The new system is an electrothermal TES device with a very low thermal capacity, held at bath temperature. However, it is increased by a factor of 2. Each TES detector is located at one of these thermal baths.

The heating Joule power of the TES is controlled by the active electrothermal feedback device, to prevent the TES detectors from too high a temperature increase, which will cause the output of the sensor to be modulated by the bias heating effect.

Three power sources: The incident photon power on the absorber; the Joule effect on the sensor caused by the bias; and the heating Joule controlled by the active electrothermal feedback device.

Three thermal baths: Cold bath (Tb), bulk phonon bath (Tb), absorber (Ta), and the heating and device electron bath (Ts, Th).

Every bath is exercising thermal power through thermal resistance and is characterised by its thermal capacity. Photons of the sensor and the heating device are well thermally coupled to the silicon bulk.

Numerical study of the model

Purpose: Numerical simulation to compare model and measurements in time domain.

Model versus measurements: Every parameter is expressed with literature definitions but controlled by the measurements. The model gives very similar data as actual TES measurements.

Without feedback we observe the effect of the thermal capacities variations due to temperature. The same heat impulse gives longer signals as the temperature increase and therefore higher thermal capacities.

With feedback we observe similar time behaviour for a 14.5 keV pulse, but this need to be perfected with less noisy measurements.

A new campaign of measurements is planned with the great improvements in noise performances needed.

Analytical study of the model

Purpose: Have a better understanding of the frequency behaviour of the system and its noise.

To enlighten parameters’ influences over the spectral resolution.

Analytical model: The electrothermal model is expressed as a block diagram. Each block represents either a thermal component (capacity or resistance), an electrical function of the model (Joule effects or amplifier transfer function) or the ddfT of parameter of the NbSi measured.

Every function is linearised and then transformed into the Laplace domain.

The diagram can be simplified and gives the total transfer function that expresses the voltage output with the input photon power. Every noise source is identified and placed on the diagram. It can be simplified again with the same noise as input.

Noise: A total of 6 noises are identified: sensor and heating Johnson noises, amplifier, thermal noises from the pixel to cold bath link and from the absorber to the pixel link, and the electronics/phonons decoupling noise.

We can derive the NEP from the transfer function of those noises by dividing them by the total input transfer function.

Spectral resolution: The maximum performance that can be expected is directly derived from NEPs.

The model can then easily predict the best resolution for given parameters of our system. The thermal model gives us the expected resolution.

For the actual pixel, we can expect 14.4 eV of spectral resolution as it is not optimised.