High-speed x-ray CT for industrial inspection through high-brightness x-ray sources and photon counting detectors

Till Dreier, *Ph.D.*
X-ray Scientist
till.dreier@excillum.com

excillum

How CT Scanning Improves Battery Inspection: 7 Examples

CT scan battery images.

The use of industrial CT scans keeps growing. Let's take a deeper look at the technology and its potential for battery inspections.

Maria Guerra | Feb 17, 2023

TRANSPO / ELECTRIC CARS / CARS

GM, Hyundai announce EV battery plants for the US

Image: Getty Images

GM is teaming up with South Korea's Samsung SDI, while Hyundai said it would create a joint venture with SK On. The new factories are the latest in a rapidly expanding EV manufacturing footprint in the US.

By Andrew J. Hawkins, transportation editor with 10+ years of experience who covers EVs, public transportation, and aviation. His work has appeared in The New York Daily News and City & State.
Apr 25, 2023 at 7:04 PM GMT+2 | 4 Comments

Factbox: Companies invest in EV battery factories in Europe

Reuters
May 31, 2023 9:19 AM GMT+2 · Updated a day ago

[1/3] FILE PHOTO-Employees work at the Northvolt facility in Vasteras, Sweden, September 29, 2021. Picture taken September 29, 2021. REUTERS/Helena Soderpalm.

Le Monde

NEWS · INTERNATIONAL · WAR IN UKRAINE · ENVIRONMENT · FRANCE · OPINION · FRENCH

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ECONOMY · FRENCH ECONOMY

Battery 'gigafactories' are flourishing across Europe

Driven by its decision to ban the sale of combustion engines after 2035, Europe is catching u in terms of battery production. But there is already a risk of overcapacity.

By Sophie Fay

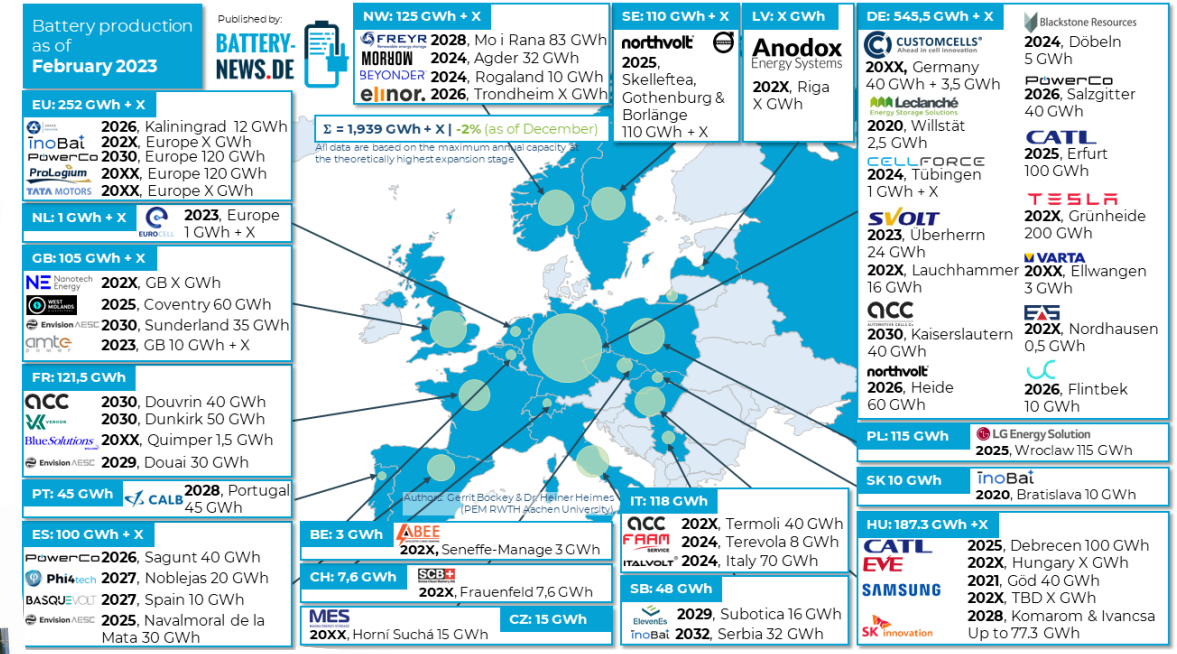
Published on May 15, 2023, at 11:06 am (Paris) · 3 min. · Lire en français

Volkswagen to Build Battery Plant in Canada to Fast-Track Expansion

- Firm says Canada offers access to raw materials, clean energy
- US green tech subsidies are tailwind to North America plans

Battery production as of **February 2023**

Published by: BATTERY-NEWS.DE



BUSINESS

2022 was a big year for EV battery plants in the U.S. How big? $73 billion big

December 30, 2022 · 5:01 AM ET

EV Markets Reports.com

Sector	Region	Author	Reading time	Publish date	Mark as favorite
Batteries	Global EV Markets	Editorial board	3 minutes	January 2023	Bookmark

Over the previous four years, about $300 billion in new lithium ion battery gigafactories have been announced, fueled by the industry's fast expansion in China, the world's largest producer.

Infographics from www.battery-news.de
Articles: www.batterytechonline.com, www.lemonde.fr, www.evmarketreports.com, www.autonews.com, www.theverge.com, www.bloomberg.com, www.npr.org , www.reuters.com

Perspective

Perspectives on Membranes and Separators for Electrochemical Energy Conversion and Storage Device

Peter N. Pintauro

Pages 201-207 | Published online: 07 May 2015

Download citation https://doi.org/10.1080/15583724.2015.1031378 Check for updates

Abstract

This article is a perspective that introduces the theme of this issue of Polymer Reviews, that being polymeric membranes and fuel cells for battery (energy storage) and fuel cell (energy conversion) applications. This short article reviews the need for batteries and fuel cells, the key properties of membranes/separators for such devices, the R&D steps required for the fabrication of new a membrane/separator, and the importance of the five review articles in this issue, in addressing cutting-edge research topics.

Lithium-ion batteries for sustainable energy storage: recent advances towards new cell configurations

Daniele Di Lecce, R. Verrelli, J. Hassoun · Published 31 July 2017 · Environmental Science, Engineering, Materials Science · Green Chemistry

The recent advances in the lithium-ion battery concept towards the development of sustainable energy storage systems are herein presented. The study reports on new lithium-ion cells developed over the last few years with the aim of improving the performance and sustainability of electrochemical energy storage. Alternative chemistries

Article | Open Access | Published: 29 April 2020

3D microstructure design of lithium-ion battery electrodes assisted by X-ray nano-computed tomography and modelling

Xuekun Lu, Antonio Bertei, Donal P. Finegan, Chun Tan, Sohrab R. Daemi, Julia S. Weaving, Kieran B. O'Regan, Thomas M. M. Heenan, Gareth Hinds, Emma Kendrick, Dan J. L. Brett & Paul R. Shearing

Nature Communications **11**, Article number: 2079 (2020) | Cite this article

5 August 2022

Research progress on improving the quality of lithium batteries

Peng Xiao

Author Affiliations +

Proceedings Volume 12326, 2nd International Conference on Materials Chemistry and Environmental Engineering (CONF-MCEE 2022); 1232606 (2022) https://doi.org/10.1117/12.2646156

Event: 2nd International Conference on Materials Chemistry and Environmental Engineering (CONF-MCEE 2022), 2022, ONLINE, United States

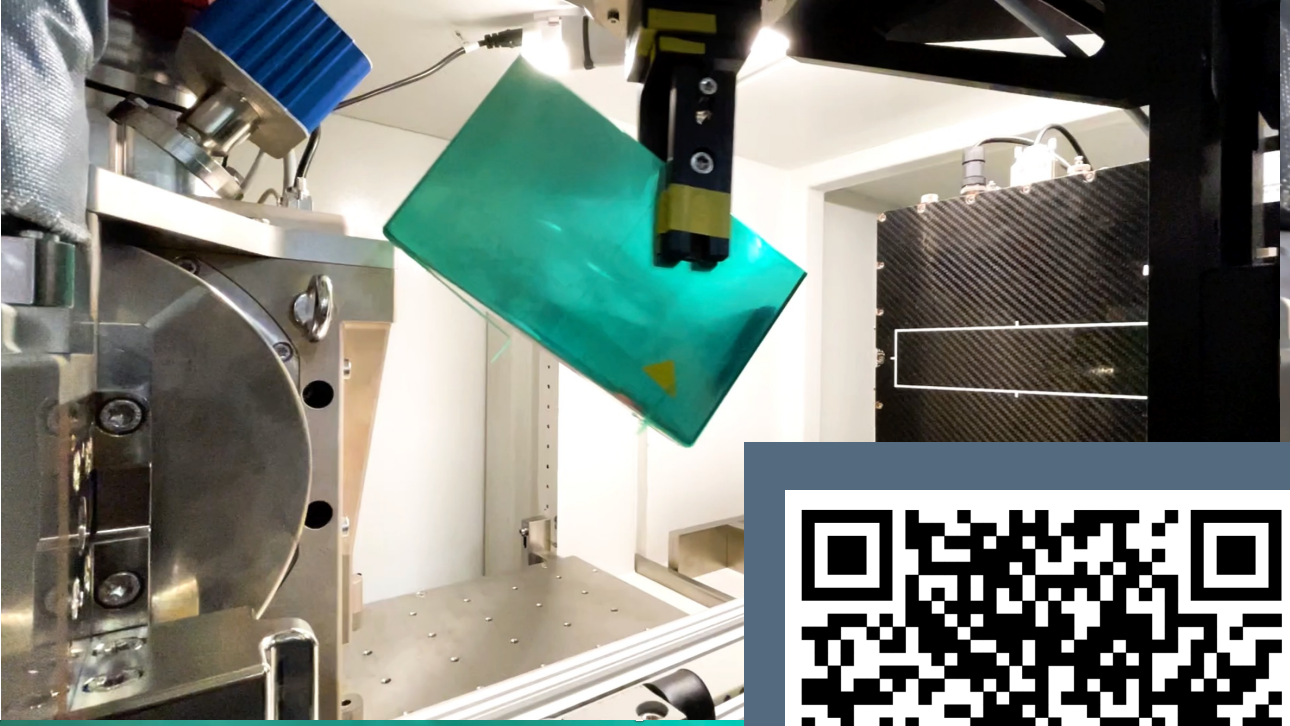
Article | Open Access | Published: 07 February 2020

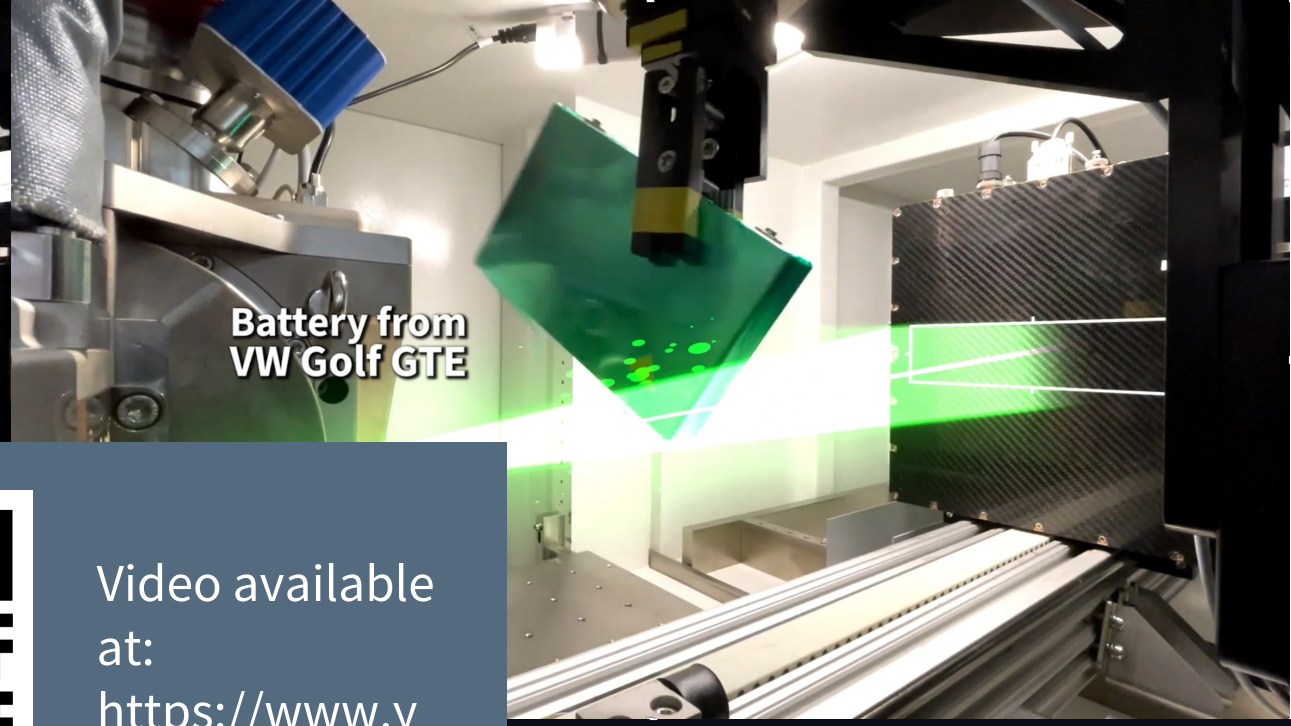
4D imaging of lithium-batteries using correlative neutron and X-ray tomography with a virtual unrolling technique

Ralf F. Ziesche, Tobias Arlt, Donal P. Finegan, Thomas M. M. Heenan, Alessandro Tengattini, Daniel Baum, Nikolay Kardjilov, Henning Markötter, Ingo Manke, Winfried Kockelmann, Dan J. L. Brett & Paul R. Shearing

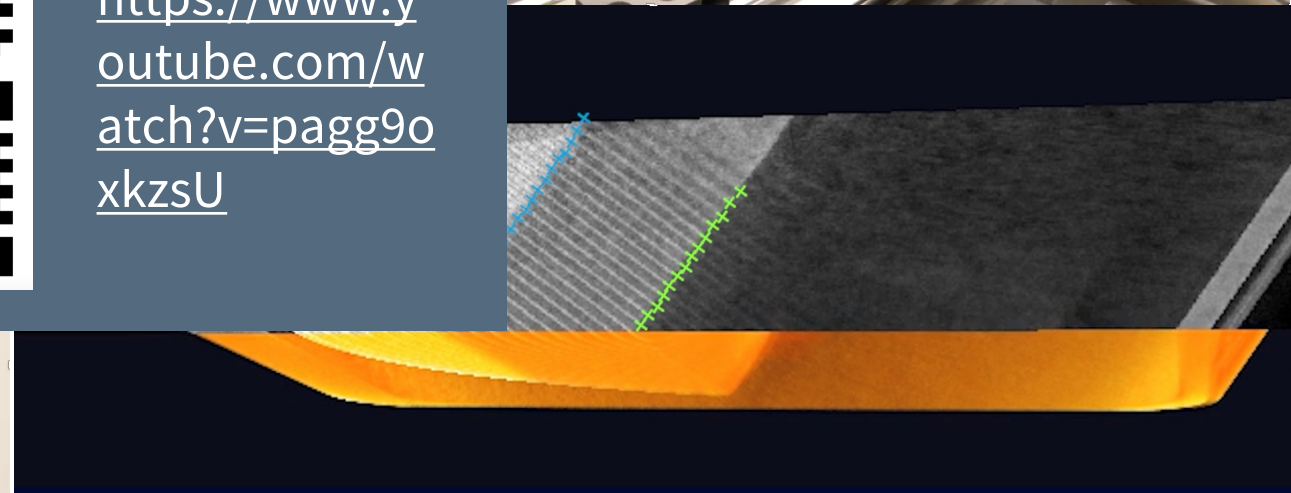
Nature Communications **11**, Article number: 777 (2020) | Cite this article

Articles: doi.org/10.1080/15583724.2015.1031378, doi.org/10.1039/C7GC01328K, doi.org/10.1117/12.2646156, doi.org/10.1038/s41467-019-13943-3, doi.org/10.1038/s41467-020-15811-x





Video available at: https://www.youtube.com/watch?v=pagg9oxkzsU



The result:

One revolution • 2.000 projections • One high-resolution 3d image

The source for X-ray innovation

Entirely devoted to advanced microfocus and nanofocus X-ray sources

… (and some pure e-beam sources)

Based in Stockholm, Sweden

Established 2007

80+ colleagues

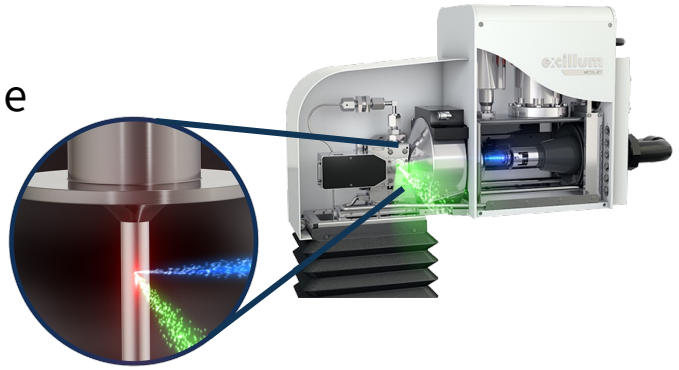
- >40 in R&D
- >10 nationalities

Our technology and product lines

MetalJet

World's brightest microfocus X-ray source

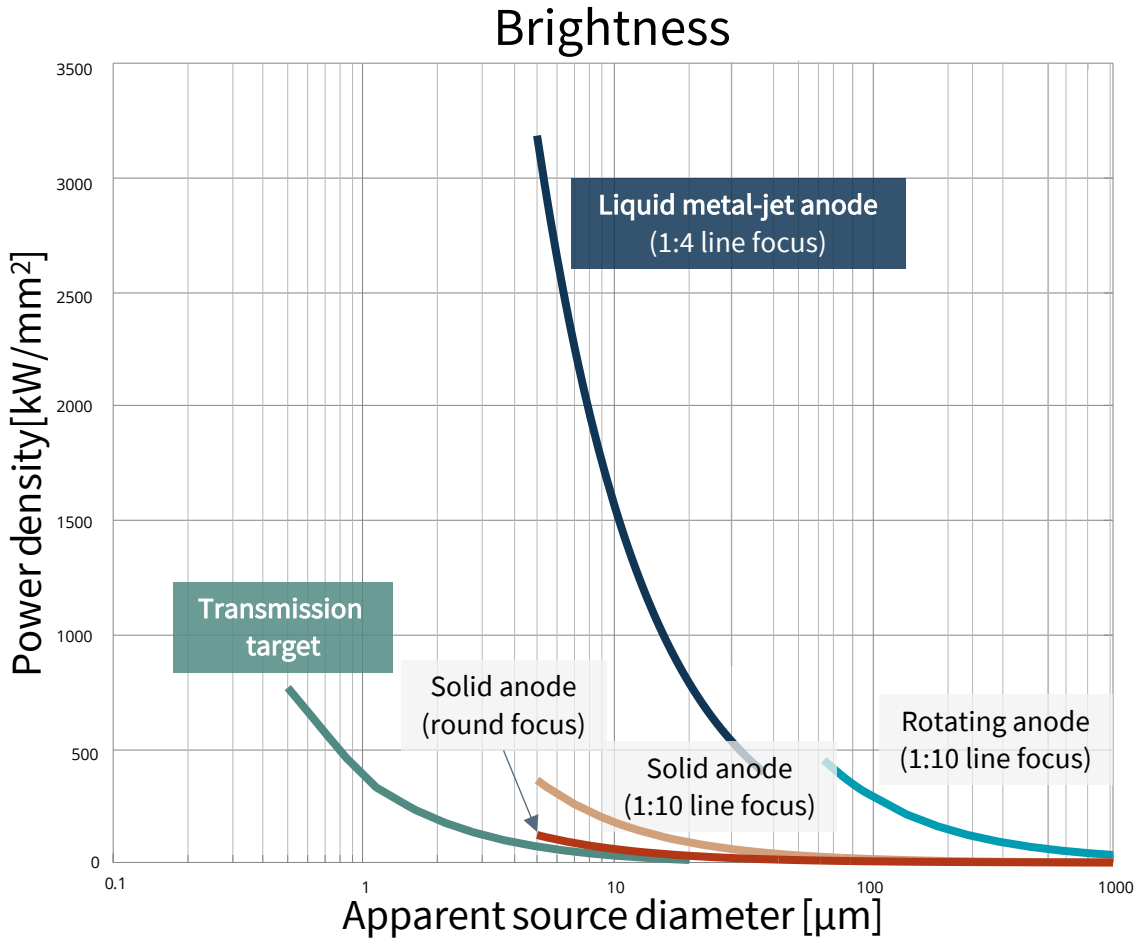
Liquid metal-jet anode technology



NanoTube

World's smallest X-ray nanospot

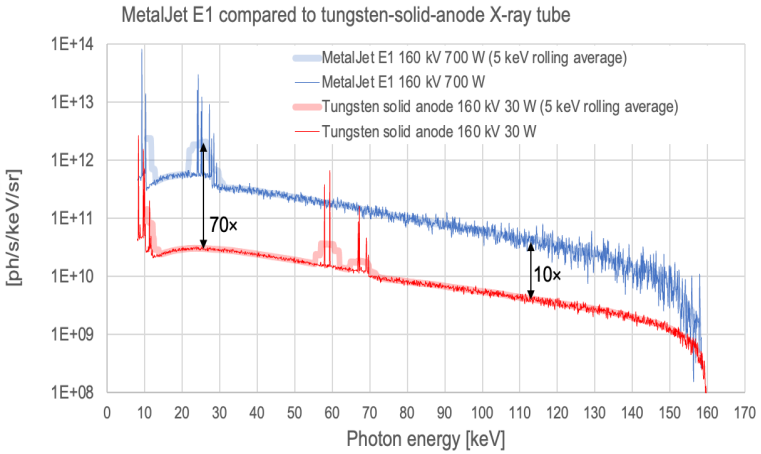
Advanced electron beam technology

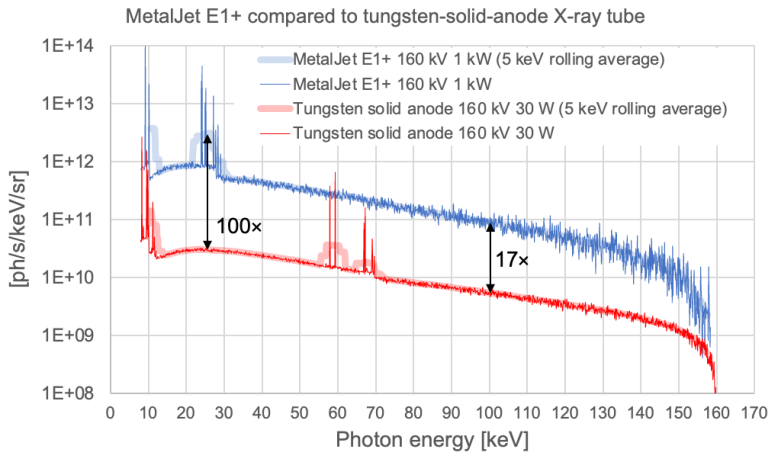


Requirements for high-speed CT

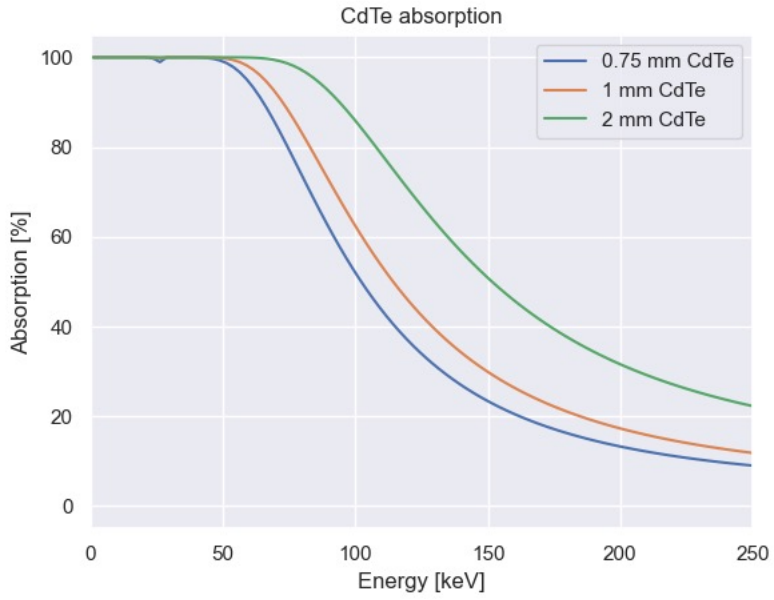
- A bright source!

MetalJet
E1+ 160 kV



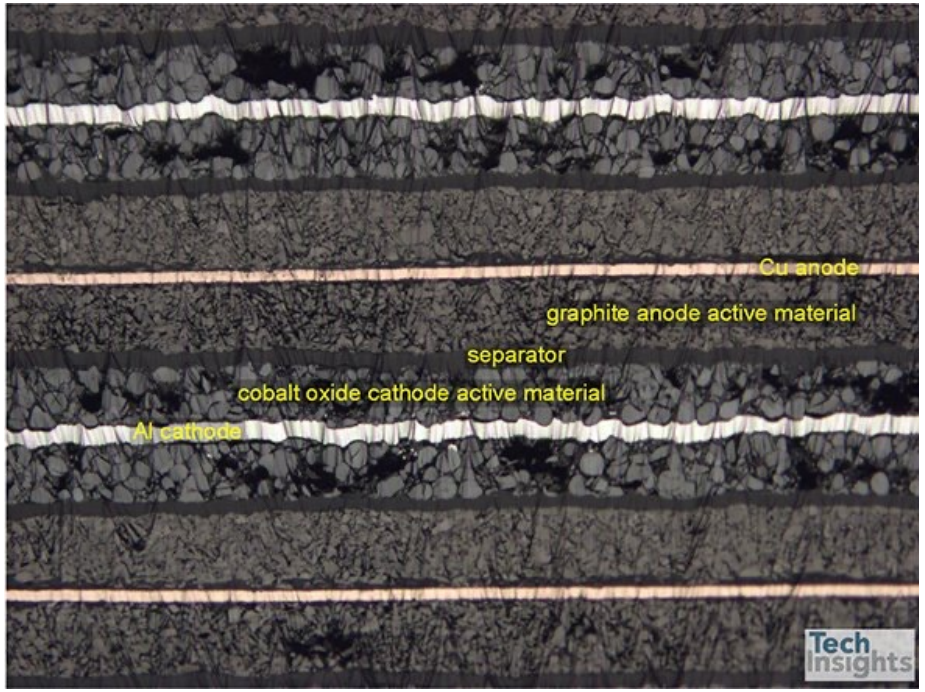


- A fast and efficient detector!
  - >1000 fps
  - Low noise, efficient detection

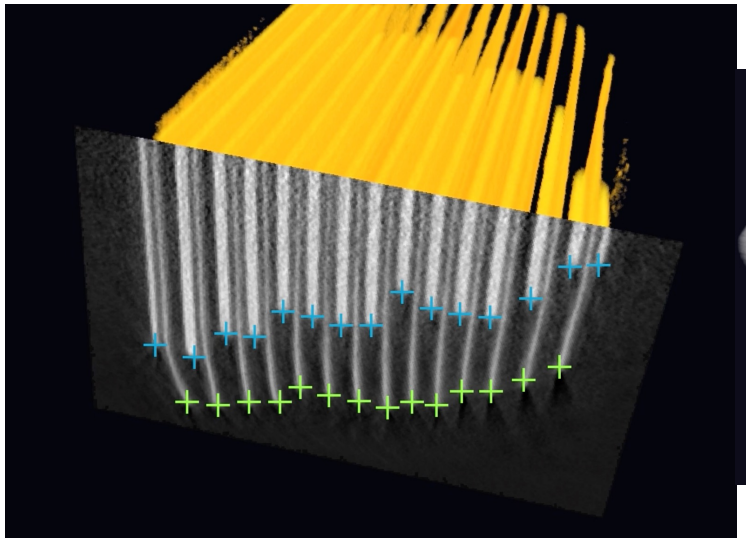


Battery inspection

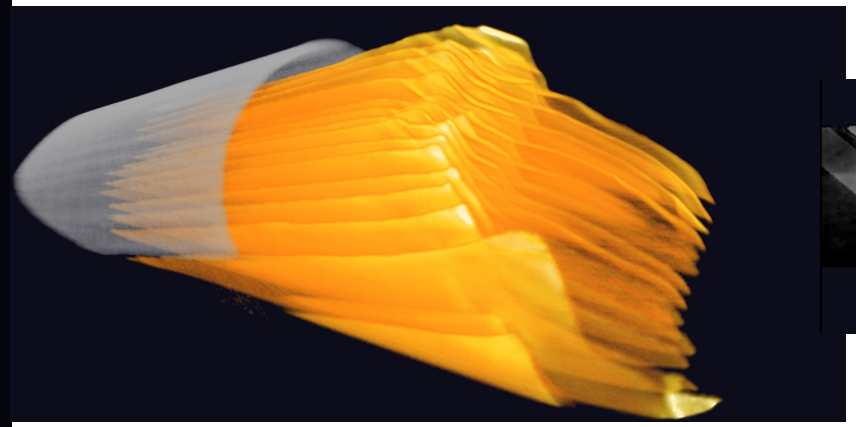
- High-speed scans for inline inspection
  - Scan times of 1s or less
- Detection of
  - Anode/cathode overhang
  - Particle detection
  - Etc …



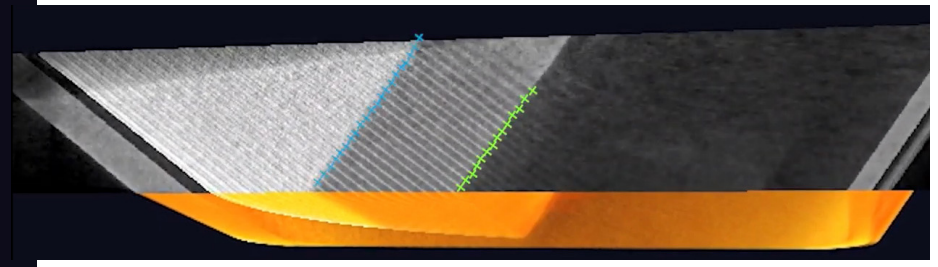
Microscopy image of anode/cathode layers inside a battery.
Image copyright – Tech Insights: https://www.techinsights.com



3D render of the edge of a phone battery with a reconstructed slice and anode/cathode overhang marked



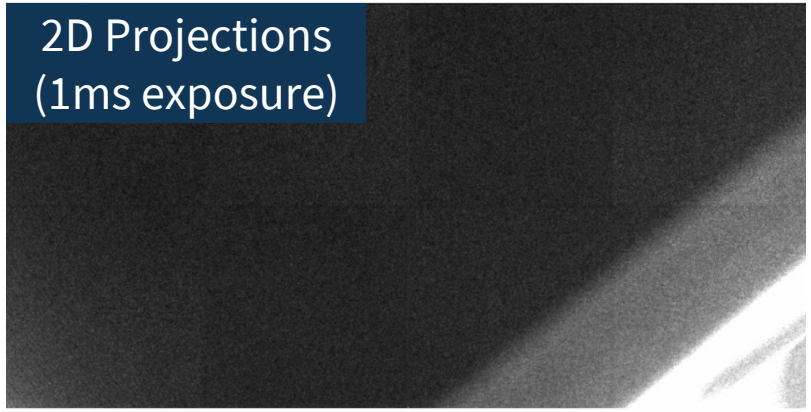
3D render of the edge of a phone battery scanned in 1s.

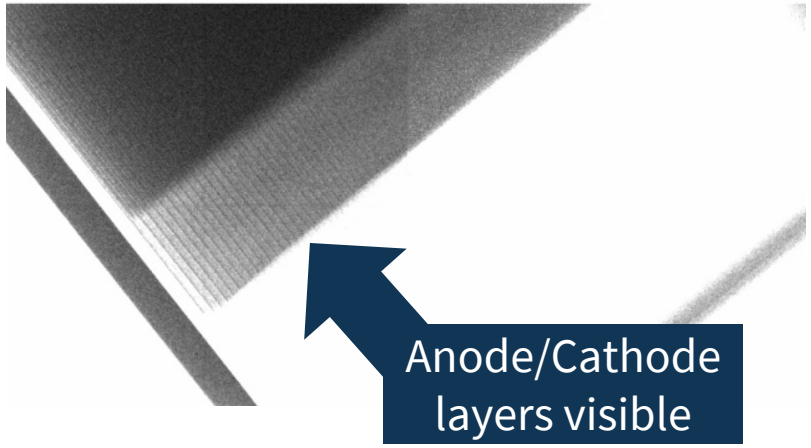


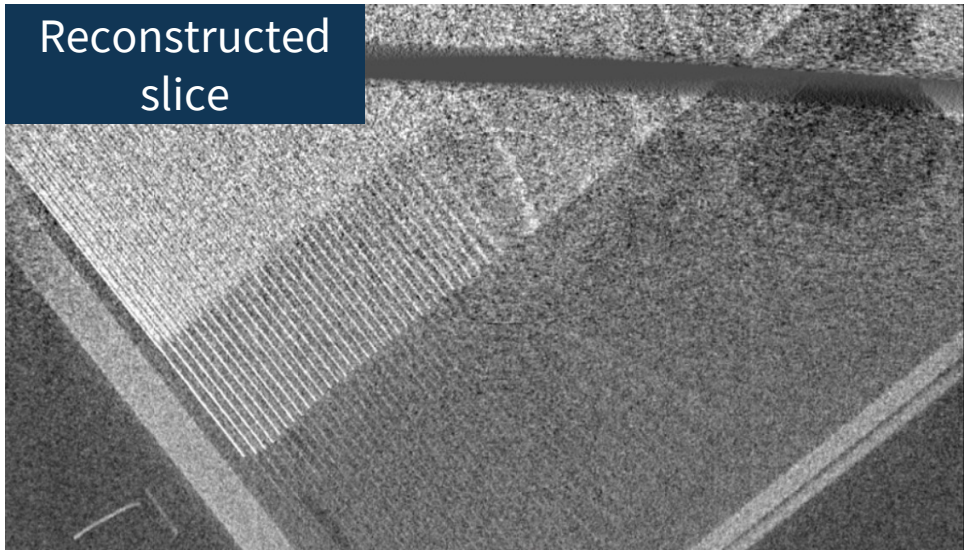
3D render of the edge of a prismatic EV battery scanned in 1s.

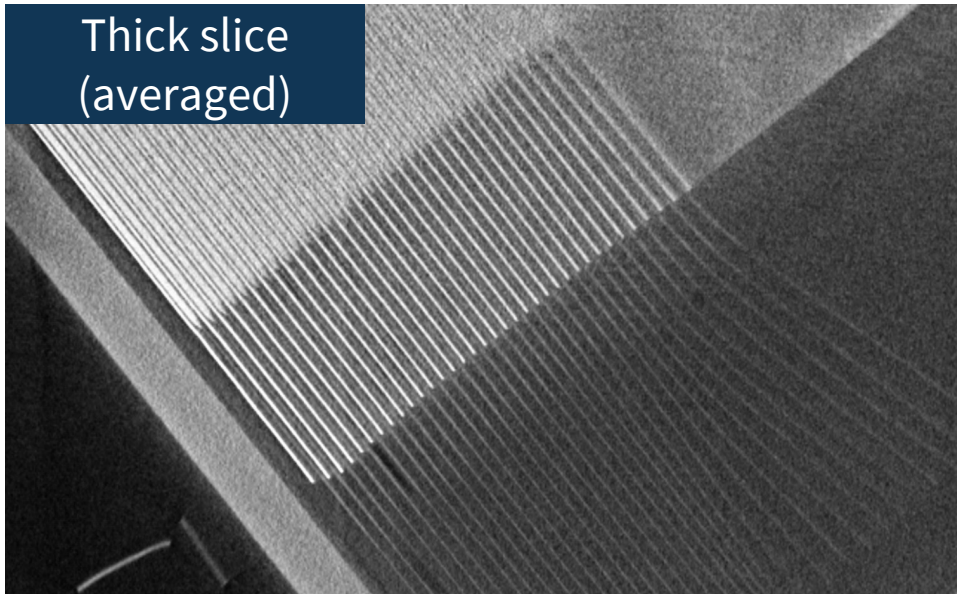
Prismatic battery cells

- 1s CT scan:
  - 1000 projections
  - 1 ms exposure
- Source: MetalJet E1+
  - 160 kV
  - 30 µm spot size
  - 700 W emission power





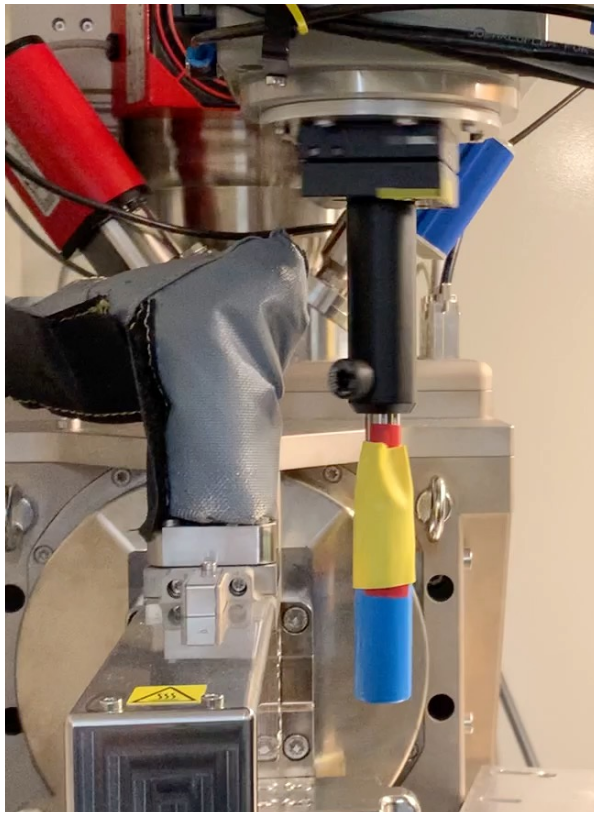




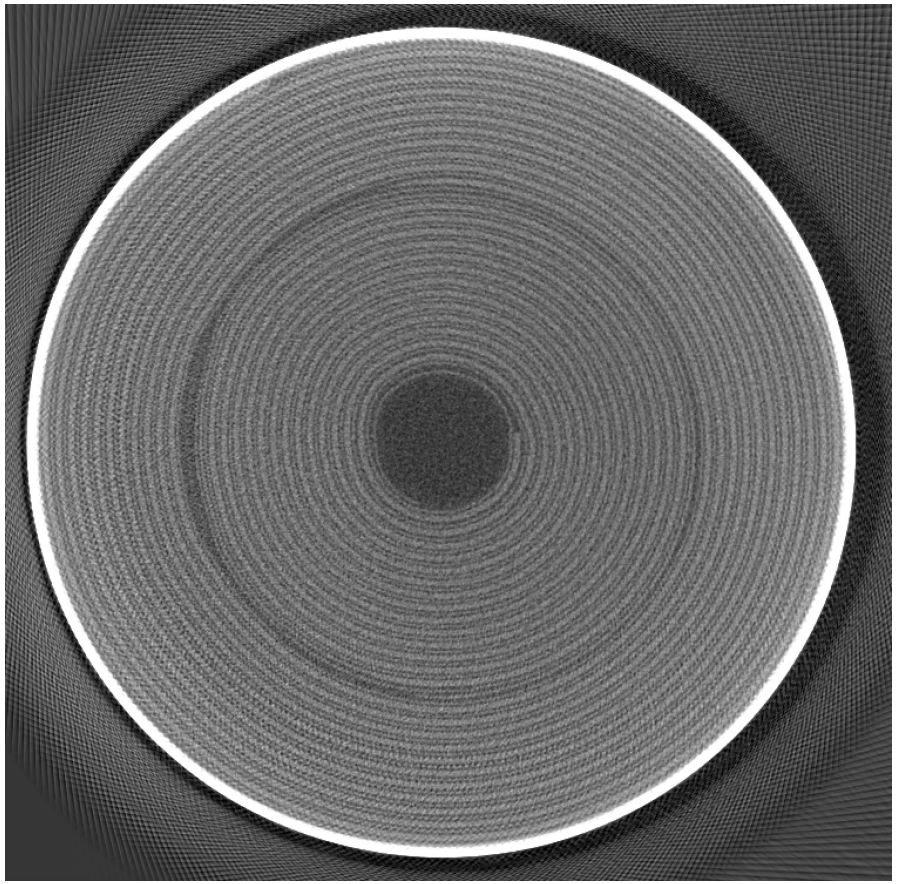
Data acquired with a Dectris Eiger 1M

21700 battery cells

- Spinning the battery at 1080 deg/s
  - *Limit of the stage*
- Acquisition at 1000 fps
- Reconstructed from 200 frames with 2x binning and median filtering
- 30 um voxel size

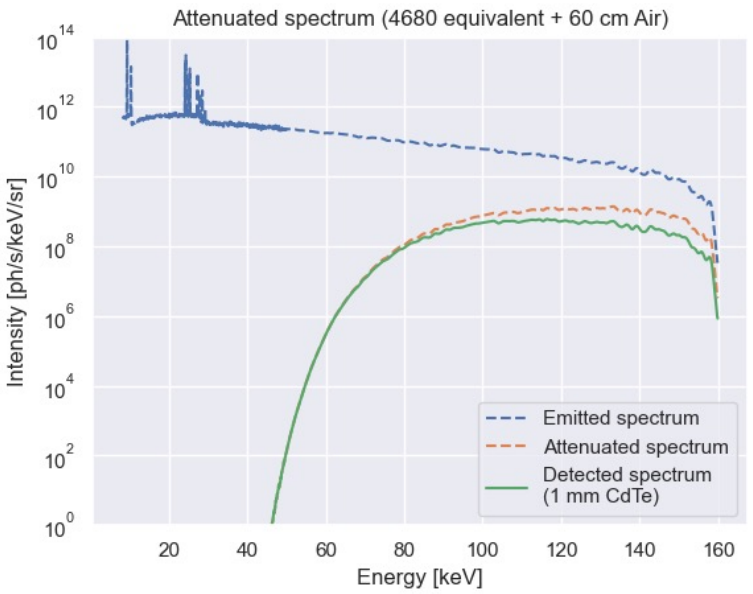


A 21700 cell spinning at 1080 deg/s.

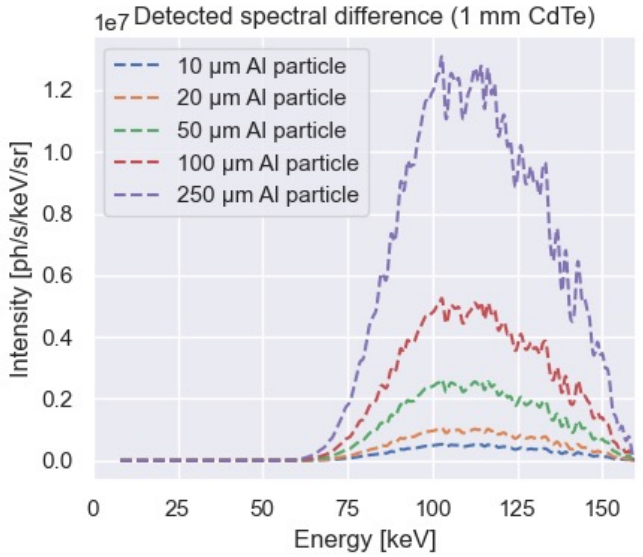


Reconstructed slice of a 200 ms CT scan.

4680 battery cells



Detecting Aluminium particles



Contrast differences (attenuated vs attenuated + particle, excl. detector):

'10um': 0.021 %
'20um': 0.042 %
'50um': 0.106 %
'100um': 0.212 %
'250um': 0.530 %

- Model of the cell:

82 cathode layers:
85 µm active layer -> 80% Ni + 10 % Co + 10 % Mn
10 µm core -> Al
-> Total: 5780 µm Ni + 697 µm Co + 697 µm Mn + 820 µm Al

82 anode layers:
assuming same thickness -> Si + Graphite (~90%)
10 µm core -> Cu
-> Total: 6274 µm C + 697 µm Si + 820 µm Cu

Housing:
500 - 600 µm Steel
-> Total: 1000 µm Fe

Other:
Assuming some Li
-> Total: 500 µm Li

Battery image from: https://www.notebookcheck.net/Samsung-developing-higher-capacity-4680-style-batteries-than-the-ones-it-prepares-for-Tesla.634548.0.html

Assumptions based on:
https://insideevs.com/news/598656/tesla-4680-battery-cell-specs/#:~:text=4680%2Dtype%20cylindrical%20lithium%2Dion,silicon)%2C%20dry%20battery%20electrode%20technology
https://researchinterfaces.com/know-next-generation-nmc-811-cathode/
https://eepower.com/new-industry-products/teslas-4680-a-cobalt-free-silicon-battery-solution/#

Detector wishlist

- Size
  - 512 x 2048 or larger
  - Industry wants 2k x 2k or larger
- Frame rate
  - > 1000 fps
  - Stable fps
- Energy efficiency
  - High efficiency up to ~240 keV
  - Charge sharing correction
  - Stable CdTe
- Price
- No gaps
  - No or minimal gaps between modules
  - Not more than 4 – 8 pixels
- Thresholds
  - As many energy thresholds as possible

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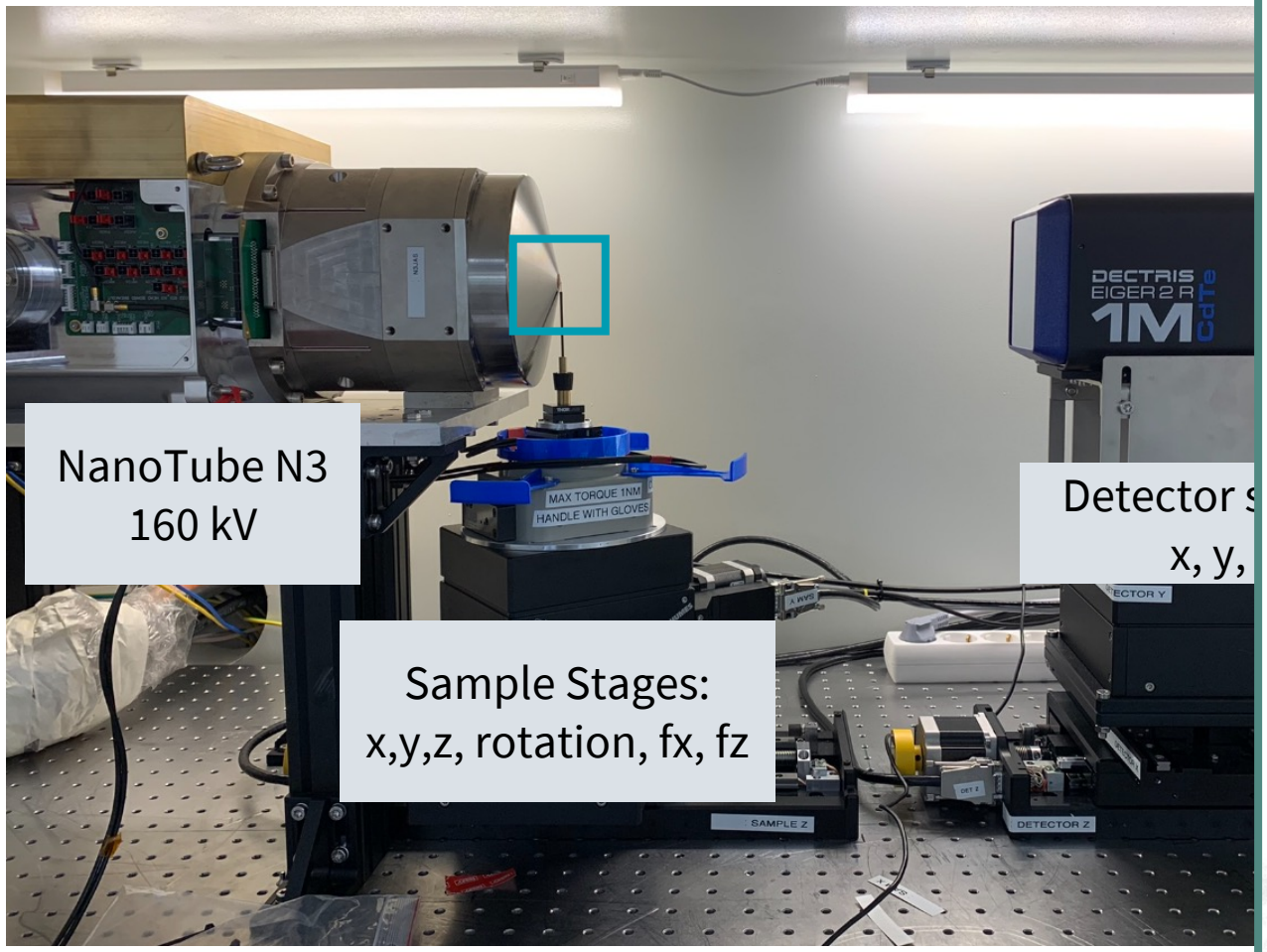
Nano-tomography

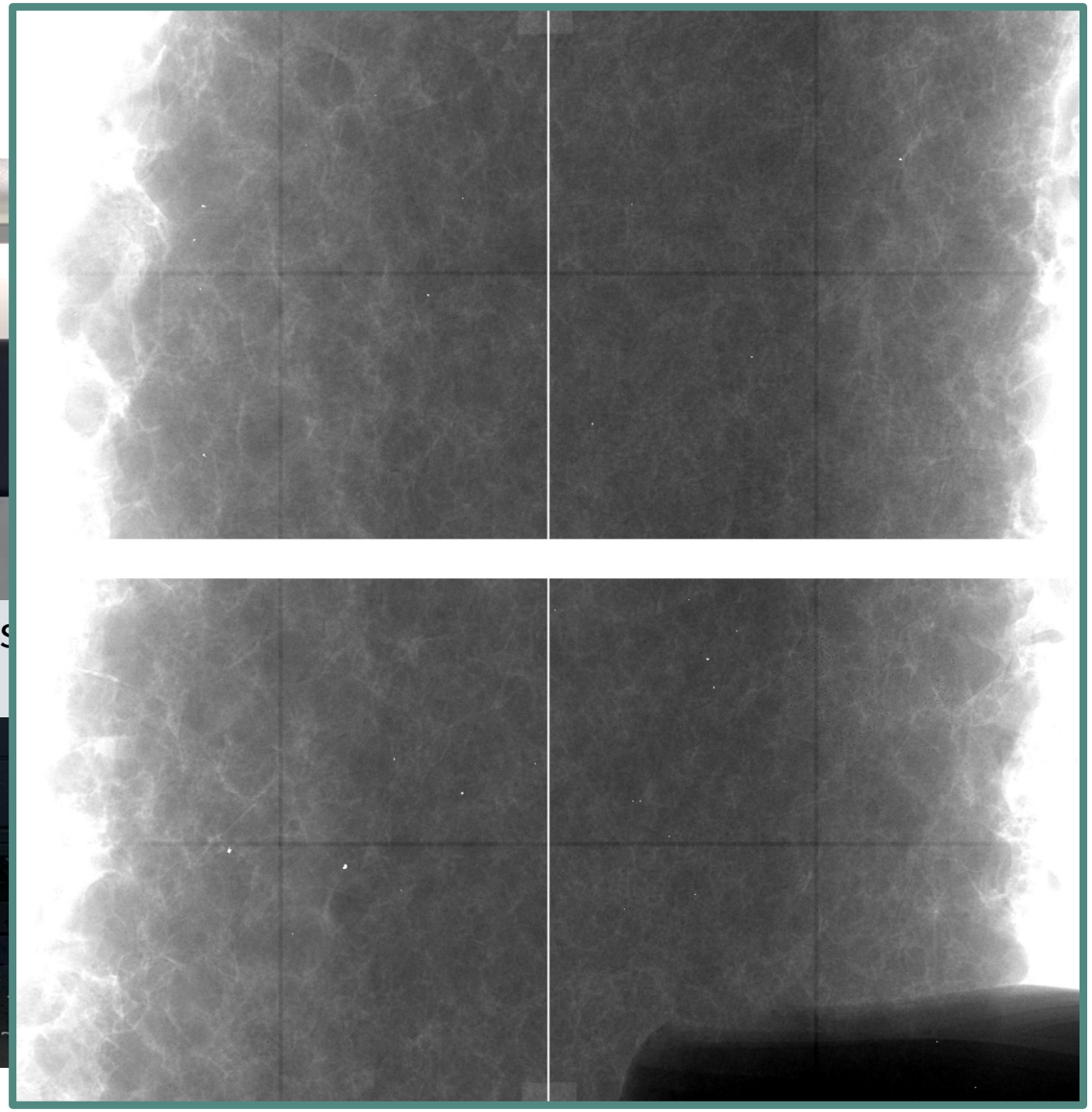
Battery cathode nano-CT



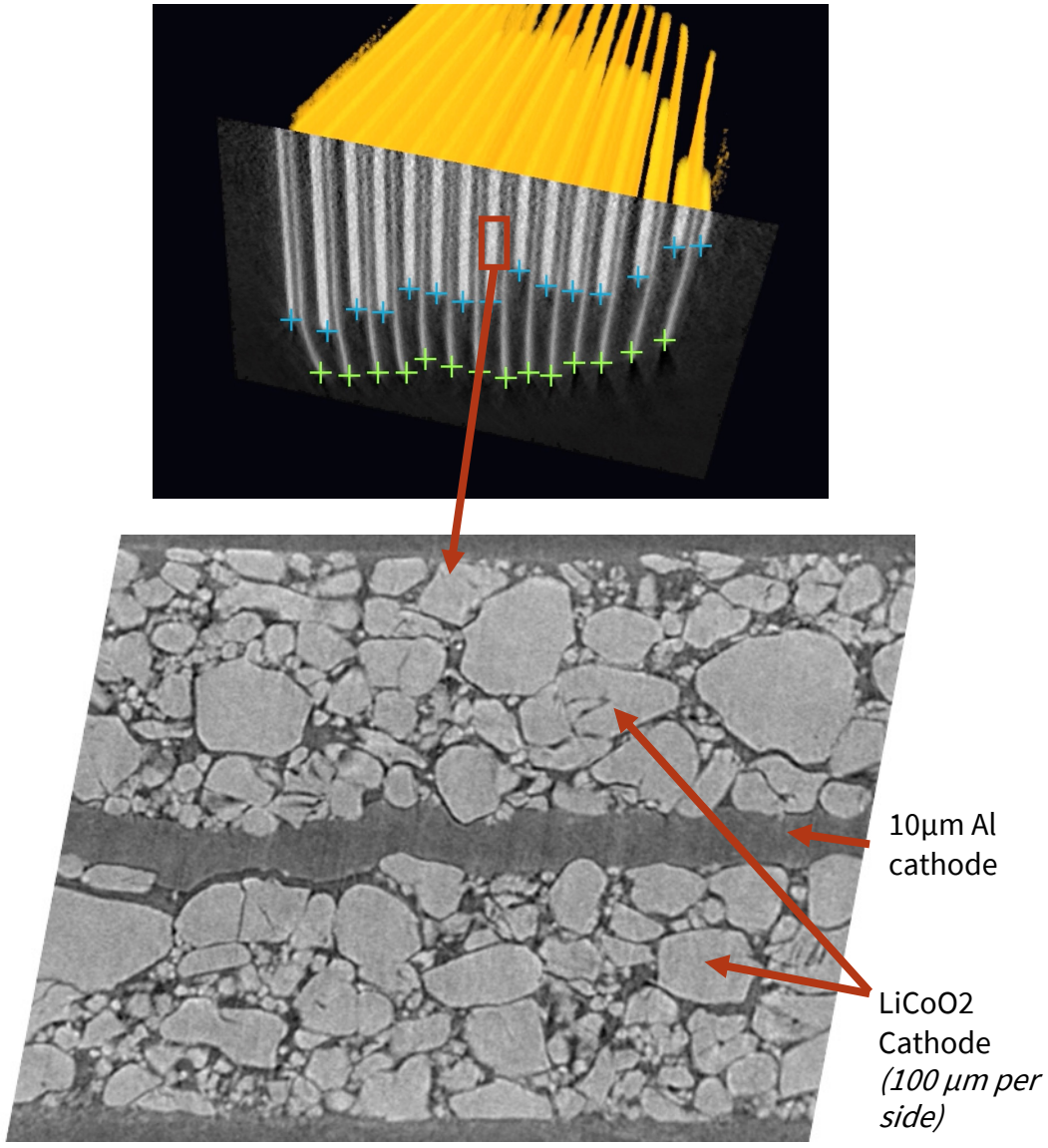
NanoTube N3
160 kV

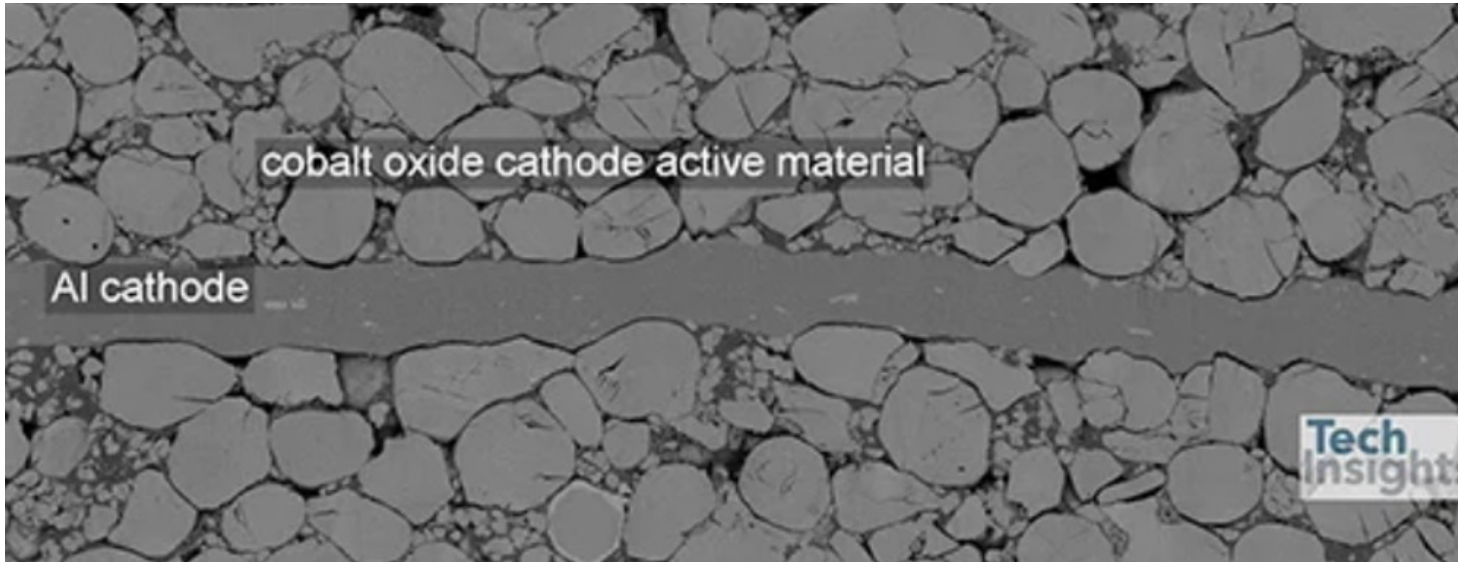
Detector s
x, y,

Sample Stages:
x,y,z, rotation, fx, fz



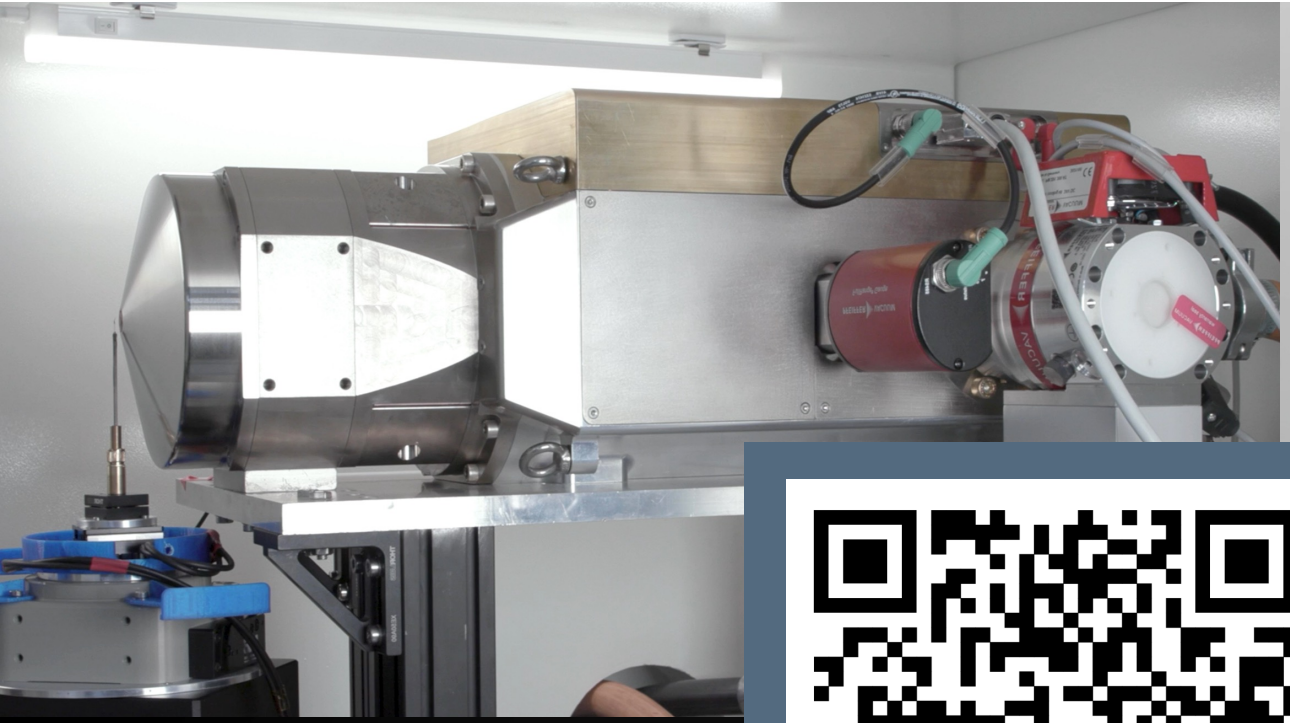
Battery cathode nano-CT



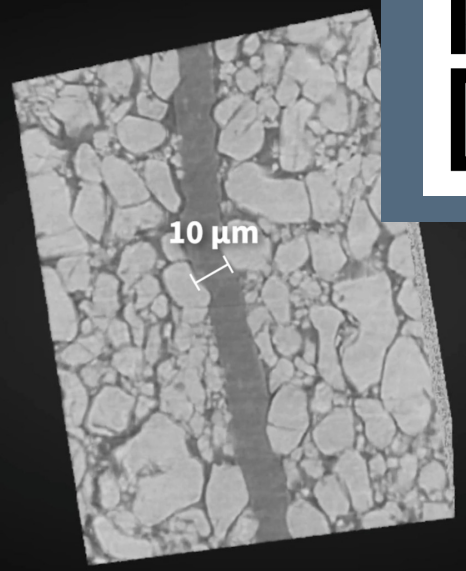


Electron-Microscopy image of an Aluminium cathode with 2 active layers.
Image copyright – Tech Insights: https://www.techinsights.com

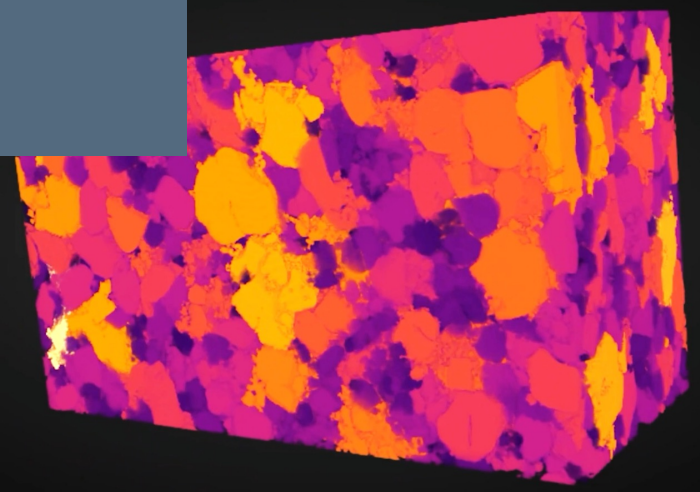
- 80 kV, 500 nm spot size, 1.8 W on target
- 5 seconds x 6000 projections = 8.33 hours scan time
- Source-Sample ~= 1.6 mm.
- Source-Detector = 341 mm
- M = 213
- Effective pixel size = 350 nm



Video available at: https://youtu.be/9wm0dGVY_eM



Enabling sub-µm analysis
Grain diameter



Thank you for your attention!

till.dreier@excillum.com

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