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

May 6, 2020

Computed Tomography Specialist's Factual Report

WPR18FA245

A. ACCIDENT

Location:	Prescott, Arizona
Date:	August 29, 2018
Time:	2035 mountain standard time
Airplane:	Cessna P210, N6500W

B. GROUP

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

C. SUMMARY

On August 29, 2018, about 2035 mountain standard time, a Cessna P210, N6500W, impacted terrain short of the runway in Prescott, Arizona. The pilot, who was the registered owner, was operating the airplane under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91. The airline transport pilot, the sole occupant, sustained fatal injuries; the airplane sustained substantial damage. The personal local flight departed from Ernest A Love Field Airport, Prescott, Arizona, about five minutes prior to the accident. Visual meteorological conditions prevailed, and no flight plan had been filed.

The internal configuration of the pressurization system heat exchanger was documented using radiographic images that were collected from November 12-21, 2019 in Chicago, Illinois. A total of 9,222 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. There were numerous void areas located within the heat exchanger metal-to-metal joints. Some joint areas within the heat exchanger had more void indications than others. There did not appear to be any leakage paths created by the voids going from one side of a joint to another, but, given the quantity of voids in some areas, such leakage paths could be possible.

2. There were a number of high-density particles noted throughout the heat exchanger. These particles did not appear to be associated with a leakage path from one side of the heat exchanger gas path to another.

D. DETAILS OF THE INVESTIGATION

1.0 General

The internal configuration of the pressurization system heat exchanger was subjected to x-ray radiograph and computed tomography (CT) scanning to document its internal condition.

The scanning was conducted from November 12-21, 2019 by Varex, Inc. under the direction of the NTSB using the Actis 500/225 micro focus system.

For the CT scans, the component was loaded into the imaging unit and placed on a turntable. The component was 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.

During the imaging work, an overall scan was conducted followed by target CT scans of each quadrant of the heat exchanger. The target CT techniques used geometric magnification to provide for enhanced resolution within a specific area of a component[1]. The field of view during these target CT scans was reduced, but the resolution within that field of view was better than in the overall component scans.

The component was scanned using a total of 9,222 slices, and the total size of the combined data sets was approximately 72.0 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 component.

[1] Geometric magnification is a scanning technique where the component is moved closer to the x-ray source. The x-ray beam passes through a smaller region within the component, and that smaller region's image information is spread across the x-ray detector. The resulting image is created at a higher resolution.

Table 1
Scan Protocols

Component	Heat exchanger – overall scan	Heat exchanger – quadrant A – target CT	Heat exchanger – quadrant B – target CT	Heat exchanger – quadrant C – target CT	Heat exchanger – quadrant D – target CT
Number of slices	1881	1848	1831	1831	1831
Voxel[2] Size - X Direction (mm)	0.101	0.037	0.037	0.037	0.037
Voxel Size - Y Direction (mm)	0.101	0.037	0.037	0.037	0.037
Voxel Size - Z Direction (mm)	0.10	0.10	0.10	0.10	0.10
Image Projections per Revolution	1800	1800	1800	1800	1800
Exposure time (ms)	285.61	285.61	285.61	285.61	285.61
Frames to Avg (frames per projection)	1	2	2	2	2
X-ray Source Voltage (kV)	223	222	222	222	222
X-ray Source Current (mA)	0.580	0.580	0.580	0.580	0.580
Source Filter Thickness (mm)	1	1	1	1	1
Source Filter Material	Brass	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 component 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.

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

The images of the component 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 component are shown in figures 1 through 42. Review of the images determined that, when the scans were conducted, the following indications were noted:

1. There were numerous void areas located within the heat exchanger metal-to-metal joints. Some joint areas within the heat exchanger had more void indications than others. There did not appear to be any leakage paths created by the voids going from one side of a joint to another, but, given the quantity of voids in some areas, such leakage paths could be possible.

2. There were a number of high-density particles noted throughout the heat exchanger. These particles did not appear to be associated with a leakage path from one side of the heat exchanger gas path to another.

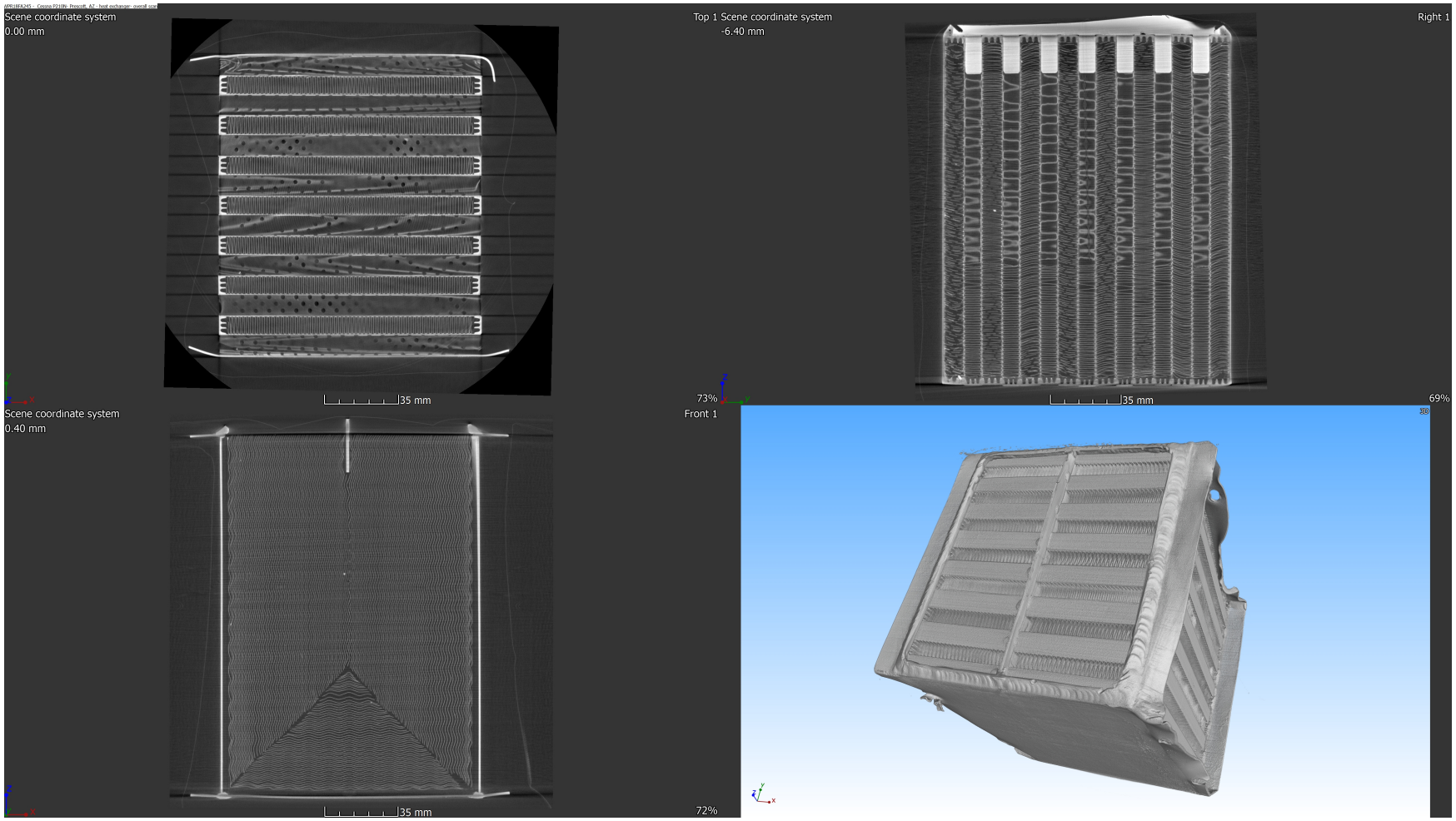


Figure 1
Heat exchanger - overview

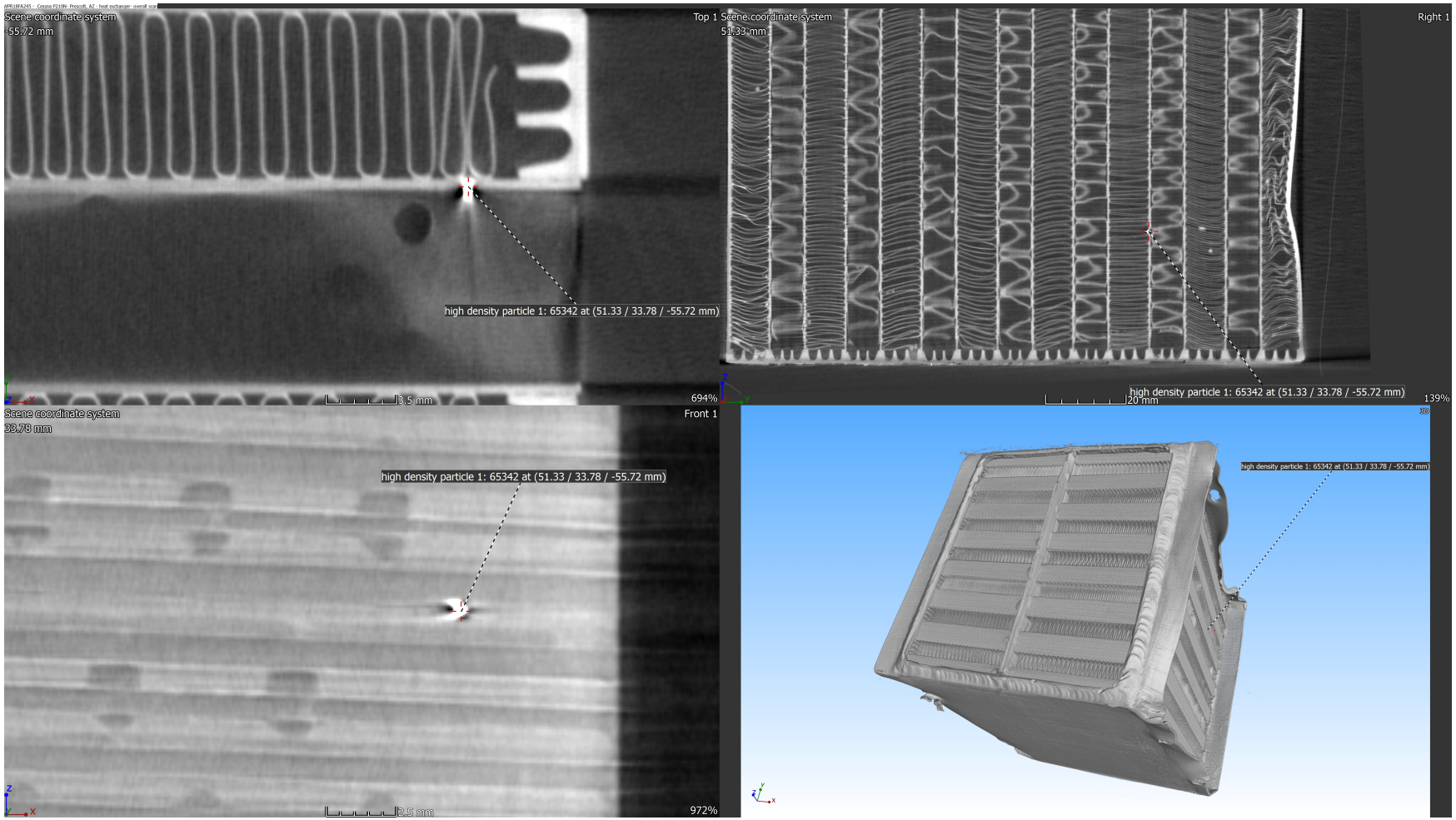


Figure 2
Heat exchanger – high density particle 1

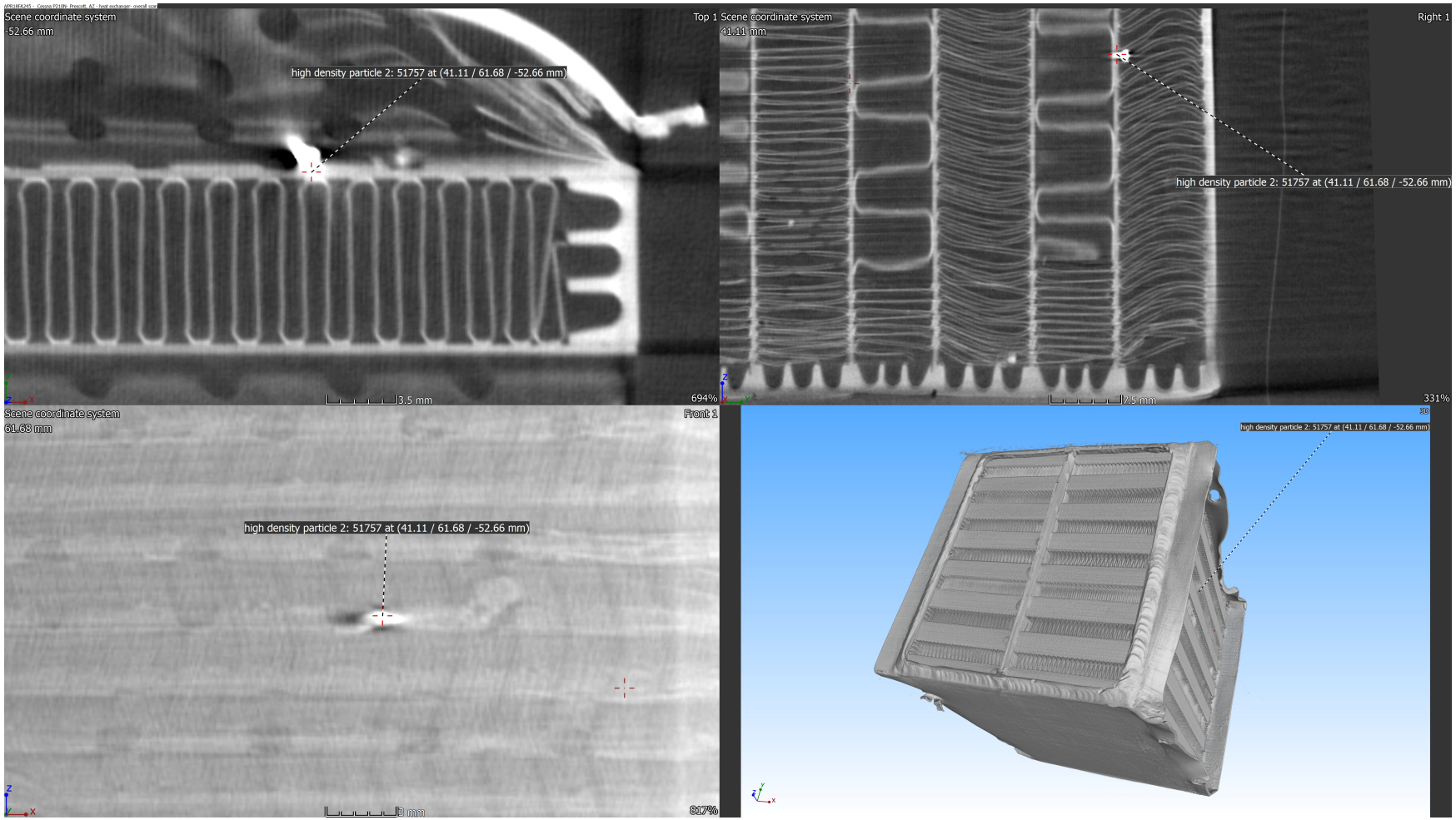


Figure 3
Heat exchanger – high density particle 2

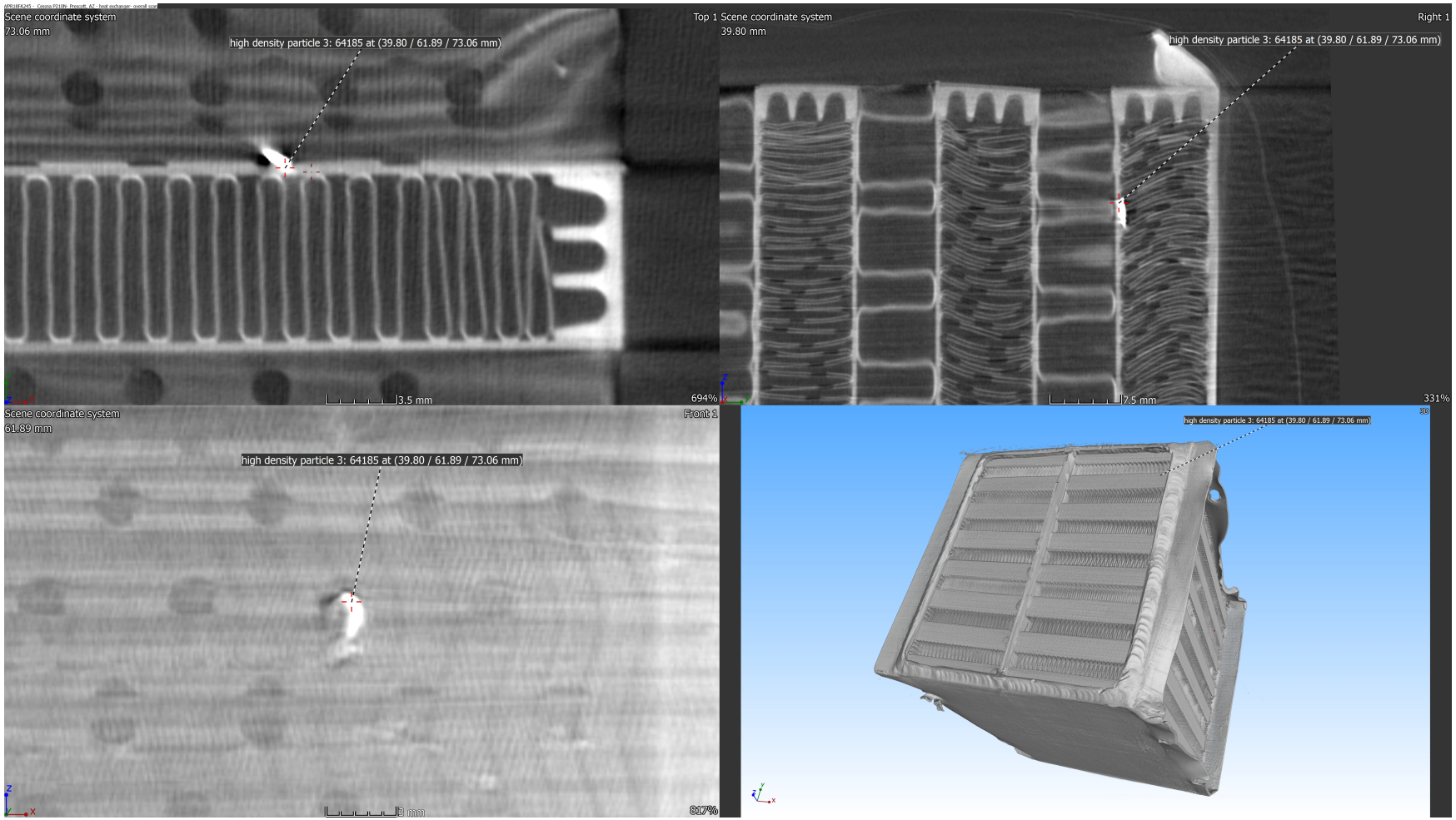


Figure 4
Heat exchanger – high density particle 3

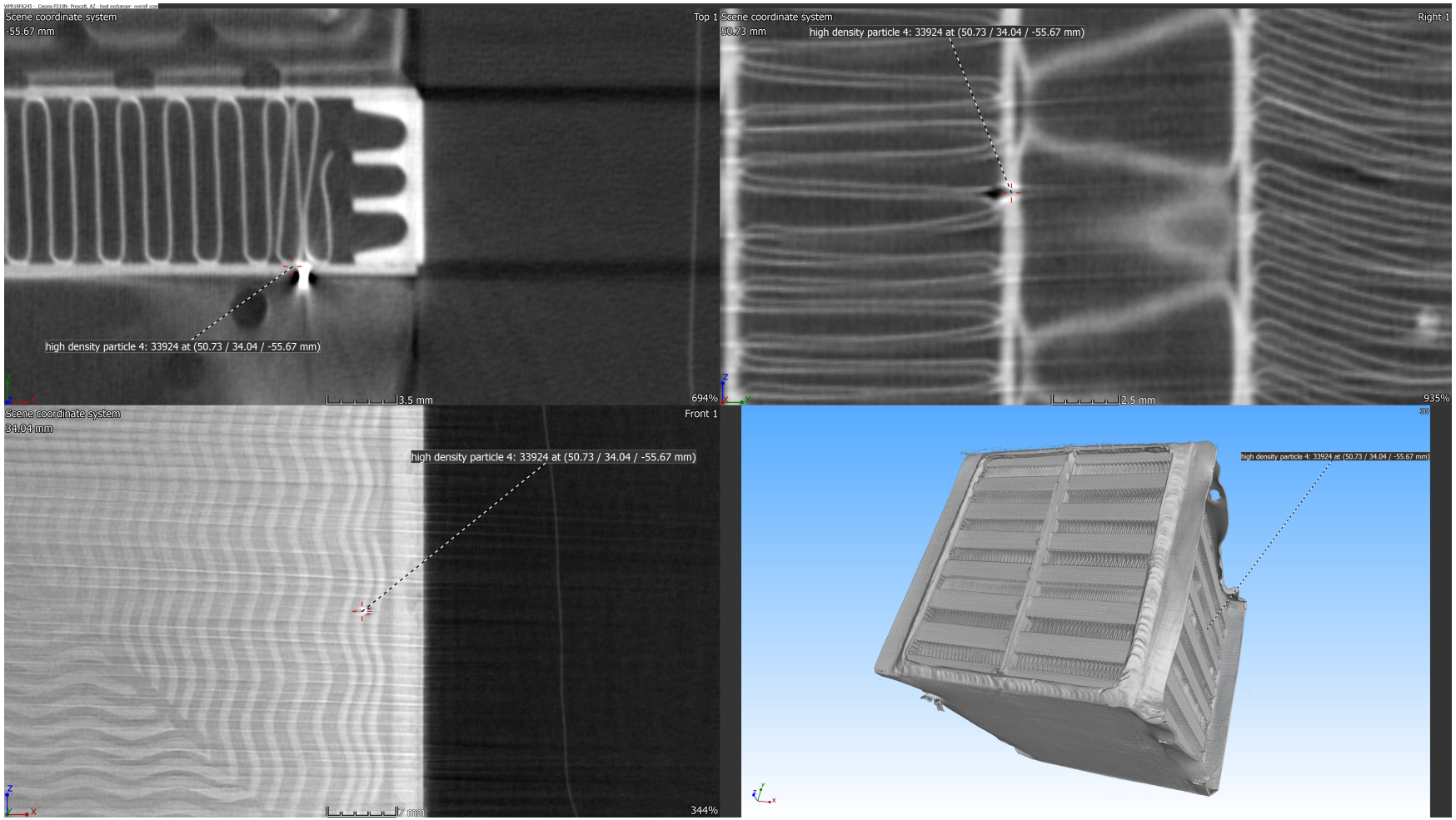


Figure 5
Heat exchanger – high density particle 4

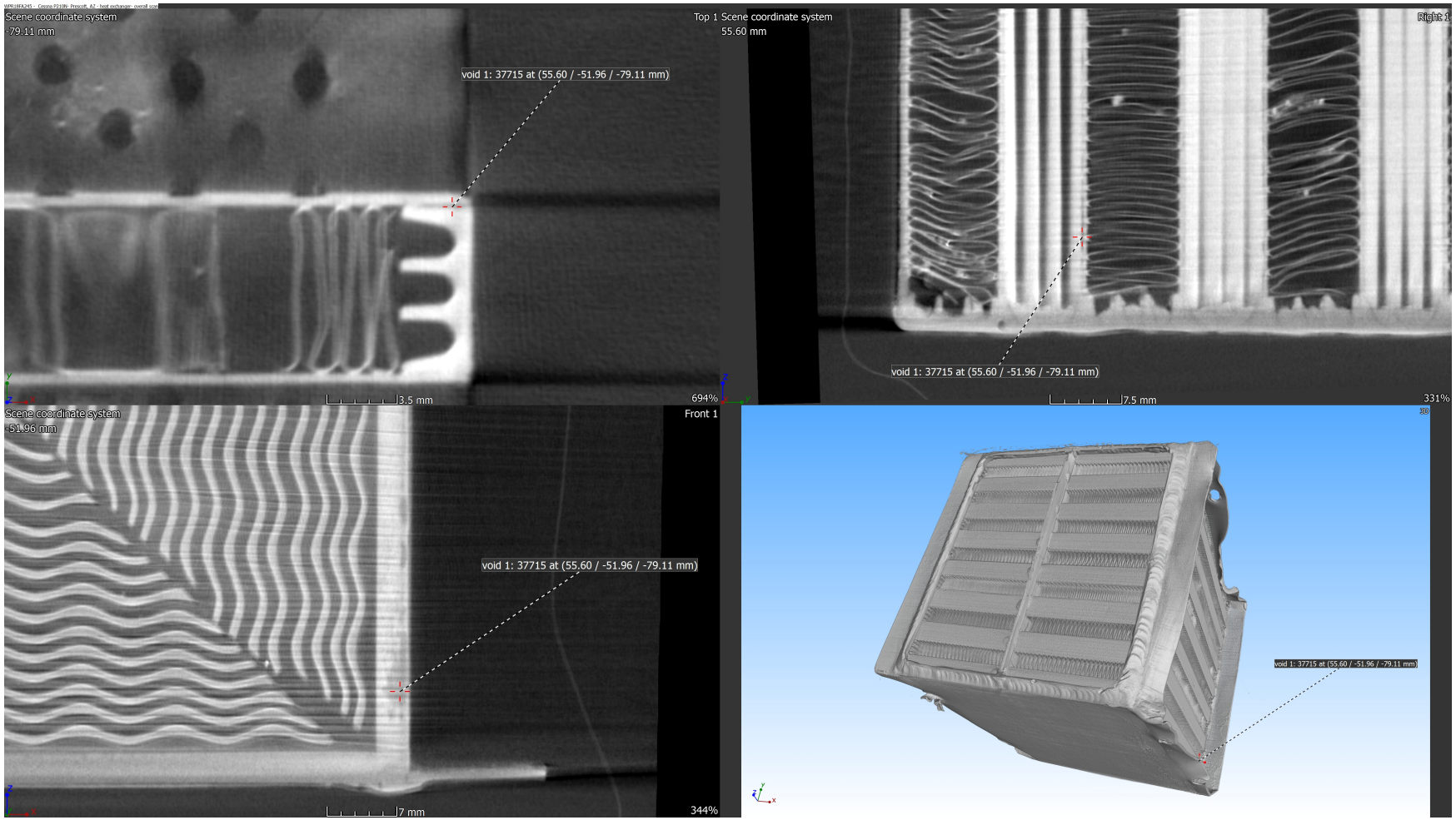


Figure 6
Heat exchanger – void 1

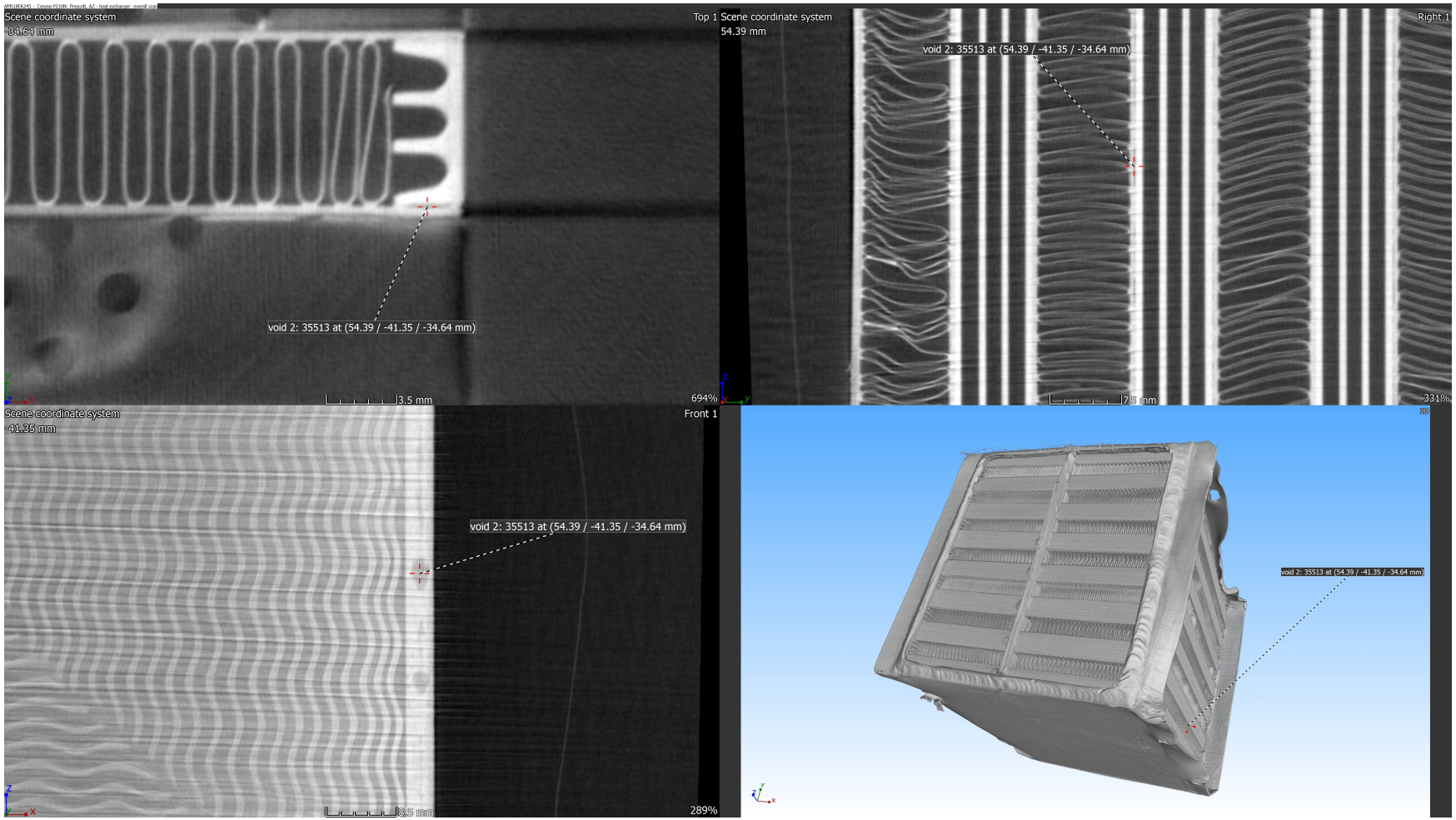


Figure 7
Heat exchanger – void 2

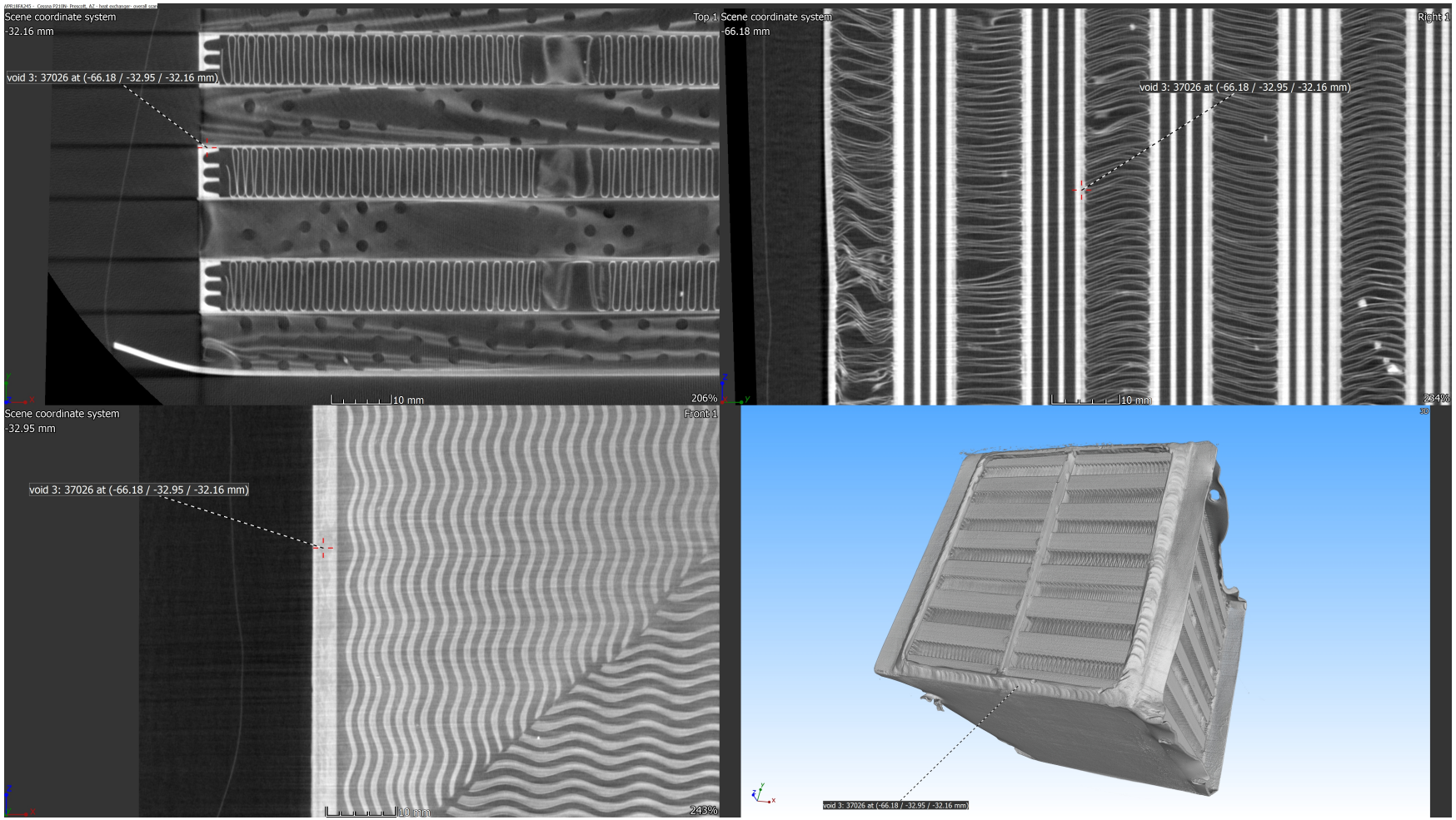


Figure 8
Heat exchanger – void 3

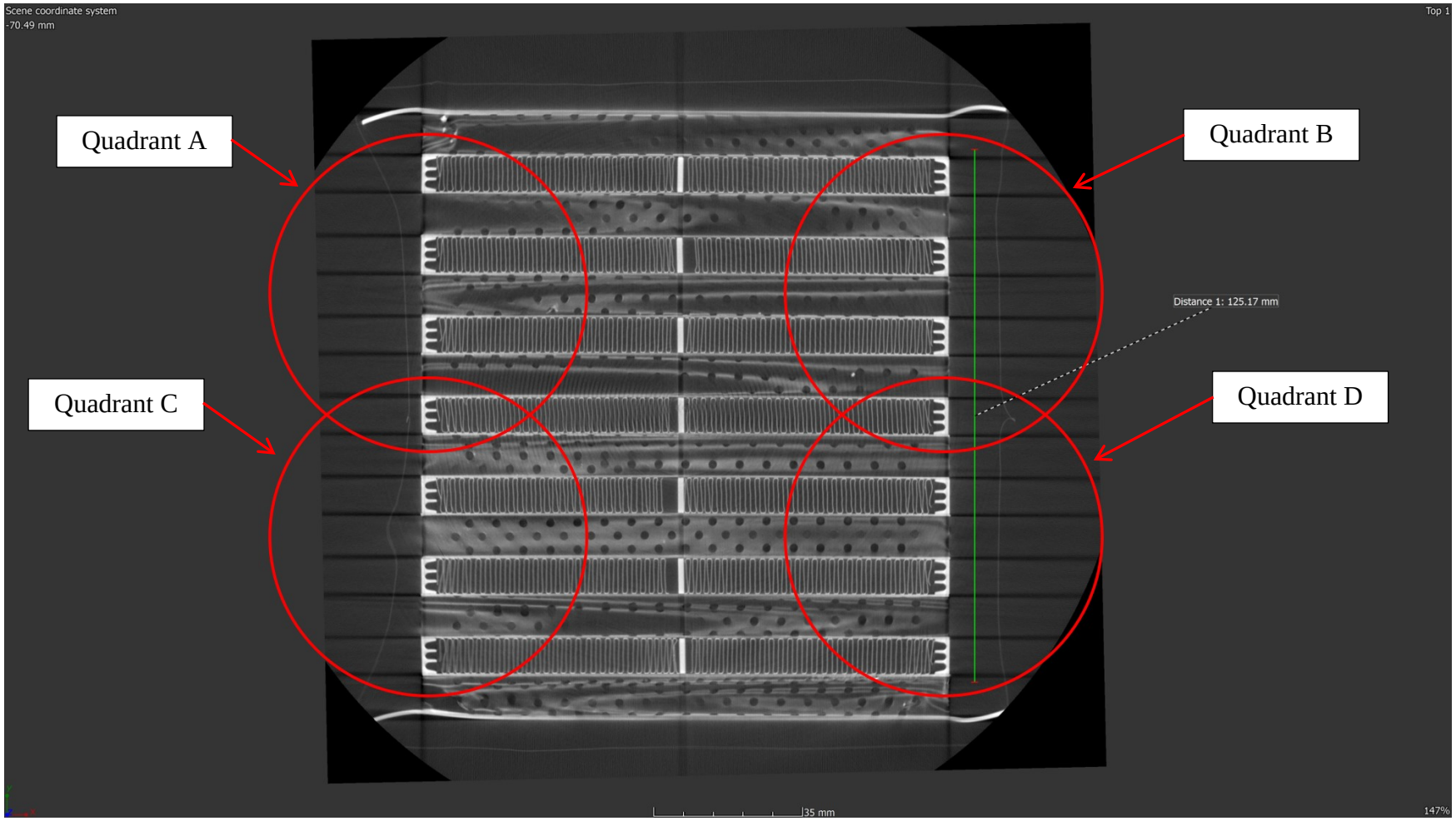


Figure 9
Heat exchanger – target CT quadrants

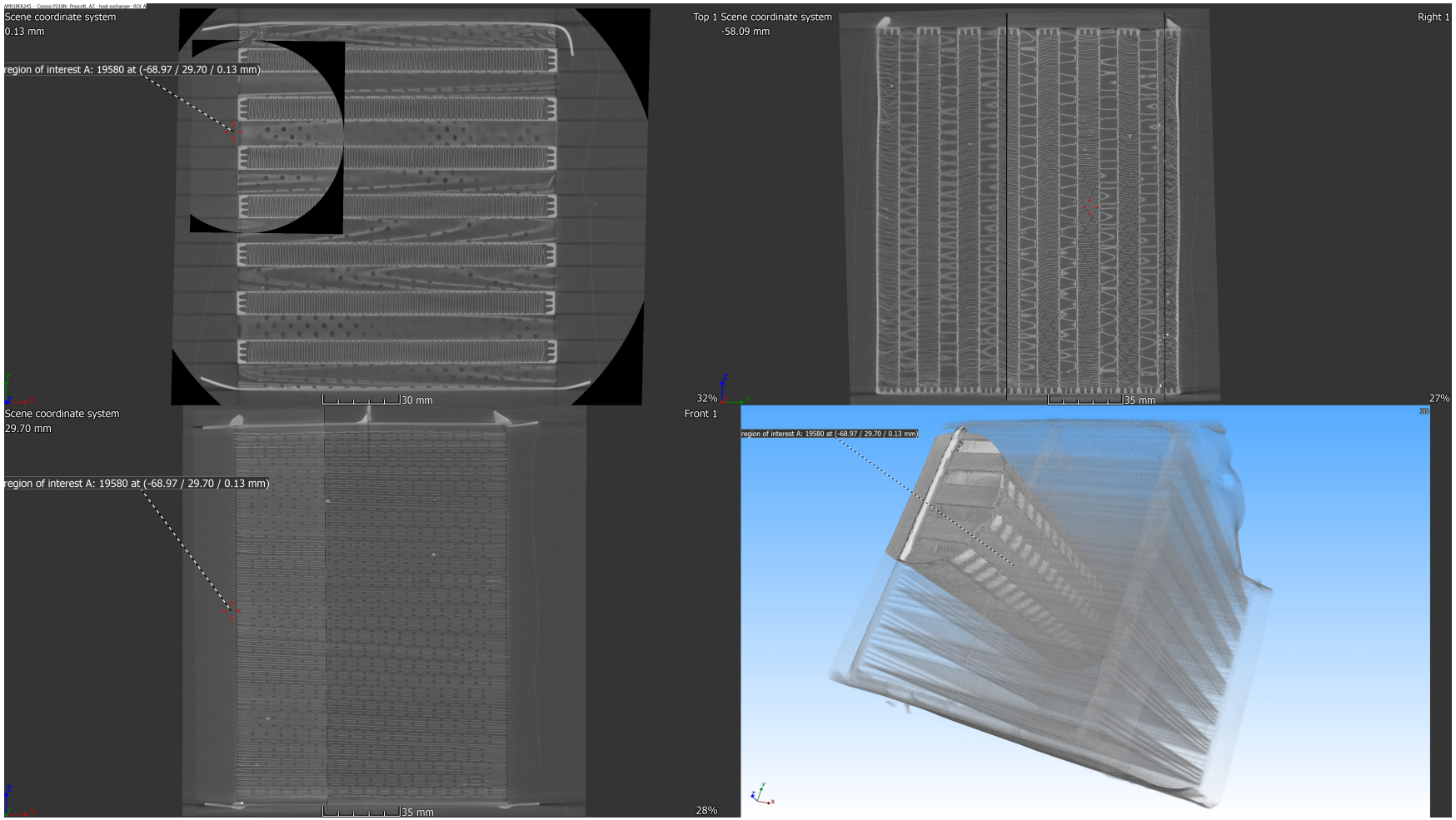


Figure 10
Heat exchanger – target CT – quadrant A overview

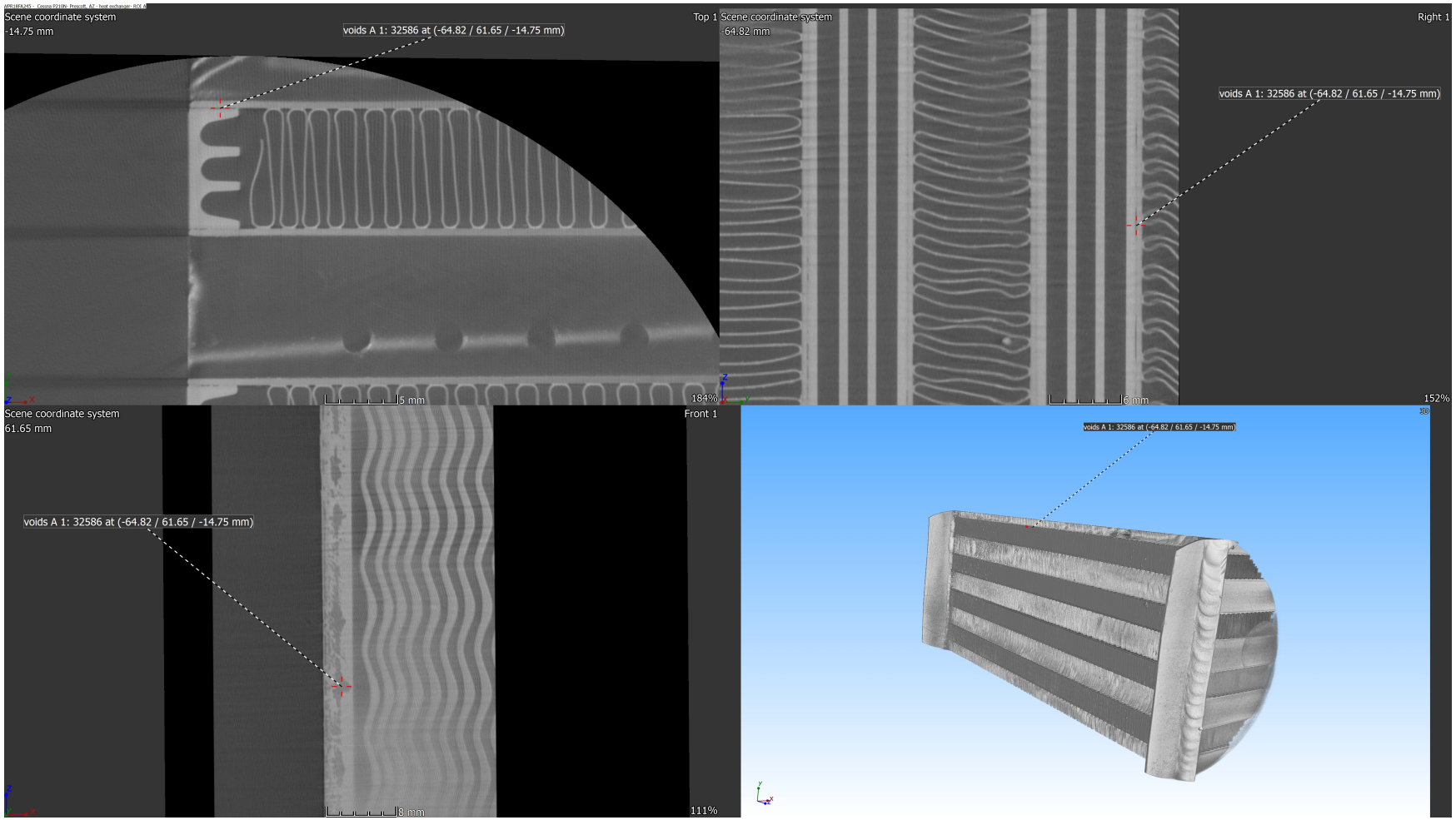


Figure 11
Heat exchanger – target CT – quadrant A - voids A1

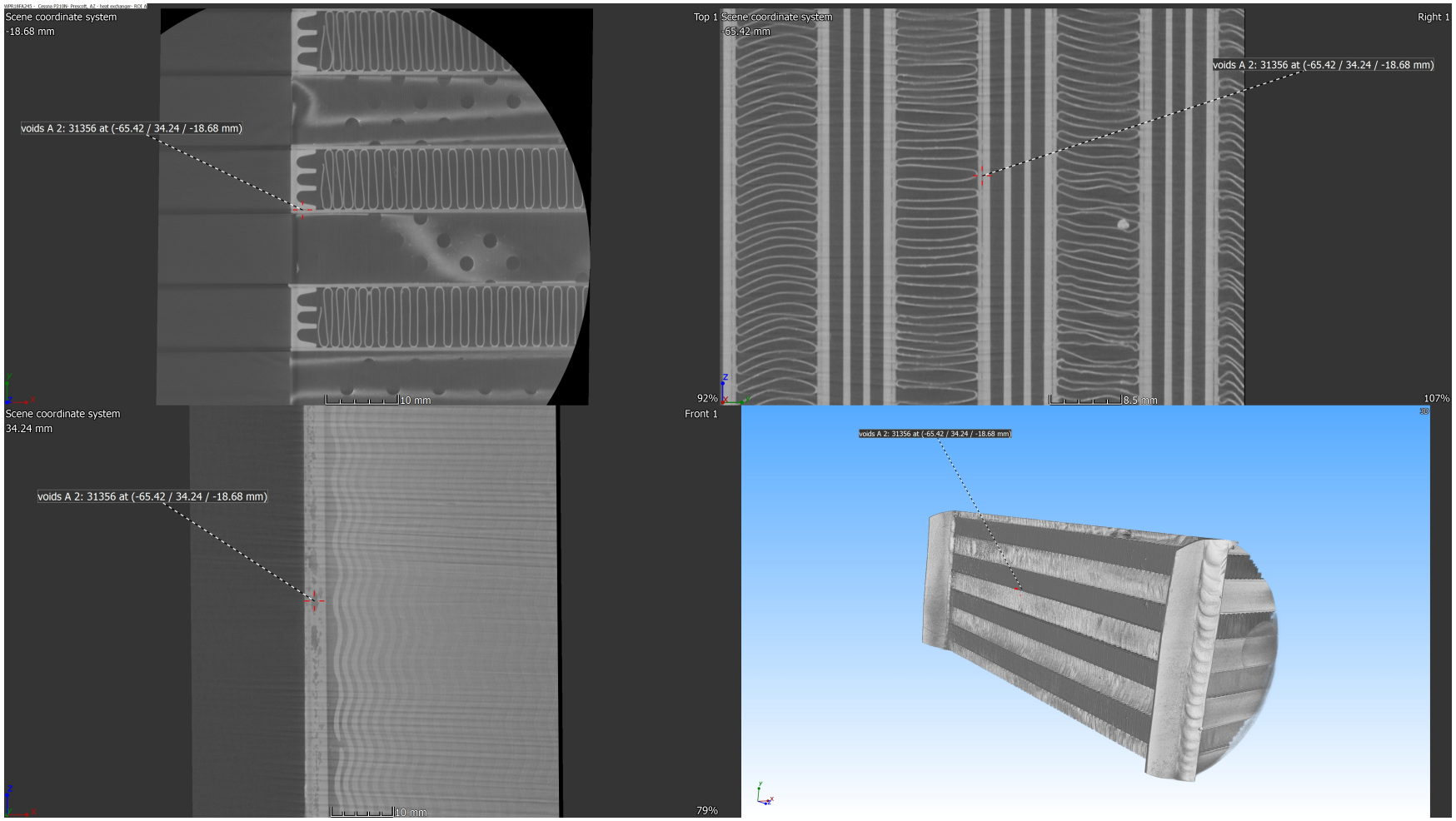


Figure 12
Heat exchanger – target CT – quadrant A - voids A2

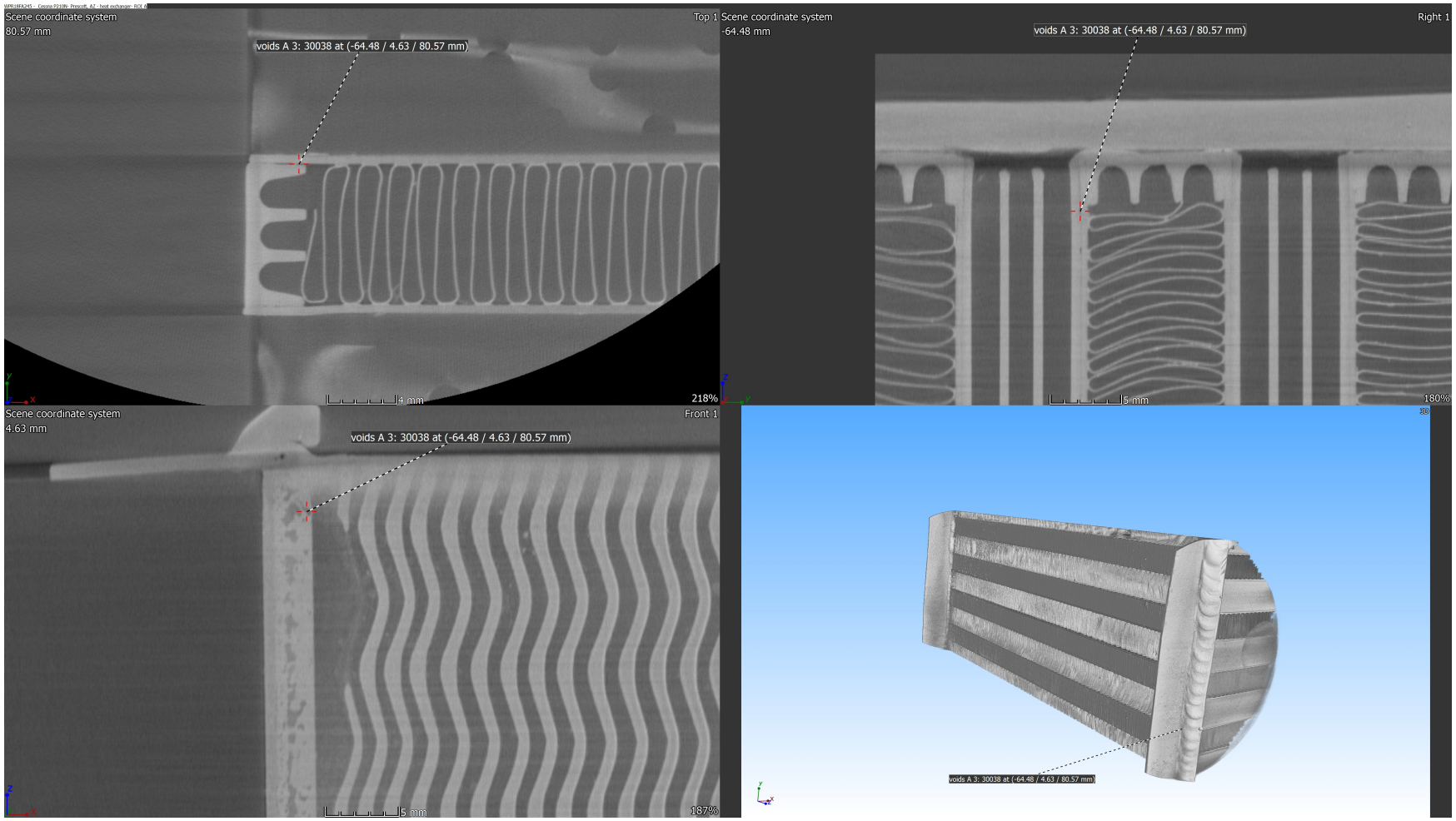


Figure 13
Heat exchanger – target CT – quadrant A - voids A3

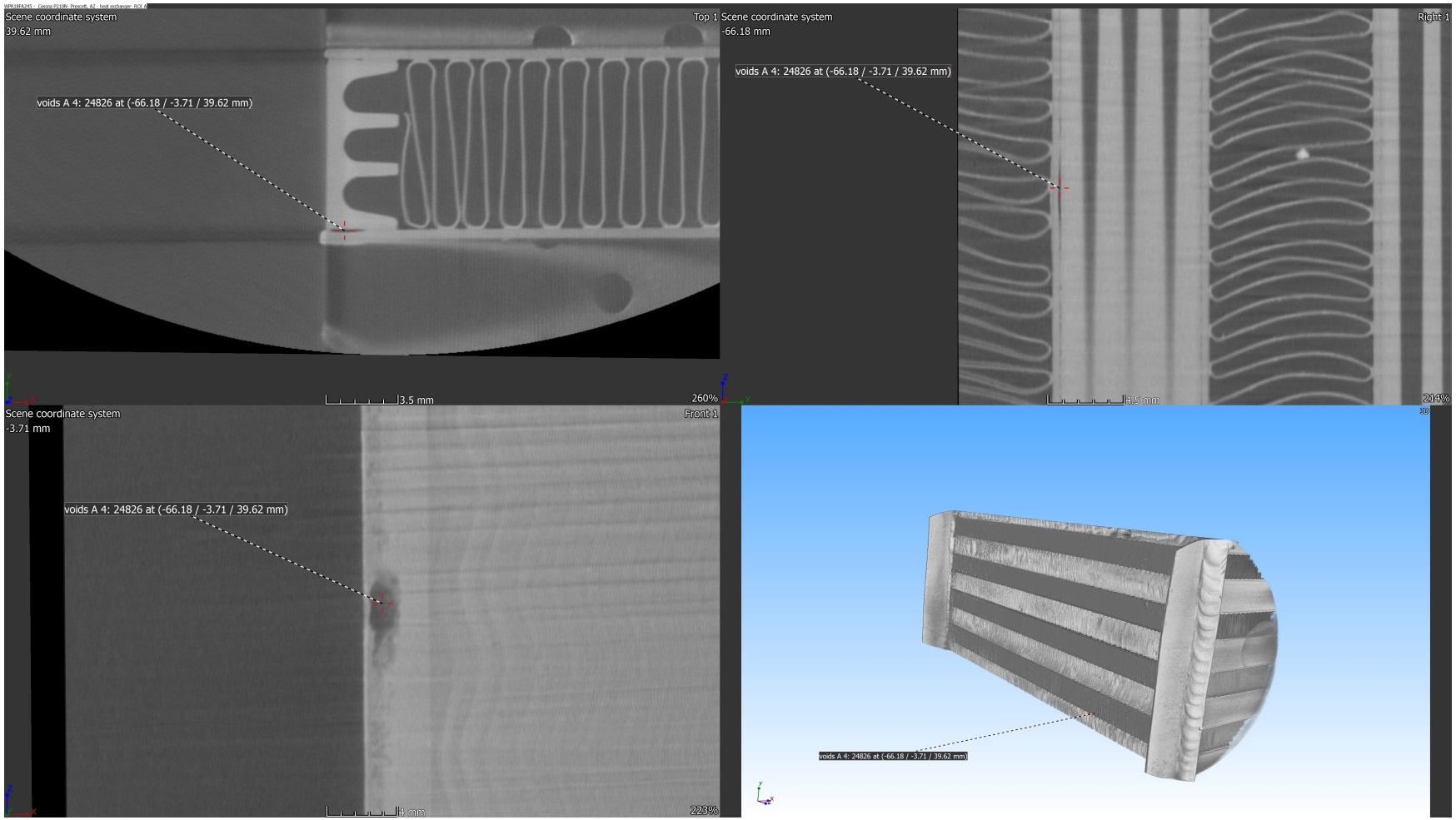


Figure 14
Heat exchanger – target CT – quadrant A - voids A4

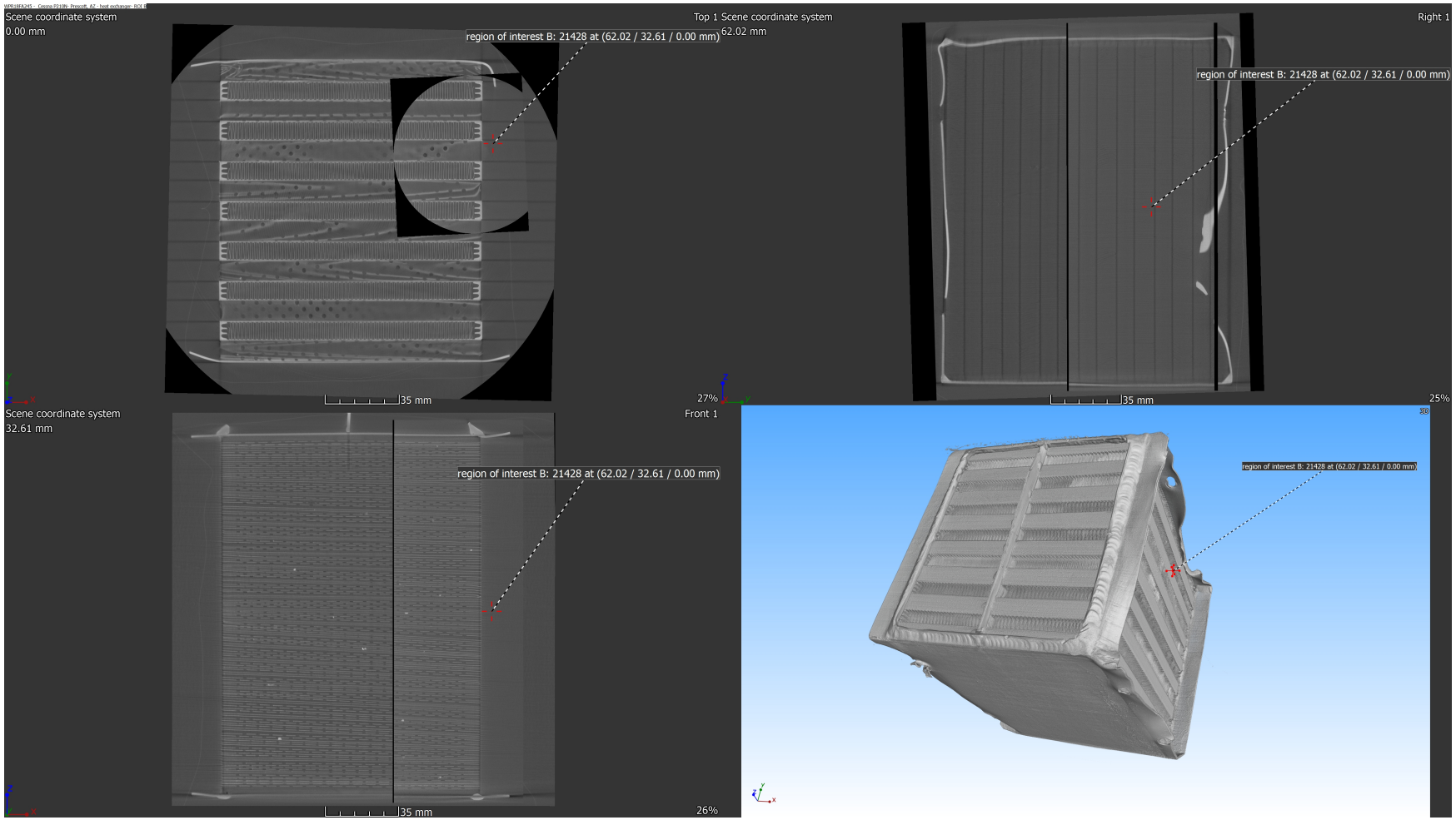


Figure 15
Heat exchanger – target CT – quadrant B - overview

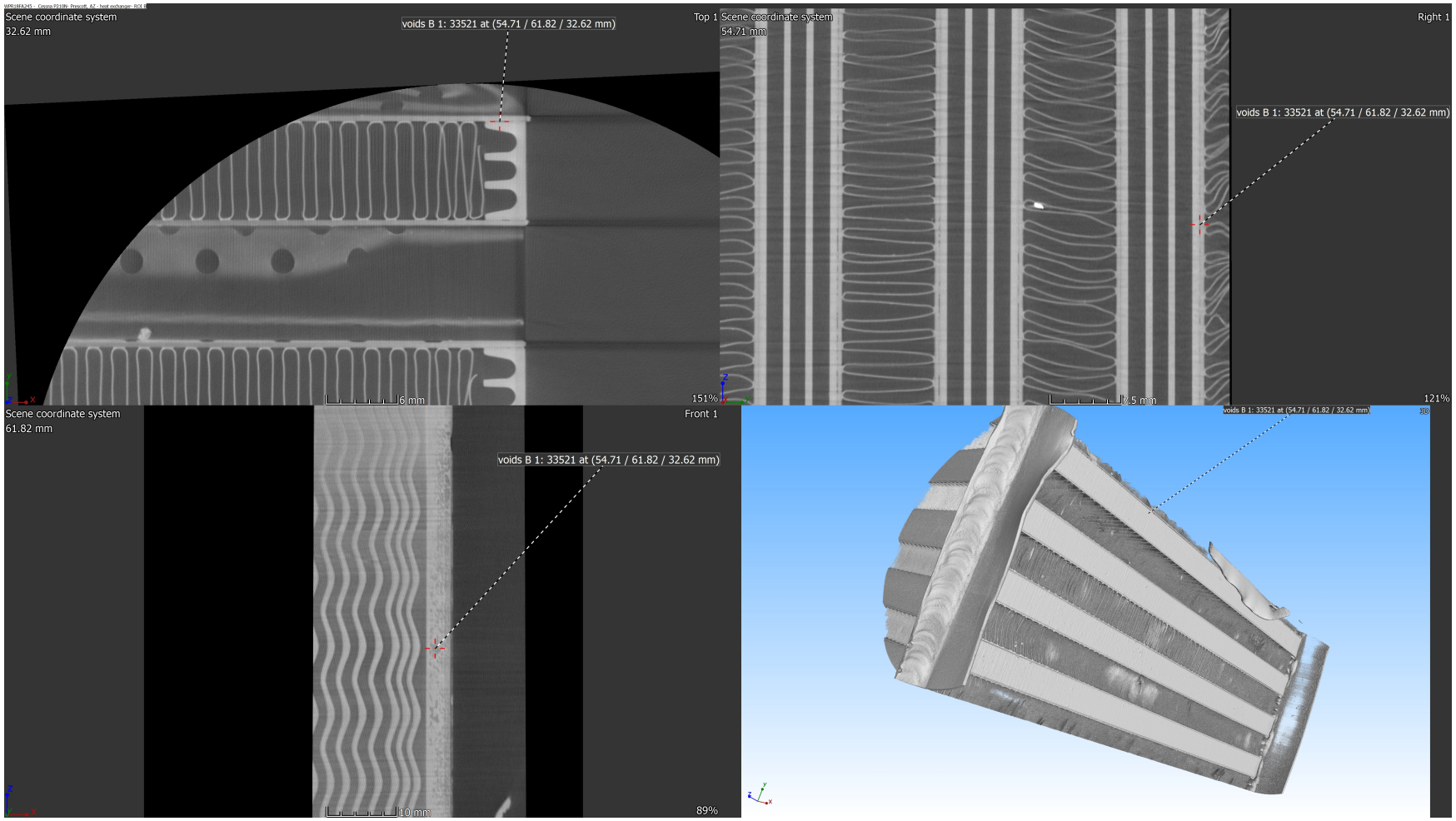


Figure 16
Heat exchanger – target CT – quadrant B - voids B1

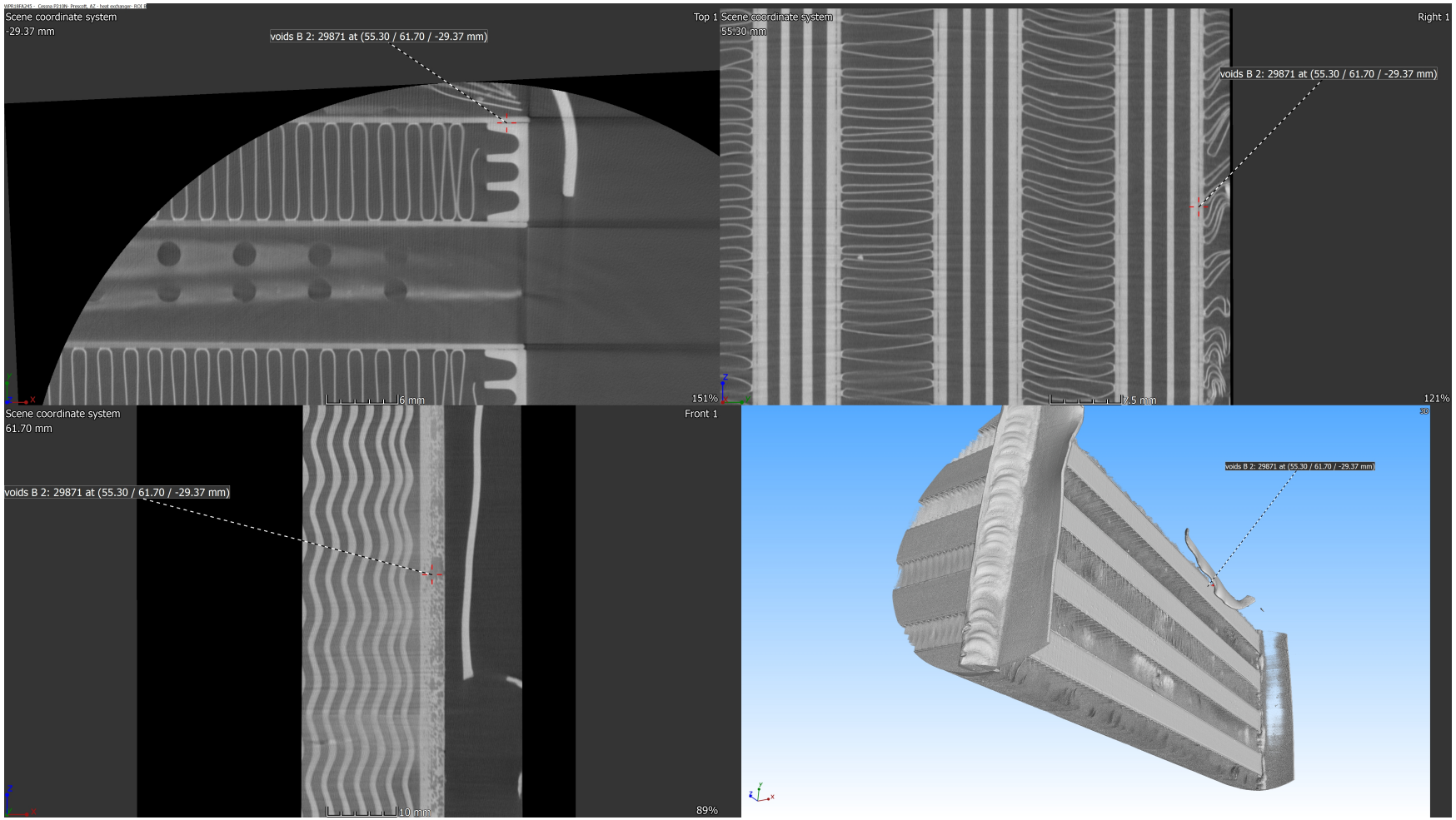


Figure 17
Heat exchanger – target CT – quadrant B - voids B2

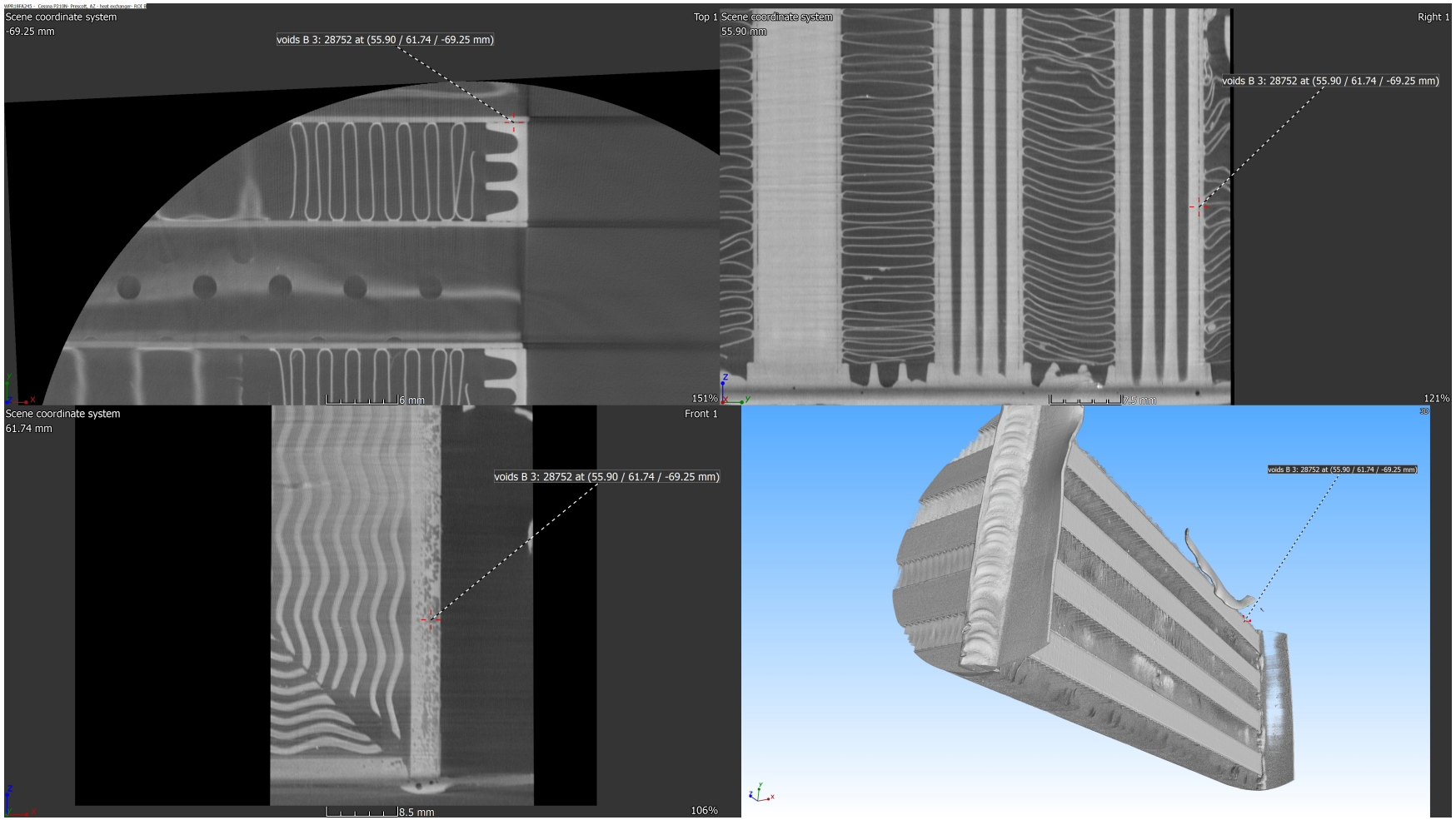


Figure 18
Heat exchanger – target CT – quadrant B - voids B3

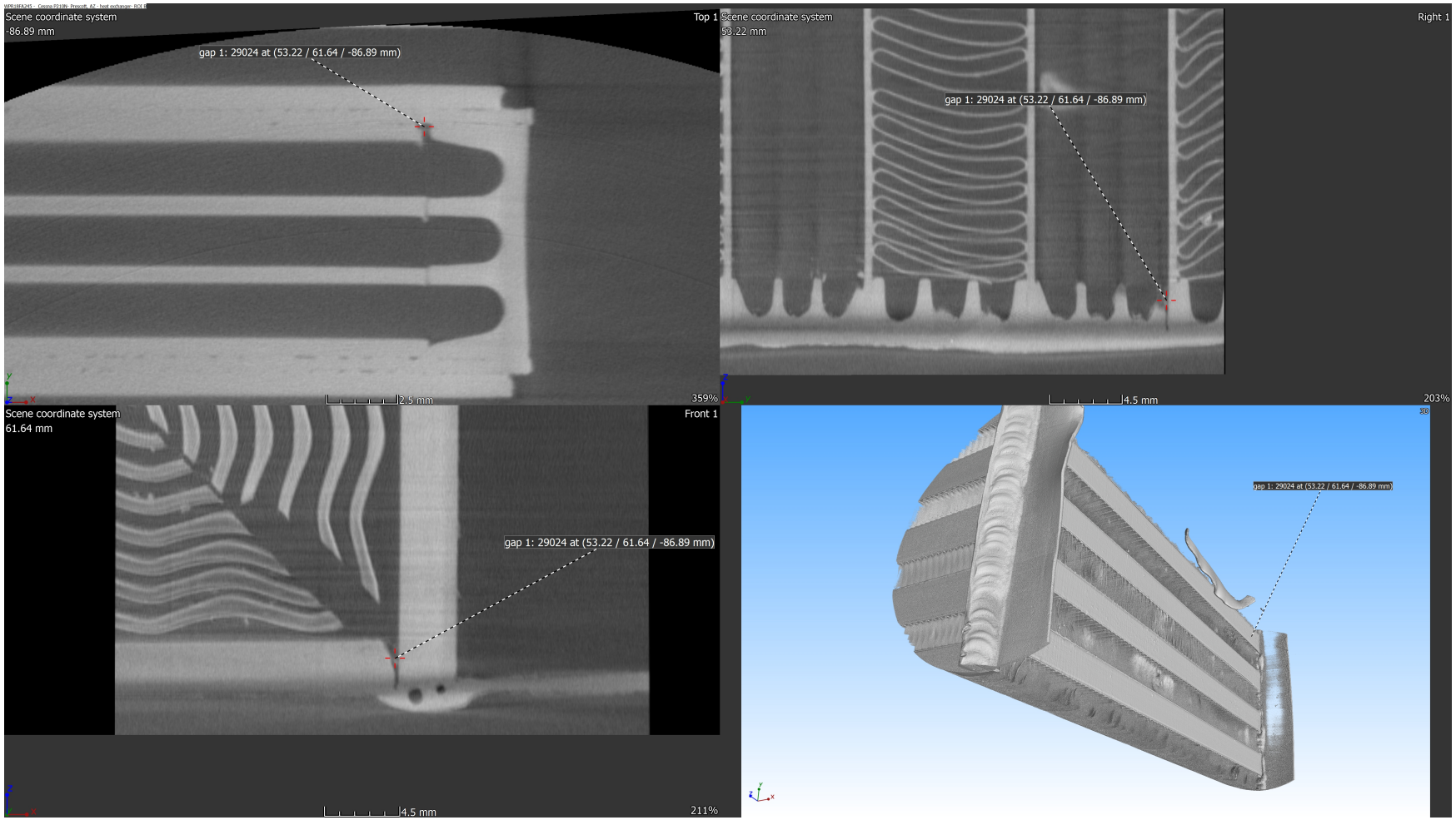


Figure 19
Heat exchanger – target CT – quadrant B – gap 1

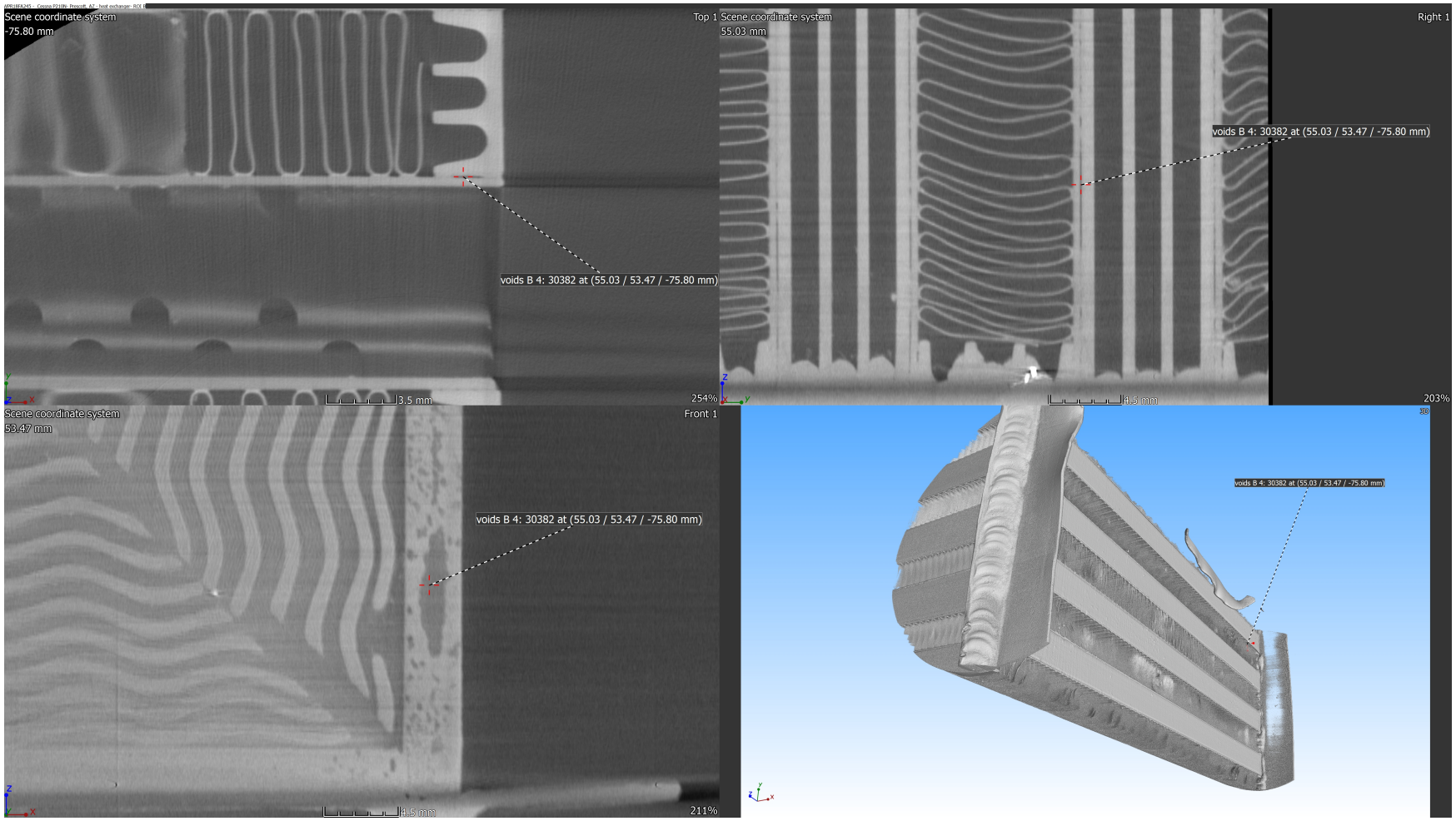


Figure 20
Heat exchanger – target CT – quadrant B - voids B4

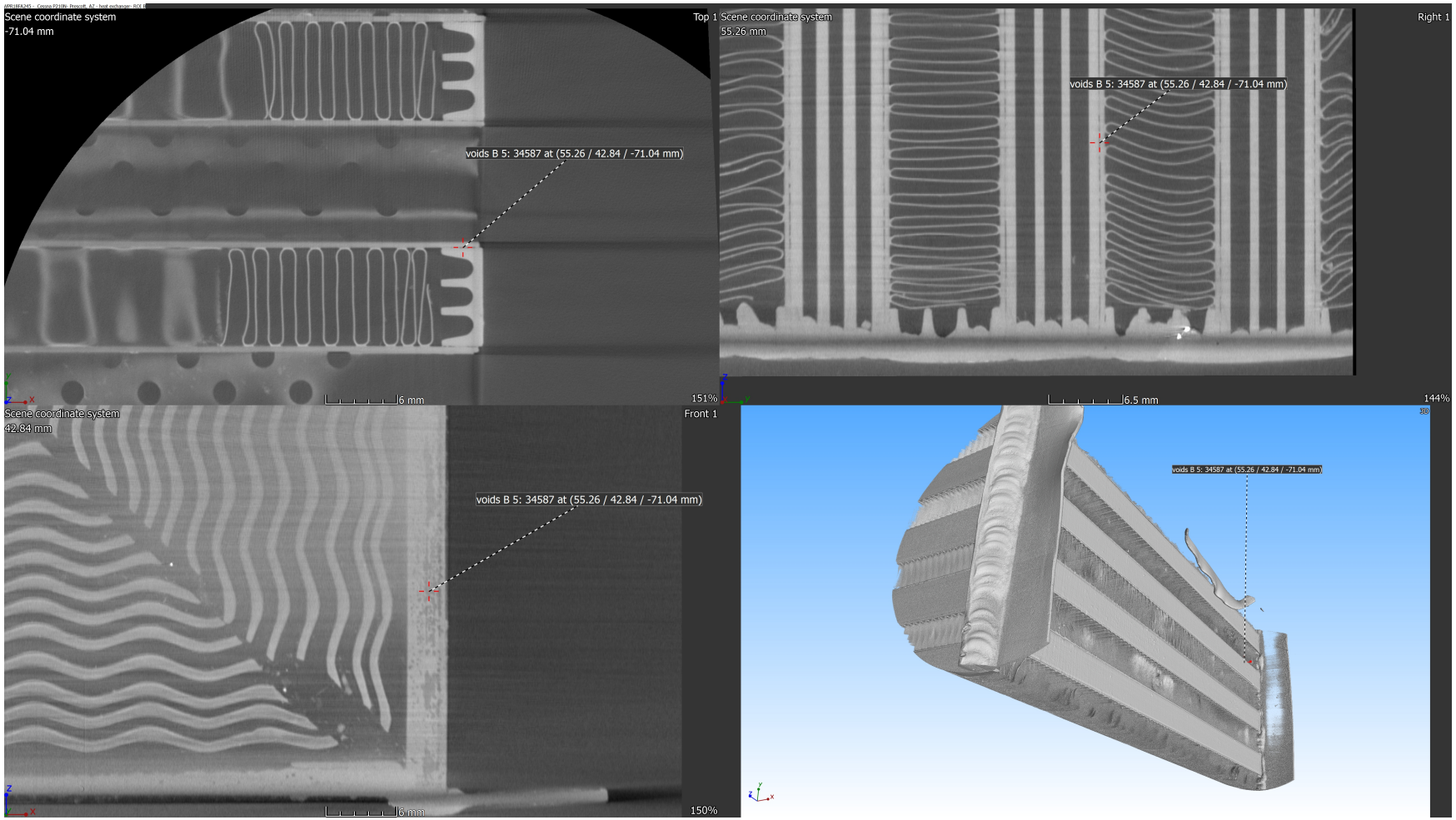


Figure 21
Heat exchanger – target CT – quadrant B - voids B5

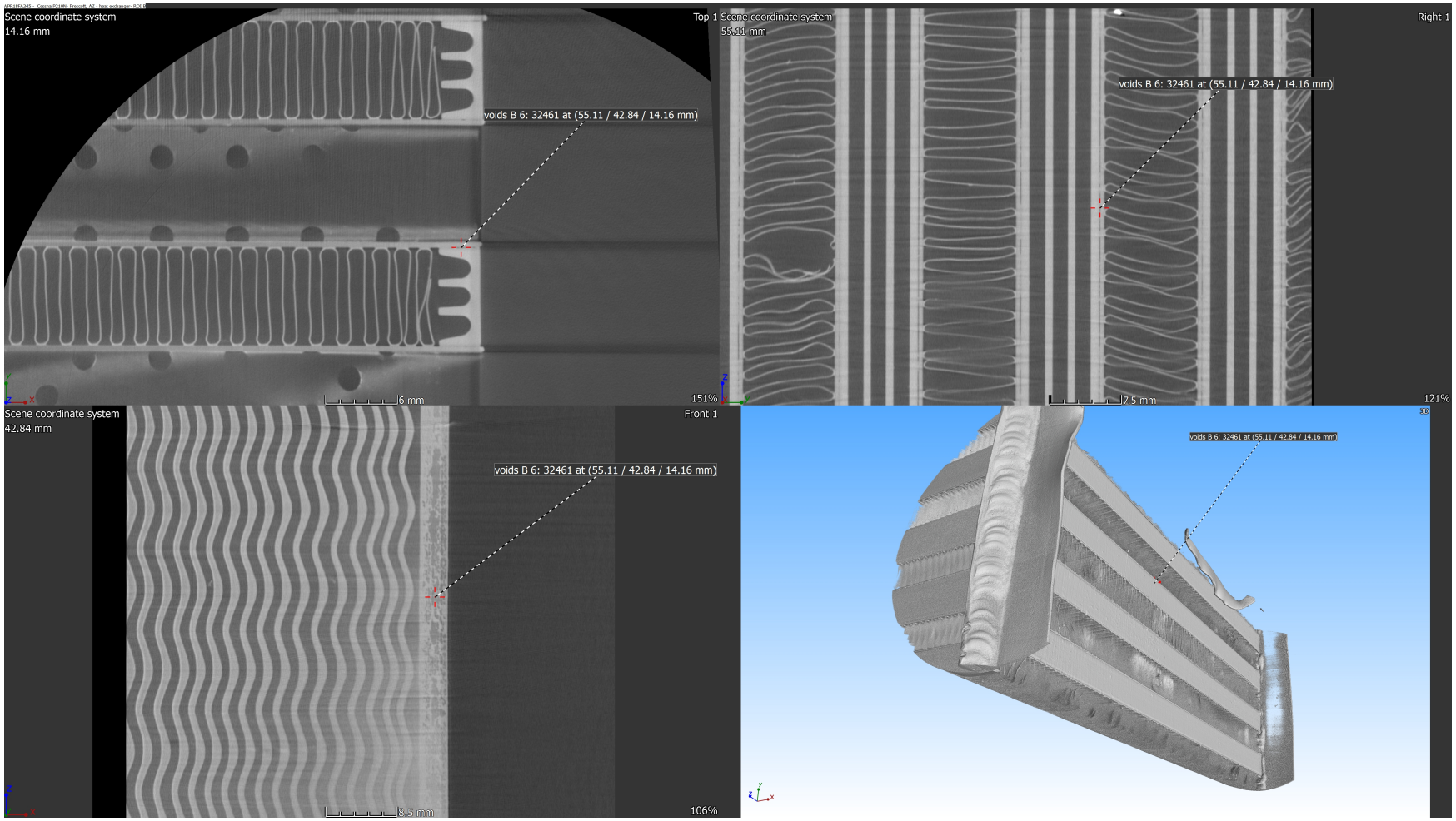


Figure 22
Heat exchanger – target CT – quadrant B - voids B6

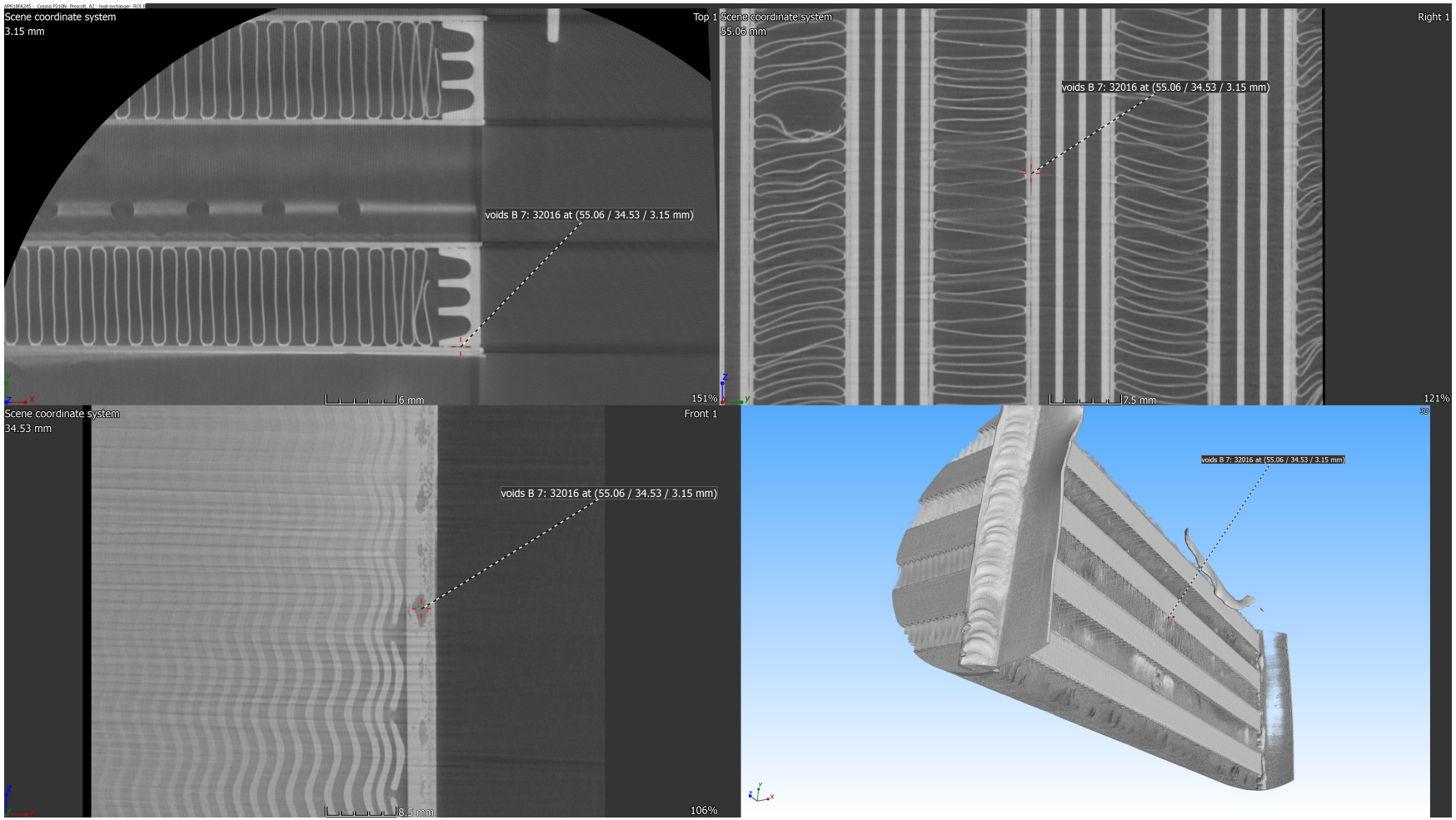


Figure 23
Heat exchanger – target CT – quadrant B - voids B7

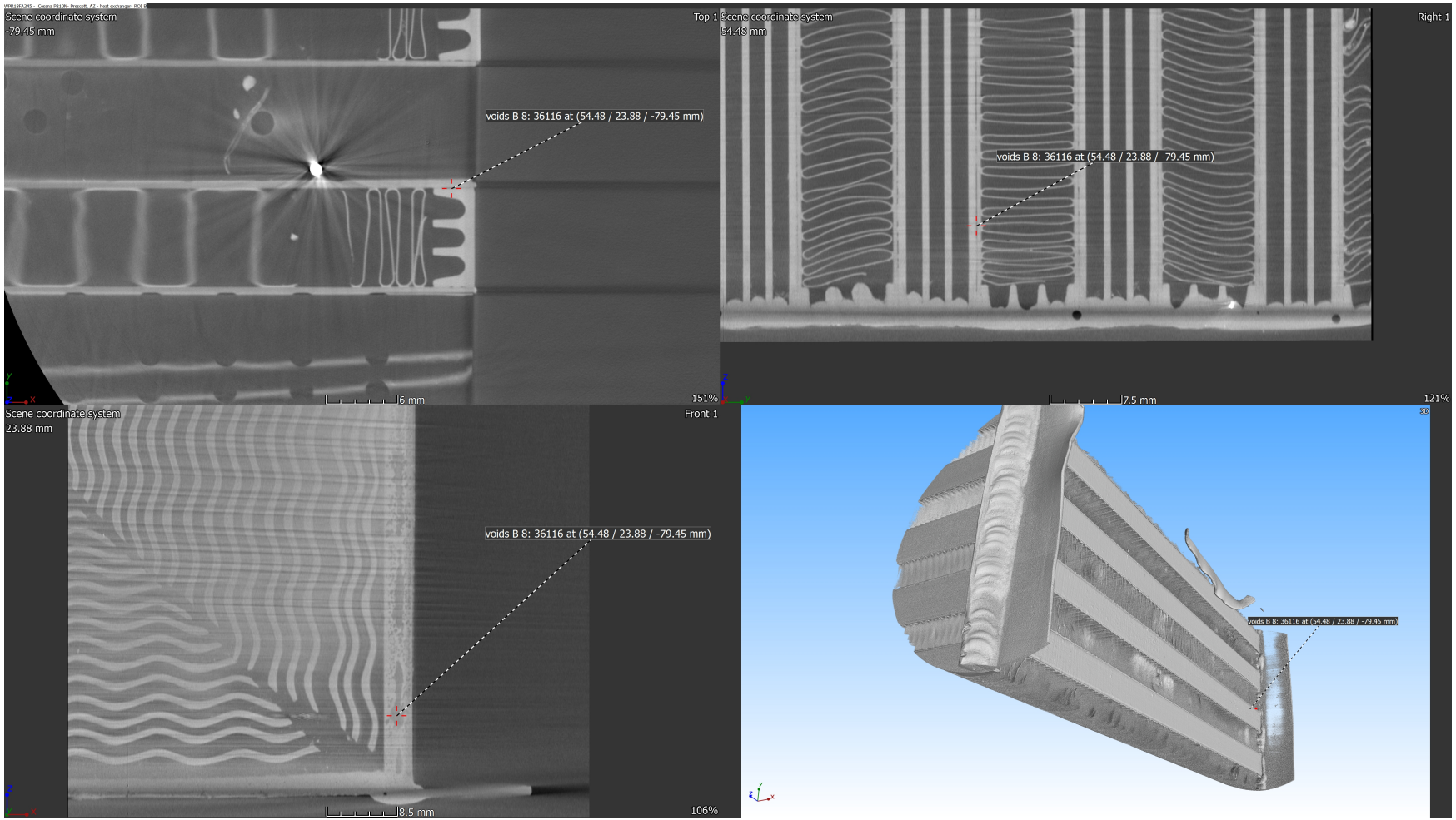


Figure 24
Heat exchanger – target CT – quadrant B - voids B8

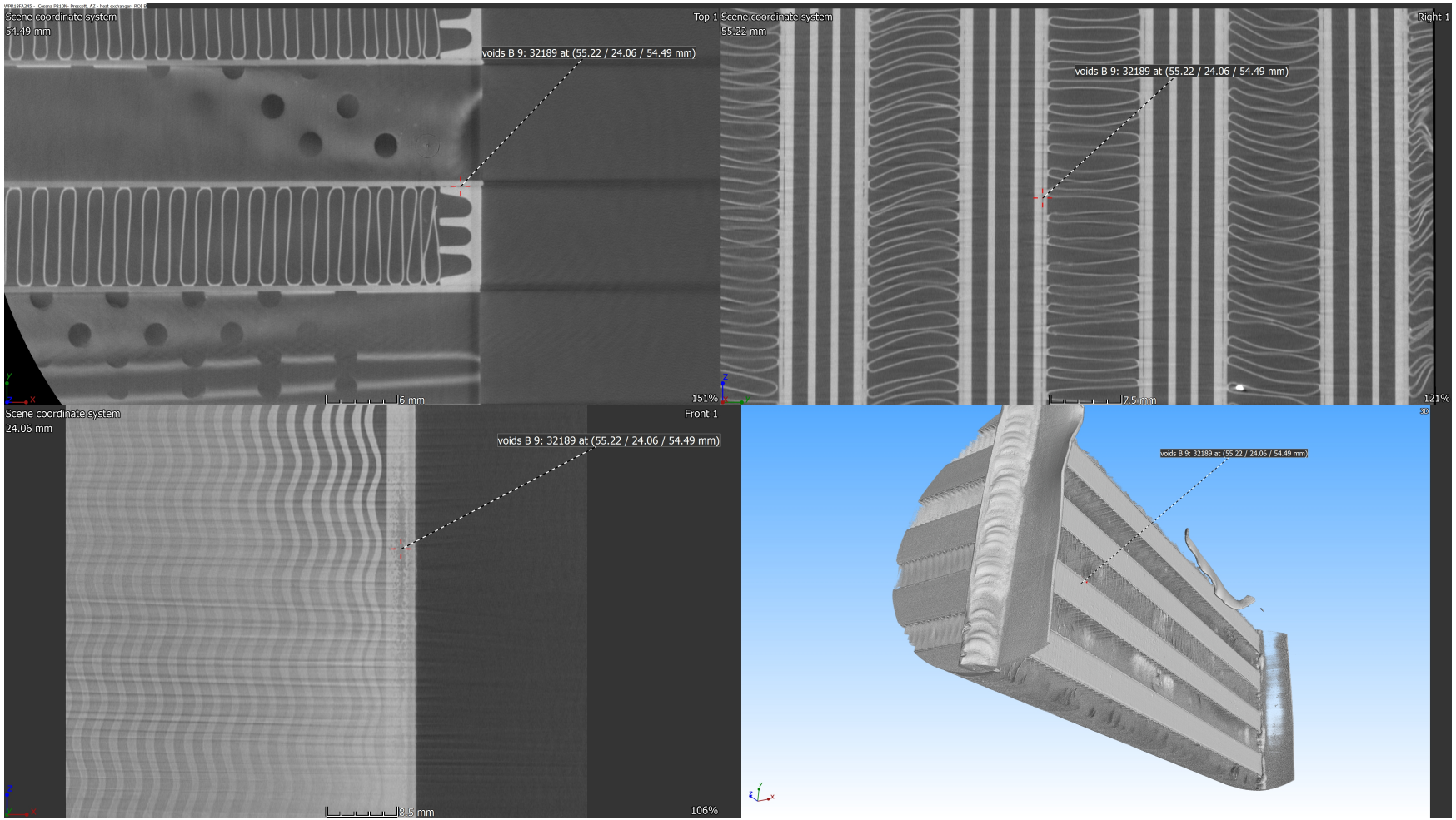


Figure 25
Heat exchanger – target CT – quadrant B - voids B9

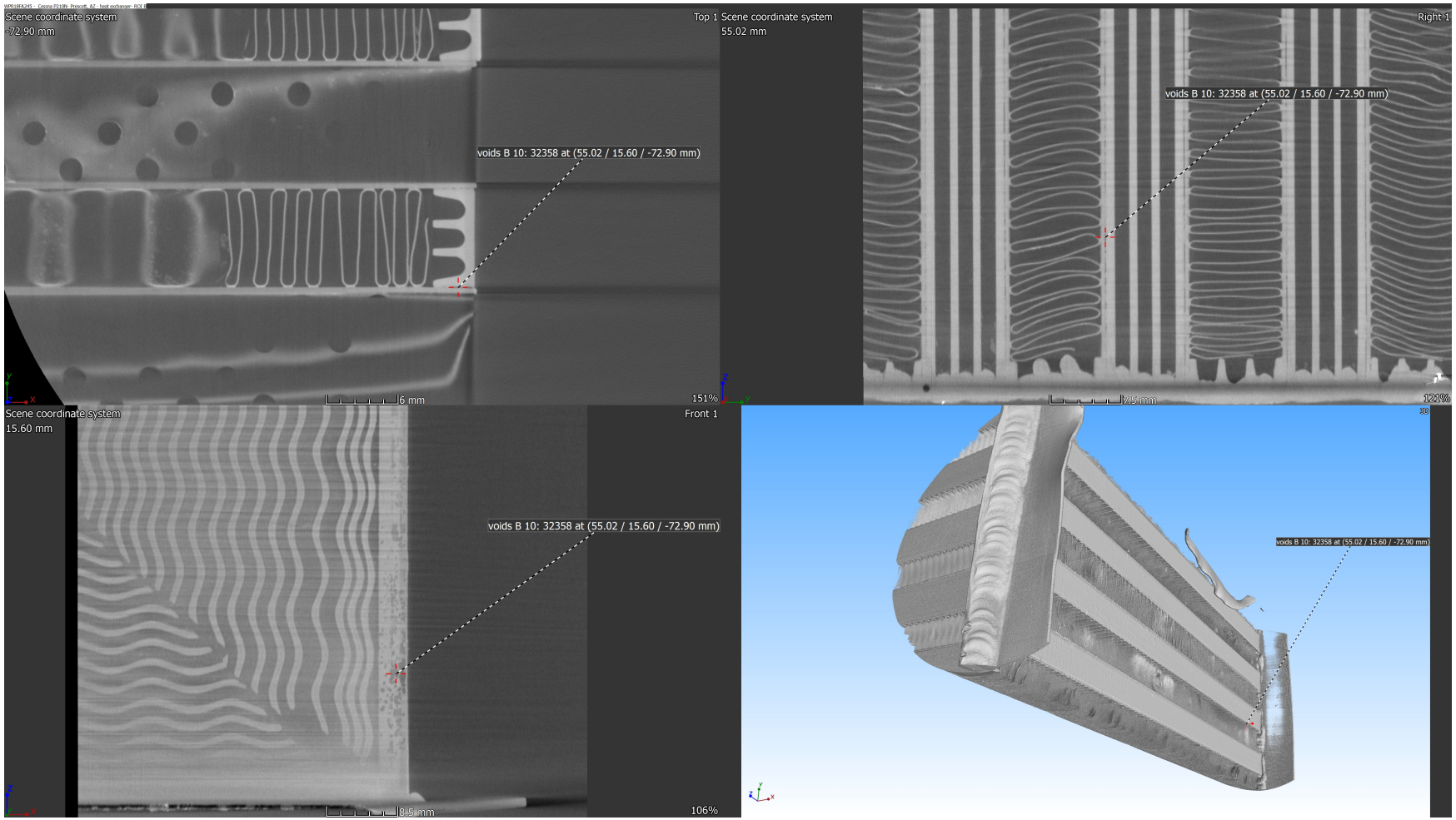


Figure 26
Heat exchanger – target CT – quadrant B - voids B10

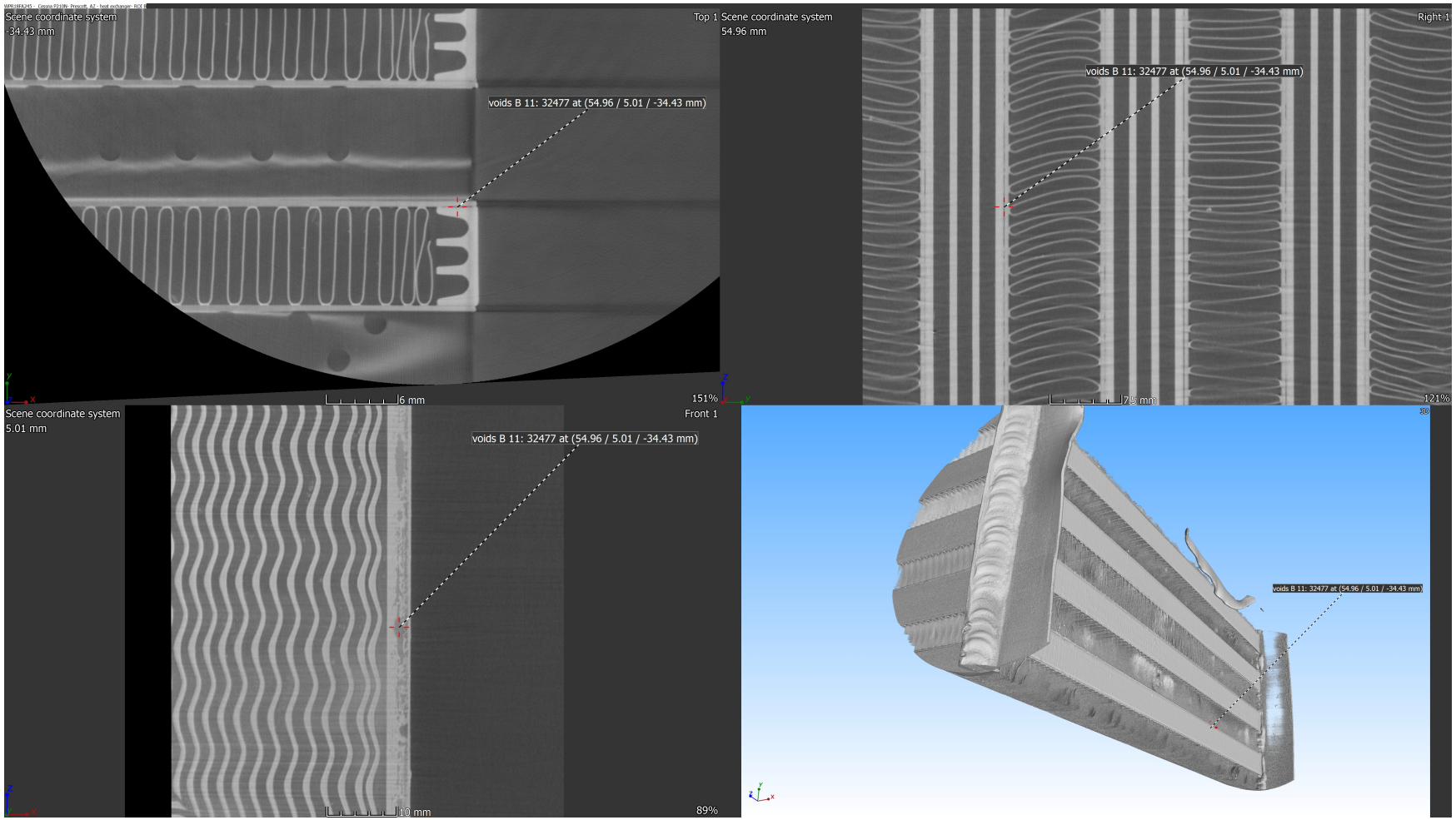


Figure 27
Heat exchanger – target CT – quadrant B - voids B11

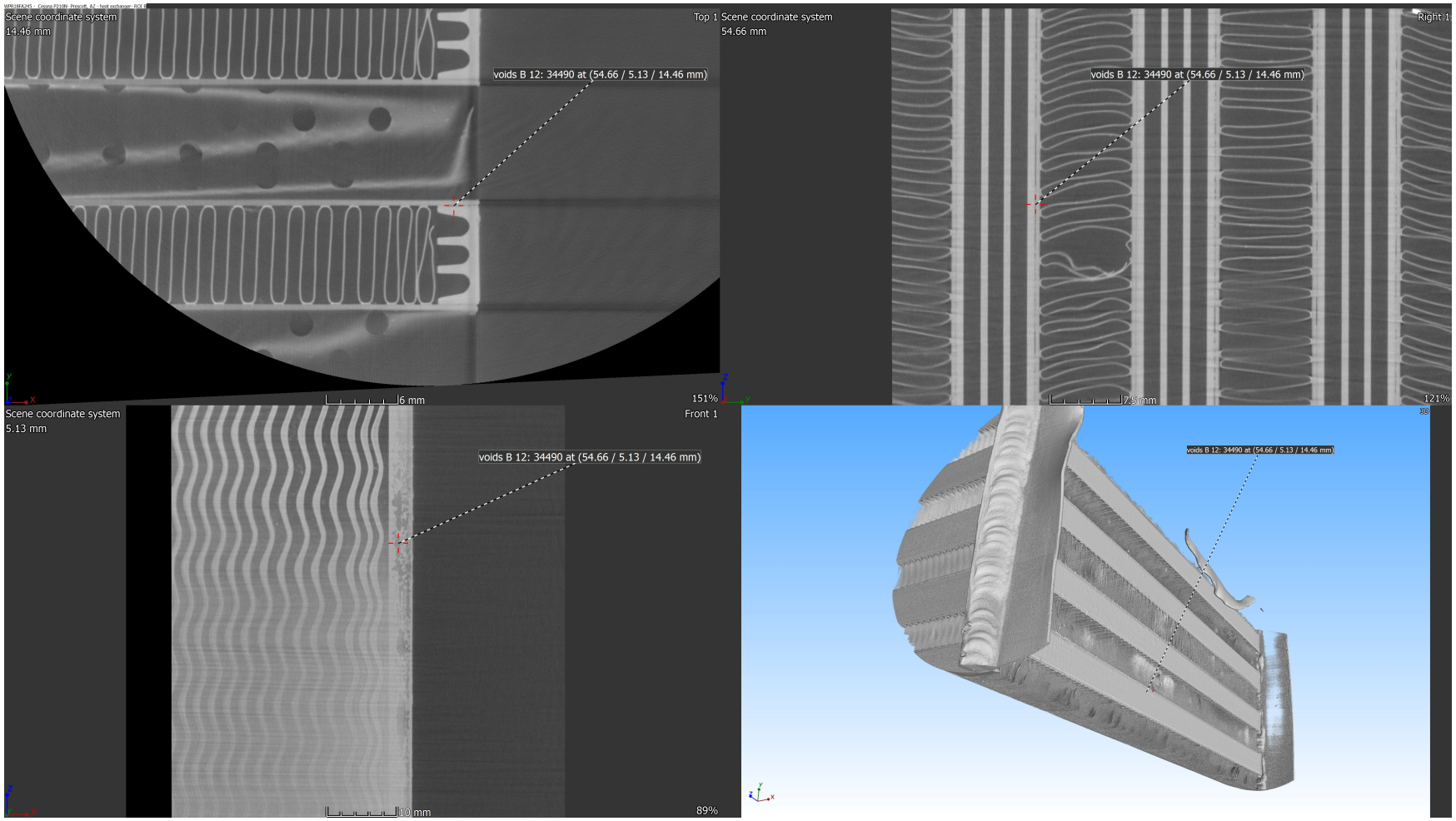


Figure 28
Heat exchanger – target CT – quadrant B - voids B12

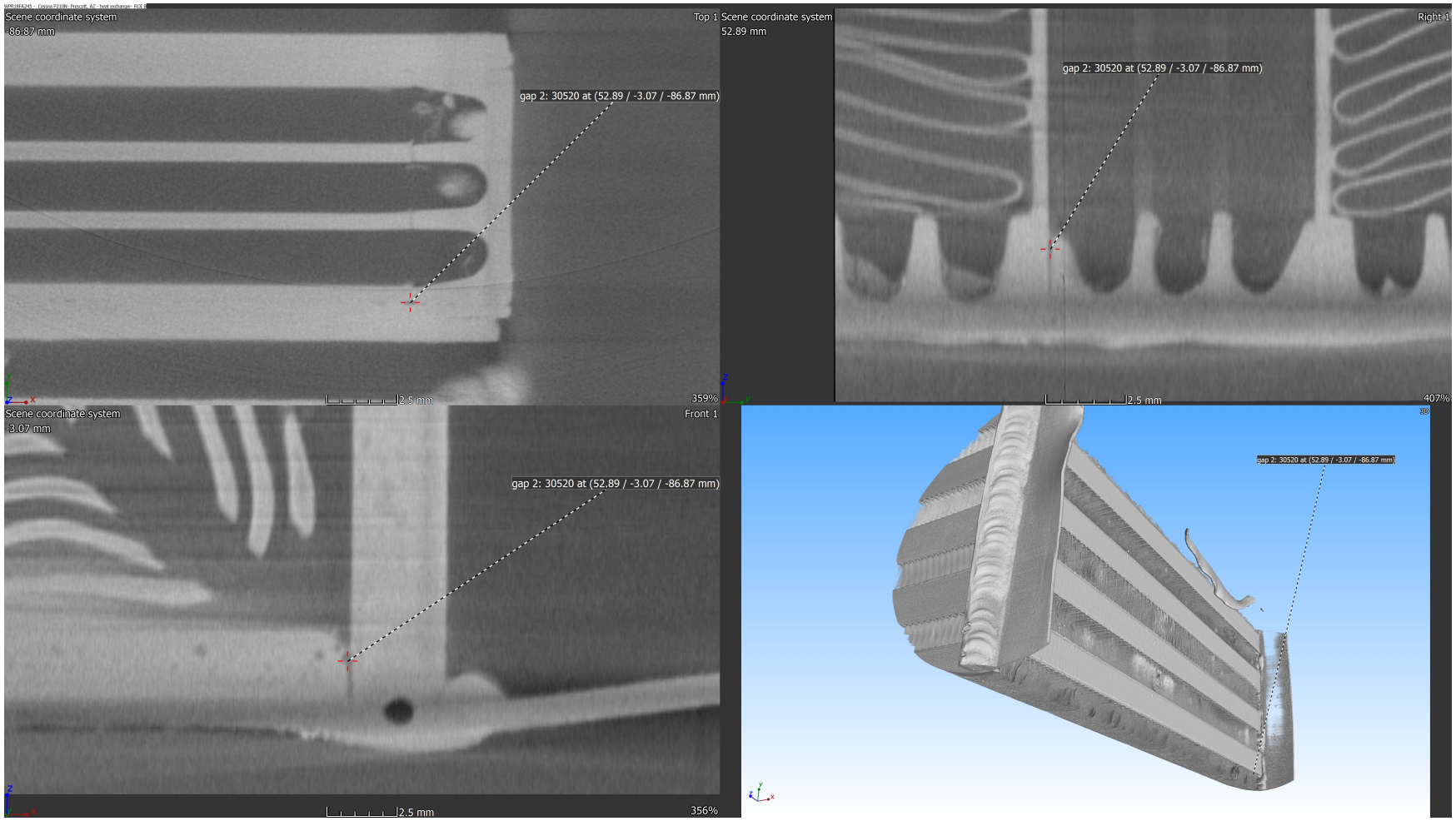


Figure 29
Heat exchanger – target CT – quadrant B – gap 2

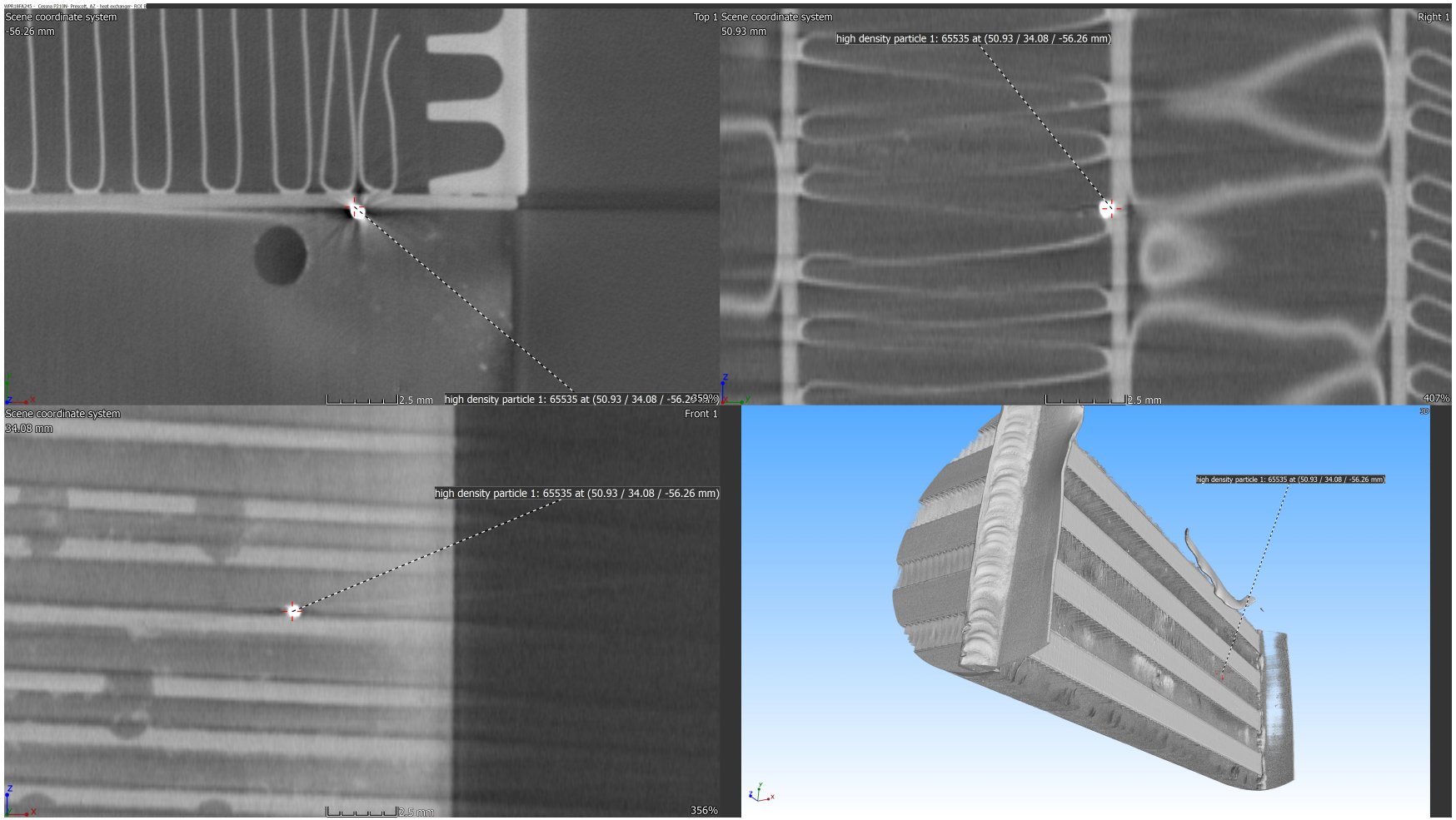


Figure 30
Heat exchanger – target CT – quadrant B – high density particle 1

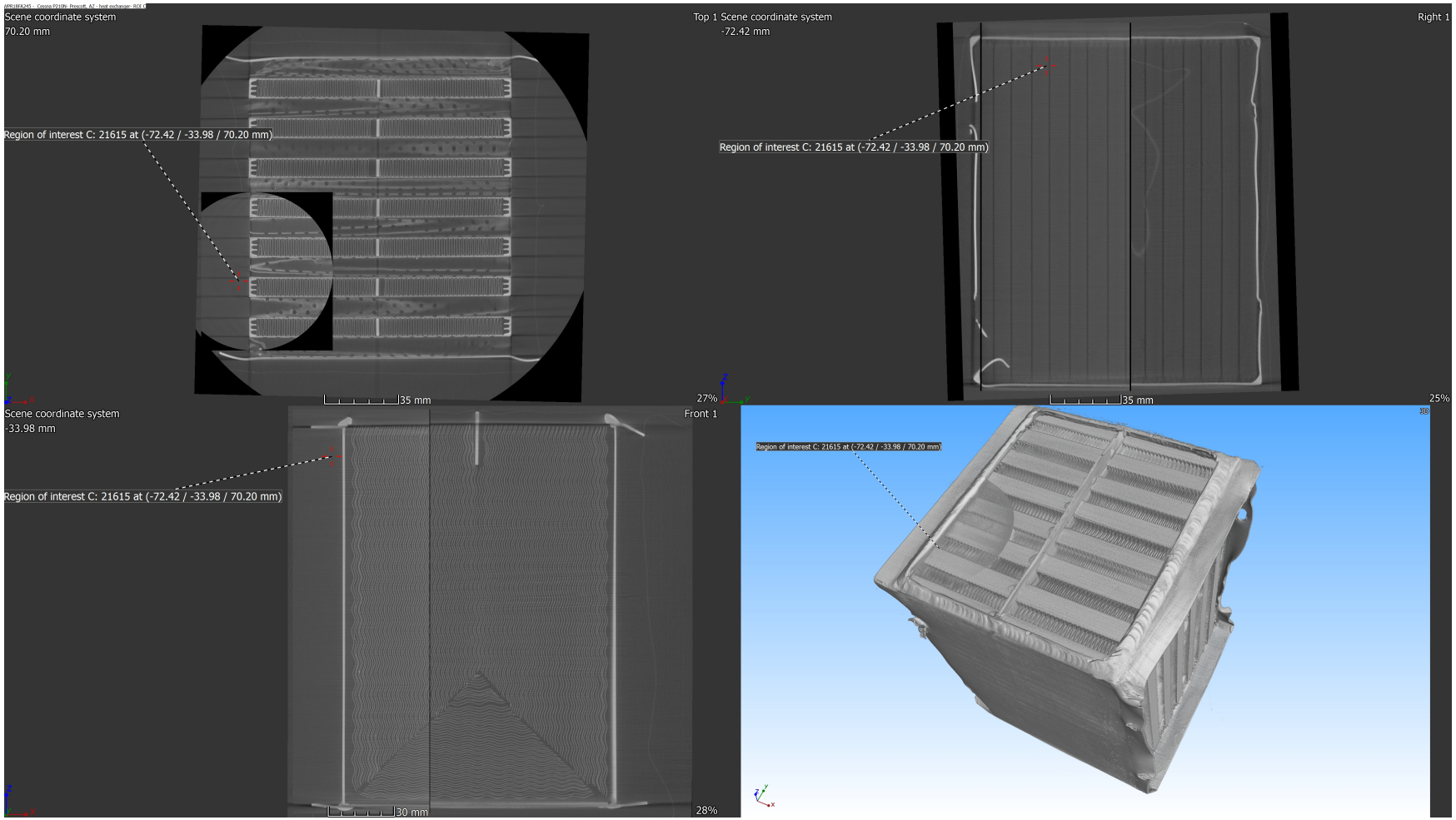


Figure 31
Heat exchanger – target CT – quadrant C - overview

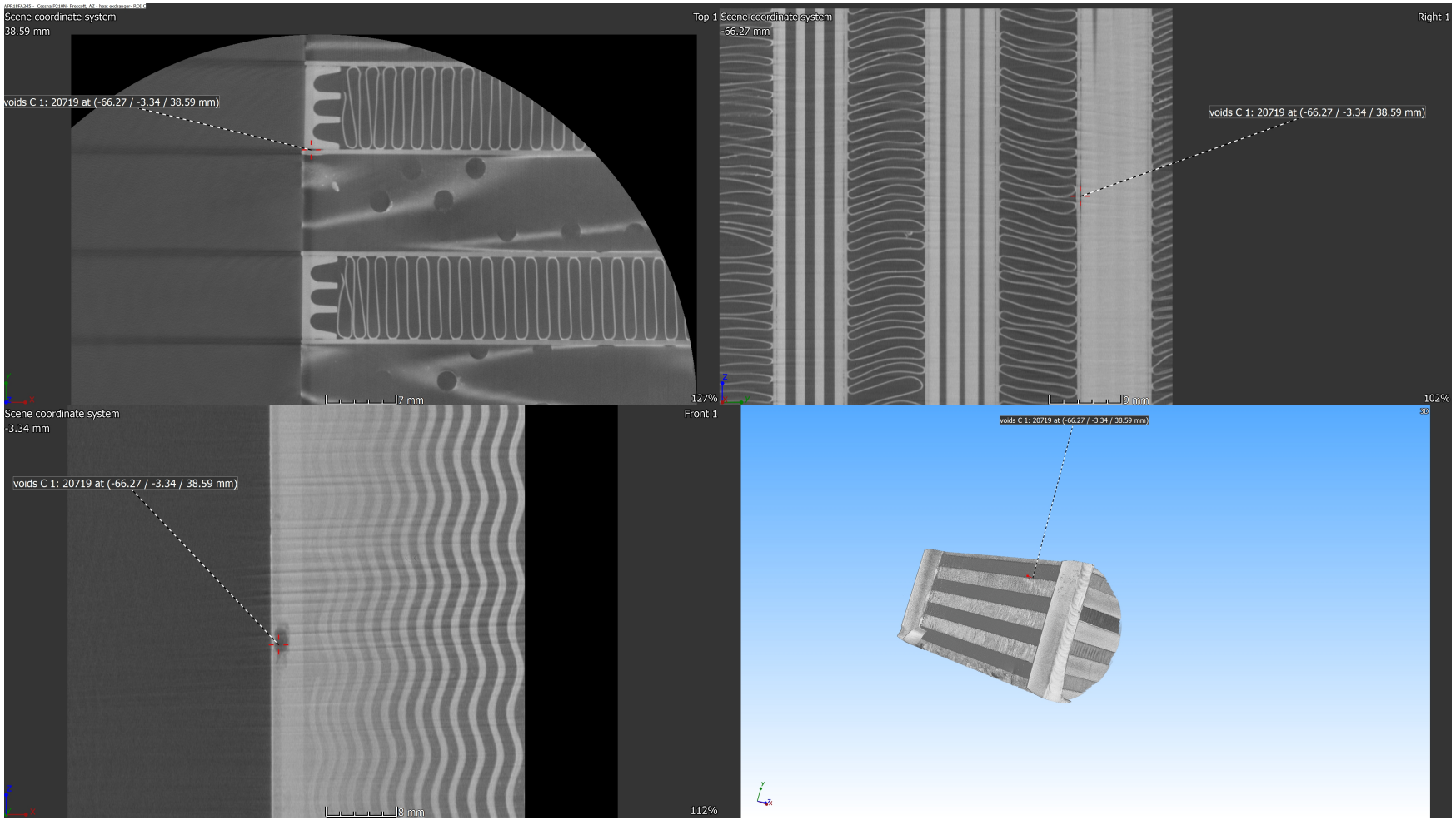


Figure 32
Heat exchanger – target CT – quadrant C - voids C1

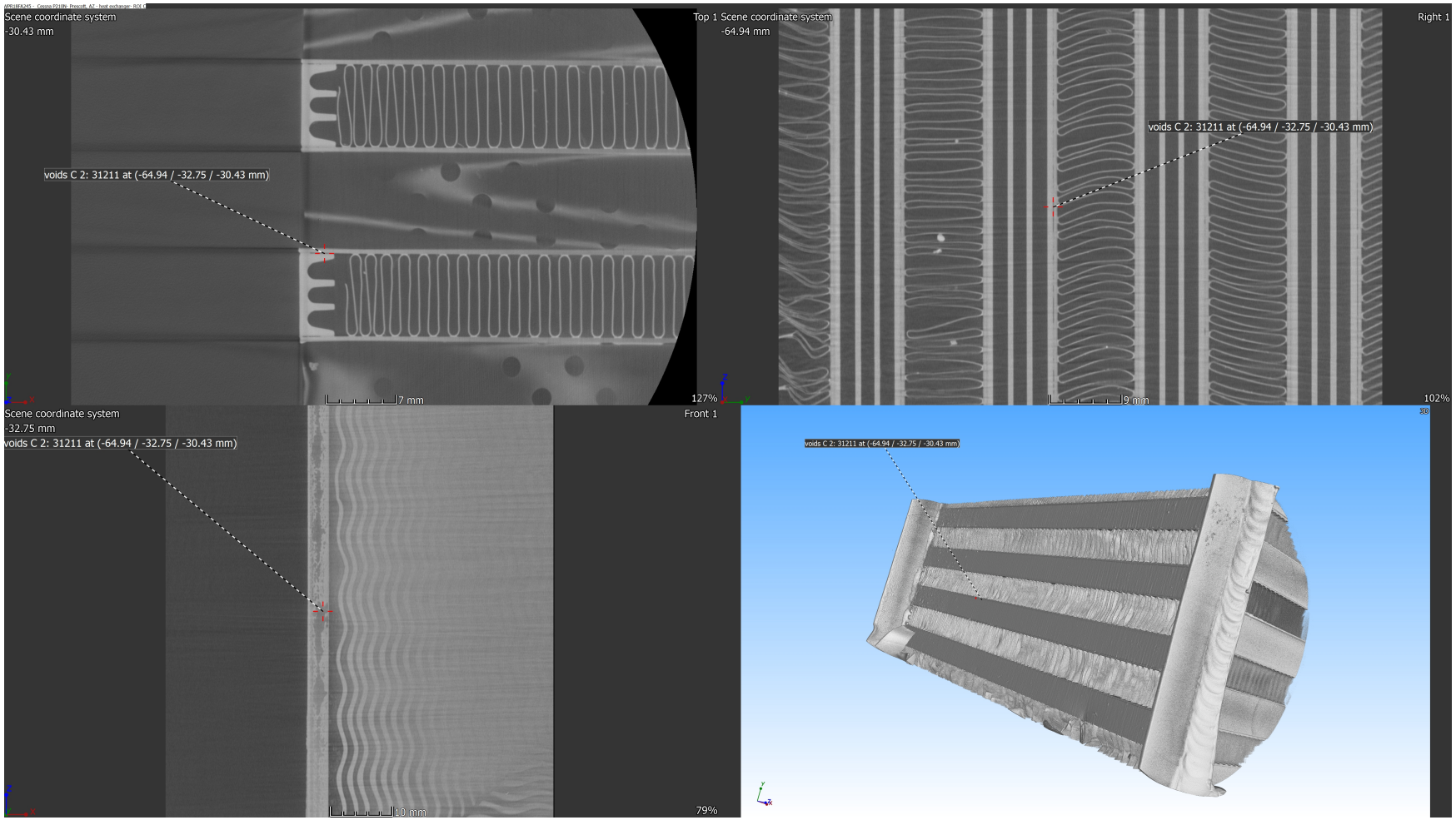


Figure 33
Heat exchanger – target CT – quadrant C - voids C2

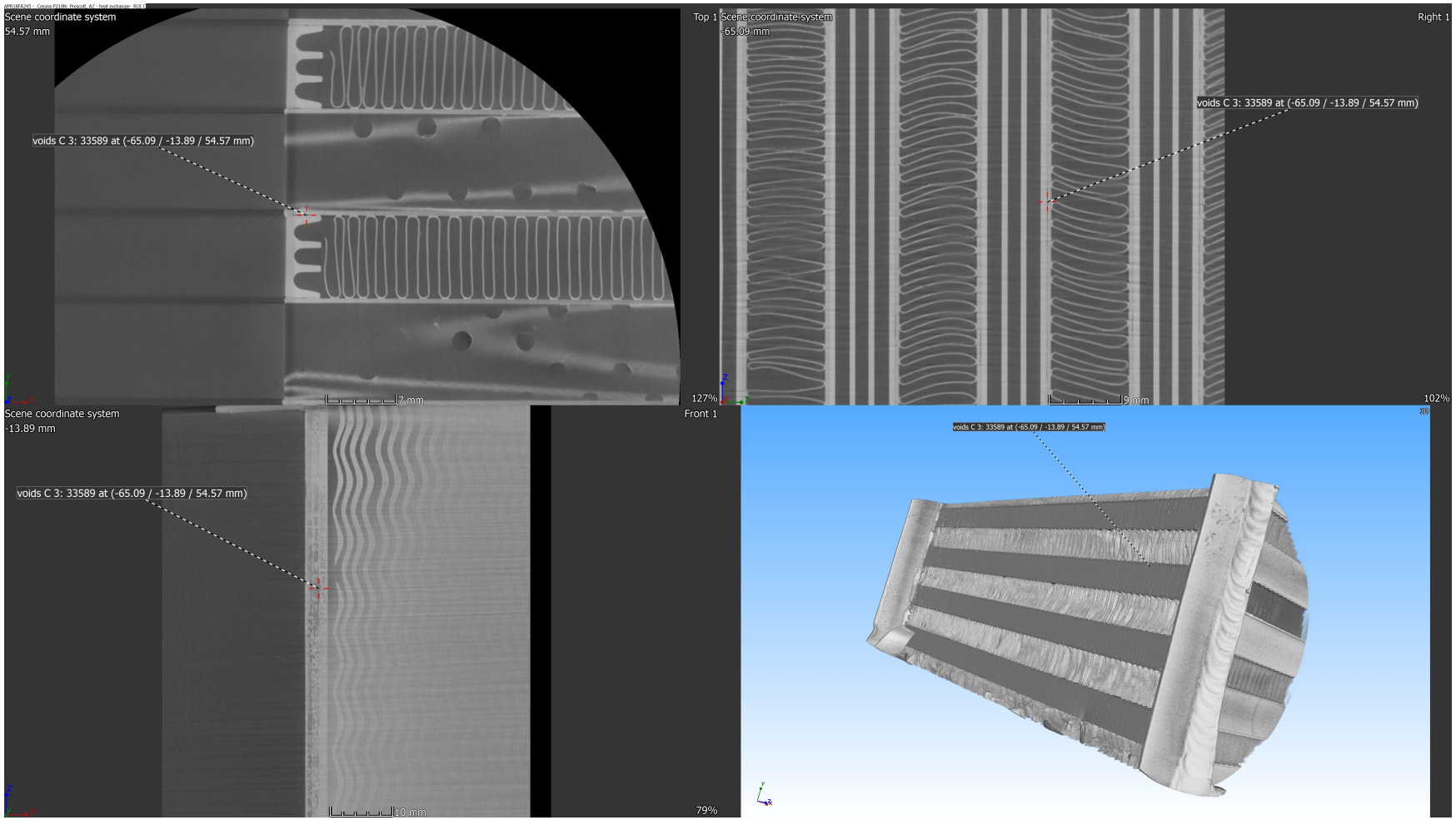


Figure 34
Heat exchanger – target CT – quadrant C - voids C3

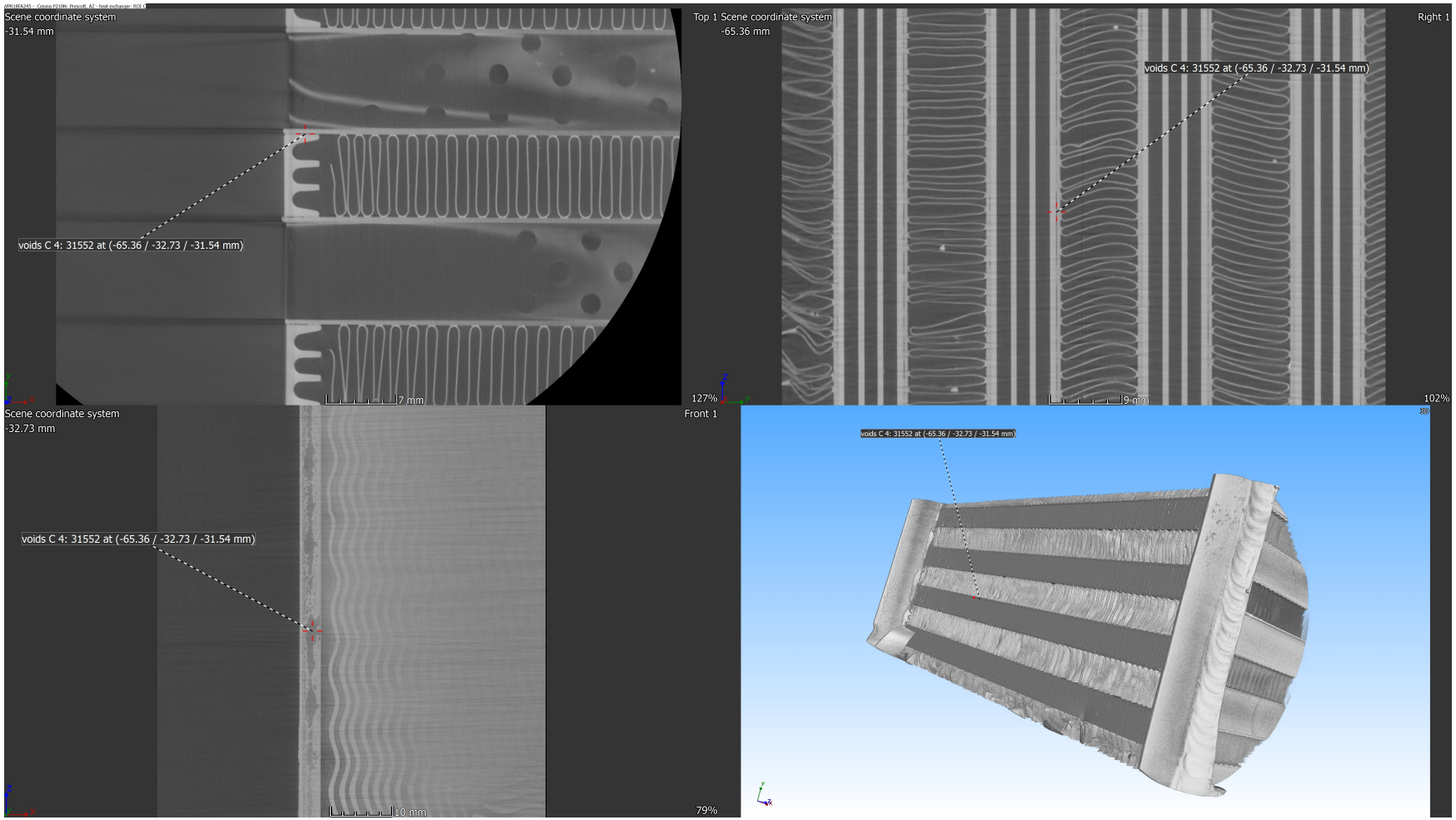


Figure 35
Heat exchanger – target CT – quadrant C - voids C4

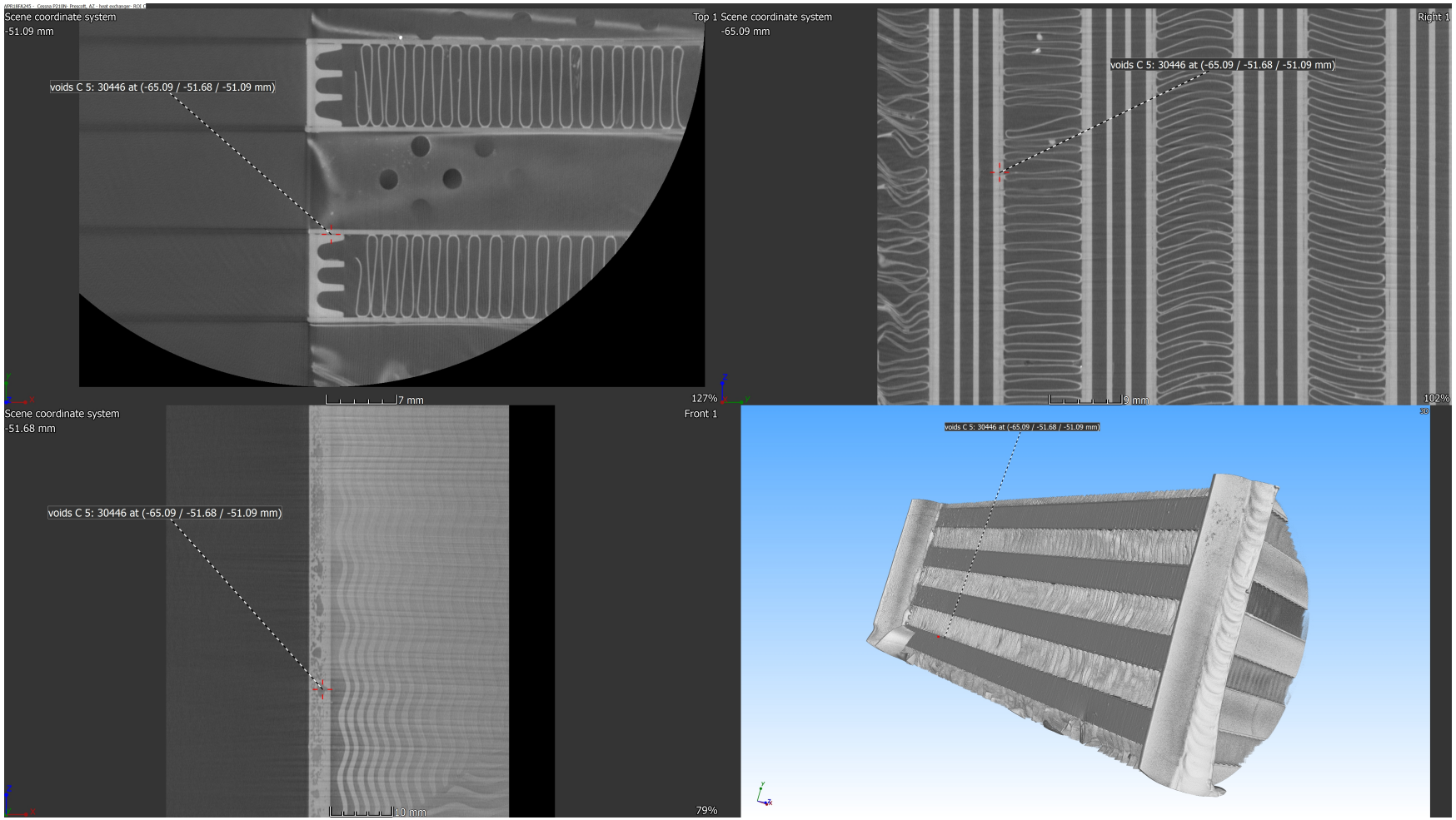


Figure 36
Heat exchanger – target CT – quadrant C - voids C5

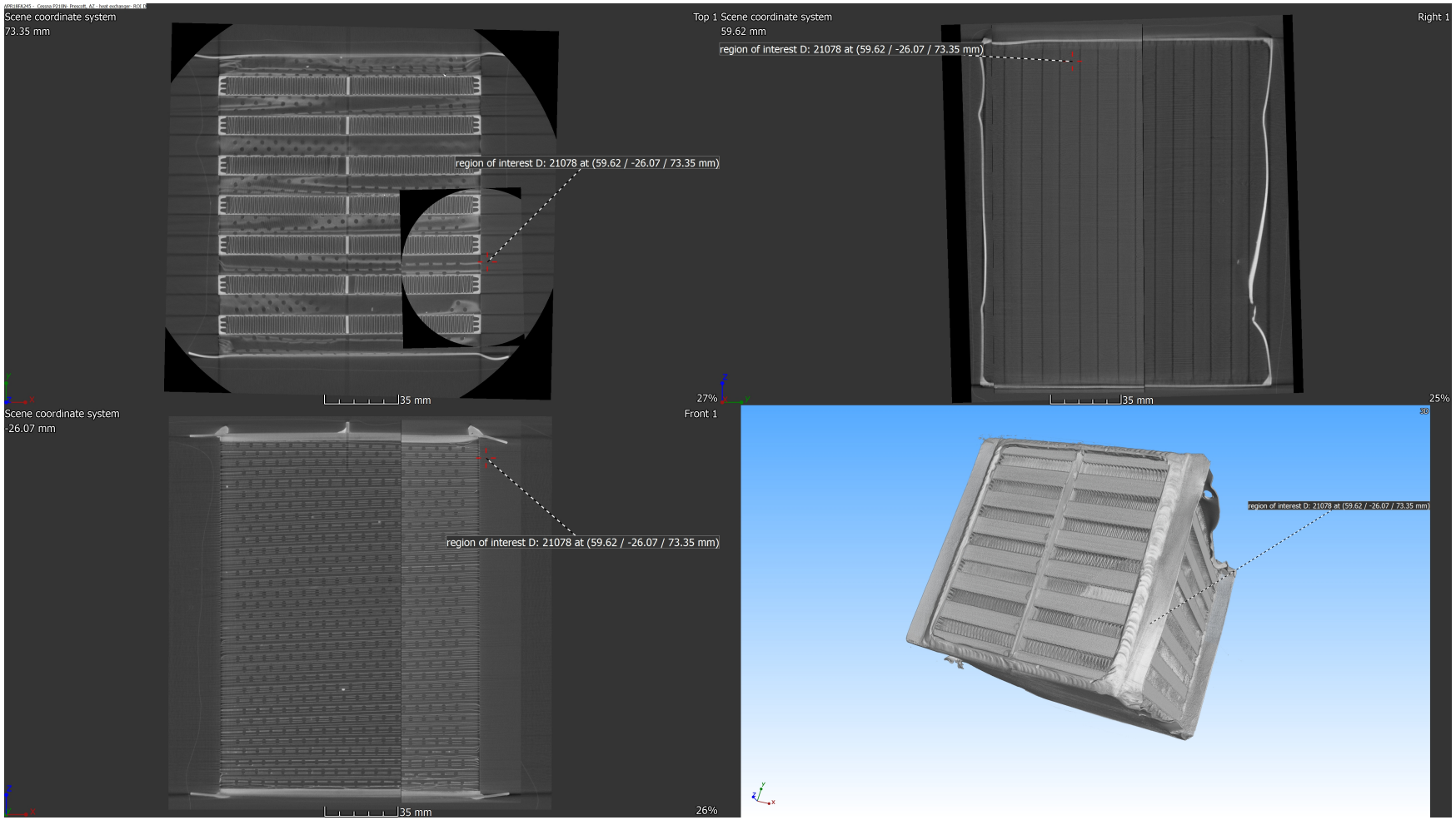


Figure 37
Heat exchanger – target CT – quadrant D - overview

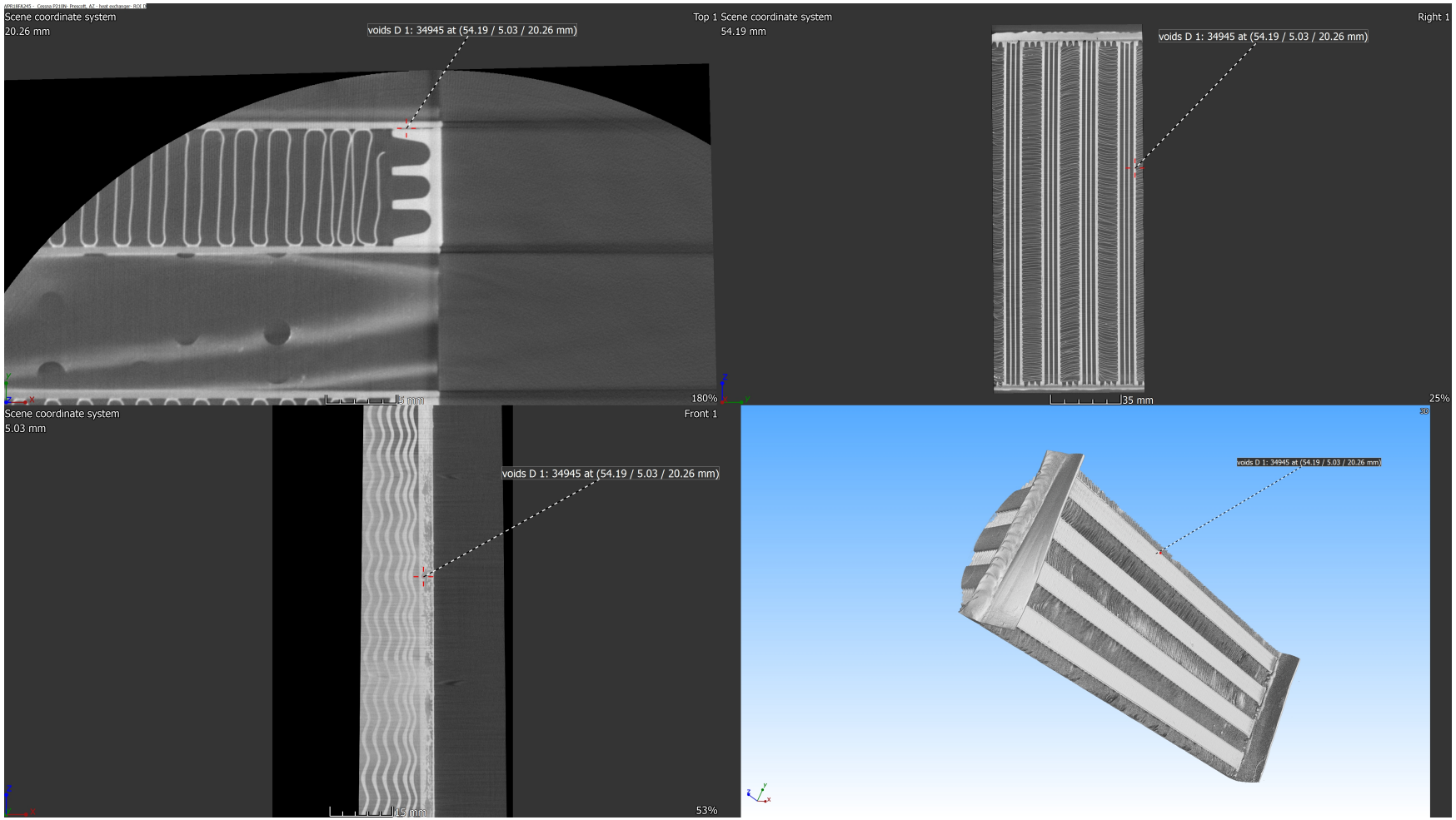


Figure 38
Heat exchanger – target CT – quadrant D - voids D1

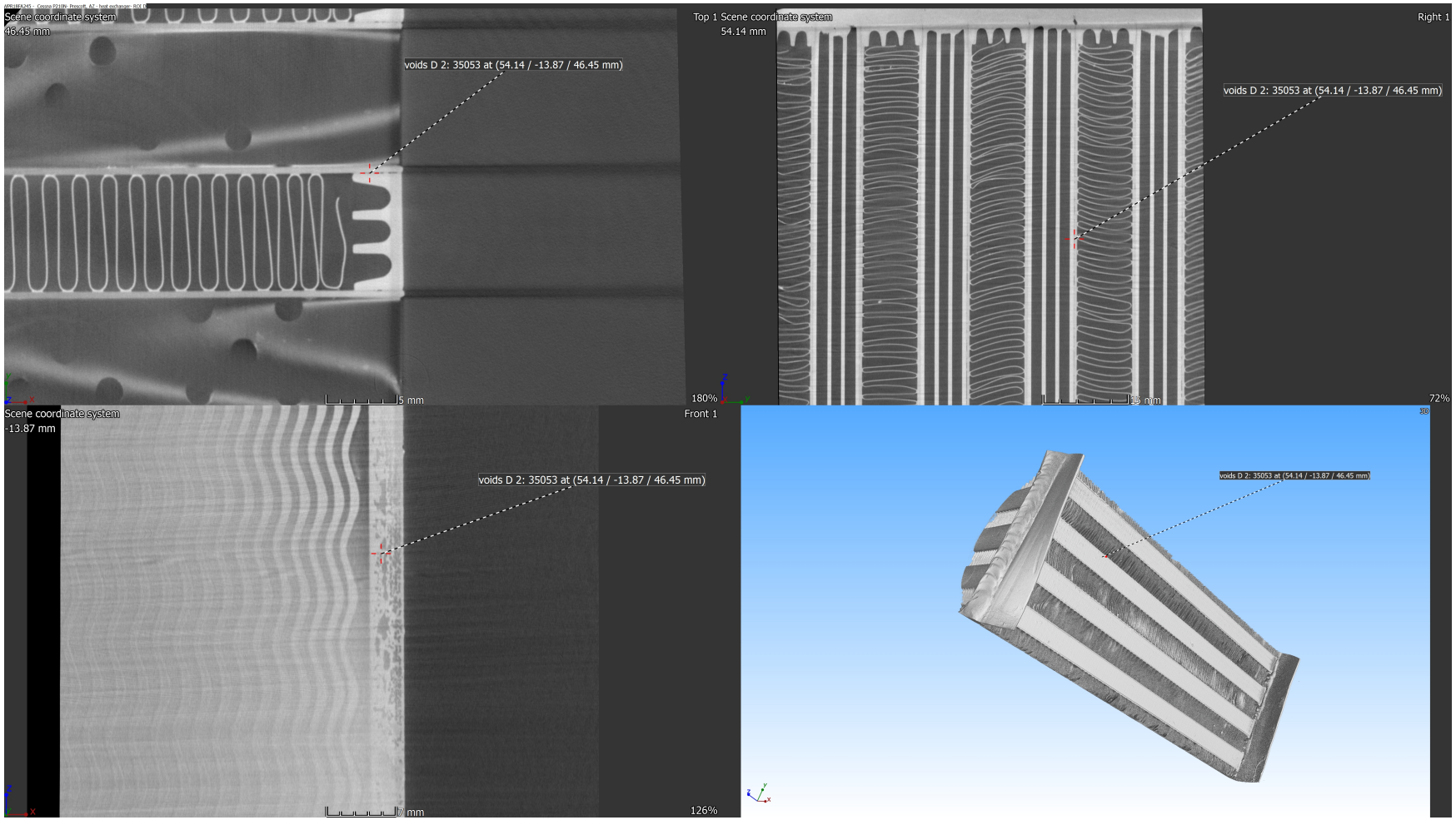


Figure 39
Heat exchanger – target CT – quadrant D - voids D2

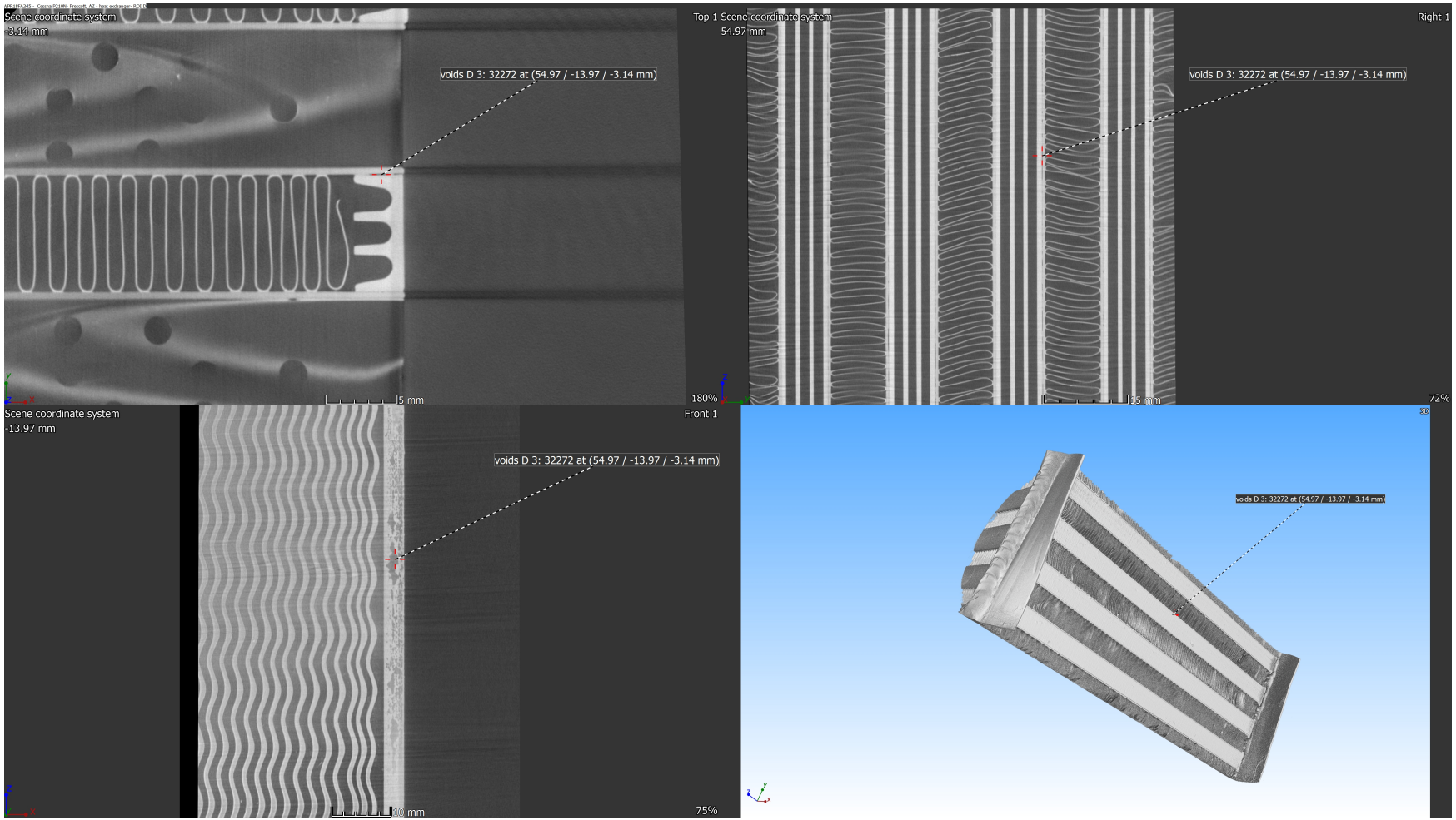


Figure 40
Heat exchanger – target CT – quadrant D - voids D3

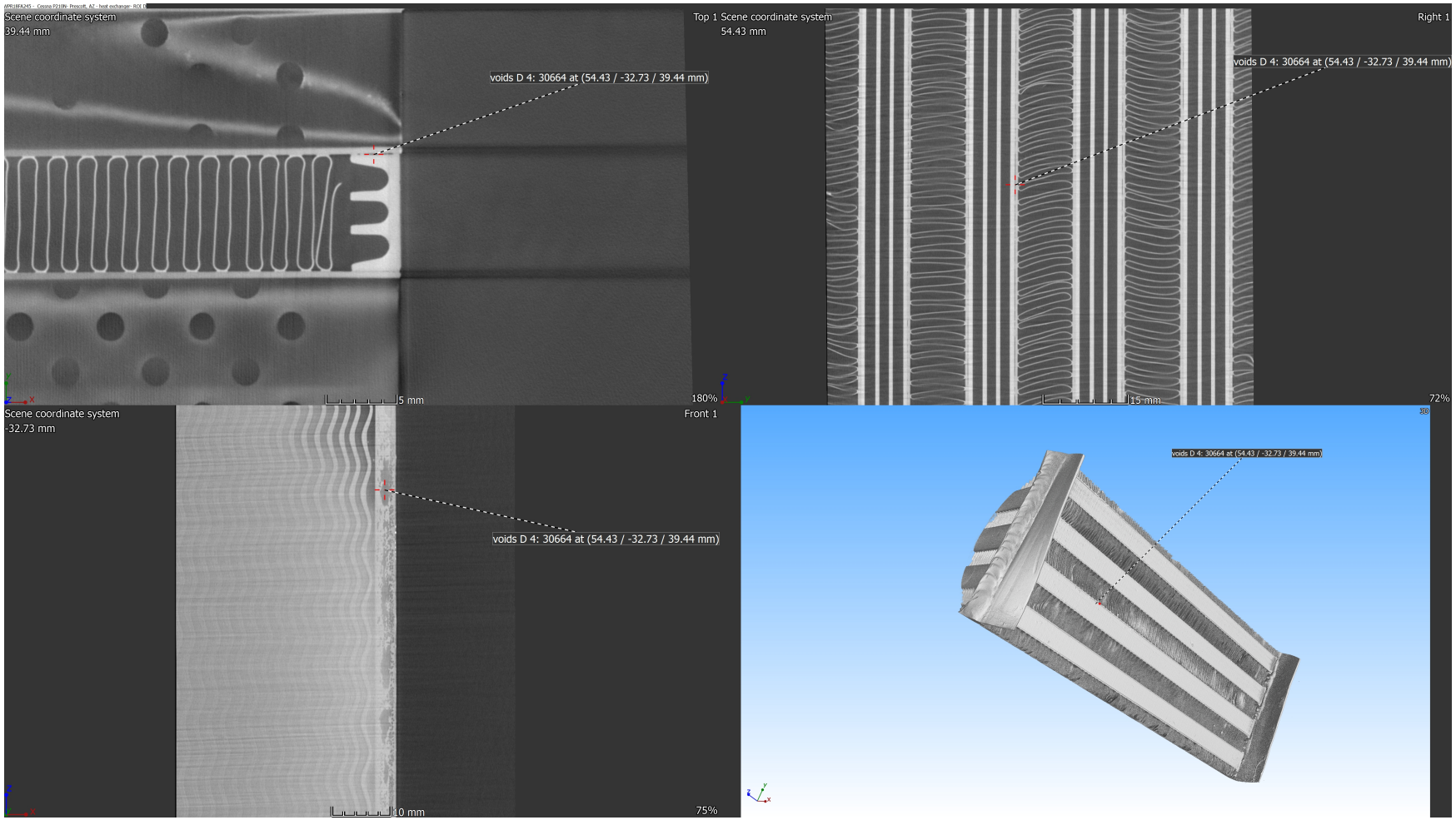


Figure 41
Heat exchanger – target CT – quadrant D - voids D4

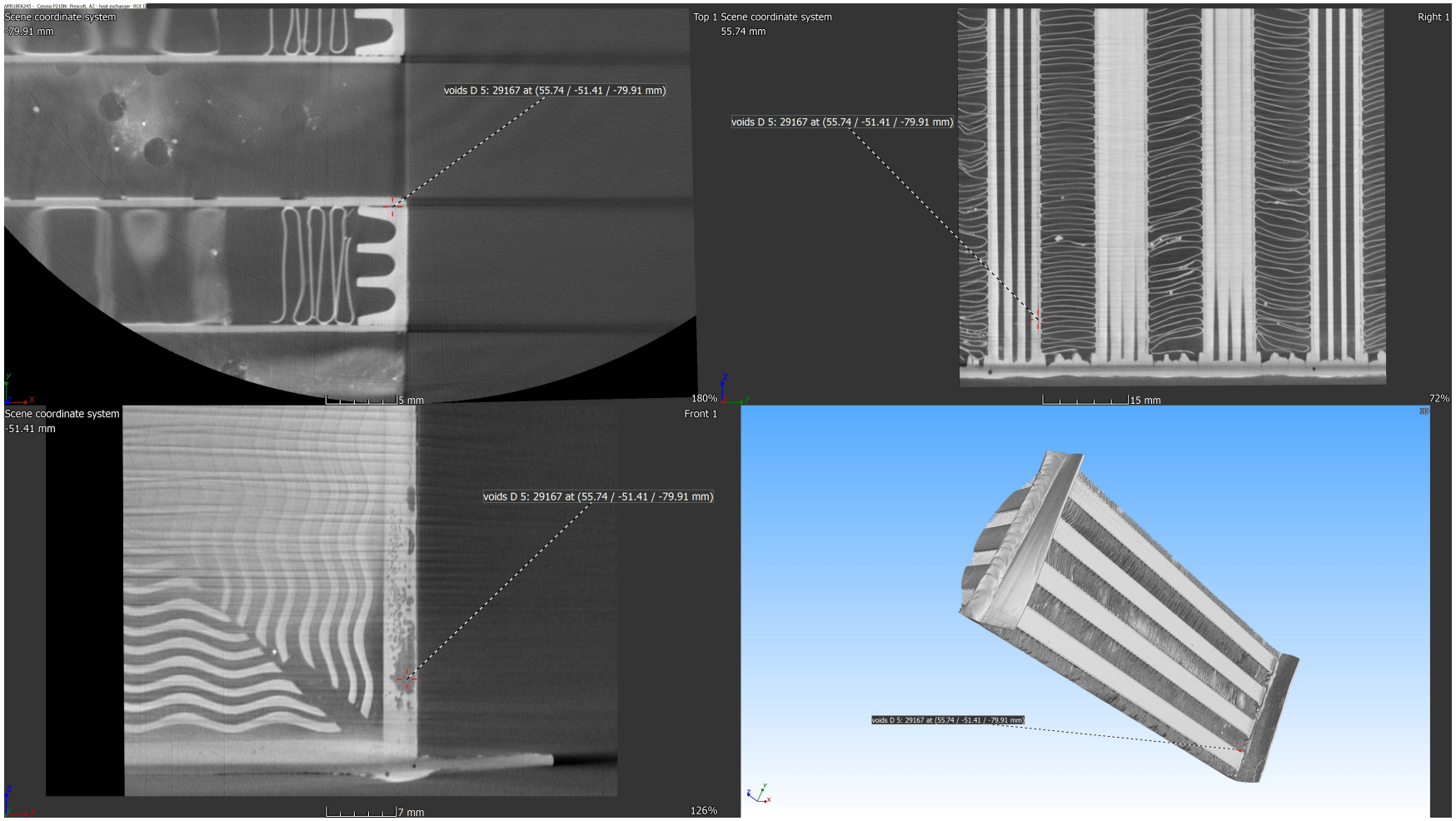


Figure 42
Heat exchanger – target CT – quadrant D - voids D5

Scott Warren
Lead Aerospace Engineer
(Computed Tomography Specialist)