

# Synopsis of the MINiature Exoplanet Radial Velocity Array (MINERVA)

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# Detecting Long Period, Low Mass Planets

- Precision Radial Velocity measurements of stellar reflex motion
- Less than meter per second precision
- Optimizing for detection of  $M_p \sin i = 3 M_\oplus$
- In their host star ‘habitable zone’
- Robotic observatory dedicated to mission
- Probing new parameter space of RV detection of planets

# MINERVA



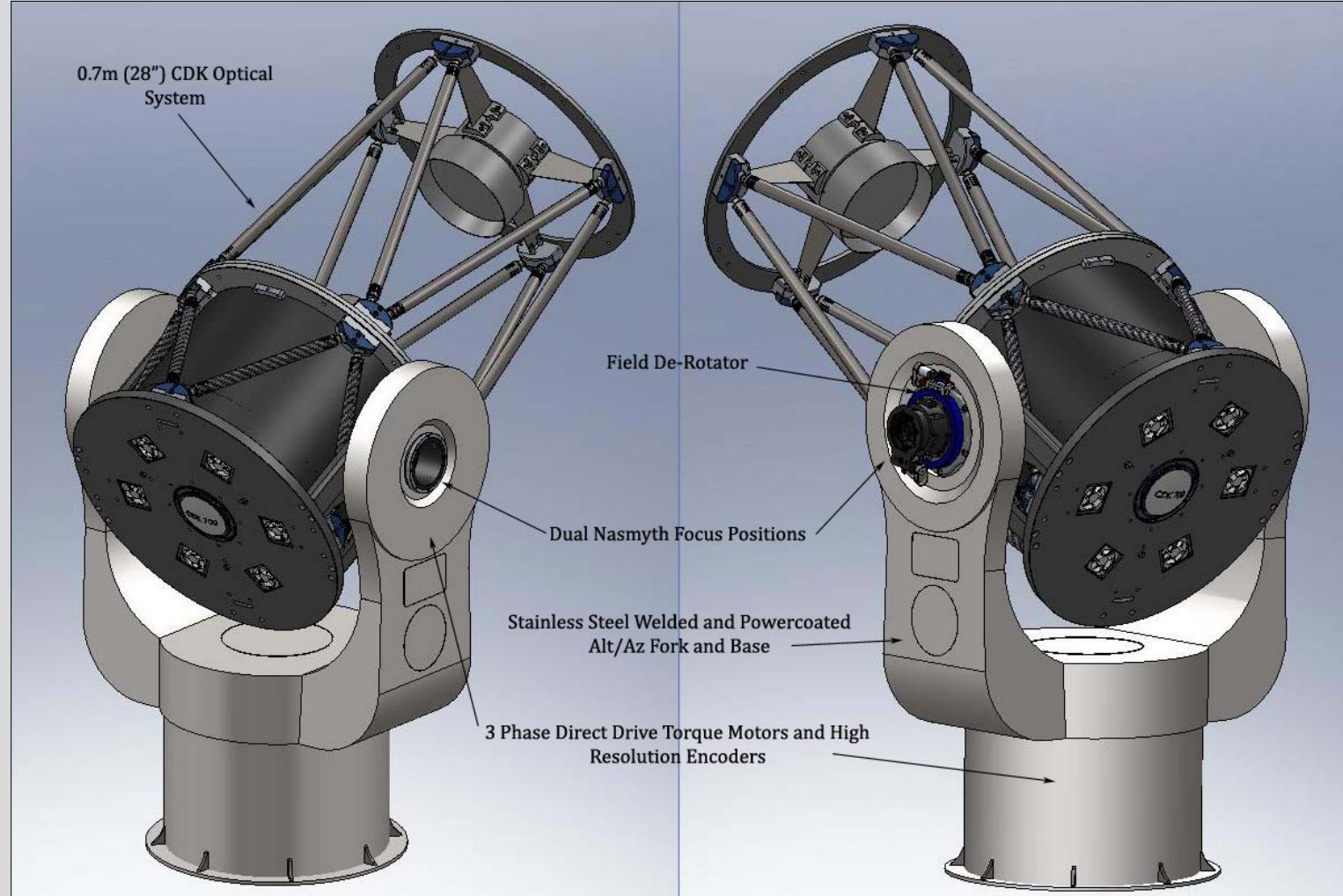
HARVARD UNIVERSITY



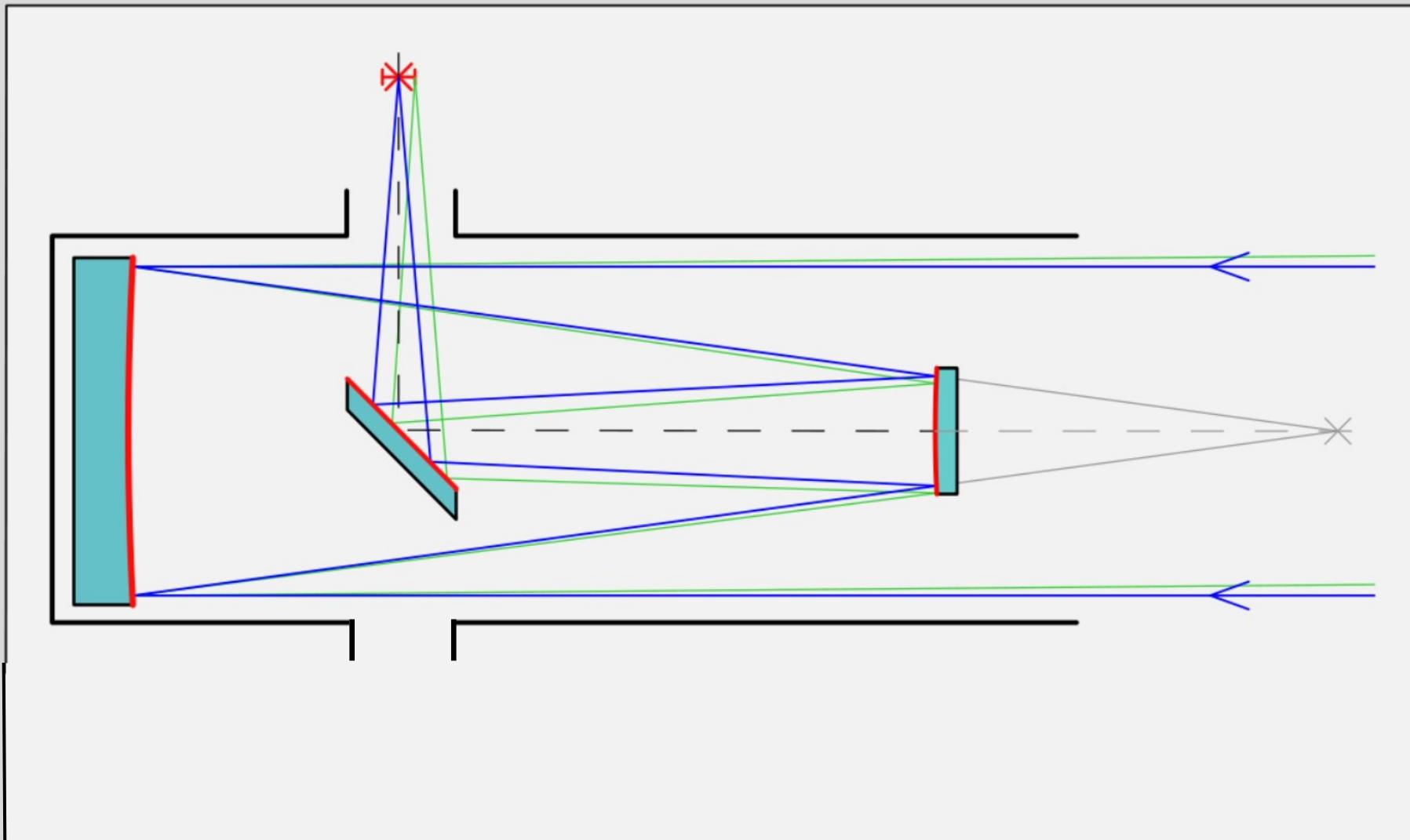
PENN STATE



# CDK 700

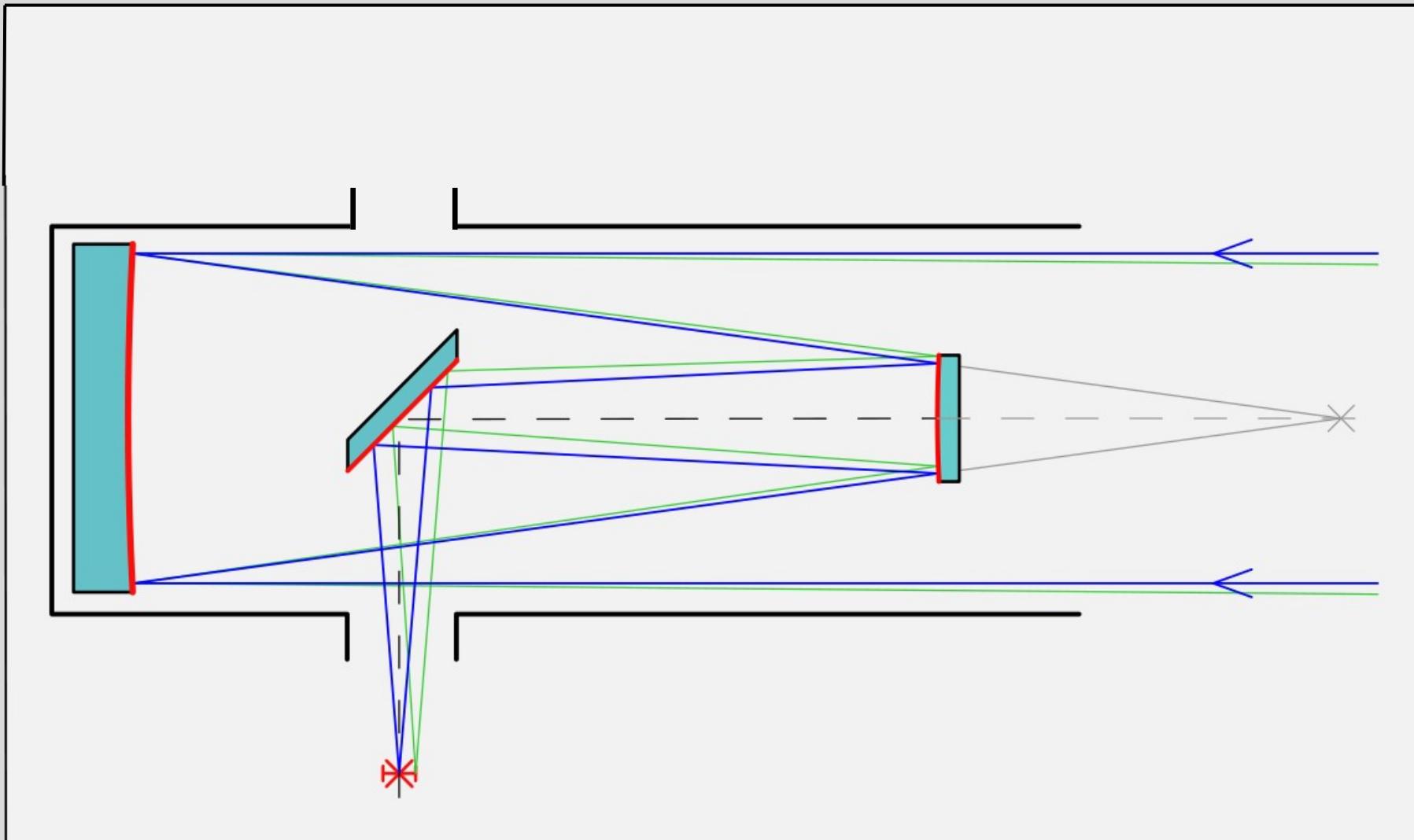


# PlaneWave CDK700

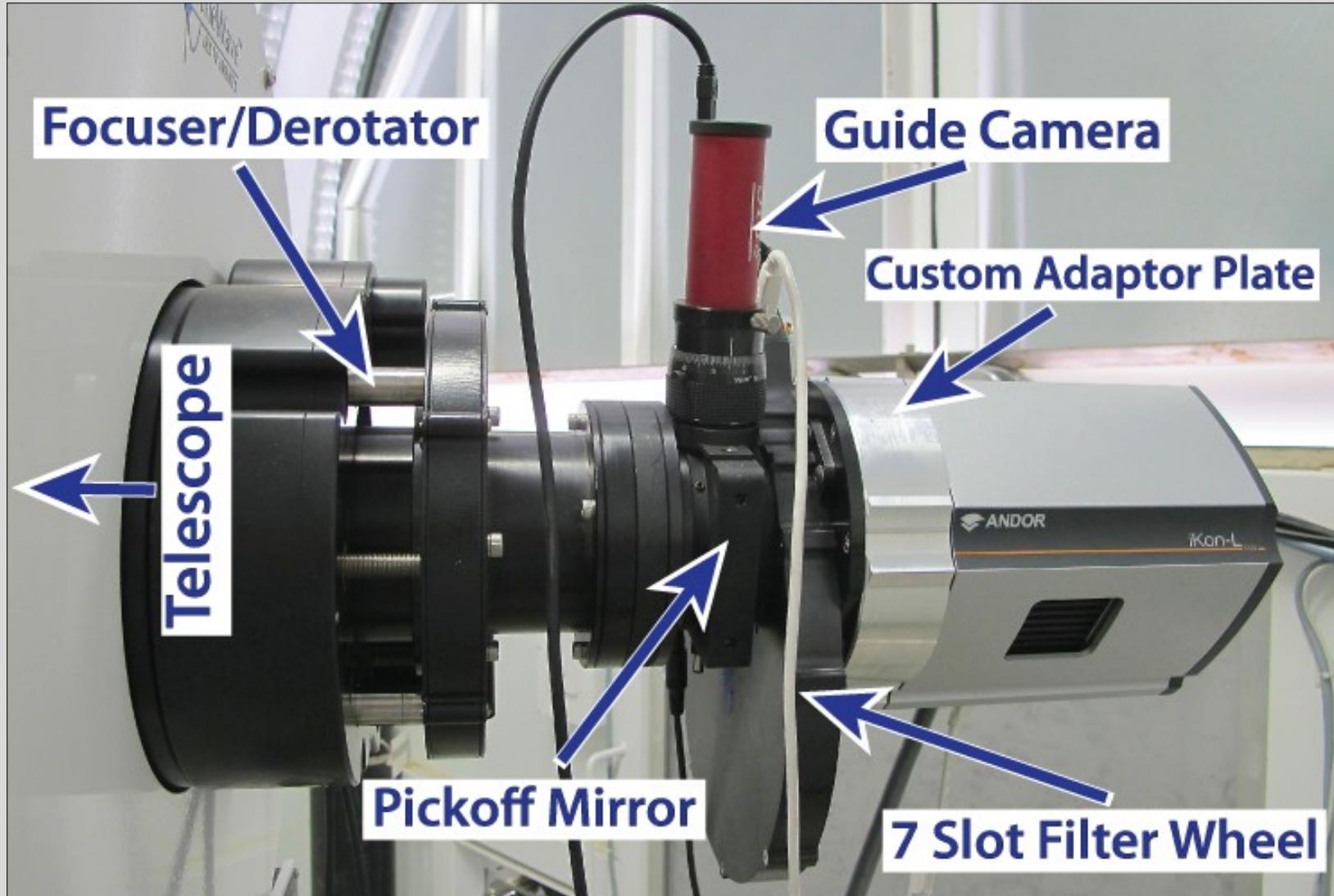


Adapted from Wikipedia

# PlaneWave CDK700

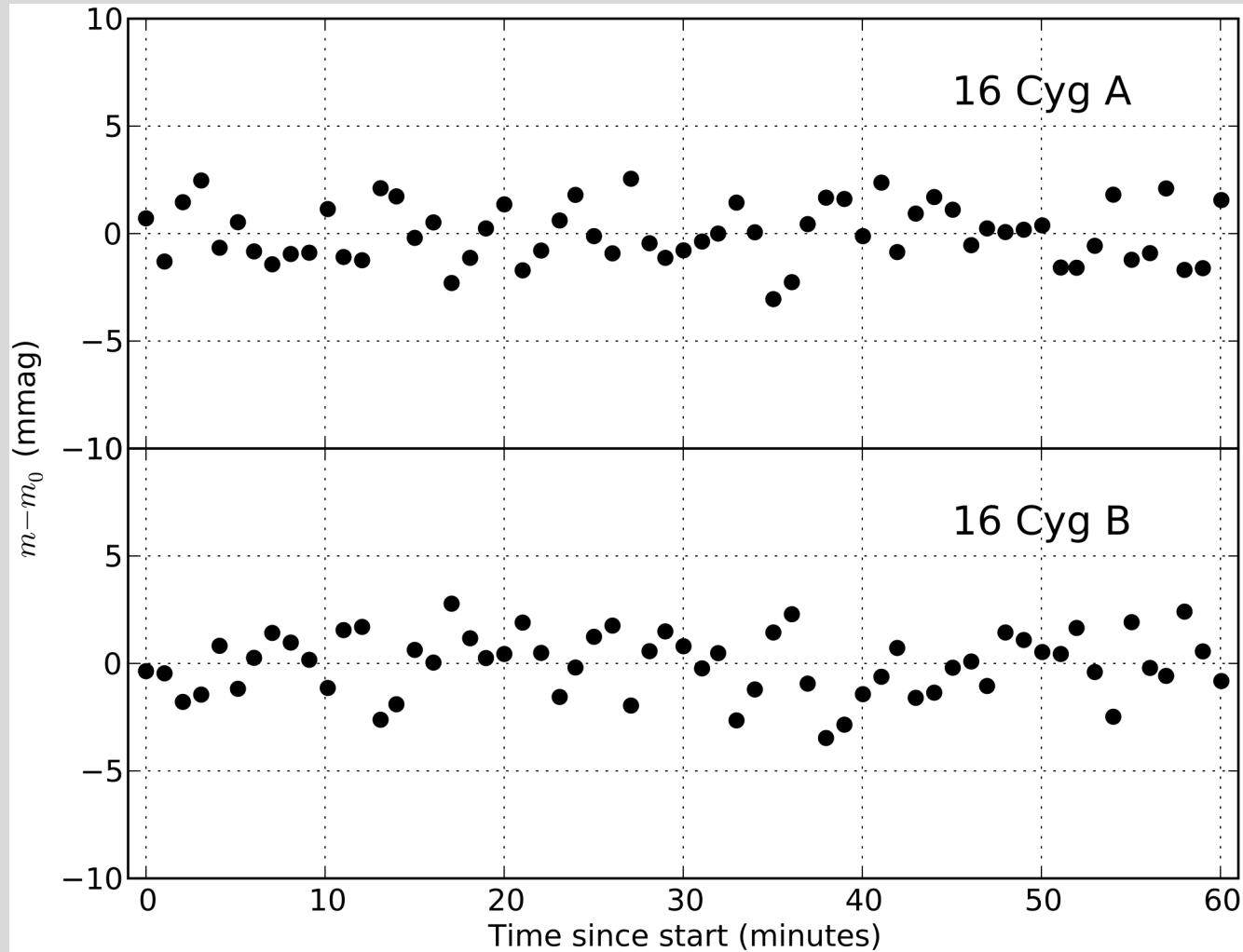


# Photometric Facilities



- 2 x Andor iKon-L
  - 2048x208
  - 20.9' field of view
- 1 x Andor iKON-L, with Deep Depletion sensor
- 1 x Apogee Aspen CG230
  - 2048x2048
  - 23.2' field of view

# 16 Cyg Photometry

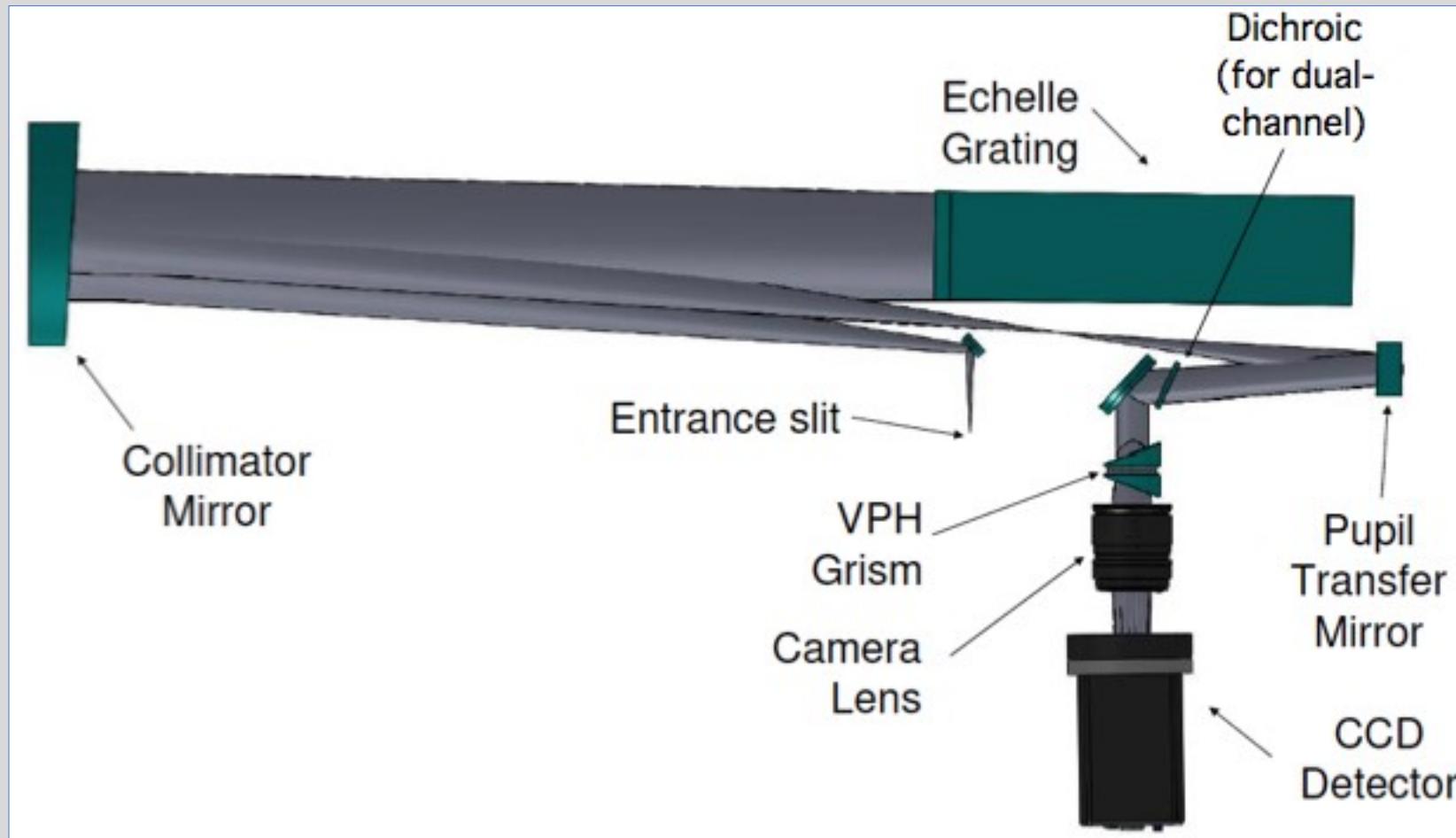


# Photometry Results

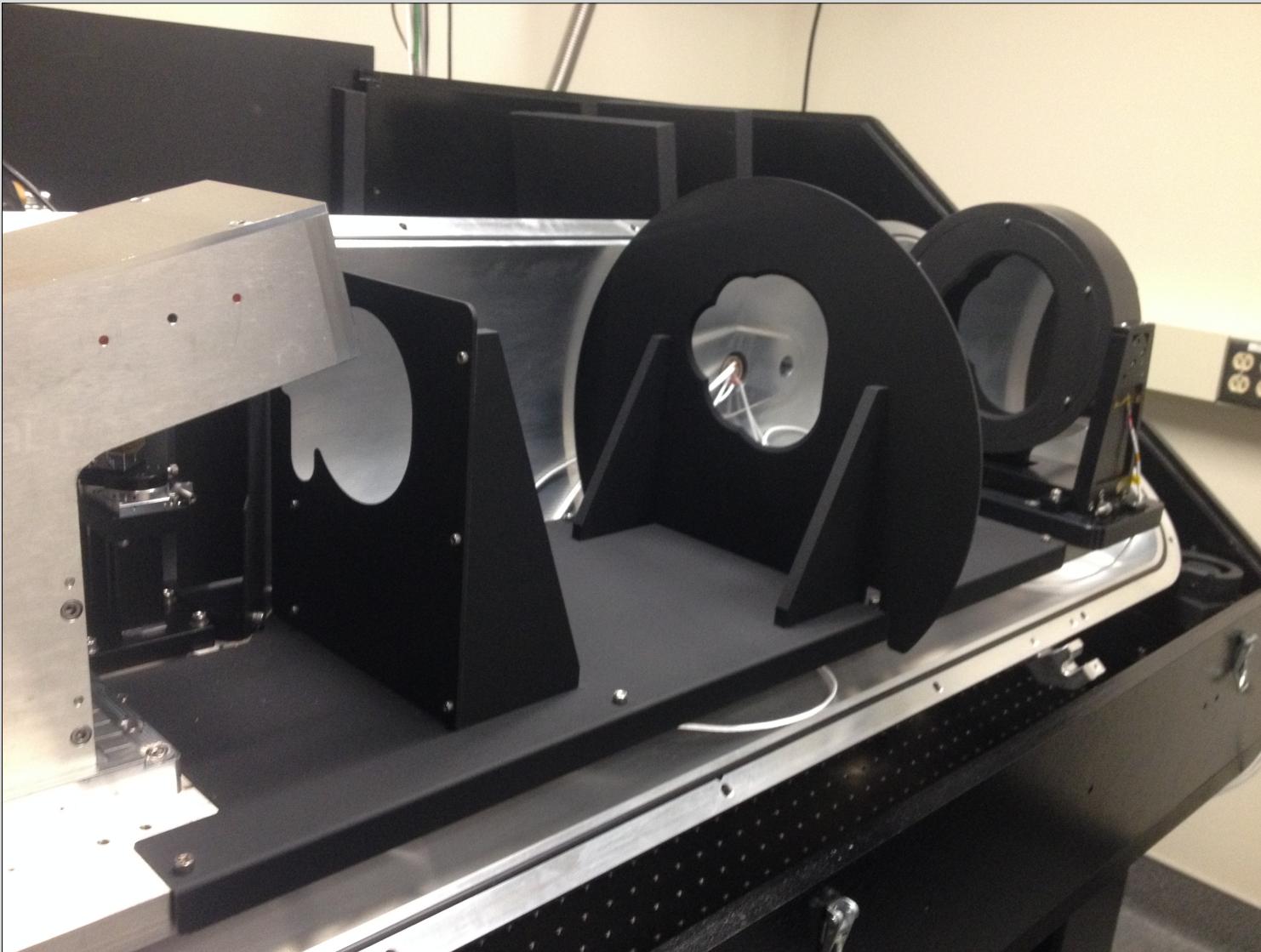
- A disintegrating minor planet transiting a white dwarf,  
Vanderburg et al. 2015
- KELT-11b: A Highly Inflated Sub-Saturn Exoplanet  
Transiting the Subgiant HD 93396, Pepper et al. 2016
- The Mysterious Dimmings of the T Tauri Star V1334 TAU,  
Rodriguez et al. 2017

# Spectrograph

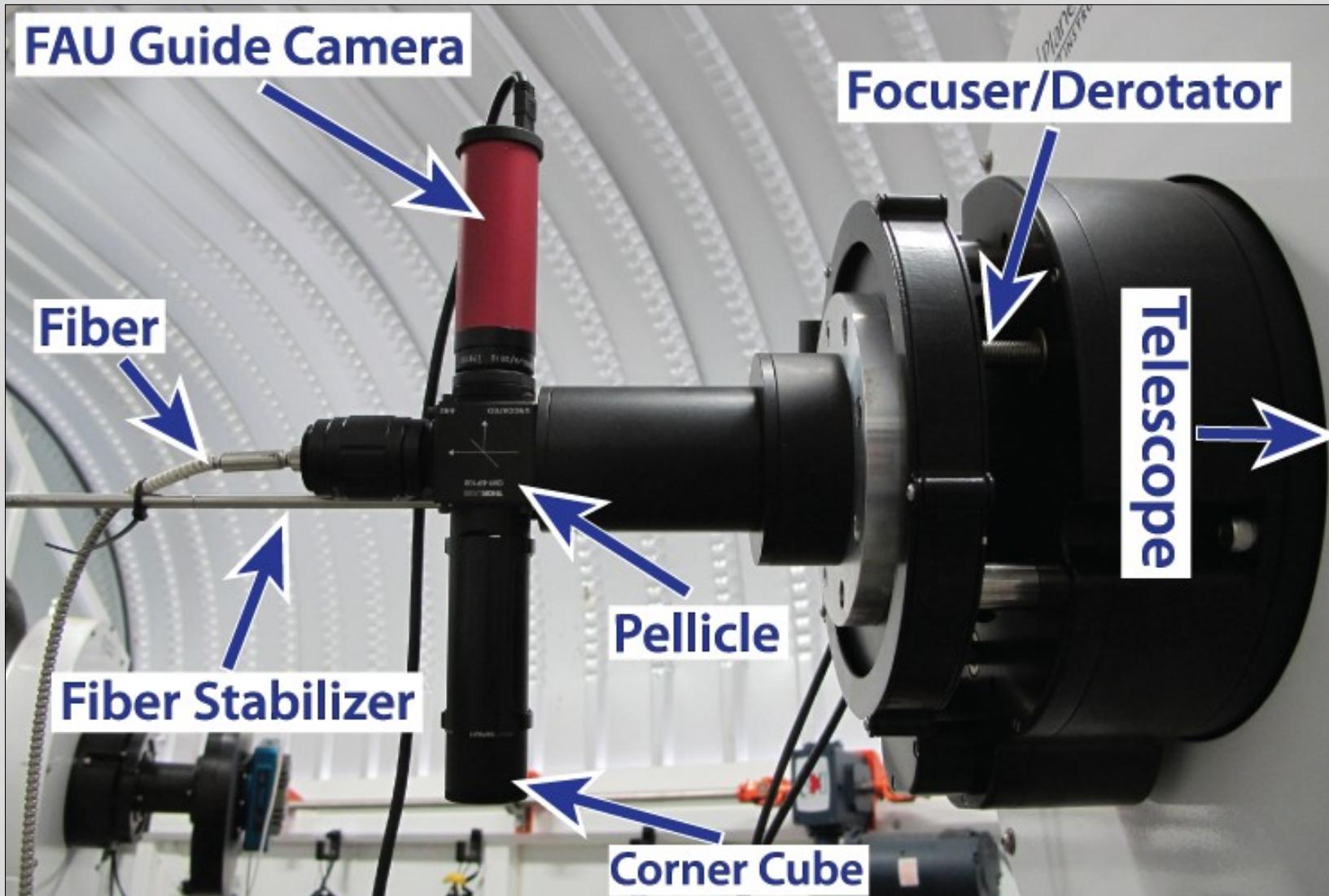
- R~75,000 echelle spectrograph from KiwiStar Optics



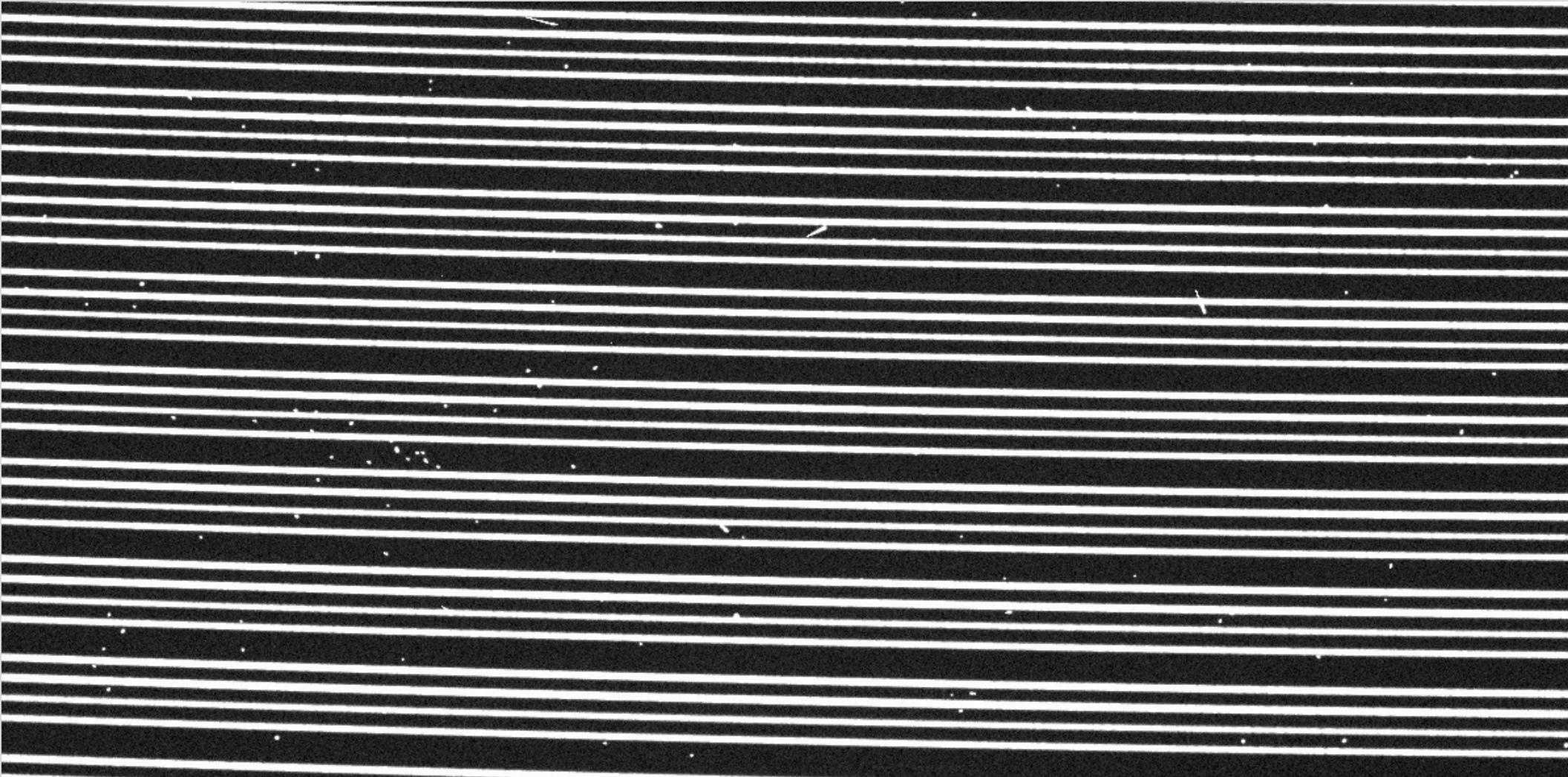
# Spectrograph



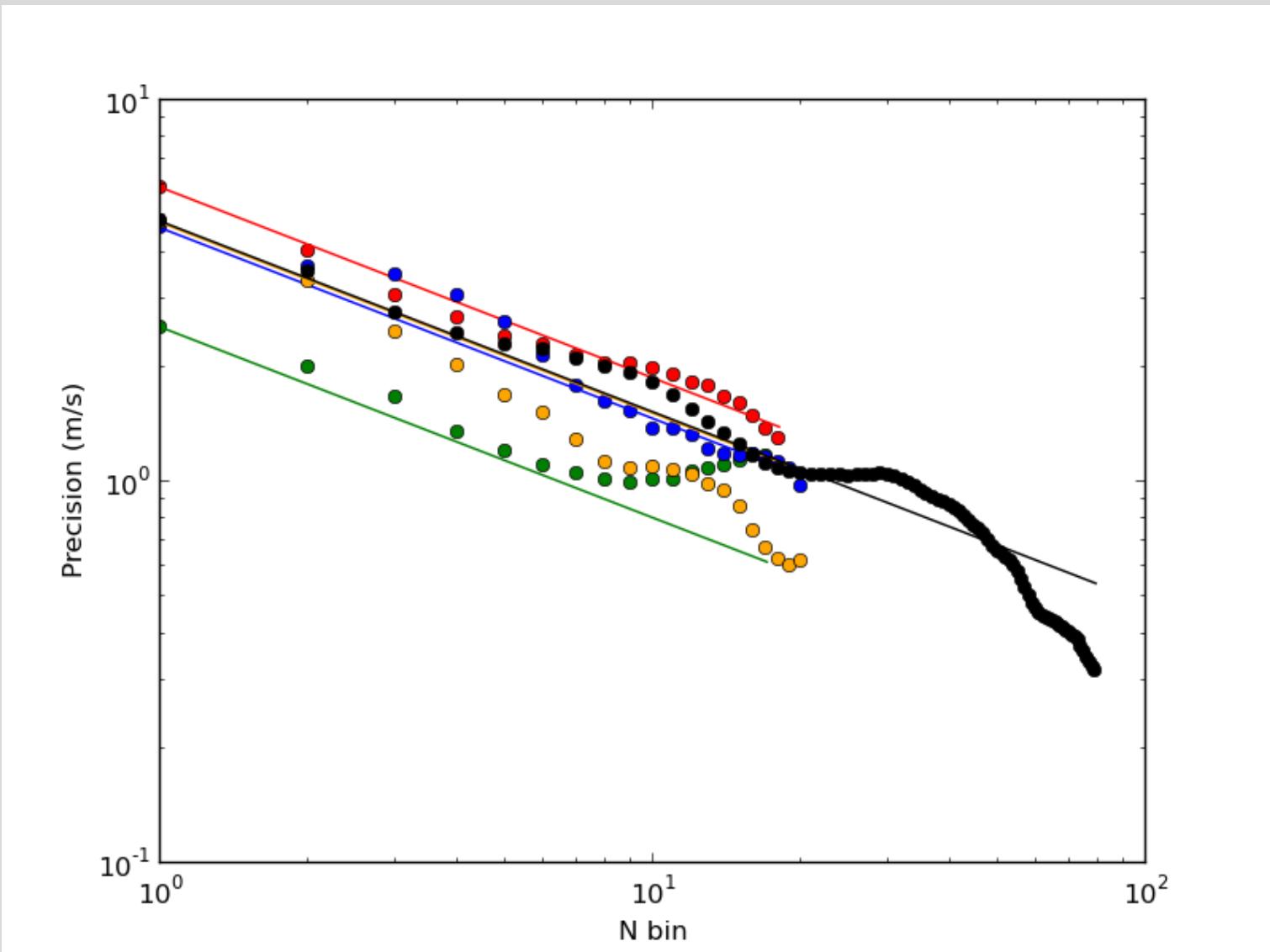
# Fiber Acquisition Unit



# First 4-Telescope Echellogram



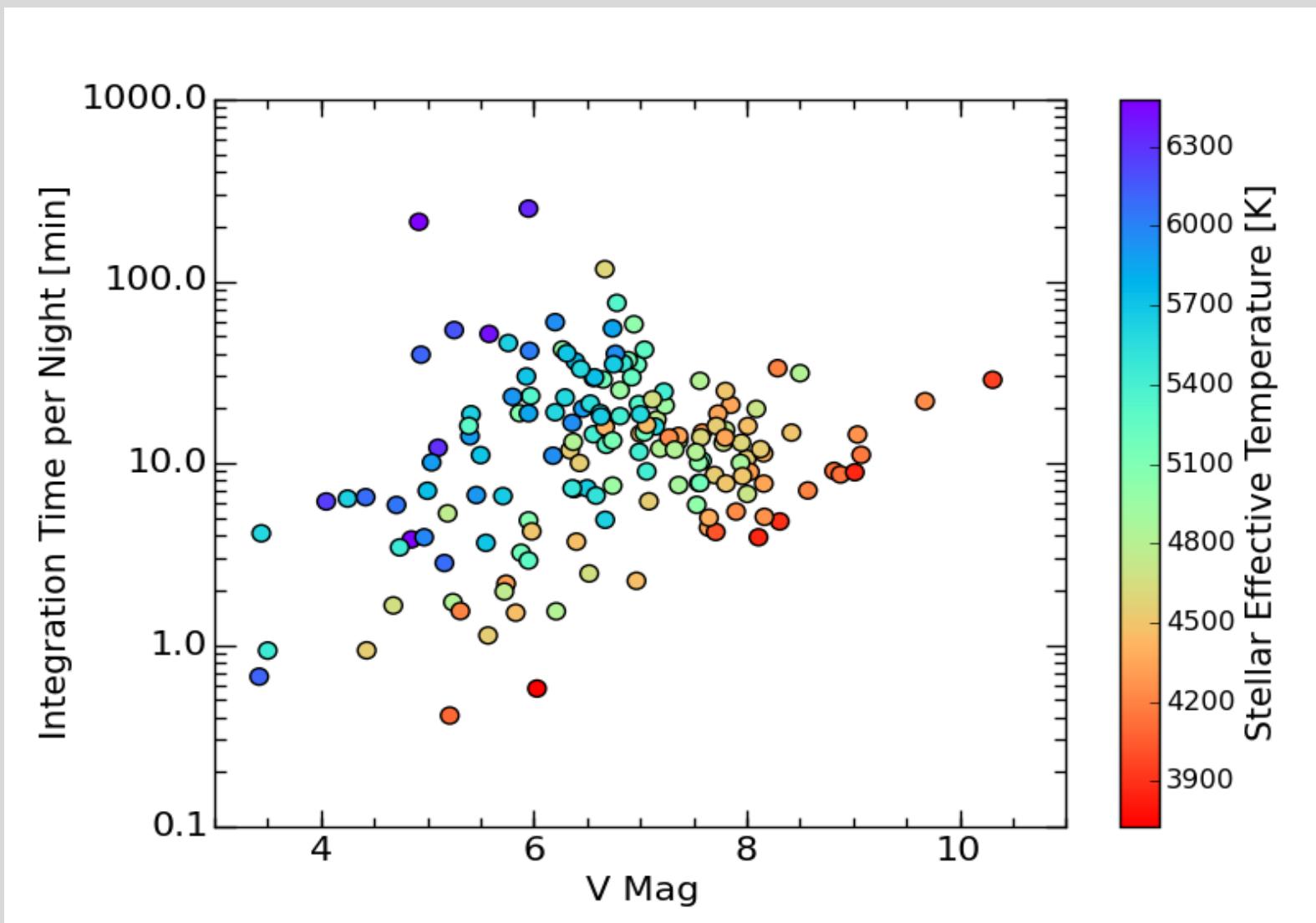
# $\sim 1$ m/s Radial Velocity Precision



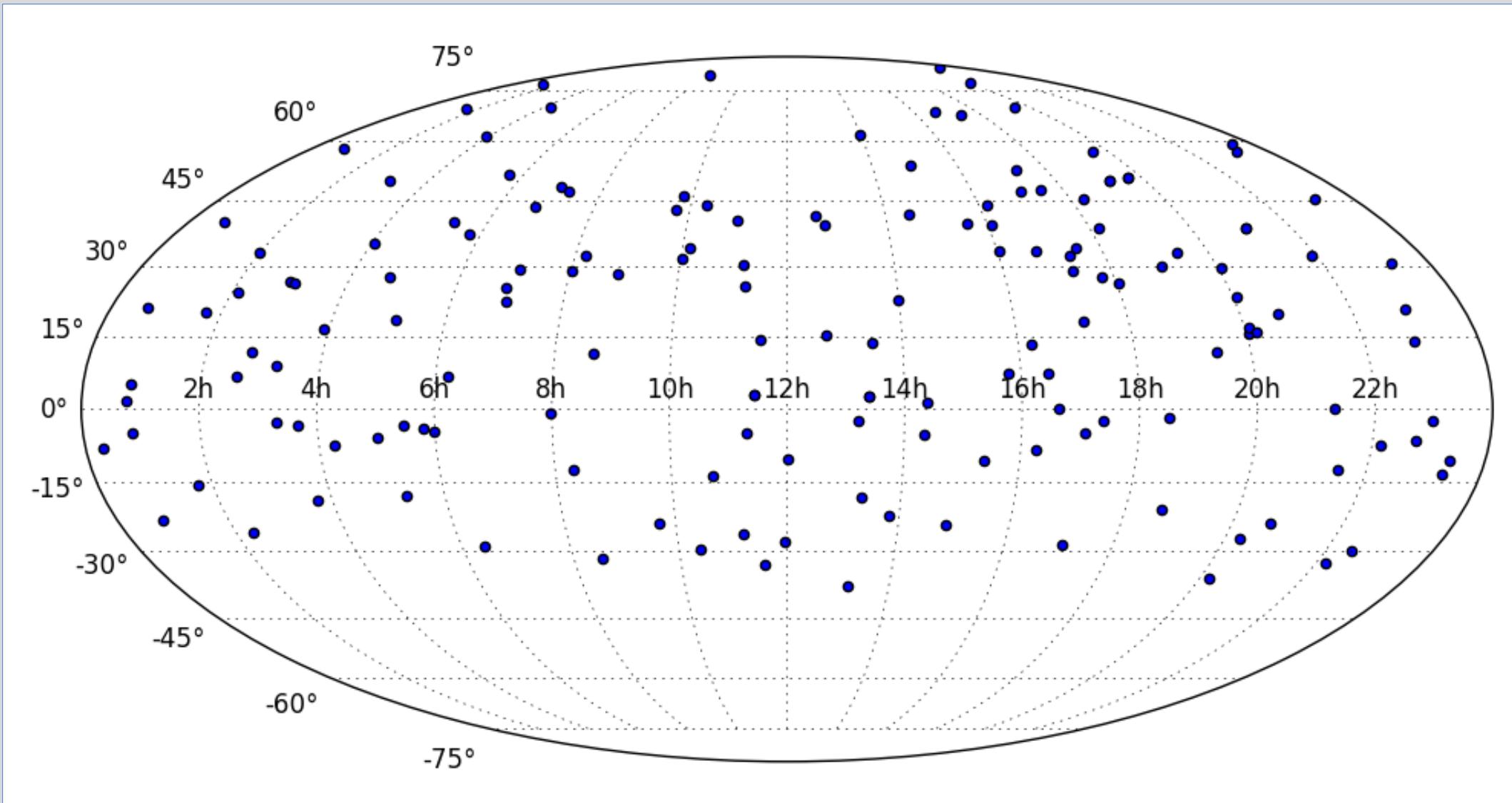
# Dispatch Scheduling

- Scheduling in real time for autonomous observations
  - Adaptive and robust operations
  - Selects optimal target with weighting function
- Use in conjunction with queue scheduling
  - Fill gaps with observations, minimal downtime
  - Dedicated observatory, no competition

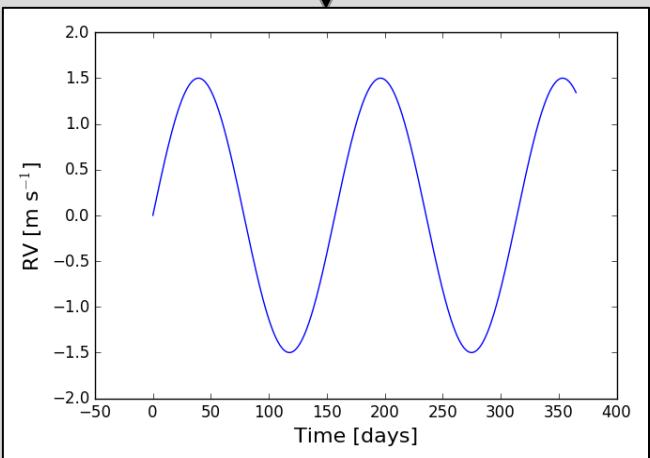
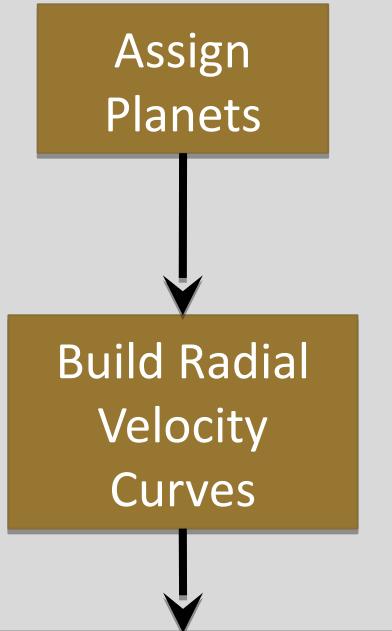
# Eta-Earth Target List



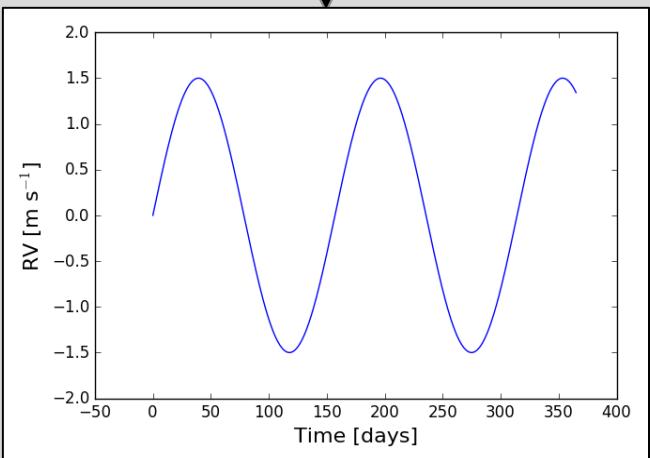
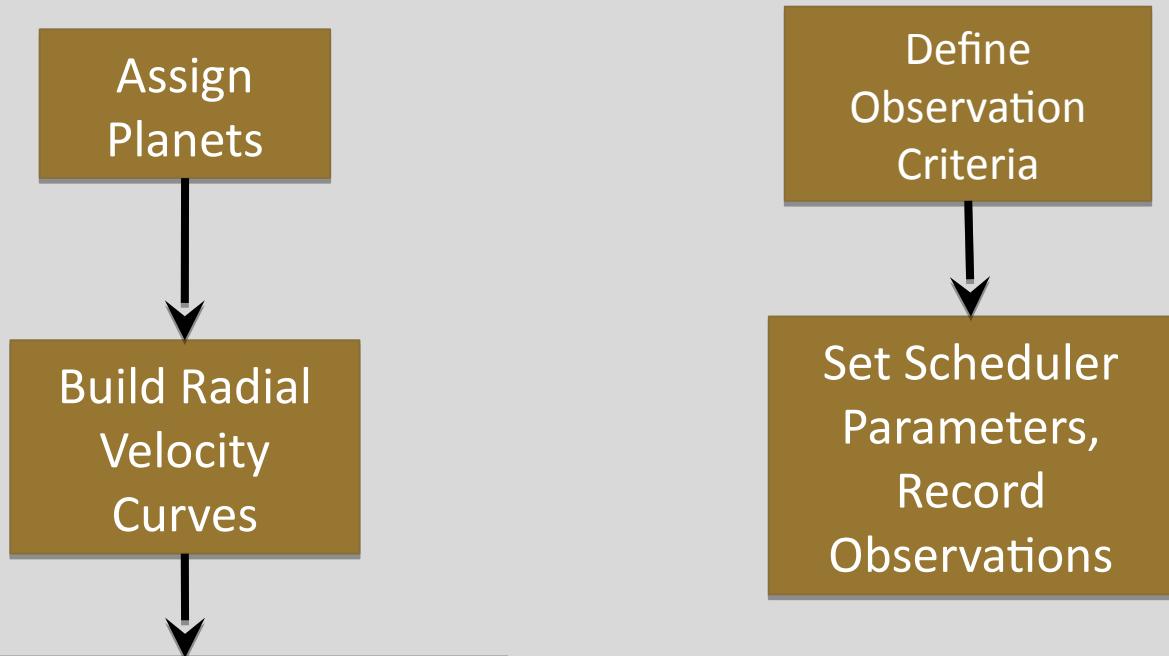
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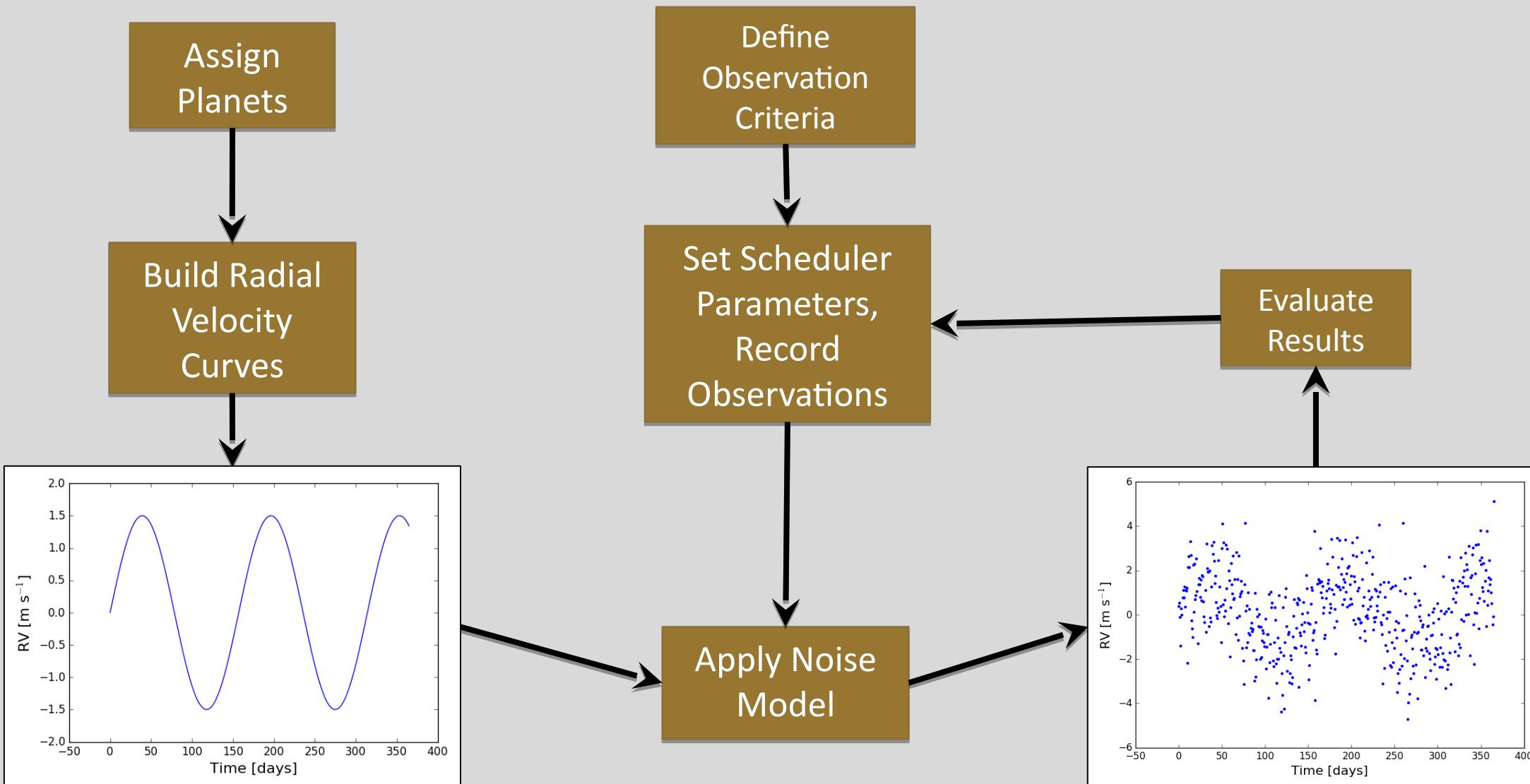
# Determining Observing Strategy



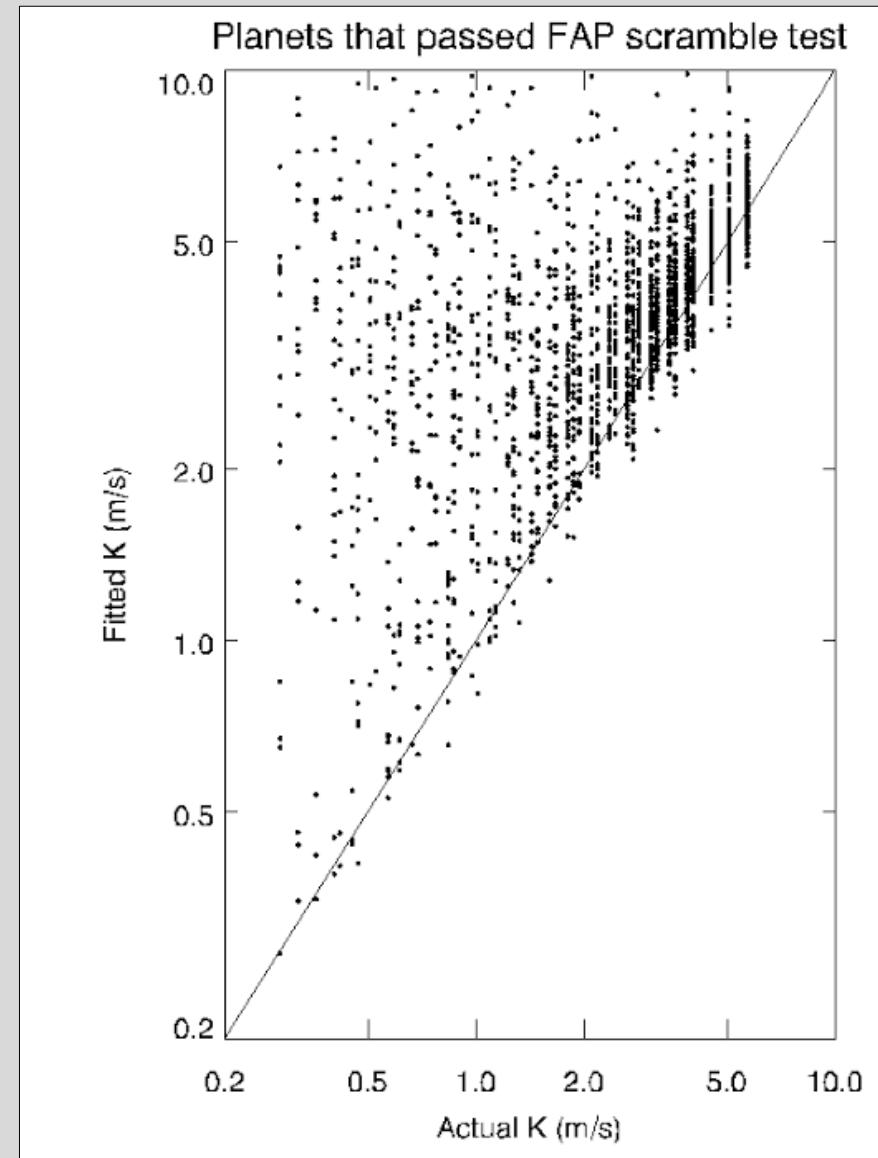
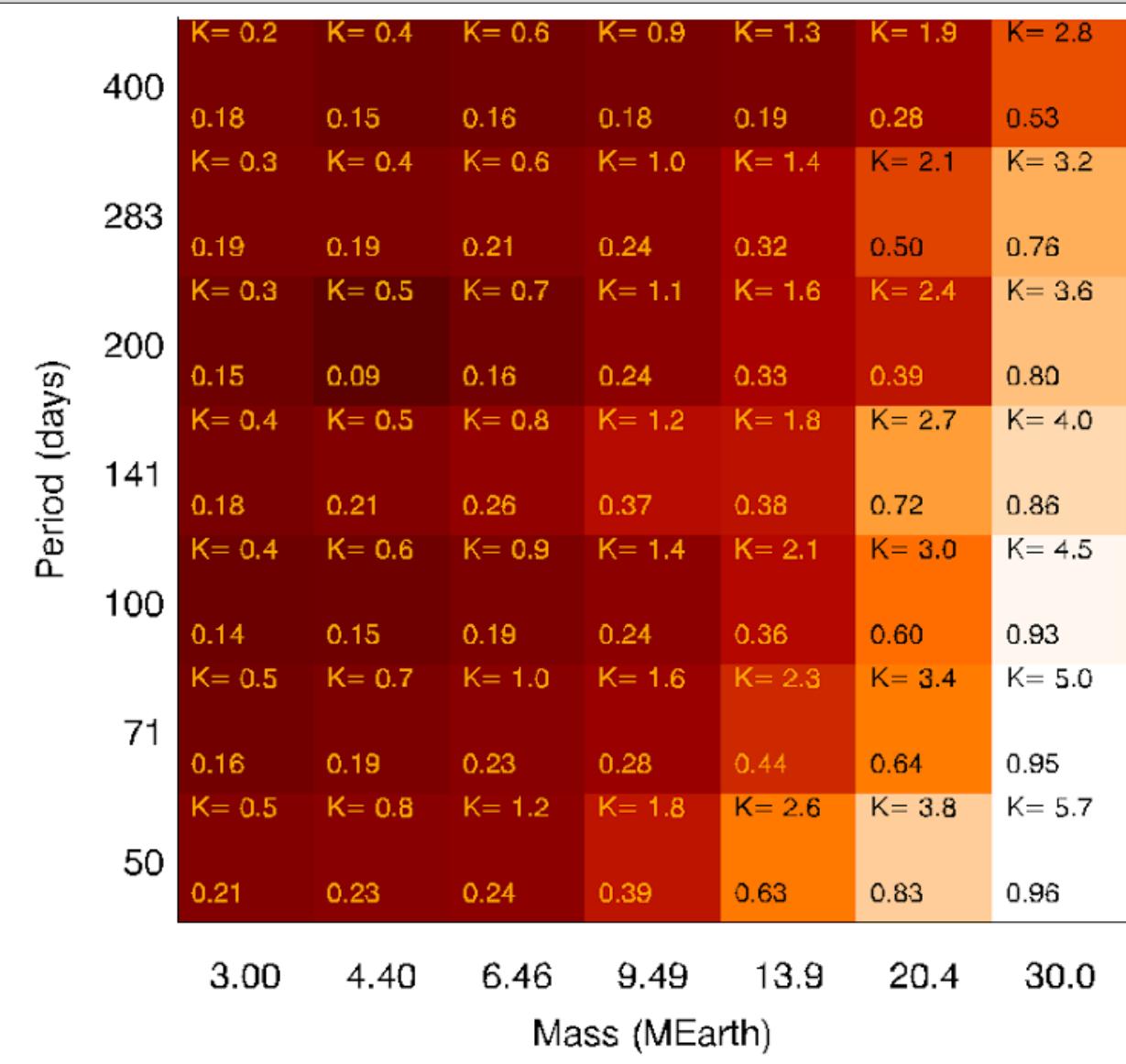
# Determining Observing Strategy



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# Preliminary Yield Results



# MINERVA

- MINERVA is a versatile observatory studying exoplanets
- Photometric and spectroscopic facilities are established
- Full operations begin Fall 2017

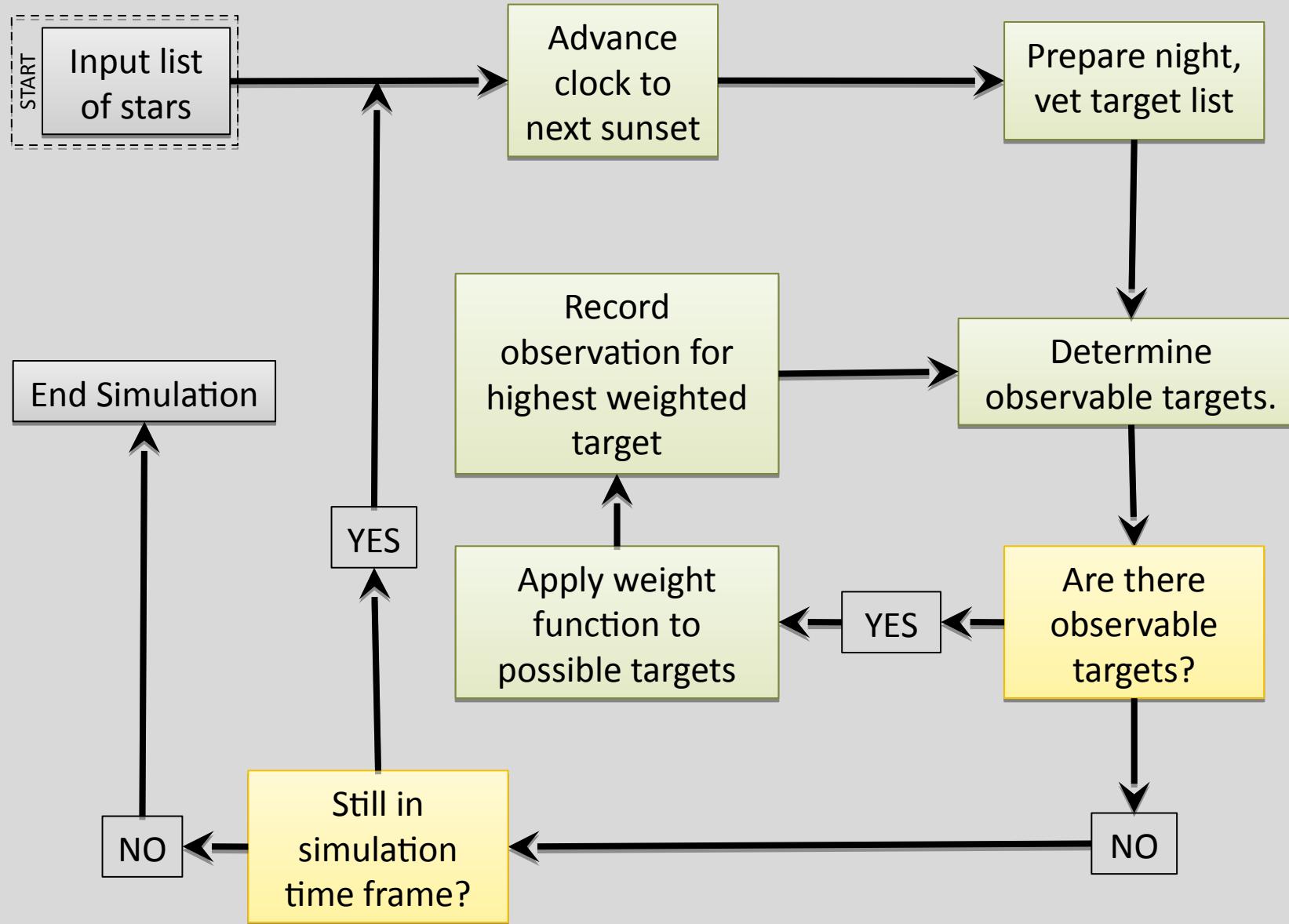


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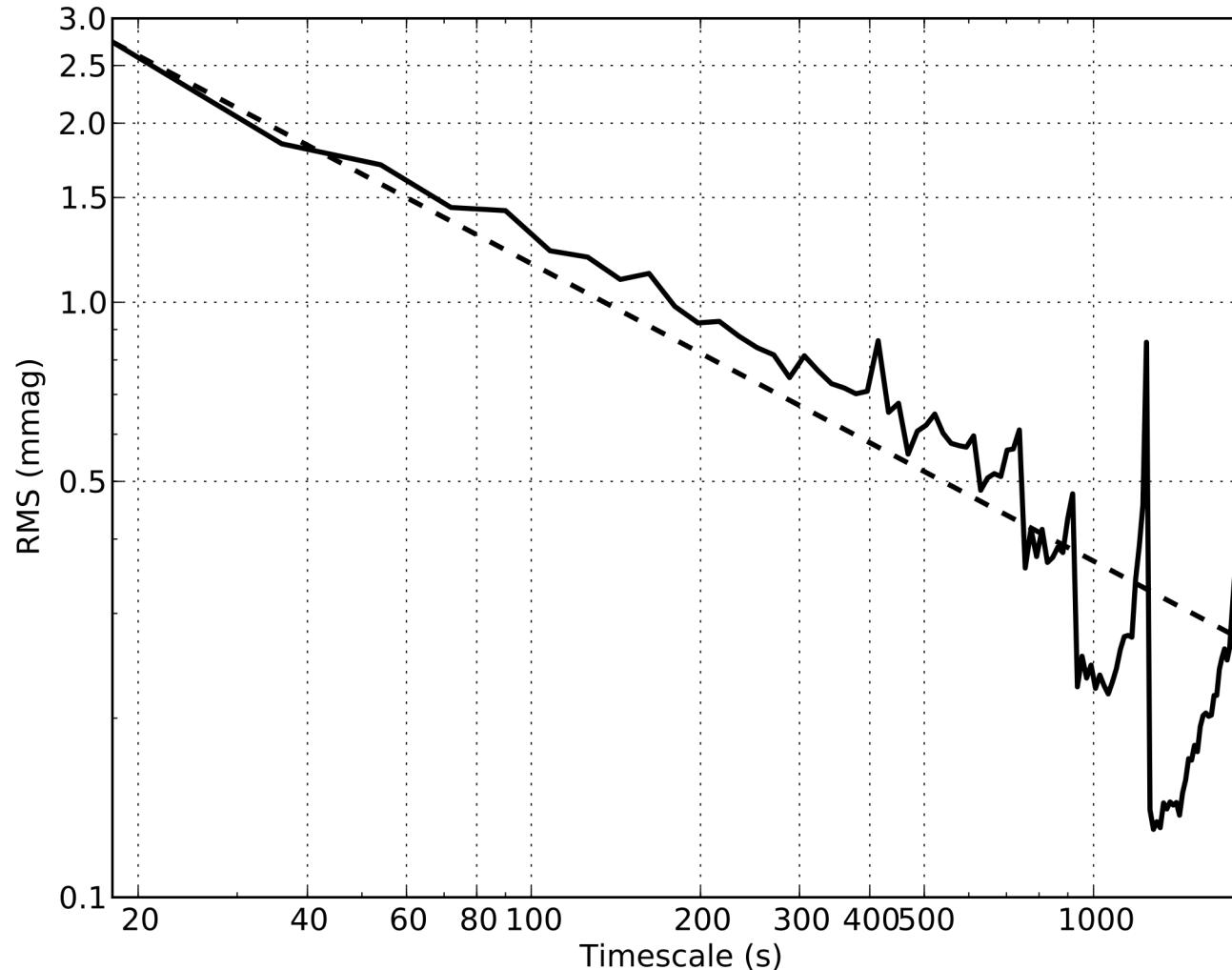
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# General Simulation Outline



# Cyg A Allen Variance Plot



# Title

# Title

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