IGOSat (Ionospheric & Gamma-ray Observations Satellite), an educational CubeSat project with scientific return through technology demonstration

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Marco Agnan, Hubert Halloin, Hana Benhizia, Philippe Laurent, Pierdavide Coisson, Hien Phan
IGOSat: Context

Origins: proposal within the LabEx UnivEarthS at Paris Diderot University:
- APC (AstroParticule & Cosmologie);
- IPGP (Institut de Physique du Globe de Paris);

Support: project within the JANUS program (Educational CubeSats) from CNES (Centre National d’Études Spatiales) since 2012, until 2019.

Brief Timeline: Student Project.
- 2012/2015: feasibility studies, preliminary design;
- 2015/2016: Flat-Sat, Engineering Model, STM;
- 2016/2017: Tests, Validations;
Scientific Objective:
To observe Total Electron Content (TEC) profiles with GPS signals measurements (L1 and L2)

Scientific Interests:
To detect violent variations of the TEC that may be caused by acoustic waves in the Ionosphere (tsunamis, earthquake...);
Example of what IGOSat may observe (opportunity mission):

Ionospheric perturbation during the Chile earthquake in 2014, measured from a ground station with GPS signals.
Mission Analysis:
Between 50 and 60 full radio-occultation per day, with an altitude between 600 and 750 km. Objective = 40 per day.
IGOSat: GPS Payload

Full instrument composed with COTS.
IGOSat: Scintillator Payload

**Scientific Objective:** To measure the flux and the energy of the electrons and the gamma photons in the poles and in the South Atlantic Anomaly (SAA).

**Scientific Interests:**
- To improve the measurements already done
- No gamma ray observations to more than 1 MeV

**Technological Interests:**
- Use of silicon photomultiplier (never used in space);
- Specific design of scintillator: CeBr3 surrounded by plastic scintillators.
IGOSat : Scintillator Payload

Objectives:
- Spectra of gamma radiation from 20 keV to 2 MeV
- Spectra of electrons from 1 MeV to 20 MeV
IGOSat : Scintillator Payload

**Detector:**
- plastic scintillator sensitive to electrons;
- cristal scintillator (CeBr3) sensitive to electrons and gamma photons;
- SiPM (Silicon PhotoMultiplier) : never used in space (technology demonstration).
IGOSat : Scintillator Payload

EASIROC Chip :
- electronic component made for particle physics in accelerators;
- 32 inputs (16 needed).

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
IGOSat: Mission Profile

Ground Station 1 (Paris)

Ground Station 2 (Hanoi)

Auroral Area (North)

Auroral Area (South)

SAA
IGOSat : Educational Return

Since 2012, approximately 200 students have been working on the project.

Students domain :
- physics (astrophysics and geophysics);
- engineering;
- computer science;

but also :
- Cinema;
- journalism…

![Graph showing student participation in projects and internships from 2012-2013 S1 to 2015-2016 S2.]

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Thank You
agnan@apc.in2p3.fr