X-ray Tomography Analysis of Short-Length HTS DEMO Conductors with different architectures

MAG-T.01.01-T047-D001

National Institute for Lasers, Plasma and Radiation Physics, Bucharest, Romania

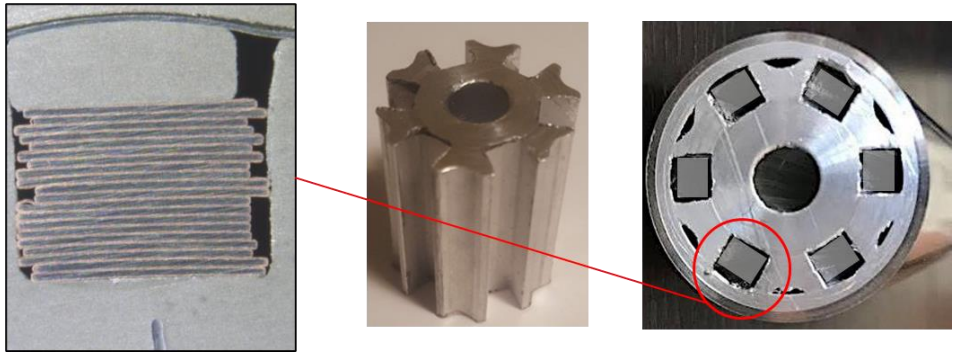
Team: Daniel AVRAM, Cosmin DOBREA, Adrian SIMA, Ioana DINCA

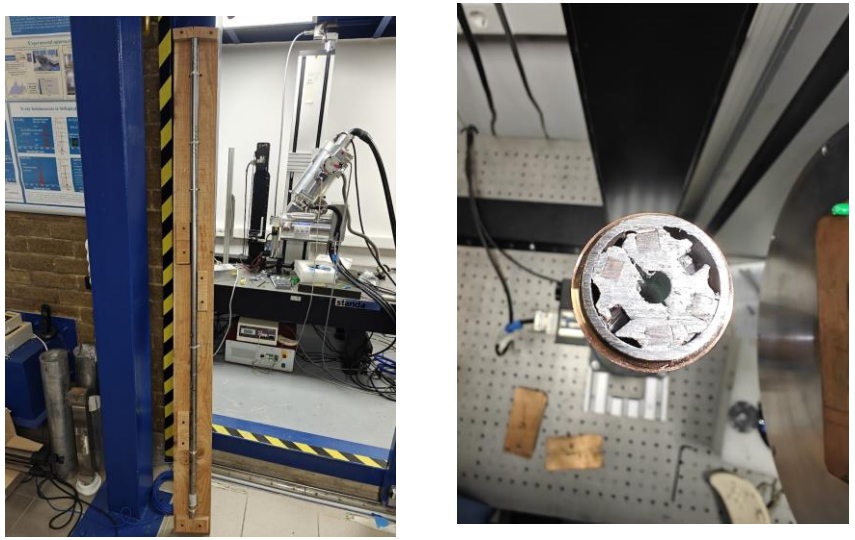
Contact person
Ion TISEANU (*ion.tiseanu@inflpr.ro*)
https://tomography.inflpr.ro/

ENEA - HTS Conductors tested at the SULTAN Facility

ENEA HTS conductor tested at the SULTAN Facility features a tape arrangement of 6 stacks × 13 HTS tapes, a total of 78 tapes. It has a 6-slot aluminium core with straight slots and straight stacks. The conductor follows a double jacket concept, consisting of an inner aluminium layer and an outer stainless steel (SS) layer, ensuring structural integrity and thermal stability.

We received the bottom and upper termination and 180 cm long section of the cable B1.





180 cm long section of cable B1

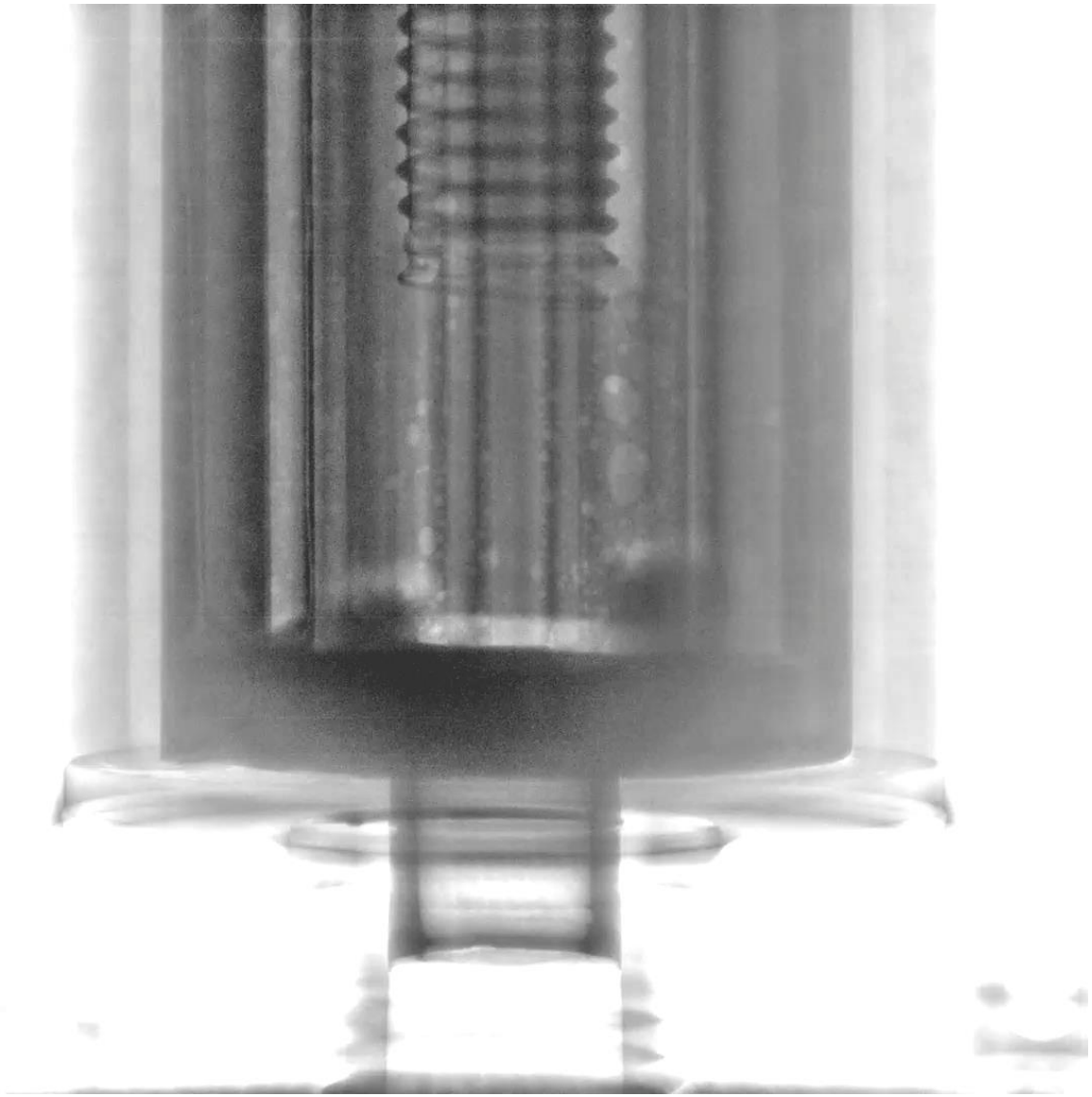
Experimental setup

320 KV high-power set-up:

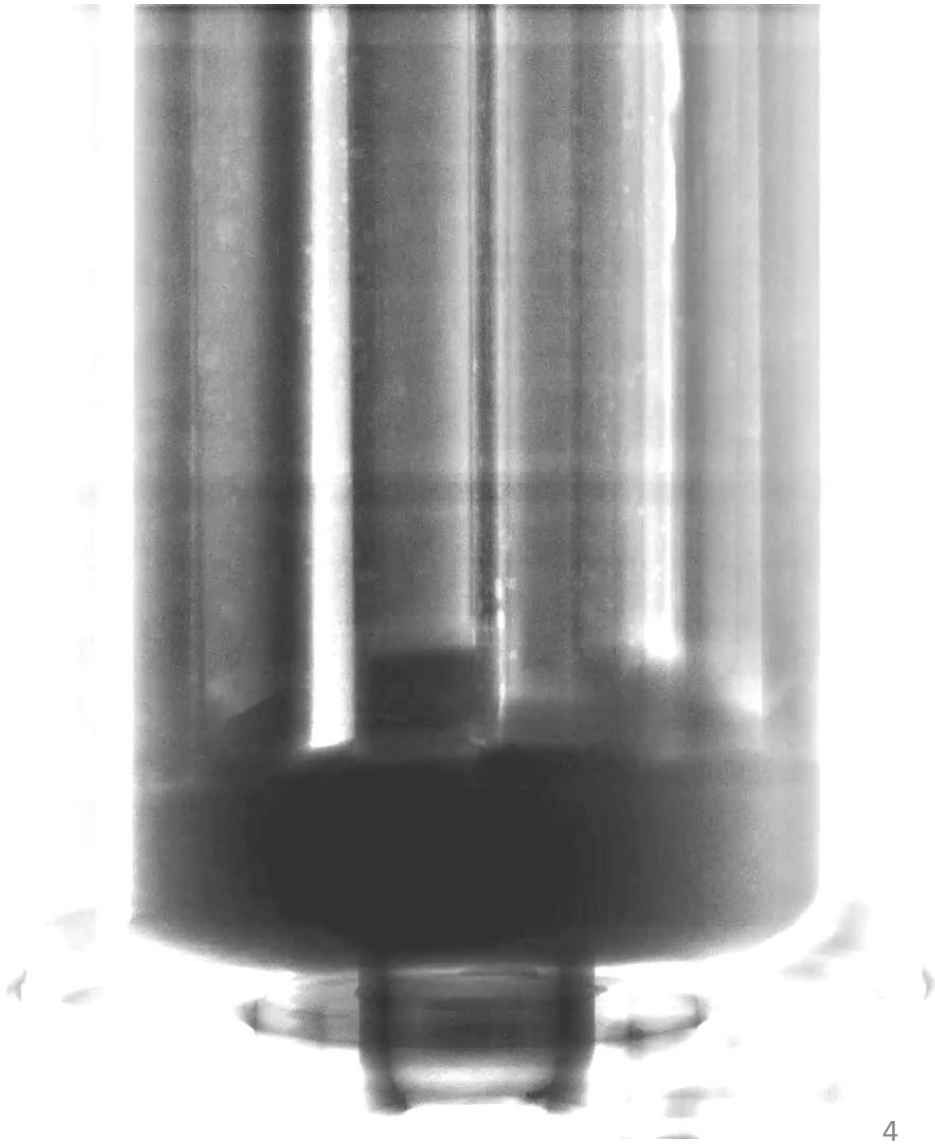
- X ray generator: Nikon micro-focus with 320 KV interchangeable module
- X ray detector: high energy flat panel with resolution 2000 x 2000 px, windows size 400 x 400 mm, pixel size 200 µm, 16 bit;
- Three high load, high precision motorized stages.
- 3D printed sample holder.
- All CT scans were measured:
  - U=290-300 kV
  - 20 µm voxel resolution
  - 1 s integration time; 2 average radiography images and 0.18 ° rotational step

Bottom and upper termination linear radiographic overview

Bottom termination

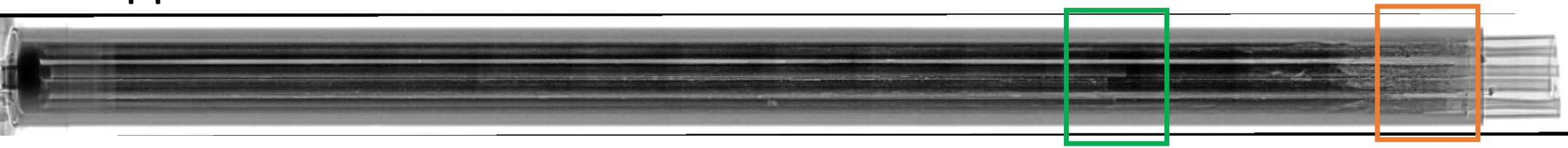


Upper termination



Bottom and upper termination linear radiographic overview

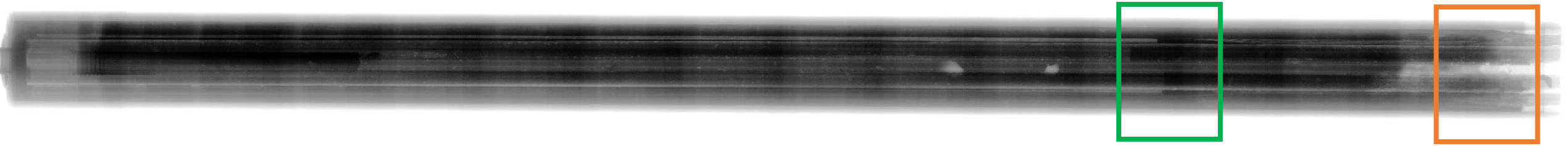
Upper termination

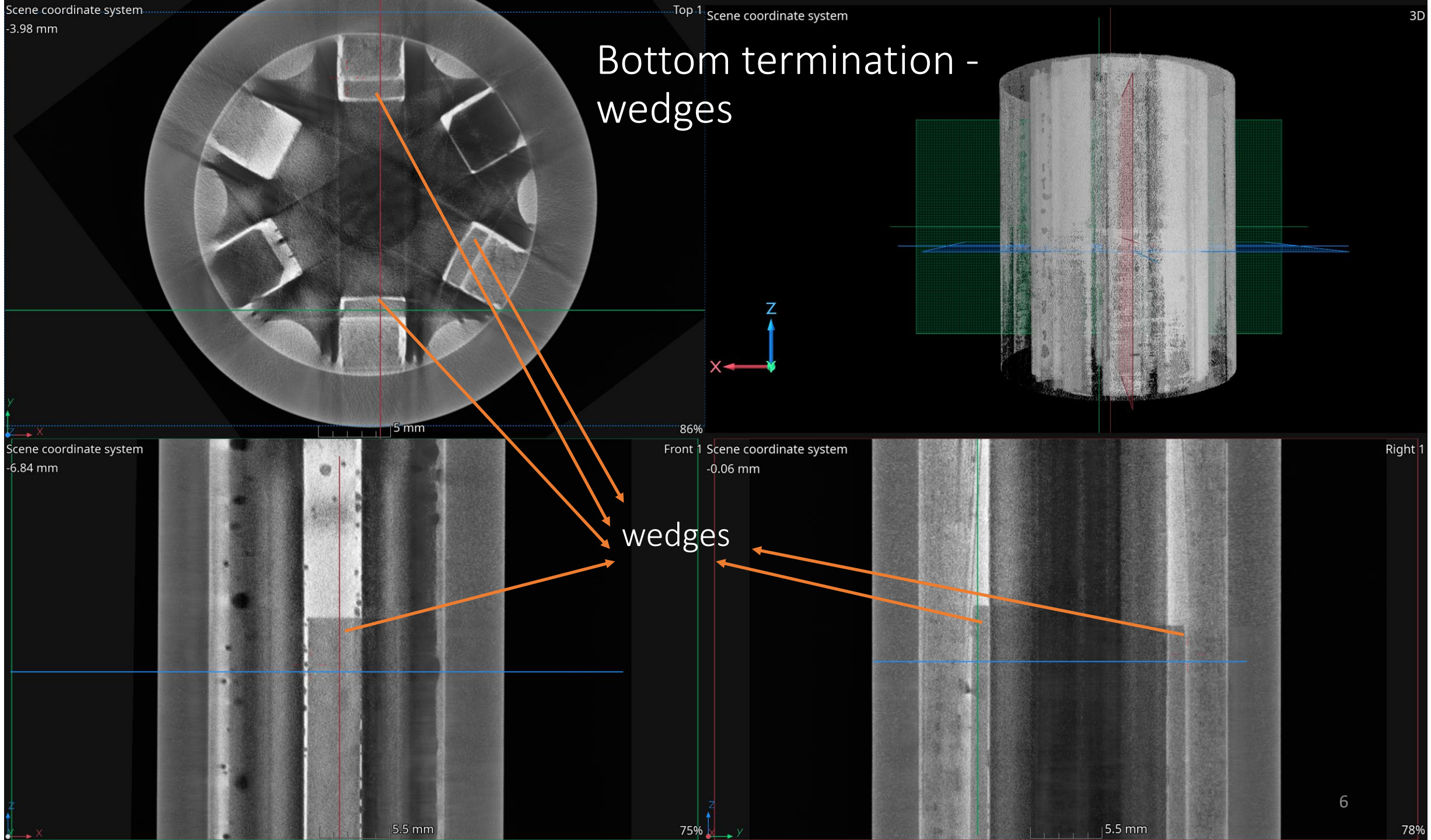


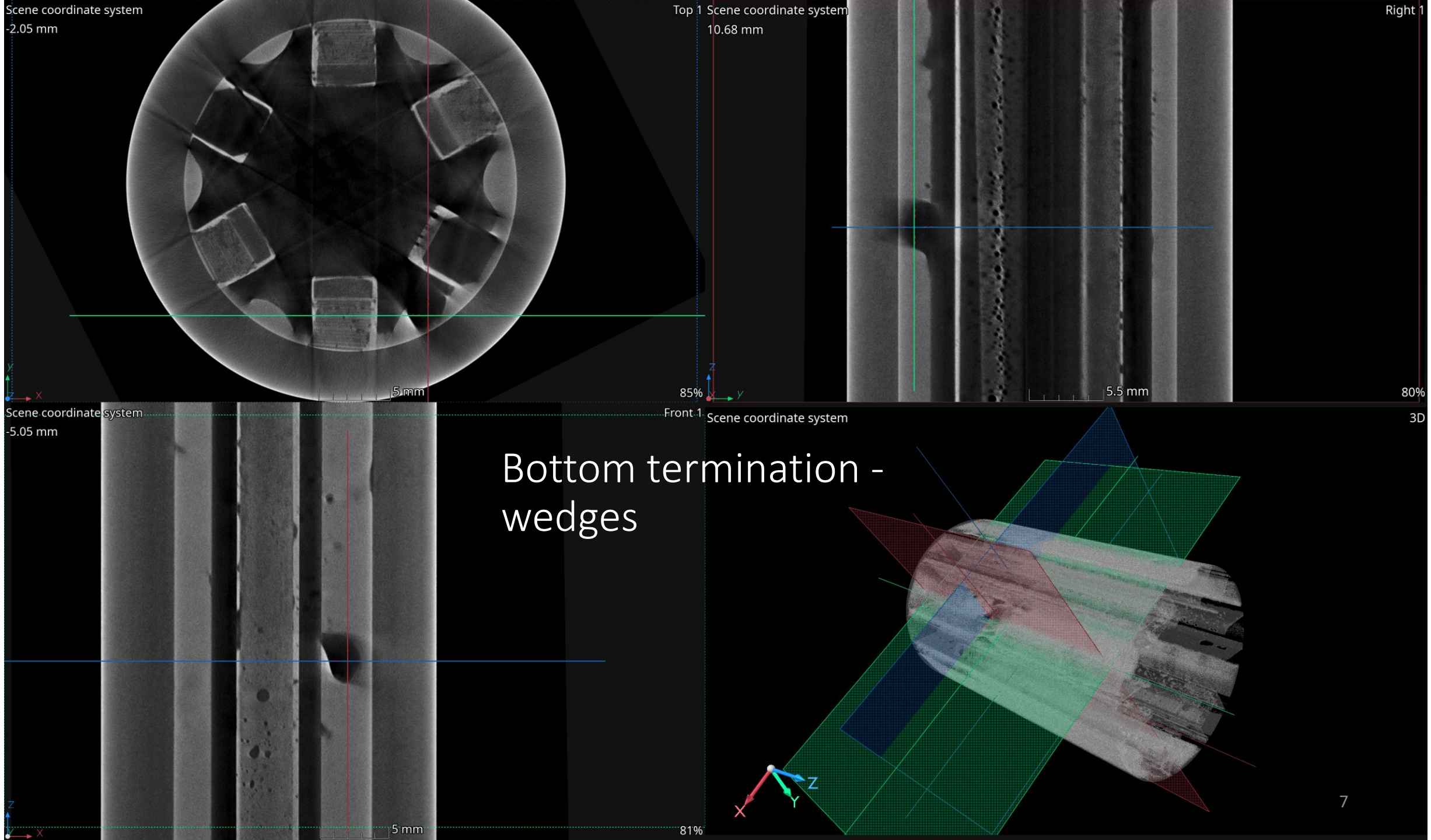
Wedges to press the soldered stacks

Solder starts to appear

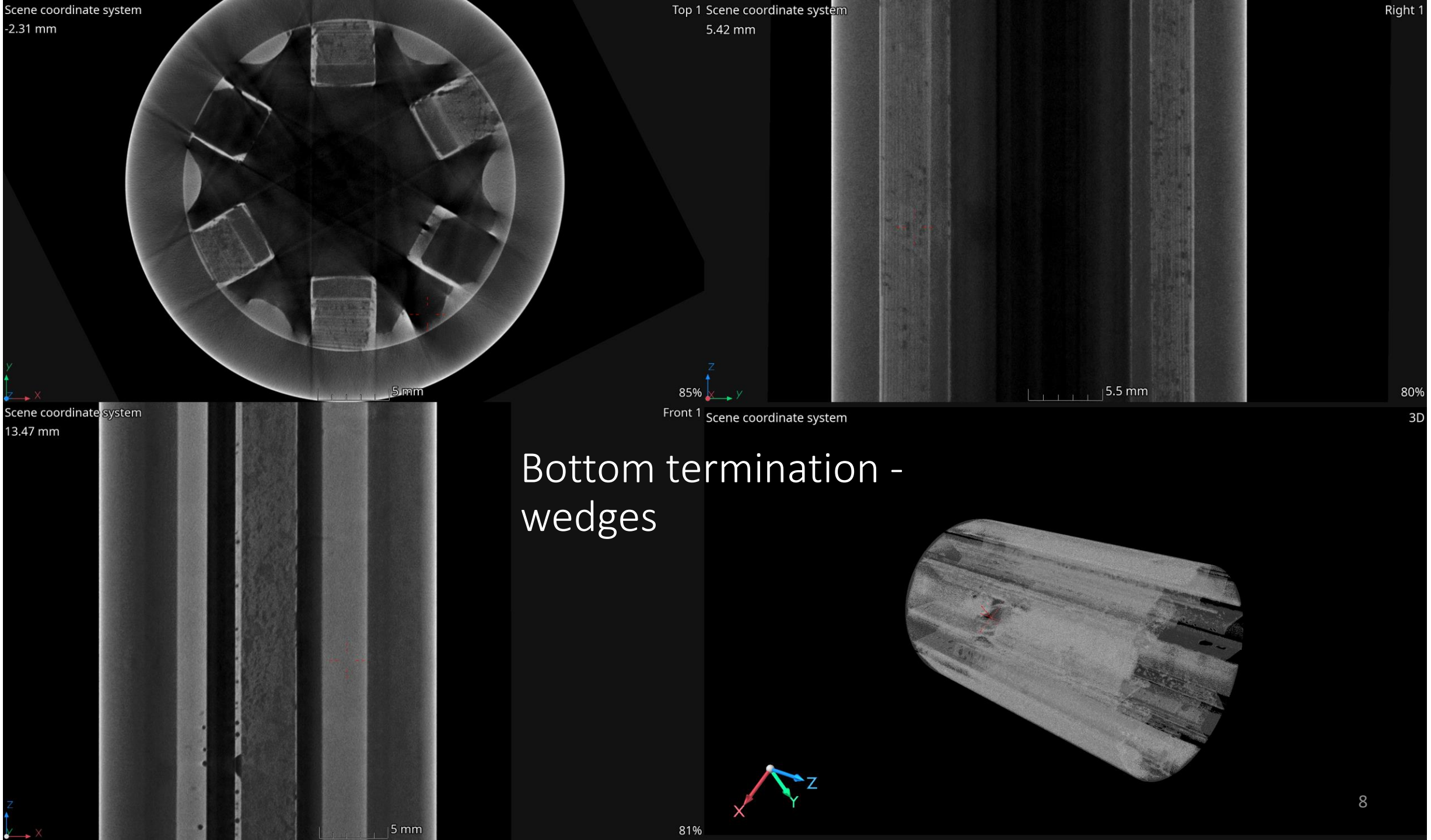
Bottom termination




Scene coordinate system
-3.98 mm
Top 1
5 mm
86%
Scene coordinate system
3D
Z
X
Bottom termination - wedges
wedges
Scene coordinate system
-6.84 mm
Front 1
5.5 mm
75%
Scene coordinate system
-0.06 mm
Right 1
5.5 mm
78%

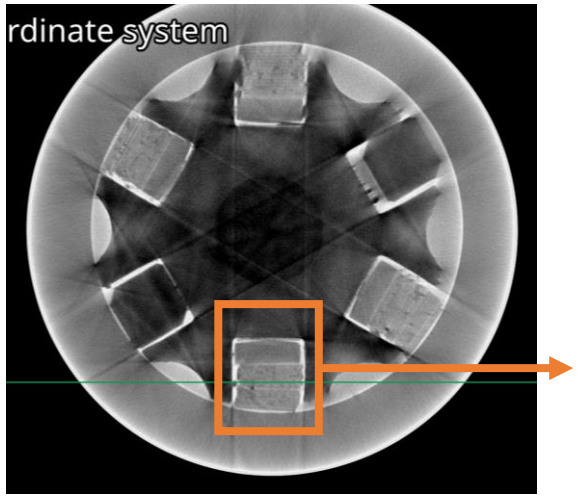


Bottom termination - wedges

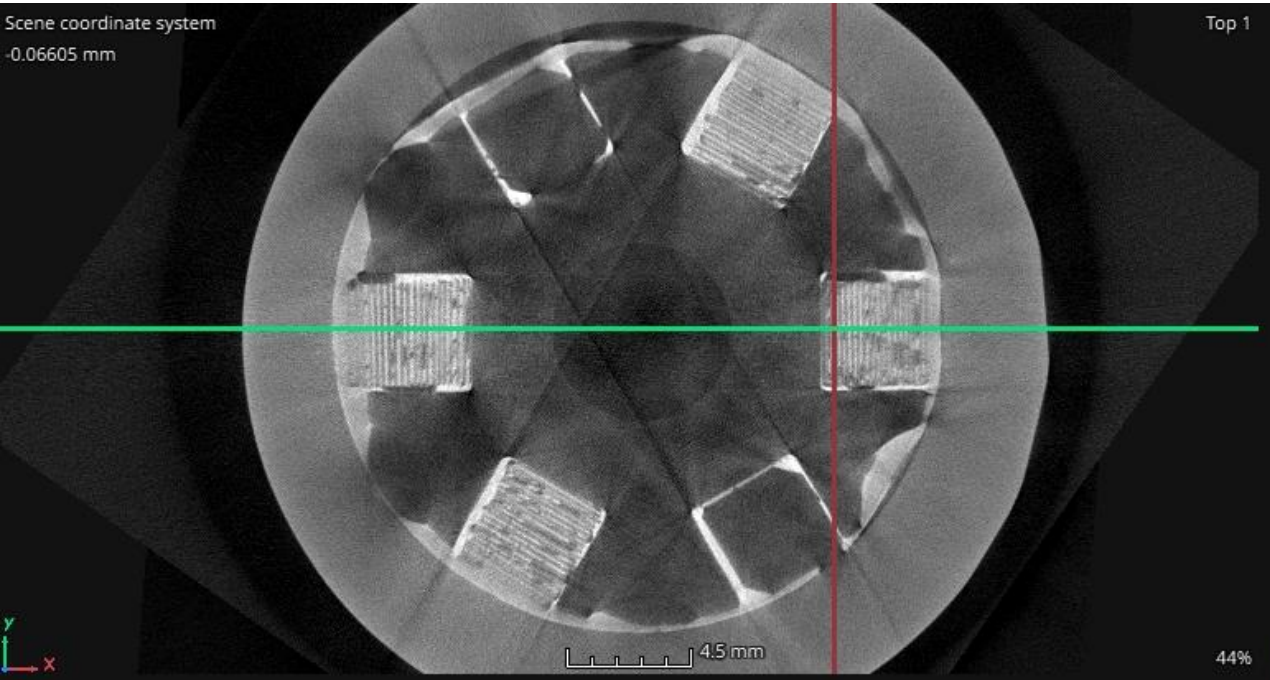


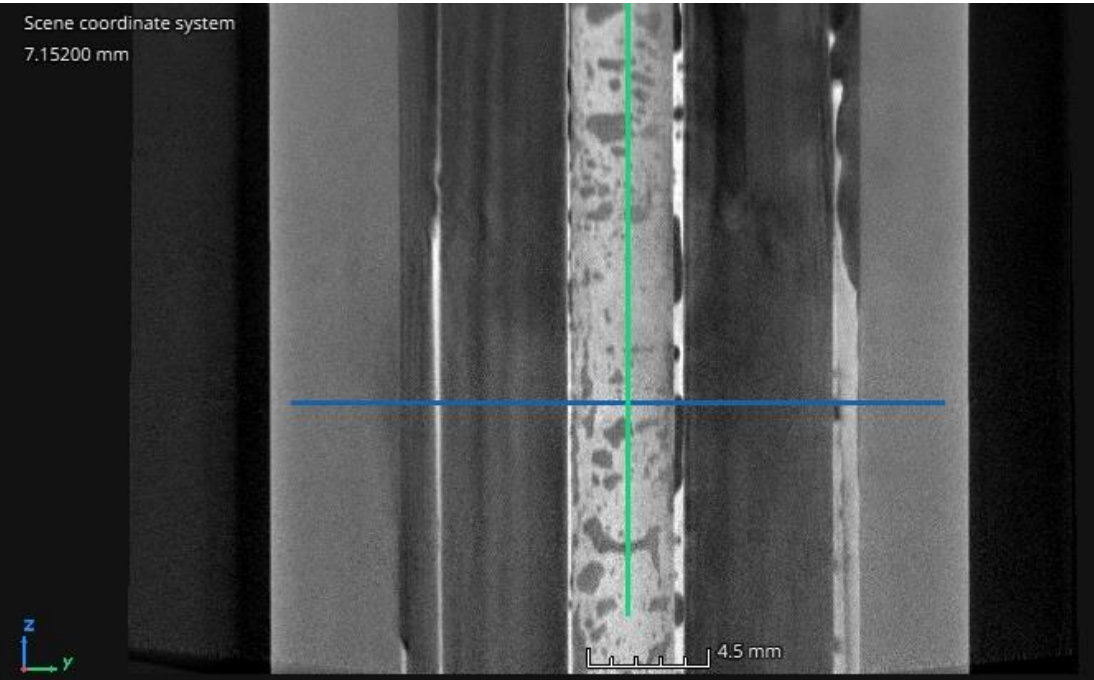
Bottom termination - wedges

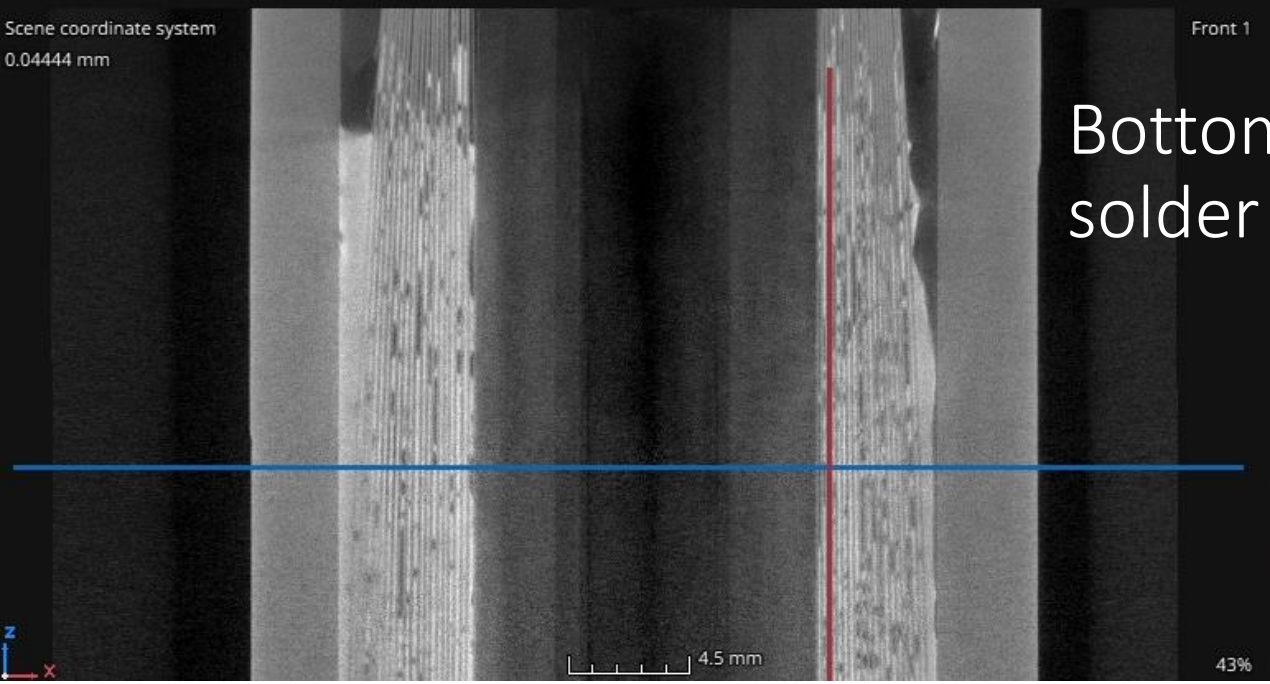
Bottom termination- wedges



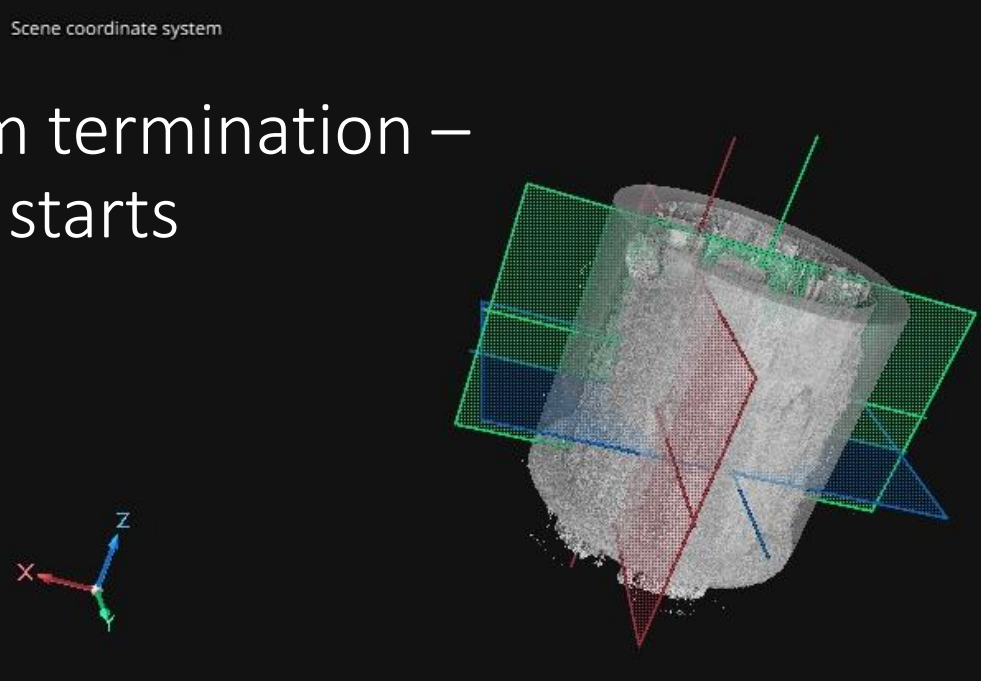
Solder between the tapes

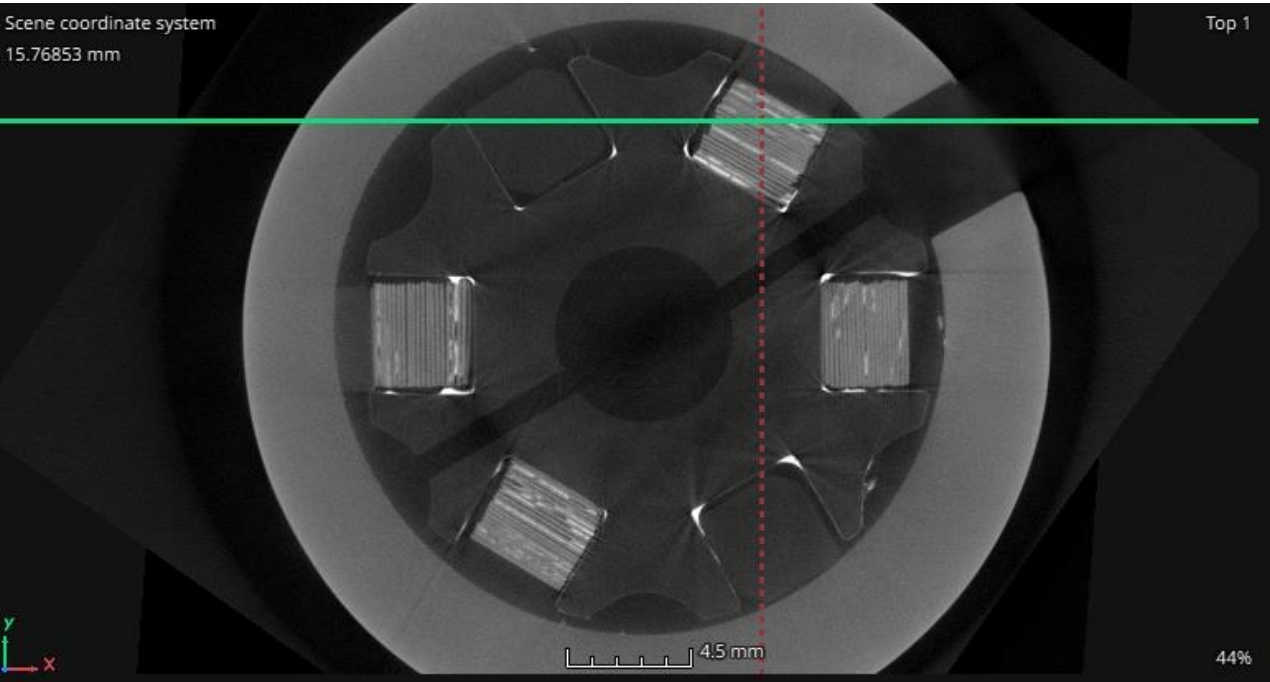


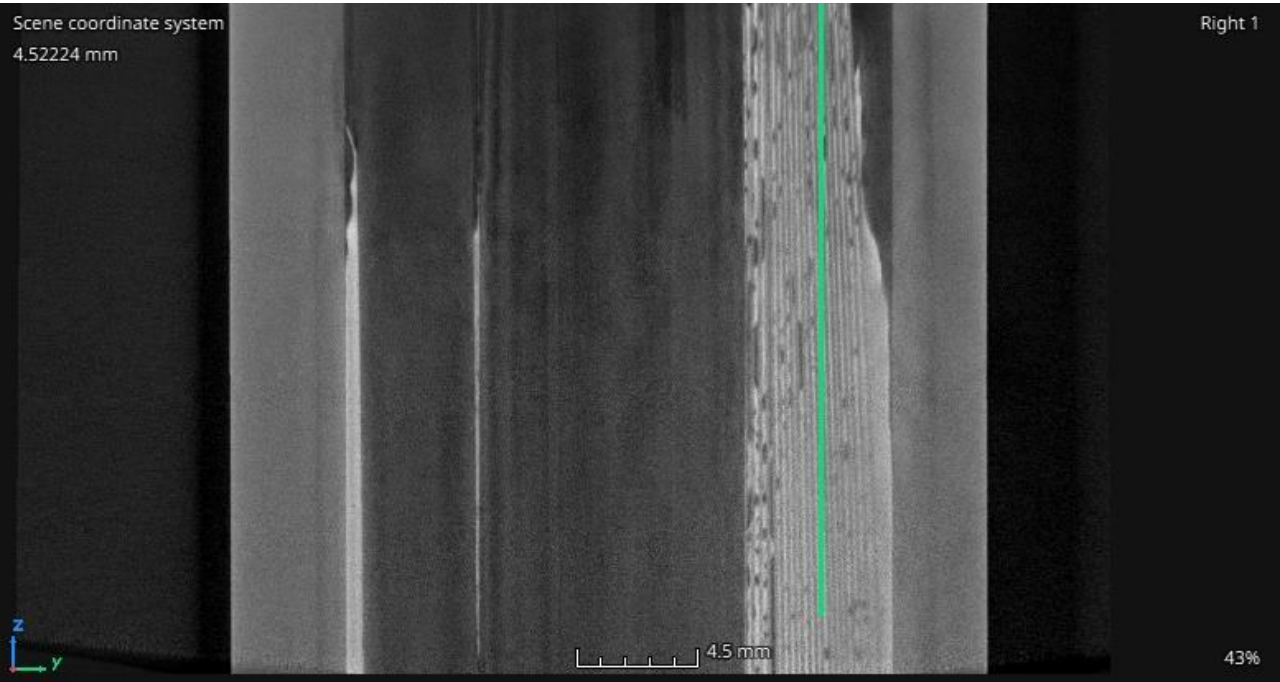


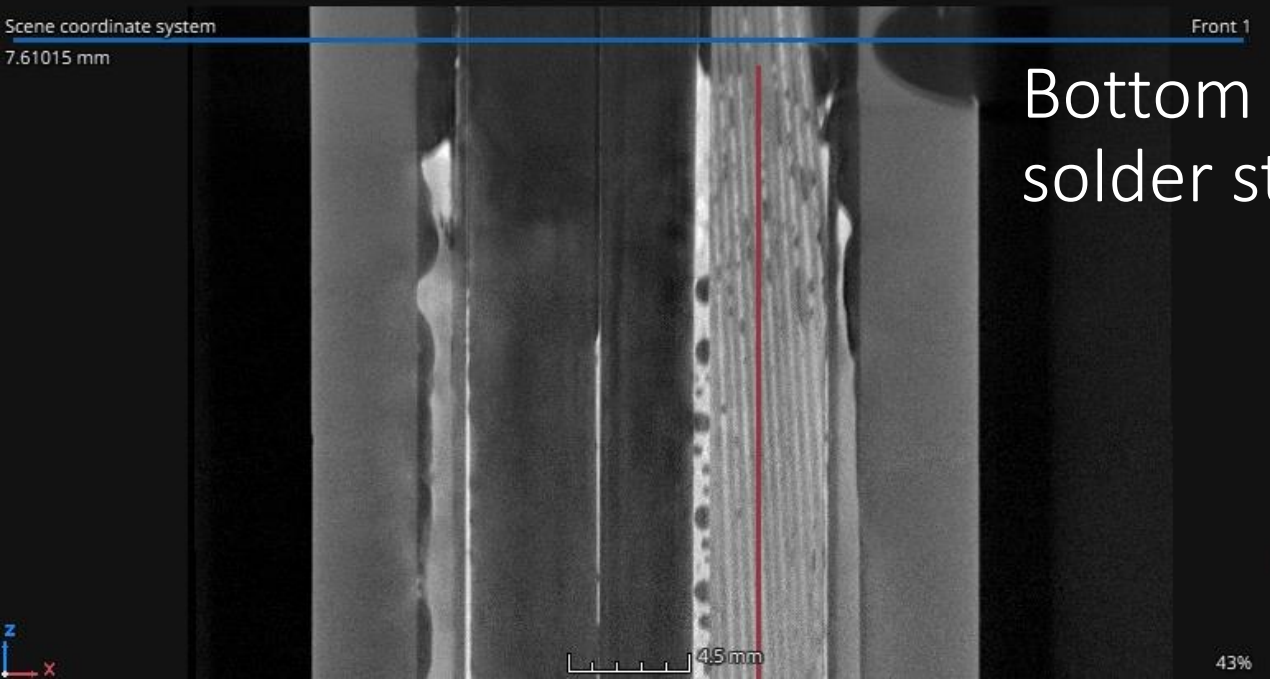


Bottom termination – solder starts

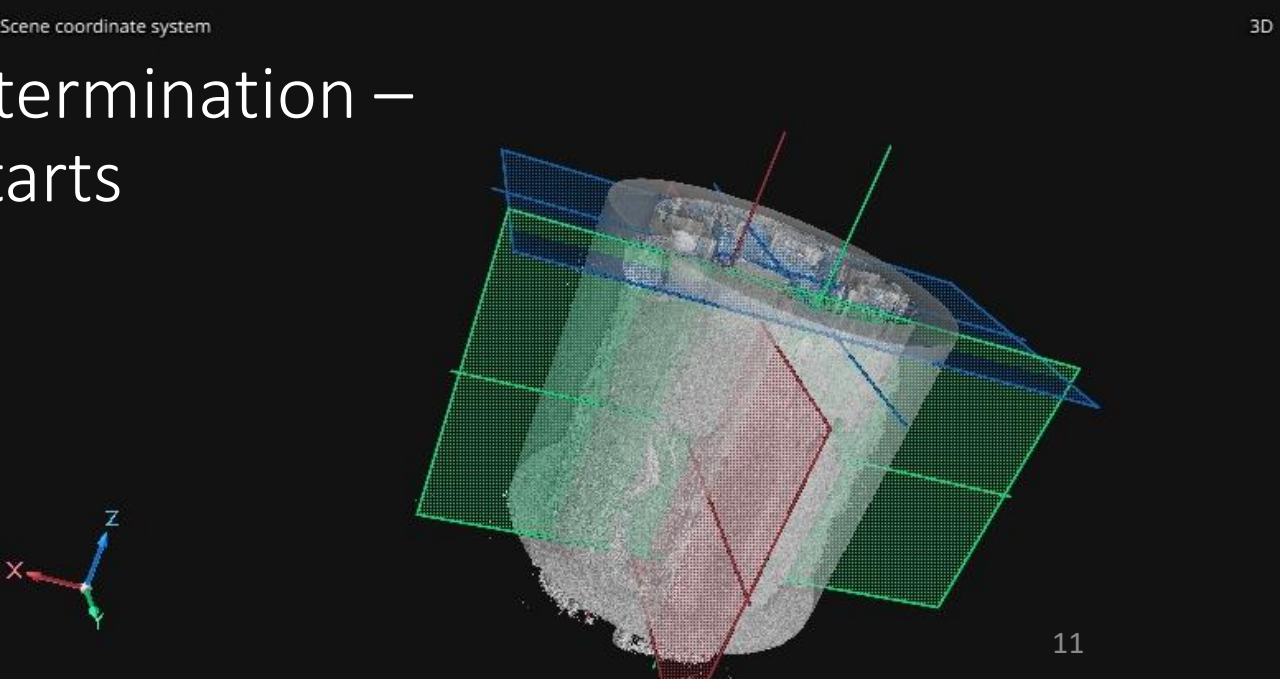


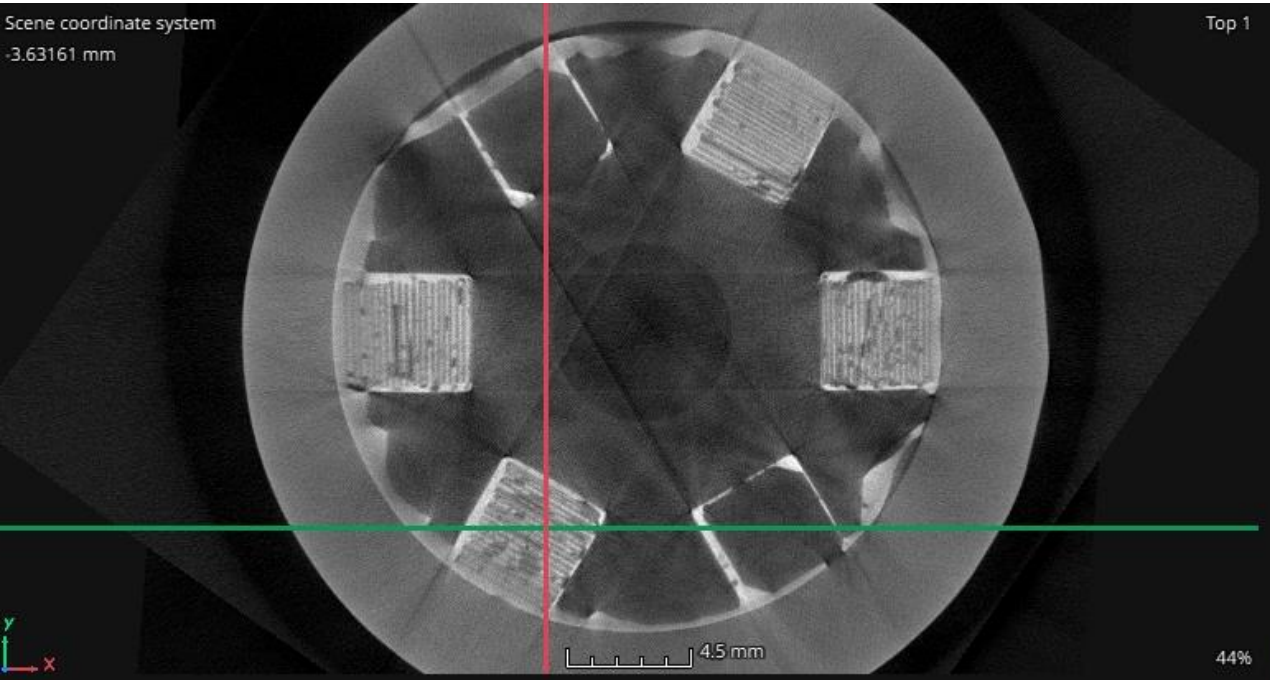


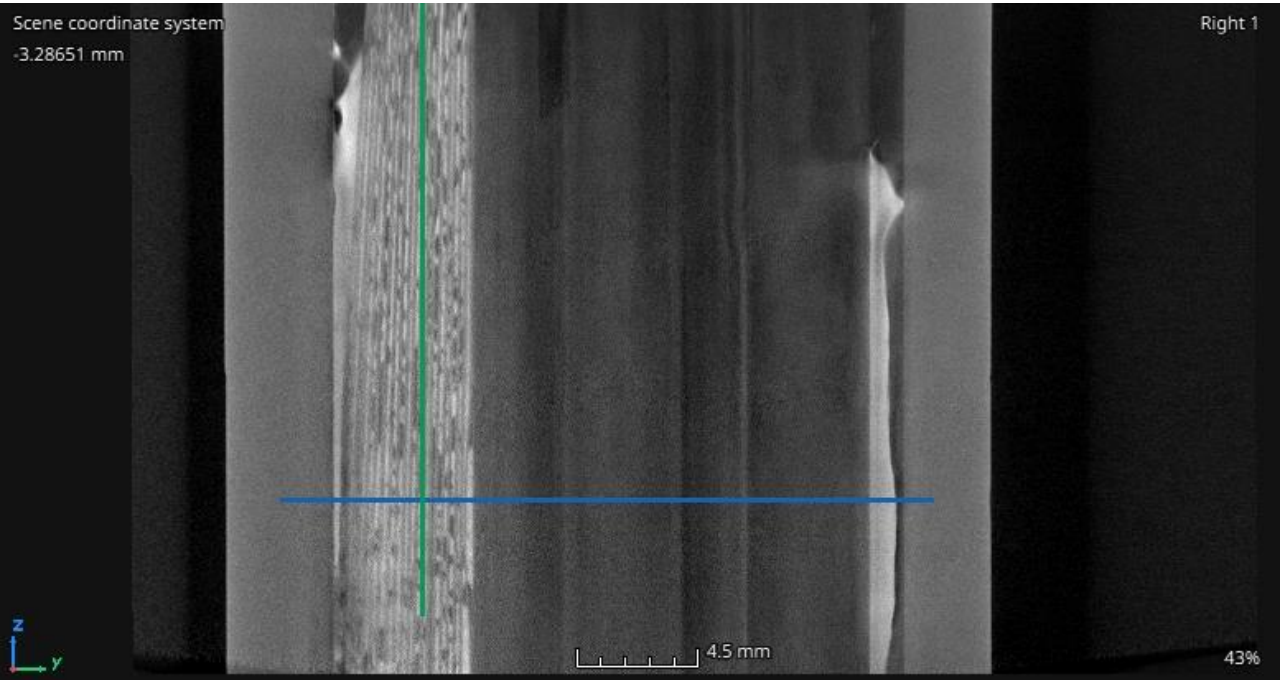


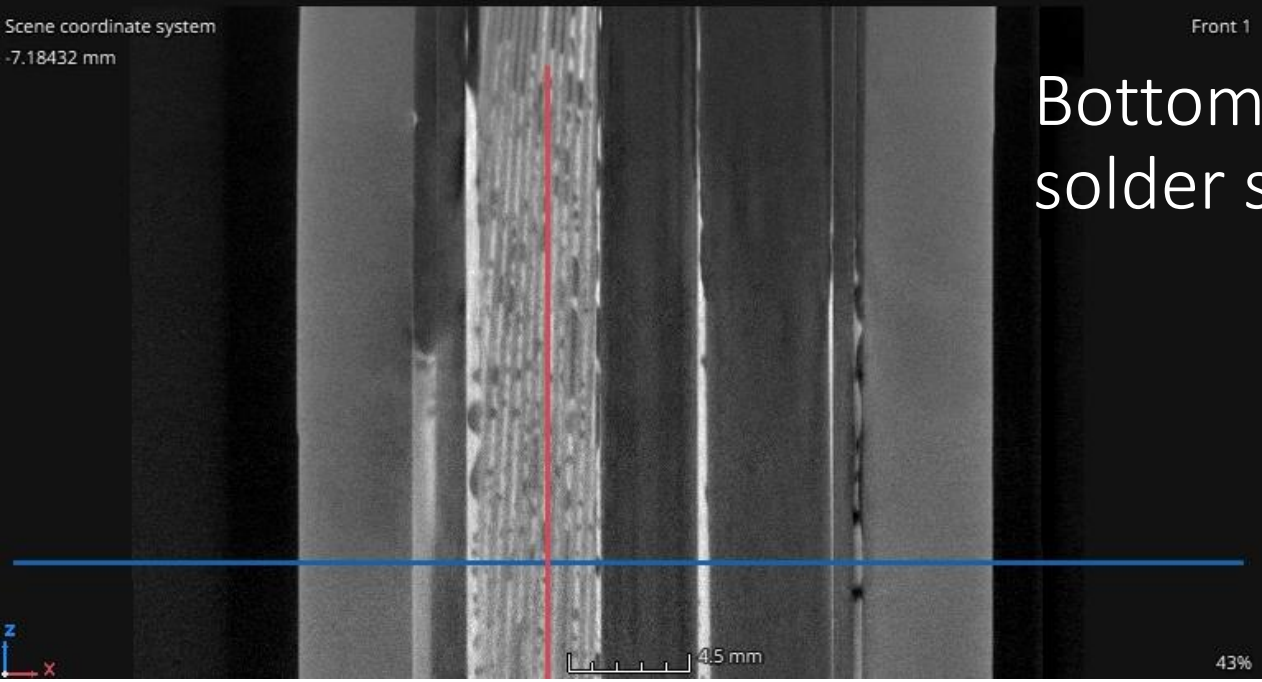


Bottom termination – solder starts

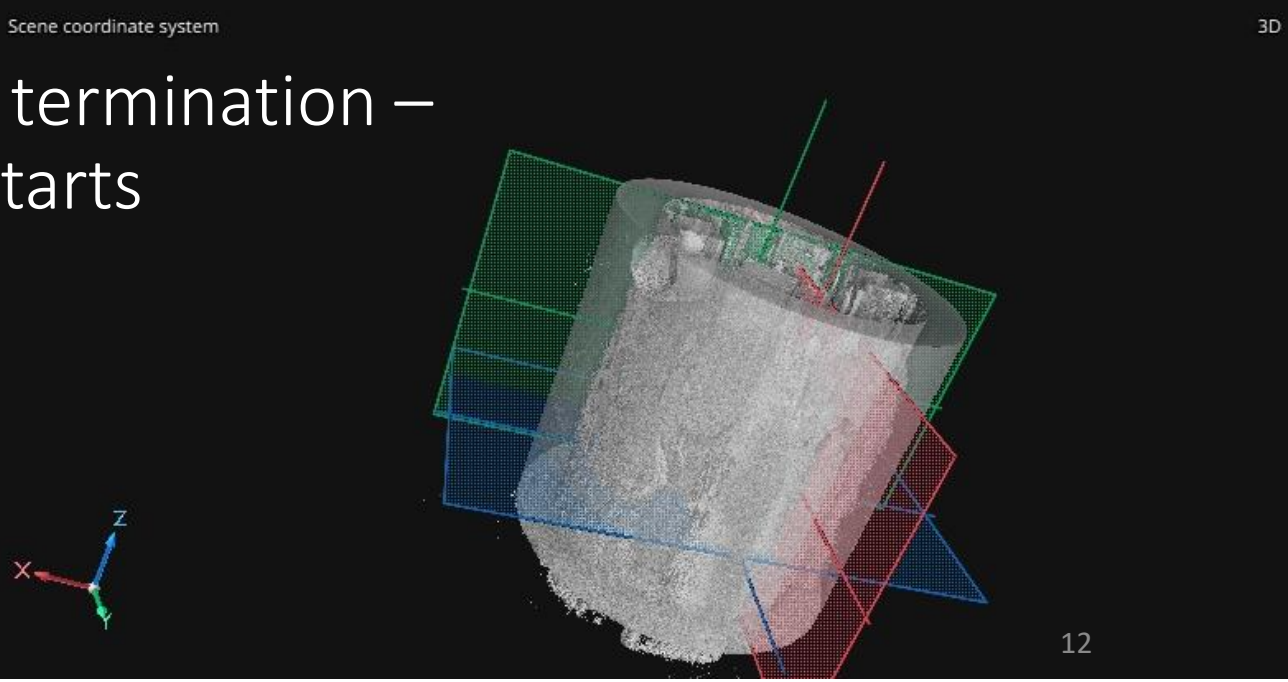




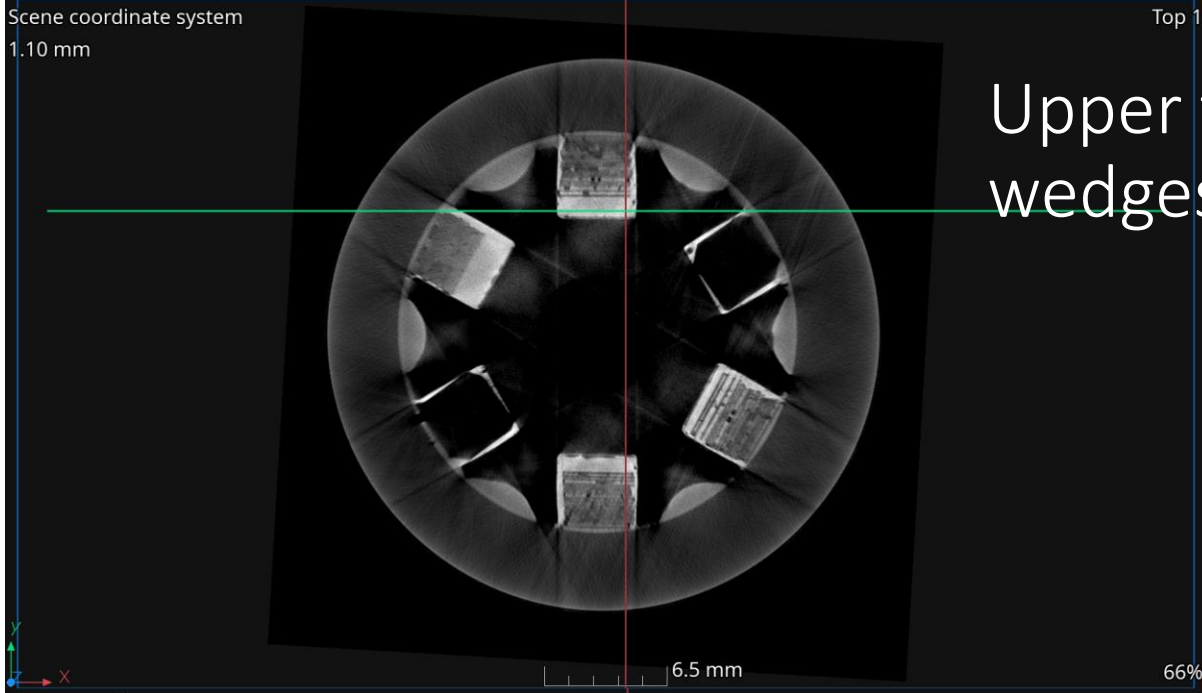


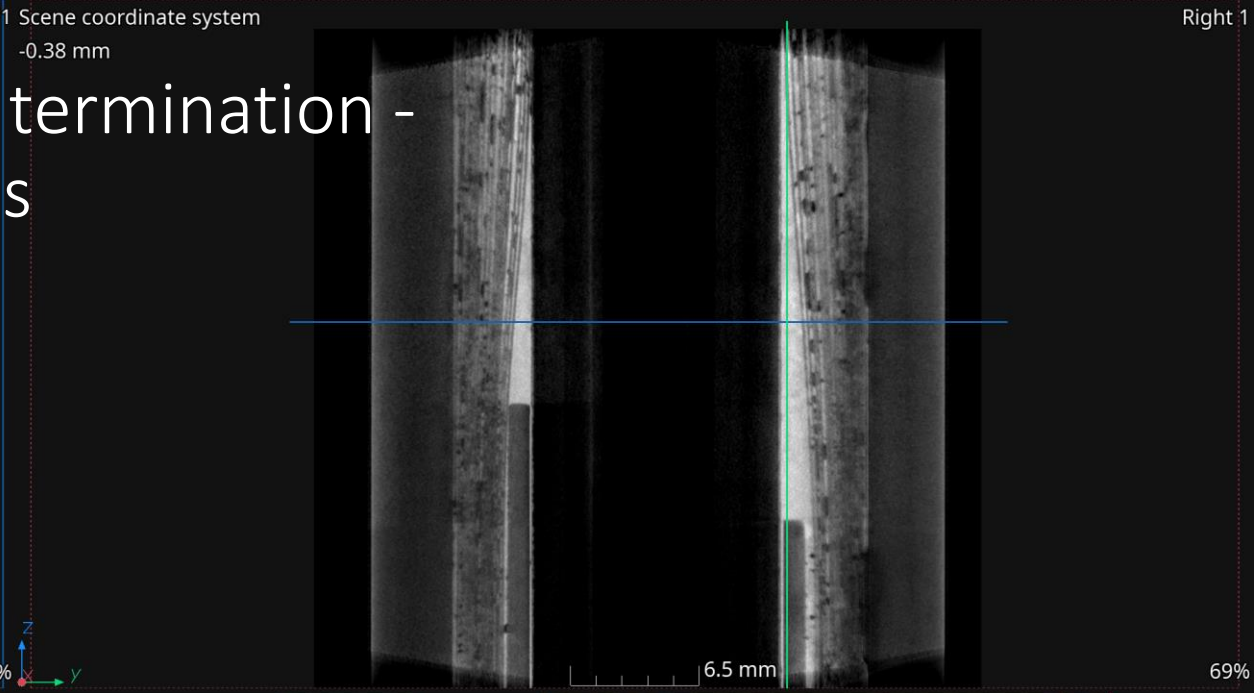


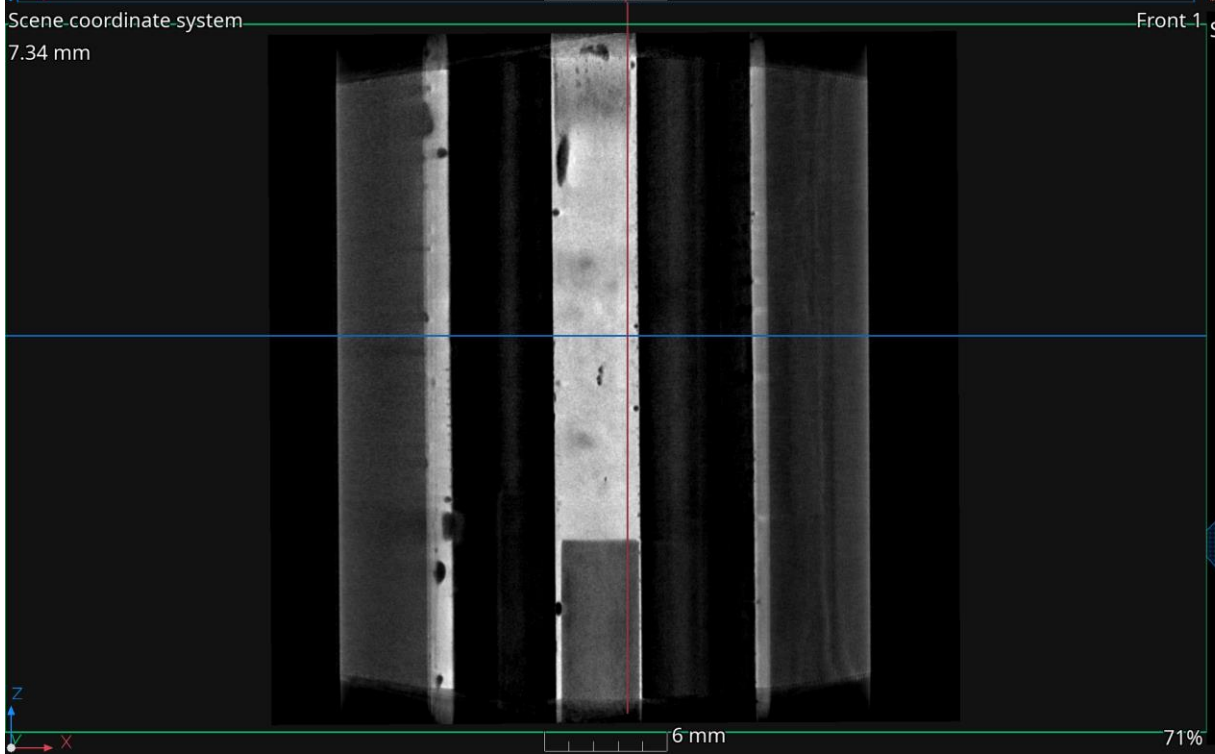
Bottom termination – solder starts

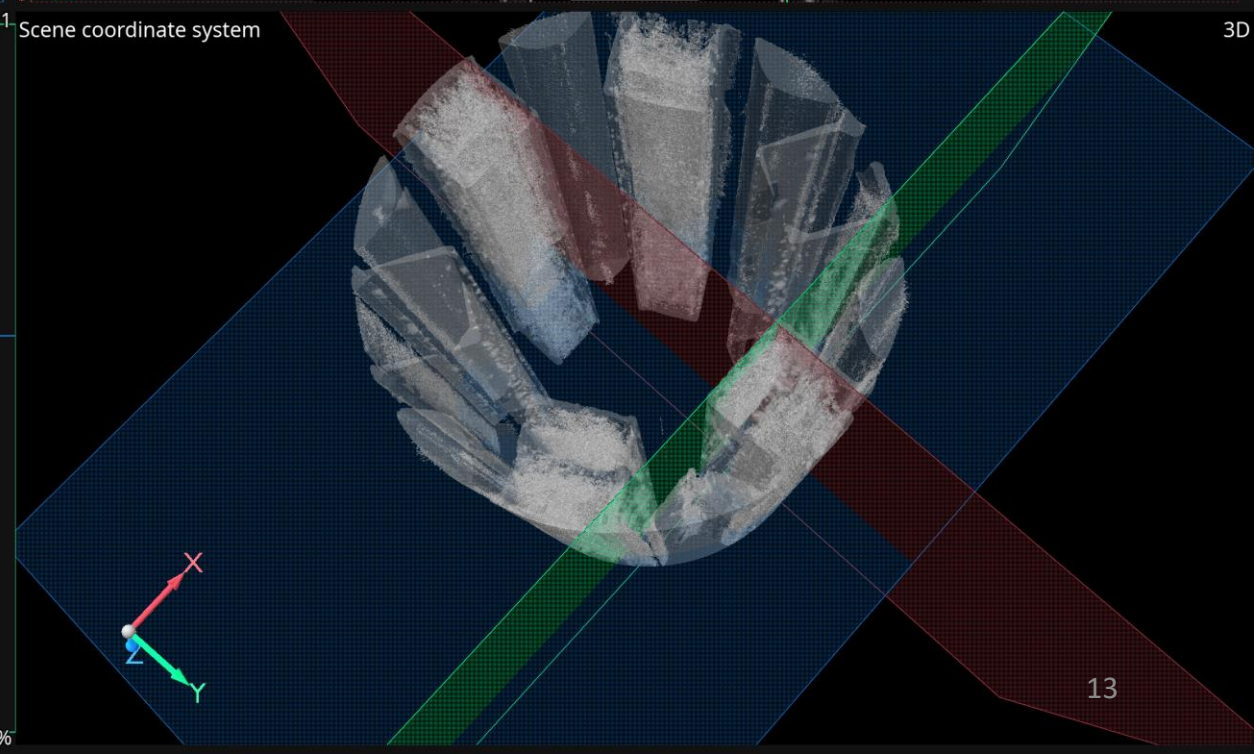


Upper termination - wedges









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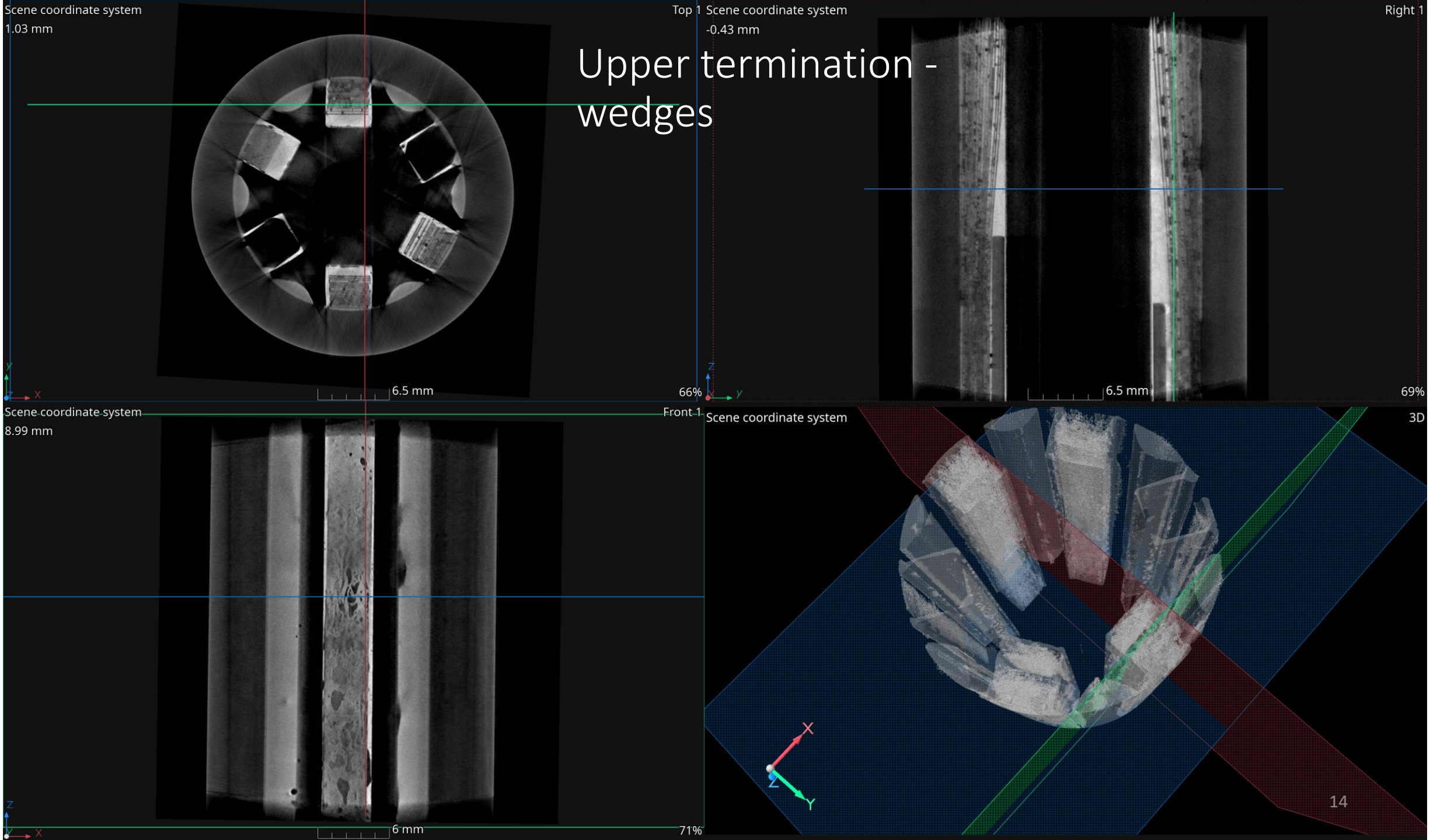
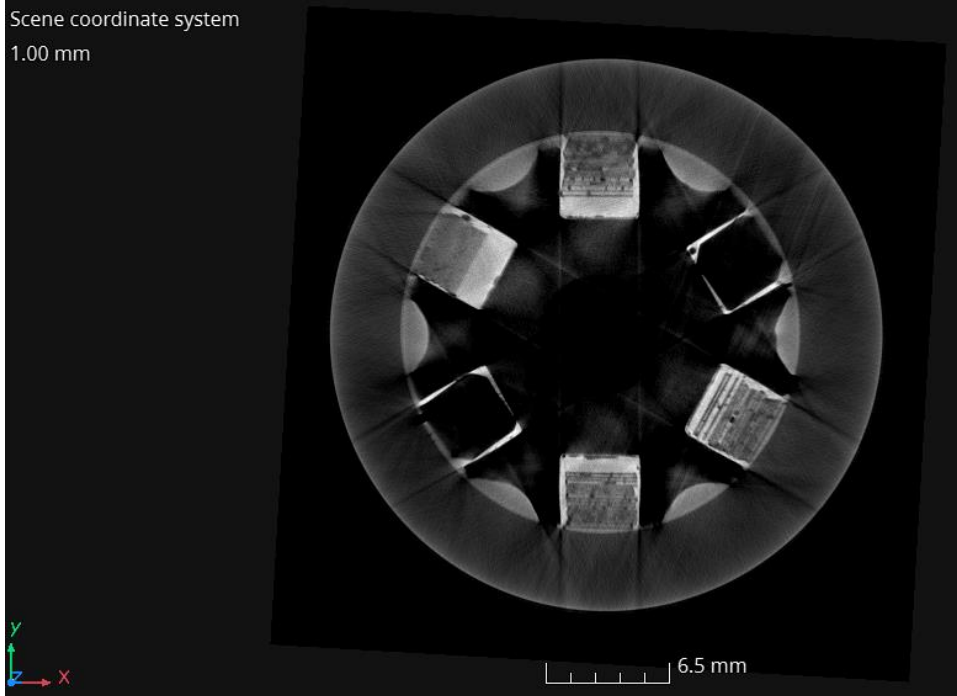
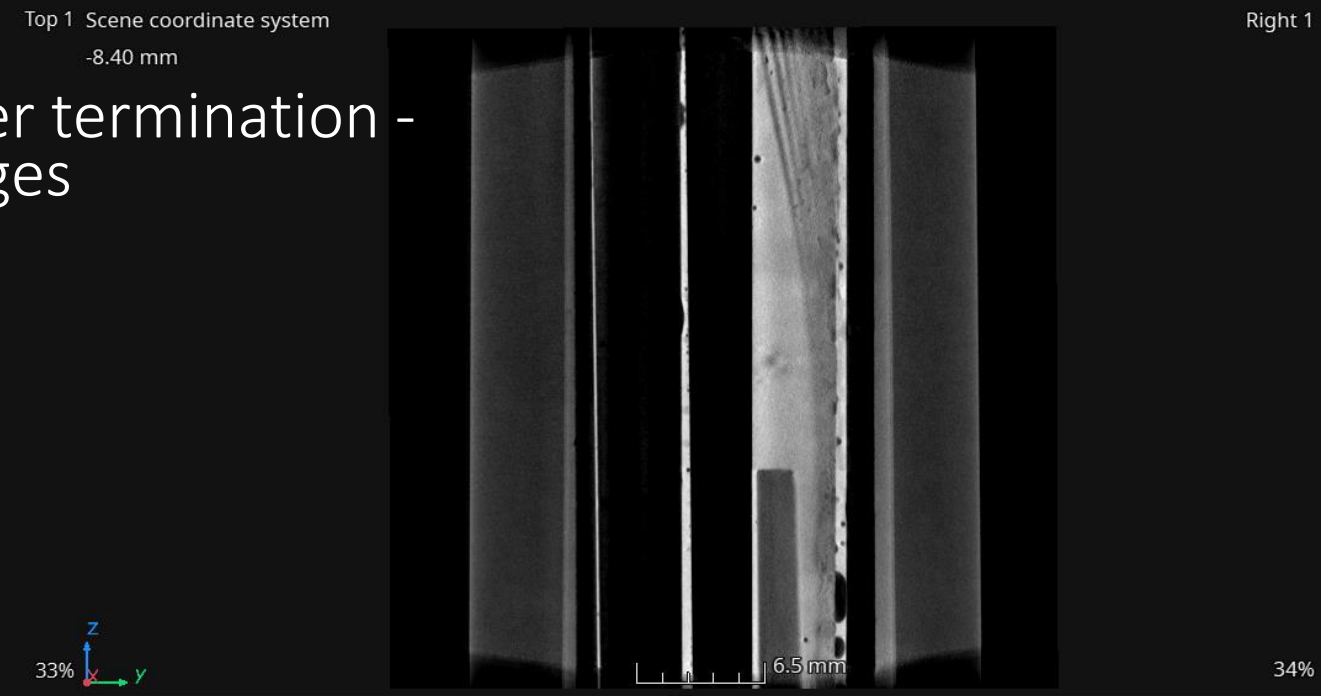
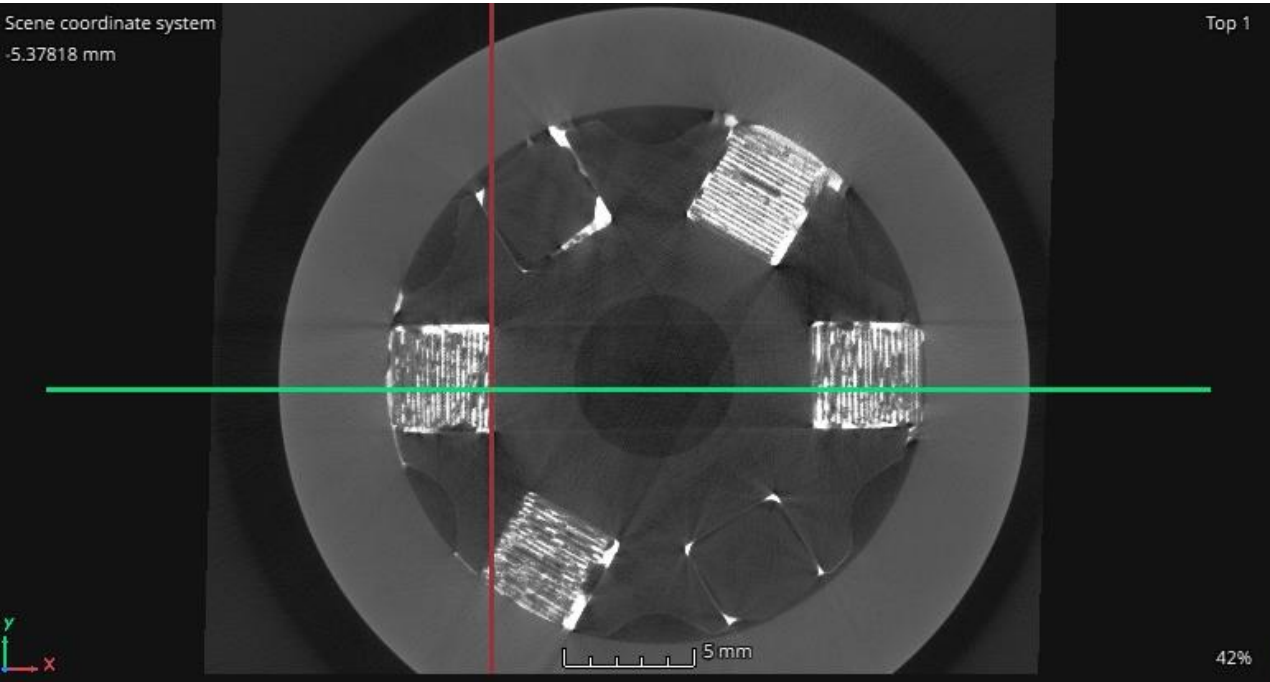
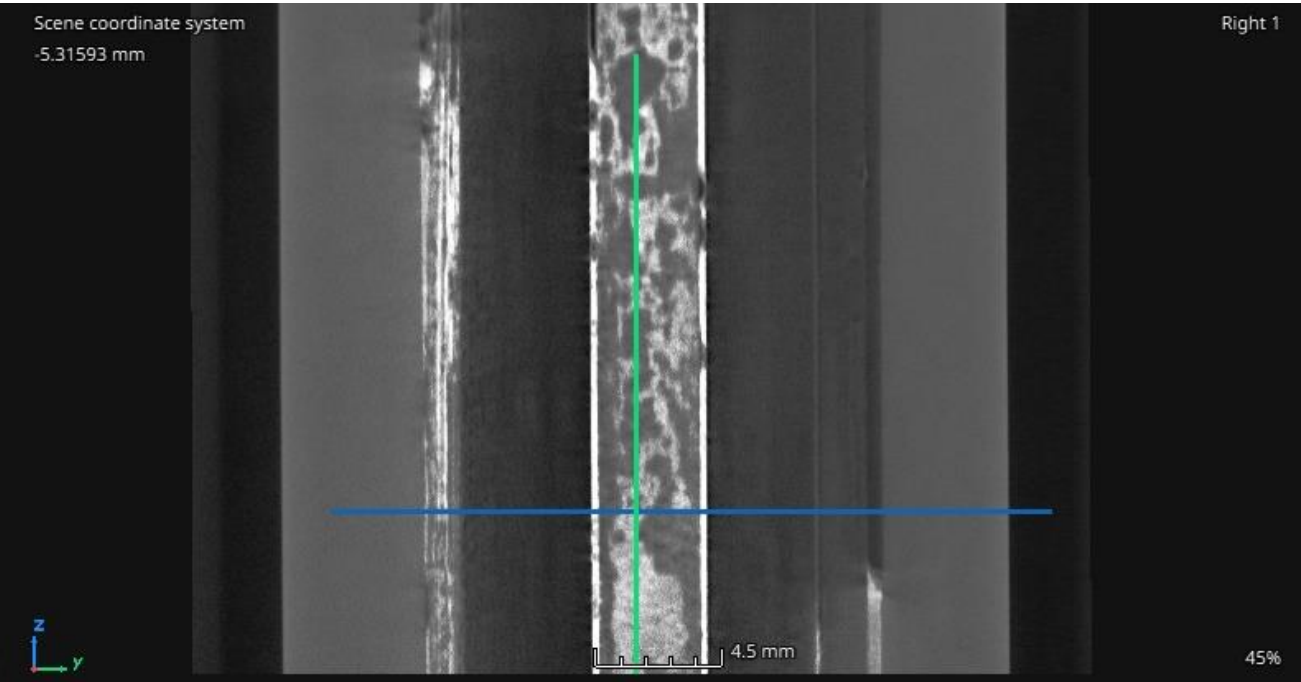


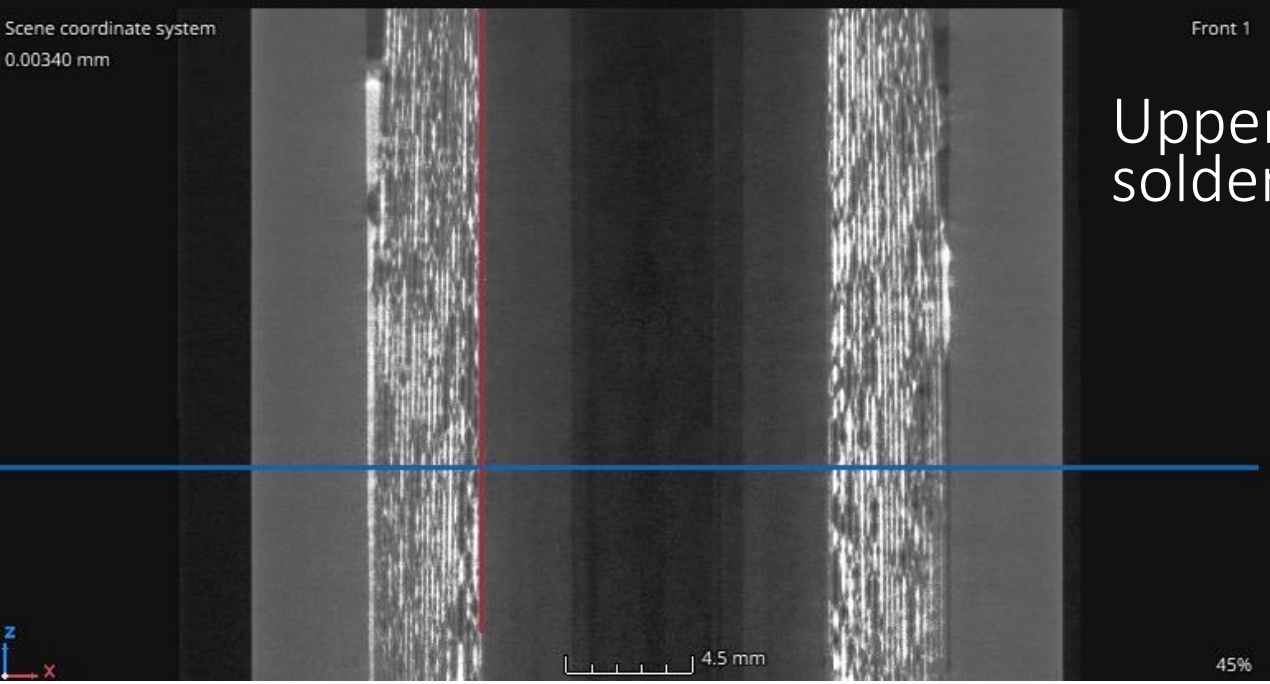
Upper termination - wedges



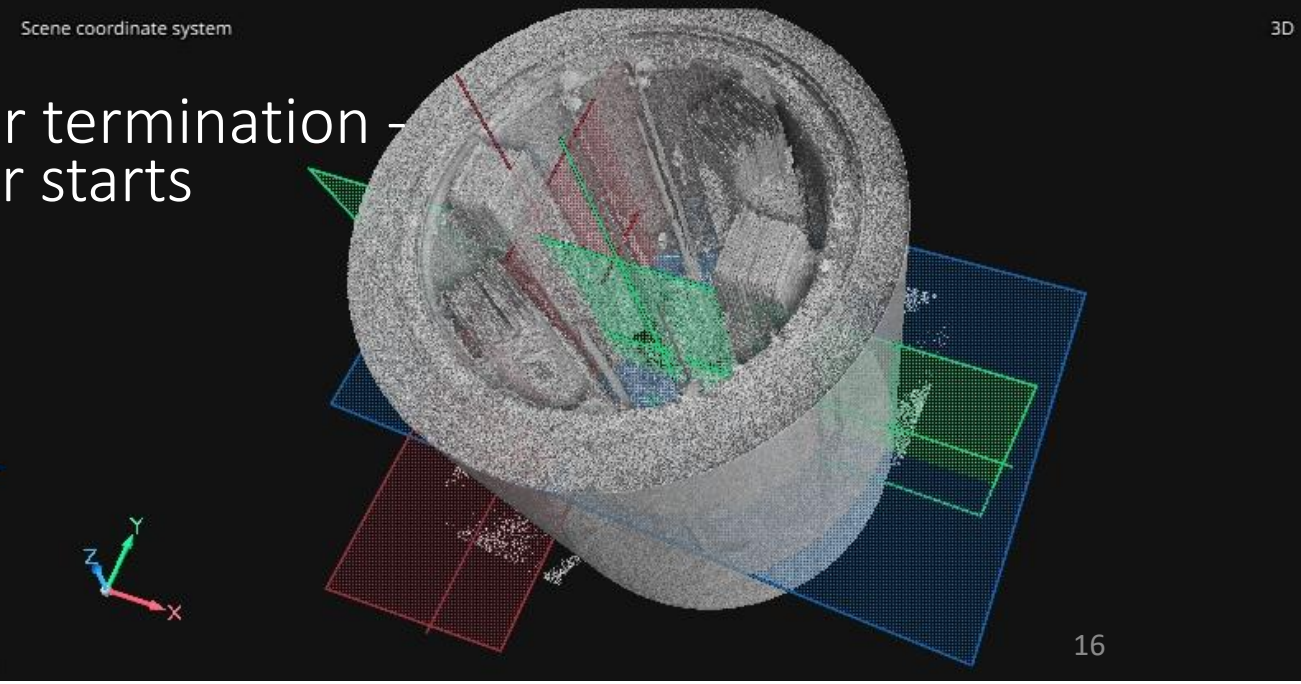


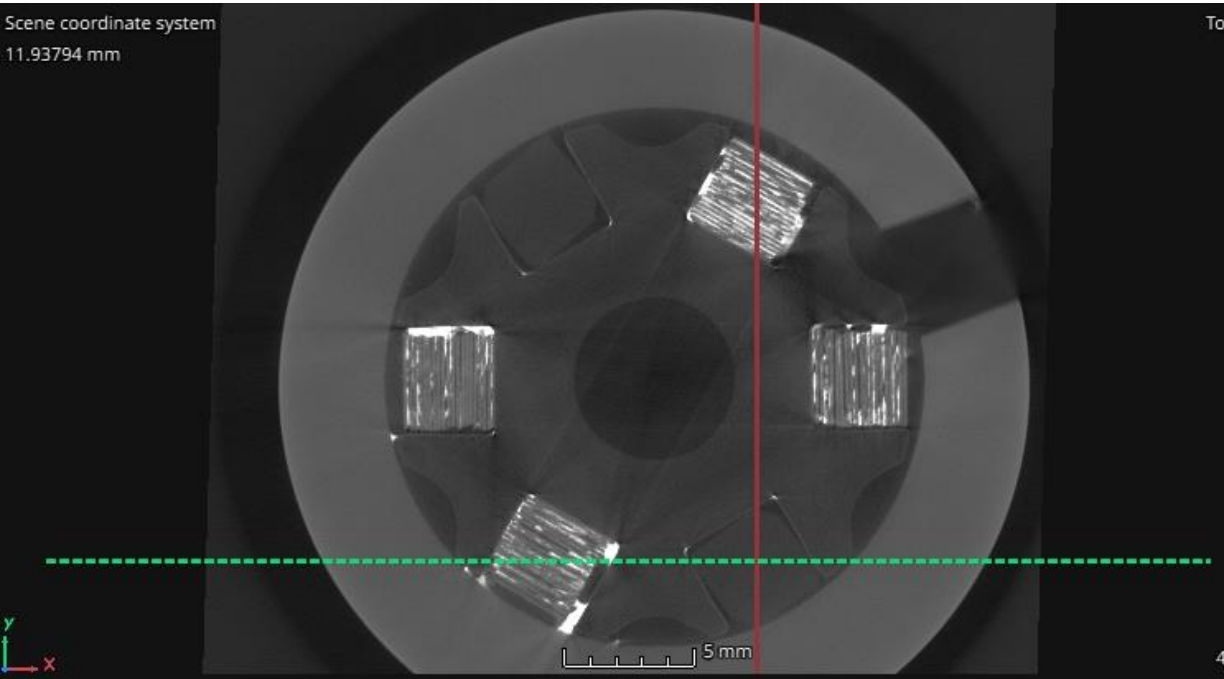


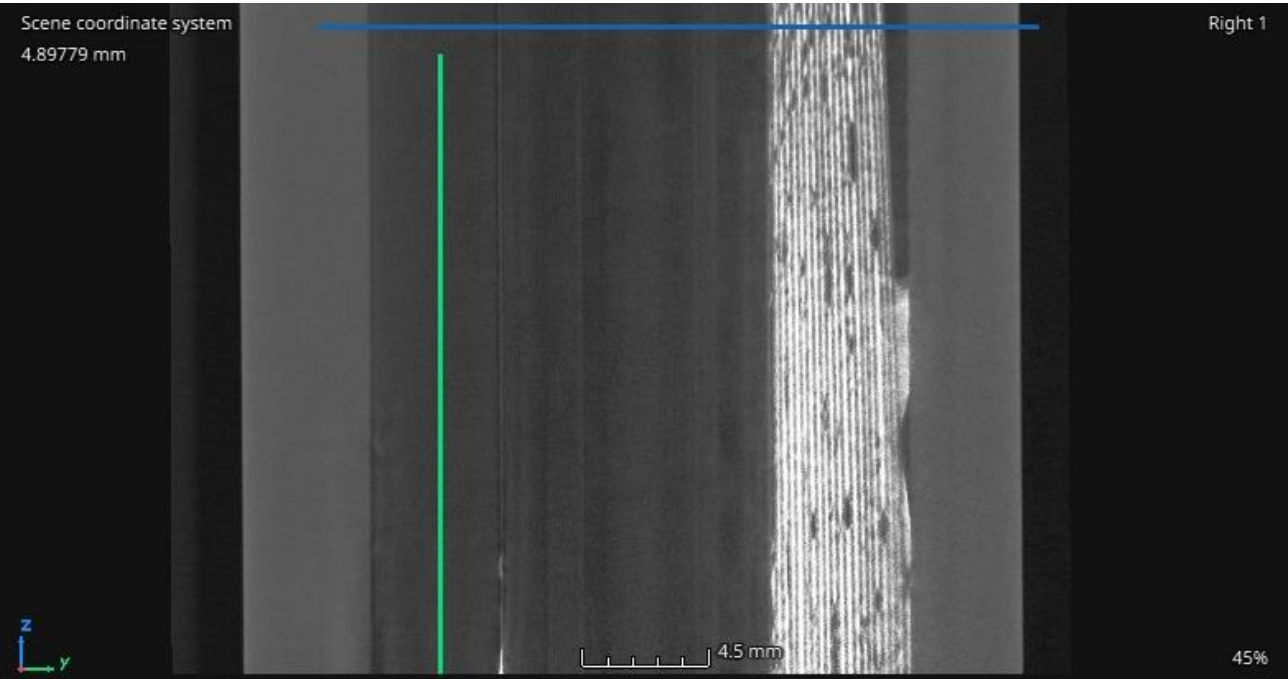


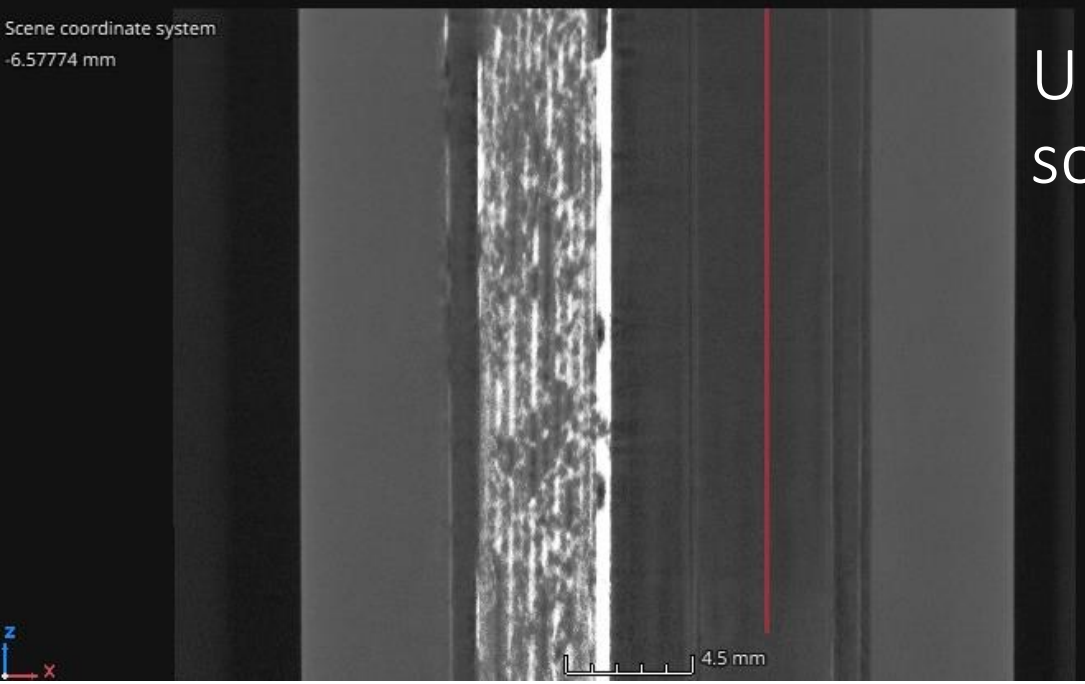


Upper termination – solder starts

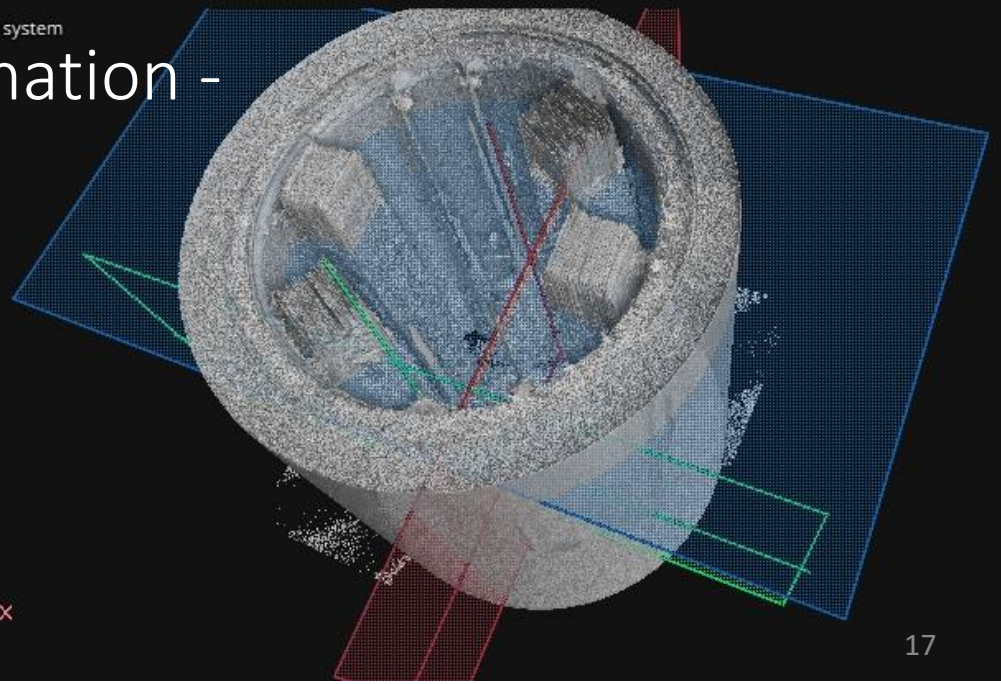


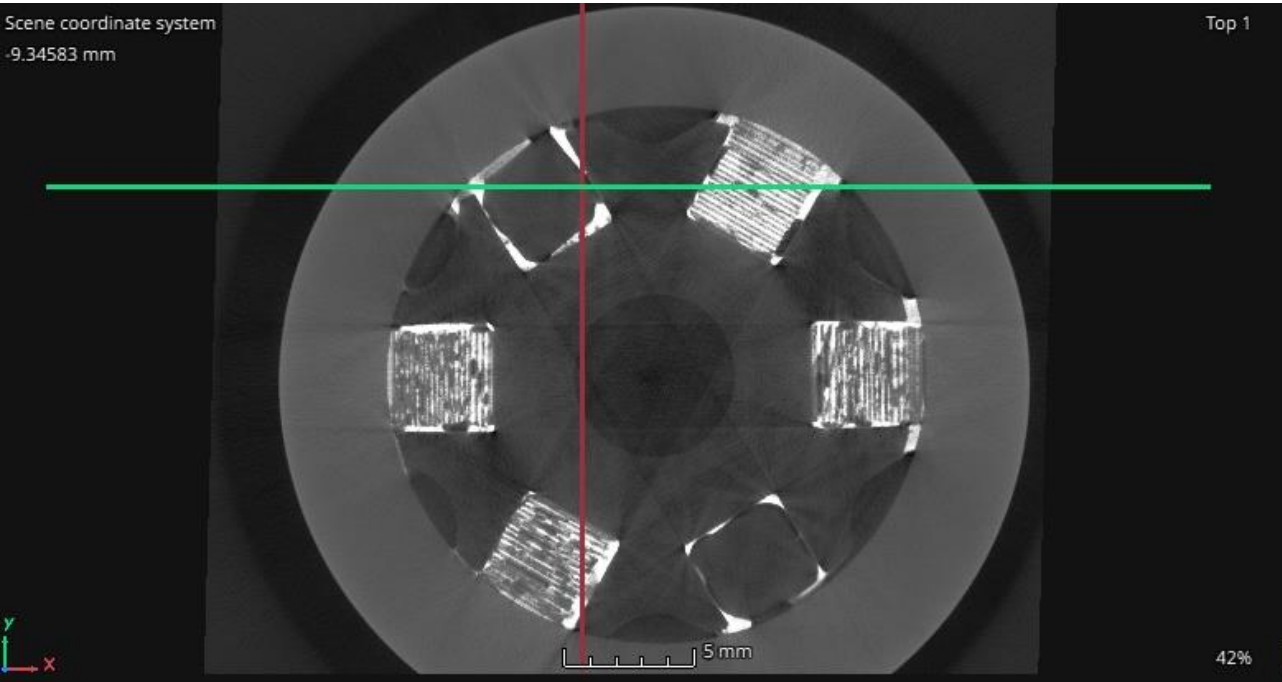


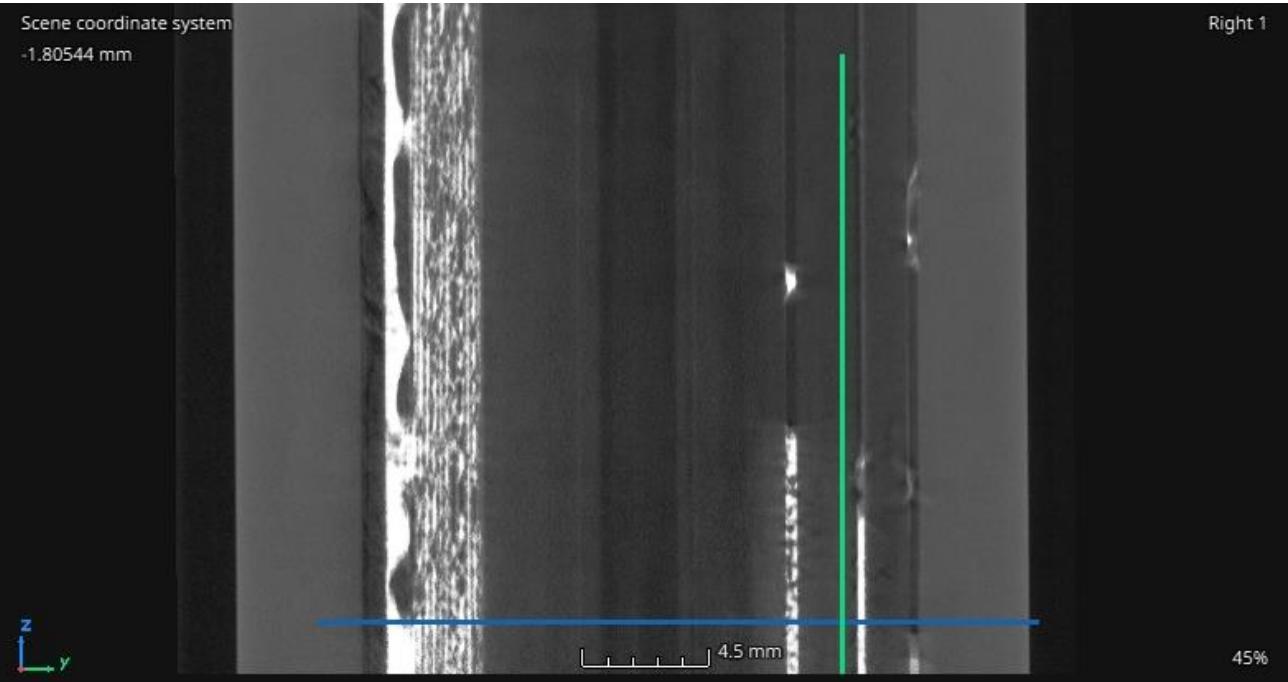


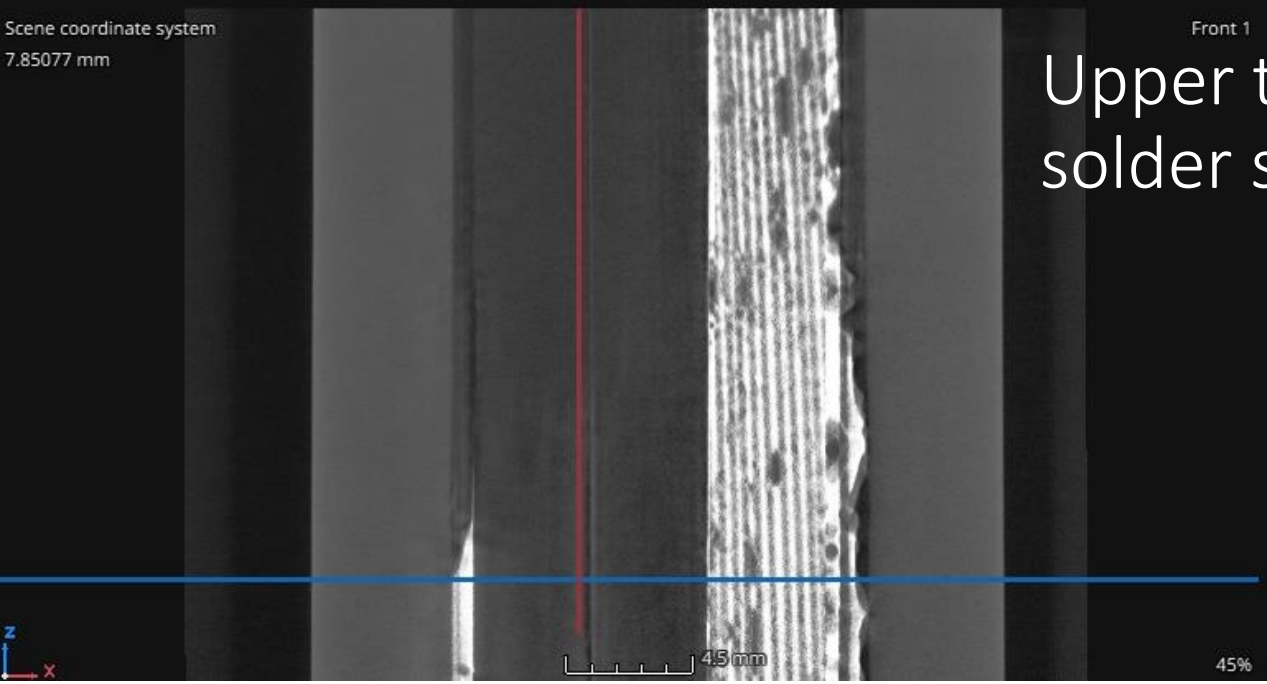


Upper termination - solder starts

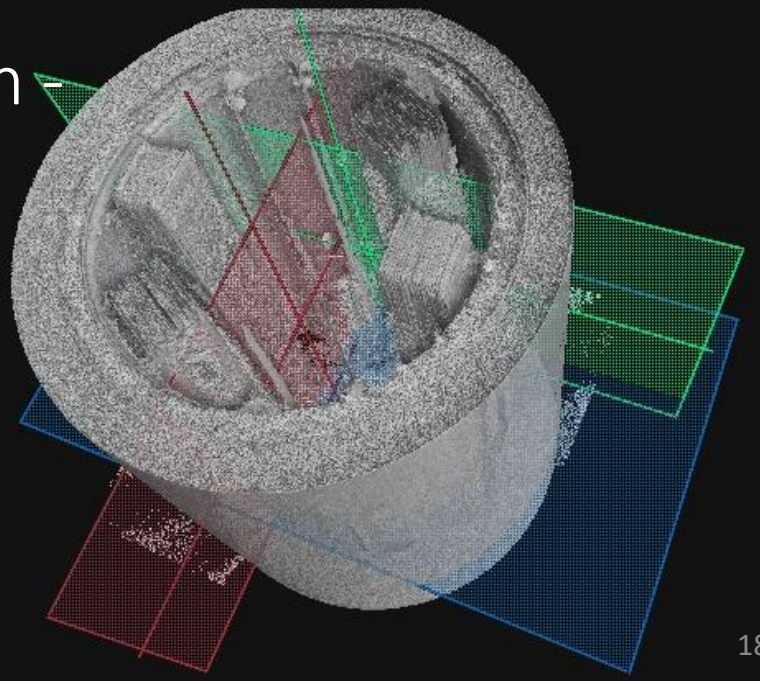


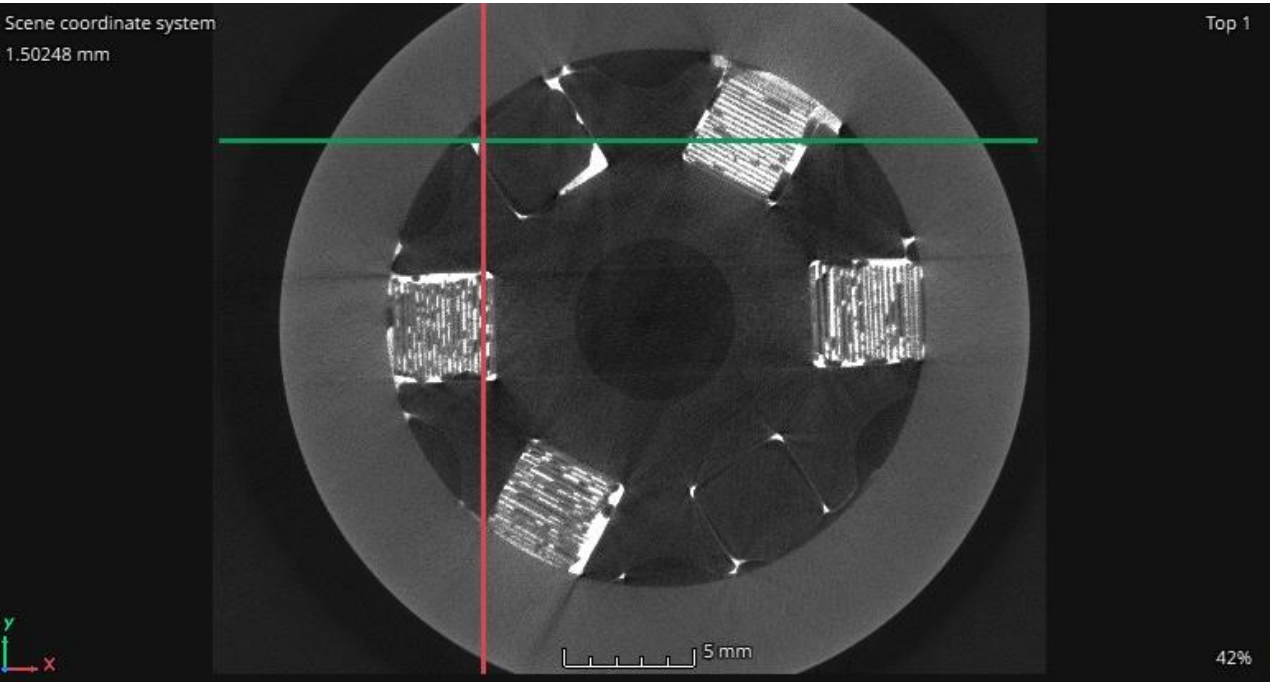


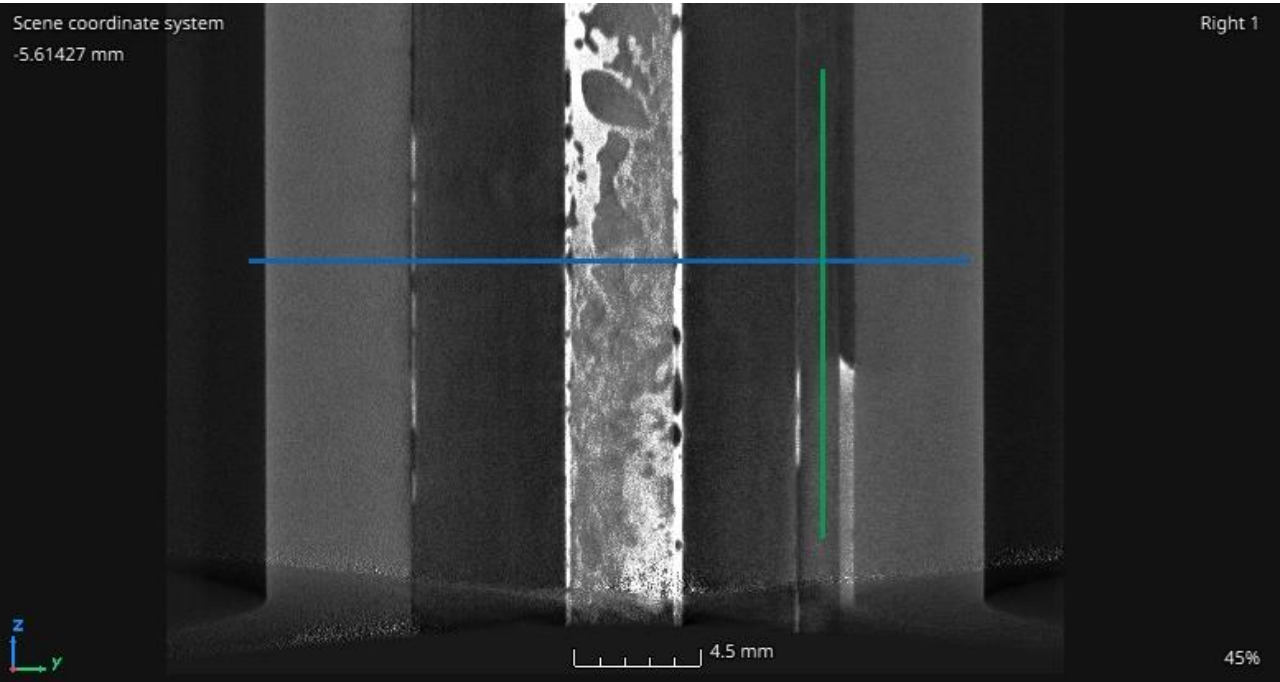


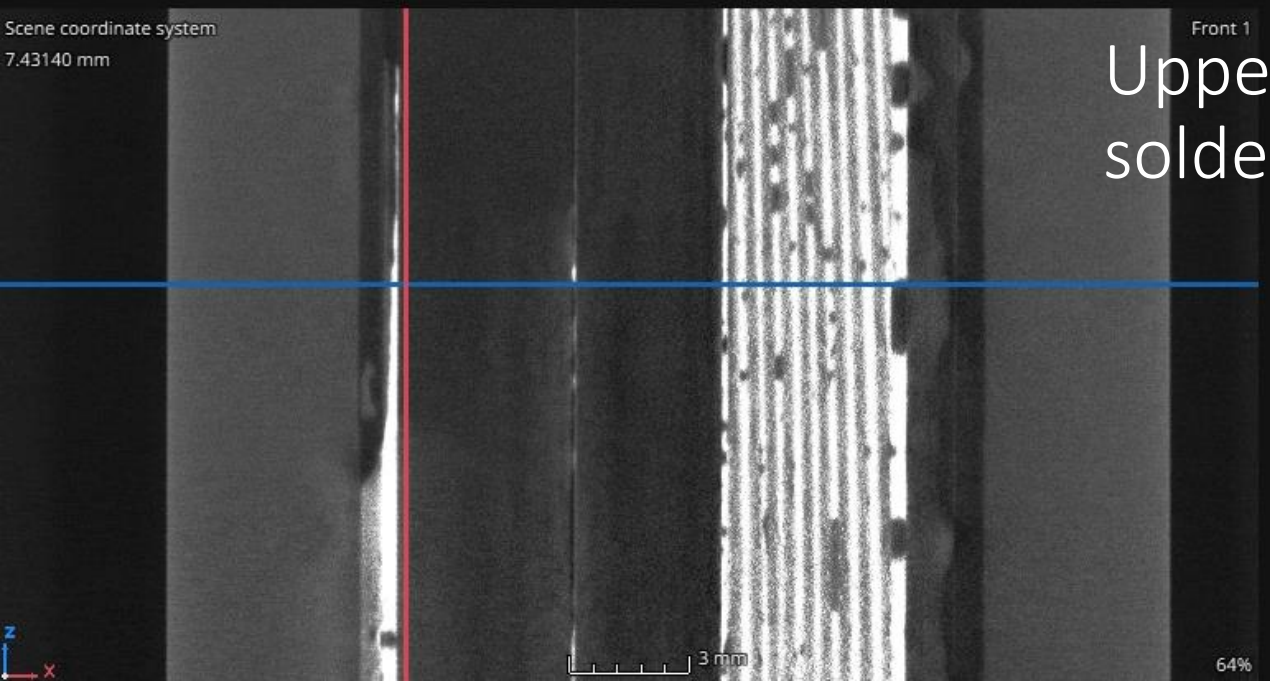


Upper termination solder starts

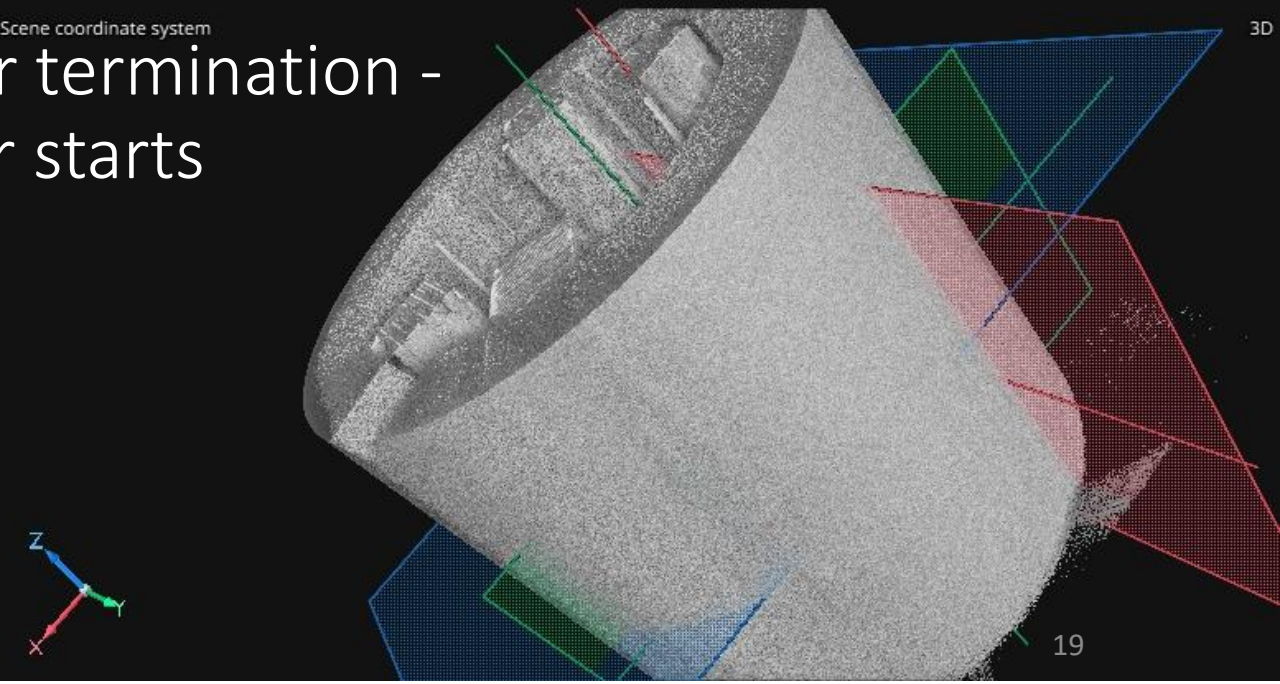


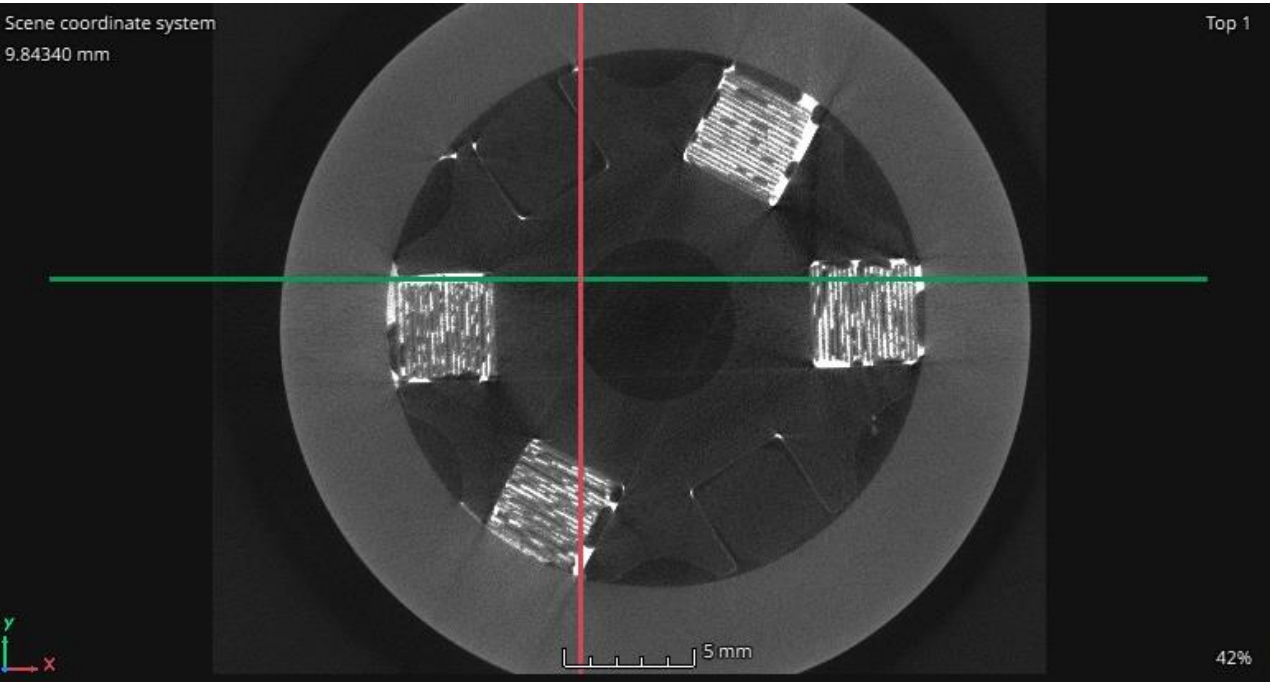


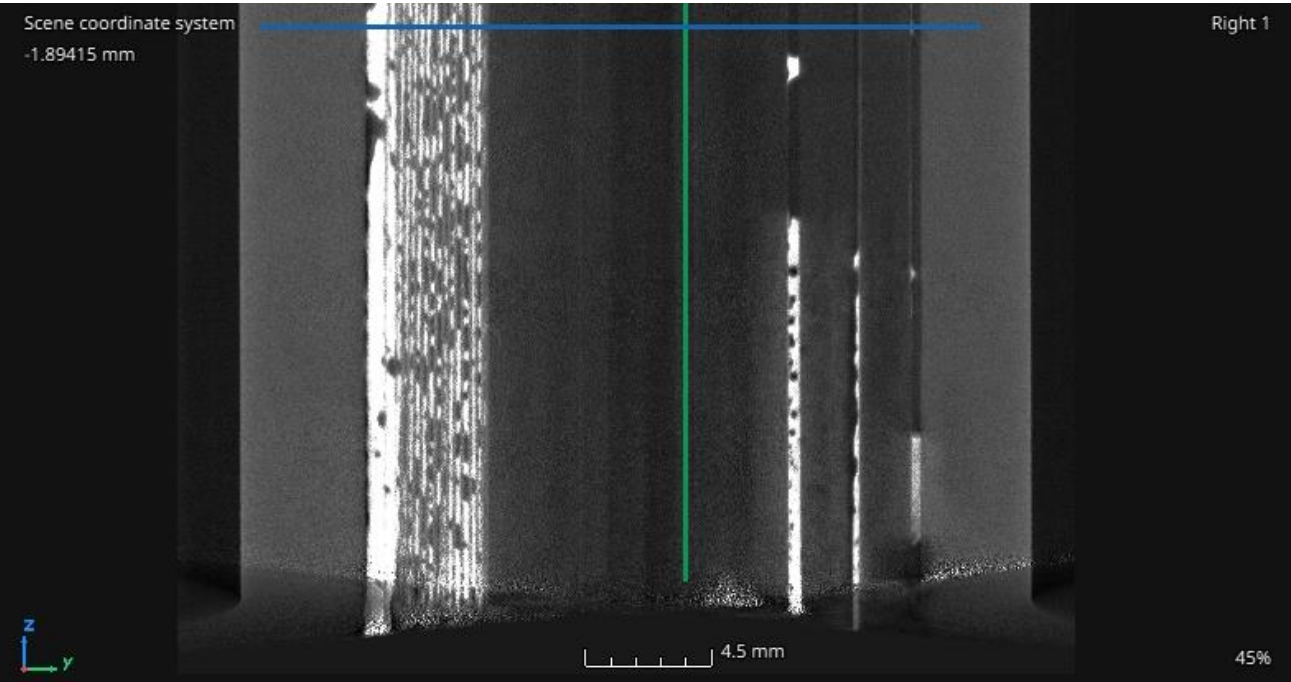


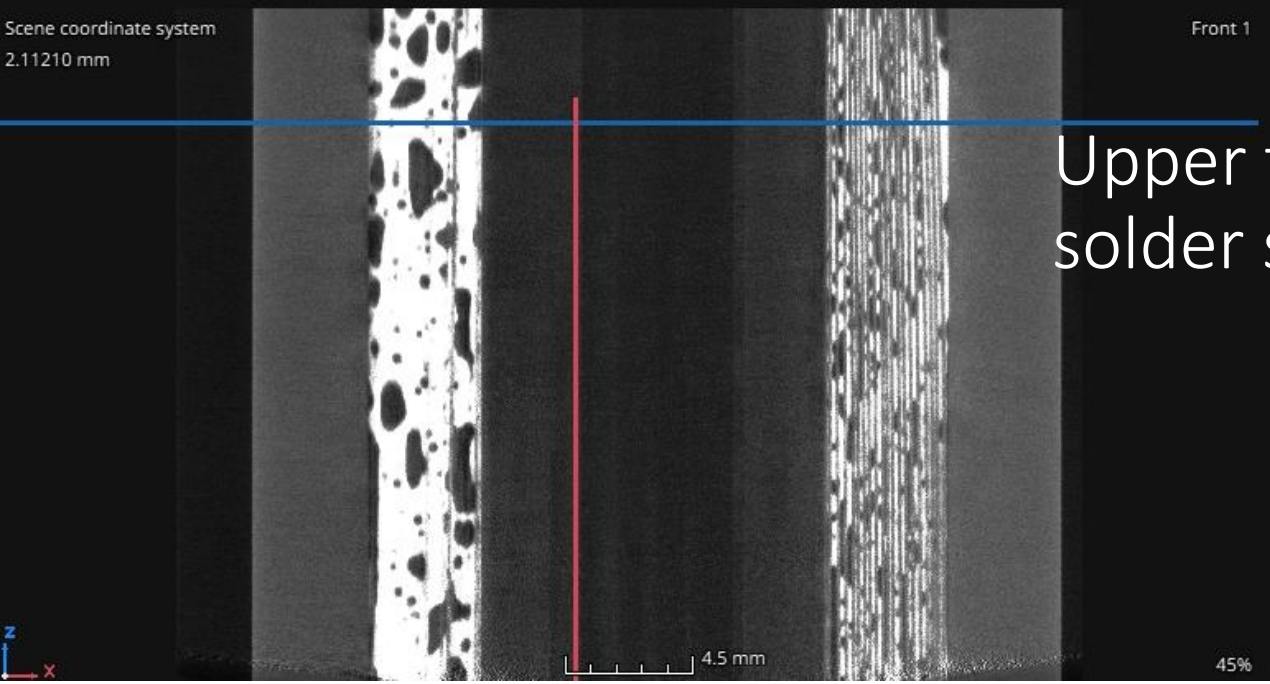


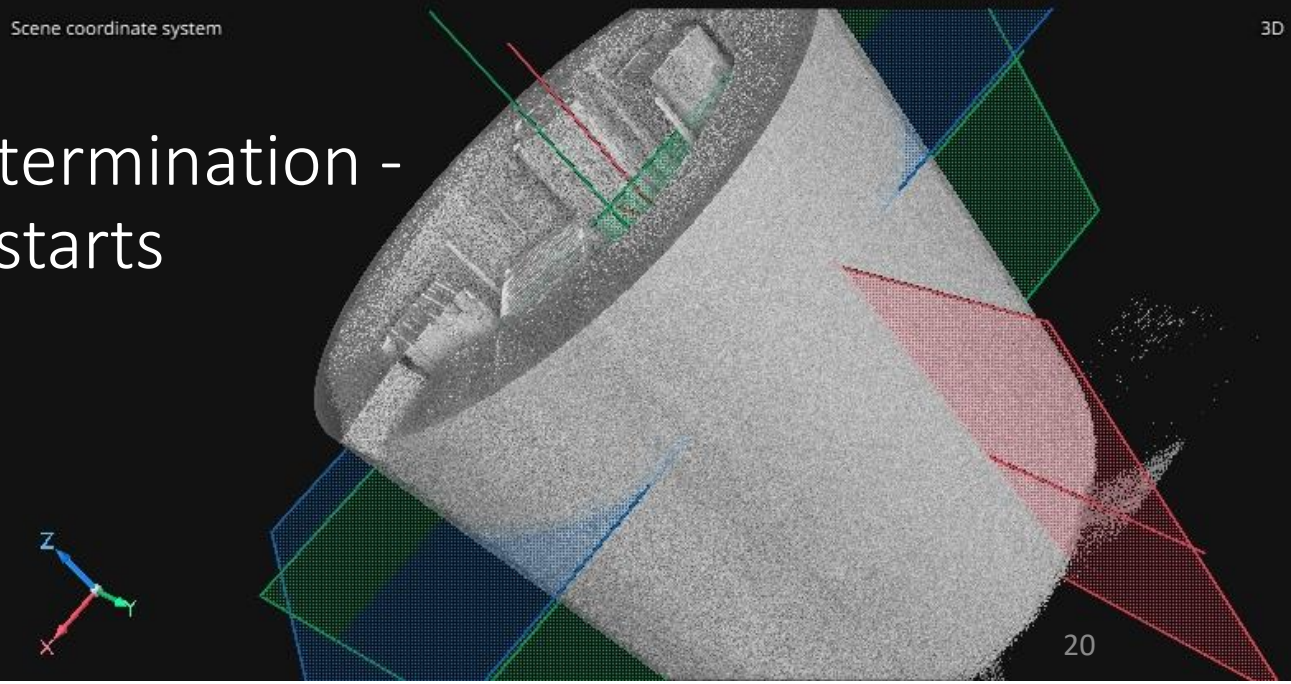
Upper termination - solder starts



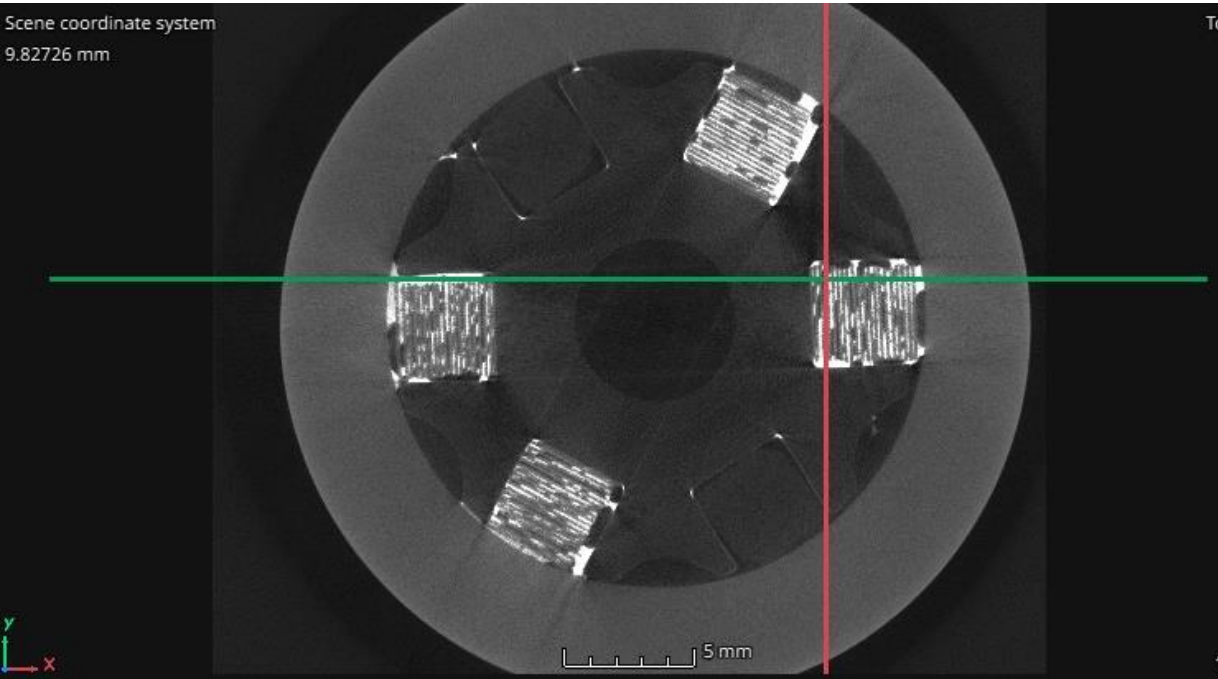


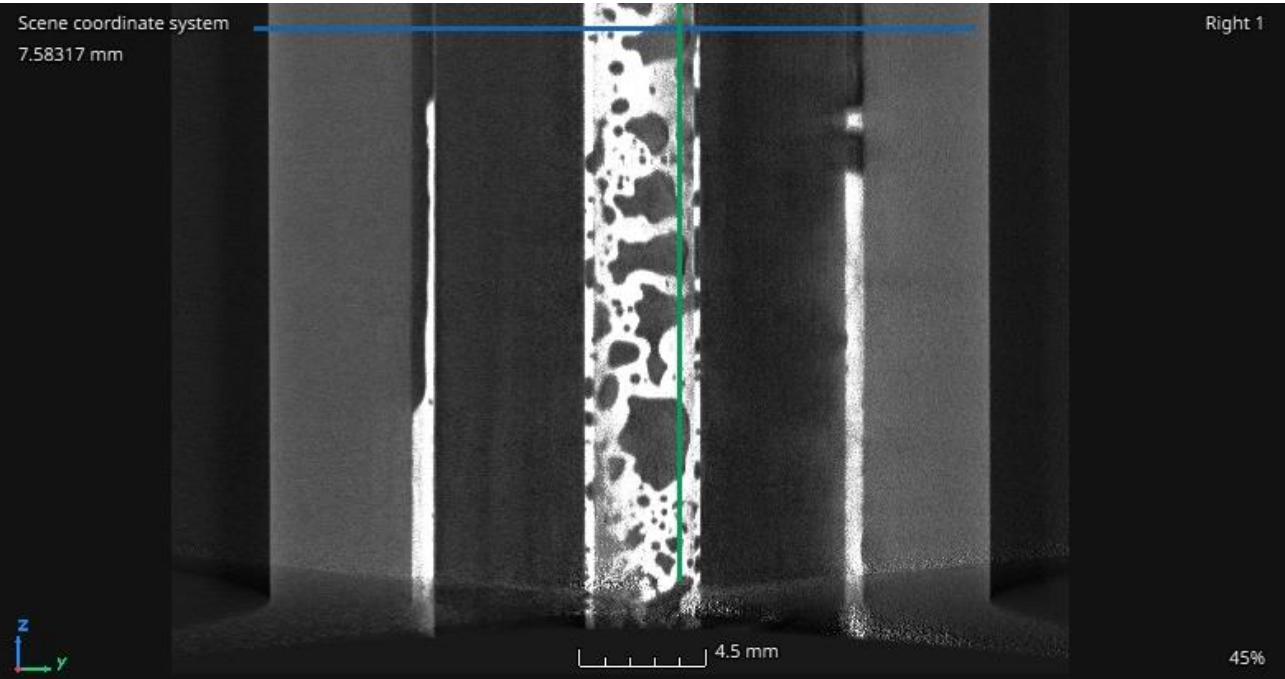


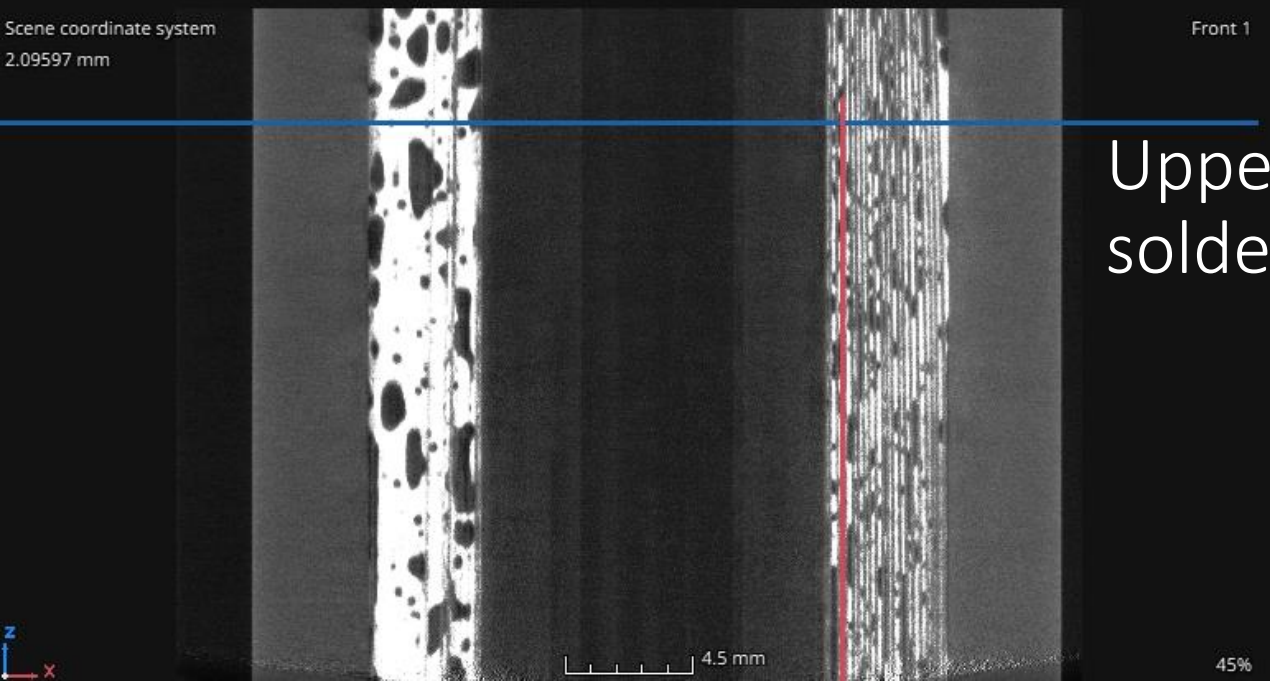




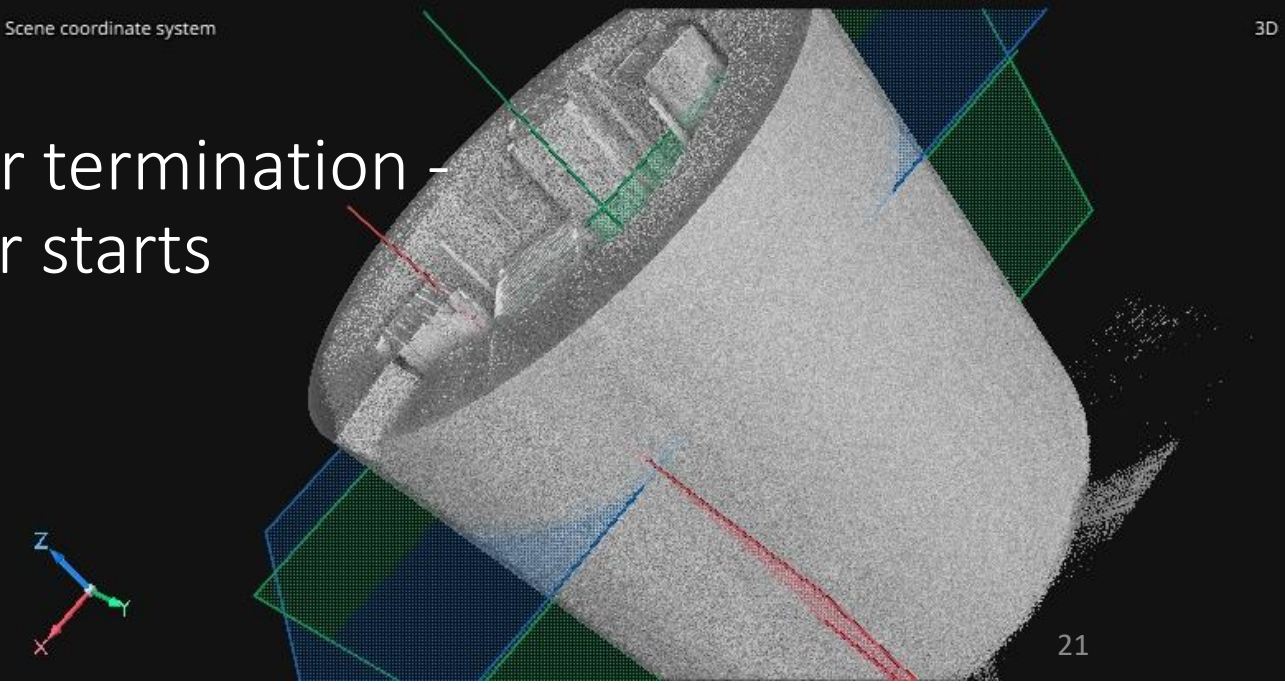
Upper termination - solder starts

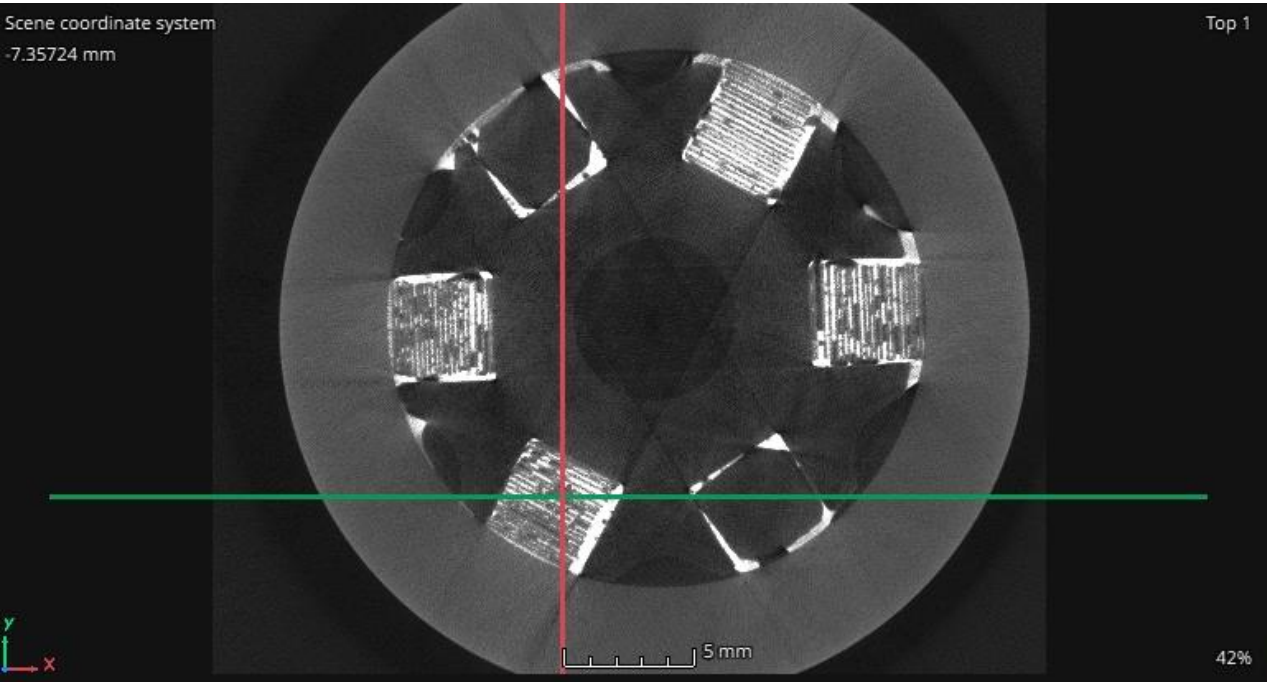


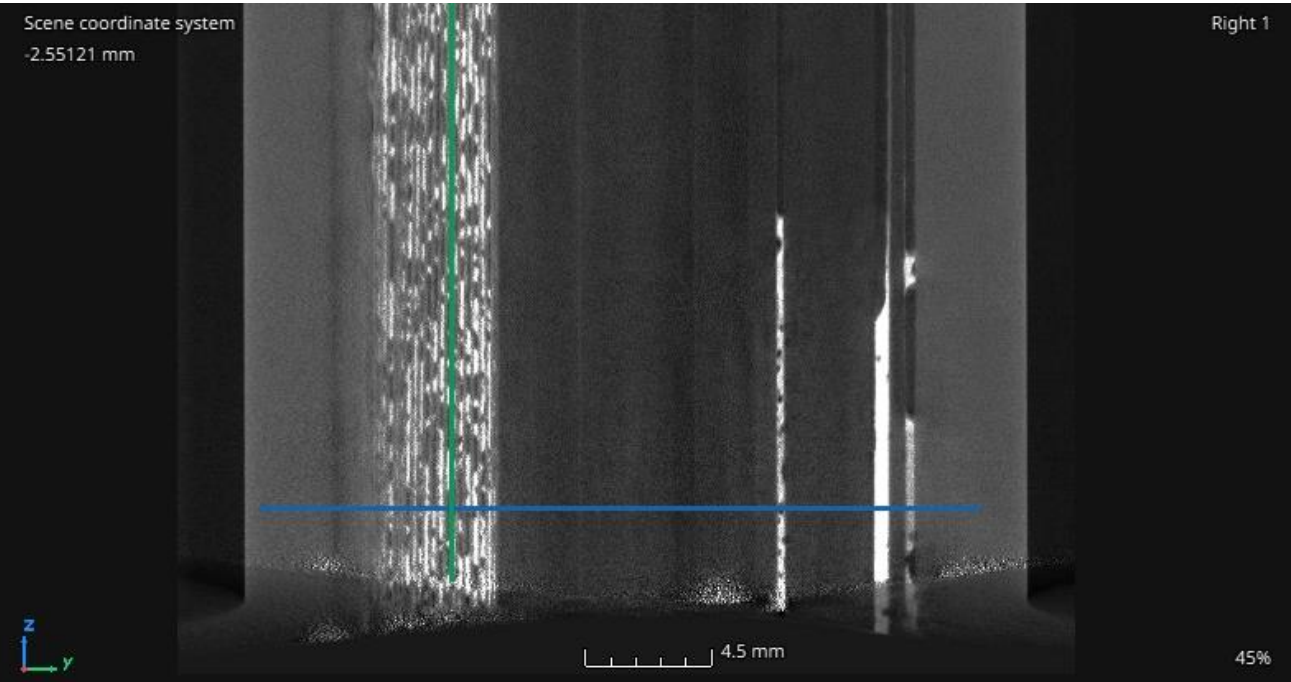


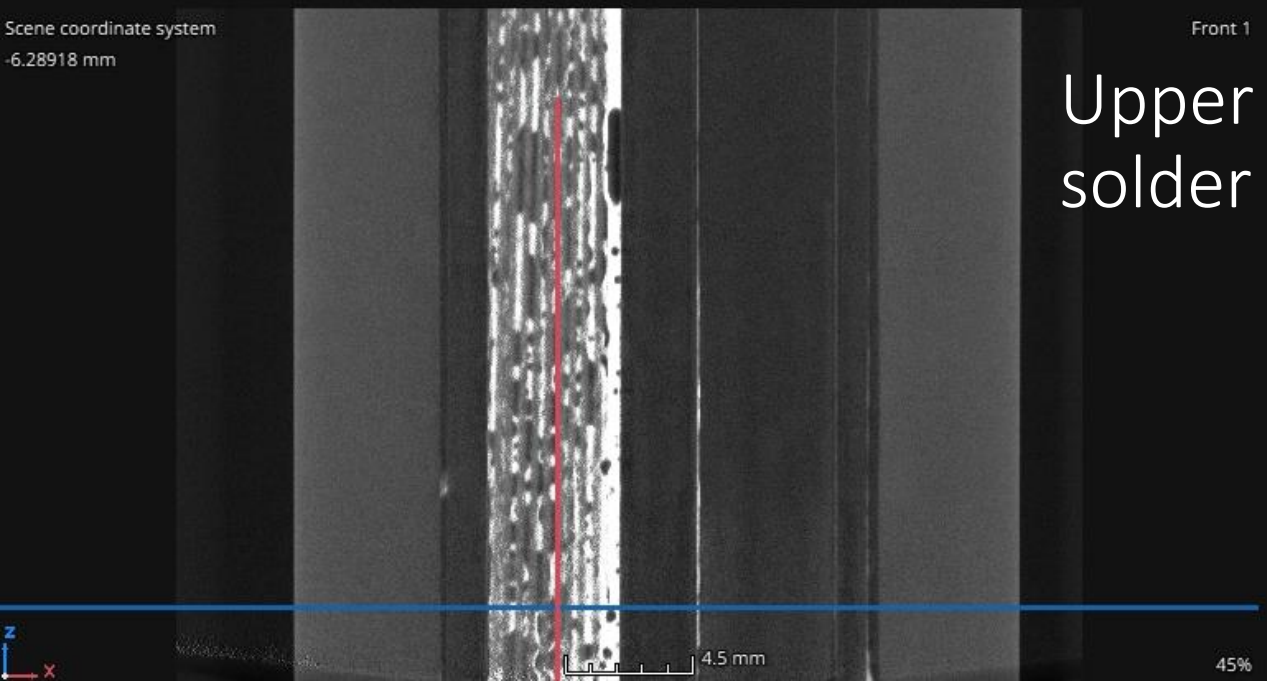


Upper termination - solder starts

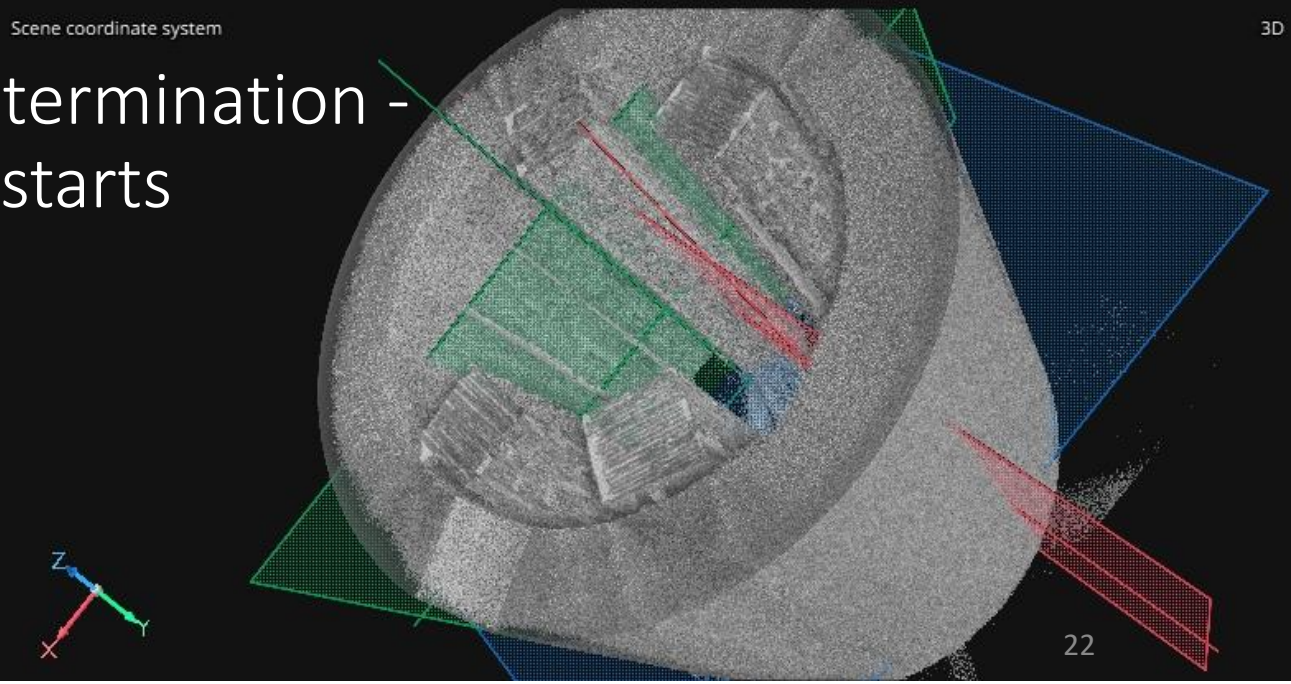


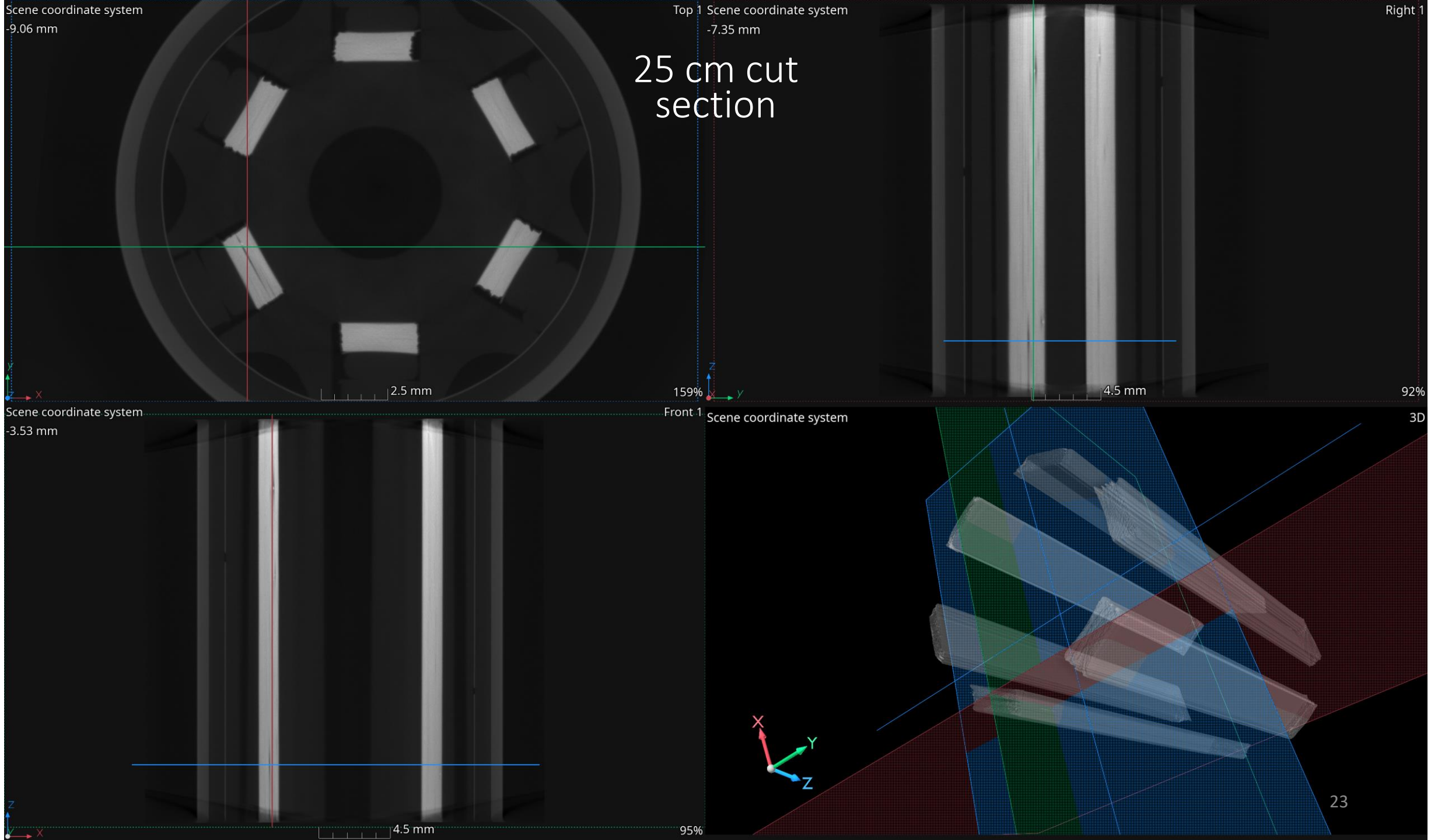




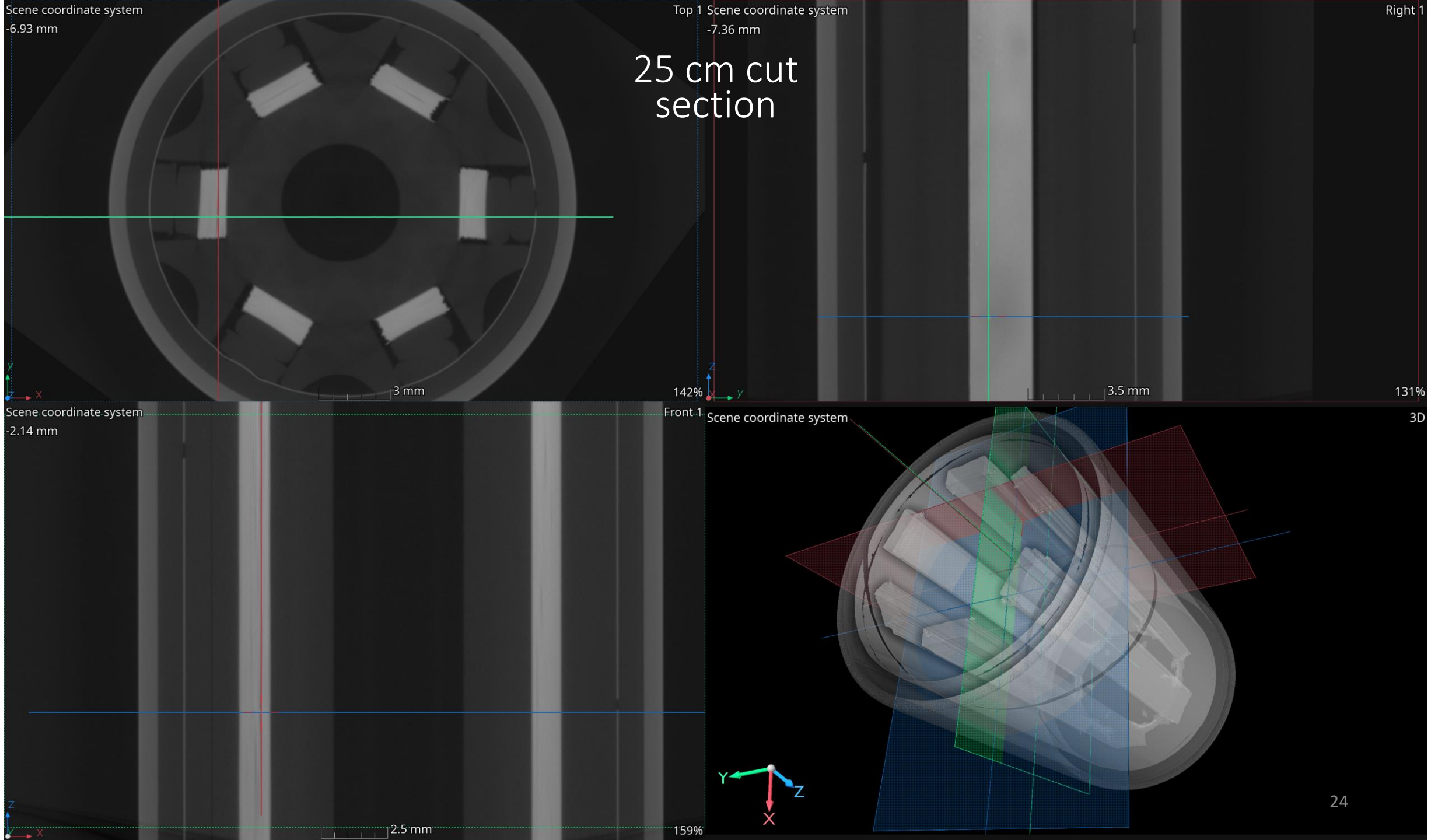


Upper termination - solder starts

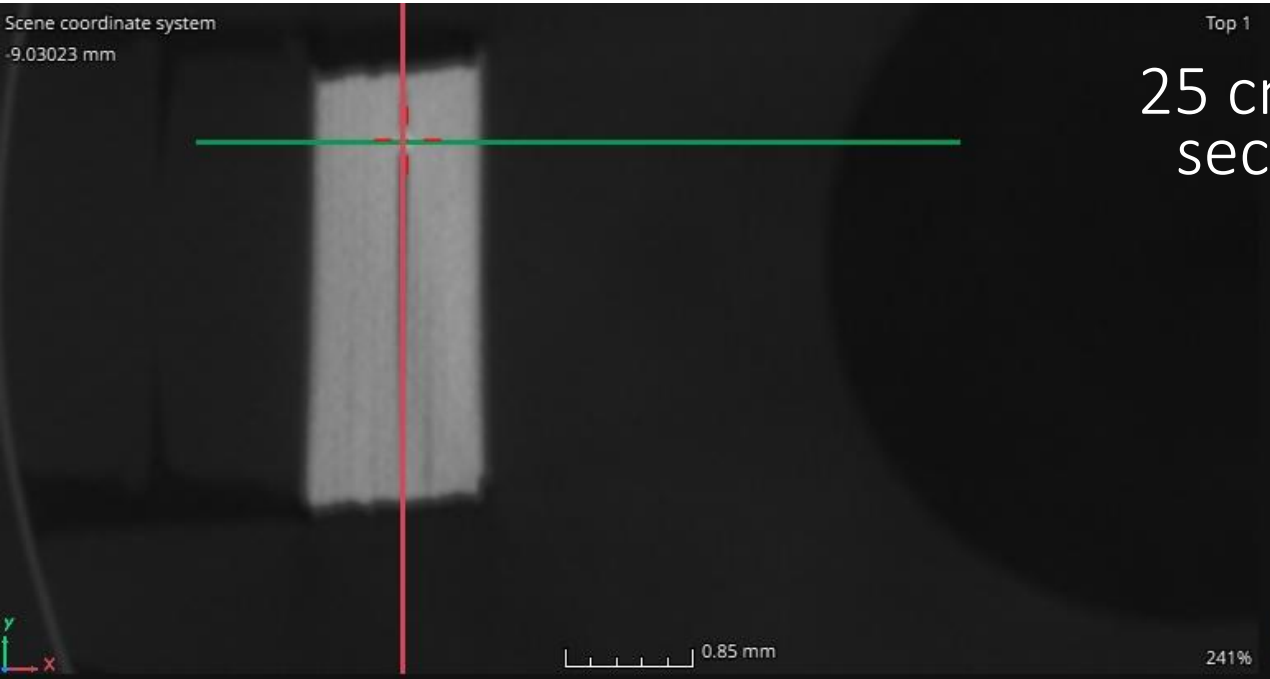


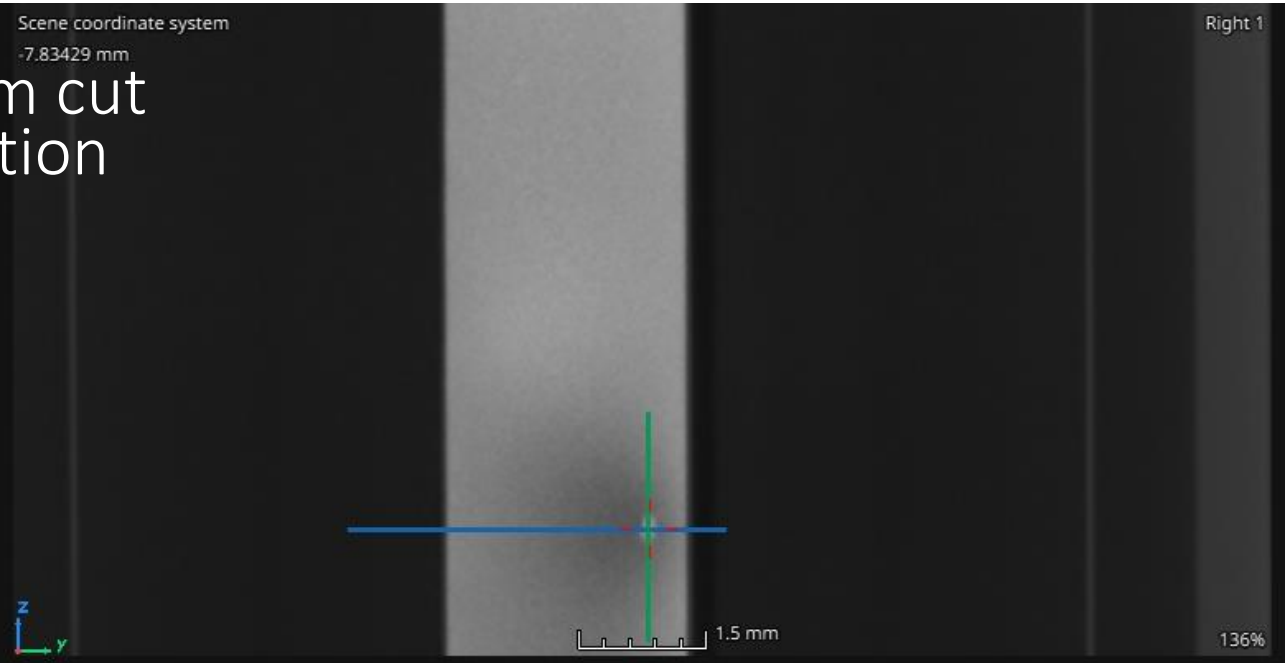


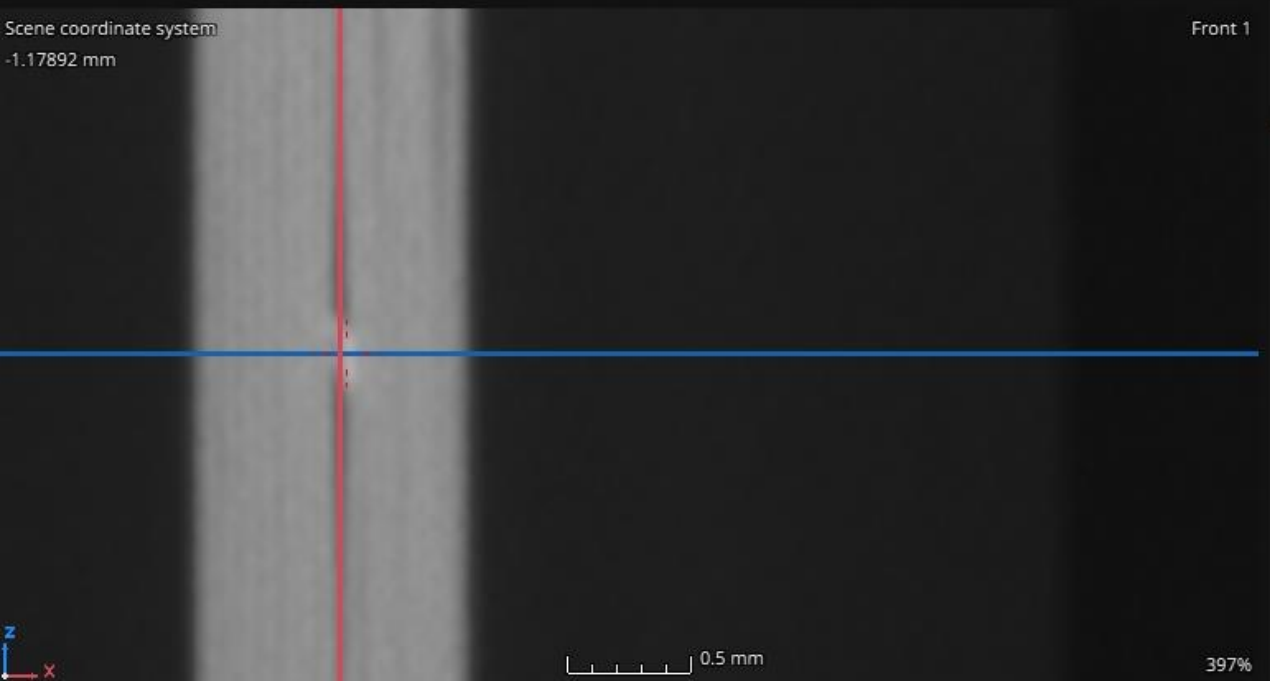
25 cm cut section

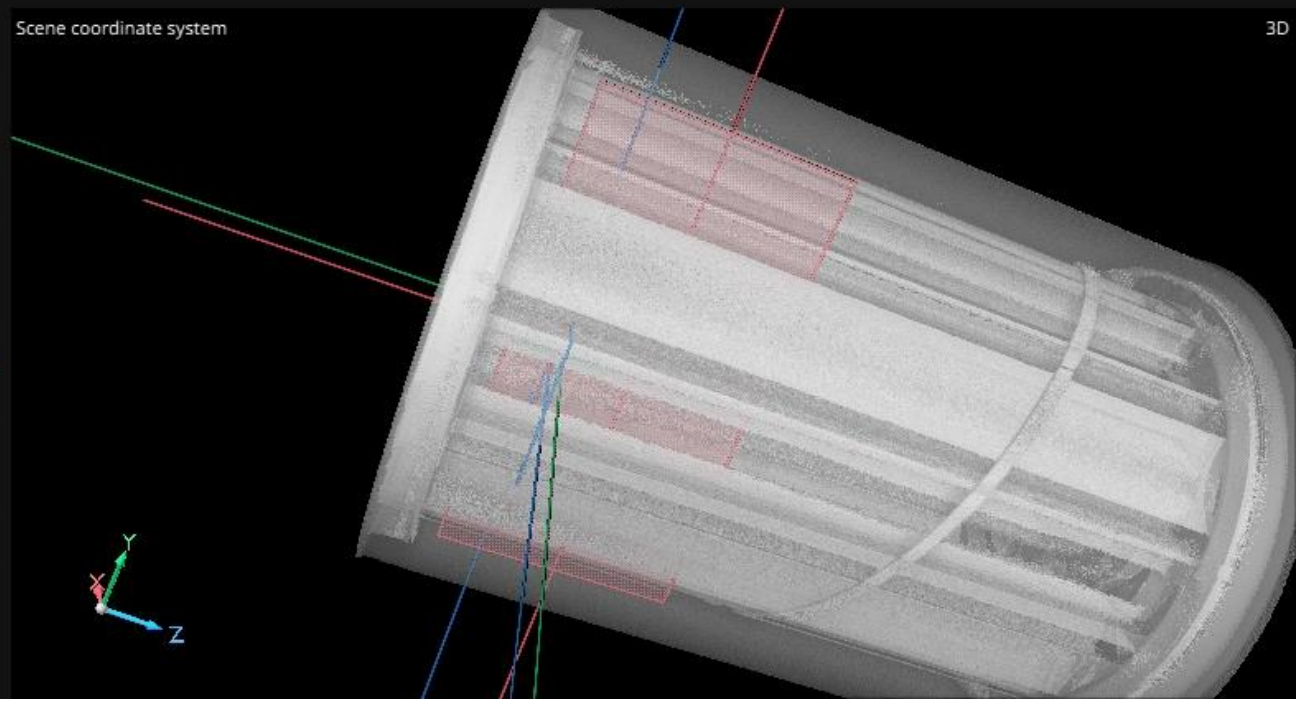

Scene coordinate system
-6.93 mm
Top 1
25 cm cut section
Scene coordinate system
-7.36 mm
Right 1
3 mm
142%
3.5 mm
131%
Scene coordinate system
-2.14 mm
Front 1
Scene coordinate system
3D
2.5 mm
159%
Y
Z
X

25 cm cut section

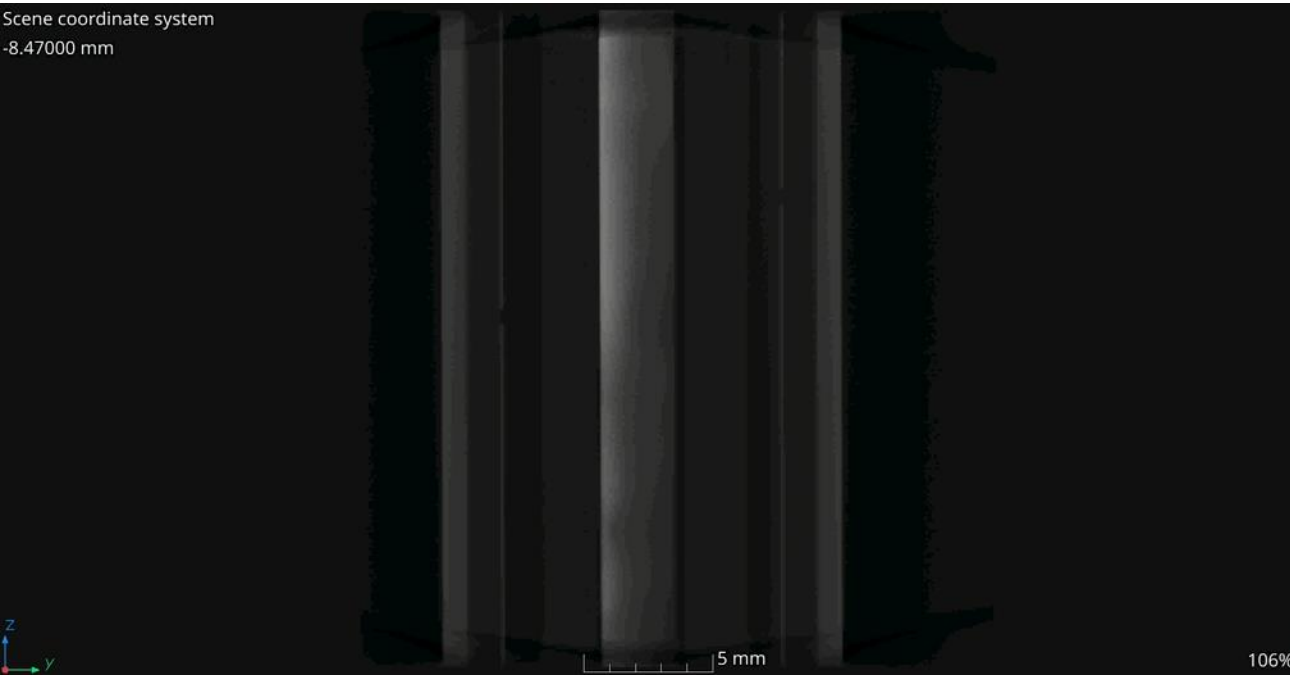


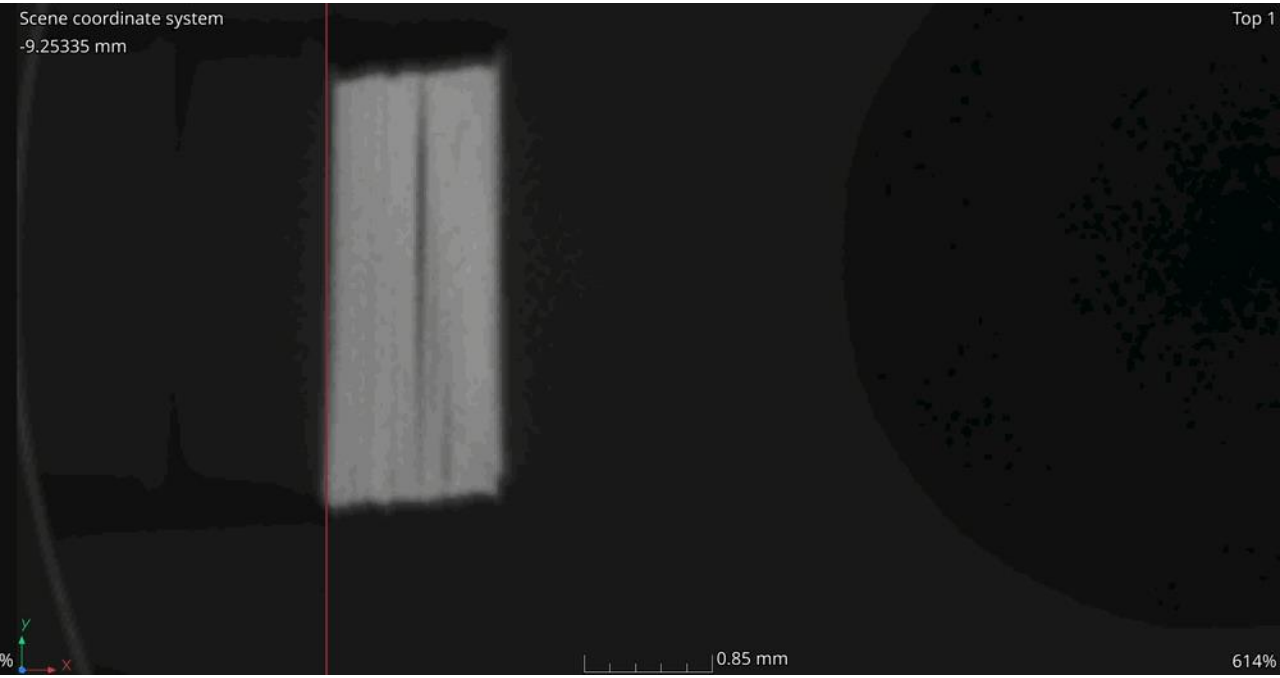






25 cm cut section



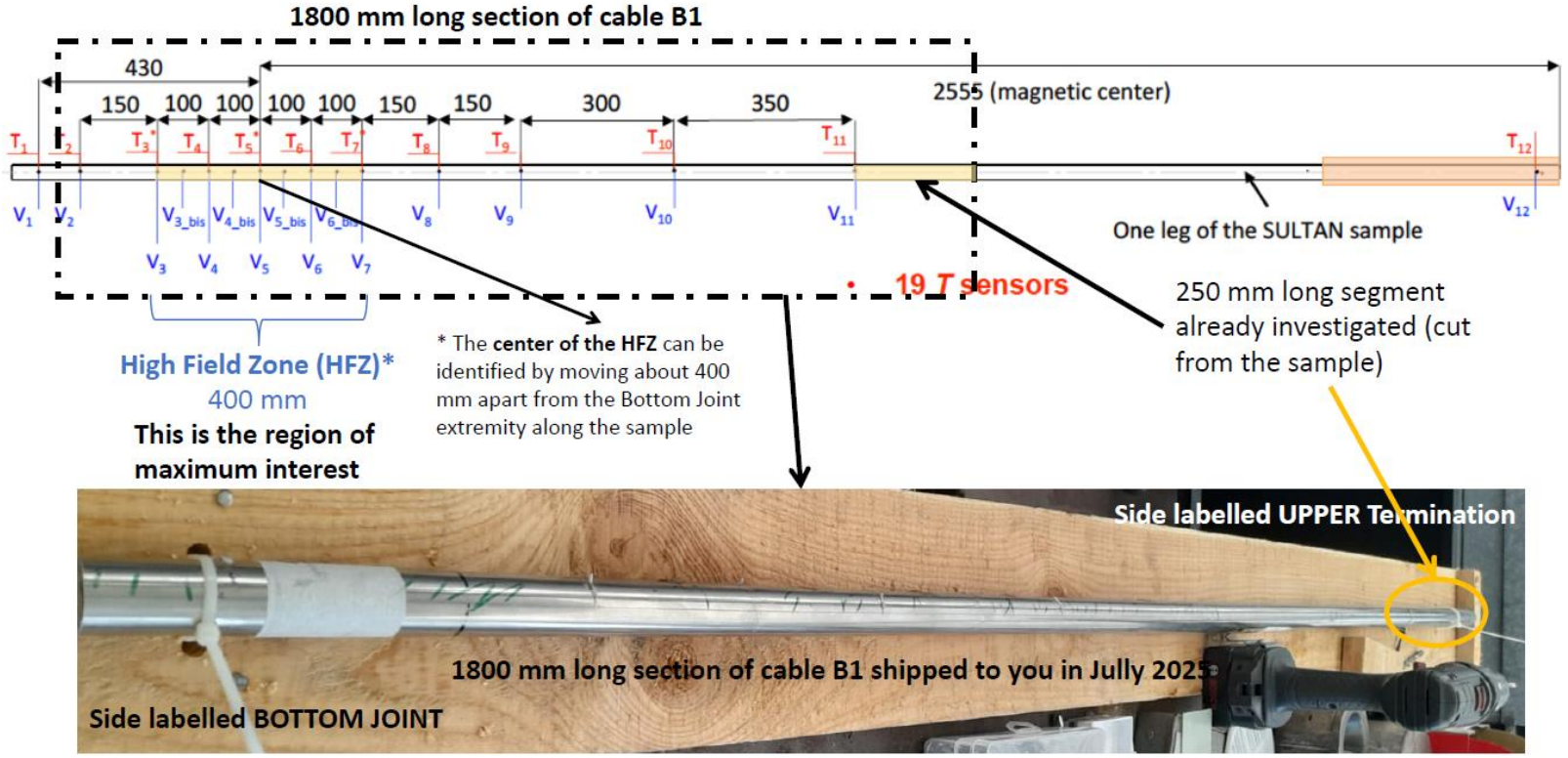


Conclusions

- Initial findings suggest that digital radiography, even when conducted from multiple angles, does not adequately visualize the stacks architecture.
- Therefore, obtaining CT scan-like data for the extra-size cables is essential.
- Preliminary results from the 320 kV X-ray generator in indicate:

i) No noticeable non-uniformities were observed in the 25 cm cut section, only small solder spots/droplets of 80-100 µm in dimensions.
ii) The CT reconstructions confirmed that all dimensions align with the manufacturer's design specifications.

Key Lessons Learned and Future Directions

•**Implementing of the 225 kV X-ray System is needed for achieving ~5 µm voxel resolution:** After feedback received from Giuseppe Celentano and Angello Vannozzi we received the regions of interest in the long middle section of B1 sample (now at 1.55 m long) that will be scanned: a section of 400 mm long is of maximum interest as being the High Field Zone (HFZ).

•In 2026 we will focus on that section, and if needed we sill ask for approval to cut the section out for easier access.