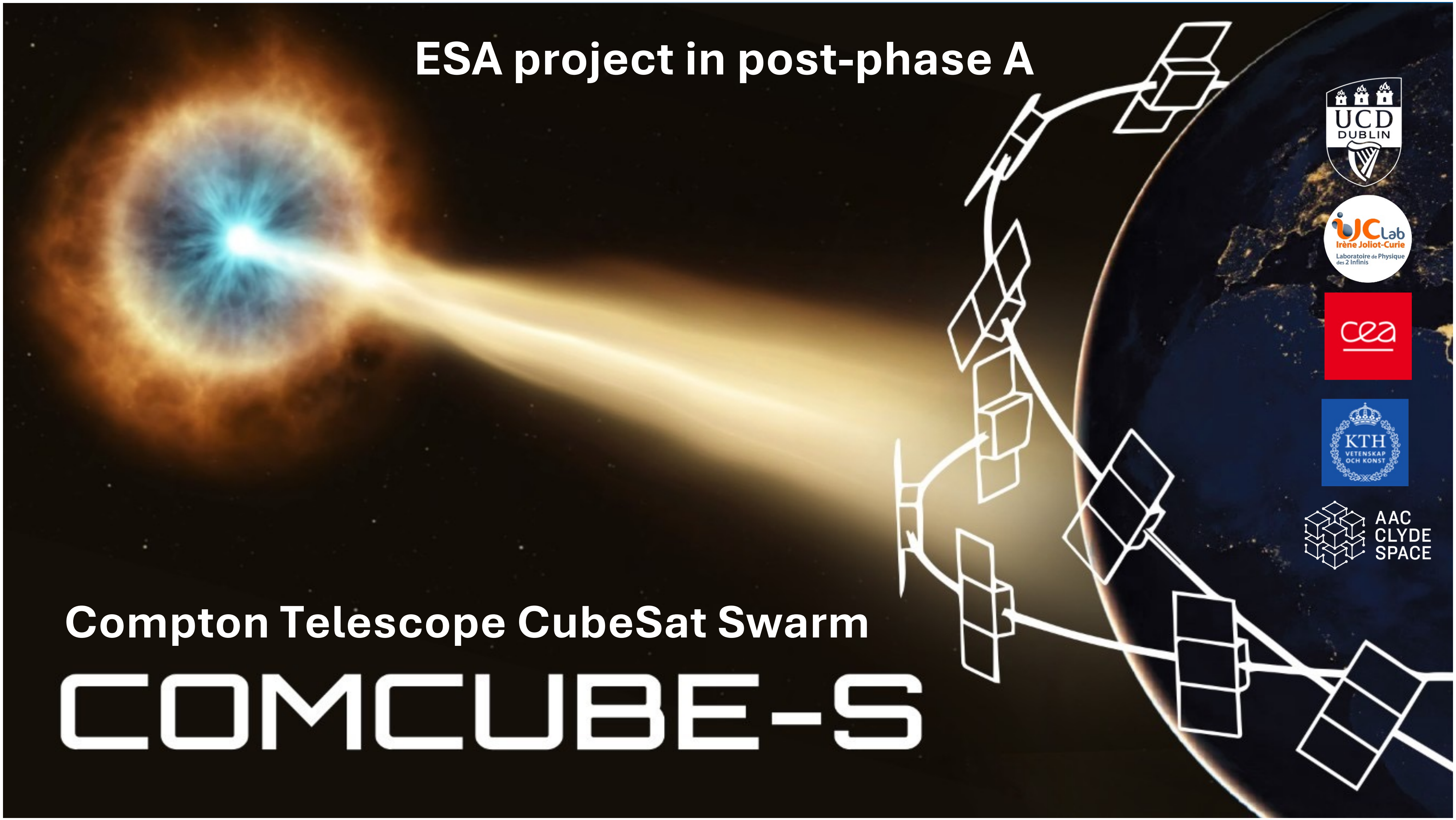
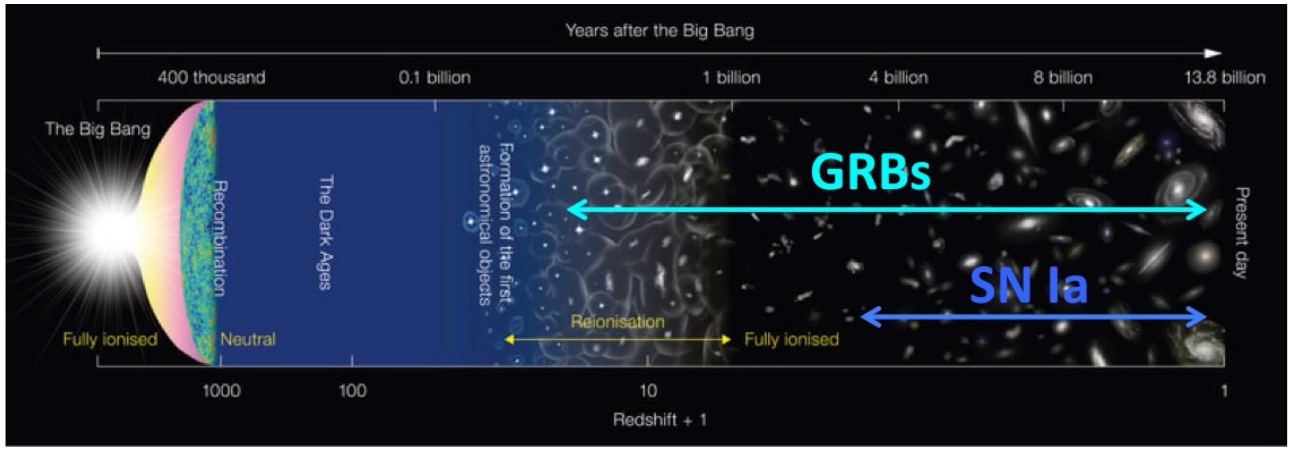
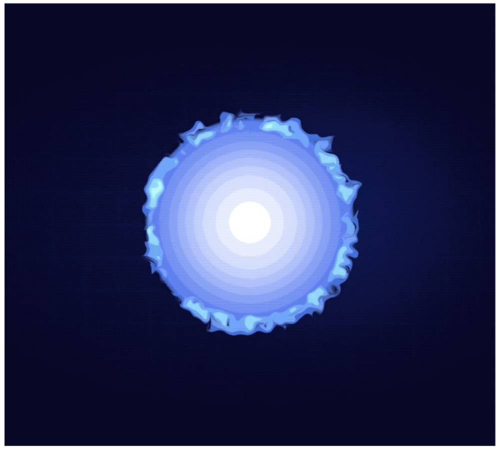

ESA project in post-phase A
UCD DUBLIN
IJCLab
Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis
cea
KTH
VETENSKAP OCH KONST
AAC CLYDE SPACE
Compton Telescope CubeSat Swarm
COMCUBE-S

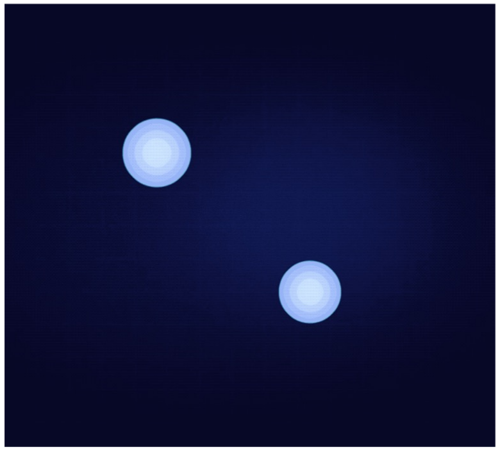
Gamma-Ray Bursts

- Brightest, most violent explosions in the Universe
- Occur at cosmological distances, detectable in the very first galaxies, up to redshift $z > 10$ (~3% of the Universe's age)
- Death of very massive stars (long GRBs, T90 > 2s) or the merger of compact objects (short GRBs)
- Could become new standard candles in cosmology if the physics of ultra-relativistic jets (Lorentz factor $\Gamma > 100$) was better understood



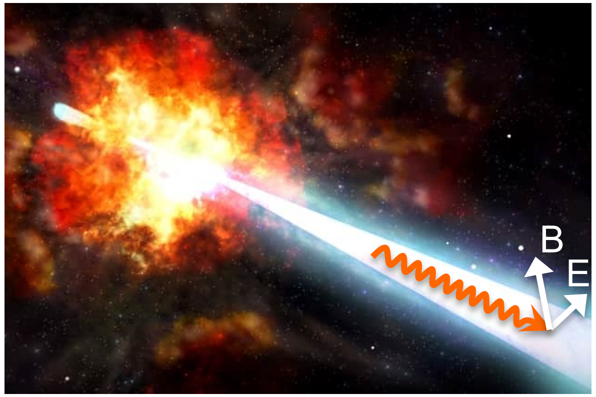


Long GRB

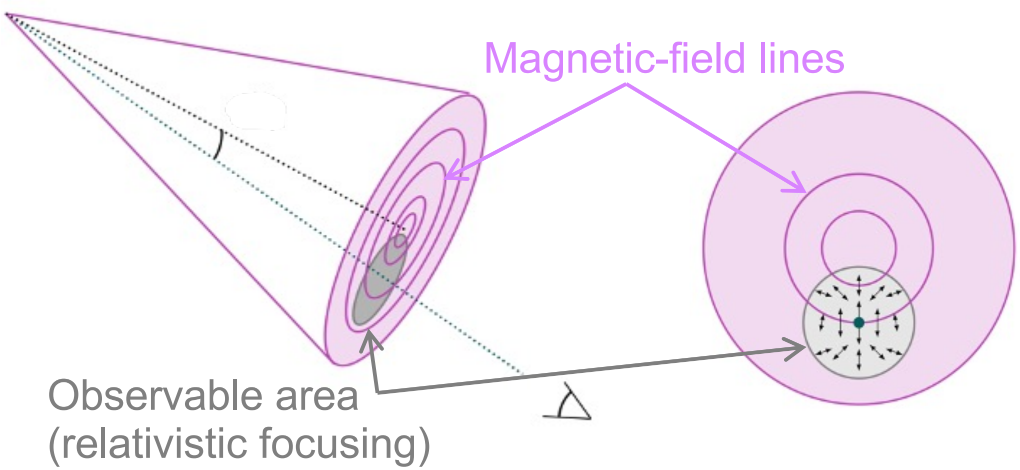


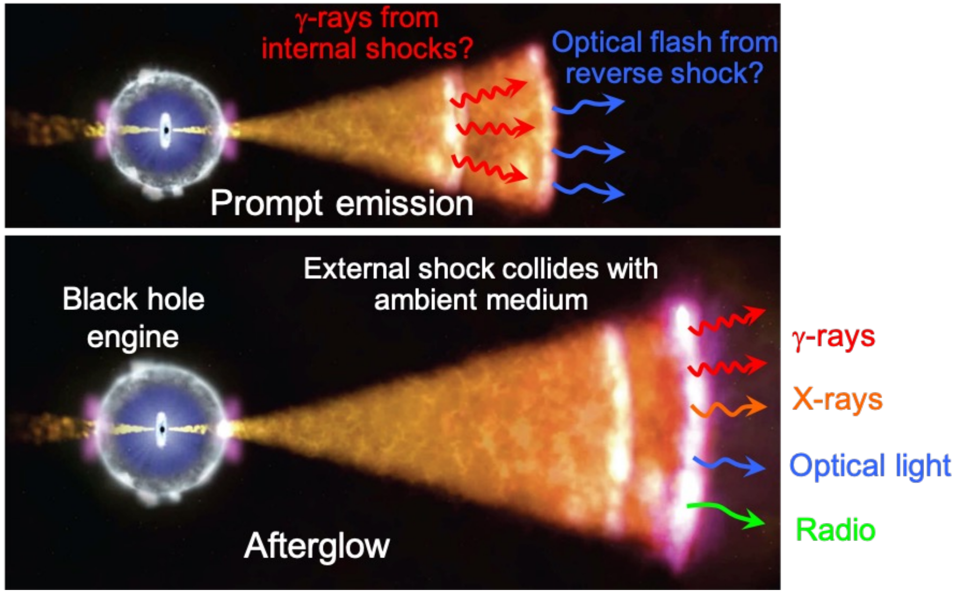
Short GRB

New approaches to studying GRBs

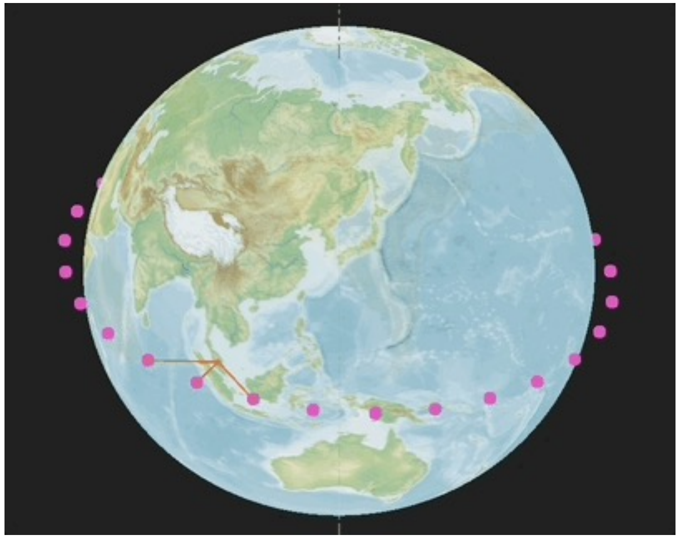


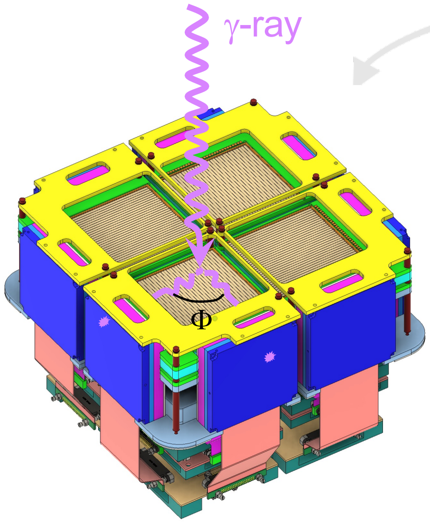
- **<u>Gamma-ray linear polarimetry:</u>** powerful new diagnostic for the **magnitude & coherence of magnetic fields** carried by jets, and the **radiation mechanism** & **viewing geometry**
- **<u>Low-latency GRB alerts with accurate localisation</u>** for prompt multiwavelength follow-up observations

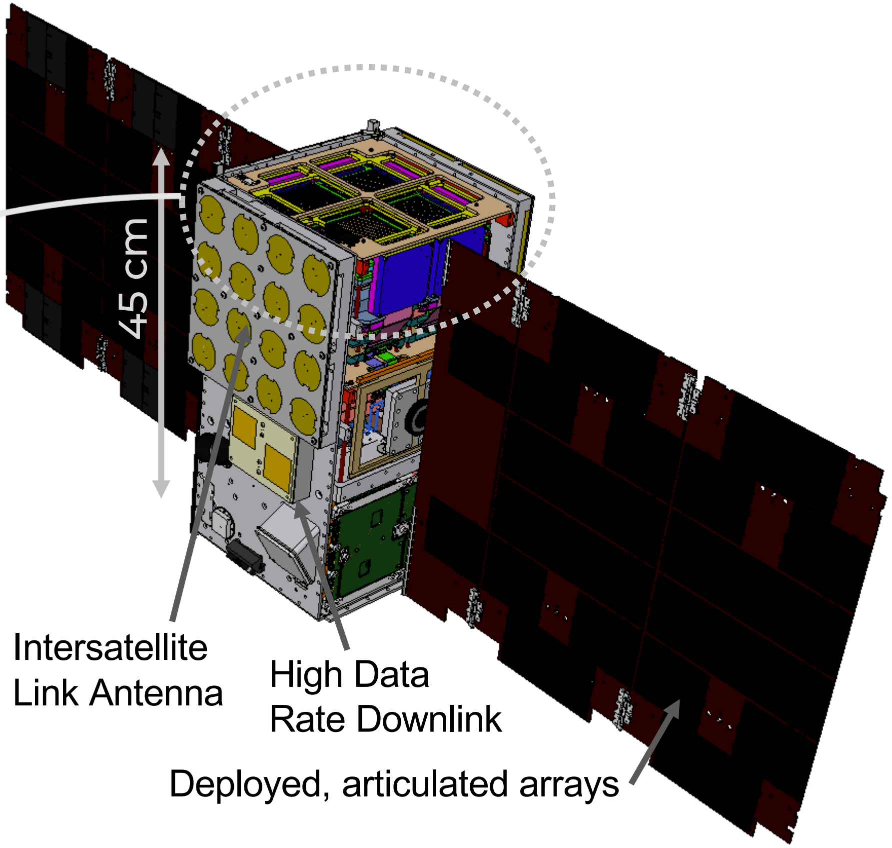


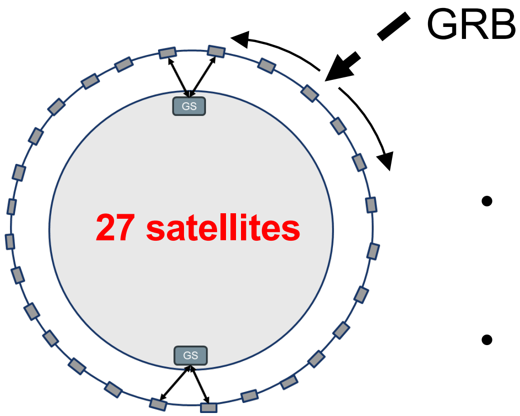


COMCUBE-S Mission



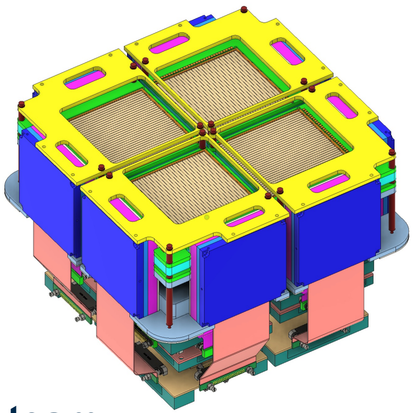






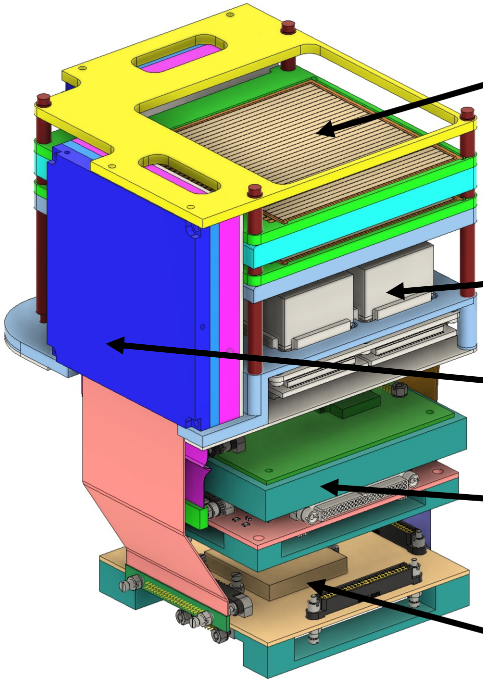
- 27 CubeSats 16U (~ 22 x 22 x 45 cm^3) carrying each a **Compton telescope** = gamma-ray polarimeter
- **Full sky coverage** with automatic data transfer via **inter-satellite links** for low-latency (< 60 s) GRB alerts

Compton Telescope Unit

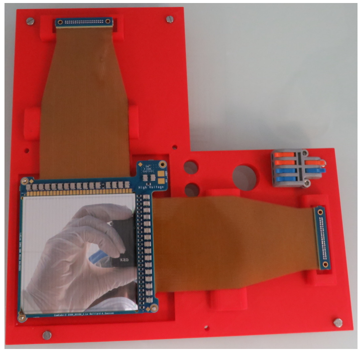


CTU project team:

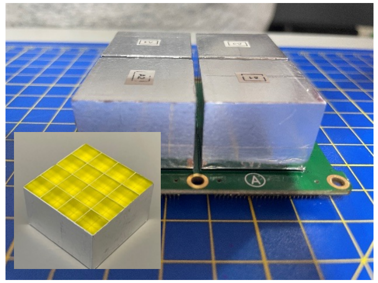
- Project Manager: VT (IJCLab)
- Scientific co-PI: David Murphy (UCD)
- Systems Engineer: Aline Meuris (CEA)
- Instrument Scientist:
  Nicolas de Séréville (IJCLab)
- Electrical/Electronic Architect:
  Eric Doumayrou (CEA)
- Mechanical and Thermal Architect:
  Christine Le Galliard (IJCLab; RT)
- Software architect: Nicolas Dosme (IJCLab)



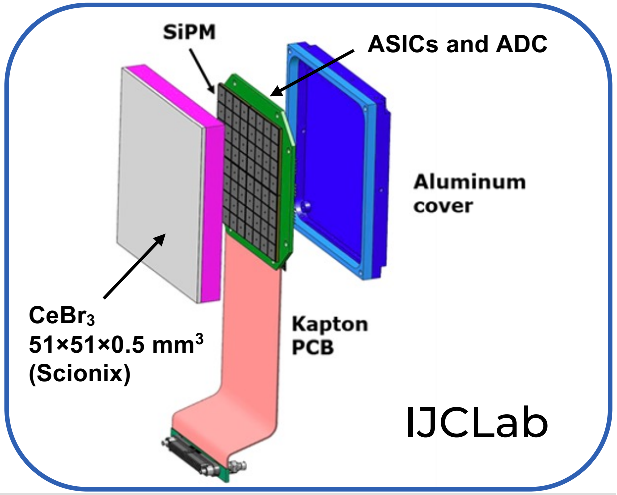
CTU 'Quad'



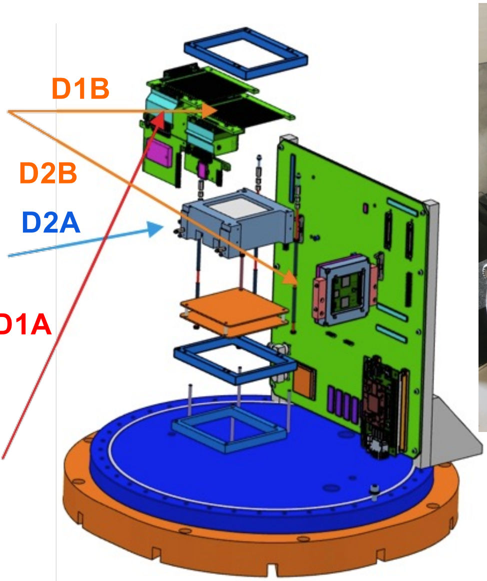
Double-sided Si strip detectors ($64\times64\times1.5$ mm^3 32+32 channels Micron BB7) – IJCLab & CEA

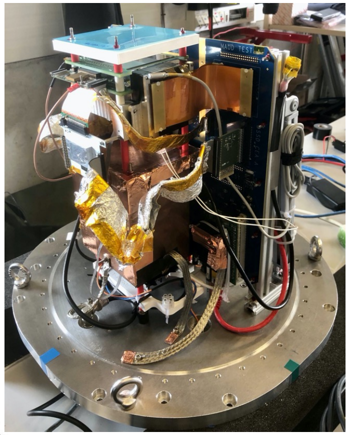


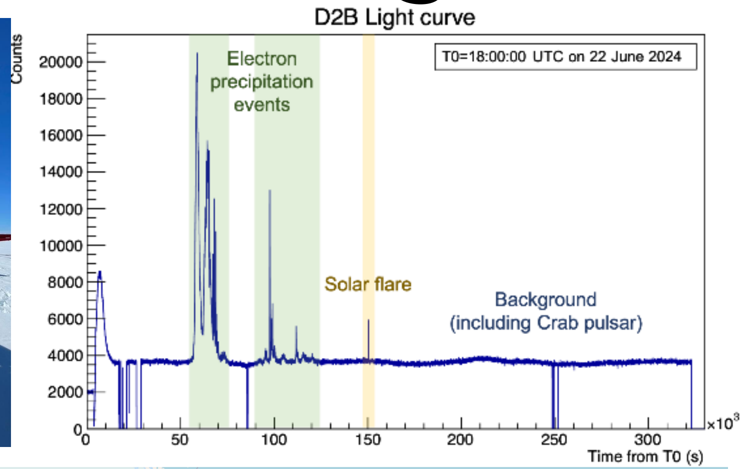
Pixelated GAGG:Ce $6.2\times6.2\times15$ mm^3 coupled to SiPM array 64 chan. – UCD



Qualification in stratospheric balloon flight



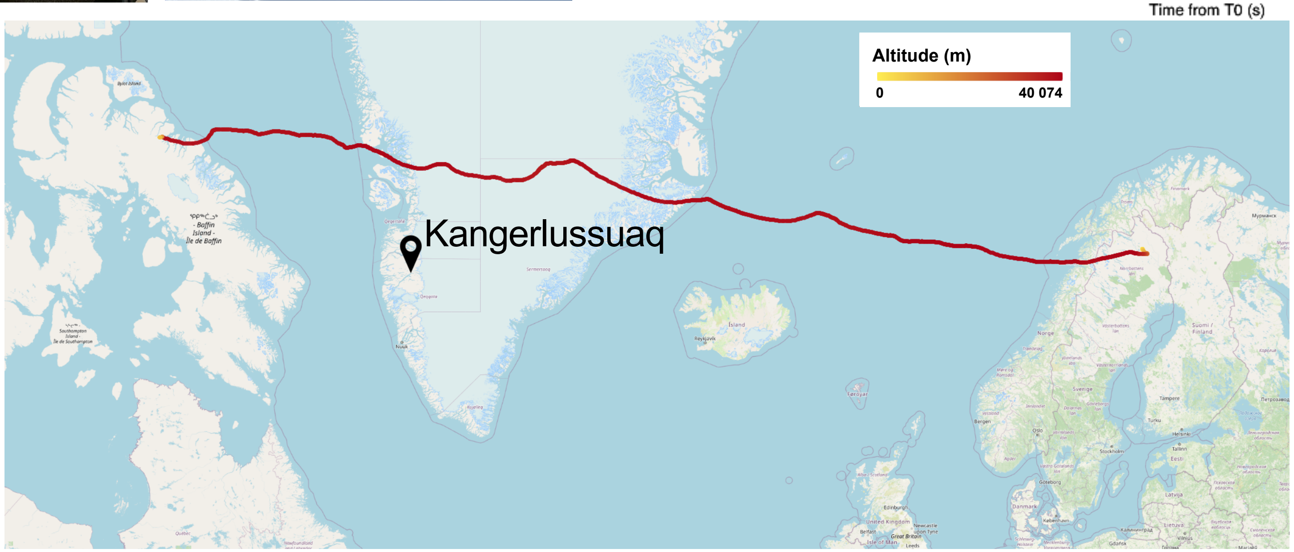




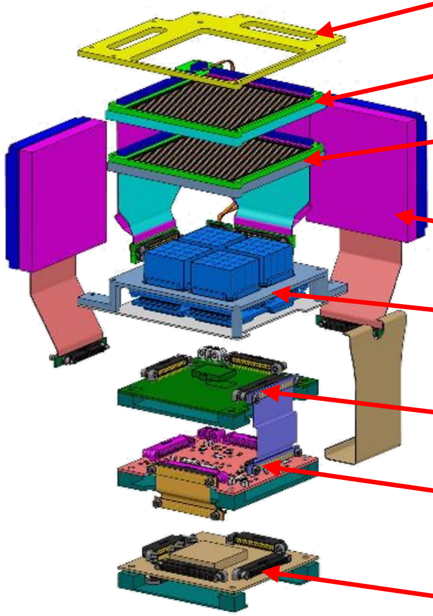
- TRANSAT flight from Esrange (Sweden) to Baffin Island (Canada) on 22-26 June 2024 (3.7 days): **first transatlantic flight operated by CNES**

⇒ Flight software for limited TM/TC

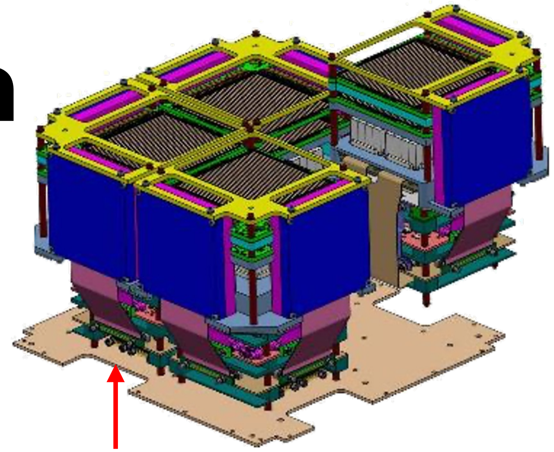
⇒ **Crab pulsar** detection (in progress)



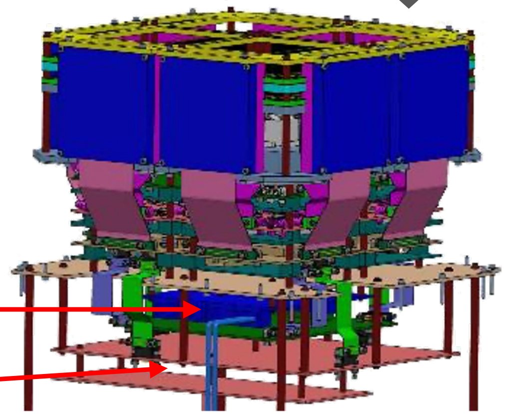
CTU Integration



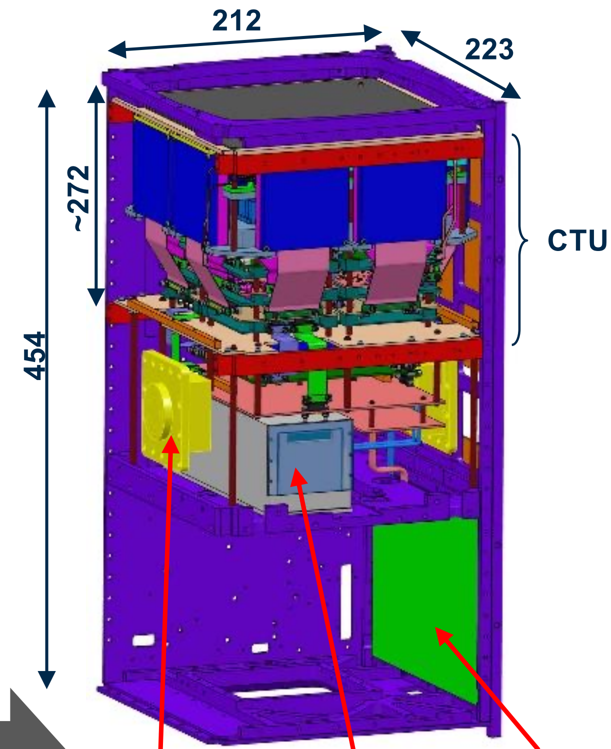
QUAD



CTU = 4 QUADs



CTU + PPB + PPSU

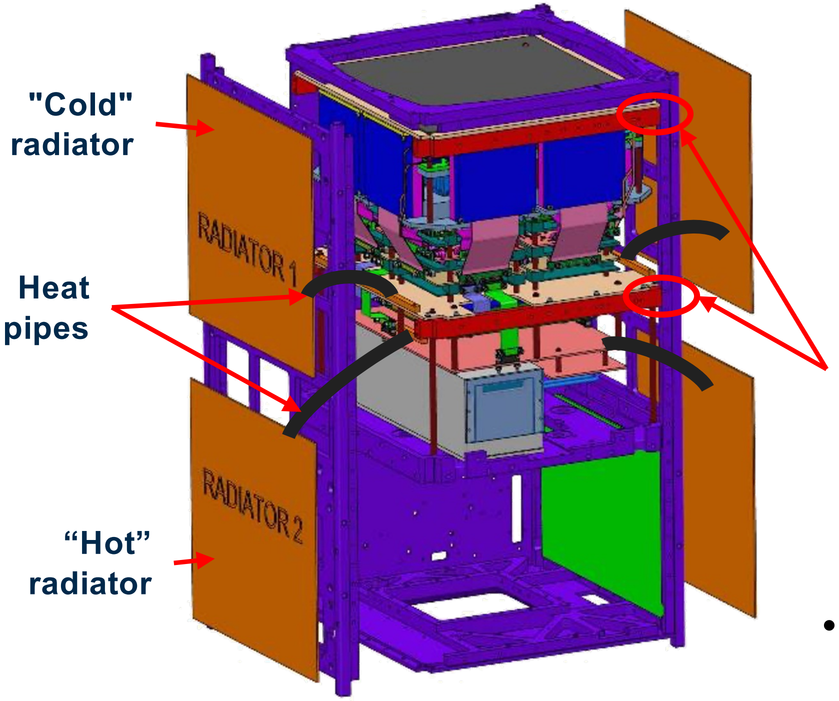


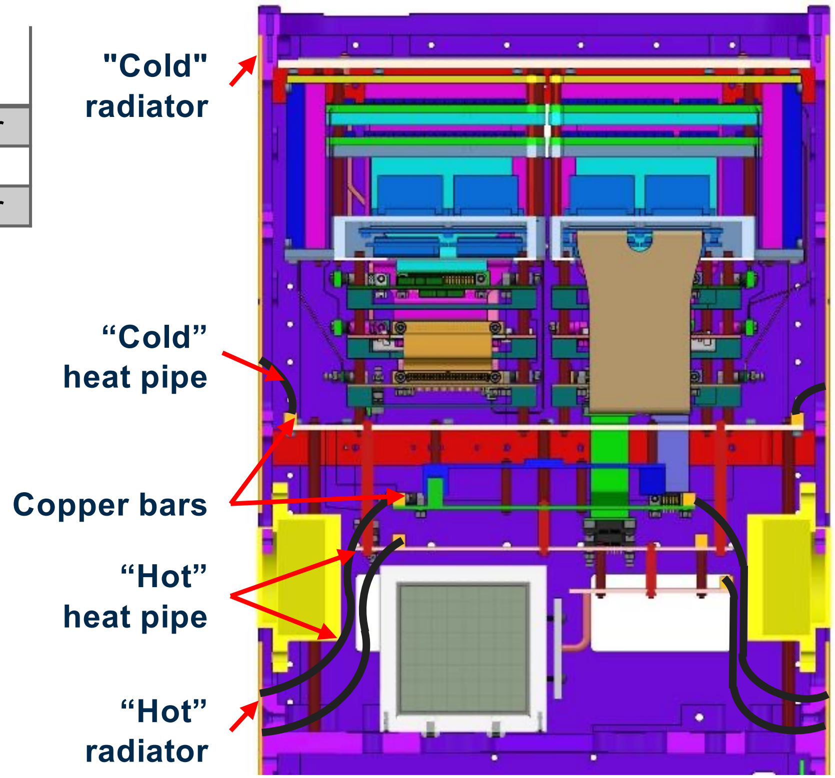
CubSat 16U

- Assembly verification using a structural model in Phase B (2027)

CTU Thermal control

TIP	Name	Non-op TMin	Op Tmin	Perfo. range	Op Tmax	Non-op Tmax	Max slope
1	DSSD	-50°C	-40°C	-20°C/+20°C	35°C	50°C	20°K/hr
2	CeBr3	-30°C	-20°C	-20°C/+30°C	30°C	50°C	8°K/hr
3	BSU	-50°C	-40°C	-30°C/+50°C	50°C	50°C	10°K/hr

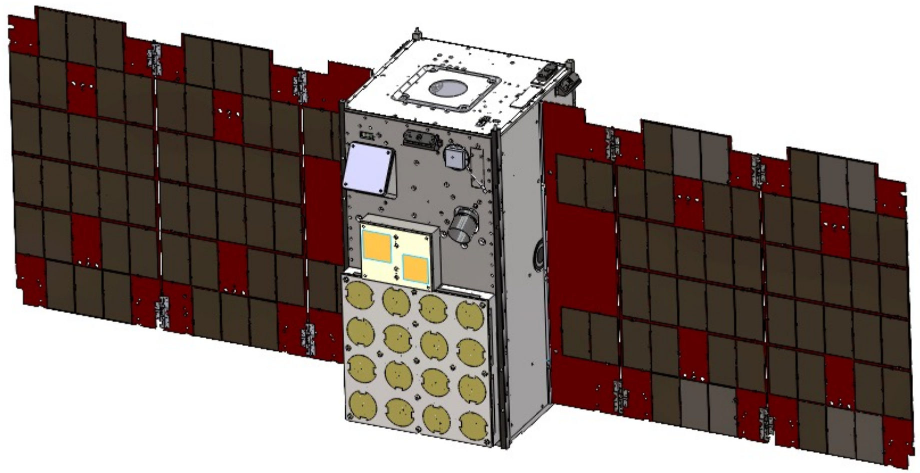




- Thermal control principle to be validated with detailed thermal simulations in Phase B (Ansys)

Mass budget

Subsystems		Without margin (g)	With equipment margin (g)	Systems margin
Payload	Payload	9500	10562.1	20.00%
Structure	End Plates	616	677.6	
	Covers	300.05	345.055	
	Rails	1626.5	1789.15	
	Bracketry	2103.28	2295.357	
	Shear Panels	802.55	882.805	
	Ribs	519.45	571.395	
	Rods	13.32	14.072	
	Spacers	15.52	16.806	
	Adaptors	15.21	16.731	
Thermal	Thermal	419.85	456.5725	
Avionics	OBDH	126	135.3	
	Power	5164	5602.5	
	Comms	1752.75	1973.2665	
	AOCS	2320.84	2497.282	
Electrical Architecture	Interfacing	1763.42	2114.604	
	Misc Electrical	6.96	7.606	
Total		27065.7	29958.202	35949.8



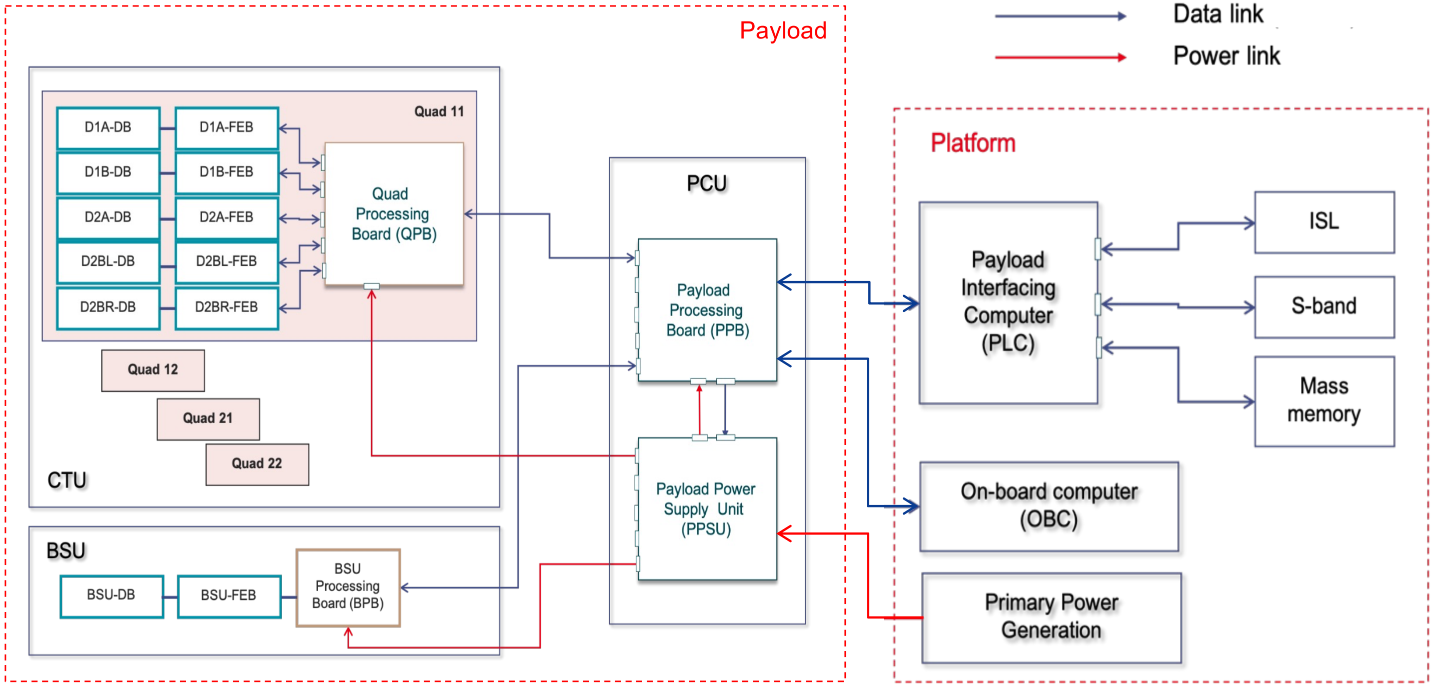
Subsystem	Mass (kg) – No Margin	Mass (kg) – Equipment Margin	Mass (kg) – 20% System Margin
CTU	4.69	5.21	6.26
BSU	3.50	3.79	4.55
PCU	0.59	0.68	0.82
Structure / thermal cont.	0.73	0.88	1.05
TOTAL	9.50	10.56	12.67

- Overall payload mass (including all margins): <u>12.7kg</u> – about 1/3 of 16U maximum (36.0 kg)

Electrical Architecture

NINANO

On Board Computer



Payload Power Budget

Subsystem	Power – no margin (W)	Power - 20% margin (W)
CTU	6.16	7.4
BSU	0.26	0.3
PCU	7.70	9.2
TOTAL	14.1	17.0

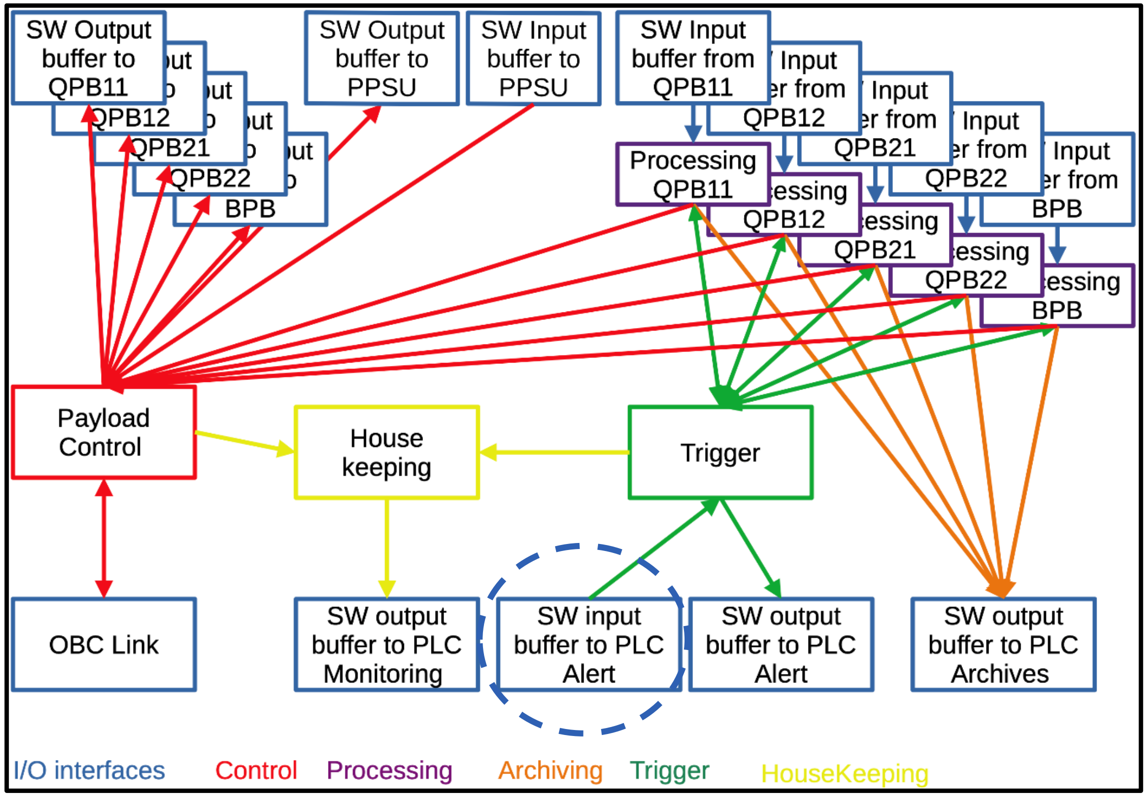
Power interfaces:

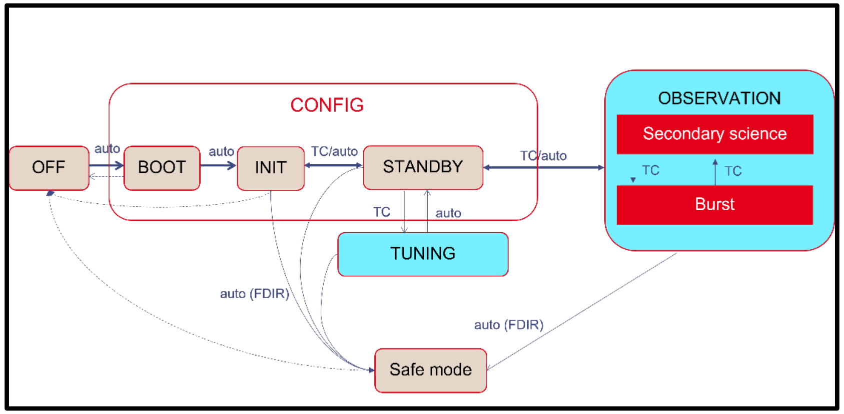
- 2x 5v inputs from platform Electrical Power System
- Independent control of payload processing and detector power-up at platform level.

Data interfaces:

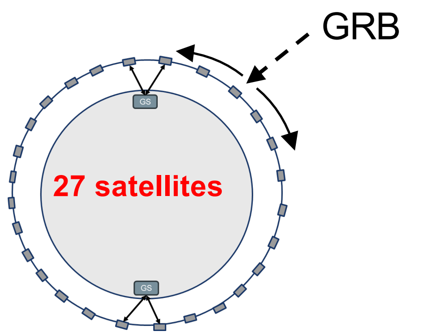
- PCU – OBC: CANbus.
- PCU – PLC: SpaceWire.
- Timing to Payload: Pulse-Per-Second – driven by chip-scale atomic clock.

Payload flight software





Data type	Telemetry – cargo size, no margin (kbits/s)	Telemetry per day – 50% margin (Mbits)
Housekeeping	2.2	285
Quick-look data	1.9	247
Science data	288	37325
Total	293	37973



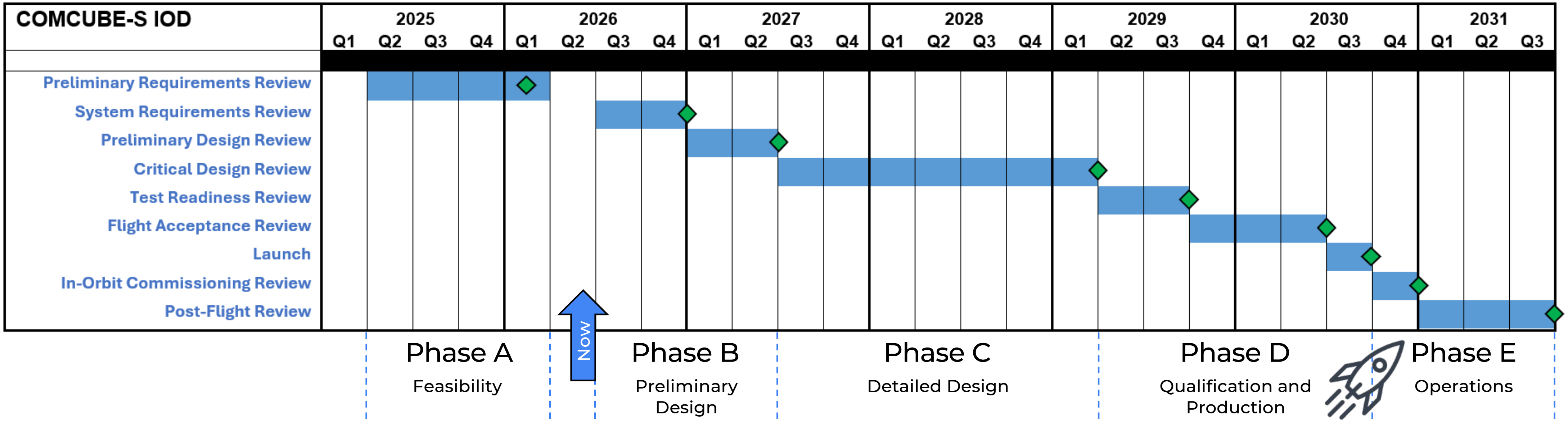
- **KOSMOS** (Kit for Onboard Software in Modular Oriented Systems)

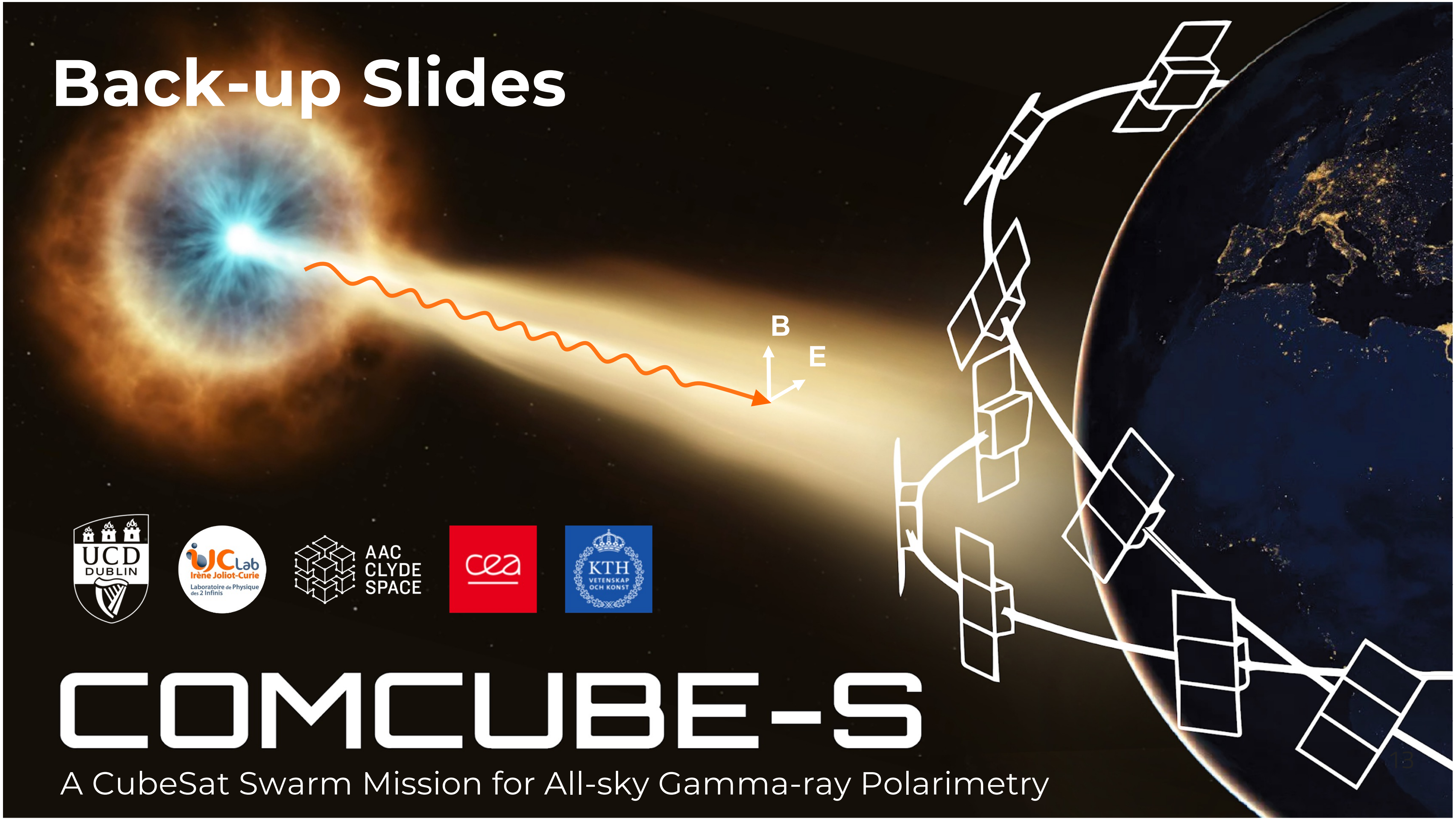
⇒ **CNES**-developed modular flight software framework enabling an hypervisor-based partitioned onboard architecture

Conclusions

- COMCUBE-S will be a key mission for **gamma-ray burst physics, multi-messenger astrophysics** and **time-domain astronomy**

- **In-Orbit Demonstration (IOD) with 2 CubeSats in 2030**: important first step towards applying new-space concepts to a keystone science mission, including swarm distributed intelligence, autonomy, communications, as well as miniaturised and highly integrated instrumentation




Back-up Slides
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COMCUBE-S
A CubeSat Swarm Mission for All-sky Gamma-ray Polarimetry

Gamma-Ray Burst Detection

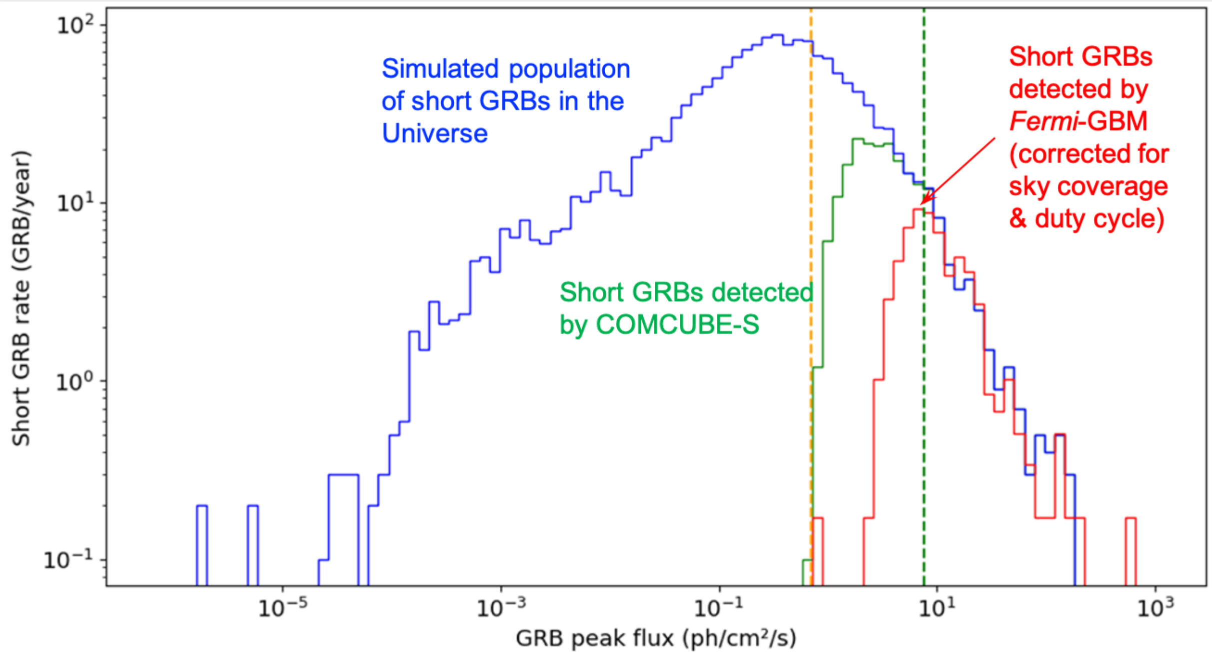
- Existing GRB catalogues insufficient for COMCUBE-S sensitivity studies

⇒ Construction of a **synthetic GRB catalogue** based on an astrophysical model (redshift, luminosity etc.; Franel et al. 2025)

- Faint GRBs can be detected by the swarm requiring **coincident count-rate increase across several interlinked CubeSats**

⇒ COMCUBE-S will detect **about 2 GRBs per day**, significantly **more than any other GRB mission**

⇒ With 2 CubeSats, **COMCUBE-S IOD should detect about 0.4 GRB/day**



Number of satellites triggering in coincidence		1	2	3	4
GRB detection rate (GRB/yr)	All GRBs	444-622	520-733	573-806	595-838
	Short GRBs	96-136	120-171	137-196	144-207
	Long GRBs	334-506	382-589	414-643	429-667