From Components to Cohesion: ATLAS ITk Inner System Assembly and Testing

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ATLAS EXPERIMENT

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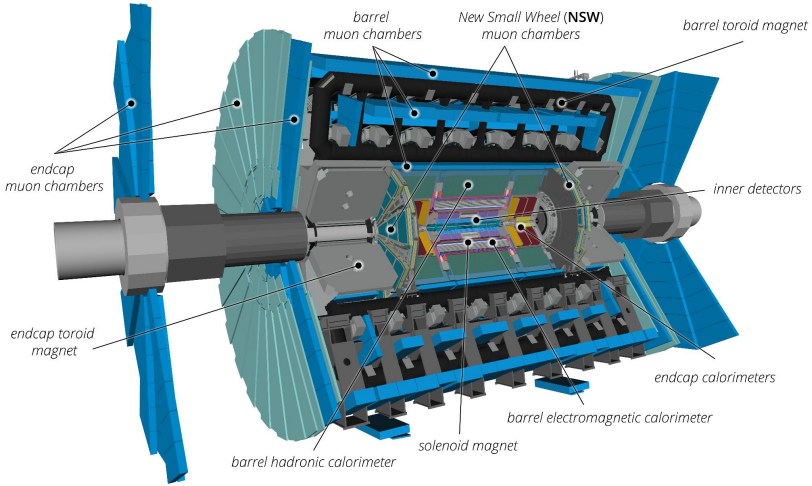
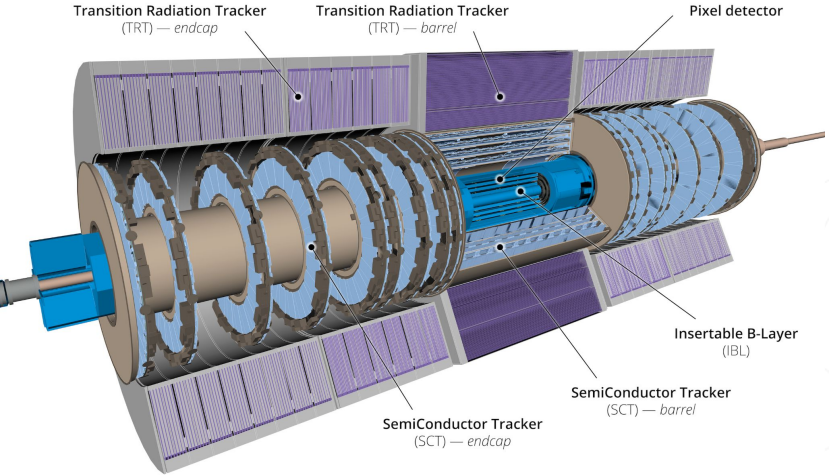
ATLAS Subsystems

- General particle detector used for wide range of studies
  - Precision Higgs
  - Dark Matter Searches
  - Long Lived Particle searches
  - Etc





- Multiple subsystems to measure particles
  - Momentum
  - Energy
  - Charge
  - Angle
  - Ionization Energy Loss

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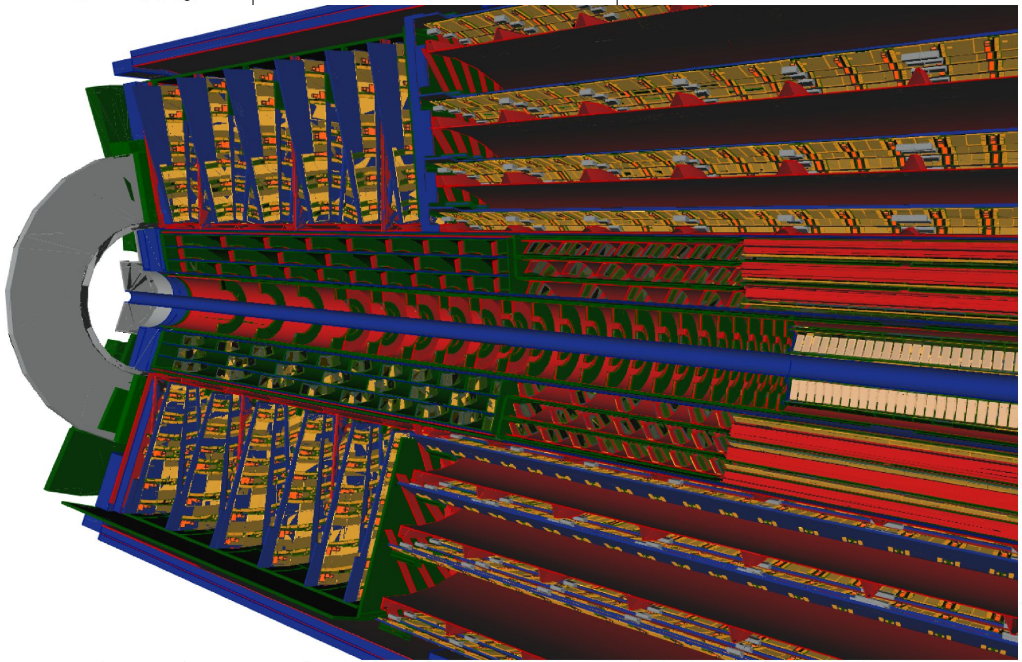
ITk An Upgrade For HL-LHC

	LHC Run 3 (Current run)	HL-LHC
Pileup	30	200
Instantaneous Luminosity	2×10^{34} cm^{-2} s^{-1}	7.5×10^{34} cm^{-2} s^{-1}
Target Integrated Luminosity	300 fb $^{-1}$	4000 fb $^{-1}$



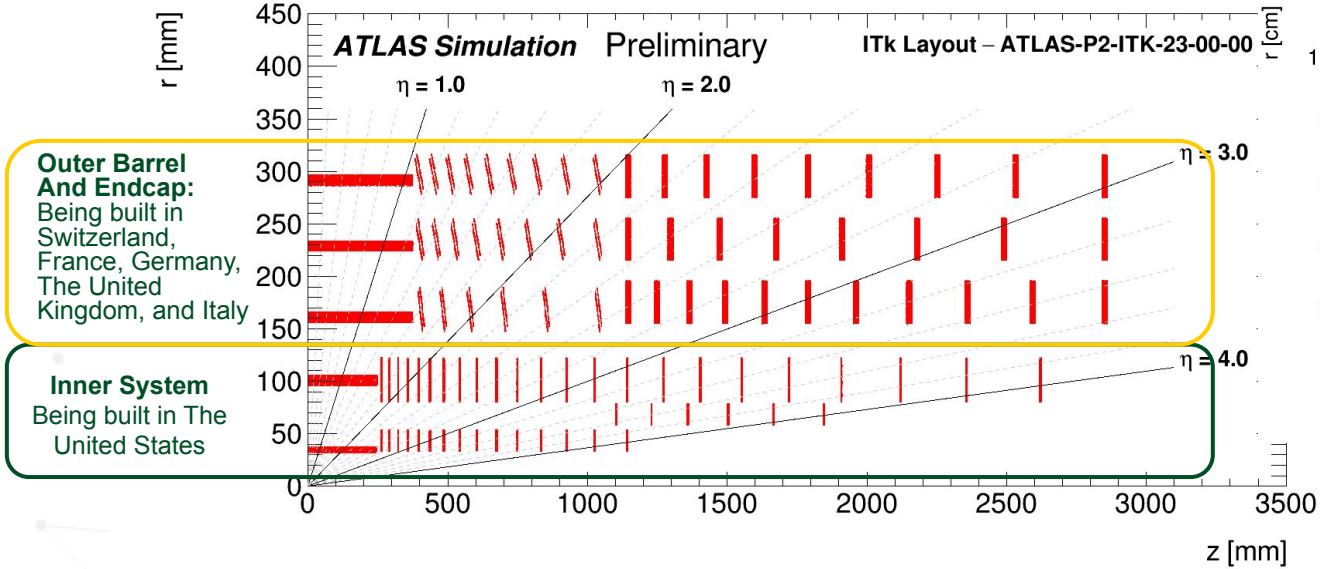
ATLAS tracker is to be replaced with a new all-silicon inner tracker (ITk), to accommodate HL-LHC conditions.

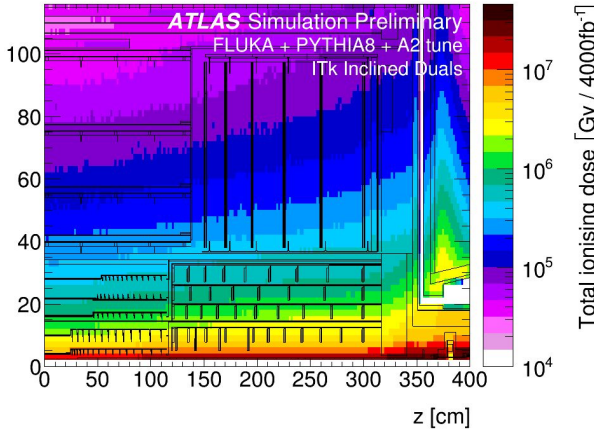
1. Increased granularity
2. Increased radiation hardness
3. Full silicon

	Current Tracker	HL-LHC Inner Tracker
# Pixels	92 Million	5 Billion
Pixel Silicon Area	1.9 m^2	12.98 m^2
Trigger Rate	100 kHz	1 MHz
η Coverage	2.5	4

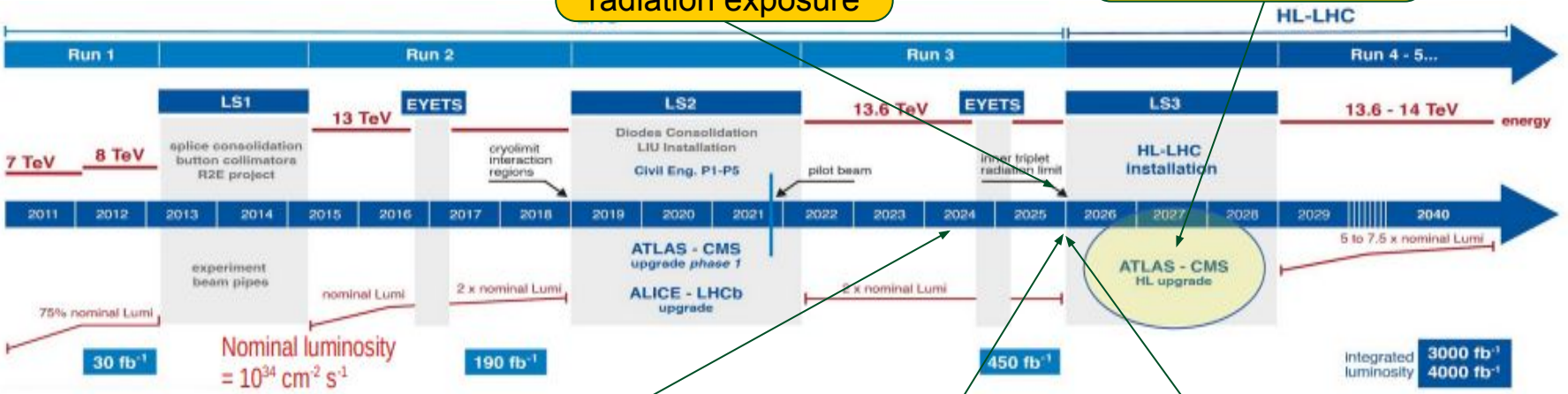
ITk Pixel Layout

- ITk Pixel is the innermost layers of ATLAS detector
- The Inner System
  - Independant from outer system
  - Replaceable
  - Receives highest radiation dose





ITk Timeline



Current tracker reaches limit of radiation exposure

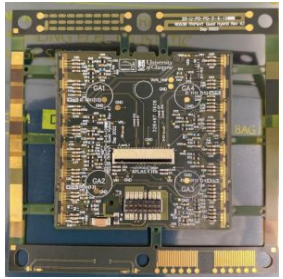
ITk installed

Currently in run three data taking

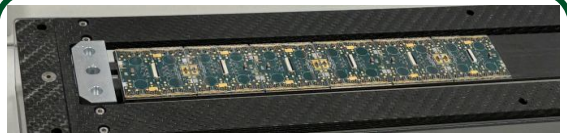
First endcap of ITk IS sent to CERN

Shutdown for HL-LHC upgrades

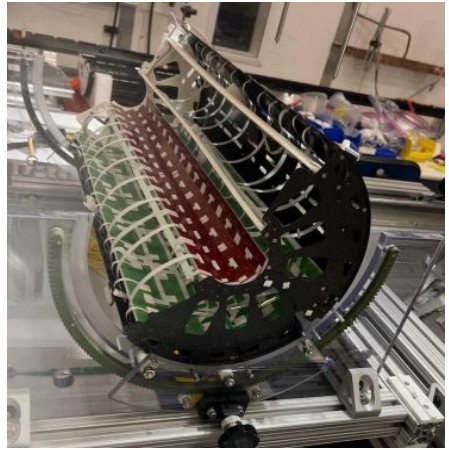
ITk Pixels Inner System Components



Sensor and front end Modules

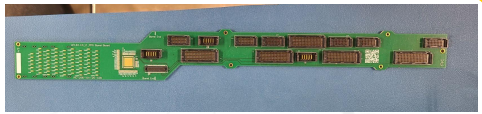


Loaded Local Support

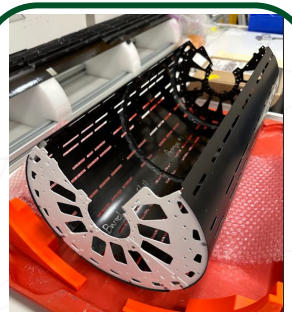


Barrel Assembly

Local supports



Type 1 services



Barrel shell

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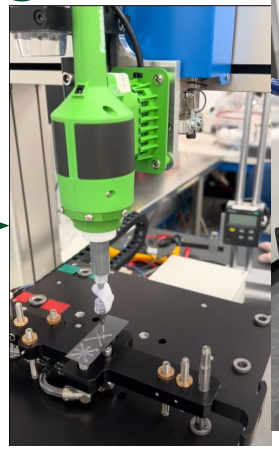
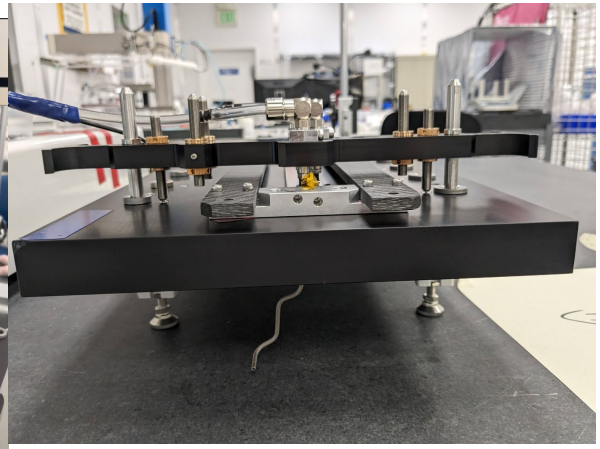
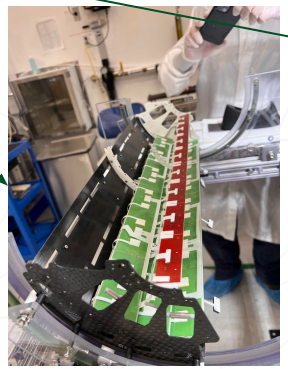
Overview of Integration At SLAC

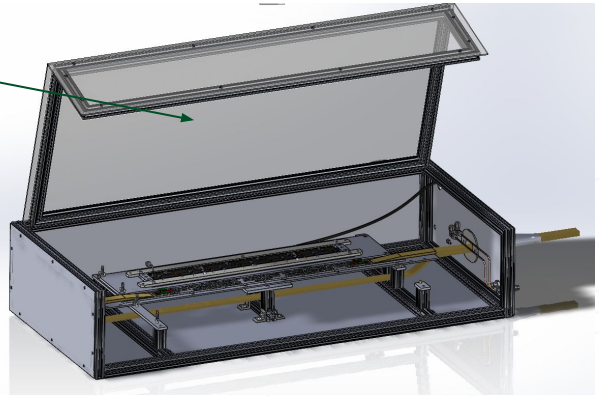
Integration of components

- Test received modules for functionality
- Load Modules onto local supports
- Load services (Power and Data)
- Test modules at operating conditions on local support
- Load local supports into shells
- Check that modules still have connectivity
- Integrate 2 shells together
- Ship halves to CERN

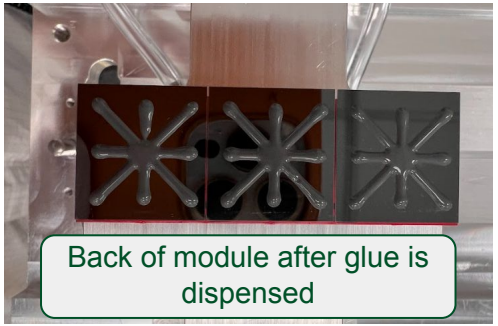




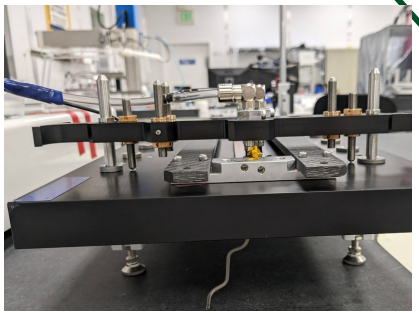




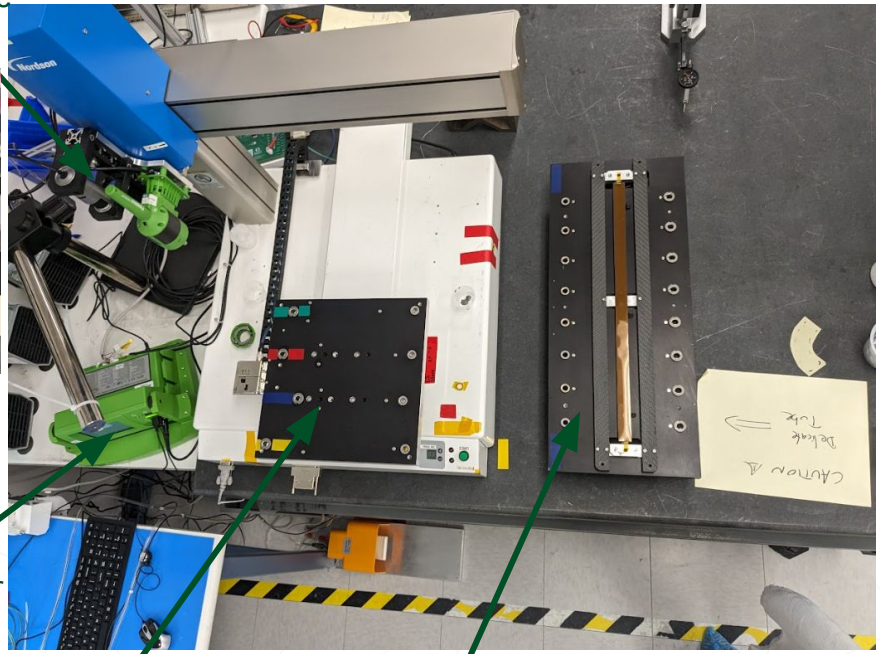
Focus on: Module Loading on Local Support



Back of module after glue is dispensed



Volumetric glue dispenser



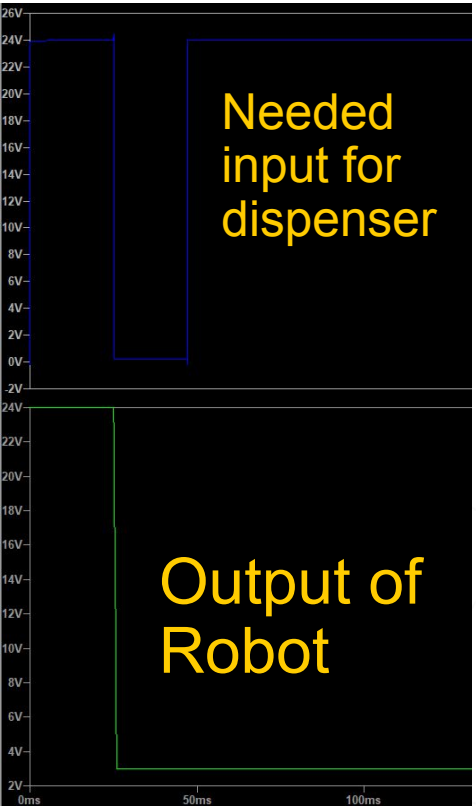
- Modules are tested for damage during shipping to SLAC
- Local Supports are loaded into fixture
- Glue is deposited on the back of modules
  - Glue is a thermal compound SE4445
  - Glue location is controlled by robot
  - Glue dispensing is controlled by volumetric dispenser
- Modules are flipped over and placed into position on the local support

Controller for dispenser

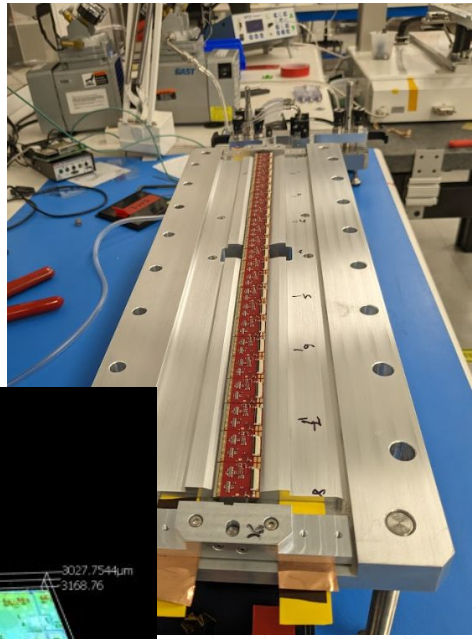
Robot

Local Support in fixture

Quality Control and Fixing Glue Dispensing



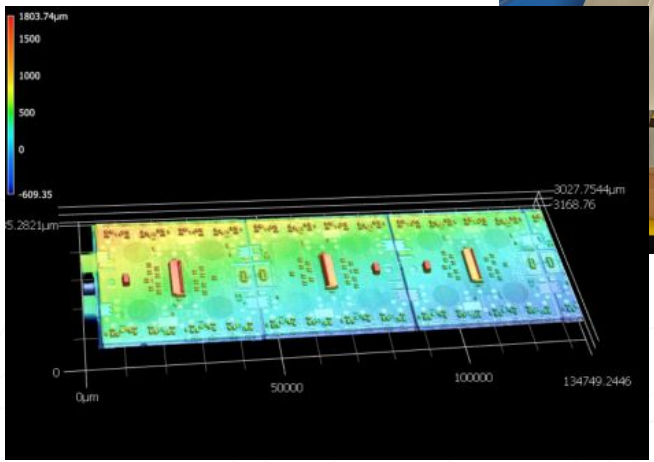
- Originally used pneumatic glue dispenser with inconsistent results
- Upgraded to volumetric dispenser currently see around 1% variance
  - Glue robot and volumetric dispenser had no premade solution to interface together.
  - Created interposer board that changed output digital signals from robot to input signal for dispenser



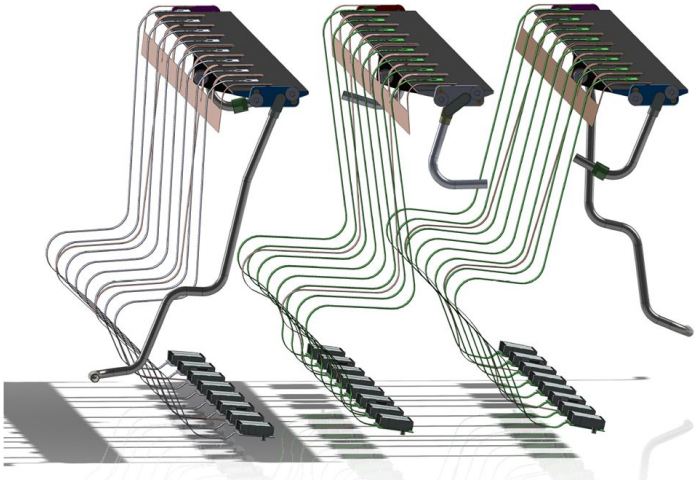
Glue coverage is important to thermal conductivity of module

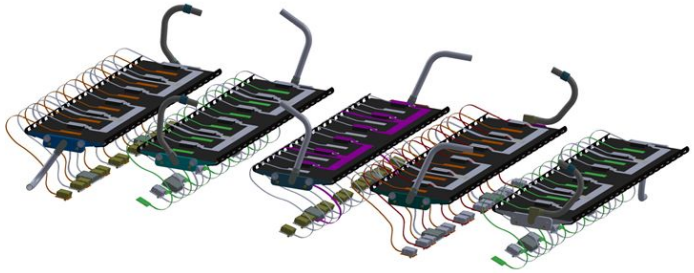
- Thermal performance of modules ensures longevity and reduced radiation damage

Glue coverage is inferred from mass deposited and height of module

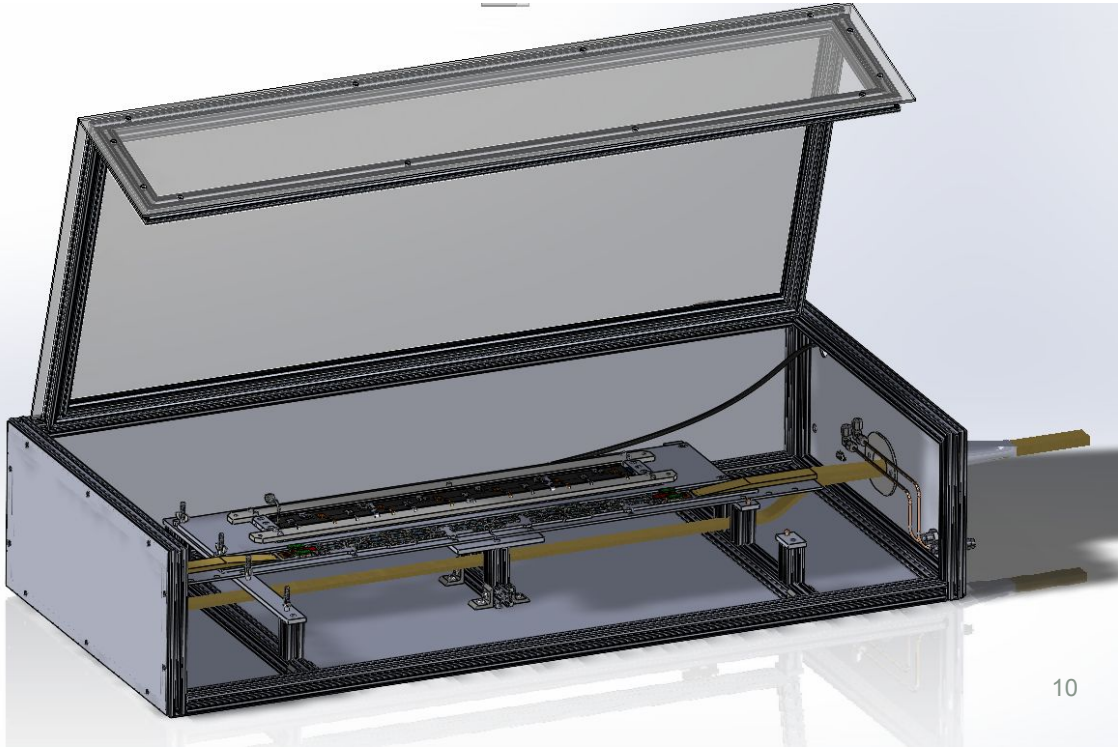


Loaded Local Support Testing



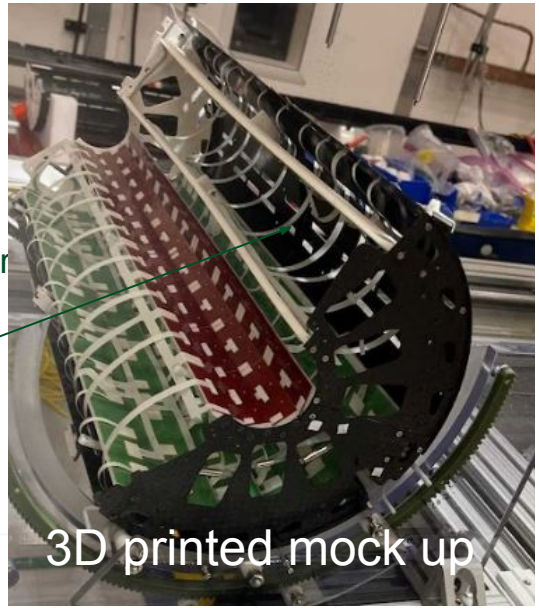


- Need to test loaded local support.
  - Tested at operating conditions
    - Minimum Temp -30C
    - Maximum Pressure in evaporators 1500 PSI
    - HV to modules and serial powered modules
- Requires making connection to the delicate 3mm titanium evaporator tubes
- 8 unique evaporator tubes of local supports and all lengths and reflections of loaded services all fit in same test fixture
- Testing is last chance to catch issues before reworking any modules because nearly impossible

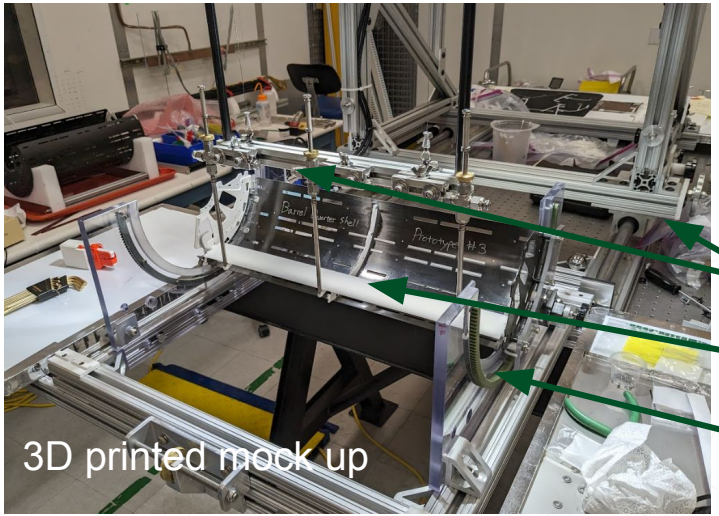


Integration and Shipping

- Developed special tooling specifically for integration
- Made 3d printed mock up of IS
- Tested and practiced assembling IS
  - Difficult to route cables through shell without touching the delicate wire bonds on modules
  - Found early enough that we have to add carbon fiber protection structur on the edge of the stave to protect modules during integration



Cable routing



Gantry system holds staves in proper location

3d printed stave for practice

Ring rotates barrel for ease of loading

Status and outlook

- Prototyping is finished.
- Now working on finishing our preproduction setup
  - Proof of ability to do production
  - Setting up quality control and quality assurance steps
  - Looking for potential problems
- Currently on schedule to ship first parts of the Inner System to CERN in early 2025

	Prototyping	Preproduction	Production
Modules Assembly	Complete	Ongoing	Upcoming
Local Supports	Complete	Ongoing	Upcoming
Loaded Local Supports	Complete	Upcoming	Upcoming
Data Transmission	Complete	Upcoming	Upcoming
Services	Complete	Ongoing	Upcoming
Mechanics/ Shells etc	Complete	Ongoing	Upcoming
Integration	Complete	Upcoming	Upcoming

Conclusion

- US ATLAS is on schedule for delivering the Inner System
- Integration of ITk is built by a large group of different institutes and labs
- Integration efforts have relied on finding problems early to ensure smooth path from components to cohesion

Special Thanks

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