Michigan Updates:

MIRC-X and MYSTIC

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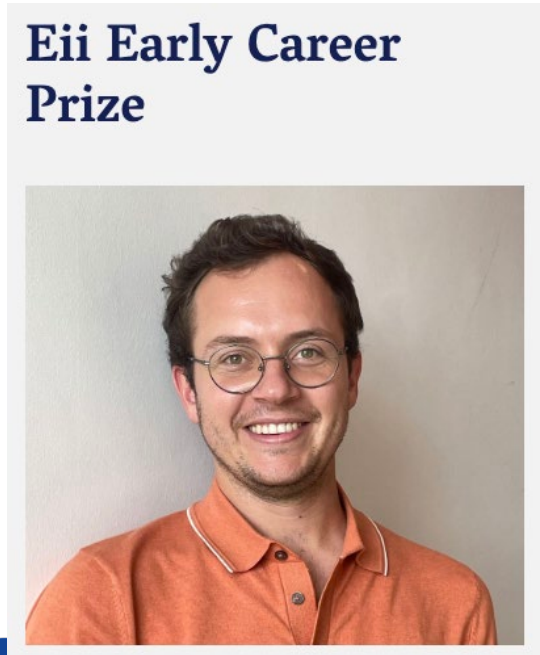
U. Michigan

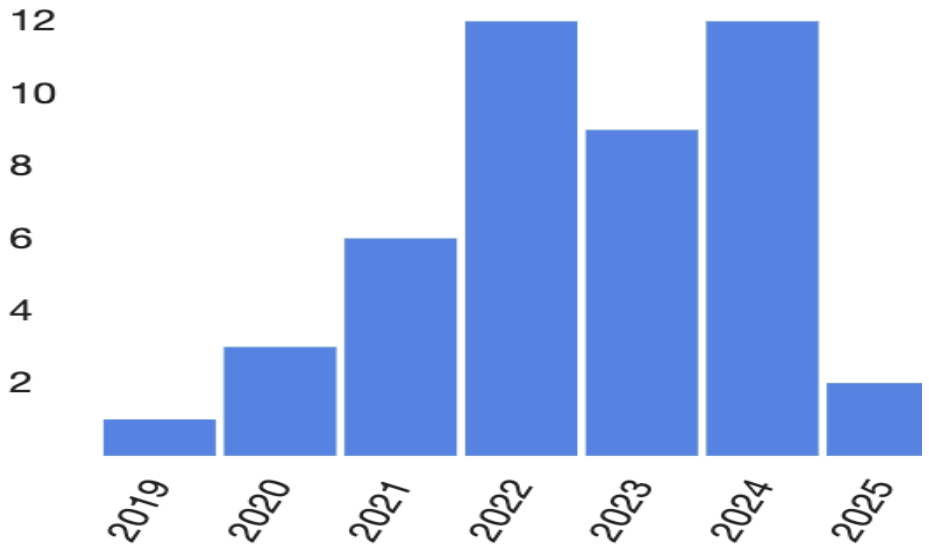
Michigan folks

- Recent changes for former/current UM Researchers:
  - Mayra Gutierrez (UM Undergrad) shifted to UCSC for graduate school.
  - Tyler Gardner received EII Early Career Prize; shifted from Exeter to Boulder (Colorado) to work for NOAA, out of astronomy
  - Noura Ibrahim received NASA FINNEST Fellowship. Graduation planned early next year.
  - Linling Shuai is finishing 2nd year, will increase CHARA research effort as classes end!
  - New graduate student Rohan Gupta (U. Chicago) will start next Fall and exploring interferometry–related projects with me (Stay Tuned!)
  - Savanna Hoin (undergraduate) graduated UM but stayed on 6 months analyzing archival MIRC-X YSO data



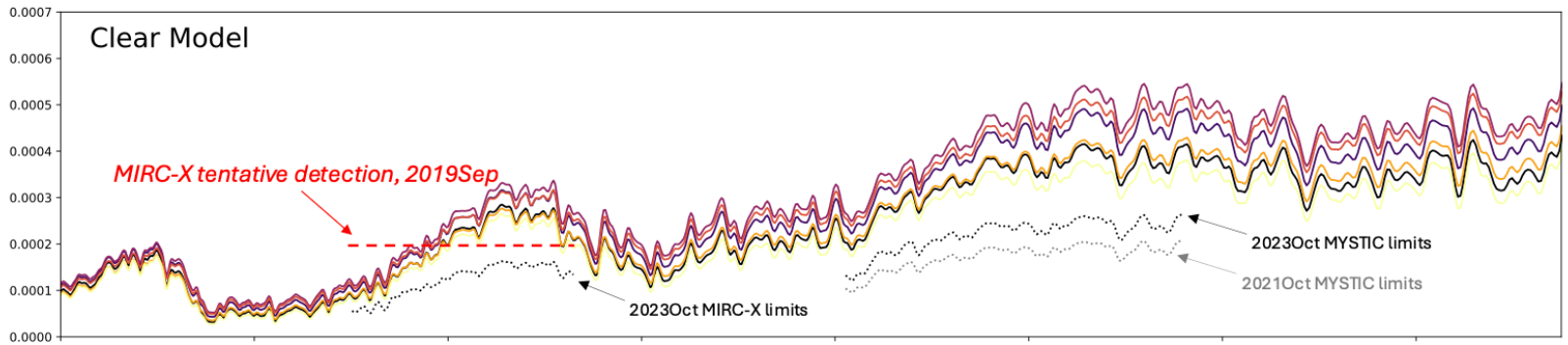
Science Updates

- MIRC/MIRC-X/MYSTIC featured in 14 refereed papers over last 12 months



Highlights

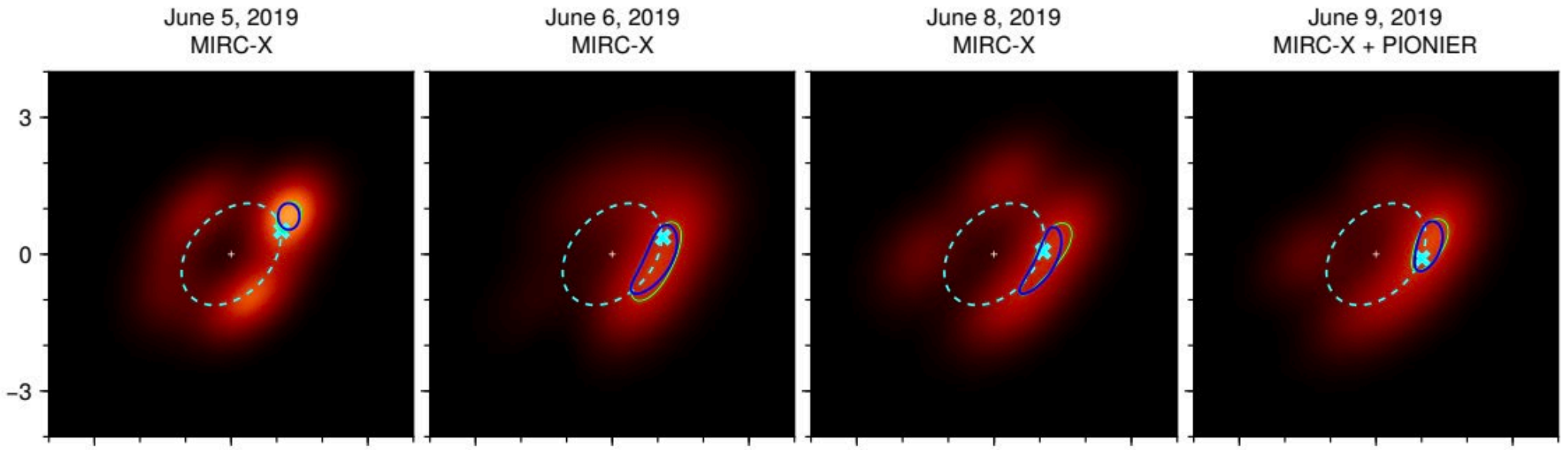
- Gardner et al. 2025 (submitted): Hot Jupiter ups And b not detected, but MIRC-X/MYSTIC limits are lower than model predictions, esp. at K band. (??)



Science Updates

MWC275 imaging hotspot motion finally in press (Setterholm et al. 2025)

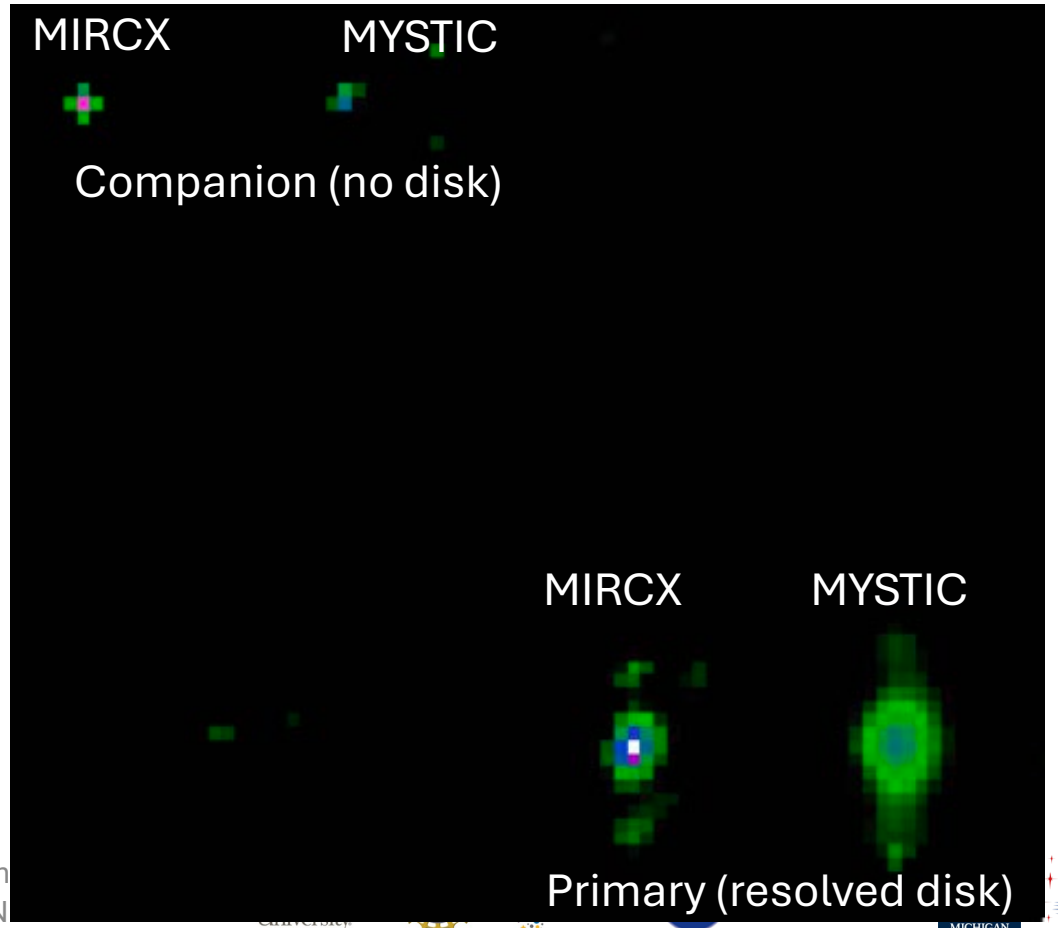
- Currently analyzing 2024 data to see if we can confirm this exciting result

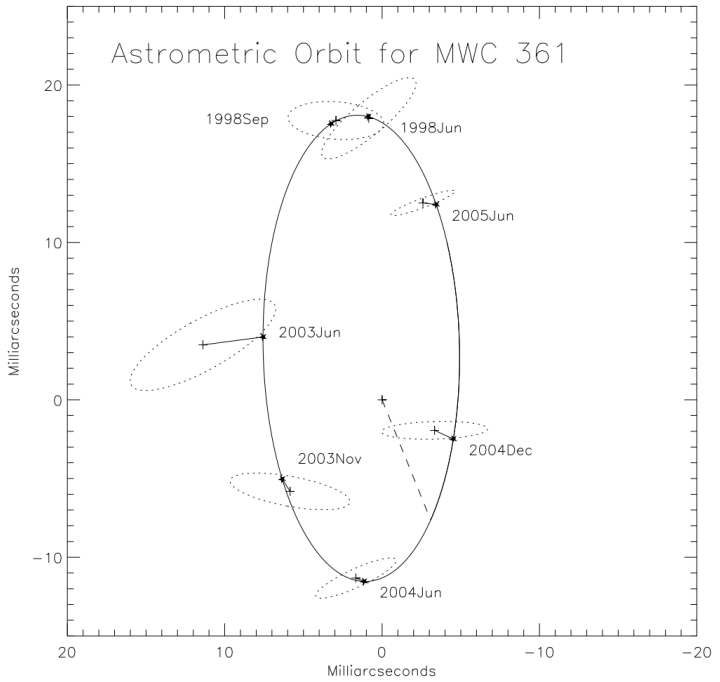


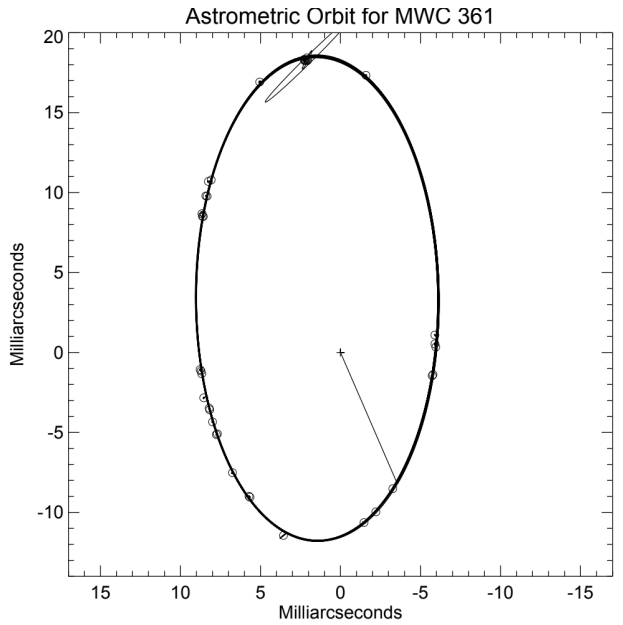
Science Updates

MWC361A young star binary paper is progressing (Monnier et al, in prep)

- Orbit+SB2+imaging



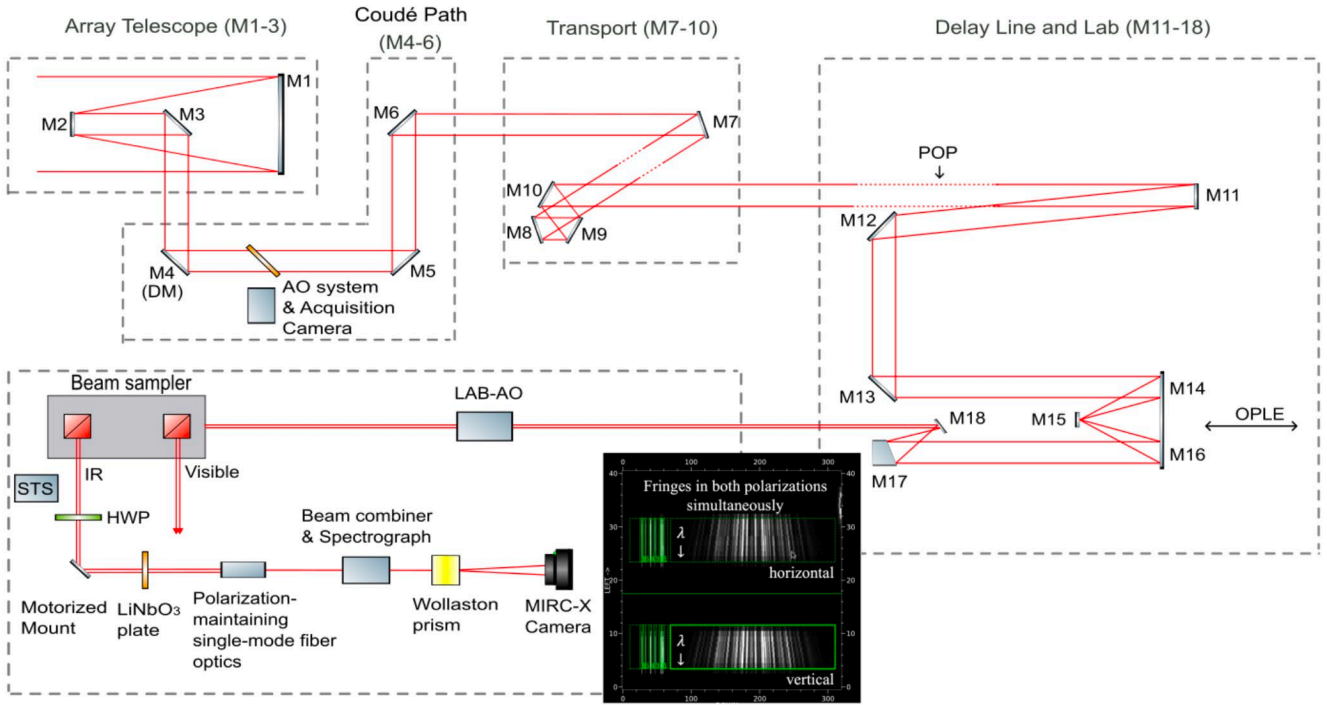


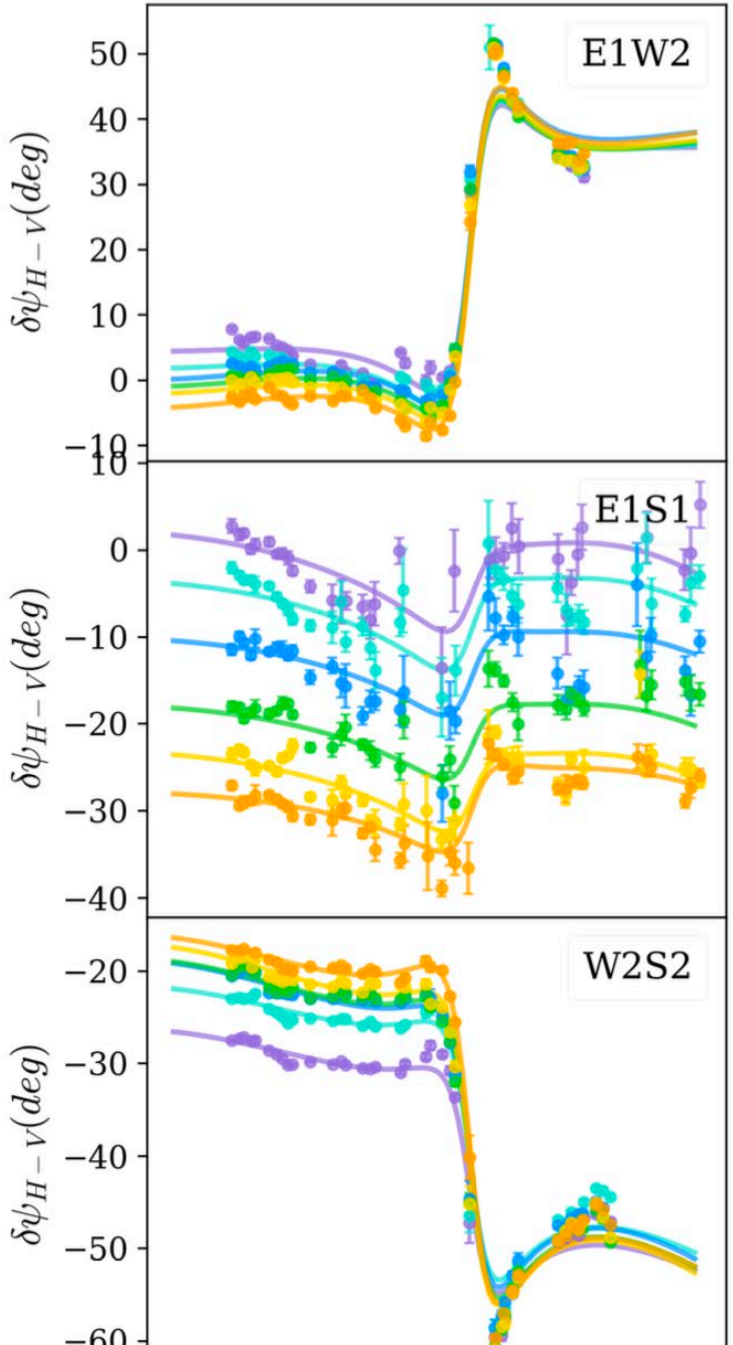


Science Updates

Shuai et al 2025 (in prep) presents a polarization model for CHARA beamtrain

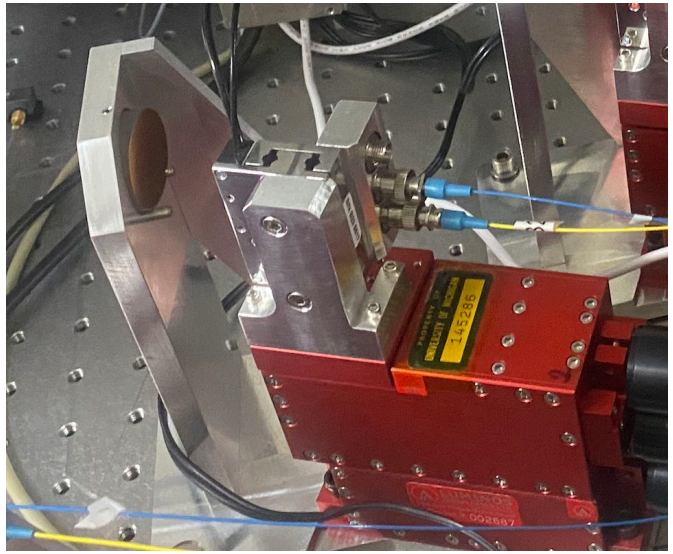
- Can calibrate differential visibilities ~4%
- Can calibrate differential phase ~2 degrees
- Found coating issue on W2 in 2022 (DM)

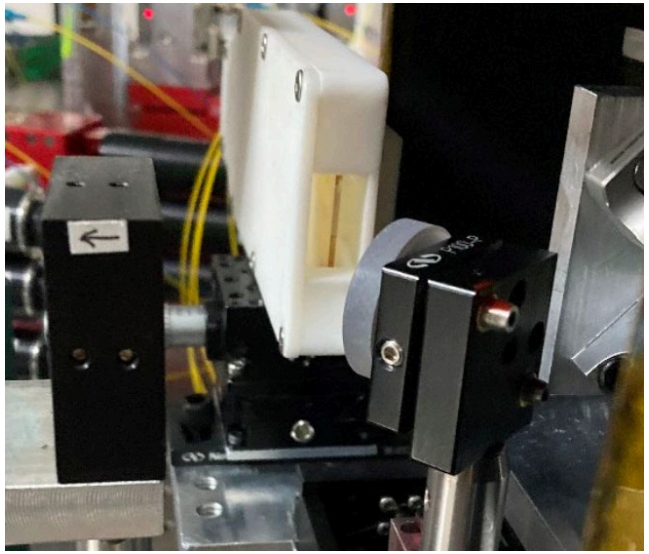


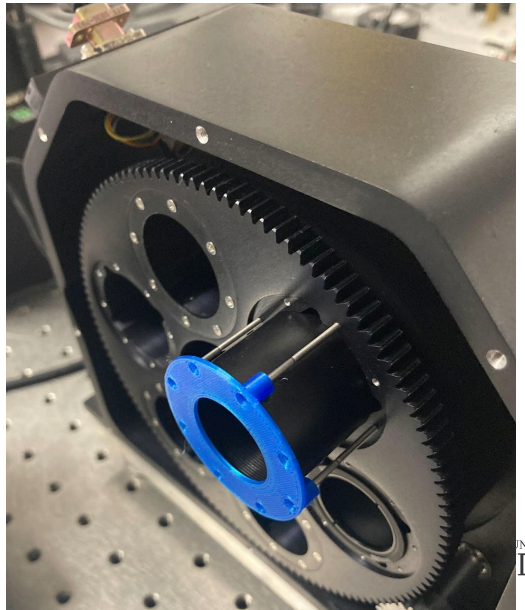


MIRC-X/MYSTIC Instrument Updates

- Major Automation upgrade complete:
  - Easy switch between UM All-in-one combiner and SPICA-FT pair-wise integrated optics combiner (fibers + combiner)
  - All spectral modes accessible via 2 new filterwheels
  - Passband filter slider also available (H only, J+H notch)
  - Shift between two different collimator lenses (only f=100mm currently installed)
  - Some repeatability problems noticed with collimator focus actuator. Monitoring…
  - The repeatability of precise angle of grisms/prisms unsure. Monitoring…



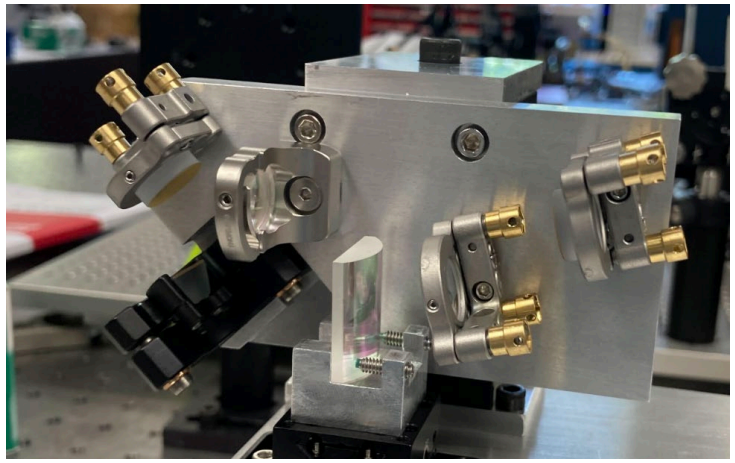


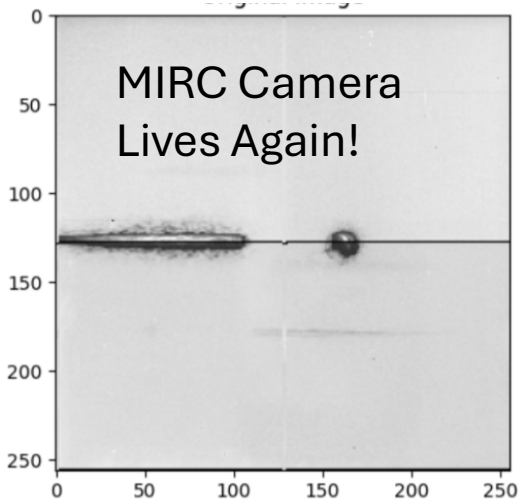


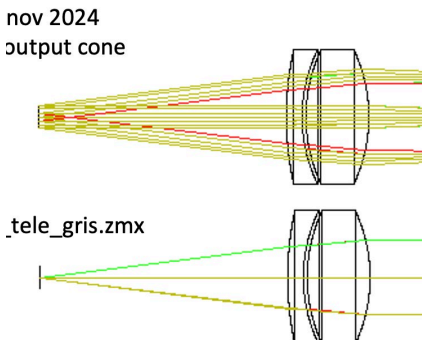
Wheel 1 (29 mm)	Wheel 2 (15 mm)
Empty	Empty
R22	Wollaston
R50	R182
R102	R625
R2314	R1170
Empty (Future VPH)	Empty

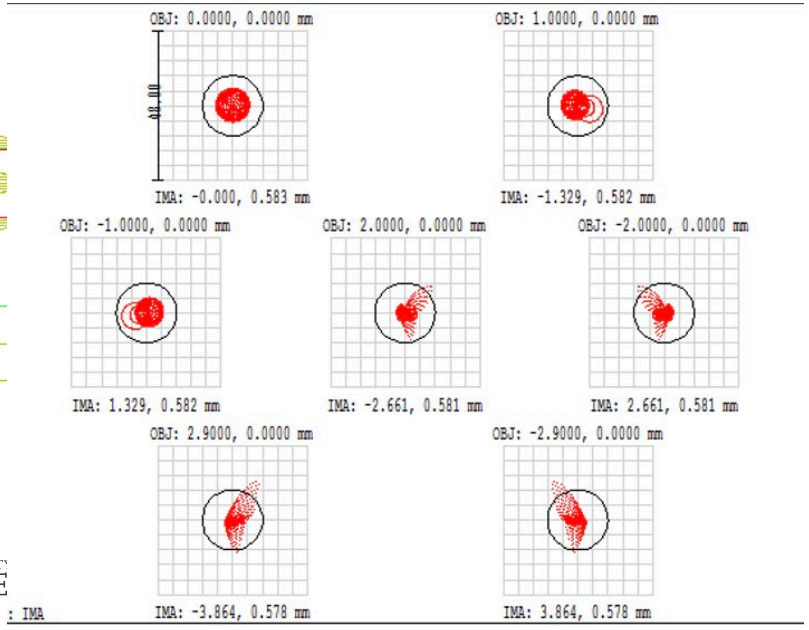
MIRC-X/MYSTIC Instrument: Future

- Remove warm vacuum window in MYSTIC to reduce thermal background
  - **STATUS: Waiting for shelf above MIRC-X to be reinforced to hold new heavier vacuum pump**
- Replace MIRC-X AIO combiner plate with new matched fibers
  - **STATUS: assembled in UM lab but no students to work on it..**
- New f=75mm J+H lens
  - New design by Ed Wishnow for diffraction-limited at J+H across full field-of-view (BaF2 + SF6, 1 aspheric)
  - **STATUS: Awaiting affordable quotes (tough) and funding**
- **See Kraus talk for MIRC-X camera upgrade and VPH R4000 grism news**



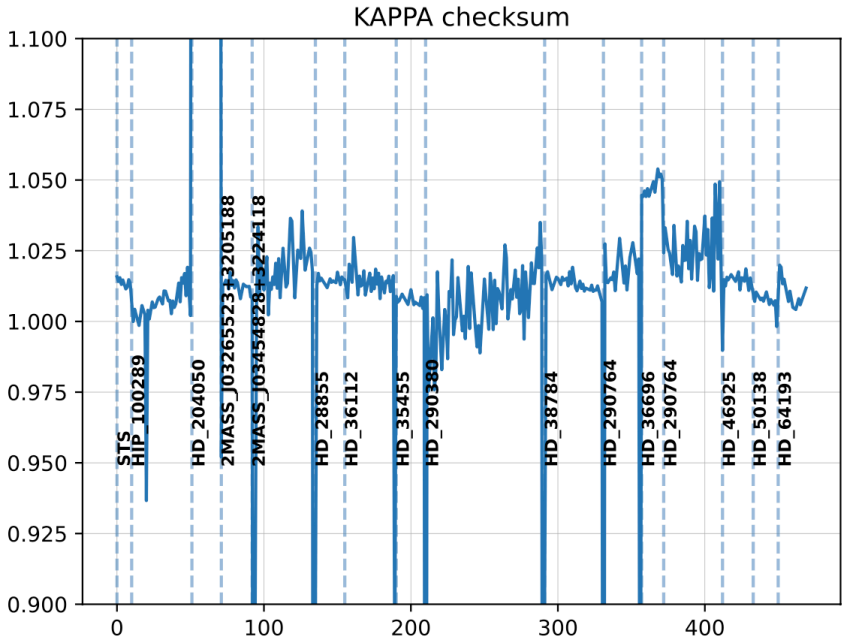


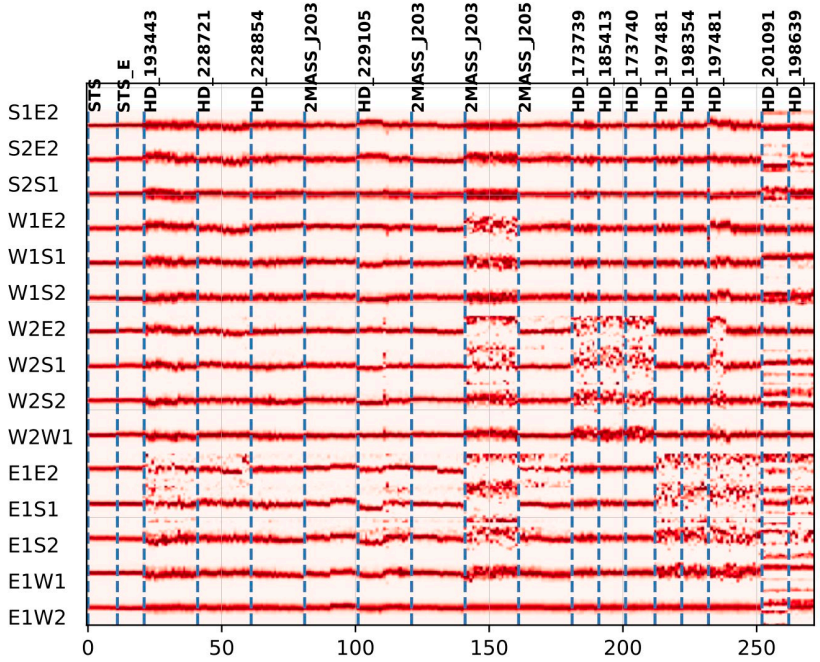




Software Progress

- mircx_jdm_develop (python branch)
  - More robust than standard branch when things go wrong in observing
  - Improved wavelength calibration
    - Each fringe is adjusted in optimizing, not one value
  - Improved shutter/beam selection for kappa calculation
  - Pdf diagnostics figures created in rts directory to check kappas (by Noura Ibrahim)
- mircx_cal (IDL) works well
  - Can autofilter outliers (“deep clean”)
  - Produces nice standard output pdfs
  - When choosing calibrators, now shows searchcal diameters along with binary detection flag from Kervella Gaia-Hipparcos paper. USEFUL.
  - Anybody want to work with chatgpt to convert this IDL code to a python gui? Current effort stalled.
- Not much progress on JDM’s long-promised major pipeline rewrite
  - Still no pipeline support for polarization or ABCD modes
- Continued MIRC ARCHIVE work
  - Let me know if you need any old MIRC data OIFITS

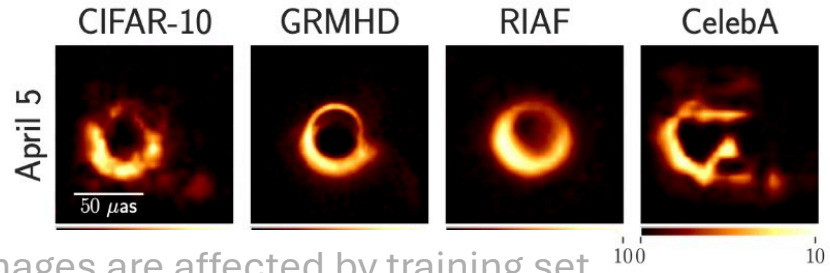




Other UM Work

- Will likely apply for internal NSF-ATI deadline to upgrade MYSTIC camera and fund cryogenic upgrade for MIRC-X (failed last year)
- **STARI formation flying cubesat project funded by NASA**
- Quantum interferometry initiative with Oregon/Illinois
  - Sky tests with Sun this summer in U. Oregon
- New highly-multiplexed heterodyne lab experiment funded
  - with Cundiff, Burghoff, Diddams, Eickenberry
  - Advertising a lab-based postdoc
- Leading ELT-METIS aperture masking design
- Working with Joel Sanchez-Bermudez on neural net based imaging algorithm for OIFITS

Neural net imaging of M87 by EHT

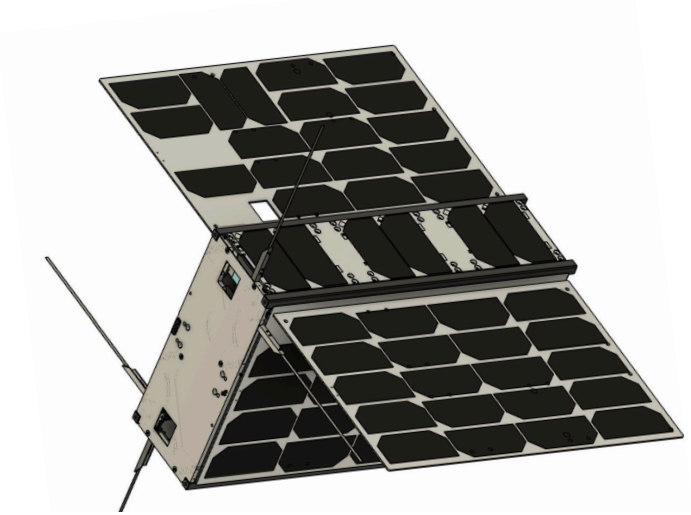


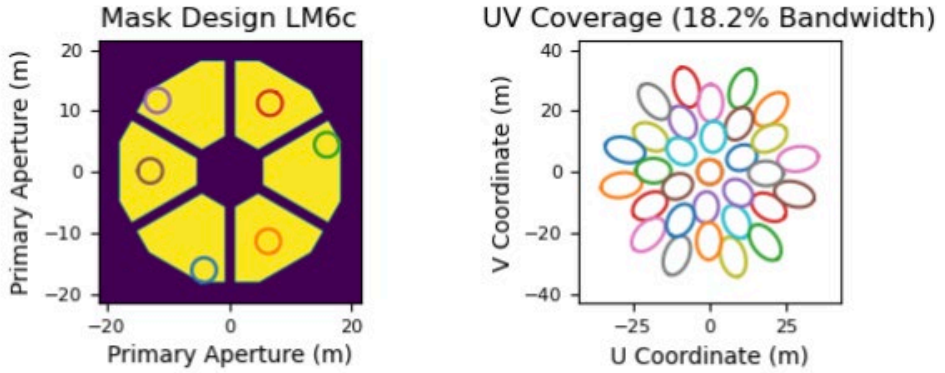
Images are affected by training set

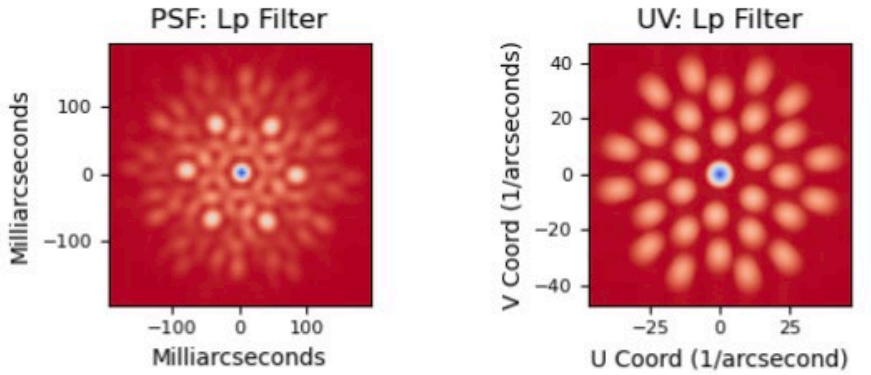
CIFAR-10: everyday objects
GRMHD: MHD simulation
RIAF: simple BH models
CelbA: human faces

Feng et al

STARI CAD (credit:Sunil)







New recommended co-authorship guidelines

Approximately 45 refereed MIRC-X (2018-) and MYSTIC (2021-) papers so far

- List of instrument co-authors on MIRC-X / MYSTIC invited on new papers kept growing (>17)

In 2023, John and Stefan polled the MIRC-X and MYSTIC instrument team on thoughts about authorship policies. General agreement that authorship should be related to the intensity and length of time worked on project (hardware and software), and whether ongoing support.

New policy based on the following principles:

- Co-authorship should be based on the year the data was taken.
- If you were working on project during the time data was taken, you will be invited as a co-author (OPT-IN); similar to policy for the observers.
- If you left the project, there will be a certain # of years that you will continue to be included as co-authors (OPT-IN), typically varying from 1 to 5 years depending on contributions
- Terms based on mutual agreement as much as possible, consistent with equity and fairness
- New focused upgrades (e.g., MIRCX-POL, VPH, SPICA-FT) will affect observers who use those modes
- Please contact John and Stefan for questions or comments

Year DATA TAKEN	Researchers to invite as coauthors
2017	JDM, SK, NA, JBB, CD, TG, CL, BS
2018	JDM, SK, NA, JBB, CD, TG, CL, BS
2019	JDM, SK, NA, JBB, CD, TG, CL, BS
2020	JDM, SK, NA, JBB, CD, TG, CL, BS
2021	JDM, SK, NA, JBB, CD, TG, NI, CL, BS
2022	JDM, SK, NA, JBB, SC, IC, CD, TG, NI, CL, BS
2023	JDM, SK, NA, SC, IC, CD, TG, MG, NI
2024	JDM, SK, NA, MG, NI, TG
2025	JDM, SK, NA, MG, NI
2026	JDM, SK, NA, NI

New guidelines in effect as of this meeting April 28, 2025

Final Thoughts (revisited from last year)

- Support for STST Guiding Mode – deterministic actuators at telescopes and better camera
  - **New grant application had $ for cred-one for STST which could largely replace lab-AO**
  - **Funding request for new dicroics (needed for effective STST use)**
  - **Can we change optics to use CLIMB dewar?**
- Look into the W2 polarization problem we recently found
  - **Moot point as W2 now as DM that *should* solve the birefringence problem we found in 2022**
- Delay line fixes to the serious clock jitter problem and 120Hz oscillations
  - **Breakthrough solution and now we have high hopes, but no apparent good news from SPICA (?)**
- Continue to work towards replacing dicroics with smaller wedge (to keep vis-NIR aligned in lab)
  - Not sure. Discussed to put funding for this in a recent grant application.
- Add White light fiber at telescope beacon focus for checking alignments on instruments
  - No.
- AO improvements; work toward new visible AO system based on MEMs mirrors
  - **New diagnostic tools leading to more alignment stability**
  - **Progress towards writing NSF-ATI/MRI for a new visible system.**
  - **To me this is the highest priority upgrade needed to stay competitive, even more important than 2m 7th telescope → essential upgrade to allow nulling**
- Support for simple delay line extension to allow more 6T sky coverage in north and south
  - No.
- Re-aluminize telescope mirrors on a regular basis
  - better
- Focus heavily on adding large central telescope for better sensitivity and uv coverage rather than fiber-linked small mobile telescope
  - **MSIPS attempt failed. But important to try! Lesson might be to ask for money to upgrade all telescopes not just one.**
- More Array oversight of ”visitor” projects. Sky time is not being used efficiently IMO
  - Better allocation of resources lately but would advocate consulting consortium members if array commits observing time to new outside projects (eg, intensity interferometers, testbeds that don’t produce science)

Final Thoughts (revisited from last year)

- Serious thoughts about 2030 Decadal Survey – New US Facility or stick with current infrastructure?
  - **Some discussion on last Friday but otherwise nothing that I know of**
- Offer NOIRLAB a simple way to request binary star observations w/o full proposal process
  - **CHARA offering some snapshot imaging nights this semester. Curious how that goes.**
- CHARA Array Code of Conduct should be developed
  - Yes!
- Creation of formal Instrument PI advisory board to advise GSU CHARA leadership, suggest Quarterly Meetings to discuss: Science, Strategy, New Funding Opportunities, Management, Climate
  - **An "Array Future Planning" Meeting zoom was held with Stakeholders before proposal season**

New final thoughts

- More discussion and explanation of the CHARA fiber telescope strategy.
  - Great progress on instrument but I'm not understanding the strategy. Why putting fibers between so many telescopes right now?
  - Main interest is adding long baselines so need longer fibers
- I'm noticing many observers choosing poor calibrators: too big, known binary in kervella, etc.
  - Especially VLTI users who are used to using cals > 1mas.
  - Diameter <0.85mas , binary SNR < 5 in Kervella catalog.
- Stick to same gain all night. If too bright, change frames per reset.
  - For MYSTIC, use gain 40. New MIRC-X camera will have different parameters. For now use gain 20.
- Always take 6T STS data no matter what. Pipeline really wants shutter data on all beams.
- Always take 6T STS Etalon data if you are doing binaries or want precision <0.5% in diameters
- When fitting diameters with MIRCX-MYSTIC, its important to let Vis(baseline=0) be a free parameters to account for a known global systematic when calibrating transfer function. This is related to either seeing or polarization variations. ** IMPORTANT **
- Watch out for new camera noise on MIRC-X. Seems to be get better if you re-start acquisition. Monitoring... **BIG WORRY**
- Delay lines have some new bad states that can be hard to notice. Need some live diagnostics to know when to reboot.
- Urgently need software pipeline activity for ABCD modes
  - Strongly urge coordination between SPICA team and Michigan team on this. Same code should work with MYSTIC-ABCD chip as MIRCX SPICA-FT.(+BIFROST!)
  - ABCD modes might have dramatically better calibration (not better sensitivity), though worth the trouble
  - Invite some interested students or postdocs to work on this and willing to do careful checks of calibration on known binaries and resolved stars.
- Can we progress to allow one person to observe with SPICA+MIRCX+MYSTIC?
- I still dream of a CHARA scheduler to automate observing.. Some kind of infrastructure?
- Implement binary fits table to go with raw camera data to carry fast changing quantities like delay line offsets and DDLs
  - Needed for fringe tracking and atmospheric studies.