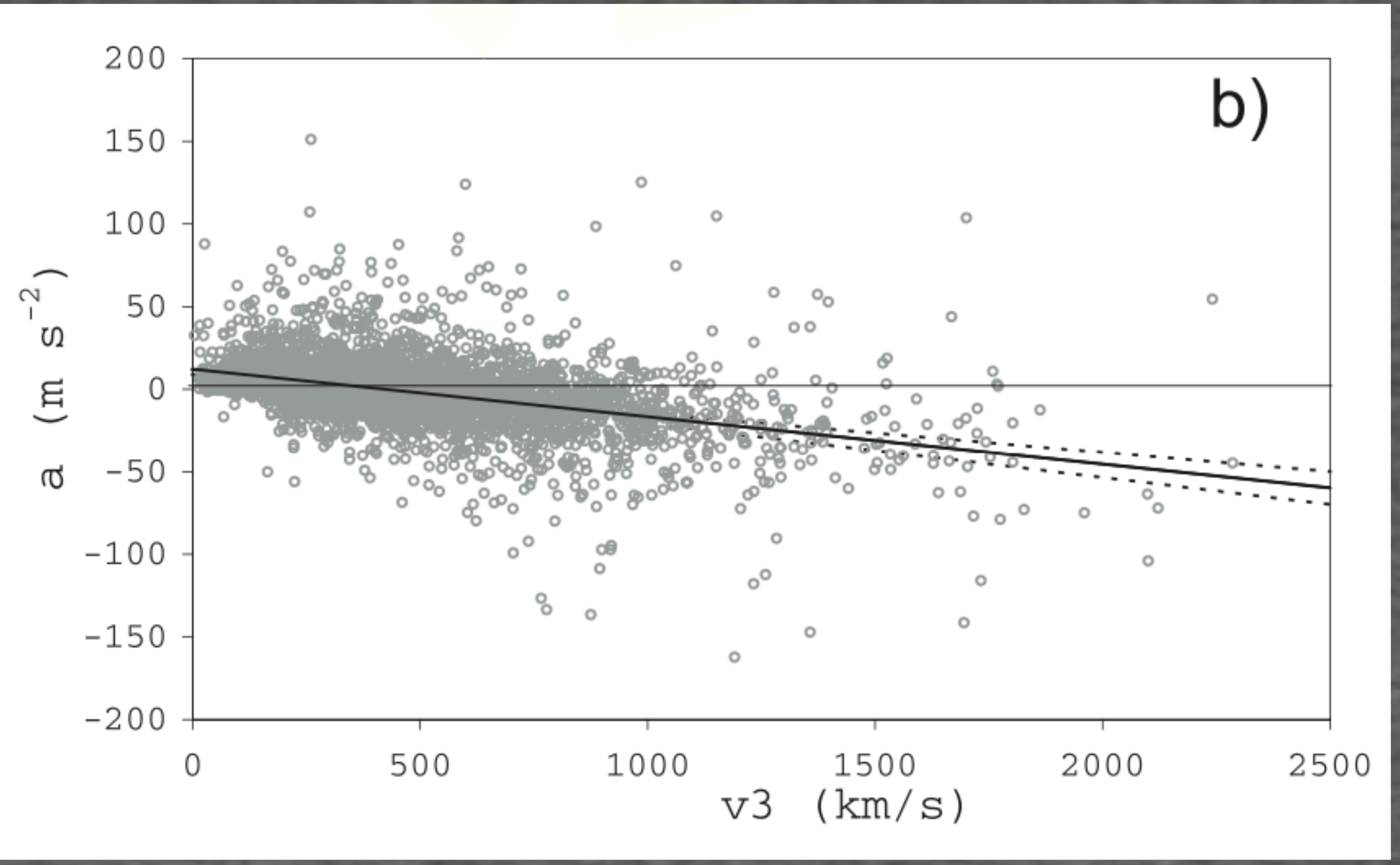
Bein et al. 2011

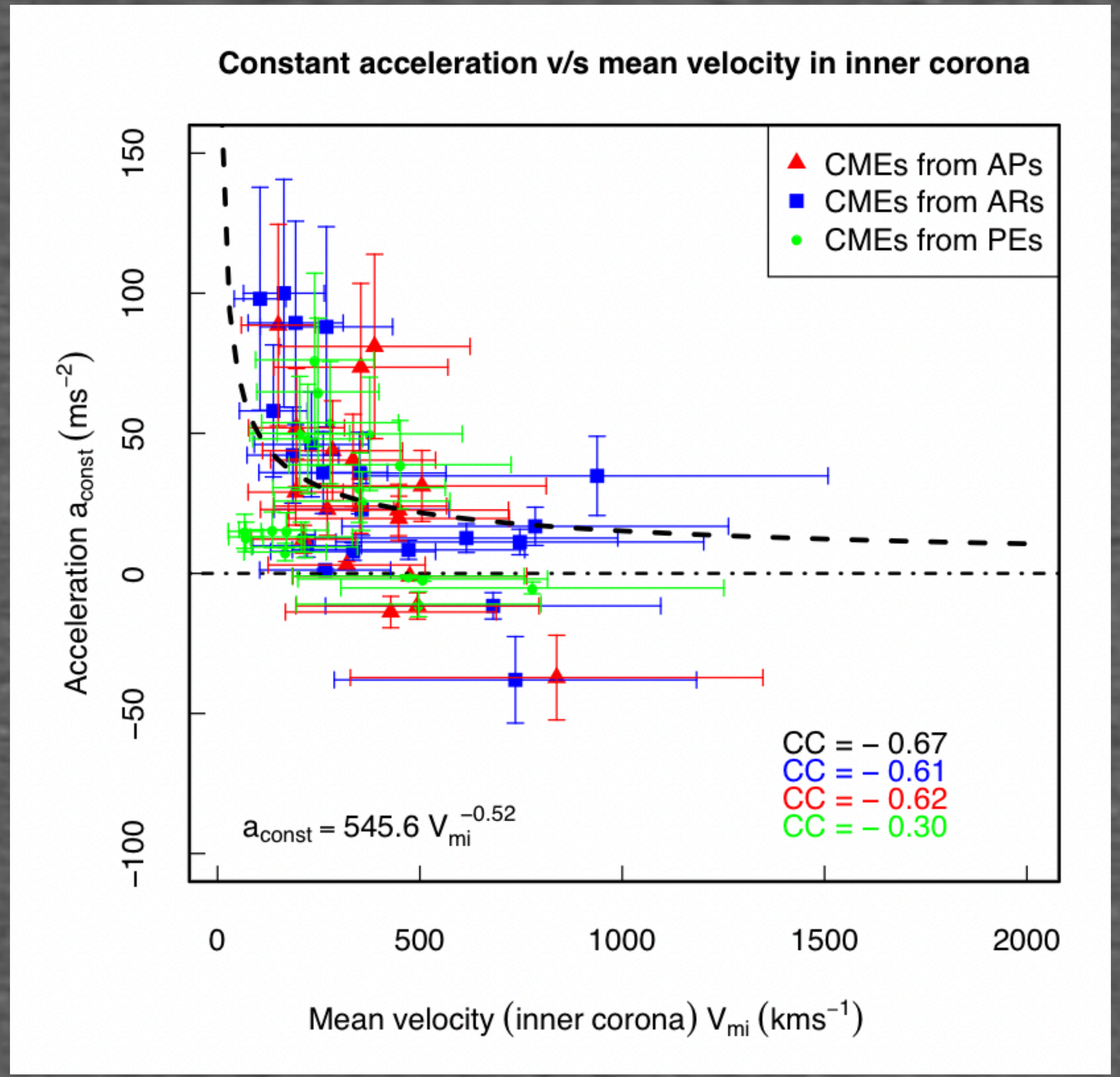


Majumdar et al. 2021



Vrsnak et al. 2004

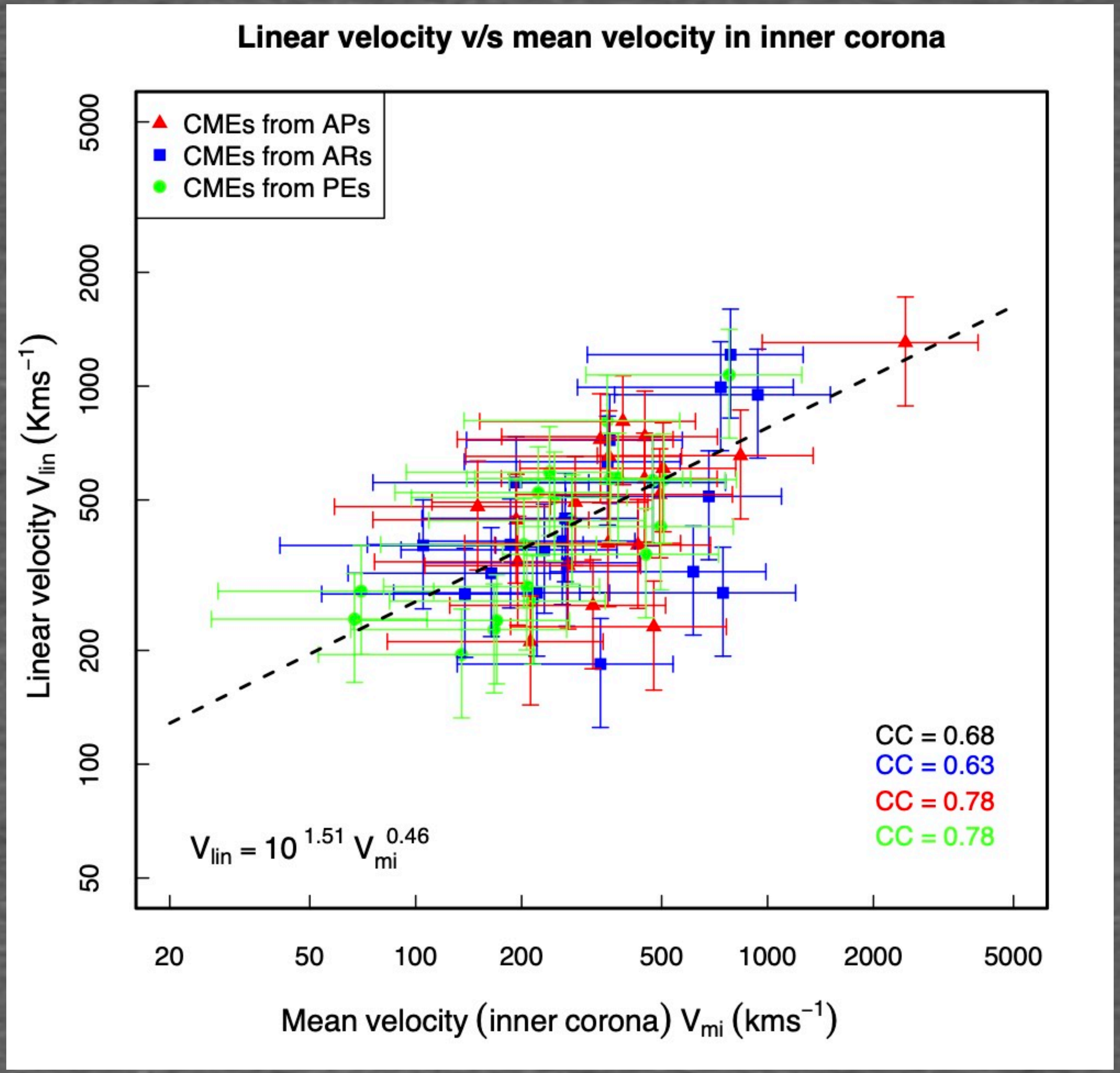




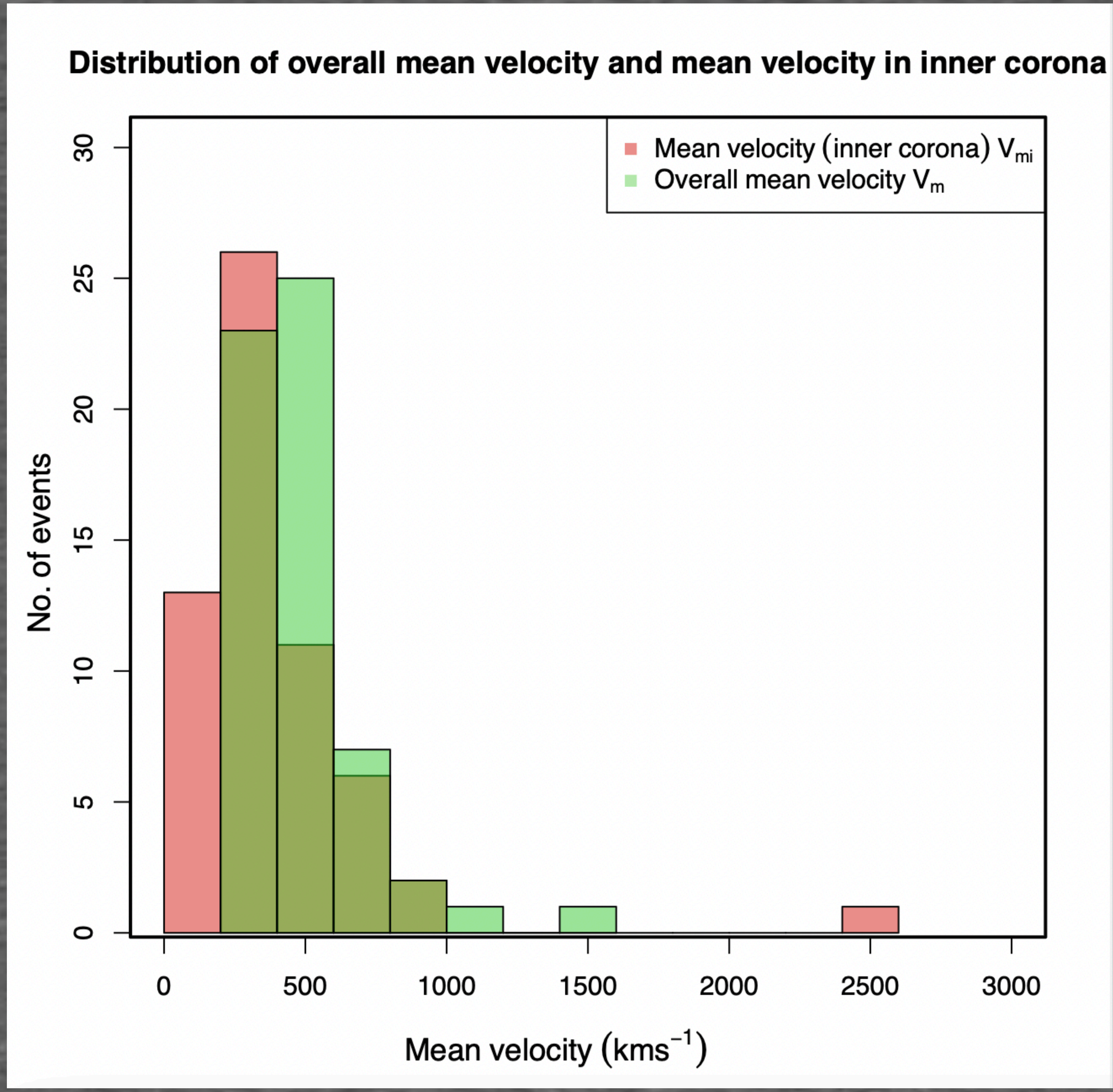
Take Home message :
The overall correlation coefficient (CC) fails to communicate the whole story. Individual CCs show conclusive evidence that CMEs from active and quiet Sun regions possibly experience different acceleration phases. Also, the drag interaction also seems different for CMEs associated/not associated with prominence eruptions -> A look back into the models ??

Results : Kinematics in the outer corona is largely coupled with the inner corona

Using the below empirical relation, the linear speed of CME can be estimated from the speed in inner corona -> Use of inner coronal observations for CME arrival time predictions ?? -> Minimisation of lead time of forecast ??



The distribution of mean speeds in the inner and outer corona do not overlap !! Is it wise to tag a CME with a single average speed ??



Take home message : A lot of kinematic properties of CMEs in the outer corona can be estimated solely from inner coronal observations -> significance of upcoming missions ADITYA-L1/ISRO !!

References :

- Majumdar, S., Pant, V., Patel, R., and Banerjee, D. (2020). Connecting 3D Evolution of Coronal Mass Ejections to Their Source Regions. The Astrophysical Journal

  doi:10.3847/1538-4357/aba1f2

- Majumdar, S., Patel, R., Pant, V. and Banerjee, D. (2021), An insight into the coupling of CME kinematics in inner and outer corona and the imprint of source regions.The Astrophysical Journal (in press)

  https://arxiv.org/abs/2107.08198

Thank You So Much..