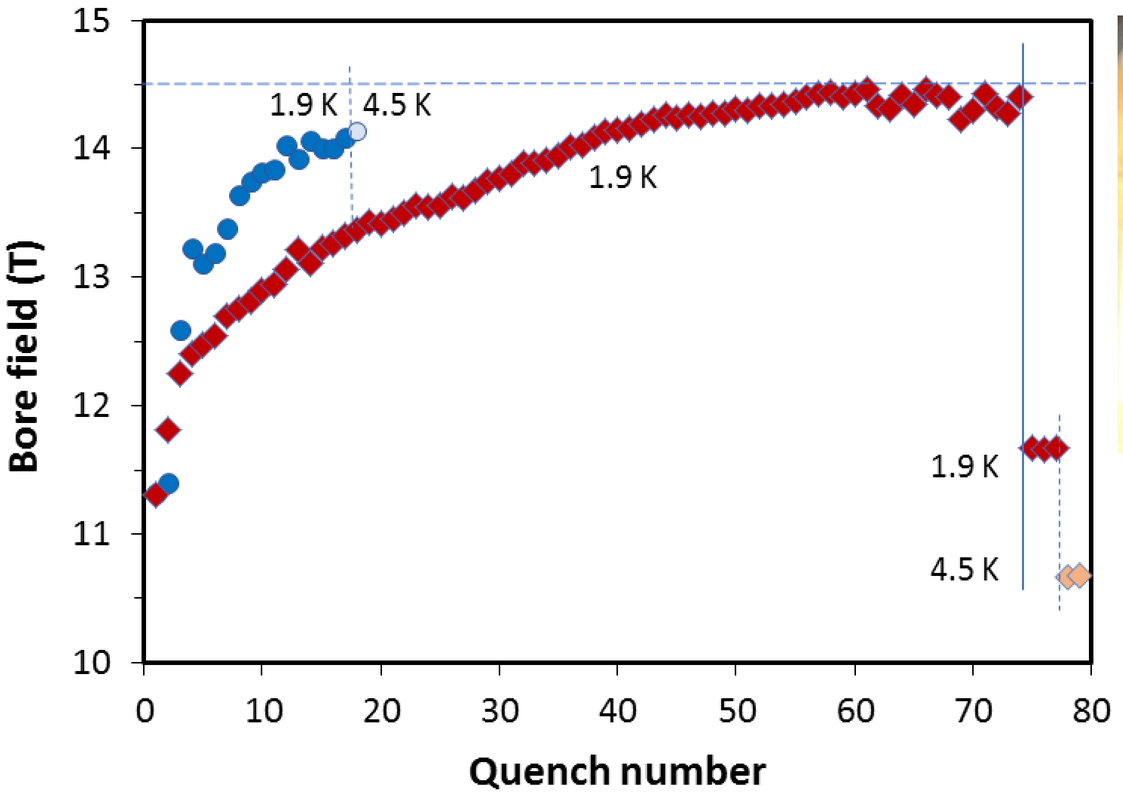
U.S. MAGNET DEVELOPMENT PROGRAM

Update on the MDPCT1 coil #5 X-ray test

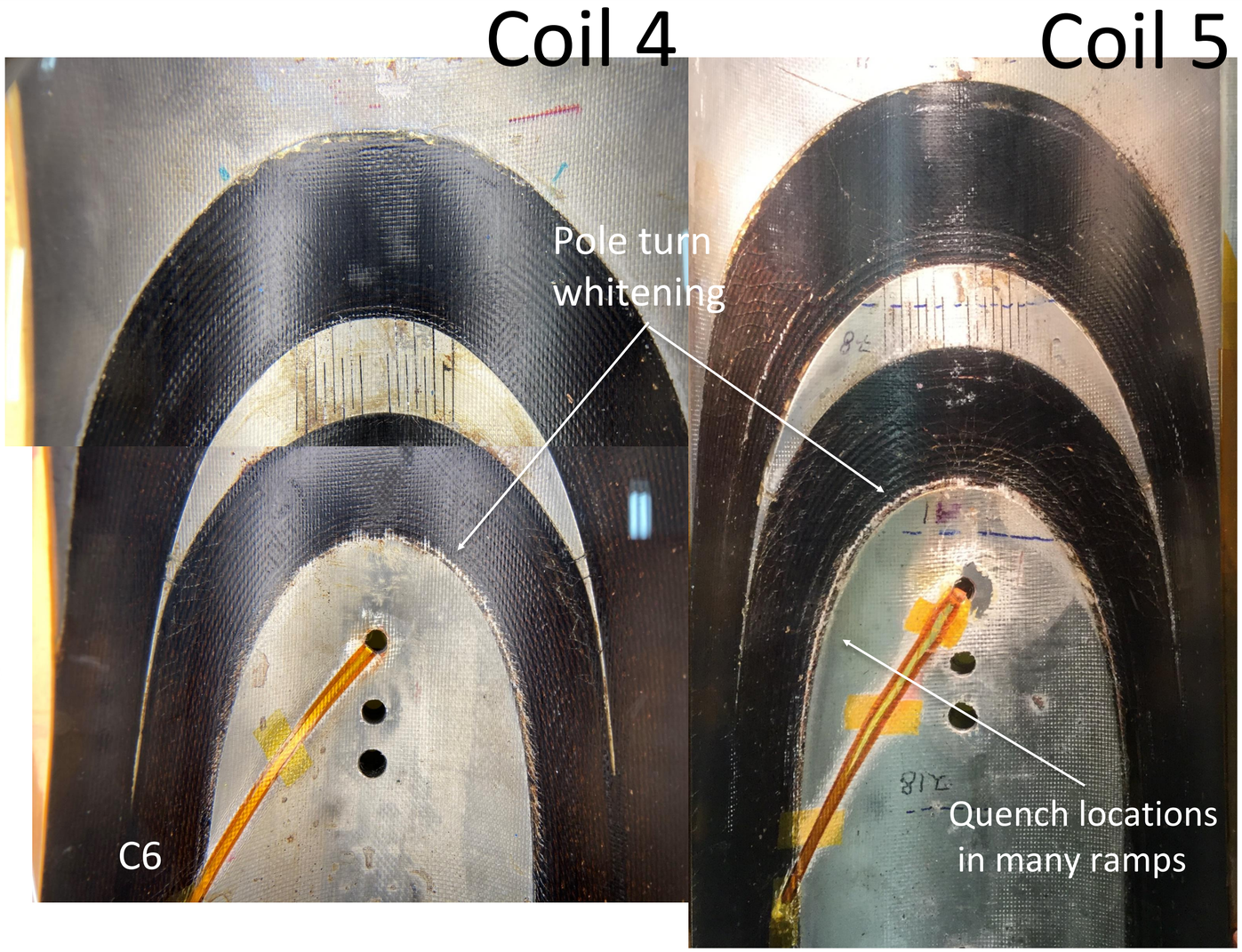
Igor Novitski
Fermilab

September 15, 2021

Outer Coils #4/5 – Inner Layer View, RE after Test 2



- Outer coils have degradation
- Can be used in hybrid configuration

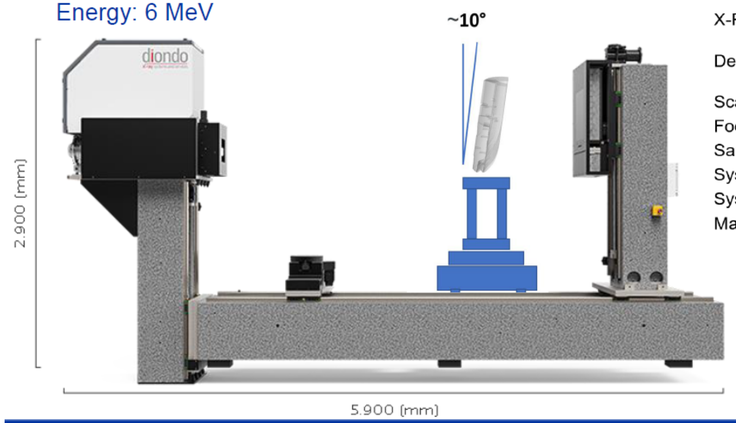


CERN 11T coil pictures

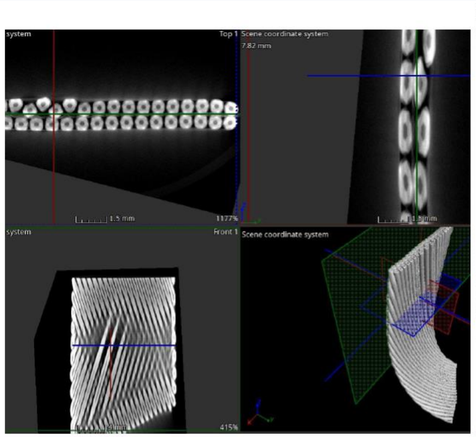
Global High Energy X-ray Computed Tomography

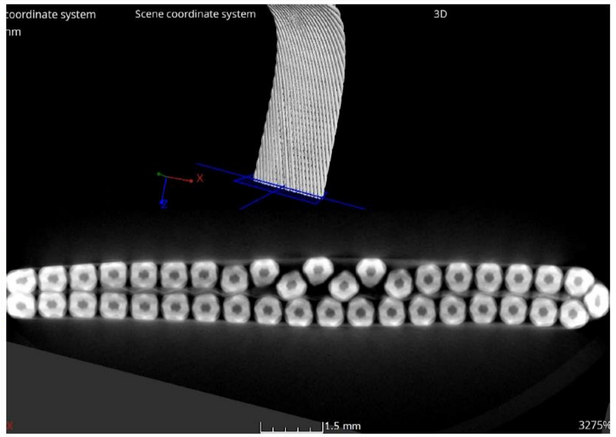
6 MeV LINAC tomography - TEC-Eurolab Modena /IT

Resolution: 120 µm
Spot size: 2 mm
Energy: 6 MeV



X-Ray Source	3 / 6 / 9 [MeV]
Detector	Flat Panel Detector 3.000 x 3.000 px, 140 [µm]
Scan Volume, maximum	Ø 700 x 1000 H [mm]
Focus-Detector-Distance	4000 [mm]
Sample Weight	200 [kg]
System Dimensions	L 5.900 x B 1.500 x H 2.900 [mm]
System Weight	17 [t]
Manipulation	granite based, 6 / 7 axes,

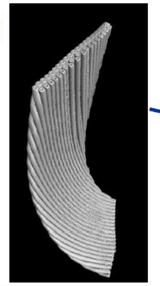


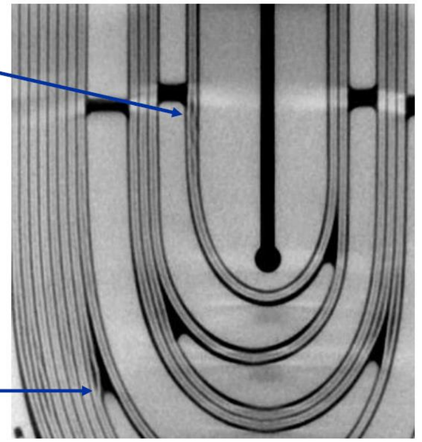


3. Coil GEC02 – Events

Event 1 – first end cable in inner layer,

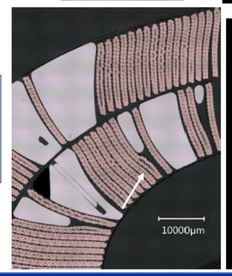
Misaligned strands (pop-in / pop-out)

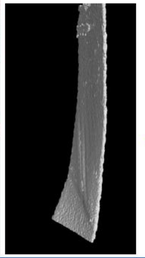




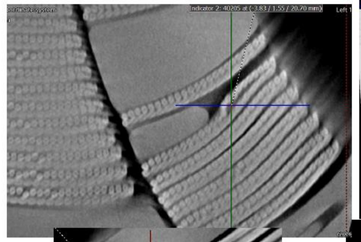
Event 2 – vicinity of fourth spacer in inner layer,

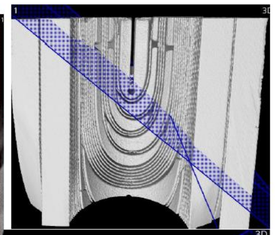
Bulged cable

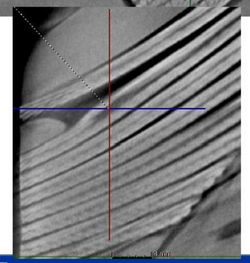


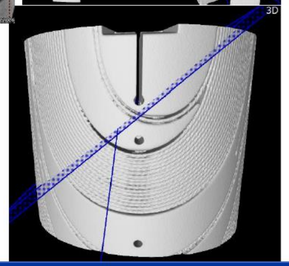


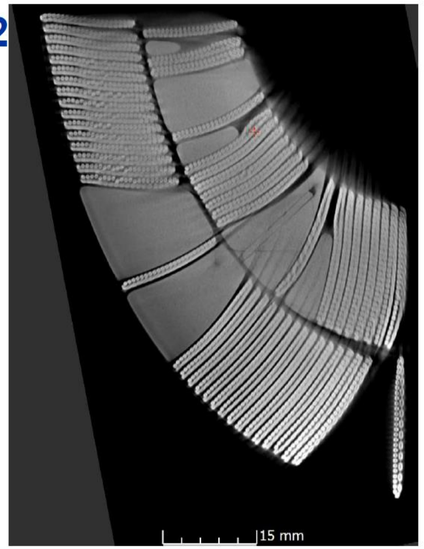
3. Local CT - Coil GEC02 – Event 2



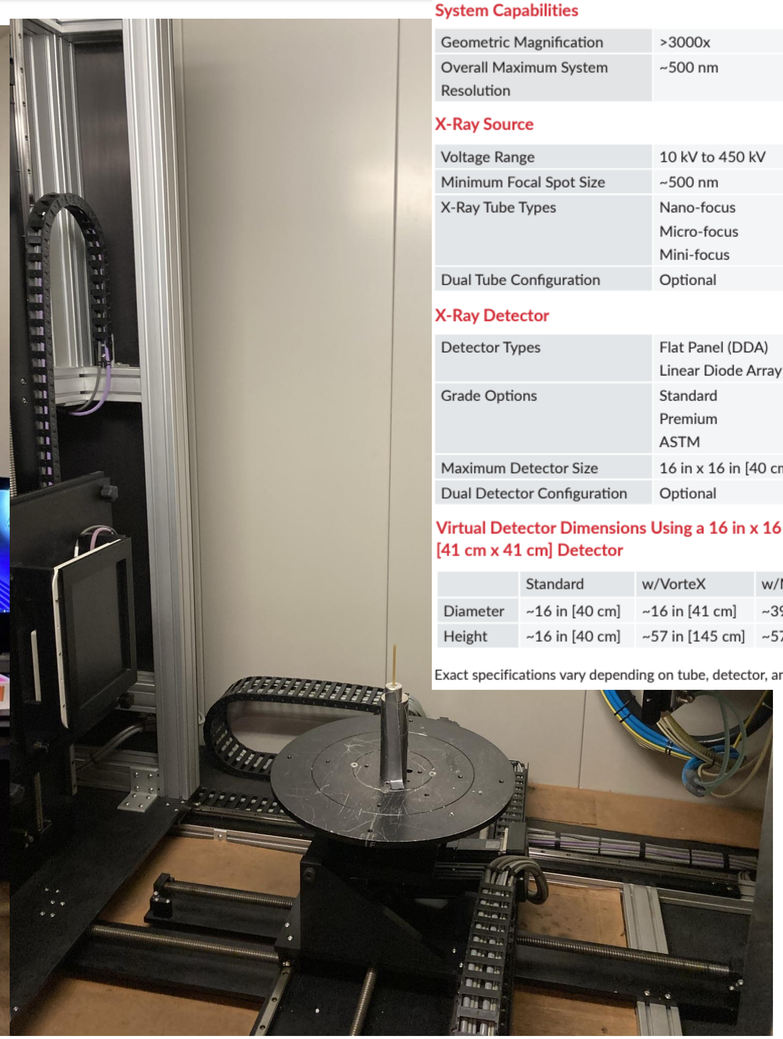








North Star 3D CT imaging at Alloyweld near O'Hare



System Capabilities

Geometric Magnification	>3000x
Overall Maximum System Resolution	~500 nm

X-Ray Source

Voltage Range	10 kV to 450 kV
Minimum Focal Spot Size	~500 nm
X-Ray Tube Types	Nano-focus Micro-focus Mini-focus
Dual Tube Configuration	Optional

X-Ray Detector

Detector Types	Flat Panel (DDA) Linear Diode Array (LDA)
Grade Options	Standard Premium ASTM
Maximum Detector Size	16 in x 16 in [40 cm x 40 cm]
Dual Detector Configuration	Optional

Virtual Detector Dimensions Using a 16 in x 16 in [41 cm x 41 cm] Detector

	Standard	w/VorteX	w/MosaiX
Diameter	~16 in [40 cm]	~16 in [41 cm]	~39 in [100 cm]
Height	~16 in [40 cm]	~57 in [145 cm]	~57 in [145 cm]

Exact specifications vary depending on tube, detector, and other optional configurations.

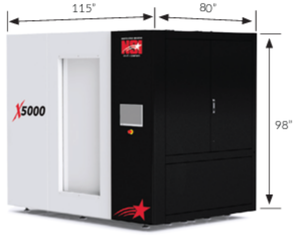
Manipulator

Maximum Sample Weight	500 lb [227 kg]
Axis Travel	Vertical: 48 in [121 cm] Horizontal: 32 in [81 cm] Tilt: +20° / -20° Rotation: 360° Continuous
Nominal Part Envelope	Diameter: 32 in [81 cm] Height: 48 in [121 cm]

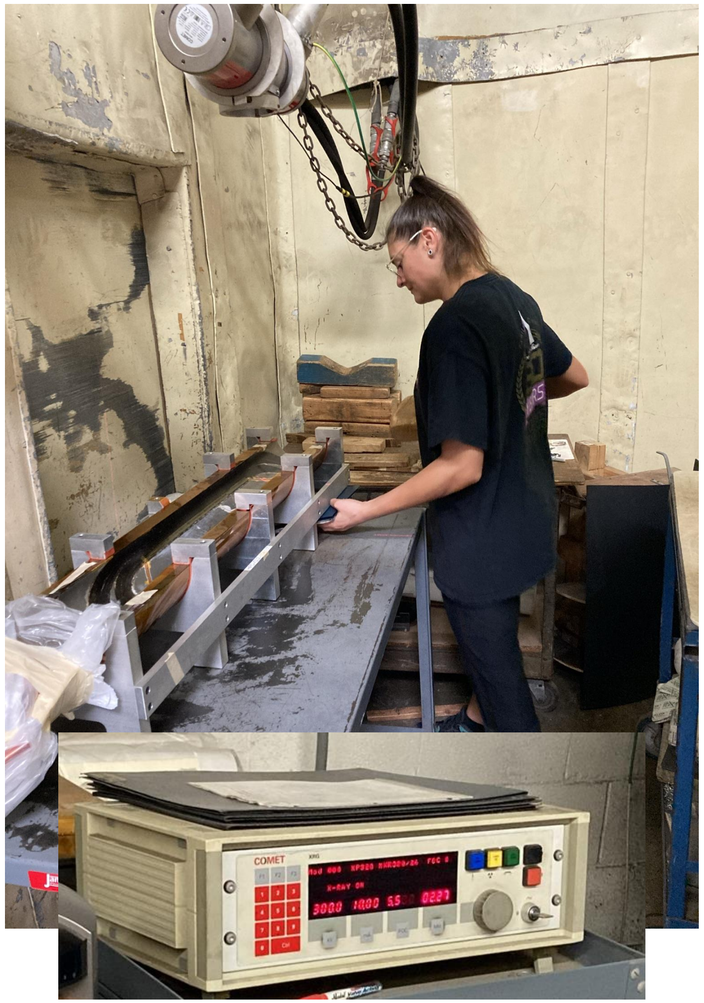
Cabinet

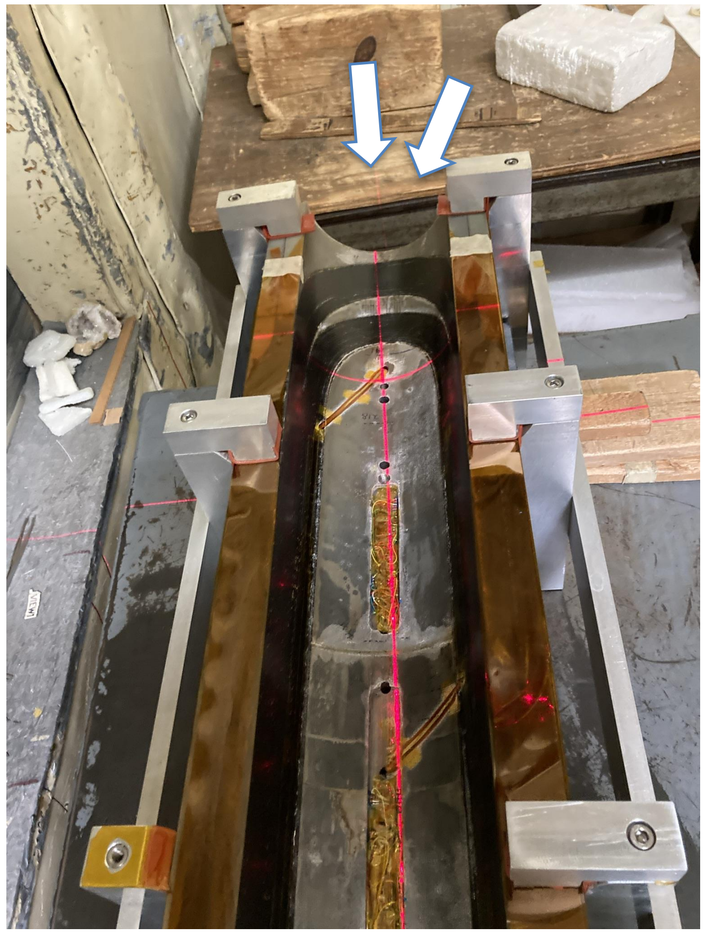
	240 kV	450 kV
Width	115 in [292 cm]	115 in [292 cm]
Depth	80 in [203 cm]	80 in [203 cm]
Height	98 in [249 cm]	928 in [249 cm]
Weight	14800 lb [6170 kg]	29000 lb [13200 kg]

All cabinets are steel/lead/steel construction that meet or exceed 21 CFR 1020.40 and EN 61010-2-091 2012.

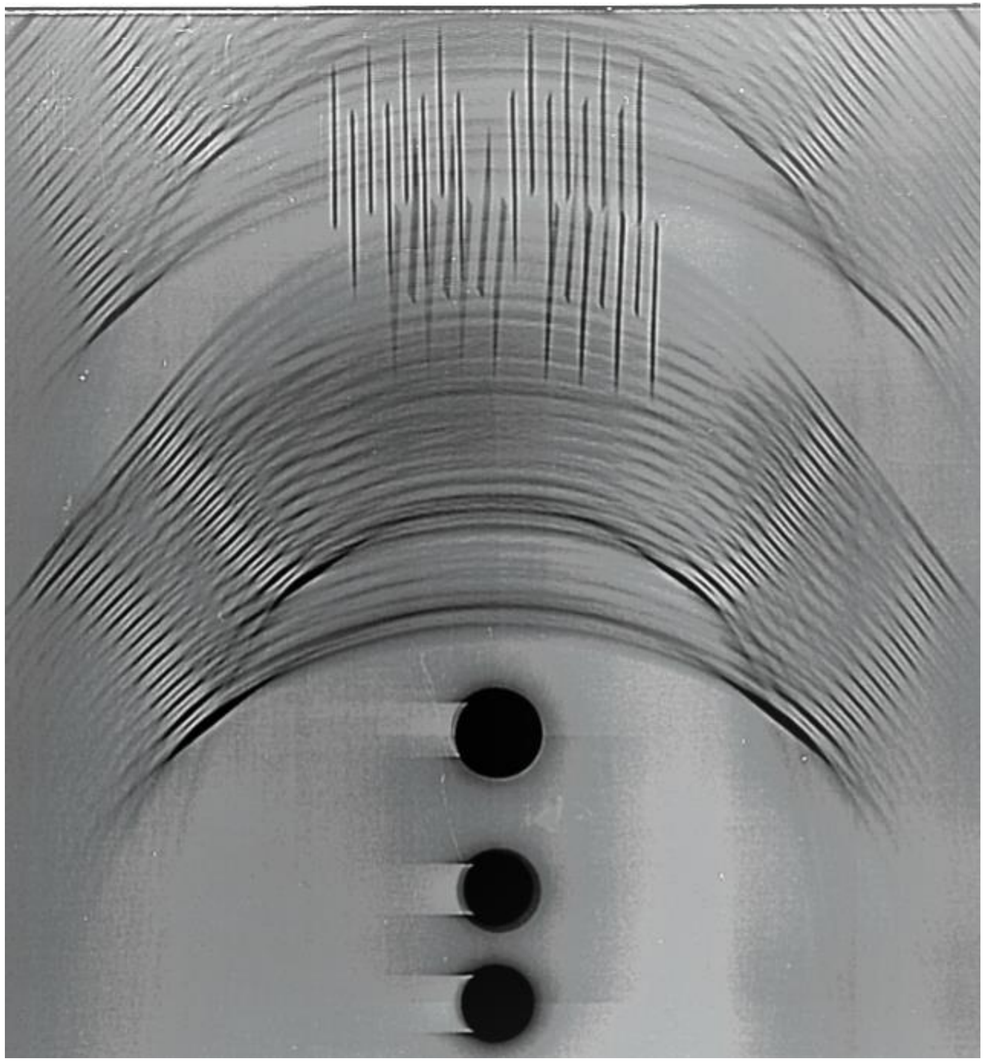


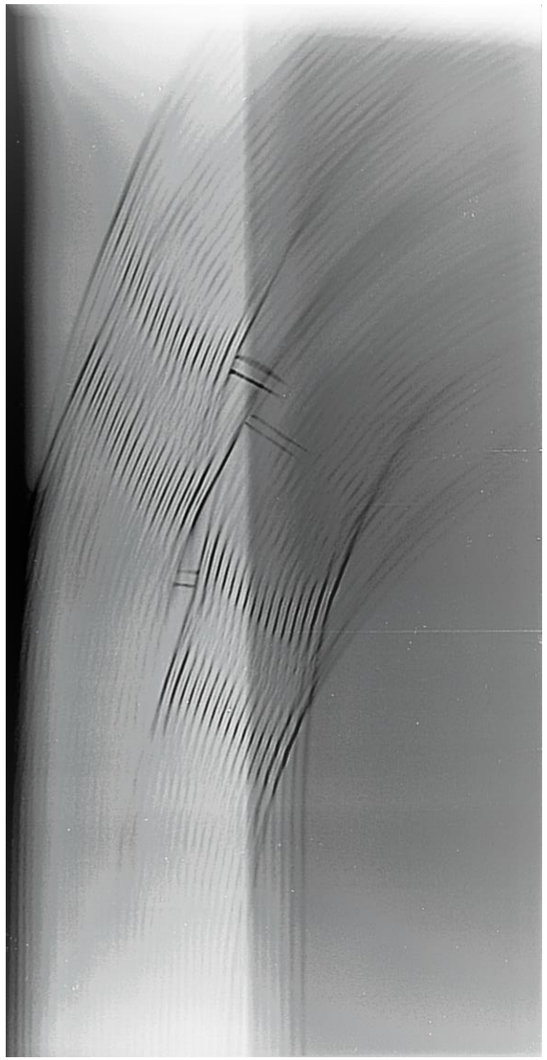
2D picture at 300 kV -10 mA- 2min 30 sec





Outer Coil #5 - Inner Layer View, RE





450 kV CT at Minnesota

From: Justin Olsen <justin@avoniximaging.com>
Sent: Friday, September 03, 2021 5:29 PM
To: Igor Novitski <novitski@fnal.gov>
Cc: Alexander Zlobin <zlobin@fnal.gov>
Subject: Re: Project Discussion

Igor,

Thanks for reaching back with all the information. I would like to set up some time to talk with you further about your project. The system we would likely need to use is our M2 with a 450kV microfocus source.

Would you have some time next week to discuss further?

Regards,

AVONIX IMAGING

Justin Olsen | Business Development Representative – Inspection Services
office: 763.447.4187 | mobile: 763.213.7079
e-mail: justin@avoniximaging.com
6705 Wedgwood CT N | Maple Grove, MN 55311

After meeting note:

The new machine set up with a manipulator to hold the whole coil will be available in November-December
with capability to CT a volume 180 mm^3 at – 450 kV
$1200 per scan + soft
Time - 2 weeks

diondo
x-ray systems and services

The company with its headquarter in Hattingen, Germany and US office in Las Vegas NV, focuses on standard as well as customized industrial CT systems by using a wide range of vendor independent X-ray sources and digital imaging detectors.

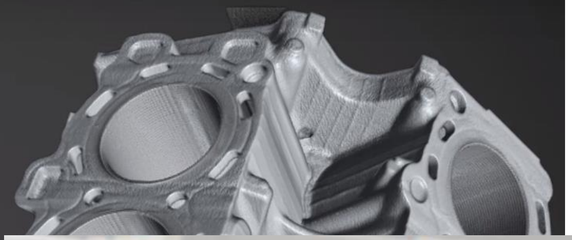
diondo d7

High-Performance Linear Accelerator CT System for Analyzing & Testing of High-Density Components

Applications

The range of applications includes everything from complex measurements of tiny components up to classical non-destructive testing of voluminous objects.
The diondo d7 is used for measuring and analyzing very diverse test parts and materials such as:

- Electric mobility
  [rotors, strators,...]
- Automotive
  [engine blocks, cylinder heads,...]
- Energy
  [turbine blades,...]
- Air & Aerospace
  [power unit components,...]
- Mechanical engineering
  [high-alloy steels, cast-iron components, ...]



CT System Specifications

X-Ray Source.....3 / 6 / 9 [MeV]

Detector:
Flat Panel Detector.....3.000 x 3.000 px, 140 [µm]
Line Detector.....px, 200 [µm]

Scan Volume, maximum
Ø 700 x 1000 H [mm] with Flat Panel Detector
Ø 1000 x 1000 H [mm] with LDA

Focus-Detector-Distance..... Variable to 4000 [mm]

Sample Weight.....200 [kg]

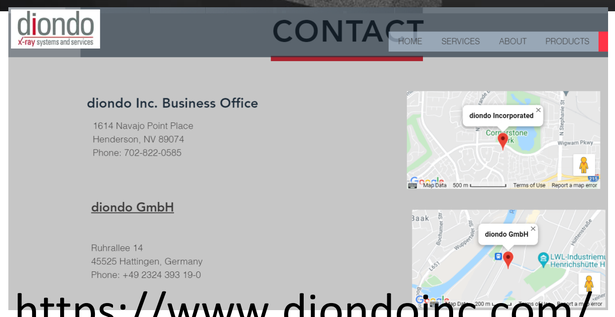
System Dimensions.....L 5.900 x B 1.500 x H 2.900 [mm]

System Weight .....17 [t]

diControl Features
DR-Function, di Scatter, Scan Enhancement, Multiline CT, Daily Check, Health Monitor, Helix CT, Batch Mode, Offset CT, Limited Angle CT

Manipulation..... granite based, 6 / 7 axes

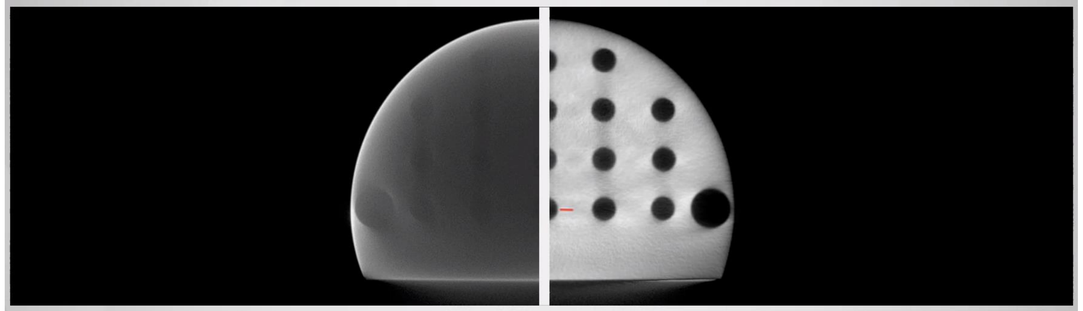
Optional customized features are available upon request.



https://www.diondoinc.com/

diondo d7

Comparison between 450 kV and 6 MeV

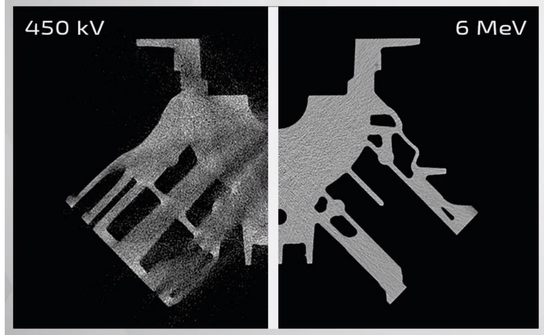


450 kV cone beam CT with flat panel detector
Test steel test specimen
- Diameter
  95 mm
- Investigation time
  1 hour

6 MeV cone beam CT with flat panel detector
Test steel test specimen
- Diameter
  95 mm
- Investigation time
  1 hour

diondo d7

Comparison between 450 kV and 6 MeV



Fan beam CT of an aluminium V8 cylinder head, Diameter 450 mm

Comparison between 450 kV and 6 MeV

450 kV
Due to the immense material thickness a reliable defect detection is not possible

6 MeV
Thanks to the high penetration power not only the measurement time is drastically reduced, but also the test result allows a reliable defect analysis. Additionally, the excellent contrast values and clear object outlines allow measurement analyses.

From: Greg Budner <Greg.Budner@diondo.com>
Sent: Thursday, September 16, 2021 9:26 AM
To: Igor Novitski <novitski@fnal.gov>
Cc: Benjamin Zengerling <Benjamin.Zengerling@diondo.com>
Subject: RE: 6 MeV imaging

Dear Igor:

We have reviewed your pictures and as discussed earlier we are familiar with this type of part. Our scanning fee is $2900 per scanning area view. There will be a shipping charge so we will need to know the weight and dimensions and we will need to make a reusable shipping container. From our dock, it is about 5 days to turn around the part.

Best regards,
Greg