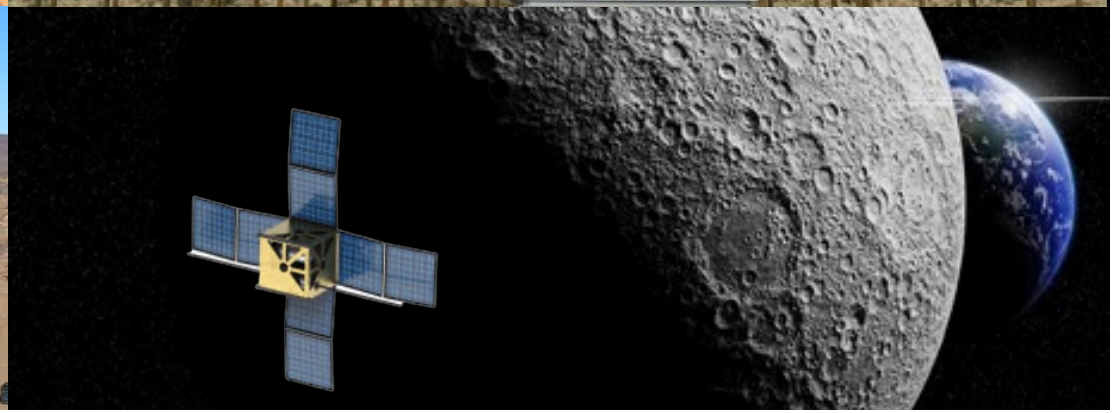
Radio Cosmology at KICC

Unveiling the infant Universe with radio experiments and mega observatories

Dr Eloy de Lera Acedo

Cavendish Radio Cosmology



Overview

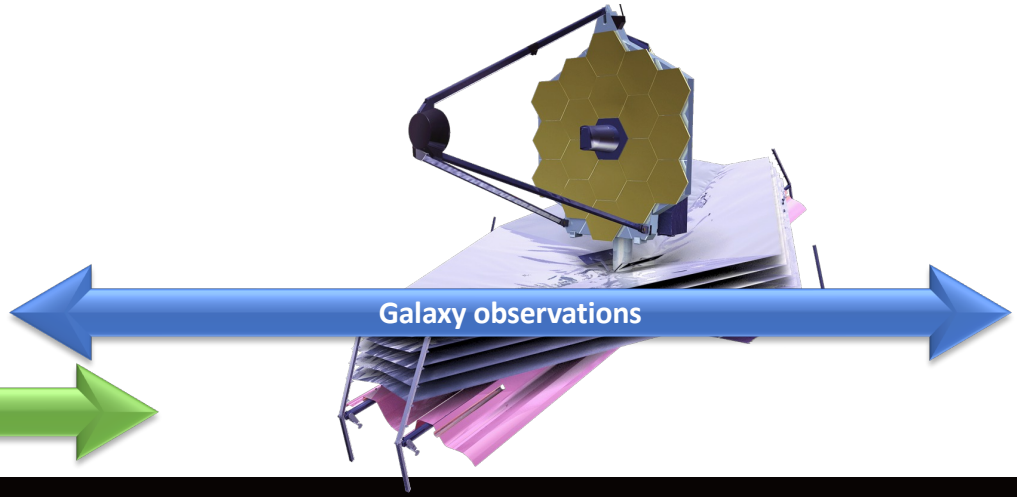
21-cm cosmology

REACH and HERA

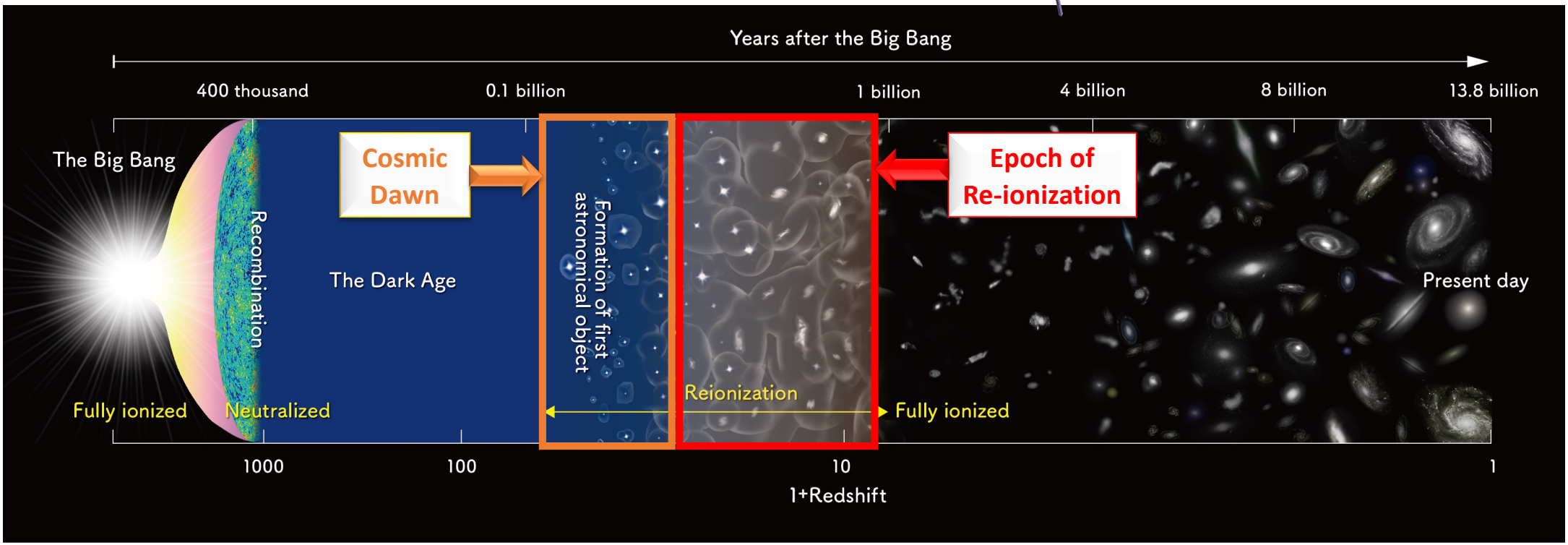
SKA

Space-based radio cosmology

21-cm cosmology



21-cm line

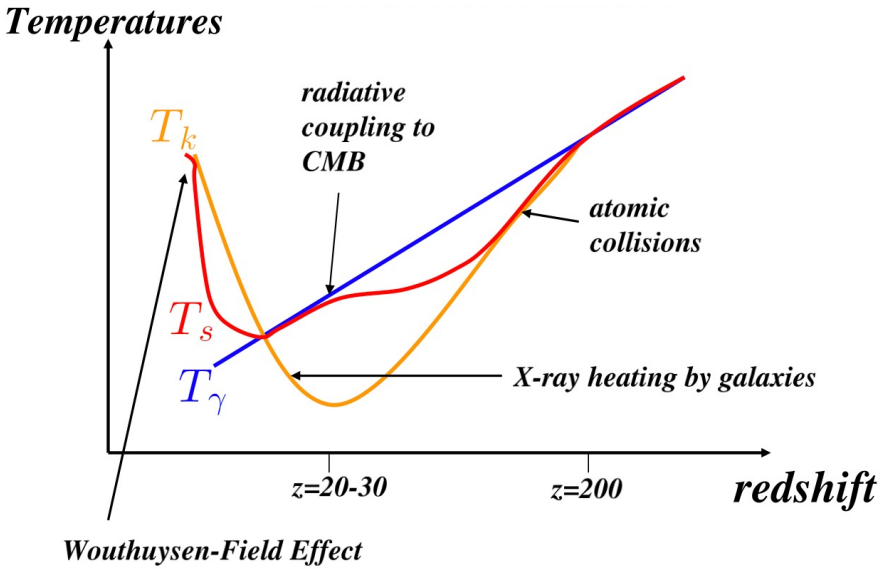


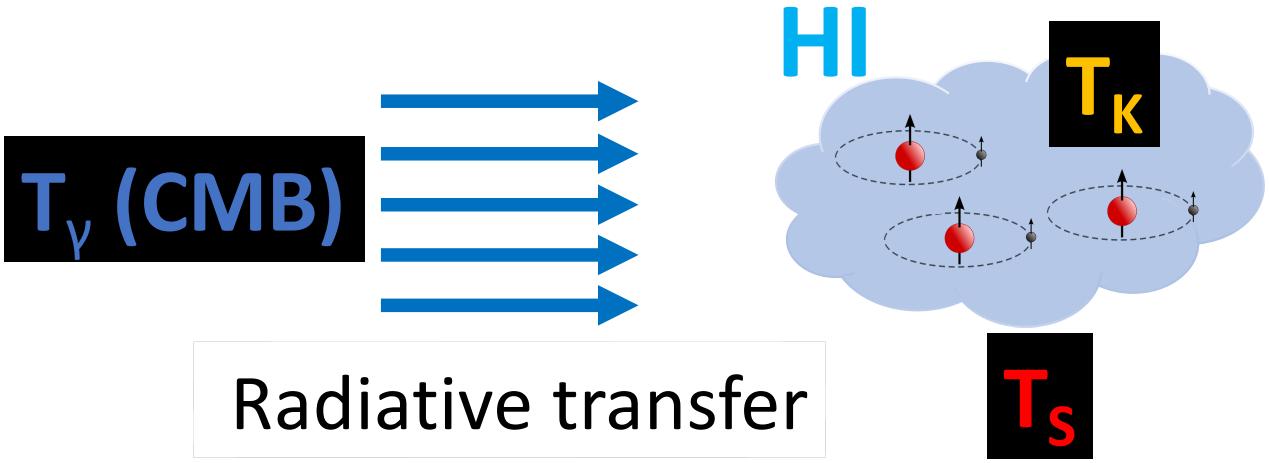
21-cm line

T_S = HI spin temperature, λ = 21 cm

T_γ = Background temperature, eg. CMB

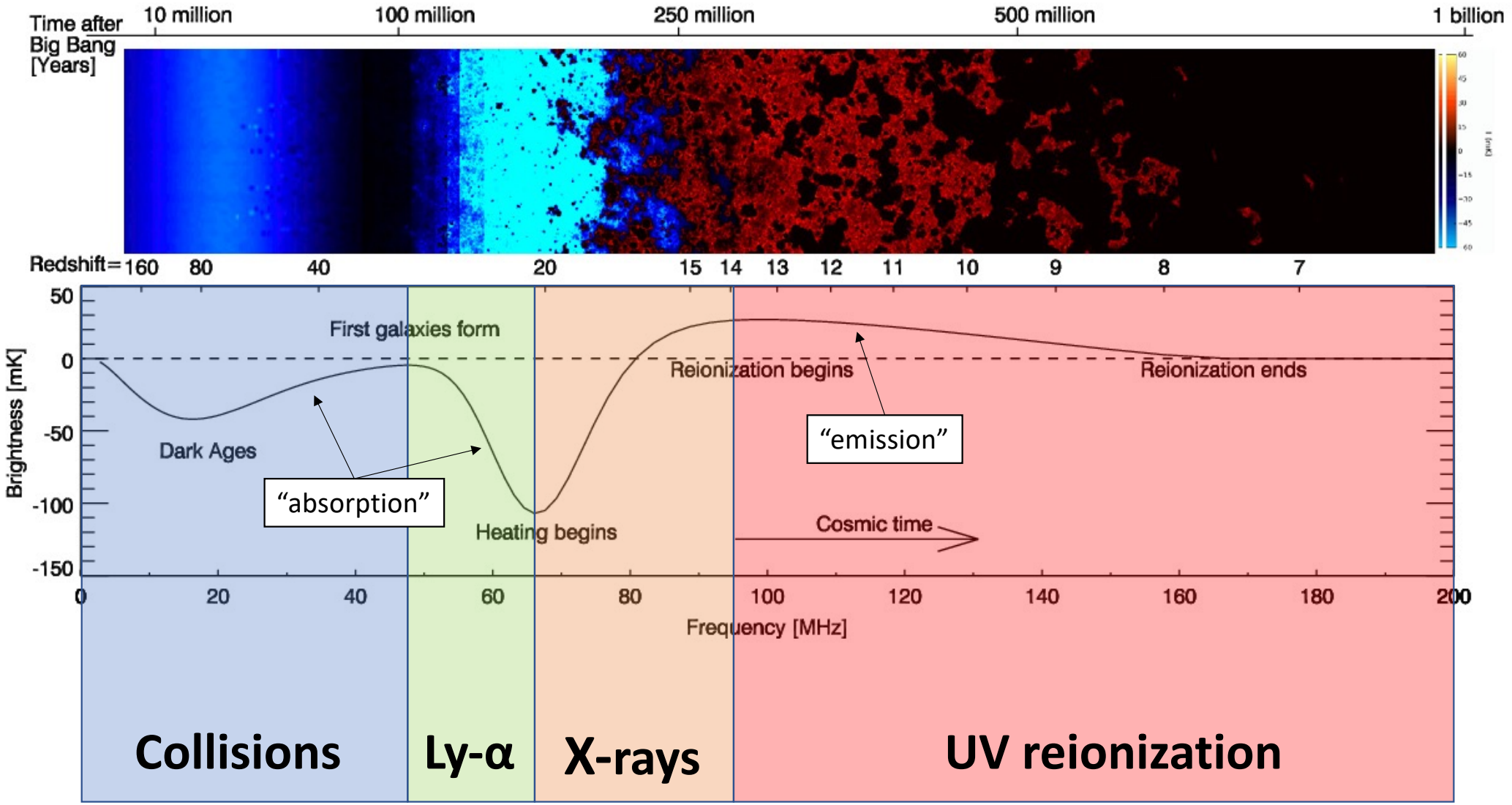
T_K = Gas Kinetic temperature



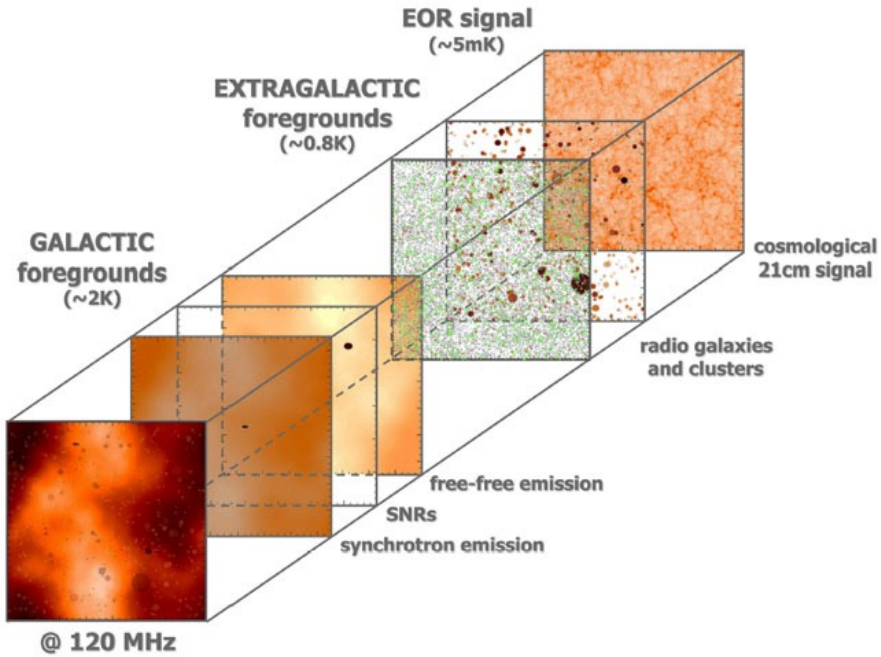


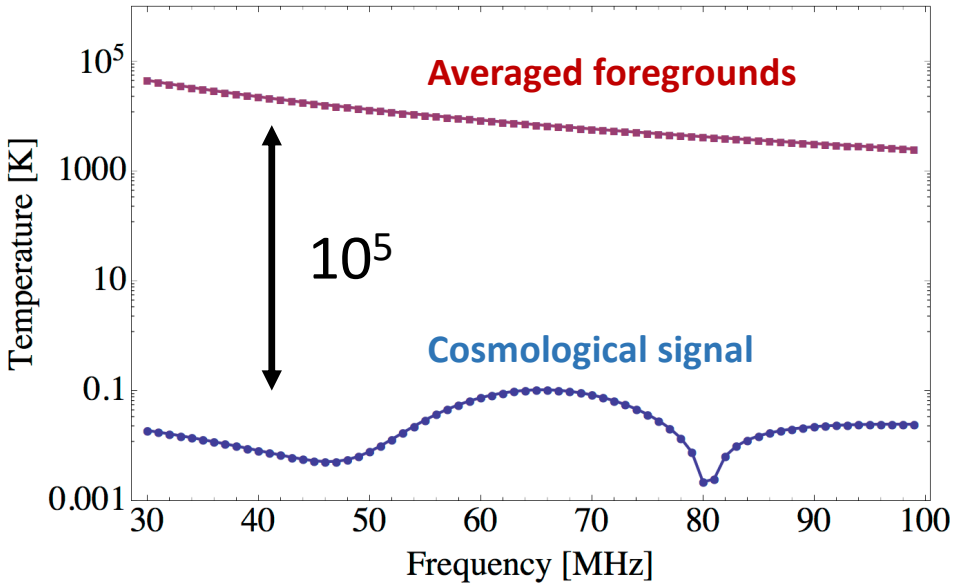
Radiative transfer

$$T_b(z) \approx \tau(T_S - T_\gamma)/(1+z)$$

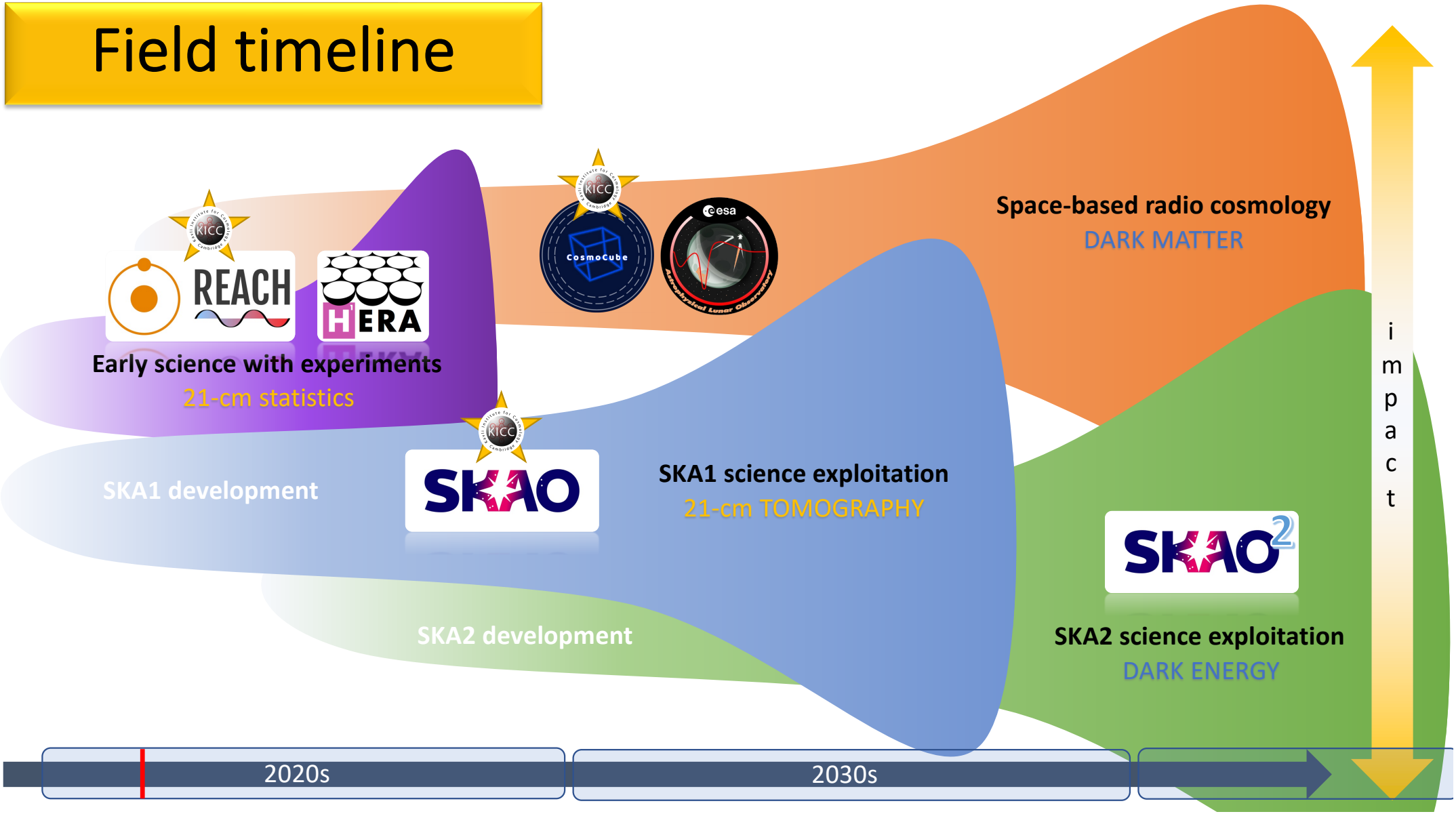

Time after Big Bang [Years]
10 million
100 million
250 million
500 million
1 billion
Redshift=
160
80
40
20
15
14
13
12
11
10
9
8
7
Brightness [mK]
50
0
-50
-100
-150
First galaxies form
Dark Ages
"absorption"
Heating begins
Reionization begins
"emission"
Reionization ends
Cosmic time
0
20
40
60
80
100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

Experimental/Observational challenge

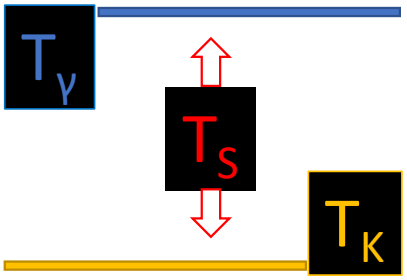


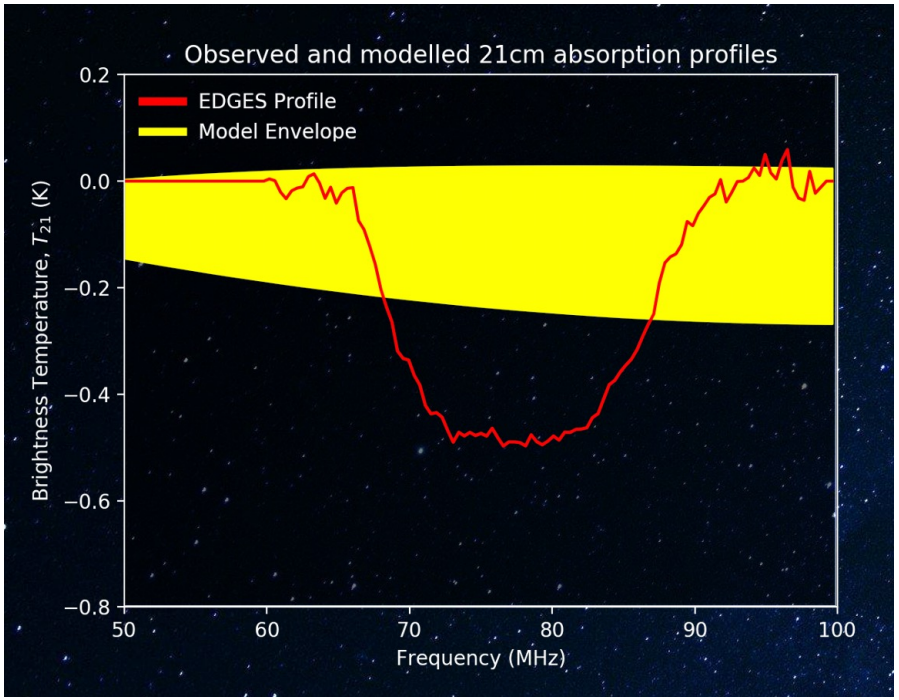


Field timeline



The EDES detection of 2018

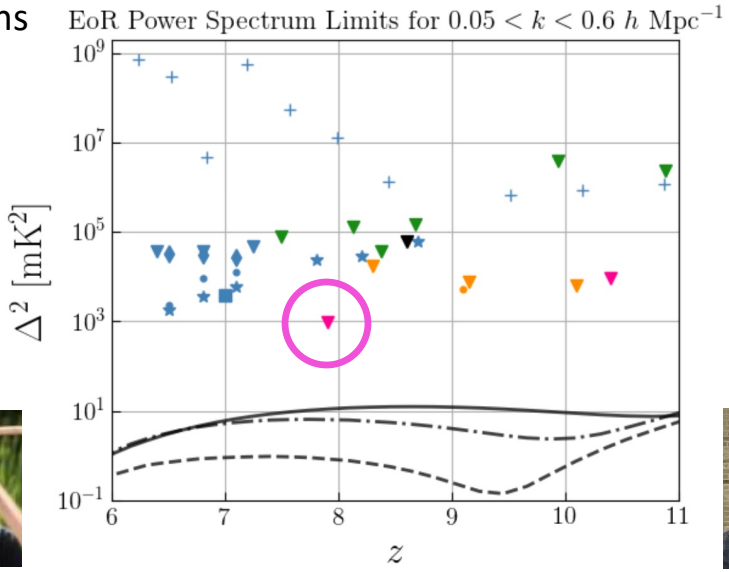




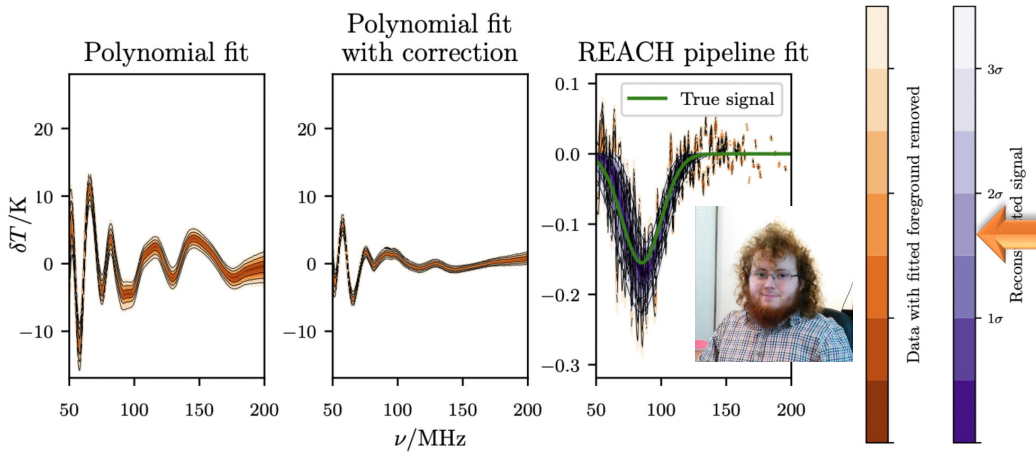
Bowman, Rogers, et al., 2018

- **Hotter background temperature T_γ ?**
  - eg. Radio loud blackholes, radiative decay of particles, annihilating dark matter, super-conducting cosmic string?
- **Colder gas temperature T_K ?**
  - eg. Dark-matter – Baryonic matter interactions?
- **Systematics?**

observations



simulation

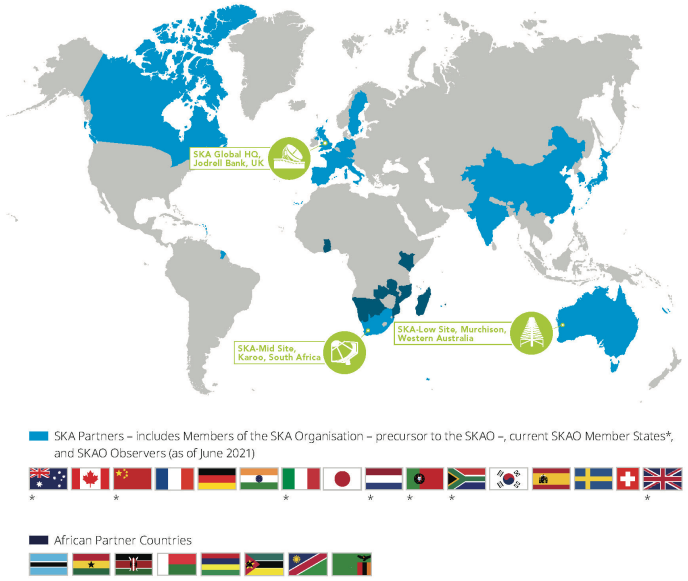


de Lera Acedo et al., Nature Astronomy 2022

SKA Observatory

SKA in the UK

- 3 host countries: **UK (SKAO headquarters at Jodrell Bank),** South Africa and Australia

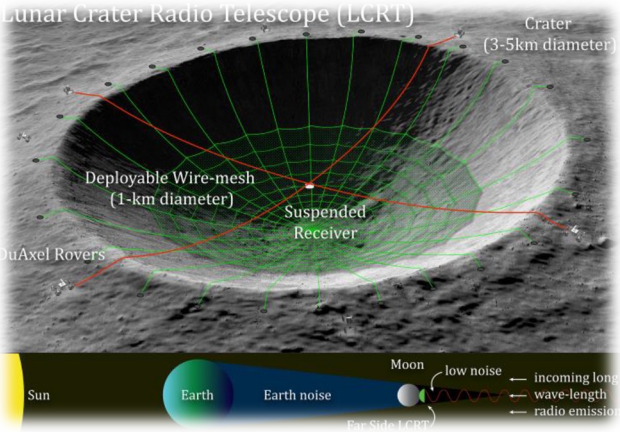


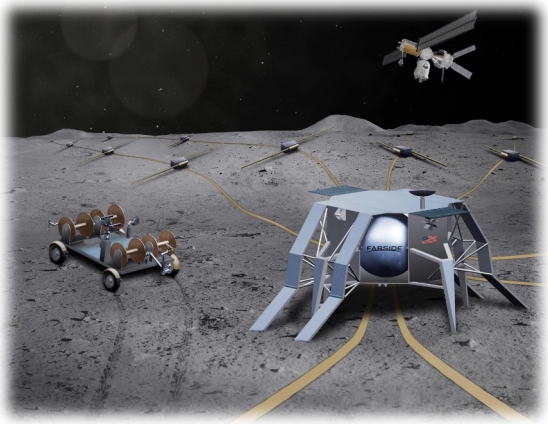
- UK is the **largest cash contributor**: £270m out Of £1.7b (£1.1b construction and £0.6b - 10 years operation)
- UK **leads key work packages** (eg. Science processor – Cambridge)

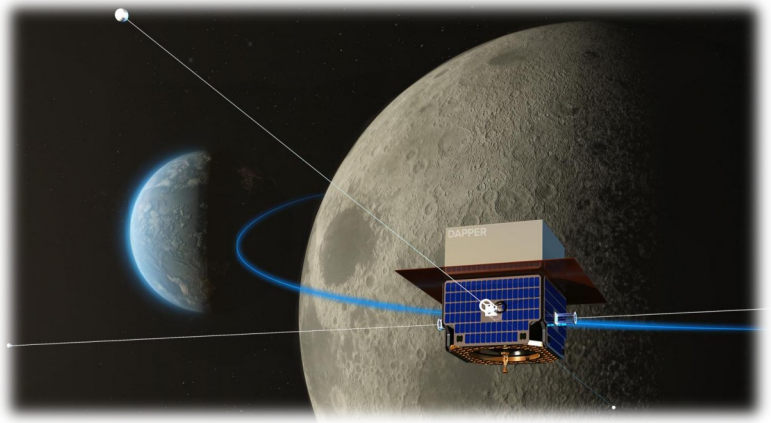
SKA in Cambridge

- Leading 2 fundamental aspects of the design:
  - Science Data Processor (http://ska-sdp.org) – science ready products
  - Low Frequency Aperture Arrays (the “Cosmic Dawn” instrument)

Radio astronomy beyond Earth

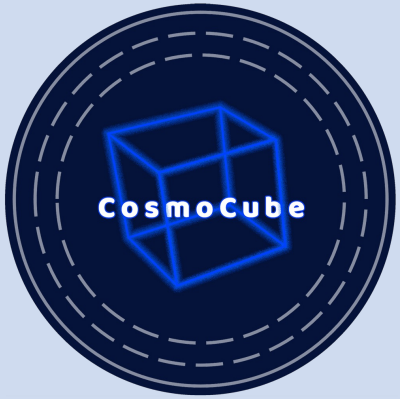


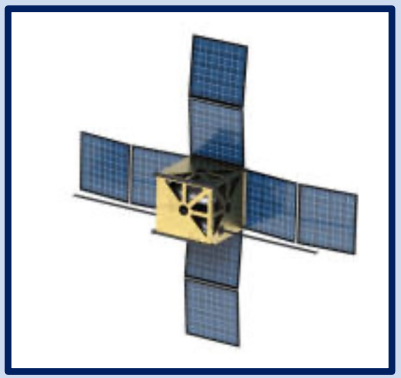




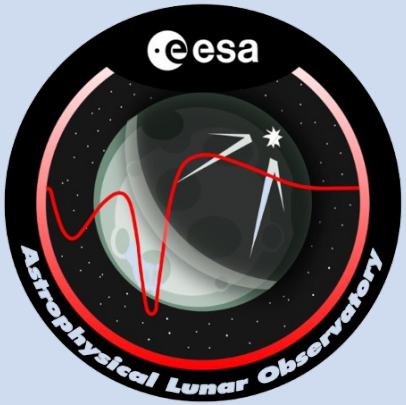
- Key science goal: Pushing into the Dark Ages with 21-cm cosmology (z > 30)
- The Moon is back in the agenda of the space agencies
  - Low RFI?, no ionosphere
- Interferometers, dishes, satellites,…

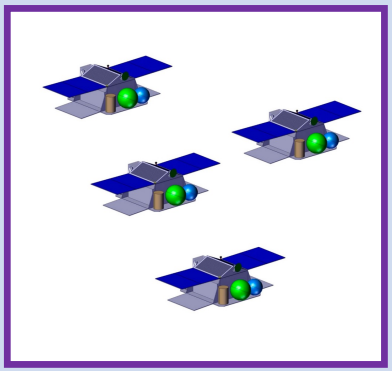
Radio Cosmology from the Moon





- Dark Ages, 25 < *z* < 150
- Cost-efficient *CubeSat* technology
- Observations from the **far-side of Moon's orbit** in late 20s
- Lead: KICC
- Partners: UK, US





- Dark Ages, 25 < *z* < 150
- Radio interferometer
- Observations from the **far-side of Moon's surface** in early 30s
- Lead: NL/ESA
- Partners: ESA, UK (KICC)

Conclusions

- 2nd golden age of radio astronomy
- KICC/Cambridge leads in several fronts
- From small experiments to mega observatories
- Next 15-20 years: mega radio-observatories SKA and NgVLA
  - “discovery” machines: Big-data, all-sky, all-digital
  - super sensitivity and resolution
- In the 30s and 40s: radio astronomy from space/Moon

End

- Thank you!