Geometric Optical simulation for AuxTel

Beamfour results for Hologram and Ronchi

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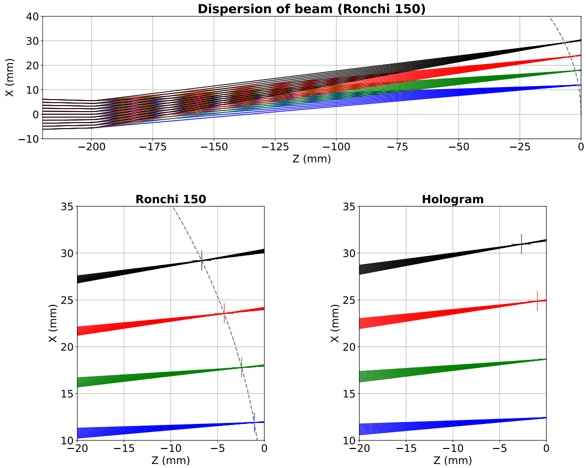
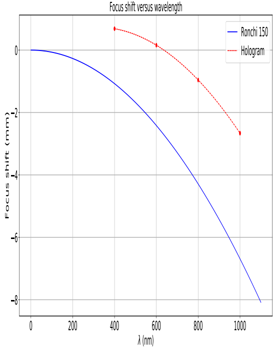
Experimental Setup

Simulated with Beamfour

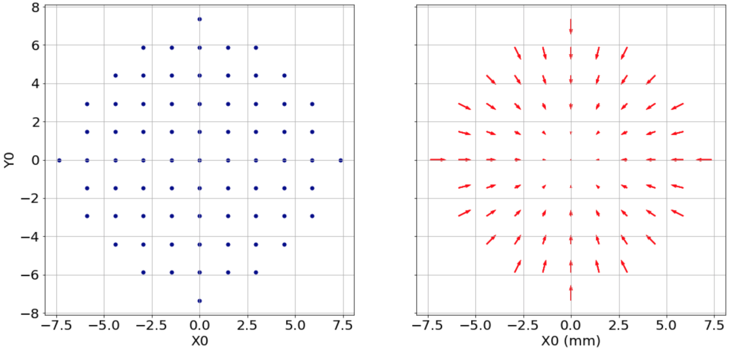
Converging beam on a disperser.





Injection of rays in Beamfour

Converging beam



- left : rays at first surface before ray tracing
- right : cosinus director of rays before ray tracing
- telescope focal length : $f_t = 21.6\mathrm{m}$
- telescope diameter : $D_t = 1.2\mathrm{m}$
- plate scale : 10 arcsec / mm

Deflection angle

$$\sin\theta_r = \sin\theta_i + p\frac{\lambda}{a}$$

- θ_i : incident angle
- θ_r : deflection angle
- p : diffraction order
- a : groove spacing

all variables having the same unit (say mm or microns).

At zero incident angle

$$\sin\theta_i = 0$$

$$\sin\theta_r = p\frac{\lambda}{a}$$

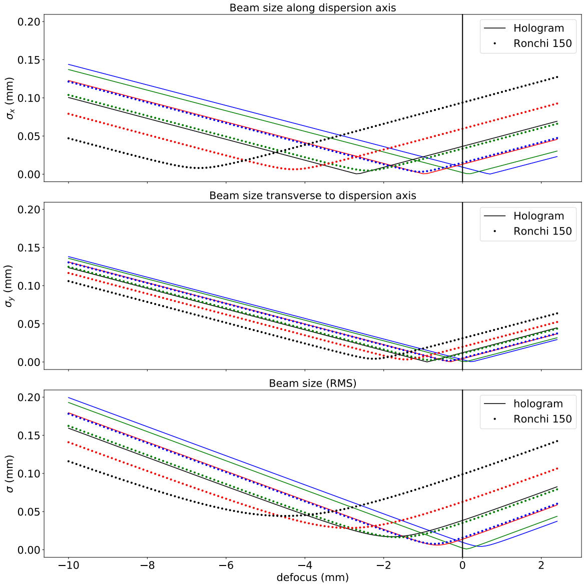
Defection at CCD plate

$$\frac{x}{D} = \frac{p\frac{\lambda}{a}}{\sqrt{1-\left(p\frac{\lambda}{a}\right)^2}}$$

- x : distance order 0 - order p on CCD plate
- D : distance disperser - CCD

Defocus in longitudinal and transverse axis

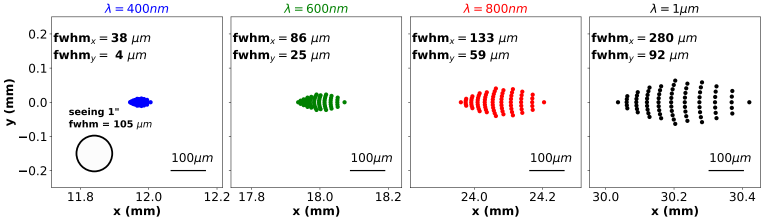
Simulated with Beamfour



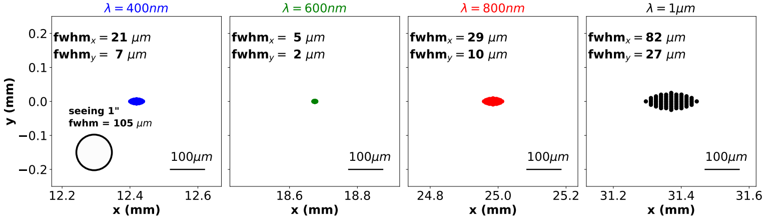
Beam spot diagram at focal plane

Simulated with Beamfour

Ronchi 150



Hologram

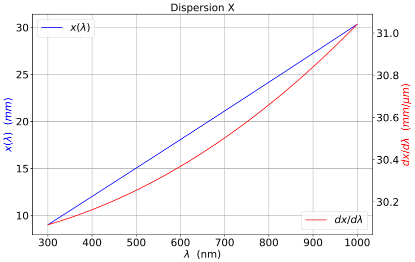


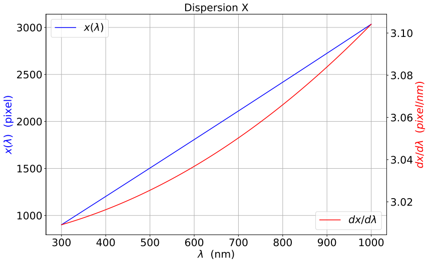
Formula to derive dispersion rate

Conversion of resolution in x into resolution in λ

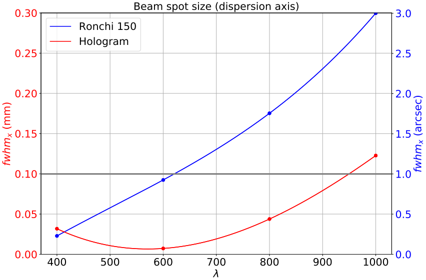
$$\frac{dx}{d\lambda} = \frac{\frac{D}{a}}{\left(1 - \left(\frac{\lambda}{a}\right)^2\right)^{\frac{3}{2}}}$$

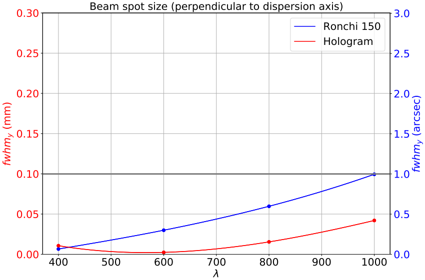
$$\sigma_\lambda = \frac{\sigma_x}{\left|\frac{dx}{d\lambda}\right|}$$

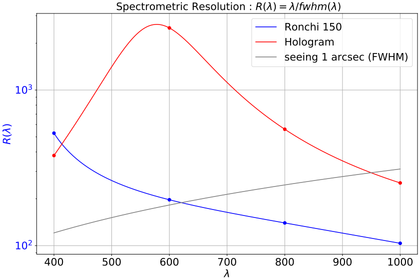




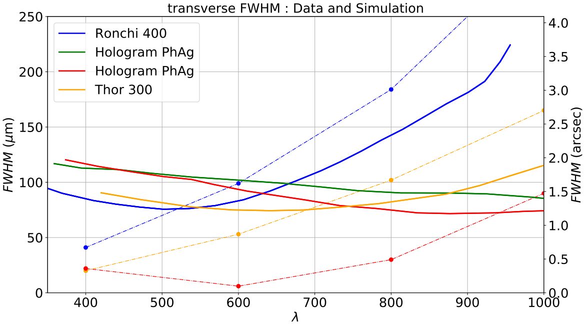
Disperser resolution







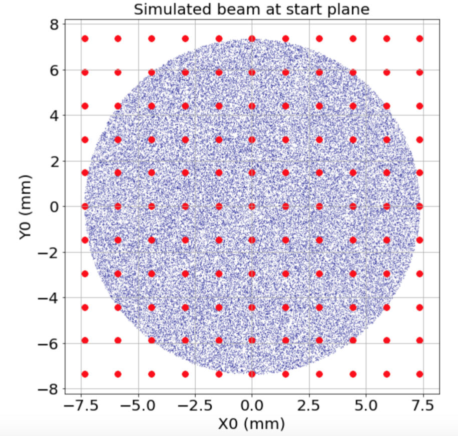
Disperser resolution : Example at CTIO



- solid line : data
- dashed line : geometric optical simulation.

- Transverse FWHM is measured in spectrogram 2D image (spectractor) before wavelength calibration,
- Moffat model parameters estimate ?
- Measured before the phase of wavelength calibration on 1D spectrum.
- CCD upstream the rue Focal Plane ?

Beam resampling

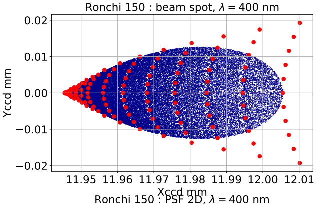


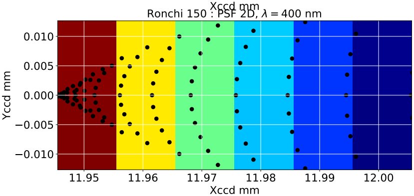
The resampled rays impact point on CCD surface is interpolated by a 2D bilinear function.

PSF2D

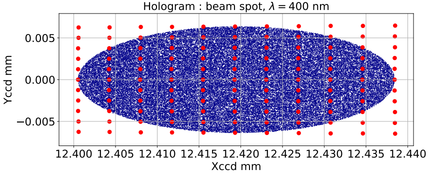
$\lambda = 400$ nm

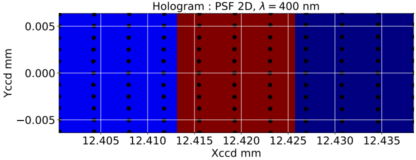
Ronchi 150





Hologram

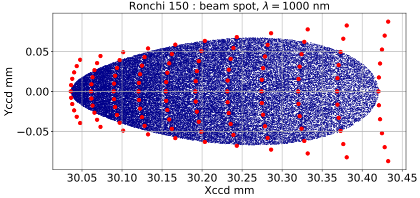


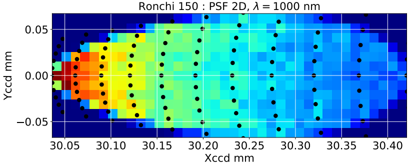


PSF2D

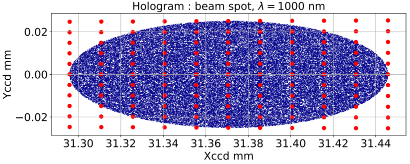
$\lambda = 1000$ nm

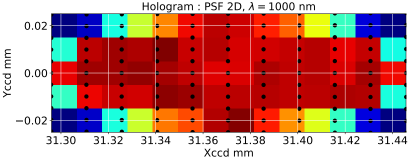
Ronchi 150



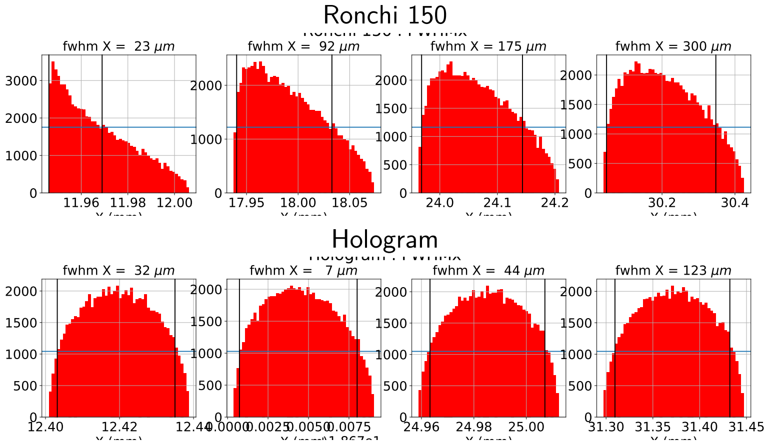


Hologram

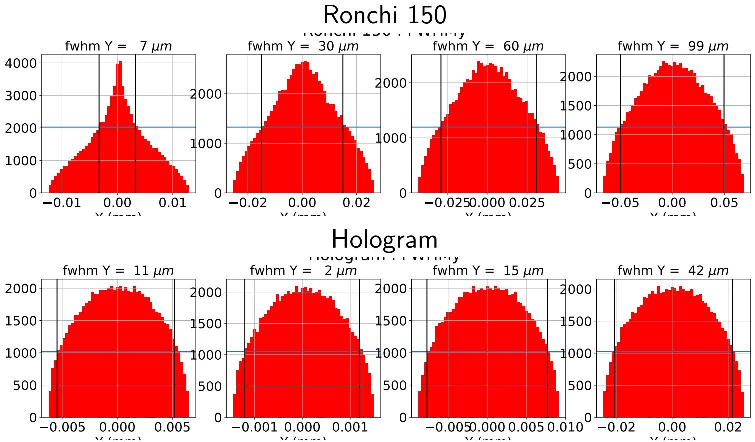




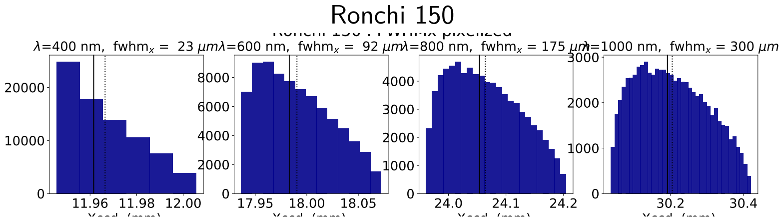
PSF1D(X)

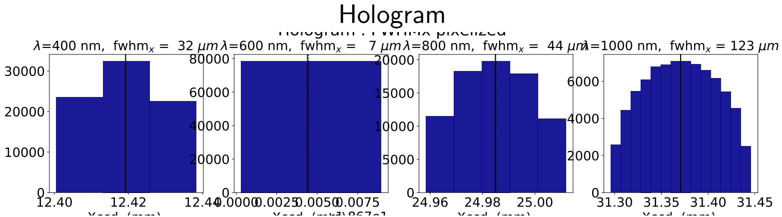

Ronchi 150
fwhm X = 23 μm
fwhm X = 92 μm
fwhm X = 175 μm
fwhm X = 300 μm
Hologram
fwhm X = 32 μm
fwhm X = 7 μm
fwhm X = 44 μm
fwhm X = 123 μm

PSF1D(Y)

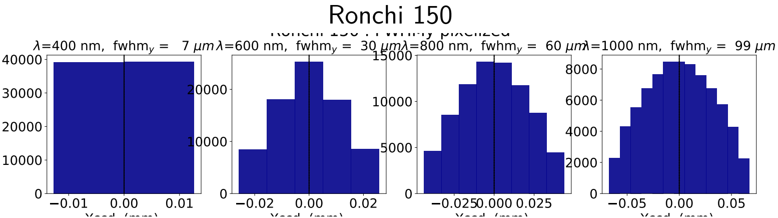


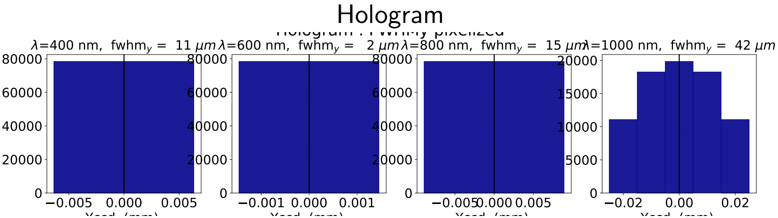
Ronchi 150
fwhm Y = 7 μm
fwhm Y = 30 μm
fwhm Y = 60 μm
fwhm Y = 99 μm
Hologram
fwhm Y = 11 μm
fwhm Y = 2 μm
fwhm Y = 15 μm
fwhm Y = 42 μm


Ronchi 150
λ=400 nm, fwhm$_x$ = 23 μm
λ=600 nm, fwhm$_x$ = 92 μm
λ=800 nm, fwhm$_x$ = 175 μm
λ=1000 nm, fwhm$_x$ = 300 μm
20000
10000
0
11.96
11.98
12.00
8000
6000
4000
2000
17.95
18.00
18.05
4000
3000
2000
1000
24.0
24.1
24.2
3000
2000
1000
30.2
30.4


Hologram
λ=400 nm, fwhm$_x$ = 32 μm
λ=600 nm, fwhm$_x$ = 7 μm
λ=800 nm, fwhm$_x$ = 44 μm
λ=1000 nm, fwhm$_x$ = 123 μm
30000
20000
10000
0
12.40
12.42
12.44
80000
60000
40000
20000
0.0000
0.0025
0.0050
0.0075
20000
15000
10000
5000
24.96
24.98
25.00
6000
4000
2000
31.30
31.35
31.40
31.45

PSF1D(Y) - Pixels





Fit : PSF1D(X) and PSF1D(Y)

Model of the compressed beam

- Beam aperture is circular upstream disperser,
- Beam aperture is ellipsoidal downstream hologram,
- Beam aperture is not downstream hologram,

Marginal distribution for PSF 1D (ellipsoid shape):

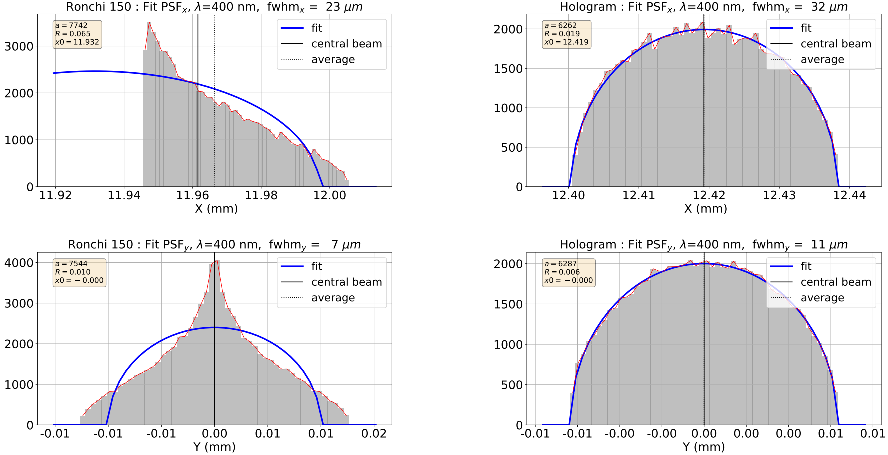
$$p(x)dx = \frac{1}{\pi R}\sqrt{1 - \left(\frac{x}{R}\right)^2}dx$$

- R : disk radius or ellipse semi-axis.

- With abberations, the beam aperture is no more ellipsoidal.

Fit : PSF1D(X) and PSF1D(Y)

$\lambda = 400$ nm



Fit PSF1D(X) and PSF1D(Y)

$\lambda = 1000$ nm