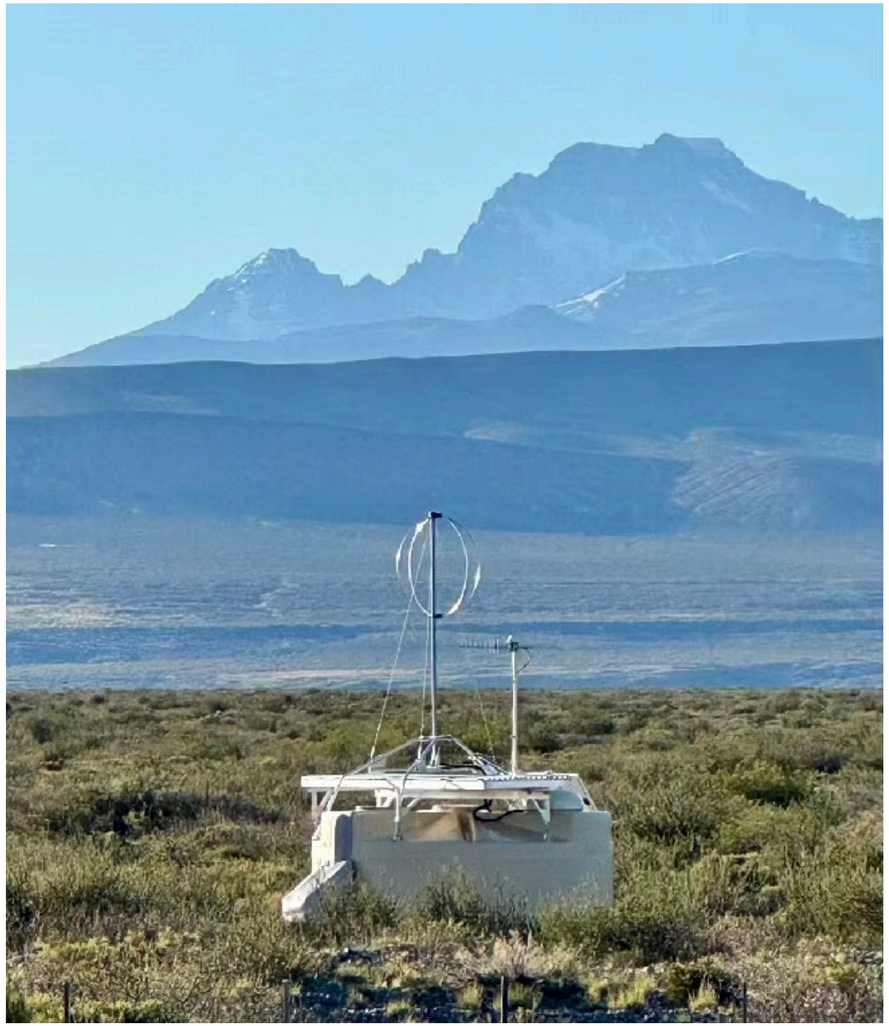
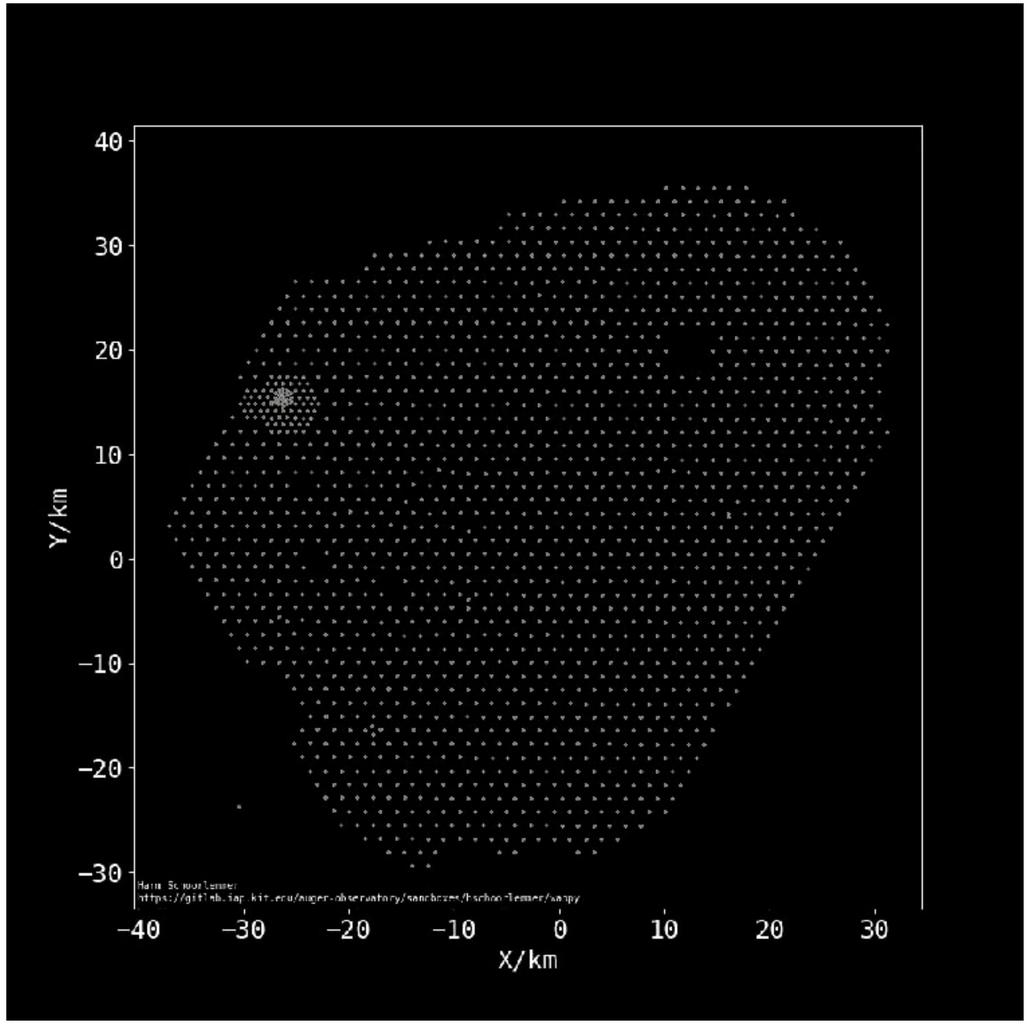
Radio Detector

Operations Readiness Report





Radio Detector

Operations Readiness Report

AugerPrime Radio detector operation readiness review

Brief report of the review committee (Petr Travnicek, Mauro Gajardo, Nicolas Gonzalez, Frank Schroeder, Ricardo Sato)

The Committee congratulates the RD team for completing the deployment of the detector and for its successful operation. We note that the material presented by the radio team was carefully prepared and answered most of the questions arising from the charges of the reviewing committee. The committee members agree that the RD system is close to passing the Operation Readiness Review i.e. to be included in the operation of the observatory for science production. A few remaining issues, which require some additional effort and/or time, were fairly mentioned by the RD team and some others were raised either by the management, committee members or by the collaboration. These are mostly minor issues and the committee believes that they can easily be resolved by the coming November meeting or earlier.

AugerPrime Radio detector operation readiness review

Brief report of the review committee (Petr Travnicek, Mauro Gajardo, Nicolas Gonzalez, Frank Schroeder, Ricardo Sato)

The Committee congratulates the RD team for completing the deployment of the detector and for its successful operation. We note that the material presented by the radio team was carefully prepared and answered most of the questions arising from the charges of the reviewing committee. The committee members agree that the RD system is close to passing the Operation Readiness Review i.e. to be included in the operation of the observatory for science production. A few remaining issues, which require some additional effort and/or time, were fairly mentioned by the RD team and some others were raised either by the management, committee members or by the collaboration. These are mostly minor issues and the committee believes that they can easily be resolved by the coming November meeting or earlier.

The remaining questions/issues include:

Equipment availability and readiness

Special tools and testing equipment:

- Ensure that the “test bench” for digitizer is delivered to Malargue (e.g. system using not commissioned UUBs or using available PC interfaces).
- Please continue and finalize the preparation of the LNA calibration device so that it can be given to staff in Malargue together with documentation.
- In case the local staff repair LNA, digitizer or other components or need to do some field testing, what equipment do you consider important/useful to have in Malargüe? (eg. spectrum analyzer, oscilloscope, etc.).

The most common failures and their mitigation plan:

- The dust accumulated in some LNA housings: is the housing tight enough against dust and water after the fix?
- Orientation of the antenna: please report after some subsequent period of operation if the problem is really solved by tightening the screws.
- Lightning events: is the rate of the failures associated with lightning consistent with previous experience before upgrade? Can you track the number with time? Is there a way to relate it with rates of similarly associated failures reported on UUBs?
- LNA amplifier chips: given the fact that 115+ destroyed chips were already needed to be exchanged (which successfully demonstrates the LNA repair procedure); is the number of spares (1000) really large enough? With the more regular operation ongoing, can we distinguish better between lost amplifier chips due to transport + installation procedure and during normal operation?
- LNA other components: please update the numbers for failures of chip and other LNA components once finishing repair of all ~175 damaged LNAs (page 50 of your presentation)
- Please keep the list of all failures and their potential sources updated, have eyes open to other types of failures not discussed so far (other components).

Long-term plan for component repairs or replacement:

- Please include your new findings into an updated long-term plan for component repairs and replacements.

Future procurements of spare parts, tools, and consumables. Spares availability:

- Please provide a list of repairable components for all sub-systems including digitizers and mechanics. These numbers would be compared to spares so we know if we have a projected deficit or not. Please mention/list the most critical component(s) in the electronics or elsewhere in the system that you foresee will not be available on the market after 5/10 years and compare to the number of spares of these components.
- What exactly do you plan for future procurements (if any)?

Data Management

Reliability and consistency of the data:

- Please report on the progress in solving the dead-time issue. Which of the three options do you finally select? How much can we reduce the issue in terms of lost events?

Monitoring of RD:

- Demonstrate progress in the integration of RD in SD monitoring and provide a timeline for final implementation. Meanwhile, make sure that the alternative MoRd system is fully accessible by RD and SD experts as well as by local staff.
- Update on the plan to integrate RD in SD shift.

Technical Documentation

- The technical documentation provided in Dropbox seems to be rather complete. Please ensure that it is transferred to EDMS and remain open to further checks of completeness of the documentation by the RD team, review committee, management and observatory staff.
- Create a landing page: The documentation of the various aspects of the RD seems to be in the various places where it belongs (EMDS, Wiki pages, Monitoring, Gitlab repositories, …). As distributed over several places, this might still be hard to navigate and find all information in a few years from now, in particular, because there is no RD landing page (website and/or wiki page as it exists for other detectors of the observatory). Such a landing page should contain links to the different places of hardware, firmware, and software documentation, the monitoring, deployment and maintenance information, etc. There is no need to duplicate information, e.g., one could link to existing sub-pages of the AERA wiki when appropriate. The purpose is simply to make all information easily accessible.

Procedures

- Maintenance/installation procedures are defined by RD team together with the local experts and they are living documents always improving over the time. Can you show a current version of such procedures as an example (in Spanish or English)? Where and how are these documents available? These ever-evolving documents can be provided as a link on the landing page (see above), so that all collaborators can check them.
- Please remember to respect availability of all procedures and aspects: general operation, hardware and software troubleshooting and maintenance, process for handling major repairs as well as inclusion of safety considerations in all procedures (e.g. when and how grounding is required).

Training

- Complete the training of the Observatory staff.

Operations costs

Resources:

- Please continue and finalize together with the local staff the evaluation of the human resources and costs needed to operate and maintain the RD system, including materials and equipment.

Rates of failures and frequency of repairs and replacements:

- The calculation of the expected failure rate is difficult due to overlap between those originating from the installation process, commissioning, and operation. The calculation presented was fair and probably the only possible way at the moment. However, the committee found it difficult to distinguish between the mentioned cases. The projection onto the next 10 years should be re-thought using new data and discriminating unavoidable failures during regular operation from those that are a consequence of a sub-optimal deployment or maintenance. The committee is aware of the fact that the next lighting season starts only in November but still the updated numbers and plots would be useful to see.

EFM installations

- Please follow the proposal from the management about the additional questions related to operation of EFM installation. Is the documentation for the operation of the EFM available? What is the failure rate and the local personpower requirement to maintain and operate it? What are the costs for operating it? (battery replacement, component replacement, etc.). Is the local staff trained to maintain and operate the system? What is the minimum required uptime for the system? Statistics on uptimes and failure rates.

Malargue, March, 12th, 2025

Petr Travnicek, Mauro Gajardo, Nicolas Gonzalez, Frank Schroeder, Ricardo Sato

Equipment availability and readiness

Special tools and testing equipment:

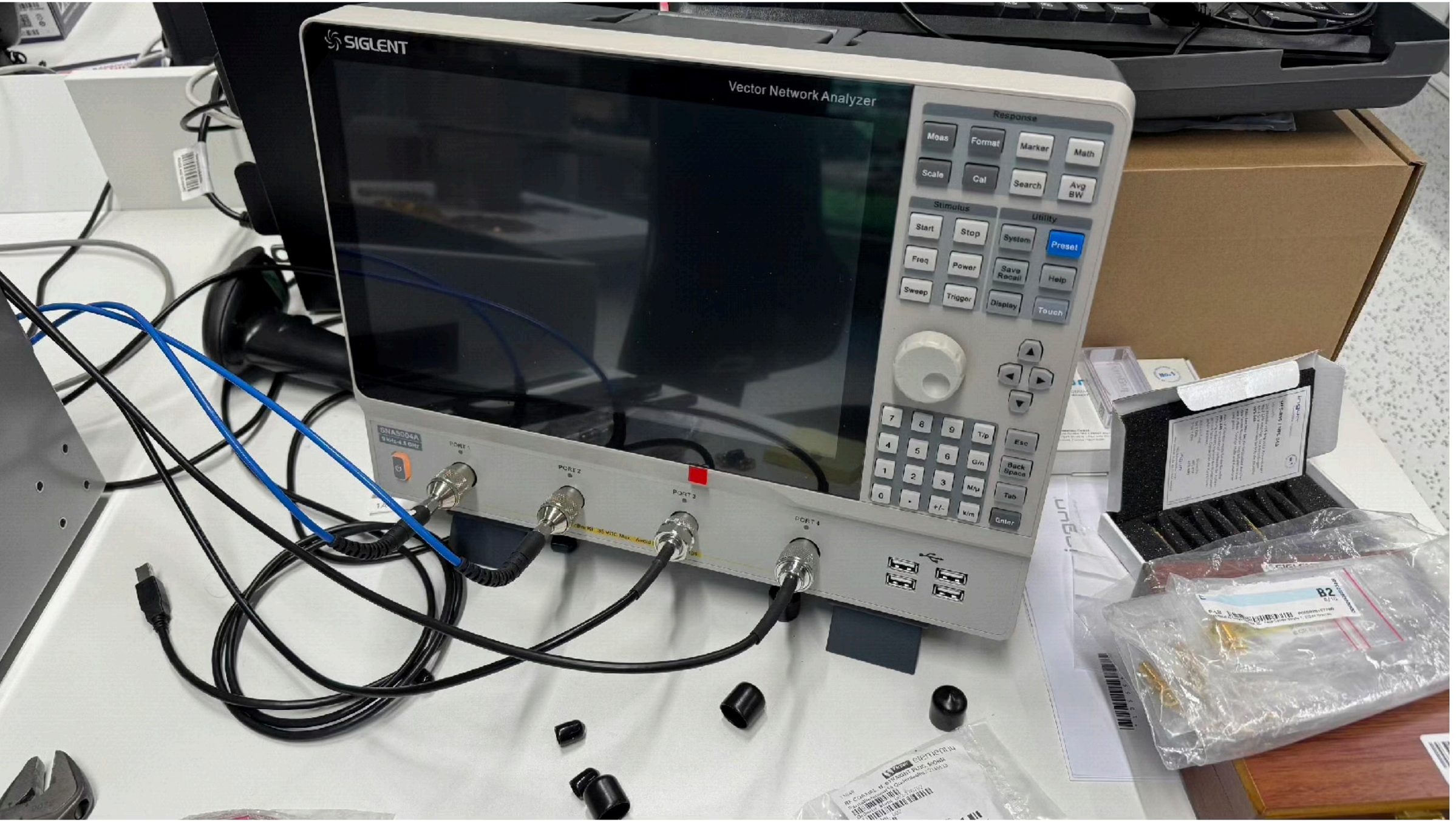
- Ensure that the “test bench” for digitizer is delivered to Malargue (e.g. system using not commissioned UUBs or using available PC interfaces).
- Please continue and finalize the preparation of the LNA calibration device so that it can be given to staff in Malargue together with documentation.
- In case the local staff repair LNA, digitizer or other components or need to do some field testing, what equipment do you consider important/useful to have in Malargüe? (eg. spectrum analyzer, oscilloscope, etc.).

equipment has been purchased

needs some finalizing (software) work

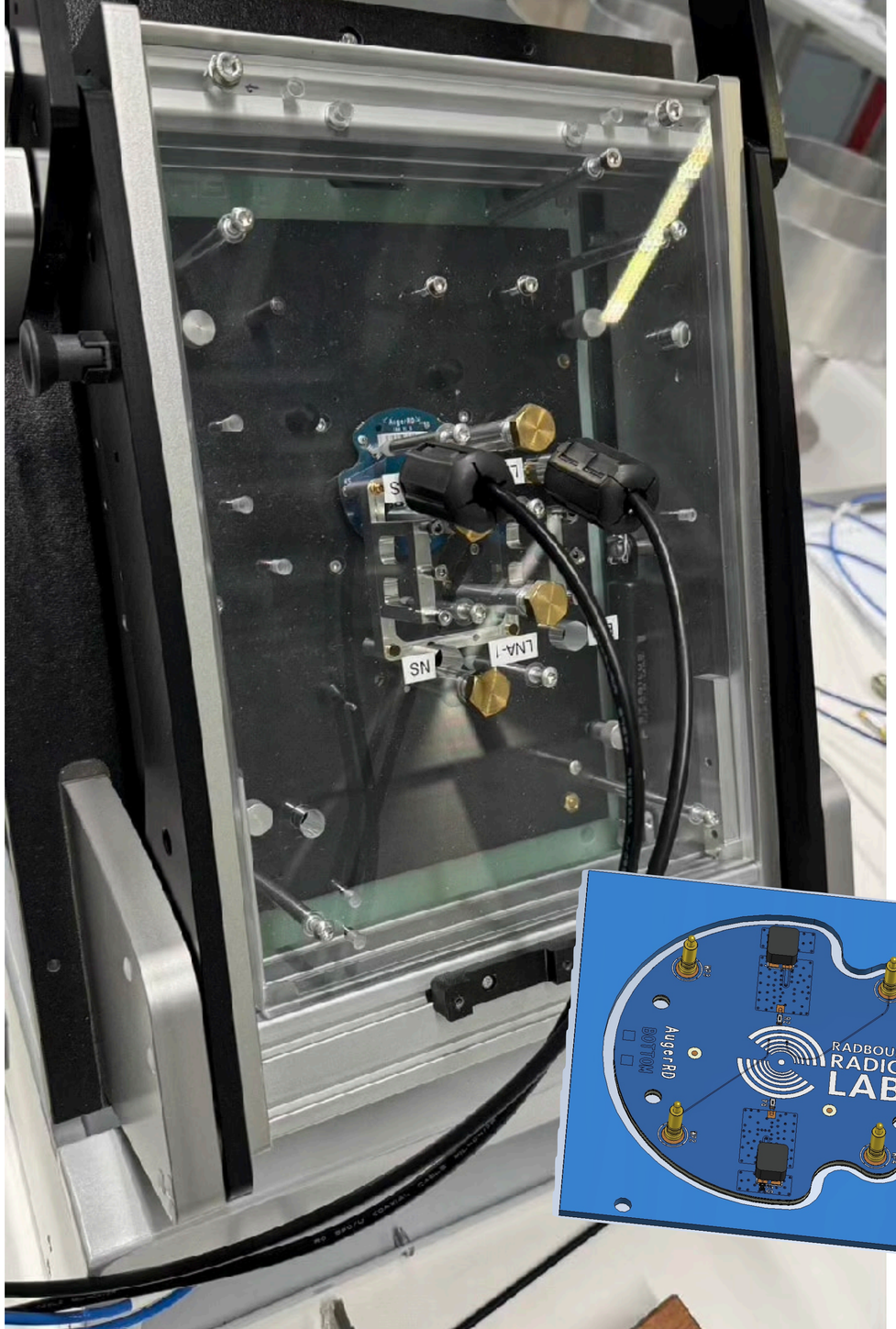
—> ship to Malargüe ~ March 2026

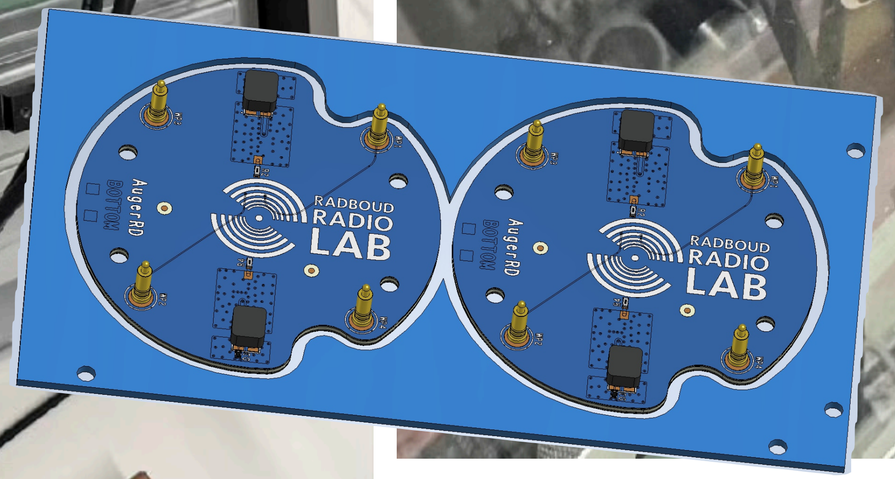
… see following slides …



new network analyzer has been purchased —> Malargüe

LNA calibration device (needs some final work) —> Malargüe





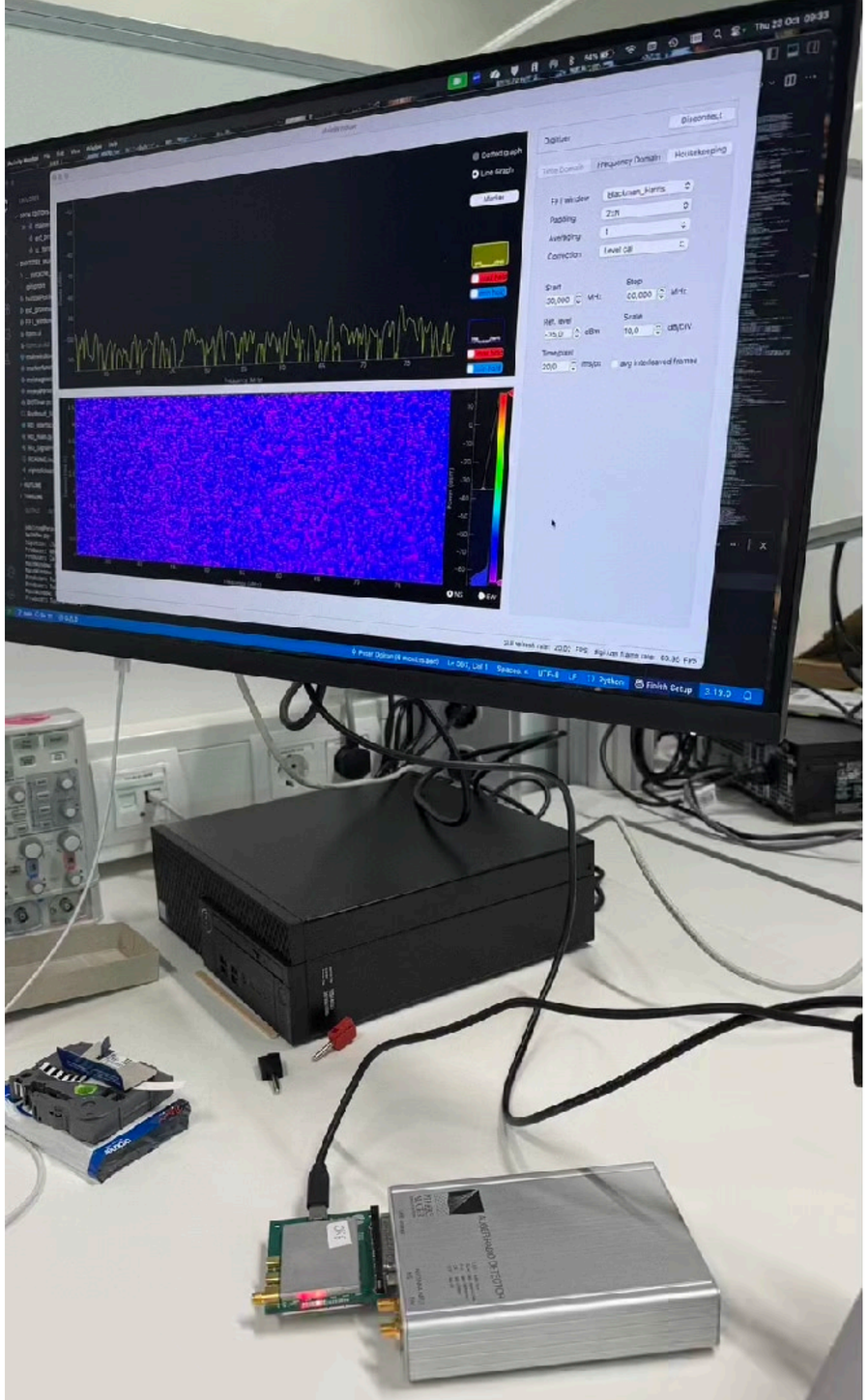
PIERRE AUGER OBSERVATORY

device has been modified

—> can now hold individual LNAs

PIERRE AUGER OBSERVATORY

interface RD-digitizer <—> USB-C



interface RD-digitizer <—> USB-C

mobile unit to test RD-digitizer with laptop in lab or in the field

- show monitoring information (temperature of board, currents and voltages to LNA, …)

- take data and calculate FFT in real time

The most common failures and their mitigation plan:

- The dust accumulated in some LNA housings: is the housing tight enough against dust and water after the fix?

this seems to be installation related - in principles the housings are tight

- Orientation of the antenna: please report after some subsequent period of operation if the problem is really solved by tightening the screws.

no further rotation of antennas observed —> we consider this solved

- Lightning events: is the rate of the failures associated with lightning consistent with previous experience before upgrade? Can you track the number with time? Is there a way to relate it with rates of similarly associated failures reported on UUBs?

we have only limited statistics of one season - we do not have any indication for a significant change

- LNA amplifier chips: given the fact that 115+ destroyed chips were already needed to be exchanged (which successfully demonstrates the LNA repair procedure); is the number of spares (1000) really large enough? With the more regular operation ongoing, can we distinguish better between lost amplifier chips due to transport + installation procedure and during normal operation?

we purchased 1000 + 2500

- LNA other components: please update the numbers for failures of chip and other LNA components once finishing repair of all ~175 damaged LNAs (page 50 of your presentation)
- Please keep the list of all failures and their potential sources updated, have eyes open to other types of failures not discussed so far (other components).

Based on (field) information from Marcos, Bjarni has worked out detailed analysis of LNA failures, see next slides

RD LNA failure analysis

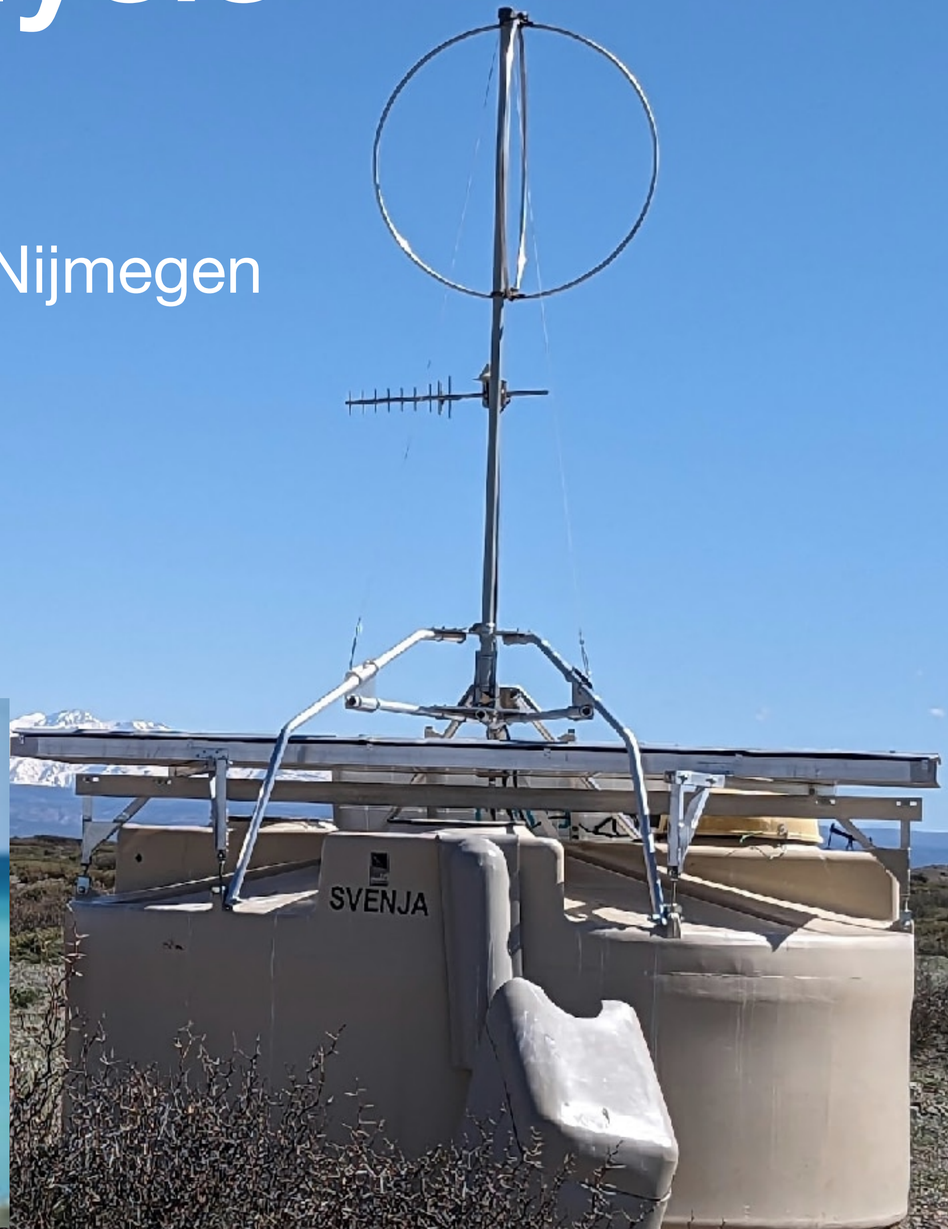
Bjarni Pont
Oct 22, 2025
Radio workshop, Nijmegen

(Auger-)
Retired

adjective. [re'tired]

I do what I want when I want.

see also: Not my problem anymore ;)

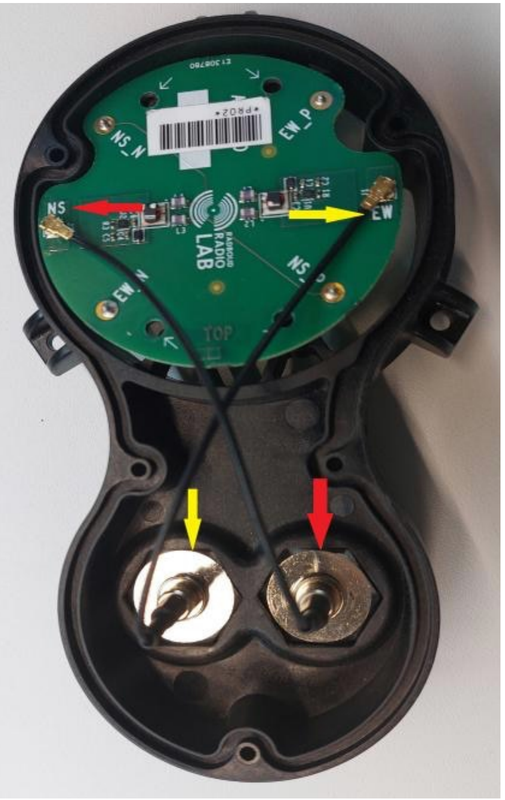


Update on failure rate estimations

- Part 1: Marcos' list of all field repairs of 2025/01 - 2025/09
  - Mainly fixing remaining deployment issues
  - + some 'normal' failures

- Part 2: 'normal' failures from MoRD data pipeline
  - Current dead channel failure rate
  - 10 year forecast

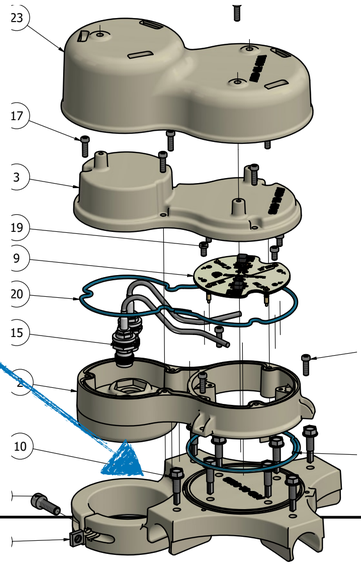
Part 1: Field repair reports

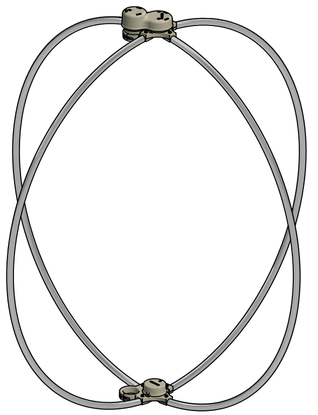


- Issues with stations are tracked by Marcos:

#	ID	Name	Date	Early Installation									Corrections		
				Broken LNA	Broken LOAD	Lightings	Selfcutting	Dome ground	Cables	Misalignment	Dirt	Tensioners	Tensioners	Cables	Sleeves
1	148	Eureka	09/01/2025						1						
2	149	Pochy	09/01/2025	1											
3	1532	Pegaso	10/01/2025						1						
4	1598	Genesis	13/01/2025			1									
5	1629	Tonga	13/01/2025									1			1
6	1096	LU4MHG	13/01/2025						1						
7	1095	Lucrecia	14/01/2025			1									
8	1413	Urania	14/01/2025			1									

- **<u>Main issue from deployment:</u>**
  - Any bad connection in signal chain —> bad grounding of LNA —> LNA at risk to induced currents —> LNA amplifier fries
  - Causes:
    - Bad contact of self-cutting screw from LNA to SALLA loops
    - Dirt in LNA housing / cable connectors
    - Damaged cables
  - Effect:
    - ‘low-gain’ stations stations when connection was bad —> one-time fix
    - ‘Dead’ stations when an induced current killed the LNA —> one-time fix





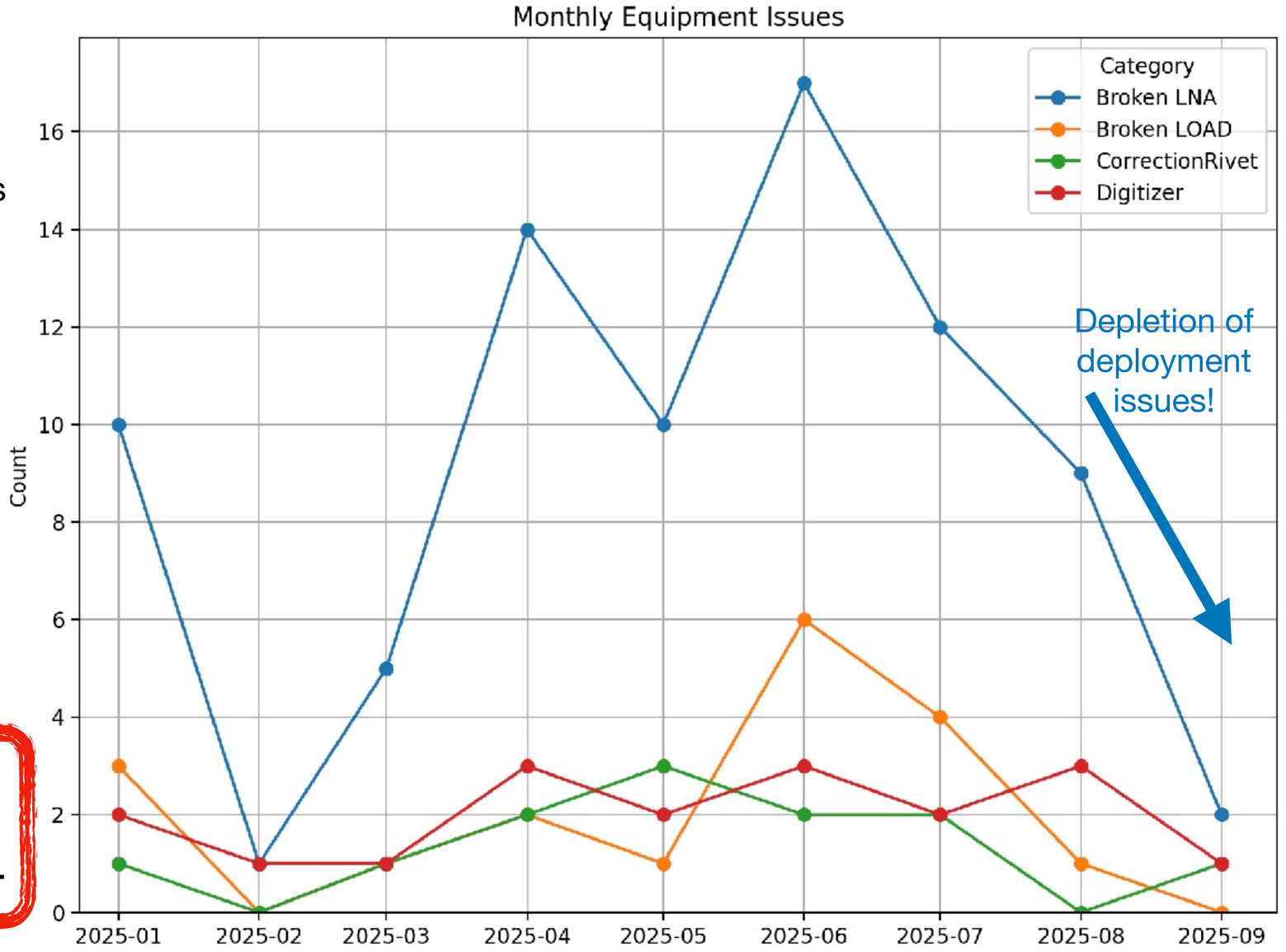
Part 1: Failure modes & maintenance

- ‘Deployment-repairs’ of **LNAs** nearly done (dropping since June)
  —> going to zero ‘soon’
- **Bottom loads** follow LNA ‘deployment’ issues (also bad connections)

- Steady low failure rate of **Digitizers**:
  2/month —> 240 over 10 years
  (ok with spares. Repairs possible)

- Steady low failure of **rivets**/rotations. Windy regions (e.g. along river) mentioned by Marcos. Wind repairs to SD GPS/solar also not uncommon.

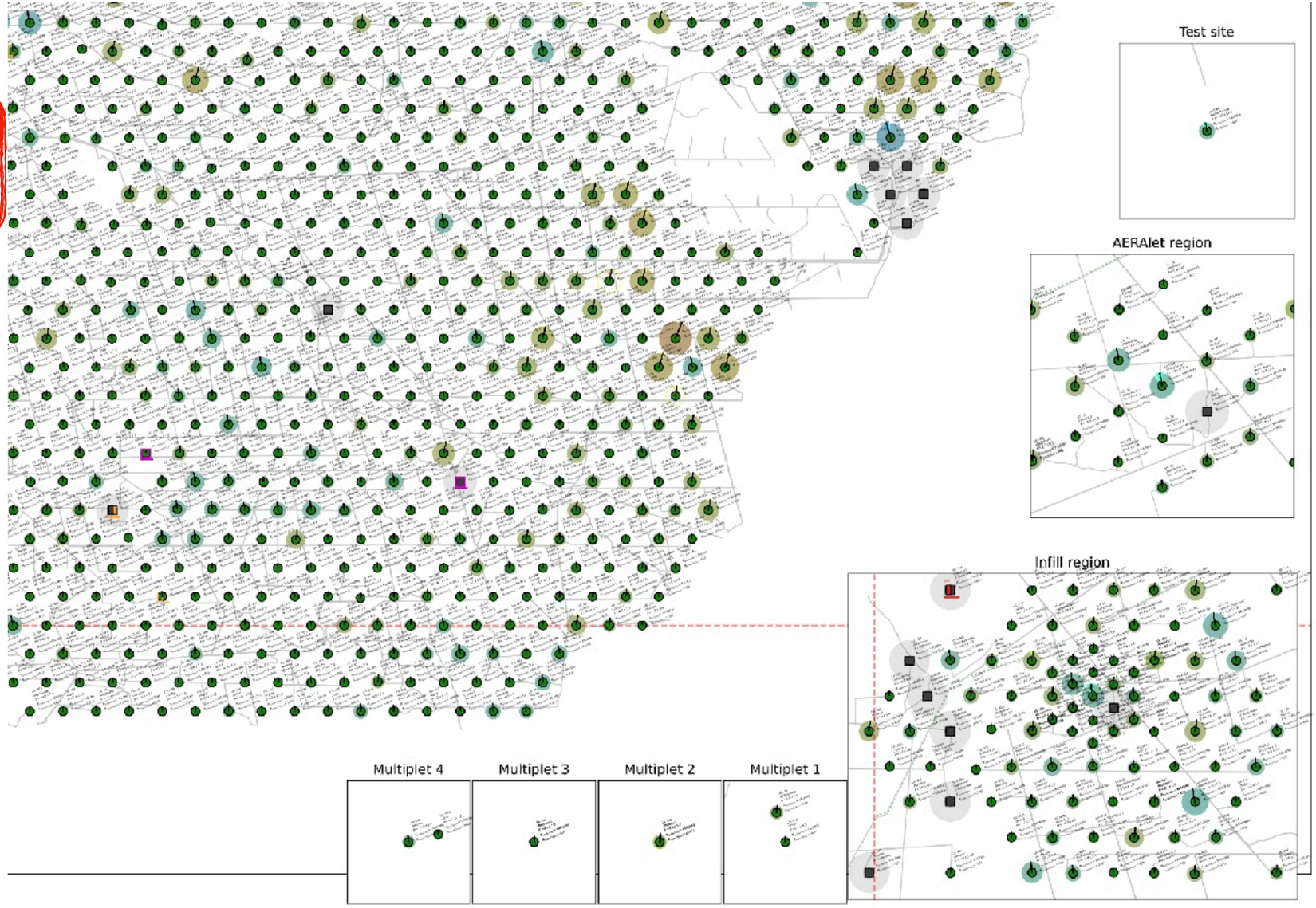
- **So:**
  - Deployment issues are mostly solved
  - ‘non-deployment’ failure rate looks nominal.



Part 2: reminder of MoRD field monitoring

https://hef.ru.nl/mord/data/Pages/[1]MaintenanceMapAndBadPeriods.html

- Daily check on MoRD data stream (also monthly for bad periods)
- **RD staff is using the MoRD page for their field repair planning & response to failures & evaluation of fixes**
- If it breaks they are blind!
  —> important to keep alive



https://hef.ru.nl/mord

Part 2: Current failure rate from MoRD data

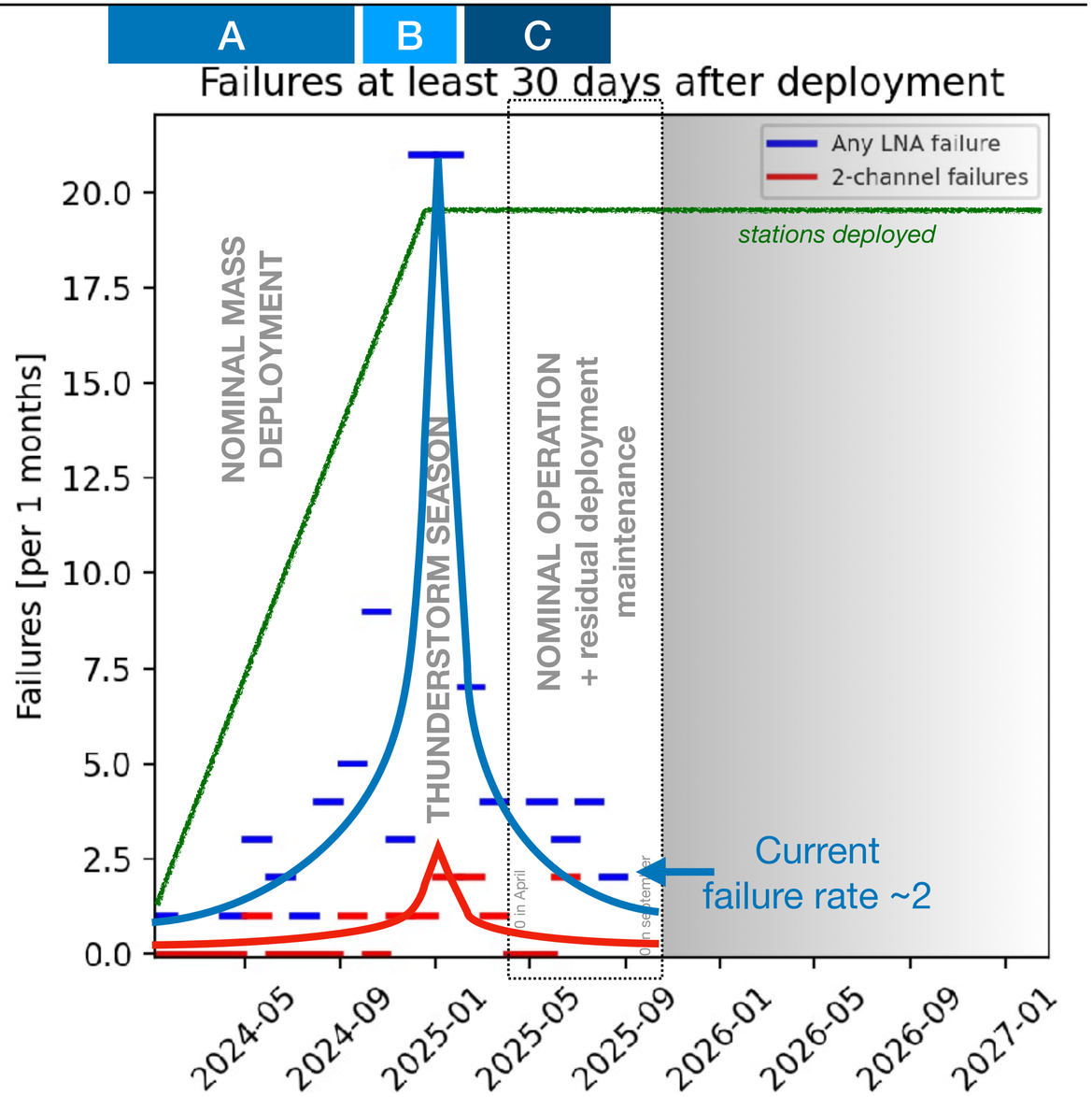
- A: **During deployment**:
  —> relatively many issues

- B: **Thunderstorm season** Dec-Jan last year
  —> bad connections caused many LNA failures

bad connection
—> bad grounding
—> build up charge

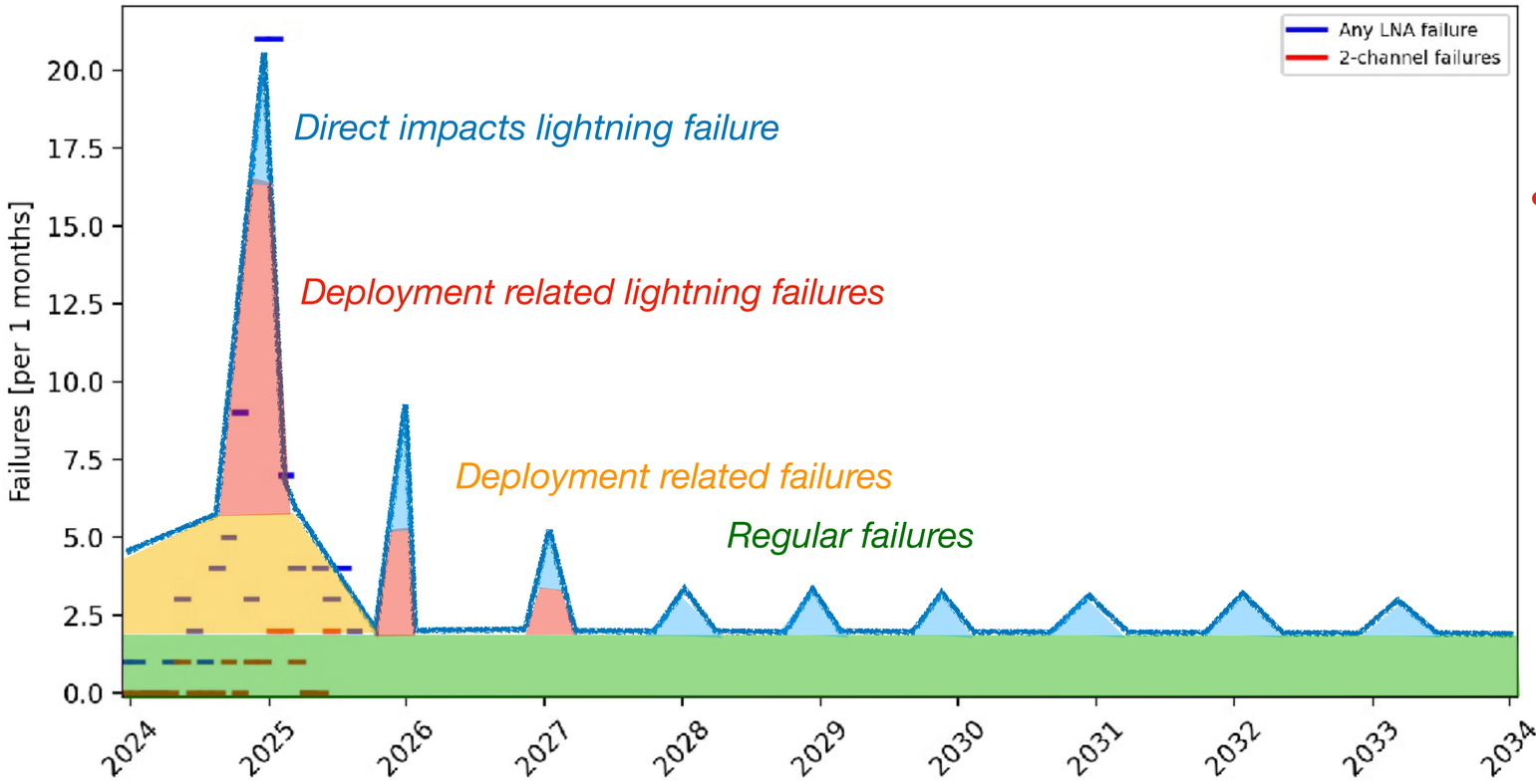
- C: **April 1 - Oct 1 period:**
  New 13 ‘dead channel’ flagged stations
  - 2 firmware issues (false dead flags)
  - 3 at LNA
  - 3 before LNA (crushed cable, issue at bottom load, …)
  - 5 unknown cause (likely some loose connection in cable/LNA/bottom load)

- So, 1-2 ‘failures’ per month, part not even the LNA itself.
  —> 1/month failure rate (excl. thunderstorms)



Part 2: Best guess at a 10yr RD LNA forecast

- My expectation:
  - Deployment-related failures will slowly all be fixed. <— Failure rates as reported in Nov'24 and Mar'25 seemed high due to this
  - Deployment-related failures induced by lightning will similarly decrease <— cause of big figure peak in Dec'24
  - Lighting impacts will continue every season <—Possibly similar numbers to SD, but will need to wait for Jan'26 numbers.
  - Regular age-related/random failures will continue. <— Last 6 months indicate this is 1-2/month
    (They might increase over time?)



after repairing deployment-related issues, we have an extremely low failure rate and a very stable detector operation

Note:

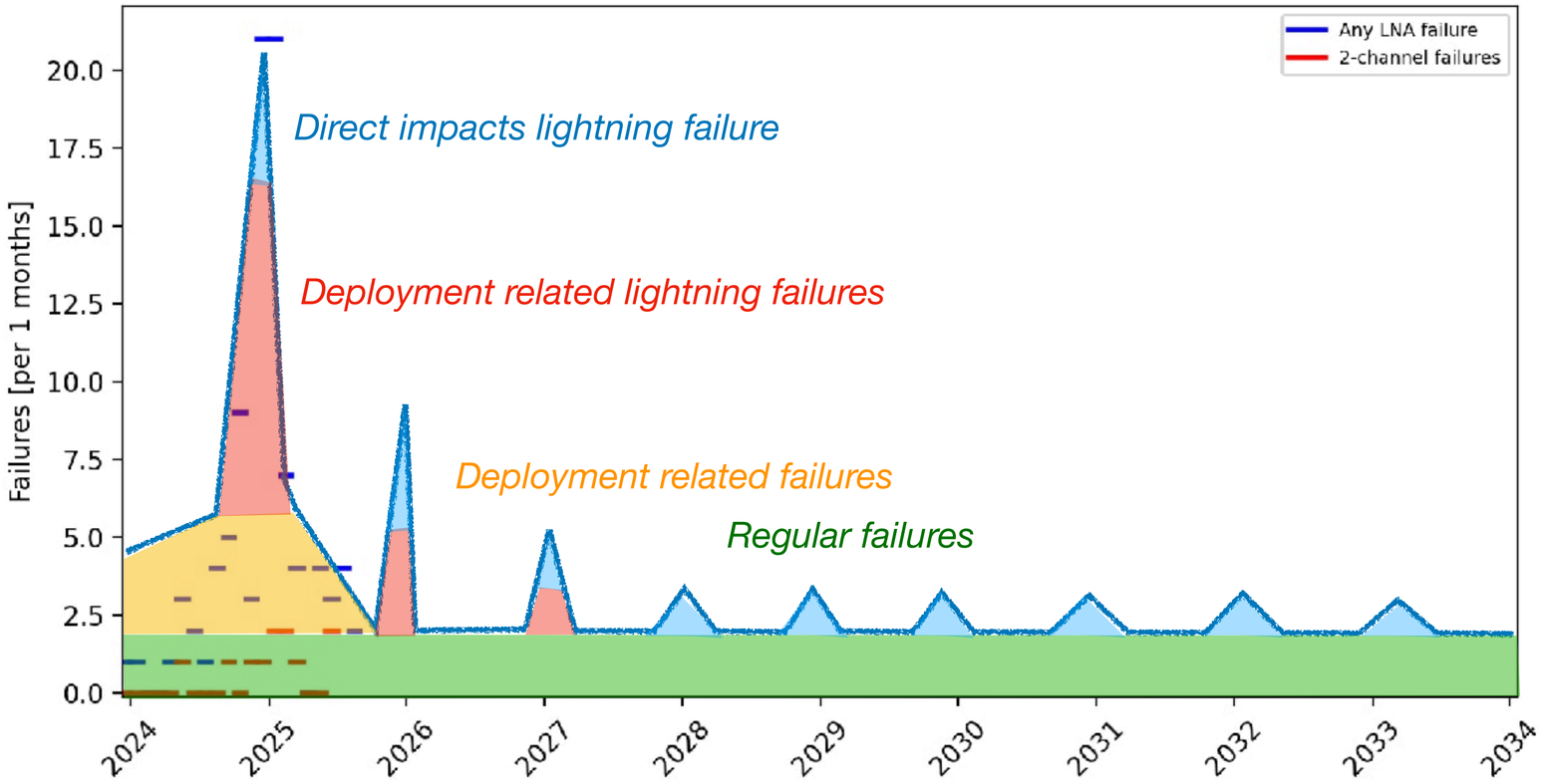
Thunderstorm peaks remain uncertain. We will know after next Jan.

Marcos' agrees expectations are roughly like this. Some staff are even more optimistic. They want to be conservative so it could be higher.

Part 2: Best guess at a 10yr RD LNA forecast

- My expectation:
  - Deployment-related failures will slowly all be fixed. <— Failure rates as reported in Nov'24 and Mar'25 seemed high due to this
  - Deployment-related failures induced by lightning will similarly decrease <— cause of big figure peak in Dec'24
  - Lighting impacts will continue every season <—Possibly similar numbers to SD, but will need to wait for Jan'26 numbers.
  - Regular age-related/random failures will continue. <— Last 6 months indicate this is 1-2/month
    (They might increase over time?)

Well within spare budget! (Originally 350 full spares + 3500 spare amplifier chips for repairs) ⟶



Rough conservative estimation of LNA spares needed:

- regular failures: 2/month —> 240/decade
- lighting failures: 10/year? —> 100/decade?

—> 340 spares? A large fraction likely repairable.
(Optimistically: 120+50 spares??)
(Pessimistically : 240+200 spares???)

Note:

Thunderstorm peaks remain uncertain. We will know after next Jan.

Marcos' agrees expectations are roughly like this. Some staff are even more optimistic. They want to be conservative so it could be higher.

Conclusions

- **Spare supply (LNA/digitizers/…) looks sufficient for the next 10 years**
- **Lighting doesn't seem a big issue. Should be monitored to be sure!**

  Any increased lighting impact chance will have to be monitored in the next thunderstorm seasons. Currently no indication that this will be an issue. See also FAQ in backup for details.

- **No new regions with antenna rotation observed. This does not seem an issue (anymore).**

  Early rotations were in the engineering phase without rivets holding the SALLA and mast in place together. This is were we learned the wind can have an effect. *Later concerns were due to rotations in the in the north-west region despite having rivets. In part this was to to increased wind speeds there. But also due to the code that determines antenna rotation from the TV4 signal struggles in the north due to lower antenna power in the past year. Due to this the issue seemed larger than it was. Field reports and the alignment analysis do not show a significant rate in the last 9 months (only 2/month were fixed). Expectations are that most future rotations will occur at the river near the infill since wind speeds are high there, similar to GPS/Solar being affected there in the past.*

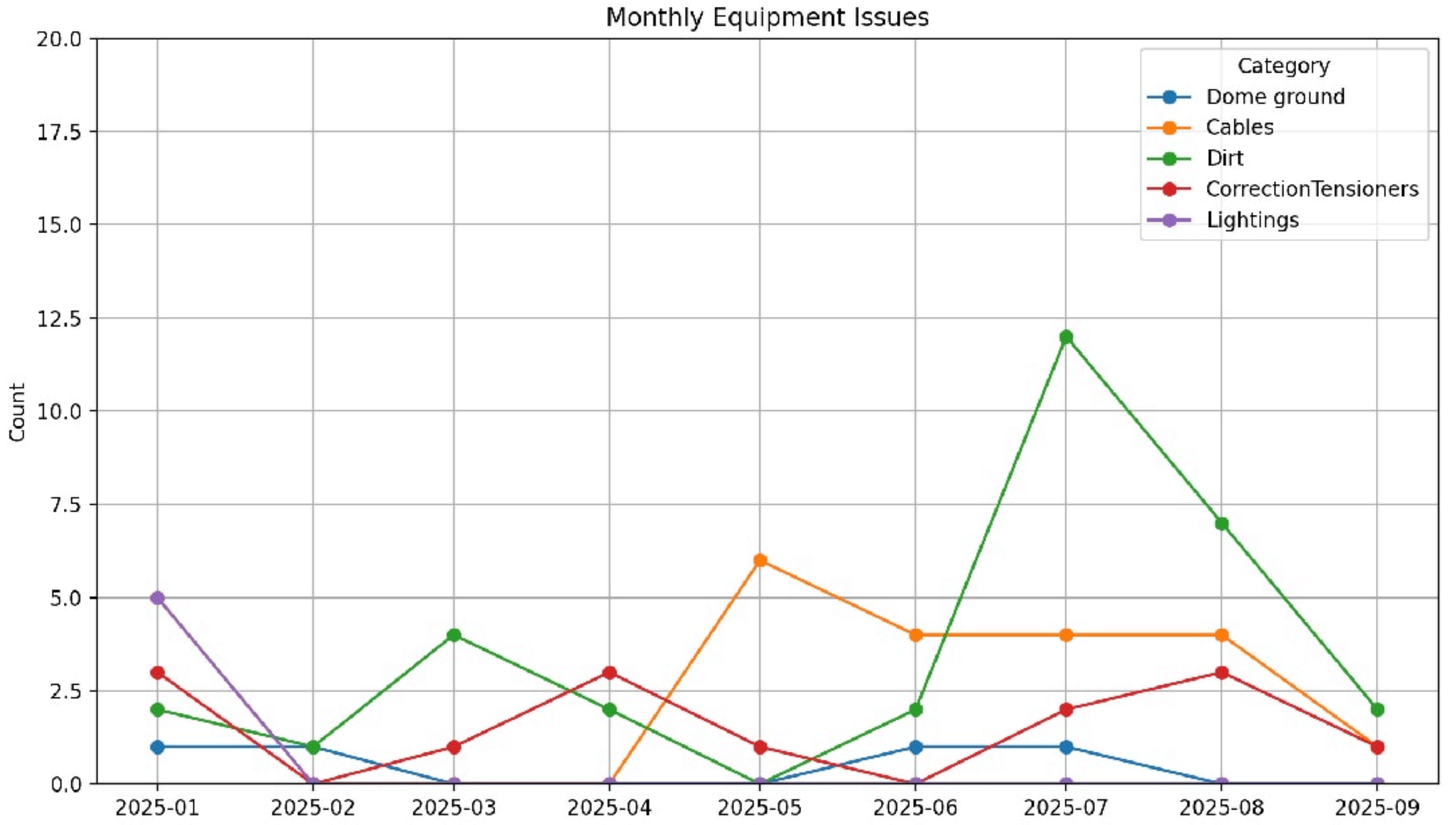
FAQ

- **In march 2025 there was the ‘175 LNAs failed’ number. 10% of the array sounds like a lot?**
  Tldr: lots of confusion back then. It was an one-time issue. It’s not representable for the failure rate of the next decade.
  Deployment had many initial issues. Transport-induced currents destroyed many. Bad-connections in the signal chain destroyed more, again due to induced currents. The 175 were the total number of LNAs brought back from the field till that point. The majority of those had been repaired again at that point. There were stil dozens with similar issues like that in the field that have come back over the past months. These failures are one-time failures. Currently these failures are not observed in these numbers. These are expected to drop to effectively zero over time.
- **In December 2024/January 2025 there were ‘many’ RD stations hit by lighting. Is this going to be a problem?**
  Tldr: It was reported while being investigated, causing confusion. It was mostly a one-time issue. Likely won’t be an issue, but should be monitored!
  2 stations had a catastrophic impact from lighting that affected RD and SD. In total 9(?) had some lighting damage to the RD only. The local staff says that up to 10 big impacts per year is to be expected and not something to worry about (from pre-RD years). An estimated 80 impacts occurred in the past 20 years of operation. We have no reason to expect a significantly higher impact on RD/SD due to lightning, except maybe a small increase because the RD antenna is slightly higher than the GPS antenna.
  Additionally, 40 LNAs died over this thunderstorm season period, as we now understand due to the bad connections and consequently bad grounding inducing damaging currents in the LNA amplifier chips. This issue should disappear over time since stations with bad connections from deployment will drop over time due to maintenance. This issue never affected any other part of the SD, but it might have caused an RD-lighting-scare among some.

Backup

Sub-Failure modes

- Additional sub-categories of issues identified in the field
- Lighting issues did not occur after January (end of thunderstorm season)
- Dirt and Cables refer to the ‘bad connection’ issues from deployment
- Tensioners refer to broken/stolen tensioner cables from the RD frame to the SALLA.

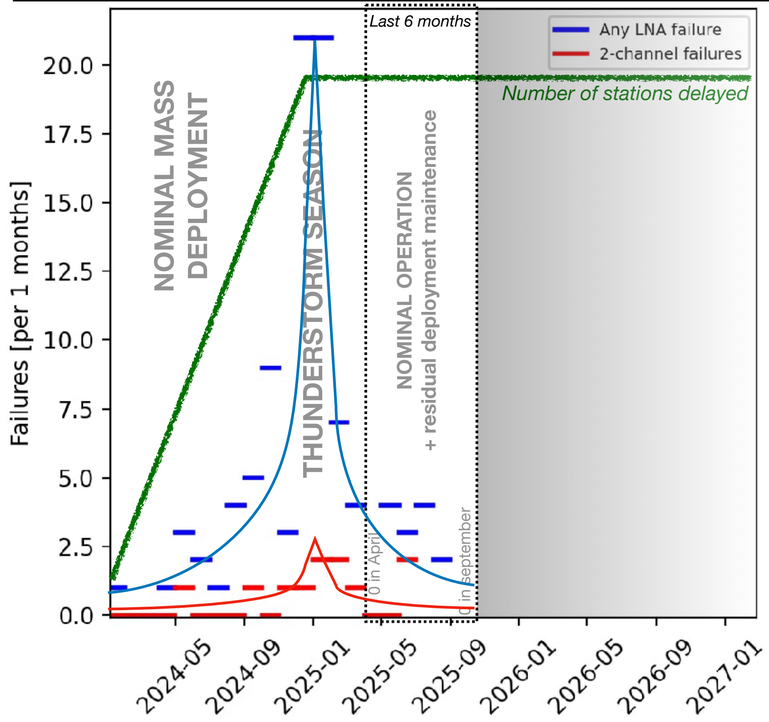


Estimation of failure rate

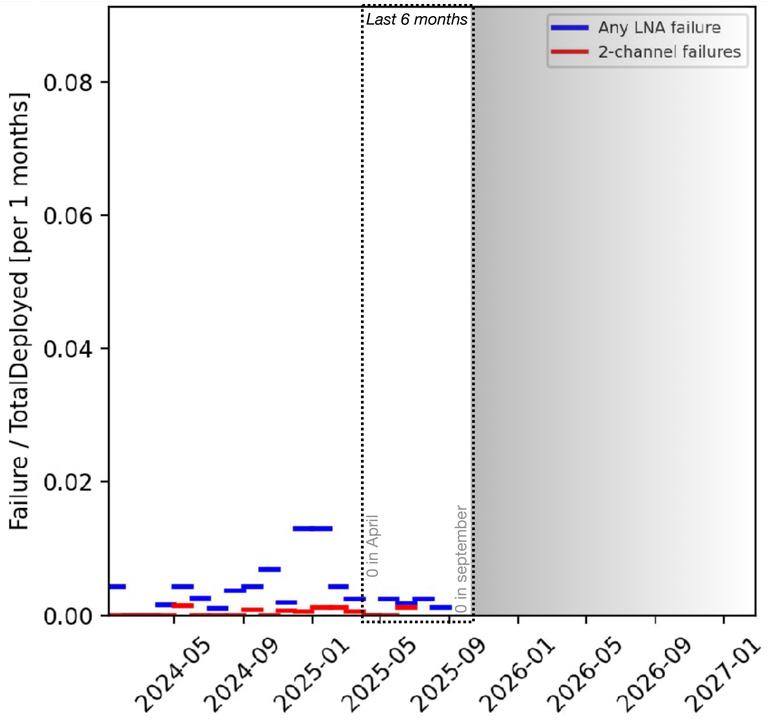
- **Analysis based on MoRD data stream (raw RD traces). This tells only part of the story and has large uncertainty on interpretation of causes. Context has to be added by the field teams.**
- *Data context*: All channels that get flagged with BadPeriod BrokenLNA flag (i.e. amplification near-zero.)
  - Does not include LowGain flags (i.e. about factor 2 gain drop), which indicate most likely some bad connections from the deployment). This will resolve over time and should not be included in LNA-failure rate estimations
- **Context on the effect of lightning from Marcos:** In Dec 2024 thunderstorm period many LNAs failed due to bad connections (dust, etc) causing bad grounding, leading to breaking diodes on the LNA boards. —> replaced diodes and bad connection addressed —> should not continue like this in the next 10 years as the number of stations with deployment issues will dissipate, so lightning failures will drop.
- **Failure rate** recent 6 months of 2025 (Apr 1 - Oct 1): **13**. (2 of which are firmware issues, misidentified as bad gain)
  - Average rate: ~2 No-Gain LNAs / month (some are very short term, so likely due to bad connections rather than failures. See next page)

- **Conclusion: the rate of LNA failures has been 1-2 per month in the past 6 months. —> 10-20 per year —> 100-200 over 10yr operation (excl direct lightning hits, excl residual deployment issues)**

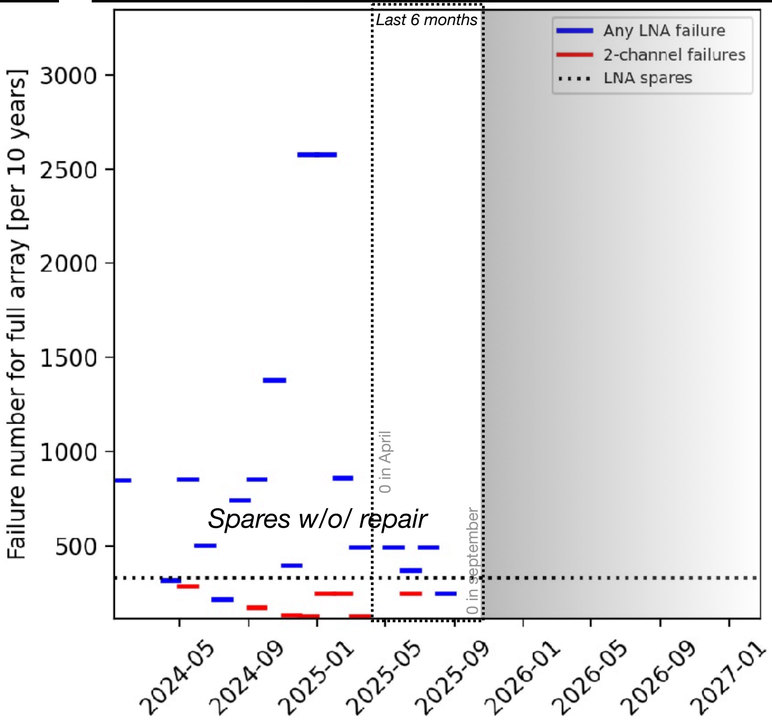
Absolute number of failures per month



% of failures per month



Rates extrapolated from 6m to 10yr



Detailed analysis of failures Apr-Sept

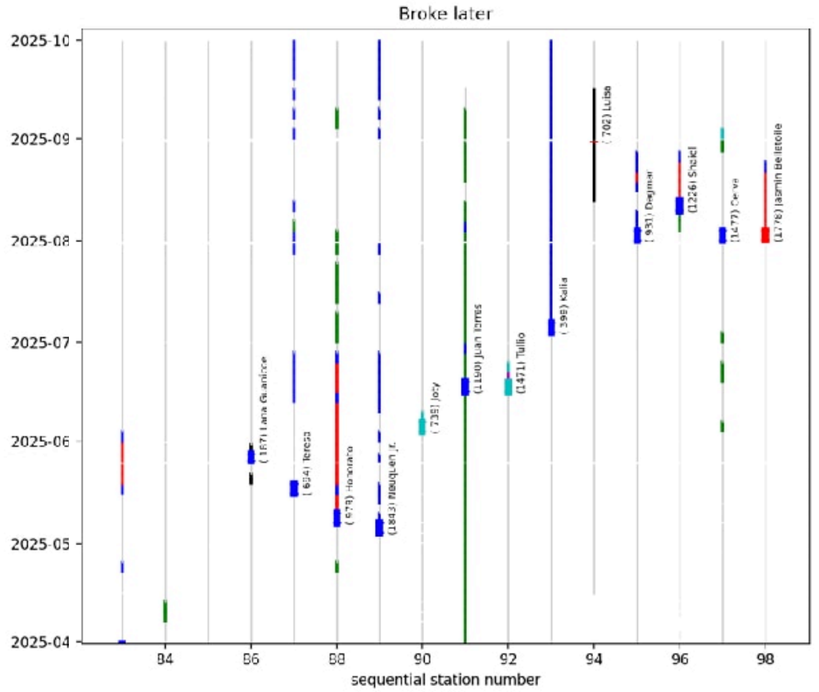
- 13 new stations flagged during 6 month period (apr 1 - Oct 1)
  - 2 with firmware issue (not gain issues)
- **11 with gain flag.**
  - 3 failures at LNA position (2 likely just failures, 1 unstable so likely just bad connections)
  - 3 gain issue before LNA (Dome/mast/base/…) (in the past: crushed cable, sabotage, issue at bottom load, …)
  - 5 gain issue with unknown cause (likely some loose connection in cable/LNA/bottom load

- Non-deployment issues likely will expect to continue for next 10 years. These include:
  - Full LNA failures
  - Issues at dome/mast/base
    —> ~6 in 6 months—> Rate of 1/month
- Lightning season might cause more failures:
  - With some residual deployment bad connectiities: increased failures like in Dec 2024
  - In the future when deployment issues get resolved: likely just similar failures to SD

Abbreviations:

- **Unst**: unstable. A channel has drops in gain for hours/days. Can be irregular and reoccurring
- **firm**: firmware issue. The code flagged erratic traces or repeated traces (buffer/cdas issues)
- **Gain cause**: The periodicity in the near-flat RD spectrum correlates with where in the signal chain the gain is lost.
  - **LNA**.: Issue is at the top of the mast at the LNA. Likely the LNA is broken/badly connected
  - **Mast**: Issue in the mast where two chapel segments have a connector. Likely bad connection
  - **Dome**: Issue at the base of the mast at the dome. Possibly the cable got crushed by the dome
  - **????**: location of the issue can't be determined (insufficient data or misc issue)
- **Ch0**: channel 0
- **Ch1**: channel 1
- **Chb**: both channels

Note.	Gain. cause	Ch.	station	date of issue	time since deployment	station name
firm		chb	LS 187	2025-05-19 06:23:59	429d12h11m32s	Lana Guanicoe
unst	????	ch1	LS 694	2025-05-16 04:01:25	477d12h51m23s	Teresa
	base	ch1	LS 979	2025-05-07 03:50:25	294d 5h 0m49s	Honorato
unst	????	ch1	LS1843	2025-05-04 03:32:36	306d 9h19m55s	Neuquen Jr.
unst	????	chb	LS 739	2025-06-04 01:10:42	214d 8h15m55s	Joty
unst	????	ch0	LS1190	2025-06-16 03:05:52	479d 8h17m37s	Juan Torres
	LNA.	chb	LS1471	2025-06-16 02:44:19	297d10h15m54s	Tullio
	LNA.	ch0	LS 399	2025-07-04 06:00:04	353d 1h15m51s	Kalia
firm		chb	LS 702	2025-08-13 03:20:58	566d10h34m47s	Luisa
	mast	ch0	LS 931	2025-08-01 04:37:05	541d 6h46m38s	Dagmar
	dome	ch1	LS1226	2025-08-10 03:18:51	549d 9h35m 0s	Shaiel
unst	????	ch1	LS1477	2025-08-01 03:13:55	279d12h16m54s	Cerva
	LNA.	ch1	LS1778	2025-08-01 07:46:14	645d15h26m18s	Jasmin Belletoile



March 2025 status: List of LNA failures and supply

- **From reports by Marcos:**
  - **2000 : original supply**
  - ~1624 **: in the field** *(number of unique station IDs that have appeared in MoRD. Maybe 5 or so are moved stations so are duplicates)*
  - **>120 : new ones not yet used** (at least 120 from the last shipment + all others [value to be confirmed])
  - ~80 **: needed to finished the current maintenance**
  - 28**: needed to fill in final landowner region**
  - ~175 : **broken, brought back from the field** (128 are already repaired and nearly all redeployed; all w/o/ further issues).
    - 115 : LNA amplifier chip repaired (From PMS).
    - 13 : 'pig-tail' repaired (From PMS)
    - 60 : to be repaired (likely 10% pigtail, 90% chip, a few misc. issue)
    - ~10? : **likely gone forever**. *(9 destroyed by lighting. Maybe a few more broken during deployment. Some still repairable.)*

- ***For context: historical lightning cases in PMS:***
  - *40 specific cases described in the history of SD. More cases where just GPS antenna was affected. PMS record is not complete.* ***80 over SD period*** *is a more likely estimate [based on Marcos asking staff]*
  - ***<10 stations / year*** *is what the staff finds acceptable normally.*
  - *We had* ***2 catastrophic failure cases with RD*** *in the recent thunderstorm season.*
    —> no reason to suspect a much higher rate. Maybe a little based on that our antenna is higher than the GPS antenna.

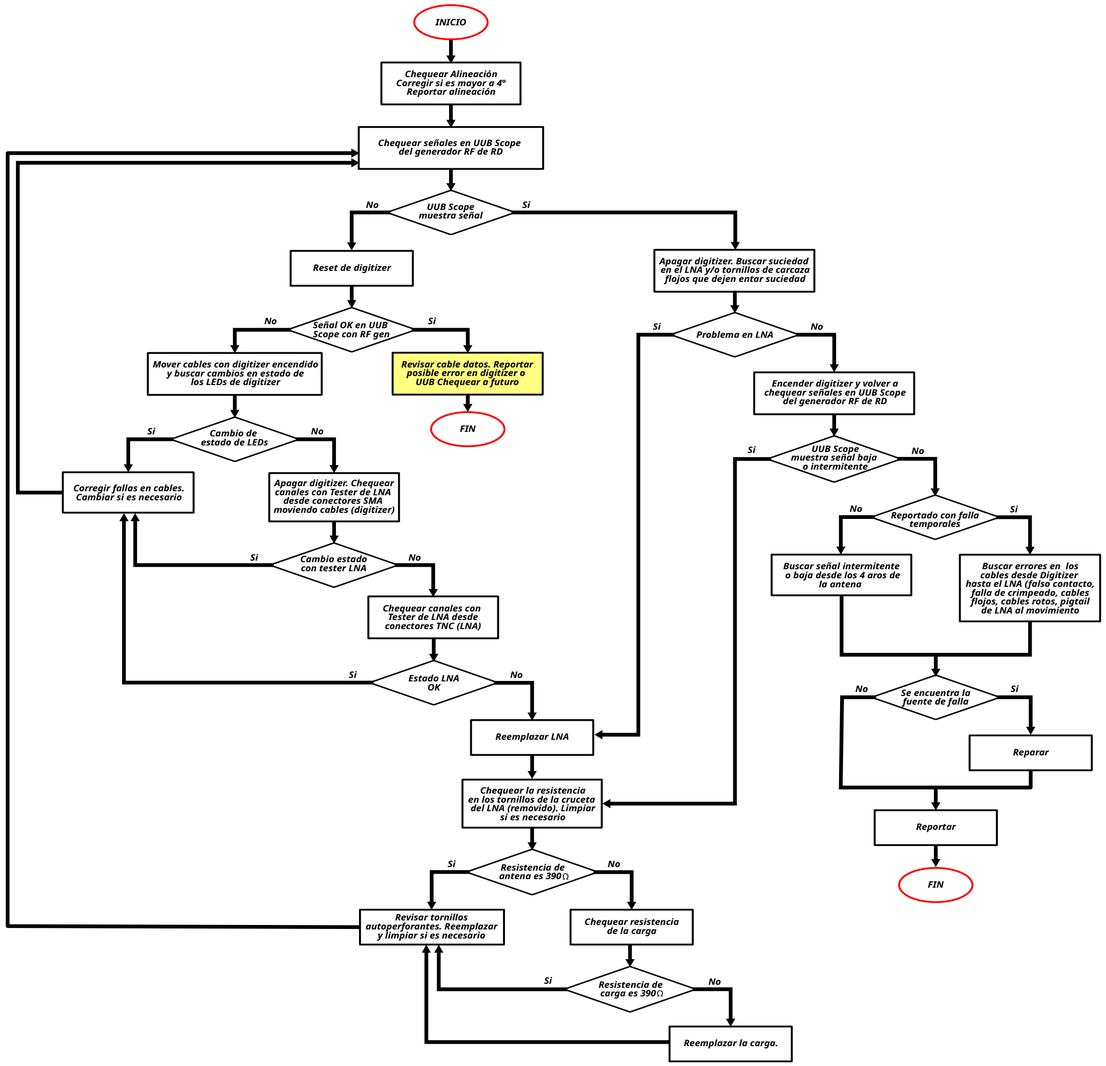
Long-term plan for component repairs or replacement:

- Please include your new findings into an updated long-term plan for component repairs and replacements.

RD maintenance/repair flow-chart by Marcos

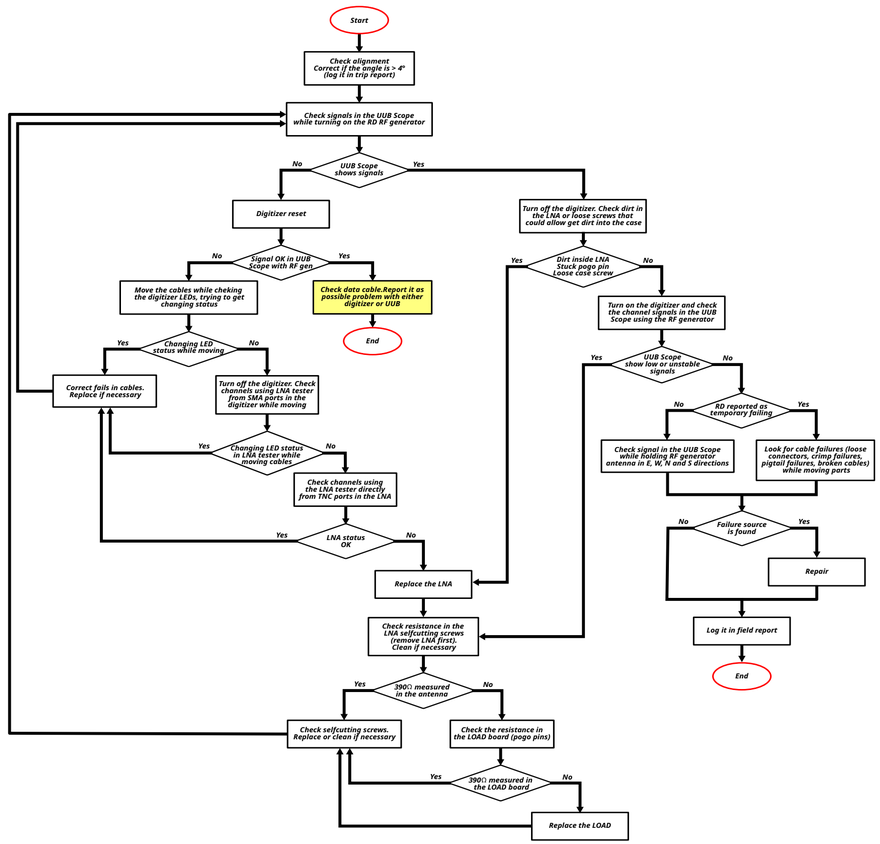
Secuencia de mantenimiento para RD

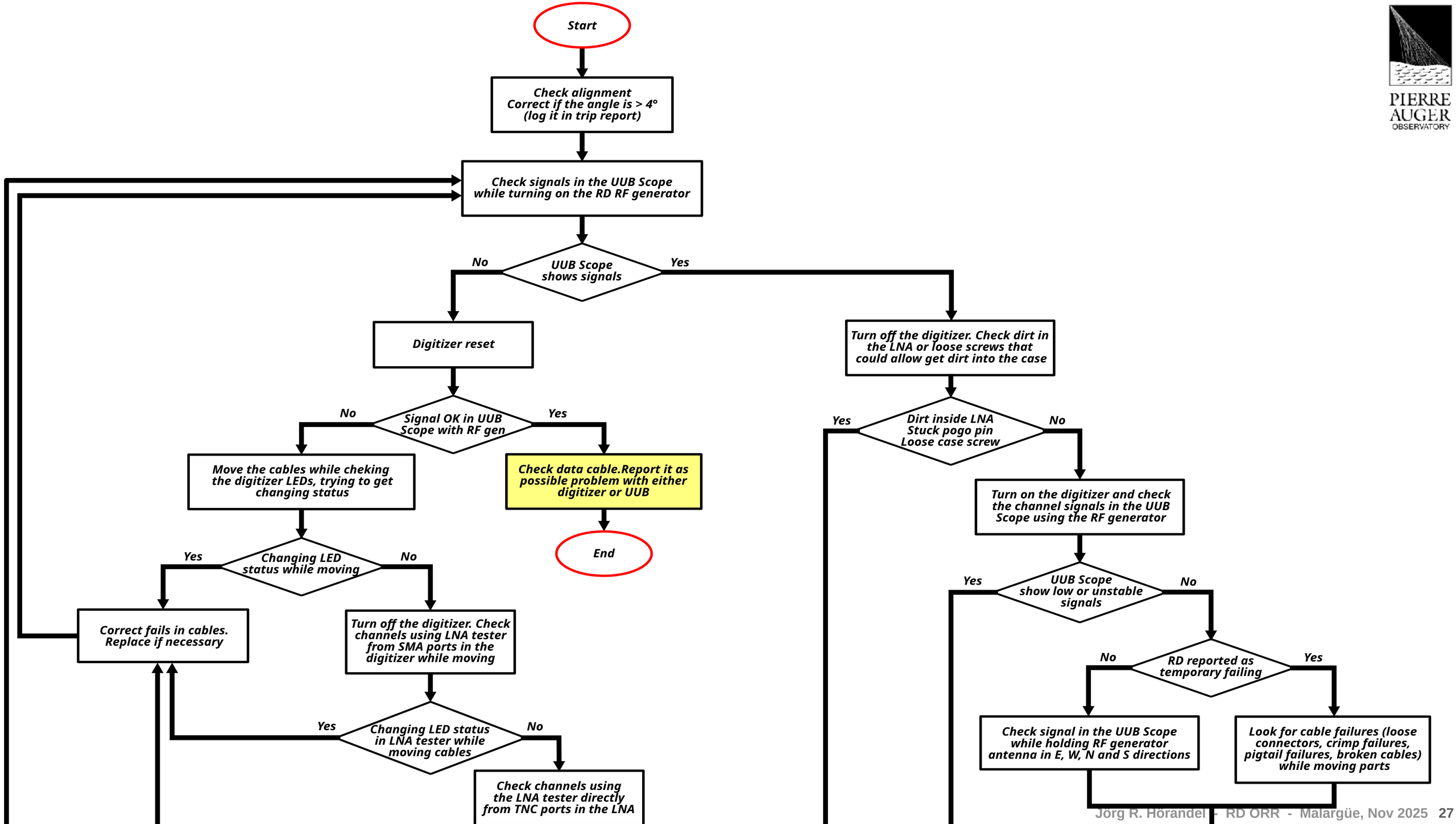
V2.2 - 13/11/25

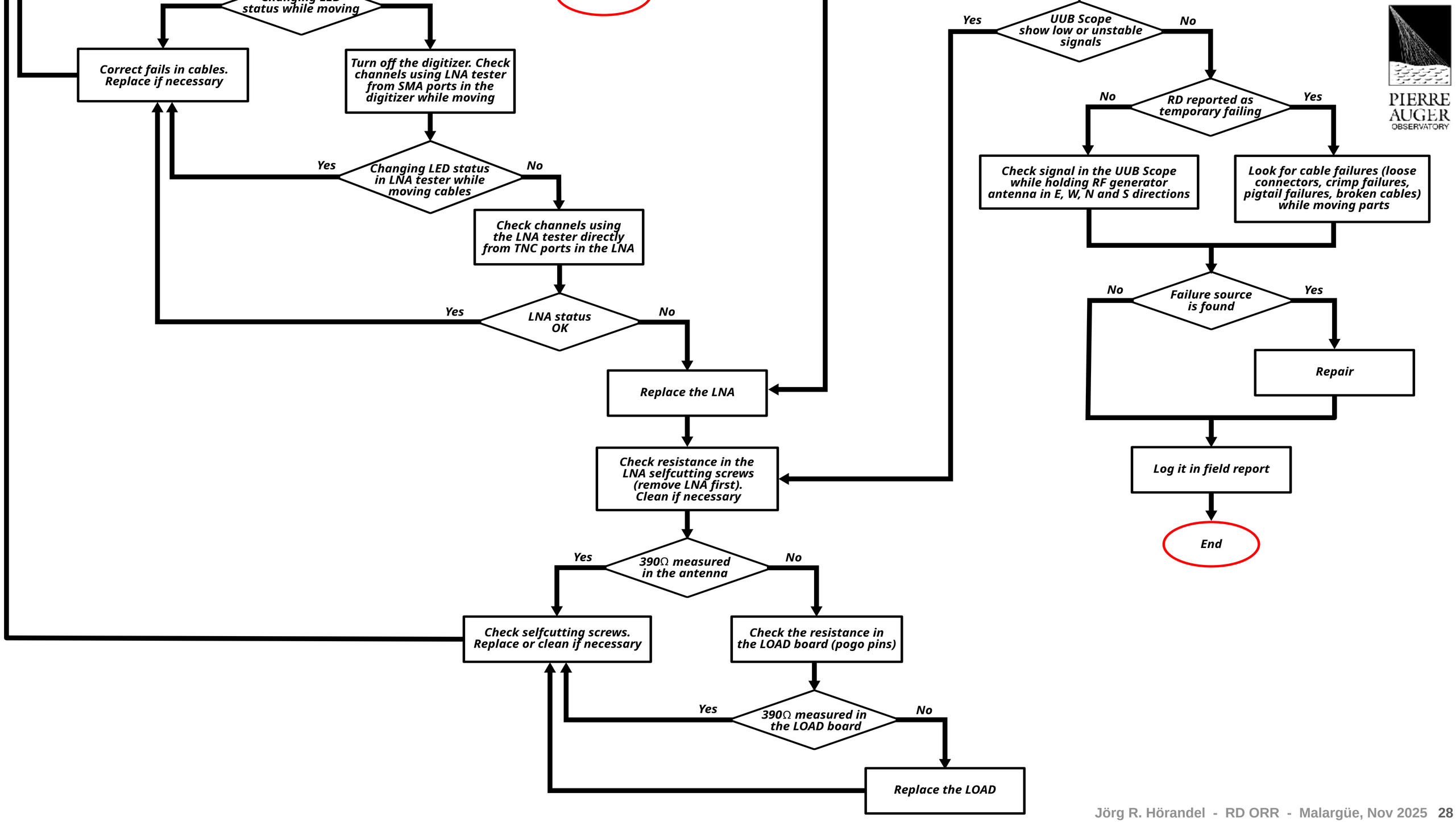


RD Maintenance guidelines

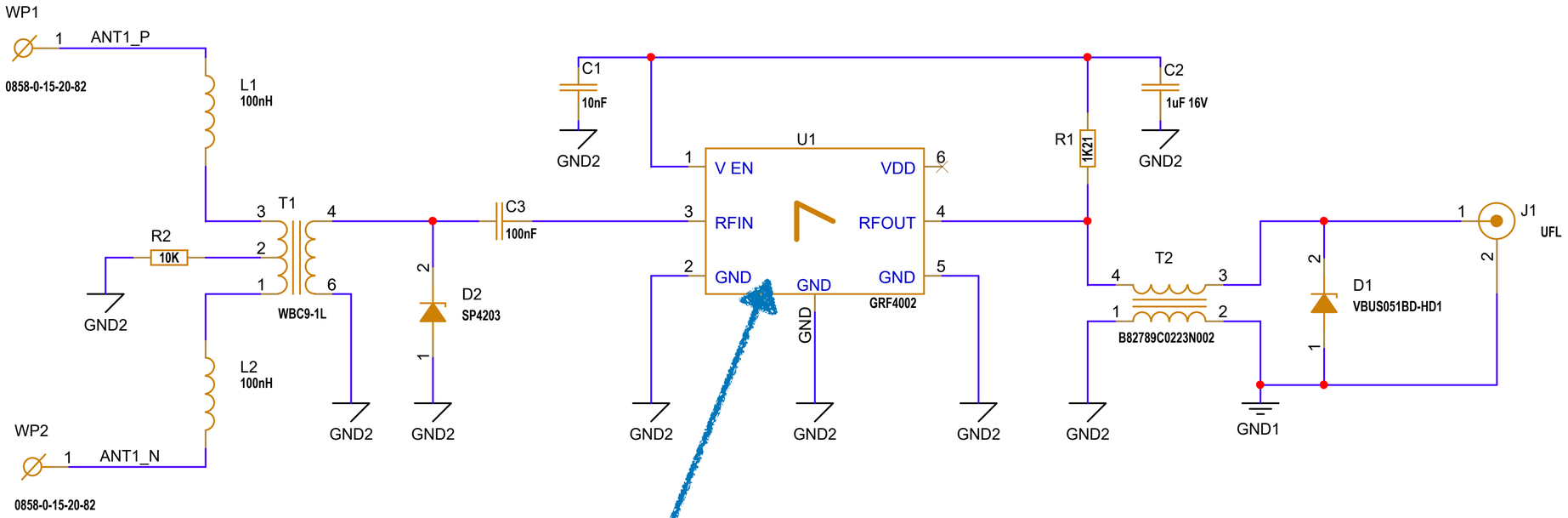
V2.2 - 13/11/25



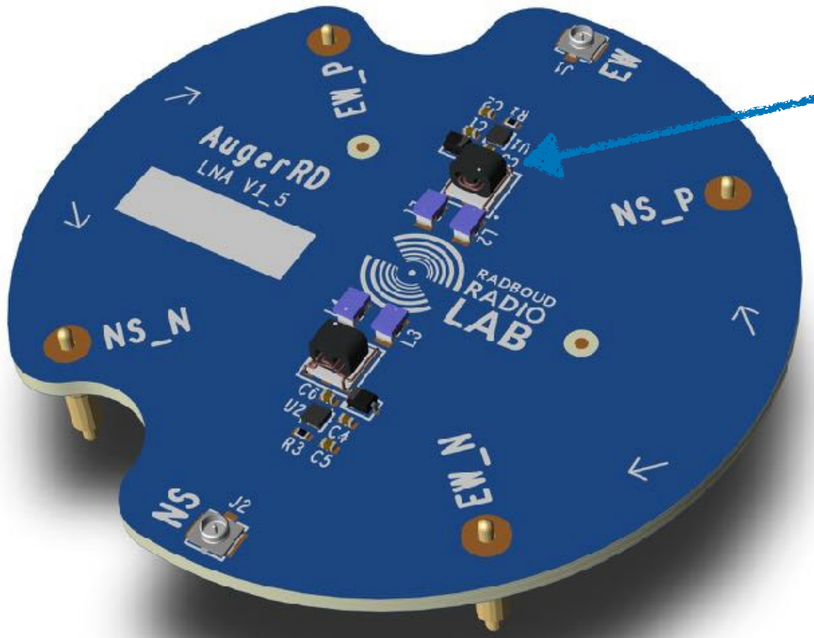

Start
Check alignment
Correct if the angle is > 4°
(log it in trip report)
Check signals in the UUB Scope
while turning on the RD RF generator
UUB Scope
shows signals
No
Yes
Digitizer reset
Signal OK in UUB
Scope with RF gen
No
Yes
Move the cables while cheking
the digitizer LEDs, trying to get
changing status
Check data cable.Report it as
possible problem with either
digitizer or UUB
End
Changing LED
status while moving
Yes
No
Correct fails in cables.
Replace if necessary
Turn off the digitizer. Check
channels using LNA tester
from SMA ports in the
digitizer while moving
Changing LED status
in LNA tester while
moving cables
Yes
No
Check channels using
the LNA tester directly
from TNC ports in the LNA
Turn off the digitizer. Check dirt in
the LNA or loose screws that
could allow get dirt into the case
Dirt inside LNA
Stuck pogo pin
Loose case screw
Yes
No
Turn on the digitizer and check
the channel signals in the UUB
Scope using the RF generator
UUB Scope
show low or unstable
signals
Yes
No
RD reported as
temporary failing
No
Yes
Check signal in the UUB Scope
while holding RF generator
antenna in E, W, N and S directions
Look for cable failures (loose
connectors, crimp failures,
pigtail failures, broken cables)
while moving parts


Changing LED status while moving
Correct fails in cables. Replace if necessary
Turn off the digitizer. Check channels using LNA tester from SMA ports in the digitizer while moving
Yes
Changing LED status in LNA tester while moving cables
No
Check channels using the LNA tester directly from TNC ports in the LNA
Yes
LNA status OK
No
Replace the LNA
Check resistance in the LNA selfcutting screws (remove LNA first). Clean if necessary
Yes
390Ω measured in the antenna
No
Check selfcutting screws. Replace or clean if necessary
Check the resistance in the LOAD board (pogo pins)
Yes
390Ω measured in the LOAD board
No
Replace the LOAD
Yes
UUB Scope show low or unstable signals
No
No
RD reported as temporary failing
Yes
Check signal in the UUB Scope while holding RF generator antenna in E, W, N and S directions
Look for cable failures (loose connectors, crimp failures, pigtail failures, broken cables) while moving parts
No
Failure source is found
Yes
Repair
Log it in field report
End
PIERRE AUGER OBSERVATORY

LNA

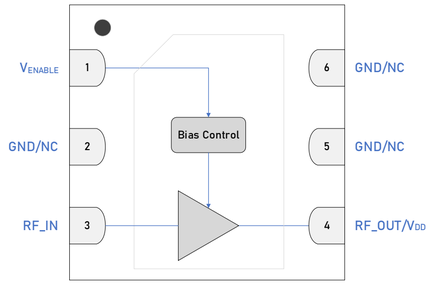


GRF4002



GRF4002

Broadband LNA / Linear Driver
0.015 to 5.9 GHz



- some of the amplifier chips break (due to over voltage)
- successfully repaired by Mauro
- bought 1000 + 2500 additional chips

Future procurements of spare parts, tools, and consumables. Spares availability:

- Please provide a list of repairable components for all sub-systems including digitizers and mechanics. These numbers would be compared to spares so we know if we have a projected deficit or not. Please mention/list the most critical component(s) in the electronics or elsewhere in the system that you foresee will not be available on the market after 5/10 years and compare to the number of spares of these components.
- What exactly do you plan for future procurements (if any)?

We provided 1700 units of all mechanical parts, like frames etc.
1660 have been installed, thus there should be ~40 spare units of all mechanical components.
This should be sufficient in cases of vandalism etc.

We provided 2000 units for all electrical components, like LNAs, load resistors, digitizers, SALLA antennas, solar panels. There should be (2000-1660) = 340 spare units each.

So far the only component with non-negligible failures is the LNA, to be more precise the amplifier chip on the LNA PCB. We did purchase additional amplifier chips.

No further procurements are planned.

Data Management

Reliability and consistency of the data:

- Please report on the progress in solving the dead-time issue. Which of the three options do you finally select? How much can we reduce the issue in terms of lost events?

This is not really an „issue“, more a design feature.

We evaluated different solutions.

We agreed that the best solution will be to implement two alternating buffers for the read-out (similar to UUB). To do this, we first need to free up space on the FPGA (different implementation of online FFT for real-time calibration).

Need man power for implementation
Dave/Sjoerd, …..

Monitoring of RD:

- Demonstrate progress in the integration of RD in SD monitoring and provide a timeline for final implementation. Meanwhile, make sure that the alternative MoRd system is fully accessible by RD and SD experts as well as by local staff.
- Update on the plan to integrate RD in SD shift.

see slides from Julian …

RD Monitoring

Julian Rautenberg

RD-Workshop

22.10.2025

RD Monitoring

- Block with variables defined and implemented in RD-FE firmware
- First test was running, Tomas had quick look to confirm data validity
- For long time not included in RD-FE firmware running in the field
- RD-FE and UUB firmware upgraded in the field on 19th Sep’24
- Sending of RD-Mon not enabled at all stations
- Not yet implemented in running CDAS LS and central version

RD-Monitoring data

- Block defined
- Monitoring sent every 400 sec
- But Mon-message not prioritized
  lost in case of high leeds-load
- For galactic calibration ok up to about 1h
- In addition RD-trigger info required:
  - cumulative T1
  - cumulative RD-traces
  - Cumulative seconds RD-T1 vetoed

RD-Monitoring data

- CDAS writes un-handled RD-Mon part to file
- Test file and code made available by Ricardo

```
========== found header ... ========
StId=0664 Pack=2 reg_time=0.000000000 276
==== Monit start time(GPSSec)=1423266439 =========
monit: temp=772 ... curr/volt(ADC)=418/734; 419/766
fft: nffts=8192;dt(ms)=3194;th=30;streach=100;offset=123;nsum=4;nvals=52;
f(MHz)  N/S          E/W
 30.03  5.4563e+13  5.8686e+13
 31.01  5.9236e+13   5.903e+13
 31.98  1.1531e+14  1.5641e+14
 32.96  6.8926e+13  6.8651e+13
 33.94  6.0954e+13  6.4047e+13
 34.91  6.0611e+13  6.8307e+13
 35.89  6.1985e+13  7.1743e+13
 36.87  6.3703e+13  6.8376e+13
 37.84  6.4802e+13   6.975e+13
 38.82  5.9649e+13  6.8857e+13
 39.79  6.0473e+13  6.9888e+13
 40.77  6.1435e+13  7.1193e+13
 41.75  7.1056e+13   7.779e+13
```

```
SdId 906 occurs 216
SdId 1747 occurs 216
SdId 904 occurs 216
SdId 1729 occurs 216
SdId 1743 occurs 216
SdId 635 occurs 214
SdId 1741 occurs 216
SdId 863 occurs 216
SdId 1738 occurs 216
SdId 663 occurs 216
SdId 665 occurs 216
SdId 1740 occurs 216
SdId 920 occurs 206
SdId 902 occurs 216
SdId 1735 occurs 213
SdId 1737 occurs 215
SdId 657 occurs 220
SdId 865 occurs 215
SdId 664 occurs 215
```

Previous works on Galactic Calibration of RD (Tomáš Fodran PhD thesis)

Periodic data

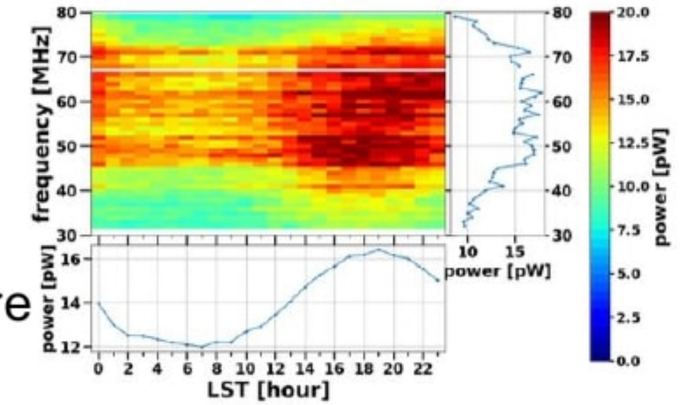
- Using periodic spectra acquired by a special algorithm in the FPGA from multiple stations

- Every 5 minutes, several thousand spectra are summed.

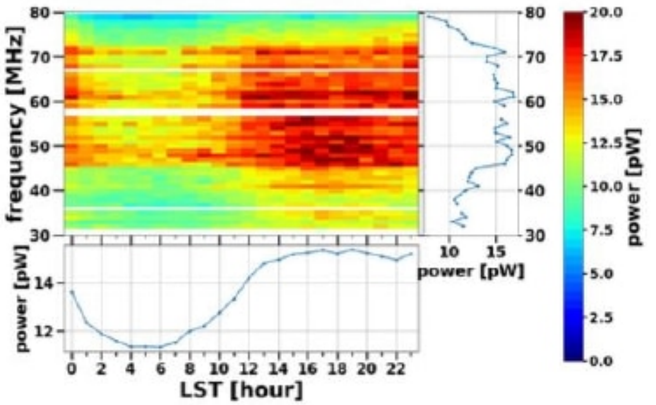
- The algorithm filters broad-band RFI using a threshold filter acting in the time domain. An experimental campaign spanning 12 consecutive days to test the algorithm was conducted

- The noise background acquired from a single day surpasses the quality of the previous dataset obtained from 4 months of triggered data.

Triggered data

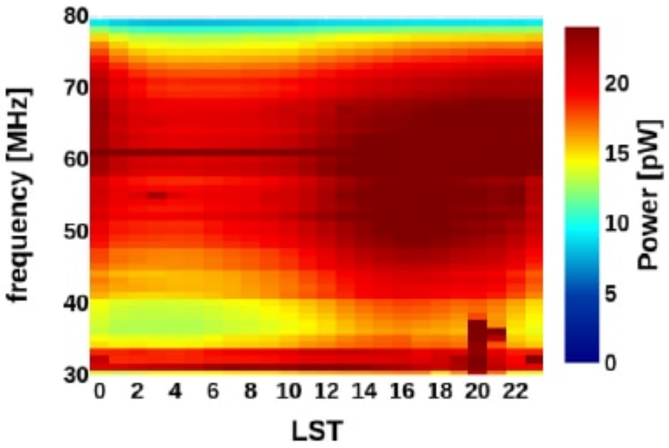


(A) EW channel dataset.

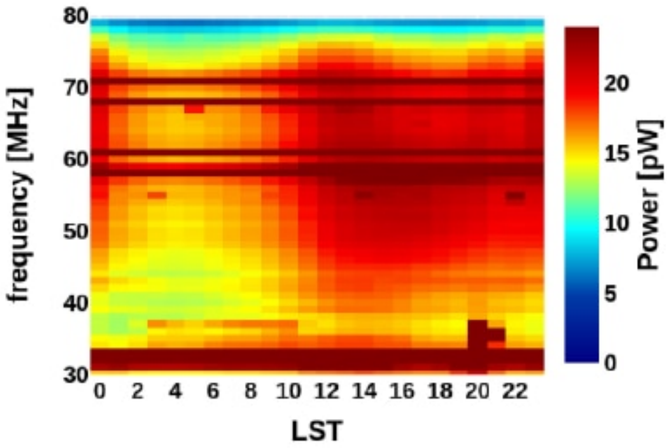


(B) NS channel dataset.

Periodic data



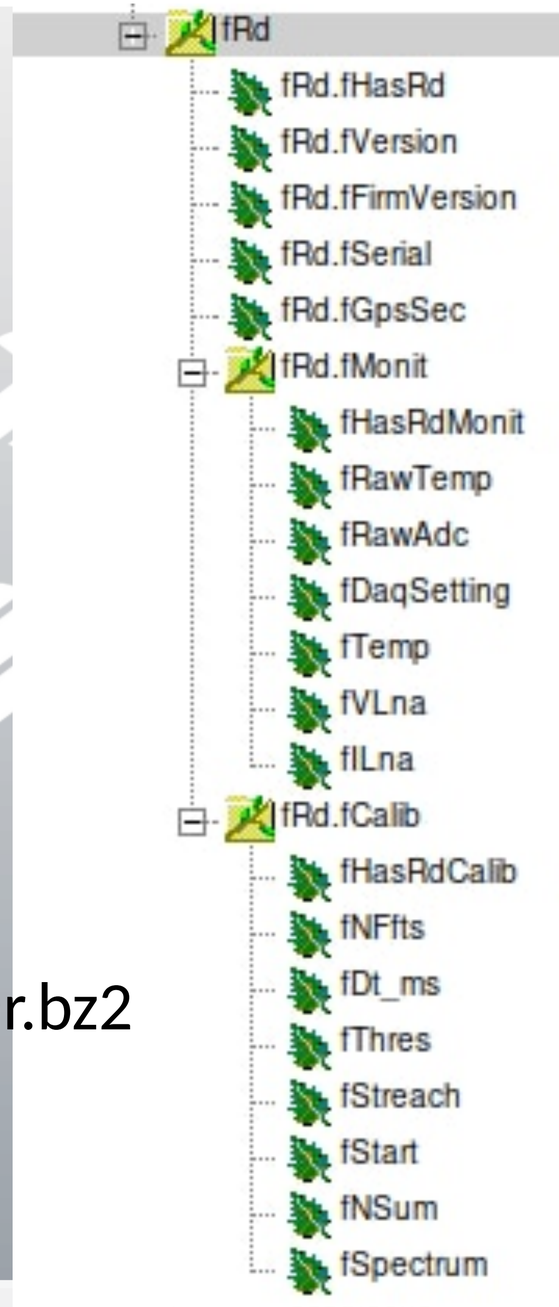
(A) Channel 0 (EW).



(B) Channel 1 (NS).

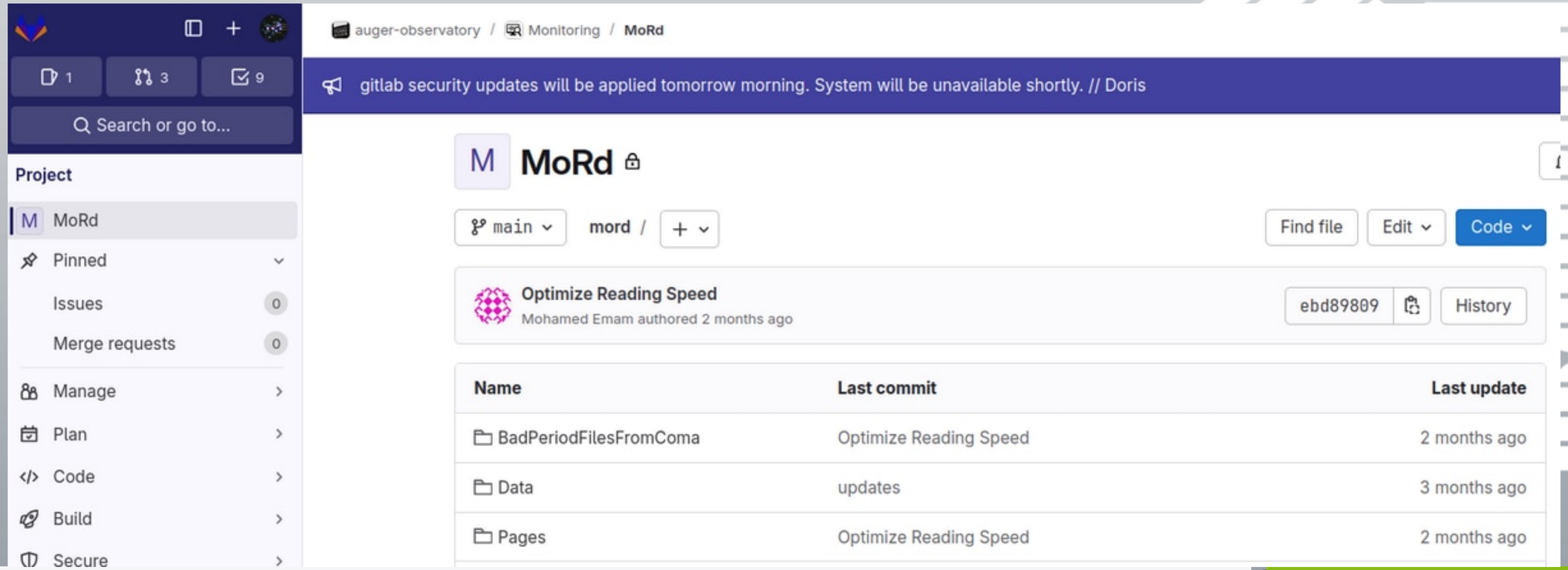
RD-Monitoring

- Block to be implemented in MonitCalib and LongTermMonitCalib
- Requires modification in CDAS-Mr,
  definition of tables in mondb
- Spectrum in MonitCalib, or also directly in other format?
  What is the input for the Galactic-Calibration analysis?
- Modification to MoRd done by Ricardo
- First test-run with new CDAS-version on 6.10.2025
  Raid/data/SdTests/2025/10/CDAS_UUB_DAQ_test_2025_10_06.tar.bz2
- Need evaluation!



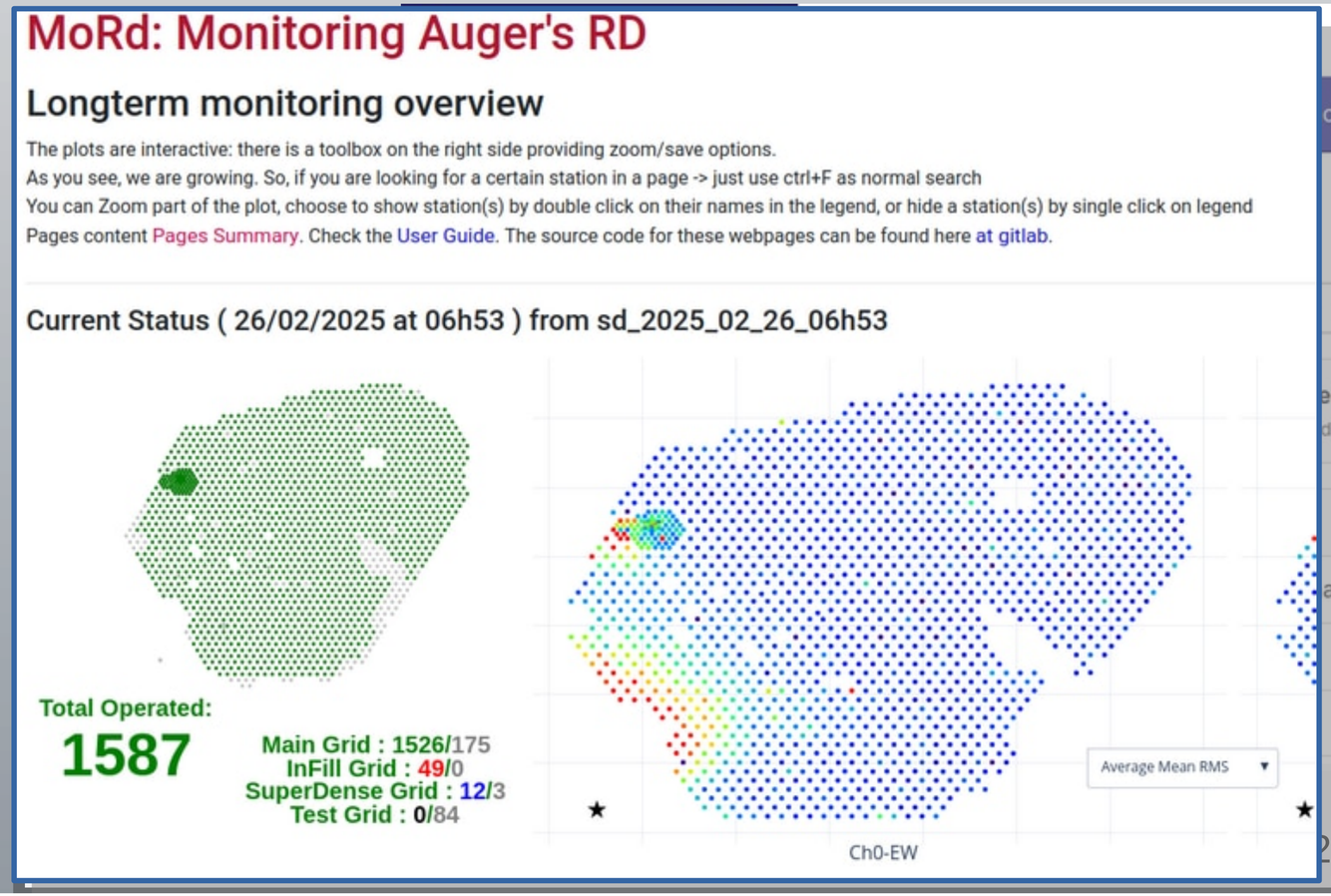
RD DQM

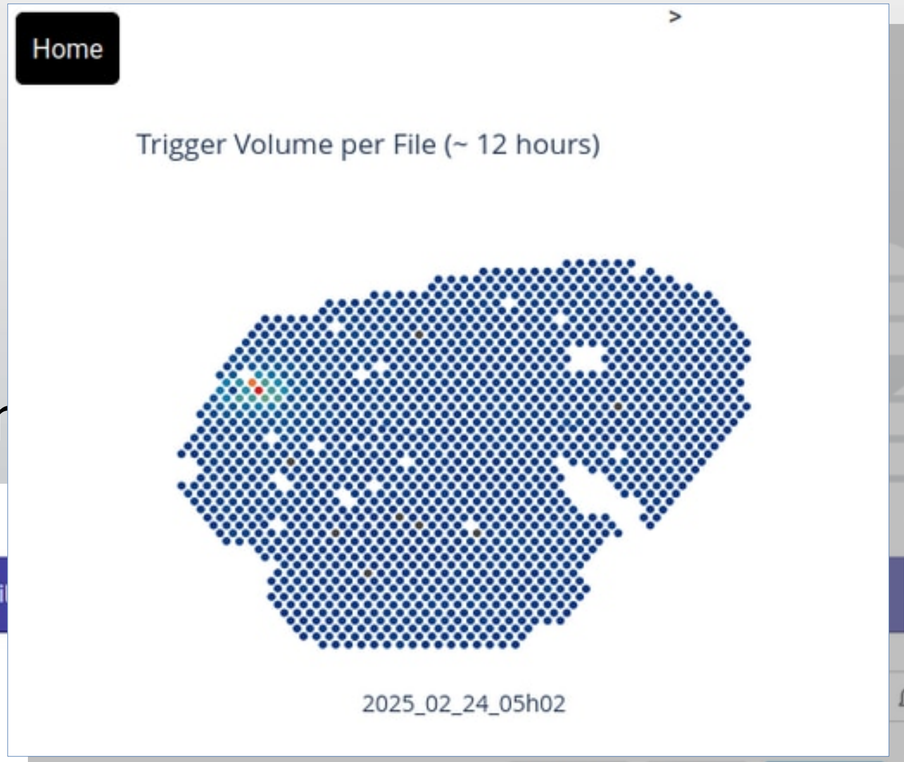
- Processing of daily sd-files
- Tool in gitlab: https://gitlab.iap.kit.edu/auger-observatory/monitoring/mord

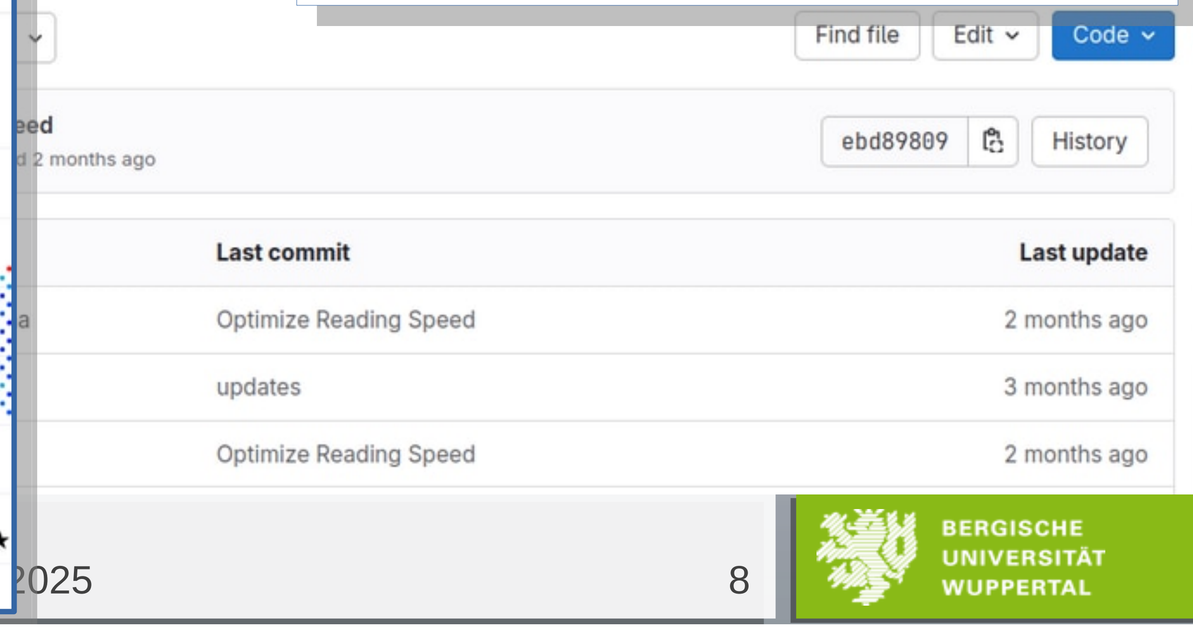


RD DQM

- Processing of daily sd-files
- Tool in gitlab: https://gitlab.iap.kit.edu/auger-observatory/mor



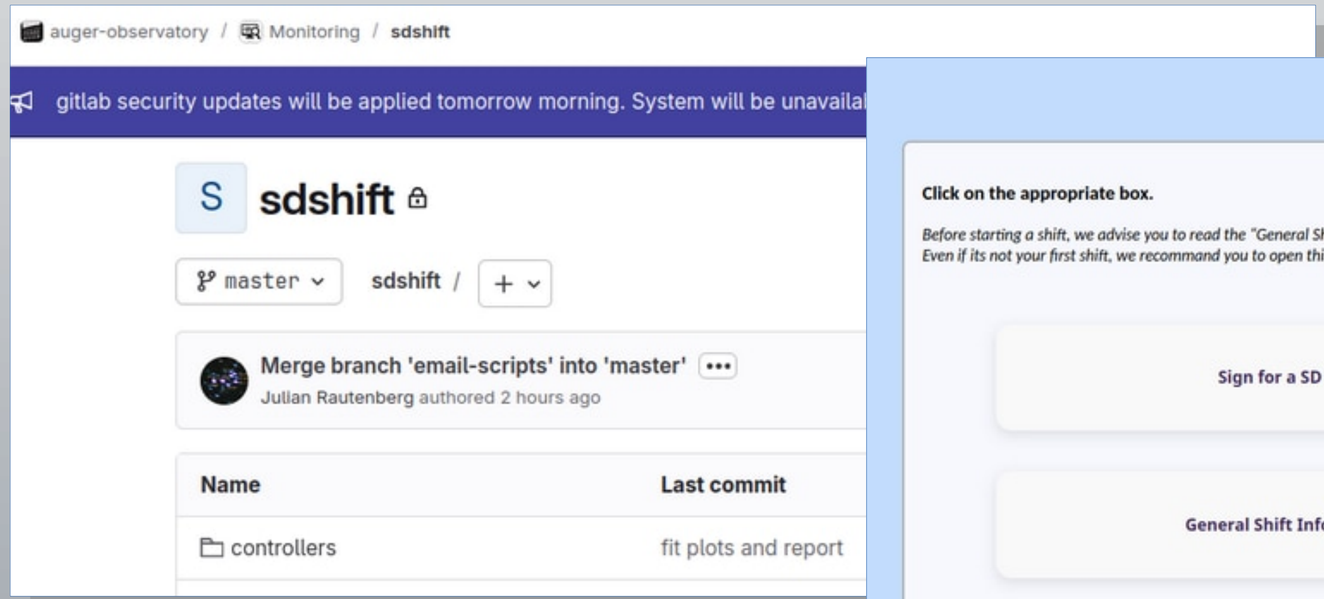


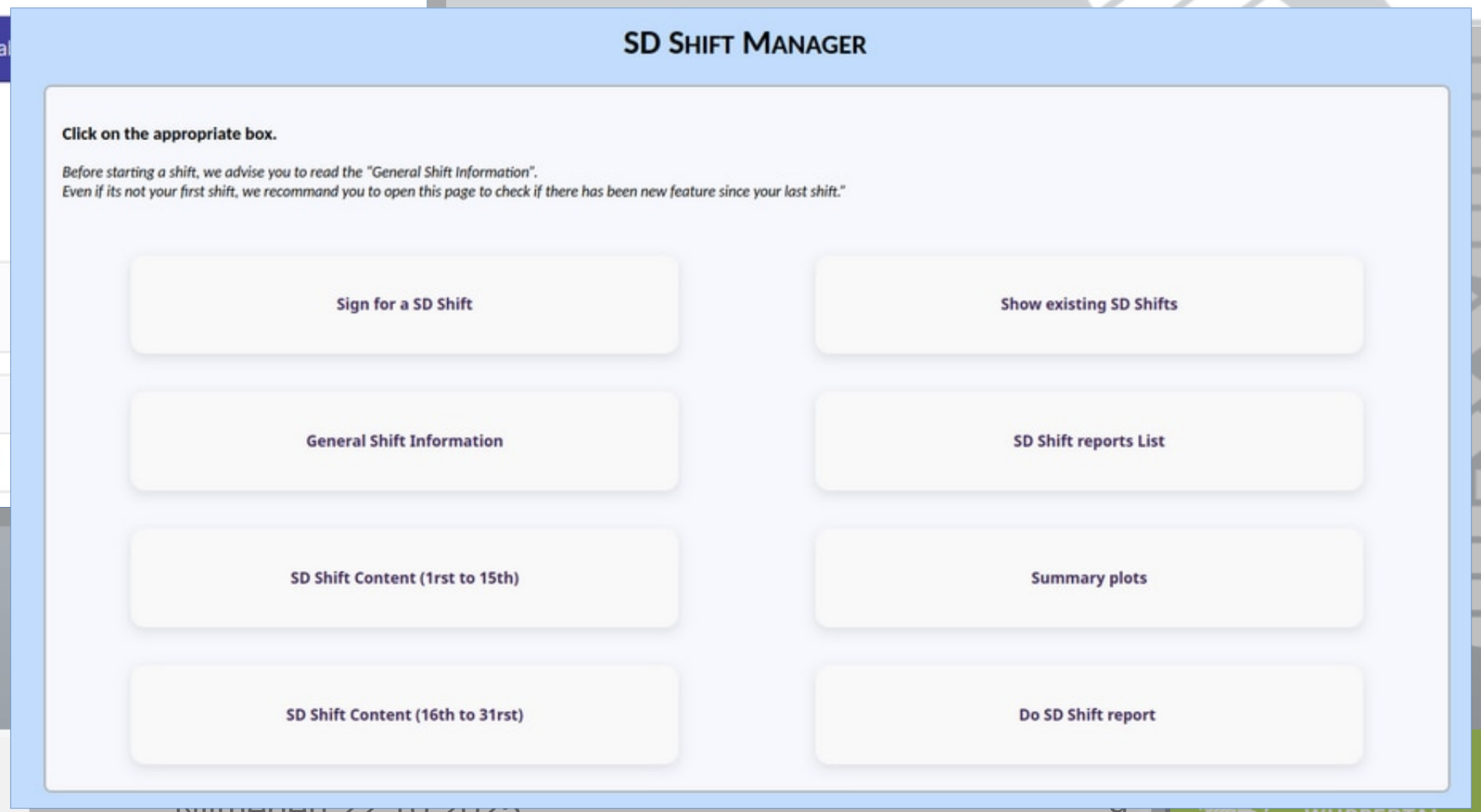


RD-Shift

DQM-Shift is now extended to other components
Right time to become active!

- RD-SQM provides plots that can be implemented in the SD shift
- SD-Shift transistion still ongoing, then open for additional components





Technical Documentation

- The technical documentation provided in Dropbox seems to be rather complete. Please ensure that it is transferred to EDMS and remain open to further checks of completeness of the documentation by the RD team, review committee, management and observatory staff.
- Create a landing page: The documentation of the various aspects of the RD seems to be in the various places where it belongs (EMDS, Wiki pages, Monitoring, Gitlab repositories, …). As distributed over several places, this might still be hard to navigate and find all information in a few years from now, in particular, because there is no RD landing page (website and/or wiki page as it exists for other detectors of the observatory). Such a landing page should contain links to the different places of hardware, firmware, and software documentation, the monitoring, deployment and maintenance information, etc. There is no need to duplicate information, e.g., one could link to existing sub-pages of the AERA wiki when appropriate. The purpose is simply to make all information easily accessible.

https://www.auger.unam.mx/AugerWiki/RD_Documentation

RD Documentation

RD monitoring https://hef.ru.nl/mord/

RD firmware Gitlab KIT https://gitlab.iap.kit.edu/auger-observatory/sde/uub/rd/

RD in CERN EDMS https://edms.cern.ch/ui/#!master/navigator/project?P:100816025:100816025:subDocs

Local copy of EDMS information

- solarpanels https://www.auger.unam.mx/AugerWiki/RD_Documentation/solar/
- frame
- antenna (SALLA)
- antenna mast
- cables
- LNA + bottom load
- digitizer
- enclosure for digitizer
- electric-field monitors

RD installation and maintenance documents

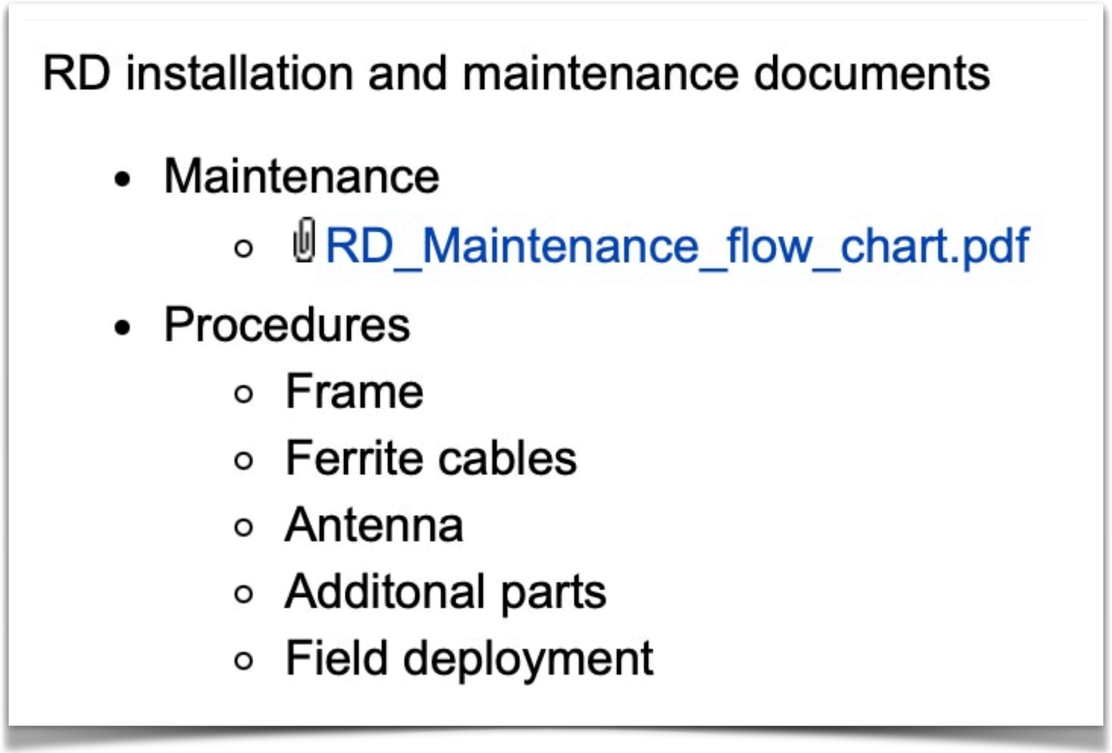
- Maintenance
  - RD_Maintenance_flow_chart.pdf
- Procedures
  - Frame
  - Ferrite cables
  - Antenna
  - Additonal parts
  - Field deployment

PIERRE AUGER OBSERVATORY

Procedures

- Maintenance/installation procedures are defined by RD team together with the local experts and they are living documents always improving over the time. Can you show a current version of such procedures as an example (in Spanish or English)? Where and how are these documents available? These ever-evolving documents can be provided as a link on the landing page (see above), so that all collaborators can check them.
- Please remember to respect availability of all procedures and aspects: general operation, hardware and software troubleshooting and maintenance, process for handling major repairs as well as inclusion of safety considerations in all procedures (e.g. when and how grounding is required).

Marcos has prepared documents (in Spanish).
They are available the wiki: https://www.auger.unam.mx/AugerWiki/RD_Documentation



Training

- Complete the training of the Observatory staff.

Marcos has completed the training

Operations costs

Resources:

- Please continue and finalize together with the local staff the evaluation of the human resources and costs needed to operate and maintain the RD system, including materials and equipment.

Rates of failures and frequency of repairs and replacements:

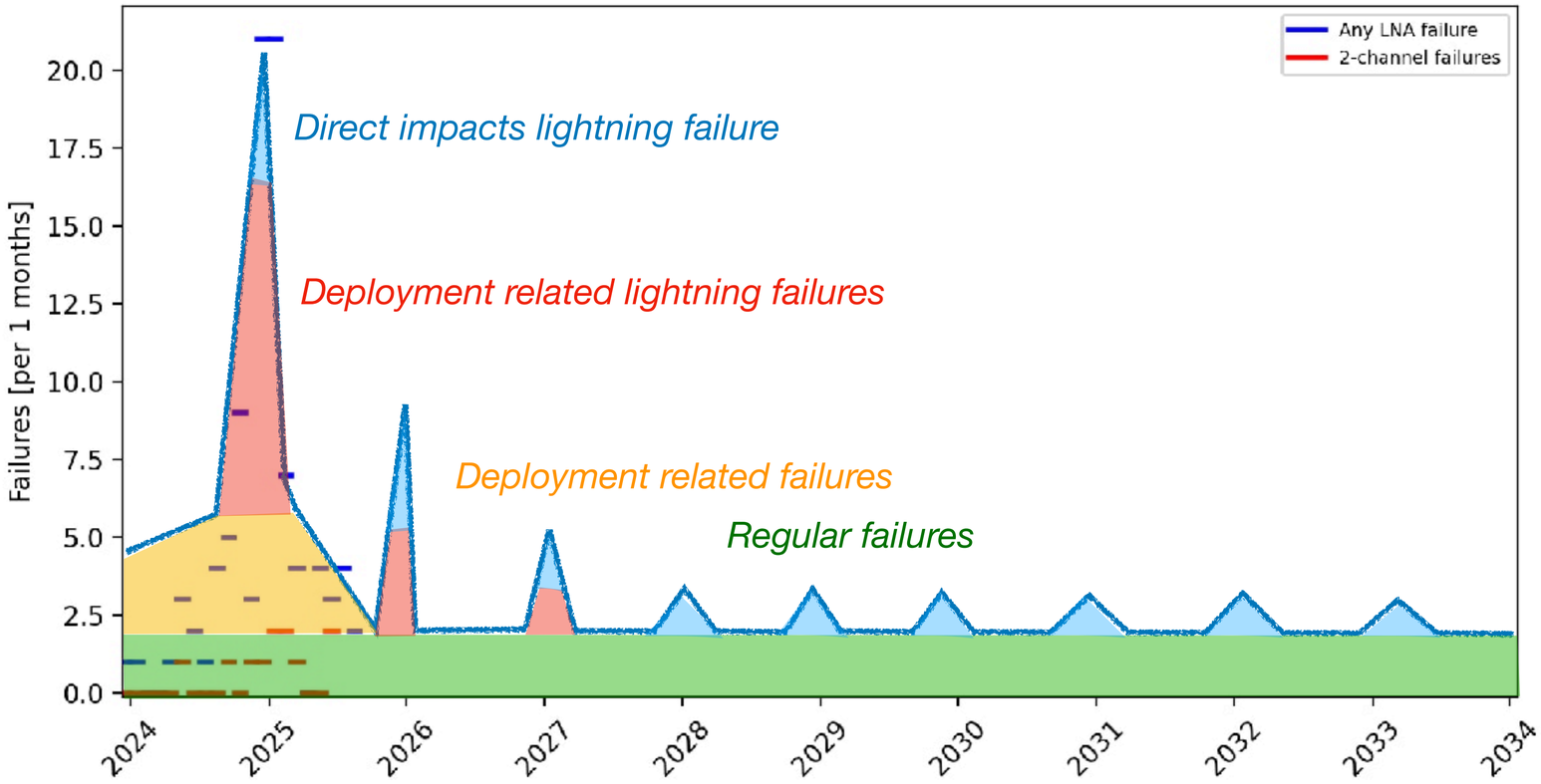
- The calculation of the expected failure rate is difficult due to overlap between those originating from the installation process, commissioning, and operation. The calculation presented was fair and probably the only possible way at the moment. However, the committee found it difficult to distinguish between the mentioned cases. The projection onto the next 10 years should be re-thought using new data and discriminating unavoidable failures during regular operation from those that are a consequence of a sub-optimal deployment or maintenance. The committee is aware of the fact that the next lighting season starts only in November but still the updated numbers and plots would be useful to see.

Based on information from Marcos, Bjarni has done an analysis, see next slides

Part 2: Best guess at a 10yr RD LNA forecast

- My expectation:
  - Deployment-related failures will slowly all be fixed. <— Failure rates as reported in Nov'24 and Mar'25 seemed high due to this
  - Deployment-related failures induced by lightning will similarly decrease <— cause of big figure peak in Dec'24
  - Lighting impacts will continue every season <—Possibly similar numbers to SD, but will need to wait for Jan'26 numbers.
  - Regular age-related/random failures will continue. <— Last 6 months indicate this is 1-2/month
    (They might increase over time?)

Well within spare budget! (Originally 350 full spares + 3500 spare amplifier chips for repairs) ⟶



Rough conservative estimation of LNA spares needed:

- regular failures: 2/month —> 240/decade
- lighting failures: 10/year? —> 100/decade?

—> 340 spares? A large fraction likely repairable.
(Optimistically: 120+50 spares??)
(Pessimistically : 240+200 spares???)

Note:

Thunderstorm peaks remain uncertain. We will know after next Jan.

Marcos' agrees expectations are roughly like this. Some staff are even more optimistic. They want to be conservative so it could be higher.

EFM installations

- Please follow the proposal from the management about the additional questions related to operation of EFM installation. Is the documentation for the operation of the EFM available? What is the failure rate and the local personpower requirement to maintain and operate it? What are the costs for operating it? (battery replacement, component replacement, etc.). Is the local staff trained to maintain and operate the system? What is the minimum required uptime for the system? Statistics on uptimes and failure rates.

- **Documentation is on dropbox (and GAP note) —> EDMS**
- **source code in Gitlab**
- **typical battery life cycle (10 yrs)**
- **failure rate**
  at start of project DAQ issues, fixed
  LA issue with lightning hit, Ubiquity Rocket at very top of tower,
  if failure repeats —> mount lower on tower
  LL Rocket problem —> moved to balcony of FD building
- **spares:**
  5x Ubiquity rocket
  spares of auxiliary devices available (bullet, charge controller, …)
  (AERA e-field mills work since 15 yrs without failures)
- **Yan is trained and responsible for virtual machine/infrastructure**
  Julian responsible for read-out
  (read-out partially through AERA infrastructure, will be harmonized after AERA shut-down —> transit to Observatory)
- **we aim for an uptime >95%**
  uptime depends on FD network availability