Dual Beam System

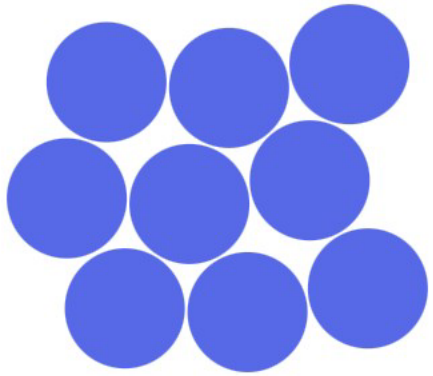
the Systems Engineering Perspective

Boudewijn Hut

ASTRON
Netherlands Institute for Radio Astronomy

DANTE Consortium meeting
Bologna, Italy
17-18 November 2025

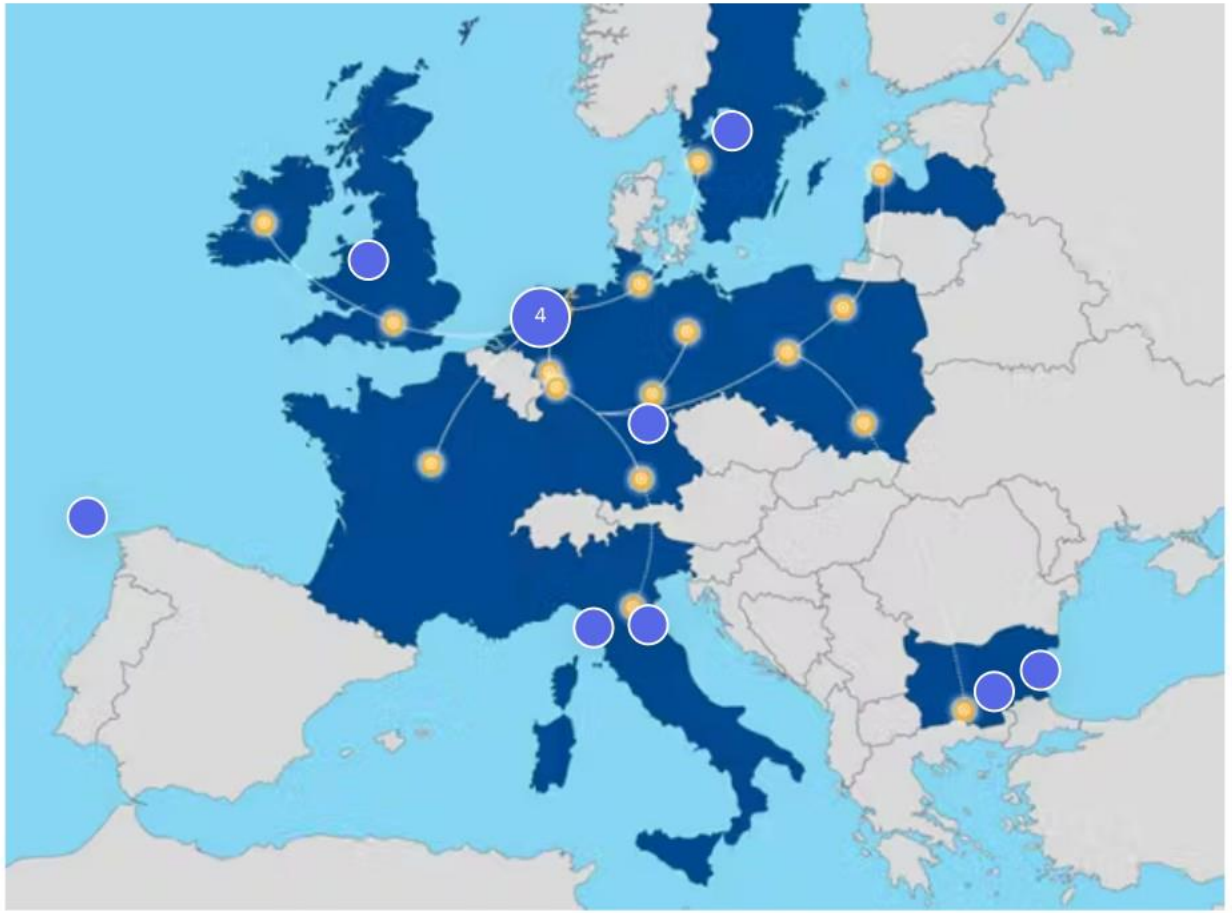
Menti Check-in: are you ready?



9 I'm physically at INAF and I'm ready. Let's start!

1 I'm connected digitally and I'm ready. Let's start!

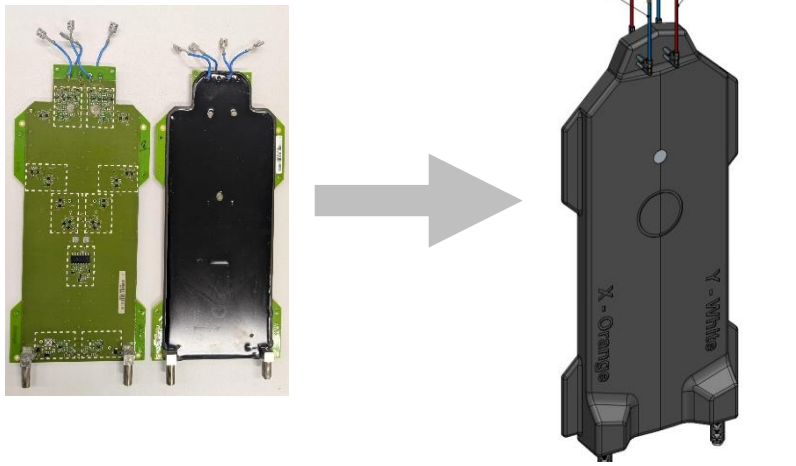
Where are you from?



The current situation

ASTRON

LOFAR 4SW



- Building on previous work
- Additional APS subracks for second beam purchased for 10 stations:

SE607	UK608	DE609	PL610	PL611	PL612
IE613	IT615	BG616	NL TBD	NL TBD	

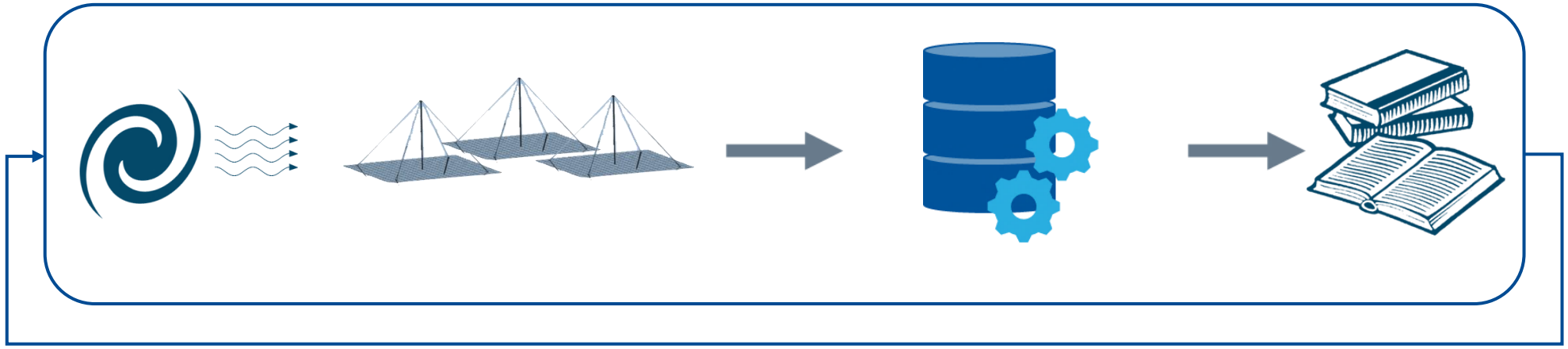
legend

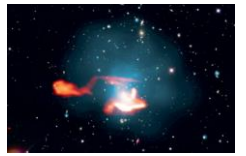
existing

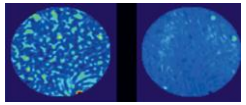
new

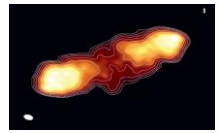
Why a Dual Beam System?

ASTRON







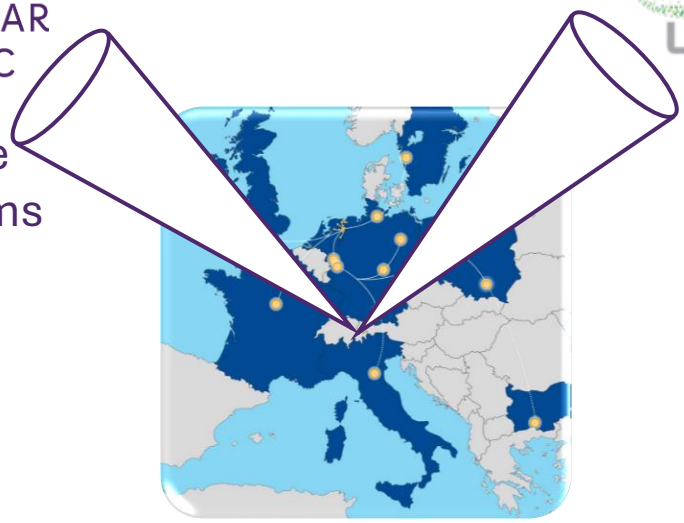


- Use Case: LOFAR4Space Weather
  - See Richards talk

- The analogue beamformer reduces the instantaneous field of view of the HBA Tile
  - “First beam” used by other science cases
  - “Second beam” needed for this use case

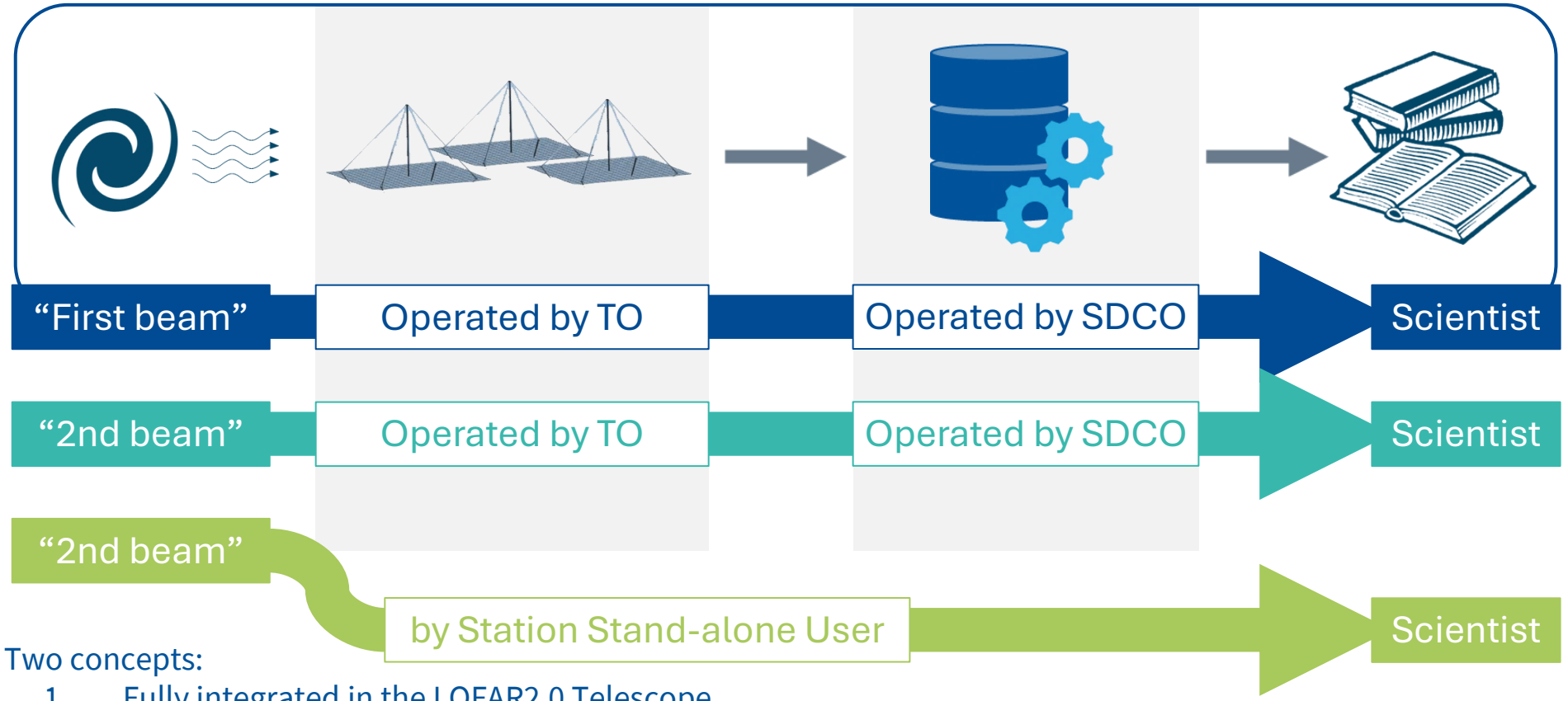
LOFAR ERIC science programs

LOFAR 4SW



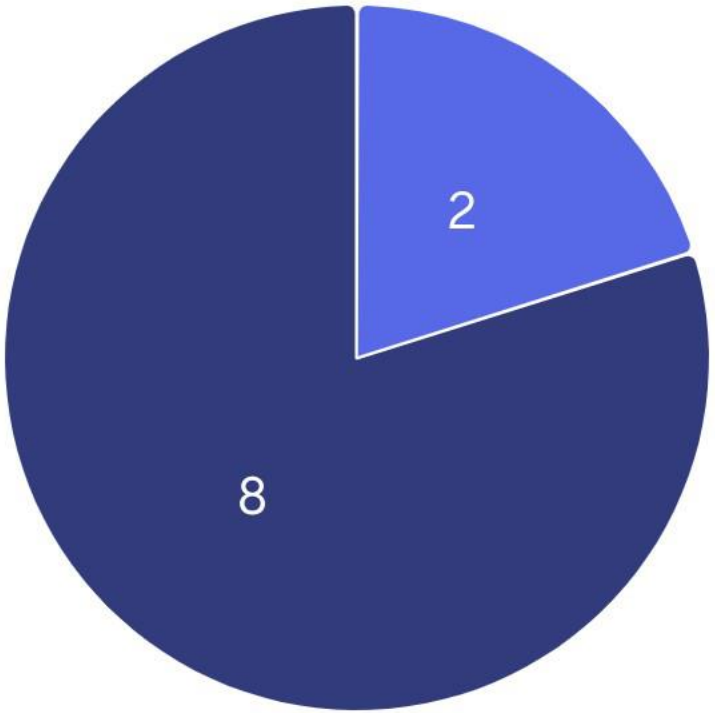
How – a Dual Beam Telescope – Two concepts

ASTRON



- Two concepts:
  1. Fully integrated in the LOFAR2.0 Telescope
     - Proposals to SDCO → Scheduling by TO → Data recording → Real-time processing → Ingest → Data product available in archive for user
  2. Station Stand-alone Mode
     - Independent second station-beam -- *As independent as possible*
     - Scheduling by station owner → Station data offloaded to local machine → Data product on own archive (or ingest to archive)

What do you think – which concept should be the primary aim for DANTE?

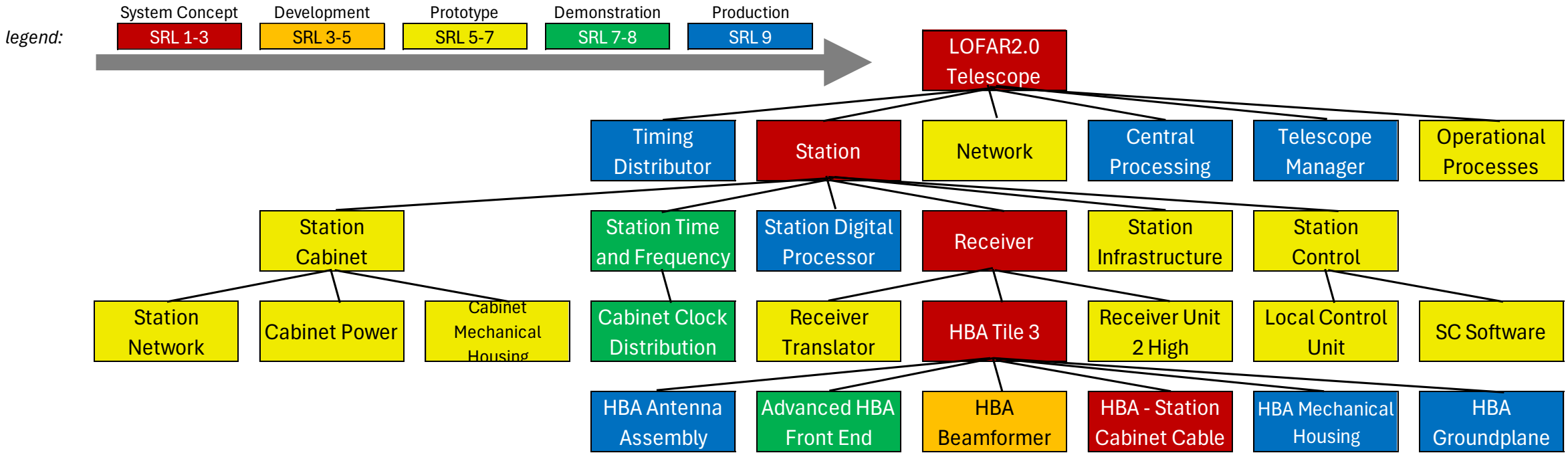


●	2	A fully integrated second beam
●	0	An independent second beam
●	8	Start small, extend later (independent beam first, don't rule out integrating later)

How to get to a Dual Beam Telescope

ASTRON

- Maturity of the end-to-end system in delivering the dual beam telescope to produce the ‘second beam’ output is tracked by the System Readiness Level.
- System Readiness Levels
  along the Product Breakdown Structure
  - Building further on the LOFAR infrastructure

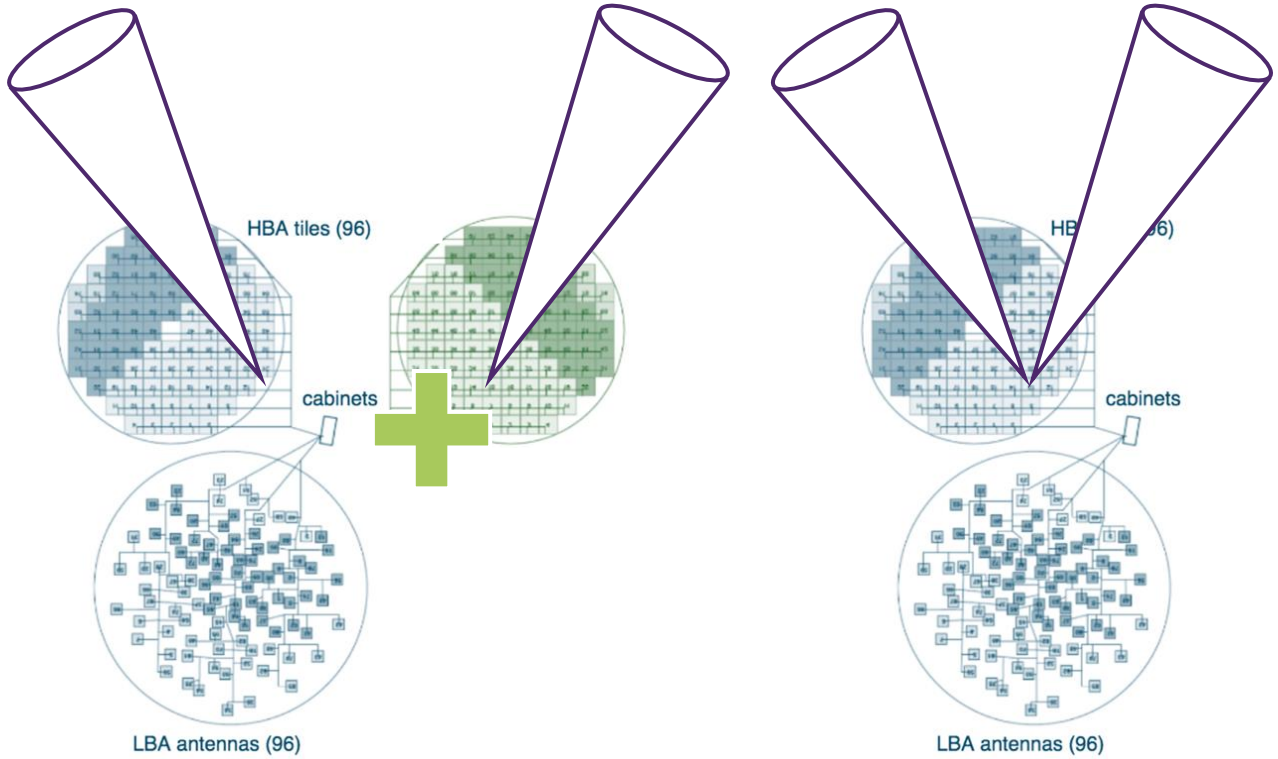


What - to make the Dual Beam Telescope

ASTRON

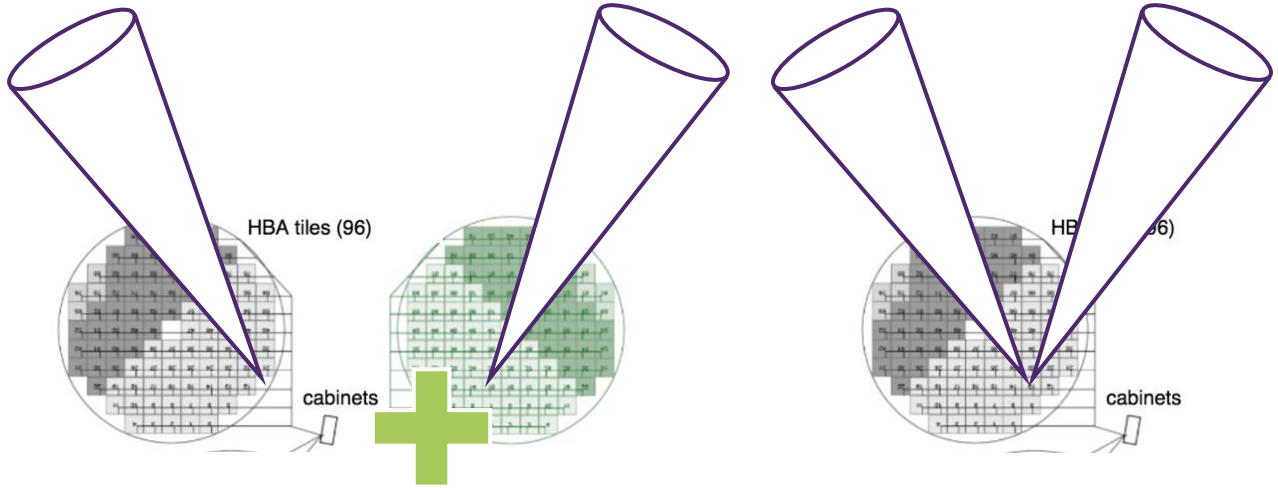
- The Dual-Beam **Station** is the key enabler for the Dual Beam Telescope
  - Focussing on the High Band

- How to upgrade the station to a dual-beam station?
- Two options:
  1. Install more ‘single-beam’ tiles
  2. Upgrade to ‘dual-beam’ tiles



The Dual-Beam Station

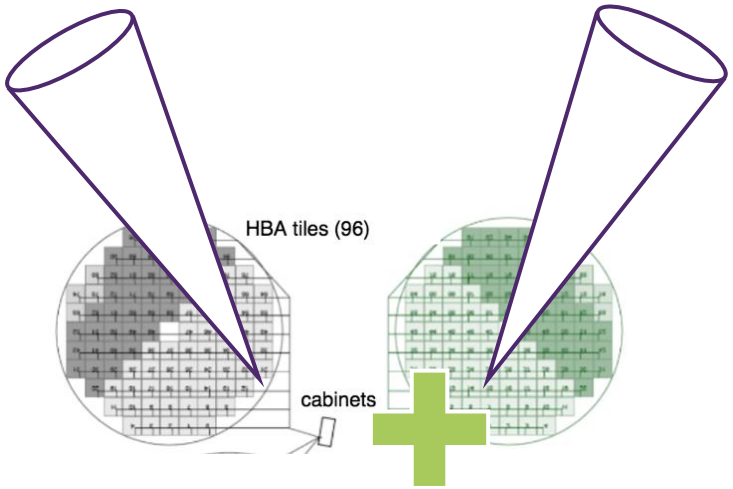
- Subracks and software needed in both options
- Station infrastructure, including cabling, in existing stations is expensive and a lot of work
  - Also – high risk on damaging existing station
- Dual-beam tile requires considerable development
  - No cheap or timely solution known to transport data from tile to cabinet
  - Low TRL → High risk
- Most expensive: both options



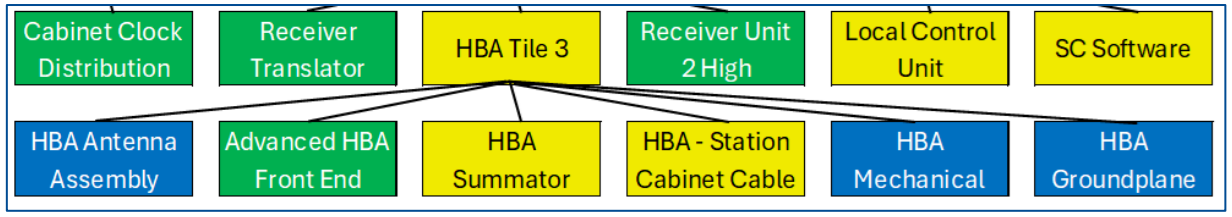
	Install more ‘single beam’ tiles	Upgrade tiles to ‘dual beam’
Terrain	Larger footprint	Smaller footprint
Rollout	Easier to rollout	Time consuming; High risk breaking existing station*
Dev. effort	Higher technology readiness: less development	Lower technology readiness: longer development
Total life cycle cost	Smaller	Larger*

What – to make the Dual-Beam Station

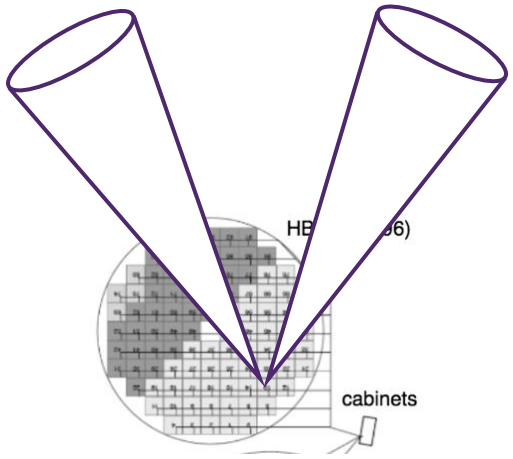
ASTRON



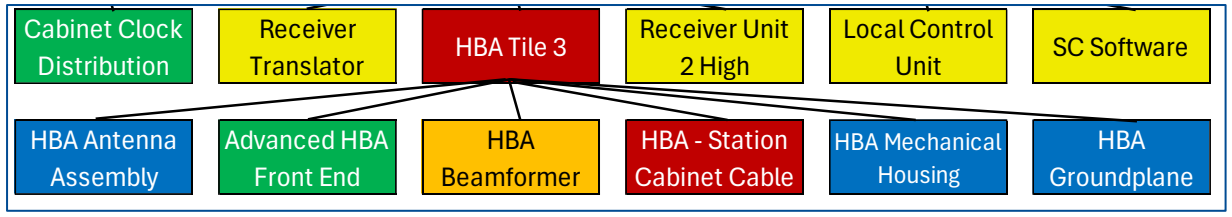
Install more ‘single beam’ tiles



VS



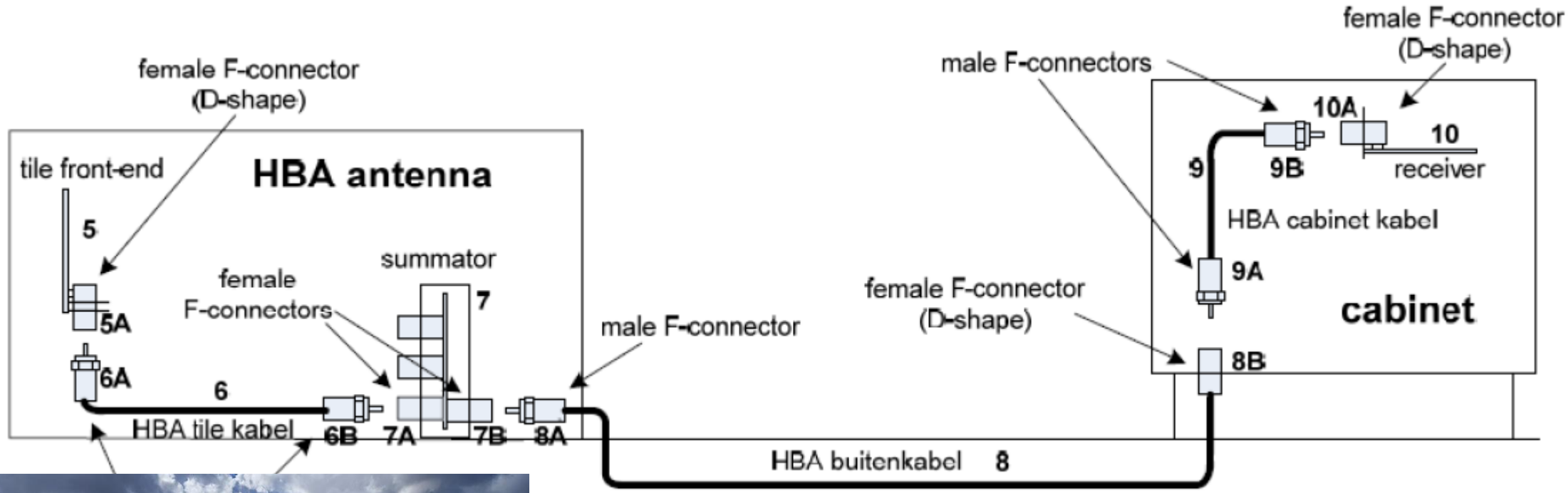
Upgrade tiles to ‘dual beam’

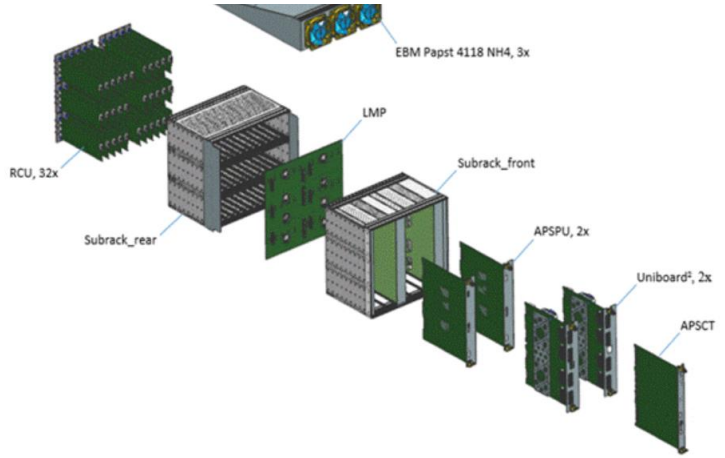


- Less development effort needed by
  - re-using more LOFAR1
  - And building further on LOFAR2.0

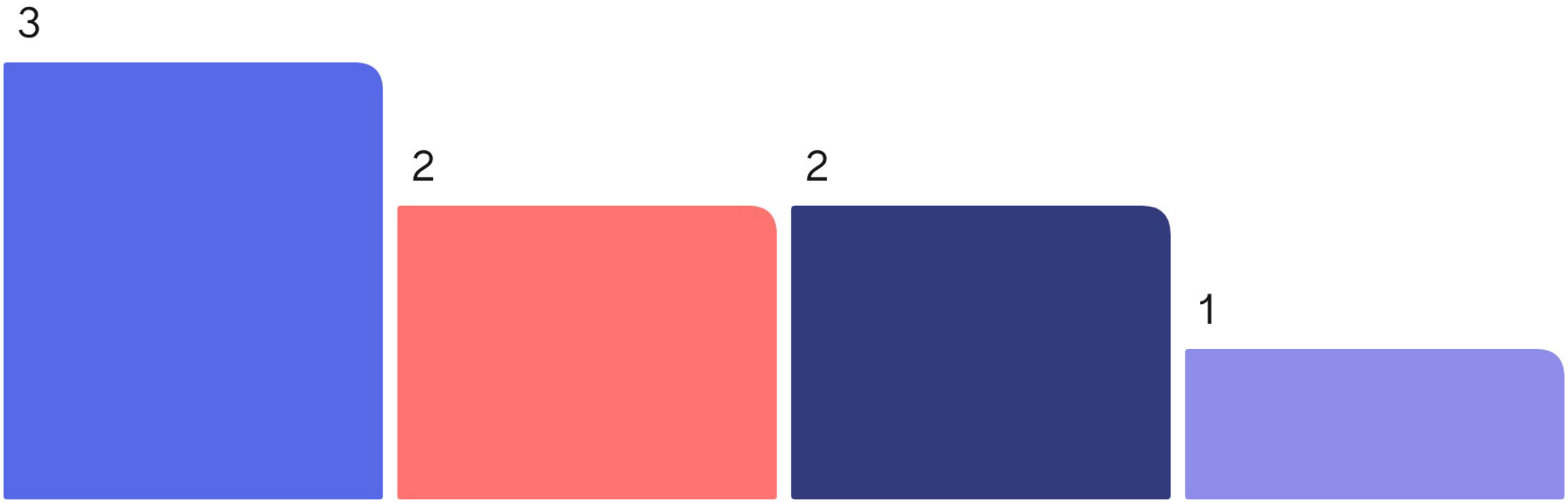
Transport data from Tile to APS subrack

ASTRON



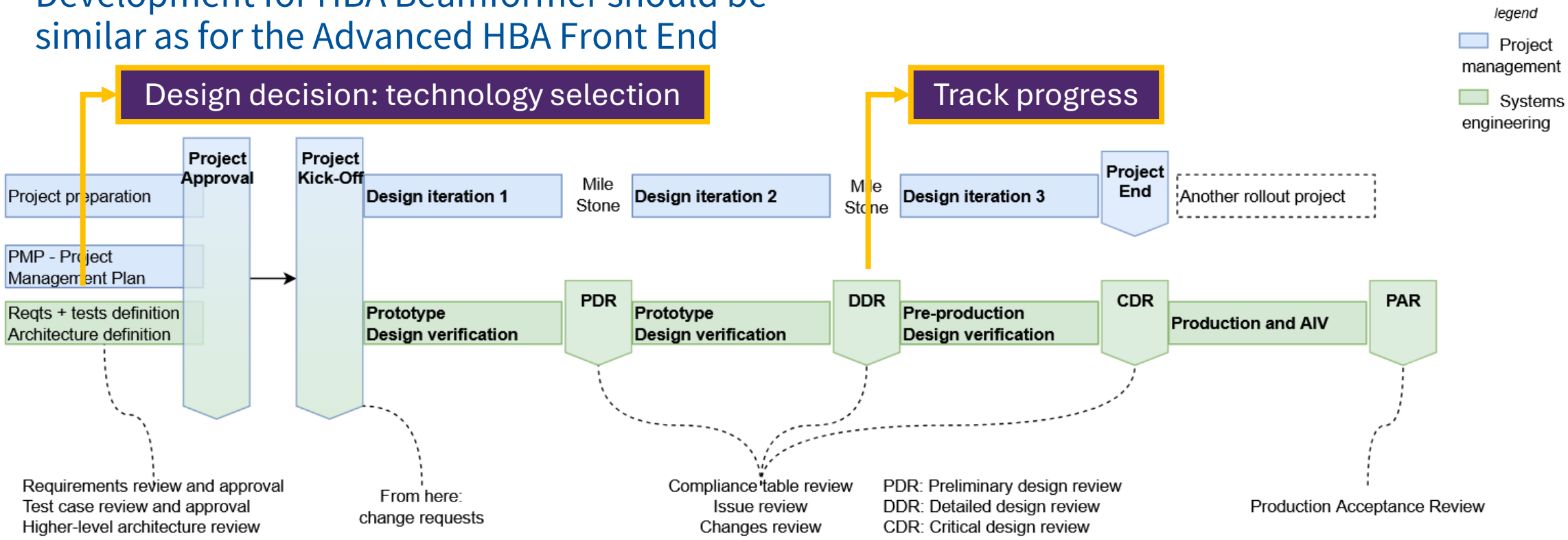


What do you think – which option would best fit your site?



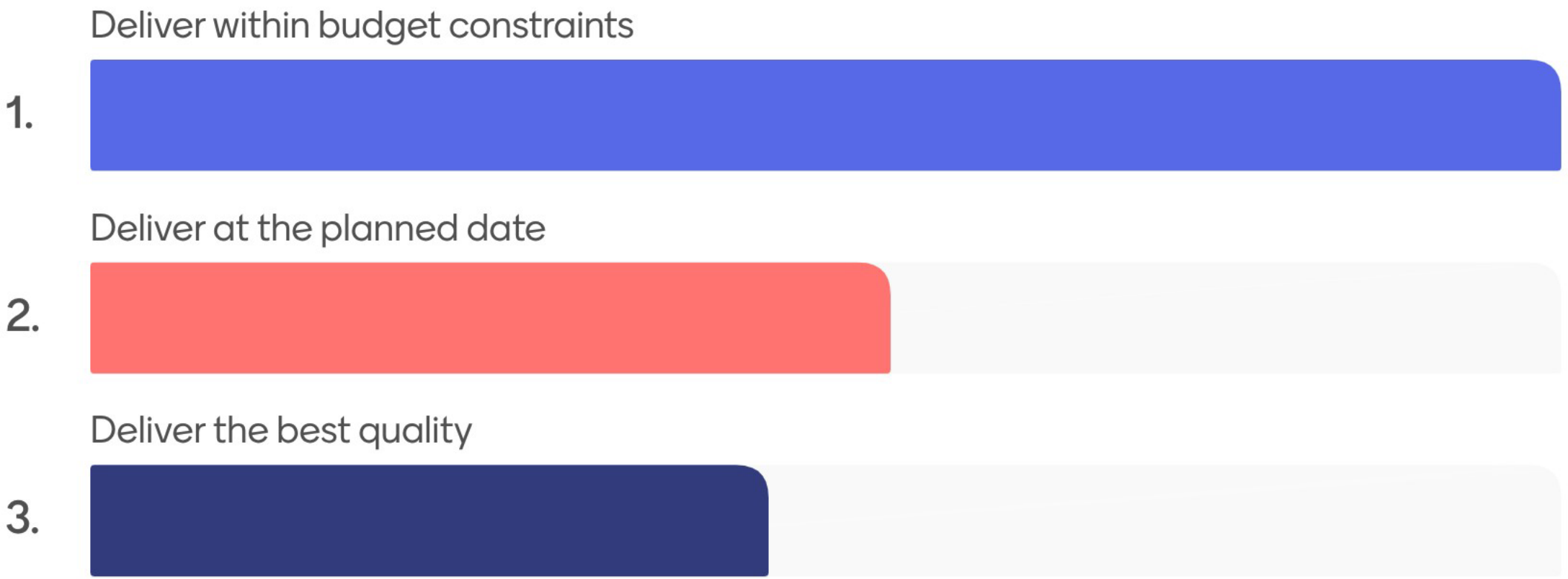
How to go forward

- Systems engineering reviews
  - Right level of information to the DANTE board, can be achieved by having a representative from the board at the systems engineering reviews
- Development for HBA Beamformer should be similar as for the Advanced HBA Front End



Setting expectations

When working on enabling the dual beam capability, we should aim to:



Summary

- We are aiming to develop a dual-beam system to enable a dedicated beam for space weather science
- Two concepts identified:
  1. Fully integrated
  2. Stand-alone
- Dual-beam station, two options:
  1. more single-beam tiles
  2. dual-beam tiles