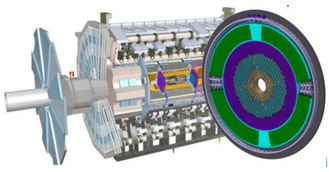
Automatic High-Granularity Timing Detector Module Assembly with Gantry System

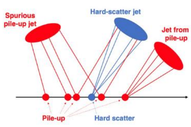
Hao Zeng
Institute of High Energy Physics, CAS, Beijing, China

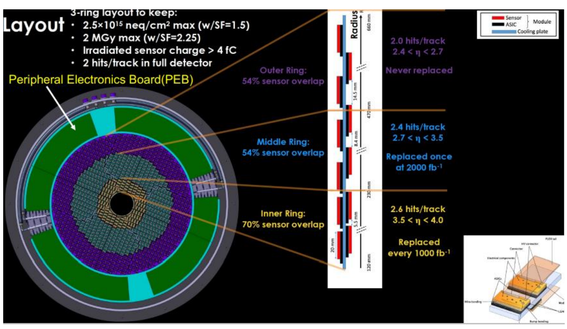
Introduction

High Granularity Timing Detector (HGTD)

- HGTD aim to reduce pileup contribution at HL-LHC
  - Timing resolution is required to be better than 50ps
  - $6.4m^2$ area silicon detector and ~ 3.6×10^6 channels
  - High Granularity: Pixel pad size: $1.3mm \times 1.3mm$
  - Radiation hardness: 2.5×10^{15} N_{eq} $/cm^2$ and 2MGy

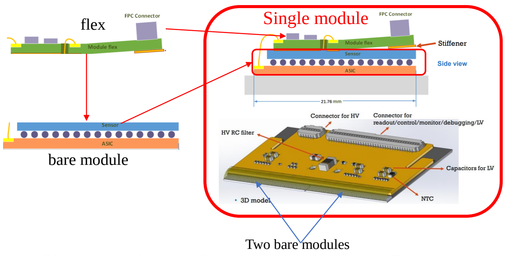




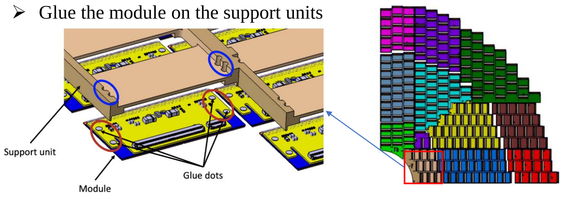


Task of the HGTD module assembly with gantry system

- Glue the flex on the two bare modules



- Glue the module on the support units

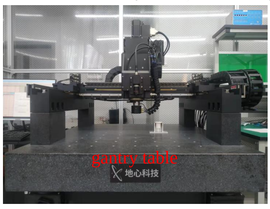


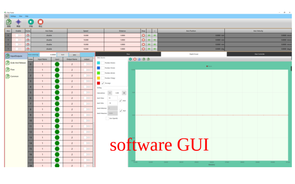
- Specification of the module mass and dimension

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

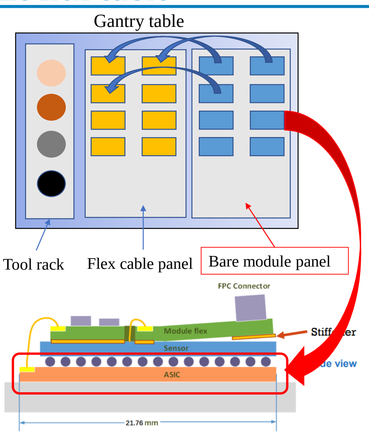
The gantry system at IHEP

- 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 ~ $1\mu m$)
  - 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
  - Open source C++ Qt program with GUI to control the whole system (still developing)

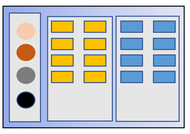




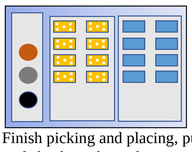
Example: Gluing of the bare module on the flex cable



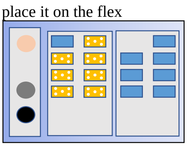
Prepare the tools, flex and bare module



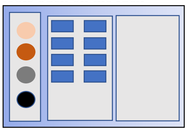
Dispense glue on the flex

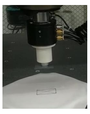


Pick the bare module and place it on the flex



Finish picking and placing, put tools back on the rack



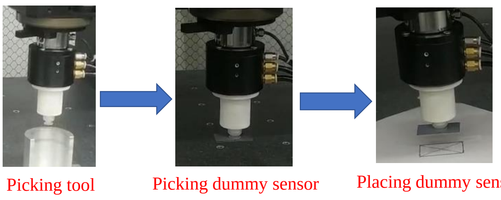


Current status at IHEP

- Gantry system has already been installed with all hardware components in a clean room:
  - Vacuum system, air pressure system and vision system
- Positioning resolution validation was done with laser system (<$1\mu m$)

Axis	Calibration interval	Test interval	Specification	Result
X	50mm	500mm	$3\mu m$	$1\mu m$
Y	50mm	500mm	$3\mu m$	$0.4\mu m$
Z	15mm	150mm	$0.8\mu m$	$0.8\mu m$
Theta	15°	360°	5arc sec	2.074arc sec

- Pick-and-place utilizing the vision system works very well
- Software developing is ongoing
  - Glue dispensing function is integrated

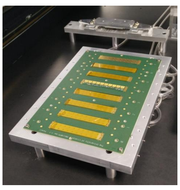


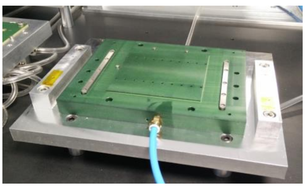
Picking tool | Picking dummy sensor | Placing dummy sensor

Dispenser controller integration

Summary and outlook

- A high precision positioning gantry system has been built in IHEP for automatic HGTD module assembly
- We performed basic testing for the gantry, it satisfied the module assembly requirements.
- Outlook:
  - Develop the standard procedure for the automatic HGTD module assembly
  - Design more custom tools and vacuum chucks (learn form itk project)
    - Continue to improve the user-friendly control software





Vacuum chucks for itk module assembly