

(Re)Development of a Capsule Fill Tube Assembly (CFTA) Production Station at LLNL

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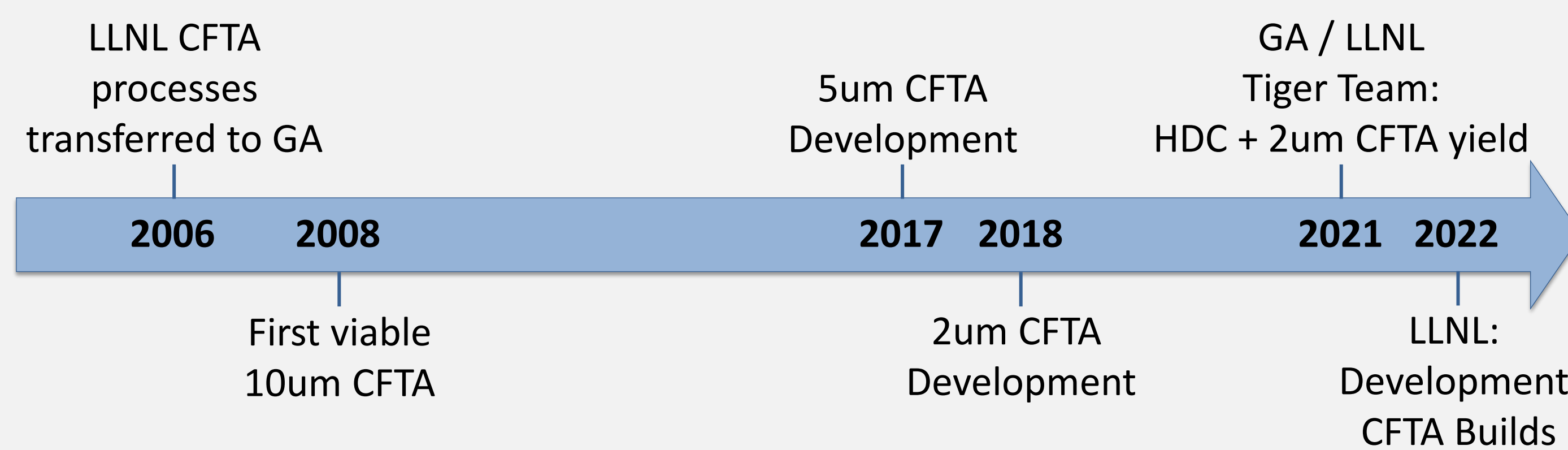
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Motivation

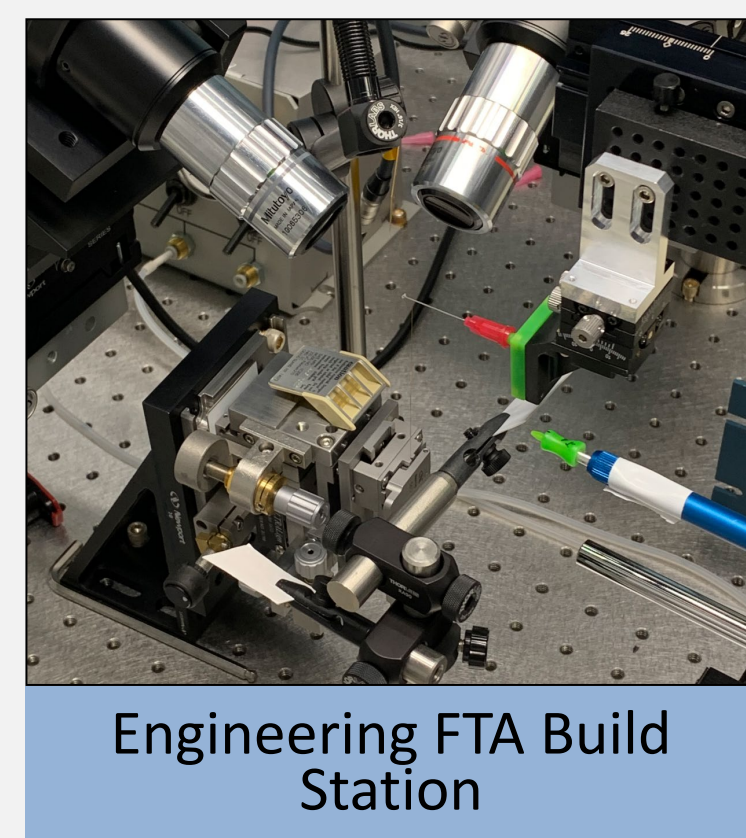
- The advent of features like 2 micrometer diameter fill tubes have dramatically increased ICF target CFTA sensitivity to the environments experienced during production.
- Some CFTA designs are unable to survive transport between GA and LLNL facilities.
- LLNL Target Fabrication seeks to reduce the environmental loads generated during handling of finished CFTAs between production and assembly. This need motivated LLNL Target Fab to re-establish the capability of producing CFTAs on-site.
- Improvements are intended to increase the reliability of fabricating challenging CFTAs in a production environment.

Manufacturing yield concerns in FY21 led to Tiger Team collaboration and complimentary CFTA production at LLNL

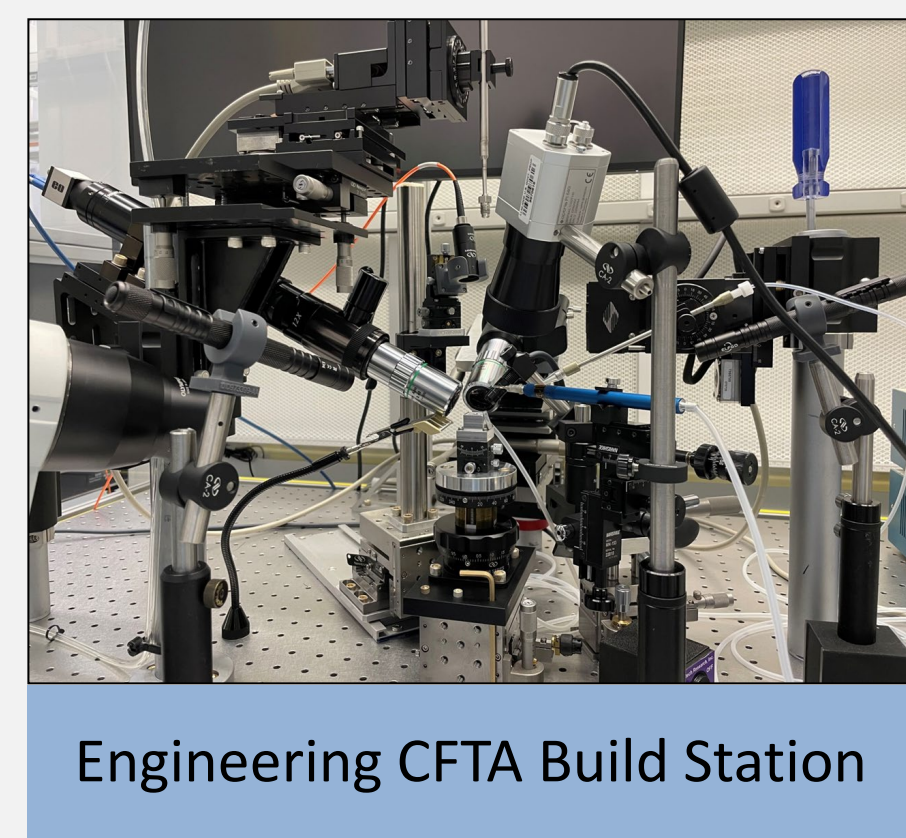
A broad chronology of CFTA manufacturing:



In 2023 the CFTA Engineering Build Stations were constructed in the west-end of B381/R1600 (Class 10K Area)



Engineering FTA Build Station



Engineering CFTA Build Station

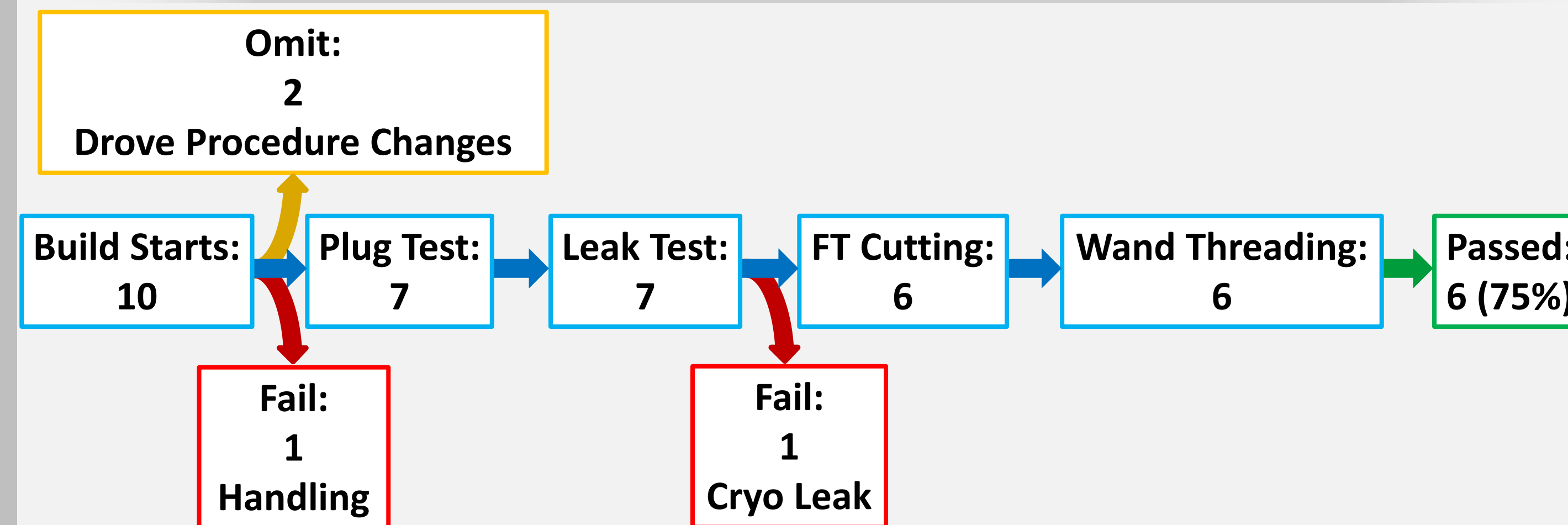


Co-located Support Equipment

- LLNL separated the FTA and CFTA assembly stations to enable parallel operations.
- Co-located equipment for secondary operations increases build efficiency and reduces transport risk.
- Enclosures with filtered laminar airflow reduce particulates that may be present in Class 10K cleanroom area.

Commissioning builds of non-production CFTAs demonstrated a need for upgrades before release to general production

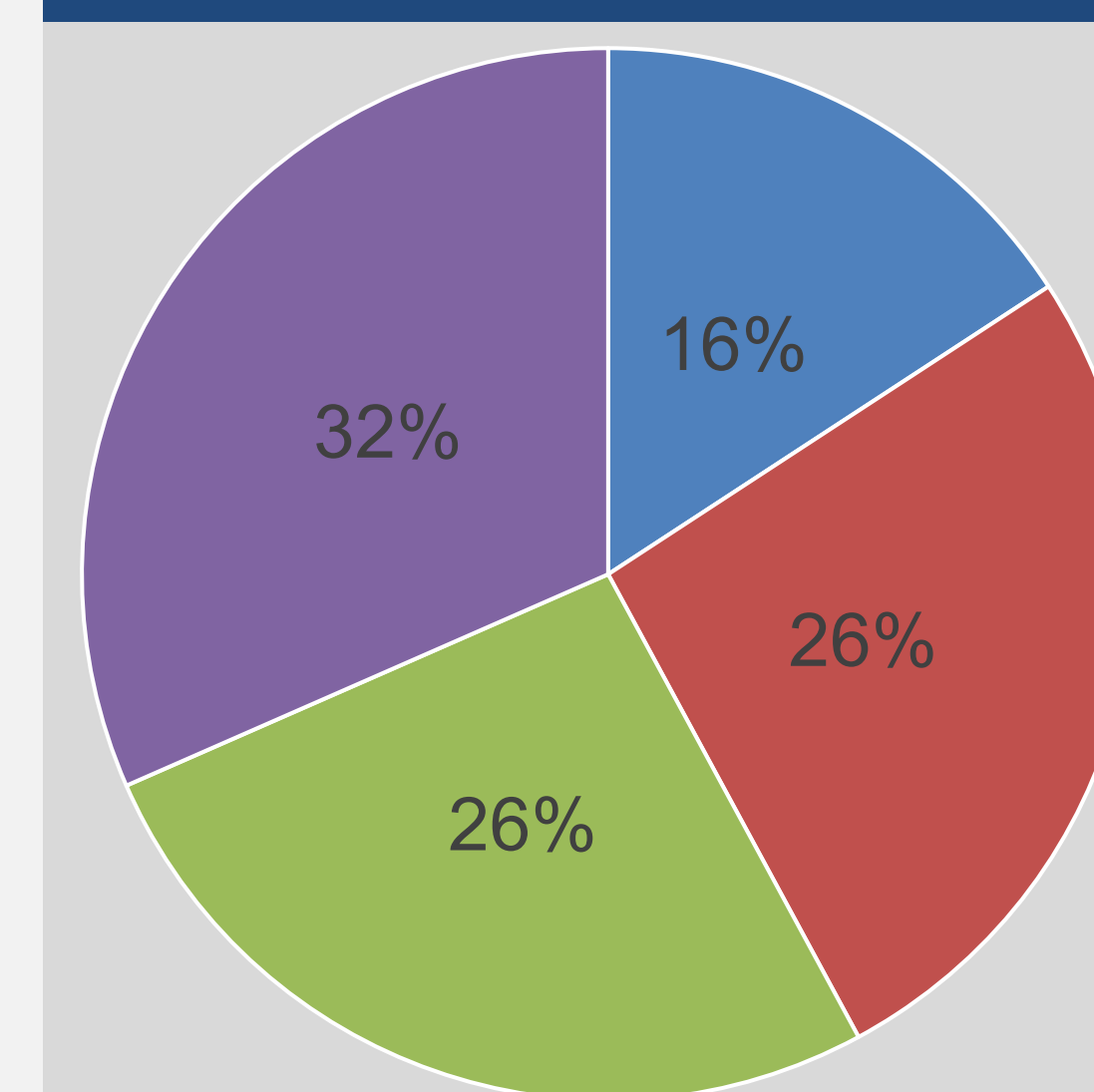
A set of ten 2um commissioning qualification builds in FY23 resulted in a 75% yield rate.



Risks and shortcomings that could compromise a robust and quality production release were identified by the CFTA team during qualification

- Difficult to Build** - Advanced technician skills required, marginal tooling performance, general risk to assembly
- Material Loss** - Damage or breakage risk to FTA/CFTA component or assembly
- Cleanliness** - Potential for particulate generation or accumulation
- Ergonomics** - Awkward or difficult to access a control point

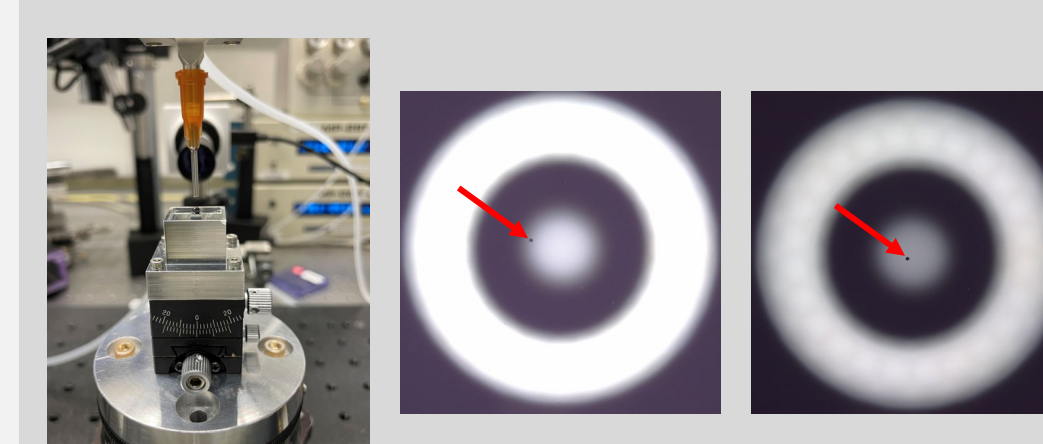
Percentage of 19 issues identified during qualification builds, by category



Further lessons have been learned as Engineering Staff continued to fabricate production CFTAs in FY24. Improvements will be applied to station upgrades.

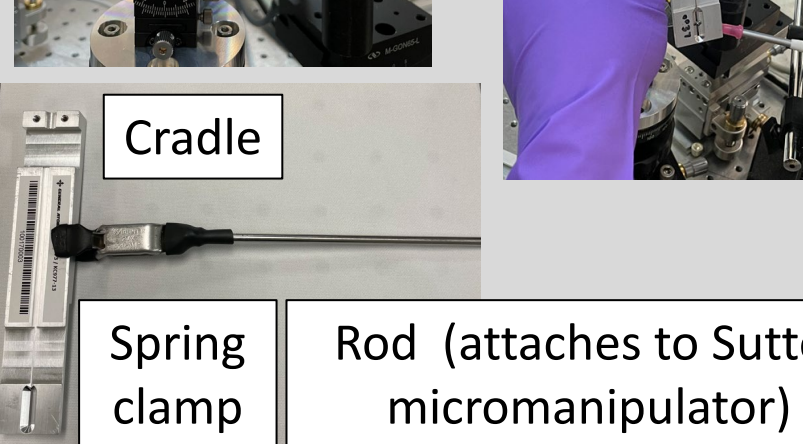
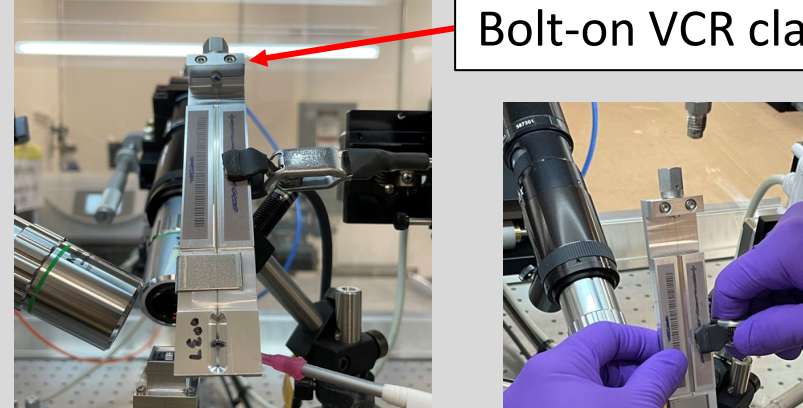
- Engineering CFTA builds have continued in parallel with development of station upgrades. Four 2 um fill tubes have been fabricated with a yield rate of 50% (failures occurred after cryogenic leak testing).
- First successful build of a 2 um HUTMP Frustrum CFTA completed by Target Fab – previous GA builds have failed due to handling or during transit from GA. Target was shot on NIF.
- First two successful builds of RadChem CFTAs - these are not able to be transported to LLNL by normal means.

Pre-orientation of Capsule Drill Hole



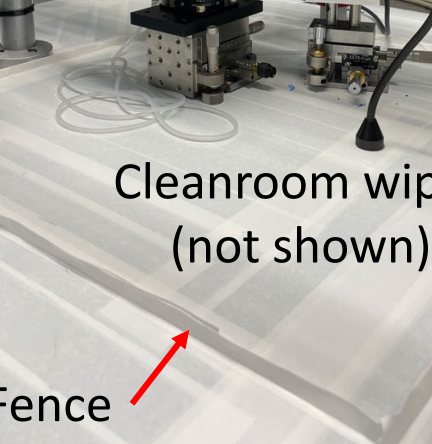
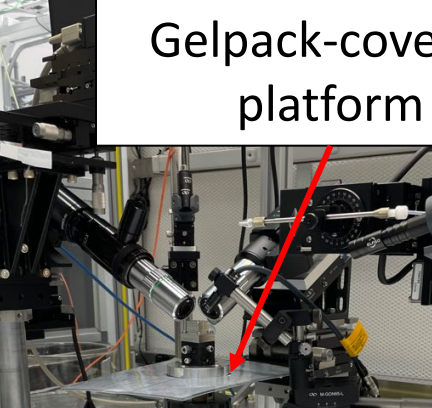
The existing process (top) used a clean swab to "nudge" the vacuum-chucked capsule to orient the hole. The new process (bottom) uses a secondary vacuum chuck and 2-axis goniometer.

CFTA Transfer Cradle Mount



The existing transfer cradle relies heavily on assembler skill and feel.

CFTA Capsule Containment

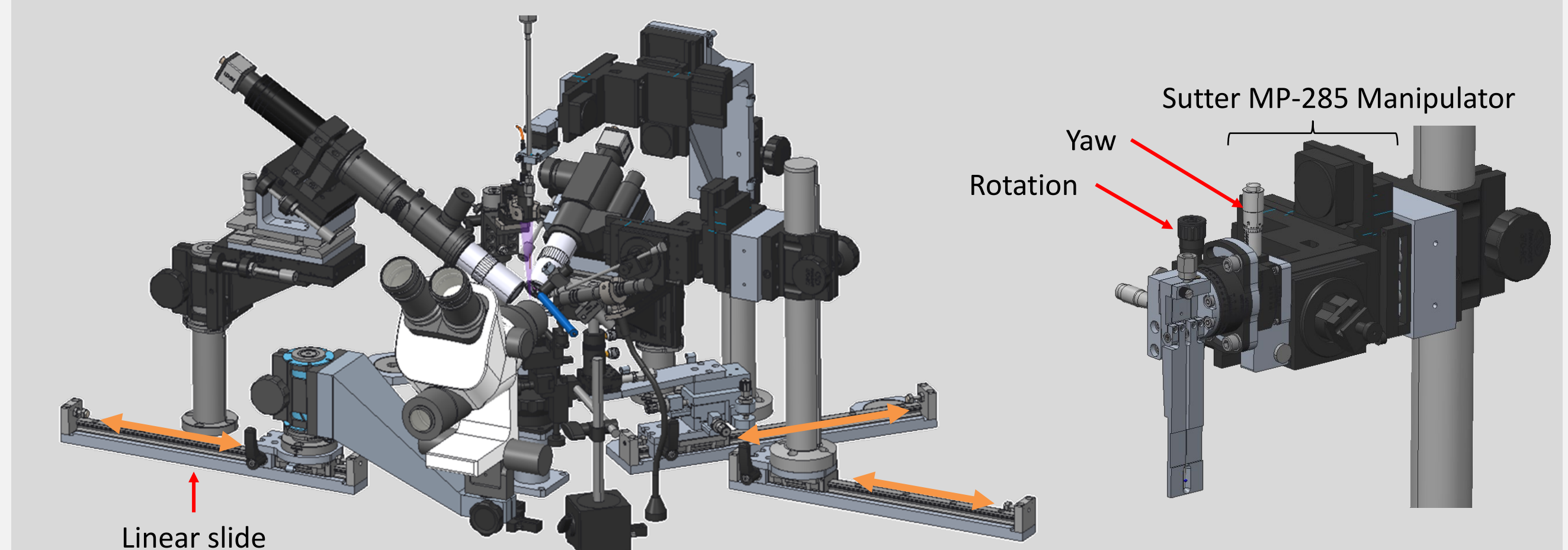


Containment mitigations were added after a capsule fell off the fill tube during build.

Upgrades to the CFTA station are currently in development

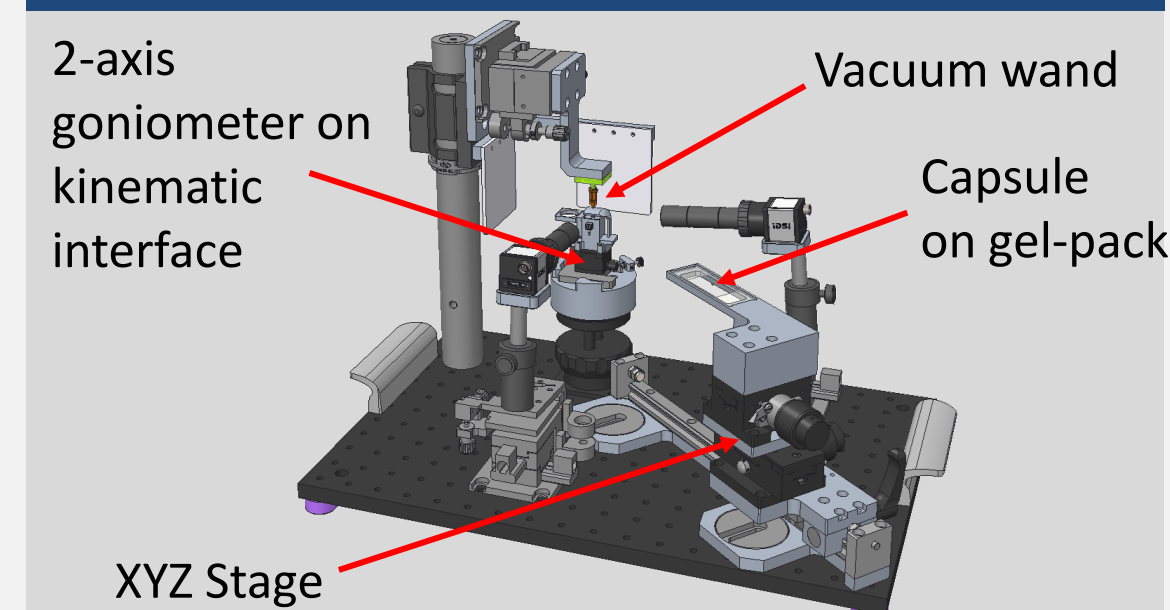
Future improvements will increase process reliability and reduce reliance on subject matter experts to fabricate CFTAs

CFTA Station Ergonomic Improvements



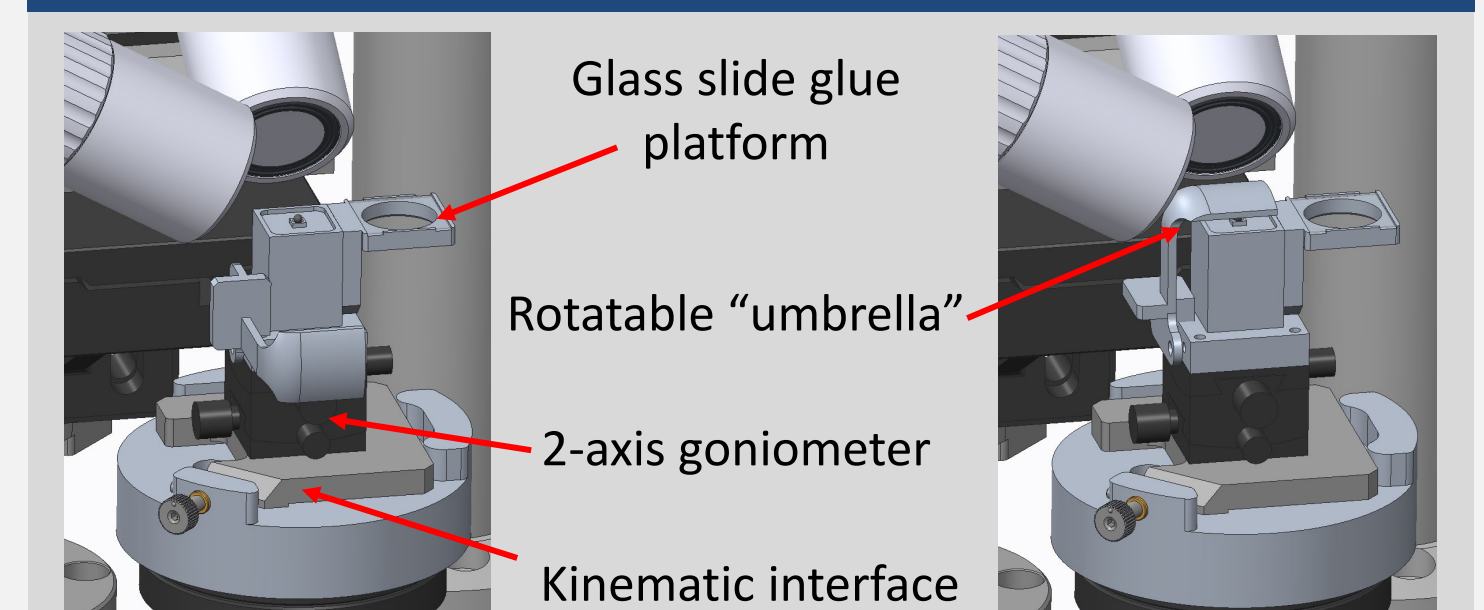
The addition of linear slides and cradle stages will improve access and control, while maintaining hardware stability.

CFTA Capsule Manipulation Pallet (CMP)



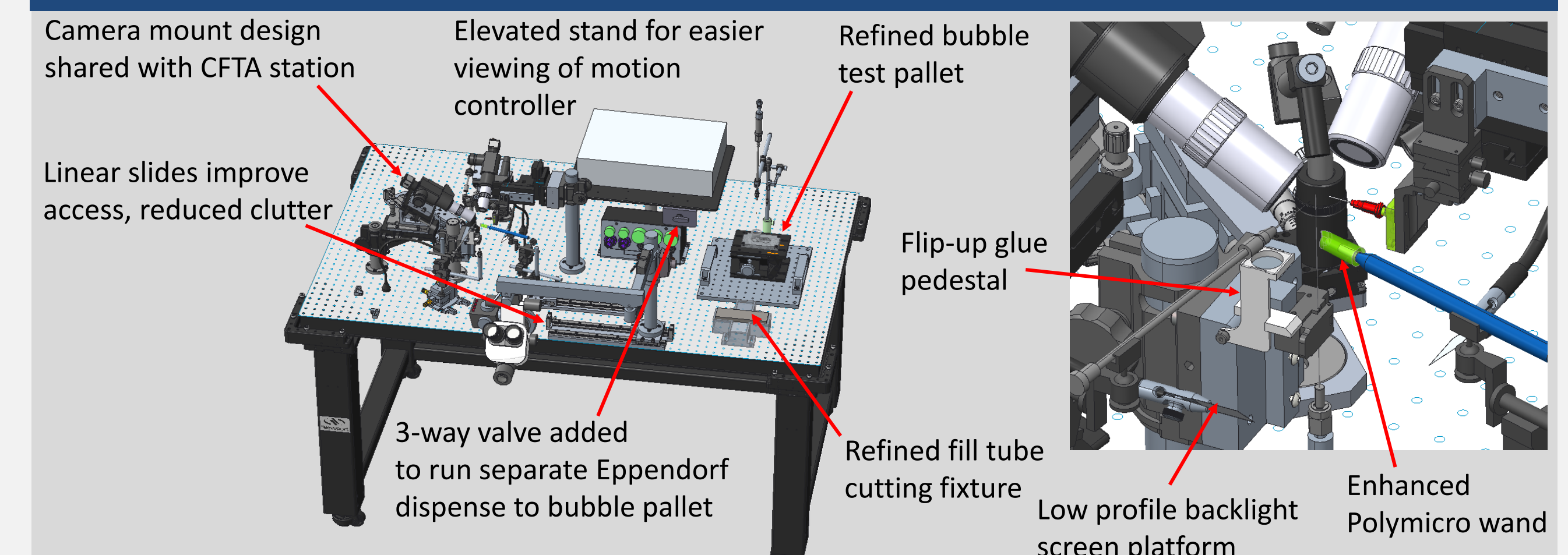
A new pallet incorporates hardware to improve drill hole orientation processes.

CFTA Capsule Chuck Subassembly



The capsule chuck preserves alignment, includes a debris shield and supports a glue supply slide.

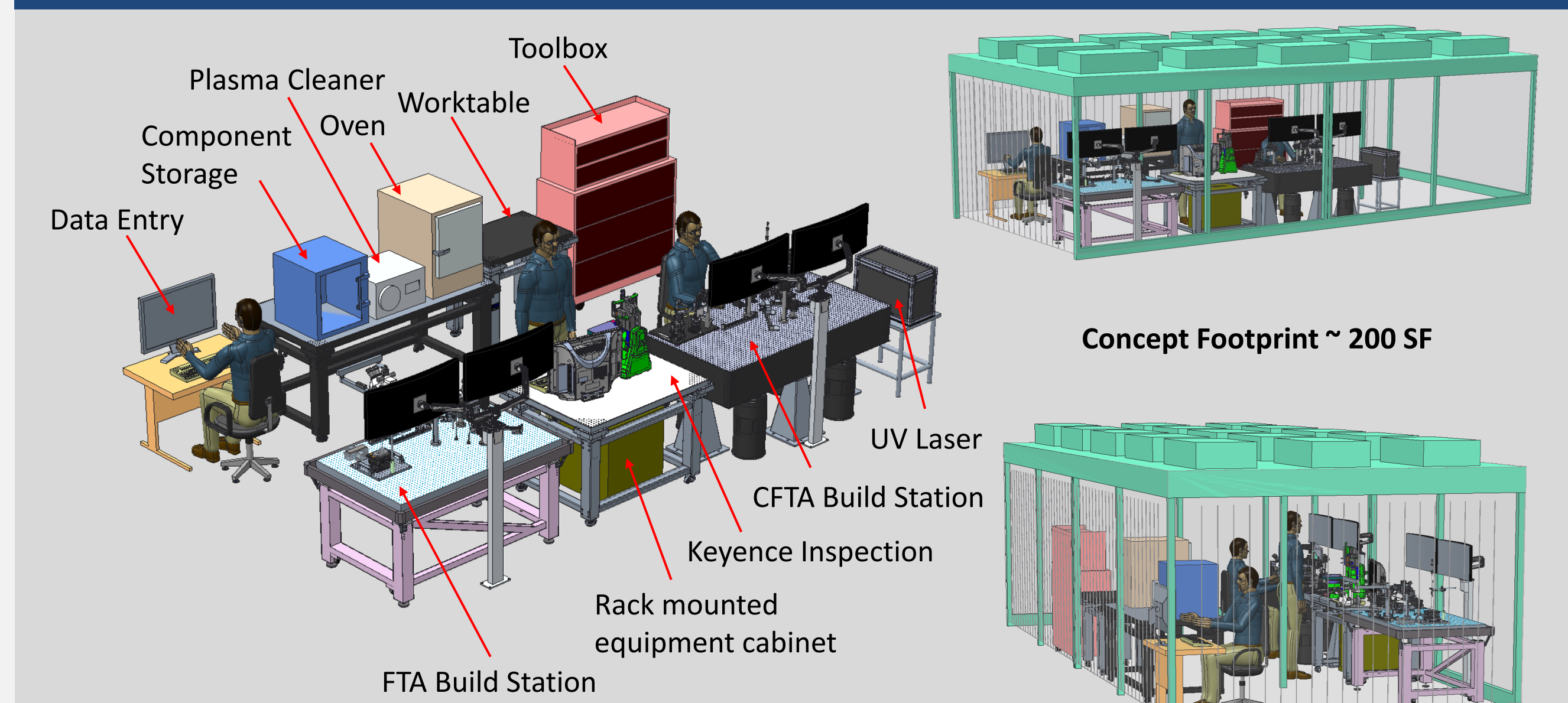
FTA Station Ergonomic and Functional Improvements



Upgrades to the FTA station will include improvements designed for CFTA station and specific improvements identified through engineering build efforts.

Future upgrade to build environment will reduce risk of particulate contamination during CFTA builds

CFTA Manufacturing Cell Concept



The modular Class 100 cleanroom would be consistent with existing B381 cleanroom facility and allow co-location of all process equipment.