

Spectroscopie UV

Présent et futur



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Atelier BDD Montpellier 15/11/2022

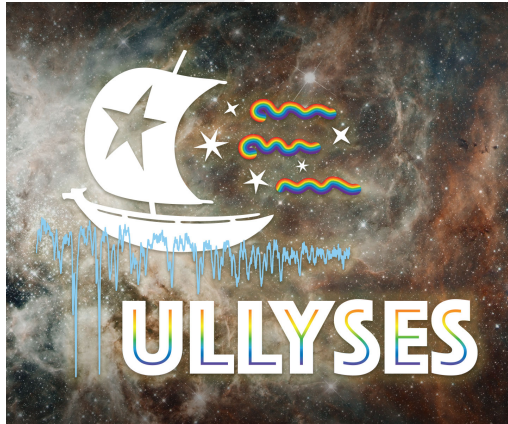
Contexte actuel des missions UV



Suite de spectrographes UV

- GHRS
- STIS (+ imagerie)
- COS

ULLYSES

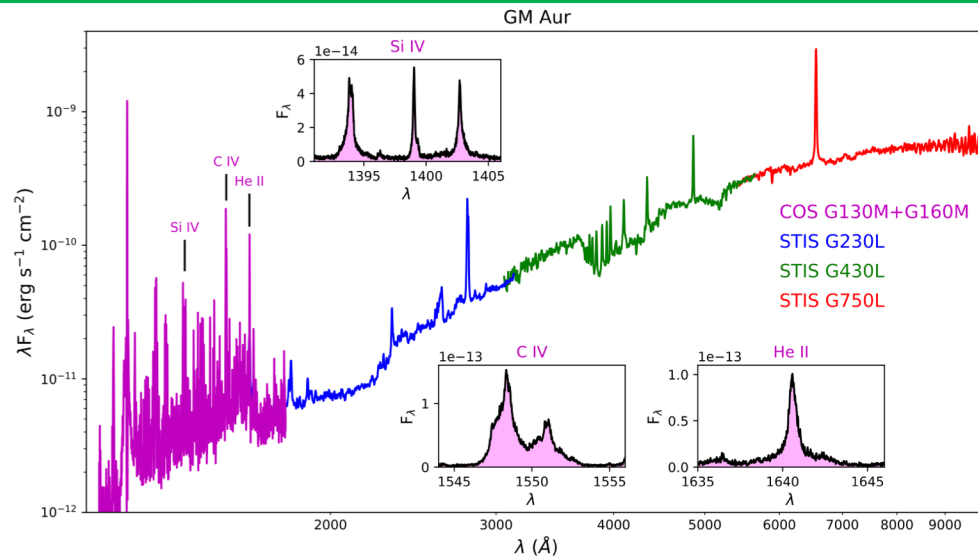


HST UV Legacy Science Definition Working Group
→ The Hubble UV Legacy Library of Young Stars as Essential Standards (ULLYSES)

~ 1000 orbits of HST time, divided equally between low-mass and high-mass stars

Mode	Wavelength range (Å)	Resolution	Continuum S/N	Spectral Types
COS/G130M/1096	937 – 1,241	3,000 – 8,000 (Segment A) 5,000 – 12,000 (Segment B)	20 at 1,080 Å	O2-O9
COS/G130M/1291	1,132 – 1,436	12,000 – 16,000	30 at 1150 Å	O2-B9
COS/G160M/1611	1,417 – 1,792	13,000 – 20,000	30 at 1,590 Å	O2-B9
COS/G185M/1953	(1,830 – 2,080)	16,000 – 20,000	20 at 1,860 Å	B2-B9
COS/G185M/1986	(1,860 – 2,110)	16,000 – 20,000	20 at 1,980 Å	B2-B9
STIS/E140M/1425	1,141 – 1,729	45,800	20 at 1,200 Å	O2-B9
STIS/E230M/1978	1,607 – 2,366	30,000	20 at 1,800 Å	O9-B9
STIS/E230M/2707	2,275 – 3,119	30,000	20 at 2,800 Å	B5-B9
COS/G140L/800 (Sextans A, NGC 3109)	798 – 1,988	1,500 – 4,000	15 at 1,600 Å	

A UV Spectroscopic Survey of Young Low and High Mass Stars



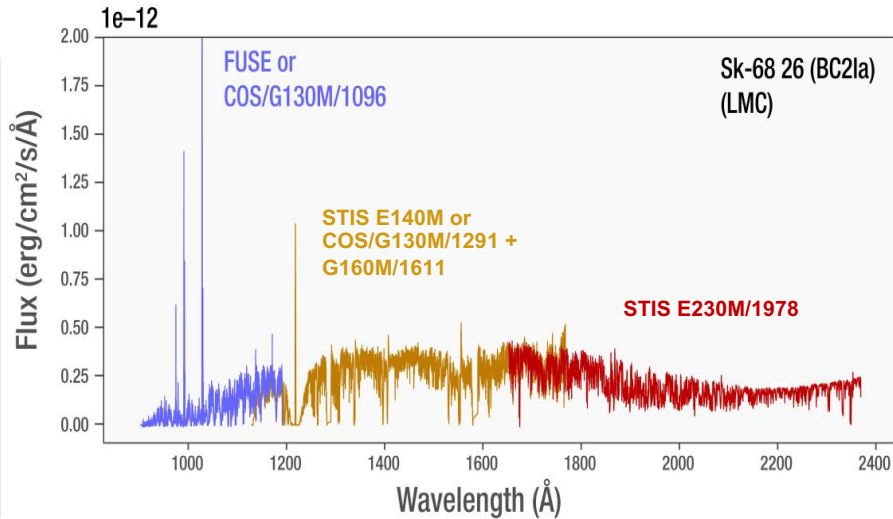
~500 HST orbits to obtain a spectroscopic library and time monitoring of T Tauri stars ($t < 10$ Myr, $M < 1 M_\odot$)

Enable transformative research in accretion and ejection physics

Study the evolution and dispersal of disks

Constrain disk chemistry and planet habitability

A UV Spectroscopic Survey of Young **Low** and **High** Mass Stars



~500 orbits to extend the spectroscopic library of O and B stars to low metallicity ($0.08 - 0.5 Z_{\odot}$)

Properties of massive stars (wind velocities and clumping, mass loss rates, CNO abundances)

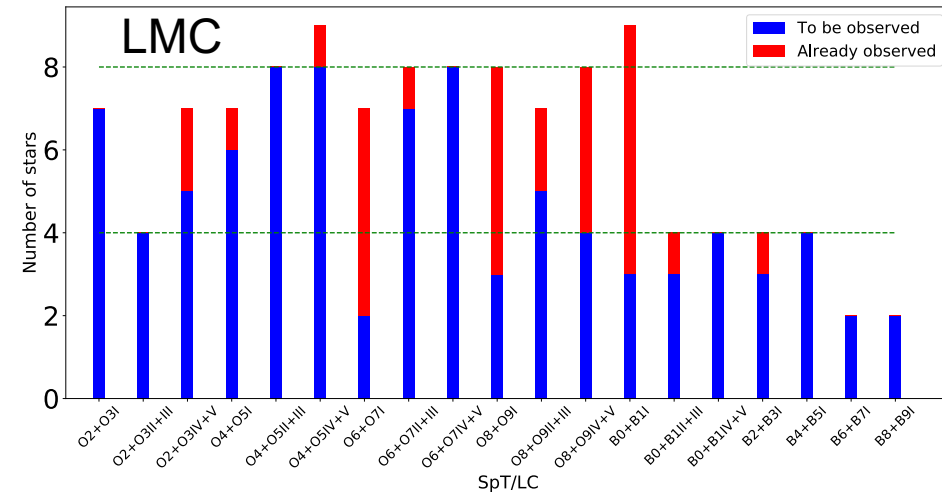
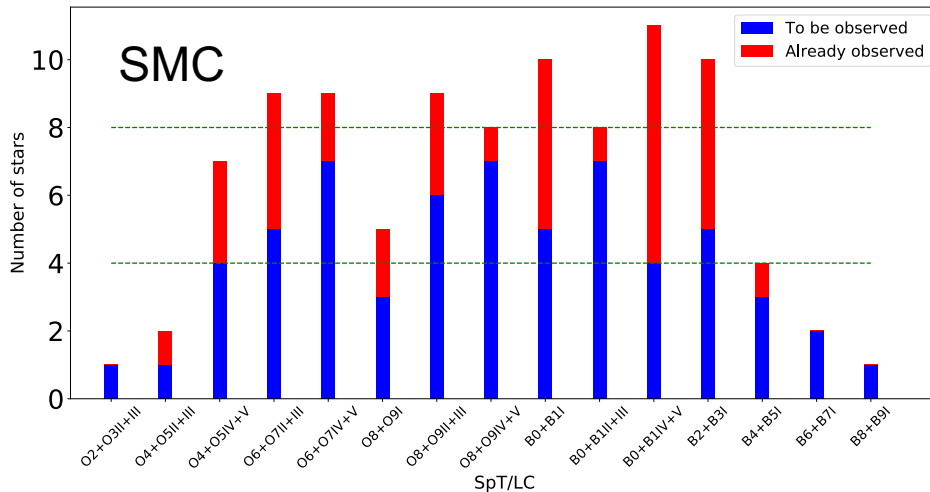
Spectral templates for population synthesis and studies of LyC escape

ISM abundances and dust depletions for studies of chemical evolution

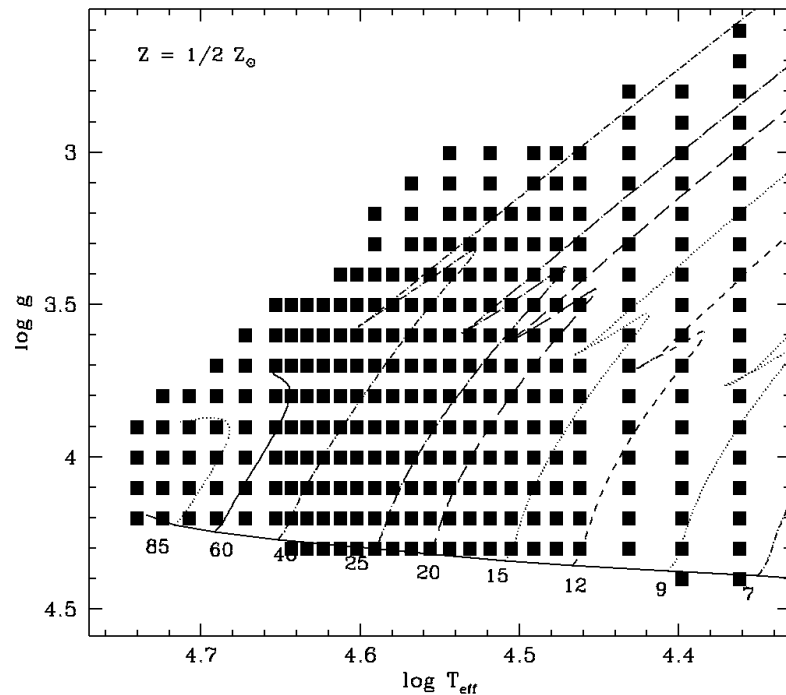
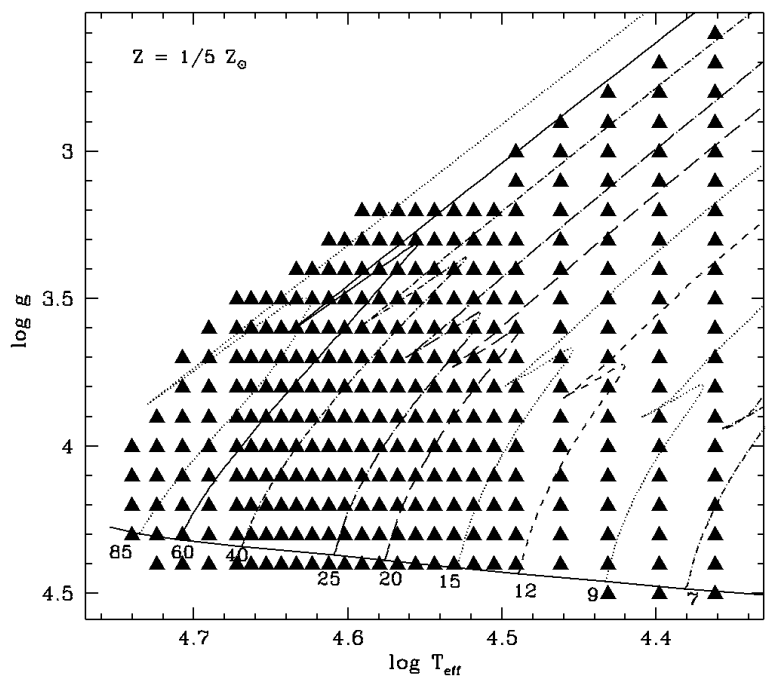
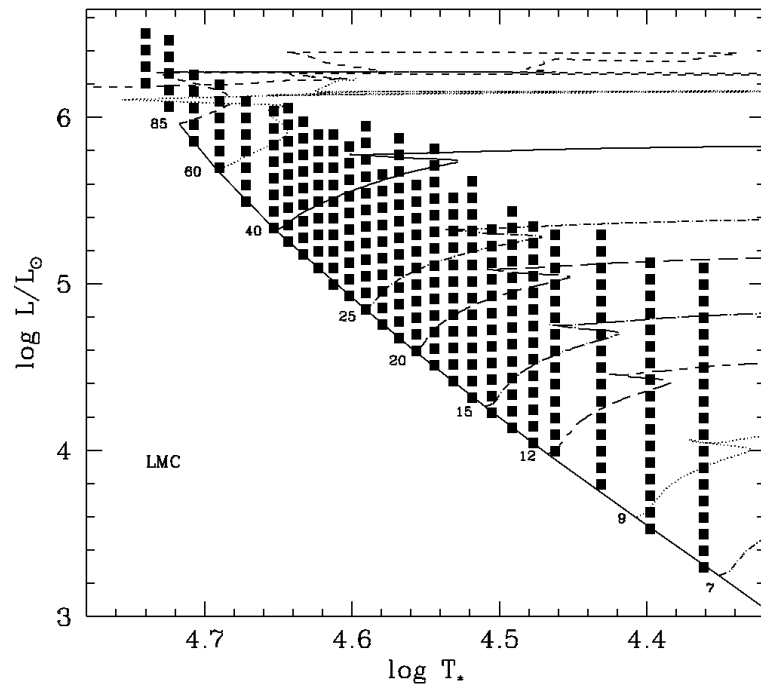
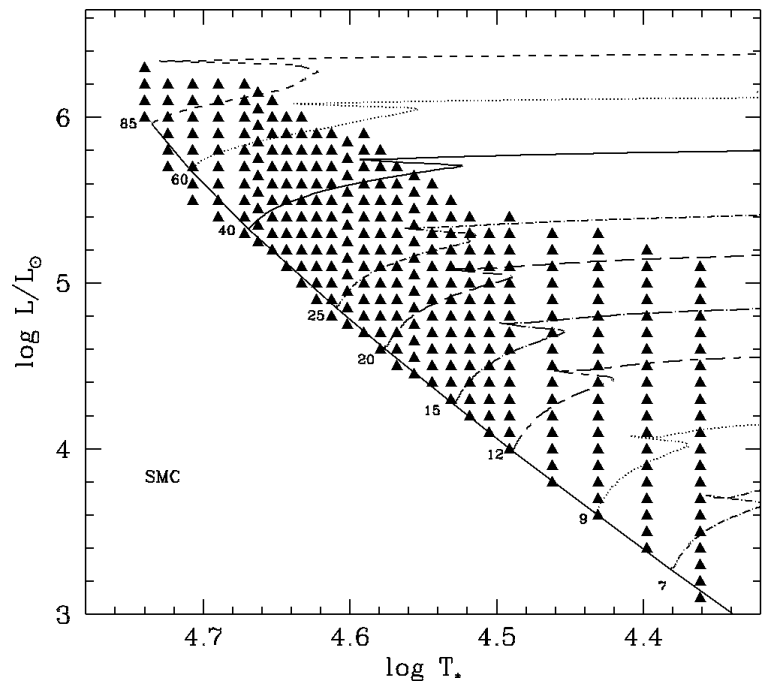
Kinematics, metallicity, and spatial distribution of galaxy-scale outflows in the CGM

Target Selection – Sampling of SpT/LC

- 4-5 O I-V per SpT/LC bin
- 2-4 B0-B1 I-V stars per bin
- 2-4 B2-B4 I per bin
- 1-2 B5-9 I per bin



- + 6 stars in Sextans-A and NGC 3109 ($Z < 1/7Z$)

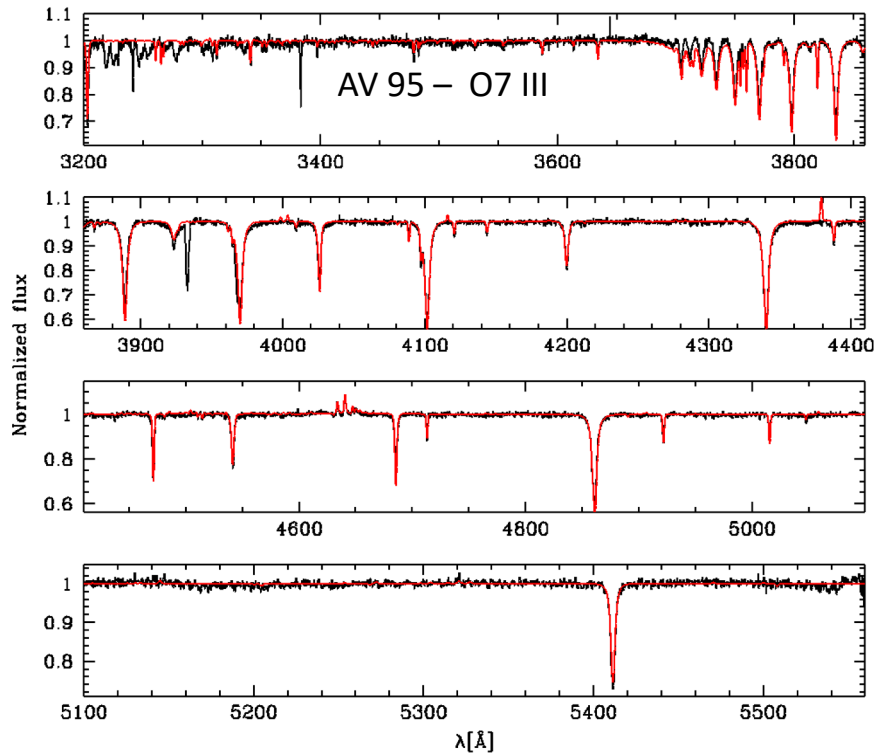
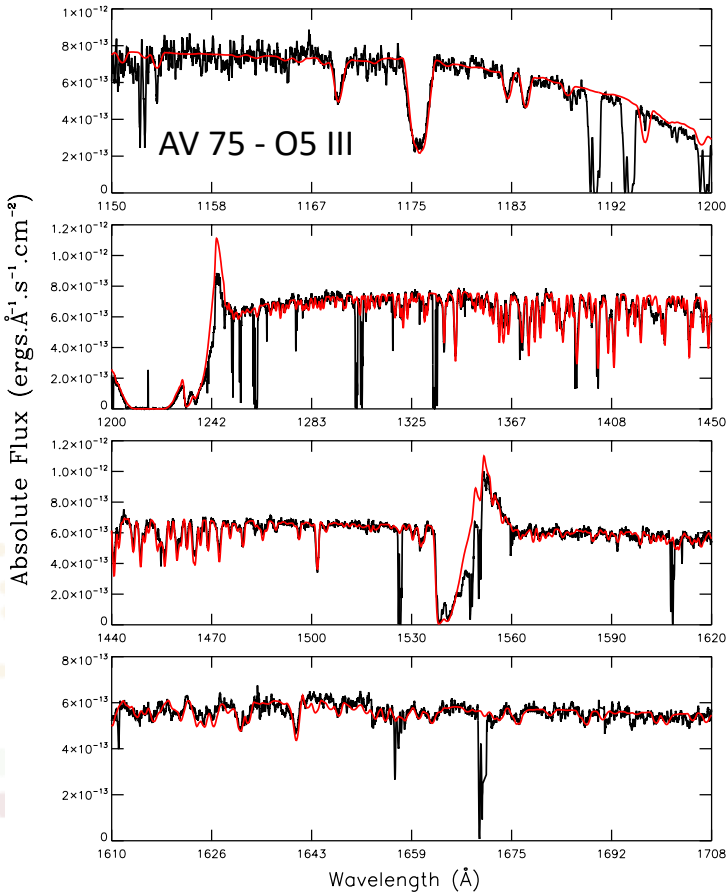
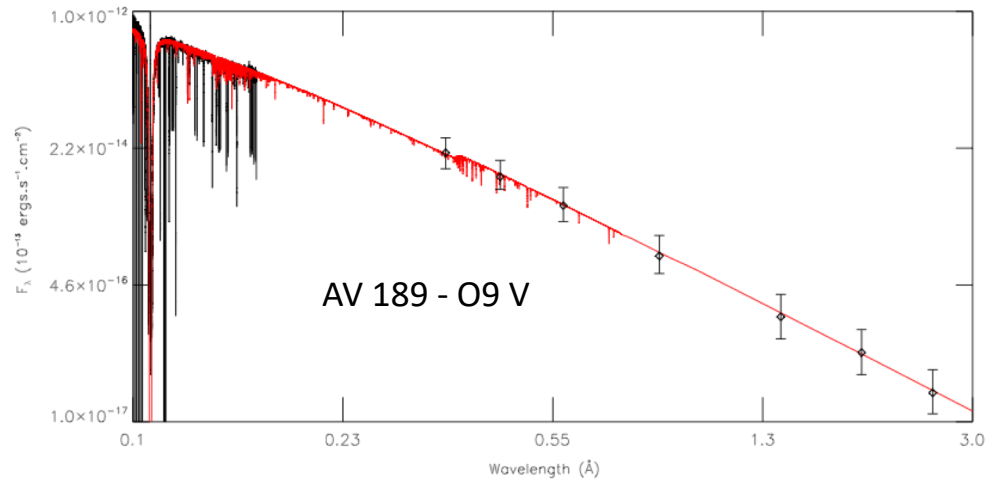


Spectroscopic analysis

Physical Parameters

T_{eff} , $L_{\star} / R_{\star} / M_{\star}$, $v \sin i$, $[X/H]$,

\dot{M} , $v(r)$, f , L_x



flux-calibrated
UV spectra
+
optical-NIR
spectra/photometry

Pour le futur

NASA Decadal survey 2020 → prochaine génération d'observatoires

The Future Great Observatories

HabEx
UV/Optical/NIR



LUVOIR
UV/Optical/NIR



Lynx
X-ray

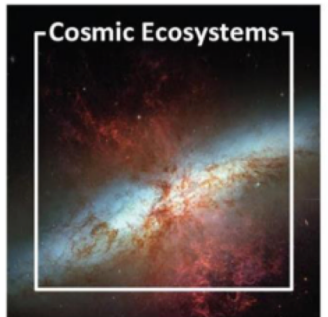
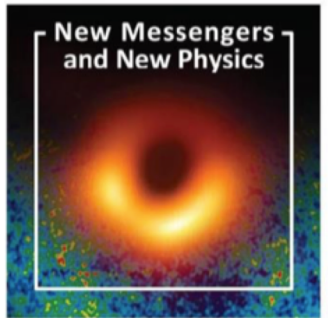
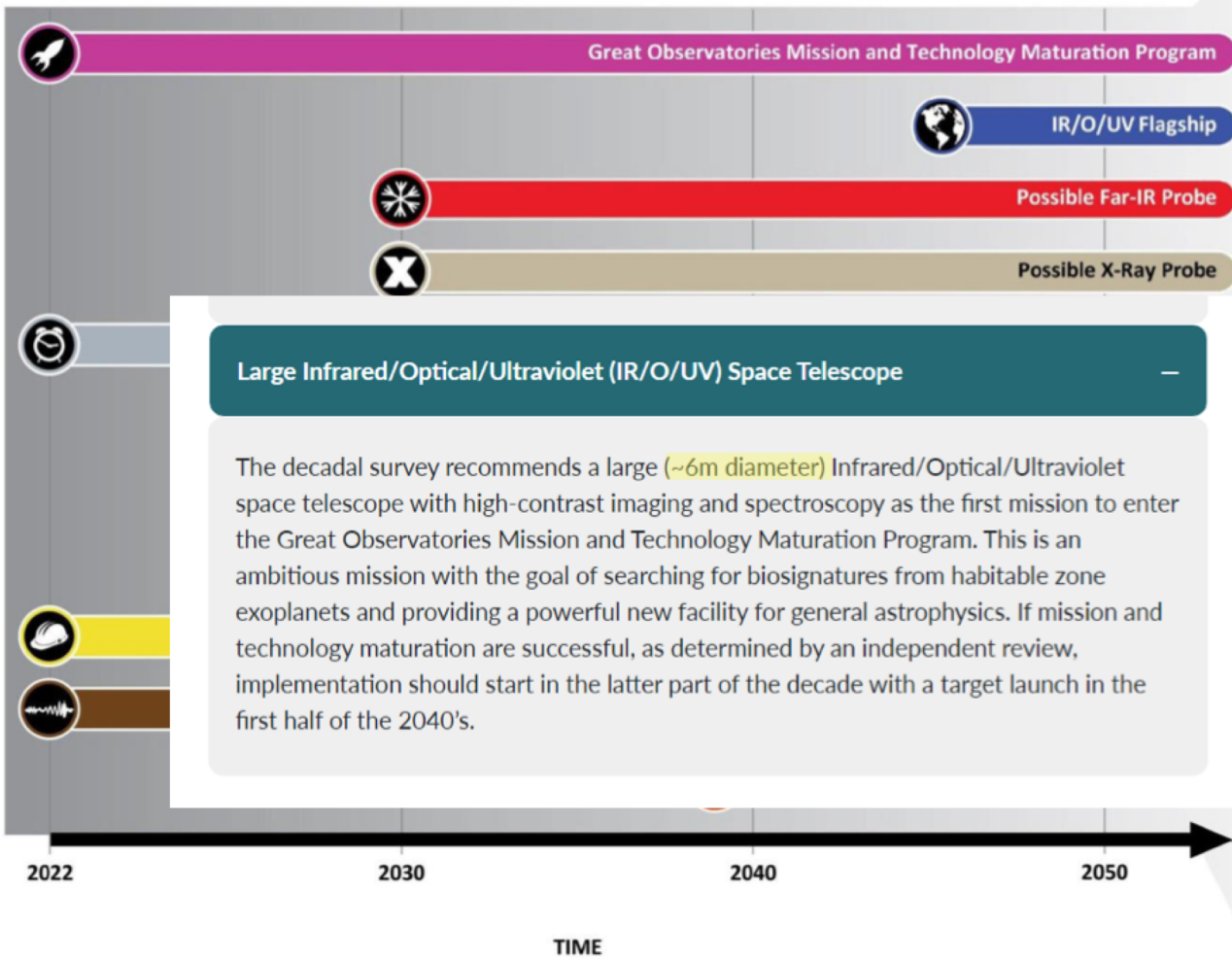


Origins
Infrared



Astro2020 recommande à la NASA de développer une nouvelle flotte de grands observatoires multi- λ

ASTRO2020 DECADAL SURVEY RESULTS

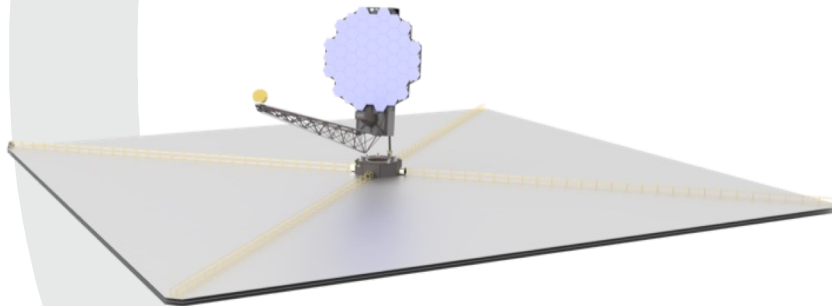


Le 1er grand observatoire

Télescope spatial Infrarouge/Optique/UV d'un diamètre $\geq 6\text{m}$

→ Recherche et caractérisation d'exoplanètes et "apporter des contributions transformatives" pour l'astrophysique générale

→ un mélange des concepts de LUVOIR et Habex (IROUV ? ou LUVEx?)



LUVOIR-B
8m aperture

HabEx
4m aperture



LUVOIR

- LUVOIR: general purpose, multi-wavelength space observatory with broad science capabilities
- LUVOIR Science : "From Big Bang to Biosignatures (and Everything in Between..)"
- Two concepts: LUVOIR-A (15m) and LUVOIR-B (~8m)
 - ❖ Suite of imagers, and spectrographs to enable broad range of scientific investigations

LUVOIR-A

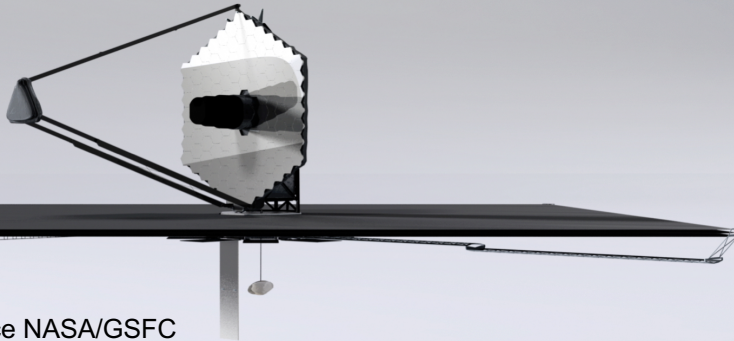


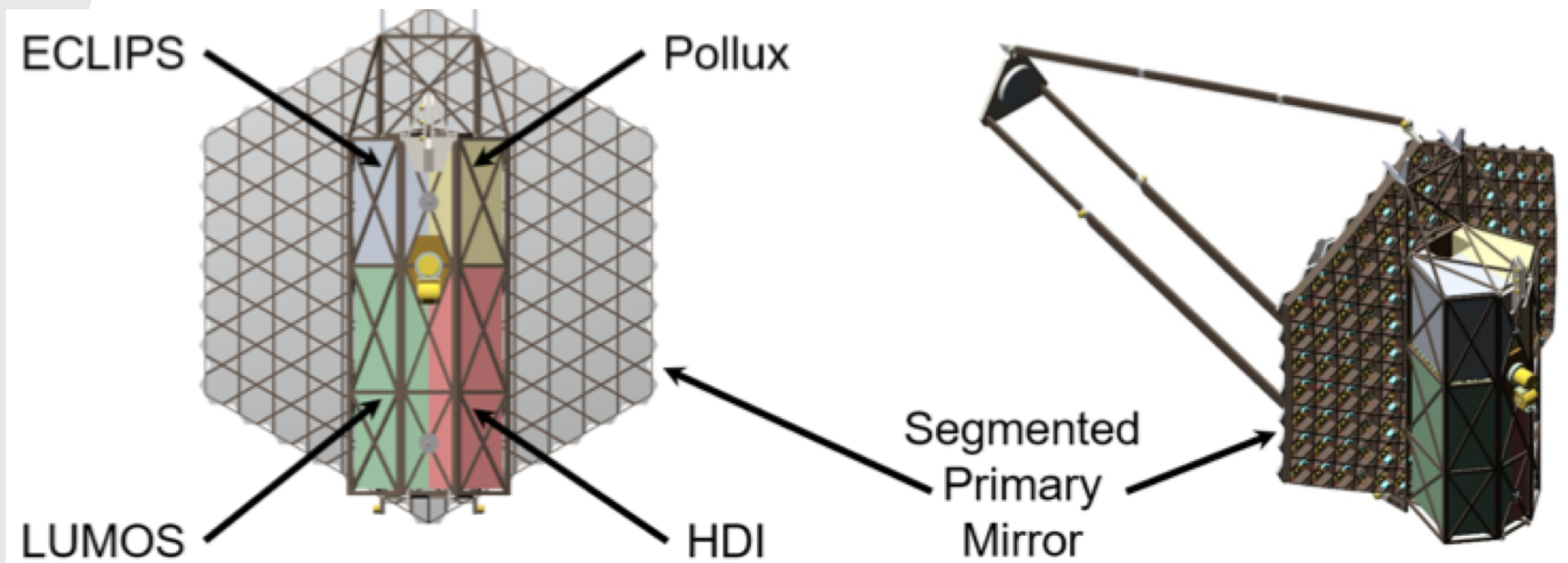
Image source NASA/GSFC

- Wavelength coverage 100 nm – 2.5 μm
- Diffraction limited at 500 nm
- Halo orbit about L2 point
- Serviceable and Upgradable
- 5-year prime mission duration
- 25-years lifetime goal for non-serviceable components
- Guest observer-driven program

<https://www.luvoirtelescope.org>

LUVOIR

- POLLUX, a high resolution UV spectropolarimeter for LUVOIR-A
- European contribution to LUVOIR study





LUVOIR Architecture A

Big Bang to Biosignatures: The LUVOIR Mission Concept



15-m telescope

Credit: A. Jones (GSFC)



Les instruments candidats pour LUVOIR

ECLIPS

Extreme Coronagraph for Living Planetary Systems

Coronagraph with imaging and imaging spectroscopy

Bandpass	200-2000 nm
Contrast	1×10^{-10}
IWA	$3.5 \lambda/D$
OWA	$64 \lambda/D$
R ($\lambda/\Delta\lambda$)	Vis: 140 NIR: 70, 200

HDI

High-Definition Imager

Wide field imager with simultaneous UV/Vis and NIR coverage

Bandpass	200-2500 nm
FoV	$3' \times 2'$
67 science filters + grism	
Nyquist sampled	
High-precision astrometry	

LUMOS

LUVOIR Ultraviolet Multi-Object Spectrograph

UV/Vis multi-object spectrograph and FUV imager

Bandpass	100-1000 nm
MOS FoV	$2' \times 2'$
Apertures	840×420
R ($\lambda/\Delta\lambda$)	500-50,000

POLLUX

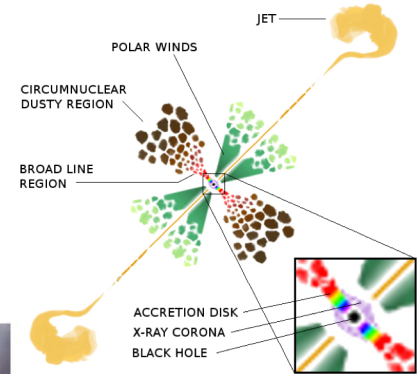
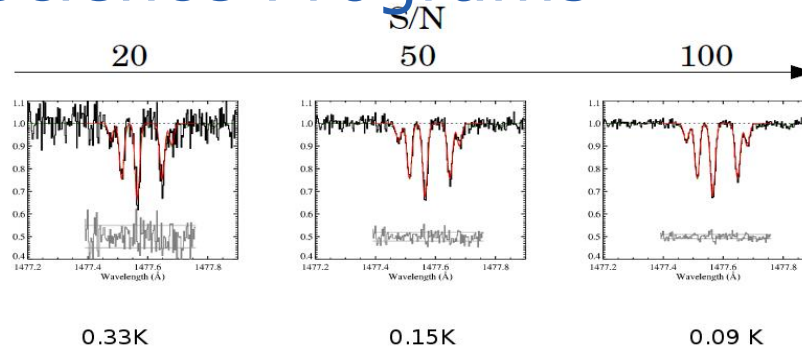
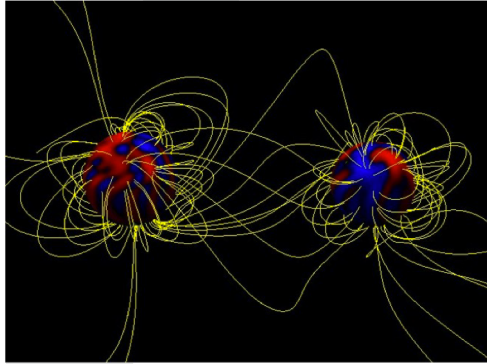
UV spectropolarimeter (on LUVOIR-A only)

Point-source UV spectropolarimeter (European study for LUVOIR-A only)

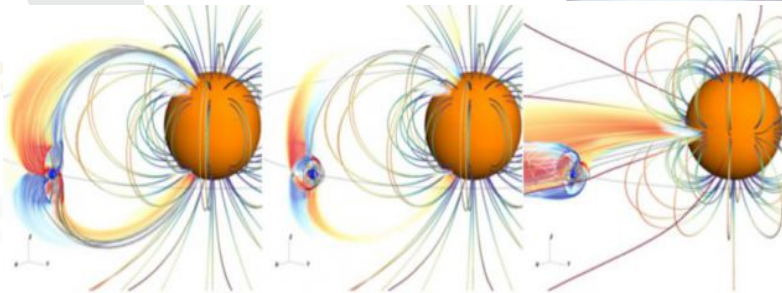
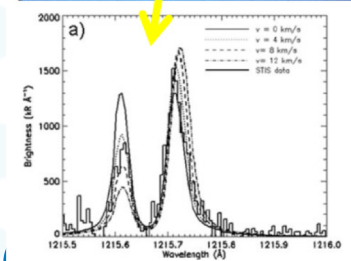
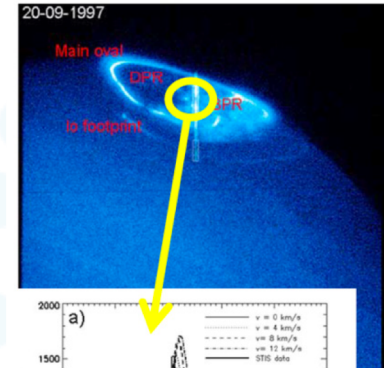
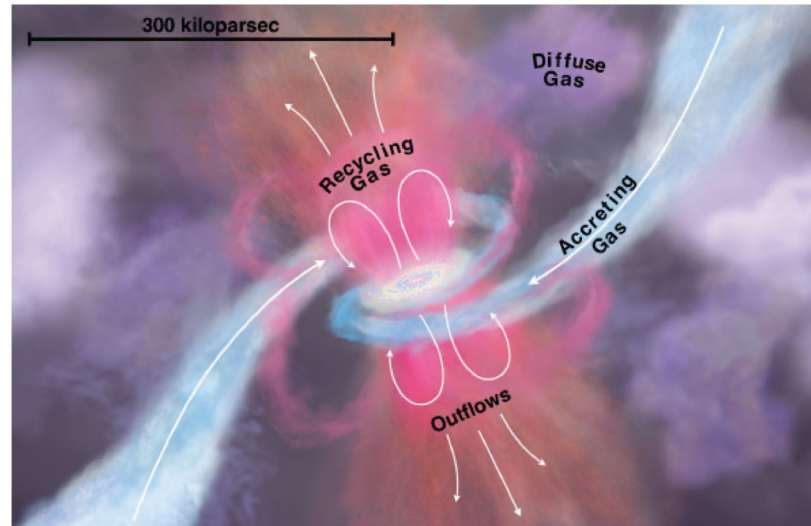
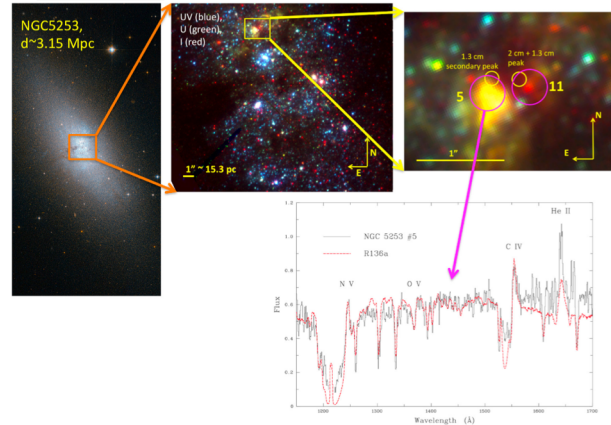
Bandpass	100-400 nm
R ($\lambda/\Delta\lambda$)	120,000
Circular + linear polarization	

<https://mission.lam.fr/pollux/index.html>

POLLUX-A: Science Programs



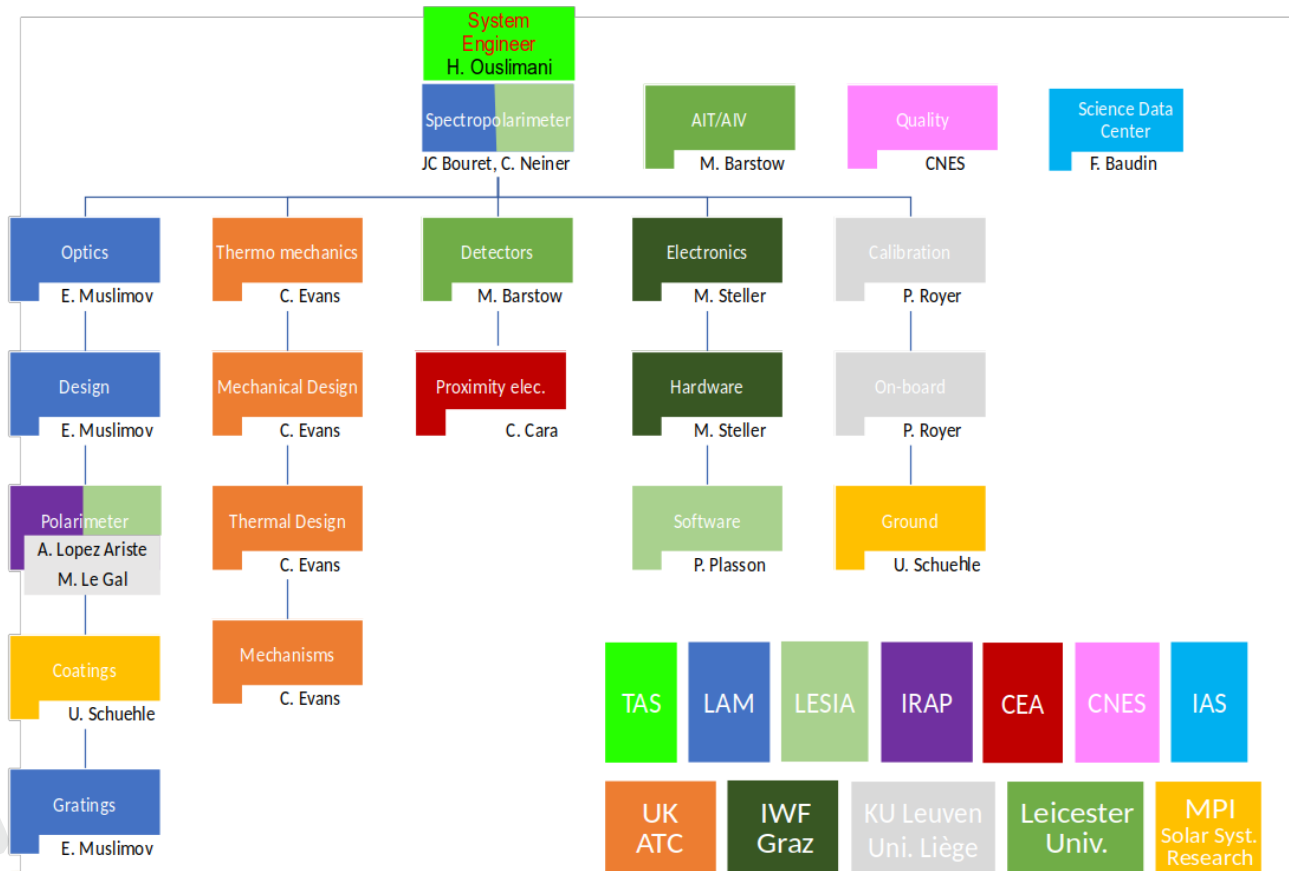
Marin 2016



Consortium

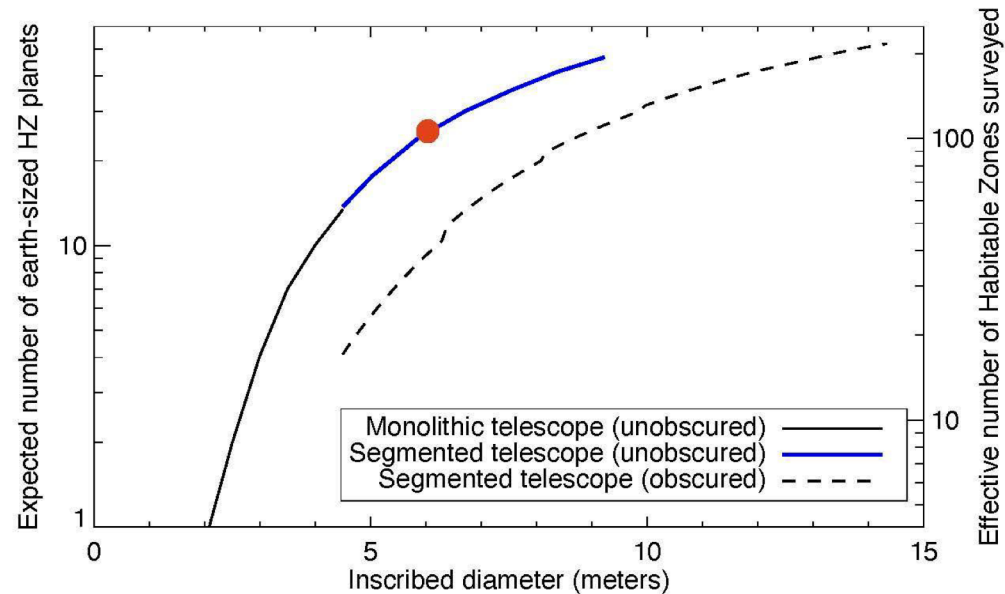
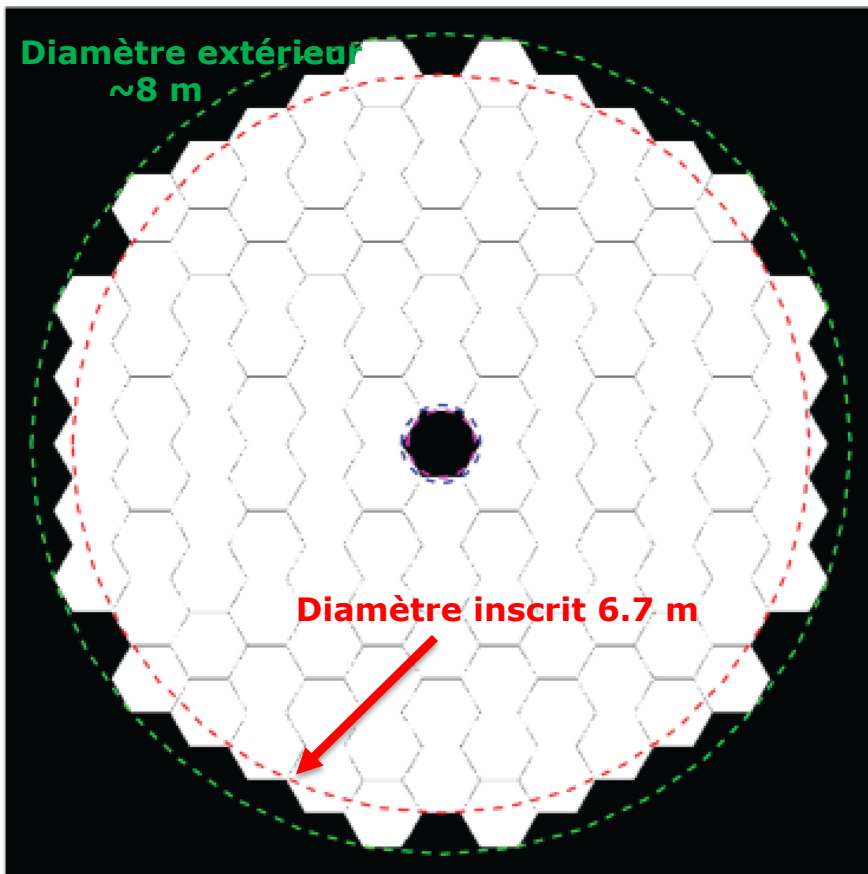


- Management → CNES (France)
- PIs **LESIA & LAM**
- Consortium: more than 180 participants, 67 institutes, 13 European countries



LUVEx

- Recommendation by NASA Decadal survey (11/2021) : An IR/O/UV Large Telescope Optimized for Observing Habitable Exoplanets and General Astrophysics → ≥ 6 m off-axis inscribed diameter



A major uncertainty: How many instrument slots? Is there room for a POLLUX in this new design?

POLLUX pour LUVEx

- Off-axis → Demodulation process less precise
 - Either requires very accurate/reliable ground calibration
 - Or additional device (mirrors) to compensate → less flux on the detector
- Redesign POLLUX, redefine science cases: re-activate consortium, re-assign responsibilities, define a steering committee
- Support from CNES likely for funding R&D, missions etc...
- Try to seek support from other space agencies
- ESA ?? (ESA Voyage 2050 → funding up to M-class for a contribution for next NASA's flagship mission)

Calendrier pour LUVex

Concept Study: prepare for decadal evaluation



We are here

Decadal survey: evaluation of science against scope: recommended for entry in GO Technology Development program with cost/scope target



Phase A start before end of 2020 decade



GO Mission and Technology Maturation (includes architecture, cost trade studies)

LUVex



launch

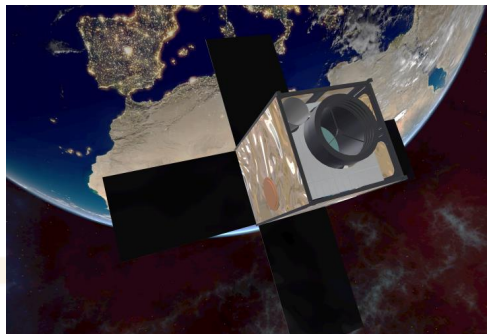
Launch early 2040s

High resolution X-ray imaging mission

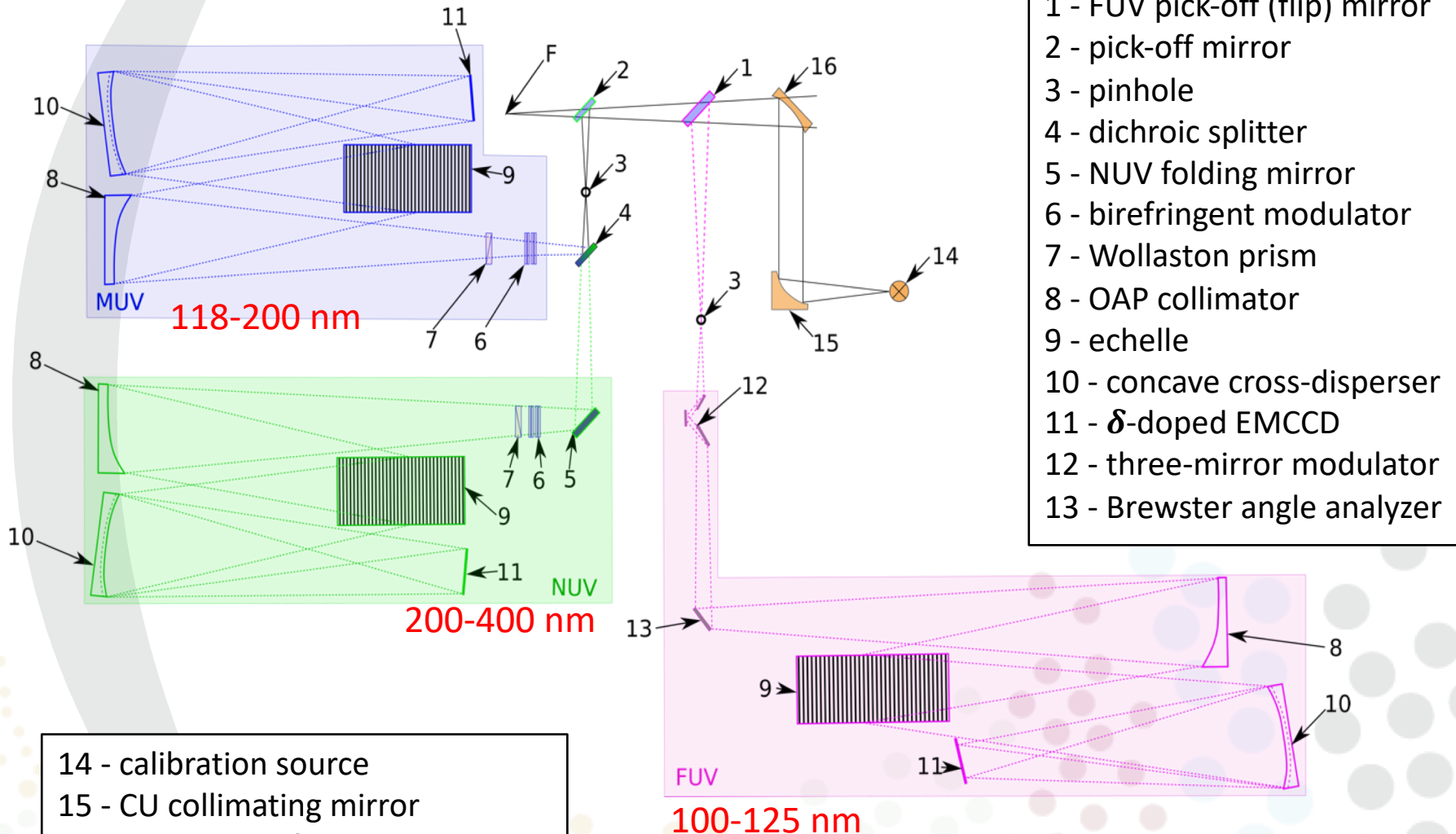
Far-IR imaging and spectroscopy mission

Steps to take

- Re-activate POLLUX consortium
- Redefine Science Objectives
- **Global optical design of the instrument**
- **Design of polarimeters (build on the knowledge from the 1st iteration (+ ARAGO))**
- **Design of gratings and cross-dispersers (high-groove densities, free-form, incident angles etc...) to improve their efficiencies**
- **Dichroics**
- Optimized coatings for each channel
- Detectors
-CASSTOR



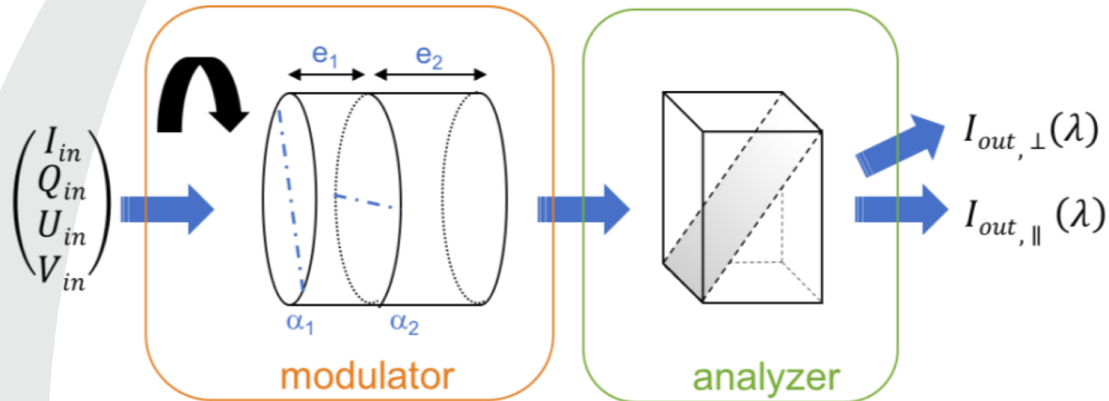
Concept



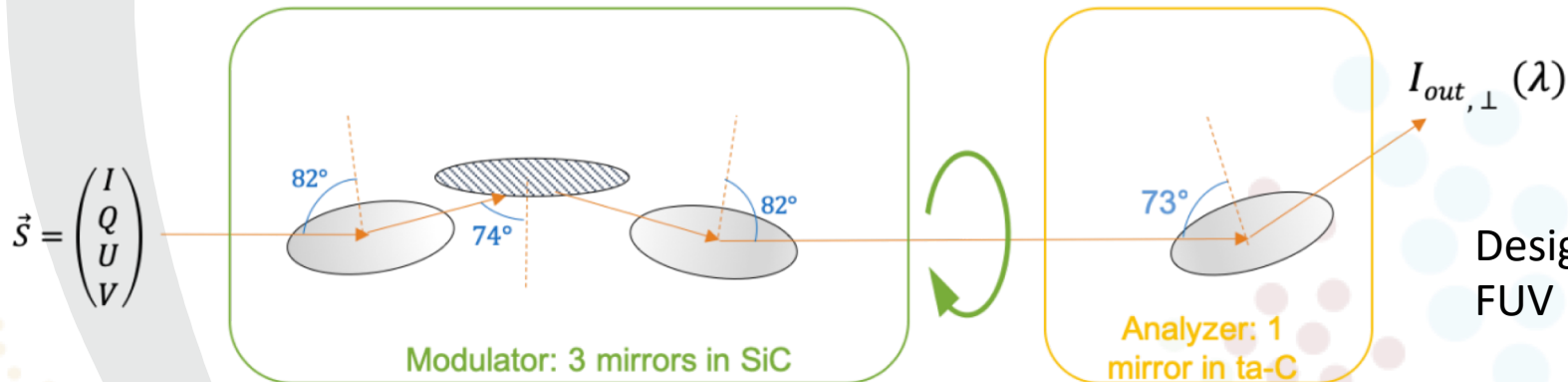
- F - telescope focus
- 1 - FUV pick-off (flip) mirror
- 2 - pick-off mirror
- 3 - pinhole
- 4 - dichroic splitter
- 5 - NUV folding mirror
- 6 - birefringent modulator
- 7 - Wollaston prism
- 8 - OAP collimator
- 9 - echelle
- 10 - concave cross-disperser
- 11 - δ -doped EMCCD
- 12 - three-mirror modulator
- 13 - Brewster angle analyzer

- 14 - calibration source
- 15 - CU collimating mirror
- 16 - CU concave flip mirror

POLLUX: concepts for the polarimeters



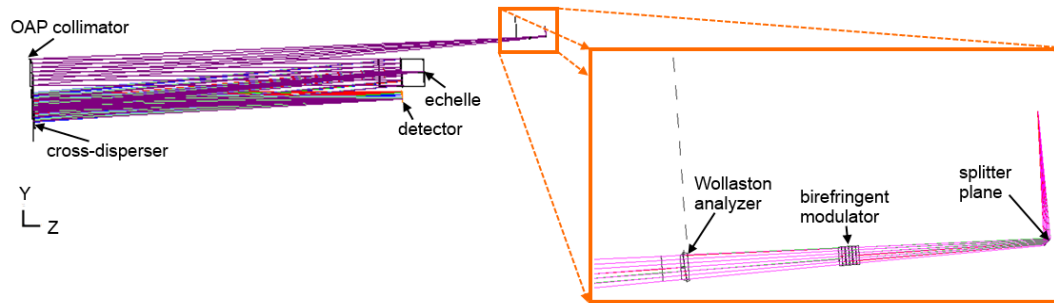
NUV and MUV
polarimeters design.



Design of the
FUV polarimeter

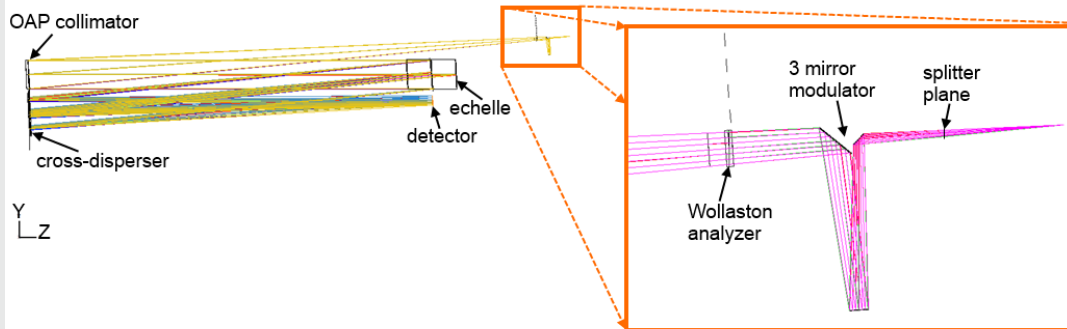
Design Solution

- High spectral resolution and large wavelength coverage → echelle spectrograph

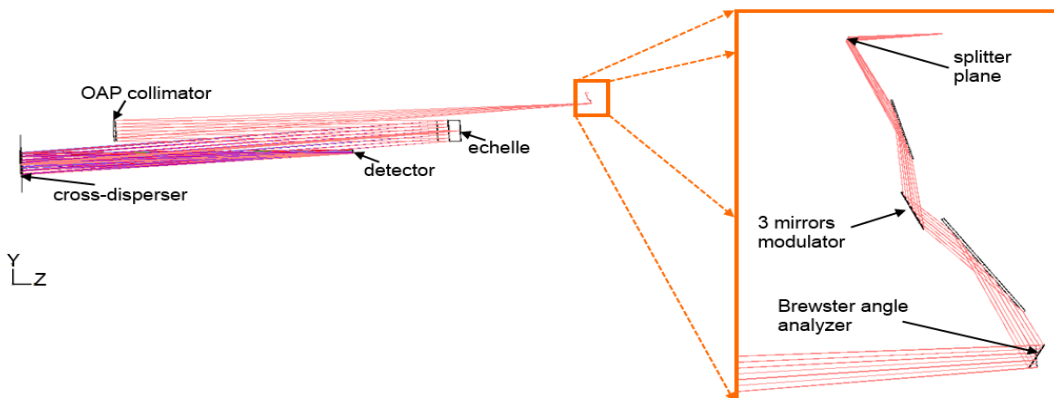


Splitting in 3 channels

NUV = 200 – 400 nm



MUV = 118.5 - 200 nm



FUV = 90 – 124.5 nm

POLLUX: mechanical design

allocated
volume

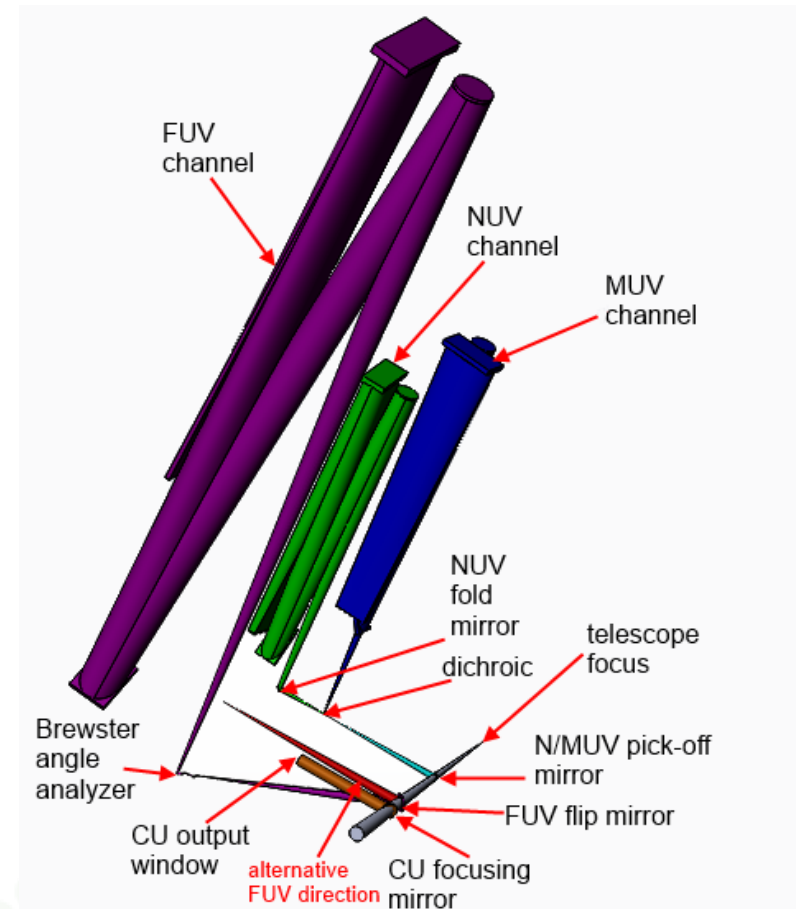
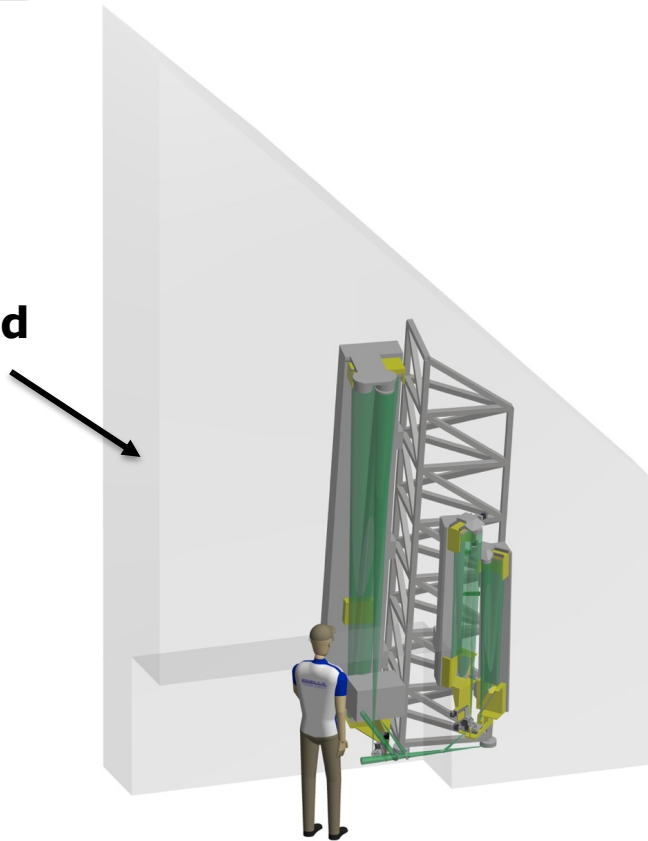


Figure 9: 3D rendering of POLLUX optical architecture

<https://mission.lam.fr/pollux/index.html>