

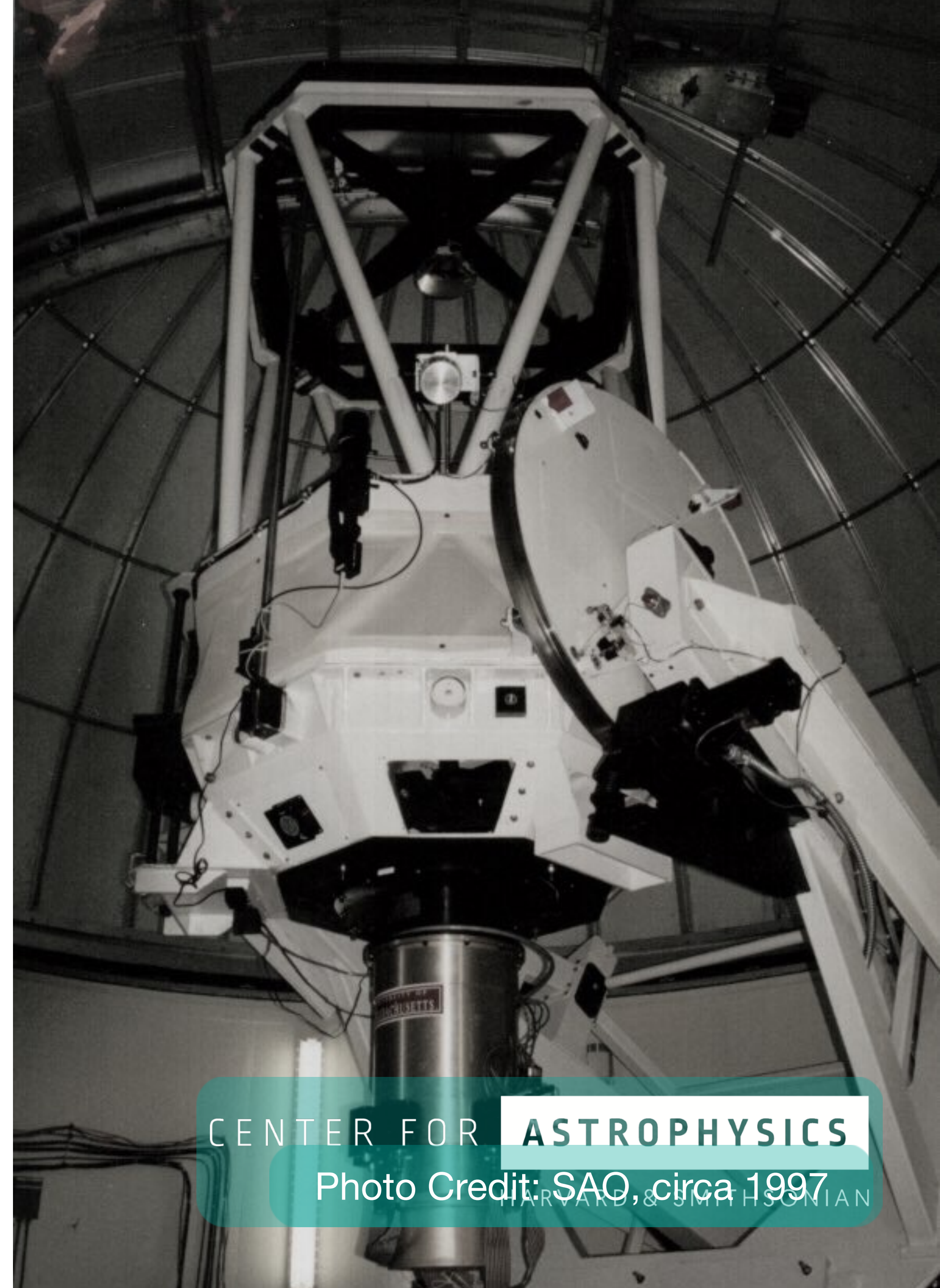
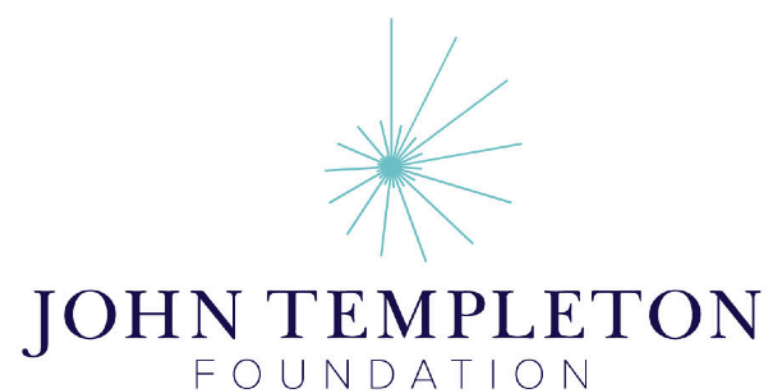
# The *Tierras* Observatory

*An Ultra-Precise Photometer to  
Characterize Nearby Terrestrial  
Exoplanets*

Juliana García-Mejía

— and —

David Charbonneau, Dan Fabricant, Jonathan Irwin,  
Emilio Falco, Joe Zajac, Bob Fata, Peter Doherty



CENTER FOR **ASTROPHYSICS**

Photo Credit: SAO, circa 1997

HARVARD & SMITHSONIAN

TRES

KeplerCam

PAIRITEL

~~2MASS-N~~

MINERVA

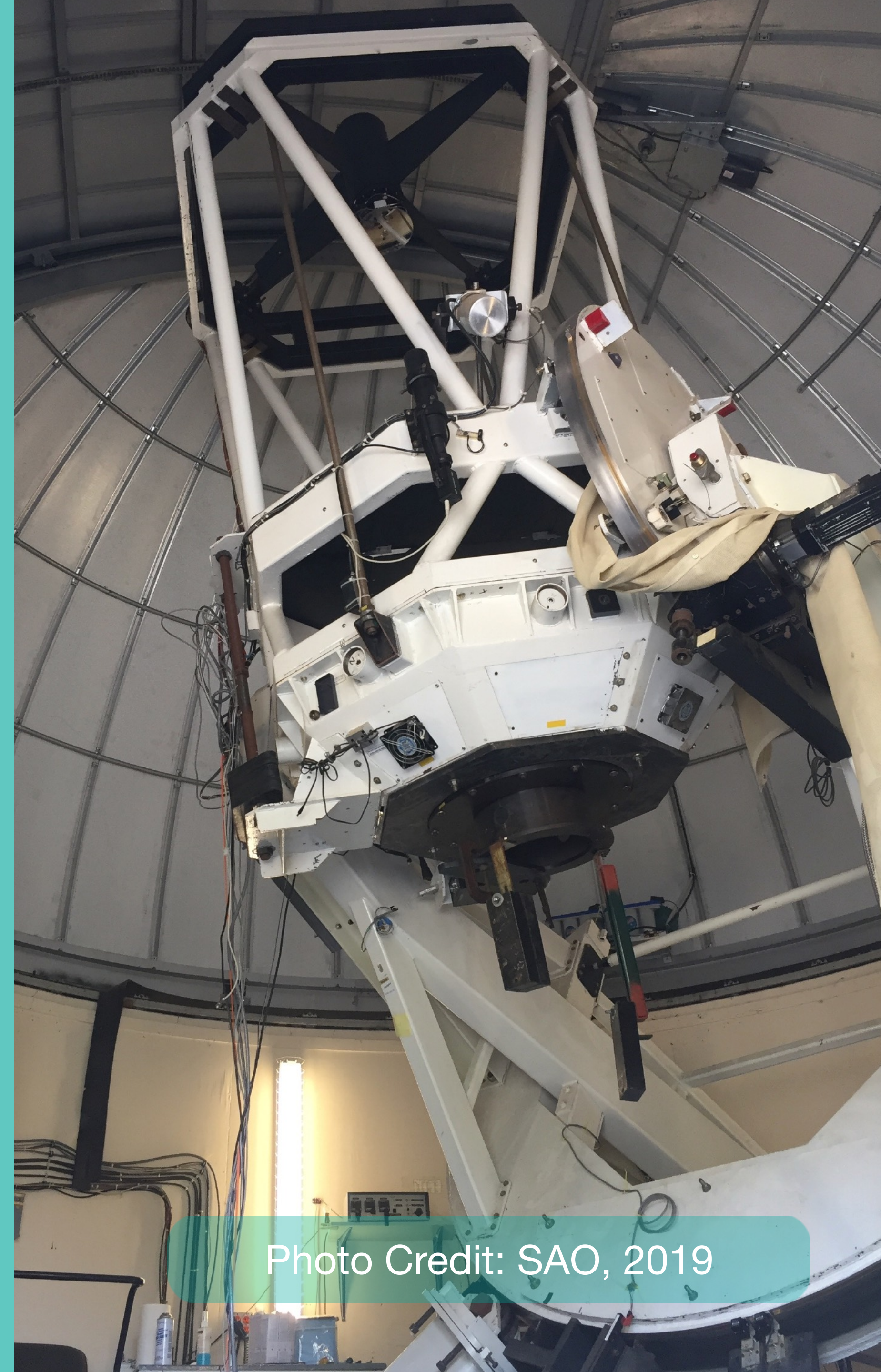
HAT-5

MEarth ↓

Fred Lawrence Whipple Observatory, Mt. Hopkins, Arizona.

The *Tierras* Observatory will repurpose the dormant 1.3-m telescope atop Mt. Hopkins, Arizona.

The telescope will be 100% dedicated to our research goals.



# The *Tierras* Observatory is designed to:

Be

an *ultra-precise* photometer regularly achieving  $<700$  ppm precision

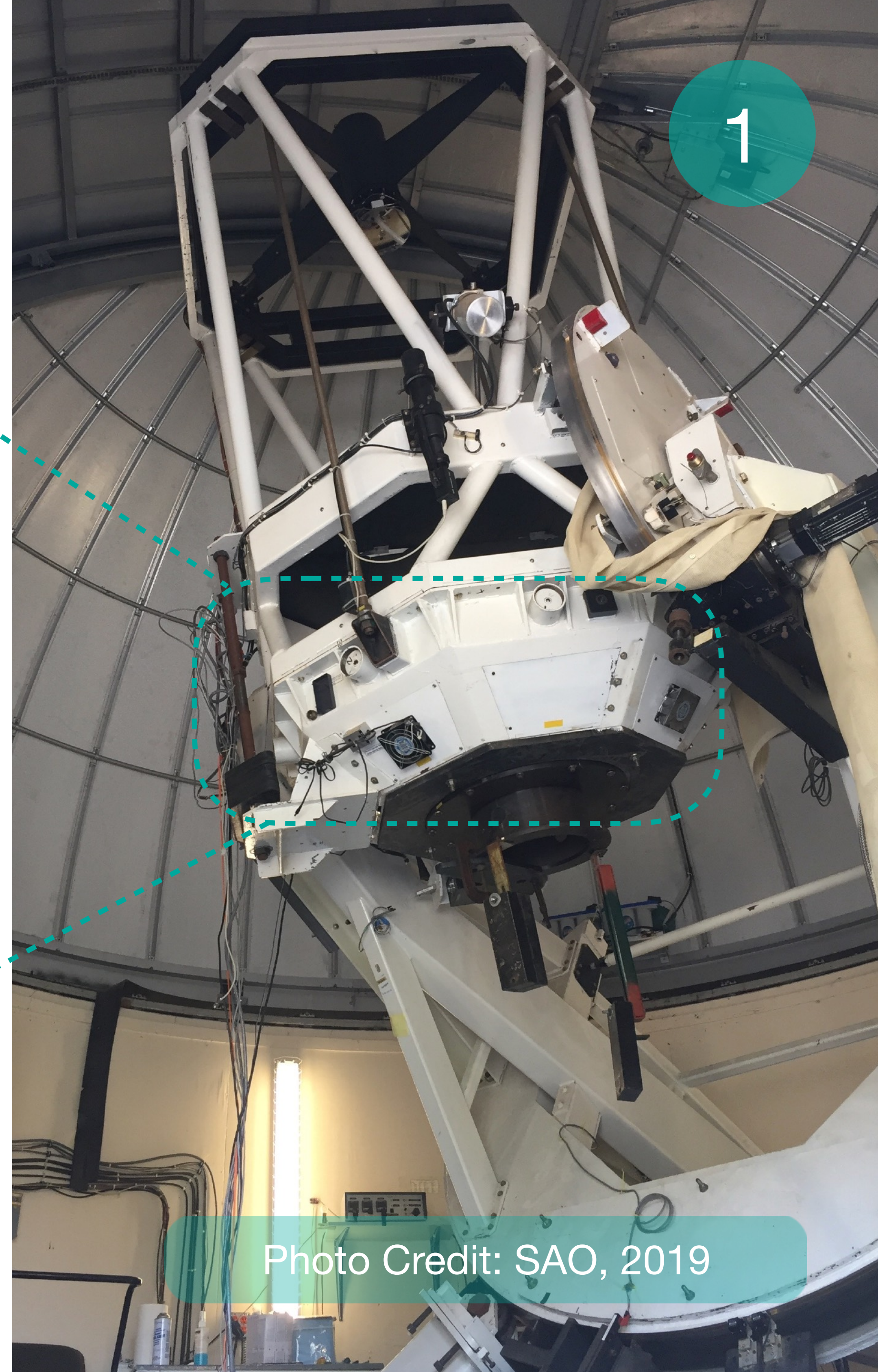
Enable

Transit detection of  $1R_{\oplus}$  planets orbiting  $0.1 - 0.3R_{\odot}$  stars with  $3\sigma$  significance

Follow-up of nearby transiting planets discovered by TESS

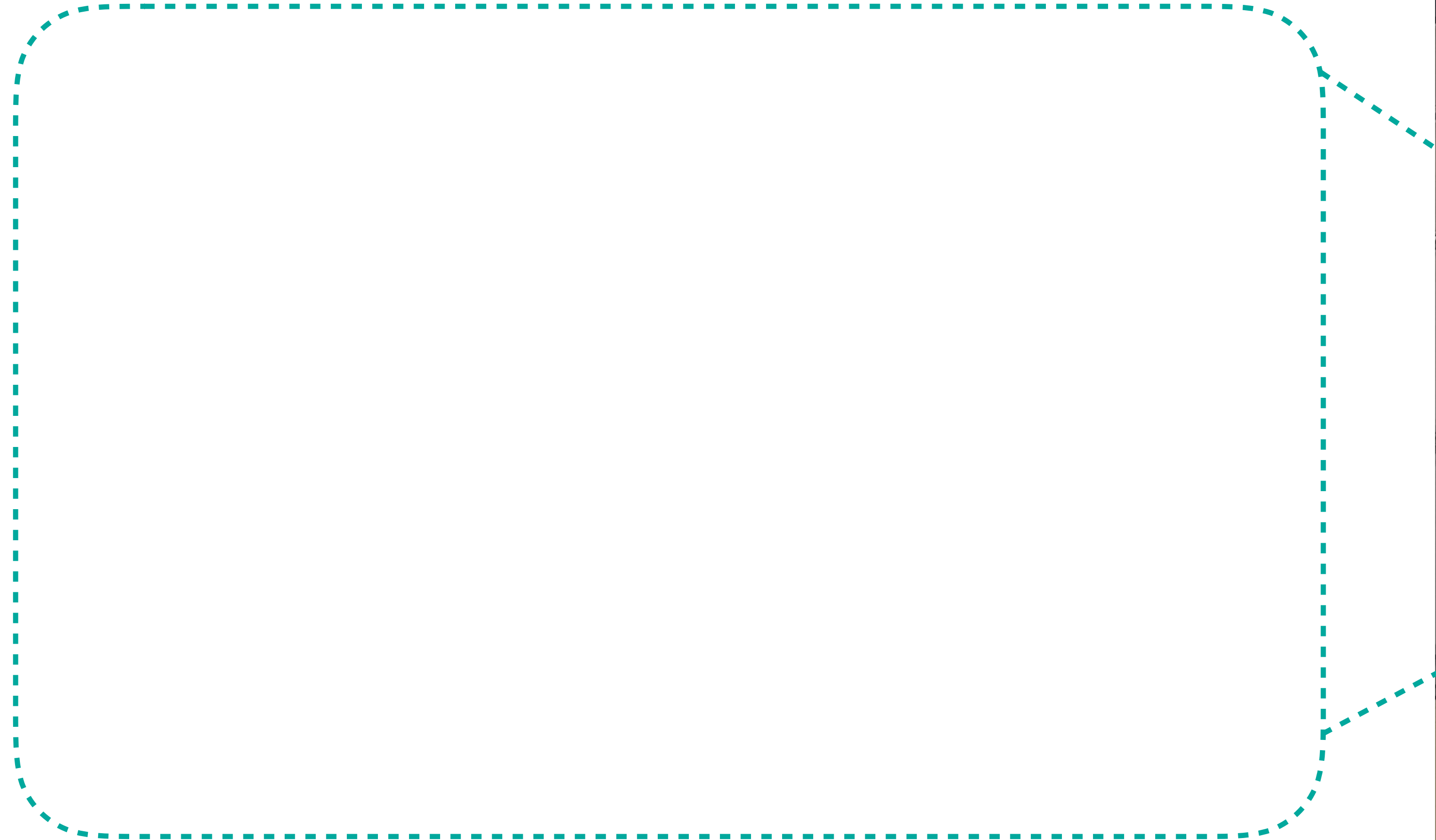


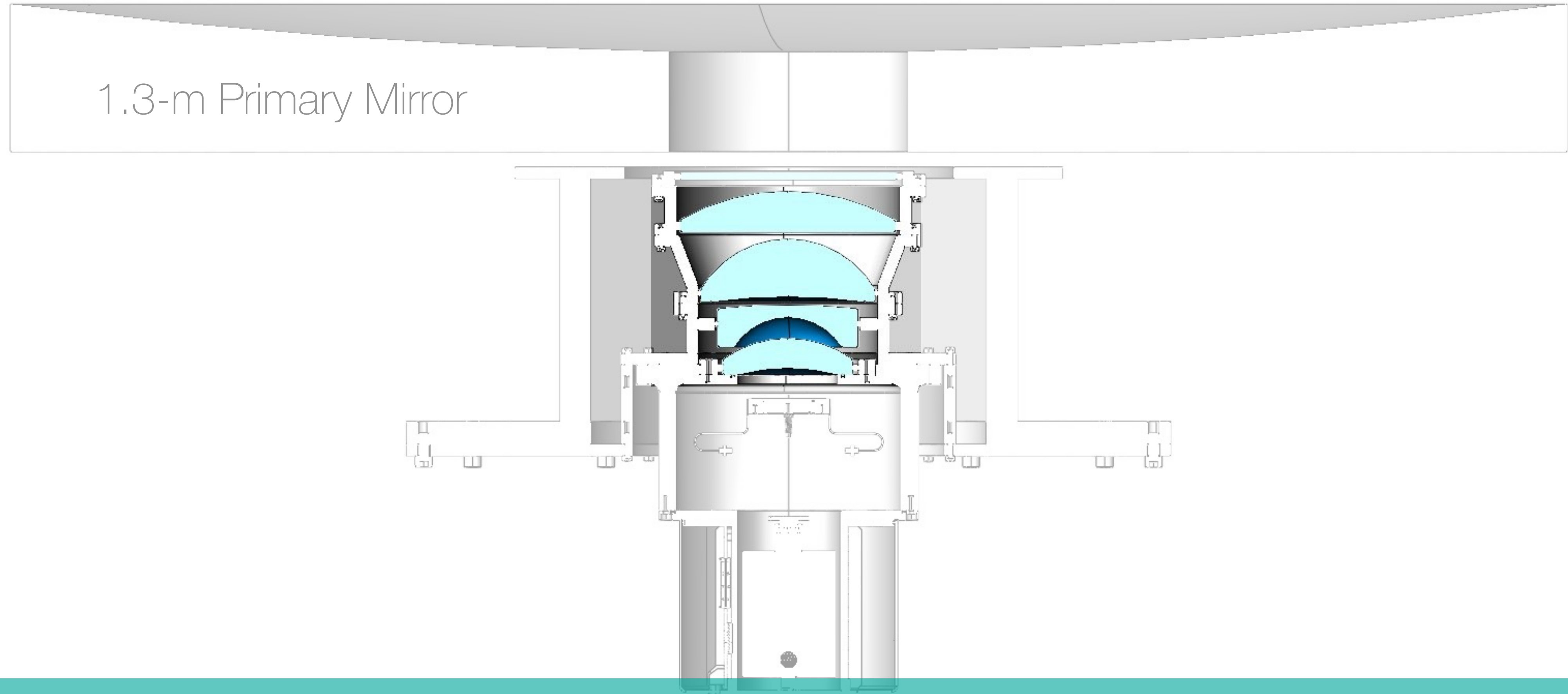
Photo Credit: SAO, 2019



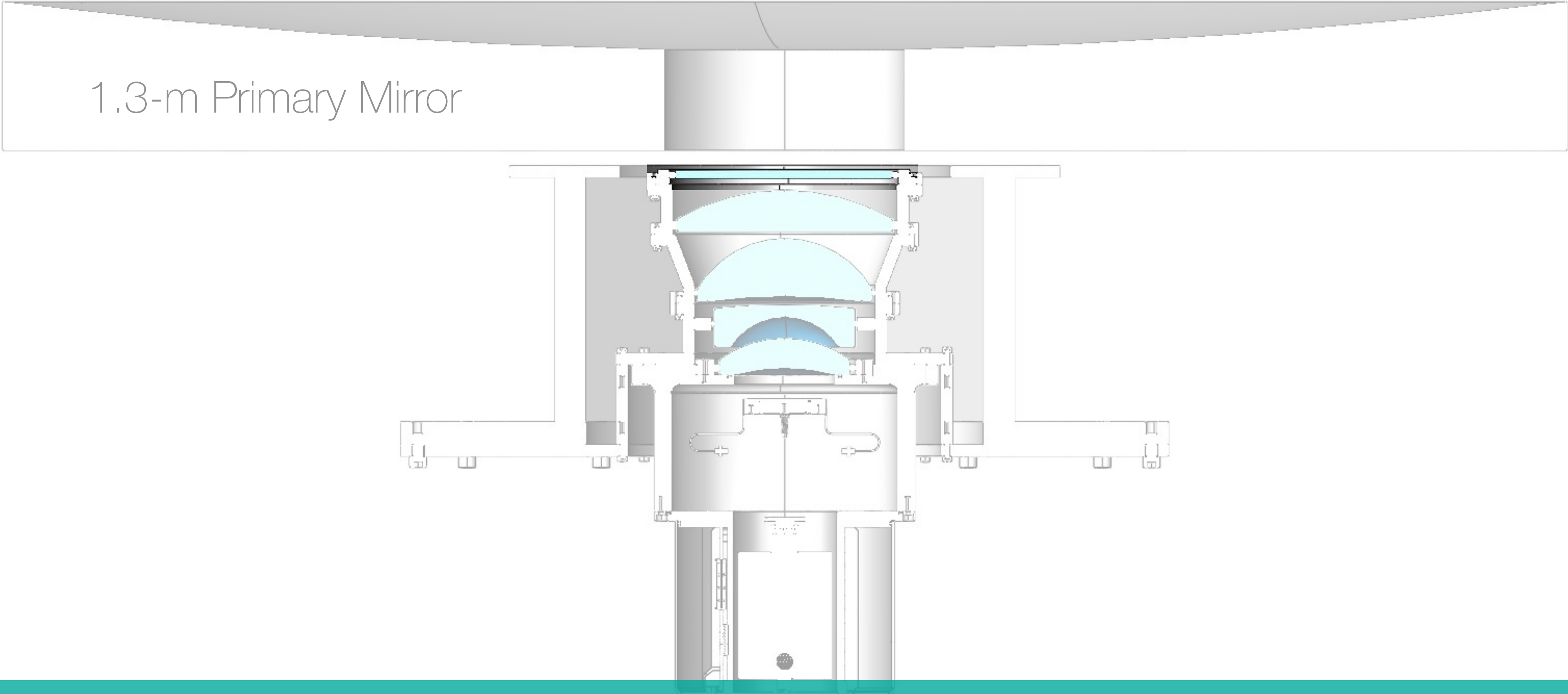
1

Photo Credit: SAO, 2019





The *Tierras* camera consists of:  
A four-lens focal reducer and field-flattener to increase the field-of-view (FOV) of the telescope from  $8.5' \times 8.5'$  to  $0.5^\circ \times 0.5^\circ$



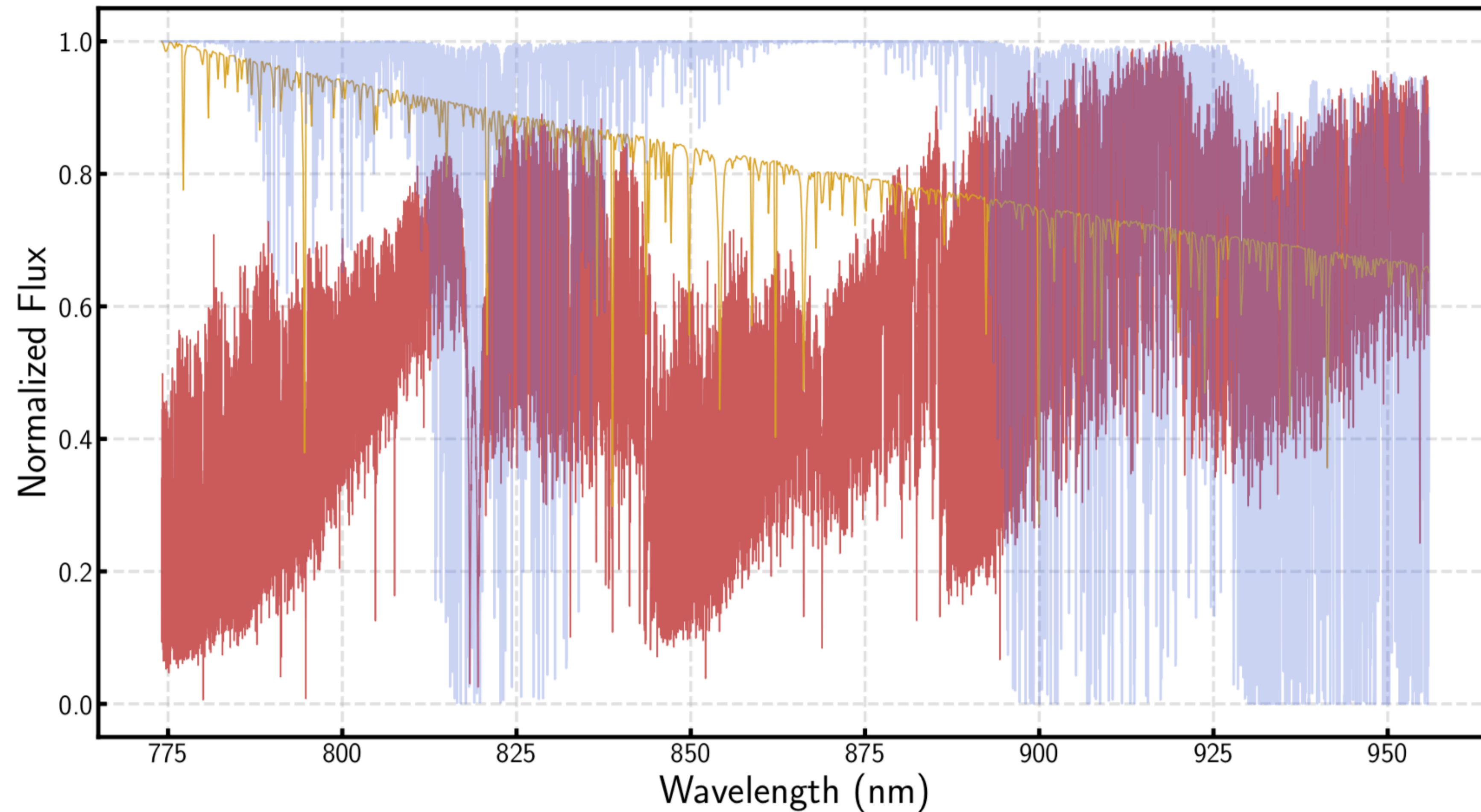
The *Tierras* camera consists of:  
a custom-made filter

M Dwarf, T=2800 K

G Star, T=5800 K

Telluric Lines (Water only)

2



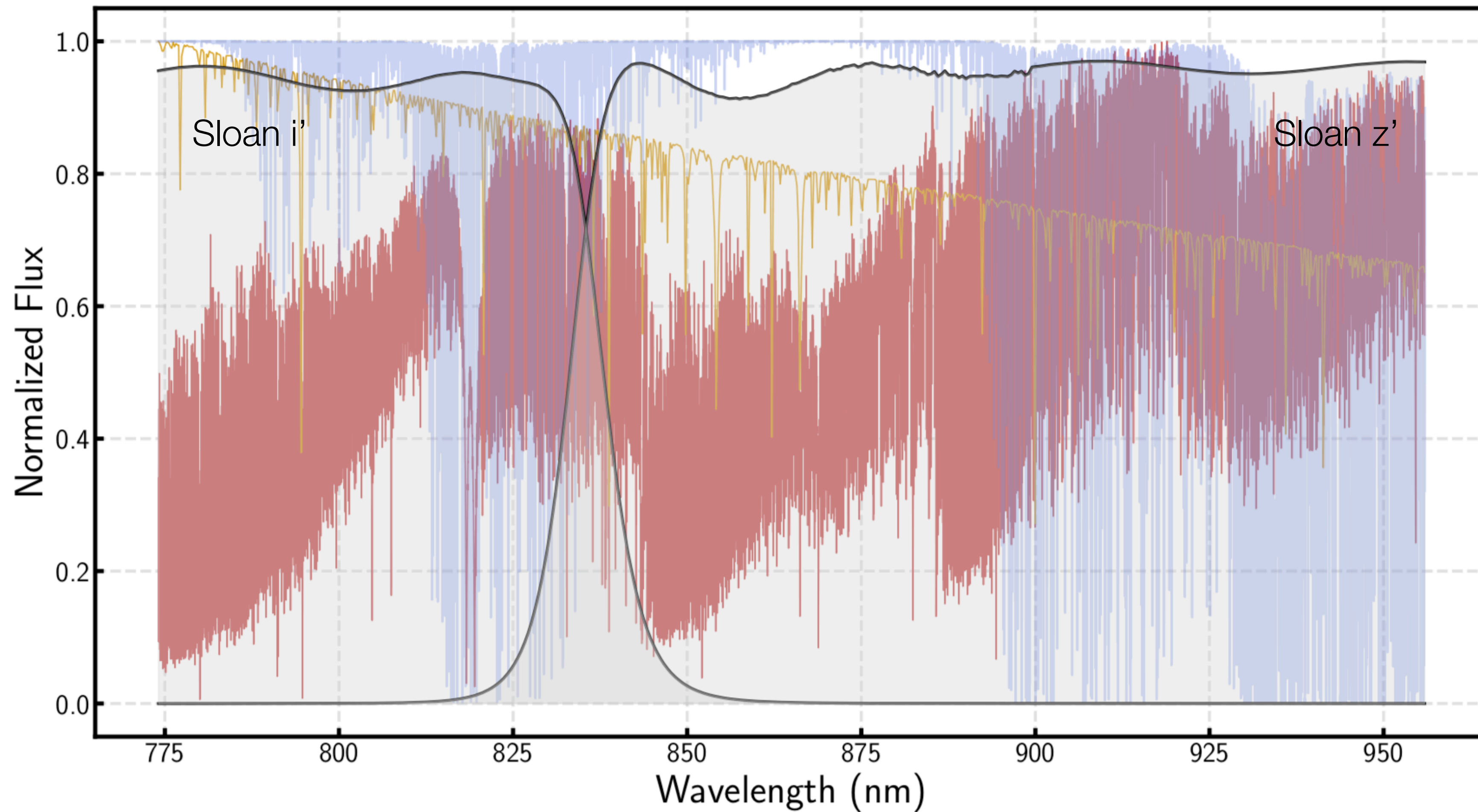
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M Dwarf, T=2800 K

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Telluric Lines (Water only)



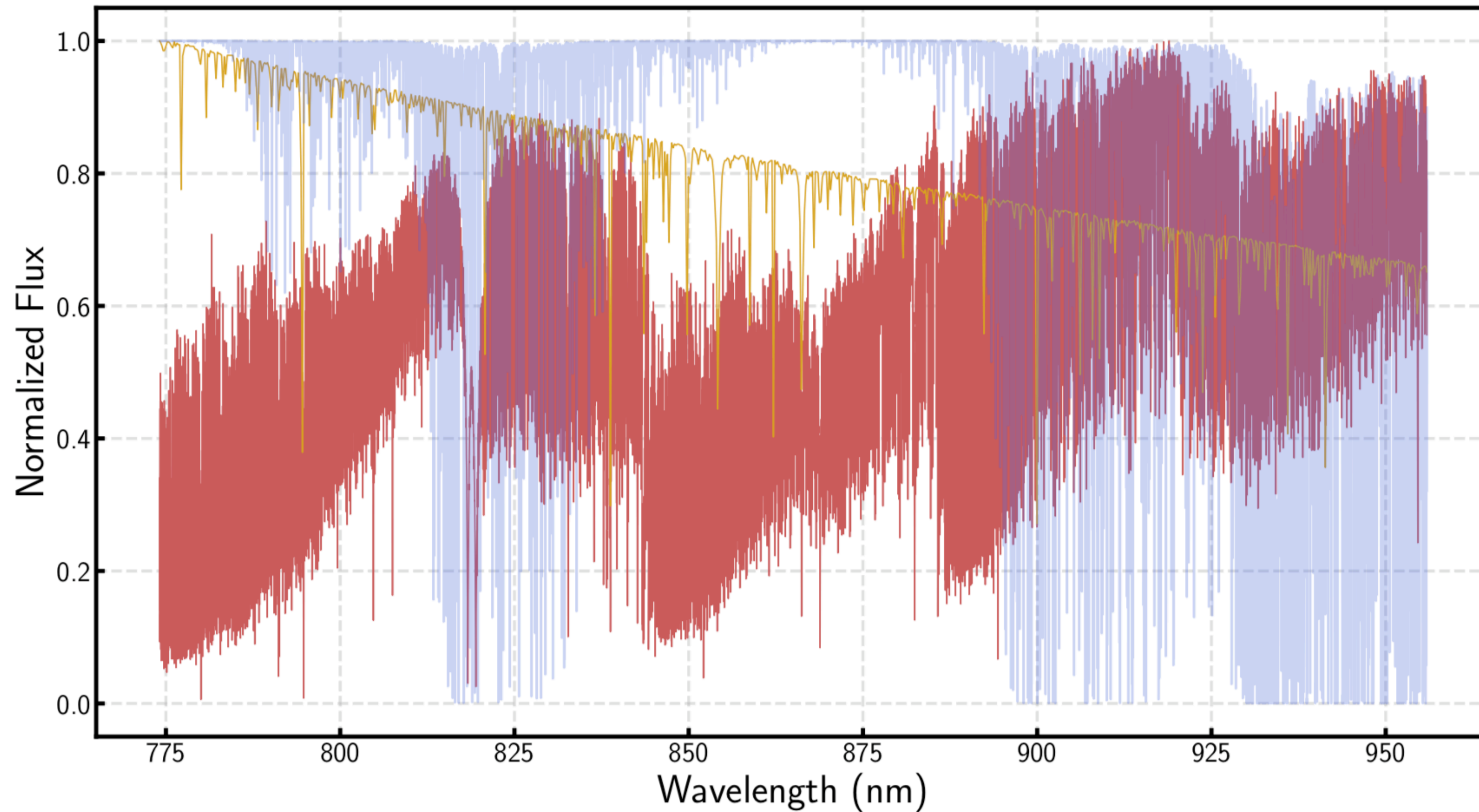
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M Dwarf, T=2800 K

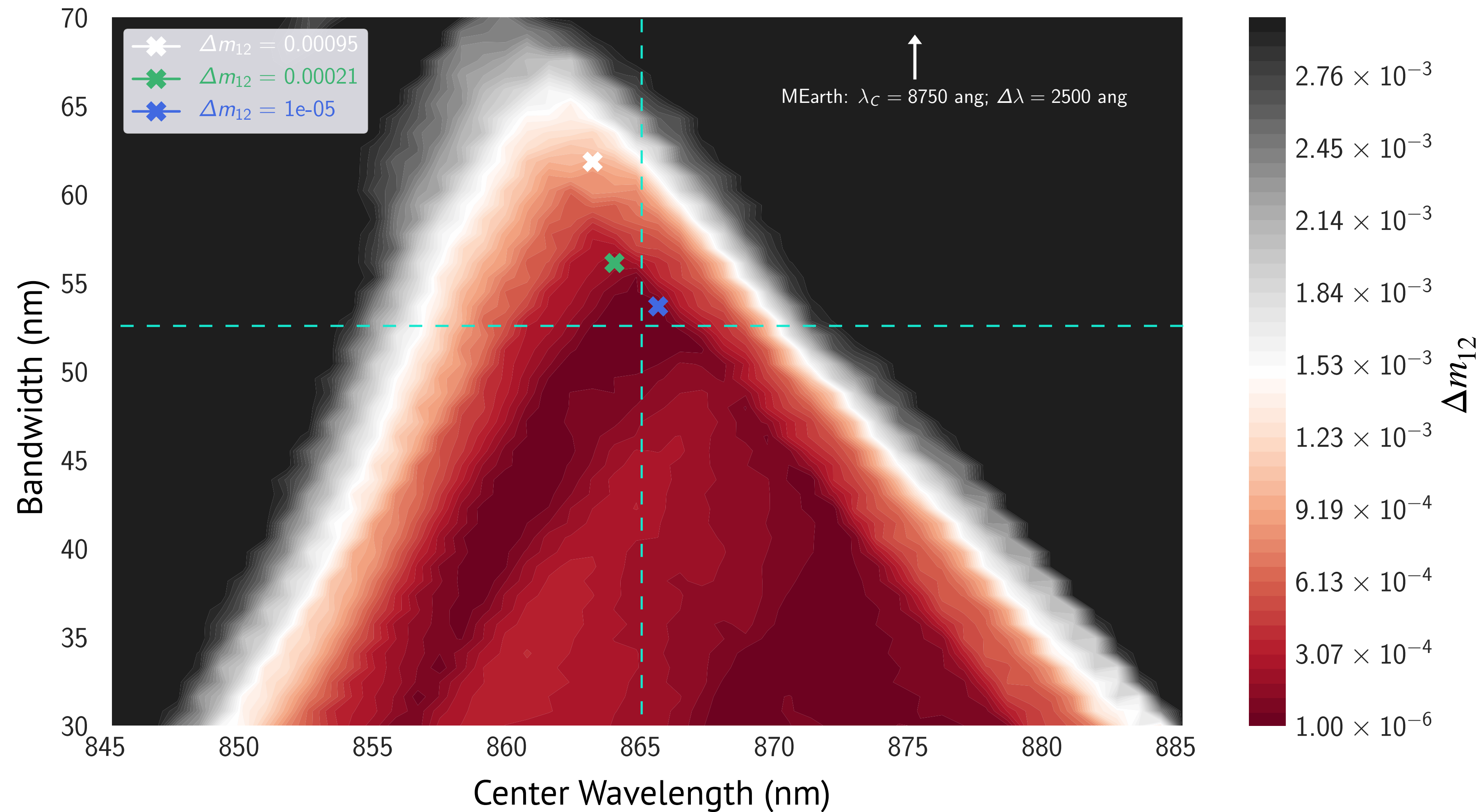
G Star, T=5800 K

Telluric Lines (Water only)

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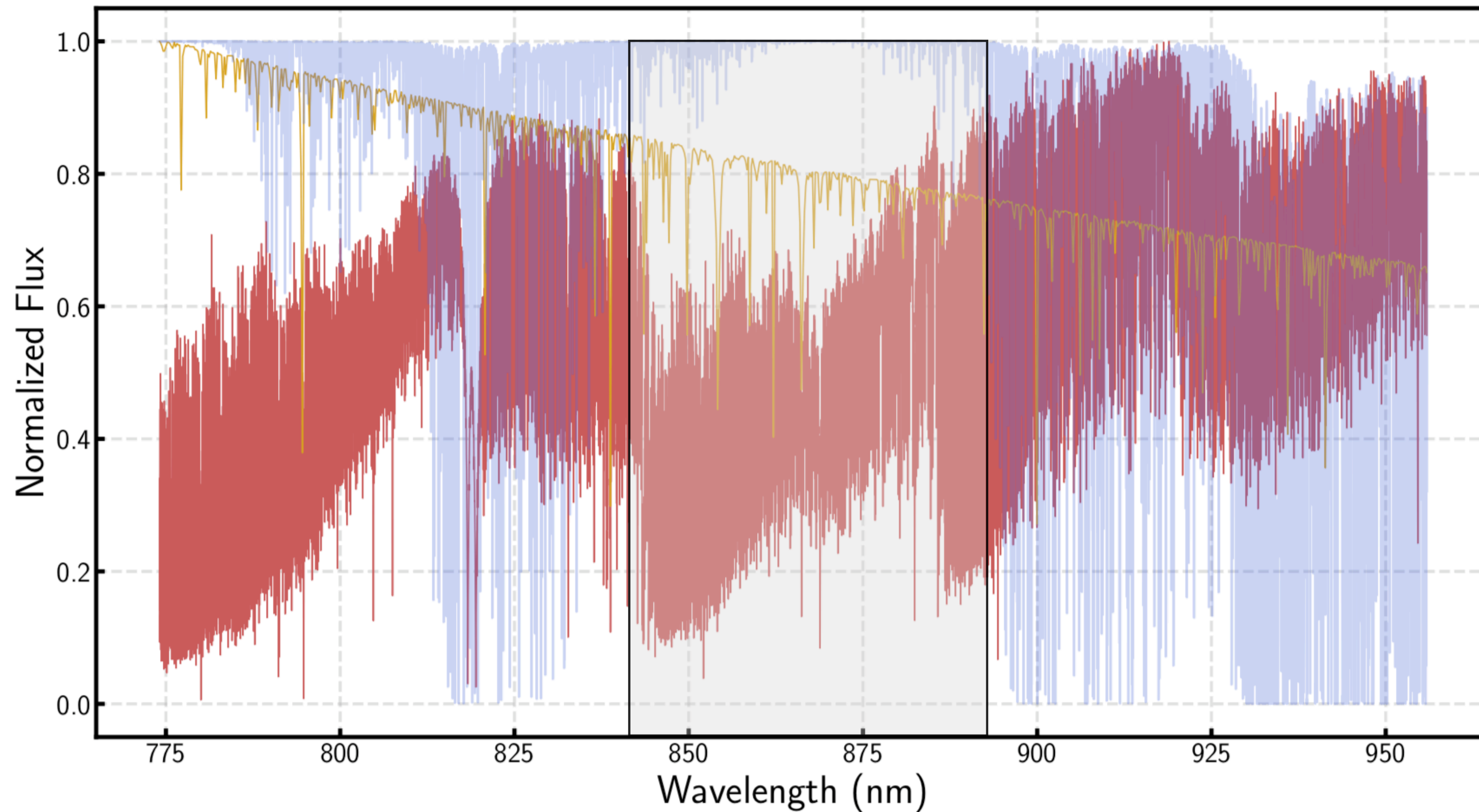
The *Tierras* camera consists of:  
a custom-made filter with a 53 nm bandpass, & centered at 865 nm.

M Dwarf, T=2800 K

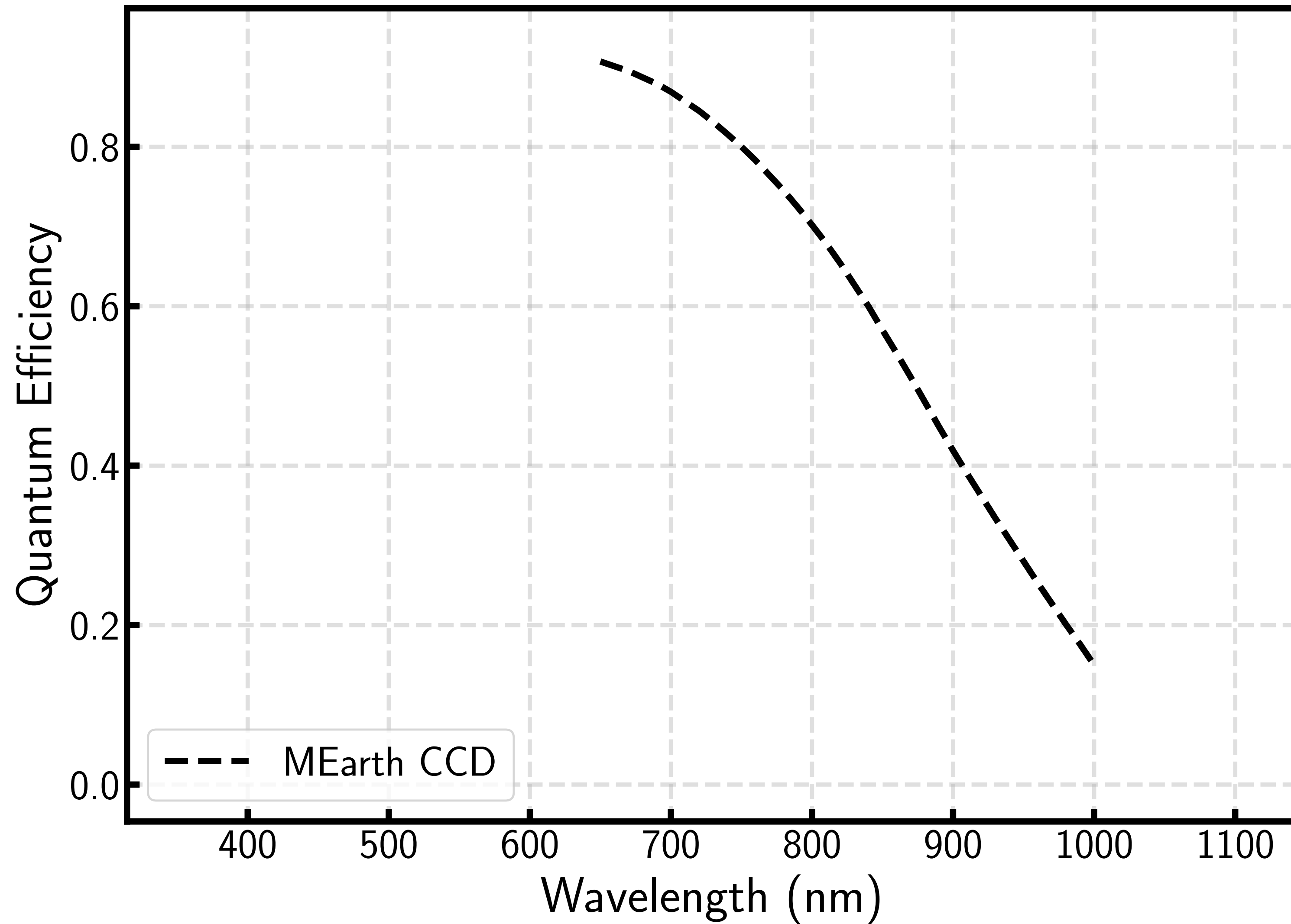
G Star, T=5800 K

Telluric Lines (Water only)

2

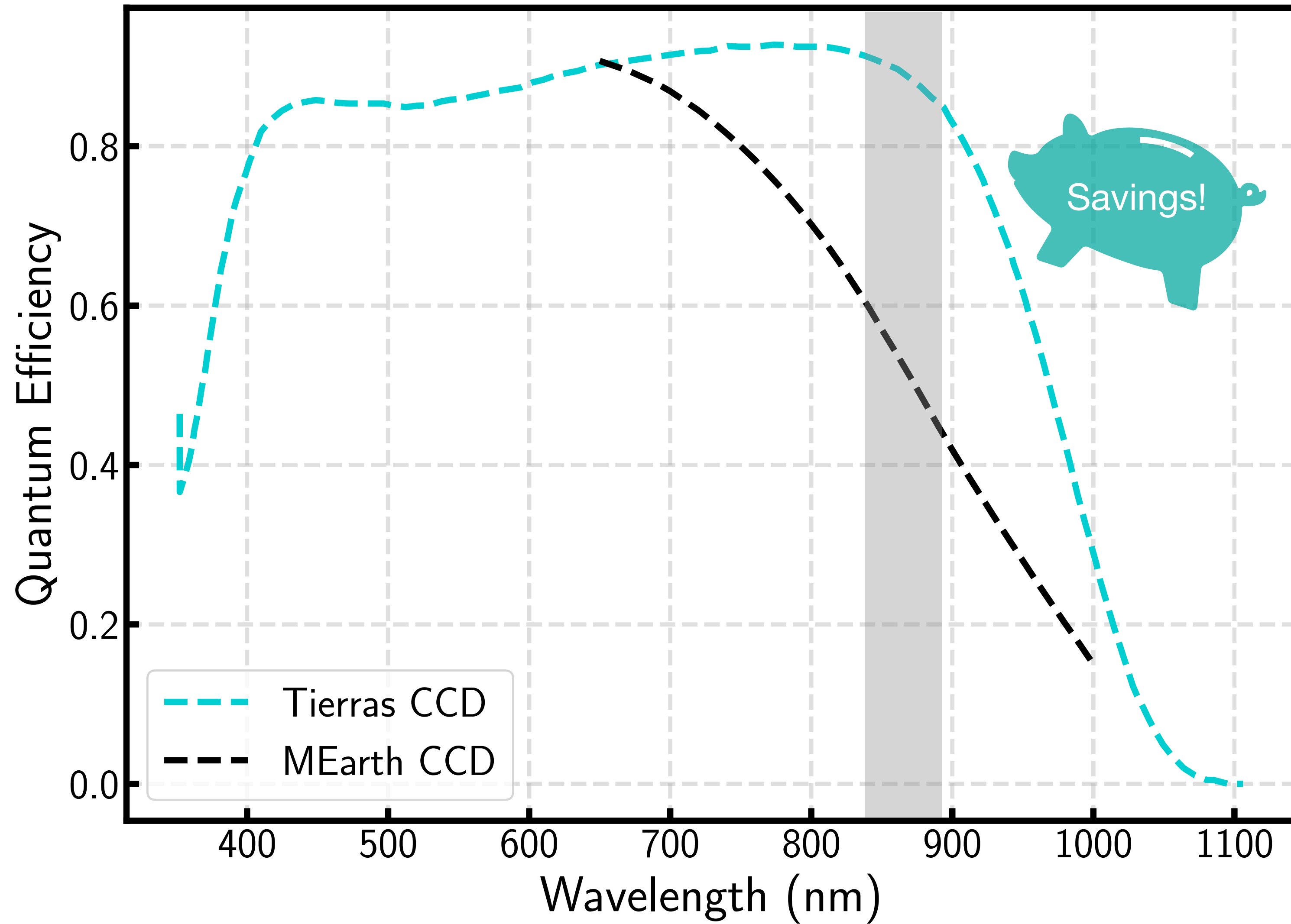


The *Tierras* camera consists of:  
a custom-made filter with a 53 nm bandpass, & centered at 865 nm.



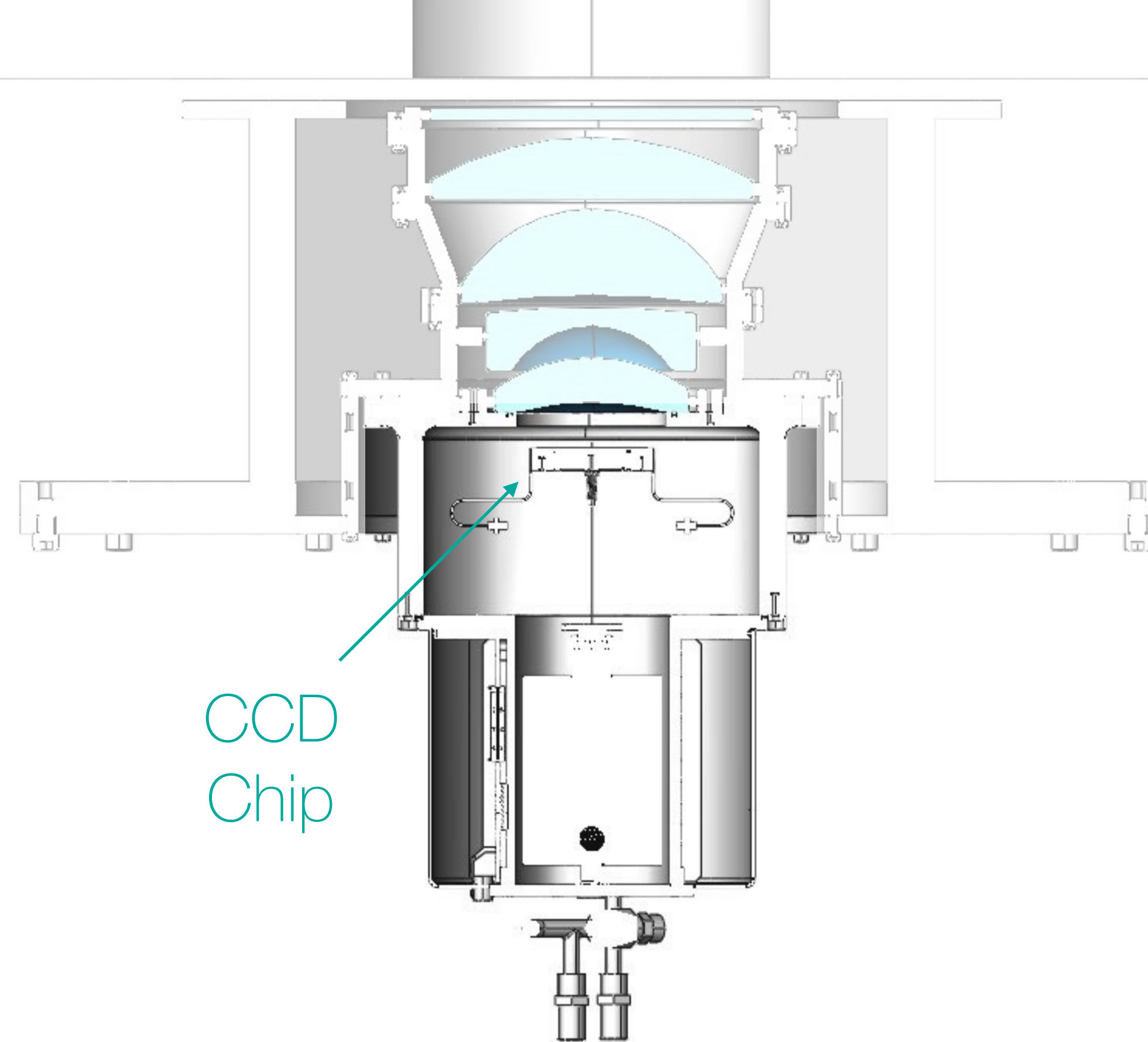
The *Tierras* camera consists of:

a 4K x 4K deep-depletion low read noise e2v CCD with >85% QE in



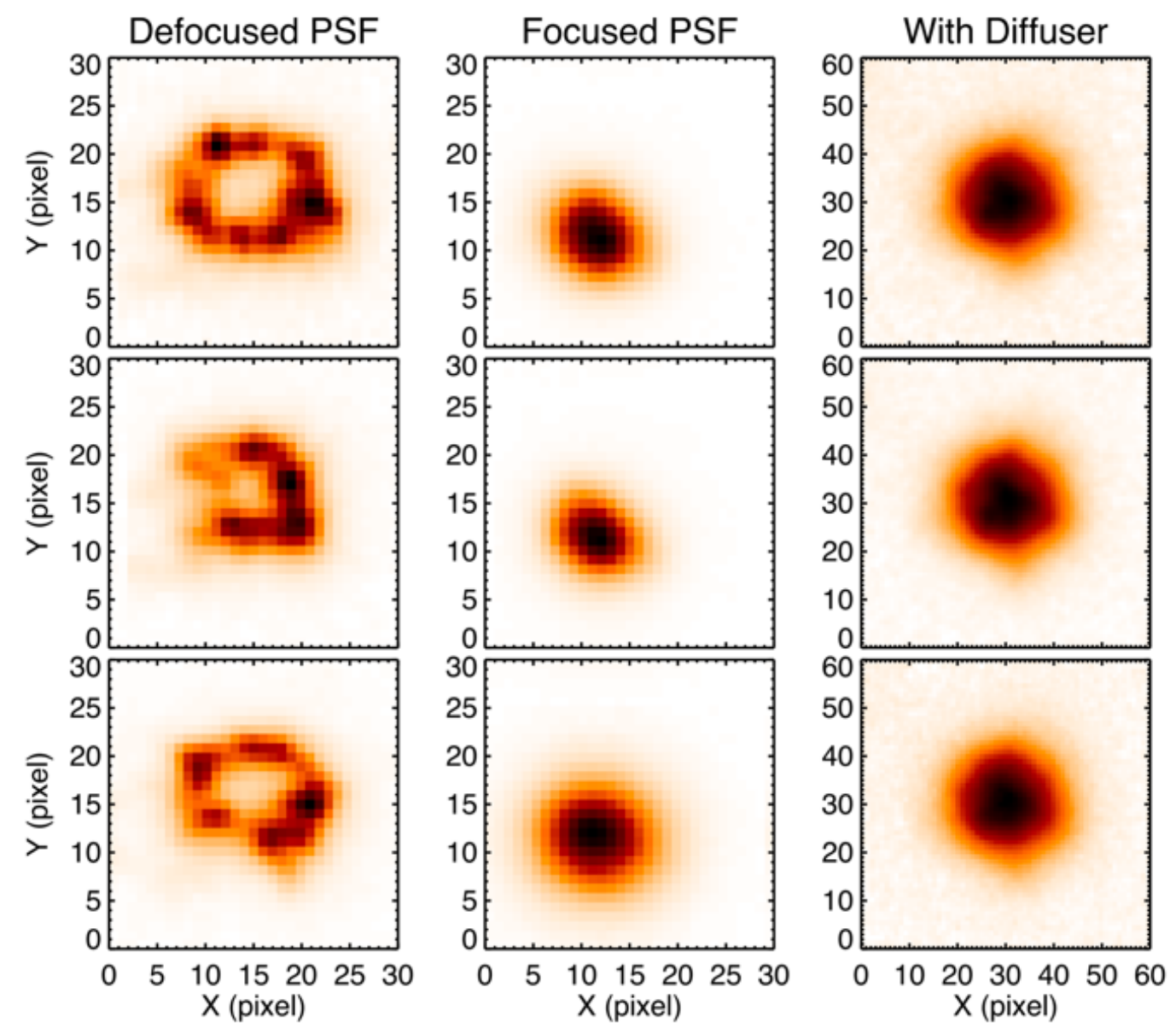
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The *Tierras* camera consists of:

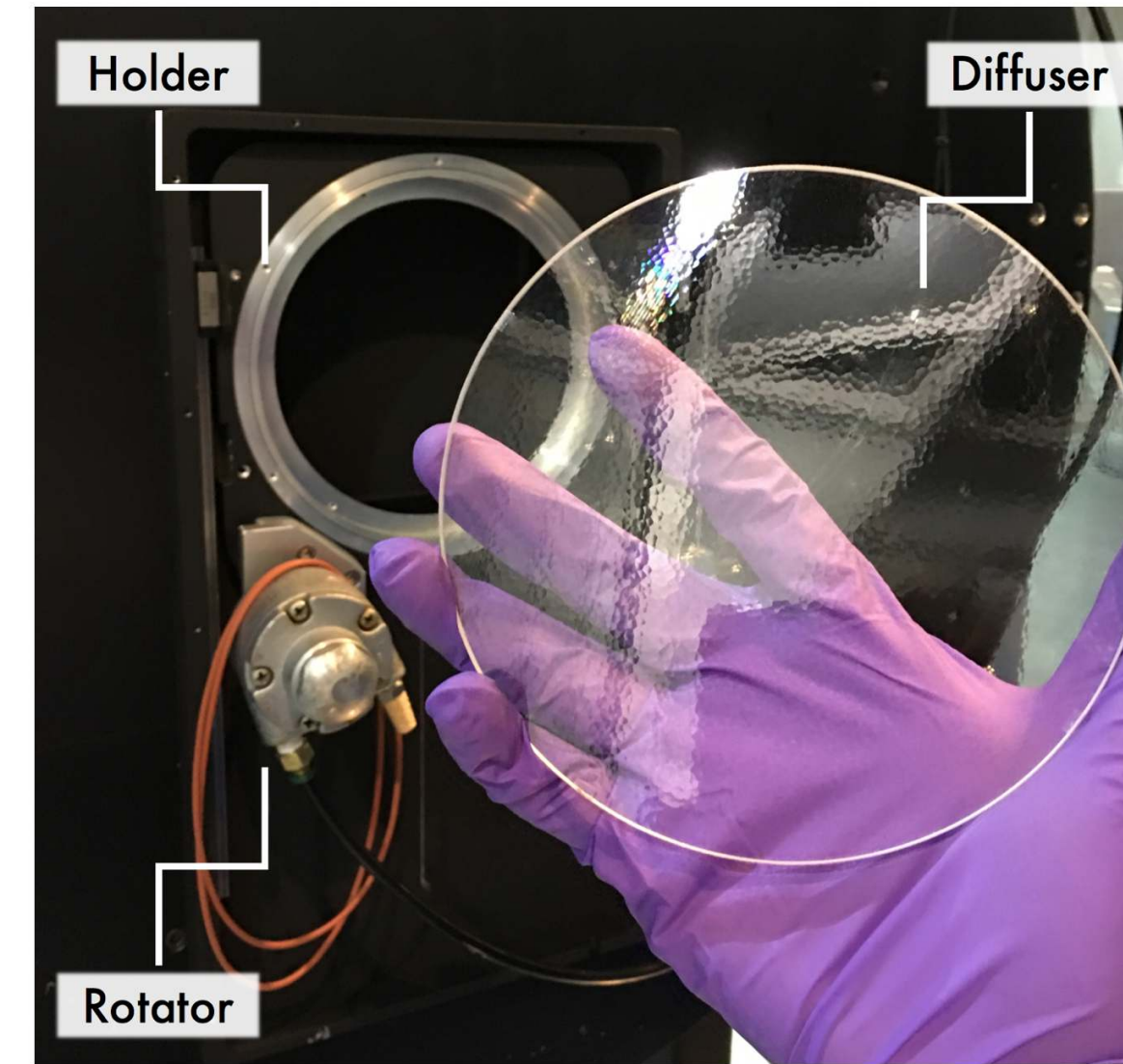
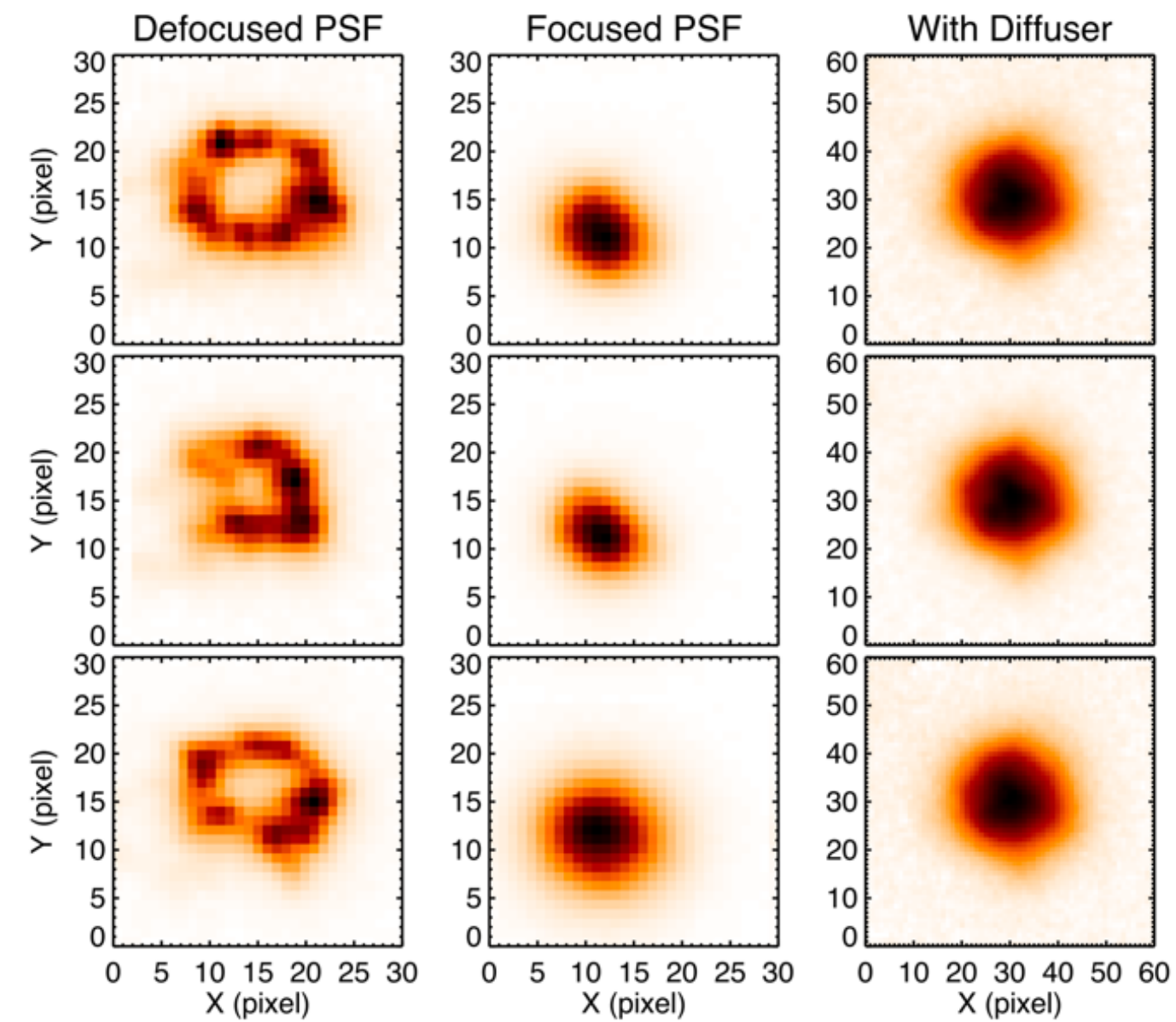
a 4K x 4K deep-depletion low read noise e2v CCD with >85% QE and housed inside a custom-made dewar.



Time



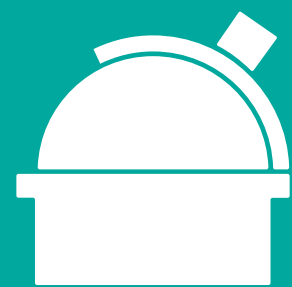
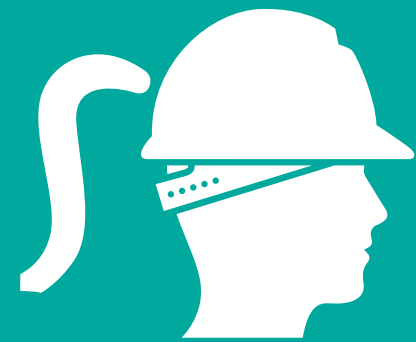
Stefansson et al. (2017) demonstrated diffuser-assisted on-sky photometric precision of  $137^{+64}_{-36}$  ppm in the NIR.



The *Tierras* camera consists of:

a custom-made nano-fabricated beam-shaping *diffuser* to mold the stellar PSF into a broad & stable top-hat shape.

# Project Status



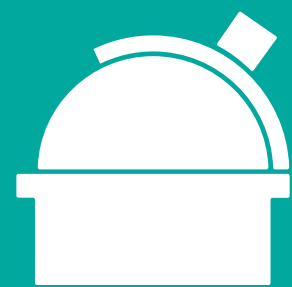
# Project Status



We have **finalized** the optical design, including lenses, opto-mechanical mounts, coatings and filter.



We have **finalized** custom CCD dewar design.



We have **ordered** all out-of-house hardware components.

# Project Status

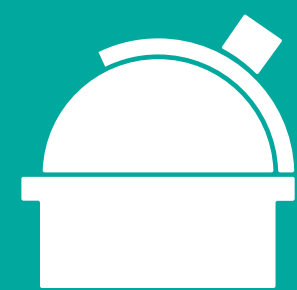


DFM Engineering has **begun** telescope refurbishment, and retrofit with new control system.



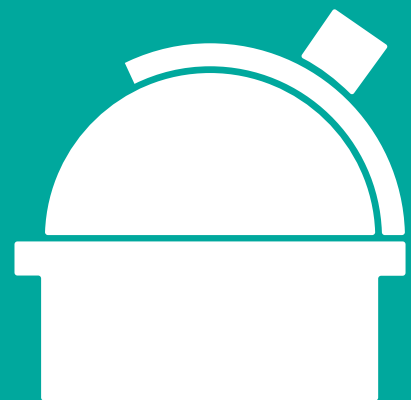
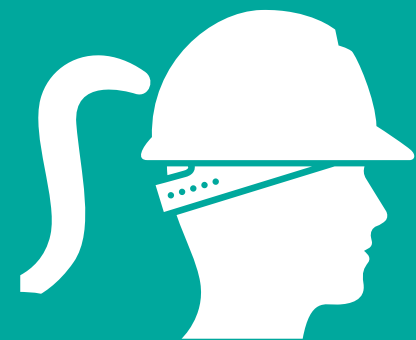
Optimax is currently **polishing** (and coating) our optics.

Spectral Instruments is **fabricating** our custom CCD dewar.



We are **building** the opto-mechanical components in-house.

# Project Status



We will be on sky in early 2020!

Q&A

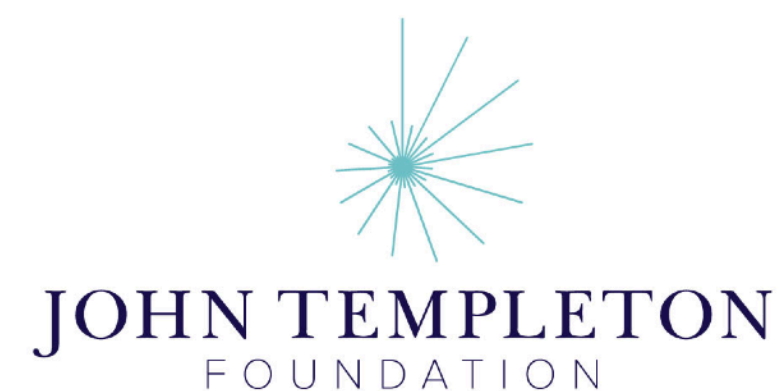
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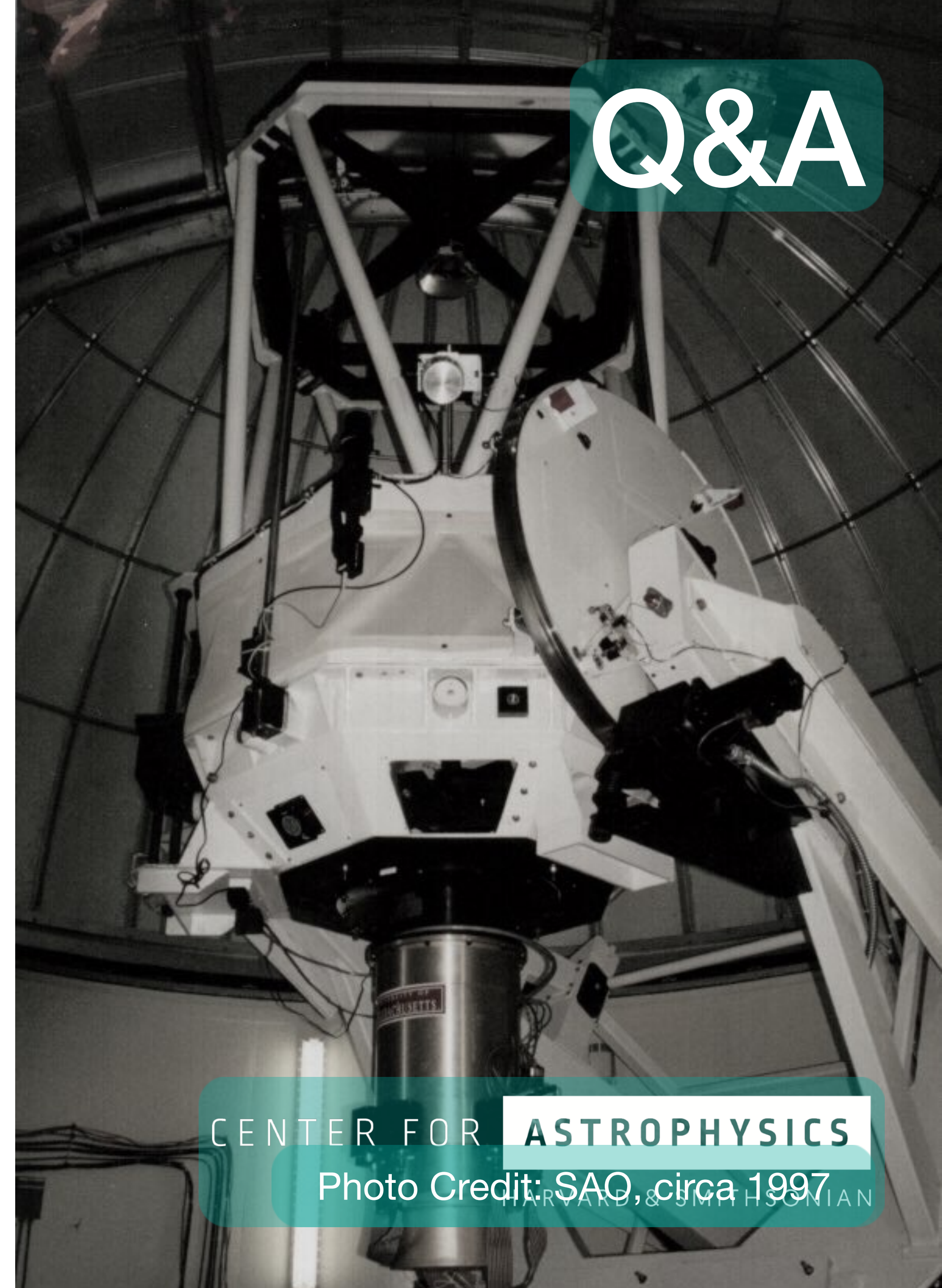
Juliana García-Mejía

— and —

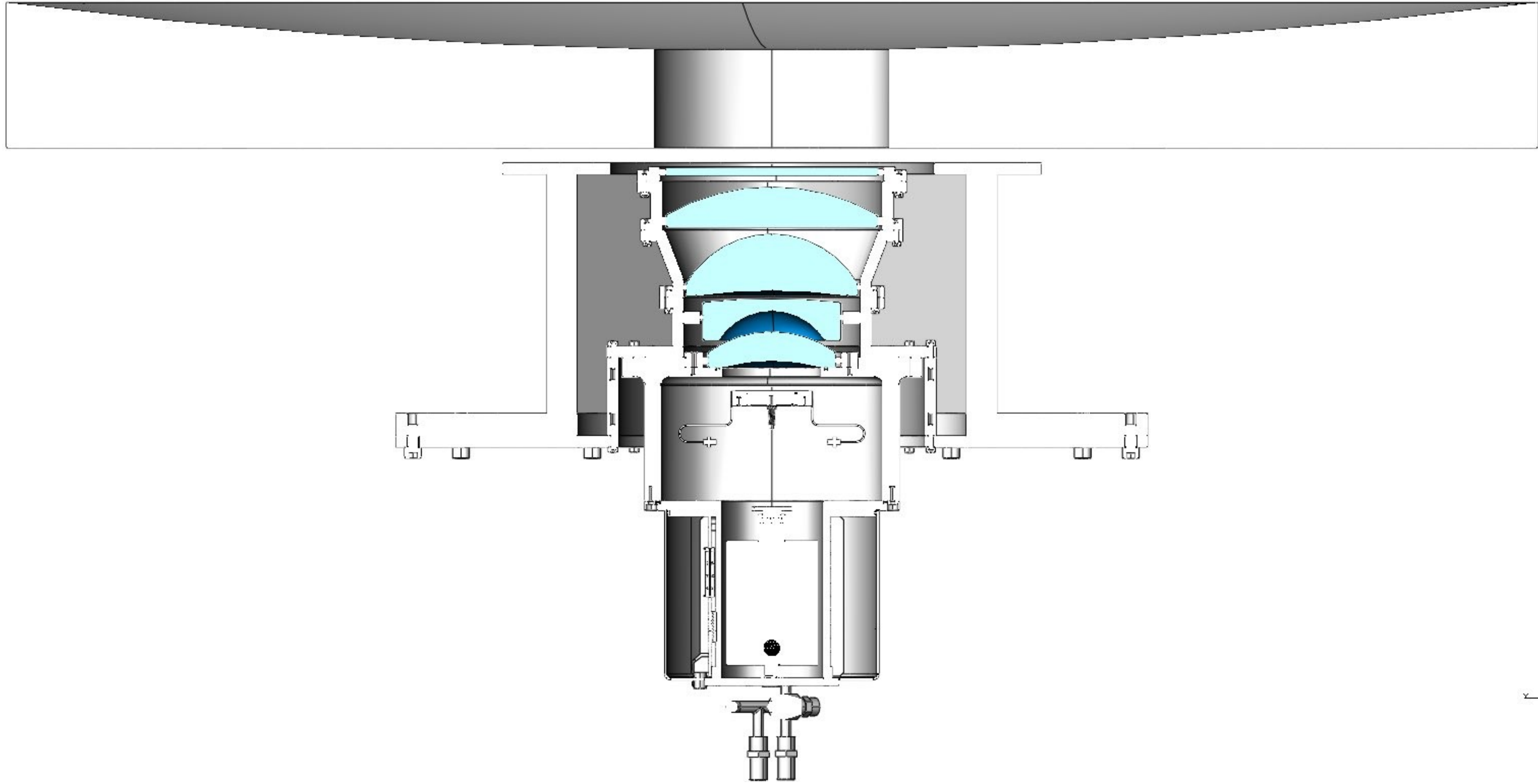
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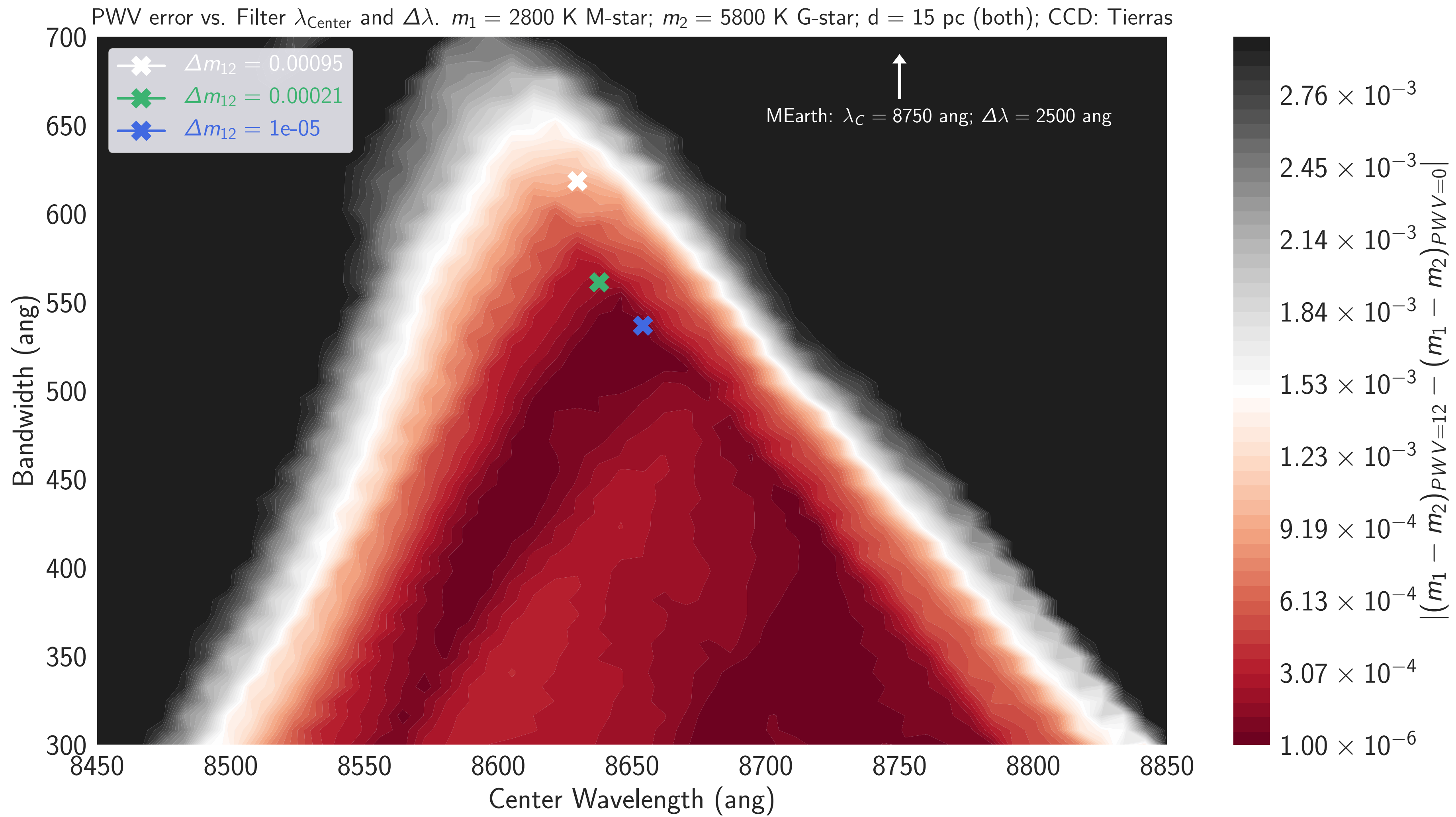
CENTER FOR **ASTROPHYSICS**  
Photo Credit: SAO, circa 1997

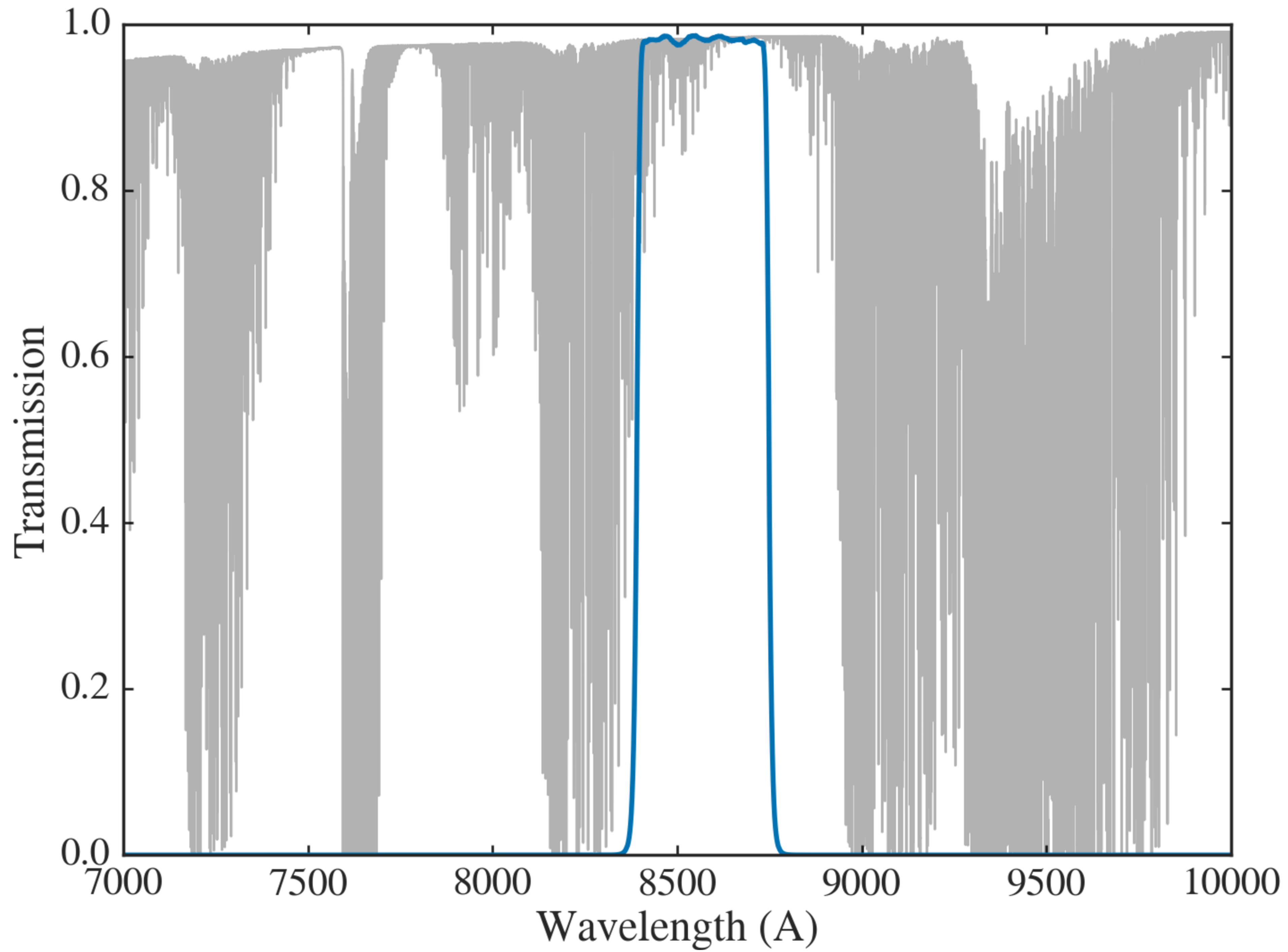


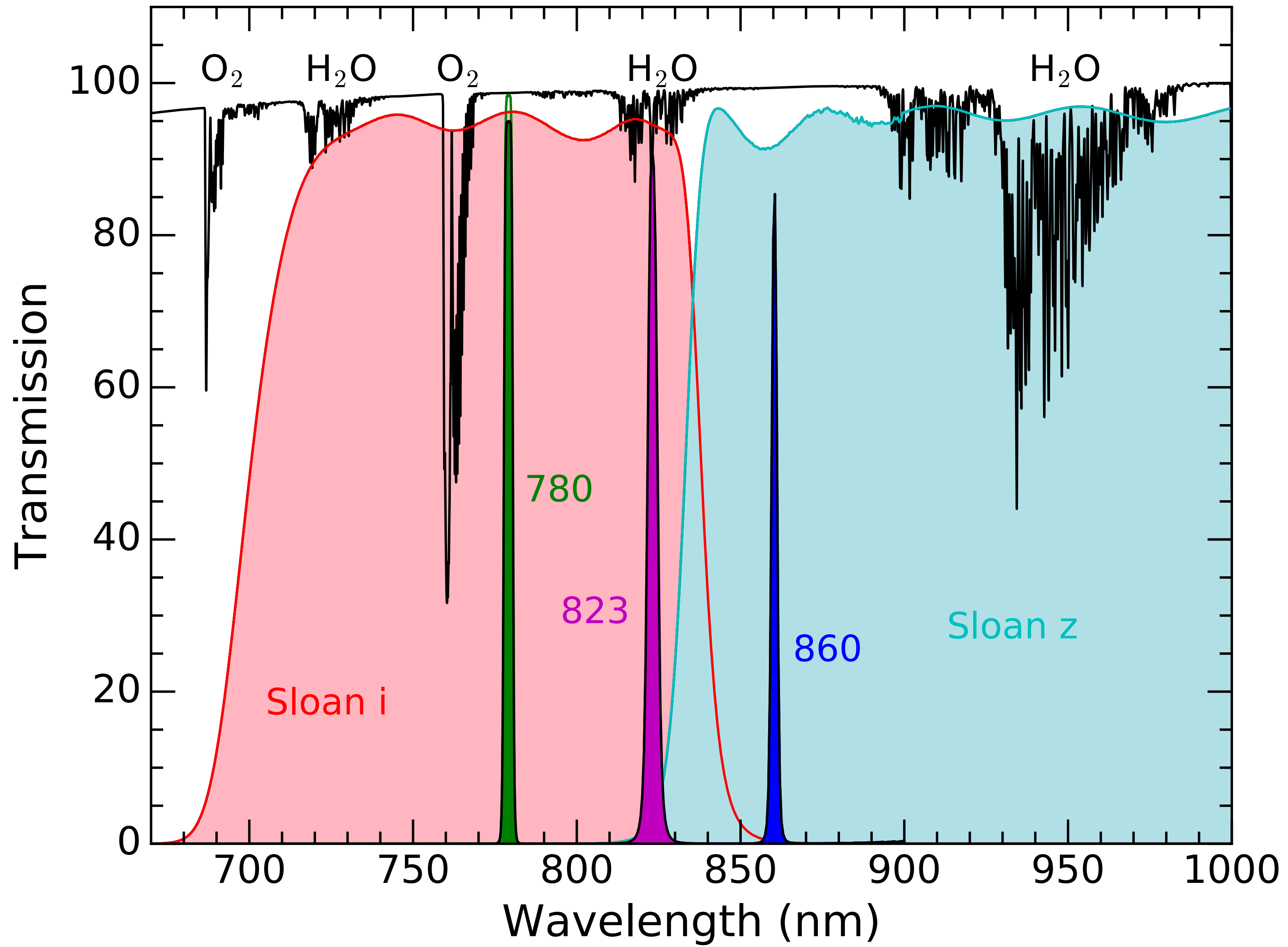
# Additional Slides



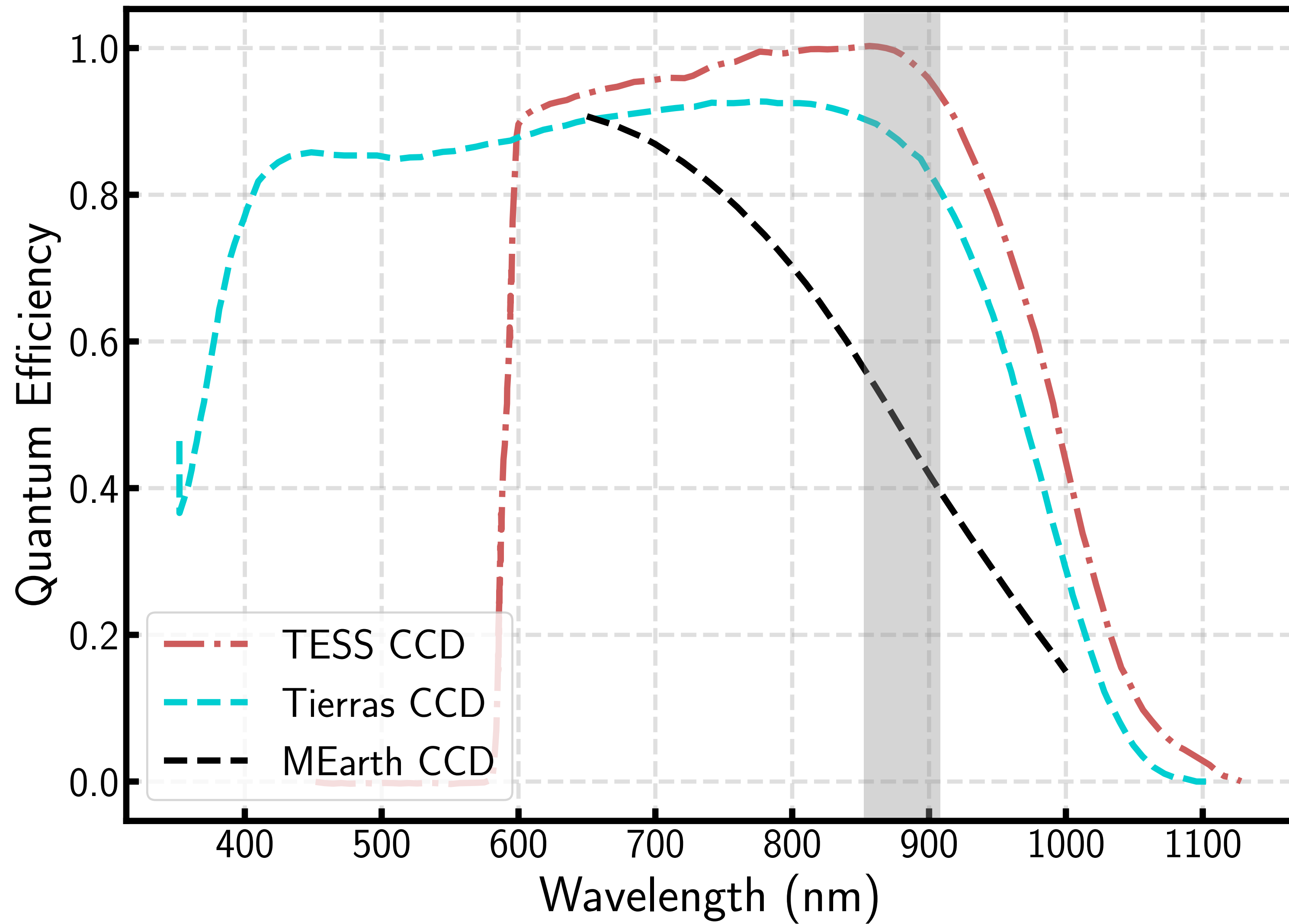




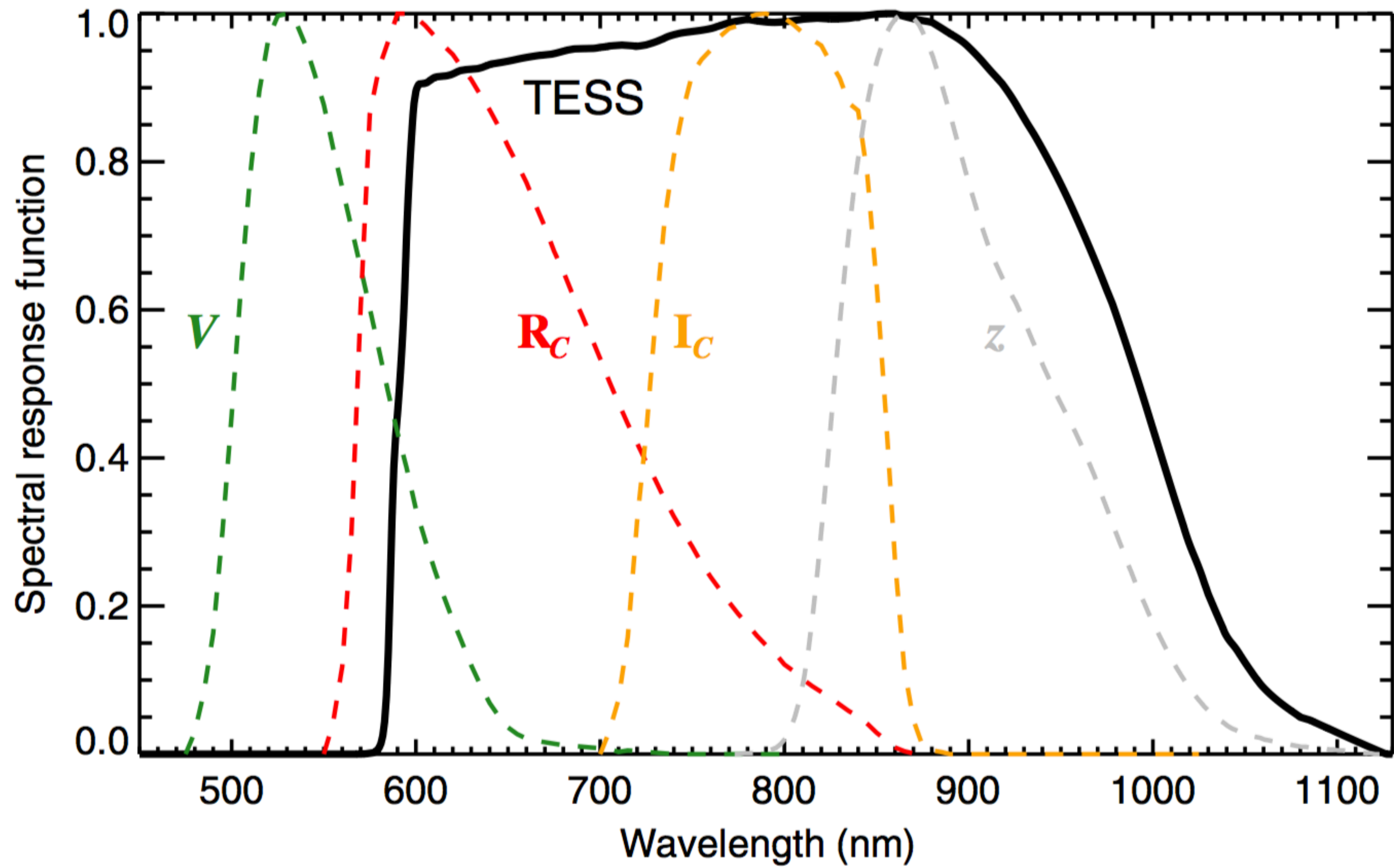




Baker et al., 2017



TESS Data: Ricker et al., 2015



T I E R R A S

Transiting Earth-like  
planets

'Round Red stars -  
an Automated Survey

**FAST** - installed in the 1.5m Cassegrain focus circa January **1994**-  
(Fabricant et al., 1996)

**2MASS North** - science acquisition between **1997-2001** (Skrutskie et al.,  
2006)

**HAT-5** - survey started in **2003** (Bakos et al., 2004)

**PAIRITEL** - science acquisition between **2004-2008\*** ([https://  
ui.adsabs.harvard.edu/abs/2006ASPC..351..751B/abstract](https://ui.adsabs.harvard.edu/abs/2006ASPC..351..751B/abstract))

**KeplerCam** - installed on the 1.2 telescope circa **2005** - ([https://  
ui.adsabs.harvard.edu/abs/2005AAS...20711010S/abstract](https://ui.adsabs.harvard.edu/abs/2005AAS...20711010S/abstract))

**TRES** - installed on the 1.5m September **2007** - ([http://  
www.sao.arizona.edu/FLWO/60/TRES/commissioning.html](http://www.sao.arizona.edu/FLWO/60/TRES/commissioning.html))

**MEarth** - survey started in **2008** ([https://ui.adsabs.harvard.edu/abs/  
2013ApJ...775...91B/abstract](https://ui.adsabs.harvard.edu/abs/2013ApJ...775...91B/abstract))

**MINERVA** - installed late **2014** (Swift et al., 2015)