

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 6, 2020

Computed Tomography Specialist's Factual Report

CEN19FA095

A. ACCIDENT

Location: 5 nautical miles east of South Lafourche Leonard Miller Jr Airport
(GAO), Galliano, Louisiana
Date: March 10, 2019
Time: 1203 central daylight time
Airplane: Bell 407 helicopter, N577AL

B. GROUP

Computed
Tomography
Specialist: Scott Warren
National Transportation Safety Board
Washington, D.C.

C. SUMMARY

On March 10, 2019, about 1203 central daylight time, a Bell 407, N577AL, impacted a marsh after descending from cruise flight from an approximate altitude of 300 feet mean sea level about 5 nautical miles east of South Lafourche Leonard Miller Jr Airport (GAO), Galliano, Louisiana. The helicopter was destroyed by impact forces. The commercial pilot and a passenger received fatal injuries. The helicopter was registered to and operated by Bristow Group Inc. under Title 14 Code of Federal Regulation Part 135 as an on-demand passenger flight that was operating on a company visual flight rules (VFR) flight plan. The flight originated from Bristow US LLC Heliport (2LS0), Galliano, Louisiana, about 1155, and was destined to an offshore platform in Viosca Knoll (VK956), Gulf of Mexico, about 69 nautical miles east/southeast of Venice, Louisiana.

The internal configuration of the hydraulic pump, the collective hydraulic actuator, the left hand cyclic hydraulic actuator, the right hand cyclic hydraulic actuator, and the tail rotor hydraulic actuator were documented using radiographic images that were collected from May 13 – June 14, 2019 in Chicago, Illinois. A total of 10,972 computed tomography (CT) slice images were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the images indicated that, when the scans were conducted, there were no indications of missing or broken components, blockages, or other abnormalities.

D. DETAILS OF THE INVESTIGATION

1.0 General

The hydraulic pump, the collective hydraulic actuator, the left hand cyclic hydraulic actuator, the right hand cyclic hydraulic actuator, and the tail rotor hydraulic actuator were subjected to x-ray radiograph and computed tomography (CT) scanning to document their internal conditions. The scanning was conducted from May 13 – June 14, 2019 by Varex, Inc under the direction of the NTSB using the Actis 500/225 standard focus and 1 MV CT systems.

For the CT scans, the components were loaded into the imaging unit and placed on a turntable. The components were then rotated in front of the x-ray source, and the x-rays were captured by a detector after they went through the part. The x-ray source produced a cone beam of x-rays, and the portion of the part imaged was adjusted slightly after each scan was completed until the entire assembly (or region of interest of the part) was scanned. The x-ray energy levels measured by the detector were recorded at several thousand different points during each rotation, and this information was converted into slice images using reconstruction algorithms.

The components were scanned using a total of 10,972 slices, and the total size of the combined data sets was approximately 85.9 Gb. The complete scan protocols are given in table 1. The digital radiograph and CT axial slice images were provided by Varex to the NTSB where they were examined, processed, and analyzed to evaluate the components.

Table 1
Scan Protocols

Component	Hydraulic Pump	Collective hydraulic actuator	Left hand cyclic hydraulic actuator	Right hand cyclic hydraulic actuator	Tail rotor hydraulic actuator
Number of slices	425	2657	2714	2565	2611
Voxel Size - X Direction (mm)	0.22	0.087	0.087	0.087	0.087
Voxel Size - Y Direction (mm)	0.22	0.087	0.087	0.087	0.087
Voxel Size - Z Direction (mm)	0.25	0.087	0.087	0.087	0.087
Image Projections per Revolution	6500	1800	1800	1800	1800
Exposure time (ms)	10	285.58	285.58	285.58	285.58
Frames to Avg (frames per projection)	1	2	2	2	2
X-ray Source Voltage (kV)	1000	450	450	450	450
X-ray Source Current (mA)	4 PPV, 2.5 ms	2	2	2	2
Source Filter Thickness (mm)	3.3	5	5	5	5
Source Filter Material	Steel	Brass	Brass	Brass	Brass
Image Matrix Size	2048 x 2048	2048 x 2048	2048 x 2048	2048 x 2048	2048 x 2048

The data sets of slice images were examined, processed, and analyzed by the NTSB using the VGStudioMax software package to convert the axial slice data into orthogonal slice images and a three-dimensional reconstructed image of the component. As part of the evaluation, some sections of the components were digitally removed or rendered transparent to allow closer observation of interior parts. In the images, the higher density areas were shown as brighter shades of gray and lower density areas were shown as darker shades of gray. The pointers shown in some of the images denote specific areas of interest within that image.

The images of the components were examined for any signs of missing or damaged parts, contamination, or any other anomalies. Specific results (including example images) are presented in subsequent sections of this report.

2.0 Computed Tomography Results

The computed tomography (CT) results for the components are shown in figures 1 through 56. Review of the images indicated that, when the scans were conducted, there were no indications of missing or broken components, blockages, or other abnormalities.

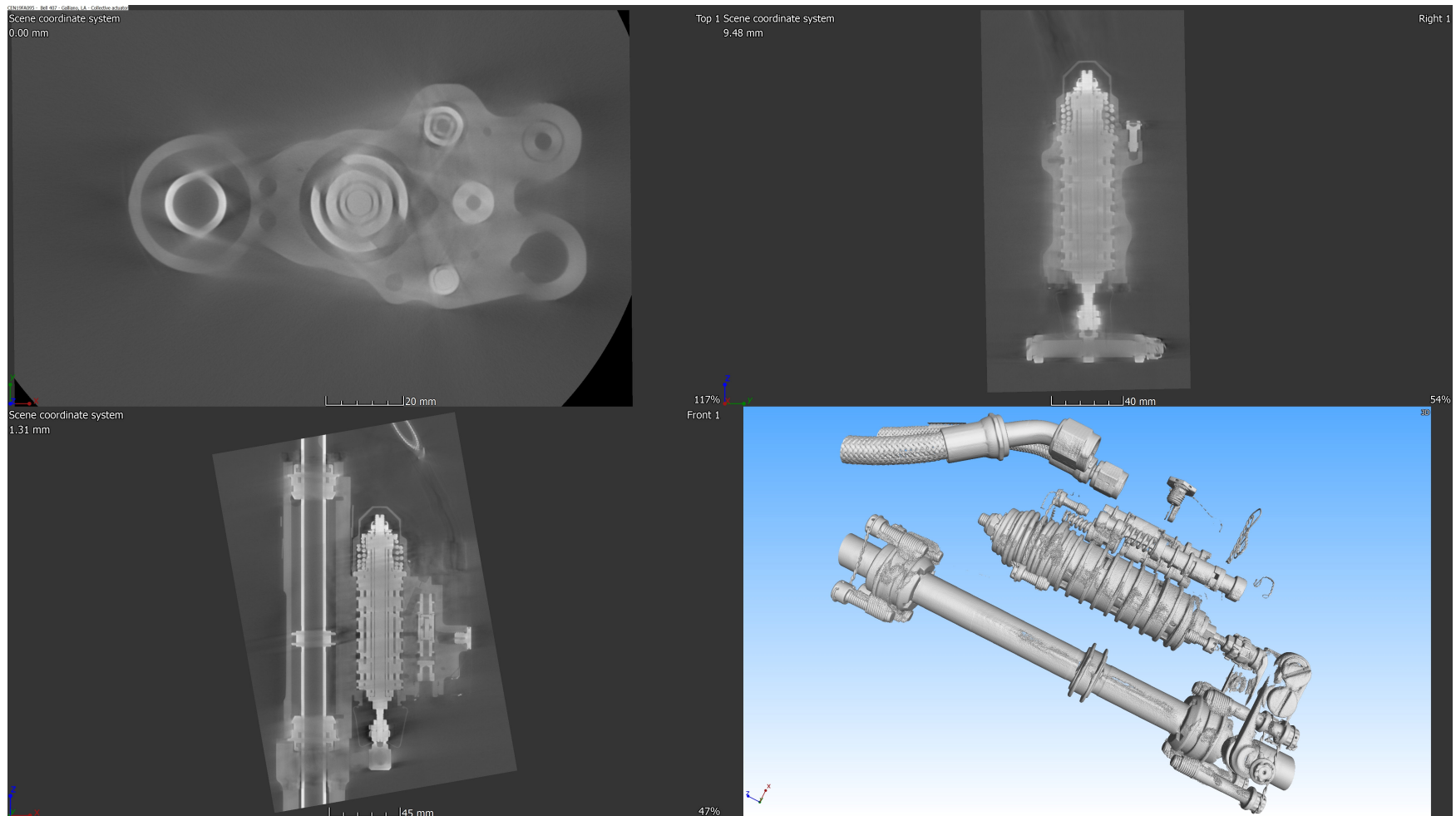


Figure 1
Collective hydraulic actuator – overview

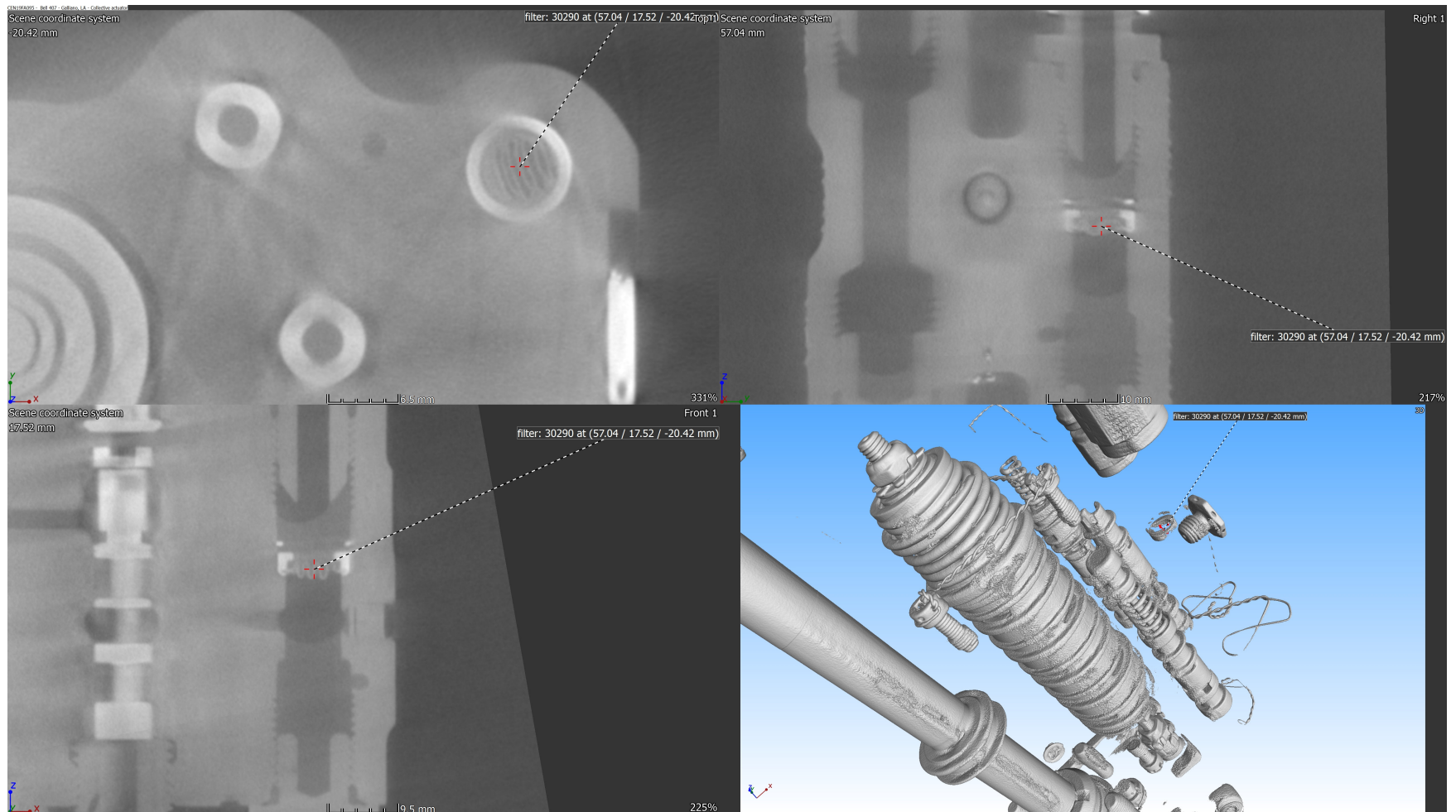


Figure 2
Collective hydraulic actuator – filter

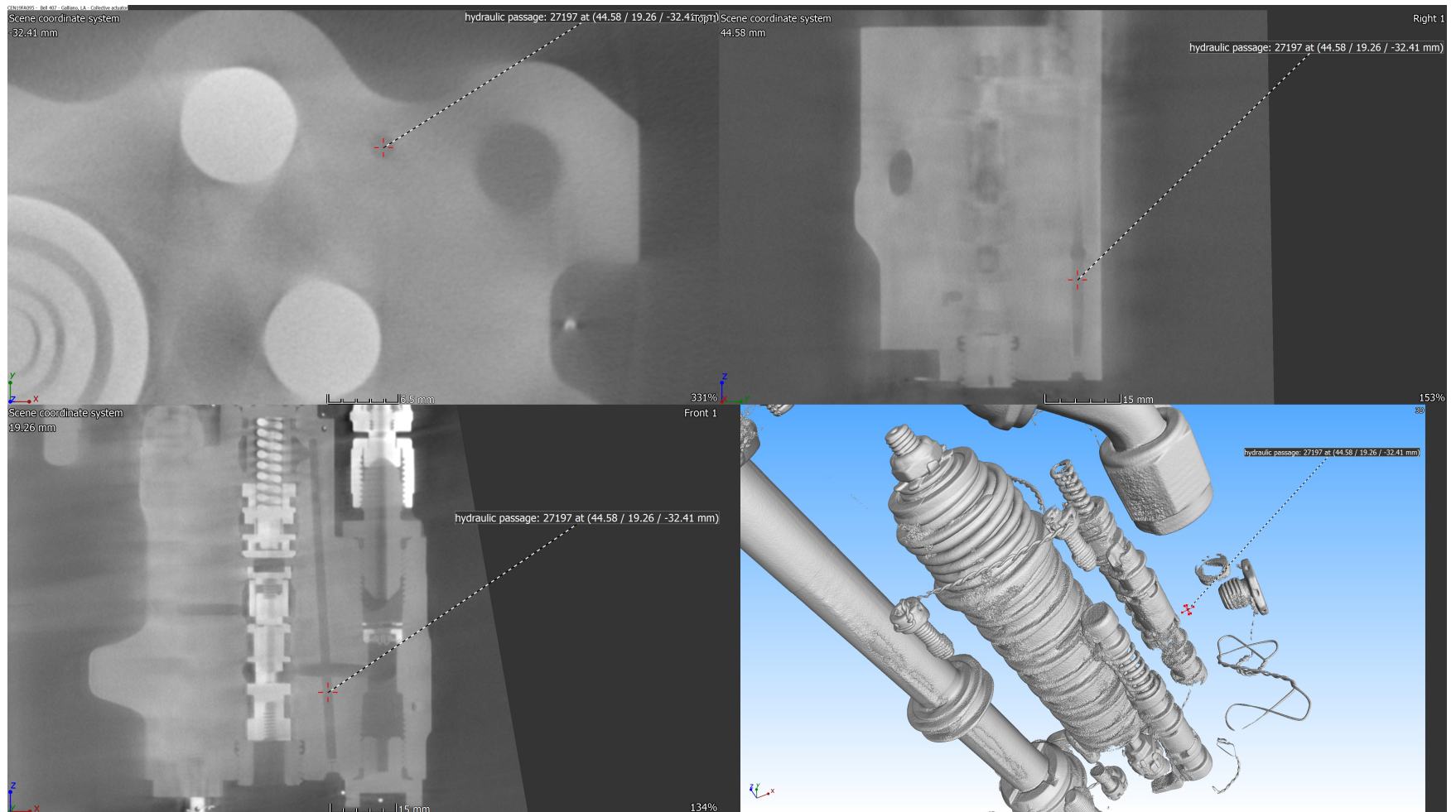


Figure 3
Collective hydraulic actuator – hydraulic passage

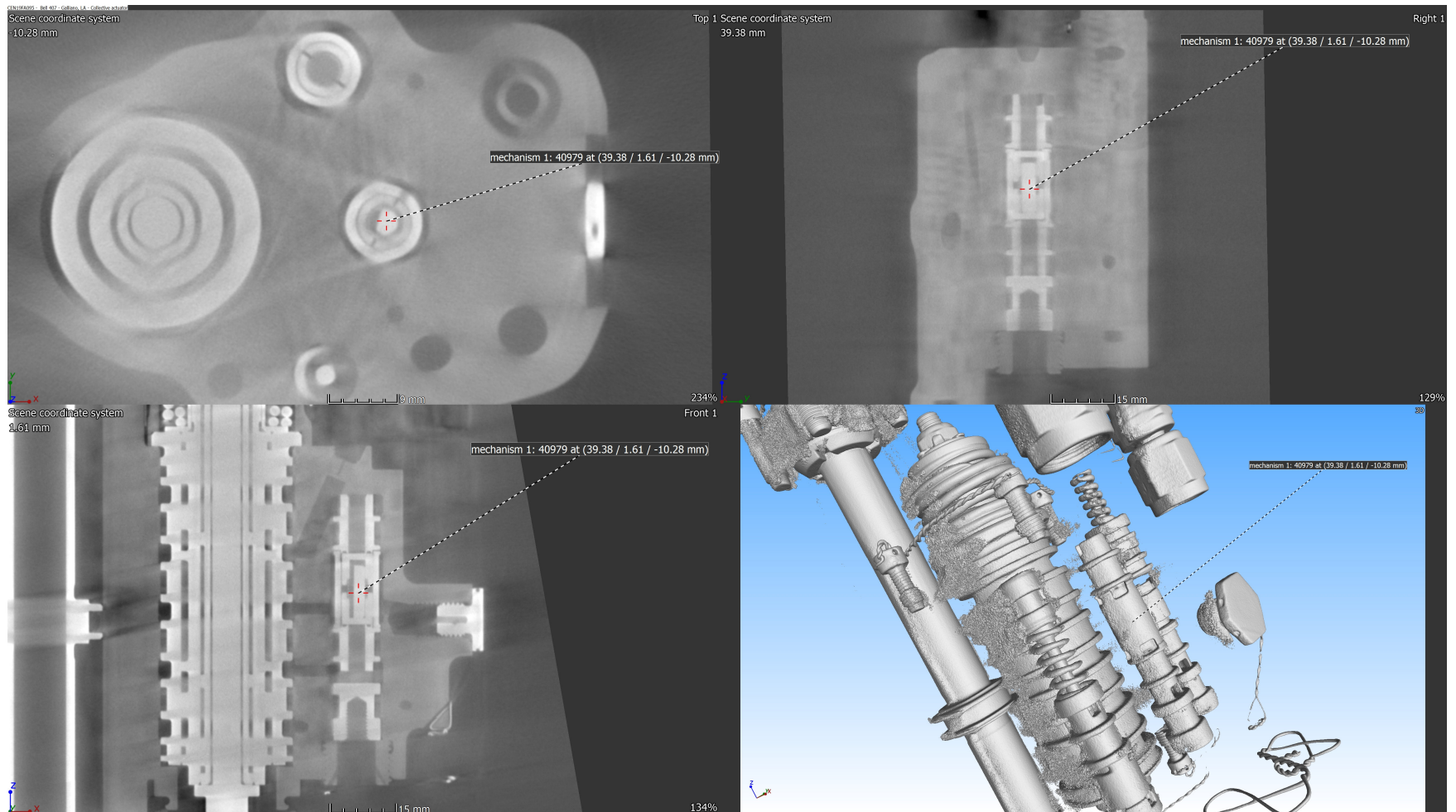


Figure 4
Collective hydraulic actuator – mechanism 1

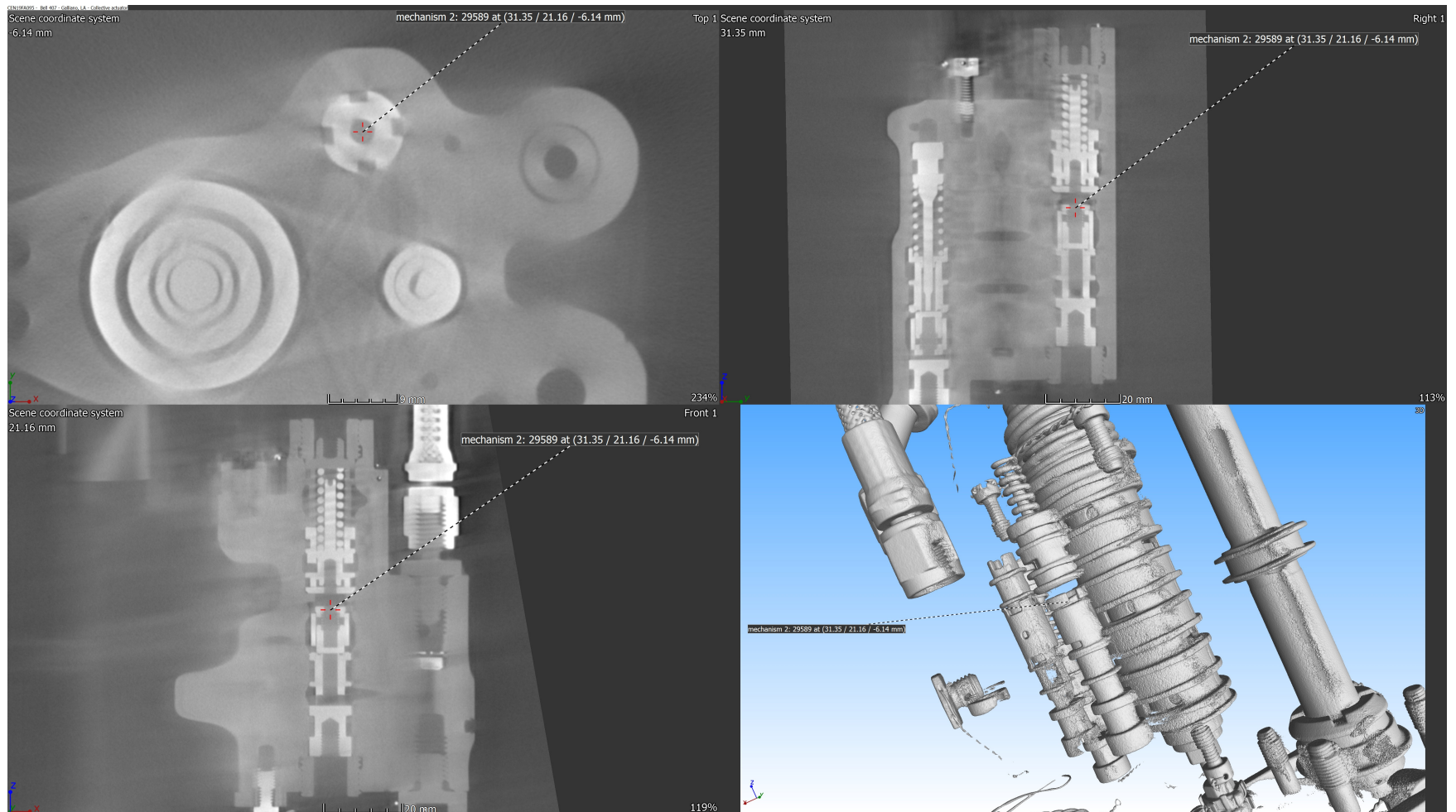


Figure 5
Collective hydraulic actuator – mechanism 2

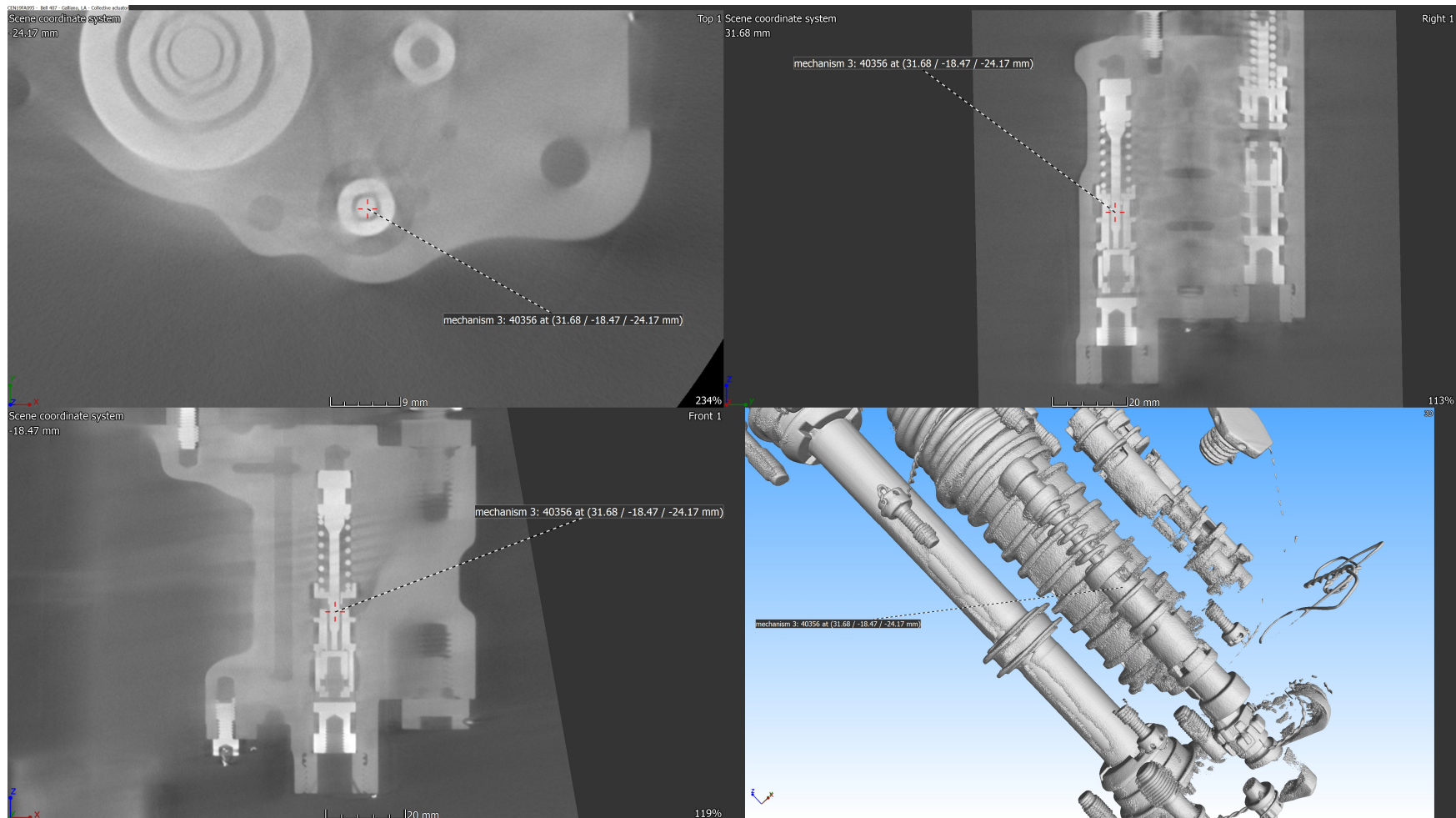


Figure 6
Collective hydraulic actuator – mechanism 3

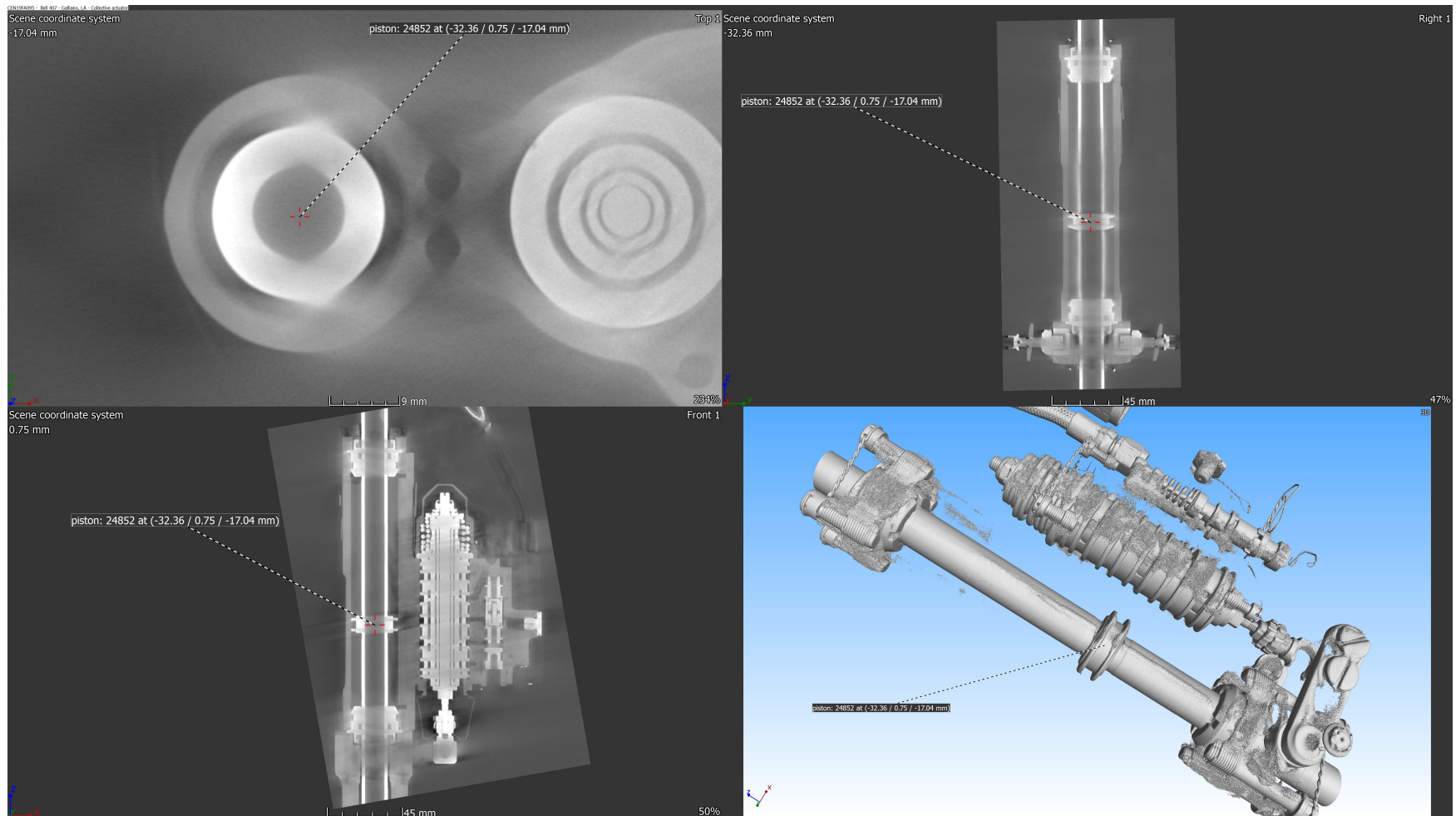


Figure 7
Collective hydraulic actuator – piston

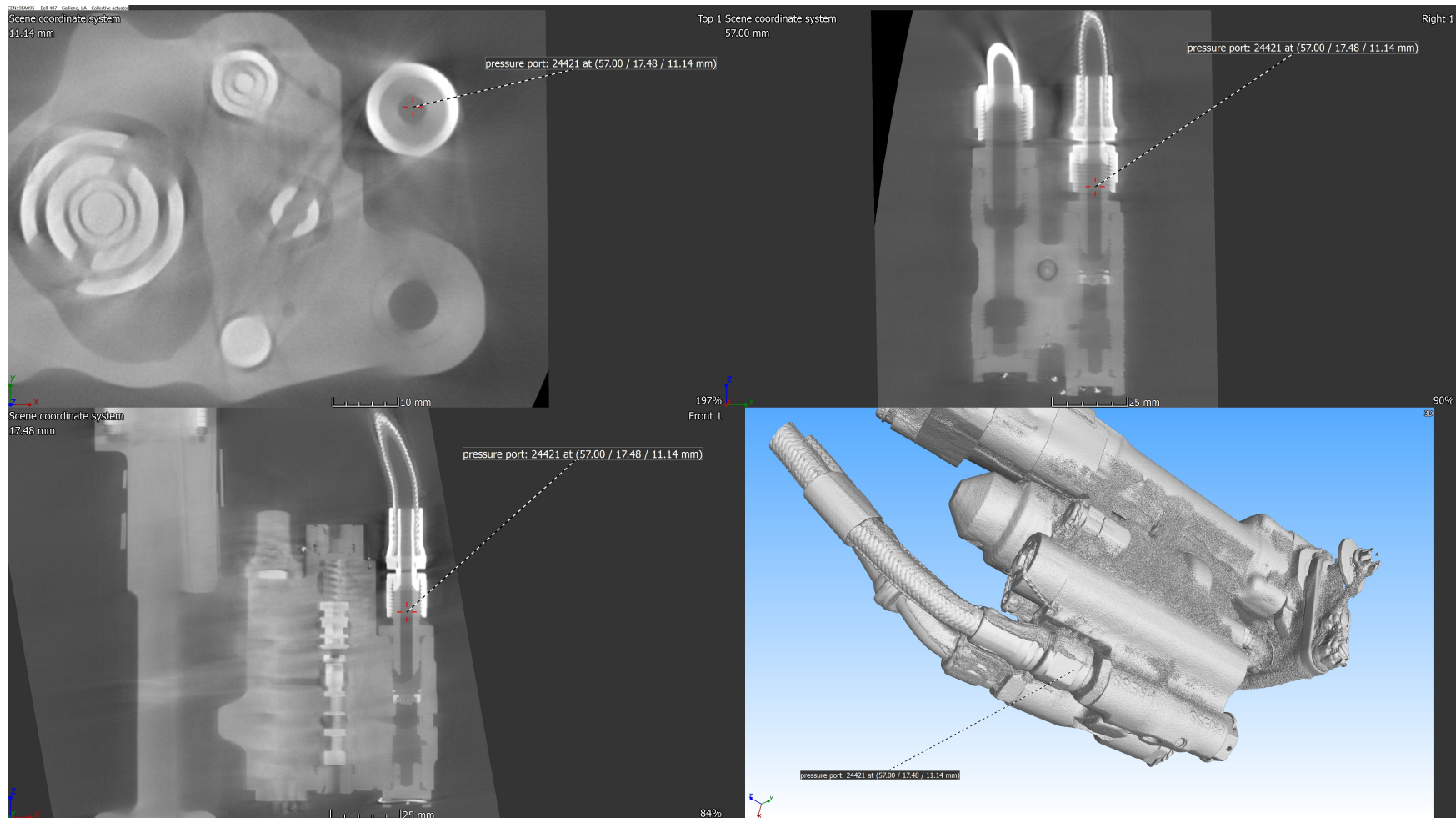


Figure 8
Collective hydraulic actuator – pressure port

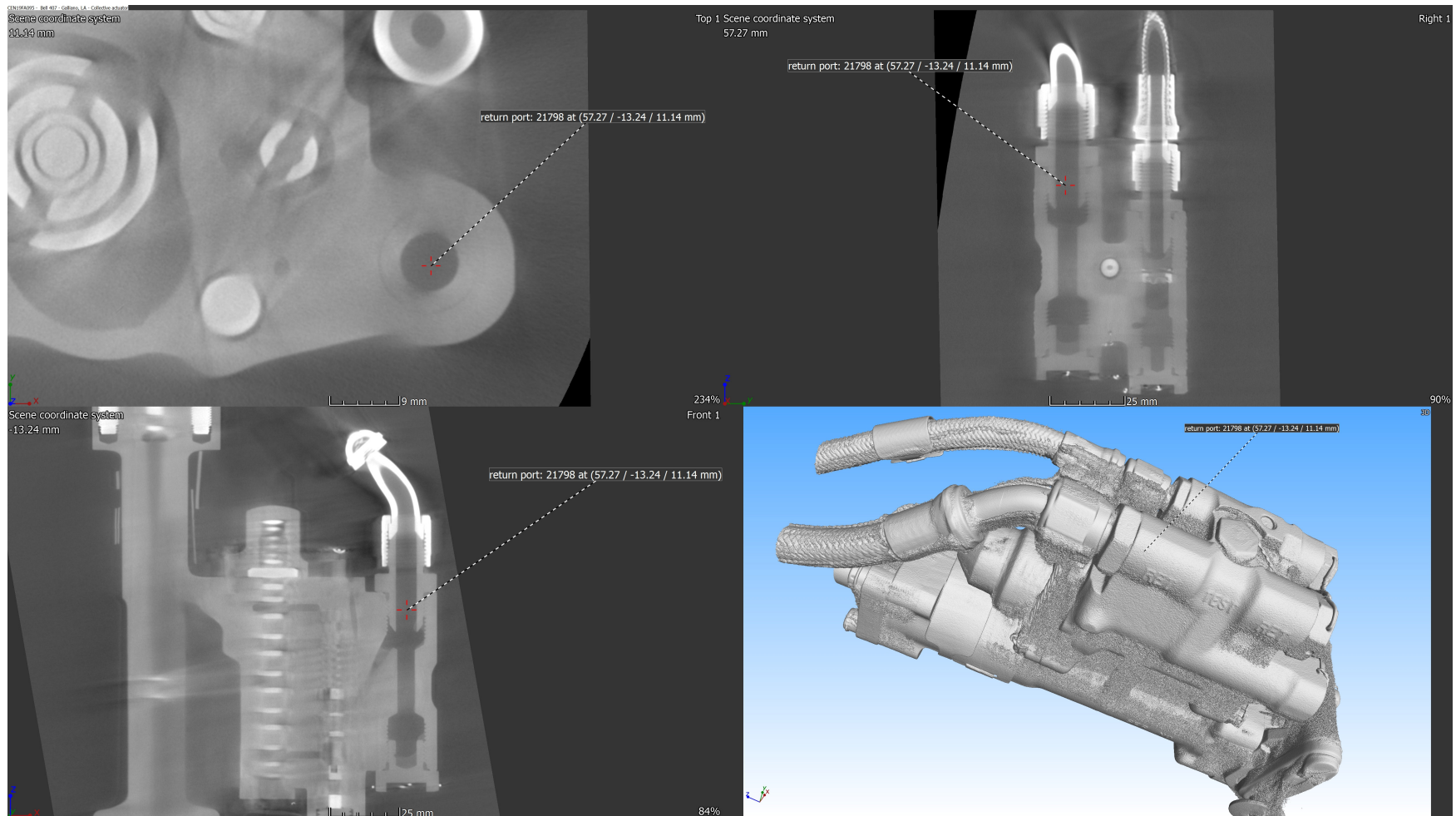


Figure 9
Collective hydraulic actuator – return port

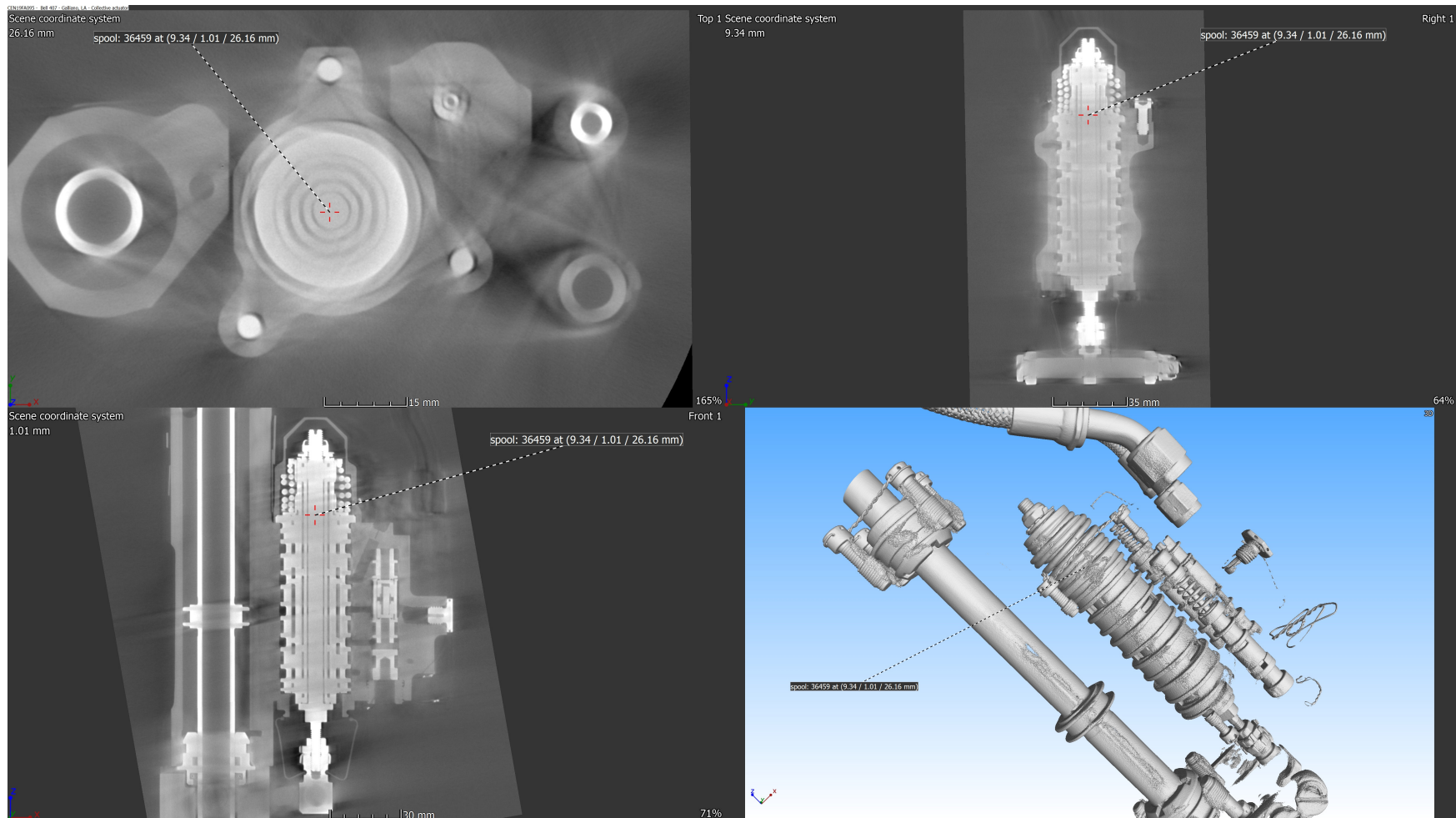


Figure 10
Collective hydraulic actuator – spool

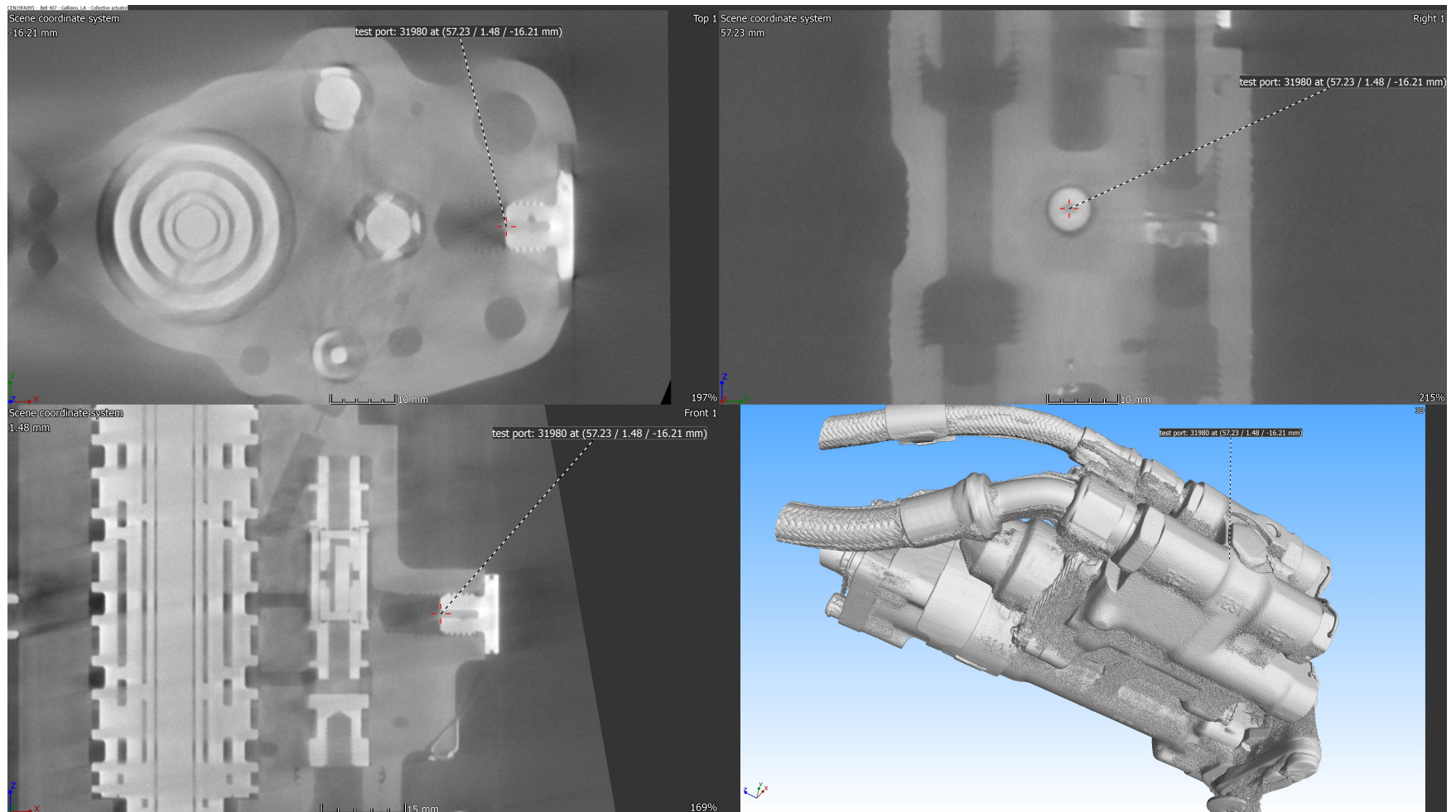


Figure 11
Collective hydraulic actuator – test port

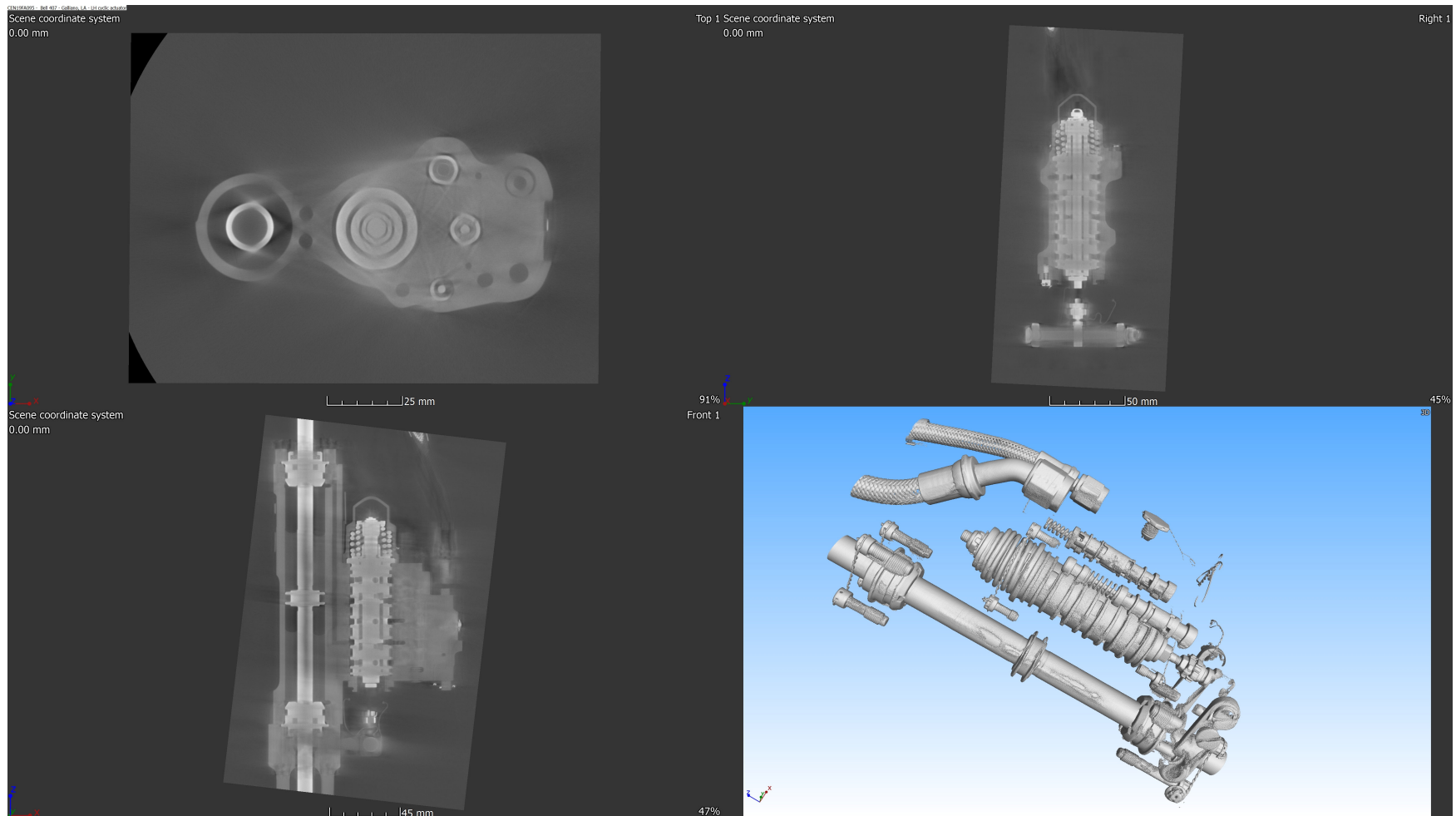


Figure 12
Left hand cyclic hydraulic actuator – overview

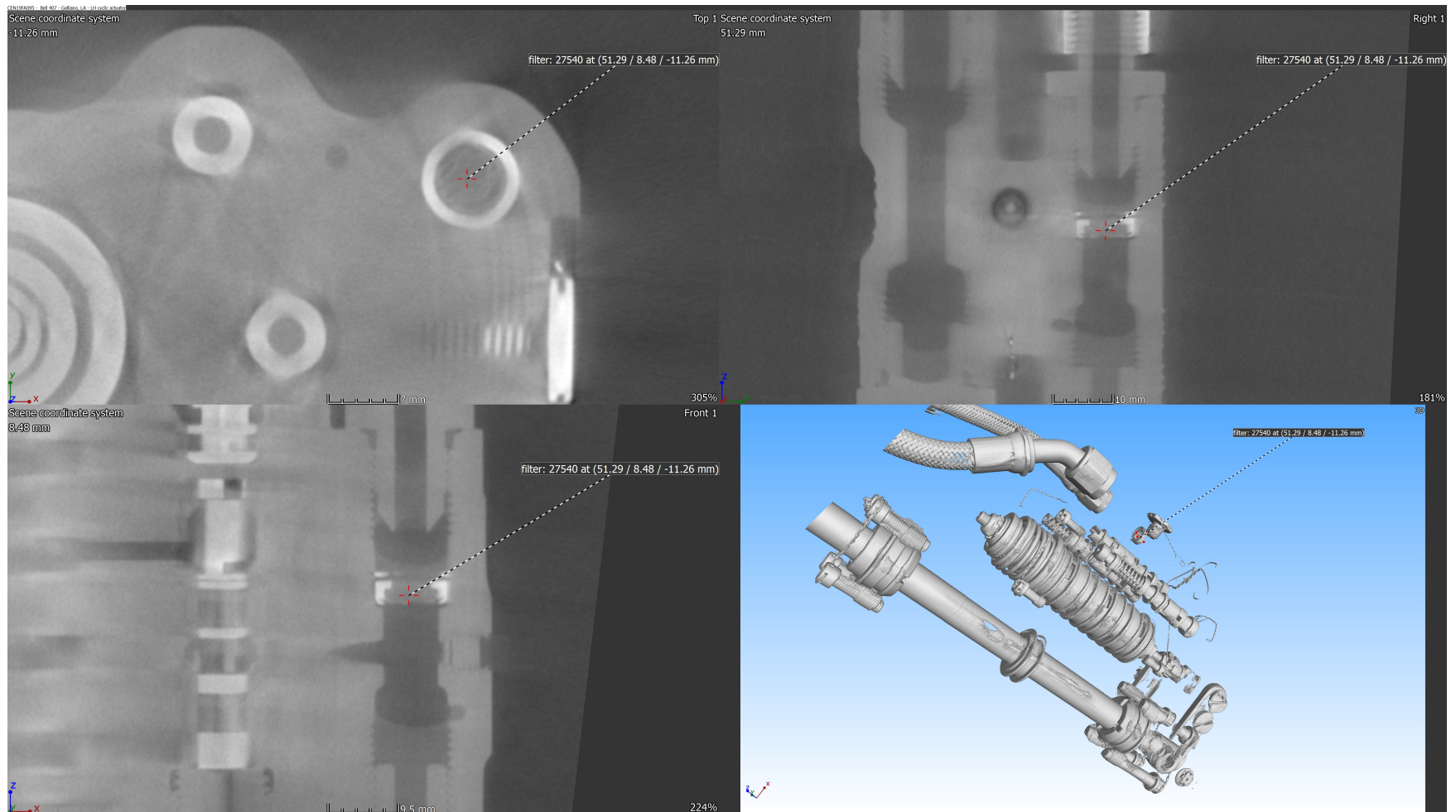


Figure 13
Left hand cyclic hydraulic actuator – filter

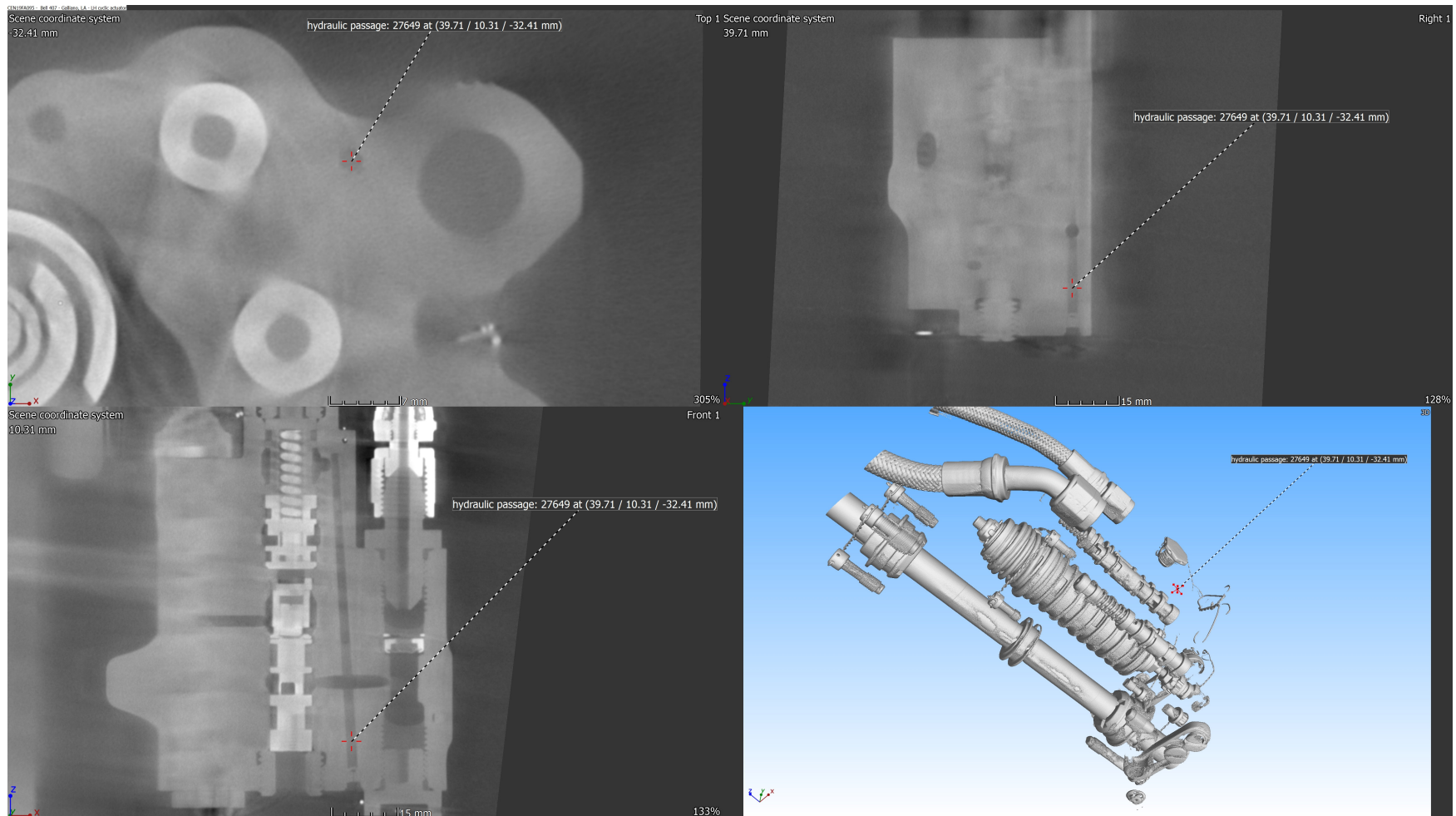


Figure 14
Left hand cyclic hydraulic actuator – hydraulic passage

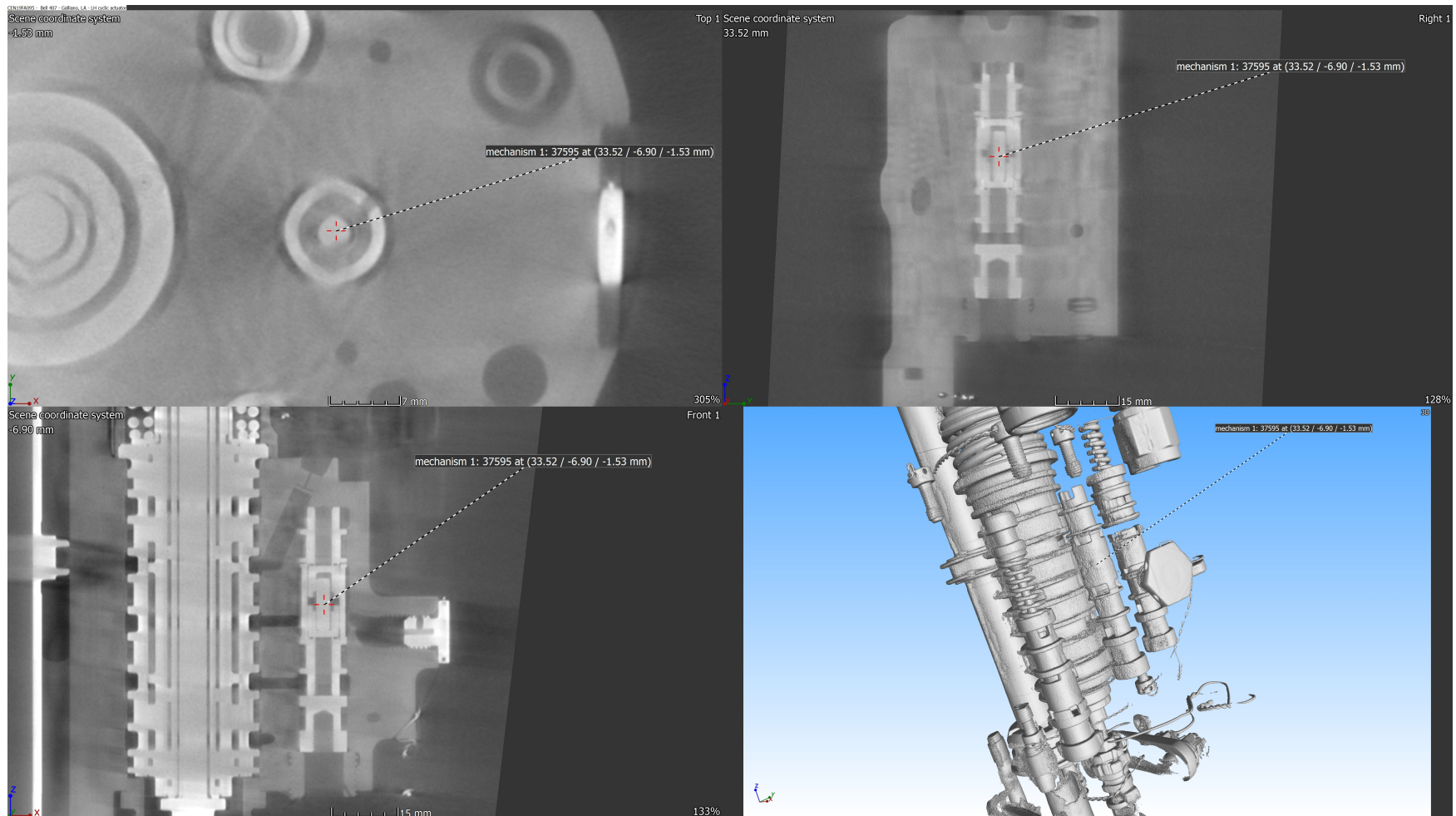


Figure 15
Left hand cyclic hydraulic actuator – mechanism 1

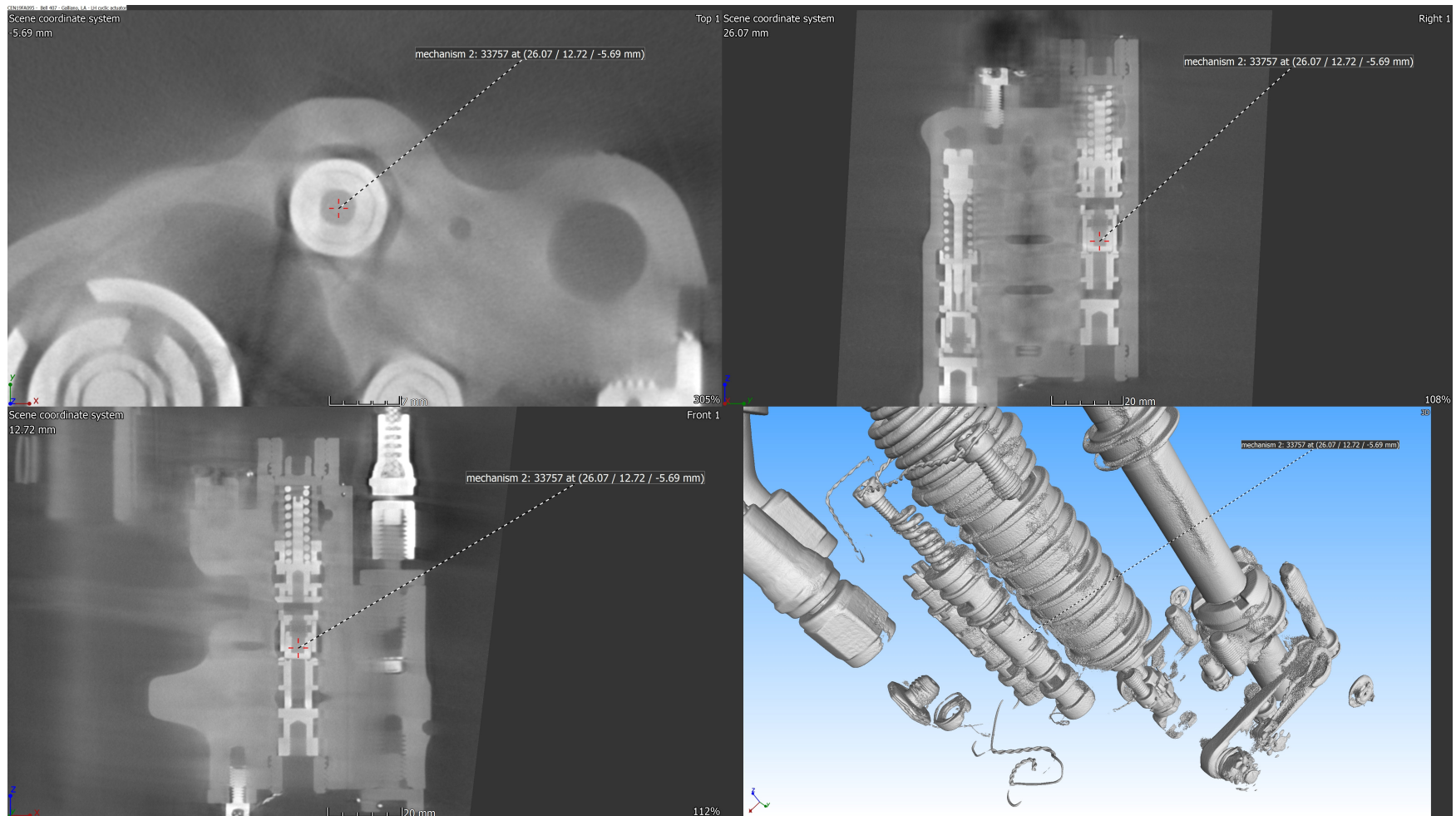


Figure 16
Left hand cyclic hydraulic actuator – mechanism 2

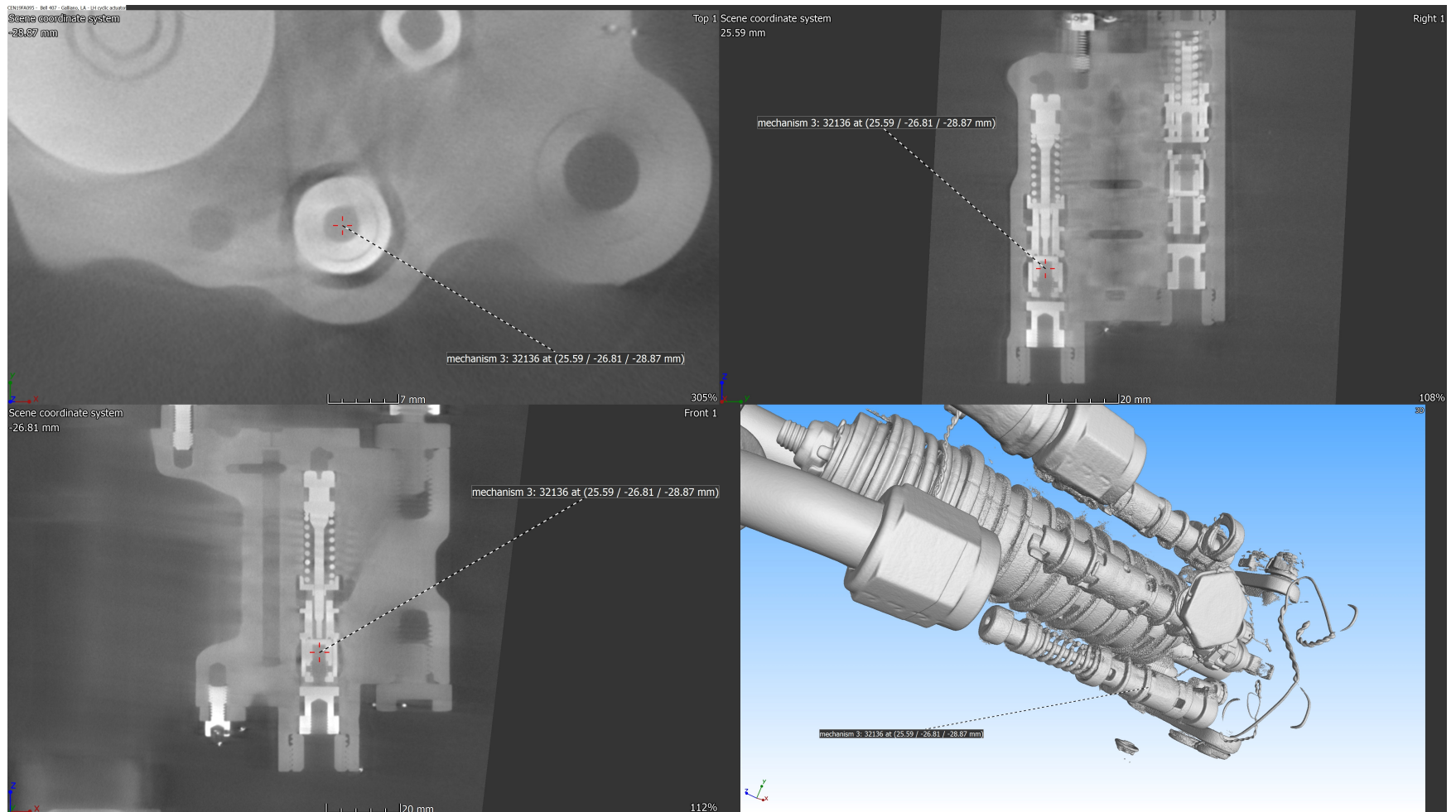


Figure 17
Left hand cyclic hydraulic actuator – mechanism 3

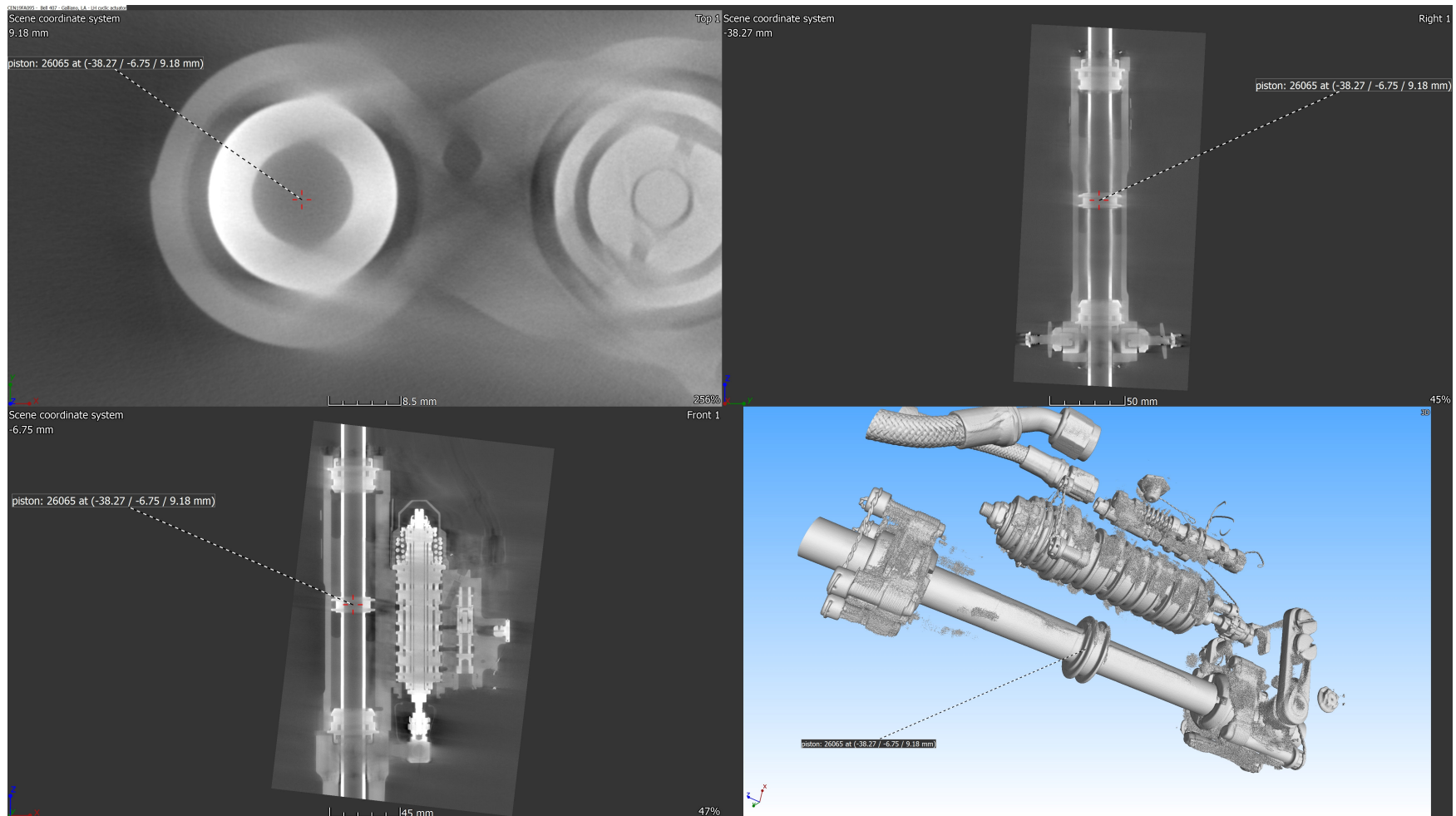


Figure 18
Left hand cyclic hydraulic actuator – piston

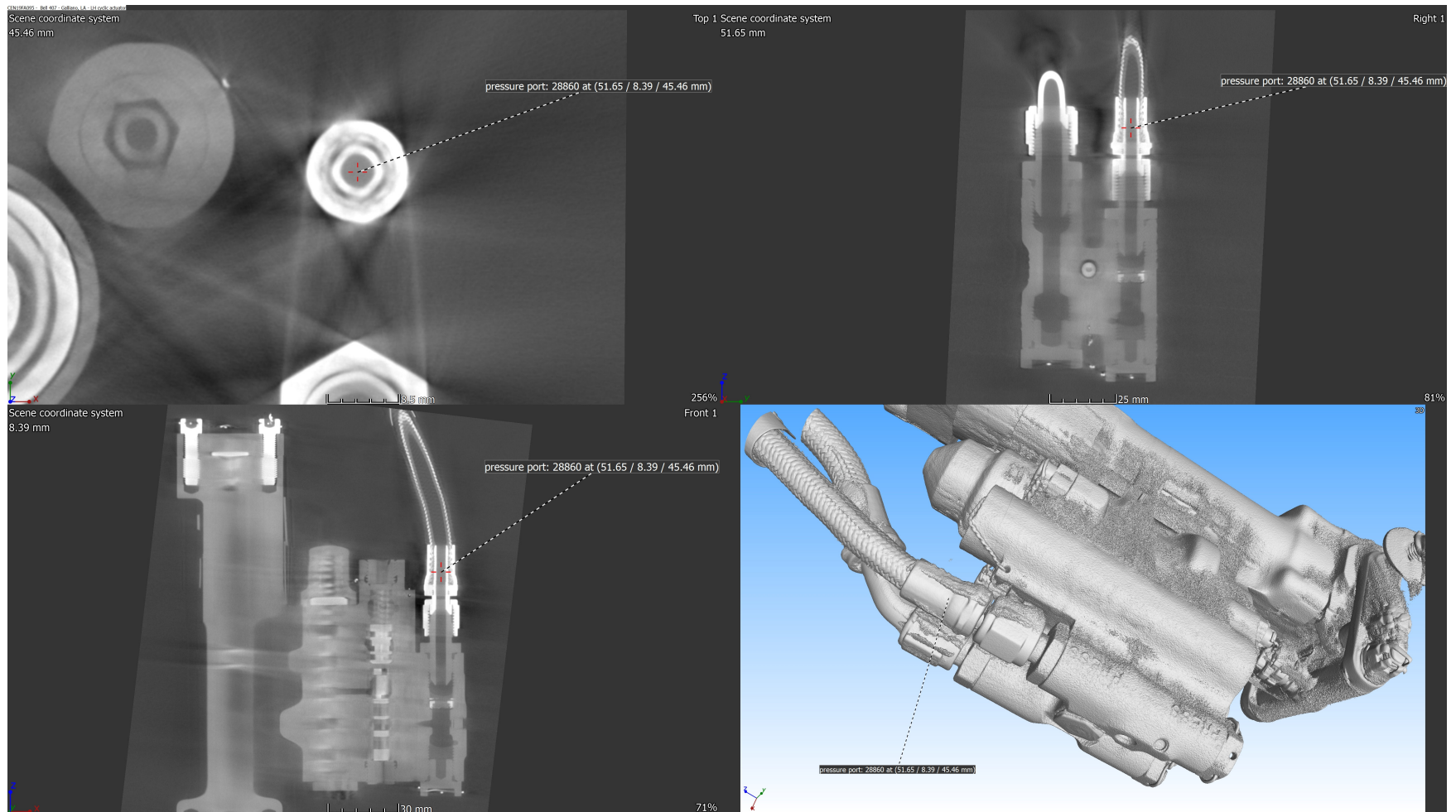


Figure 19
Left hand cyclic hydraulic actuator – pressure port

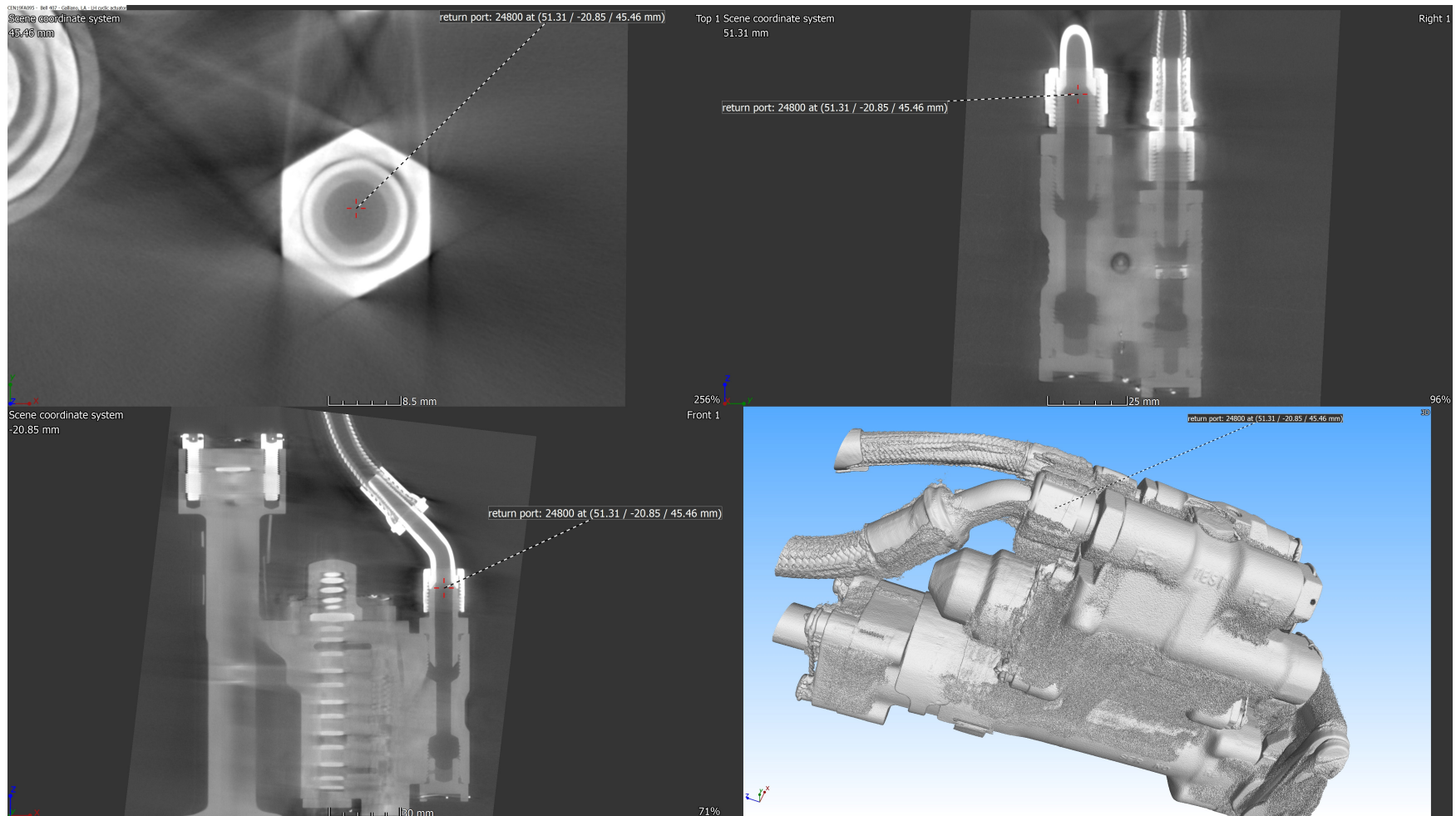


Figure 20
Left hand cyclic hydraulic actuator – return port

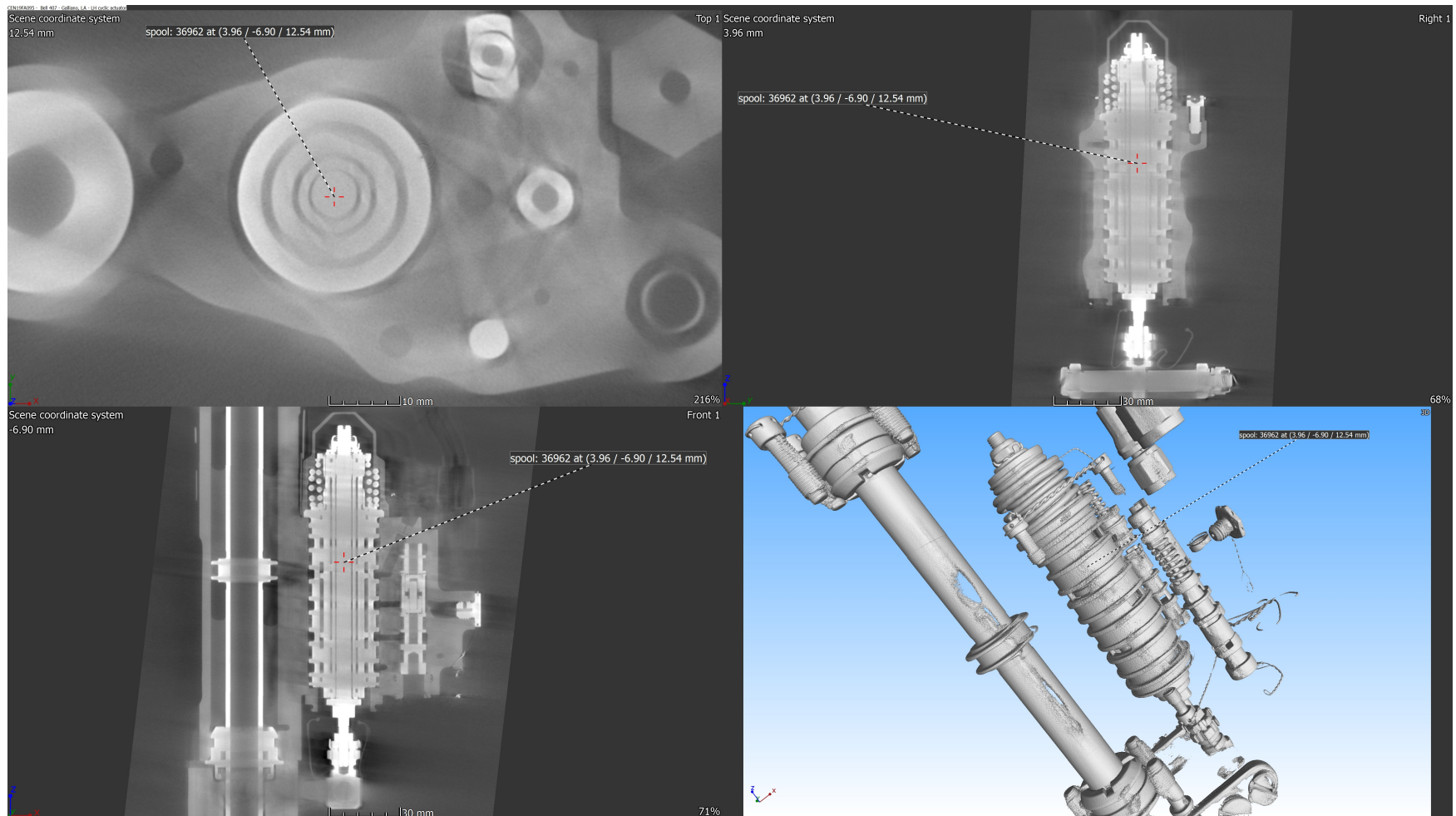


Figure 21
Left hand cyclic hydraulic actuator – spool

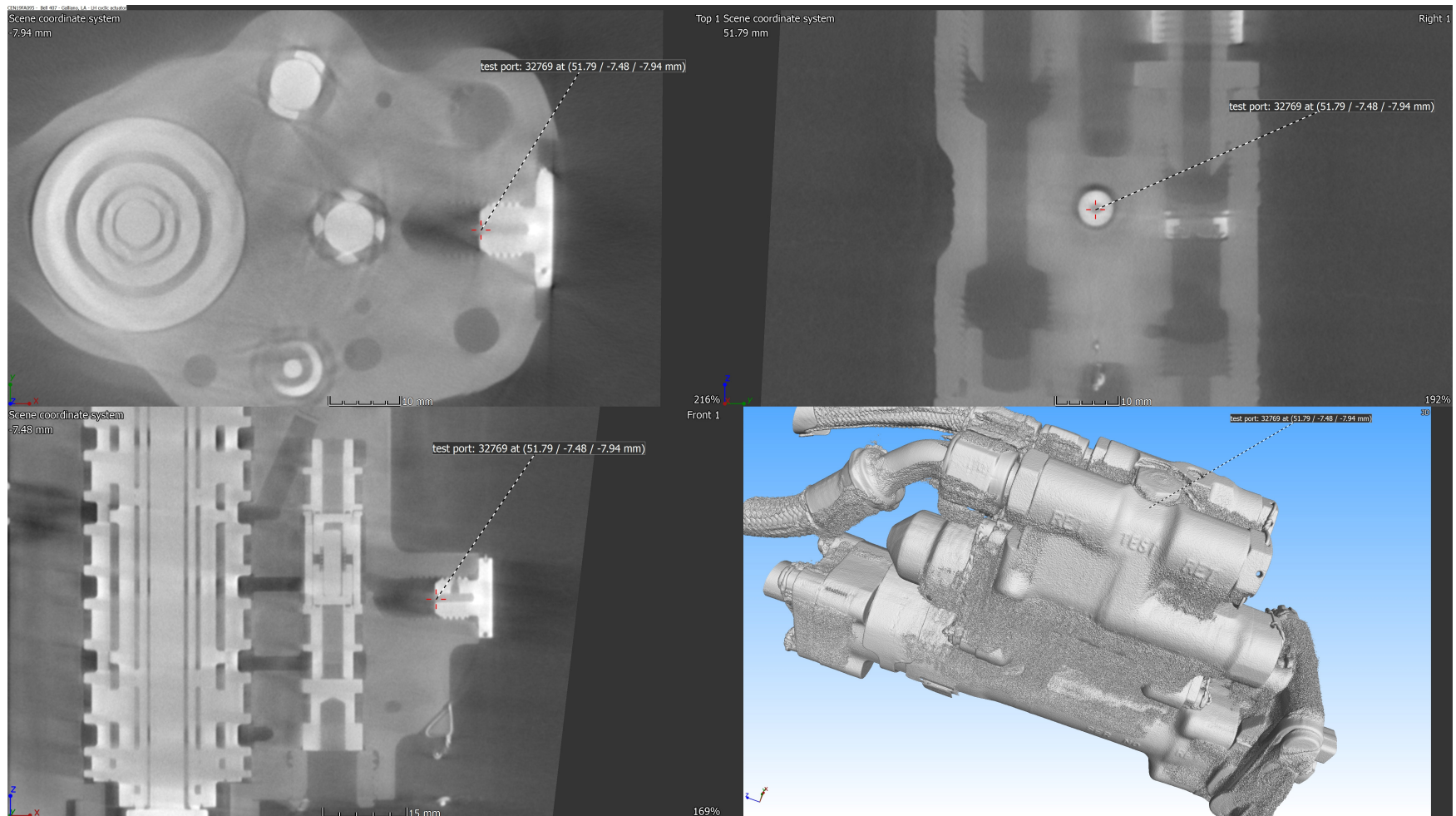


Figure 22
Left hand cyclic hydraulic actuator – test port

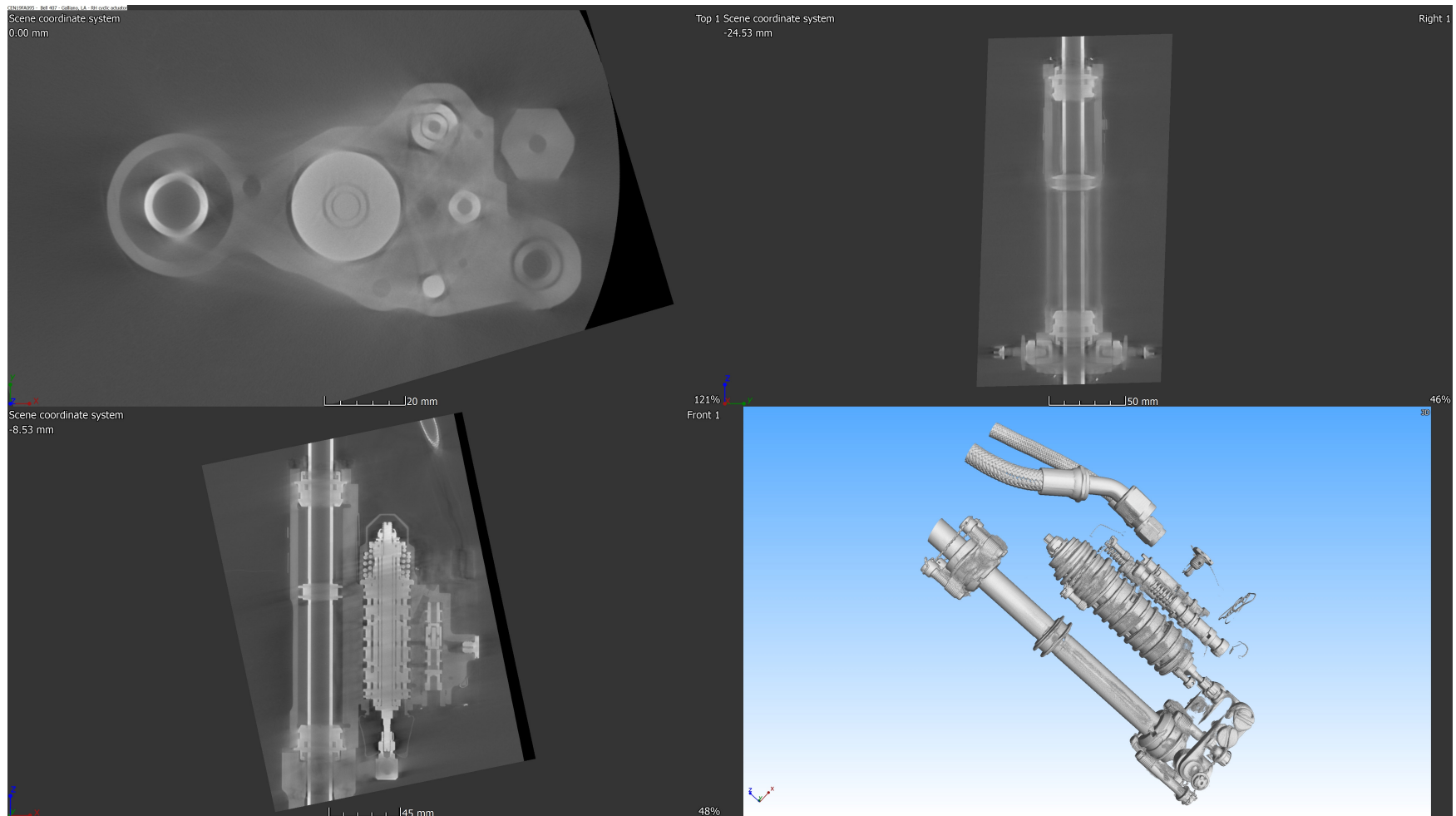


Figure 23
Right hand cyclic hydraulic actuator – overview

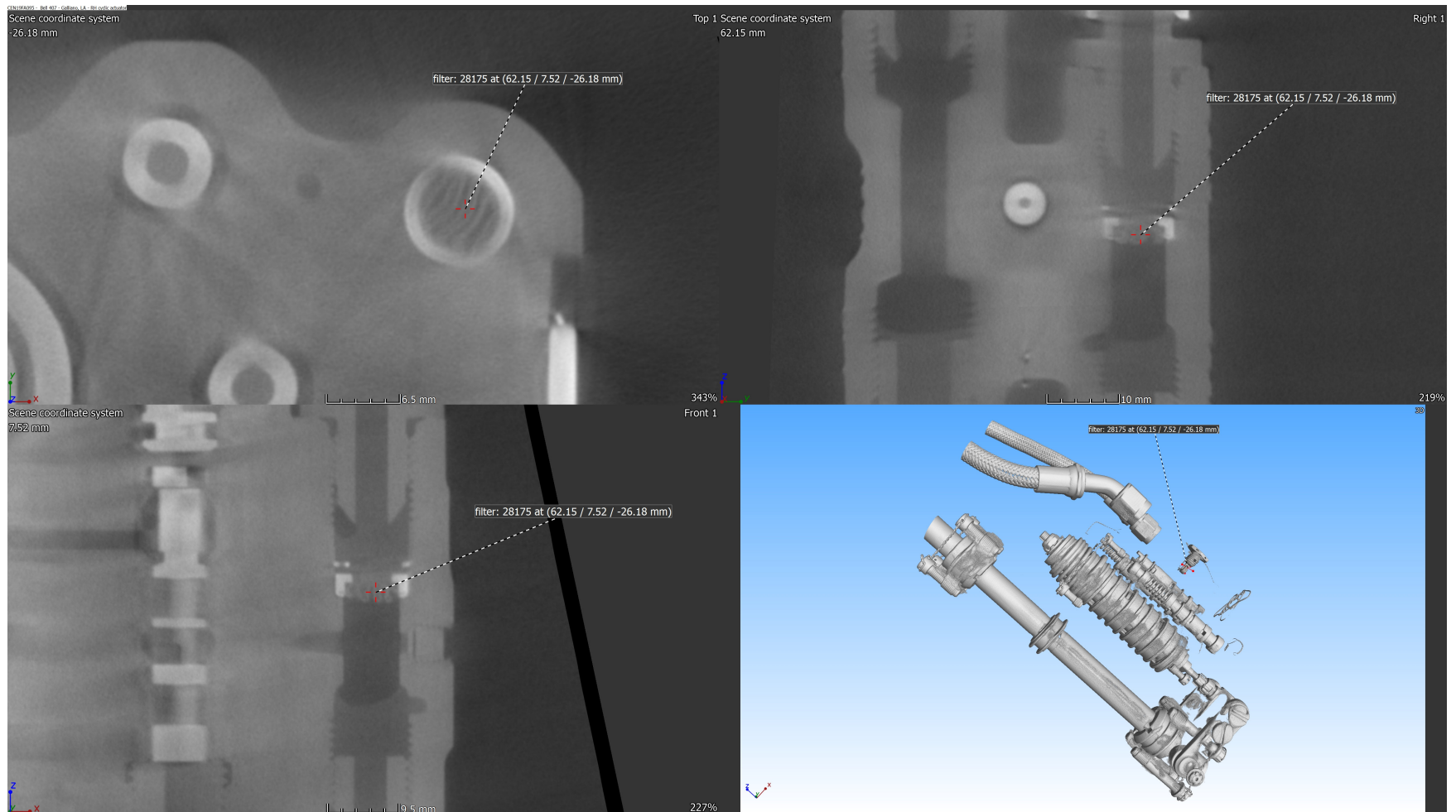


Figure 24
Right hand cyclic hydraulic actuator – filter

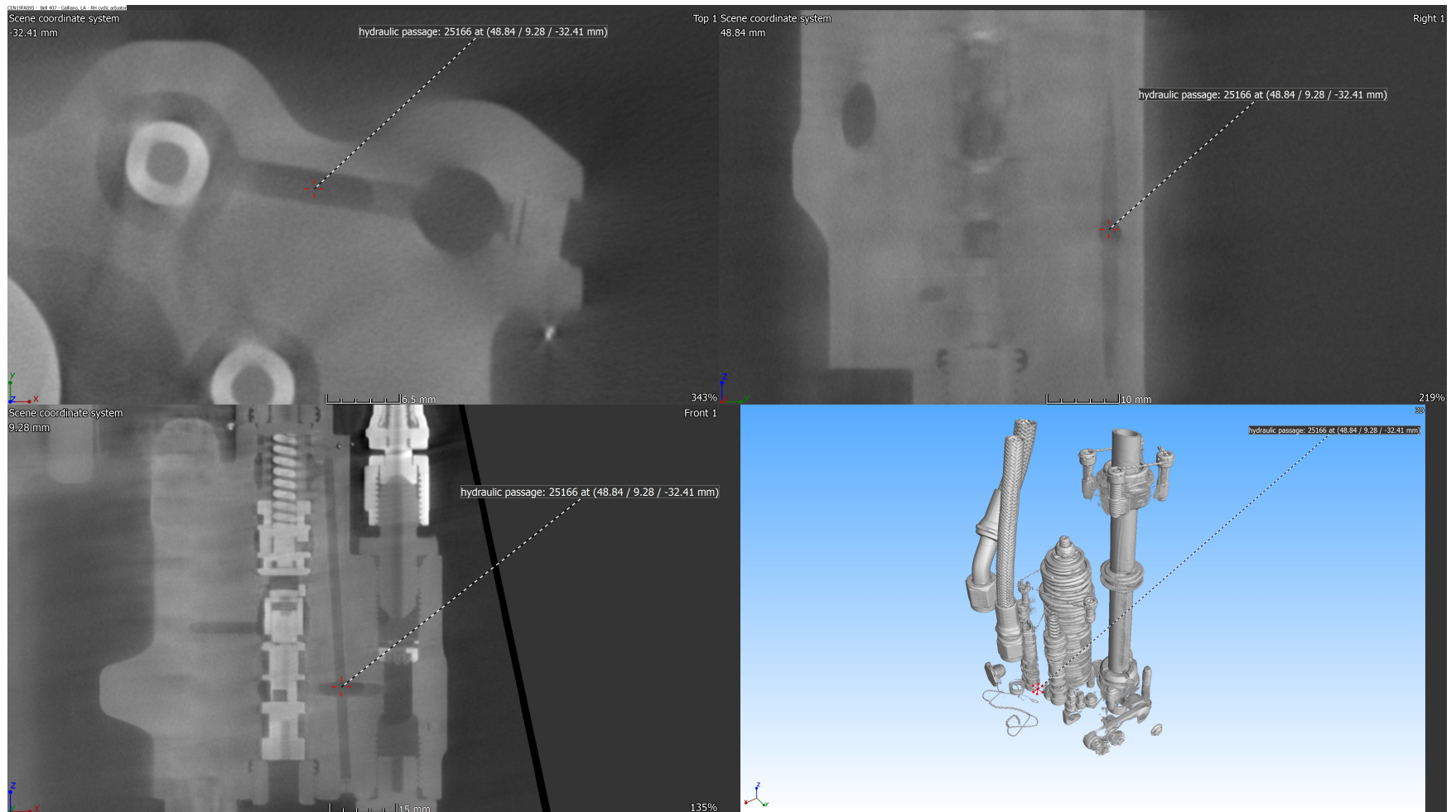


Figure 25
Right hand cyclic hydraulic actuator – hydraulic passage

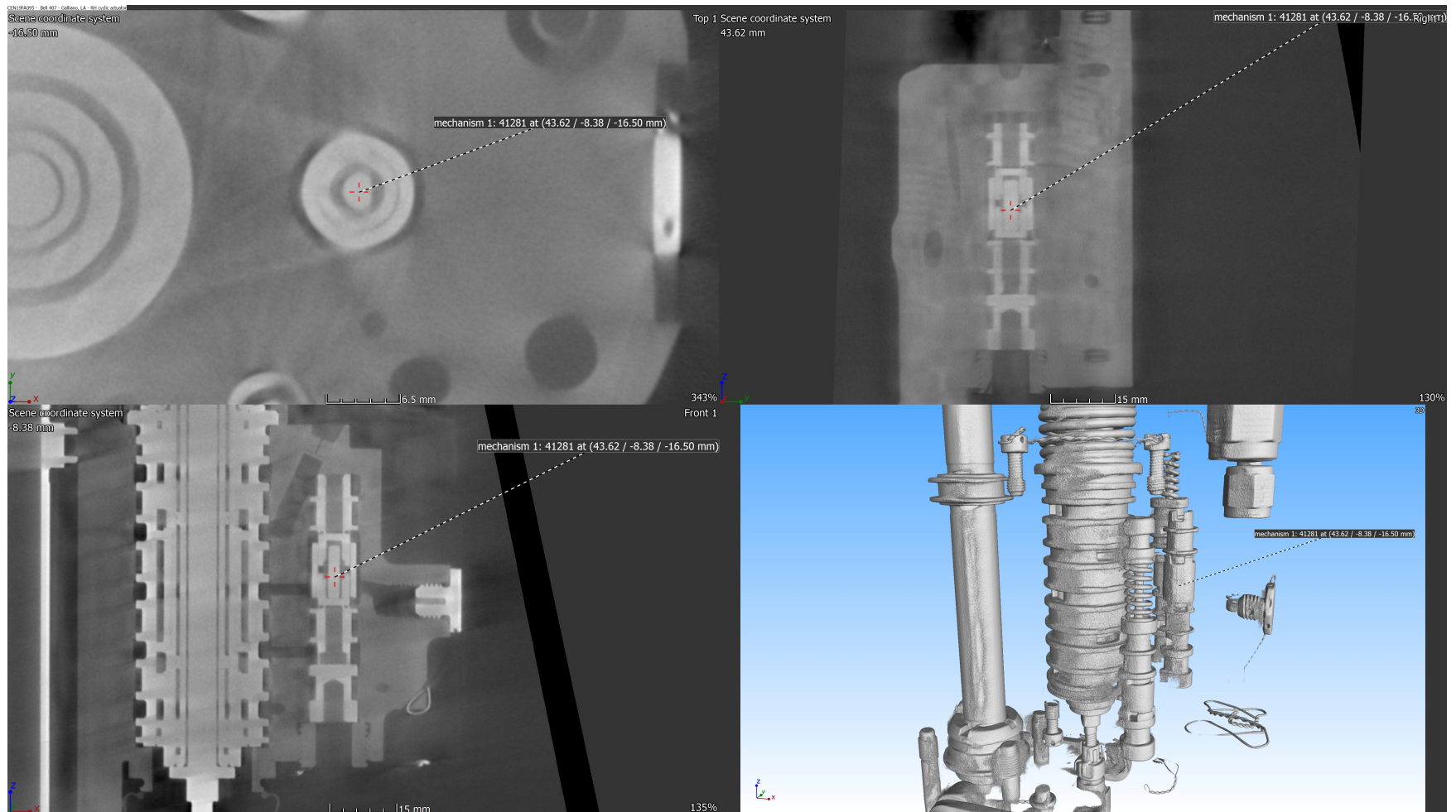


Figure 26
Right hand cyclic hydraulic actuator – mechanism 1

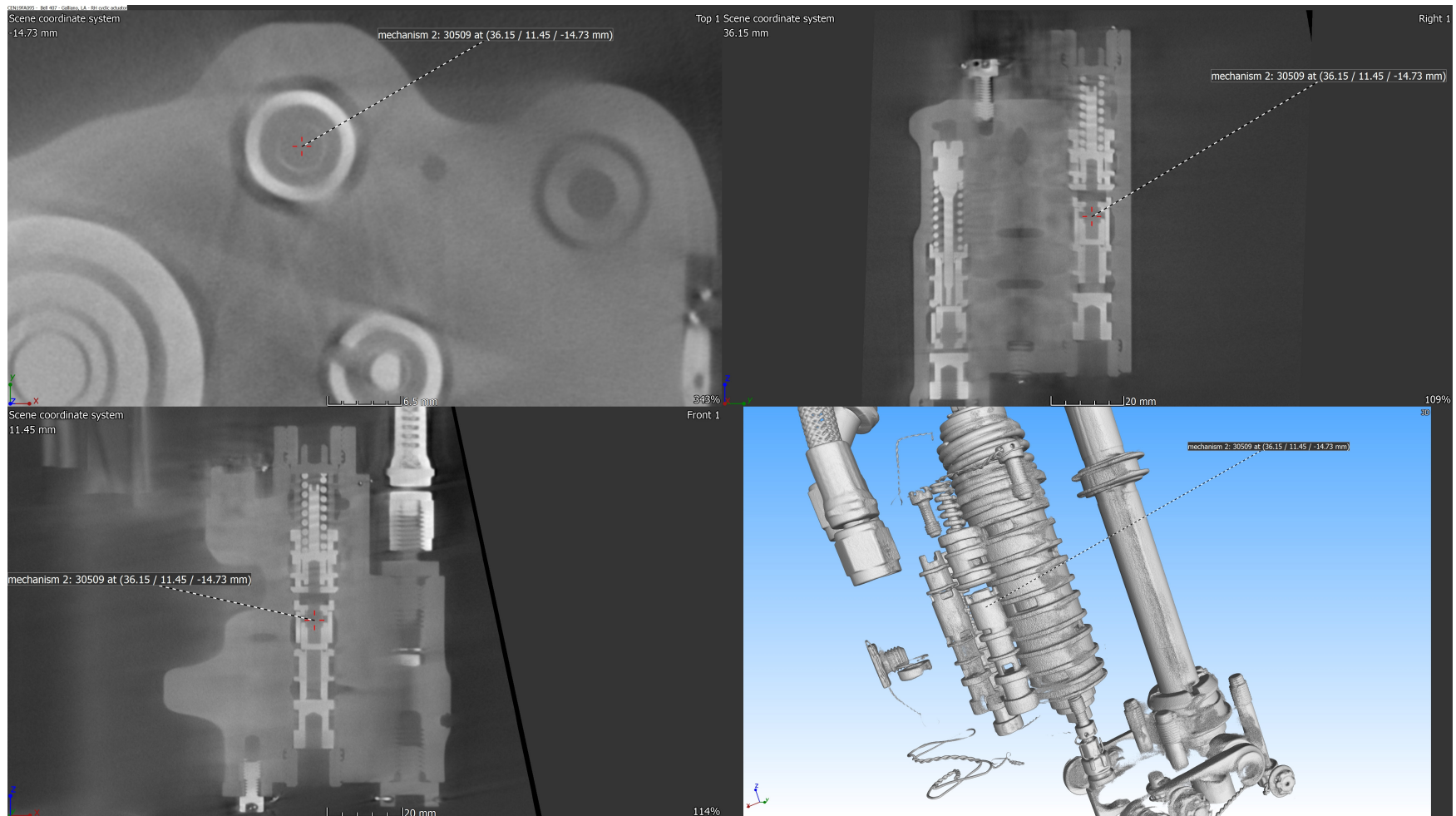


Figure 27
Right hand cyclic hydraulic actuator – mechanism 2

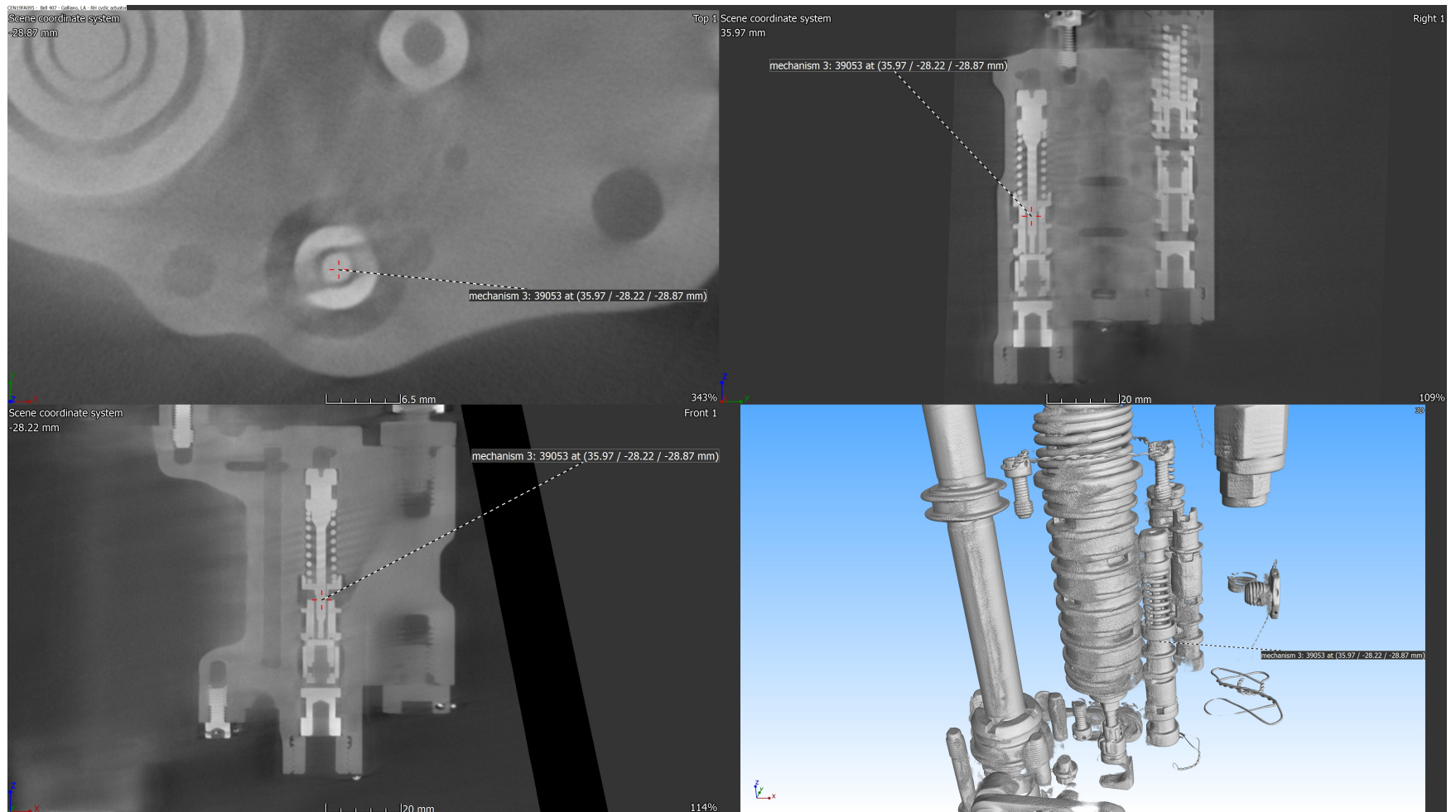


Figure 28
Right hand cyclic hydraulic actuator – mechanism 3

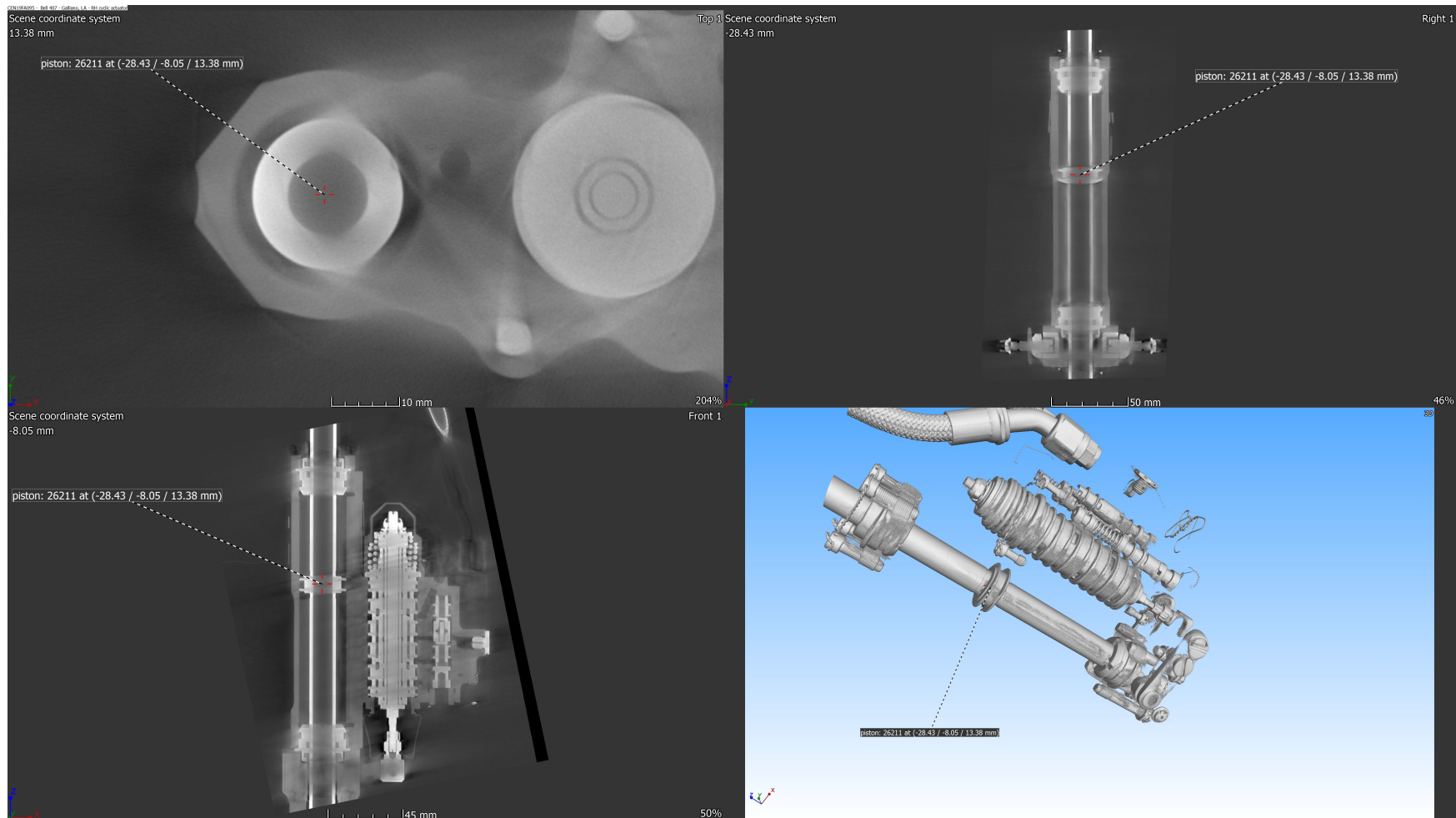


Figure 29
Right hand cyclic hydraulic actuator – piston

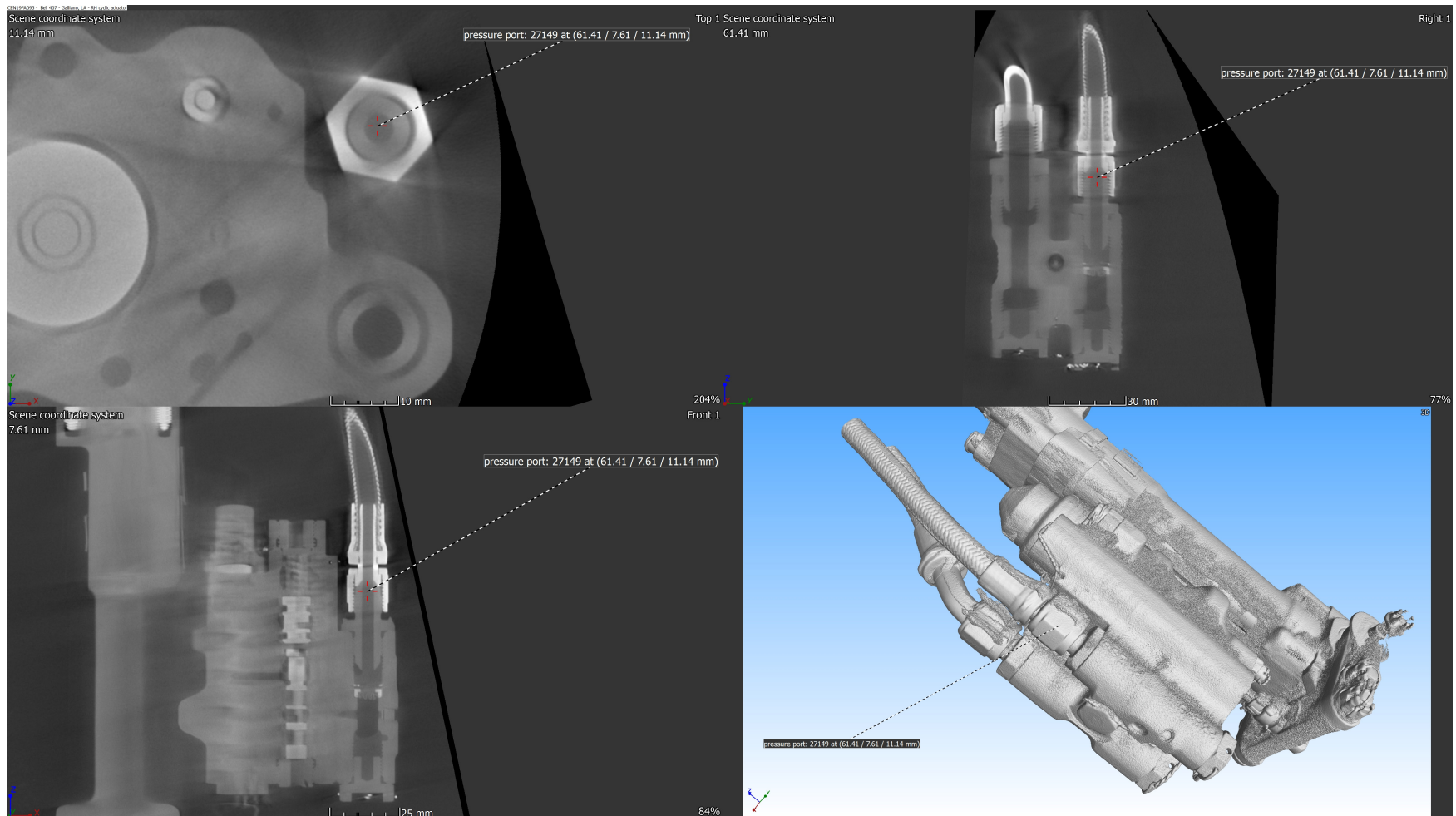


Figure 30
Right hand cyclic hydraulic actuator – pressure port

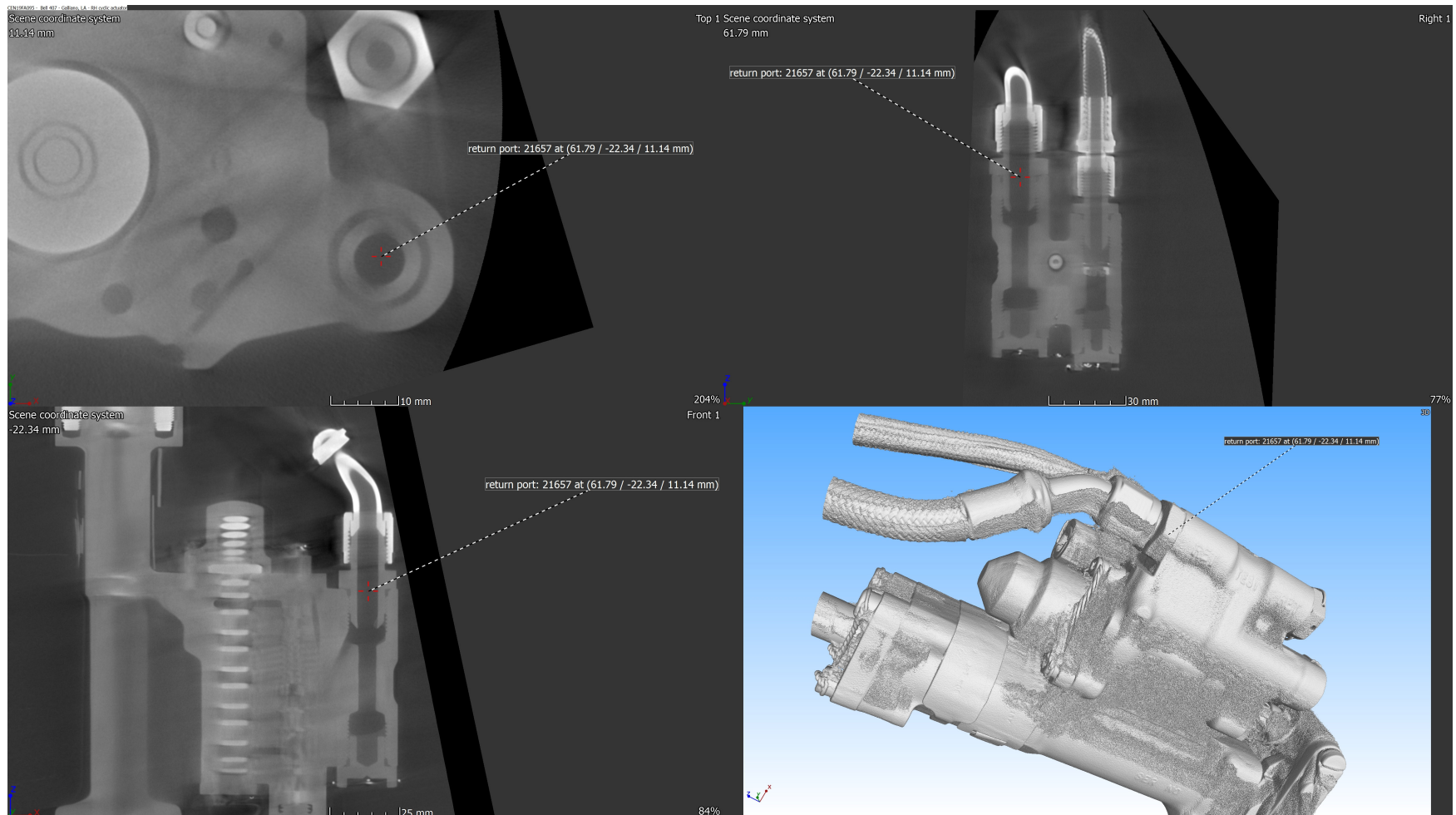


Figure 31
Right hand cyclic hydraulic actuator – return port

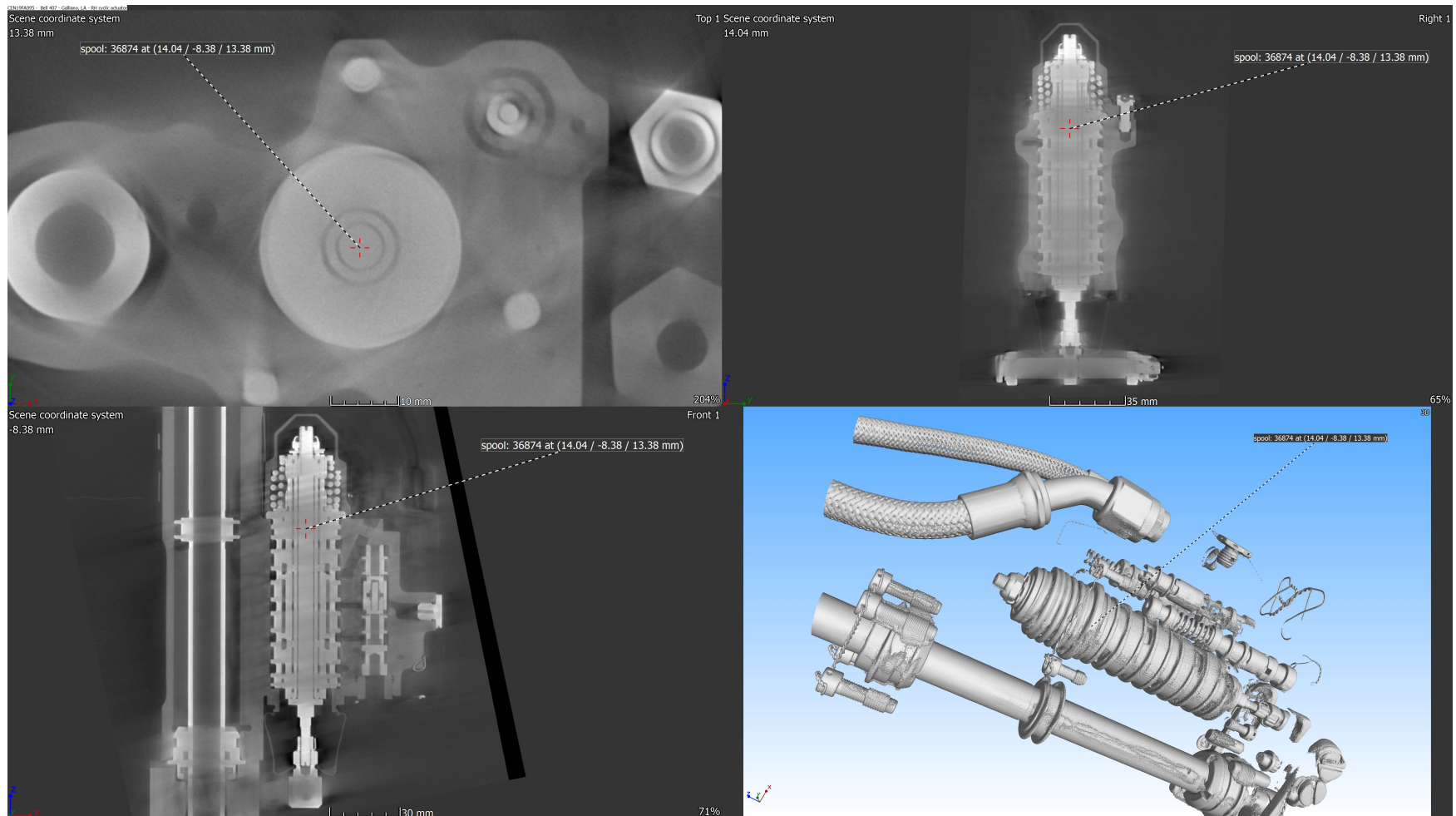


Figure 32
Right hand cyclic hydraulic actuator – spool

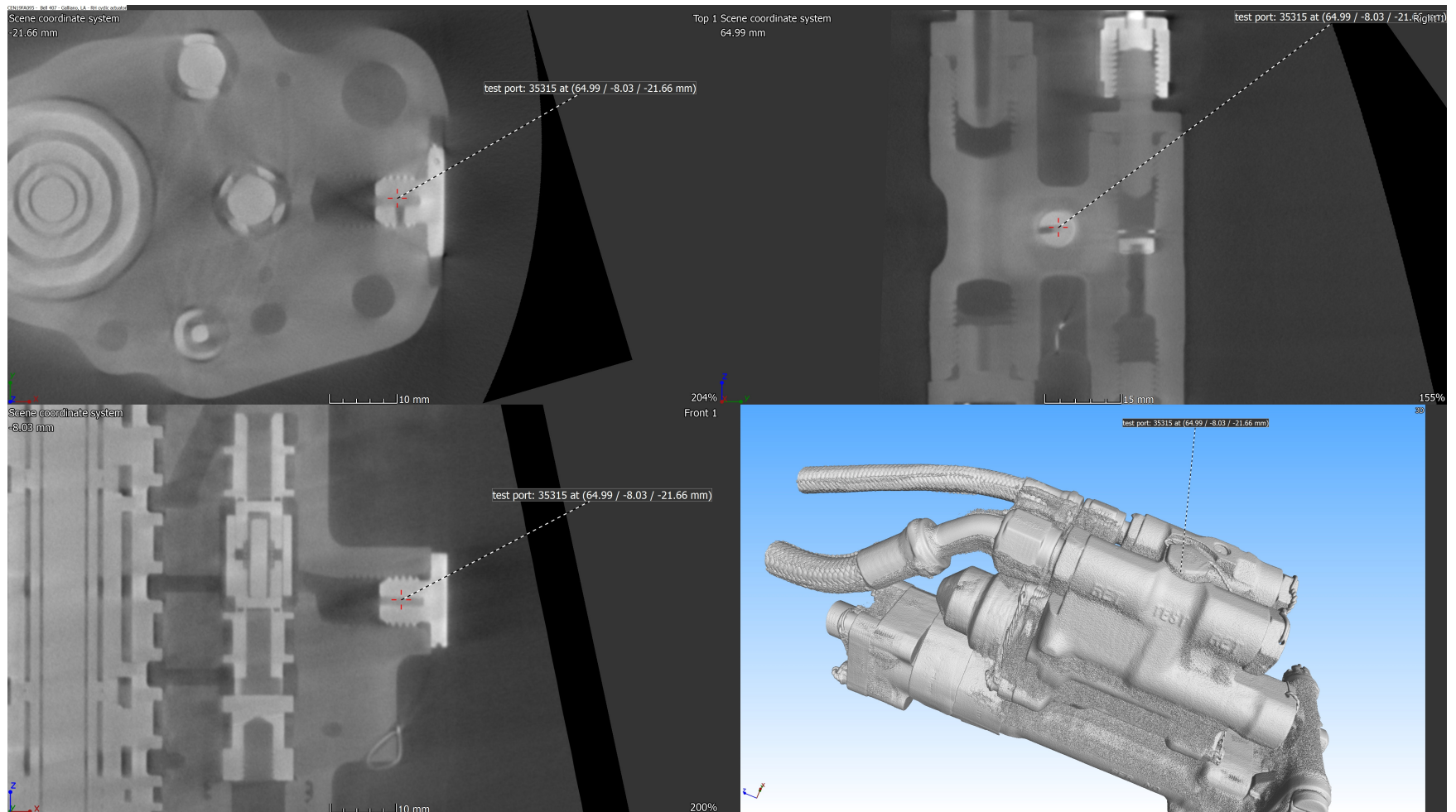


Figure 33
Right hand cyclic hydraulic actuator – test port

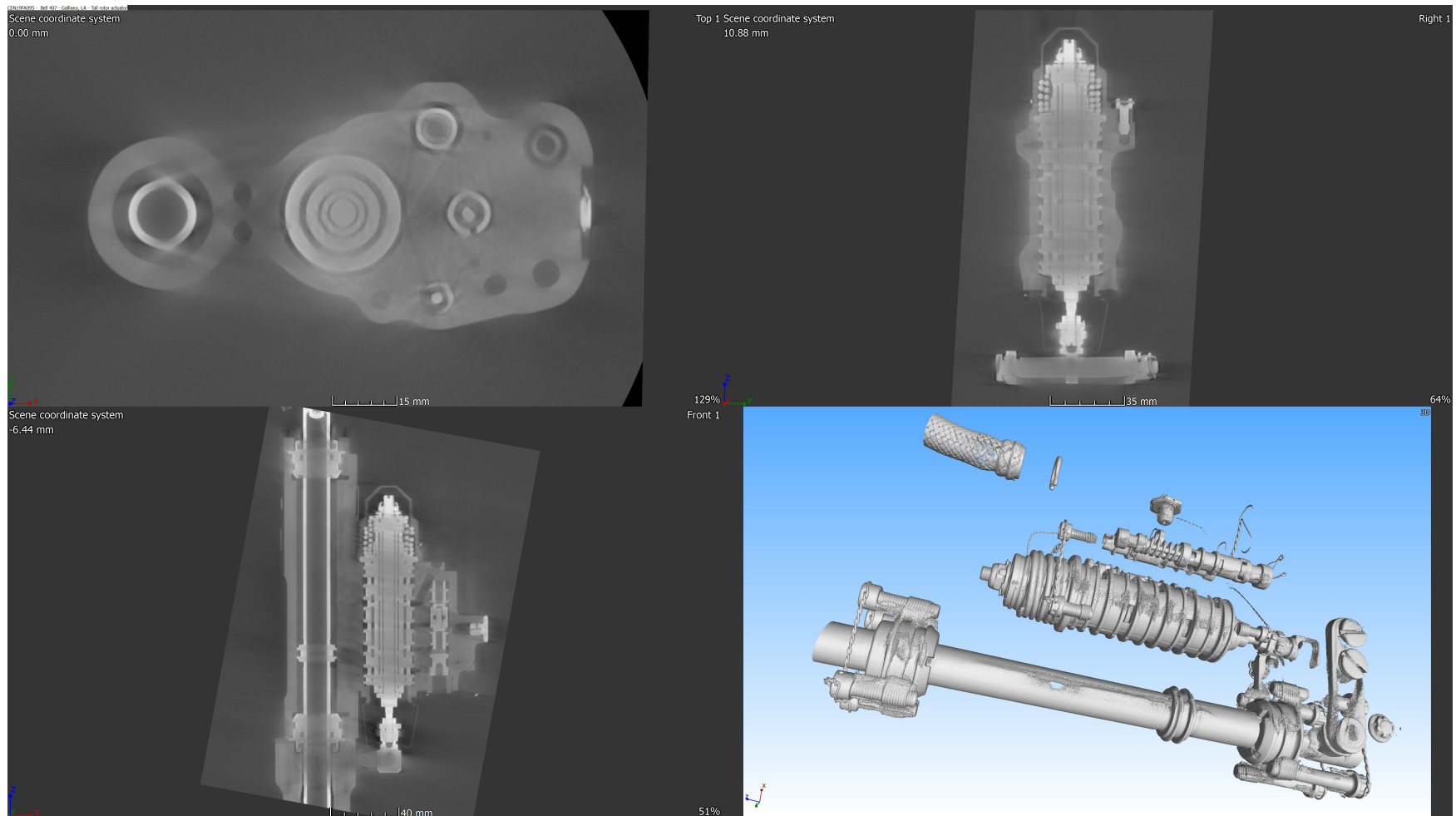


Figure 34
Tail rotor hydraulic actuator – overview

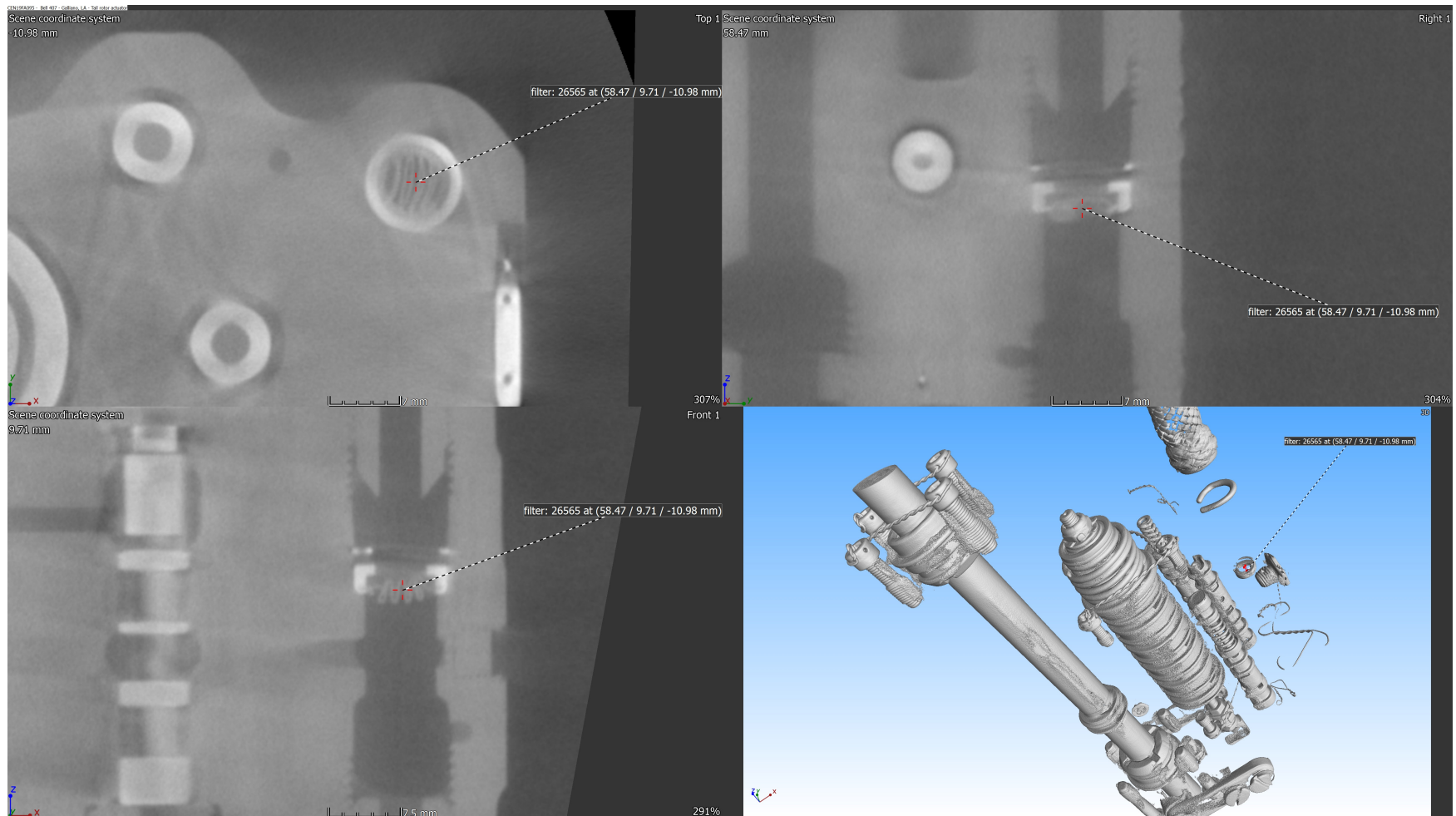


Figure 35
Tail rotor hydraulic actuator – filter

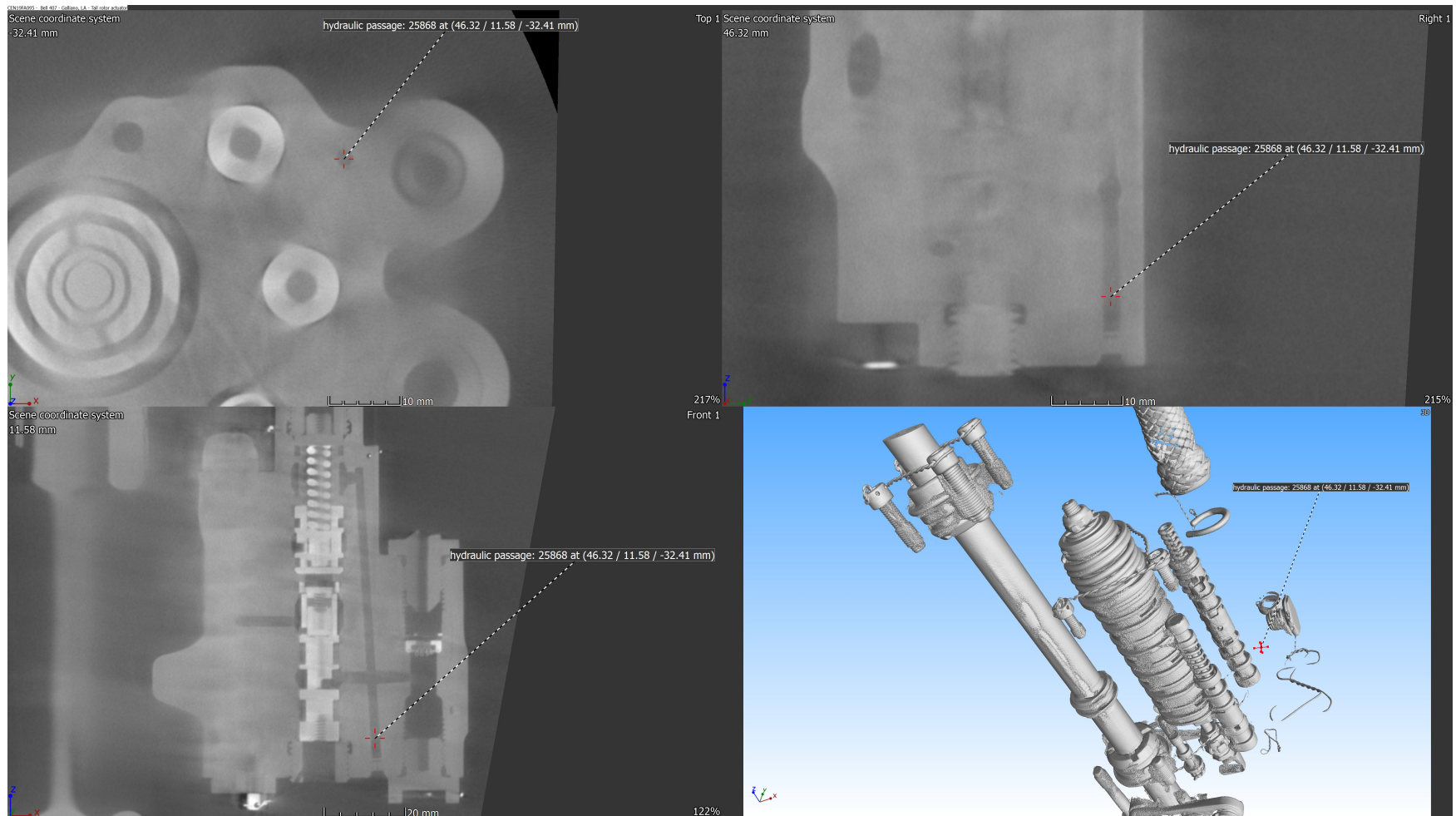


Figure 36
Tail rotor hydraulic actuator – hydraulic passage

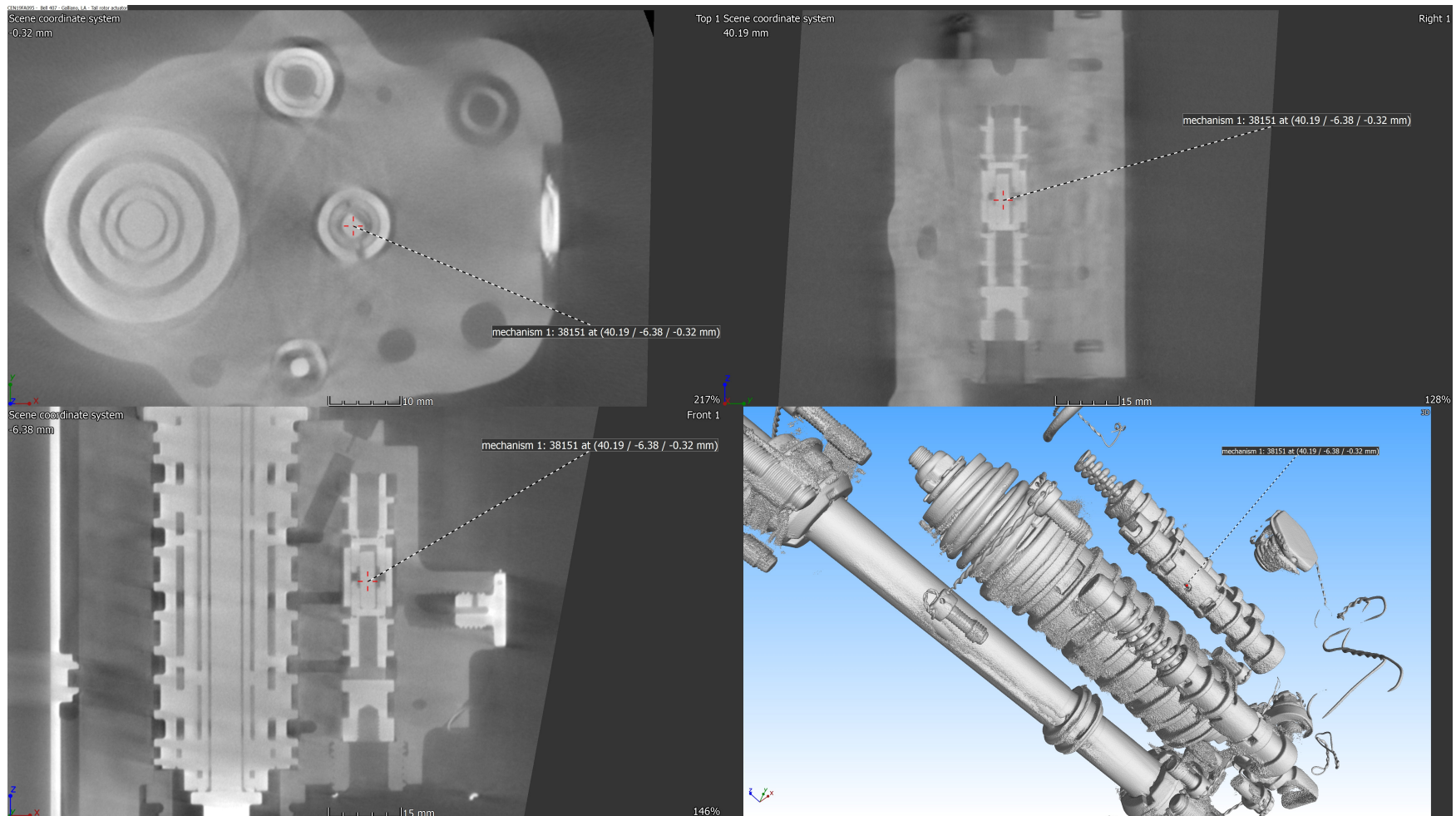


Figure 37
Tail rotor hydraulic actuator – mechanism 1

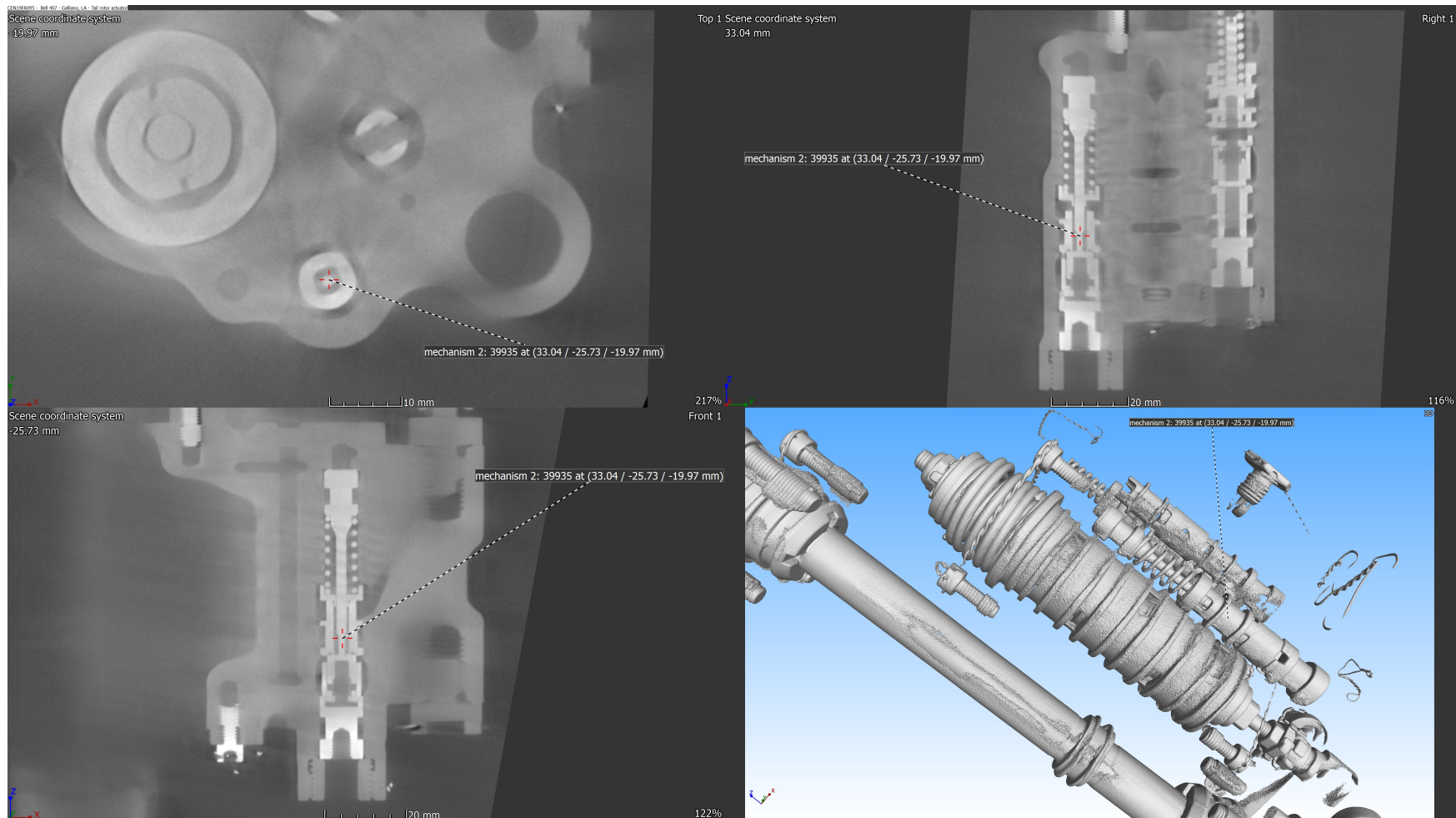


Figure 38
Tail rotor hydraulic actuator – mechanism 2

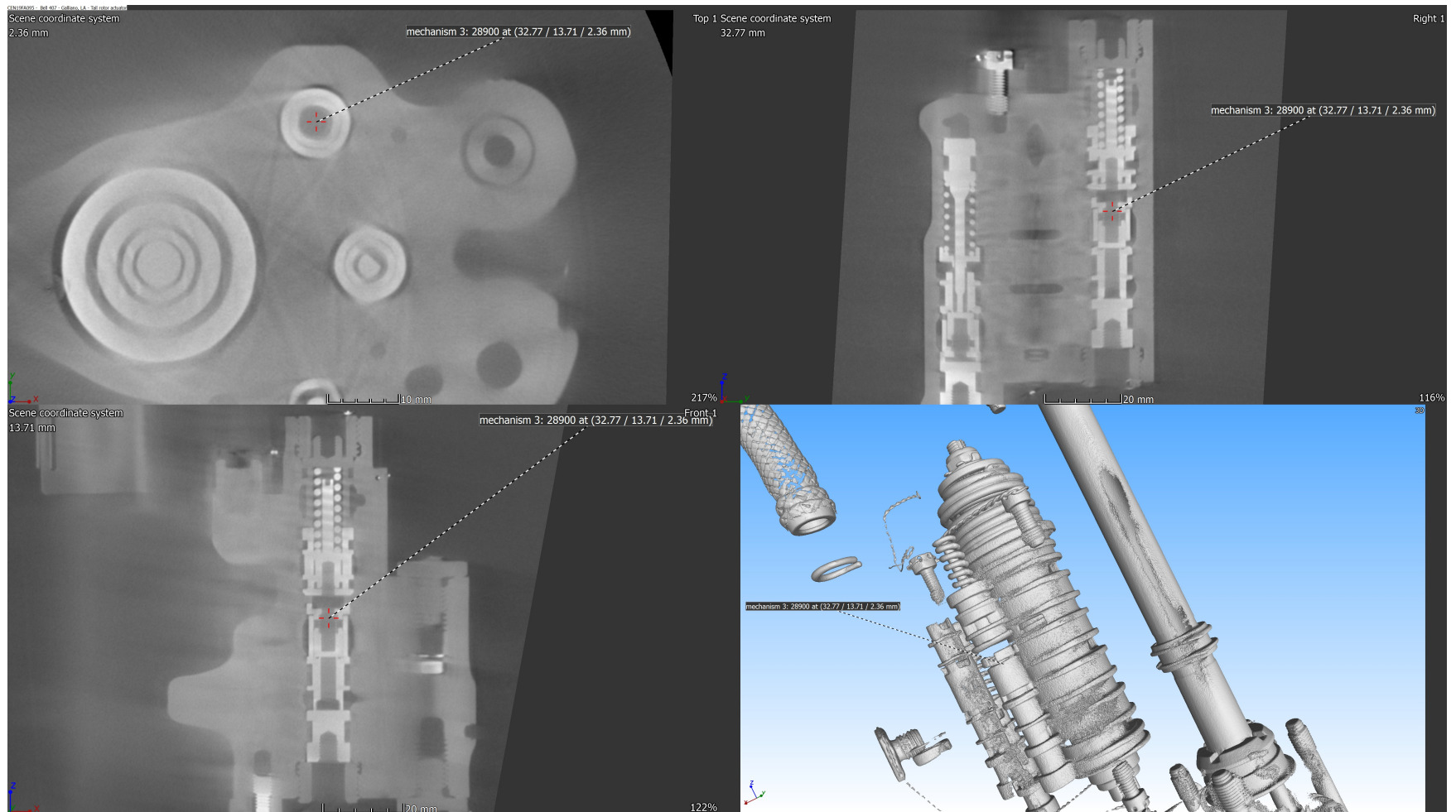


Figure 39
Tail rotor hydraulic actuator – mechanism 3

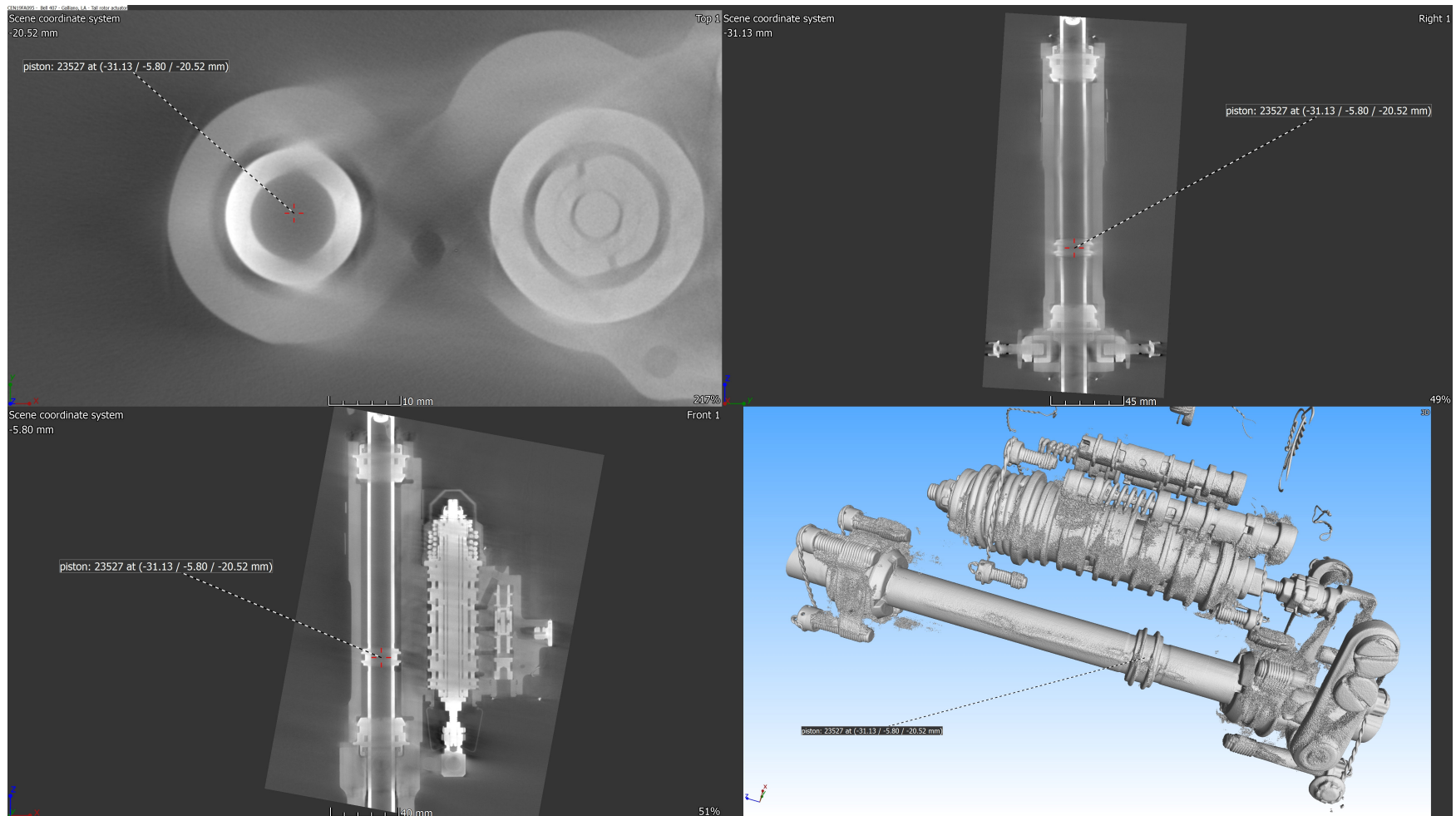


Figure 40
Tail rotor hydraulic actuator – piston

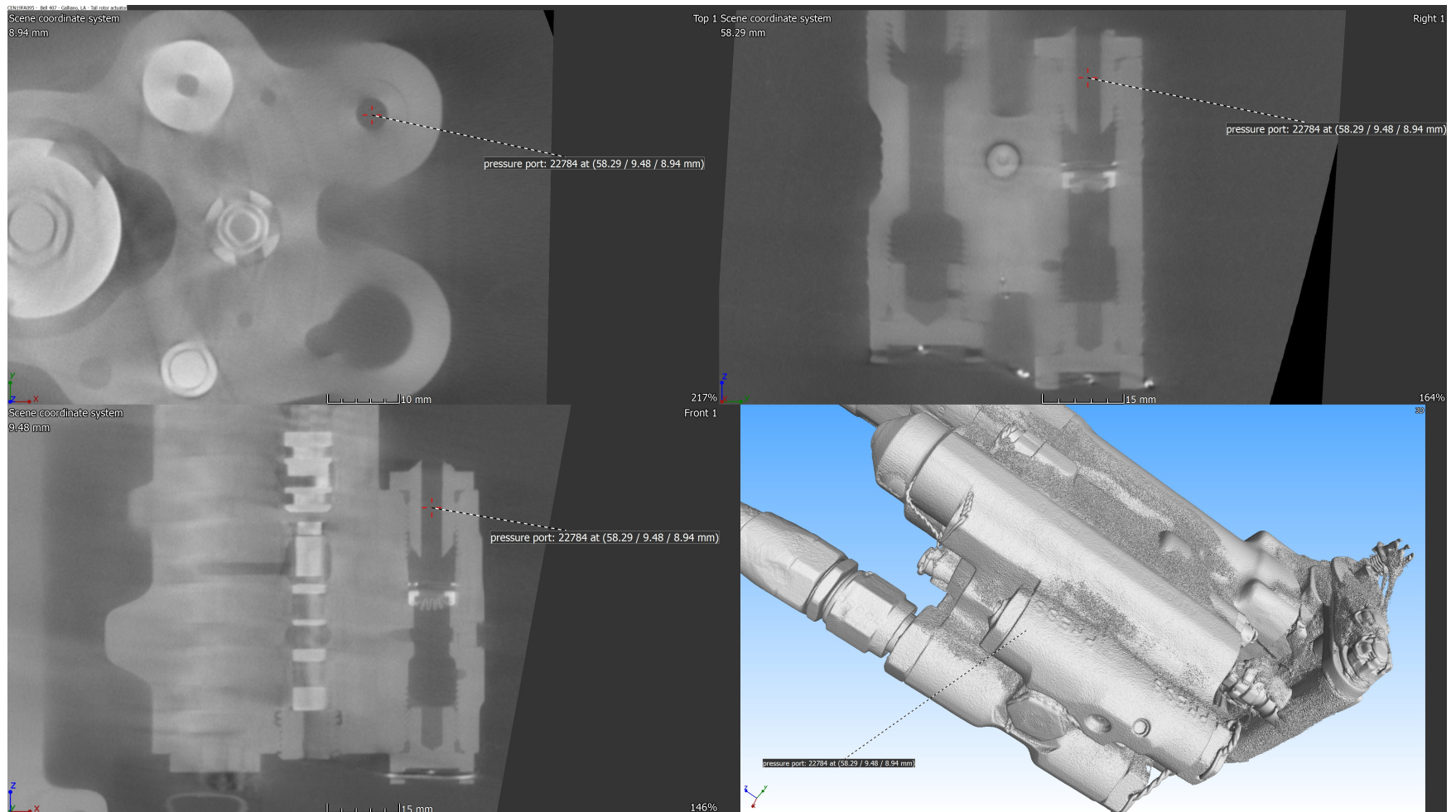


Figure 41
Tail rotor hydraulic actuator – pressure port

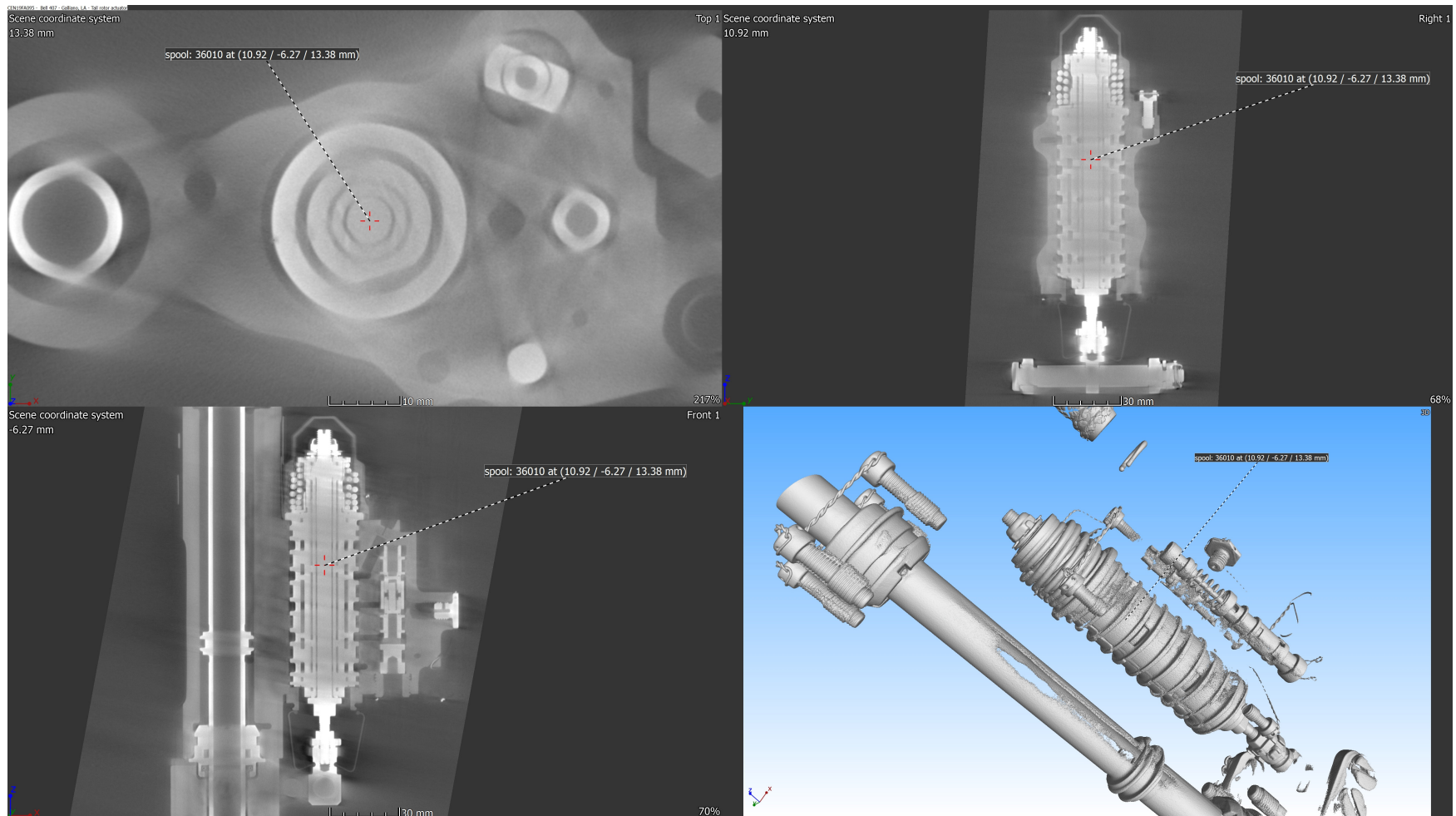


Figure 43
Tail rotor hydraulic actuator – spool

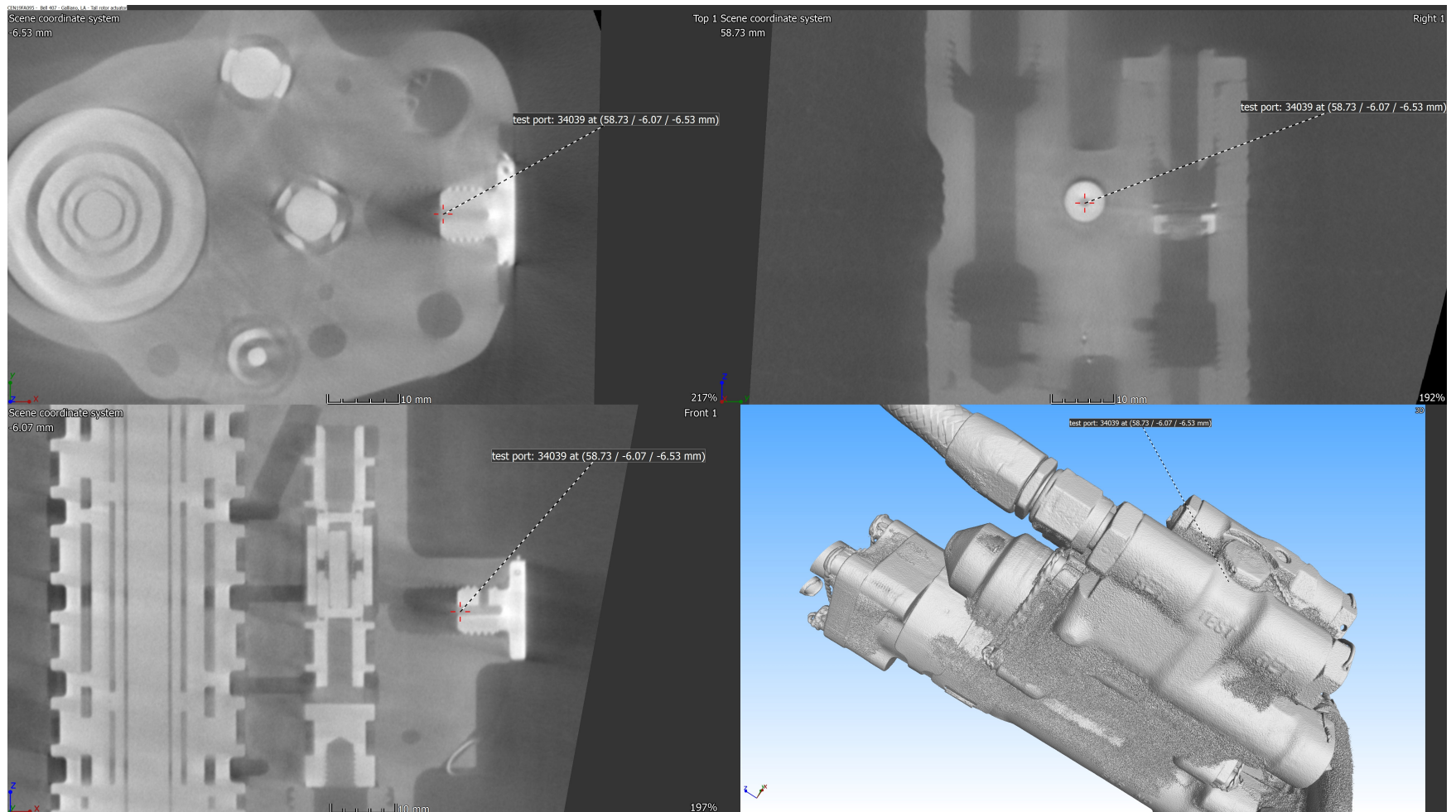


Figure 44
Tail rotor hydraulic actuator – test port

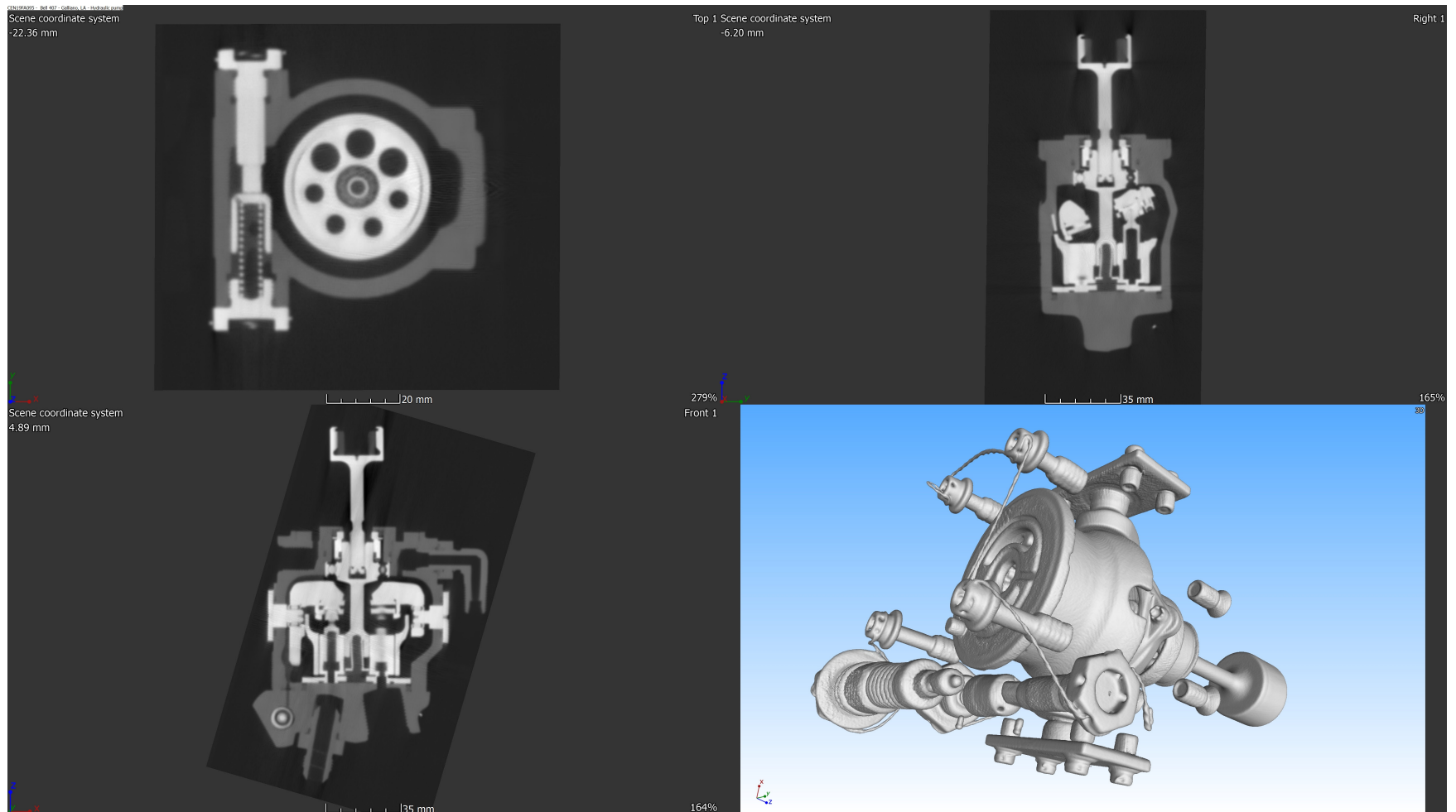


Figure 45
Hydraulic pump – overview

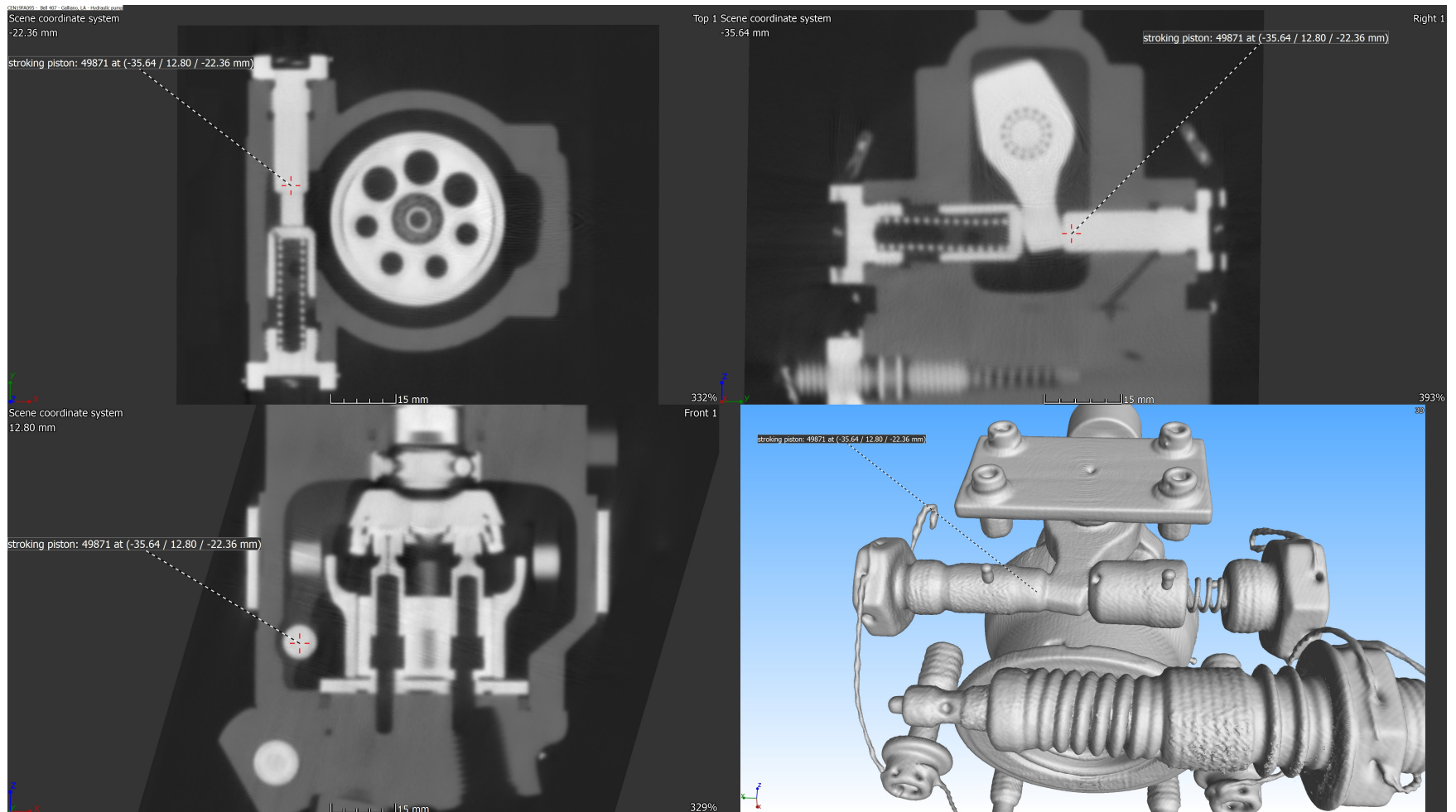


Figure 46
Hydraulic pump – stroking piston

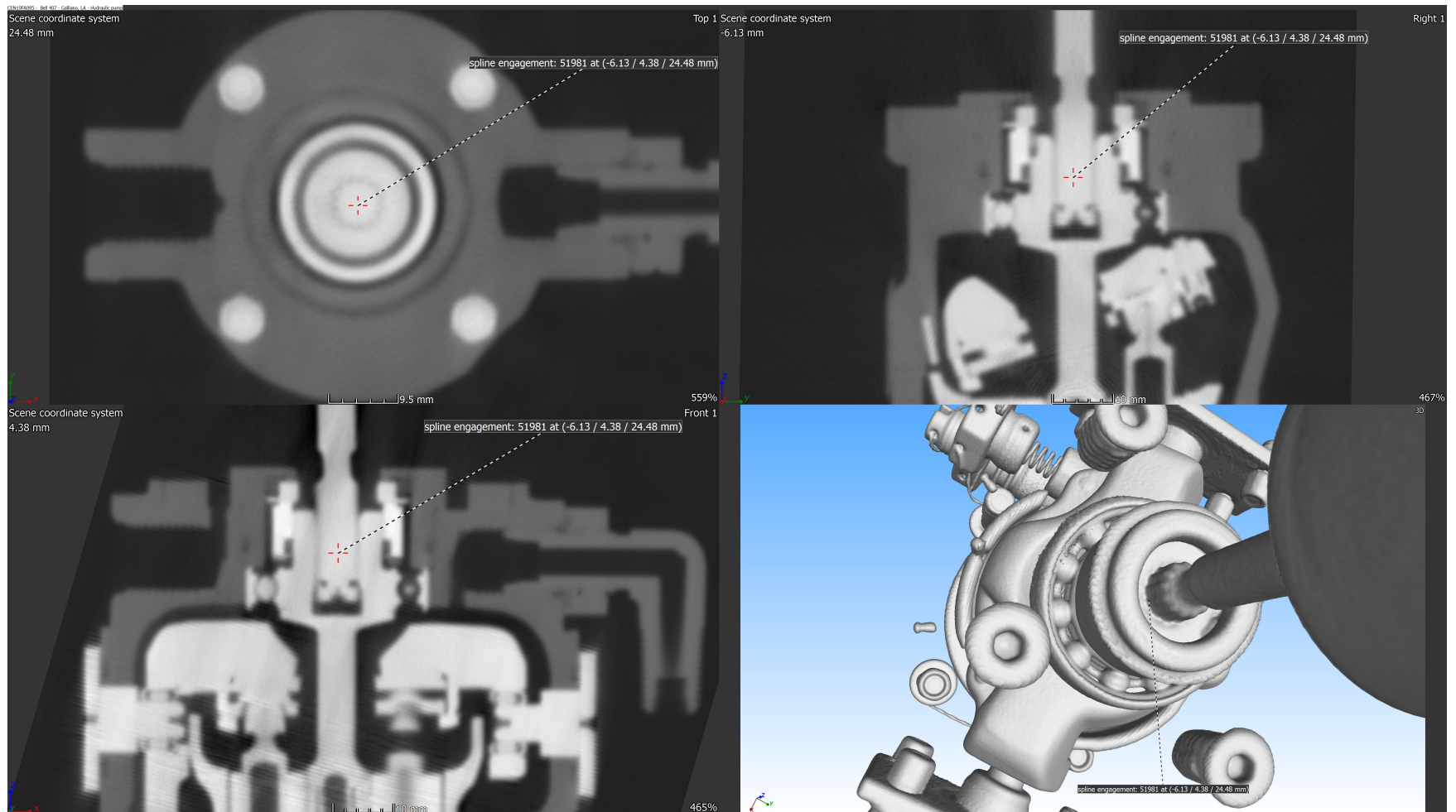


Figure 47
Hydraulic pump – spline engagement

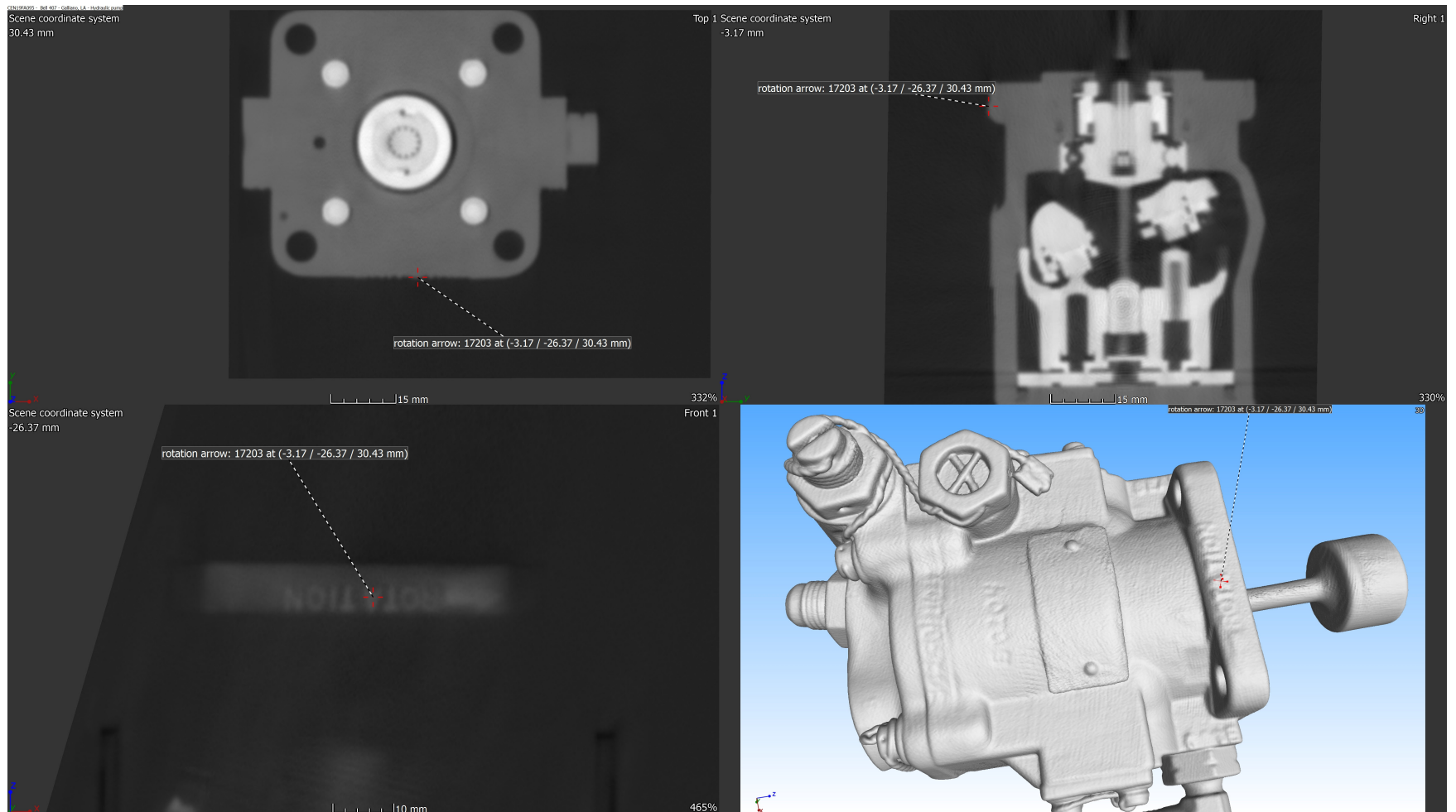


Figure 48
Hydraulic pump – rotation arrow

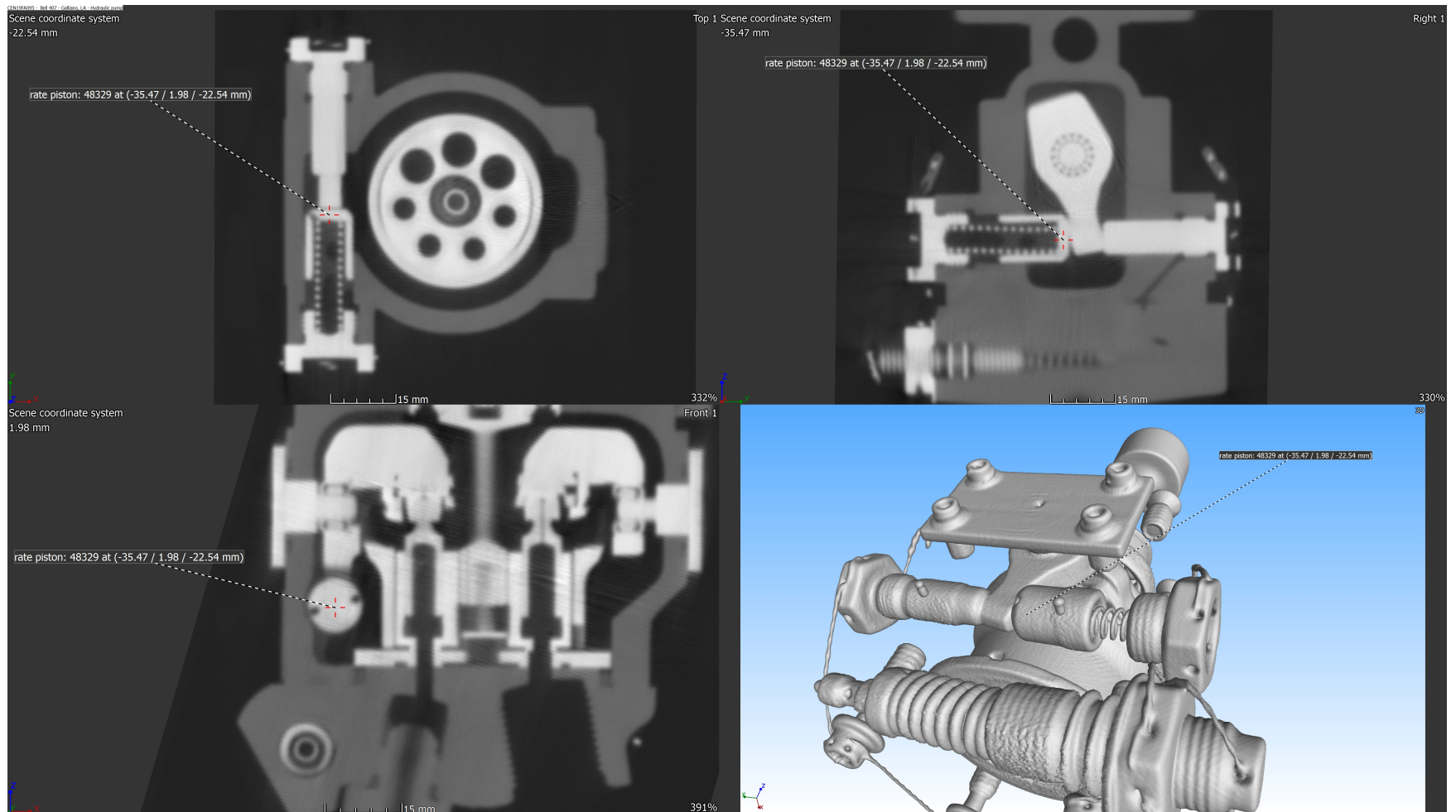


Figure 49
Hydraulic pump – rate piston

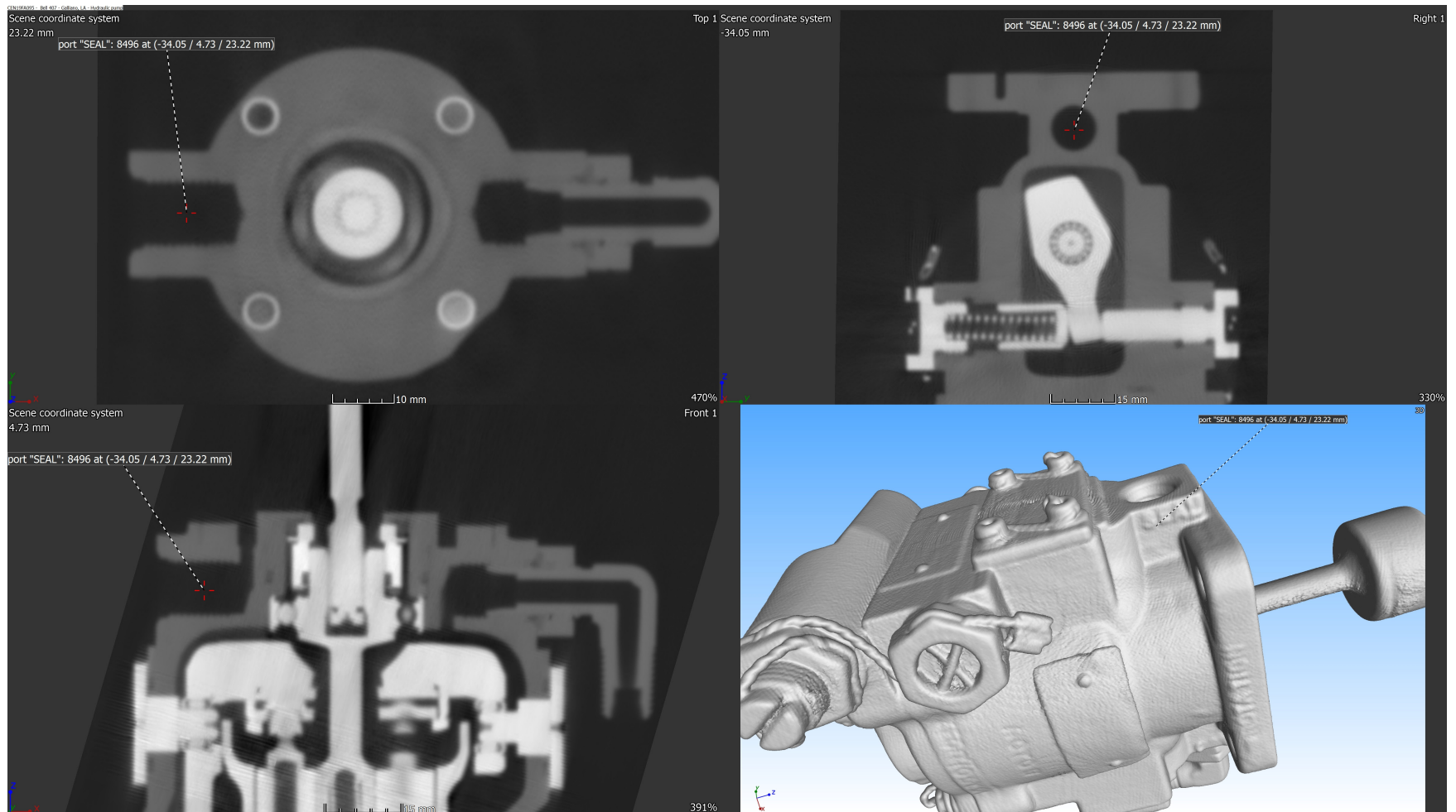


Figure 50
Hydraulic pump – port “SEAL”

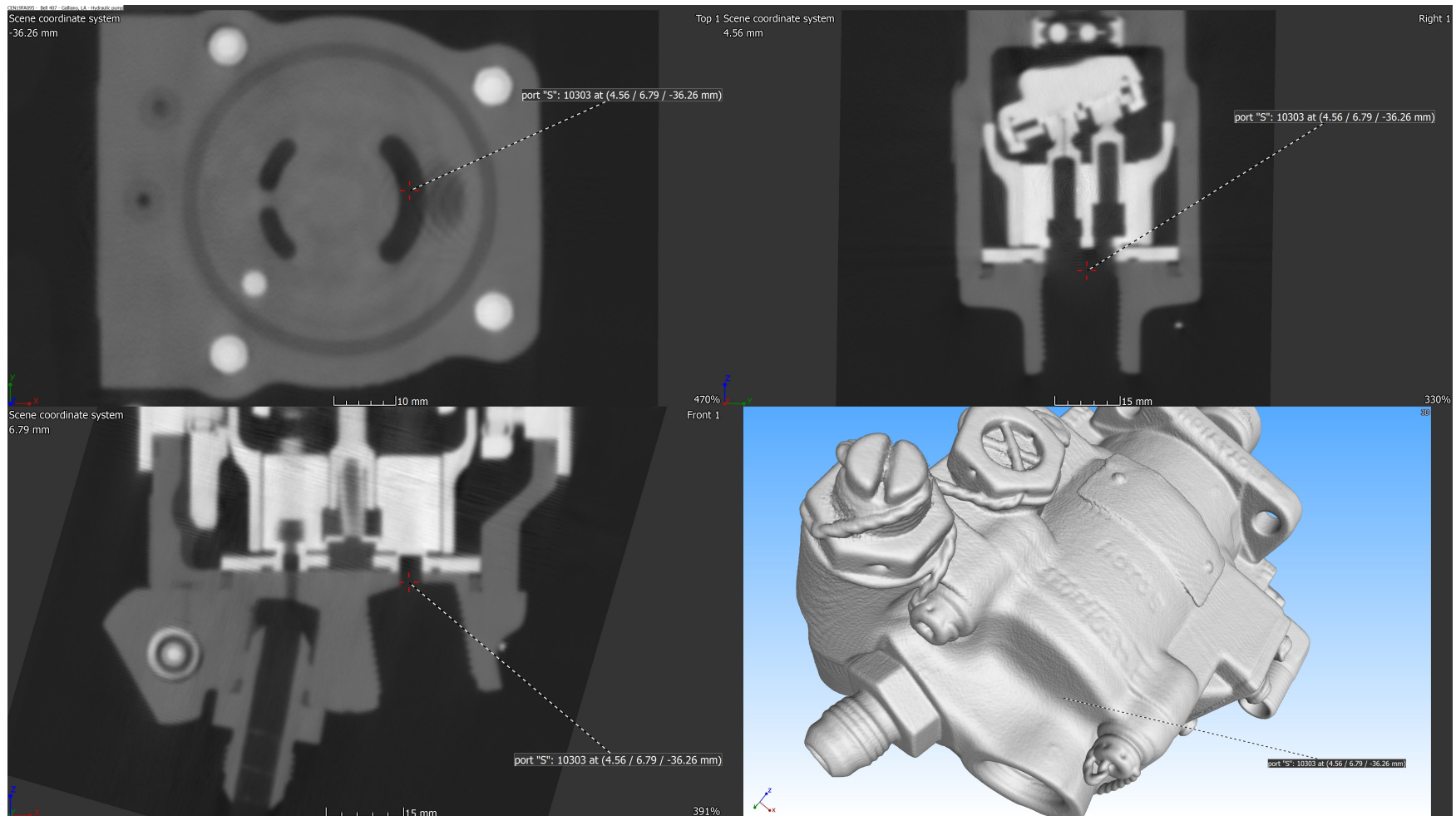


Figure 51
Hydraulic pump – port “S”

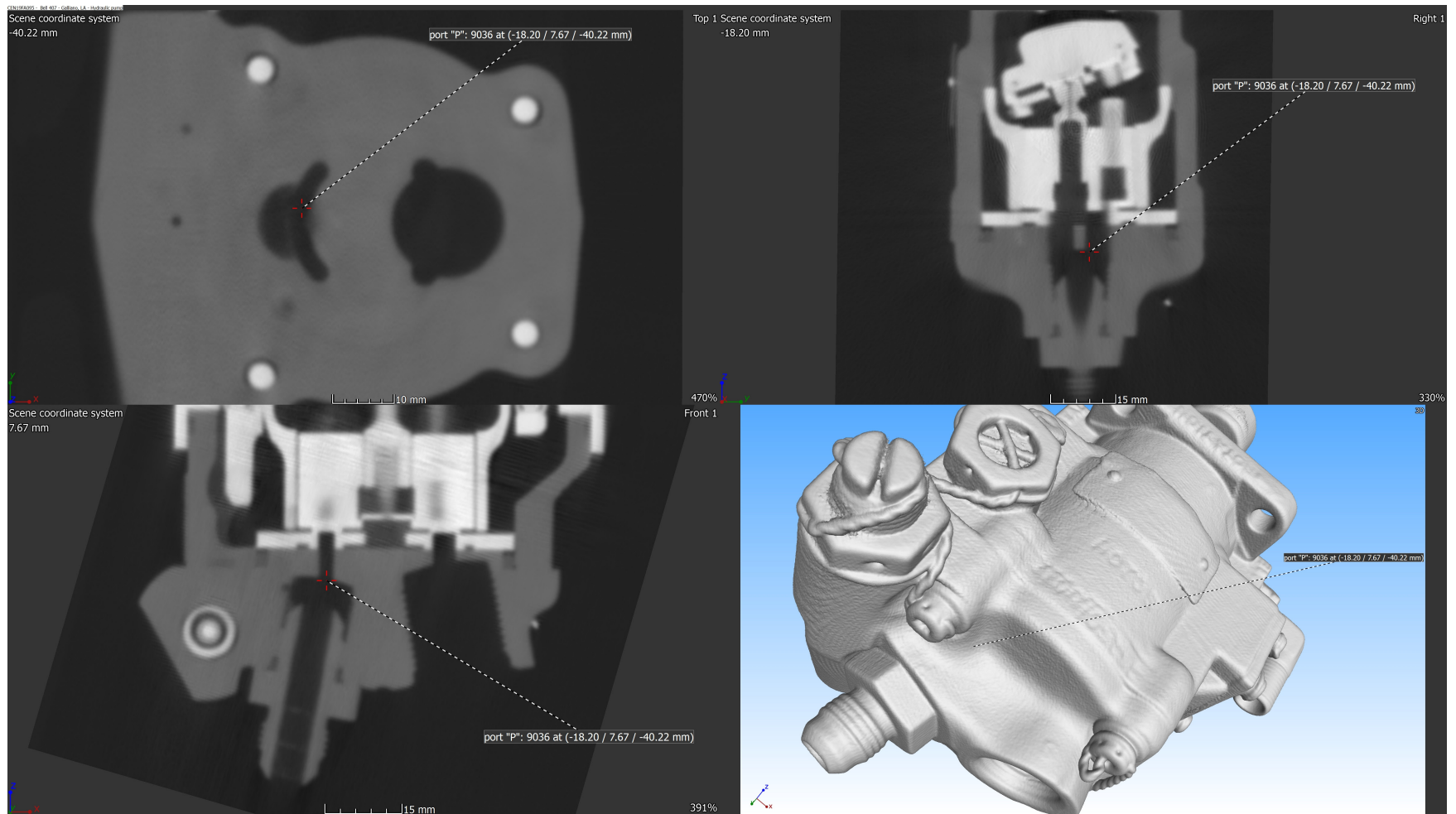


Figure 52
Hydraulic pump – port “P”

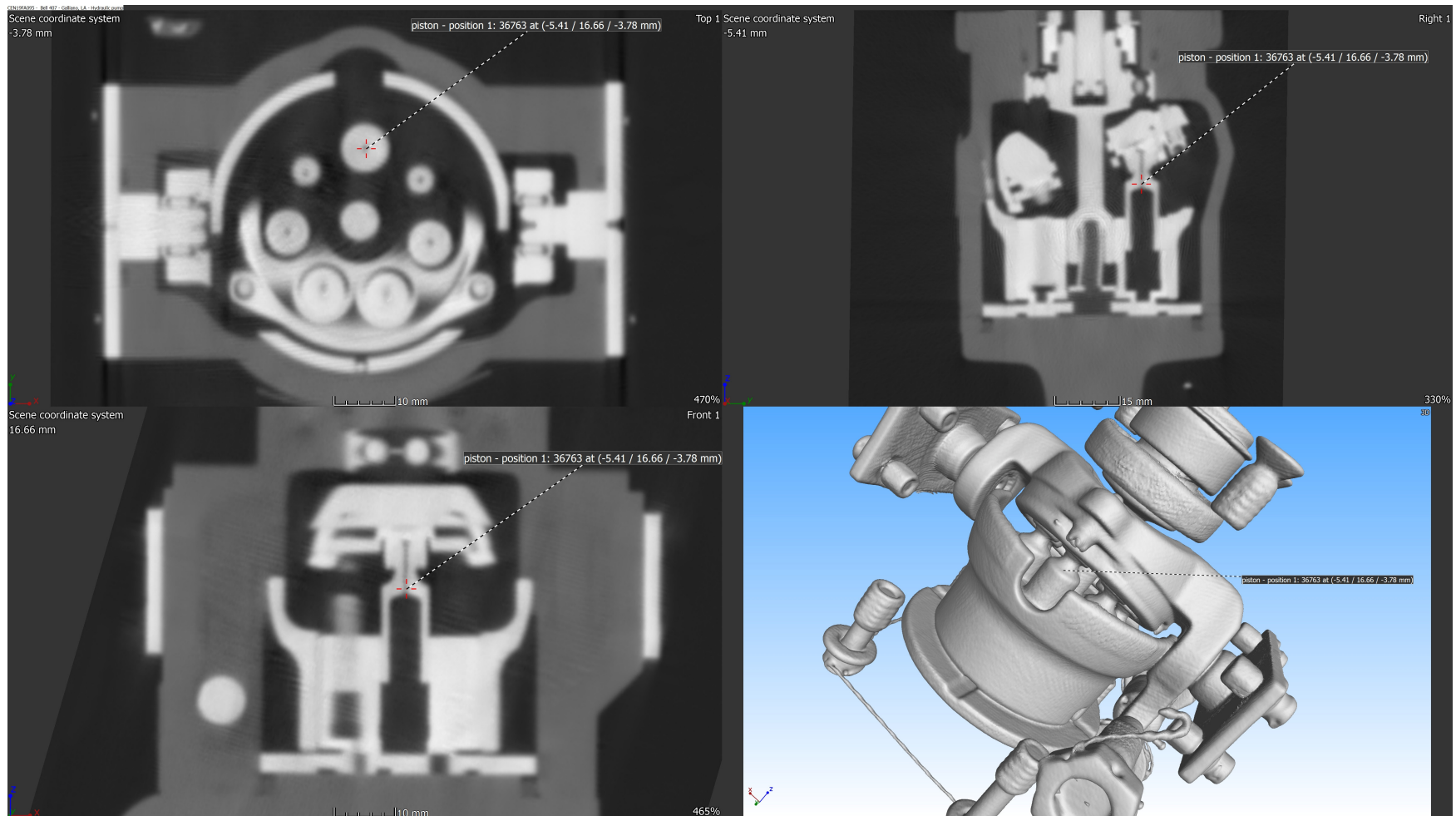


Figure 53
Hydraulic pump – piston – position 1

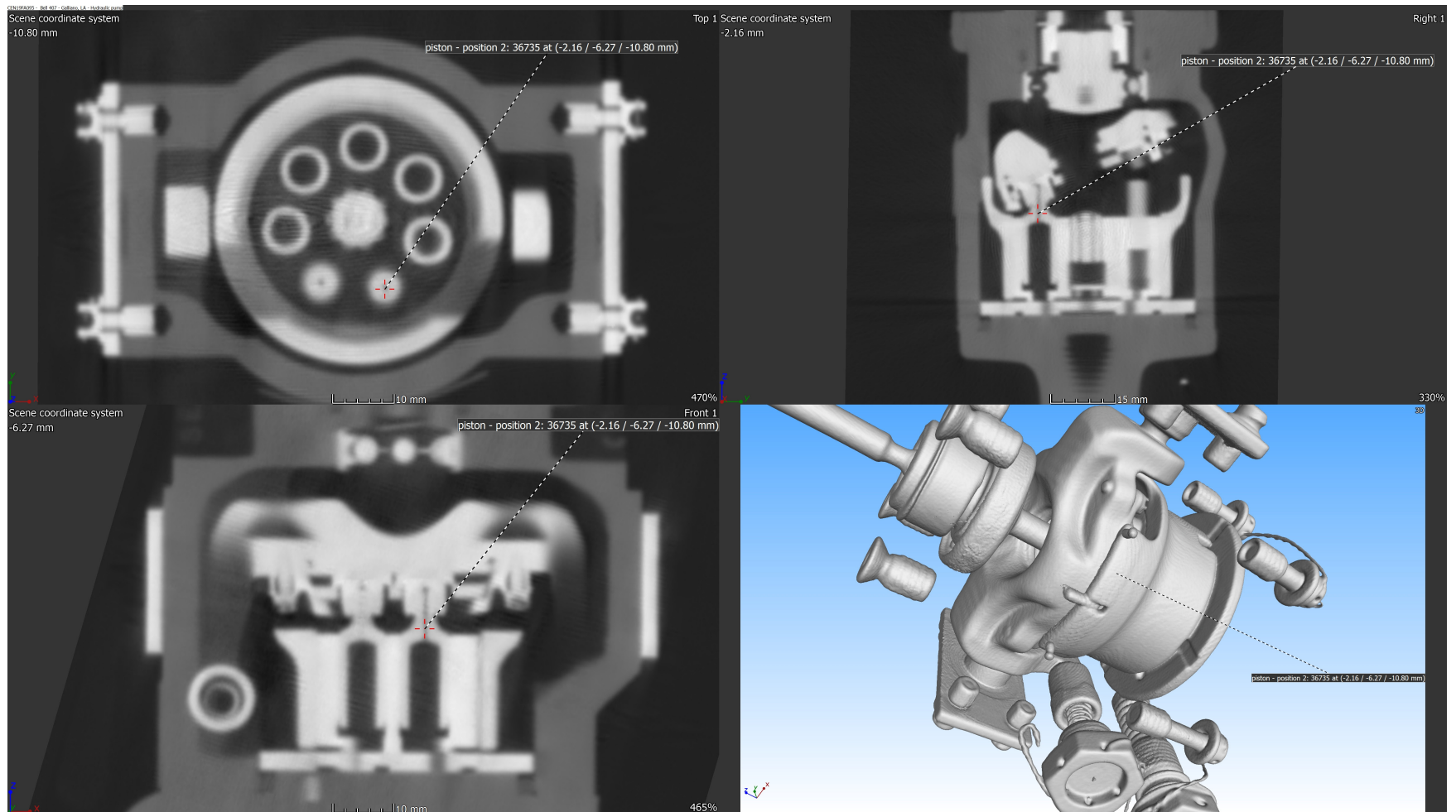


Figure 54
Hydraulic pump – piston – position 2

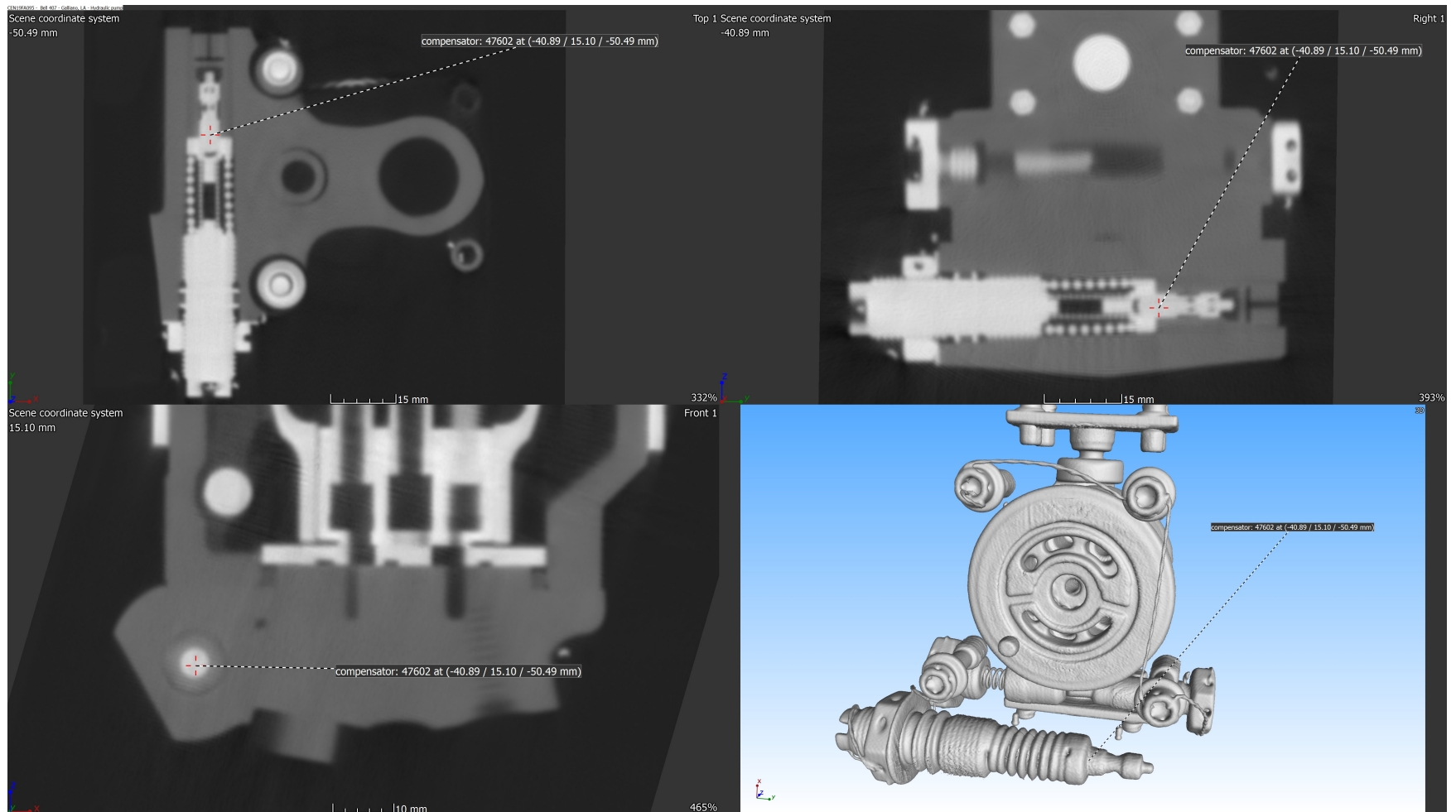


Figure 55
Hydraulic pump – compensator

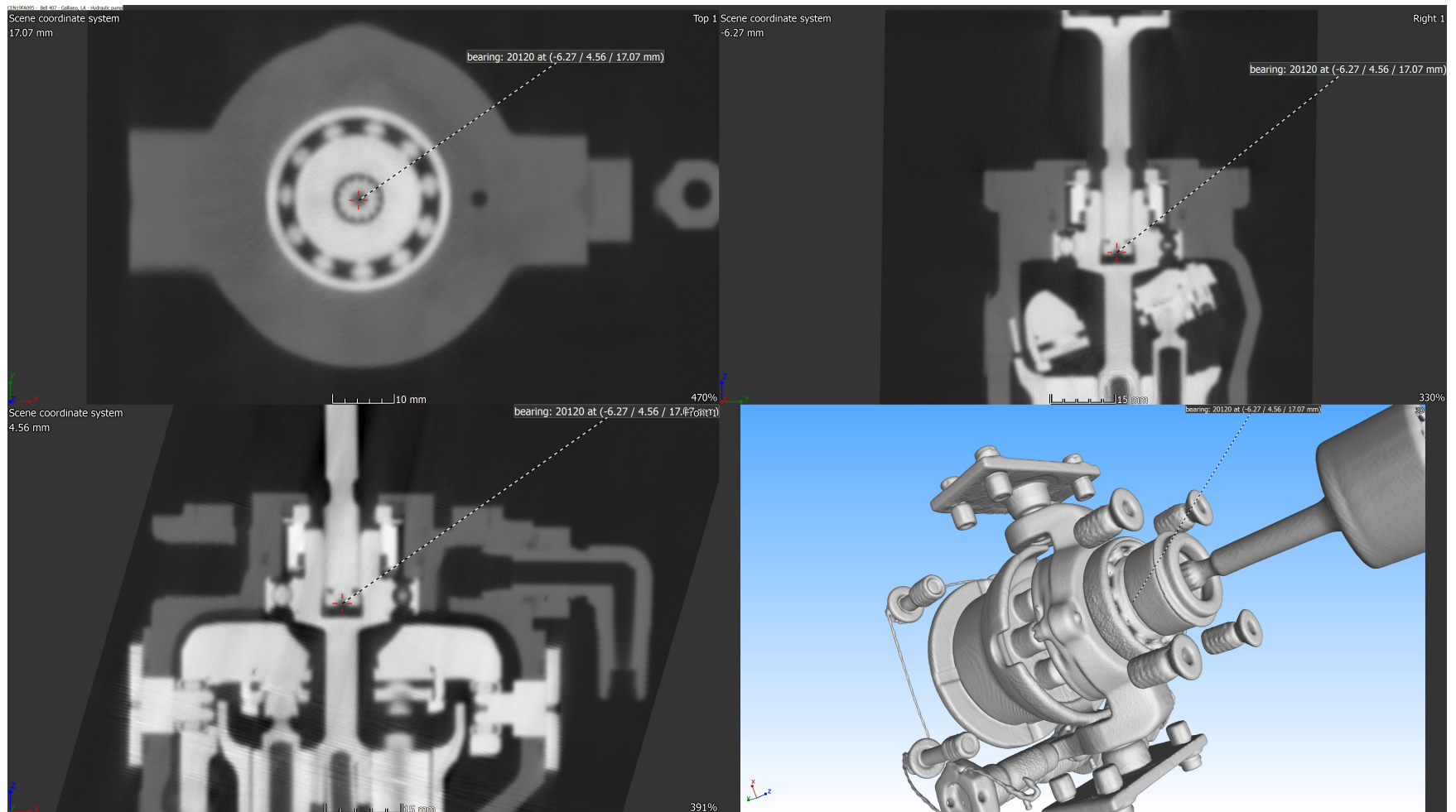


Figure 56
Hydraulic pump – bearing

Scott Warren
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