LHCb UP Module and Stave Assembly Development

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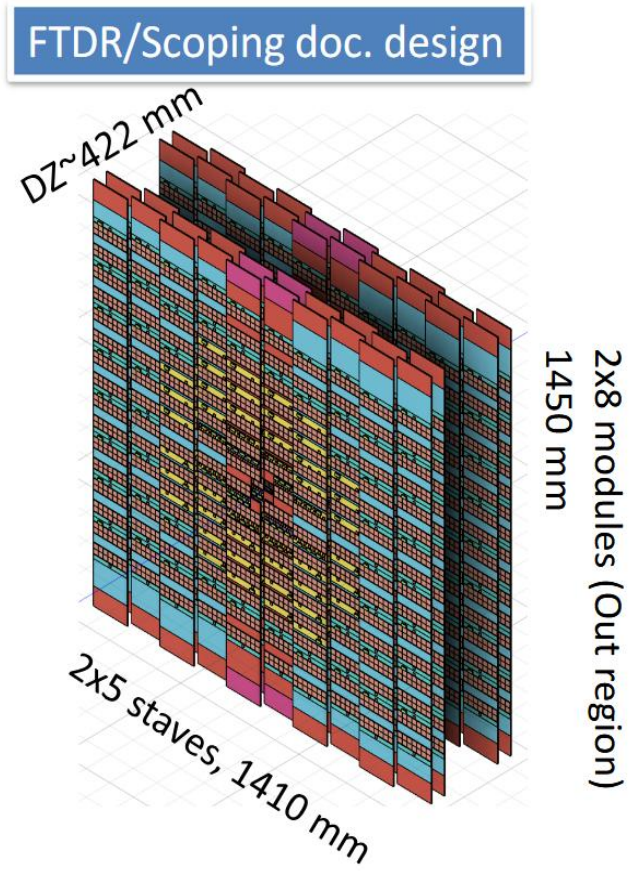
Outline

- Introduction
- Assembly of dummy Module
- Assembly of Bare stave
- Future plan
- Summary

Layout of UP

UP will have similar layout as current UT



As in FTDR/scoping doc., UP has 4 layers

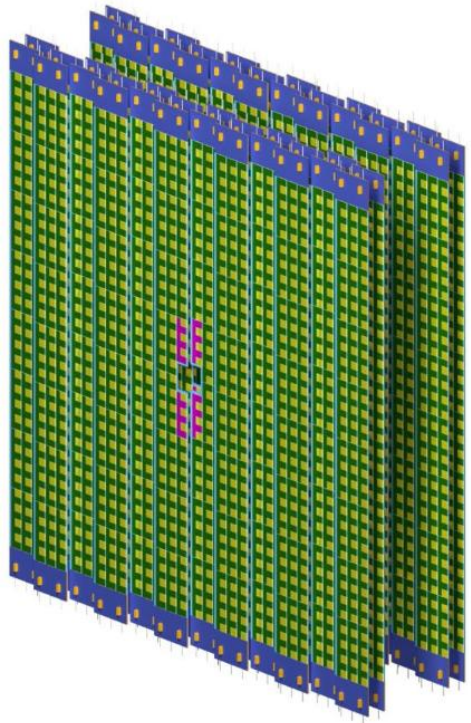
- Each layer has 2×5 staves
- The modules are staggered vertically, mounted on both the front and back sides of the UP stave
- Center hole for beam pipe is 8x8 cm
- One layer has 70×64 HVCMOS chips

A new design still has 4 layers

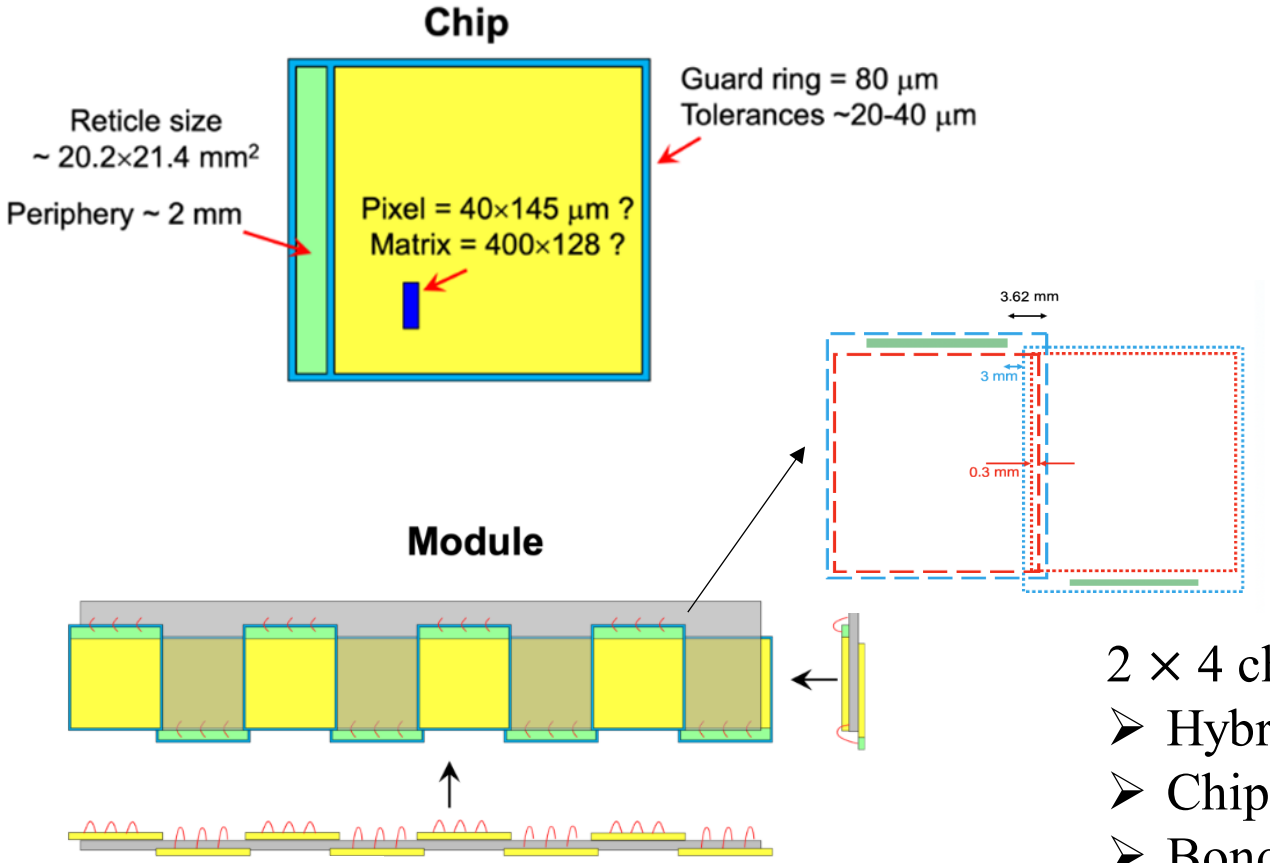
- 2×6 staves per layer, 3×2×8 = 48 modules per stave
- One layer has 72×64 HVCMOS chips
- Still 8×8 cm beam pipe hole

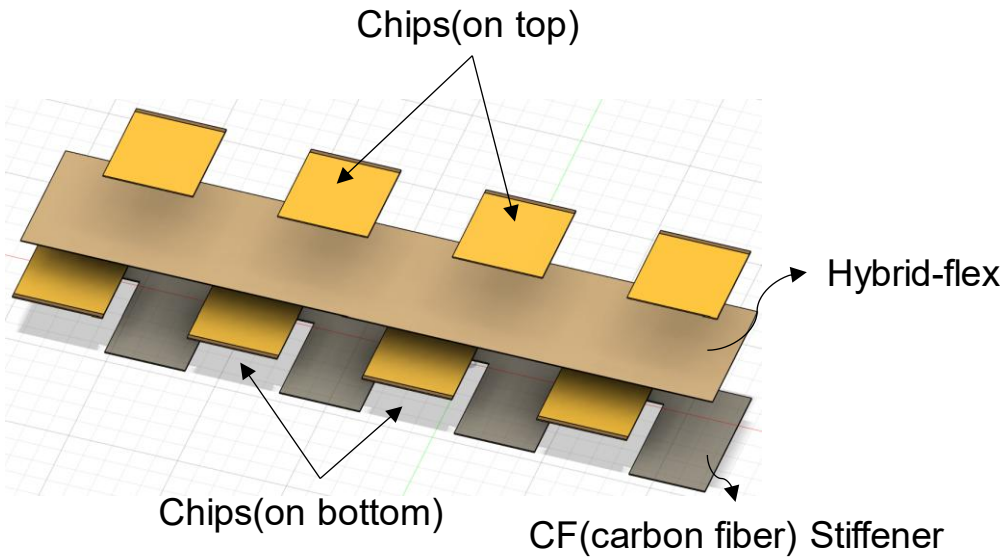
Readout electronics placed externally → reducing amount of substance

Full detector coverage → improving track detection efficiency



Module design



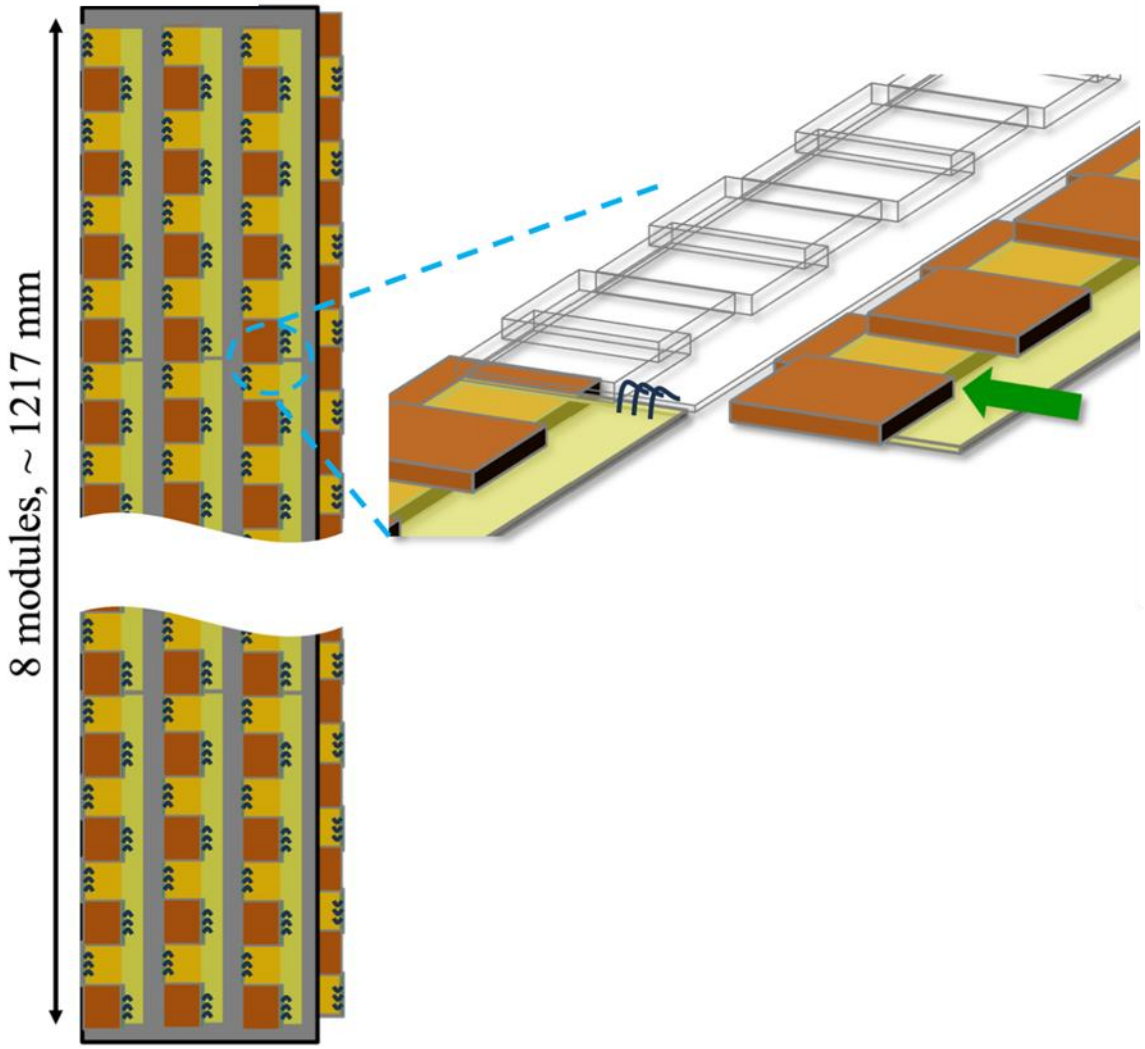


2 × 4 chips mounted on both face of Hybrid

- Hybrid thickness 0.2 mm
- Chip-by-chip overlap ~ 0.6 mm, 0.3 mm for sensitive region
- Bonding pad to chip edge: 3.6 mm

No dead area on modules

Stave layout design



2 (face) × 3 (column) × 8 modules per stave

- Bare stave thickness 4 mm,~5.3 mm w/ chip/module
- Module-by-module in a column overlapped by shorter-hybrid design (~0.3 mm for active area)
- Column-by-column overlapped by assembling on two faces per stave (~1.5 mm for active area)
- Stave-by-stave overlapped by staggered structure in a single Up layer (~5 mm for active area)

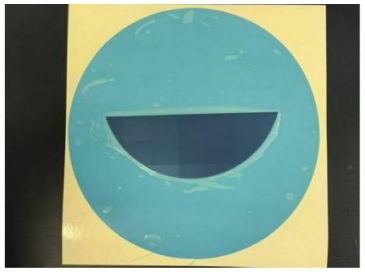
No dead area on single stave

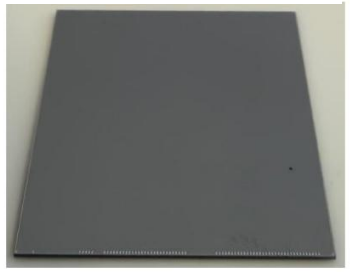
Components for Assembling dummy Module

Materials for module prototype prepared

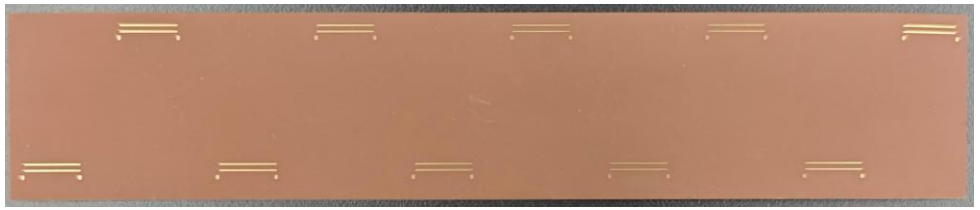
- Chips ~ 2025/03; Dummy hybrid ~ 2025/05; CF (carbon fiber) shim ~ 2025/06;

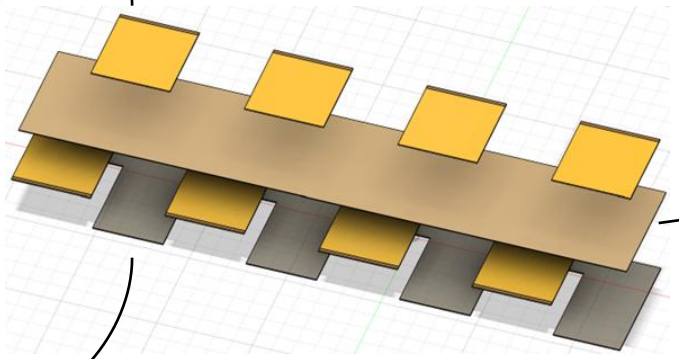
Chips for mechanical tests



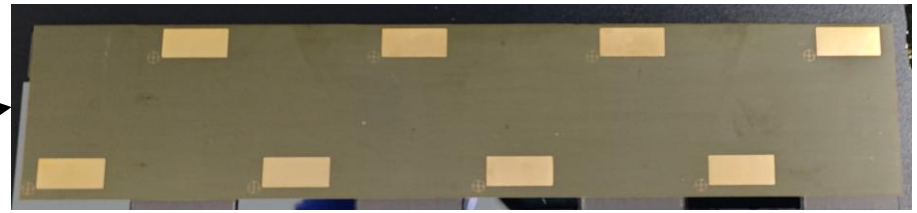


Dummy hybrid (v1)

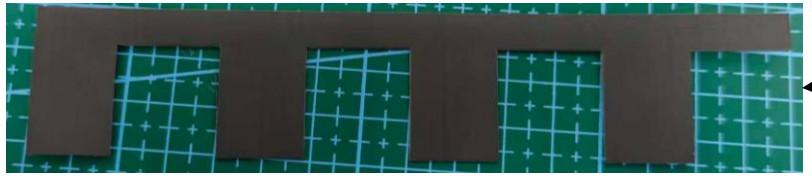




Dummy hybrid (v2)

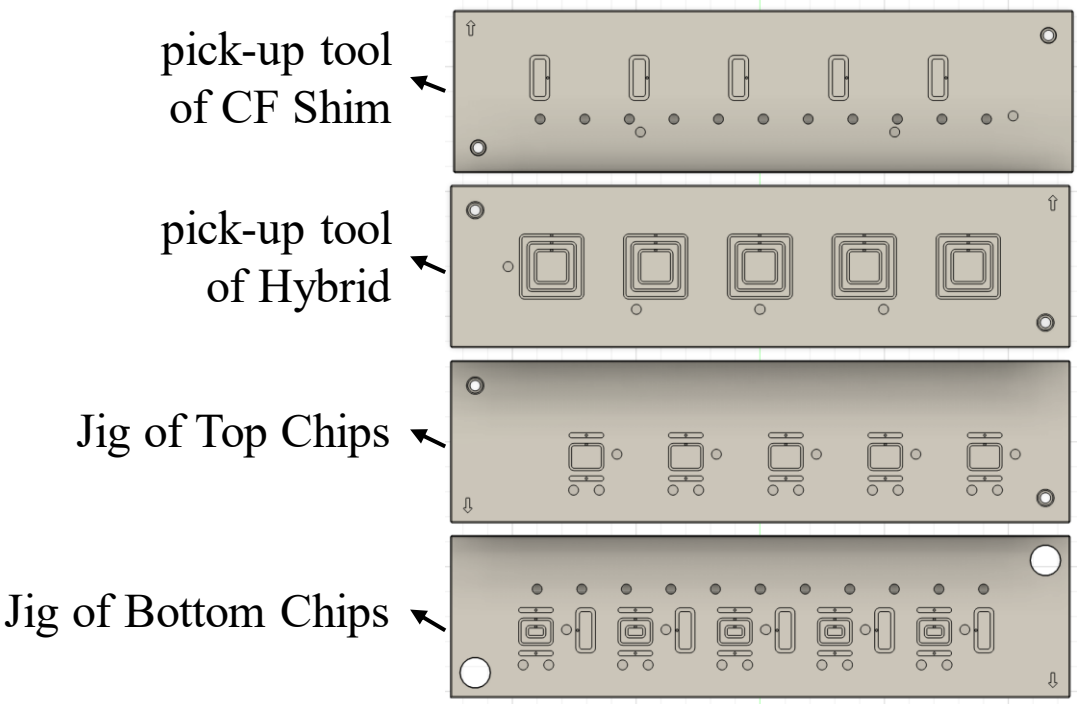


CF shim

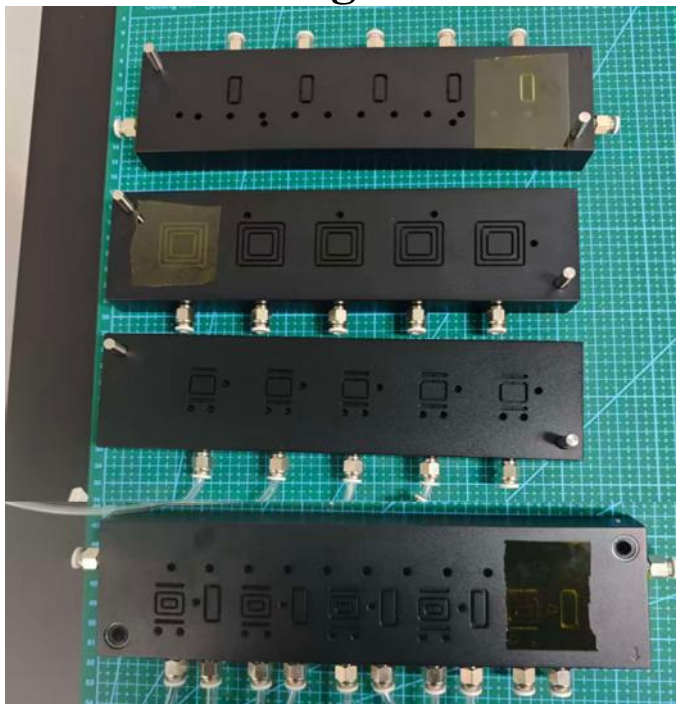


Jigs for Dummy Module

Drawings of Jigs



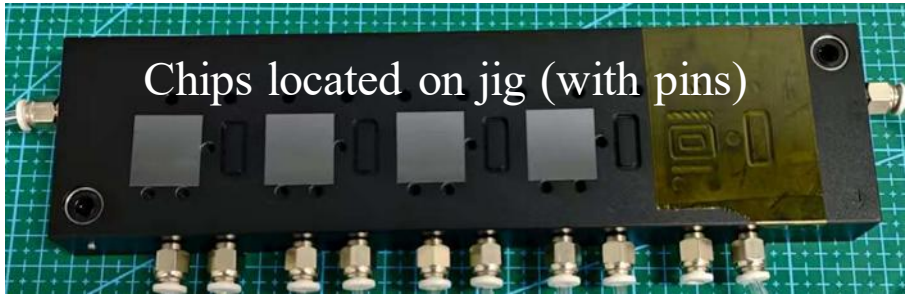
Jigs

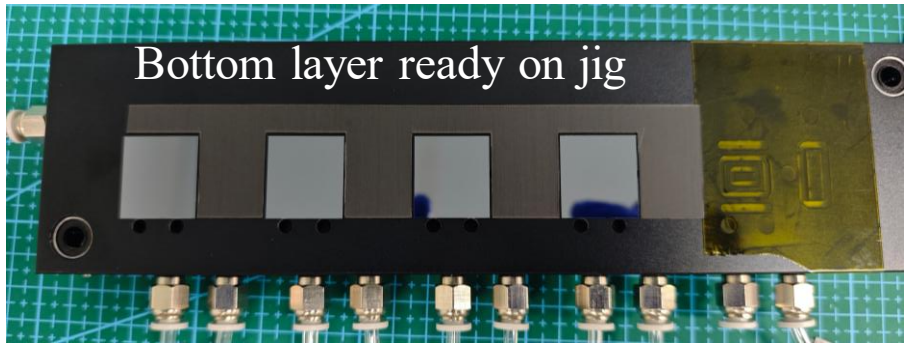


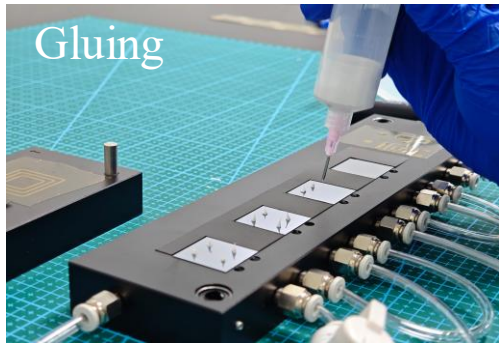
D-shape pins

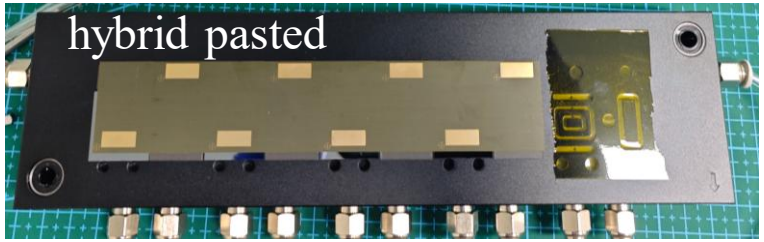
- Corresponding vacuum slots and positioning holes for each component are designed on every jig.
- machining accuracy of the jigs being 0.01 mm
- D-shape pins avoid chip contact during removal to ensure precision and protect chips

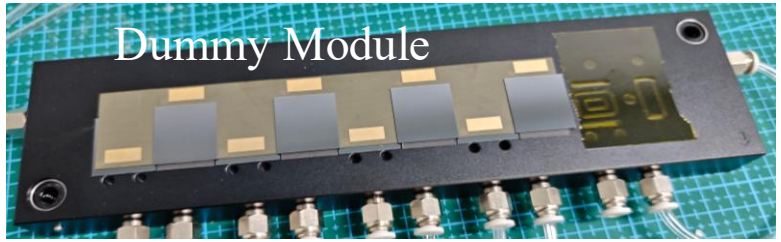
Dummy Module Assembly



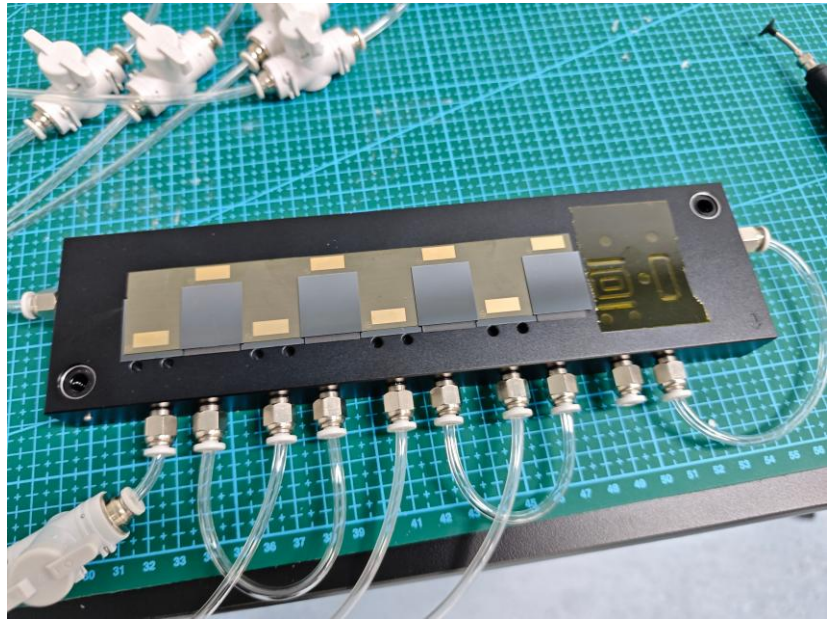




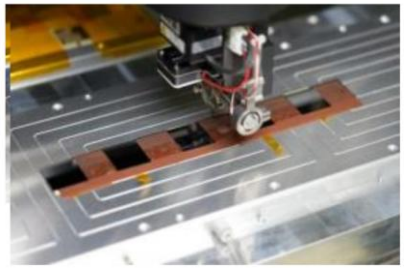


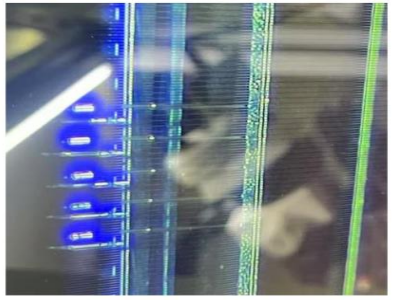


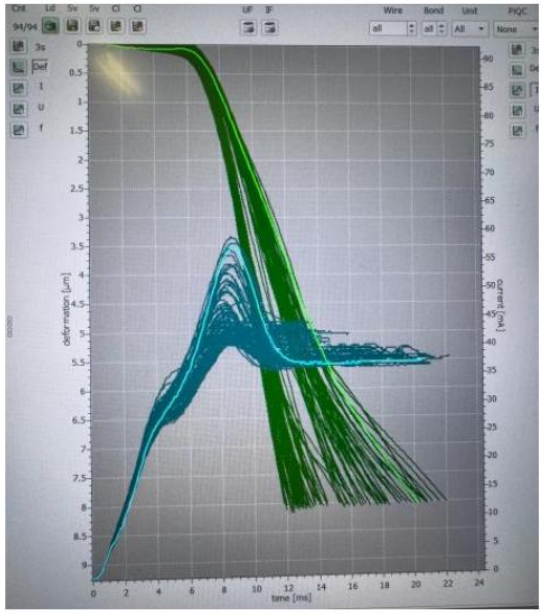
Module Prototyping

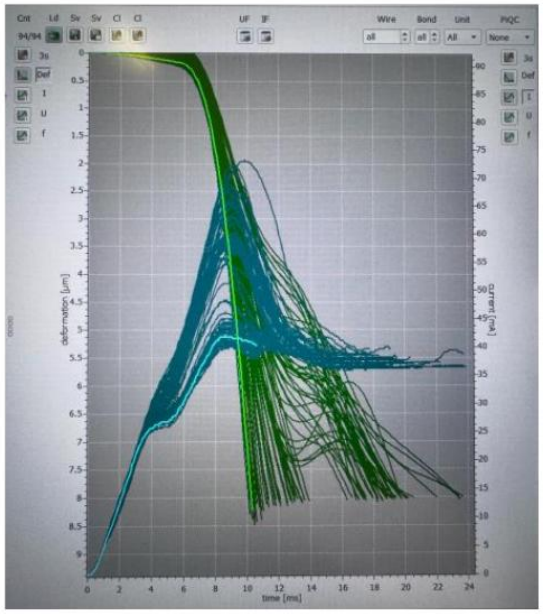


Dummy Module







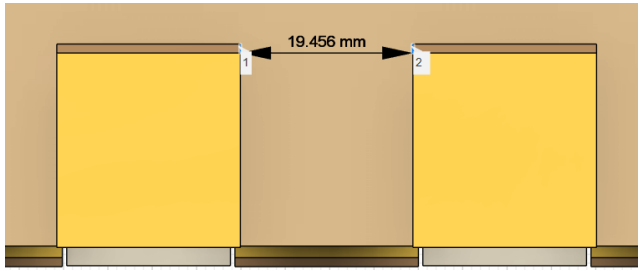


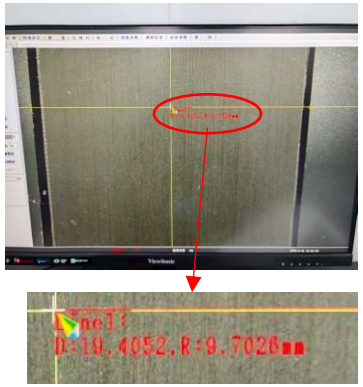
Deformation + US voltage curve for wire bonding on top (left) & bottom (right) chips

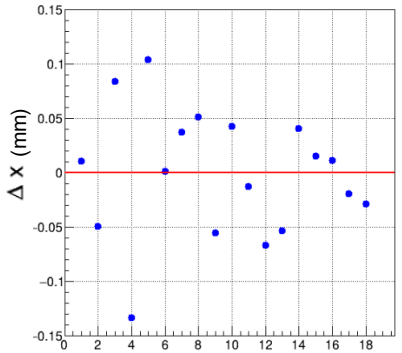
- Assembly is performed using the **jigs**.
- Position the chip using **D-shaped** pins and fix it with **vacuum**.
- **Wire bonding tests**: Two layers of the chips are both bonded.
- Subsequently, **gantry** and **robot arm** will be used for automated assembly.

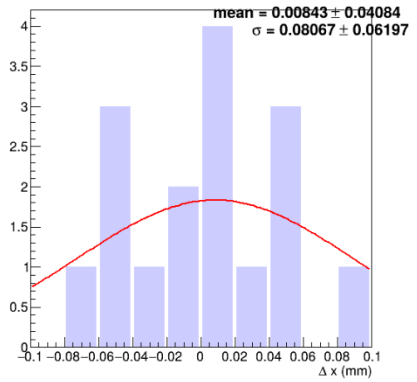
Current Dummy Module

- The placement accuracy of the current dummy module is 0.1 mm.

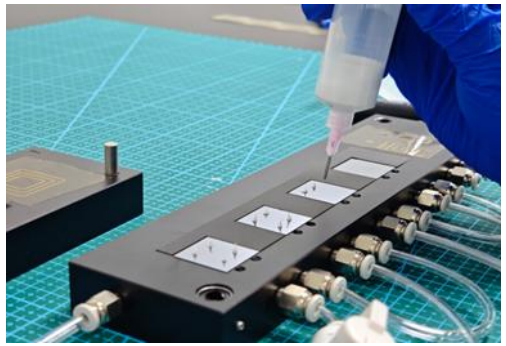


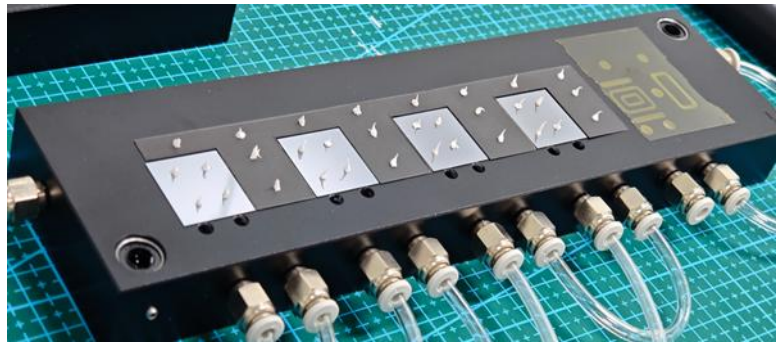




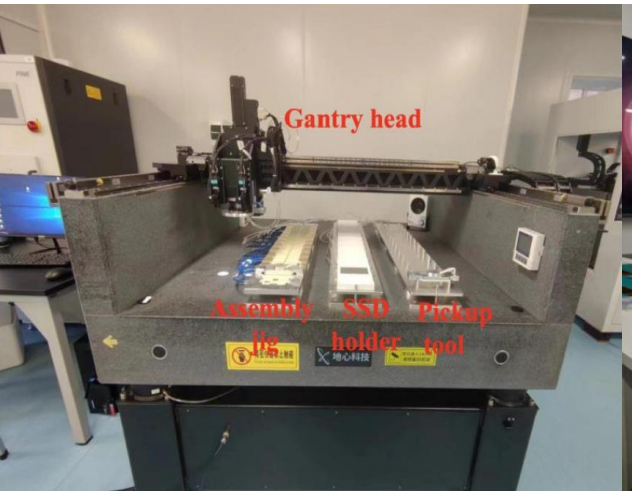


- Manual dispensing



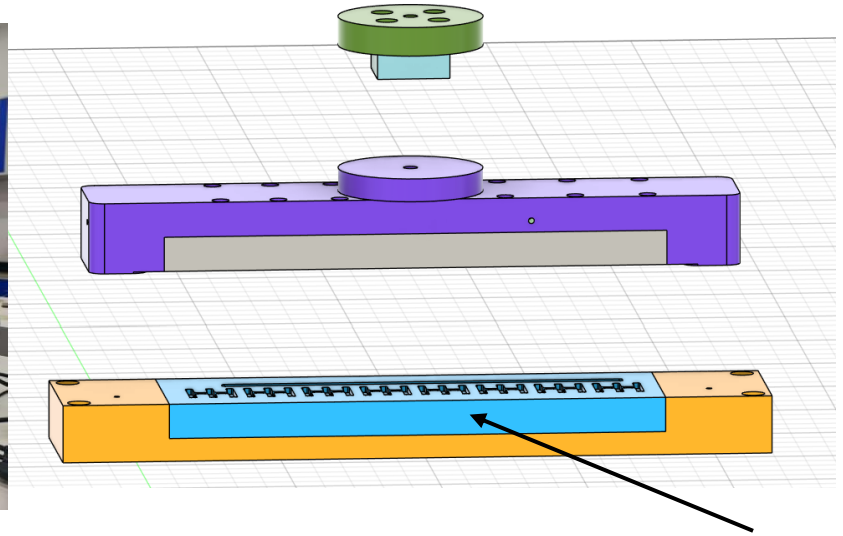


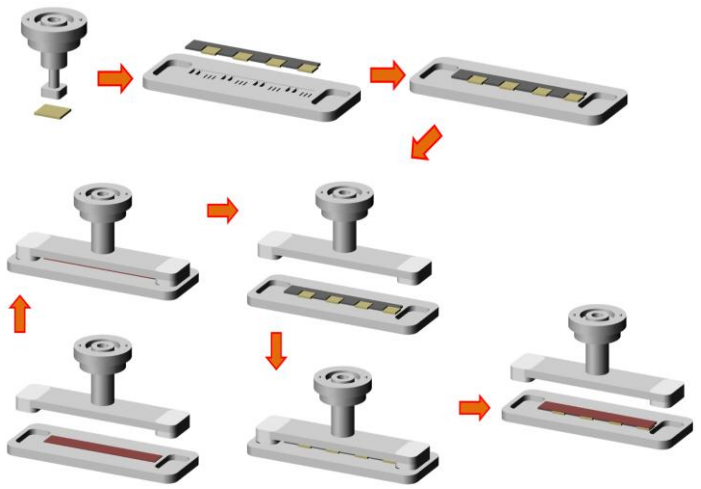
Next steps of dummy Module



Gantry

Robot arm

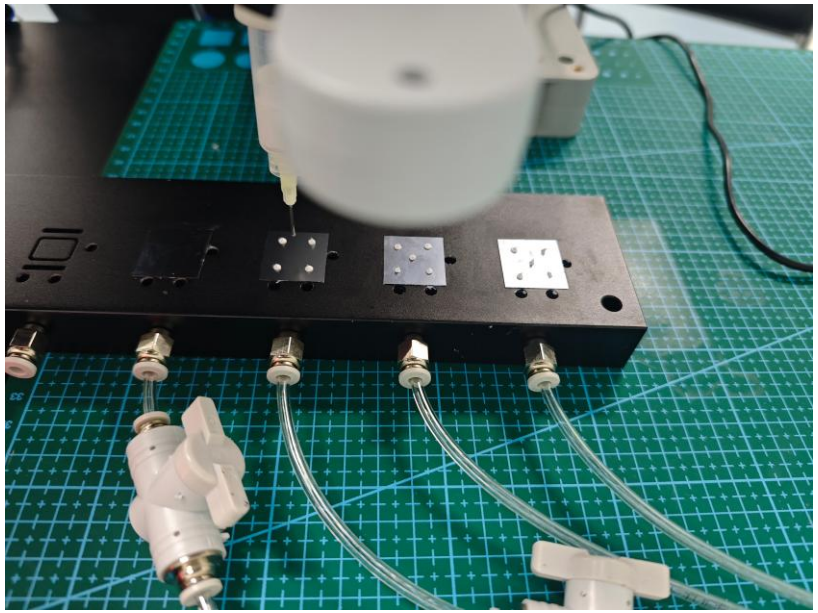


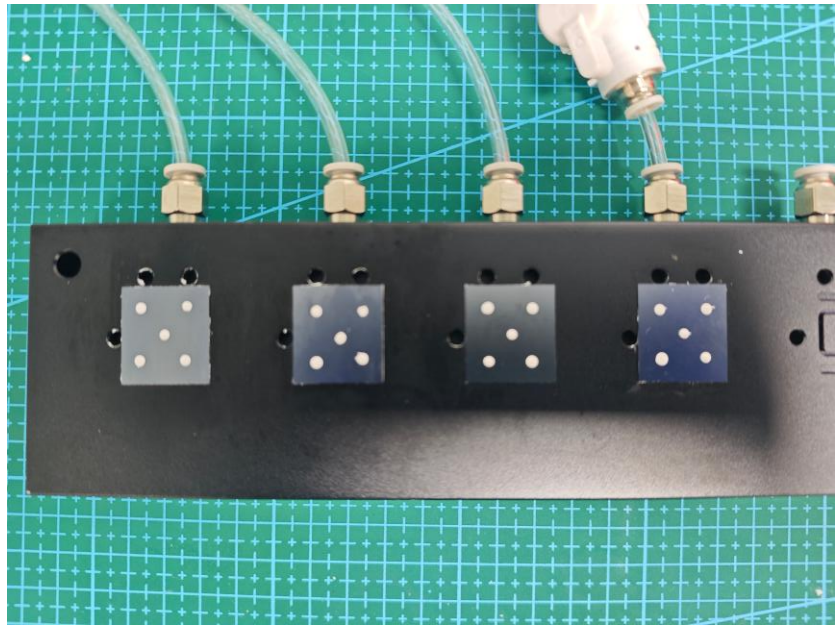


Inlaying Teflon material
to protect chips

- Gantry/robot arm to be used
- The jigs for the gantry/robot arm are currently in production
- An assembly procedure using a gantry/robot arm has been designed

Robot Arm Dispensing Adhesive





- Robot arm dispensing has been realized.

The next step

- Accomplish more complex dispensing processes through image recognition technology.

CF comb bare stave

- Carbon fiber
- Titanium tube

➢ Carbon fiber honeycomb + two carbon fiber surface

At FTDR level, we expect the same materials as the current UT

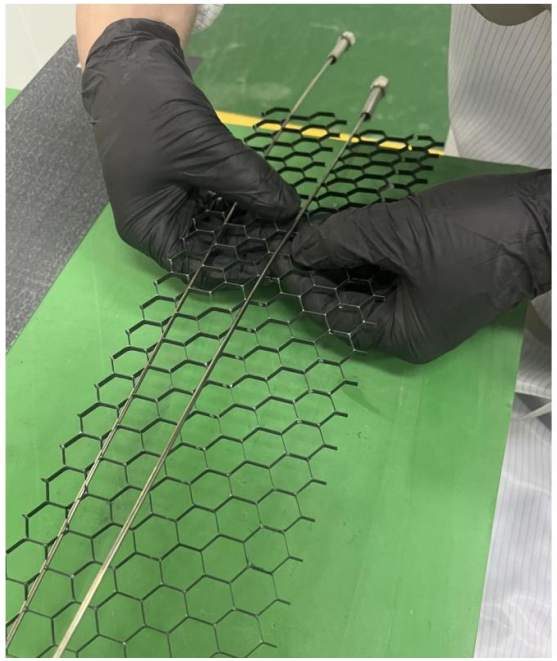
➢ Structure foam: Evonik Rohacell 51 IG (0.051g/cm^3)

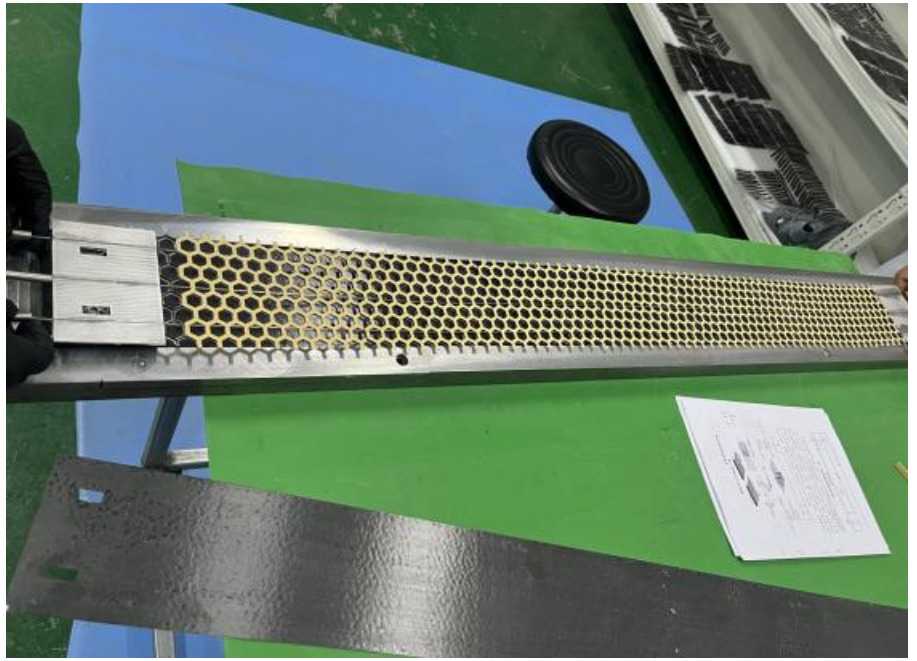
➢ Thermal foam: Allcomp K-9 carbon foam (0.2g/cm^3,~35W/m·K)

➢ Carbon fiber: K13C2U high-modulus carbon fibers in EX1515 epoxy matrix (45 gsm, 0.21mm THICK)

➢ Ti cooling tube: D 2.75 mm, Thickness 0.1 mm

First bare stave prototype



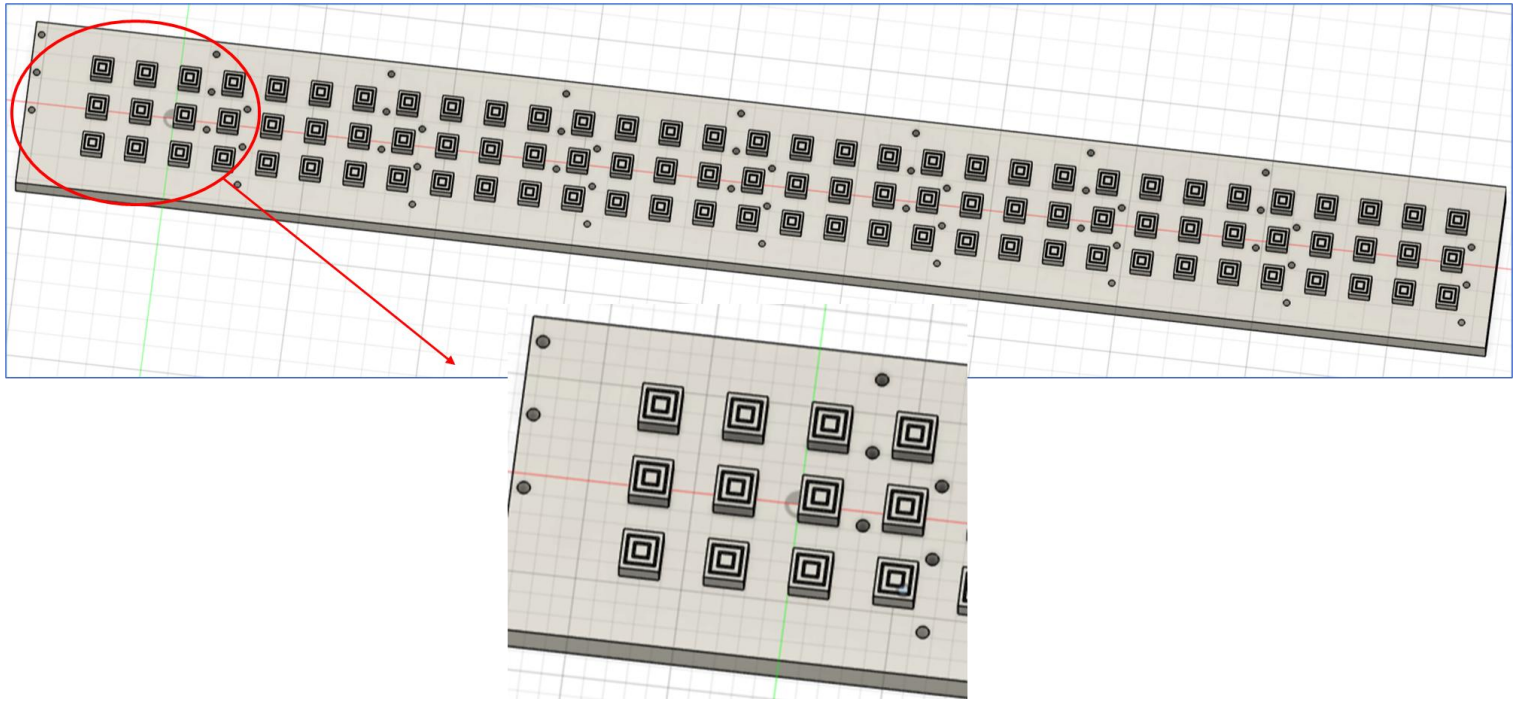



Two CF facing + CF comb + 3 × Ti tubes + 2 × Al end of stave

- Titanium tube-embedded Carbon fiber
- Assembling Al plates
- Place the first skin panel into the Jig
- Place the carbon fiber into the Jig

The mass in the active area: 23.2 + 12 (Ti) x 3 + 40 g + 120 x 2 g, with density ~ 0.5 g/cm3

Preparation for Staves Assembly



- Discussions on the assembly of staves have kicked off.
- A jig has been designed to disscuss the assembly method.
- The procedure still requires further in-depth research.

Summary

- The assembly procedures for both the module and the bare stave are progressing well.
- We are currently exploring how to use a gantry or a robot arm for assembly.
- Design a method to measure assembly precision to ensure assembly quality.

Thank you!