NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

May 19, 2020

Computed Tomography Specialist's Factual Report

CEN20FA035

A. ACCIDENT

Location:	Gulf of Mexico
Date:	December 7, 2019
Time:	0918 central standard time
Airplane:	Bell 407 helicopter, N79LP

B. GROUP

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

C. SUMMARY

On December 7, 2019, at 0918 central standard time, a Bell 407 helicopter, N79LP, went missing in the Gulf of Mexico about 25 nautical miles southeast of Grand Isle, Louisiana. The commercial rated pilot is still missing, and the passenger was fatally injured. The helicopter was registered to and operated by Panther Helicopters Inc., under the provisions of Title 14 *Code of Federal Regulations* Part 135 as a business flight. Visual meteorological conditions prevailed in the area and the flight operated on a company visual flight rules (VFR) fight plan. The flight had departed from oil platform WD109 and was en route to oil platform WD73.

The internal configuration of two oil delivery tube assemblies were documented using radiographic images that were collected from January 31 – March 5, 2020 in Chicago, Illinois. A total of 8,793 computed tomography (CT) slice images were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the images determined that, when the scans were conducted, the following indications were noted:

1. The image data for the oil delivery passage within the large tube was examined, and the passage was found to have indications of material obstructing it. The passage was examined at three cross sectional locations (figures 3-8), and the obstructing material indications were documented.
2. The image data for the oil delivery passages within the small tubes was examined, and the passages were found to have indications of material obstructing them (figures 12-35).
3. Nomenclature markings were found on two different surfaces of the small tubes (figures 36-37).
4. The image data for the oil delivery passages within the bearing 4/5 oil delivery tube was examined, and two of the passages were found to have indications of material obstructing them (figures 40-47). The remaining passage within this component did not show any indications of material within the passage (figures 48-49).
5. A mass of medium density material was found within the larger, central passage of the bearing 4/5 oil delivery tube. The material can be seen in several images, but it is highlighted in figures 38, 39, 44, and 48.
6. Nomenclature markings were found on two different surfaces of the bearing 4/5 oil deliver tube (figures 50-51).
7. The image data for the anomalous material found in the filter area at the base of the small tubes was examined at three cross sectional locations (figures 57-59).

D. DETAILS OF THE INVESTIGATION

1.0 General

The internal configurations of two oil delivery tube assemblies were subjected to x-ray radiograph and computed tomography (CT) scanning to document their internal conditions. One oil delivery tube assembly was scanned as three separate data sets:

1. A scan of just the large tube section of the assembly.
2. A scan of the two smaller tubes.
3. A scan of the filter section below the two smaller tubes.

The other oil delivery tube assembly (bearing 4/5 oil supply tube) was scanned as a single data set.

The scanning was conducted from January 31 – March 5, 2020 by Varex, Inc under the direction of the NTSB using the Actis 500/225 micro focus system.

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 shaped 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 8,793 slices, and the total size of the combined data sets was approximately 68.8 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	Large tube	Small tubes	Small tubes – filter section	Bearing 4/5 oil supply tube
Number of slices	2524	2328	1705	2236
Voxel[1] Size - X Direction (mm)	0.030	0.030	0.030	0.018
Voxel Size - Y Direction (mm)	0.030	0.030	0.030	0.018
Voxel Size - Z Direction (mm)	0.031	0.031	0.031	0.017
Image Projections per Revolution	1440	1440	1440	1440
Exposure time (ms)	285.61	285.61	285.61	285.61
Frames to Avg (frames per projection)	2	2	2	2
X-ray Source Voltage (kV)	222	222	222	222
X-ray Source Current (mA)	0.550	0.550	0.550	0.550
Source Filter Thickness (mm)	1	1	1	1
Source Filter Material	Brass	Brass	Brass	Brass
Image Matrix Size	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.

[1] A voxel is a three-dimensional picture element (pixel).

Each component contained one or more openings designed as oil delivery passages[2]. Material found within these passages had varying density levels. The various density levels were colorized during the image analysis to help visualize the density variations within the passages. The density variations were color coded blue for the lowest density material, green for medium density material, and red for the highest density material. Each of the color codes used represent relative density variations for that component only. Due to variations between the scanning data sets, there was no way to colorize the images so that a gray value that was translated to a given color in one data set would also be that same color in a different data set. In addition to showing images of the passages at their respective midpoint cross sections, the points of maximum passage blockage were determined for each passage and shown with both gray scale and colorized images.

All of the individual data sets were combined to document the position and extent of a mass of anomalous material. The anomalous material was color coded blue for easier visibility.

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 59. Review of the images determined that, when the scans were conducted, the following indications were noted:

1. The image data for the oil delivery passage within the large tube was examined, and the passage was found to have indications of material obstructing it. The passage was examined at three cross sectional locations (figures 3-8), and the obstructing material indications were documented.
2. The image data for the oil delivery passages within the small tubes was examined, and the passages were found to have indications of material obstructing them (figures 12-35).
3. Nomenclature markings were found on two different surfaces of the small tubes (figures 36-37).
4. The image data for the oil delivery passages within the bearing 4/5 oil delivery tube was examined, and two of the passages were found to have indications of material obstructing them (figures 40-47). The remaining passage within this component did not show any indications of material within the passage (figures 48-49).

[2] For the components with multiple openings, the openings were arbitrarily labeled to provide a definitive reference for each opening.

5. A mass of medium density material was found within the larger, central passage of the bearing 4/5 oil delivery tube. The material can be seen in several images, but it is highlighted in figures 38, 39, 44, and 48.
6. Nomenclature markings were found on two different surfaces of the bearing 4/5 oil deliver tube (figures 50-51).
7. The image data for the anomalous material found in the filter area at the base of the small tubes was examined at three cross sectional locations (figures 57-59).

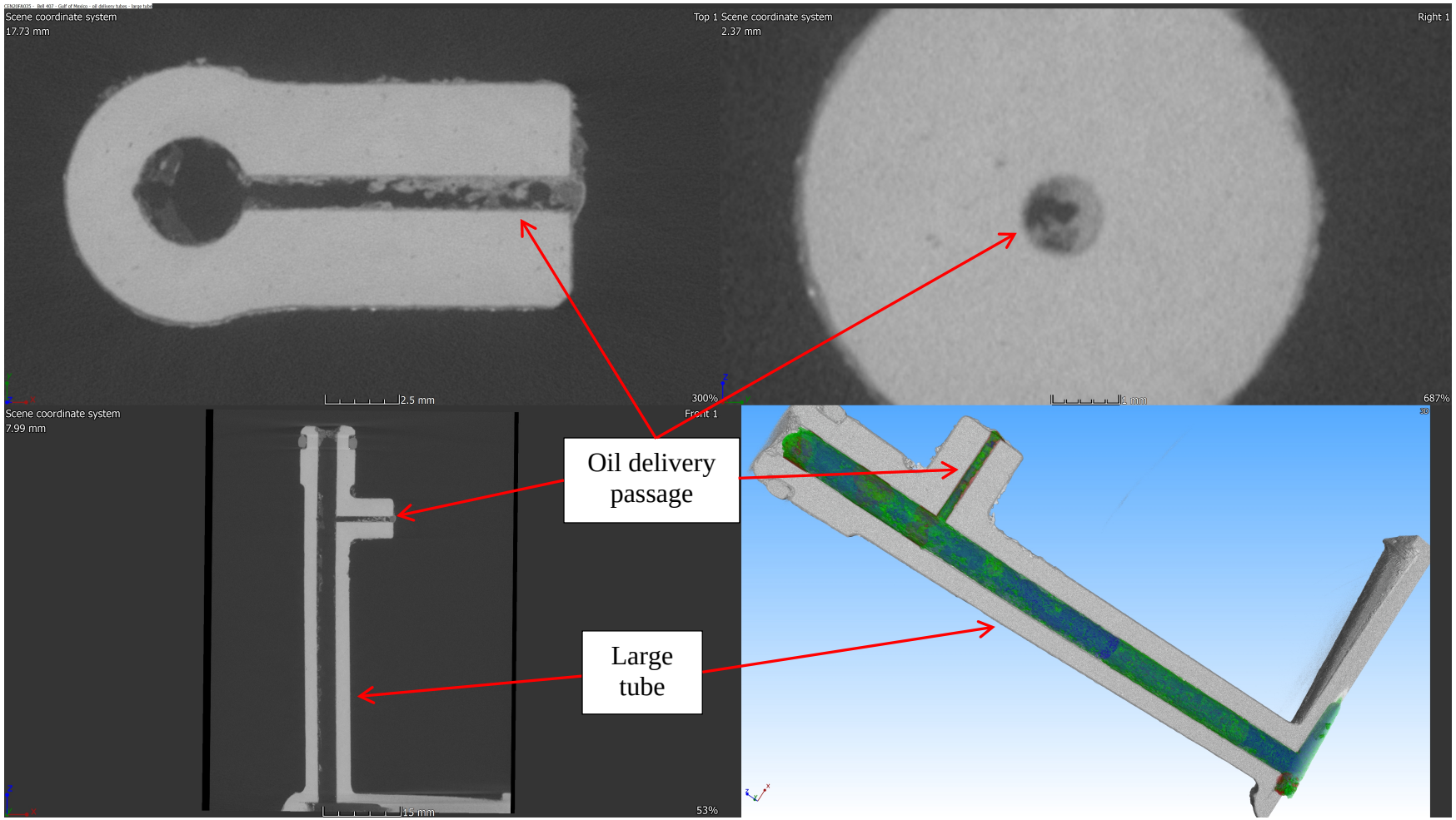


Figure 1
Large tube - overview

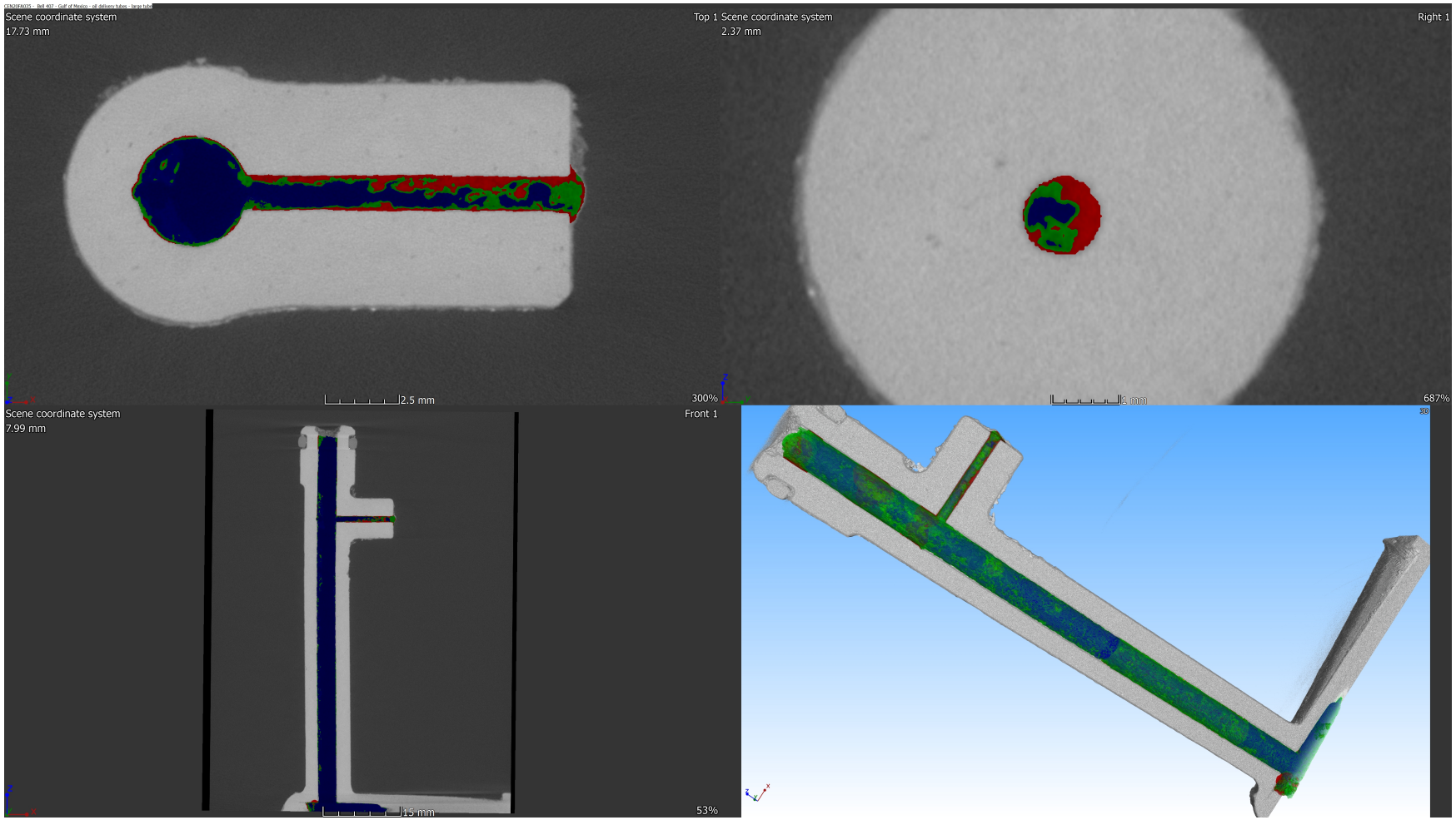


Figure 2
Large tube – overview - colorized

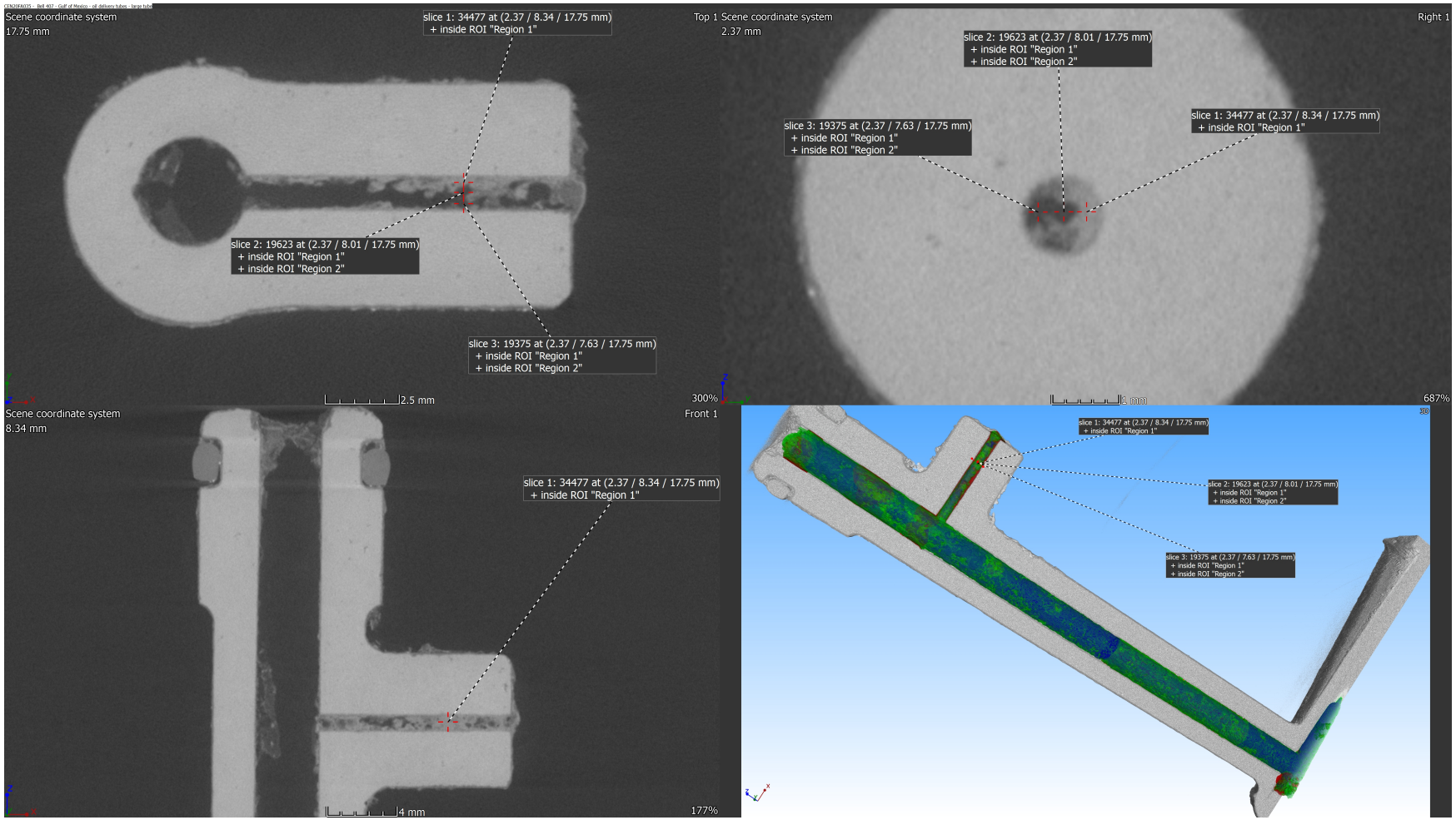


Figure 3
Large tube – slice 1

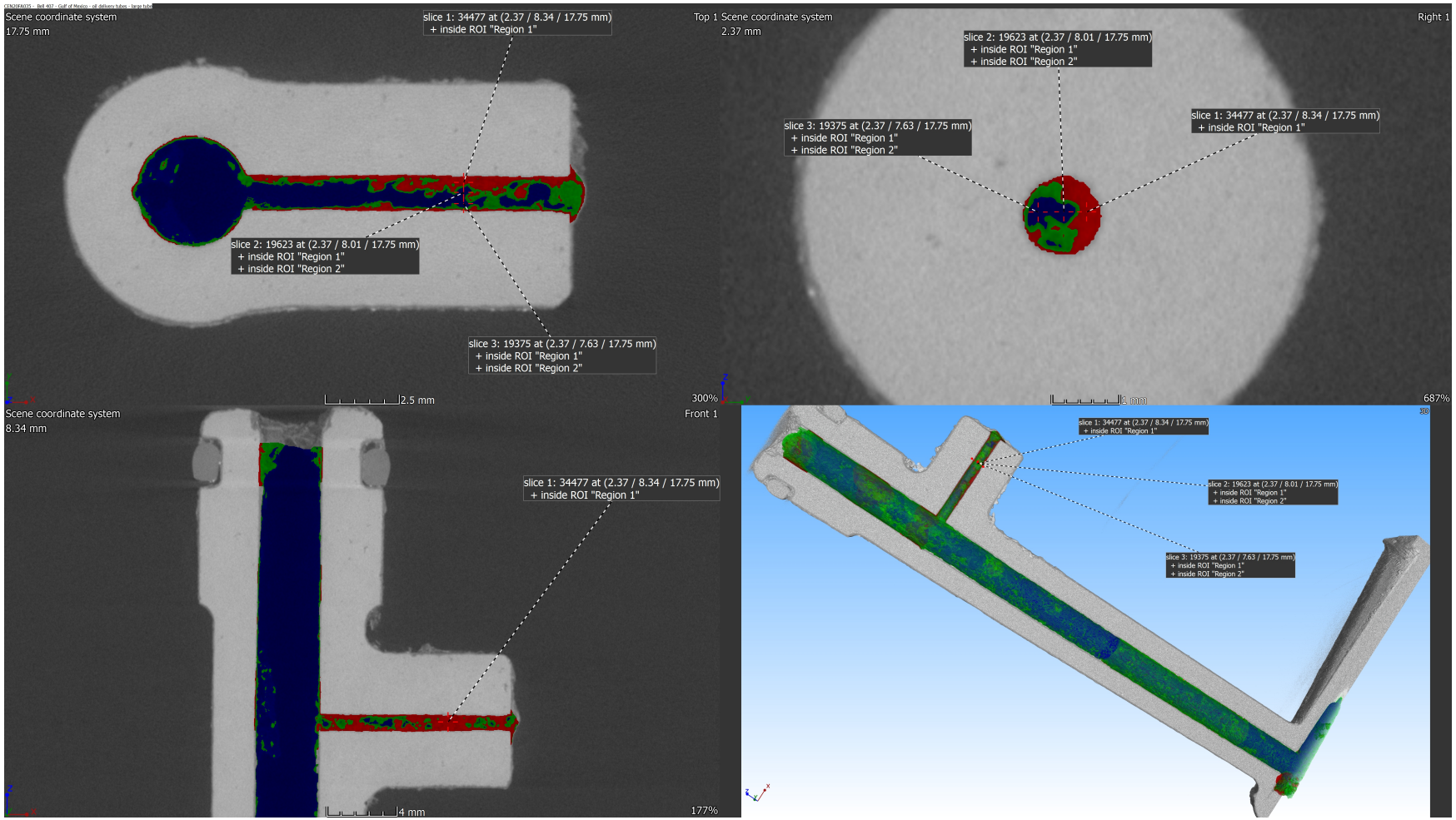


Figure 4
Large tube – slice 1 - colorized

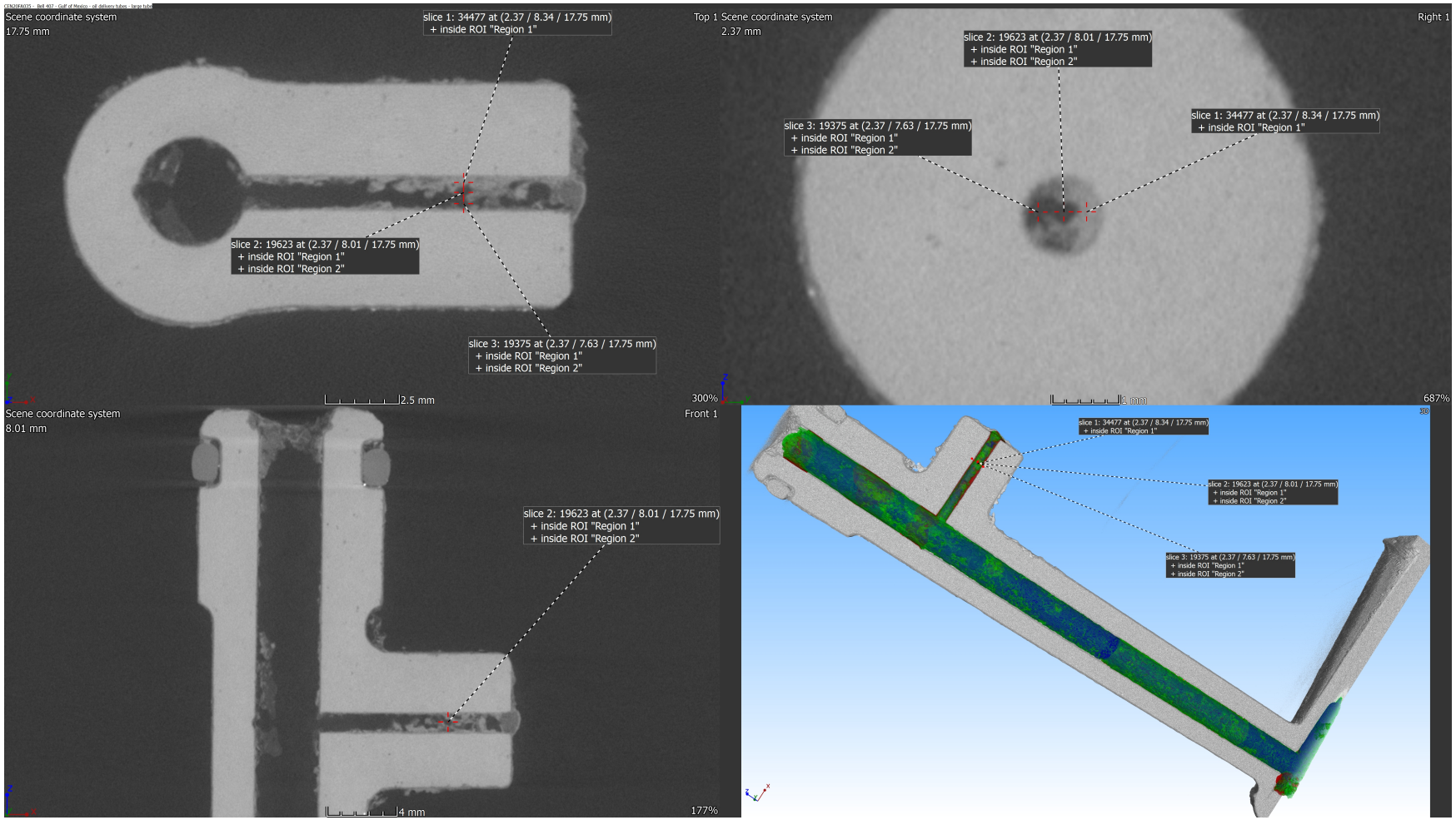


Figure 5
Large tube – slice 2

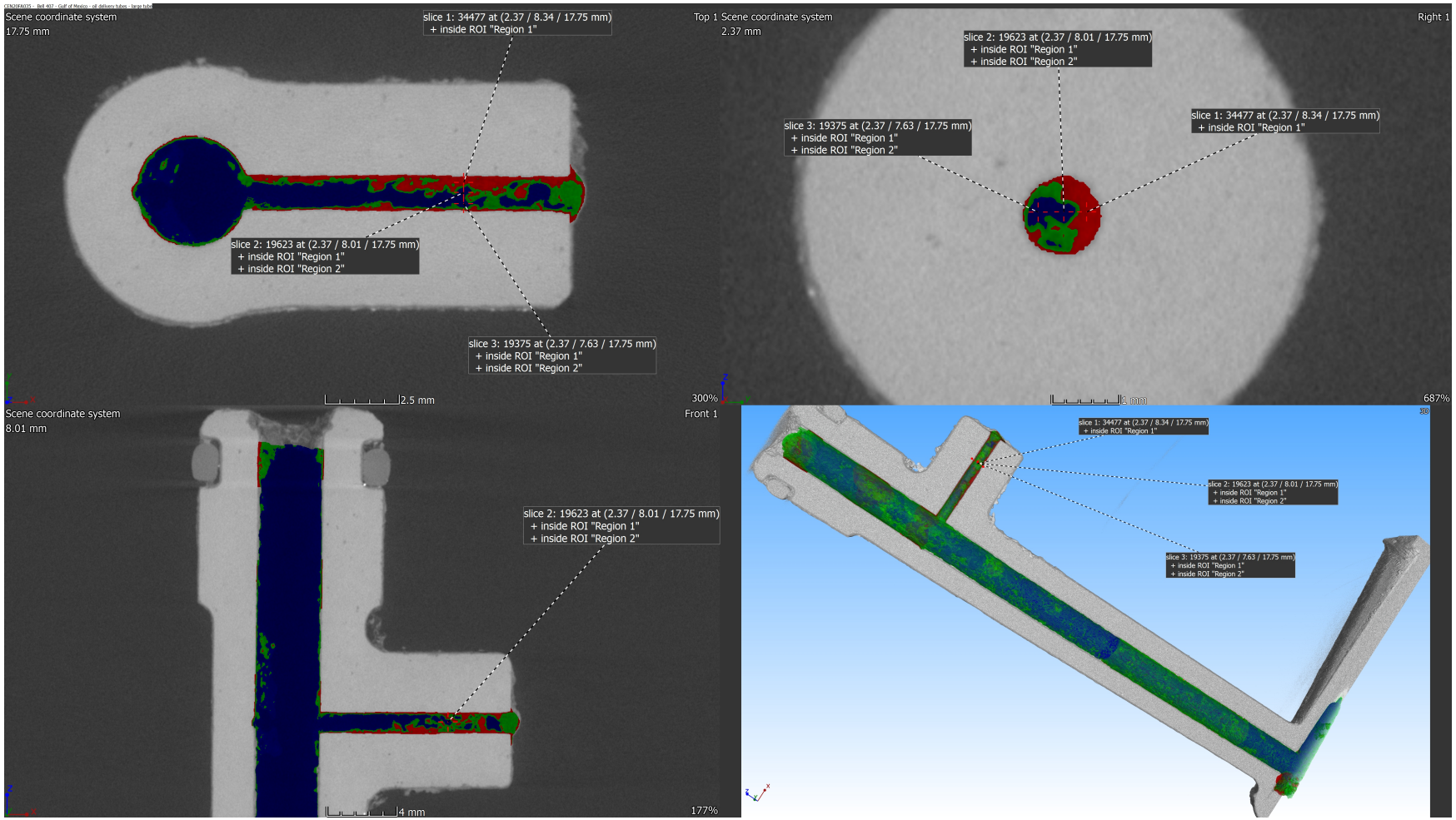


Figure 6
Large tube – slice 2 - colorized

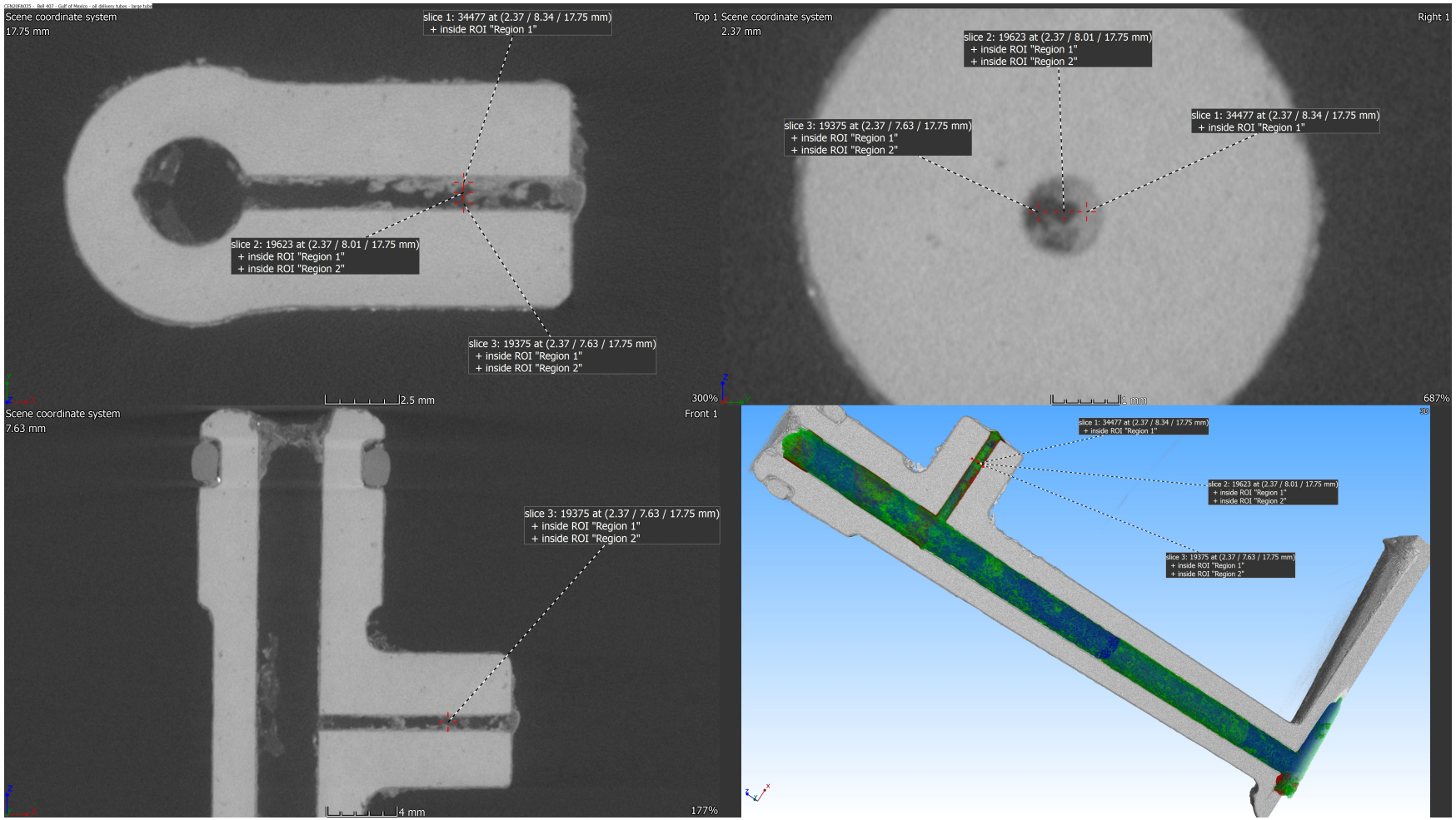


Figure 7
Large tube – slice 3

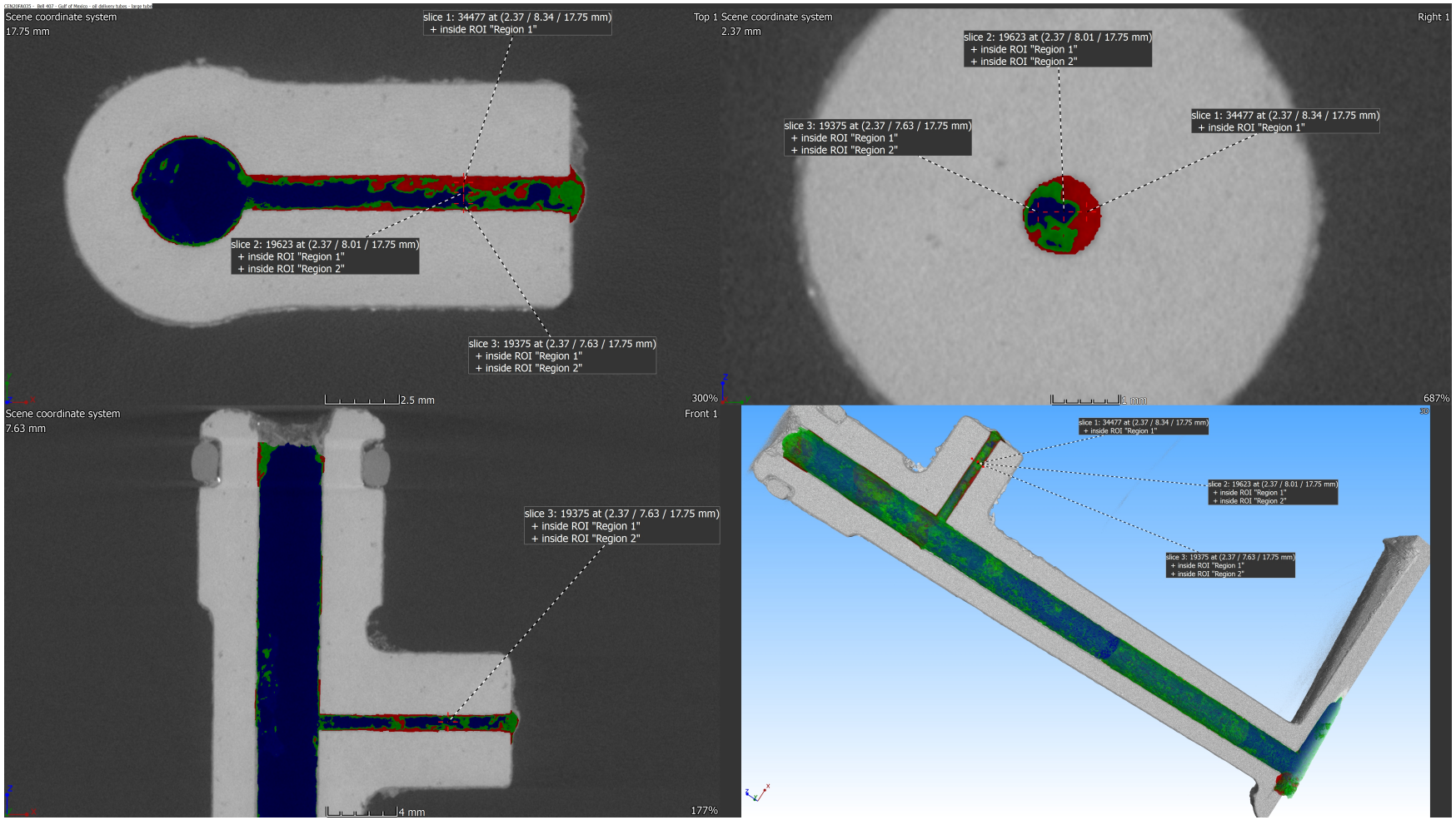


Figure 8
Large tube – slice 3 - colorized

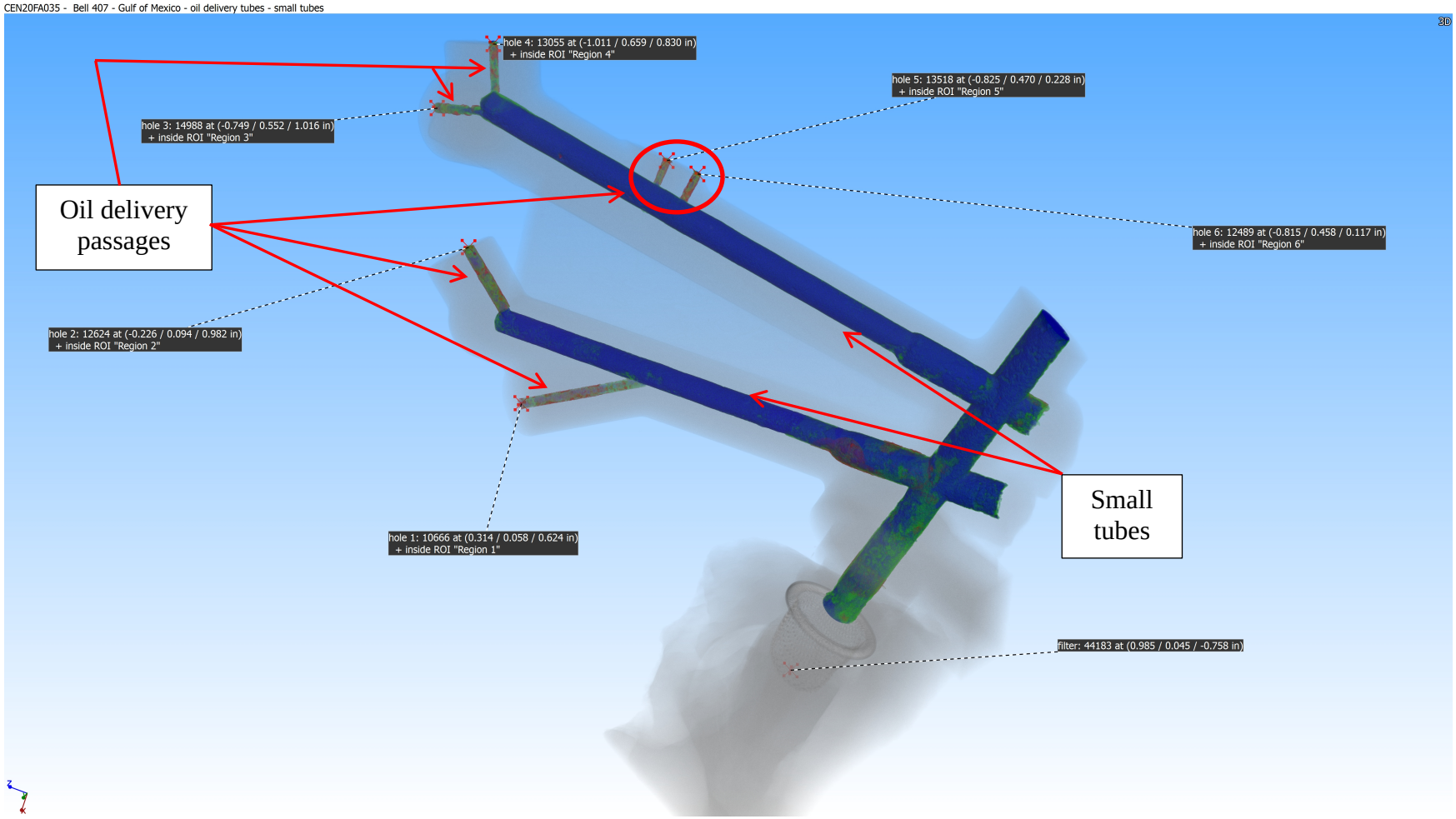


Figure 9
Small tubes – overview

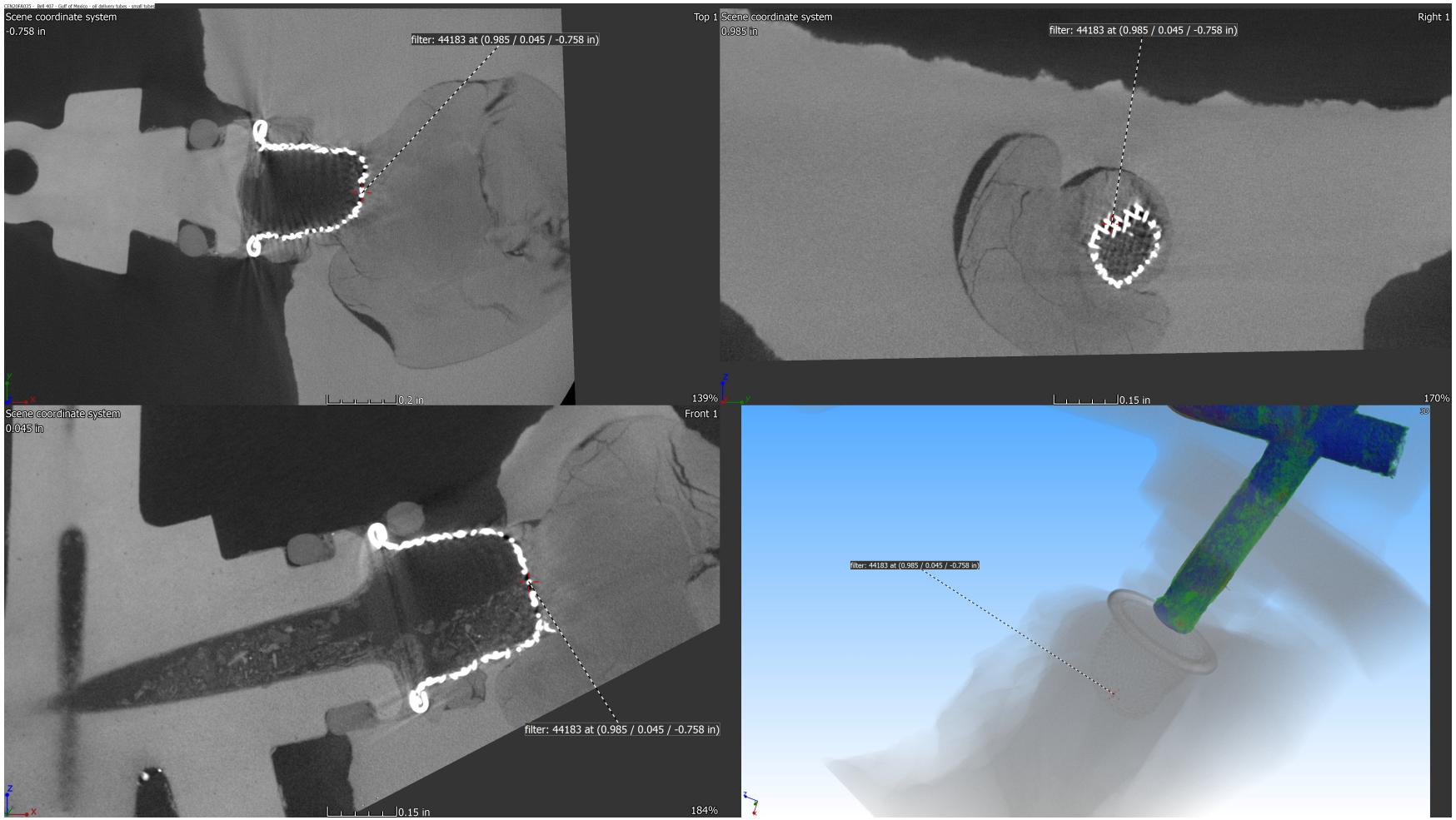


Figure 10
Small tubes – filter

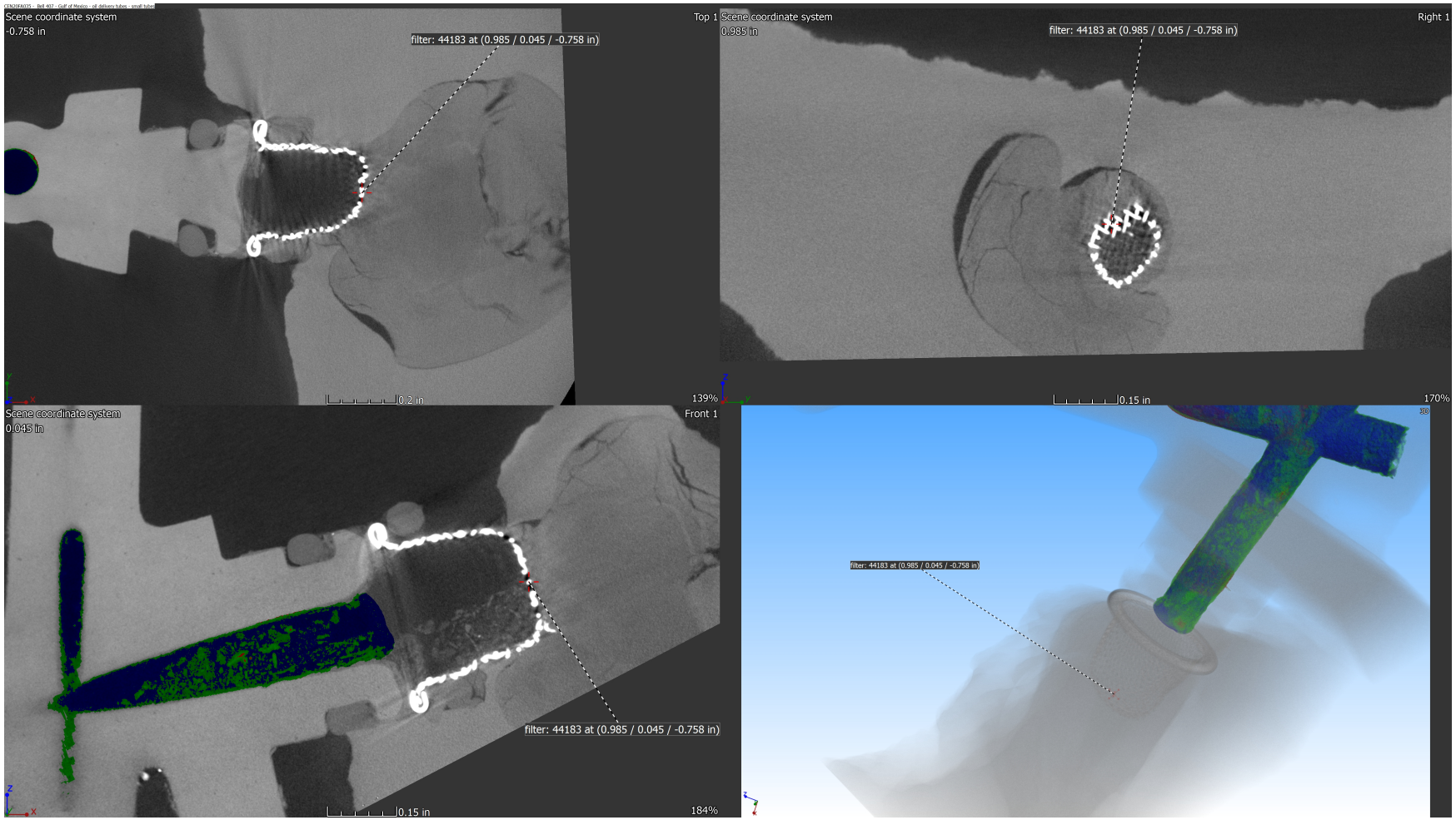


Figure 11
Small tubes – filter - color

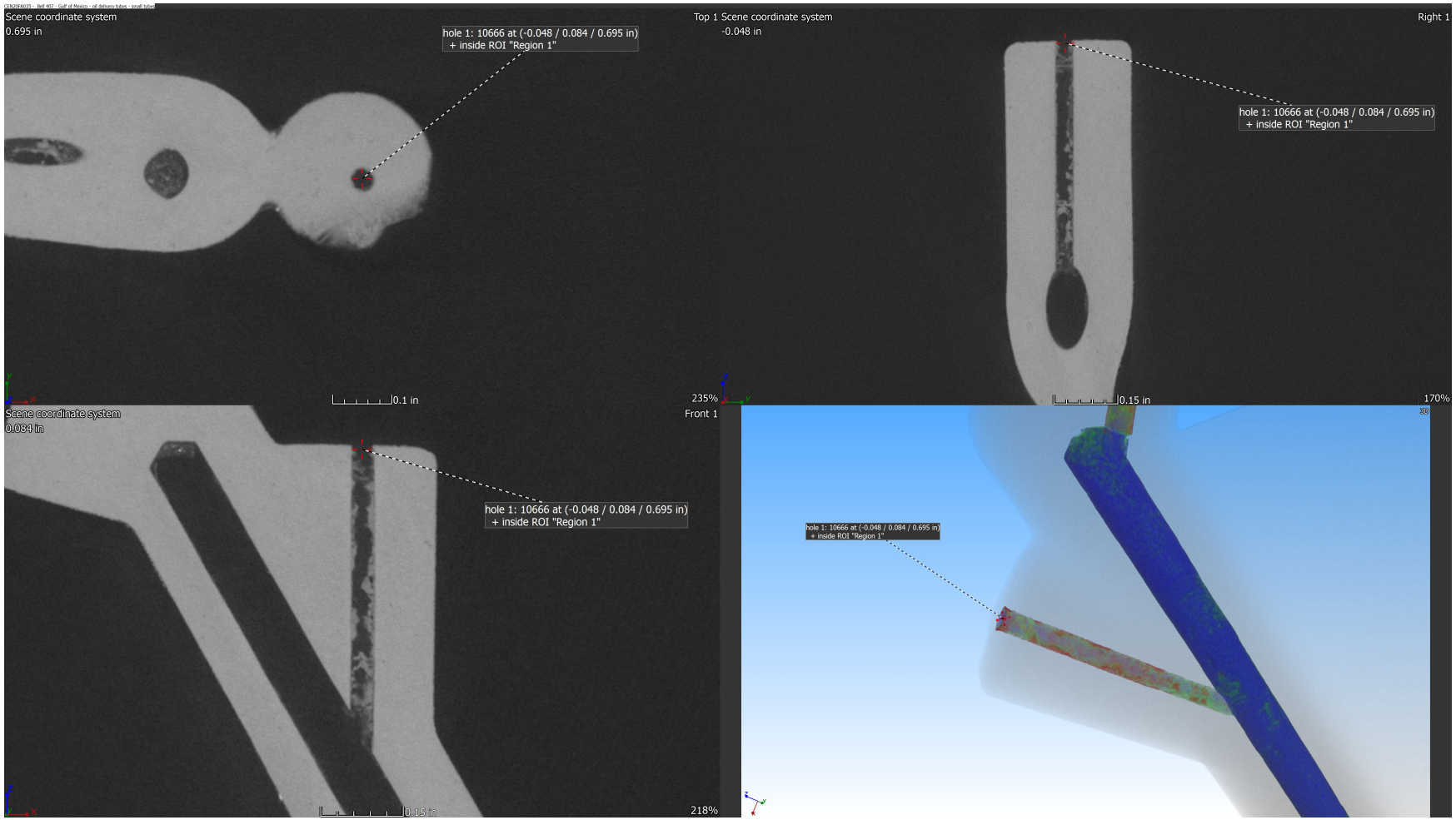


Figure 12
Small tubes – hole 1

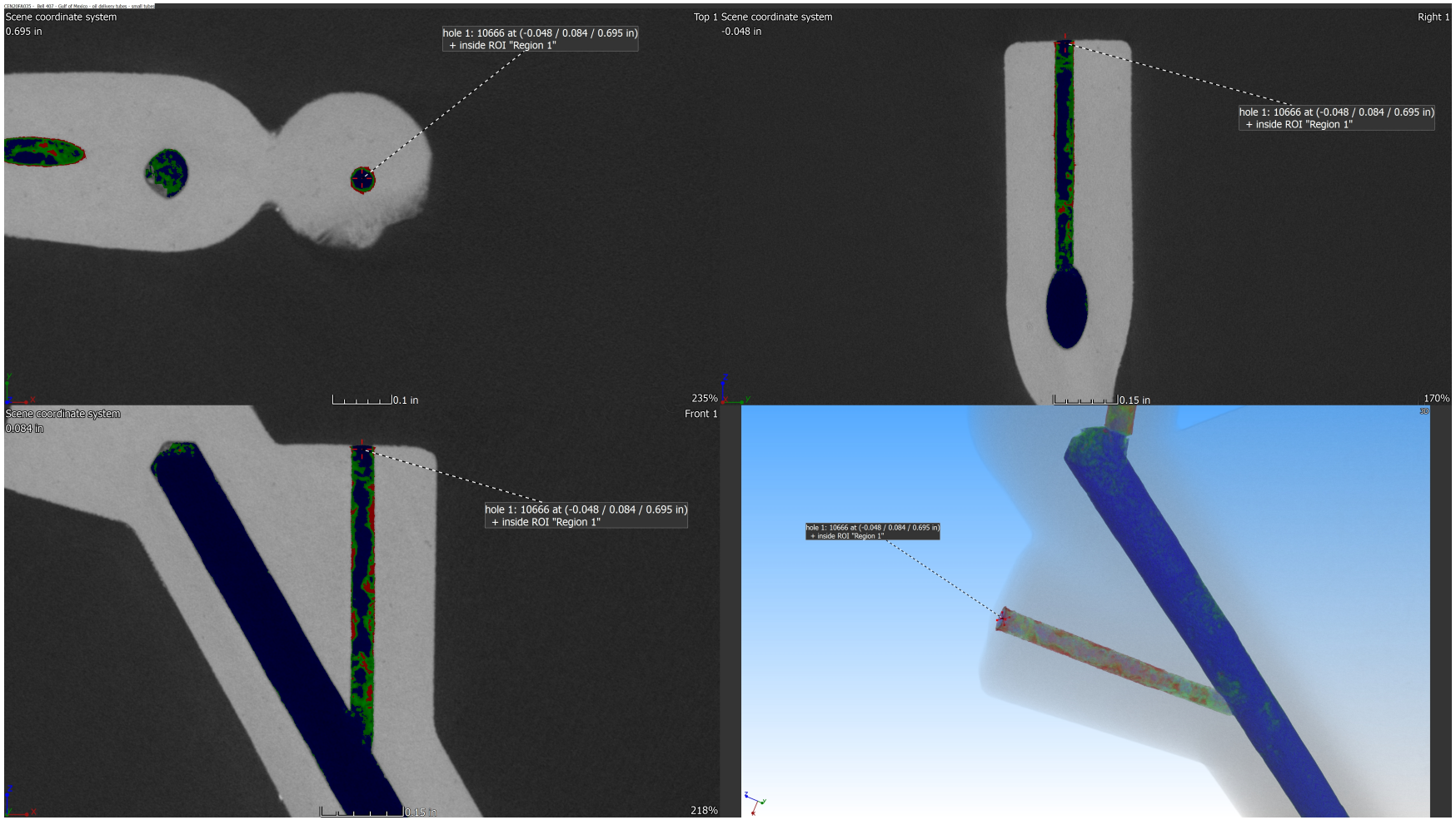


Figure 13
Small tubes – hole 1 - colorized

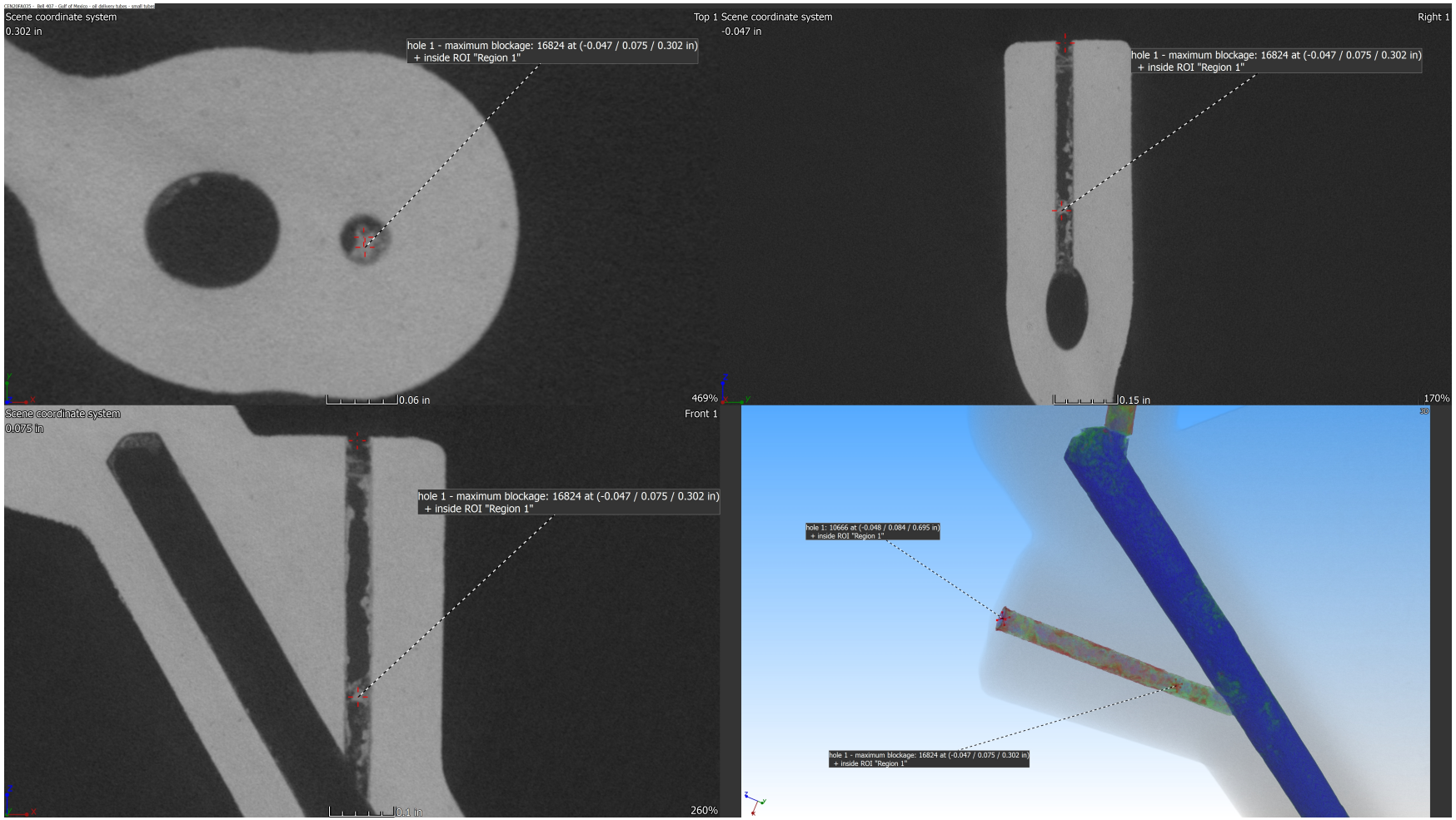


Figure 14
Small tubes – hole 1 – maximum blockage

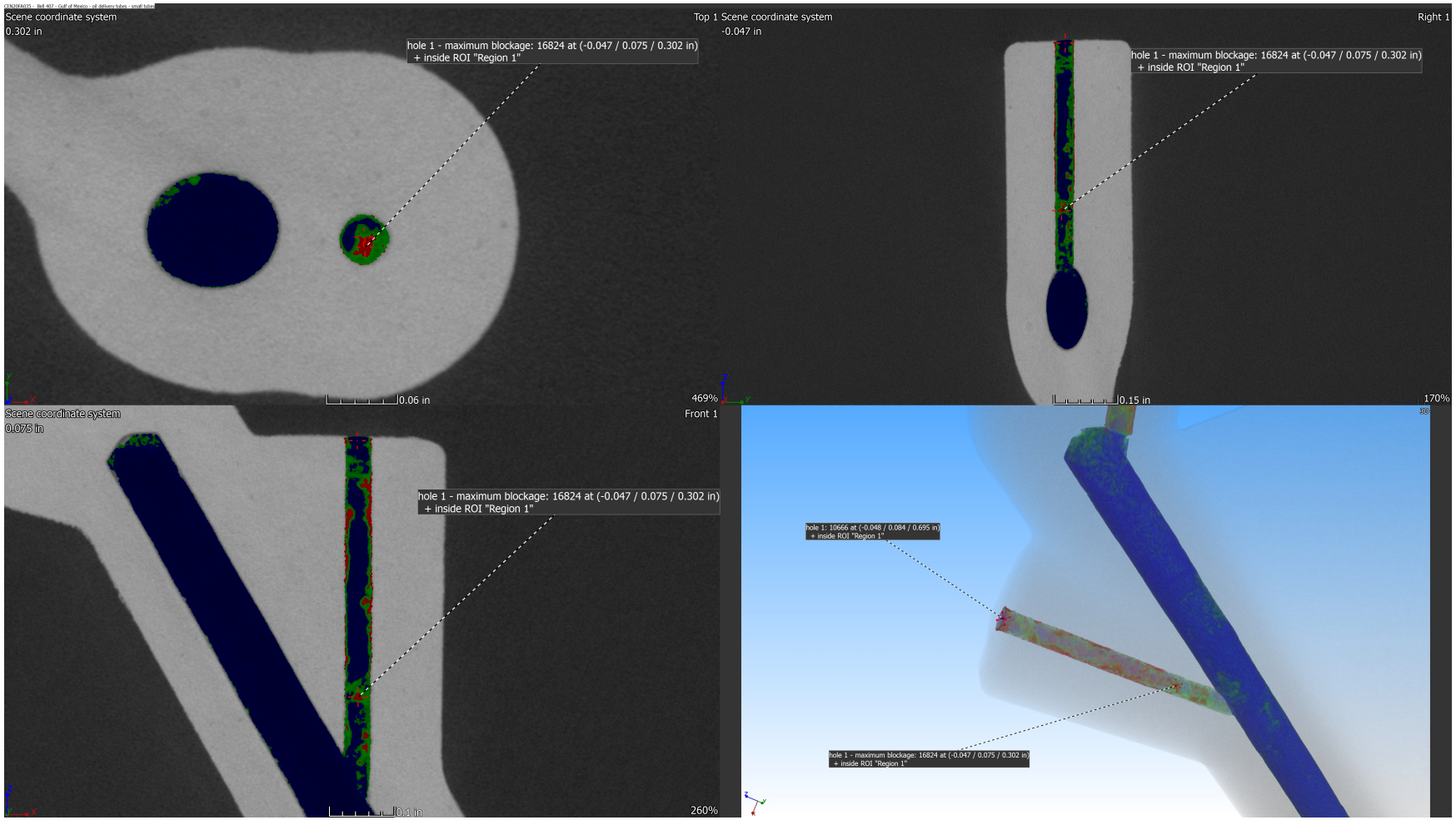


Figure 15
Small tubes – hole 1 – maximum blockage - colorized

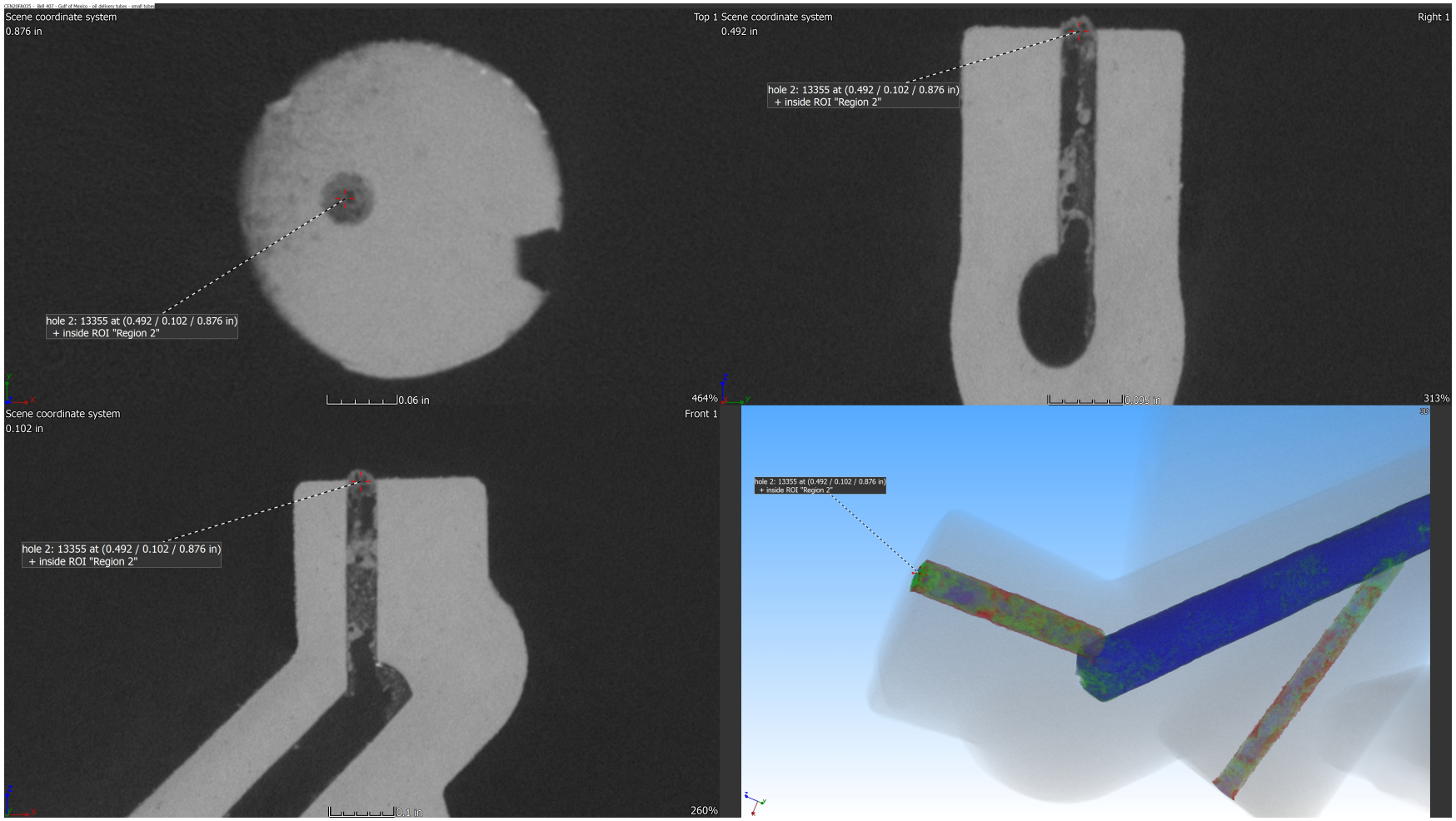


Figure 16
Small tubes – hole 2

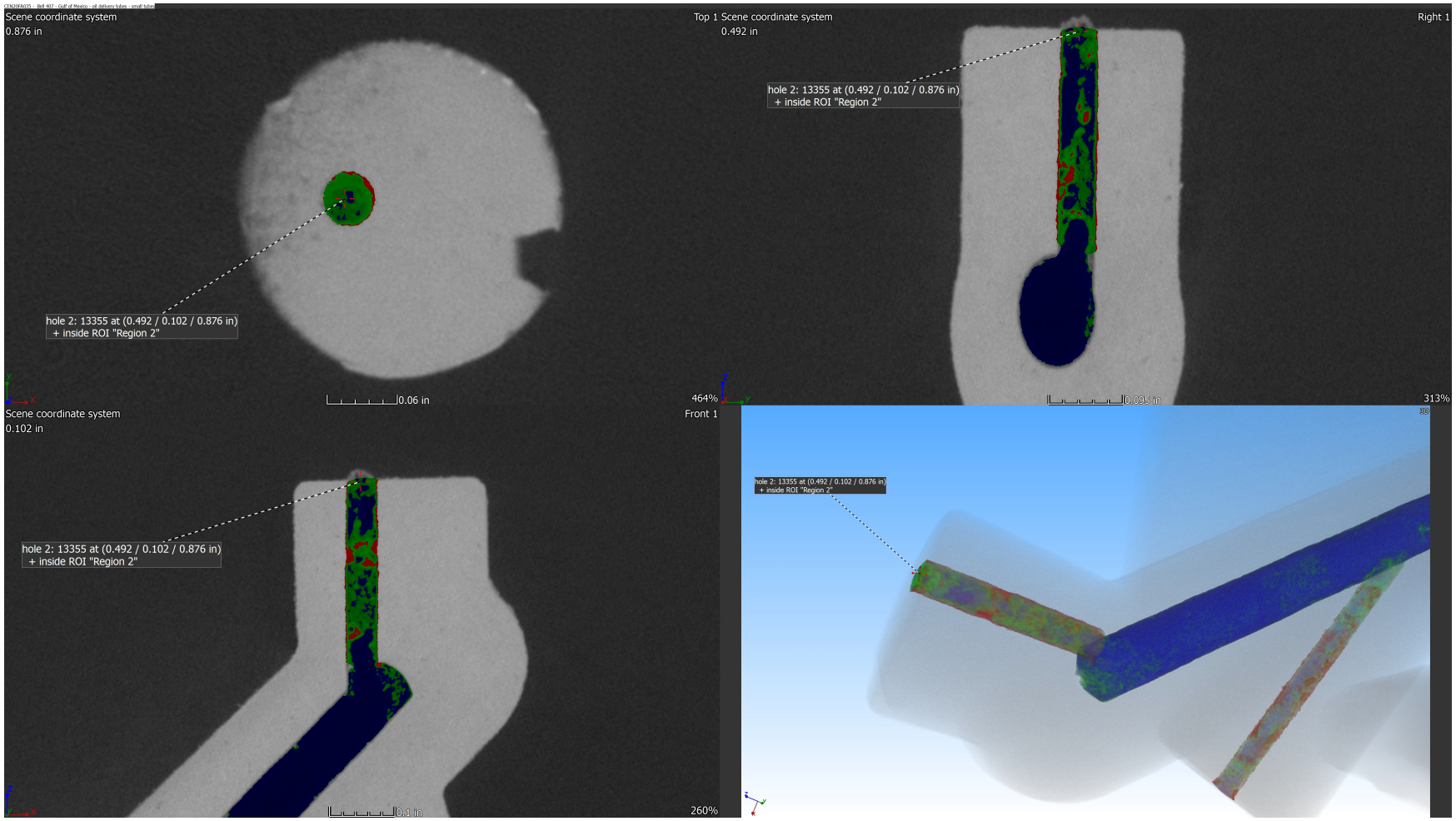


Figure 17
Small tubes – hole 2 - colorized

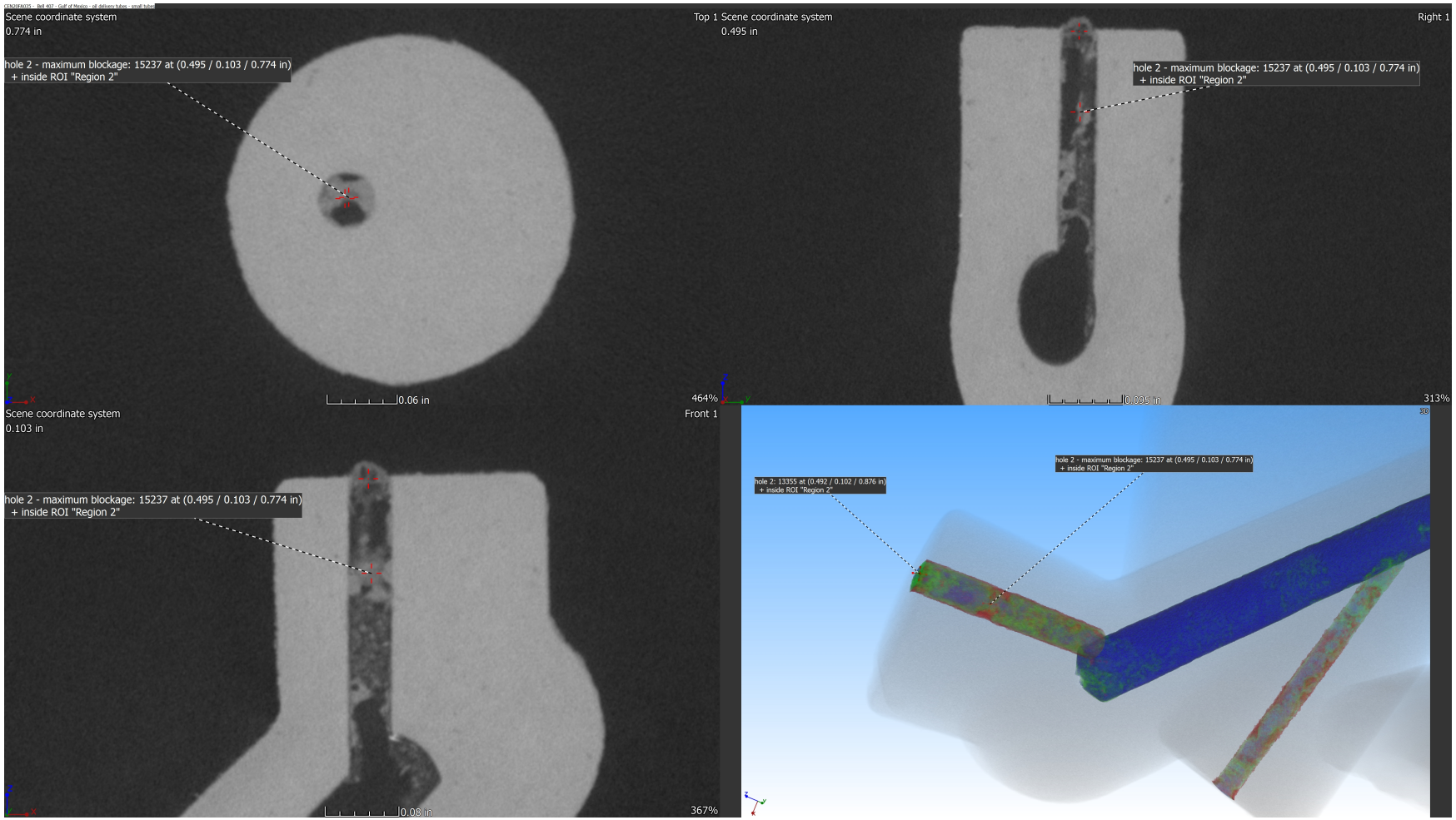


Figure 18
Small tubes – hole 2 – maximum blockage

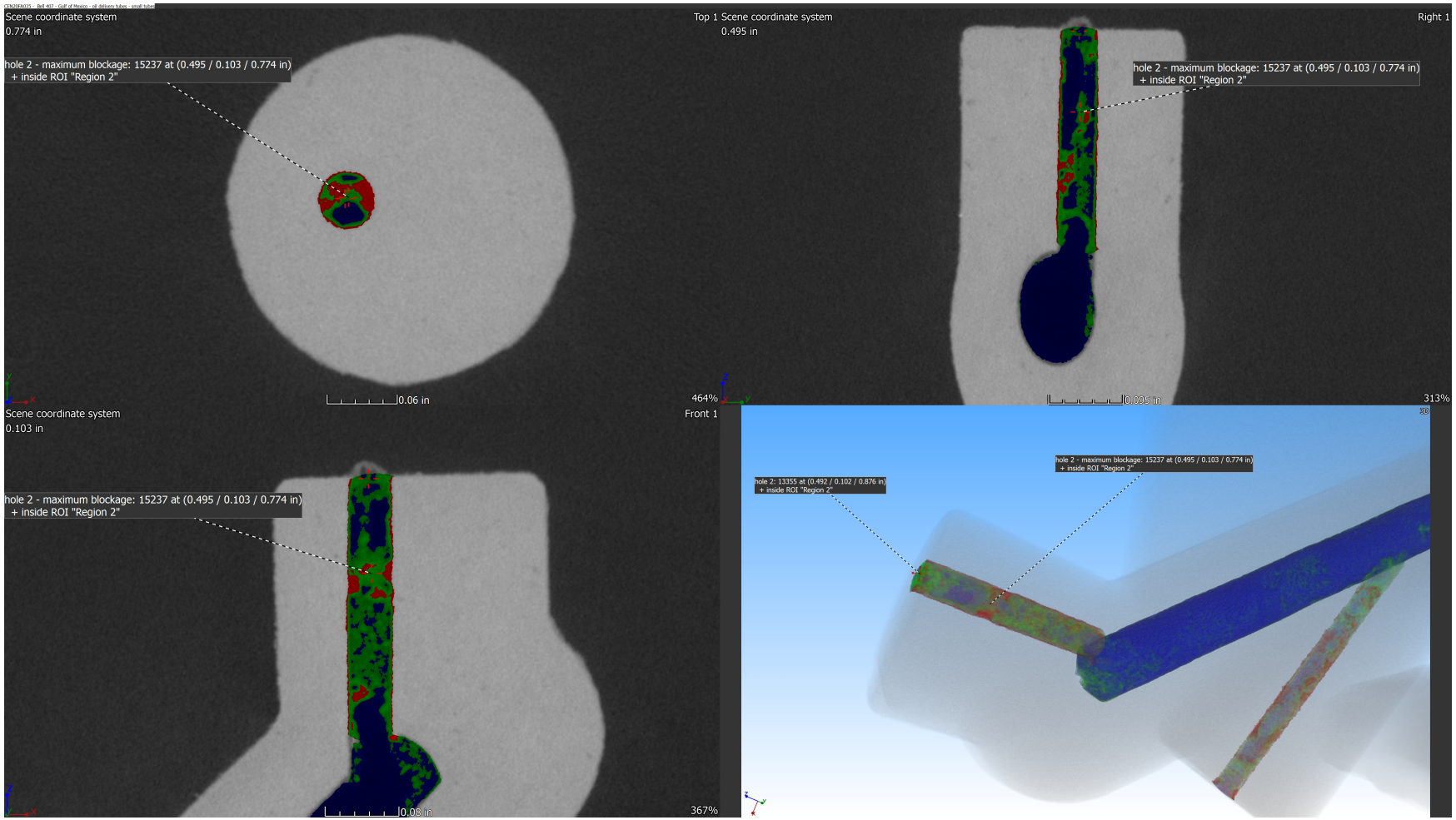


Figure 19
Small tubes – hole 2 – maximum blockage - colorized

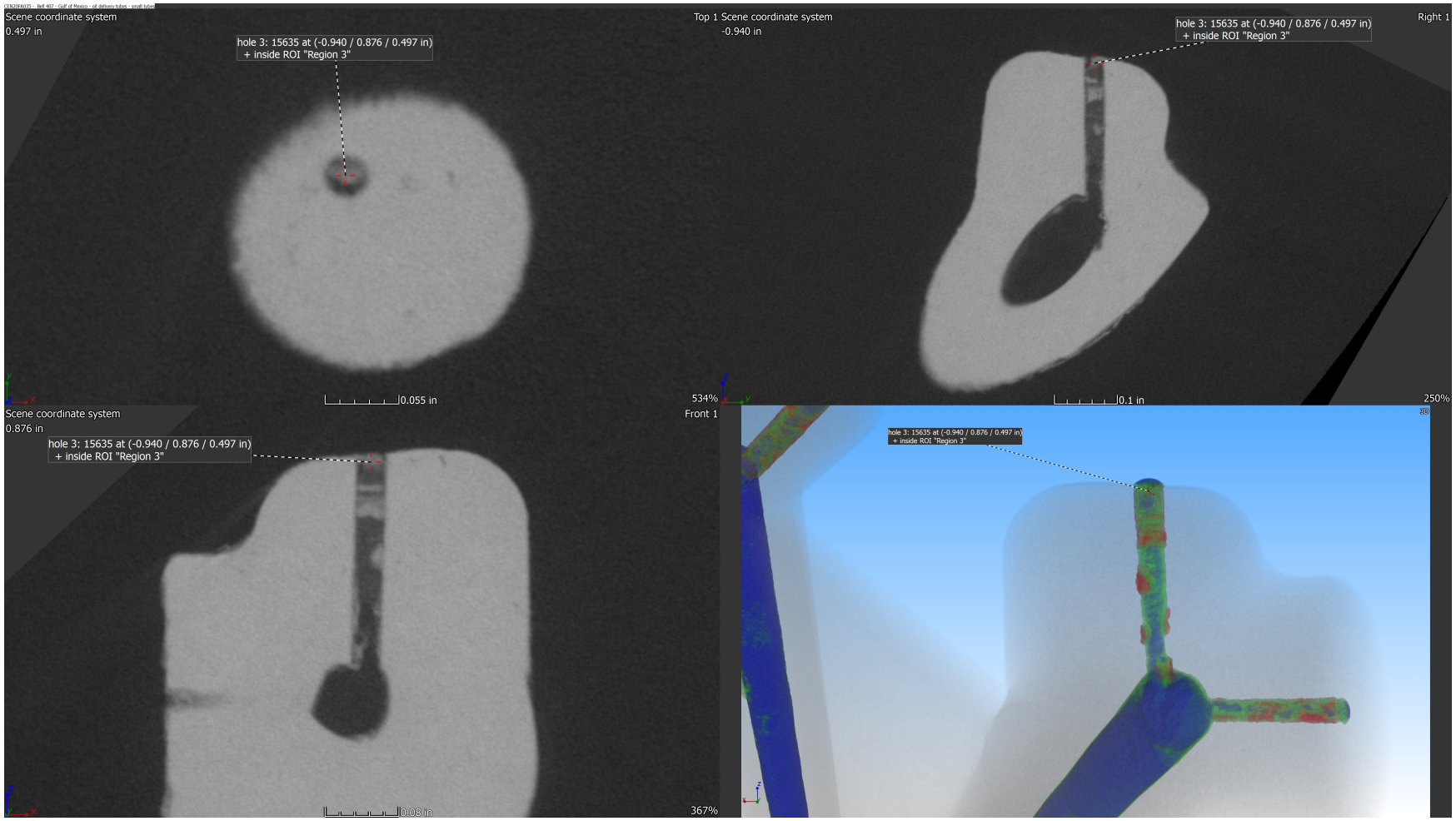


Figure 20
Small tubes – hole 3

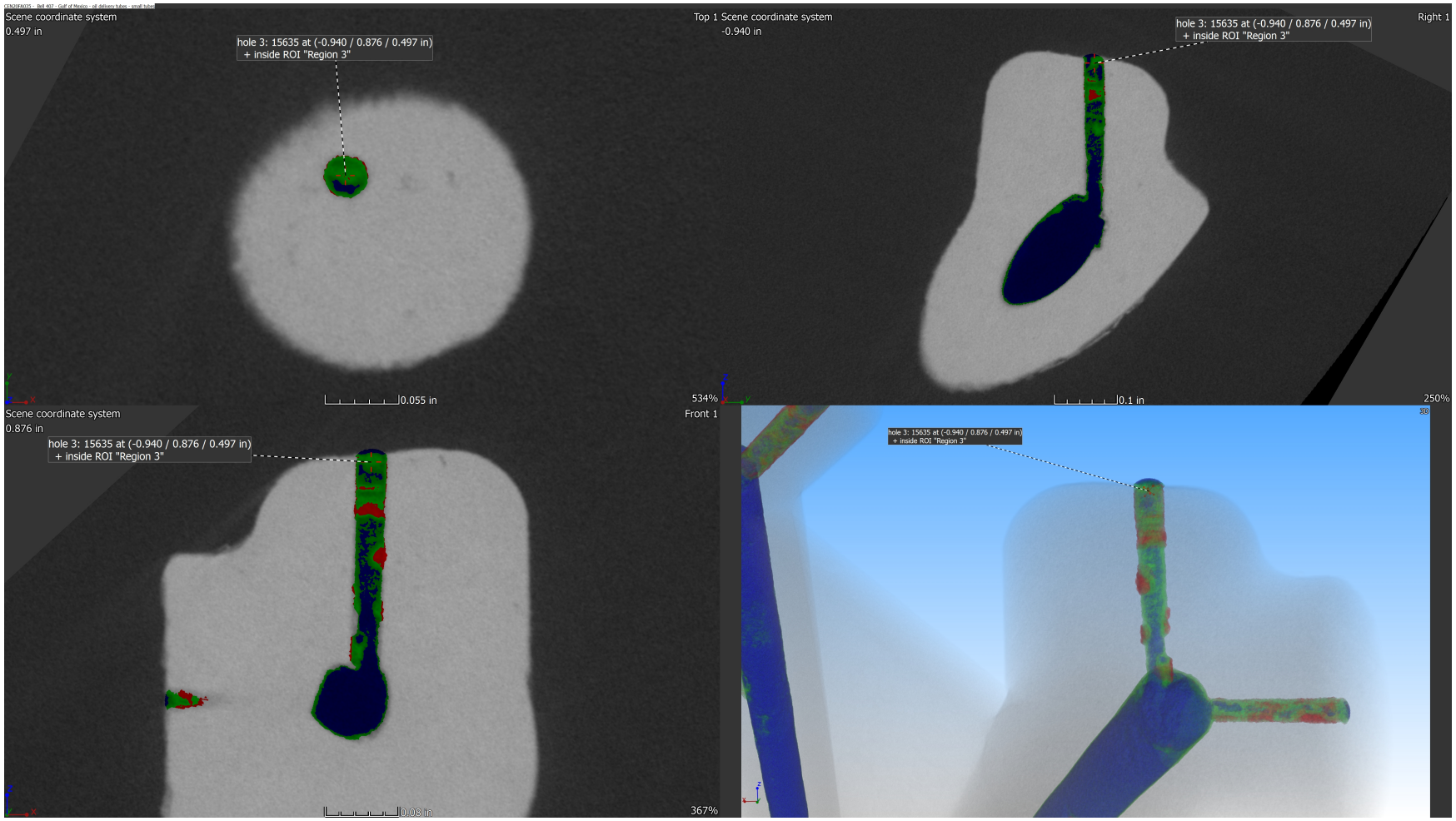


Figure 21
Small tubes – hole 3 - colorized

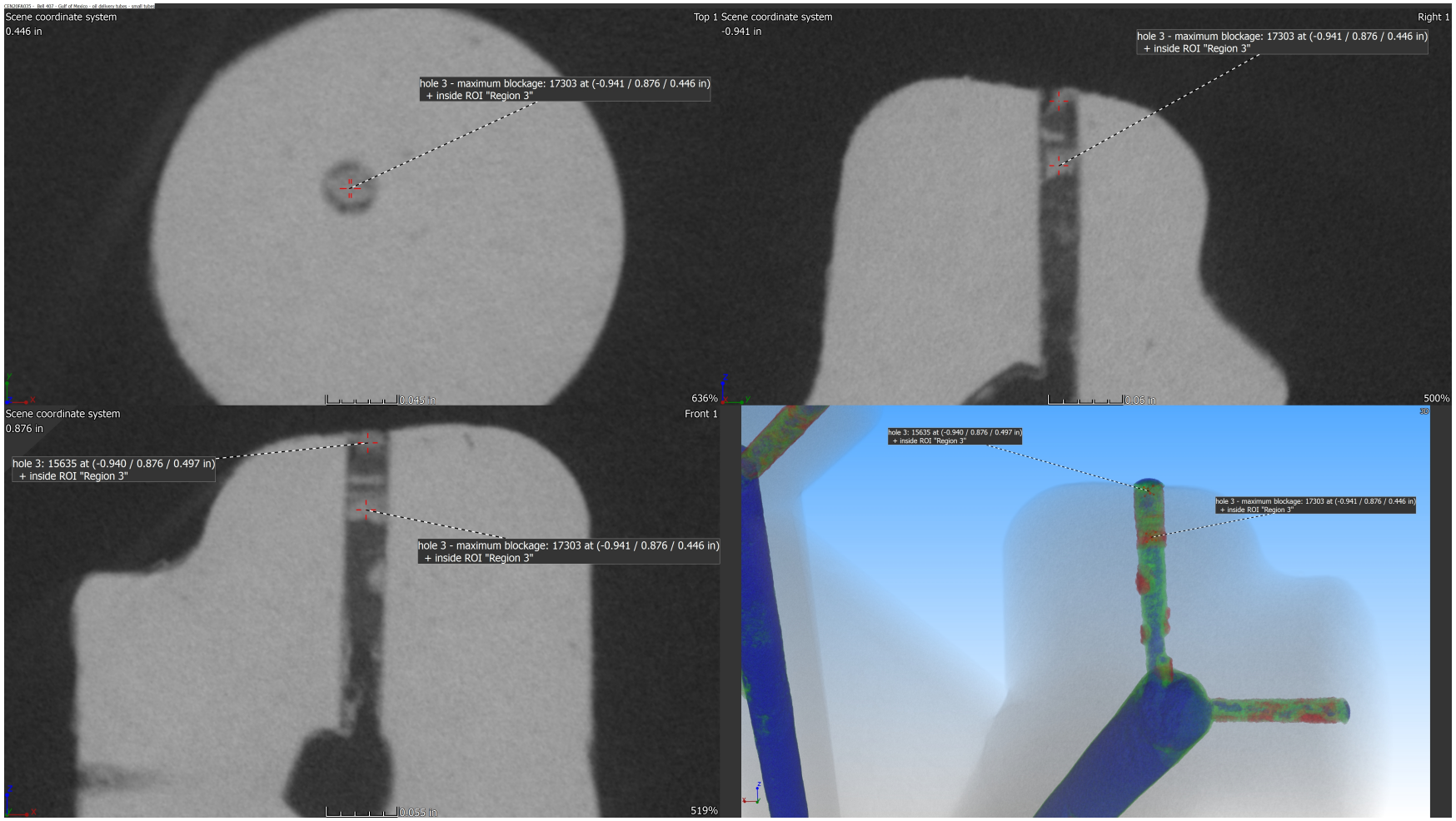


Figure 22
Small tubes – hole 3 – maximum blockage

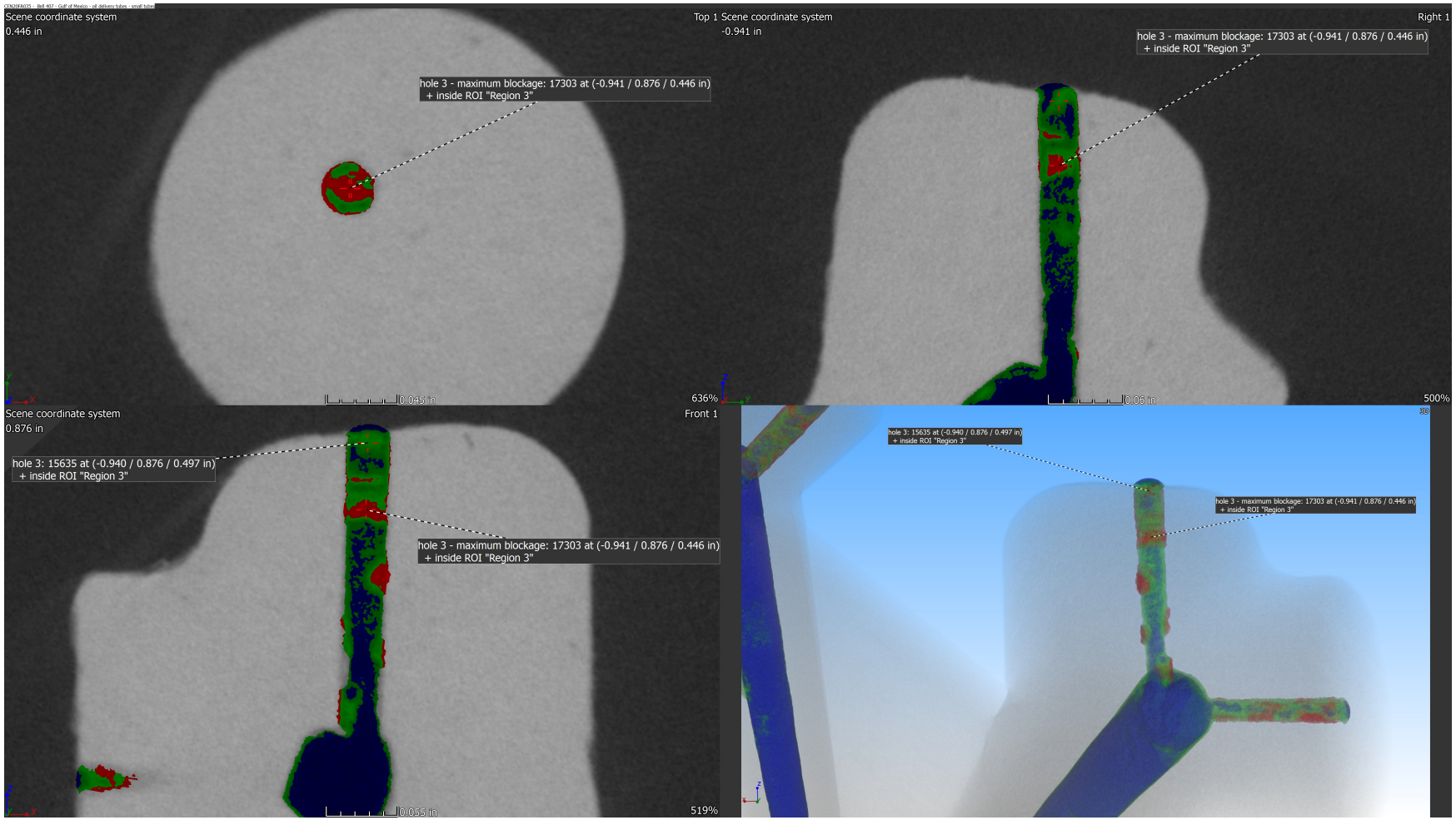


Figure 23
Small tubes – hole 3 – maximum blockage - colorized

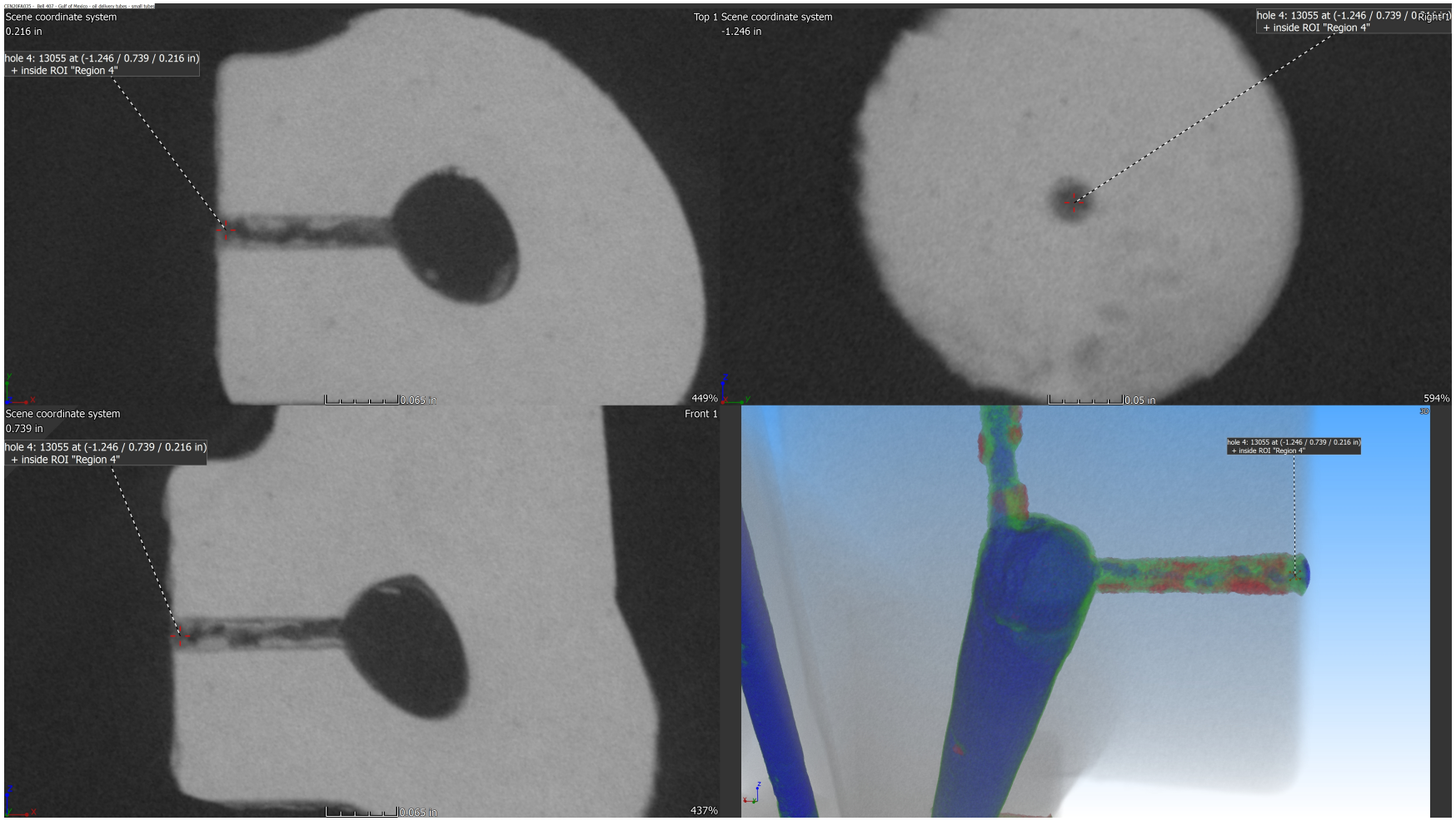


Figure 24
Small tubes – hole 4

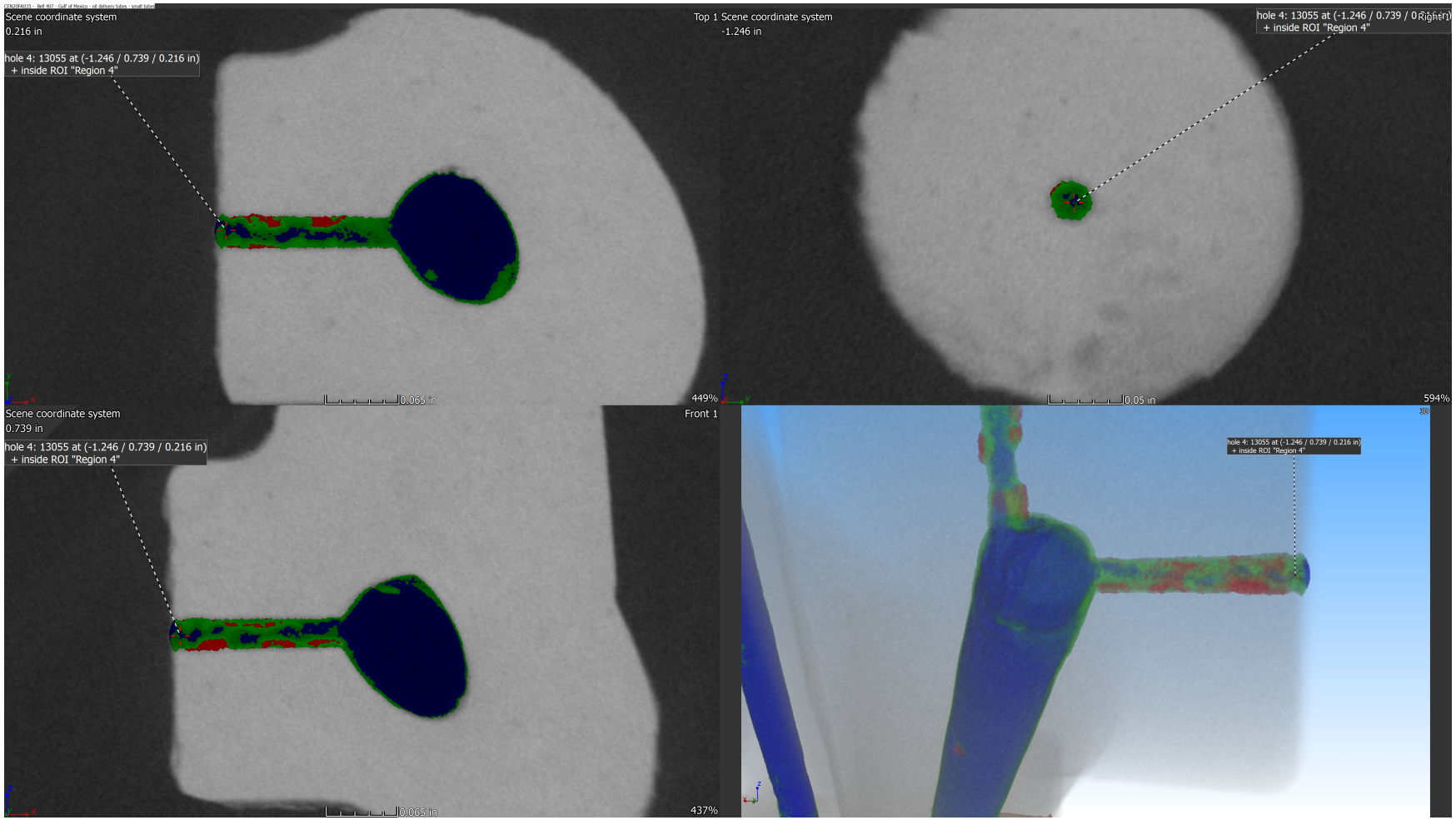


Figure 25
Small tubes – hole 4 - colorized

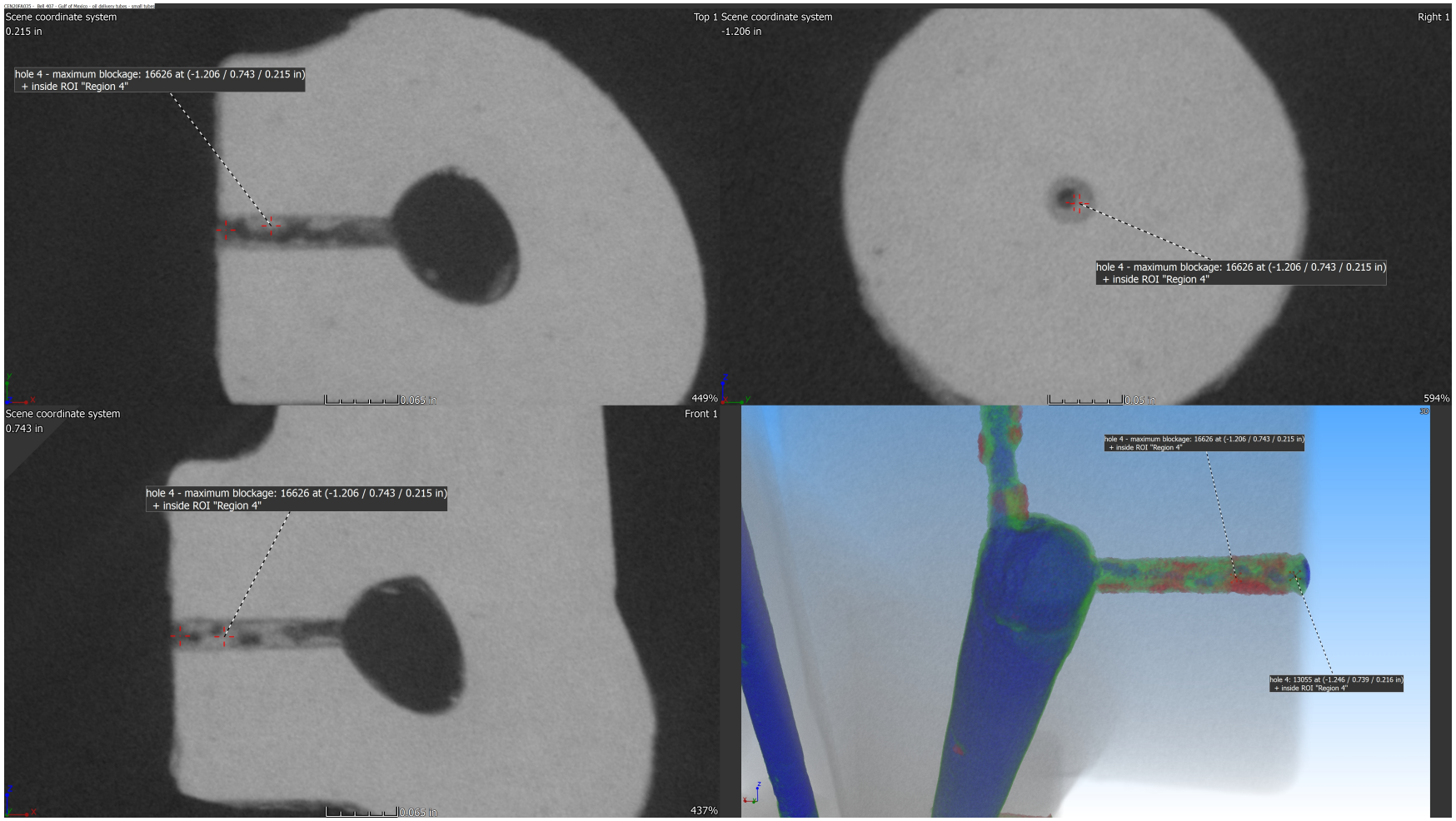


Figure 26
Small tubes – hole 4 – maximum blockage

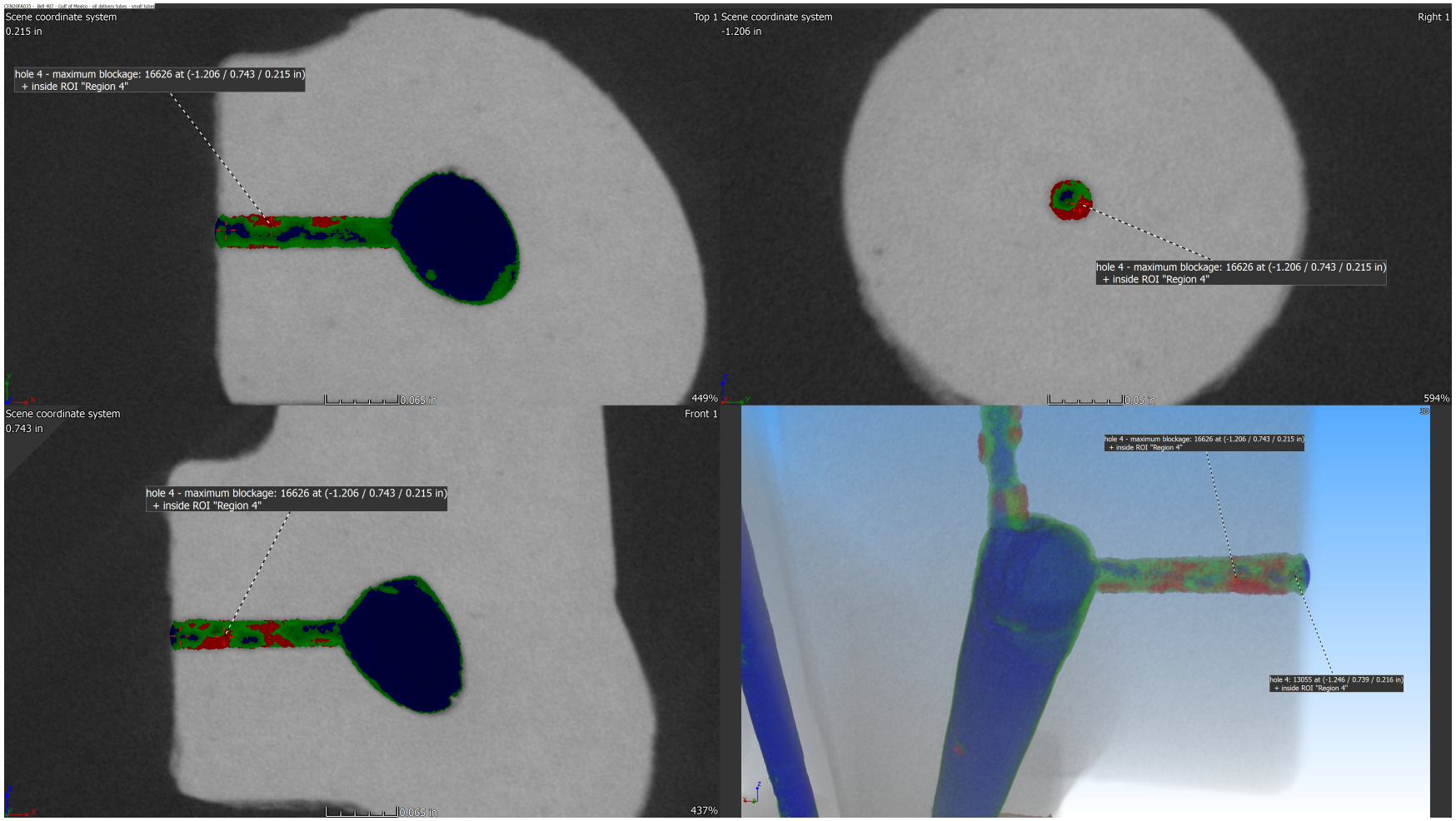


Figure 27
Small tubes – hole 4 – maximum blockage - colorized

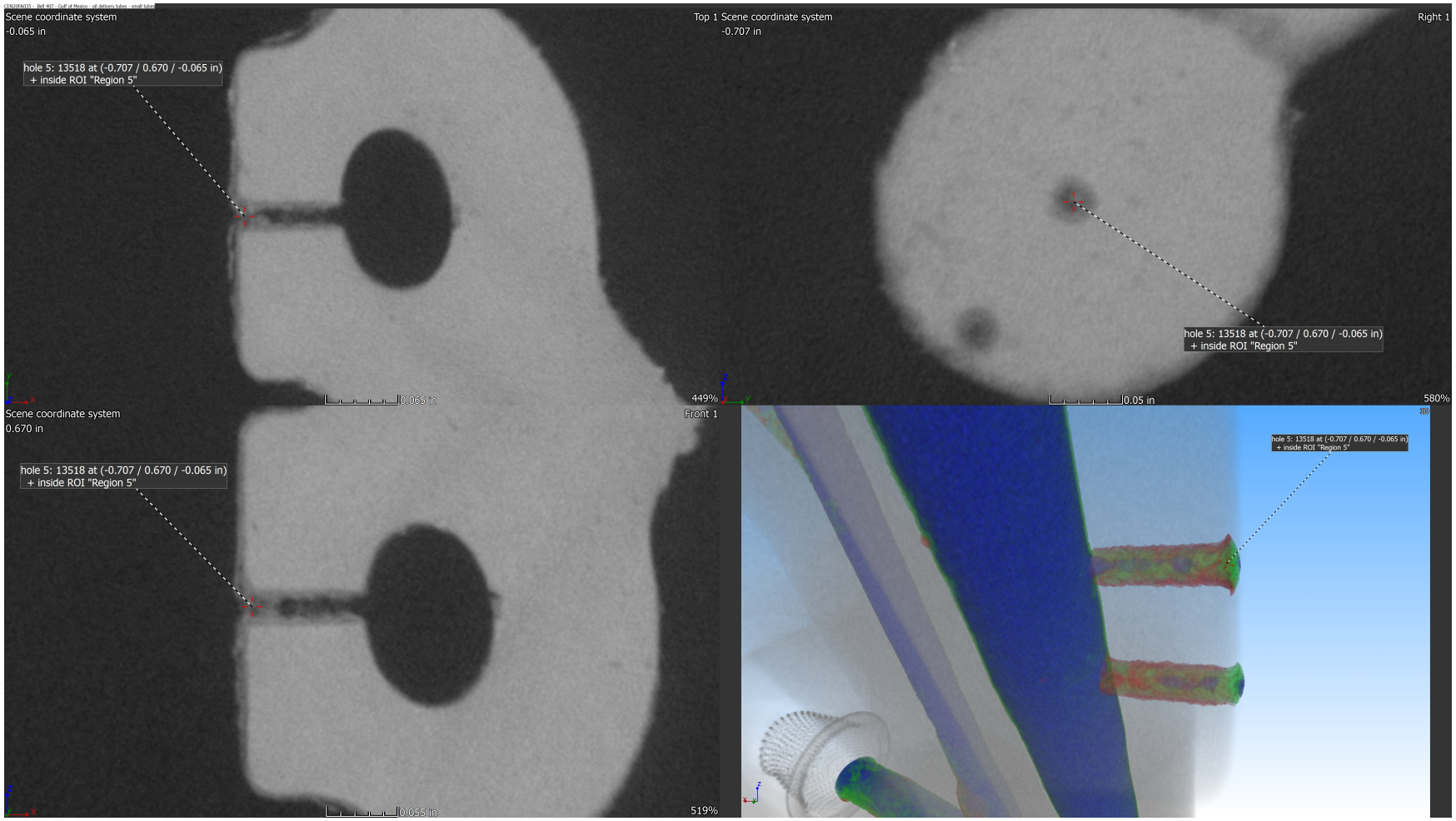


Figure 28
Small tubes – hole 5

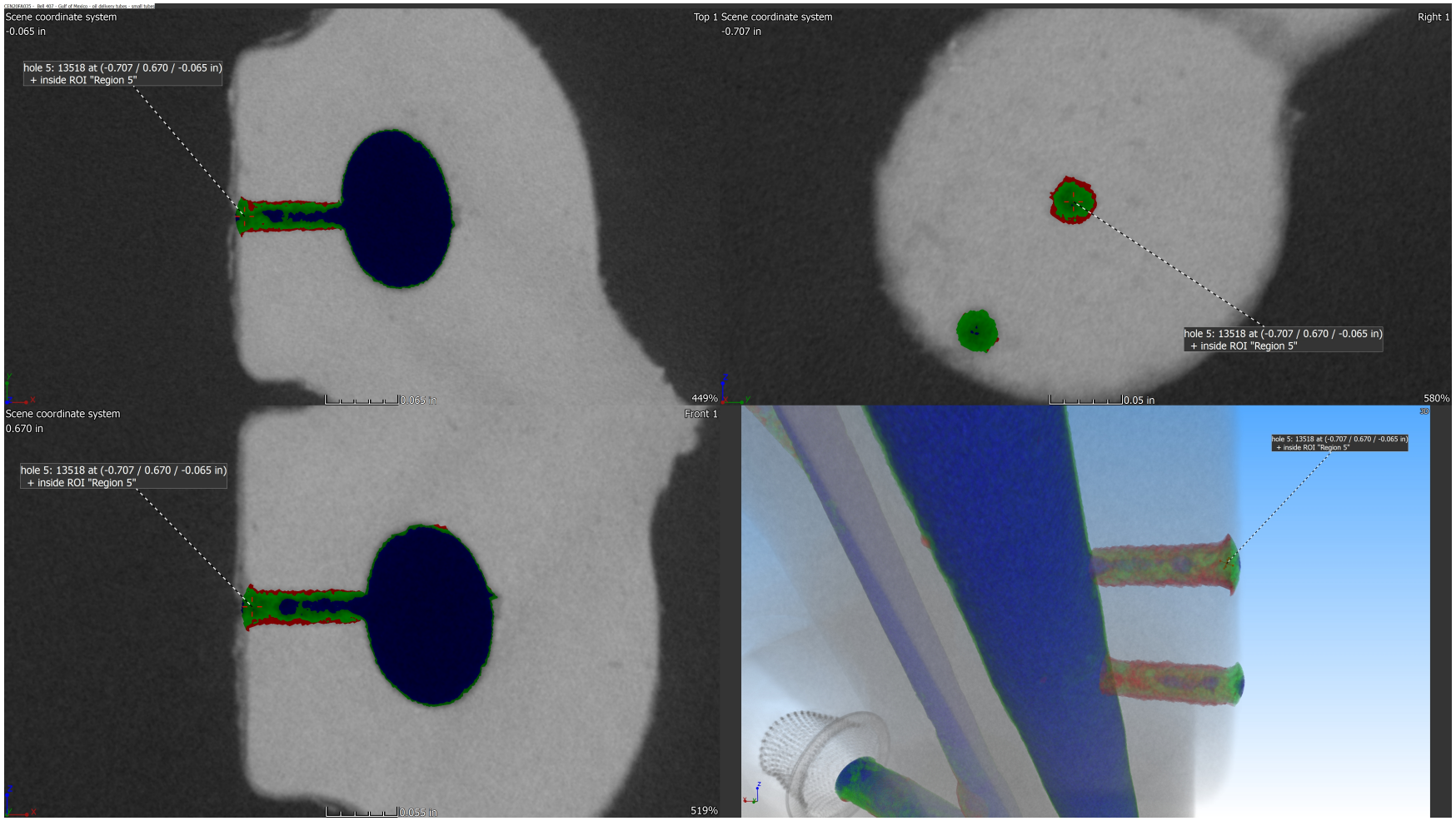


Figure 29
Small tubes – hole 5 - colorized

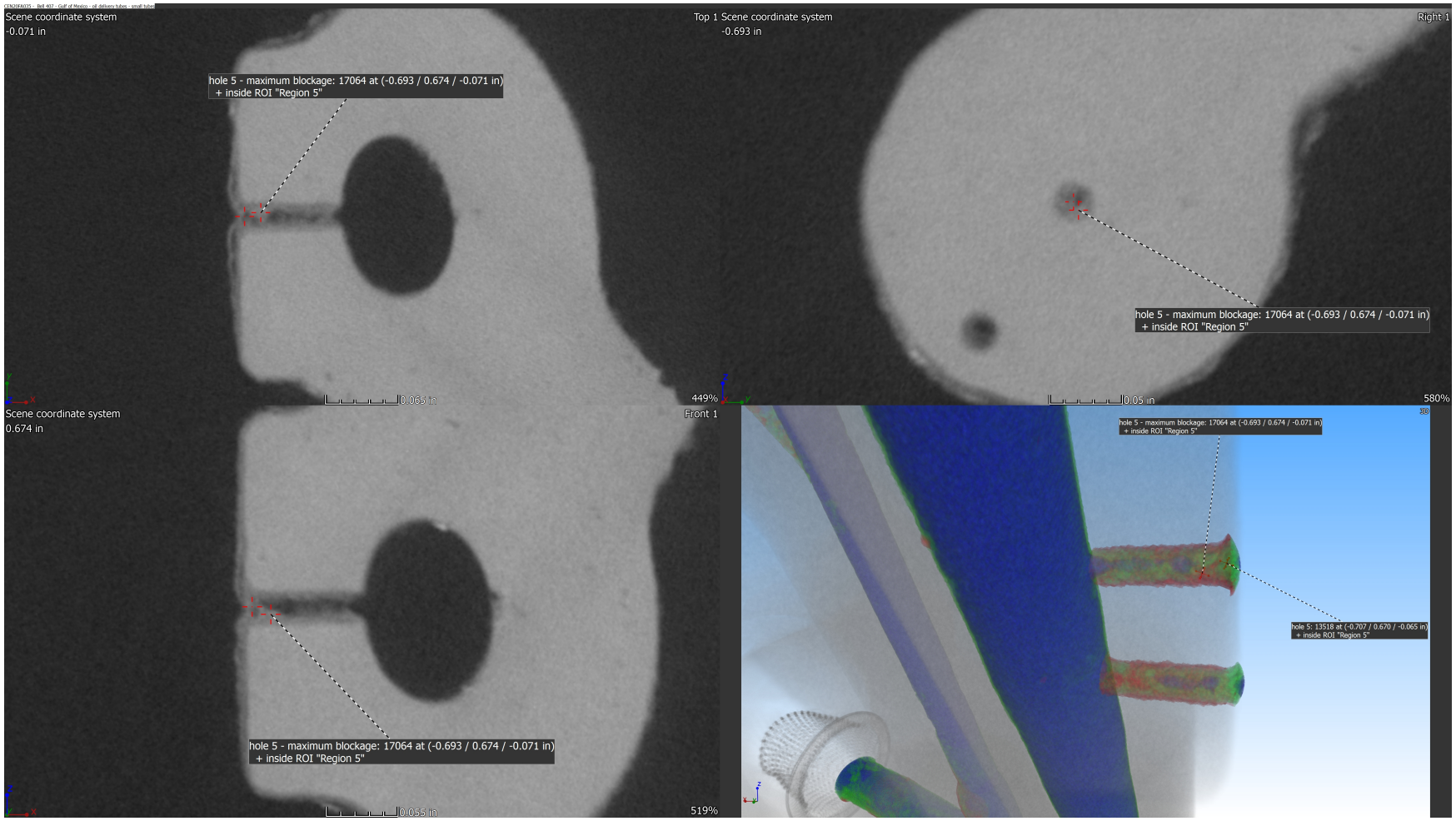


Figure 30
Small tubes – hole 5 – maximum blockage

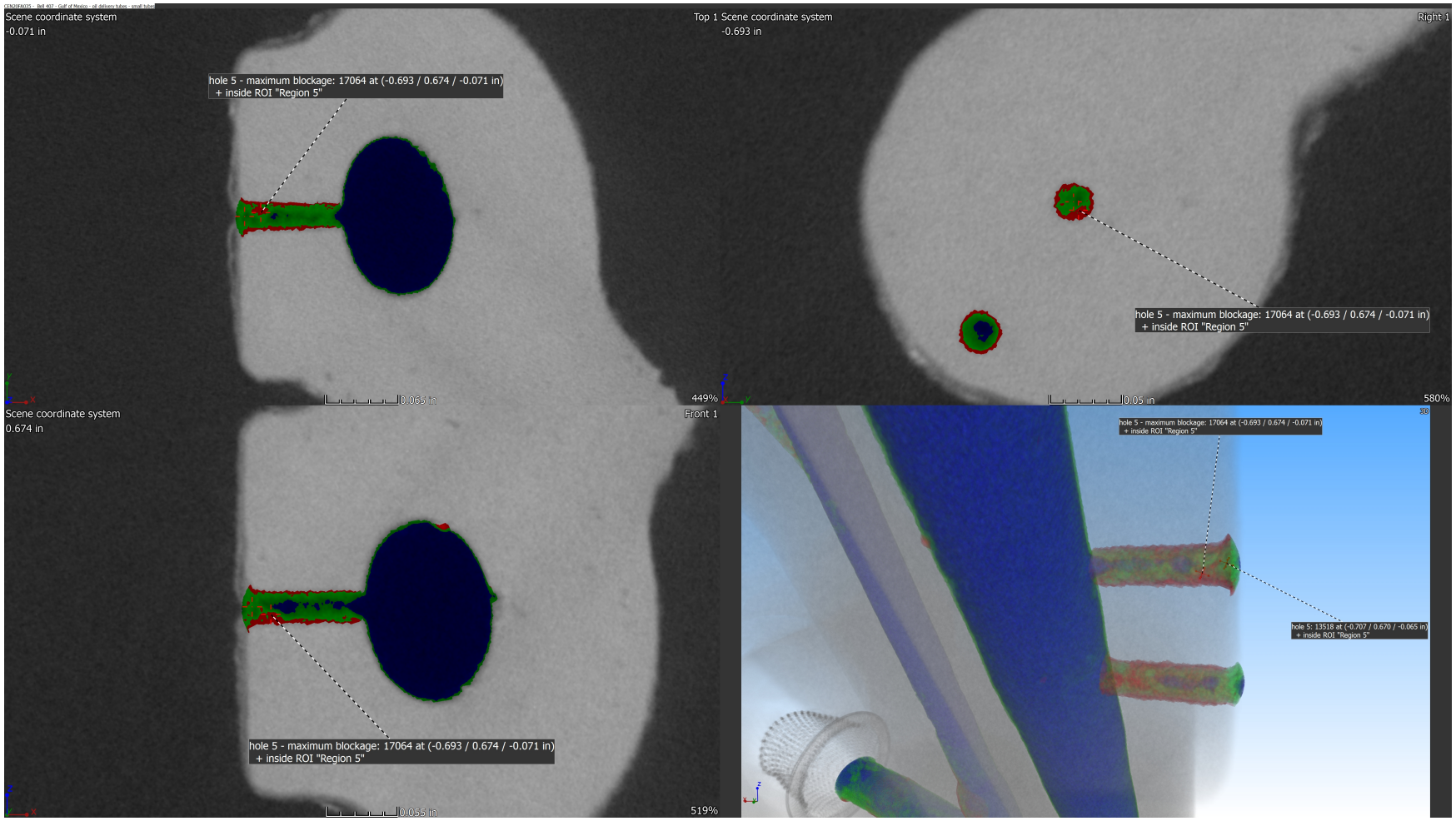


Figure 31
Small tubes – hole 5 – maximum blockage - colorized

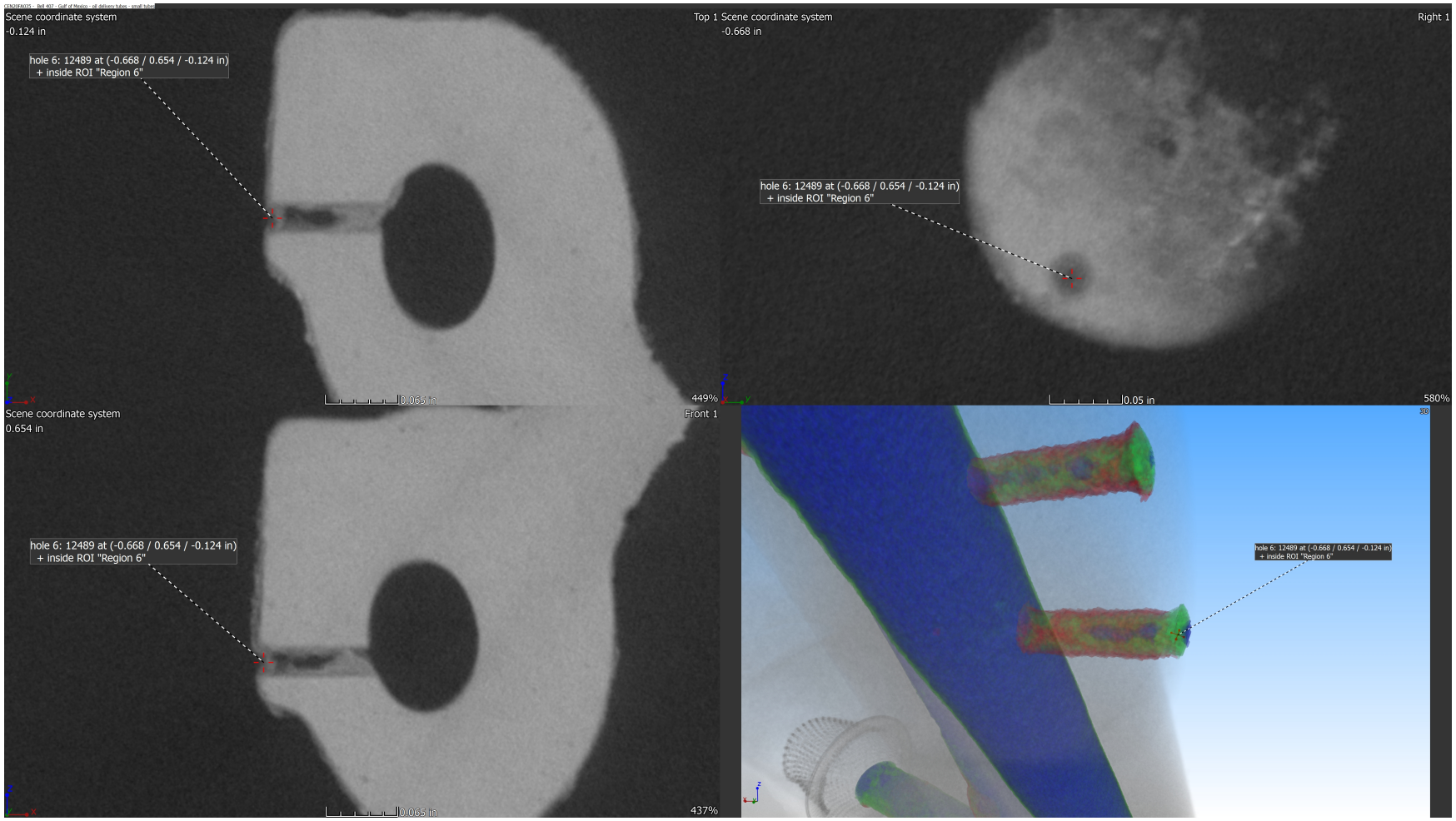


Figure 32
Small tubes – hole 6

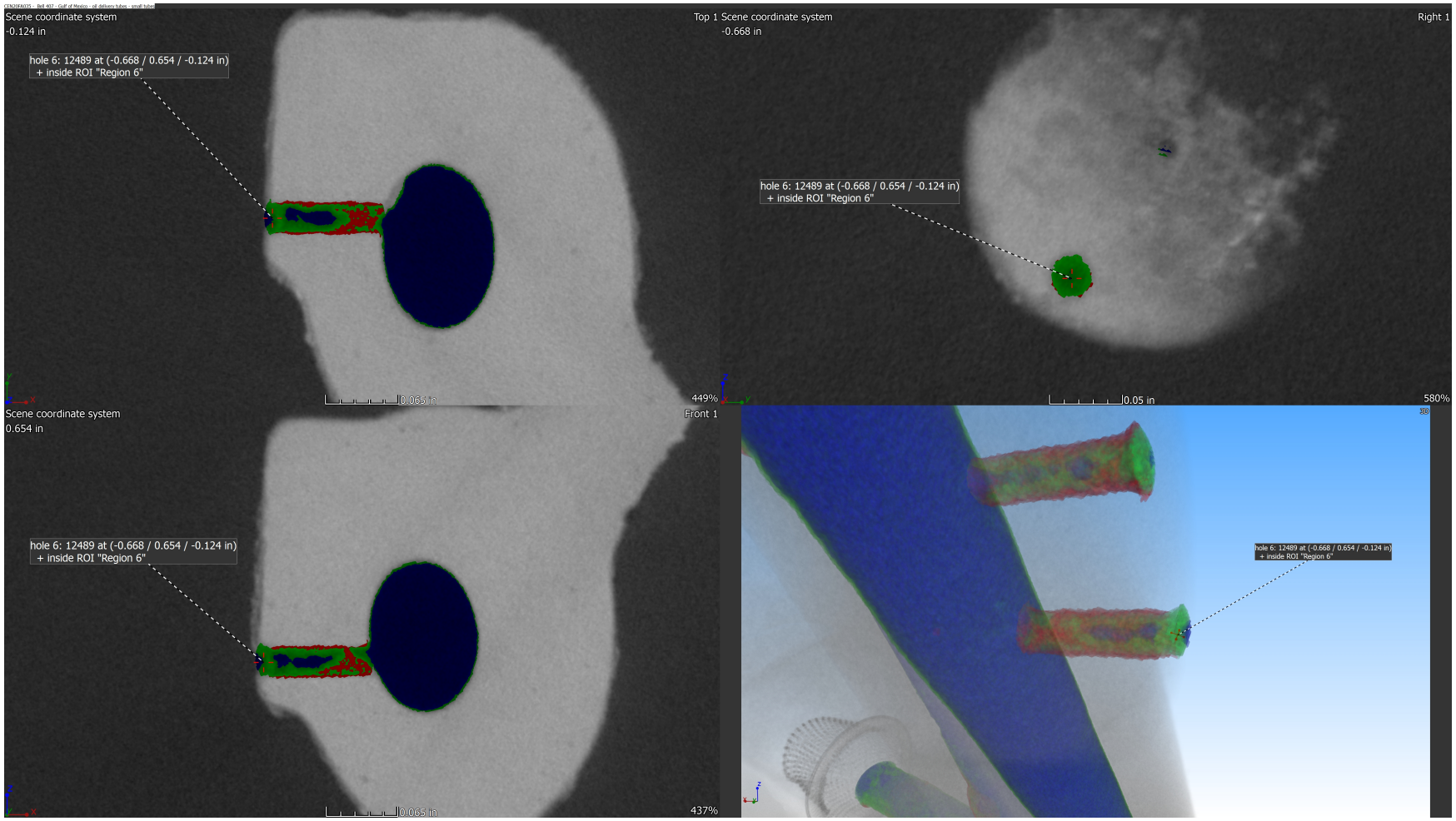


Figure 33
Small tubes – hole 6 - colorized

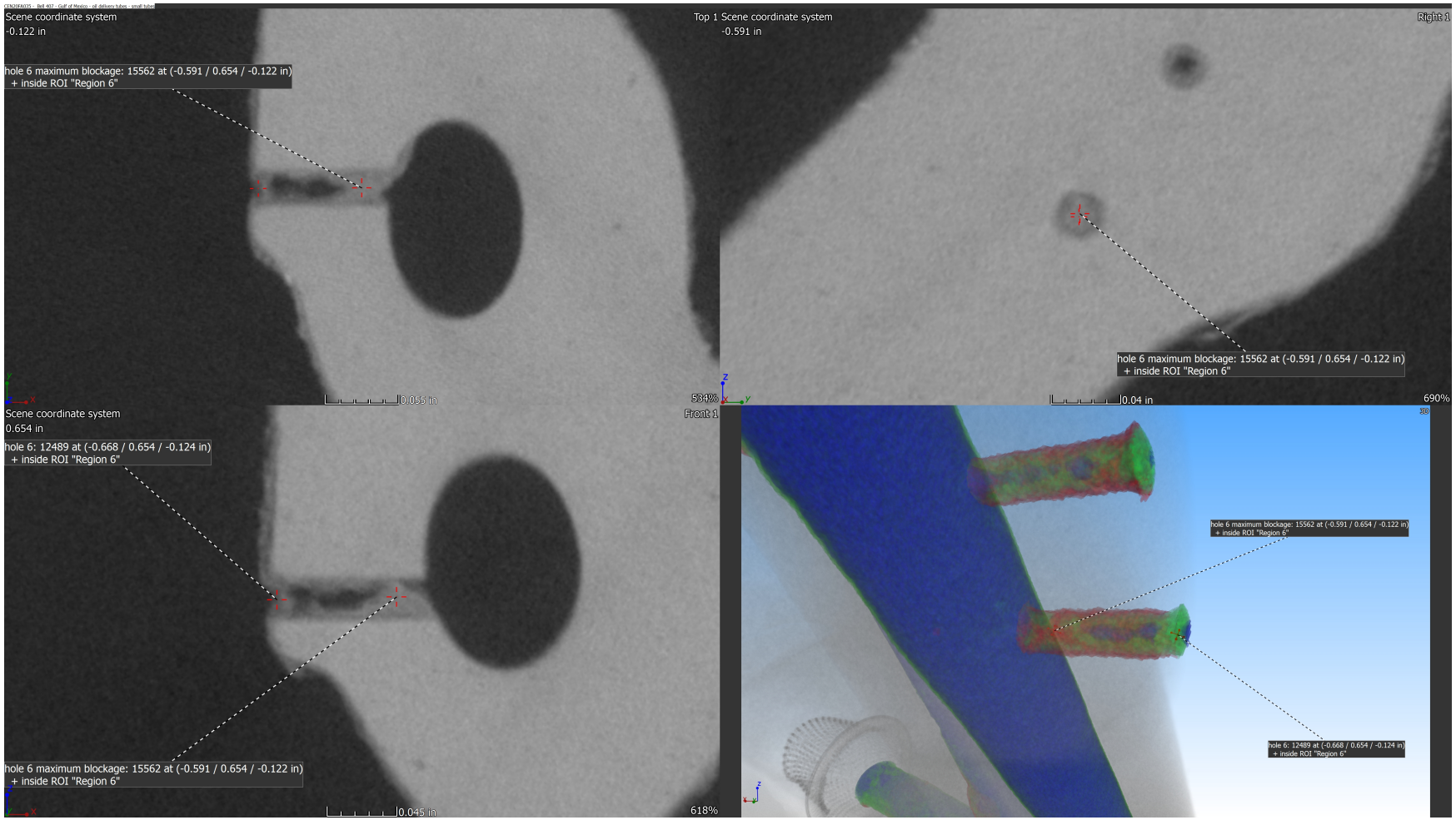


Figure 34
Small tubes – hole 6 – maximum blockage

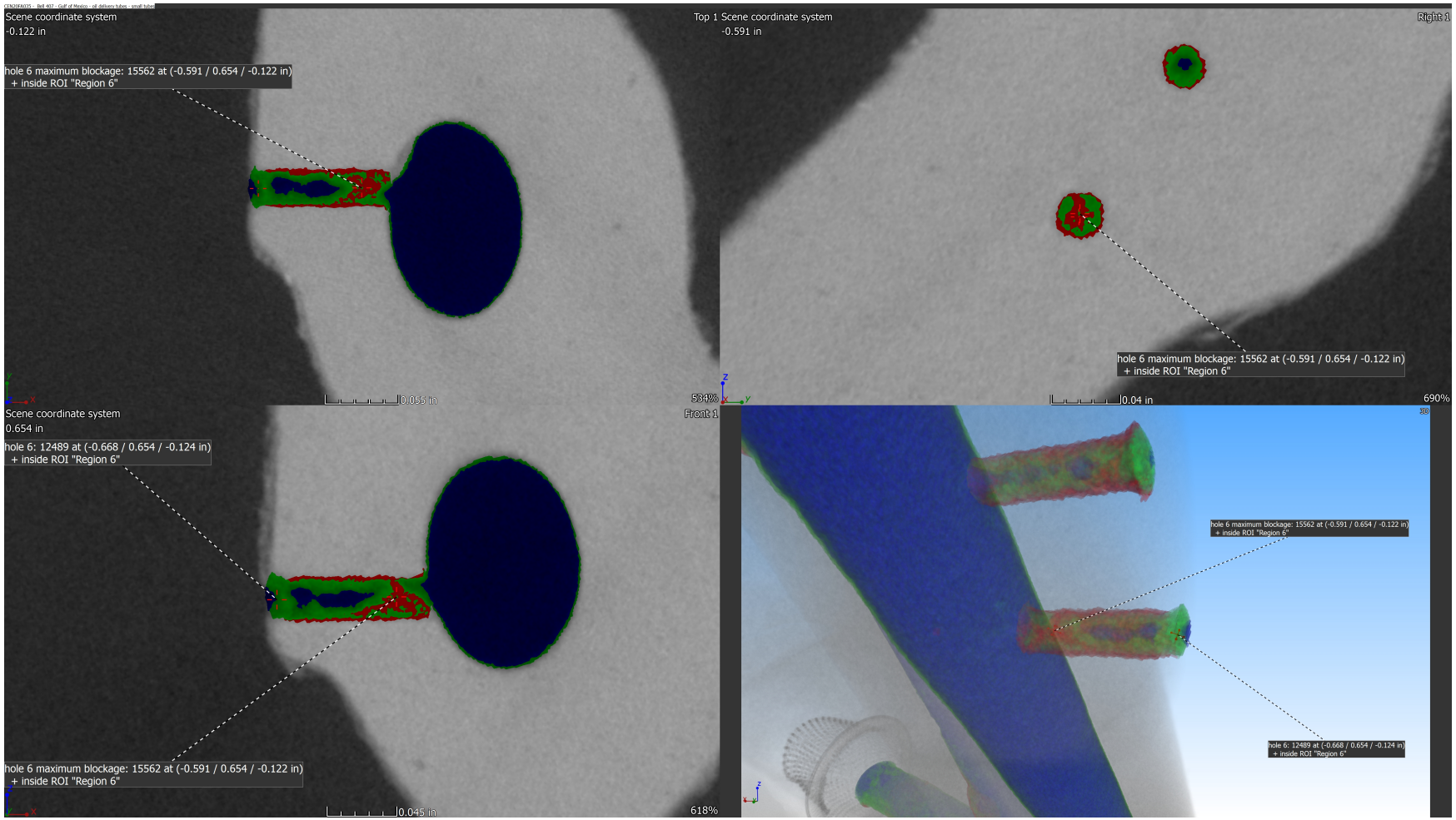


Figure 35
Small tubes – hole 6 – maximum blockage - colorized

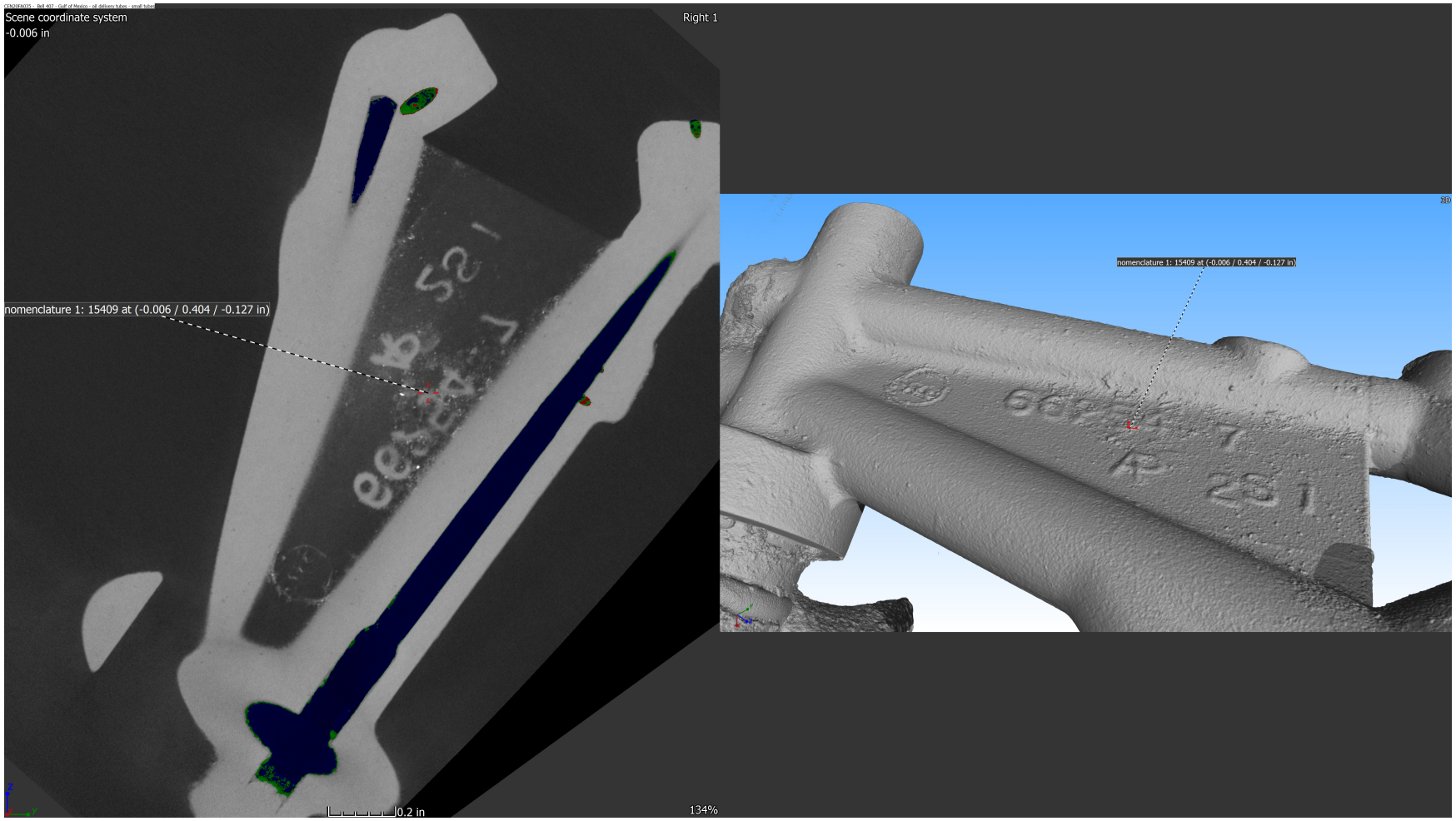


Figure 36
Small tubes – nomenclature 1

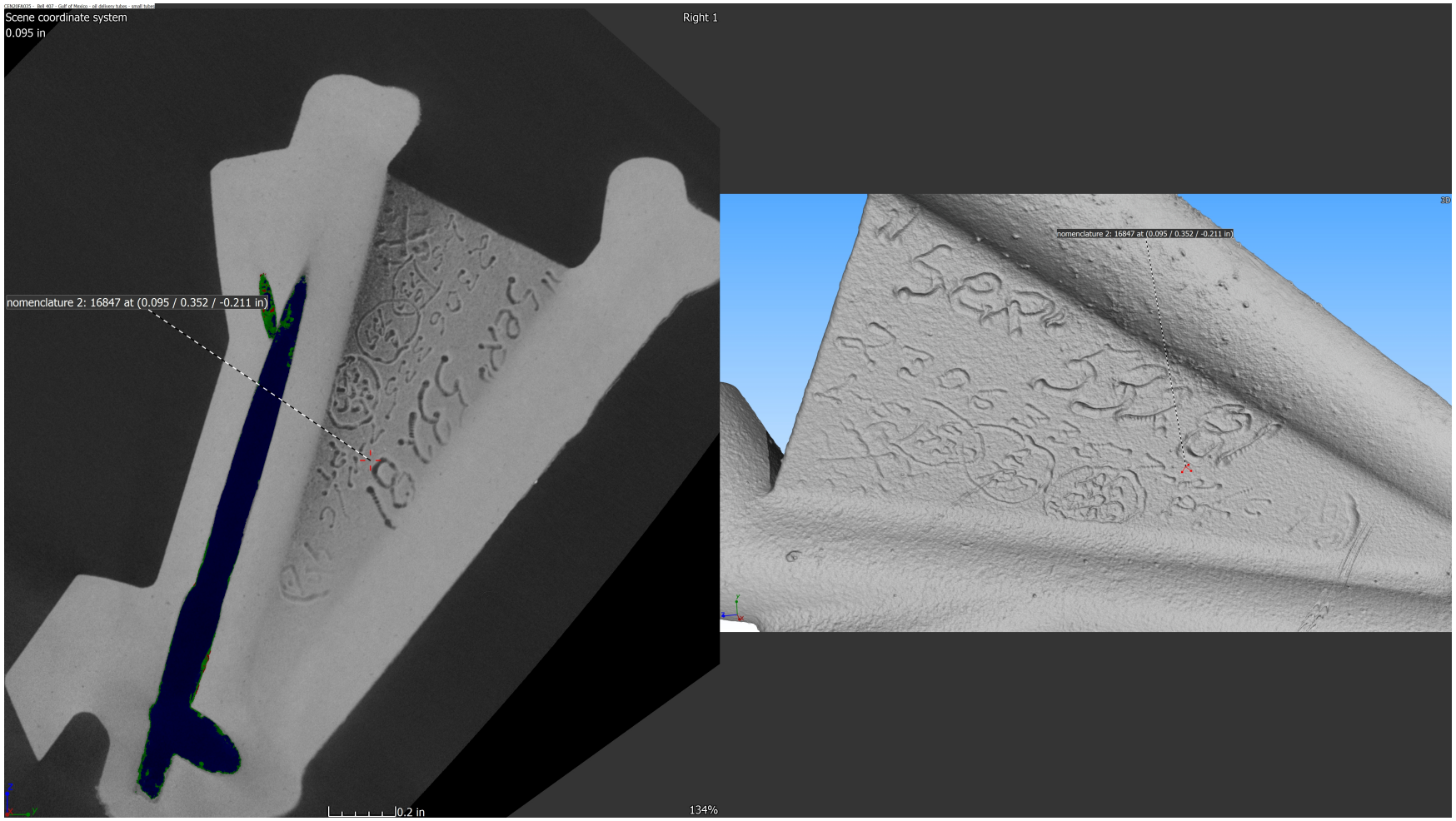


Figure 37
Small tubes – nomenclature 2

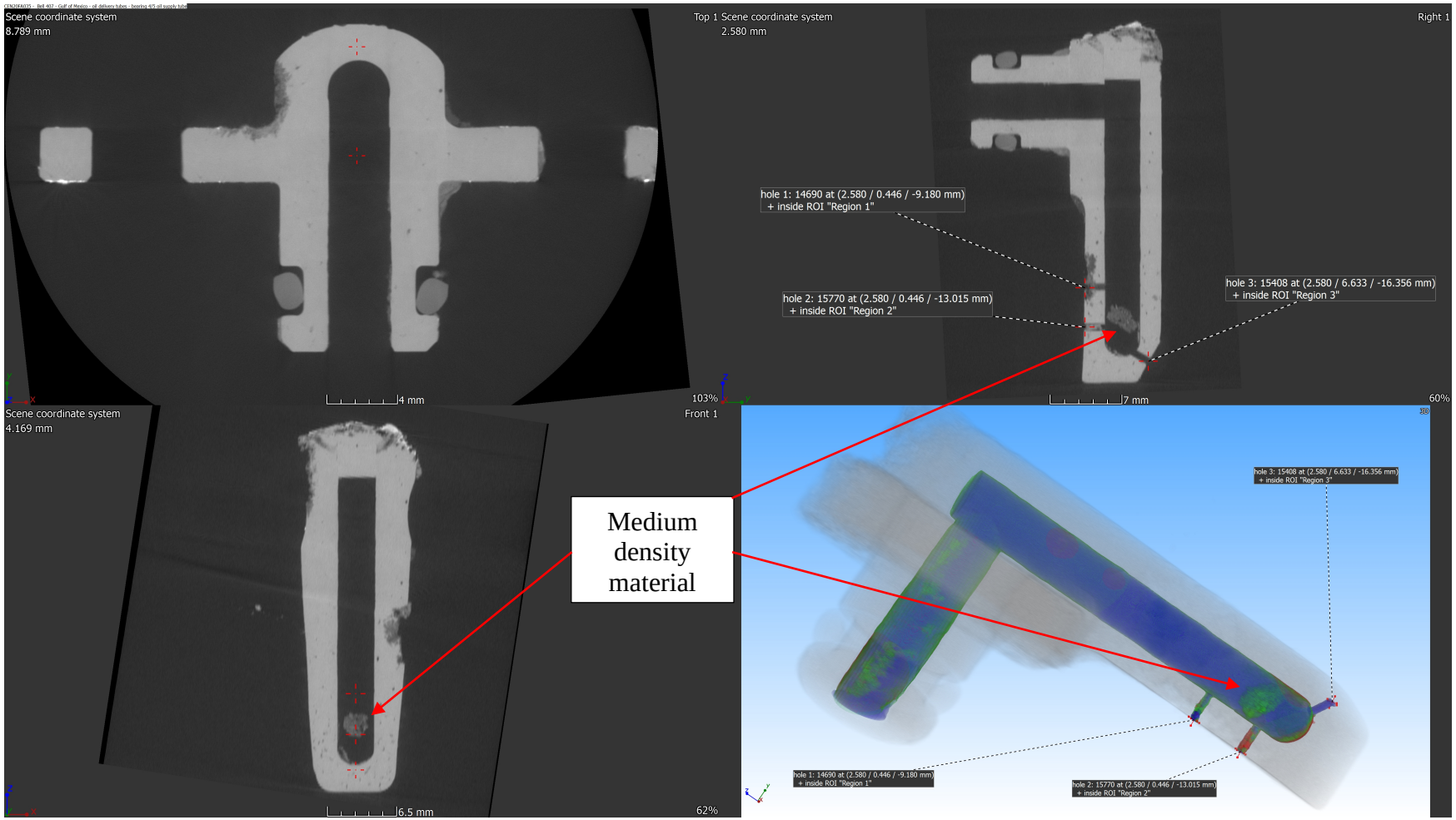


Figure 38
Bearing 4/5 oil supply tube – overview

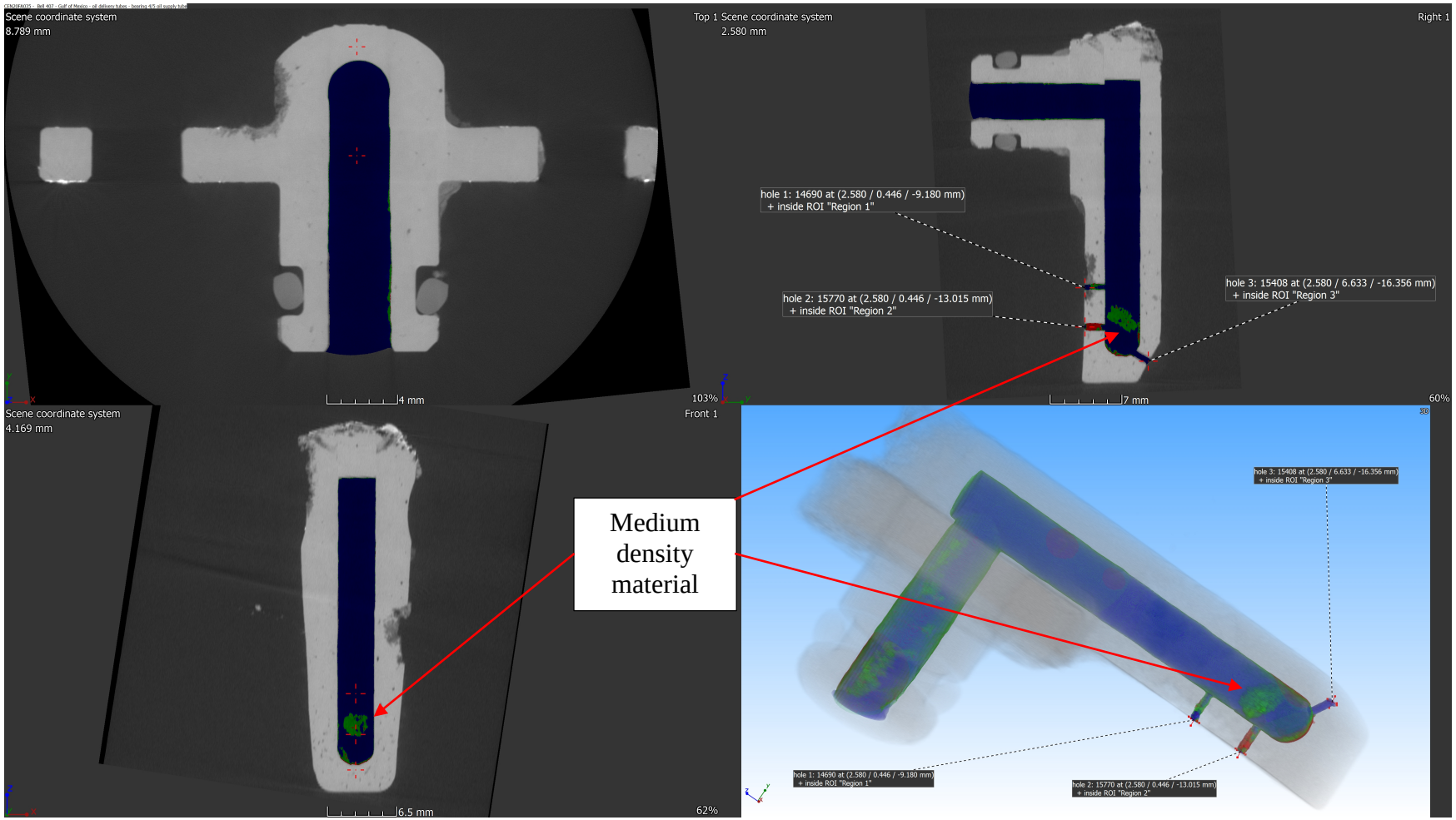


Figure 39
Bearing 4/5 oil supply tube – overview - colorized

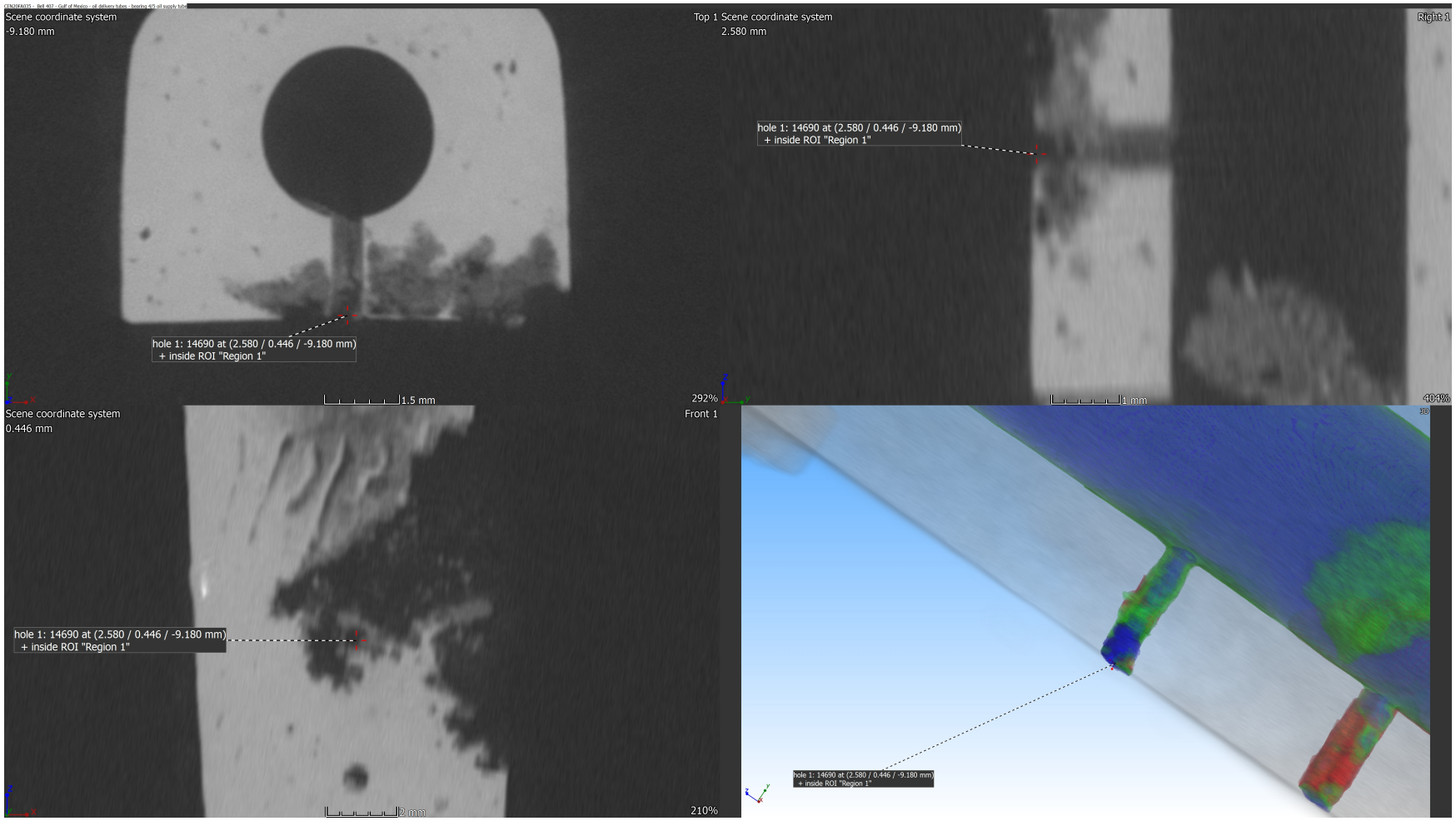


Figure 40
Bearing 4/5 oil supply tube – hole 1

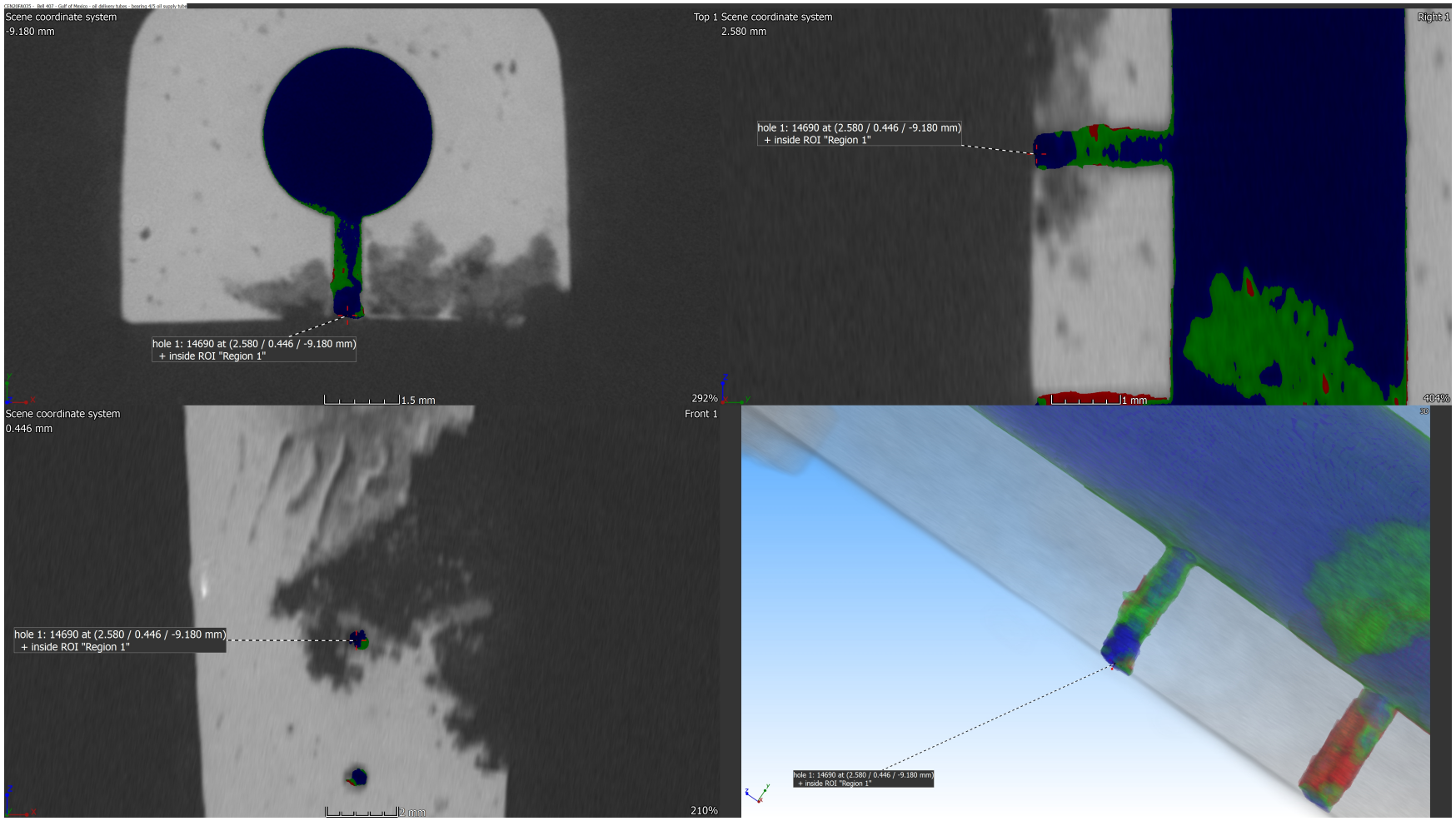


Figure 41
Bearing 4/5 oil supply tube – hole 1 - colorized

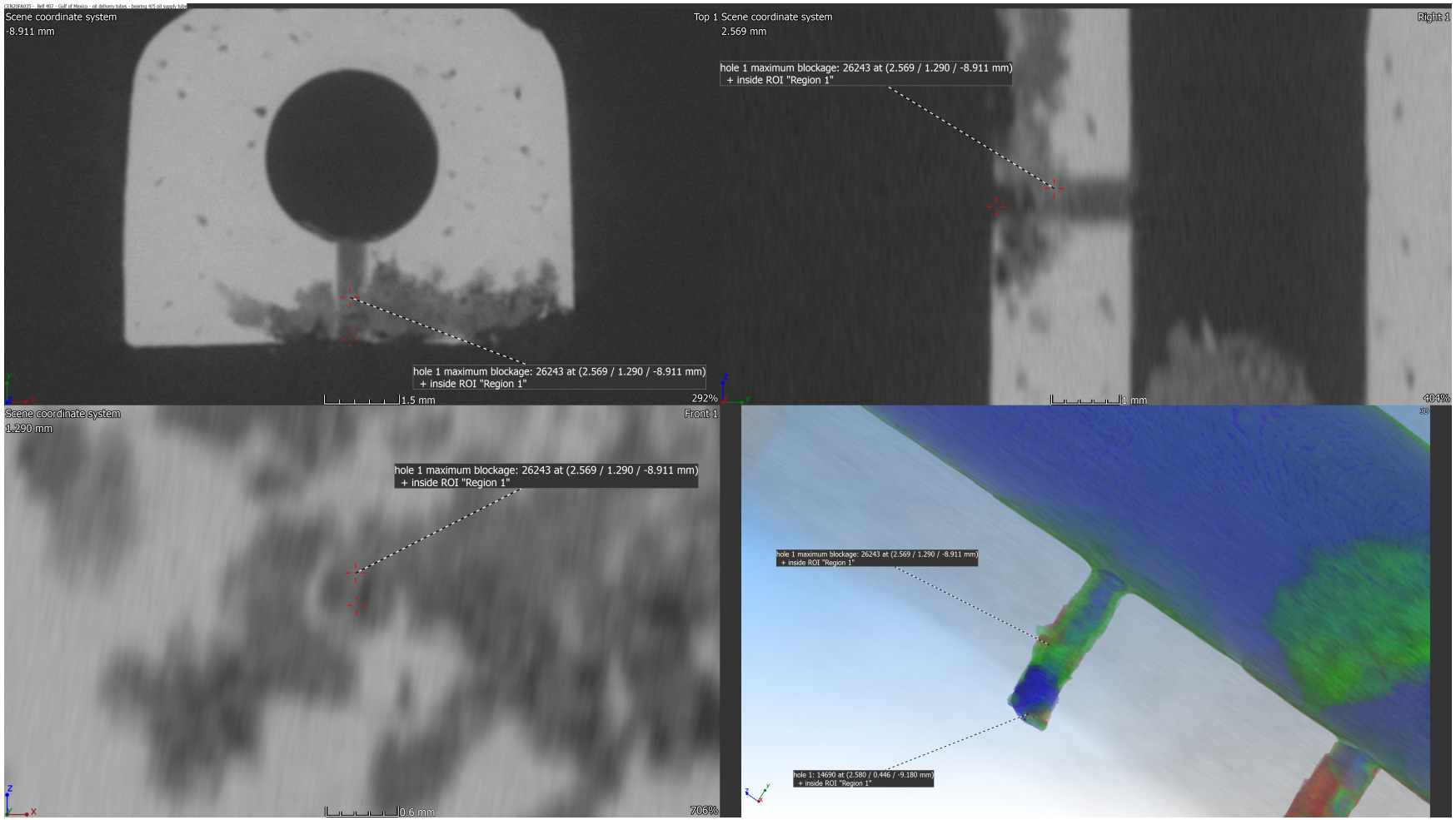


Figure 42
Bearing 4/5 oil supply tube – hole 1 – maximum blockage

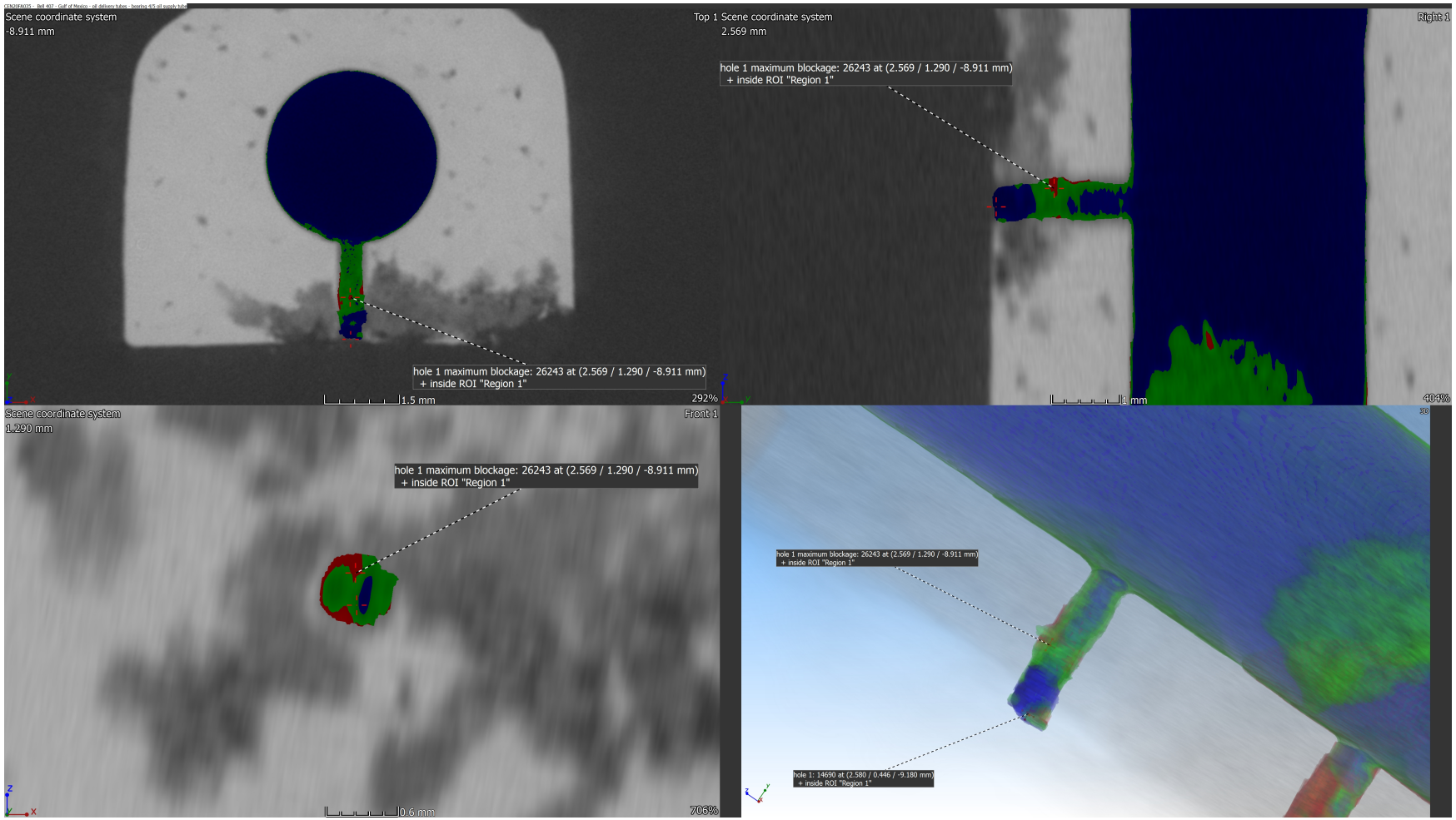


Figure 43
Bearing 4/5 oil supply tube – hole 1 – maximum blockage - colorized

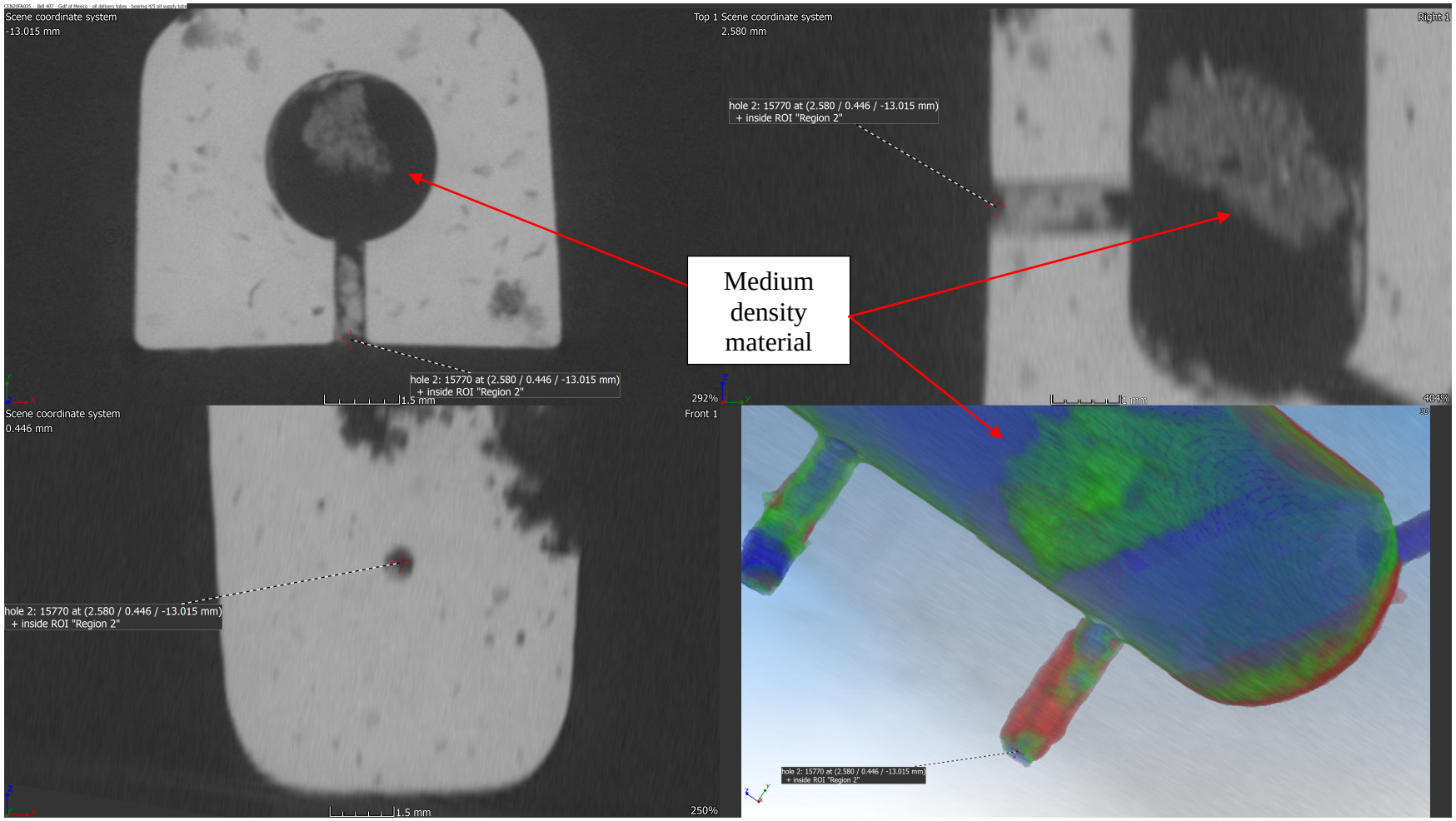


Figure 44
Bearing 4/5 oil supply tube – hole 2

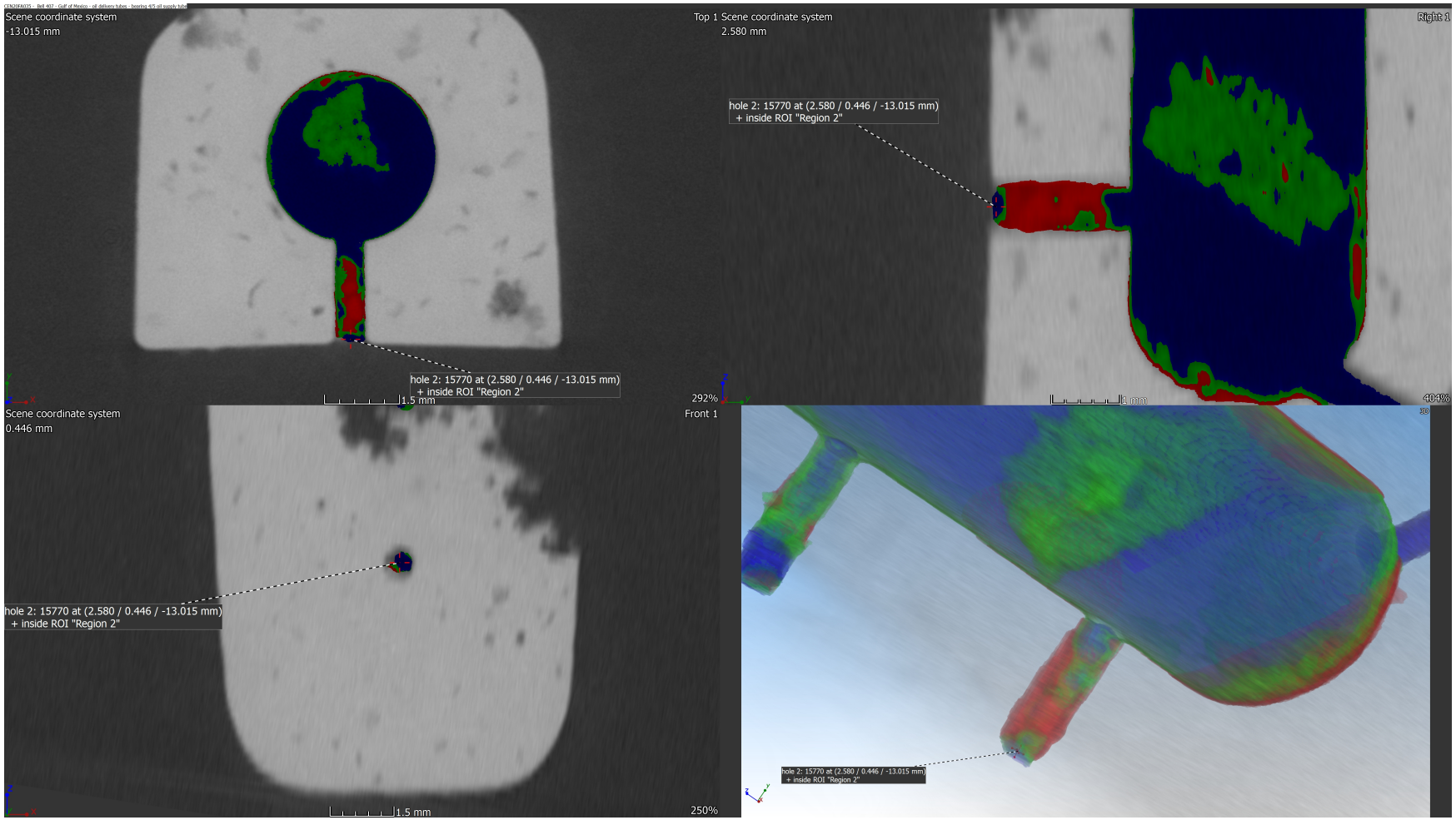


Figure 45
Bearing 4/5 oil supply tube – hole 2 - colorized

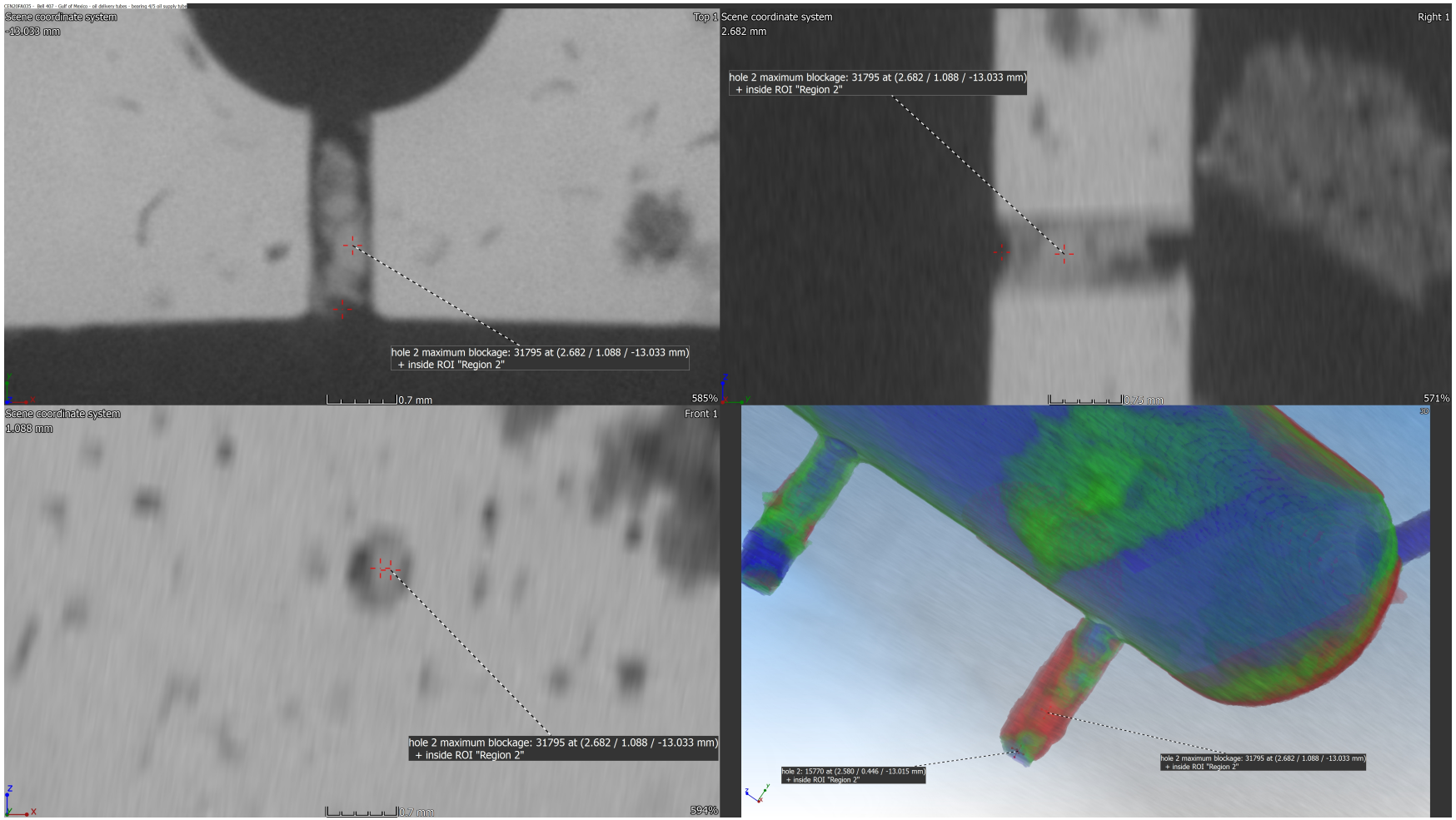


Figure 46
Bearing 4/5 oil supply tube – hole 2 – maximum blockage

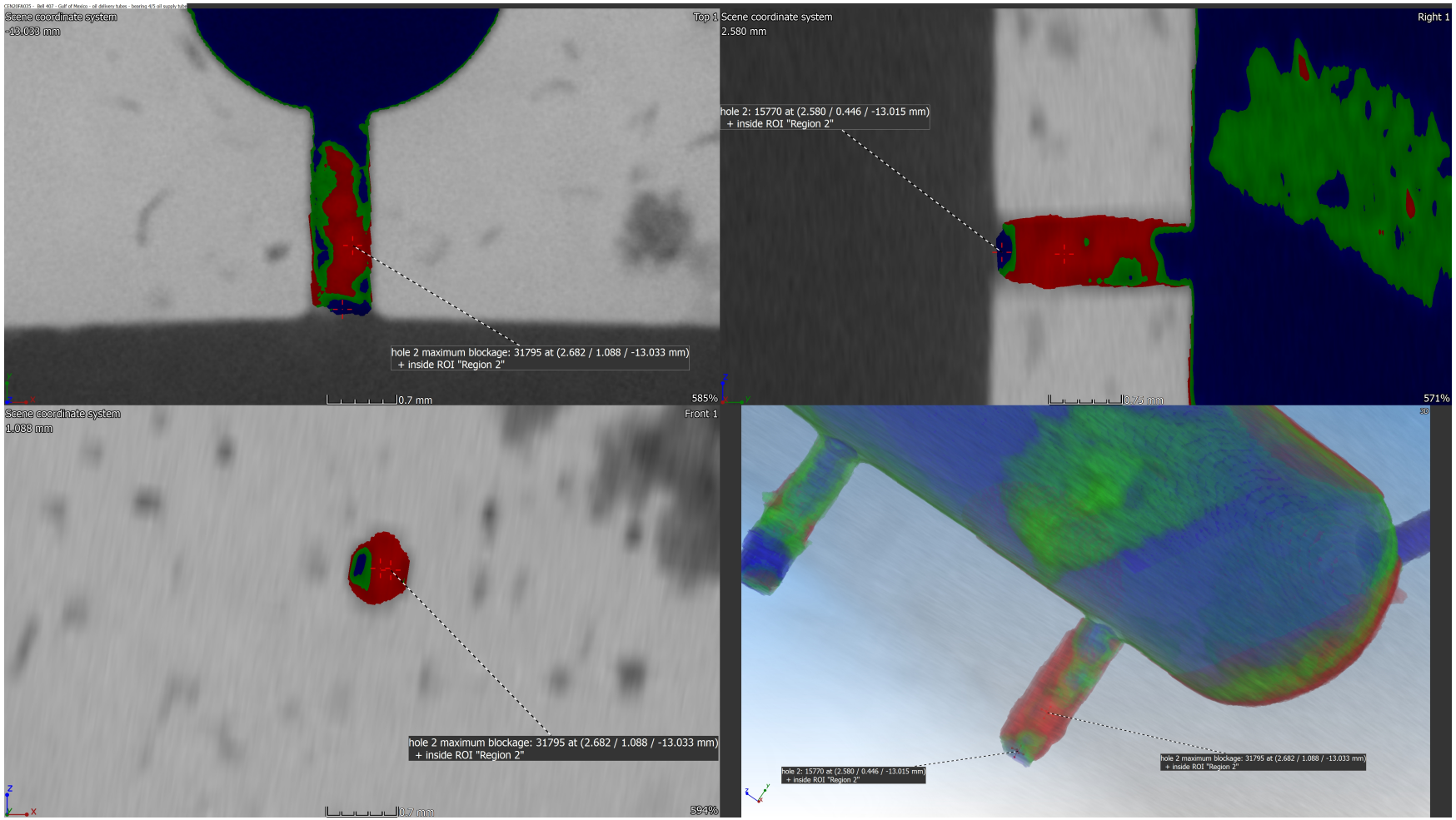


Figure 47
Bearing 4/5 oil supply tube – hole 2 – maximum blockage - colorized

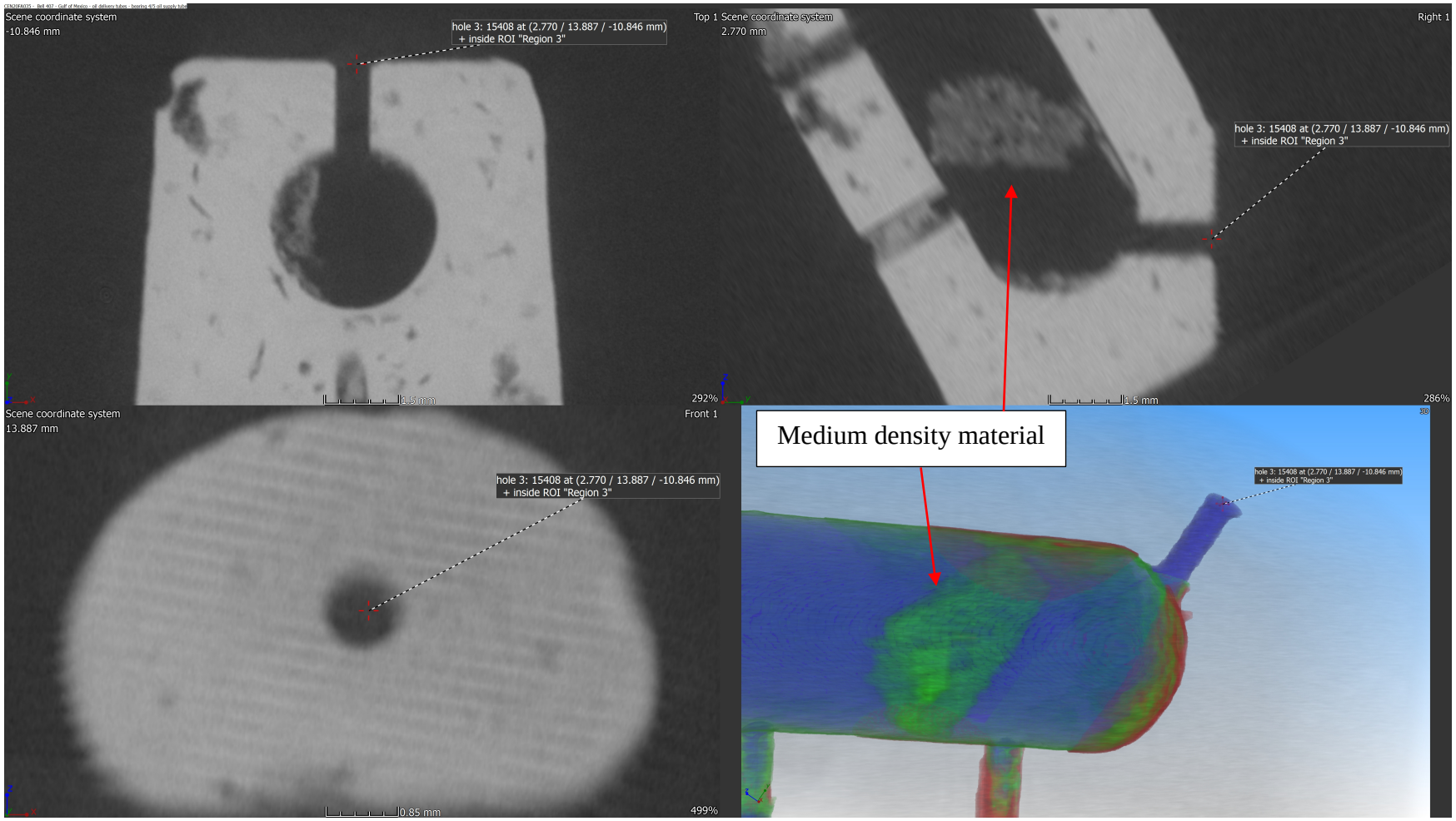


Figure 48
Bearing 4/5 oil supply tube – hole 3

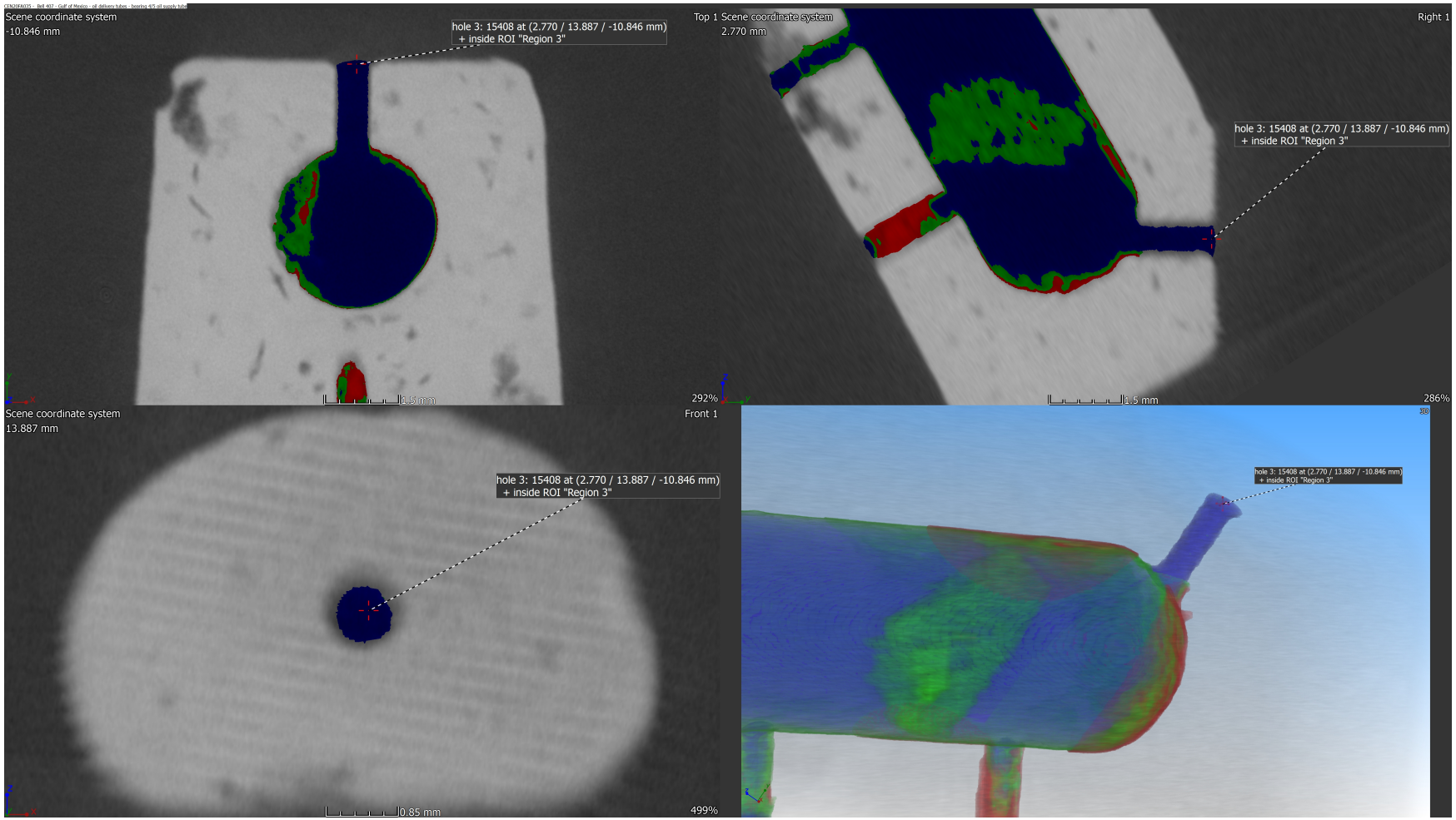


Figure 49
Bearing 4/5 oil supply tube – hole 3 - colorized

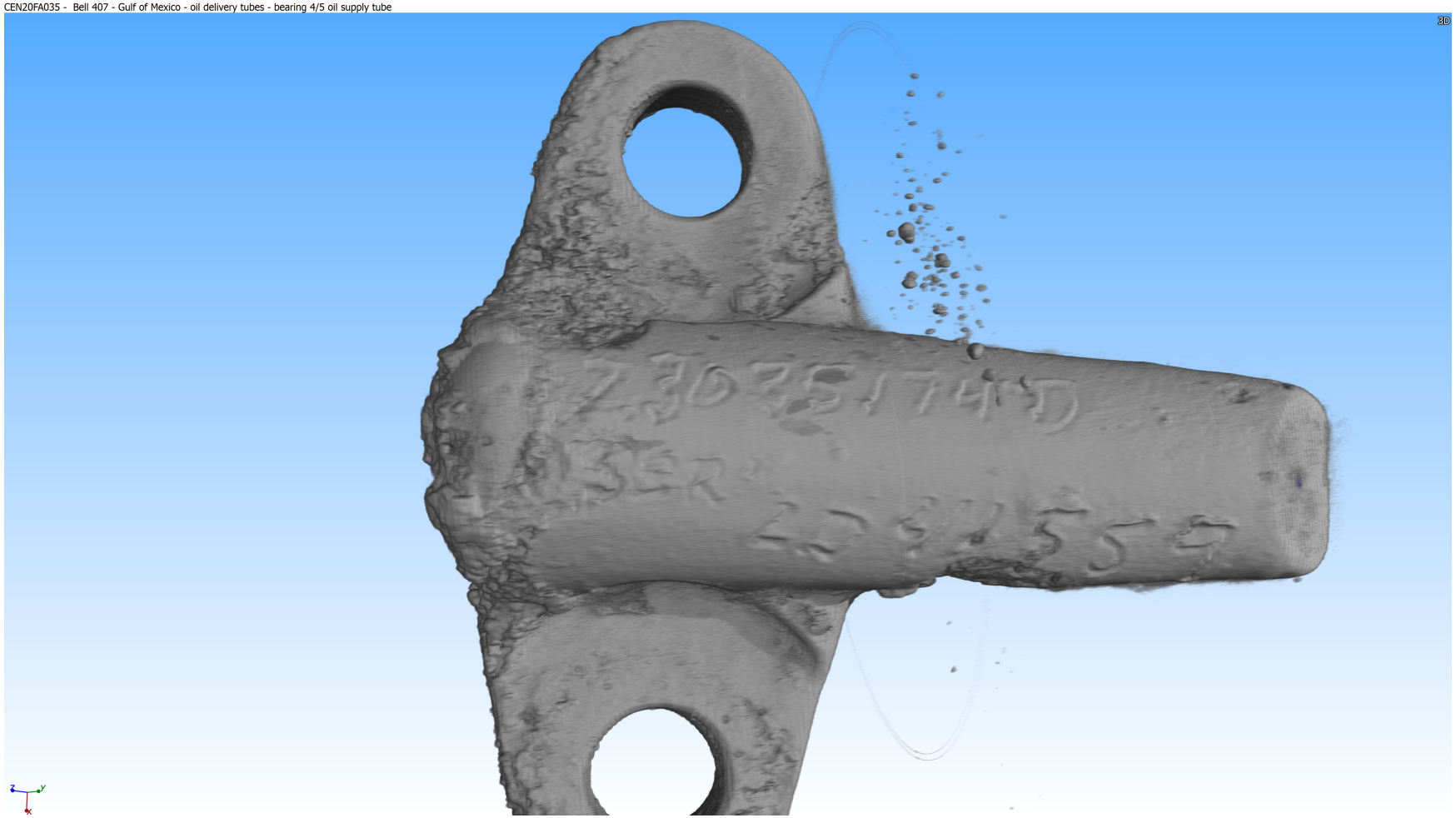


Figure 50
Bearing 4/5 oil supply tube – nomenclature 1

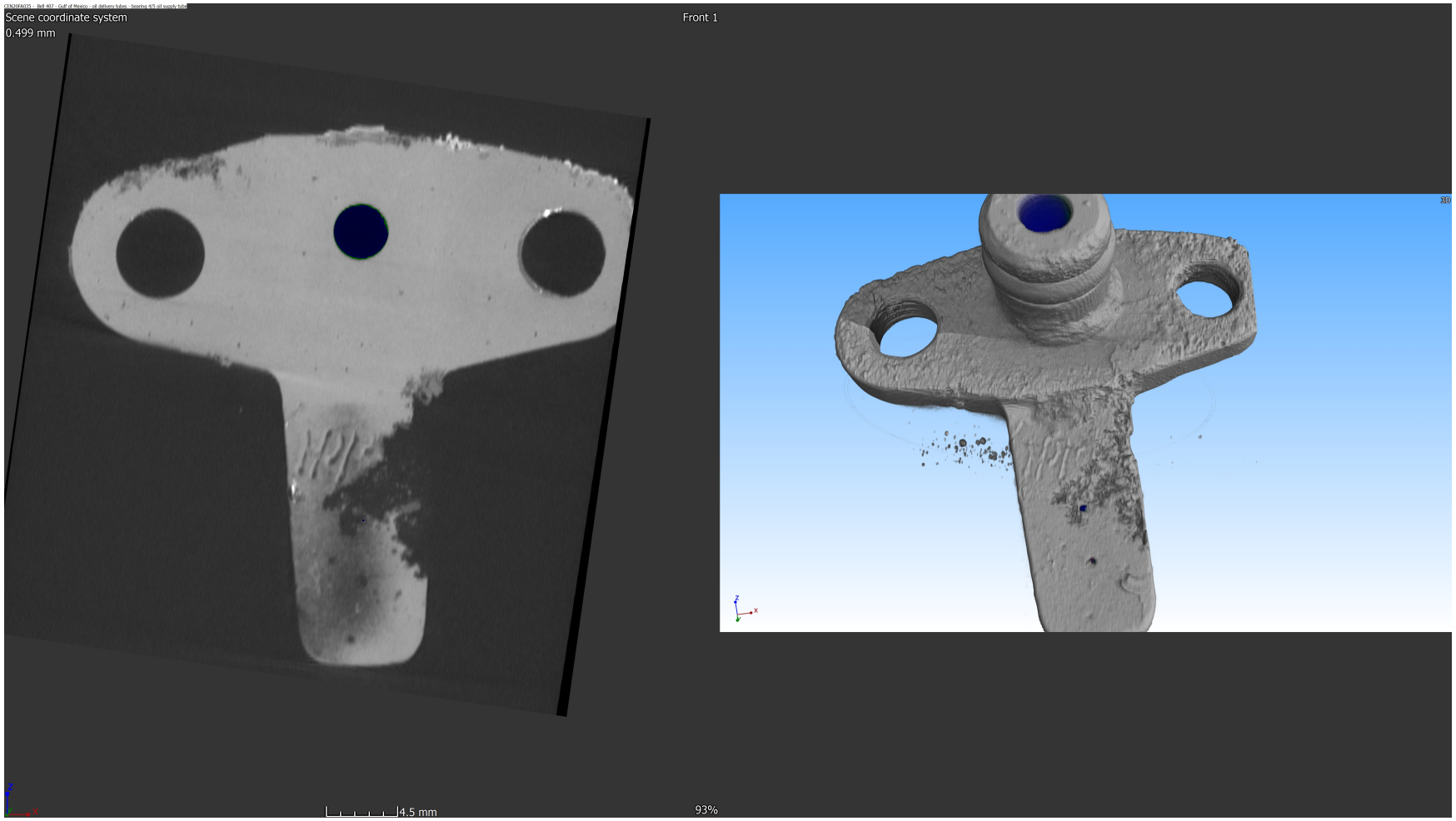


Figure 51
Bearing 4/5 oil supply tube – nomenclature 2

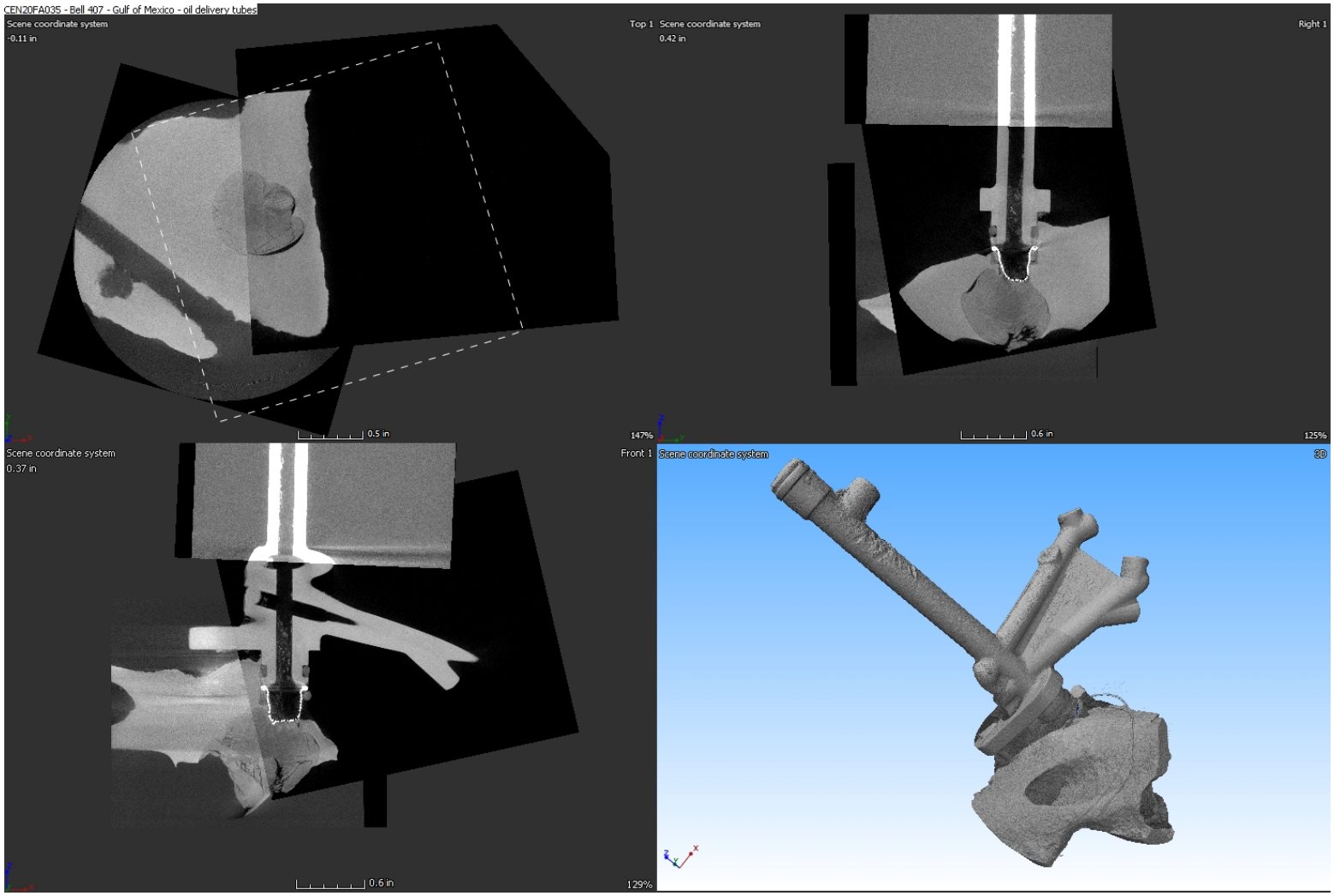


Figure 52
All tubes – overview 1

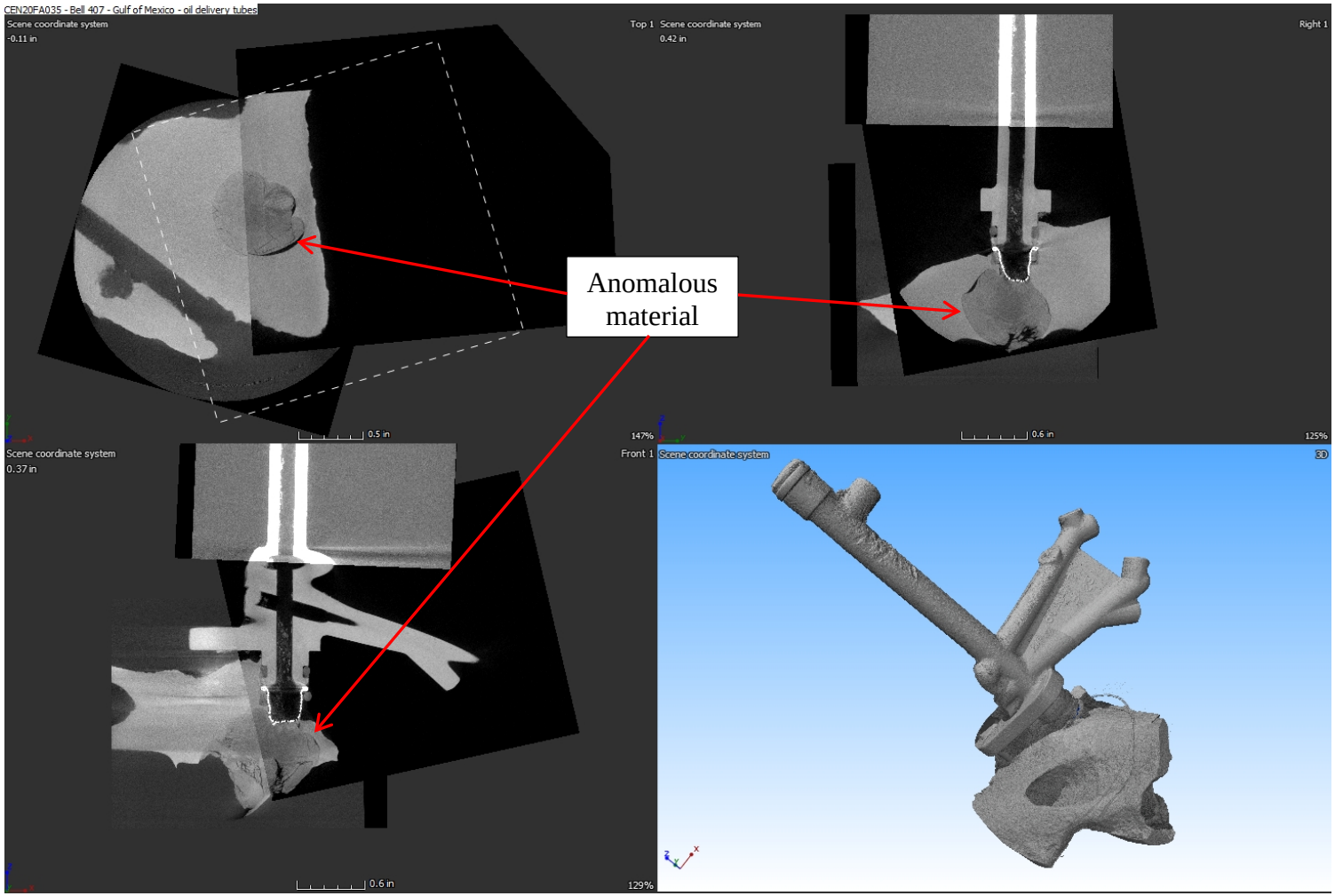


Figure 53
All tubes – overview 2

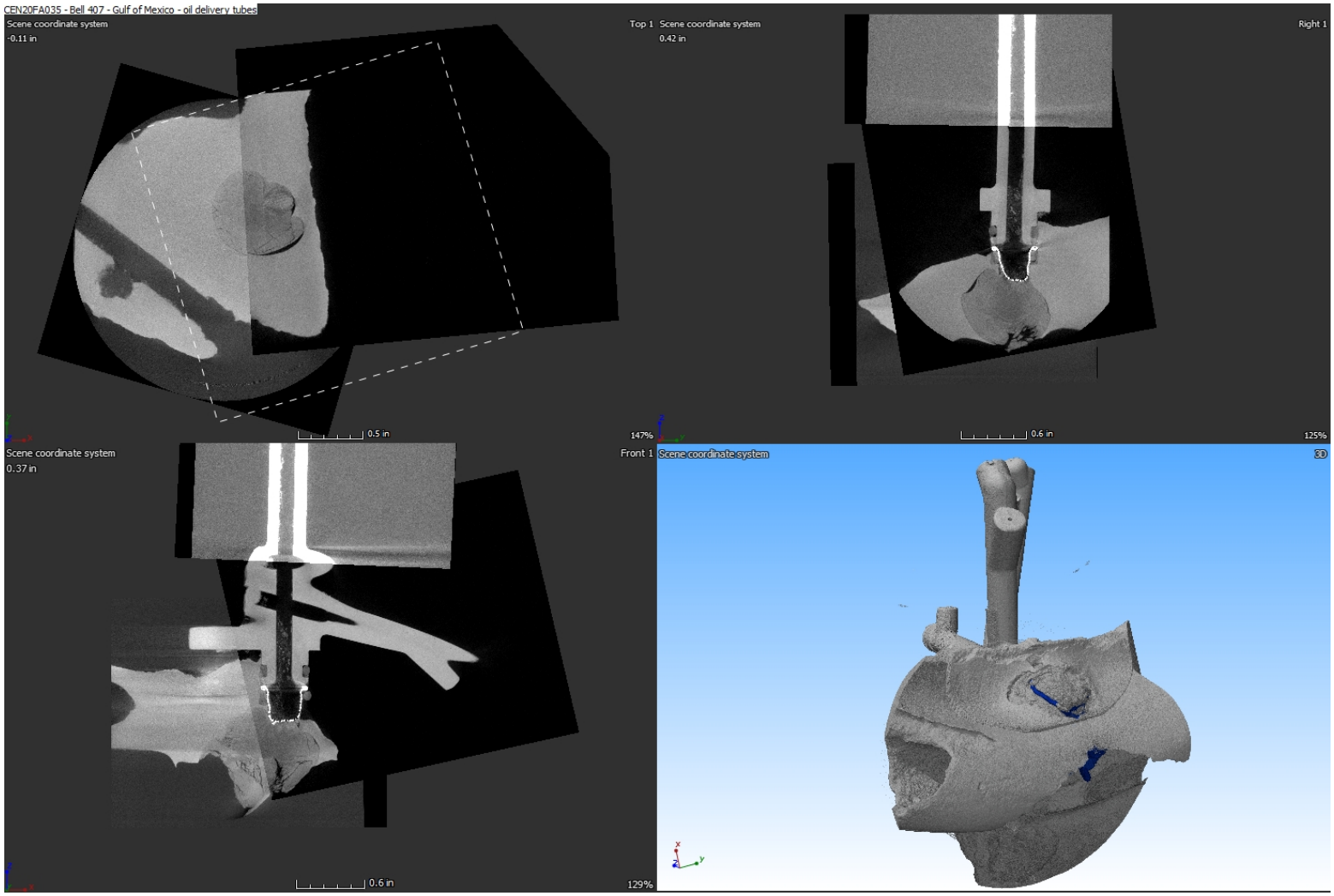


Figure 54
All tubes – overview 3

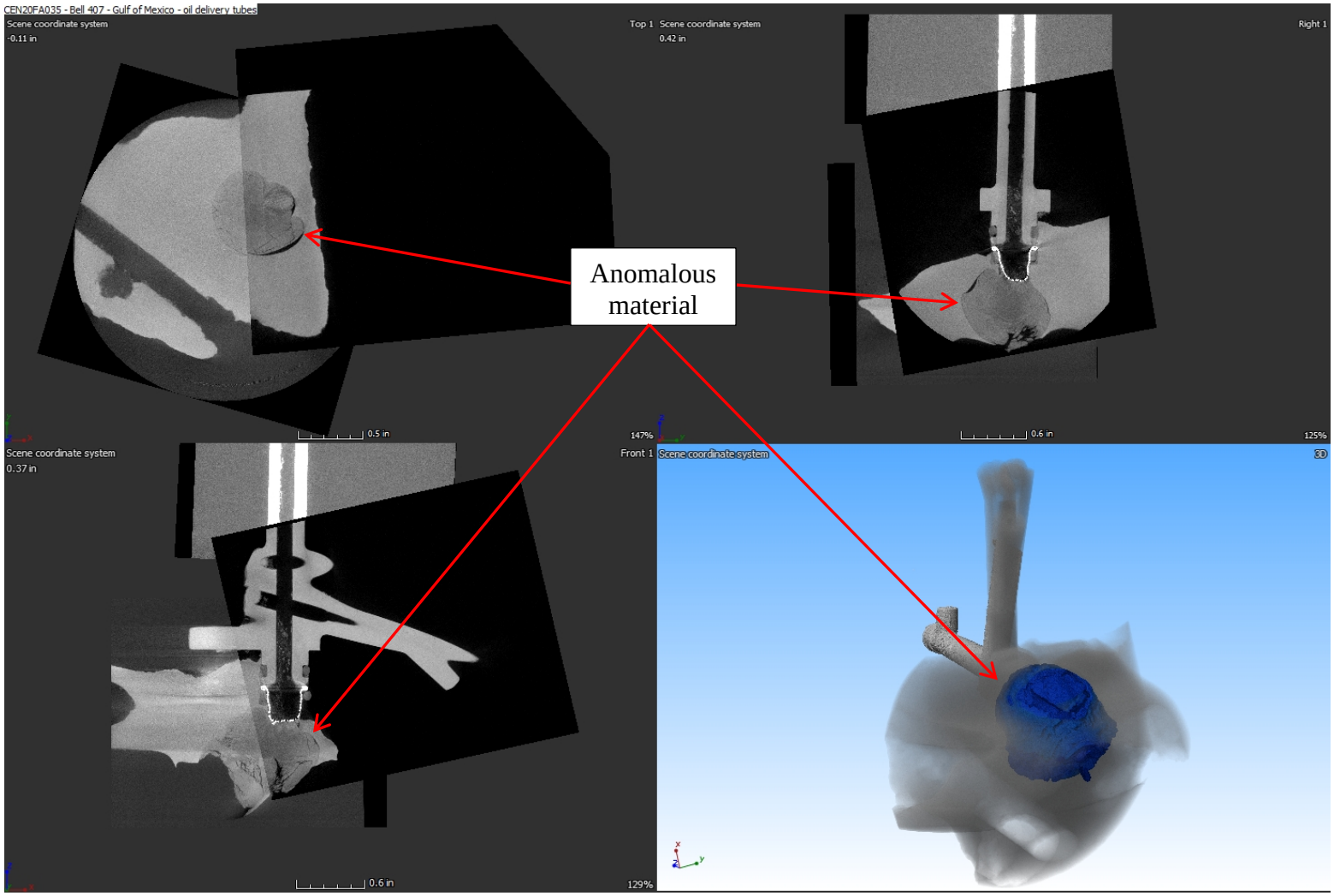


Figure 55
All tubes – overview 4

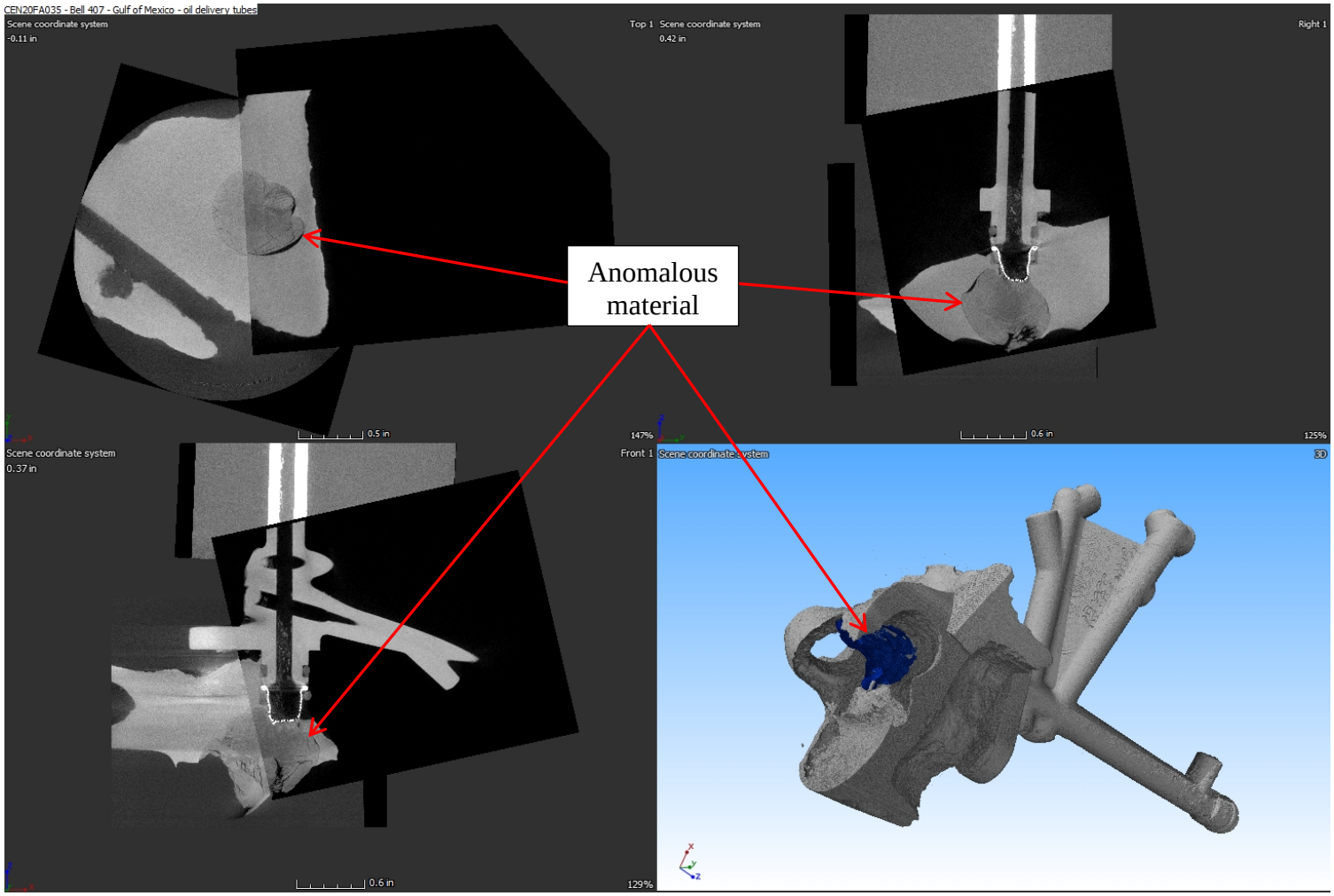


Figure 56
All tubes – overview 5

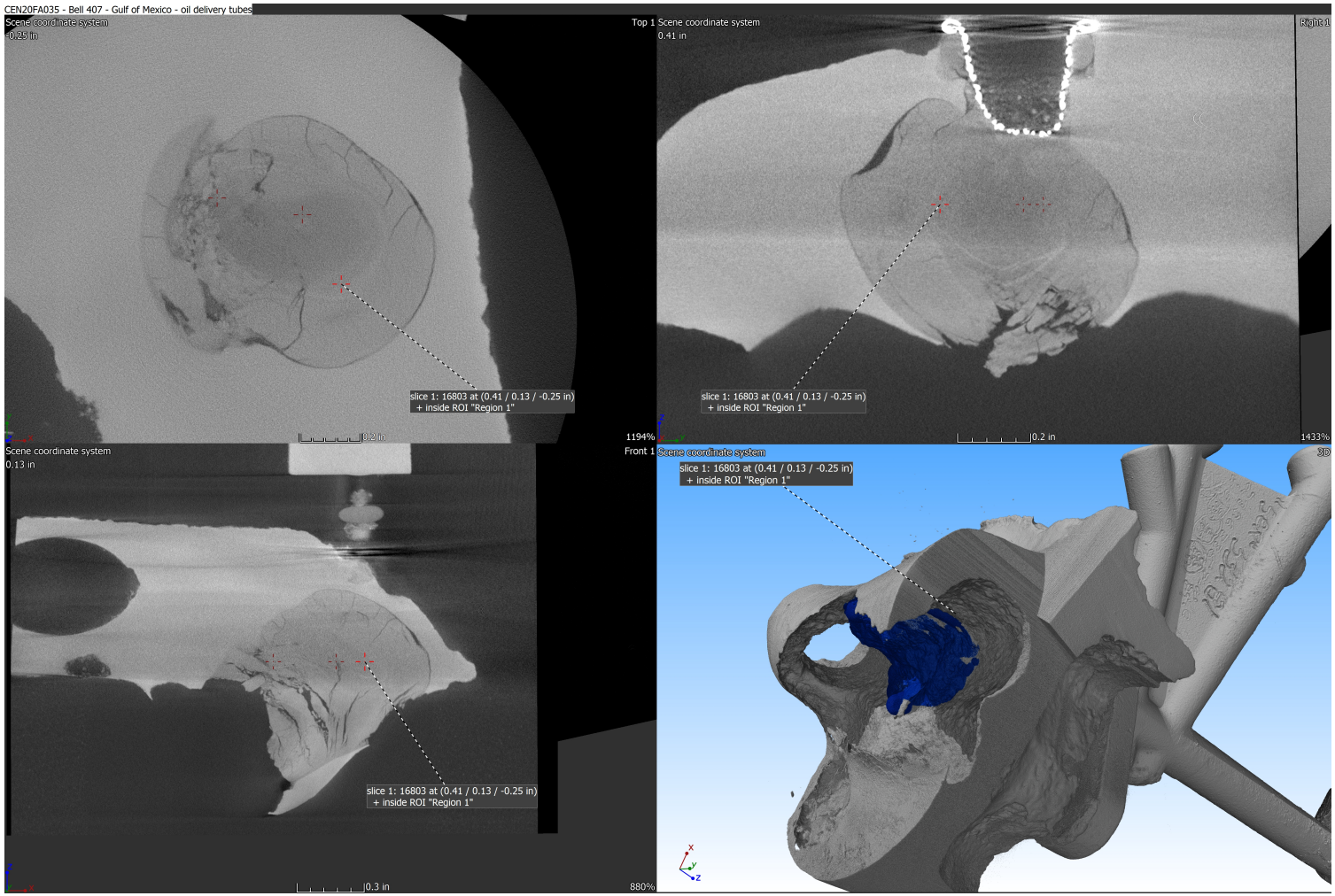


Figure 57
All tubes – anomalous material – slice 1

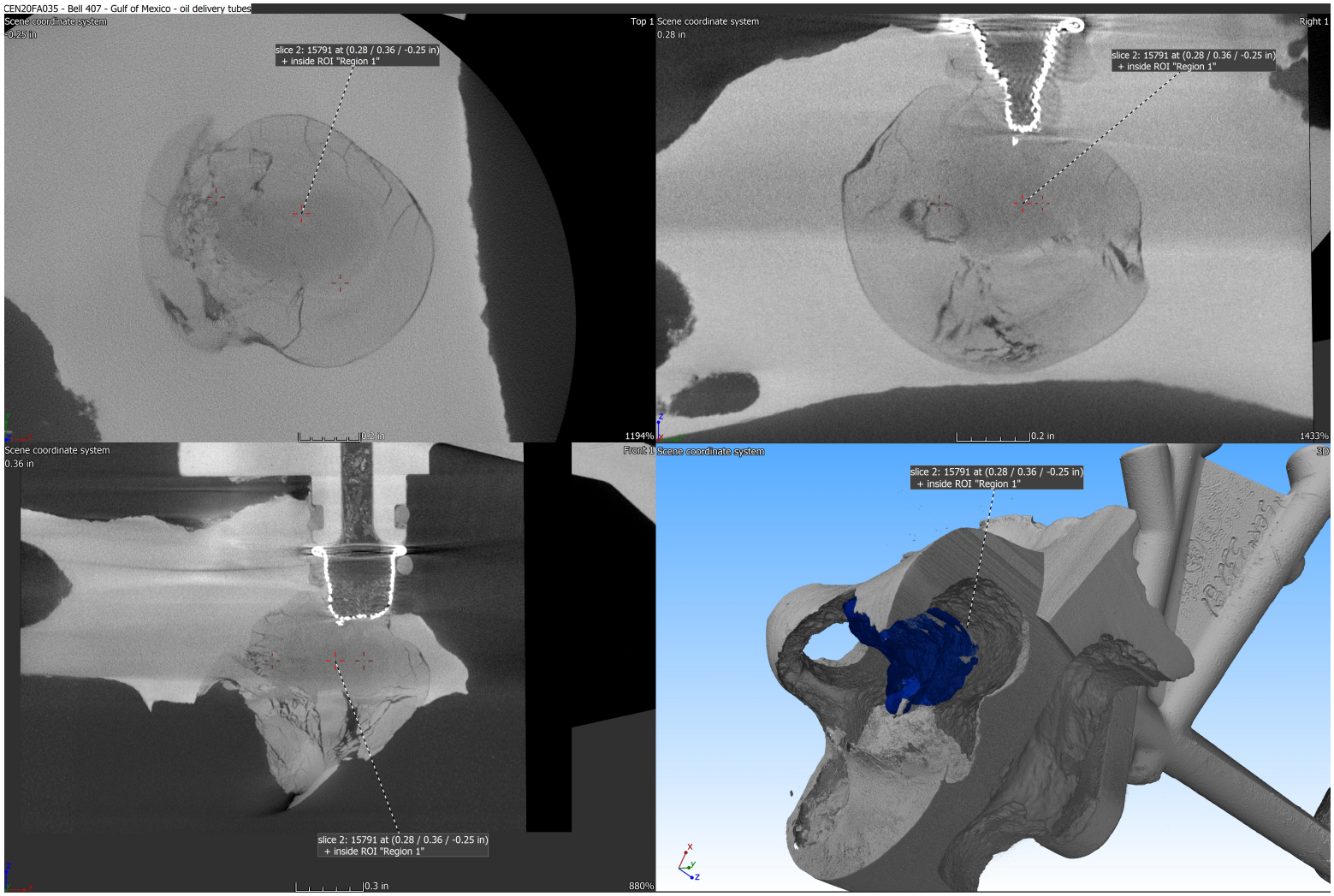


Figure 58
All tubes – anomalous material – slice 2

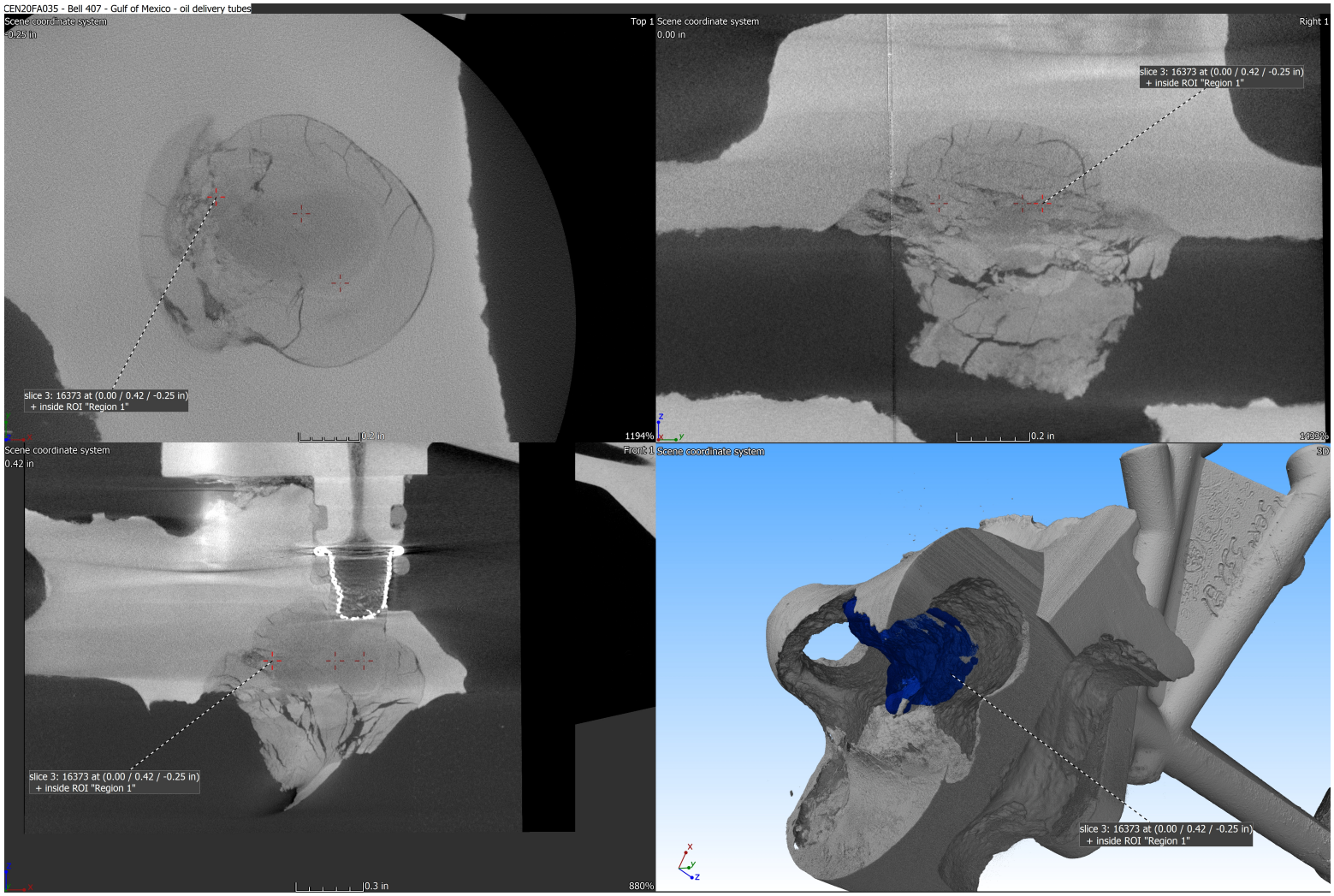


Figure 59
All tubes – anomalous material – slice 3

Scott Warren
Lead Aerospace Engineer
(Computed Tomography Specialist)