Progress on designing a dedicated electrical test board for the IZM structure

Universität Siegen, October 30th, 2025

The HEP Group and the Electronics Laboratory

We are interested in designing a PCB to host and electrically interface the **IZM structure** with **emphasis on characterizing the data transmission lines**.

• We need a **supporting PCB** with the necessary wire bond pads and some routing of traces, as well as appropriate connectors to interface the differential pair to the measuring equipment.

• Apart from the careful design of the high-speed traces, we must understand **how to achieve impedance matching**, in principle and in practice, **for the wire bonds** connecting the transmission lines of the structure to the traces and connectors on the PCB; another test board to study the matching.

• Use the **simulation software Ansys** (HFSS and SIwave tools) for modeling the structure and calculating the electrical properties of differential pairs.

Using our Tektronix **differential TDR device** (BW 20 GHz), the following measurements can be taken:

- **S-parameters**: input reflection coefficient (S11) and transmission coefficient (S12).
- **Impedance profile** of differential pair traces.

- From it, we can build an electrical model of the transmission line from the S-parameters for use in SPICE simulation.

- Predict the **maximum transmission rate** with the simulation.
- Verify this rate and **measure the bit error rate** as a function of the transmission rate.

On the IZM structure we have **six** Differential Transmission Lines in **M2 metal** layer with WB pads in M3 on left side:

a) open at the end: vias from M2 to M1 and Al with "buried pads" (not accessible); the lengths of pairs 1-4 are**:**

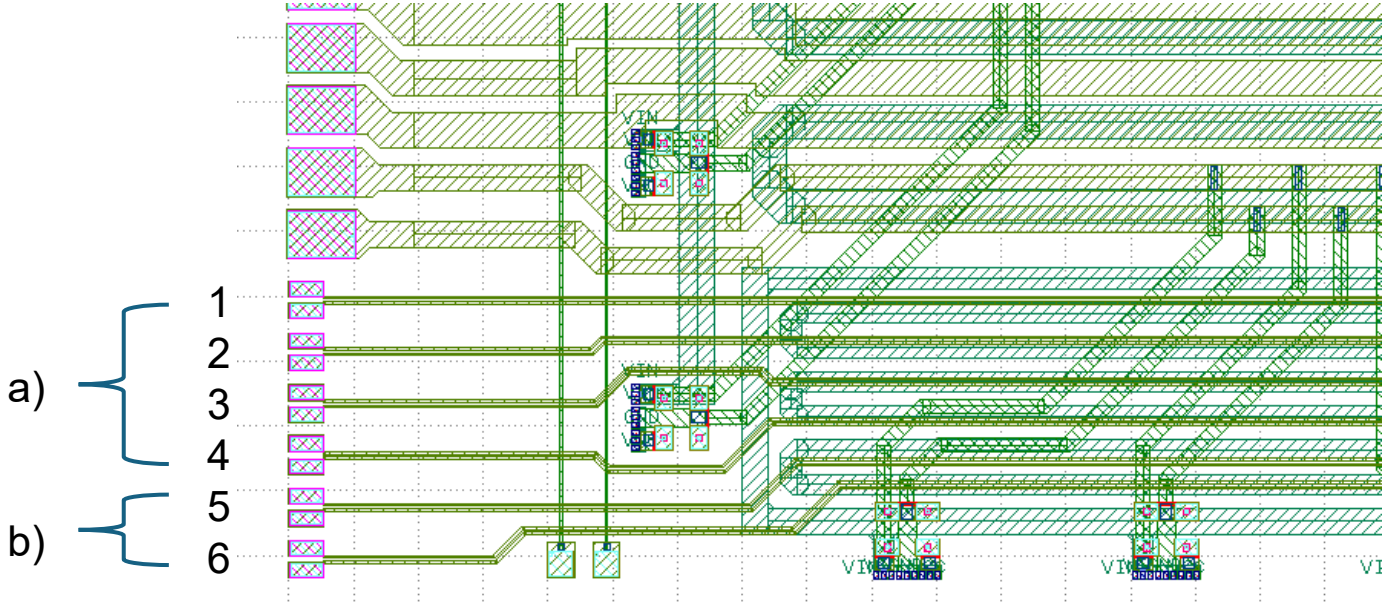
1 => ~12 cm
2 => ~ 9 cm
3 => ~ 6 cm
4 => ~ 3 cm

→ Possible measurements: reflection coefficient, and impedance profile.

b) full length pairs, ~12 cm, with four intermediate bridges in M1, at the end with WB pads in M3 (300µm x 210 µm)

5 => ~12 cm
6 => ~12 cm

→ Possible measurements: reflection and transmission coefficients, and impedance profile.



Brief overview of our activities

• Two IZM structures with their ‘front and back parts’ cut off arrived in Siegen.
Thank you, Andreas and Marco!

• Our Master's student, **Darshil G. Vagadiya** has taken precise measurements of the structure's geometry.
This has provided us with the distances between the wire bond pads and the edges of the structure.

• **Stefan** is working on evaluation PCBs for studies of the IZM structure and the wire bonding impedance matching.

• **Darshil** is preparing a laboratory setup to measure the ohmic resistance of the traces.
This involves electrically connecting the traces on their pads using four probe needles and applying a measurement using a Keithley Source Meter Unit.

• Preparing for the Ansys simulation:
- A new computer has been purchased.
- Access has been obtained to the Ansys software under the university licence agreement.
- Installation of the software packages under a Linux operating system is in progress.

PCB design for testing and studying the impedance matching of the wire bonds

Implemented are four groups of 20 cm long structures:

- **A. Singel-ended strip transmission line:**
  1. made of segments with 4 mm wire bonds and 1 cm traces,
  2. made of segments with 1 mm wire bonds and 1 cm traces,
  3. long trace only as reference,
  4. made of 1 mm wire bonds and bond pads only.

- **B. Differential strip transmission line:**
  5. made of segments with 1 mm wire bonds and 1 cm traces,
  6. long traces only as reference.

- **C. Differential two-wire-balanced transmission line (no ground reference):**
  7. made of segments with1 mm wire bonds and 1 cm traces,
  8. long traces only as reference.

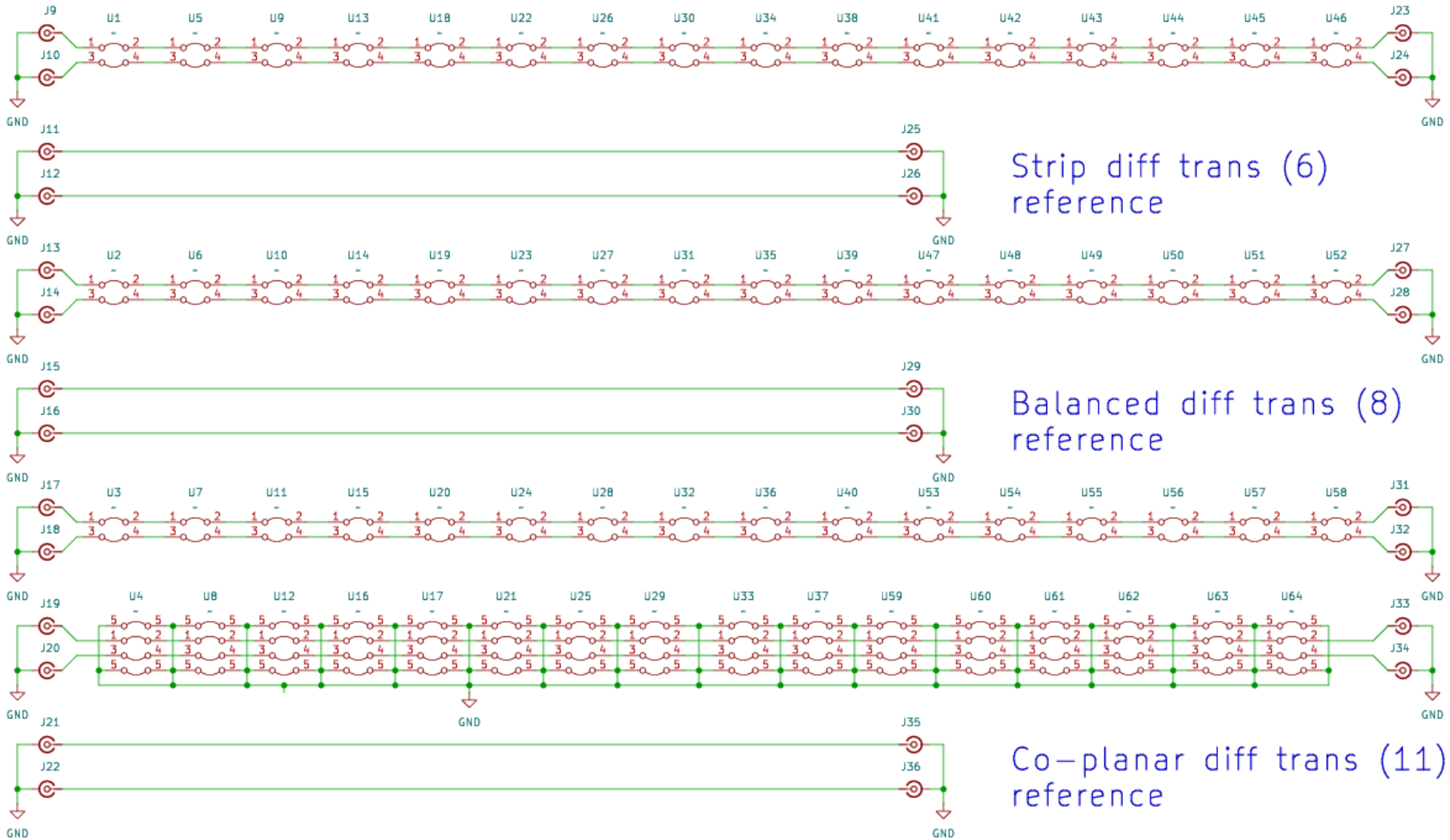
- **D. Differential co-planar transmission line:**
  9. made of segments with 1 mm wire bonds and 1 cm traces,
  10. made of segments of 1 mm wire bonds and 1 cm traces plus two guarding wire bonds,
  11. long traces only as reference.

PCB design for testing and studying the impedance matching of the wire bonds

- All traces are 280 µm wide.
- The structures are suitable for single, double and triple thin wire bonds (25 µm), as well as wide strip bonds.
- We plan to perform wide strip bonding with the help of external companies.

PCB design for testing and studying the impedance matching of the wire bonds

PCB design for testing and studying the impedance matching of the wire bonds



1mm Bonds
Strip diff trans (5)

Strip diff trans (6)
reference

Balanced diff trans (7)

Balanced diff trans (8)
reference

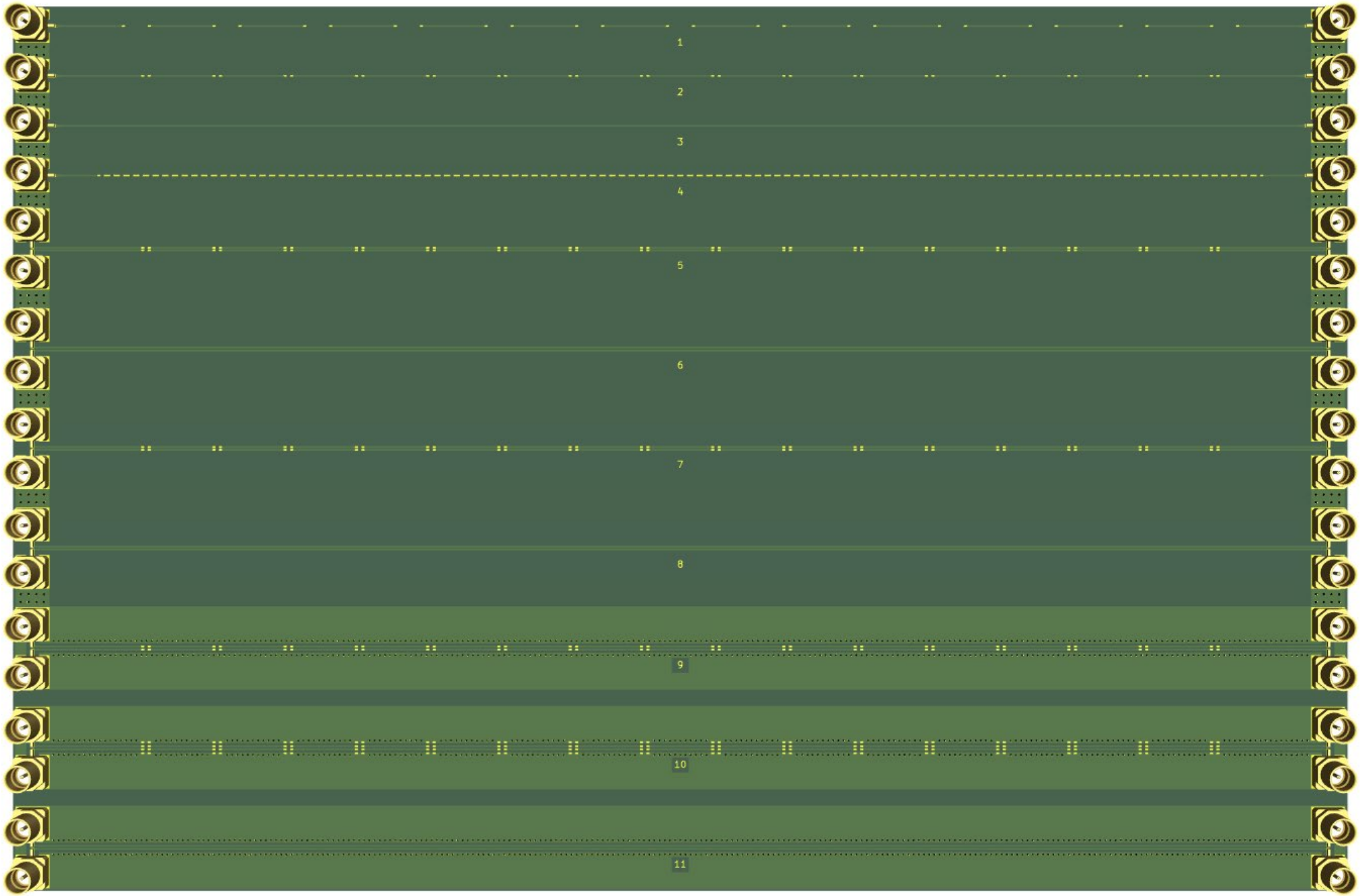
1mm Bonds, 1cm Trace (9)
Co–planar diff trans

1mm Bonds, 1cm Trace (10)
Co–planar diff trans
Guarding wire bonds

Co–planar diff trans (11)
reference

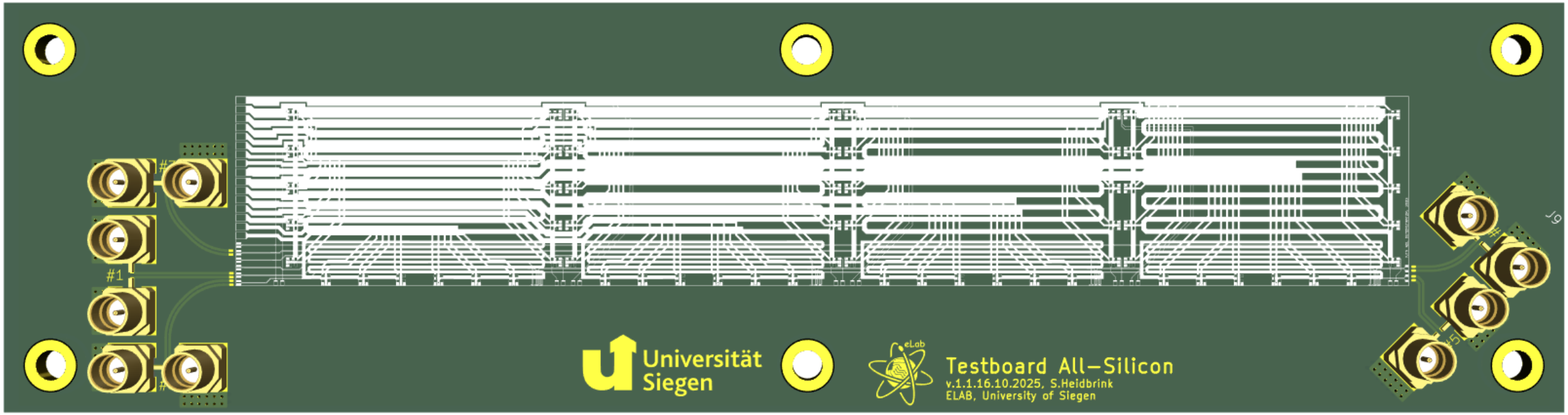
PCB design for testing and studying the impedance matching of the wire bonds

Implemented are four groups of 20 cm long structures:



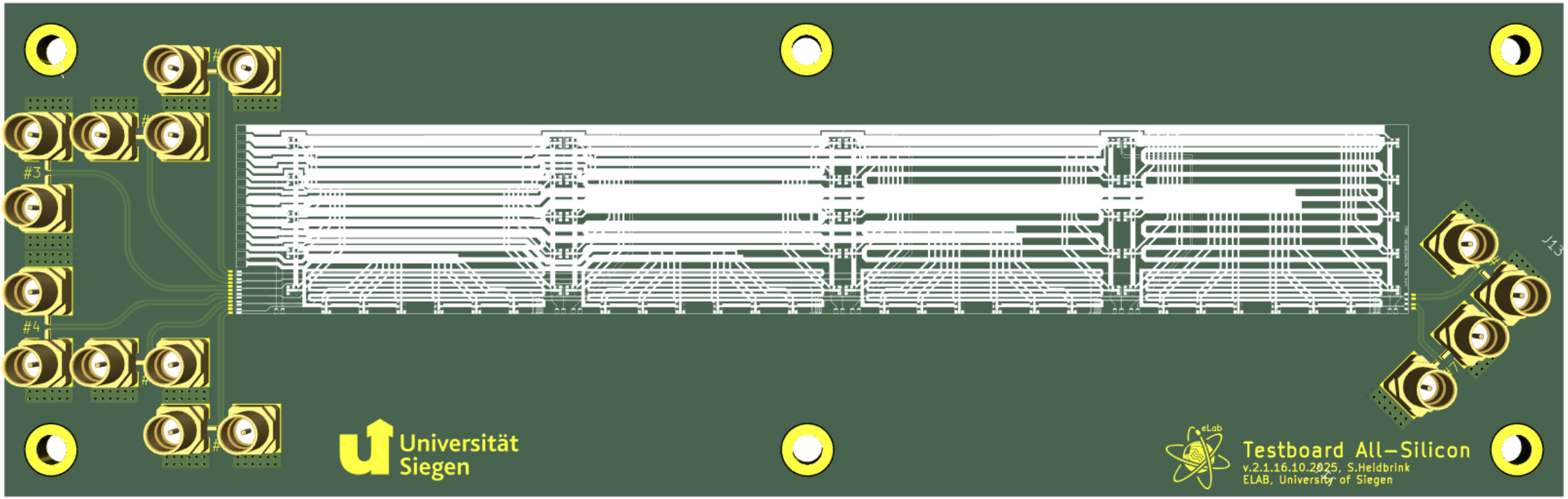
This is our preliminary PCB design for hosting the structure and interfacing with measuring devices:

A flavor “Short” optimized for short signal traces.
Four upper differential pairs share one pair of SMP connectors with optional wire bonding.



This is our preliminary PCB design for hosting the structure and interfacing with measuring devices:

A flavor “All” providing pairs of SMP connectors for all six differential pairs.



Outlook:

- Finalize the design of both PCBs → perform independent cross checks

- Submit designs for production

- Study the impedance matching for wire bonds

- Measure ohmic resistance of the traces on the IZM structure using a probe station

- Attache one of the IZM structures to the PCB

- Perform first measurements

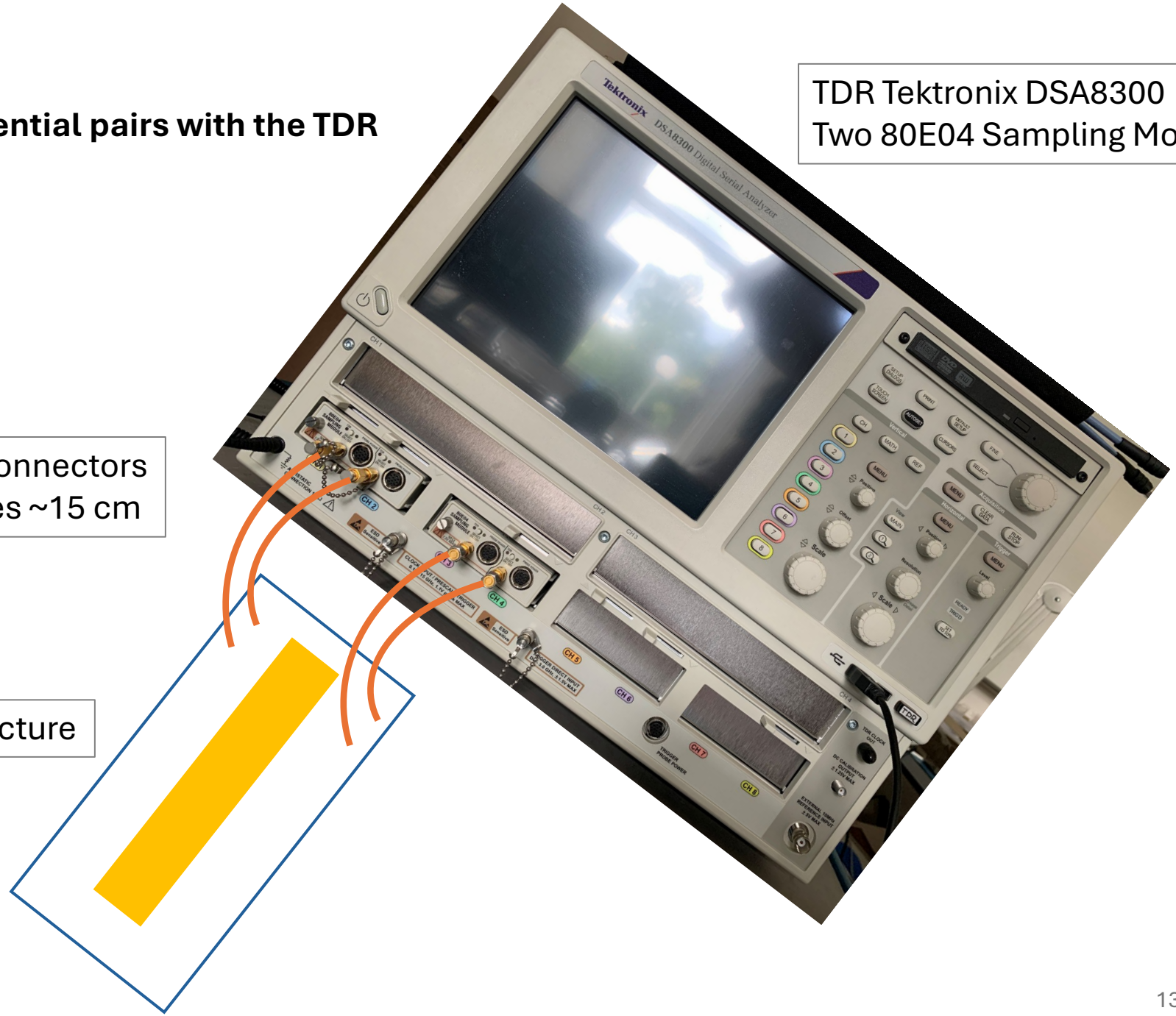
- Start learning how to use the Ansys software for electrical simulations in practice.

Example: Characterizing differential pairs with the TDR

TDR Tektronix DSA8300
Two 80E04 Sampling Modules

SMP micro connectors
coaxial cables ~15 cm

PCB with IZM structure



We will use a microwave small size connector of SMP type to allow for shorter traces on the PCB

We’ve got five

coaxial cables of 15 cm
SMA to **SMP** standard

bandwidth of 20 GHz

built by Mini-Circuits company