

# Event-based image sensor designed for space applications

**Key words :** Event-based sensors, micro/nanoelectronics, semiconductor device physics, integrated CMOS devices, radiation, ionizing dose, displacement damage dose.

**Department:** Electronics, Optronics and Signal (DEOS)  
CNES department : Optoelectronics and Detection (OED)

## JOB DESCRIPTION:

A CMOS event-based image sensor, also known as an event-based camera, represents a cutting-edge imaging technology that operates differently from traditional sensors like CCDs (Charge-Coupled Devices) or conventional CMOS sensors. Rather than capturing frames at fixed intervals, an event-based sensor detects changes in a scene in real-time, pixel by pixel.

Event-based sensors are asynchronous devices inspired by the functioning of the human visual system. Each pixel operates independently and activates only when a change in light intensity surpasses a predefined threshold, generating an event that contains information such as the pixel's position, the precise timestamp, and the polarity of the light change (whether the brightness increased or decreased).

An event-based camera can detect changes in a scene without transmitting redundant data. Pixels are no longer read at constant intervals but only when they contain useful information. The main advantages of this approach include lower power consumption, reduced data transmission, an increased dynamic range, and improved temporal response due to low latency (on the order of microseconds).

In the space domain, potential applications of such sensors include space situational awareness (SSA), such as in-flight detection of orbital debris or spacecraft, autonomous satellite navigation for collision avoidance, or the landing of space vehicles on celestial bodies. Additionally, event-based sensors offer the potential to record high-frequency events with a suitably low bandwidth, making

them ideal for observing lightning at the tops of thunderstorms and sprite phenomena, as FalconNeuro, an event-based sensor on the International Space Station, depicted hereafter. This thesis will aim to analyze, design, fabricate, and test the performance of these sensors while exploring how the various pixel components, from the photodiode to the associated readout electronics, can be optimized to improve sensor performance for integration into future space vehicles.

Specifically, the research will investigate architectures that can mitigate the effects of the space environment, such as radiation. Other key areas for improvement, relevant to space applications, may include enhancing pixel sensitivity to minimal light variations while avoiding false triggers due to background noise, reducing noise to prevent false detections, and improving readout circuits in terms of energy consumption and detection speed—essential for applications like space debris detection or the observation of fast astronomical phenomena.

#### WORK PLAN:

The candidate will need to:

- Conduct a comprehensive review of the current state-of-the-art research and technology, focusing on:
  - o Different types of event-based sensors;
  - o Understanding CMOS technology and its use in image sensors;
  - o The components of event-based sensor pixels, from the photodiode to the integrated readout electronics;
  - o The main architectures used for event-based pixels;
  - o Key performance parameters of event-based sensors, such as sensitivity, background rate, latency, and dynamic range;
  - o Characterization of these performance parameters;
  - o Space applications using event-based sensors, such as space situational awareness (SSA);
  - o The effects of radiation on semiconductors.
- Analyze, model, and simulate the sensors, particularly using Technology ComputerAided Design (TCAD) to design and test representative test structures;

- Identify and develop techniques to mitigate parasitic effects;
- Design and fabricate test structures in CMOS technology;
- Perform electro-optical characterizations of these structures;
- Irradiate the structures with particles and flux representative of space and nuclear environments;
- Measure the performance degradation caused by radiation and analyze the effect of various test structure parameters on the extent of degradation;
- Synthesize the research findings and propose guidelines for designing event-based sensors optimized for space applications, particularly in terms of radiation resistance and other challenges related to space surveillance, navigation, and similar applications.

#### REQUIRED PROFILE:

The candidate must be in the final year of a master and/or engineer diploma (or equivalent) specialized in at least one of the following topic : nano/microelectronics (conception, fabrication process) / optoelectronics / electronic imagery, detectors, semiconductor device physics / solid physics / analog and digital signal.

#### LOCATION:

ISAE-SUPAERO Toulouse  
Pyxalis – Moirans

#### DURATION:

3 years

#### START DATE :

September 2025

### RESPONSIBLE OF THE SUBJECT:

Aymeric Panglosse (CNES) - [aymeric.panglosse@cnes.fr](mailto:aymeric.panglosse@cnes.fr)

Cédric Virmontois (CNES),

Vincent Goiffon (ISAE-SUPAERO) - [vincent.goiffon@isae-supero.fr](mailto:vincent.goiffon@isae-supero.fr)

Julien Michelot (Pyxalis) - [julien.michelot@pyxalis.com](mailto:julien.michelot@pyxalis.com)

### APPLICATION PROCESS:

All applications should be send by 14/03/2025 at the last.