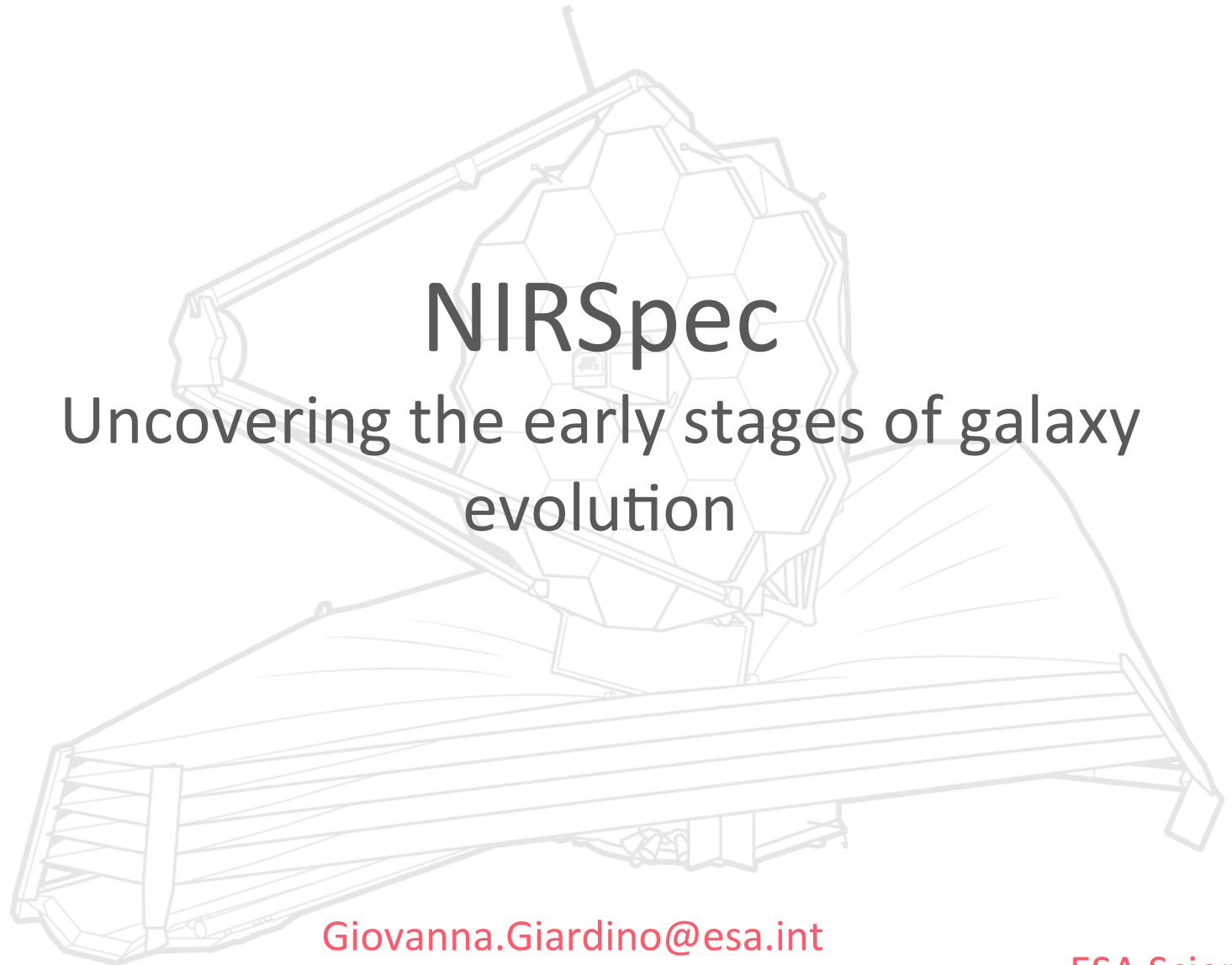




→ it will be a large and cold telescope optimized for the IR



## NIRSpec

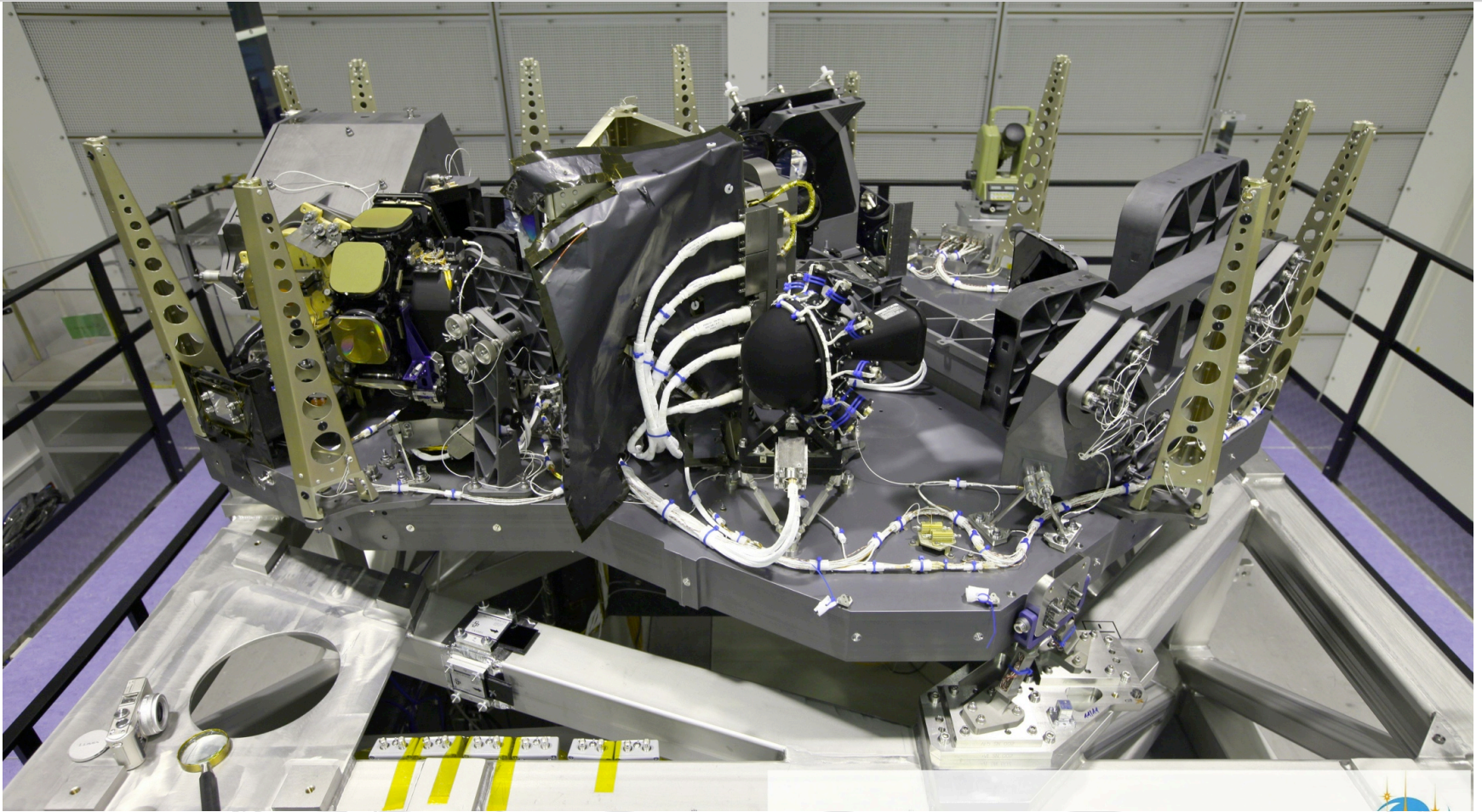
Uncovering the early stages of galaxy evolution



# Credits

- NIRSpec was developed by the European Space Agency (ESA) with Airbus (Germany) as the prime contractor, with major hardware contributions from NASA
- This presentation is built upon the work of many people in different teams in Europe and in the USA.
- Many elements of this presentation are based on existing presentations, prepared by other members of the JWST project, the instrument team, and STScI

# NIRSpec

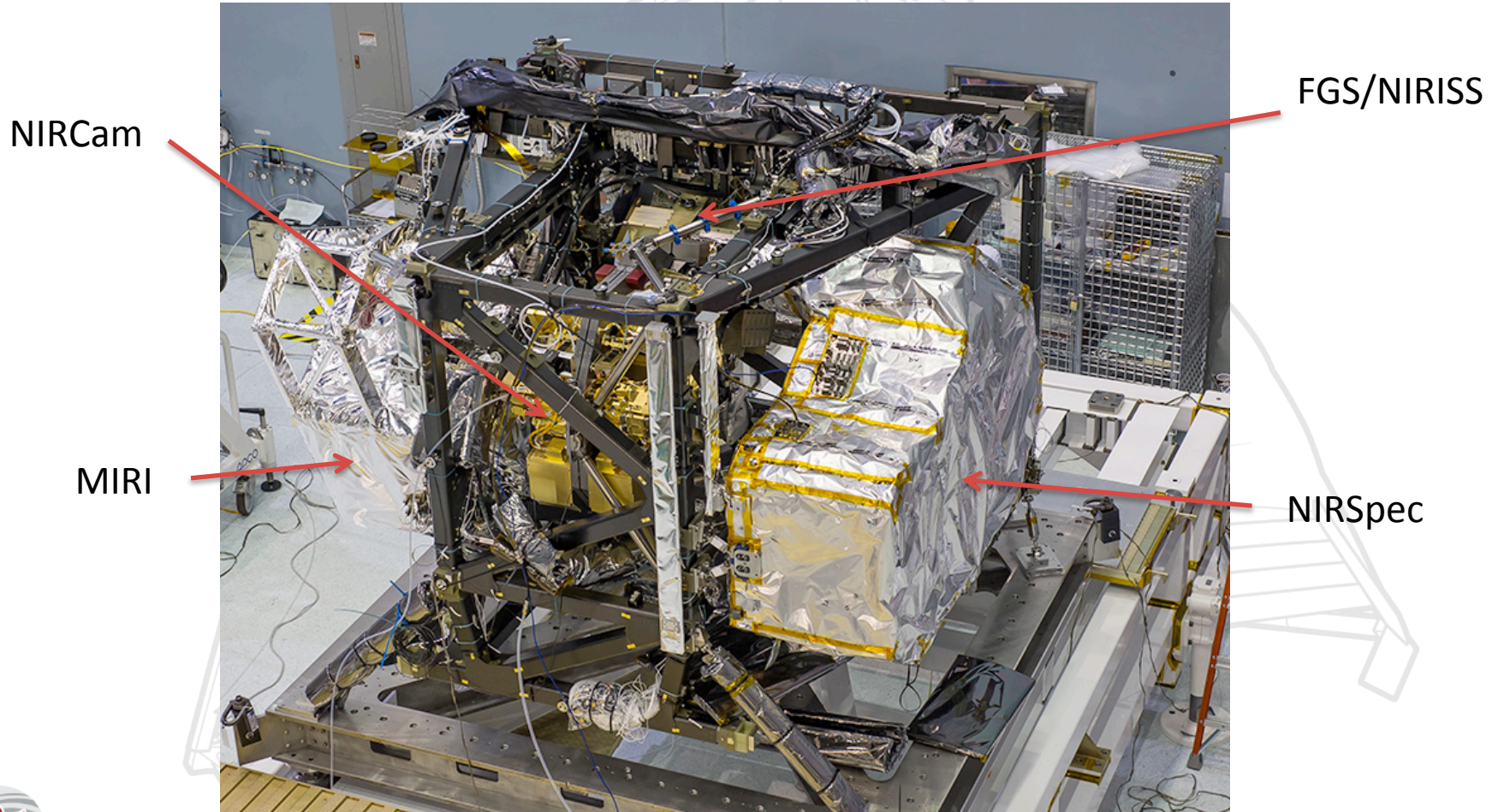


NIRSpec flight model in November 2012 at the end of its integration at Airbus (Ottobrunn site), before undergoing an extensive test and calibration campaign in 2013



# NIRSpec in ISIM

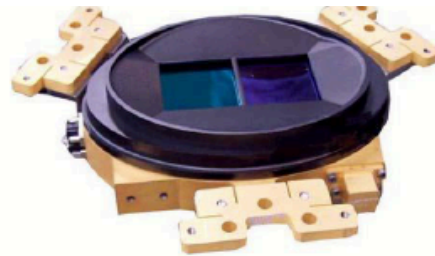
NIRSpec after its integration in JWST Integrated Science Instrument module (ISIM) in March 2014.



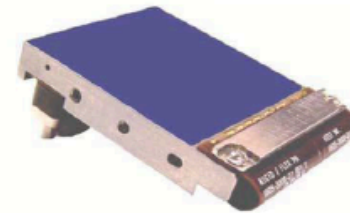
# NIRSpec detectors

Two 2048 x 2048 pixel Teledyne HAWAII-2RG (H2RG) sensor chip assemblies (SCAs)

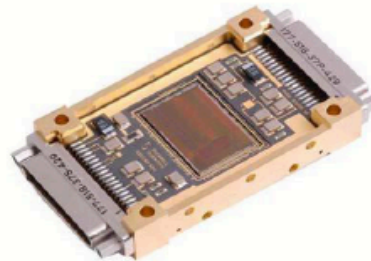
- 18  $\mu\text{m}$  pixel pitch
- 5.3  $\mu\text{m}$  cutoff
- $\Delta\lambda = 0.6 - 5.3 \mu\text{m}$



FPA STM



SCA



SIDE CAR ASIC

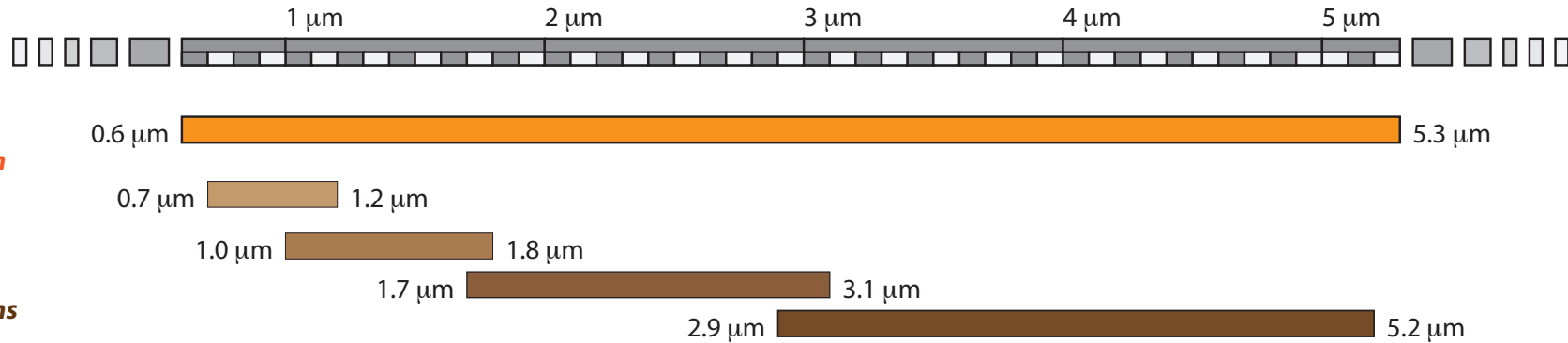


DU FPE



→ Ultra low-noise detectors

# Spectral configurations

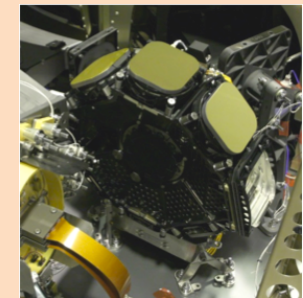
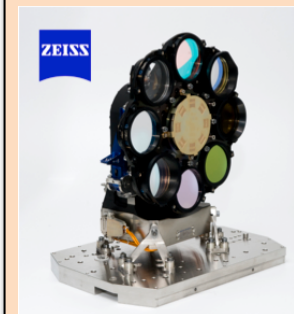


**Low spectral resolution configuration**

**Medium and high spectral resolution configurations**

Wavelength range	Resolution
0.6 – 5.3 μm	100 (Prism)
0.7 – 1.2 μm 1.0 – 1.8 μm 1.7 – 3.1 μm 2.9 – 5.2 μm	1000 (3 Medium Resolution Gratings)
0.7 – 1.2 μm 1.0 – 1.8 μm 1.7 – 3.1 μm 2.9 – 5.2 μm	2700 (3 High Resolution Gratings)

Configurations that can be obtained thanks to a combination of filters and dispersers installed on two wheels (FWA and GWA)



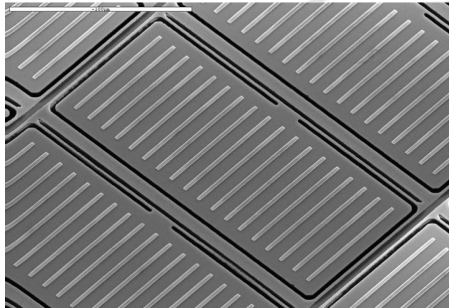
# The Micro Shutter Assembly (MSA)



- The MSA uses 4 arrays of 365x171 micro-shutters
- Each micro shutter: 80  $\mu\text{m}$  x 180  $\mu\text{m}$ , or 0.2"x0.5"
- Developed at Goddard (NASA)
- Implemented using Micro Electro-Mechanical systems (MEMs)

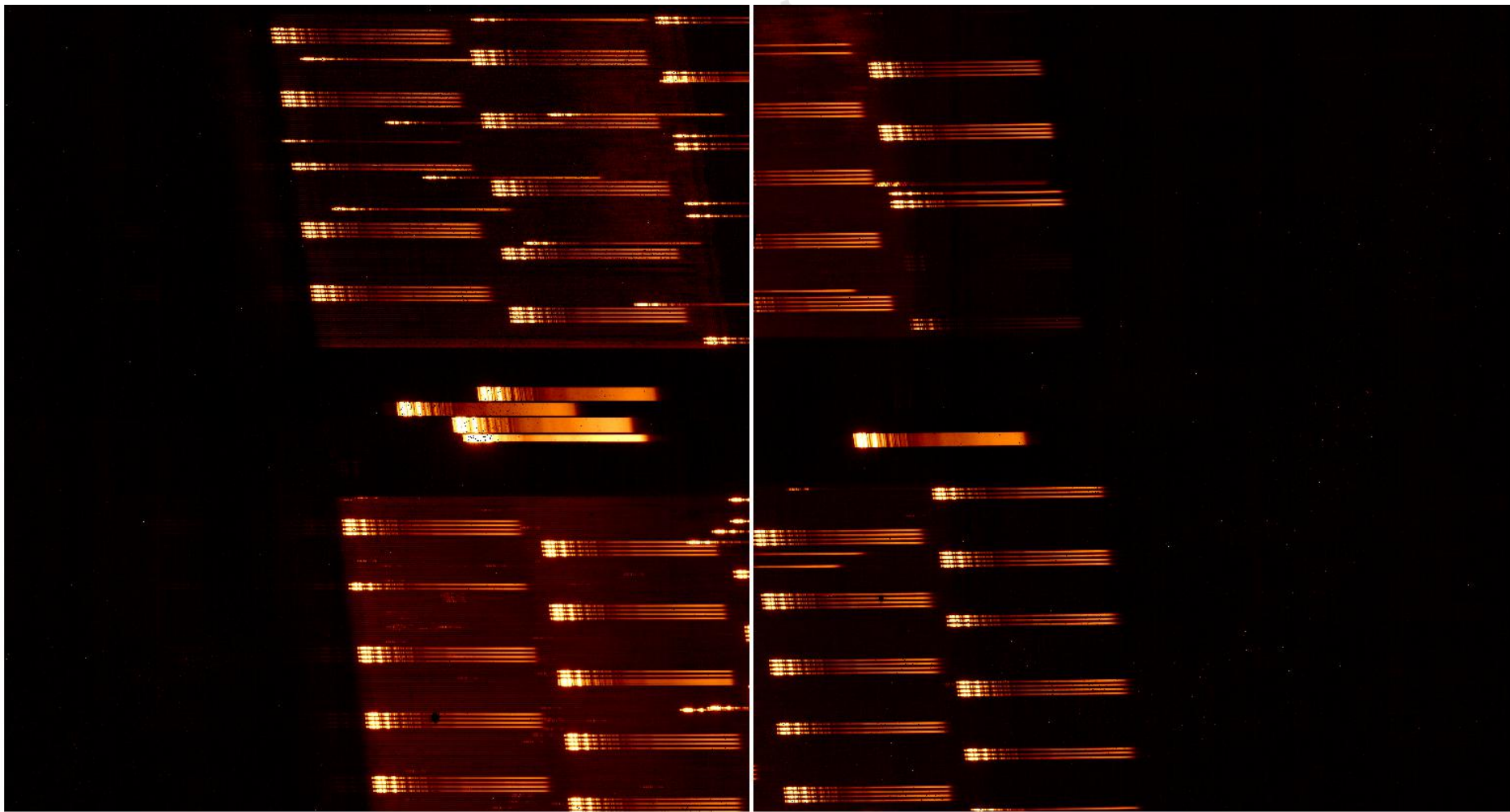
→ 250,000 individually addressable shutters

→ 9 arcmin<sup>2</sup> FOV





# MSA: multiplexing example (2013)



4

12

28

59

123

249

499

1005

2005



just



→  $\approx 80$  simultaneous spectra

ESA Science

# MSA: operational challenge

The **NIRSpec** team and software developers at the Space Telescope Science Institute (STScI) have been implementing specialized algorithms to facilitate the complex planning process of real observations.

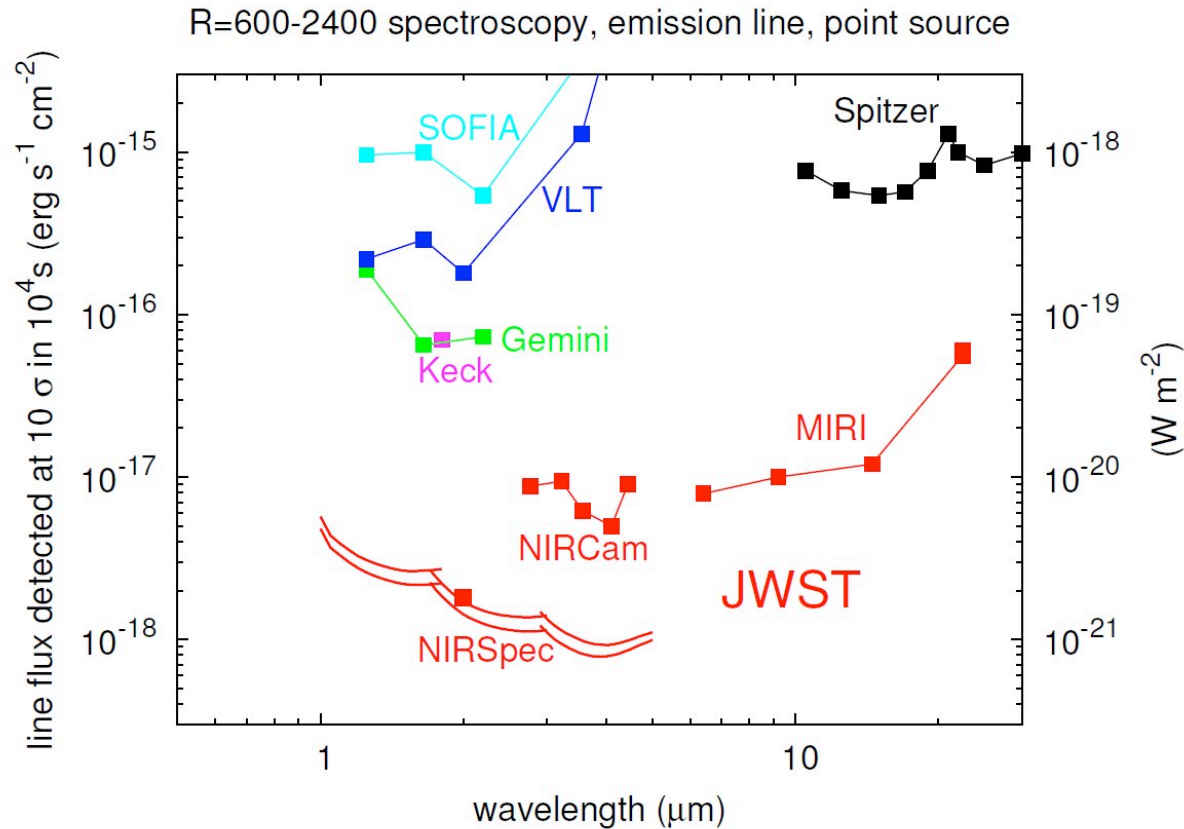
## Posters

- *Observing Resolved Stellar Populations with the JWST Near Infrared Spectrograph* by **Karoline Gilbert**
- *A tool for planning optimal MOS observations with JWST/NIRSpec* by **Diane Karakla**
- *MOS Spectroscopy with JWST/NIRSpec: Calibration, Data Products, and Analysis Tools* by **James Muzerolle**

**Demo!**



# NIRSpec sensitivity



➔ NIRSpec will be the most sensitive near-IR spectrograph available, at the end of this decade



just

ESA Science

# NIRSpec sensitivity: verified!

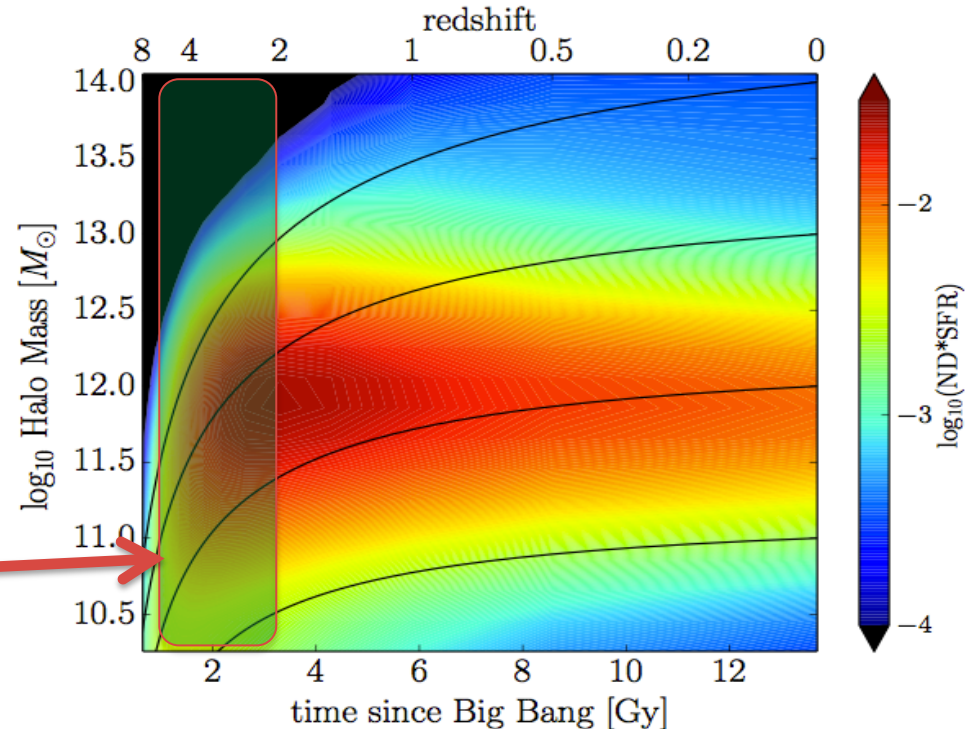
- Instrument high through-put was confirmed during the calibration campaign in 2013:  $\approx 40-50\%$
  - A couple of months ago, NIRSpec was fitted with two new H2RG Teledyne detectors: detector level testing confirm low noise figure:  $\approx 6 e^-$  total noise over 1 ks of integration time
  - The operability of the shutters is a also key performance parameter:  $\approx 90\%$  functioning micro shutters
- NIRSpec can deliver its scientific objectives

# Galaxy assembly studies

**Objectives:** i) *Uncovering galaxies early stages* ii) *Determine how galaxies and dark matter, gas, stars, metals, morphological structures, and active nuclei within the galaxies evolved from the epoch of re-ionization to the present day*

→ **Keys in understanding the physics of these processes**

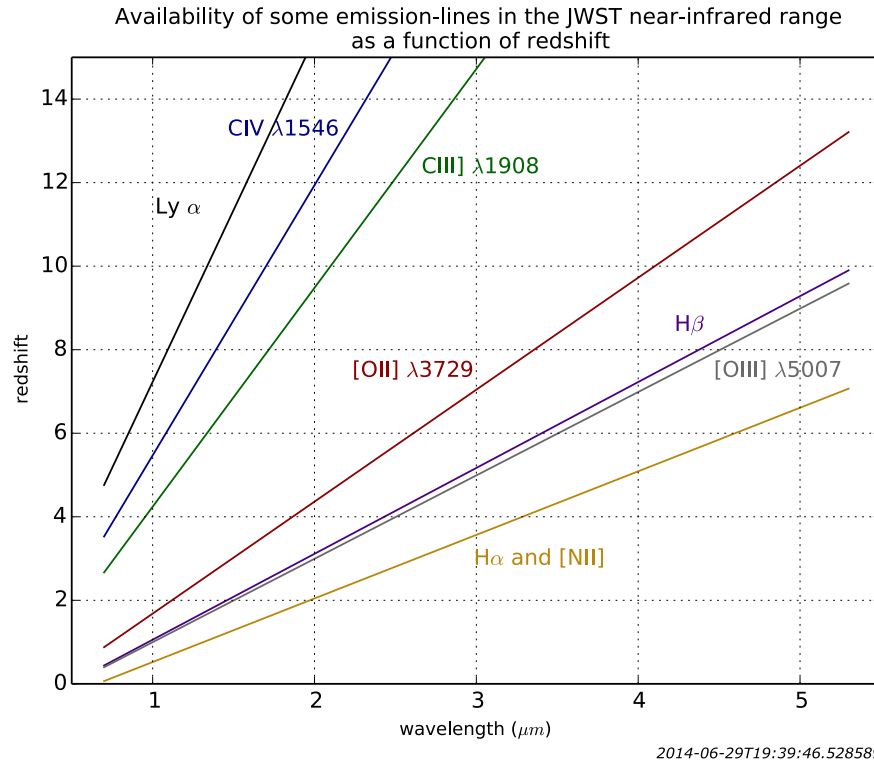
- Spectral observation of high-redshift galaxy ( $z > 8$ )
- characterizing a large number of galaxies within red-shift range  $2 < z < 7$



*Birrer, Lilly, Amara et al., 2014, ApJ*



# Diagnostics



Classical diagnostics available in the near-infrared instruments

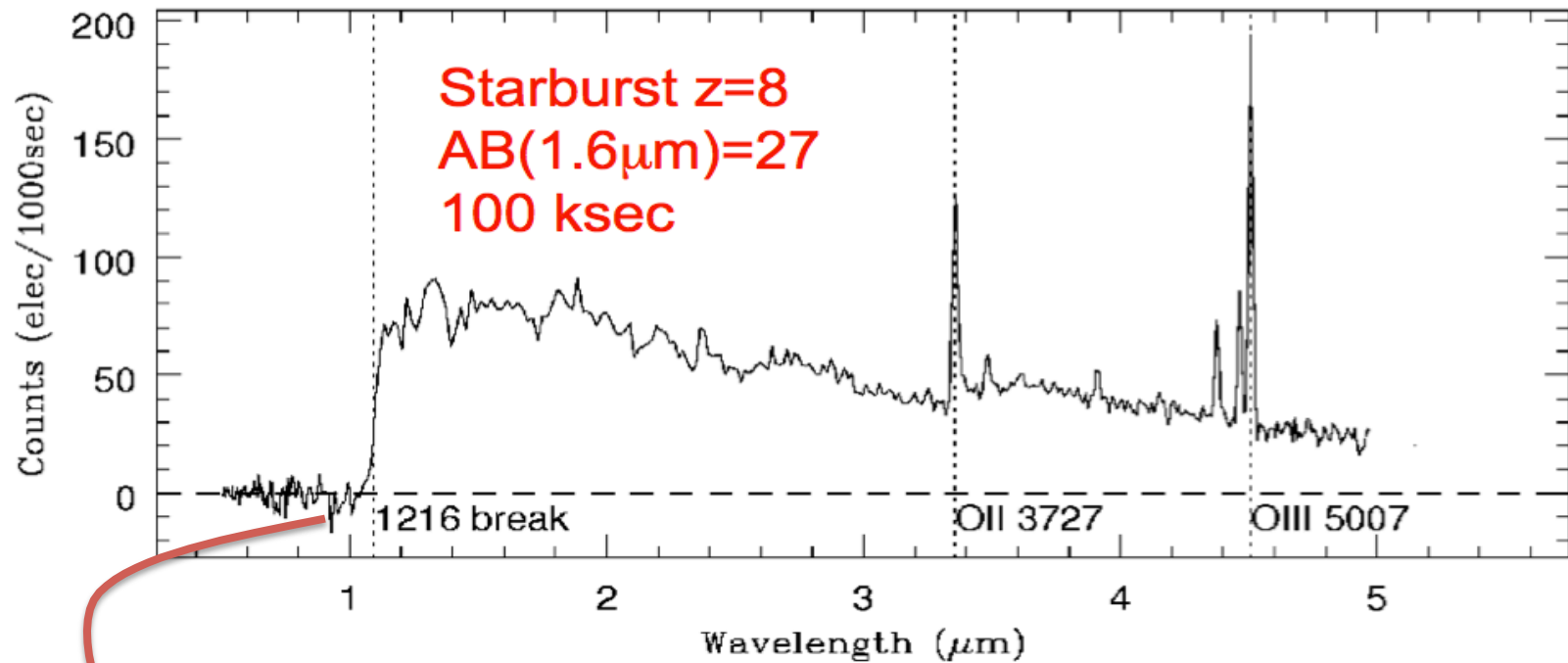
- ➔ For  $2 < z < 7$ : classical spectral diagnostic of a galaxy star formation rate, fall in the wavelength range 2 – 5  $\mu\text{m}$
- ➔ For  $z > 8$ : UV emission lines + also OII in the near-IR



# High-sensitivity: Spectral deep-fields

WFC-3 on HST can now detect drop-out galaxies out to  $z = 8$ : it is still extremely hard to obtain spectra of any of these galaxies. Their typical magnitude is  $AB > 27$

From Maiolino 2014, presentation at the HST conference IV in Rome



accurate red-shift, measures emission lines

→ constraints the nature of primeval galaxies at  $z > 8$



just

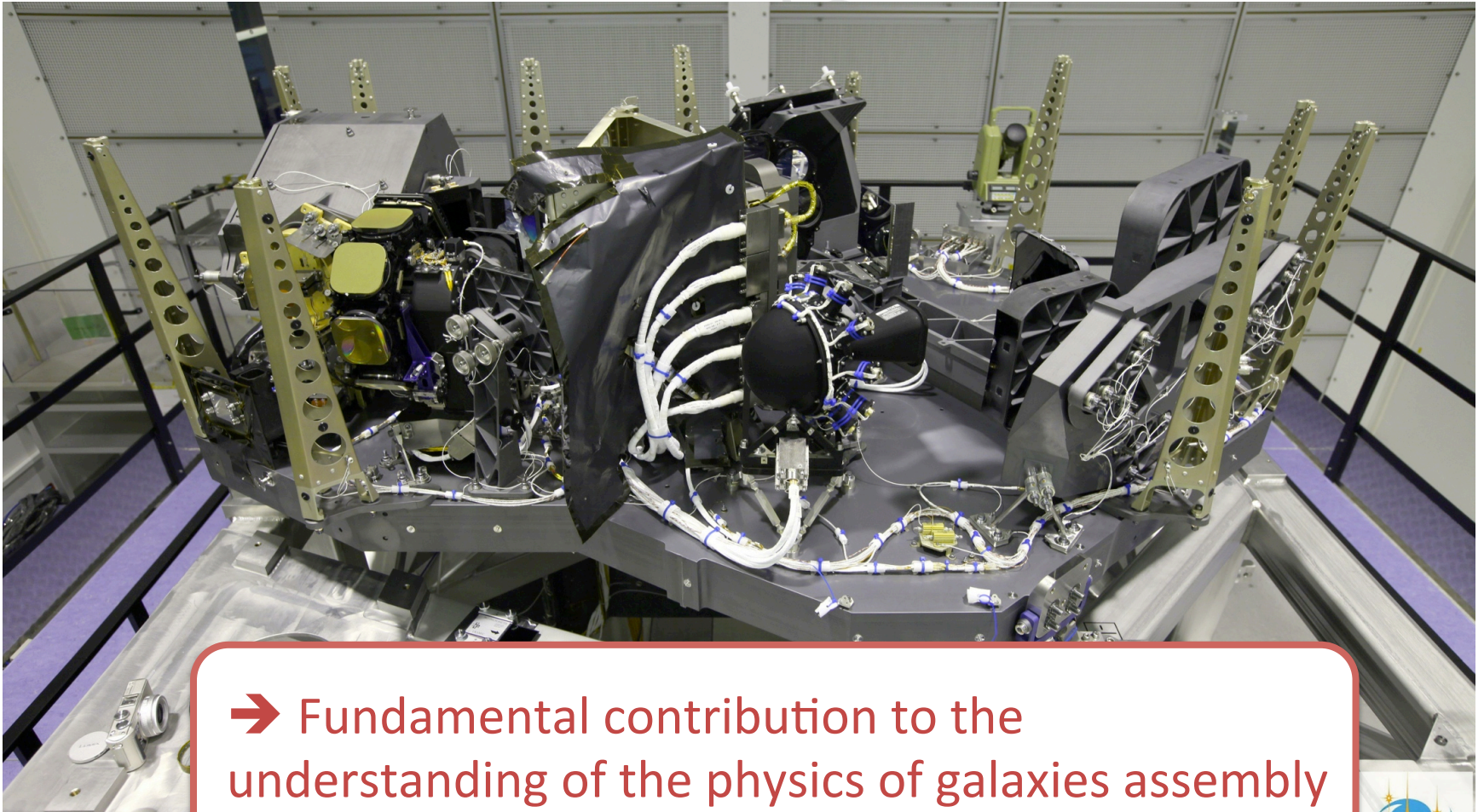
ESA Science

# High multi-plexing: many galaxies

- NIRSpec: low and medium resolution spectra of 10,000 galaxies with  $2 < z < 7$ , in  $\approx 500$  hours of observations
- get very accurate redshifts, and hence determine accurate restframe properties
  - measure emission lines ( $H\alpha$ ,  $H\beta$ ,  $OIII$ ,  $OII$ ), to constrain:
    - star formation rate, attenuation by dust
    - ionization state and metallicity of the interstellar medium
    - presence of an AGN
  - for larger galaxies, get spatially resolved information: constrain the build-up of galaxies with studies of rare sources, such as those ongoing mergers, events that might contribute significantly to galaxy evolution



# NIRSpec



→ Fundamental contribution to the understanding of the physics of galaxies assembly



# JWST/NIRSpec links

- NASA JWST site [jwst.nasa.gov](http://jwst.nasa.gov)
- ESA science and operation team  
<http://www.cosmos.esa.int/JWST/>
- ESA Science and technology section dedicated to JWST  
<http://sci.esa.int/jwst/>
  - Latest news with the press releases for major milestones.
  - Spacecraft testing section with a “journal” following what happens to MIRI and NIRSpec.
- JWST web site at STScI <http://www.stsci.edu/jwst/>

➔ **Thank you for your attention!**



# JWST/NIRSpec – Overview

- Like all JWST's instrument, NIRSpec will have an unprecedented combination of sensitivity and spatial resolution.
  - Fantastic discovery space.
  - The instrument meets its performance requirements.

