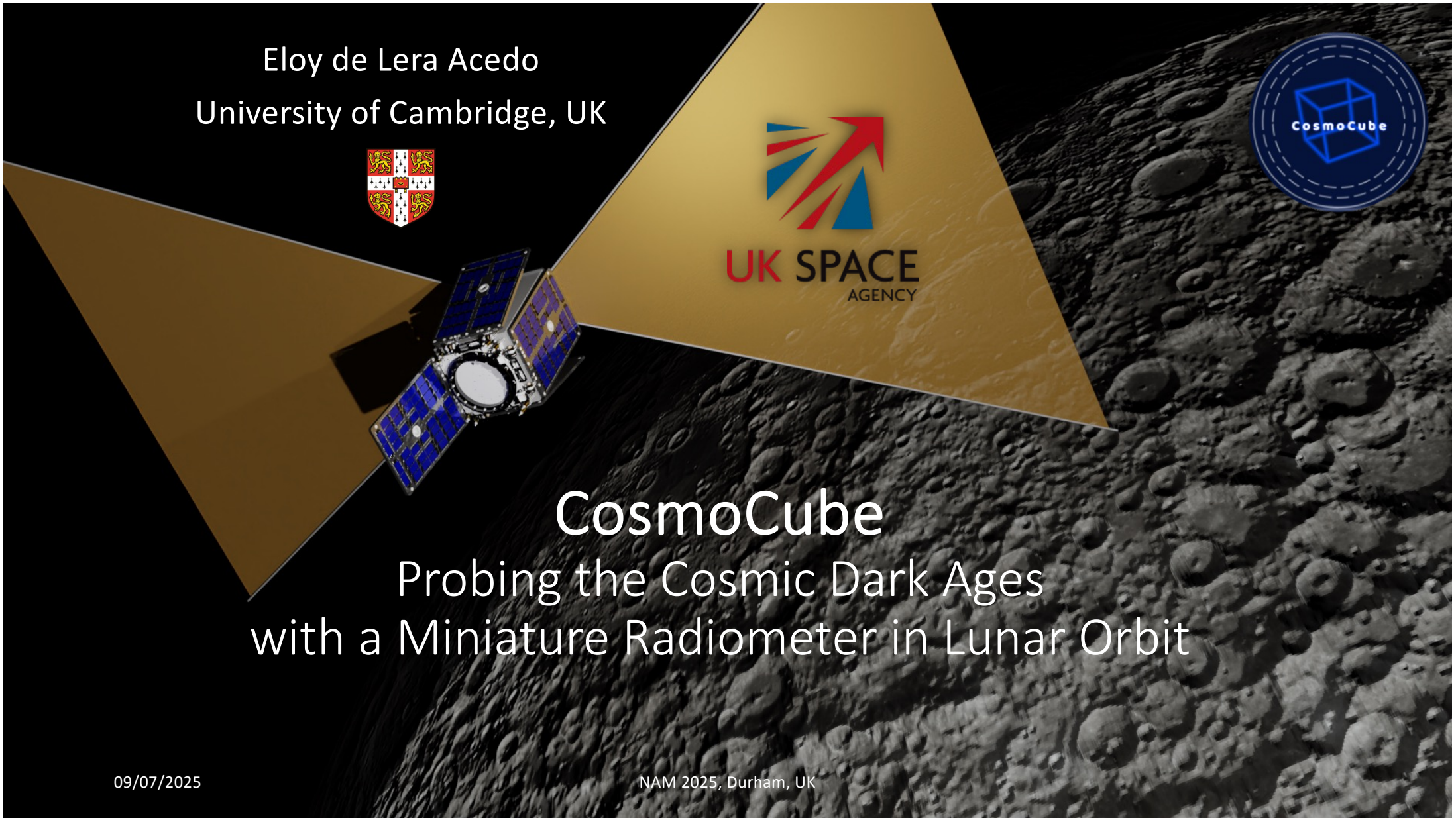
Eloy de Lera Acedo
University of Cambridge, UK



CosmoCube

Probing the Cosmic Dark Ages with a Miniature Radiometer in Lunar Orbit

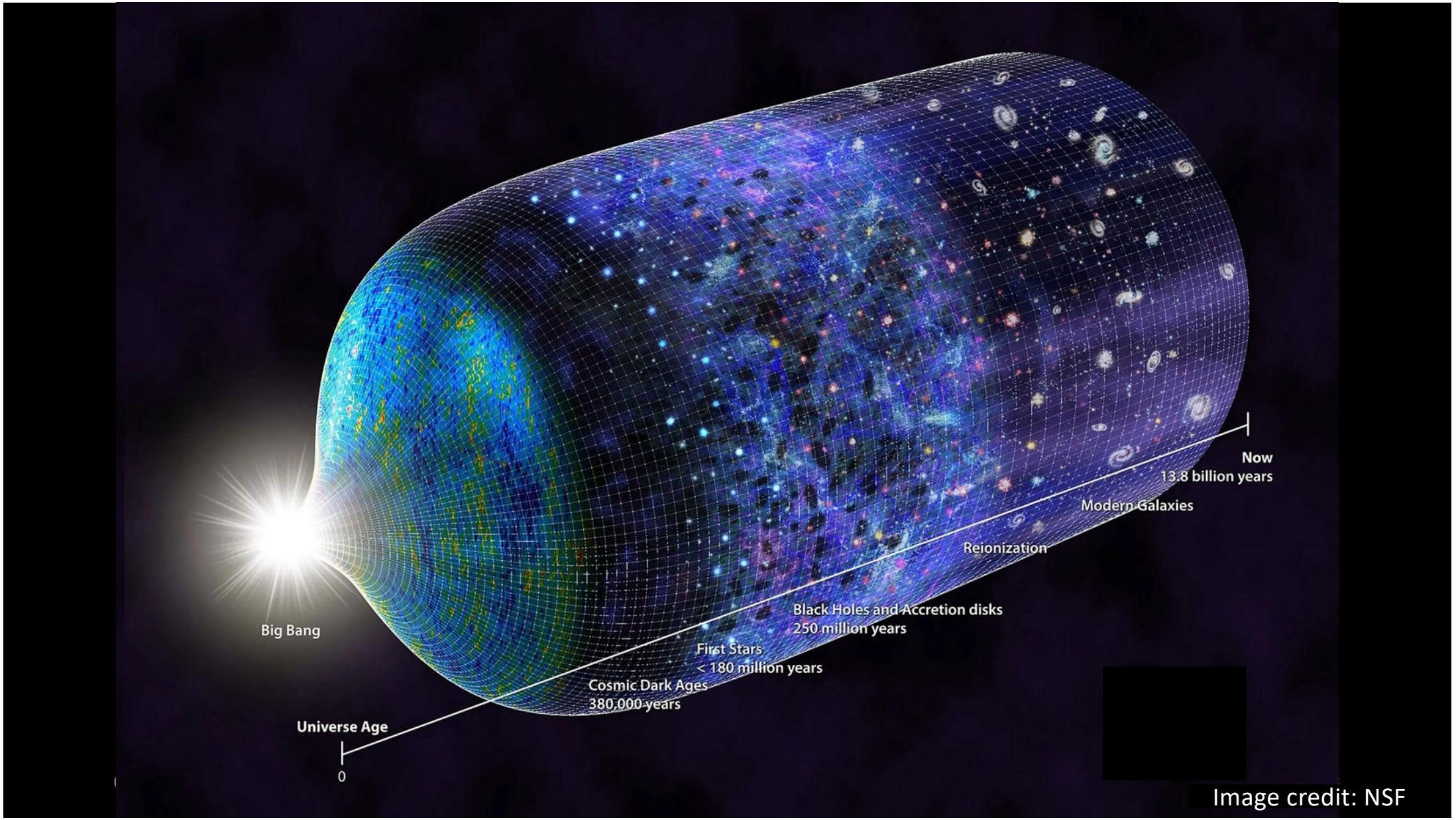


Image credit: NSF

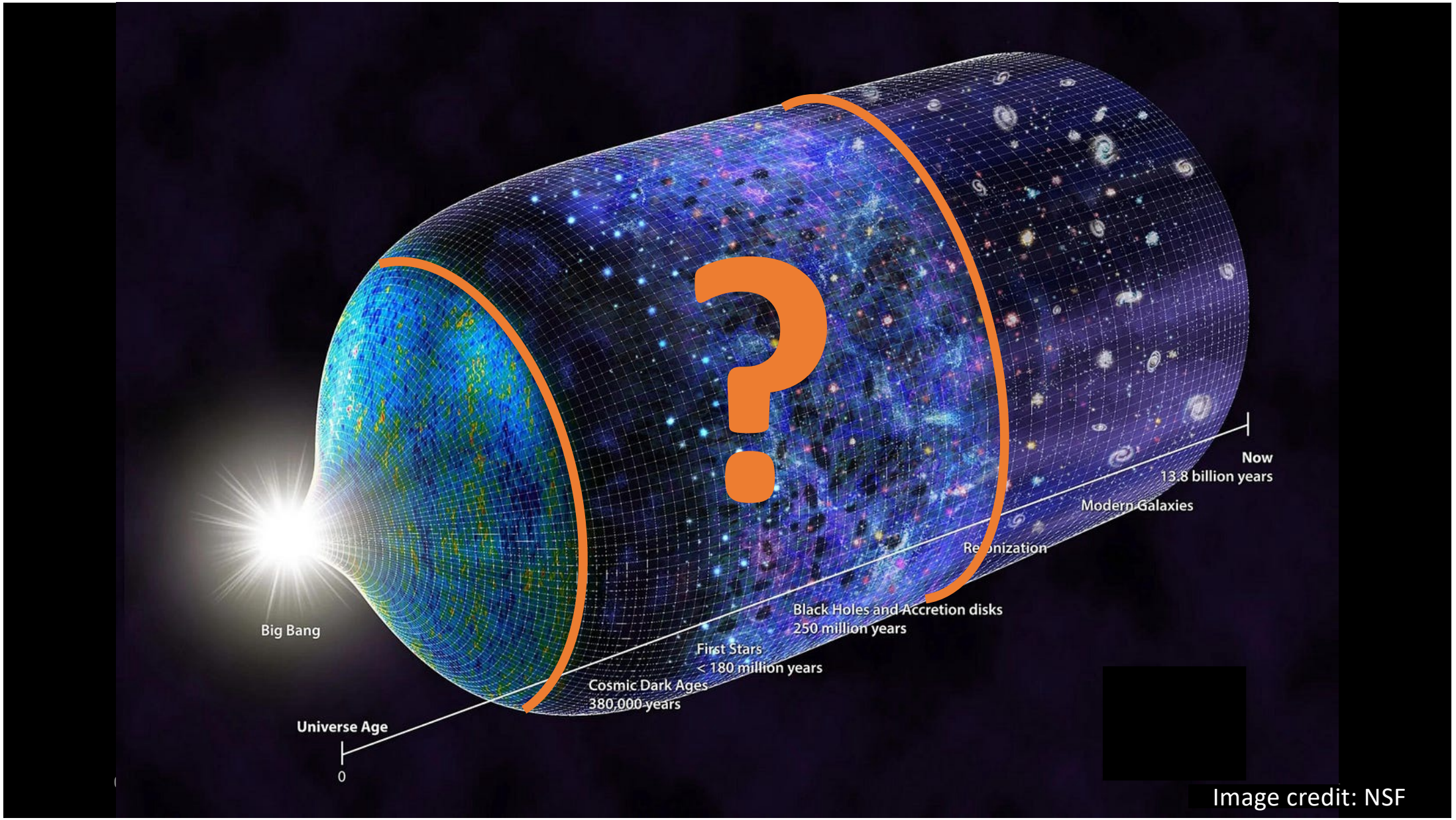


Image credit: NSF

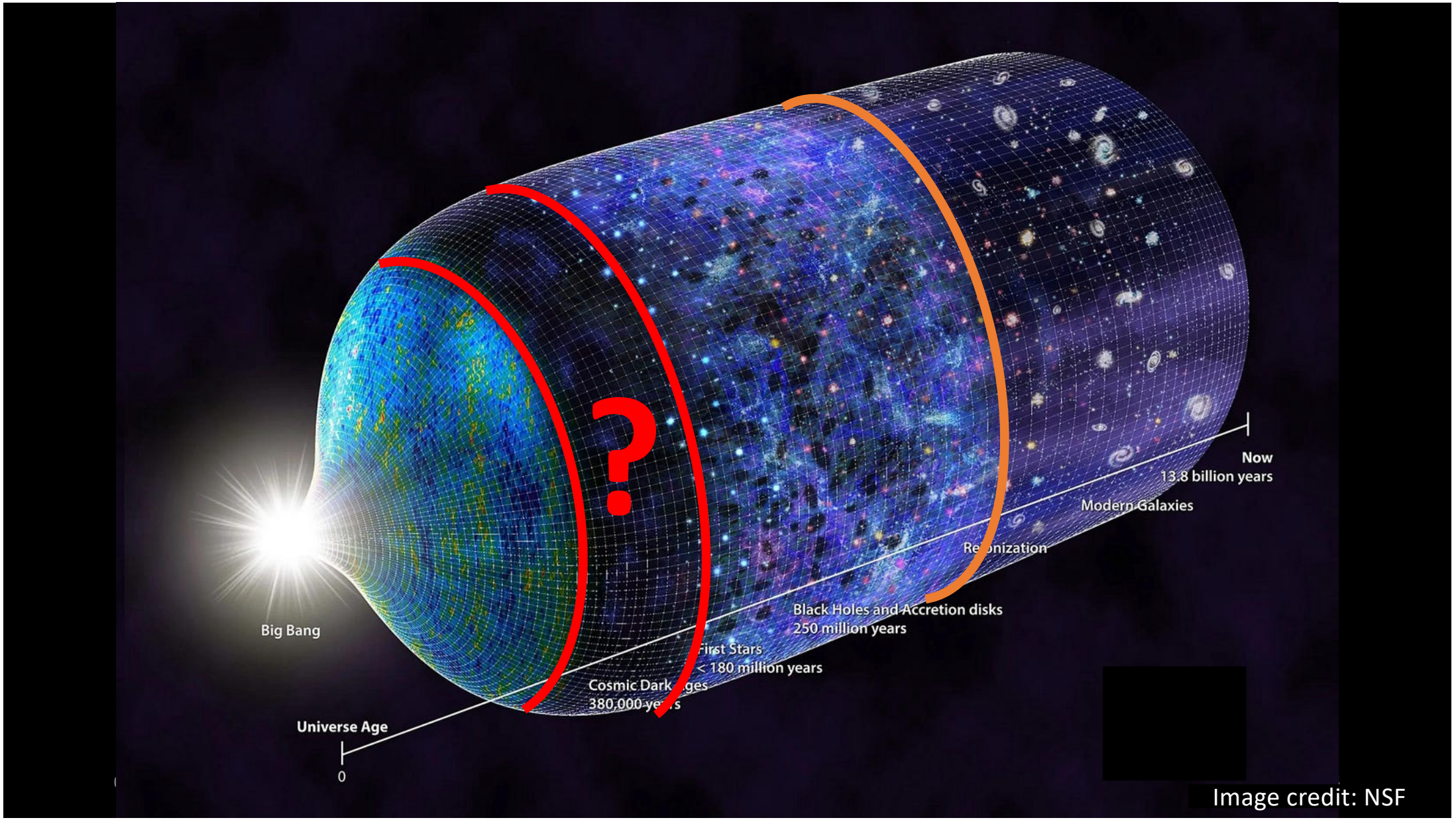
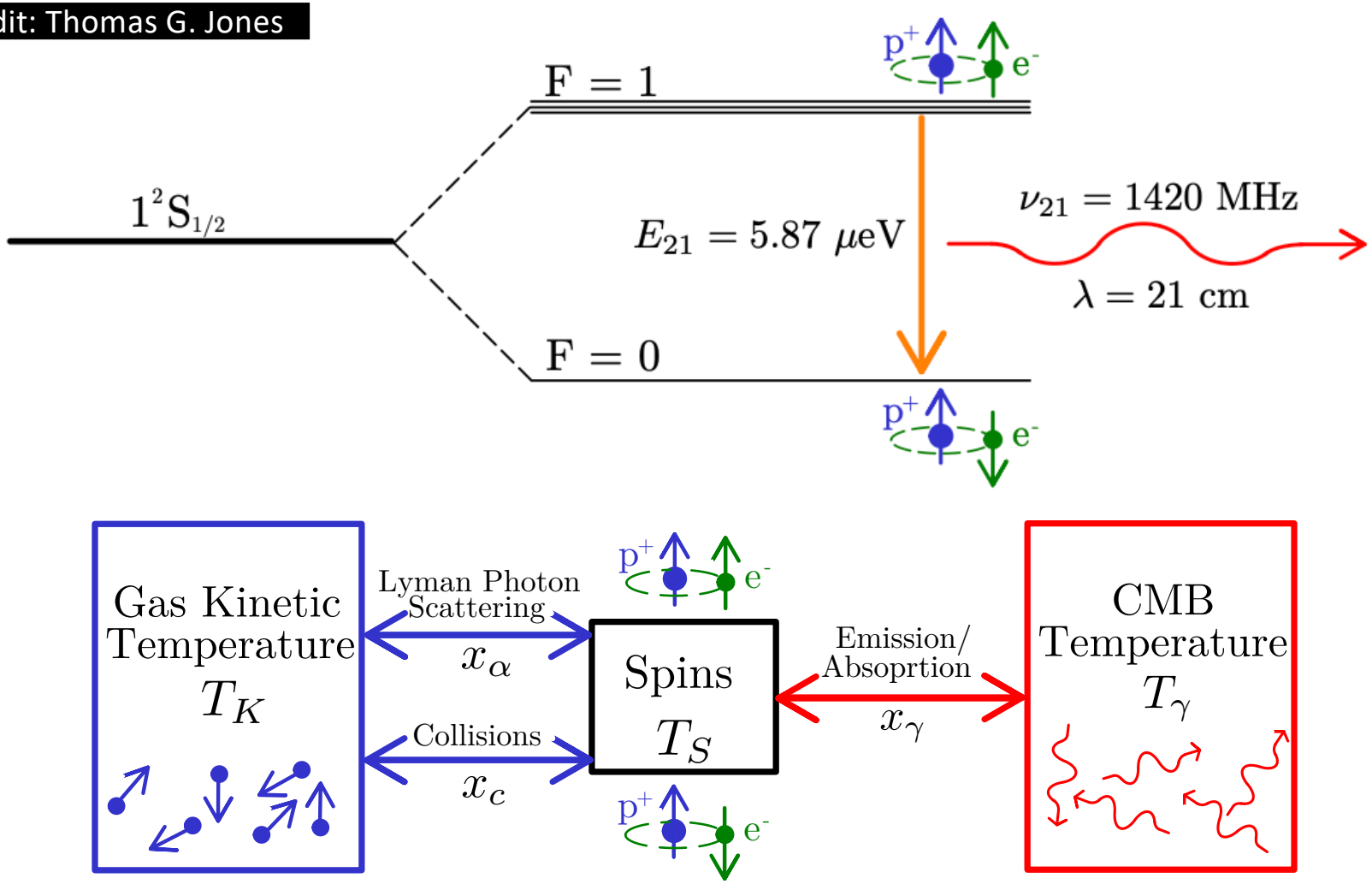
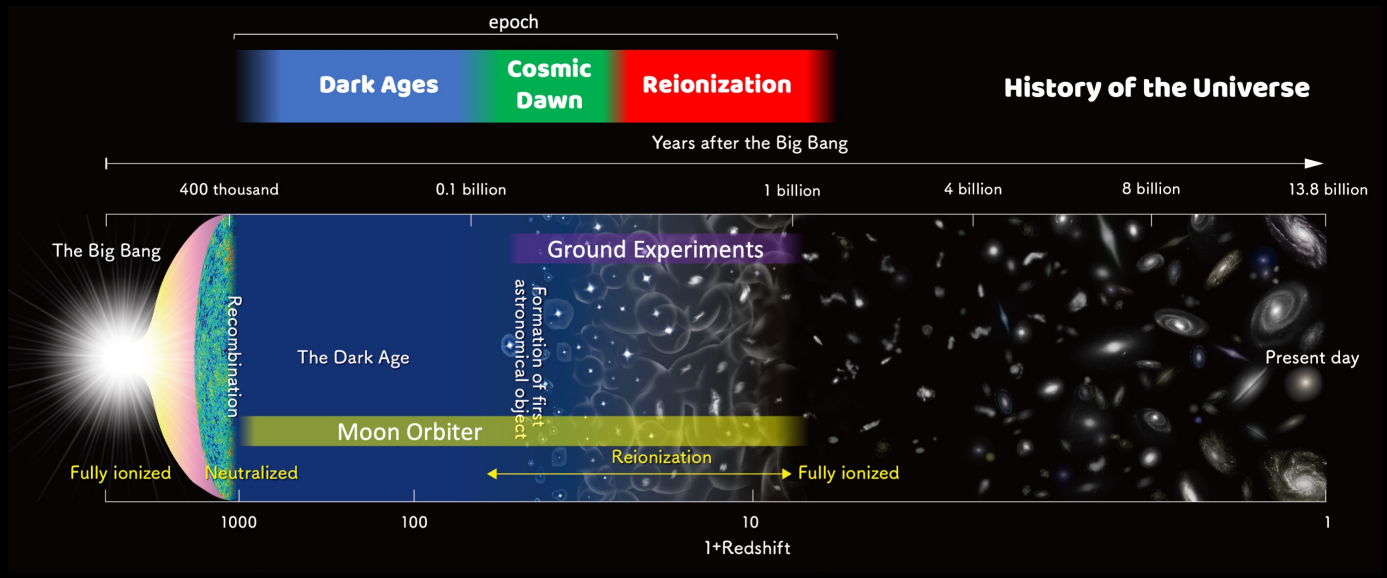
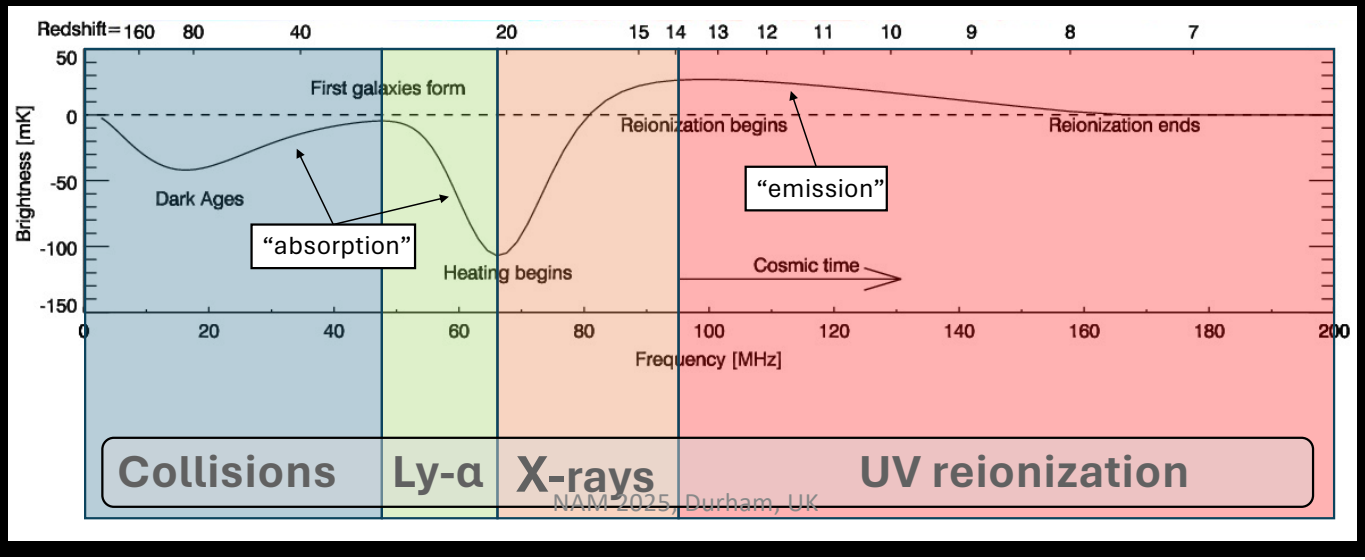


Image credit: NSF

Image credit: Thomas G. Jones




epoch
Dark Ages
Cosmic Dawn
Reionization
History of the Universe
Years after the Big Bang
400 thousand
0.1 billion
1 billion
4 billion
8 billion
13.8 billion
The Big Bang
Recombination
The Dark Age
Formation of first astronomical object
Ground Experiments
Moon Orbiter
Present day
Fully ionized
Neutralized
Reionization
Fully ionized
1000
100
10
1
1+Redshift


Redshift=
160
80
40
20
15
14
13
12
11
10
9
8
7
Brightness [mK]
50
0
-50
-100
-150
First galaxies form
Dark Ages
"absorption"
Heating begins
Reionization begins
Reionization ends
"emission"
Cosmic time
0
20
40
60
80
100
120
140
160
180
200
Frequency [MHz]
Collisions
Ly-α
X-rays
UV reionization

Ground-based experiments

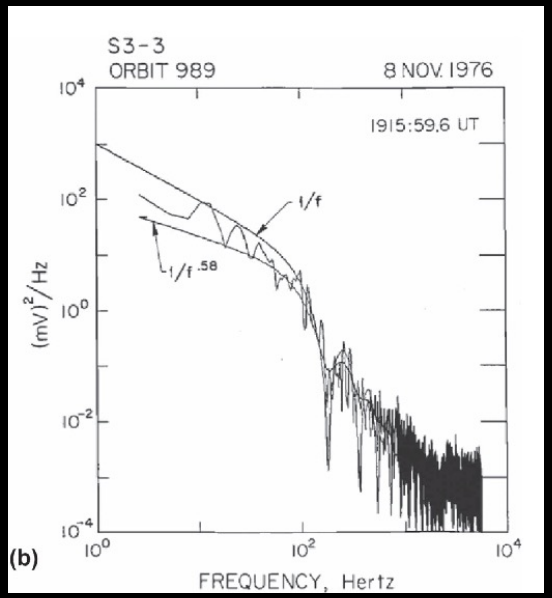
Foreground power: ~ 5,000.0 K

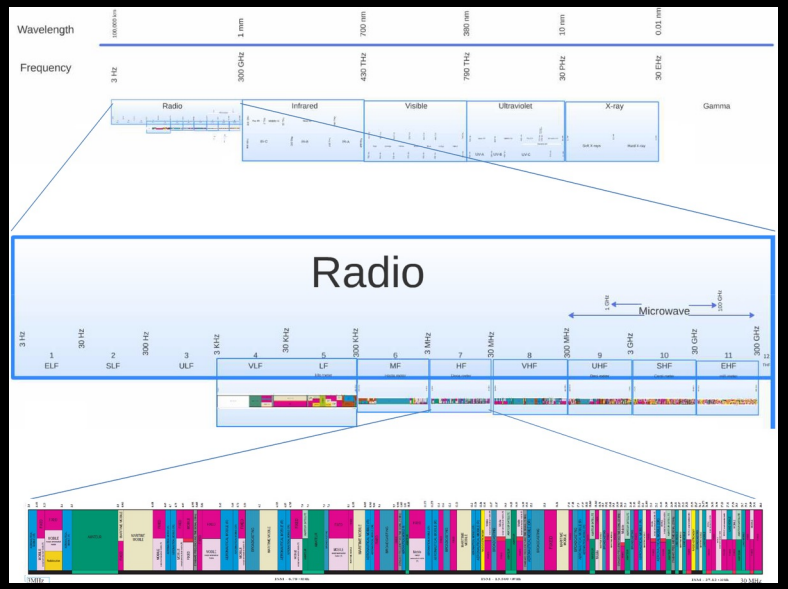
Systematics: ~ 100.0 K

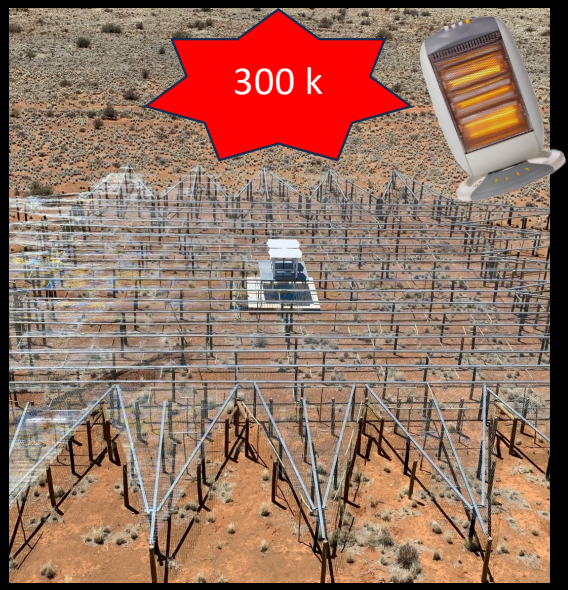
21-cm signal: ~ 0.1 K

Exquisite foreground and radiometer calibration required

Challenges on the ground







Earth's Ionosphere

RFI

Near field emissions

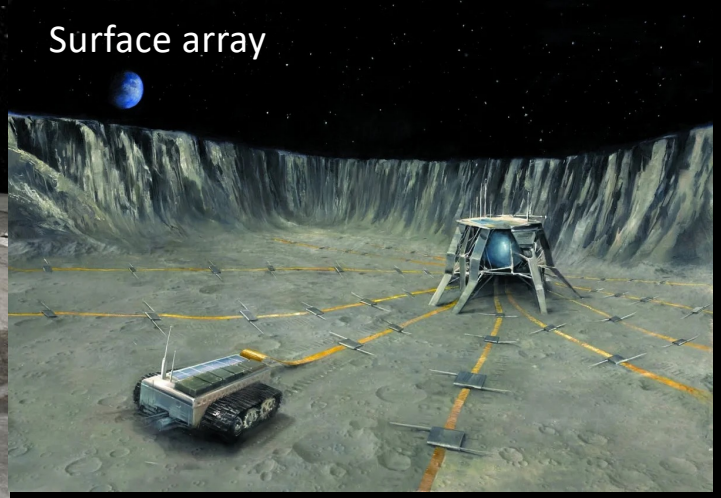
Solutions in space

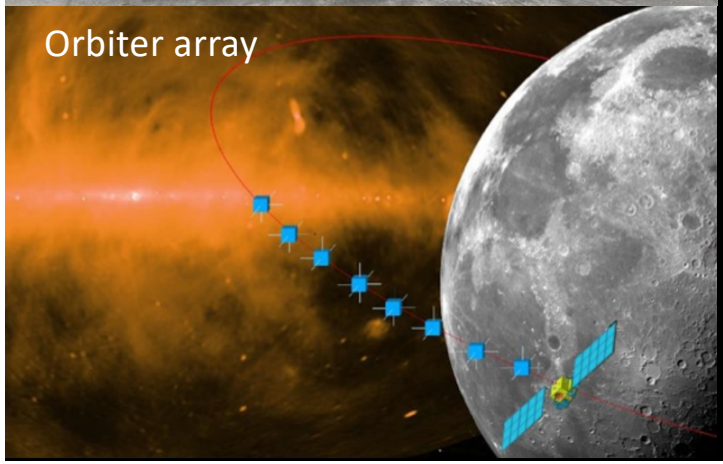
- Earth's Ionosphere
- RFI
- Near field emissions

A space mission on the far side of the Moon, in orbit

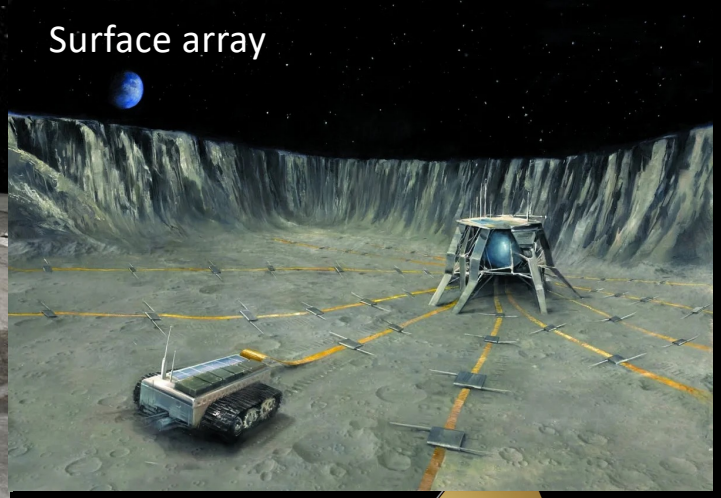
Unique opportunity if humankind's history, first time we are capable of doing this, but maybe the last time too…

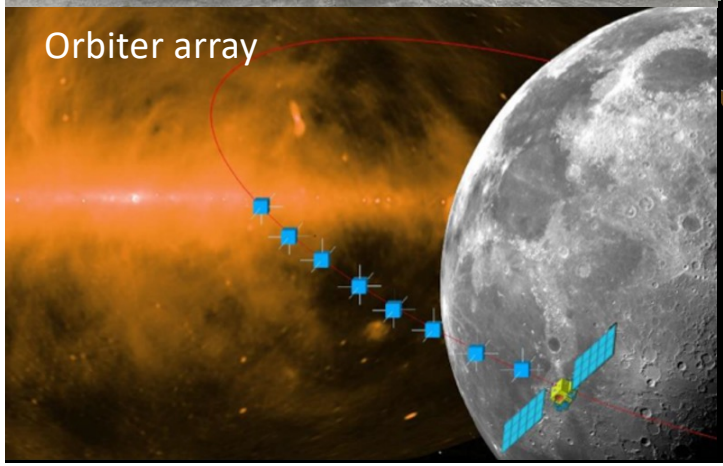
The Moon is back on the agenda

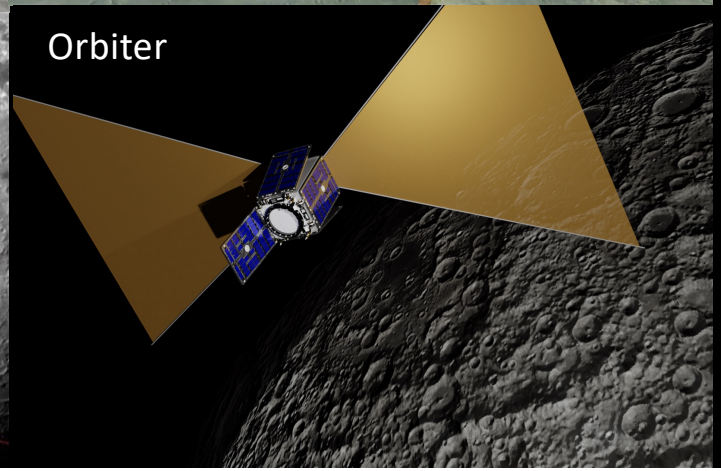




The Moon is back on the agenda







Funding

UK SPACE AGENCY

Core members

UNIVERSITY OF CAMBRIDGE

UNIVERSITY OF PORTSMOUTH

RAL Space

Collaborators

NASA Jet Propulsion Laboratory California Institute of Technology

SURREY

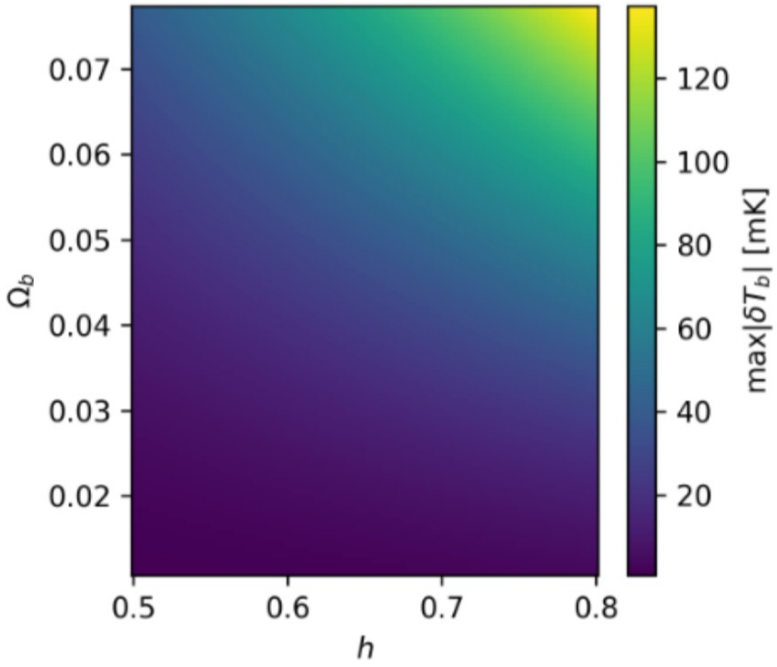
L-Università ta' Malta

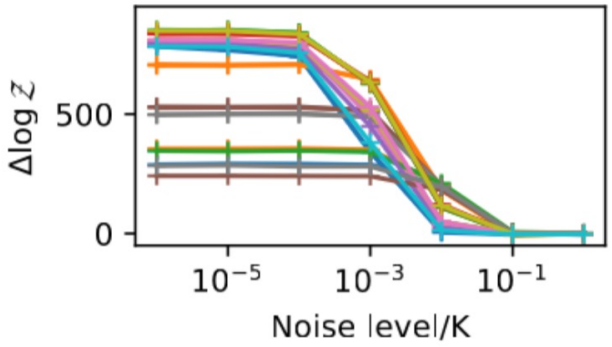
EMBRY-RIDDLE 1926 AERONAUTICAL UNIVERSITY

ASU

^ *de Lera Acedo et al.,* 2025, in review. (Nat Ast)

Requirements

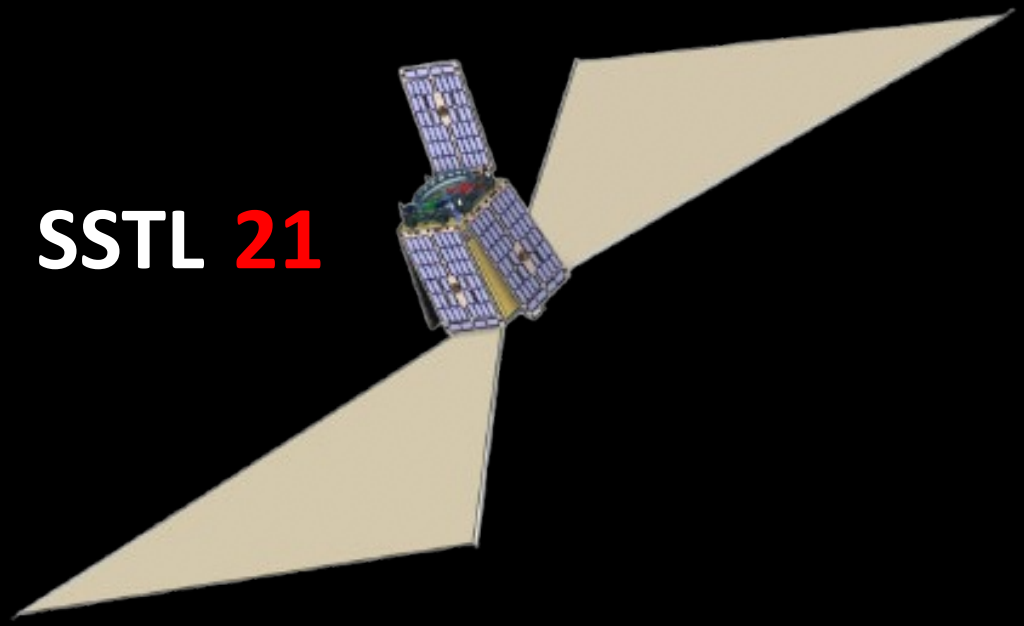




CosmoCube will be sensitive to baryon over density – hubble constant fluctuations with a radiometer noise of ~10 mK across 8-45 MHz in a 2-year mission in Moon's orbit

The platform and payload

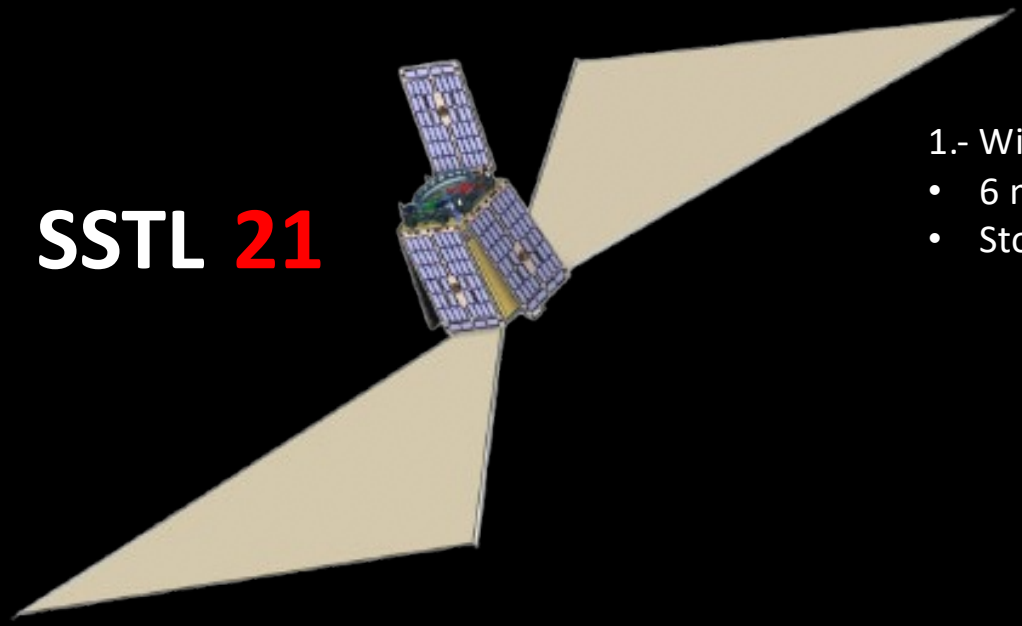
SSTL 21



* *Kaan and de Lera Acedo,* RASTI 2024
~ *Zhu, de Lera Acedo et al.,* RASTI 2024

The platform and payload

SSTL 21

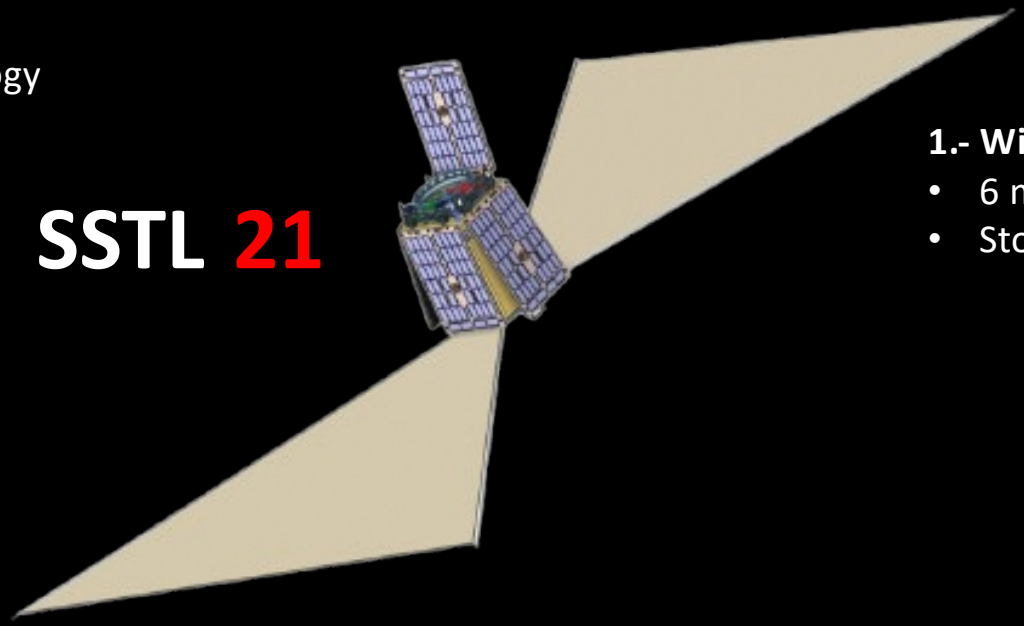


1.- Wideband deployable antenna
- 6 m long once deployed
- Stowed during launch

* *Kaan and de Lera Acedo,* RASTI 2024
~ *Zhu, de Lera Acedo et al.,* RASTI 2024

The platform and payload

2.- Integrated radiometer
- Using COTS RFSoC technology
- Dicke-switch calibrator



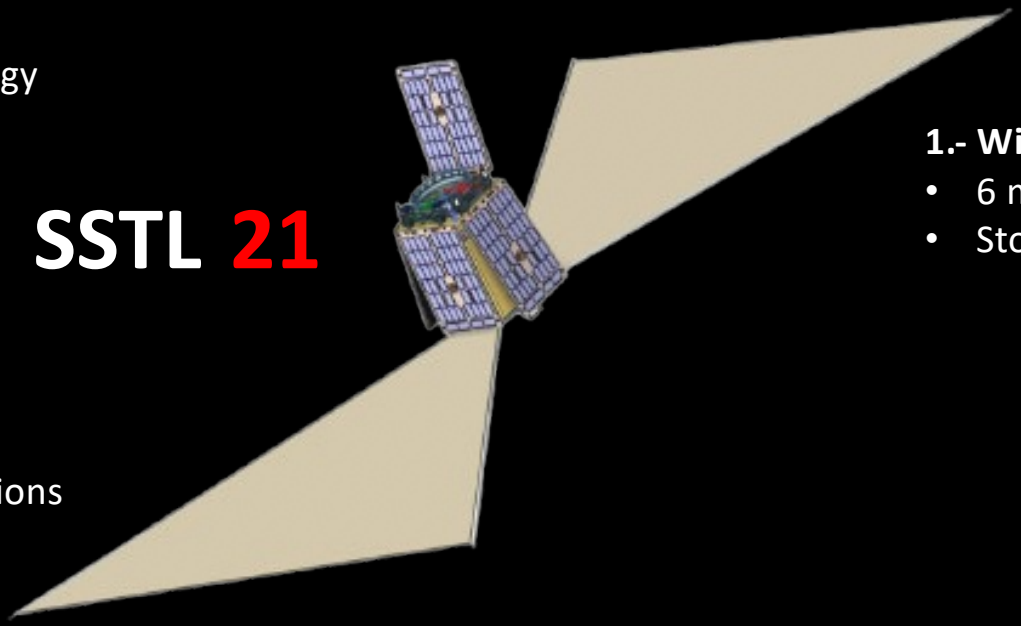
1.- Wideband deployable antenna
- 6 m long once deployed
- Stowed during launch

* *Kaan and de Lera Acedo,* RASTI 2024
~ *Zhu, de Lera Acedo et al.,* RASTI 2024

The platform and payload

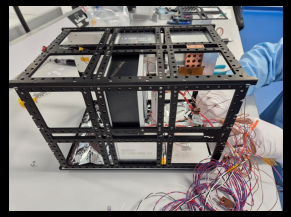
2.- Integrated radiometer
- Using COTS RFSoC technology
- Dicke-switch calibrator

SSTL 21



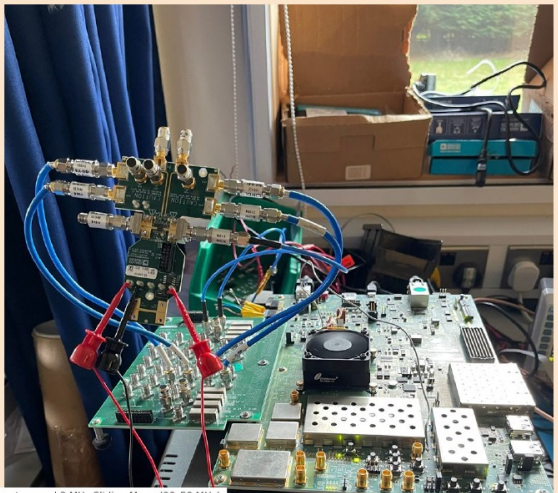
1.- Wideband deployable antenna
- 6 m long once deployed
- Stowed during launch

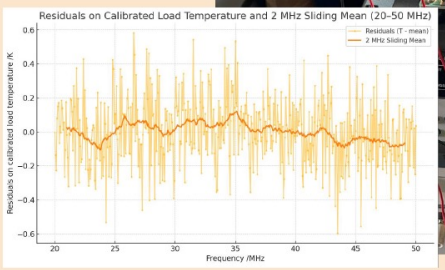
3.- Thermal control
- 10 mK rms during observations

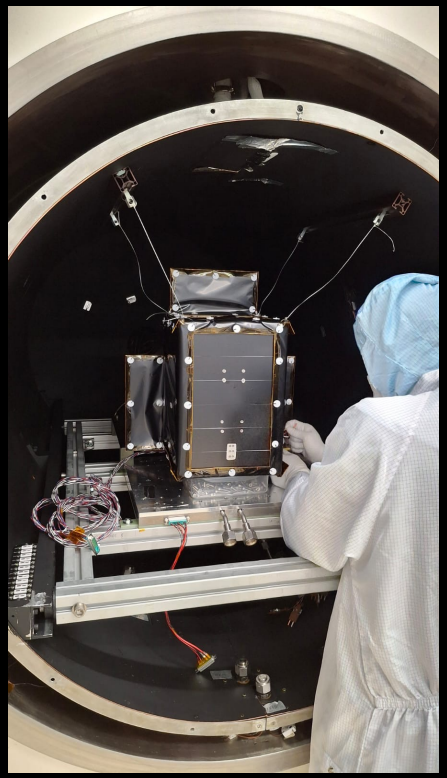


Mission status

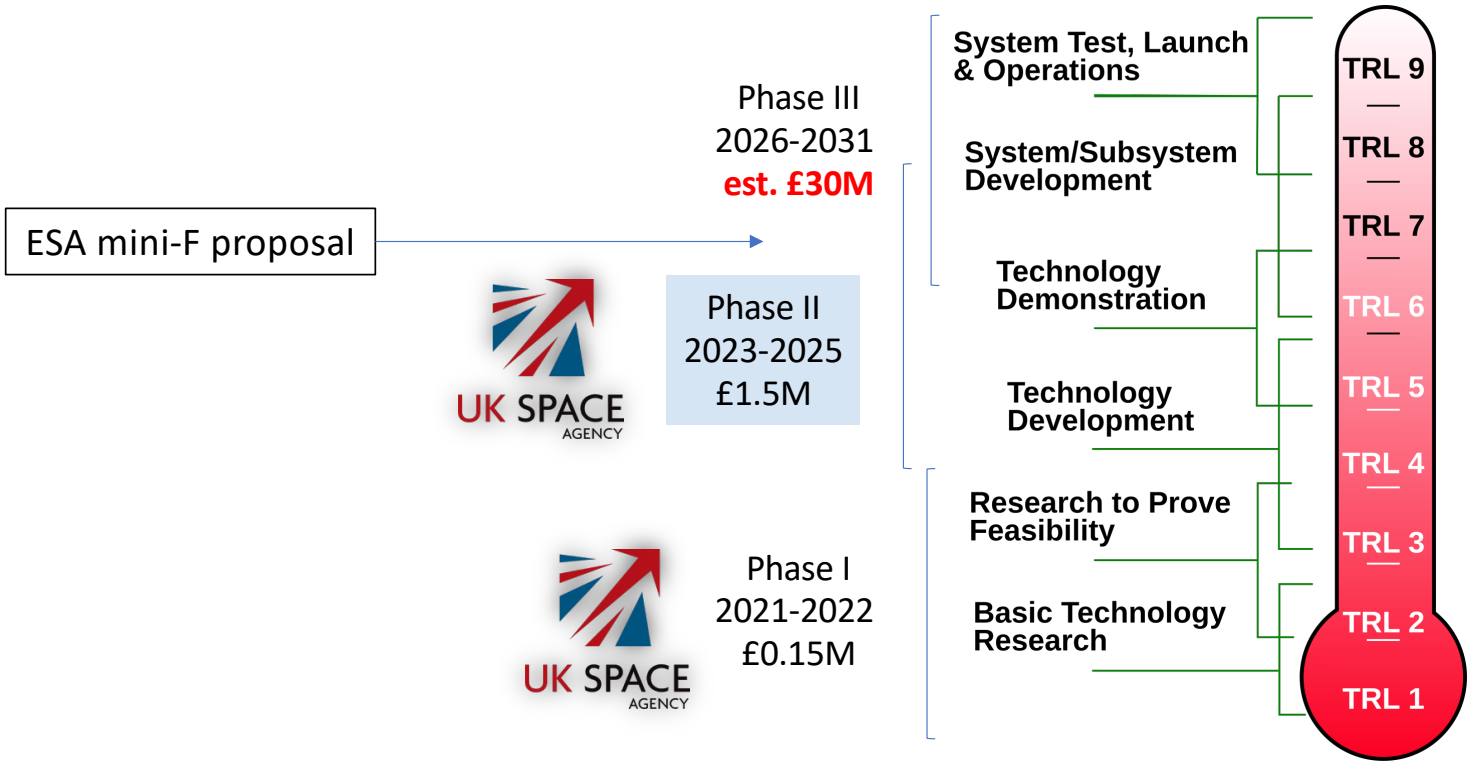
Full system



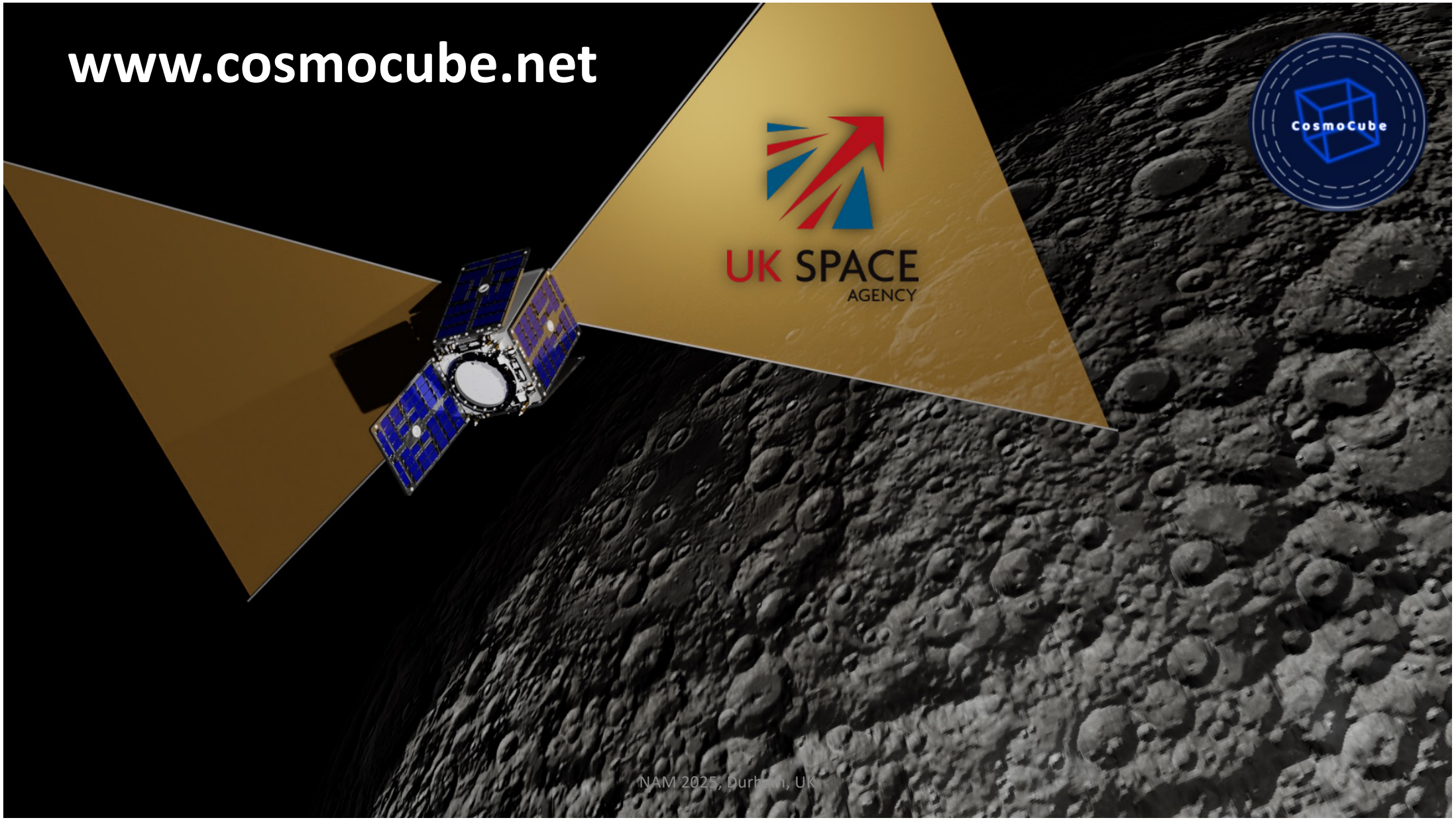




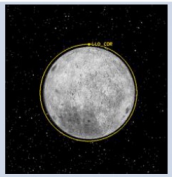
Mission status



www.cosmocube.net



The orbit

	Circular polar orbit	LLO 100	Frozen orbit 41x190	Frozen orbit 70x166	Frozen orbit 100x199	Frozen orbit 90x190
						
Hp x Ha (km x km)	100 x100	100.58 x 100.62	41 x 190	70.537 x 166.663	100x199	90x190
a (km)	1837.4	1838.00	1853.201	1856	1887.117	1877.3639
e	0	1.00E-05	0.04036	0.025896	0.026291	0.0266139
i (deg)	90	94	90	91	90	90
RAAN (deg)	0	0	0	0	0	0
AoP (deg)	270	90	270	270	270	270
M (deg)	0	0	0	0	0	0
Time in RF shield per year [hr]	998	1023.7	957	955	840	872
Time in RF shield and Sun eclipse per year [hr]	389	415.72	363	373	307	324
Minimum lifetime for 1296 in RF shield [years]	1.30	1.27	1.35	1.36	1.54	1.49
Minimum lifetime for 1296 with in RF shield and Sun eclipse [years]	3.33	3.11	3.57	3.47	4.22	4

Dealing with the Sun

Reducing the impact of the **Earth** and the **Sun**