Building a Target to Directly Measure Rayleigh-Taylor Instabilities on the FlexFAM

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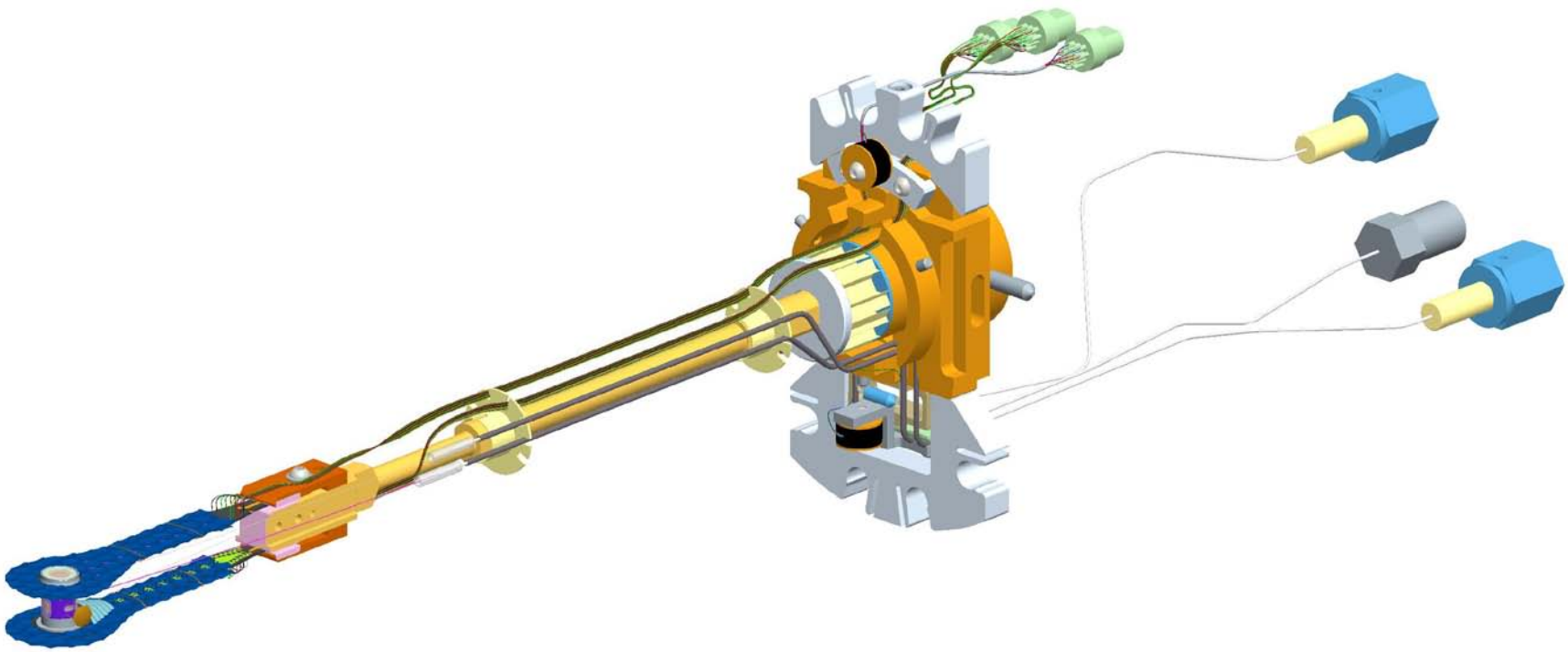
Introduction

- The purpose of my talk is to describe the design and assembly of a target developed to directly measure Rayleigh-Taylor instabilities growth. The target was named MixC. It will be fielded at the National Ignition Facility (NIF) laser

- We explore the challenges of assembling the target and the tooling that was developed for it. We also look at the configurations of the Flexible Final assembly machine (FlexFAM) that is used to build experimental and production fusion targets

Purpose: Study Mix with an Engineered Defect

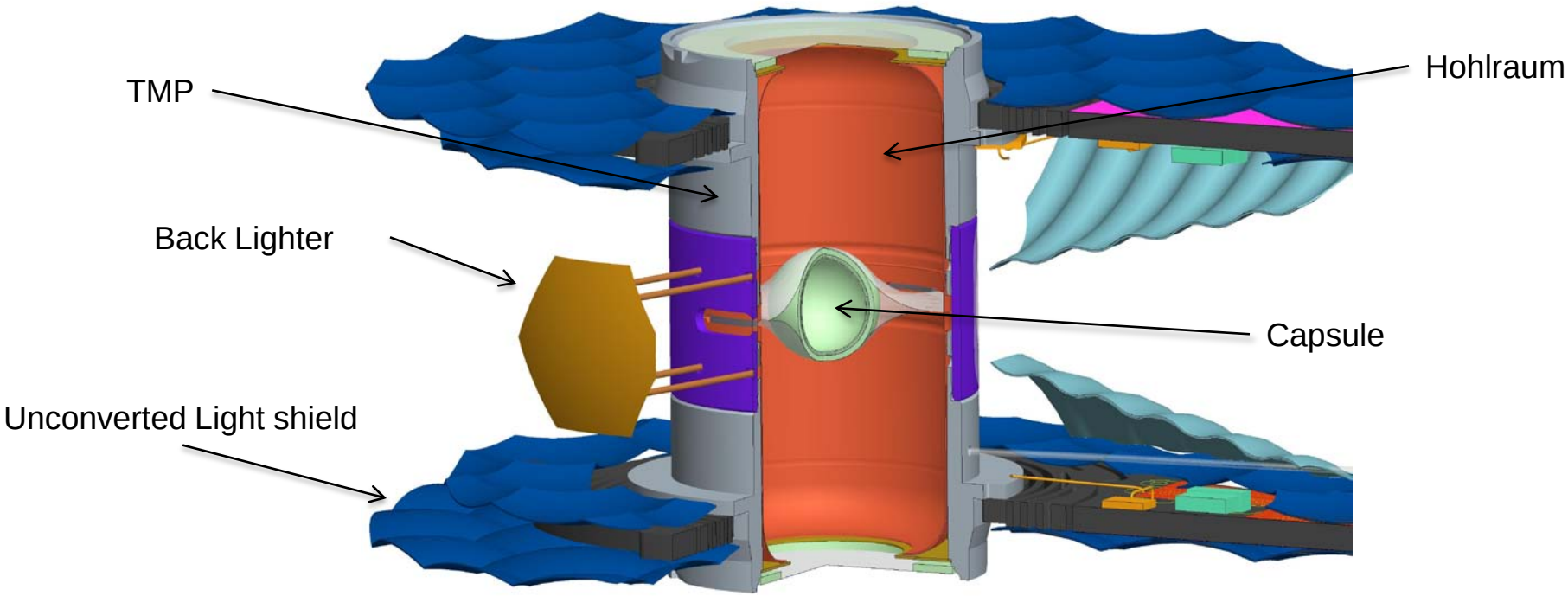
- **The Engineered Defect Target (MixC) is an experimental target designed to directly measure the Rayleigh-Taylor instability by backlighting the growth of an engineered defect on the capsule. This data will be used to benchmark our radiation-hydrodynamics simulation codes that are used to set the specifications on capsule defects and roughness.**



MixC Cryogenic Target Design

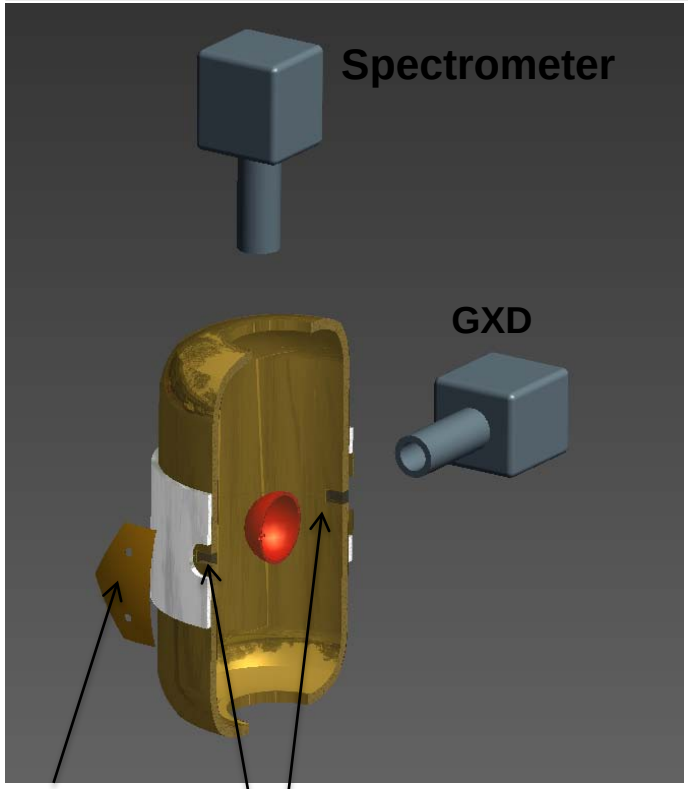
- **Tuning targets**
  - **The National Ignition Campaign (NIC) targets are designed so that the physics package (hohlraum, capsule and the gas between them) can be tailored independently of the thermal-mechanical package (TMP) that holds it.**
  - **The Diagnostic Band holds and positions diagnostic components**

Model of a NIC Tuning Target



Studying Mix with an Engineered Defect Capsule

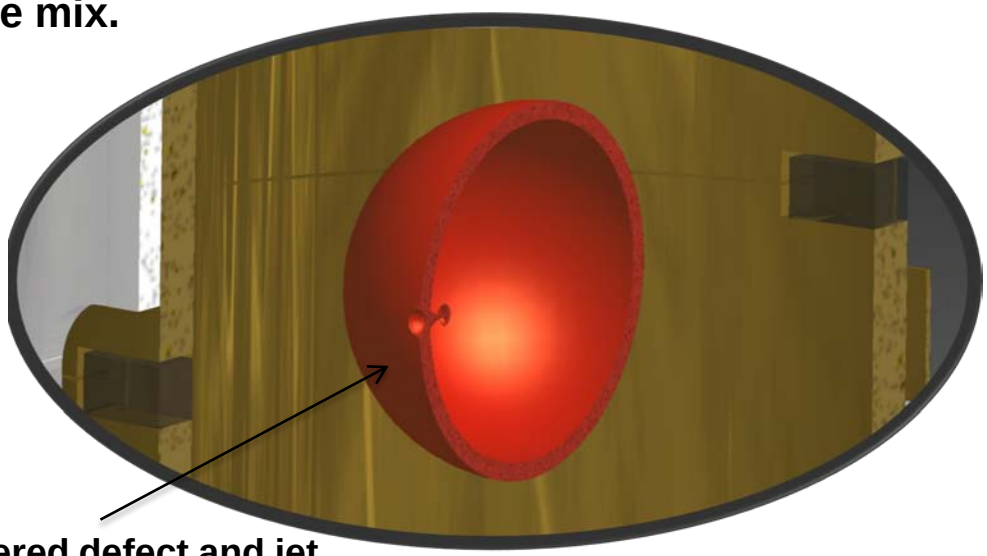
Dramatization of defect growth observed with Gated X-ray Detector (GXD) and a Ge Spectrometer



Backlighter

High Density Carbon Windows

- A capsule with multiple divots machined around the equator is aligned and tented in a Hohlraum.
- One divot (40 x 0.6 um) is positioned so that it is collinear with the GXD and the backlighter, it will be radiographed face-on.
- A spectrometer from the pole will measure germanium emission, which can be correlated to core mix.



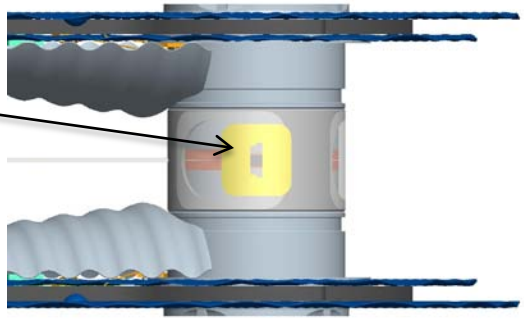
Engineered defect and jet formation

Target Design

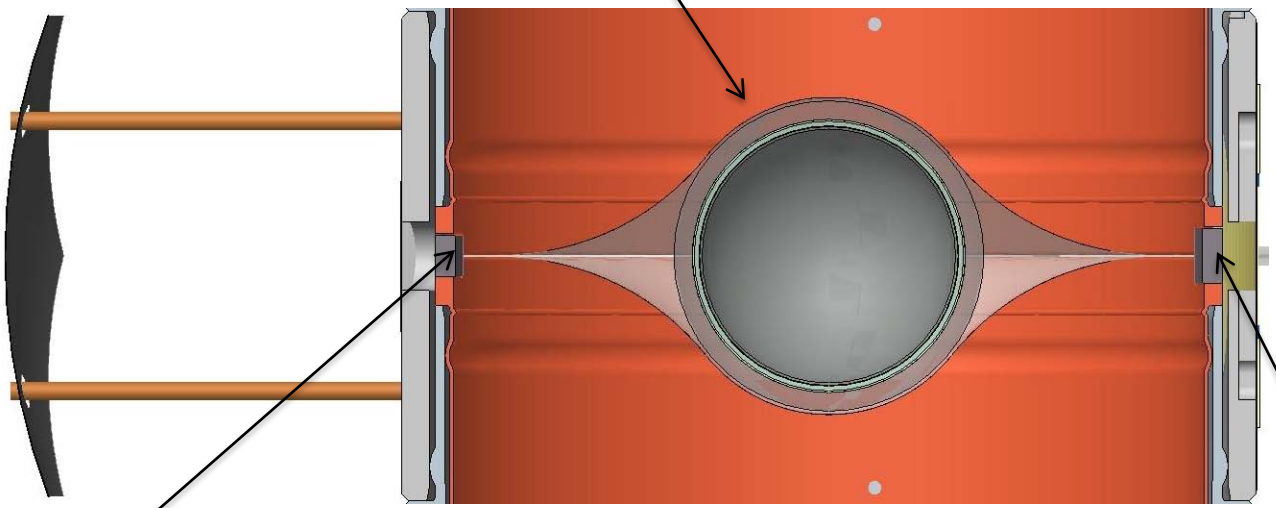
Cross Section View of Physics Package

Backlighter:
8 µm-thick Zn foil
(≈ 3.5 mm diam, 5 mm RoC)

Gold Aperture



Engineered Defect Capsule



to GXD

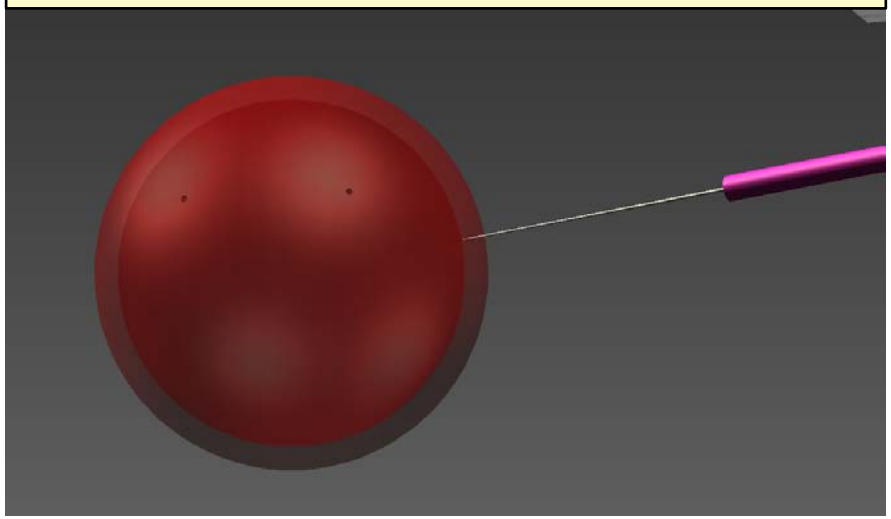
Backlighter HDC Window
150 µm thick, 300 µm-tall by 1.1 mm long diamond fills slot 320 µm tall by 1.2 mm long slot

GXD HDC Window
150 µm thick, 400 µm-tall by 1.1 mm long diamond fills slot 420 µm tall by 1.2 mm long slot

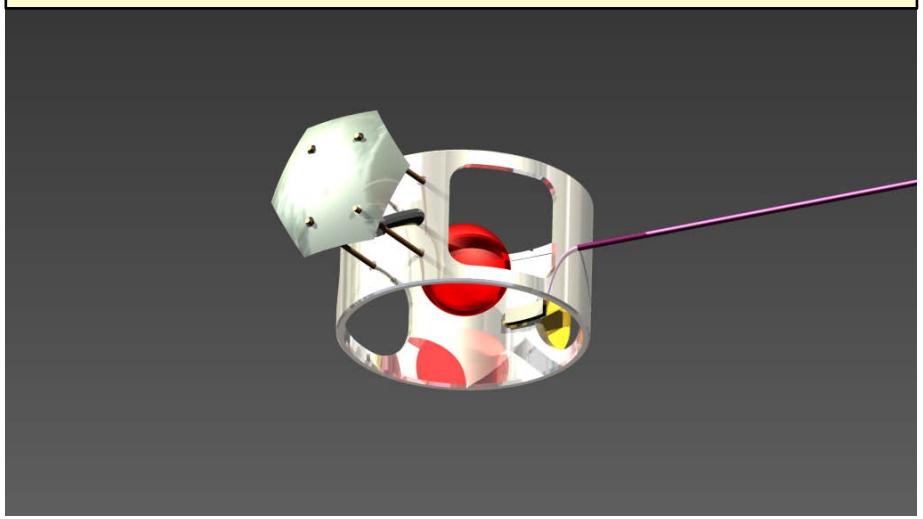
General Atomics (GA) CFTA with Engineered Defects

- **Two Capsule Fill Tube Assemblies (CFTA) were made**
- **Divots were laser machined**
- **PSDI used to locate position of all divots**
- **Fiducial used to align divots during assembly**

Model of Capsule with Divots

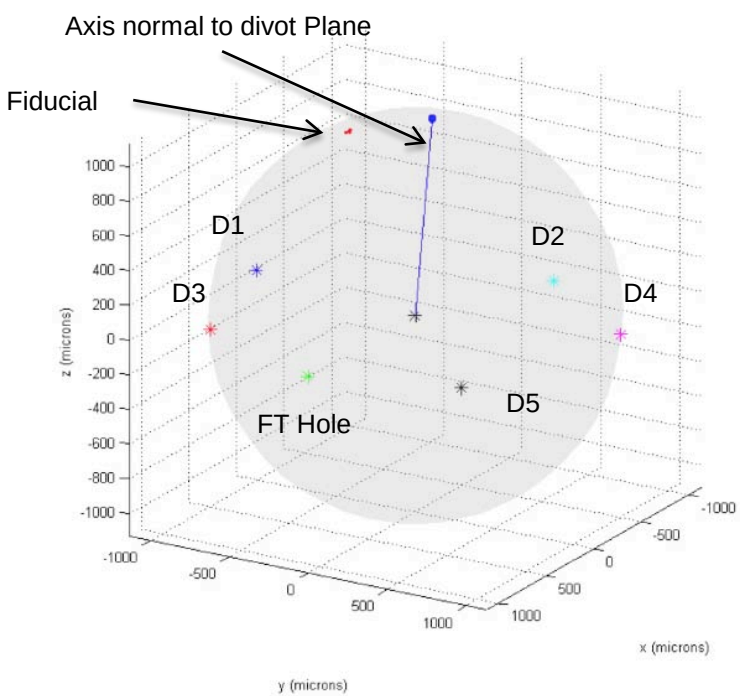


Model of CFTA and Diagnostic Band



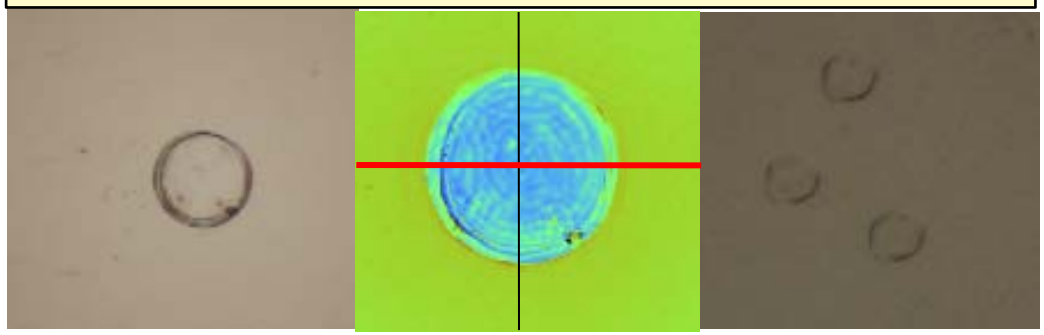
Capsule Metrology

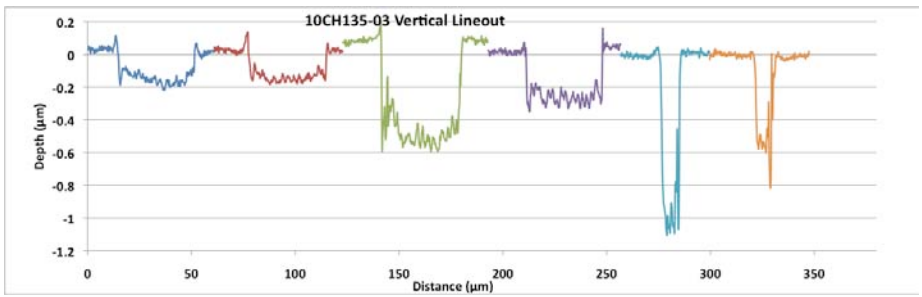
		Fill Hole Divot		D3		D1		D2		D4		D5	
		Theta	Phi	Theta	Phi	Theta	Phi	Theta	Phi	Theta	Phi	Theta	Phi
	Specification	90	232	90	185	90	135	90	45	90	0	90	280
	Tolerance	2	2	2	6	2	2	2	6	2	6	2	6
10CH135-03	Location	89	232	91	186	91	136	90	47	87	0	87	280
	Dev. From Nom	1	0	-1	-1	-1	-1	1	-2	3	0	3	0
10CH135-05	Location		232		184		133		42		0		276
	Dev. From Nom		0		1		2		3		0		4



PSDI Capsule Map and Data

Divot (D1) and Fiducial Photographs

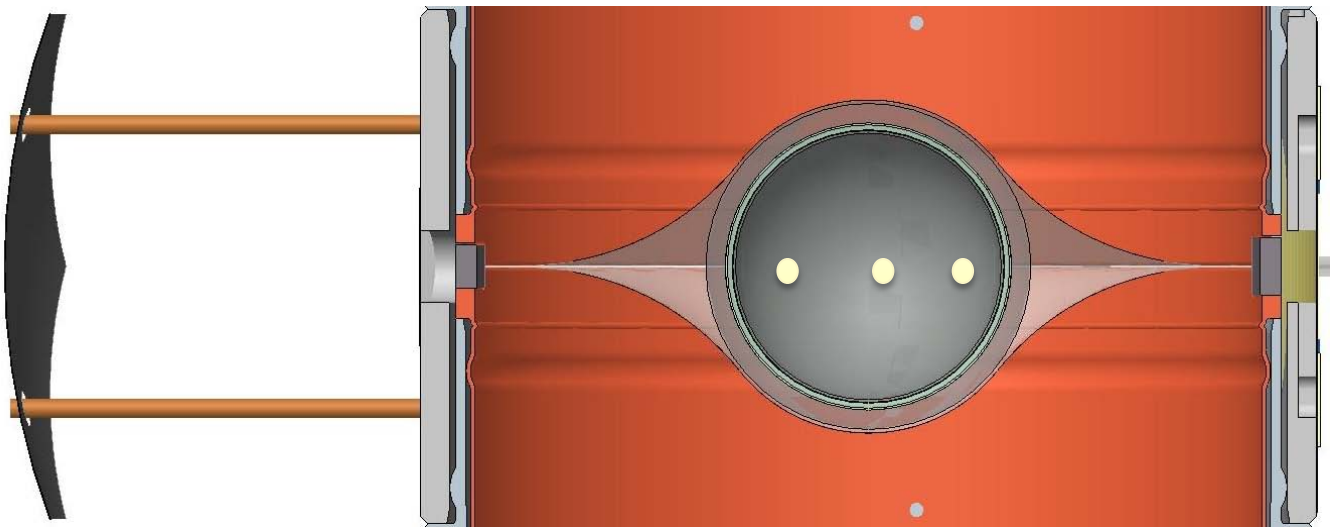




Challenges

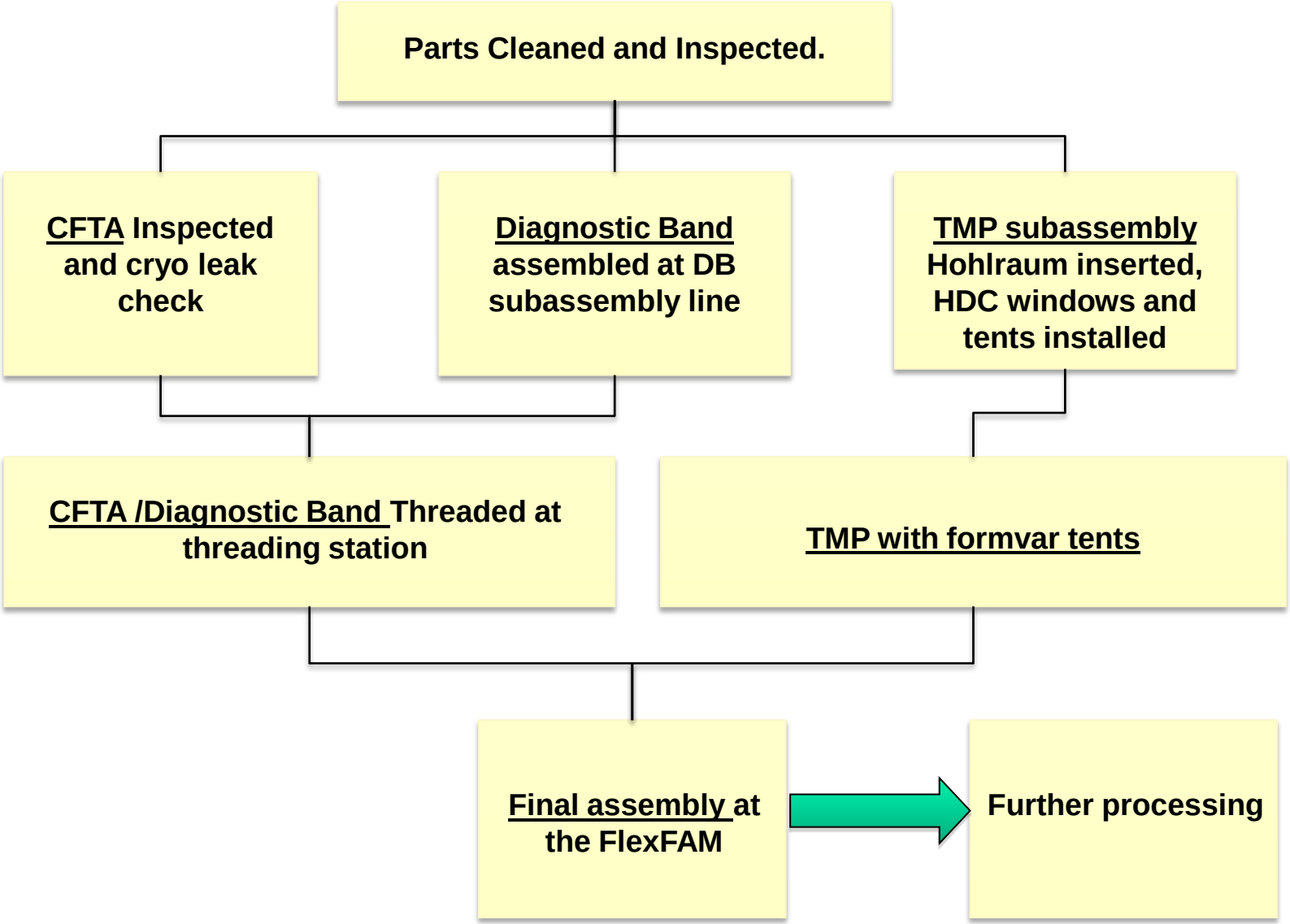
- Locating capsule divots during CFTA to diagnostic band threading.
- Positioning capsule divots during tenting and final assembly.
- Delivery date

Z Positioning Tolerances	
Capsule	± 20 µm
BL-side Slot	± 10 µm
HDC on BL-side	± 10 µm
GXD-side Slot	± 20 µm
Pitch wrt LoS	± 5 mrad



- Zn foil with 5 mm radius of curvature placed at ≈6.0 mm for BL beams to clear shield
- One sided gap, on top, for HDC windows shall be < 20 microns

Assembly Flow

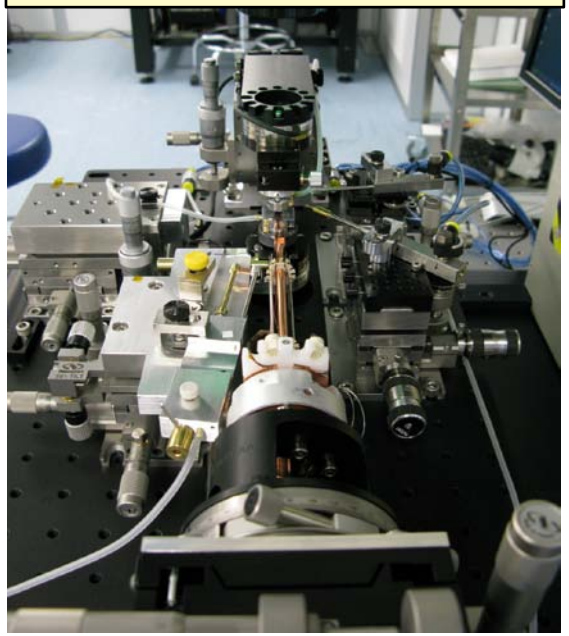


Reconfigurable Manipulator System (FlexFAM)

- **The machine consist of a manipulator system integrated with an optical coordinate measuring machine (OCMM).**
- **The manipulator system consists of an arrangement of mechanical stages and tooling that are configured to provide the necessary degrees of motion freedom for the subassemblies and components needed to manufacture a particular type of target.**
- **The system consists entirely of manually-actuated stages, which enables a quick path to developing a motion system that is compact and simple to operate and reconfigurable.**

Photo of manipulator system

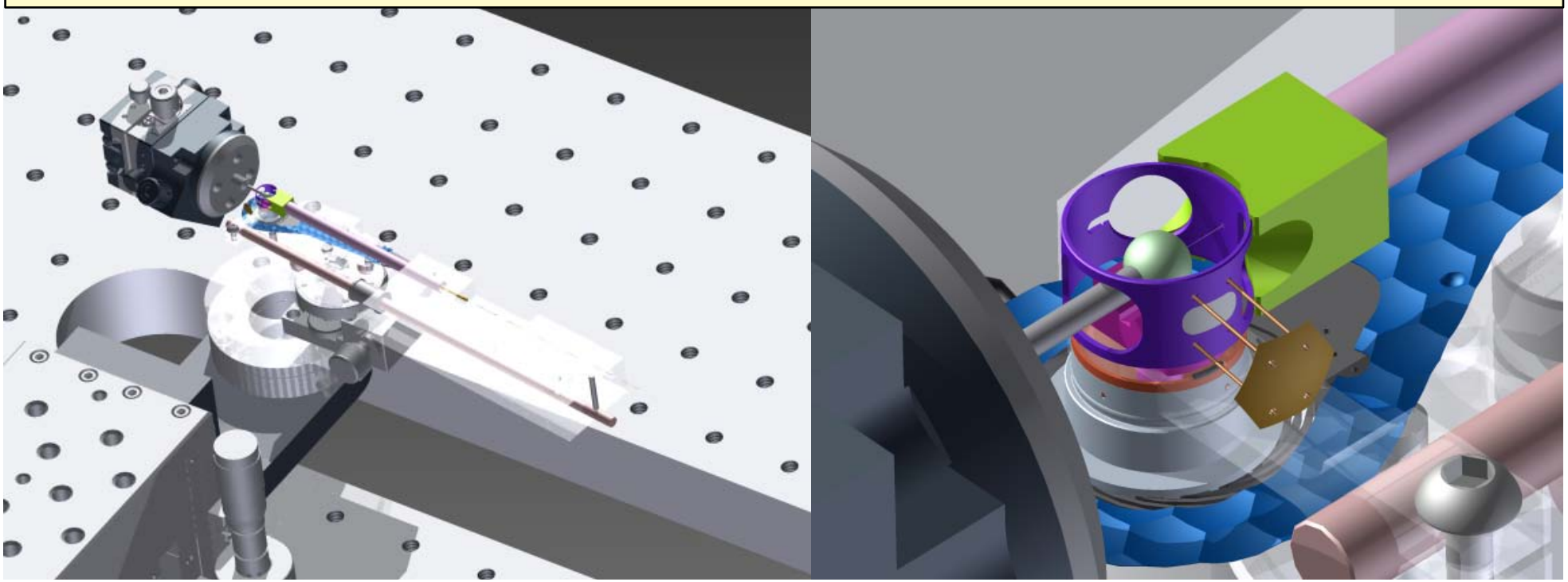
FlexFAM manipulators



Tooling Design

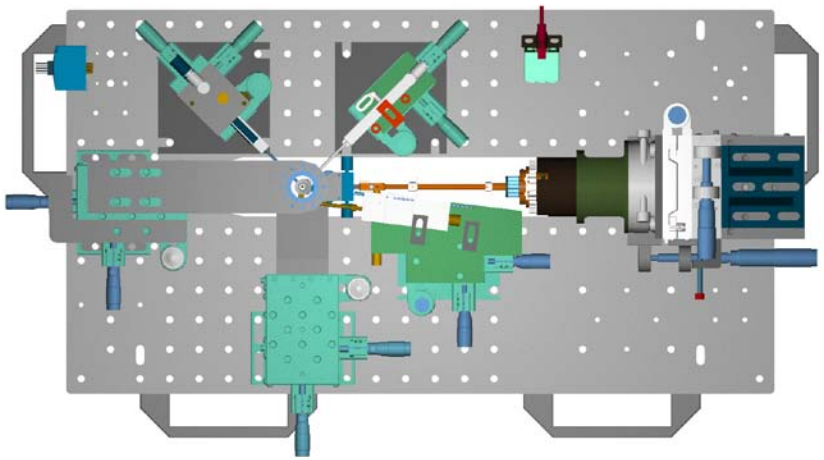
- **The capsule vacuum chuck is attached to 2 axis Goniometer coupled with a rotary stage which allows Capsule rotation about XYZ axis.**
- **Attaching the Capsule Manipulator to an XYZ translation stage gave the capsule 6 degrees of movement.**

Model of Capsule positioning tools

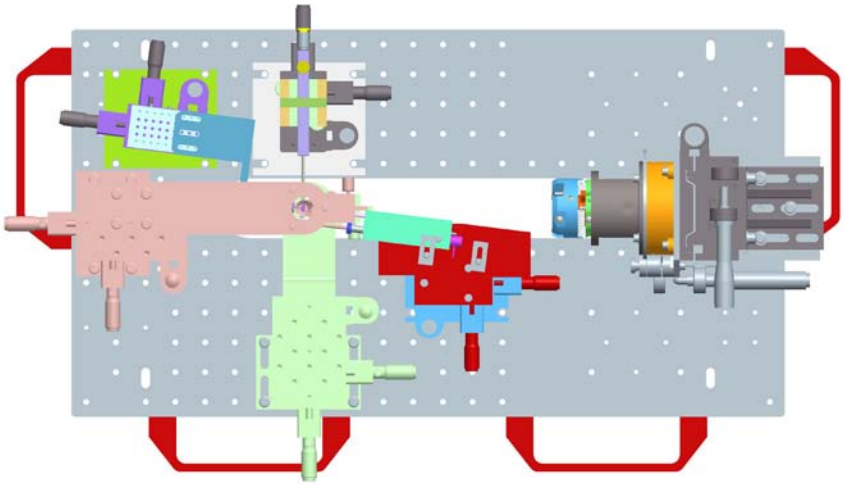


FlexFam Configuration

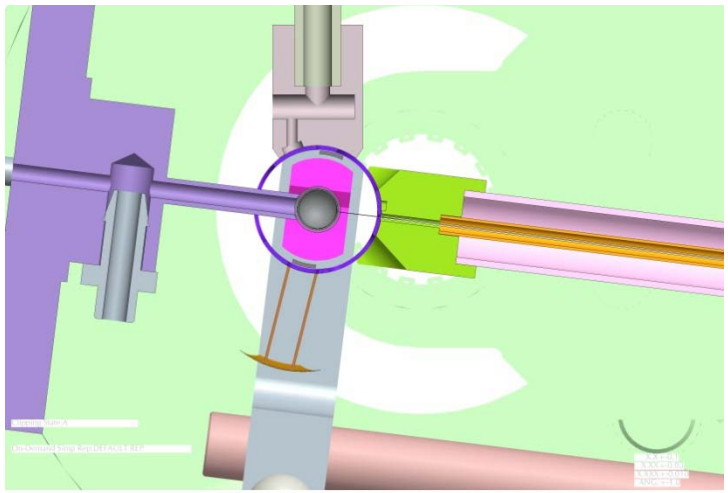
Model FFAM configured for Ignition Target assembly



Model FFAM configured for MixC Target assembly



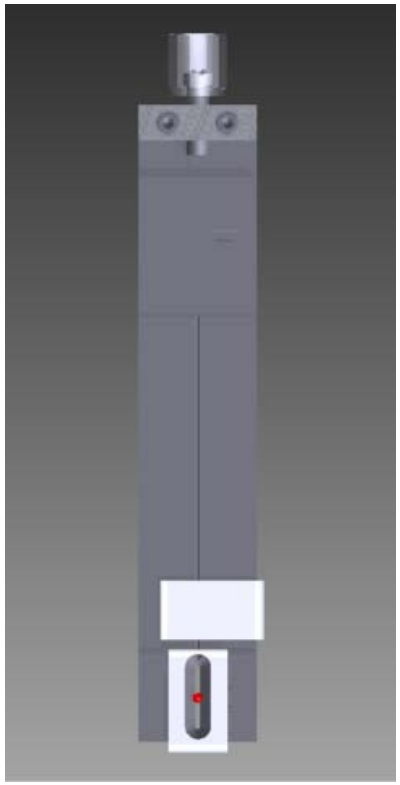
The manipulator system of the FlexFAM resides on a platform that can be readily removed and replaced from the OCMM. A reconfigured manipulator system was used in the assembly of the MixC target.

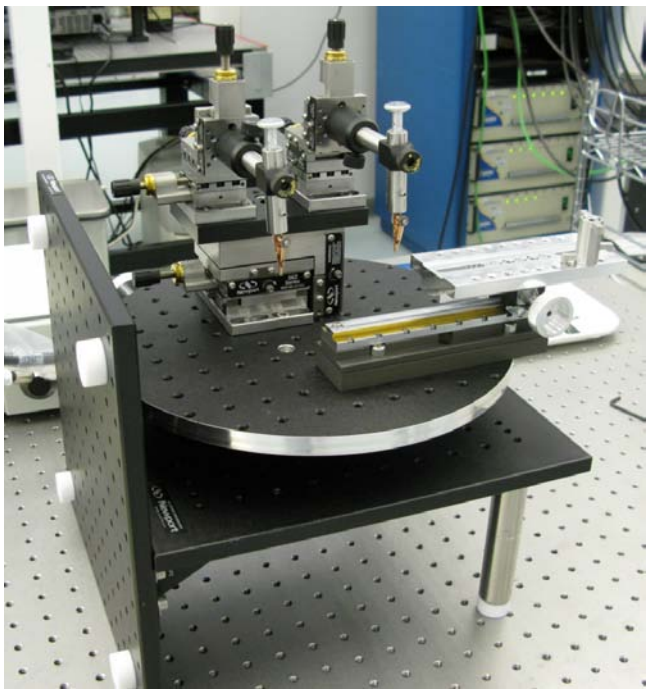


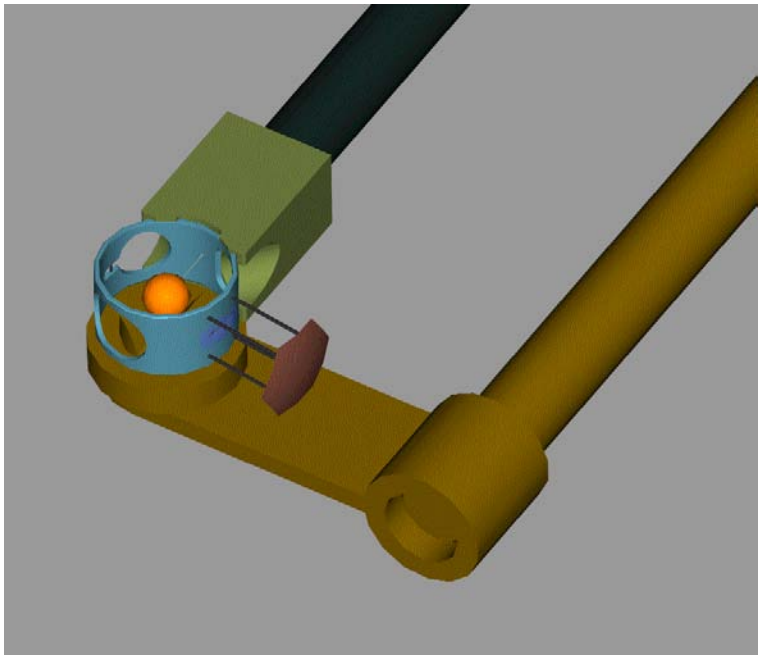
Capsule fill-tube assembly (CFTA) thread and Diagnostic Band transfer

The CFTA is pre-threaded into the diagnostic band before the two items reach the FlexFAM

- **Divots were located using a high magnification stereo microscope.**
- **The divot plane and Fiducial were visually aligned to the diagnostic band.**
- **The CFTA is then threaded through the diagnostic band held by the CFTA transfer tooling.**



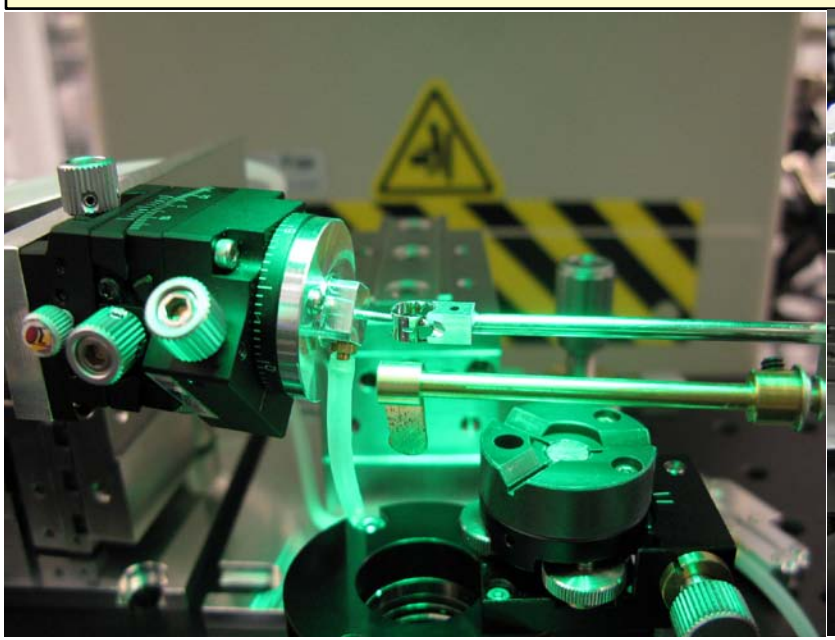


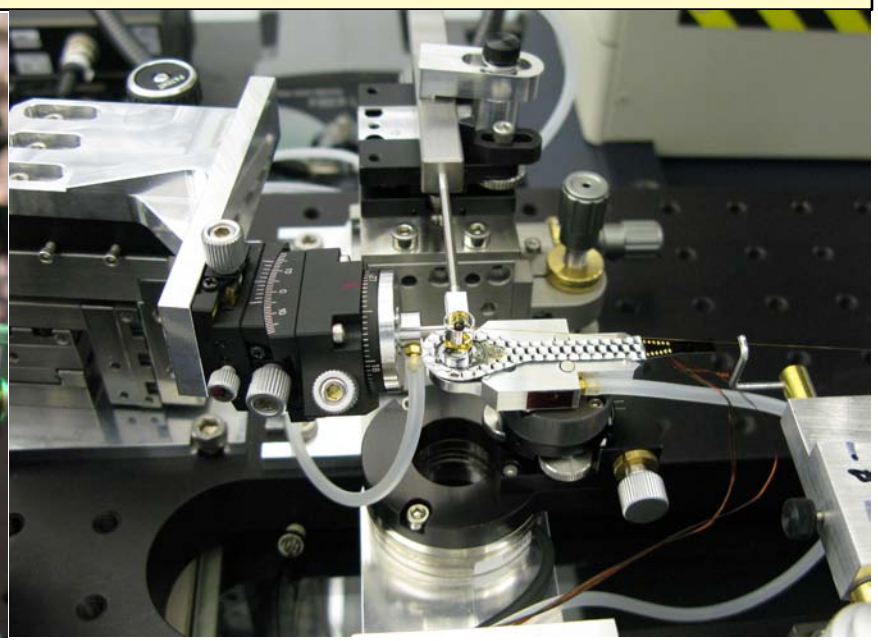


CFTA loaded on FLEXFAM

- **The CFTA / Diagnostic band is then placed on the assembly station and secured to a 5 degrees of freedom (DOF) translation stage.**
- **The CFTA diagnostic band subassembly is then transferred to the capsule positioning chuck and FlexFAM diagnostic band chuck.**
- **The transfer tooling is withdrawn inline with the capsule fill-tube, clearing the TMP halves and providing support of the fill tube.**

Photos showing the CFTA diagnostic band transfer tools

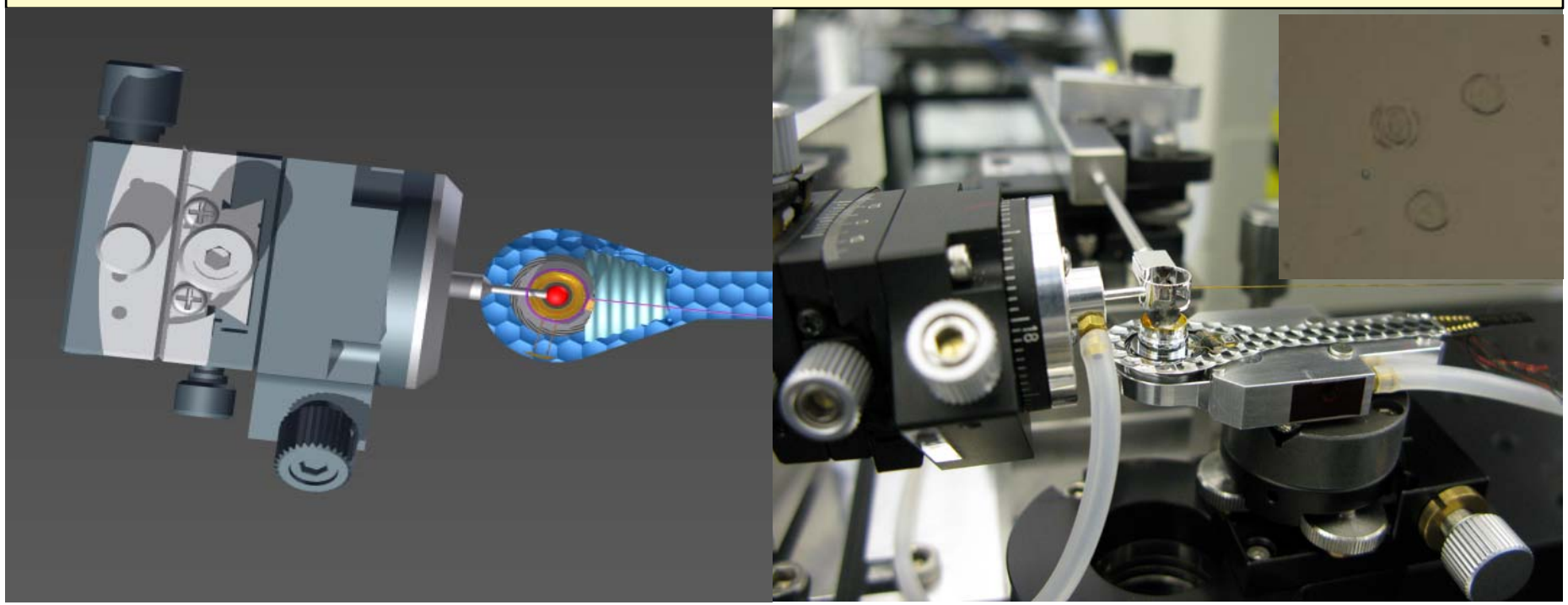




Capsule Divots Alignment

- **GA provided map of Fiducial position relative to defect locations was used to position defects.**
- **Engineered defects were aligned with the 6 axis manipulator in conjunction with the OCMM**

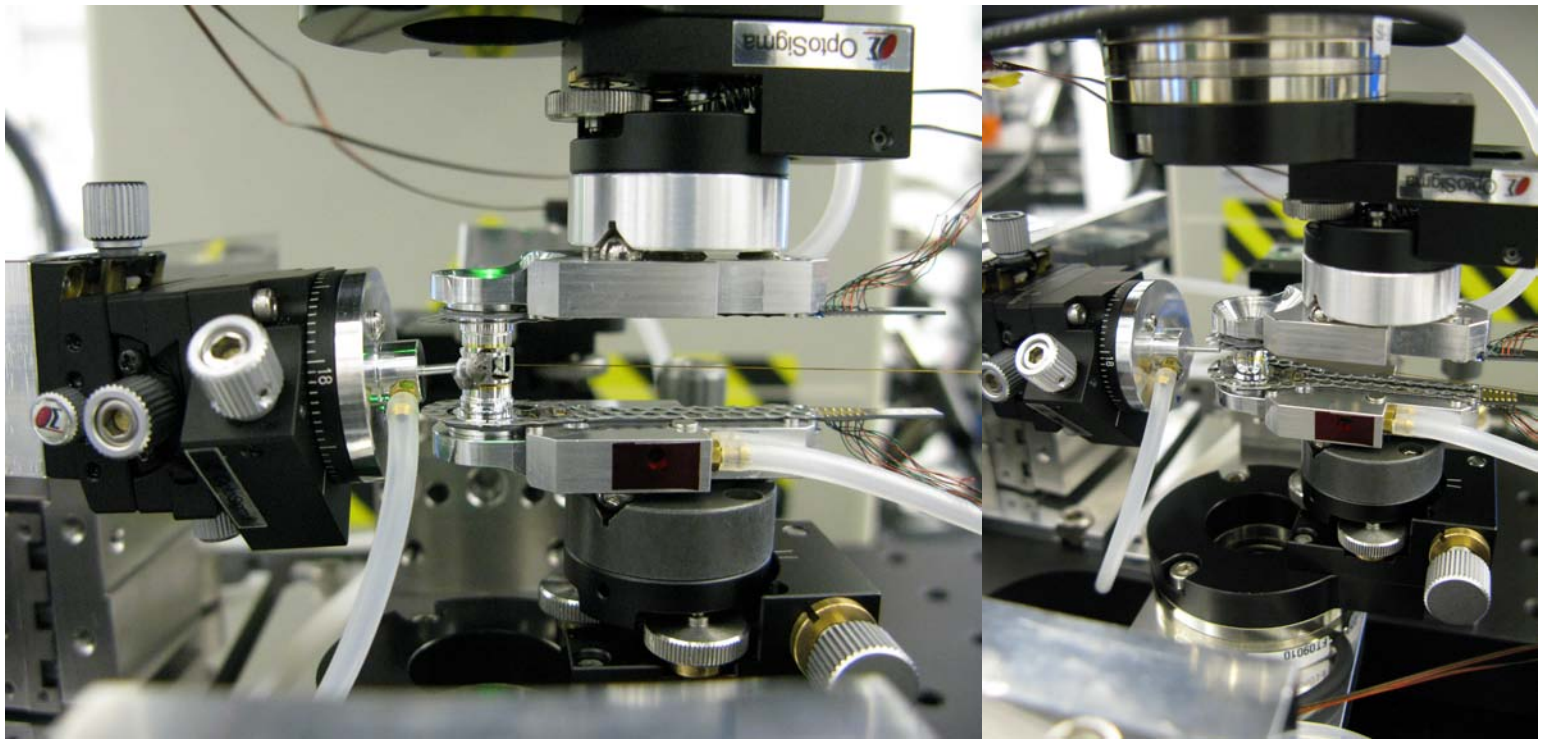
Photo and model showing the 6 axis manipulator positioning divots during final assembly.



Tenting the Capsule

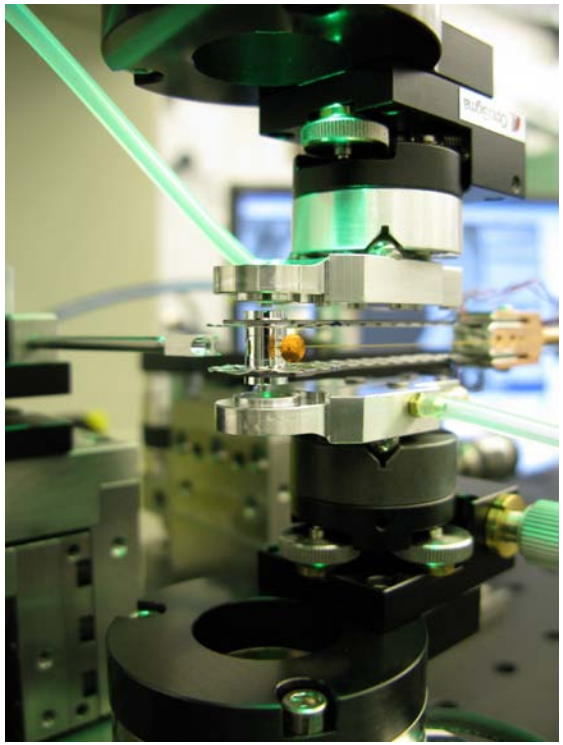
- **The two halves are then simultaneously adjusted to bring the two TMP-halves together to mate with the diagnostic band and tent the capsule.**

Photo of tenting operation



Target Base installation

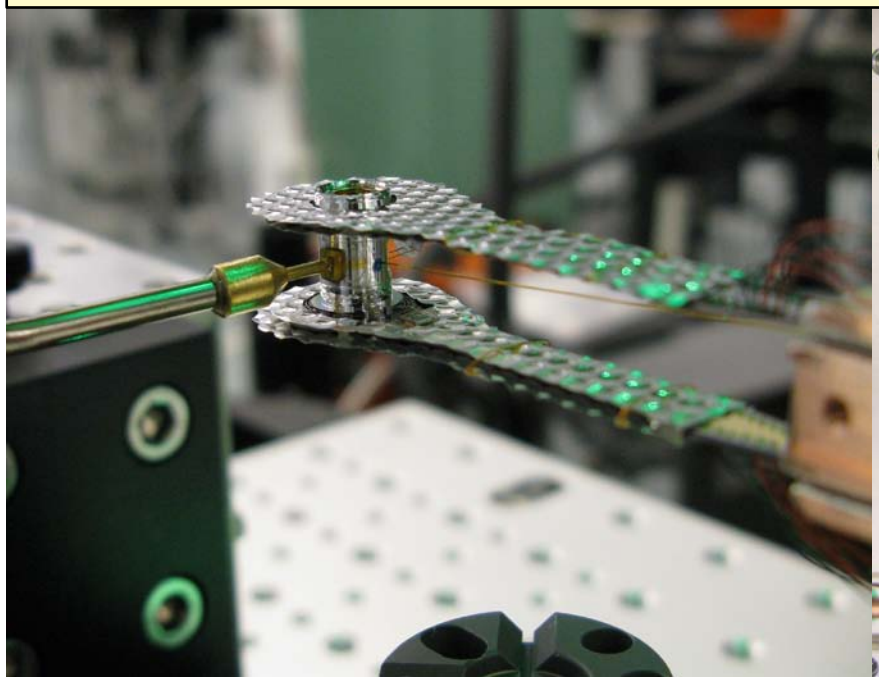
- The capsule fill-tube and TMP-halves are adhesively tacked to the diagnostic band.
- The target base is then attached to the target assembly using mechanical clamps .
- The assembled target is then released from the FlexFAM and packaged for further processing.

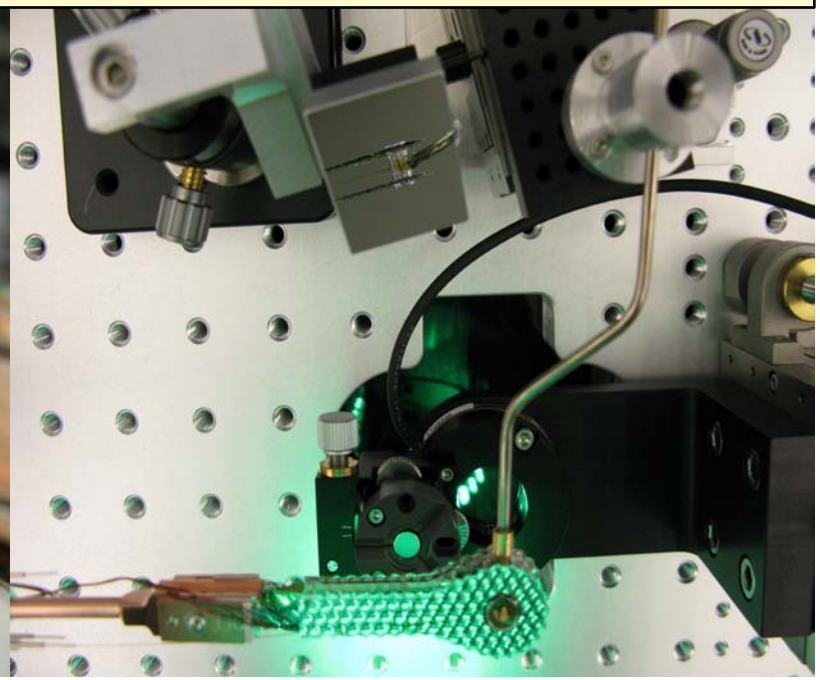


Au Aperture installation

- After the target base is installed, the target can be rotated 180° to facilitate the installation of the Au aperture.
- Tooling was developed to accurately position the aperture with the aid of the OCMM.

Au Aperture installation

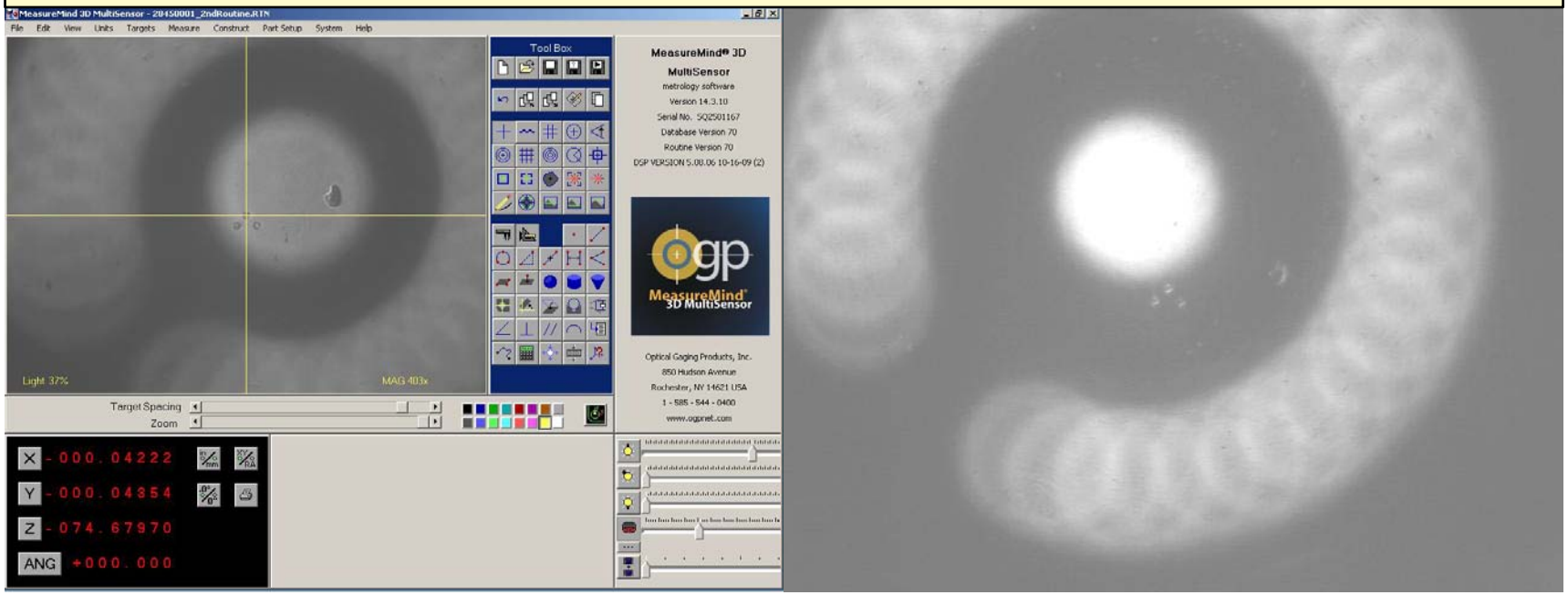




Results Metrology

- **Divot 1 location tolerance Theta= 90°+/-2.5°, Phi= 135°+/-4°**
- **Capsule defect (Divot 1) was positioned within the tolerances specified, based on the fiducial location**

OCMM view of fiducial



Target Assembly Improvements

- Pocket will be machined on the diagnostic band for the Au aperture, so that it is installed under the diagnostic band windows not over them
- 6 degrees of freedom manipulator for Au aperture installation
- Threading station hardware will be modified to improve positioning of the divot plane during threading
- Capsule will be mapped and with 4pi tooling and software

Summary

- Target Fabrication group has developed the tools to assemble and deliver MixC targets.
- The MixC target was successfully assembled within the specified tolerances and met the delivery time line.
- Novel target assembly tooling developed for and tested during assembly is now being migrated to other machines used to build NIC targets.