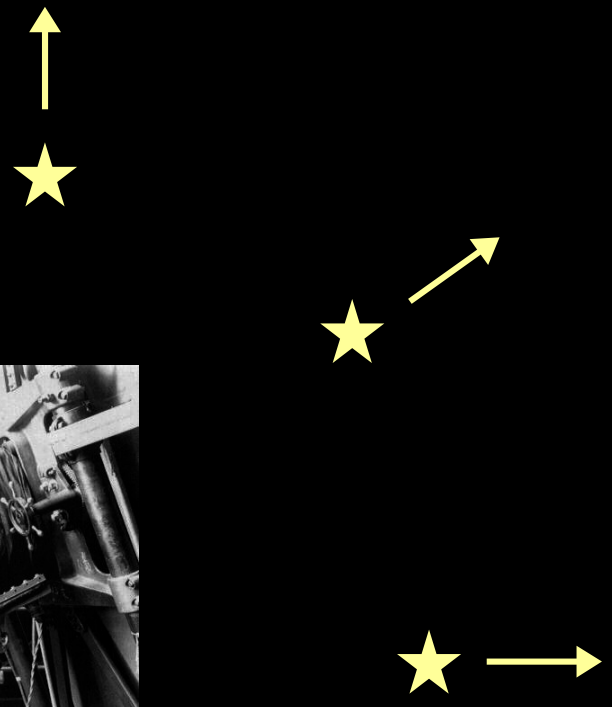
Exploring the Cosmos from the Ends of the Earth

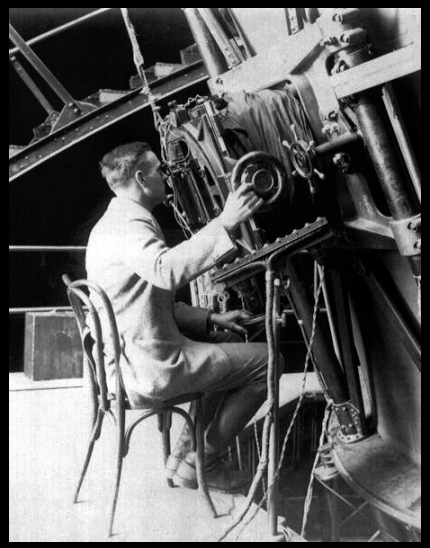
H. Cynthia Chiang
McGill Physics

Háskóli Íslands public talk
7 May 2024

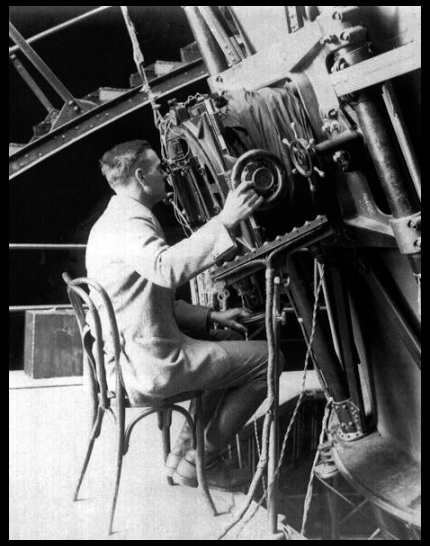
The birth of modern cosmology

The birth of modern cosmology

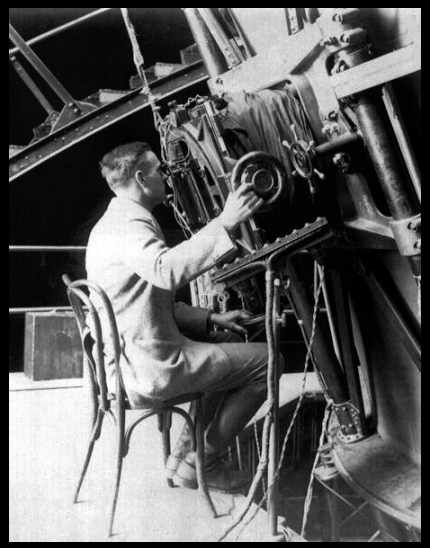




The birth of modern cosmology

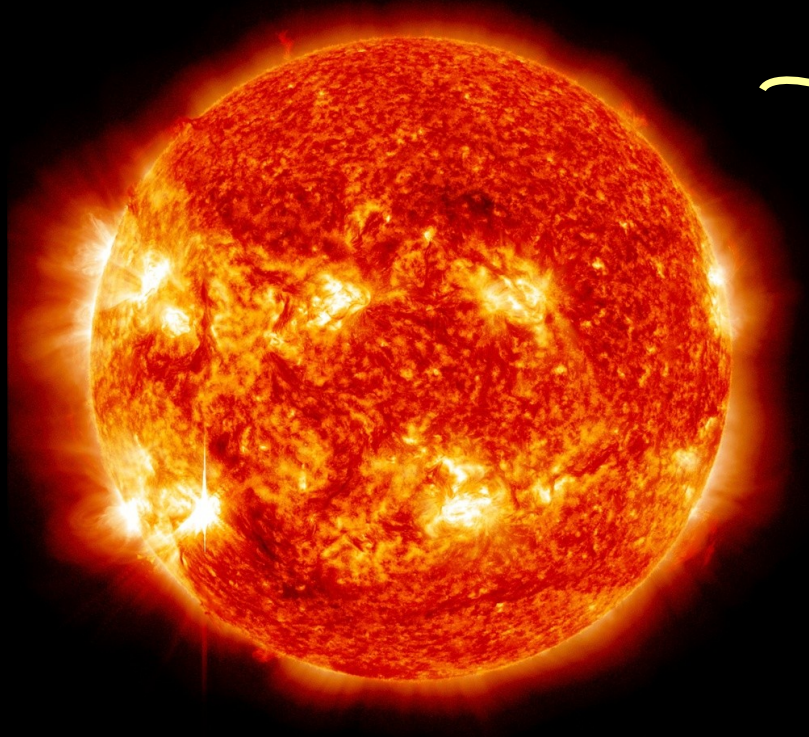


The birth of modern cosmology



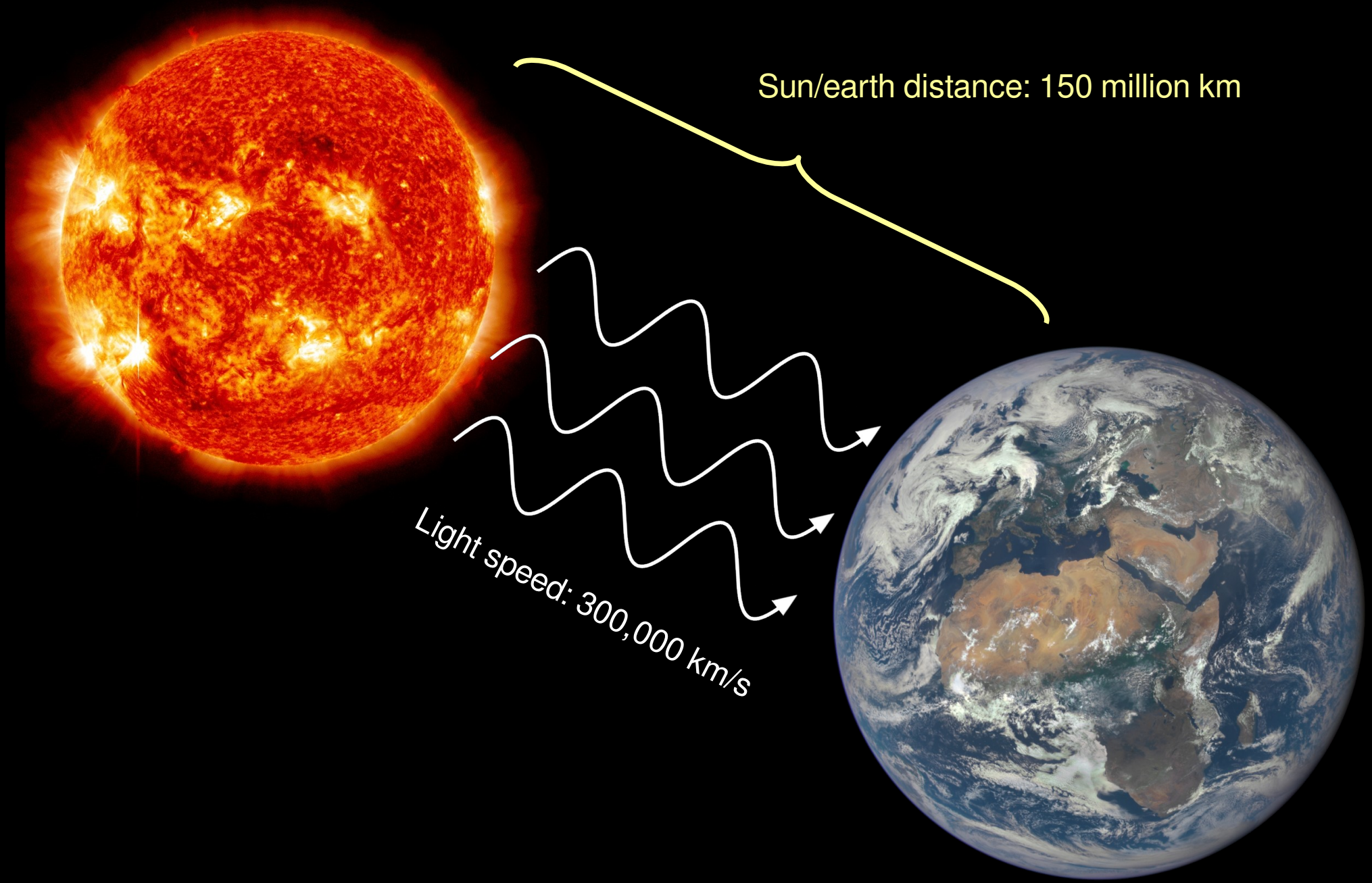
The universe is **expanding,** and farther objects move away faster.

Seeing the past

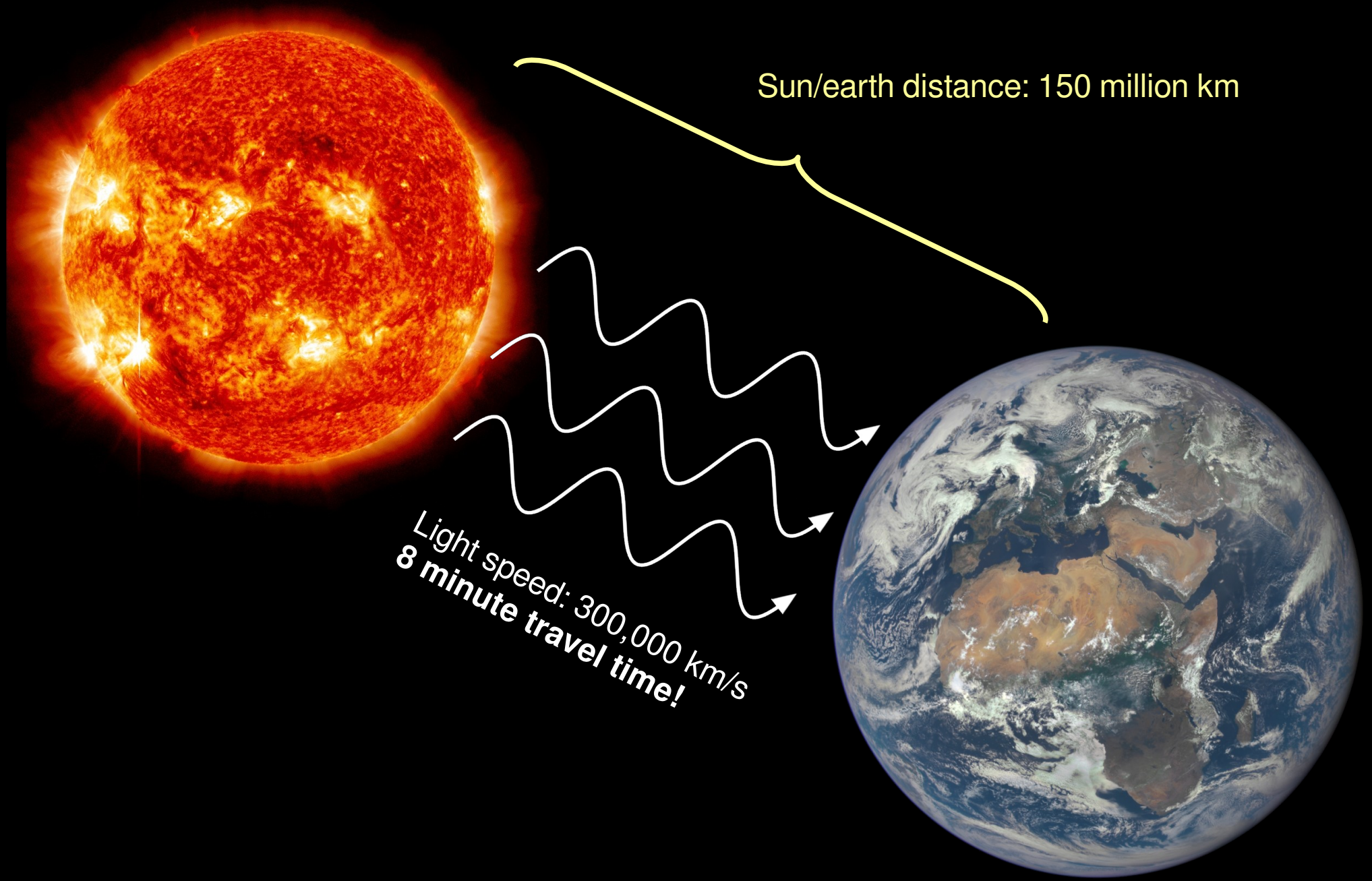


Sun/earth distance: 150 million km

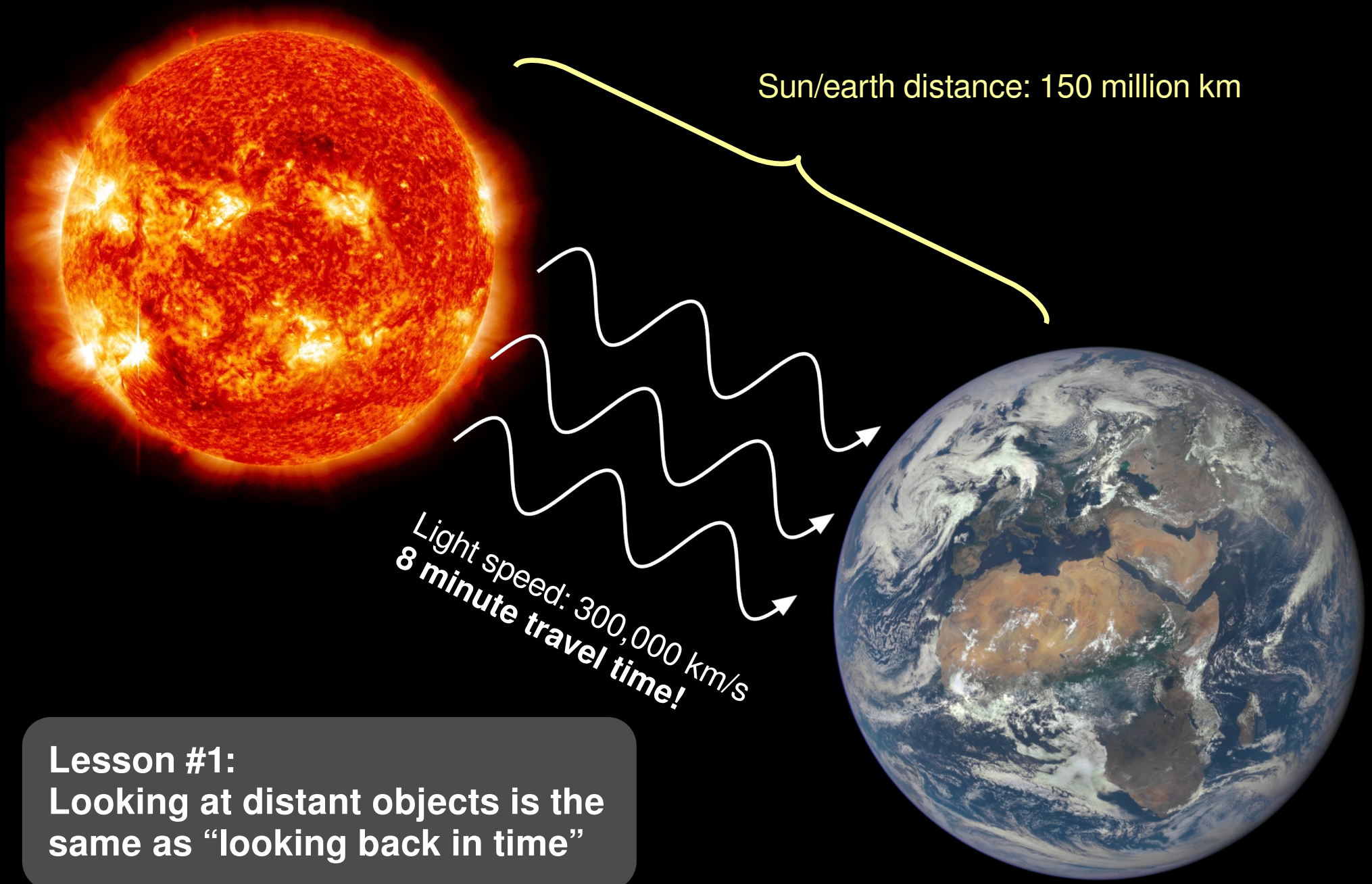
Seeing the past



Seeing the past

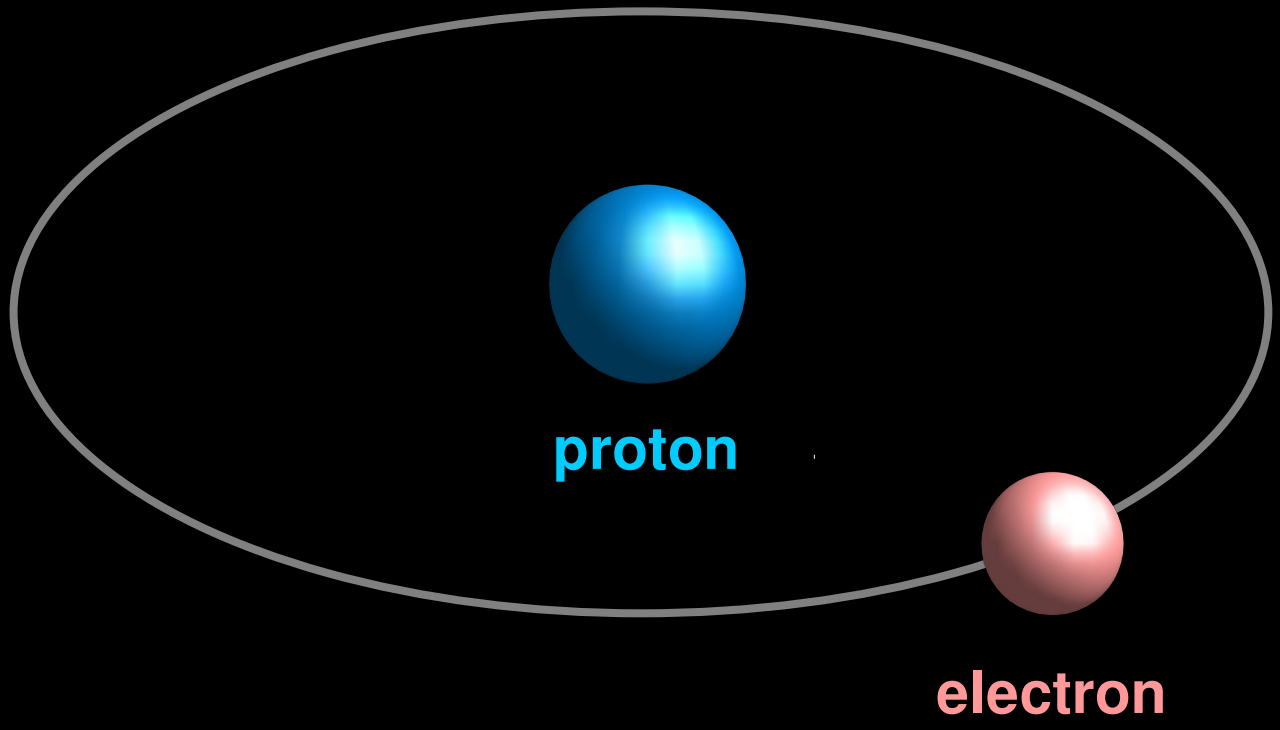


Seeing the past

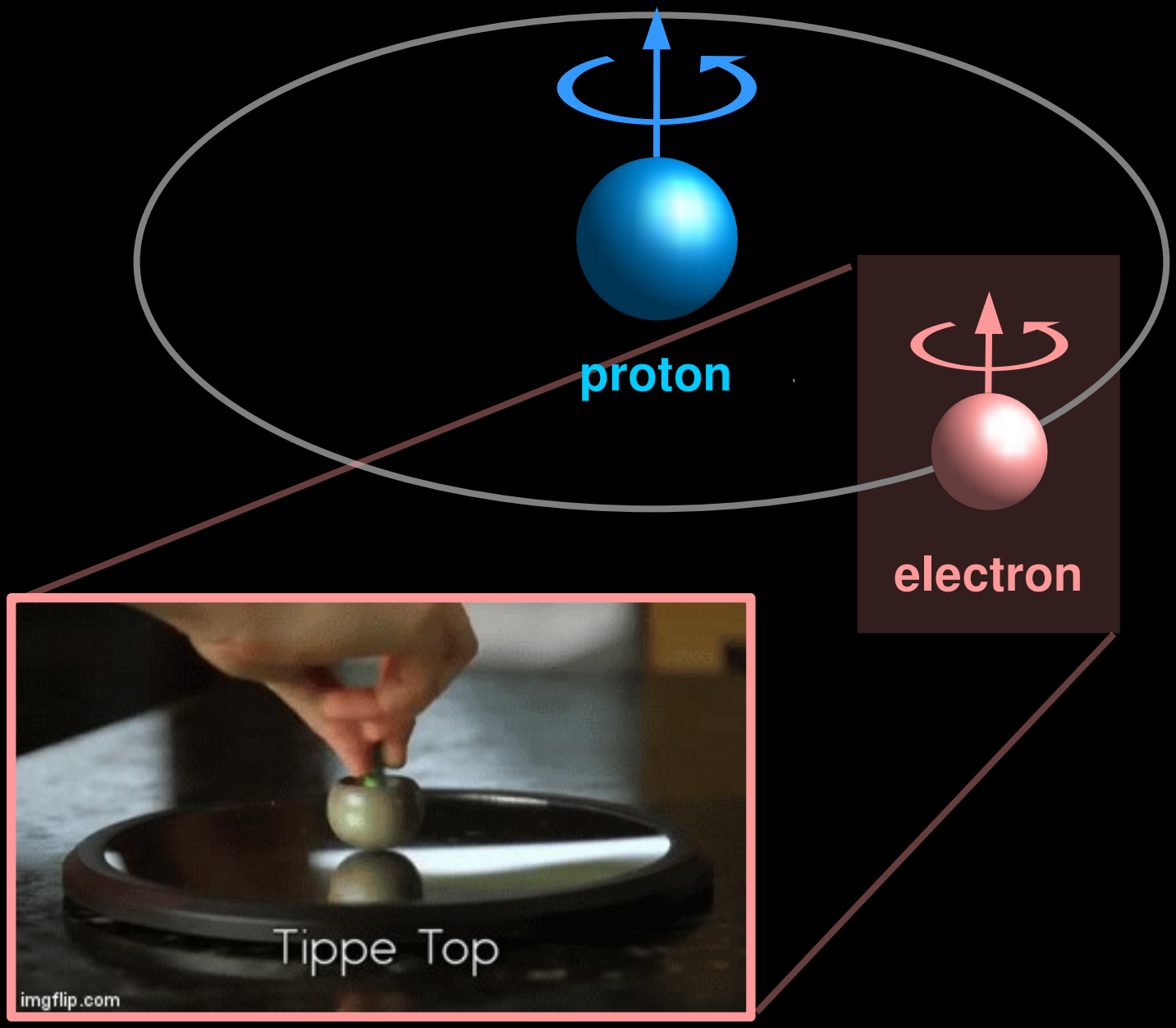


Lesson #1:
Looking at distant objects is the same as “looking back in time”

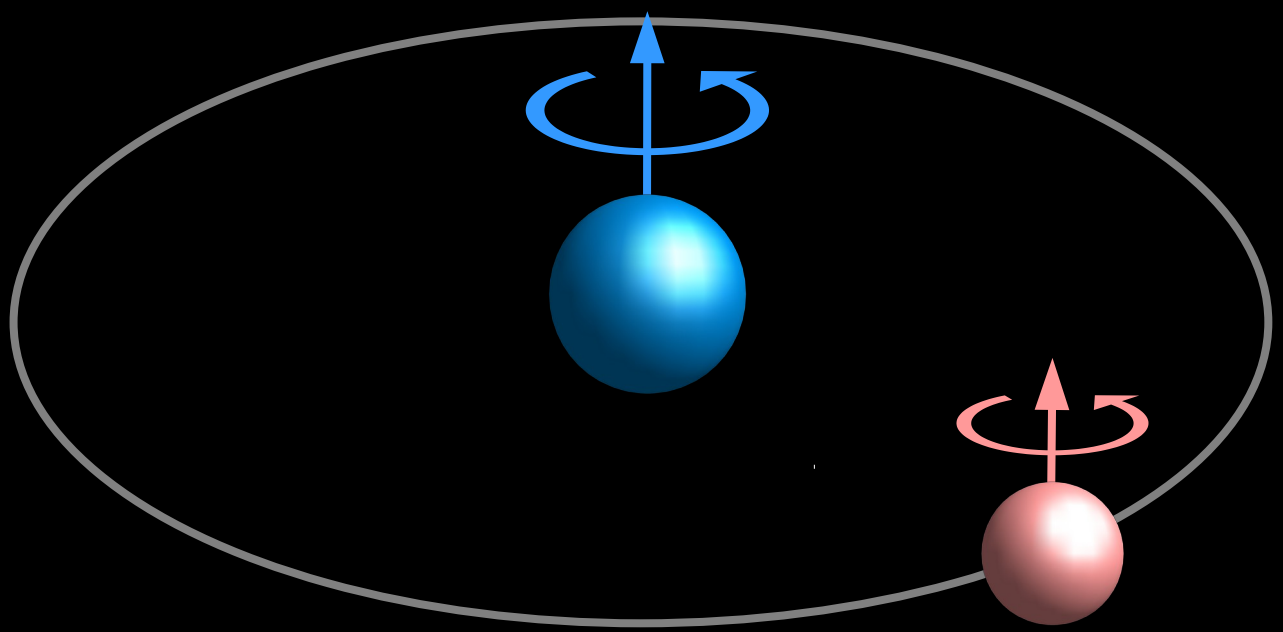
Hydrogen atoms



Hydrogen atoms



Hydrogen atoms



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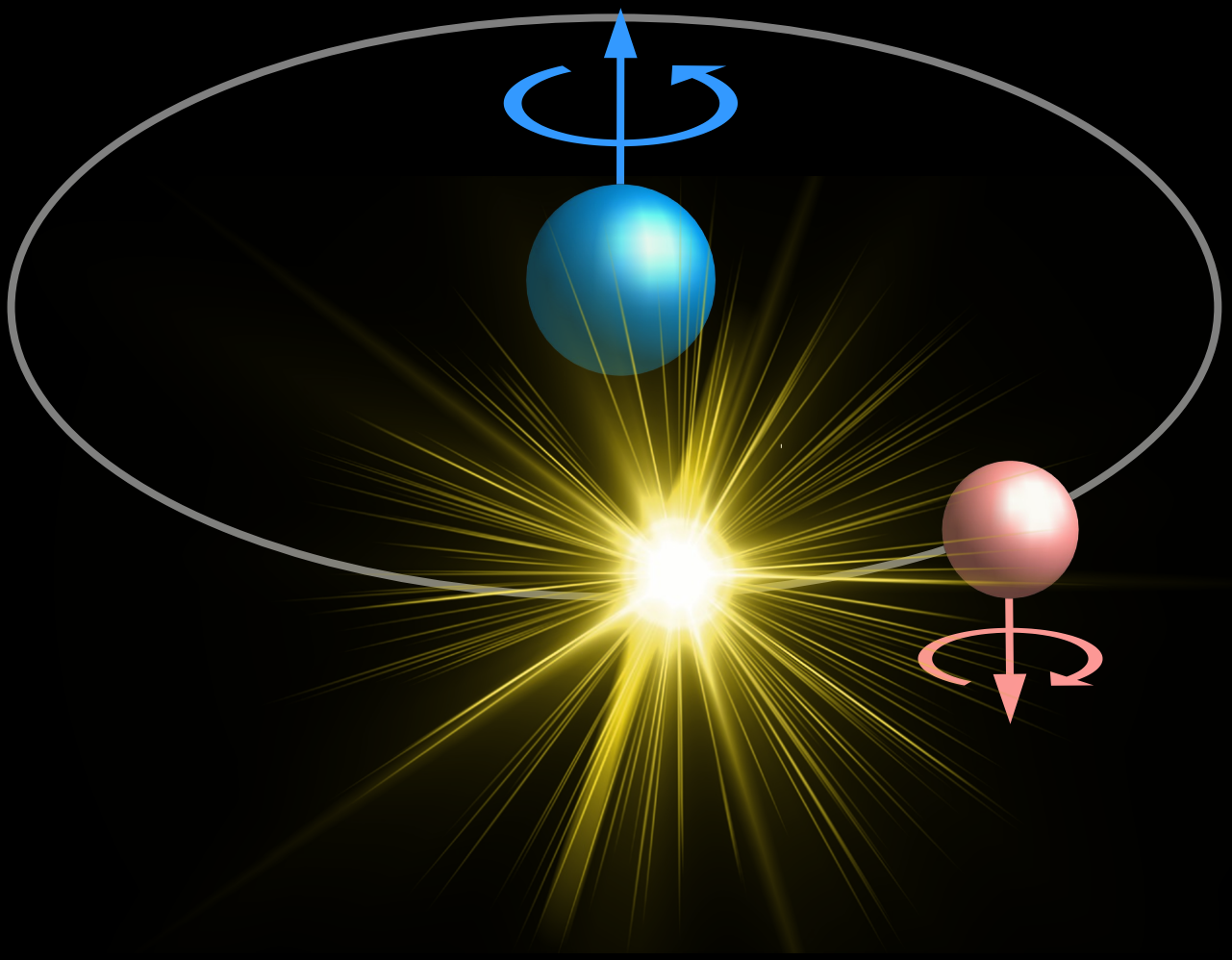
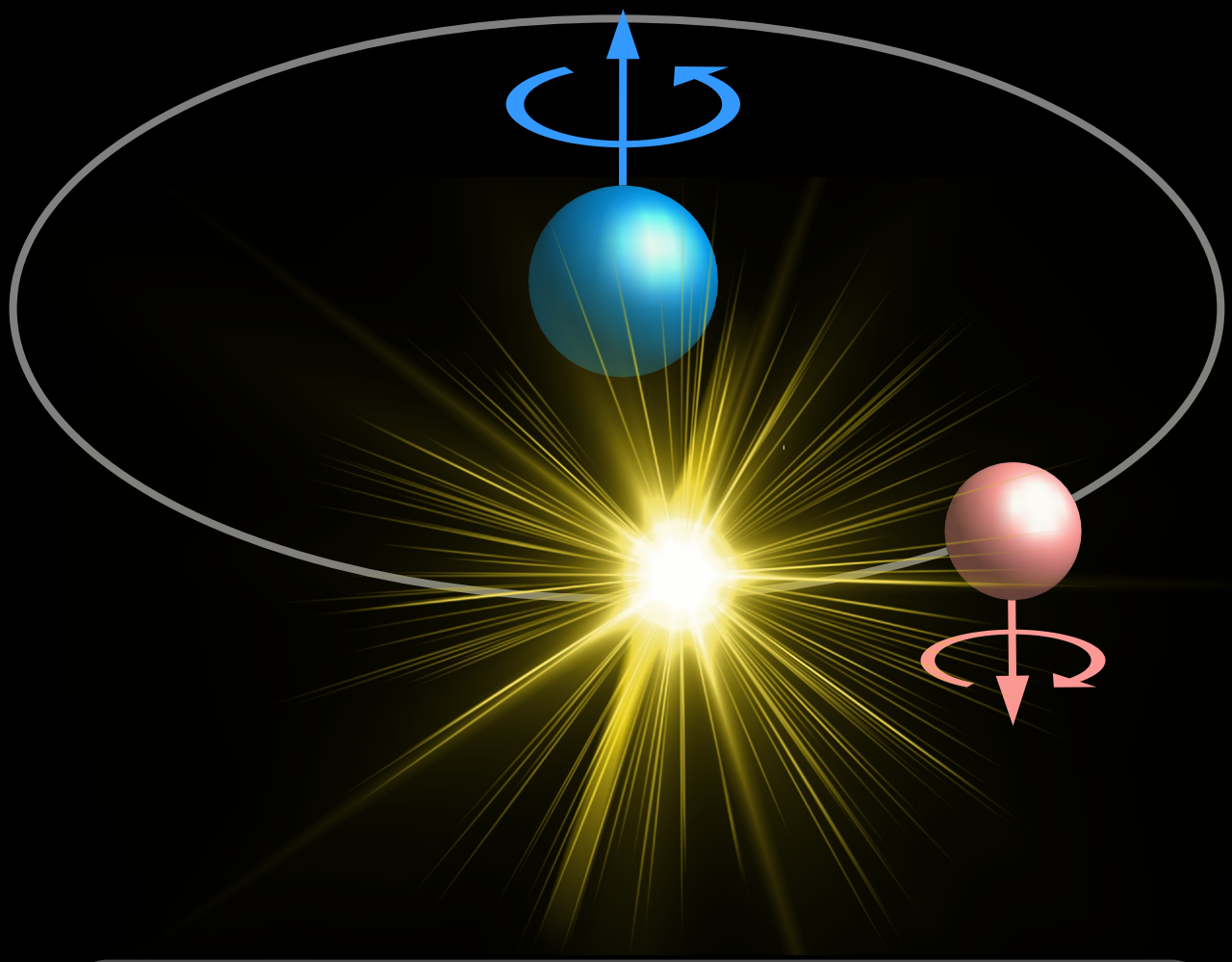
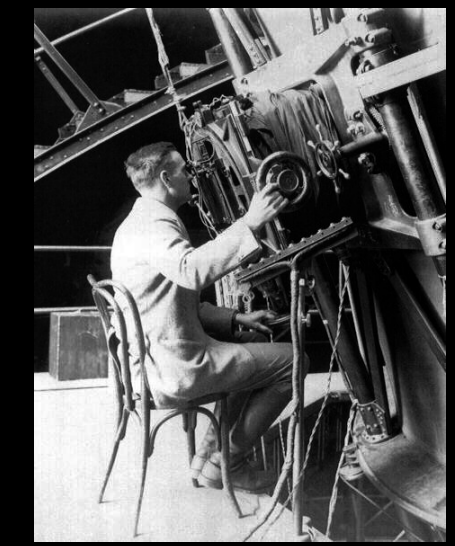


Hydrogen atoms

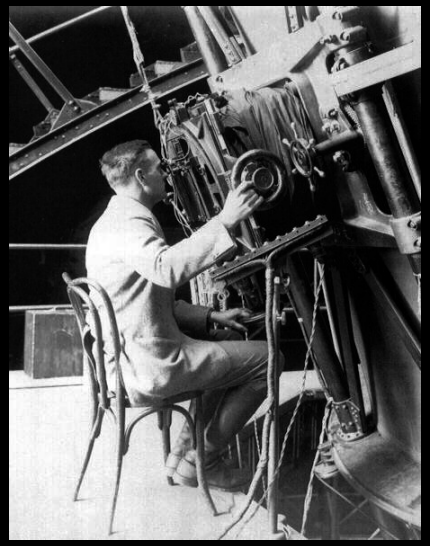


Lesson #2:
Hydrogen “glows” with radio light
21 cm wavelength, or 1420 MHz frequency

Light from moving objects



Light from moving objects



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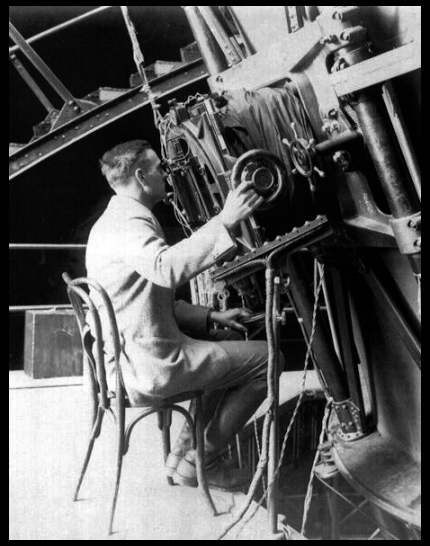
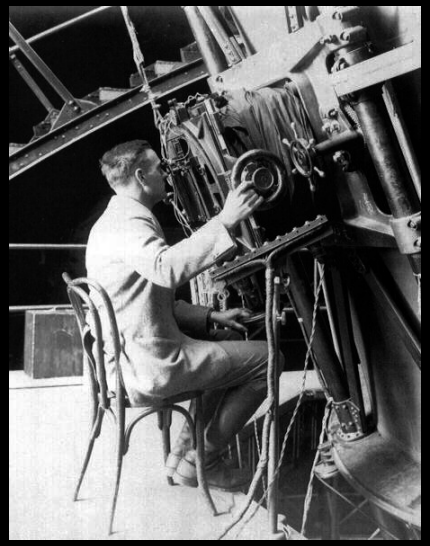
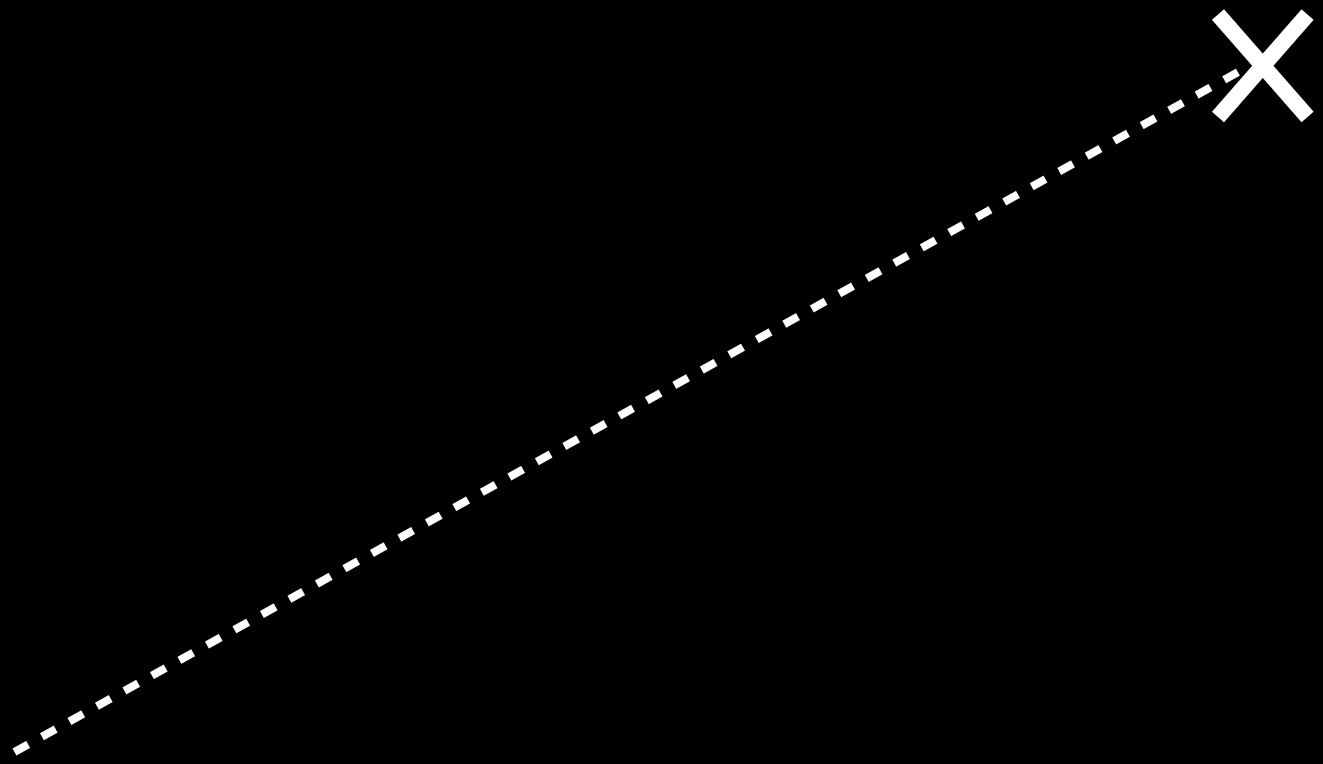


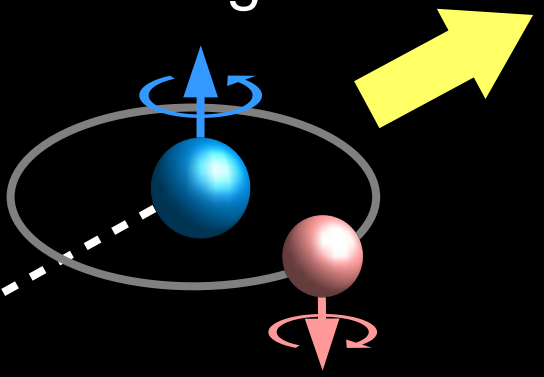
Lesson #3:
Light from objects moving away is stretched out, or redshifted

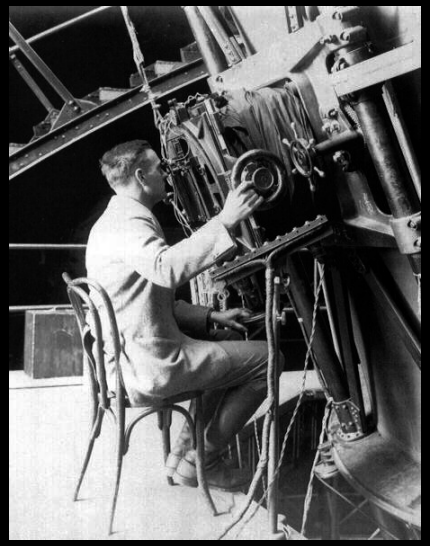
Step 1:
We choose how far back in time (distance) we want to look



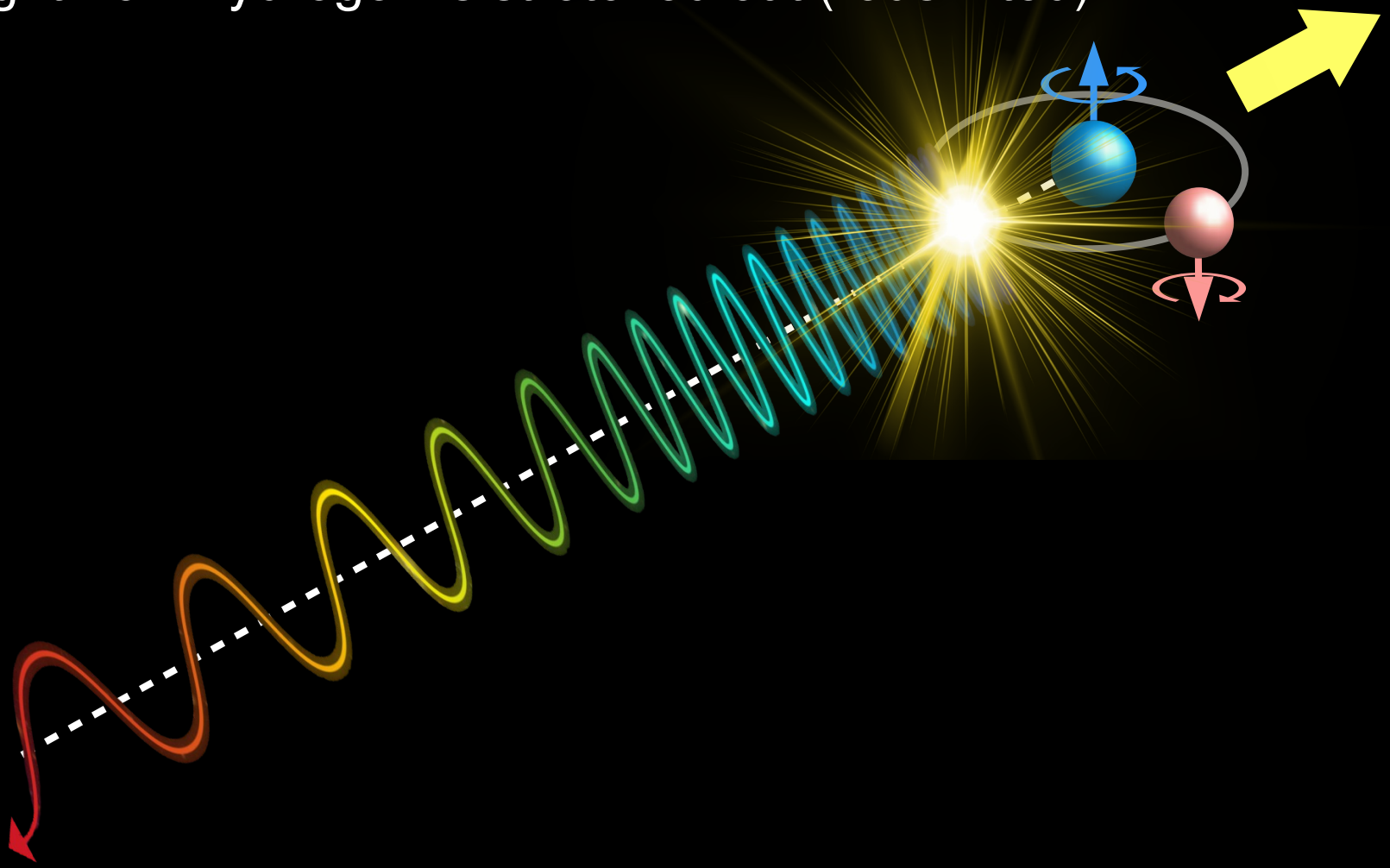


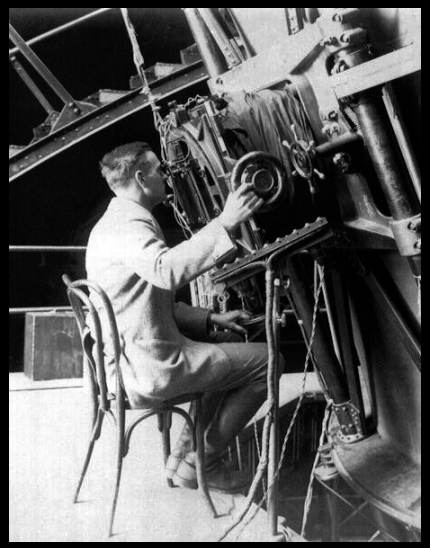
Step 2:
Hydrogen is out there, and we know how fast it's moving



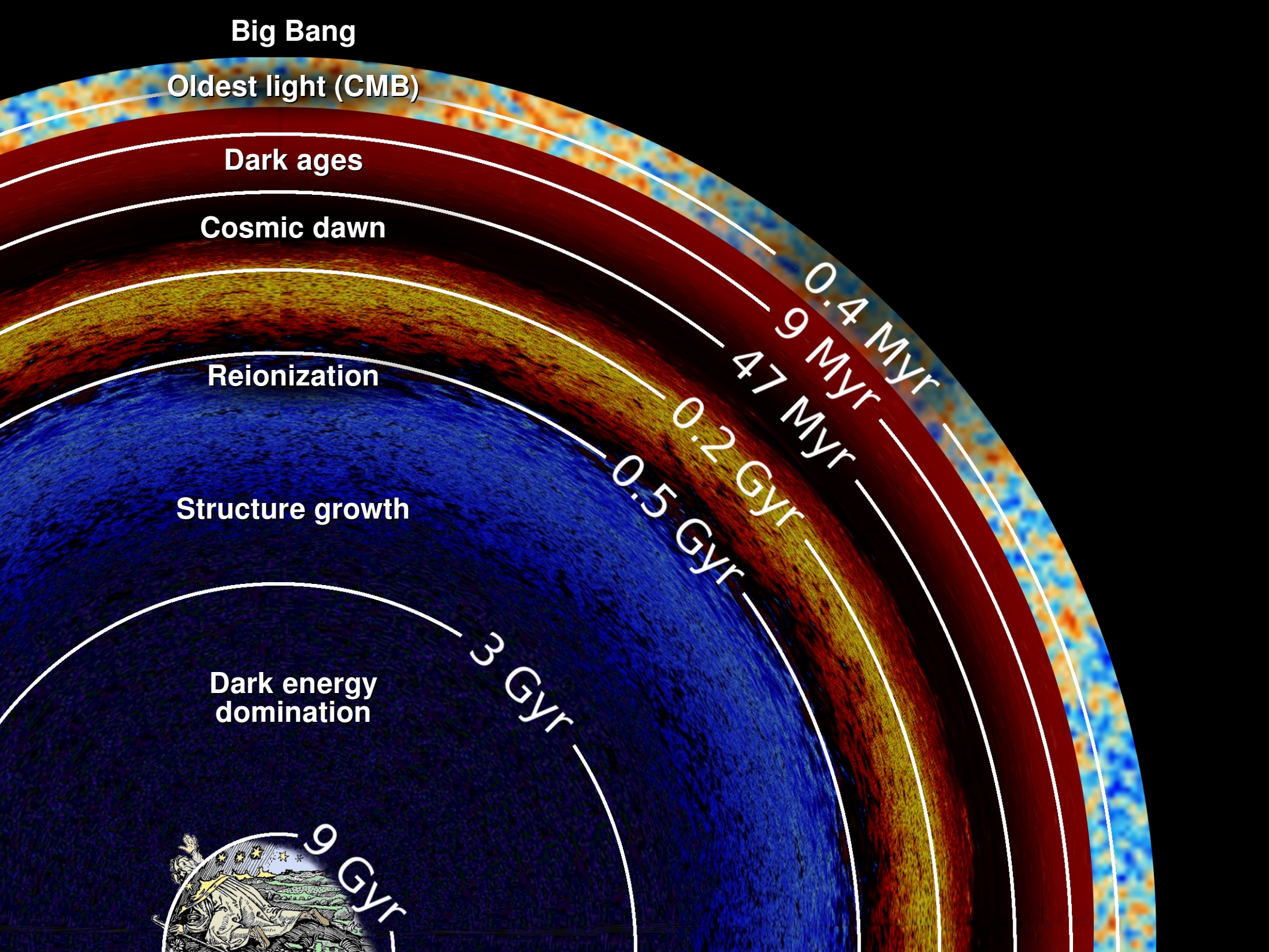


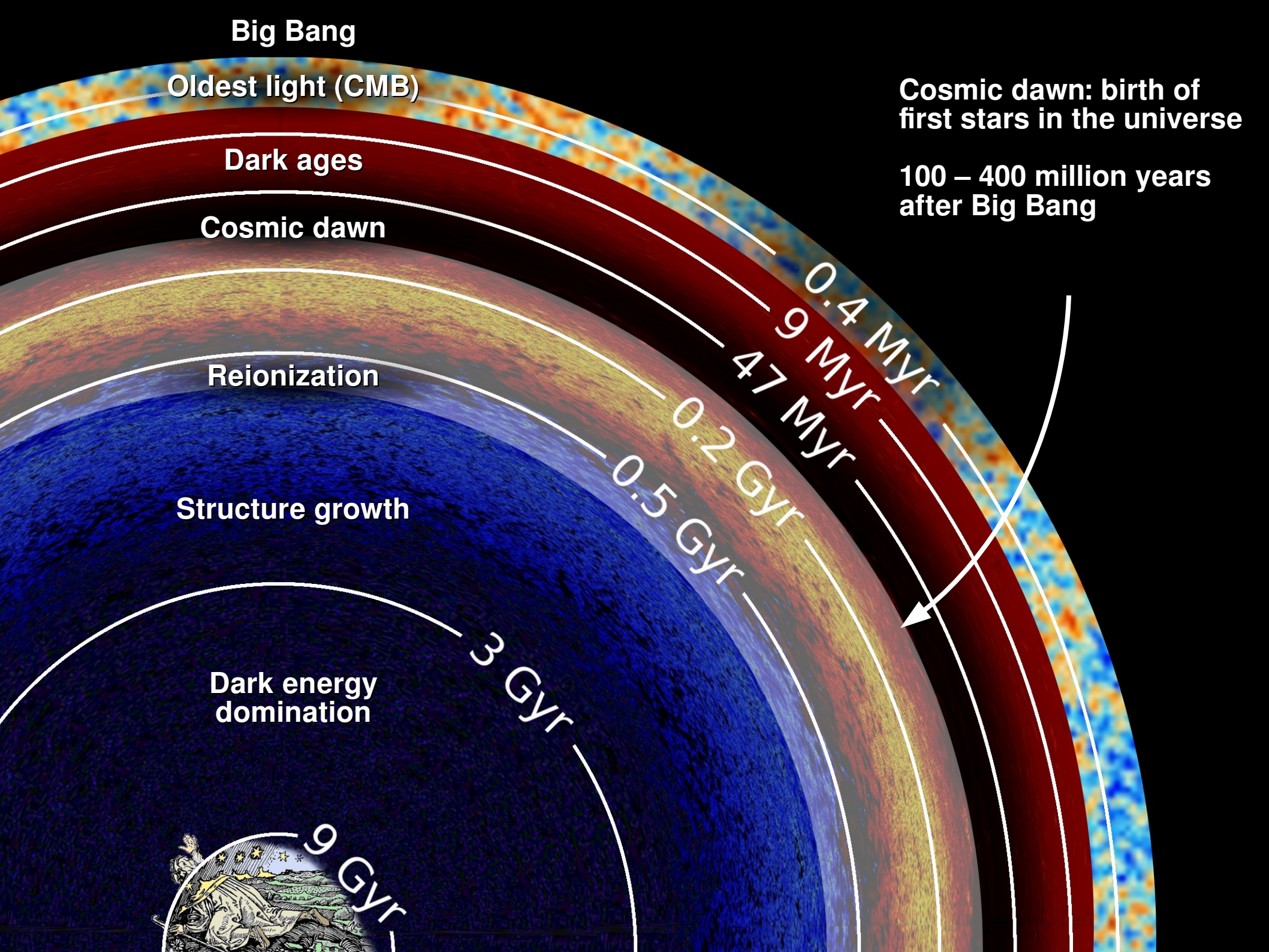
Step 3:
Radio light from hydrogen is stretched out (redshifted)





We can observe a specific time in the universe's history by tuning our radio to the correct wavelength


Big Bang
Oldest light (CMB)
Dark ages
Cosmic dawn
Reionization
Structure growth
Dark energy domination
0.4 Myr
9 Myr
47 Myr
0.2 Gyr
0.5 Gyr
3 Gyr
9 Gyr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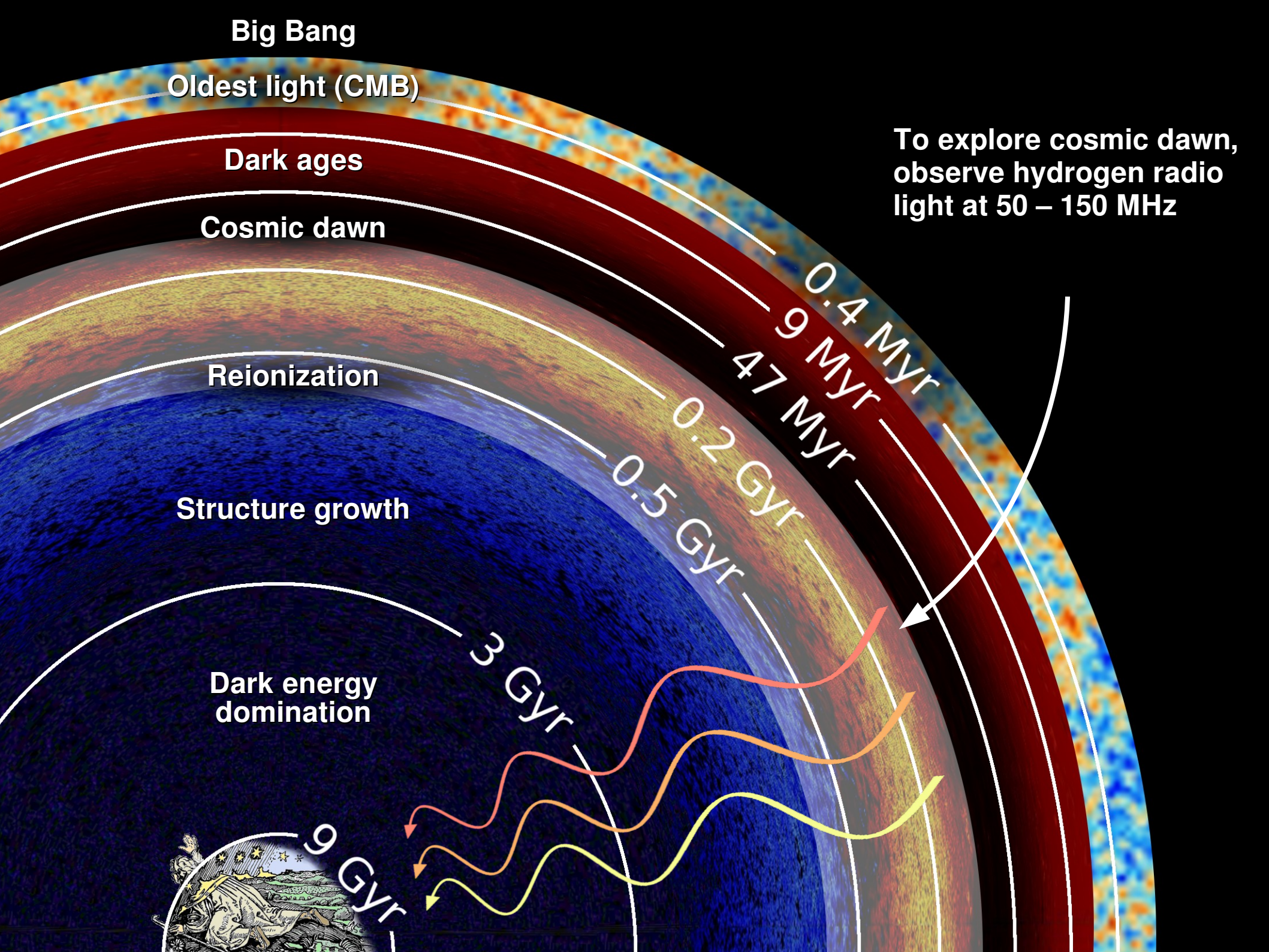
Cosmic dawn: birth of first stars in the universe
100 – 400 million years after Big Bang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9 Myr
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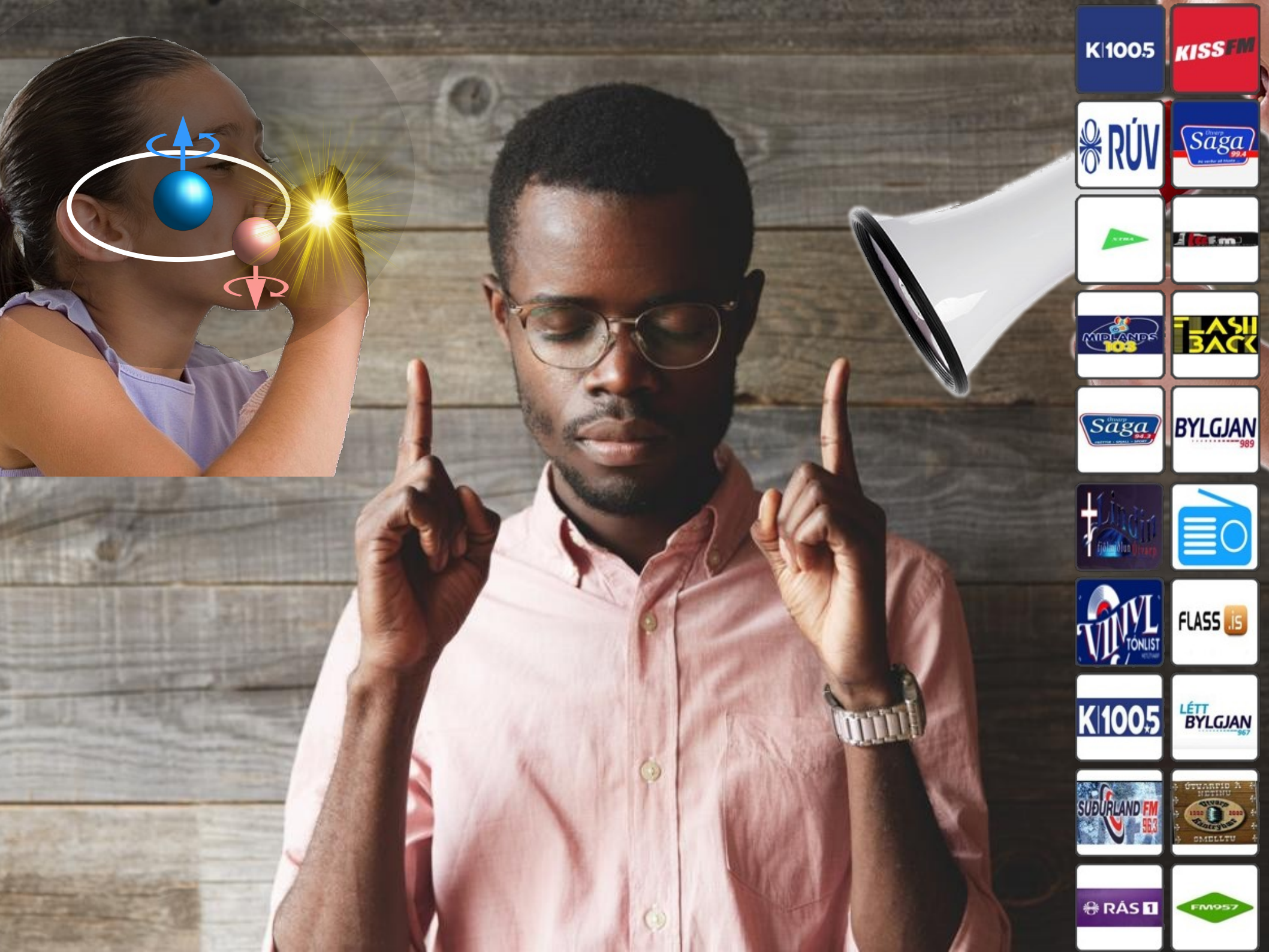
0.5 Gyr
3 Gyr
9 Gyr
To explore cosmic dawn, observe hydrogen radio light at 50 – 150 MHz

How do you catch a radio wave?

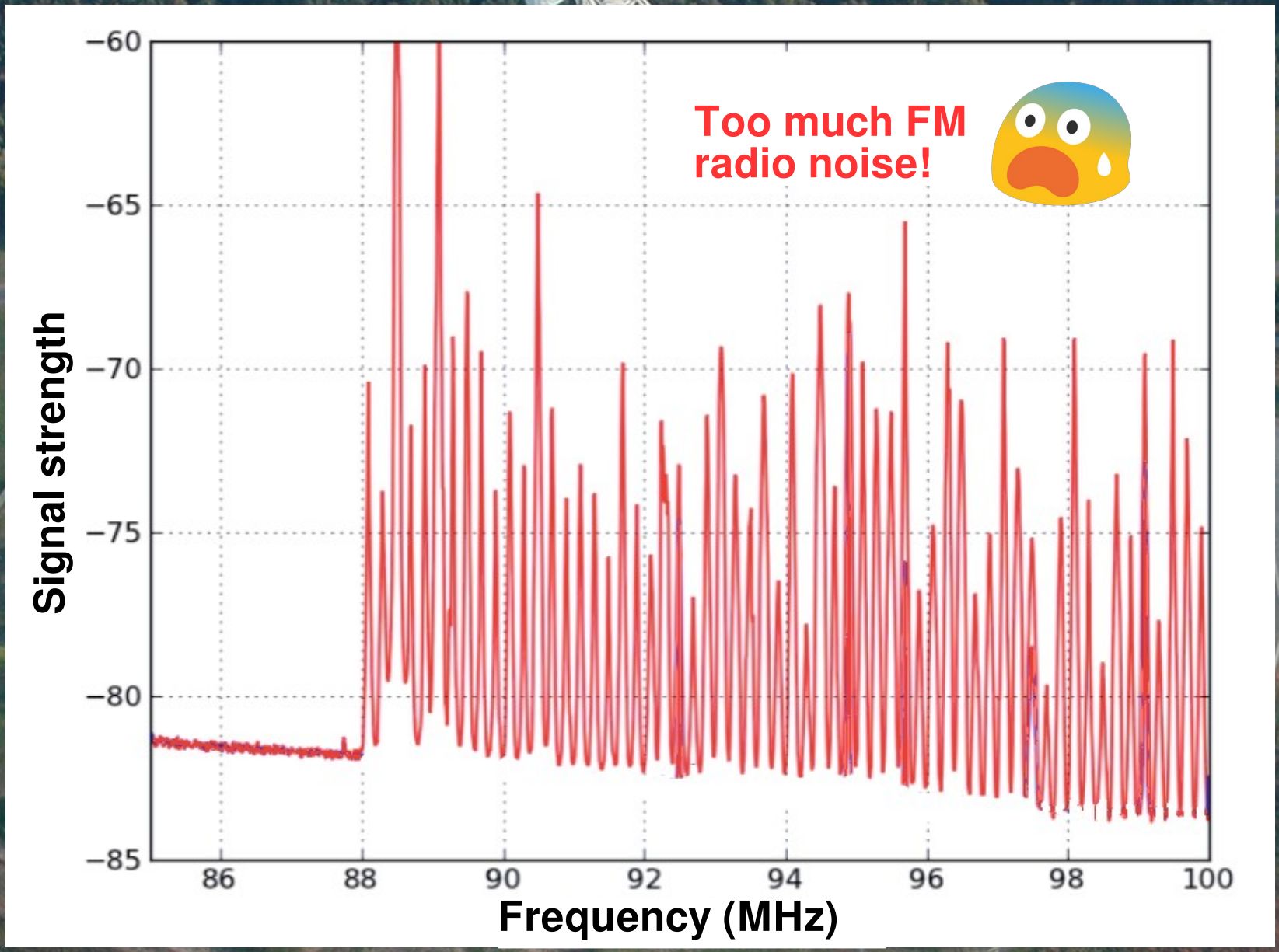
Image credit:
http://www.abrandao.com

Everybody has an FM radio! This is easy!


K100.5
KISS FM
RÚV
Saga 99.4
MIDLANDS 103
FLASH BACK
Saga 94.3
BYLGJAN 989
VINYL TÓNLIST
FLASS .IS
K100.5
LÉTT BYLGJAN 96.7
SUÐURLAND FM 96.3
RÁS 1
FM957

Green Bank: “National Radio Quiet Zone”

Green Bank: "National Radio Quiet Zone"



EDGES telescope in
Western Australia

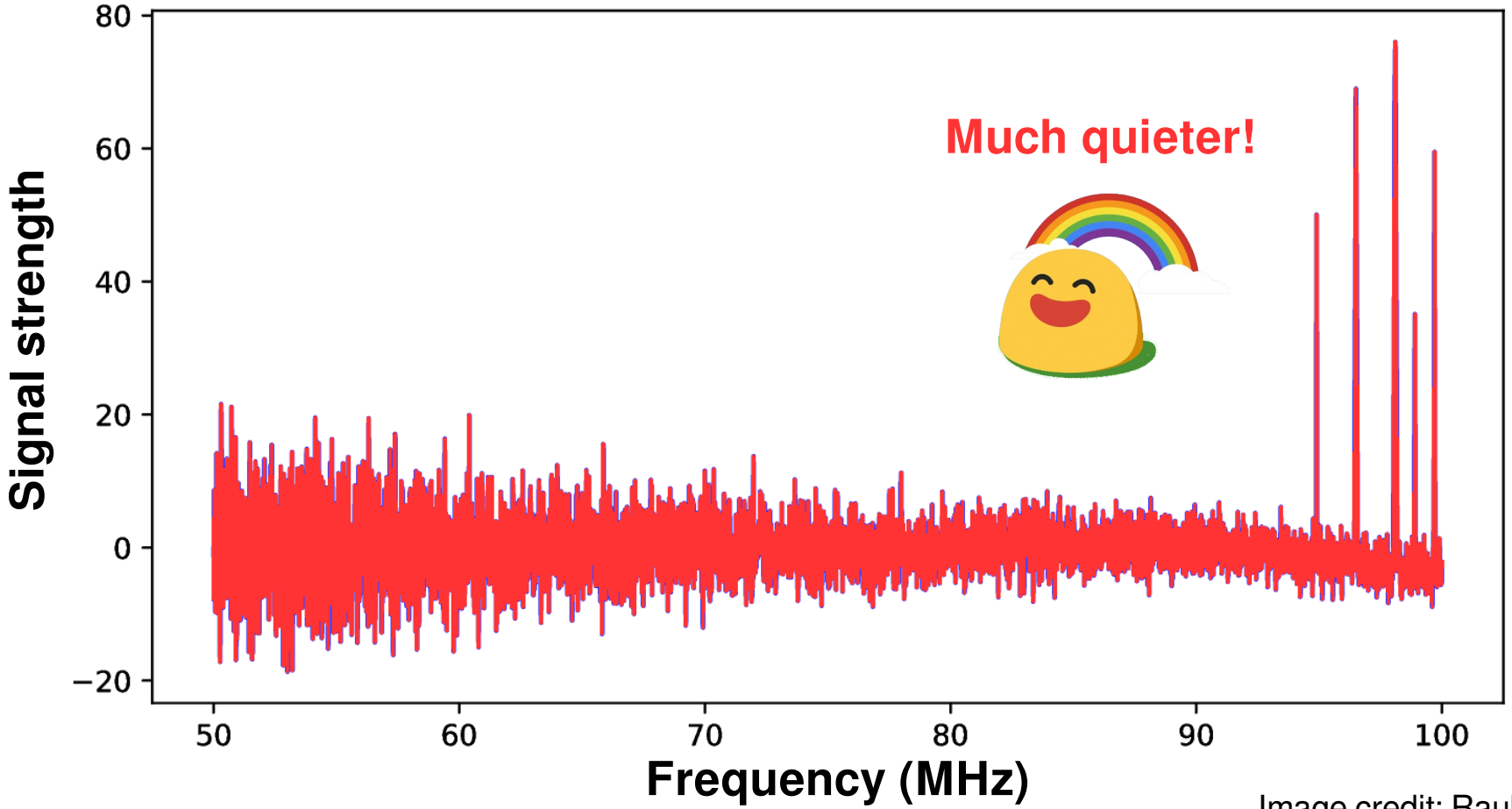


Image credit: Raul Monsalve

The New York Times

February 2018

When Stars Were Born: Earliest Starlight's Effects Are Detected

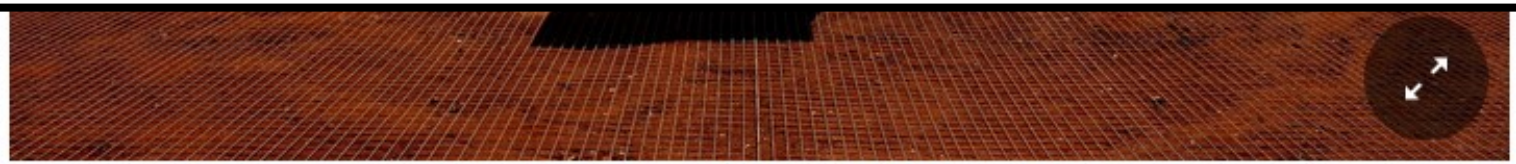
A radio telescope in western Australia that picked up effects of the first starlight in the universe, a mere 180 million years after the Big Bang. CSIRO Australia

The New York Times

February 2018

When Stars Were Born: Earliest Starlight's Effects Are Detected

None of this is for certain. Yet. Both Dr. Bowman and Dr. Barkana emphasized that the observations need to be confirmed by other instruments and experiments. The EDGES result was based on averaging observations over the whole sky. But new projects in the works, like the Square Kilometer Array in Australia and South Africa will be able to measure these temperature discrepancies in different parts of the sky and track the different evolution of dark and luminous matter.



A radio telescope in western Australia that picked up effects of the first starlight in the universe, a mere 180 million years after the Big Bang. CSIRO Australia


Marion Island

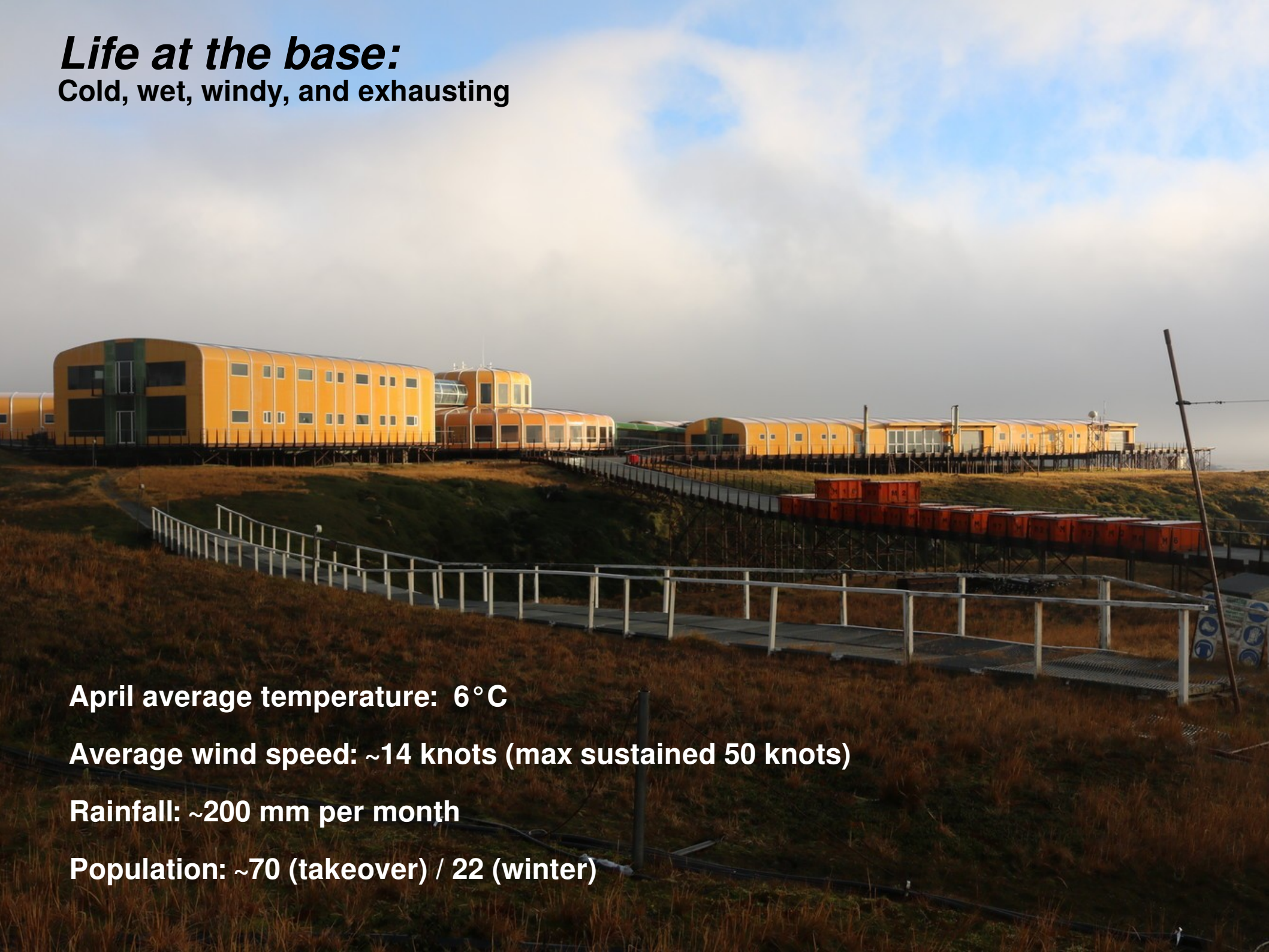

S. A. AGULHAS II
PETRO L
2


HELI
ONLY
3.6T


ZS-HNC
Ultimate HELI
(PTY) LTD
S. A. AGULHAS
IMO 9577135

Life at the base:

Cold, wet, windy, and exhausting



April average temperature: 6°C

Average wind speed: ~14 knots (max sustained 50 knots)

Rainfall: ~200 mm per month

Population: ~70 (takeover) / 22 (winter)


McGill Arctic
Research Station
Resolute
Bay
Reykjavik
Montreal


Three weeks of (food* and) science!
OUTBOUND
patagonia
FRAGILE

Three weeks o


AUTHORIZED
PERSONS ONLY
D.O.T.
RESTRICTED AREA
ZONE RÉGLEMENTÉE
PERSONNES AUTORISÉES
SEULEMENT
M.D.T.

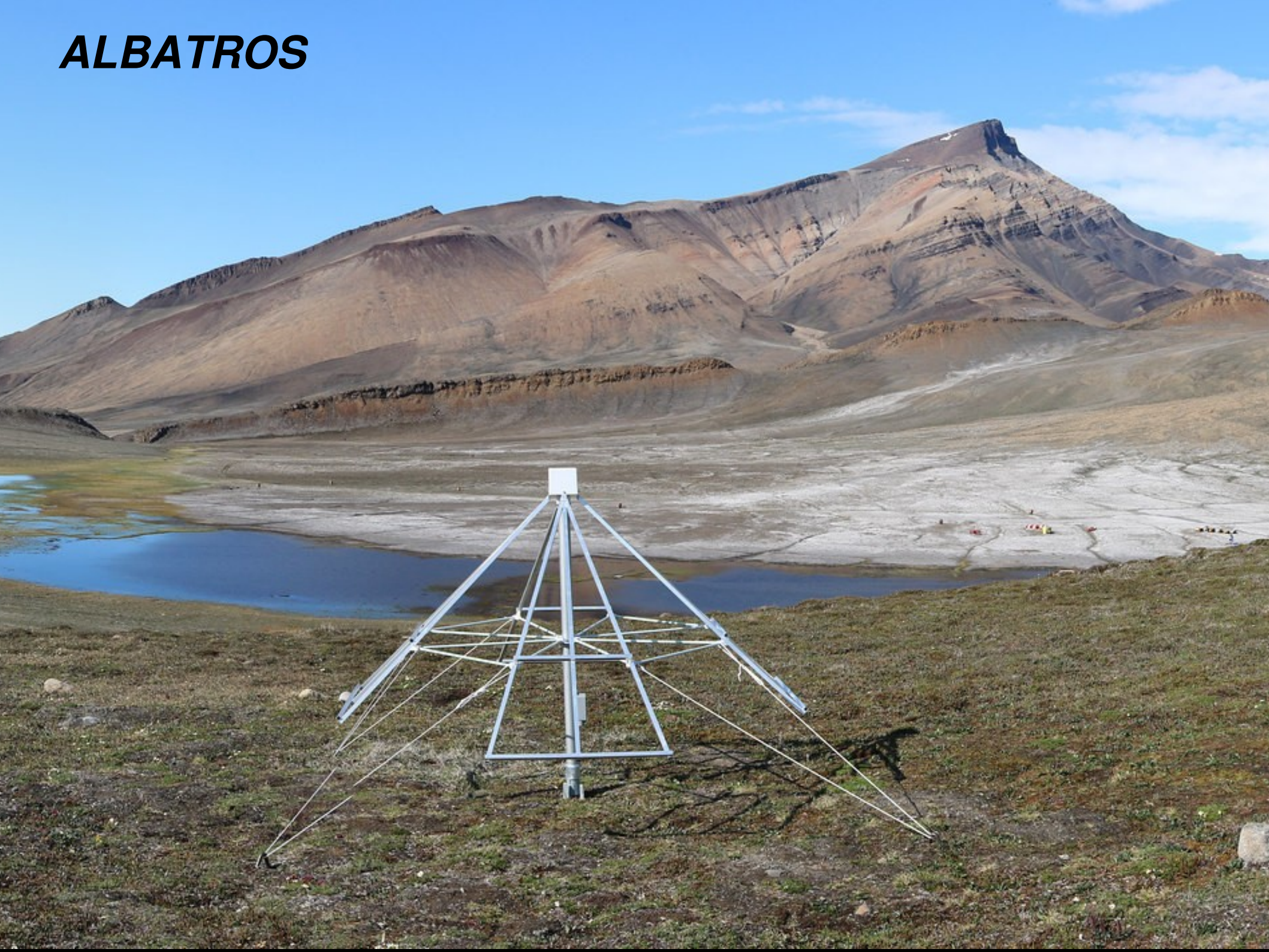

Canada
2500 HD
4x4

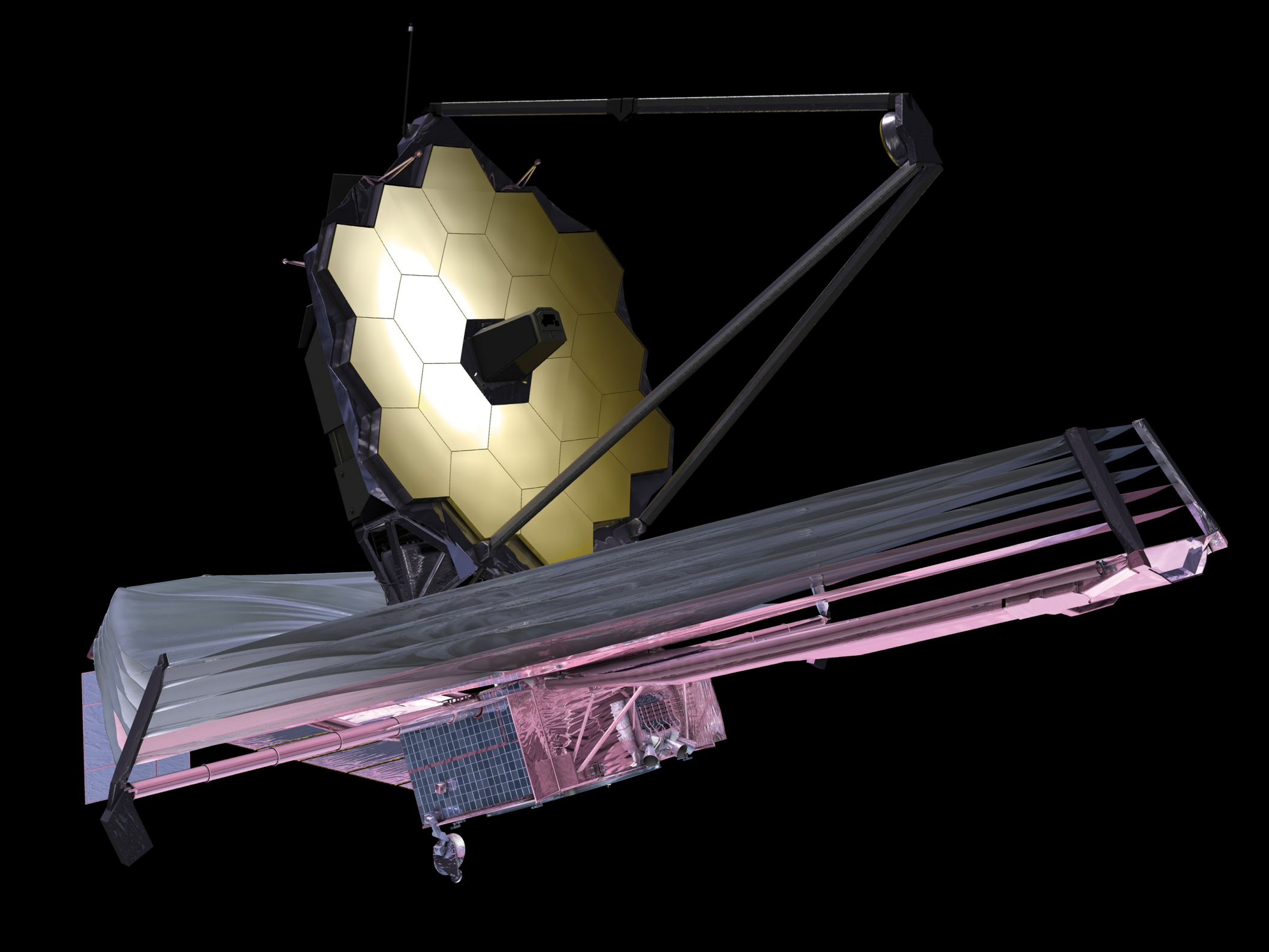

Eureka!

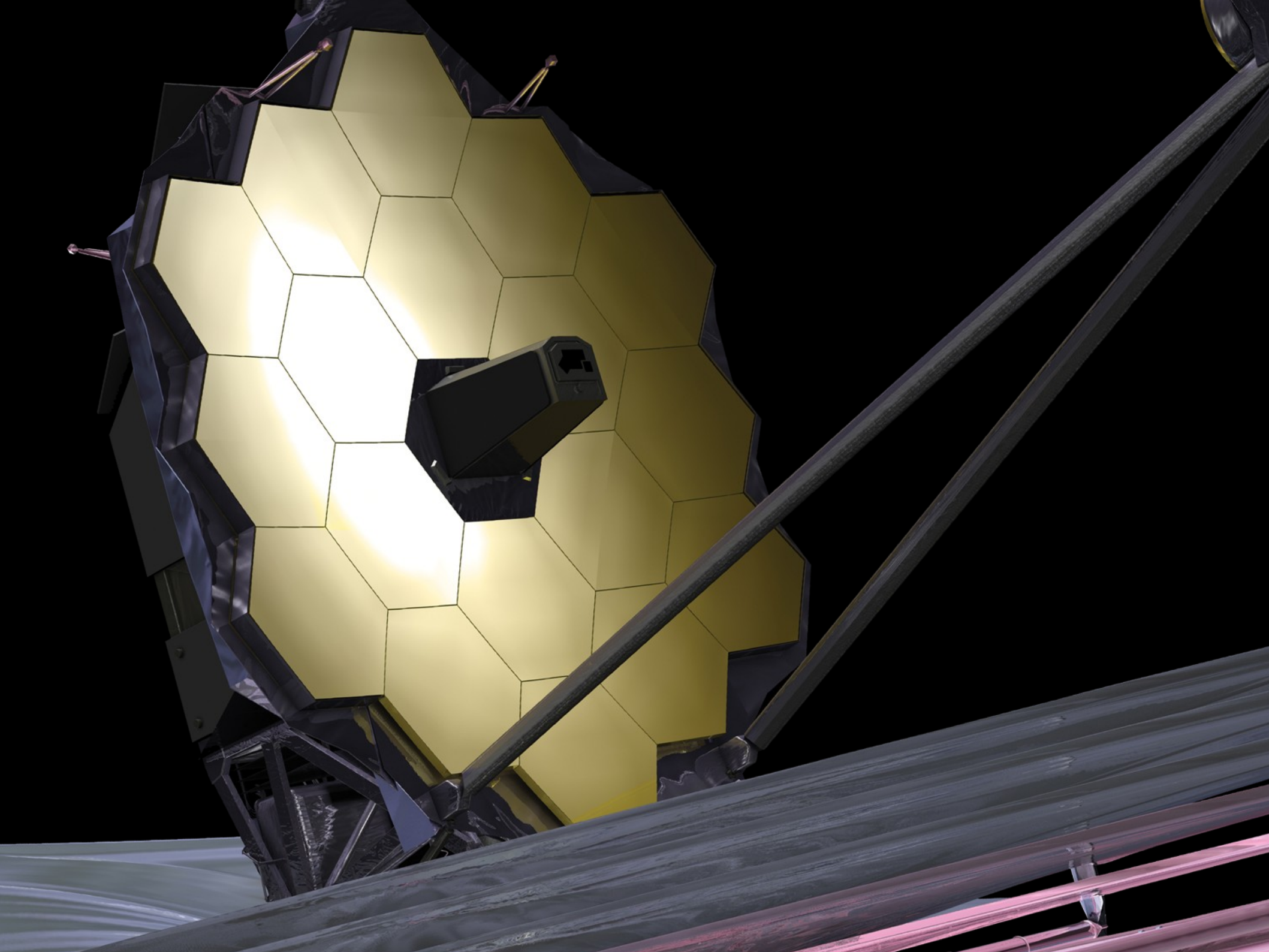

TUNDRA

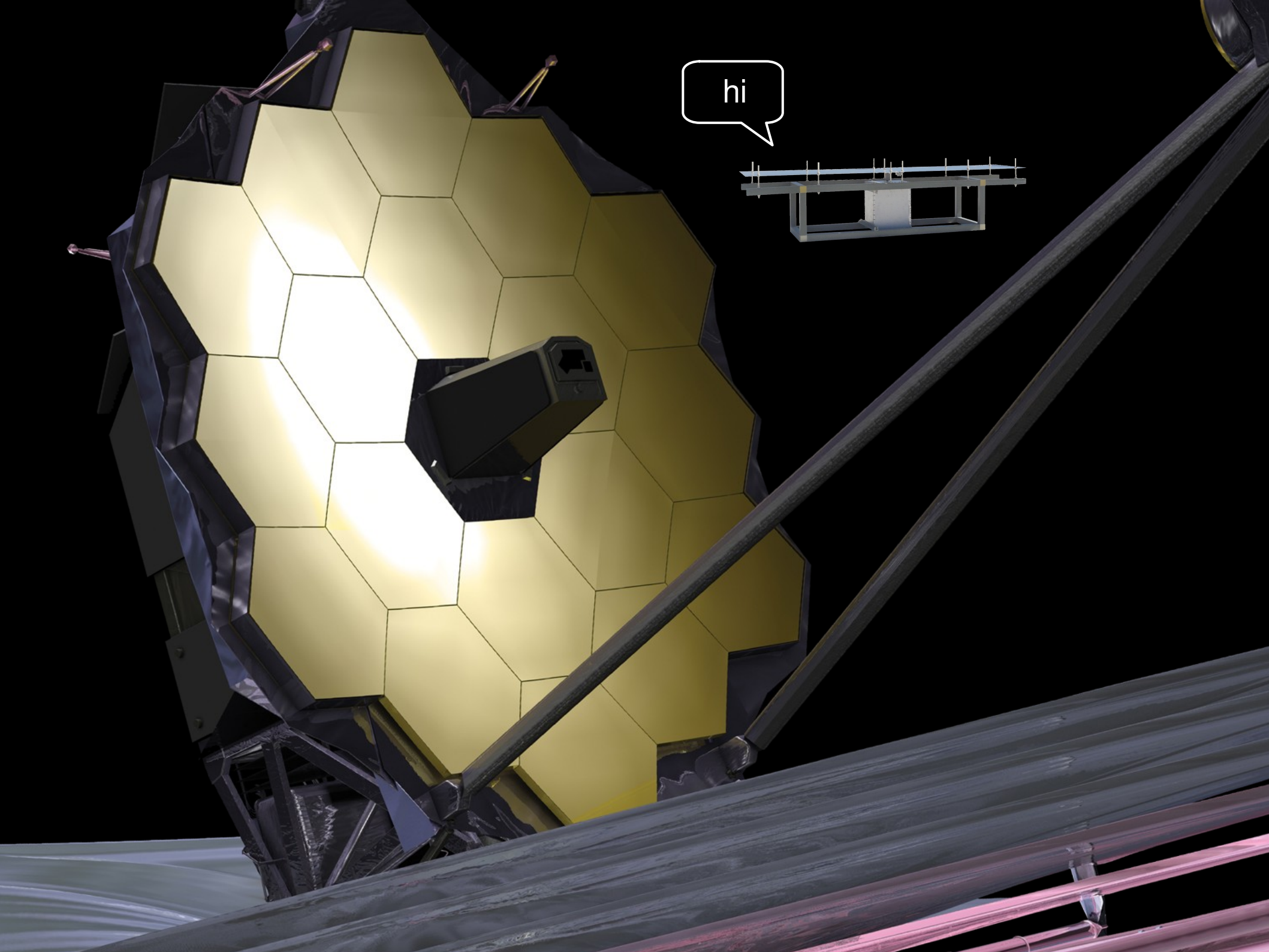
MIST

ALBATROS





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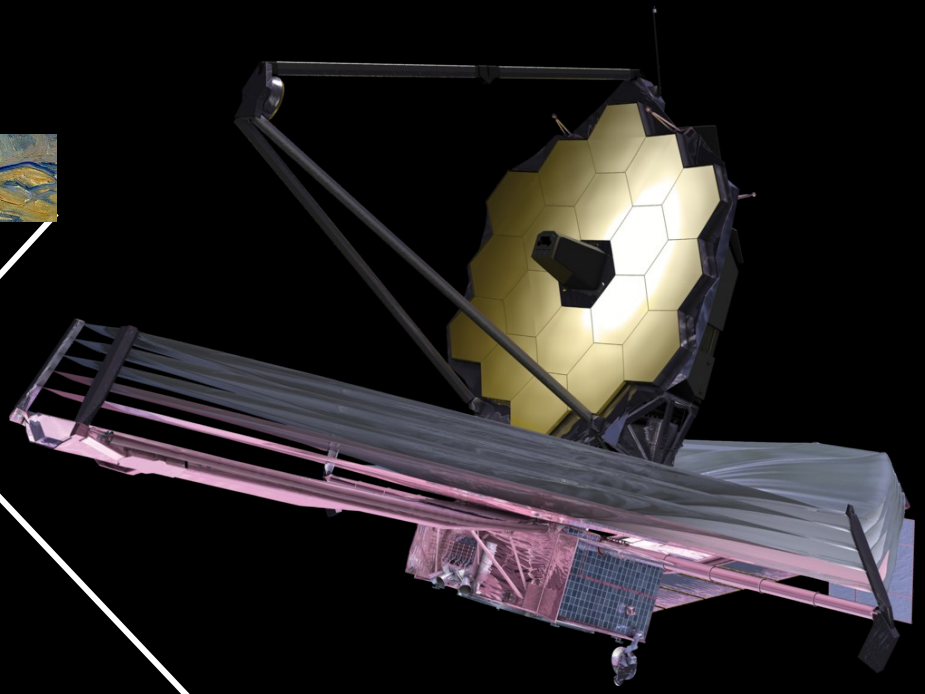
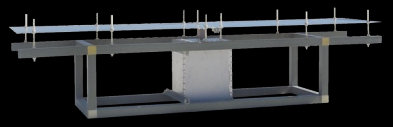
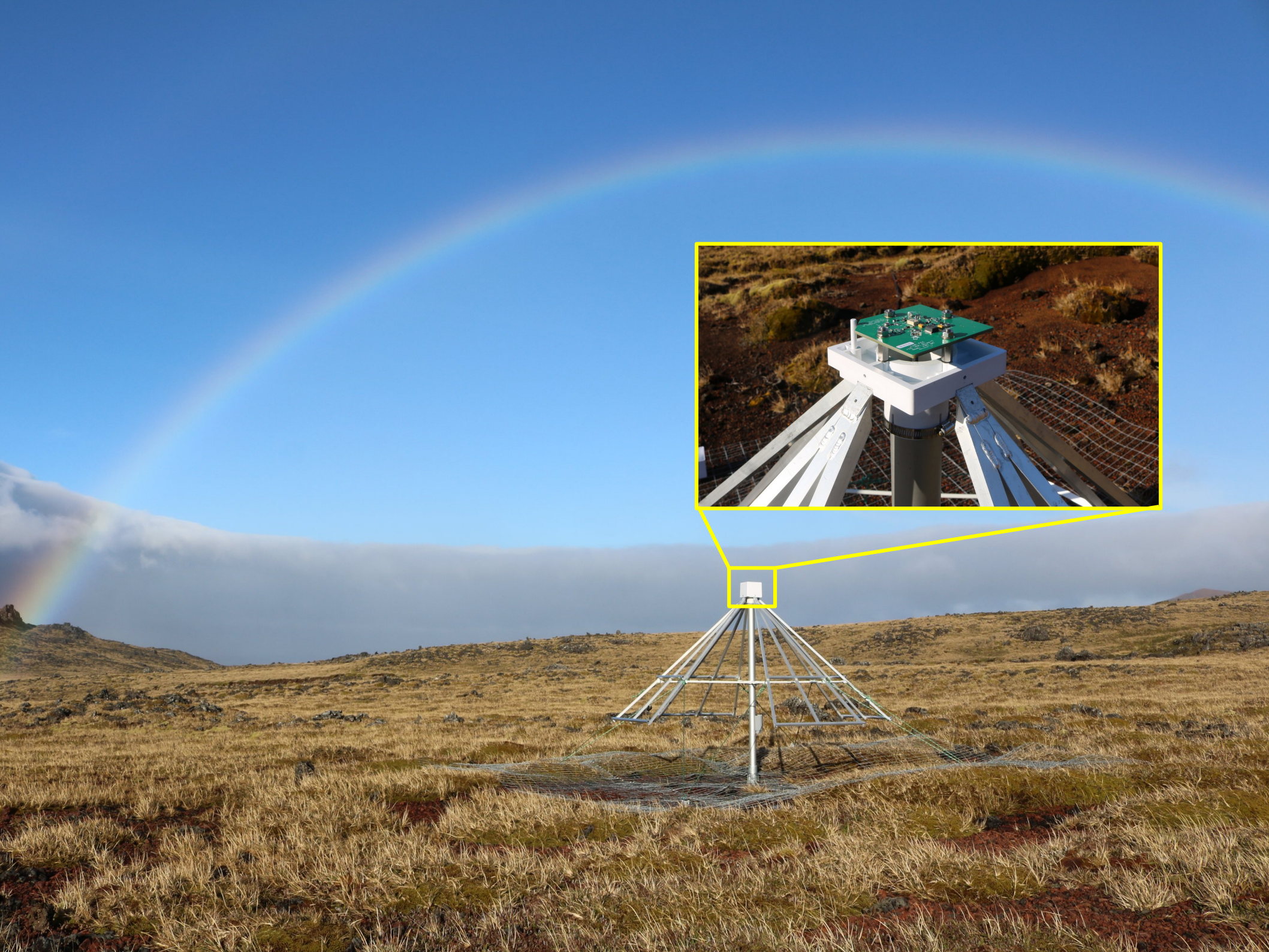
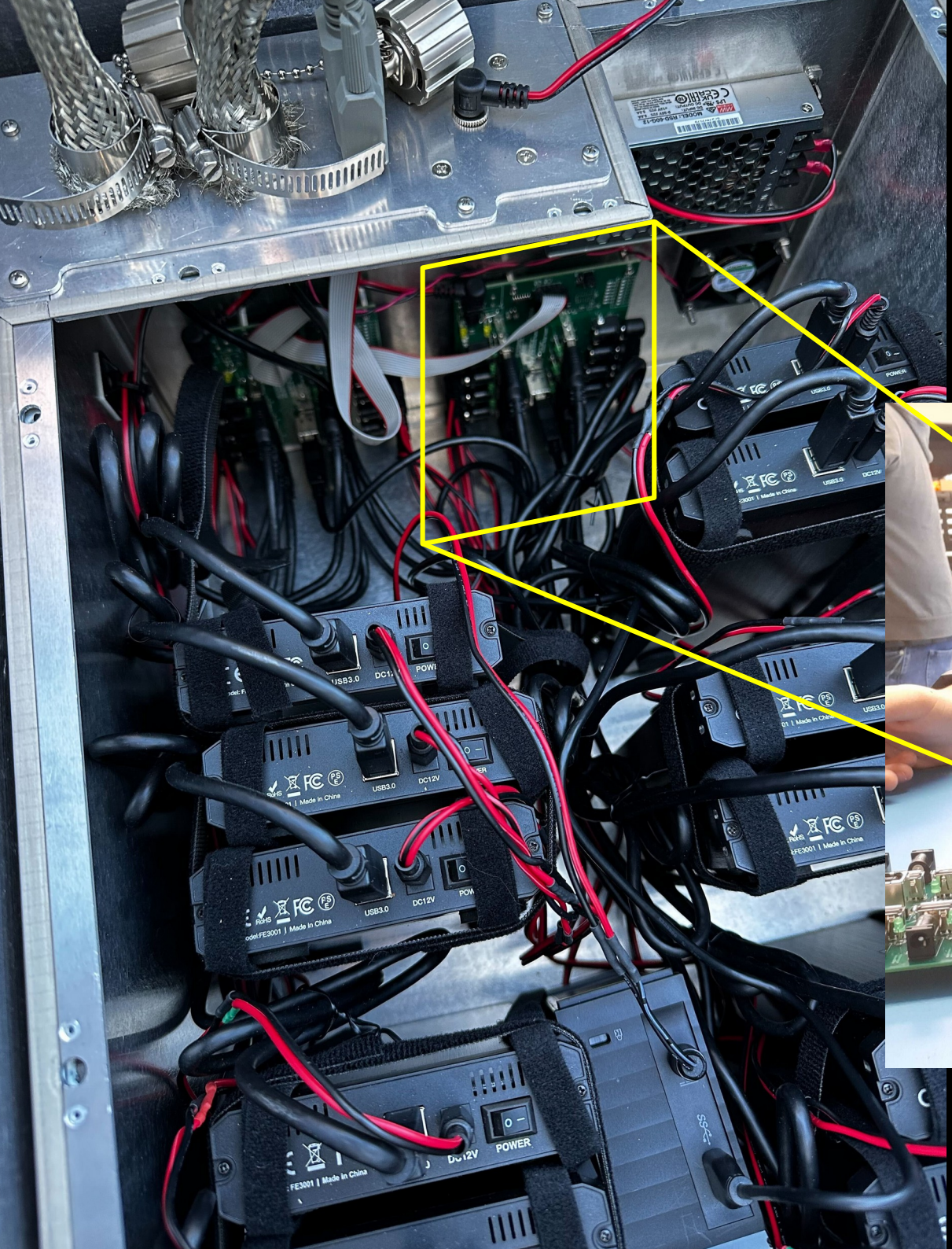
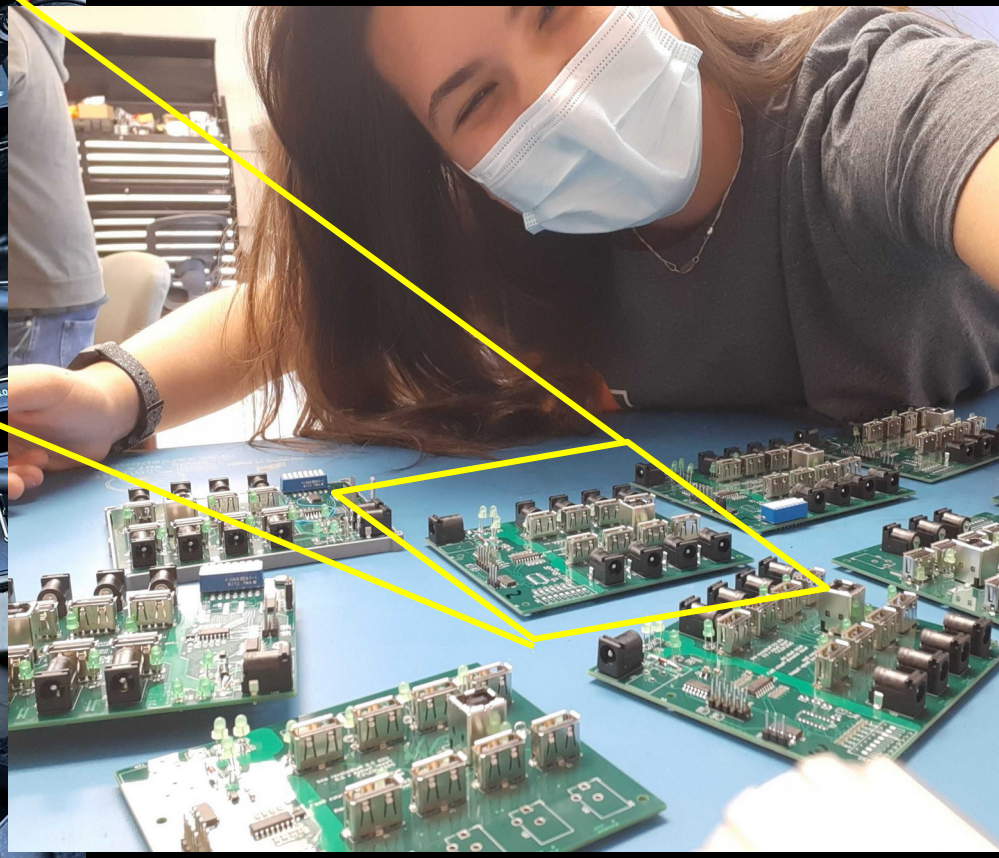


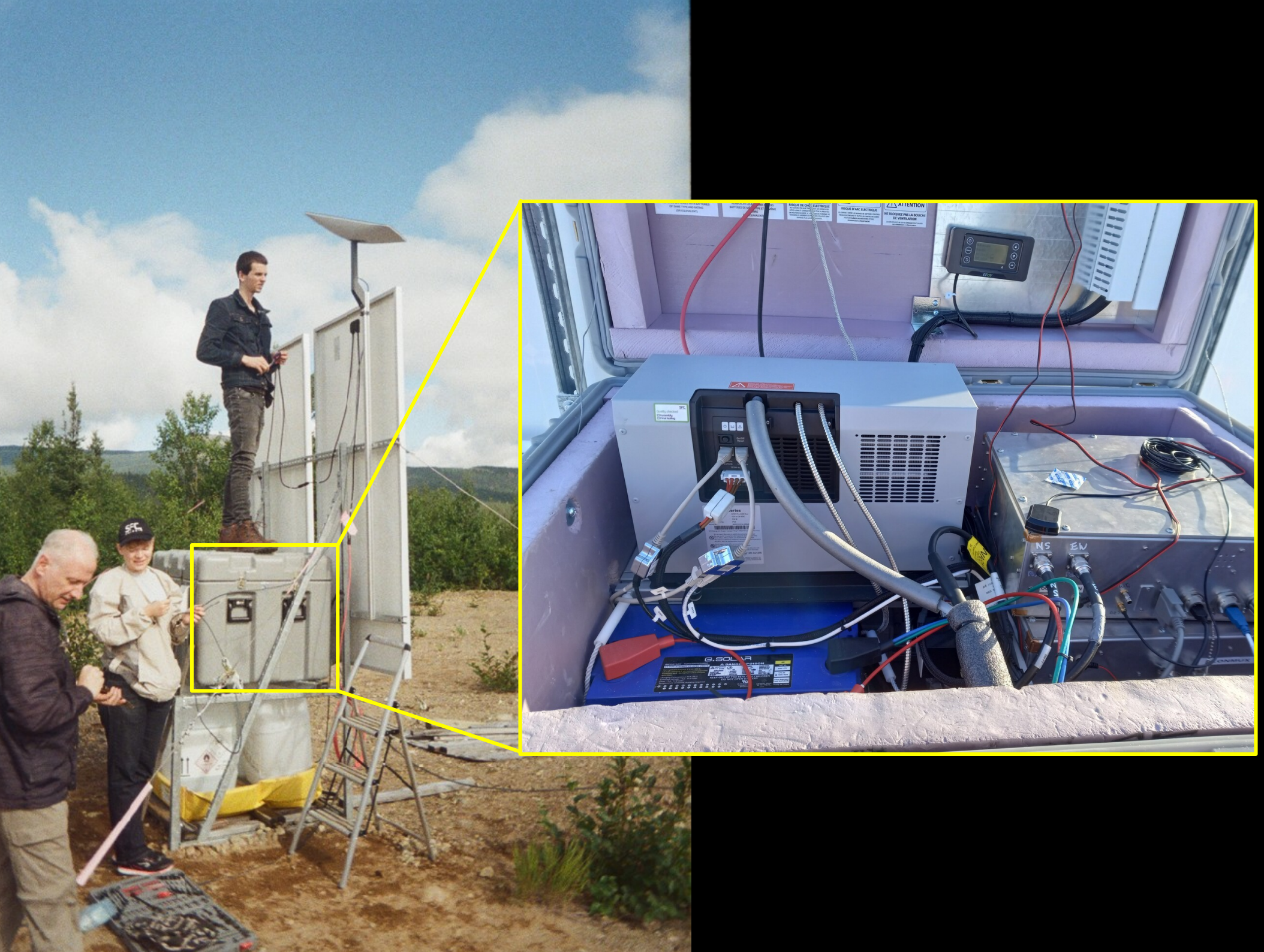





A
B
OUT
IN
GPS
SNAP 3
146.230.92.185


USB3.0
DC12V
POWER
Made in China



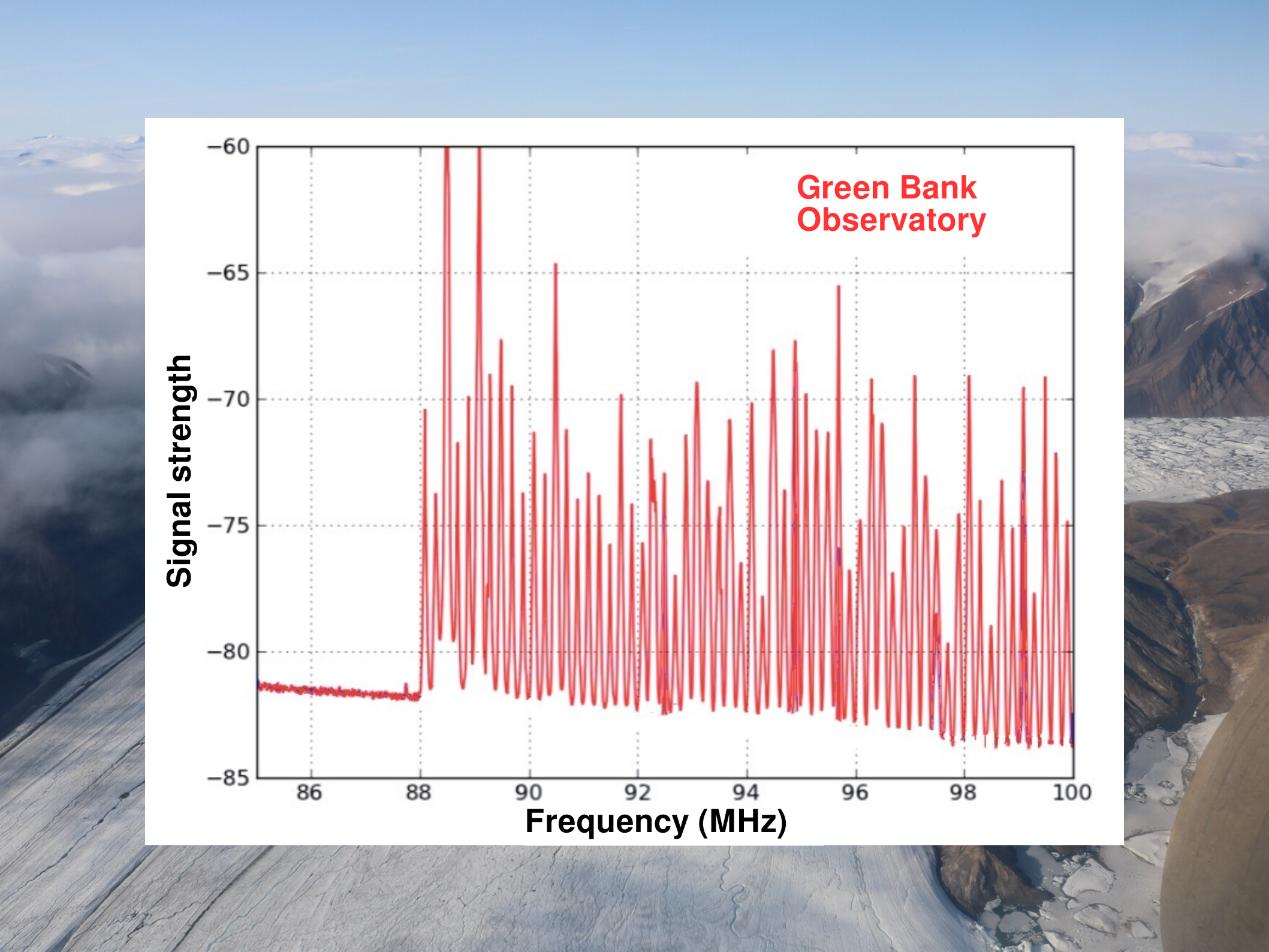


Amlóði

Hálfdrættingur

Hálfsterkur

Fullsterkur


Green Bank
Observatory
Signal strength
−60
−65
−70
−75
−80
−85
86
88
90
92
94
96
98
100
Frequency (MHz)

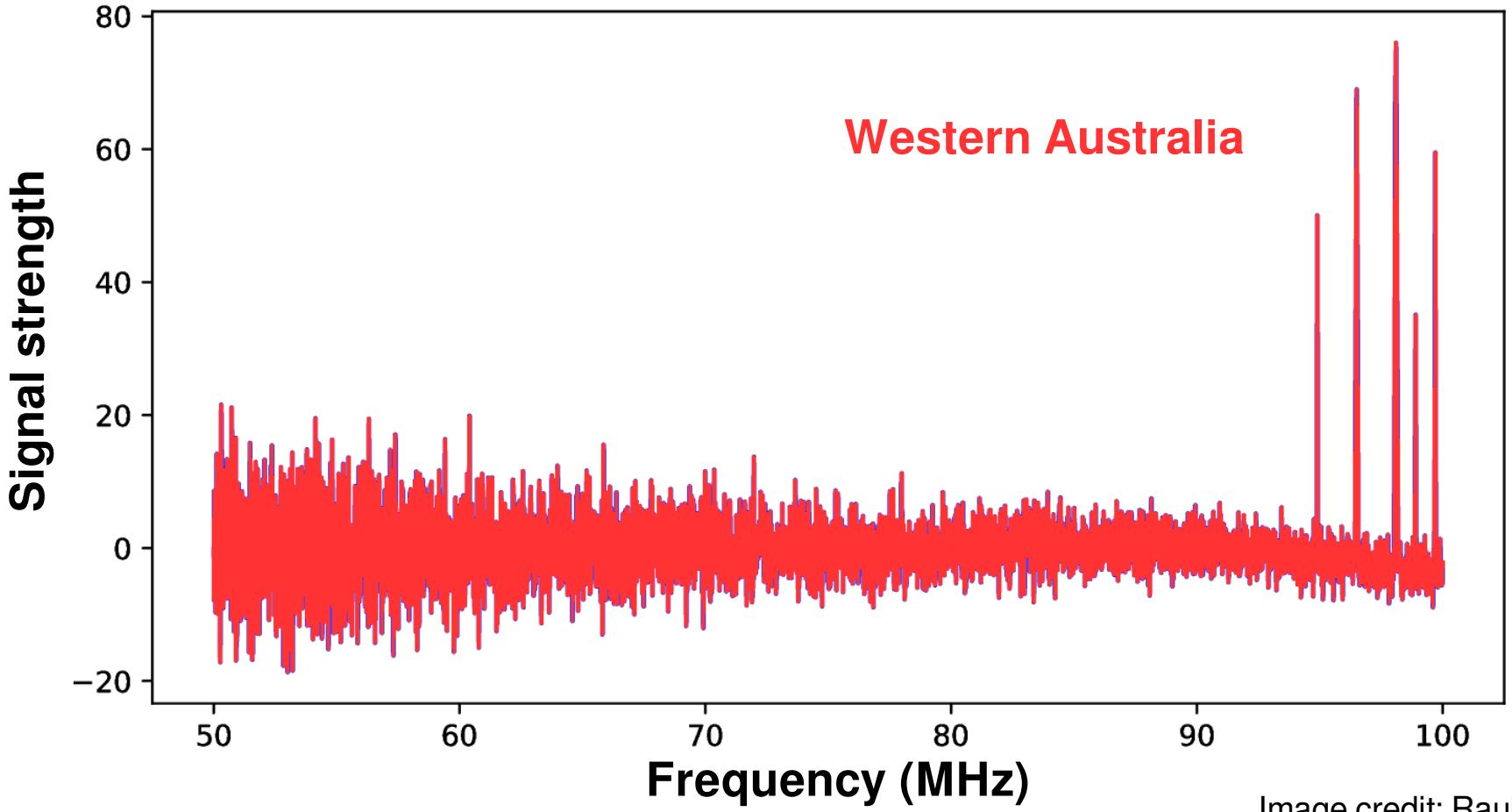
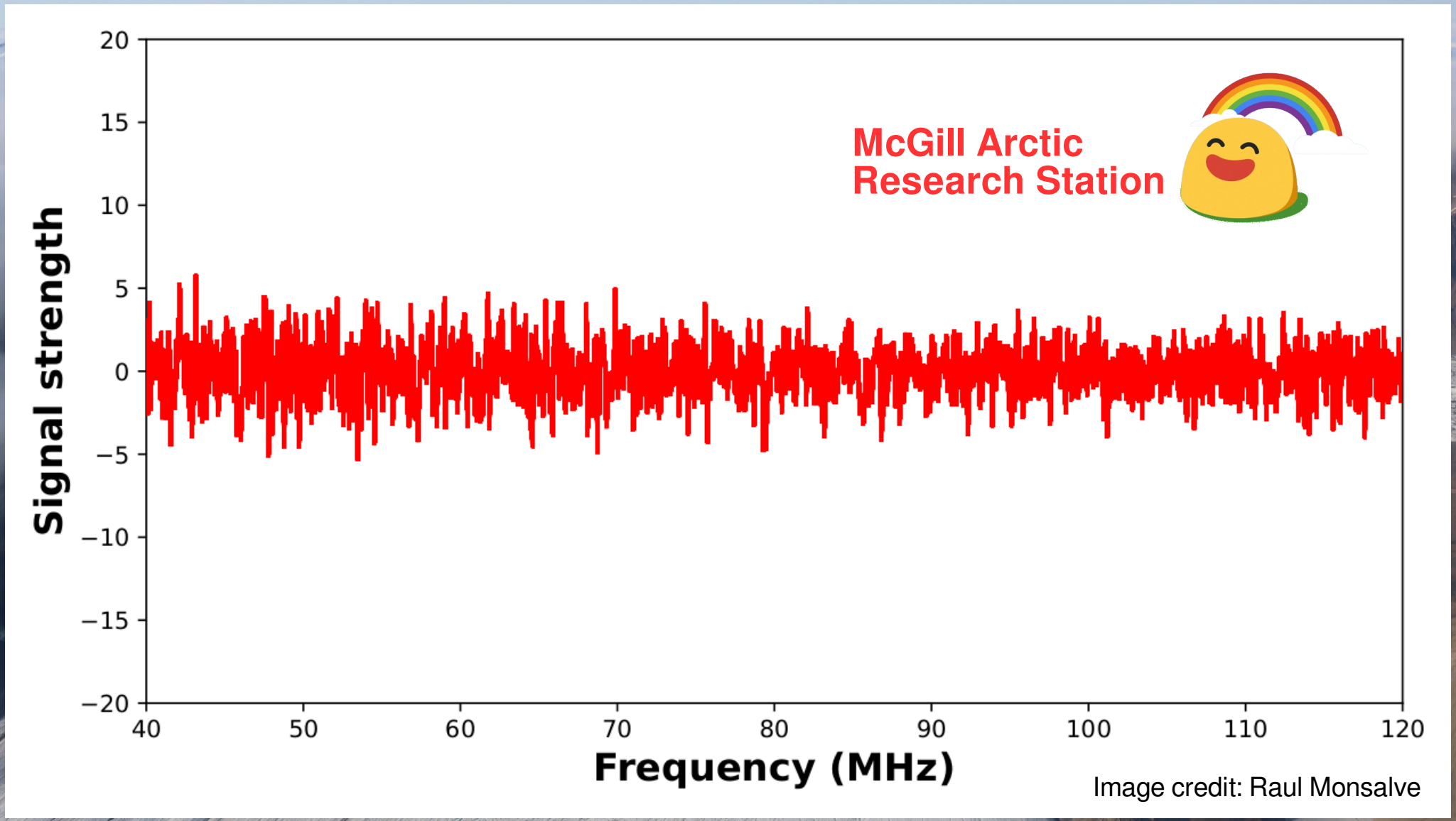


Image credit: Raul Monsalve



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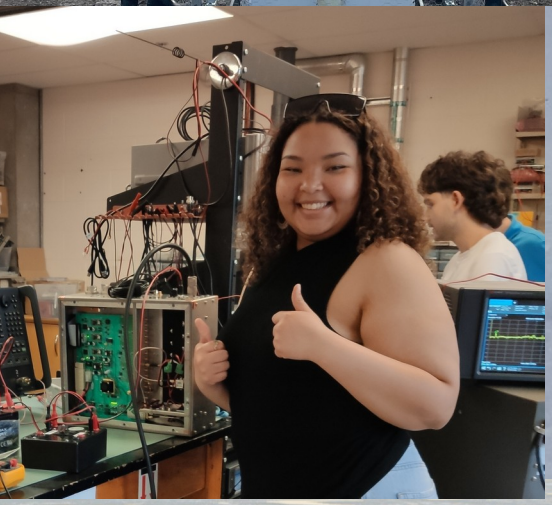


SUBARU

Thanks for listening!

@mcgillradiolab

Email: hsin.chiang@mcgill.ca

Radio astronomy lets us explore uncharted territory in the universe's history

We can listen to slices of history by literally tuning our radio telescopes

Big science questions + instrument building + adventure = FUN!