# IGOSat Educational CubeSat for measuring Gamma-ray and TEC in the Ionosphere

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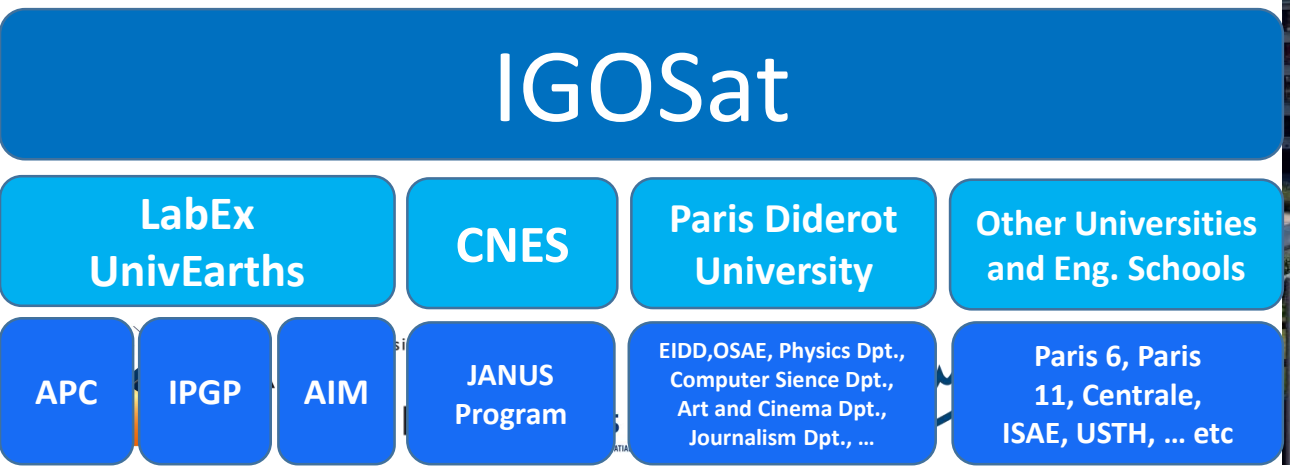
# General Introduction: University context



- **IGOSat**: **I**nospheric and **G**amma-ray **O**bservation **Sat**ellite
  - 3U CubeSat (LEO, 600Km<Altitude<700Km)
  - University Paris Diderot (Paris VII)
  - A joint project in Earth Sciences and Astrophysics within the framework **of LabEx UnivEarths** (Laboratoires d'Exellences), a **clustering** of 3 main laboratories: **AIM** (***A**strophysics, **I**nstrumentation, **M**odelling*), **IPGP** (*Institut de **P**hysique du **G**lobe de **P**aris*) and **APC** (*AstroParticule and Cosmology*)
  - Supported by CNES (Centre Nationale d'Etudes Spatiales), part of Janus Program

# General Introduction: University context

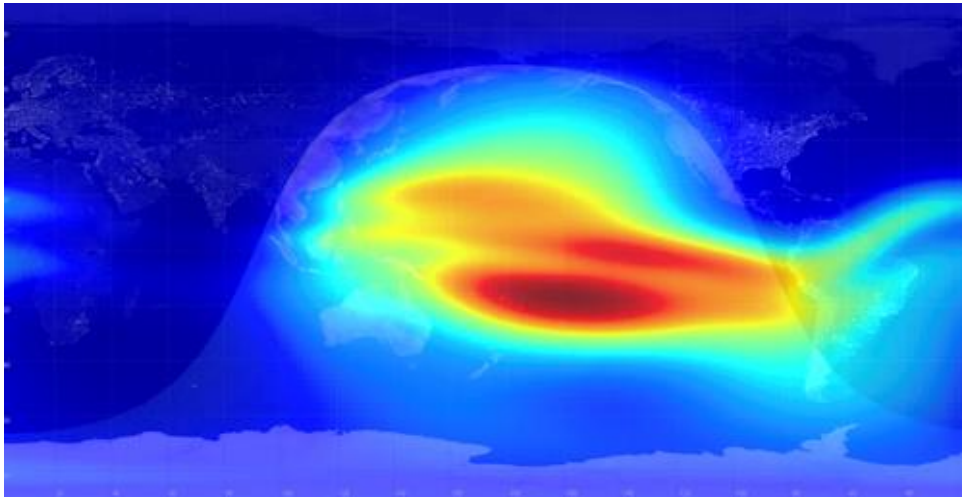


- Creation of a Student Space Campus in Paris Diderot in 2014
- An educational project
- Work package Leader: **Hubert Halloin**

- **IGOSat Project Managers:**
  - **Natacha Combier**
    2013 – 2014
  - **Marco Agnan**
    2014 – 2016
  - **Hana BENHIZIA**
    *since* October 2016

# IGOSat Project: Scientific Objectives

1. **Measuring the Total Electron Content (TEC) in the Ionosphere:**
   - TEC measurement densification, creation of a data base at IPGP
     - Using top-down Radio-Occultation Method
   - Ionosphere response analysis depending on the solar activity
   - Detection of gravity waves in case of major volcanic or geology phenomenon.



**IRI 2007 (modèle empirique ionosphérique)**

- **Payload:**
  - Dual-frequency GPS
    - GPS NovAtel OEM615 (CubeSat format by Pumkin)
    - Tallysman AntennaTW3870E

➢ **Principal Investigator**:

**Pierdavide Coisson**,
IPGP, *coisson@ipgp.fr*

# IGOSat Project: Scientific Objectives



2. **Measuring the Gamma rays spectrum ( between 20keV and 2MeV) and electrons (1MeV – 20MeV) in auroral zones and South Atlantic Anomaly (SAA)**
   - Electrons measurements densification, update gamma measurements (little bit of data around the MeV) in the auroral zones and SAA.
   - Distinguish the photons from the detector internal activation, terrestrial albedo and radiations belt to predict the satellite background noise in LEO.
   - Time evolution (spectrum/flux) and ionosphere-magnetosphere coupling (e.g. linked to solar wind)

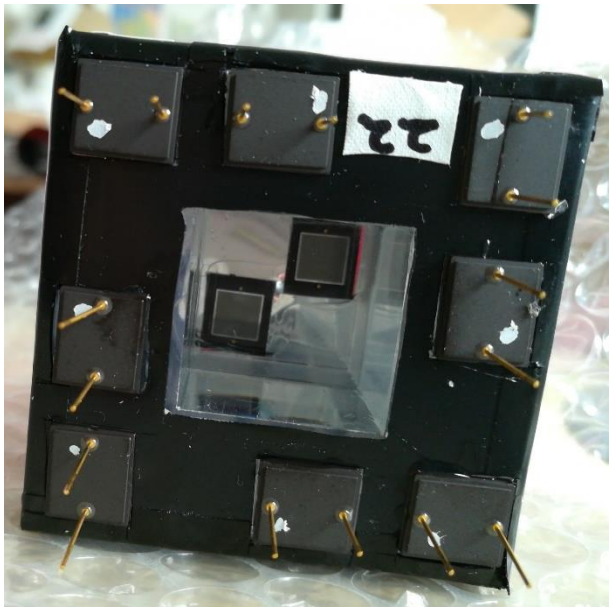
**Principal Investigator**:
**Philippe Laurent**, CEA,
*philippe.laurent@cea.fr*

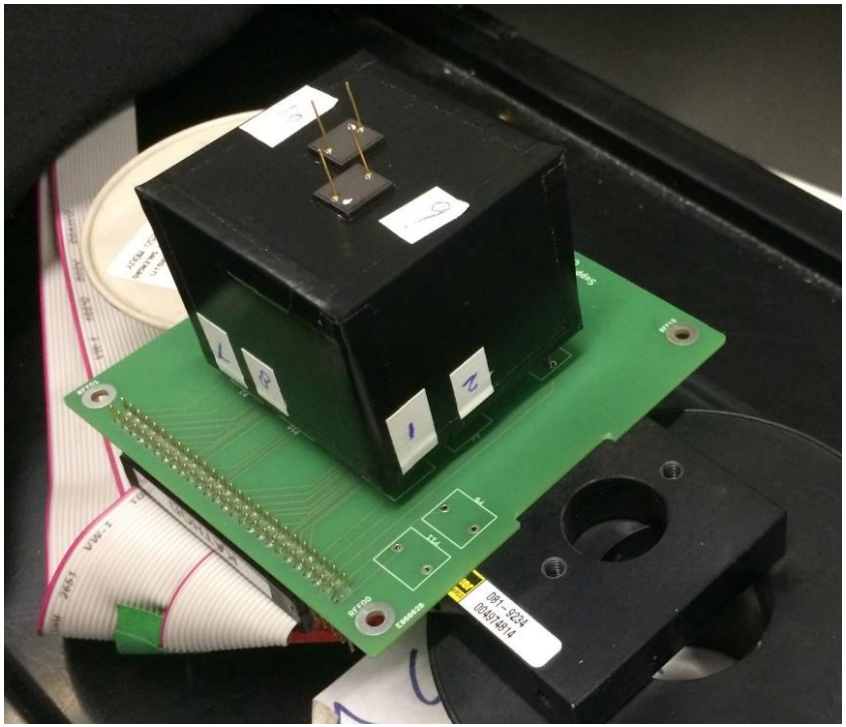
- **Payload:**
  - Organic and Inorganic Scintillator
    - Home Made
    - PhD student, Hien Phan

# Scintillator Payload

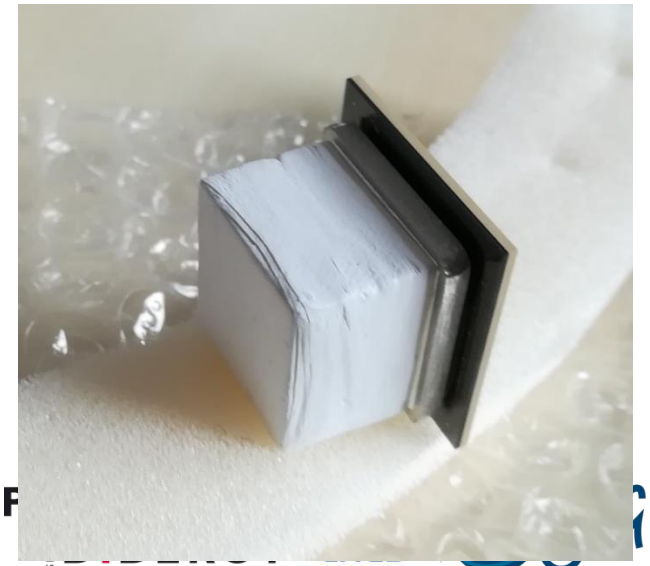


Plastic
EJ200





Crystal
CeBr3

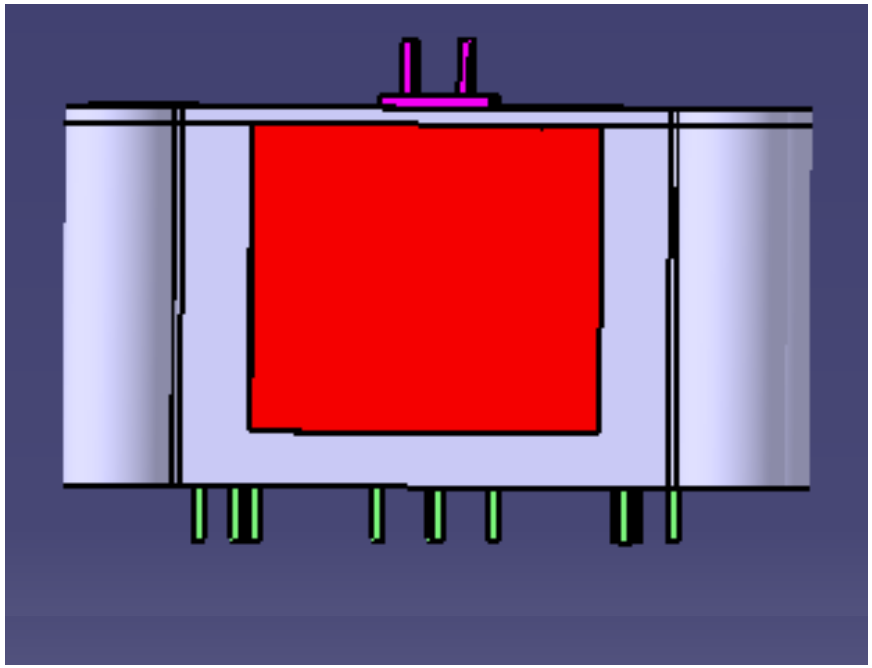


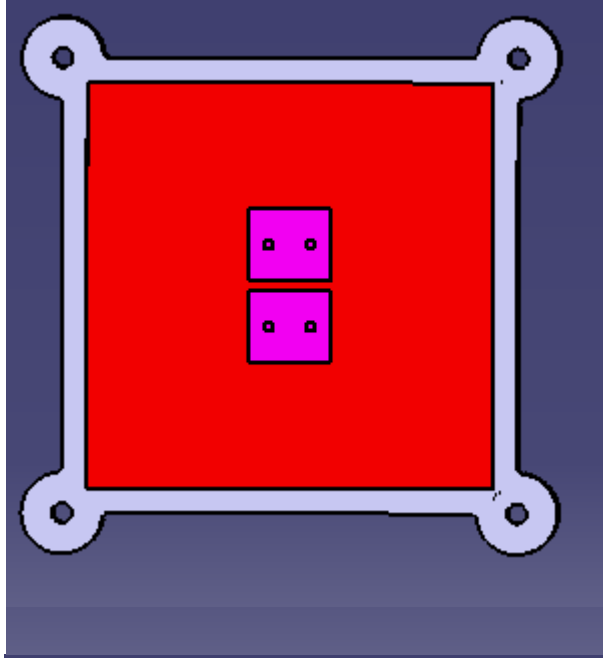
# SCI Payload: Cage

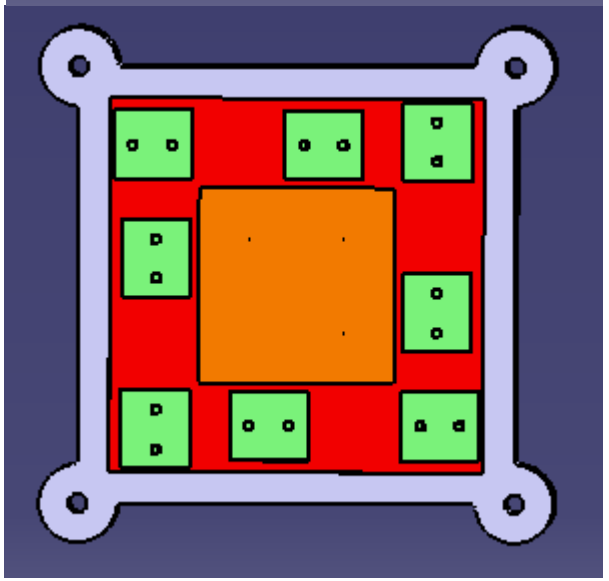
**Made by Aluminium with the thickness of 2 mm, covering the edges of scintillator and leave windows at the sides for the incomming particle.**

**This cage is aimed to keep the scintillator stable during the launch.**

**There are 4 screws at 4 corners of the scintillator that is sticked to the support board and the shield.**



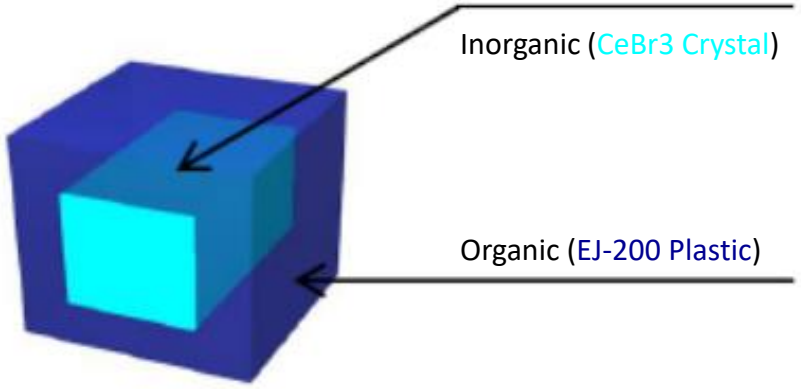


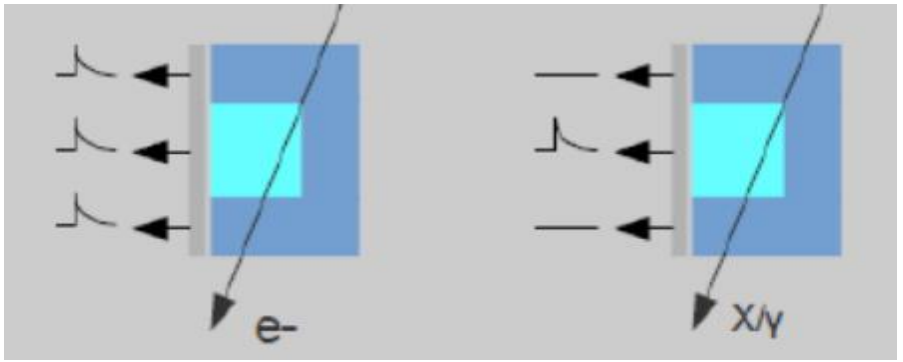


# The Scintillator Payload

The gamma-rays and electrons interact with matters inside the scintillators and then emit the luminosity photon which will be captured by the MPPC.

- When a high energy particle pass or is absorbed by a scintillator, it loses its energy and produces fluorescence. The longer the path is, the more fluorescence photons are produced.
- The Crystal part can detect gamma rays from 20 keV to 2 MeV while the Plastic scintillator can discover electrons from 1 MeV to 20 MeV.
- Since the CeBr3 can detect both gamma rays and electrons whereas the plastic scintillator can detect solely electron particles, the combination of two scintillator types is needed in order to discriminate these two kinds of particles.



# IGOSat Project: Design Development

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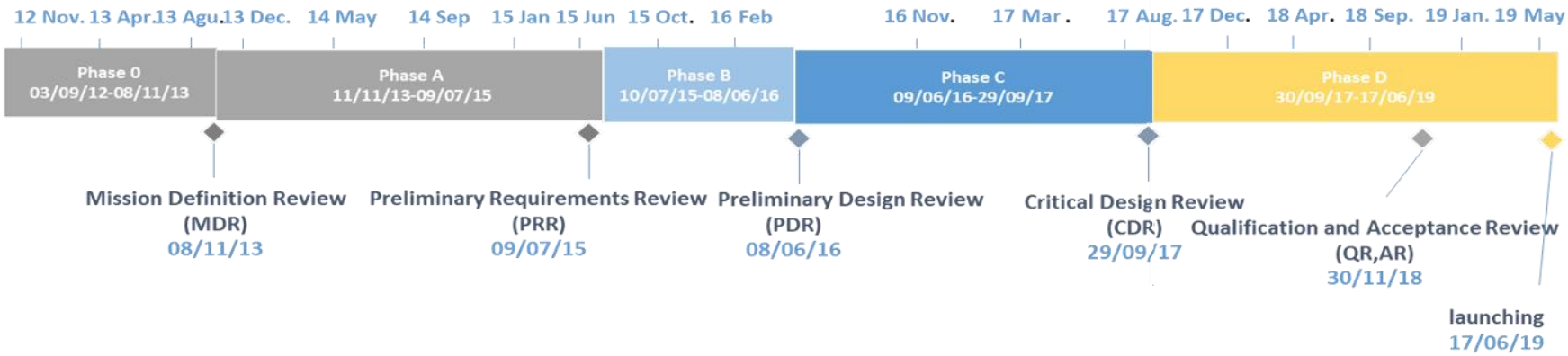
- **Space Project Management Phases: Recall**
  - Phase 0: Mission Analysis
  - Phase A: Feasibility
  - Phase B: Preliminary Definition
  - **Phase C:** Detailed Definition
  - Phase D: **Qualification and Production**
  - Phase E: Operations / Utilization
  - Phase F: Disposal

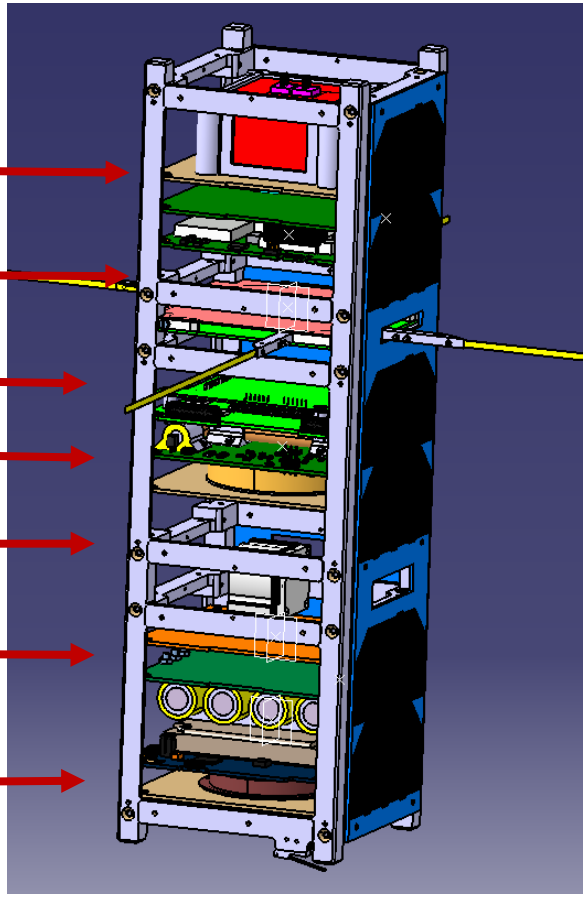
➢ **IGOSat currently in Phase D (one year delay)**




➢ **Objective**: To be ready for a launch end of 2020

# IGOSat Project: Design Development






- **Philosophy:** In- House Subsystems, as much as possible

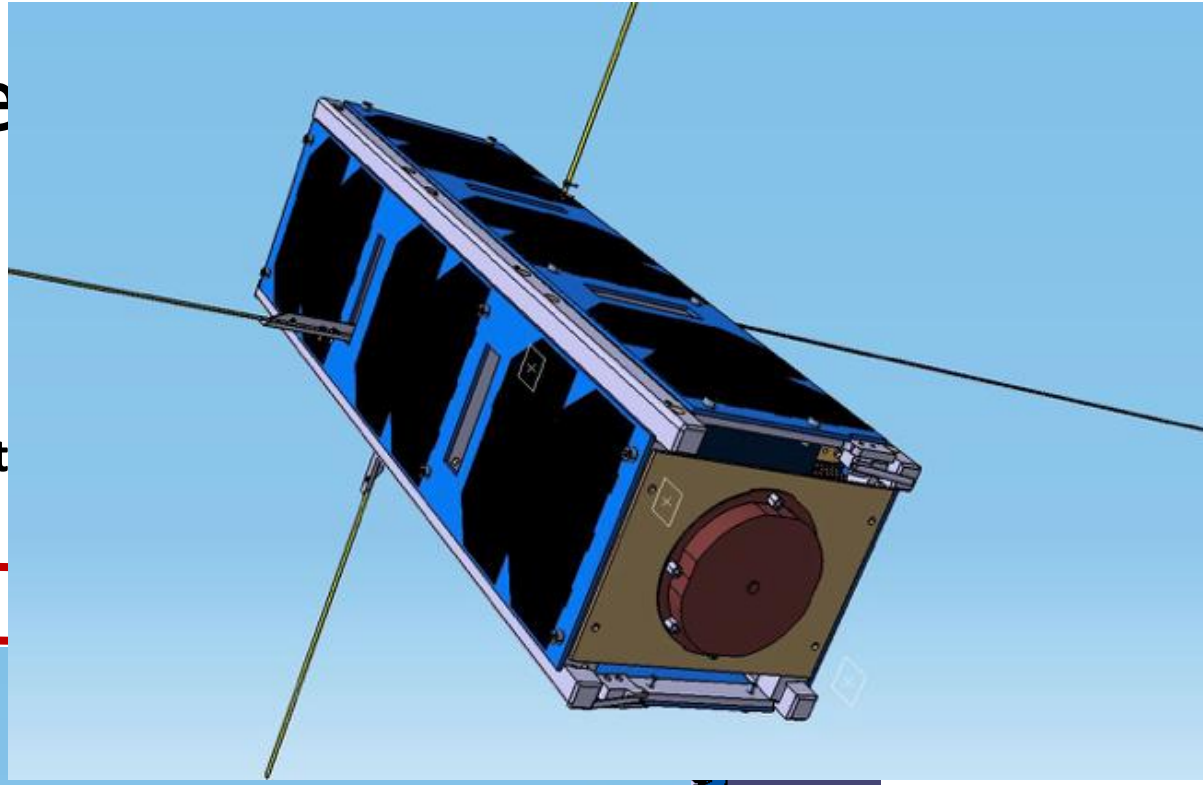
# IGOSat Project: De

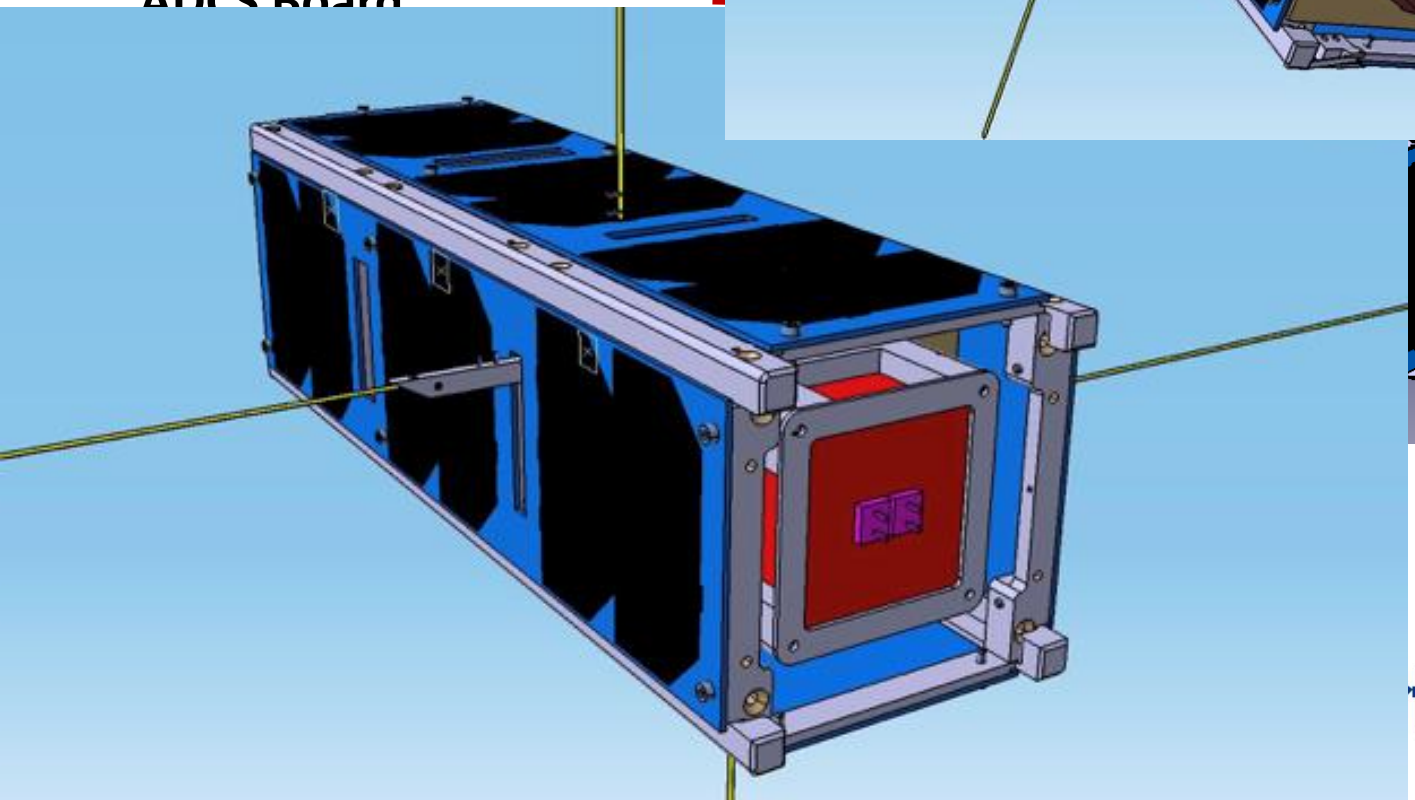
**Scintillator Payload**

**Telecommunication sub-syst**

**OBC**

**ADCS Board**





# IGOSat Project: Design Development



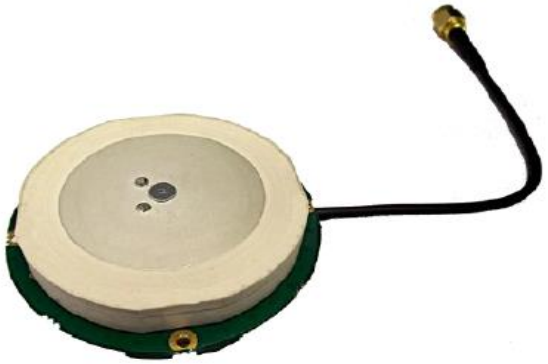
- In-house subsystems:
  - Scintillator Payload
  - Electrical Power system (Solar Panels, Power Supply Board, Battery Board)
  - ADCS Board with home-made aircoil
  - Mechanical Structure

# IGOSat Project: Design Development



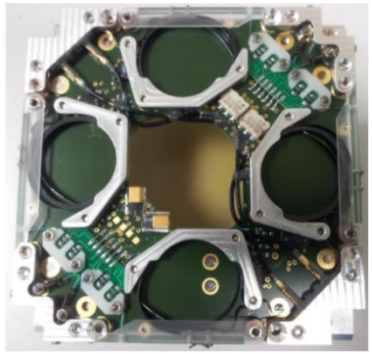
- Purchased subsystems:
  - GPS Payload ( Receiver from Pumpkin, Antenna from Tallysman)


www.cubesatkit.com/docs/.../DS_CSK_GPSRM_1



www.tallysman.com/wp-content/.../TW3870E_Datasheet_rev1

  - Telecommunication Antenna, Receiver Board (TRXVU) and OBC

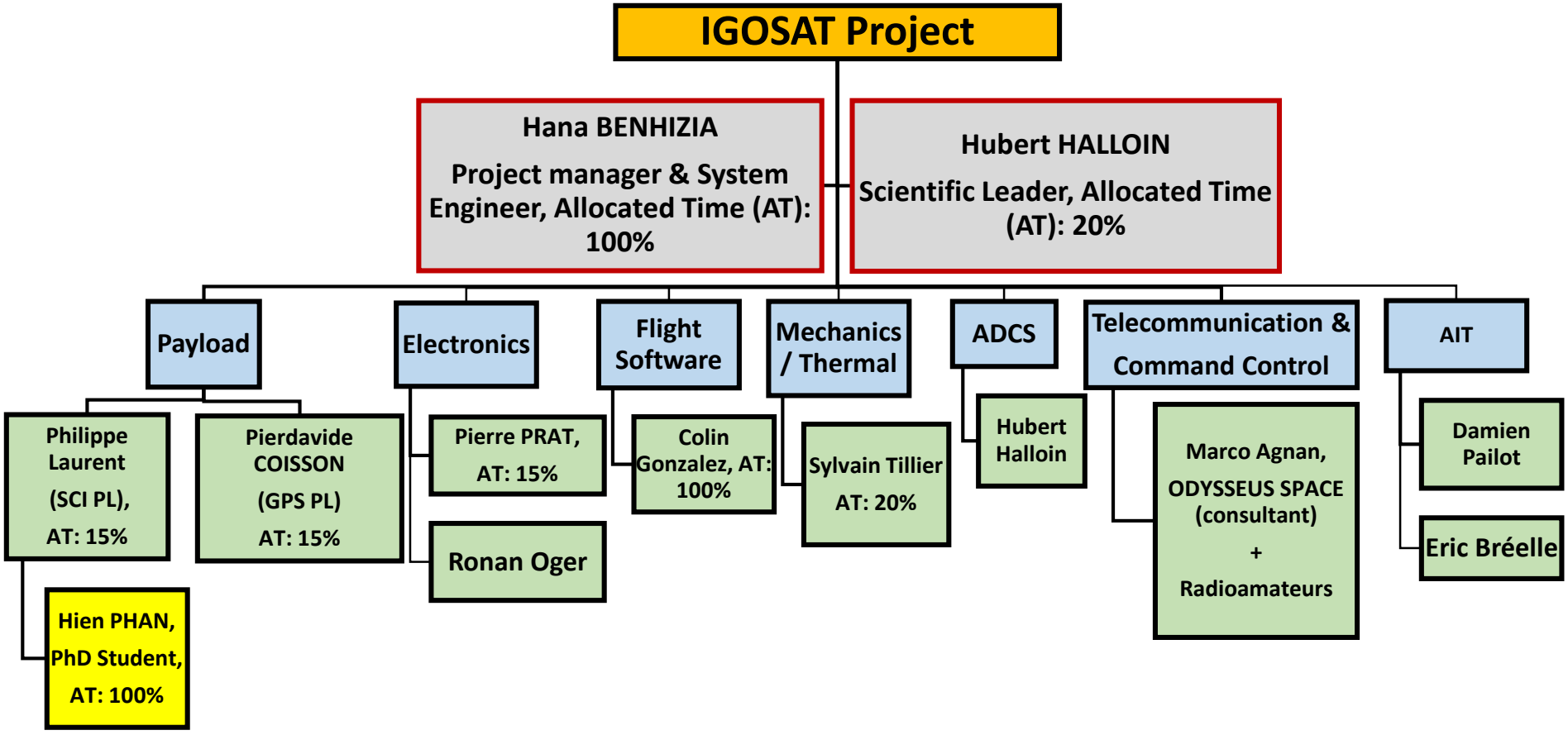


  - Ferrit coils for magnetorquers and RW

# IGOSat Human Resources and Means

# Human Resources: IGOSat Experts



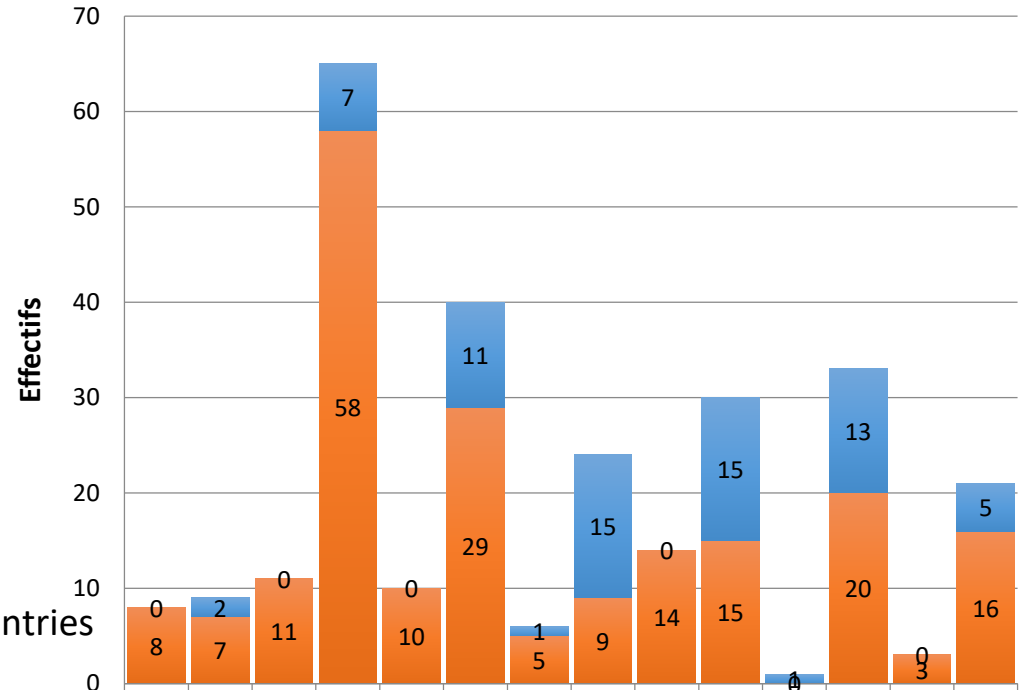


# Human Resources: Students



- Since September, 2012, more than 270 students have worked on a project related to IGOSat
- Initial training included in the project:
  - Engineering Schools
  - Universities (Physics, Electronics, Instrumentation, computer sciences, Mechanics, etc.)
  - Journalism & literature department
  - Arts and Cinema Department
- Internships (70):
  - From 1 to 6 months
  - Bachelor degrees to Master degrees, Engineering programs, etc.
  - Interns from different nationalities and countries
- Theses :
  - PhD Student, SCI PL
  - PhD Student, (3 months/year) for the development of ADCS test device

**Répartition des étudiants en stage ou projet**

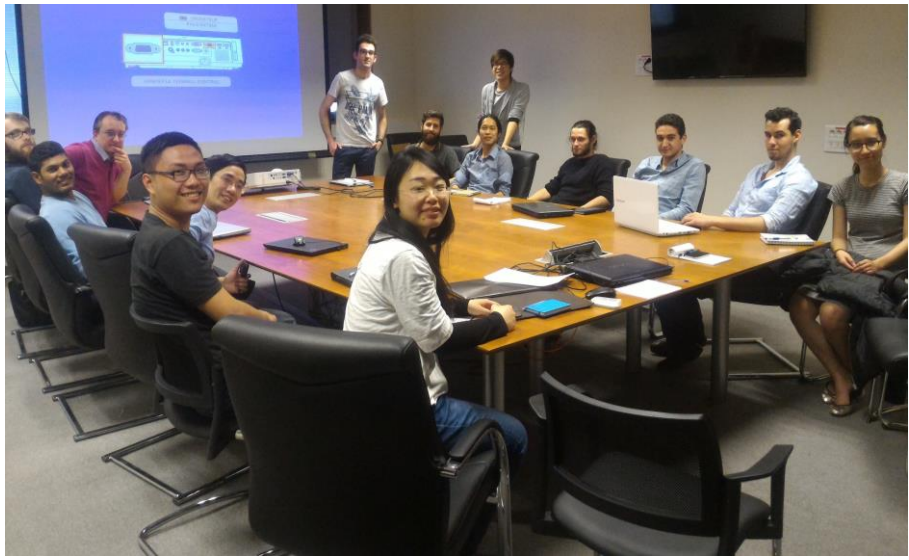



| | 2012 - 2013 S1 | 2012 - 2013 S2 | 2013 - 2014 S1 | 2013 - 2014 S2 | 2014 - 2015 S1 | 2014 - 2015 S2 | 2015 - 2016 S1 | 2015 - 2016 S2 | 2016 - 2017 S1 | 2016 - 2017 S2 | 2017 - 2018 S1 | 2017 - 2018 S2 | 2018 - 2019 S1 | 2018 - 2019 S2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stage | 0 | 2 | 0 | 7 | 0 | 11 | 1 | 15 | 0 | 15 | 1 | 13 | 0 | 5 |
| Projet | 8 | 7 | 11 | 58 | 10 | 29 | 5 | 9 | 14 | 15 | 0 | 20 | 3 | 16 |

# IGOSat Project: Means



- Room + dedicated office (IPGP building)
  - Ground stations
  - TM/TC @Paris Diderot (Antenna on the Lamarck building)
  - TM @USTH (Hanoï)
- Communication antenna installed on the roof of the building
  - IPGP Clean Room
- Means available in the lab
  - Cleanroom
  - Vacuum chamber
  - 3D printer (since July 2015)
  - Laboratory equipment (optics, etc.)
  - Magnetic characterization equipements (Chambon-la-Forêt)
- Computer licenses via l'IN2P3 :
  - CATIA, ANSYS, Labview, Matlab, Mathematica, etc.



# Ground Station equipment

- Coder / Decoder external TNCs (Kamtronix) or TNC software
- Radio Kenwood TS2000
- Yagi Antennas
- Universal rotator controller for the antennas
- Software: HRD for satellite tracking

# Partners



- Institutional
  - UnivEarthS, CNES, Paris Diderot …
  - Campus Spatial Paris Diderot
  - University of science and technology of Hanoï
  - Vietnam National Satellite Center
  - Vietnamese German University (VGU)
  - Latmos
- (Semi)Private
  - Omega Micro
  - Airbus D&S (Systema/Thermica)
  - Université Versailles-St Quentin (PIT)
  - Odysseus Space

# Educational CubeSat Management Constraints



- High students turnover
- University Environment
  - Internship duration: 6 months maximum, anytime between February and September
  - Research projects: ½ day per week dedicated to the project
- Students lack of experience
- Short time allocated on the project to university experts
- Dealing with the University administration
  - Administration staff often overbooked
  - Internship agreements management
- Managing documentations
- Funding

# Thank you




Réponds à l'appel de l'espace !
Rejoins le projet iGOSAT et participe à la conception d'un satellite étudiant !
http://www.igosat.fr
igosat@univearths.fr
UnivEarthS
cnes


DON'T JUST STAND THERE
Rejoins le projet iGOSAT et participe à la conception d'un satellite étudiant !
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