Stanford

Norbert Pelc

Boston Scientific Applied Biomedical Engineering Professor and Professor of Radiology, Emeritus

Curriculum Vitae available Online

Bio

BIO

Norbert Pelc is Professor of Radiology, Emeritus. His primary research interests are in the physics, engineering, and mathematics of diagnostic imaging and the development of applications of this imaging technology. His current work focuses on computed tomography, specifically in methods to improve the information content and image quality and to reduce the radiation dose from these examinations. He holds a doctorate and master degrees in Medical Radiological Physics from Harvard University and a BS from the University of Wisconsin in Madison. He served on the first National Advisory Council of the National Institute of Biomedical Imaging and Bioengineering of the NIH. He is a member of the National Academy of Engineering and a Fellow of the American Association of Physicists in Medicine, the International Society for Magnetic Resonance in Medicine, the American Institute of Medical and Biological Engineering, and of SPIE.

ACADEMIC APPOINTMENTS

- Emeritus Faculty, Acad Council, Radiology
- Member, Bio-X
- Member, Cardiovascular Institute
- Member, Stanford Cancer Institute

ADMINISTRATIVE APPOINTMENTS

- Chair, Department of Bioengineering, (2012-2017)
- Associate Chair, Department of Radiology, (2004-2012)

HONORS AND AWARDS

- Fellow, Council on Cardiovascular Radiology, American Heart Association (-)
- Fellow, Society of Magnetic Resonance in Medicine (-)
- Fellow, American Institute for Medical and Biological Engineering (2006)
- Fellow, American Association of Physicists in Medicine (2008)
- Fellow, SPIE (2016)
- Member, National Academy of Engineering (2012)
- Edith Quimby Lifetime Achievement Award, American Association of Physicists in Medicine (2013)
- Outstanding Researcher Award, Radiological Society of North America (2013)
- Doctor of Medicine, Honoris Causa, Friedrich Alexander University of Erlangen-Nuremberg (2016)

PROFESSIONAL EDUCATION

- Sc.D., Harvard University , Medical Radiological Physics (1979)
- S.M., Harvard University , Medical Radiological Physics (1976)
- B .S., University of Wisconsin , Engineering and Physics (1974)

LINKS

- CAP website: http://med.stanford.edu/profiles/bioengineering/faculty/Norbert_Pelc/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

Medical imaging has made enormous strides in recent decades. In clinical medicine, imaging plays an increasingly important role in patient care. A recent study found that internists rank the development of computed tomography (CT) and magnetic resonance imaging (MRI), together, as the most important innovation in medicine (Health Affairs, Vol 20, p. 30, 2001). At the same time, experts in a completely different scientific field, the National Academy of Engineering, ranks the development of imaging as one of the top 20 greatest engineering achievements of the 20th century (www.greatachievements.org), amazingly at a rank higher than that of household appliances and nuclear technology. Imaging is also taking on an increasing role in research, improving our understanding of both normal and diseased states and as a surrogate endpoint in the evaluation of therapies. Imaging allows serial studies in the same individual, thereby increasing statistical power and reducing the number of subjects needed in a study. Imaging is also a powerful tool to guide minimally invasive therapies.

The effectiveness of imaging and the powerful impact of visual images have led to a major increase in the utilization of this strategy, a trend that will continue but will evolve in coming years. Further advances will lead to improved detection, localization, and characterization of disease which should enable more accurate selection of optimized therapies for individual subjects (personalized medicine) as well as treatments that are more effective, less expensive, and less traumatic. Imaging will also play an increasingly important role in the challenges facing biomedical research.

There are many imaging “modalities”, each acquiring data using physical mechanisms such as x-ray transmission, nuclear magnetic resonance, acoustic or optical properties, and signals from radioactive tracers. Optimal design and utilization of each requires an appreciation of the underlying physical phenomena. Each modality uses sensors to detect signals and mathematical methods to covert the measured signals to images. Additional image processing methods are used to extract physiological information from the images.

My own interests center on the physics, engineering and mathematics of medical imaging. While I have worked on many imaging modalities over the past decades, my current projects are focused on computed tomography, digital x-ray imaging, and hybrid multimodality systems. An area of current focus is understanding the potential impact of a new class of x-ray detectors for CT imaging, energy discriminating photon counting detectors. They promise improved tissue characterization and dose efficiency, but currently available detectors have imperfections that detract from their performance. Important questions for this and other new technologies are: what are the real benefits and when is it worthwhile adopting them into clinical systems.

In addition to these technical projects, I am also interested in the development of new clinical and research applications of medical imaging. This is highly interdisciplinary research, incorporating not only the latest imaging technology but also fundamental appreciation of anatomy and pathophysiology.

CLINICAL TRIALS

- Comparison of I-124 PET/CT, F-18 FDG PET/CT & I-123 Whole Body Scintigraphy for Recurrent Thyroid CA, Not Specified

Publications

PUBLICATIONS

- **A virtual trial evaluation of patient motion in arc and linear system designs in body digital tomosynthesis.** *Biomedical physics & engineering express*
  Samei, E., Segars, P. W., Shoval, L., Karniel, G., Daliot, A., Pelc, N. J.
  2025

- **Analytical model for pulse pileup spectra and count statistics in photon counting detectors with seminonparalyzable behavior.** *Medical physics*
  Yang, Y., Pelc, N. J., Wang, A. S.
  2025

- **Spectral optimization using fast kV switching and filtration for photon counting CT with realistic detector responses: a simulation study.** *Journal of medical imaging (Bellingham, Wash.)*
  Wang, S., Yang, Y., Pal, D., Yin, Z., Maltz, J. S., Pelc, N. J., Wang, A. S.
  2024; 11 (Suppl 1): S12805

- **The effects of intra-detector Compton scatter on low-frequency DQE for photon-counting CT using edge-on-irradiated silicon detectors.** *Medical physics*
  Grönberg, F., Yin, Z., Maltz, J. S., Pelc, N. J., Persson, M.
  2024

- **Empirical optimization of energy bin weights for compressing measurements with realistic photon counting x-ray detectors.** *Medical physics*
  Yang, Y., Wang, S., Pal, D., Yin, Z., Pelc, N. J., Wang, A. S.
  2023

- **Early CT physics research at massachusetts general hospital.** *Medical physics*
  Pelc, N. J., Chesler, D. A.
  2023

- **A Methodology to Train a Convolutional Neural Network-Based Low-Dose CT Denoiser With an Accurate Image Domain Noise Insertion Technique** *IEEE ACCESS*
  Kim, B., Divel, S. E., Pelc, N. J., Baek, J.
  2022; 10: 86395-86407

- **Fast kV Switching for Improved Material Decomposition with Photon Counting X-ray Detectors**
  Wang, S., Yang, Y., Pal, D., Pelc, N. J., Wang, A. S.
  edited by Zhao, W., Yu, L.
  SPIE-INT SOC OPTICAL ENGINEERING.2022

- **Empirical Optimization of Energy Bin Weights for Compressing Measurements with Photon Counting X-ray Detectors**
  Yang, Y., Wang, S., Pal, D., Pelc, N. J., Wang, A. S.
  edited by Zhao, W., Yu, L.
  SPIE-INT SOC OPTICAL ENGINEERING.2022

- **How CT happened: the early development of medical computed tomography.** *Journal of medical imaging (Bellingham, Wash.)*
  Schulz, R. A., Stein, J. A., Pelc, N. J.
  2021; 8 (5): 052110

- **Special Section Guest Editorial: Computed tomography (CT) at 50 years.** *Journal of medical imaging (Bellingham, Wash.)*
  La Riviere, P. J., Fahrig, R., Pelc, N. J.
  2021; 8 (5): 052101

- **Findings of the AAPM Ad Hoc committee on magnetic resonance imaging in radiation therapy: Unmet needs, opportunities, and recommendations.** *Medical physics*
  McGee, K. P., Tyagi, N., Bayouth, J. E., Cao, M., Fallone, B. G., Glide-Hurst, C. K., Goerner, F. L., Green, O. L., Kim, T., Paulson, E. S., Yanasak, N. E., Jackson, E. F., Goodwin, et al

2021

- **Spectral Photon Counting CT: Imaging Algorithms and Performance Assessment.** *IEEE transactions on radiation and plasma medical sciences*
  Wang, A. S., Pelc, N. J.
  2021; 5 (4): 453-464
- **A dynamic simulation framework for CT perfusion in stroke assessment built from first principles.** *Medical physics*
  Divel, S. E., Christensen, S., Segars, W. P., Lansberg, M. G., Pelc, N. J.
  2021
- **Simulation of contrast agent dynamics in digital brain phantom for CT perfusion optimization**
  Divel, S. E., Christensen, S., Lansberg, M. G., Pelc, N. J.
  edited by Chen, G. H., Bosmans, H.
  SPIE-INT SOC OPTICAL ENGINEERING.2021
- **Analytical model for pulse pileup in photon counting detectors with seminonparalyzable behavior**
  Yang, Y., Pelc, N. J., Wang, A. S.
  edited by Bosmans, H., Zhao, W., Yu, L.
  SPIE-INT SOC OPTICAL ENGINEERING.2021
- **CNN-based CT denoising with an accurate image domain noise insertion technique**
  Kim, B., Divel, S. E., Pelc, N. J., Baek, J.
  edited by Bosmans, H., Zhao, W., Yu, L.
  SPIE-INT SOC OPTICAL ENGINEERING.2021
- **Detective quantum efficiency of photon-counting CdTe and Si detectors for computed tomography: a simulation study.** *Journal of medical imaging (Bellingham, Wash.)*
  Persson, M., Wang, A., Pelc, N. J.
  2020; 7 (4): 043501
- **Principles and Applications of Multi-energy CT Report of AAPM Task Group 291.** *Medical physics*
  McCollough, C. H., Boedeker, K. n., Cody, D. n., Duan, X. n., Flohr, T. n., Halliburton, S. n., Hsieh, J. n., Layman, R. n., Pelc, N. J.
  2020
- **Acoustic Attenuation: Multifrequency Measurement and Relationship To CT and MR Imaging.** *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*
  Webb, T. D., Leung, S. A., Ghanouni, P. n., Dahl, J. J., Pelc, N. J., Pauly, K. B.
  2020; PP
- **Spectral modulator with flying focal spot for cone-beam CT: a feasibility study.** *SPIE Medical Imaging 2020: Physics of Medical Imaging*
  Gao, H., Zhou, H., Zhu, L., Pelc, N., Bennett, R., Wang, A.
  2020
- **Spectral Photon Counting CT: Imaging Algorithms and Performance Assessment.** *IEEE Transactions on Radiation and Plasma Medical Sciences*
  Wang, A. S., Pelc, N. J.
  2020
- **Implementation of a piecewise-linear dynamic attenuator** *JOURNAL OF MEDICAL IMAGING*
  Shunhavanich, P., Bennett, N., Hsieh, S. S., Pelc, N. J.
  2019; 6 (2)
- **Simulation model for evaluating energy-resolving photon-counting CT detectors based on generalized linear-systems framework**
  Persson, M., Pelc, N. J.
  edited by Schmidt, T. G., Chen, G. H., Bosmans, H.
  SPIE-INT SOC OPTICAL ENGINEERING.2019
- **Noise reduction in photon-counting CT using frequency-dependent optimal weighting**
  Persson, M., Pelc, N. J.
  edited by Matej, S., Metzler, S. D.

SPIE-INT SOC OPTICAL ENGINEERING.2019

- **Accurate image domain noise insertion in CT images.** *IEEE transactions on medical imaging*
  Divel, S. E., Pelc, N. J.
  2019
- **Detective Efficiency of Photon Counting Detectors with Spectral Degradation and Crosstalk.** *Medical physics*
  Rajbhandary, P. L., Persson, M. n., Pelc, N. J.
  2019
- **Fluid-filled dynamic bowtie filter: Description and comparison with other modulators** *MEDICAL PHYSICS*
  Shunhavanich, P., Hsieh, S. S., Pelc, N. J.
  2019; 46 (1): 127–39
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  Persson, M., Rajbhandary, P. L., Pelc, N. J.
  2018; 45 (11): 4897–4915
- **A framework for performance characterization of energy-resolving photon-counting detectors.** *Medical physics*
  Persson, M., Rajbhandary, P. L., Pelc, N. J.
  2018
- **Photon-counting CT: Technical Principles and Clinical Prospects.** *Radiology*
  Willemink, M. J., Persson, M., Pourmorteza, A., Pelc, N. J., Fleischmann, D.
  2018: 172656
- **Modeling charge transport in photon-counting detectors** *NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT*
  Fang, Y., Xu, C., Yao, Y., Pelc, N., Danielsson, M., Badano, A.
  2018; 899: 115–21
- **Effect of Spectral Degradation and Spatio-Energy Correlation in X-Ray PCD for Imaging** *IEEE TRANSACTIONS ON MEDICAL IMAGING*
  Rajbhandary, P. L., Hsieh, S. S., Pelc, N. J.
  2018; 37 (8): 1910–19
- **Measurements of the Relationship Between CT Hounsfield Units and Acoustic Velocity and How It Changes With Photon Energy and Reconstruction Method** *IEEE TRANSACTIONS ON ULTRASONICS FERROELECTRICS AND FREQUENCY CONTROL*
  Webb, T. D., Leung, S. A., Rosenberg, J., Ghanouni, P., Dahl, J. J., Pelc, N. J., Pauly, K.
  2018; 65 (7): 1111–24
- **Spectral resolution and high-flux capability tradeoffs in CdTe detectors for clinical CT** *MEDICAL PHYSICS*
  Hsieh, S. S., Rajbhandary, P. L., Pelc, N. J.
  2018; 45 (4): 1433–43
- **Frequency Dependent DQE of Photon Counting Detector with Spectral Degradation and Cross-talk**
  Rajbhandary, P. L., Persson, M., Pelc, N. J.
  edited by Lo, J. Y., Schmidt, T. G., Chen, G. H.
  SPIE-INT SOC OPTICAL ENGINEERING.2018
- **Effect of Electronic Noise and Lowest Energy Threshold Selection in Photon Counting Detectors**
  Rajbhandary, P. L., Pelc, N. J.
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  SPIE-INT SOC OPTICAL ENGINEERING.2018
- **Energy dependence of SNR and DQE for effective monoenergetic imaging in spectral CT**
  Rajbhandary, P. L., Pelc, N. J.
  edited by Lo, J. Y., Schmidt, T. G., Chen, G. H.

SPIE-INT SOC OPTICAL ENGINEERING.2018

- **Implementation of a Piecewise-linear Dynamic Attenuator**
  Shunhavanich, P., Bennett, N., Hsieh, S. S., Pelc, N. J.
  edited by Lo, J. Y., Schmidt, T. G., Chen, G. H.
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- **Generalized linear-systems framework for performance assessment of energy-resolving photon-counting detectors**
  Persson, M., Rajbhandary, P. L., Pelc, N. J.
  edited by Lo, J. Y., Schmidt, T. G., Chen, G. H.
  SPIE-INT SOC OPTICAL ENGINEERING.2018

- **Can image-domain filtering of FBP CT reconstructions match low-contrast performance of iterative reconstructions?**
  Divel, S. E., Hsieh, S. S., Wang, J., Pelc, N. J.
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  SPIE-INT SOC OPTICAL ENGINEERING.2018

- **Segmented targeted least squares estimator for material decomposition in multibin photon-counting detectors.** *Journal of medical imaging (Bellingham, Wash.)*
  Rajbhandary, P. L., Hsieh, S. S., Pelc, N. J.
  2017; 4 (2): 023503-?

- **Special Section Guest Editorial: Positron Emission Tomography: History, Current Status, and Future Prospects.** *Journal of medical imaging (Bellingham, Wash.)*
  Pelc, N. J., Kinahan, P. E., Pettigrew, R. I.
  2017; 4 (1): 011001-?

- **Improvements in low contrast detectability with iterative reconstruction and the effect of slice thickness**
  Hsieh, S. S., Pelc, N. J.
  edited by Flohr, T. G., Lo, J. Y., Schmidt, T. G.
  SPIE-INT SOC OPTICAL ENGINEERING.2017

- **Sensitivity Analysis of Pulse Pileup Model Parameter in Photon Counting Detectors**
  Shunhavanich, P., Pelc, N. J.
  edited by Flohr, T. G., Lo, J. Y., Schmidt, T. G.
  SPIE-INT SOC OPTICAL ENGINEERING.2017

- **Effect of Spatio-energy Correlation in PCD due to Charge Sharing, Scatter and Secondary Photons**
  Rajbhandary, P. L., Hsieh, S. S., Pelc, N. J.
  edited by Flohr, T. G., Lo, J. Y., Schmidt, T. G.
  SPIE-INT SOC OPTICAL ENGINEERING.2017

- **Multisource inverse-geometry CT. Part I. System concept and development.** *Medical physics*
  De Man, B., Uribe, J., Baek, J., Harrison, D., Yin, Z., Longtin, R., Roy, J., Waters, B., Wilson, C., Short, J., Inzinna, L., Reynolds, J., Neculaes, et al
  2016; 43 (8): 4607-?

- **Multisource inverse-geometry CT. Part II. X-ray source design and prototype.** *Medical physics*
  Neculaes, V. B., Caiafa, A., Cao, Y., De Man, B., Edic, P. M., Frutschy, K., Gunturi, S., Inzinna, L., Reynolds, J., Vermilyea, M., Wagner, D., Zhang, X., Zou, et al
  2016; 43 (8): 4617-?

- **Image quality comparison between single energy and dual energy CT protocols for hepatic imaging.** *Medical physics*
  Yao, Y., Ng, J. M., Megibow, A. J., Pelc, N. J.
  2016; 43 (8): 4877-?

- **A prototype piecewise-linear dynamic attenuator** *PHYSICS IN MEDICINE AND BIOLOGY*
  Hsieh, S. S., Peng, M. V., May, C. A., Shunhavanich, P., Fleischmann, D., Pelc, N. J.
  2016; 61 (13): 4974-4988

- **Improving pulse detection in multibin photon-counting detectors.** *Journal of medical imaging (Bellingham, Wash.)*

Hsieh, S. S., Pelc, N. J.
2016; 3 (2): 023505-?

- **A limit on dose reduction possible with CT reconstruction algorithms without prior knowledge of the scan subject.** *Medical physics*
  Hsieh, S. S., Chesler, D. A., Fleischmann, D., Pelc, N. J.
  2016; 43 (3): 1361-?
- **Digital Tomosynthesis System Geometry Analysis Using Convolution-Based Blur-and-Add (BAA) Model** *IEEE TRANSACTIONS ON MEDICAL IMAGING*
  Wu, M., Yoon, S., Solomon, E. G., Star-Lack, J., Pelc, N., Fahrig, R.
  2016; 35 (1): 131-143
- **Limits to dose reduction from iterative reconstruction and the effect of through-slice blurring**
  Hsieh, S. S., Pelc, N. J.
  edited by Kontos, D., Flohr, T. G., Lo, J. Y.
  SPIE-INT SOC OPTICAL ENGINEERING.2016
- **Lossless Compression of Projection Data from Photon Counting Detectors**
  Shunhavanich, P., Pelc, N. J.
  edited by Kontos, D., Flohr, T. G., Lo, J. Y.
  SPIE-INT SOC OPTICAL ENGINEERING.2016
- **"Conventional" CT images from spectral measurements**
  Rajbhandary, P. L., Pelc, N. J.
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- **Upper-Bound on Dose Reduction in CT Reconstruction for Nodule Detection** *IEEE ACCESS*
  De Man, R., Wang, G., Kalra, M. K., Otrakji, A., Hsieh, S., Pelc, N.
  2016; 4: 4247-4253
- **Raw data normalization for a multi source inverse geometry CT system** *OPTICS EXPRESS*
  Baek, J., De Man, B., Harrison, D., Pelc, N. J.
  2015; 23 (6): 7514-7526
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- **Multivariate Gaussian Model Based Cramer-Rao Lower Bound Evaluation of the In-Depth PCXD**
  Yao, Y., Pelc, N. J.
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  SPIE-INT SOC OPTICAL ENGINEERING.2015
- **Pulse detection logic for multibin photon counting detectors: beyond the simple comparator**
  Hsieh, S. S., Pelc, N. J.
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  SPIE-INT SOC OPTICAL ENGINEERING.2015
- **First results from a prototype dynamic attenuator system**
  Hsieh, S. S., Peng, M. V., May, C. A., Shunhavanich, P., Pelc, N. J.
  edited by Hoeschen, C., Kontos, D.
  SPIE-INT SOC OPTICAL ENGINEERING.2015
- **Statistical bias in material decomposition in low photon statistics region**
  Rajbhandary, P. L., Pelc, N. J.
  edited by Hoeschen, C., Kontos, D.
  SPIE-INT SOC OPTICAL ENGINEERING.2015

- **Fluid-filled Dynamic Bowtie Filter: a Feasibility Study**
  Shunhavanich, P., Hsieh, S. S., Pelc, N. J.
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  Hsieh, S. S., Pelc, N. J.
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- **Control algorithms for dynamic attenuators.** *Medical physics*
  Hsieh, S. S., Pelc, N. J.
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  Hsieh, S. S., Pelc, N. J.
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  Yao, Y., Wang, A. S., Pelc, N. J.
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  Hsieh, S. S., Heanue, J. A., Funk, T., Hinshaw, W. S., Wilfley, B. P., Solomon, E. G., Pelc, N. J.
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- **The feasibility of a piecewise-linear dynamic bowtie filter** *MEDICAL PHYSICS*
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- **Novel motor design for rotating anode x-ray tubes operating in the fringe field of a magnetic resonance imaging system** *MEDICAL PHYSICS*
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- **Optimized control of a dynamic, pre-patient attenuator**
  Hsieh, S. S., Pelc, N., J.
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- **Dynamic bowtie for fan-beam CT** *JOURNAL OF X-RAY SCIENCE AND TECHNOLOGY*
  Liu, F., Wang, G., Cong, W., Hsieh, S. S., Pelc, N. J.
  2013; 21 (4): 579-590
- **Truncation artifact correction by support recovery** *Conference on Medical Imaging - Physics of Medical Imaging*
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