Forbush Decrease Prediction Based on Remote Solar Observations

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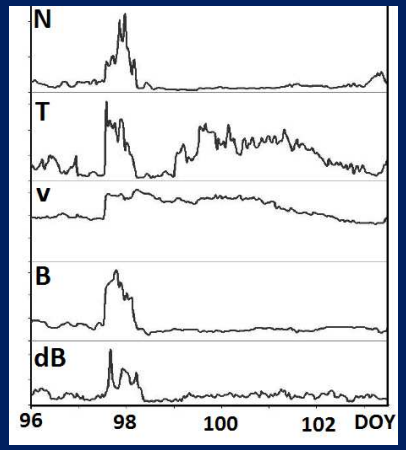
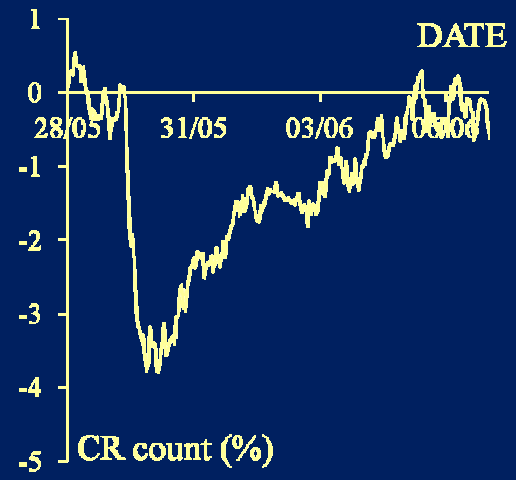
CME → ICME → FD





CME and associated solar flare (LASCO/SOHO and AIA/SDO)

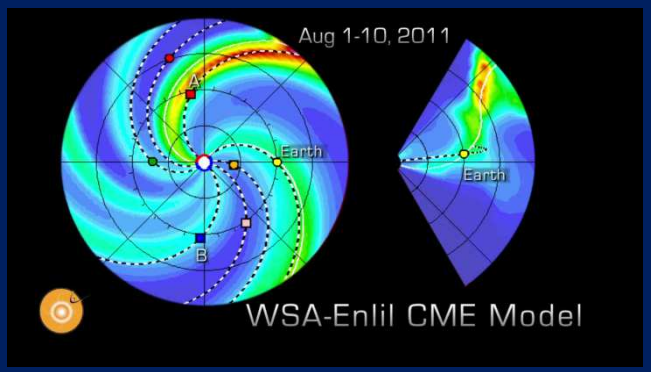
ICME in situ parameters (SWEPAM and MAG/ACE)

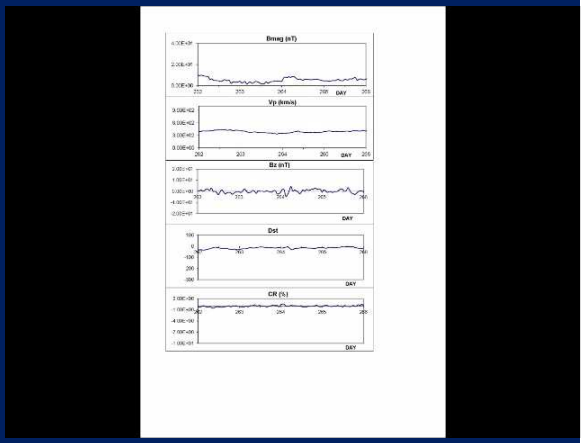
FD (ground-based neutron monitor measurements)

CMEs lead to disturbances in the solar wind and IMF

Solar wind and IMF modulate CR flux

FORBUSH DECREASE PREDICTION PROBLEM





What are we looking at?

CME speed, spatial extend, origin….

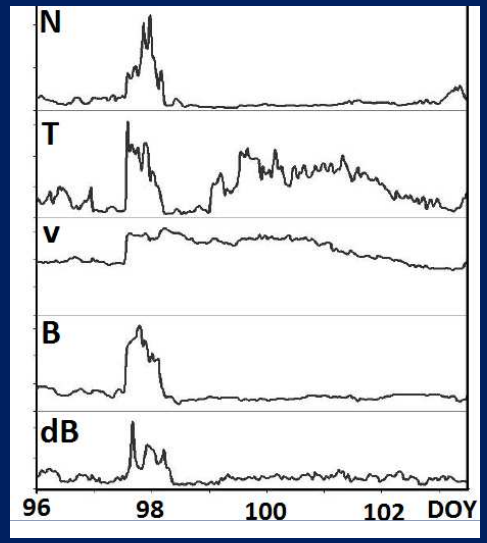
Evolution of CME not solved

Propagation? Magnetic field structure?

Forbush decrease phyisical mechanism not solved

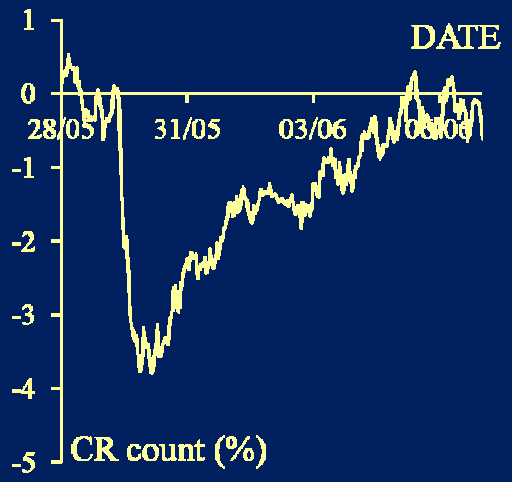
FORBUSH DECREASE PREDICTION APPROACH

SOHO EIT&LASCO composite

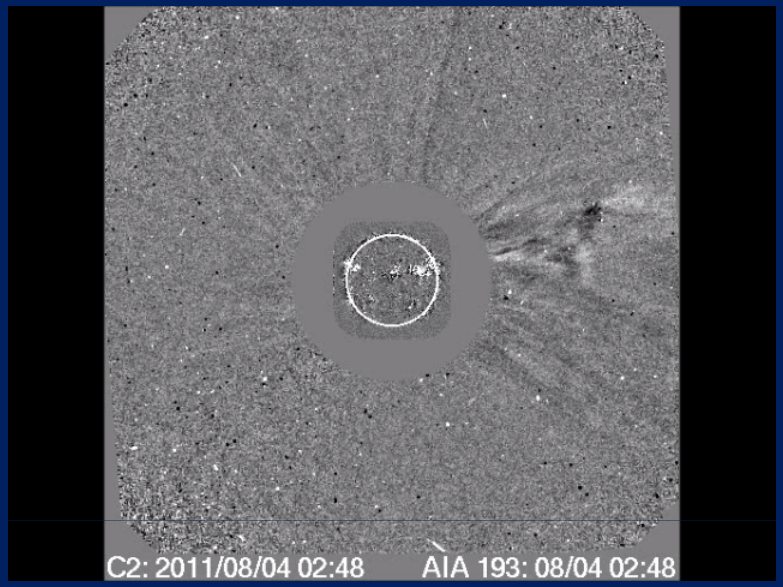


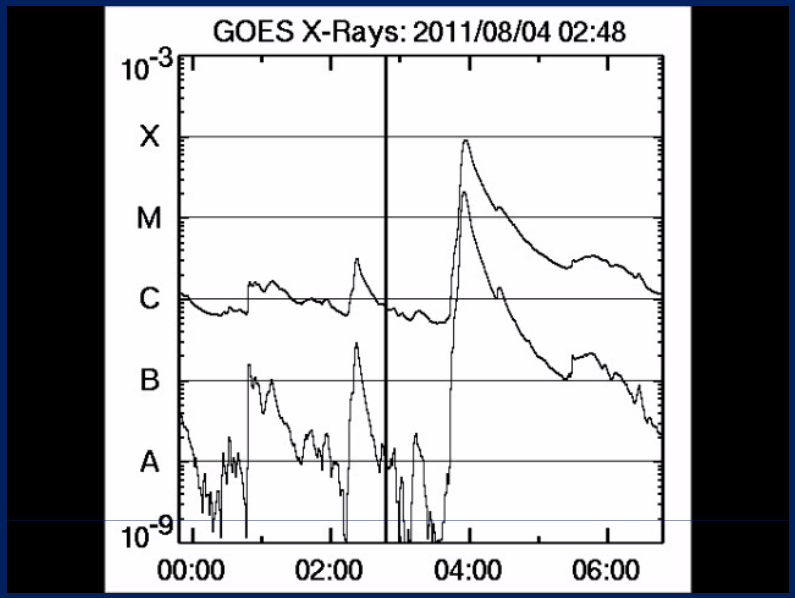
Focus on L1 remote observations and CR flux (without any regard to in situ data)

=> What can be derived?



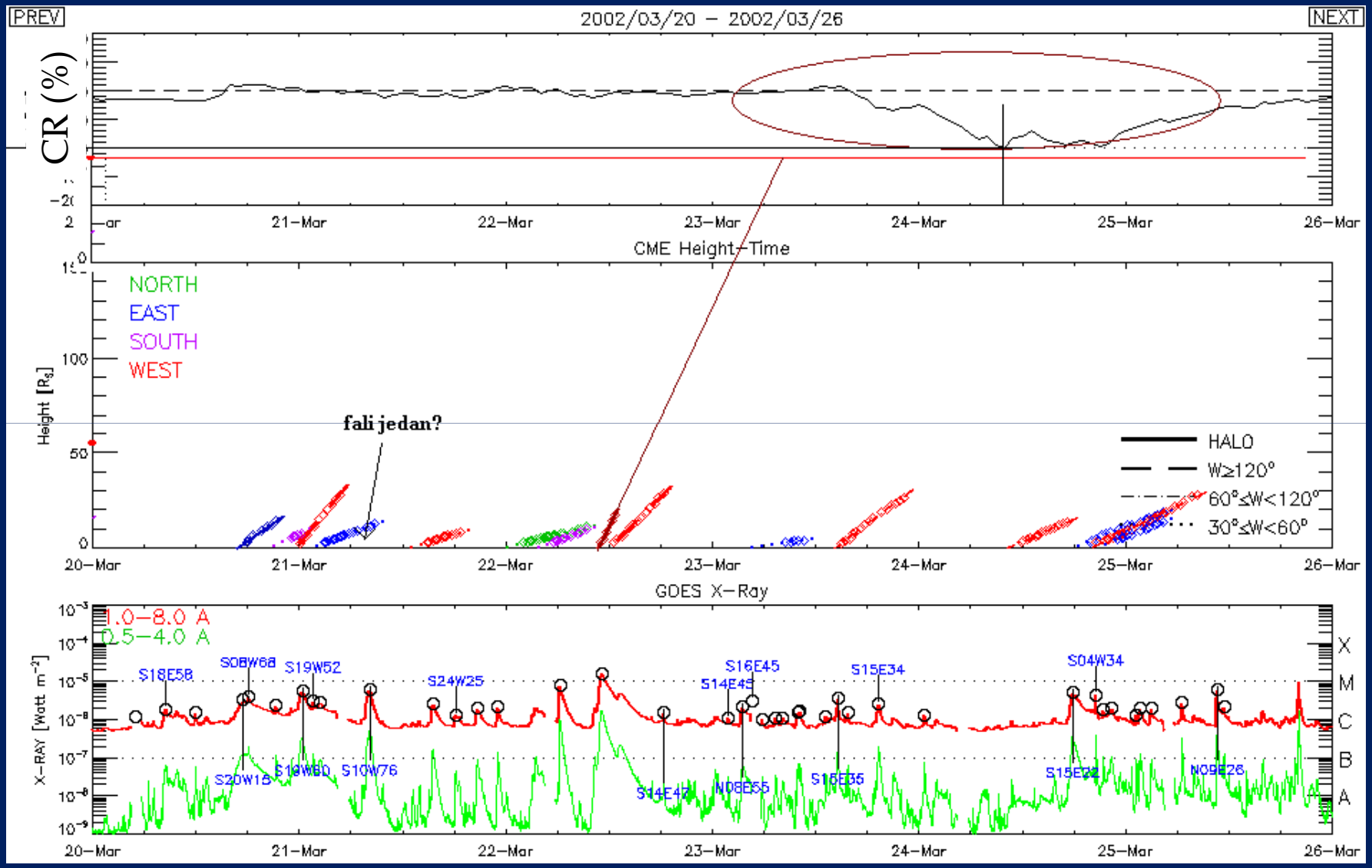
REMOTE SOLAR OBSERVATIONS → FD





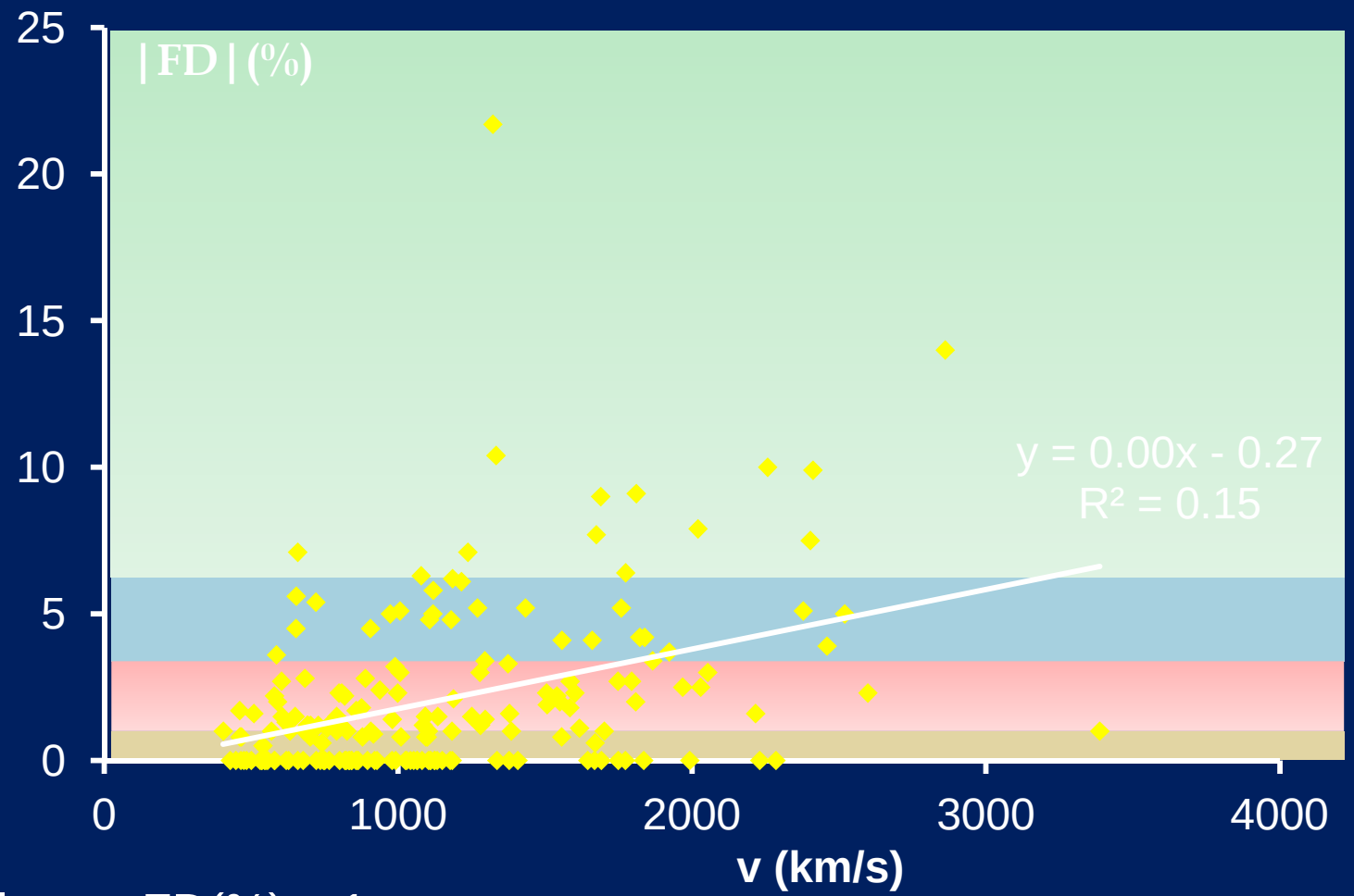
CME-flare associations (frontsided events)

REMOTE SOLAR OBSERVATIONS → FD



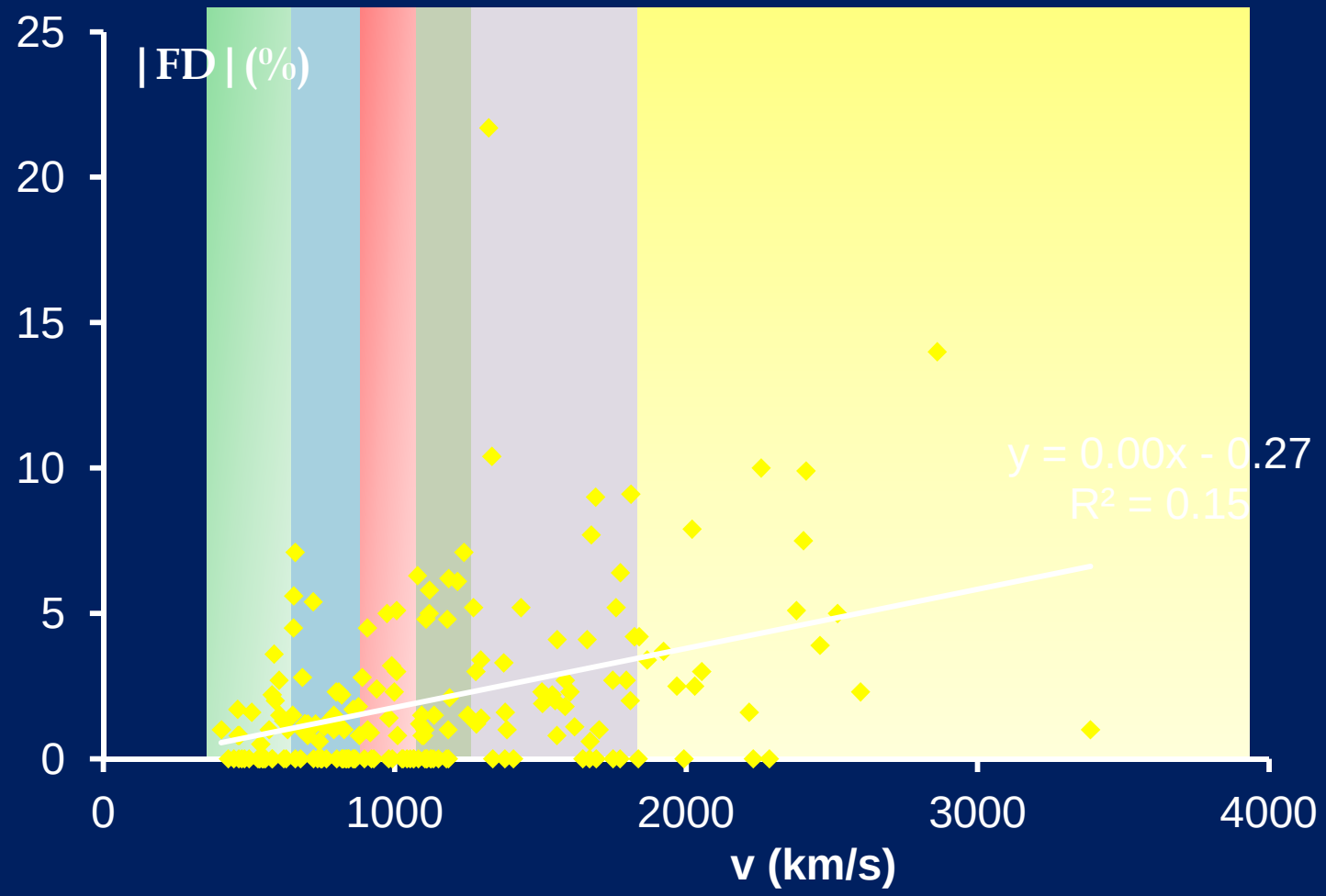
187 CME-flare-CR flux variation associations (not necessarily FD!)

STATISTICAL ANALYSIS - METHOD



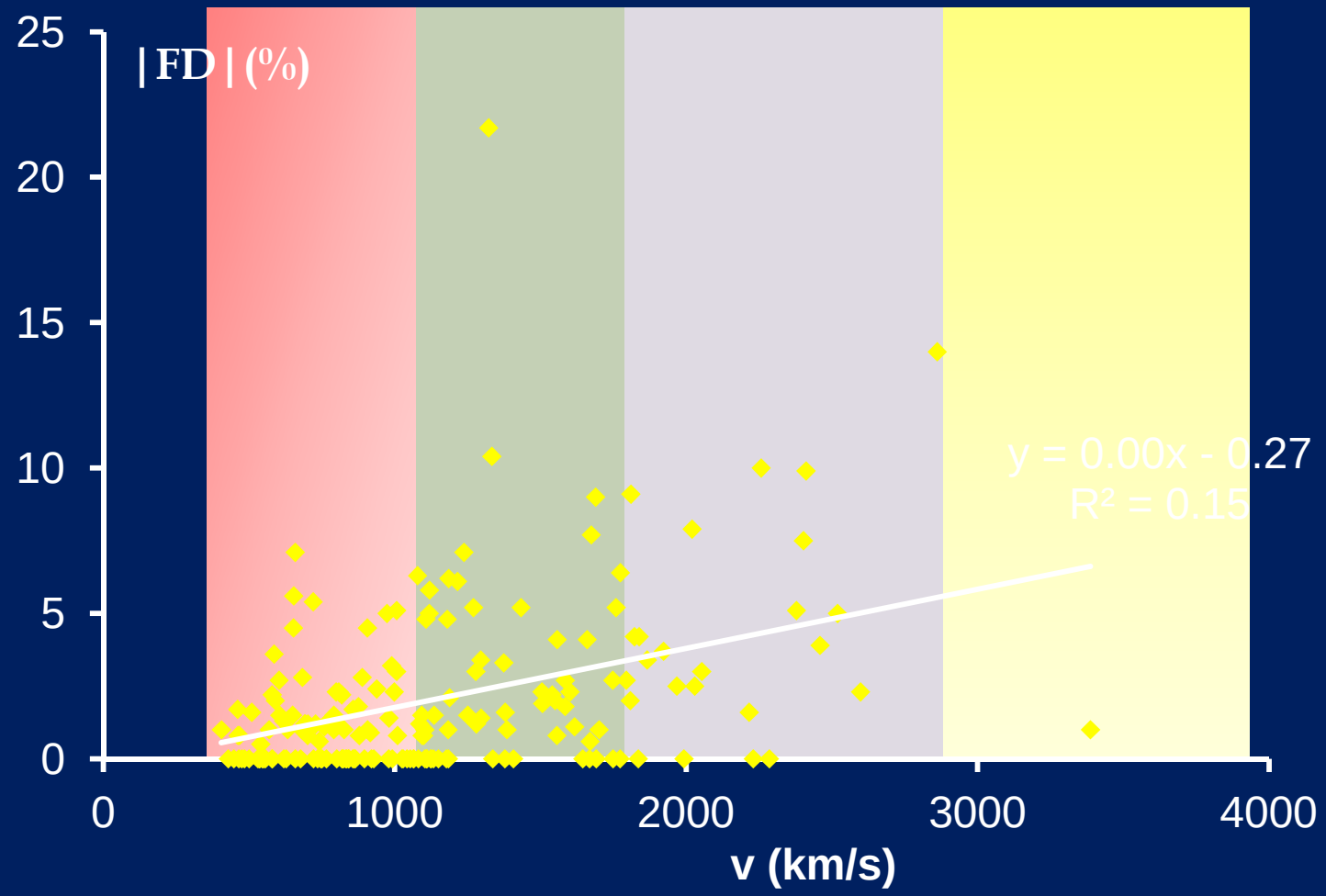
4 FD levels: FD(%) < 1;
1 < FD(%) < 3;
3 < FD(%) <6
FD(%) > 6

STATISTICAL ANALYSIS - METHOD



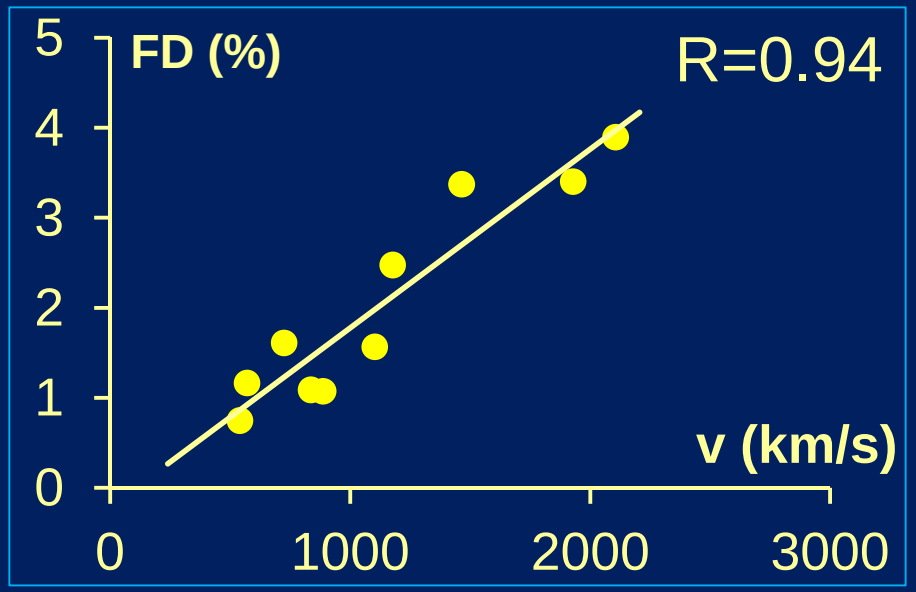
CME/flare parameters also grouped and averaged

STATISTICAL ANALYSIS - METHOD



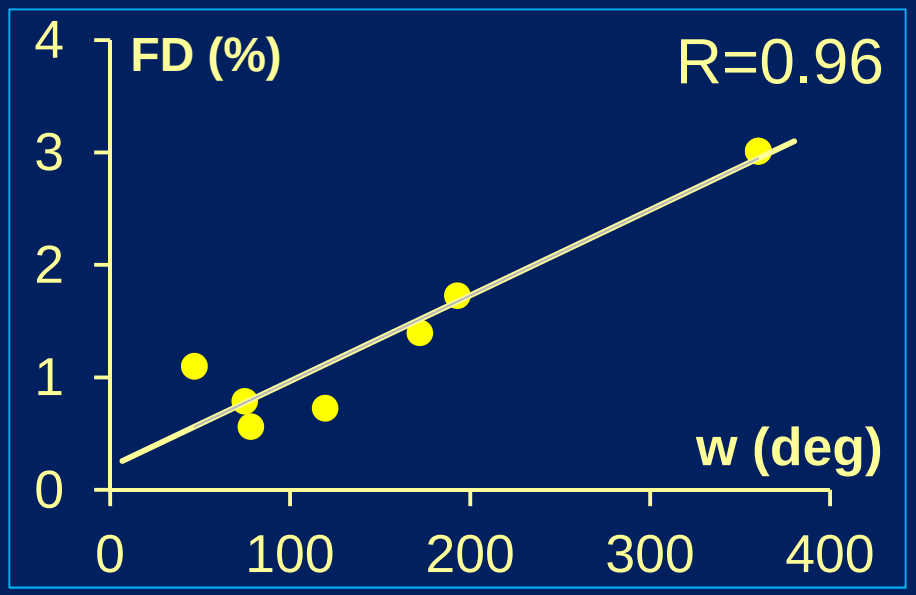
Overlapping bins method – additional data points
(statistics more significant)

STATISTICAL ANALYSIS - RESULTS



CME speed, v

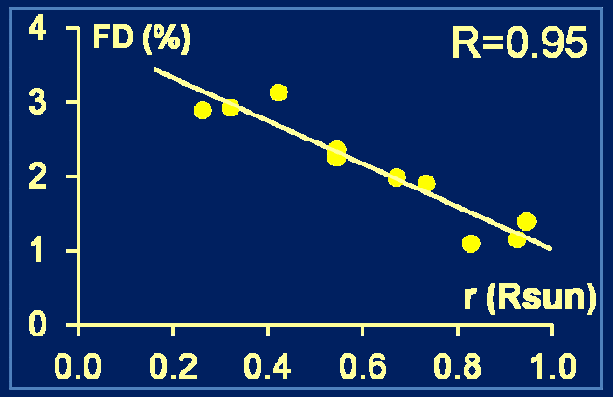
FD(%) is larger for faster CMEs



CME width, w

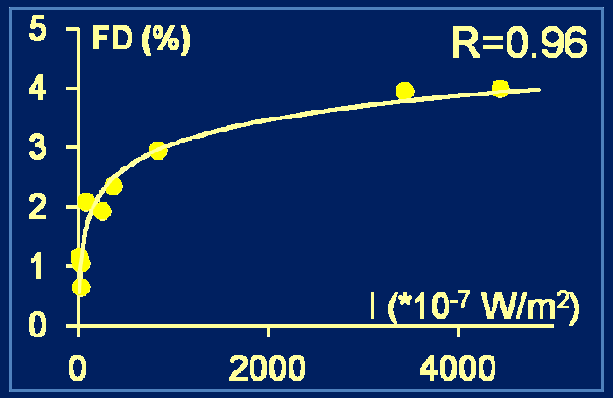
FD(%) is larger for wider CMEs

STATISTICAL ANALYSIS - RESULTS



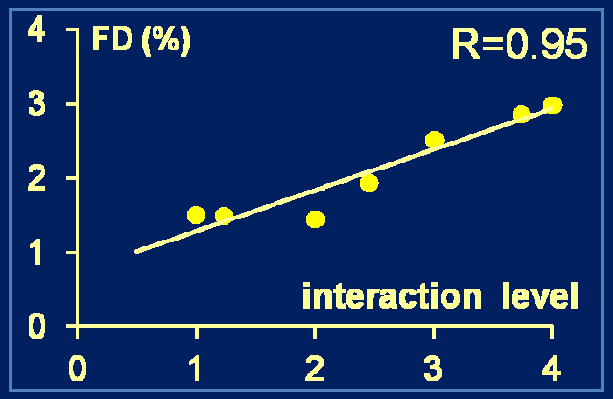
CME/flare position, r

FD(%) is larger for flares originating close to the center of the solar disc



flare Soft X peak intensity, f

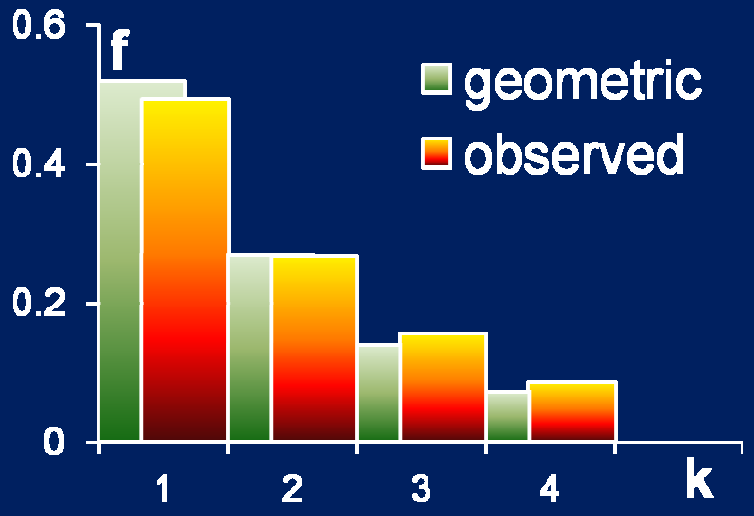
FD(%) is larger for stronger flares



CME-CME interaction level, i

FD(%) is larger for interacting/multiple CMEs

THE MODEL



The distribution of observed Forbush decrease magnitudes (FD(%)) resembles the geometric distribution when the following association is made:

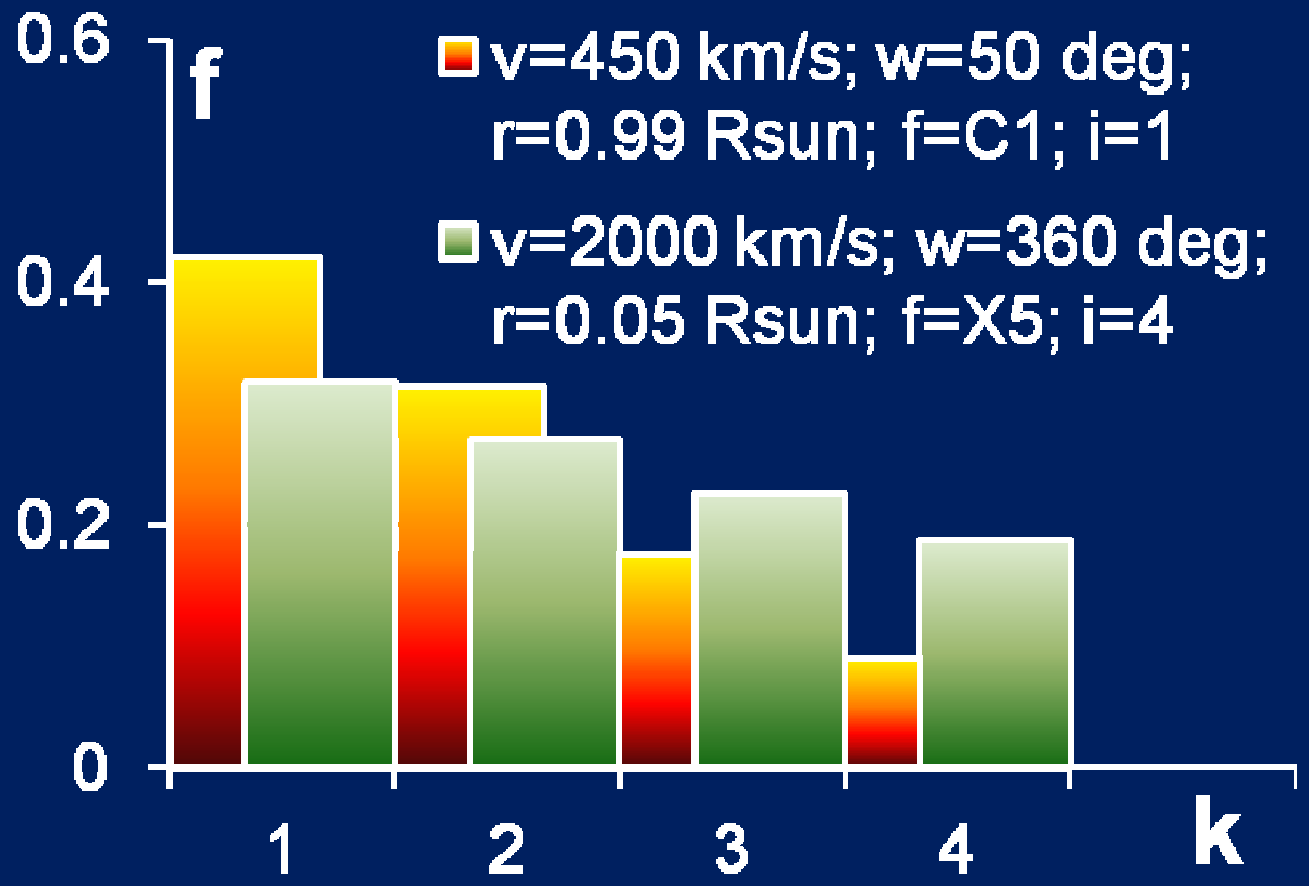
k = 1	FD(%) < 1
k = 2	1 < FD(%) < 3
k = 3	3 < FD(%) <6
k = 4	FD(%) > 6

Assumption: ensemble of events = ensemble of possible “states” for 1 event

Results of the statistical analysis are used to construct the probability distribution for each event

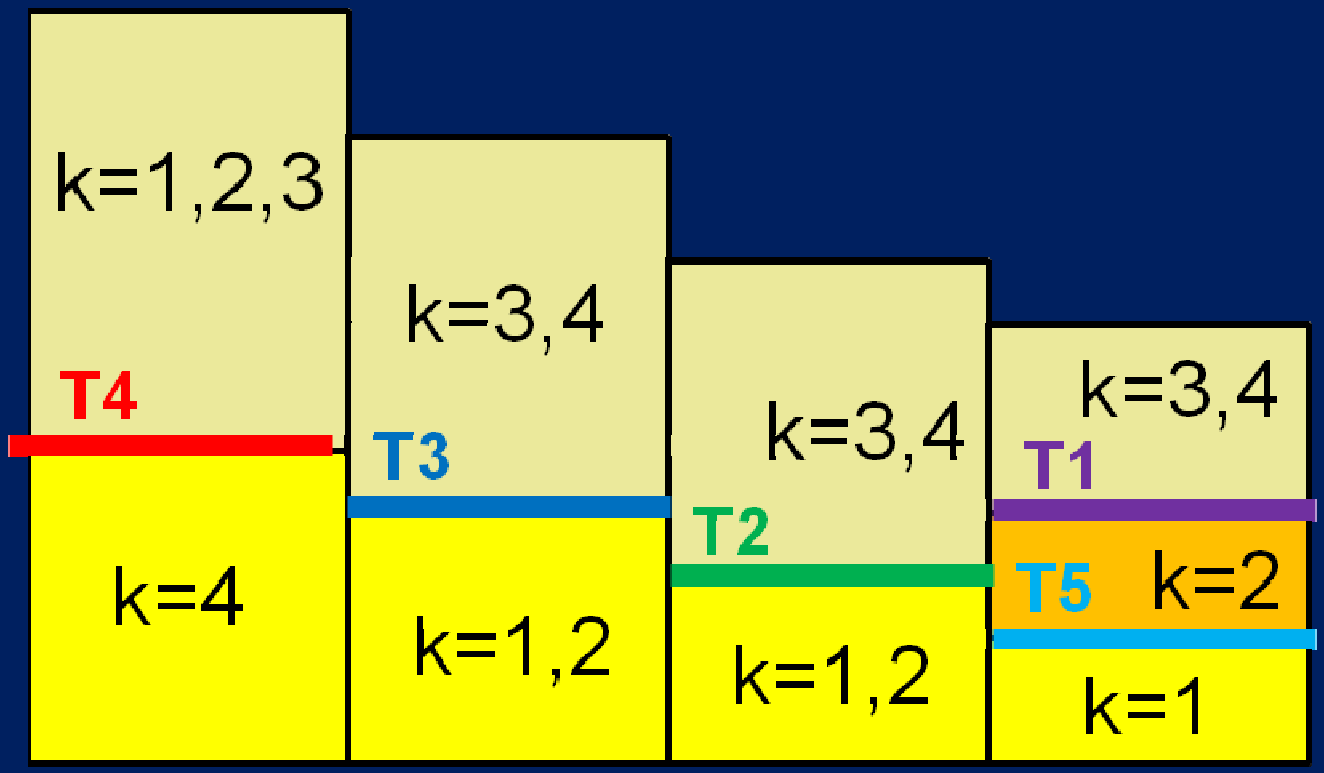
Probability distribution is constructed using geometric distribution fitting

THE MODEL



A constructed probability distribution changes with the solar parameters. However, regardless of the solar parameters the probability distribution always peaks for k=1, i.e. there is always the highest probability that there will be no Forbush effect.

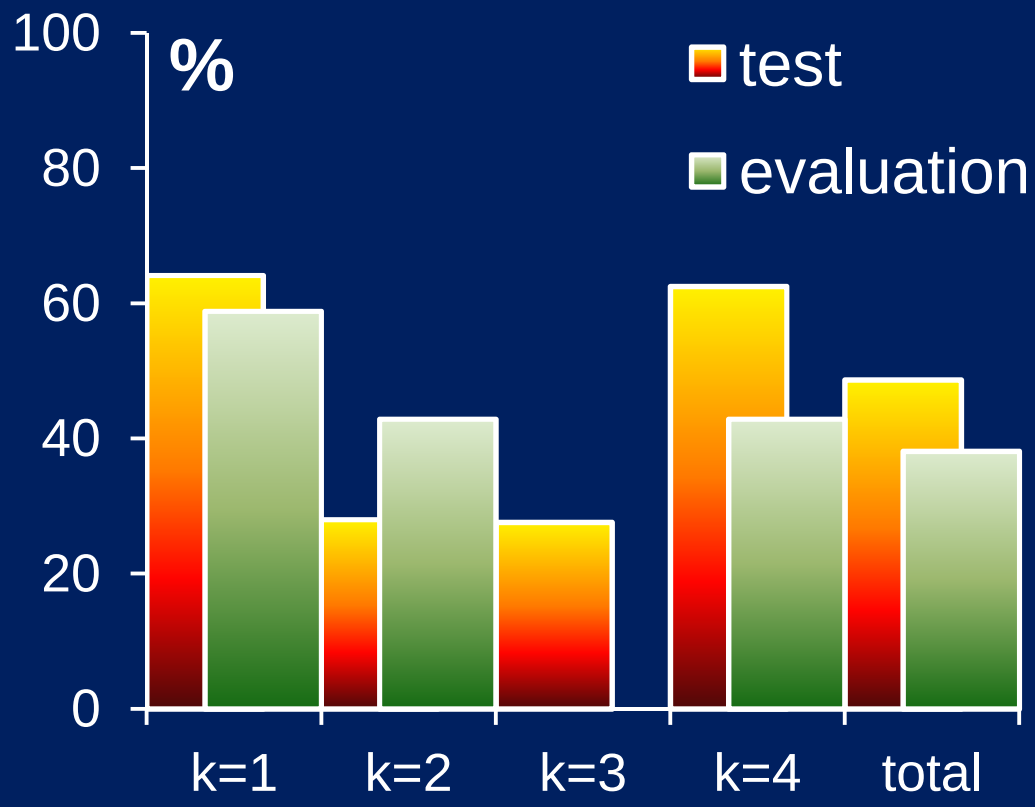
THE MODEL



Therefore, thresholds (T1-T5) have to be set and some conditions imposed on the probability distribution to forecast more (k=1,2,3,4) or less (k>1,k>2, k>3) specific Forbush decrease magnitudes

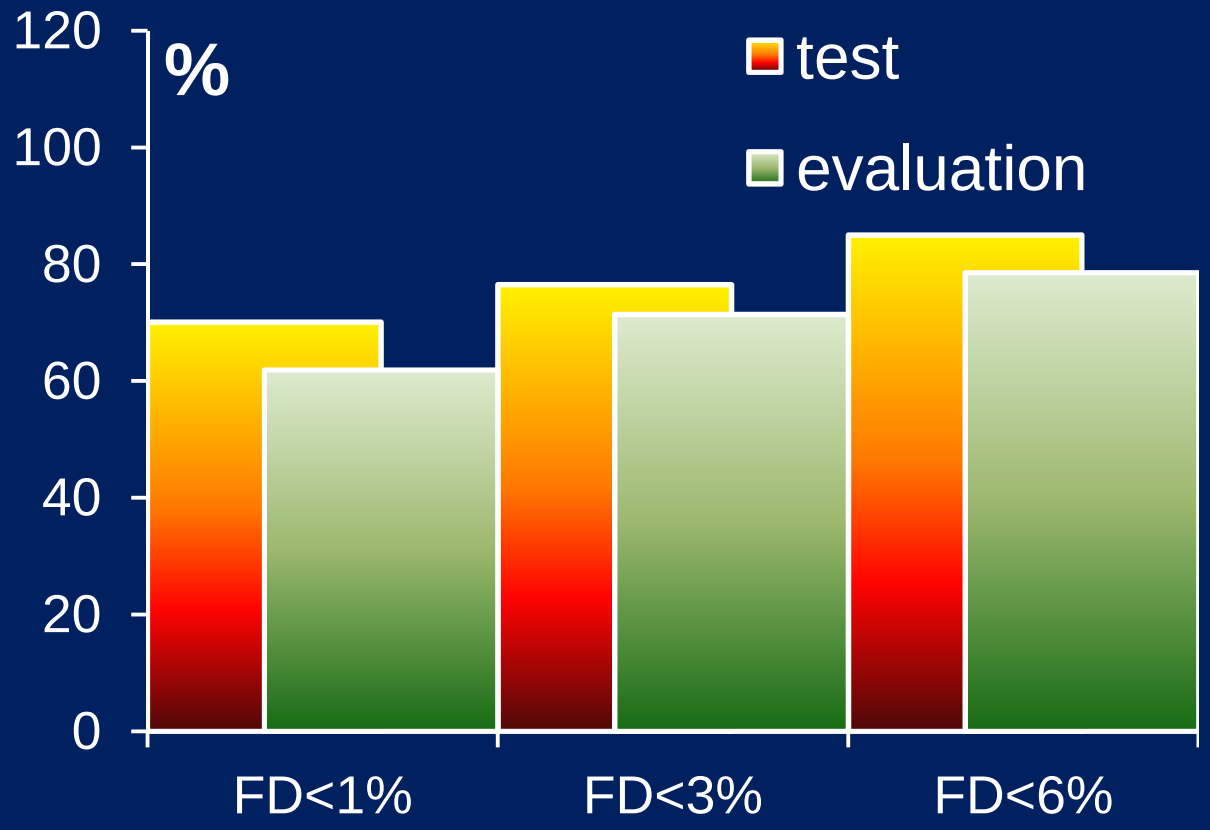
EVALUATION

Evaluation is performed counting the number of “hits” (observed FD equals predicted FD) on the **test sample** (187 CME-flare-FD sample used for the statistical analysis) and **evaluation sample** (independent sample of 42 CME-flare-FD events).



Forecast of specific FD magnitudes (k=1,2,3,4)

EVALUATION



Forecast of less specific
FD magnitudes
(k<2, k<3, k<4)

SUMMARY & CONCLUSIONS

AIM: employ remote solar observations for Forbush effect forecast

METHOD: statistical analysis, distribution fitting

THE MODEL: empirical, statistical, probabilistic

INPUT: remote solar observations of CME and associated solar flare

OUTPUT: expected Forbush decrease magnitude (FD(%))

DRAWBACKS: as the forecast tends to be more specific it is less reliable

ADVANTAGES: early warning (~1 day), input is not necessarily satellite-dependent

Thank you for your attention!

ACKNOWLEDGMENTS:

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