



U. Michigan Update:

MYSTIC, STST, pipelines.... and more

John Monnier

MIRC-X / MYSTIC Collaboration

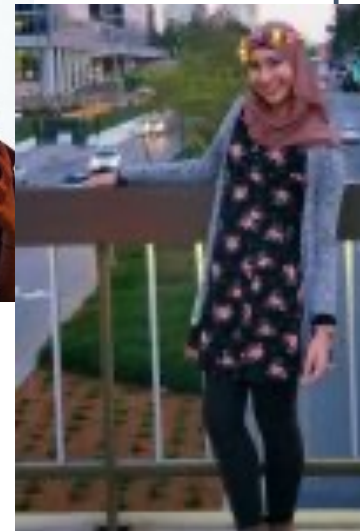
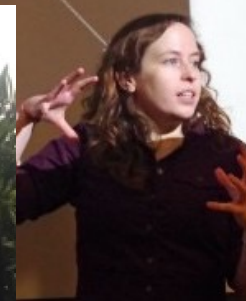
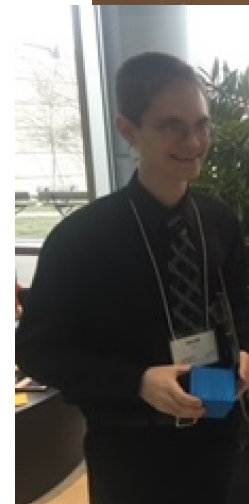
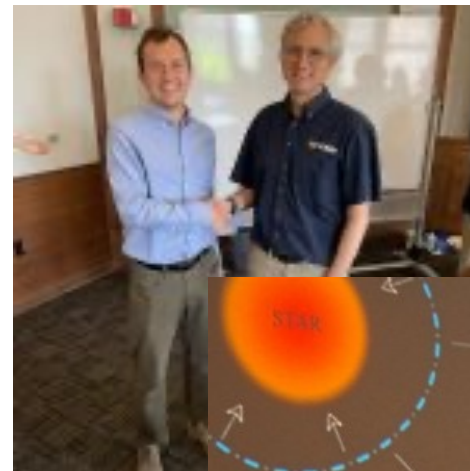
Your Talk Title Here





Big Changes in Group

- Tyler Gardner graduated PhD
 - Won UM Proquest Dissertation Prize
 - Now working with Stefan Kraus in Exeter
- Ben Setterholm graduated PhD
 - Now working in UM College of Engineering on SunRISE, the first space interferometer!
- Jacob Ennis moved on to new things!
- Noura Ibrahim advanced to PhD candidacy
- Rachael returned to UM as 51 Peg b Fellow!
- Had 3 extended visits last year from Exeter
 - Great to work with Issy, Dan, and Sorabh!

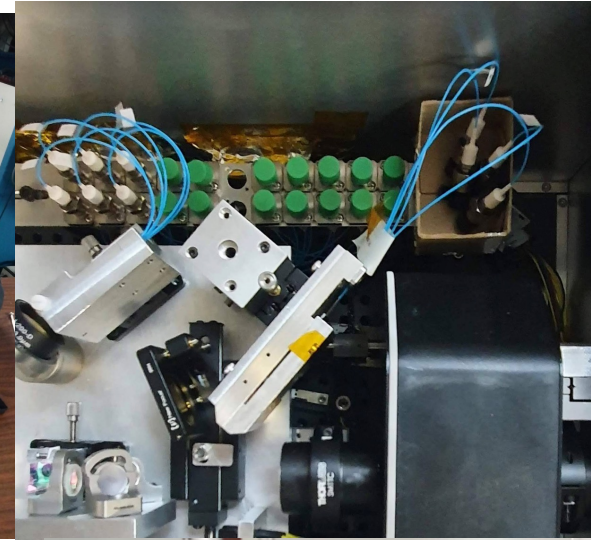


BIG THANKS TO EVERYONE FOR ALL THEIR AMAZING CONTRIBUTIONS!!



Installation of GRAVITY

- JB, Ben, Dan +company installed GRAVITY chip into MYSTIC
 - Amazingly, no problems
- Four new OAPs + periscopes installed to avoid un/plugging fibers
 - Amazingly, no problems
- Final installation of grisms/prisms
 - Ok.. Some small problems here...



Optic(s)	R	Kmag
Prism	20	7.9
Prism	49	7.5
2 × Prism 49	100	7.1
Grism	278	5.8
Grism	981	5.1
Grism	1724	4.8



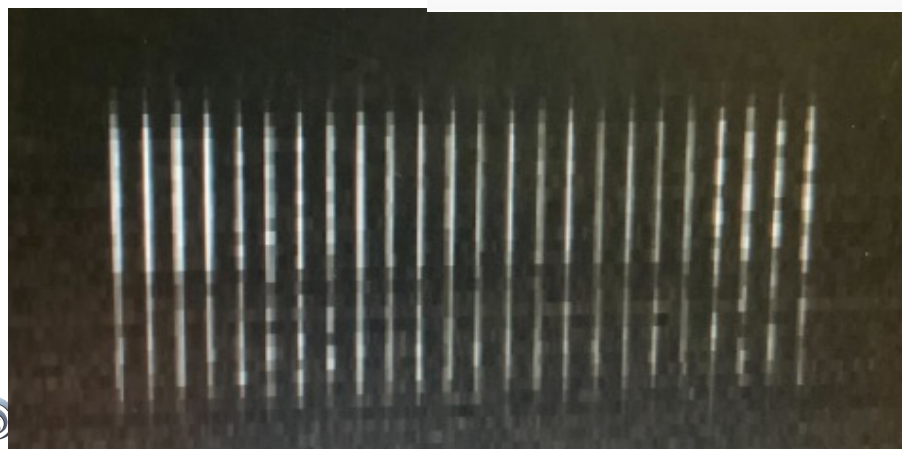
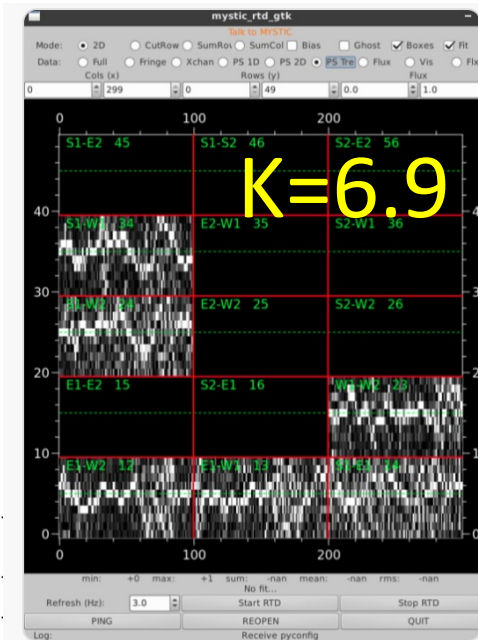
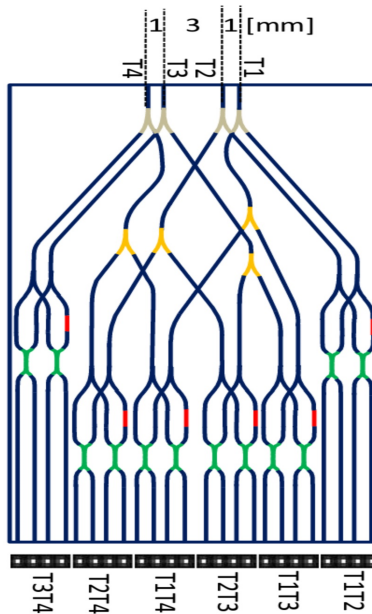


The hopes and dreams for ABCD mode

- Better visibility calibration
 - Visibility insensitive to flux ratios
- No cross talk
 - Great for very resolved targets or precision closure phases (Exoplanets)
- More sensitive ?
 - Able to use R20 mode, but hard to track !!

Software Status:

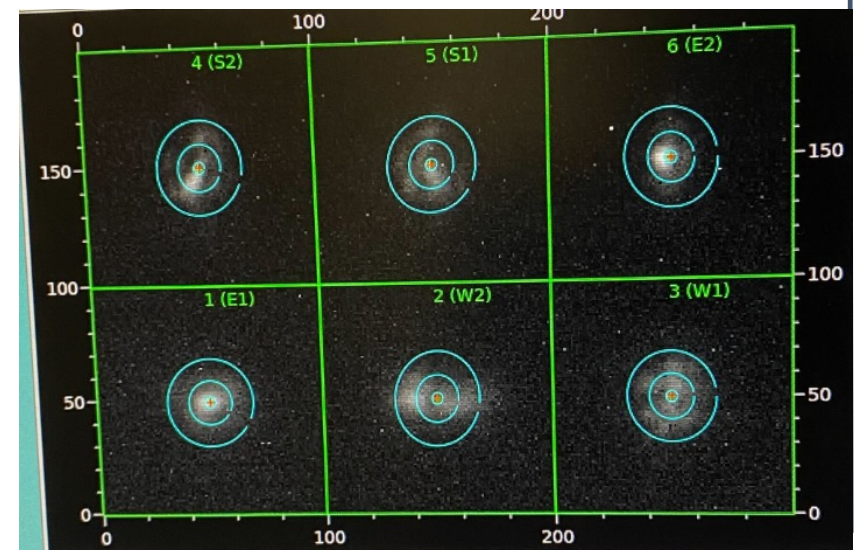
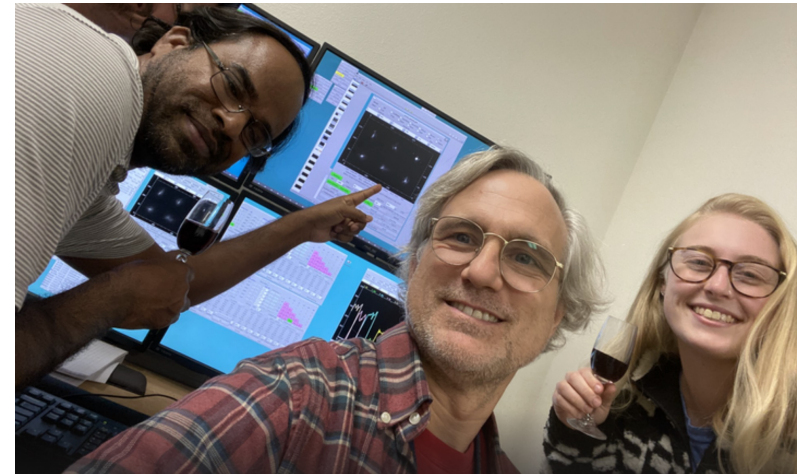
- Realtime observing software ready
- Data Pipeline still not ready for science





Six Telescope Star Tracker

- STST is essentially the same as the STS reference source backwards
 - Mostly built by Jacob and Mayra
- Bare glass reflects 4% of NIR light to STST on a retractable stage
- CRED2 sensitivity J+H' (thanks Exeter!)
- Lens located in filterwheel to allow pupil imaging
 - + J,H filters (in future) simultaneous photometry
- Installed Aug 2022 by Rob, Narsi, Sorabh (John got covid!)
 - Followup visit John and Issy (added water cooling)



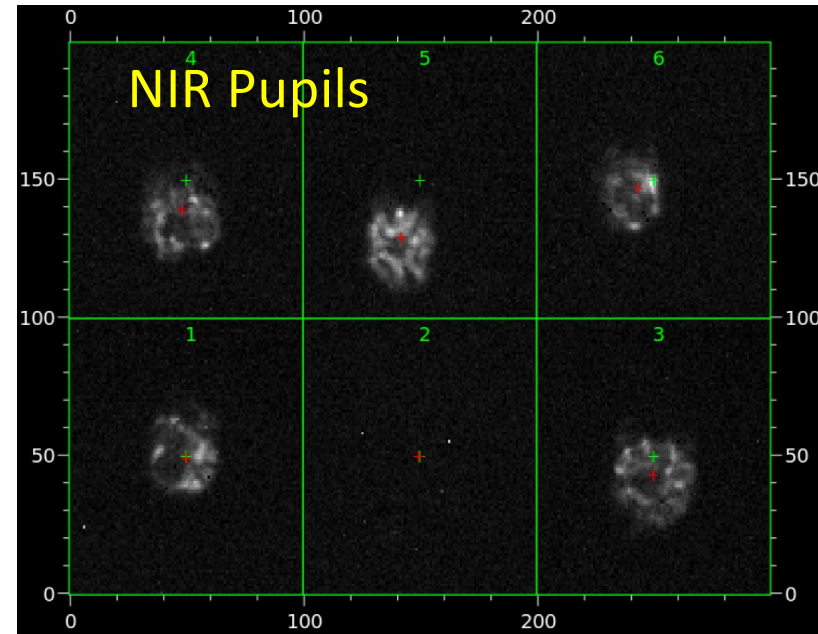
Observatoire de la COTE d'AZUR





STST Performance

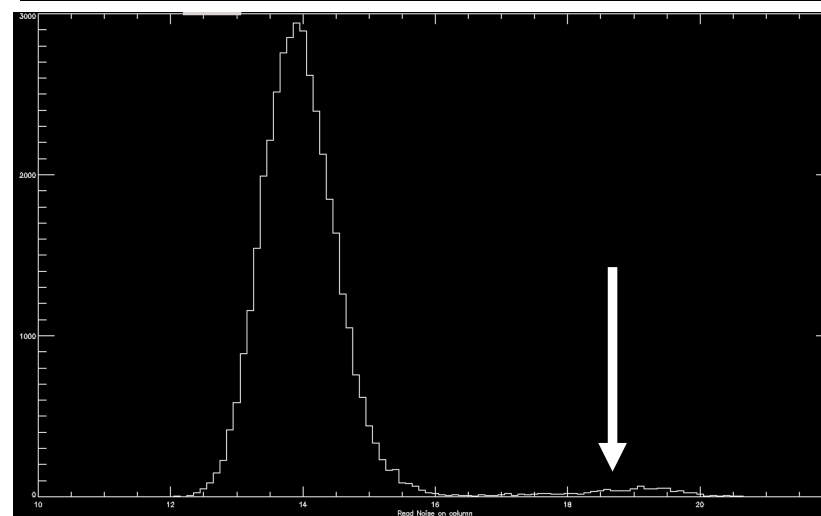
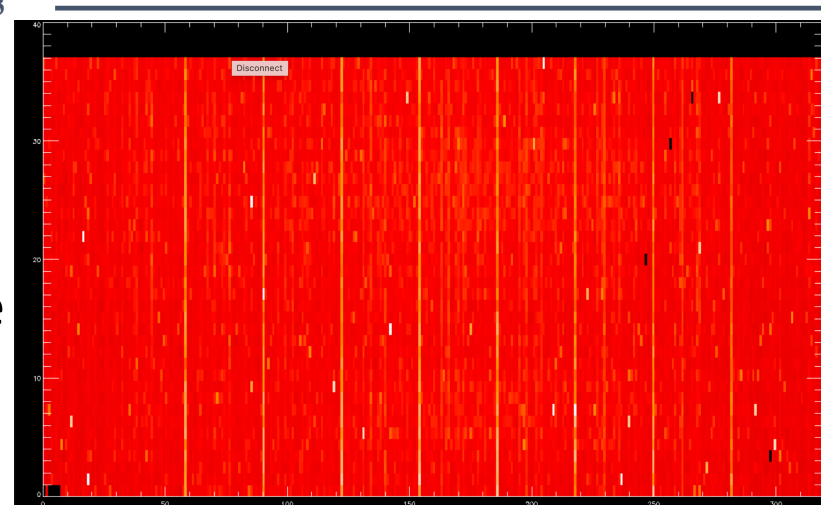
- Huge amazing software work by Narsi
- John+Narsi worked on camera optimization
- We can track objects down to $H \sim 6$
 - Rob and Narsi reduced backgrounds a lot
- Next: work on long exposure mode to get down to $H \sim 7.5$
- Real-time tracking does substantially reduce drifts
- But our method to track too often fails due to sometimes large differences between visible/IR beams ☹️
 - Pupil sometimes terribly off (x10 loss, cause still under investigation)





New issues with detectors

- Sometimes MYSTIC shows some pattern noise
 - Restart camera if you see it
- Noise pattern changed (Fall 2022)
 - Same for mircx + mystic, so likely related to new colder chiller or firmware update
- Seems to mess up bad pixel flags in some nights
 - Increase badpix threshold 15 sigma.
- Weird issues?
 - email me monnier@umich.edu
 - post on UM slack #data_pipeline

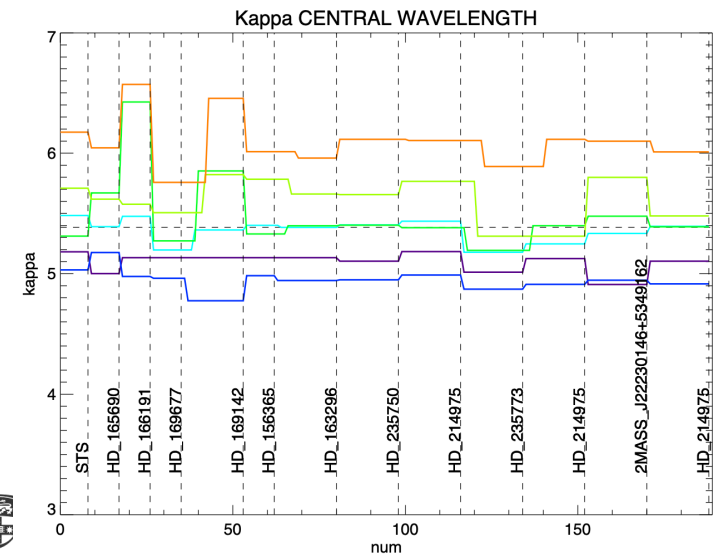
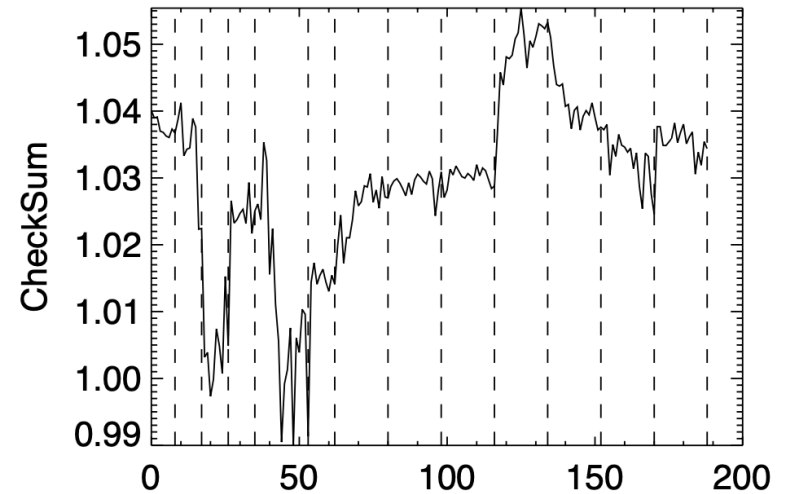




Example of using Kappa diagnostics

- Kappas are critical for calibrations V2
Fringe Power = Kappa X Photometric channels
- Checksum: Predicted Fringe Power / Actual Measured Fringe Power
- If kappas jump around too much during night then problem
 - Bad or low quality shutters

2019-07-13



Observatoire de la COTE d'AZUR

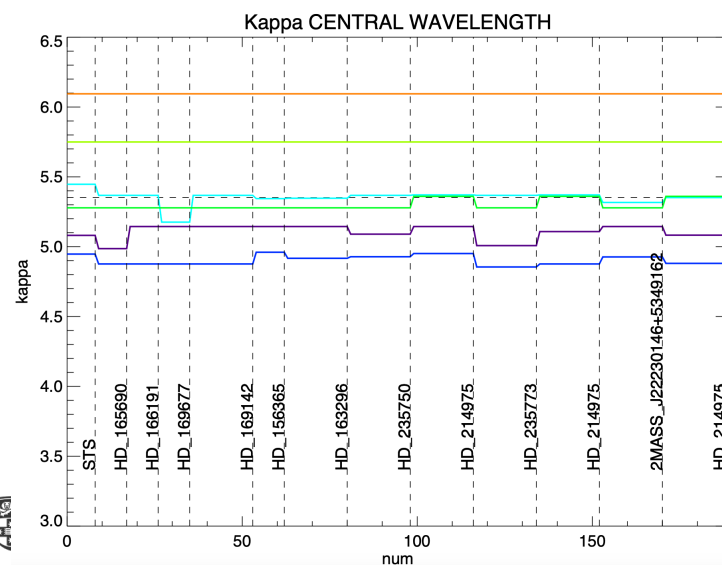
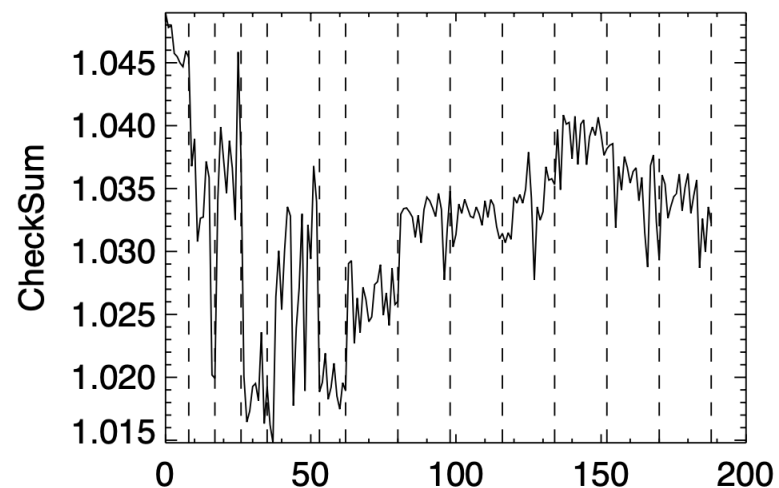




Example of using Kappa diagnostics

- Default behavior is to take closest kappa measurement in time with quality >5
 - This is not good enough. Way too noisy
- Proposed default to use
 - A) best same target kappa quality (Q>50)
 - B) if no A, best one of night (Q>5)
- Note the checksum is still offset from 1
 - Why?

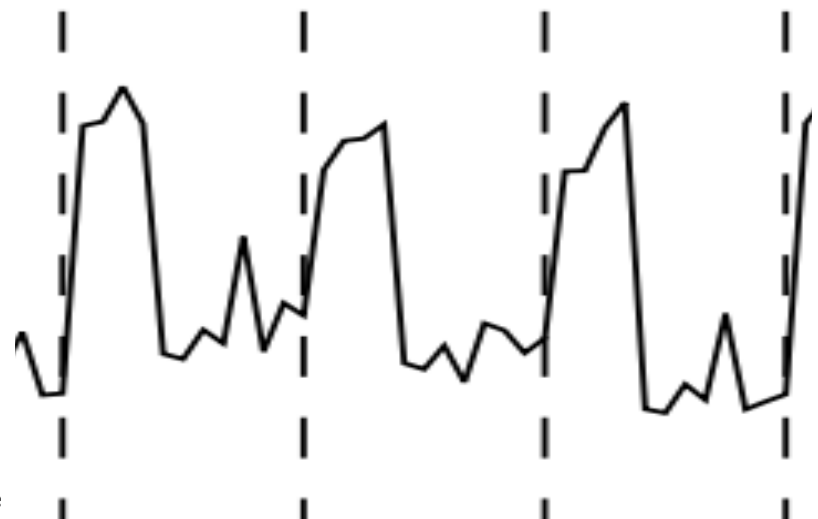
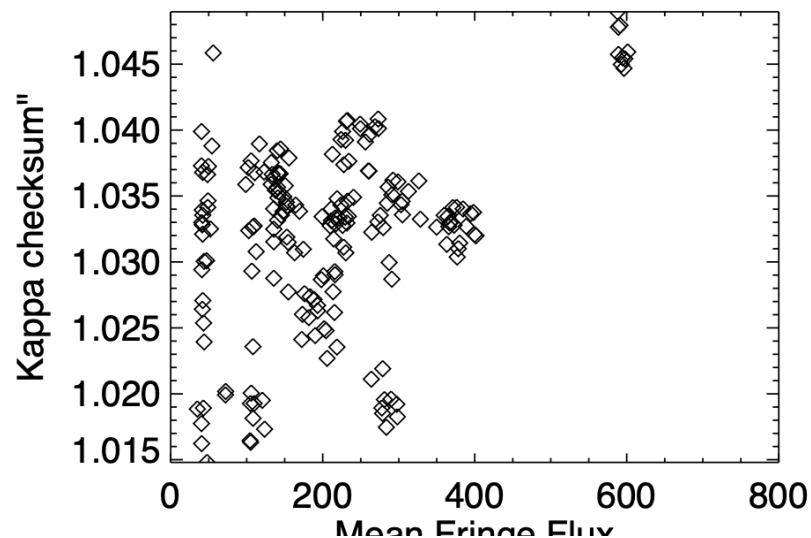
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Example of using Kappa diagnostics

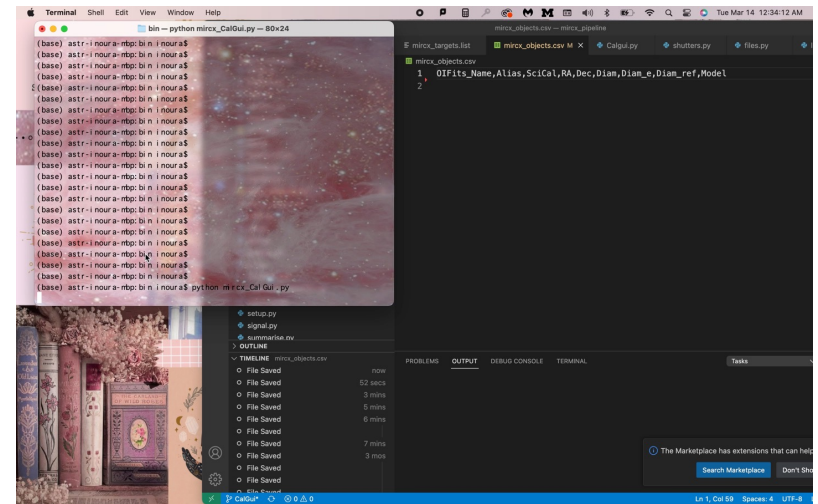
- Checksum >1 could be due detector nonlinearity, but no dependence with flux seen
- I retagged the individual beam shutters to be interpreted as data, so see if the checksum 1 was recovered.
 - It was for half the beams but not the other half
- To be continued.....
 - Not fixed yet.
- This and more things you wish you didn't know on slack #data_pipeline





Python version of IDL mircx_cal

- Use of the mircx_cal IDL script vastly improves data quality and makes calibrating your data FUN!!
 - Recently John+Gail added “Deepclean”ing to automatically flag outliers in an objective way
- Issy and Noura working to update the IDL mircx-cal to be
 - Fully pythonic
 - Fully interactive for data editing and inspection
 - Have modern features like “undo” and “save flags”
 - Creates summary pdf files
 - Work with any oifits not just mircx/mystic





Goals for new mircx_mystic pipeline

- Edit headers through a spreadsheet
- Extensive checking for bad shutters
- Better removal of camera interference, background drifts, non-linearity
- More advanced and sensitive kappa modelling w/ errors
- Use Beam profiles as flat fields
- Support flexible group delay tracking methods
 - Needed for polarization modes or when using mircx to track fringes on mystic
- Calibrations of differential quantities, differential phase
- Better error bars on interferometric observables
- FASTER – use multiple cores
- Produce nightly summary plots to speed up data quality checking





Biggest array technical concerns

- Delay line oscillations when carts are at certain speeds.
 - Need realtime monitors to detect and also way to reproduce in lab
- AO performance is not reliable
 - One AO system still not working >6 months.
 - Need to engage more of the collaboration to help
- Beams not always aligned to lab well
 - 3-10x losses randomly. Not repeatable. Why?
 - Recent STST tests are going in right direction.
- Mystic FSM mirrors oscillating and overheating
 - Probably related to our wiring and amplification of pickup signals
- Heat load from MIRCX/MYSTIC
- STST sensitivity (work needed on long exposures)
- Lack of folks contributing to data pipeline development and testing





Archives

- Michigan cloud storage got more expensive and will be moving to a less expensive option
 - Total MIRC+MIRCX+MYSTIC archive now > 140 TBytes
 - Nights are tarballed into 1 big file
- UM funding two undergraduates to create L1 oifits for all/most MIRC Archival data
 - Upload all oifits to JMMC
 - Encourage other teams to do the same (classic, climb, fluor, pavo)

MIRC Statistics	
Operational	2006-2017
# nights	~500
# of observed targets	~500
# refereed papers	44
# Nature/Science papers	4
# of UM PhDs	7





MIRC-X and MYSTIC Consortia News

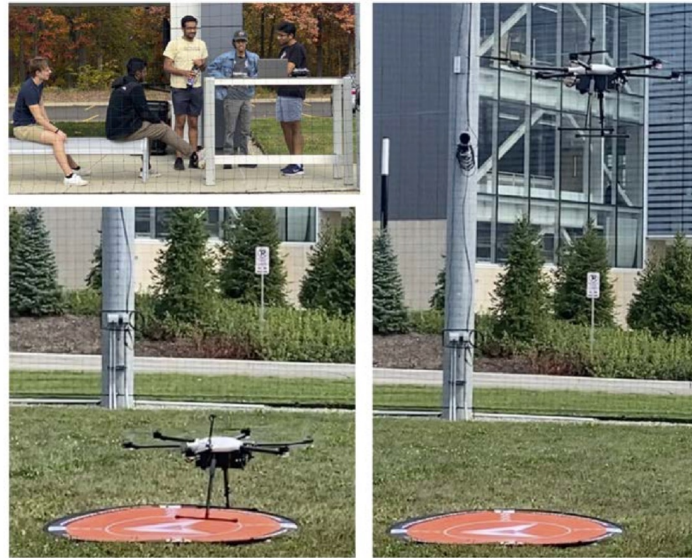
- We plan to hold a zoom meeting this year to discuss many issues
- Code of conduct
 - We won't tolerate unethical behavior in our collaboration
 - Open invitation to talk with me about any issues you see
- Evolving Authorship Policies
 - Follow recommendations of other medium-sized groups
 - Co-authorship should depend on level of contribution and is not meant to be permanent
 - Find ways to keep people involved after leaving groups
 - Special cases for incidental use of MIRCX/MYSTIC data
 - Shorter co-author list





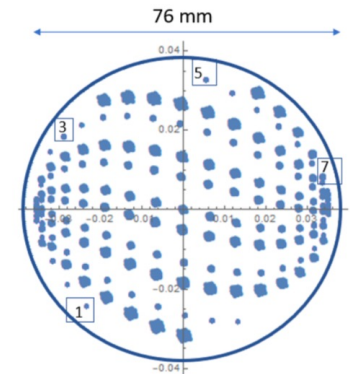
Other interferometry activities at UM

- Drone Interferometry
 - With Aerospace Engineering
- Cubesat Interferometry (STARI)
- Quantum Interferometry with Entangled Photons
- Compact delay lines for future fiber-connected array
- Nulling Interferometer Combiner for CHARA/MROI
- PFI → Science Case for a Stellar Imaging Interferometer



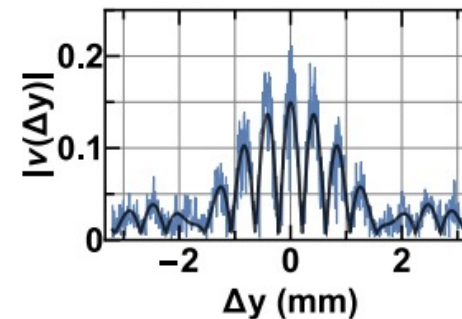
Harriot Cell Multi-pass DL

400m delay
170 bounces
82% efficiency
1.5—1.75micron
Arnold et al.



Interferometric imaging using shared quantum entanglement

Matthew R. Brown,^{1,*} Markus Allgaier,¹ Valérian Thiel,² John Monnier,³ Michael G. Raymer,¹ and Brian J. Smith¹





The future is bright

- H+K band MIRC-X + MYSTIC routine
- New polarization mode for MIRC-X ready for science
- New high spectral resolution mode ready for science
- Hopefully soon we can do simultaneous R+J+H+K science

Come join us in Michigan!

Happy to support applications for

- NSF, Hubble, Sagan, 51 Peg b Fellows
- Marie Curie Fellows (from Europe)
- CHARA+ VLT/IRIS Projects
- Advanced mode!

