

**Photon Counting Detector CT:
Opportunities and Challenges in Clinical Applications**

Lifeng Yu, PhD, FAAPM
Professor of Medical Physics
Department of Radiology, Mayo Clinic, Rochester, MN


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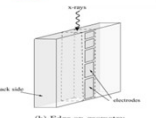




Major contributors

- ▶ Cynthia H. McCollough, PhD
- ▶ Joel G. Fletcher, MD
- ▶ Shuai Leng, PhD
- ▶ Kishore Rajendran, PhD

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Whole-body PCD-CT Systems

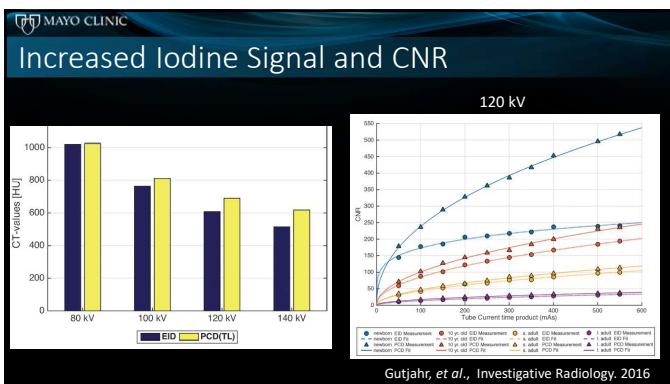
  <p>https://www.siemens-healthineers.com</p>	<ul style="list-style-type: none"> - NAEOTOM Alpha, 2021/10, FDA cleared, CdTe detector (QuantaMax, 1.6 mm thick) - Dual-source dual detector, 144x0.4 mm regular, 120x0.2 mm UHR, 0.25 sec rotation time (Rajendran K et al, Radiology 2022) 	  <p>(b) Edge-on geometry</p>	<ul style="list-style-type: none"> - Research prototype, deep silicon technology (Danielsson M et al, PMB 2021) - Clinical trial at Karolinska University
  <p>https://www.franceimaging.fr/science/central-photon-counting-ct-ct-scanner-lyon/</p>	<ul style="list-style-type: none"> - Research prototype, CZT detector (2 mm thick) - 1.75 cm z coverage, 0.27 mm pixel size; 0.33 sec rotation time, 5 energy thresholds (Si-Mohamed SA et al, Radiology 2022) 	  <p>https://us.medical.canon/</p>	<ul style="list-style-type: none"> - Research prototype, CZT detector (Redlen)

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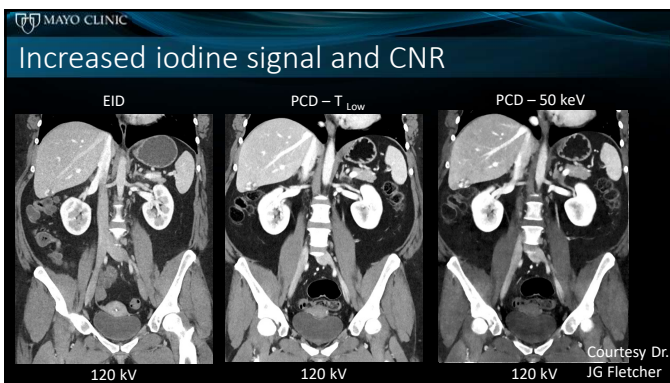
Clinical Benefits of PCD-CT

- ▶ Improve signal and contrast to noise ratio (optimal energy weighting)
- ▶ Improve low-dose/low-signal performance (reduced electronic noise)
- ▶ Improve spatial resolution (smaller detector pixel)
- ▶ Improve dose efficiency (no septae; small pixel effect; optimal weighting; reduced electronic noise)
- ▶ Simultaneous multi-energy + high spatial resolution imaging
- ▶ Simultaneous multi-energy + high temporal resolution imaging
- ▶ Simultaneous multi-energy multi-contrast agent imaging

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PCD: Improved low-dose/low-signal performance

EID-CT PCD-CT

Improved visualization of the brachial plexus Courtesy Dr. CH McCollough

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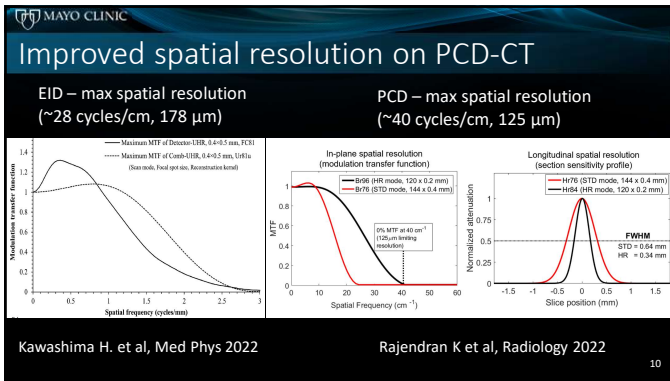
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Clinical Benefits of PCD-CT

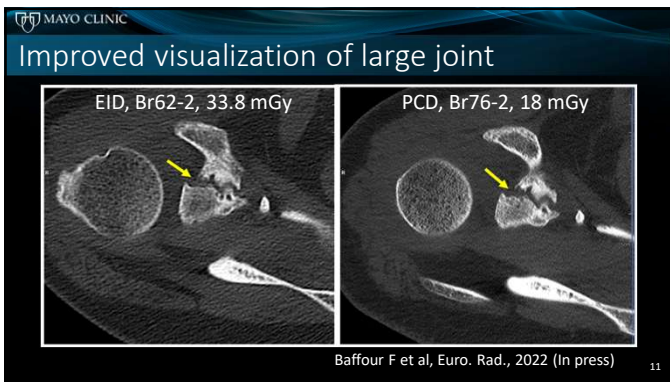
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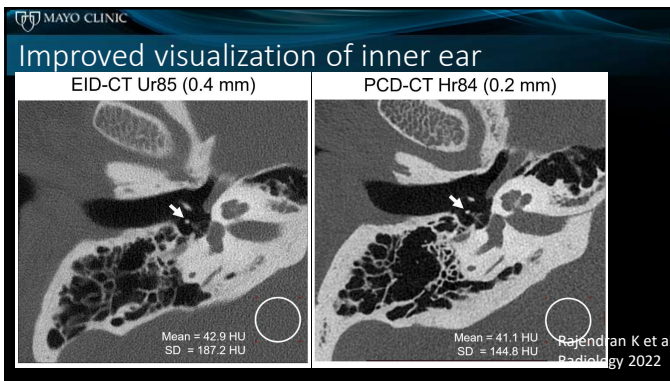
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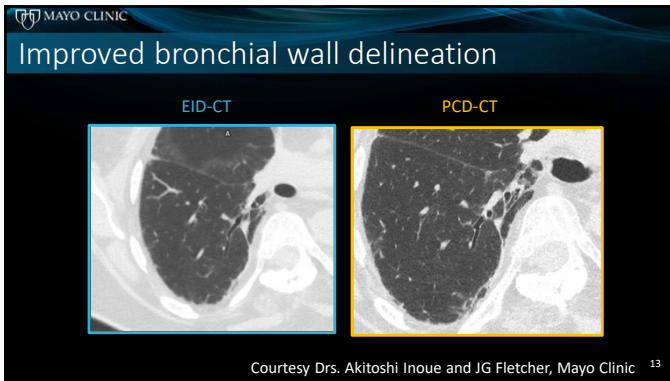
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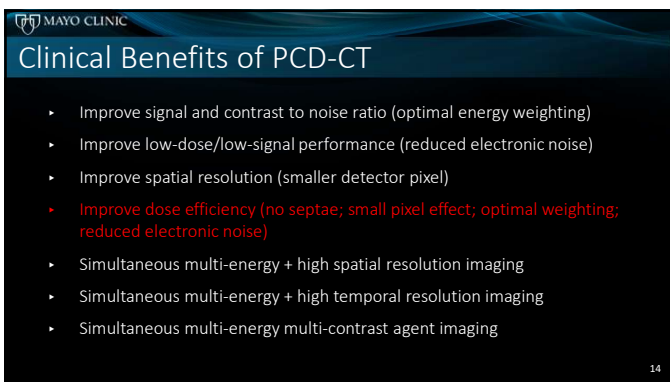
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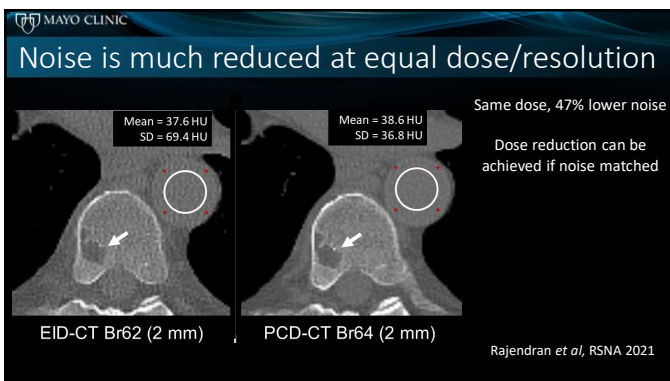
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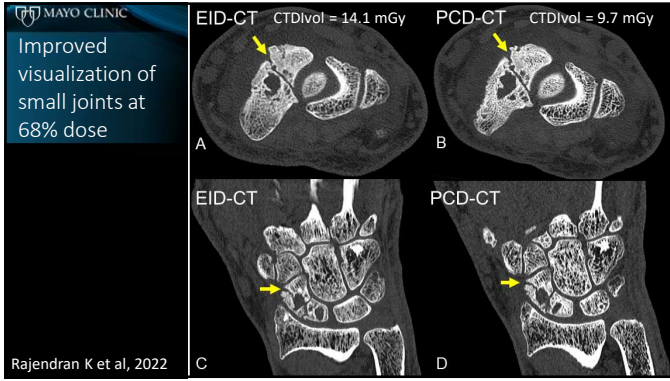
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Simultaneous multi-energy and high-resolution

High resolution head CTA Automatic calcium removal

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Cardiac Multi-energy CT

EID-CT: 90 kV
724 HU

PCD-CT: 120 kV (55 keV)
800 HU

PCD-CT: Iodine map
16.7 mgI/cc

PCD-CT: VNC
72 HU

Rajendran K et al, Radiology 2022

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Use of multiple k-edge contrast agents

- Iodine and gadolinium**
 - Single scan for multi-phase liver and kidney imaging – (Muenzel et al, 2016; Rolf et al, 2017; Ren L et al, 2020; Zhou Z et al, 2022)
- Iodine and bismuth**
 - Small bowel imaging – separate lumen and bowel wall (Qu et al, 2010; Morgan et al, 2012; Ren L et al, 2021)
- Iodine and tungsten**
 - multi-phase in one single scan (Morgan et al, 2012)
- Iodine and gold + calcification**
 - Cardiovascular – characterize macrophage burden, calcification, and stenosis of atherosclerotic plaques (Cormode et al 2010; Baturin et al, 2012)
- Iodine and gadolinium + calcification**
 - CTA – detect endoleaks at arterial phase (I) and at venous/delayed phase (Gd) following endovascular aortic repair (Dangelmaier et al, 2018)

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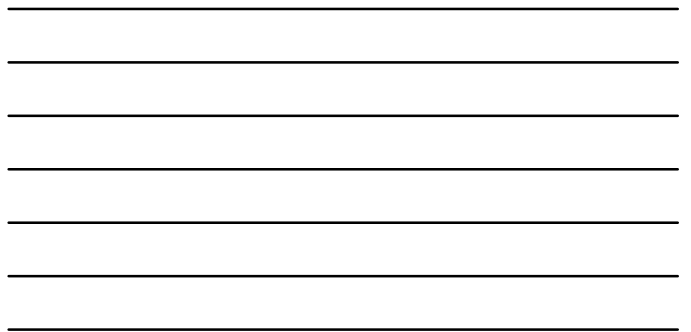


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Simultaneous Iodine/Gadolinium imaging for bi-phase liver

Ren L et al, Invest Radiology 2021

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Simultaneous Iodine/Bismuth imaging for small bowel imaging

Ren L et al, Invest Radiology 2020

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Challenges in PCD-CT Clinical Applications

- ▶ High-spatial resolution → high noise
- ▶ Multi-energy spectral performance need further improvement
- ▶ A large amount of new scan/recon parameters → challenges on protocols
 - Spectral or non-spectral; Threshold low or VMI at different keVs
 - High resolution or regular → appropriate selection of kernel and matrix size
- ▶ A large amount of new information → challenges on user training and radiologist interpretation

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Summary: PCD-CT Clinical Applications

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Thank you!

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