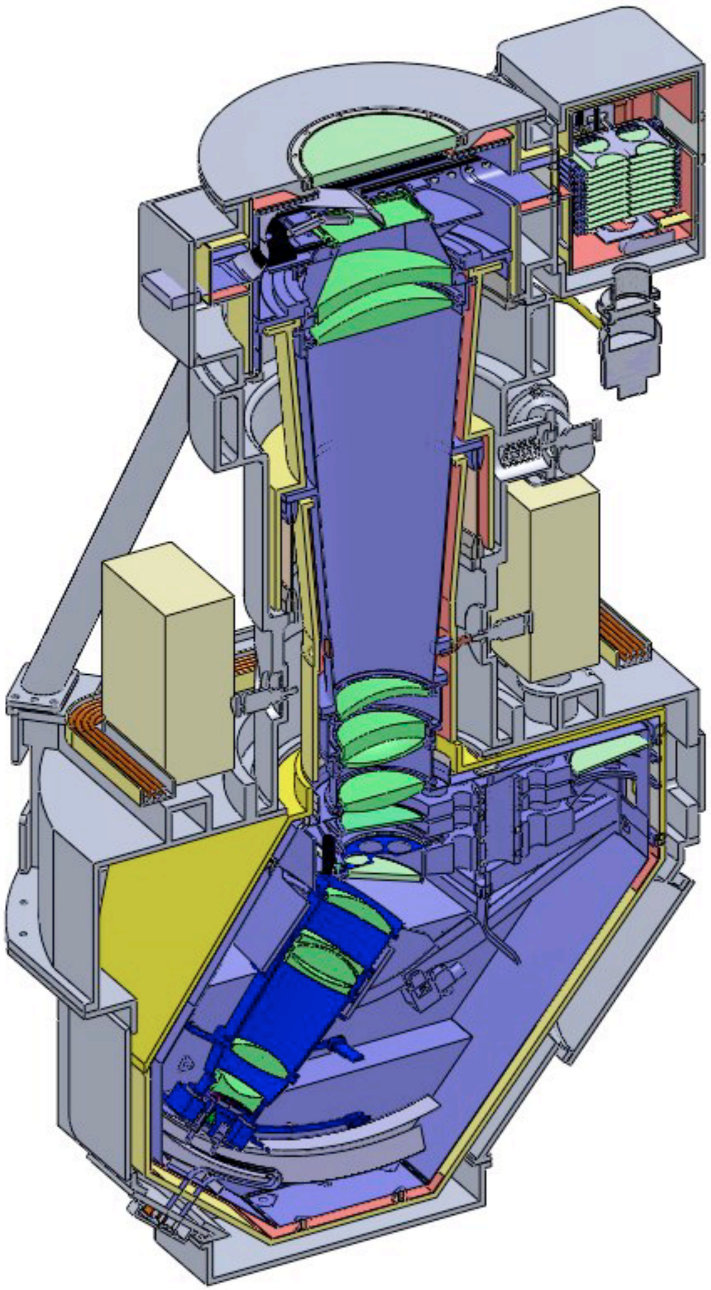

NIRMOS

: Near-Infrared Multiple Object Spectrograph for the GMT

(Fabricant et al., 2012)

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Introduction

- Near-Infrafed Multiple Object Spectrograph (NIRMOS)
- NIRMOS : 0.9 - 2.5μm imager/spectrograph concept for the GMT

Parameter	Requirement	Goal	Notes
Wavelength Range	1 – 2.5μm	0.9 – 2.5μm	Coverage of a full band in a single exposure
Spectral Resolution	$R\varphi \geq 1{,}500$	R=5000 with narrow slits	Baseline mode is expected to match GLAO image sizes
Multiplex Factor	> 100	-	For slit MOS mode
Field of View Slit MOS	20 $arcmin^2$	25 $arcmin^2$	
Field of View Imaging	5′ x 5′	-	
Field of View Fiber MOS	Full 20′ diameter field		Only expected to operate in the J & H bands
Image Quality	0.15″ 80%EE	-	Don't degrade images from telescope/site by more than 5%
Velocity Stability	< 0.1	-	Flexure in units of spectral resolution element per hour
Throughput	≥ 20% at 2.2μm	≥ 30% at blaze peaks	Exclusive of slit losses, telescope and atmosphere

[Detailed requirements of the GMT project office]

Optical Design

- Use of **<u>refractive</u>** optics
  1. reflective optics
     a. simple, achromatic nature
     b. impossible for wide-field spectroscopic design & fast camera
  2. more feasible refractive optics

- Material
  ; CaF_2, infrared fused quartz, S-TIM28 - only suited for large telescopes

- **Aspheric** surface
  ; expensive, but better performance in scattered light and throughput

- Scattered light
  1. potential problems in IR spectroscopy
  2. sources - light scattered from gratings and detectors
  3. 3% of sky background in J Band & 8% of sky background in H Band
     ; can be reduced by using VPH grating

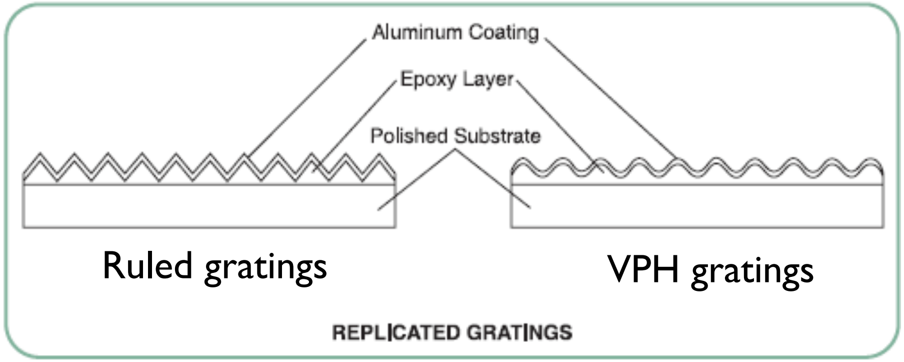
Optical Design

◉ **V**olume **P**hase **H**olographic(VPH) transmission gratings

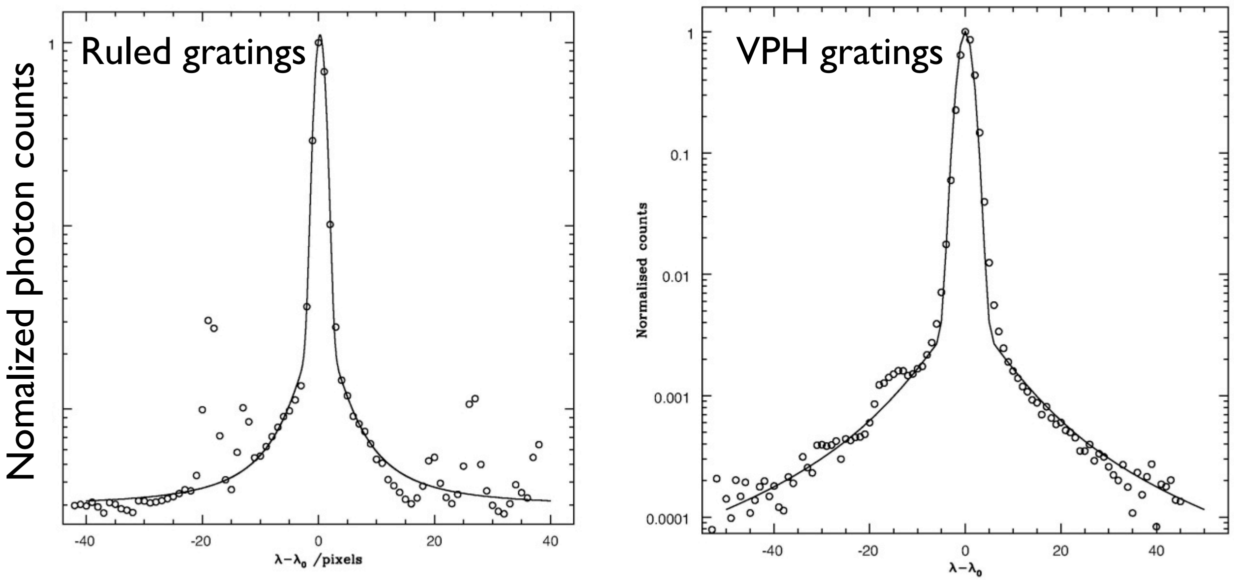
1. two transmission gratings
   ; ruled gratings, holographic gratings

2. cryogenic environment of NIRMOS
   ; holographic gratings

3. VPH gratings
   a. higher efficiency
   b. lower scattering



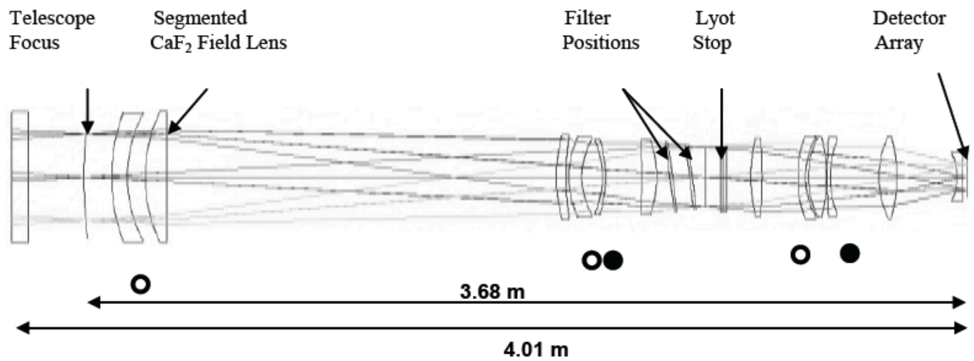
[Scattering profile]



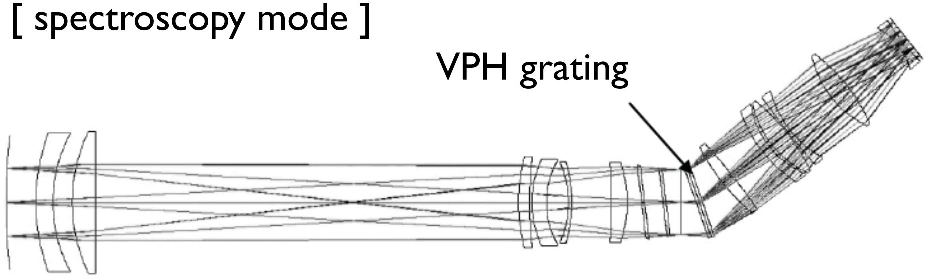
Optical Design

Parameter	Value
FOV	**42** arcmin^{-2}
Multiplex Capability	~ **80** with 5 inches long slits
Scale at Detector	**0.049** arcsec / pixel
Collimated Beam Diameter	270 mm
Collimator Focal Length	2200 mm
Camera Focal Length	665 mm
Camera Focal Ratio	f/2.4

[imaging mode]

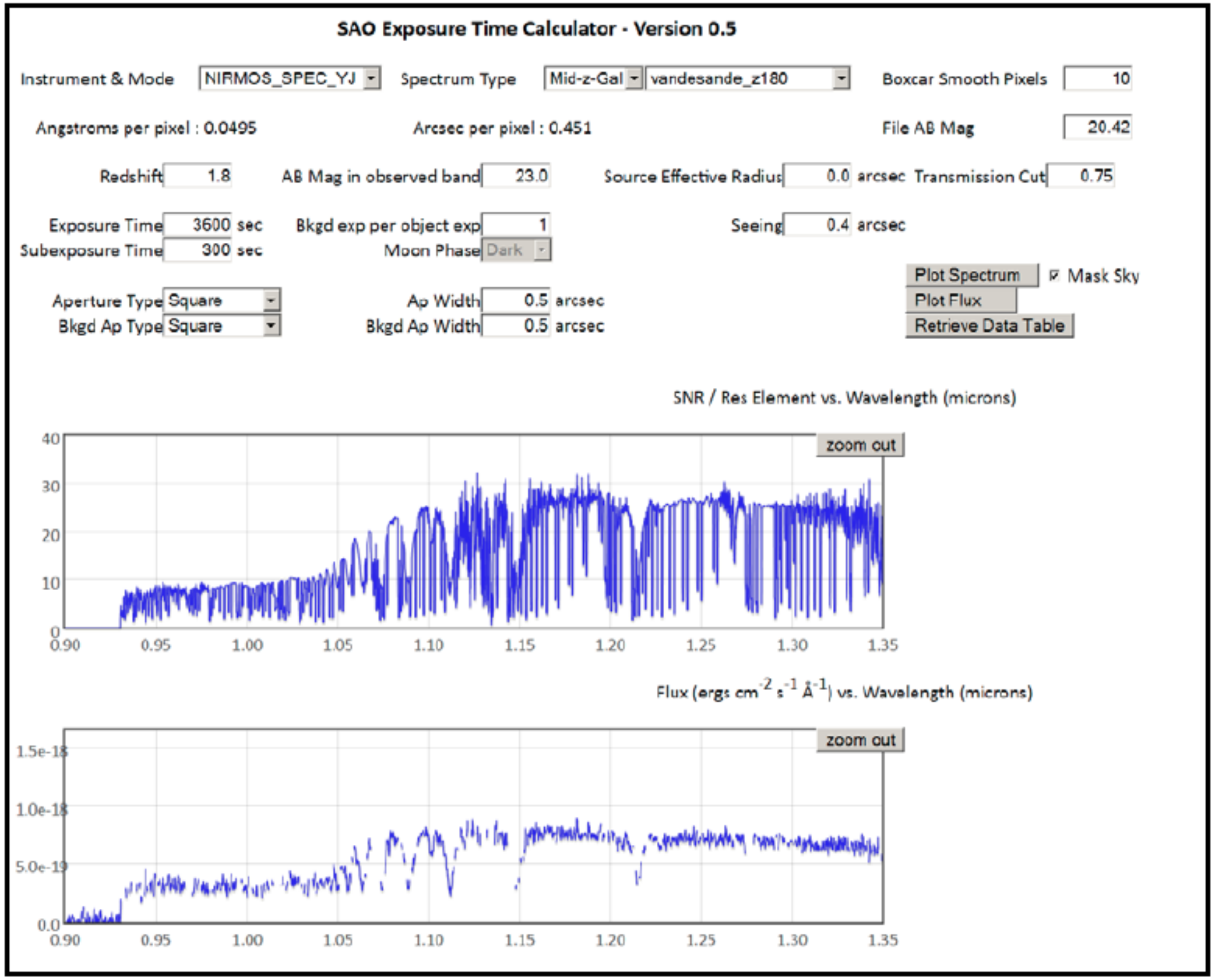


[spectroscopy mode]



Multiplex advantage & sensitivity

[NIRMOS exposure time calculator and spectral simulator]



Noise source

- atmospheric emission lines
- sky background
- dark current
- read noise

(http://hopper.si.edu/saoetc/sao-etc)

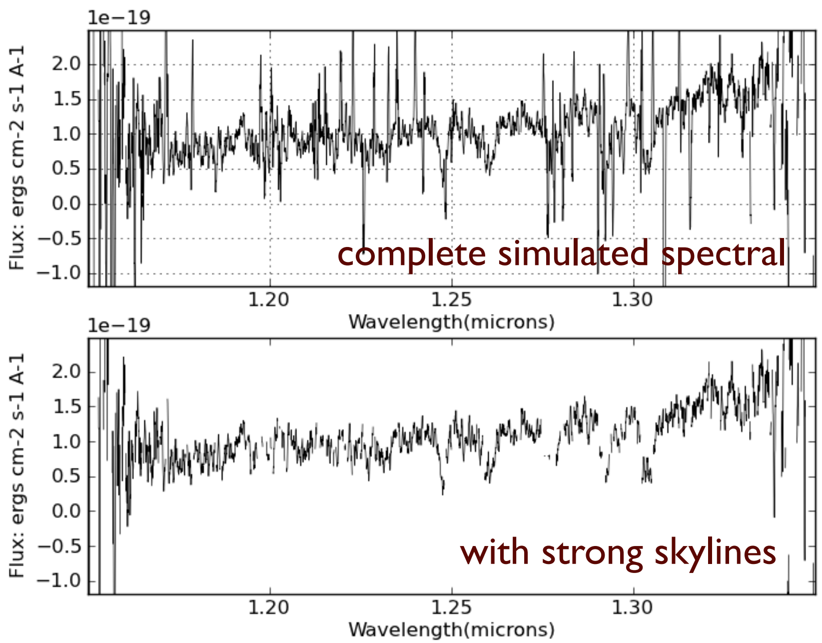
Multiplex advantage & sensitivity

[Galaxy counts with photometric z>2 from Chandra Deep Field South from Franx]

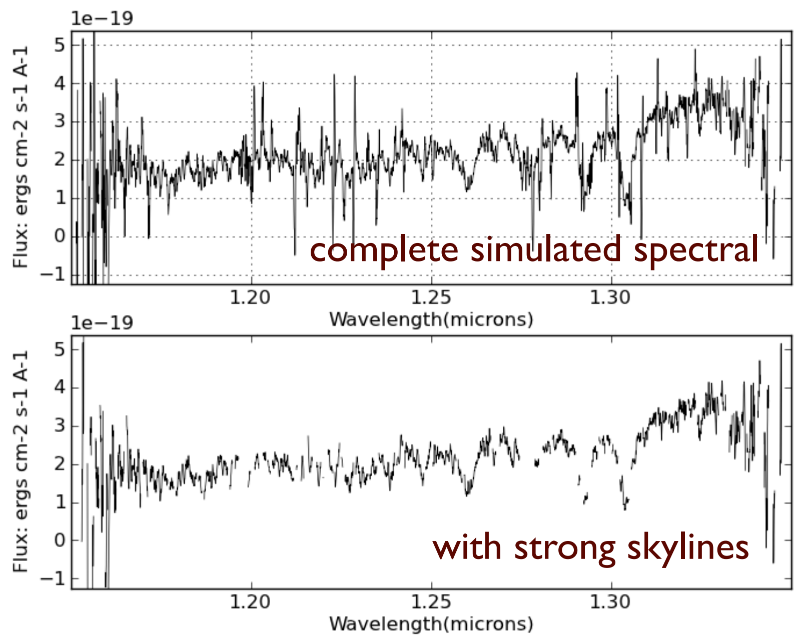
K_{AB}	z>2 galaxies per sq. arcmin	z>2 galaxies in 42 sq. arcmin. NIRMOS field
22.7	1.0	42
23	1.7	71
23.5	2.6	109

Multiplex Capability ~ **80** with 5 inches long slits

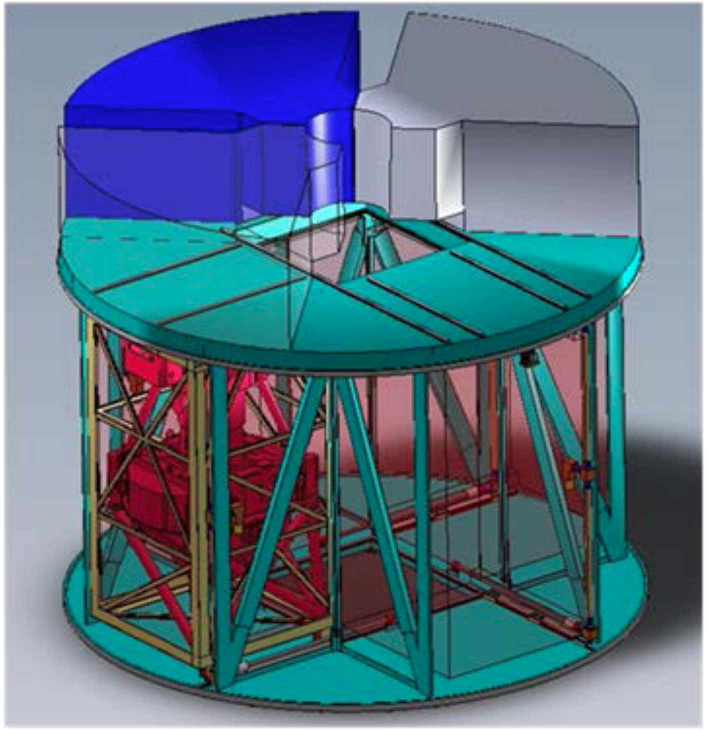
Simulated J band spectrum of z=2.3 galaxy
- J_{AB}=24.6 (K_{AB}=23.5)
- four hours exposure time



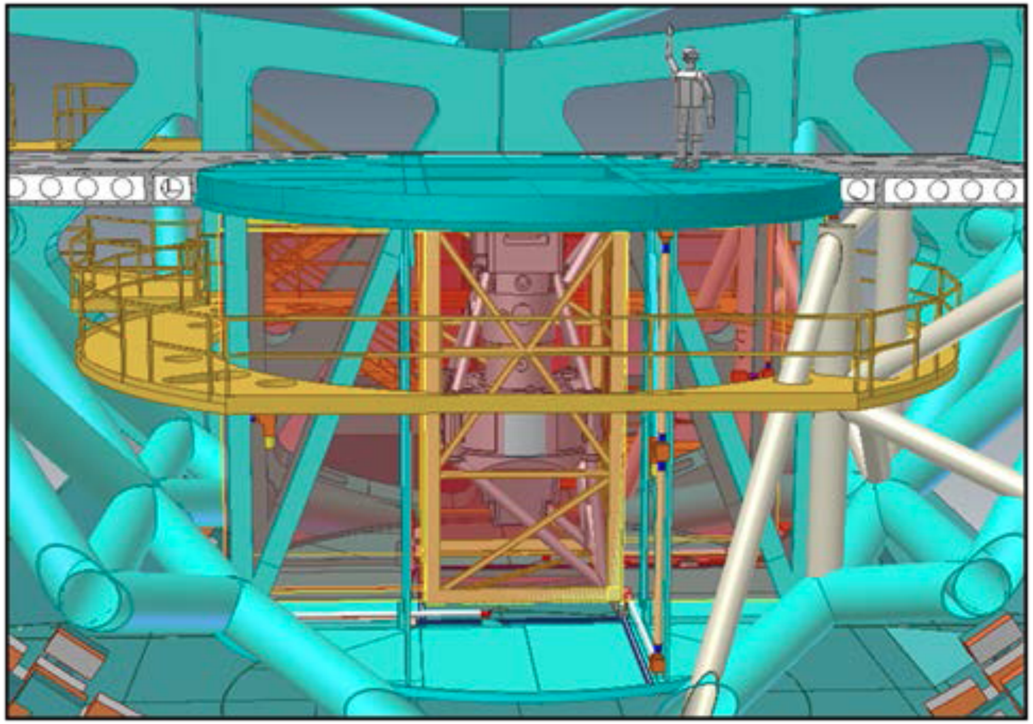
Simulated J band spectrum of z=2.3 galaxy
- J_{AB}=23.8 (K_{AB}=22.7)
- four hours exposure time



Mechanical overview



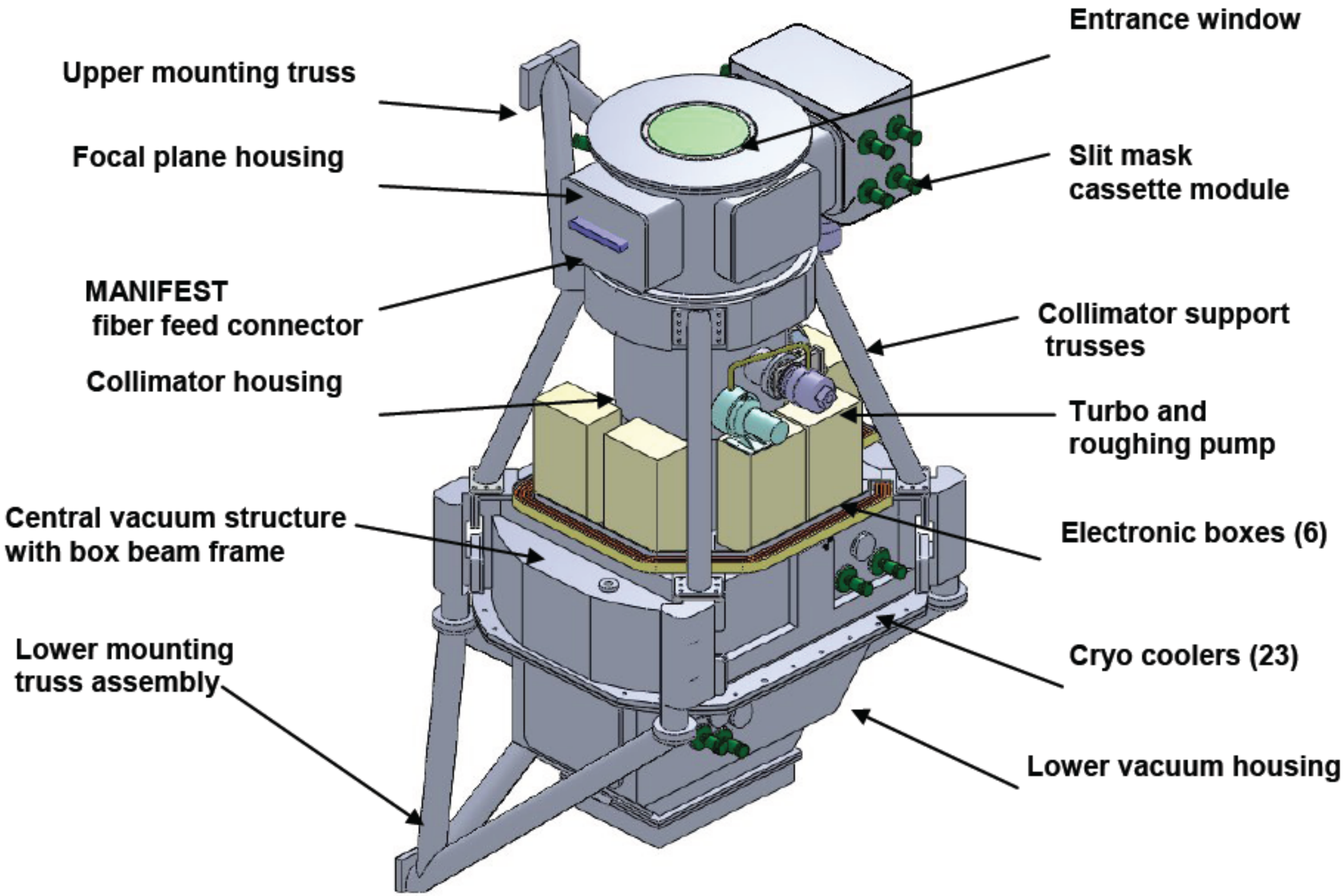
[NIRMOS within the rotating Gregorian Instrument Assembly (GIA)]



[GIA location within the instrument platform]

◉ NIRMOS : a large cryogenic instrument with a total mass of ~ 9,000kg

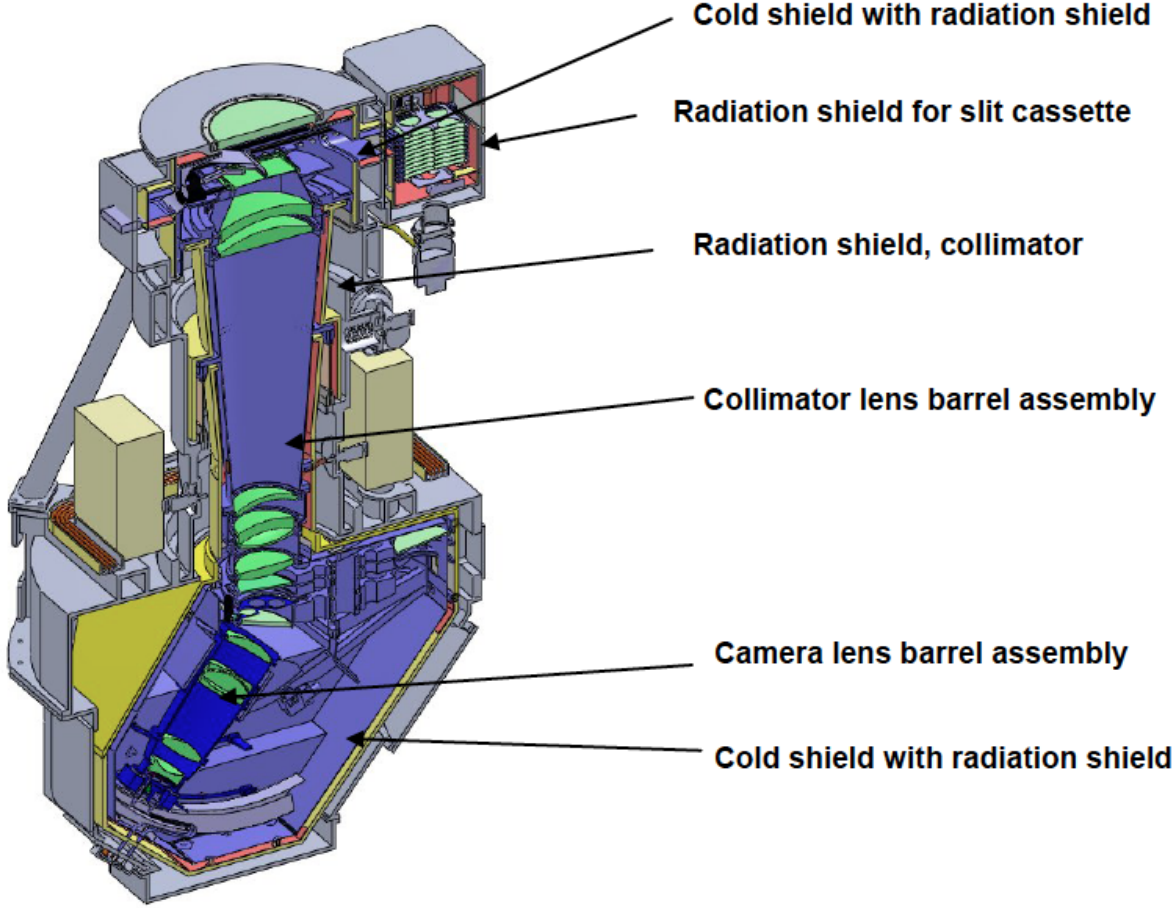
Mechanical overview



[External overview model of NIRMOS]

◉ The NIRMOS electronics boxes provide the mechanism control, cryogenic control, temperature control, vacuum control, detector support, etc.

Mechanical overview



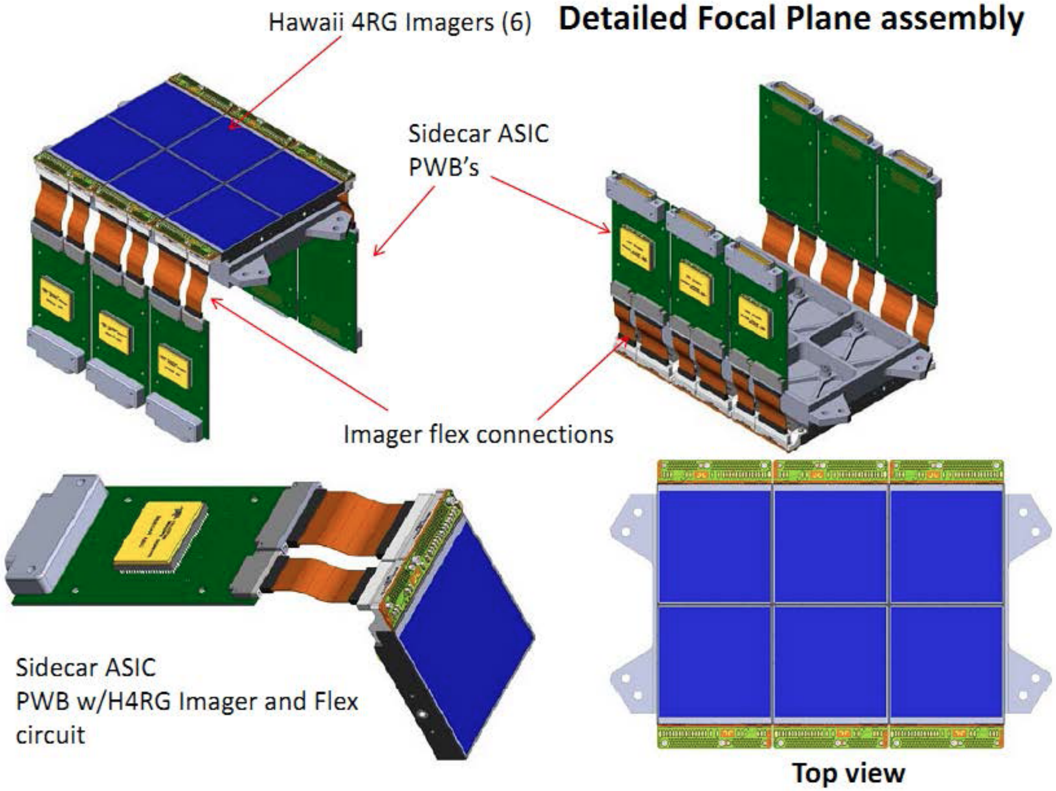
[Cross-sectional view of NIRMOS]

◉ The NIRMOS optics are completely baffled using cold shield.
→ the temperature of the optics is ~ 120K

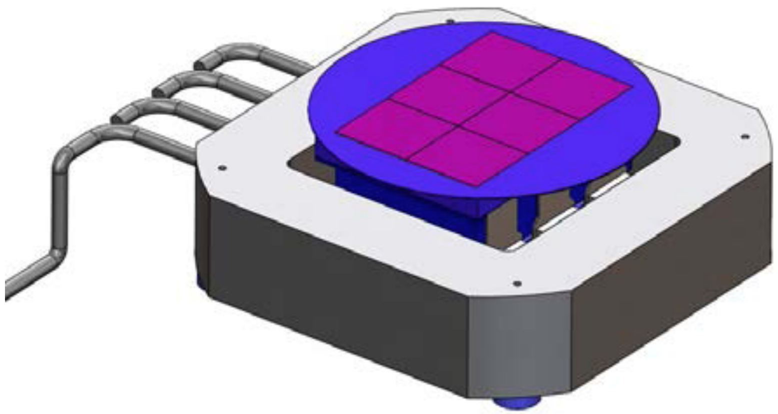
◉ A radiation shield consists of 3 layers of gold coated Kapton.

Detector assembly and flexible control

[Detector assembly]



[Focal plane array of six HAWAII 4RG]



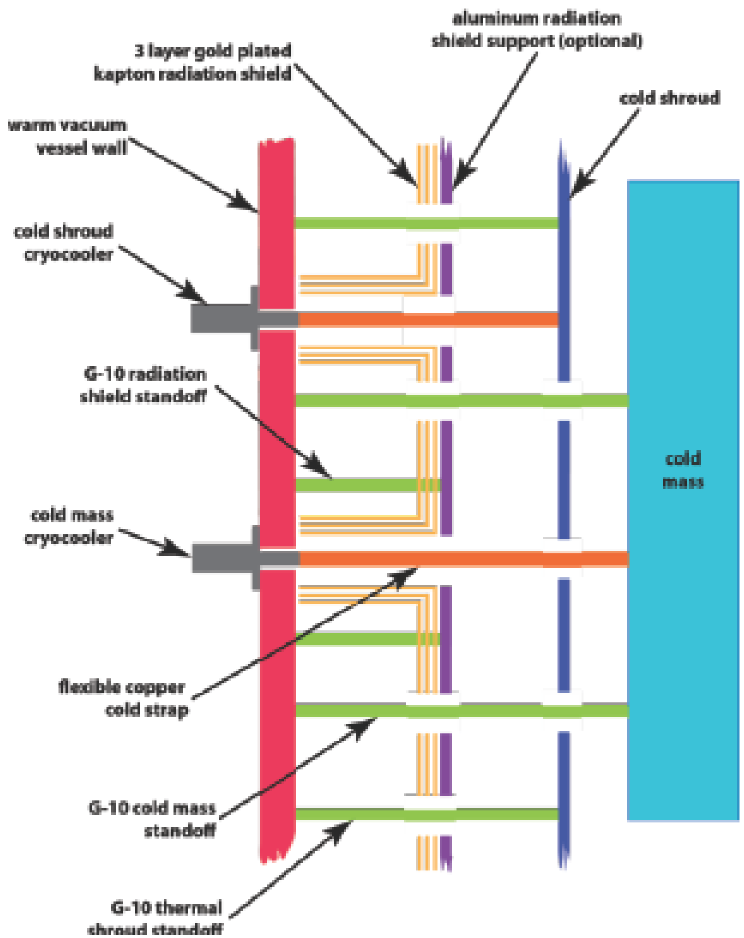
nano-positioning
- X & Y axes : 1mm
- Z axis : 1.5 mm
Maximum speed : 500μm/s

Thermal design

- Cryogenic temperatures : cooling 1,530 kg, toward120 K

  transient cool-down (293K → 120K, 7days)

  & warm-up (120K → 293K, 5days)



Discussion - GMT Science with NIRMOS

- The near-infrared(NIR) play a central role in the science programs for ELTs

1) At $z \sim 2.5$ (the peak of the universal star formation), optical emission line tracers are shifted into the NIR.

2) Spectroscopy of high-z sources is very important for the measurement of cosmic reionization.

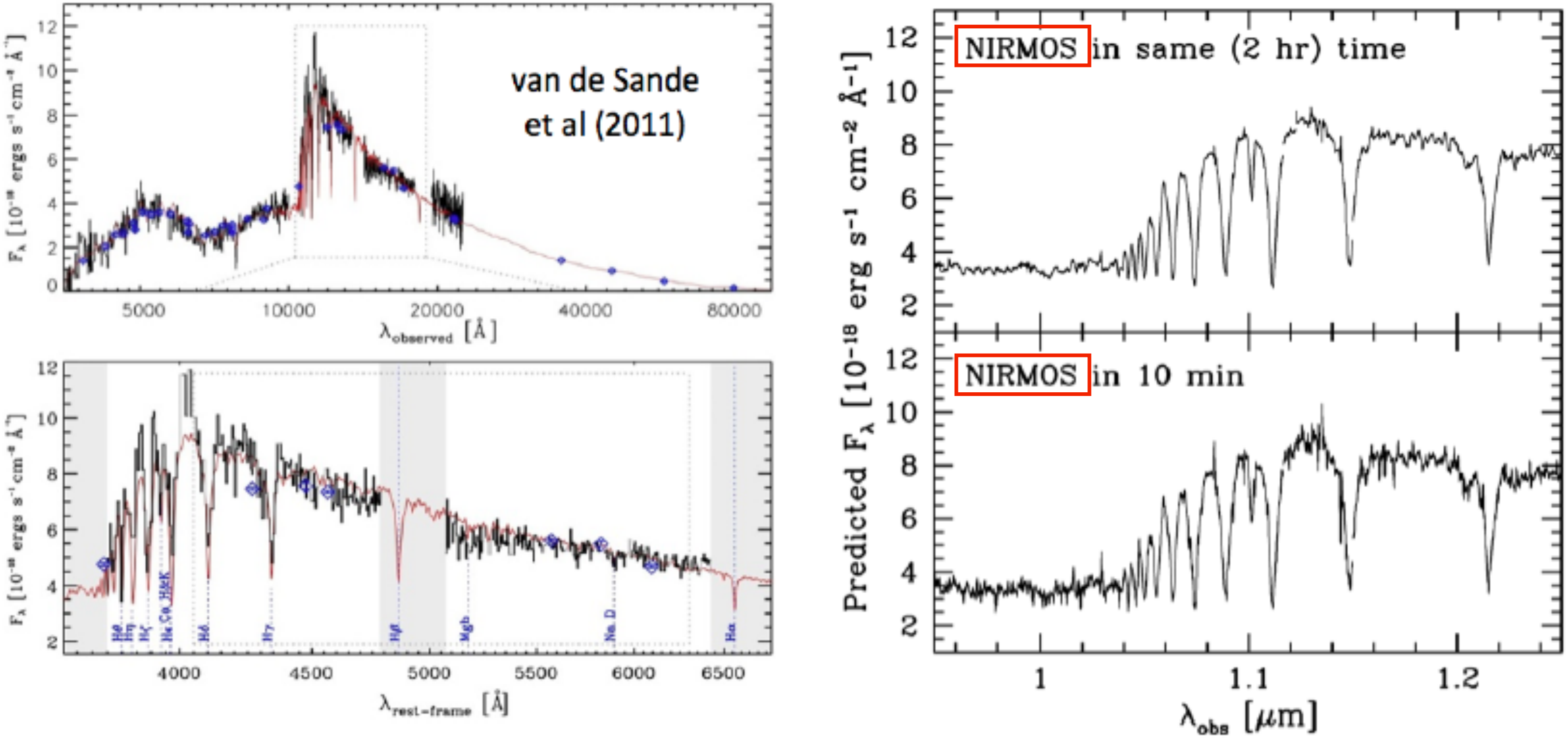
   a) Ly-α emission from the first galaxies at $z>7$

   b) the afterglows of gamma ray bursts at $z>7$

Discussion - Dynamic masses

[Comparison between VLT XShooter spectra and NIRMOS simulated spectra]

z=1.8, J_{AB}=19.9 - 2 hr with VLT XShooter

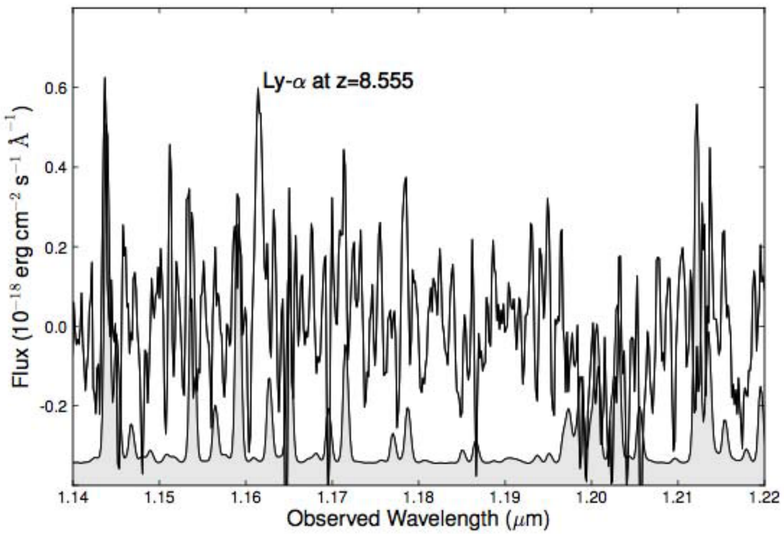


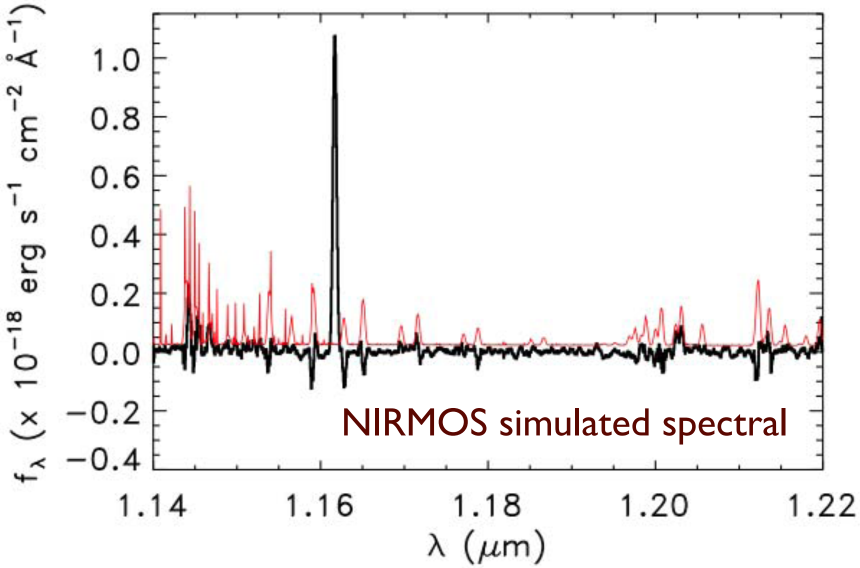
◉ The GMT+NIRMOS will allow the measurement with high confidence in massive galaxies, and the observation of L* galaxies at t z~2.

Ref.) www.gmto.org/Resources/GMT-SCI-REF-00483_2_GMT_Science_Book.pdf)

Discussion - High redshift galaxies

[Comparison btw VLT/SINFONI spectrum of the z=8.56 galaxy and simulated spectrum]





◉ The GMT/NIRMOS will allow us to confirm the redshifts and high quality spectra of the brightest galaxies at z>7.

◉ It will be possible to obtain the UV luminosity function for high-z galaxies.

Ref.) www.gmto.org/Resources/GMT-SCI-REF-00483_2_GMT_Science_Book.pdf)

Thank you