The challenge of the NIRSpec design

NIRSpec is an IR (near infrared) spectrometer
for the
James Webb Space Telescope

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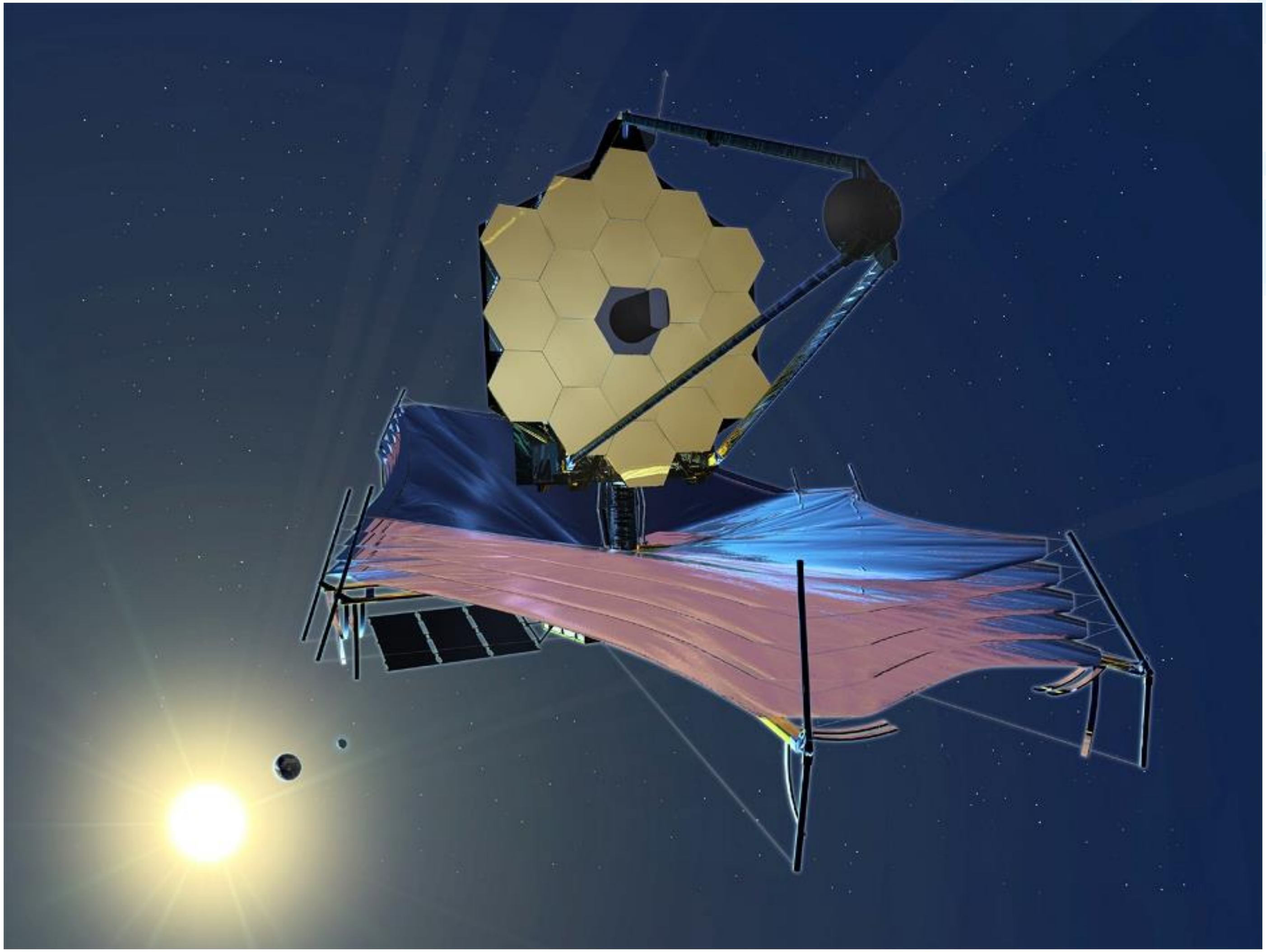
NIRSpec – an IR spectrometer for the James Webb Space Telescope

- James Webb Telescope
- NIRSpec Objective
- NIRSpec Science Goals
- MOS & IFS Design Requirements
- MOS Functional Block Diagram
- Main Optical Design Requirements
- NIRSpec Optical Design
- NIRSpec Optical Layout
- Optical Interface
- Overall Mechanical Configuration
- US MEMS
- MOS Principle of Operation and Observing Modes

James Webb Space Telescope



NIRSpec Objective

- NIRSpec is a spectrograph that works in the near infrared spectral region from 0.6μm to 5μm and allows the observation of spectral features of the incident light with different spectral resolutions (R=100, R=1000, R=3000).
- It is designed for spectroscopy of more than 100 objects simultaneously.
- The optical design of the NIRSpec instrument is characterized by a straight optical system layout: It constitutes of a set of optical modules of similar optical design type with high performance and low module tolerances.

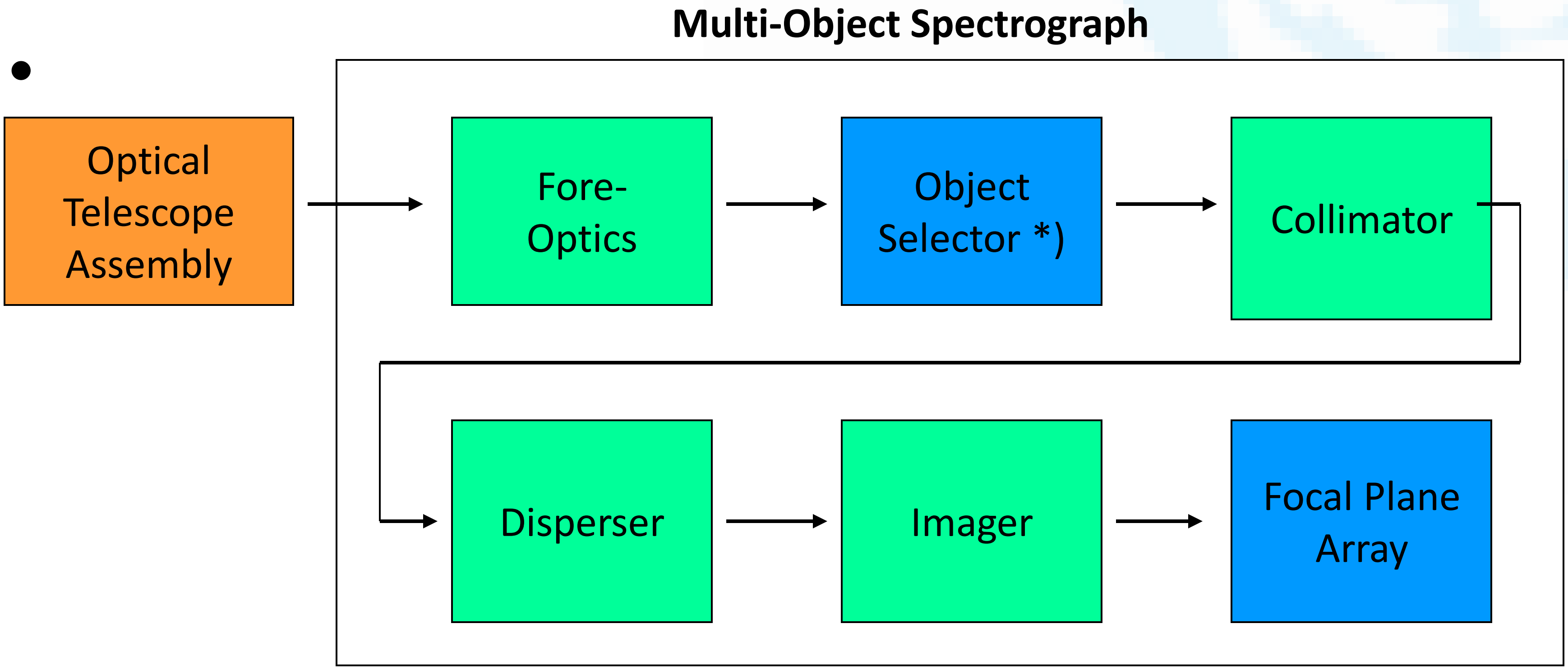
NIRSpec Science Goals

DRM Program	DRM Rank	Spectral R	AB mag
Formation and evolution of galaxies Deep galaxy spectroscopic survey	2	~ 100 - 3000	31
Probing IGM to reionization epoch	4	~ 100	29
Measuring cosmological parameters	5	~ 300	31
Physics of star formation: protostars	7	~ 100 - 3000	31
Evolution of SN rate	11	~ 1000	34
Formation and evolution of galaxies Deep cluster spectroscopic survey	13	~ 100 - 5000	24-27
Formation and evolution of galaxies near AGNs	14	~ 1000 - 5000	27
GRB spectra and hosts	22	~ 100 - 3000	24.5-28.5

Multi-Object-Spectrograph & Integral Field Spectrograph Design Requirements

Characteristics	**Multi-Object Spectrograph**	**Integral Field Spectrograph**
Wavelength Range	1– 5 μm (0.6μm for R=100)	1 – 5 μm (0.6μm for R=100)
Observing Modes	Imaging R = 100 R = 1000	- (IFS is an imager) R = 100 R = 1000
Field Of View	3.4' x 6.7' (Imaging, R=100) **3.4' x 3.4'** (R = 1000)	**23" x 23"**
Spatial Sampling	**0.1"**	**0.18"**
Detector Array Size	2048 x 4096	4 x 2048 x 2048

MOS Functional Block Diagram



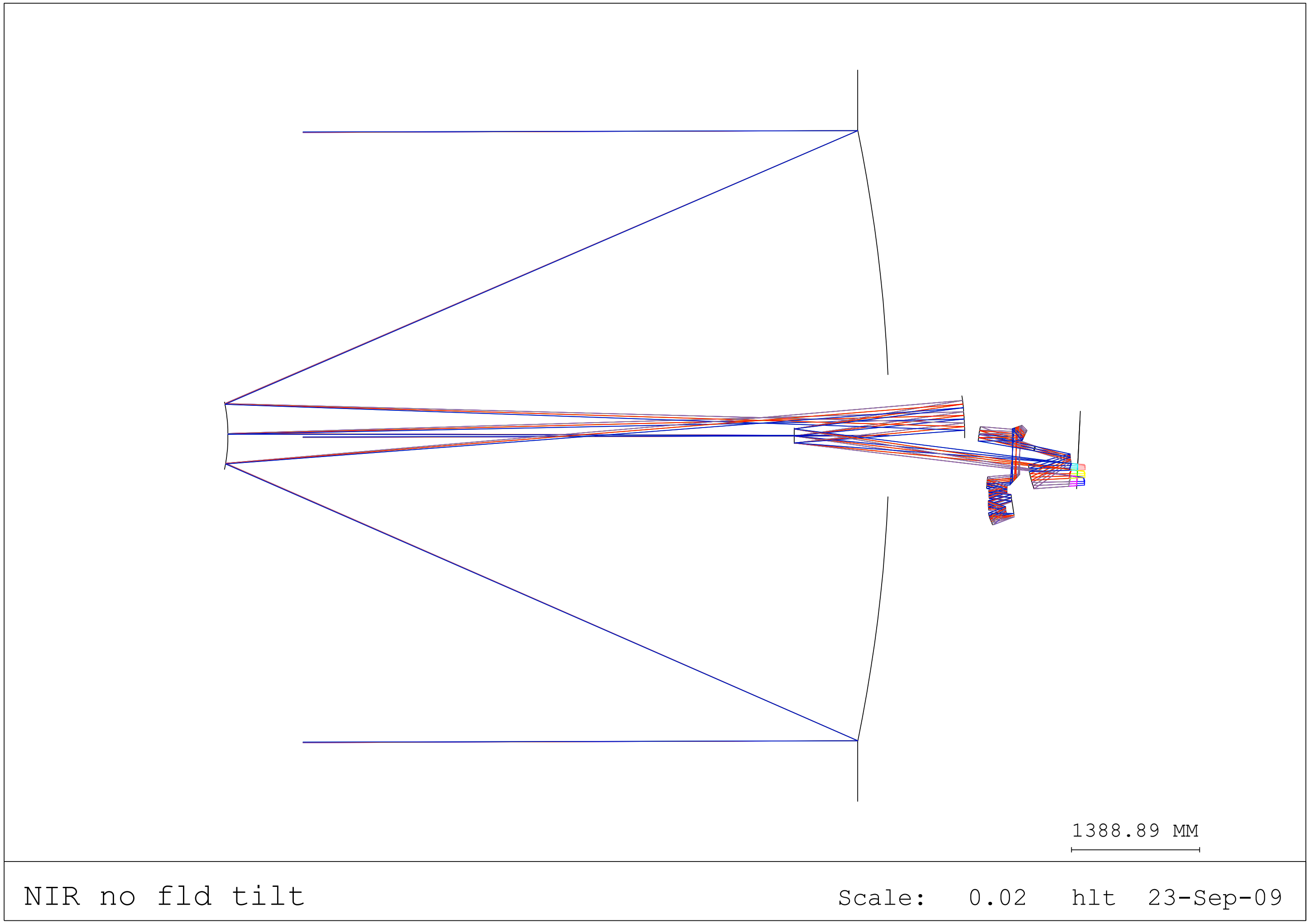
*) Micro-Electro-Mechanical-Systems (MEMS)

Main Optical Design Requirements

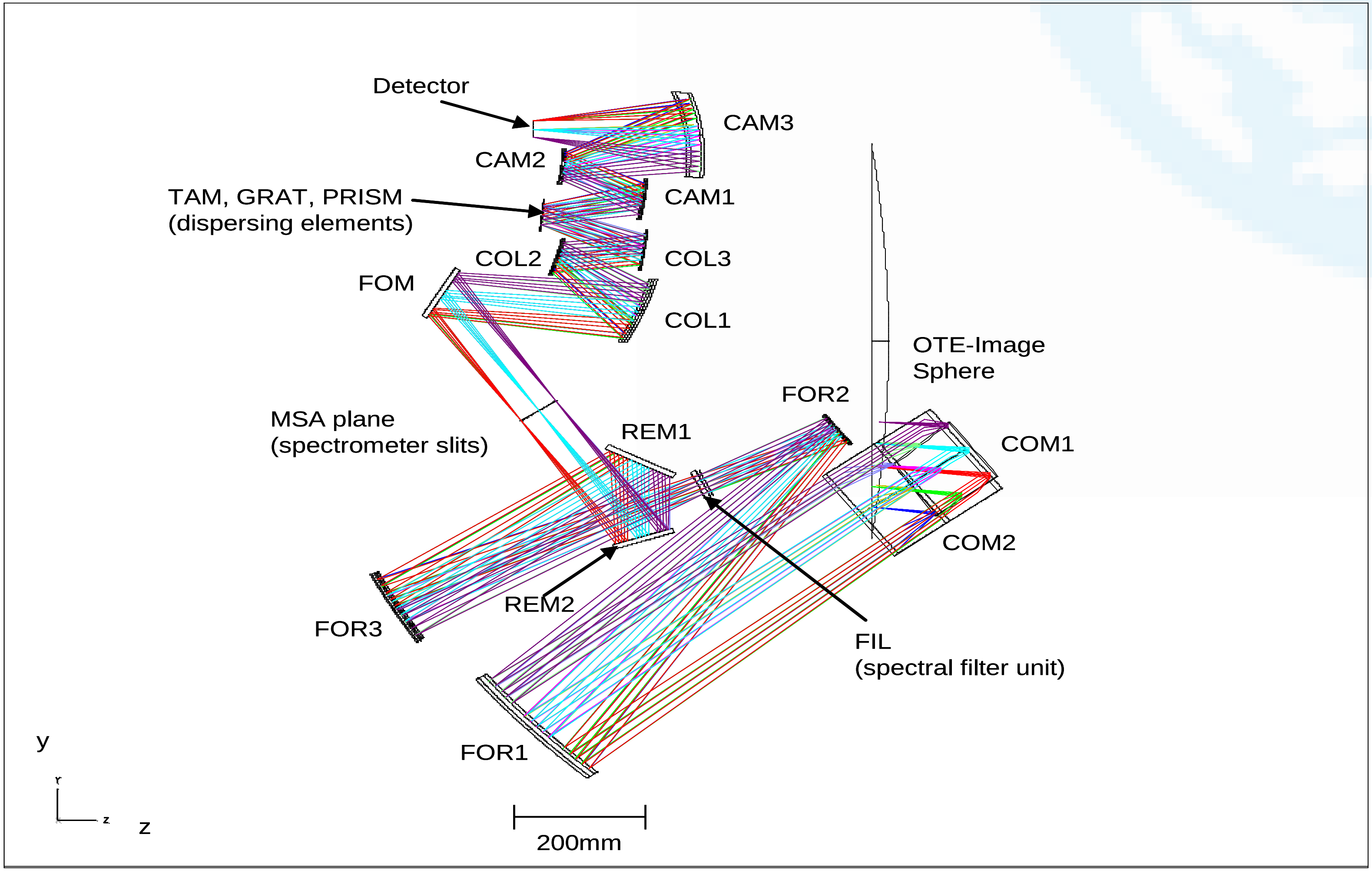
- **Design Requirements**

- Minimize the optics aberrations in spectral direction
- Provide an accessible pupil in the fore-optics for filters
- Provide a flat and telecentric intermediate focal plane at the Micro Shutter Array (MSA) position
- Provide a collimated beam with flat pupil at the disperser location
- Provide simple interfaces between fore-optics, collimator and camera
- Provide accessible OTE-NIRS interface for OTE simulator (Telescope simulator for)

NIRSpec Optical Design



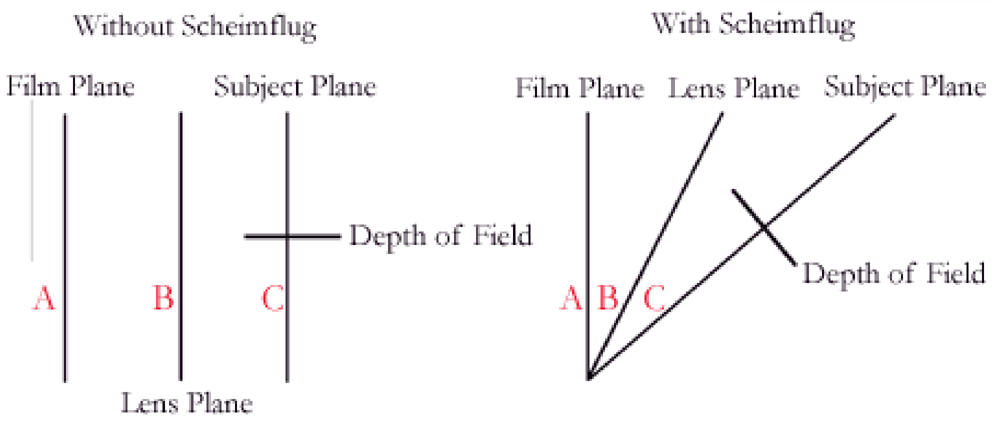
NIRSpec Optical Layout



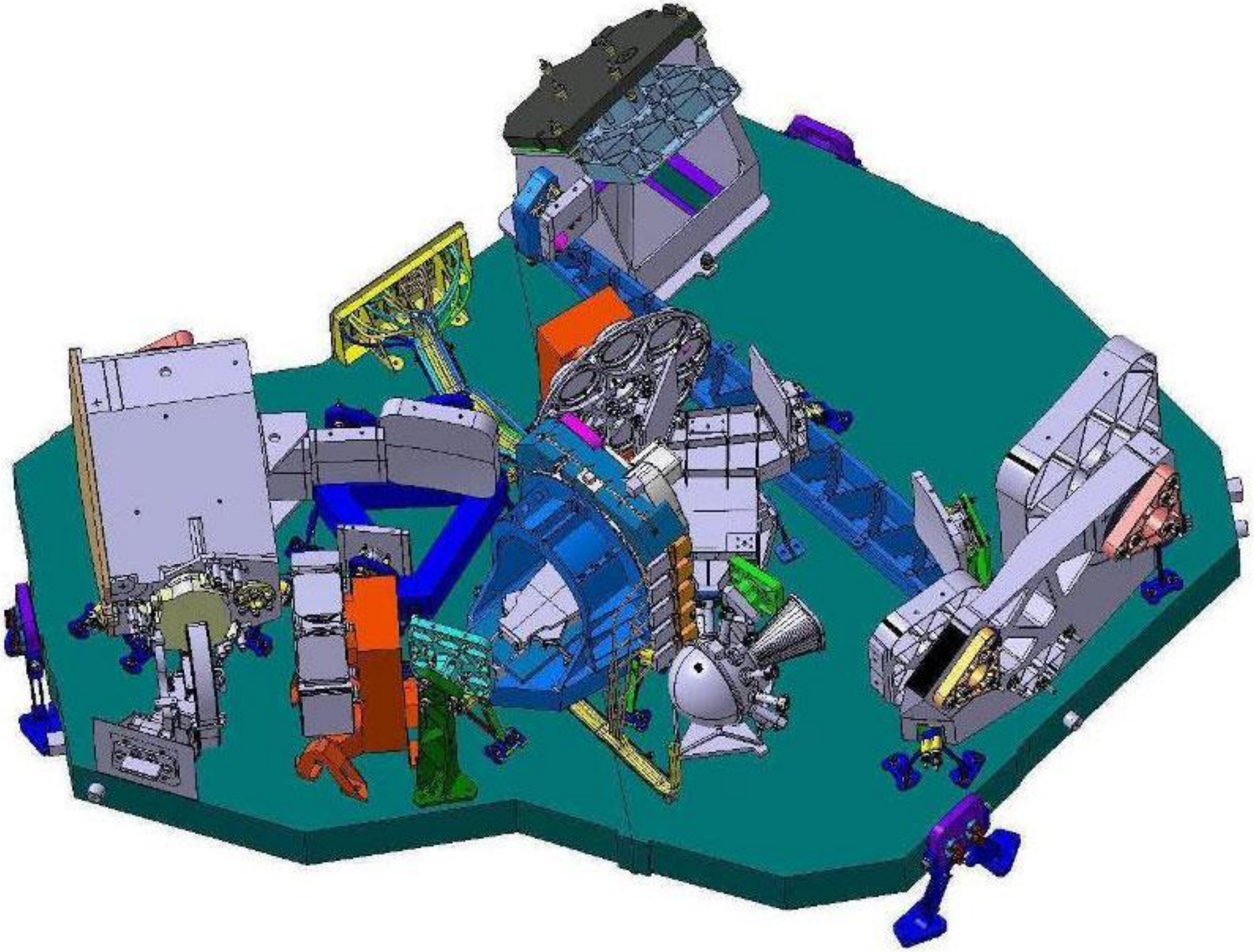
Optical Interface

Scheimpflug Effect

„In a normal camera the lens plane, the film plane and the subject plane are parallel to each other. But, if you tilt the lens so that an imaginary line drawn through the film plane A, and similar imaginary lines drawn through the lens plane and the image plane (B and C respectively) meet at a single point, then everything along the image plane (C) will be in focus” (from http://www.luminous-landscape.com/tutorials/movements.shtml)

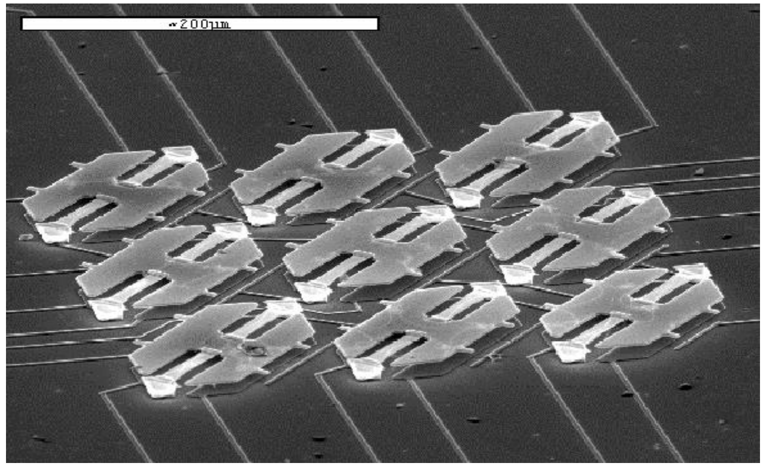


Overall Mechanical Configuration

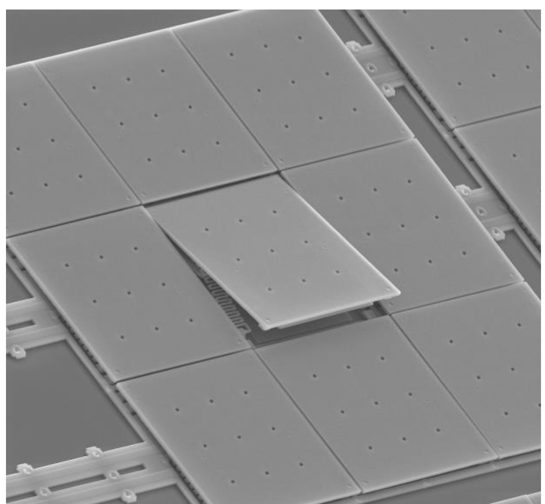


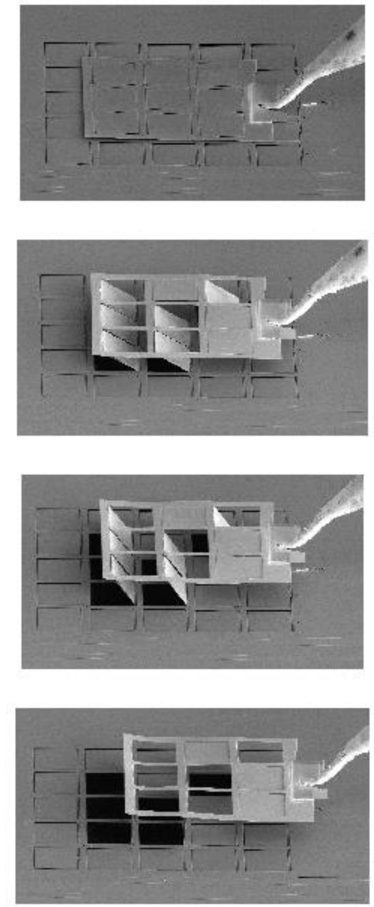
US MEMS

GSFC µ-mirrors (structure below mirrors)



Sandia
µ-mirrors
(100µm x 100µm)





GSFC µ-shutters
(100µm x 100µm)

MOS Principle of Operation

Scene

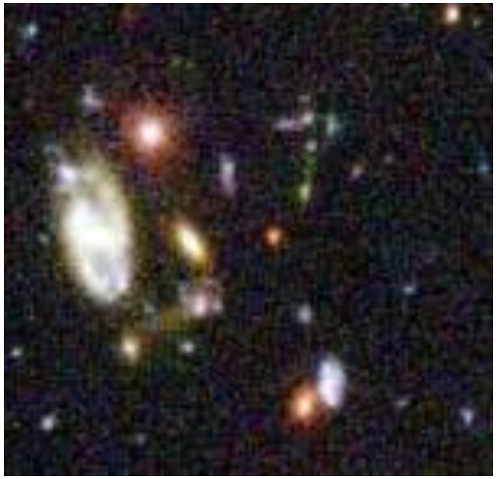
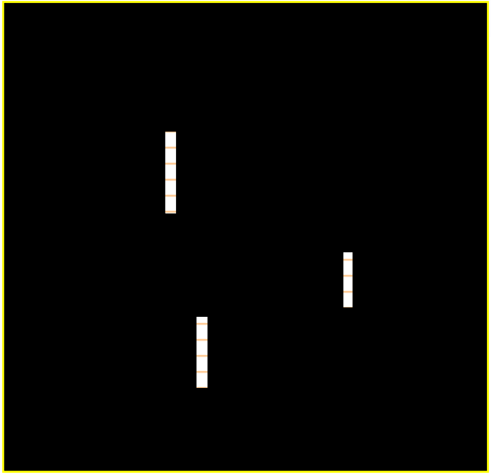
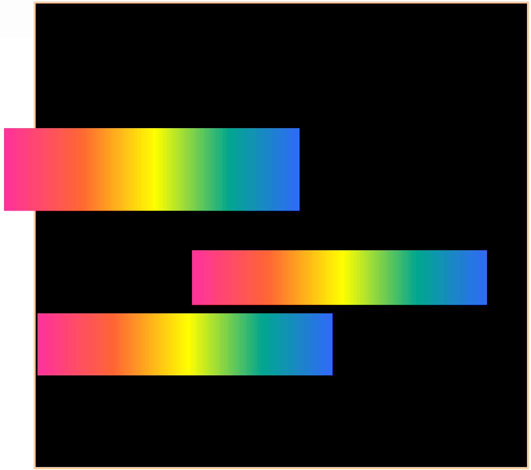


Image
on MEMS

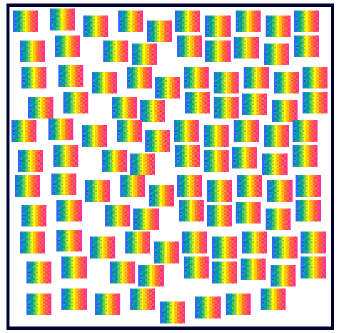
Selected
Targets



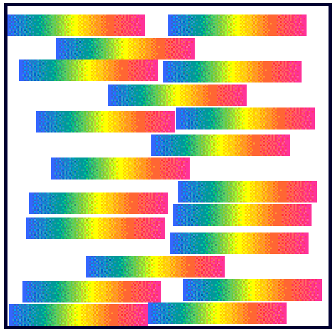


Spectra
of Targets

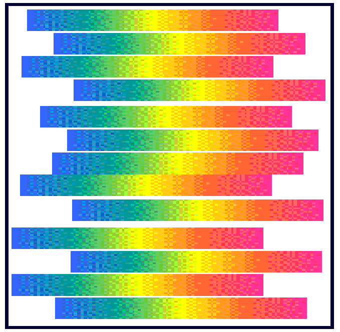
MOS Observing Modes



MOS - R=100

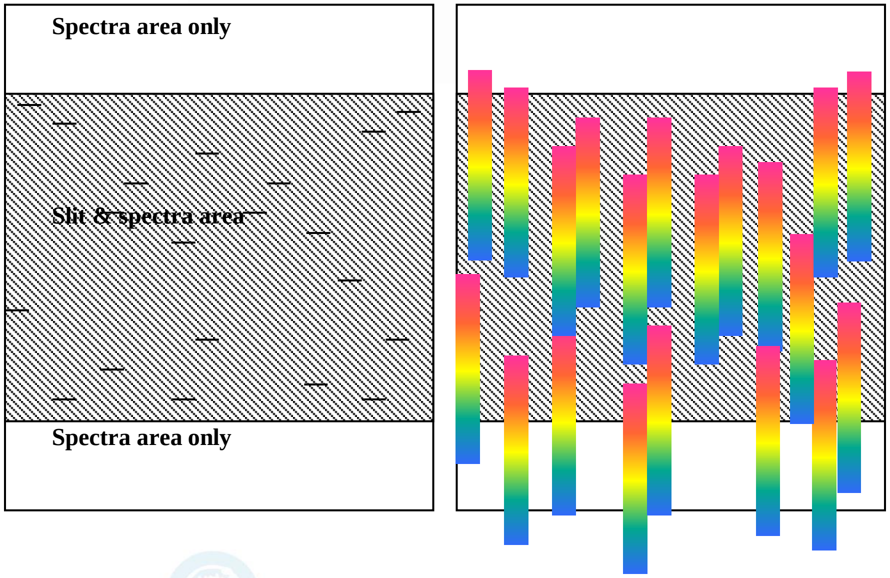


MOS - R=1000

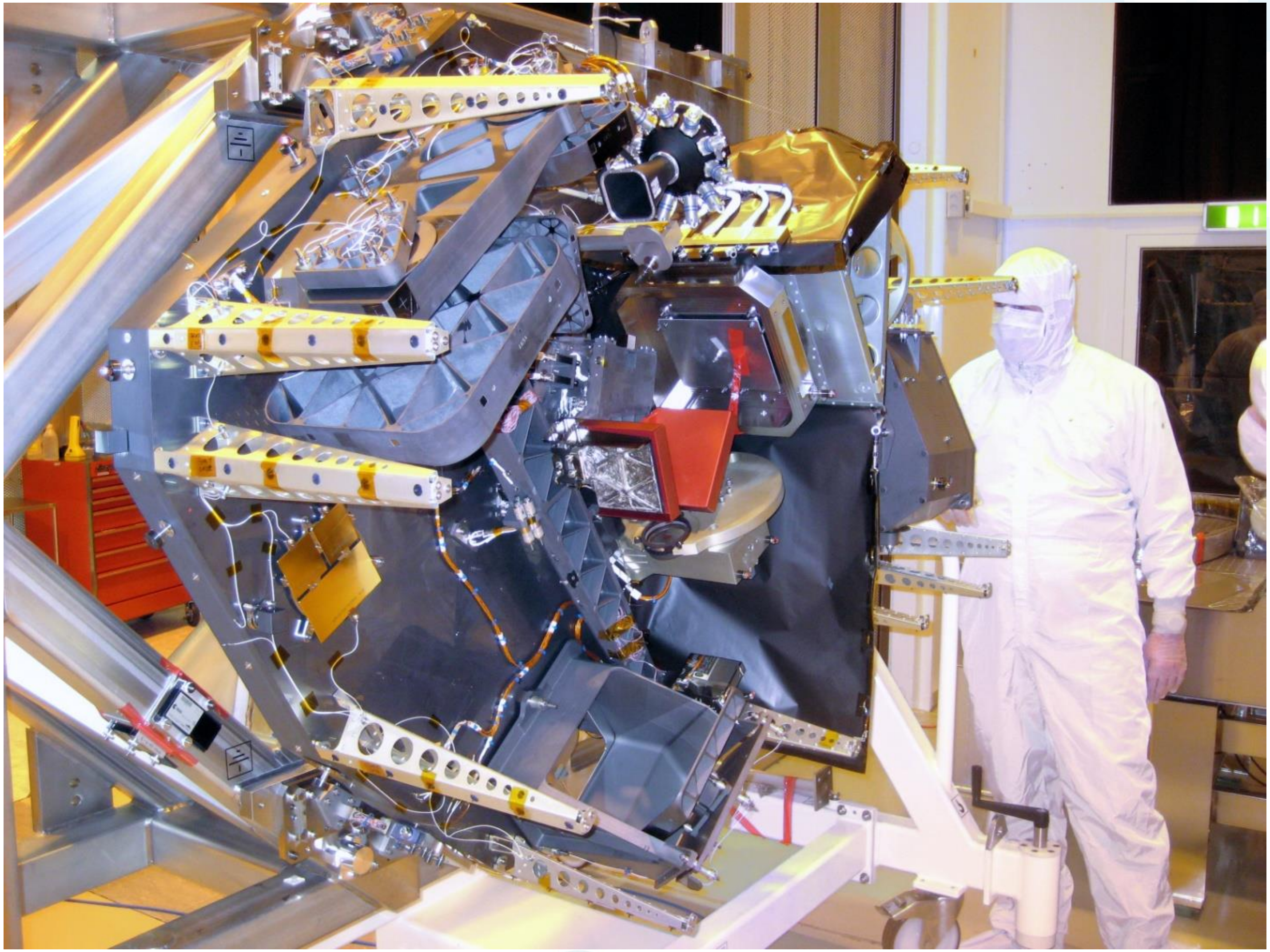


MOS - R=3000

Usable Field depending on Resolution



NIRSpec during integration



JWST Team in Munich

Thank you for your attention !