MIRCx+MYSTIC as a Fringe Tracker

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MIRCx

- ERC-funded project to equip MIRC with SELEX/SAPHIRA-based detector
- Other improvements in optical design to optimize sensitivity (new fibers, V-groove) and accuracy (polarisation control; reduced cross-talk)
- Simultaneous J+H observations
- Options for high-spectral resolution mode and observations in polarized light

MYSTIC

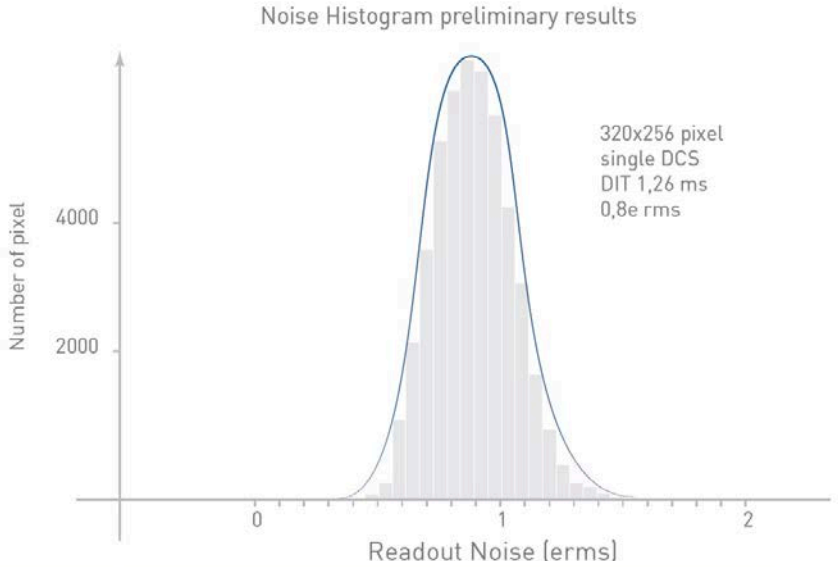
- NSF-funded project to build new cryogenic instrument operating in K-band
- Also based on SELEX/SAPHIRA-based detector
- Different optical designs under discussion, incl.
  - MIRC-like All-in-One combination
  - 3x4T GRAVITY IO combiners
  - New 6T IO combiner from ANU
- Options for high-spectral resolution mode and observations in polarized light

SELEX/SAPHIRA detector

Current PICNIC detector:
Read-noise 17.7e$^-$ (single read, 300 Hz)

➜ SAPHIRA: read-noise (0.8 e$^-$, 3507 Hz)

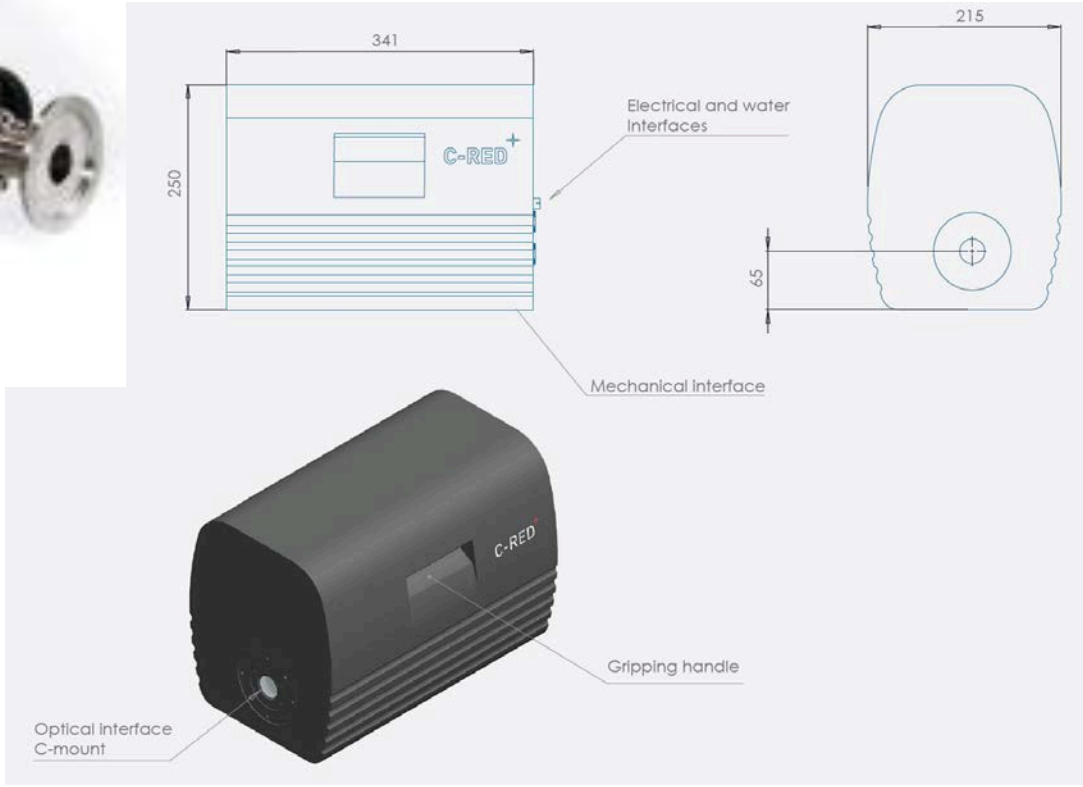
➜ Read-noise reduction by factor ~20



Test measurement	Result	Unit
Maximum speed	3507	FPS
Mean Dark + Readout Noise at 3500 fps and gain ~ 30	<1	e-
Quantization	16	bit
Detector Operating Temperature	80	K
Peak Quantum Efficiency from 1.3 µm to 2.5 µm	>70	%
Operability ± 30%	99.3	%
Image Full well capacity at gain X1, 3500 fps	200 000	e-
Excess noise Factor F	1.25	n/a

Credit: First Light Imaging

SELEX/SAPHIRA detector



- Pulse tube cooling (vibration-free)
- 1 cold filter possible

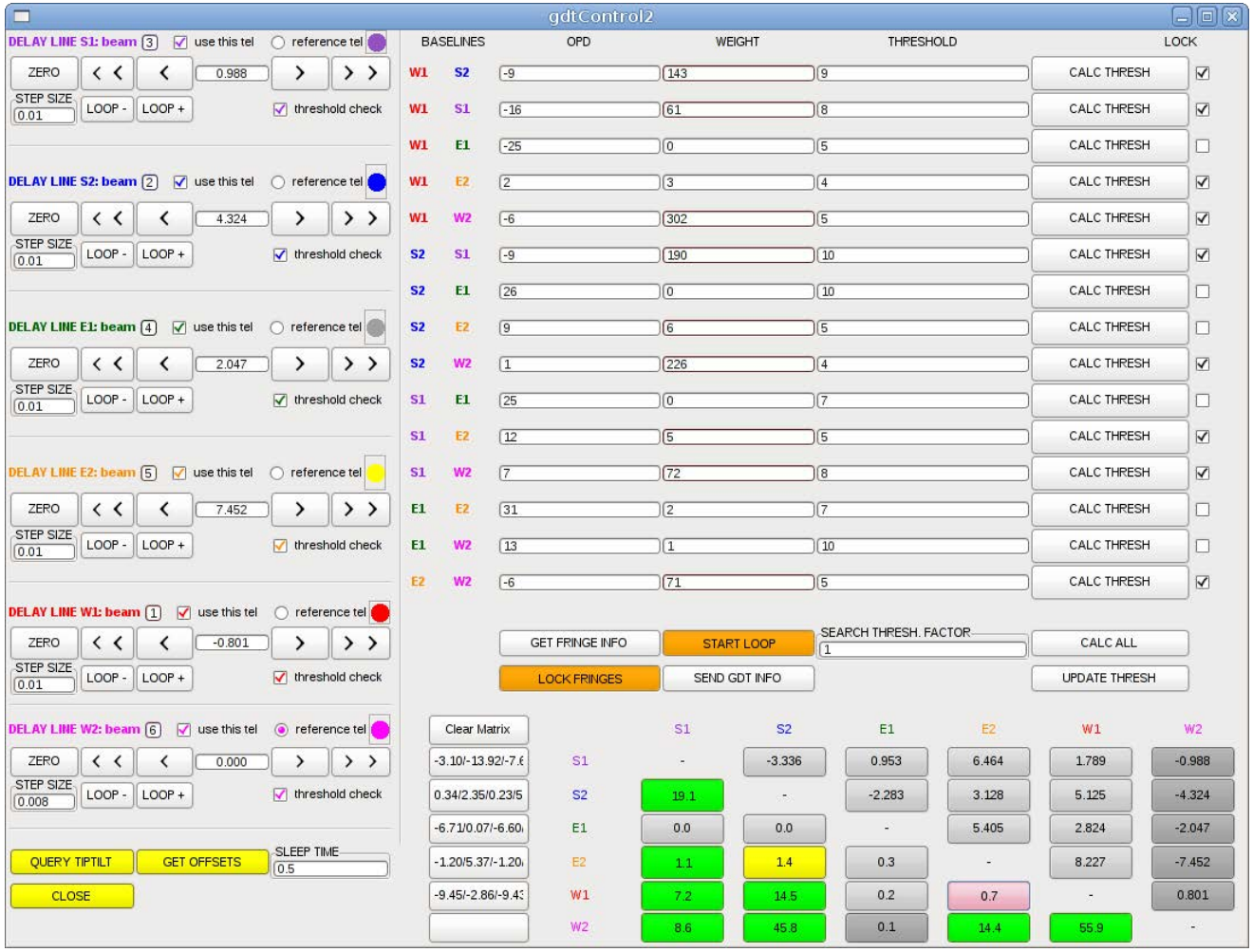
Credit: First Light Imaging

MIRCx+MYSTIC

- Preliminary timescale for commissioning (earliest times):
  2017 (MIRCx), 2019 (MYSTIC)
- MIRCx and MYSTIC will be designed to act as fringe-tracker for each other
- We build on MIRC design, experience, and software

Group-delay tracking

- Group-delay tracking (10 Hz, max. 30 Hz) implemented as standard MIRC observing mode, was also used to support VEGA



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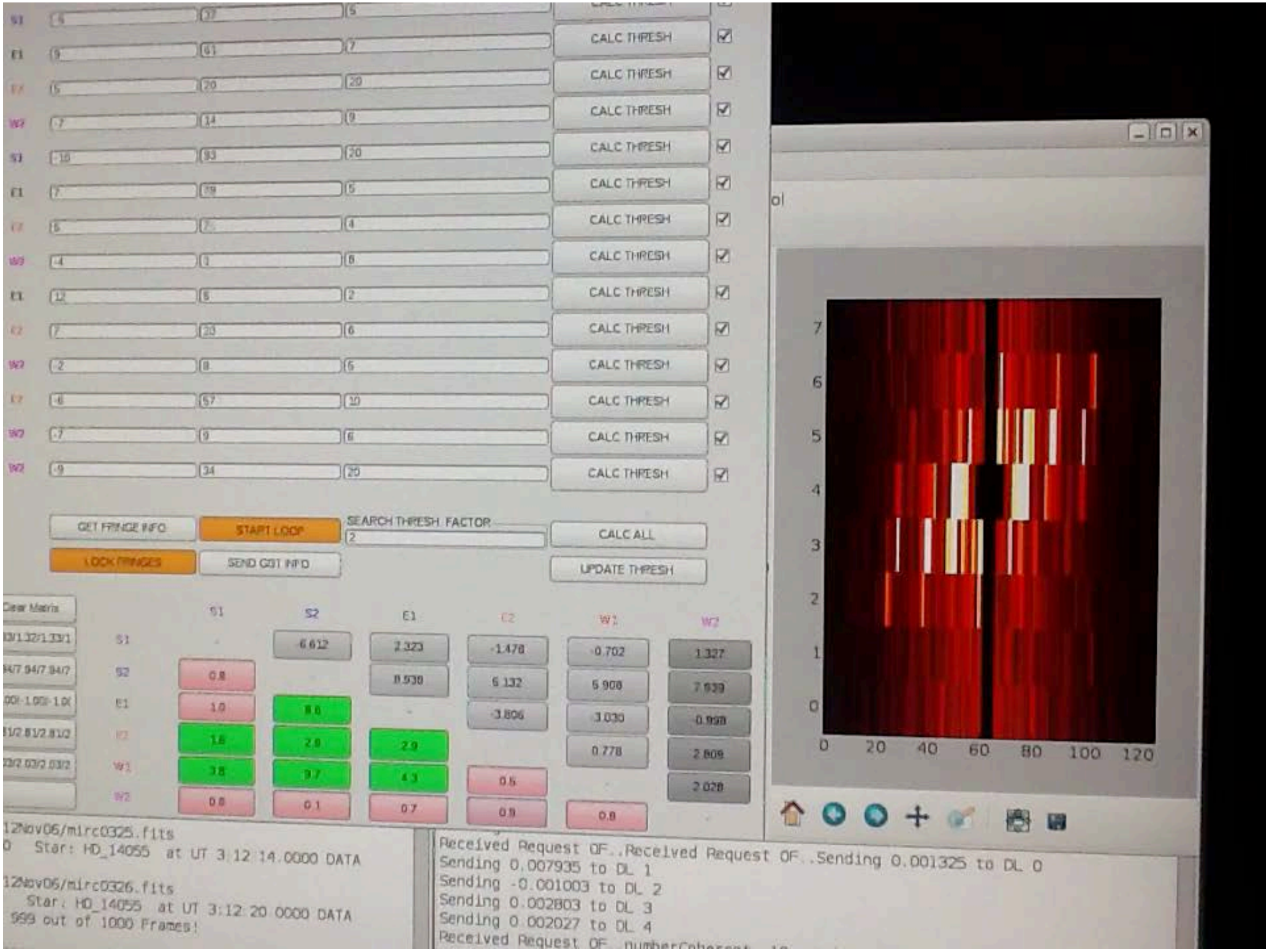
CALC THRESH
GET FRINGE INFO
START LOOP
SEARCH THRESH FACTOR
2
CALC ALL
LOCK FRINGES
SEND GUI INFO
UPDATE THRESH
S1
S2
E1
W1
W2
6.612
2.323
-1.478
-0.702
1.327
0.8
8.938
6.132
5.908
7.939
1.0
-3.806
3.030
-0.958
1.6
2.9
0.778
2.809
3.8
4.3
0.5
2.028
0.8
0.1
0.7
0.9
0.8
12Nov06/mirc0325.fits
Star: HD_14055 at UT 3:12:14.0000 DATA
12Nov06/mirc0326.fits
Star: HD_14055 at UT 3:12:20.0000 DATA
999 out of 1000 Frames!
Received Request OF..Received Request OF..Sending 0.001325 to DL 0
Sending 0.007935 to DL 1
Sending -0.001003 to DL 2
Sending 0.002803 to DL 3
Sending 0.002027 to DL 4

Group-delay tracking

- First implementation could re-use MIRC coherencing code, with one instrument acting as FT
- Goal is to implement global MIRCx+MYSTIC coherencing code, that uses fringe detections in any band (J/H/K) for group-delay tracking
- MIRCx: Read noise-reduction and improvements in optics should push sensitivity by 2-3 mag
- Allows for coherent integration of differential phase in spectral lines

Phase tracking

- SAPHIRA can go fast (3500 Hz), which could enable efficient phase-tracking (¼ radian for bright stars?)
- Objective to have longer integrations for high-spectral resolution observations
  (J-band: Paβ; H-band: [FeII], …; K-band: Brγ, CO)
- Implementation is not highest priority, but could reuse some CHAMP code

Application to visible light

Supporting visible instrument:

- MIRCx (J+H) obvious choice (closer in wavelength, more flux for blue objects), but ultimate goal is to track on any fringe detected in J/H/K
- Three 6T instruments need to be co-phased: MIRCx+MYSTIC+VIS (OPD between MIRCx and MYSTIC controlled internally)
- Longitudinal dispersion correctors → transmission problem in NIR?
- Group delay tracking: Compared to 3T (e.g. CLIMB), phase residuals should improve when going to 6T
- Phase tracking: Gains in V-band need to be quantified
- Coherent post-processing using FT information possible, if accurate timestamp information is kept on all instruments