The COMCUBE project for GRB polarimetery

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The COMCUBE project

- COMCUBE is a European project funded by AHEAD2020
 - To develop a concept of a Compton telescope for a CubeSat mission and evaluate its potential for GRB polarimetry using Monte-Carlo simulations
 - To develop and qualify technologies for future MeV-GeV astronomy missions
- Collaboration:
 - IJCLab (Orsay): V. Tatischeff (PI), N. De Séréville, J.-J. Dormard, C. Le Galliard,
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 - UCD (Dublin): L. Hanlon, S. McBreen, J. McDaid, D. Murphy, A. Uliyanov
 - CEA-IRFU (Saclay): P. Laurent, I. Cojocari
 - INFN (Rome): A. Morselli, V. Vitale, G. Fernandez
 - LIP (Coimbra): R. Curado da Silva, H. Neves
 - CNRS-IRAP (Toulouse): P. Von Ballmoos
 - Johannes Gutenberg University (Mainz): U. Oberlack, J.P. Lommler

4U payload for a 6U CubeSat



Double-sided silicon strip detectors

IJCLab DSSD (ComptonCam)

CEA DSSD

BB7 DSSD from Micron Semiconductor

- Thickness: 1.5 mm
- Active area: 64 x 64 mm²
- Strip number: 32 + 32
- Strip pitch: 2 mm
- Bias voltage: 400 500 V



CEA detector: Idef-X analogue readout ASIC coupled to OWB-1 ADC ASIC

IJCLab detector: 2 VATA460.3 readout ASICs per DSSD (adapting the ComptonCam detector to the CubeSat form factor)

- Energy resolution (FWHM): 15 keV
- Trigger threshold: 30 keV

Side scintillator module (IJCLab)





Anger camera: 51 x 51 x 10 mm³ monolithic CeBr3 crystal coupled to an 8 x 8 SiPM array

ANN is used to reconstruct the 3D interaction position from the observed light distribition

Position resolution is σ≈2.5 mm above 150 keV (obtained with an 8x8 multi-anode PMT)

Energy resolution is about 5% at 662 keV (FWHM)

SiPM readout: 32-channel Citiroc 1A ASICs from WEEROC (France)

Bottom scintillator module (UCD)

Original development: Monolithic 25 x 25 x 20 mm³ CeBr3



Alternative:

25 x 25 x 15 mm³ GAGG array (4x4 pixels) with TiO2 reflector around the pixels, coupled to a 4x4 aray of J-series SiPMs



- Position resolution is defined by the pixel pitch size (6.3 mm)
- No interaction depth resolution
- 9.1% energy resolution @662 keV
- Position and energy measurements are less affected by SiPM noise
- Non-hygroscopic scintillator

SiPM readout: 16-channel SIPHRAASIC from IDEAS (Norway)

Compton imaging with a DSSD and a scintillator (IJCLab)



30

-50

70-

-50

Phi [deg]

50

- with respect to the setup axis
- Selected fully absorbed events (662 keV) for imaging
- Results are consitent with simulations

Polarisation measurements



- Scattered γ -ray beam to generate partially polarised photons of \sim 356 keV (theoretical polarisation fraction $\pi \approx 60\%$)
- Measured signal modulation, $\mu_{100}\pi = 0.252 \pm 0.023$ and polarisation angle $\eta = 109^{\circ} \pm 3^{\circ}$ consistent with the simulation results: $\mu_{100}\pi = 0.210 \pm 0.018$, $\eta = 106^{\circ} \pm 2^{\circ}$

Simulations - 4U instrument

Photoelectric effective area: ~200 cm² at 100 keV Compton effective area: ~8 cm² at 300 keV Angular resolution measure (ARM): ~25° at 300 keV



Based on the 10-year GBM GRB spectral catalogue, a single COMCUBE instrument would detect **192 long GRBs/yr** and **32 short GRBs/yr** (assuming an equatorial LEO with zero instrument downtime).

Polarisation measurements:

With 1/4/16 satellites in random positions and with 20% downtime, COMCUBE would observe 1/5/20 GRBs/yr with MDP₉₉ < 30%.





1U prototype for a balloon flight

- Proposal submitted to CNES for a ZP balloon flight from Timmins in Summer 2023
- A transatlantic flight from Kiruna in 2024 could test the polarimetric capabilities of COMCUBE 1U with the Crab nebula (to be confirmed in 2023)



Thank you!