News from the CHARA-Array Beam Combination Lab

Judit Sturmann

Outline

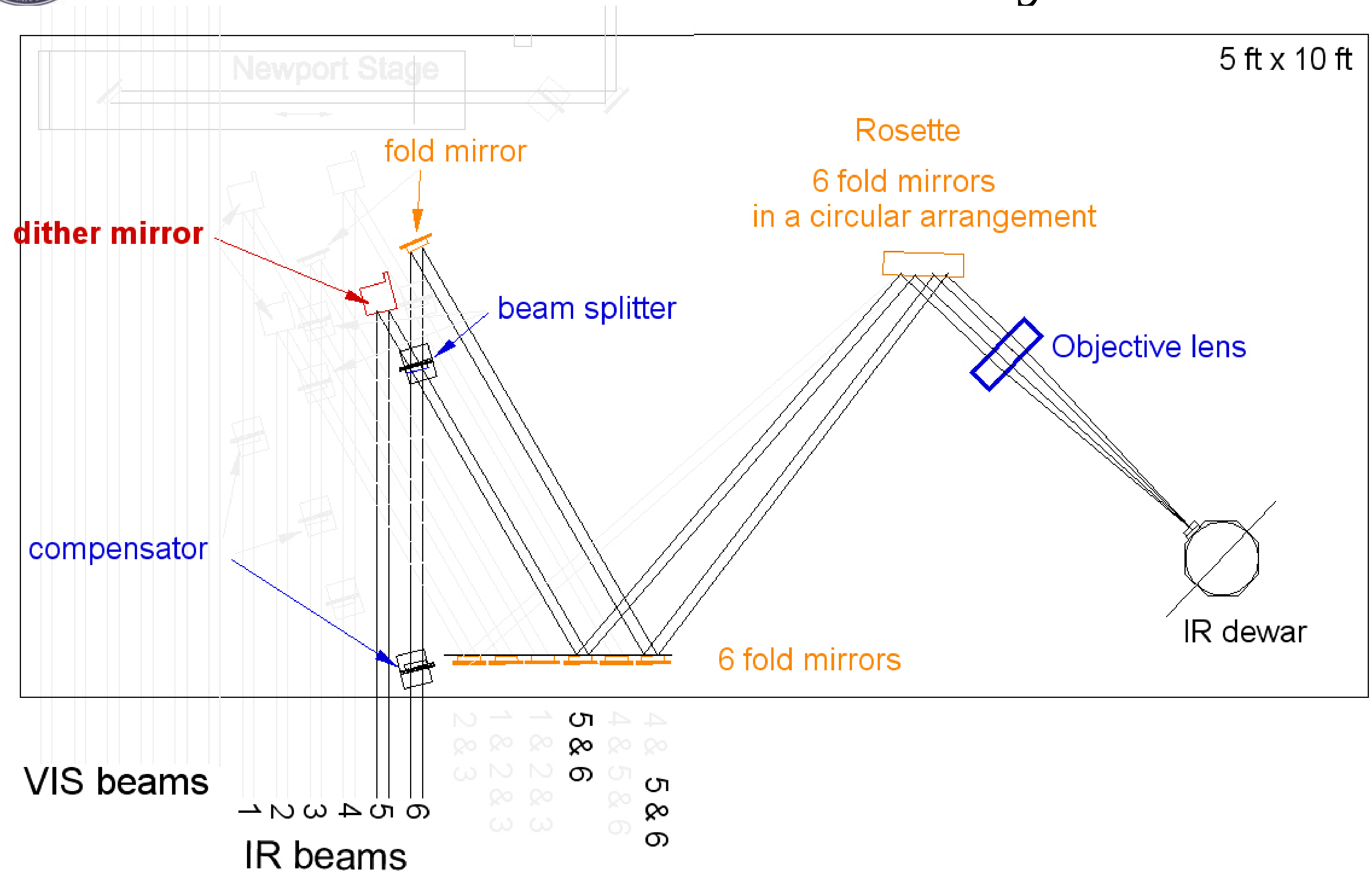
Front page news

- Classic Infrared Multiple Beamcombiner (CLIMB)
- New optics for the IR camera, NIRO
- White light source wave front tests

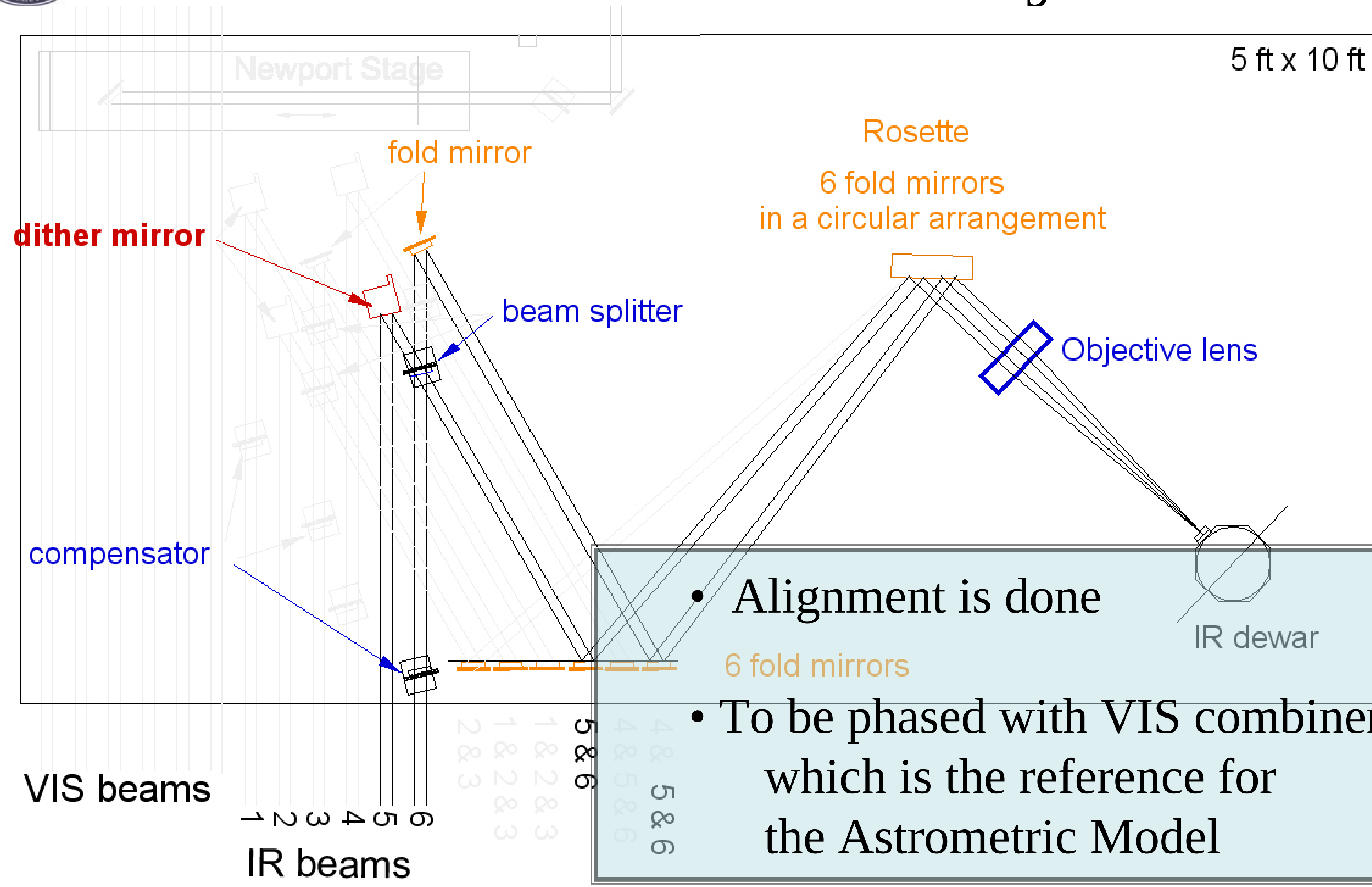
Short reports

- Steps taken against noises: electrical, lab seeing, vibrations
- Coming soon: - variable aperture for IR beams
  - alternative set of tip-tilt splitters

CHARA Classic Layout

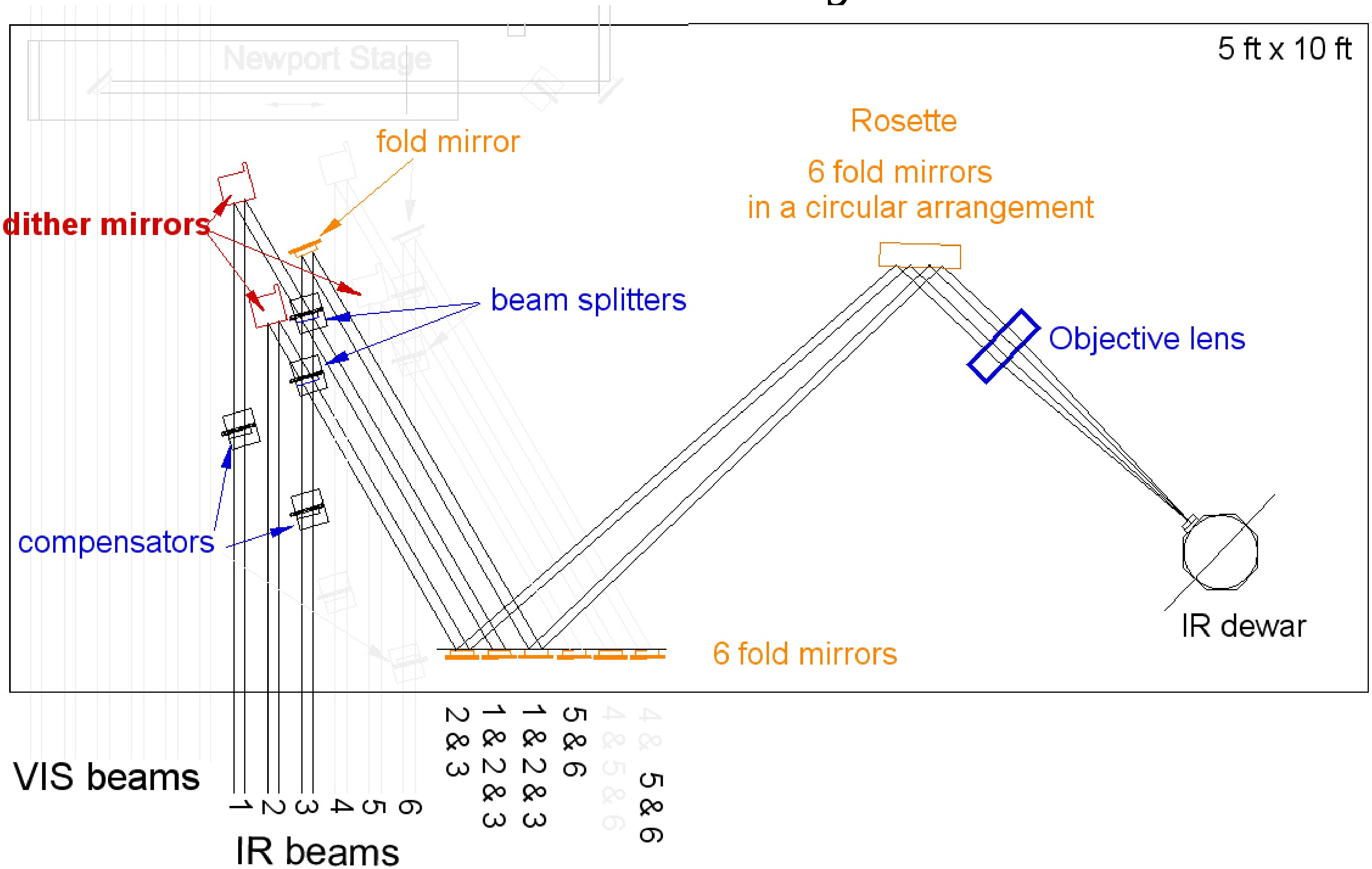


CHARA Classic Layout

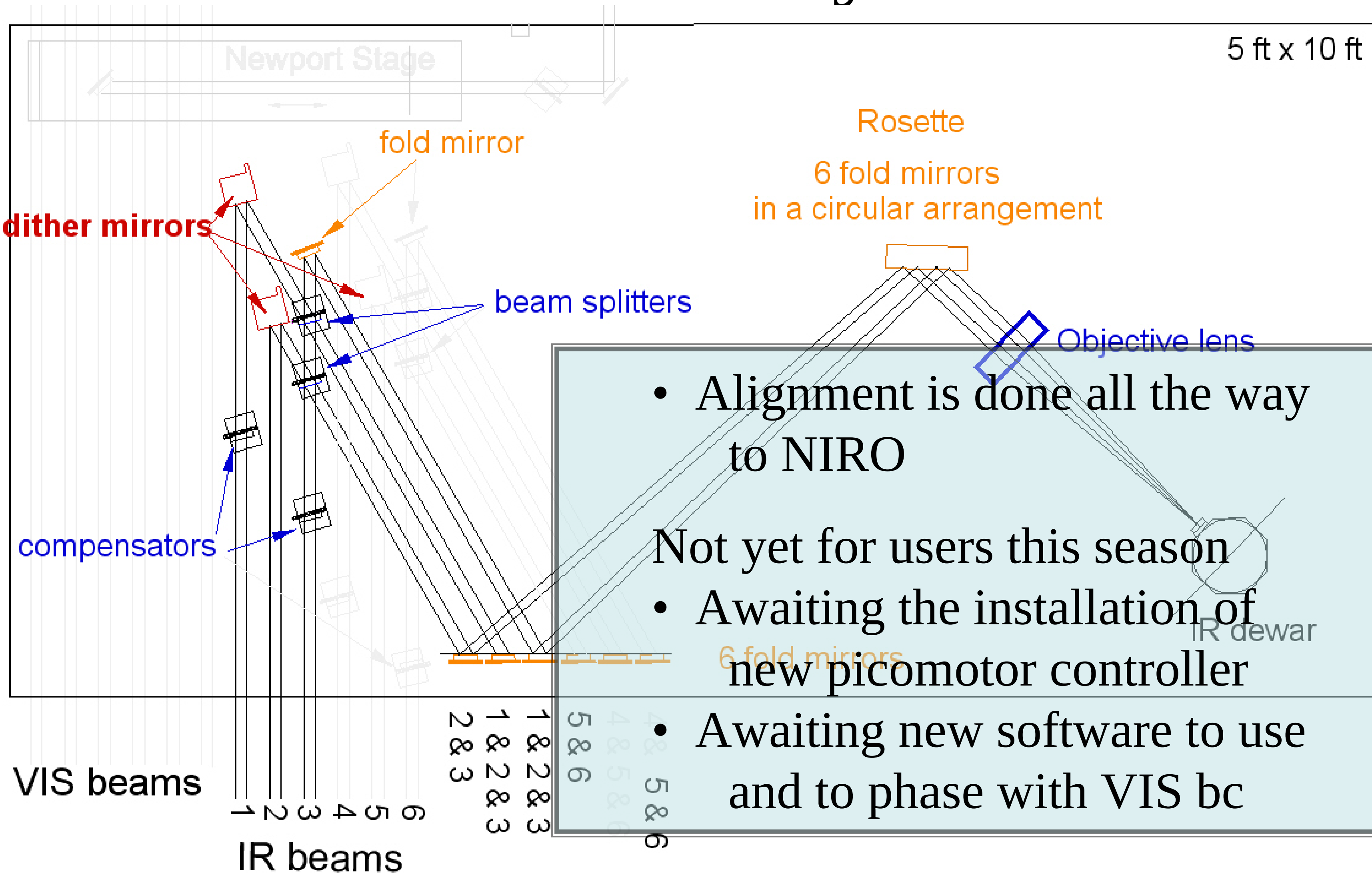


- Alignment is done
- To be phased with VIS combiner, which is the reference for the Astrometric Model

CLIMB Layout



CLIMB Layout

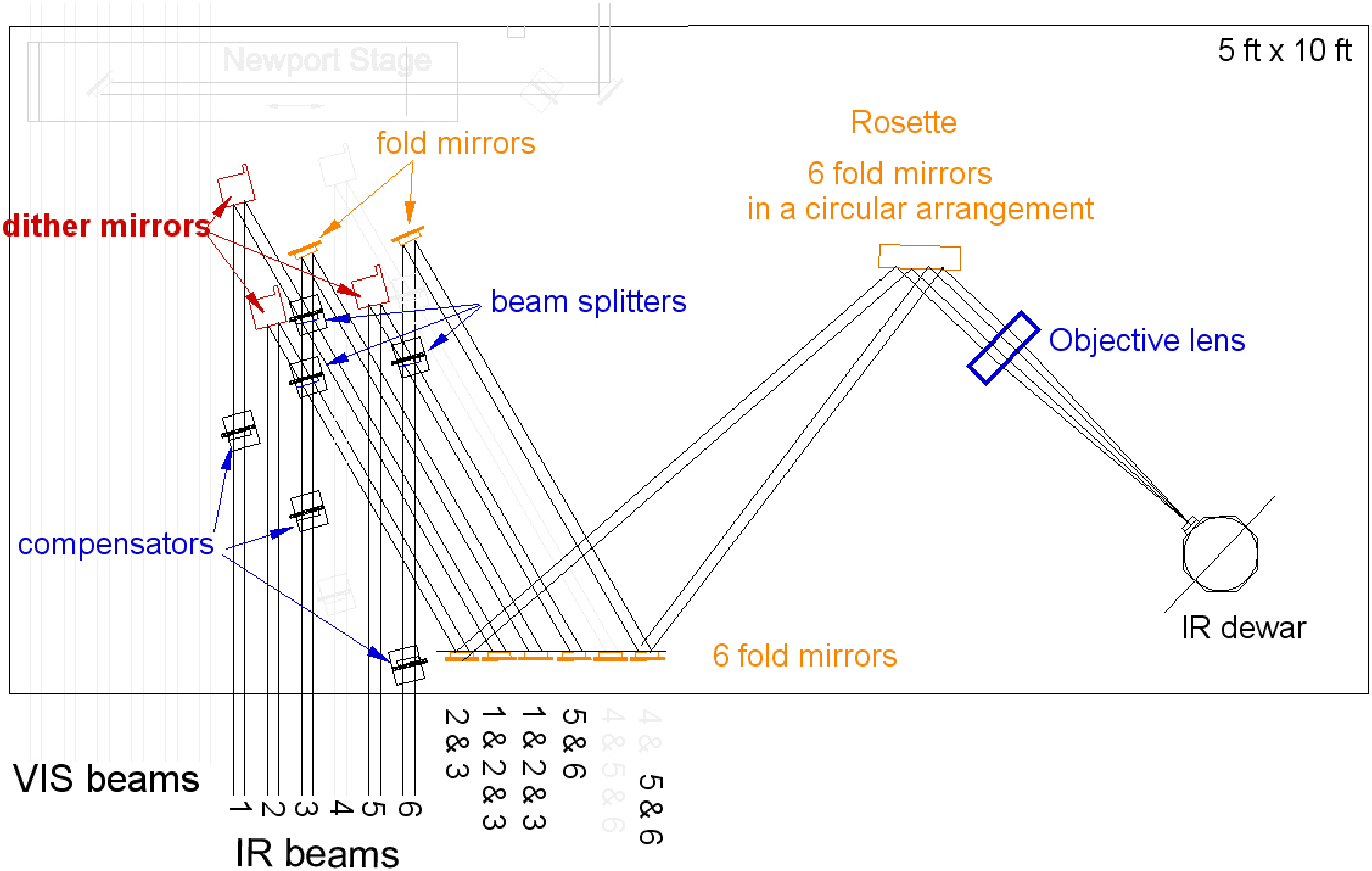


- Alignment is done all the way to NIRO

Not yet for users this season

- Awaiting the installation of new picomotor controller
- Awaiting new software to use and to phase with VIS bc

CLIMB and Classic



CLIMB and Classic

NIRO Optics Design Considerations 1

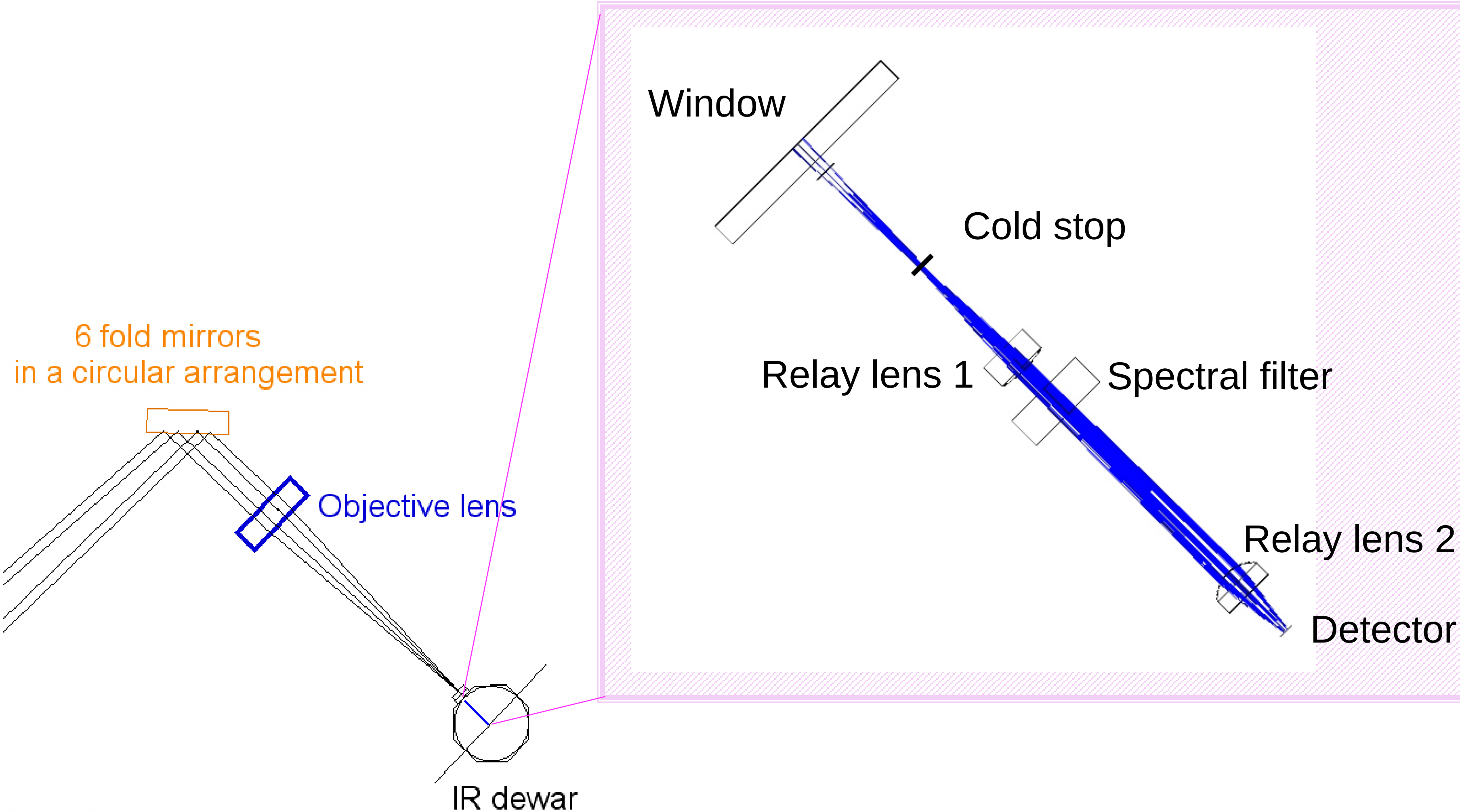
- Input: 6 collimated beams d=19mm
- 6 star images on the detector
  separated by 7-10 pixels
- Each image spot should fit on 1 pixel
- 1 detector pixel (40 μm) is
  0.8 arcsec projected on the sky

NIRO Optics Design Considerations 2

- Working bands J, H, K without much focus adjustments
- Relay optics and spectral filters must fit in the existing dewar (housing our PICNIC array).
- Minimize background with a cold stop

We contracted Arthur H. Vaughan, who considered it all with us. He did the calculations and specified the optics to do exactly those things.

Layout of the Feed Optics

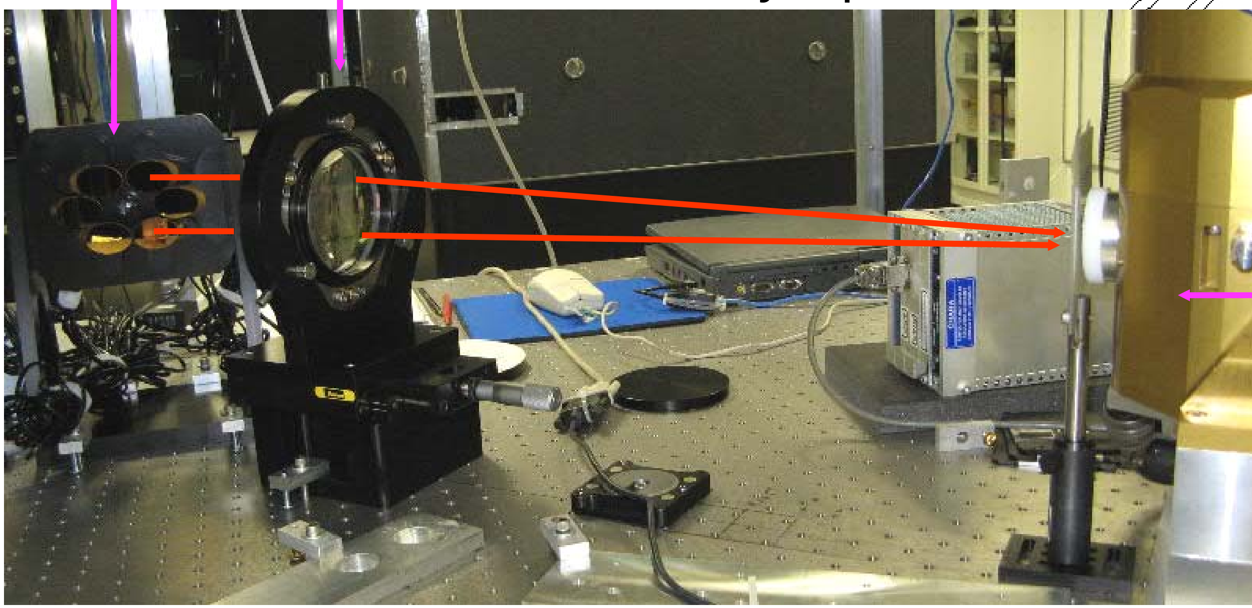


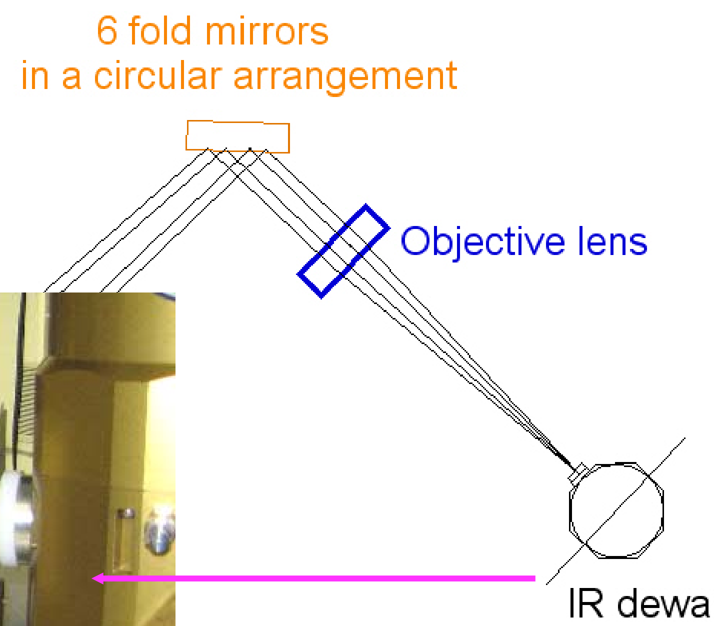
NIRO Optics Outside the Dewar

Objective

Fused Silica – CaF2
air spaced doublet
Fabricated by Optimax

Rosette

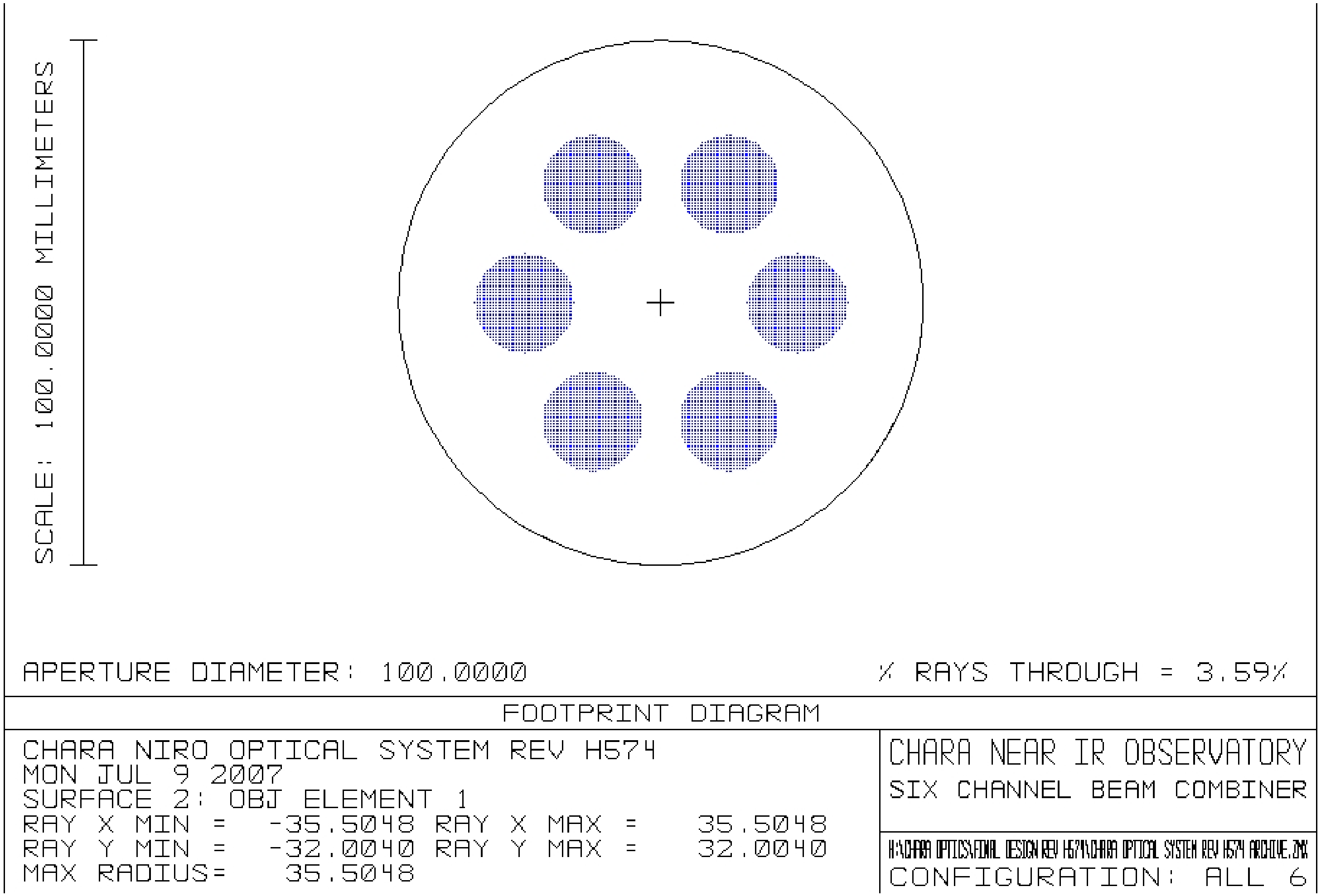




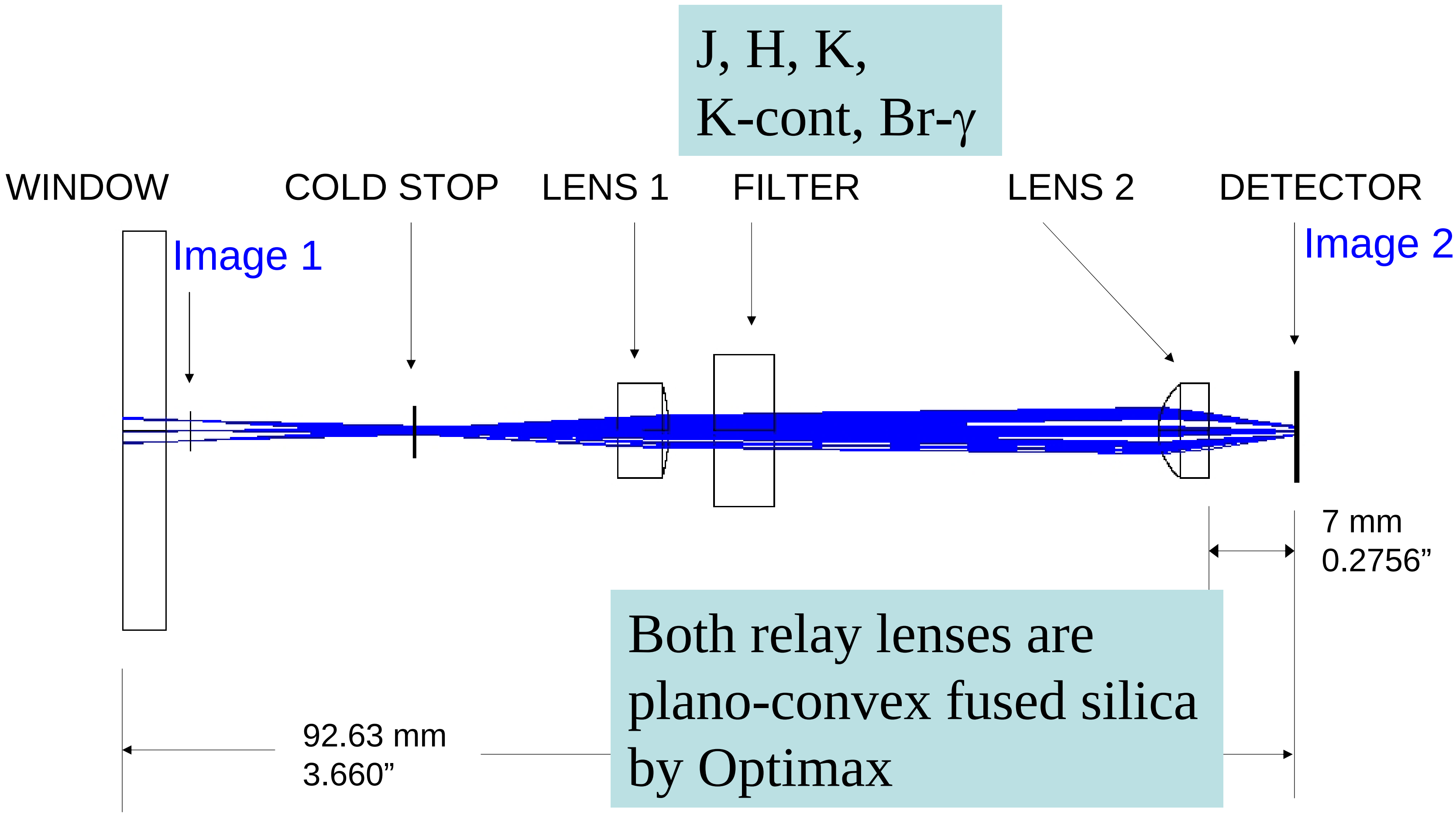
Mounts designed by Laszlo Sturmann
Fabricated in GSU Shop, Charles Hopper

Beam Pattern on Objective Lens

Arthur H. Vaughan July 10, 2007

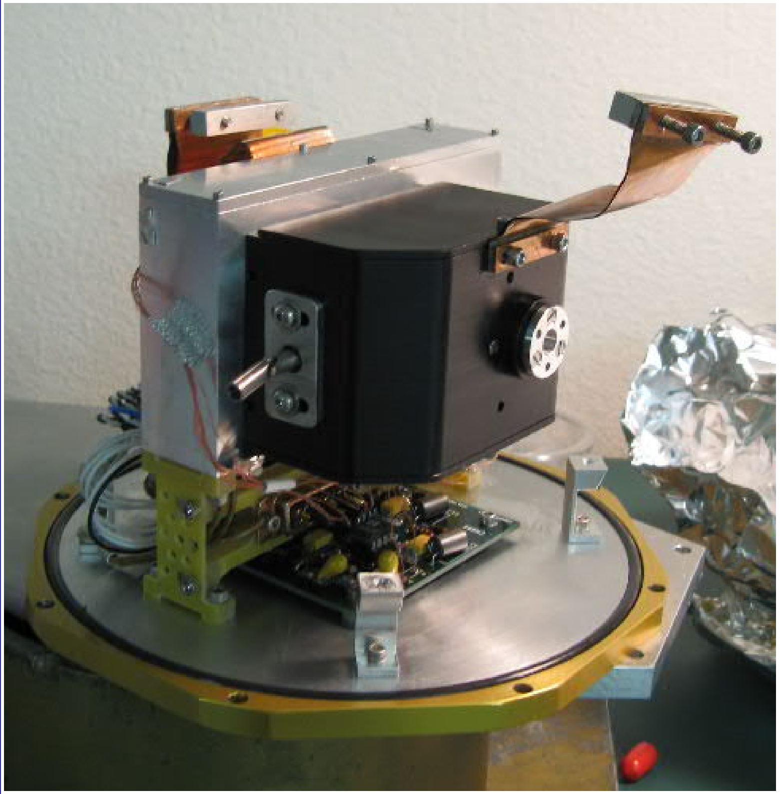


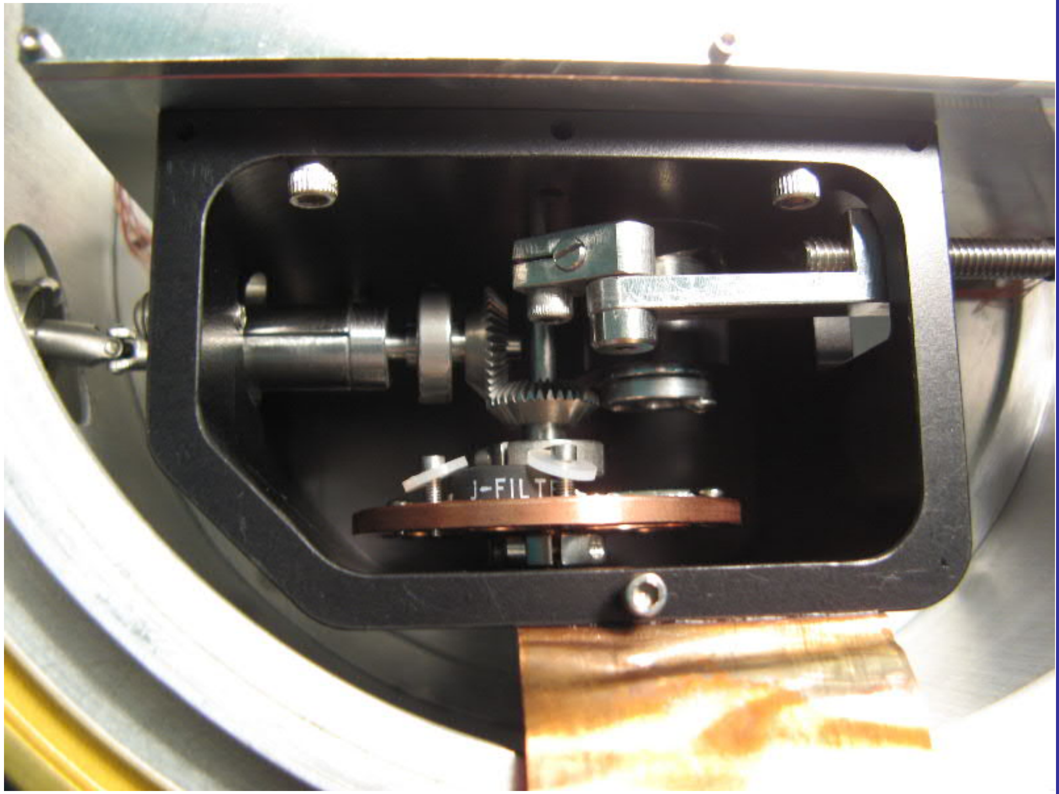
Optical Layout in Dewar



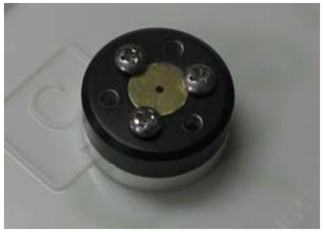
Both relay lenses are plano-convex fused silica by Optimax

Opto Mechanics Inside



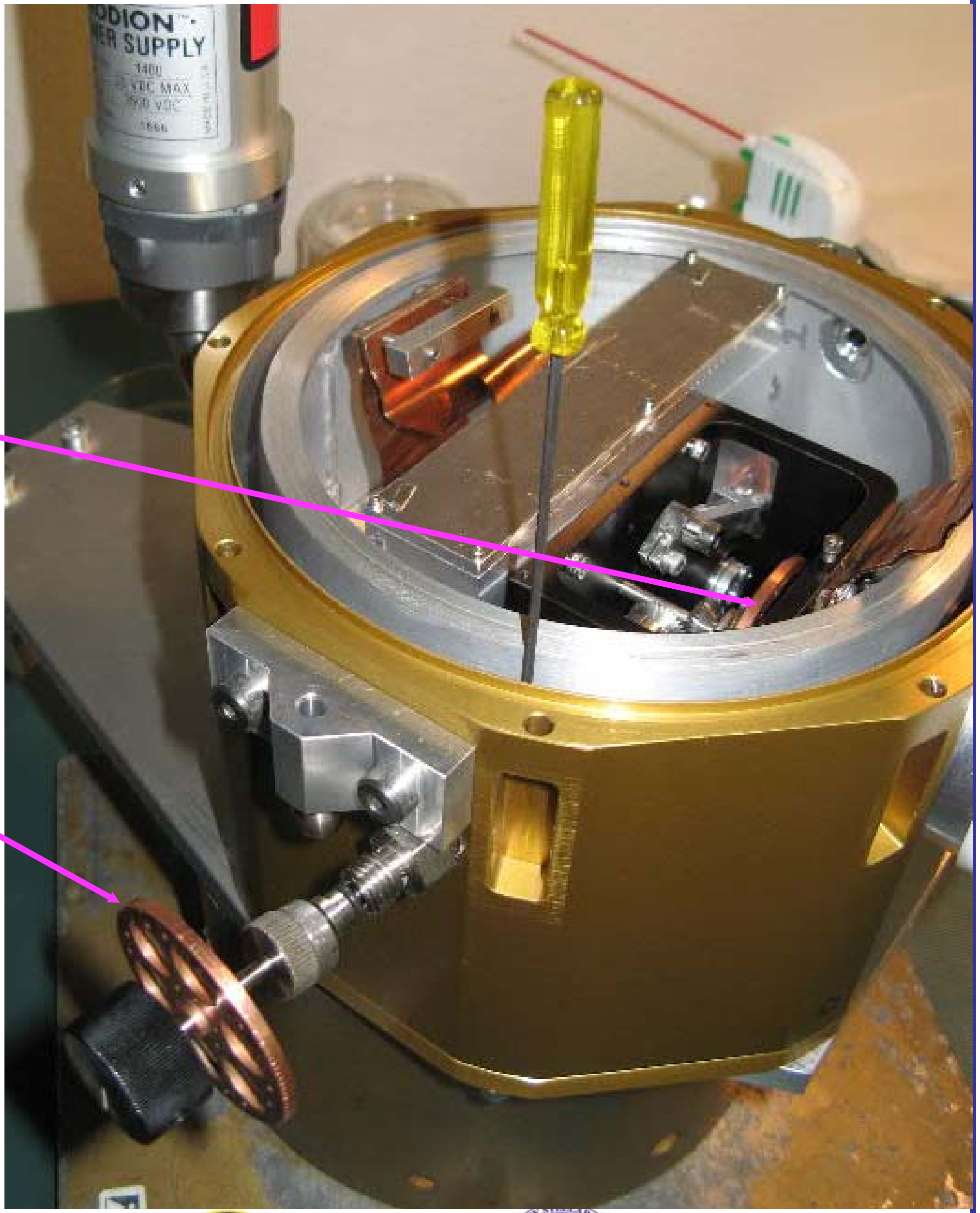


Cold stop
D ~ 1 mm



Mechanical Design by Laszlo Sturmann
Fabricated in GSU shop
and by Laszlo in CHARA shop

The Filter Wheel



The working wheel inside is moving in sync with the wheel outside, which is labeled according to the filters.

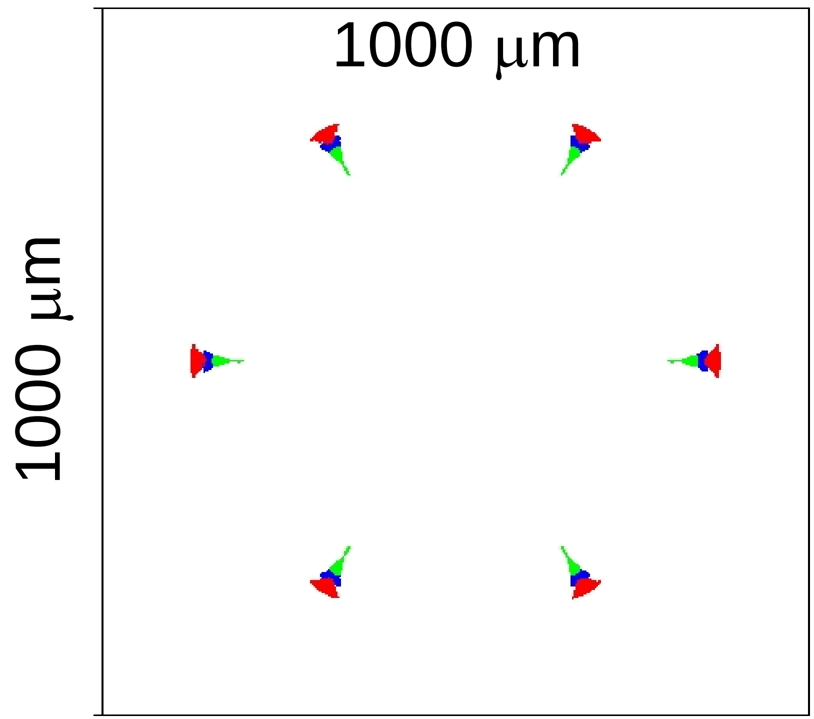
The lower most position on the outside wheel corresponds to the filter in the beam.

Filter change will be motorized later.

Images on the Detector

Arthur H. Vaughan July 10, 2007

OBJ: 0.0468, -0.0819 DEG



WAVELENGTHS IN MICRONS

1.286 GREEN
1.673 BLUE
2.133 RED

IMA: 0.000, -0.001 MM

SURFACE: IMA

SPOT DIAGRAM

CHARA NIRO OPTICAL SYSTEM REV H574
TUE JUL 10 2007 UNITS ARE MICRONS.
FIELD : 1
RMS RADIUS : 352.221
GEO RADIUS : 377.764
BOX WIDTH : 1000 REFERENCE : CENTROID

CHARA NEAR IR OBSERVATORY
SIX CHANNEL BEAM COMBINER

CHARA OPTICAL SYSTEM REV H574 ARCHIVE.ZMX
CONFIGURATION: ALL 6

Synopsis of Image Sizes

Arthur H. Vaughan July 10, 2007

WAVELENGTH		A	B	C
1.286	RMS RADIUS MICRONS	11.27	N/A	10.25
	EE INSIDE 20 MICRONS RADIUS	0.906	N/A	0.959
1.673	RMS RADIUS MICRONS	10.24	10.24	10.24
	EE INSIDE 20 MICRONS RADIUS	0.935	0.946	0.954
2.133	RMS RADIUS MICRONS	12.14	11.33	10.38
	EE INSIDE 20 MICRONS RADIUS	0.912	0.951	0.954

EE MULTIPLIED BY DIFFRACTION LIMIT

A: THREE WL'S OPTIMIZED TOGETHER
B: TWO WL'S OPTIMIZED TOGETHER
C: EACH WL OPTIMIZED SEPARATELY

Practical Conclusions

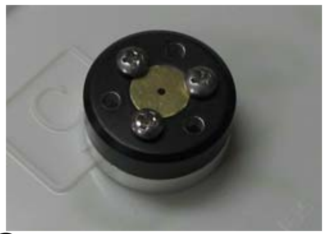
By Arthur Vaughan, based on Zeemax calculations

- Refocusing for different wavelengths will not be necessary.

- Lateral color (see earlier slide) will necessitate re-aiming of the beams to center the images on individual pixels when the wavelength is changed.

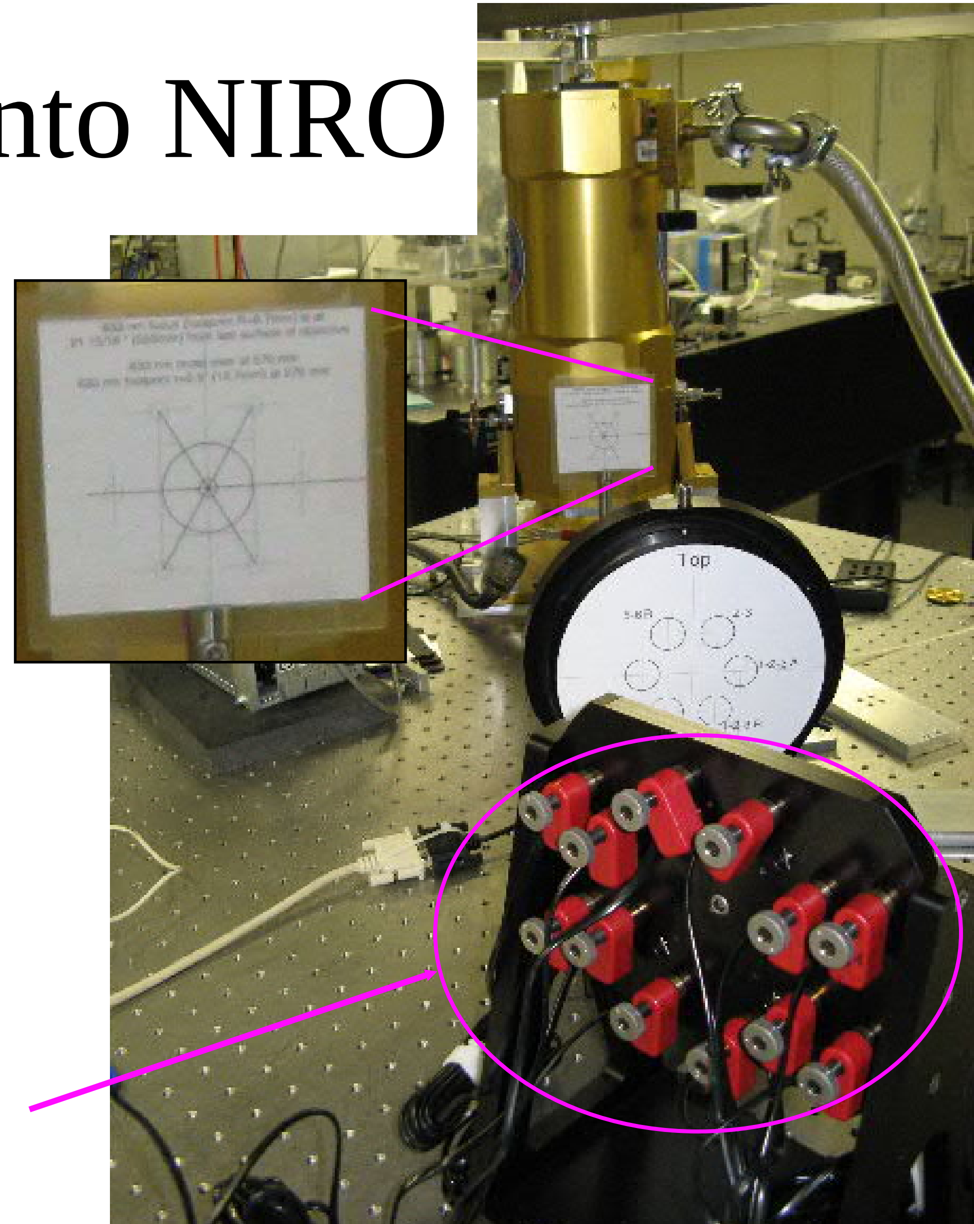
Beam Paths into NIRO

Alignment notes:

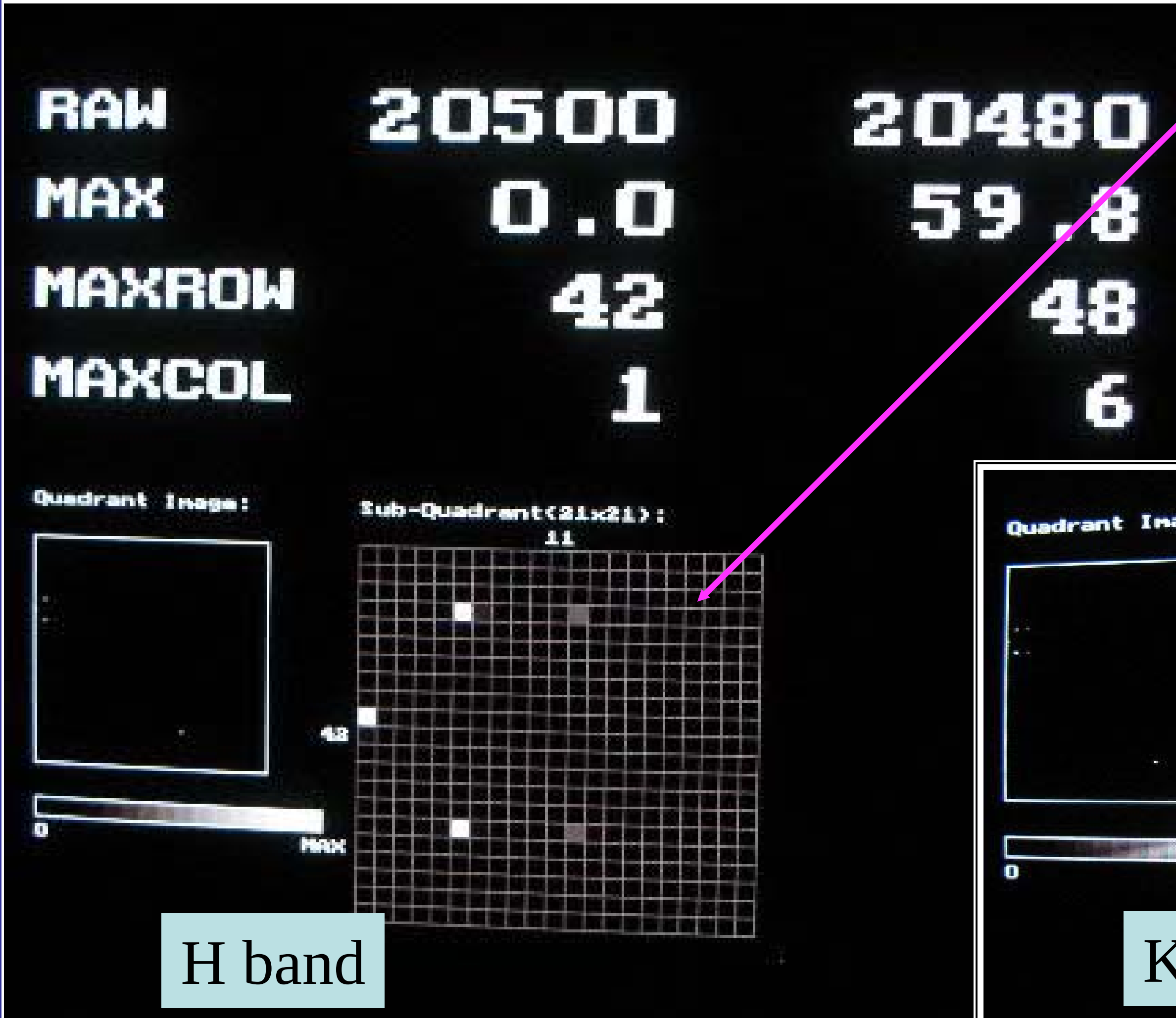


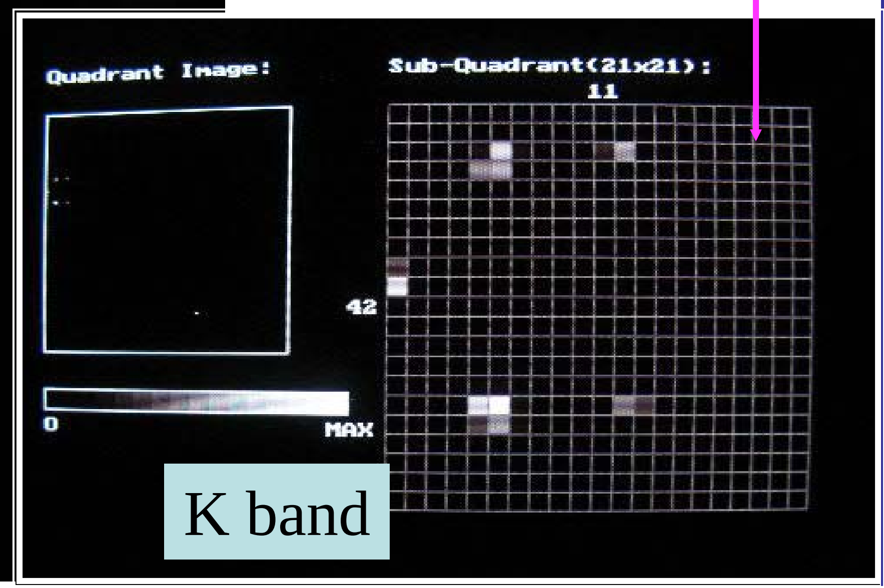
Each HeNe beam has to go through the hole, behind the window.

Re-aiming while watching IR image is possible remotely using picomotors on the rosette.



First Real Spots





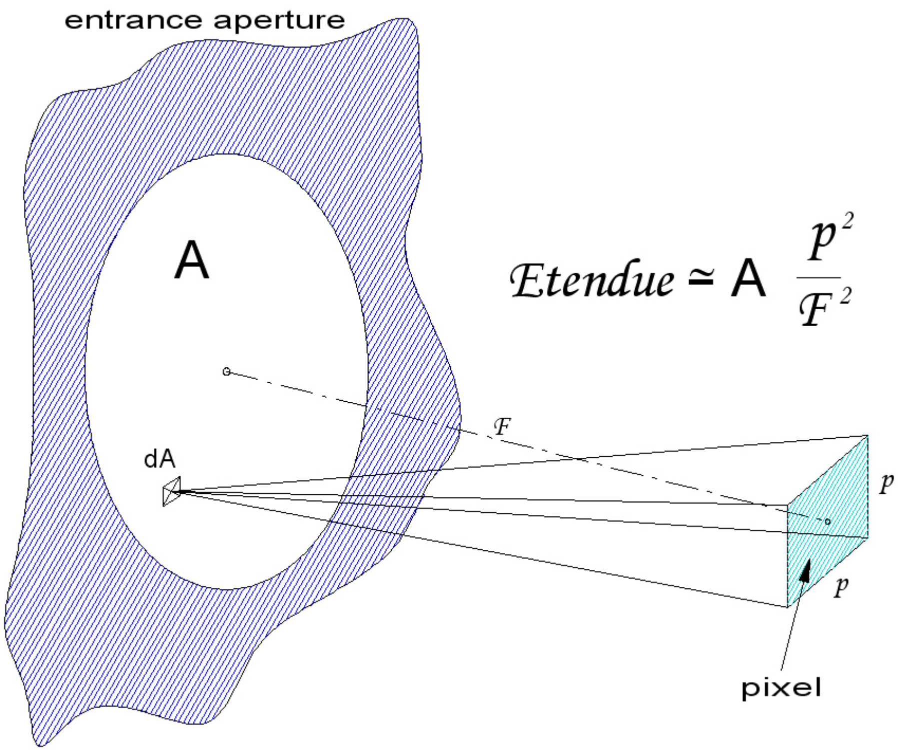
The beams were aimed and focused in H band.

Nothing was adjusted only using K filter here.

Minimizing the Background

The physical quantity to minimize is the product of the aperture size and the solid angle of the pixel seen from the warm aperture.

Etendue **$= \iint dA * \Omega$**



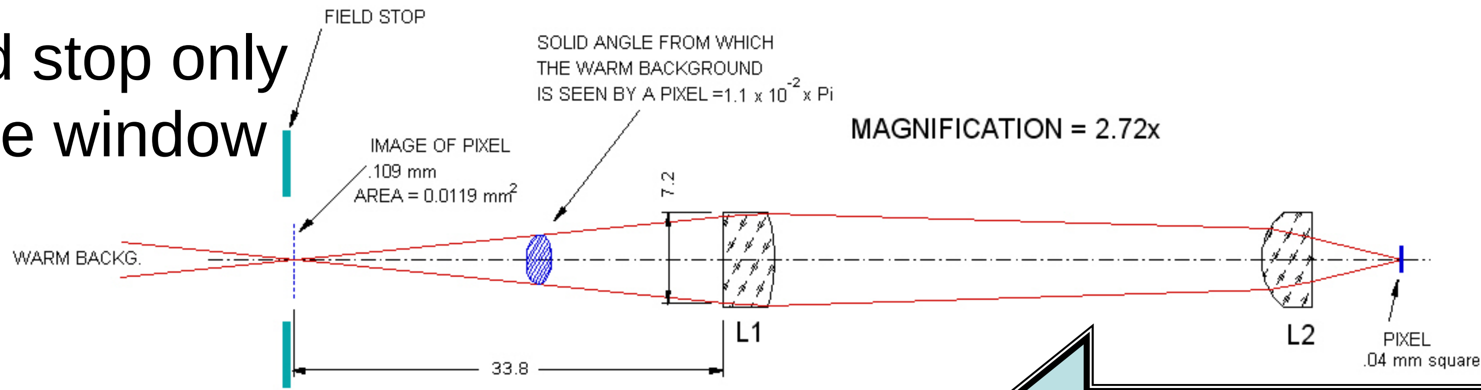
$$\mathcal{E}tendue \simeq A \frac{p^2}{\mathcal{F}^2}$$

NIRO with the OAP

$= 1.1 \times 10^{-4}$ mm^2

Minimizing the Background

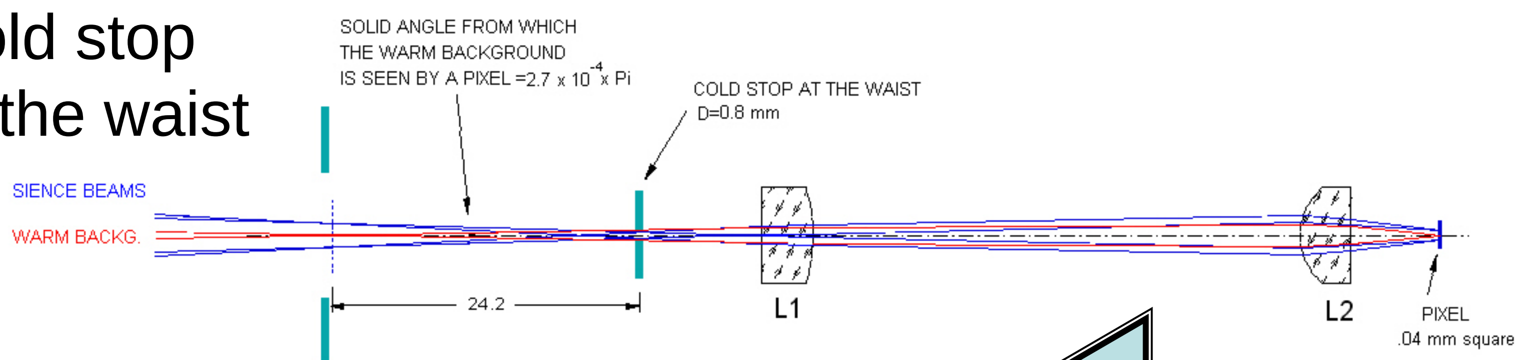
Field stop only
at the window



ETENDUE = 4.1 x 10^{-4} mm^2
WITHOUT COLD STOP

Worse than before

Cold stop
at the waist



ETENDUE = 1 x 10^{-5} mm^2
WITH COLD STOP

1 order of magnitude better

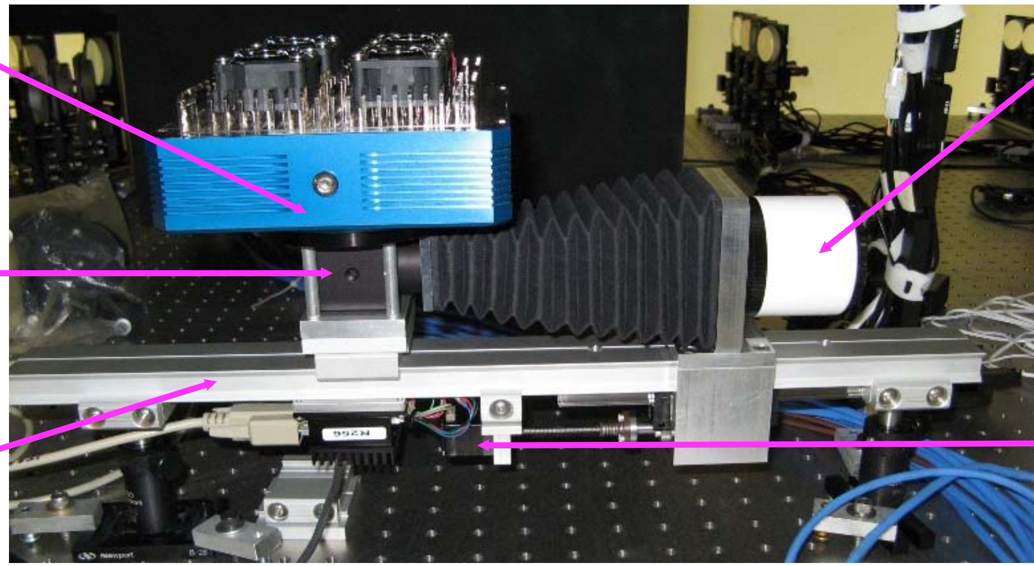
Georgia State University · NSF · NOAO · l'Observatoire de Paris · LESIA · The University of Michigan · NExScI NASA Exoplanet Science Institute · SUSI · Observatoire de la Côte d'Azur

White Light Source Test With the Small-beam Tester

CCD camera

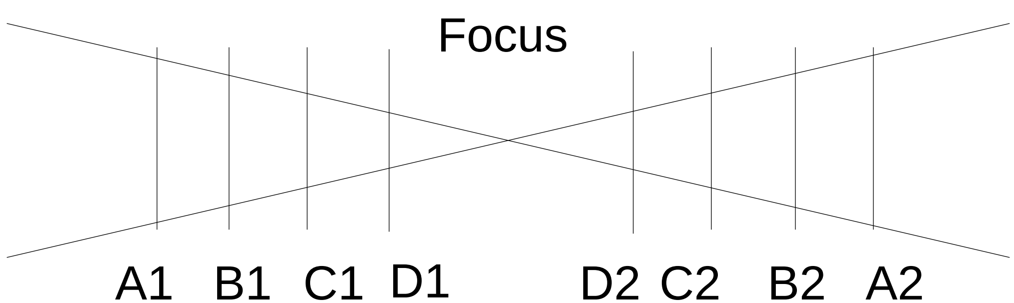
Beam splitter cube

Optical rail



Borg 50 mm F/5 acromat

Micro stepper, better than 10 μm resolution

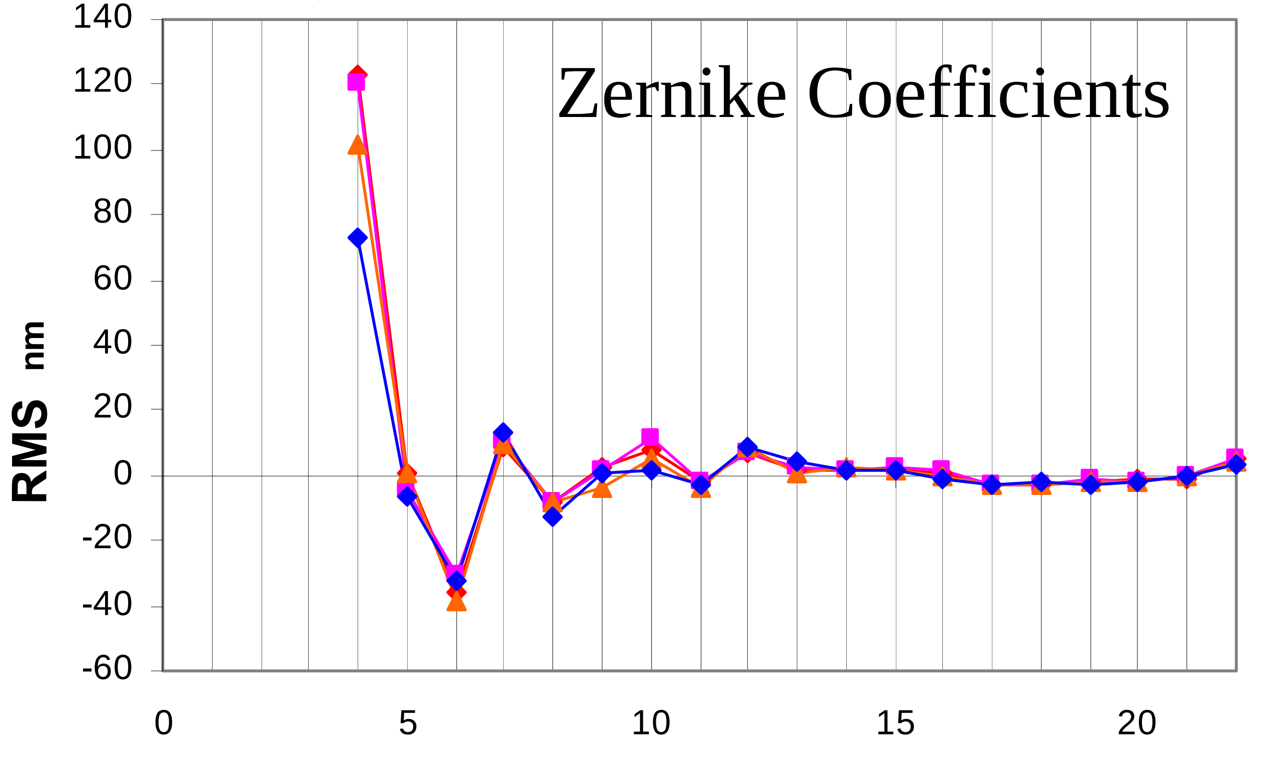


Results of White Light Beam Tests

Data reduced with “ef” wavefront reduction package

by Laplacian Optics Inc.

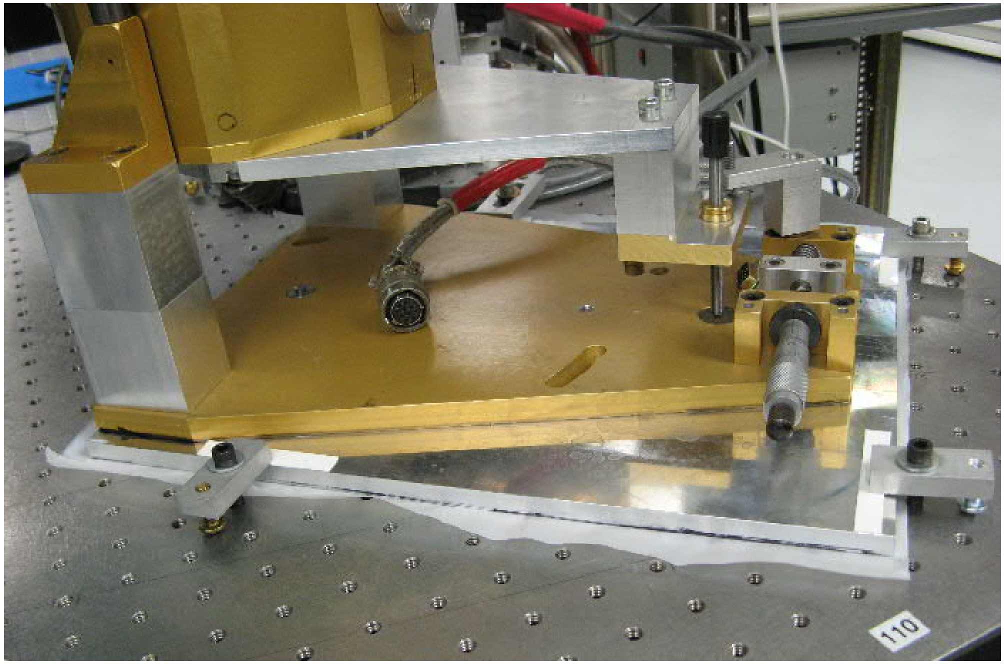
Focus was tested separately with auto collimated scope



4	focus
5	astigmatism (sin)
6	astigmatism (cos
7	coma (sin)
8	coma (cos)
9	trefoil (sin)
10	trefoil (cos)
11	spherical
12	sph astig (cos)
13	sph astig (sin)
14	quad astig (cos)
15	quad astig (sin)
16	r^5 cos(1)
17	r^5 sin(1)
18	r^5 cos(3)
19	r^5 sin(3)
20	r^5 cos(5)

NIRO Insulated

A teflon sheet and plastic shim stock is used to electrically insulate the dewar from the optical table.



Insulation improved FLUOR and MIRC cameras.

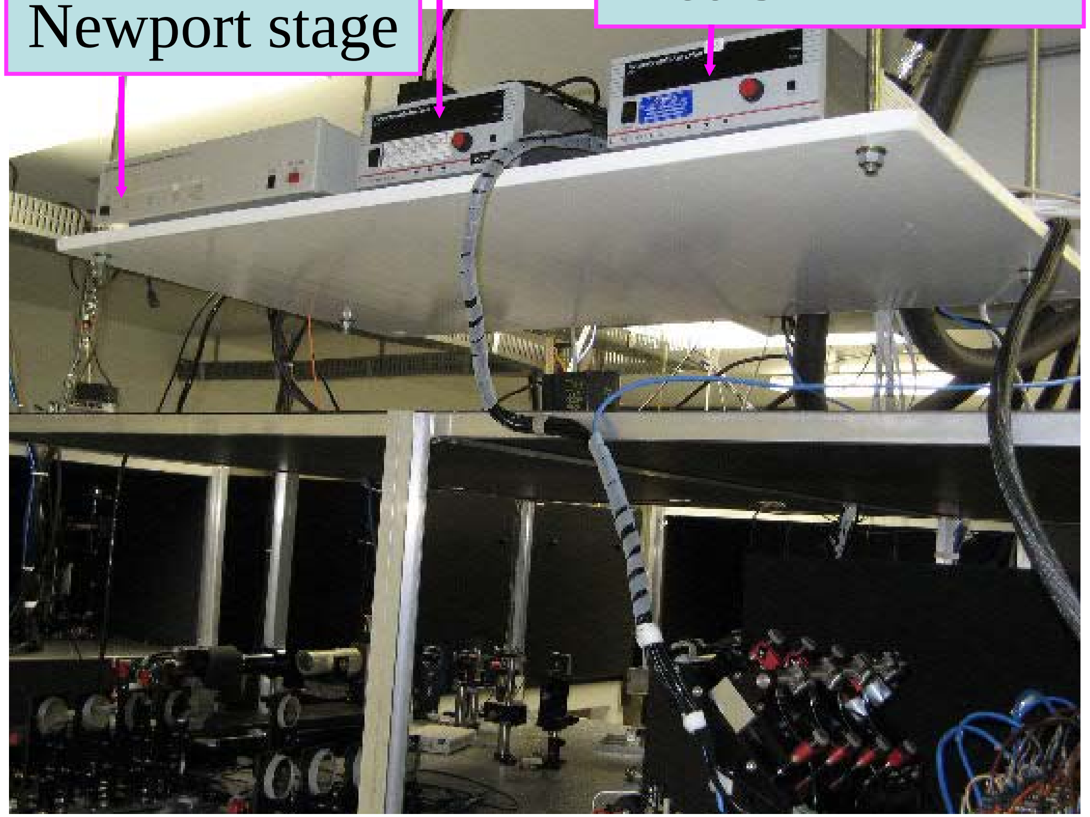
Tests need to be done to characterize current noise level and compare with previous tests on NIRO.

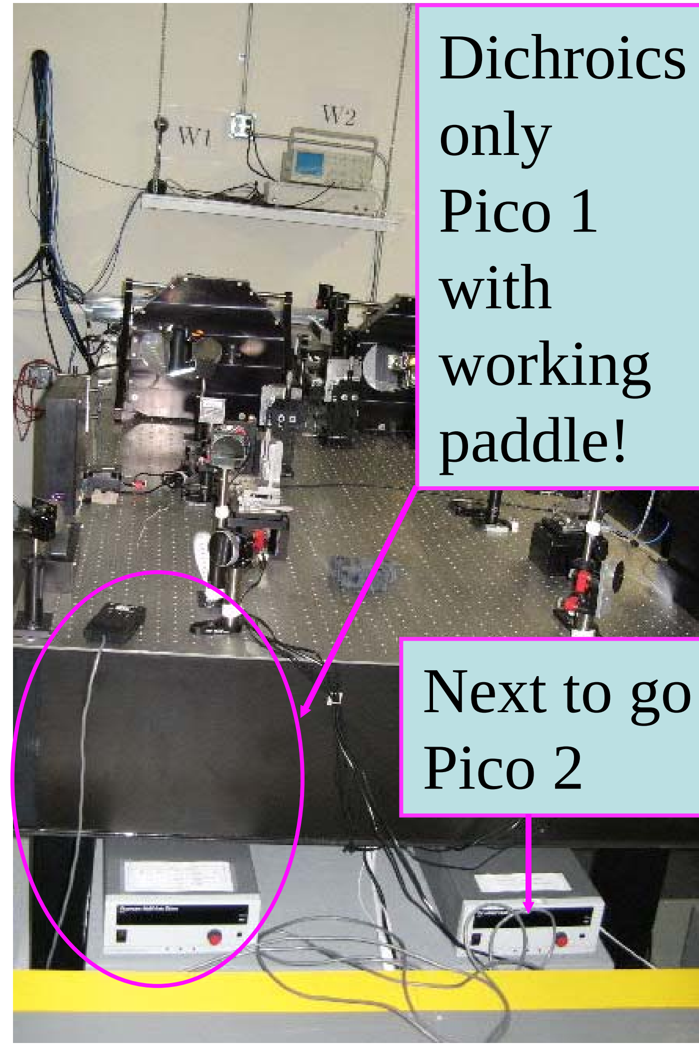
Controllers With Fans Moved

VIS beams
Newport stage

VEGA
Pico 6

VIS BC, Tip/tilt,
Classic IRBC
Pico 3





Dichroics only
Pico 1 with working paddle!

Next to go
Pico 2

Recap

- Classic Infrared Multiple Beamcombiner (CLIMB)
- New optics for the IR camera, NIRO
- White light source wave front test result
- Steps taken against noises: electrical, lab seeing, vibrations

- Coming soon: - variable aperture for IR beams

Design is ready, most hardware at hand

- alternative set of tip-tilt splitters

Denis Mourard:
"I have received the 6 new beam splitters (90%->VEGA, 10%-> TT) and they look pretty nice with a good behavior of the coating over 450-850nm."