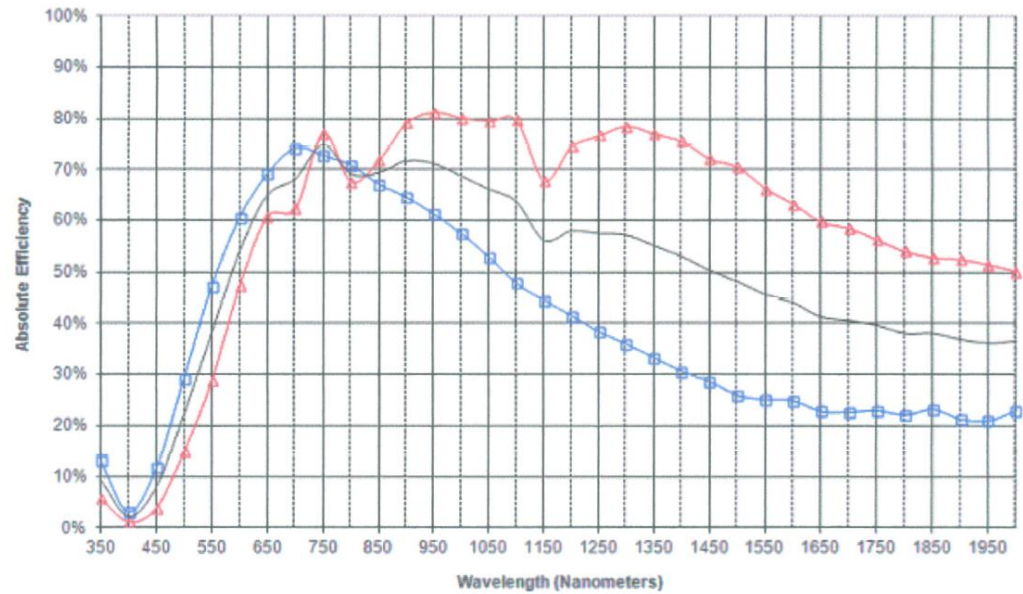
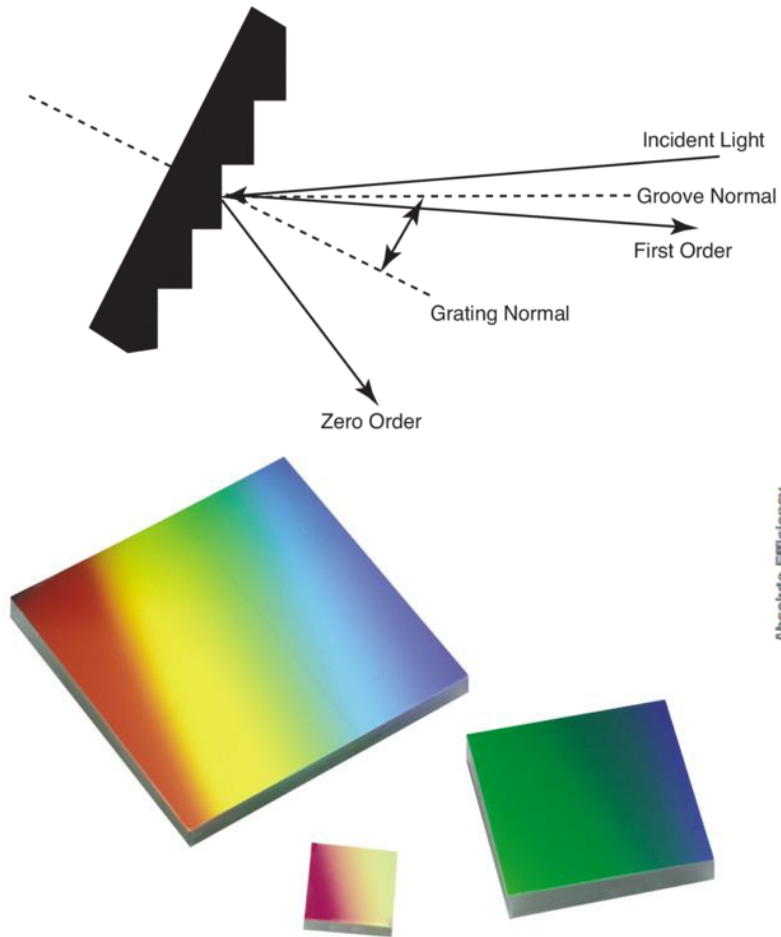


# 天体計測学特論 I Observational Astronomy I

## Lecture 08: Designing systems for spectroscopic observations

# Dispersing element (1)

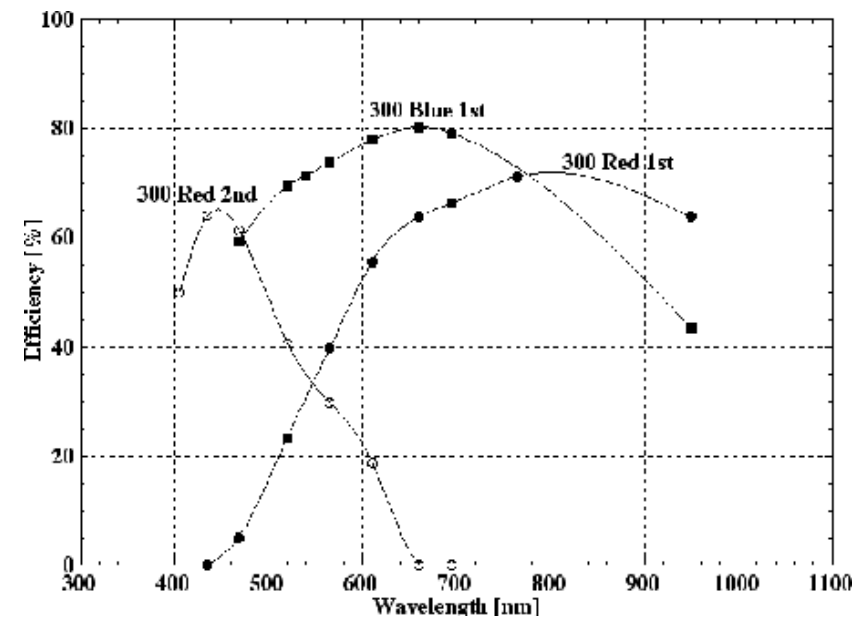
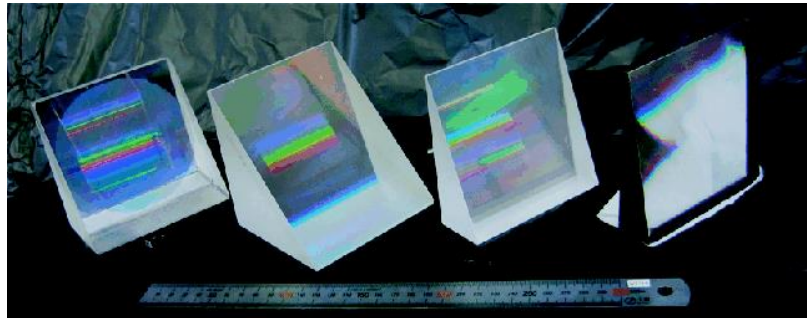
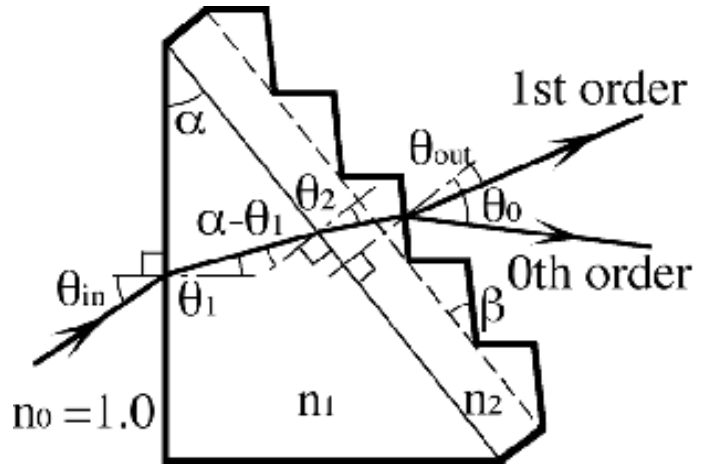
- Reflection grating



From Newport

# Dispersing element (2)

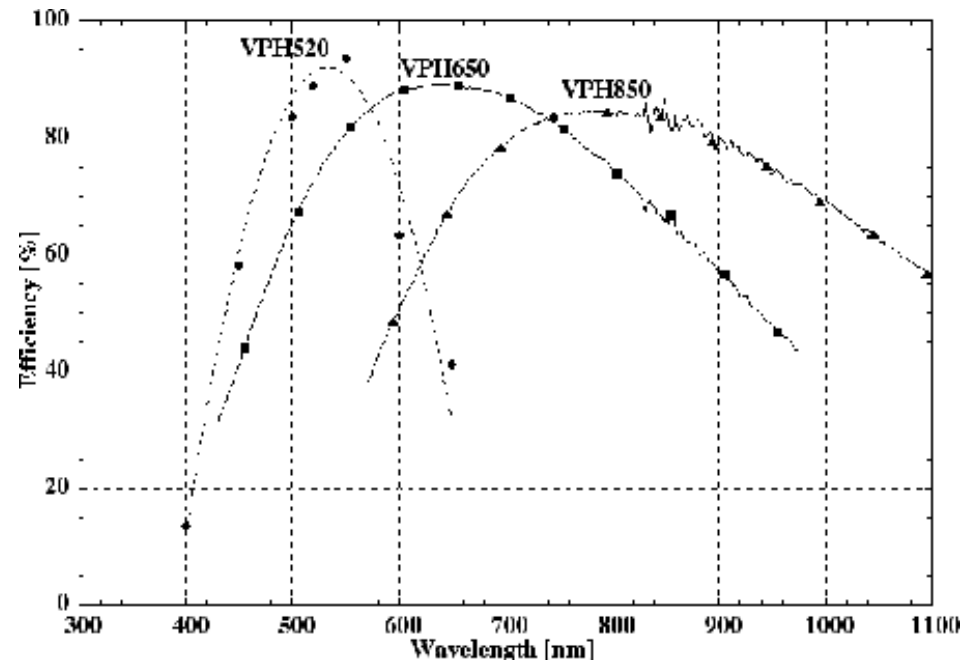
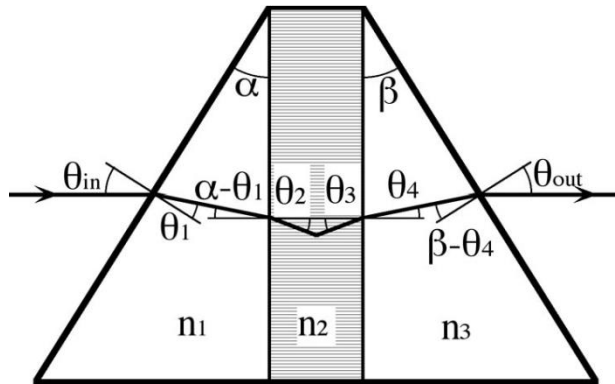
- Grism (for FOCAS)



Ebizuka et al. 2011

# Dispersing element (3)

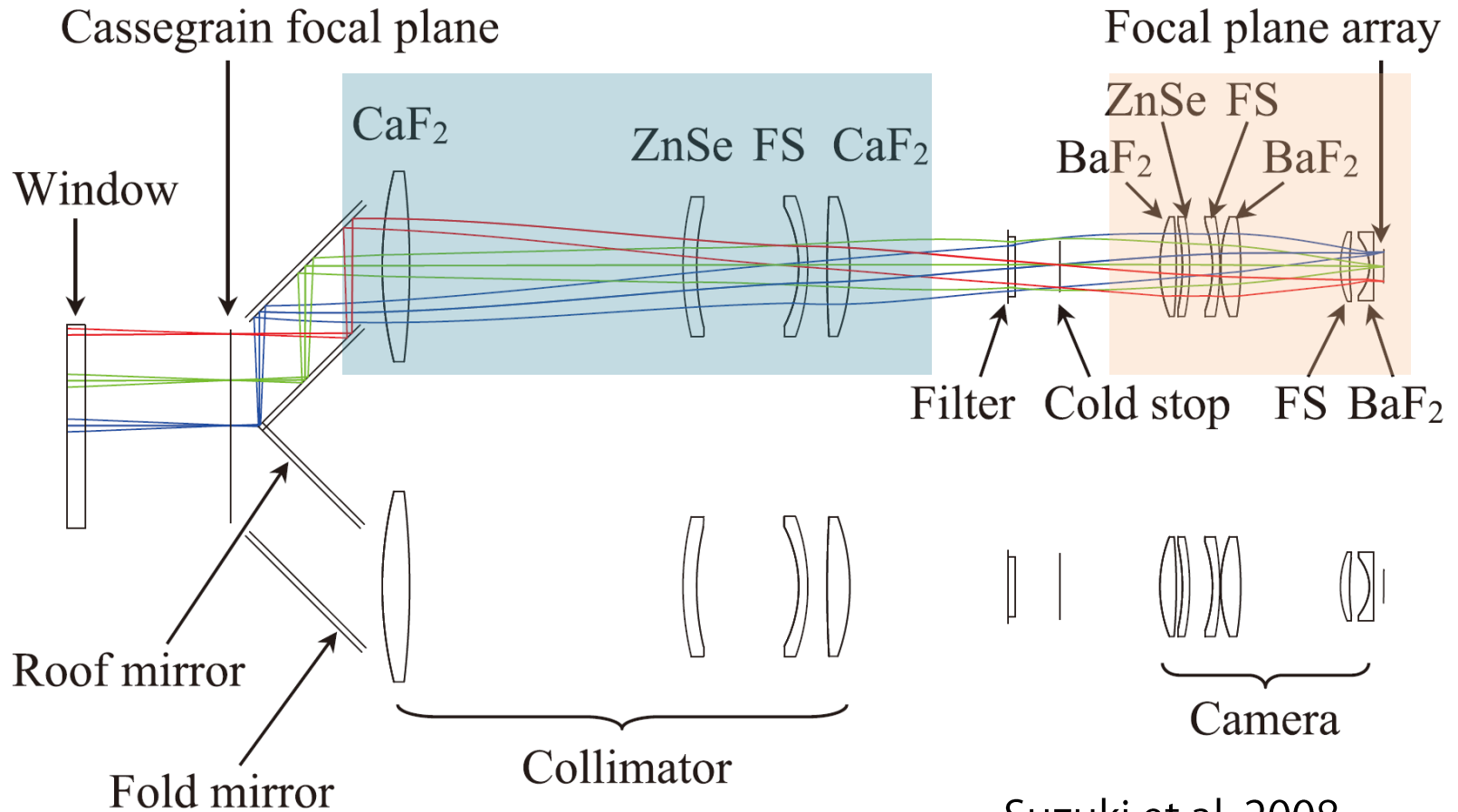
- VPH grating (for FOCAS) : High-throughput



Ebizuka et al. 2011

# Optical system for a spectrograph MOIRCS

- Grism (Grating, Prism) as a dispersion element.



Suzuki et al. 2008

# Optical system for a spectrograph

- Reflectin grating as a dispersion element.

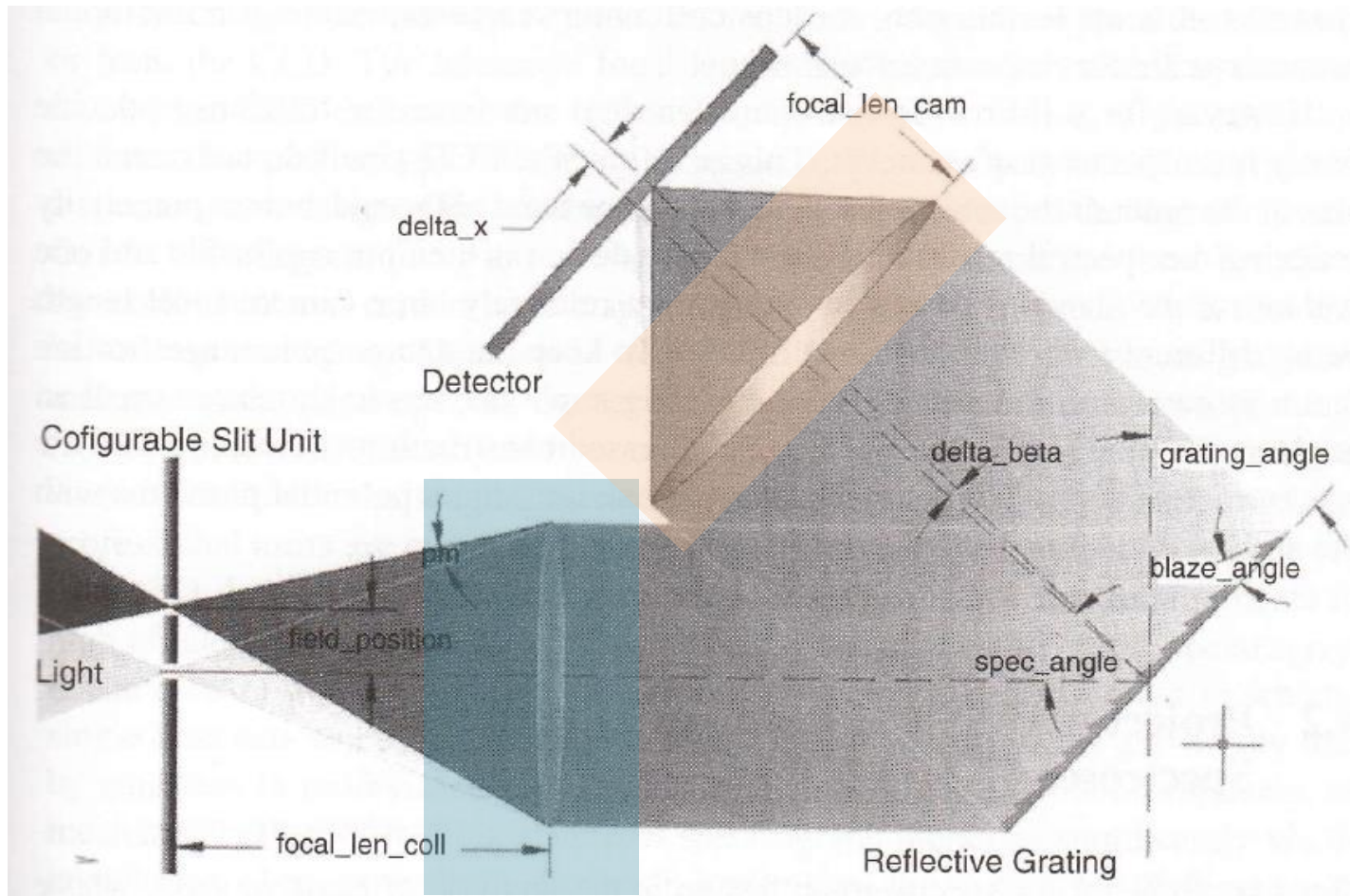
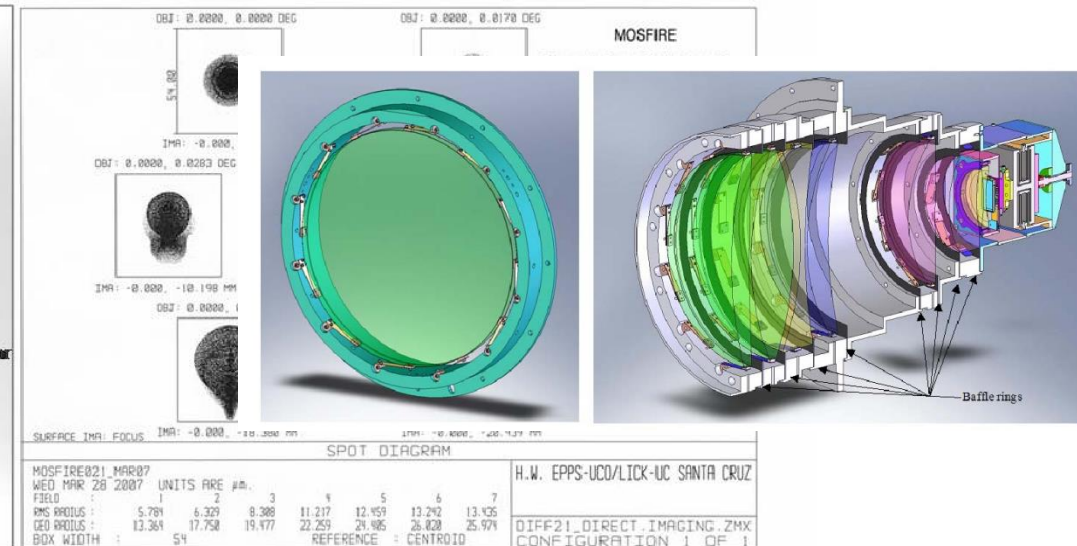
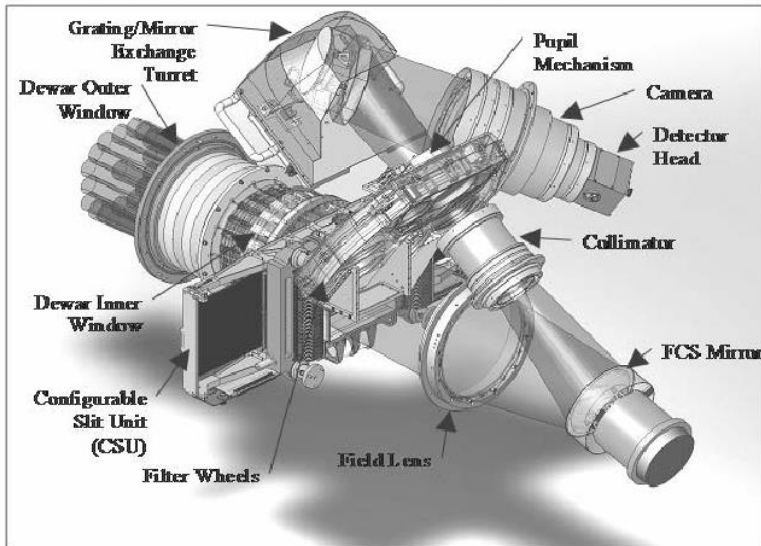
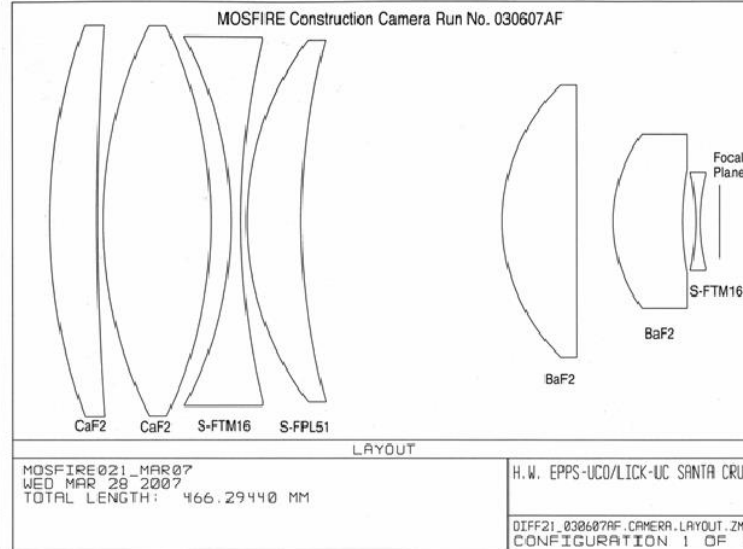
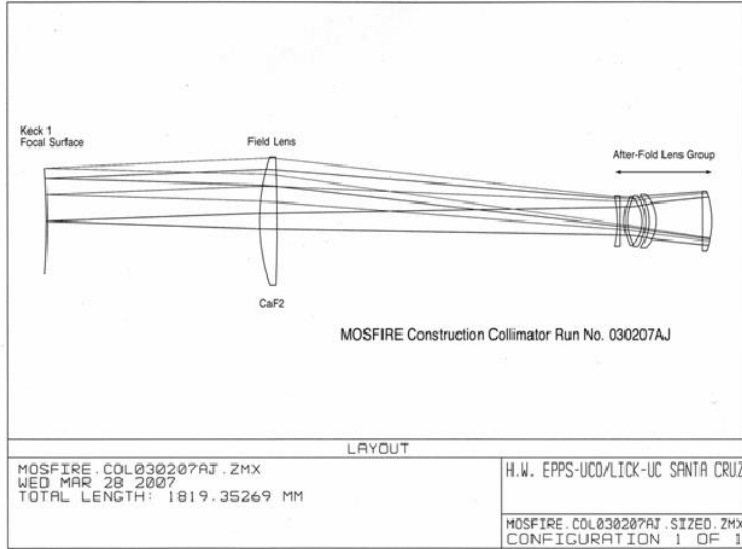


Fig. 4.12 Angles in a classical spectrograph

# Optical system for a spectrograph MOSFIRE

- Reflectin grating as a dispersion element.



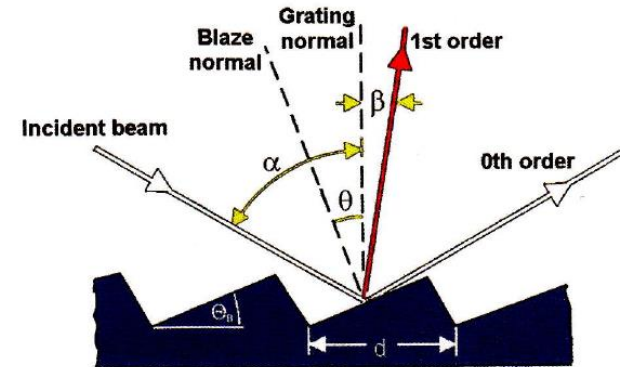
# Spectral resolution and sampling

- Spectral resolution, R :

- Grating equation and dispersion (n: order)

$$n \cdot \lambda = d(\sin \alpha + \sin \beta)$$

$$\frac{d\beta}{d\lambda} = \frac{n}{\cos \beta \cdot d}$$



Eversberg 2015

- Spectrograph diffraction-limited condition (size  $B = d \times N$ )

- Note: diffraction of the spectrograph optics : not telescope. (This is usually not the case.)

$$\Delta\beta = \frac{\lambda}{B} \quad R = \frac{\lambda}{\Delta\lambda} = \frac{N \cdot n}{\cos \beta}$$

- Image-size (“Seeing”/“Telescope-diffraction”)-limited condition

- image size  $d_{\text{image}}$  on the spectrograph detector,
- spectrograph camera focal length  $f_{\text{camera}}$

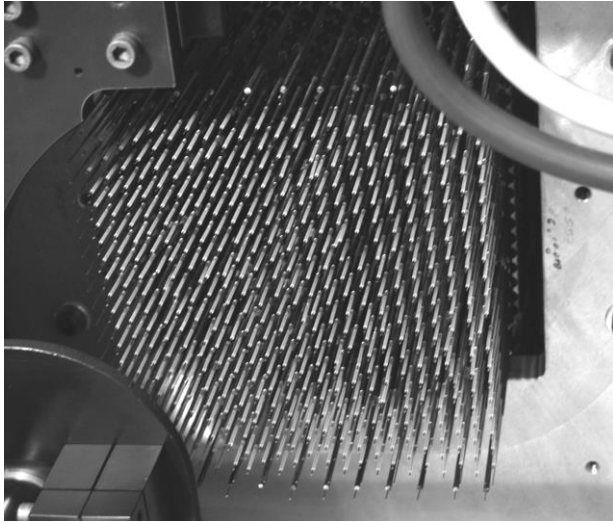
$$\Delta\beta = \frac{d_{\text{image}}}{f_{\text{camera}}} \quad R = \frac{\lambda}{\Delta\lambda} = \frac{f_{\text{camera}}}{d_{\text{image}}} \cdot \frac{\lambda n}{d} \cdot \frac{1}{\cos \beta}$$

- Sampling (nm/pix, A/pix)



# Multi-object spectrograph

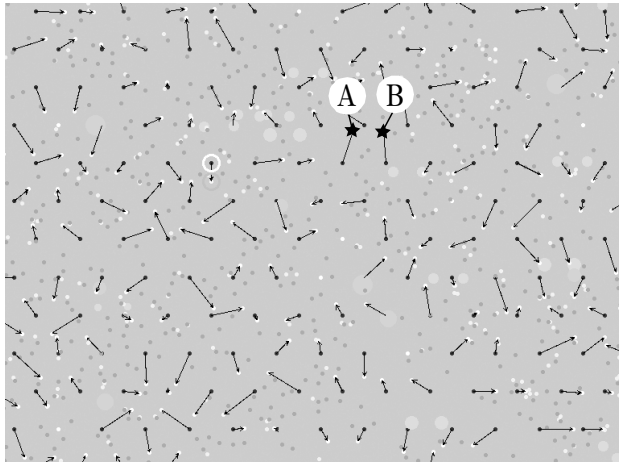
- Fiber (Subaru FMOS) vs. Slit masks (Subaru MOIRCS)



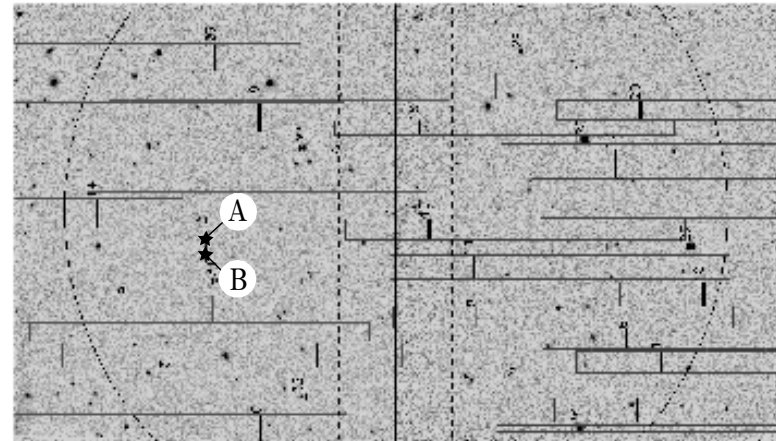
焦点面に取り付けられるファイバー配置機構



焦点面に取り付けられるスリットマスク



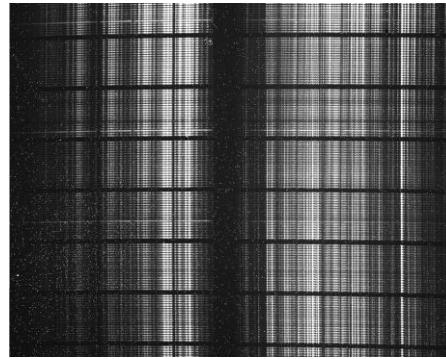
専用ソフトウェアによるファイバー配置(一部拡大)  
ファイバー多天体分光器 FMOS の観測例



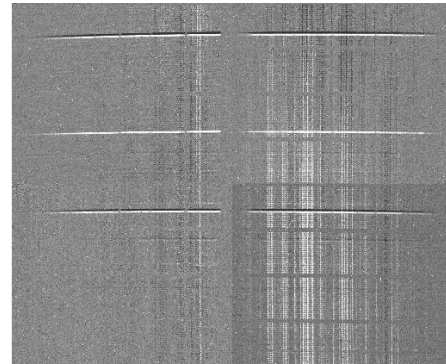
専用ソフトウェアによるスリット配置  
多スリット多天体分光器 MOIRCS の観測例

# Out put from MOS

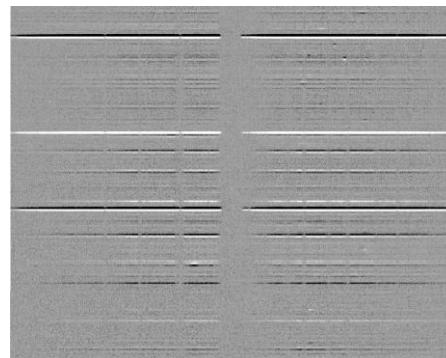
- Fiber (Subaru FMOS) vs. Slit masks (Subaru MOIRCS)



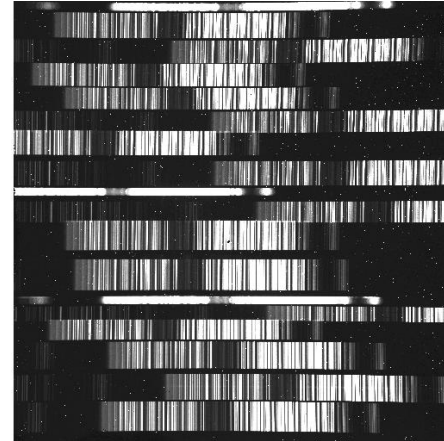
得られたスペクトル画像  
1分光器分一部拡大 15分間の積分



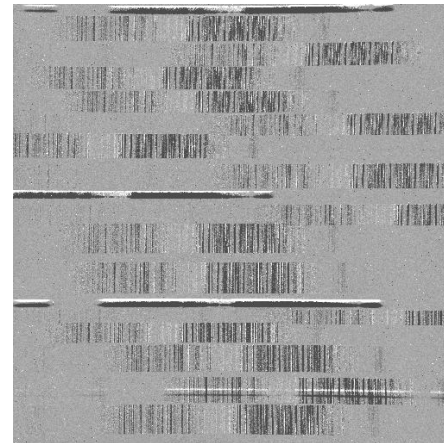
A-B の引き算画像



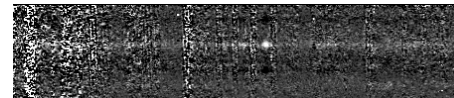
解析されたスペクトル 10時間の積分  
多スリット分光器 FMOS のデータ例



得られたスペクトル画像  
1チャンネル分 15分間の積分



A-B の引き算画像

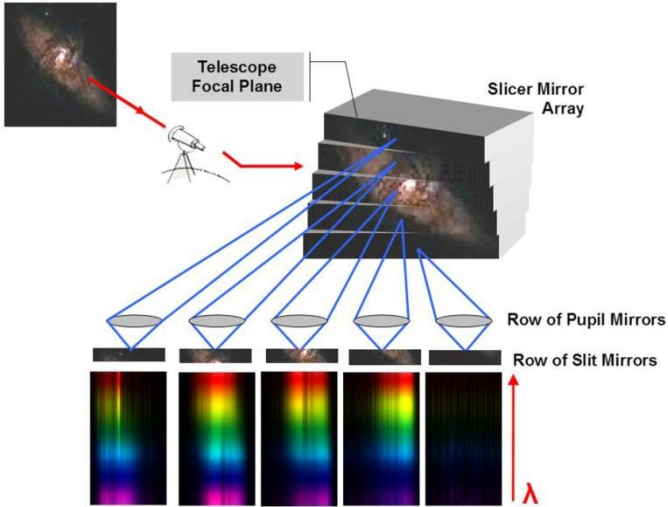
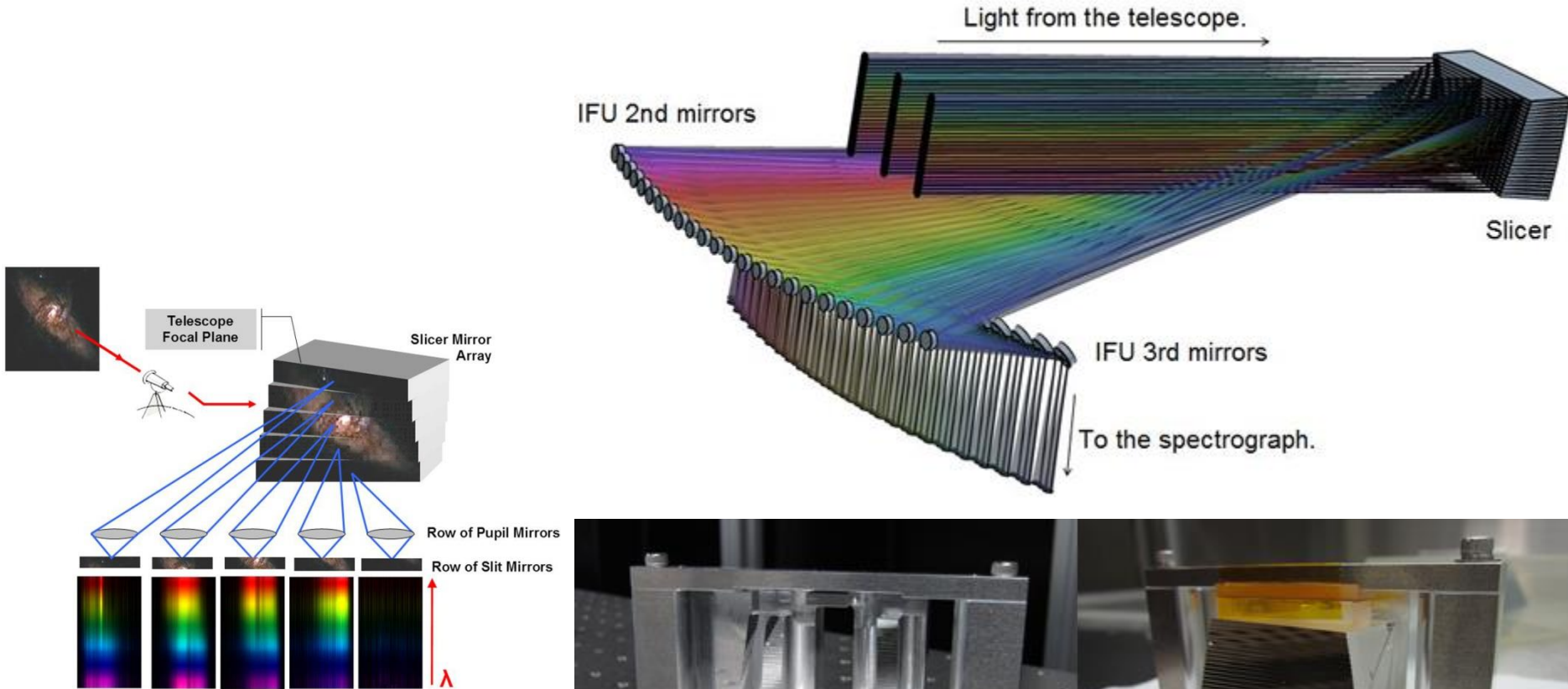


解析されたスペクトル(1天体分)

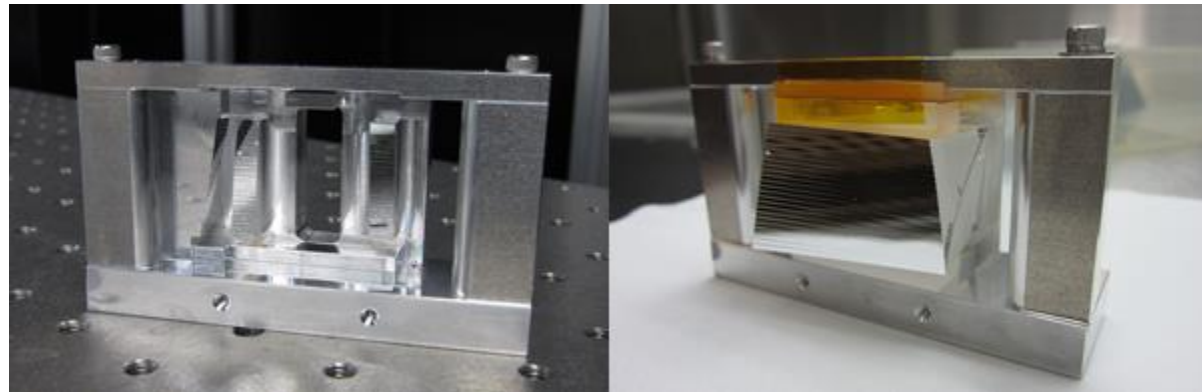
多スリット分光器 MOIRCS のデータ例

# Integral Field Spectroscopy

- Image slicer (for FOCAS)



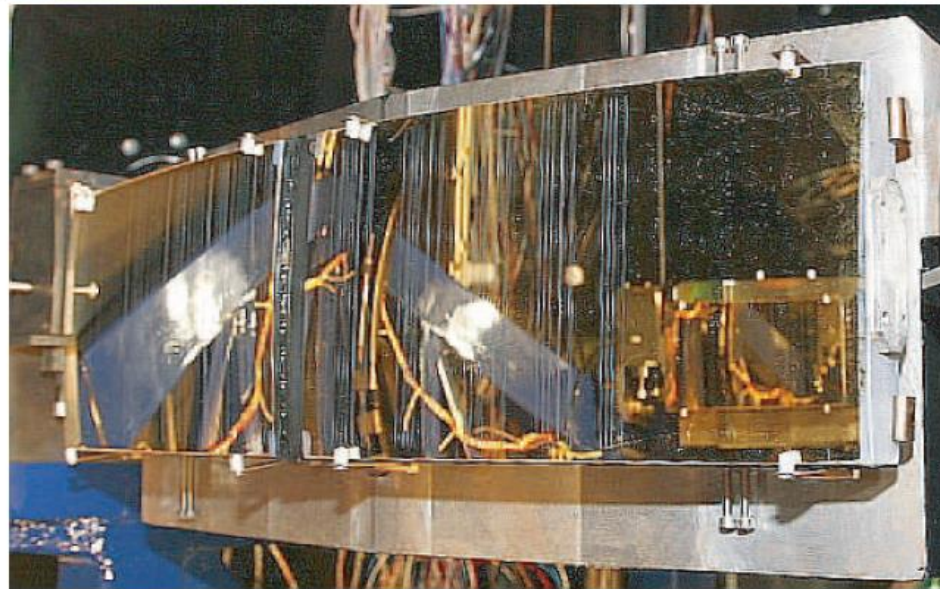
From SPIE



From ATC website

# Night sky OH line suppression

- Optically masks the wavelength range affected by strong OH sky lines.



Kimura et al. 2010