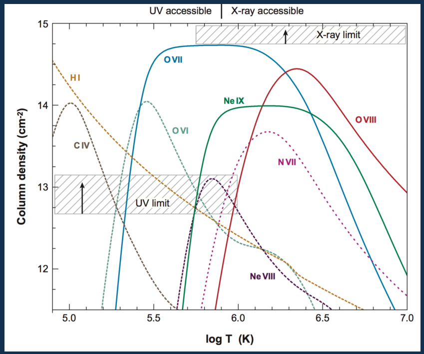
The future of UV astronomy in GECO

Support for the group prospective

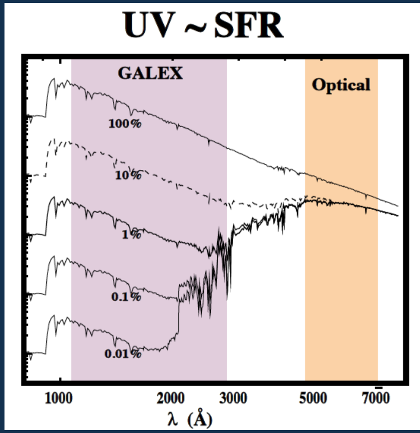
- Why UV? (basics)
- Long term/large missions
- Mid & short term / medium + small missions
- Options for the GECO future

Why UV?

- Resonance lines and many major line diagnostics < 200 nm:
  - Ions: H Ly-a, CIV, OVI, SiIV, CII, SiII, CIII, SiIII, (He I 504)
  - Molecules: H2, CO

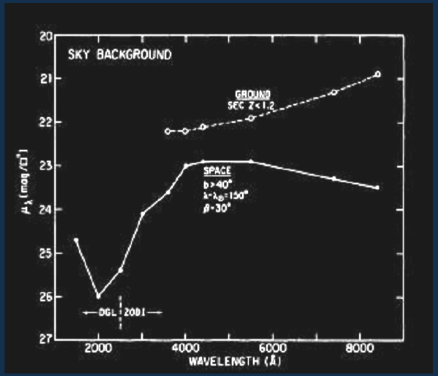


- Peak emission of young (and some old) stars populations



→ space UV   *except > 10 bn years*

- Sky background = ground based /10



- Topics of Interest @ GECO *non exhaustive*
  - [Exoplanets and atmospheres]
  - Reionisation
  - Universe < 10 bn years
    - IGM/CGM
    - Feedback, cooling flows
    - SFR/ galaxy evolution
    - QSOs
    - Dust
    - ISM
    - Young stars

The future of (space) UV astronomy in GECO
92-320 nm 2016-2039

- Long term / Large Observatories
  - Landscape very constrained
  - ESA L-Class Missions: L1 2022 JUICE, L2 2028 ATHENA+, L3 2034 Gravity Waves
  - NASA Flagship Missions 2018 JWST, 2024 WFIRST-AFTA, ~2030 Habitable planets, ~2035 X-Ray / FIR / LUVOIR Surveyors
  - Some UV support in EU (former EUVO, UV working group)

- Mid & short term / Dedicated missions
  - Much constrained landscape → 2025 at ESA
    - M1 Solar Orbiter, M2 EUCLID, M3 PLATO 2024, M4 X-RAY EXO Plasma 2025 ?, M5 2029 (Letter of Intent DL 0ct 2016)
  - More open at NASA
    - NASA Explorers MIDEX (<250 M$) calls every 4 years, next this year
    - Probes (250M$ - 1 Bn$). Next priority is Inflation Probe

NASA LUVOIR

http://asd.gsfc.nasa.gov/luvoir/

http://cor.gsfc.nasa.gov/sigs/sig2.php

NASA HabEX Habitable Exo-Planet imaging mission

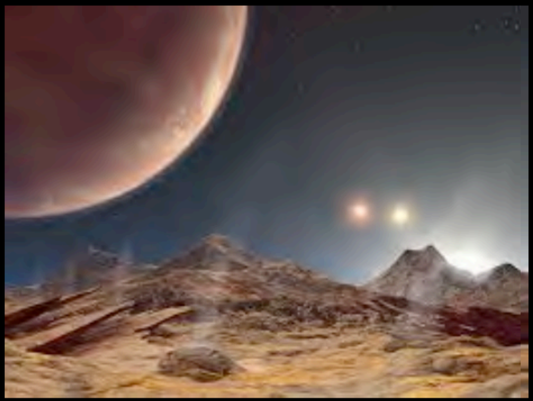
http://science.nasa.gov/media/medialibrary/2016/03/22/Presentation_15_-_Mennesson_Habex_Planning_Report.pdf

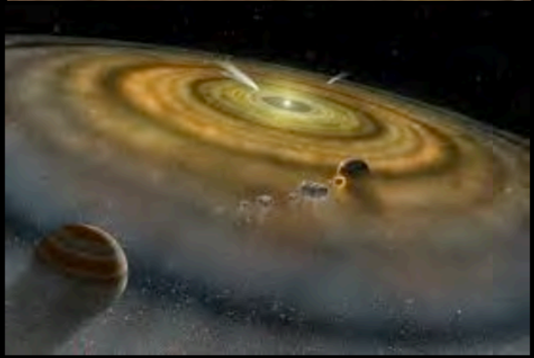
https://exoplanets.nasa.gov/exep/exopag/sigs/

X-Ray Surveyor	Far-Infrared Surveyor	UV/Optical/IR Surveyor	Habitable Exo-Planet Imaging Mission
Primary Science Goals: • Origin & growth of 1st supermassive black holes • Co-evolution of black holes, galaxies & cosmic structure • Physics of accretion, particle acceleration and cosmic plasmas **Measurement Requirements:** • Chandra-like (0.5") angular resolution • Detection sensitivity ~ 3 x 10^{-19} erg cm^{-2} s^{-1} • Spectral resolving power: R>3000 @ 1 keV; R~1200 @ 6 keV **Architecture and Orbit:** • Eff. area ~3 m^2 • Sub-arcsecond angular resolution • High-resolution spectroscopy (R ~ few x 10^3) over broad band via micro-calorimeter & grating spectrometer instruments • FOV $\gtrsim$ 5' • Energy range ~0.1-10 keV • Orbit: L2 likely	**Primary Science Goals:** • History of energy release in galaxies: formation of stars, and growth of black holes. • Rise of first heavy elements from primordial gas. • Formation of planetary systems and habitable planets. **Measurement Requirements:** • Spectral-line sensitivity better than 10^{-20} Wm^{-2} in the 25-500 μm band. (5σ, 1h) • Imaging spectroscopy at R~500 over tens of square degrees. • R~10,000 imaging spectroscopy of in thousands of z<1 galaxies and protoplanetary disks. • High-spectral-resolution capabilities desired for Galactic star-forming systems and the Galactic Center. **Architecture & Orbit:** • Complete spectroscopic coverage at R~500 from 25-500 um. • Monolithic telescope cooled to <4 K, diameter ~5 m. • FOV = 1 deg at 500 µm • R~10,000 mode via etalon • Background limited detector arrays with few x 10^5 pixels, likely at T<0.1 K. • Mission: 5 years+ in L2 halo orbit. • High-resolution (heterodyne) spectroscopy under study, possibly for warm phase.	**Primary Science Goals:** • Direct imaging of Earthlike planets, search for bio-signatures • Broad range of cosmic origins science **Measurement Requirements:** *Cosmic Origins Science:* • HST-like wavelength sensitivity (FUV to Near IR) • Suite of imagers & spectrographs, properties to be determined *Exo-Earth Detection:* • ~10^{-10} contrast • Coronagraph (likely), perhaps with a starshade • Optical and near-IR camera for planet detection and characterization. • IFU, R>70 spectrum of 30 mag exoplanet • 1" radius FOV Possible instrument for spectroscopic characterization of transiting planets. **Architecture and Orbit:** • Aperture: ~8-16m likely • Likely segmented, obscured primary. • Orbit: L2 likely	**Primary Science Goals:** • Direct imaging of Earthlike planets. • Cosmic origins science enabled by UV capabilities; considered baseline science. **Measurement Requirements:** *Exo-Earth Detection:* • ~10^{-10} contrast • Coronagraph and/or starshade • Optical and near-IR camera for planet detection and characterization • IFU, R>70 spectrum of 30 mag exoplanet • 1" radius FOV *Cosmic Origins Science:* • UV-capable telescope / instrument suite: properties and wavelength range to be determined. • Enable constraints on the high-energy radiation environment of planets. Possible instrument for spectroscopic characterization of transiting planets. **Architecture and Orbit:** • Aperture: <~8m likely • Monolithic or segmented primary • Optimized for exoplanet direct imaging, • Orbit: L2 or Earth-trailing likely.

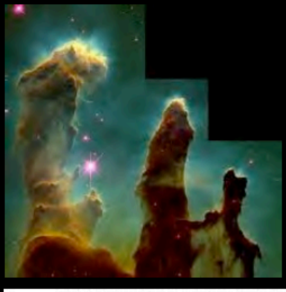
Two ''killer apps ''

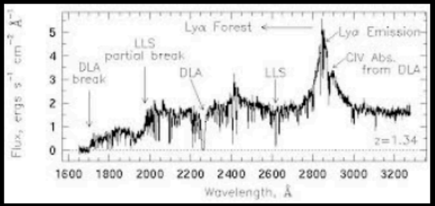
EXOPAG





COPAG



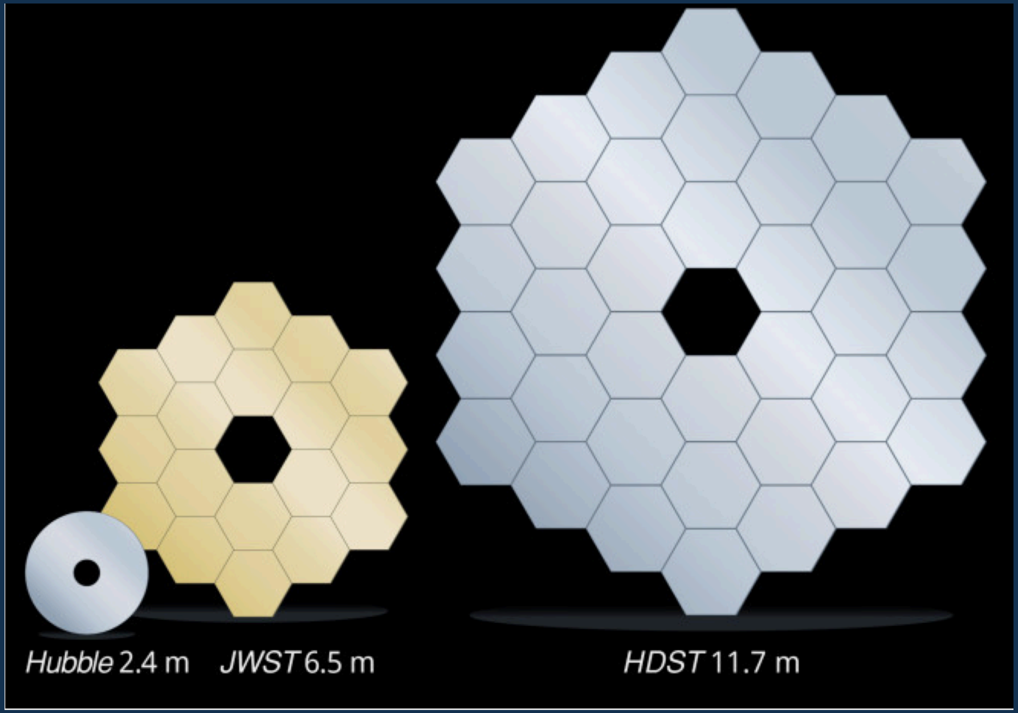


In the UVOIR, the goals and requirements are very similar

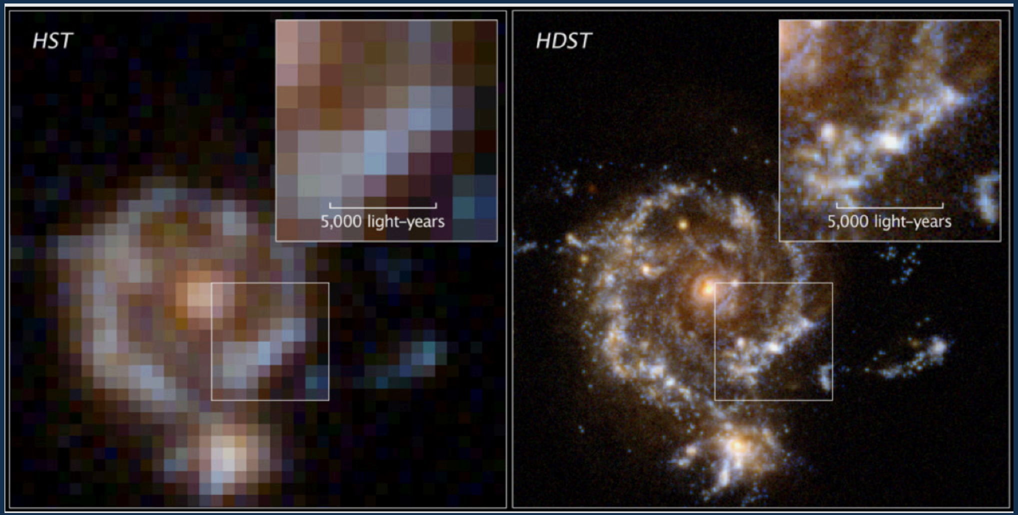
One mission + Broad science = Large Community

HDST

- 10m class
- Exoplanet driven

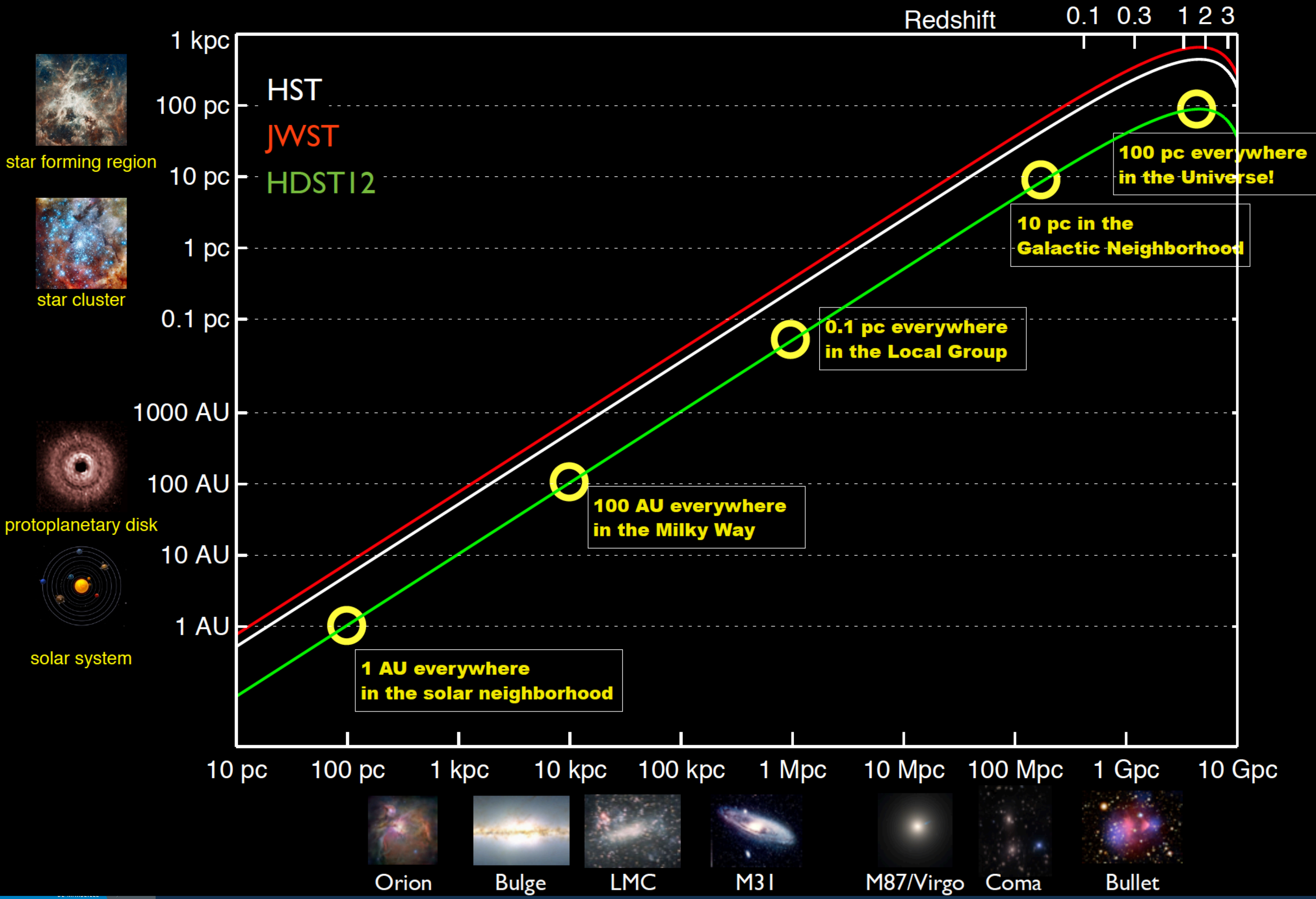


- 0.01’’ -> 100 pc anywhere
- Multiwavelengths high resolution
- Coronagraph



- Dalcanton+15 https://arxiv.org/abs/1507.04779

HDST: Breaking Resolution Barriers



HDST

HDST at a Glance

Mirror: 12 meter class, segmented primary mirror, diffraction limited at 500 nm.

Observatory operating temperature: Non-cryogenic, with a sunshade and active thermal control system for stability. Likely range: 250–295 K.

Wavelength range: 100 nm to 2 microns (baseline); options to extend bluewards to 90 nm and redwards to 3 to 5 microns (but without resorting to cryogenic telescope structures) to be explored.

Nominal orbit: Halo orbit about the Sun-Earth L2 point.

Stability: Active wavefront sensing and control system, active thermal control system, internal metrology system, and vibration isolation and disturbance suppression system.

Serviceability: Designed with modular sub-systems and science instruments, and potential for later starshade.

Notional Science Instruments:

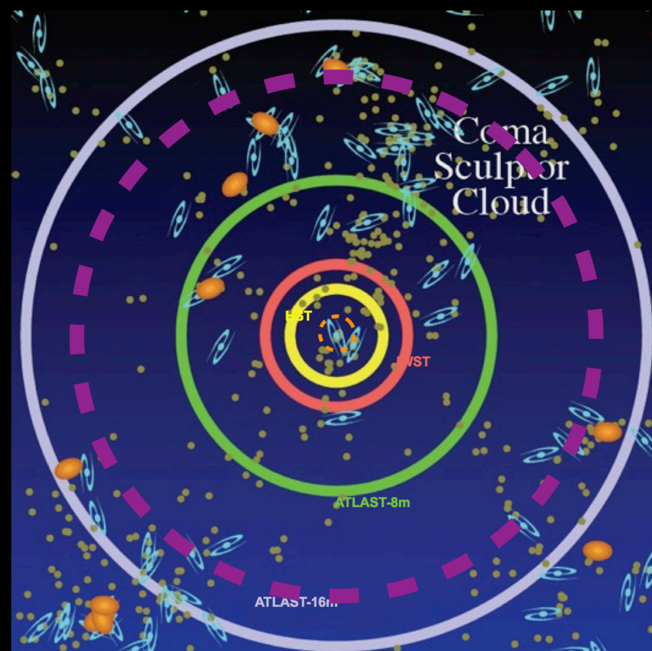
- Internal Coronagraph with visible-near-IR IFU (400 nm–2 microns), FOV 10'', 10^{10} starlight suppression, 35 milliarcsec inner working angle (3 λ/D at $\lambda = 650$ nm, D = 12 m).
- UV Integral Field Spectrometer (90 nm–300 nm), FOV 1'–3', R ≤ 100,000.
- Visible Imaging Array (300 nm–1 micron), FOV 6', Nyquist sampled at 500 nm.
- Near-IR imager and spectrograph (1 micron–2 microns), FOV 4', Nyquist sampled at 1.2 microns.
- Multi-object spectrograph (350 nm–1.6 microns), FOV 4', R ≤ 2000.
- Mid-IR imager (2.5 microns–5 microns), potential second generation instrument, if it can be implemented without impacting performance of UV or exoplanet instruments.

IGM

- More QSO’s
- Galaxy-Galaxy absorption
- IGM tomography

. . . beyond HST: Galaxies and gas flows in “High Definition”

Map of Galaxies within 12 Mpc of Our Galaxy



COS can in principle observe ~10 QSOs within 100 kpc of Andromeda. (small orange circle).

An 8-m can reach QSOs at m_{FUV} ~ 22, where there are ~ 10 / deg^2.

An 8-m can observe ~10 QSOs behind all galaxies within ~ 10 Mpc and > 1 out to 30 Mpc (purple line).

An 8m could “transcend serendipity” for all types of galaxies in the local Universe, for which we also can fully piece together the star formation history.

MID and SMALL space UV missions

- Existing lines of work/thinking
  - ARAGO supported by CNES -> ESA M5 -> PI Coralie Neiner, LAM Cécile Gry
  - Under study:
    - ISTOS/LAEX (PI C.Martin) a Lyman Alpha Explorer will be proposed end 16 to NASA MIDEX
      LOI sent to CNES this year for the french part
      130-300 nm MOS & IFU
    - MESSIER submitted to CNES PASO (PI David Valls-Gabaud)
      UV 200 nm2-3 narrow bands and a few visible bands
      High SB sensitivity -> Archaeoastronomy & Ly-a emitters, CGM

Options for GECO

- Long term = be in the LUVOIR dynamics
  - Science (multiwavelengths studies, galaxy evolution, structure)
  - Software development (photoz)
  - Observation simulation (simulation of emission, instrument models etc)
  - Instrument development (UV gratings, optical design)
  - Synergy with the exoplanets group and LOOM (Marc Ferrari in in the LUVOIR panel as a CNES representative, non-voting)

- Short term
  - Stay involved in missions to prepare scientifically and technically the LUVOIR