

Front-end Electronics of the Forward Strip Detector for the ATLAS HL-LHC Upgrade

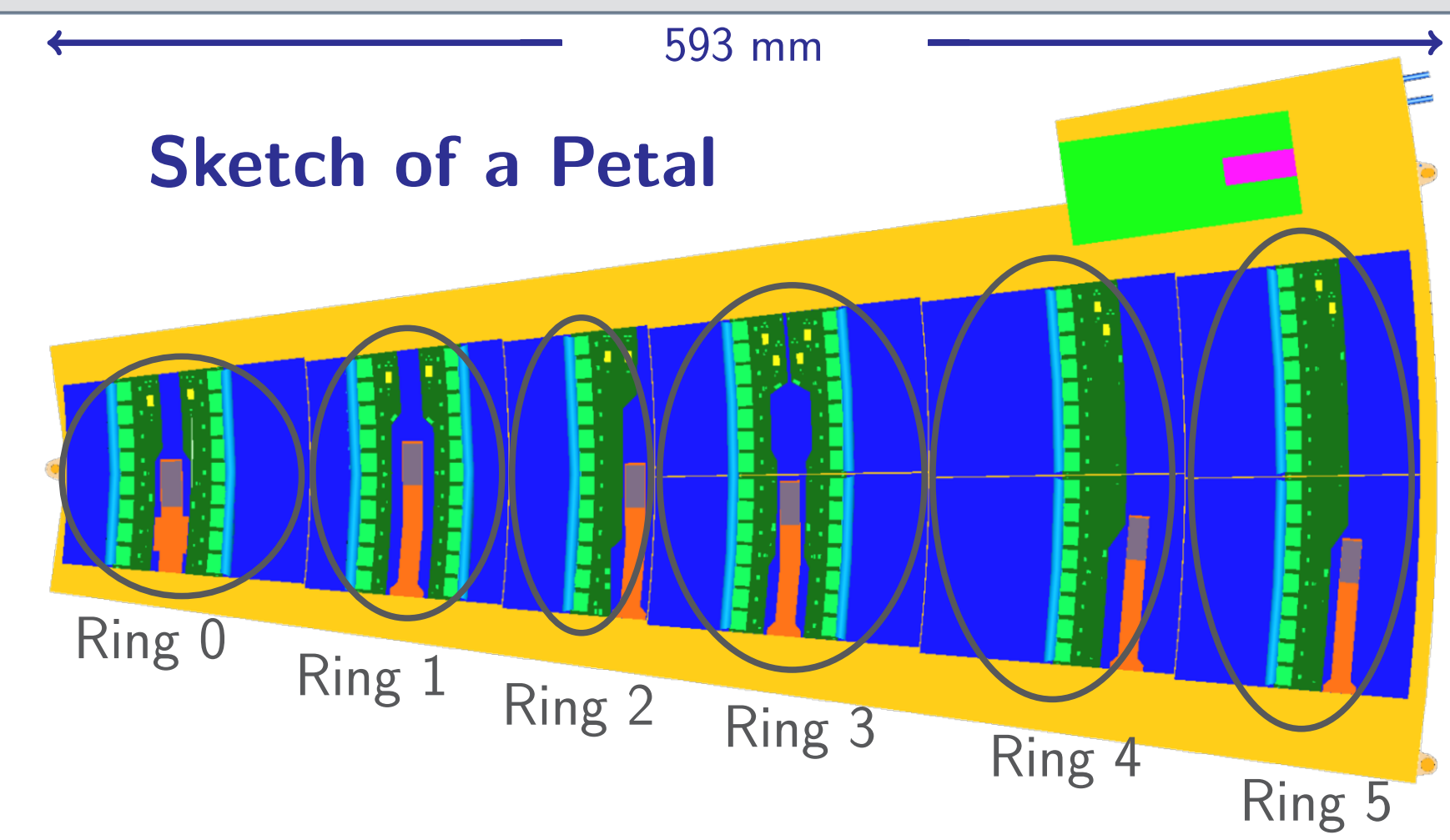
Carlos García Argos¹, Kambiz Mahboubi¹, Marc Hauser¹, Liv Wiik-Fuchs¹, Ulrich Parzefall¹, Karl Jakobs¹, Ashley Greenall², Sven Wonsak²

¹Albert-Ludwigs-Universität Freiburg (Germany), ²University of Liverpool (UK)

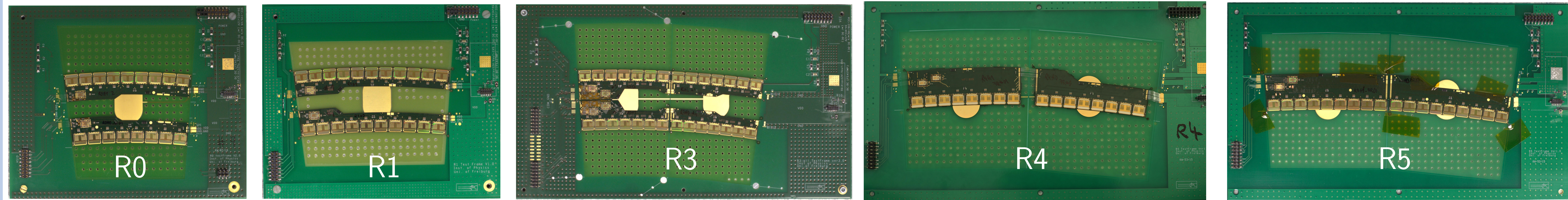
The ATLAS ITk Strip Detector

- ▶ **All-silicon detector** with around 70 million read-out strips.
- ▶ **Modular design** with modules assembled into larger structures: staves and **petals**.
 - ▶ Four barrel layers and six end-cap discs per side.
 - ▶ Integrated cooling, power and read-out electronics.
- ▶ We present here the construction and testing of prototype hybrids for **rings 0, 1, 3, 4 and 5**.

- ▶ **Read-out chips** glued and wire-bonded onto the hybrids.
 - ▶ ABC (ATLAS Binary Chip) analogue read-out chip connected to the strips, sends data to HCC.
 - ▶ HCC (Hybrid Controller Chip) digital read-out chip sends data from ABC to the DAQ.
- ▶ **Forward region** uses “Stereo Annulus” shaped sensors and modules, arranged in rings.
 - ▶ Different number of strips leads to different number of front-end read-out chips.
 - ▶ Changing strip pitch and length for each segment.



Hybrids Built and Tested



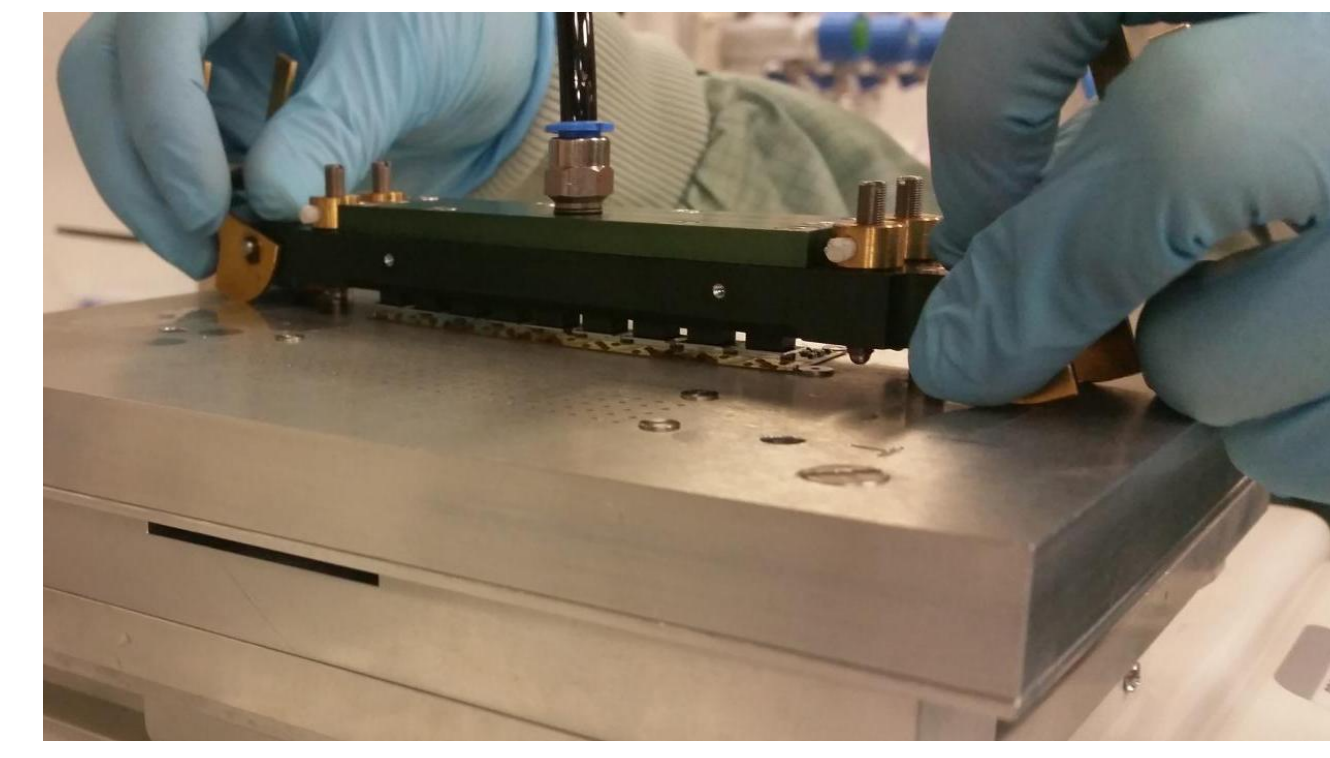
Hybrid Circuits

- ▶ **Polyimide** circuit with 4 copper layers, 300 μm target thickness.
 - ▶ Dedicated **ground and power planes** and two signal layers.
 - ▶ PCBs produced at Würth Elektronik.
- ▶ Rings 3 to 5 have a **split area** for two sensors side by side.
- ▶ Each hybrid has **different number of chips** for the changing number of strips in R:

Hybrid	R0H0	R0H1	R1H0	R1H1	R3H0	R3H1	R3H2	R3H3	R4H0	R4H1	R5H0	R5H1
HCCs	1	1	1	1	0	2	0	2	0	2	0	2
ABCs	8	9	10	11	7	7	7	7	8	8	9	9

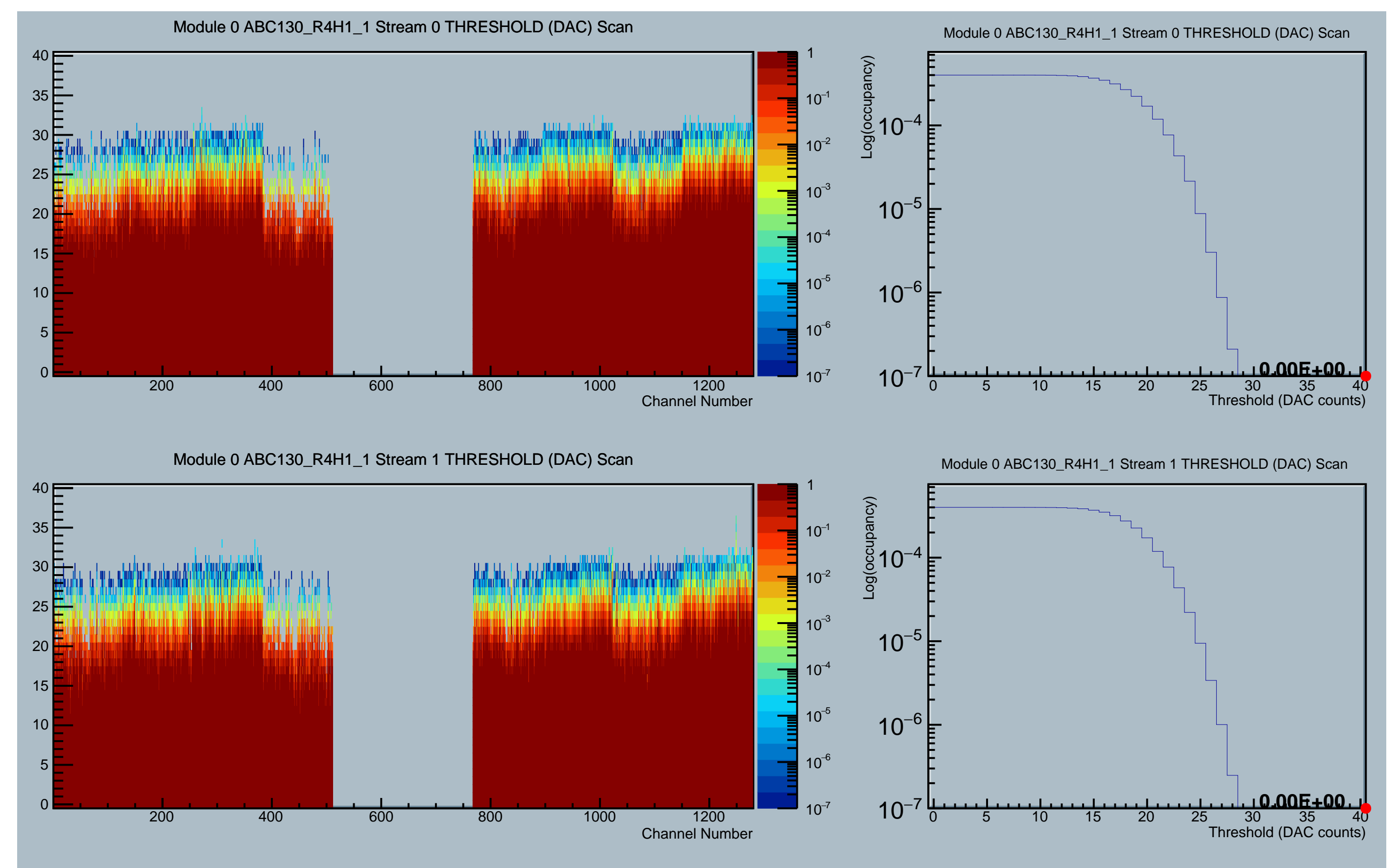
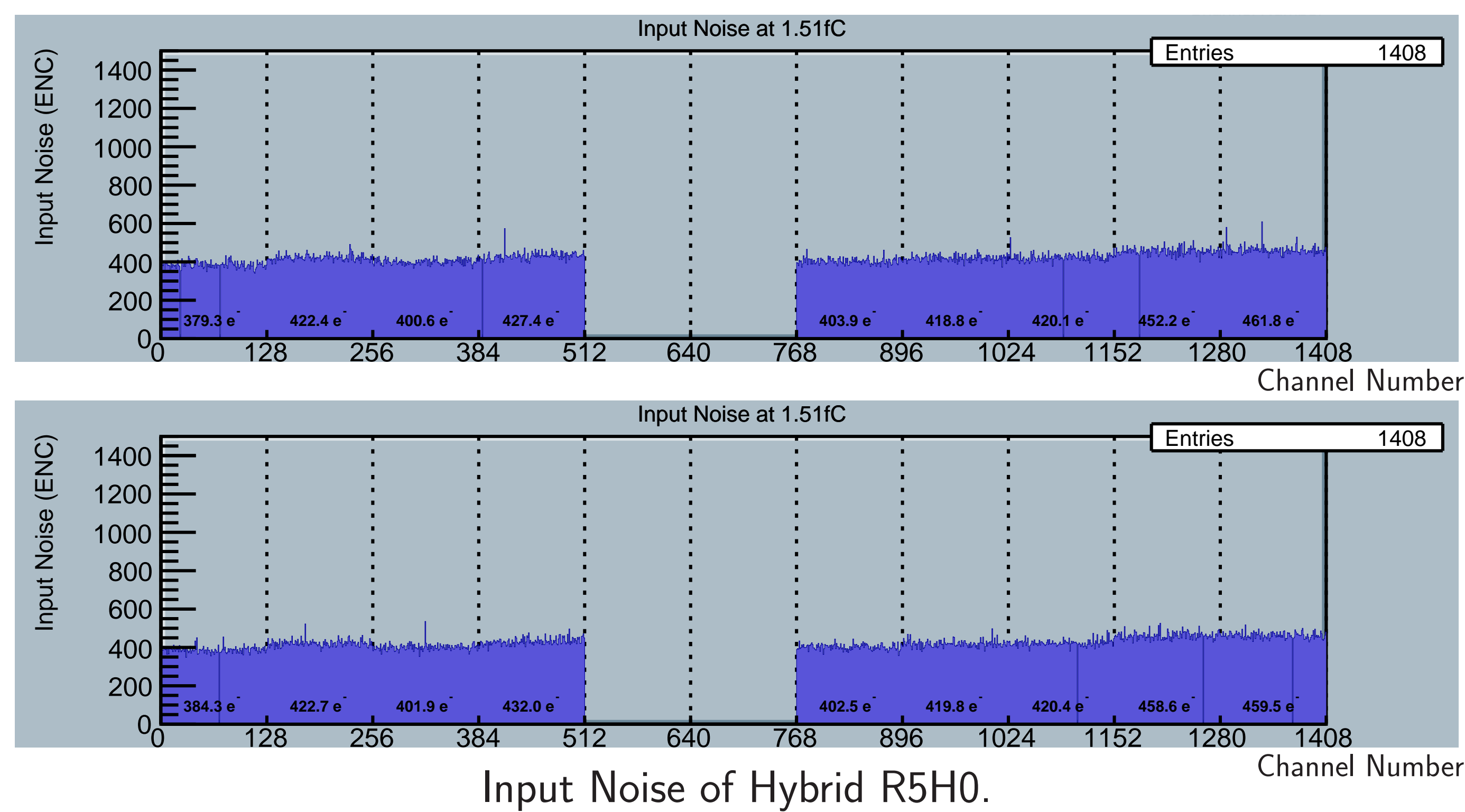
Hybrid Assembly

- ▶ PCBs **populated in-house** with passives.
- ▶ **ASICs** designed at CERN, produced by GF.
- ▶ **Hybrid to ASIC attachment:**
 - ▶ **UV cured** glue.
 - ▶ **Glue dispensing** robot.
 - ▶ Precise tooling for positioning and glue height control.
 - ▶ Tools designed and fabricated in-house.
- ▶ **Wire-bonding** for the electrical connections.

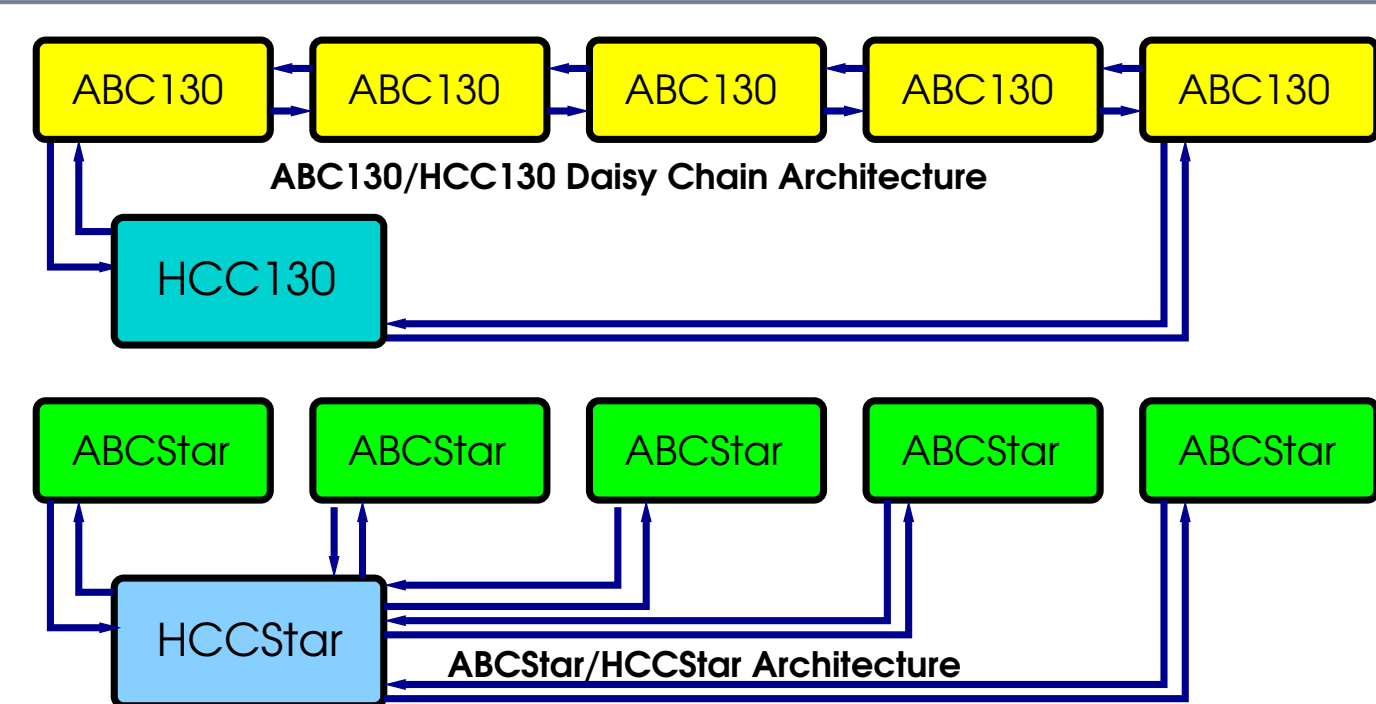


Electrical Tests

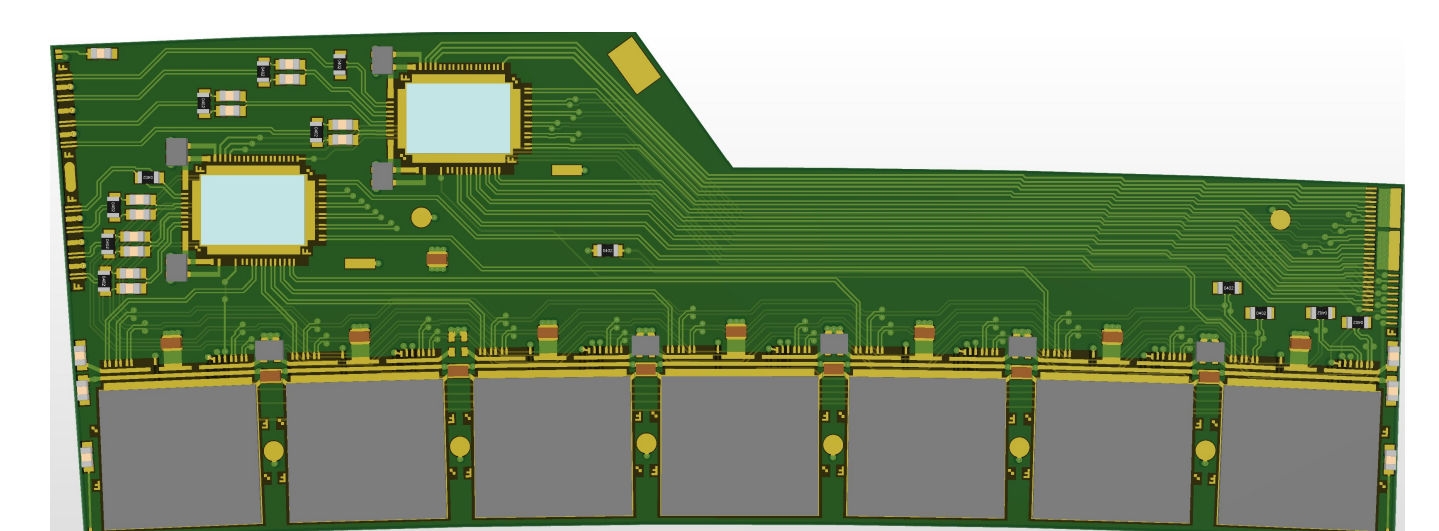
- ▶ All these hybrid types have been built and tested. A subset of the results are shown.
- ▶ Characterised by: **Input Noise** (Equivalent Noise Charge, ENC) and Noise Occupancy.
- ▶ Tests: **Response Curve** and Noise Occupancy Scan.
- ▶ All chips behave as expected by the designers.



Starchips: From Prototyping to Production



- ▶ Prototype hybrids use the so called ABC130/HCC130 chipset, built in a 130 nm process.
- ▶ **Starchips:** new chipset in the same 130 nm process.
- ▶ **Architecture change:** from daisy chain read-out of the ABCs to star point read-out.
 - ▶ Challenge for PCB routing using 4 layers.
 - ▶ Largest hybrid has 12 ABCStar chips (and 2 HCCStar): 12 sets of data lines.
- ▶ Data output from HCCStar at 640 Mbps.
- ▶ Clock to HCCStar and ABCStar is 160 MHz.



R3H1 Hybrid Design for the Starchips

Conclusions

- ▶ The design of the hybrids for the ATLAS ITk Strip Detector read-out is well advanced.
- ▶ Performance of the built hybrids is adequate.
- ▶ We have presented the prototype developments of the majority of the end-cap hybrids, as well as the first iteration of the designs with the final chipset.



Topical Workshop on Electronics for Particle Physics
17 – 21 September, 2018 – Antwerp, Belgium

TWEPP-18