An Instrumental concept to monitor the sky at very low radio frequency

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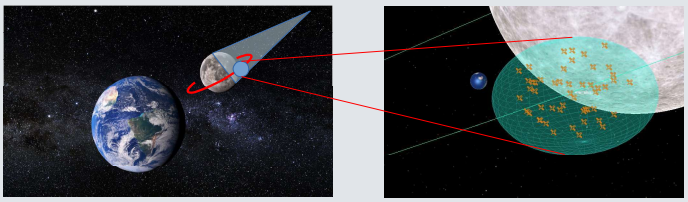
NOIRE project

(Nanosatellite pour un Observatoire Interférométrique Radio dans l'Espace)

NOIRE is an instrumental concept study that consists in an interferometer in space at observing at very low frequency (30kHz – 100MHz) [1]

Autonomous Scientific Observatory

~ 50 nanosat in lunar orbit in a formation of 100 km

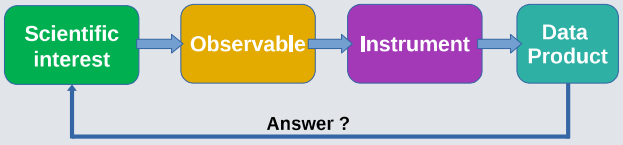


Simulation purpose

Various specification requirements are yet to be defined.

The scientific objectives are driving their definition.

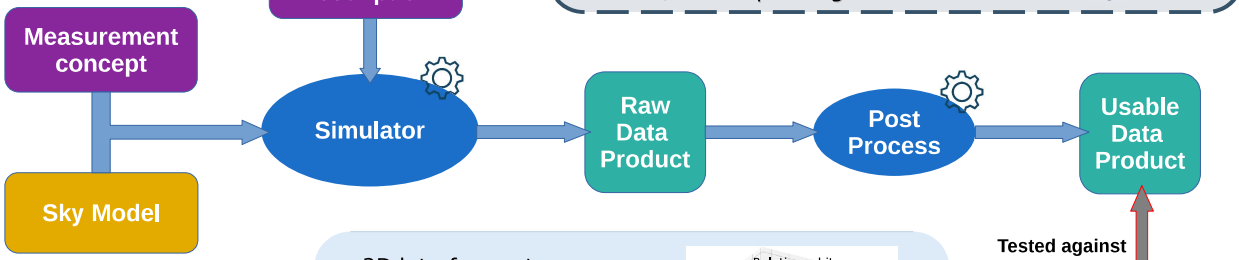
The instrumental simulation is implemented to test a given set of specification in regards to a science case.



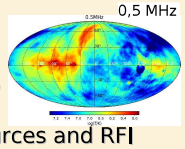
The Simulation Pipeline

- Hardware specifications
  - Clock accuracy
  - Antenna Gain
- Software specifications
  - Position accuracy
- Data Volume
- Relays
- more

- Δυ, τ
- # Satellites
- Orbits
- Strategy

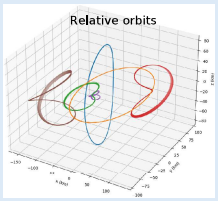


- Model of the source of interest
- Background :
  - GSM
  - USLA [2]
  - (model with absorption)



- Model of foreground sources and RFI

- 3D interferometer
- Significant relative velocities
- Full sky imaging
- SWHT [3] to simulate background visibilities
- Multiple aquisition modes

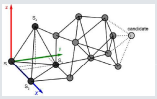


Tested against

Scientific interest

Unique Constraints

- **Topology**
  - Baselines have to be measured onboard
  - Low control → UVW coverage
  - Relative velocities → limit integration time

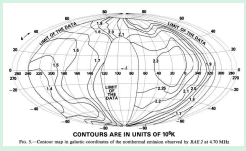


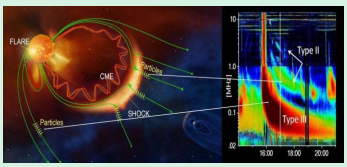
- **Data limitation**
  - Strong restriction on the volume produced → Telecom, Onboard computation, Power
- **Clock accuracy**
  - Regular Synchronizations, SNR degradation
- **Antenna Diagram**
  - Gain, short dipole regime

Scientific Objectives

Map the sky at extremely low frequency

The sky remains mostly unknown in this frequency range



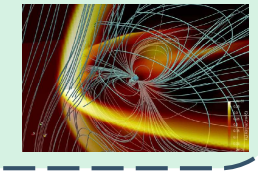


Track the propagation of Solar burst (type II and III)

As a tracer of the particle acceleration in the inner heliosphere and potential magnetic connections from the lower solar corona to the larger heliosphere.

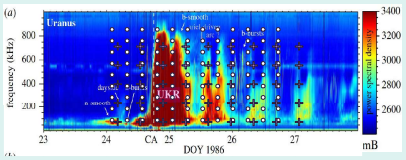
Study planetary magnetospheres
- radiation belts
- atmospheric electricity

Opportunity to observe Uranus and Neptune (<10MHz) since Voyager



Test Different Observation strategy

Test Mission Profile vs detectability level



Références :

[1] Cecconi *et al.* (2018), NOIRE Study : Towards a low frequency radio interferometer in space, IEEE Aerospace Conference
[2] Cong *et al.* (2021), An Ultra-long Wavelength Sky Model with Absorption Effect, *The astrophysical journal*
[3] Carozzi T. D. (2015), Imaging on a Sphere with Interferometers : the Spherical Wave Harmonic Transform, *Monthly Notices of the Royal Astronomical Society: Letters*
[4] Novaco & Brown (1978), Nonthermal galactic emission below 10MHz, *Astrophysical Journal*
[5] Lamy *et al.* (2020), Auroral emission from Uranus and Neptune. *Phil. Trans.*

Image Credit :

- Duisterwinkel et al (2018)
- dias.ie/cosmicphysics/astrophysics/astro-surround/
- Jarmak et al (2020)
- NASA/JPL-Caltech/SwRI/JunoCam