Automatic High-Granularity Timing Detector Module Assembly with Gantry System

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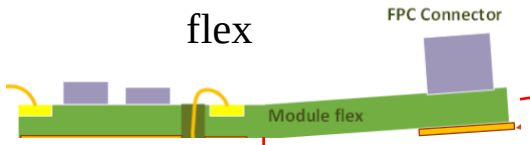
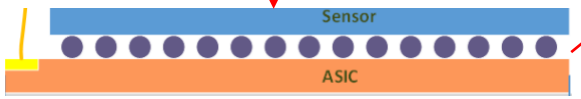
Qualification task description

- This project is to develop the procedures of positioning and gluing steps in HGTD module assembly. The tools for manual assembly have been developed. This project is to develop module assembly with an automatic robot. Hao will develop the assembly procedure steps and required tooling. In addition, he will program the robot to position the bare module (the bare sensor bump-bonded to the ASIC) onto the module flex (flexible PCB board) with a precision of tens of micrometers. He will also program the robot to perform the gluing of the bare module on the module flex. The assembly procedure will be documented in an ATLAS internal note.

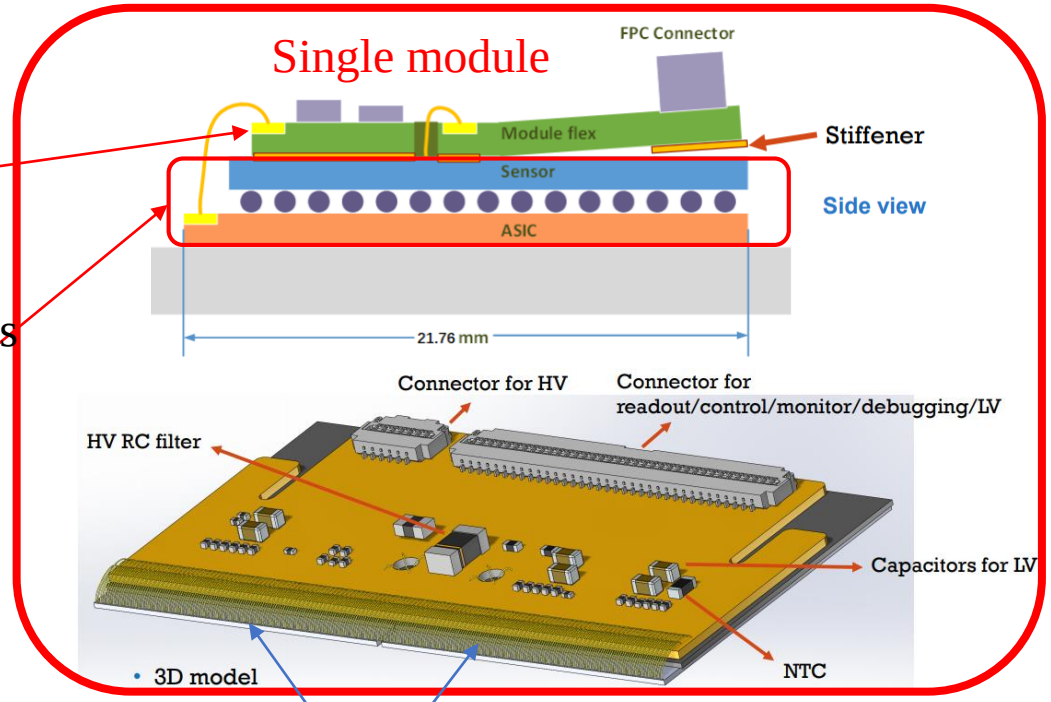
HGTD module assembly



1. glue the flex on the two bare modules

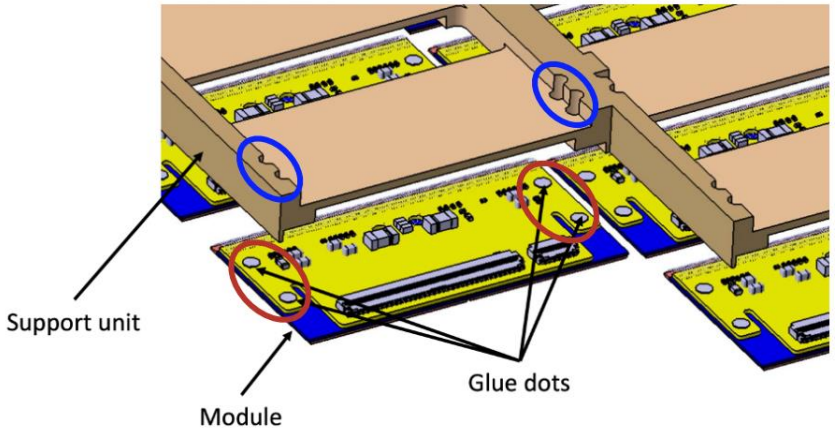


bare module

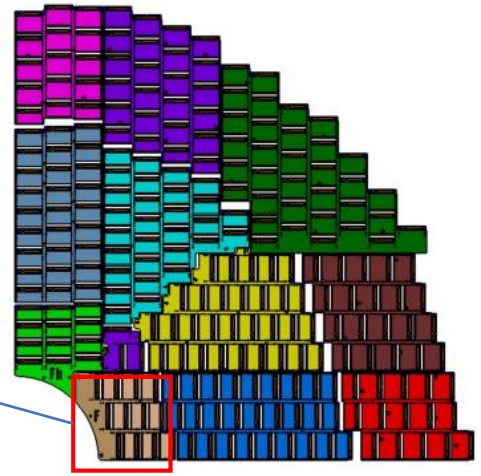


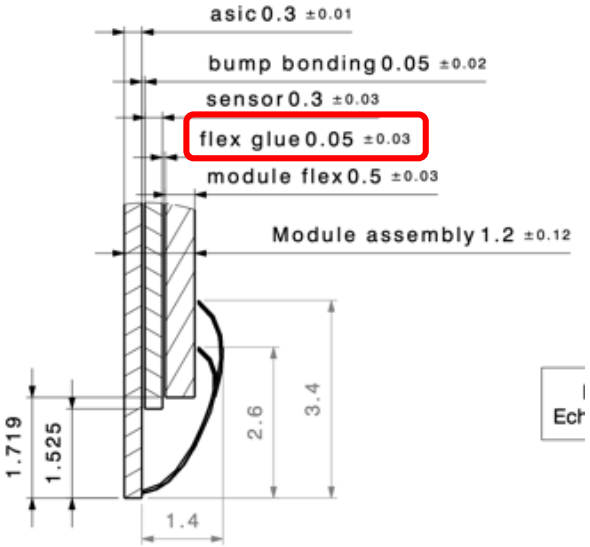
Specification of the module mass and dimension
Module weight 3.0 g
Nominal thickness of the module 2.52 mm
Maximum thickness of the module 3.32 mm
Maximum width of the module 40.6 mm
Nominal gap between two bare modules 200 μm
Minimum gap between two bare modules 50 μm

2. glue the module on the support units

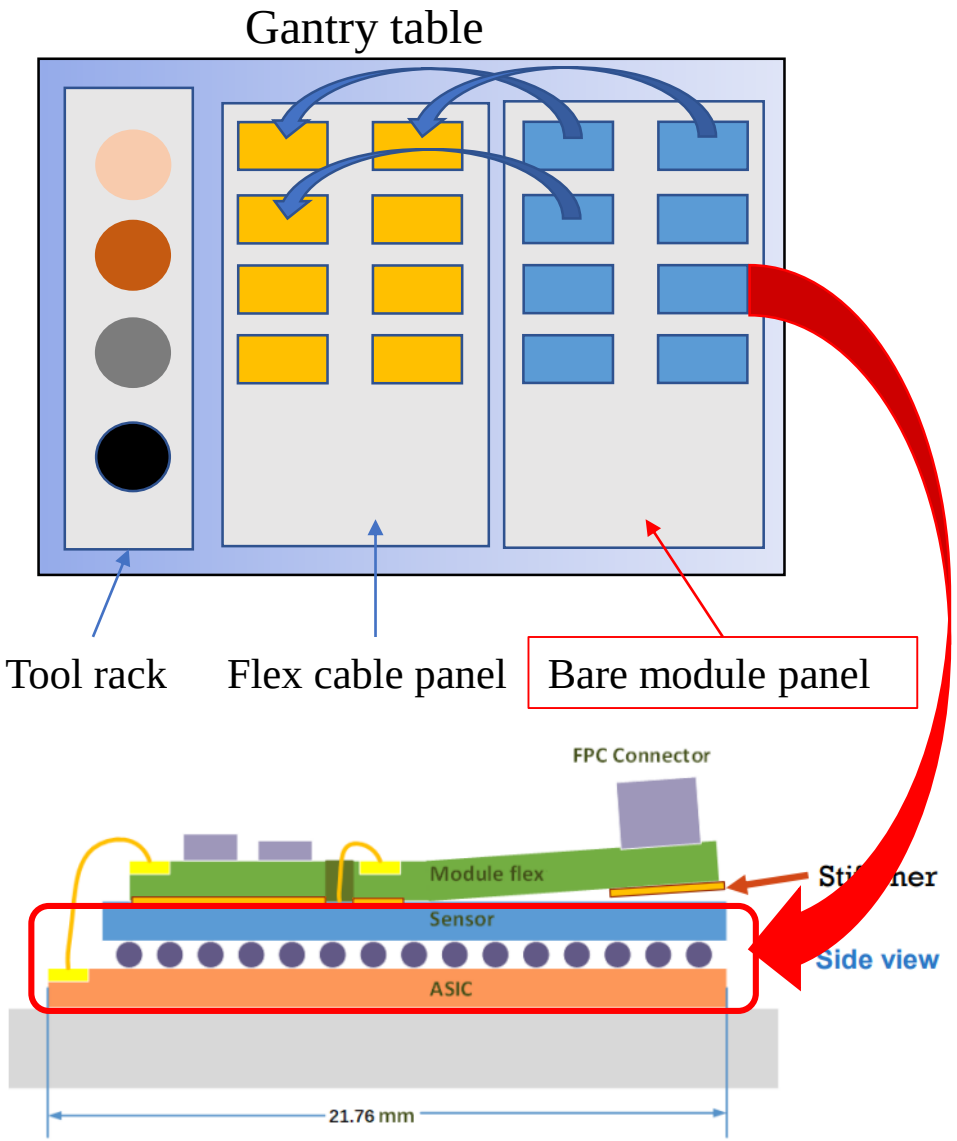


2 bare modules

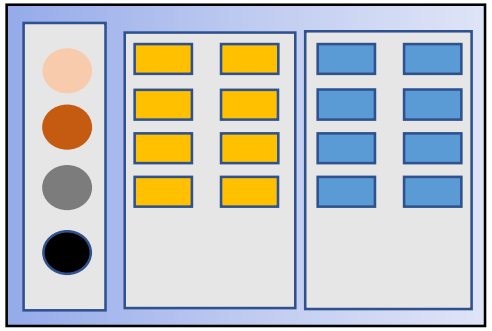




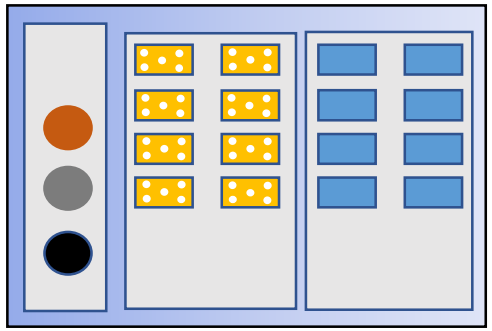
Method 1: Gluing of the bare module on the flex cable



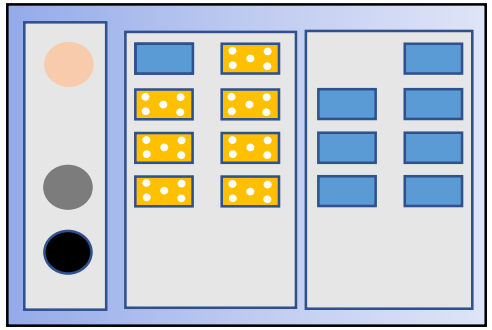
Prepare the tools, flex and bare module



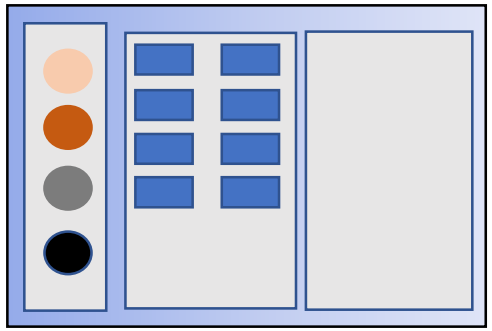
Dispense glue on the flex



Pick the bare module and place it on the flex

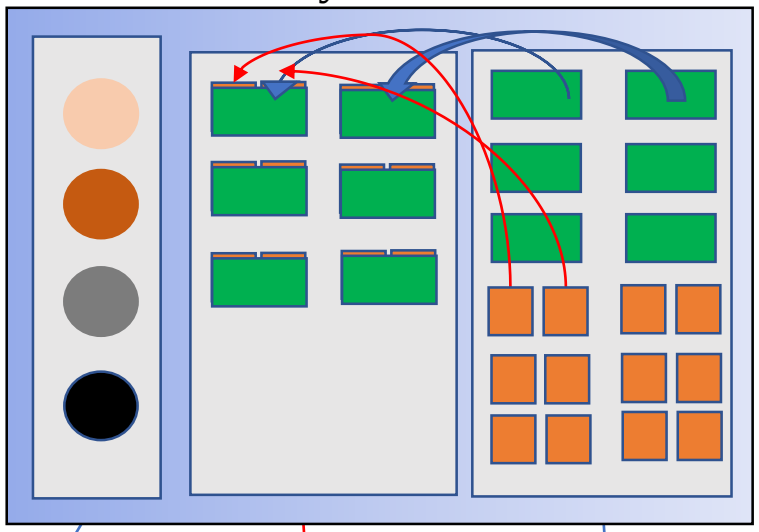


Finish picking and placing, put tools back on the rack

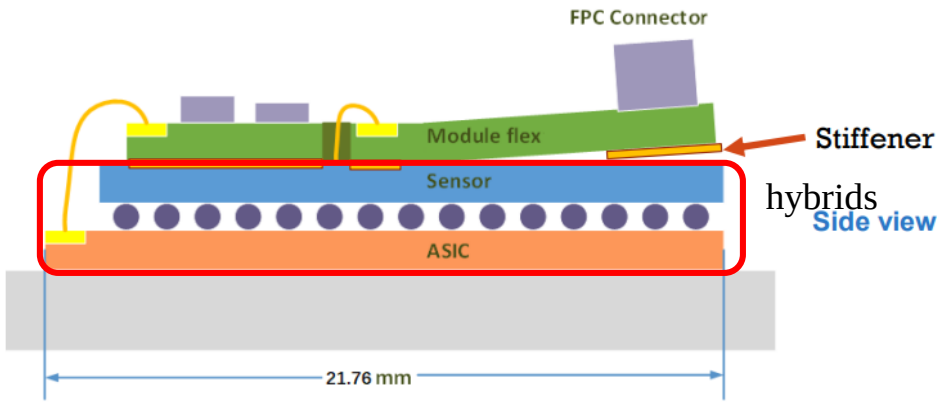


Gluing of the flex cable on the bare module

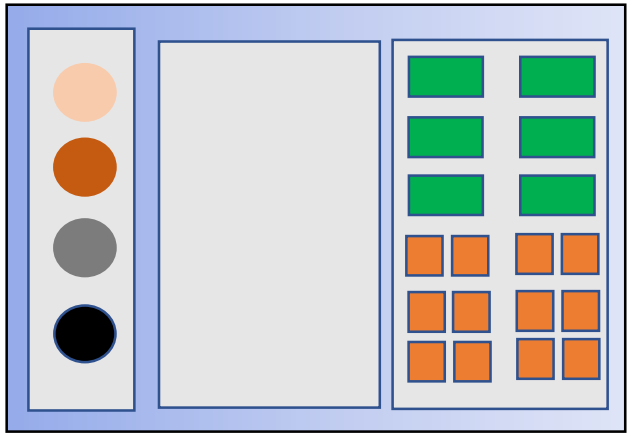
Gantry table



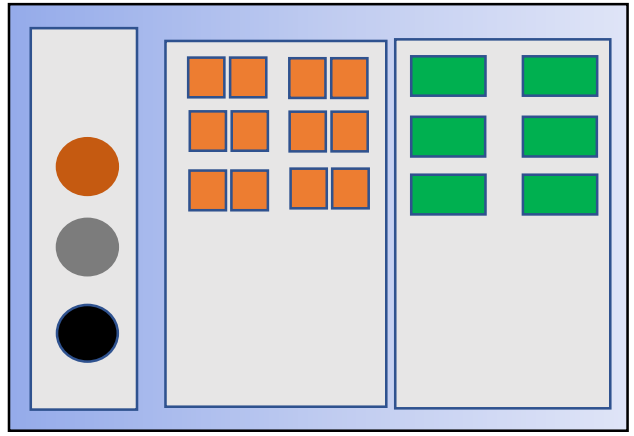
Tool rack | vacuum chuck | Flex cable chuck



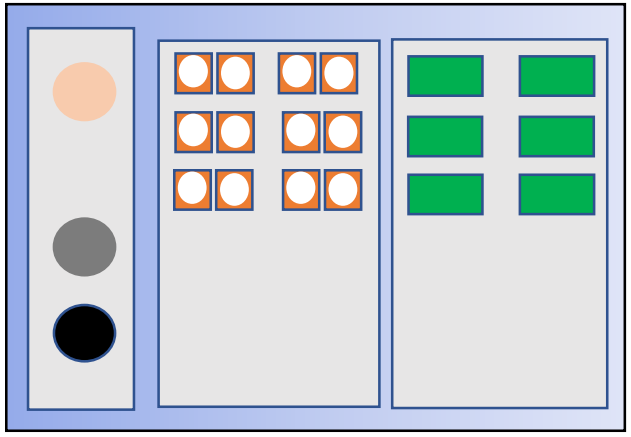
Prepare the tools, flex and hybrids



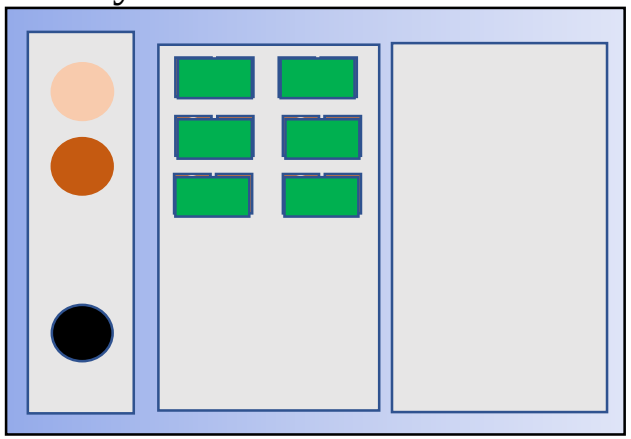
Pick-and-place the hybrids to the vacuum chuck



Dispense glue on the hybrids

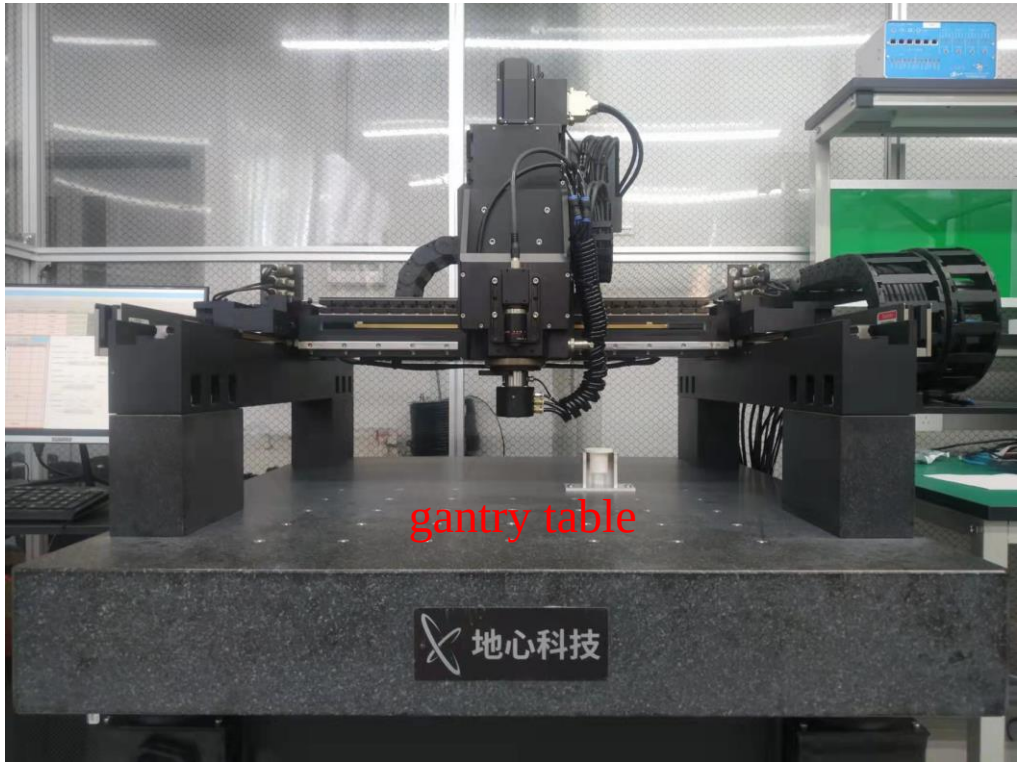


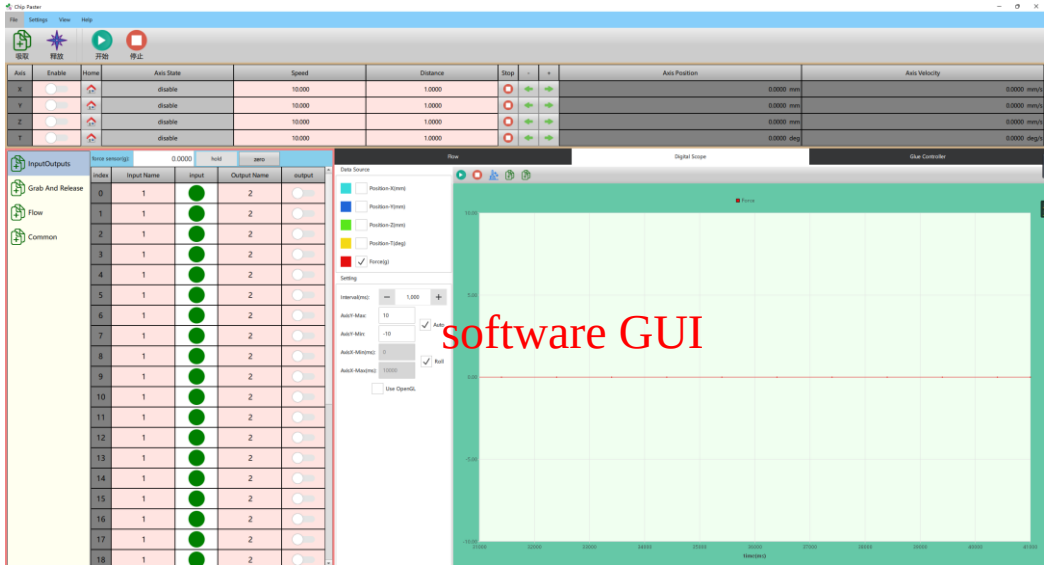
Pick the flex and place it on the hybrids

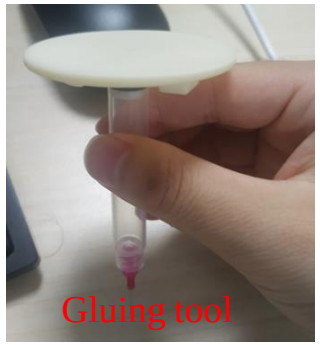


The gantry system at IHEP

- Robotic pick-and-place for systematic module assembly (gantry), consists of:
  - Coretech gantry positioning system with ACS motion controller (500 mm * 500 mm * 150 mm * 340° travel, repositioning resolution ~ 1μm)
  - Integrated with Keyence vision system, pressure sensor, multi-channel electro-valves (maximum 32), Nordson EFD Glue Dispensing controller, flexible vacuum and air pressure piping system, and custom picking and gluing tools
  - Controlled with GUI based on C++ and Qt

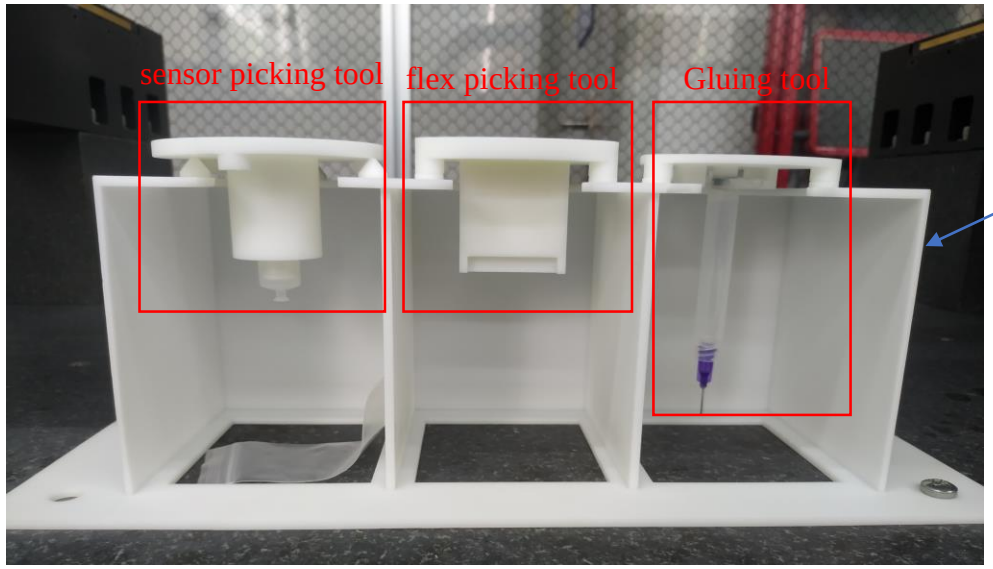


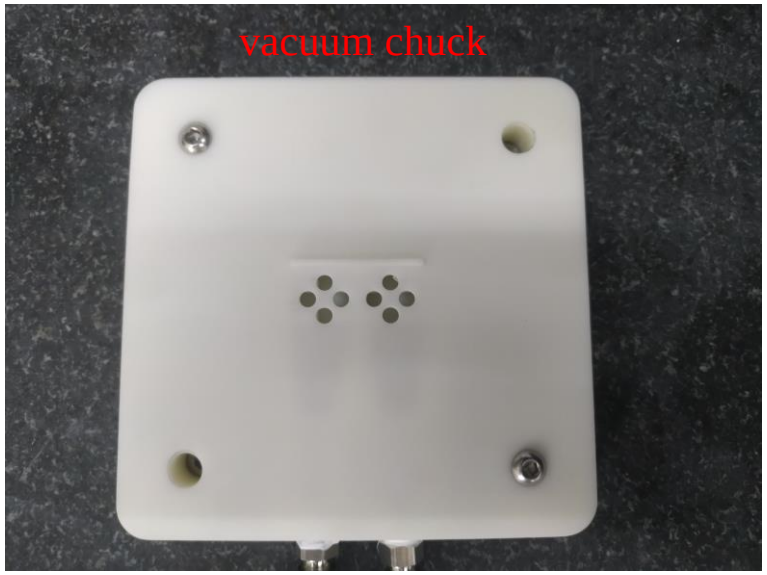




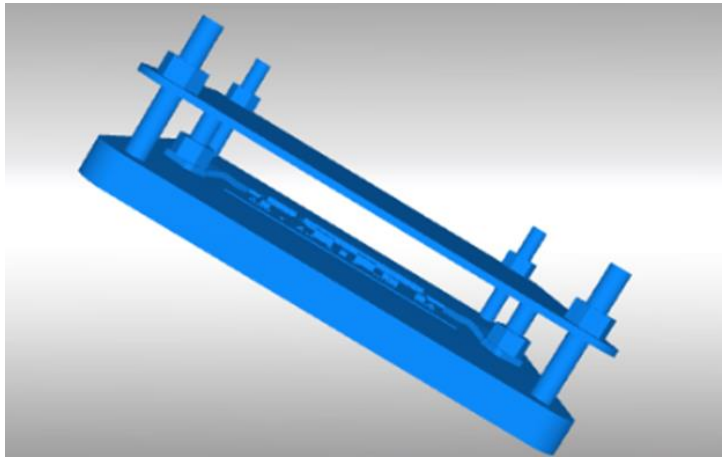
Tools design

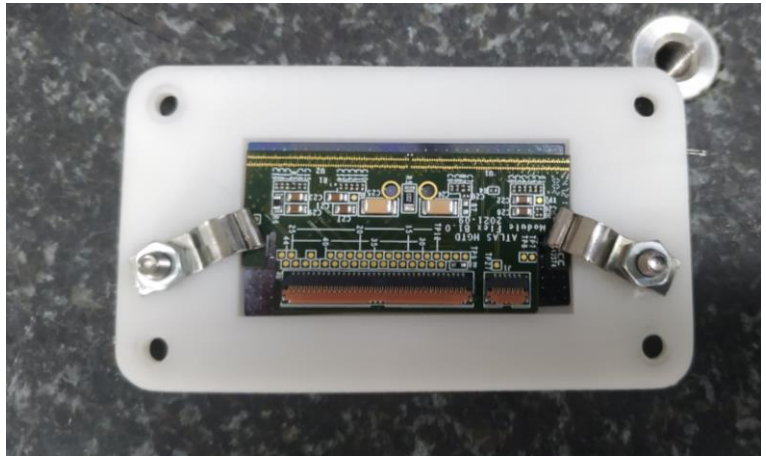
- Tools we have now:
  - 3D-printing sensor picking tool, flex picking tool and gluing tool
  - 3D-printing tool rack and vacuum chuck





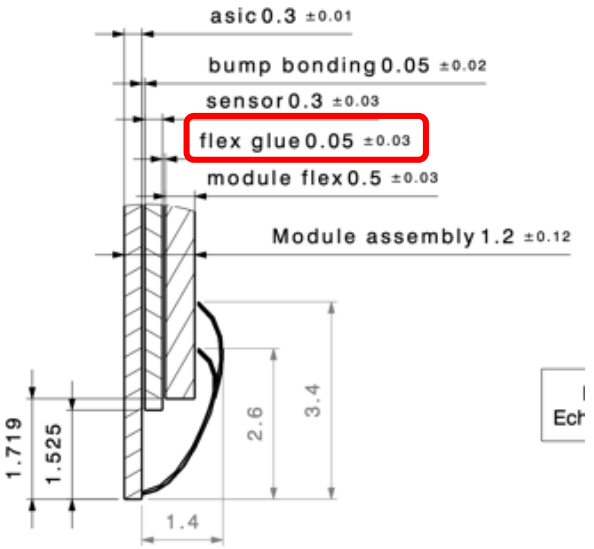
- Protection box:





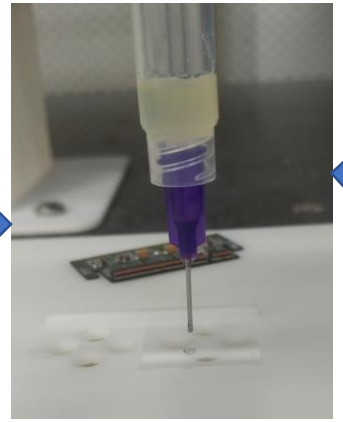
Glue weight study

- In the SPR, only the specification of the glue thickness is given ($0.05 \pm 0.03mm$)
- There are no specification on the glue weight, especially for the automation assembly for which we use a very high quality dispensing controller.
  - Program to control the pressure, time and patterns of the glue
- Finally, we can give the specification of the glue for the automation module assembly
  - Glue weight, dispensing pressure, dispensing time…

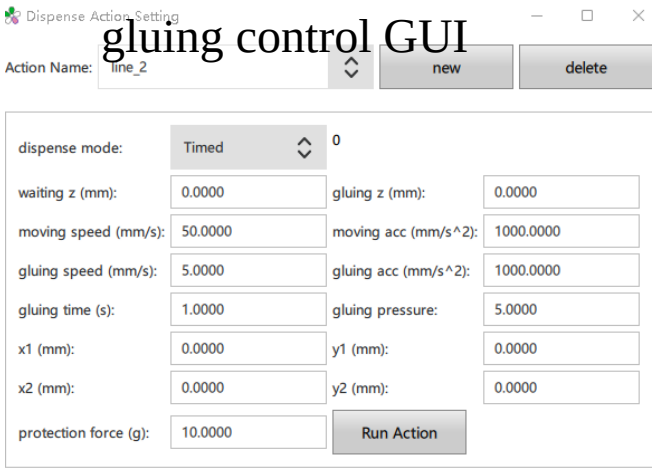


Glue weight measurement

- Gluing setup
  - Air compressor connected to dispenser controller (send command to the controller via gantry software)
  - The glue syringe connected to the dispenser controller via electronic switch
  - Dispense glue on the glass sensor
  - Weigh the glue with the balance



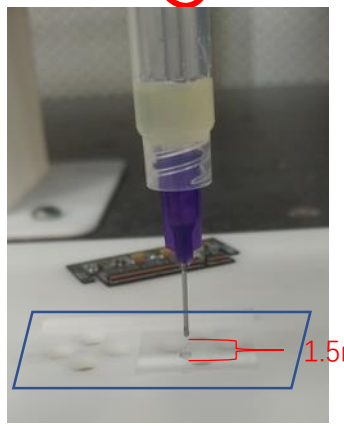
Electronics balance



gluing control GUI

Glue weight measurement method

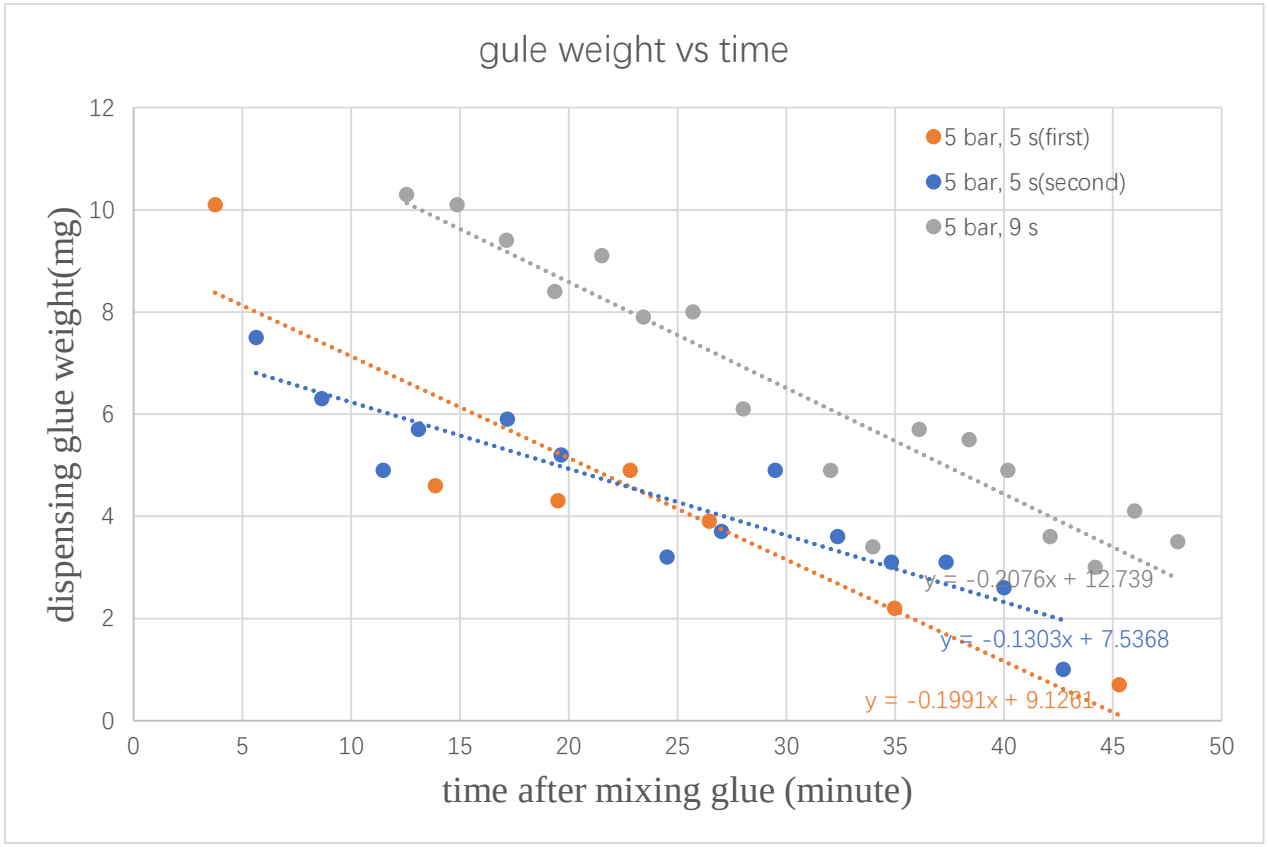
- Many factors will affect the glue weight:
  - Temperature: 28.1°C
  - Humidity: 31.6%RH
  - Needle size: 21G
  - Mixing head: MA3.0-7S
  - Dispensing time(s): 5 second, 9 second
  - Dispensing pressure: 5 bar
  - Curing time (time after mixing the glue): variate
  - Distance between glass and needle: 1.5mm
  - Dispensing pattern: dot

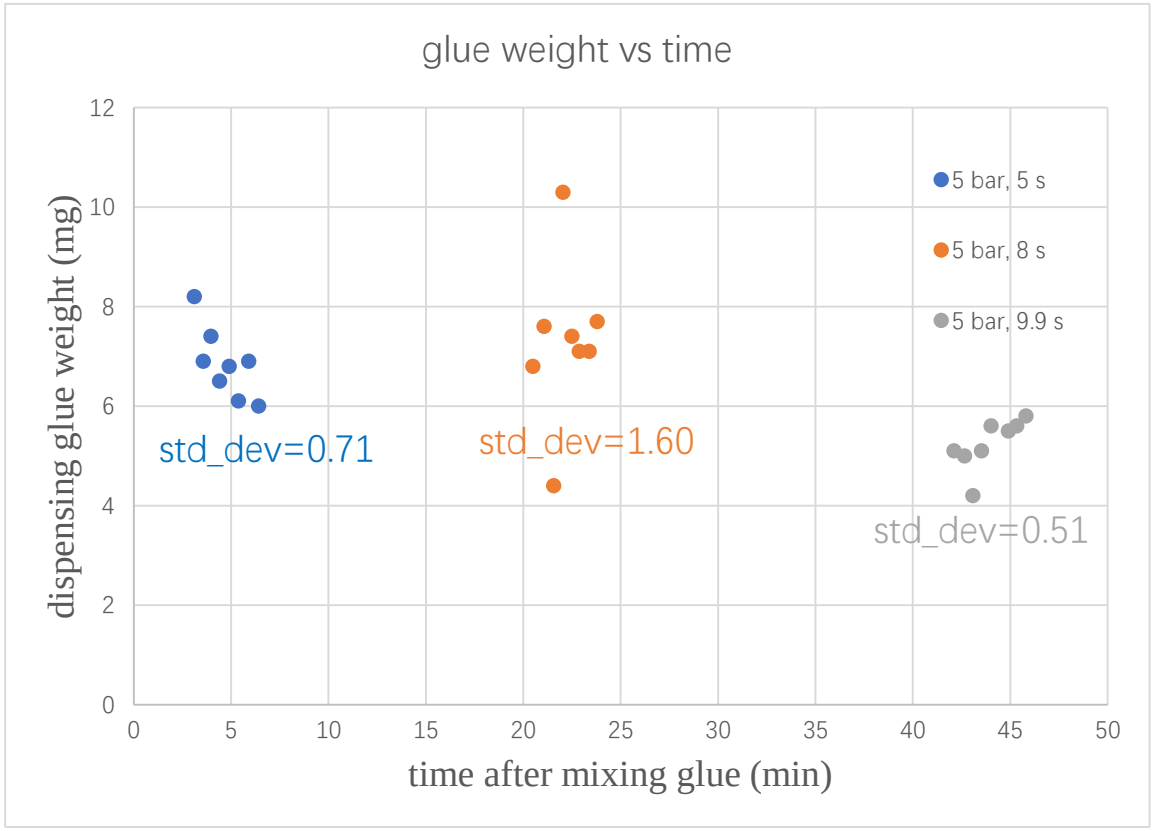


- Only change one factor and control all other factors (control variable method)

Glue weight result

The glue weight decreases linearly
Fit it with linear function, which can be used for dispensing time calibration
The glue weight variation is very small if you finish gluing within 5 minutes





Where are we now?

- This project is to develop the procedures of positioning and gluing steps in HGTD module assembly. The tools for manual assembly have been developed. This project is to develop module assembly with an automatic robot. Hao will develop the assembly procedure steps and required tooling. In addition, he will program the robot to position the bare module (the bare sensor bump-bonded to the ASIC) onto the module flex (flexible PCB board) with a precision of tens of micrometers. He will also program the robot to perform the gluing of the bare module on the module flex. The assembly procedure will be documented in an ATLAS internal note.
- The procedures of positioning: only have the concept of how to position but image recognition still has problem
- Gluing steps: tools are done, glue weight calibration is on-going.
- Tools: already have all tools for assembly one module
- Program: basic function of assembly one module is done

How to finish: Next to do

- Demonstrate the positioning procedures and gluing steps work
  - Finish the glue weight calibration, then we can provide the glue specification for automation module assembly
    - Measure the thickness of glue
    - Needle size, mixing head size, dispensing time, dispensing pressure and dispensing pattern
  - Using the vision system to recognize the flex and bare module for positioning them
    - Finalize the tools, finish the coordinate transformation, measure the alignment (gap between two bare module, alignment between flex and bare module)
  - Assembly one functional module?