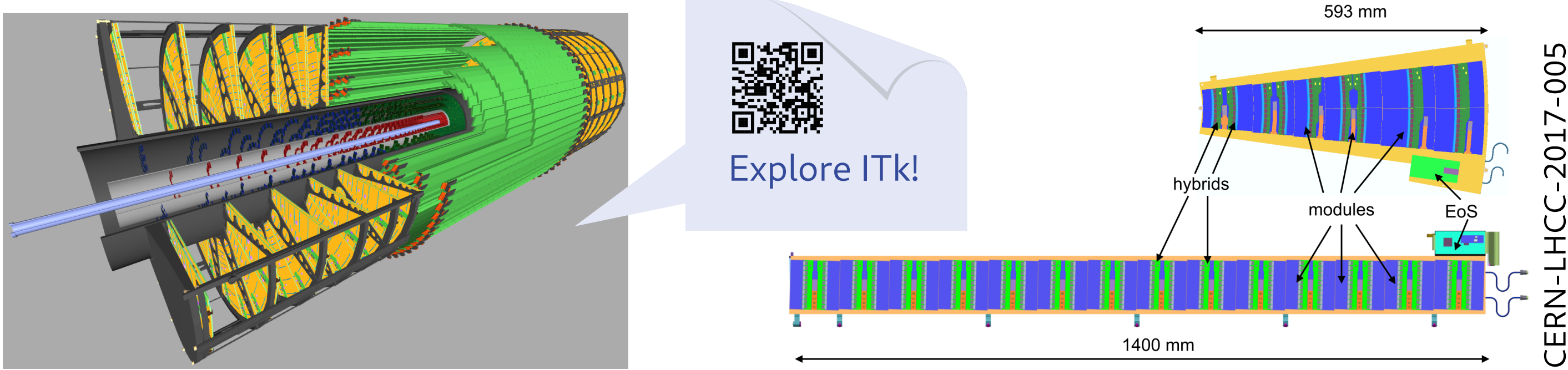


Roland Koppenhöfer¹ and Dennis Sperlich¹ for the Freiburg ITk Strips Group

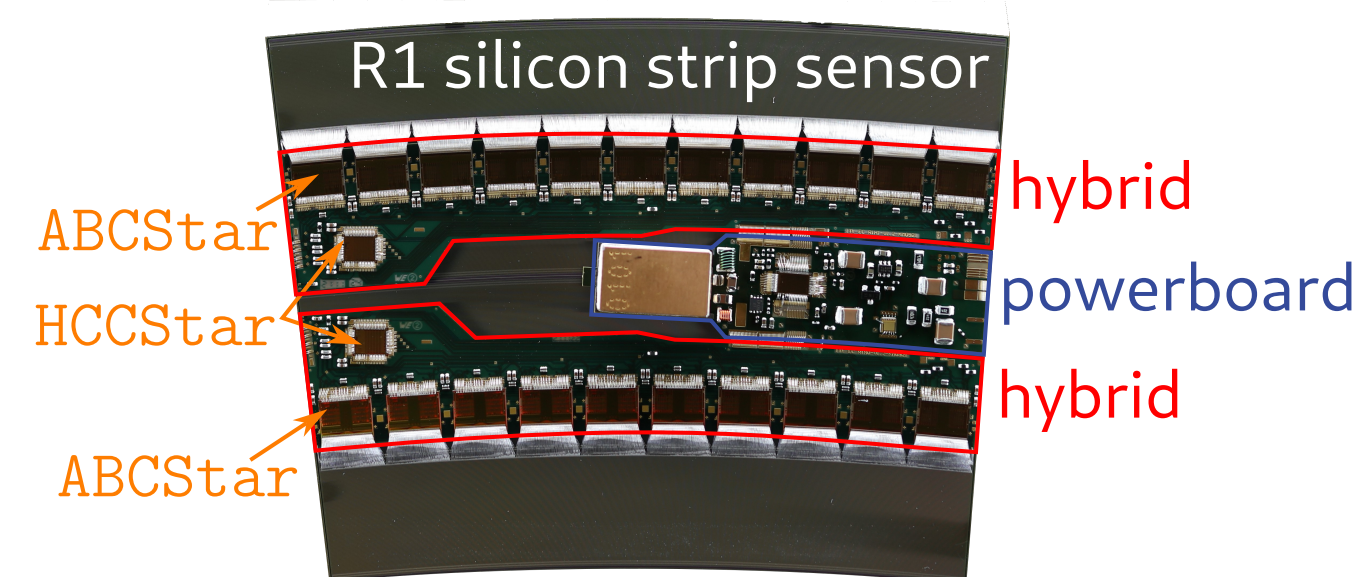
ATLAS ITk Strip Detector

- **ATLAS:** general-purpose detector at Large Hadron Collider at CERN
- New all-silicon tracking detector (ITk) for High-Luminosity LHC
- **ITk Strip detector:** strip modules located at radii $r \geq 384$ mm
 - **ITk Strip barrel:** staves with 14 detector modules per side
 - **ITk Strip endcap:** petals with nine detector modules per side
 - Radially oriented strips in **six module flavours** R0 to R5



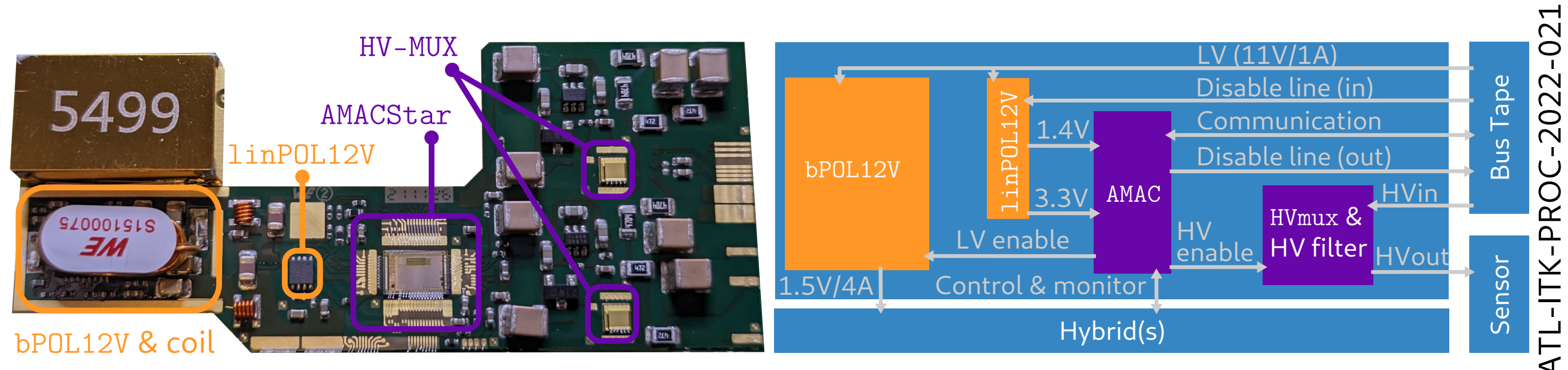
Endcap Strip Module Design

- **Silicon sensors:**
 - 320 μm thick, n^+ -in- p doped
- **Hybrids:** glued onto silicon sensor
 - Polyimide flexible PCBs (*flex*) housing readout and aggregation ASICs

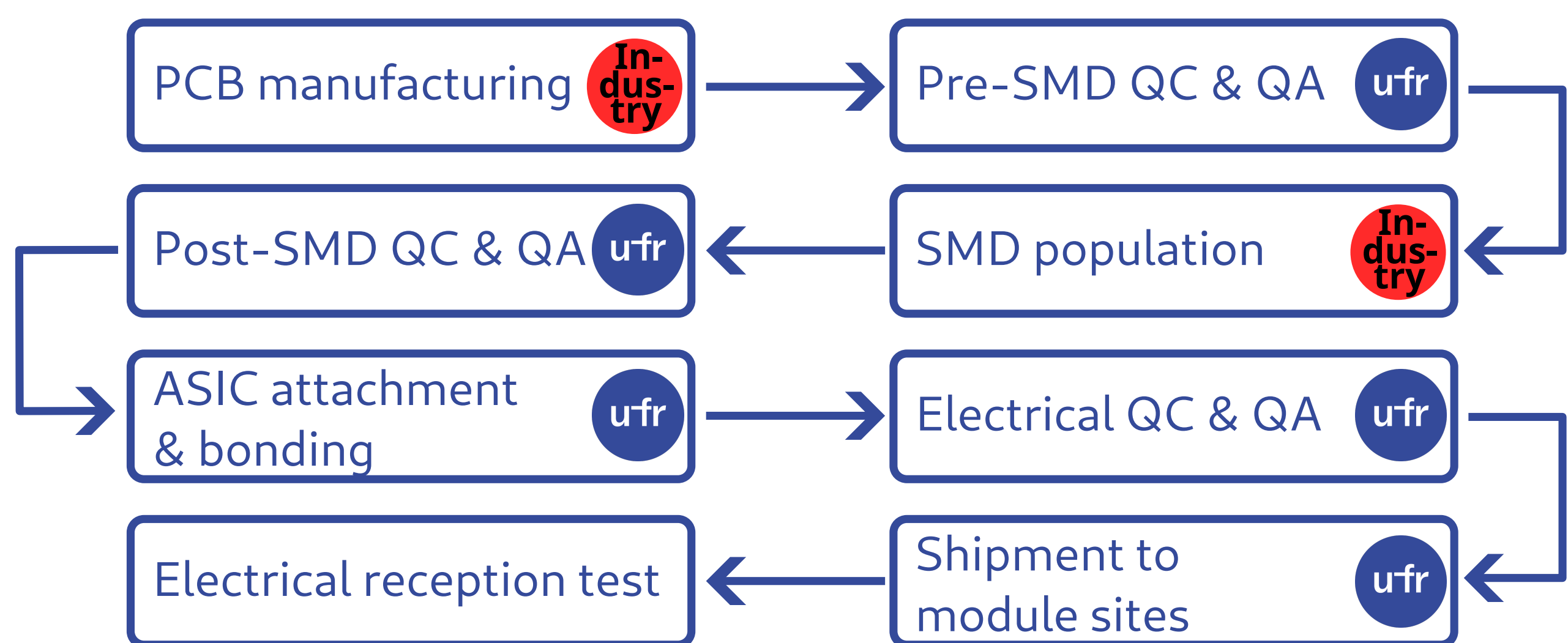


Powerboard: glued onto silicon sensor

- Polyimide flexible PCBs housing voltage sources
 - **On-module DC-DC buck converter** bPOL12V for hybrid(s) power
 - **Linear regulator** linPOL12V for ASIC power
- **Control and monitoring ASIC** for voltages and temperatures (AMACStar)
- **High voltage filter circuitry and GaN FET HV-MUX** for sensor biasing



Flex Production and Testing Flow



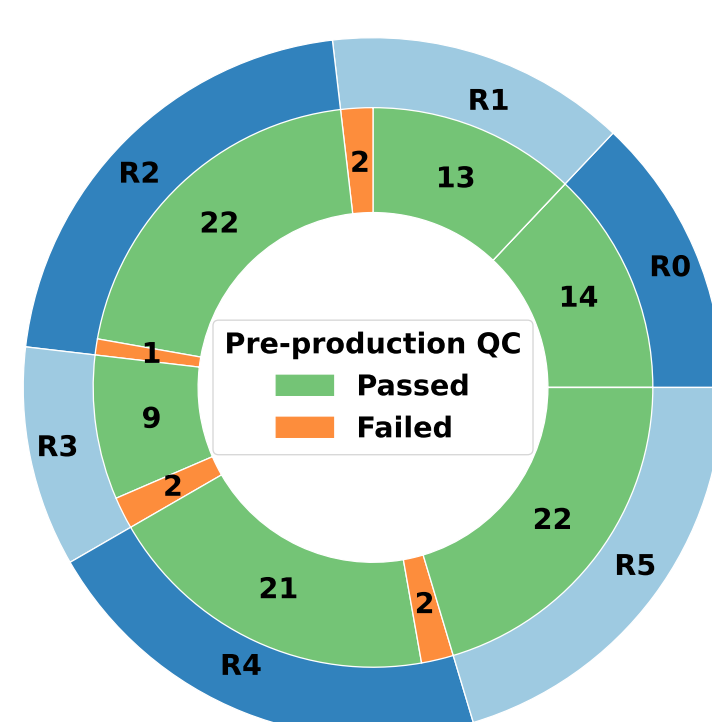
Assembly Status

Pre-production:

- 270 powerboards assembled (≈ 45 per type)
- Electrical QC done for 108 powerboards: **yield 93%**

Production:

- Slow ramp-up to validate latest design since May 2024 \Rightarrow 126 powerboards until 08/2024
- **5600 powerboards** to be assembled **until Q2/2026**
- Necessary assembly rate in full production: **8 powerboards / week / type**
- Testing capacity: **15 powerboards / week / type**



QC and QA Procedures

Flex QC (pre and post SMD)

All flexes:

- Cleaning and visual inspection
- Envelope check

Individual flexes per sheet:

- Thickness measurement
- Thermal cycling (reflow profiles)
- Bond pull tests
- R and C measurements
- Metrology

Flex QA (pre and post SMD)

- Irradiation tests
- Thermal shock and cycling tests

Electrical QC

All powerboards:

- Electrical tests at 20°C and -50°C
- 10 thermal cycles (-50°C to +30°C)
- 100 h operation at 3 A load

Electrical QA (planned)

Powerboards on a sample basis:

- Additional thermal cycles ($n \gg 10$)
- Operation at 3 A load for $t \gg 100$ h
- Irradiation and magnetic field tests performed on module level

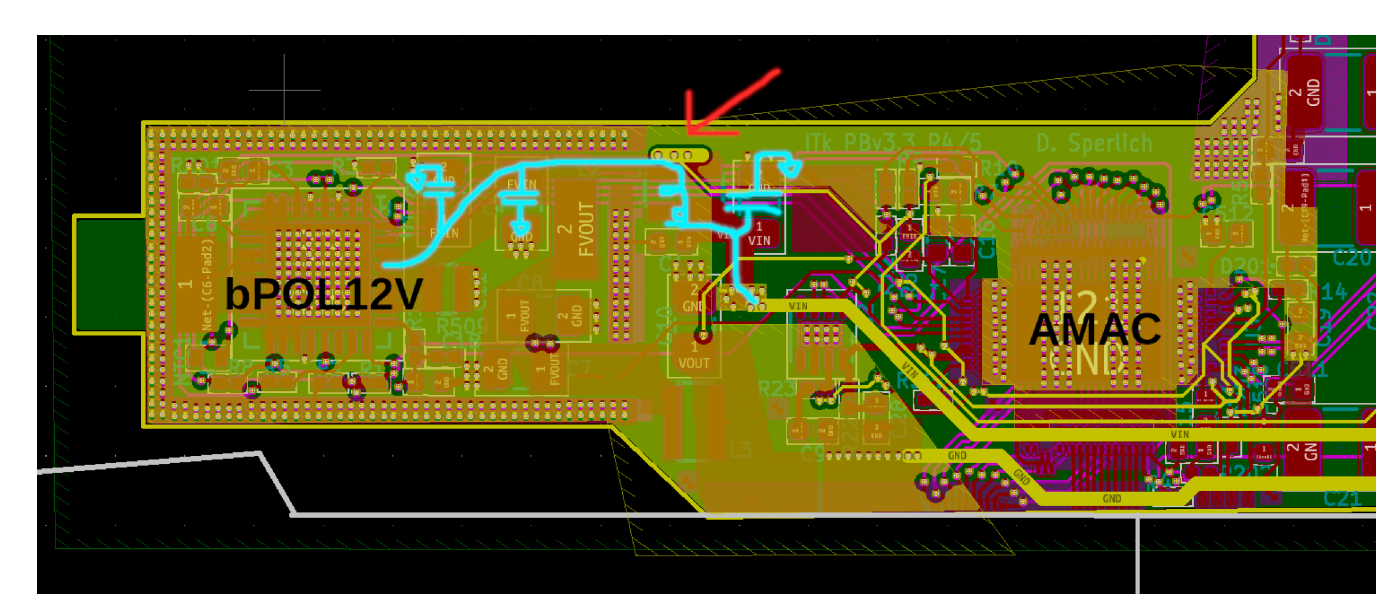
Design Changes during Pre-Production

- **Limited availability of powerboard types during prototyping**

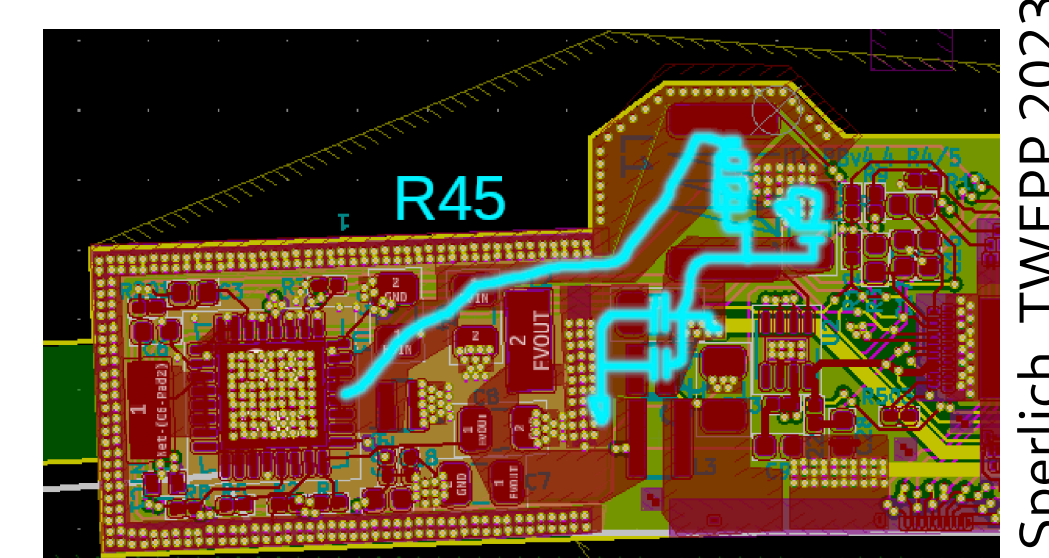
\Rightarrow Few module types first properly assembled in pre-production

Increased Noise on R3, R4 & R5 modules: presented at TWEPP 2023

- Restriction in GND plane \rightarrow high impedance in GND path of input pi filter
- Re-arrangement of components and GND plane locations
- Additionally increase inductance of input pi filter



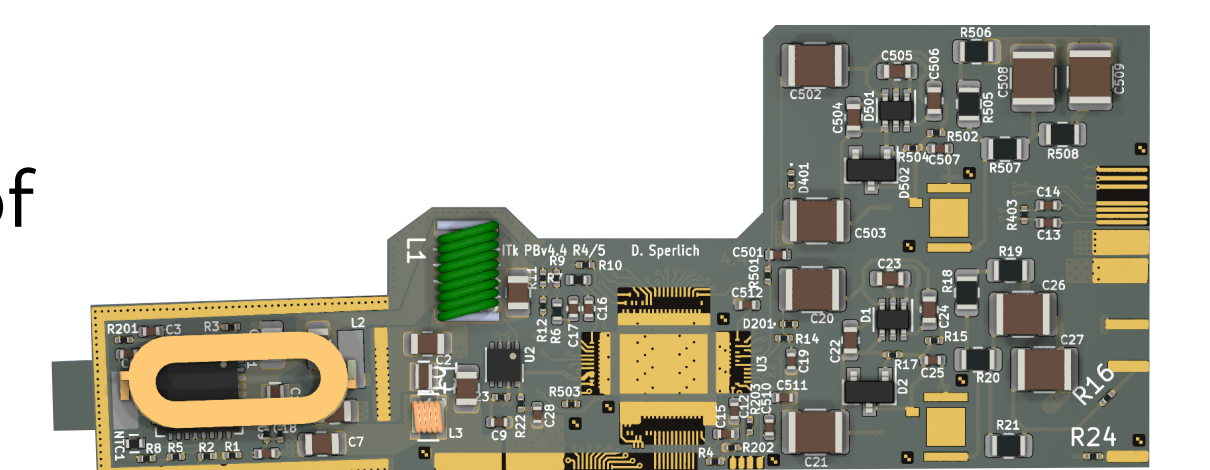
Design with GND plane restriction (red arrow)



Updated flex design

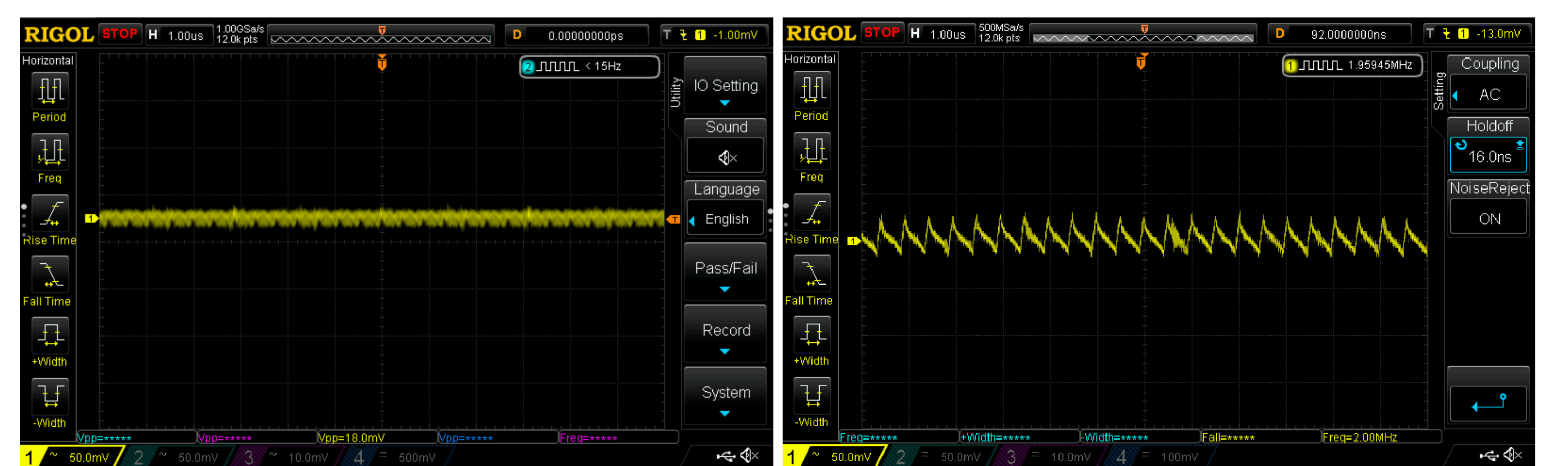
"Concave" Powerboards:

- Insertion simulation of petals: near collision of R5 shieldbox and carbon fibre observed
- Outline change for R4 & R5 flex



Voltage Ripples on bPOL Output;

- 01/2024: Modules built from latest powerboard batch show increased noise
- Correlation with voltage ripples on bPOL output line
- Suspected cause: broken vias due to batch-related flex quality issue
- Overlooked in electrical QC due to rapid prototyping assembly
- Developed additional electrical QC tests



bPOL output voltage for normal powerboards

Voltage ripple for problematic powerboard

Conclusions and Outlook

- Flex and electrical QC procedures at University of Freiburg established
- **Design changes during pre-production necessary** to solve weaknesses:
 - Latest observed noise problems due to batch-related flex quality issue
 - **Flex design and QC procedures successfully adapted**
- **Production started and ramp-up ongoing**