Building SPADE – Status Update

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Radio Solar Observations in Belgium – The Humain Radio–Astronomy Station

Relative location of the Humain Radio-Astronomy Station in Belgium

• The Solar Influences Data analysis Centre of the Royal Observatory of Belgium operates and maintains the **Humain Radio-Astronomy Station**

• **Main goal**: monitoring the solar activity in the metric and microwave range, giving near real time information on eruptive events
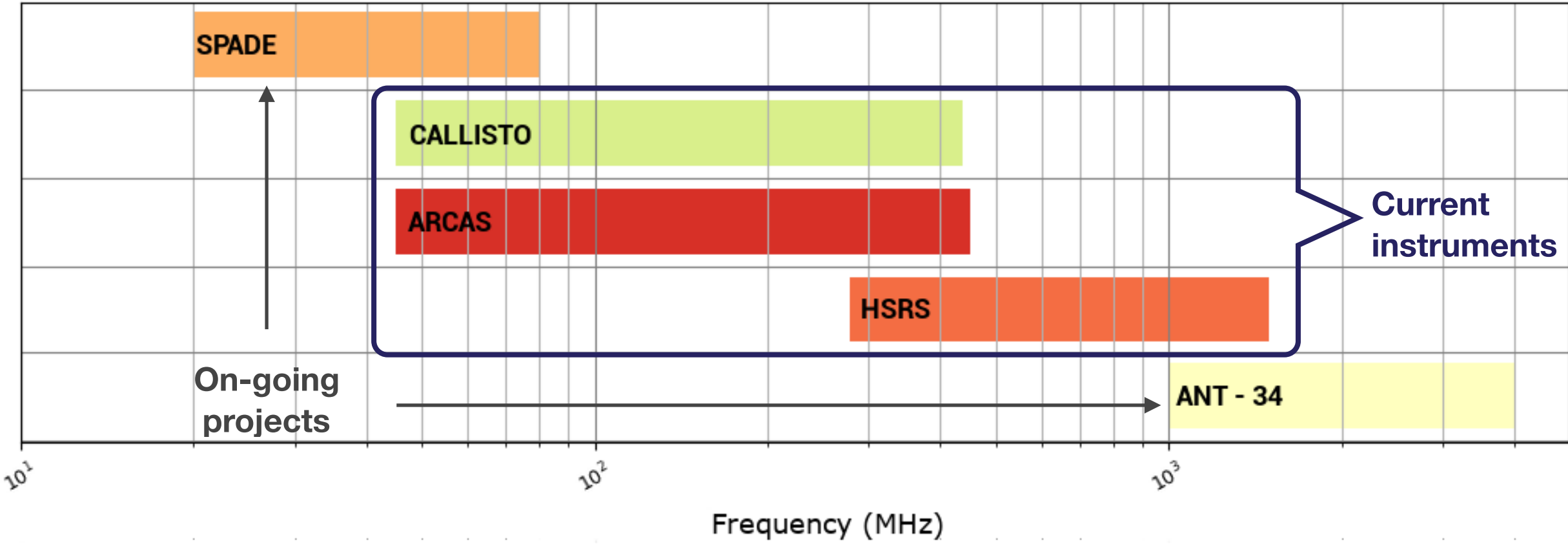
Frequency range chart of the current and future solar radio telescopes at Humain Radio-Astronomy Station

Satellite photo of the Humain Radio-Astronomy Station

6m-dish structure (HSRS) and its piggy back log-periodic antenna (ARCAS & CALLISTO)

SPADE
Small Phased Array Demonstrator

The instrument in brief

• Project's Kick-off: January 2016
• Small array of 8 antennas
• Envisaged frequency range: 20 — 80 MHz
• Main goal: Dynamic spectra (not imaging)
• Usage of SDR-based receivers
• Beam-forming will be carried out *digitally*

Benefits
• No mechanical parts
• Digital processing allows high flexibility
• Near-realtime dynamic spectrum observations

Antenna

• Type: Cross tied fork dipole (NenuFAR)
• Active balun/pre-amp
• Additional conductive grid underneath
• Dual polarisation available

Antenna setup during testing period at ROB

Array Configuration

The circular distributed array with central antenna element shows a good balance in total gain and reduced side lobes levels, even in steering mode simulations.
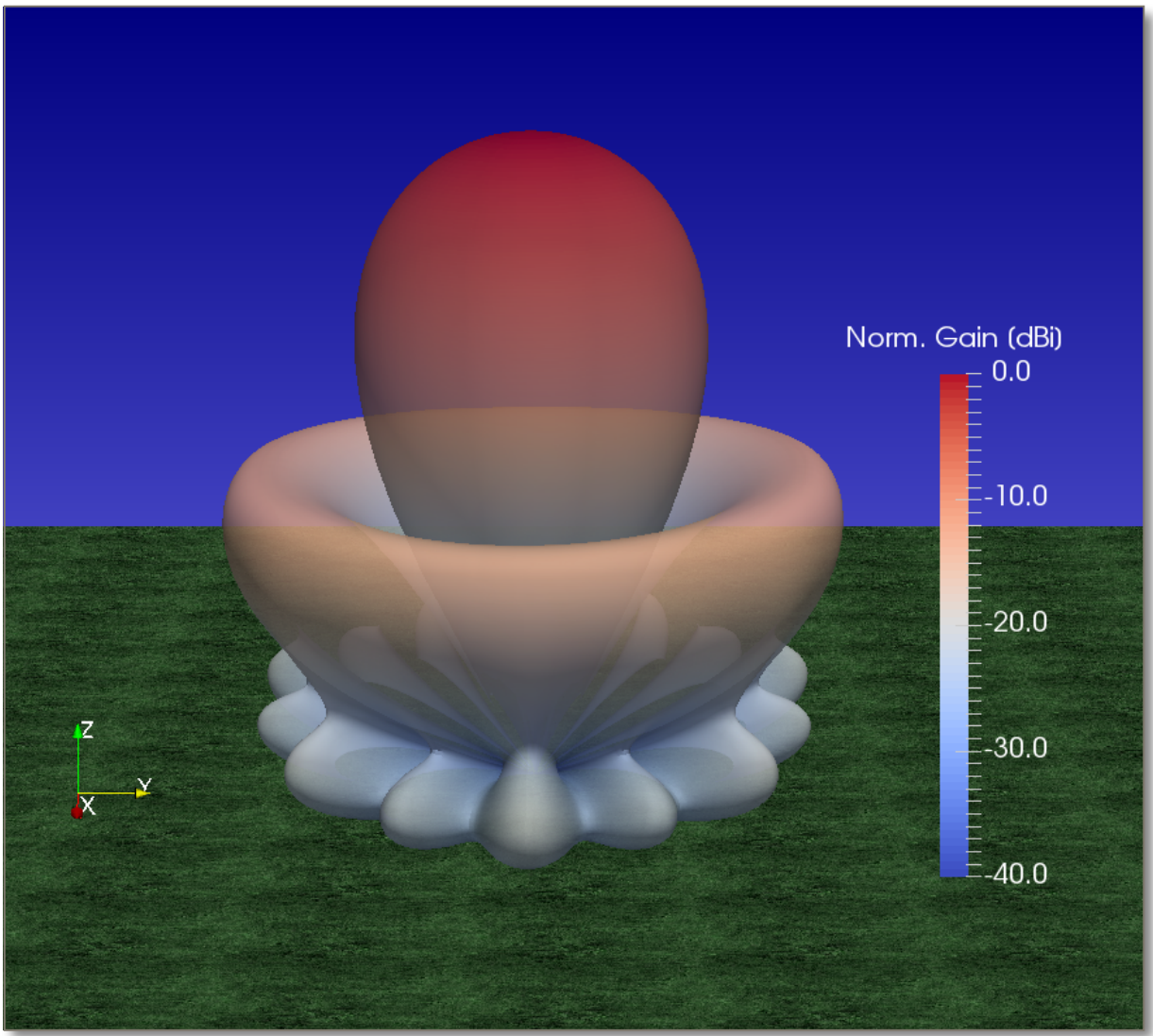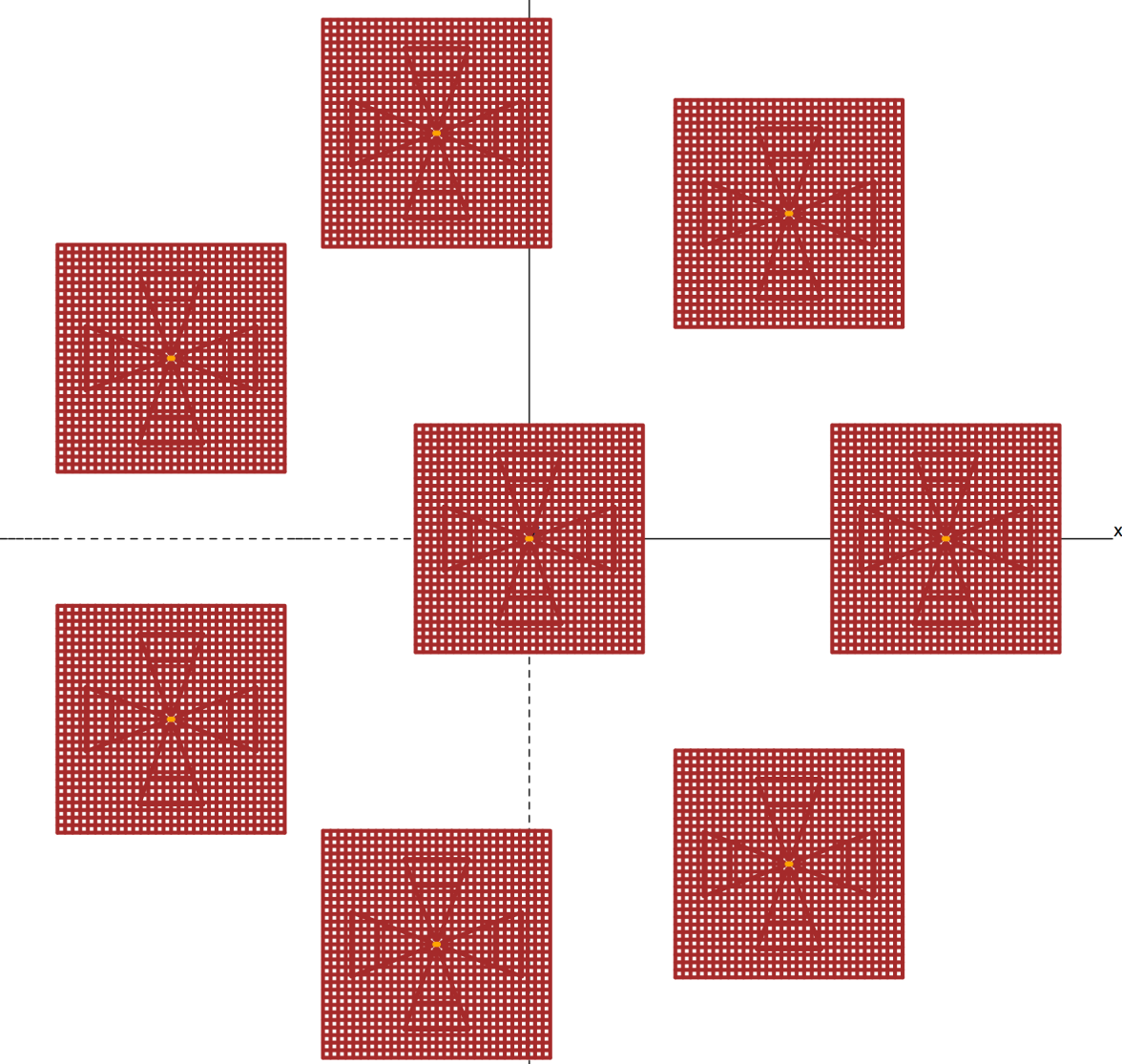
3D visualization of the array's directional pattern for 50 MHz of a circular configuration with central element

Array Field
### Terrain preparation & ground plane

General view of SPADE array field. Behind the SPADE antennas, the cabin and the 6m-dish including its piggy-backing log-periodic antenna can be seen

• The array location was chosen to be not far from the existing instruments' cabin in order to harbour appropriately the rest of the electronic equipment.

• Obtaining beam patterns that are as similar as possible to the design requires the area of the array field been as planar as possible. An accuracy of ± 6 cm was achieved when flattening.

• A ground plane of 20 m × 20 m was installed using galvanized welded wire mesh material (15 cm × 15 cm, 6 mm diameter).

• The final location of the antennas was measured using a *Differential GPS* device (~80 mm precision error).

*General view during the flattening works*
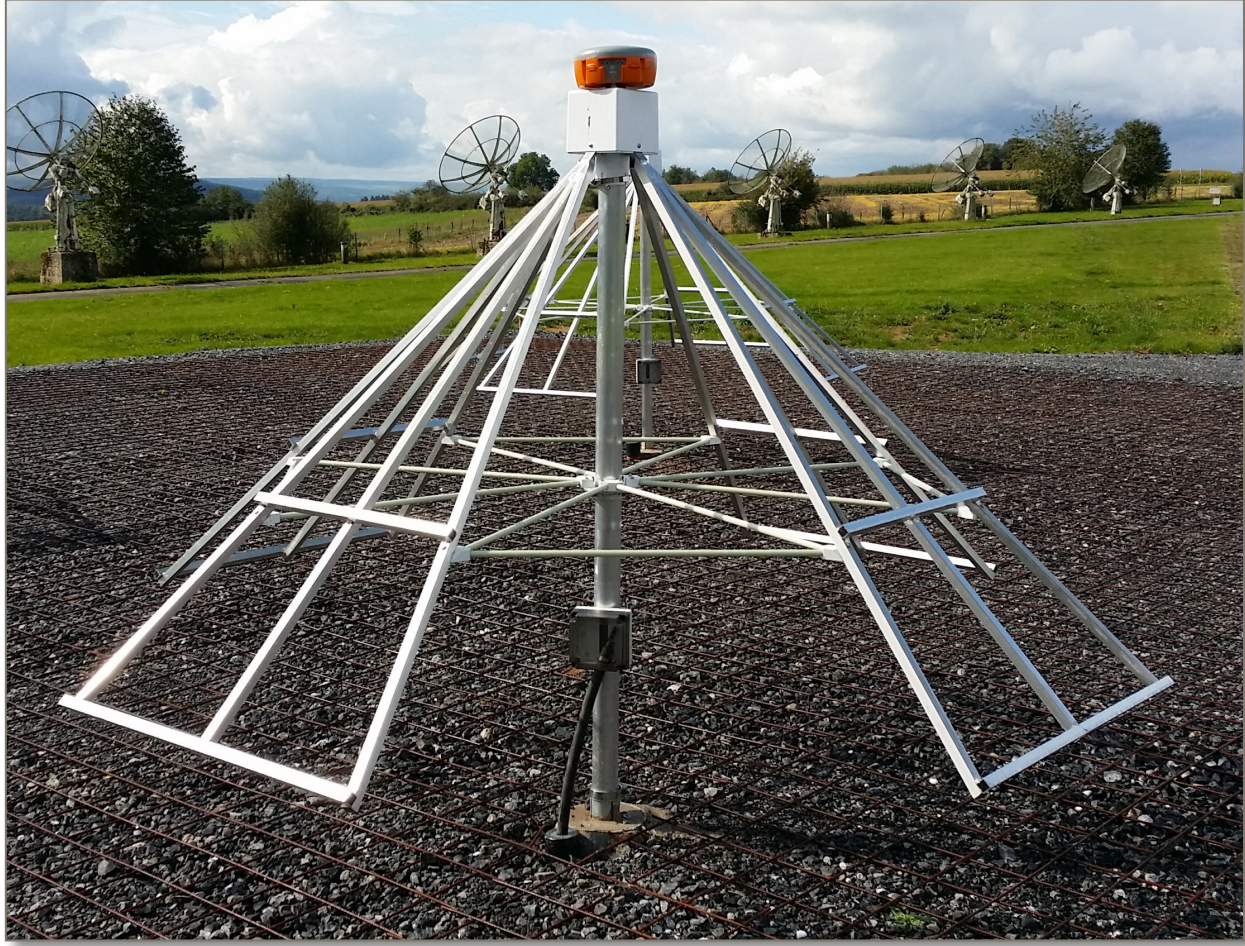
SPADE antenna location being measured with a D-GPS

Digital beam–forming
Signal path & processing

• The first phase of operations will include one polarization only.

• The RF signal coming from each antenna is digitalized by an Ettus `BasicRX` daughterboard (2 RF inputs).

• Two of this daughterboards can be accommodated in one Ettus `X300` `USRP` unit, conforming one SDR.

• Each SDR have 4 inputs in total, and delivers two 10 GbE data streams directly to the main processing computer.

• A reference clock module is included in one SDR. The reference signal is sent to the other SDR in order to keep them synchronized.

• Low-pass filters are included before digitalizing in order to reduce any aliasing issues.

• In the server, free and open `GNU Radio` (Linux) libraries will be employed to weight appropriately each of the digitally represented signals and sum them in order to shape and point the beam.
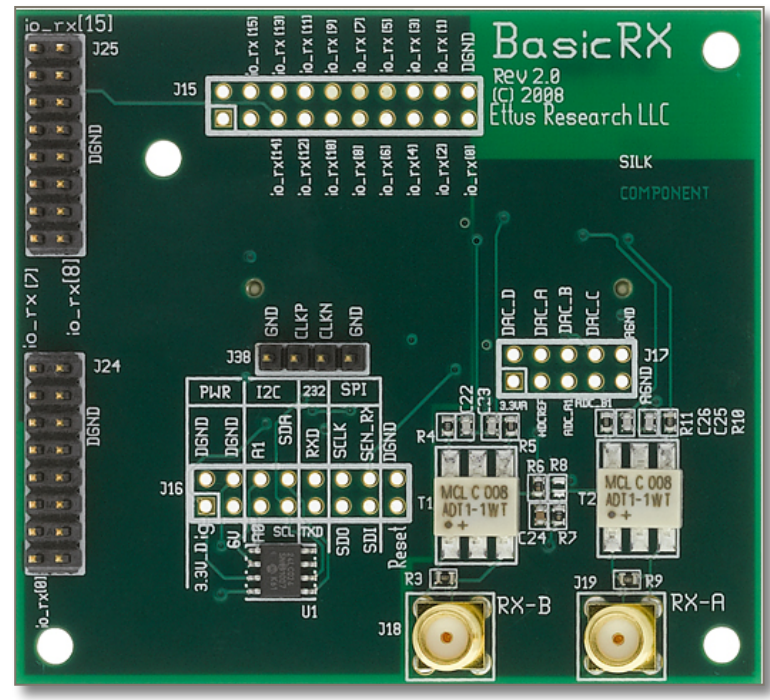
Ettus BasicRX Daughterboard

Ettus USRP X300
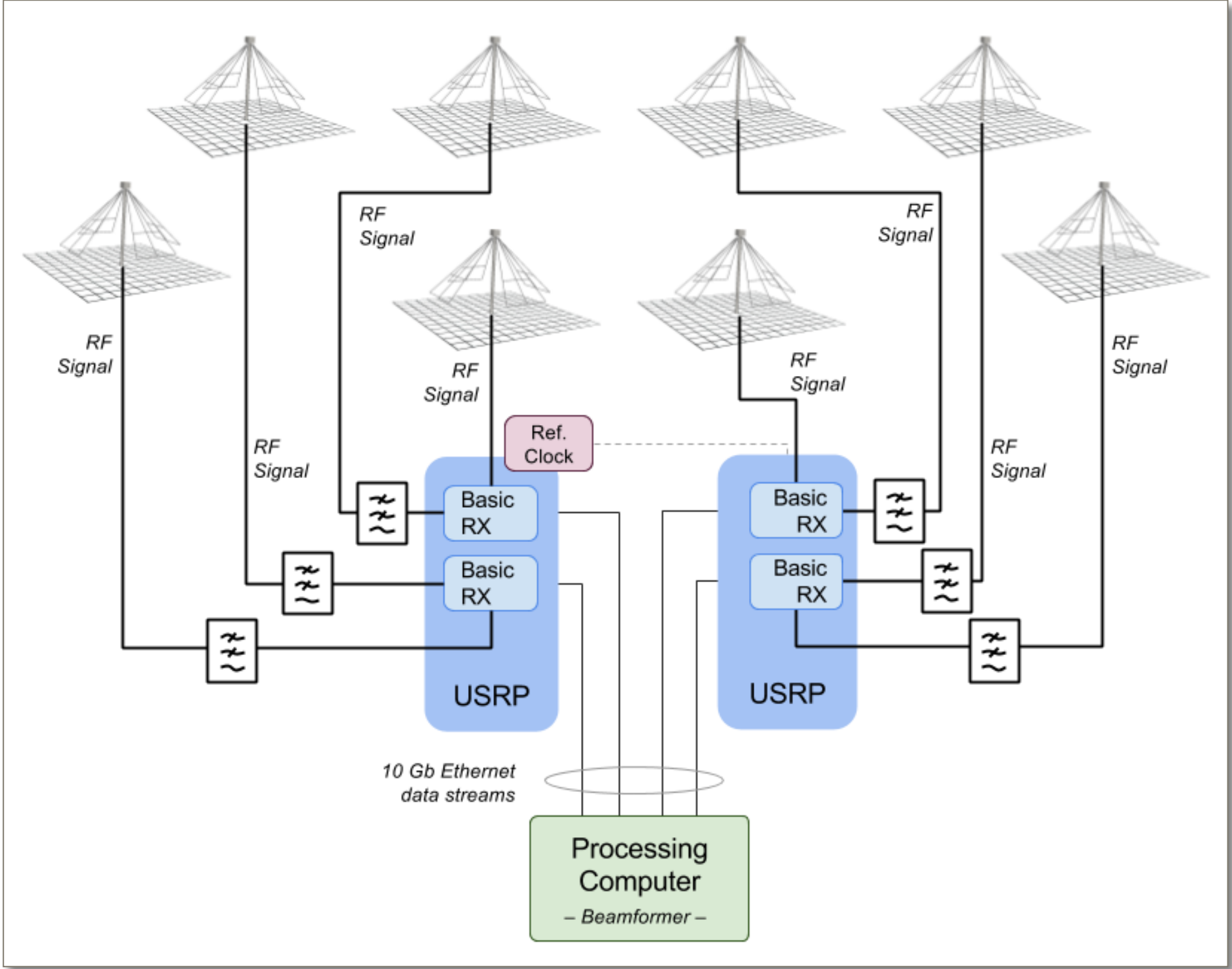
General diagram of the different SPADE signal paths.