



Observation and Analysis of dust polarization Interstellar Medium with the PILOT experiment

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The Polarized Instrument for Long-wavelength Observation of the Tenuous interstellar medium (PILOT) is a balloon-borne astronomy experiment designed to study the linear polarization of the Far Infra-Red emission, 240 μm (1.2 THz) and 550 μm (545 GHz) with an angular resolution of a few minutes of arc, from dust grains present in the diffuse interstellar medium, in our Galaxy and nearby galaxies. The polarisation of light is measured using a half-wave plate (HWP). We performed the instrumental tests from 2012 to 2014 and are planning a first scientific flight in September 2015 from Timmins, Ontario, Canada. This poster describes the measurement principles of PILOT, the results of the laboratory tests and its sky coverage.

Instruments

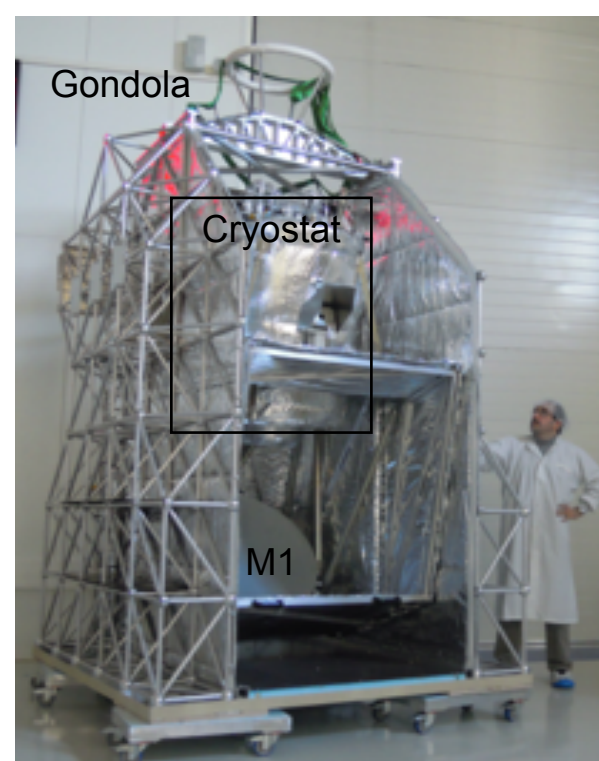


Figure 1. PILOT instruments

• **Science Objective:** measure the linear polarization of the dust emission in the Far-InfraRed

- Reveal & understand
 - structure of the magnetic field
 - geometric & magnetic properties of dust grains
 - Polarized foreground

- Complement Planck observations at $\lambda < 850 \mu\text{m}$ with better accuracy & higher angular resolution

• **Observations:**

- Galactic plane ($|b| < 20^\circ$)
- Diffuse Interstellar medium (cirrus).

• **Characteristics:**

$\lambda = 240$ (& $550 \mu\text{m}$)
resolution: $1.4'$ (& $3.3'$)
Bolometer array of 2048 detectors

• **Weight, Altitude:** ~ 1 ton, 40 km

• **Status:** Funded by CNES.
just finished the test phase
shipped PILOT instruments for the 1st flight

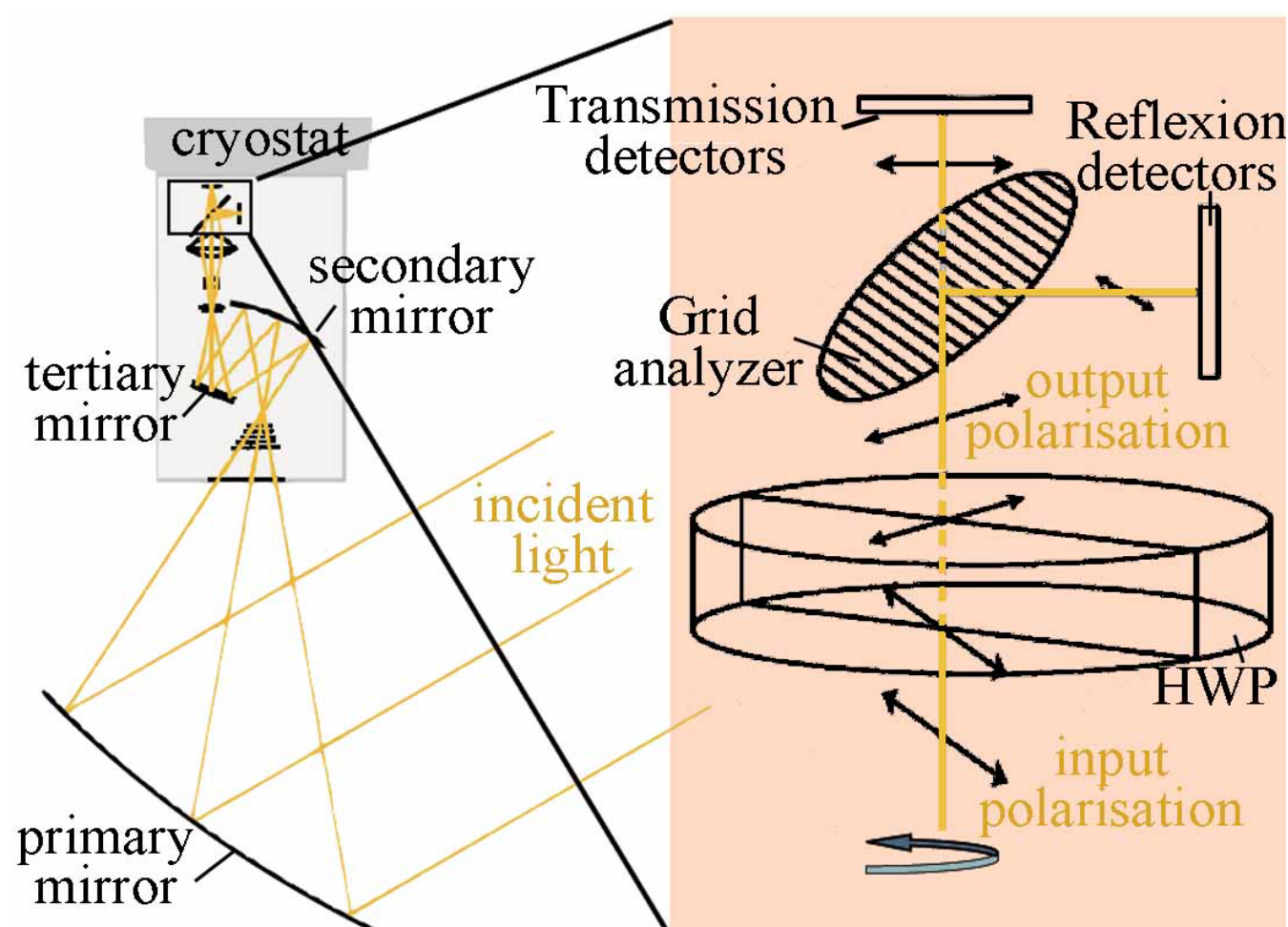


Figure 2. Left: Schematic diagram of the PILOT optics. The cold optics inside the cryostat is maintained at 4 K. The detectors operate at a temperature of 300 mK. Right: Schematic of the action of the HWP on the incident polarized signal.

End-to-End Test

To characterize the PILOT instrument, we performed photometer tests between 2012 and 2013 and end-to-end tests between 2013 and 2014.

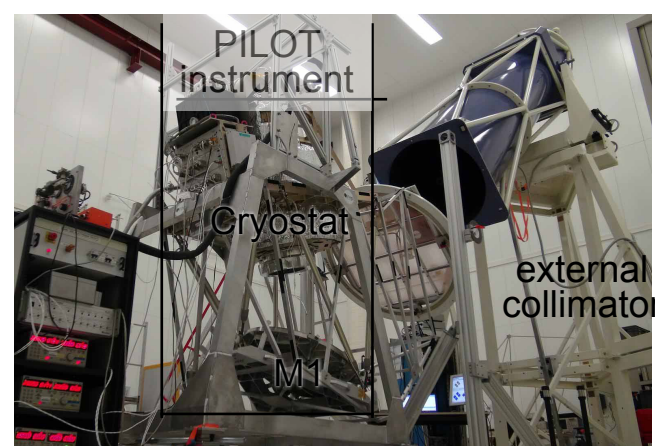


Figure 3. Setup for the end-to-end ground tests including the external collimator (left) and the PILOT instrument (right).

Defocus

• **Purpose:**

Derive the best position of the primary mirror M1 with respect to the photometer

• **Method:**

Performed a series of defocusing along three orthogonal axes (X,Y,Z), around the best focus provided by the Zemax model (The Z axis corresponds to the optical axis of the photometer.)

To estimate the impact of defocusing on the optical performances, all three axis of the focal plane have been explored with a point source generated with an external collimator.

• **Result:**

The full width at half maximum (FWHM) of the observed source on an array at several defocusing distances along the Z axis. The data allows to find the best focus position of M1 in Fig. 4.

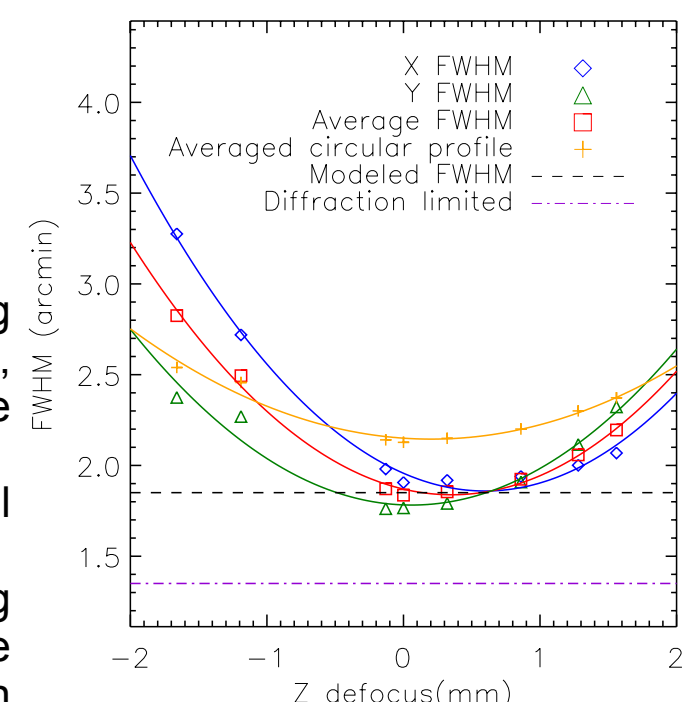


Figure 4. Variation of the FWHM with focus distance along the Z axis. The horizontal lines show the diffraction limit (dash-dotted) and the simulated FWHM value (dashed).

The results indicate that the acceptable region around the best focus is larger than expected. The initial requirement of 0.3mm can therefore be relaxed safely by a factor of 2 to 0.6mm.

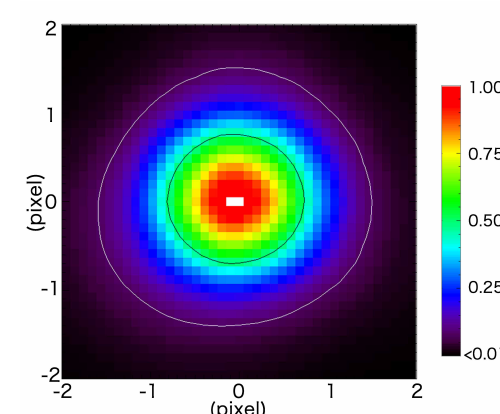


Figure 5. PSF as measured in the PILOT focal plane using the collimator point source.

• **PSF:**

Set the M1 at the best position and measured and characterized the point spread function (PSF).

• **Result:**

We compared with simulations, which take into account the realistic collimator properties, in particular the secondary mirror occultation and finite size of the source diaphragm. The observed PSF is in good agreement with the simulated PSF in Fig. 5.

Sky Coverage

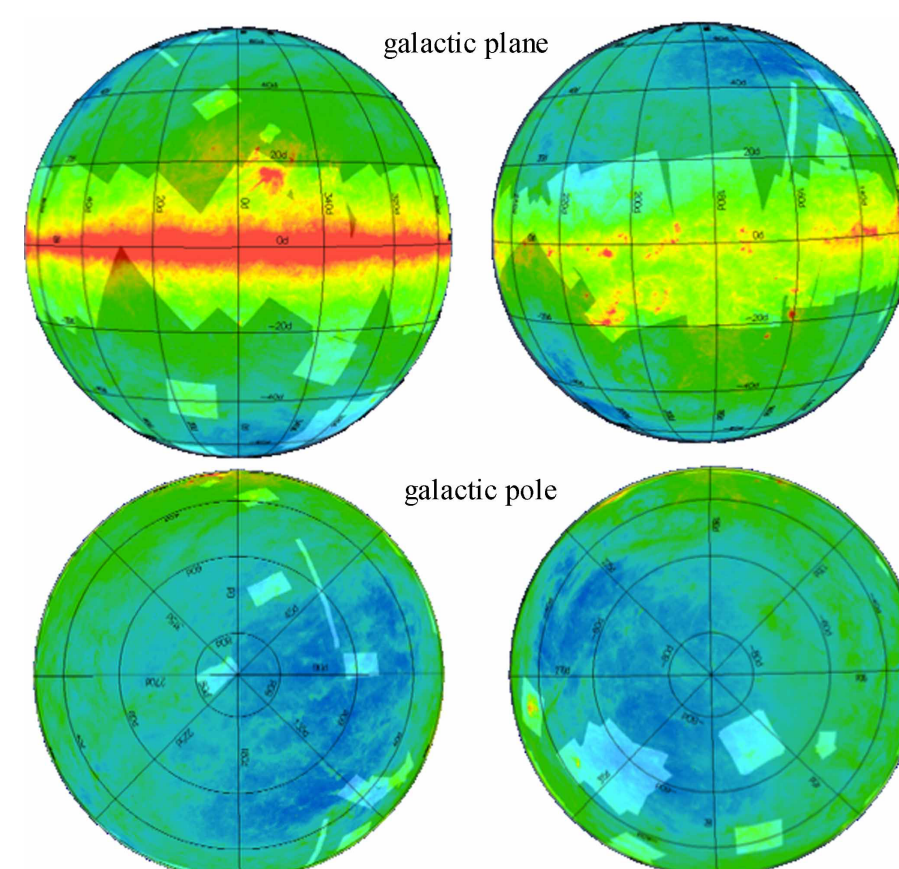


Figure 6. Sky coverage maps expected for 3 flights of the experiment.

• **Schedule:**

- 3 scientific flights
- 2 north hemisphere
- 1 south hemisphere

• **Hypothesis:**

- 24 hrs flight from Timmins (Canada)
- 26 hrs flight from Australia
- 14 hrs flight from Sweden

• **Combined sky coverage of 3 flight:**

- 32 % of the sky
- 97 % of the Milky Way

*This sky coverage is preliminary and will be optimized based on the performances measured during the first flight.