Improved Receive Path Amplification Circuitry

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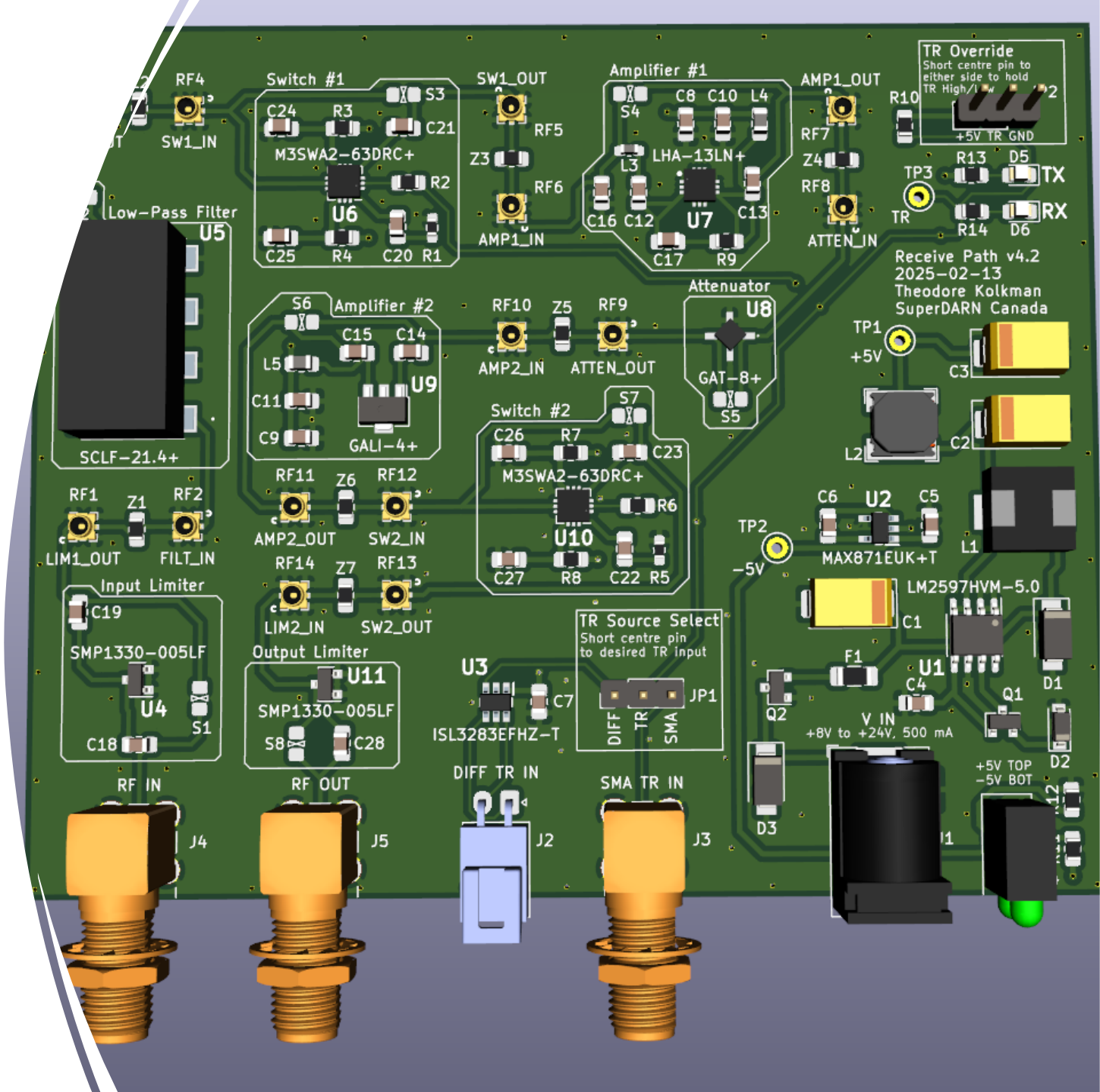
SUPERDARN CANADA

UNIVERSITY OF SASKATCHEWAN

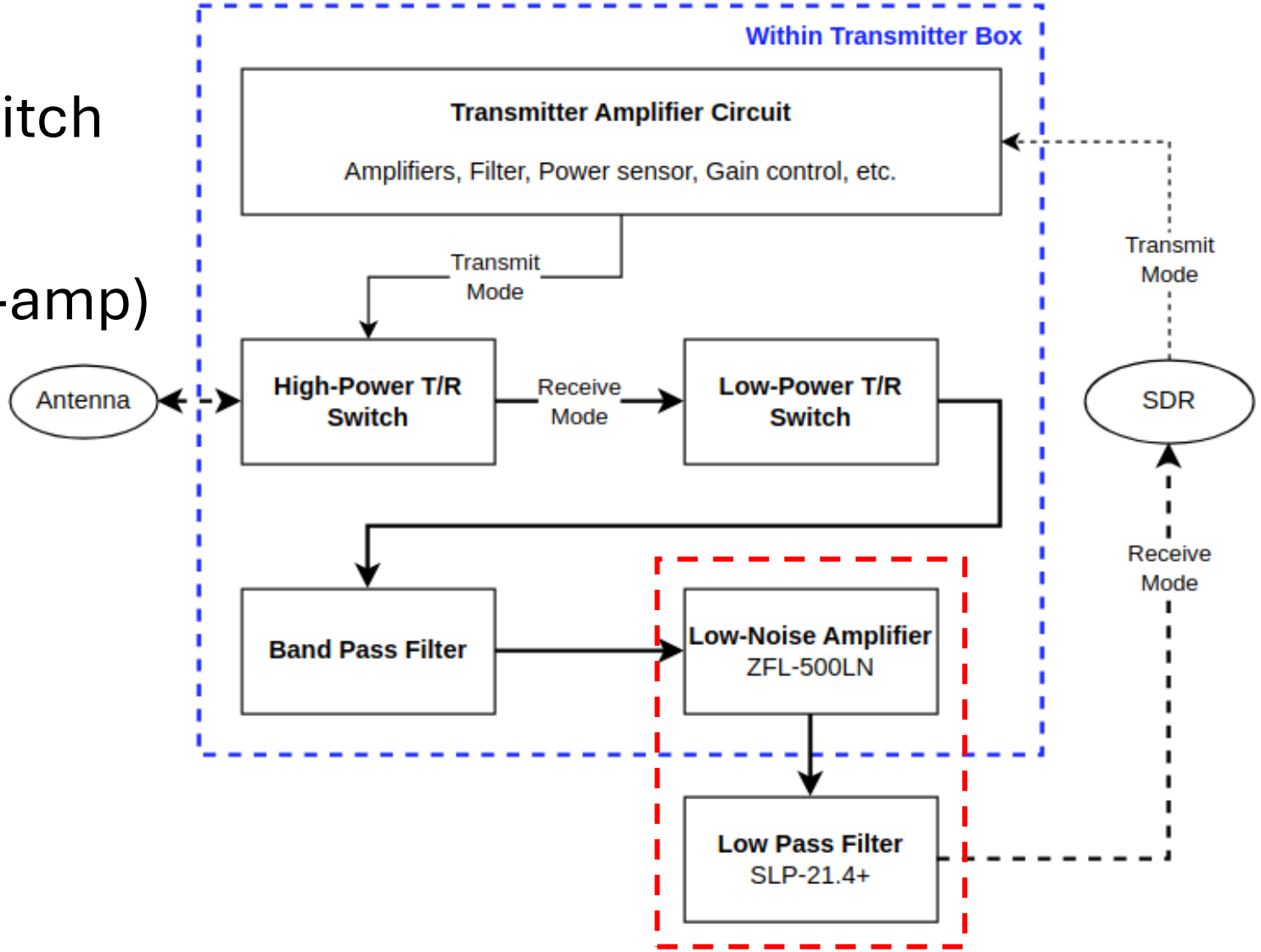
Overview

- Background/motivations
- Design process
  - Revision changes
  - Intermediate testing
  - Final revision overview
- Final testing results
- Installation plans



The Receive Chain (Main Array)

- High- and Low-Power Switch
- Band pass filter
- Low-noise amplifier (Pre-amp)
- Low pass filter

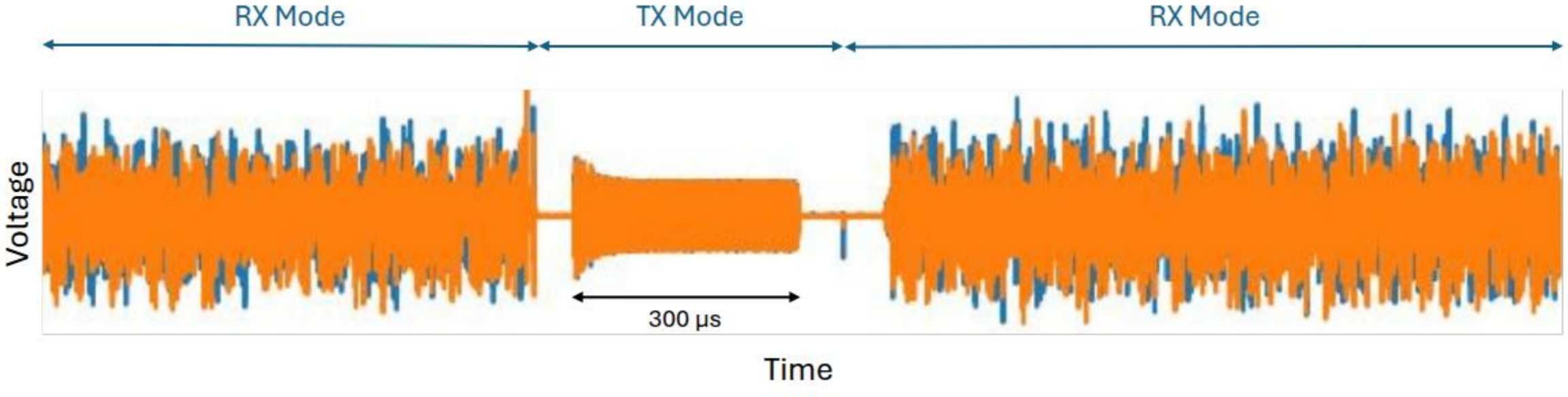


The Receive Chain (Interferometer Array)

- ~~High- and Low-Power Switch~~
- Band pass filter
- Low-noise amplifier (Pre-amp)
- Low pass filter

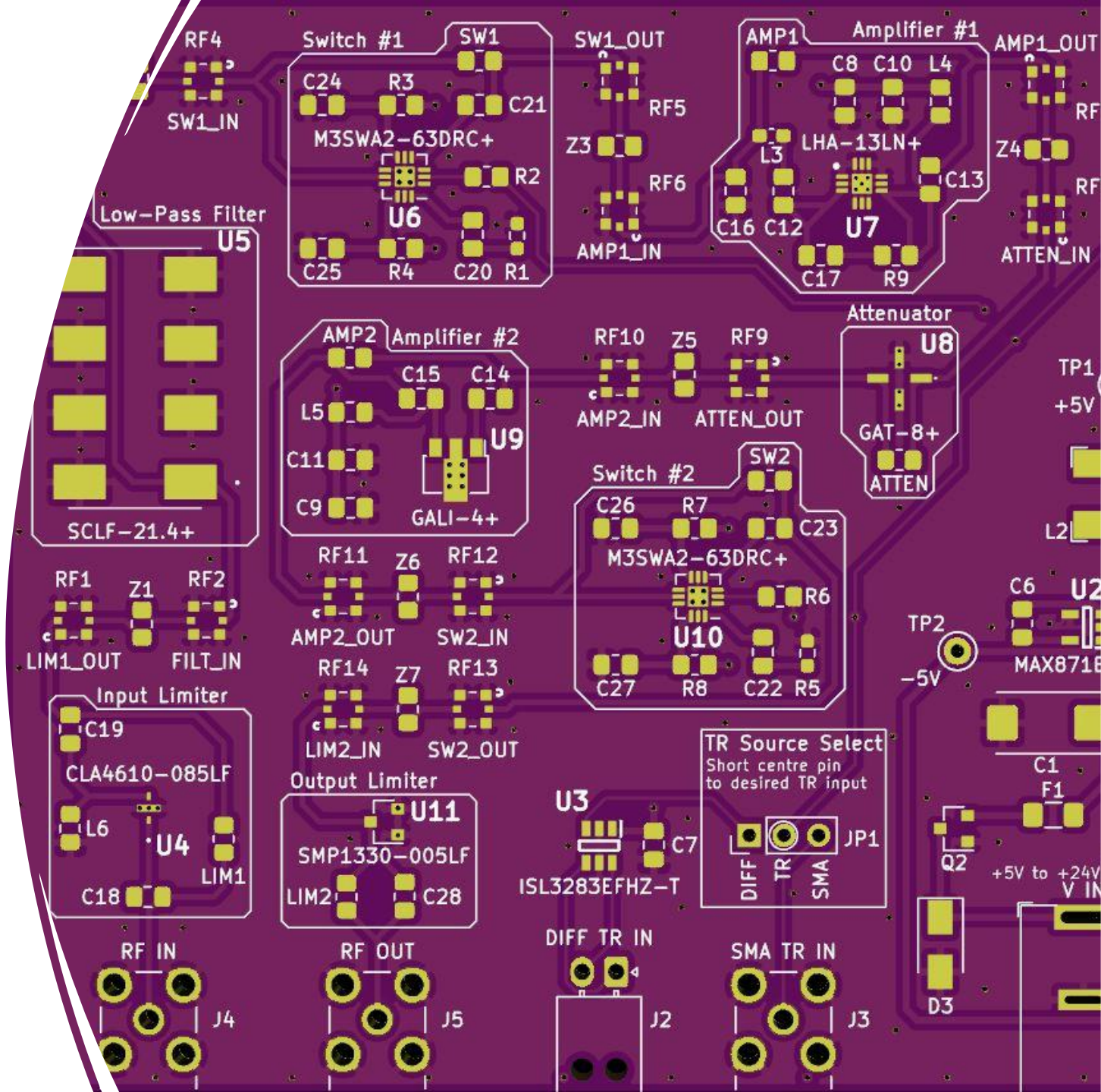
The Received Signal

- During RX mode: signal passes through switch and amplified by pre-amps
- During TX mode: signal blocked by switch (some transmit pulse still leaks through)
- TR Signal: The control signal for RF switches within the Transmitter, switching between TX mode and RX mode



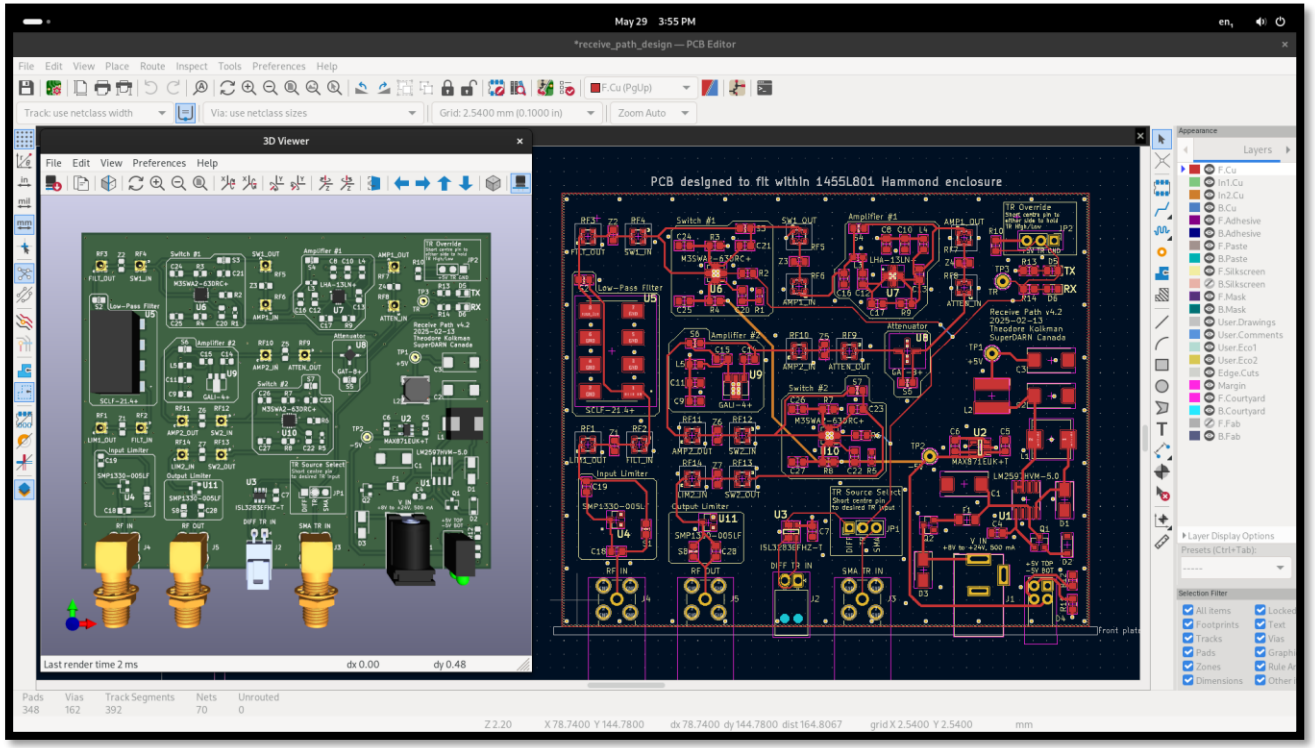
Motivations

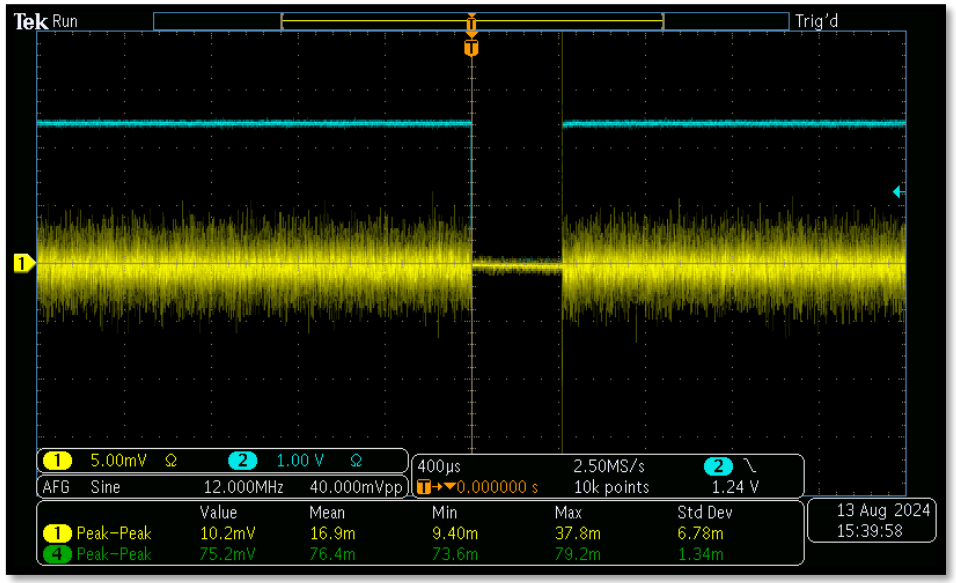
- Pre-amps continually failing
  - Most commonly on the interferometer
- Cost of replacing pre-amps
- Improvements in TX pulse suppression
- Increased circuit protection



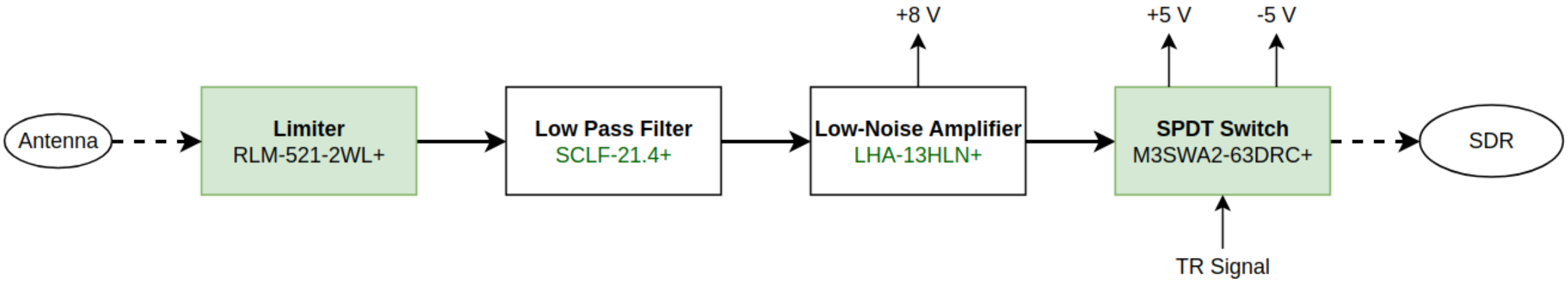
Design Process

- Circuit board designed with KiCad
- Assembled by hand
- Testing:
  - RF characteristics with network analyzer
  - Signal shape with oscilloscope
  - RX to TX switching time
  - On-site installation
- Iterate

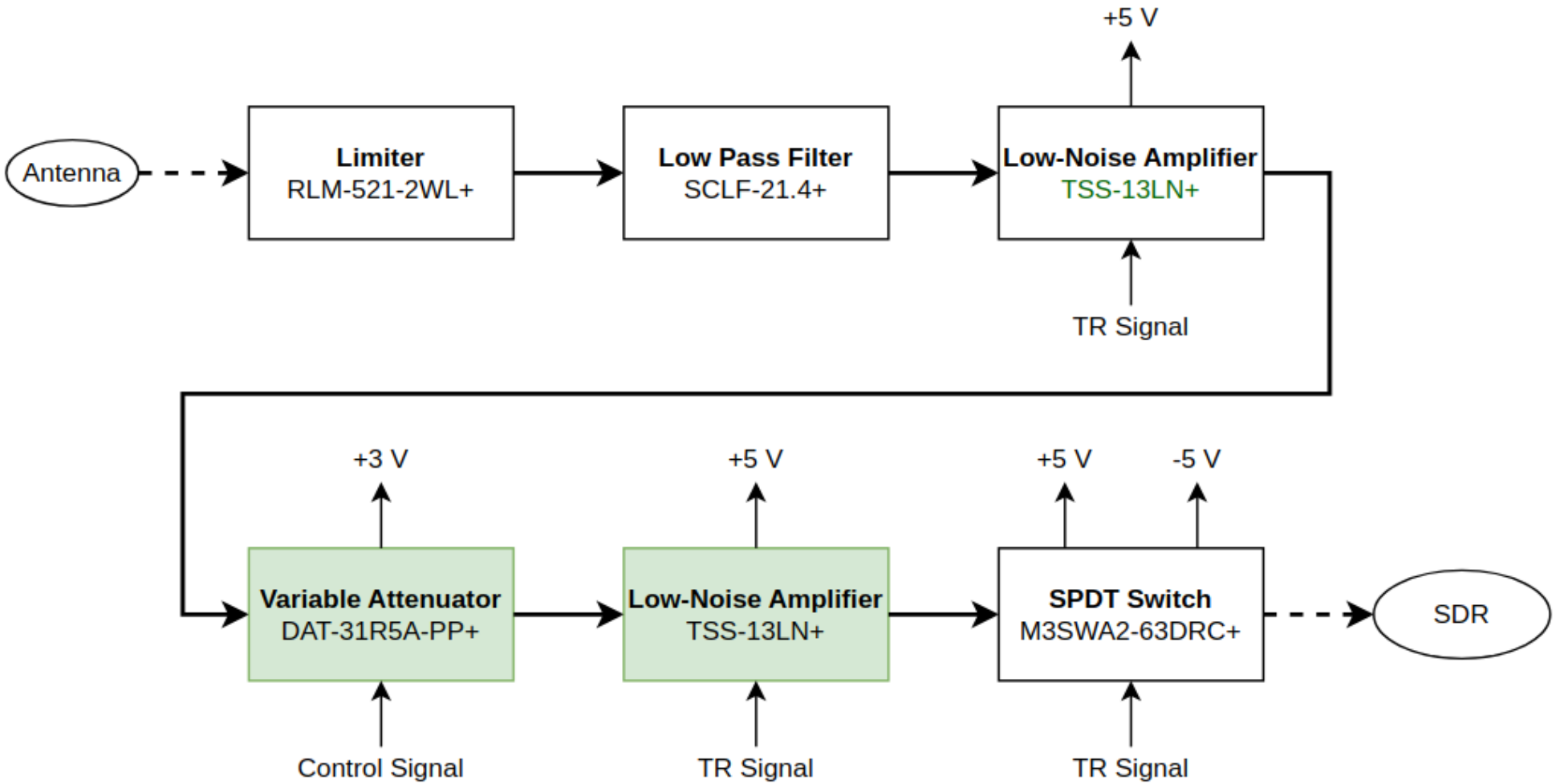




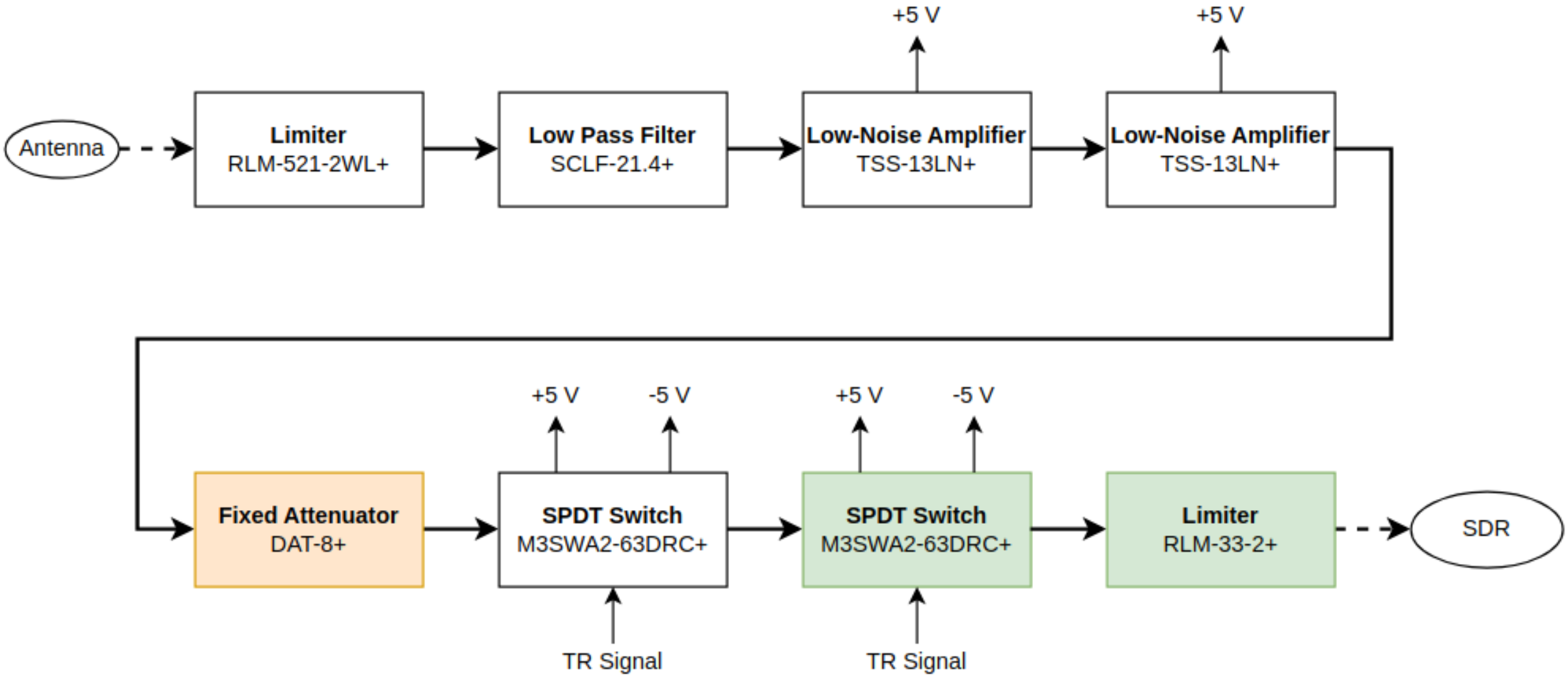
First Revision



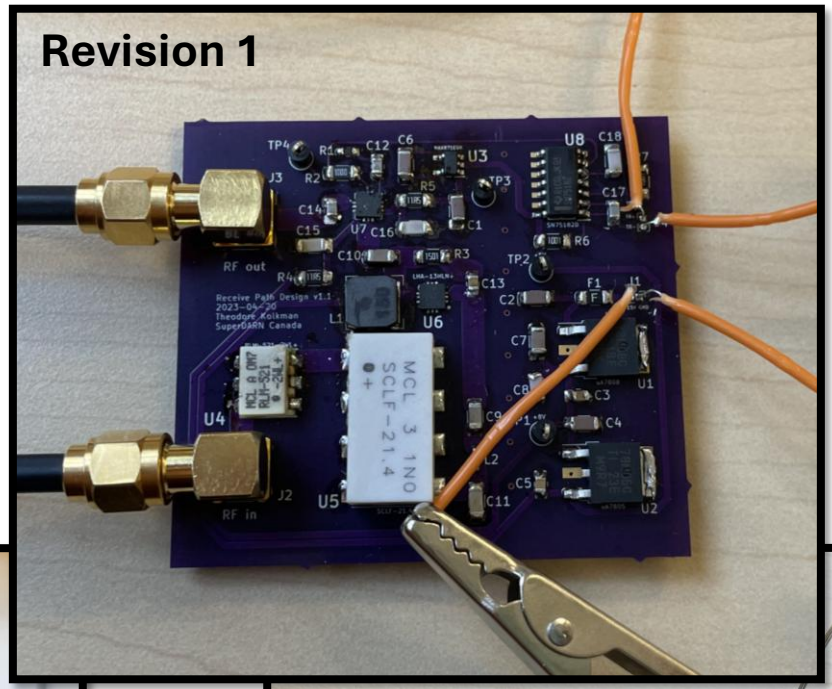
Second Revision

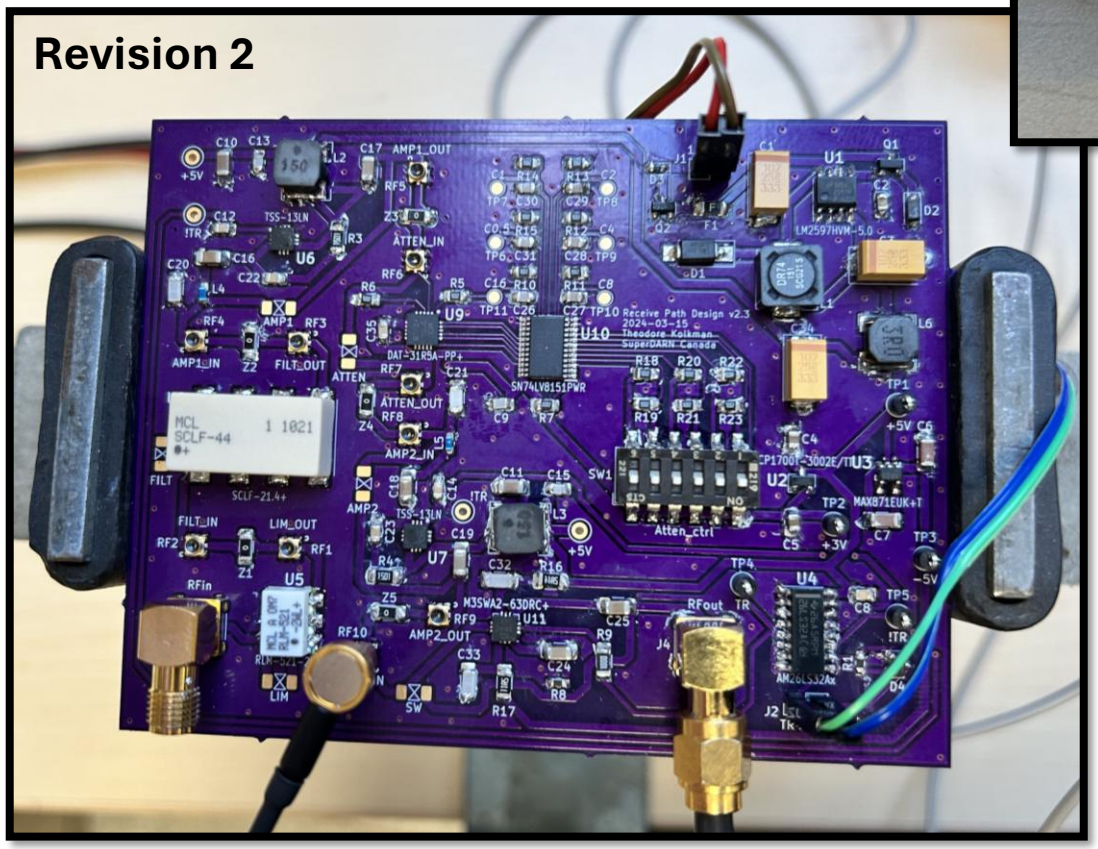


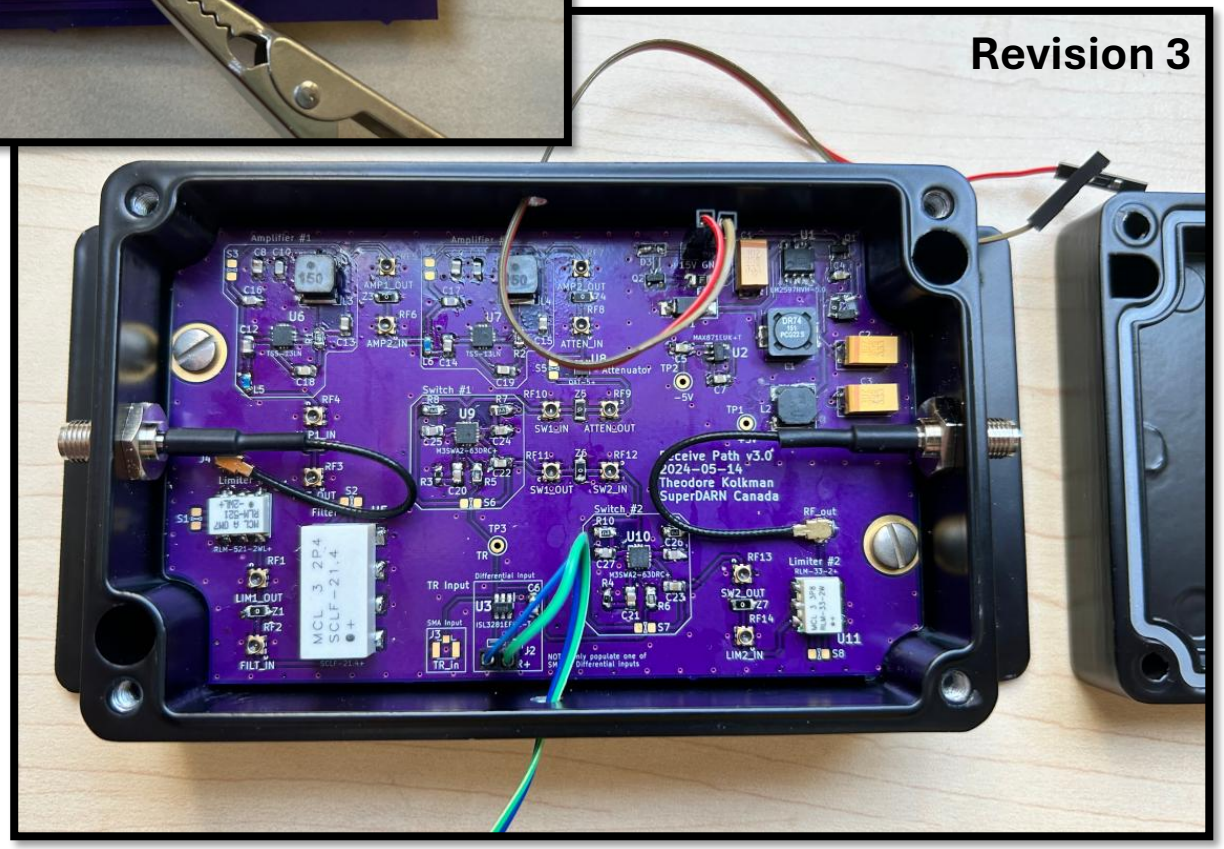
Third Revision



Initial Revisions

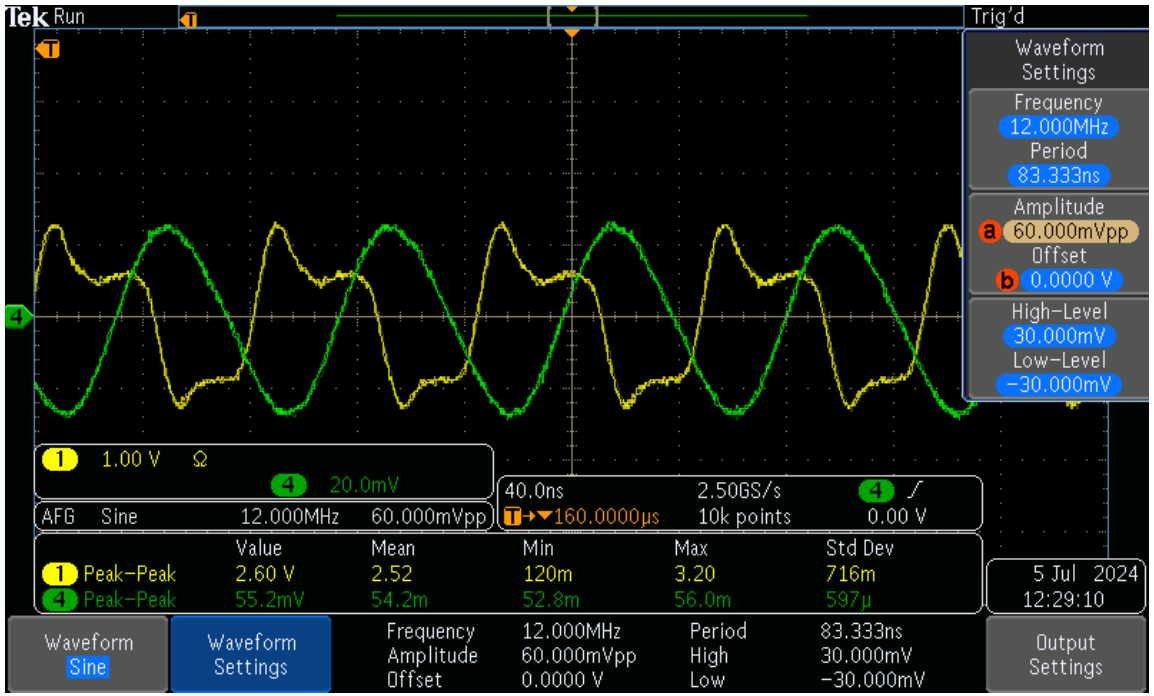


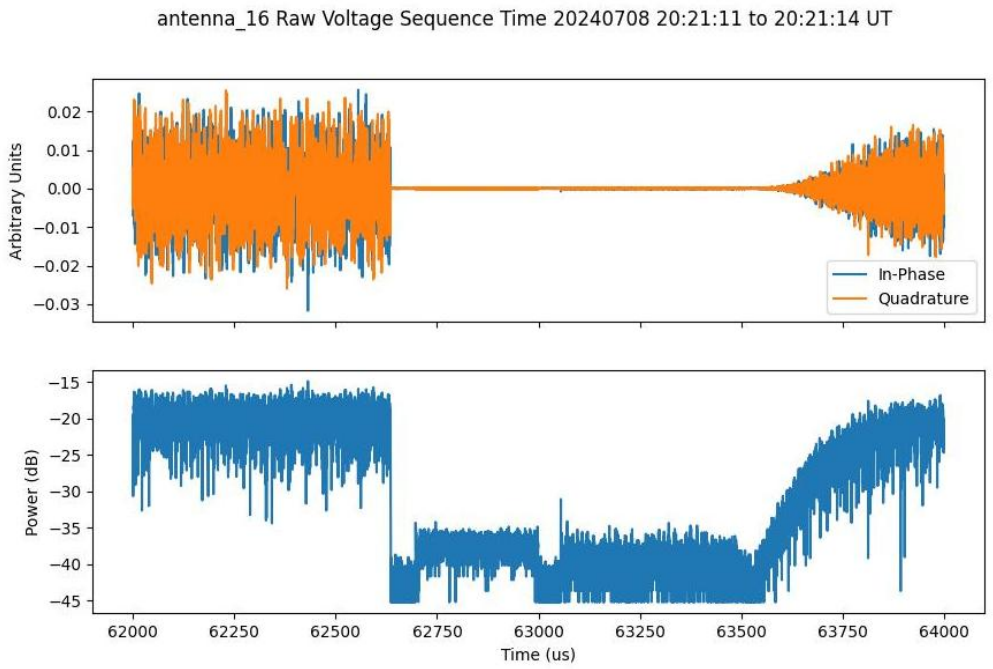




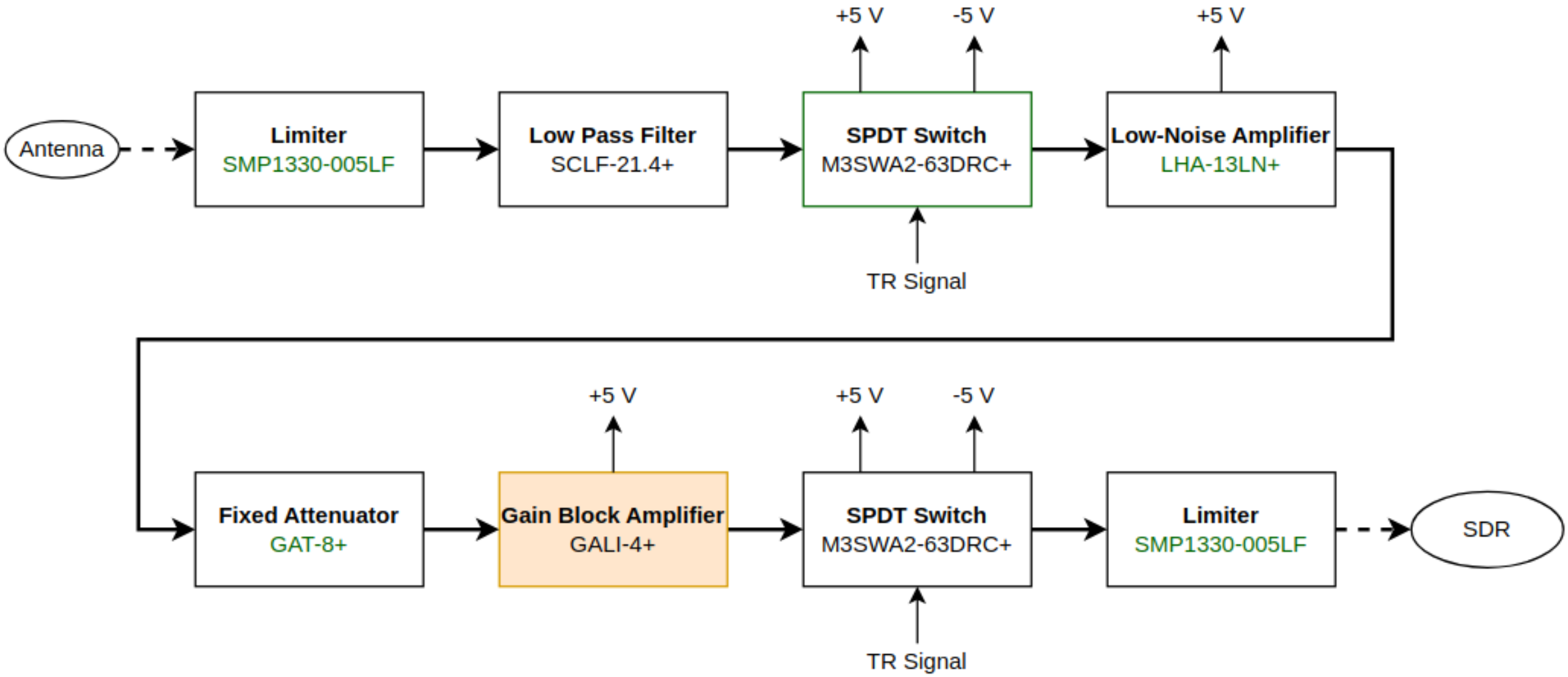
Issues Resolved

- Signal distortion at certain power
  - Reduce amplification, change device order
- Site test: Interferometer failed due to high input power
  - Move switch in front of amplifiers

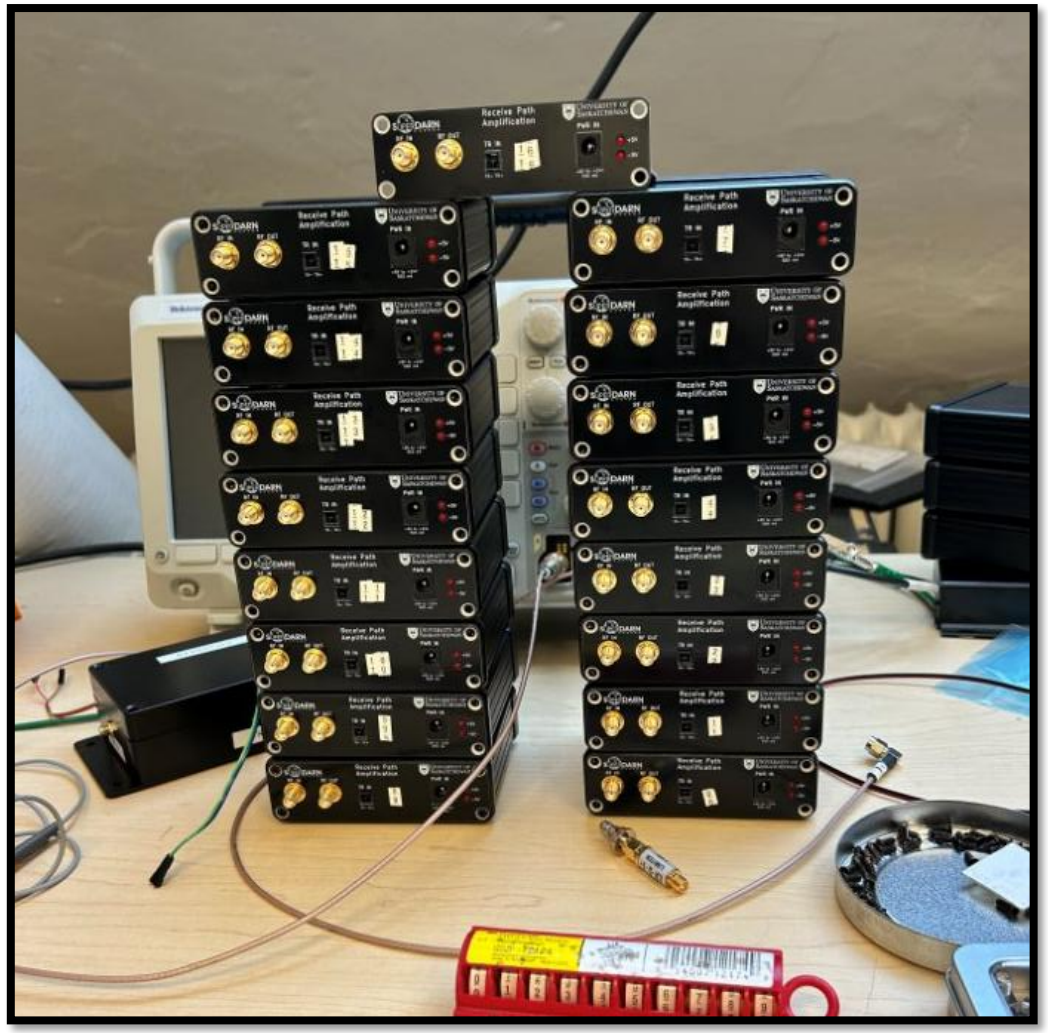




Final Revision

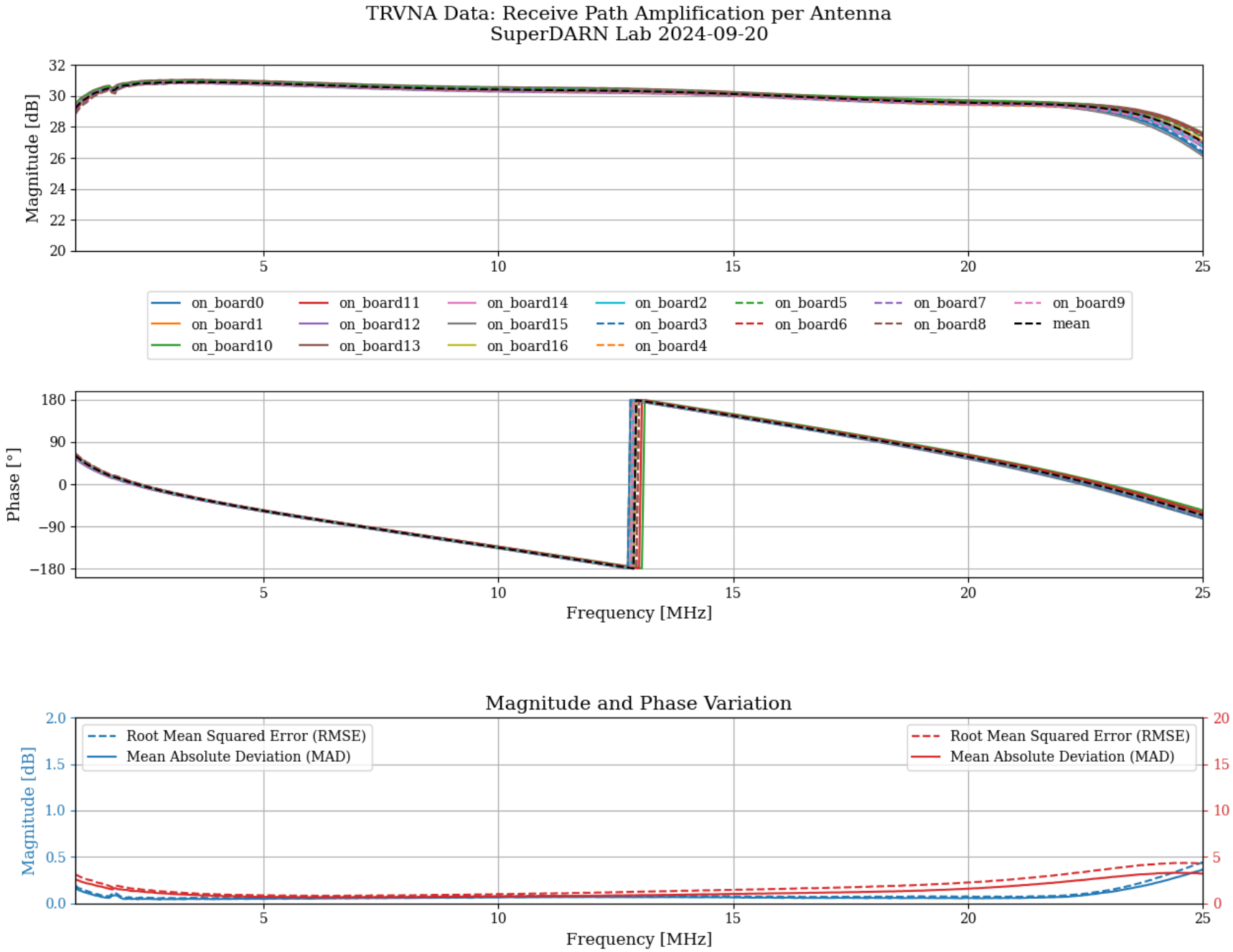


Final Revision

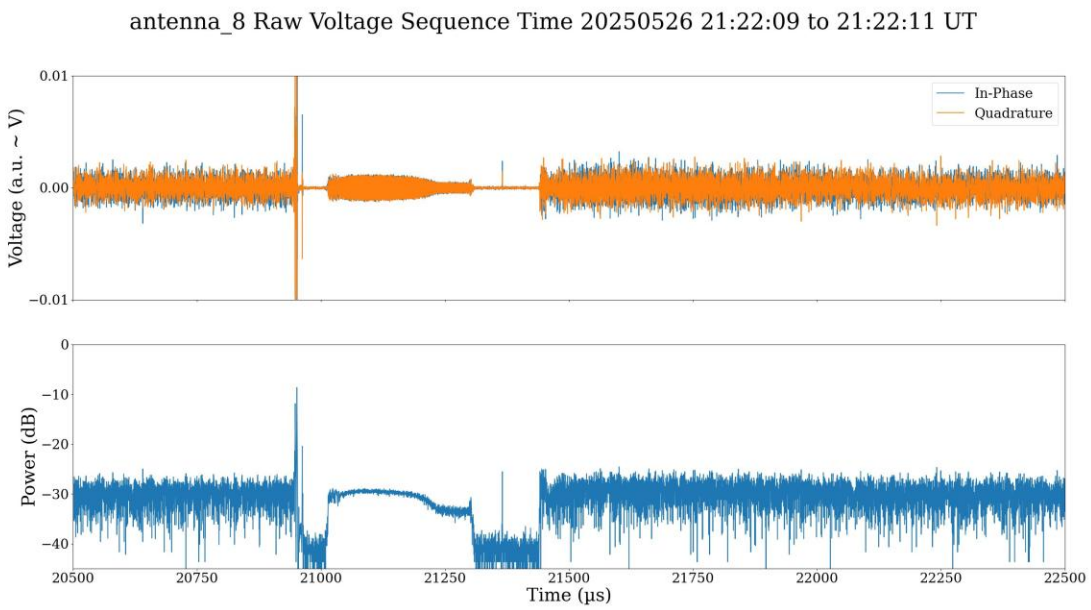


Final Testing

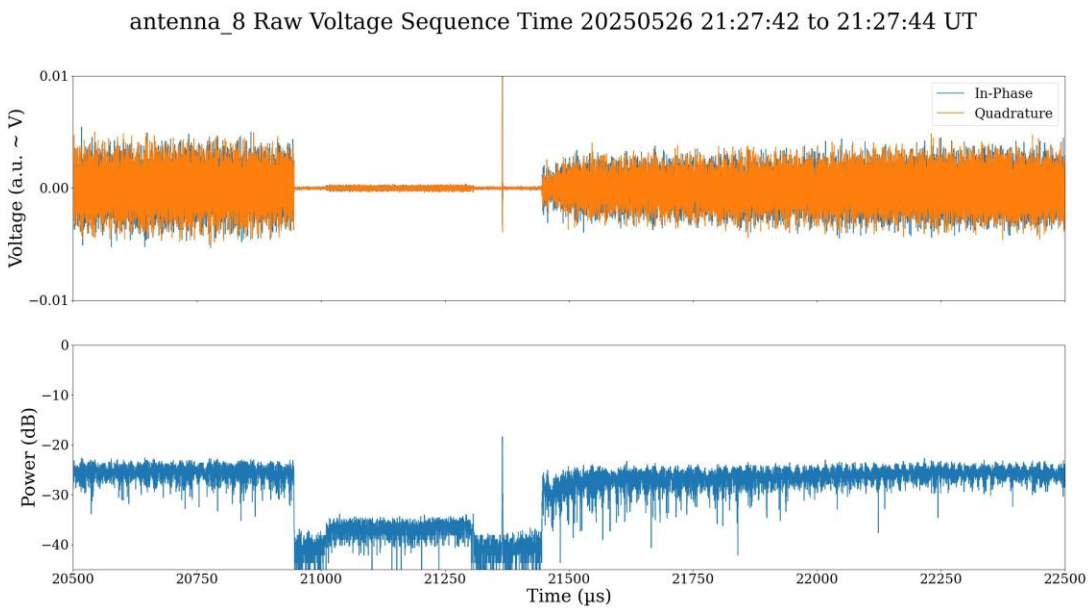
- Amplification: +30 dB
- Amplification deviation: ~0.1 dB
- Phase deviation: ~1°



Raw RF Pulse Comparison – Main

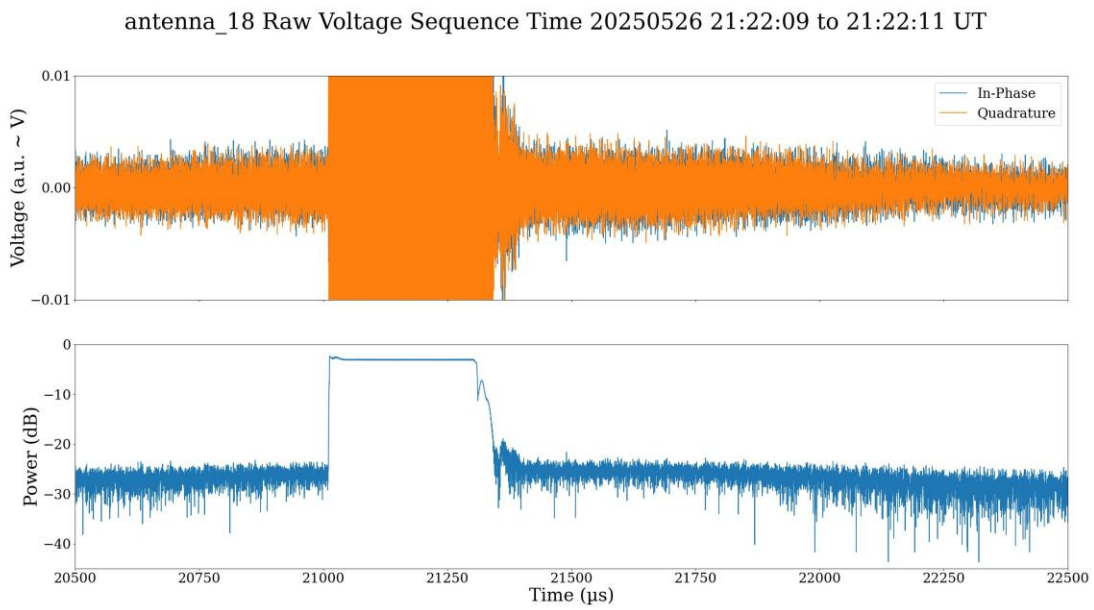


Old Receive Path

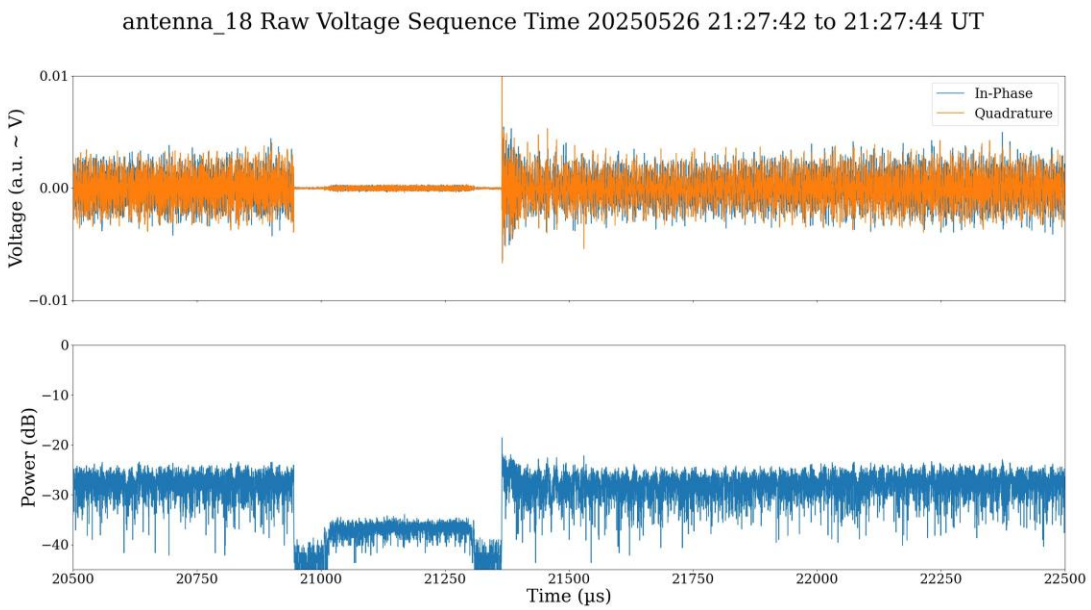


New Receive Path

Raw RF Pulse Comparison – Interferometer

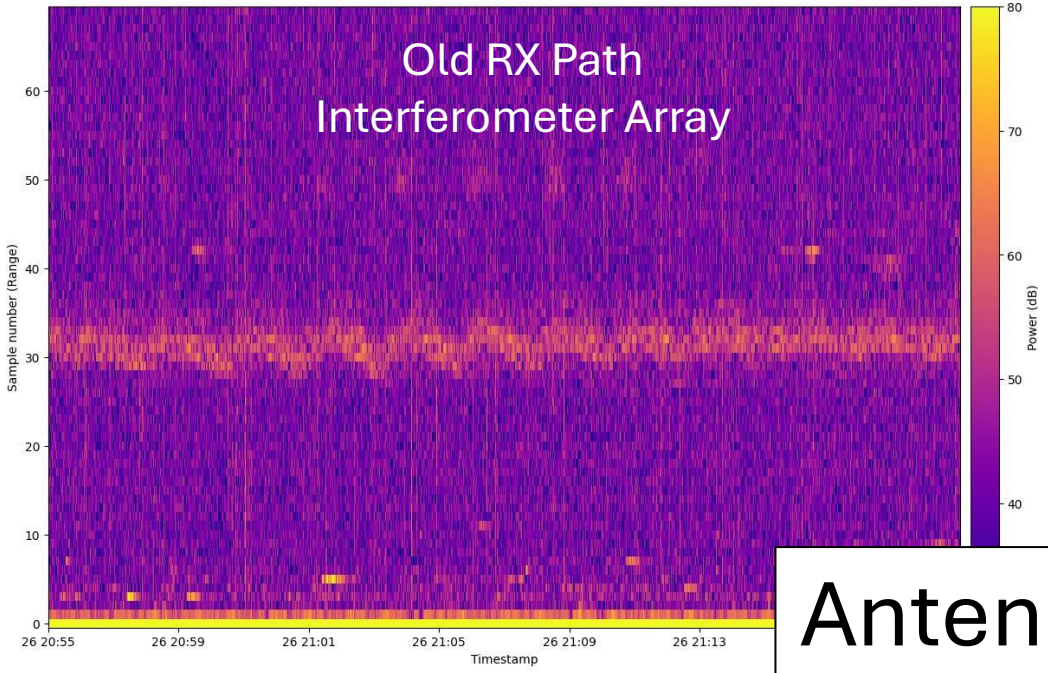


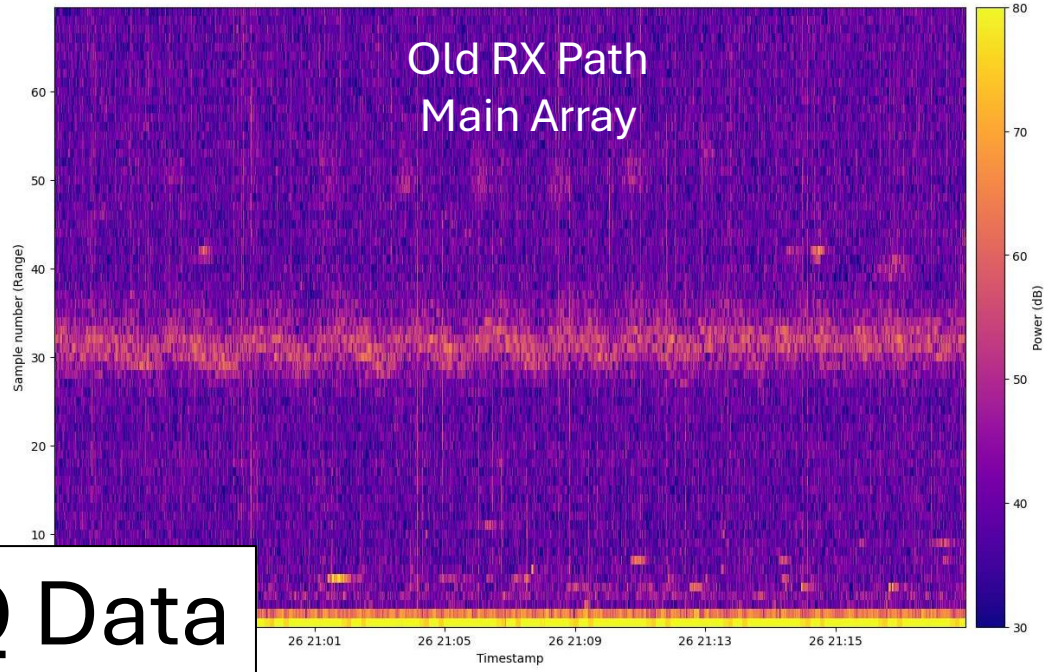
Old Receive Path

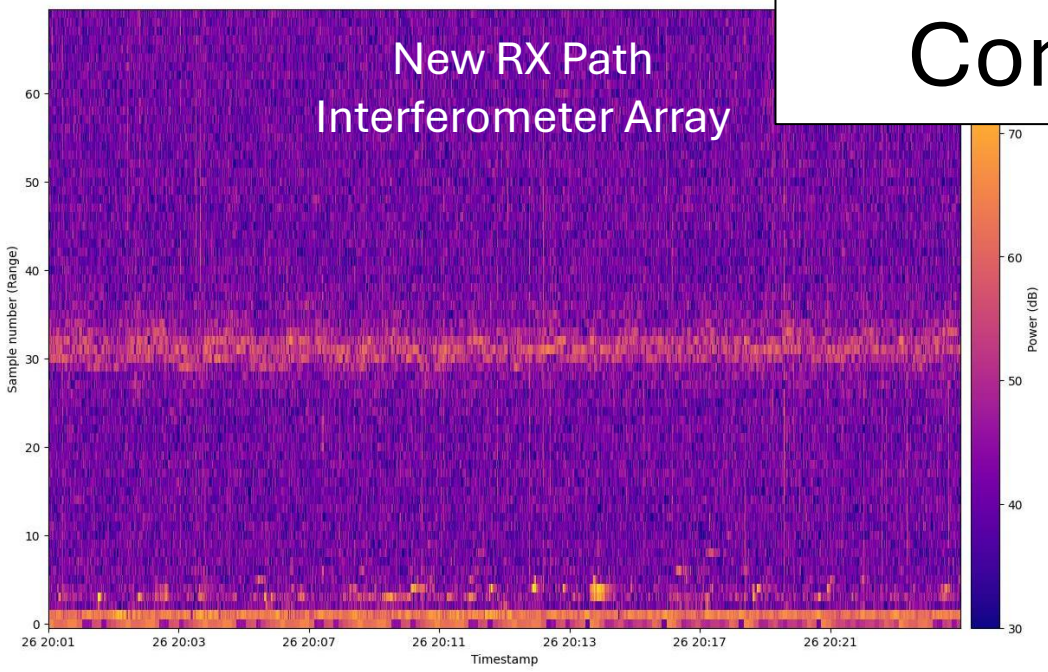


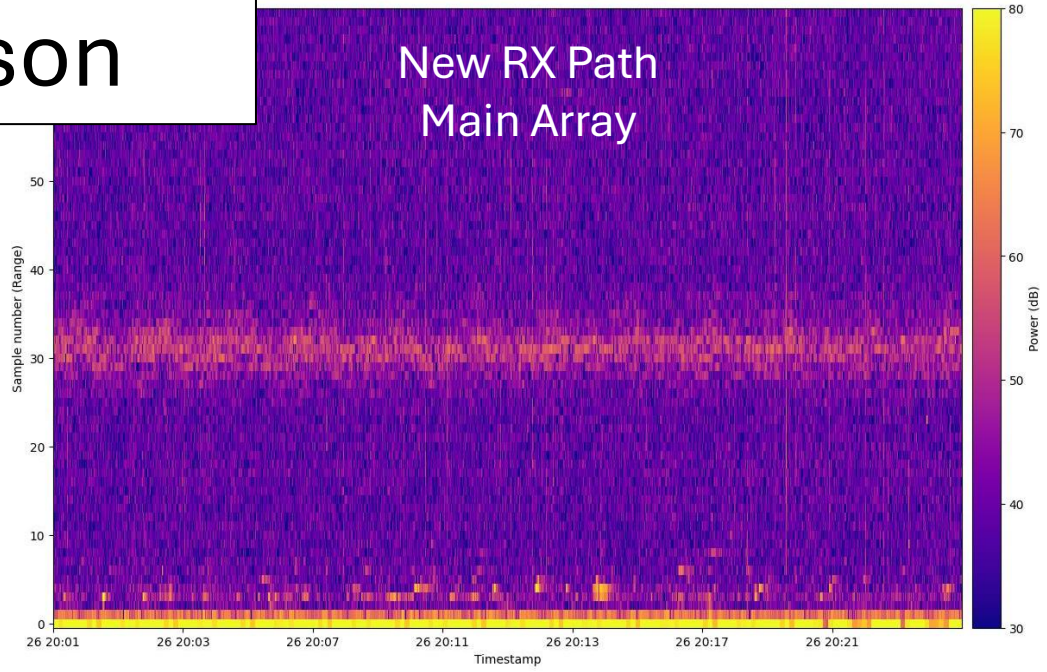
New Receive Path

Antennas IQ Data Comparison









Sample Number (Range)

Sequence Number (Time)

Installation Schedule

- October 2024:
  - Saskatoon (SAS)
- July 2025:
  - Rankin Inlet (RKN)
  - Clyde River (CLY)
- Summer 2026:
  - Prince George (PGR)
  - Inuvik (INV)

Thank you for listening!