In this poster we present a brief summary of a concept study that has been undertaken by a consortium of European institutes for a European instrument for the Japanese-led MIR/FIR mission, SPICA. ESI — the European SPICA Instrument — is an imaging spectrometer that will operate over the ~30-210 µm waveband. We describe the core science justification for an instrument working in this wavelength range; a possible conceptual design; its predicted performance and the technical challenges that need to be met in order to realise the potential of the instrument.

**The Far-Infrared Waveband**

The Mid- and Far-Infrared (MIR/FIR) waveband plays host to a unique spectroscopic and photometric toolkit with which to not only advance our understanding of the formation/evolution of many structures in the local and distant Universe, but also the physical processes that drive them. The proposed SPICA mission represents the next step in MIR/FIR astronomy, building on the IRAS/ KAO/ISO heritage, more recent successes of AKARI and Spitzer, and (to-be-launched) Herschel. With its 3.5 m aperture cooled to ~5K, SPICA will be at least 20 times more sensitive than Herschel in the 30-210 µm waveband. Such sensitivity will open up, for the first time, the detailed study of the evolution of galaxies from the epoch of the peak of star formation to present, will allow us to determine the chemical composition of dust in the ISM and planetary systems, and will provide the unique possibility of unbiased, spatial line surveys with which to map the galaxy population responsible for the bulk of the Cosmic Infrared Background.

**Current Instrument Concept**

- Imaging Fourier Transform Spectrometer
- Wavelength coverage of ~30–210 µm (set by beam split performance), achieved using 3-4 detector arrays
- Spatial sampling of F/2 at centre of array bands
- Field of view of 2’ x 2’, set by no: pixels/detector array sizes
- Spectral resolution R=100–10,000 (photometric mode R<10)
- Photometric sensitivity <50 µJy (5µ-1hr); line sensitivity of <few x 10⁻¹⁴ W/m² (5µ-1hr) at R=2000
- Detector options include photoconductors (cf. Herschel/PACS/ Spitzer) operating at 1.7–4.5 K, Transition Edge Superconducting bolometers (TES) operating at <100 mK, Silicon bolometers and Kinetic Inductance Detectors (KIDs)

**ESI: A European SPICA Instrument**

**Galaxy Evolution: near and far**

- The AGN-starburst connection at high-z: By the time of launch of SPICA, deep cosmological surveys have detected many thousands of faint, distant MIR/FIR galaxies. Herschel will measure the FIR continuum in these sources, constraining dust temperatures and masses out to z very high. SPICA will detect the spectral and broadband features to be found in the galaxy FIR emission, providing the means by which to trace non-polar organic molecules which are otherwise invisible, yet play a key role in the interplay between gas and dust chemistry. SPICA will measure the FIR contamination of the gas, providing the means by which to constrain the local radiation fields and to start to disentangle the interplay between AGN and starburst activity.
- Deep cosmological surveys: ESI’s exquisite photometric sensitivity will enable large area surveys to the contamination limit at 70 µm to be made. Such surveys will provide the most accurate measurement of the star formation rate in distant galaxies (without FIR contamination) and will complete the census of the growth of massive black holes by probing the missing population of dust-obscured AGN. SPICA will be able to measure the 44 µm line in the massive dusty galaxy population, but also to measure redshifts and so to start to constrain the bolometric luminosity of luminous infrared galaxies.
- Local galaxies—proxies for the distant Universe

**Planetary System Formation: From Gas/Dust to Planets, Ices to Oceans**

- Dust in circumstellar disks: FIR spectroscopy provides a unique means to which to trace the early evolution of many young stars. The photometric capabilities of ESI will trace the variation in gas/surroundings distribution and temperature in the dusty disks, both of which are expected to evolve with stellar age, and which manifest themselves most markedly in the FIR.
- Water ices—the “snow-line”: ESI’s access to the FIR water ice feature will enable tracing a large range of water ice in the formation and evolution of planetary systems.
- Evolved stars—dust factories: Evolved stars are the principal source of dust in the ambient ISM. ESI’s photodetector spectroscopy provide a unique means by which to probe the inner warm, dense circumstellar shells tracing non-polar organic molecules which are otherwise inaccessible, yet play a key role in the interplay between gas and dust chemistry. SPICA will be able to use the 44 µm line to trace the evolution of the ISM, and to detect the dusty galaxy population, but also to measure redshifts and so to start to constrain the bolometric luminosity of luminous infrared galaxies.
- Simple to complex molecules: The ISM plays host to many complex molecules, yet until now we lack a complete understanding of how these form in space. ESI will provide the first opportunity to make systematic observations of the more complex carbon chains, many of which have no dipole moment and so can only be detected in the FIR through their vibrational transitions.

**Technical/Technological Challenges**

European institutes and industry are world-leaders in many of the technology areas relevant to ESI and SPICA. There are, however, several technical challenges that need to be met to realise the full potential of ESI:

- **Detector Technology:**
  - TES detectors offer the best prospects for high-sensitivity arrays. Several European groups are working on TES technology, along with the multiplexing/support electronics, for x-ray/ submillimetre-wave applications.
  - Frequency coverage is excellent, dynamic range may be an issue.
  - Photoconductor technology to cover much of the ESI waveband has already been developed for existing space missions, with additional scaling development of reliable cold electronics only required. Detector time constants may be an issue for an FTS-type instrument. Detector development over the 35–50 µm waveband is needed, and is planned by the Japanese.

- **Cooler Technology:**
  - Cooling to <100 mK is required if TES detectors are to be used. An ultra-compact, lightweight hybrid cryostat is required.

- **Cryogenic Materials for the Telescope/Optical Structures:**
  - Silicon Carbide has many excellent materials properties that make it particularly suitable for cryogenic application. European industry leads the world in this area.