WISH
IFS DESIGN CONSIDERATIONS

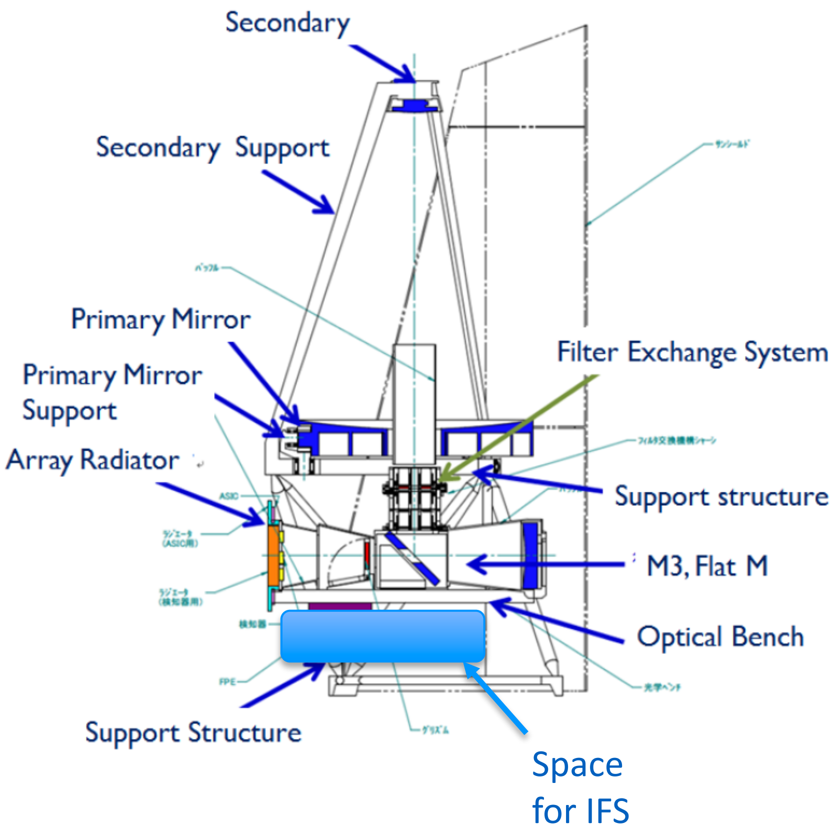
Sebastien Vives, Kjetil Dohlen, Denis Burgarella

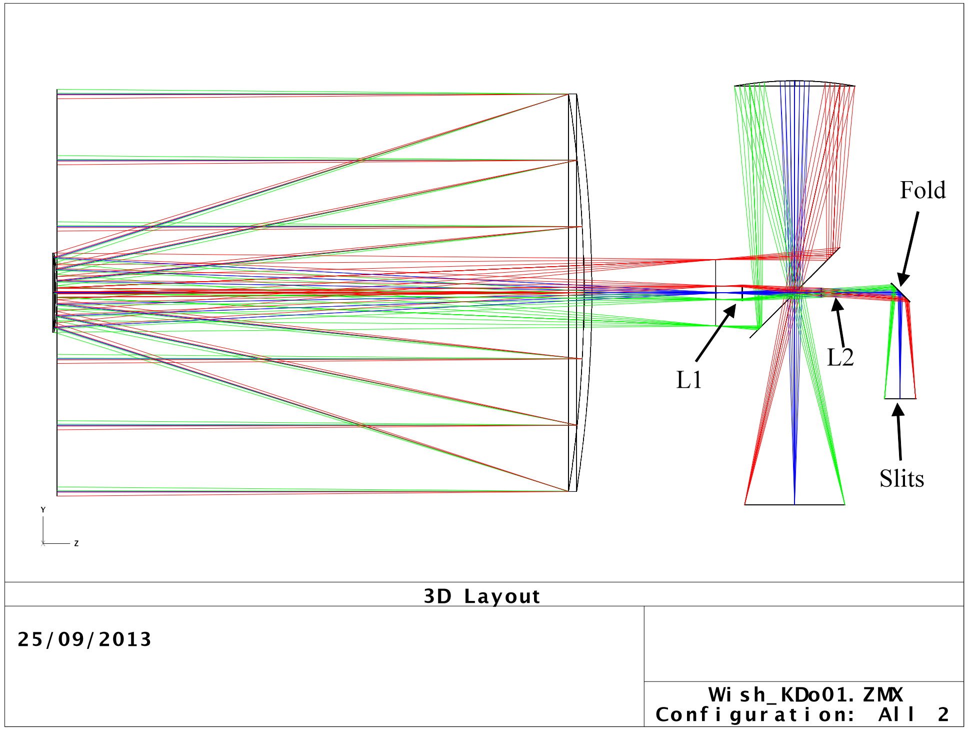
LAM, 11/9/14

Basic idea of implementation

A small central FOV can be available through the hole in the fold mirror

- Possibly passing up to a few arc minutes towards the bottom of the space craft
- Space available below the optical bench
- A "reasonable" design could fit in a (large) shoebox





Wanted main characteristics

WISH list

- Integral field spectrometer with FOV: 1x1′
- Angular resolution: 0.5″
- Spectral range: 1-5μm (at least 2.2-5μm)
- R=λ/Δλ: 600 - 1000

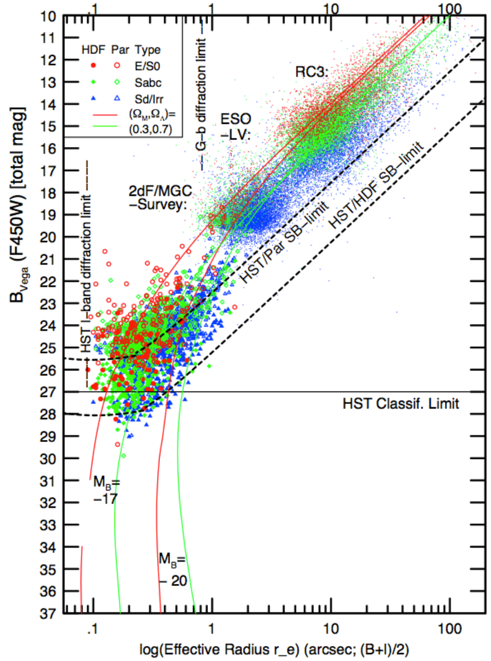
For comparison: JWST IFU characteristics

- FOV: 3x3″
- Angular resolution: 0.1″ per slice, ie 30 slices
- Spectral range: 0.6-5μm
- R: 100, 1000, 2700

Consequences:

- For Nyquist sampling, need two slices per resolution element
- Then we would need 2 x 1′/0.5″ = 240 slices
- A reasonable number is 40 slices, otherwise need multiple units, cf MUSE
- Spectral range 1-5μm covers more than two octaves, so would need three different gratings
- For single-grating system should limit range to an octave, eg 2.2-4.4 or 2.5-5

MIS-KIS approach (make-it-simple-keep-it-simple)



System based on a single slicer stack and Hawaii-2RG detector

- Assume 40 slices
- Go to 30''
  - still 10 x JWST's IFU on a side
  - ~100 x JWST's IFU in area
- Spatial sampling is then defined by the 0.75” slice width
- For a typically 0.4” diameter galaxy this means forgetting about Nyquist and letting the object define the effective slit

For spatial along-slice sampling equal to across-slice sampling

- Need anamorphic fore optics (classical)
- 40x40 = 1600 spatial detector pixels

System based on a single grating

- Spectral range limited to an octave, say 2.5-5μm
- Object defines the spectral resolution, assume 2 spectral pixels on an object of 0.4”
- Spectral resolving power of R=1000 requires ~2000 spectral detector pixels

Some scientific trades-off …

The present design suggests that the MIS-KIS is FOV = 0.5’, R = 1000 and Δλ ≈ 2.5 – 5 µm (1 octave).

- **Is it possible (simple ?) to modify the design to reach FOV = 1.0’**

Tentative answer:

1) You can double the spatial sample size, ie 1.5”, but then your camera will become more difficult to realize (f/D ~ 1.7)

2) You can split the field and have a set of 4 slicer stacks, spectrographs, cameras.

- **Is it possible (simple ?) to modify the design to reach Δλ ≈ 1.25 – 5 µm ?**

Tentative answer:

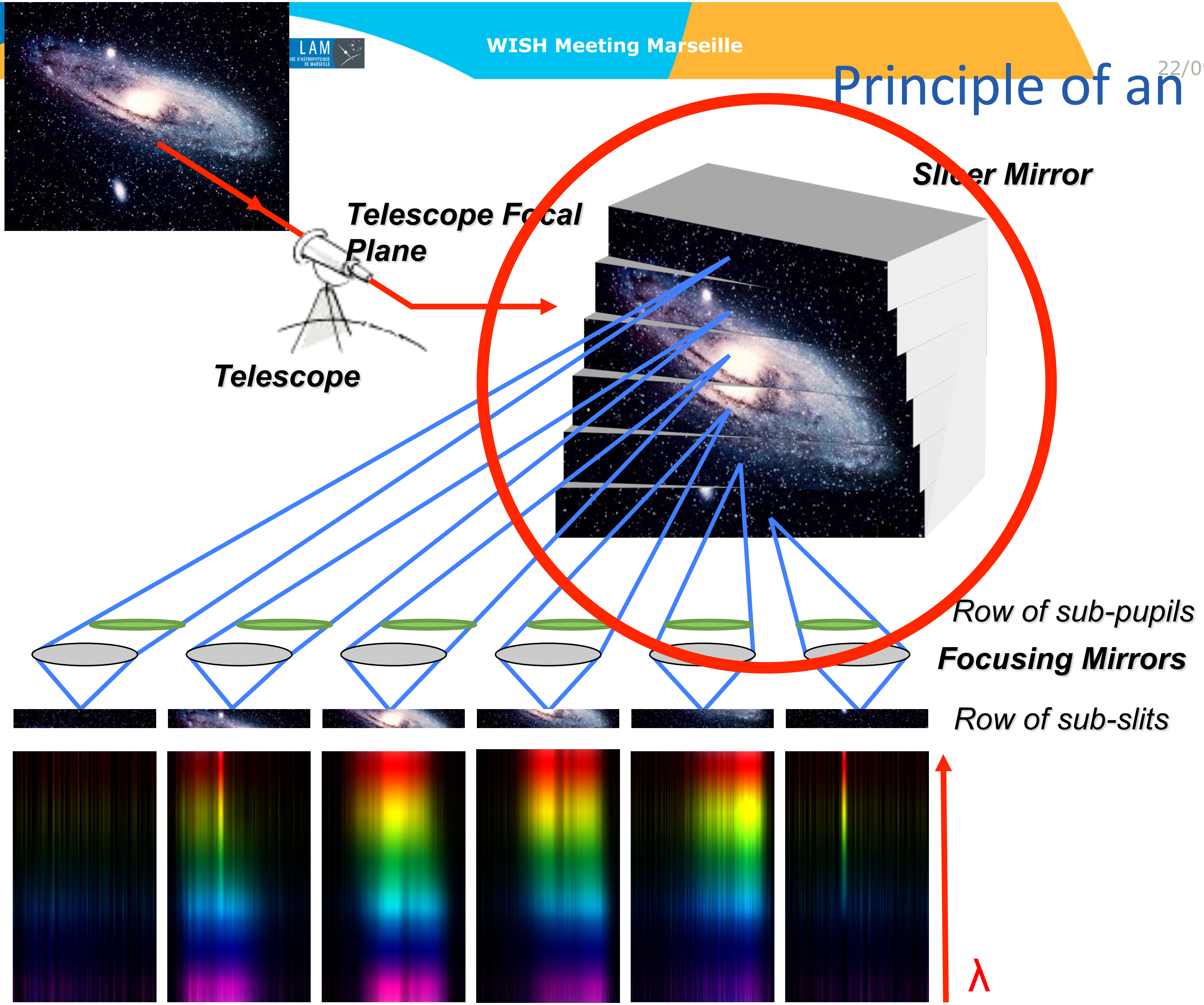
This would require two gratings and could be obtained either using an exchange mechanism with a single spectrograph or by splitting the flux with a dichroic somewhere after the slicer stack and have two spectrographs, hence two detector arrays.

- **We might imagine to relax the constraint on R to R = 500 – 600, does that help?**

Hmm, help in what sense? It would liberate pixels, but it would not reduce complexity, since you then need to pipe the light from different spectrograph units onto a small detector chip.

LAM’s heritage in Image slicer Instruments

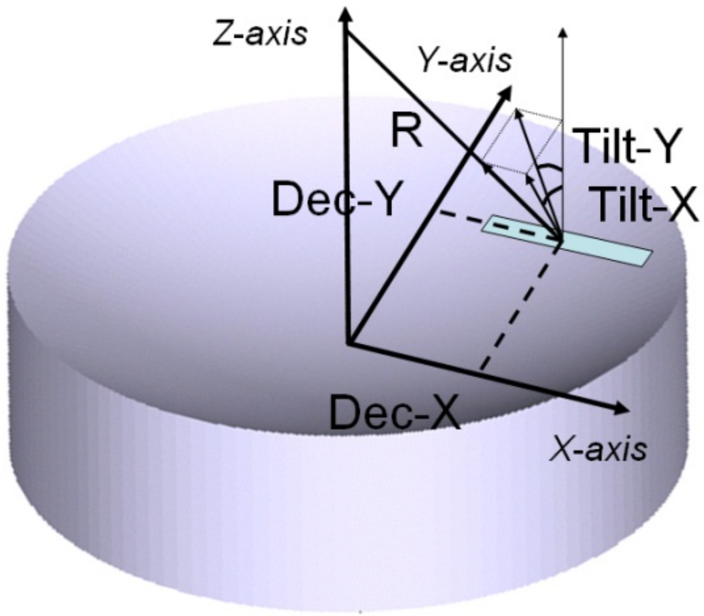
Principle of an IFS

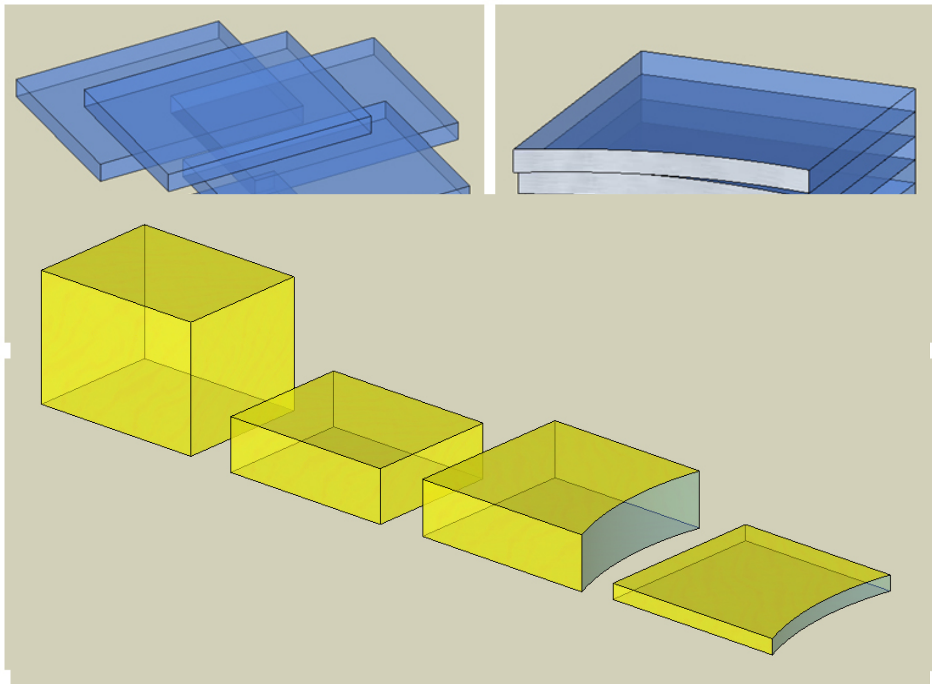


High performance Low-cost IFU

In 2006, LAM and Winlight proposed an innovative approach to make slicer mirrors

- A single classical polishing process to polish several dozen of slices.
- Therefore we are able for the first
-

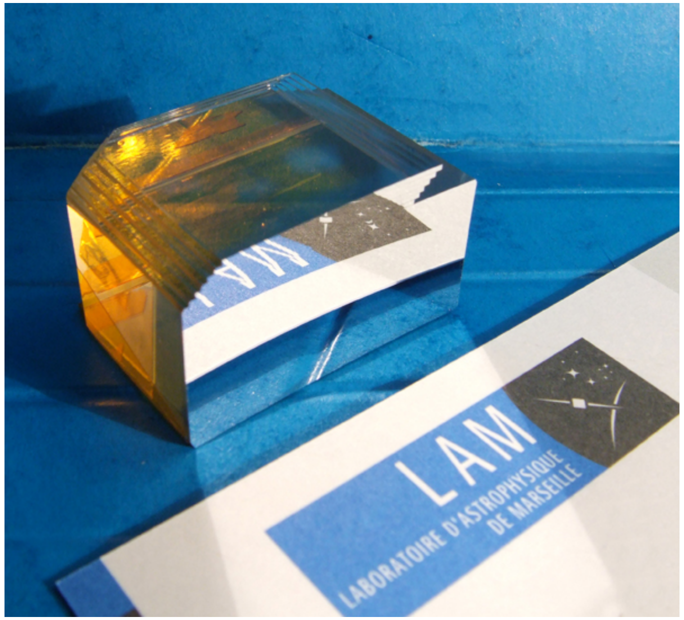




Vives, S.; Prieto, E., Salaun, Y., Godefroy, P.,

“New technological developments in Integral Field Spectroscopy”, Proc. SPIE 7018, 70182N (2008)

First Demonstrator (2006)…

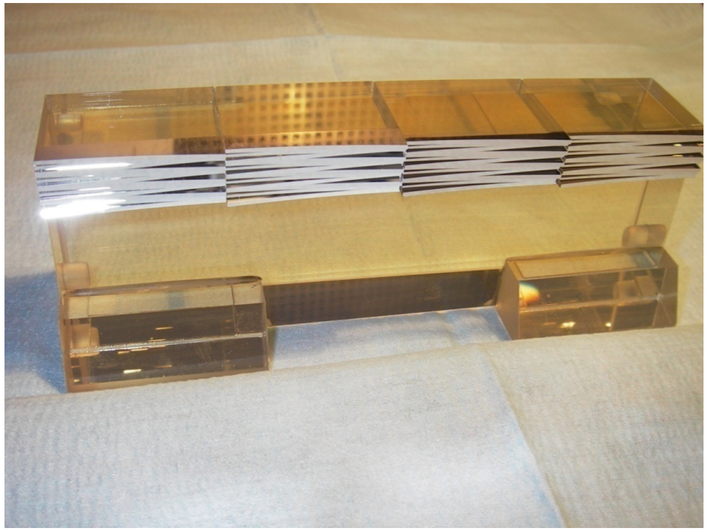


PERFORMANCE

Generic optical specification for these components using our approach:

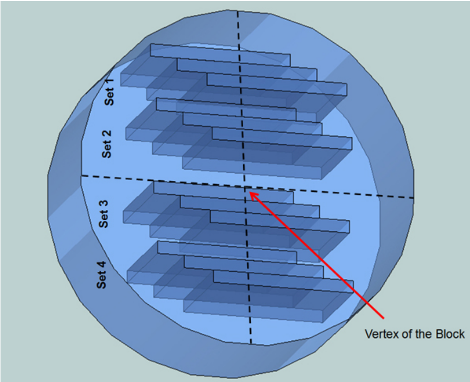
Surface quality **~λ/100 rms**	Surface roughness **~ 0.4 nm**
Edges **~1 µm**	Tilt error of the slices **<15 arcsec PTV**

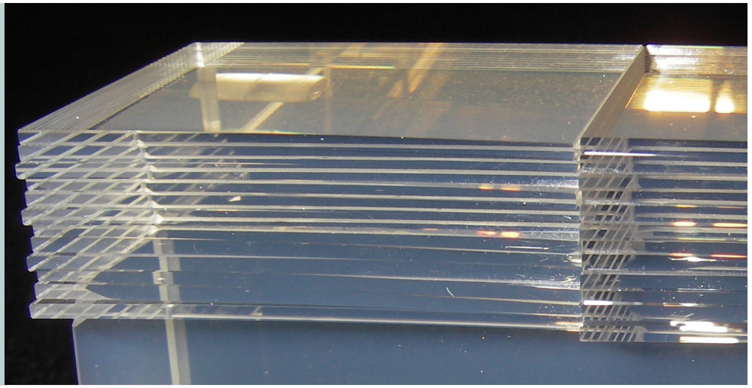
… applied on MUSE (2014) !

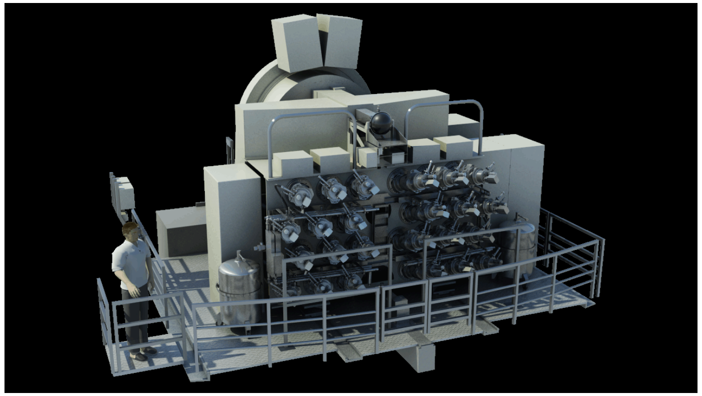


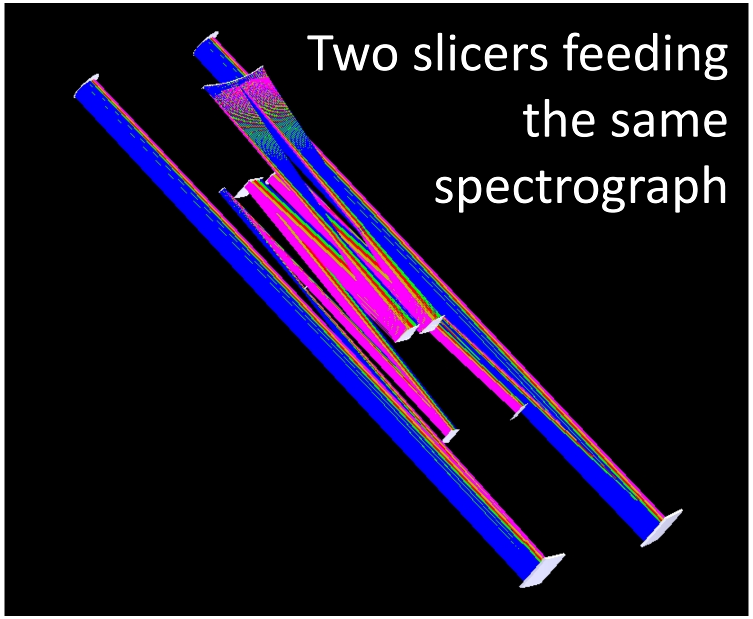
Few optical designs we have proposed for ground based instruments

VLT/MUSE: Optimize manufacturing process



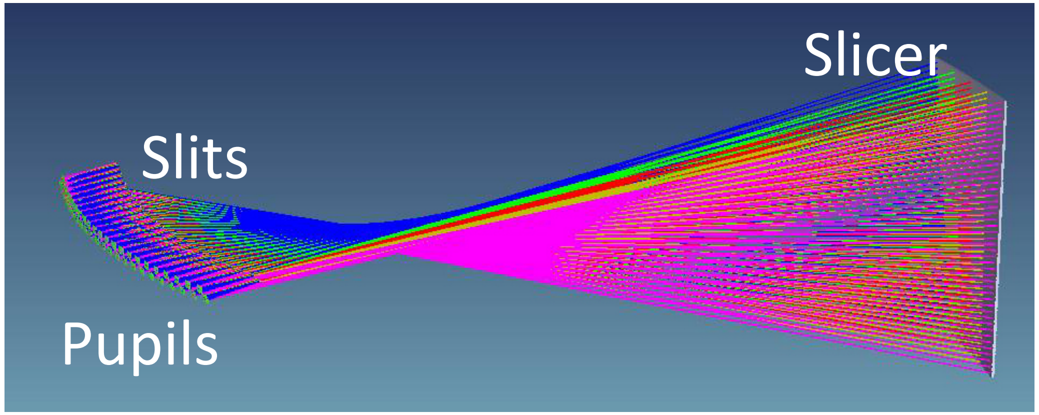






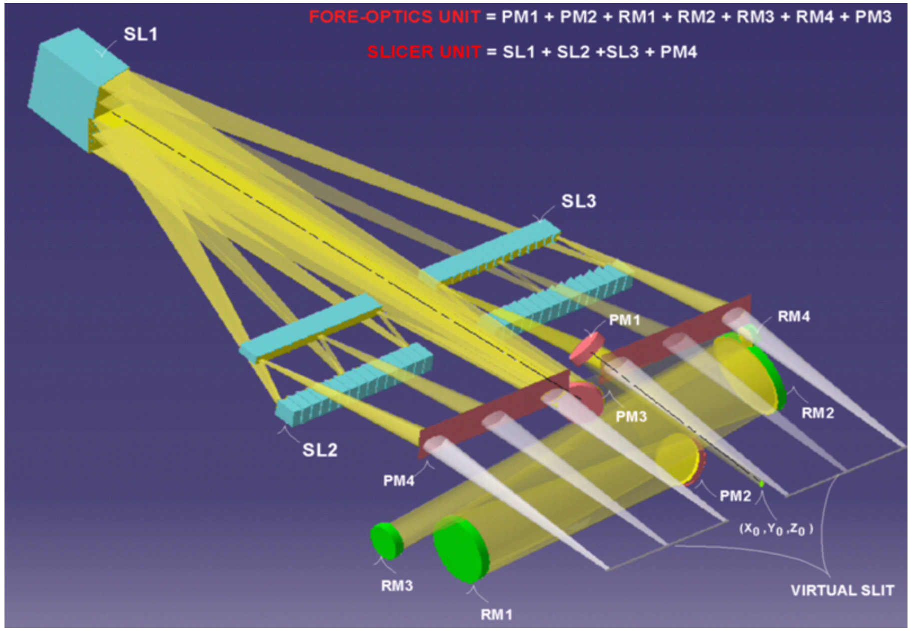
ELT/EAGLE:

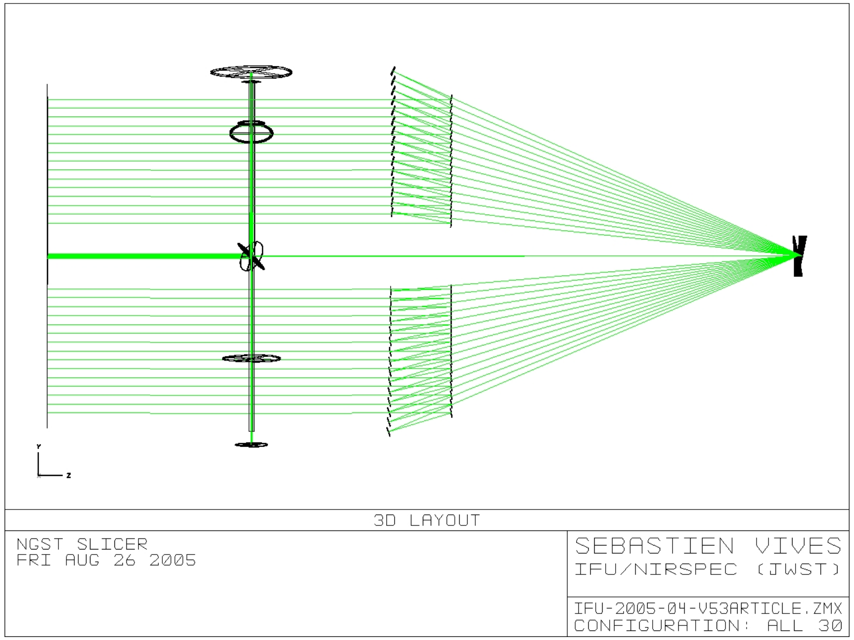
Minimize amount of optics



Few optical designs we have proposed for spaceborn instruments

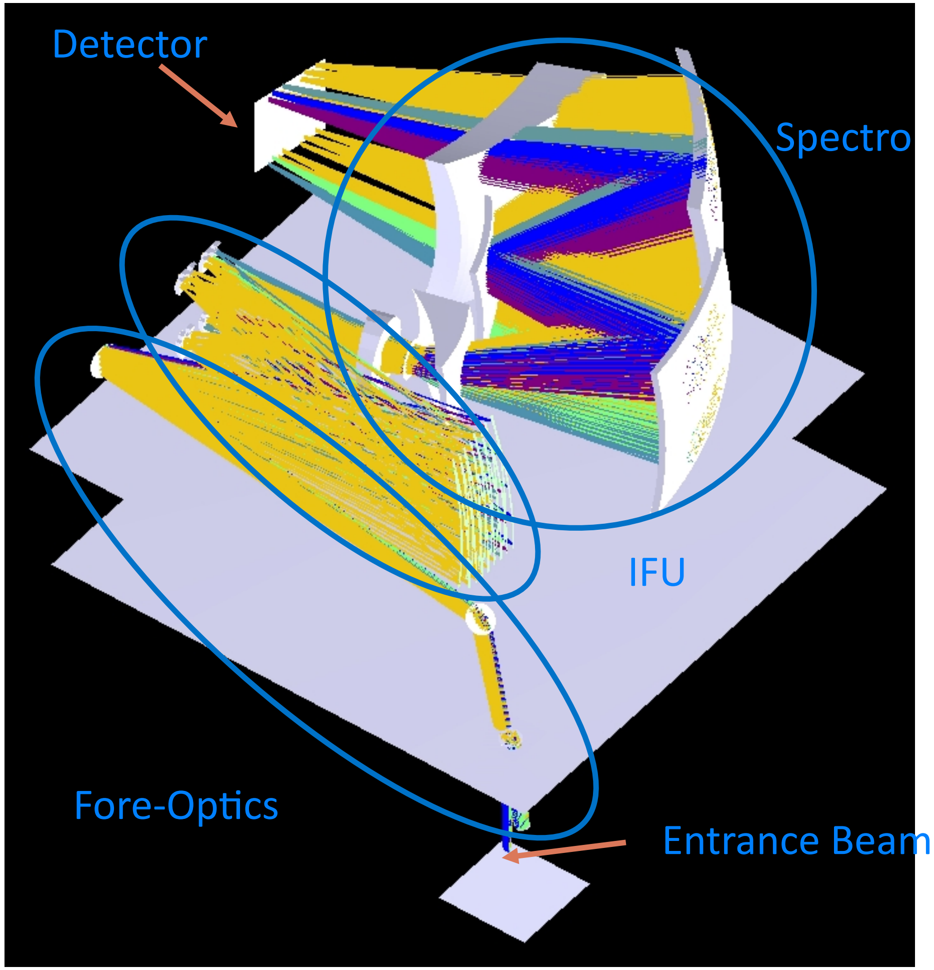
JWST/NIRSpec: Optimize image quality





Few optical designs we have proposed for spaceborn instruments

SNAP: Optimize image quality of both IFU+Spectrograph wihtin limited volume



- Volume Allocation:
  - ~270 x 270 x 200 mm
- Field of view:
  - 10 x 20 arcsec²
- Wavelength range:
  - 0.4 to 1.7 μm
- Spectral resolution:
  - R~100 @ 1 μm
- Spatial Sampling:
  - 0.15 arcsec/px

The IFU technology is

- flexible and very powerful
- well adapted to the WISH mission

Some specifications have to be clarified (trades-off) before going more deeply into the optical design of the IFS

MERCI !

Et bon Appétit…