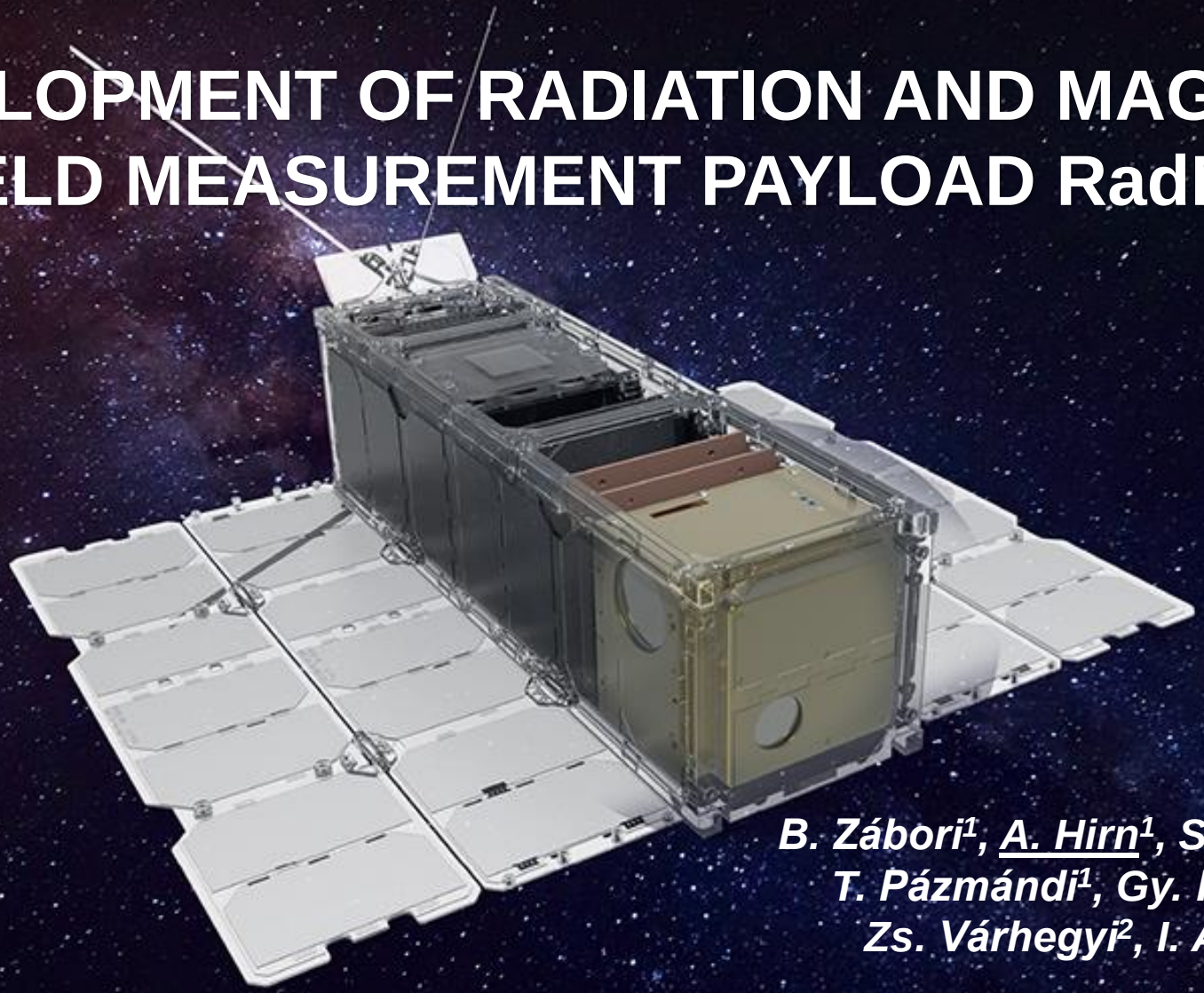
COMPLEX SYSTEMS & SMALL SATELLITES

DEVELOPMENT OF RADIATION AND MAGNETIC FIELD MEASUREMENT PAYLOAD RadMag



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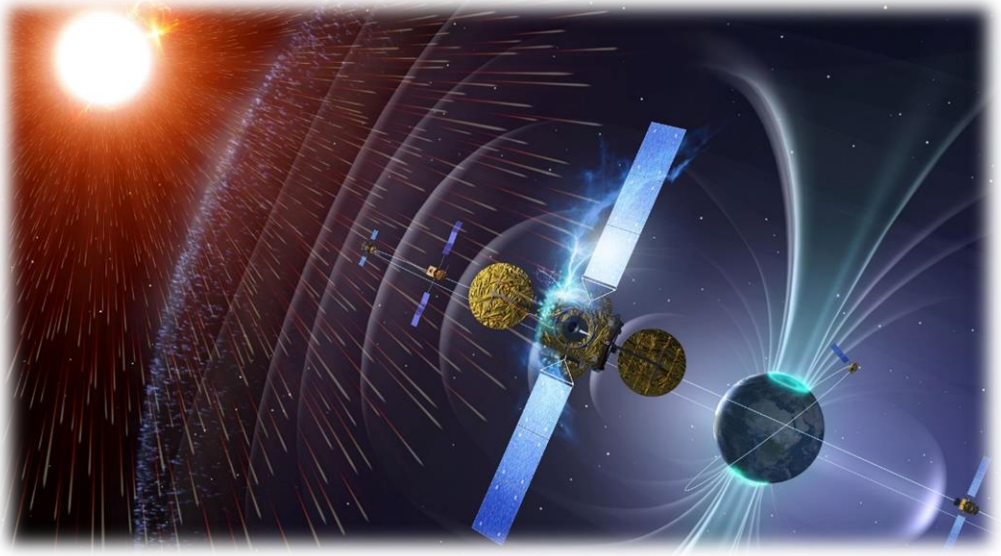
Outline

- ***Objectives of RadMag development***
- ***Detector concept***
- ***RADCUBE: a demonstration CubeSat mission***
- ***Summary and future outlook***

Credits: NASA



Credits: ESA

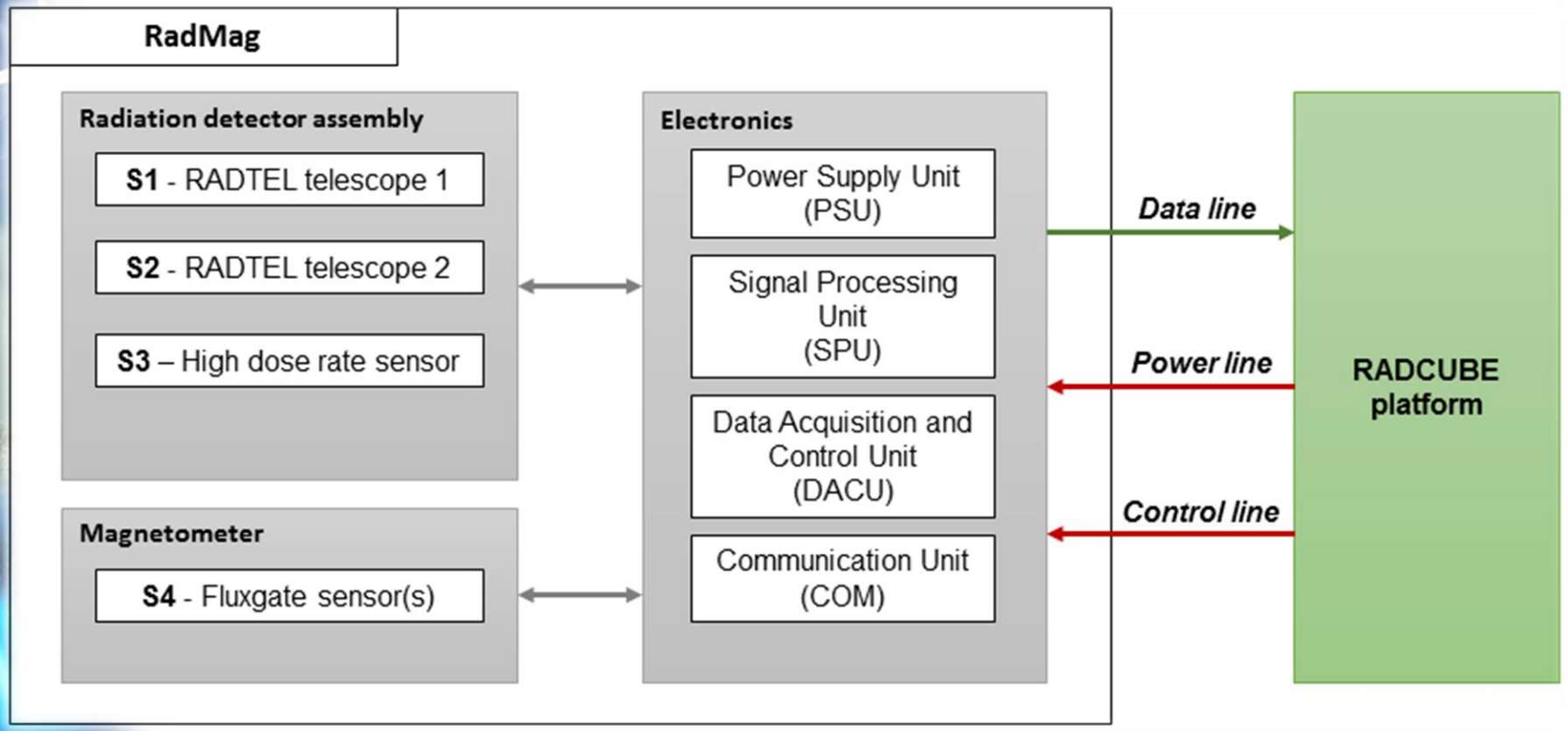
Primary RadMag Mission Objectives

Objective ID	Description
RadMag-O-01	To demonstrate – through successful mission operation – the future use and applicability of the RadMag instrument in strategically important fields, such as space weather research, forecast and general radiation damage monitoring for commercial use as a service.
RadMag-O-02	To demonstrate – through successful mission operation – the operability of the RadMag cosmic radiation and magnetic field measuring instrument for future CubeSat missions in order to provide global coverage of the near-real-time cosmic radiation and magnetic field data.
RadMag-O-03	To perform in-situ measurements of the cosmic radiation field environment in LEO.
RadMag-O-04	To demonstrate the technical feasibility of the magnetic field measurements as a part of the RadMag instrument package.

RadMag conceptual approach

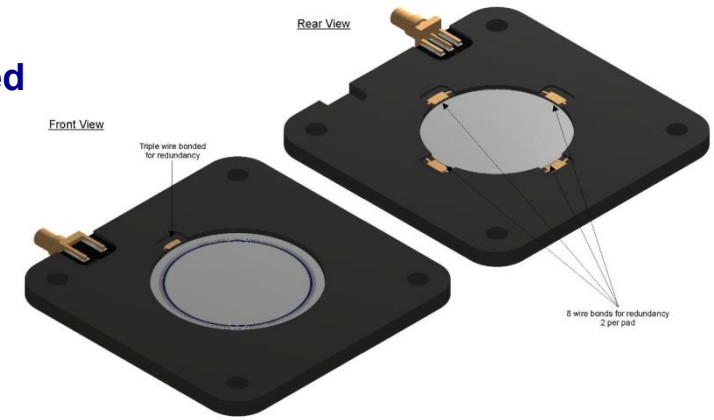
RadMag instrument setup

- ***Compact design:***
  - **» to be realised in 1U standard dimensions (10x10x10 cm^3)**
  - **» mass: below 1 kg**
  - **» power consumption: below 5 W**
  - **» modularity**

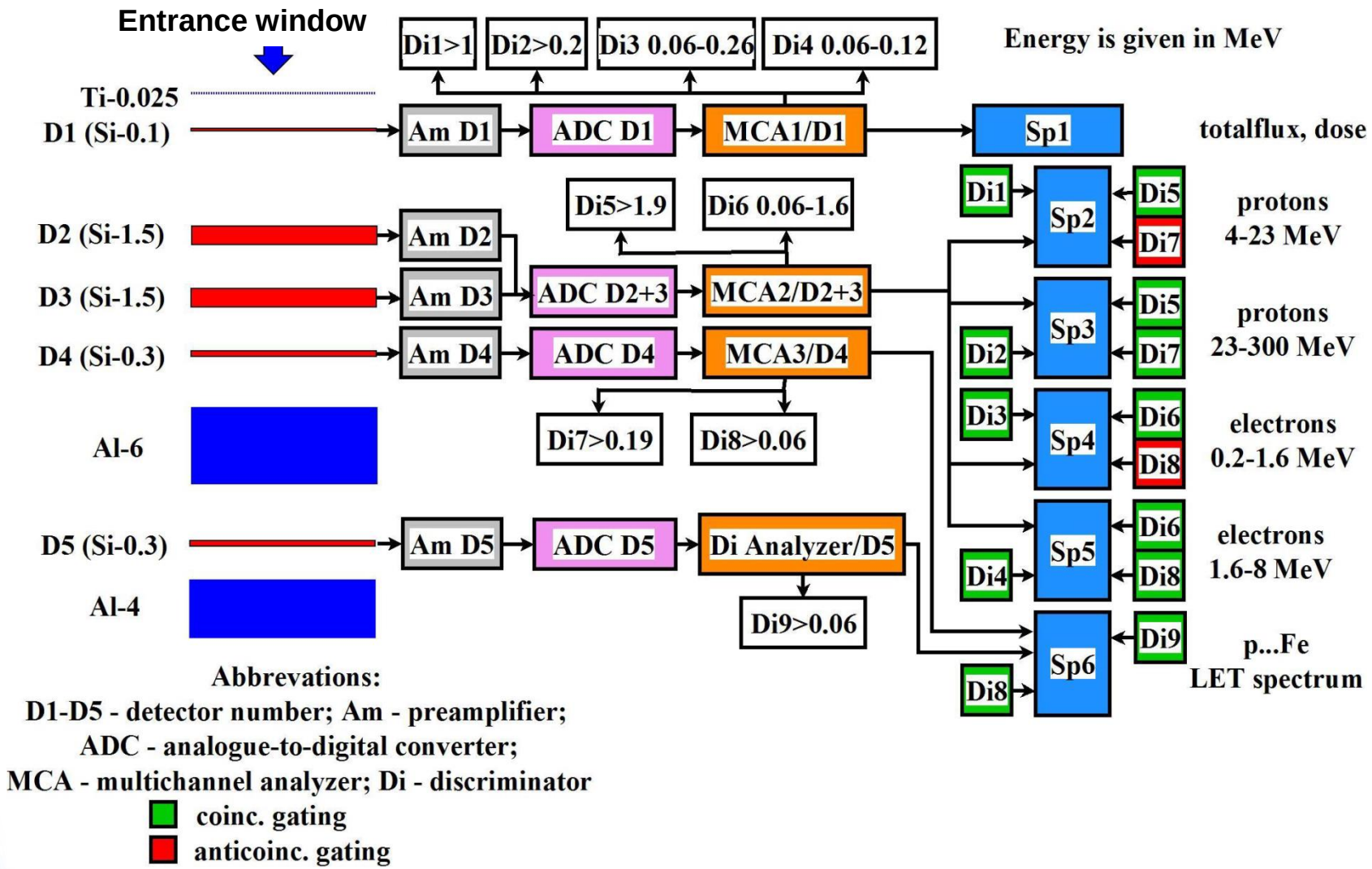


RadMag radiation detector – RADTEL telescopes

- ***Telescopes:***
  - » **to be realised with ion implanted fully depleted planar silicon detectors**
    - **thin lightproof Ti entrance window**
    - **ΔE and E detectors**
    - **Al absorber(s)**
    - **coincidence/anti-coincidence logic**
- ***Analyses (to be) performed:***
  - » **First analysis performed based on stopping power approximations/numerical calculations**
  - » **Monte Carlo simulations just to be started**

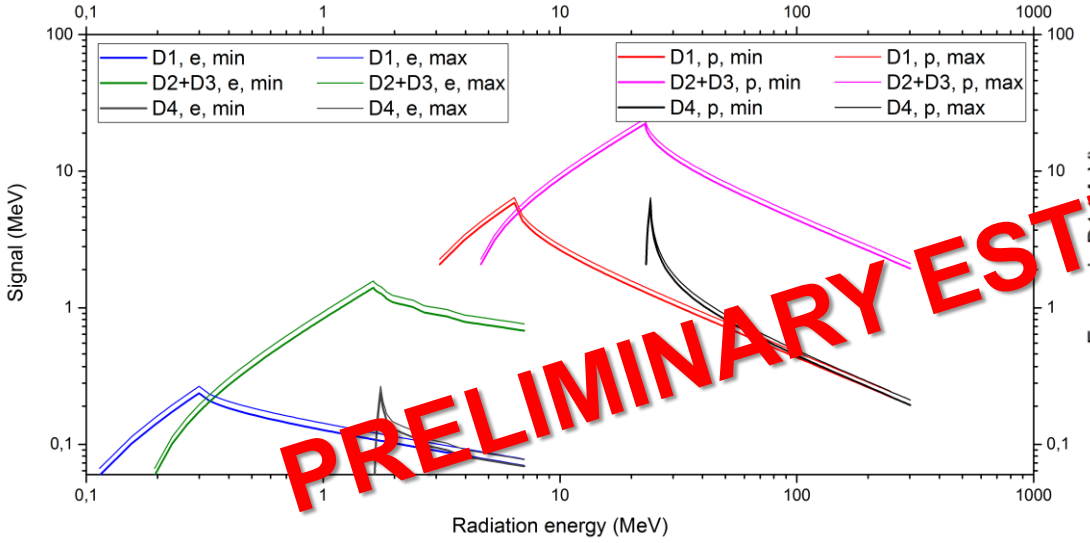


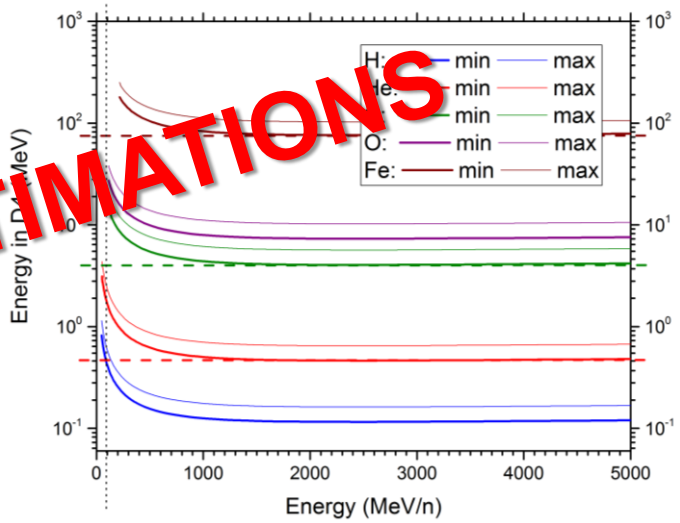
RADTEL logic



The targeted energy ranges

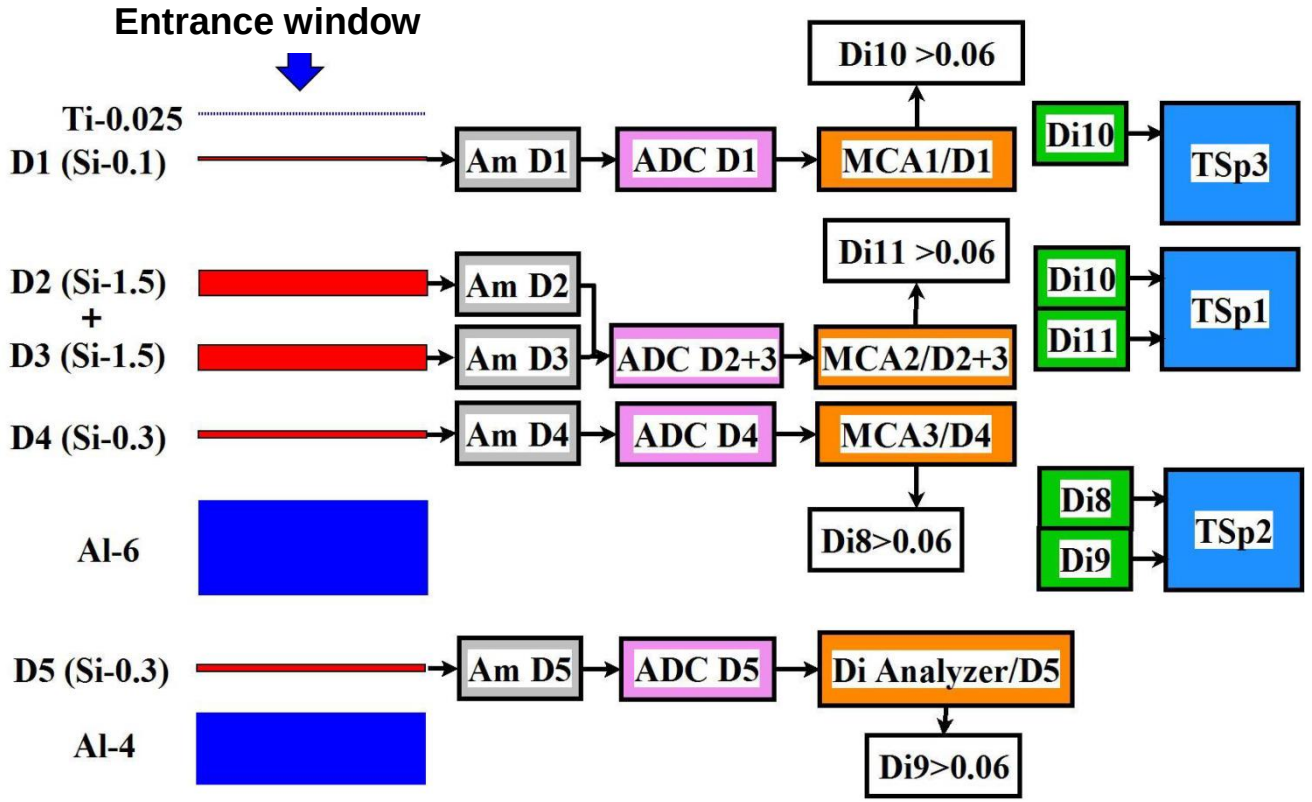
Parameter	Values, ranges
Particle types	electrons, protons, ions
Electron energy range (number of channels)	0.2 MeV – 1.6 MeV (≤24, *TBC*)
	1.6 MeV – 8 MeV (≤11, *TBC*)
Proton energy range (number of channels)	4.0 MeV – 23 MeV (≤19, *TBC*)
	23 MeV – 300 MeV (≤28, *TBC*)
	>100 MeV – 10 GeV (4-5)[1)]
He ion energy range(number of channels)	100 MeV/n – 10 GeV/n (4-5)[1)]
C&N&O ion energy range(number of channels)	100 MeV/n – 10 GeV/n (4-5)[1)]
Fe ion energy range(number of channels)	100 MeV/n – 10 GeV/n (4-5)[1)]





PRELIMINARY ESTIMATIONS

RADTEL logic



Abbrevations:

D1-D5 - detector number; Am - preamplifier;
ADC - analogue-to-digital converter;
MCA - multichannel analyzer; Di - discriminator

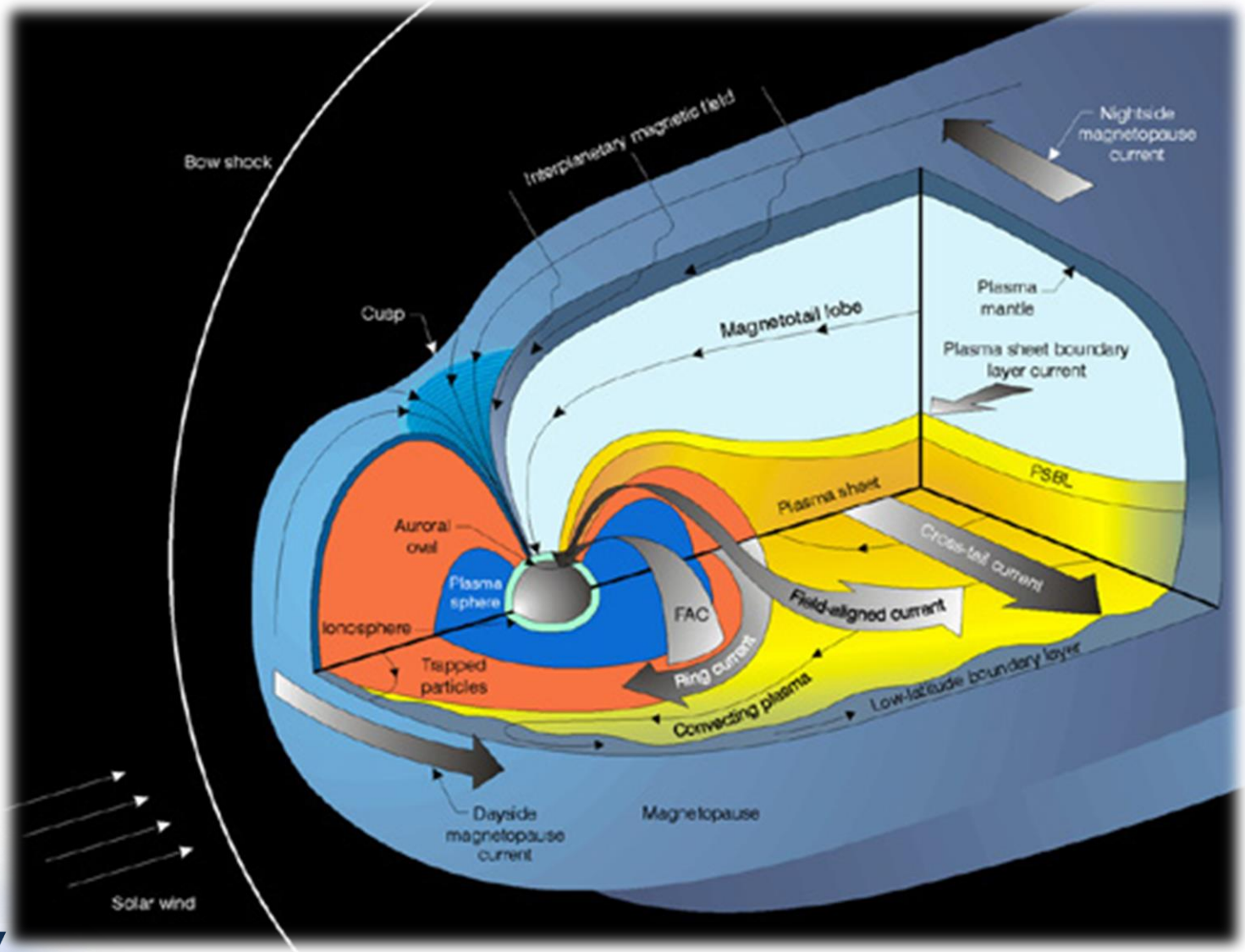
coinc. gating

anticoinc. gating

Energy is given in MeV

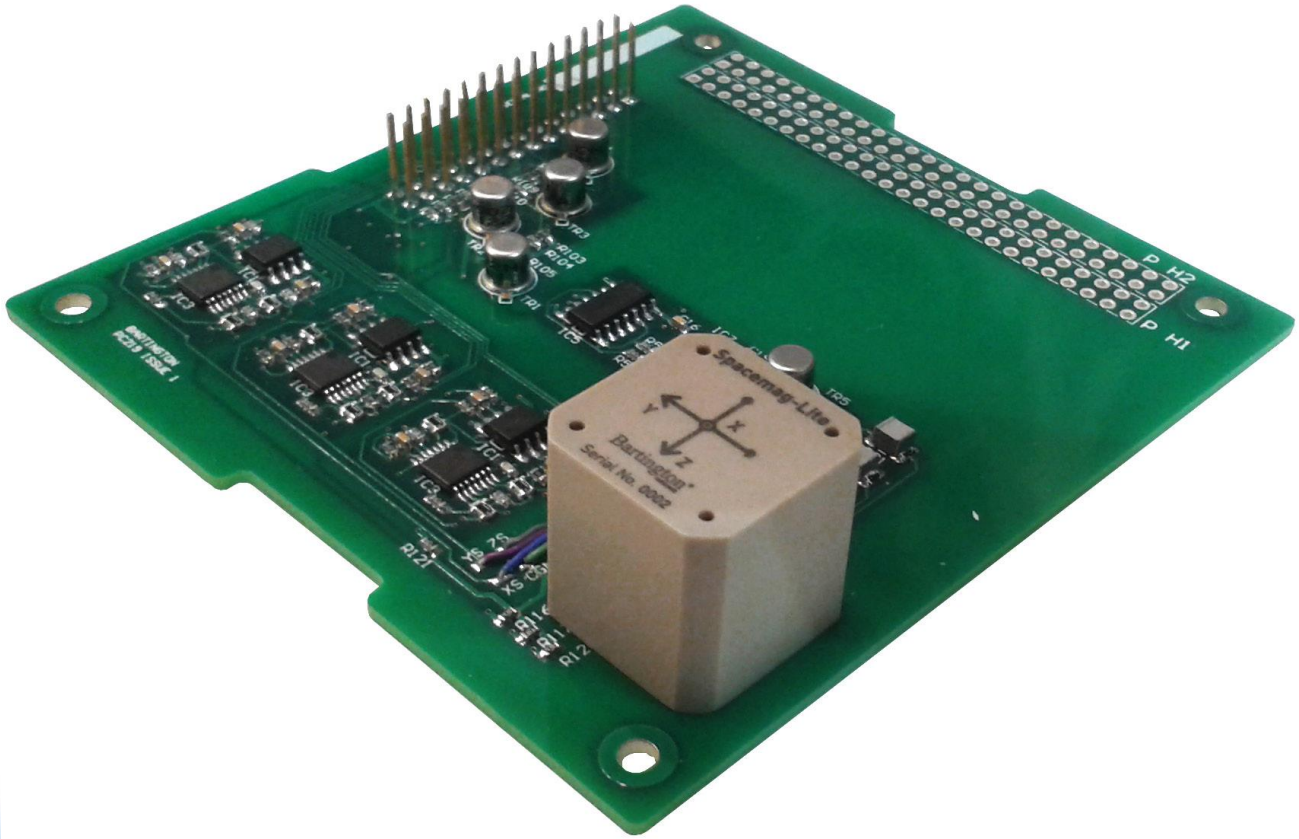
RadMag radiation detector – dose rate measurements

EURORAD 7mm^2 Si diodes for high flux measurements (pulse and current measurement mode)


Bow shock
Interplanetary magnetic field
Nightside magnetopause current
Cusp
Magnetotail lobe
Plasma mantle
Plasma sheet boundary layer current
PSBL
Plasma sheet
Aurora oval
Plasma sphere
Ionosphere
Trapped particles
FAC
Ring current
Field-aligned current
Cross-tail current
Convecting plasma
Low-latitude boundary layer
Dayside magnetopause current
Magnetopause
Solar wind

RadMag Magnetometer

Three-axis fluxgate magnetometer (one possible solution: Spacemag-Lite)



RadMag Magnetometer

Noise from platform (dipole approximation):

Distance from the centre of the dipole (cm)	Magnetic noise (nT) for different source magnetic moments			
	20 mA·m²	40 mA·m²	60 mA·m²	80 mA·m²
5	16,000	32,000	48,000	64,000
10	2,000	4,000	6,000	8,000
30	74	148	222	296
100	2	4	6	8
200	0.25	0.5	0.75	1

→ **Sensor on boom + internal reference sensor ?**

RadMag Magnetometer

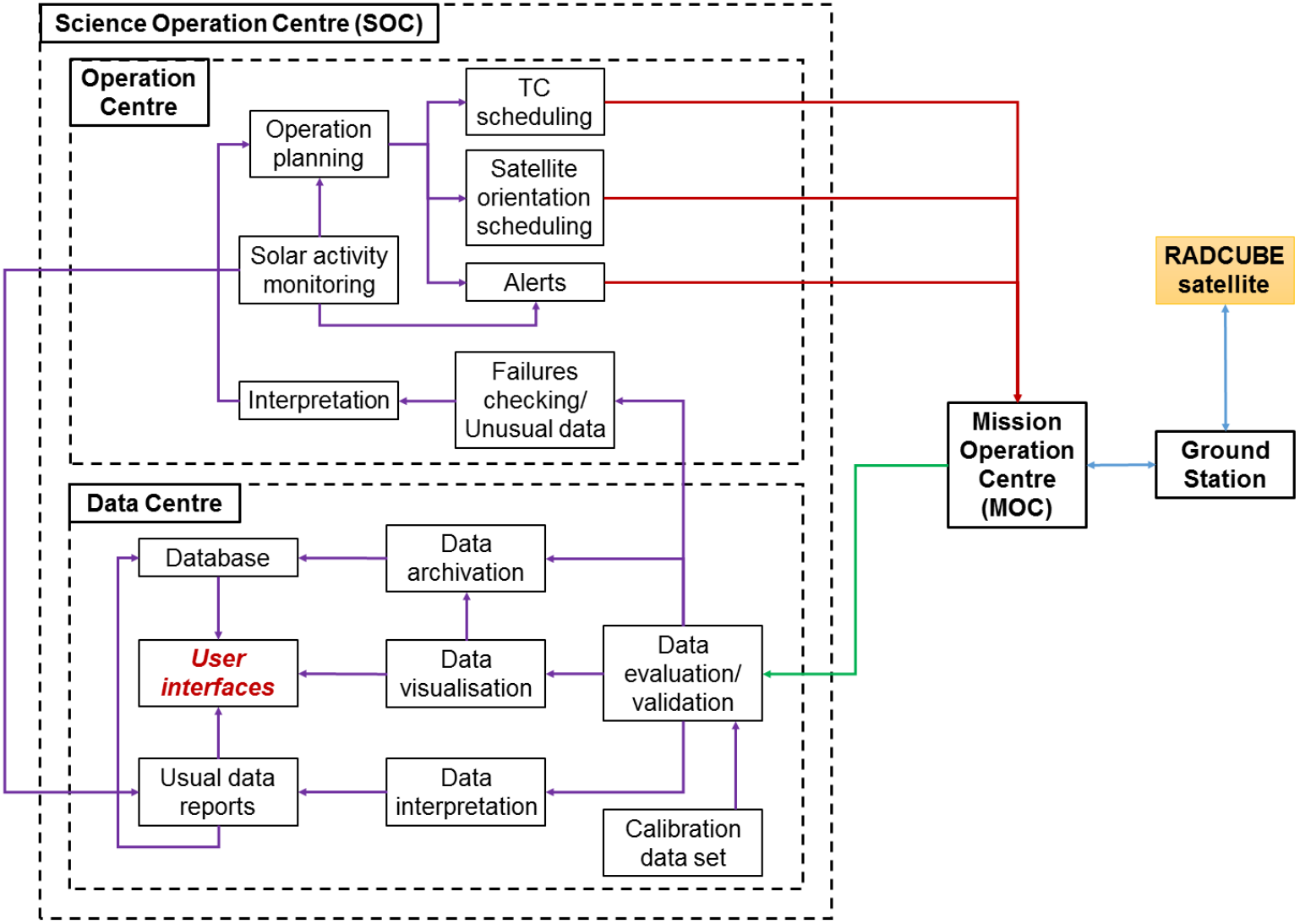
RadMag magnetometer goals		
Measurement levels	**Level 1 in nominal operation mode**	**Level 2 in high resolution mode**
Scientific goals	- overall mapping of the geomagnetic field to support radiation data analysis. - data contribution for attitude determination.	- geomagnetic field region localization to support radiation data analysis (SAA, FACs – auroral oval); - inputs for geomagnetic field model validations/comparison.
Range	±60000 nT	±60000 nT
Accuracy	1000-5000 nT	1-10 nT
Sampling rate	0.05-0.5 Hz	0.5-10 Hz

RadMag Technical Details – Budgets

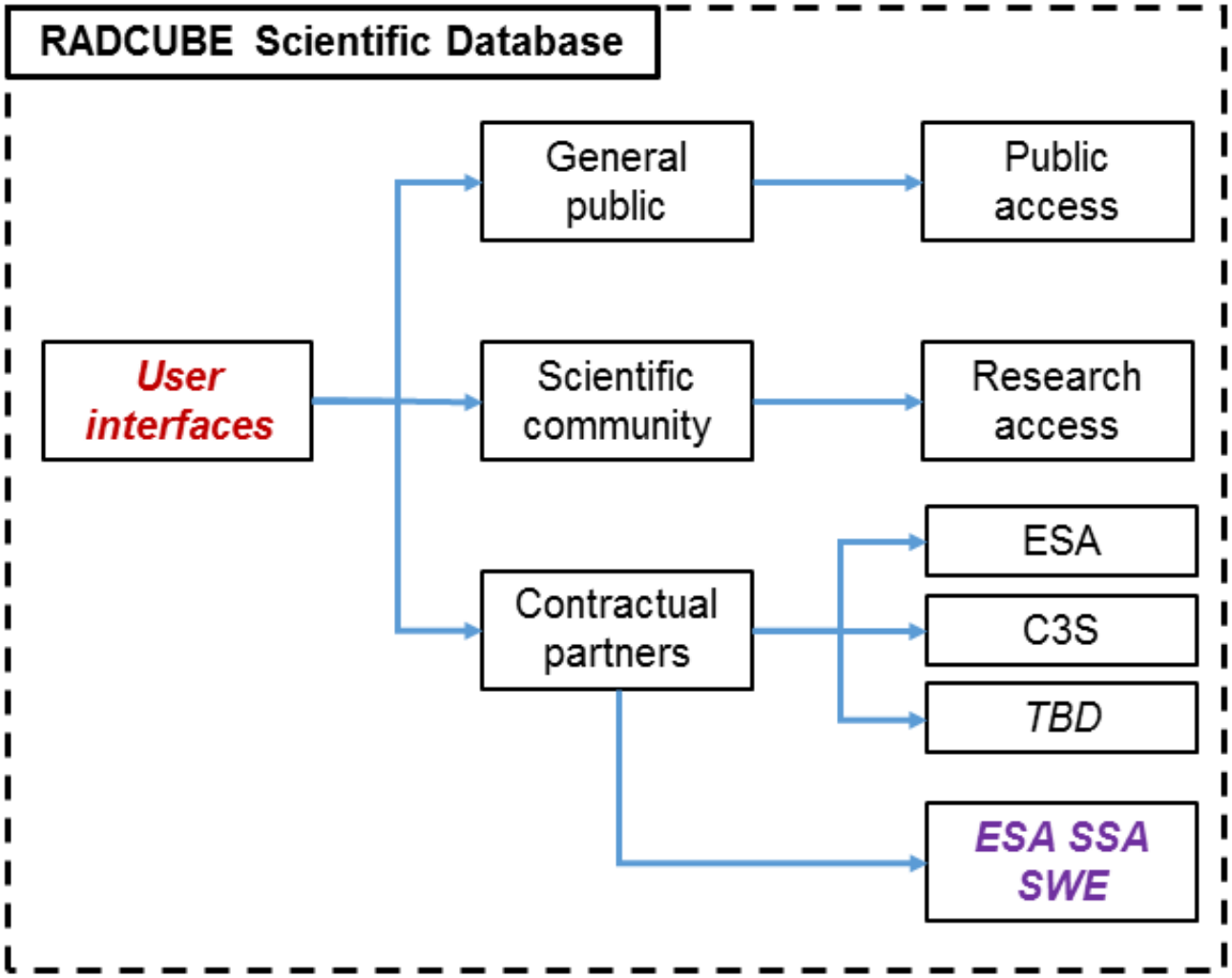
Technical constraints	Preliminary limits	Margin
Volume	Lenght ≤ 14 cm (Cross-section 10×10 cm^2)	With 20% included
Mass	≤ 1.1 kg	With 20% included
Power consumption	≤ 5.5 W	With 20% included
Provided data rate	≤ 170 kByte/orbit	With 20% included
Operational temperature range	Operational: [-40; +40] °C Non-operational: [-40; +60] °C	N/A

Category	Design maturity	Margins
A	Existing hardware	±5%
B	Design based on existing hardware with minor modifications	±10%
C	Detailed Design	±15%
D	Preliminary Design	±20%

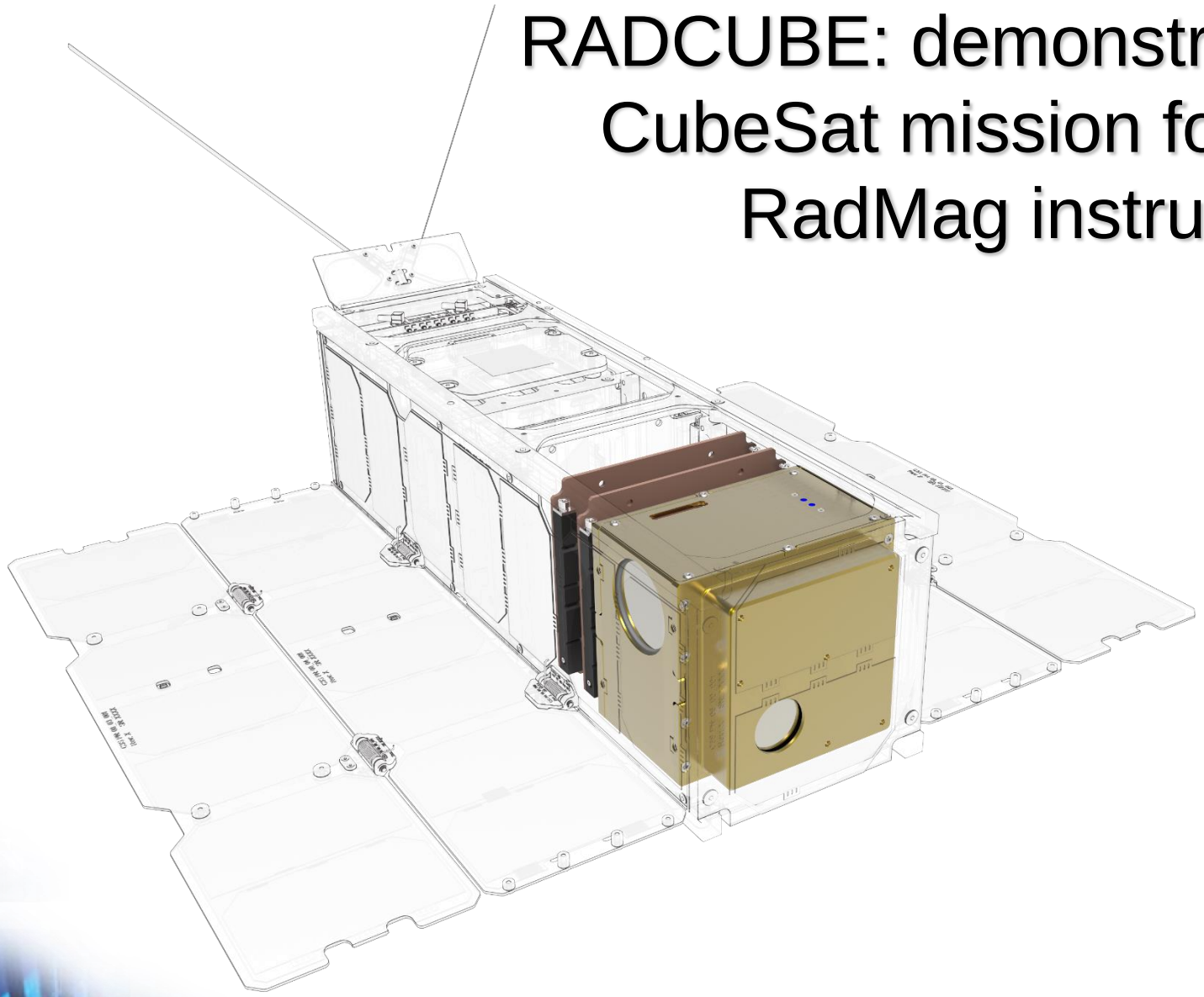
RadMag Science Operation and Data Centre



RadMag Science Operation and Data Centre



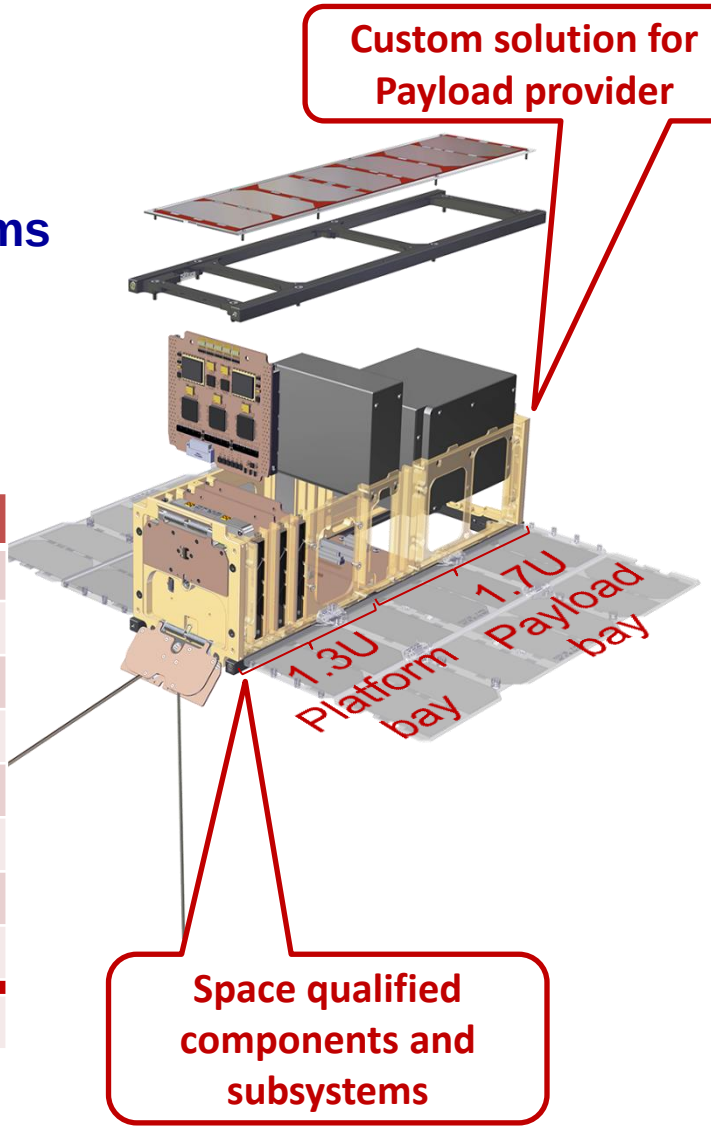
RADCUBE: demonstration CubeSat mission for the RadMag instrument



3U/6U CubeSat Platform by C3S LLC

- ***Key features***
  - » **Single-point failure tolerant**
  - » **Double redundancy in all subsystems**
  - » **High reliability and availability**
  - » **3 year design lifetime in LEO**
- ***Planned first IOD mission: 2018***

Technologies	Provider	Availability	ESA support
STRU	C3S	*TRL 7*	✓
OBC	C3S	*TRL 7*	✓
EPS	C3S	TRL 3	
COM-UHF TX/RX	C3S	*TRL 7*	✓
COM-S TX	C3S	TRL 3	
ADCS	3rd party		
GNS RX	3rd party		
IPC	C3S / 3rd party		
Payload(s)	C3S / 3rd party		



C3S

3U/6U CubeSat Platform by C3S LLC

Less than 10 min. **integration time** for any subsystem

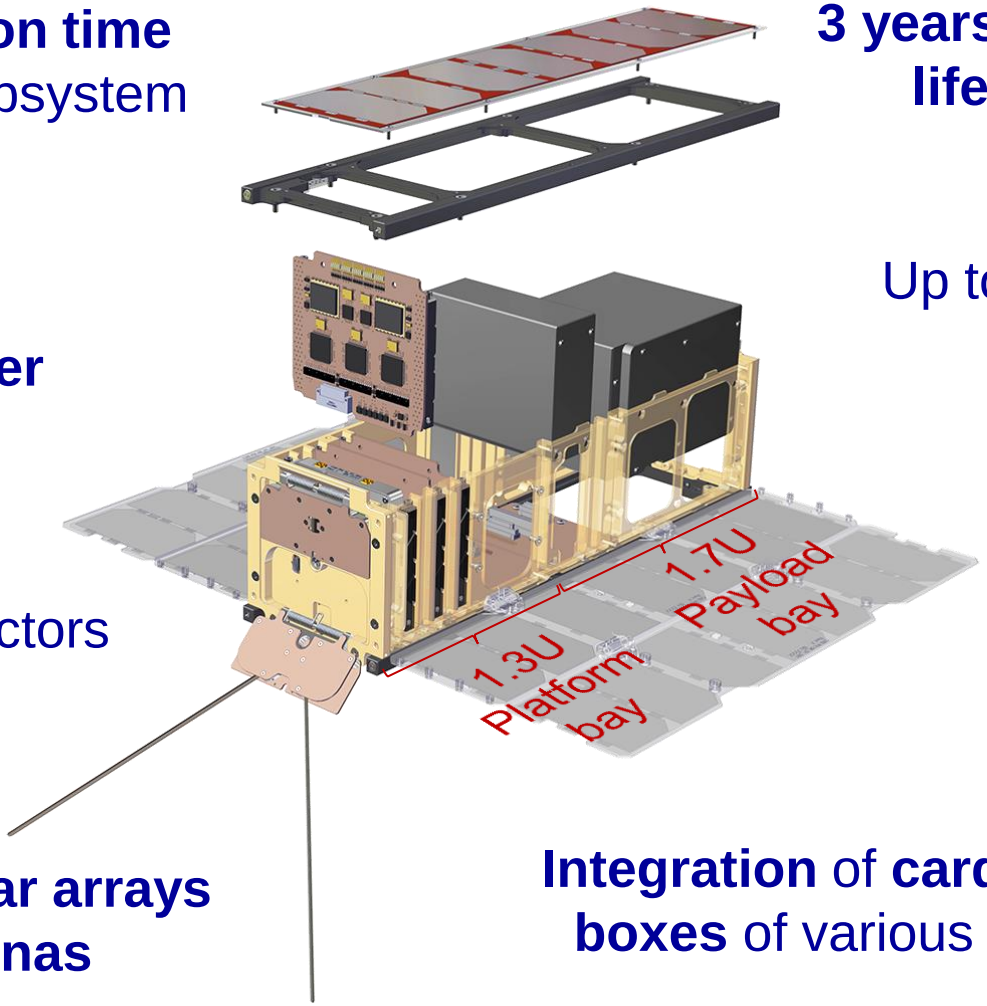
3 years design lifetime in LEO

PC 104 compatible **converter**

Up to **60W Input** Power

Space qualified connectors

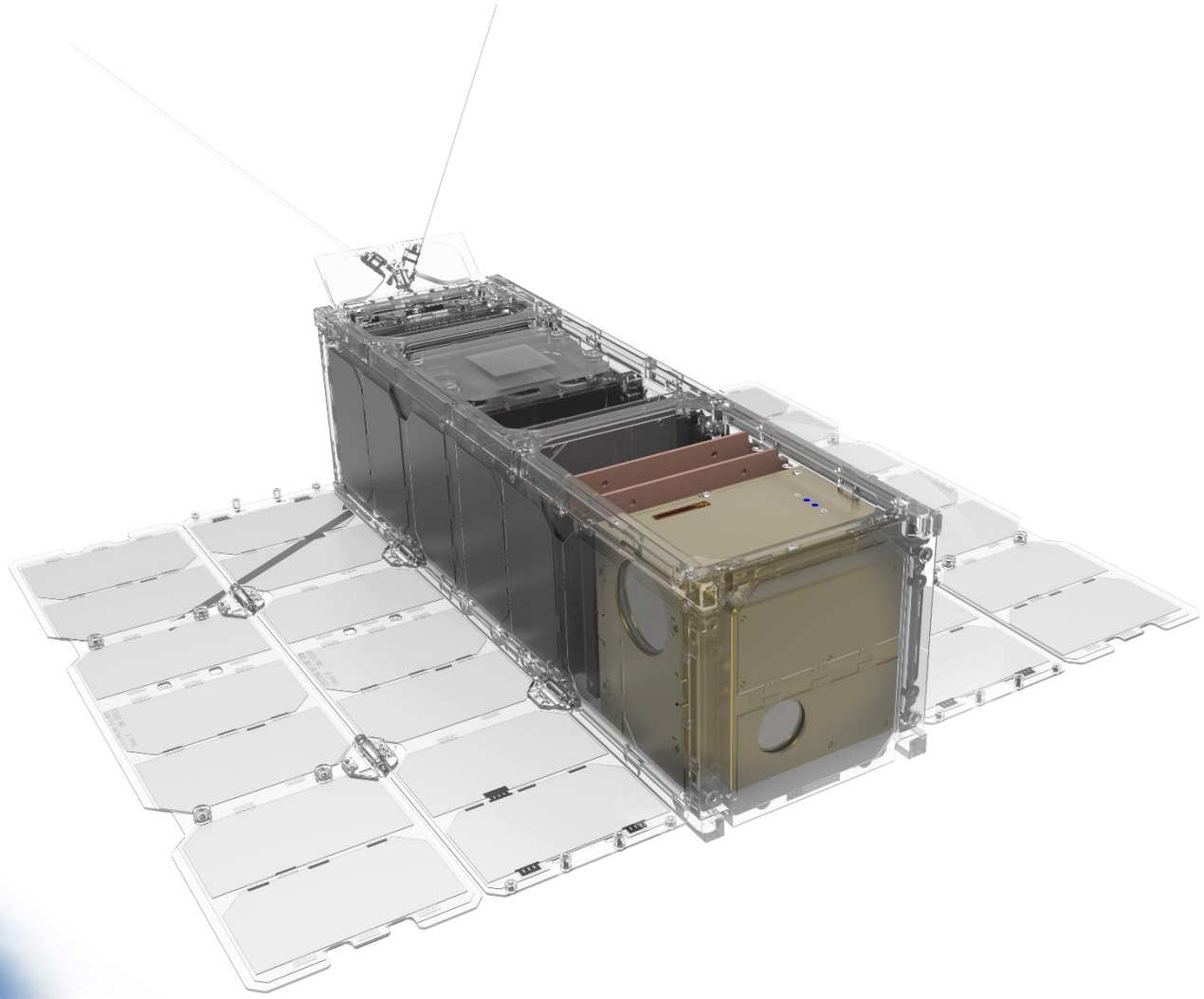
Up to **60% Payload** Bay



Deployable **solar arrays and antennas**

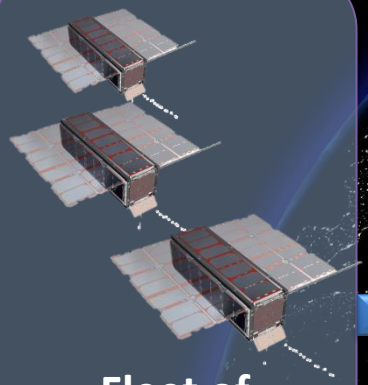
Integration of **cards and boxes** of various sizes

C3S



Summary and future outlook

Future space weather services using fleet of CubeSats



Fleet of CubeSats and Ground Stations

Space radiation environment information system

Space weather/ radiation damage related database

Space weather/ radiation damage forecast services

Users:

RADCUBE – GSTP 6.3 IOD CUBESAT MISSION

Phase A/B1 is being realised under
ESA contract No. 4000117620/16/NL/LF/as

Thank you for your attention

www.radcube.hu