

# Compact Spectrometers for Astronomy: Coupling the Detector and the Photonic Integrated Circuit

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## ABSTRACT

Compact spectrometers in the infrared are very interesting for spatial applications thanks to the reduced footprint and weight. Even for ground based applications, in particular in the near and mid IR, the small volume allows to reduce the size of the cryogenic chamber, therefore improving the energy consumption. We have been working since several years in the development of compact Fourier Transform Spectrometers, where a stationary is obtained in a single mode waveguide. In order to sample the signal, a nano-groove or nano-dot is regularly set on the surface of the waveguide (see Fig. 1). Moreover, to get the most compact device, a detector is then set on top of the waveguide, allowing to obtain a monolithic spectrometer without any relay optics. The sampling centers are set at regular spacing, ideally corresponding to the pixel pitch of the detector, which is typically 10  $\mu\text{m}$ . Although this will introduce some aliasing issues, the typical Nyquist window will be around 10 nm, which can be enough for applications. Besides, as the resolution is related to the total sampling length, using detectors having 2048 pixels and 10  $\mu\text{m}$  size, the expected resolution can be around  $R = 80000$  at  $\lambda = 1$   $\mu\text{m}$ .

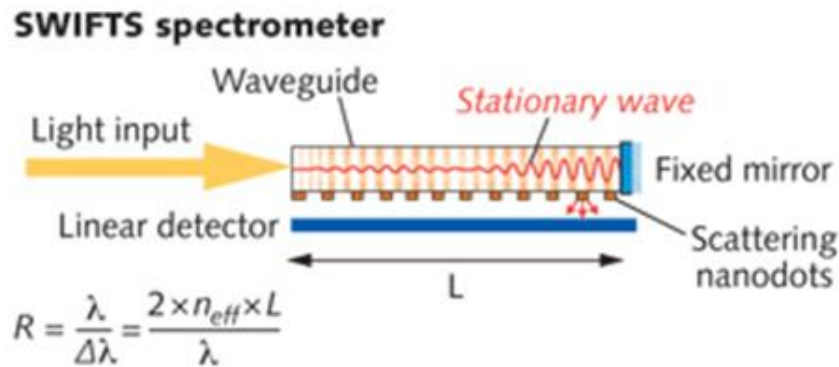


Fig.1: Principle of the Stationary Wave Integrated Fourier Transform Spectrometer (SWIFTS)

The issue here is to achieve the coupling between the commercial detector and the waveguide on the top surface. In this work, we will present two configurations that are under study. In the first configuration (Fig.2, left) we modify the detector (mechanical modification, window removal) in order to get the waveguide as close as possible to the physical pixels. In a second configuration (Fig. 2, right), we collaborate with a technological partner in order to obtain a semiconductor photo-sensitive layer over the antenna that will act as a pixel-on-chip.

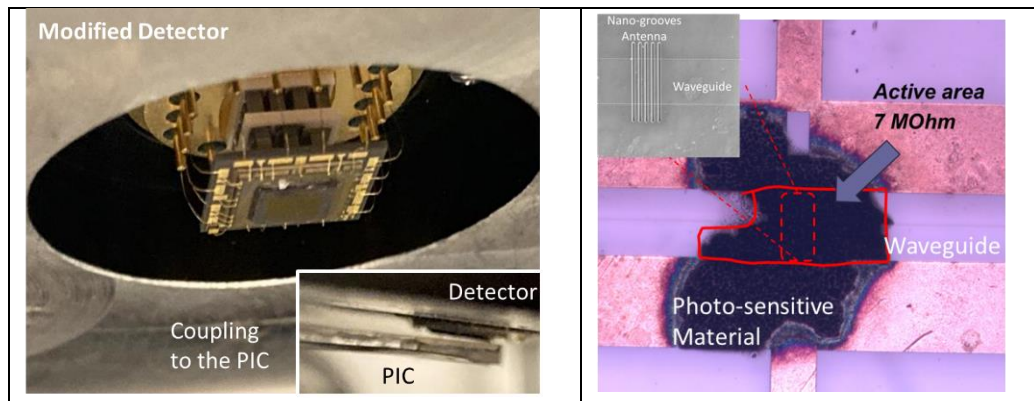


Fig.2: (left) A 2D Hamamatsu detector coupled to our PIC, after custom mechanical modification (right) Image of a pixel on-chip, fabricated over the antenna and the waveguide.

In this presentation, we will show the results obtained on a commercial Hamamatsu detector (128 x 128 pixels) coupled to the waveguide that allows for wavelength detection with 300 pm resolution, in the near IR. We will also show our first results on the resistivity modification of the photosensitive material as mid IR light is extracted from the waveguide, using the configuration of Fig.2 (right). These results confirm the feasibility of detector modification to adapt to the chip and even the fabrication of the pixel directly on the Photonic Integrated Circuit. We will discuss the future work, aiming at coupling the Hamamatsu detector to a 2D Fourier Transform Spectrometer in Gabor configuration that will optimize the pixel filling and increase the spectral band.

## References

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