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The Institute  
of Photonic  
Sciences



## **Master in Photonics – “PHOTONICS BCN” Master ERASMUS+ “EuroPhotonics”**

### **MASTER THESIS PROPOSAL**

**Dates: April 2020 - September 2021**

**Laboratory:** Institute of Cosmos Sciences of the University of Barcelona (ICCUB)

**Institution:** Universitat de Barcelona

**City, Country:** Barcelona, Spain

**Title of the master thesis:** Single photon detectors for optical quantum information applications: modelization and characterization

**Name of the master thesis supervisor and co-supervisor:** Sergio Gómez, David Gascon, Bruno Julia Diaz

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**Keywords:** single photon sensors, SPAD, SiPM, PMT, ASIC, jitter

### **Summary of the subject (maximum 1 page):**

The past decade has seen a dramatic increase in interest in new single-photon detector technologies. A major cause of this trend has undoubtedly been the push towards optical quantum information applications such as quantum key distribution. These new applications place extreme demands on detector performance that go beyond the capabilities of established single-photon detectors. There has been considerable effort to improve conventional photon-counting detectors and to transform new device concepts into workable technologies for optical quantum information applications<sup>1</sup>. Semiconductor-based detectors such as single-photon avalanche diodes have attained a high level of maturity and are widely used in laboratory quantum optics and quantum information experiments. Photodetection efficiency, dark count rate and timing jitter are the most important parameters to define the figure of merit for a single photon detector for quantum information applications and depend on the sensor and readout electronics specifications. The main goal of this master thesis is to study the characterize and model SiPM/SPAD solid state single photon sensors for quantum information applications.

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<sup>1</sup> R. H. Hadfield. Single-photon detectors for optical quantum information applications. Nature Photonics, 3:696–705, 2009.

This will be done in the laboratory of the technology unit of the Institute of Cosmos Sciences of the University of Barcelona (ICCUB)<sup>2</sup>. The ICCUB is an interdisciplinary center devoted to fundamental research in the fields of cosmology, astrophysics, particle physics and quantum physics. In addition, the institute has a strong technology program through its participation in international collaborations in observational astronomy and experimental particle physics as the LHCb experiment at CERN. In this context the unit has been developing single photon instrumentation for more than 20 years.

The specific goals of this thesis are:

- Sensor modeling, including random and correlated noise sources using GATE<sup>3</sup>.
- Experimental validation of the model.
- Characterization of the detectors using a dedicated ASIC<sup>4</sup> developed by the ICCUB and CERN.
- Evaluation of the detector (sensor and electronics) in a quantum information experiment.

**Additional information (if needed):**

\* Required skills: Working with laboratory instrumentation and programming.

\* Miscellaneous:

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<sup>2</sup> <http://icc.ub.edu/technology/unit>

<sup>3</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3267383/>

<sup>4</sup> <https://ep-news.web.cern.ch/node/3172>