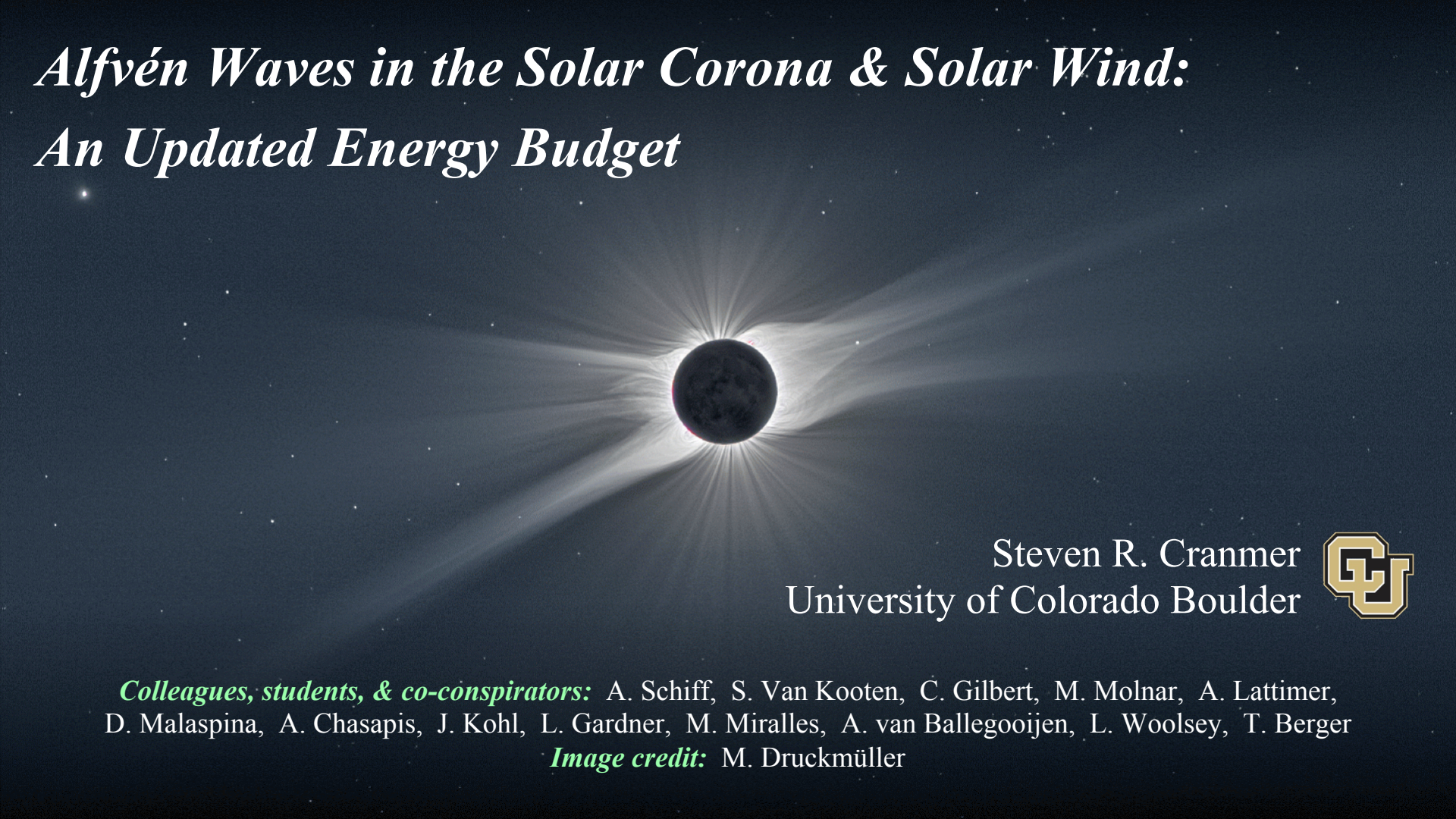
Alfvén Waves in the Solar Corona & Solar Wind: An Updated Energy Budget



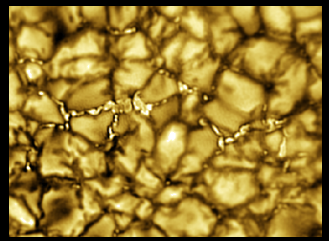
Steven R. Cranmer
University of Colorado Boulder

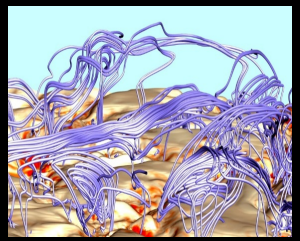
Colleagues, students, & co-conspirators: A. Schiff, S. Van Kooten, C. Gilbert, M. Molnar, A. Lattimer, D. Malaspina, A. Chasapis, J. Kohl, L. Gardner, M. Miralles, A. van Ballegooijen, L. Woolsey, T. Berger

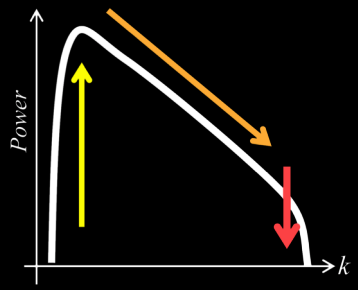
Image credit: M. Druckmüller

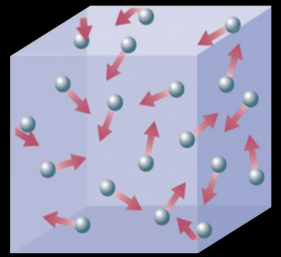
The coronal heating problem

- Why is the corona so hot? *And* how does it produce the varied **solar wind** properties we see?
- Many theories exist. Each needs to be tested by comparison with data.
- MHD turbulence? Convection seems to drive waves, which evolve into nonlinear fluctuations, which then "cascade" to small scales to dissipate:





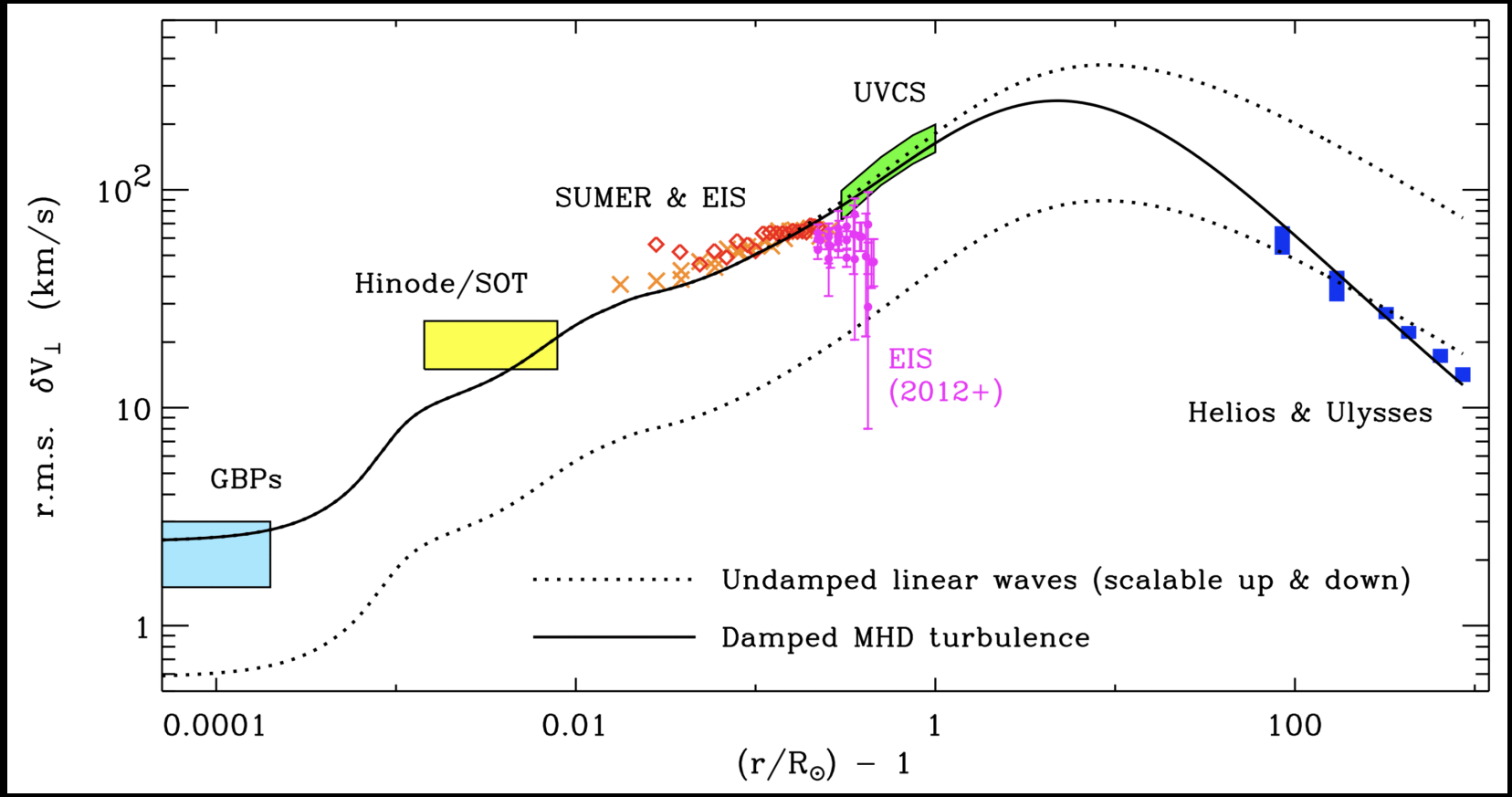




So why haven't we solved it yet?

- Problem #1: turbulence is complex, stochastic, multi-scale, kinetic, . . .
- Problem #2: it's not easy to identify coronal origins of fast wind ≠ slow wind

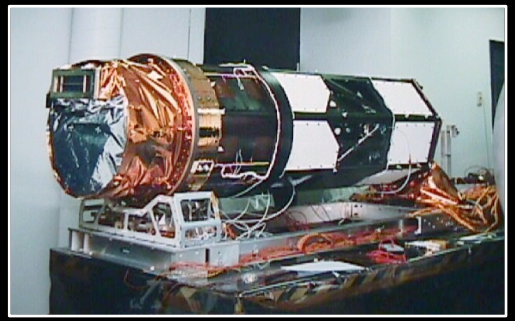
Problem #3: Many different measurements are needed

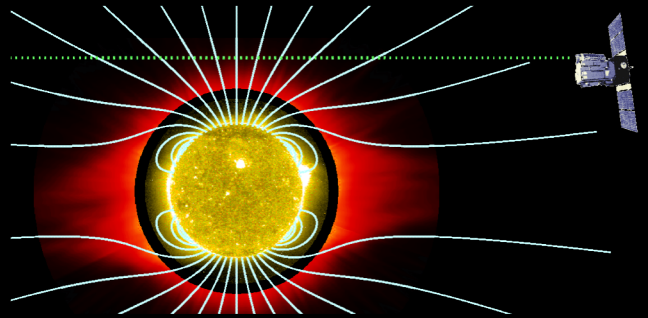


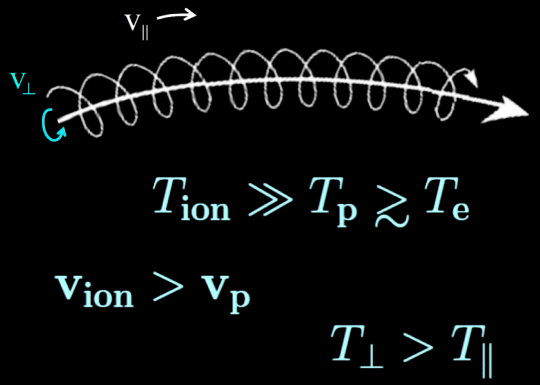
New data points to add to the plot . . .

1. **Parker Solar Probe,** of course! My analysis, compared with Chen et al. (arXiv:1912.02348)

2. Re-analysis of H I Lyman α data, in polar coronal holes, from the **Ultraviolet Coronagraph Spectrometer (UVCS)** on *SOHO*.

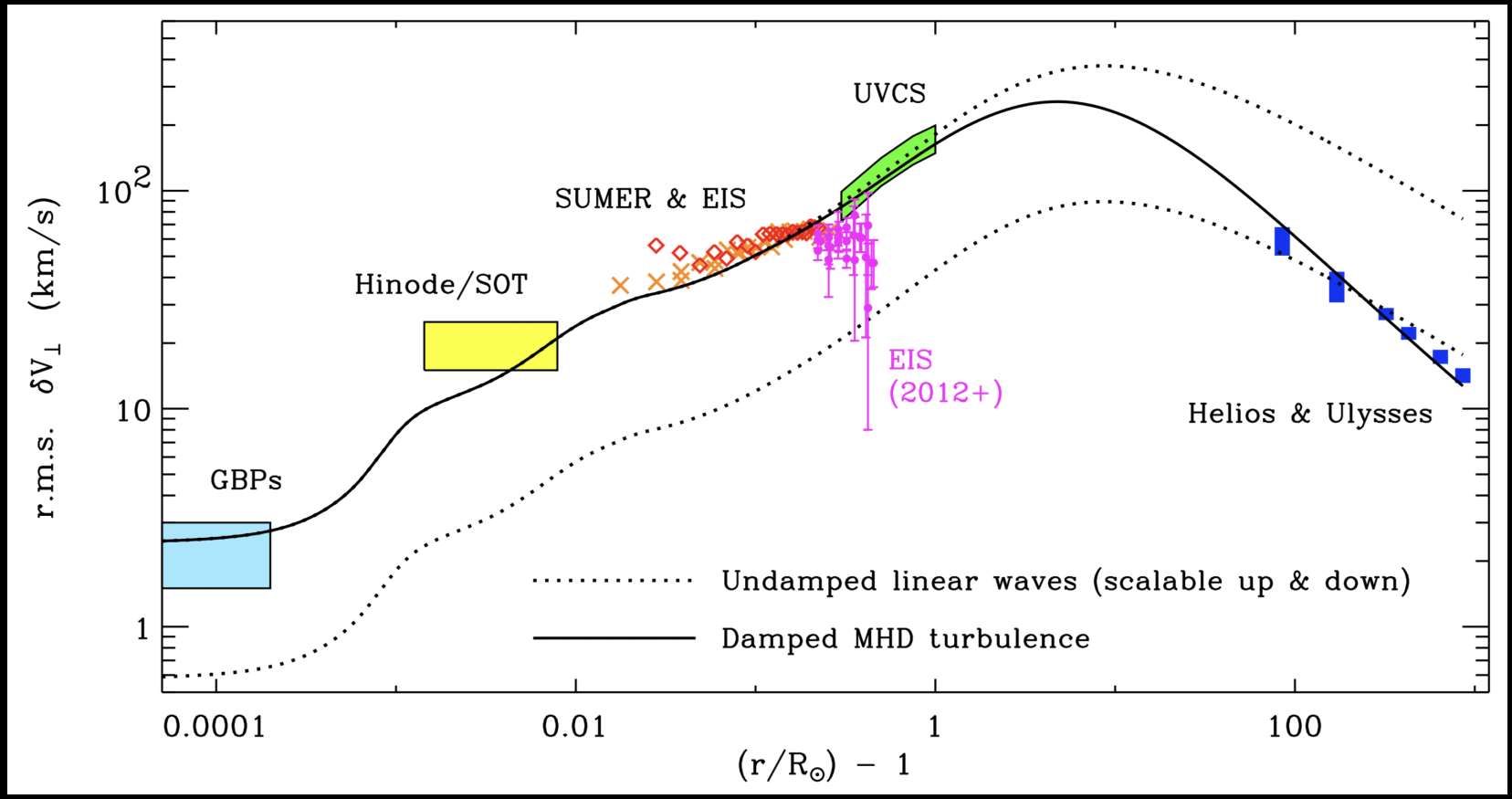




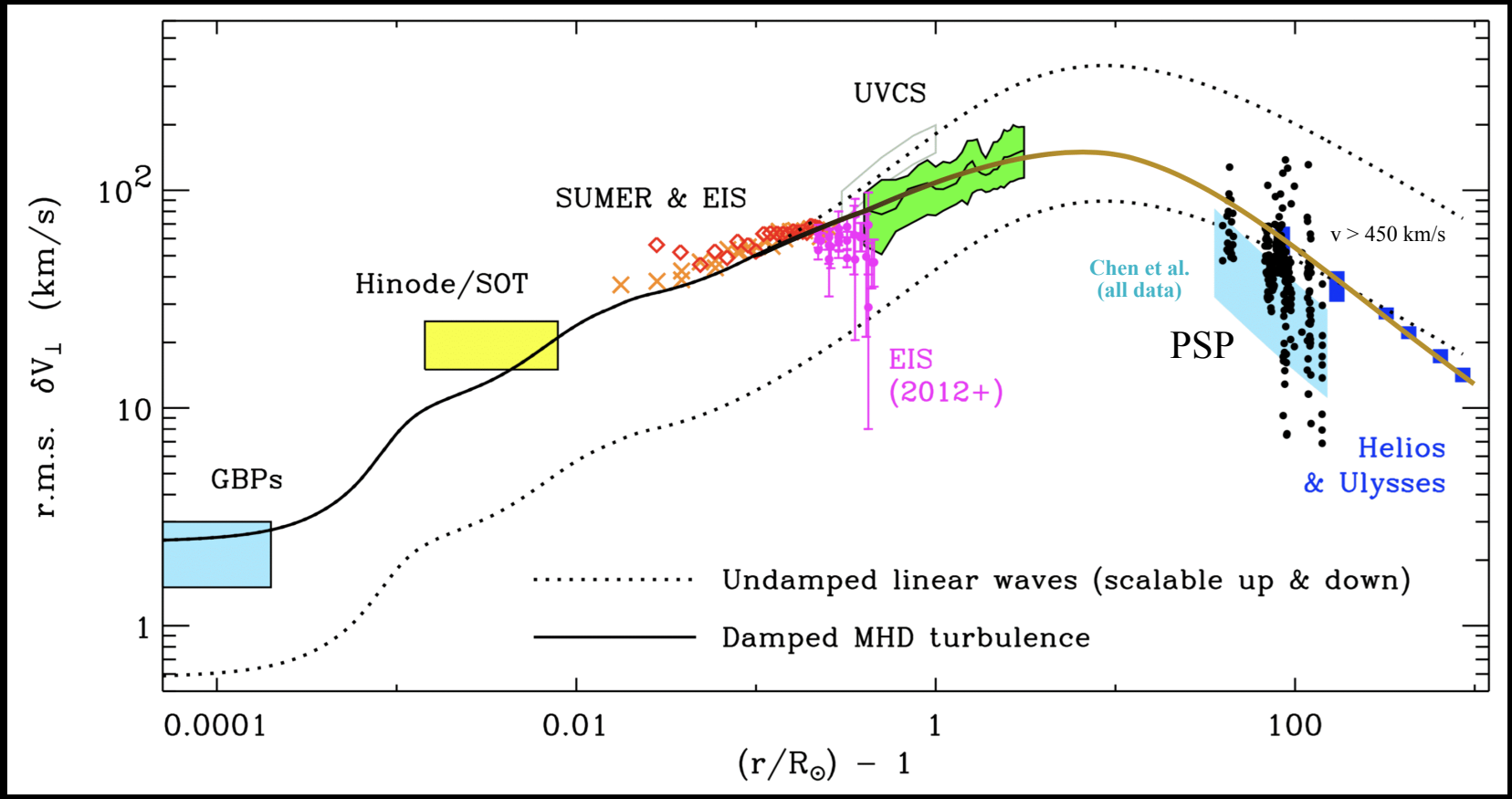


- Monte Carlo forward-modeling: 2.8 million trial sets of plasma parameters were tried...
- Only 3,507 of them (0.125%) agreed with observations & mass/momentum conservation.

New data points for MHD turbulence amplitudes



New data points for MHD turbulence amplitudes



Conclusions

- MHD turbulence may be slightly weaker than expected, but that seems to indicate more damping **(more heating?)** in the extended corona.
- We're still looking forward to future PSP perihelia that sample more fast wind.
- Additional observational & modeling synergy is needed . . .

@solarstellar