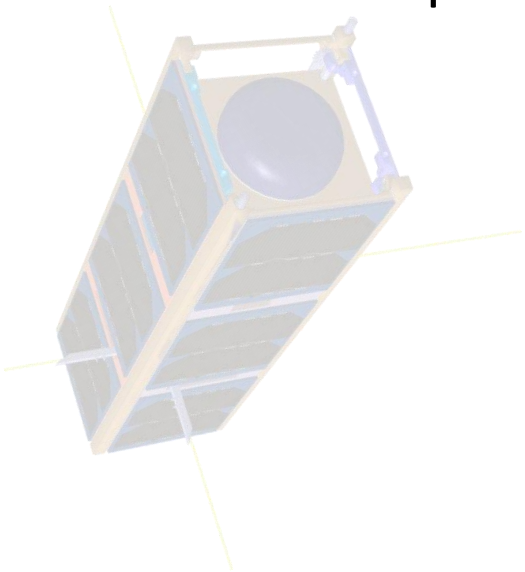
PROJECT IGOSAT
June 10th 2016

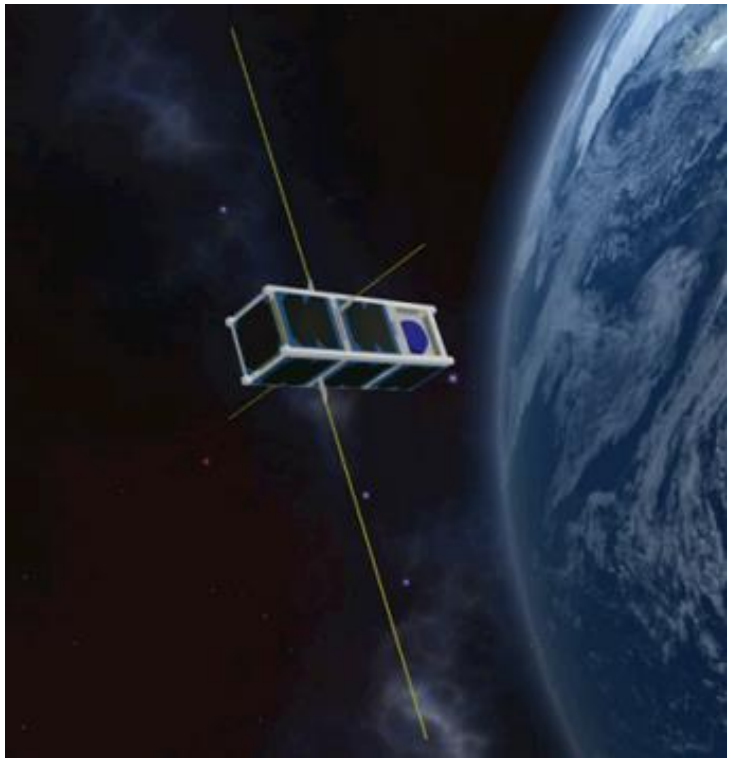
- Ionospheric & Gamma-Ray Observation SATellite



- Hillton Tang

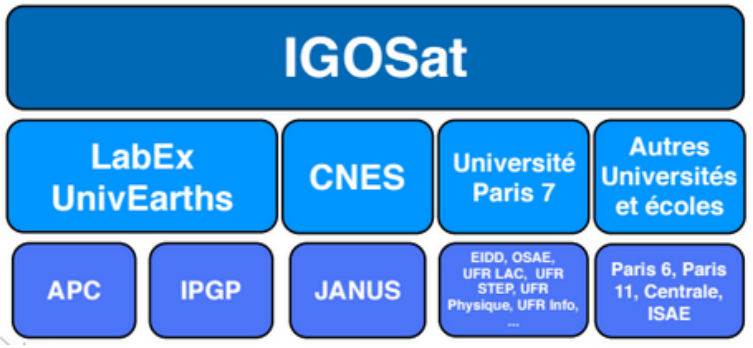
SUMMARY

I. The project IGOSAT
II. Scientific requirements
III. Mission profile
IV. Payload (GPS and Scintillator)

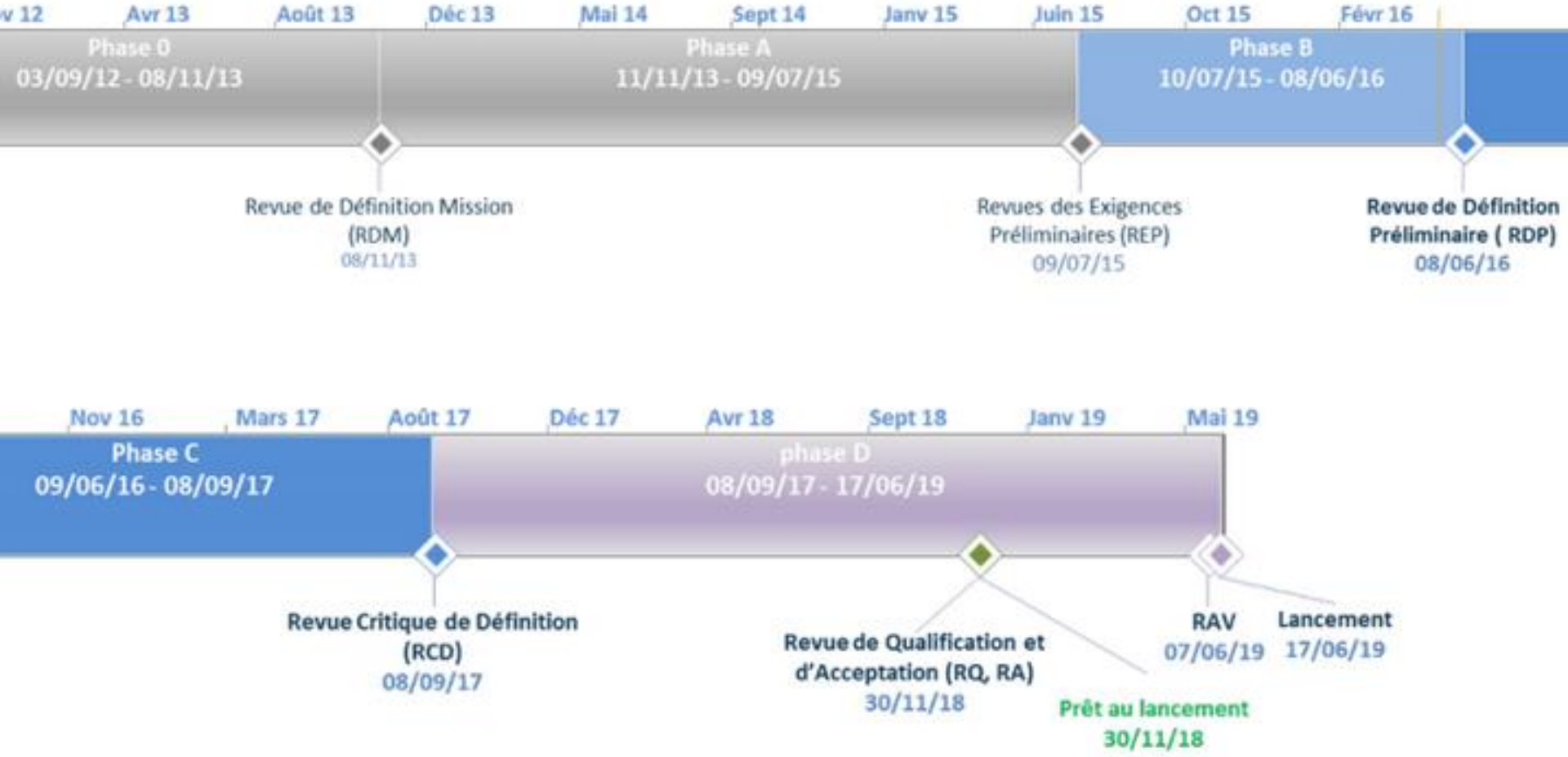


IGOSAT: context

- From the LabEx (Laboratoire d'excellence) UnivEarthS
- Join project from University Paris Diderot laboratories : APC (AstroParticule et Cosmologie) and IPGP (Institut de Physique du Globe de Paris)
- Support from the CNES
- Project manager : Marco Agnan
- Project scientist :
  - Hubert Halloin (system)
  - Pierdavide Coïsson (GPS)
  - Philippe Laurent (SCI)
- Aim: conception and ready-to-launch satellite by the end of 2018



IGOSAT: context



IGOSAT: context

- Since September 2012, more than 170 students have worked on project and internship related to IGOSAT
- Projects from :

  - EIDD (Ecole d'Ingénieurs Denis Diderot)

  - Master OSAE (Outils et système de l'Astronomie et de l'Espace), Planetology, Computer Science

  - UFR de Physique

  - UFR Lettres, Art et Cinéma

- Internship :

  - 1-6 month

  - L3 to M2, Ph.D, engineering schools, ….

IGOSAT: scientific requirements

- 2 payloads:

  - GPS

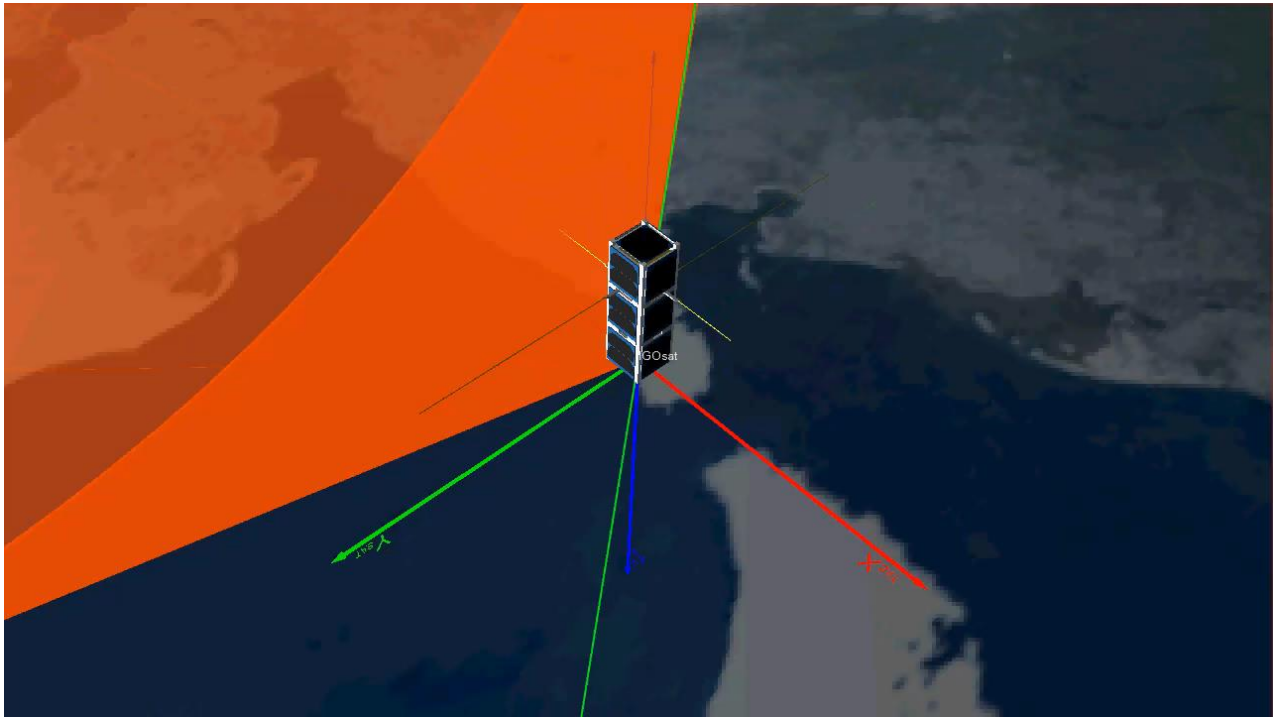
  - Scintillator

- GPS: the aim is to study the TEC (Total Electron Content) of the ionosphere.
- SCI: the aim is to measure the energy spectrum of electron and gamma rays in the SAA (South Atlantic Anomaly) as well as in the aurora zones.

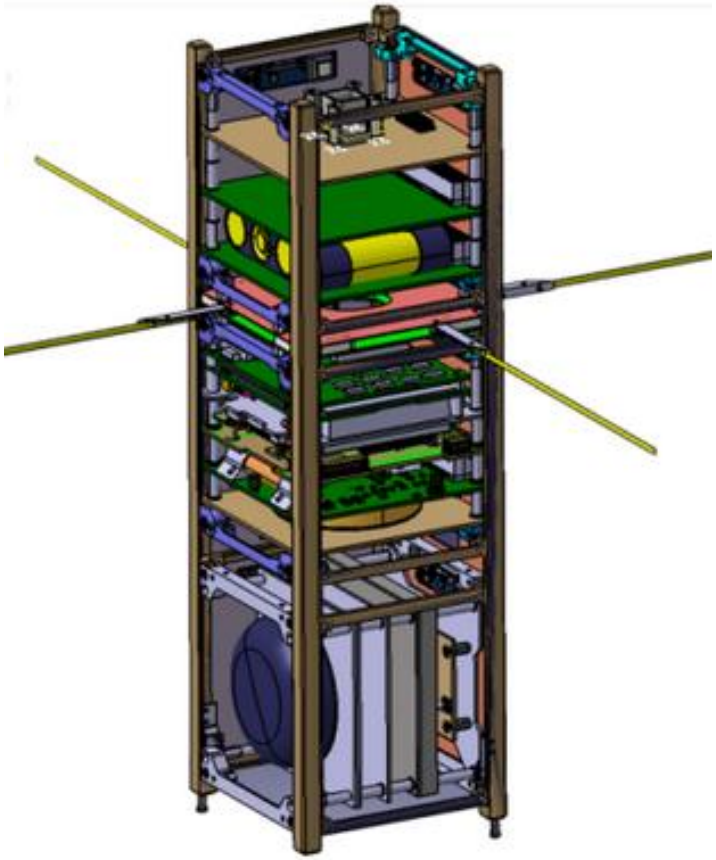
IGOSAT: mission profile

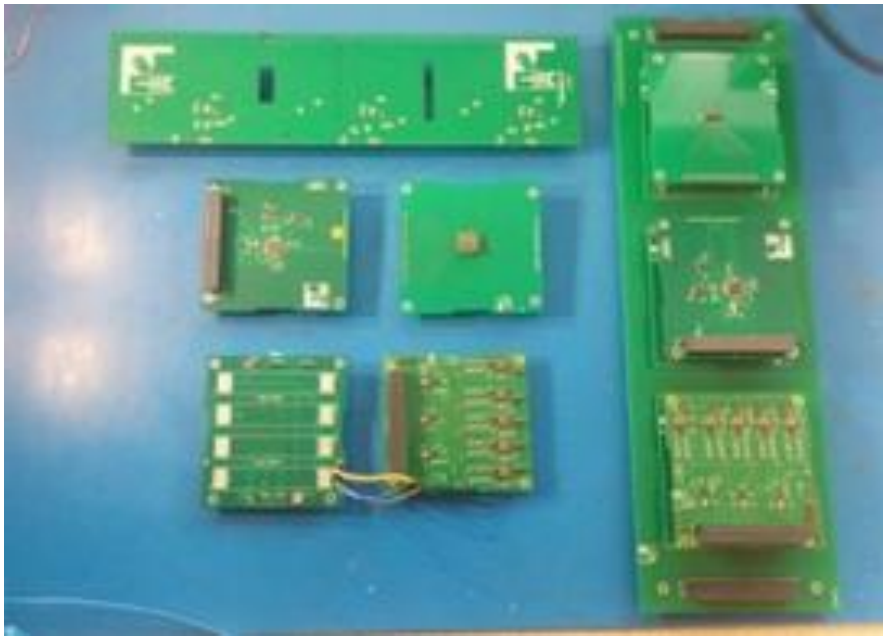
- Ideal orbit:

- altitude: around 650km
- sun synchronous polar orbit

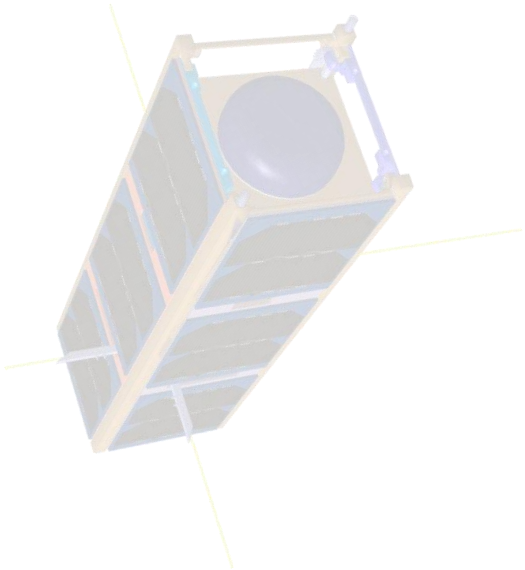


IGOSAT: configuration





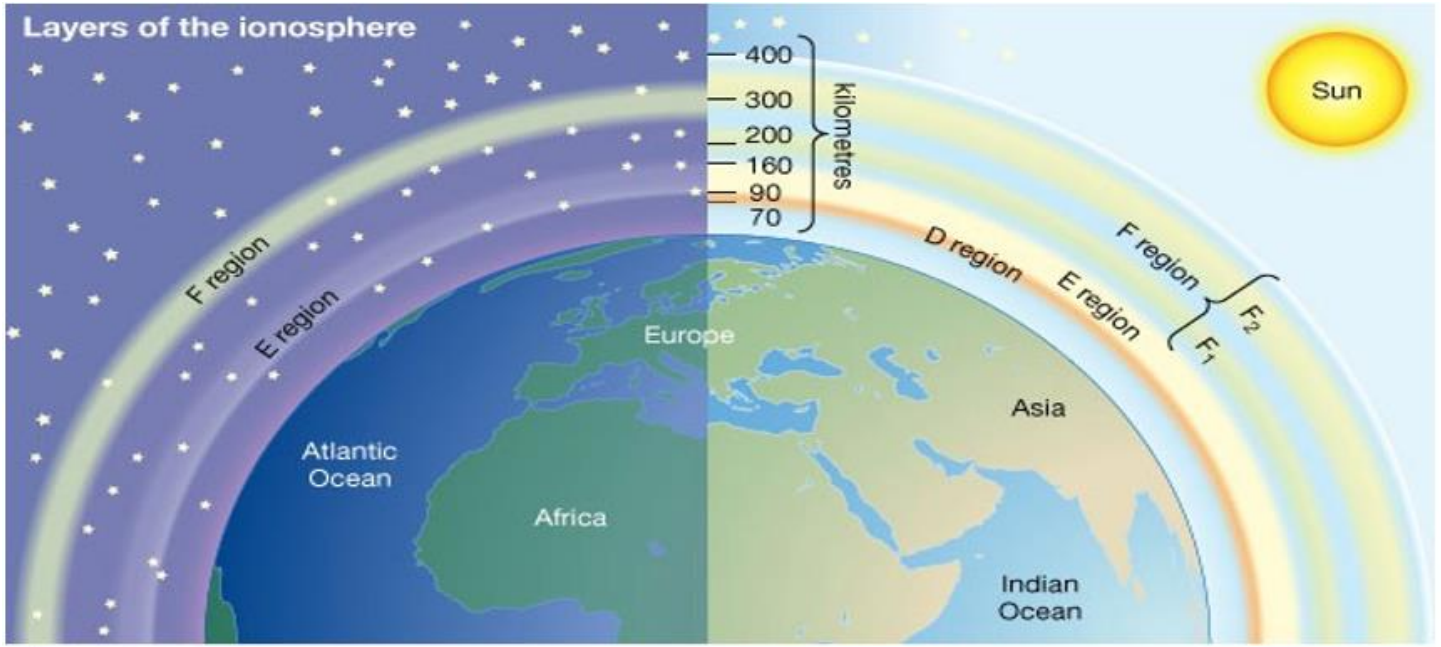
GPS PAYLOAD



- Ionospheric occultations

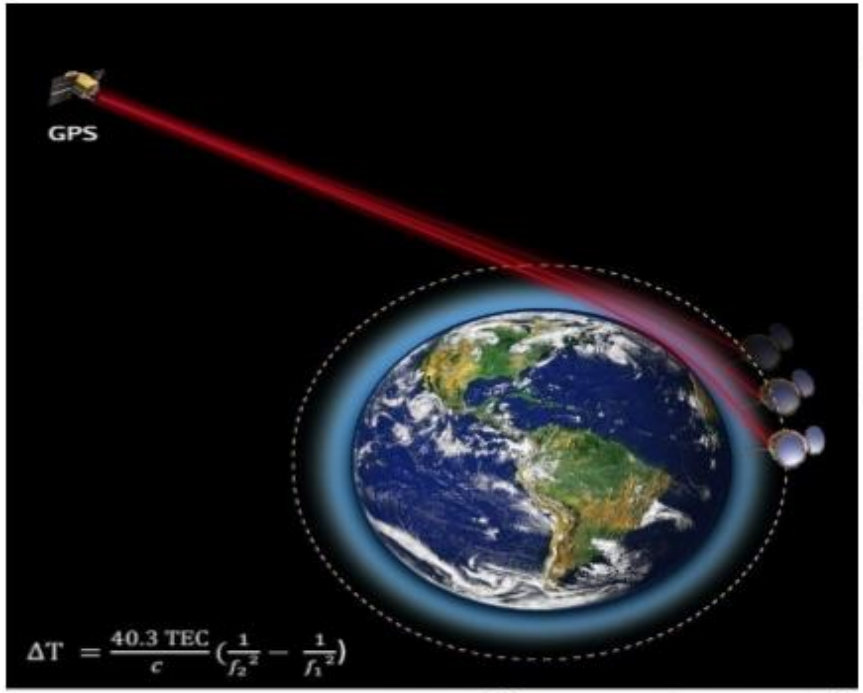
- Antoine Boizard

Object of interest: the ionosphere

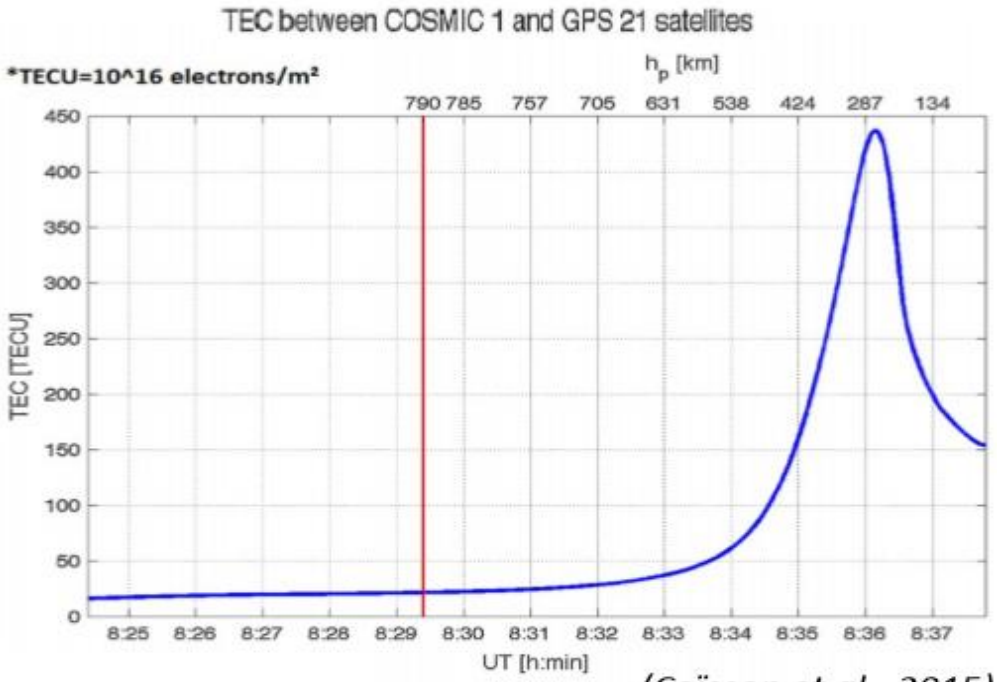


- Presence of ion-electron couples due to solar radiation
- Free electrons affect the propagation of radio waves: slowdonw etc…
- The ionosphere is a dispersive medium for those waves, the group delay induced depends on their frequency

Measurement principle

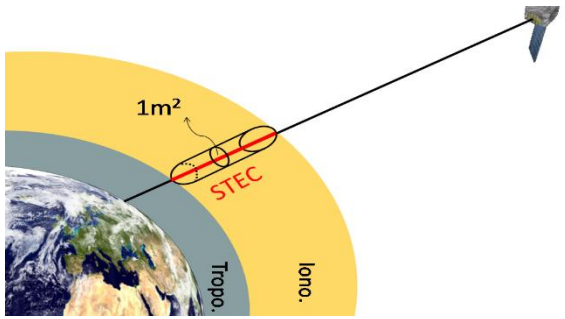


http://www.cosmic.ucar.edu/



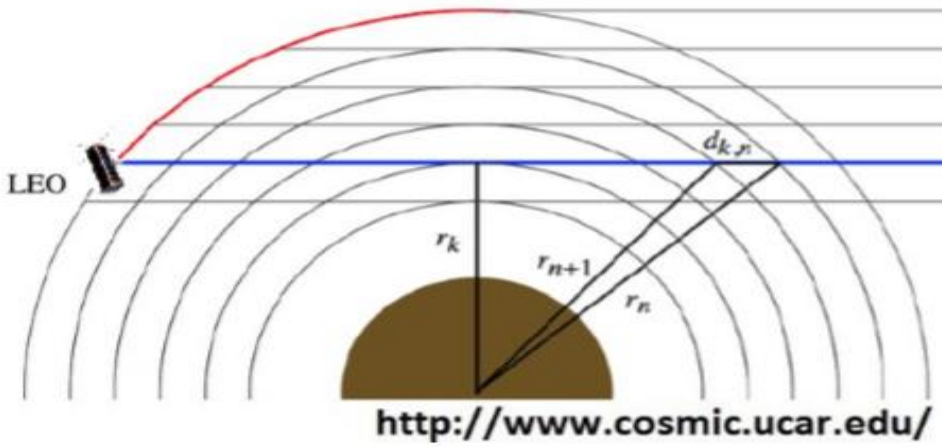
(Coïsson et al., 2015)

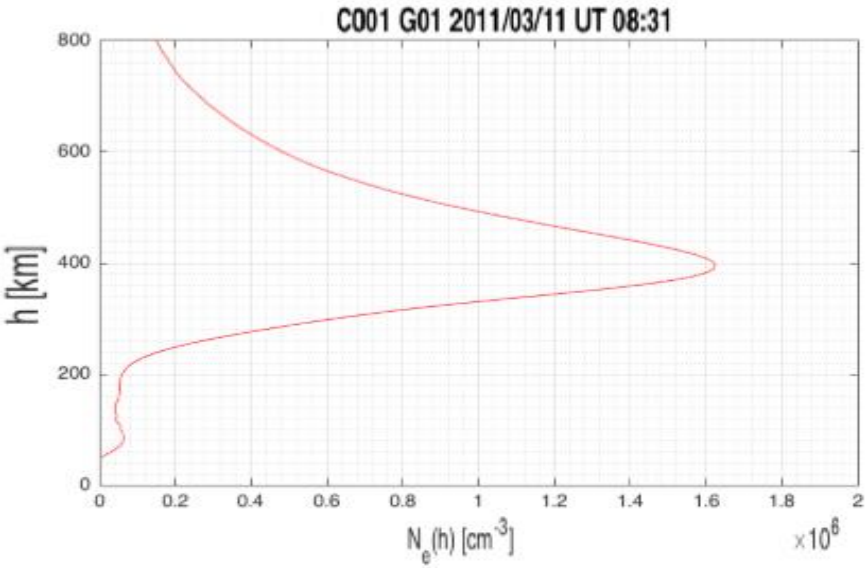
- Measuring the Slant Total Electron Content (STEC)
- Average occultation time: 5 min
- <u>Needs :</u> dual-frequency receiver, opposite to the velocity vector, sampling at 1Hz



(Royal Observatory of Belgium)

Inversion algorithm

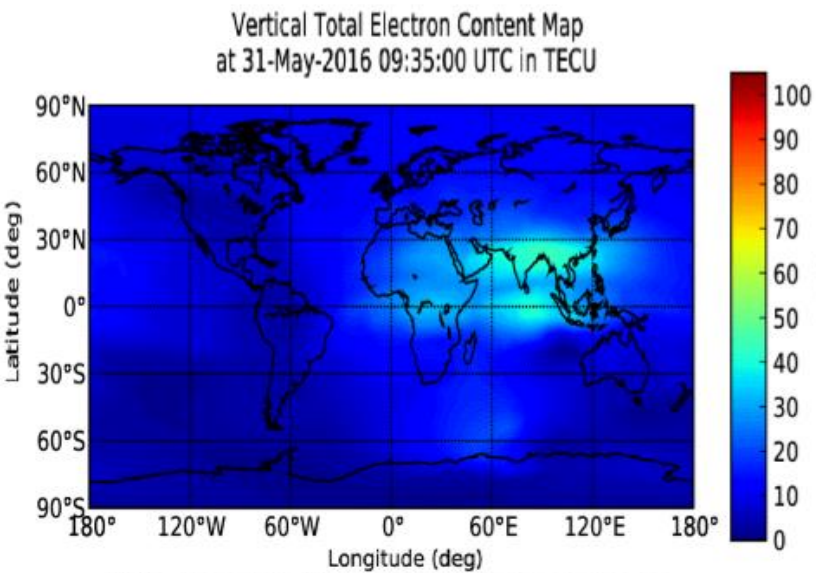




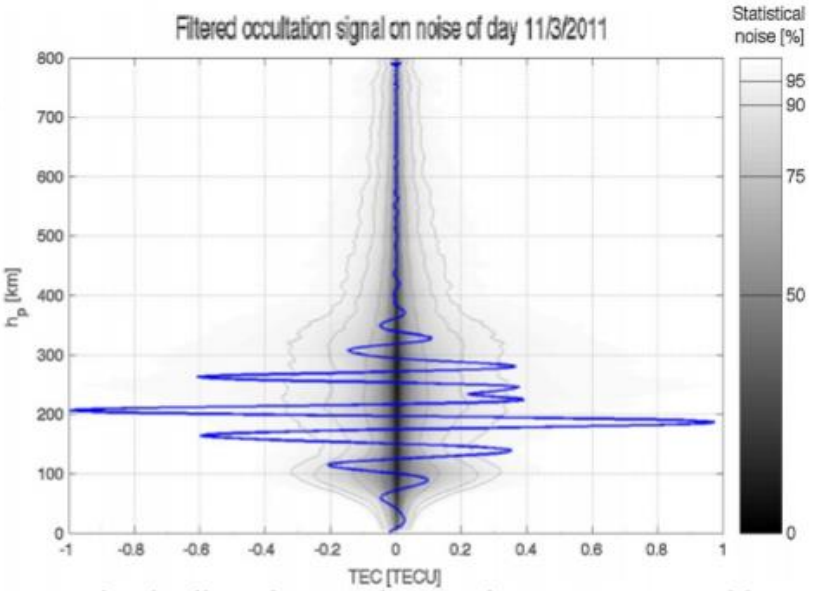
(Pierdavide Coïsson)

- Aim: obtain electron density profil from STEC
- Hypothesis :
  - Spherical symmetry
  - Homogeneous layers
- Done on ground during post processing

Scientific objectives



(http://iono.jpl.nasa.gov/latest_rti_global.html)

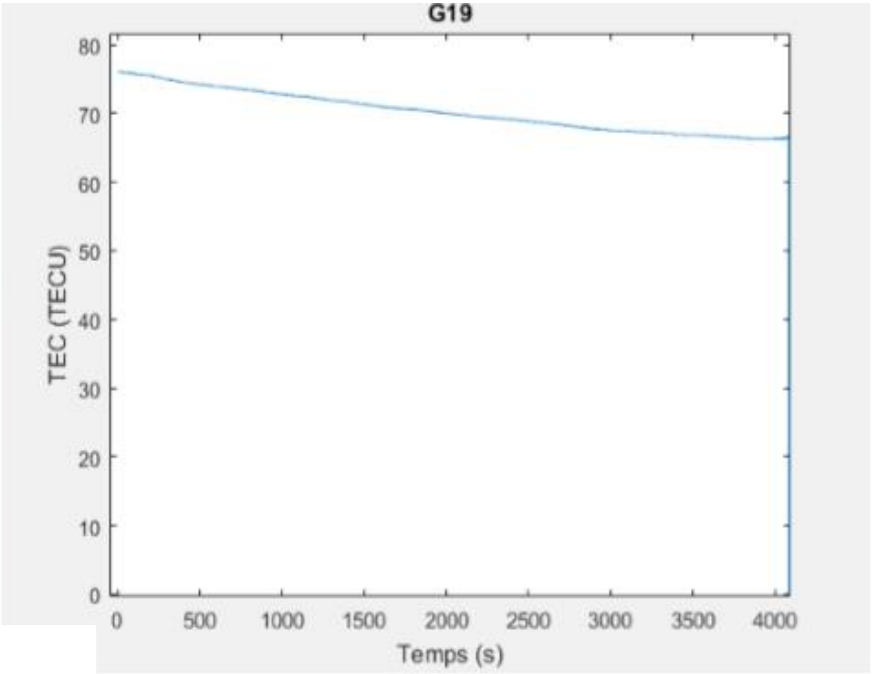


Ionospheric disturbance due to the 2011 tsunami in Tohoku (Japan) and observed by the COSMIC mission.

(Coïsson et al., 2014)

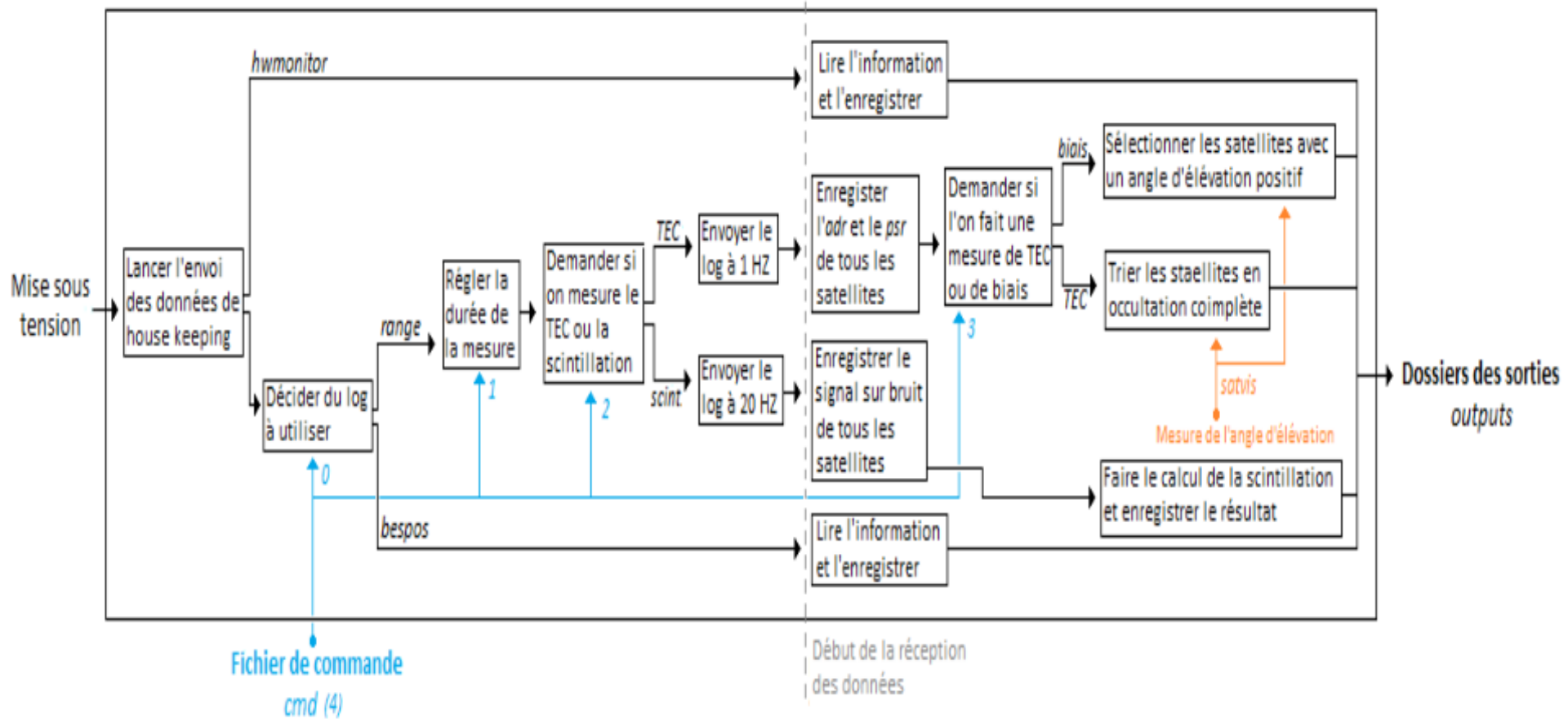
- Measurement of the TEC in complementarity with measurements by ground stations
- Measurement of scintillation index for observing small variation of the ionosphere
- Detect TEC changes due to gravity waves propagation in the ionosphere

Test bench



- Test bench installed in IGOSAT facilities
- Using a GPS receiver NOVATEL OEM 615
- Using a dual-frequency GPS test antenna
- Communication with C scripts developed for the project

Block diagram



Results and prospects

DONE :

- First version of GPS control software

TO DO :

- Selection of full occultations (scanning all ionosphere)
- Implement the calculation of the scintillation
- Importation on FreeRTOS (Operating System)

- Several acquisitions

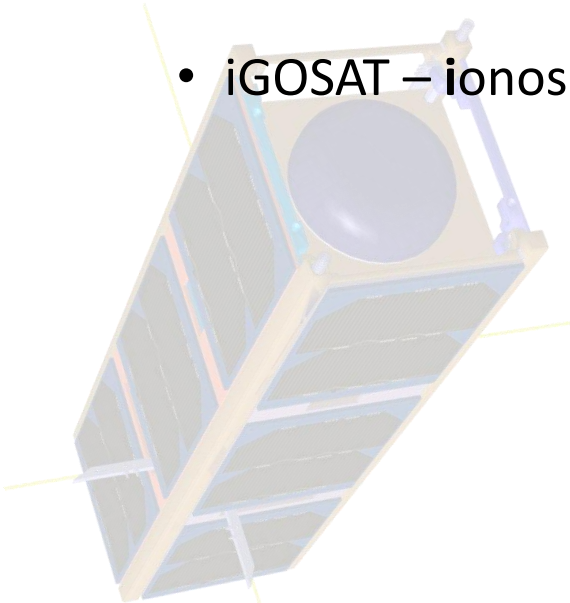
- Estimation of the effect of multi-path of the test environment
- Preparation of the tests on the antenna Tallysman

- Study of the needs for the tests with a constellation simulator

- Delay of position calculation and quality of the measurement
- Receiver robustness to the Doppler effect

The Scintillator Payload

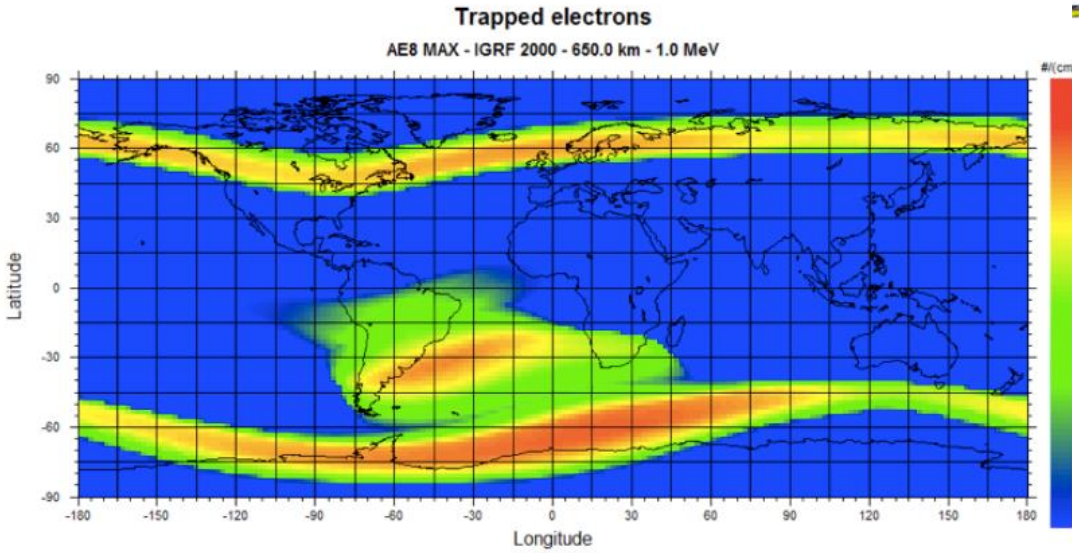
- iGOSAT – **i**onospheric **G**amma-ray **O**bservations **SAT**ellite

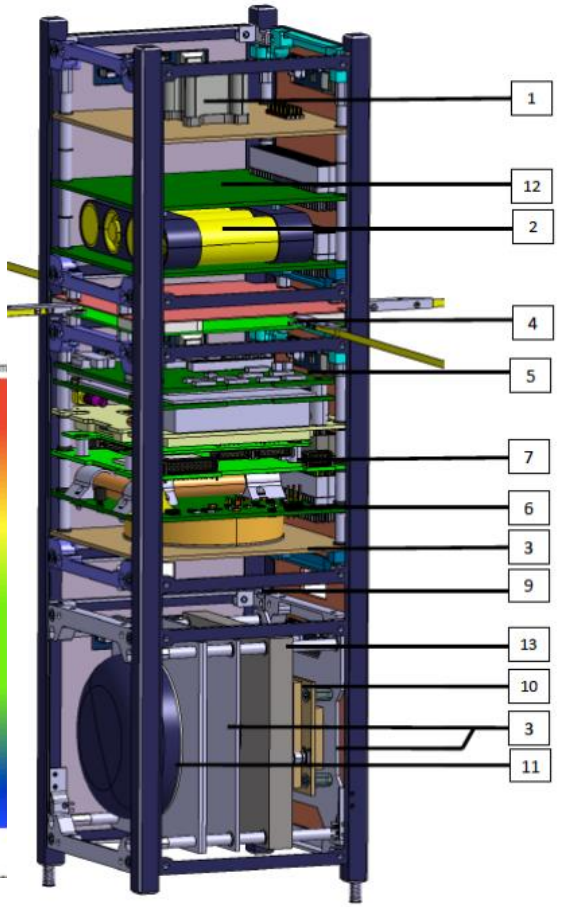


- Hien T. PHAN

Introduction

iGOSAT (**i**onospheric **G**amma-ray **O**bservations **SAT**ellite) Scintillator payload aims to measure The spectrum of gamma radiation (20 keV to 2 MeV) and electrons (1 MeV to 20 MeV) in the aurora zones and the South Alantic Anomaly.



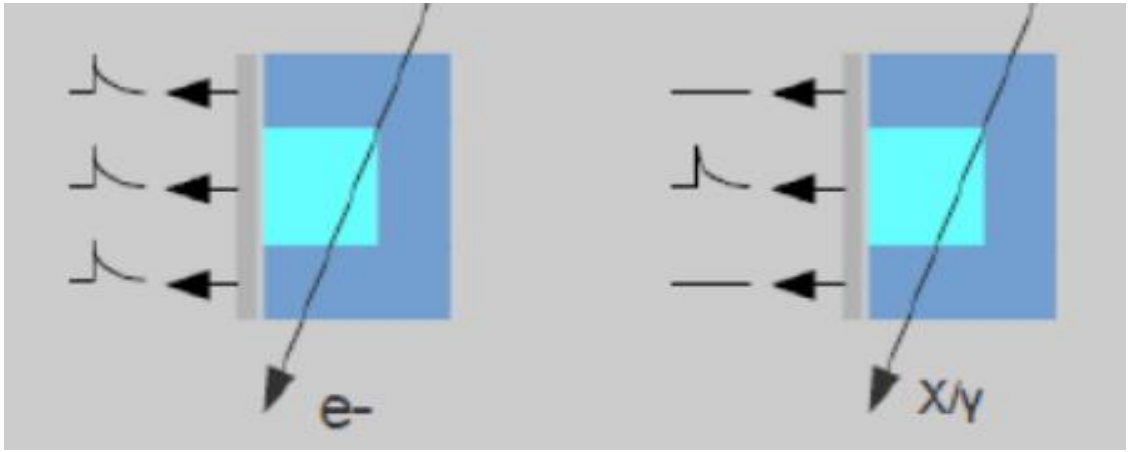


CATIA PLAN B MODEL

1. Scintillator with shielding
2. EPS
3. Empty board
4. ISIS UHF/VHF Antenna
5. AMSAT Communication board
6. Actuator board
7. ISIS Onboard Computer
8. Sun sensor
9. GPS Receiver
10. Monitoring board
11. GPS Antenna
12. EASIROC Card
13. Mass balancer

How it works ?

- 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.



The scintillator board

Containing the Plastic and Crystal scintillators and a MPPC. The gamma-rays and electrons were absorbed inside the scintillator and then emit the luminosity photon which will be captured by the MPPC.

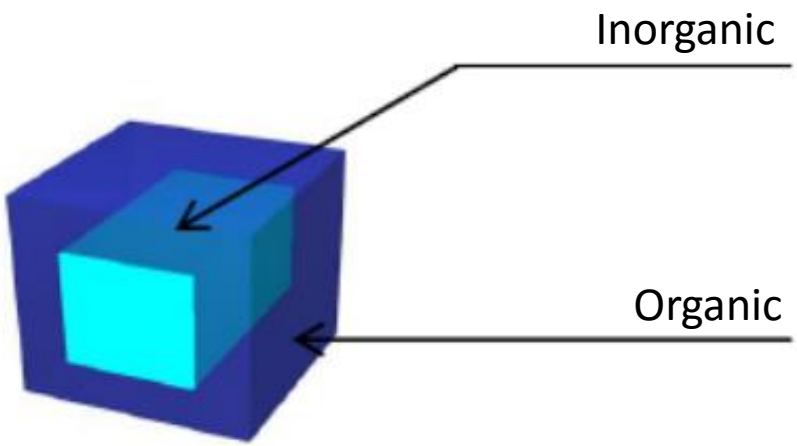
Scintillator

Scintillator board

- Cristal: **CeBr3** from Hellma Materials
- Plastic: **BC-412** from Saint-Gobain
- SiPM/MPPC: **S13361-6050AE-04** from HAMAMATSU

EASIROC board

- EASIROC chip
- HV conversion
- Microcontroller



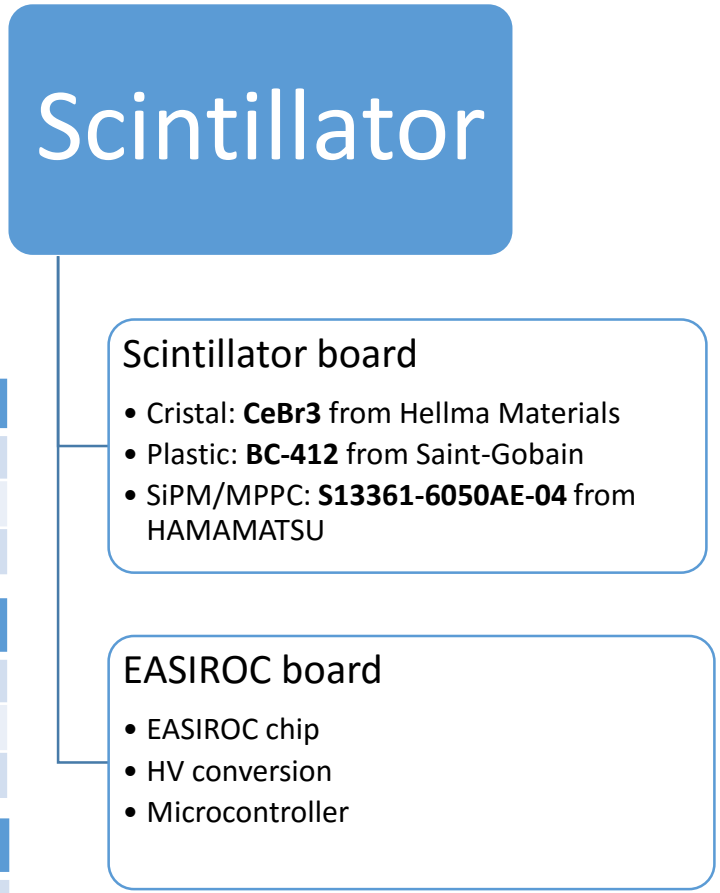
The scintillator board

- The Crystal Scintillator from Hellma Materials: **CeBr3**
- The Plastic Scintillator from Saint-Gobain: **BC-412**
- The SiPM/MPPC from HAMAMATSU: **S13361-6050AE-04**

CeBr3 Scintillation properties	
• Emission wavelength [nm]	380
• Energy resolution @ 662 keV [% FWHM]	3.8
• Decay time [ns]	19

BC-412 Scintillation properties	
• Wavelength of Max. Emission [nm]	434
• Pulse Width, FWHM [ns]	4.2
• Decay Time [ns]	3.3

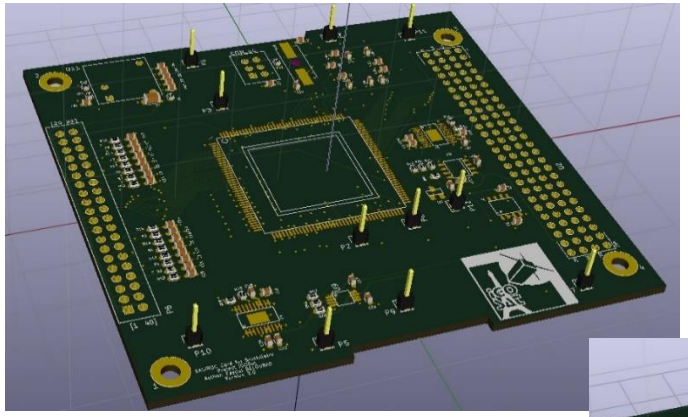
SiPM/MPPC S13361-6050AE-04	
• Number of channels	16 (4×4) ch
• Effective photosensitive area / ch	6 x 6 mm
• Spectral response range	320 to 900 nm
• Peak sensitivity wavelength (typ.)	450 nm
• Gain (typ.)	1.7×10^6
• Measurement condition	Ta=25 ℃

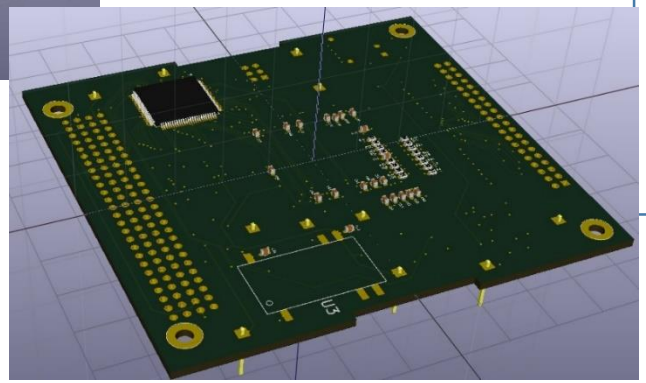


The EASIROC card

- Receive the signal from SiPM and convert it in a comprehensive language for the computer.

- Then, it send data to the OBC (On Board Computer).





Scintillator

Scintillator board

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EASIROC board

- EASIROC chip
- HV conversion
- Microcontroller

OMEGA Microelectronics

iGO SAT iUnivEarthS

JANUS

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

Labex UnivEarthS

université PARIS DIDEROT

Simulation and test bench

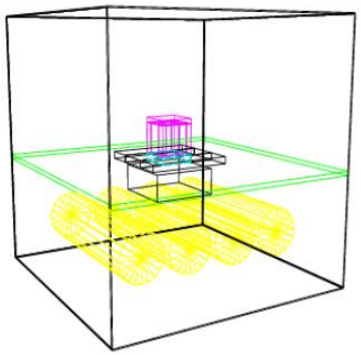
- **Simulation with MegaLib**

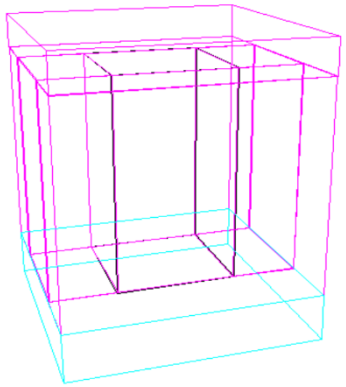
- Provides the sizing of the Scintillator, size of the shield.

- Lea Bourhis made some simulation last year, and we will continue her work.

MegaLib: is a simulation software for particle physics. Inside Megalib, we use three build-in softwares:

- Geomega: defines the geometry of sensors and the satellite for the simulations.
- Cosima: defines the characteristics of the simulations.
- Revan: analyzes the simulations.



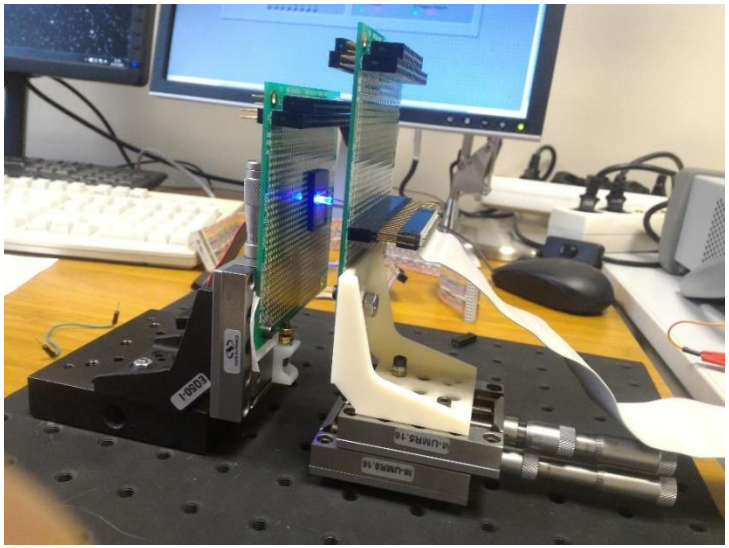


Simulation and test bench

- **Test Bench**

Aimed to test the performance of the MPPC, the test bench was set up with a blue LED (it is near the wavelength of the scintillation photons) and a MPPC sticking on the translation system (allows us to change the position of the LED pointing to every pixels of the MPPC).

All of them were put in a black box.



Summary

Next objectives:

Simulation with MEGALib

- Size of Scintillator
- Size of the Shield

Test bench

- Efficiency of the MPPC
- Efficiency of the EASIROC board

Scintillator

Scintillator board

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Thank you for your attention