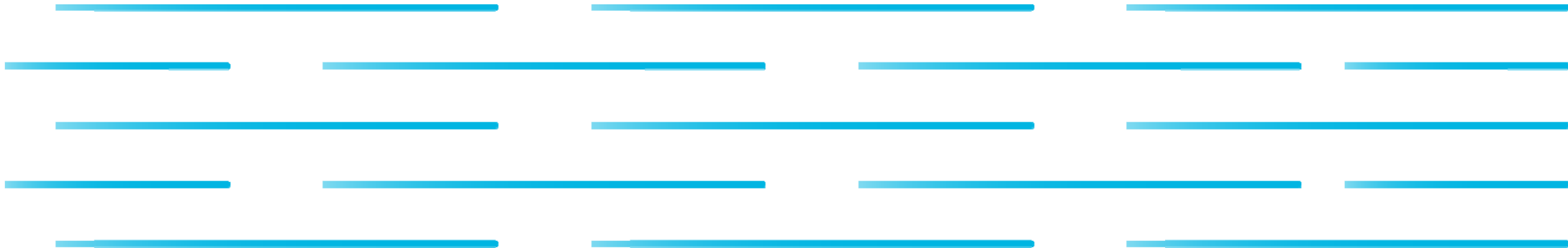




Introduction of new Core Technology improving industrial CT productivity

VG User Group Meeting 2017

Dr. Oliver Brunke GE Inspection Technologies Wunstorf



New Technologies Overview



New industrial X-ray CT Technologies 2017

X-ray detectors

GE Inspection Technologies

Doubled CT resolution at same scanning time

dynamic 41|100 digital detector

GE's superior image quality X-ray detector for 2D radiographic inspection and high resolution CT

Key features & benefits

- 16" X-ray detector with 100 µm pixel size (16 MPixels) designed and optimized for long-term reliability at industrial high-energy use
- High-resolution images for easy detection of subtle indications (up to 50 µm feature detection with minifocus X-ray tubes)
- Next generation photodiode design for up to 10x improved efficiency and sensitivity compared to state of the art 200 µm pixel detectors allows 2x resolution increase without cycle time impact
- Detection of 2x smaller defects without increase of geometric magnification allows imaging of large objects at higher resolution



X-ray sources

GE Inspection Technologies

high-flux|target

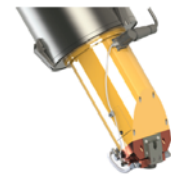
For up to 2 times faster microCT scans or doubled resolution



Innovative, patented composite target.

Today, throughput-optimized high-power CT scans require larger focal spots to prevent target material from melting. But the larger the focal spot becomes, the lower the image quality, and the precision.

The new GE proprietary high-flux|target makes CT scanning more efficient. Due to its high thermal conductivity properties, the new target allows higher power on a smaller focal spot, so users can maintain high image quality and scan much faster or with improved accuracy.



Key features & benefits

- GE patented advanced X-ray target design based on material properties, not on a mechanical rotating anode concept
- Higher flux density due to optimized thermophysical performance
- Works with all lab and production process control microCT applications

X-ray Imaging

GE Inspection Technologies

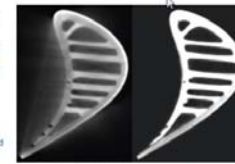
Boosting CT inspection speed and precision

scatter|correct

Unique tool for high quality scatter reduced industrial CT scans acquired in significantly shorter scan time

Key features & benefits

- Low artifact high precision performance of fan beam CT combined with up to 100 times faster* inspection speed of cone beam CT
- Provides significant quality improvement not only for high scattering materials such as steel and aluminum, but also for composites and multi-material samples
- Better material penetration length at same energy level or same CT quality with less complex CT equipment
- Proprietary GE technology - relatively available as option for the industrial mini- and microCT scanner phoenix v|tome|x c and m as well as upgrade package for installed systems



Conventional cone beam CT with scatter radiation artifacts Advanced scatter|correct cone beam CT

* While a typical fan beam CT scan of 1000 slices requires 1 minute per slice = 1000 minutes, a cone beam CT scan requires only 10 minutes.

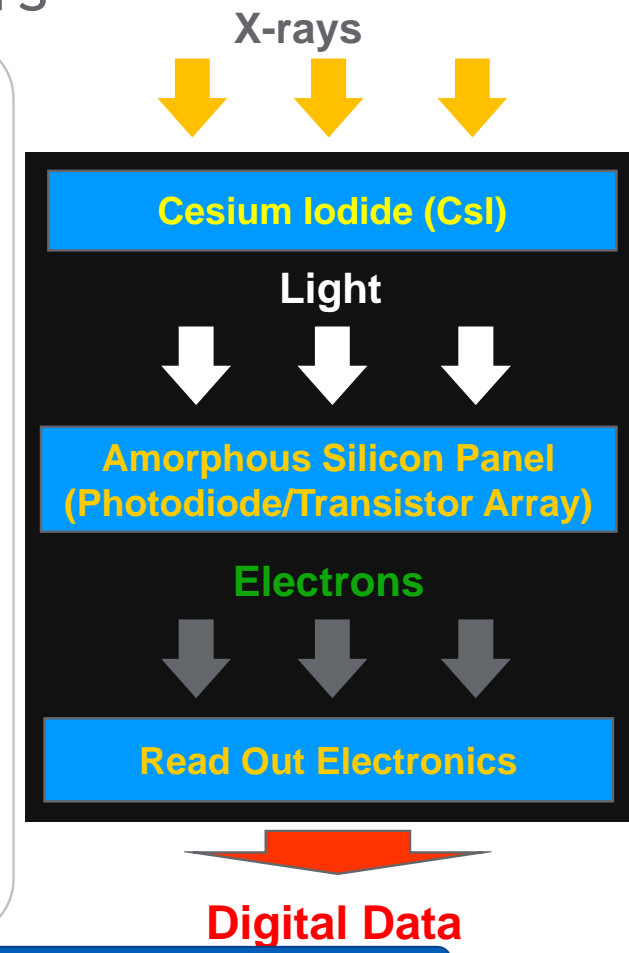
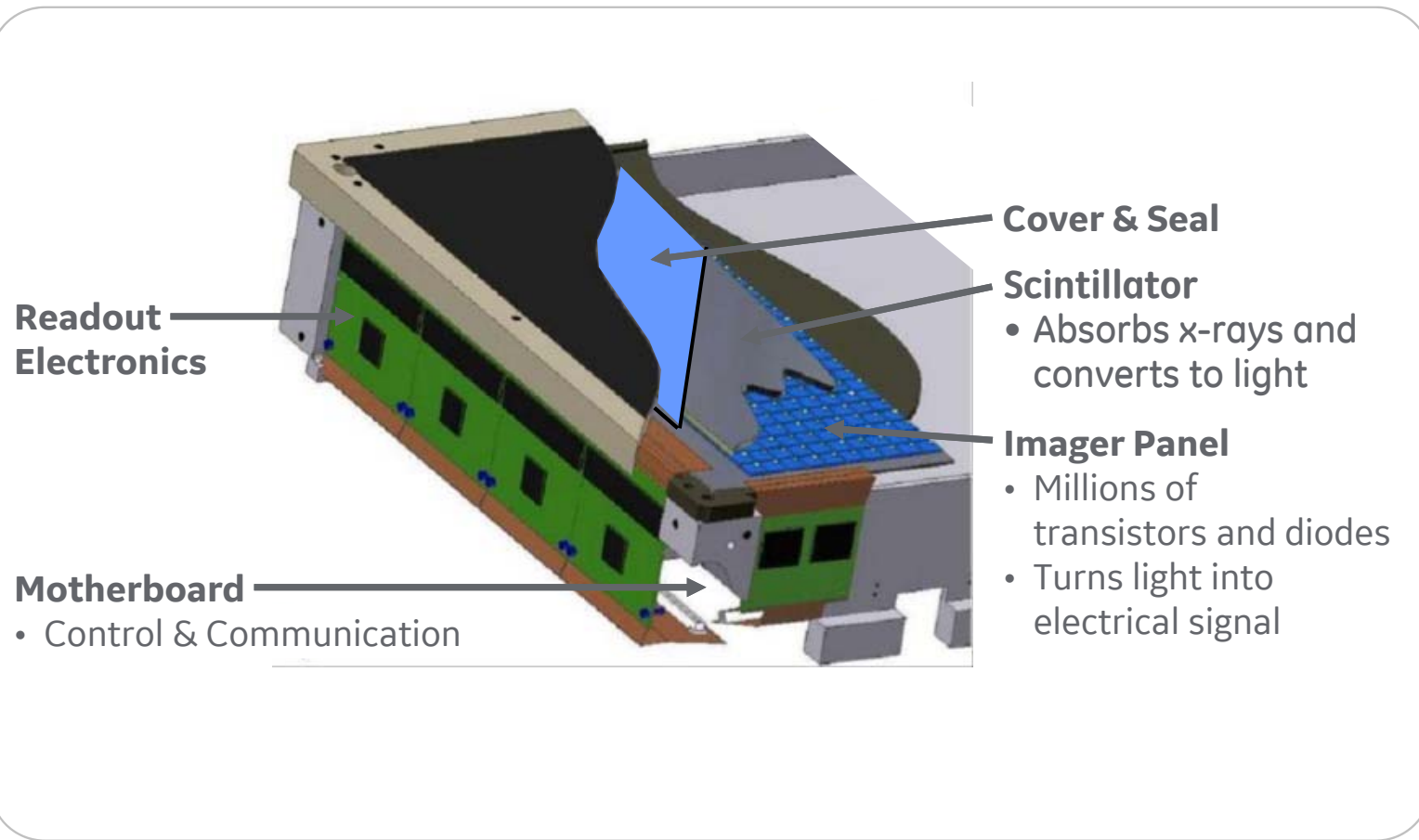
Robotics & Automation



X-ray Detector: dynamic 41|100/200



Amorphous silicon based X-ray flat panel detectors



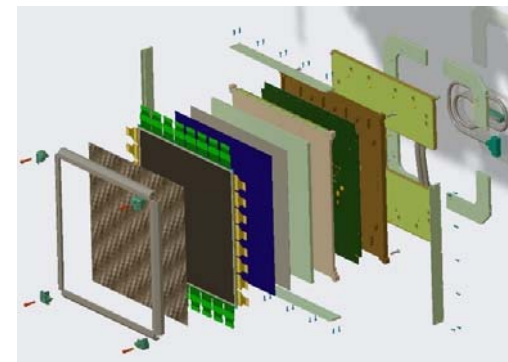
Each component or sub-system can be optimized for specific applications.



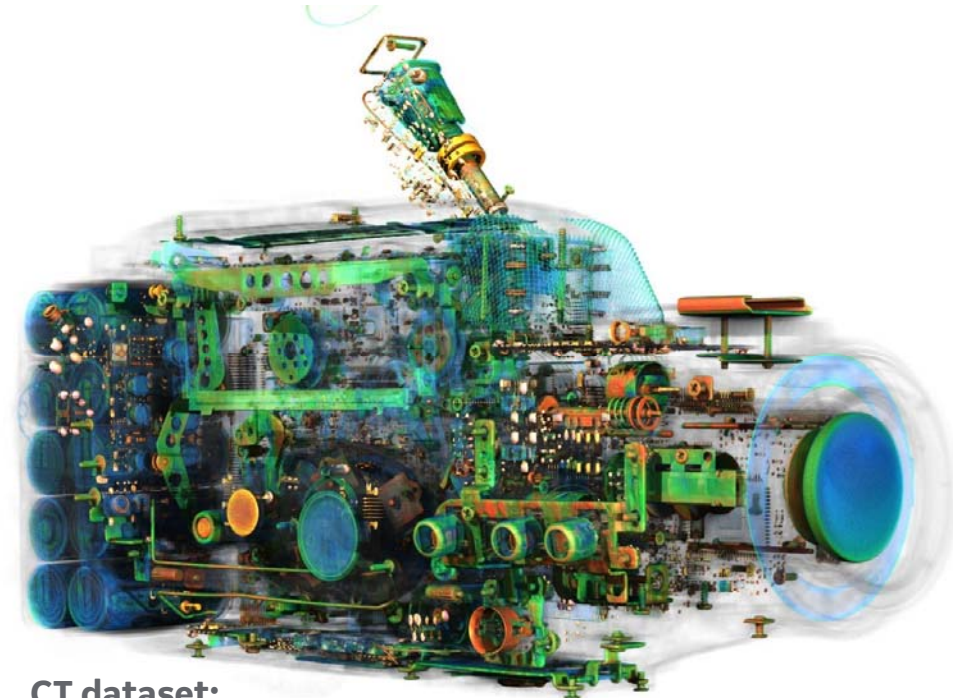
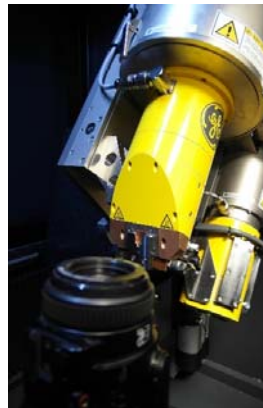
X-ray Detector: dynamic 41|100 & 200

Key features & benefits

- 16" X-ray detector family with 100 μ m & 200 μ m pixel size (16/4 Mpixel) designed and optimized for long-term reliability at industrial high-energy use
- High-resolution images for easy detection of subtle indications (up to 50 μ m feature detection with minifocus X-ray tubes)
- Next generation photodiode design for up to 10x improved efficiency and sensitivity compared to state of the art 200 μ m pixel DXR detectors allows 2x resolution increase without cycle time impact (41|100) or 2-3x cycle time increase without
- Detection of 2x smaller defects without increase of geometric magnification allows imaging of large objects at higher resolution (41|100)



CT Case Study: CT parameter study of a 1993 Video Camera with dynamic 41 X-ray detectors



Test Object:

- Hi8 video camera
- Chip: 1/3" CCD sensor
- Resolution: 470 000 pixel
- Data storage type: Magnet tape

CT Scan:

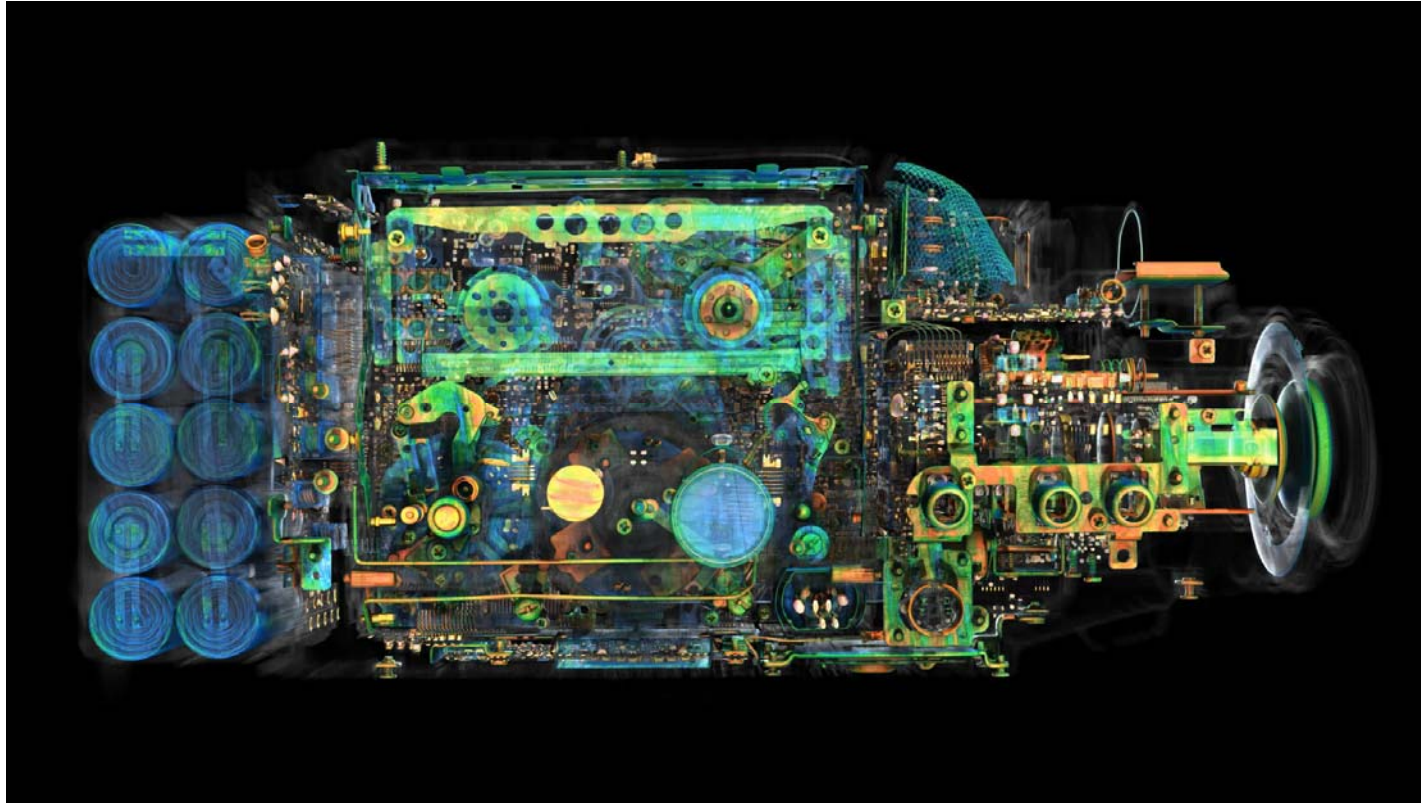
- Scanner: phoenix vtomex m 300 with scatter|correct technology
- detector: dynamic41|100/200
- X-ray parameters $U = 270\text{kV}$, $I = 400 \mu\text{A}$
- 2x 4000 projections

CT dataset:

- voxelsize: 35/70 μm
- Dataset size: ~2500*3500*7000 (dynamic41|100)
- Reconstruction time: ~35 min



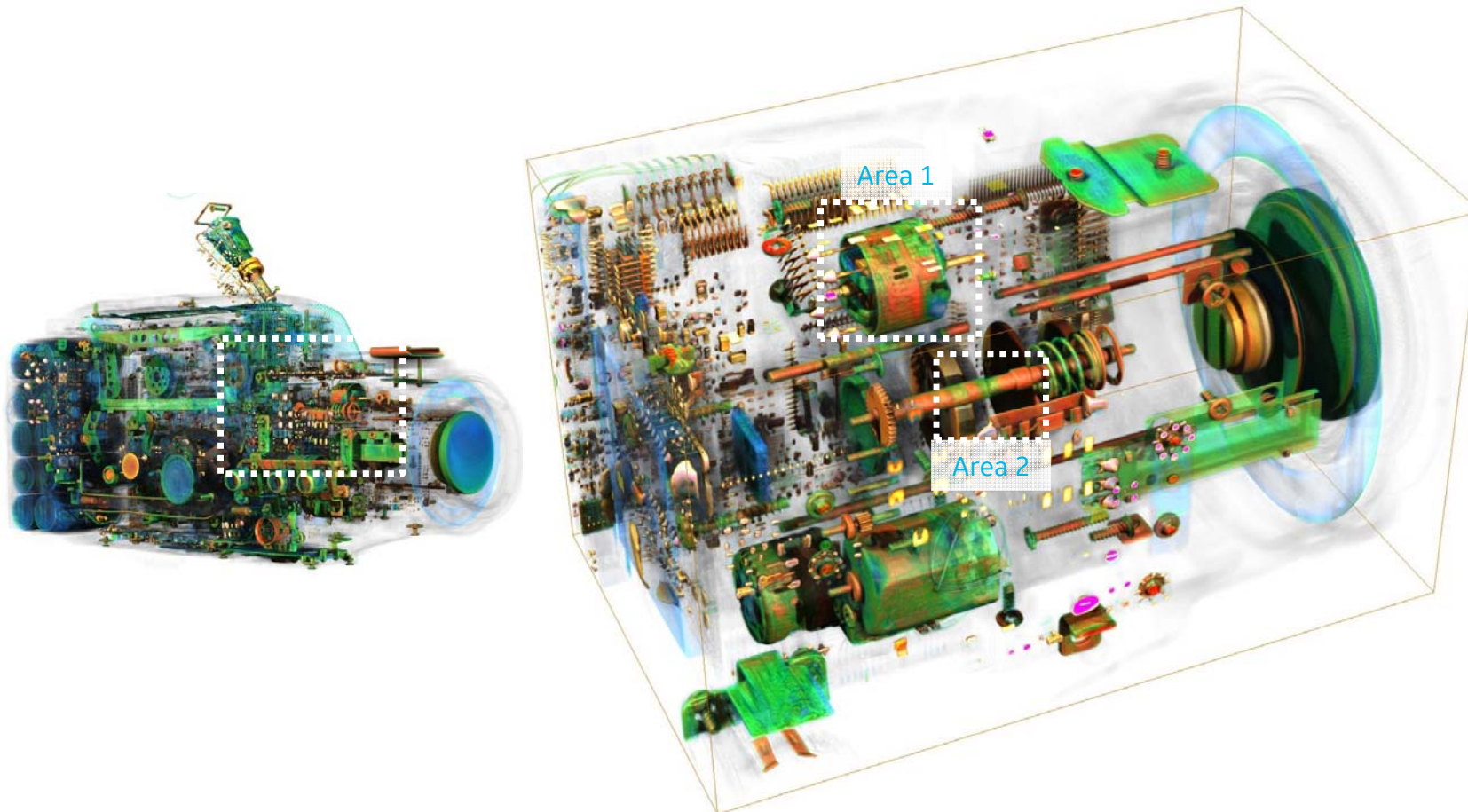
CT Case Study: CT parameter study of a 1993 Video Camera with dynamic 41 X-ray detectors



Rendering of dataset by VGStudioMax 3.0 with friendly support of the VG team

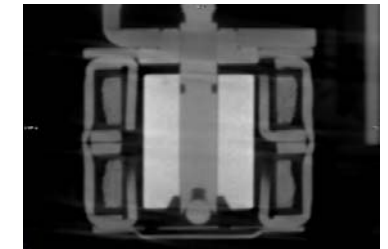


dynamic 41 CT Case Study: Choice of test areas



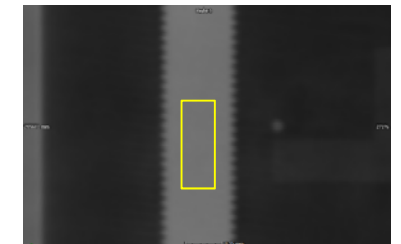
Area 1: Zoom Motor

„Resolution test“



Area 2: Driveshaft Optical Zoom

„SNR test“



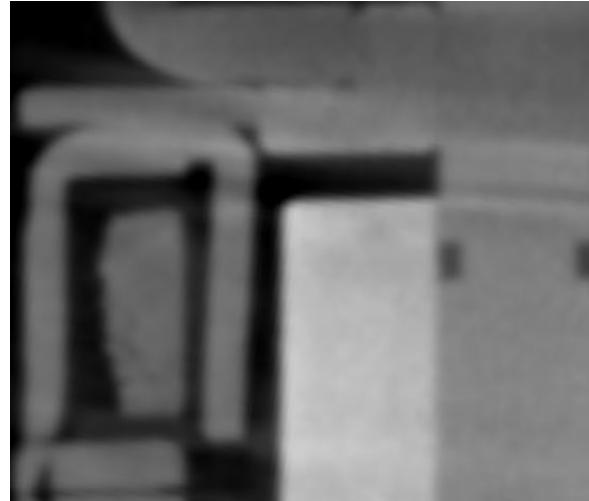
CT Case Study: dynamic 41|100 vs DXR250

Area 1: Zoom Motor „Resolution test“



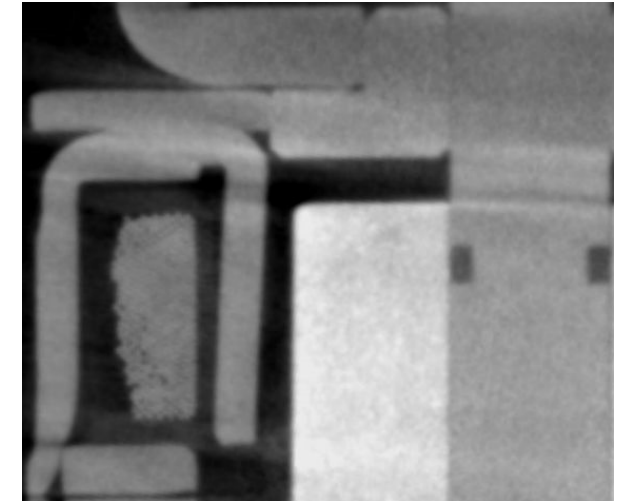
DXR250
60 min

baseline



Dynamic41|100 2x2 binning
30 min

2x faster
same resolution



Dynamic41|100
60 min

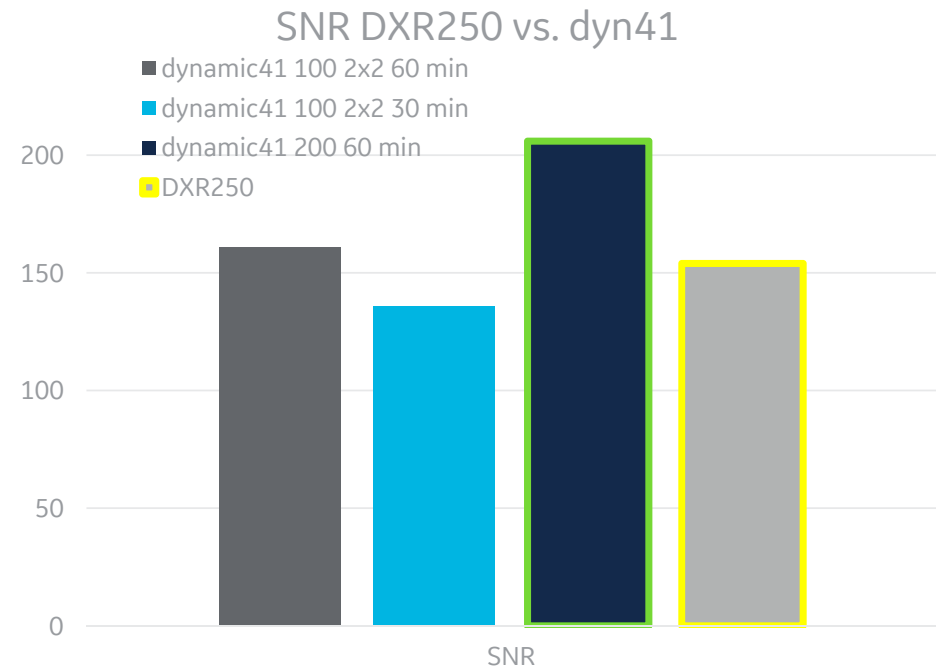
Same speed
2x higher resolution



CT Case Study: dynamic 41|100/200 vs DXR250

Area 2: Driveshaft Optical Zoom: „SNR test“

Detector	dynamic 41 100		dynamic 41 200	DXR250
Scan Time	60 min	30 min	60 min	60 min
Voxelsize	70 μ m (2x2 binning)	70 μ m (2x2 binning)	70 μ m (native)	70 μ m (native)
SNR	161	136	206	154



Conclusion: dynamic 41 allows ~1.2-1.7x **better image quality** (SNR) at same speed or 1.5-3x **higher speed** at same image quality (SNR)



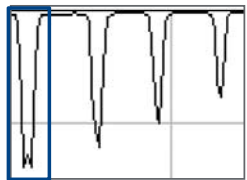
dynamic 41|100 Resolution & CNR in 2D

DXR250

dynamic 41|100

X-ray parameters:

U=220kV
 P=100W
 Filter= 0.5mm Cu
 Timing=333ms
 Avg=4s
 Mag=1x



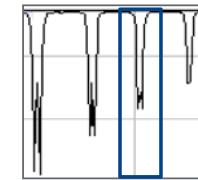
D7=200µm



DXR 250RT 200µm pixel



dynamic 41|100



D9=130µm

Identical X-ray parameters and exposure time

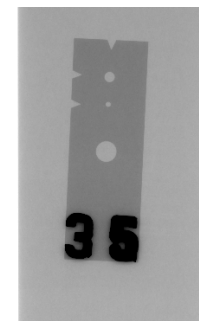
Increased resolution

Comparable CNR

$$\begin{aligned} \text{CNR} &= (4678 - 4459) / 8,5 \\ &= 219 / 8,5 \\ &= 26 \end{aligned}$$



$$\begin{aligned} \text{CNR} &= (4961 - 4732) / 8,8 \\ &= 229 / 8,8 \\ &= 26 \end{aligned}$$



X-ray Detector: dynamic 41|100/200

Technical data features & benefits

Detector Property	Dynamic41-100 (100µm)	Dynamic41-200 (200µm)
Total area	41cm x 41cm	41cm x 41cm
Pixel Matrix	4096 x 4096	2048 x 2048
ROI	Centered: • 20cmx20cm	Centered: • 20cmx20cm
Binning	Software only (2x2)	2x2 (400µm x 400µm)
Max Frame rate	Full FOV: ➢ 3 fps cROI: ➢ 5 fps	Full FOV: ➢ 12fps (native) ➢ 30 fps (binned) cROI: ➢ 30 fps (native)
Electronics Shielding	<ul style="list-style-type: none"> • New proprietary design for heavy industrial use • No external Pb frame needed 	
IQ: • Ghosting (Lag) • Brightness	<p>Low ghosting – Optimized for industrial kV, mA, lifetime</p> <ul style="list-style-type: none"> ➢ Scintillator (Endurance CsI) ➢ New light imager design ➢ More uniform detector response over detector lifetime (longer) <p>Bright – new light imager design means ~10x shorter exposures</p>	
Scintillator	Endurance CsI, 440µm (~80% increase compared to current state of the art 100 µm panels)	Endurance CsI, 700µm (~30% increase compared to current state of the art 200 µm panels)
Readout	Fiber optic	Fiber Optic



X-ray Sources: high-flux|target



X-ray Sources: high-flux|target

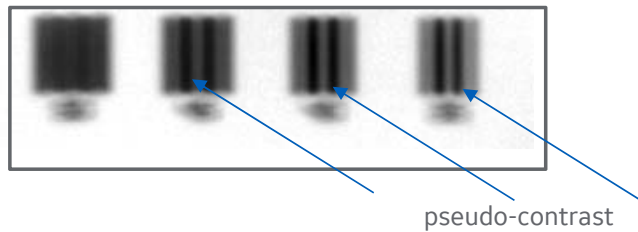
Key features & benefits

- GE patented advanced X-ray target design based on material properties, not on a mechanical rotating anode concept
- Higher flux density due to optimized thermo-physical performance
- Works with all lab and production process control microCT applications
- By doubling the X-ray inspection power from 50 to 100W without enlarging the focal spot size, the high-flux|target provides better CT quality with less image noise, enabling users to get more accurate results or to scan twice as much



high-flux|target for microfocus 240/300kV tubes

standard target



Focal spot size $\approx 100\mu\text{m}$

$50\mu\text{m}$ structure width is not possible to resolve

X-ray resolution test JIMA250kV, 100W with 50, 45, 40, 35, 30 μm structure width

high-flux|target



Focal spot size $\approx 50\mu\text{m}$

$30\mu\text{m}$ structure width is possible to resolve



- Up to 2 times more resolution in the same time



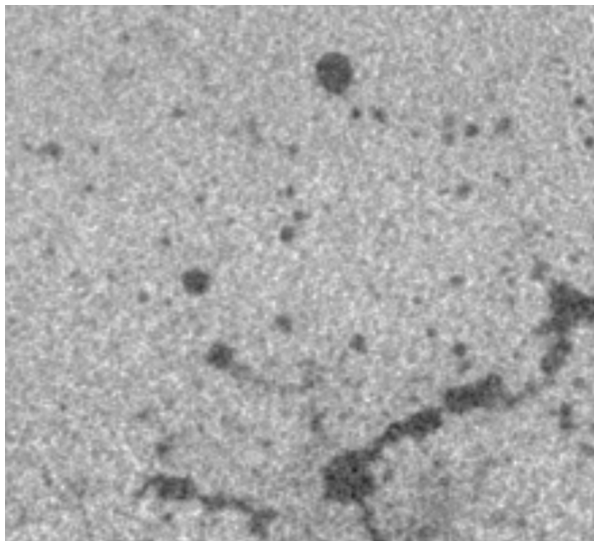
high-flux|target: higher productivity & performance

conventional target - 50W power

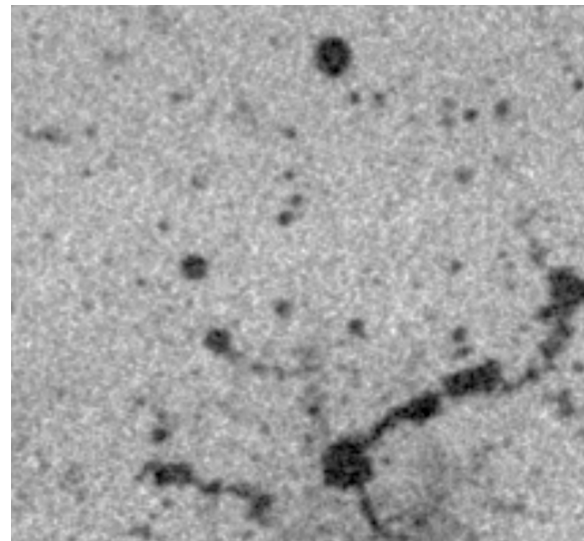
conventional target - 100W power

high-flux|target - 100W power

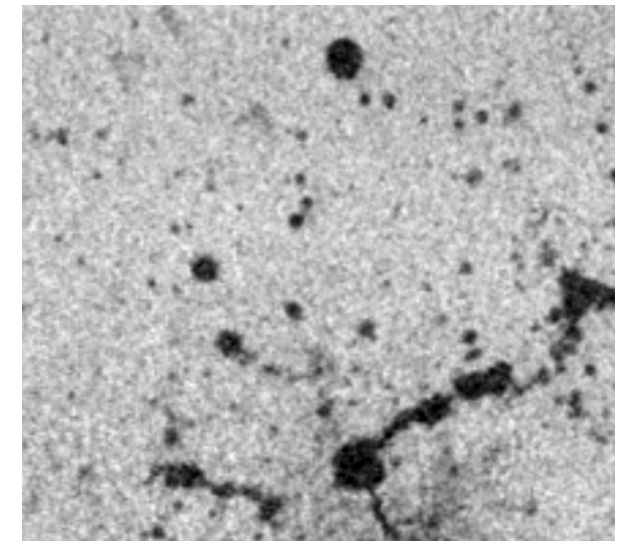
CT cross sections of aluminum casting, scanned 28 minutes with 5x casting magnification at 40 μ m voxel size



- Base line



- More contrast
- Less sharpness

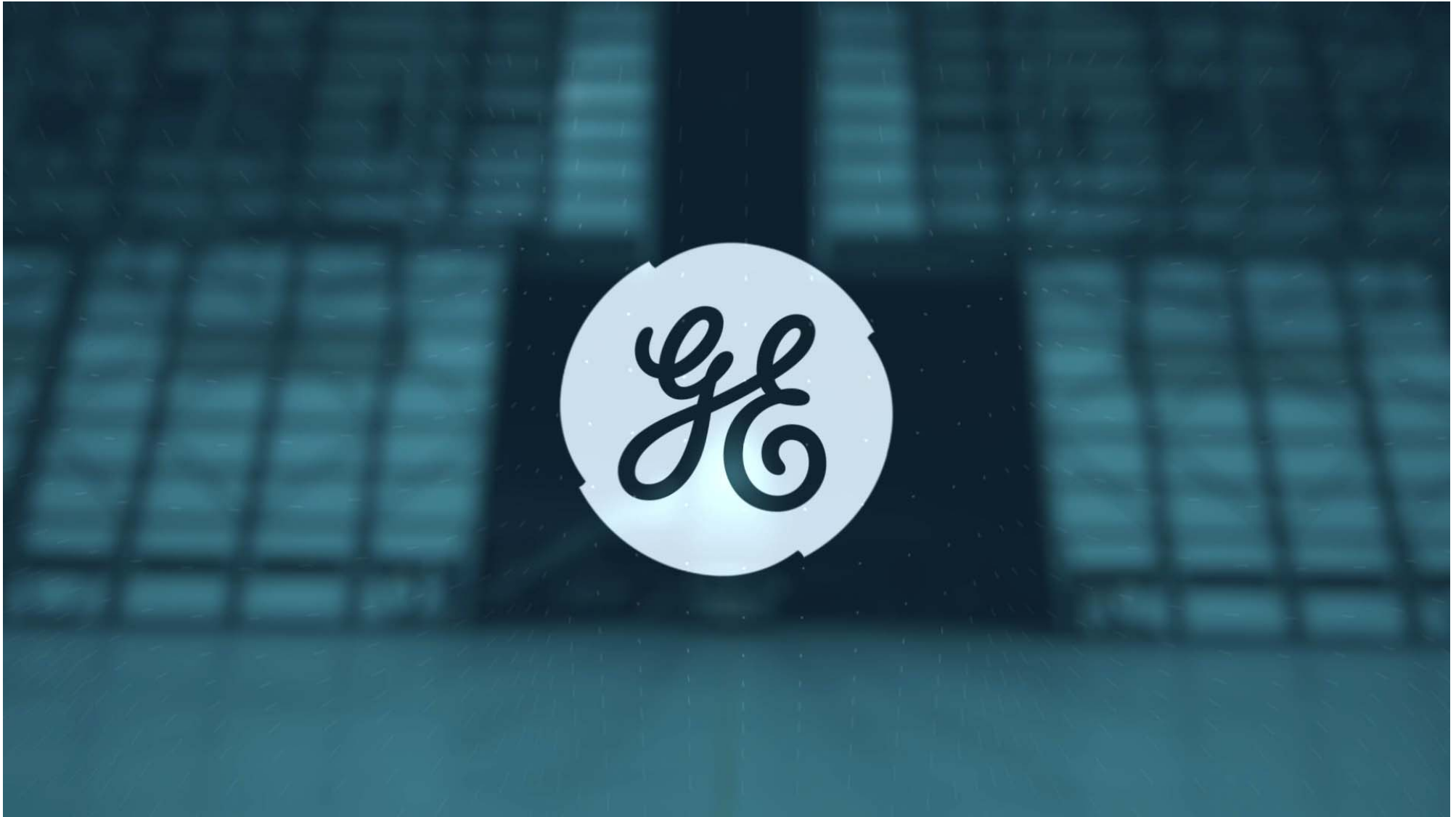


- More contrast
- Equal sharpness



Robotics & Automation





Showcase 1: speed|scan CT64 inline with robot based part loading and speed|ADR

speed|scan CT64 inline



- speed|scan CT64 combined with industrial robot
- Enhanced productivity through fully automated workflow including unique 3D speed|ADR



Showcase 2: collaborative robot with v|tome|x m

v|tome|x m with APAS assistant collaborative robot

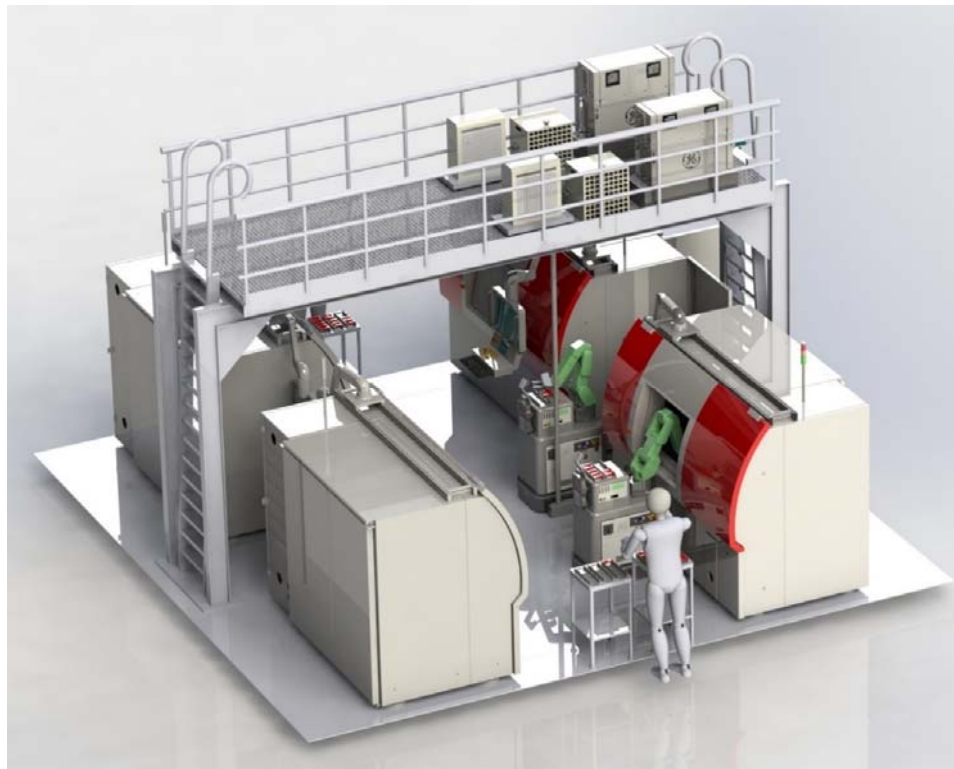


- v|tome|x m production|edition
- For inline CT inspection and 3D metrology eg. for additive or composite parts
- v|tome|x m combined with Bosch APAS assistant collaborative robot
- Enhanced productivity through combined manual and robot assisted workflows



Showcase 2: collaborative robot with v|tome|x m

v|tome|x m with assistant collaborative robot



- Flexible and extendable for up to 4 automatic CT Systems
- Robot based part handling with Automated Guided Vehicles
- Compact for optimized floor space
- Flexible interface to Brilliant Manufacturing IT system



