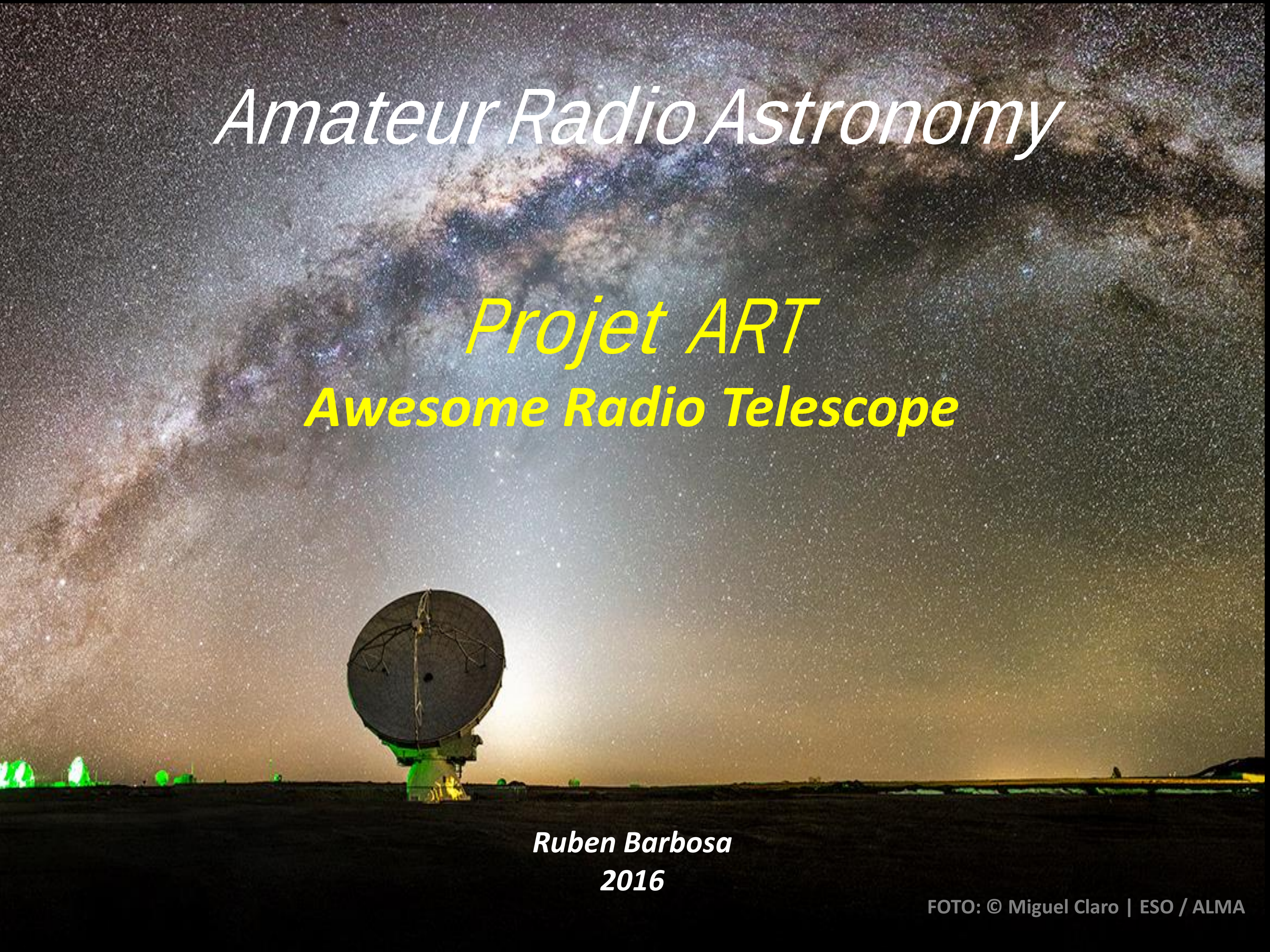


Amateur Radio Astronomy

Projet ART

Awesome Radio Telescope

Ruben Barbosa

2016

How to explore the Universe?

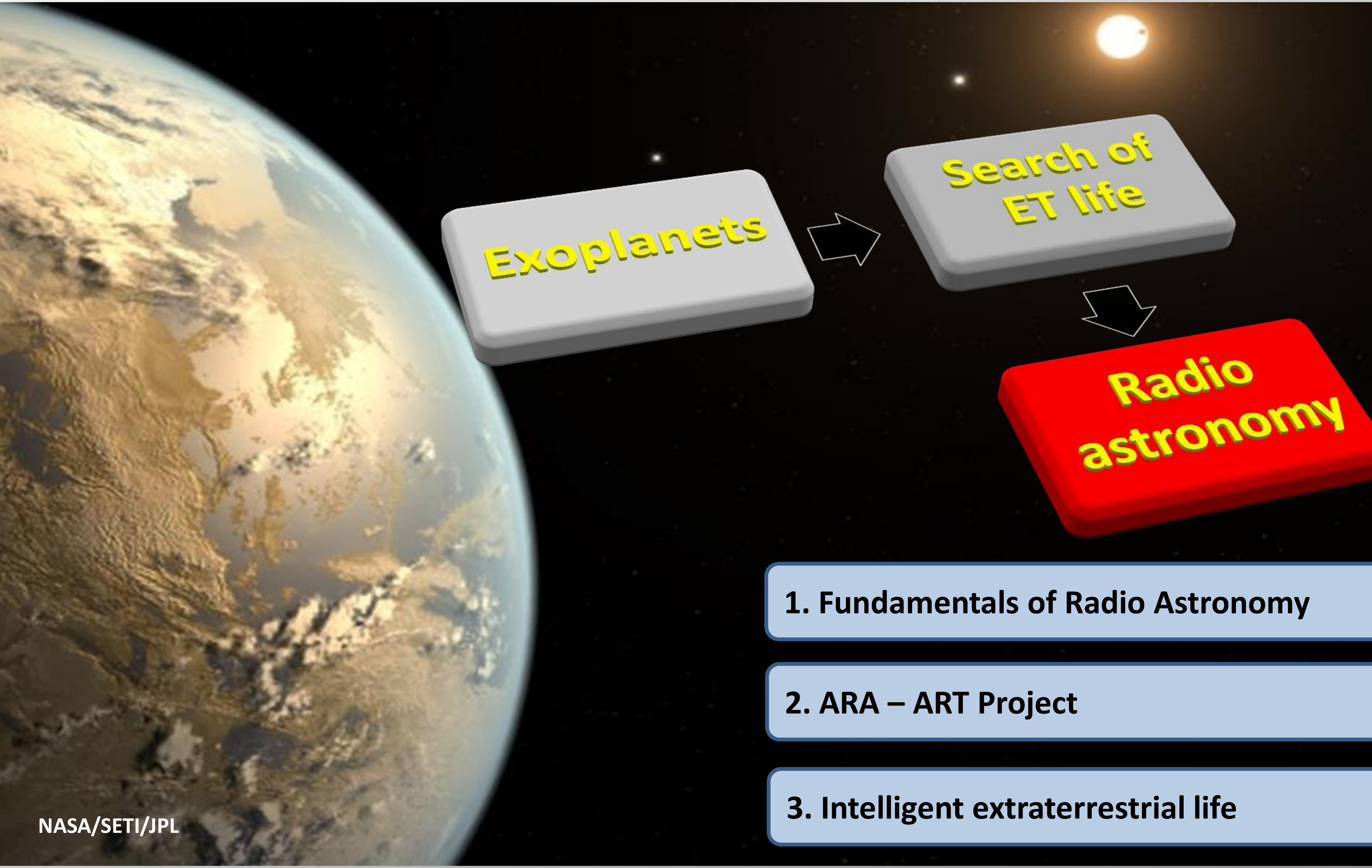
The search for ET life follows 3 main directions:

1. looking for primitive life (bacteria) → the solar system, by sending automated interplanetary probes,

2. biomarker detection (ozone) → in exoplanets similar to Earth located in habitable zones and

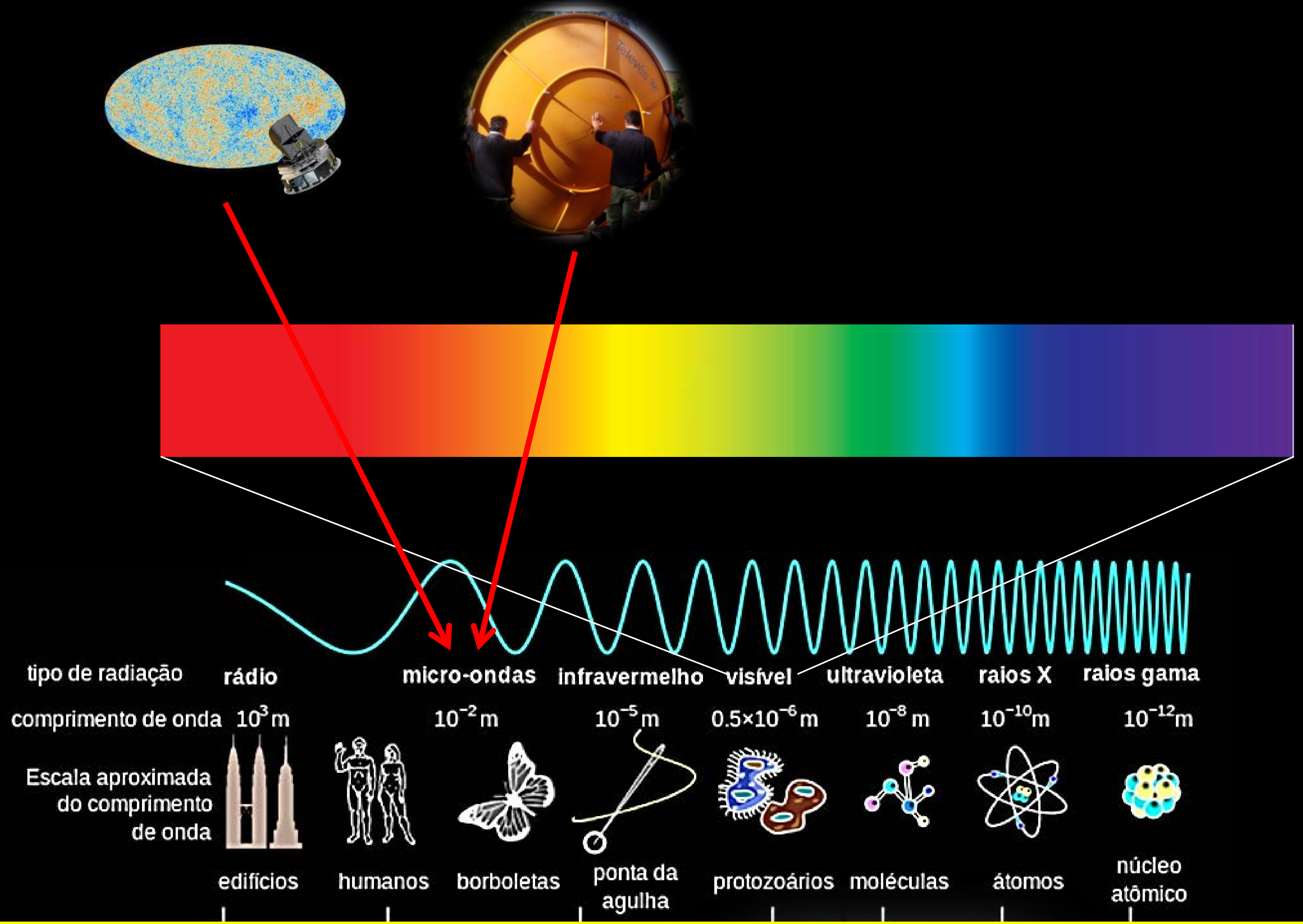
3. complex life demand (iET) → forms of life with technology similar to ours, by SETI

The rise of ART Project



1. Fundamentals of Radio Astronomy
2. ARA – ART Project
3. Intelligent extraterrestrial life

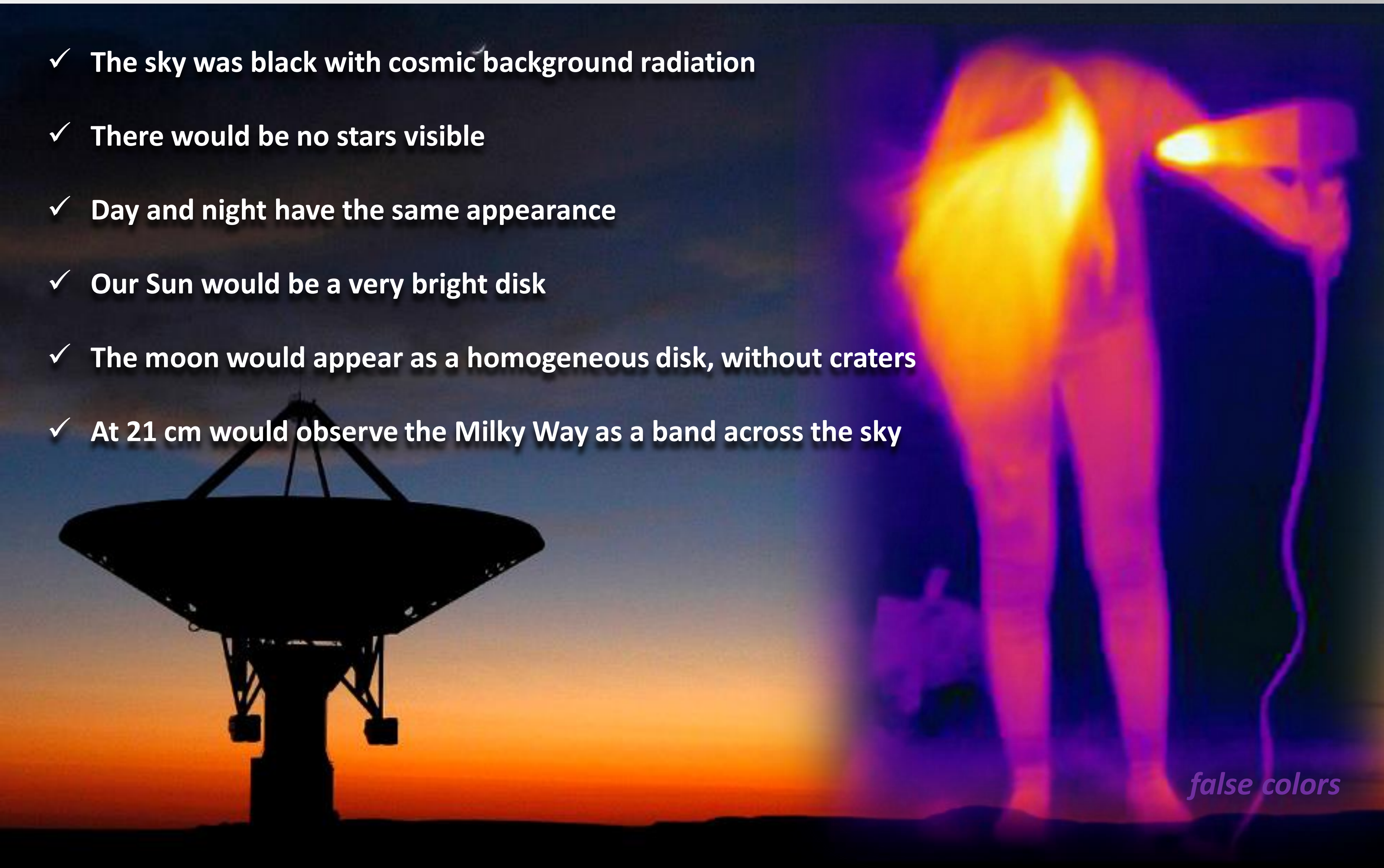
The electromagnetic spectrum



Thermal Imaging

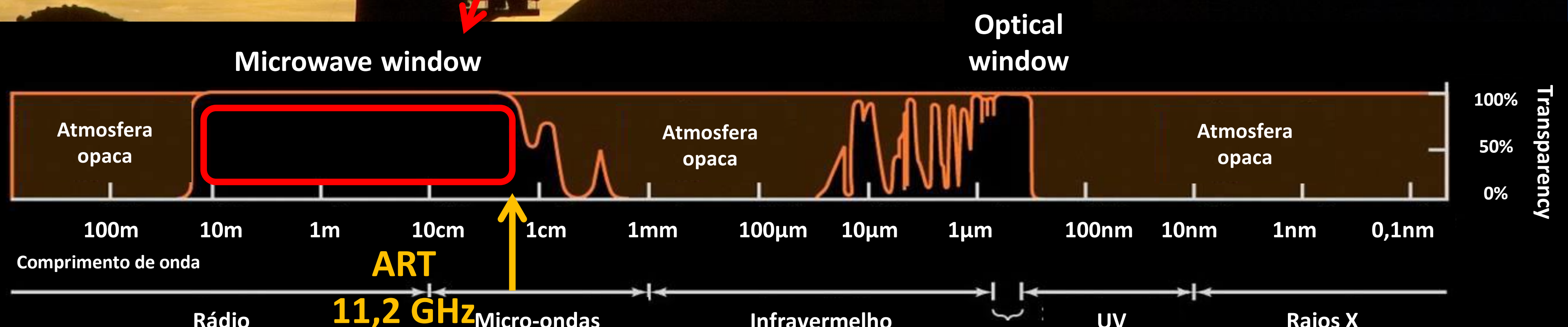
If our eyes were sensitive to radio ...

- ✓ The sky was black with cosmic background radiation
- ✓ There would be no stars visible
- ✓ Day and night have the same appearance
- ✓ Our Sun would be a very bright disk
- ✓ The moon would appear as a homogeneous disk, without craters
- ✓ At 21 cm would observe the Milky Way as a band across the sky



Microwave window

- Radio broadcast, covers frequencies from a few MHz (100 m) to frequencies of 300 GHz (1 mm)
- Microwave window 1 GHz to 10 GHz (30 cm to 3 cm), characterized by low background noise
- Minimum frequency limit is caused by the strong absorption in the atmosphere of the elements: O_2, CO_2, H_2O
- Maximum frequency limit is due to the opacity of the ionosphere



NRAO/ Ian Parker

Emission sources

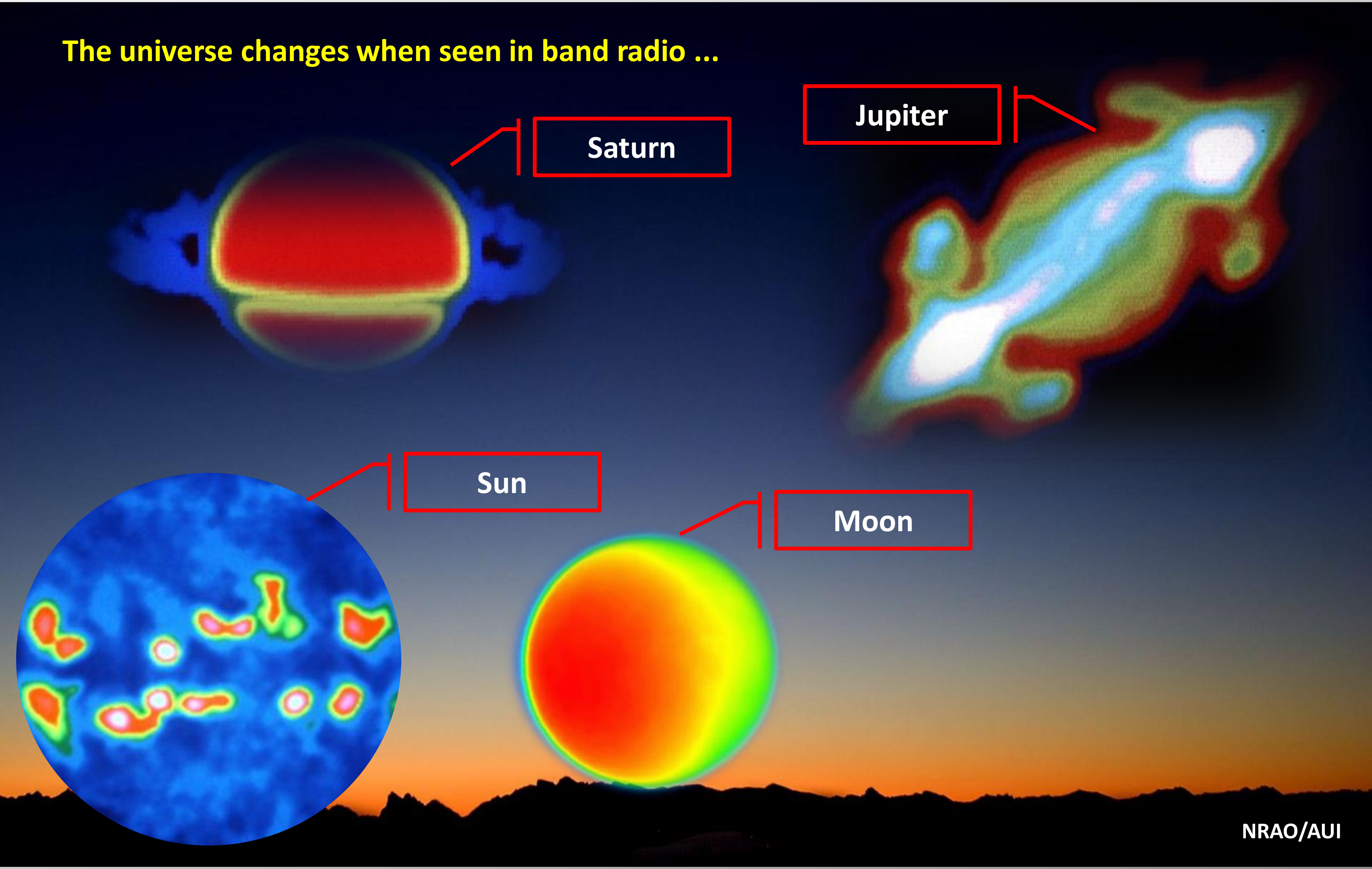
- ✓ **Thermal radiation:**
  - ✓ Black body: temperature of the planets
  - ✓ Bremsstrahlung (free-free): HII in M42
  - ✓ Spectral Ringer HI 21cm in the Milky Way

- ✓ **Non-thermal radiation:**
  - ✓ Synchrotron: magnetic fields in pulsars, supernovas, radio galaxies

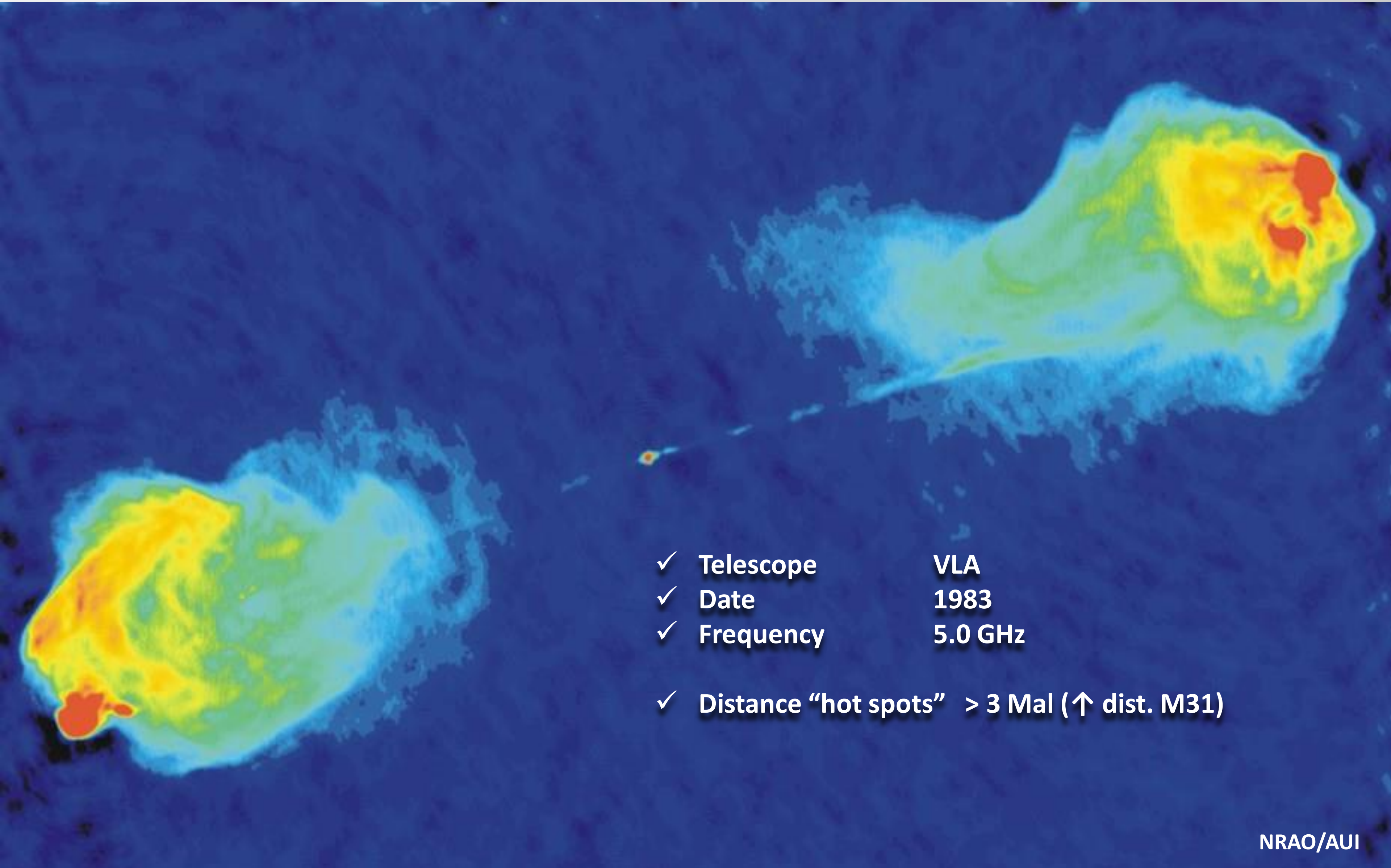
Spectral distribution of general energy

Bremsstralung (free-free): HII in M42

Solar System radio



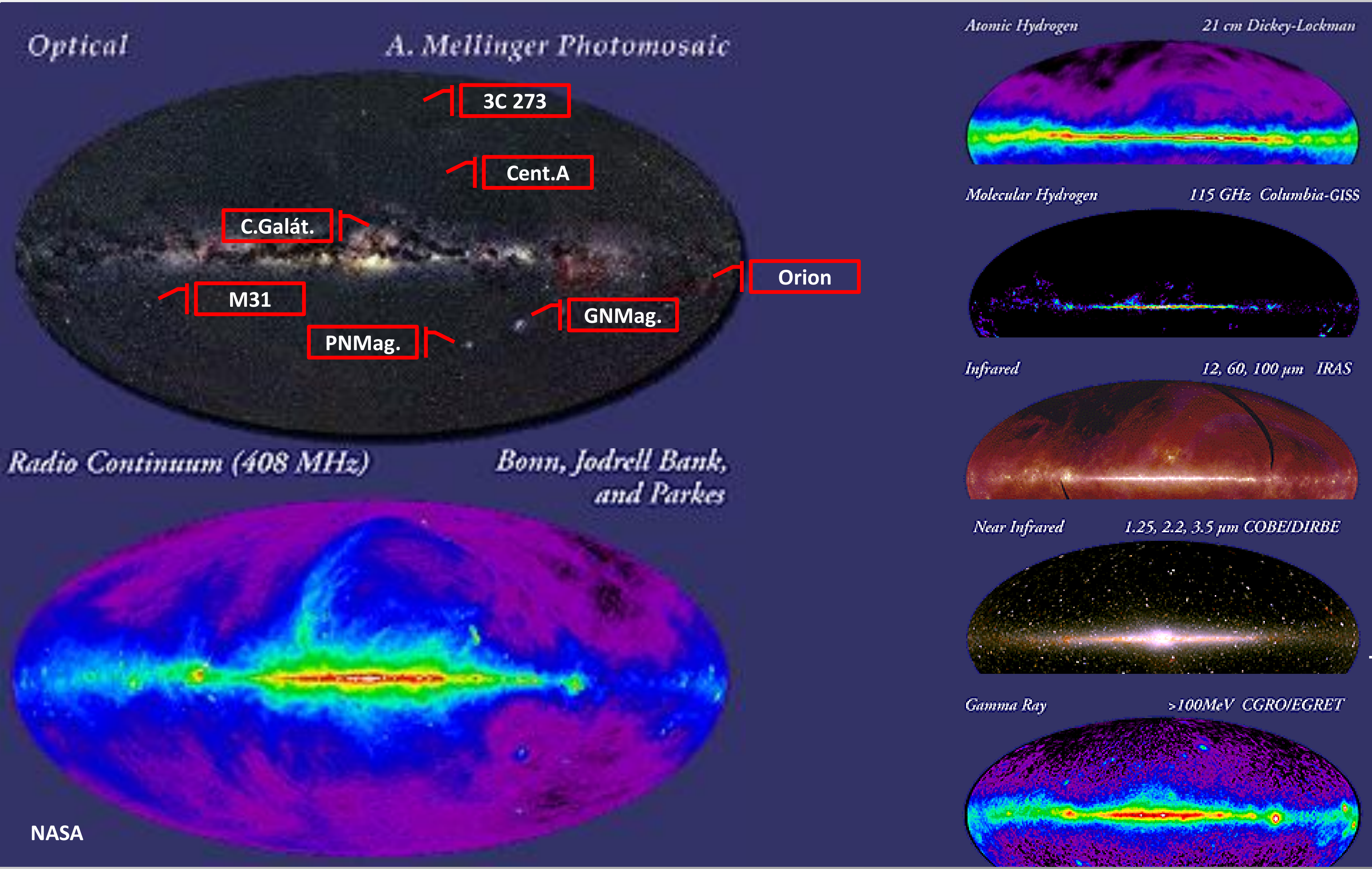
Radio galaxy Cygnus A



- ✓ Telescope VLA
- ✓ Date 1983
- ✓ Frequency 5.0 GHz

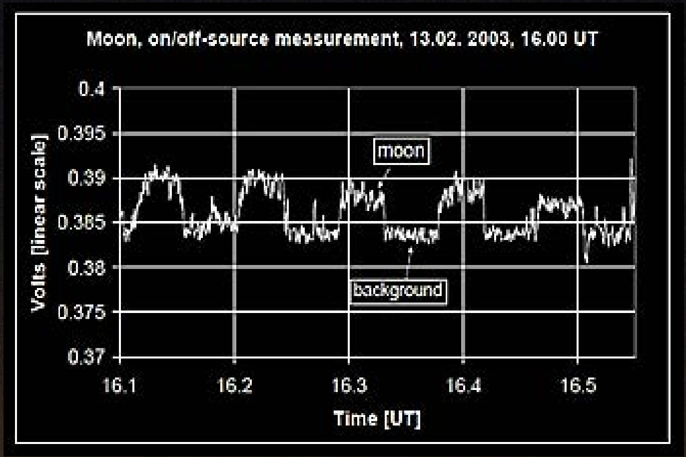
- ✓ Distance “hot spots” > 3 Mal (↑ dist. M31)

Milky Way in the optical and radio (408 MHz)



Radiation mediation methods

- ✓ **On/off-source**
  The source is measured for a few minutes and then the antenna is pointed at a site sky (cold) during the same period of time, where the source will pass again.



- ✓ **Transit**
  The telescope is targeted to the area where the source will carry over (2 hours prior to measuring the background radiation).

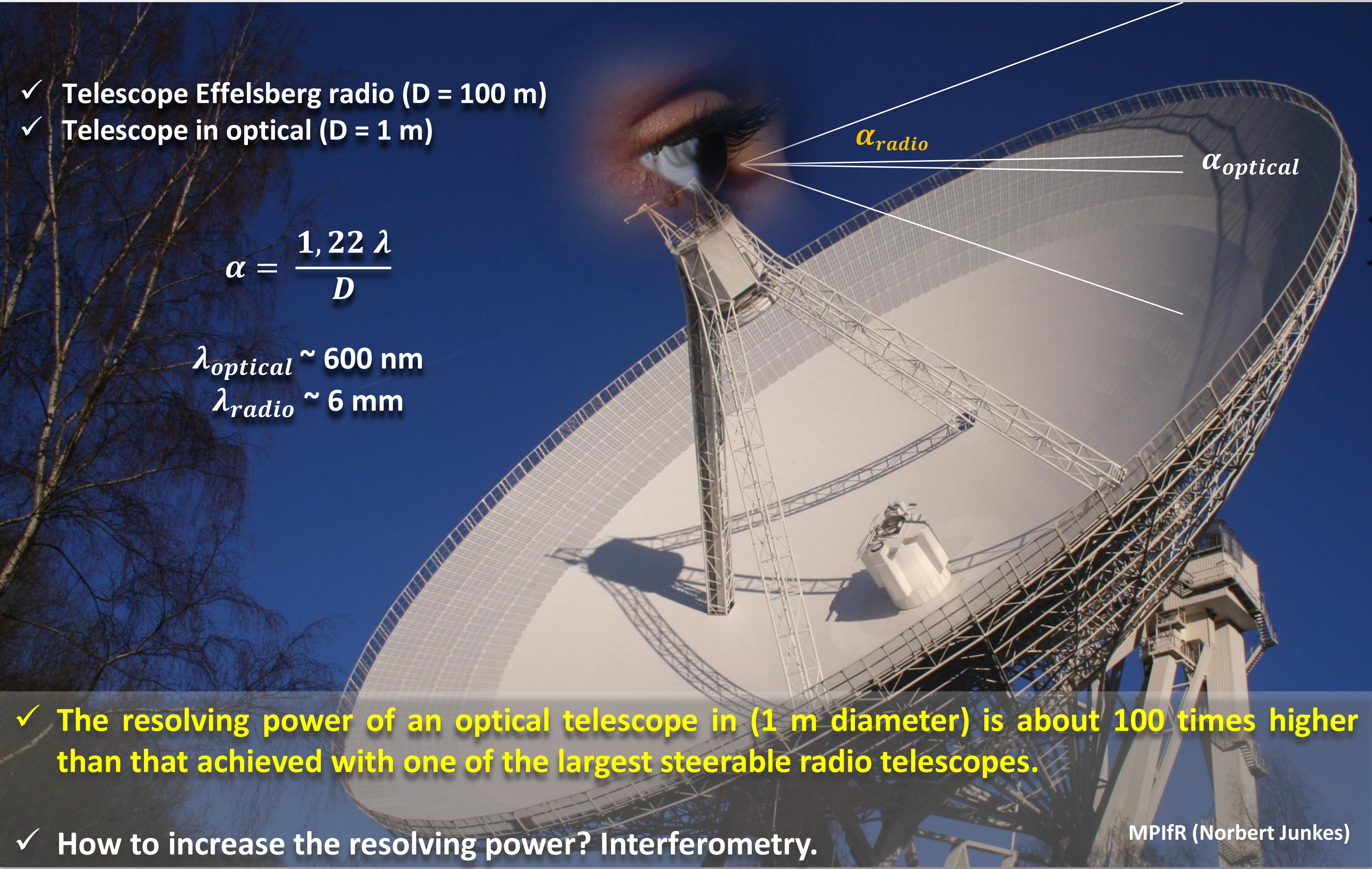
NRAO/ Ian Parker

Scientific importance of radio observing

- ✓ Cosmic microwave background radiation (Penzias and Wilson, 1963)
- ✓ Spiral structure of the Milky Way and rotation curve (note the letter of 21 cm of hydrogen)
- ✓ Discovery of new objects: Pulsars (Antony Hewish, 1974) and Quasars
- ✓ Observation of molecular clouds and star formation zones

NASA, APOD 2008-03-10, Graeme L. White & Glen Cozens

Resolution comparison



- ✓ Telescope Effelsberg radio (D = 100 m)
- ✓ Telescope in optical (D = 1 m)

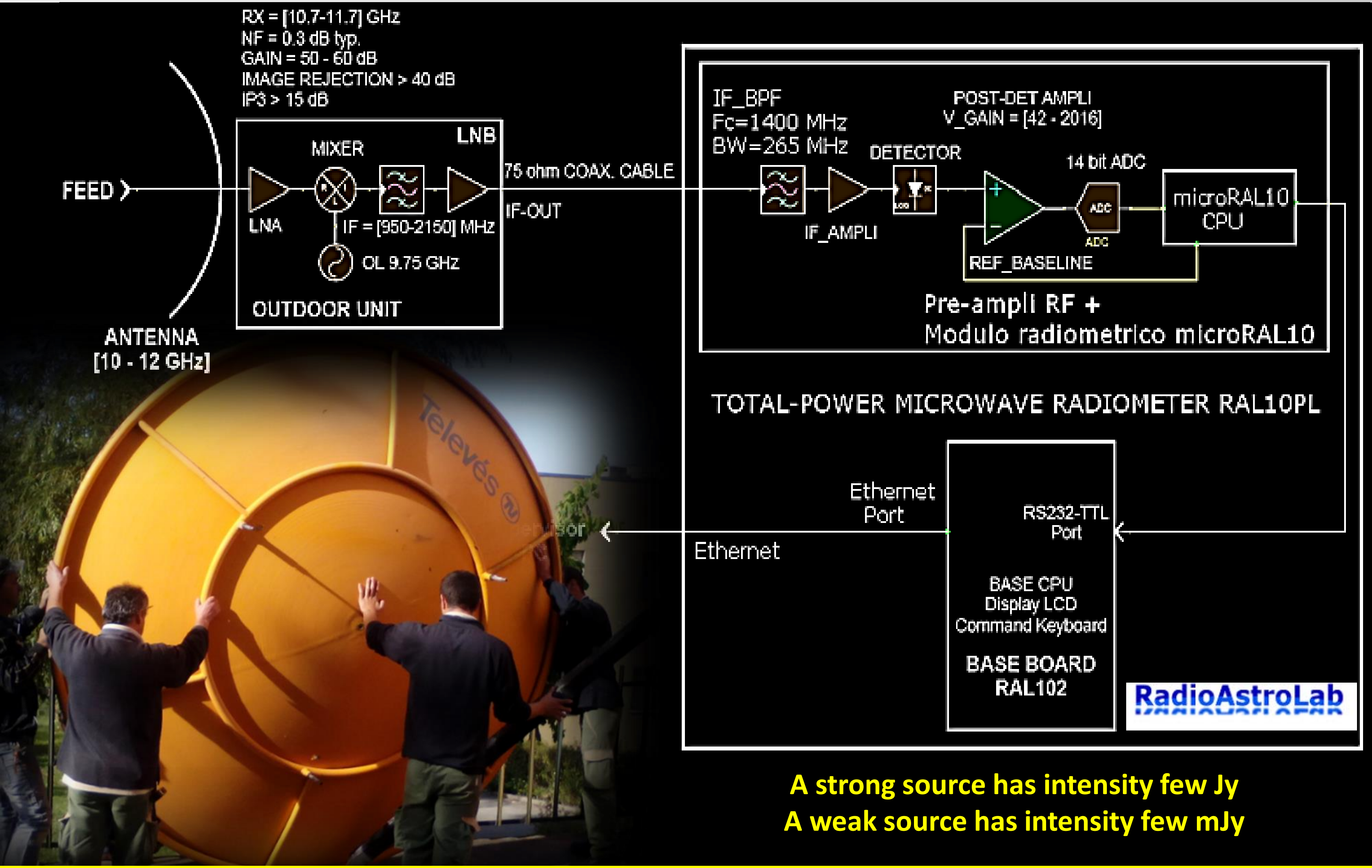
$$\alpha = \frac{1,22\,\lambda}{D}$$

$\lambda_{optical}$ ~ 600 nm
λ_{radio} ~ 6 mm

- ✓ **The resolving power of an optical telescope in (1 m diameter) is about 100 times higher than that achieved with one of the largest steerable radio telescopes.**

- ✓ How to increase the resolving power? Interferometry.

Scheme ART



A strong source has intensity few Jy
A weak source has intensity few mJy

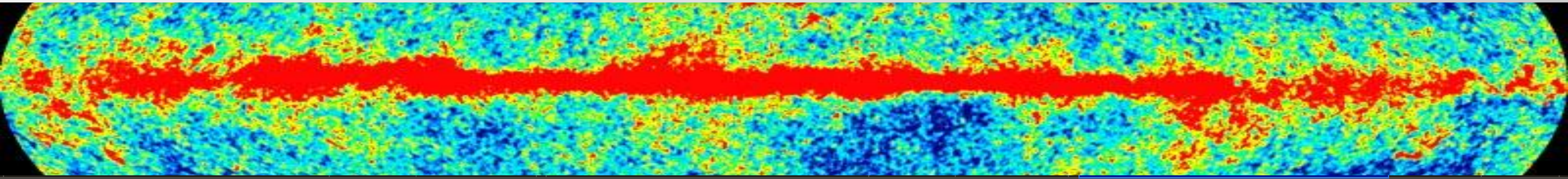
Why 11,2 GHz?

- ✓ Low cost of material (wide availability of material for satellite TV)
- ✓ Acceptable resolving power
- ✓ Minimum level of sky noise
- ✓ Strong immunity to artificial noise (can be used in urban areas)

- ✓ Radio astronomical sources in this frequency are not numerous or powerful, which means that small satellite dishes (up to 1.5 m) allow only observe the Sun (thermal component) and the moon, and
- ✓ Geostationary satellites can be a source of artificial noise.

Andrew Clegg/National Science Foundation

ART's cokpit (Mars detection in opposition)



Global definitions		
Frequency (f)	11.200	MHz
Wavelenght (λ)	2,677	cm
Diameter of the aperture (D)	3,00	m
Antenna aperture efficiency (η)	0,50	
Antenna depth (d) / Focal lenght (z)	30	m (z = 1,88 m)
Analysys parabolic reflector antenna with circular symmtery		
Antenna gain (Ga_max)	61.988	times
Antenna gain (Ga_max_dB)	47,9	dB
Effective diameter of the antenna (Deff)	2,12	m (Aeff=3,534 m2)
Theoretical Beamwidth - HPBW (Θ) = ~0,7439°	**0,744**	° = 44,64 arcmin
Theoretical Beamwidth (max) - HPBW (λ/D)	0,624	° = 37,42 arcmin
Diameter of the full covered area (BWFN)	1,49	° (+3dB HPBW)
Geometric area of the dish (A)	**7,07**	m2
Primus focus [0,32 - 0,43]	1,1	m
Receiver parameters		
GLNB	55	dB
Line amplifier gain + GIF	0	dB
Losses coaxial cable and connectors	1	dB
Total gain (G)	**54,0**	dB
Total gain (G)	251.189	times
LNB noise (Fr_dB)	0,4	dB
Noise temperatura of the receiver (Tr)	28,9	k
Integration time (τ)	0,1	' (RMS10%=3,8 ')
Bandwidth of the receiver (BW)	250	MHz
Impedance F connector for RF-IF input (R)	75	ohm
Voltage input to the doide detector	1,37	mV (ΔdBm= ,)

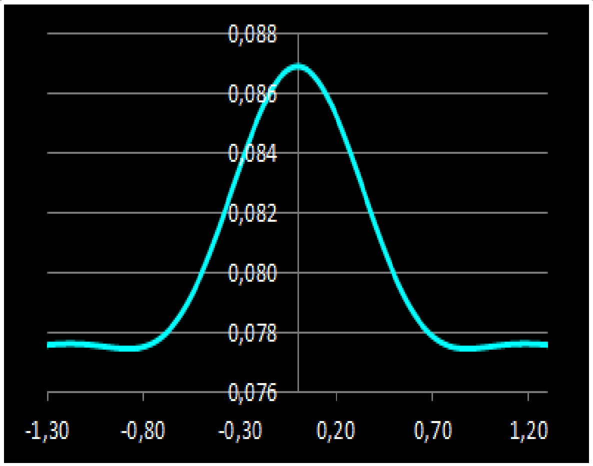
Parameters of the observed radio source		
Fictitious angular diameter - non thermal	2,81	arcmin
Apparent angular diameter	0,30	arcmin
Solid angle subtented by the source (Ωr)	5,98E-09	rad^2
RT's acceptance (Ω)	5,30E-04	rad^2
Real flow of the radio source (Sv)	5,1	Jy
Brightness temperature (ΔT)	221	k
Empirically adjustment (A)	3,59654	

Flux correction		
Measured temperature	210	k
Source measured flux	4,8	Jy
Atmospheric opacity (τA)	0,05	
Elevation angle of the antenna (ϕ)	70,0	
Zenith opacity estimate (τZ)	0,05	
Elevation to predict	85,0	°
Flux density estimate	4,9	Jy (T = 211 k)

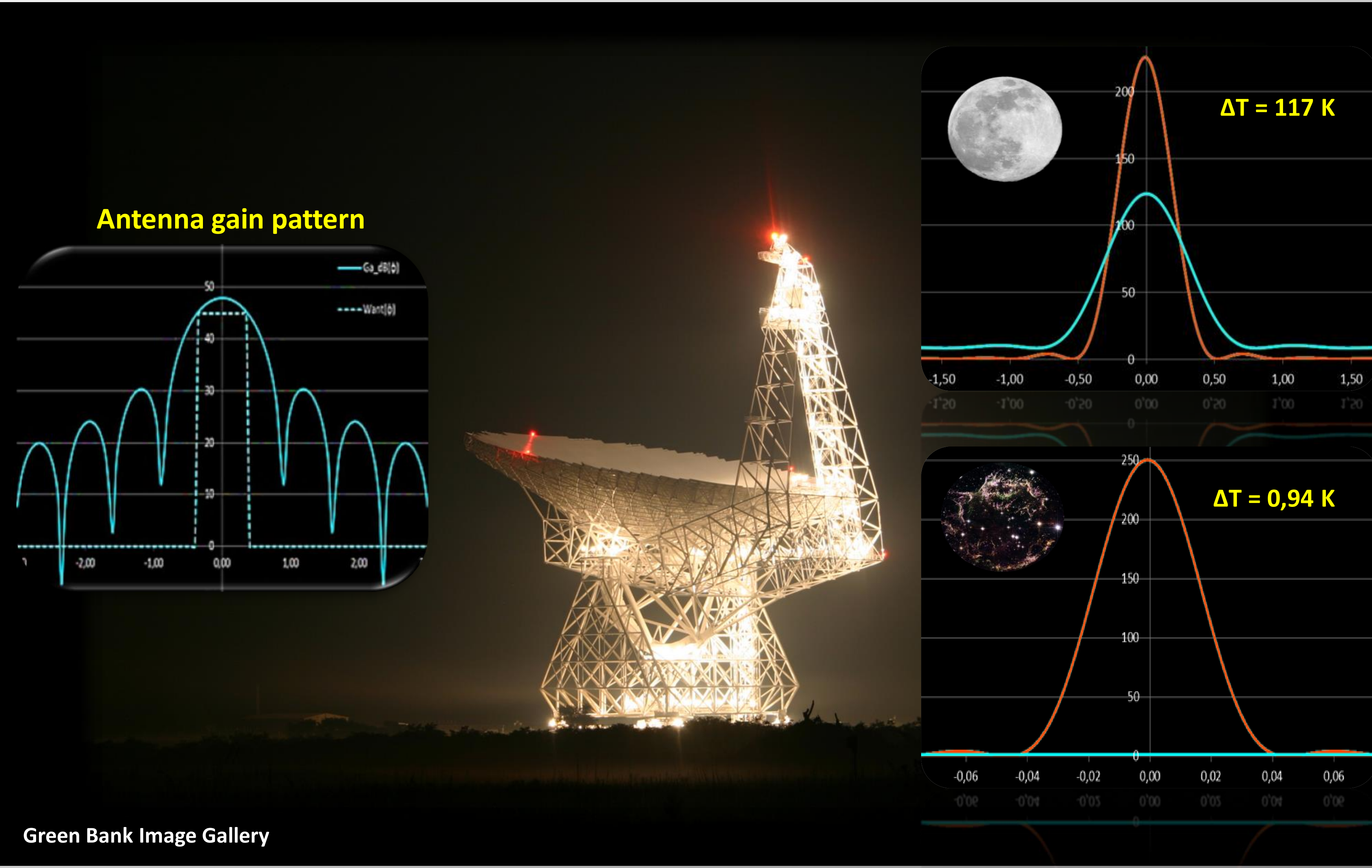
Antenna temperature		
BT of the cosmic µwave background (Tcmb)	2,8	k
BT of the atmosphere with attenuation (Tatm)		
BT of the atmosphere (Tatm)	3,6	k
Noise of the ground (Tgnd)	4,6	k (ϕ=1,498°)
Azimuthal distribution of BT of the RS →Ts(ϕ)	221,4	k (ϕ=0,000°)
Sky temp.: T(0) I T(out) I Δ=221,4 k	**232,4**	k (T = 11,0 k)
Antenna temp.: Ta(0) I Ta(out) I Δ=0,009 k	**0,087**	k (T = 0,077 k)
System temp.: Tsys(0) I Tsys(out) I Δ=0,009 k	**29,0**	k (T = 29,0 k)

Sensitivity of the receiver		
Minimum measurable change (Δt_min)	**0,0058**	k
Min. detectable source flux density (ΔS_min)	**4,533**	Jy
Coefficient of performance degradation (ξ)	5	
Detection signal variation	0,000	k

Drifting versus HPBW		
Source drift time (BWFN)	1110	"
Source transit angle (BWFN)	4,63	°
Source drift angle from equator	#NÚM!	°
Source declination (δ)	22,0	°
Max. time drift (HPBW)	161,4	" = 3 '
HPBW	**4,288**	°

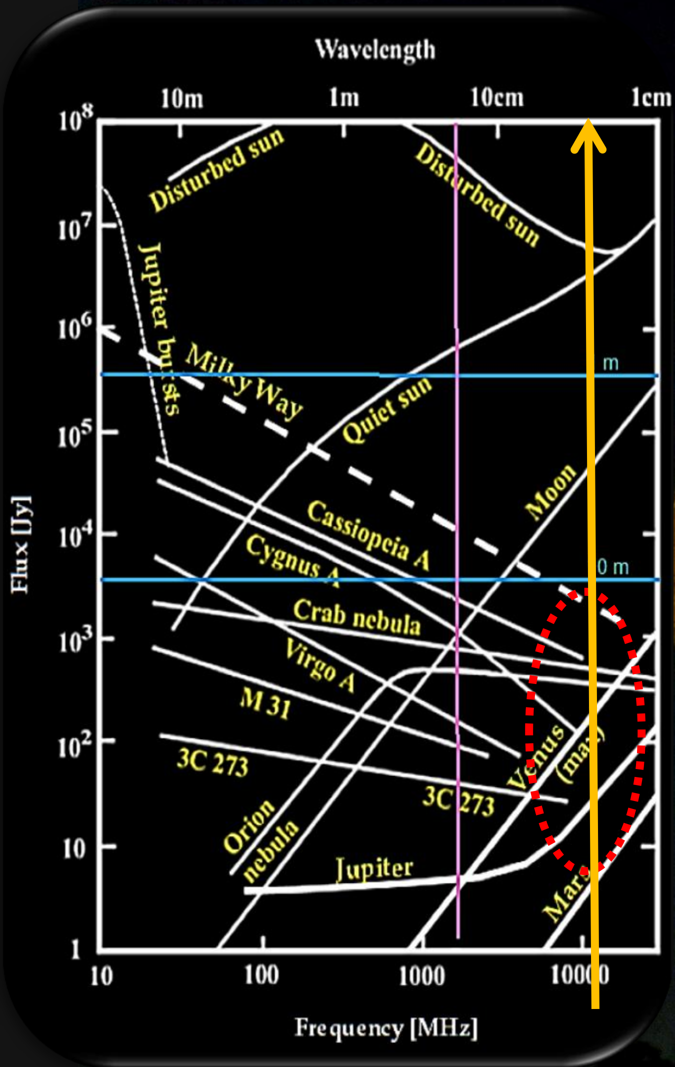


Theoretical models



Green Bank Image Gallery

Scope of observations



Solar system
Sun Transit
Moon: temperature x phase
Venus, Mars, Jupiter

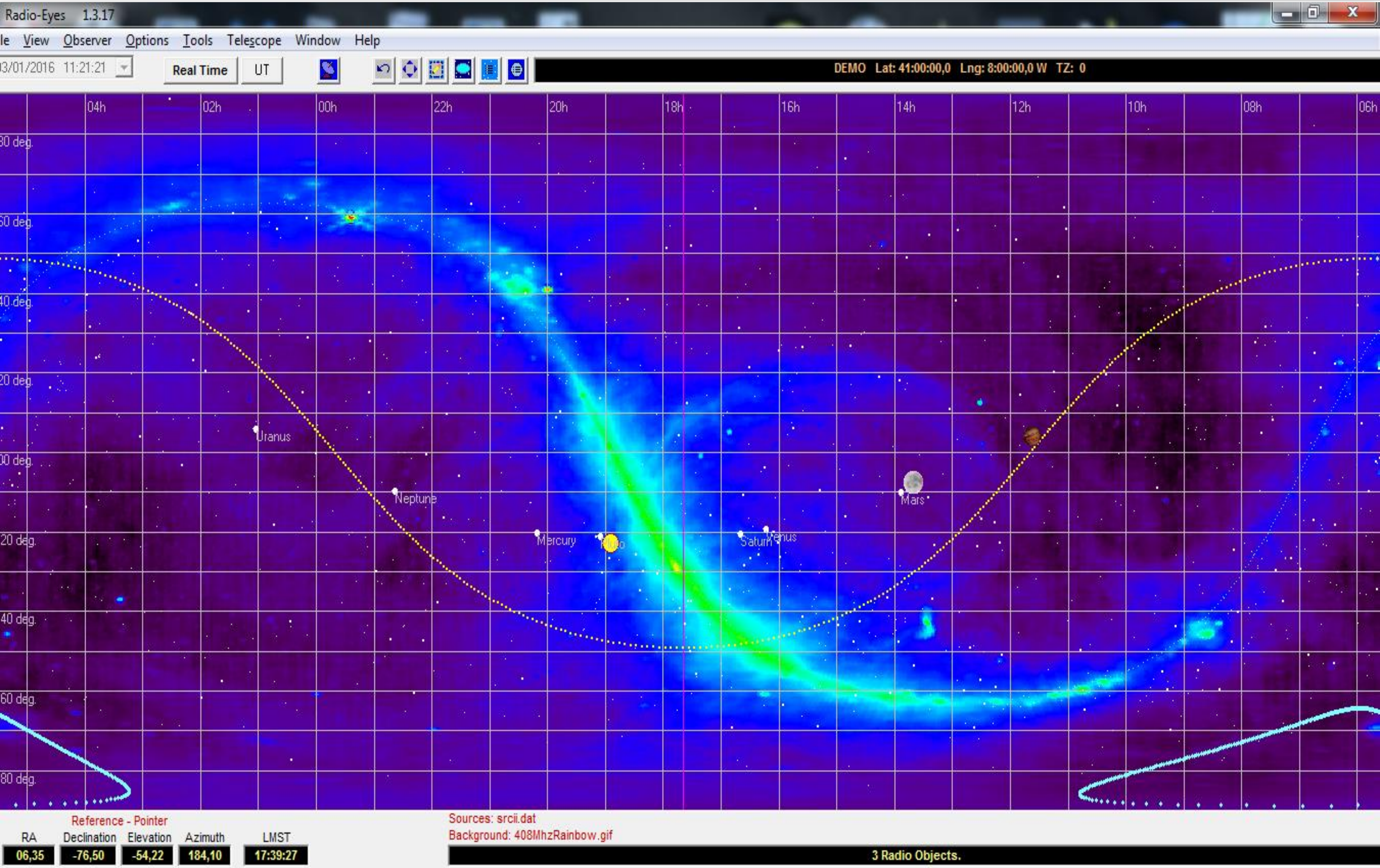
Remnants of SNR
Taurus
Cassiopeia A

Milky Way
Sagittarius A *
Map the galaxy in H21

Radio galaxies
Cynus
Virgo
Andromeda

AGNs
Quasar 3C 273

Software: Radio-Eyes



Can we communicate with iET?

- ✓ The next region of the spectrum of 1420 MHz (21 cm), radio broadcasts have very low noise levels and absorption by the interstellar medium is minimal.

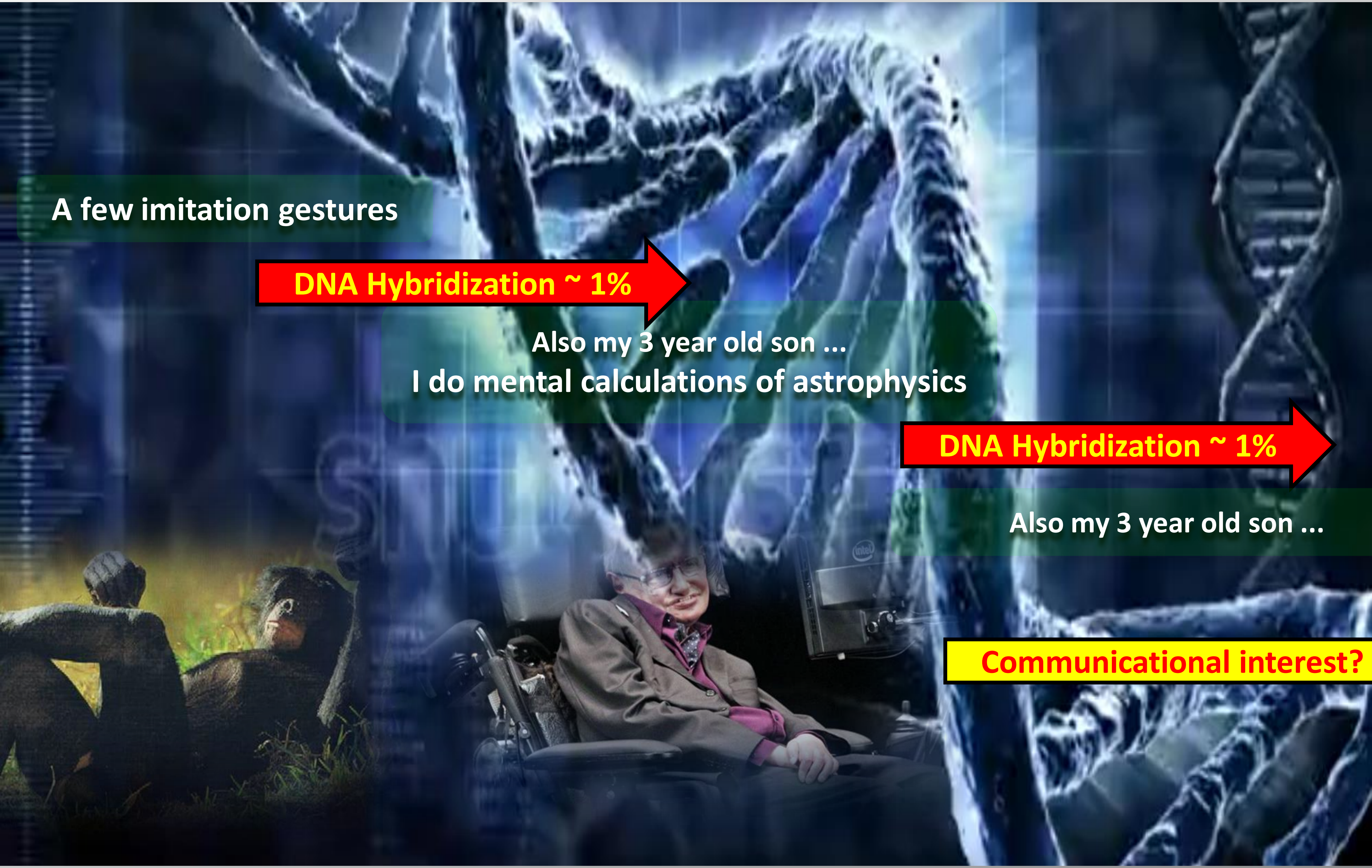
- ✓ Hydrogen being one of the fundamental building blocks of the universe, one o'clock ET civilization will also possess this knowledge.

- ✓ Civilizations ET distance of 150 al equipped with RT 300 meters similar to Arecibo, can transmit radio signals detectable on Earth.
- ✓ Terrestrial antennas 10 meters can reach ~ 21,500 stars (600 s).
- ✓ Terrestrial antennas 3 meters have an average range of 5 star ...

Radio Telescope & Milky Way
by Seth McCubbin

Global definitions		
Frequency (f)	1.420	MHz
Wavelenght (λ)	21,11	cm
Diameter of the aperture (D)	10,00	m
Antenna aperture efficiency (η)	0,75	
Integration time (τ)	600,0	
Bandwidth of the receiver (BW)	256	MHz
SETI		
ETI transmitter power (P)	10.000.000	Mw
Diameter of the aperture antenna ETI	300	m
Distance from Earth (R)	46,8	pc
Stars in our range	21.479	

Establishing contact ...



Questions we would like to make a iET?

Communicational interest?

1. Is there any creator of the universe? Big Bang?
2. What is the universe made? Dark matter? Dark Energy?
3. What is the purpose of the universe? Real? Simulation?
4. Are we alone in the Galaxy?

The End