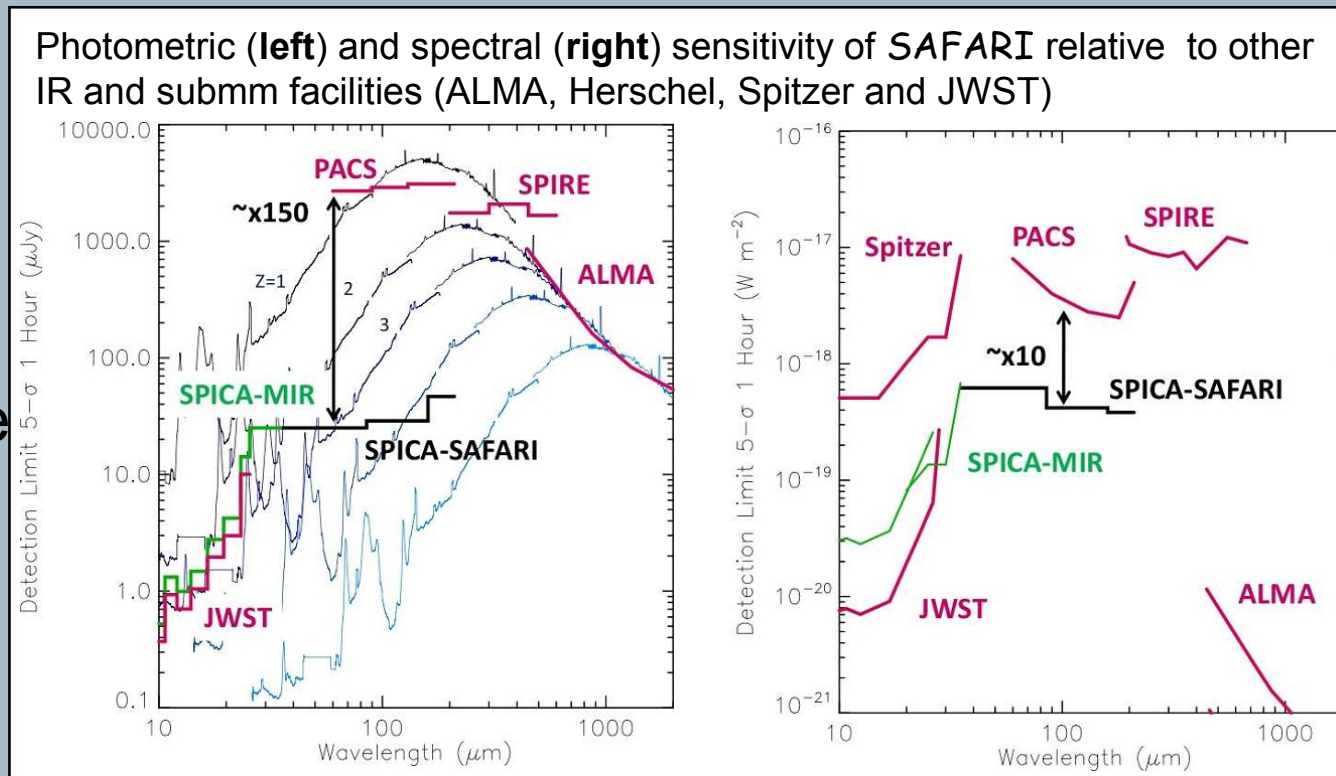
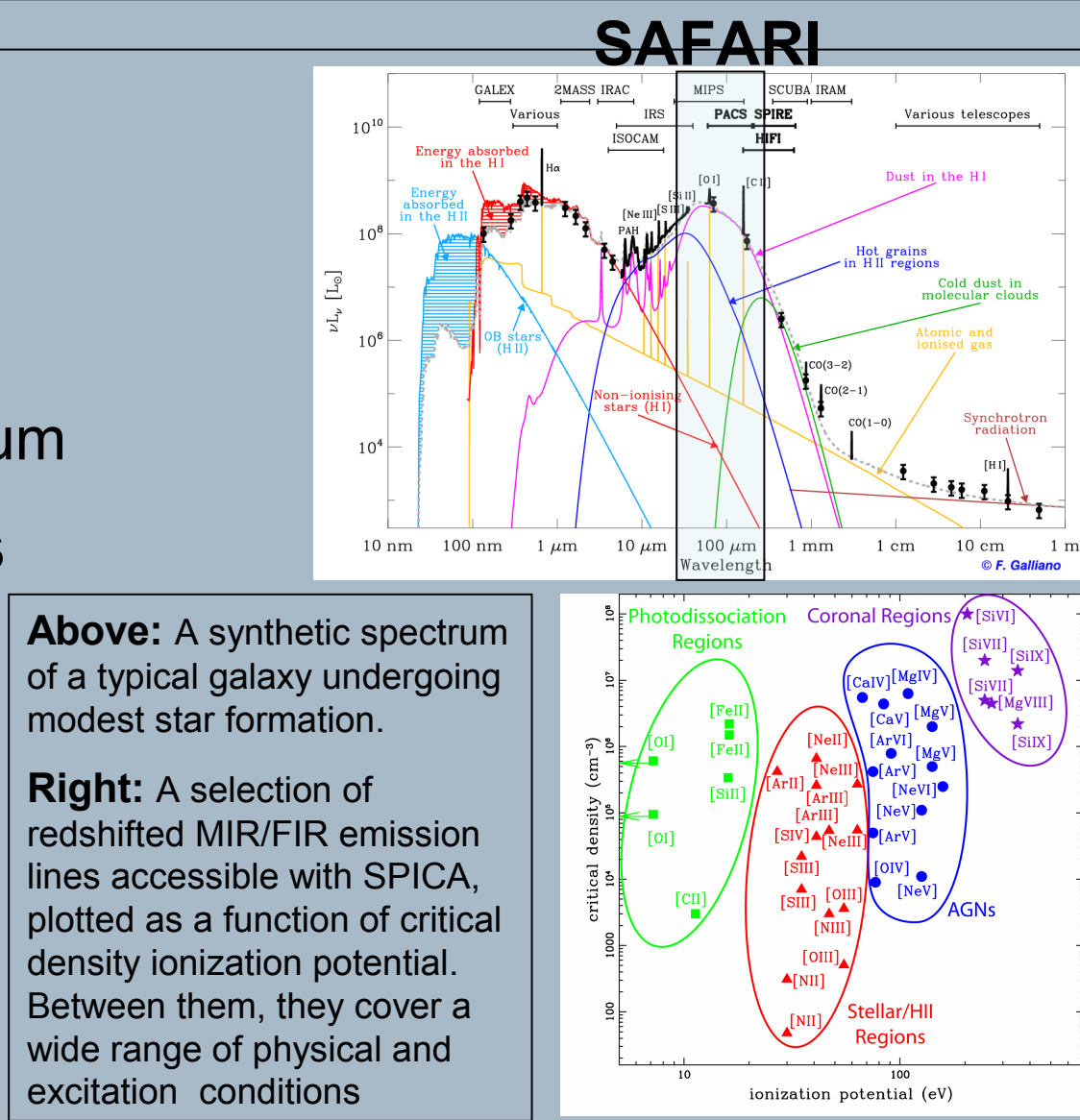




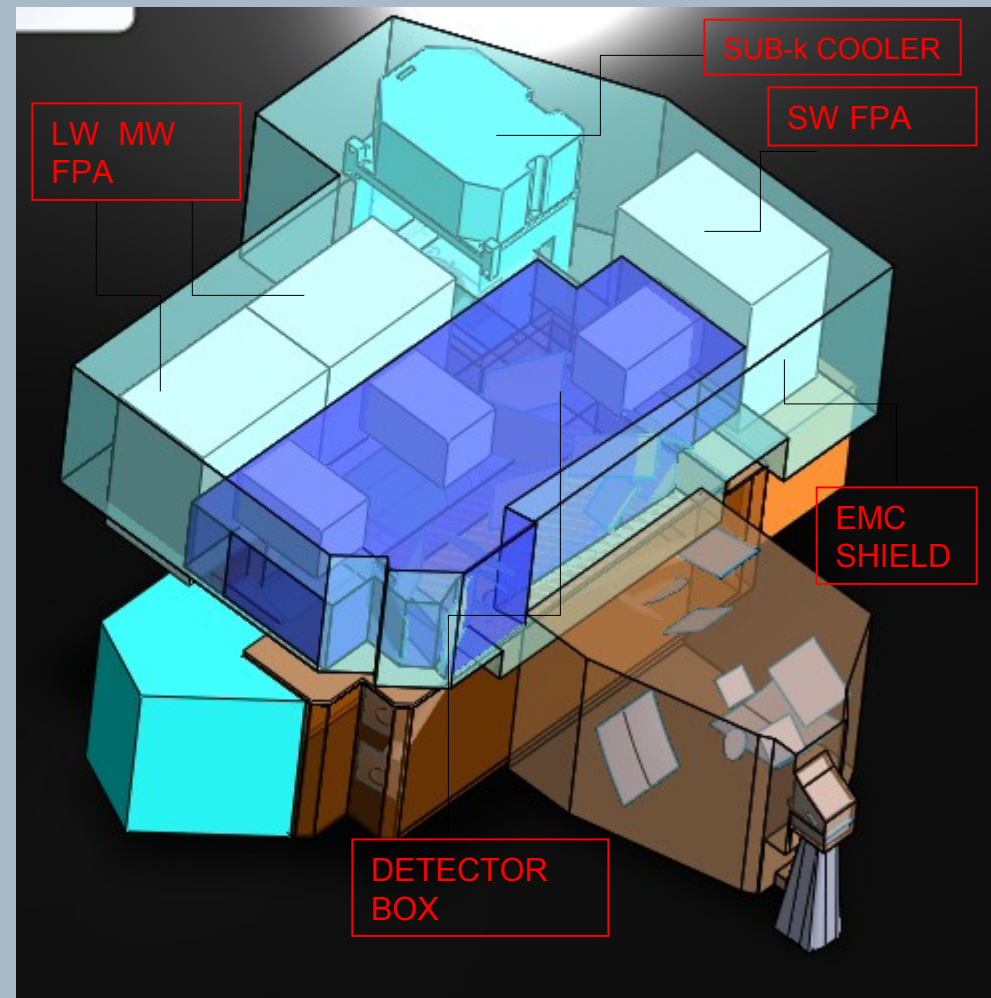
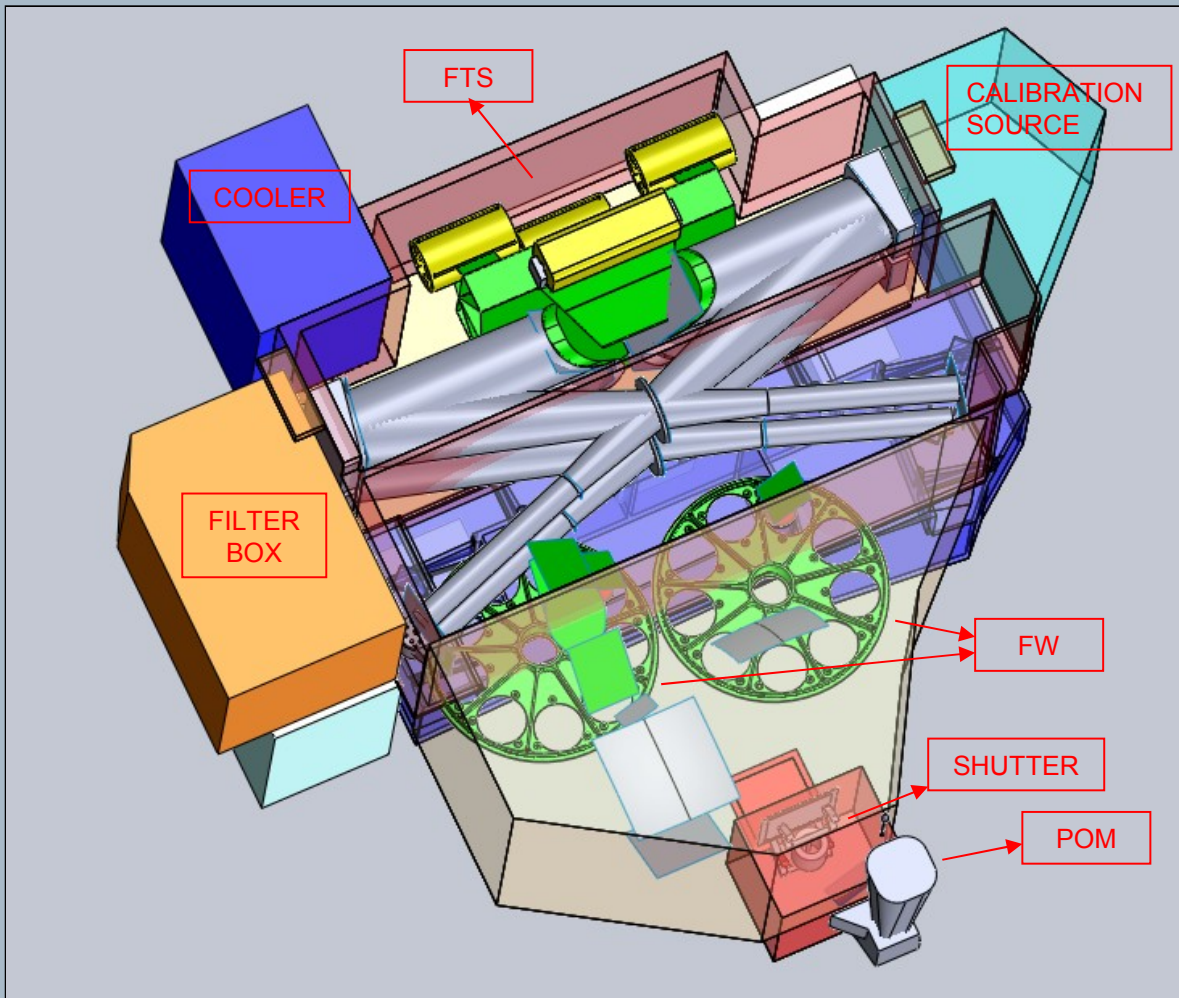
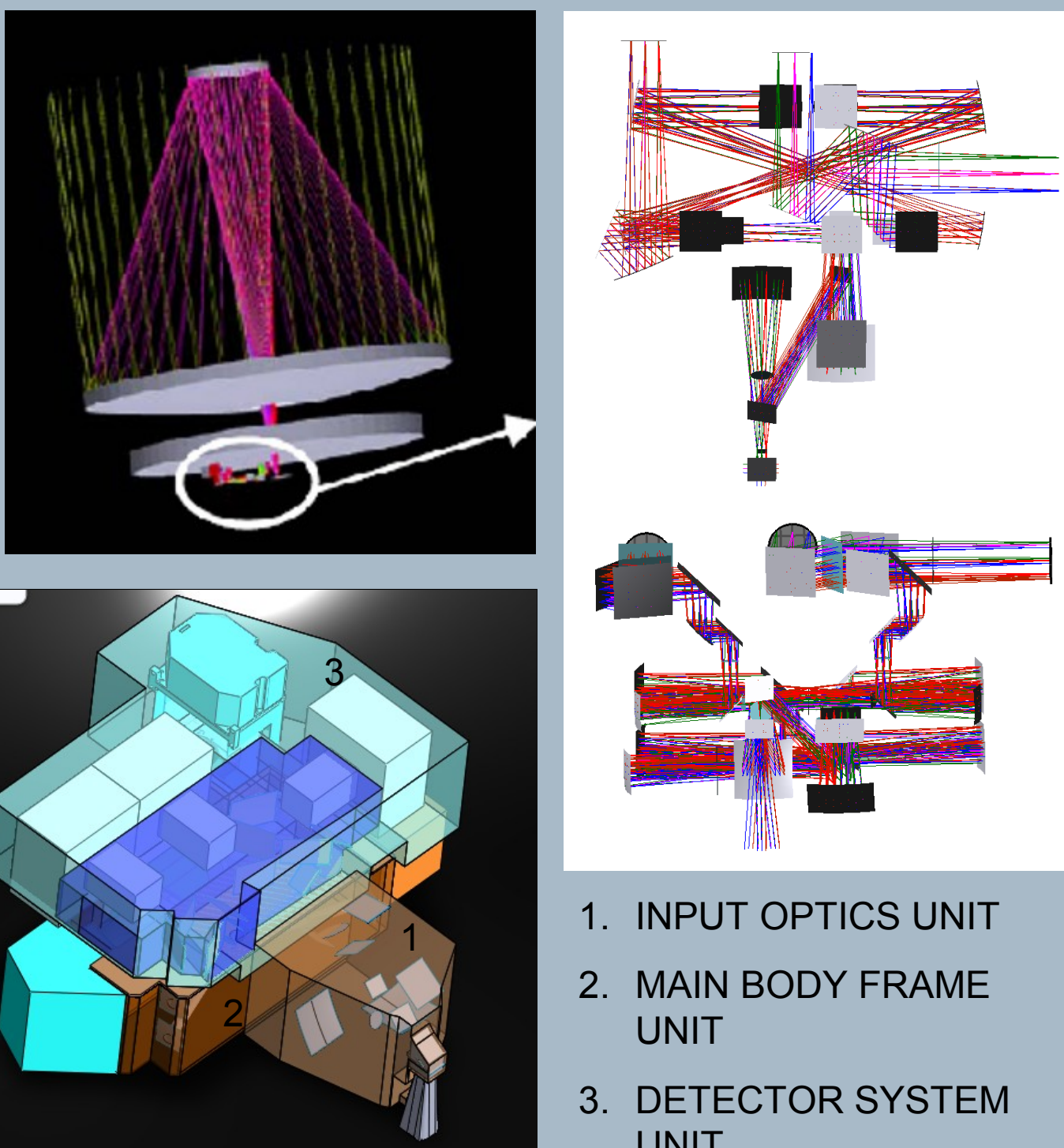
We present an outline of a study that is being undertaken by a consortium of European, Canadian and Japanese institutes, along with JPL, for a FIR instrument for the proposed JAXA-led Japanese-ESA mission, **SPICA**. SPICA is a **JAXA proposed mission** to be launched in early 2020s to conduct innovative infrared observations. SPICA is also proposed to ESA as one of a small number of missions that are being under selection to go to the next stage of the recent ESA's **Cosmic Vision** process. **SAFARI – SpicA FAR-infrared Instrument** – is an imaging spectrometer with both spectral and photometric capabilities covering the ~34-210 μ m waveband. We highlight the core science justification for the instrument, a possible conceptual design; its predicted performance and the technical challenges that need to be met in order to realise the full potential of the instrument.

- **Key wavelength**
 - Unique and extensive spectroscopic toolkit of key diagnostic lines (FIR+redshifted MIR) + thermal continuum
- **Long lineage of very successful FIR missions**
 - IRAS, KAO, ISO, IRTS, Spitzer, AKARI, Herschel...
- **Herschel?**
 - Confusion-limited at $\lambda > 100\mu\text{m}$, detector-limited below due to passively cooled, warm ($\sim 80\text{ K}$) mirror
- **ALMA?**
 - “complementary” science
 - FIR: undetectable λ 's from ground
- **SPICA ($< 6\text{ K}$) \rightarrow Cooled Herschel:**
 - Much lower background \rightarrow deep spectroscopy
 - Imaging vs. point-source \rightarrow determines science capabilities/sensitivities/instrument design
 - Long lived mission \rightarrow no cryogenics

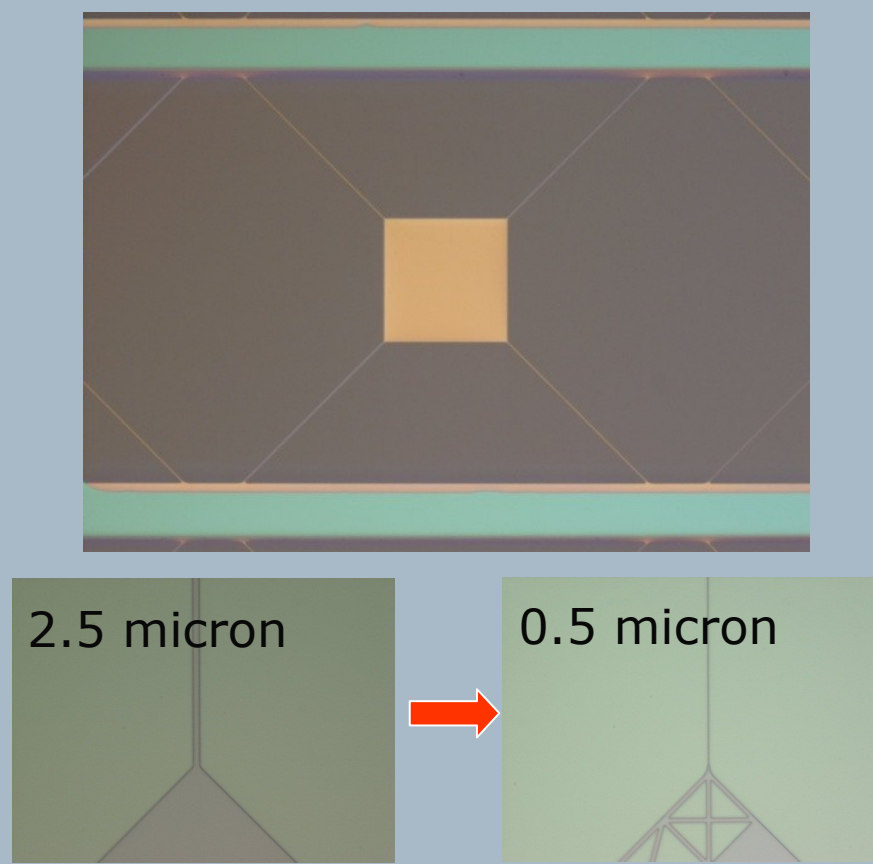
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- Imaging Fourier Transform Spectrometer (FTS)
- Wavelength coverage** of ~34-210 μ m
(using 3-detector arrays, F/2 sampling)
- Range **not covered** by JWST or ALMA!
- Field of view** of 2' x 2'
- Spectroscopy** R up to ~2,000 + photometry (R~3)
- Sensitivity** required:
Unresolved lines 5 σ -1hr. few $\times 10^{-19}$ W/m²
Photometry 5 σ -1hr : <50 μ Jy
- Technical challenges and solutions:**
 - Detector sensitivity, dynamic range and complexity
 - Cooler technology: a full multi-stage ADR and a hybrid sorption cooler/ADR are under consideration
 - Broadband beamsplitters and filters: ~3 octave bandwidth required
 - FTS cryo-mechanisms: space-qualified mechanisms exit
 - EMC susceptibility: careful shielding / filtering / operation concept required

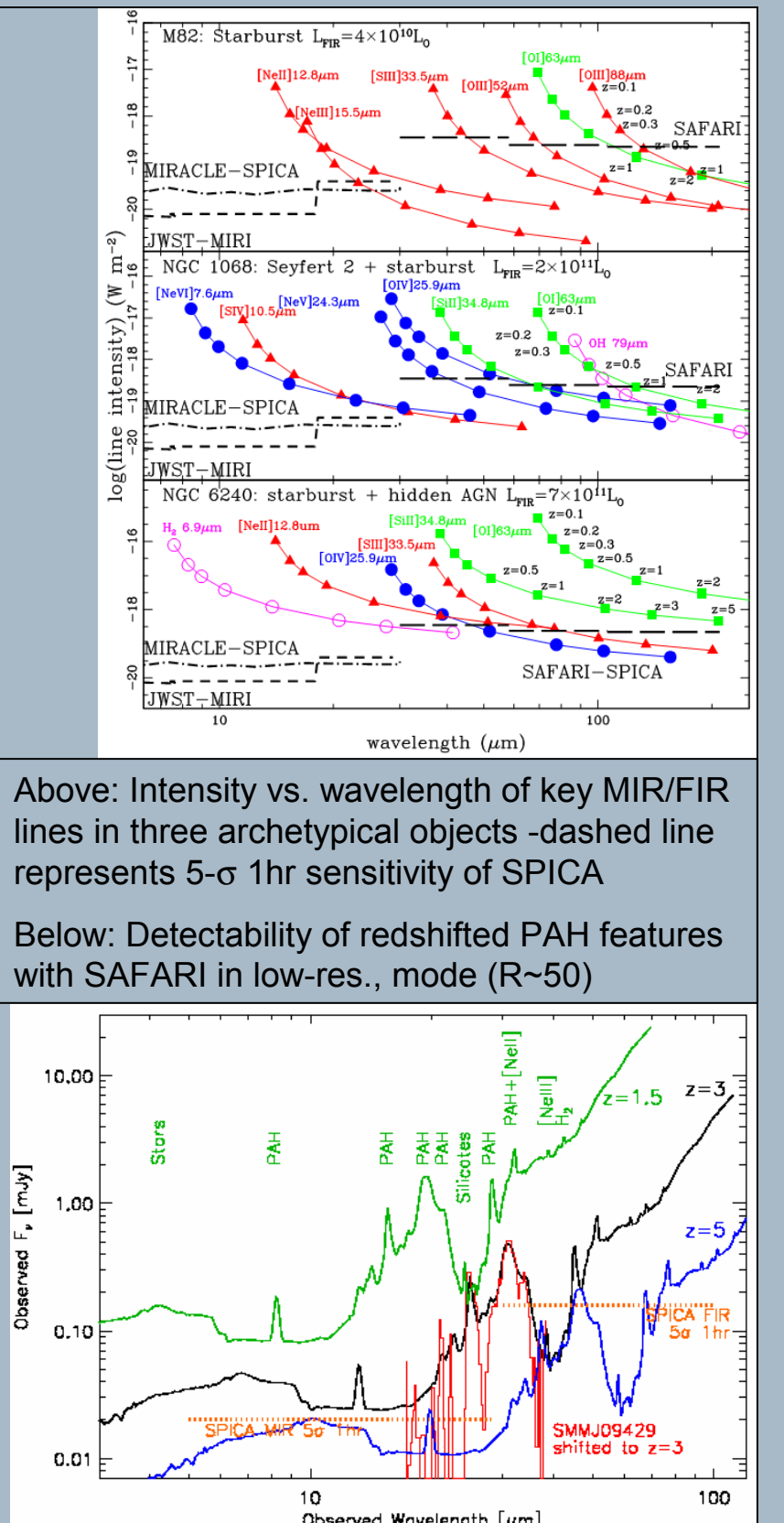


Prototype 388 TES array (1.6mm pitch) with flat Si backshorts					
	Band	λ_c	Pixel Size on sky	Number of pixels	Field size
	μm	μm	arcsec		Arcmin
SW	34-60	48	2.68	43x43	1.92
MW	60-110	85	3.05	38x38	1.93
LW	110-210	160	5.75	20x20	1.917

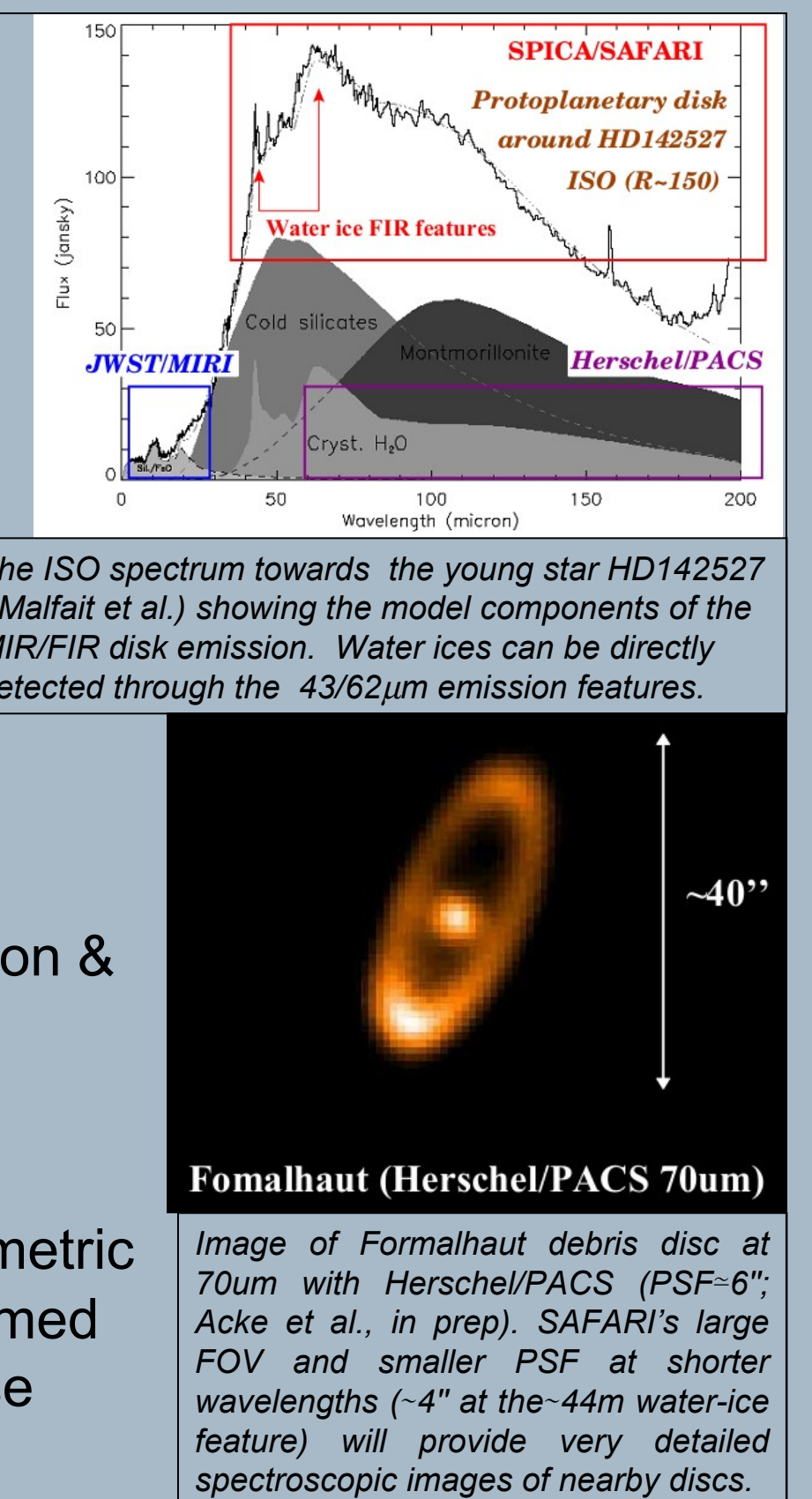


Thinner SiN suspension for higher sensitivity

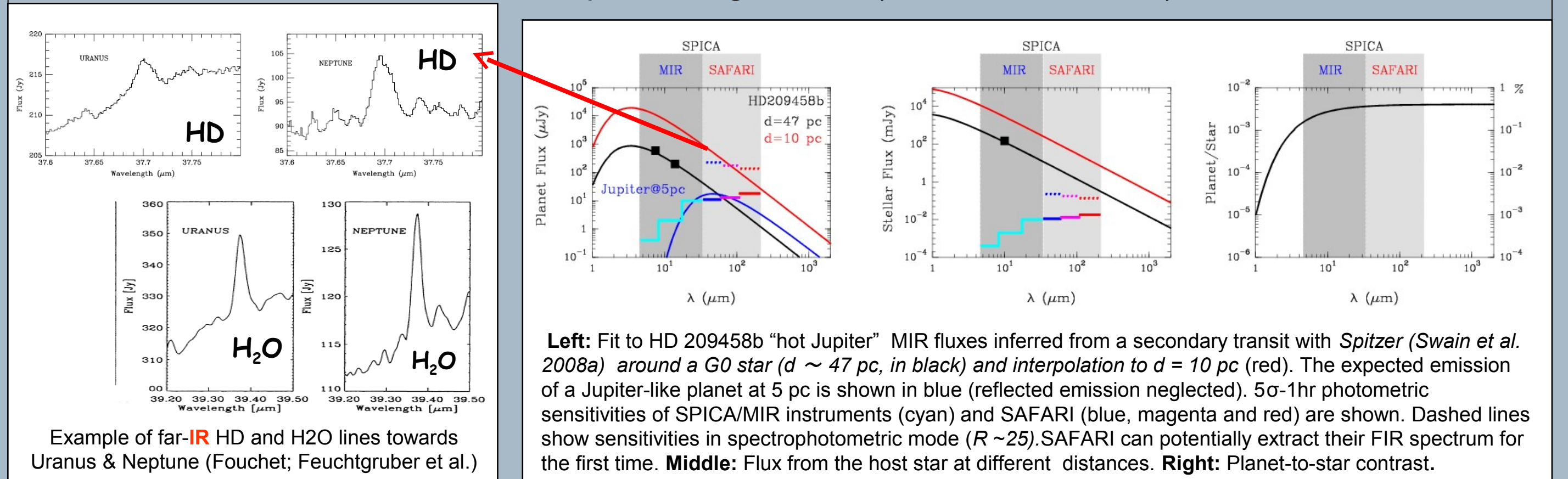
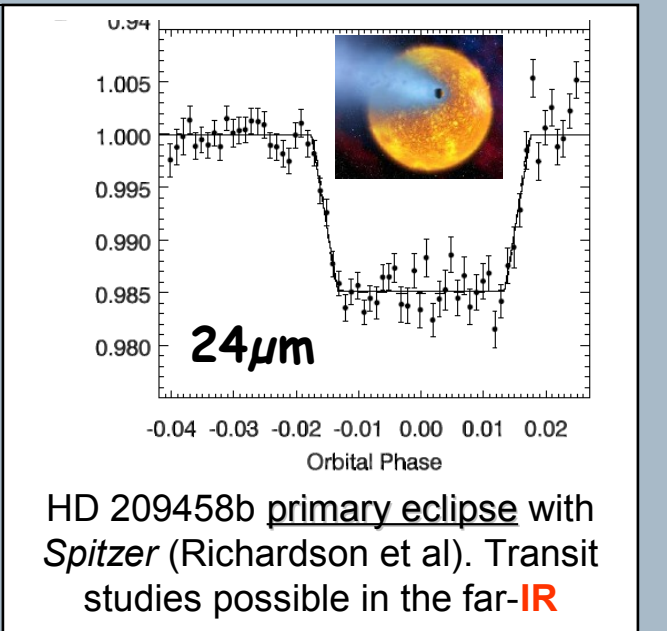
- **The AGN-starburst connection at high- z**
 - Through deep spectroscopy, characterise the distant MIR/FIR galaxy population out to $z \sim 4$ and beyond, and start to disentangle the interplay between AGN and starburst
- **Deep cosmological surveys:**
 - Through deep, confusion limited surveys at $70\mu\text{m}$ complete a census on (i) star formation down to $M_{\text{W}}/4$ @ $z \sim 1$, 90% of the CIRB over 80% of Hubble time (ii) massive black-hole growth by unveiling the missing dust-obscured, Compton-thick AGN population responsible for the 30keV peak in the x-ray background
- **Punching through the traditional confusion limit:**
 - Break confusion through deep, spectral imaging of “blank” sky
- **Cosmology at low spectral resolution:**
 - Deep surveys using redshifted PAH features
- **Local galaxies: proxies for the distant Universe**



- **Protoplanetary disks: from ices to oceans**
 - Tracing the presence of stellar FIR photometric excesses (due to circumstellar disks) out to the edge of the galaxy
 - Providing a comprehensive inventory of stars with circumstellar disks for future planet imaging facilities
 - Resolving the "snow line" (water ice) in nearby "Vega" disks
 - Access to the main gas coolants & key chemical species (e.g. water, oxygen, organics) in proto-planetary disks
 - Searching for FIR signatures of transiting exoplanets (water?)
- **Building blocks of the Solar System:**
 - Determining the chemical history of the Solar nebula by detection & characterisation of 100s of asteroids, TNOs and KBOs
- **The dust life-cycle:**
 - Tracing the evolutionary cycle of dust through spectral & photometric imaging of the faint, extended medium where dust grains are formed (e.g. evolved stars) and reprocessed (SNe remnants & the diffuse ISM), before incorporation into star-forming clouds



- 2 orders of magnitude higher sensitivity than Herschel/PACS to detect and characterize zodiacal backgrounds in a statistical sample of stars ($\sim 10^5$ Sun-like stars at $d < 180$ pc).
- Key to prioritising Earth-like candidates for future TPF-type missions.
- Complement to SPICA's mid-IR coronagraph and spectrometer.
- Very stable detectors and efficient, high cadence and high S/N observations to perform **transit photometry** and low-R spectroscopy in the far-**IR**.
- Cool EPs around cool stars ? Spectral signatures (water?, HD?, ice?)



- The outer Solar System provides the closest “template” to study the composition, processing and transport of minerals, ices and organic matter by studying debris disc bodies “one by one”.
- SAFARI photometry (~48, 85 and 160 μ m) and low spectral resolution (a few hundred) spectroscopy of bodies in the Solar System Kuiper Belt (KBOs or TNOs). For the first time SAFARI provides the required sensitivity to carry out FIR spectroscopy of TNOs and study their grain and ice composition at their emission peak.
- SAFARI will detect photometrically almost all known KBOs (those with diameters > 100 km) in only ~ 75 hr at a rate of ~1 object per minute.
- The expected sensitivity in the SED mode will be a factor ~x2.5 better than Herschel photometric cameras (i.e. all TNOs detected photometrically with Herschel could be observed spectroscopically with SPICA-SAFARI).

