Removing Stellar Activity from RVs Using Machine Learning

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HARPS-N Solar Telescope Collaboration

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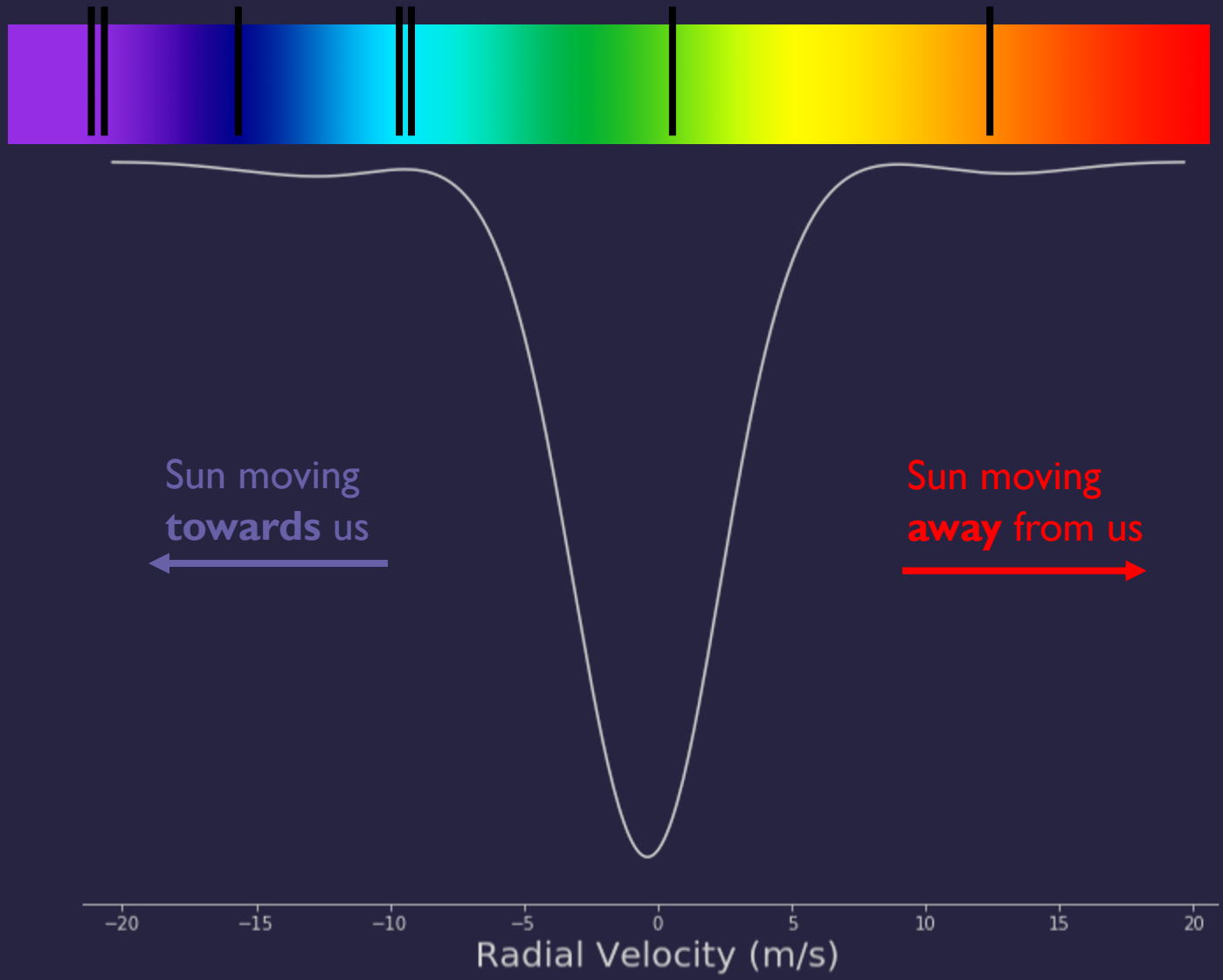
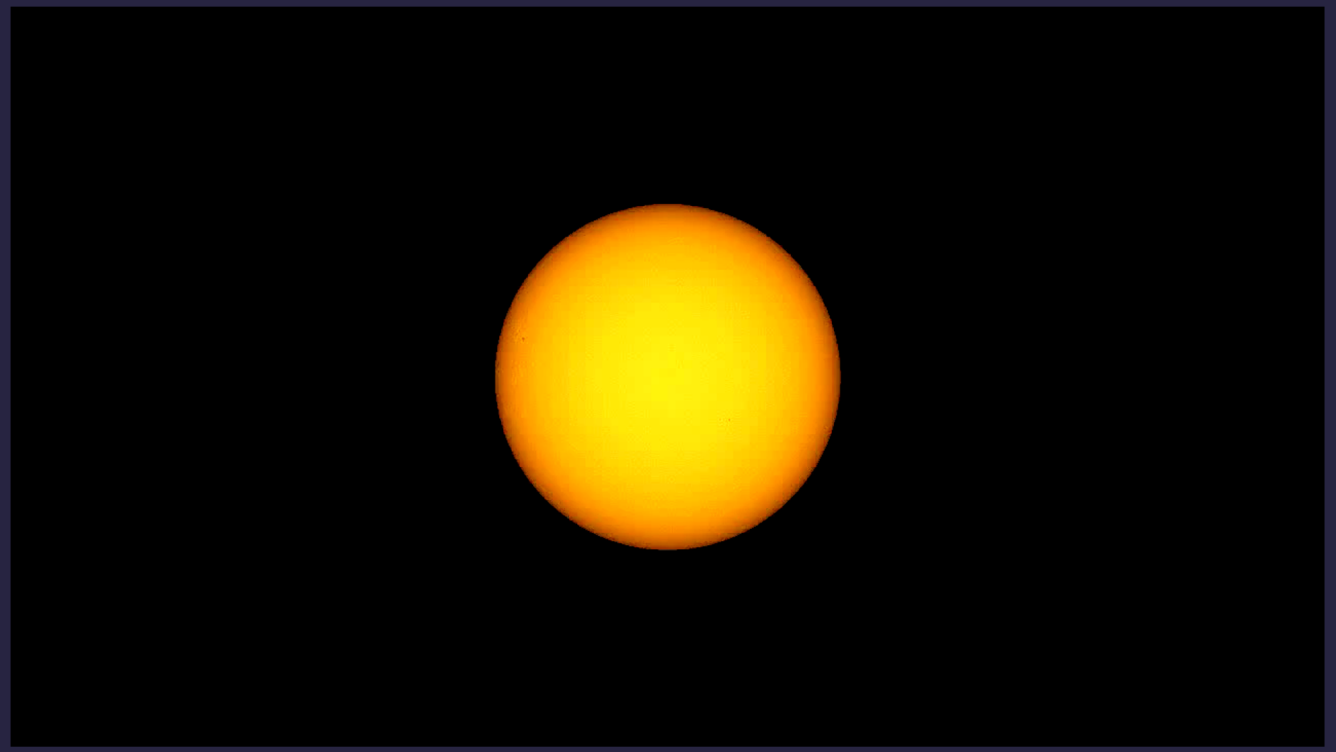
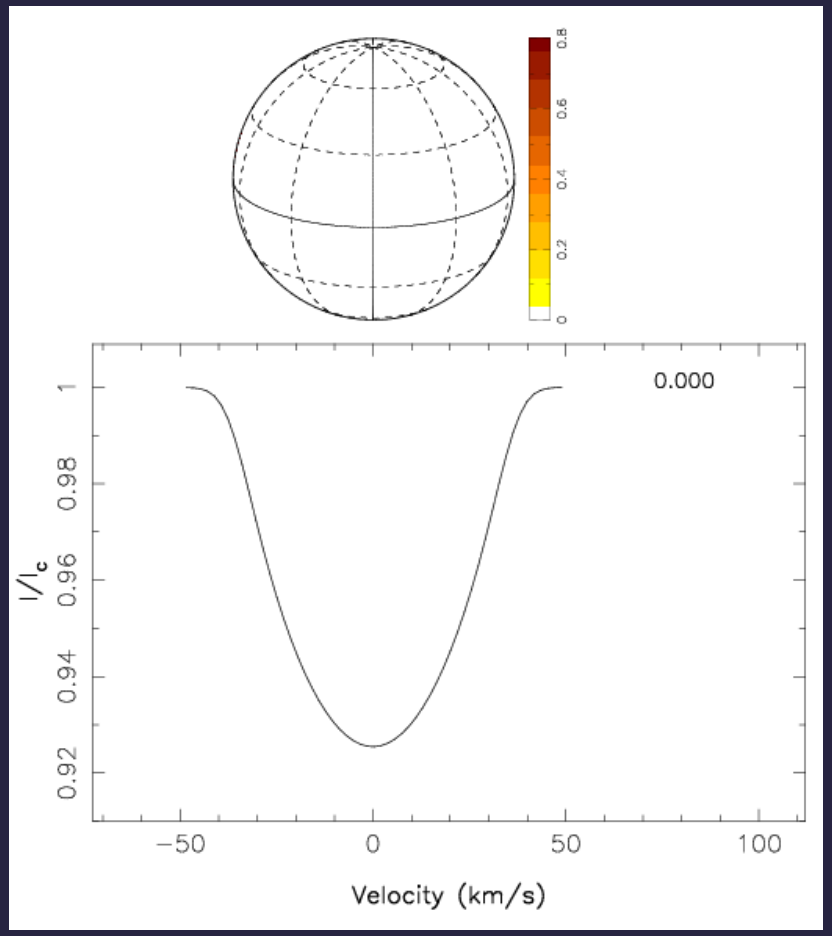
RV Method: Planets introduce translational shifts to CCF



Problem: Stellar activity changes the line shape of CCFs

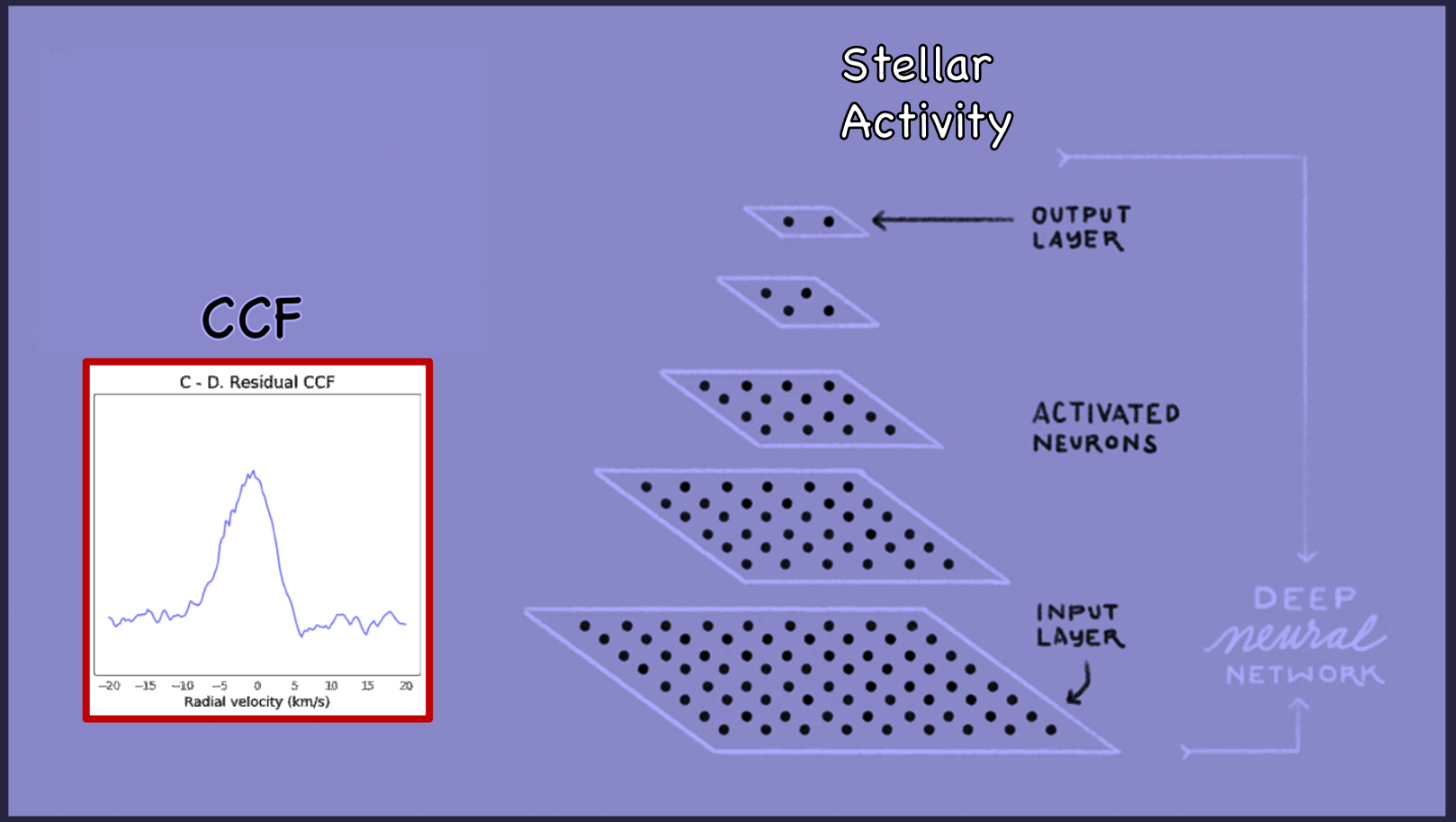


Source: Solar and Heliospheric Observatory



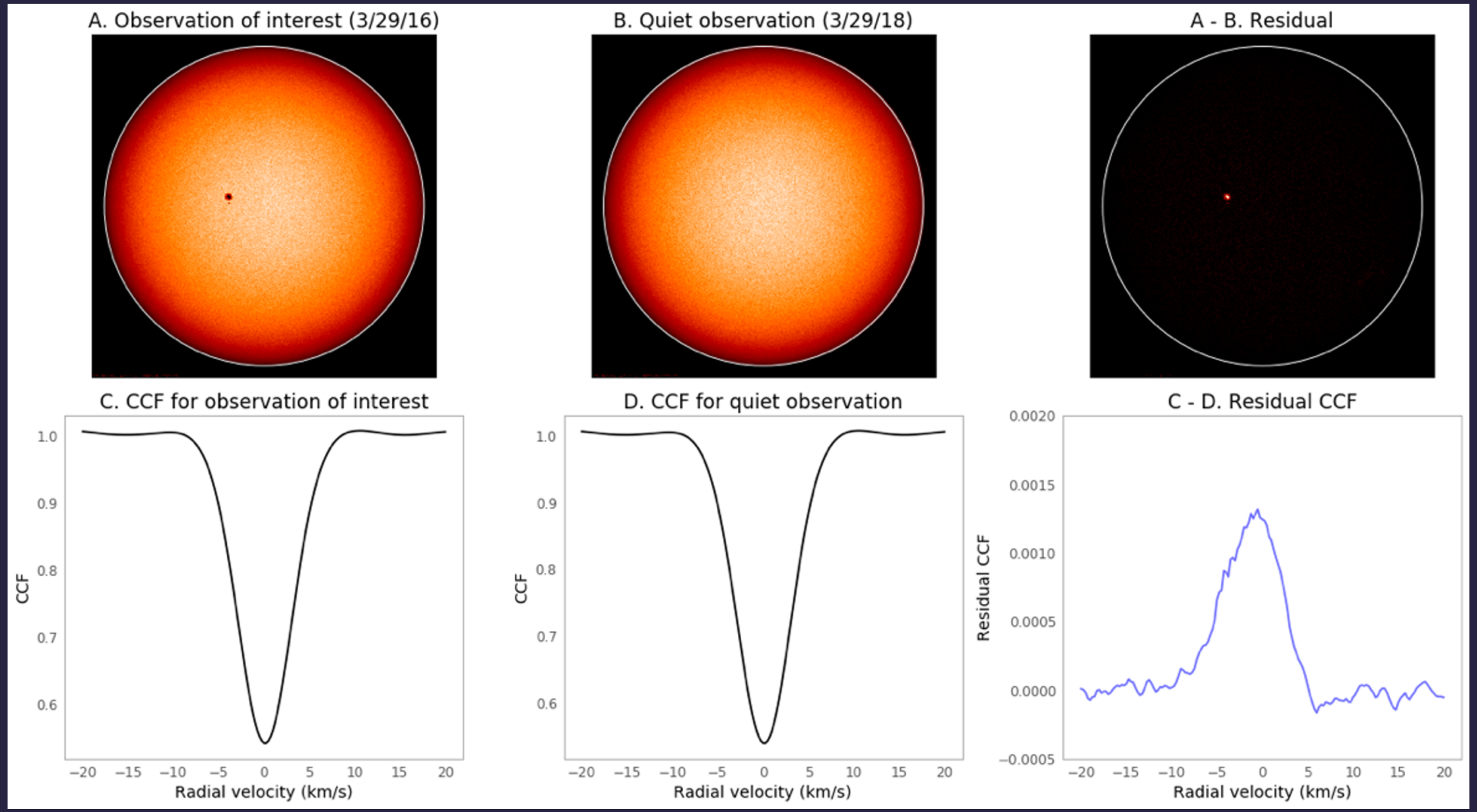
Source: Jean-François Donati

Our solution: Train a neural network to remove stellar activity noise



Modified from Google

What information do we give the neural network?



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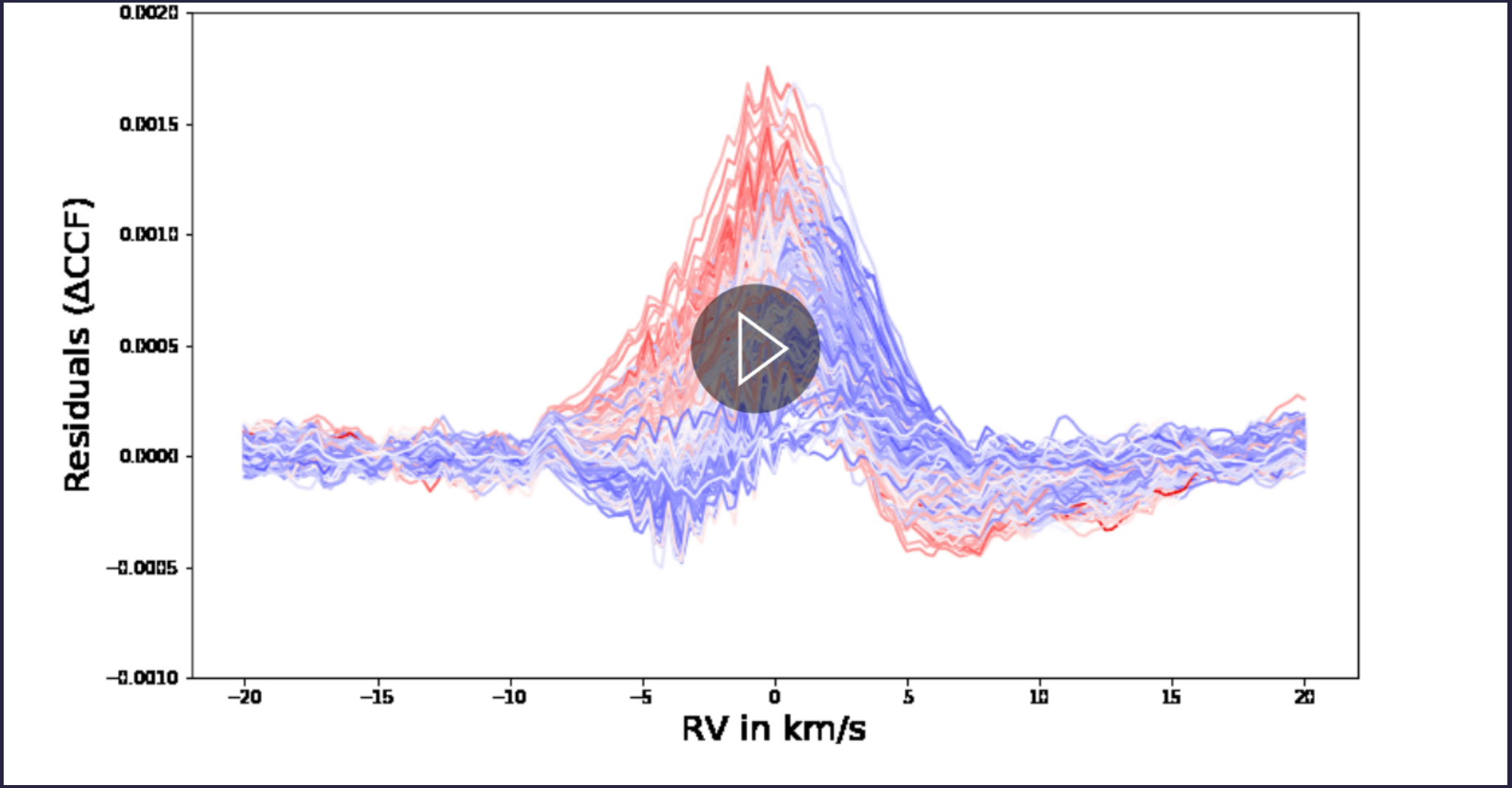
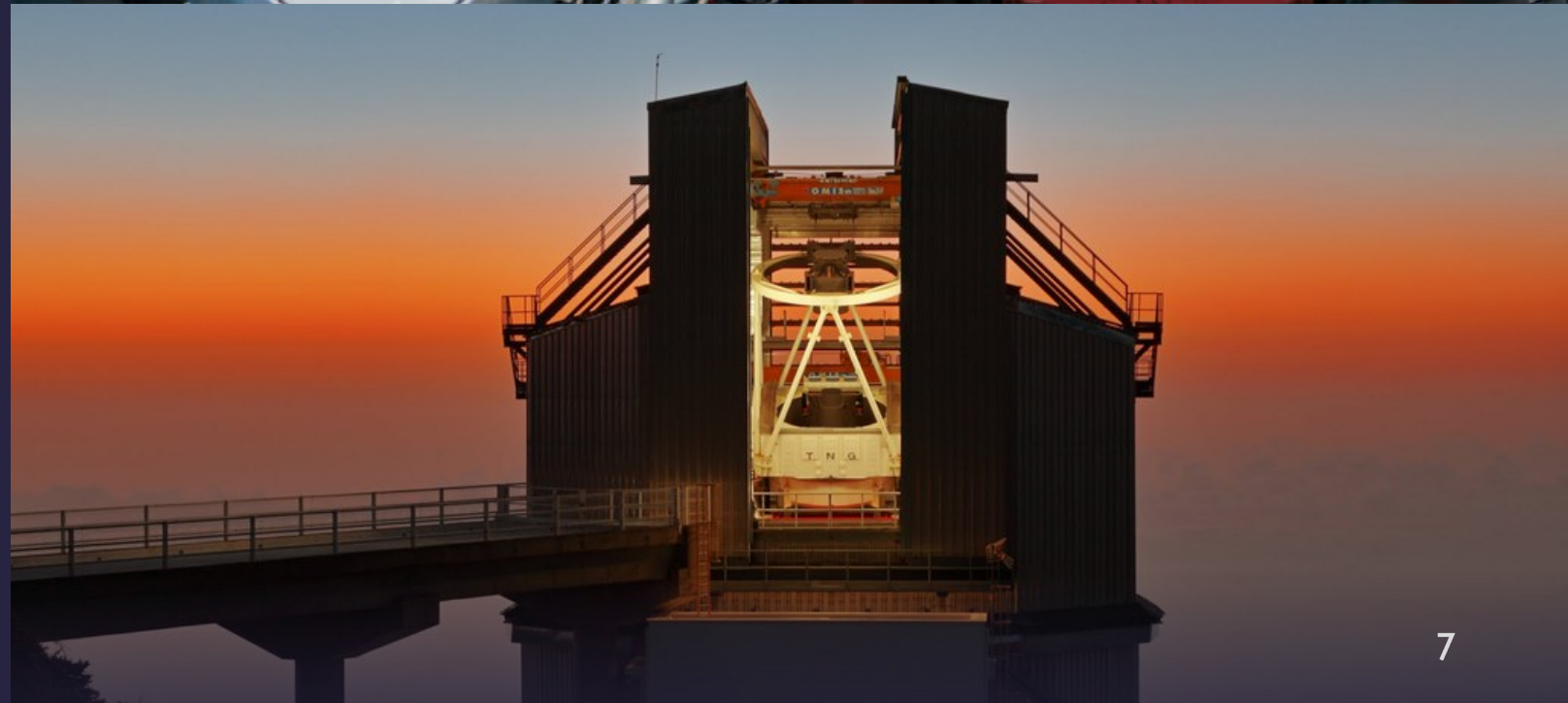


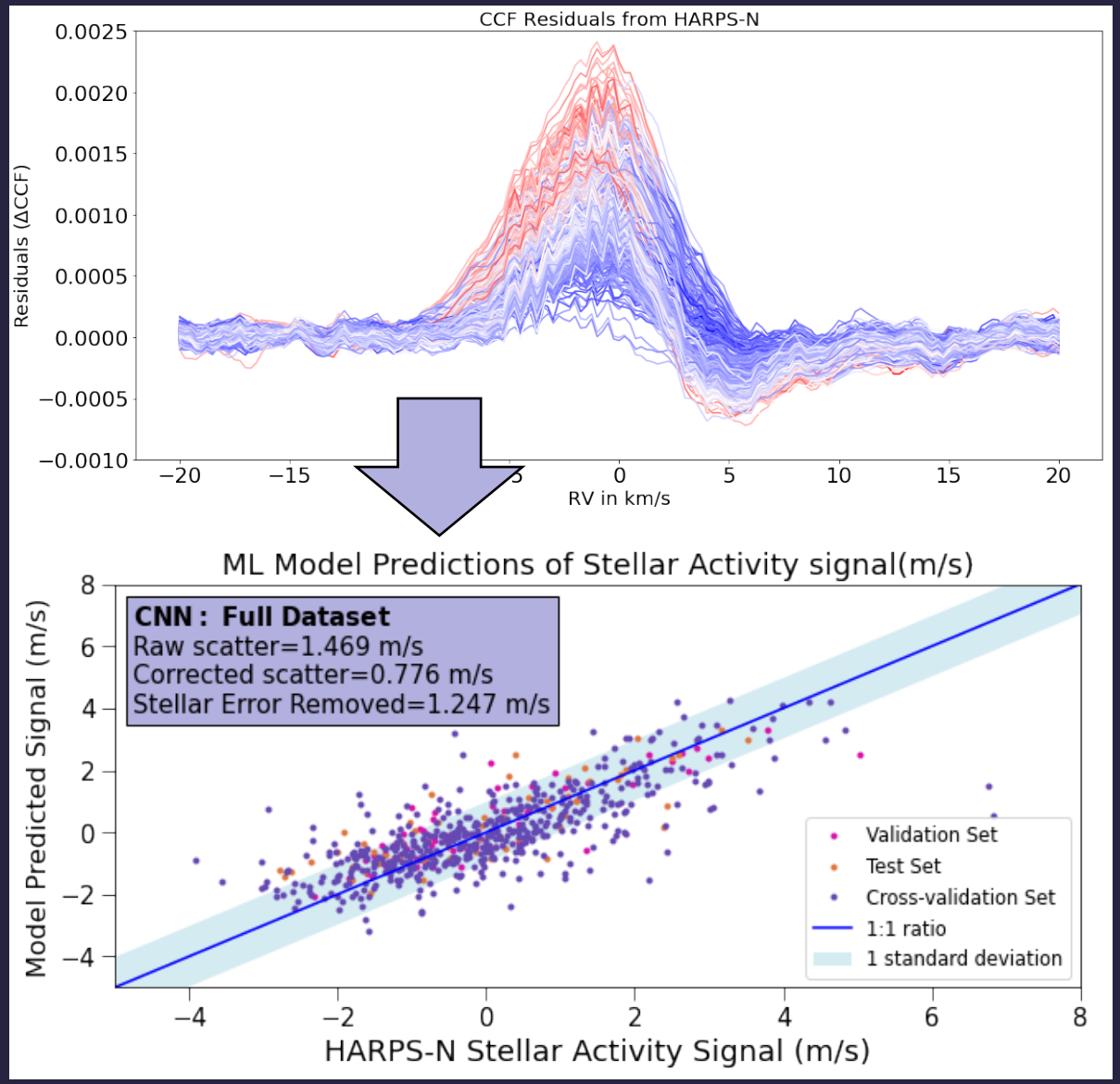
Training Set: HARPS-N Solar Telescope Observations

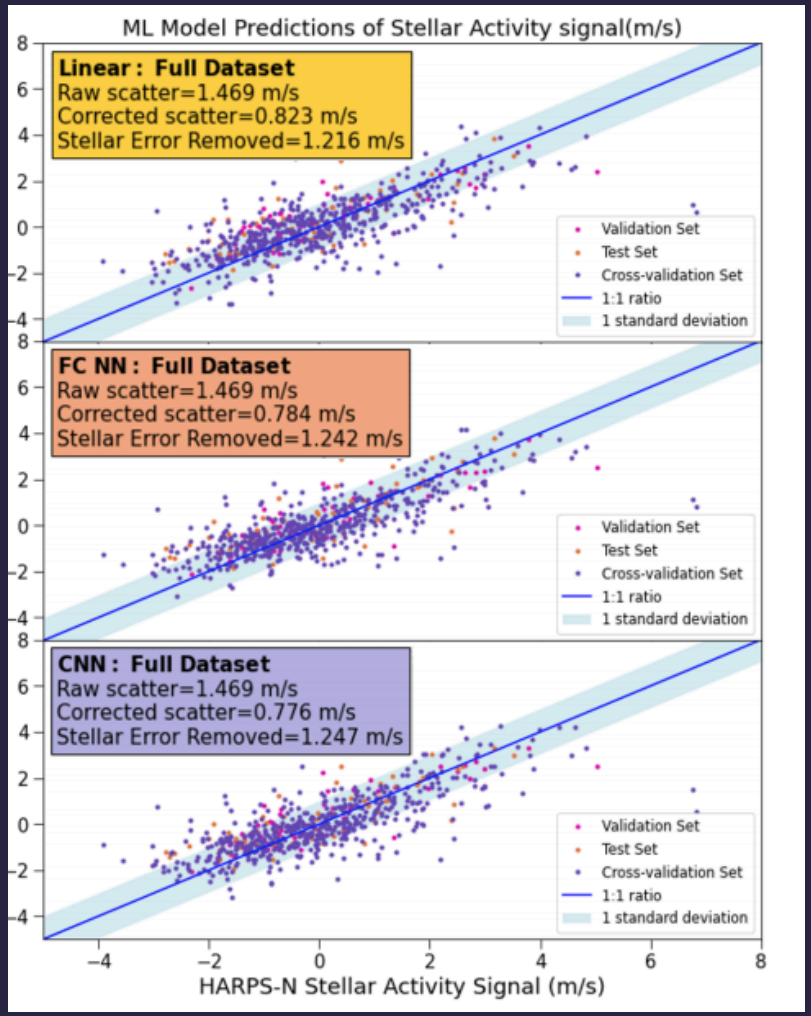
HARPS-N Solar Telescope

- A high-precision spectrograph
- Located on the Telescope Nazionale Galileo (TNZ) in La Palma, Canary Islands, Spain
- HARPS-N Observations from July 2015 to December 2018



For Solar Data, we reduced RV jitter by a factor of ~2 using these methods





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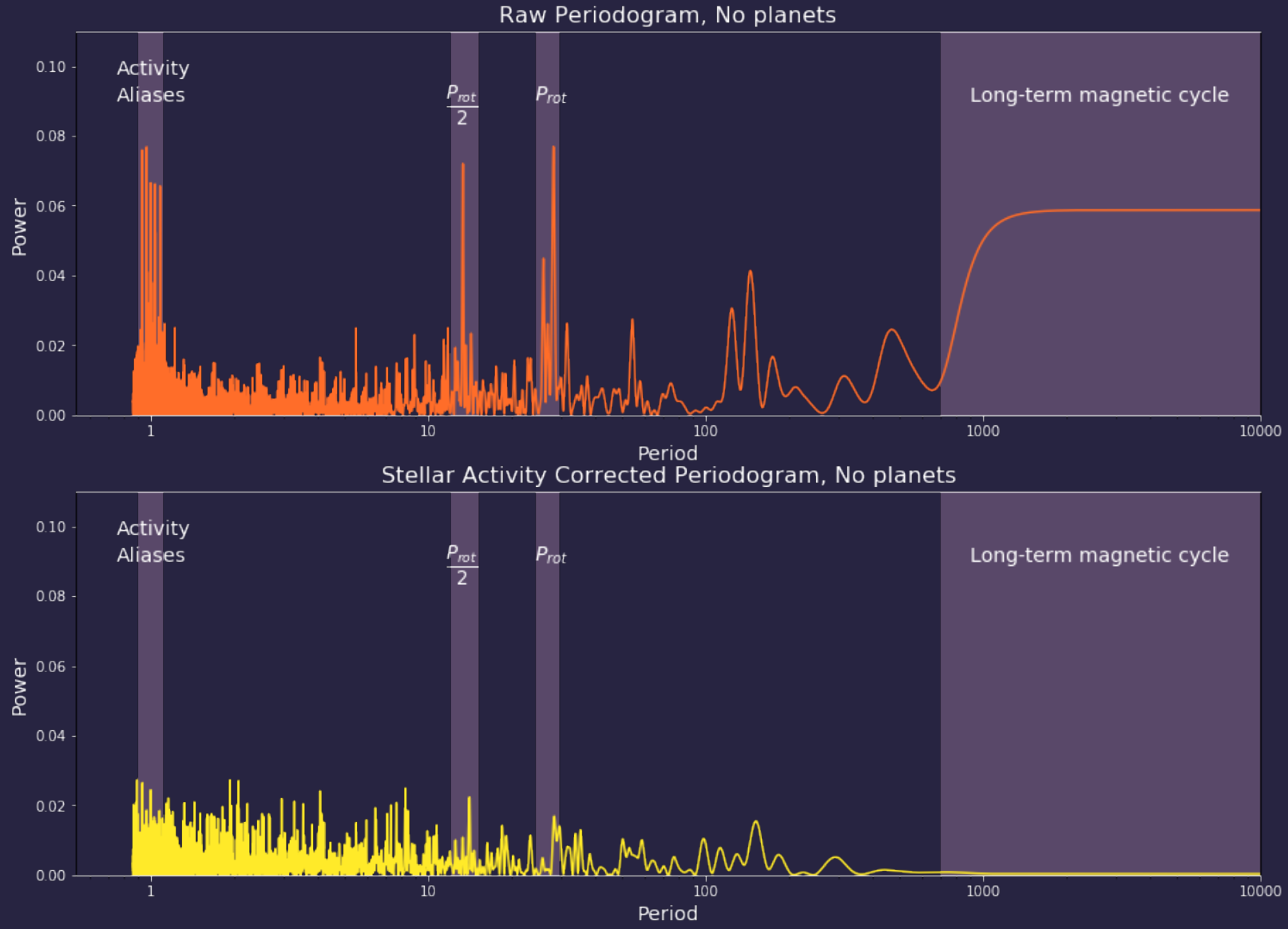
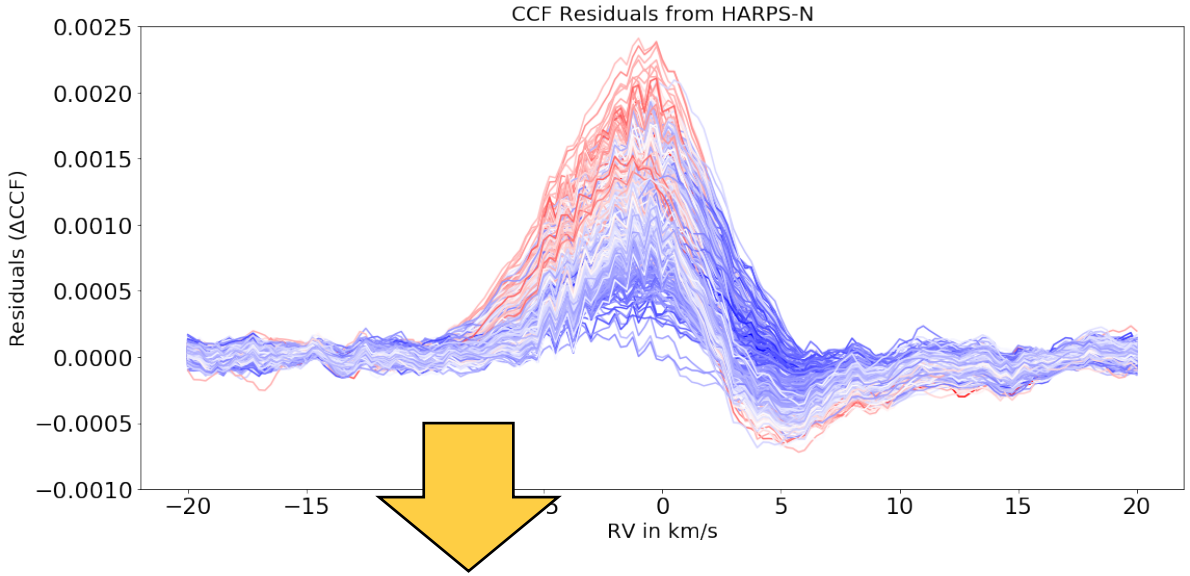
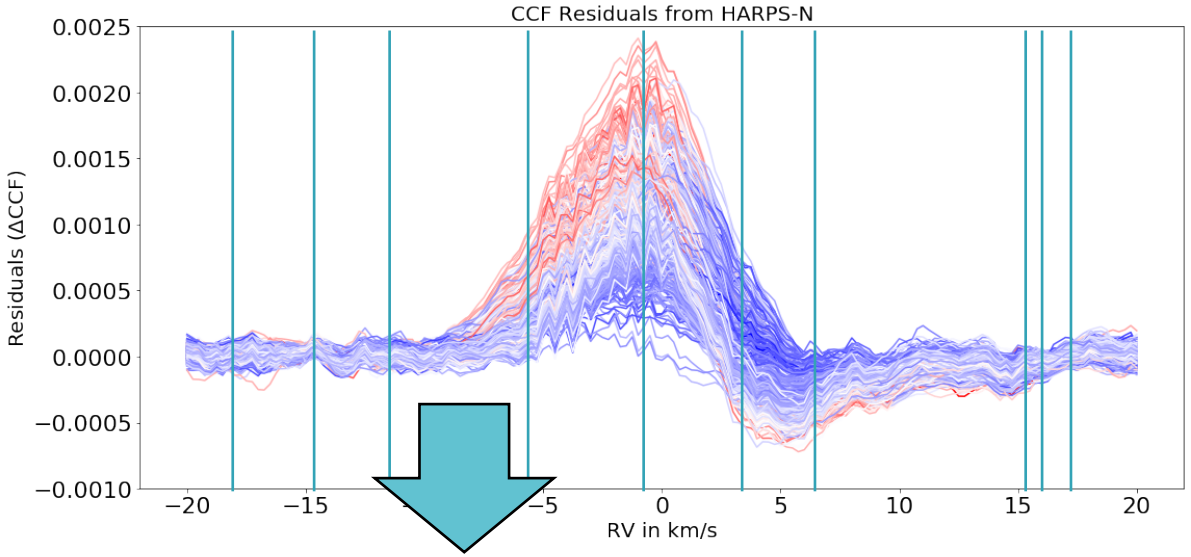
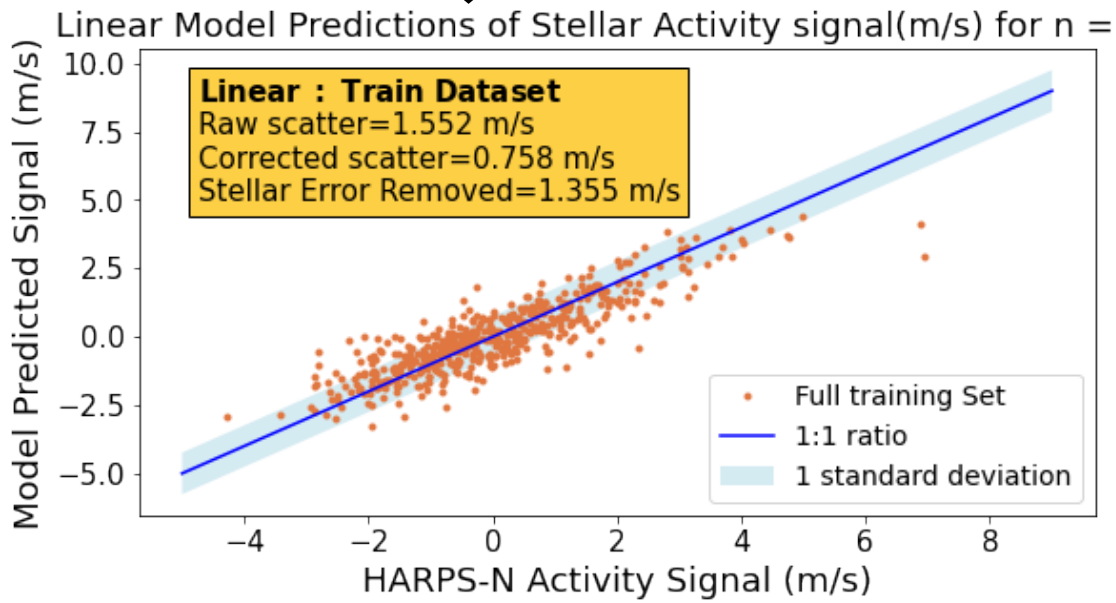
Our results in the form of periodograms

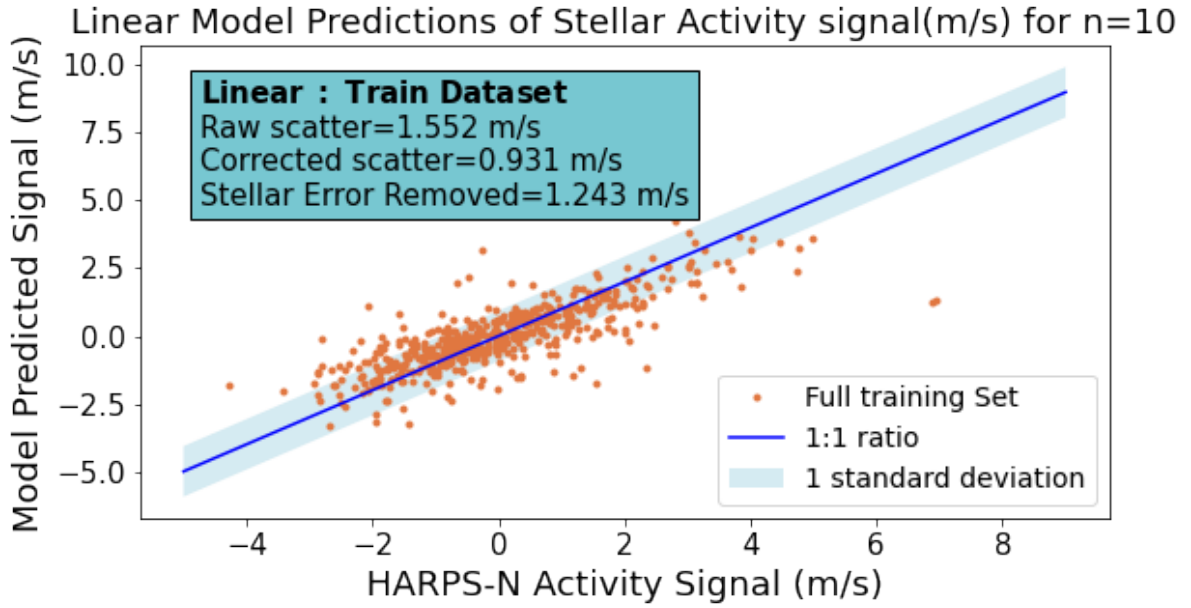


Reduce the number of CCF inputs, still a significant reduction in RMS



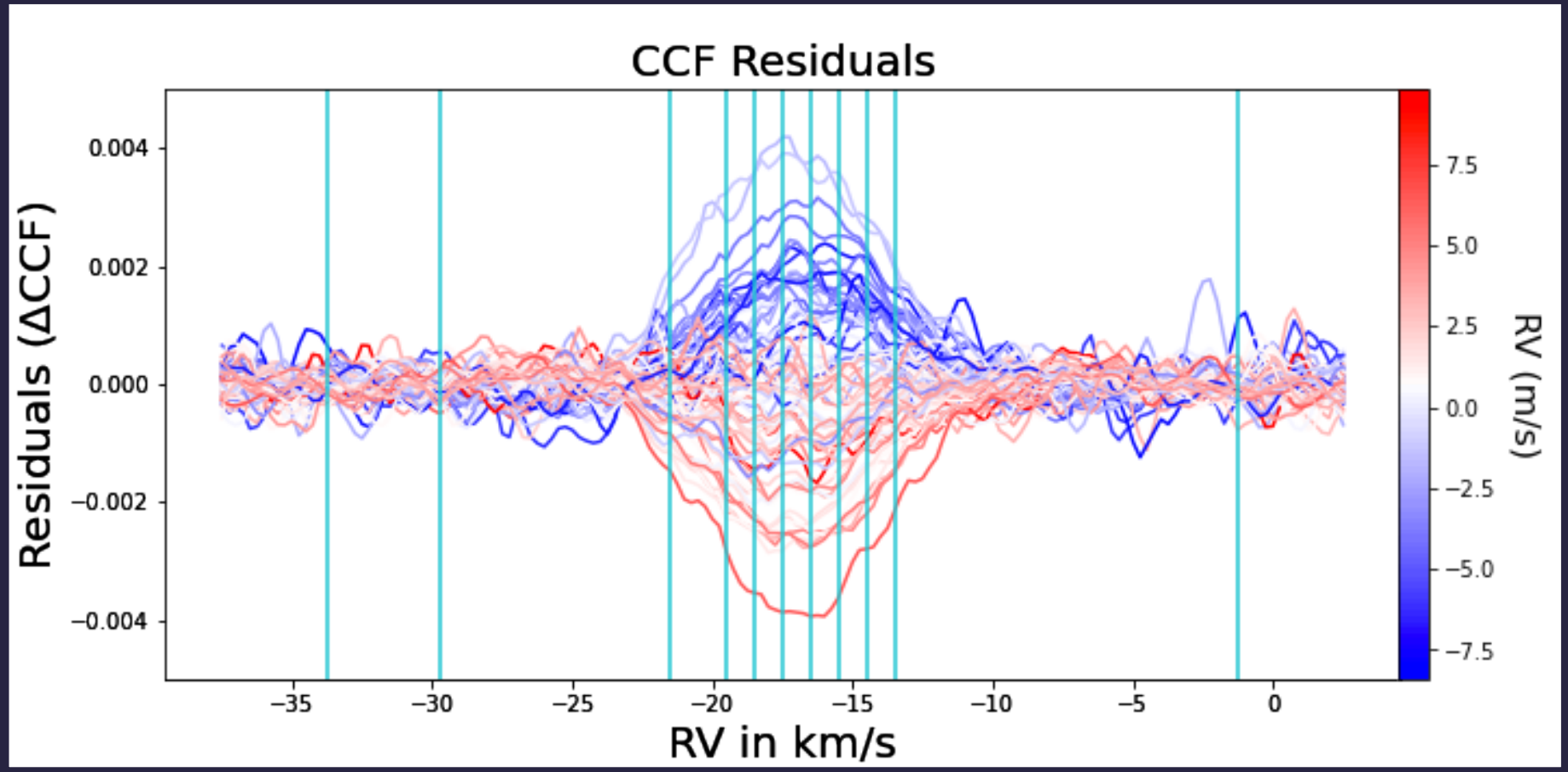




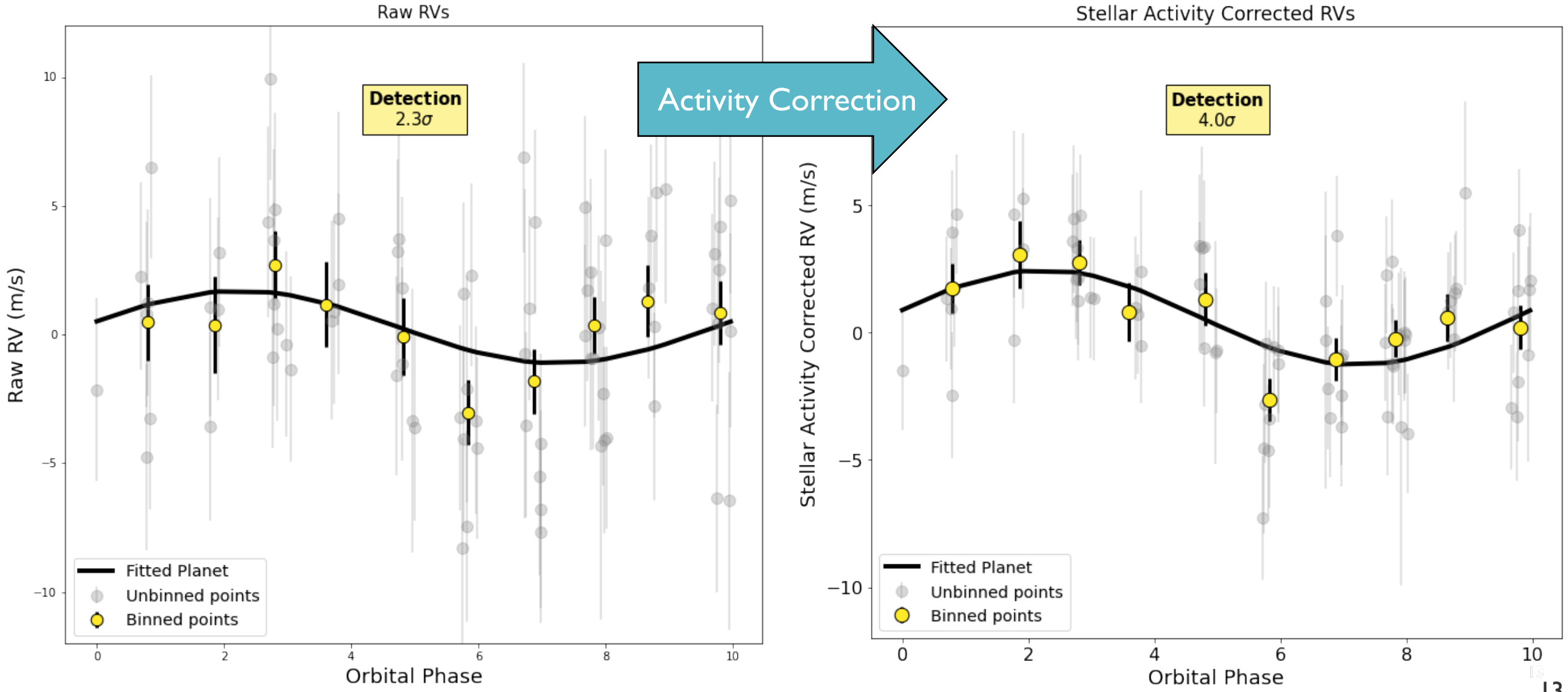


Could this work for nighttime data?
Test case: bright star with a validated planet
(observed with K2, TESS, HARPS-N)

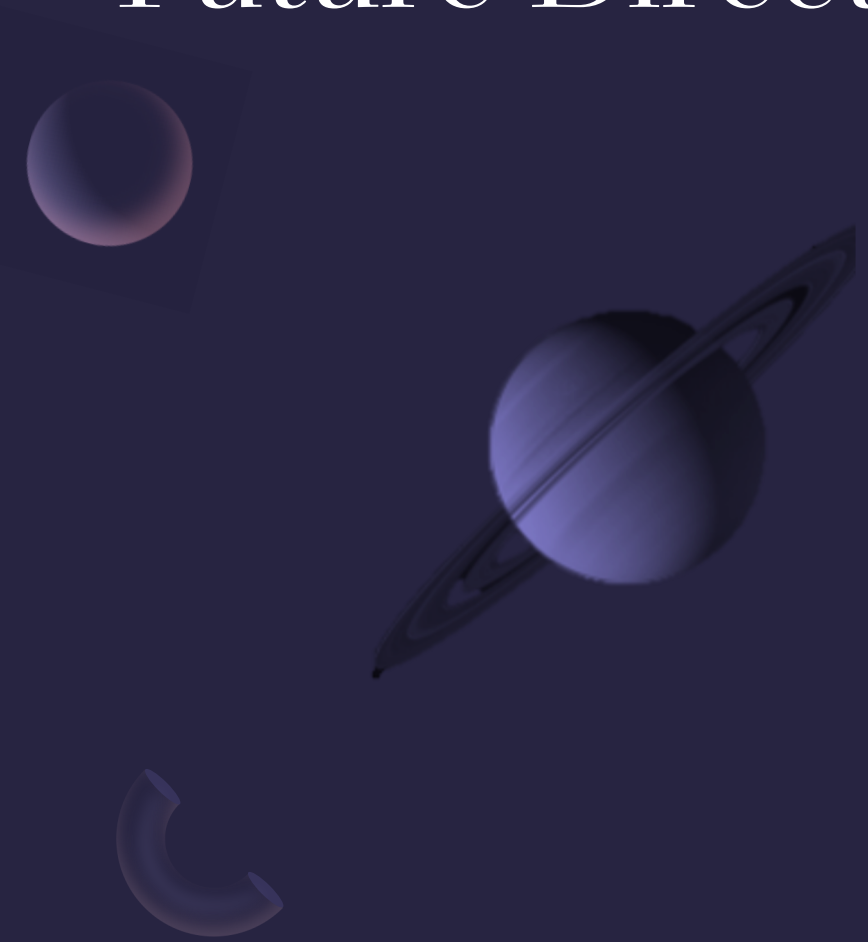
What do these CCFs look like for this extrasolar star? Can we simultaneously fit Keplerians & CCF parameters?



PRELIMINARY



Conclusion and Future Directions



- Machine learning methods can reduce stellar activity jitter by a factor of ~2 for our Sun, paving the way towards higher precision RVs.
- In the future, we want to continue this synergy between solar and extrasolar observations to further the goal of mitigating stellar activity and ultimately detecting smaller planets around bright nearby stars.

Questions?