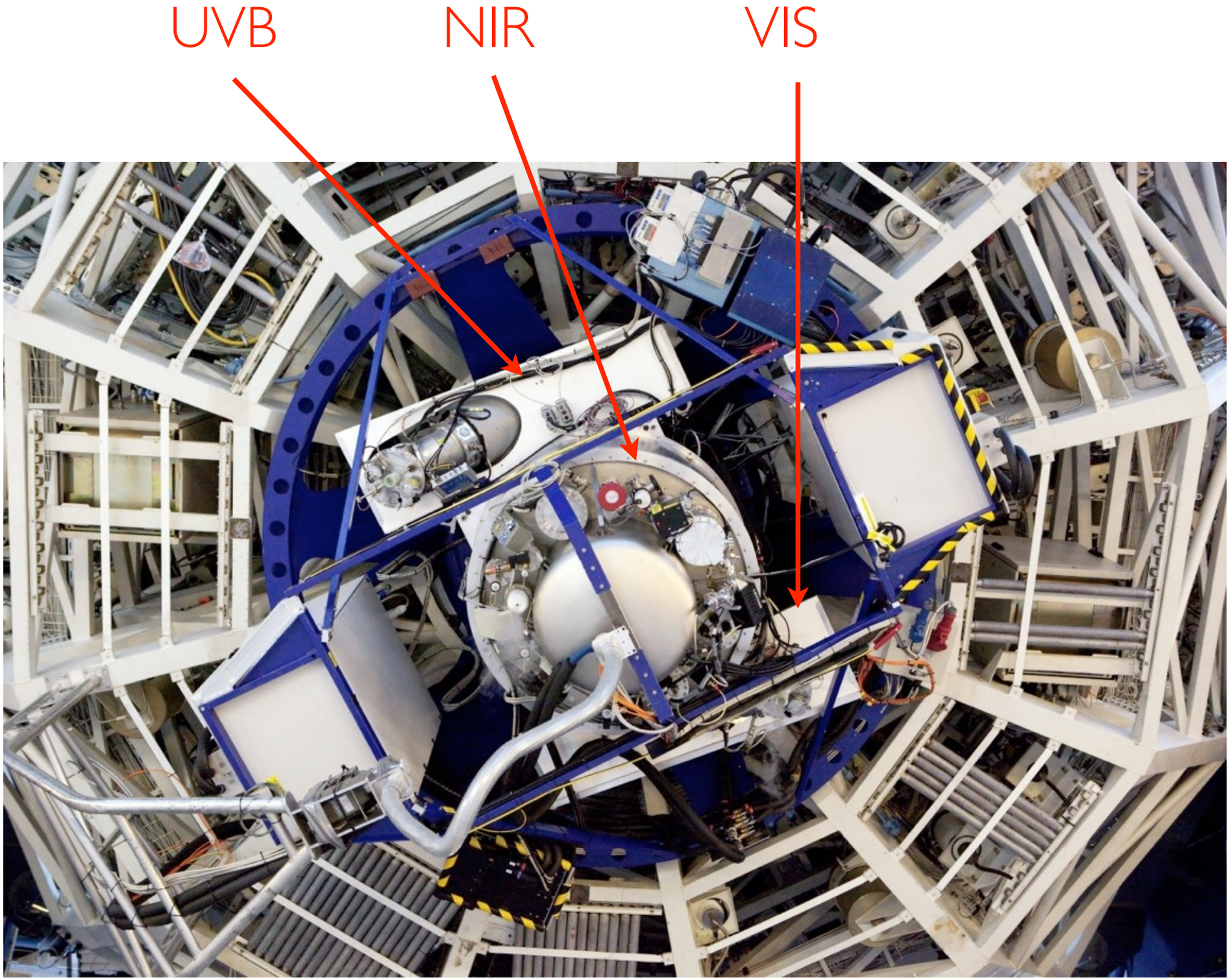
X-shooter design & performance

Joël Vernet

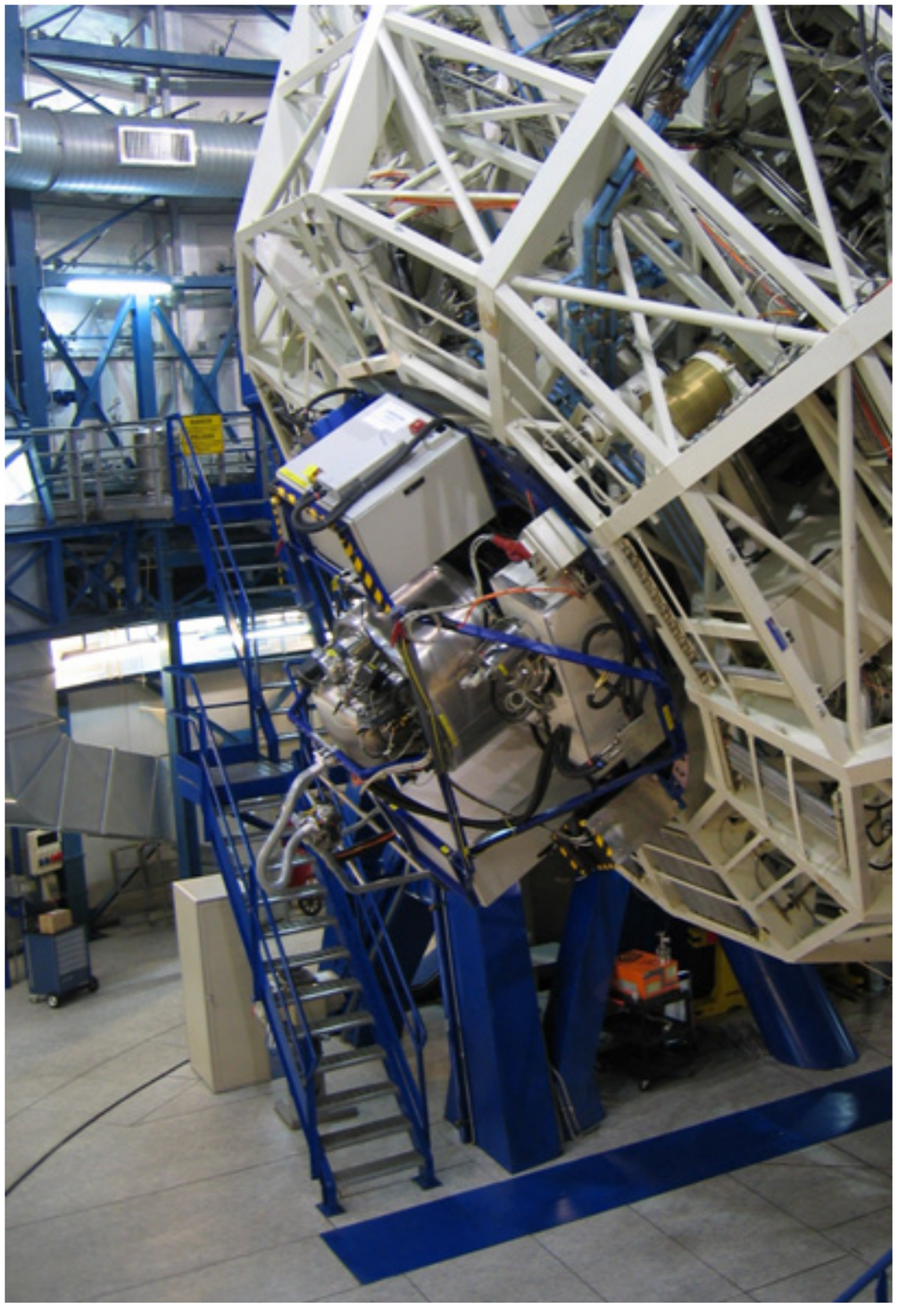
9 May 2016

X-shooter @ UT2 Cassegrain

- Obtain spectra from 300 to 2500 nm in one shot
- R=5100, 8800 and 5600 for 1”/ 0.9”/0.9” slits in UVB/VIS/NIR
- single object, 11” slit or 4”x1.8” IFU
- Light split by two high efficiency dichroics
- 3 arms, cross-dispersed échelle spectrographs

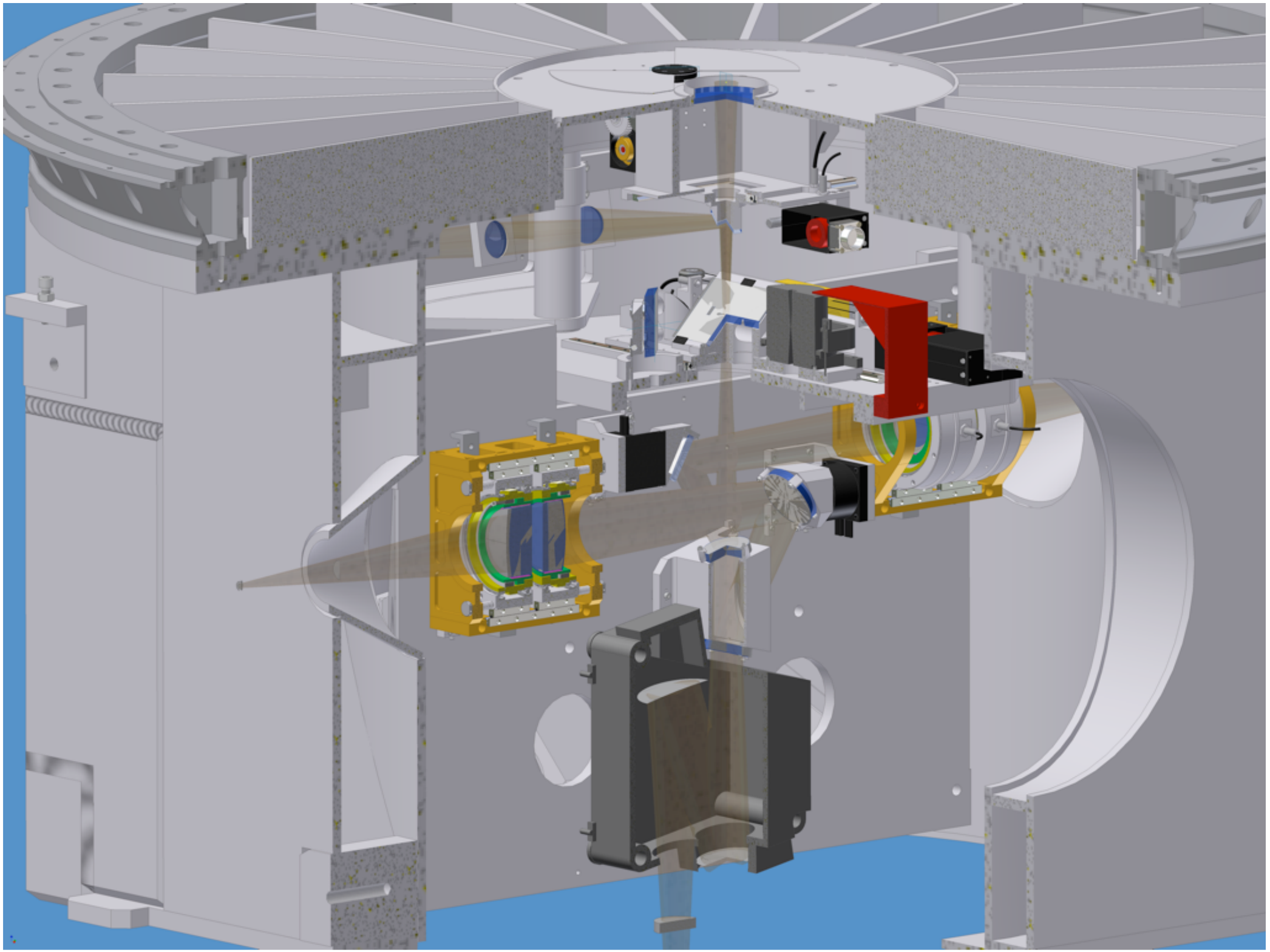


A European project



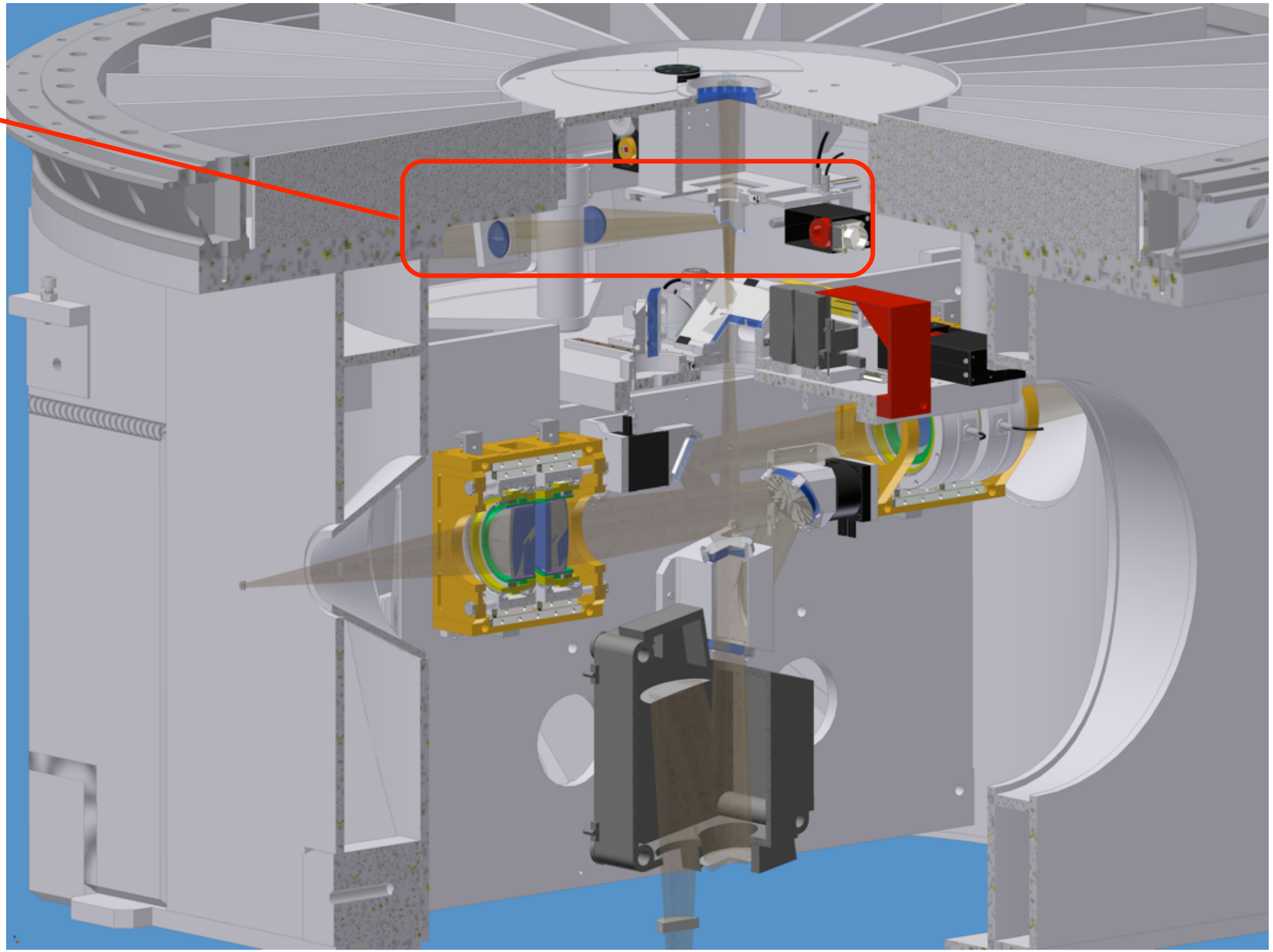
- 11 institutes
- 5 countries
- 5.3 millions €
- 70 person-years
- 5 years development
- in operations since 1/10/2009

The Backbone



The Backbone

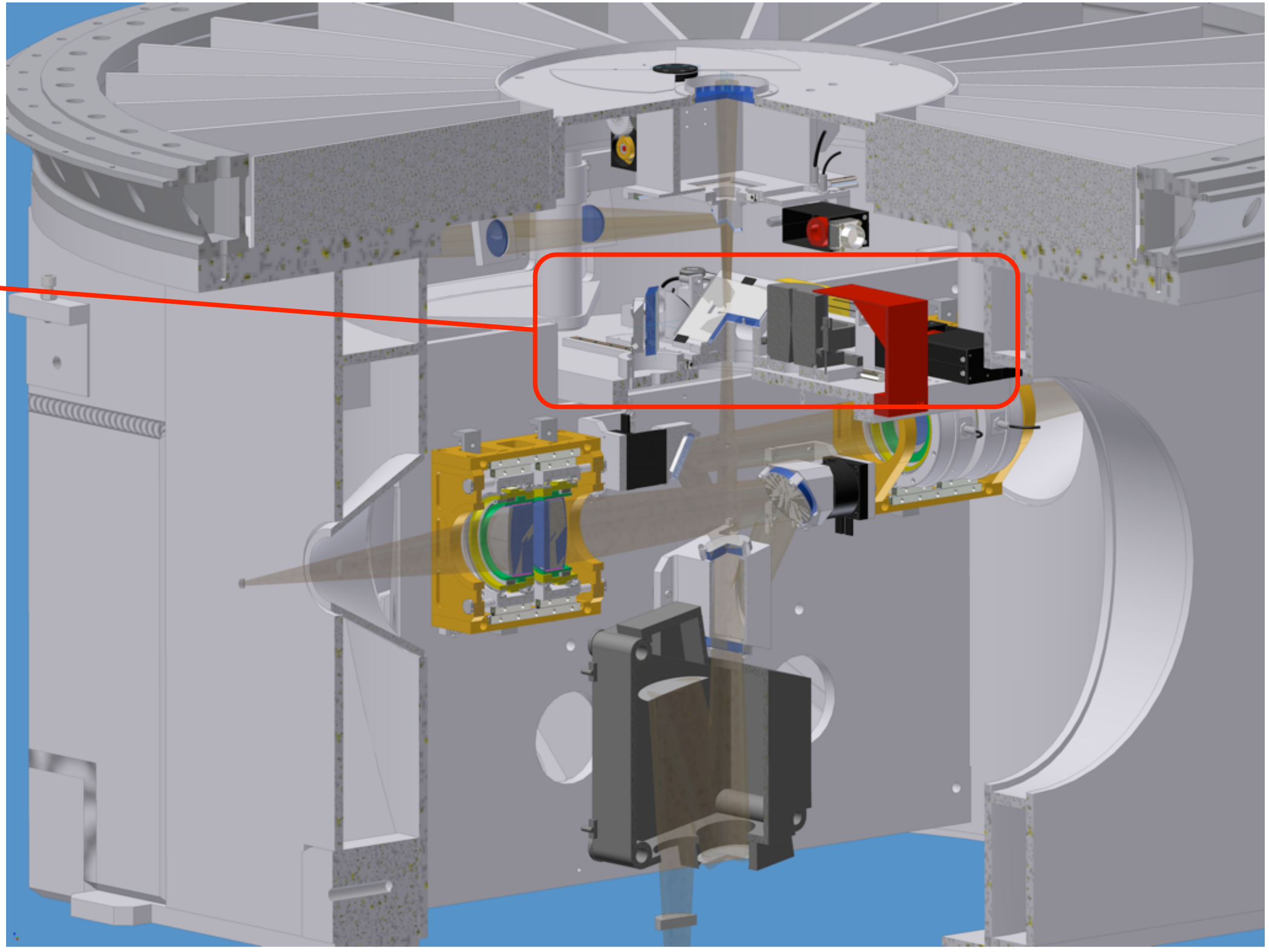
Calibration unit



The Backbone

Cassegrain focal plane:

- acquisition
- reference pinhole
- IFU



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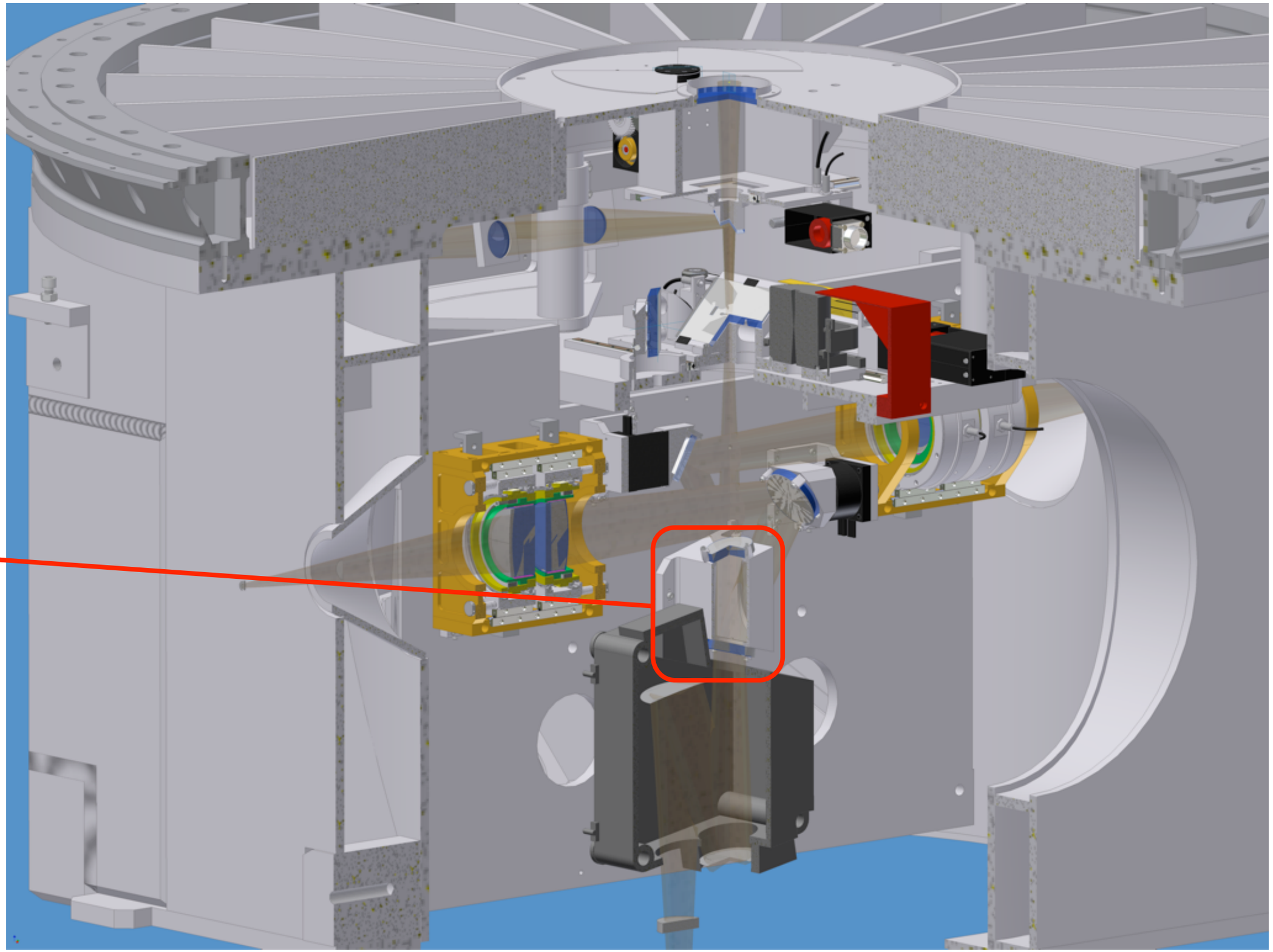

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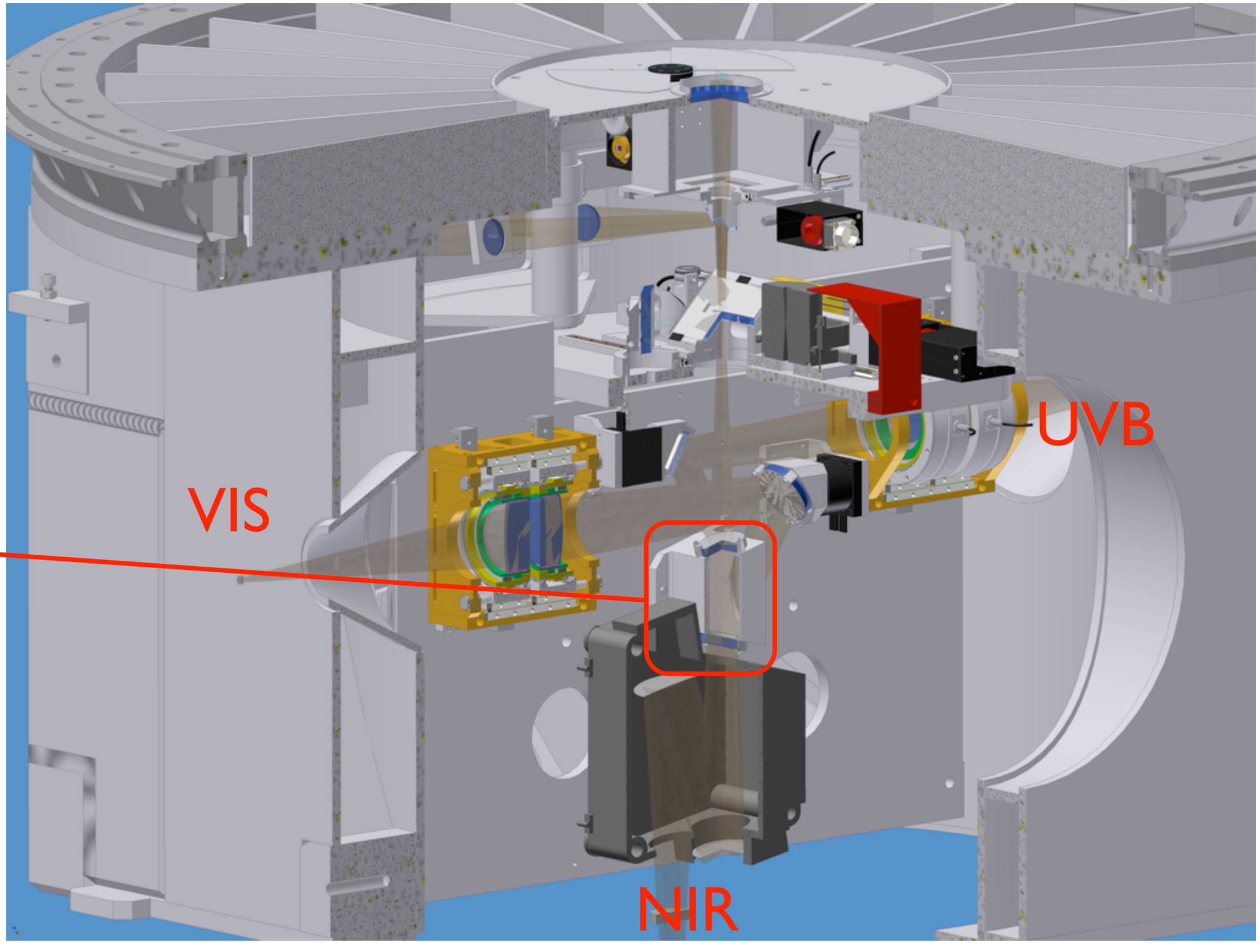
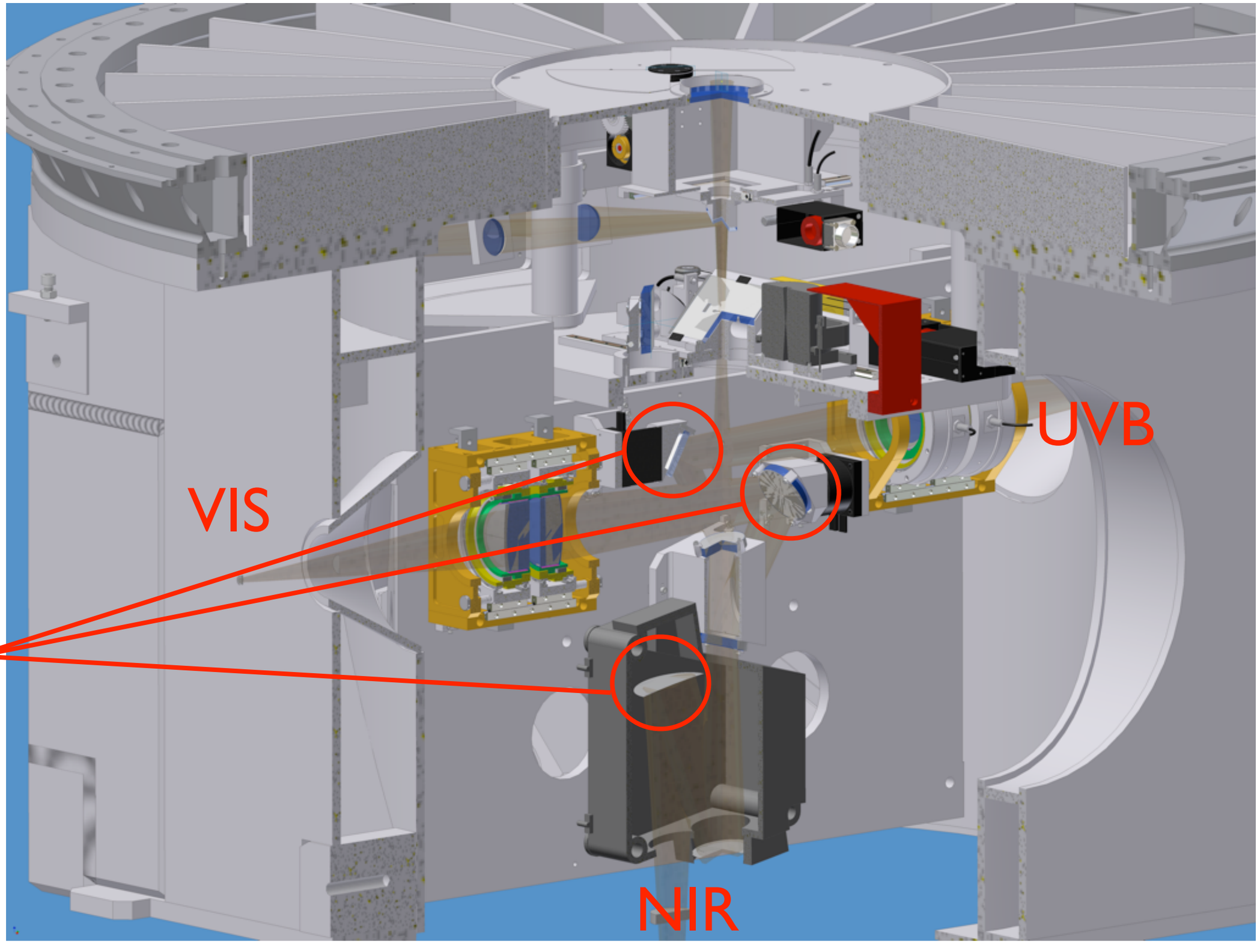


The Backbone



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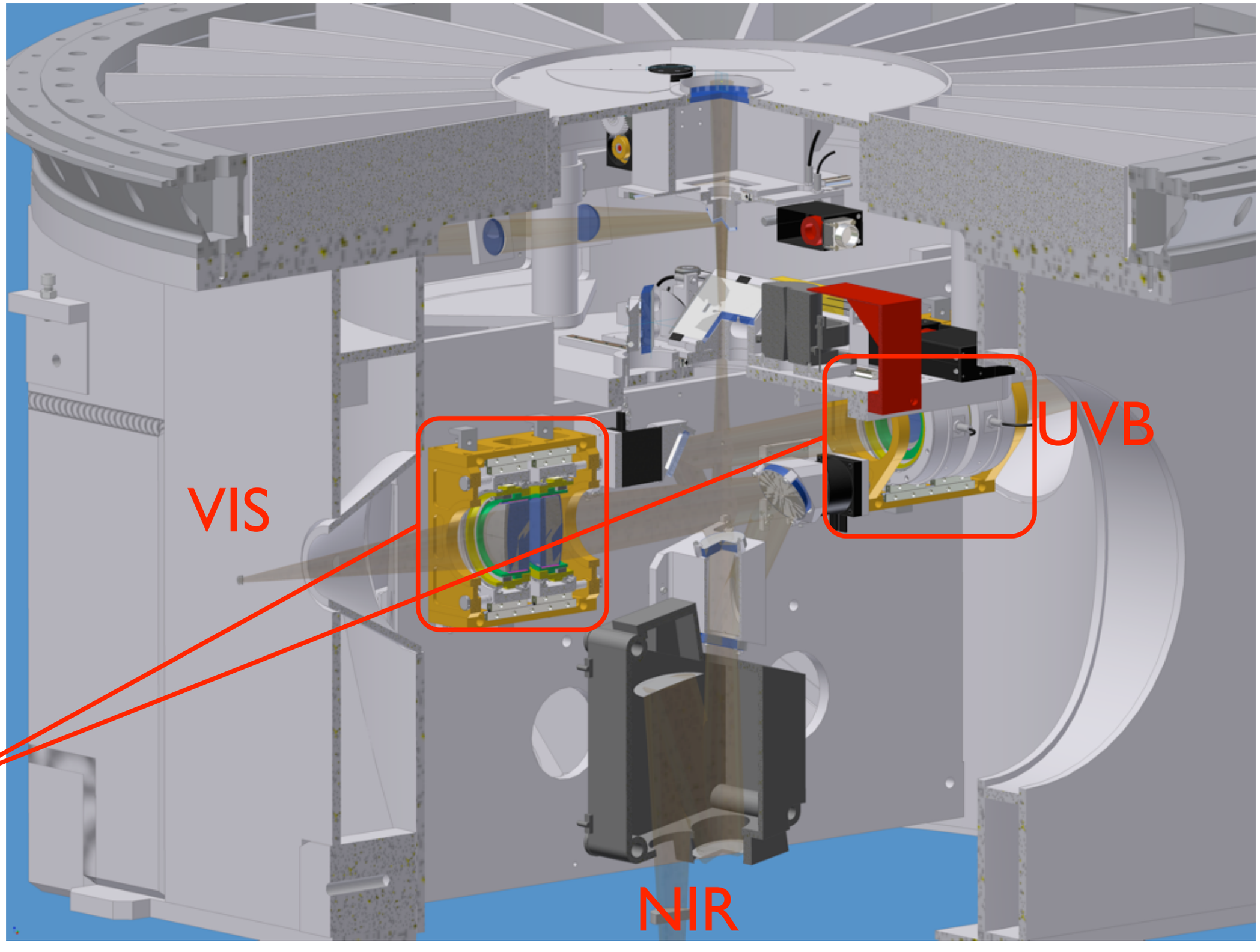
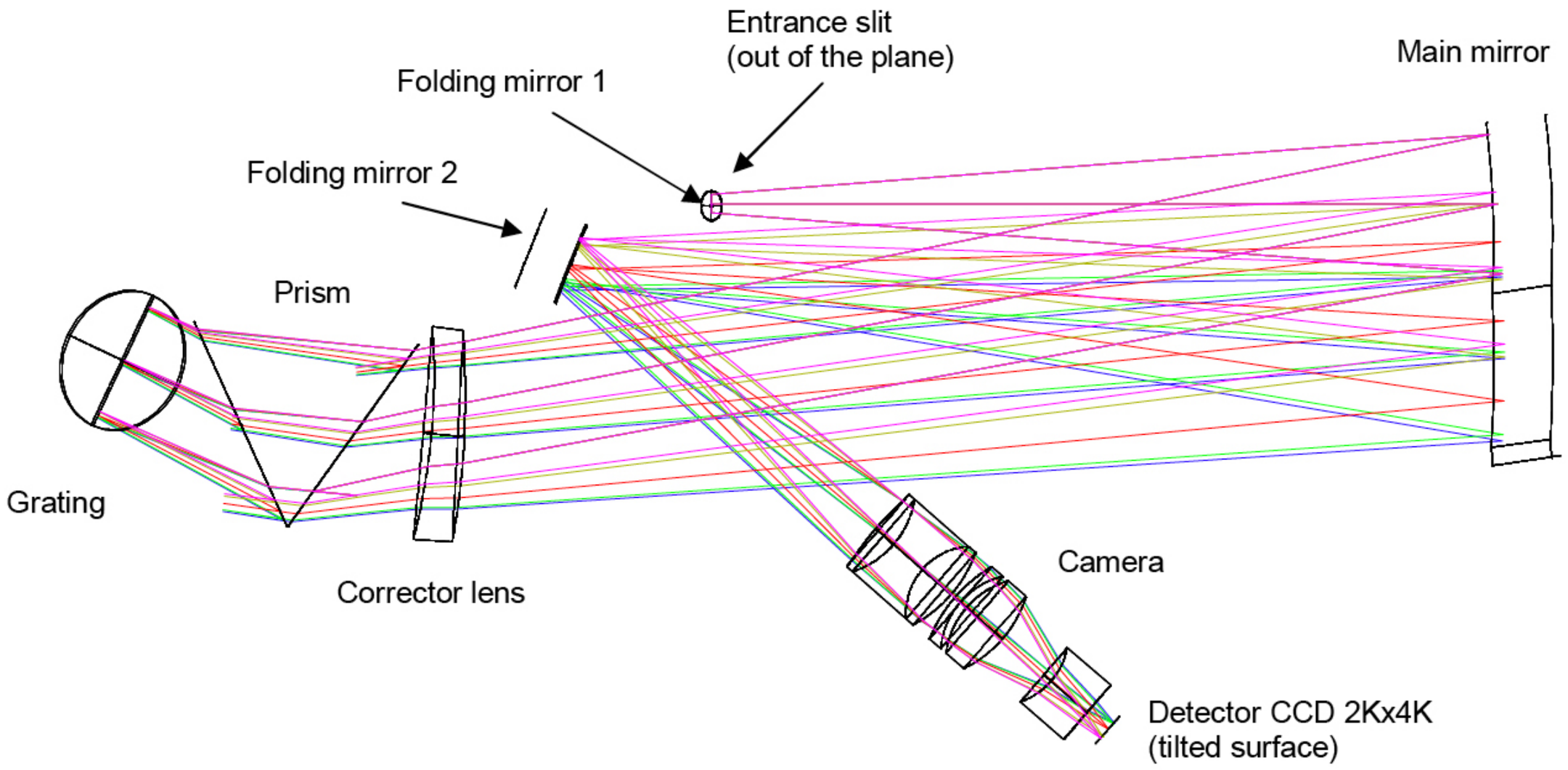


Cross-dispersed échelle spectrographs



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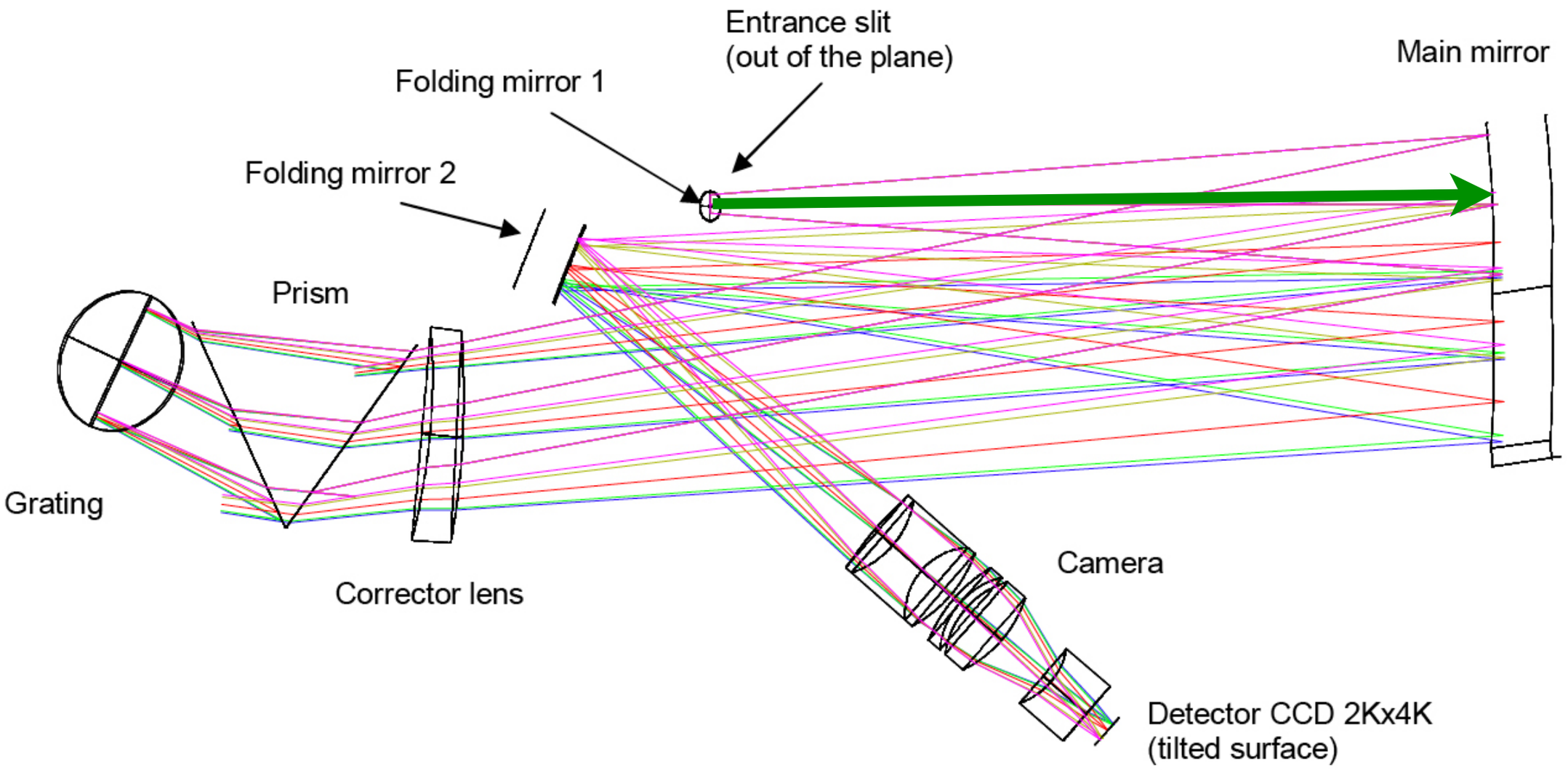

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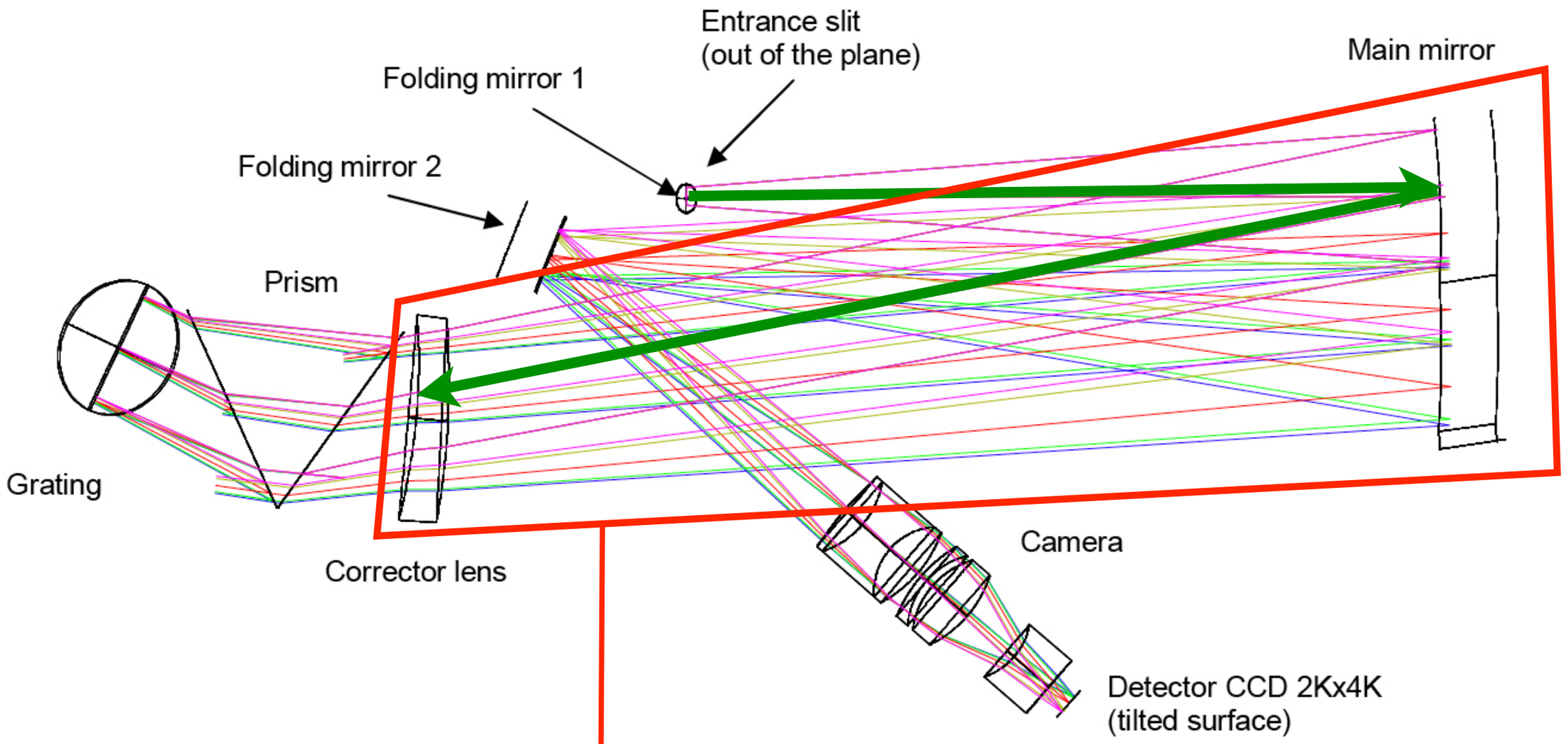
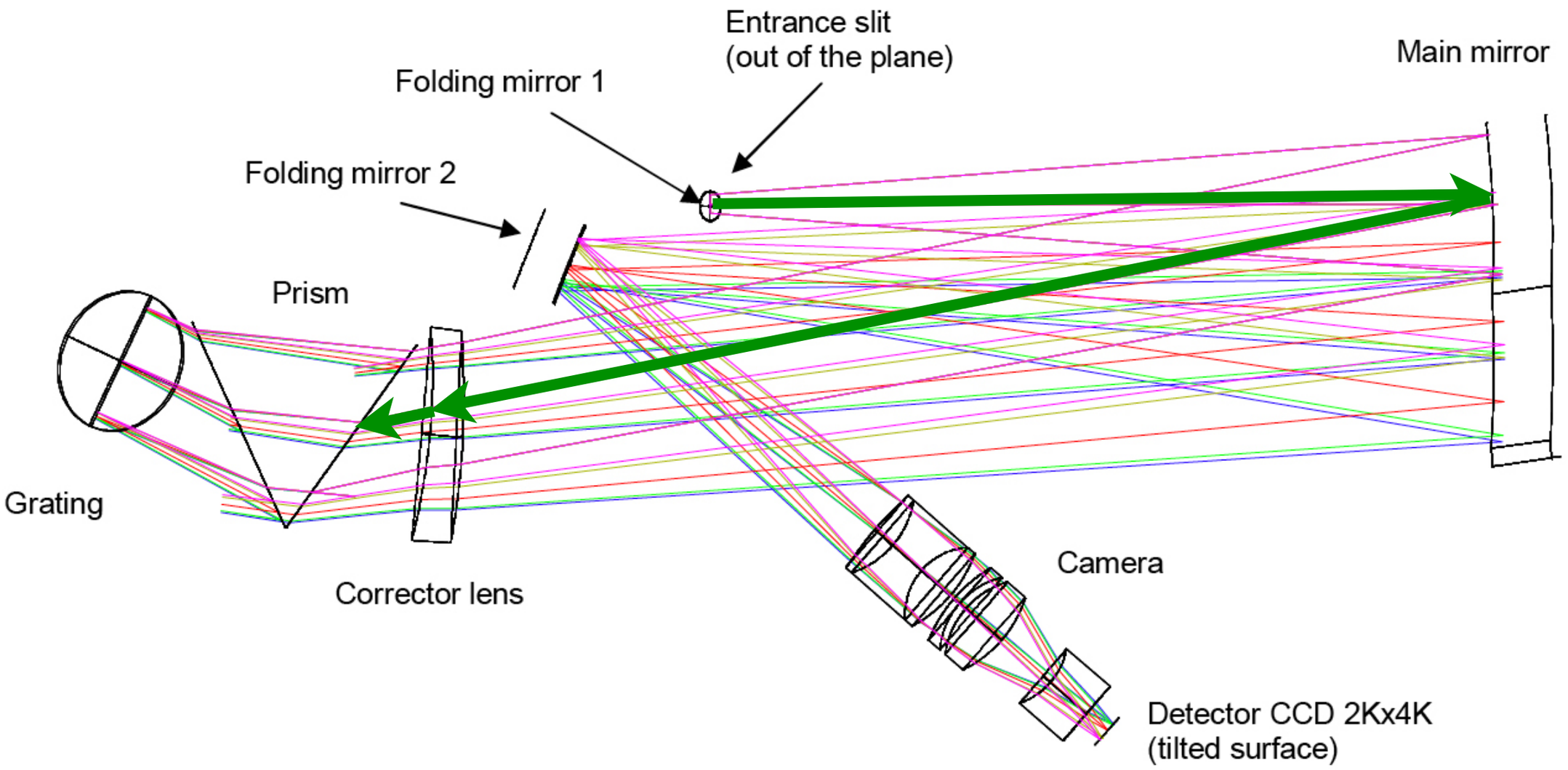


5° off-axis
Matsukov collimator

Cross-dispersed échelle spectrographs



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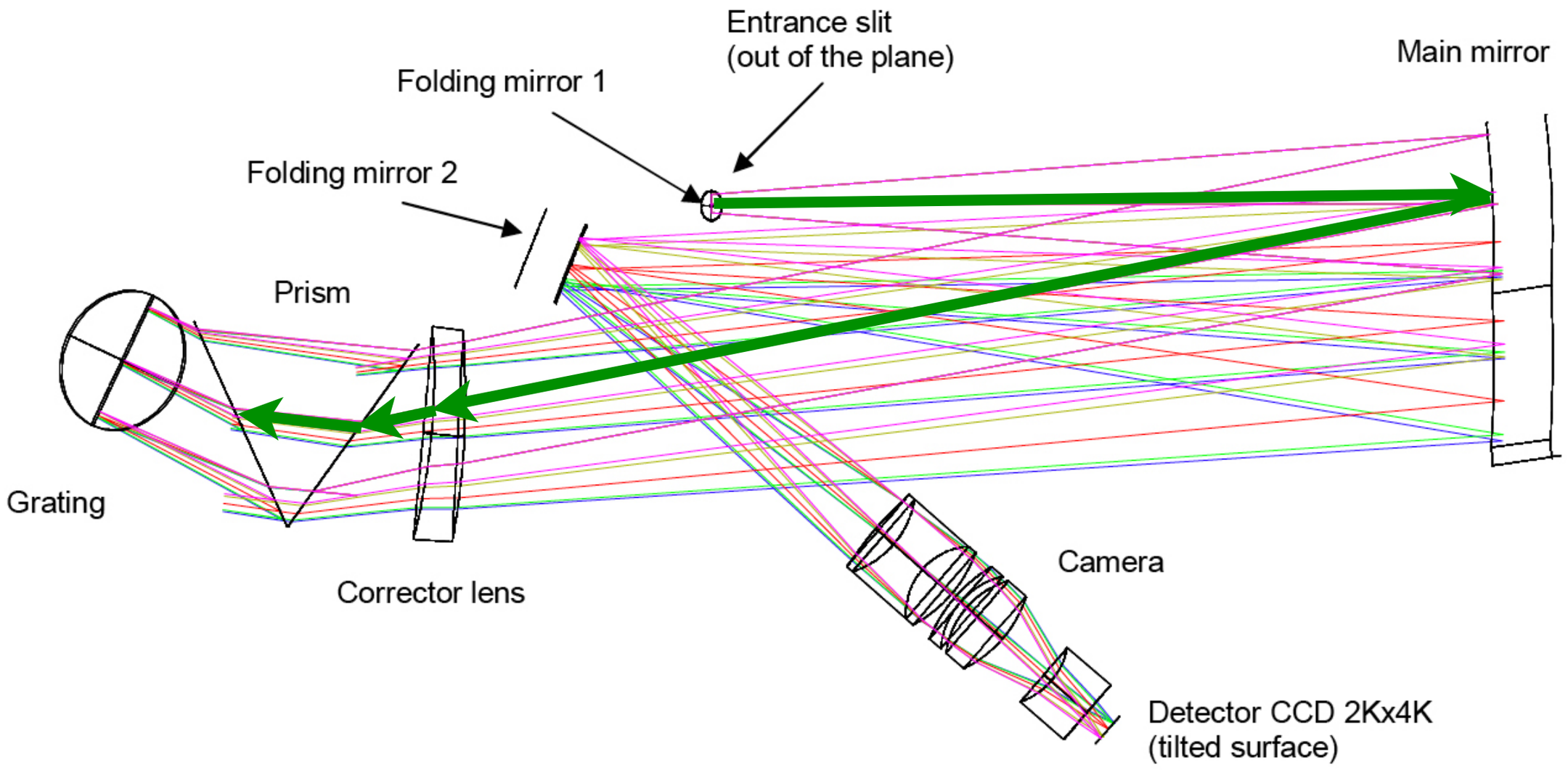

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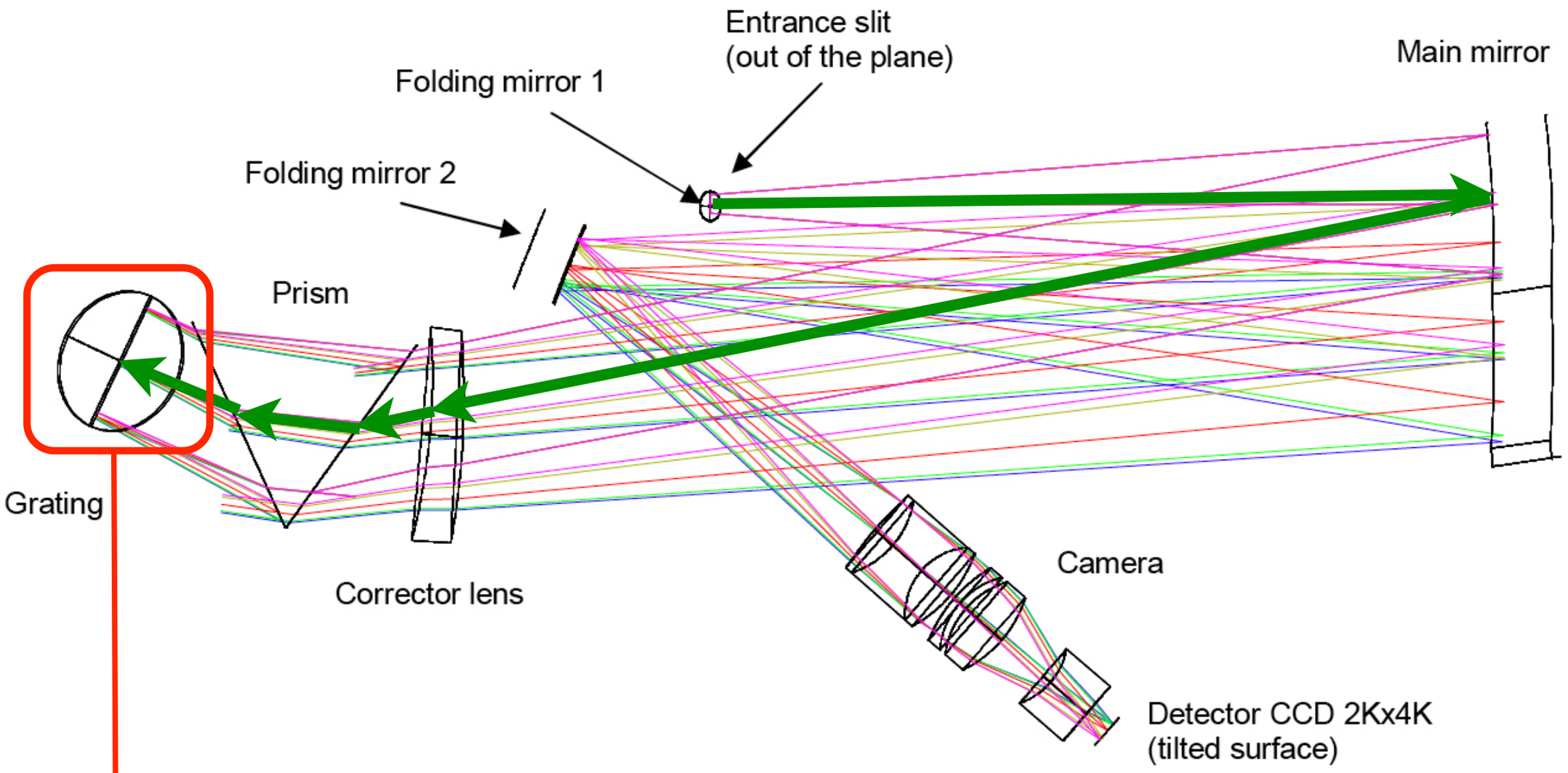
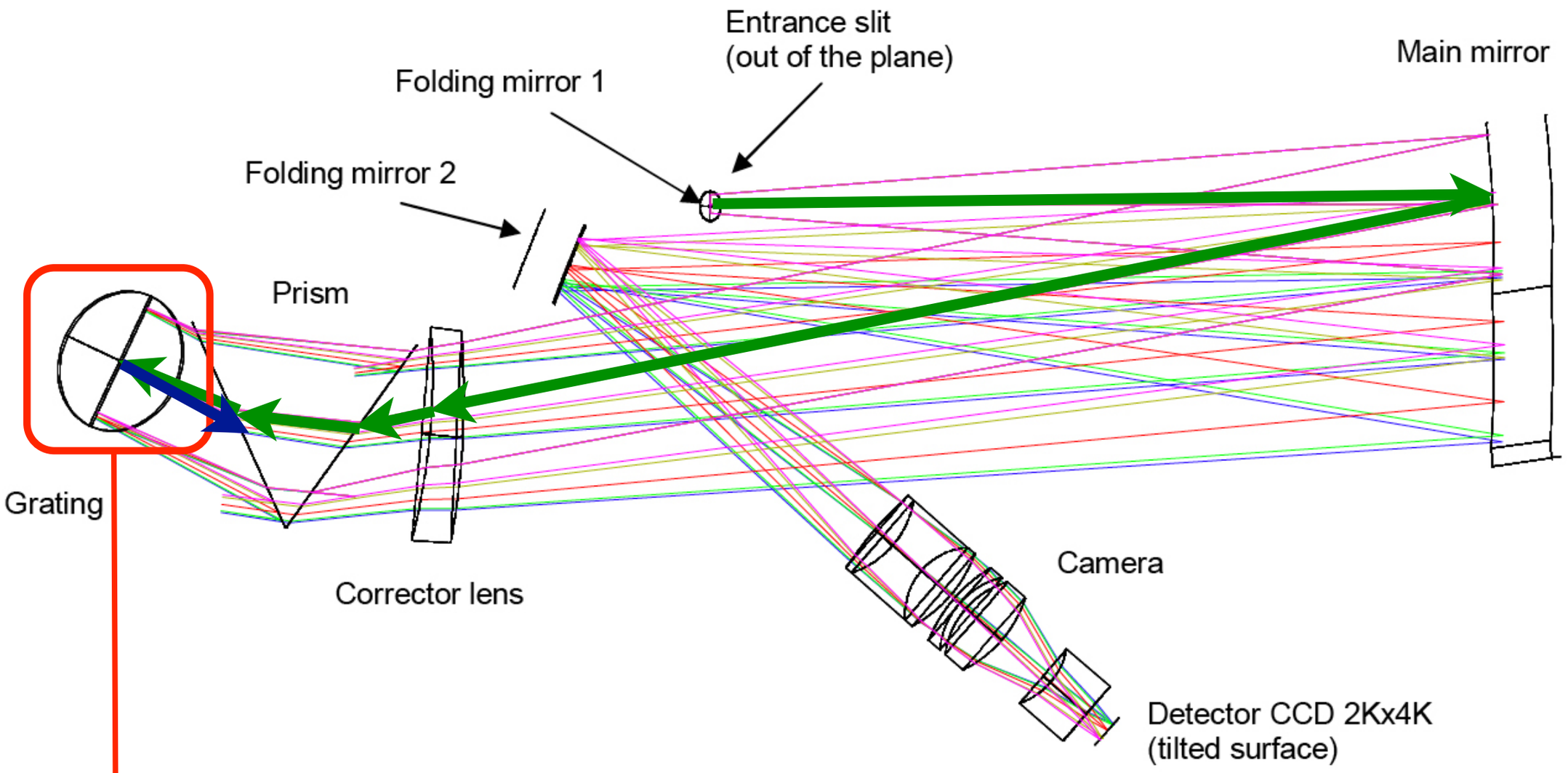


180 grooves/mm échelle grating blazed at 41.77°.
off-blaze angle: 0.0°,
off-plane angle: 2.2°

Cross-dispersed échelle spectrographs



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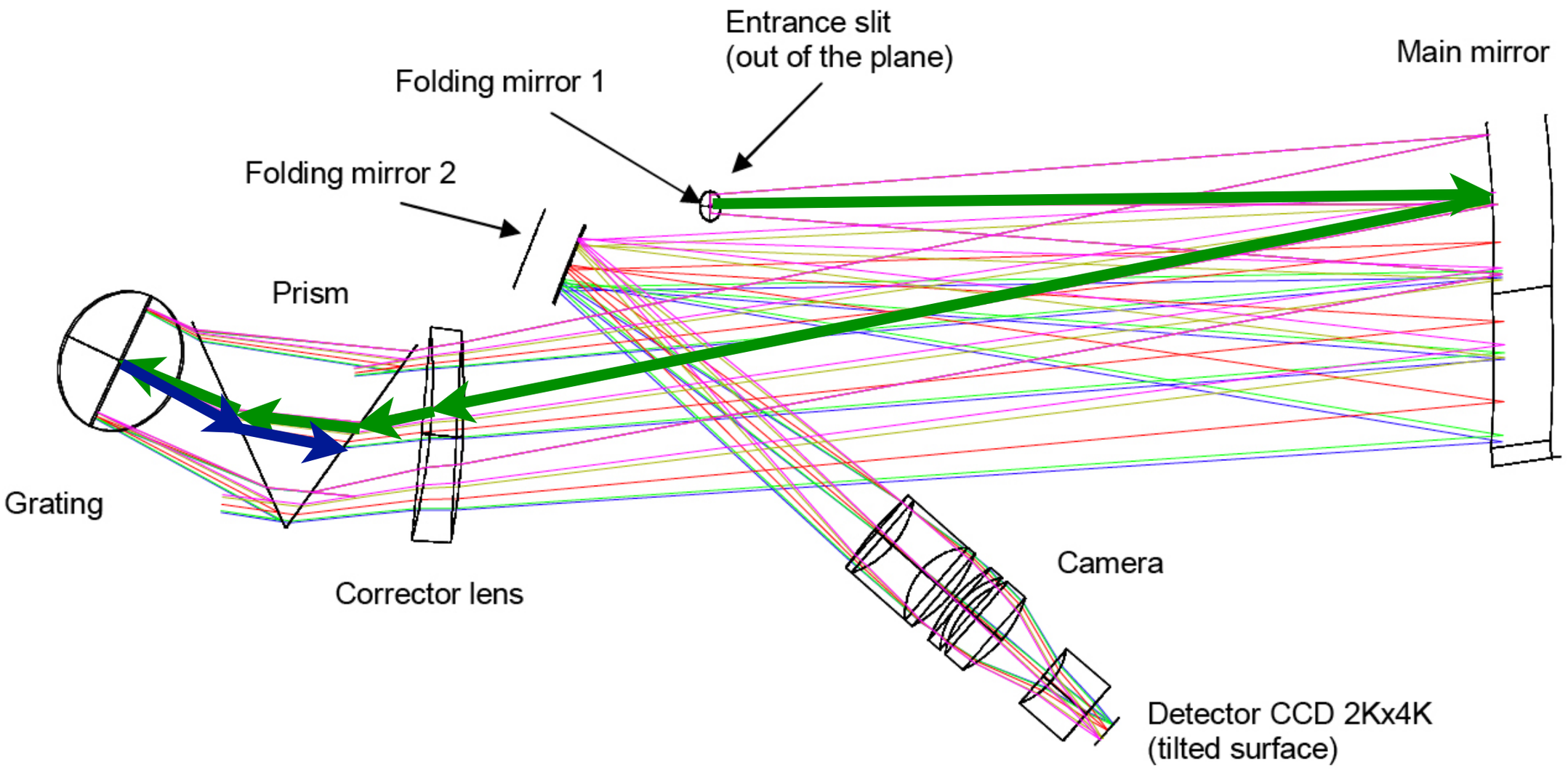

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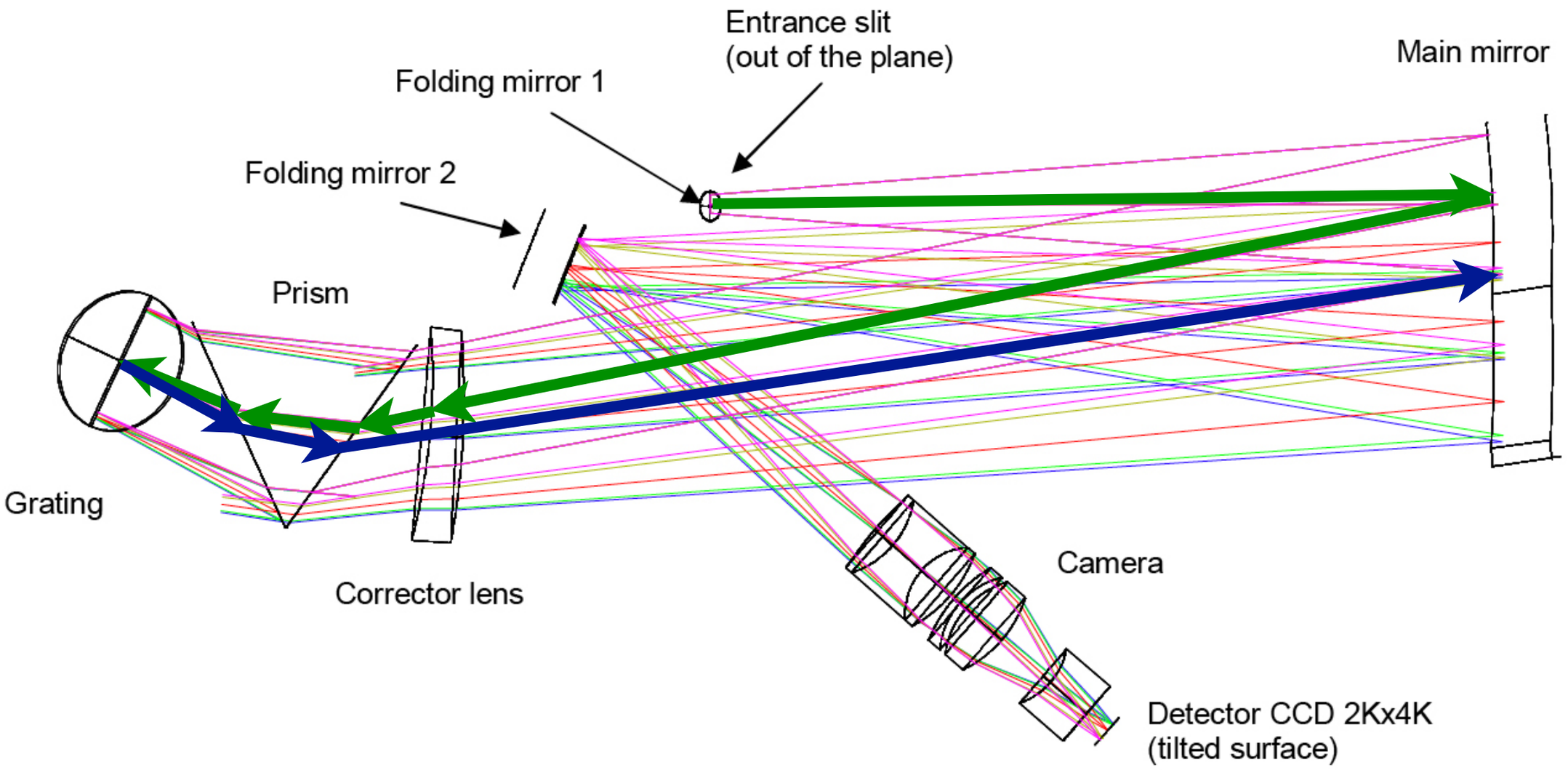

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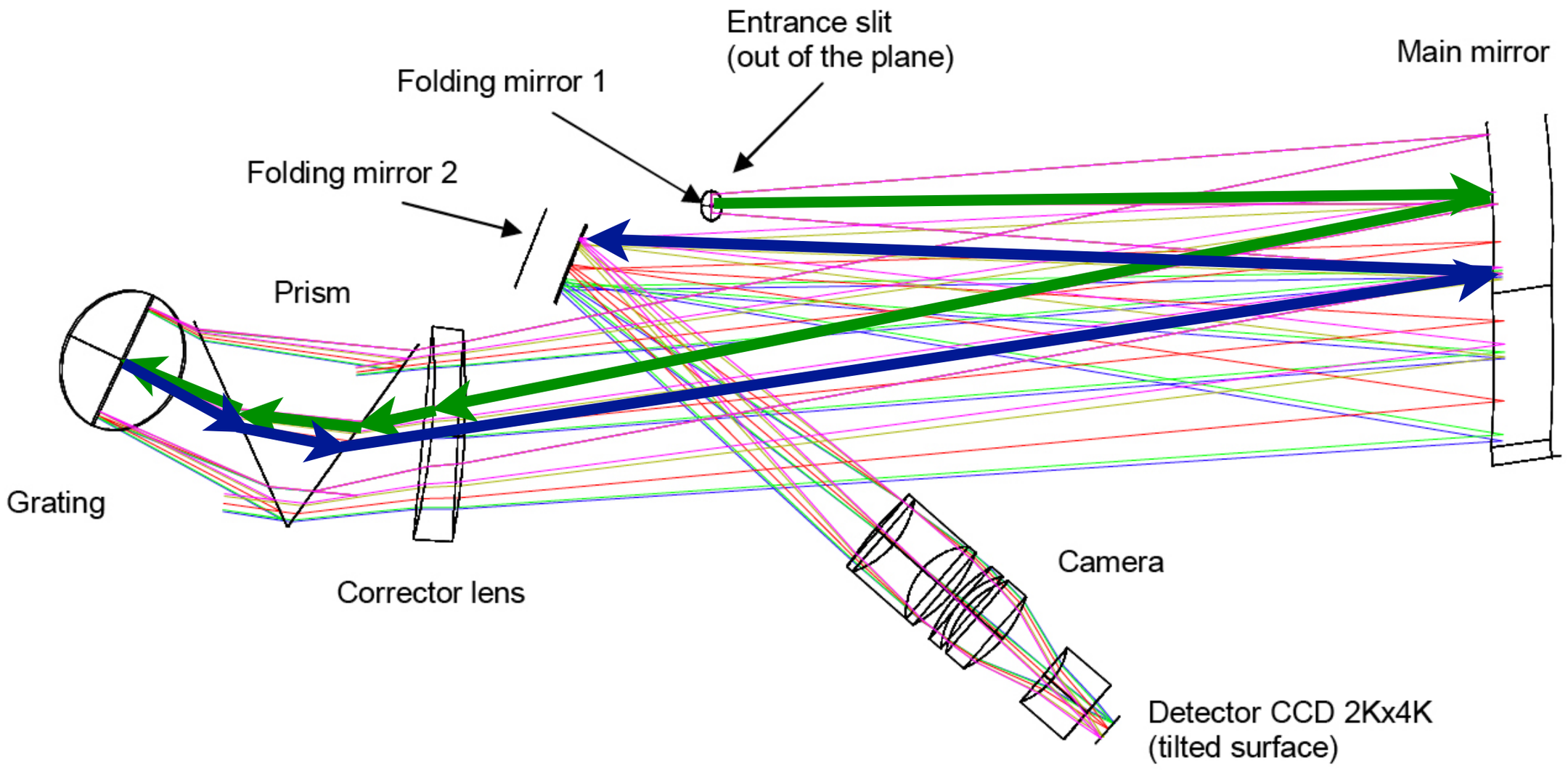

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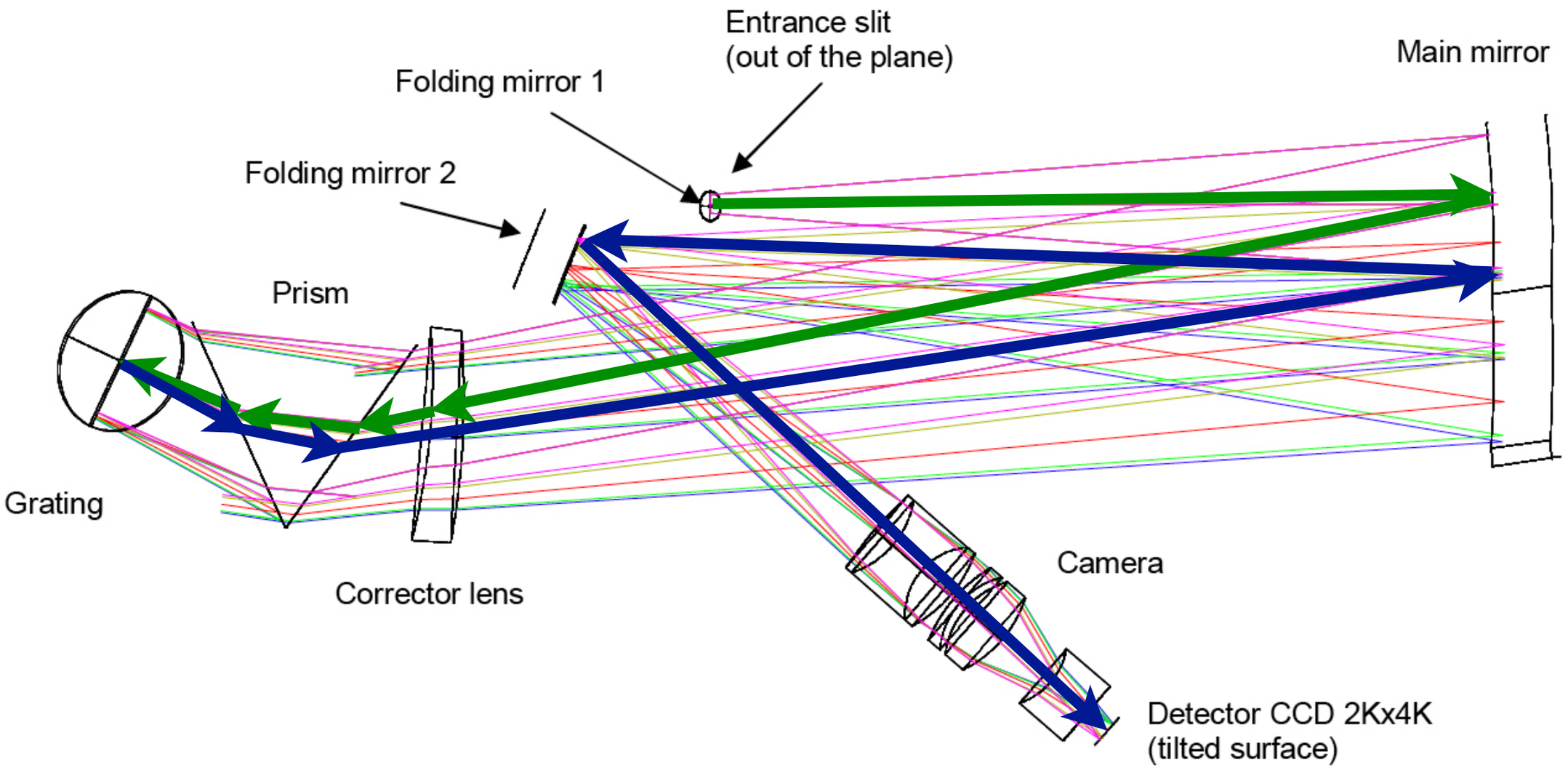

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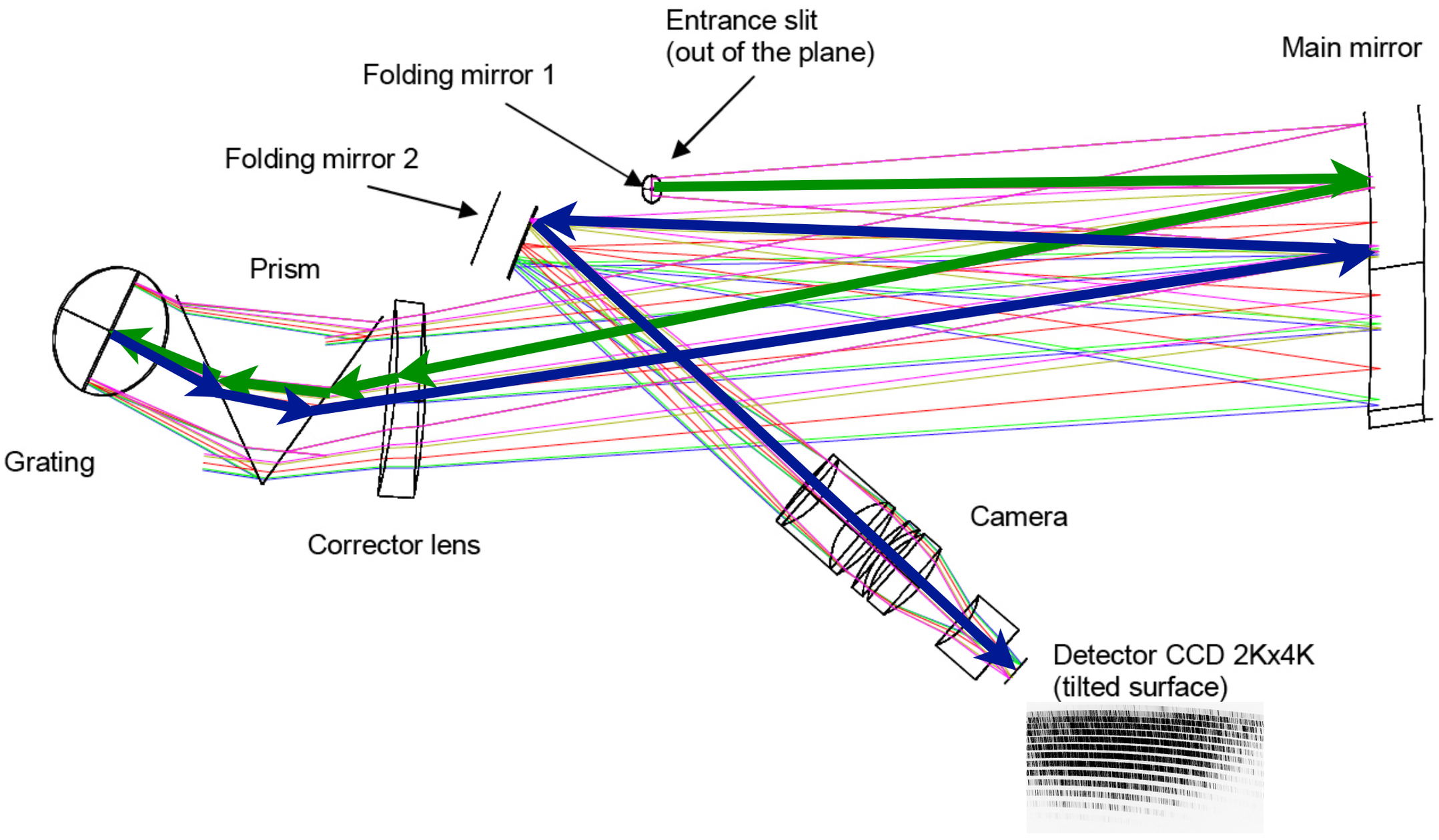
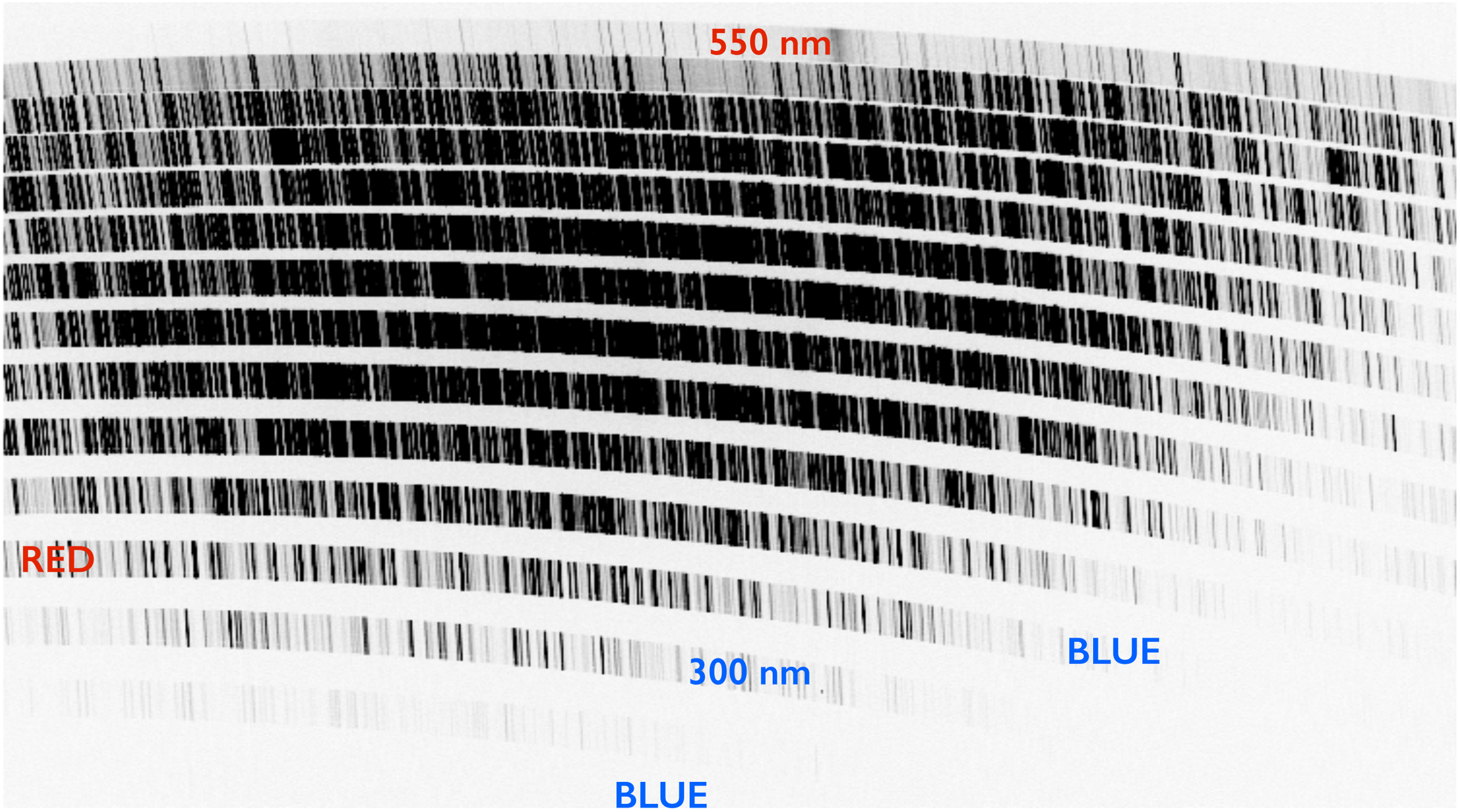
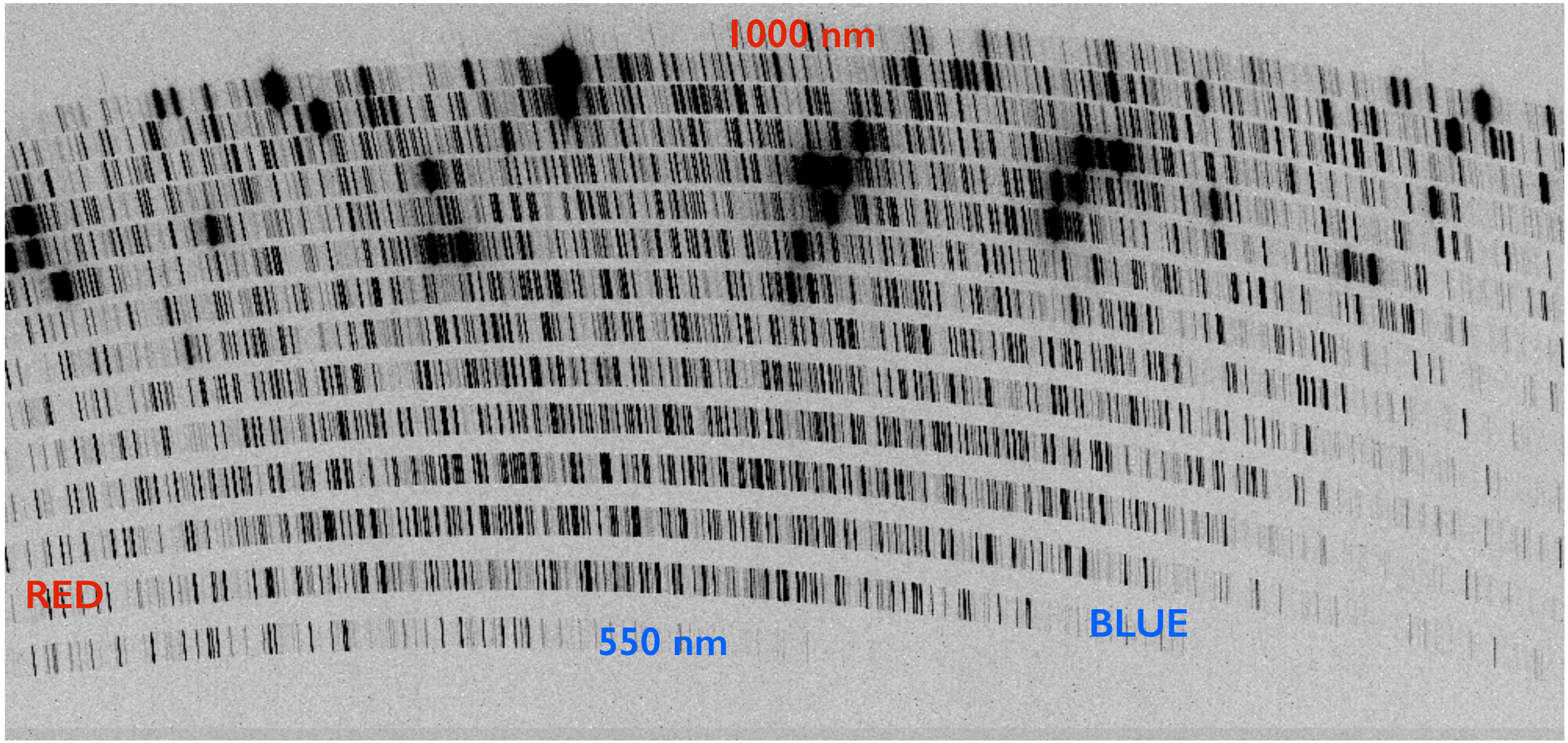


Spectral format (UVB)



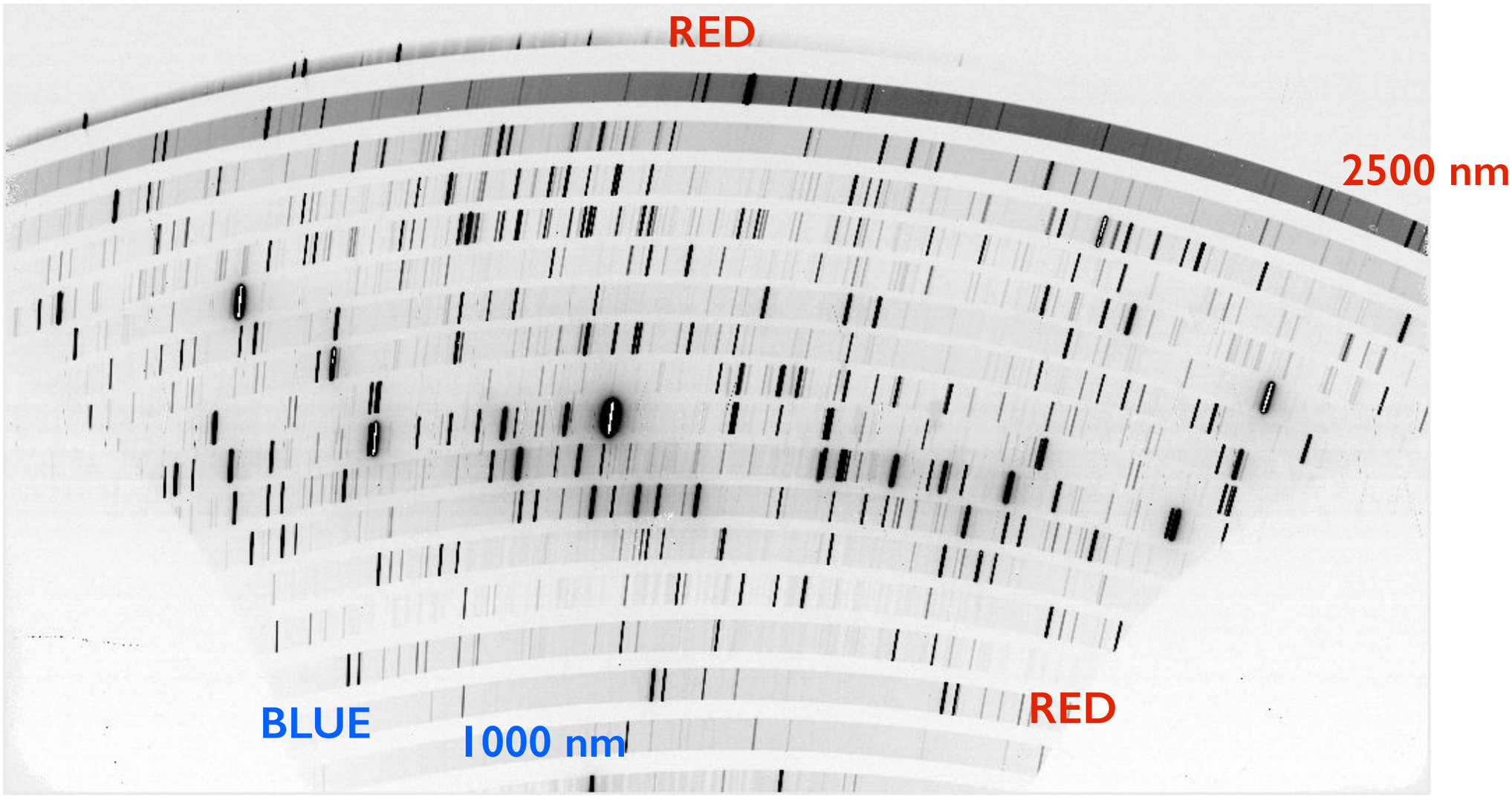
Spectral format (VIS)

RED



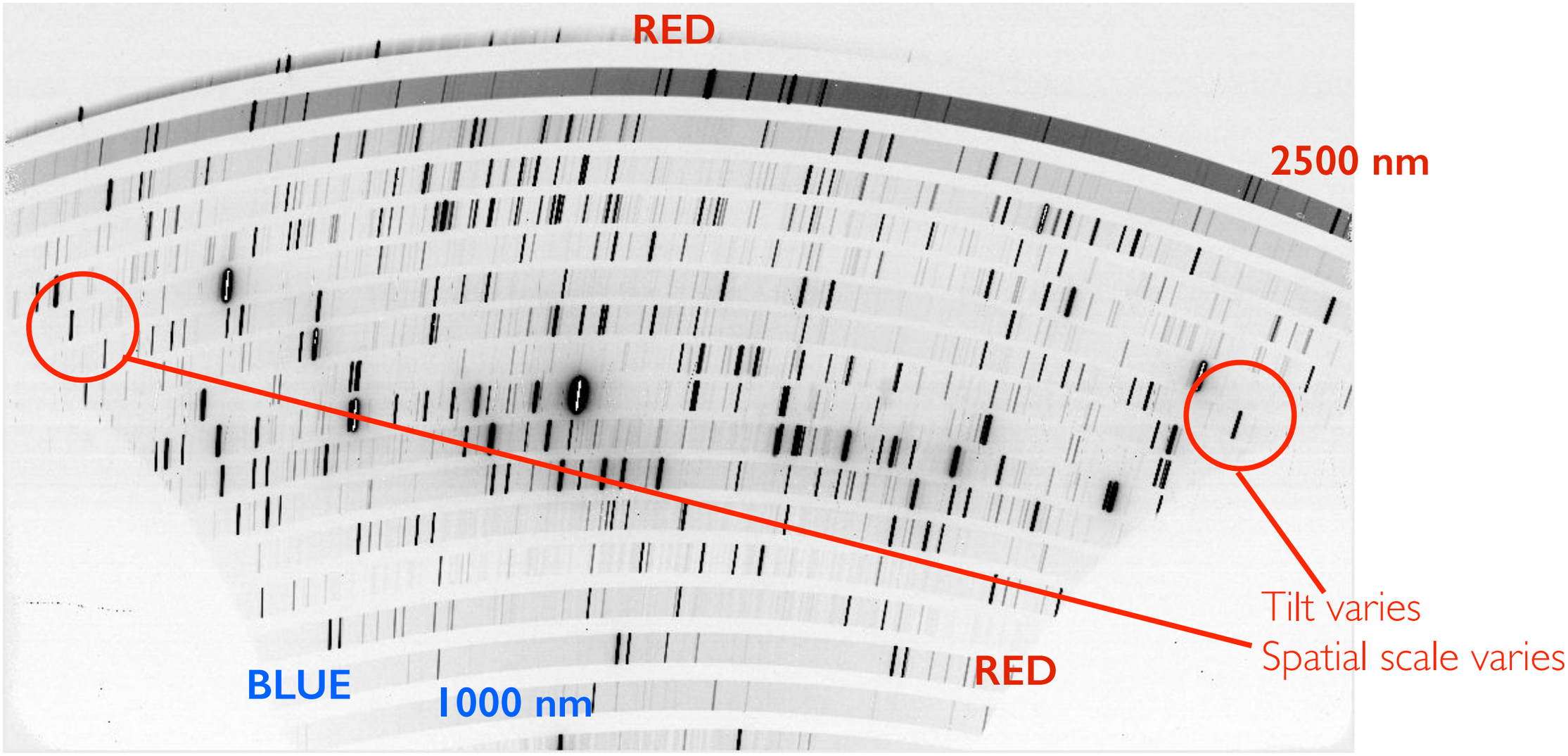
BLUE

Spectral format (NIR)



BLUE

Spectral format (NIR)



BLUE

Performances of X-shooter

- Stability
- Throughput
- Background

Performances of X-shooter

- **Stability**
- Throughput

- Background

Stability

- ☐ Before the slits (backbone flexures)
- ☐ After the slit
  - ☐ spectrograph flexures
  - ☐ thermal effects

Stability

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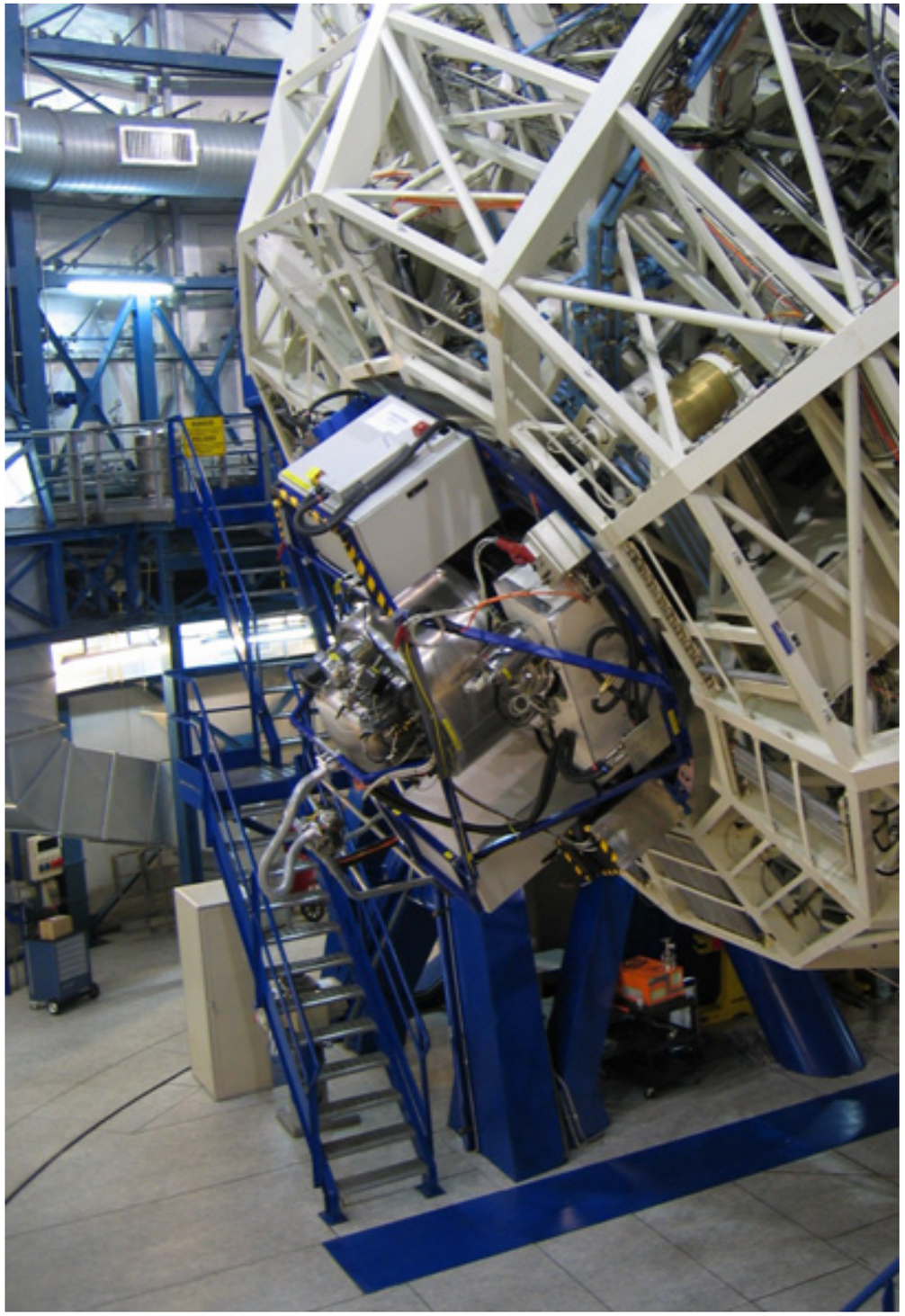
Pre-slit stability

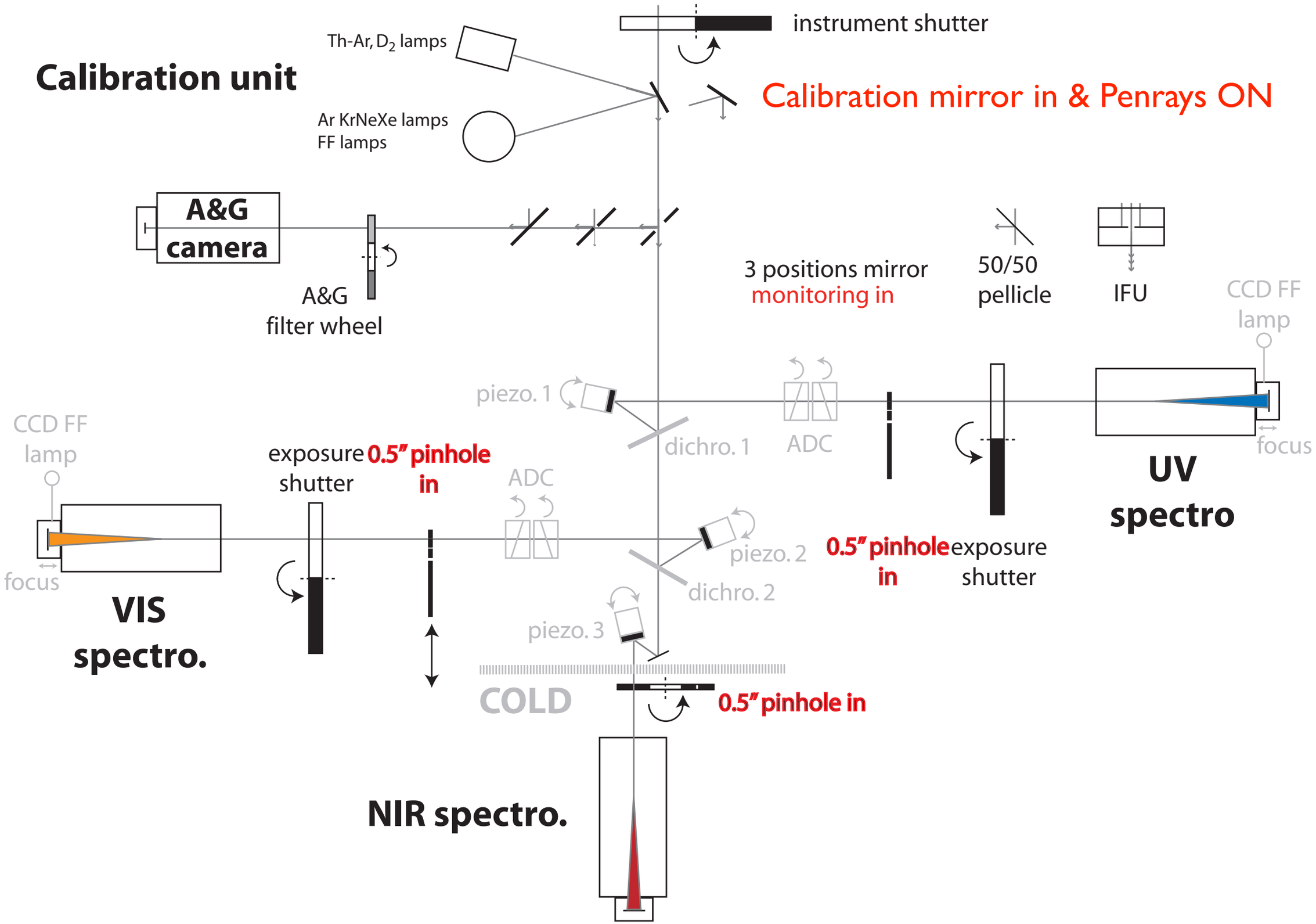
3 arms design at Cassegrain focus is challenging

- How to keep the 3 slits staring at the same patch of sky?
- ... i.e. to less than 1/10th of the narrowest slit
- alignment has to be <0.04" at any position angle and ZD<60°

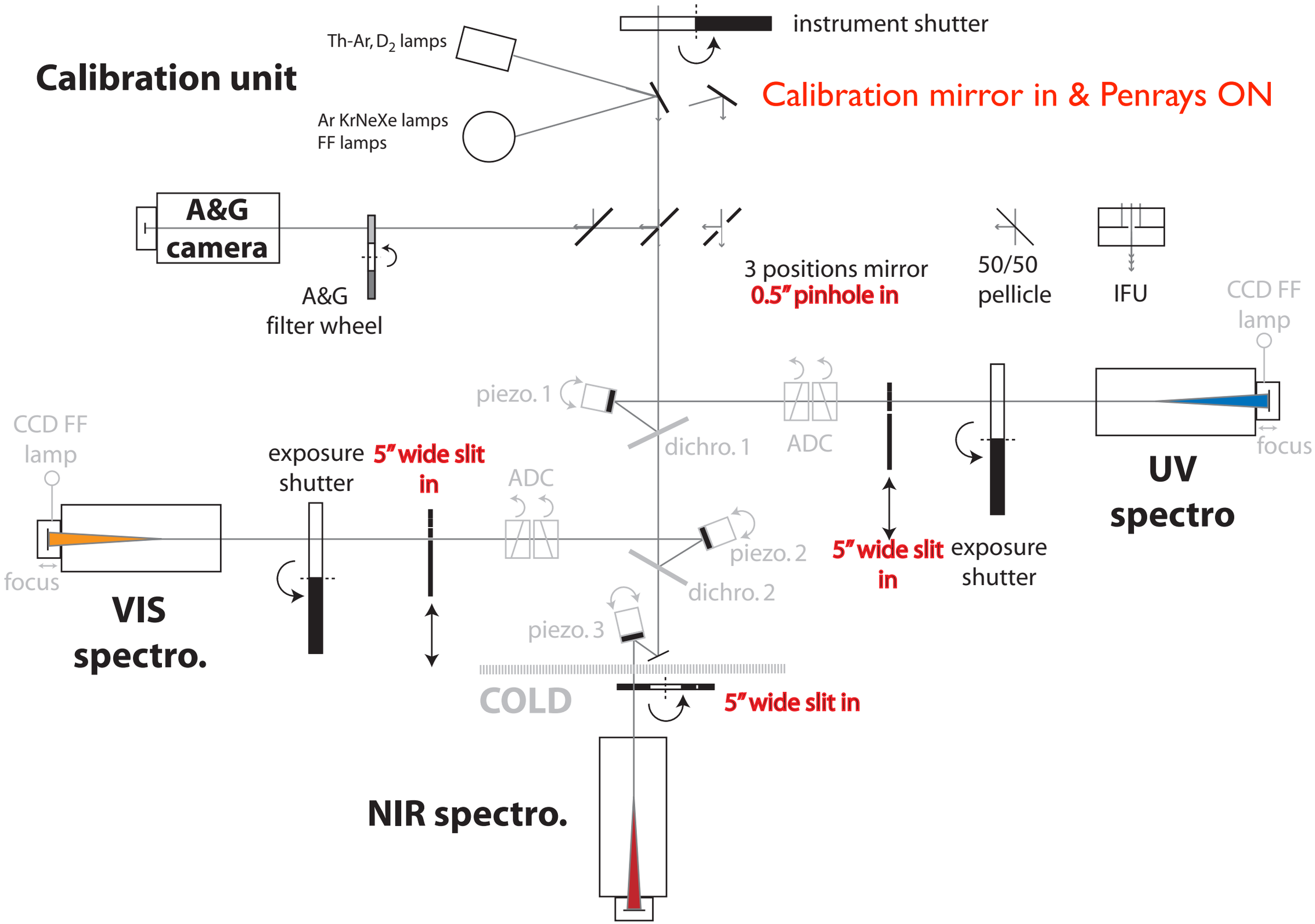
Active Flexure Compensation



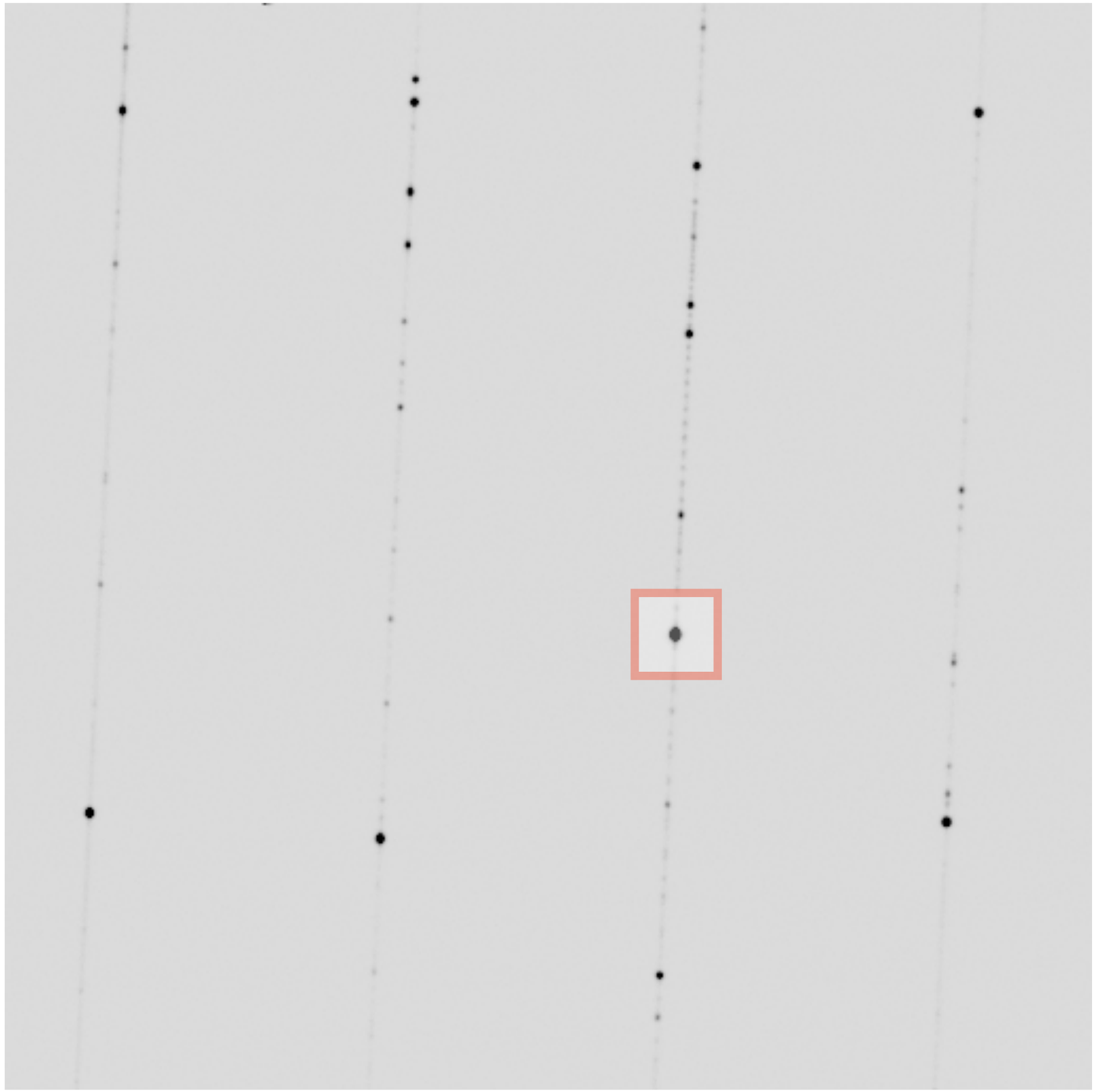
Calibration unit



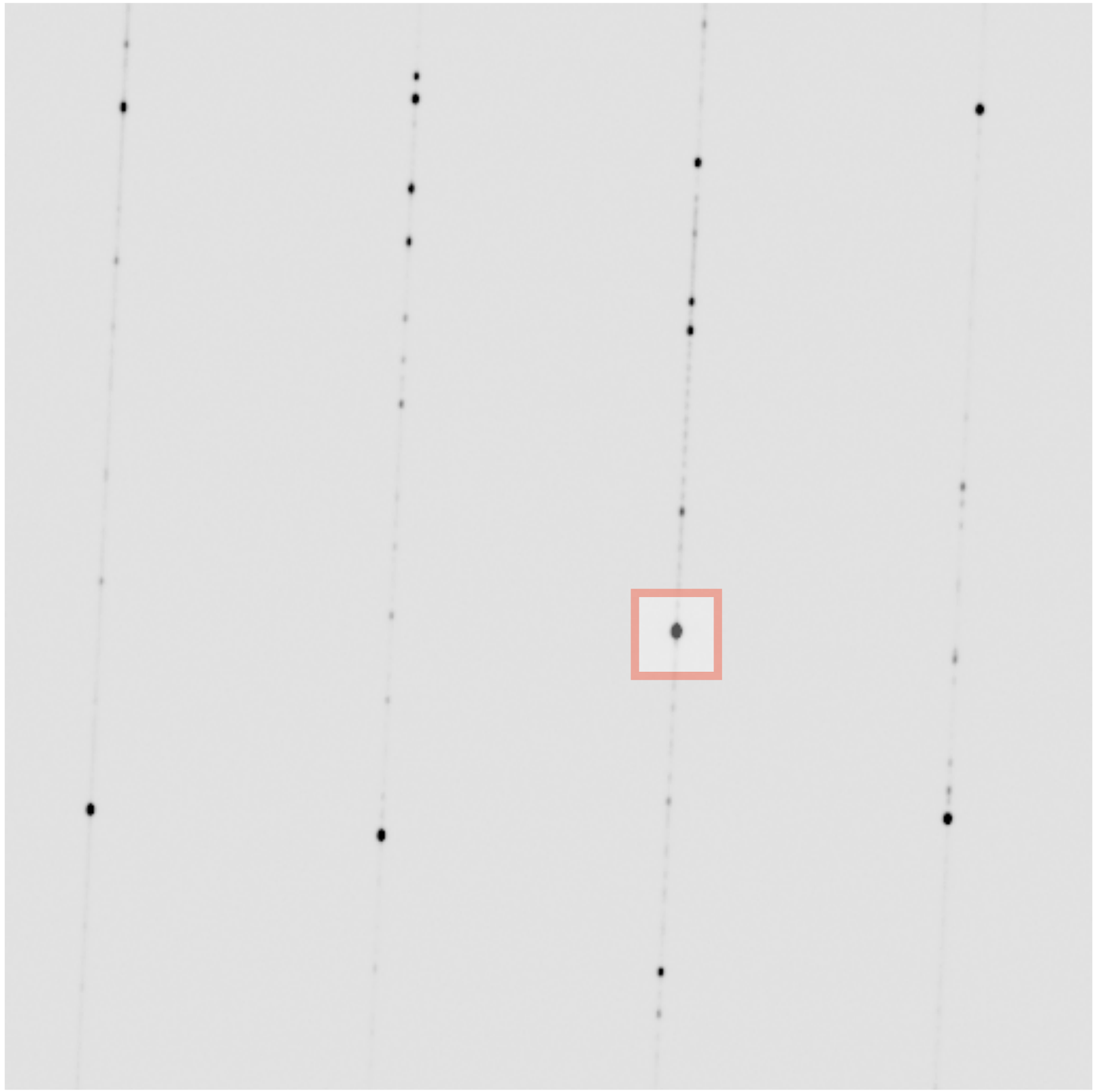
Calibration unit



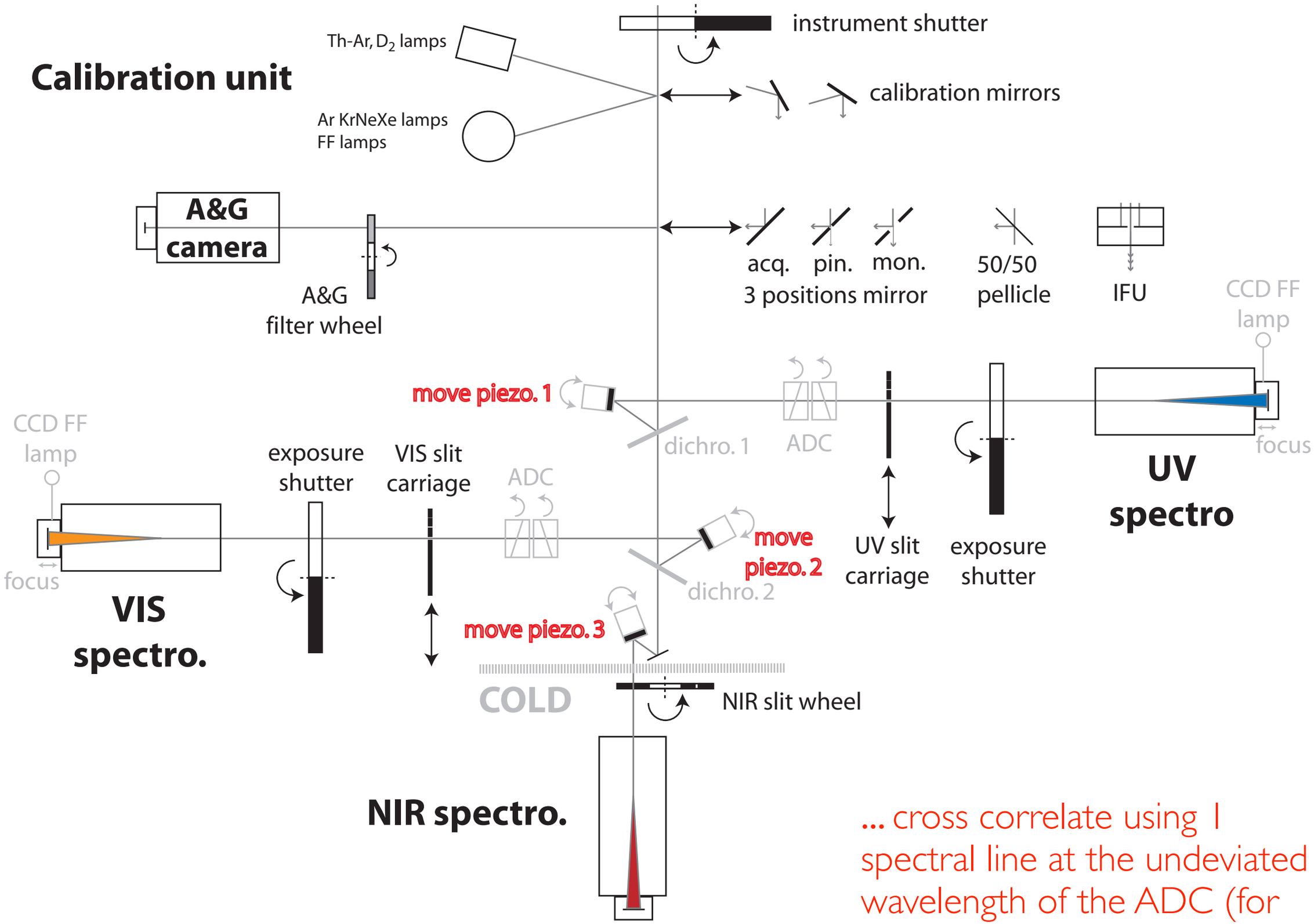
3x Frame2 UVB, VIS, NIR



3x
Frame I
UVB, VIS,
NIR

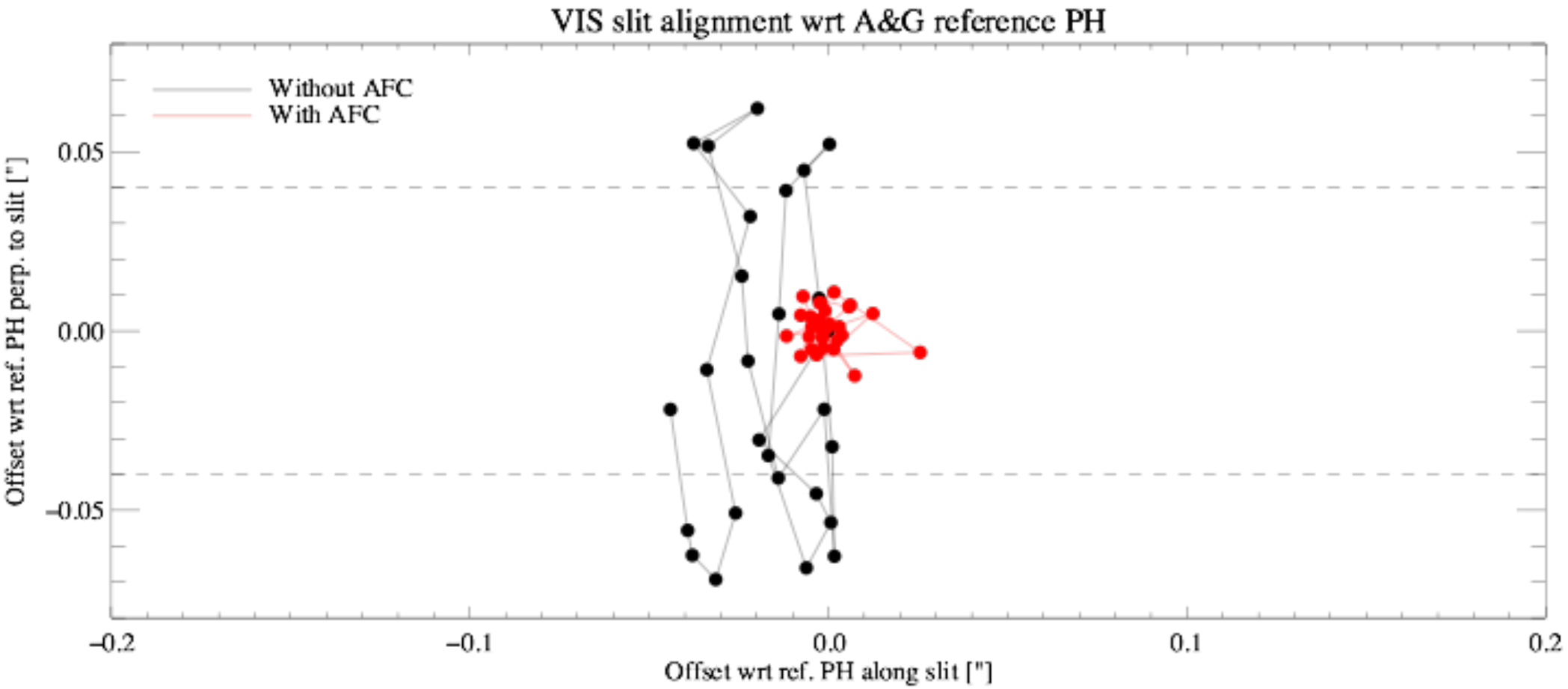


Calibration unit



... cross correlate using 1 spectral line at the undeviated wavelength of the ADC (for UVB and VIS)...

Active Flexure Compensation



Stability

- ☐ Before the slits (backbone flexures)
- ☐ After the slit
  - ☐ spectrograph flexures
  - ☐ (thermal effects - DRS model)

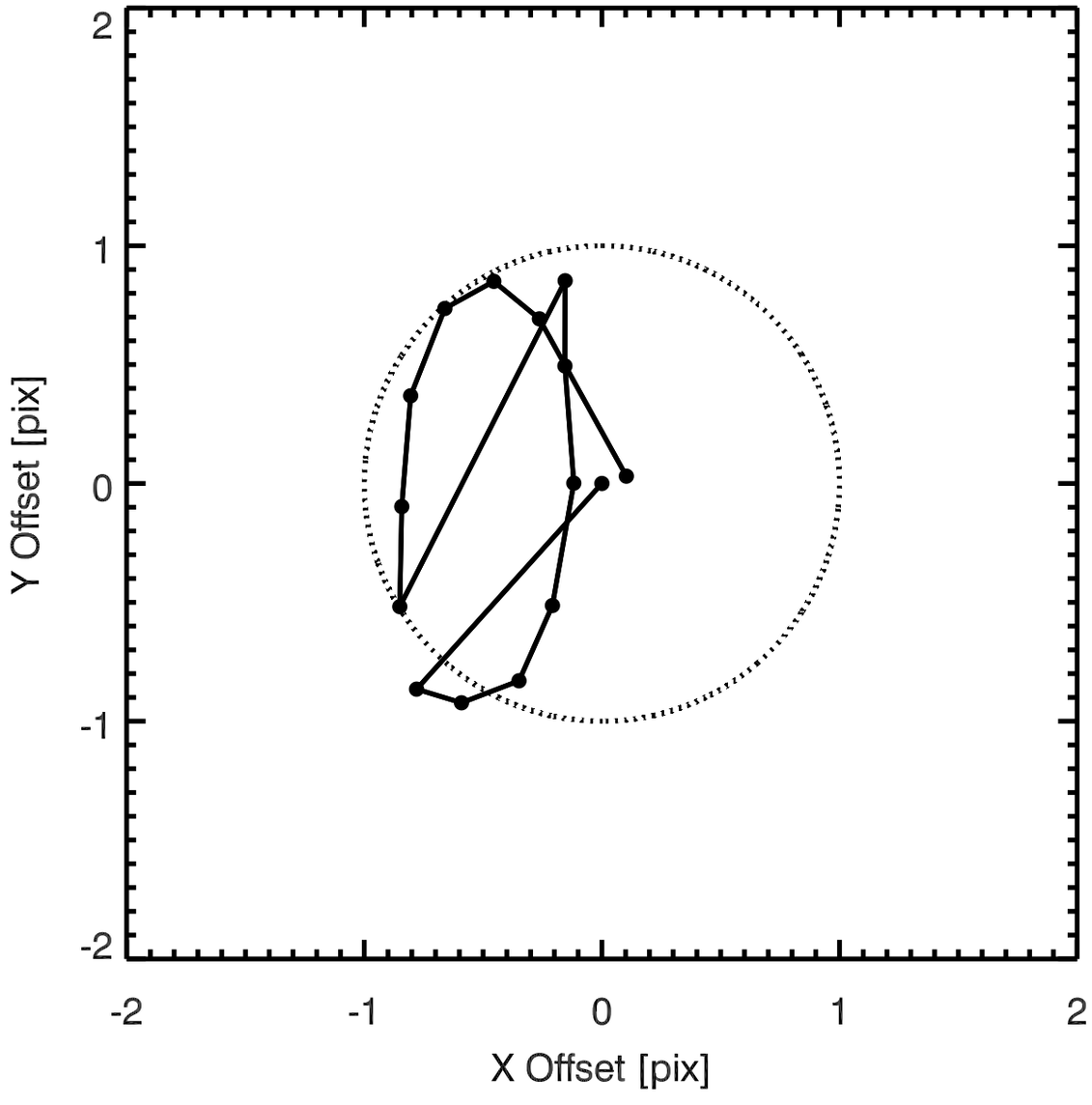
Spectral format stability

Flexures will never be 0 at Cassegrain but has to be kept to a minimum

- Has direct implications on the accuracy of the wavelength calibration
- ... on the flat-fielding
- ... and on the sky subtraction

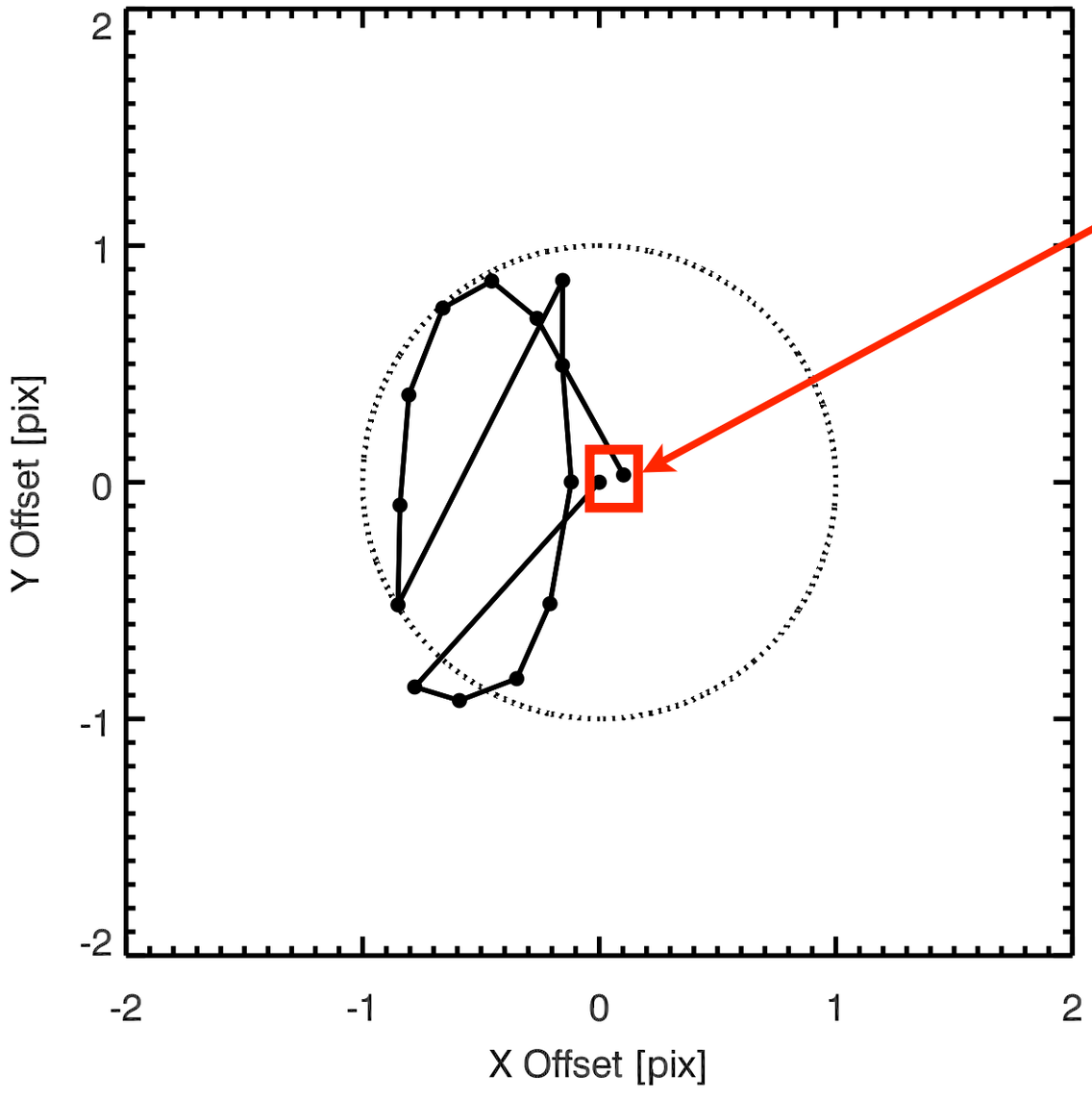
Spectrograph flexures (UVB/VIS)

Movement of the spectral format



Spectrograph flexures (UVB/VIS)

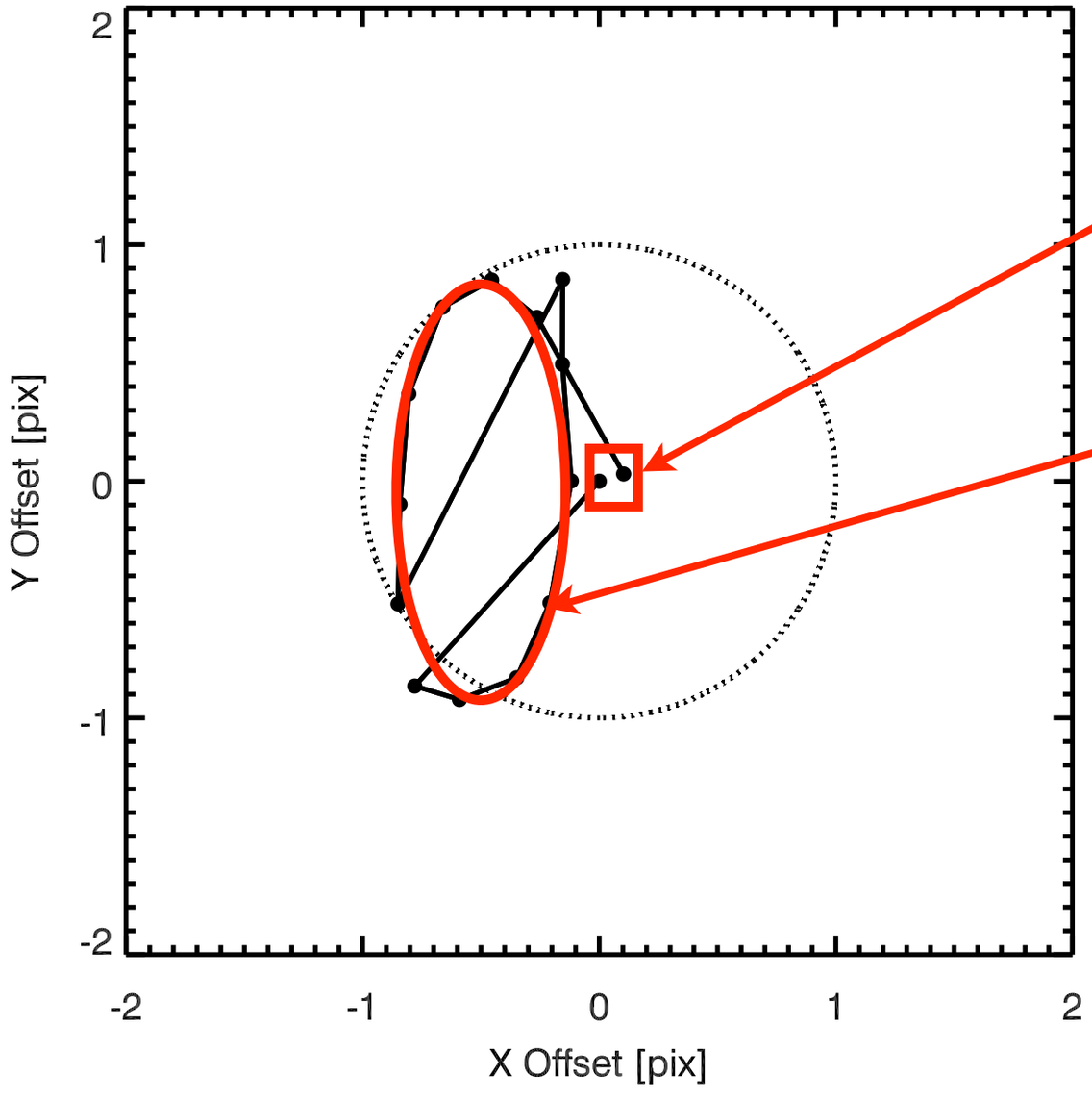
Movement of the spectral format



Daytime calibrations (zenith)

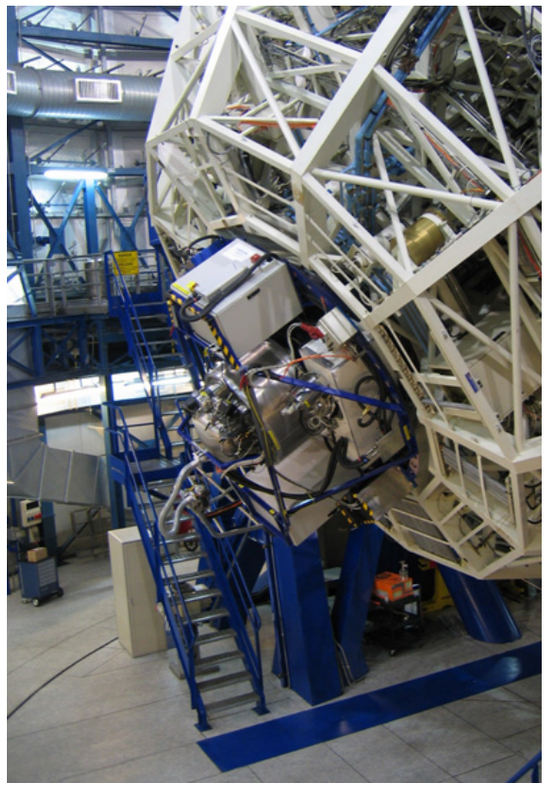
Spectrograph flexures (UVB/VIS)

Movement of the spectral format

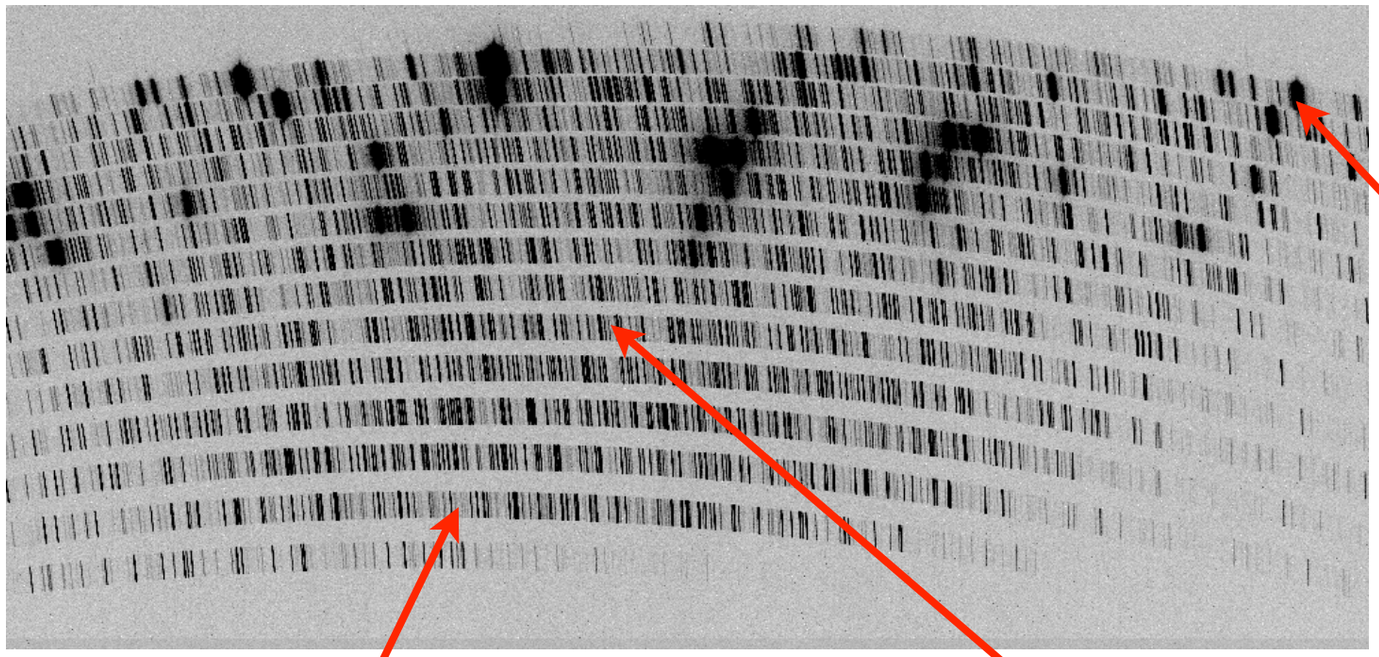


Daytime calibrations (zenith)

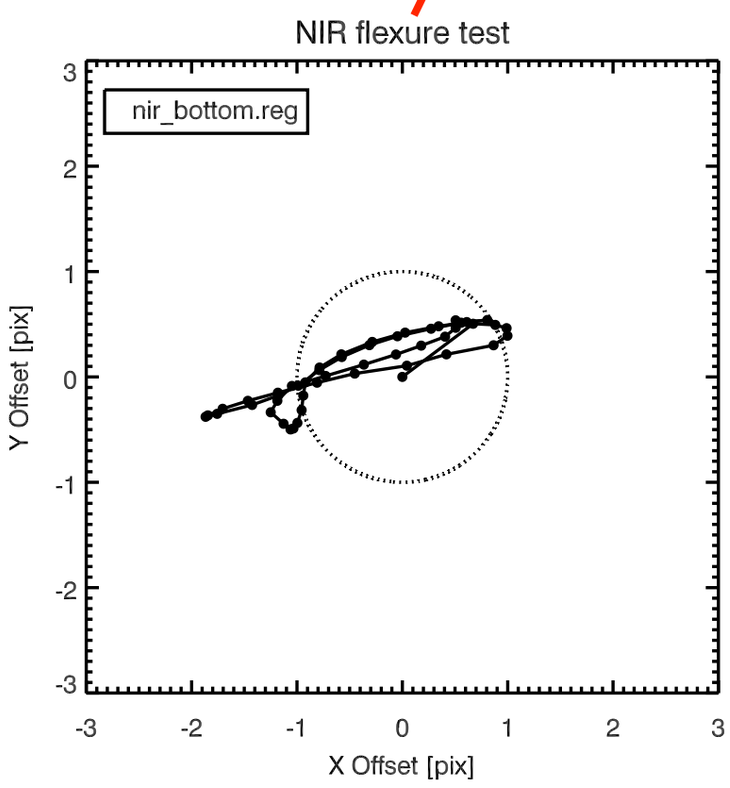
Full rotation at ZD=60°

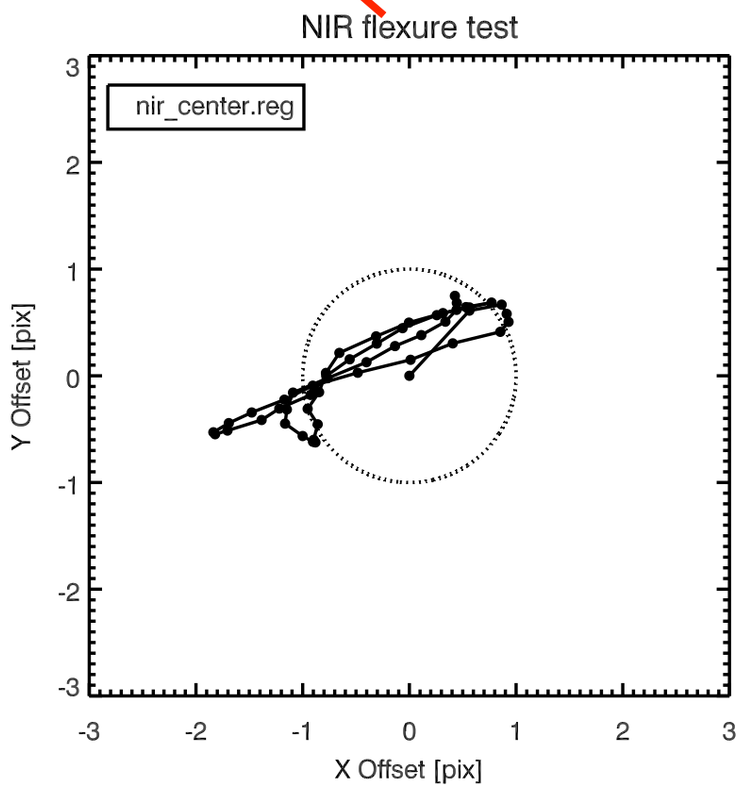


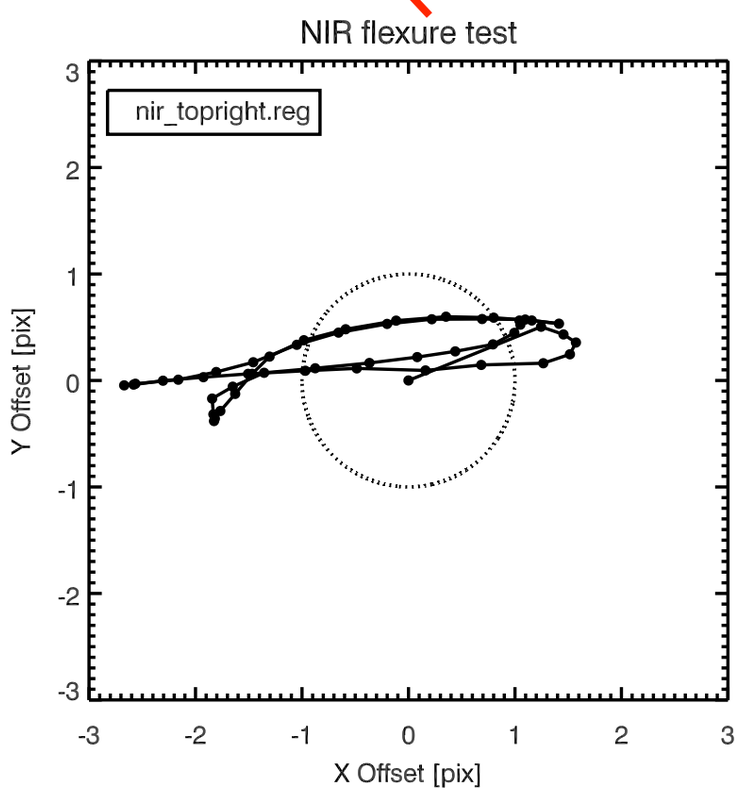
Spectrograph flexures



Shift is not rigid
(slight defocus)



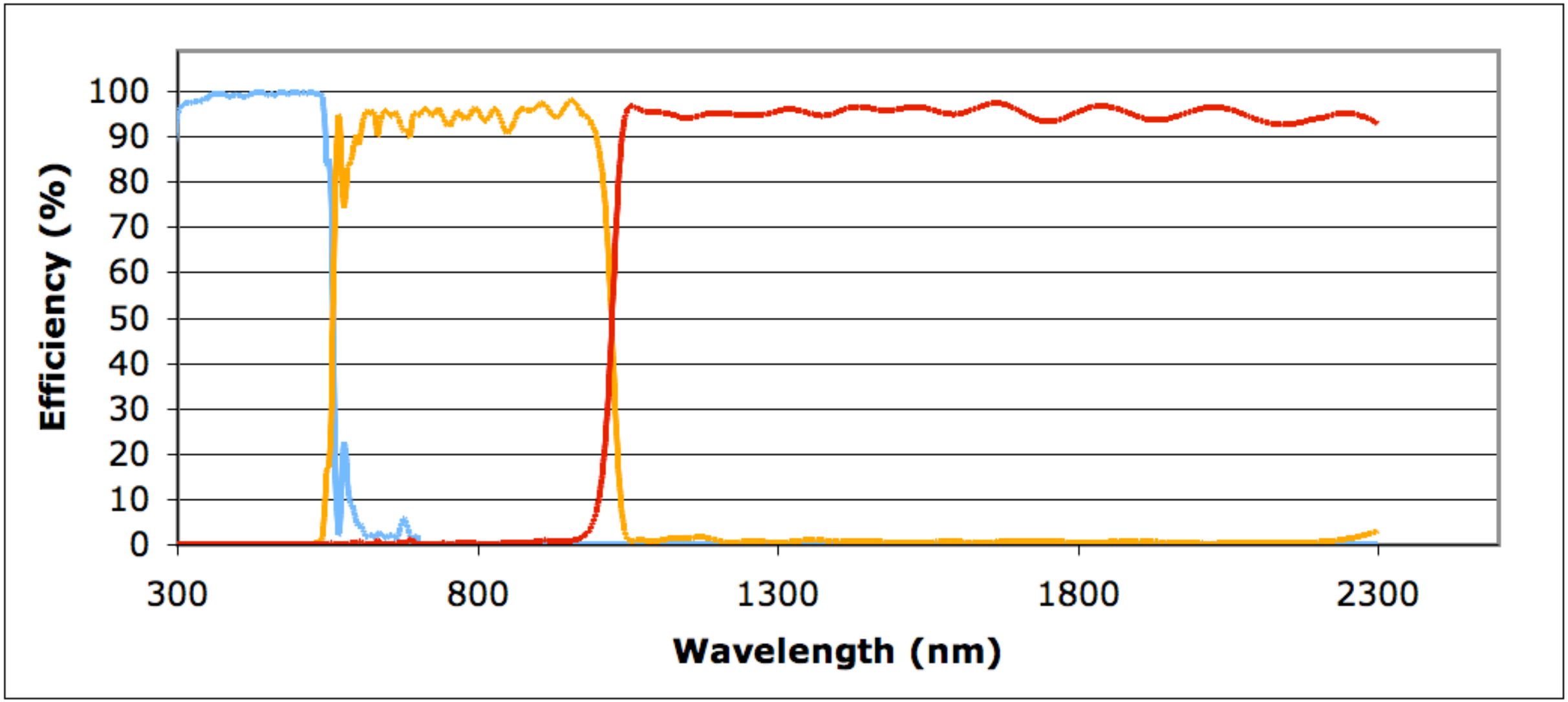




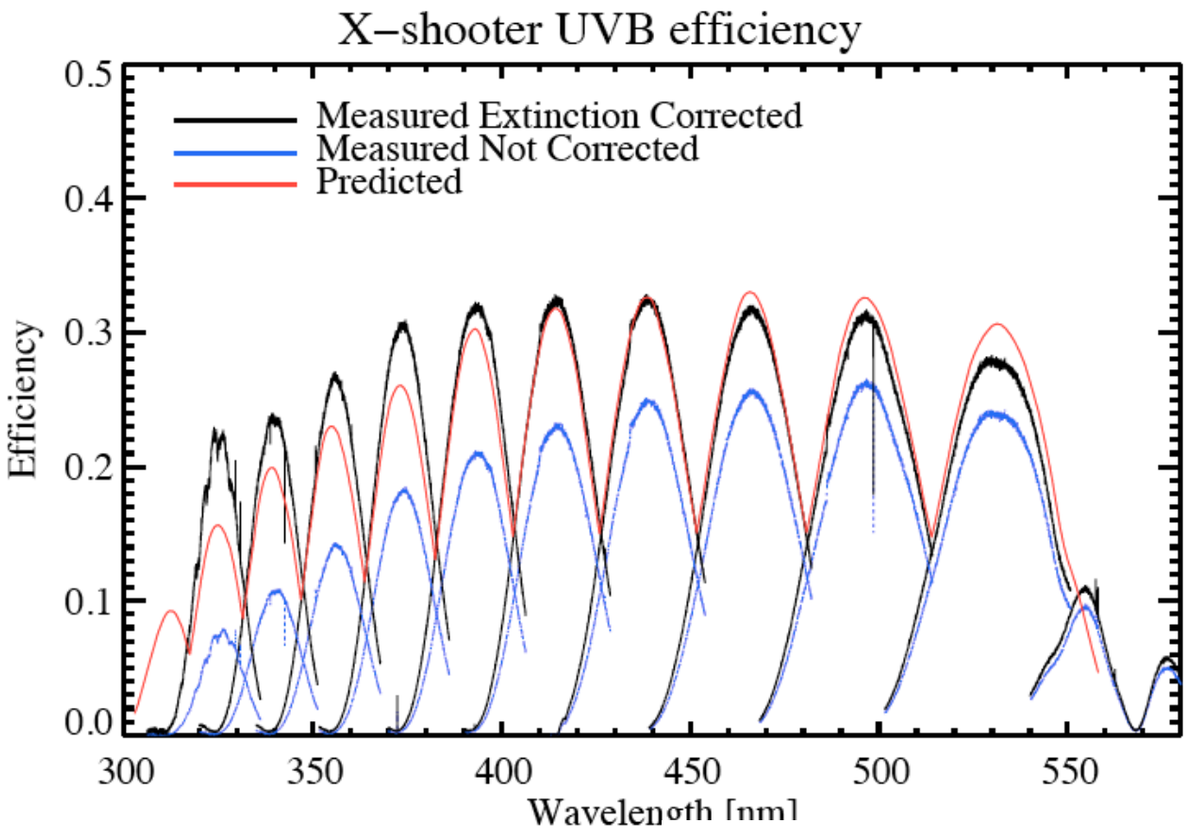
Performances of X-shooter

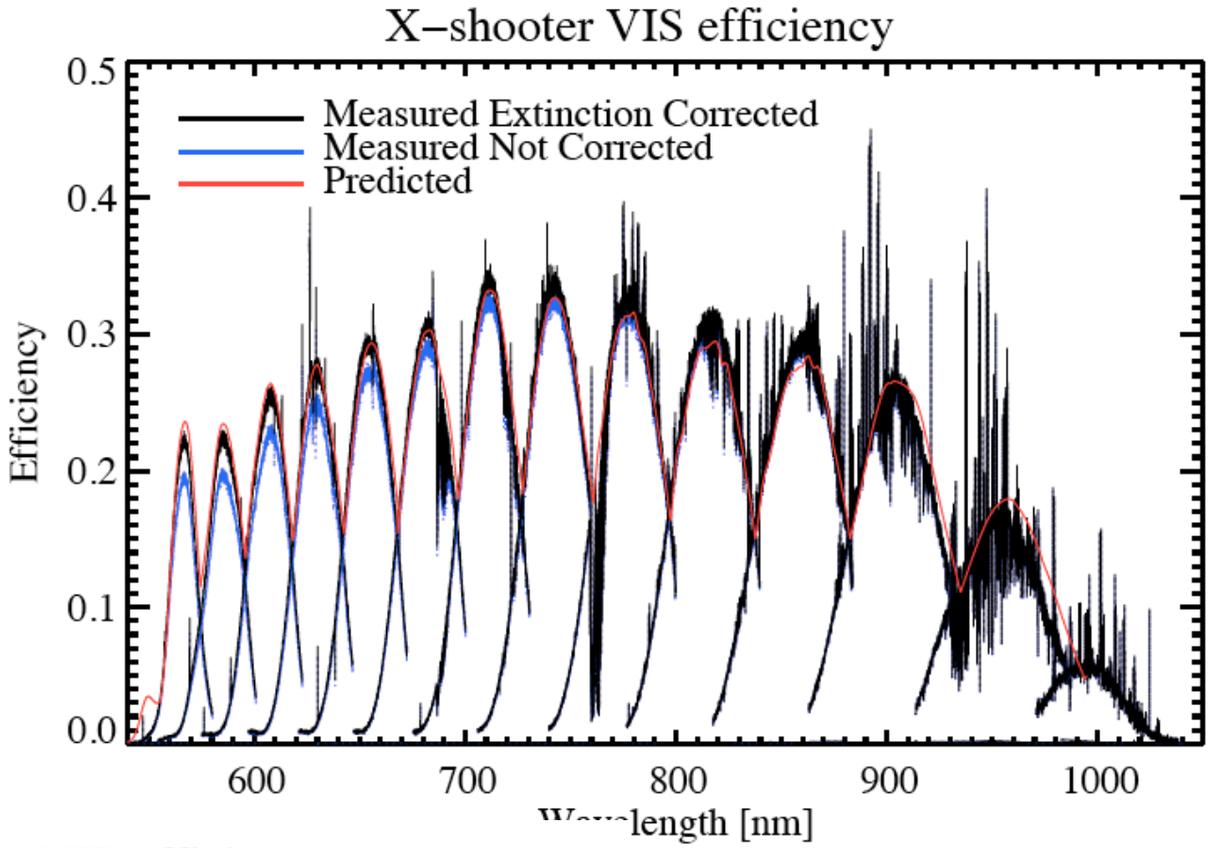
- Stability
- Throughput
- Background

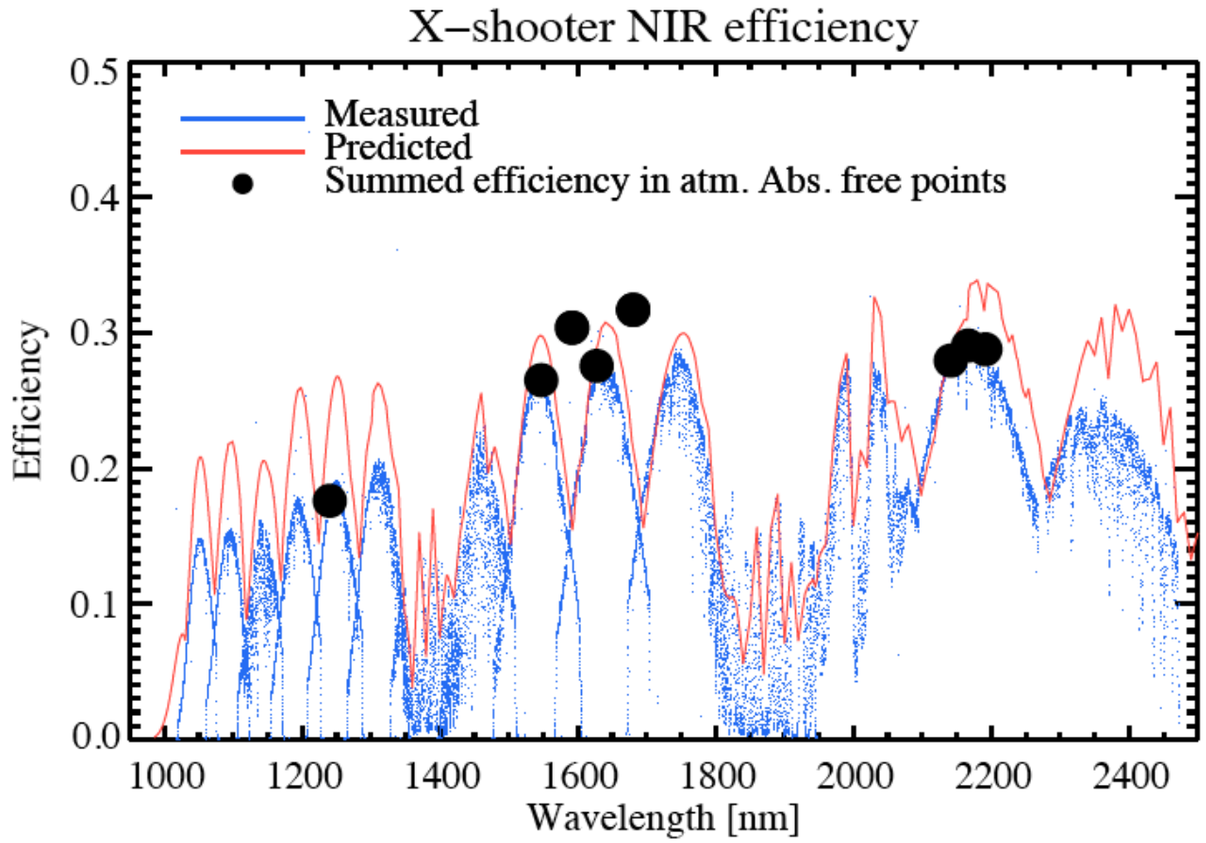
High efficiency dichroics



Efficiency


X−shooter UVB efficiency
Measured Extinction Corrected
Measured Not Corrected
Predicted
Efficiency
0.0
0.1
0.2
0.3
0.4
0.5
300
350
400
450
500
550
Wavelength [nm]


X−shooter VIS efficiency
Measured Extinction Corrected
Measured Not Corrected
Predicted
Efficiency
0.0
0.1
0.2
0.3
0.4
0.5
600
700
800
900
1000
Wavelength [nm]

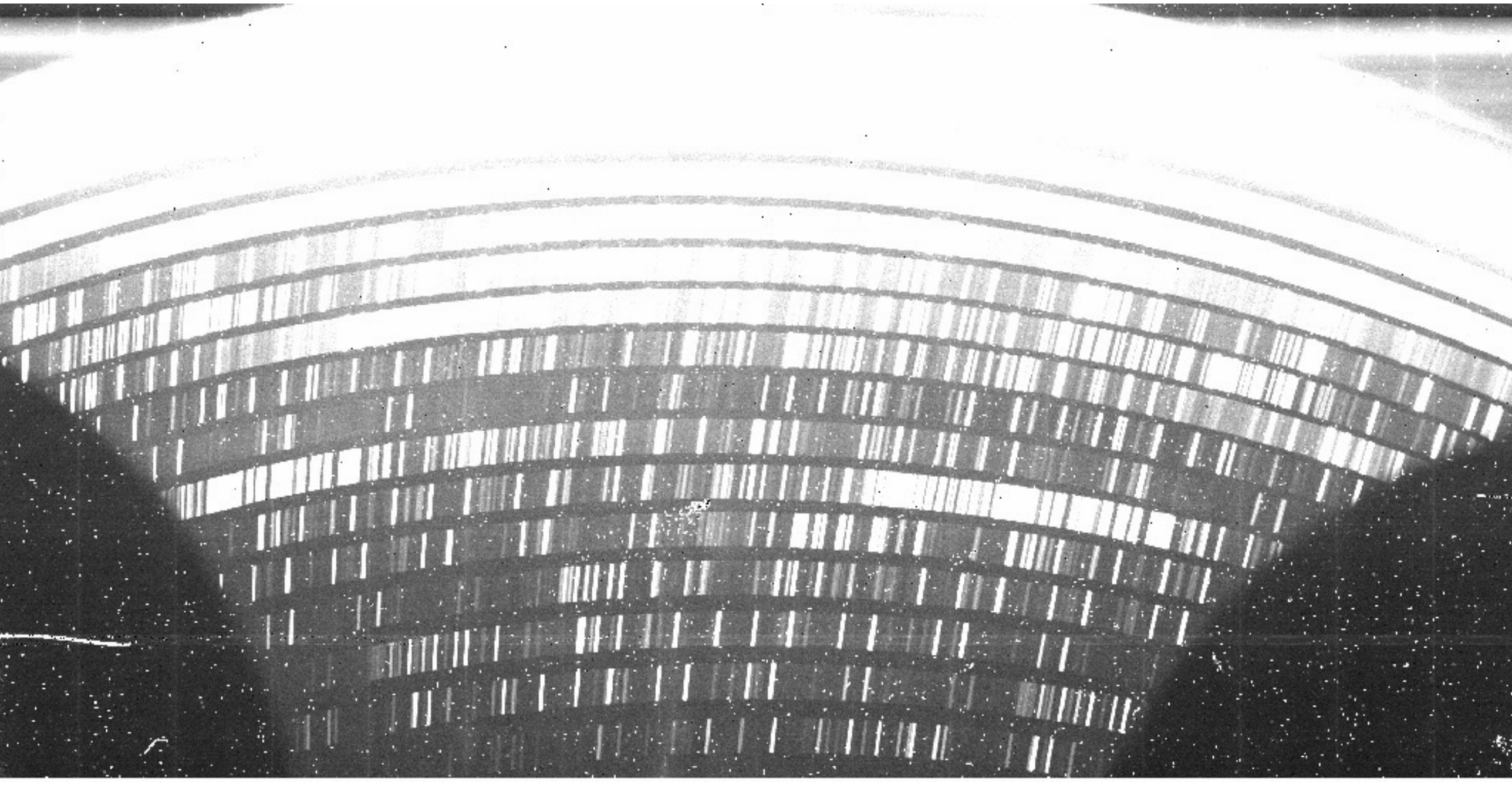

X−shooter NIR efficiency
Measured
Predicted
Summed efficiency in atm. Abs. free points
Efficiency
0.0
0.1
0.2
0.3
0.4
0.5
1000
1200
1400
1600
1800
2000
2200
2400
Wavelength [nm]

Performances of X-shooter

- Stability
- Throughput
- Near-IR Background

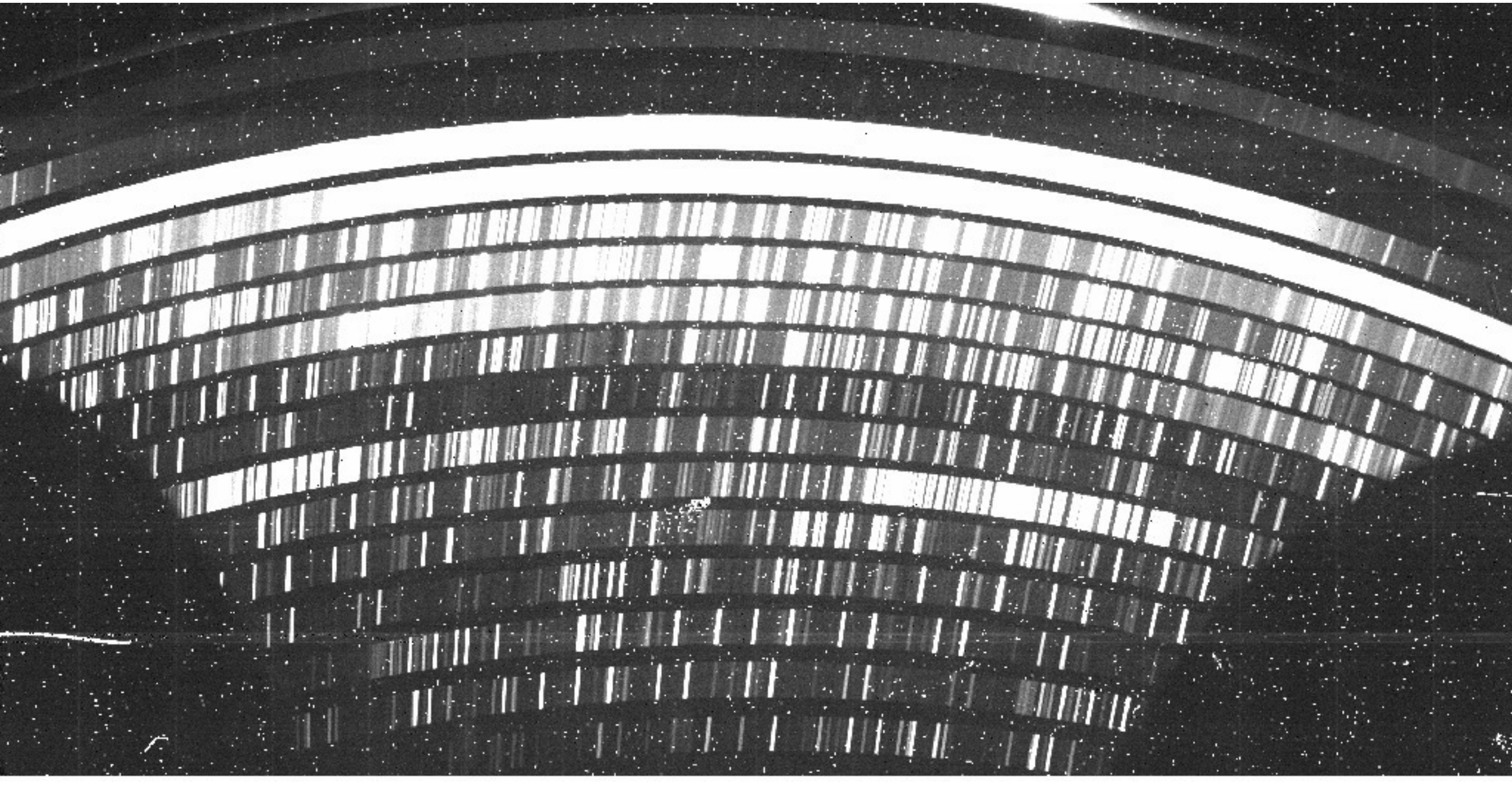
Background light in the NIR

NIR 0.9” slit

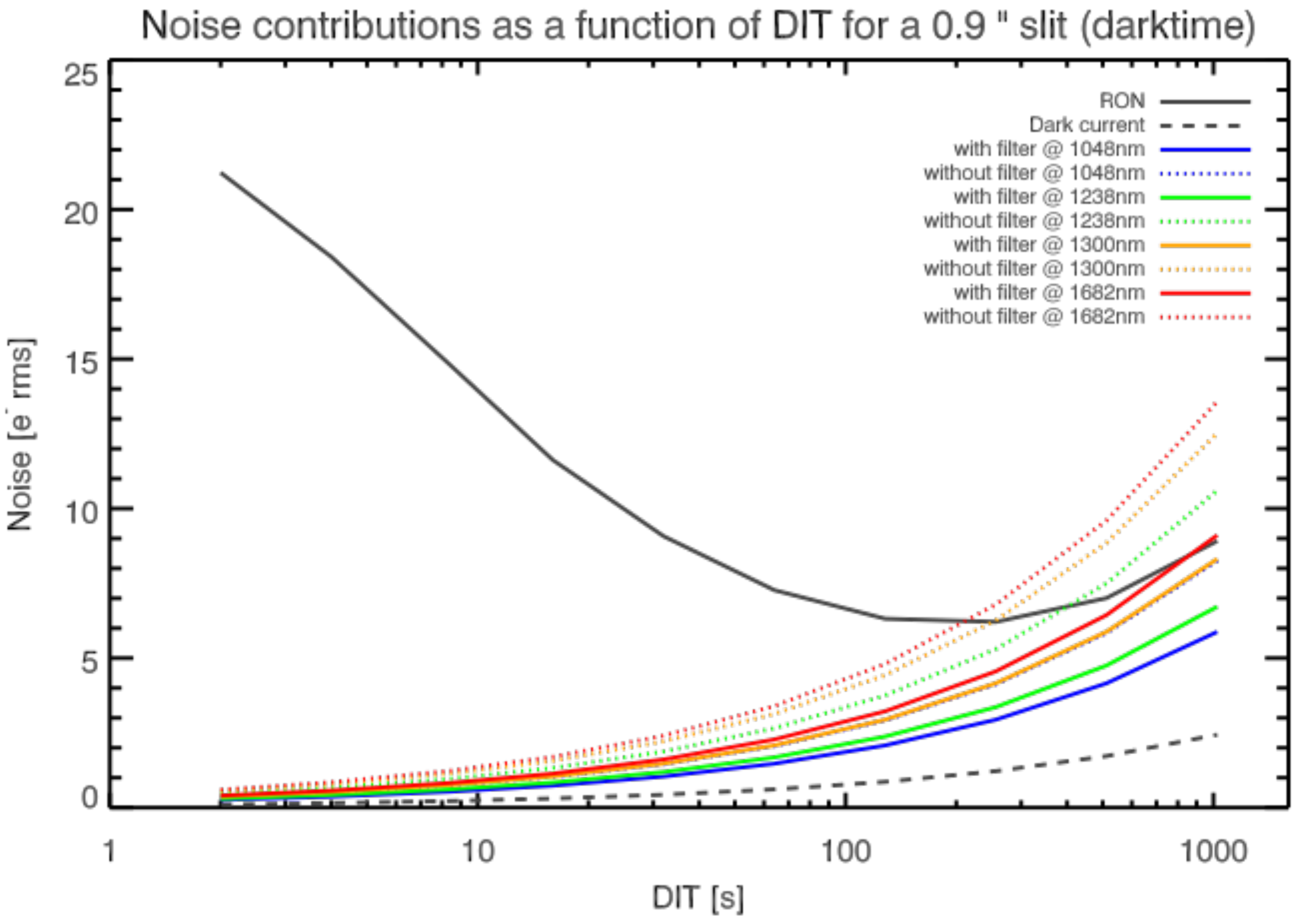


Background light in the NIR

NIR 0.9” slit + K band blocking



Background light in the NIR



Key points

- unprecedented simultaneous wavelength coverage
- very well chosen intermediate resolution for wide range of applications
- high overall efficiency
- easy to use. point & shoot.
- ... and very popular