Discussing LOFAR2.0: Some Broad Options and *Rough* Costs

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Rough costing info from

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NB: Costs are guesstimates!!!

For example, assume:

- HBA tile: 3.5kEur/antenna
- LBA dipole: 300Eur/antenna
- Station electronics: 100kEur/station
- Networking: 150kEur/station
- Manpower/development not included!

Won't Discuss Improvements to...

- General system monitor and control.
- Long-term archive.
- Responsiveness.
- Calibration and algorithms
- etc.

...these can all be big science drivers, but won't sell an NWO-G on their own.

The Options

- These aren't mutually exclusive.
- Could go for some combination of these.
- *But* NWO-G can't look like a "grab bag" of incremental improvements: there needs to be a central big idea (perhaps to carry the smaller improvements).

Increase Number of Core Stations

Scenarios:

- Add 12 Core stations on pre-defined plots (perhaps all on Superterp).
- Create a few Core "superstations" (96 HBA)?

Pros:

- Improves 100m - 2000m *uv*-coverage.
- Improves filling factor.
- Collecting area is cheap per square meter.
- Land is "free" (?) and already prepared (?).
- Great for EOR, Pulsars, Cosmic-Rays, Transients.

Cons:

- Ignores health issues with current stations.

Increase Number of Core Stations

Cost:

- HBAs: 12*48*3.5kEur = 2MEur
- LBAs: 12*96*0.3kEur = 0.35MEur
- Station electronics: 12*100kEur = 1.2MEur
- Networking: 1.7MEur
- NB: Core and Remote stations connected to the Concentrator node have 10 GbE link to CEP. Other Remote stations: situation more complicated.
- Land: free?
- Total: 5.2MEur

NB: Costs are guesstimates!!!

Increase Number of Remote Stations

Scenarios:

- Add 8 Remote stations.
- Add "very" Remote stations (baseline 100-200km) to bridge *uv* gap to International stations.

Pros:

- Improves 10 - 100km *uv*-coverage.
- Help with calibration and image fidelity.
- Fortify a unique aspect of LOFAR.
- Great for Surveys.

Cons:

- Ignores health issues with current stations.
- Extra collecting area comes with a bigger cost per square meter.

Increase Number of Remote Stations

Cost:

- HBAs: 8*48*3.5kEur = 1.3MEur
- LBAs: 8*96*0.3kEur = 0.23MEur
- Station electronics: 8*100kEur = 0.8MEur
- Networking: 1.9MEur
- NB: Core and Remote stations connected to the Concentrator node have 10 GbE link to CEP. Other Remote stations: situation more complicated.
- Land: ????
- Total: 4.2MEur + Land????

NB: Costs are guesstimates!!!

Very-High-Band Antennas

Scenario:
- Add 250-500MHz antennas at all stations.
- Could be SKA-Low-like antennas.

Pros:
- Adds a completely new facet to the array.
- Feed into SKA-Low development.

Cons:
- Would this be competitive with VLA?
- Doesn't add collecting collecting area or *uv*-coverage

Cost:
- Prohibitive (~15MEur).
- RF part of system quite expensive.
- Also could require upgrade of clock and backend.

Simultaneous LBA+HBA or 96 LBA, etc.

Scenario:

- Double or triple station electronics in order to use all 96 LBAs or LBA+HBA.
- Also need to double/triple fiber link.

Pros:

- Increase in sensitivity and simultaneous LBA +HBA may help significantly with calibration.
- Leverages hardware already in field.
- No new design needed.
- Great for all science cases. Also, could enable much more commensal and serendipitous science.

Cons:

- No new, interesting technical challenge.

Simultaneous LBA+HBA or 96 LBA, etc.

Cost:

- Electronics 100kEur/station
- Extra network capacity: 30kEur/station (avg)
- Total: 5MEur

NB: Costs are guesstimates!!!

Sea of Elements

Scenario:

- Create a "sea of elements" in the LOFAR Core using e.g. ~1024 densely packed HBA tiles.

Pros:

- Feed into SKA-Low development.
- Great for pulsar surveys (and EOR?).

Cons:

- Correlator/beamformer *very* expensive and challenging. (though if we can't do this, then we can't do the SKA)
- Minimal help for general LOFAR imaging.

Sea of Elements

Cost:

- HBAs: 1024*3.6kEur = 3.6MEur
- Correlator/beamformer: ~3MEur
- Networking: 0.8MEur
- Land prep: ????
- Total: 7.4MEur + Land prep????

NB: costs really driven by flexibility of correlator/beamformer.

NB: Costs are guesstimates!!!

Real-time Imager and Beamformer

Scenario:
- A new version of COBALT that will produce calibrated images and beam-formed data in real time, such that the data are nearly science ready.

Pros:
- Greatly reduce current logistical hurdles.
- Bring LOFAR science closer to non-experts.
- Feeds very nicely into SKA developments.

Cons:
- A lot of challenging development work needed.
- Harder to sell than hardware?
- Telescope's raw capabilities unchanged.

Cost:
- DRAGNET (hardware): 0.5MEur for 100 beams.
- COBALT (hardware): 0.3MEur for 80 stations.
- Total: new system (hardware): 2MEur?

Redesign of LBA

Scenario:
- Replace all LBAs with a more powerful design.

Pros:
- Could provide better sensitivity at the lowest frequencies.
- More robust to RFI?

Cons:
- Doesn't increase *uv*-coverage.

Cost:
- 500Eur per dipole????
- Total: 1.2MEur for whole Core (2304 dipoles)

NB: Costs are guesstimates!!!

Redesign of HBA

Scenario:
- Replace all (or worst) HBAs with a version more robust against water damage.
- Some other new HBA functionality? e.g. multi-beaming?

Pros:
- Might be necessary to ensure a working HBA system for the next 5-10 years.

Cons:
- Doesn't increase collecting area or *uv*-coverage.

Cost:
- 5kEur per tile????
- Total: 6MEur for whole Core (1152 tiles)

NB: Costs are guesstimates!!!