P-086

A SPICA far-IR instrument SAFARI

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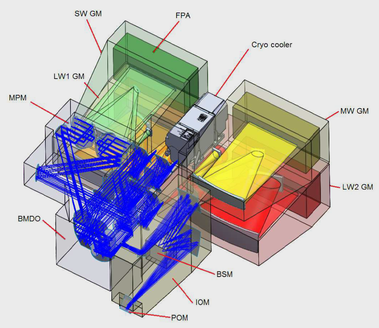
Abstract

SAFARI (SpicA FAR-infrared Instrument) consists of two main functions, namely SAFARI/SPEC and SAFARI/POL. SAFARI/SPEC is a powerful spectrum mapping machine that covers 34–230μm, where we can observe many important gas diagnostic lines of distant galaxies and reveal their evolutional histories. A grating spectroscopy mode with $R \sim 300$ achieves a high sensitivity of $6 \sim 8 \times 10^{-20}$ [Wm^{-2}], which enables us to study not only exotic bright galaxies but also main-stream galaxies from z $\simeq$ 3 to the present. By adding a Martin-Puplett Fourier spectrometer to its optical path, SAFARI/SPEC achieves higher spectral resolutions of $R = 11000$ (34μm) to $R = 1500$ (230μm) with a comparable sensitivity of 1×10^{-19} [Wm^{-2}] to its base spectroscopy mode. TES detector with ultra-low noise (NEP $= 1 - 2 \times 10^{-19}$ [W/$\sqrt{\text{Hz}}$]) is being fabricated to achieve the ultra-high sensitivity of SAFARI/SPEC. SAFARI/POL is a unique instrument that has a polarimetric/photometric mapping capability at 100μm, 200μm and 350μm. The prime science driver for SAFARI/POL is the polarimetric mapping of Galactic filamentary structures. Polarisation-sensitive Si bolometer-array detectors with 3×10^{-18} [W/$\sqrt{\text{Hz}}$] gives us a high dynamic range sensitivity that is required for observations of Galactic extended emissions. We present the details of the instrument specifications that is being proposed as the candidate ESA M5 mission.

SAFARI SPEC & POL

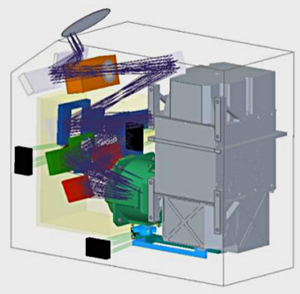
SAFARI/SPEC – high sensitivity grating spectrometer

- Basic $R \simeq 300$ mode $\rightarrow 5 \sim 7 \times 10^{-20}$ [W m^{-2}] (1hour, 5σ)
  - [OIV] 25.9 μm $\simeq 1 \sim 2 \times 10^{-20}$ [W m^{-2}] ($L \simeq 10^{11.5} \sim 10^{12} L_\odot$ @ z=3)
- Martin Puplett Interferometer to provide High-R mode
  - $R \simeq 1500 \sim 11000 \leftrightarrow \Delta V \simeq 200 \sim 30$ [km s^{-1}]
- 4 bands instantaneously covering 35 $\sim$ 230 μm
  - 230 μm $\leftrightarrow$ [NIII] 57 μm @ z=3
- Spatial Resolution: 3″ – 21″



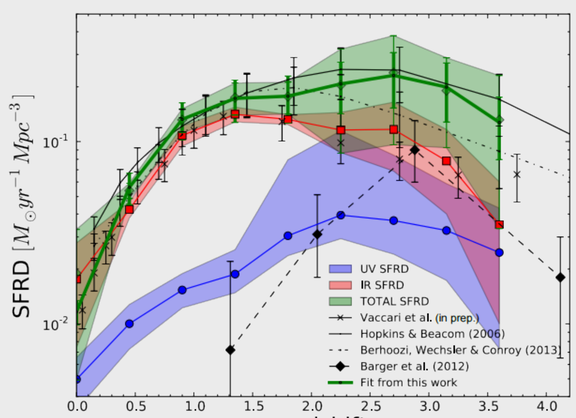
SAFARI/POL – imager polarimeter

- Polarization sensitive bolometers
- 3 bands centring at 110, 220, 350 μm
- Spatial Resolution: 9″ – 32″
- FOV: 160″ × 160″ (for each band / overlapped)

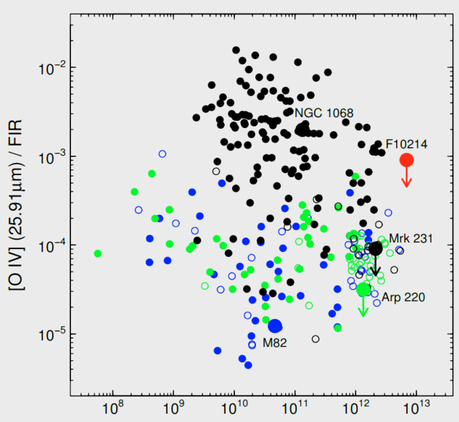


Galaxy Evolution at z$\sim 1-3$ to the Present

One of the key scientific objectives of the SPICA mission is to reveal the whole process of the galaxy evolution. SAFARI will detect key diagnostic lines and reveal physical conditions of distant galaxies at z $\sim 1-3$, where the star formation activities were of their peak, as well as nearby galaxies to reveal the variety of physical conditions at the present epoch.



Burgarella *et al.* (2013)

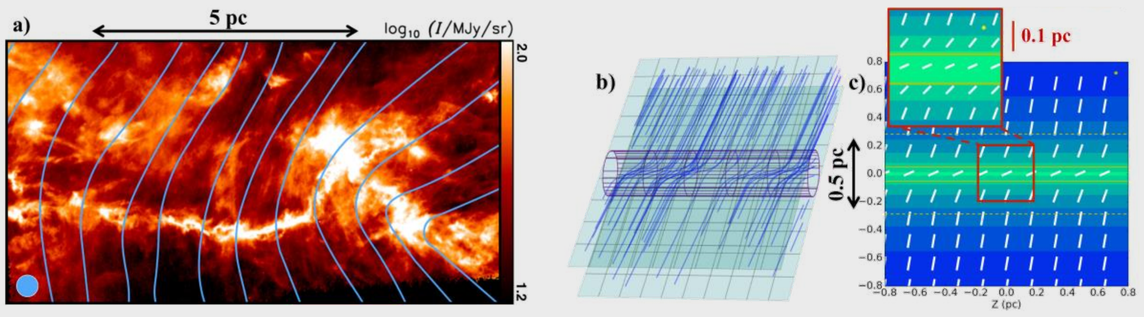


Sturm *et al.* (2010)

Seyferts/LINERs/Star-forming galaxies

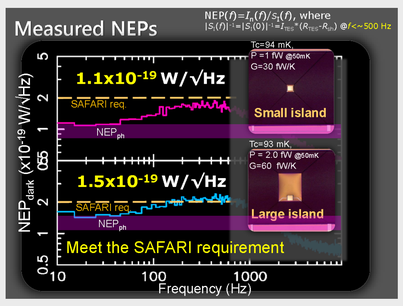
Magnetic Field in Star-Formation Regions

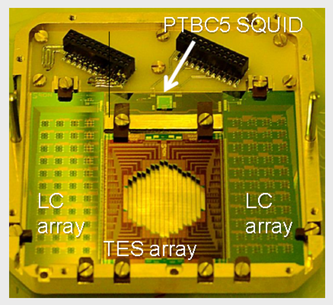
SAFARI/POL will unveil the significant role of magnetic fields in the star-formation process by imaging the magnetic field lines in interstellar media of degree-wide areas with 30 times better resolution comparing to Planck.

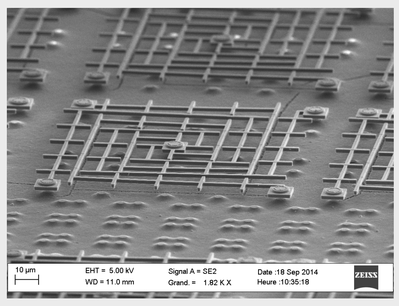


Interstellar magnetic field observed by Planck superposed on interstellar filaments observed by Herschel (a). Simulated magnetic field in filamentary structure (b) and its synthetic polarisation map on the sky (c). Figures are cited from the SPICA M5 proposal document.

Cutting-edge Detector Technologies







Recent TES detector developments:

- $NEP_{det} = 1 \times 10^{-19}$ W Hz$^{-1/2}$ for single pixels
- successful ×132 FDM readout has been achieved

Polarisation-sensitive bolometer array with readout analogous to Herschel/PACS system