First results from MAROON-X

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Former Contributors: Leonardo dos Santos, Emily Gilbert, Katrina Miller, Zachary Robertson, Adam Sutherland

MAROON-X

Primary science driver: Confirmation and mass measurement of transiting, temperate, and terrestrial planets that are feasible targets for atmospheric spectroscopy. I.e., *TESS* follow up.

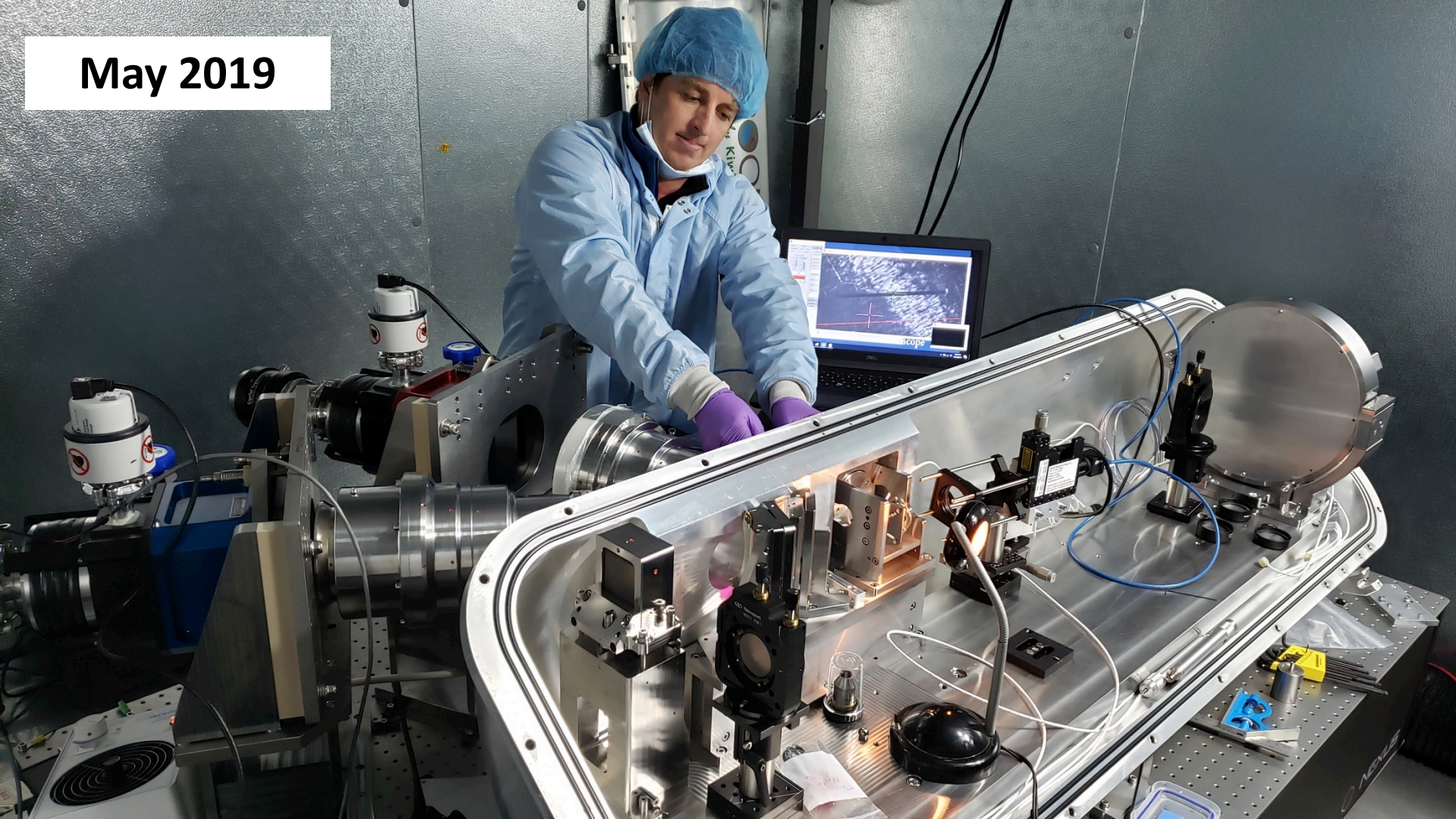
Goal: σ = 1 m s^{-1} in <30 min for late M dwarfs out to 20 pc (V=16.5).

Approach: A highly-stabilized, fiber-fed spectrograph covering 500 – 900 nm at R=85k with simultaneous calibration feed and pupil slicing.

Status: The instrument is fully operational, first science data being prepared for publication, open community use begins in 2020B

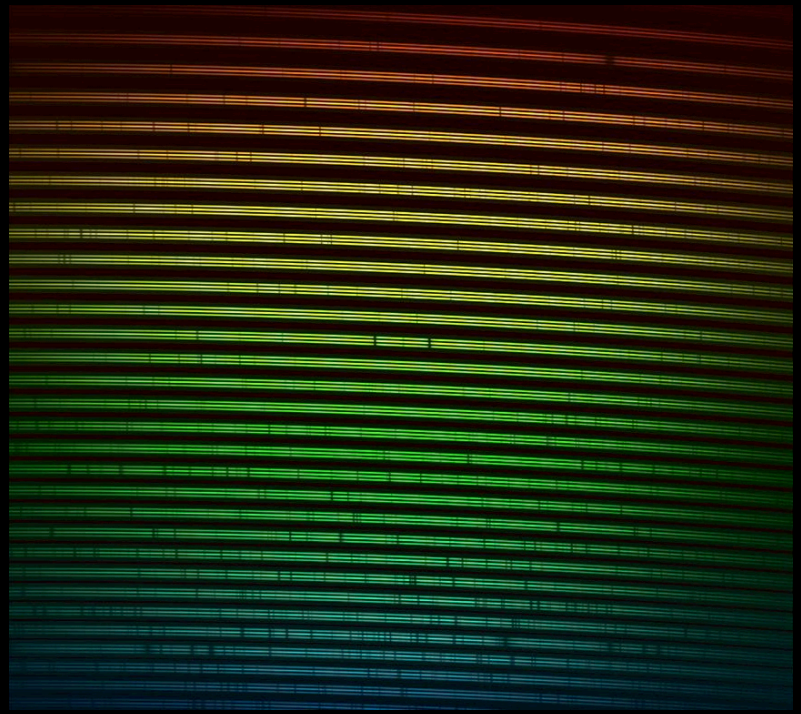
New Radial Velocity Instrument for M Dwarfs at Gemini-N


May 2019
ULINE
HANDLE WITH CARE
HANDLE WITH CARE


May 2019

MAROON-X first light September 23, 2019!

Red arm



Blue arm

Microlens-array based pupil slicer and double scrambler

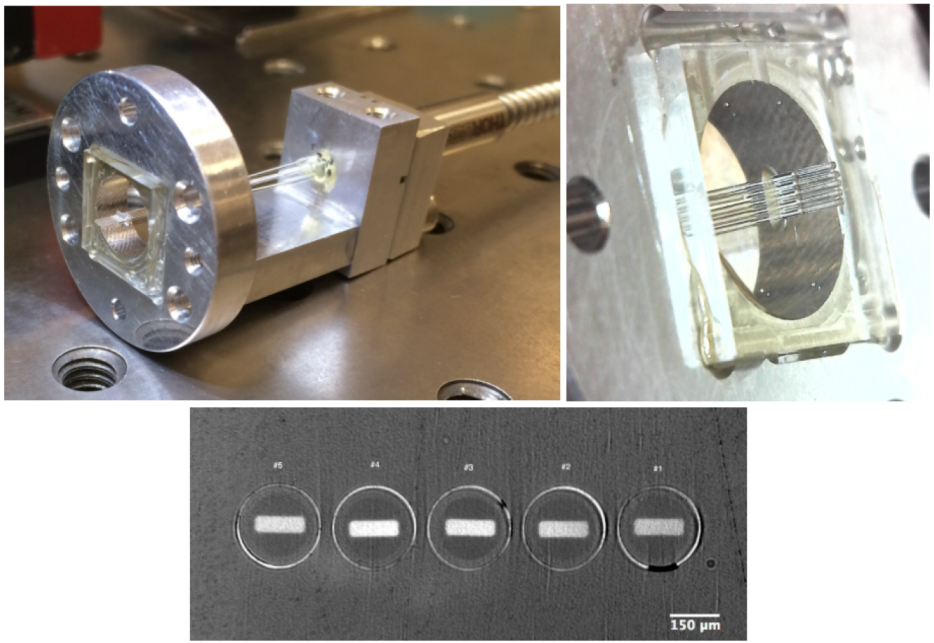


Figure 5: **Prototype linear fiber array and pseudo-slit for MAROON-X**. Top left: FEMTOprint fiber slit plate in a custom mount fixture with five Ceramoptec 50 μm × 150 μm rectangular fibers already inserted. Top right: Close-up of the slit plate. The fibers stick out a couple mm from the front of the plate. At this step the fibers are already glued into the guide block for strain relief and to fix their rotation angle but adhesive is not yet applied to the bare fiber ends in the slit plate. Bottom: Same assembly after polishing. While technically within specification, the prototype slit plate shown here has still sub-optimal alignment. The fibers were etched slightly too long, making them 5 μm to 6 μm smaller than the holes in the plate, which leads to offsets. Likewise, rotational alignment of two fibers (#3 and #4) is off by $-1.5°$ and $1.1°$, respectively.

Seifahrt+ 2016, SPIE

Wavelength calibration: stabilized Fabry-Perot etalon

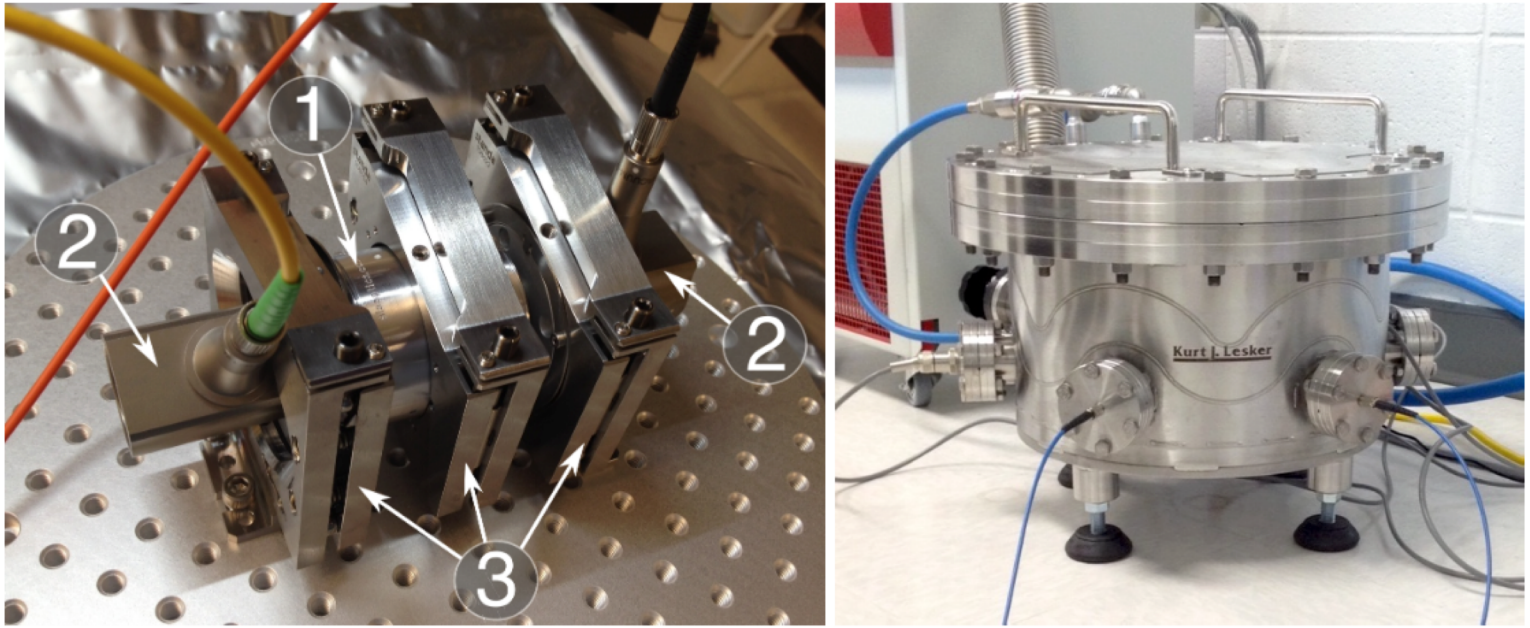
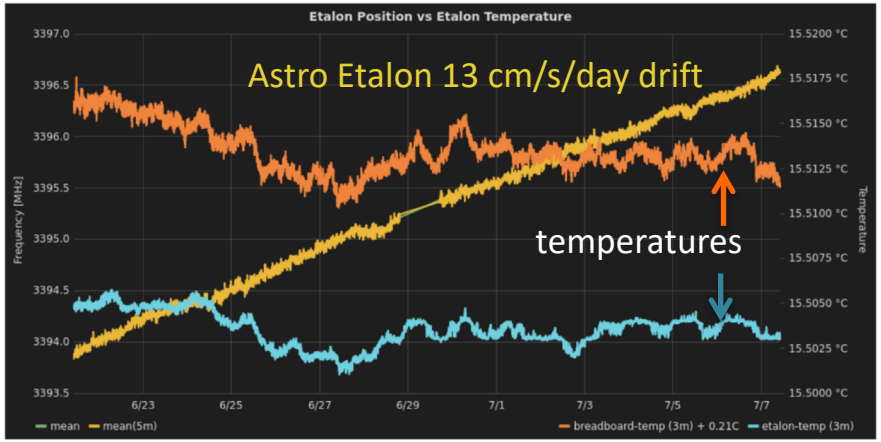
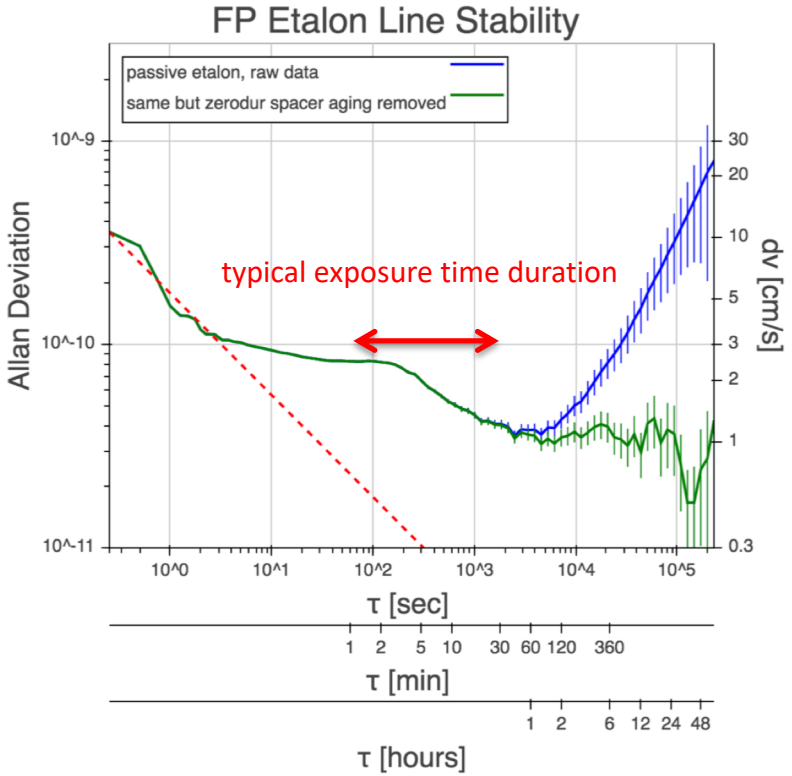


Figure 1. FP etalon opto-mechanics and vacuum chamber. Left: FP etalon (1) and OAP collimators (2) in vacuum compatible tip-tilt mounts (3) on a breadboard before vacuum integration. Right: System integrated in a vacuum chamber from J.K. Lesker with in-built channels for liquid circulation to provide temperature control at the $\leq 5\,\mathrm{mK}$ level with an external bath thermostat (not shown). During operation the vacuum vessel is contained in another insulation box (also not shown here) to attenuate temperature variation of the room.

Stürmer+ 2017, JATIS

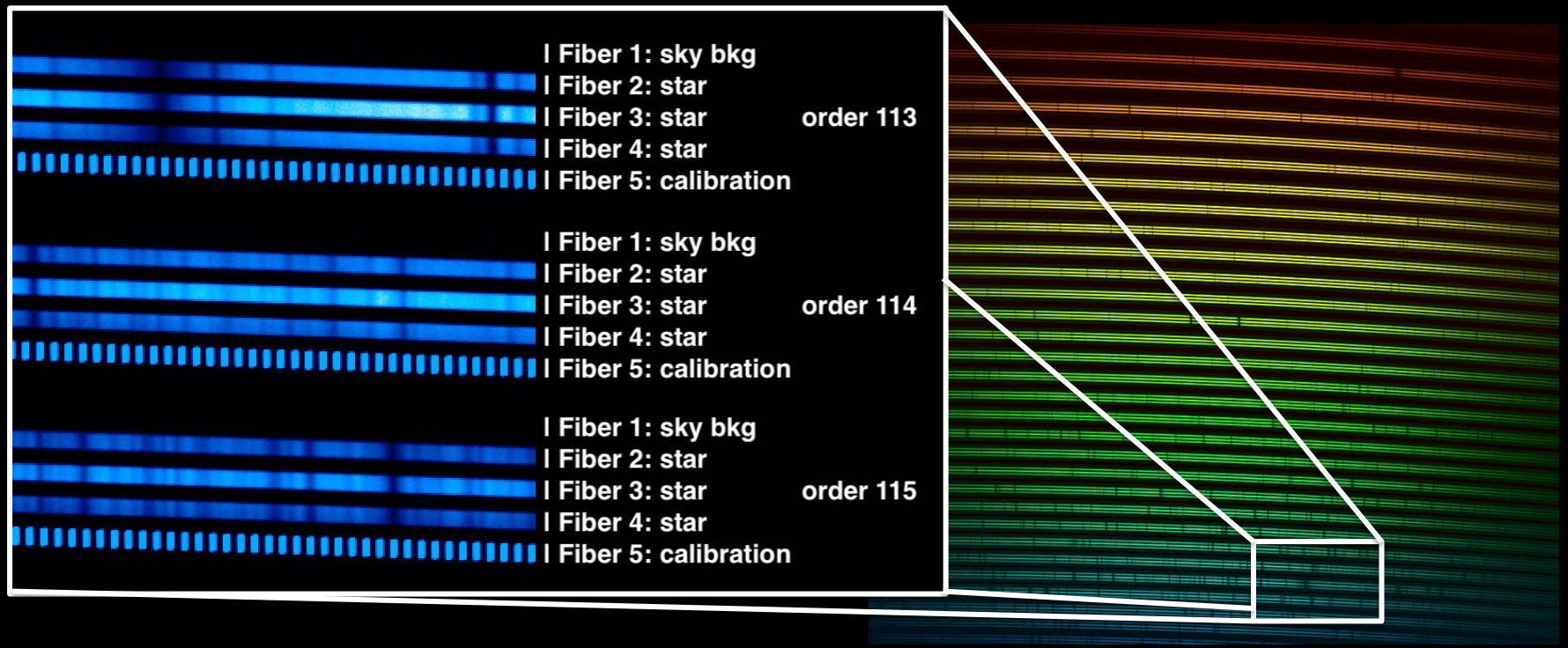
Wavelength calibration: stabilized Fabry-Perot etalon

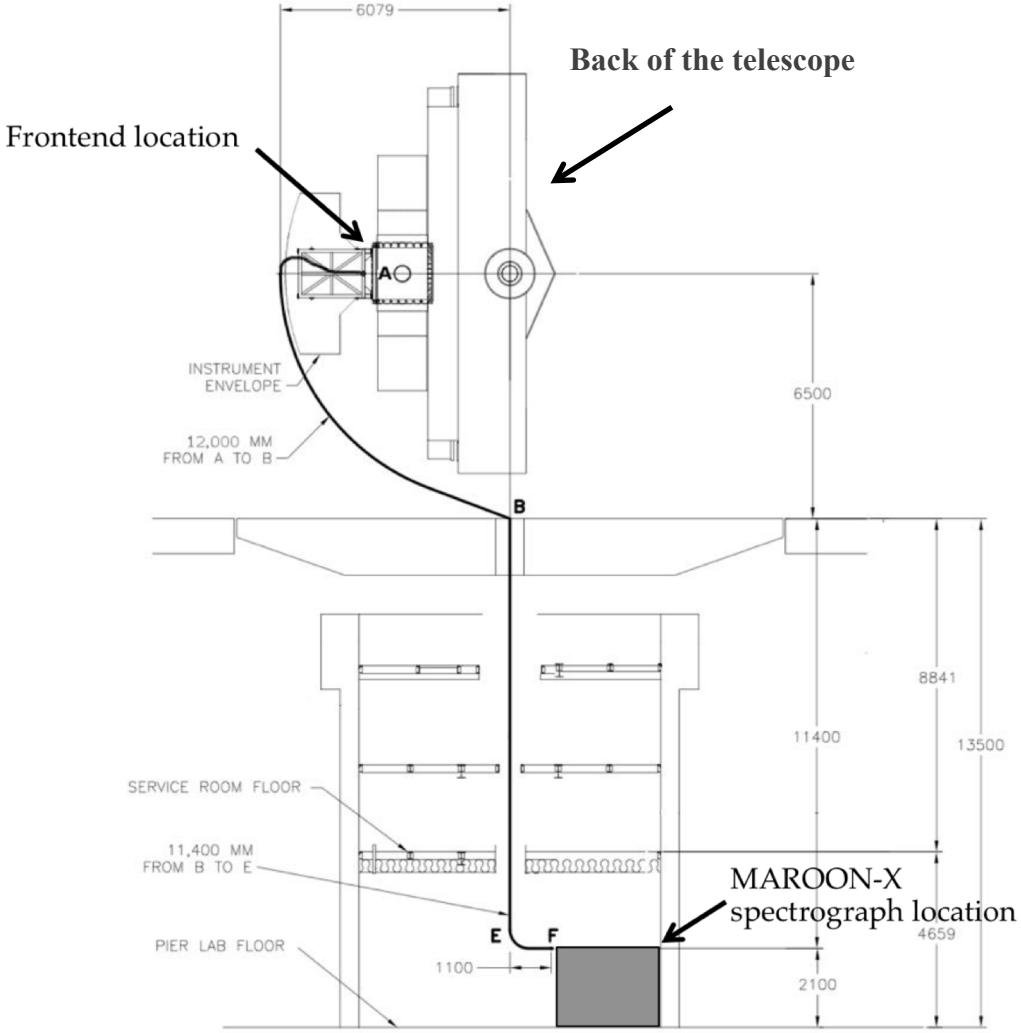


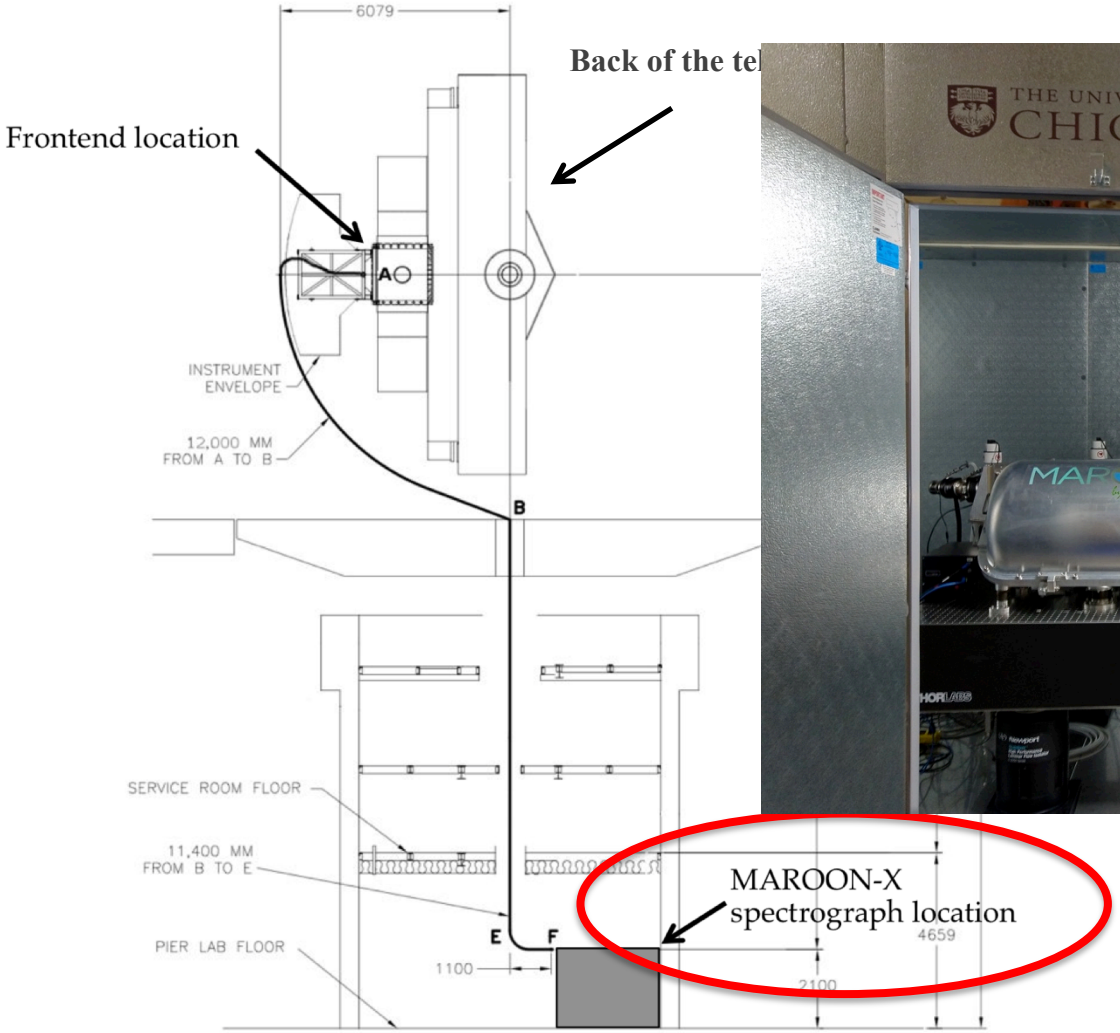


Stürmer+ 2017, JATIS

MAROON-X Data Format




6079
Back of the telescope
Frontend location
A
INSTRUMENT ENVELOPE
12,000 MM FROM A TO B
B
6500
8841
11400
13500
SERVICE ROOM FLOOR
11,400 MM FROM B TO E
MAROON-X spectrograph location
E
F
PIER LAB FLOOR
1100
4659
2100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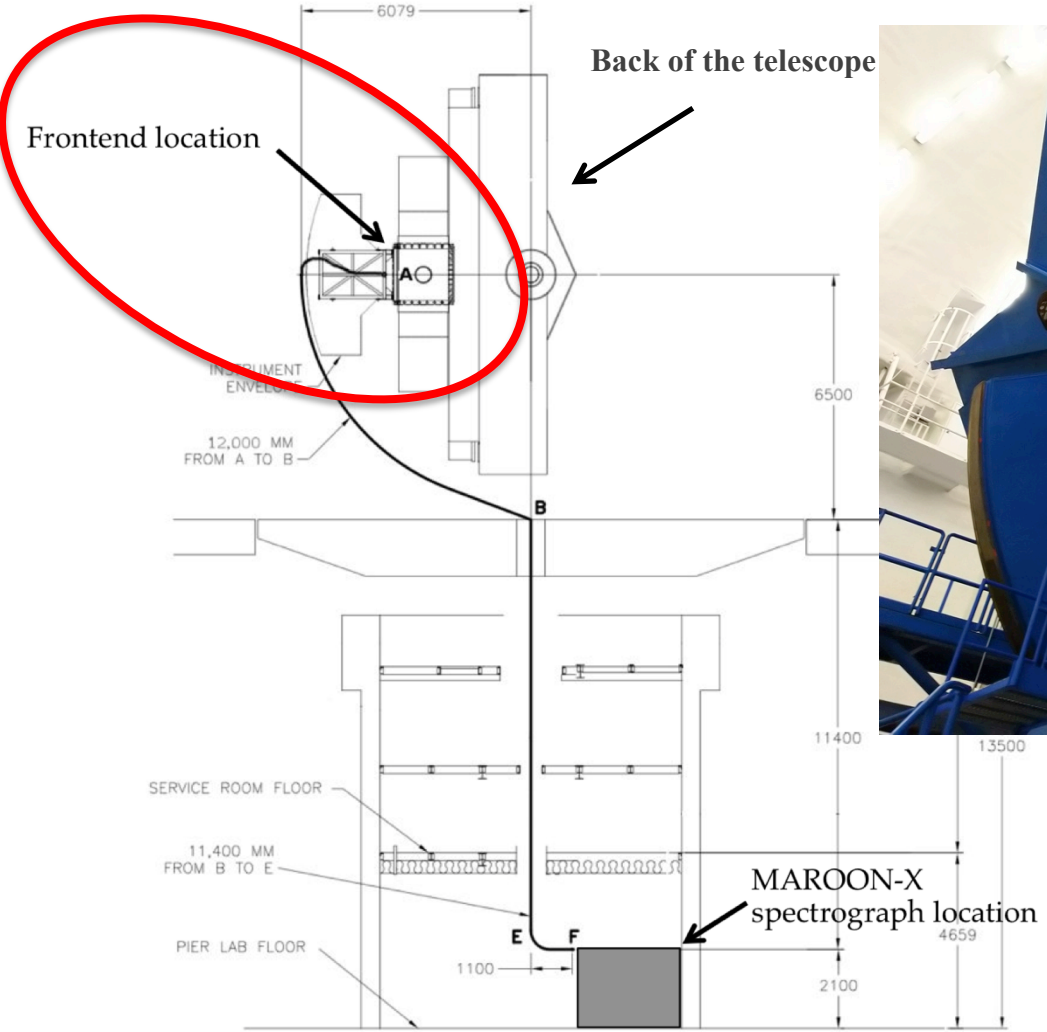
THE UNIVERSITY OF CHICAGO
MAROON-X
MAROON-X
KiwiStar Optics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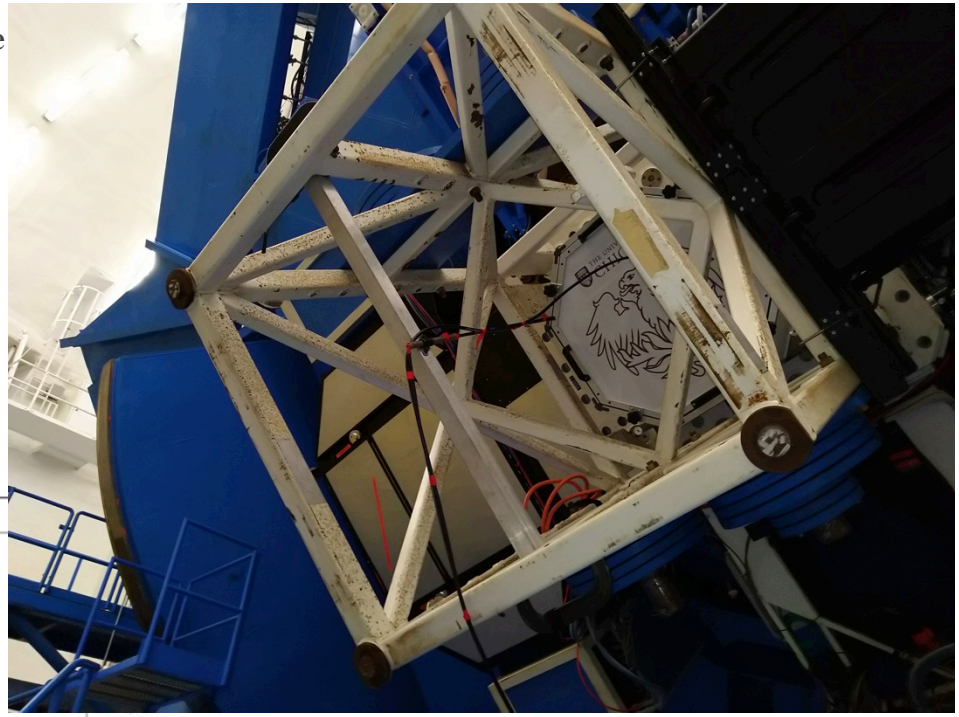
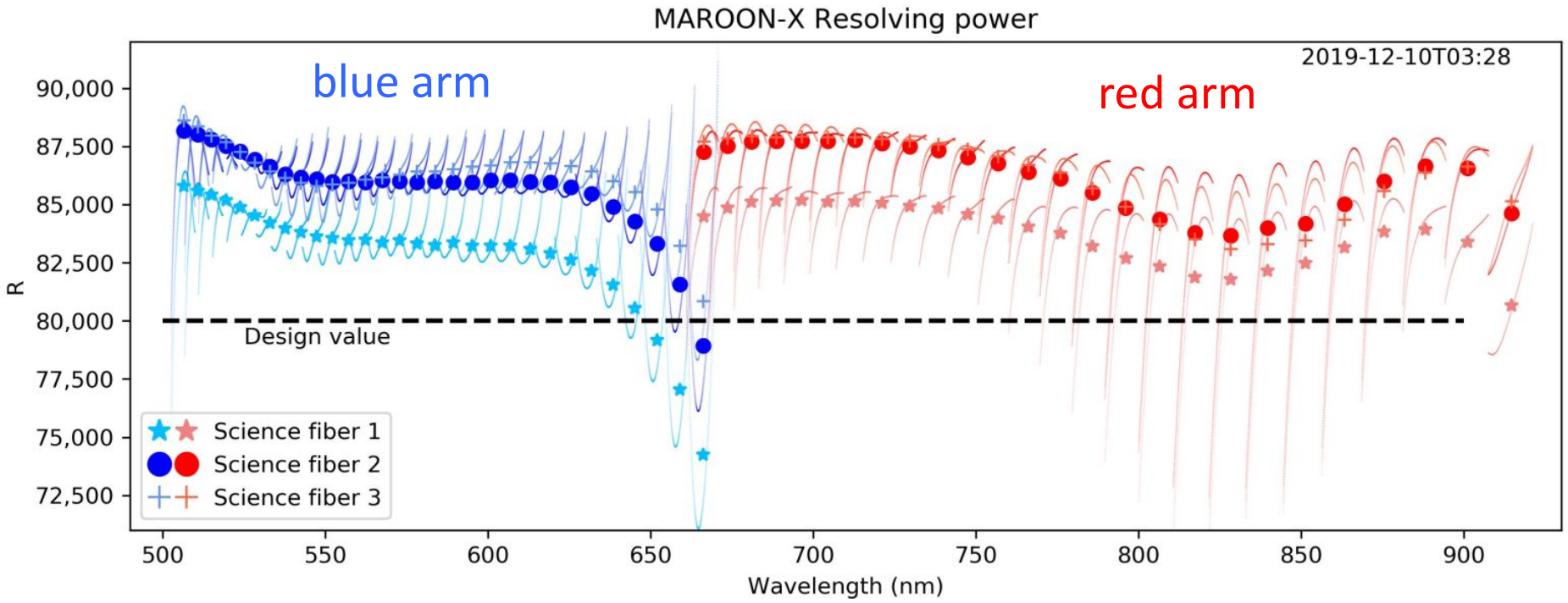


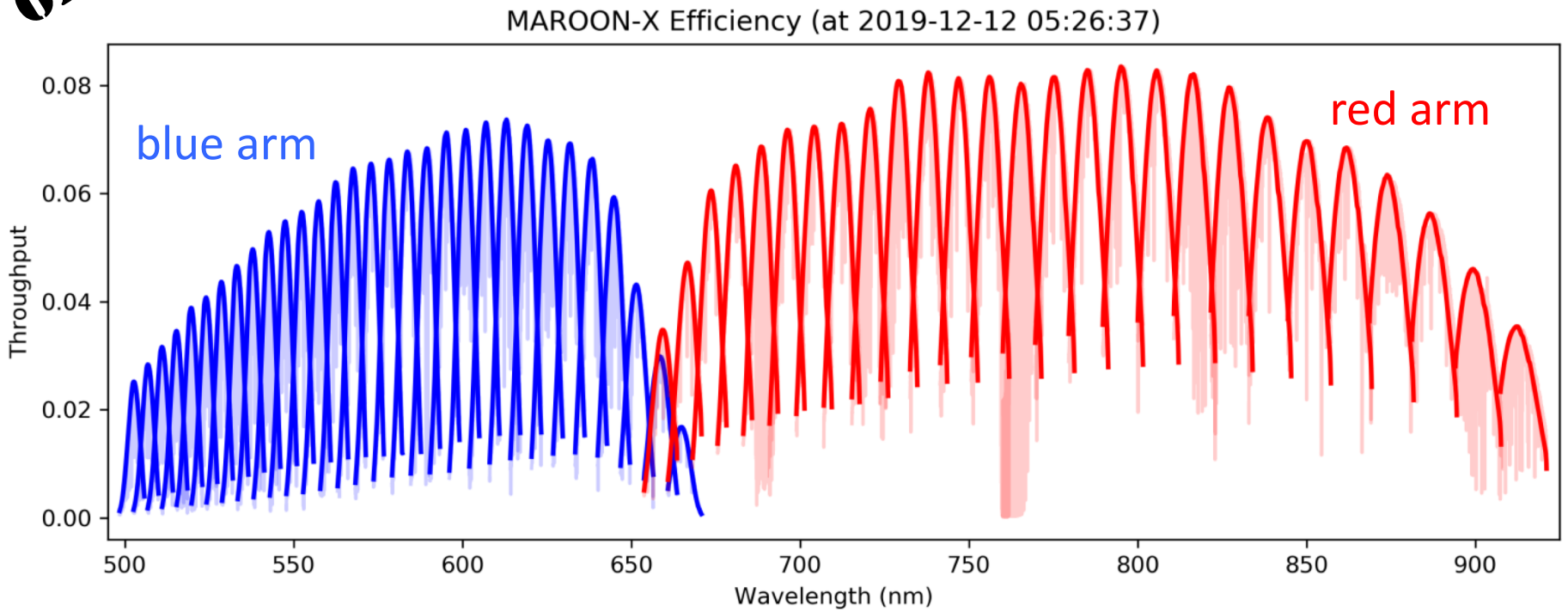
Current Performance: Resolution

ON SKY



Current Performance: Throughput

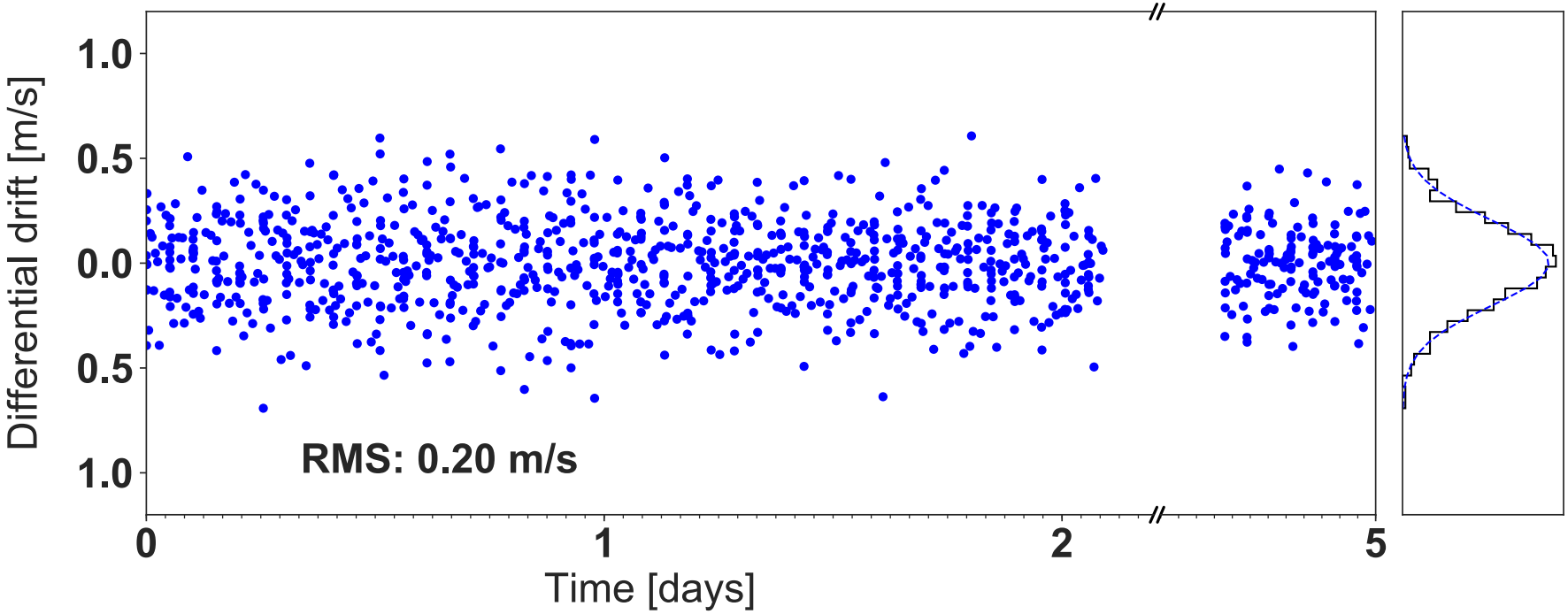
ON SKY



--numbers valid for typical Gemini seeing conditions (~0.6”)--

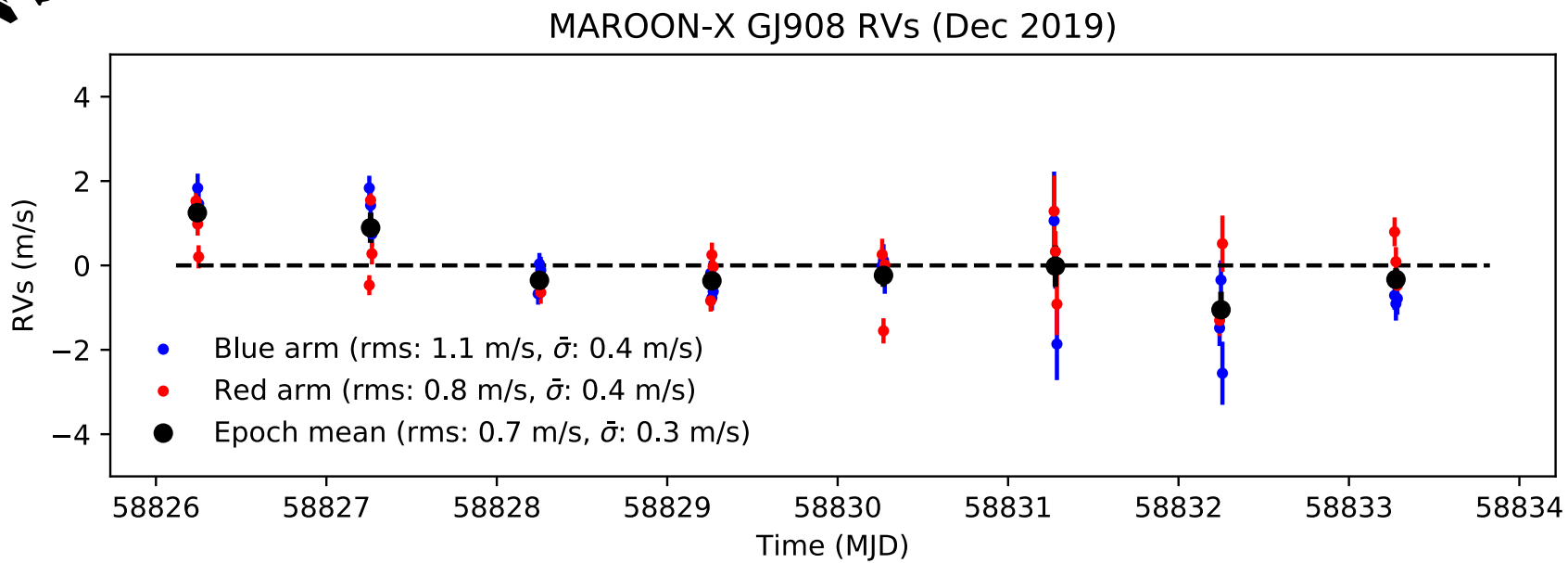
IN THE LAB

Current Performance: Stability



Current Performance: RV Precision

ON SKY

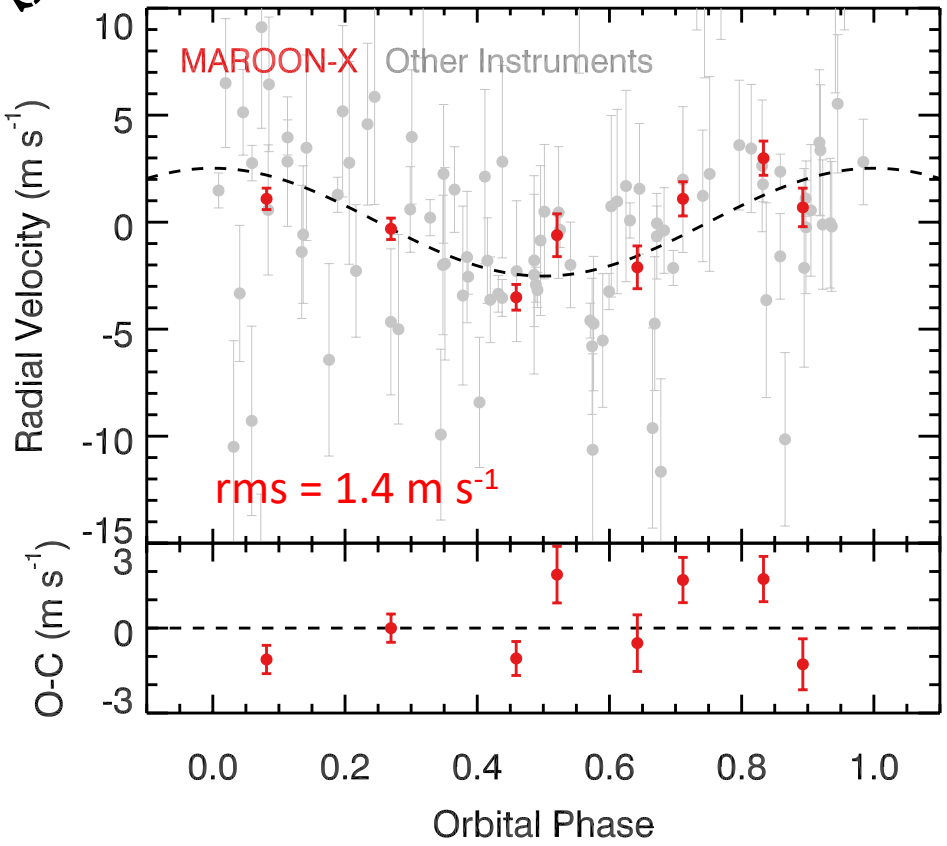


Notes:

- Data taken in December were without the simultaneous calibration
- Individual exposure times were 5 min in highly variable conditions
- These are the raw velocities with no de-trending

Current Performance: RV Precision

ON SKY



Data taken in December 2019 aid in the mass measurement of LTT1445Ab (= TOI 455.01)

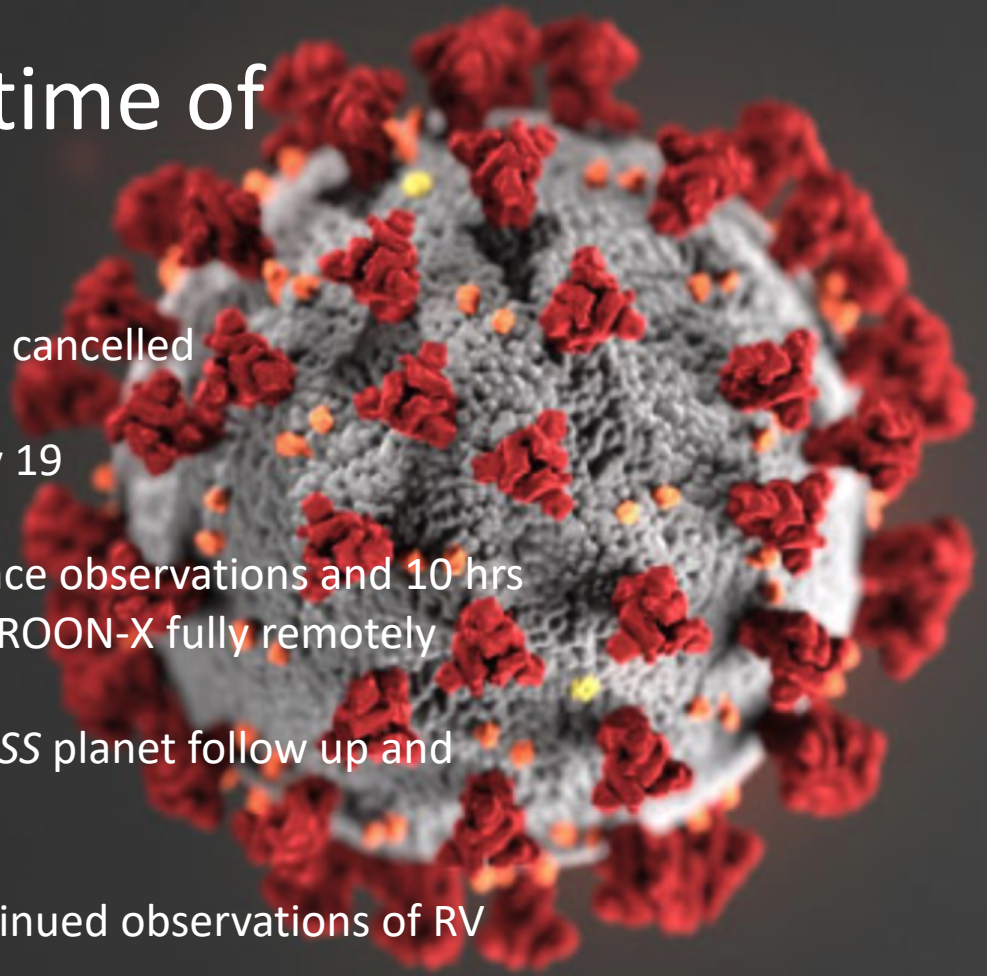
$K = 2.6$ m s^{-1}

$M_p = 2.9\ M_{Earth}$

Current fit doesn't include orbital motion due to stars B & C

Results will be presented in Winters et al. (in prep)

MAROON-X in the time of the coronavirus



A planned in-person run in March was cancelled

Gemini-N resumed operations on May 19

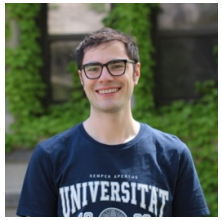
We recently performed 30 hrs of science observations and 10 hrs of engineering observations using MAROON-X fully remotely

Science observations were a mix of *TESS* planet follow up and transit spectroscopy

Engineering time was focused on continued observations of RV standards (e.g., 51 Peg)

Core Team Members and Sponsors

Andreas Seifahrt
Research Scientist



Julian Stürmer
Former postdoc
Now at Heidelberg Observatory

David Kasper
Postdoc

Ben Montet
Former Sagan Fellow
Now at UNSW

THE UNIVERSITY OF CHICAGO

the David & Lucile Packard FOUNDATION

GEMINI OBSERVATORY

HEISING-SIMONS FOUNDATION

MAROON-X

GEMINI NORTH // OPTICAL

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MAROON-X is a new instrument recently constructed at the University of Chicago which is expected to have the capability to detect Earth-size planets in the habitable zones of mid- to late-M dwarfs using the radial velocity method. At its core, the instrument is a high-resolution (R~80,000) optical (500-920nm), bench-mounted, fiber-fed echelle spectrograph designed to deliver 1 m/s radial velocity precision for M dwarfs down to and beyond V = 16.

AVAILABLE:

https://www.gemini.edu/instrumentation/current-instruments/maroon-x