DANTE

Phase 1 Summary
Development of the advanced HBA frontend

Mark Ruiter - Lead engineer

Consortium board meeting – 17.11.2025

ASTRON
Netherlands Institute for Radio Astronomy

The goal of DANTE is to ensure that the HBA continues delivering science in the LOFAR2.0 era and to deliver a dual beam capable tile.

This presentation

Phase 1

Will deliver a production-ready (TRL9) frontend design that will allow dual beam capability in the future;

- Focus is to deliver single beam AHBAFE
- Allows for continuation of Phase2

Scenarios

- Replacement for HBA (complete tiles)
- Production of new stations with single beam HBA tiles

Bologna meeting

Phase 2

Will deliver a dual beam capable HBA tile (building on DANTE and LOFAR4SW deliverables)

- Hardware: Tile beamformer (TBC)

Scenario

- New and existing stations upgraded to dual beam HBA tiles.

Phase 3

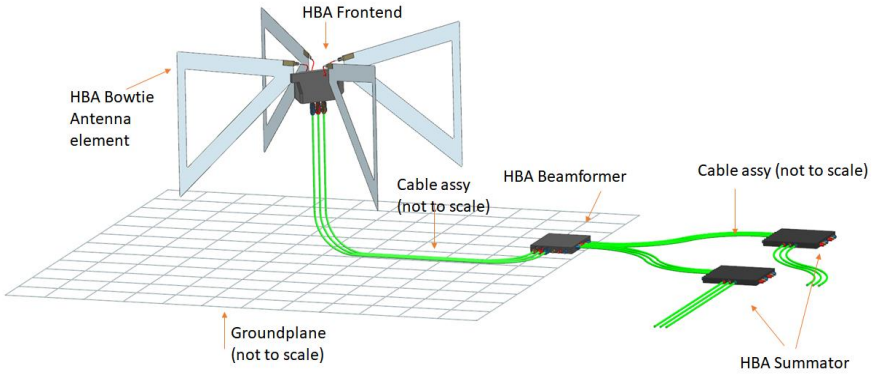
Will deliver a dual beam capable HBA tile (building on DANTE and LOFAR4SW deliverables)

- System : TBC

Scenario

- Dual beam capability for LOFAR2 stations and LOFAR2 telescope

LOFAR4SW Re-use



LOFAR4SW Final Conceptual Design

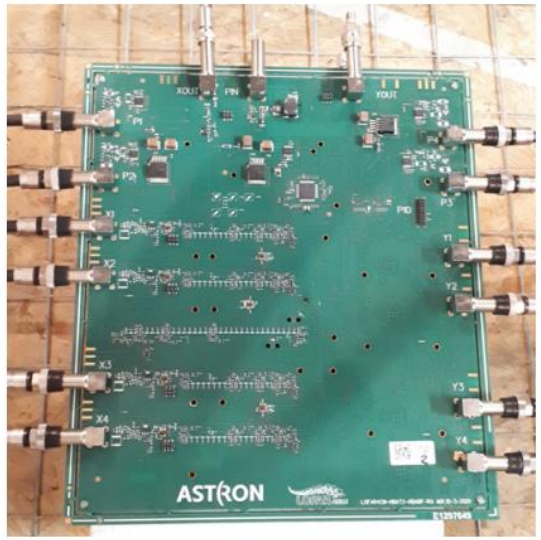
DOI: 10.3030/777442

Q4 2017

Q1 2022

LOFAR4SW

Product	TRL
HBA Frontend board (discrete parts)	6
HBA Frontend board (ASIC parts)	4
HBA Beamformer board (discrete parts)	4
HBA Beamformer board (ASIC parts)	4
HBA Summator board	4
HBA Tile	4
HBA Intra-cable	4
HBA LNA SiGe ASIC	4
HBA Beamformer SiGe ASIC	4



LOFAR4SW
Grant agreement ID: 777442
Project website

DOI
10.3030/777442

Project closed

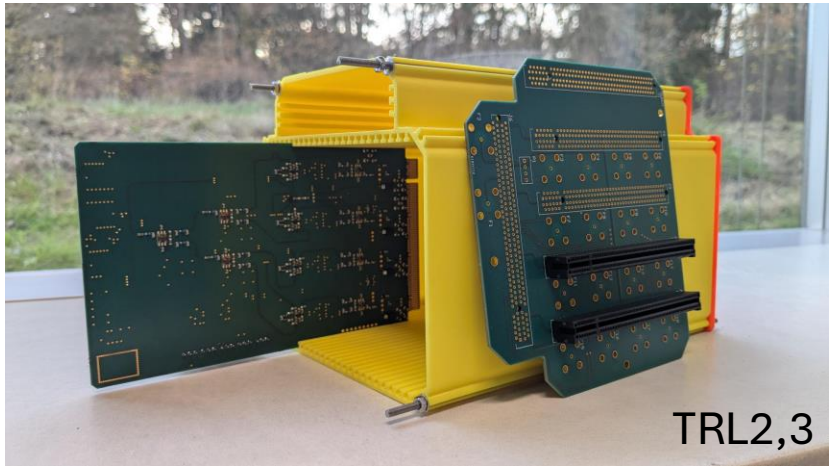
EC signature date
22 November 2017

Start date 1 December 2017
End date 28 February 2022

Funded under
EXCELLENT SCIENCE - Research Infrastructures

Q4 2023

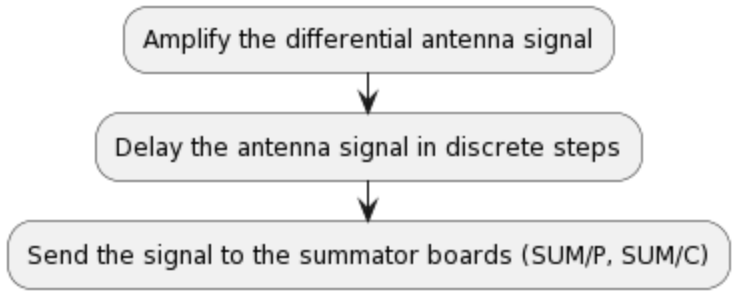
Beamformer box student minor project (3Month)



DANTE PHASE 1

Product: *production-ready and technically verified design, incl. documentation to tender the FE boards. The design should be mature enough to be used for manufacturing a large number of boards (10000's) at an acceptable low risk.*

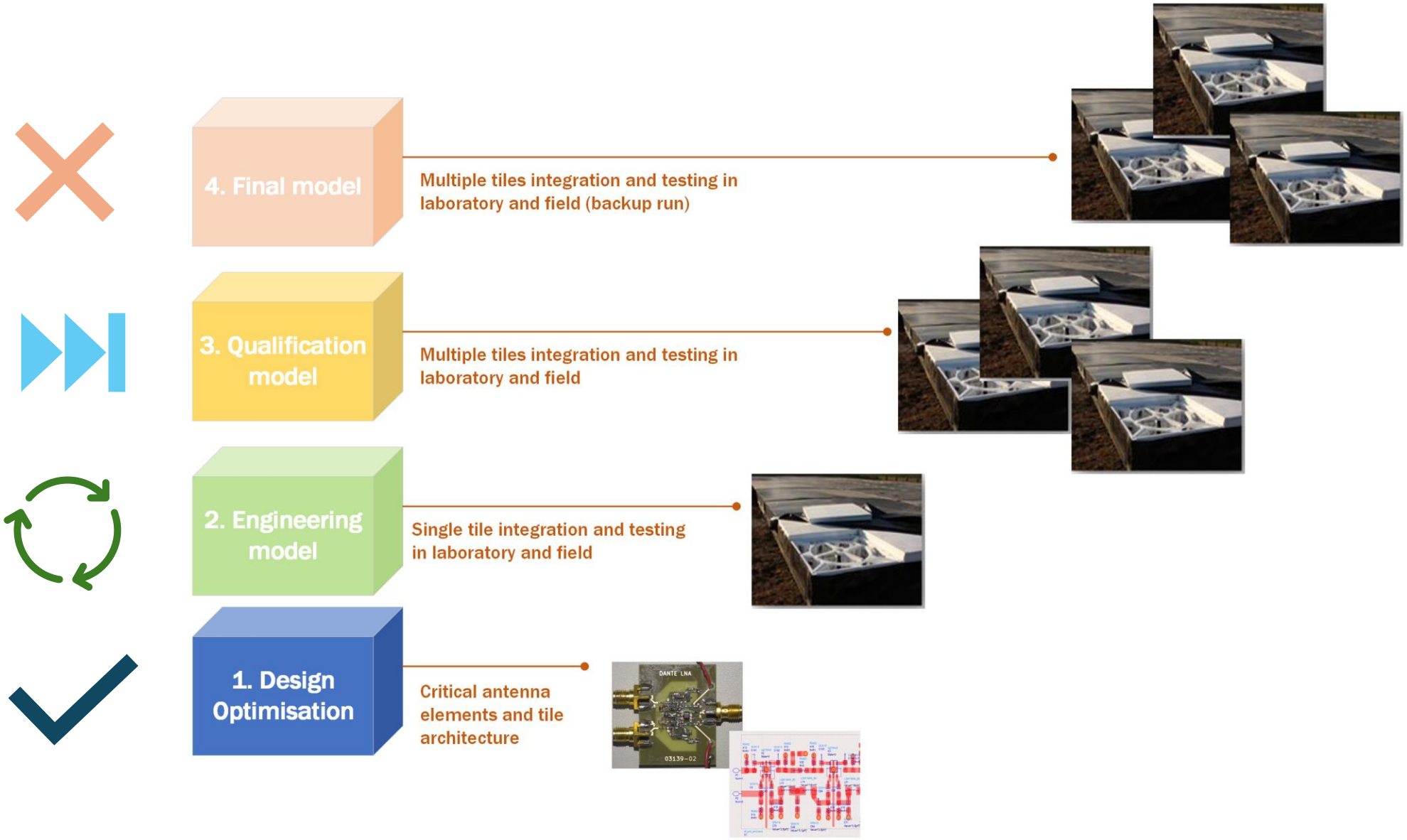
Compatibility is only ensured with LOFAR2.0 RCU.
Assumes that replacement will happen per tile.
Rollout is not part of the project.



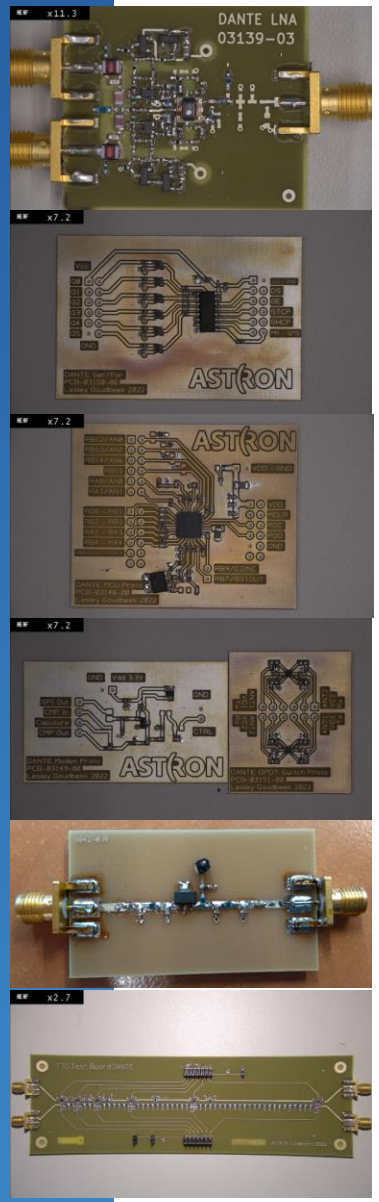
~800 per Dutch station

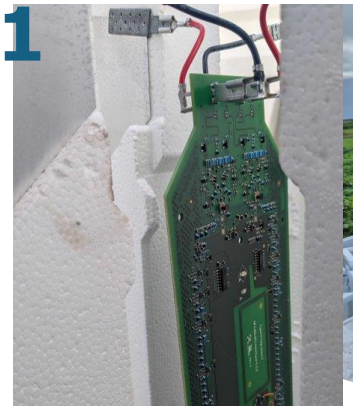
~1600 per International stations

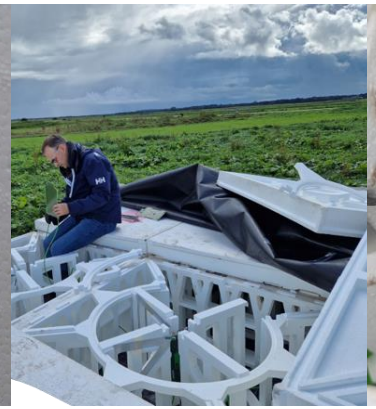
PHASE 1 DEVELOPMENT APPROACH

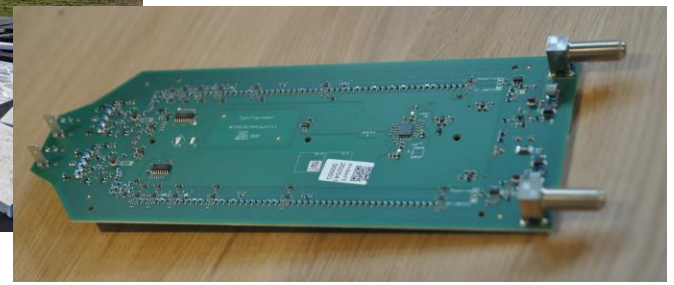


PHASE 1









Q2 2022

Q3 2025

System Arch. → EM → QM → FM

PDR 13-10-2022

DDR 17-4-2024

CDR 20-12-2024

Delta-CDR 30-06-2025

- 64 potted AHBAFE in the field for > 6 months

First 100 board verification:

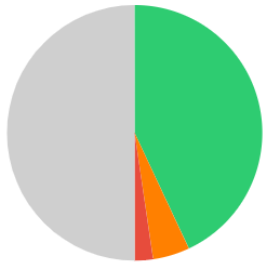
- Potting geometry improvement
- Return loss verification with potting
- 48V test on both outputs
- Control with solved wire modification
- Datapack finalization and archiving

Delta - Critical Design Review

30/06/2025

AHBAFE-CDR-1 - Critical Design Review

Test Run Status - Open



37	4	2	0
Passed	Passed with Failures	Failed	Blocked

43
Executed

Description

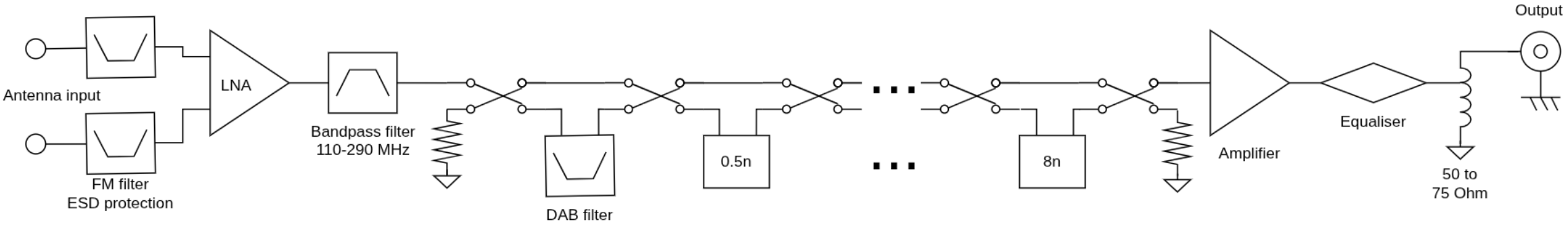
Test Result	Test Case
Passed with Failures	LOFAR2-12745 - TEST:CE:EMC:IMMUNITY
Passed with Failures	LOFAR2-11971 - Test: AHBAFE linearity: The AHBAFE shall have an IIP3>3.4 dBm and IIP2 >5dBm.
Passed with Failures	LOFAR2-12003 - Test: No special components
Passed with Failures	LOFAR2-12744 - TEST:CE:EMC:RED

Tests - AHBAFE-CDR-1 - Critical Design Review

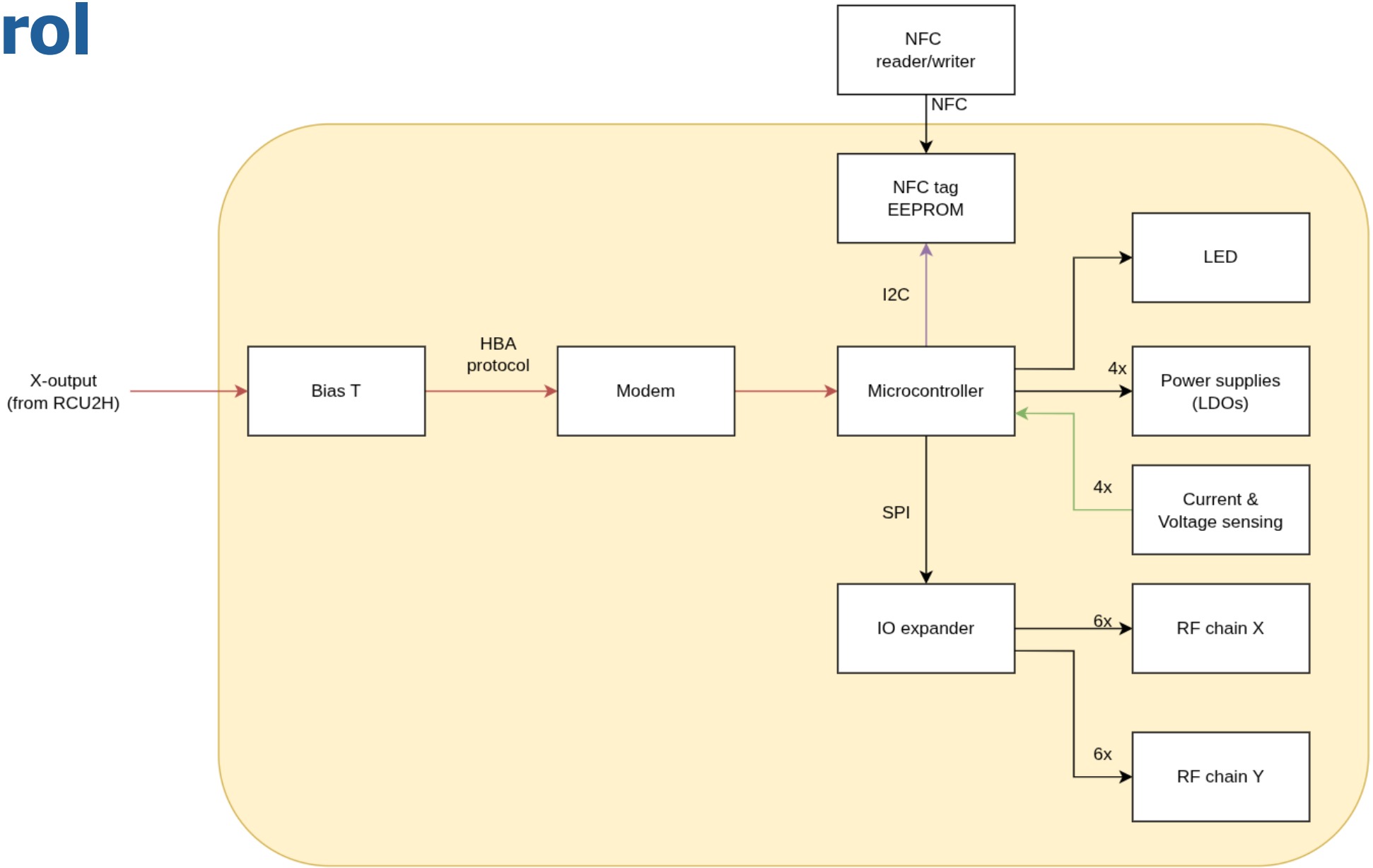
Test Result	Test Case
Passed	LOFAR2-12740 - Remote monitoring of voltage and current
Passed	LOFAR2-12741 - Test: Main LED
Passed	LOFAR2-12759 - Test: AHBAFE seamless Control
Passed	LOFAR2-12753 - TEST: Delay requirements
Passed	LOFAR2-11972 - Test: AHBEFE power consumption: 140mA/frontend/pol.
Passed	LOFAR2-11921 - Test: Spactral noise
Passed	LOFAR2-11952 - Test: m&c points in ICD
Passed	LOFAR2-11706 - Test: AHBAFE States and State transitions
Passed	LOFAR2-12767 - Inspection: PCBA Bow and Twist
Passed	LOFAR2-12765 - EEPROM readout with debug LED in parallel
Passed	LOFAR2-11959 - Test: Manufacturing cost
Passed	LOFAR2-11943 - Test: IF: Mechanical support
Passed	LOFAR2-11948 - Test: IF: Optical indicators and labels
Passed	LOFAR2-11937 - Test: AHBAFE Modes and Mode transitions
Passed	LOFAR2-11920 - Test: Hot cold measurement
Passed	LOFAR2-12749 - Test: AHBAFE: Frequency bandpass
Passed	LOFAR2-12763 - Test: COMMISSIONING AHBAFE TILES: Pointing
Passed	LOFAR2-12762 - Test: COMMISSIONING AHBAFE TILES: Performance
Passed	LOFAR2-12742 - Test: AHBAFE: RF CM suppression
Passed	LOFAR2-12803 - Production spread FM series
Passed	LOFAR2-12766 - Test: AHBAFE: Thermal behaviour
Passed	LOFAR2-11953 - End-to-end Test: m&c points
Passed	LOFAR2-11961 - Test:CE:Immunity:ESD
Passed	LOFAR2-12754 - TEST:AHBAFE: FMECA
Passed	LOFAR2-11954 - Test: Electrical design documentation
Passed	LOFAR2-11973 - Test: AHBAFE: Grounding
Passed	LOFAR2-12756 - Test: AHBAFE TILE Modes and Mode transitions
Passed	LOFAR2-12757 - Test: AHBAFE TILE States and State transitions
Passed	LOFAR2-11951 - Test: Lifecycle documentation
Passed	LOFAR2-11958 - Test: Reliability: Environmental outside test
Passed	LOFAR2-12764 - Test: COMMISSIONING AHBAFE TILES: IMAGING
Passed	LOFAR2-12743 - TEST:CE:EMC:EMISSION
Passed	LOFAR2-12824 - Test: Corner behaviour
Passed	LOFAR2-11944 - Test: IF: Cable connector
Passed	LOFAR2-12760 - Test: Reliability: Environmental climate test
Passed	LOFAR2-11955 - Test: Mechanical design documentation
Passed	LOFAR2-12746 - TEST:OVERVOLTAGE protection X,Y output ports

Test Result	Test Case	Defect
Failed	LOFAR2-11941 - End-to-end Test: Remote firmware update	LOFAR2-12772
Failed	LOFAR2-11945 - Test: IF: Power consumption	LOFAR2-12163

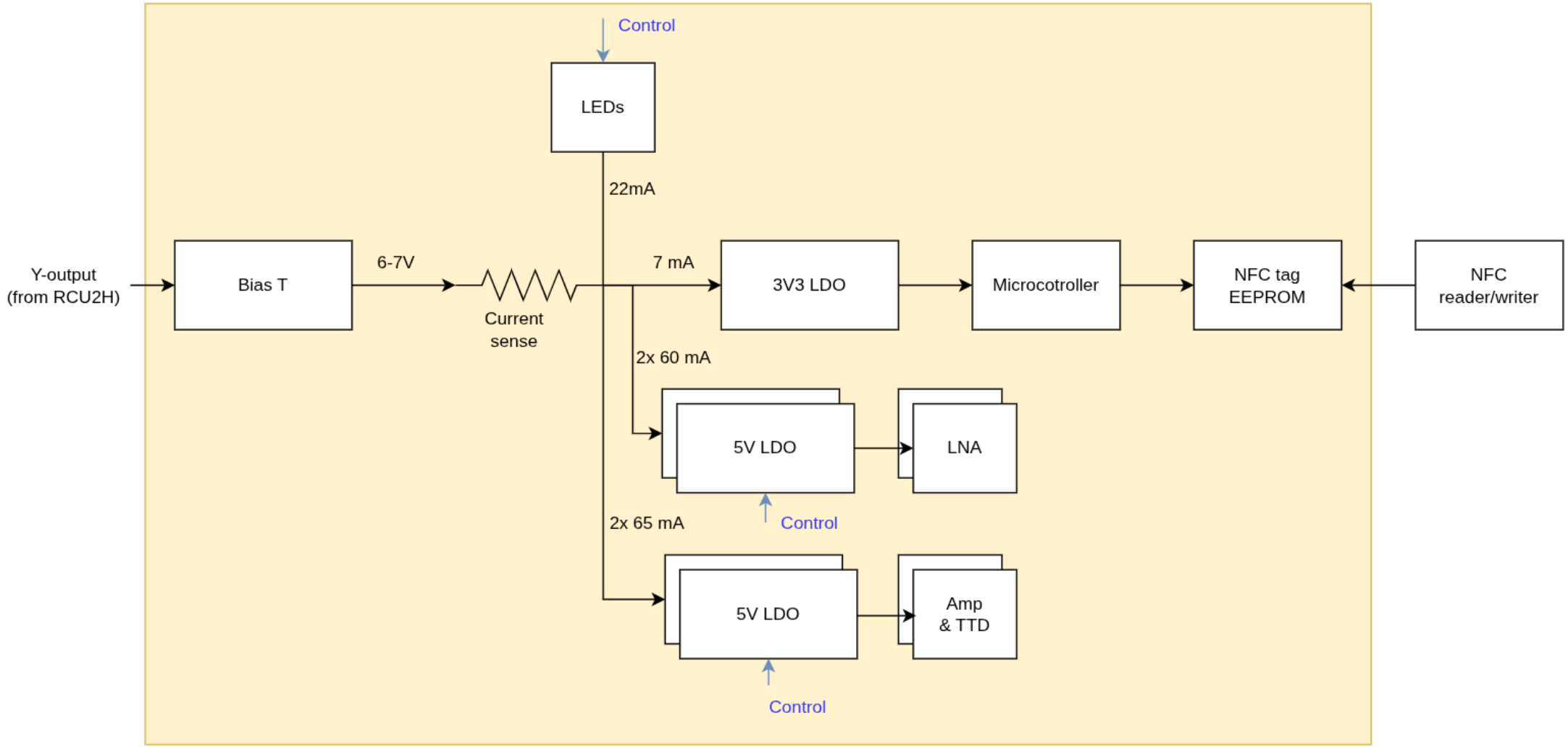
AHBAFE RF Blockdiagram



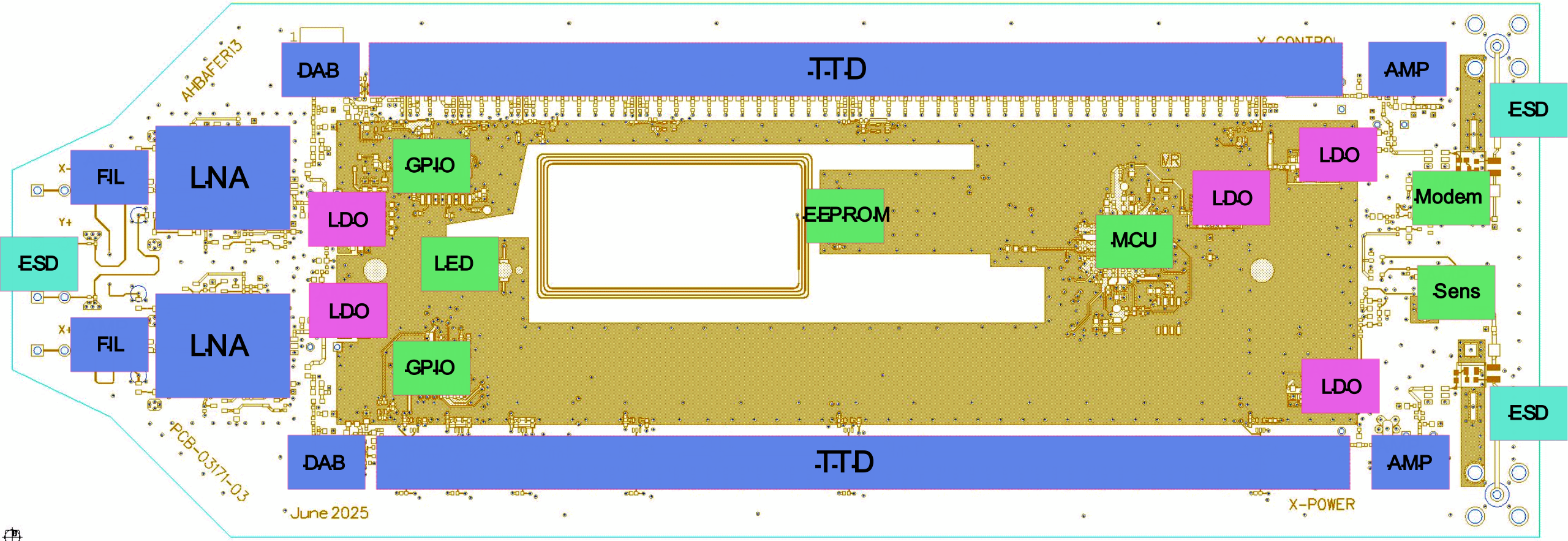
Control


NFC
reader/writer
NFC
NFC tag
EEPROM
I2C
LED
X-output
(from RCU2H)
Bias T
HBA
protocol
Modem
Microcontroller
4x
Power supplies
(LDOs)
4x
Current &
Voltage sensing
SPI
IO expander
6x
RF chain X
6x
RF chain Y

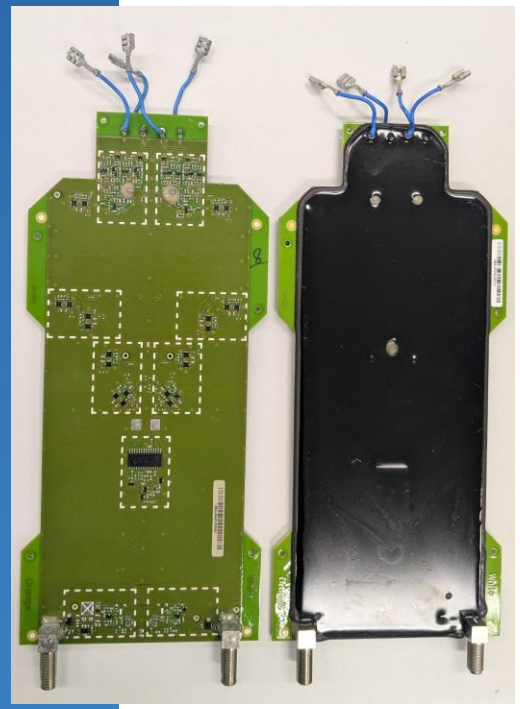
Power

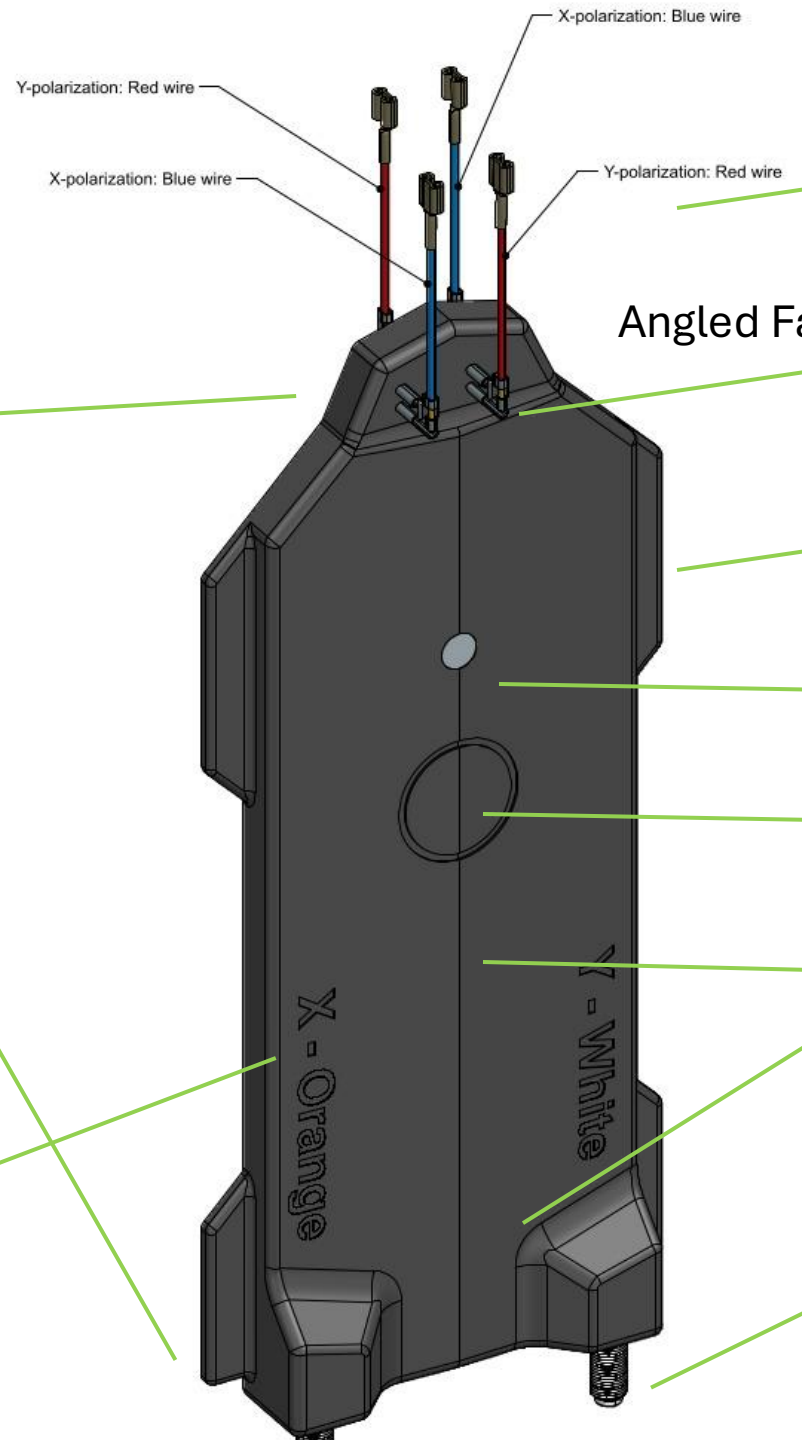

Control
LEDs
22mA
Y-output
(from RCU2H)
Bias T
6-7V
Current
sense
7 mA
3V3 LDO
Microcotroller
NFC tag
EEPROM
NFC
reader/writer
2x 60 mA
5V LDO
LNA
Control
2x 65 mA
5V LDO
Amp
& TTD
Control

Function floor plan in AHBFE layout



Mechanical Design





Unique color per polarization

Angled Faston connection

Room for easy positioning

Locking edges

LED (both sides)

NFC (ID)

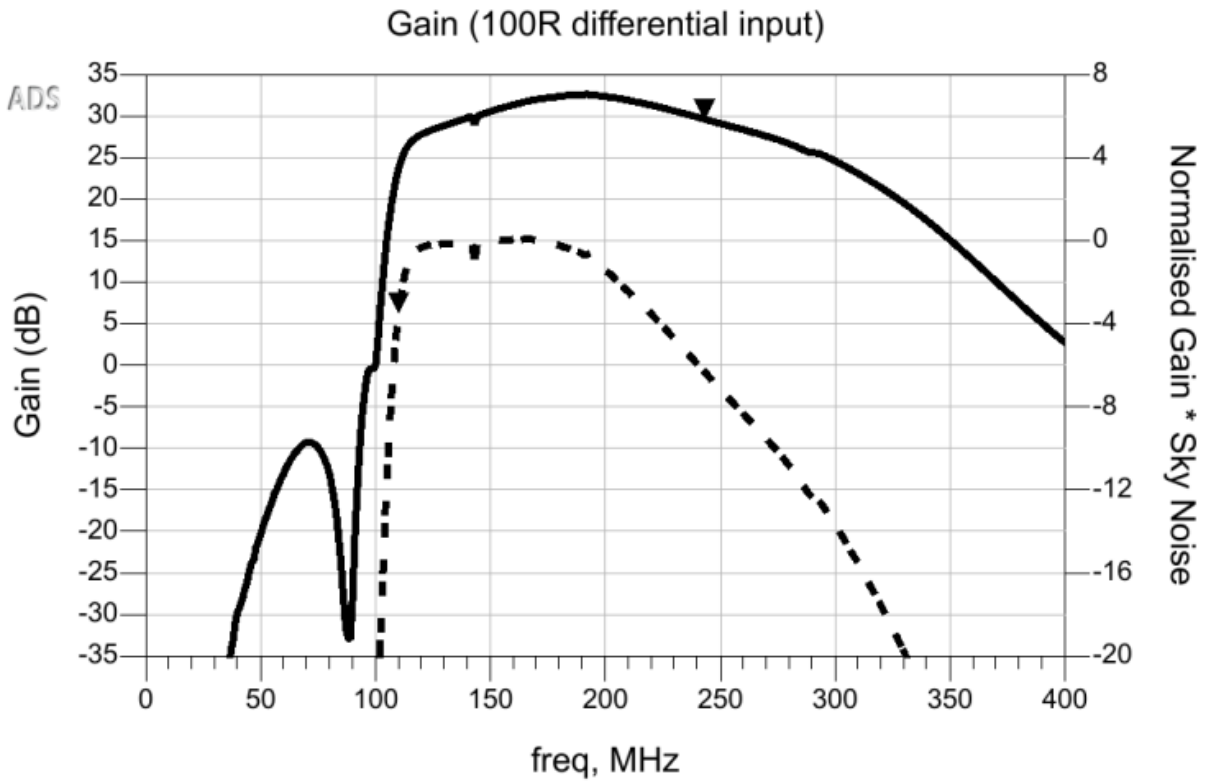
Improved water evacuation

Clear marking

Reduced the area of connector exposed to corrosion

AHBAFE POTTED

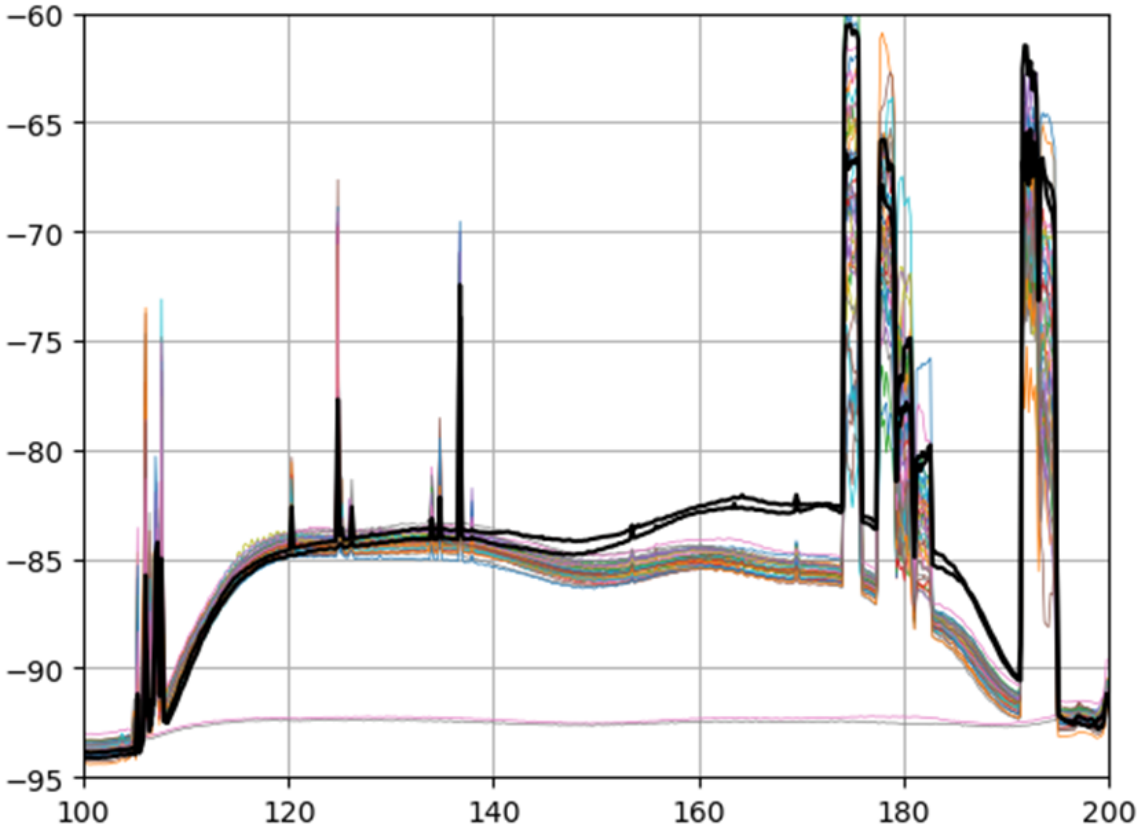
Gain profile



Tile test

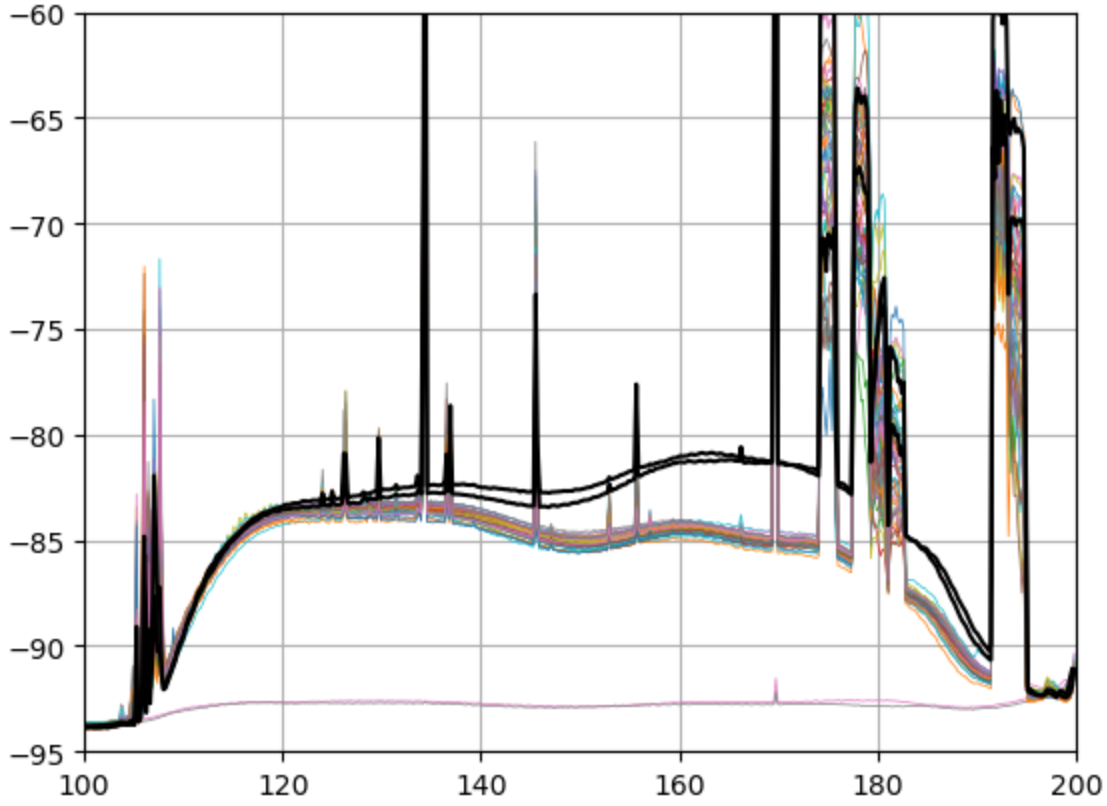
Before potting

Bandpass (zenith)

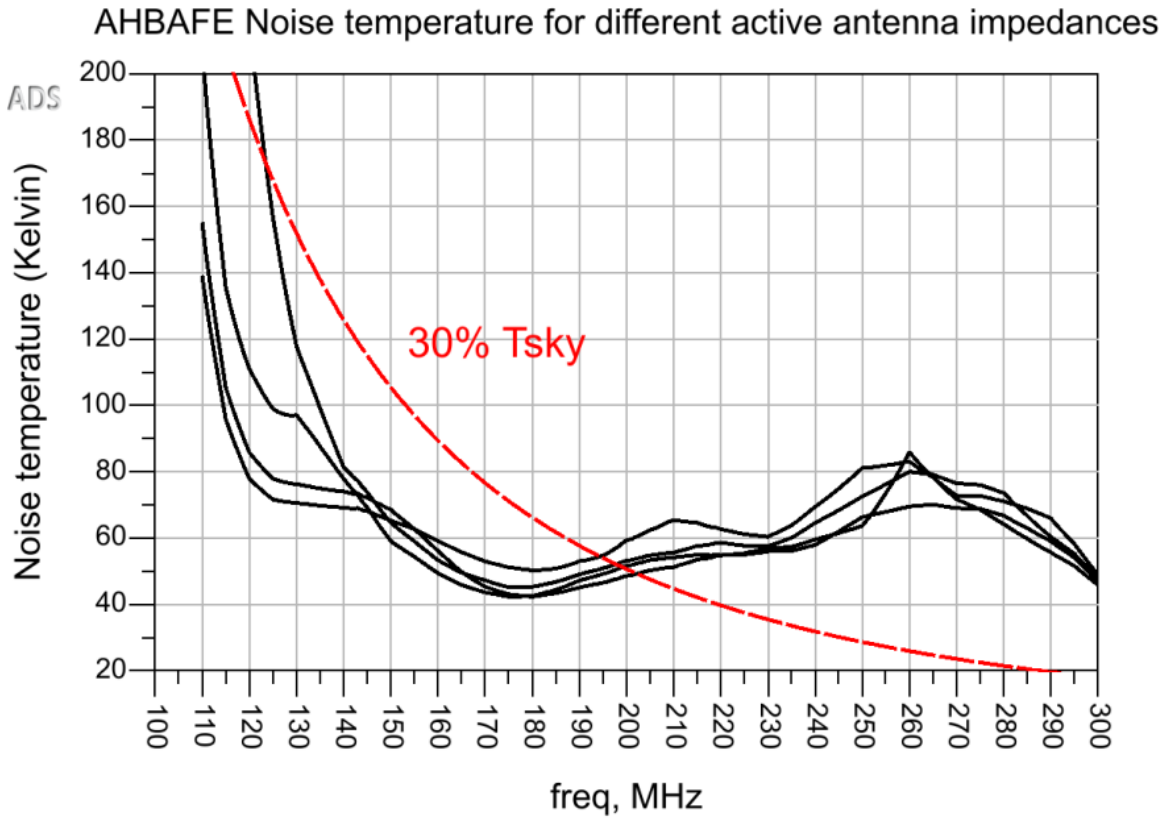


After potting

(different time)



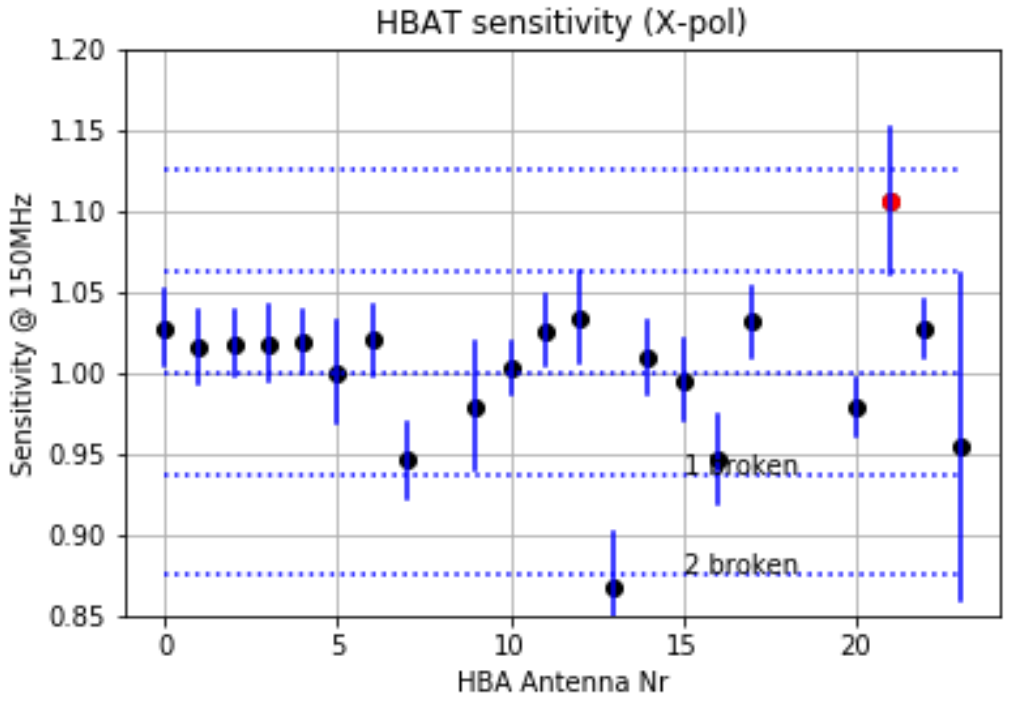
Noise temperature

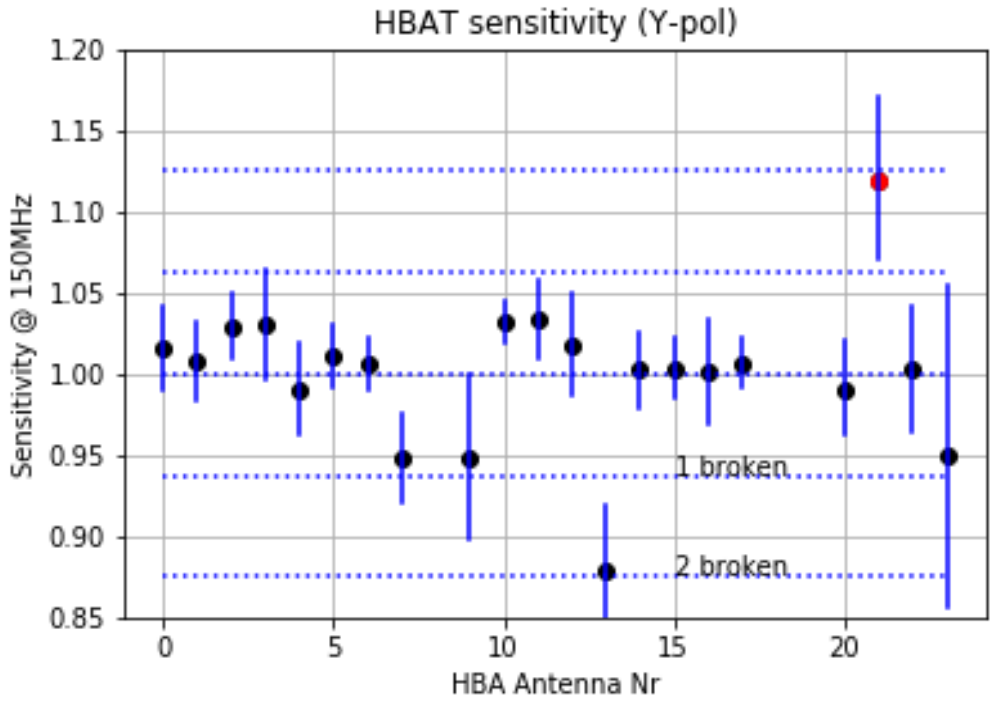


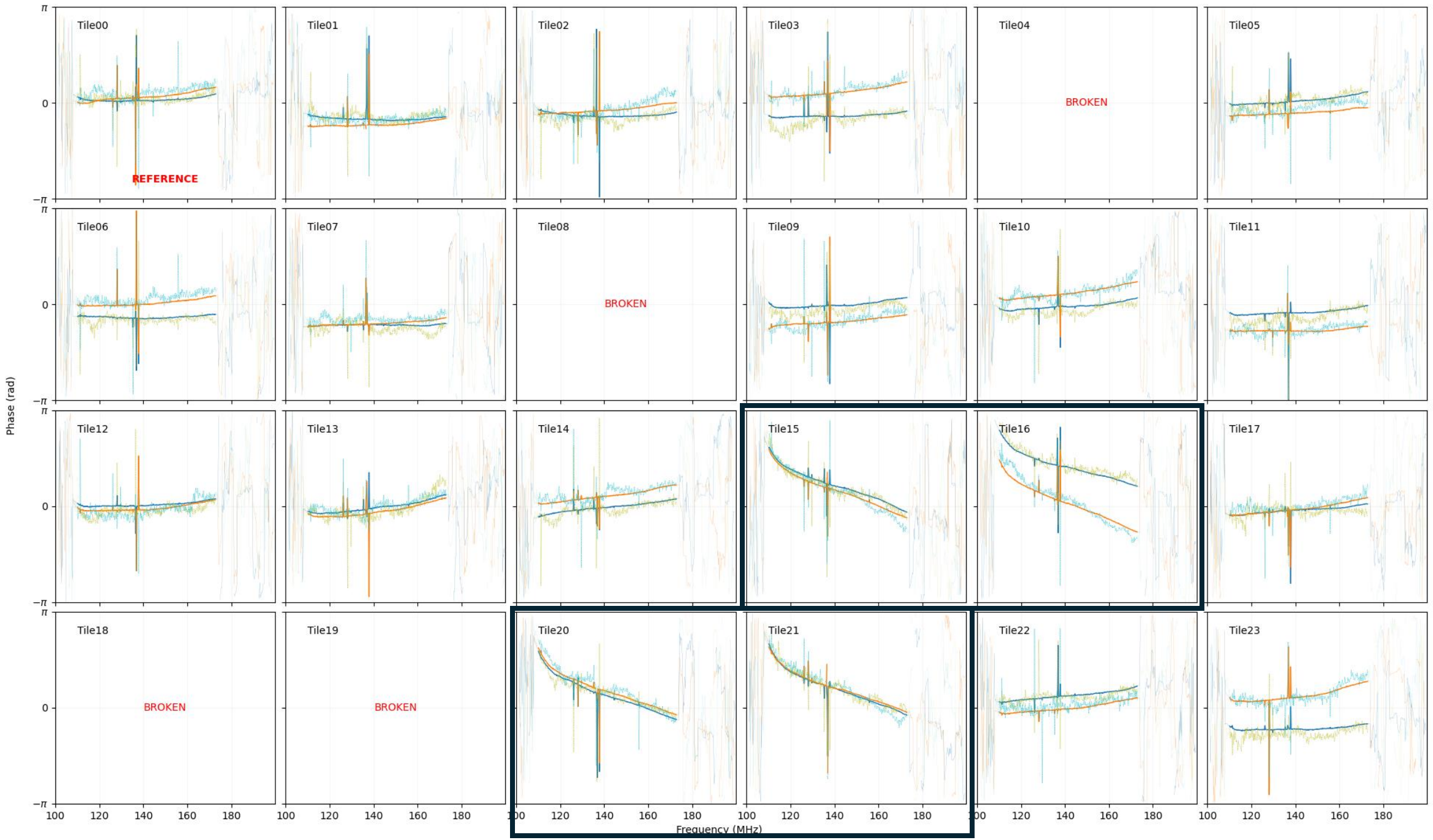
Layout met alle blokken erin

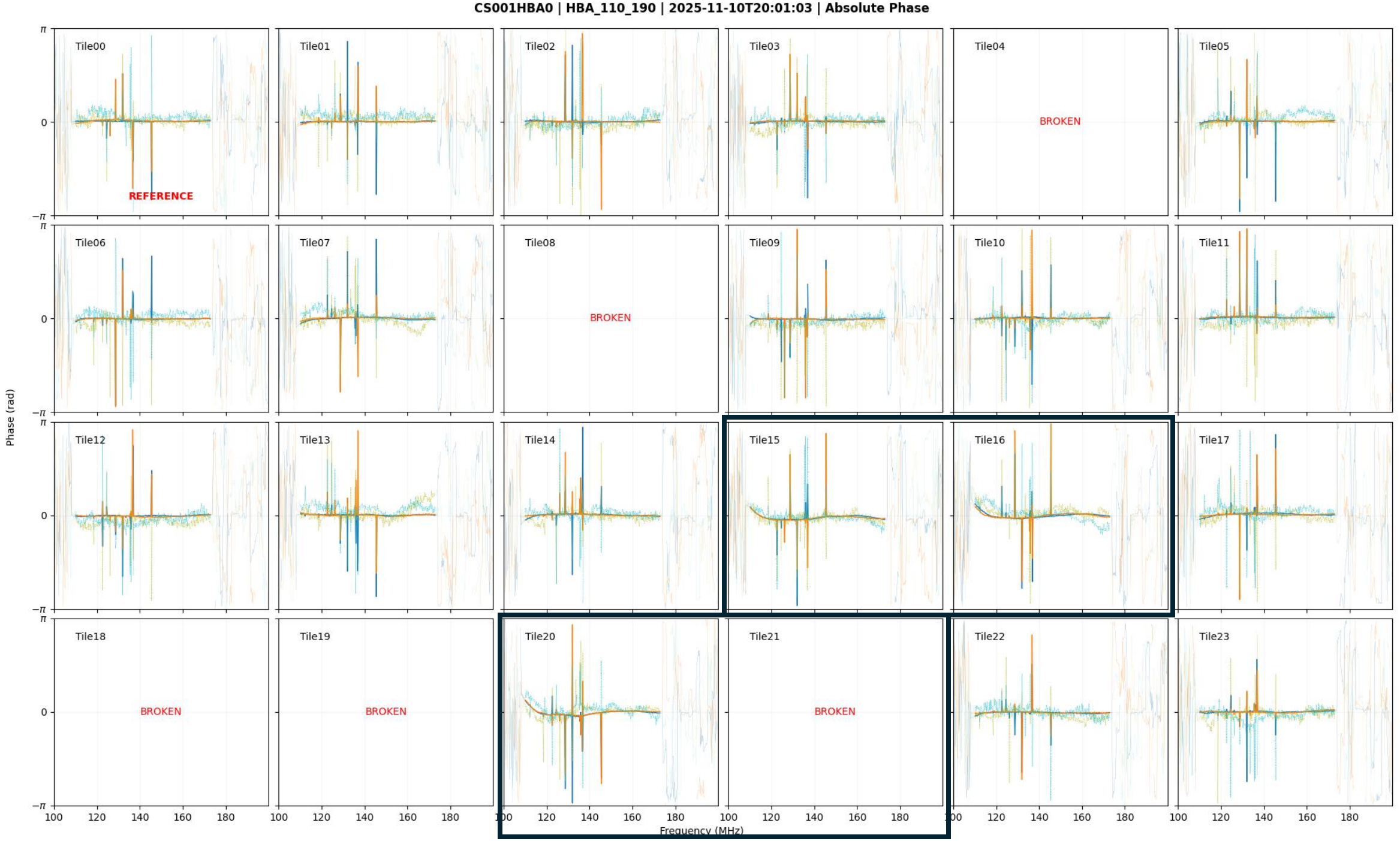
Tile sensitivity test

- Track CasA
- Compare sensitivity between tiles having the same baseline
- Can see tiles with broken elements
- DANTE 10% improved sensitivity = 17.5 element LOFAR1 tile (@150 MHz)






CS001HBA0 | HBA_110_190 | 2025-10-19T21:00:47 | Absolute Phase
Tile00
REFERENCE
Tile01
Tile02
Tile03
Tile04
BROKEN
Tile05
Tile06
Tile07
Tile08
BROKEN
Tile09
Tile10
Tile11
Tile12
Tile13
Tile14
Tile15
Tile16
Tile17
Tile18
BROKEN
Tile19
BROKEN
Tile20
Tile21
Tile22
Tile23
Phase (rad)
Frequency (MHz)


CS001HBA0 | HBA_110_190 | 2025-11-10T20:01:03 | Absolute Phase
Tile00
REFERENCE
Tile01
Tile02
Tile03
Tile04
BROKEN
Tile05
Tile06
Tile07
Tile08
BROKEN
Tile09
Tile10
Tile11
Tile12
Tile13
Tile14
Tile15
Tile16
Tile17
Tile18
BROKEN
Tile19
BROKEN
Tile20
Tile21
BROKEN
Tile22
Tile23
Phase (rad)
Frequency (MHz)

		Measured	Required	
Gain (antenna impedance)	dB	>30	>30	same or large than HBAT1
Delay step gain variation (rms)	dB	<0.1	<0.4	DANTE RF design
Delay step phase variation (rms)	deg	<3	<3	0.52ns steps (100-180MHz) 0.525ns steps (180-240MHz)
Input reflection	dB	<-20	<-20	L2-6657
PCB phase variation (rms)	deg	<5	<8	L2-5443
	deg	+-10@130MHz	<8	between DANTE&HBAT1
PCB gain variation (rms)	dB	<0.25	<0.25	L2-6588
	dB	+-1.5@130MHz	<0.25	between DANTE&HBAT1
Current	mA	239	<250	HBAT1 around 230mA . (L2-6428)

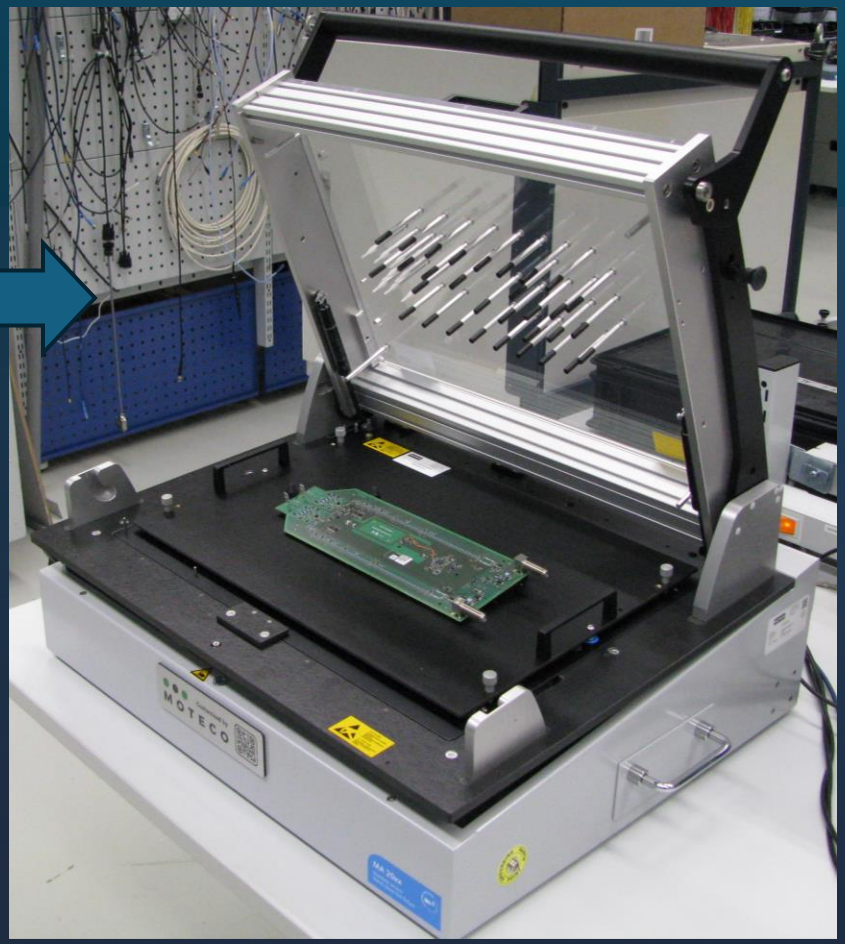
RF compliancy

- Mixed tiles don't comply to L2 beamforming requirement.
- Gain depends on beam direction.

AHBFE specification (measured)

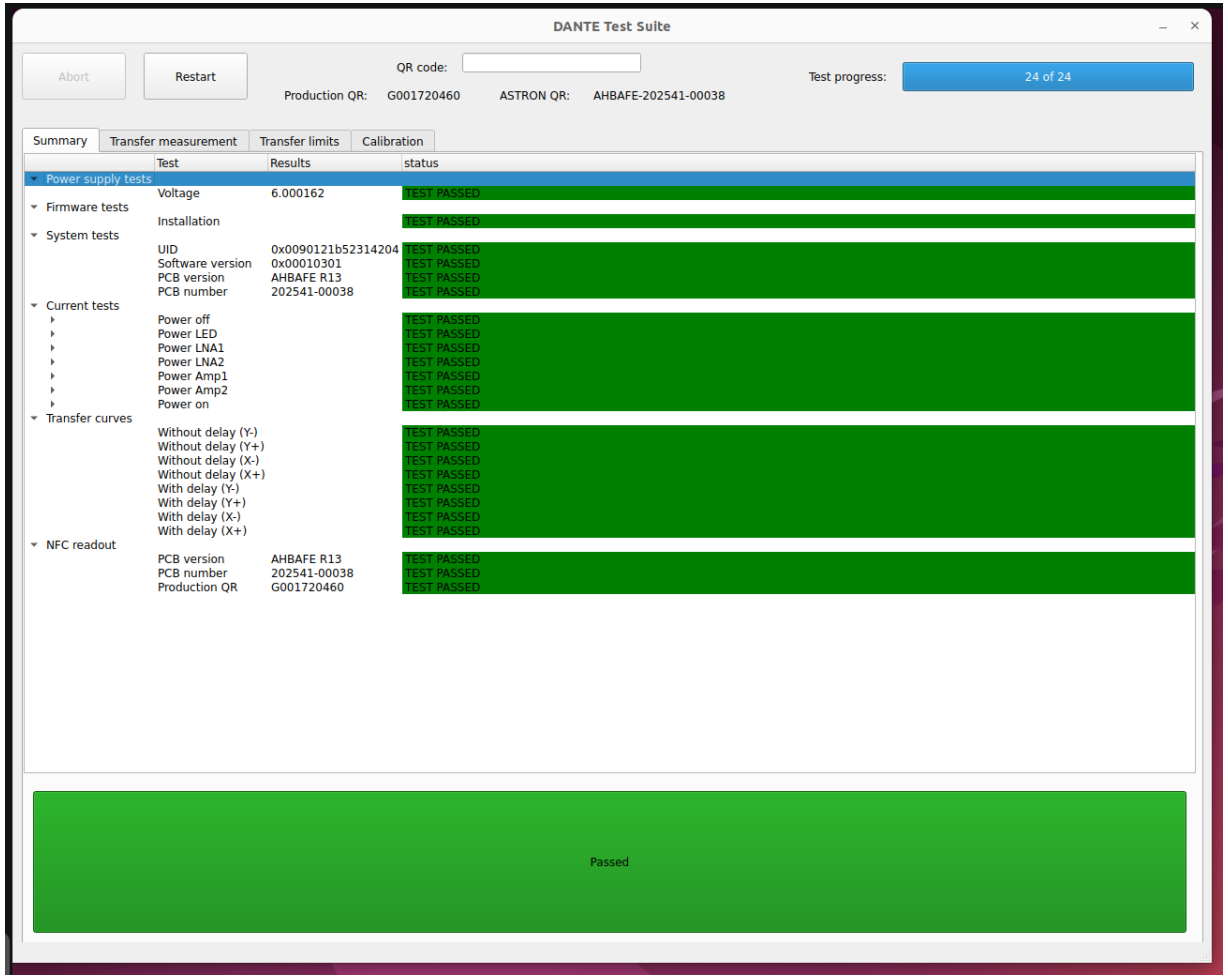
Parameter	Value	Unit	Remarks
Gain	32	dB	100R input
Gain bandwidth	110-240	MHz	-3dB points shown on gain graph
Noise	<30%	Sky noise	110-190 MHz
	<60	Kelvin	190-240MHz
OIP3	>25	dBm	DAB RFI
IIP2	>25	dBm	DAB + FM RFI
Output reflection	<-20	dB	75Ohm output
Current	<260	mA	
Beamformer efficiency	>96	%	180MHz
Delay step size	520	ps	110-190 MHz
Delay range	16.6	ns	
CMRR	>20	dB	

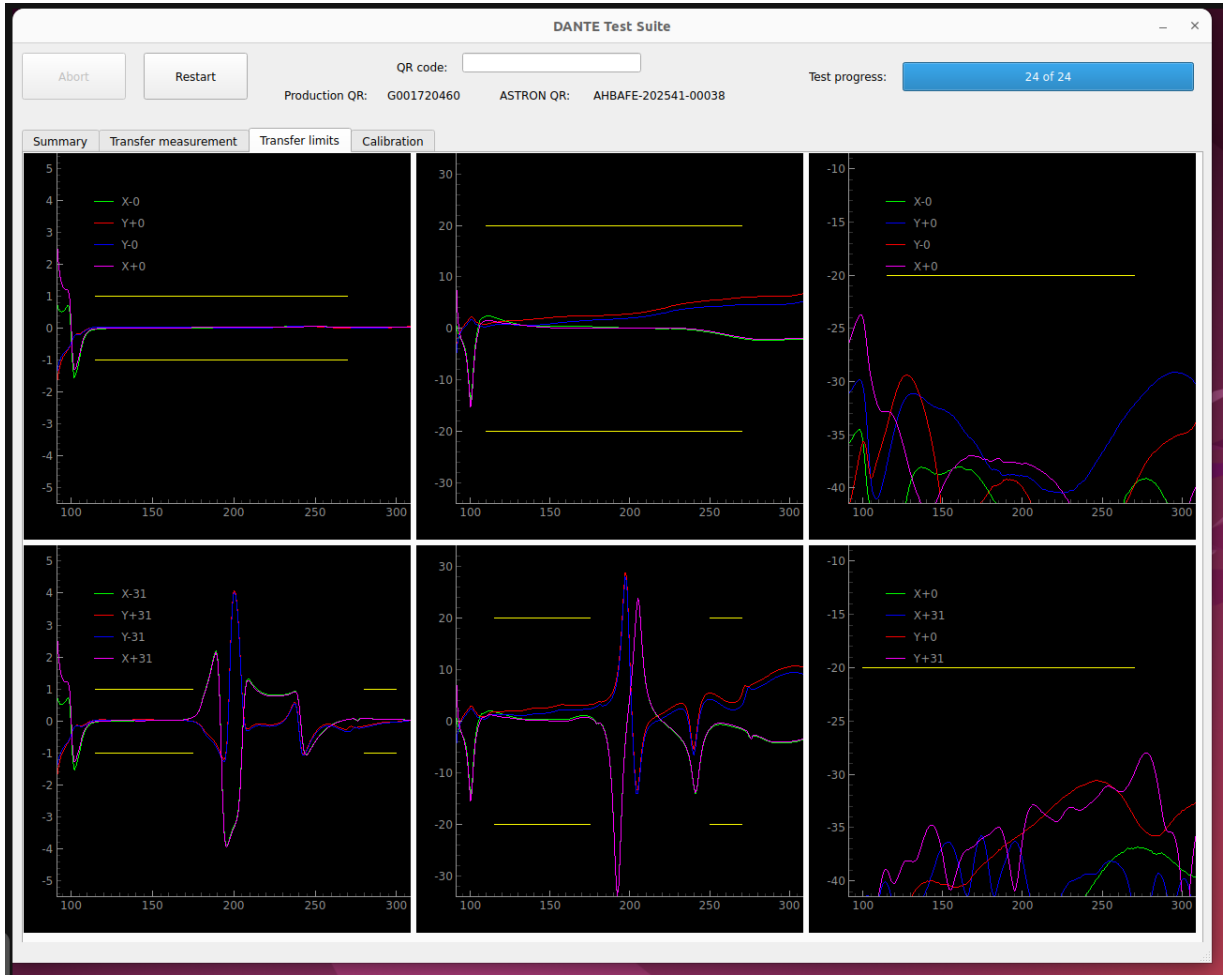
How to test >10.000 boards quick and reliable?



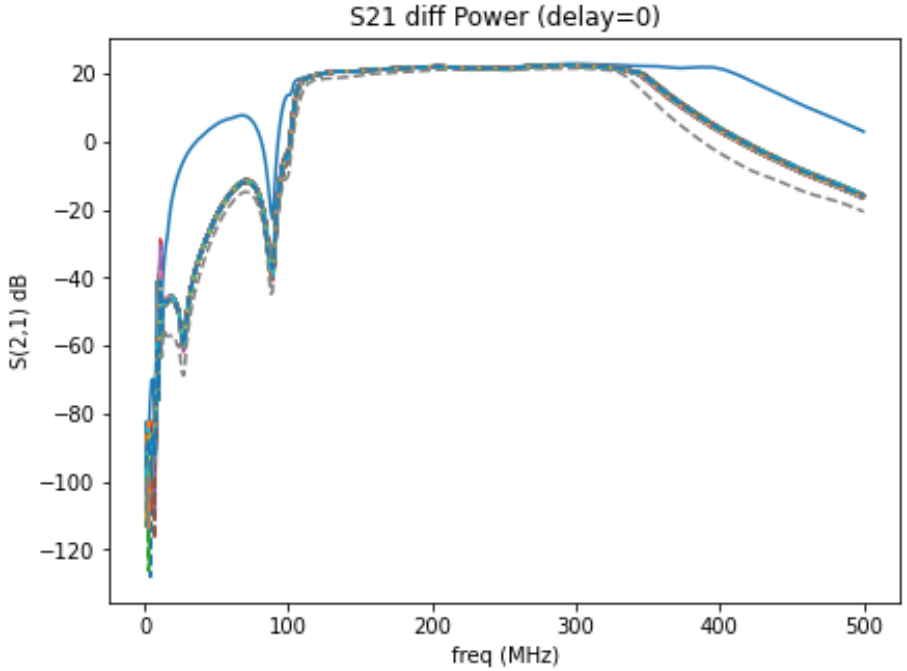
Production test setup

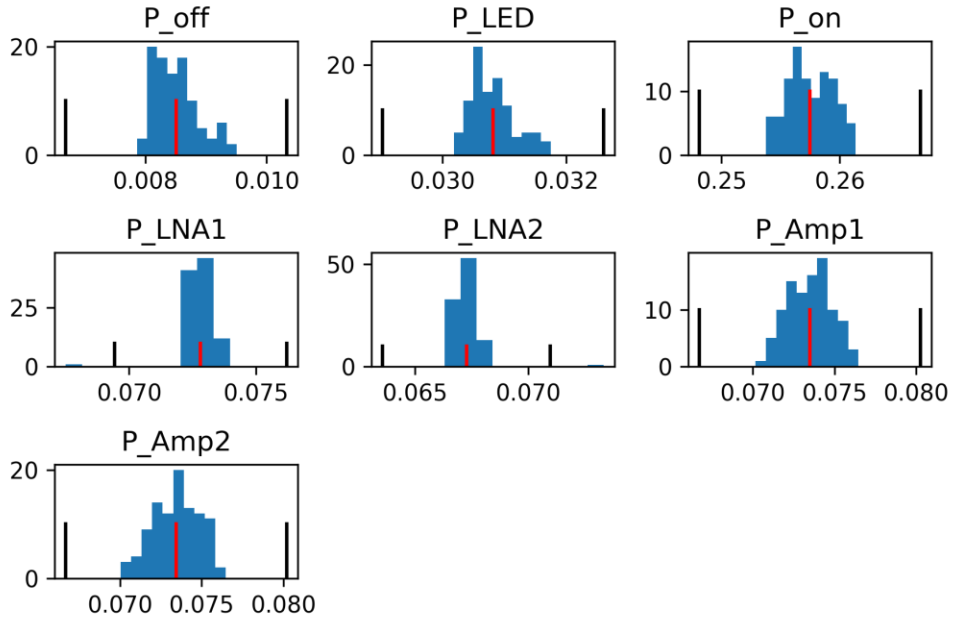
Testsetup User Interface

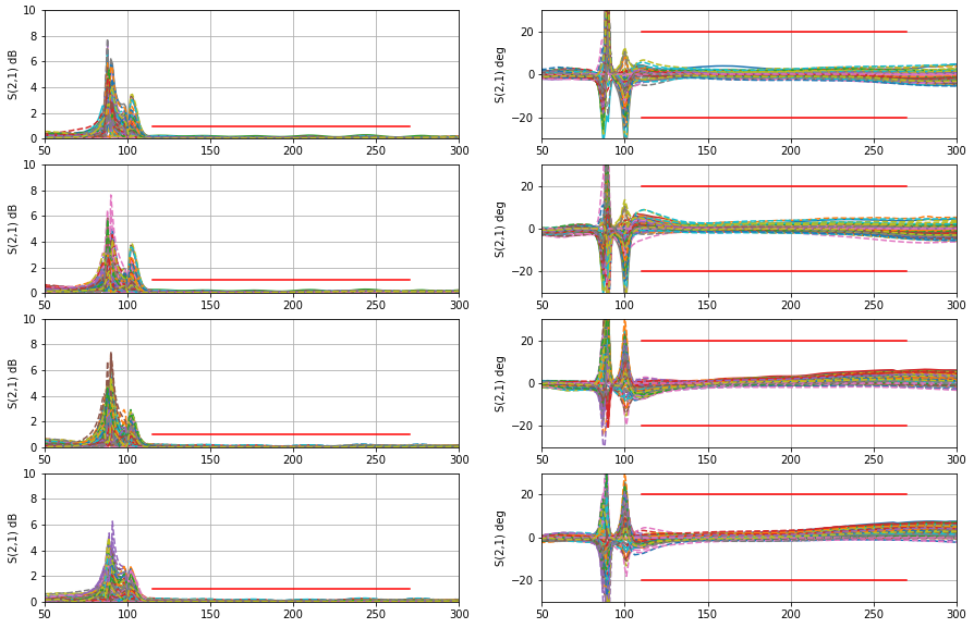


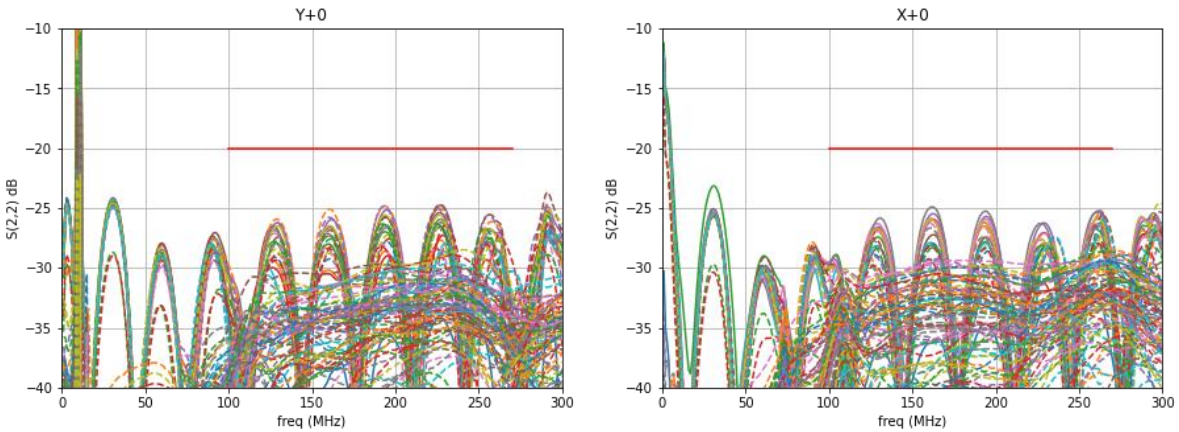


Measurement results of the first batch



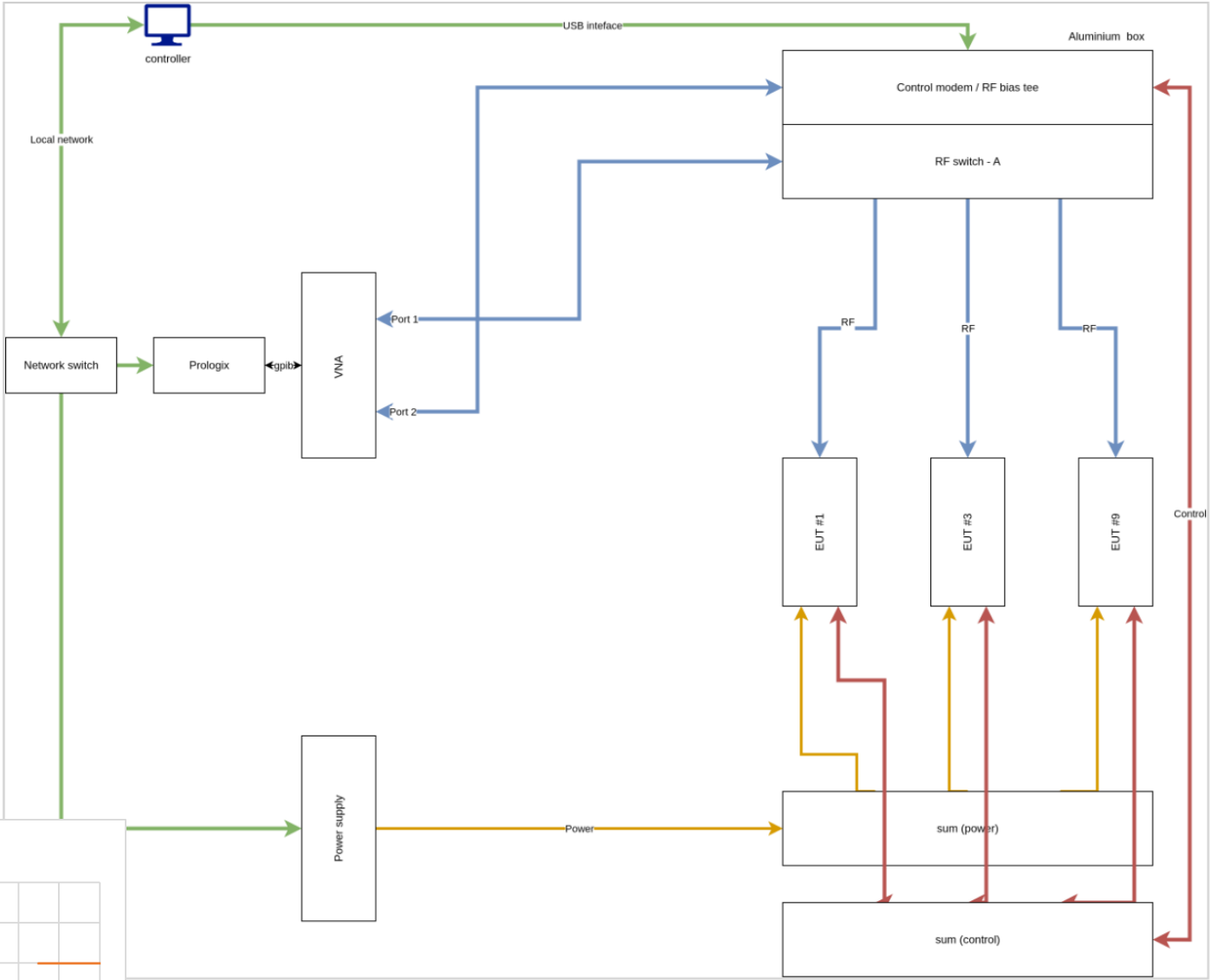


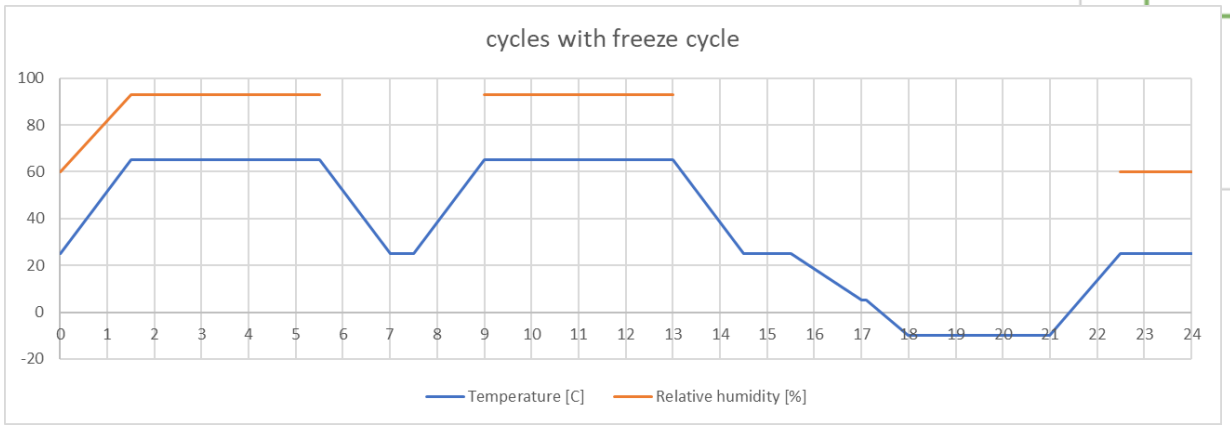




TLS environmental testsetup

- Full lifespan test
- Meas. Setup delivered at TLS
- Currently testing the system



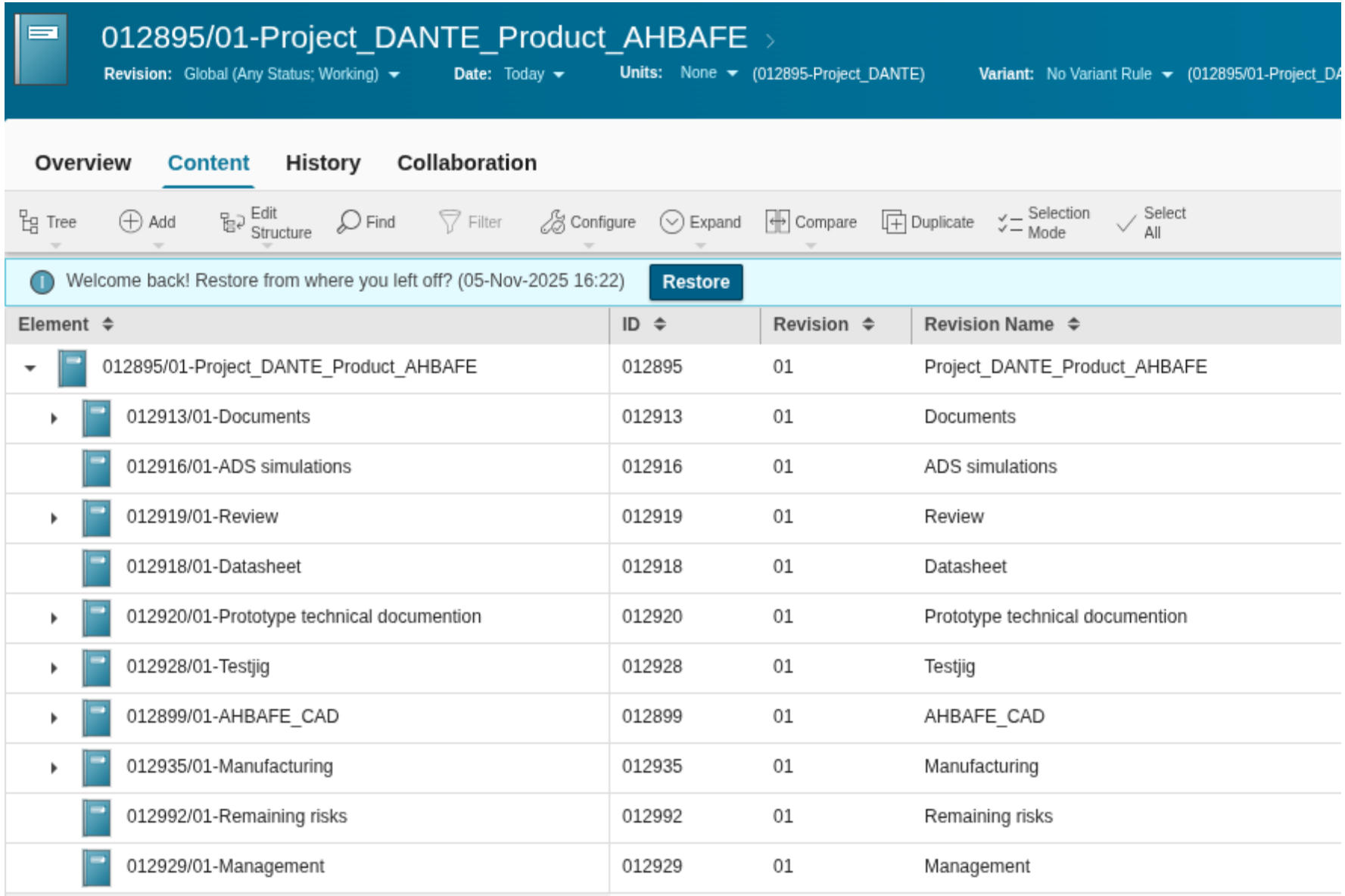


How to store all data to store and trace the product lifecycle?

(And make sure we can react fast on changes?)

Documentation of DANTE

- Project information transferred to Teamcenter database
- AHBAFE datapack Omnify database
- E-maint (CMMS) product lifecycle tracking
- If components are obsolete the evaluation of this can go fast



Element	ID	Revision	Revision Name
012895/01-Project_DANTE_Product_AHBAFE	012895	01	Project_DANTE_Product_AHBAFE
012913/01-Documents	012913	01	Documents
012916/01-ADS simulations	012916	01	ADS simulations
012919/01-Review	012919	01	Review
012918/01-Datasheet	012918	01	Datasheet
012920/01-Prototype technical documention	012920	01	Prototype technical documention
012928/01-Testjig	012928	01	Testjig
012899/01-AHBAFE_CAD	012899	01	AHBAFE_CAD
012935/01-Manufacturing	012935	01	Manufacturing
012992/01-Remaining risks	012992	01	Remaining risks
012929/01-Management	012929	01	Management

Summary

- AHBAFE data pack is handed over to ILT-rollout project
- DANTE document archiving is finalizing
- PCBA is in production (update ILT-rollout, Pieter Benthem)
- DANTE team is available for support, fine-tuning test setup

- Lessons learned session: Right level of information to the board can be achieved by having a representative from the board at the system engineering reviews.

financial update

	Original budget	Budget revision 2023	Budget revision 2025	Final costs
Personnel costs	€ 373,686	€ 569,912	€ 758,264	€ 747,072.30
Materials costs	€ 20,000	€ 90,910	€ 90,910	€ 77,012.05
Travel	€ 1,500	€ 0	€ 0	
Contingency		€ 50,000	€ 30,000	
Total	€ 395,186	€710,822	€879,174	**€ 824,084.35**

ASTRON will invoice € 779,084.35 to the LOFAR ERIC: The final project costs €824,084.35 minus the € 45,000 contribution that TLS made directly to ASTRON.

The ASTRON contribution to DANTE (€200,000 + €100,000 contingency) still needs to be settled against this amount.