Statistical study on the kinematic distribution of CMEs from 1996 to 2015

Seong-Gyeong Jeon, Yong-Jea Moon,
Kangwoo Yi, and Harim Lee

School of Space Research, Kyung Hee University, Korea

jsg0901@khu.ac.kr

International Study of Earth-affecting Solar Transients 2017 Workshop
International Convention Center JEJU
18 September 2017

Table of content

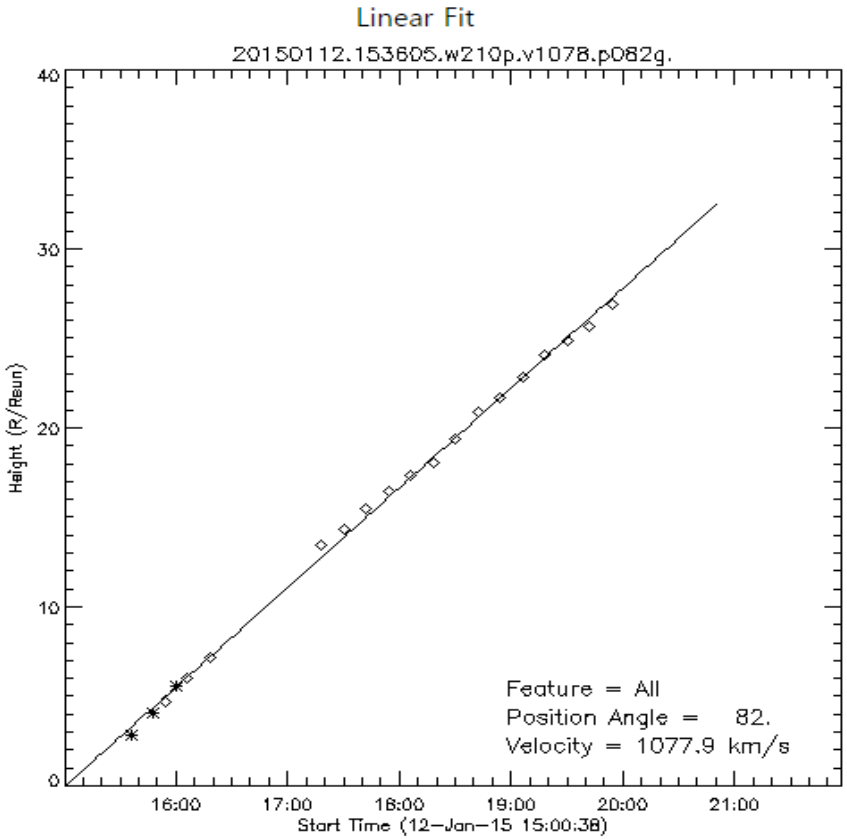
1. Introduction

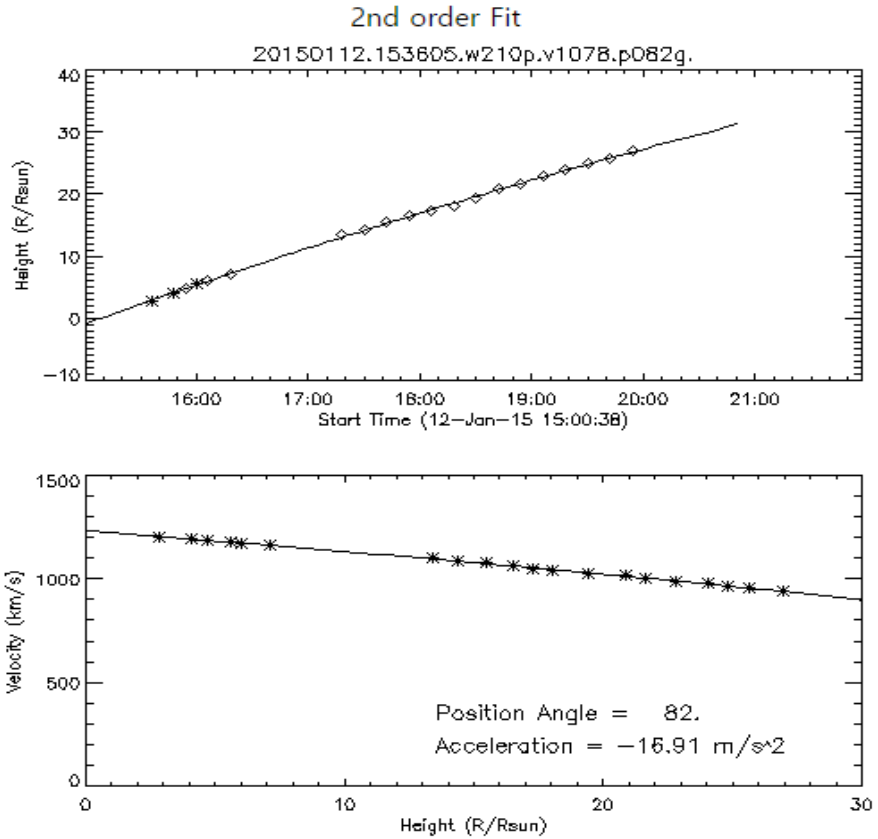
Previous study

Moon et al. (2002) studied two type of CME. One is low speed CME and the other is high speed CME. The low speed CME tend to accelerate and associate with filaments (filament-associated CME). The high speed CME tend to decelerate and associate with flare(flare-associated CME)

Low Speed CME	High speed CME
Acceleration	Deceleration
Filament-associated CME	Flare-associated CME

1. Introduction





There are two fitting(1st or 2nd order fit) methods for CME motions.

1. Introduction

Constant acceleration model

CME {
- **Constant Deceleration motion**
- **Constant Velocity motion**
- **Constant Acceleration motion**

How can we Classify CME motions ?

2. Data

We use LASCO CMEs from 1996 to 2015.

We Exclude all poor events recorded in catalogue.

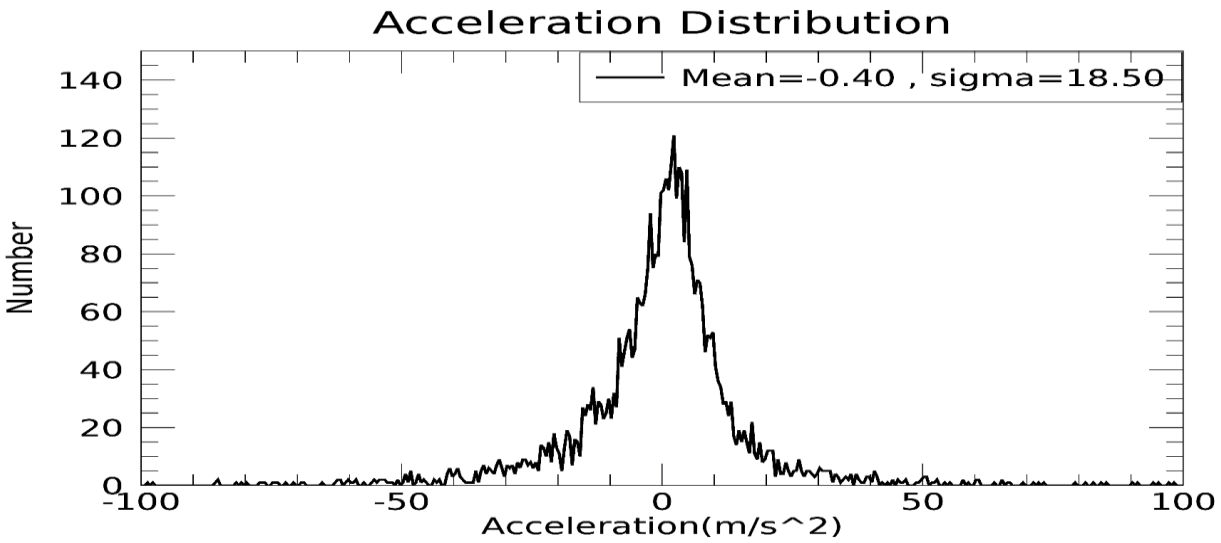
We use CME having Higher than 60 degree angular width

We use C3 CME data among C2 and C3 data

We use 4,271 CME data

3. Classification Method

1) Acceleration Method



Deceleration : $a < m - \sigma$

Constant velocity : $m - \sigma \leq a \leq m + \sigma$

Acceleration : $m + \sigma < a$

3. Classification Method

2) Speed variation Method

CME speed uncertainty of C3(σ) and speed variation(ΔV)

The CME speed uncertainty for the LASCO C3(σ) is 80km/s. [Shanmugaraju et al. 2010]

3σ=240km/s

Speed variation on the acceleration motion

$$\mathrm{V}_{final} - \mathrm{V}_0 = \Delta \mathrm{V} = \mathrm{a}\Delta \mathrm{t}$$

$$\Delta V = at_{final}$$

3. Classification Method

2) Speed variation Method

Compare 3σ with speed variation

3σ=240km/s

$$\Delta V = at_{final}$$

Deceleration : $\Delta \mathrm{V} < -3\sigma$

Constant velocity : $-3\sigma \leq \Delta \mathrm{V} \leq 3\sigma$

Acceleration : $3\sigma < \Delta \mathrm{V}$

3. Classification Method

3) Height contribution Method

Distance on the acceleration motion

$$\mathrm{H} = \frac{1}{2}at^2 + Vt$$

$$\frac{1}{2}at^2 = kH, Vt = (1-k)H$$

Deceleration : $a < 0$ and $0.1 < k$

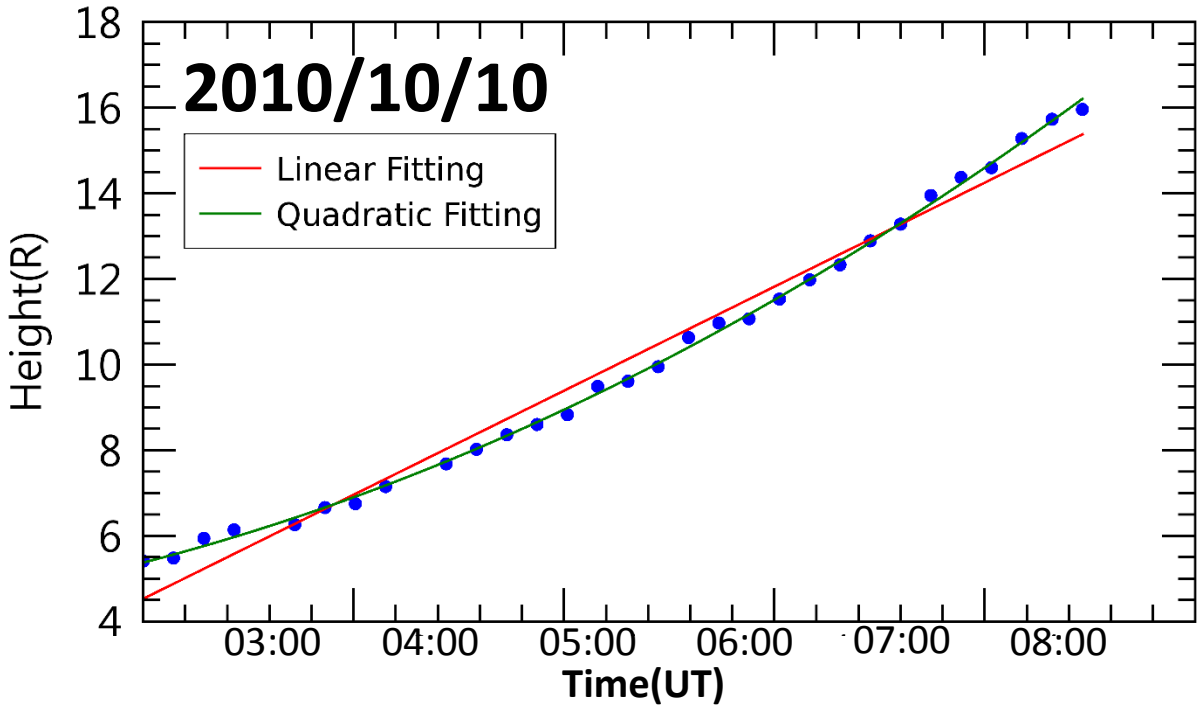
Constant velocity : $0 \leq k \leq 0.1$

Acceleration : $0 < a$ and $0.1 < k$

3. Classification Method

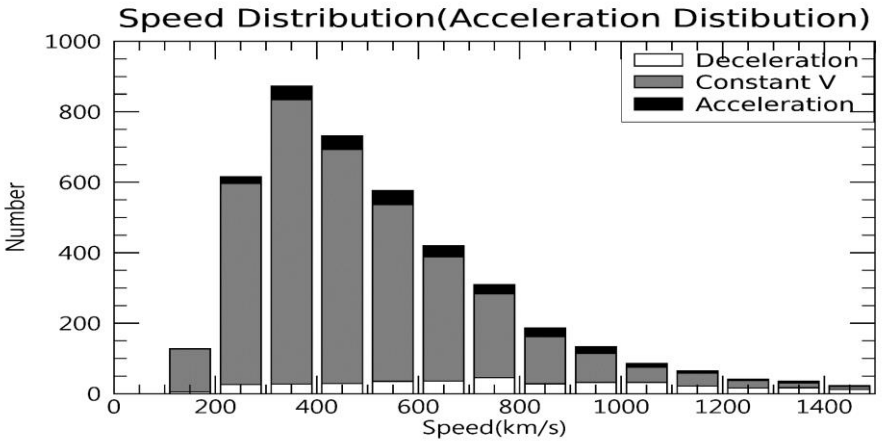
4) Visual inspection Method

Which line (1st or 2nd order fit) is closer to observations ?

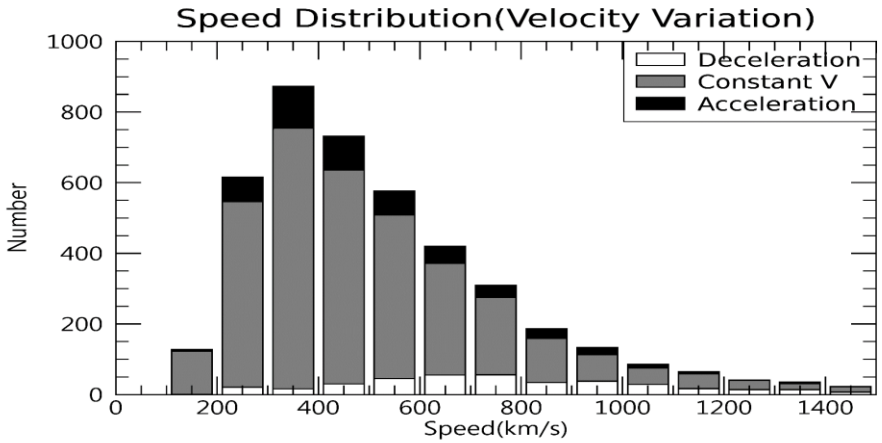


4. Result

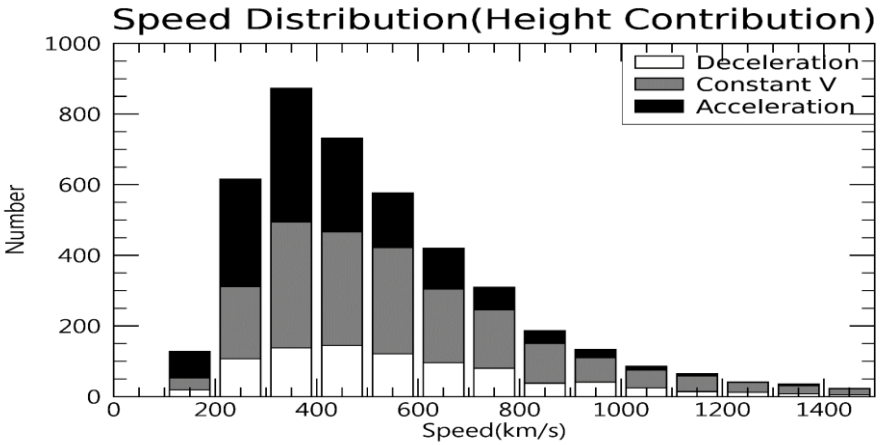
1) Acceleration Method



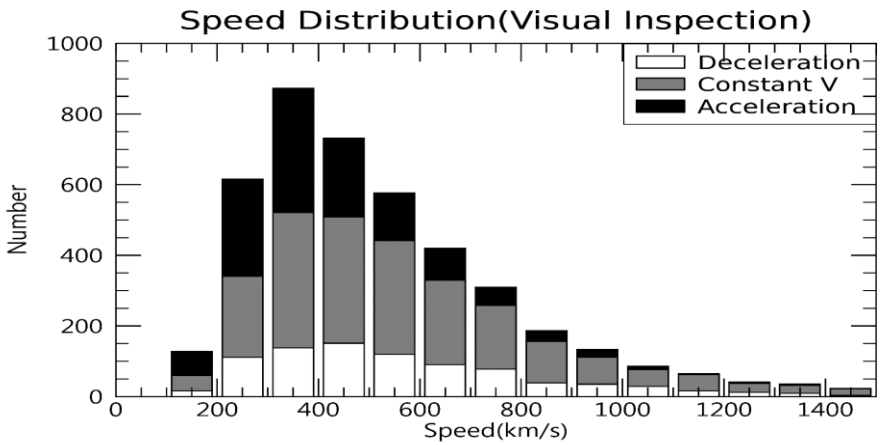
2) Speed Variation Method



3) Height contribution Method



4) Visual inspection Method



4. Result

Cross-comparison Table

		Visual Inspection			
Height Contribution		Deceleration	Constant V	Acceleration	Total
	Deceleration	**762**	96	2	860
	Constant V	97	**1821**	45	1963
	Acceleration	1	221	**1226**	1448
	Total	860	2138	1273	4271

$$\textit{The fraction of coincidence}\ \text{events} = \frac{752 + 1821 + 1226}{4271} = 0.89$$

4. Result

Total fraction

Height Contribution Method

Deceleration: 19%
Constant velocity : 47%
Acceleration : 34%

Visual Inspection Method

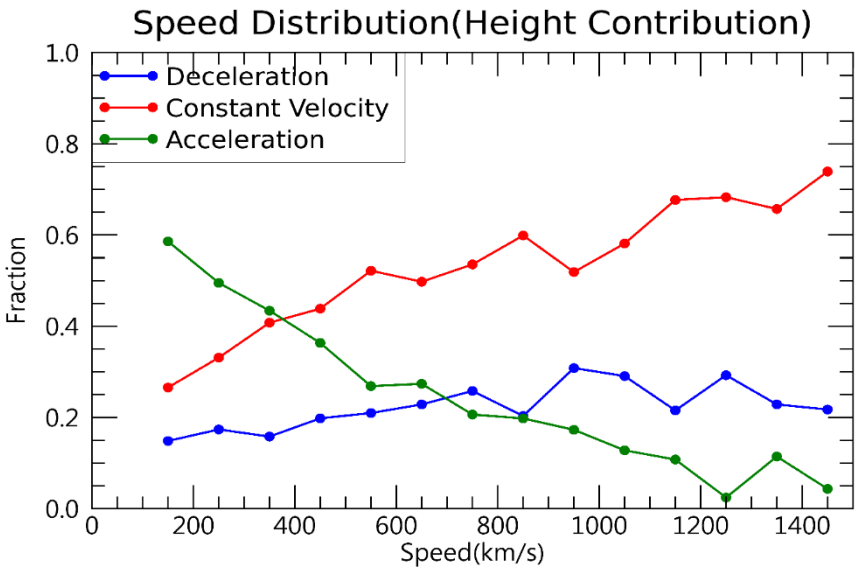
Deceleration: 19%
Constant velocity : 52%
Acceleration : 29%

Deceleration	Constant Velocity	Acceleration
20%	50%	30%

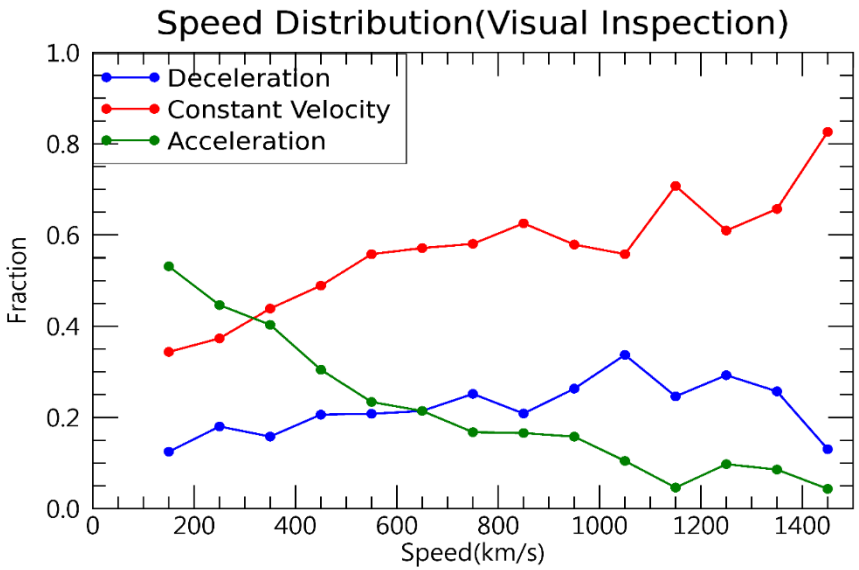
4. Result

Fractions of CME motion on the CME speed distribution

Height Contribution Method

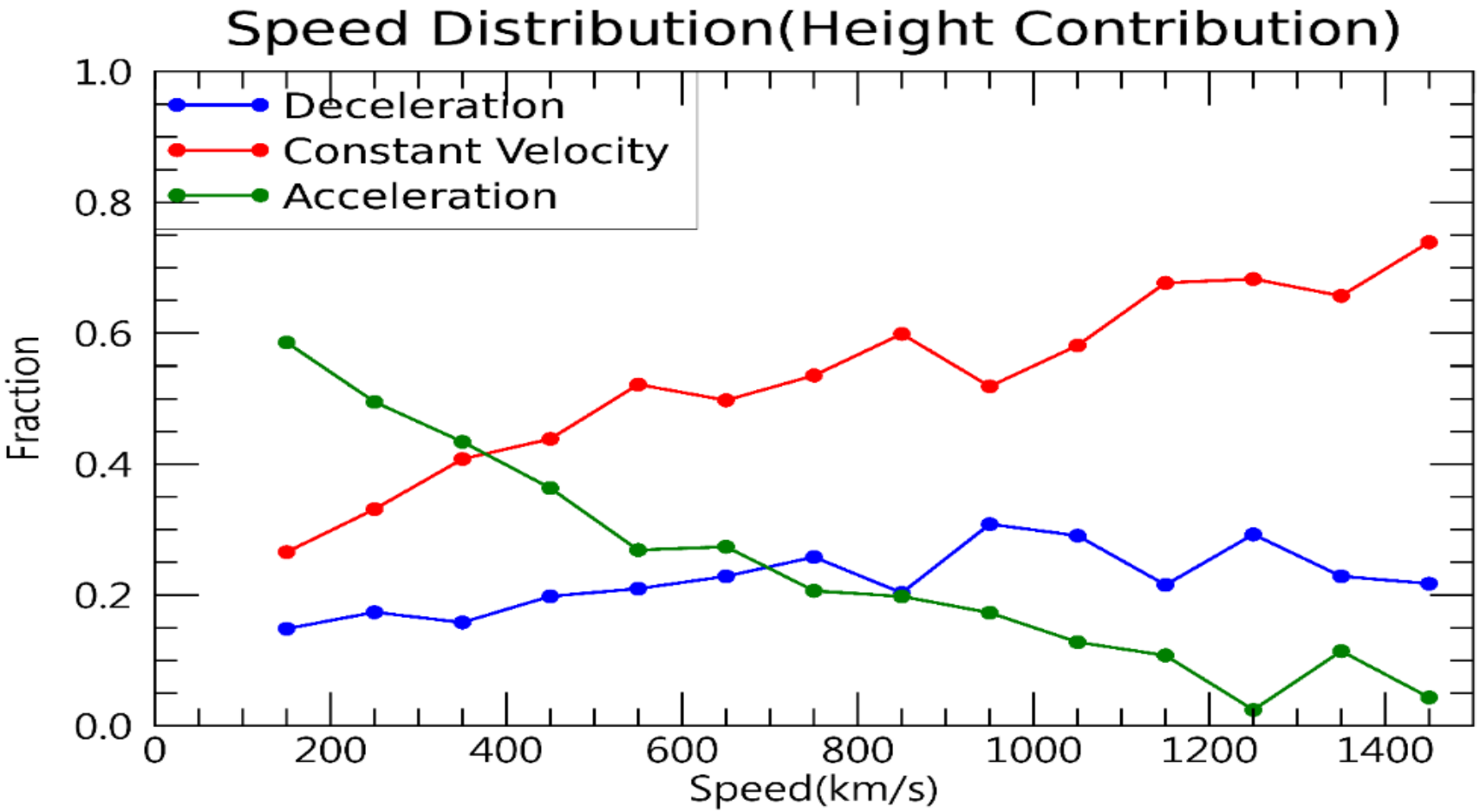


Visual Inspection Method

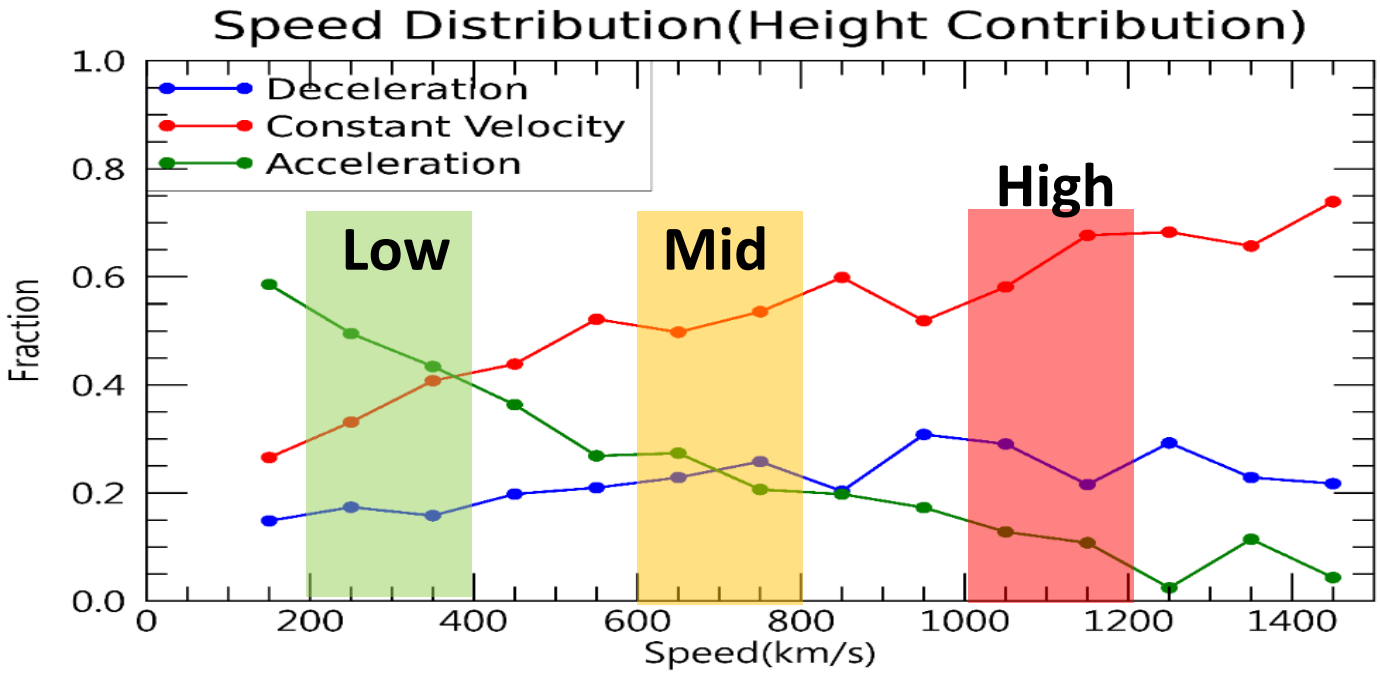


4. Result

Fractions of CME motion on the speed distribution



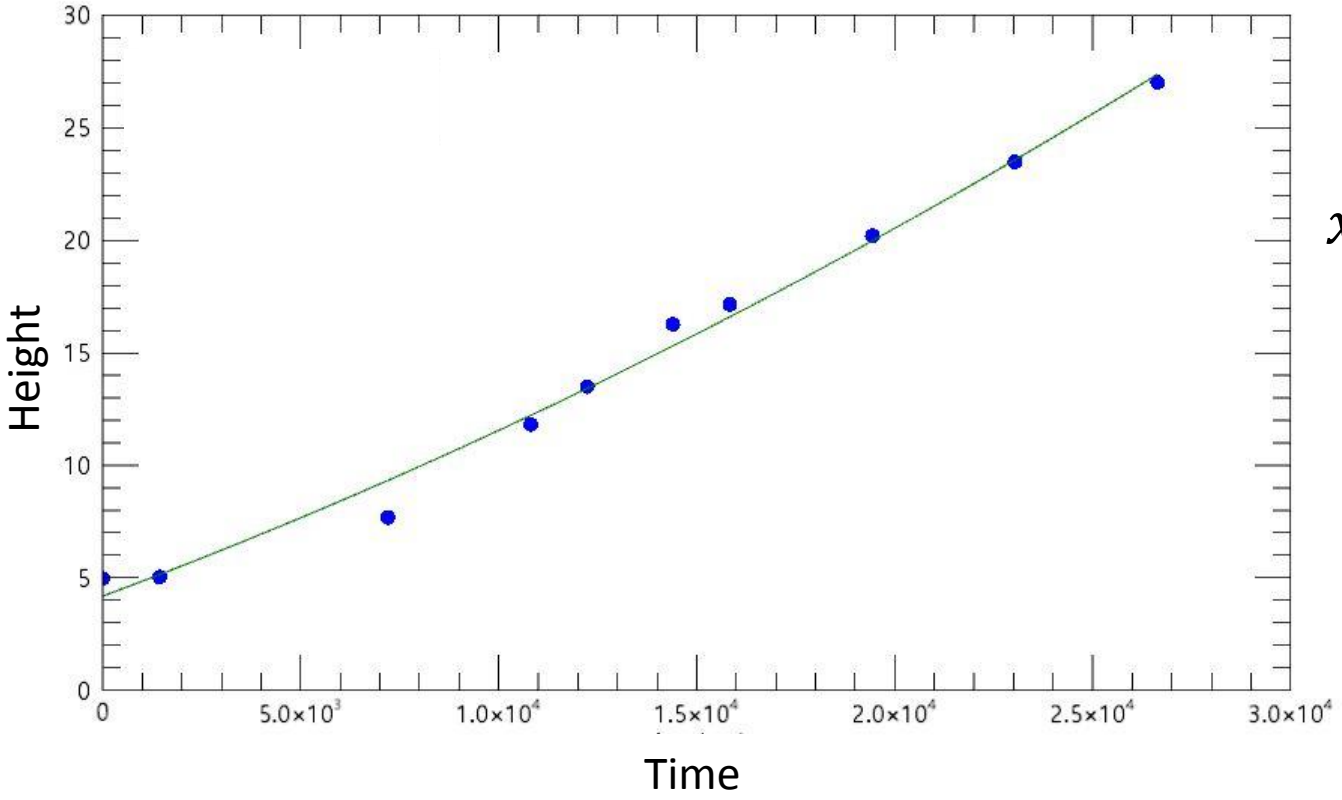
4. Result



	Low(200~400km/s)	Mid(600~800km/s)	High(1000~1200km/s)
Deceleration	16%	25%	26%
Constant velocity	38%	**51%**	**62%**
Acceleration	**46%**	24%	12%

5. Discussion

CME event with Large RMSE

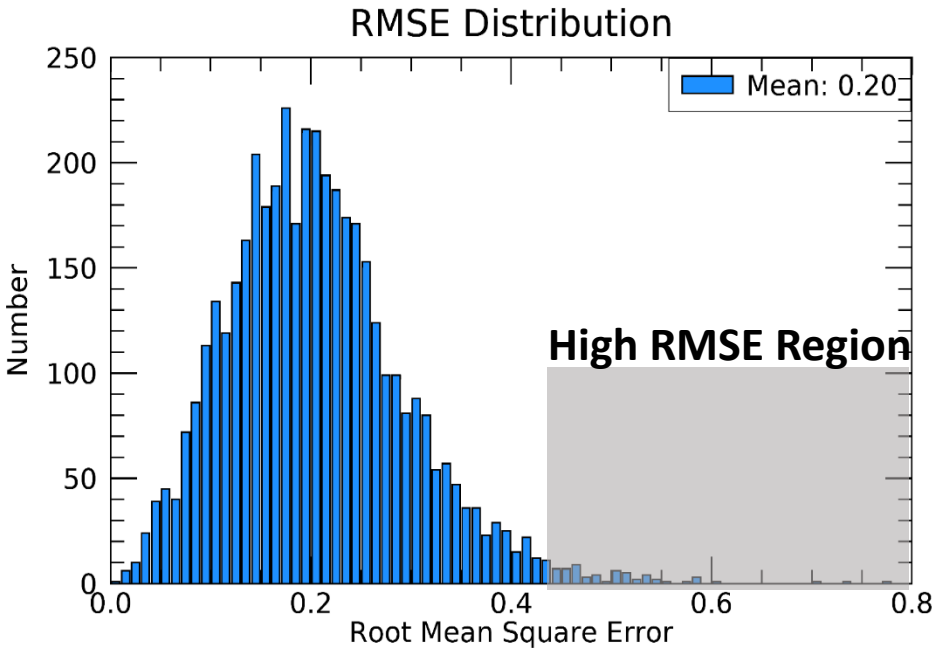


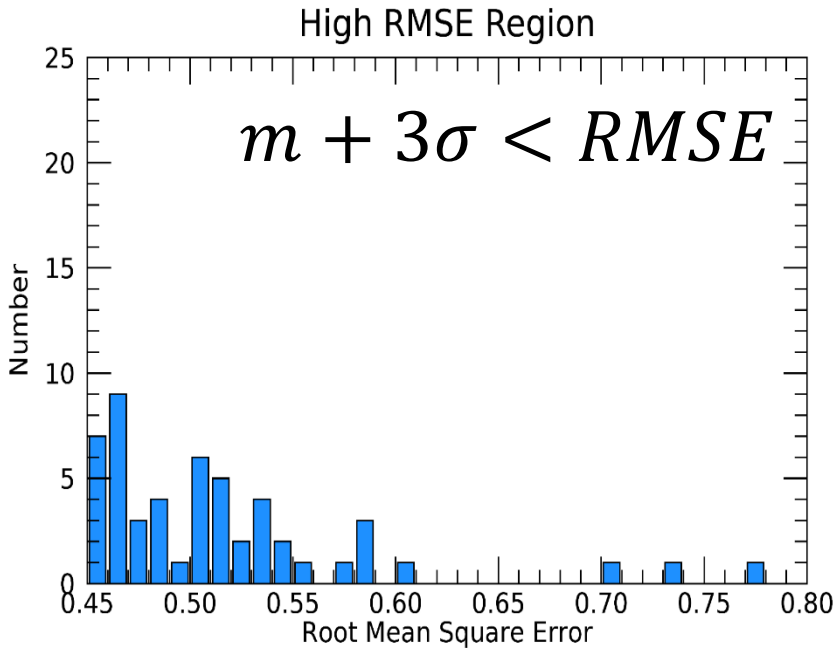
$$x_{rms} = \sqrt{\frac{\sum(x_i - \hat{x}_i)^2}{n}}$$

RMSE = 0.70

5. Discussion

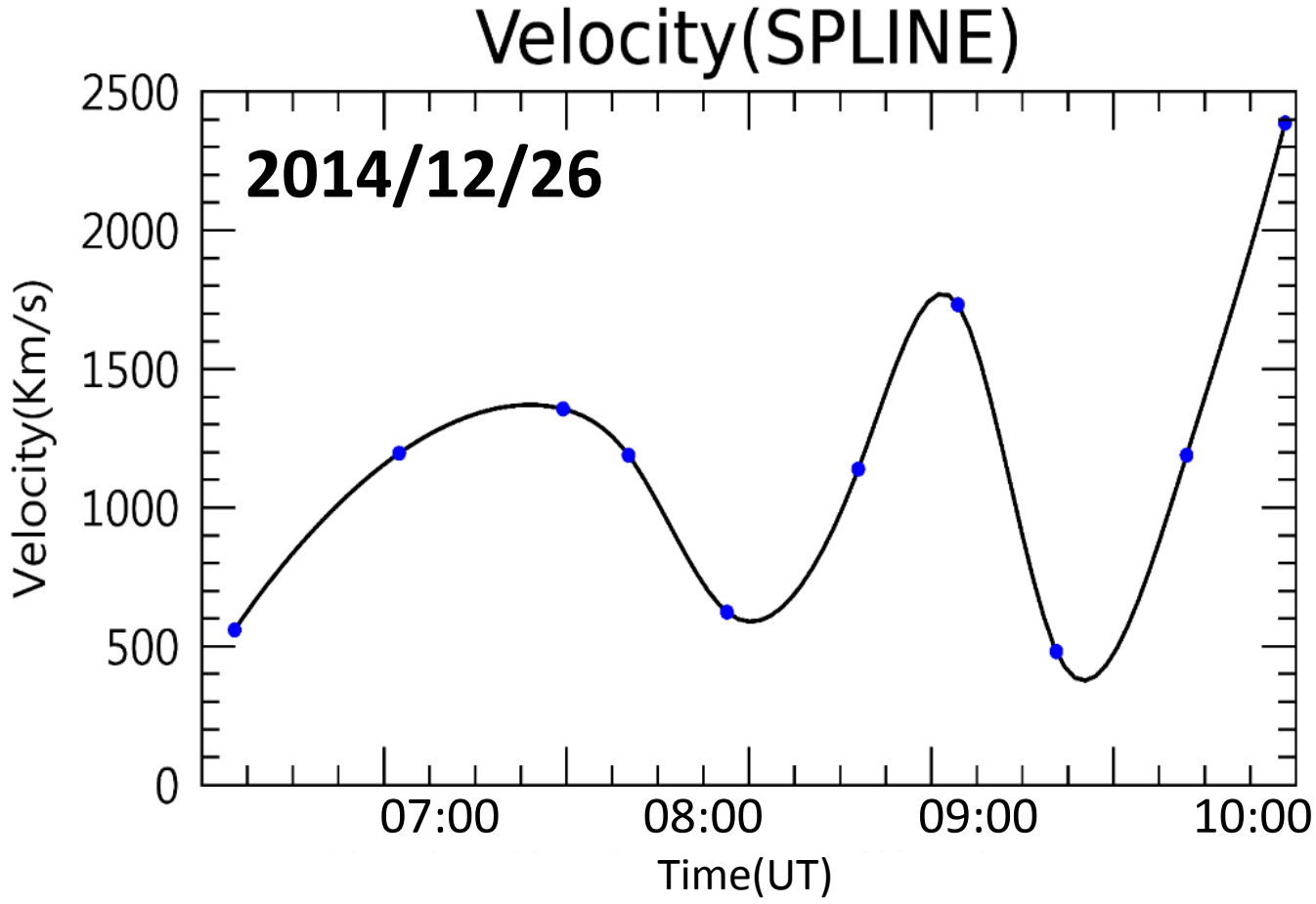
CME events with Large RMSE





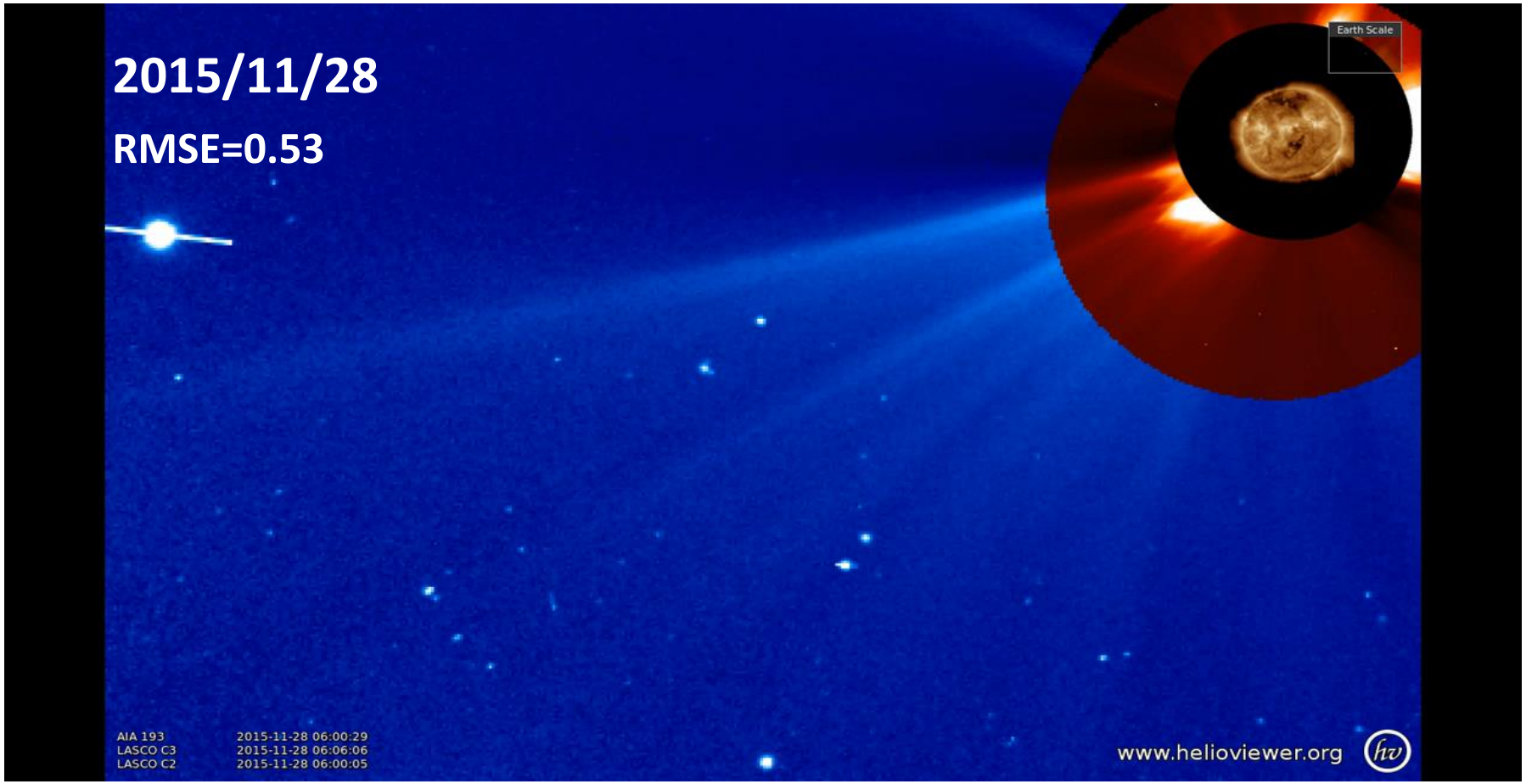
5. Discussion

1) Quasi-periodic oscillations



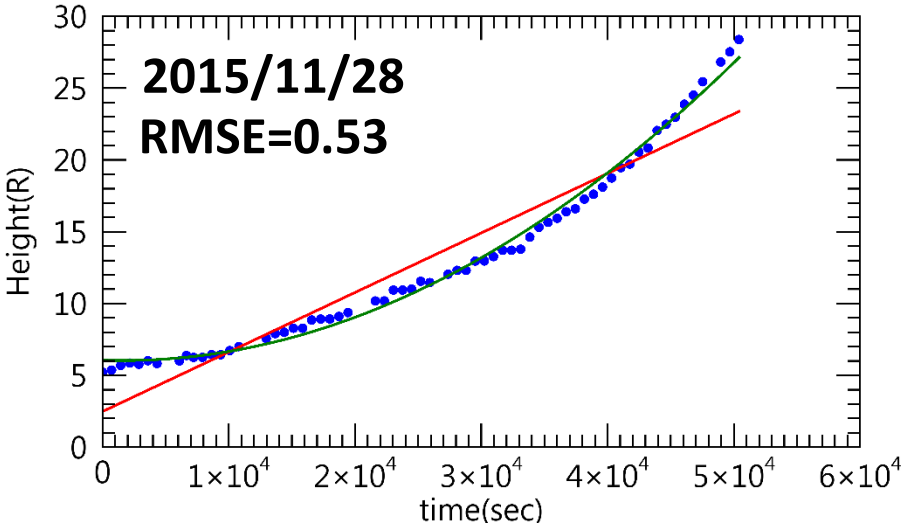
5. Discussion

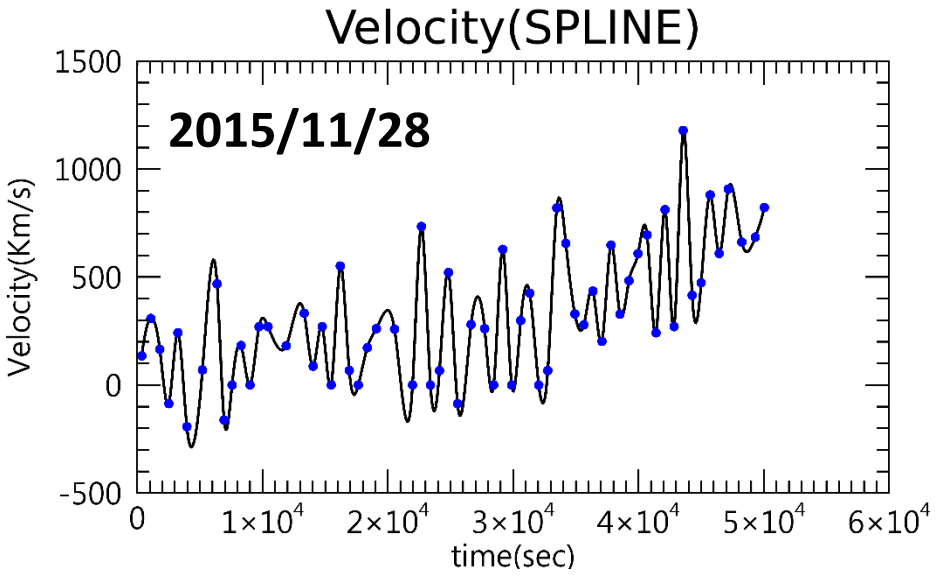
2) Multiple events



5. Discussion

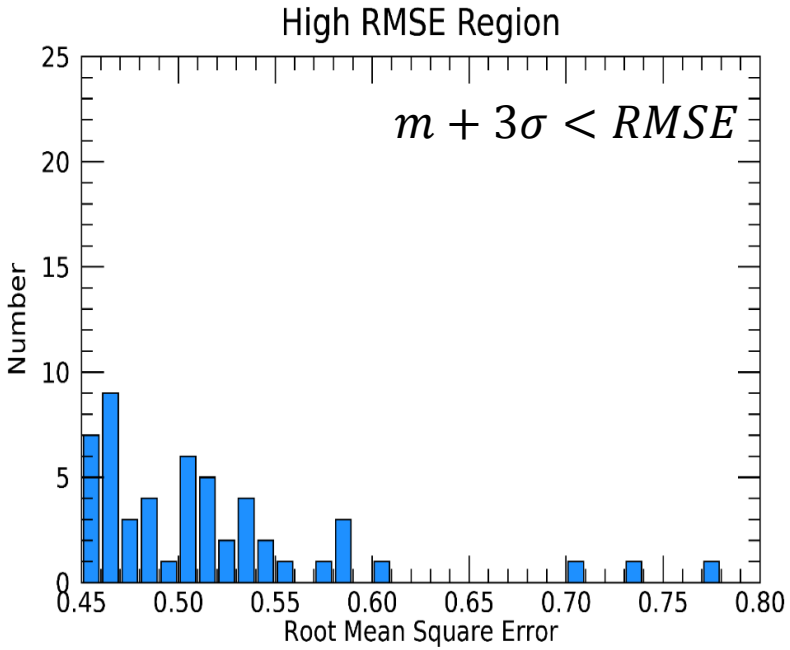
2) Multiple events





5. Discussion

CME events with Large RMSE



Event	number	percentage
Oscillations	10	30%
Multiple	12	36%
Low quality	11	33%

6. Summary

First, the fractions of three motion groups depend on the method used.

Second, the results of the height contribution method are most consistent with those of the visual inspection method, which is thought to be most promising.

Third, the fractions of different kinematic groups for the height contribution method are: Deceleration (19%), Constant velocity (46%), and Acceleration (34%).

6. Summary

Fourth**, the fractions also depend on CME speed**; the fraction of deceleration increase with speed and the fraction of acceleration decreases with speed.

Fifth, **the low speed CMEs tend to accelerate**. But **the high speed CMEs tend to have constant velocity motion**.

Sixth, we examined 33 CMEs with Large RMSE. It is found that about 30 % of these CMEs show quasi-periodic oscillations and 36% of these CMEs show multiple events.

Thank You

jsg0901@khu.ac.kr