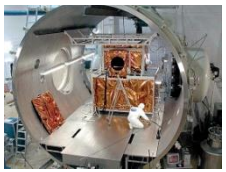
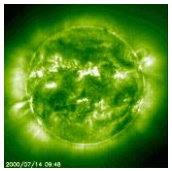
Centre Spatial de Liège
Université de Liège

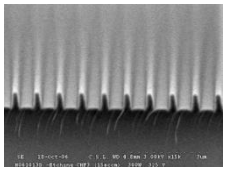
Design, assembly and test of a near-infrared spectrograph for the TIGRE telescope

4th TIGRE Workshop

01/12/2015







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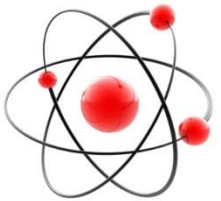
Project overview – *Why studying massive stars ?*

- **Massive? Initial mass above** $8\ M_{Sun}$

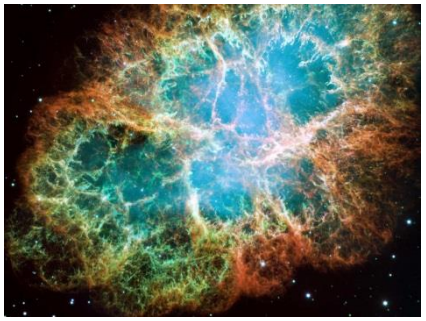
  $\rightarrow$ *Production of heavy elements*



- **High temperature:** $20000K \rightarrow 120000K$

- **Mass loss:** $10^{-7} \rightarrow 10^{-3}\ M_{sun}\ yr^{-1}$

  $\rightarrow$ *Stellar wind* $\gg$



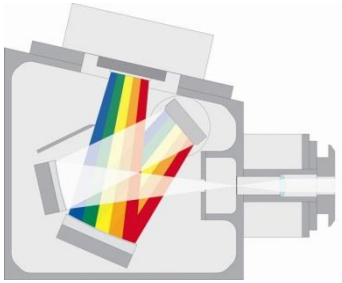
- **Death:** *gigantic supernova*

They are key players for the evolution of the universe !

Project overview – *New instruments*

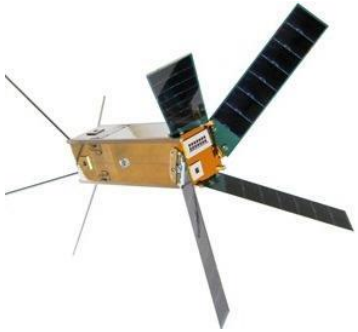
- **Near-IR spectrograph**

  → mounted on the TIGRE **(ground)**



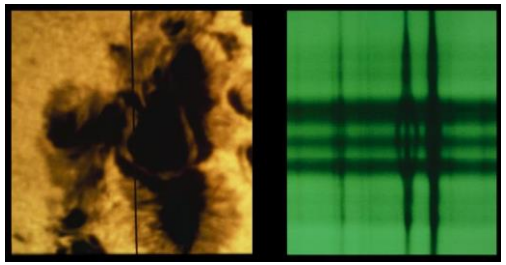
- **UV observing nano-satellite**

  → feasibility study **(space)**



- **UV-VIS Spectropolarimeter**

  → pre-phase-A and phase-A **(space)**

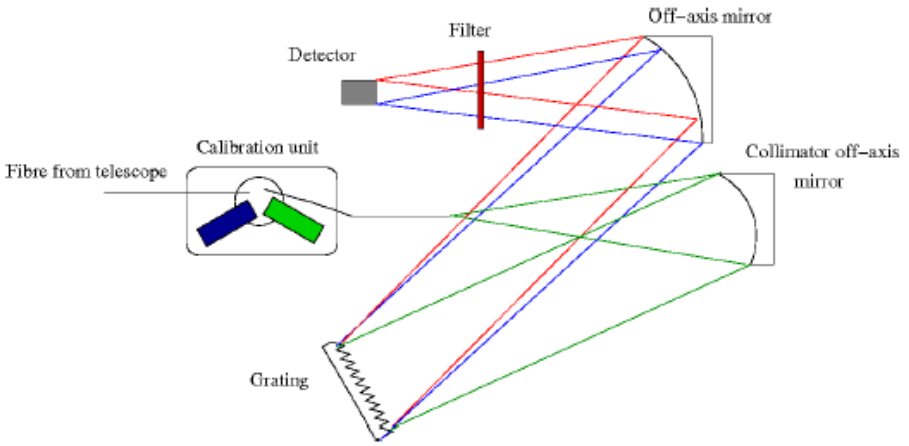


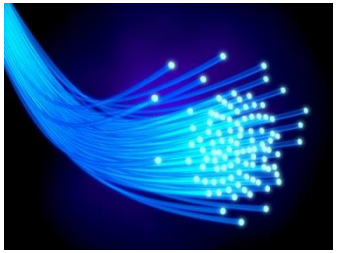
Project overview – *Near-IR spectrograph*

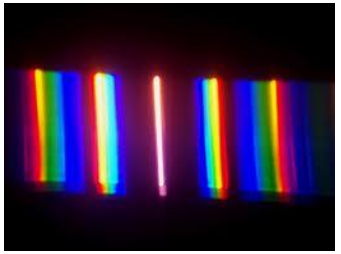
- **Resolving power needed:** 10 000 (goal 20 000)
- **Spectral domain:** 1 to 1,1 μm
- **Detector trade-off:**

  → CCD or specific IR detector ?
- **Versatile interface:**

  → fibre-fed
- **Should be adaptable to other telescopes (ARIES)**

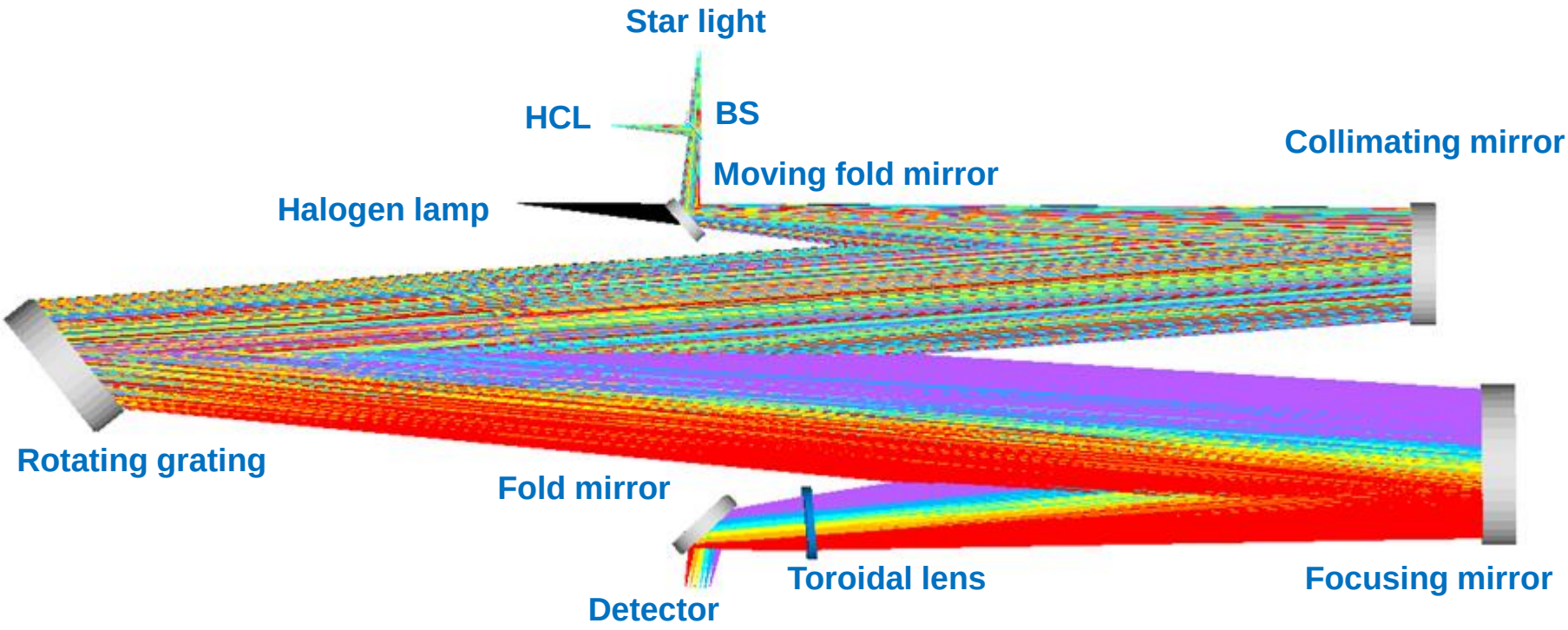






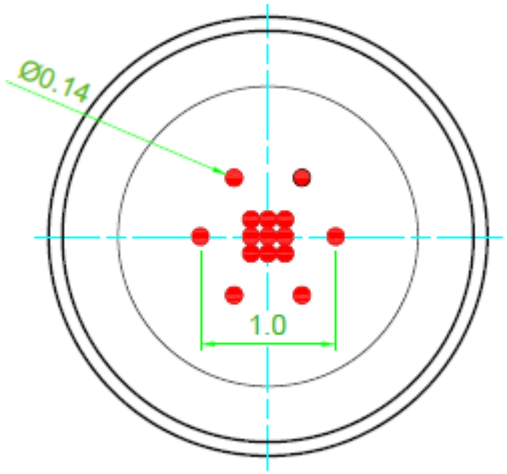
Optical design: *From scientific requirements to instrument specifications*

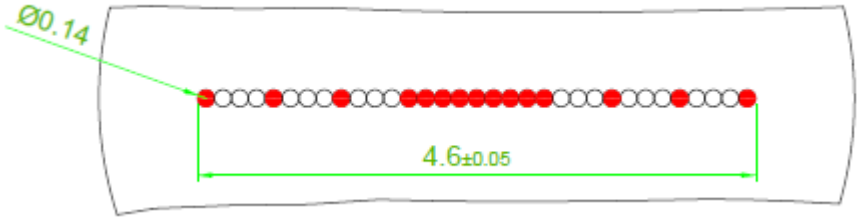
- **Bibliography:** find articles related to spectrograph design
- **Results:** obtain constraints on optical elements' properties, rough location in space, …
- **Start optical implementation and optimization**



Optical design: *Bundle configuration*

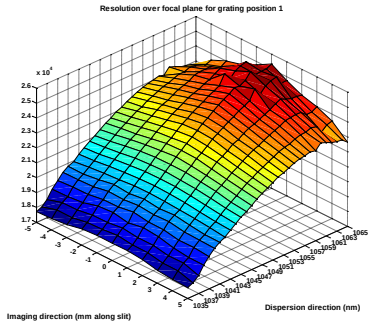
- **Configuration:** circular input to linear output
- **Center part:** 3x3 squared area which intends to collect target star light
- **"Satellite" fibers:** surrounding area is designed to collect background and, maybe, another star light

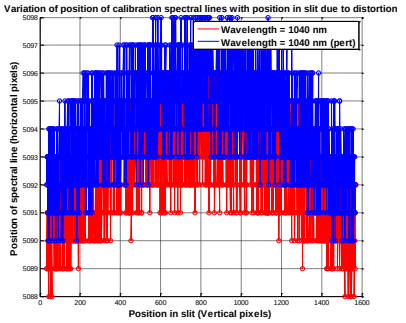


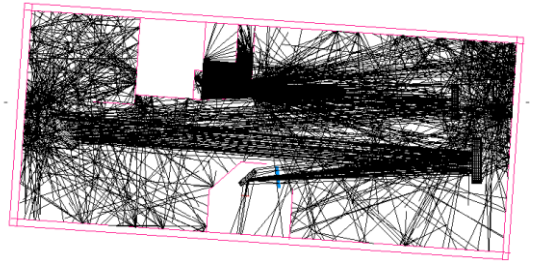


Optical design: *Analyses*

- **Resolution:** investigate variation of resolution through focal plane (VS. λ and along slit direction)
- **Tolerancing:** performance budget with optical, mechanical and alignment tolerances.
- **Calibration:** effects of rotating grating and translating mirror positions on calibration precision
- **Straylight:** Identify potential ghosts, 0^{th} order path and multiple reflections' paths
- **Crosstalk:** Fix fibers' spacing to avoid crosstalk
- **Star positioning system:** align star image on fiber core

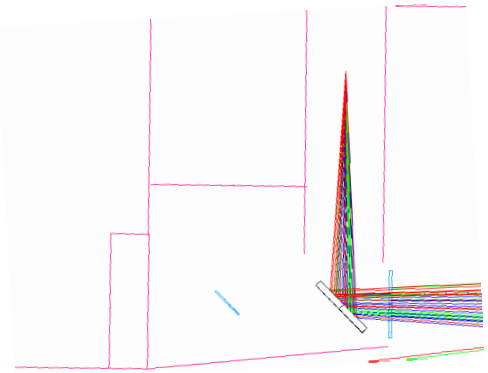




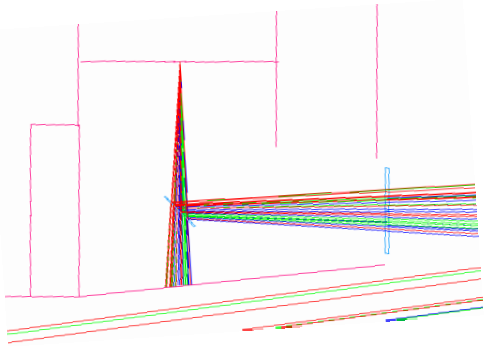


Calibration unit

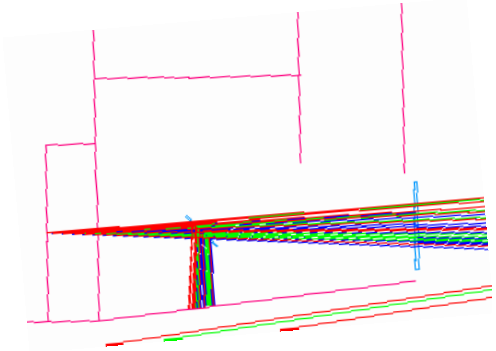
- **Star light:**
  - light from the fiber bundle is selected with a moving fold mirror



- **Hollow cathode lamps (U-Ne):**
  - light is selected with a beamsplitter (reflection)
  - registration of focal plane pixels



- **Halogen lamp:**
  - light is selected with a beamsplitter (transmission)
  - measure pixel response (spectral "flat field")



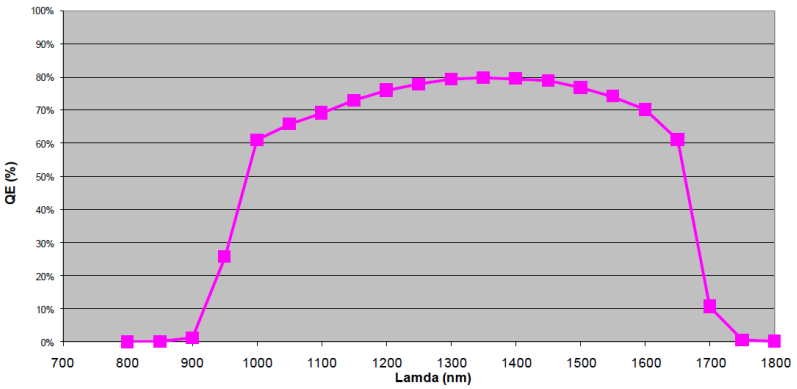
Photometric budget

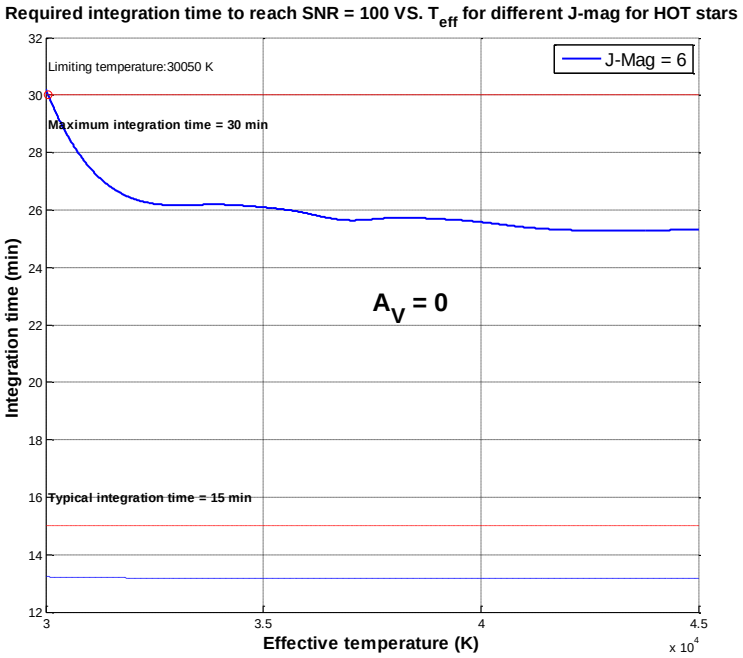
- **InGaAs detectors:**

→ **high** quantum efficiency at $1\ \mu m$

→ DC ↘ if $T°$ ↘

→ Best detecting operating temperature **IS** usually the lowest operational one





Photometric budget

- **NIR-enhanced CCD detectors:**

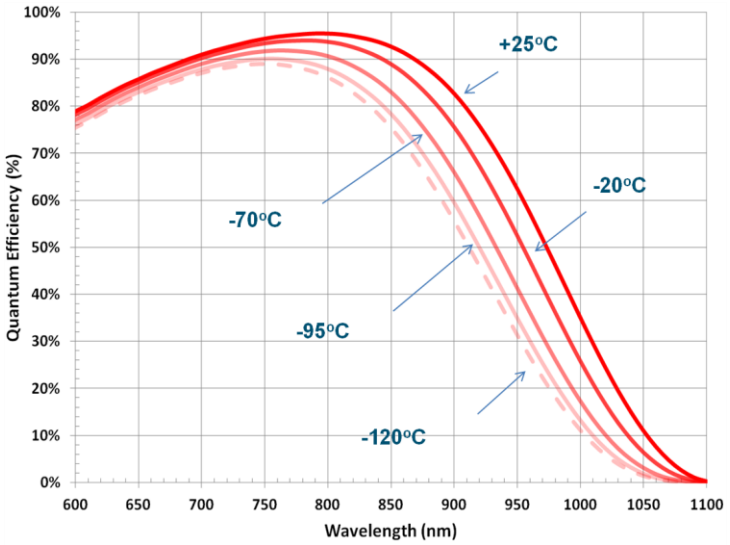
→ **low** quantum efficiency at 1 μm

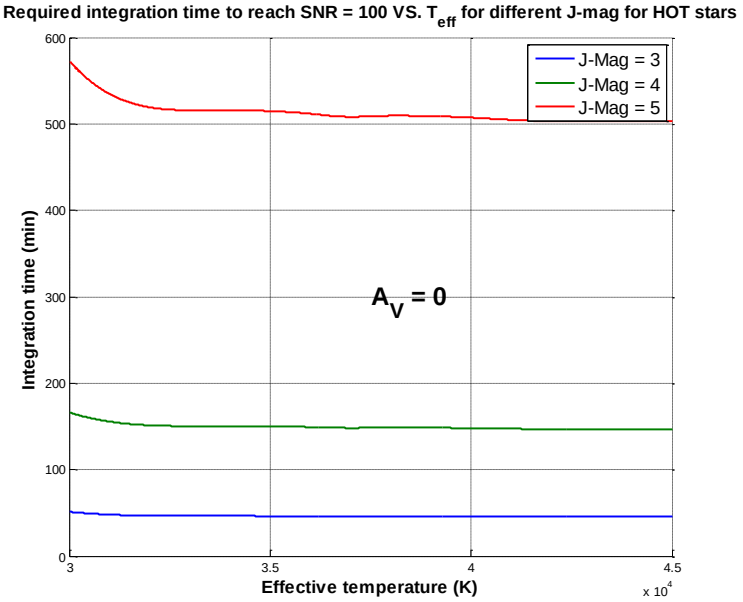
→ DC ↘ if $T°$ ↘

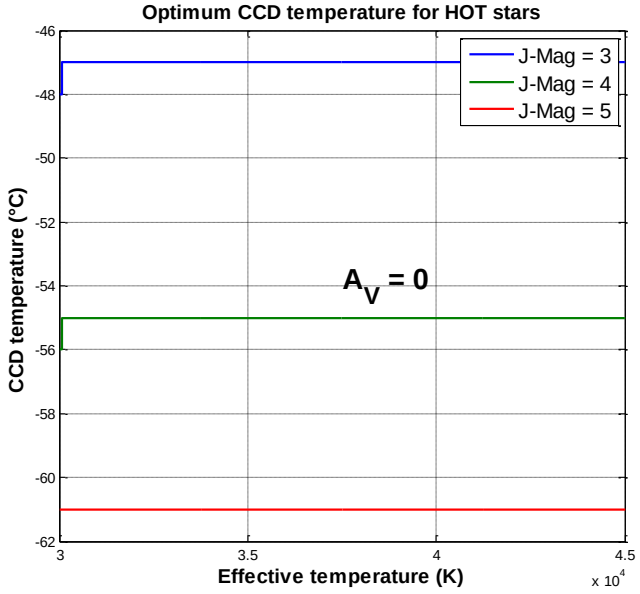
→ BUT QE ↘ if $T°$ ↘

→ Best detecting operating temperature **IS**

NOT the lowest operational one

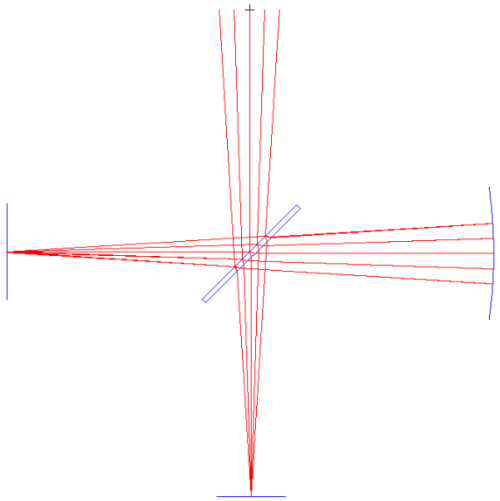




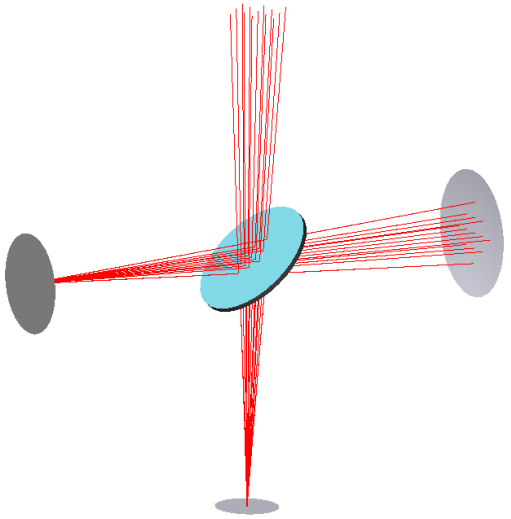


Star positioning system

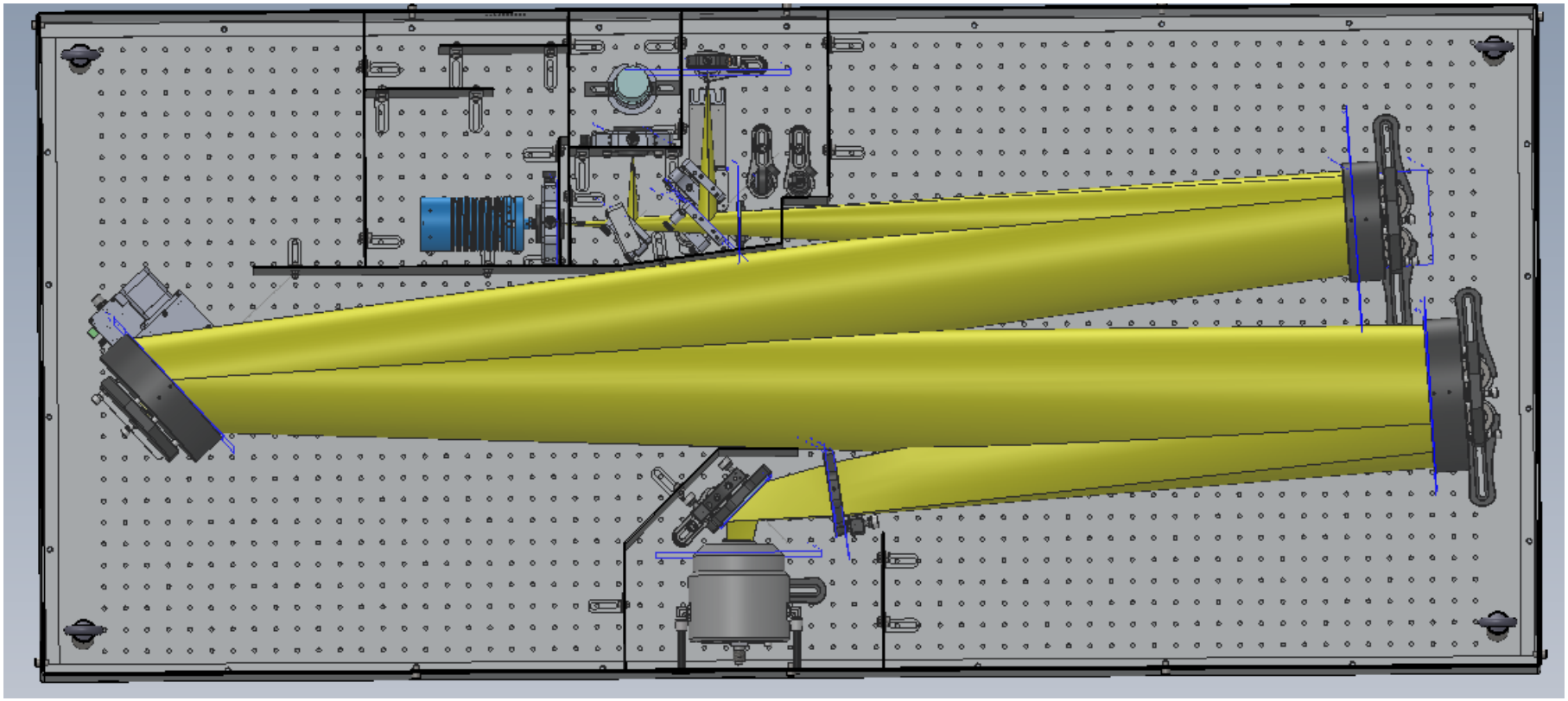
- **From telescope to fiber:**
  - Light from telescope reaches a AR window
  - It acts as a dichroic BS (poor AR quality in visible)
  - VISIBLE star light imaged on camera
  - NEAR-IR star light goes to fiber



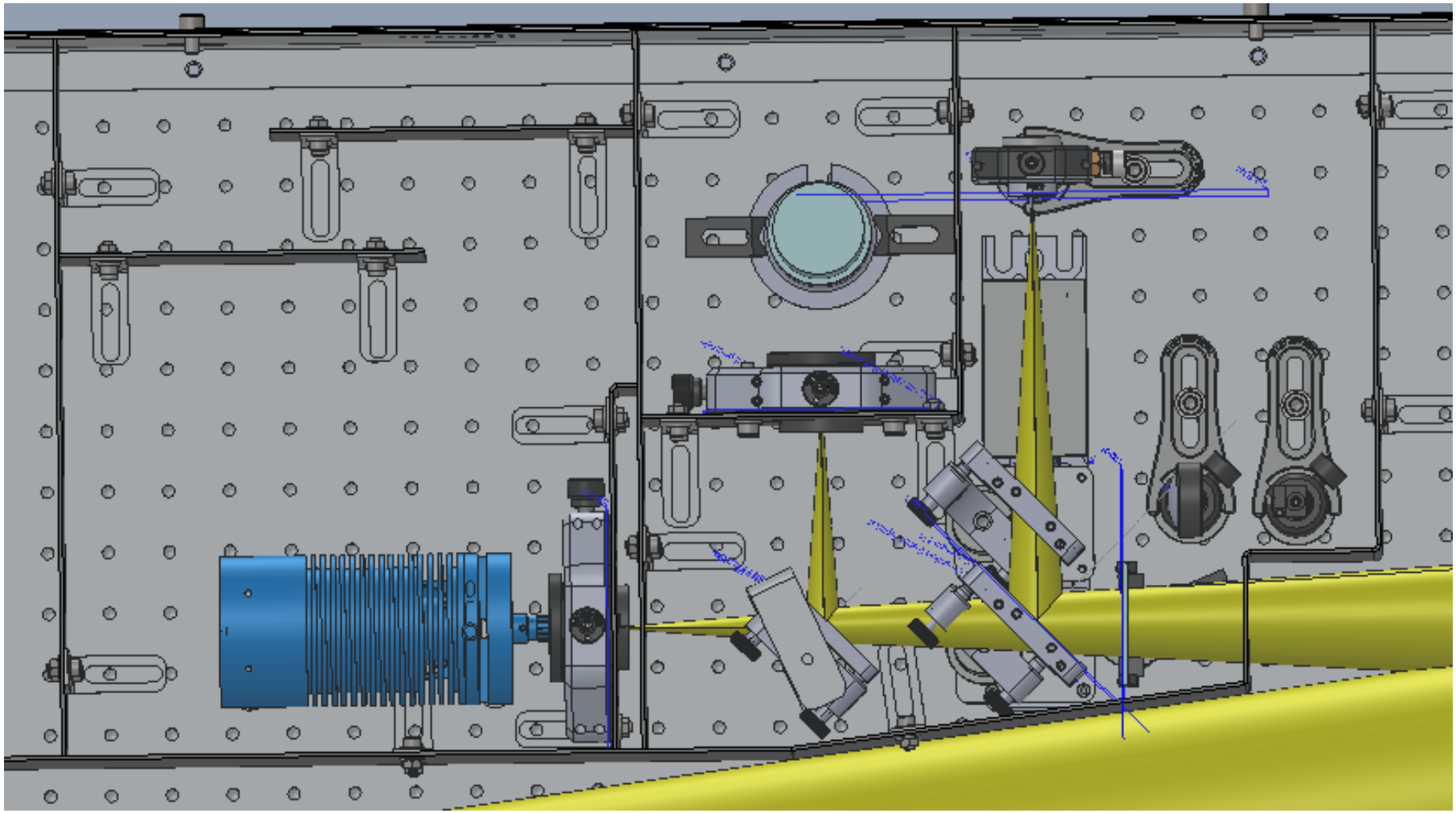
- **From fiber to telescope**
  - Fiber bundle end is illuminated by a LED
  - Visible light from fiber is reflected by window
  - Reflected light goes to a spherical mirror
  - Light is transmitted through window
  - Transmitted light goes to camera



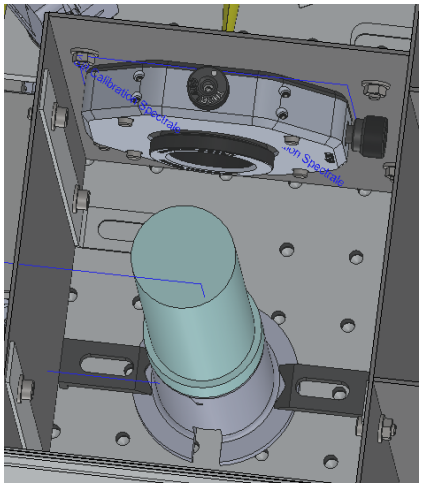
Mechanical assembly: *Spectrograph*

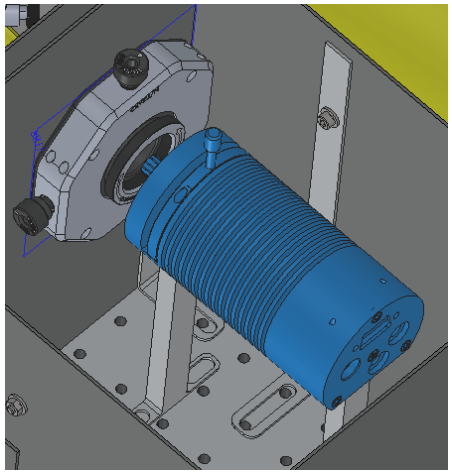


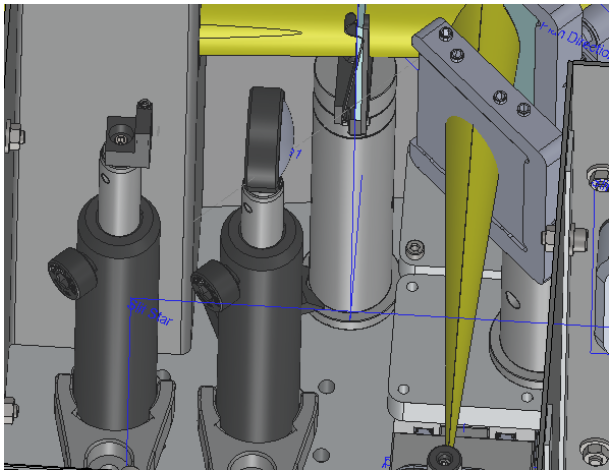
Mechanical assembly: *Spectrograph*

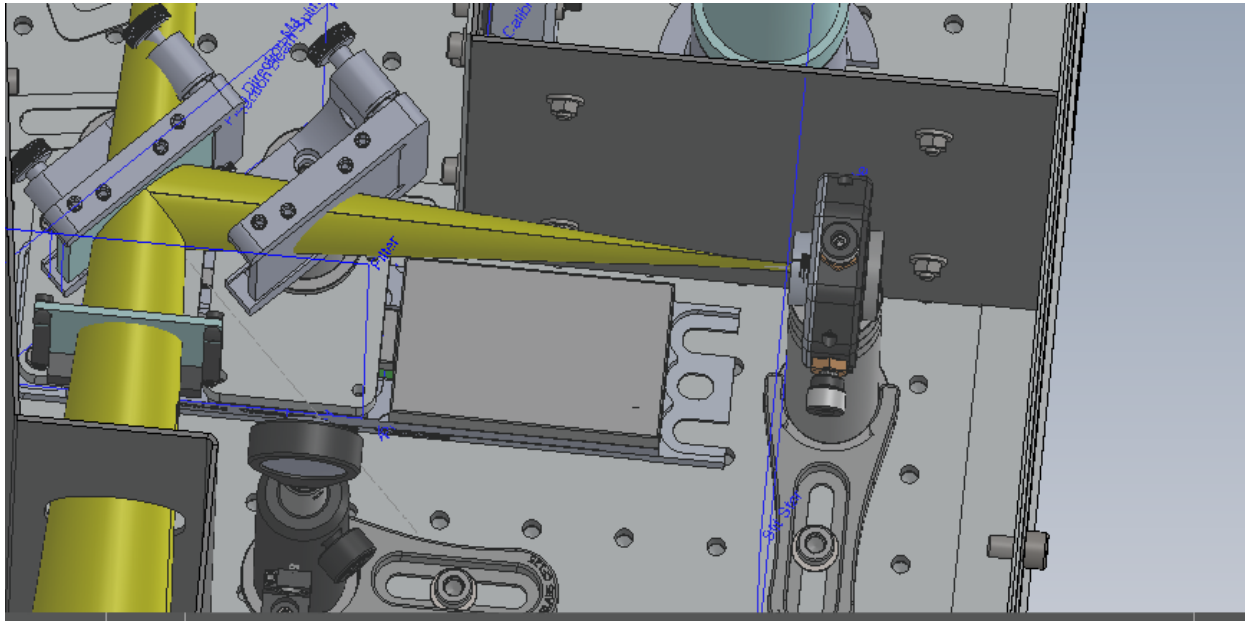


Mechanical assembly: *Spectrograph*

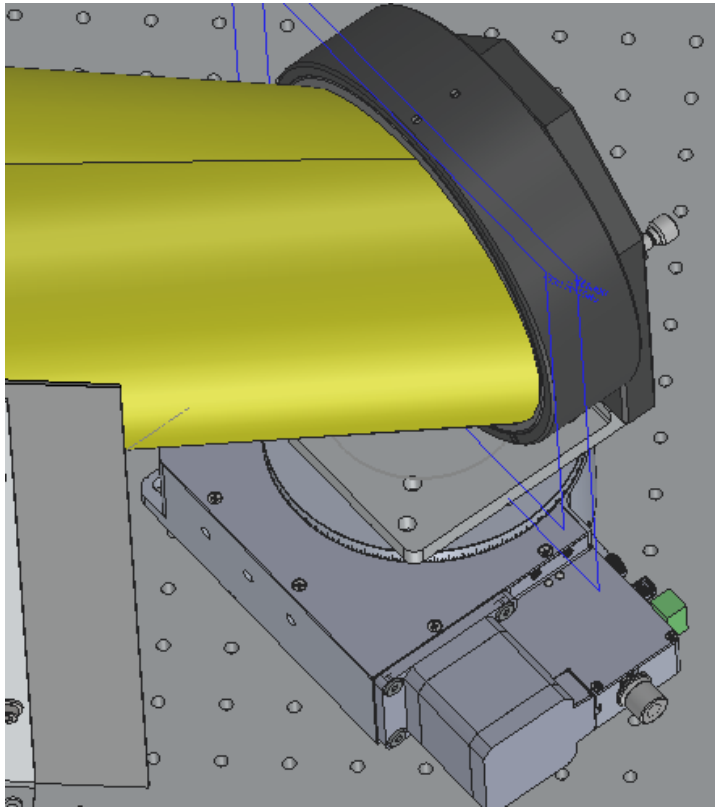


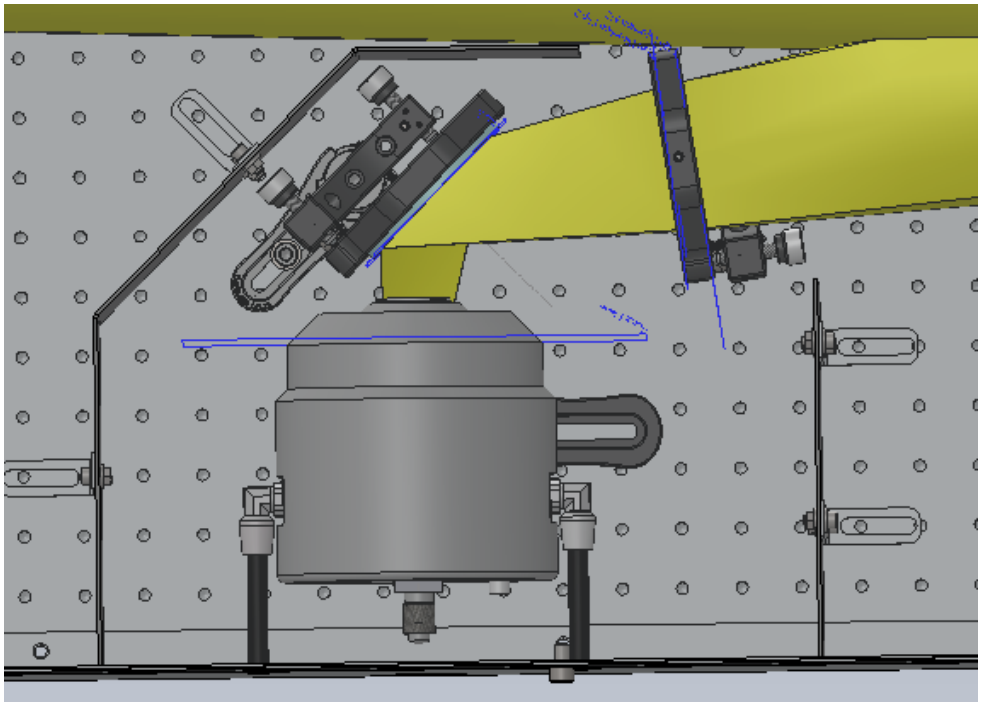




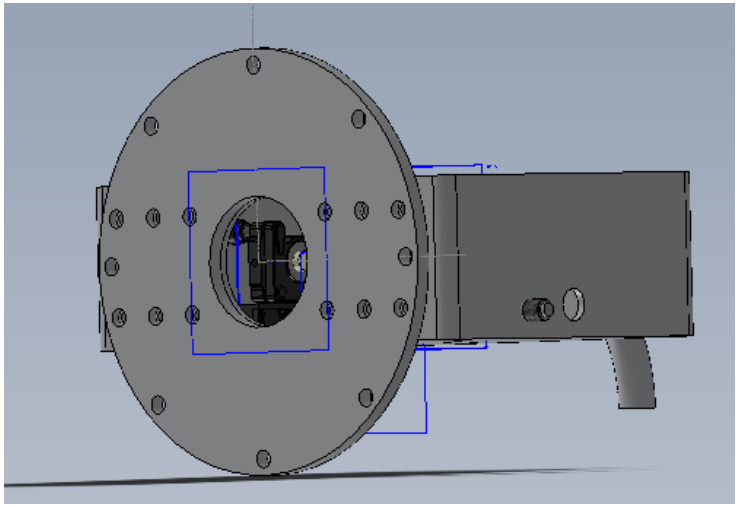


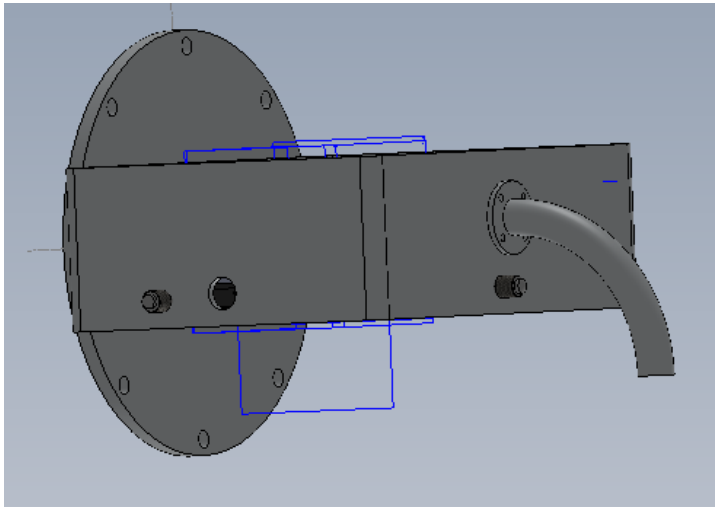
Mechanical assembly: *Spectrograph*

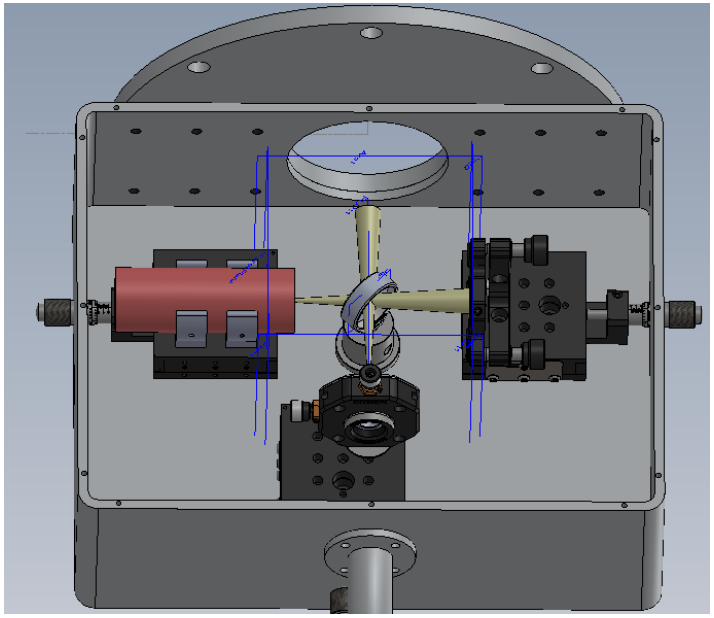


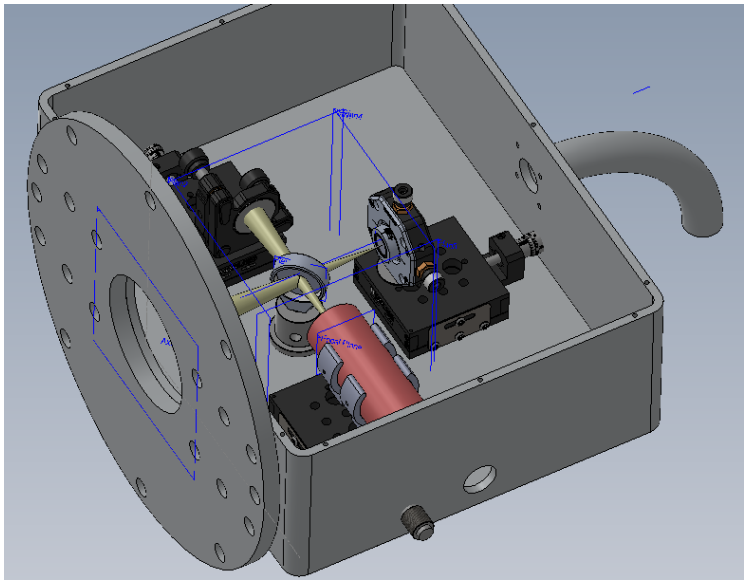


Mechanical assembly: *Star positioning system*

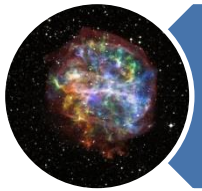




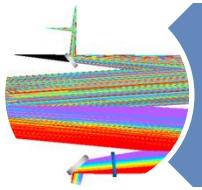




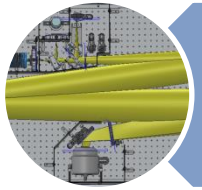
Conclusion



Different instruments, same goal… study massive stars!



From scientific requirements to optical design



Mechanical design completed

Integration and tests: coming soon!

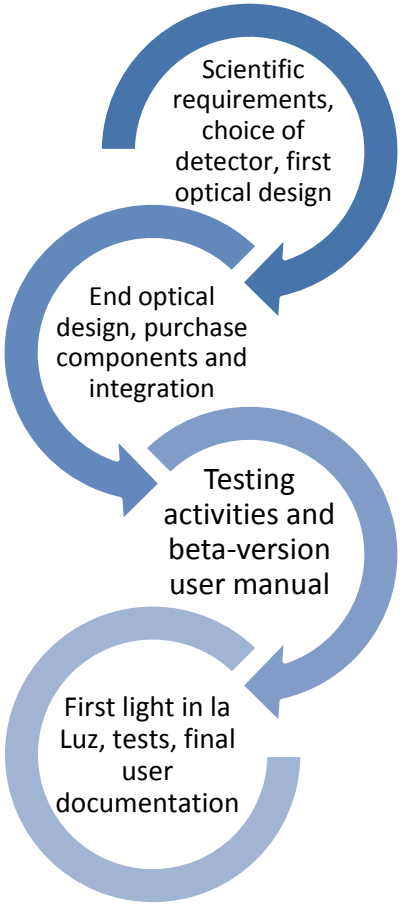
IR Spectrograph

2013-2014

2014-2015

2015-2016

2016-2017



Thank you for your attention

Any question ?