



# Assembly and Testing of the Vertex Detector for the Mu3e Experiment

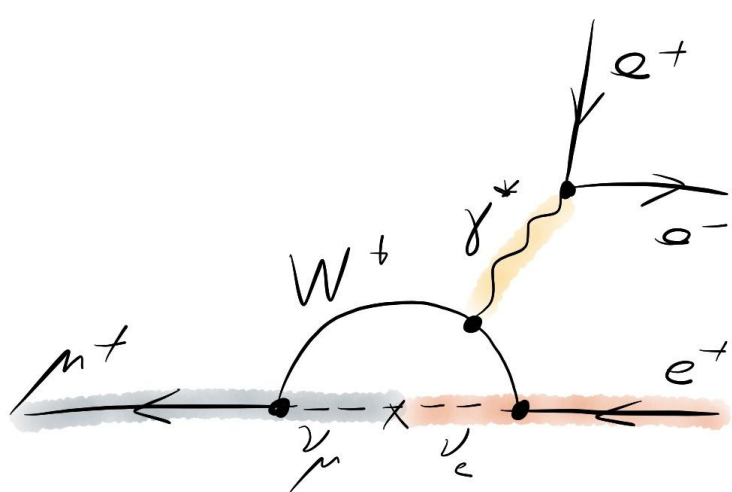
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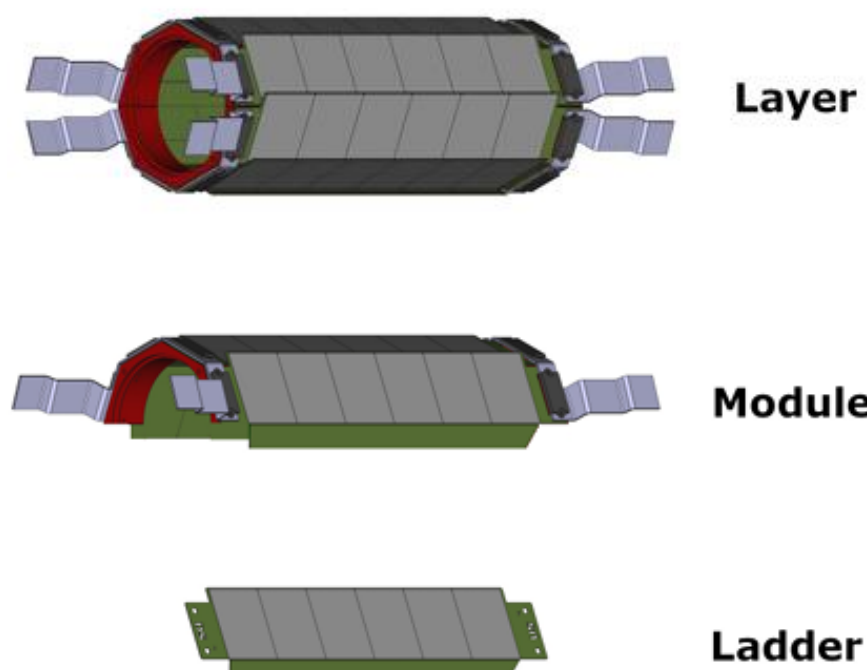
## Introduction

- The Mu3e Experiment is looking for charged lepton flavour violation (cFLV) in the  $\mu^+ \rightarrow e^+ e^- e^+$  decay channel
- Standard Model predicts a branching ratio of the order of  $10^{-54}$ , while Mu3e aims for an ultimate single event sensitivity of  $10^{-16}$



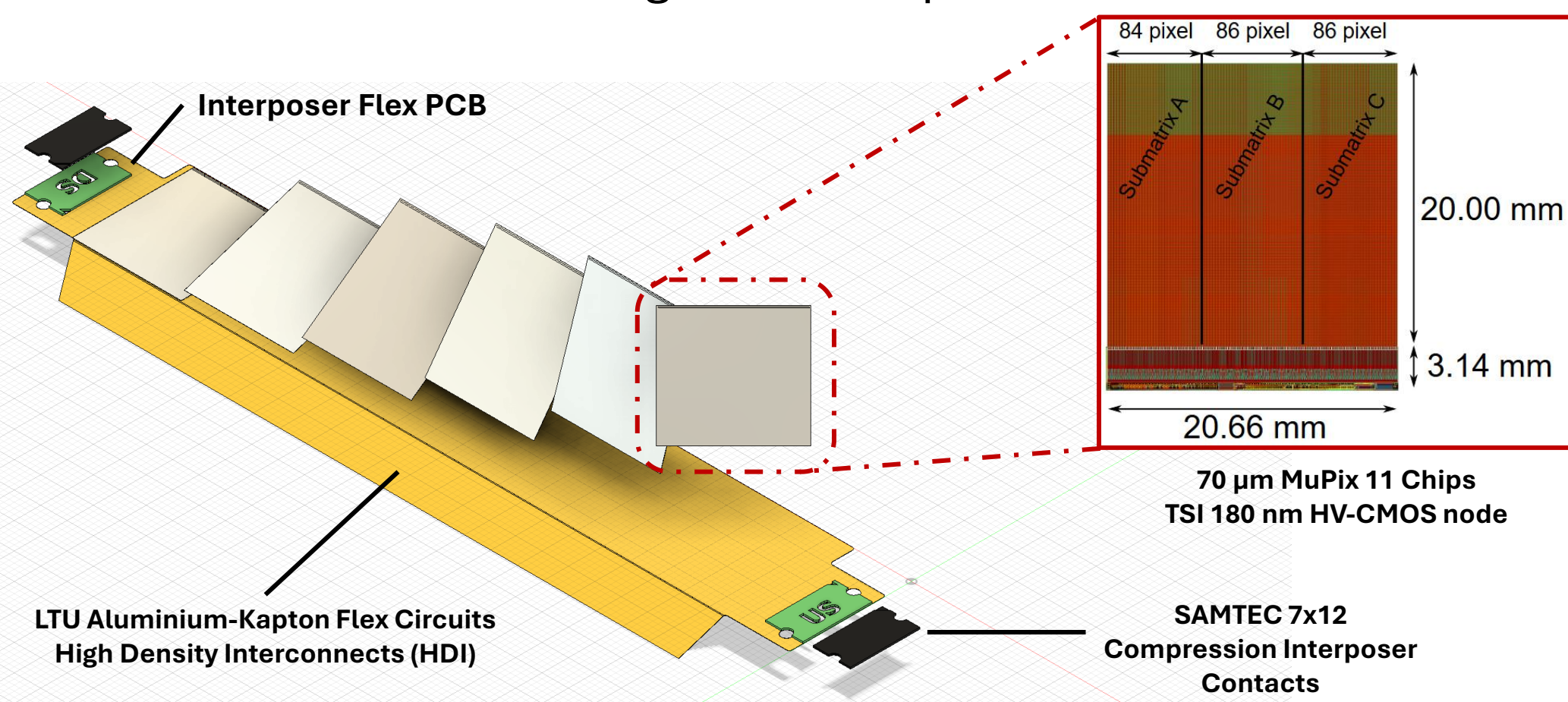
## Inner Pixel Detector.

- The tracking component of the Mu3e detector consists of four layers of "ladders" in three stations, concentric on the mylar-based stopping target
- The **two inner layers of the central station** of the Pixel Detector form the **Vertex Detector**
- 18 ladders** are assembled into 4 modules which are later formed into layers of 8 & 10 ladders each



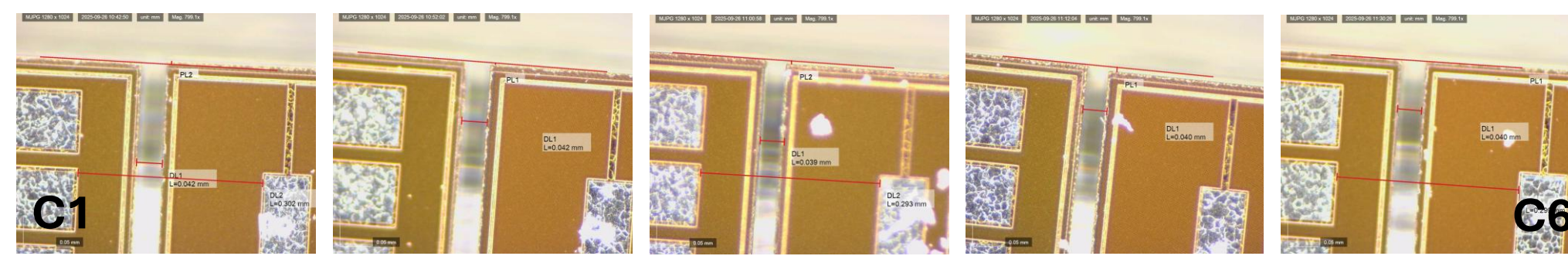
## Vertex Ladders

- A single ladder of the Vertex Detector is composed of six 50 (70)  $\mu\text{m}$  thin **MuPix11** High Voltage Monolithic Active Pixel Sensors (**HV-MAPS**) sensors glued onto aluminium-polyimide laminate High Density Interconnect structures (**HDI**)
- Single point tape automated bonds (**spTABs**) provide the electrical connections between the MuPix11 chips, the HDI and flex PCBs
- Ladders are mounted onto **anodized aluminium frames with ESD-safe covers** for storage and transportation



## Alignment

- High accuracy required for chip positioning, lateral separation between chip guard rings restricted to **75-85  $\mu\text{m}$**



Serial In (SI) Bus Traces above corresponding pads

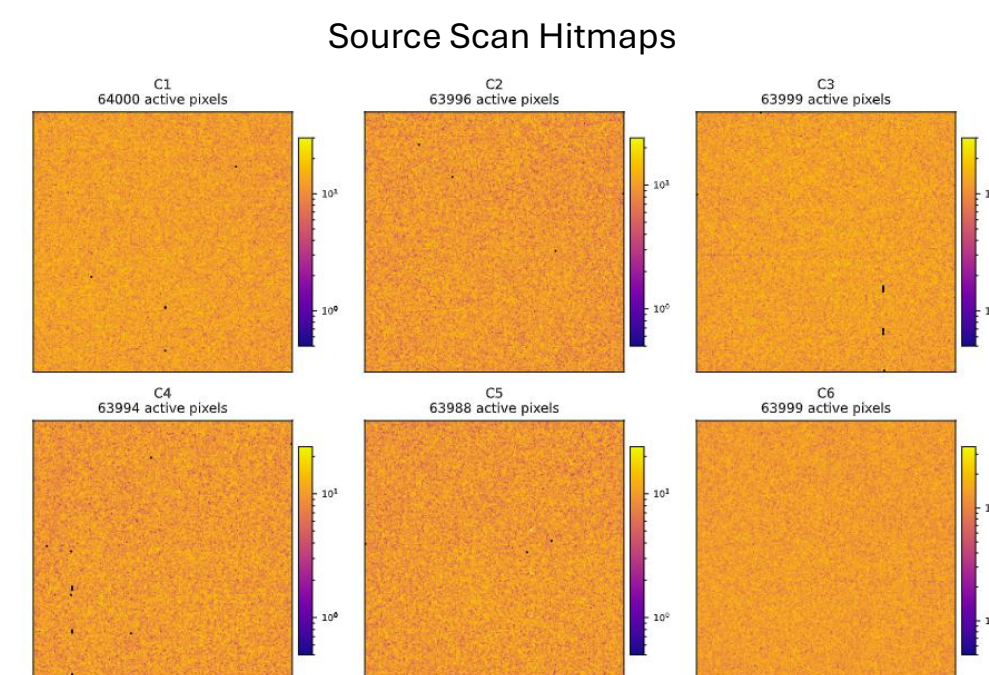
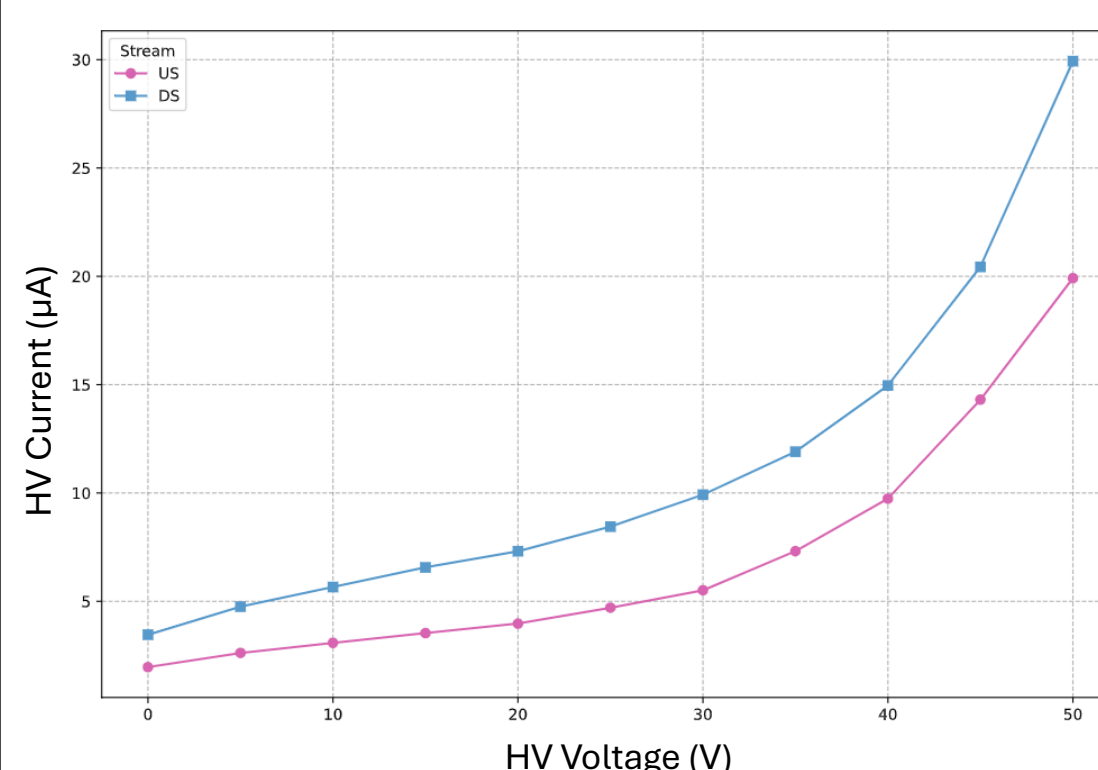
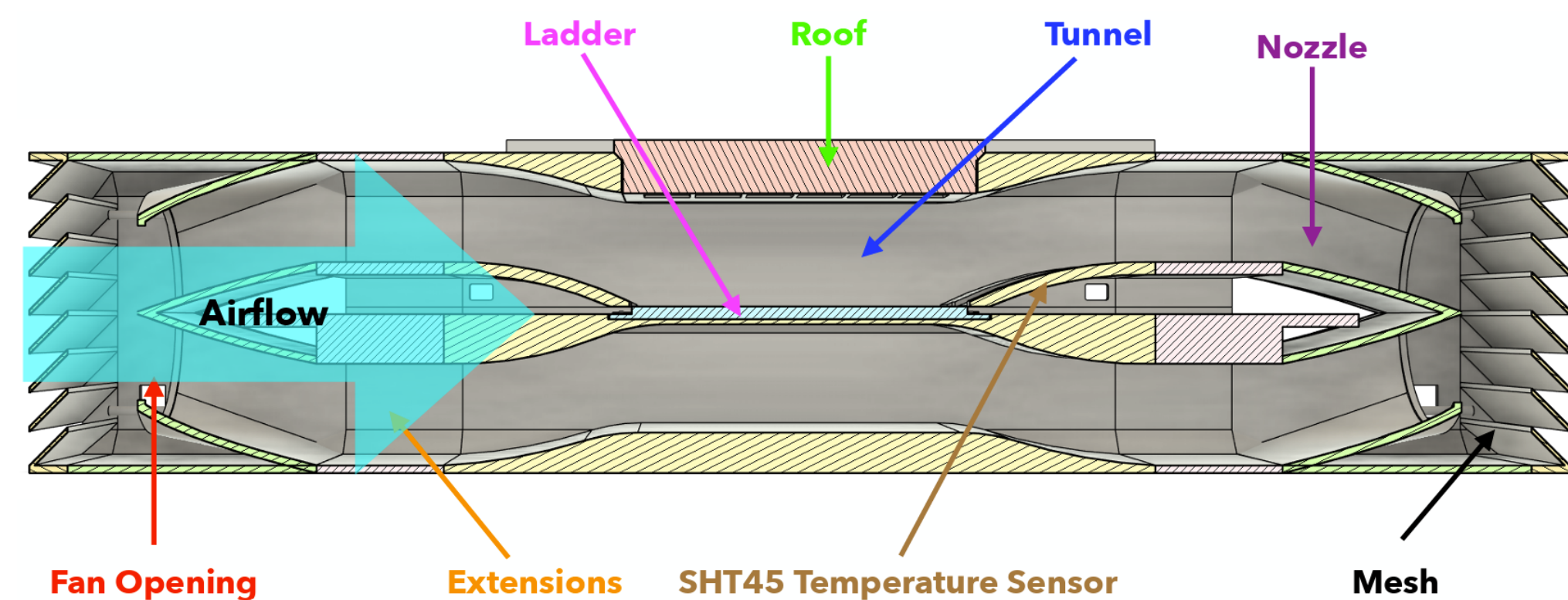
High Voltage (HV) pad of neighbouring chip

Clock (CLK) bus traces above corresponding pads

Pads only 90  $\mu\text{m}$  wide, have to align across six chips simultaneously

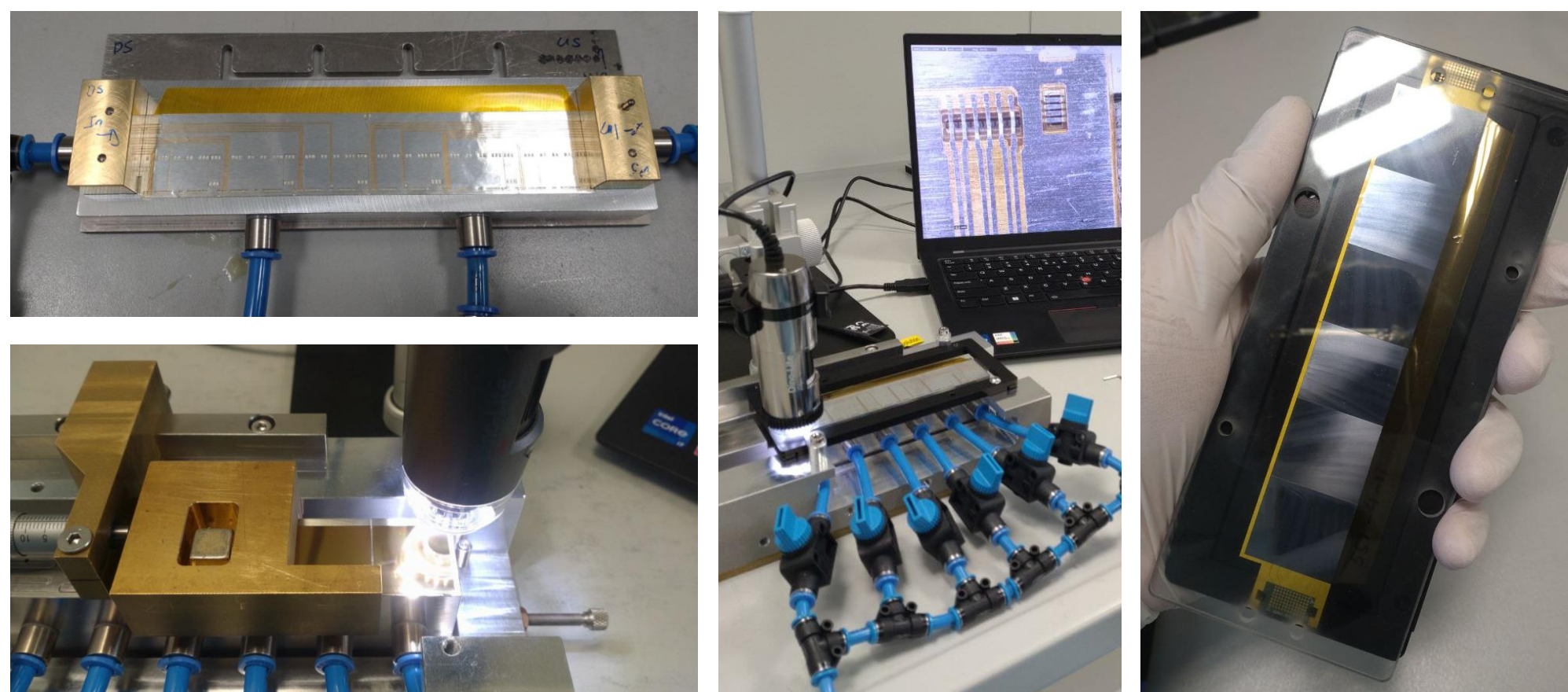
## Quality Control

- Ladder QC setup provides **air cooling** in a **light-tight** environment, with a **similar data acquisition chain** to the actual detector
- Set of tests executed to **characterize and qualify** produced ladders, before they are selected based on a grading system



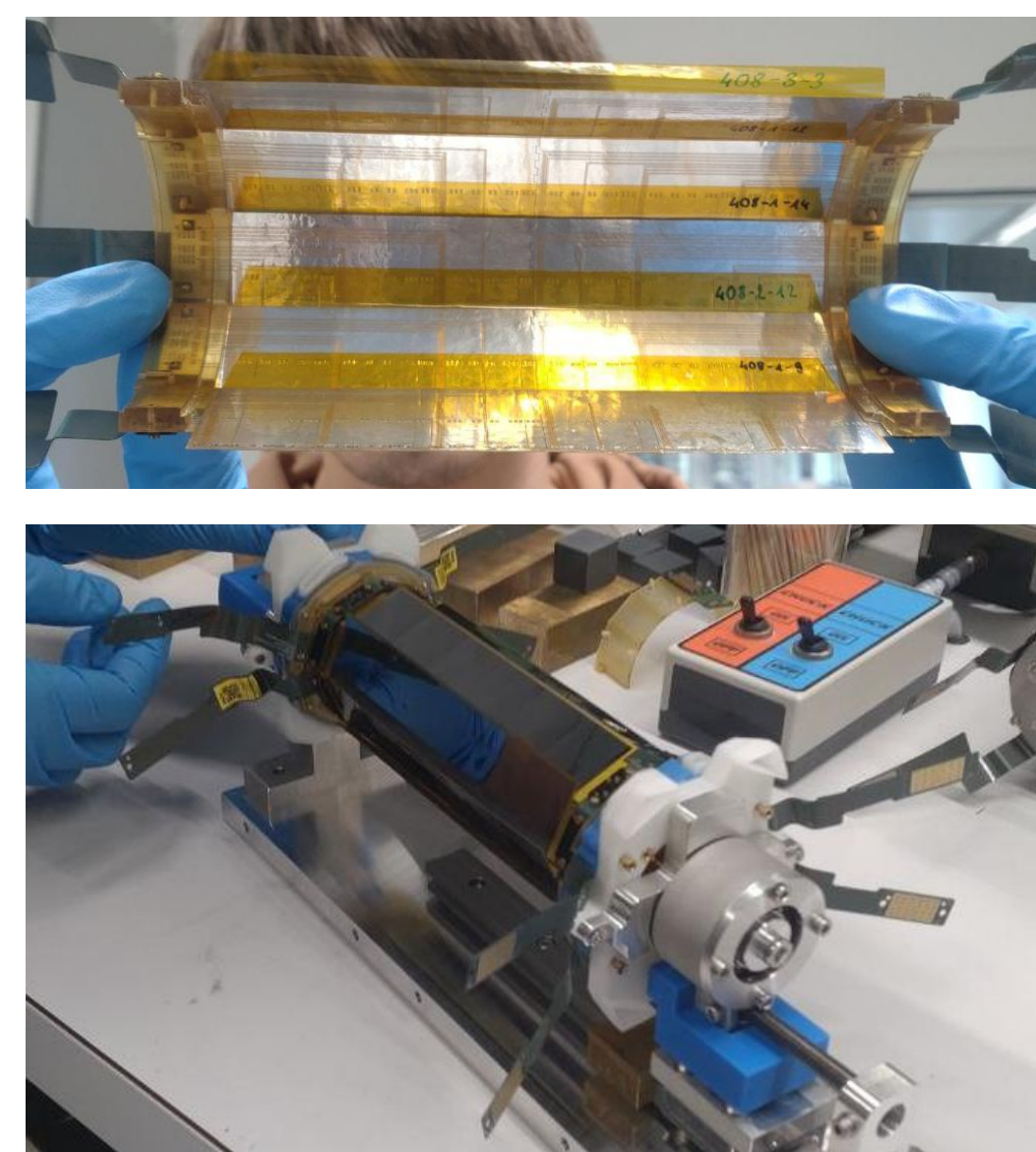
## Ladder Assembly

- Manual method and tooling** used for Vertex ladder assembly
- Assembly flow and tooling revamped for production of second Vertex Detector, including **tooling-assisted alignment** and to be less dependent on experienced operators only



## Module and Barrel Assembly

- The current method builds modules by **gluing ladders to each other** on the flaps to provide **mechanical stability**
- Ladders are then secured on both sides by screwing on two polyetherimide endrings
- Modules are then assembled into the barrel together with the air duct structures using the barrel assembly tool



## Summary

The assembly flow and quality control setup & tests for the production of the Mu3e Vertex Detector have been well established, allowing for more accessibility, reproducibility and a controlled environment to ensure an excellent detector for data-taking.