Assembly and Loading

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MOST ATLAS Detector Upgrade Project, 2025 Annual Meeting

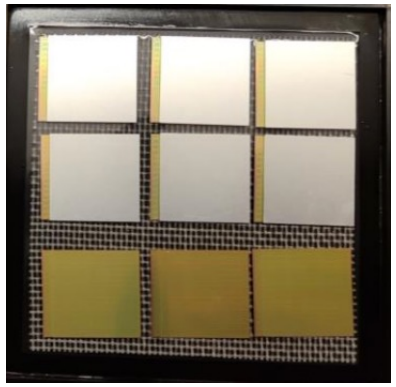
Expected deliverables

PBS		Production step	Yield (%)	Number of modules
8.4.1	Bare module hybridisation	Sensor UBM	99.5	10855
		ASIC Bump deposition	99.5	10800
		Flip-chip	97	10747
8.4.3	Module assemblies	Flex module gluing	97	10431
		Wire Bonding	98	10112
		Test	98	9910
		Burn-in tests	95	9712
8.4.4	Detector Units	Loading on Detector Units	95	9226
		Test	98	8765
		Transport	99	8589
8.6	Detector assembly and QA on surface	Assembly on cooling plates	96	8503
		Test	99	8163
Overall yield			**74**	8032

Site number	Site name	Fraction
S_1	IHEP	34%
S_2	France	20%
S_3	Morocco	16%
S_4	Mainz	10%
S_5	Spain	10%
S_6	USTC	10%

Ref: https://edms.cern.ch/document/2569751/1

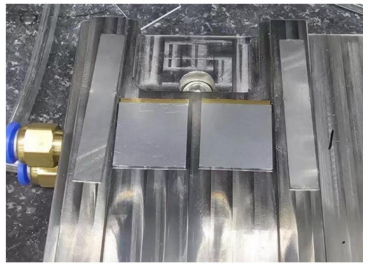
Module assembly procedures



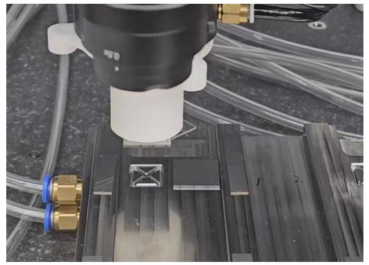
Hybrids

Gluing

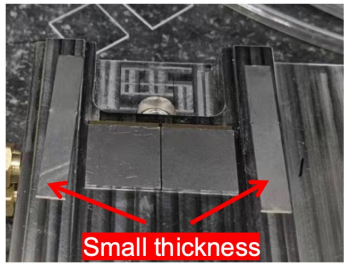
1. Roughly put the hybrids



2. Locate and pick up the hybrids

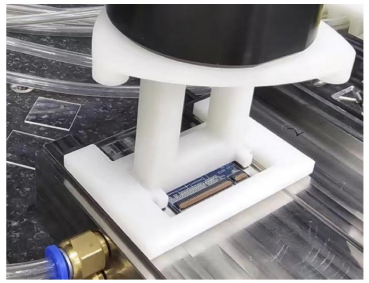


3. Place to the designed position

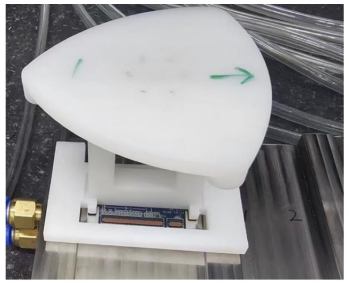


4. Dispense glue pattern

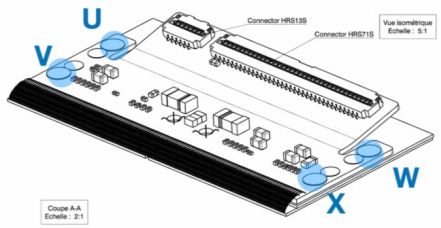
5. Place the flex on the hybrids

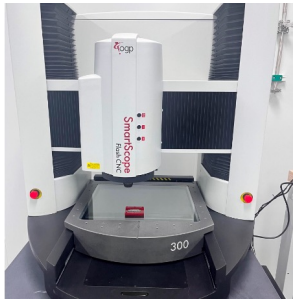


6. Leave for the glue curing

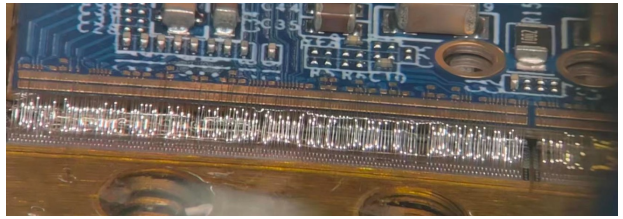


Metrology

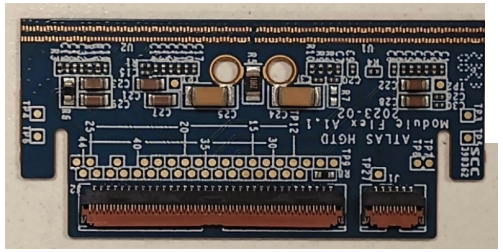




Wire bonding



Module flex



Module QA/QC

Module QA/QC

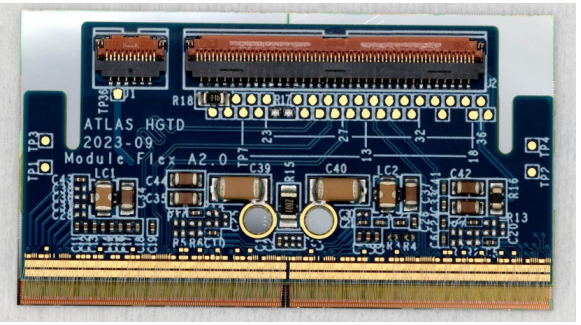
- Refs:
  - https://indico.cern.ch/event/1578005/#423-module-qc-procedures-for-p
  - https://hgtd-module-qc.docs.cern.ch/electrical_tests/qa_qc_tests/

Glue Spillage
Module Width and Length
Hybrids to Flex Alignment
Inter-Sensor Gap
Assembly Thickness
Module Weight
Wire Bond Tests

module IV
module flex NTC verification
DC levels verification
I2C communication
Timing and luminosity data functionality
Module tuning and charge scan
TOA and TOT LSB
Bump connectivity
Burn-in thermal cycles

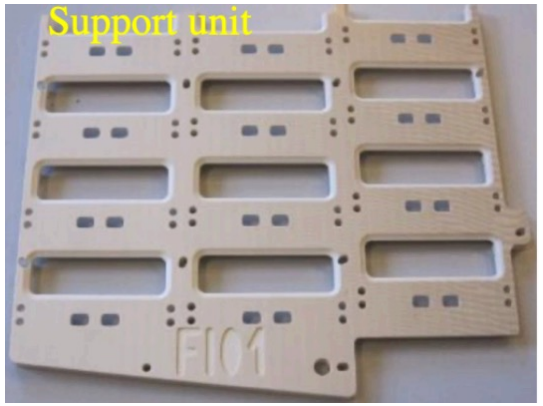
Detector unit loading procedures

Ref: https://edms.cern.ch/document/3172470/1

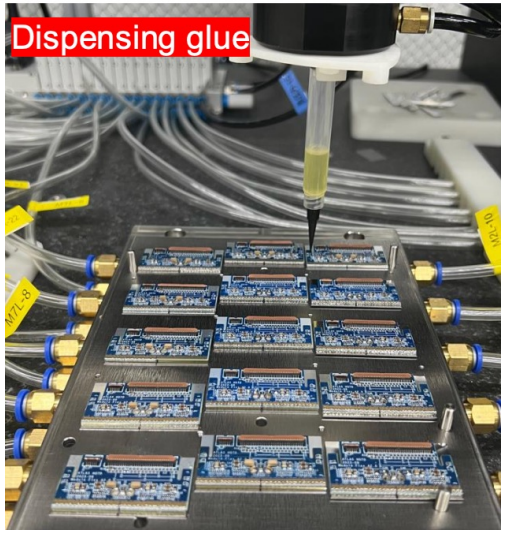


Modules

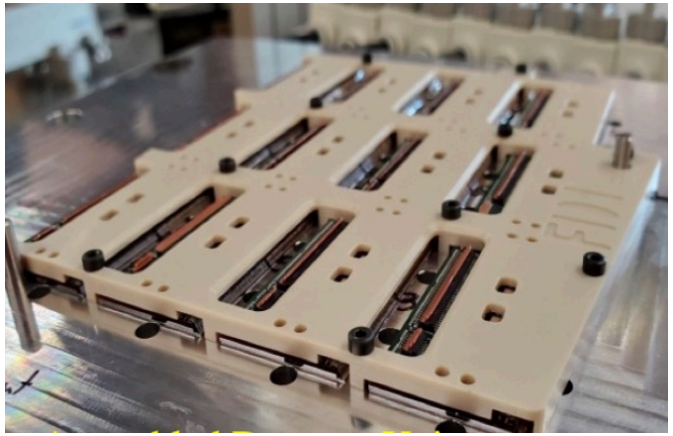
Support unit



Gluing



Loading



DU QA/QC

Loading: site qualification

Site qualification procedure for loading

1. Pre-qualification (stage 1)

Loading a Detector Unit with dummy modules (glass) and lower-quality 3D printed Support Unit:
- show control of automatic glue deposition and tooling (plates, vacuum, …)
- verify correct positioning and alignment of modules onto Support Unit

\+ Repeat with one pre-prod SU and tooling with glass dummies to save modules

2. Qualification (stage 2) 2 extra SUs of the first kind available for this step, 1 for TC (partially loaded)

Loading a Detector Unit with thick ALTIROC-A modules:
- perform Support Unit metrology
- show that loading satisfies metrology requirements (connector position)
- show that loading does not damage modules (wire bonding, bumps)
- upload data to production database (metrology and electrical measurements)

These first Detector Units from pre-production will be used for demonstrator and module-0

Timelines for Assembly

Original assembly production plan (2024)

batch	start date	end date	IHEP	USTC
1	2025-Sep-9	2025-Sep-22	20	6
2	2025-Sep-23	2025-Dec-9	27.4	8
3	2025-Dec-10	2026-Feb-27	31	9.1
4	2026-Mar-2	2026-May-12	34.2	10.1
5	2026-Mar-13	2026-Jul-20	37.9	11.1
6	2026-Jul-21	2026-Sep-21	38	11.2
7	2026-Sep-22	2026-Nov-20	37.9	11.1
8	2026-Nov-23	2027-Jan-27	38	11.1
9	2027-Jan-28	2027-Mar-30	42.6	12.6

- Module and DU PRR was expected to be in Q2 2026
- The goal is to build 450 new modules during the pre-production
  - IHEP+USTC: 450*44% = 198 modules

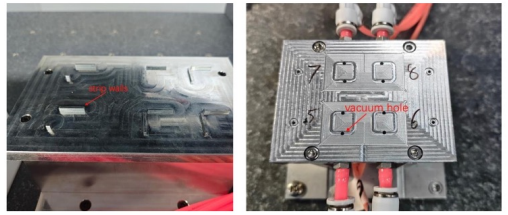
Top production rate per week taking into account 74% yield:

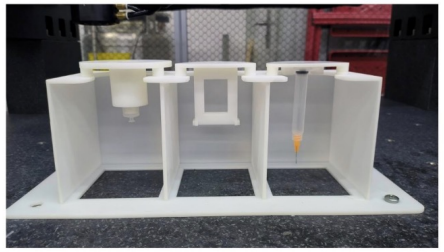
- Assuming 78 weeks in total
- IHEP+USTC: 57.6+17.1= 75 modules / week

https://edms.cern.ch/ui/file/2569751/1/HGTD_production_rate_v3.pdf

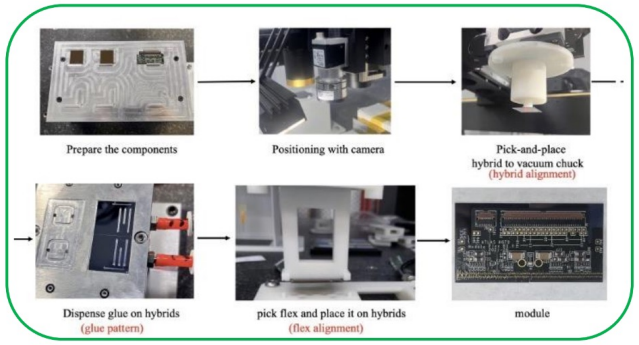
Current status of the assembly

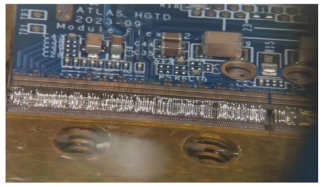
- Full procedure already developed with both gantries at IHEP and USTC

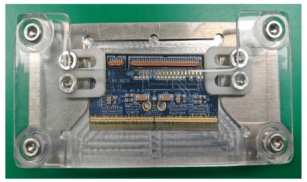




Customized tools







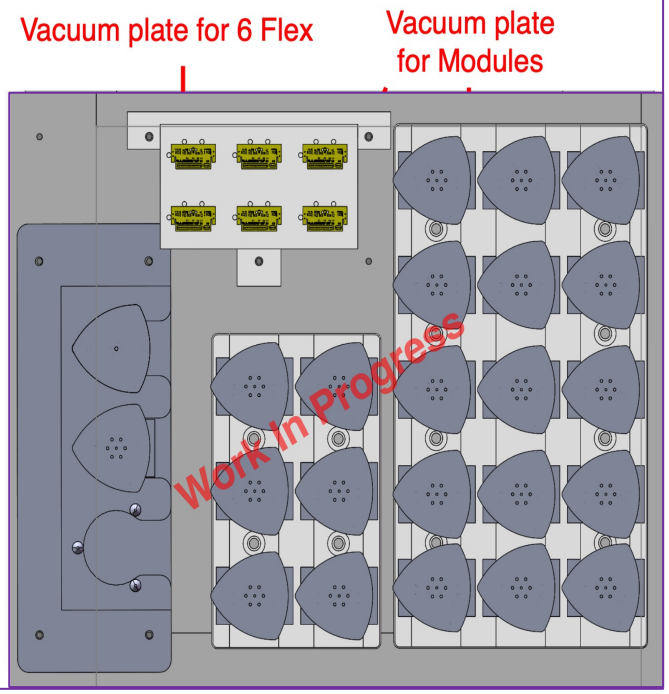
Wire-bonded module

20

USTC Assembly

Multi-module assembly system

- New assembly system developing:
  - Expect to assemble 21 modules per shift;
    - Still in developing…
  - Investigating to assemble another 6 modules;
- Modules produced per day:
  - 4 batches: 5 + 5 + 5 + 6;
  - ~20 mins to dispense glue on 5 modules, the glue need to be refilled after that;
  - **Take about 4 hours per day, only one shift;**
  - **Left for curing during the nights.**
- Work in progress:
  - Managing the vacuum pipes;
  - Designing the route of the workflow.



IHEP Assembly
Documentation at: https://hgtd-ihep-module-assembly.docs.cern.ch/Intro/Intro/

Timelines for Loading

- Qualification + first SU loaded to be exercised:
  - FO05DU IHEP/USTC (10 modules)
  - FO06DU IHEP/USTC (11 modules)

Ref from the Nov HGTD Week

- Nov HGTD week: "Aim at site loading qualification by end of the year / January, DUs at CERN in February – March"

Table 8 Baseline distribution: list of detector units for a quadrant of the back side for each institute

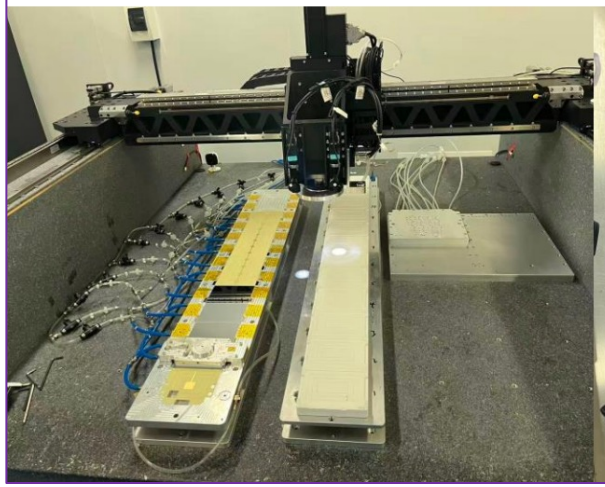
Institutes for sequence 1	Detector Units	Percentage	# loaded modules
IFAE	BO12DU BM08DU	10%	26
IHEP	BI12DU BM10DU BI10DU BO06DU BO04DU BO03DU BO02DU BI01DU	33%	82
LPNHE	BM12DU BM09DU BO05DU BM05DU BM02DU	21,00%	55
Mainz	BM11DU BO08DU	10%	25
MAScIR	BO10DU BM06DU BM03DU BM01DU	15,00%	36
USTC	BO07DU BO01DU BM04DU	11%	27
Total	**24 detector units – One quadrant of the back side**	**100%**	**251**

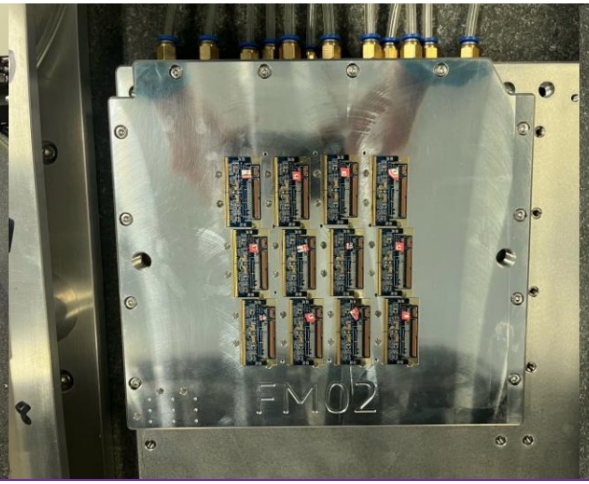
For production: 82+27 = 109 DUs to be loaded

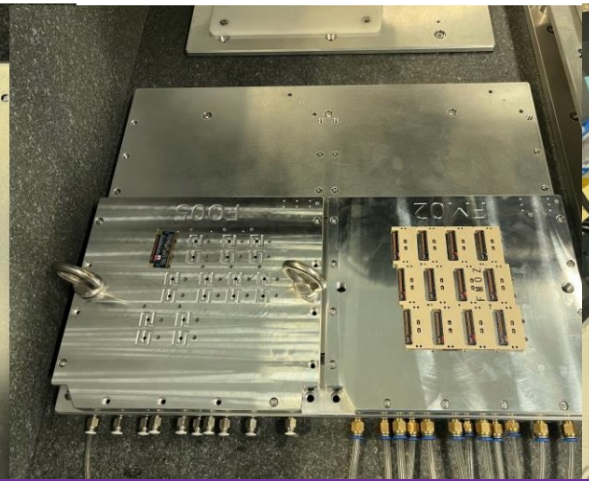
Current status of the loading

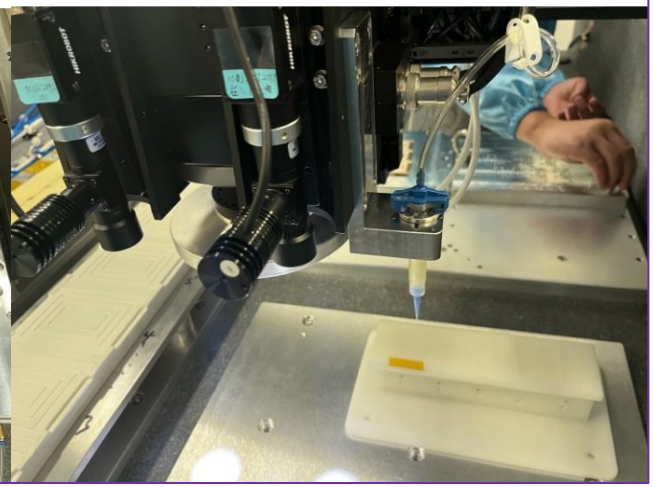
Loading preparation status at IHEP- USTC

- Implemented automated loading process on AMS gantry for FM02
- New gantry used for loading: larger area and can accommodate 4 vacuum plates
- Total of 24 vacuum circuits; 12 of them used to verify the loading process of FM02SU.
- For a DU of 12 modules, after optimizing the process, it is expected that the entire loading process will take 30 minutes
- The airtightness result shows that VP with poor flatness can still meet the requirements









Current status of the loading

- Loading with the AMS gantry still in development, with some issues to be finalized
  - Validate the loading procedure with the updated software to tune the camera filed of view → USTC team plans to visit IHEP next week to work on this
  - Hybrids handling (currently done manually for dummies)
  - Extend the number of vacuum channels (12→16)
  - Exercise the full loading procedure with dummies
  - Metrology to ensure meeting the specifications
- Should aim to pass the site qualification on loading in Jan

Action items

- Are we really confident that we are 100% ready for the (pre-)production of both the assembly and loading?
  - Assuming the hybrids, module flexs, support units will come in time
- Some open questions:
  - Is the assembly procedure with the R107 gantry fully automated or manual intervention still needed?
  - Is the procedure fully optimized or there is still room for improvement?
  - Do we have enough experts (besides Xinhui) that know all the details (hardware, software), from assembly to QA/QC?
  - Do we have a clear and practical plan for the (pre-)production?
  - Do we have a list of shifters that will participate in the (pre-)production?
  - Do we have a plan to train the shifters?
  - Documentation
  - …

Random thoughts on moving forward

- The China cluster should, and actually always has the strong will to, work together as a team to ensure the success of the project
- There are too many critical tasks that need dedicated experts and person-power
  - Sensor production and QA/QC
  - ASIC probing
  - Hybridization and hybrids QA/QC
  - Module flex/SU production and QA/QC
  - Module assembly and QA/QC
  - Wire bonding
  - Loading and QA/QC
  - Electronics
  - …

- China cluster is involved in all these critical tasks (almost all institutes expressed interest in assembly and loading in the NSFC project)
- But we only have very limited experts and it is impossible for them to take care of all of them simultaneously
- It is probably more efficient to assign dedicated responsibles to coordinate and oversee the progress in each area
- We can have a China HGTD organization structure to implement the tasks
- Other ideas to enhance the efficiency and collaboration?