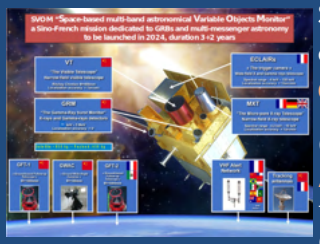
# Flux reconstruction for the NIR camera CAGIRE at the focus of the telescope Colibri

Alix NOUVEL DE LA FLÈCHE
Supervised by Jean-Luc ATTEIA & Olivier GRAVRAND

## Context

SVOM : Space based multi-band astronomical Variable Objects Monitor
Study transient high energy sources such as Gamma Ray Bursts (GRBs).

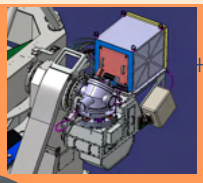


**Space:** ECLAIRs localises the prompt emission of the GRB and sends the position to Ground Follow-up Telescopes (GFTs).

**Ground:** Colibri (GFT) at Observatorio Astronomico Nacional (Mexico), points the source, looks at the afterglow of the GRB with DRAGGO (VIS) & CAGIRE (IR).

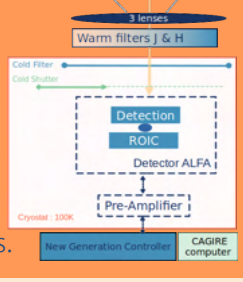
Launch : end of 2023

## CAGIRE



+ Infra-red camera : 1.1µm to 1.8µm.
+ ALFA sensor :
Astronomical Large Format Array

HgCdTe detector
2048*2048pixels
+ Up the Ramp mode :
Continuously accumulates charges while imaging.
Whole array read every 1.3s.




## Pre-Processing pipeline

### Goals :

+ Provides flux maps from ramps : first step before **astronomy analysis**
+ Corrects detector effects : **Non linearity, noise**
+ Corrects environmental effects : **Cosmic rays**
+ **Fast** enough to avoid data clogging
+ Uses **maps calibrated at CPPM** under CAGIRE conditions

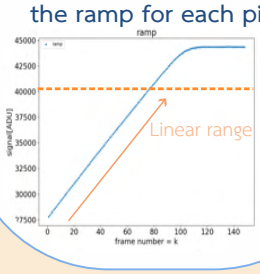
### Pipeline Diagram

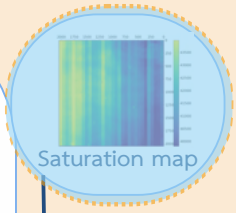
| Input parameter | Computation | Output |
|---|---|---|
| **Step 1 : Find Saturated pixels** | | |
| Last frame of raw ramp<br>Saturation level map | Find Saturated pixel<br>Compute fitting range | Map of saturated pixels<br>Map of number of frames to fit |
| **Step 2 : Subtract Master Bias and correction by reference pixels** | | |
| Raw ramp<br>Master bias map | Subtract master bias and correct all frames with reference pixels | Ramps (corrected frames) |
| **Step 3 : Construct Corrected differential ramps** | | |
| Corrected ramp | | Corrected differential ramp1 (CDR1) |
| **Step 4 : Flag cosmic rays (CR) candidates** | | |
| CDR1 | CR candidates identification | Map of CR candidates<br>CDR2 |
| **Step 5 : Flux estimation** | | |
| CDR2<br>Map of non linearity coef | Flux estimation | Flux and Variance maps |

Pre-processing step
Product from calibration phase (Maps needed for pre-processing)

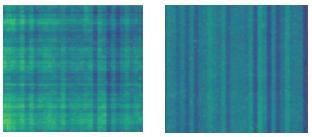
### 1 Finds saturated pixels

+ Defines a useful range of the ramp for each pixel



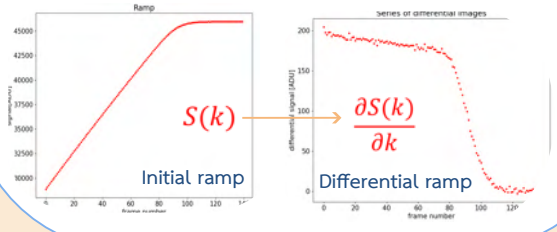




### 2 Corrects common modes noise thanks to reference pixels

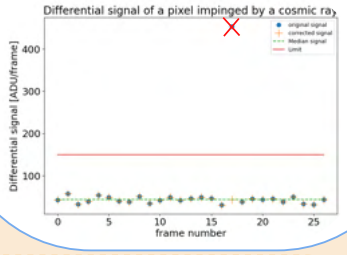


Noise before correction — Noise after correction

### 3 Constructs a differential ramp : substraction of 2 consecutiv frames




### 4 Flags cosmic rays impact and corrects the signal of impacted pixels

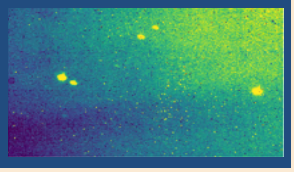



## Results and Conclusions

This software will be implemented on the telescope.

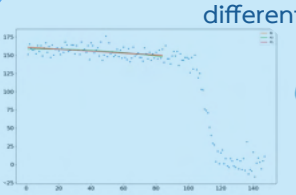
**Preprocessing pipeline:**

+ **Fast** : ~ 1/2 the acquisition time to process a ramp.
+ Suitable for the **astronomy pipeline** : fluxes computed on sky images are in line with 2MASS catalog.
+ Adapted to correct each pixel & its **non linearity**



Flux map processed with the pipeline on images acquired with RATIR, a camera similar to CAGIRE

### Computes a parameter γ of non linearity by linearly fitting differential ramps (calibrated ramps)



$$d_k = a_0 + a_1 \times k$$

$a_0$ Offset of the fit (flux)
$a_1$ Slope of the fit

$$\gamma = \frac{a_1}{a_0^2}$$

γ is independant of the flux

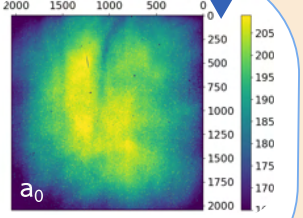
Note : different fitting functions have been compared thanks to Chi² tests.
The linear fit contains the relevant information from the differential ramps.

### 5 Estimates signal and error for each pixel

Computes $a_0$ solving:

$$d_k = a_0 + {a_0}^2 \times \gamma \times k$$

$a_0$ Signal estimator : proportionnal to the flux
$\gamma$ Parameter of non linearity
$k$ Frame number of the ramps
$d_k$ Differential ramp value at frame k




+ Corrects $a_0$ from flux non linearity thanks to a calibrated relation between incident flux and $a_0$ (CPPM)