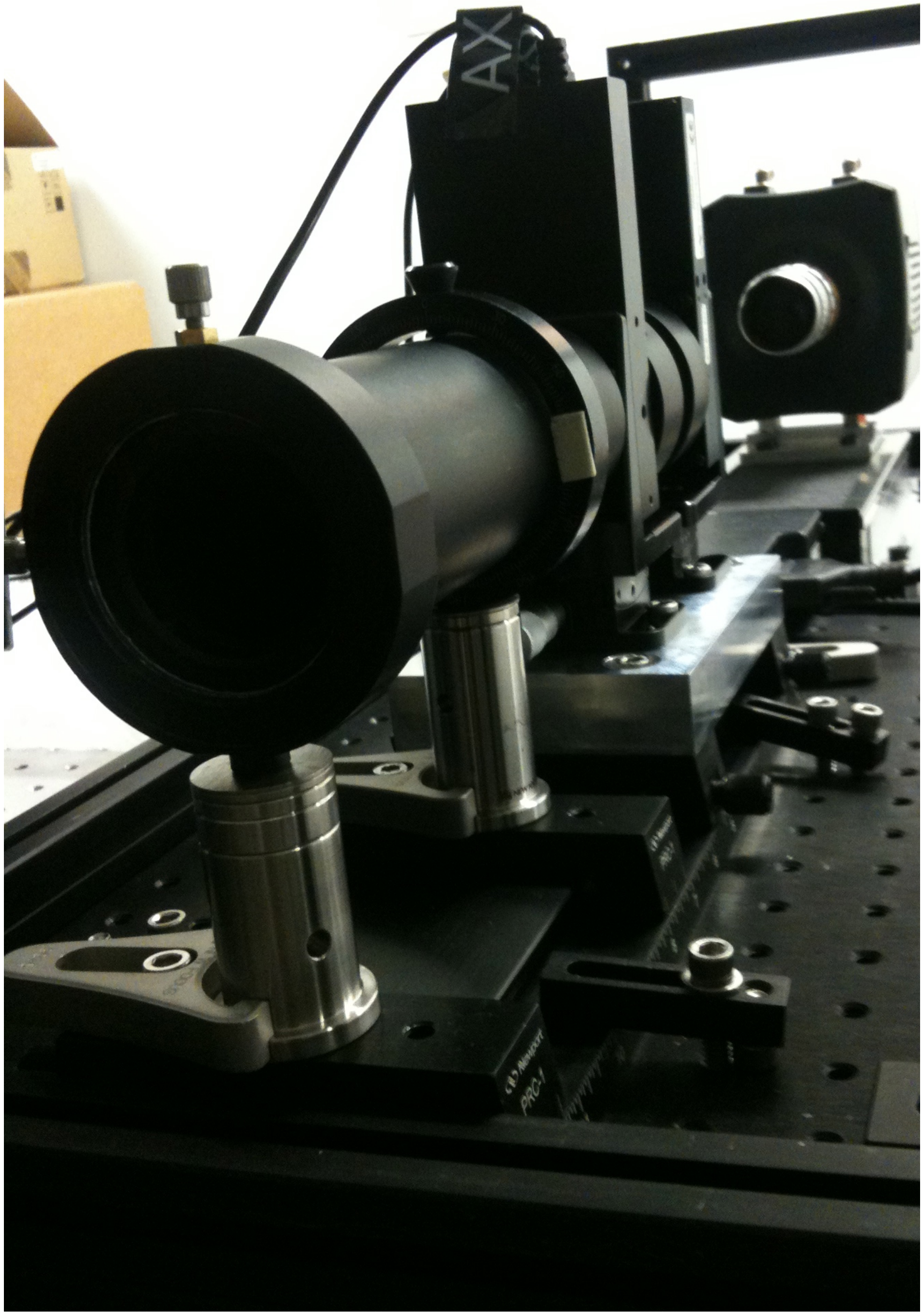


The MilliArcSec camera (TMAS)

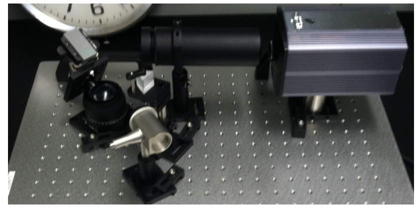
Astronomical Spectroscopy
with Electron-Multiplied CCDs (EMCCDs)

July 28, 2015

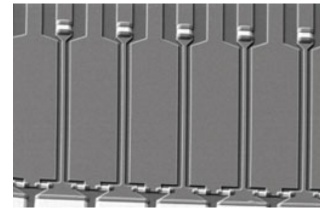
Richard Dekany

Caltech Optical Observatories
California Institute of Technology

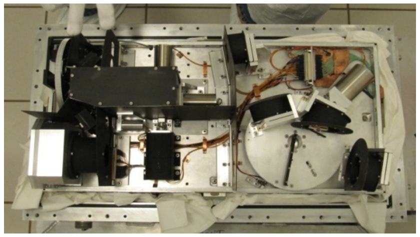
PALM-3000 Instruments



VERVE PRV demo?
(TBD)

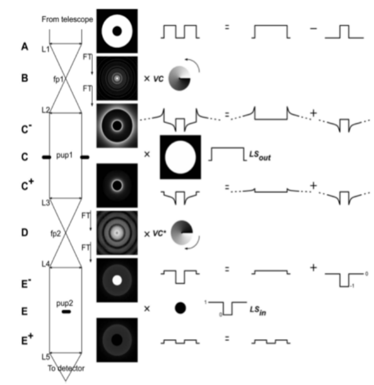


DARKNESS
(UCSB, Summer 2016)

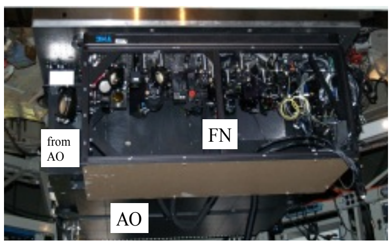


PHARO
(Cornell, 1999)

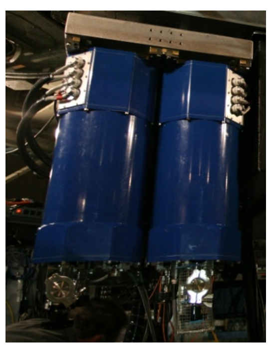
(Caltech & JPL, 2011)



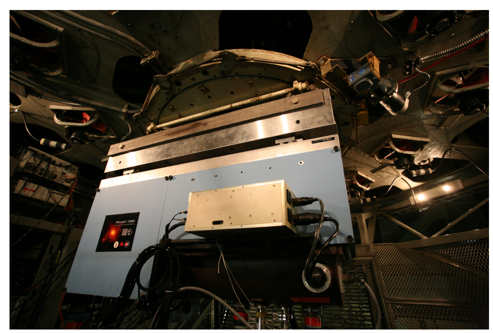
Stellar Double Coronagraph
(JPL, 2014)



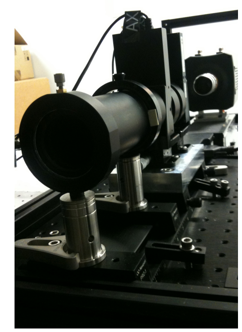
Fiber Nuller
(JPL, 2006)



SWIFT Visible IFU
(Oxford, 2008)

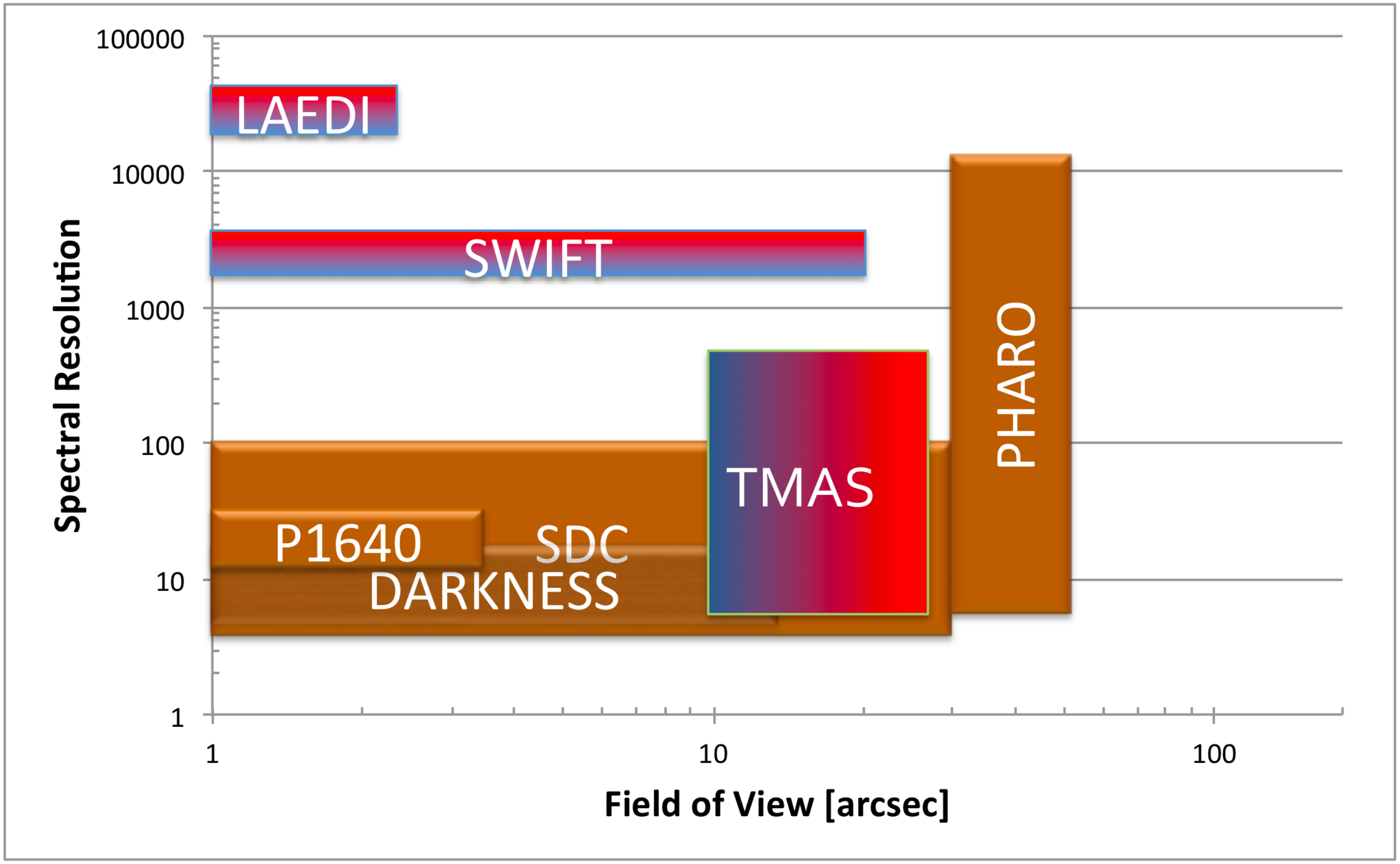


P1640
(AMNH,2008)



TMAS
(Caltech, 2012)

PALM-3000 Instruments



NASA Picture of the Day:

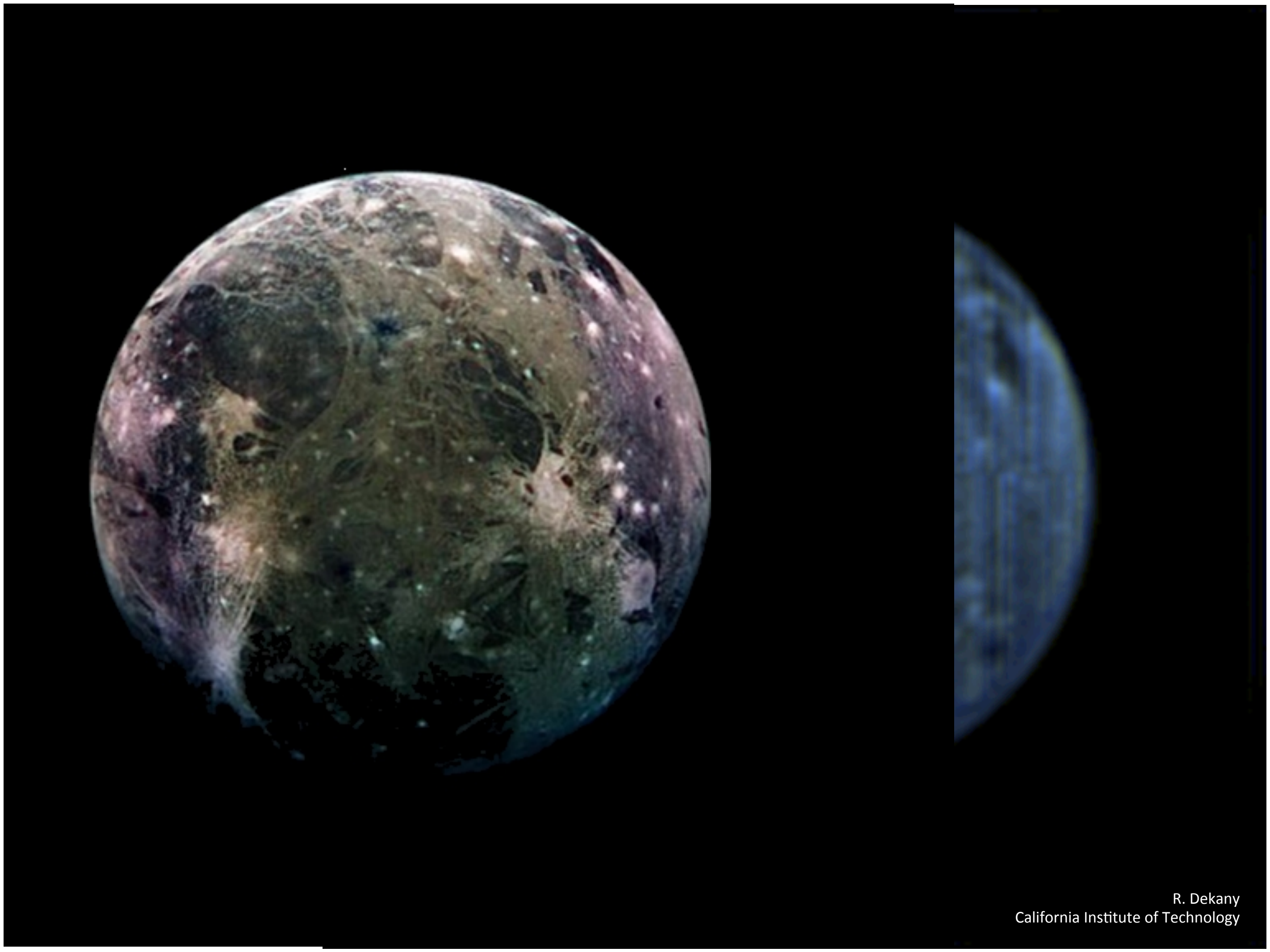
Ganymede from the Ground - Sept 10, 2011

Credit: Damian Peach

HST Image

TMAS 1st-Light Image (Ganymede)

taken with initial sCMOS camera (an Andor NEO); September 26-27, 2012



Short-exposure image stack
(S. Hildebrandt; no selection, no flat-fielding)

SCMOS camera proved unusable due to variable bias and variable flat-field behavior
→
Motivation for EMCCD camera upgrade

The upgrade path…

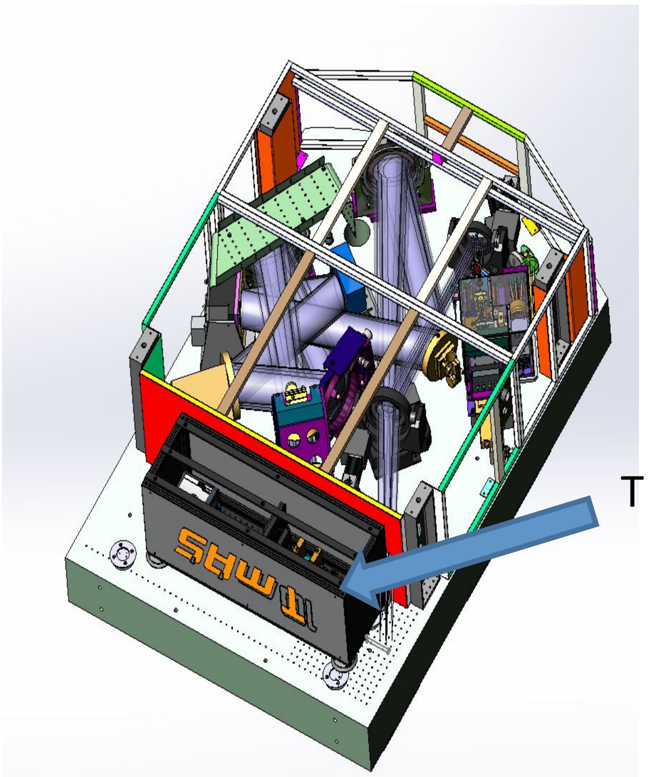
- Over three engineering runs and 24 months, we borrowed and tested on the sky three different Andor Ultra 888 (EMCCD) camera within TMAS.
  - Unfortunately, on none of these runs was the delivered AO performance at visible wavelengths as good as for our first light run.

- In Jan 2015, we adopted a new science strategy for visible-light exoplanet science
  - Develop speckle nulling calibration schemes (D. Mawet and M. Bottom)
  - Co-mount with PHARO to enable flexible observing to exploit opportunities of exquisite AO performance (R. Jensen-Clem)
  - Enable better dark speckle data acquisition
  - Implement spectral differential imaging (SDI) to exploit H_{α} emissions, including circumstellar material, at a fine plate scale of 4 - 5 mas/pixel.
  - These motives prompted a rebuild of TMAS in 2015
    - Summer project for Akamai Scholar Jasmine Feliciano

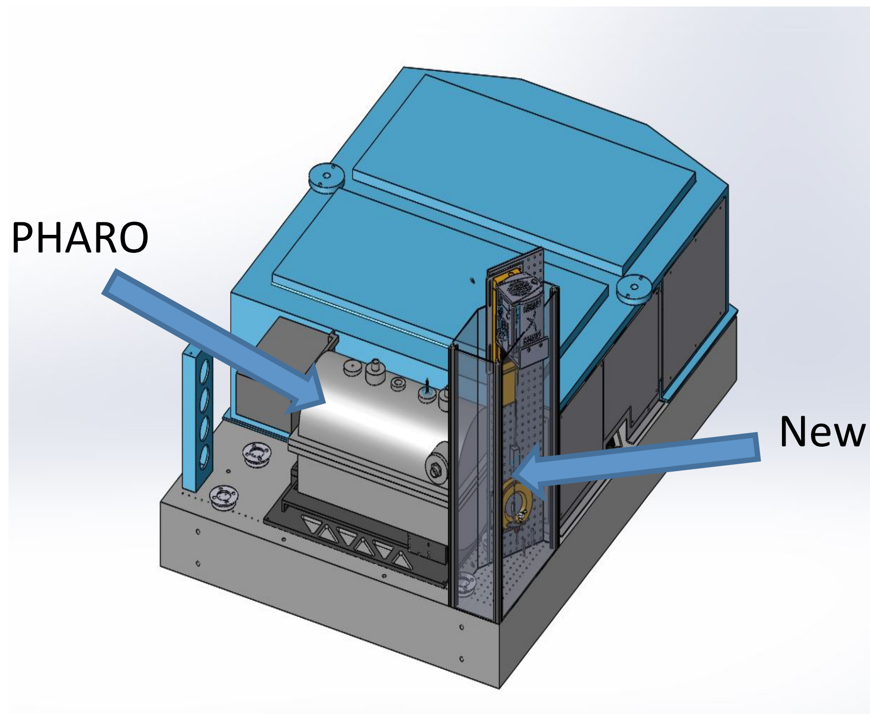
- In collaboration with E. Serabyn (JPL), we also identified a longer-term solution for use of an Andor Ultra 888

The Big Change

- TMAS must be reconstructed for co-mounting



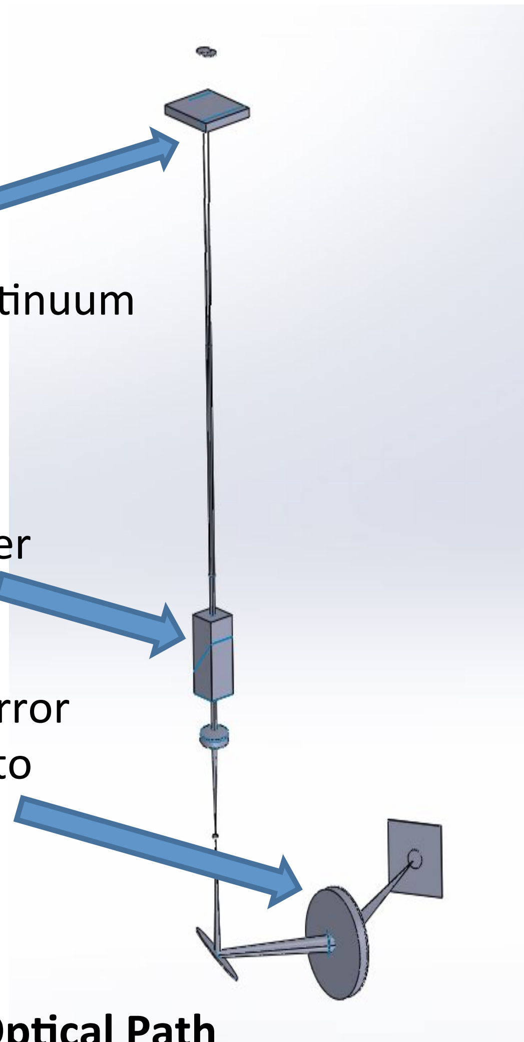
Before: CAD model of TMAS on bench alone



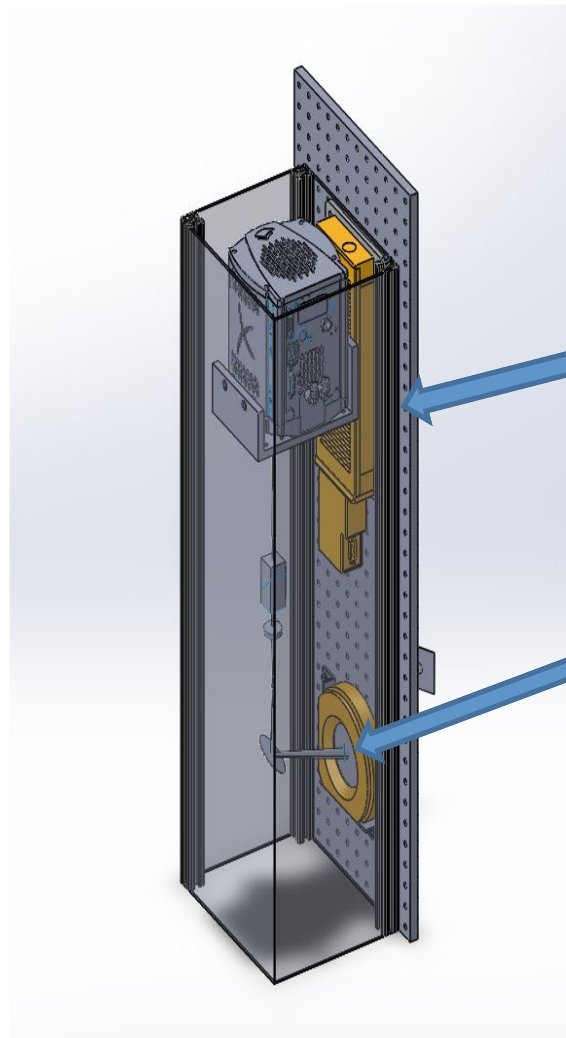
After: CAD model of TMAS and PHARO on bench

J. Feliciano

Basic design of TMAS



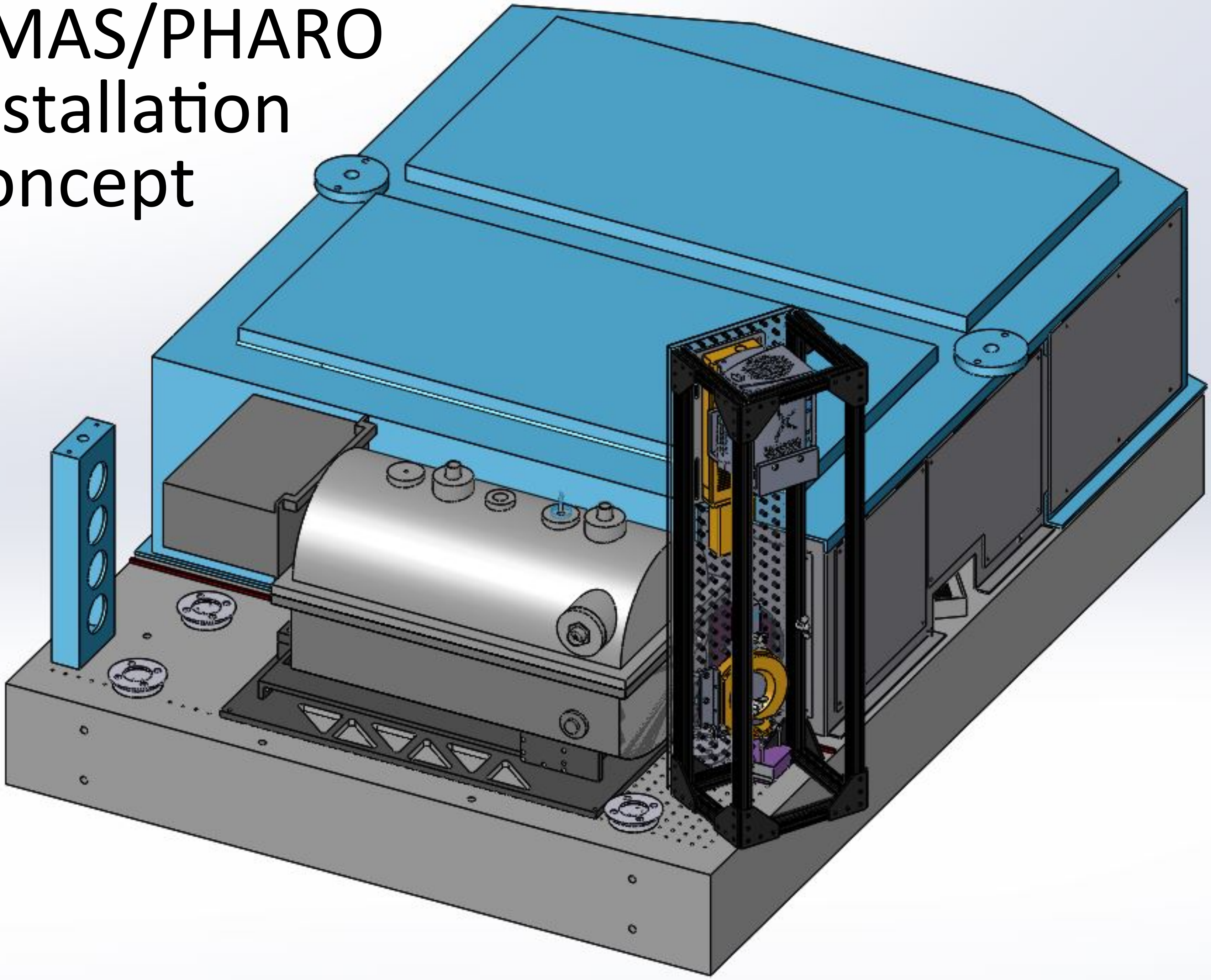
Optical Path
(add'l filter wheel not shown)



Current mech design concept

J. Feliciano

TMAS/PHARO installation concept



TMAS summary

- We are using a commercial EMCCD camera for exoplanet direct imaging science
  - Stellar speckle calibration through SDI
    - Short exposure, very low noise
  - Speckle nulling algorithm development
    - Fast readout (relative to NIR PHARO)
  - Dark speckle development
    - Photon-counting, ease of use (relative to DARKNESS MKID's)
- TMAS will also support multipurpose fast-framing visible AO capability for synthesizing best optical spatial resolution
  - This is typically not an EM application