BATTERY QUALITY CONTROL VIA HIGH-THROUGHPUT CT SCANNING

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2024 NASA Aerospace Battery Workshop

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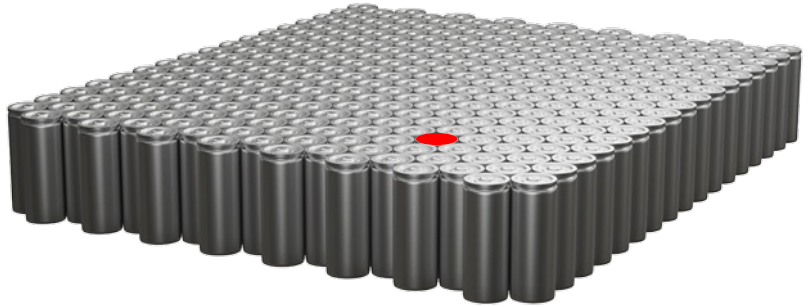
THREE PROBLEMS FACING THE INDUSTRY

SAFETY

RELIABILITY

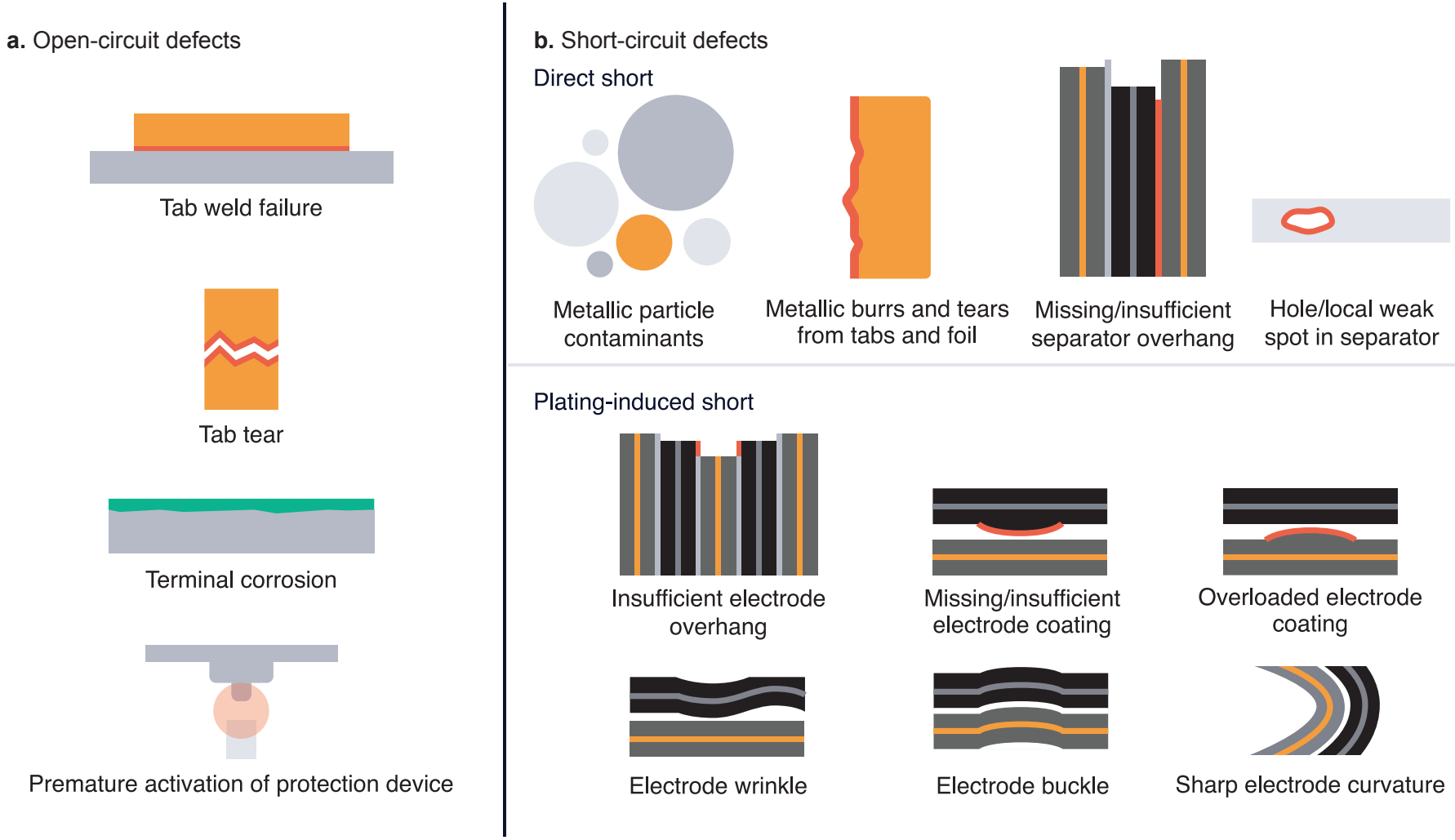


MANUFACTURABILITY

All three problems are closely related to **battery quality**

Attia et al. (2024). *arXiv* 10.48550/arXiv.2403.01065

CELL-LEVEL DEFECTS

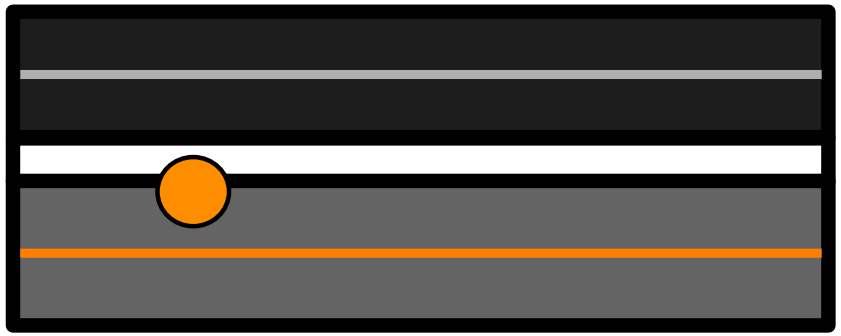


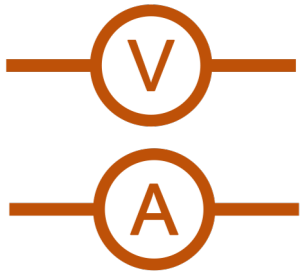
Subtle structural defects can cause reliability and safety issues

Attia et al. (2024). *arXiv* 10.48550/arXiv.2403.01065

LATENT DEFECTS

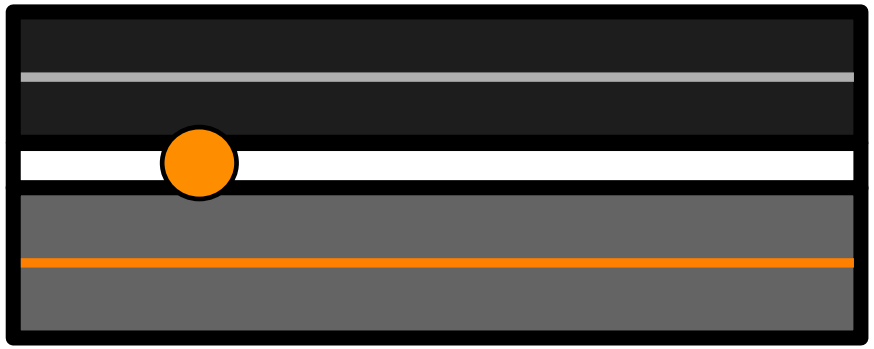
Metallic particle present, but not yet connecting anode and cathode

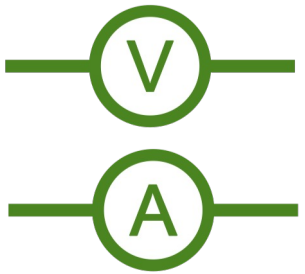




❌ No electrochemical signal

Metallic particle present and connecting anode and cathode





✅ Electrochemical signal

Latent defects have no electrochemical signal until failure

Attia et al. (2024). *arXiv* 10.48550/arXiv.2403.01065

INSPECTION TECHNIQUES

	Non-destructive	Scalable to ≤10s/cell	Full cell inspection	Spatially resolved	Resolution of ≤50 μm
Cycling & Storage	❌	❌	✅	❌	
Ultra High Precision Coulometry (UHPC)	❌	❌	✅	❌	
Electrochemical Impedance Spectroscopy (EIS)	✅	❌	✅	❌	
OCV decay during formation	✅	❌	✅	❌	
High Potential testing (HiPot)	✅	✅	✅	❌	
Dissection	❌	❌	✅	✅	✅
Cross section	❌	❌	❌	✅	✅
In-line vision	✅	✅	❌	✅	✅
Acoustics	✅	✅	✅	✅	❌
2D X-ray imaging	✅	✅	❌	✅	✅
3D X-ray imaging (CT scanning)	✅		✅	✅	✅

Attia et al. (2024). *arXiv* 10.48550/arXiv.2403.01065

GLIMPSE: IMPROVING SCAN TIME

Optimized hardware
(X-ray source, detector, fixturing…)

+

Optimized scan recipe
(source, detector, positions…)

+

Image enhancement
(corrections, denoising, …)

Nikon scanner

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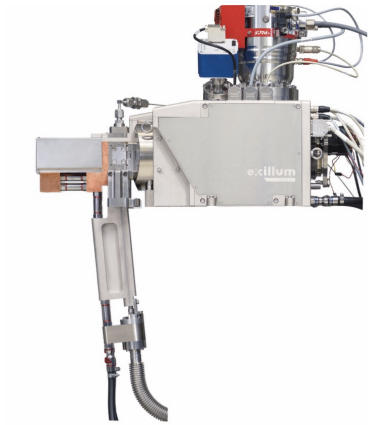
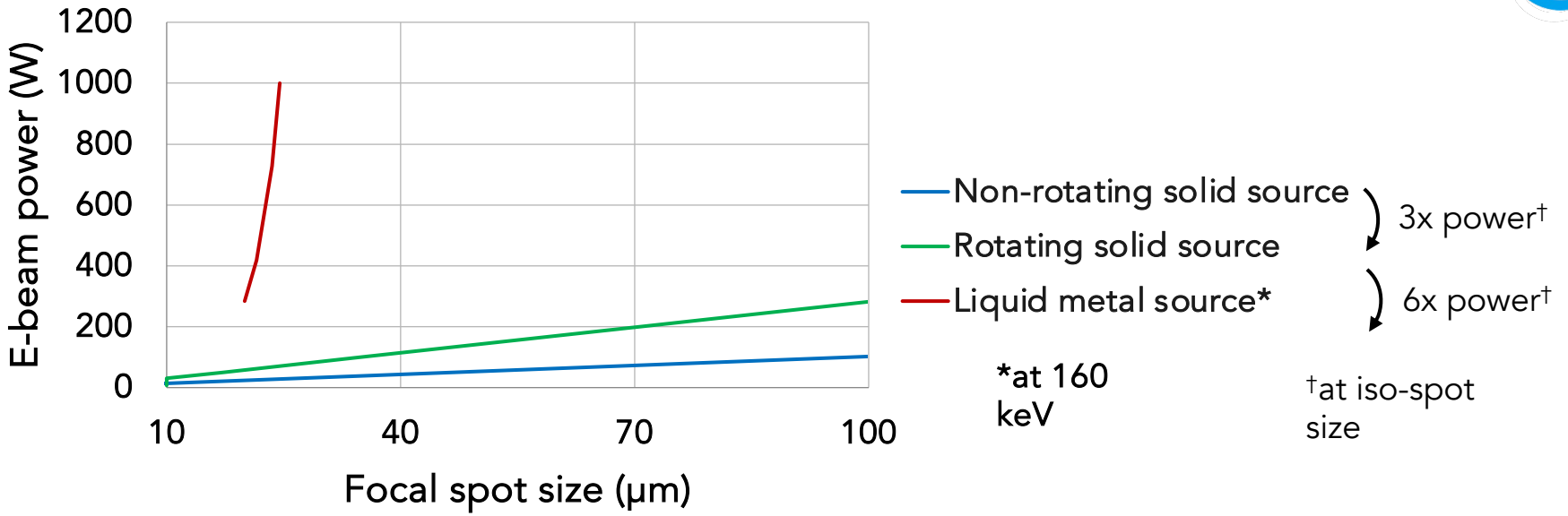
Glimpse's standard cylindrical cell scans take **2 minutes**

FASTER SCANS VIA THE "SUPERSCANNER"



Excillum MetalJet X-ray source



VisiConsult + Glimpse "superscanner"

≤10 seconds/scan with next-generation CT scanner (VCB2)

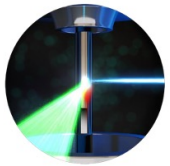
GLIMPSE: IMPROVING ANALYSIS TIME

Each scan of a 2170 battery is ~50 GB 🤯

10 sec/scan = 18 TB/hour. How do we extract insights from it?

Data Generation

X-ray source



CT Scanner

Data Processing

Computing hardware

Image Reconstruction

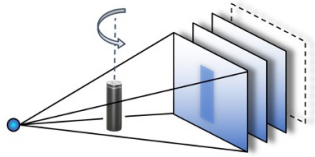
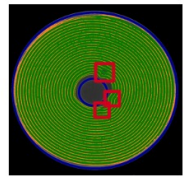


Image post-processing

Insight Extraction & Visualization

Automated Inspection



Battery Quality Monitoring Platform

GLIMPSE

The old way: Slow, local, expensive 🐢⏳

With Glimpse: Fast, automatic, collaborative 🐇⏱️

Fast scan time + fast analysis time = **fast "time to insights"**

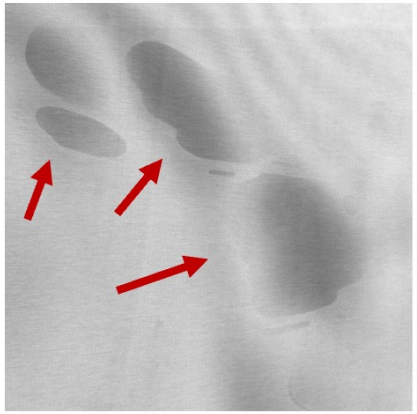
THE GLIMPSE PORTAL™: SINGLE SCAN VIEWER

Condon et al. (2024). *Data in Brief* 10.1016/j.dib.2024.110614

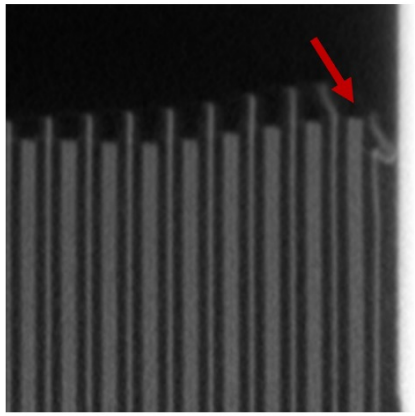
THE GLIMPSE PORTAL™: AUTOMATED INSPECTION DASHBOARDS

Condon et al. (2024). *Data in Brief* 10.1016/j.dib.2024.110614

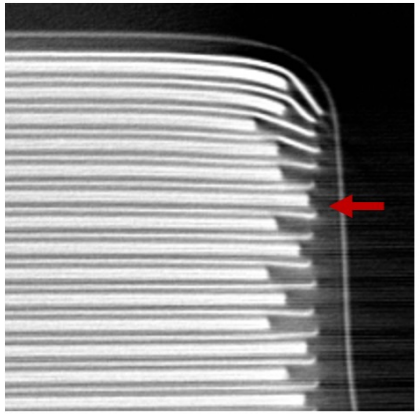
SOME CT-DETECTABLE DEFECTS



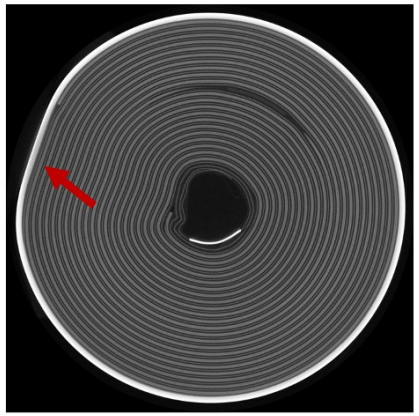
Gas bubbles



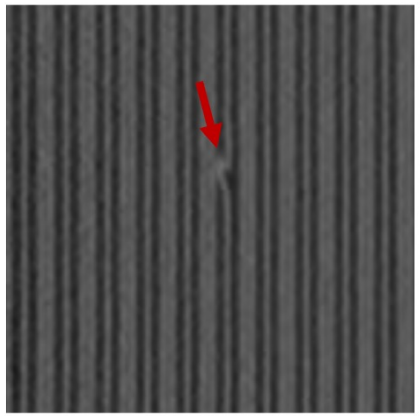
Folded anode tip



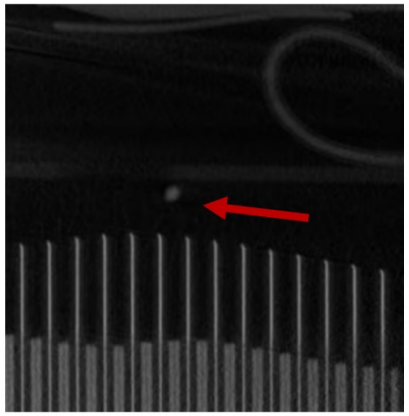
Electrode overhang violation



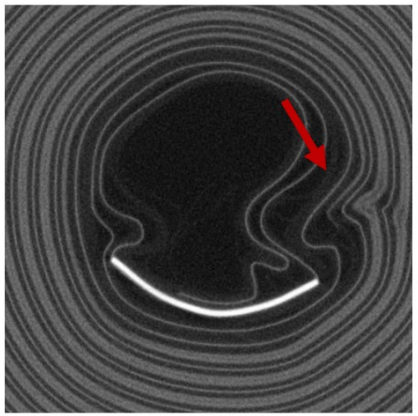
Dented can



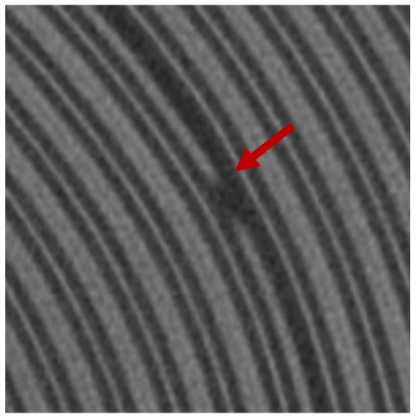
Wrinkled electrode



Metallic contaminant

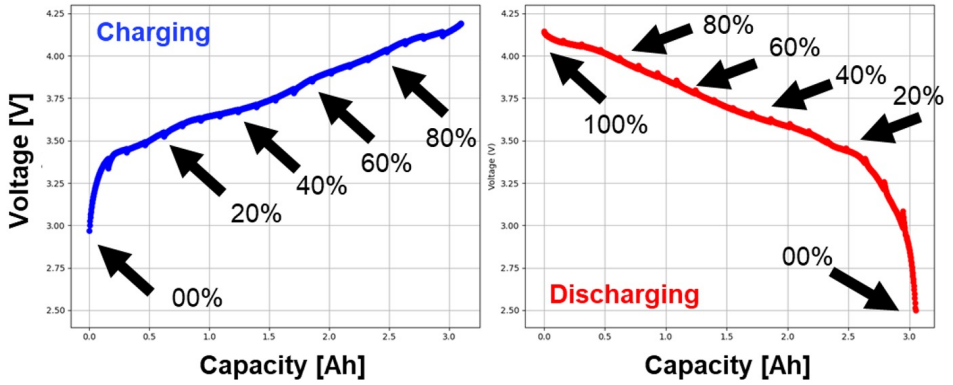


Buckled jellyroll

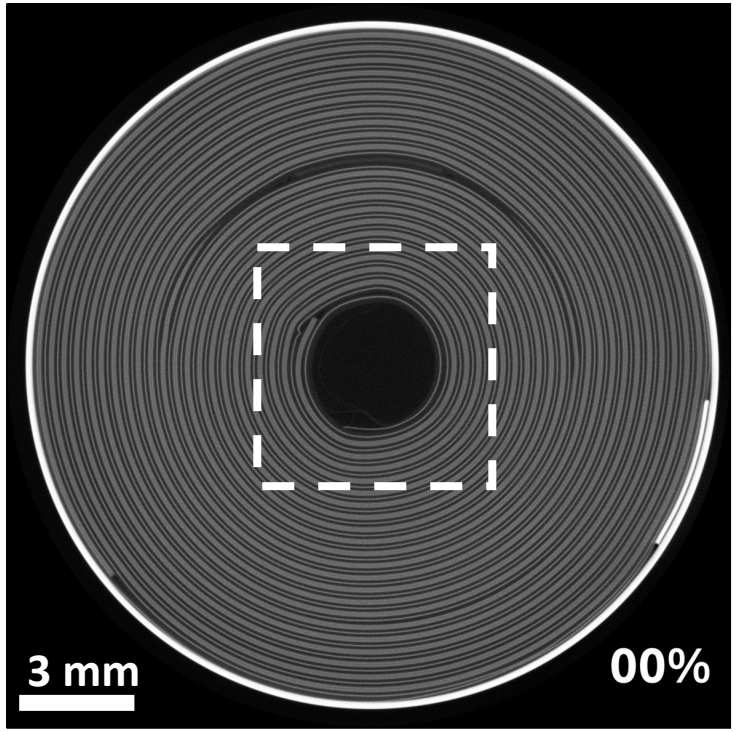


Missing electrode coating

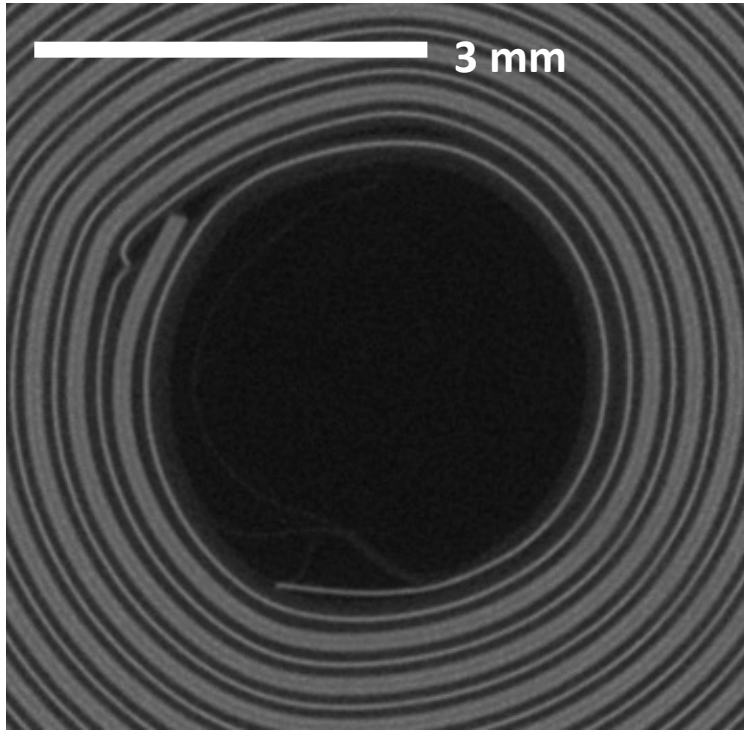
STUDYING BATTERY SWELLING AND AGING VIA CT



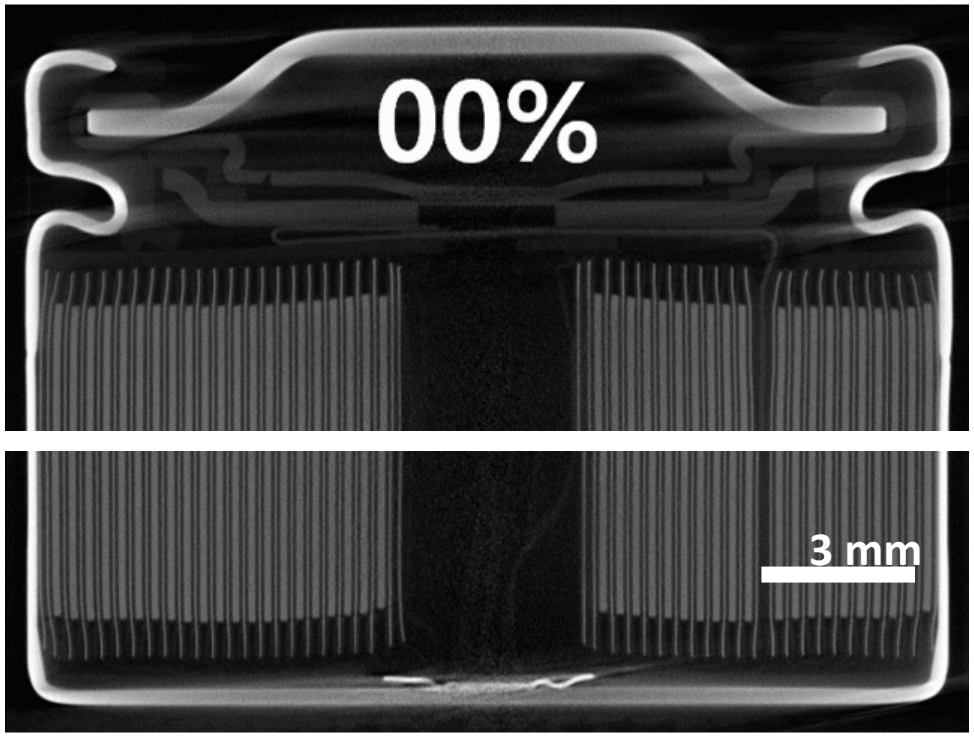
EVE 18650 LIB cell



Radial slice



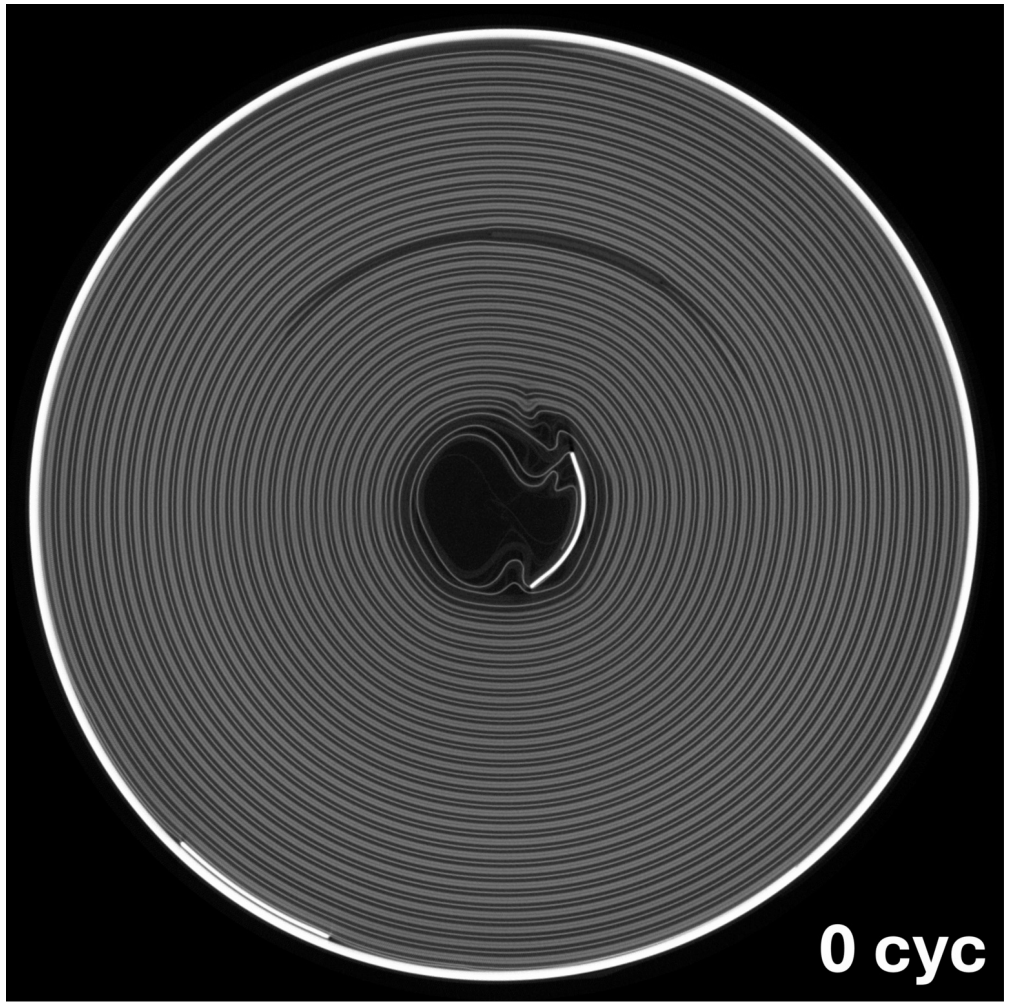
Magnified



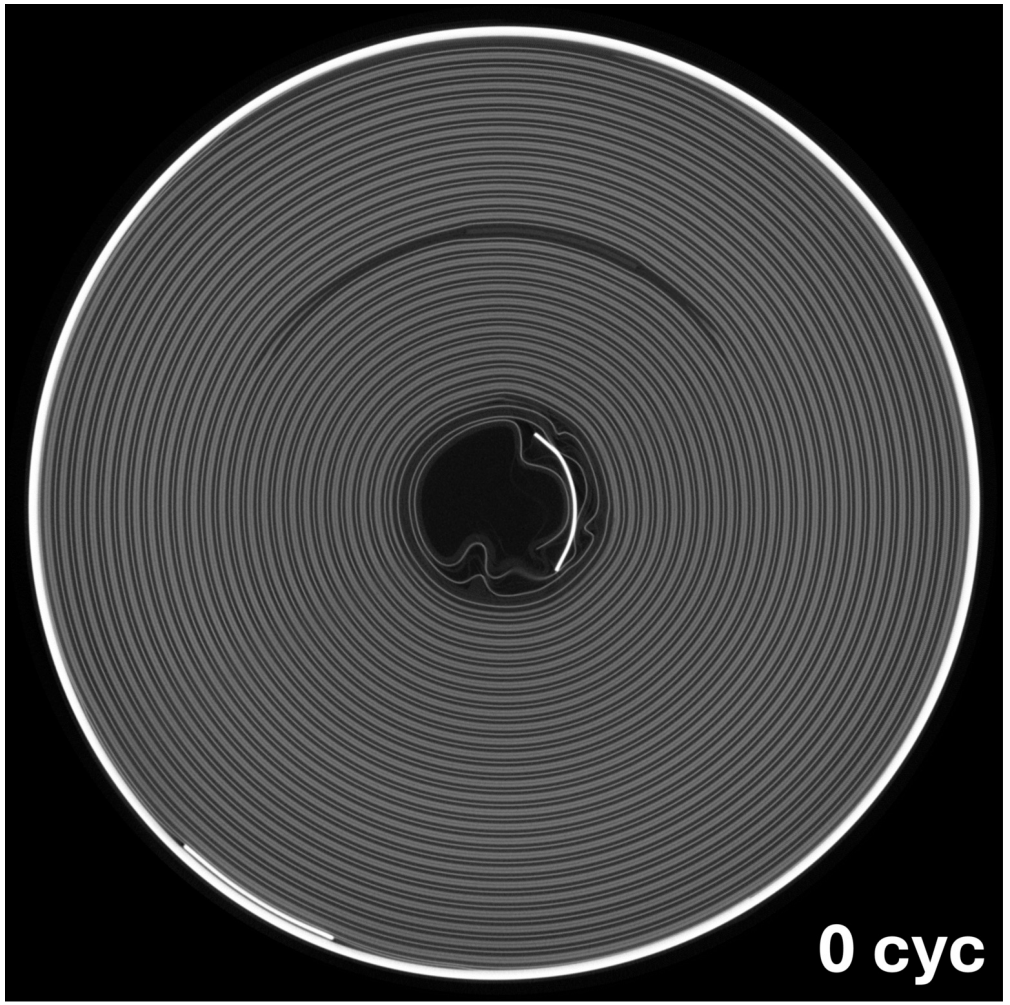
Axial slice

STUDYING BATTERY SWELLING AND AGING VIA CT

Buckling present at cycle 0

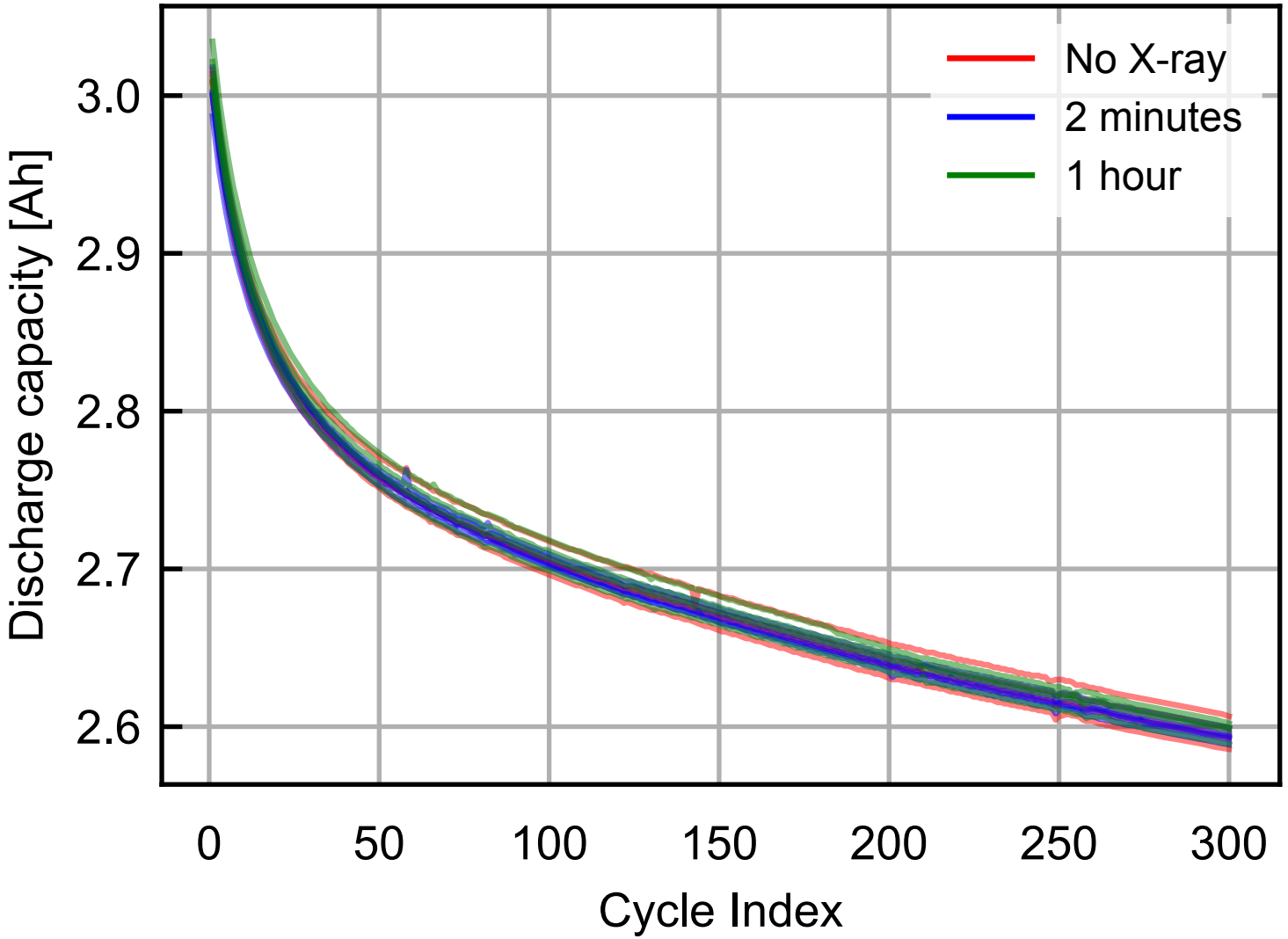


Buckling **not** present at cycle 0



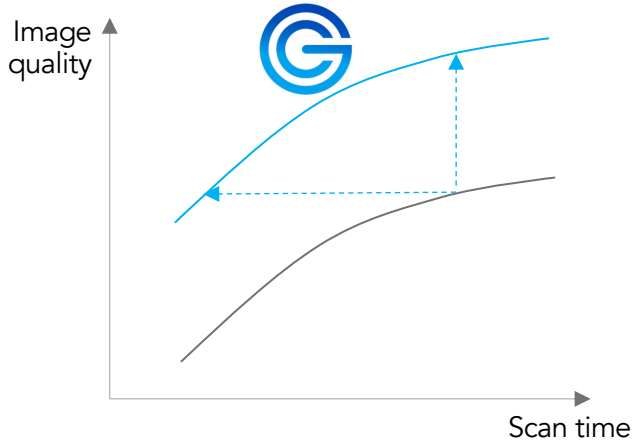
Vapcell F56 LIB cell

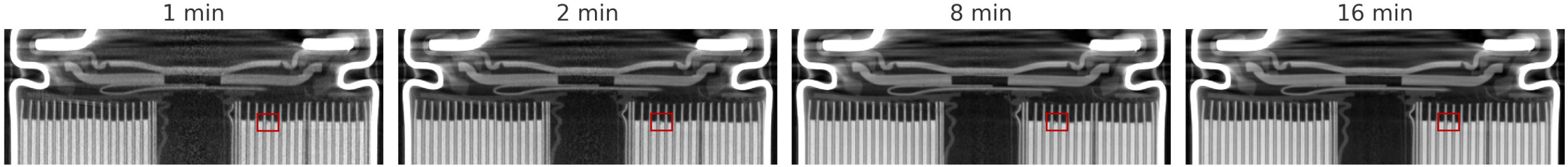
VALIDATION: X-RAY BEAM DAMAGE

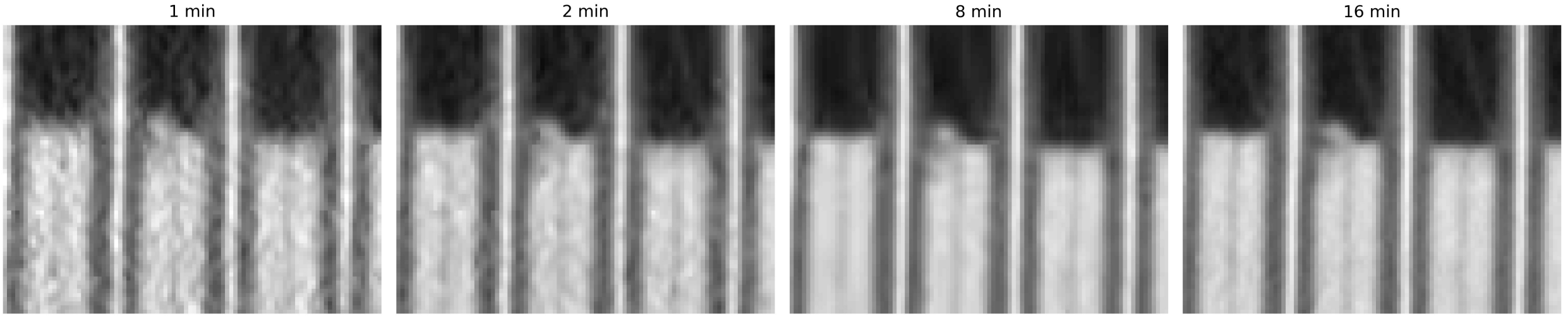


Min, Condon, Attia (2024). *ECSarXiv* 10.17605/OSF.IO/R9VEM

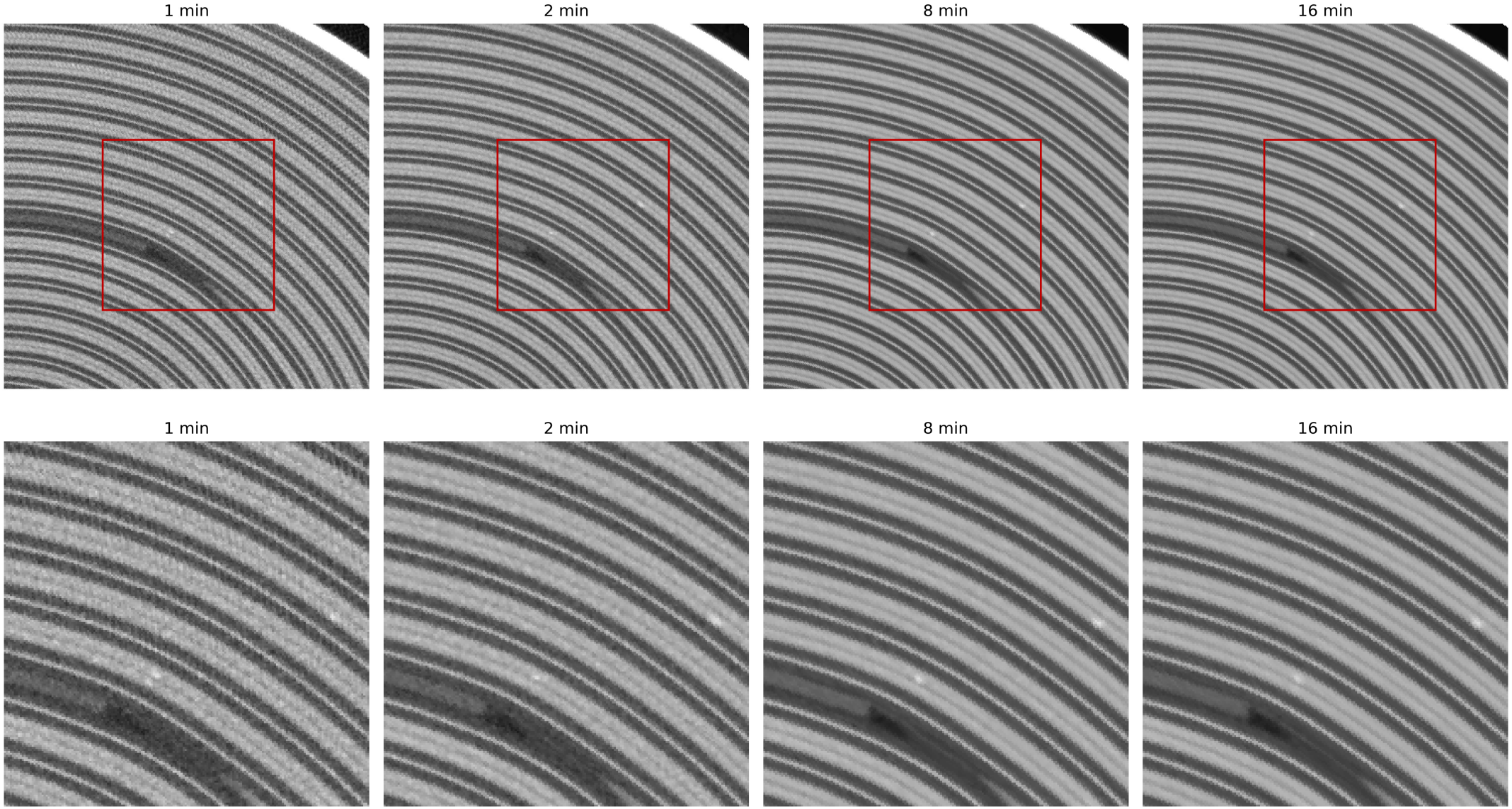
VALIDATION: SCAN TIME VS. IMAGE QUALITY



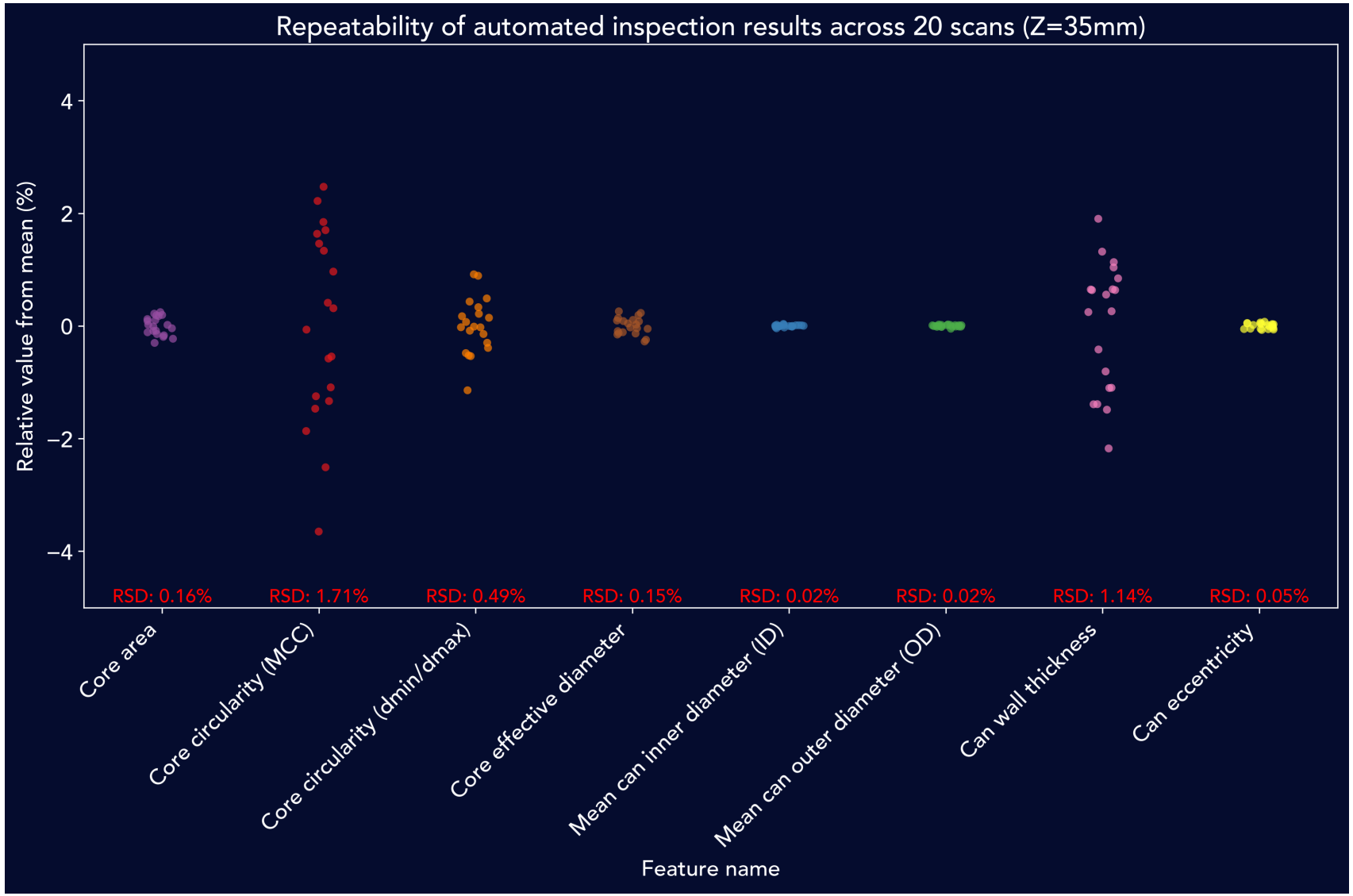




VALIDATION: SCAN TIME VS. IMAGE QUALITY



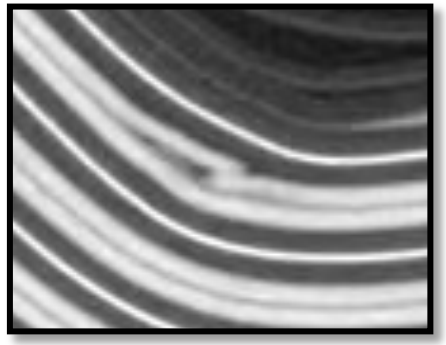
VALIDATION: ALGORITHM REPEATABILITY



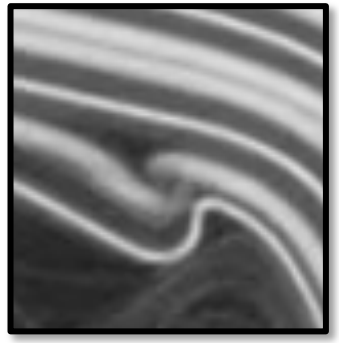
GLIMPSE'S WORK WITH NASA: SAMSUNG ICR18650-26F EVA SCAN REVIEW

Credit:
Douglas Zupan
Sean Murray
Martin Martinez
Sam Russell

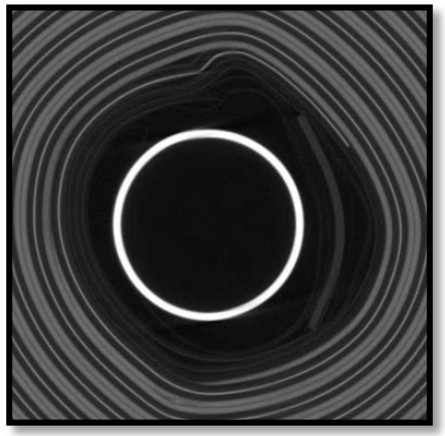
Pits in cell cap crimp area



Delamination/cracking of active material

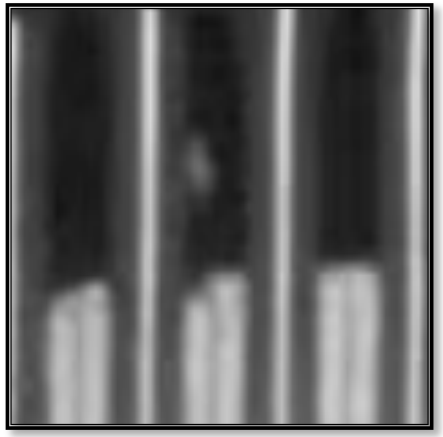


Delamination/cracking of active material



Poor core circularity

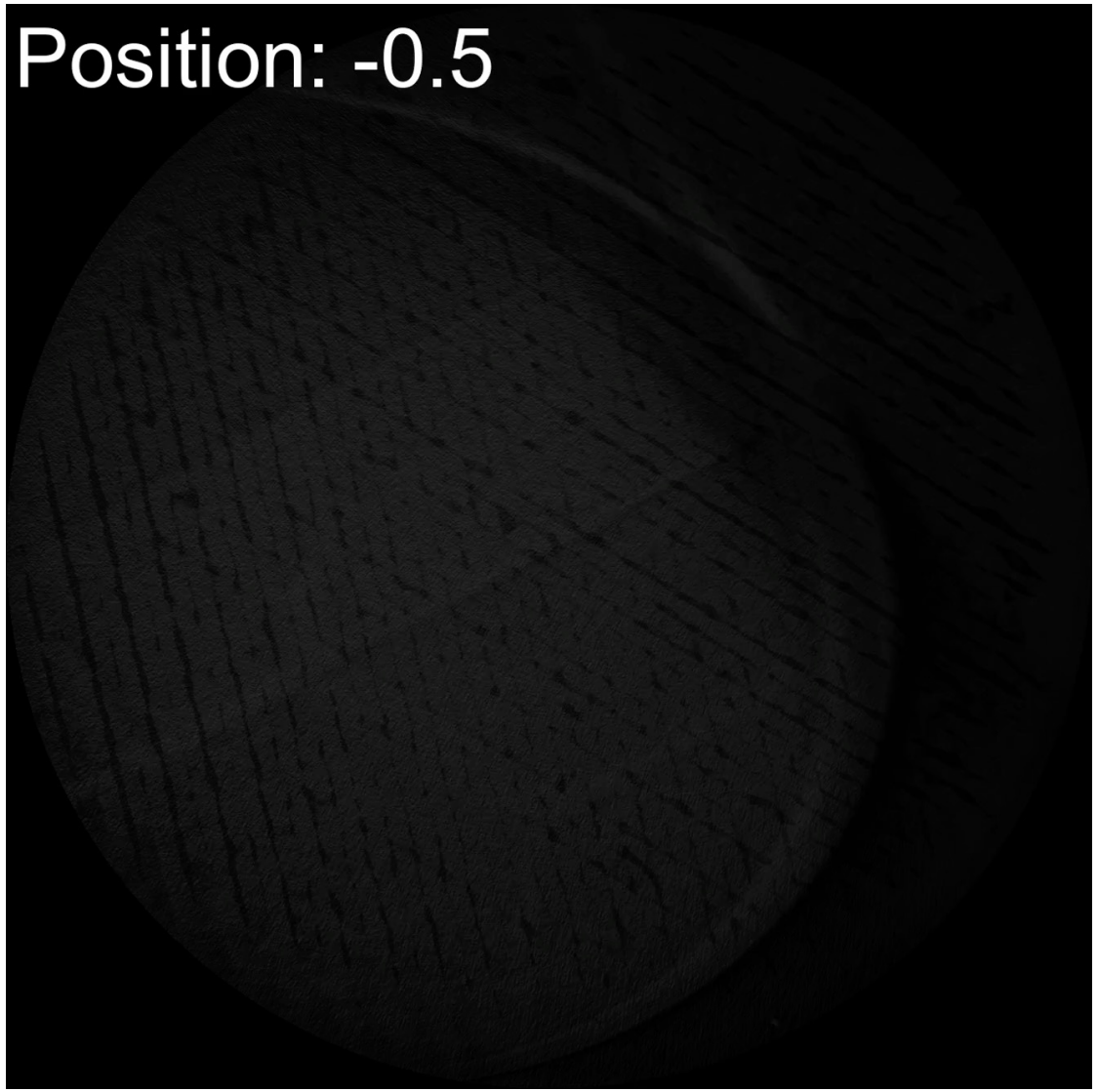
Delamination/cracking of active material

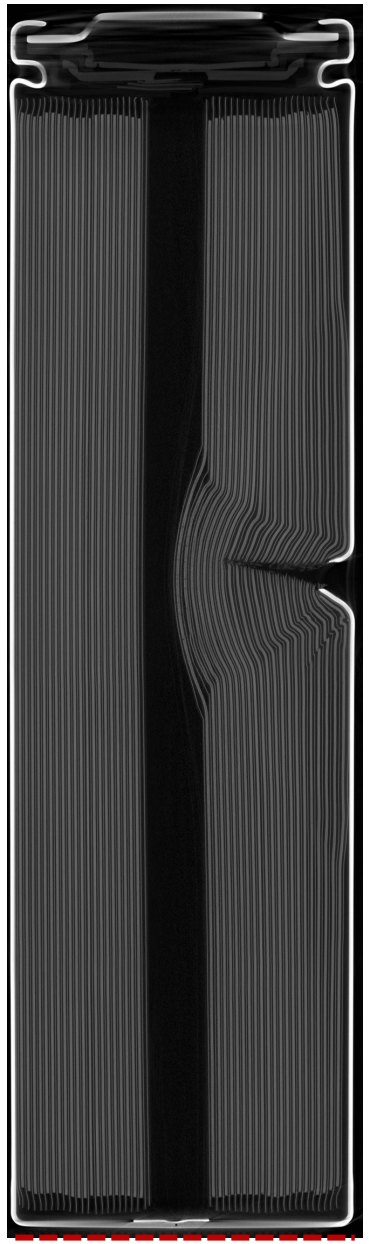


Liberated active material

Gap in active material

GLIMPSE'S WORK WITH NASA: NAIL PENETRATION CELL





Credit:
Eric Darcy
David Petrushenko
Jesus Trillo

GLIMPSE'S WORK WITH NASA: INVESTIGATING NEW CELL DESIGNS

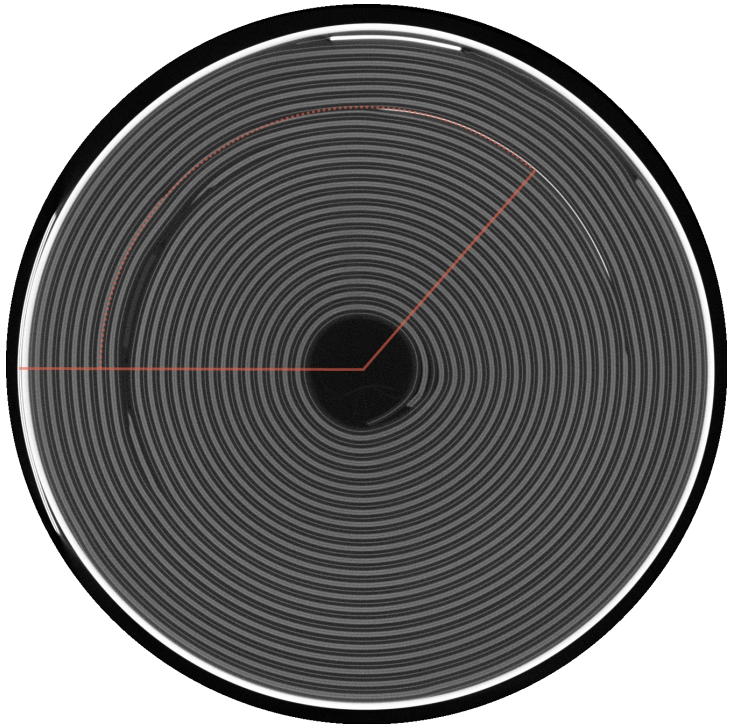
Credit:
Eric Darcy
David Petrushenko
Jesus Trillo

LG M52V

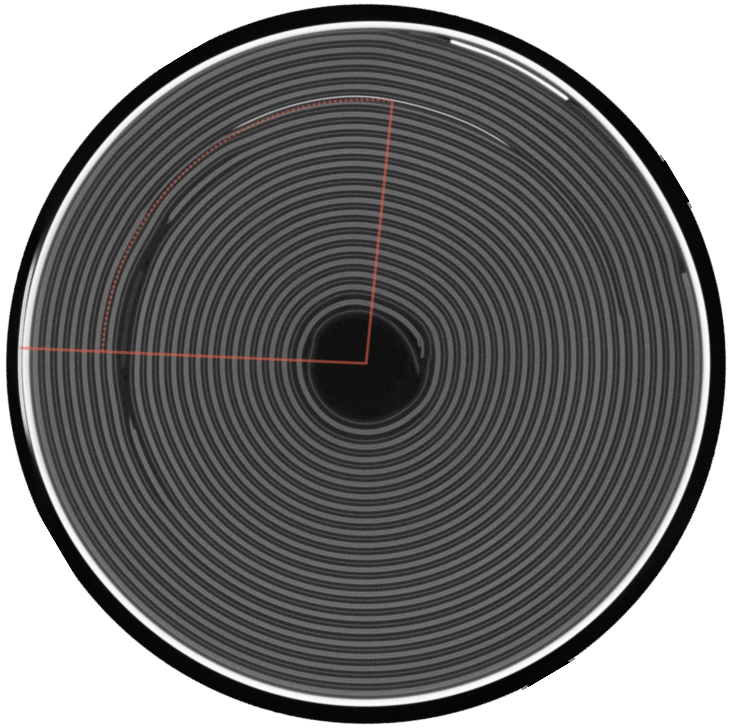
Samsung 53G1

GLIMPSE'S WORK WITH NASA: INTERNAL SHORT CIRCUIT DEVICE (ISCD) CELLS

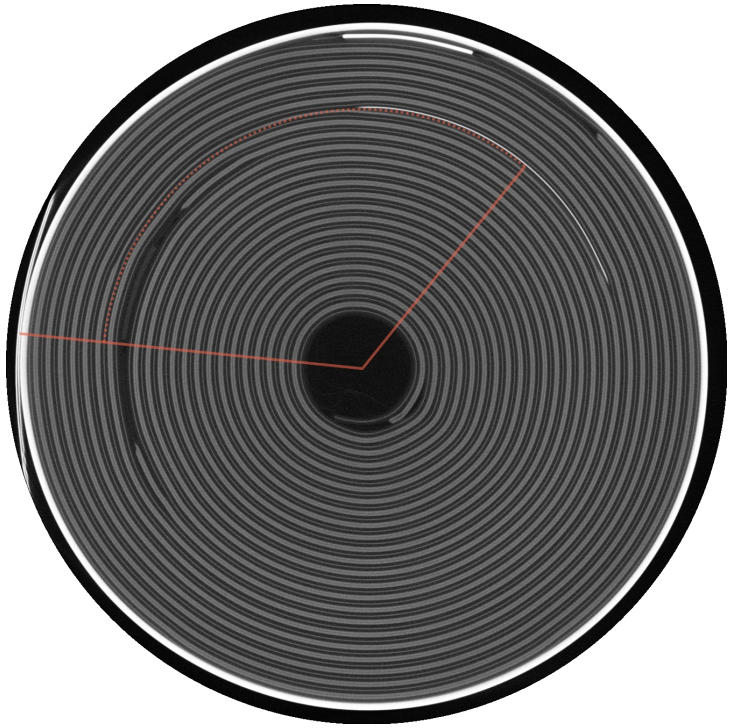
Credit:
Eric Darcy
David Petrushenko
Jesus Trillo
Donal Finegan



Angle: 130°

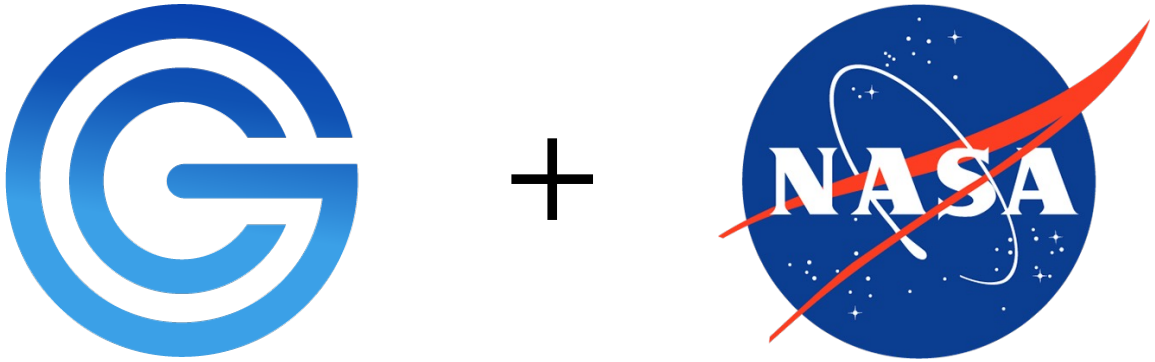


Angle: 93°



Angle: 122°

PROPOSALS FOR JOINT FORWARD WORK

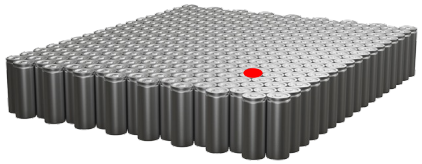


Goal: Drive down cost & effort for aerospace organizations to evaluate battery quality via CT

1. Glimpse: Reduce scan time/cost ("superscanner" + new algorithms)
2. Glimpse + NASA: Understand impact of defects for NASA mission profiles (cycling studies)
3. Glimpse + NASA: Map out confidence in defect detection vs. scan time/cost
4. Glimpse + NASA: Develop automated defect detection algorithms for relevant defects

CONCLUSIONS

1. Battery quality is a big problem



2. Glimpse's mission is to enable battery quality at scale
   by driving down the scan time & analysis time of battery CT scanning

3. Glimpse's technology is unlocking new insights into NASA's cell quality

4. Glimpse and NASA can continue to work together to reduce cost and improve effectiveness of defect screening


GLIMPSE
ENABLING BATTERY QUALITY AT SCALE