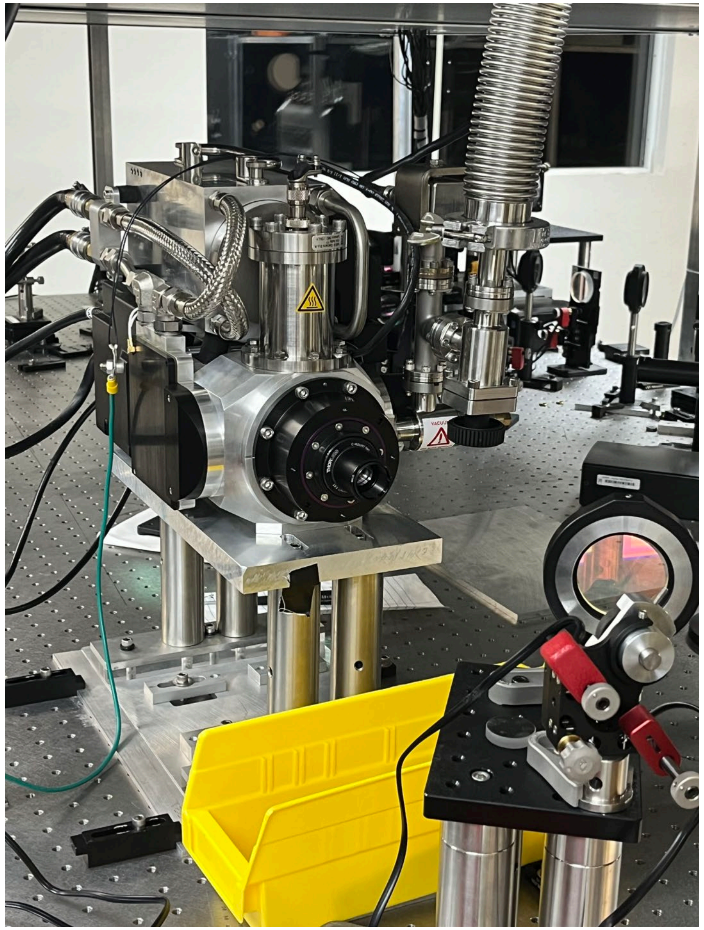
Update on Silmaril

By Cyprien Lanthermann

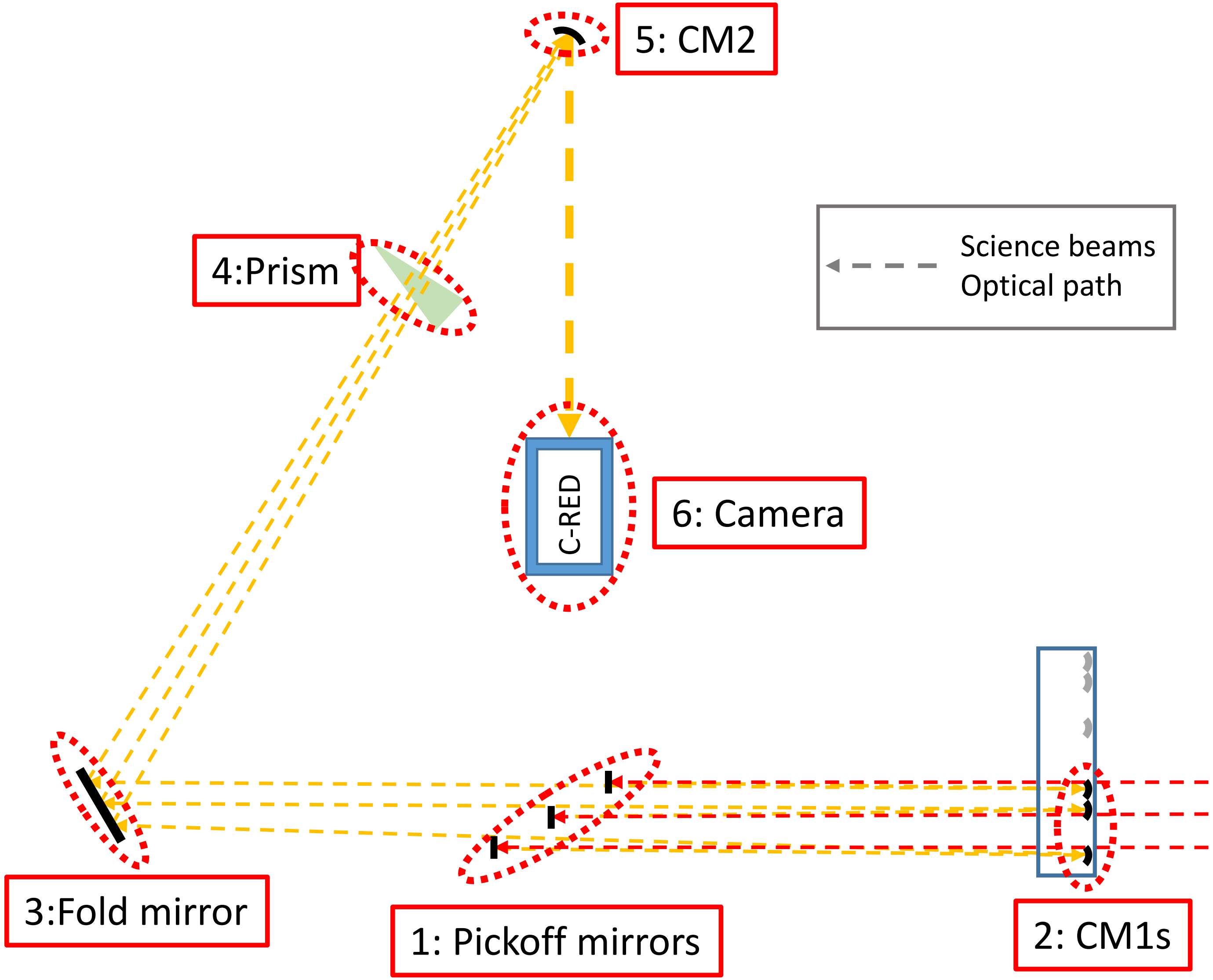
Introduction

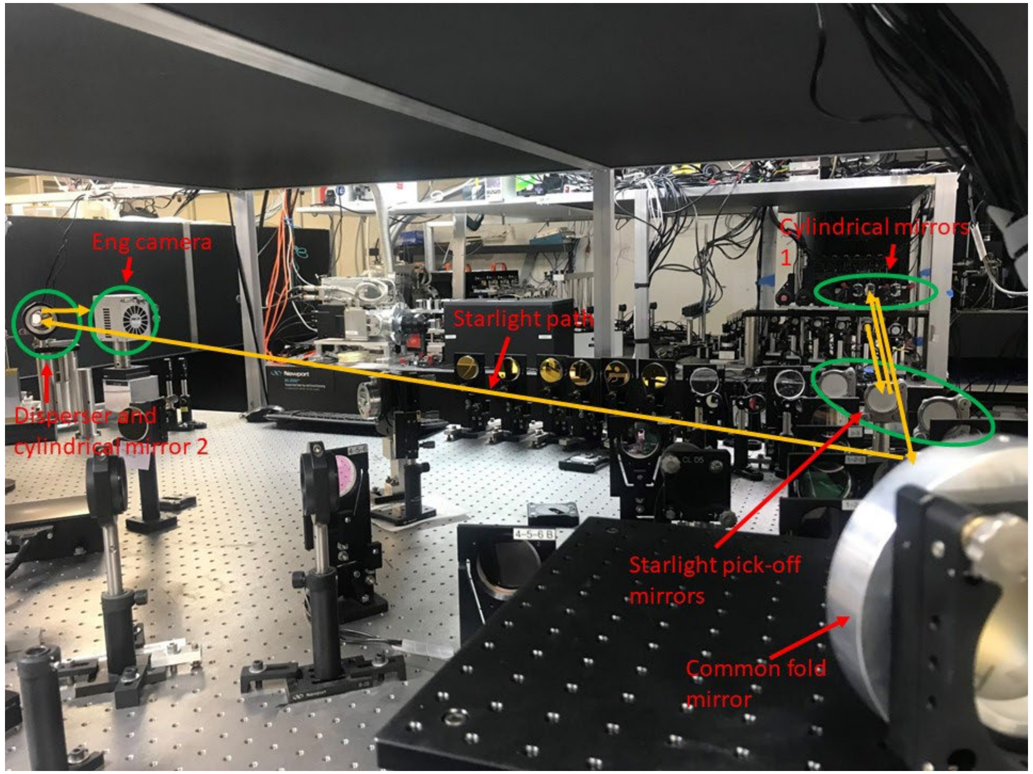


Started as CLASSIC/CLIMB upgrade project
Goal: sensitivity (H/K > 10)

- 3T
  - more sensitive
  - still allow 1 closure phase
- Using saphira e-APD detector (C-RED ONE camera from FLI)
  - fast frame rate (> 300 Hz)
  - ultra low read-out noise (< 1 e/pix/s)
  - low dark current (< 100 e/pix/s)
- totally new design
  - Image plane design
  - as few optical element as possible
    - long focal length cylindrical mirrors (f = 5.3 m) in the fringes' direction
    - shorter focal length cylindrical mirrors (f = 35 cm) in the spectral direction
  - low spectral resolution (R ~35)
    - trade off between sensitivity and capacity to perform group delay tracking

Optical design

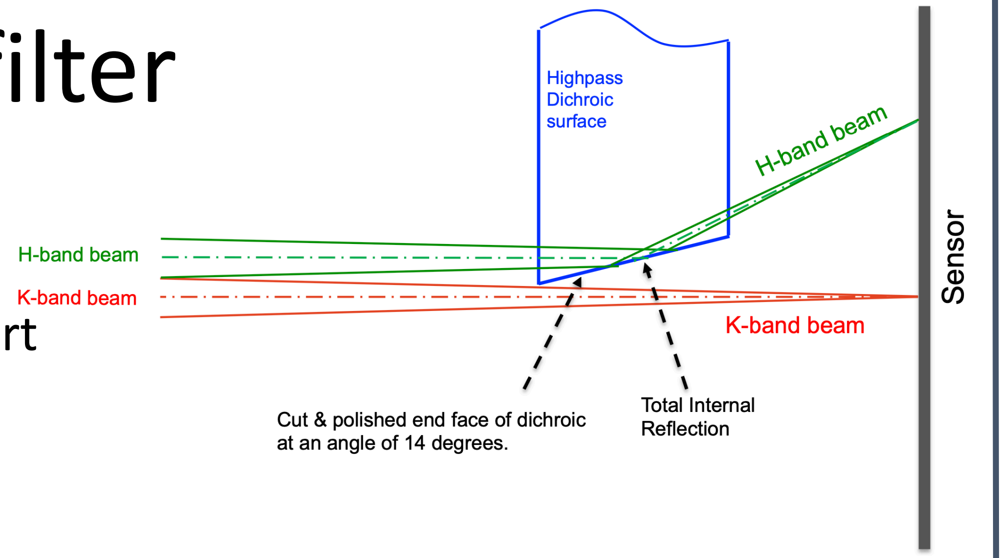




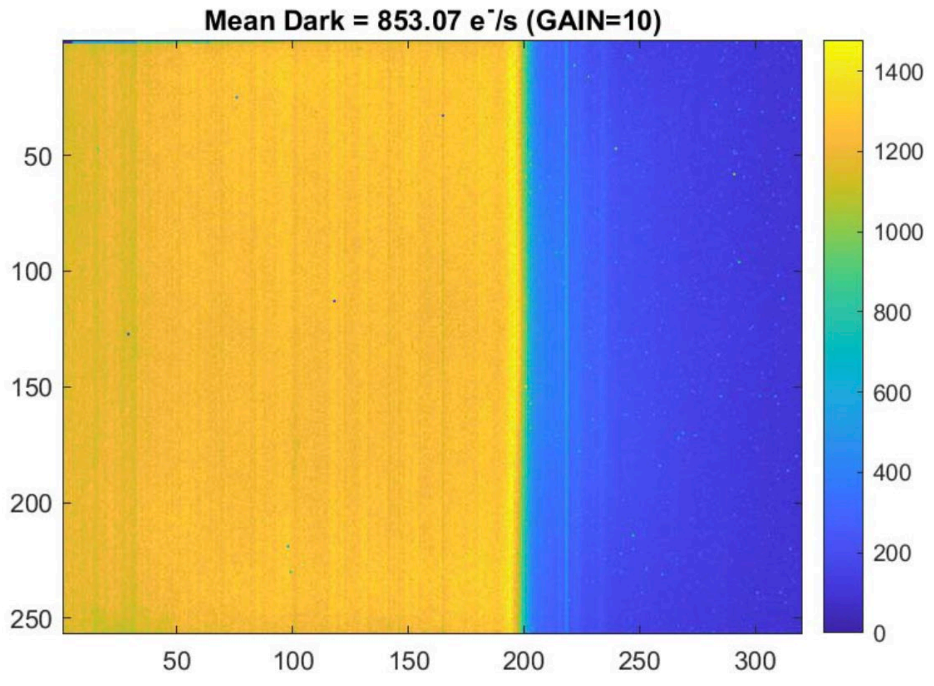
Knife edge half filter

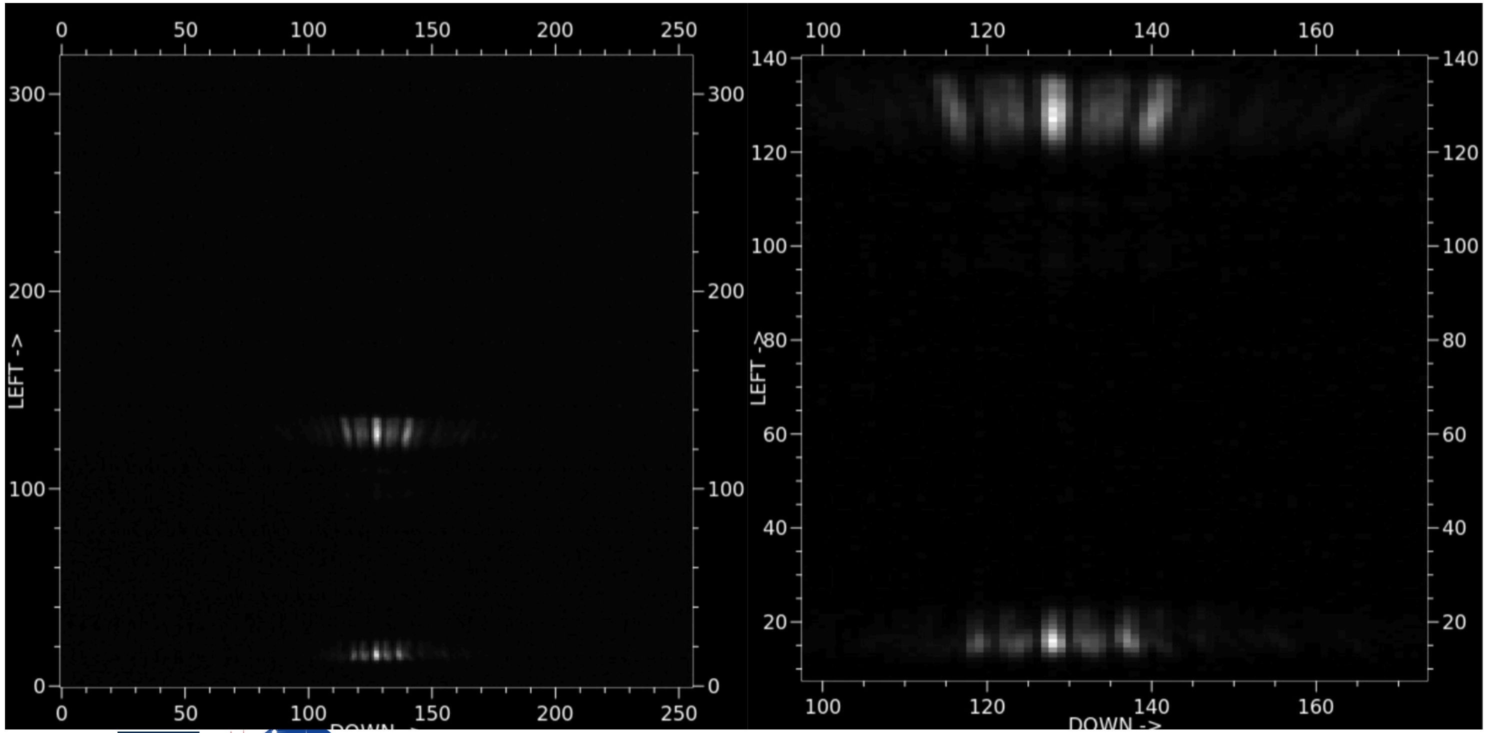
Internal reflection design

- K-band science beam not touched
- H-band science beam reflect away from central detector part
- K-band photons filtered out of H-band part of detector



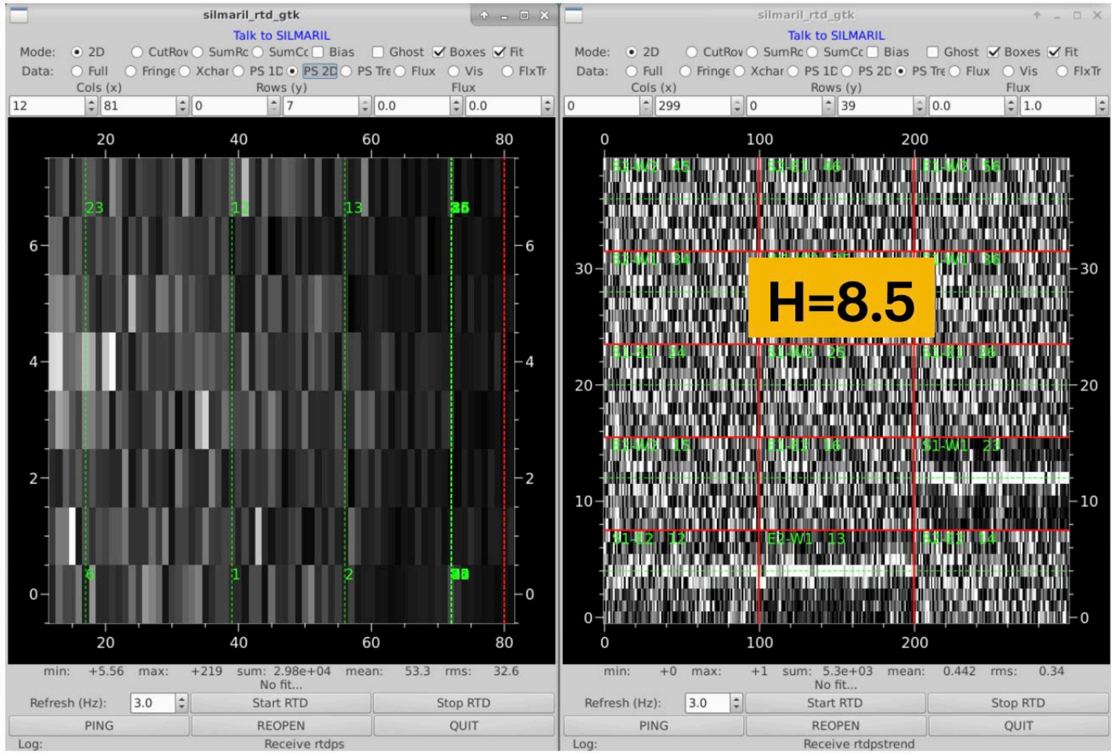
Tested in lab, needs to be tested on-sky





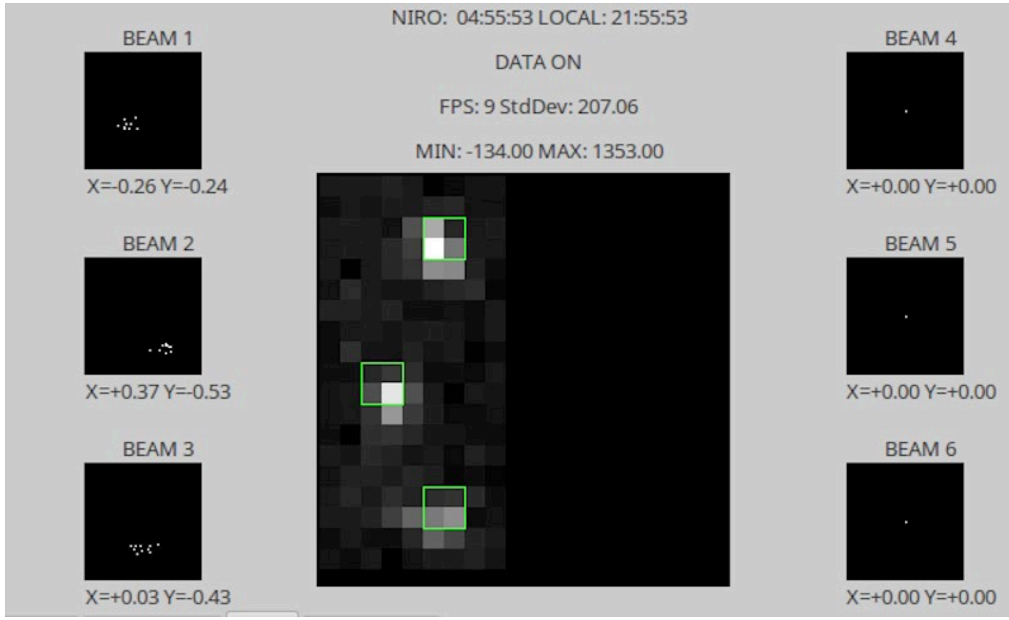
On-sky performance

- Fringe tracking successfully tested in normal conditions
  - Current spectral resolution R ~26, will be slightly easier once the final R = 35 prism will be used
- Alignment procedure being improved as first on-sky experience showing us domains where to improve
  - slow beam drift
  - rapid jitter
- Faintest fringe tracking and recording on on H = 8.5
  - did not worked yet for AGNs, but could see light on NGC 4151 (H ~ 9/9.5)



Incoming hardware improvements

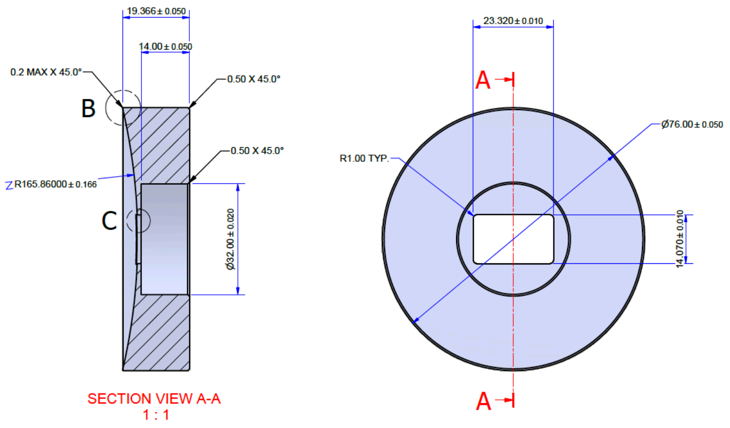
- Strider: beam tracking using NIRO camera
  - sending 5% of the light on a 2x2 square on NIRO allowing tip-tilt tracking
  - correcting beam drift
  - attempting to correct fast jitter if frame rate and sensitivity allows
  - will give photometric information for data reduction
- Narcissus mirror
  - reduce thermal background
  - allow limited spatial filtering
  - need a 2 stages narcissus mirror
- second set of 3 beams
  - will allow doubling the number of visibilities and closure phases
  - need bigger (new) prism

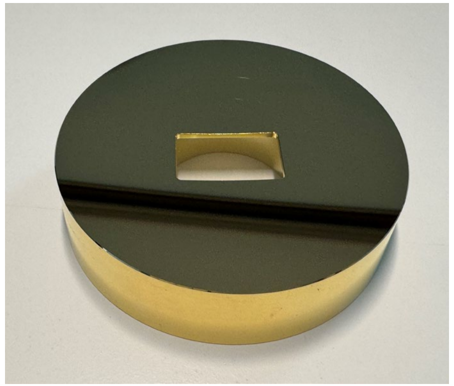


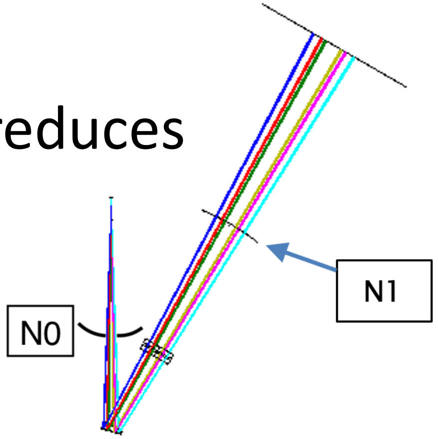
Narcissus mirror design

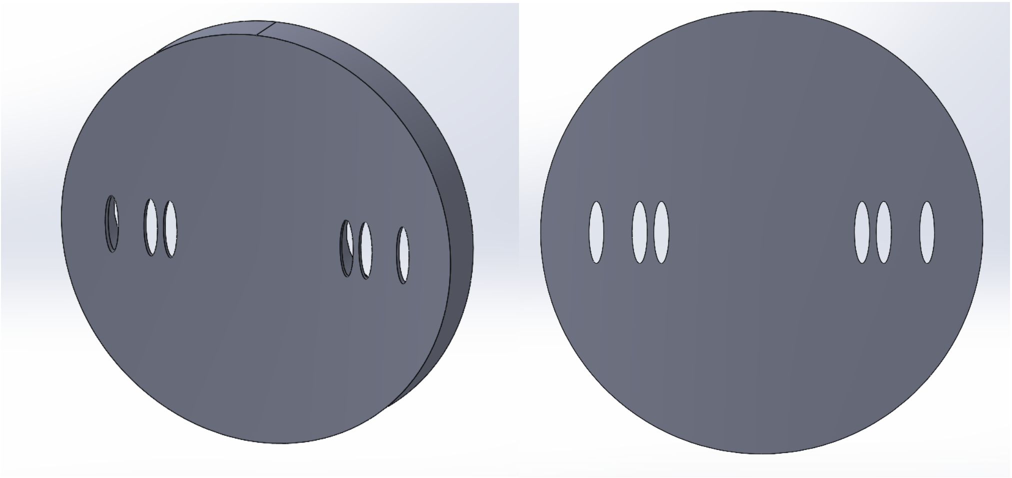
Spherical mirror with focal length equal to its distance to the cold pupil of the camera, the detector only see its own thermal background (80 K)

- too big of a mirror if only one mirror
- separated into two stages
    - N0: close to the camera, reduces external edges thermal background
    - N1: further from camera, reduces most of central thermal background





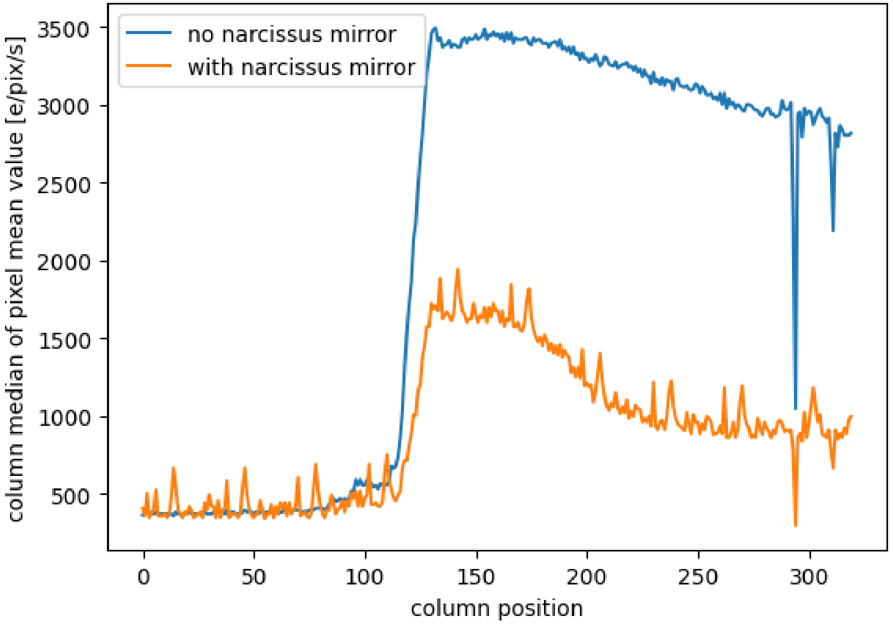




Narcissus mirror performance

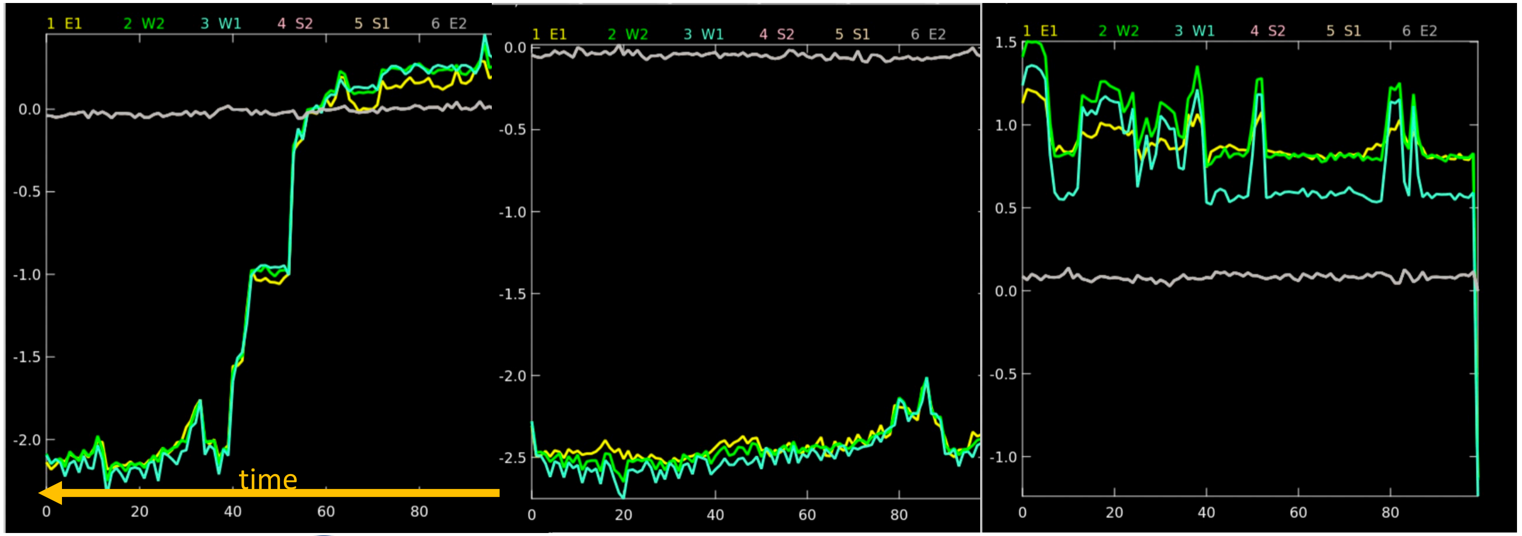
First test with a full spherical mirror (no hole), roughly aligned

- thermal background reduction: from ~3500 e/pix/s to ~1800 e/pix/s
  - not the >90% expected: could be due to the imperfect alignment and/or the front of the camera being reflective (instead of blacked out)



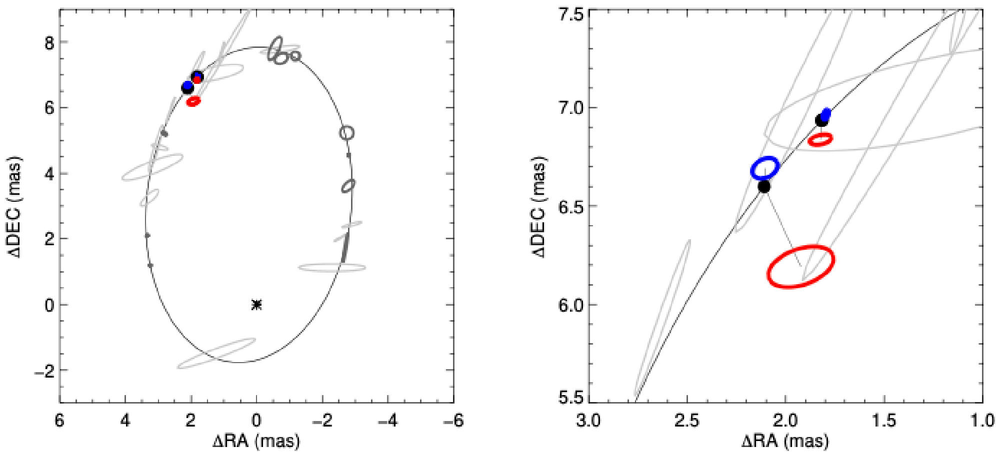
Second test with N0, not at the optimal position, but better global alignment

- big impact once alignment close to big good
- test with black cardboard in front of the camera show the effect of the thermal background reduction
- Need quantitative analysis



Data reduction

- Started with same observing strategy as MIRC-X/MYSTIC
  - issues with calibrating visibilities due to unstable beam positions
  - no real time photometric information
- Adapted observing strategy to get shorter sequences and more frequent photometric information (still not real time)
  - visibilities way better calibrated
  - having coherent calibrated data with expected result from previous measurement
- we may have non-zero calibrated closure-phase
  - need to be investigated and corrected



Incoming software improvements

- On-sky software
  - camera configuration improvement
    - implement smaller reading window
      - potential higher framerate
      - smaller file size
    - implement multiple reads and loops of IOTA mode (currently 1/1)
      - reduce readout => improve sensitivity
    - test best parameter configuration for bright/faint scenario
  - tracking software
    - may try new algorithm and software specifically for faint stars/fringes
- Data reduction software
  - make adaptation of the MIRC-X/MISTYC pipeline to specificities/differences of Silmaril
  - improve parts that may impact Silmaril calibration the most
  - working on new methods to retrieve missing information from the raw data

Conclusion

- Instrument works and starts producing science data
- sensitivity is not there yet
  - goal: H/K > 10
  - so far: H = 8.5
- Improvement (both hardware and software) are on their way to reach the sensitivity goal
- Strider works relatively well
  - need to procure 95/5 beam splitters
  - need some work to make it more robust
- Narcissus mirror shows successful thermal background reduction
  - need to be placed and aligned properly
  - need quantitative measurement of the efficiency once properly installed
- Data reduction pipeline has been improved
  - need more work and test to be validated