ILS and alignment revisited

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with very significant inputs from
John Robinson (Lauder)
Frank Hase (KIT)
Graham Kettlewell (UoW)

UNIVERSITY OF WOLLONGONG

IFS125 FT spectrometer

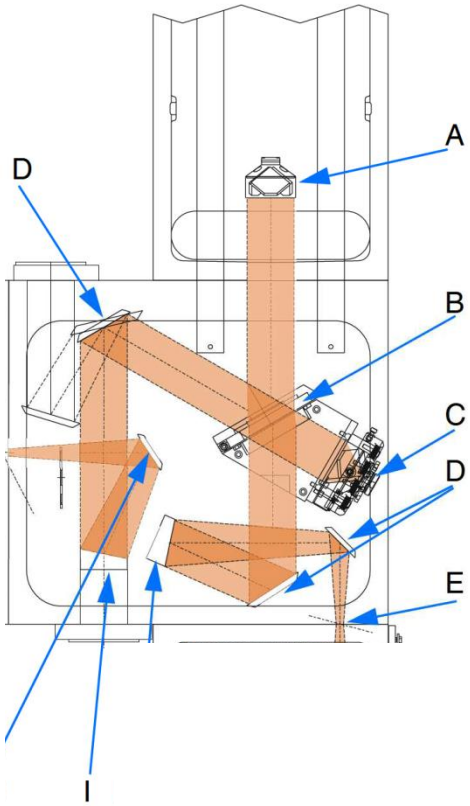
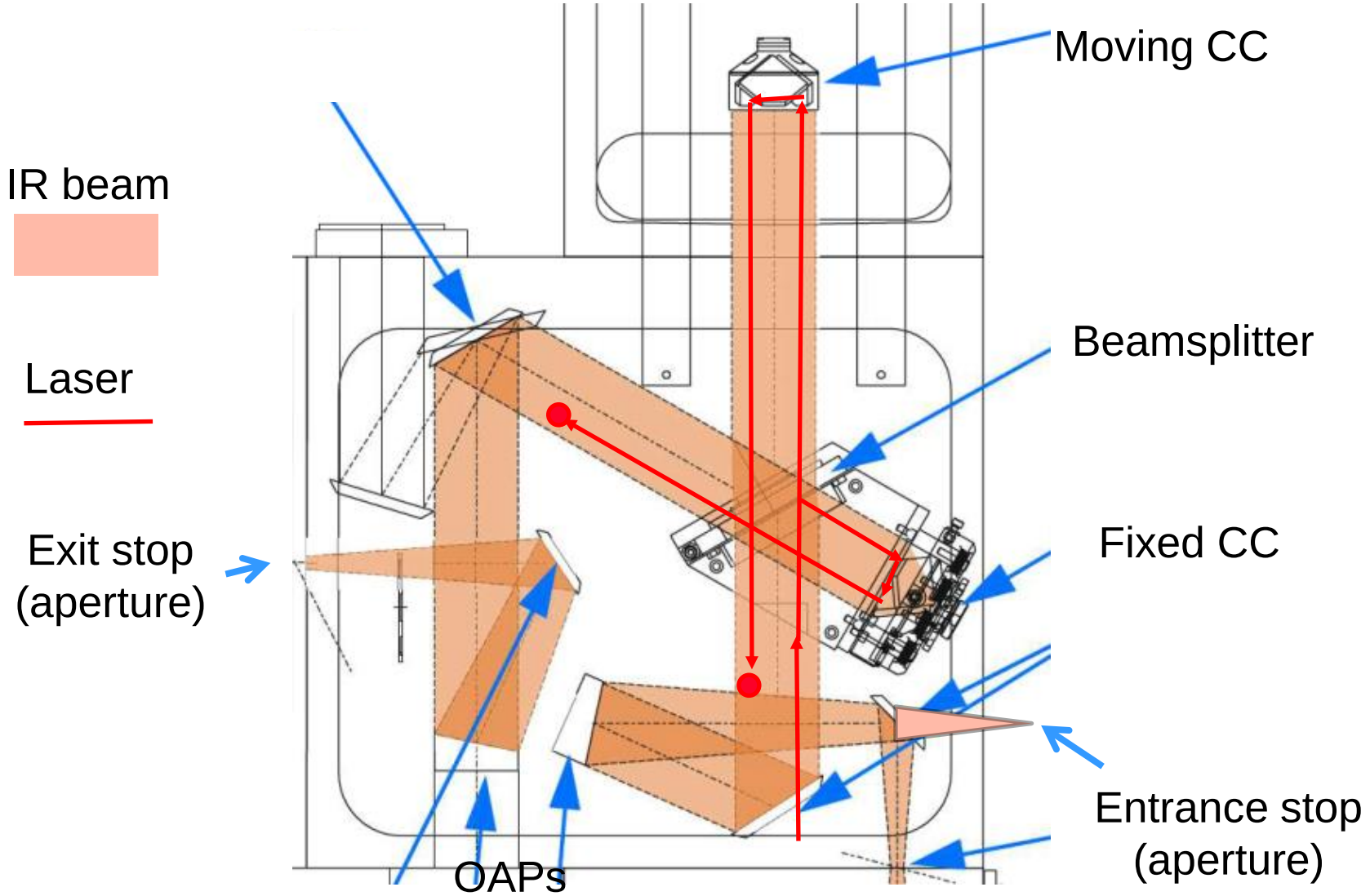


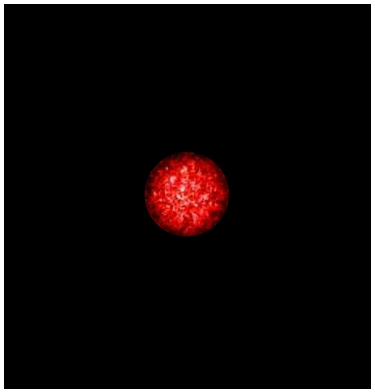
Figure 20: IFS 125 HR - Optical path

IFS125 interferometer

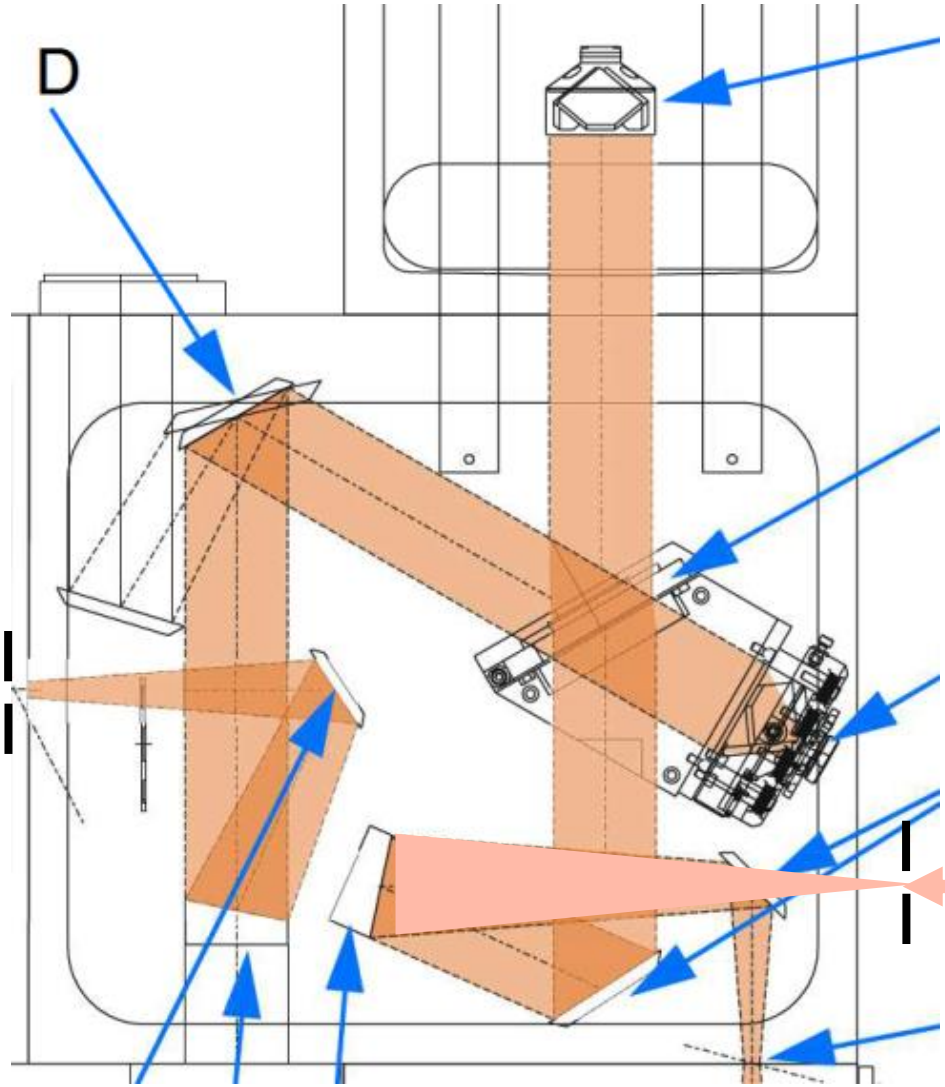


The IR beam path

Haidinger fringes at exit



4mm



Beam-expanded HeNe laser at input aperture

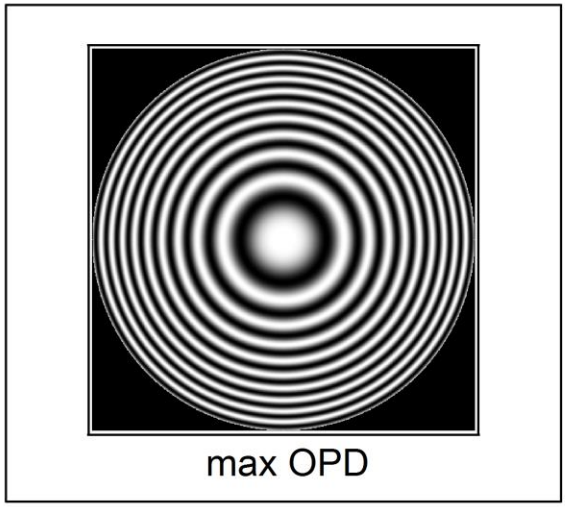
HeNe

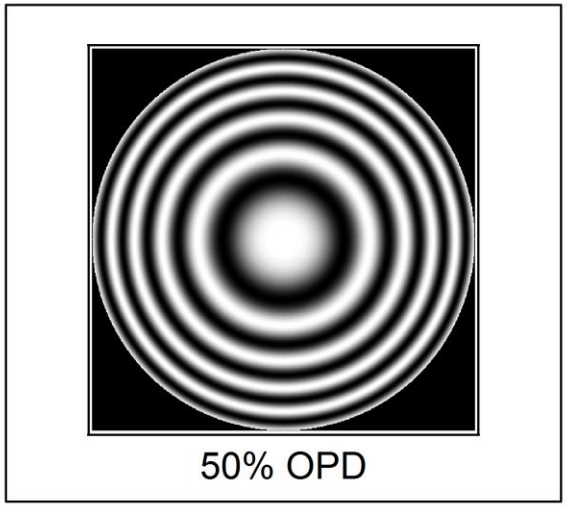
Some important points

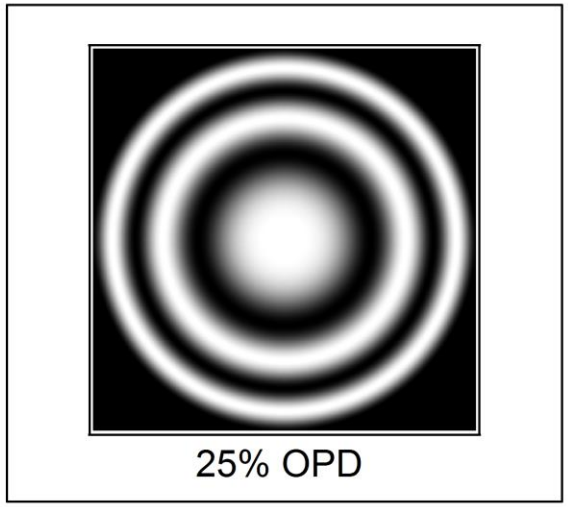
- The IR and laser alignment are independent of eachother
  - There are no shared adjustments
- Laser affects wavenumber scale, does not affect ILS
- IR alignment affects the ILS
- There are two alignment methods on the wiki

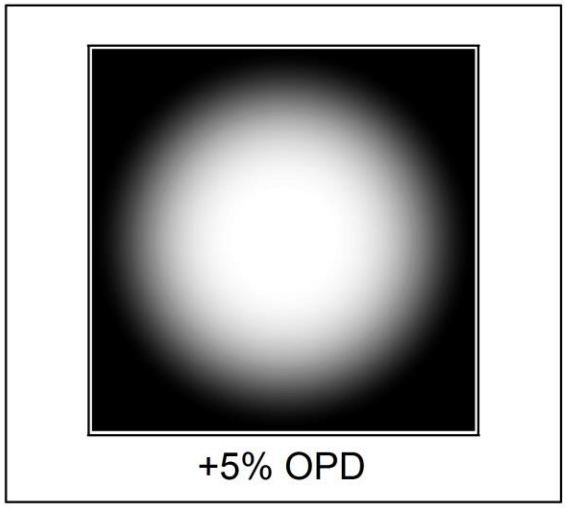
1. Caltech/JPL method (Blavier, Washenfelder, Wunch)
   1. Align the laser for max modulation (=> on interferometer axis)
   2. Locate IR axis (input & exit apertures) on the laser axis
   3. Iteratively adjust the apertures and fixed CC for best ILS
2. Karlsruhe method (Hase, Blumenstock)
   1. Align IR axis (ie apertures) to centre on the Haidinger fringes at large OPD
   2. Align fixed corner cube to centre fringes near ZPD
   3. Align laser for either max modulation or centre on IR axis

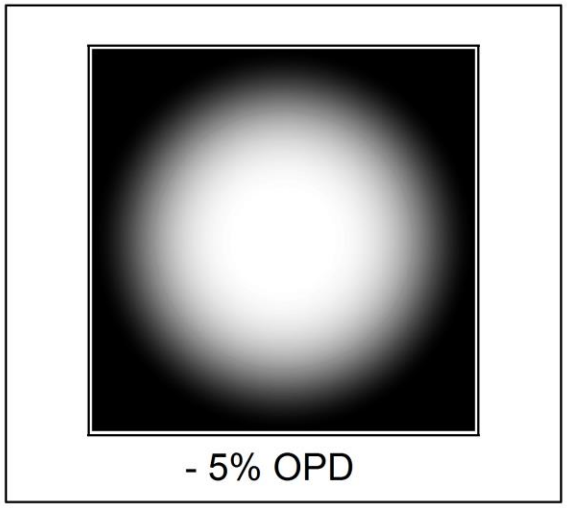
Align 5.4 Perfect alignment



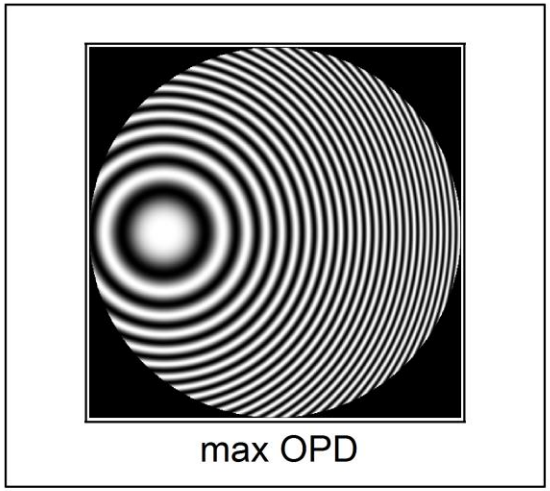


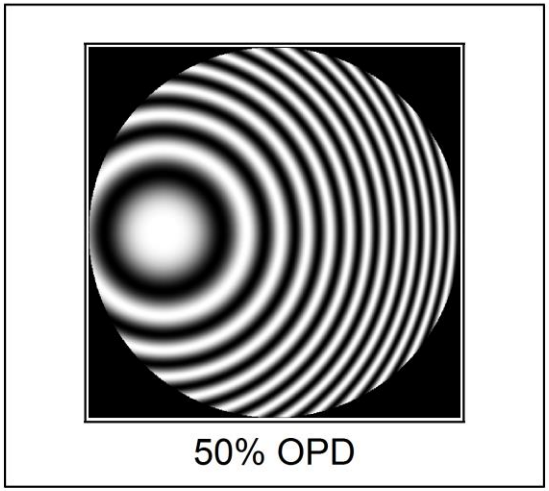


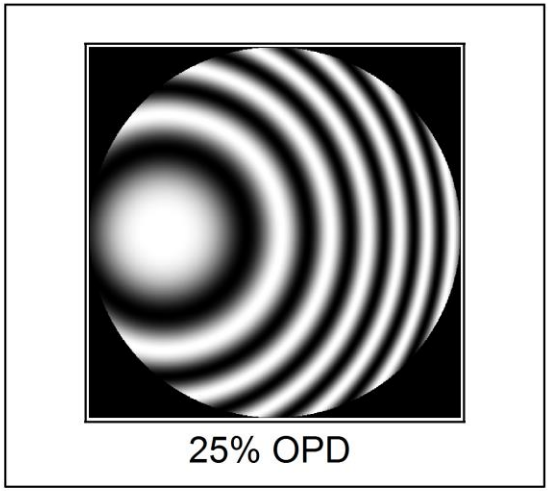


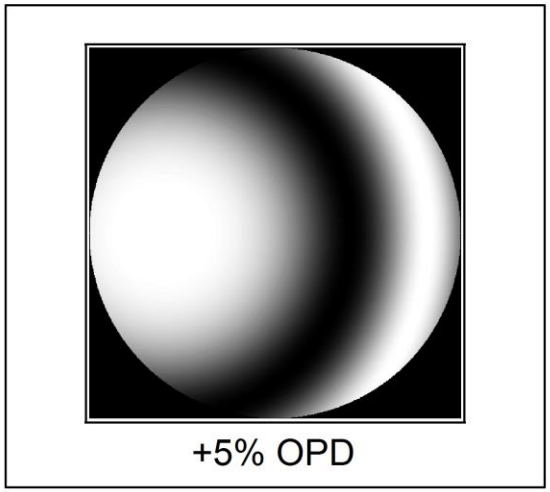


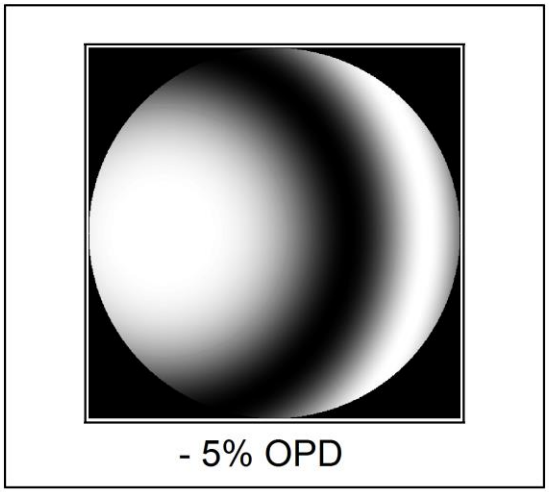
FOV 3mrad off axis



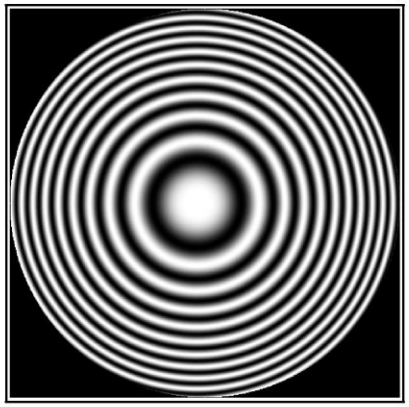




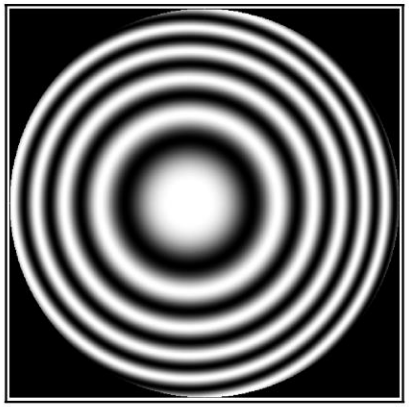




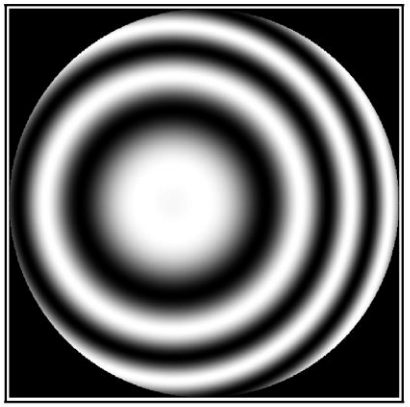
Fixed CC shear 0.05mm



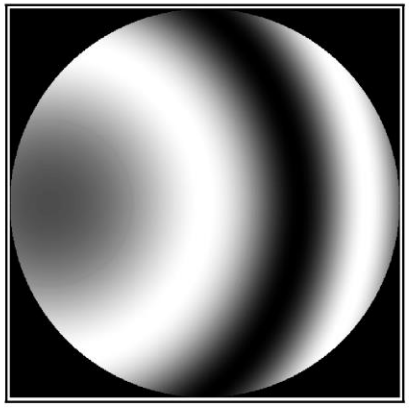
max OPD



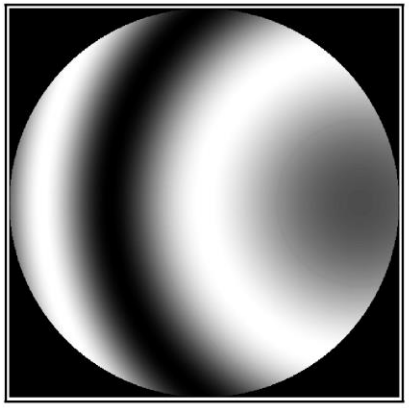
50% OPD



25% OPD



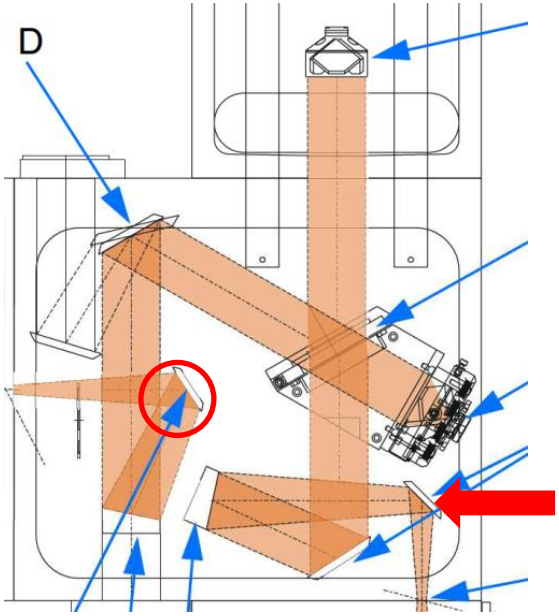
+5% OPD

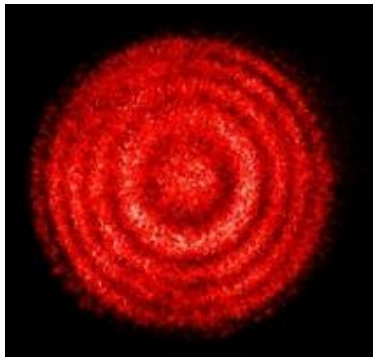


- 5% OPD

Align the IR 1: fringes

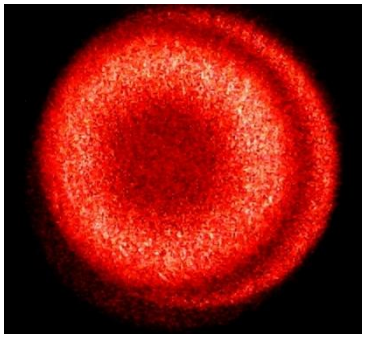
- Illuminate entrance stop with beam expanded HeNe laser
  - Vellum on aperture to diffuse beam
- Fold exit beam upwards and view image at exit stop focus with eyepiece or USB microscope
  - Alternative: remove exit OAP and view through external telescope
- Observe fringes and image of entrance stop while adjusting entrance stop position at mid – long OPD
- Observe fringes around ZPD while adjusting fixed CC position



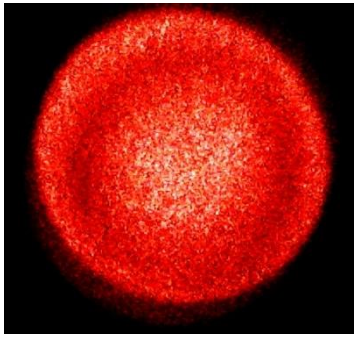


Viewing fringes

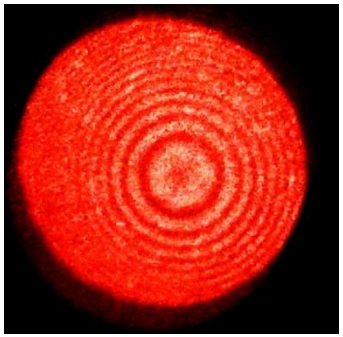
Small OPD: shear offset



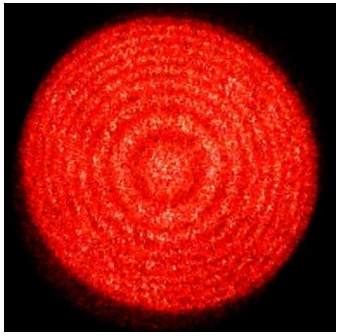
aligned



50 cm OPD: FOV offset

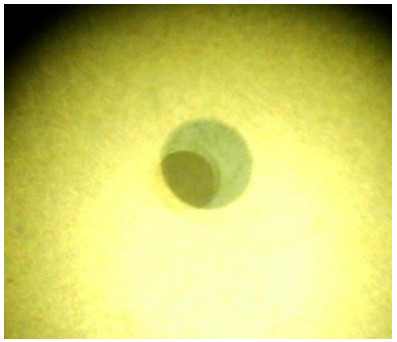


aligned



Align the IR 2: exit stop

- Mount a telescope in the scanner arm and view the entrance and exit stops
  - First focus it to infinity => focuses parallel beam
- Adjust exit stop to centre on the entrance stop
  - It is normally one setting larger
- After laser alignment, can also check alignment of laser relative to stops



Misaligned

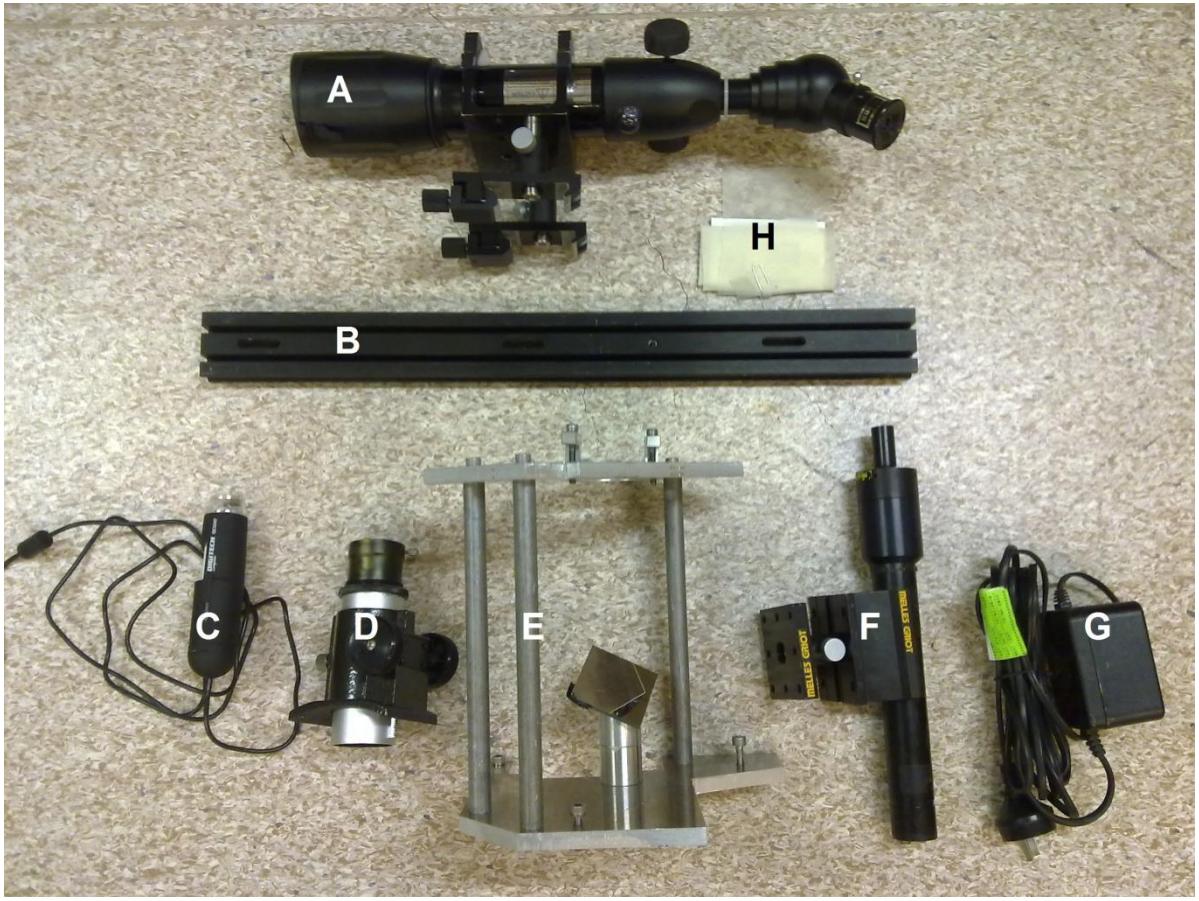
Co-aligned, with laser

Align the laser

- Make laser path parallel to the interferometer axis
  - Adjust input mirrors/prisms, and detector collection OAP
- Two methods

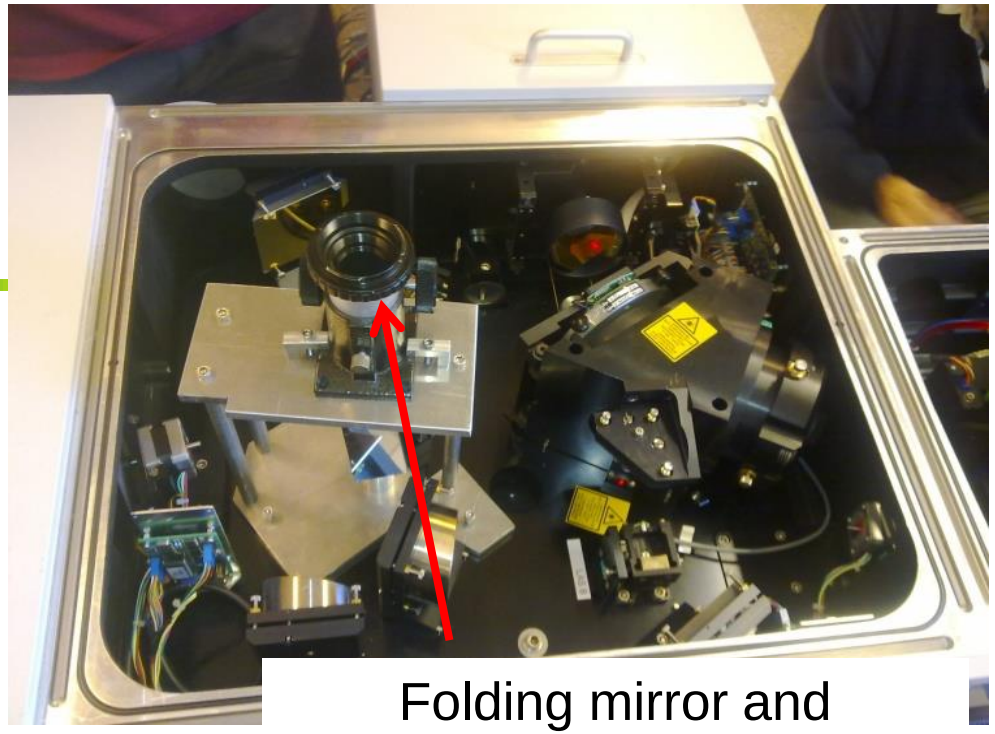
1. Maximise modulation (laser interferogram) at max OPD
2. Coalign to the IR beam after IR alignment
   - Via Haidinger fringes or apertures.

Equipment

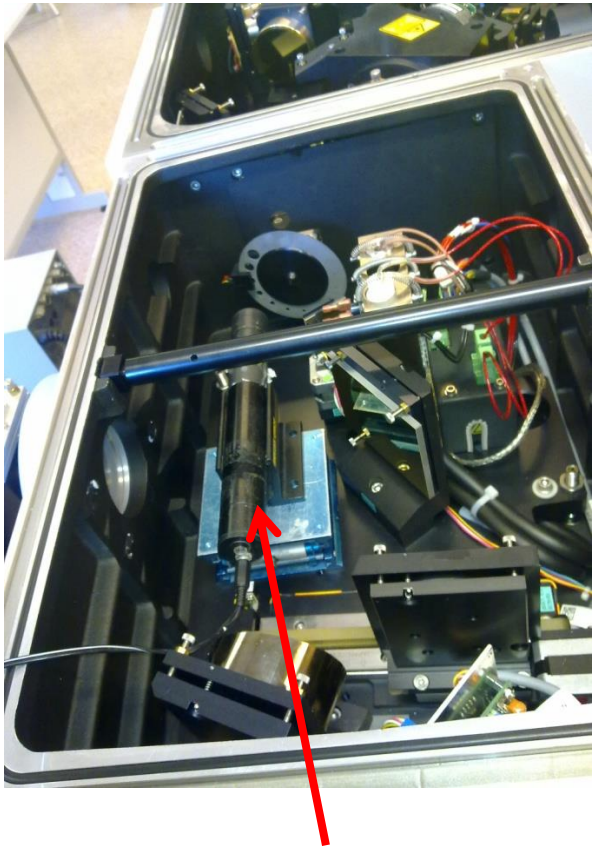


A. Telescope and improvised holder
B. Rail to hold the telescope above the scanner arm of the IFS-125
C. USB microscope
D. Periscope eyepiece
E. Periscope mount and flat reflecting mirror
F. HeNe laser with beam expander and mount
G. HeNe Laser power supply
H. Vellum and paper for blocking laser beams

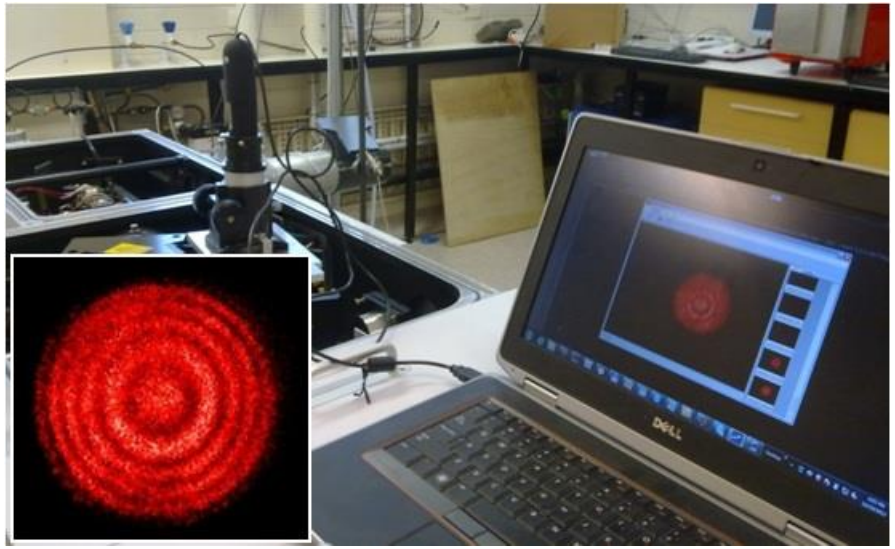
Laser and fringe viewer



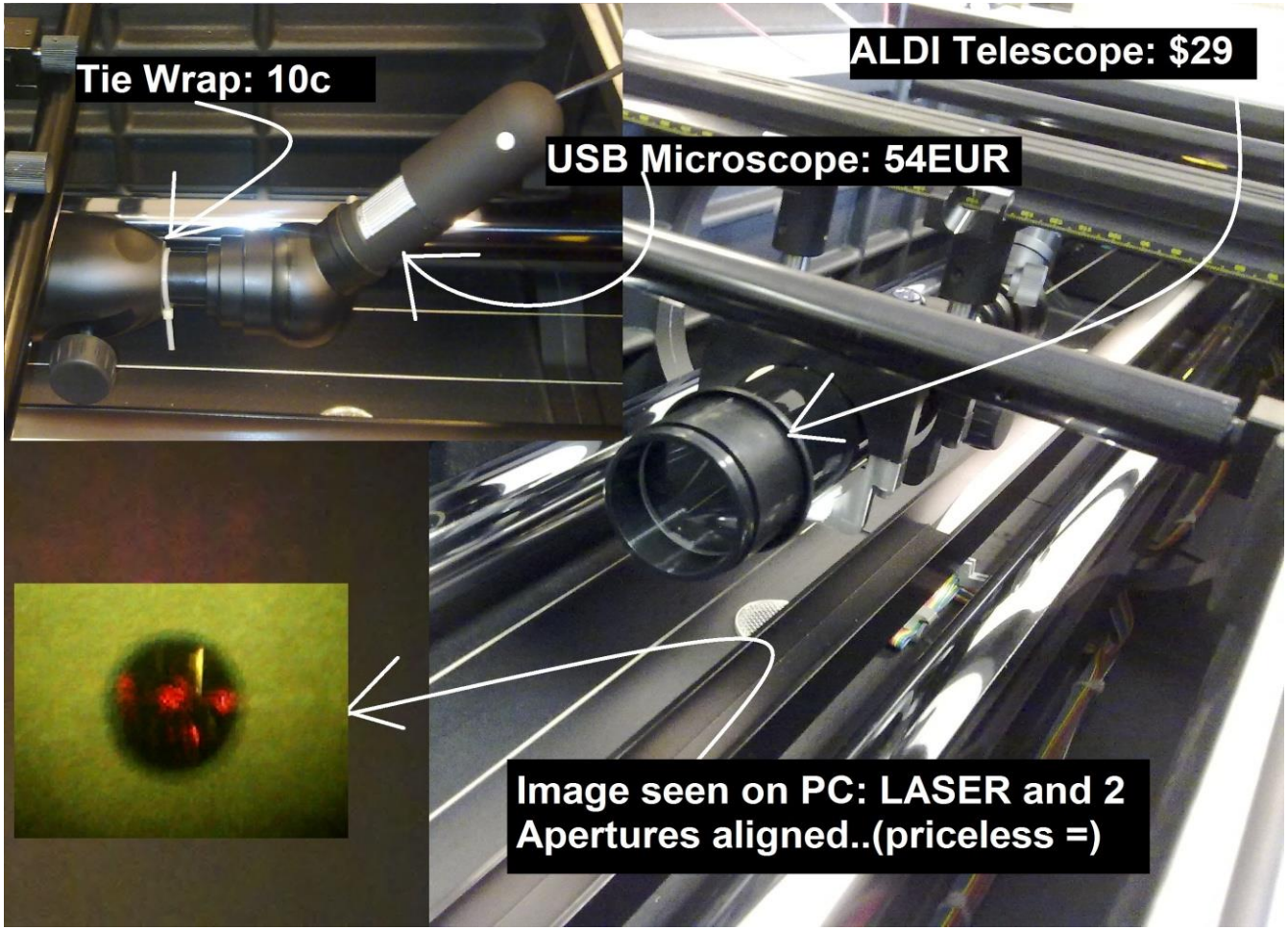
Folding mirror and eyepiece/microscope holer



HeNe laser



Telescope mounted in scanner arm

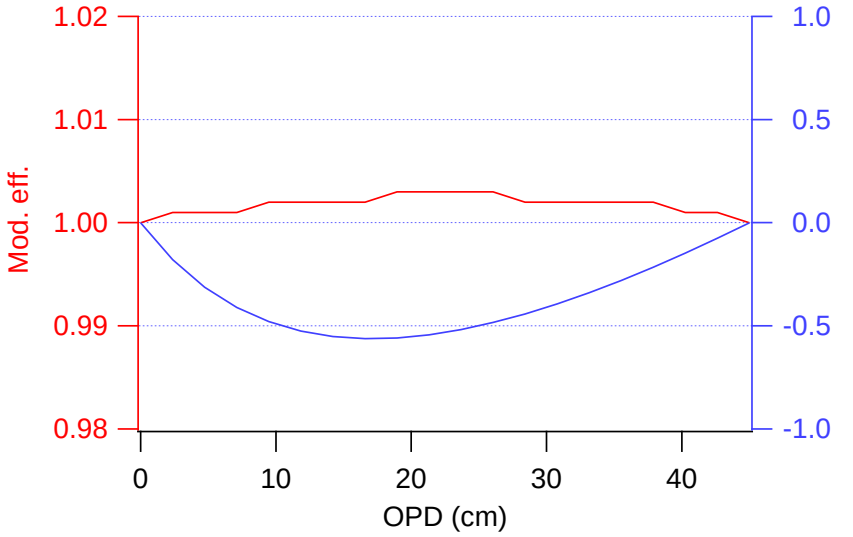


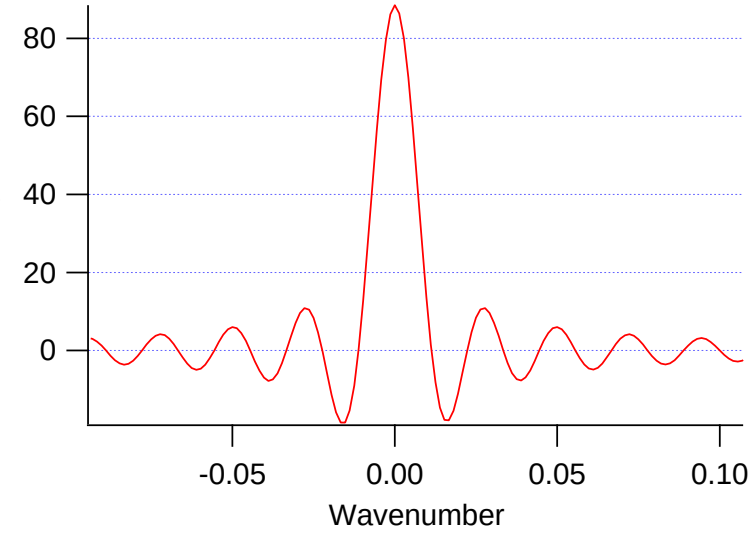
USB microscope

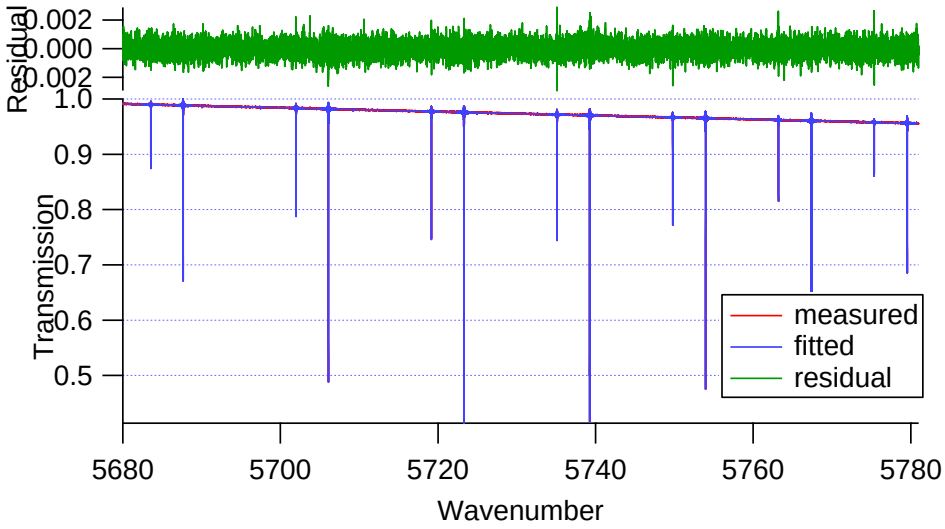
US Microscope: typical specs:

Main Features:
- Adjustable LEDs for object illumination
- 1.3 Megapixel lens
- Measurement function using enclosed software
- Snapshot and video recording function
- Alloy stand and stand alone capture button
- Tacton rubber touch housing
- 20x or 200x magnification
- Fine slider adjustment for brightness, hue, saturation and sharpness, plus a black and white display mode
- VMS-001 USB Microscope is supplied with Windows and Mac drivers. For software for side-loading CD drives just visit the download centre
- The 1.3 megapixel CMOS lens can be adjusted to point in any direction using the movable arm
- Simply install the drivers, plug the microscope into your computer via the USB and you're ready to go

The result


1.02
1.01
1.00
0.99
0.98
Mod. eff.
1.0
0.5
0.0
-0.5
-1.0
Phase (o)
0
10
20
30
40
OPD (cm)


80
60
40
20
0
ILS
-0.05
0.00
0.05
0.10
Wavenumber


0.002
0.000
0.002
Residual
1.0
0.9
0.8
0.7
0.6
0.5
Transmission
measured
fitted
residual
5680
5700
5720
5740
5760
5780
Wavenumber

But wait, we have a problem …

- 3 cells @ Wollongong, 3 different ILSs !
- Absolute retrieved ILS / ME depends on:
  - Pressure HCl in cell
  - Pressure air in cell
  - Hitran linewidths and strengths
- Measurement of one cell does NOT define the ILS / ME
- Refer to Frank Hase's telecon paper from May 2013
  - Some cells appear to have air in them (up to 1 mb?)
  - Retrieved ME depends on choice of P_{total}, P_{HCl} in linefit
  - Frank uses C2H2 cell to define ILS and ME
- Sensitivity:
  - ΔP_{HCl} =1 mb => ΔME = 5%
  - ΔME = 1% => ΔX_{CO2} = 0.01% = 0.04 ppm

The end

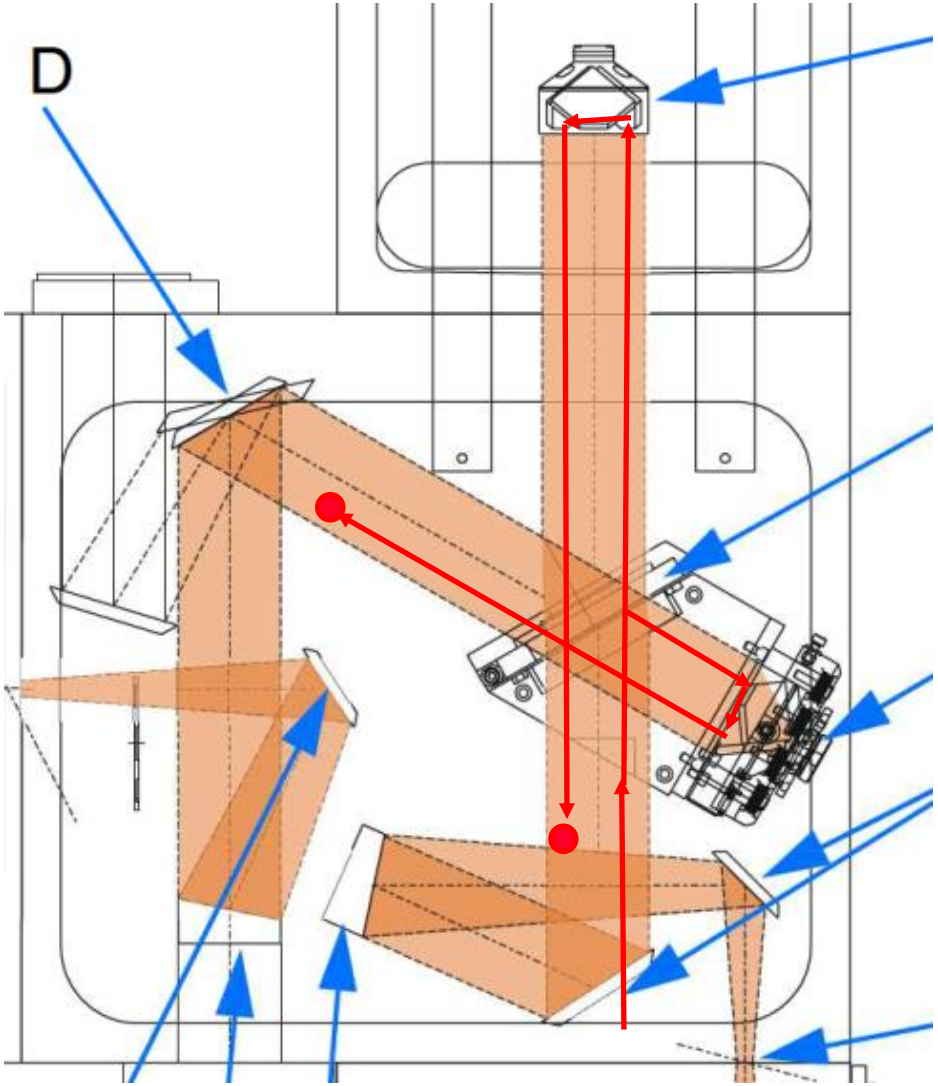
- We need to agree on how to manage this
- Await Frank's analysis of all cells and updating his telecon paper

- Thanks especially to John Robinson, NIWA, for the tips on implementing Frank and Thomas's alignment procedure.

IFS125 interferometer

IR beam

Laser



IFS125 interferometer