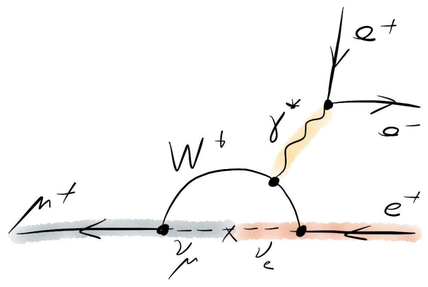
# Construction and Commissioning of the Mu3e Vertex Detector

Afiq Azraei bin Rishinsa[1)], for the Mu3e Collaboration[2)]

[1)] Universität Heidelberg [2)] Universität Heidelberg, Karlsruhe Institut für Technologie, Johannes Gutenberg-Universität Mainz, Université de Genève, Paul Scherrer Institut, ETH Zürich, Universität Zürich, University of Bristol, University of Liverpool, University of Oxford and University College London

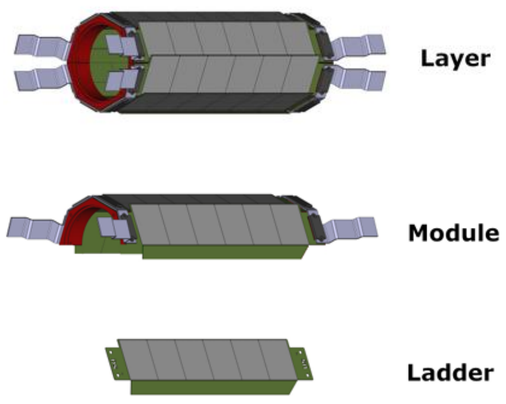
## Introduction

- 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 $10^{-16}$



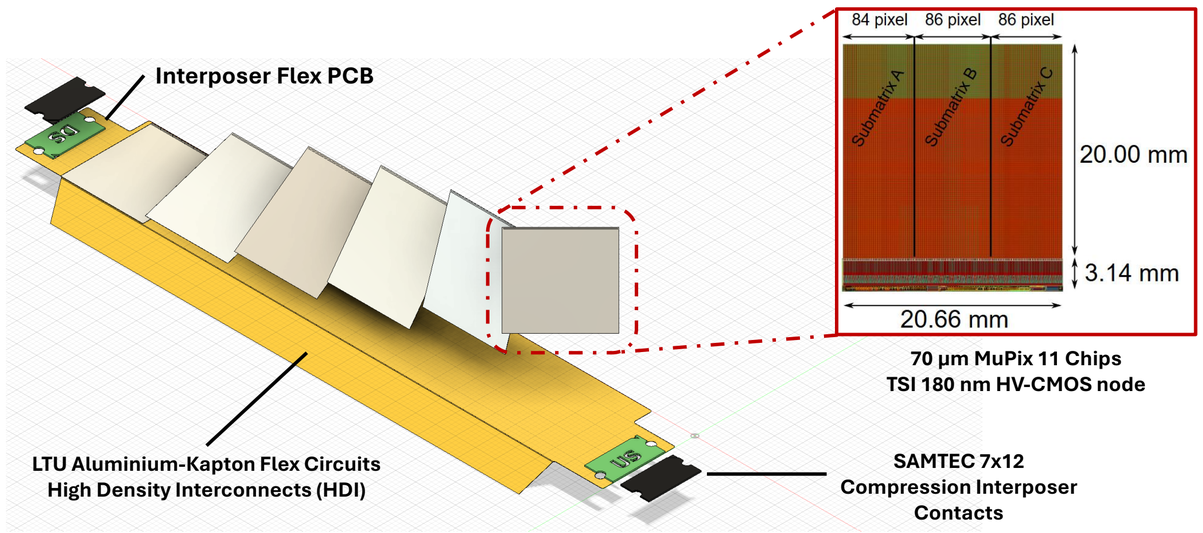

## Vertex Detector

- The tracking component of the Mu3e detector consists of four layers of "**ladders**" in three stations, concentric around the 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



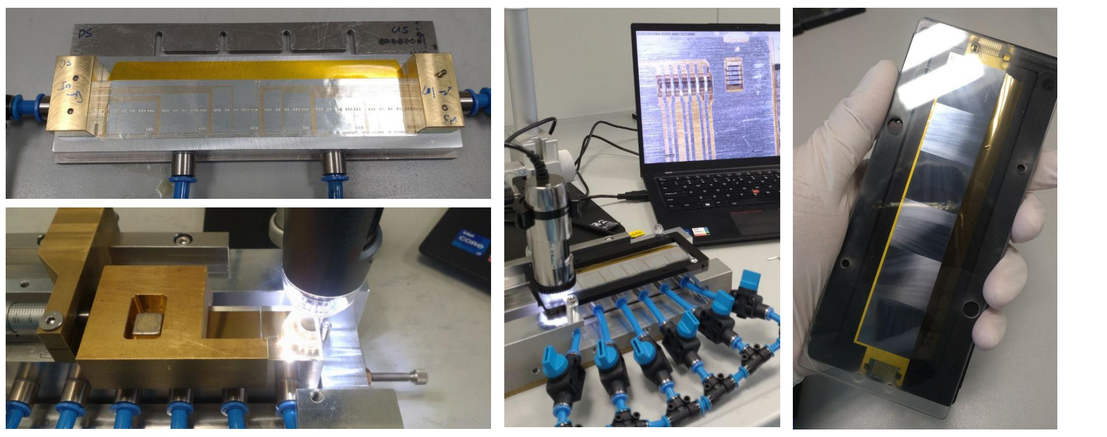

## Ladders

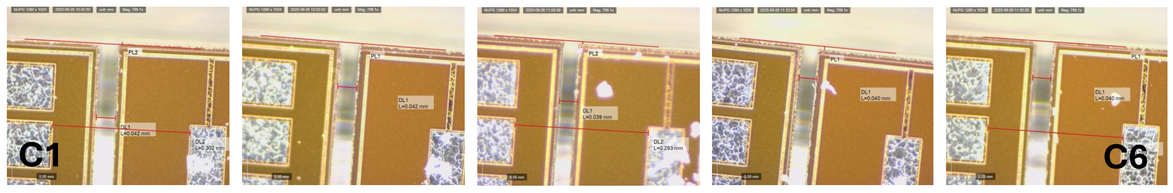
- A Vertex Detector ladder is made of 70 µm thin **MuPix11** High Voltage Monolithic Active Pixel Sensors (**HV-MAPS**) sensors glued onto Al-polyimide laminate High Density Interconnect structures (**HDIs**)
- Single point tape automated bonds (**spTABs**) provide the electrical connections between the MuPix11 chips, the HDI and flex PCBs




## Ladder Assembly

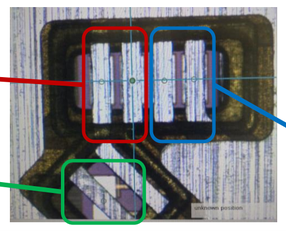
- **Manual method and tooling** used for Vertex ladder assembly
- Assembly flow and tooling revamped for production of second Vertex Detector, including **tooling-assisted alignment** and to be less dependent on experienced operators only






Serial In (SIn) bus traces above corresponding pads

High Voltage (HV) pad of neighbouring chip

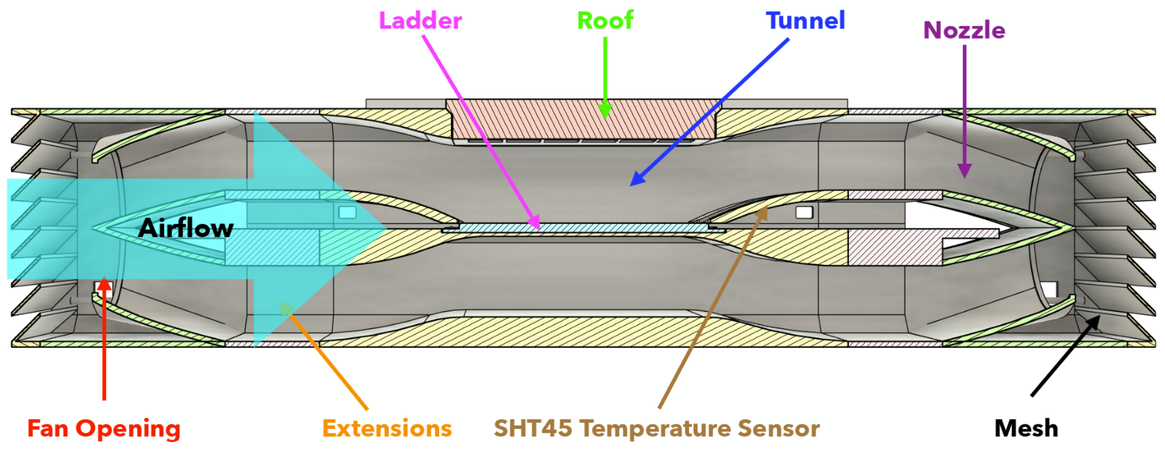


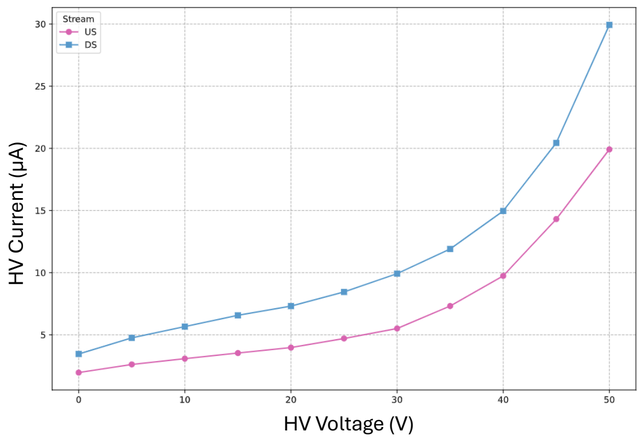
Clock (CLK) bus traces above corresponding pads

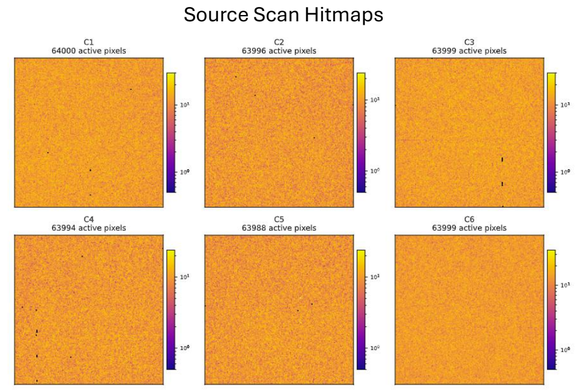
Pads only 90 µm wide, have to align across six chips simultaneously

## 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

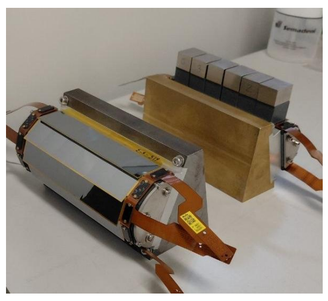


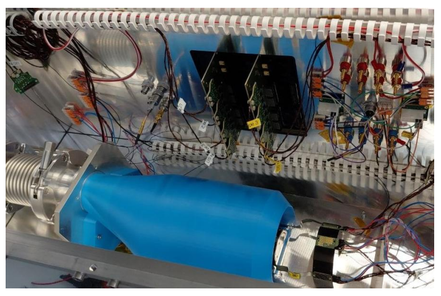



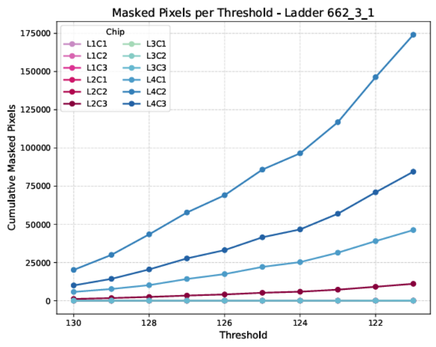




## Module Assembly & QC

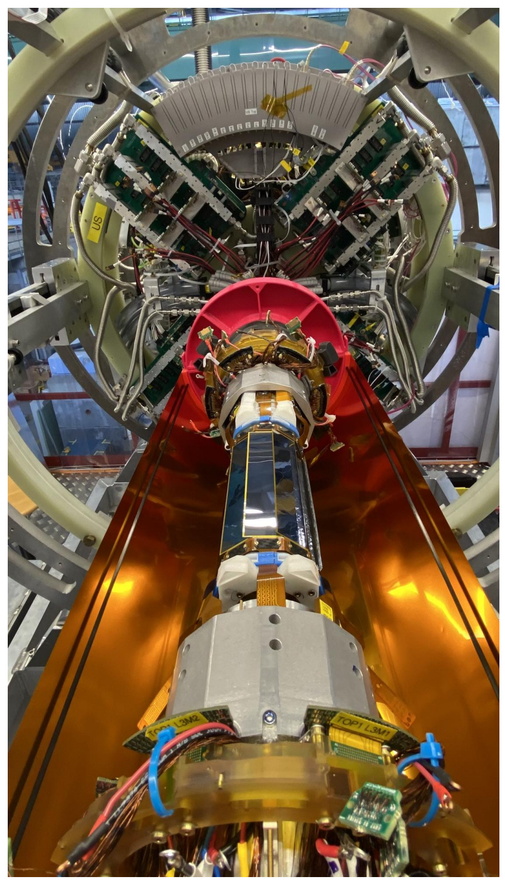
- Modules are built by **gluing ladders to each other** on the flaps for **mechanical stability**
- Ladders are then secured on both sides by screwing on two polyetherimide endrings
- Each module is subjected to an air tunnel for QC and characterization, for later selection into the final barrel configuration



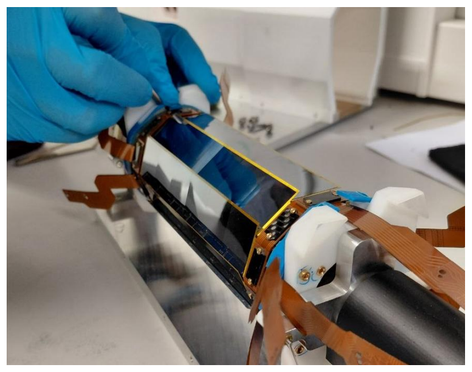





## Installation & Commissioning



- The Vertex Detector is assembled by connecting the four modules to the Helium cooling & PEI support structures
- The detector is then positioned and screwed into place with spring-loads to compensate for thermal expansions
- With the electrical LV/HV wiring connected, and the Helium cooling & interlock system commissioned, the detector is initially tuned on one half-ladder at a time to evaluate functionality



**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.

**Contact**: binrishinsa@physi.uni-heidelberg.de

**References**: Arndt, Kirk, et al. "Technical design of the phase I Mu3e experiment." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 1014 (2021): 165679.

DFG Deutsche Forschungsgemeinschaft German Research Foundation