QUANTITATIVE IMAGING WORKSHOP XIX: Utilizing Quantitative Thoracic Imaging to Optimize Population Health November 3-4, 2022 | Virtual

<u>Session Five</u>: Exploring New CT Imaging & Artificial Intelligence Technical Opportunities

New CT Technologies: Opportunities and Challenges

Mario Silva, MD, PhD University of Parma (Italy) UMass Chan Medical School, Worcester (MA, USA)



UMass Chan MEDICAL SCHOOL







Disclosure:

Speaker Coreline
 Astra Zeneca
 Roche



Same energy-signal...what characterization? **TAKE IT ALL!!!**



Energy-integrated detector (EID)



Photon counting detector (PCD)

<u>Energy</u>-The absorbed x-rays produce **electron**hole pairs which are separated and drift to the anodes where they **induce short current pulses**. <u>Geometry</u>-Each **"macro pixel"** confined by collimator blades can be divided into **smaller sub-pixels** which are read-out separately to increase spatial resolution

mario.silva@unipr.it



Same energy-signal...what characterization? TAKE IT ALL!!!

--scintillator detector lodine K-edge - - photon counting det Detector responsivity [a.u.] ~ **E** ~ const Collimato Collimator blades blades TiO₂ based Detector responsivity Cathode High voltage ~1000\ CdTe Electrons Scintillator: D(E)~E ixelated anodes +1 +1 +1 +1 +1 +1 Photo-diodes Photon counter: D(E) = const z-direction z-direction **Detector element** Detector element top view top view 20 60 100 140 Potential Collimator Collimator sub-pixel blades blades structure X-ray energy [kev]

Energy-integrated detector (EID)

Photon counting detector (PCD)

Flohr T, Physica Medica 2020

b)

Dead zones

~0.1mm







All current pulses produced by absorbed x-rays are counted as soon as they

exceed a threshold energy TO.

In a photon-counting detector for medical CT, T0 is about 20–25 keV.

mario.silva@unipr.it

Detector element

top view

Collimator

Photon counting detector (PCD)

blades

Potential

sub-pixel structure



as they

Imaging

th

MAGING

exceed a threshold energy TO.

In a photon-counting detector for medical CT, T0 is about 20–25 keV.

Photon counting detector (PCD)

structure

Less streak artifacts and more stable CT-numbers

diagnostics

Article

Low-Dose High-Resolution Photon-Counting CT of the Lung: Radiation Dose and Image Quality in the Clinical Routine

Matthias Michael Woeltjen *[®], Julius Henning Niehoff, Arwed Elias Michael, Sebastian Horstmeier [®], Christoph Moenninghoff, Jan Borggrefe [®] and Jan Robert Kroeger [®]

ORIGINAL ARTICLE

Potential of Photon-Counting Detector CT for Radiation Dose Reduction for the Assessment of Interstitial Lung Disease in Patients With Systemic Sclerosis

Lisa Jungblut, MD, * André Euler, MD, * Jochen von Spiczak, MD, * Thomas Sartoretti, * Victor Mergen, MD, * Vanessa Englmaier, MD, * Anna Landsmann, * Carmen-Marina Mihai, MD, † Oliver Distler, MD, † Hatem Alkadhi, MD, MPH, EBCR, FESER, * Thomas Frauenfelder, MD, * and Katharina Martini, MD*

ORIGINAL ARTICLE

Estimating the Clinical Impact of Photon-Counting-Detector CT in Diagnosing Usual Interstitial Pneumonia

Akitoshi Inoue, MD, PhD,* © Tucker F. Johnson, MD,* Darin White, MD,* Christian W. Cox, MD,* Thomas E. Hartman, MD,* Jamison E. Thorne, BSc,* Elisabeth R. Shanblatt, PhD,† Matthew P. Johnson, MS,‡ Rickey E. Carter, PhD,§ Yong S. Lee, PhD,* Kishore Rajendran, PhD,* Shuai Leng, PhD,* Cynthia H. McCollough, PhD,* and Joel G. Fletcher, MD* ©

Inoue, 2022 Invest Radiol

Woeltjen MM, Diagnostics 2022

Jungblut L, Invest Radiol 2023

Simultaneous read-out of CT data in different energy bins: SPECTRALLY RESOLVED MEASUREMENTS

MDPI

Less streak artifacts and more stable CT-numbers



Article

Low-Dose High-Resolution Photon-Counting CT of the Lung: Radiation Dose and Image Quality in the Clinical Routine

Matthias Michael Woeltjen *[®], Julius Henning Niehoff, Arwed Elias Michael, Sebastian Horstmeier [®], Christoph Moenninghoff, Jan Borggrefe 💿 and Jan Robert Kroeger 💿

URIGINAL ARTICLE

Potential of Photon-Counting Detector CT for Radiation Dose Reduction for the Assessment of Interstitial Lung Disease in Patients With Systemic Sclerosis

Lisa Jungblut, MD,* André Euler, MD,* Jochen von Spiczak, MD,* Thomas Sartoretti,* Victor Mergen, MD,* Vanessa Englmaier, MD,* Anna Landsmann,* Carmen-Marina Mihai, MD,† Oliver Distler, MD,† Hatem Alkadhi, MD, MPH, EBCR, FESER, * Thomas Frauenfelder, MD, * and Katharina Martini, MD*

ORIGINAL ARTICLE

Estimating the Clinical Impact of Photon-Counting-Detector CT in Diagnosing Usual Interstitial Pneumonia

Akitoshi Inoue, MD, PhD,*
 Tucker F. Johnson, MD,* Darin White, MD,* Christian W. Cox, MD,* Thomas E. Harman, MD,* damison E. Thorme, BSc,* Elisabeth R. Shanblatt, PhD,† Mathew P. Johnson, MS, Rickey E. Carter, PhD,S Jong S. Lee, PhD,* Kishore Rajendran, PhD,* huai Leng, PhD,* Cynthia H. McCollough, PhD,* and Joel G. Fletcher, MD*

Lower dose, higher image quality









Inoue, 2022 Invest Radiol

Woeltjen MM, Diagnostics 2022

MDPI

Jungblut L, Invest Radiol 2023

Less streak artifacts and more stable CT-numbers

a diagnostics	MDPI
* w-Dose High-Resolution Photon-Cou	nting CT of the Lung:

Low-Dose High-Resolution Photon-Counting CT of the Lung-Radiation Dose and Image Quality in the Clinical Routine

Matthias Michael Woeltjen *©, Julius Henning Niehoff, Arwed Elias Michael, Sebastian Horstmeier ©, Christoph Moenninghoff, Jan Borggrefe © and Jan Robert Kroeger © URIGINAL ARTICLE

Potential of Photon-Counting Detector CT for Radiation Dose Reduction for the Assessment of Interstitial Lung Disease in Patients With Systemic Sclerosis

Lisa Jungblut, MD,* André Euler, MD,* Jochen von Spiczak, MD,* Thomas Sartoretti,* Victor Mergen, MD,* Vanessa Englmaier, MD,* Anna Landsmann,* Carmen-Marina Mihai, MD,† Oliver Distler, MD,† Hatem Alkadhi, MD, MPH, EBCR, FESER,* Thomas Frauenfelder, MD,* and Katharina Martini, MD*

Improved the reader confidence for

- reticulation,
- GGO
- mosaic pattern

Improvement in confidence in UIP presence.

ORIGINAL ARTICLE

Estimating the Clinical Impact of Photon-Counting-Detector CT in Diagnosing Usual Interstitial Pneumonia

Akitoshi Inoue, MD, PhD,*
^o Tucker E Johnson, MD,* Darin White, MD,* Christian W. Cox, MD,* Thomas E. Harman, MD,* Jamison E. Thorme, BSc,* Elisabeth R. Shanblatt, PhD,† Matthew P. Johnson, MS,‡ Rickey E. Carter, PhD,§ Yong S. Lee, PhD,* Kishore Rajendran, PhD,* Shuai Leng, PhD,* Cymhia H. McCollough, PhD,* and Joel G. Fletcher, MD*
^o





Inoue, 2022 Invest Radiol

Woeltjen MM, Diagnostics 2022

Jungblut L, Invest Radiol 2023

Less streak artifacts and more stable CT-numbers

Simultaneous read-out of CT data in different energy bins: SPECTRALLY RESOLVED MEASUREMENTS

diagnostics			

Low-Dose High-Resolution Photon-Counting CT of the Lung: Radiation Dose and Image Quality in the Clinical Routine

Matthias Michael Woeltjen *©, Julius Henning Niehoff, Arwed Elias Michael, Sebastian Horstmeier 🕫 Christoph Moenninghoff, Jan Borggrefe 🛛 and Jan Robert Kroeger 💿

Potential of Photon-Counting Detector CT for Radiation Dose Reduction for the Assessment of Interstitial Lung Disease in Patients With Systemic Sclerosis

Lisa Jungblut, MD,* André Euler, MD,* Jochen von Spiczak, MD,* Thomas Sartoretti,* Victor Mergen, MD,* Vanessa Englmaier, MD,* Anna Landsmann,* Carmen-Marina Mihai, MD,† Oliver Disiler, MD,† Hatem Alkadhi, MD, MPH, EBCR, FESER,* Thomas Framefielder, MD,* and Katharina Martini, MD*

ORIGINAL ARTICLE

Estimating the Clinical Impact of Photon-Counting-Detector CT in Diagnosing Usual Interstitial Pneumonia

Akitoshi Inoue, MD, PhD,* ^(a) Tucker F. Johnson, MD,* Darin White, MD,* Christian W. Cox, MD,* Thomas E. Hartman, MD,* Jamison E. Thorne, BSc,* Elisabeth R. Shanblatt, PhD,†
Matthew P. Johnson, MS,‡ Rickey E. Carter, PhD,§ Yong S. Lee, PhD,* Kishore Rajendran, PhD,* Shuai Leng, PhD,* Cynthia H. McCollough, PhD,* and Joel G. Fletcher, MD* ^(a)

Radiation dose reduction of 66% compared with EID-CT is feasible, without penalty in image quality and diagnostic performance for the evaluation of ILD.



Woeltjen MM, Diagnostics 2022

Jungblut L, Invest Radiol 2023



Simultaneous read-out of CT data in different energy bins: SPECTRALLY RESOLVED MEASUREMENTS

TNC



ARTERIAL

FULL PAPER

Performance of virtual non-contrast images generated on clinical photon-counting detector CT for emphysema quantification: proof of concept

¹LISA JUNGBLUT, MD, ¹THOMAS SARTORETTI, ¹DANIEL KRONENBERG, ¹VICTOR MERGEN, MD, ¹ANDRE EULER, MD, ²BERNHARD SCHMIDT, ¹HATEM ALKADHI, MD, MPH, EBCR, FESER, ¹THOMAS FRAUENFELDER, MD and ¹KATHARINA MARTINI, MD



Jungblut L, Br J Radiol 2022

mario.silva@unipr.it



ess streak artifacts and more stable CT-numbers

Simultaneous read-out of CT data in different energy bins: SPECTRALLY RESOLVED MEASUREMENTS



ARTERIAL

VENOUS



FULL PAPER

Performance of virtual non-contrast images generated on clinical photon-counting detector CT for emphysema quantification: proof of concept

¹LISA JUNGBLUT, MD, ¹THOMAS SARTORETTI, ¹DANIEL KRONENBERG, ¹VICTOR MERGEN, MD, ¹ANDRE EULER, MD, ²BERNHARD SCHMIDT, ¹HATEM ALKADHI, MD, MPH, EBCR, FESER, ¹THOMAS FRAUENFELDER, MD and ¹KATHARINA MARTINI, MD

Jungblut L, Br J Radiol 2022

<u>mario.silva@unipr.it</u>



Less streak artifacts and more stable CT-numbers

Simultaneous read-out of CT data in different energy bins: SPECTRALLY RESOLVED MEASUREMENTS

Computed tomography emphysema quantification was **significantly affected by intravenous contrast administration and VMIenergy level** (80 keV yielded most comparable results to VNC)

The **best trade-off** in qualitative as well as in quantitative image quality evaluation was determined **at 60/70 keV.**

% Emphysema



FULL PAPER

Performance of virtual non-contrast images generated on clinical photon-counting detector CT for emphysema quantification: proof of concept

LISA JUNGBLUT, HO, 'THOMAS SARTORETTI, 'DANIEL KRONENBERG, 'VICTOR MERGEN, HO, 'ANDRE EULER, HO, 'BERNHARD SCHMIDT, 'HATEM ALKADHI, HO, HPH, EBCR, PESER, 'THOMAS FRAUENFELDER, HO and 'KATHARINA MARTINI, HO

ORIGINAL ARTICLE

Impact of Contrast Enhancement and Virtual Monoenergetic Image Energy Levels on Emphysema Quantification Experience With Photon-Counting Detector Computed Tomography

Lisa Jungblut, MD,* Daniel Kronenberg, MD,* Victor Mergen, MD,* Kai Higashigaito, MD,* Bernhard Schmidt,† Andre Euler, MD,* Hatem Alkadhi, MD, MPH, EBCR, FESER,* Thomas Frauenfelder, MD,* and Katharina Martini, MD*



QUANTITATIVE IMAGING WORKSHOP XIX: Utilizing Quantitative Thoracic Imaging to Optimize Population Health November 3-4, 2022 | Virtual

<u>Session Five</u>: Exploring New CT Imaging & Artificial Intelligence Technical Opportunities

New CT Technologies: Opportunities and Challenges

Mario Silva, MD, PhD University of Parma (Italy) UMass Chan Medical School, Worcester (MA, USA)



UMass Chan MEDICAL SCHOOL



