



XACT for Radiological Imaging and Radiotherapy

Liangzhong (Shawn) Xiang

Associate Professor

Department of Radiological Sciences &
Department of Biomedical Engineering &
Beckman Laser Institute & Medical Clinic &
Chao Family Comprehensive Cancer Center

University of California, Irvine

Present at the





Wilhelm Conrad Röntgen



1895

X-Rays Discovered



1908

Radiation therapy



1900

1930

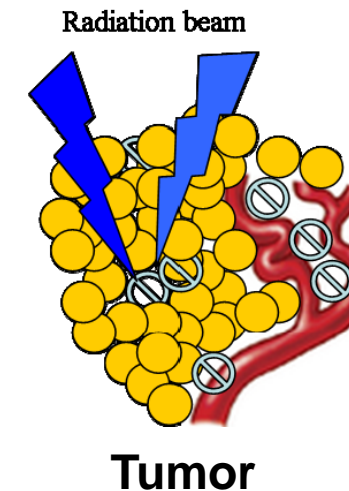
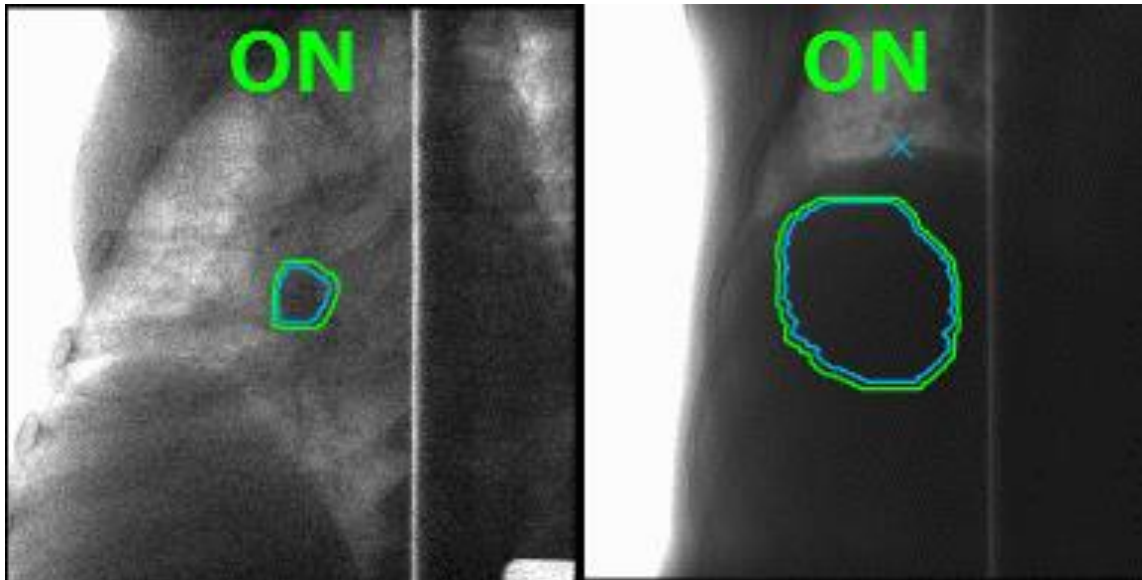
1960

1990

2020

- **Intratumoral dosimetry in radiation therapy**

- RT is received by over 14 million people a year (50 – 60% of total cancer patients).
- No visualize of the radiation beam in patient
- No dose verification on the tumor in patient





Wilhelm Conrad Röntgen



1895

X-Rays Discovered

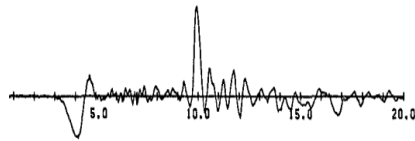


1908

Radiation therapy

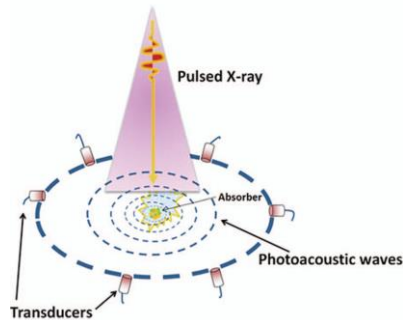


Emil Grubbe



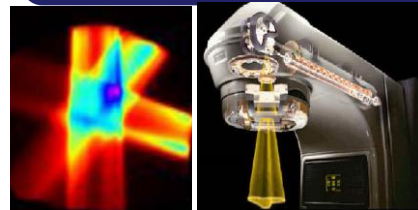
1983

X-ray acoustics

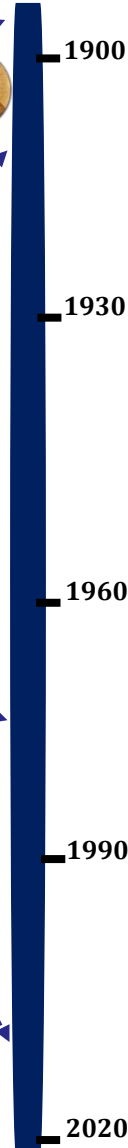


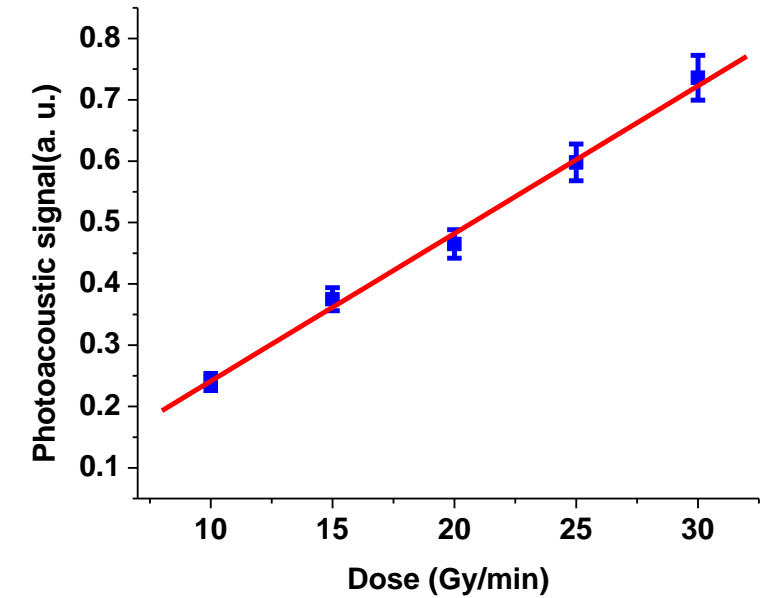
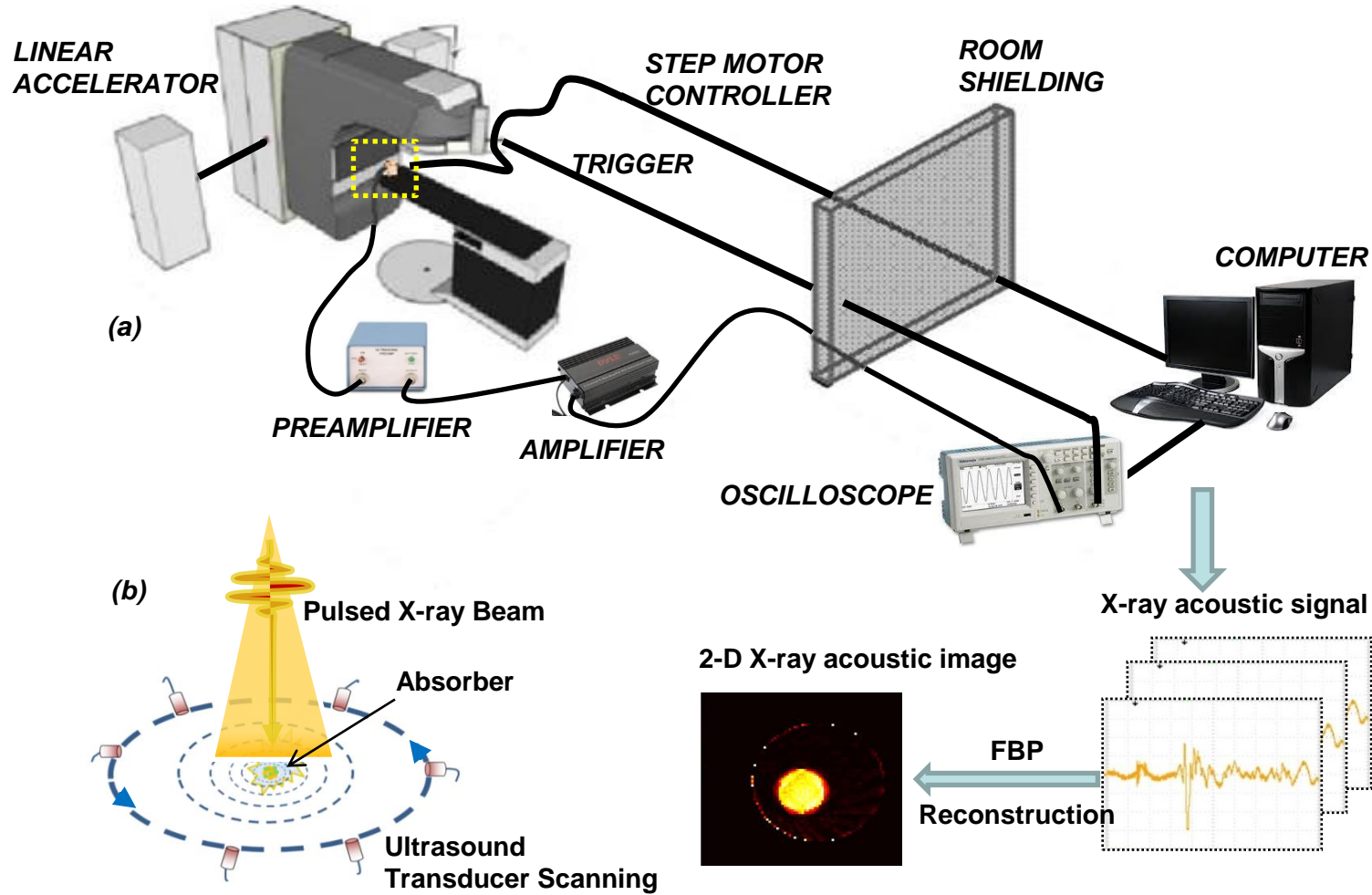
2013

XACT imaging for RT

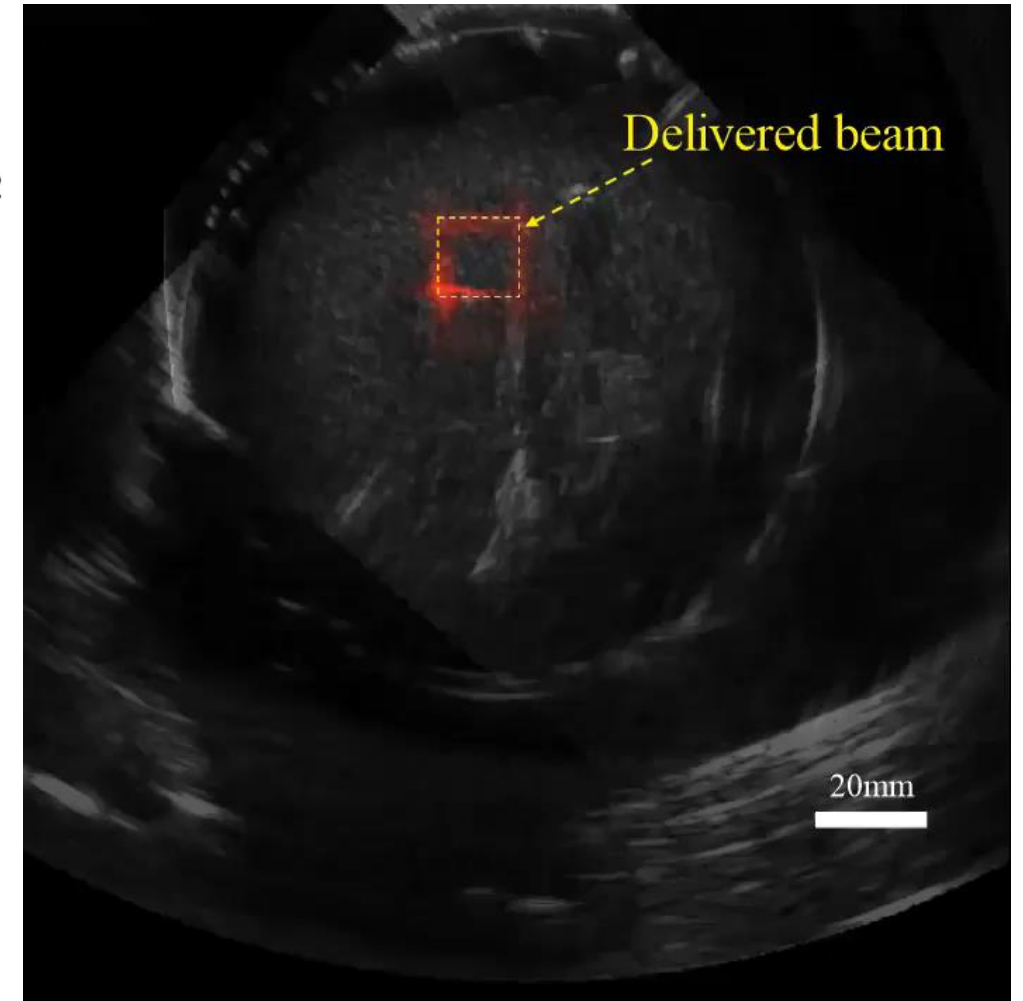
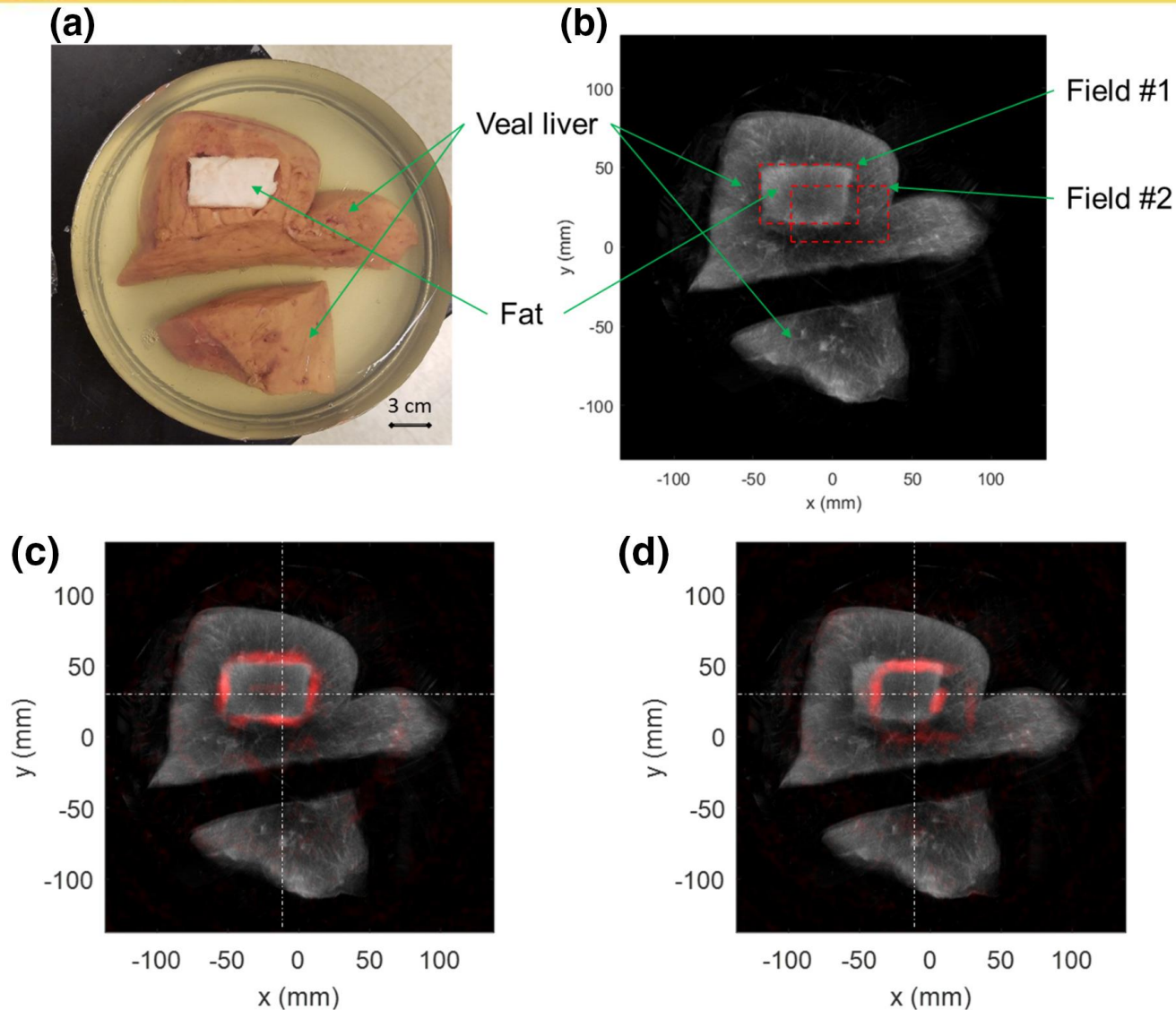


LINAC



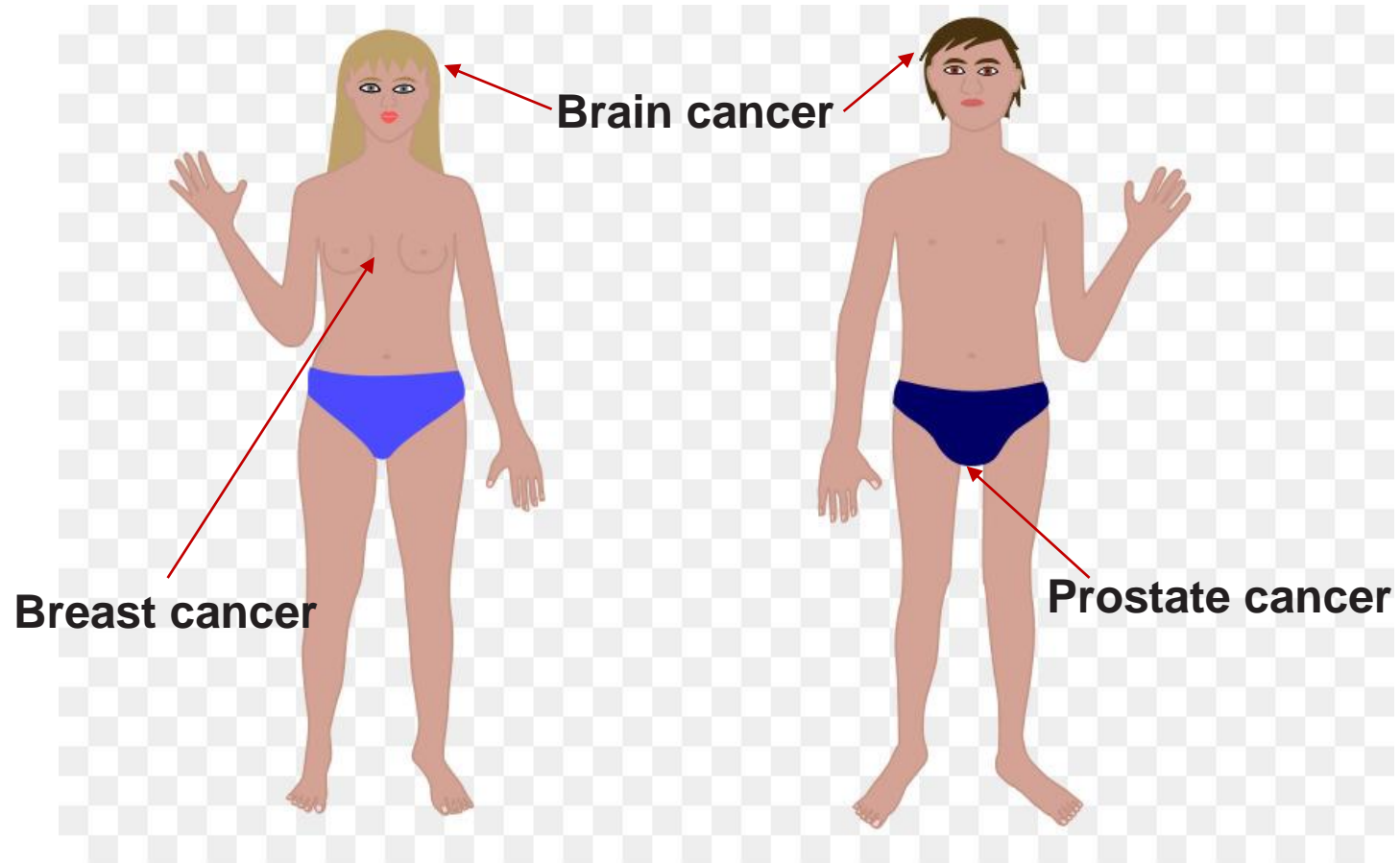


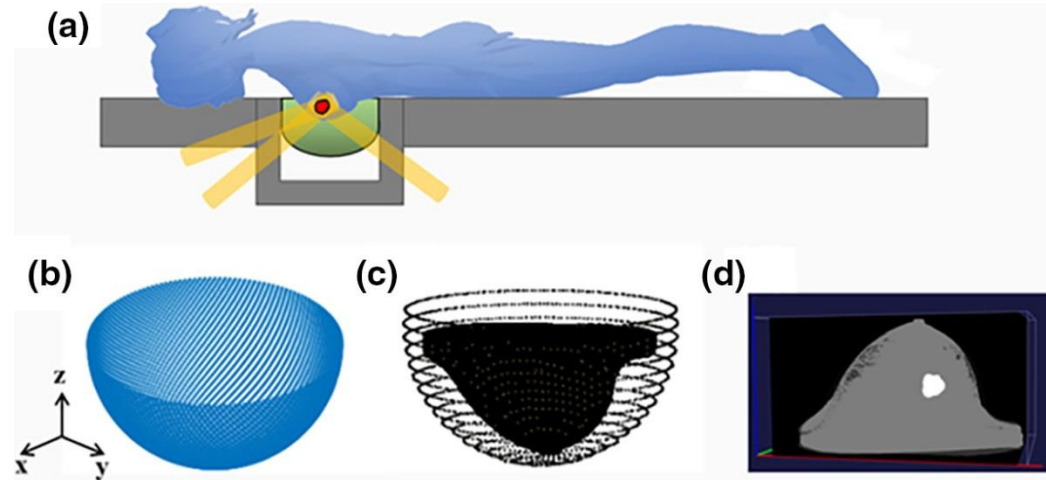
Liangzhong Xiang, et al. X-ray acoustic computed tomography with pulsed X-ray beam from a medical linear accelerator, **Medical Physics**, 40 (1),010701 (2013). (Cover of Medical Physics)



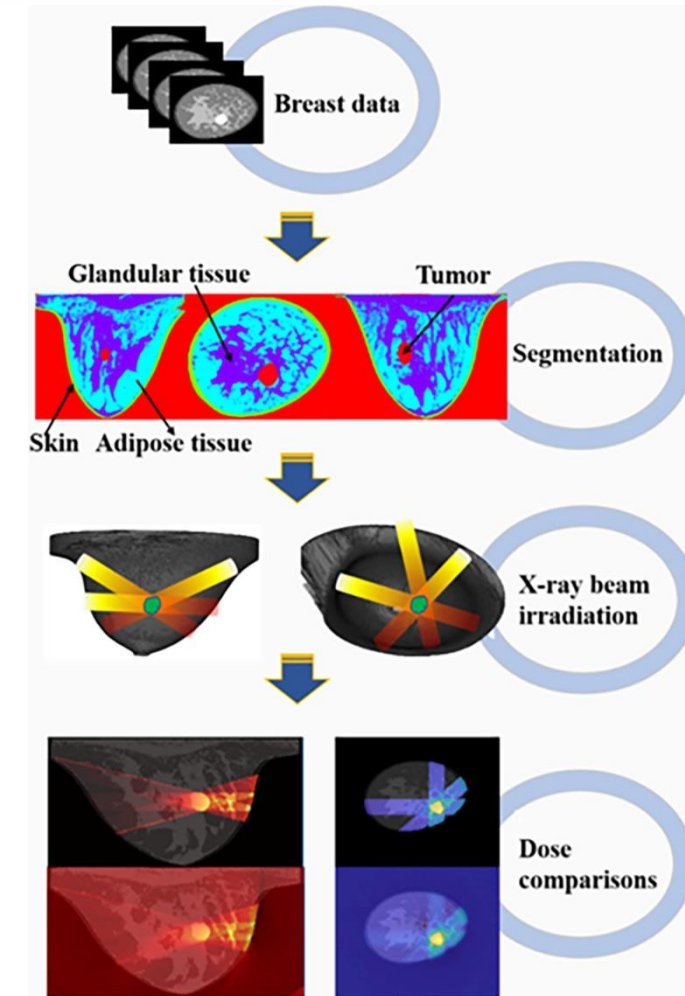
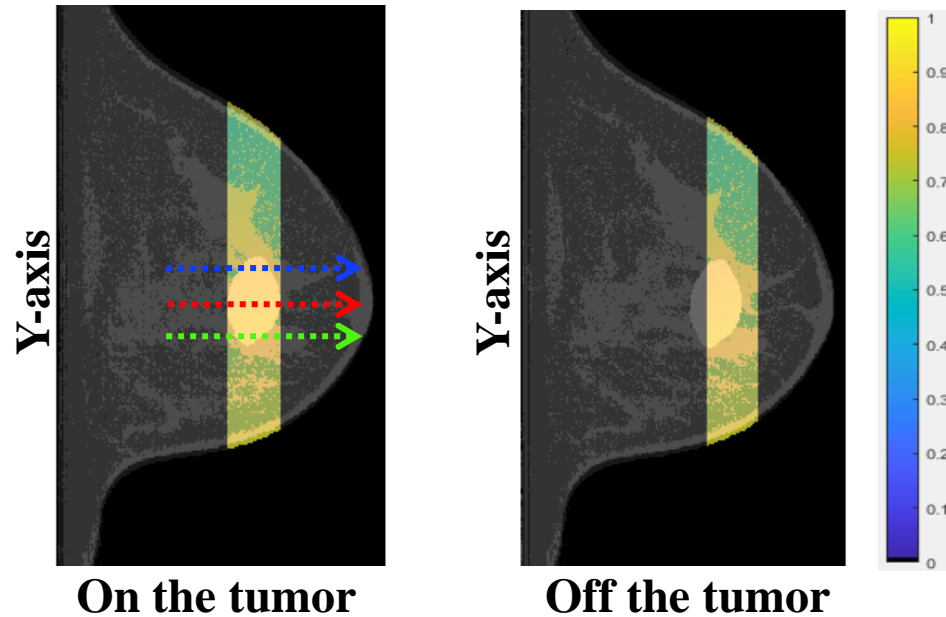
Xueding Wang Issam El Naqa et al., *Medical Physics*, (2018)

Wei Zhang, *et al.* Dual-Modality X-Ray-Induced Radiation Acoustic and Ultrasound Imaging for Real-Time Monitoring of Radiotherapy, *BME Frontiers*, 26 May (2020).



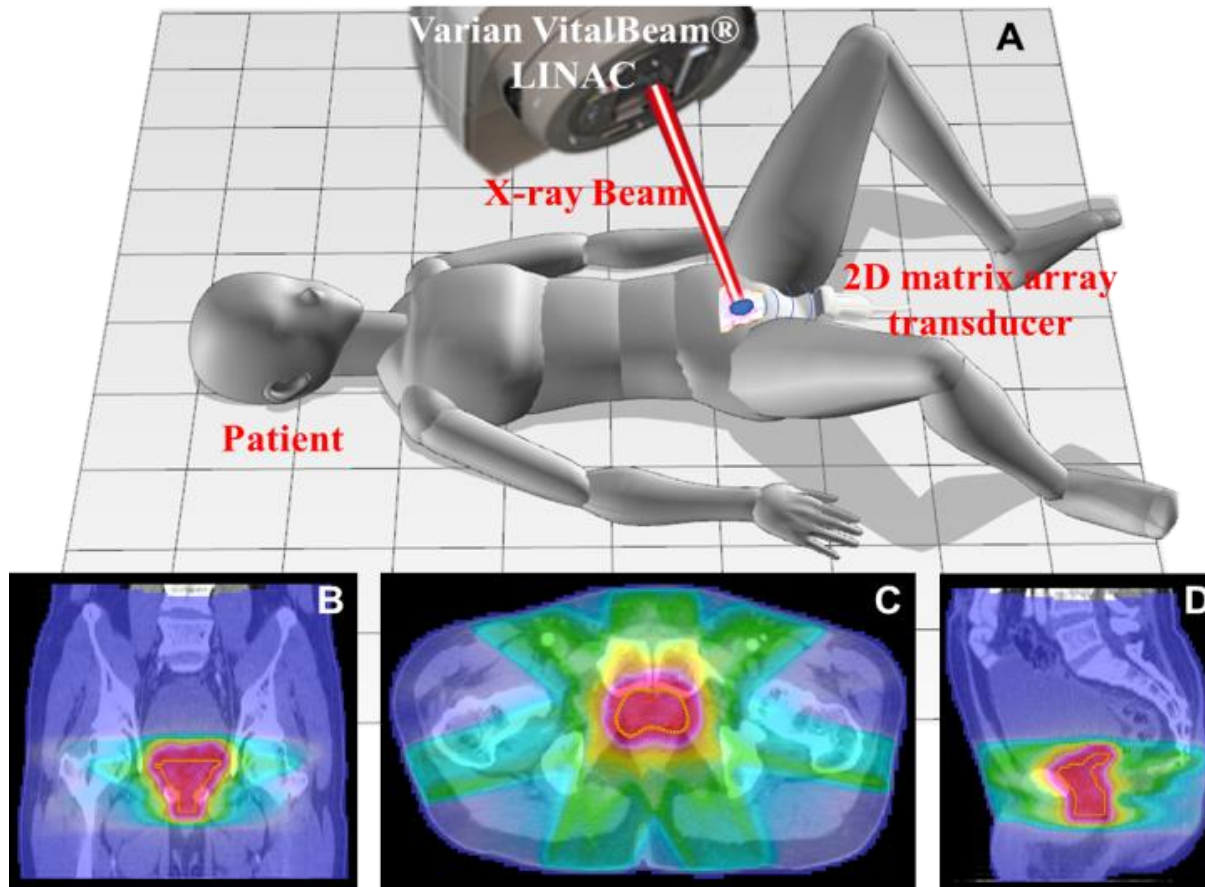


XACT Image-guided breast radiotherapy

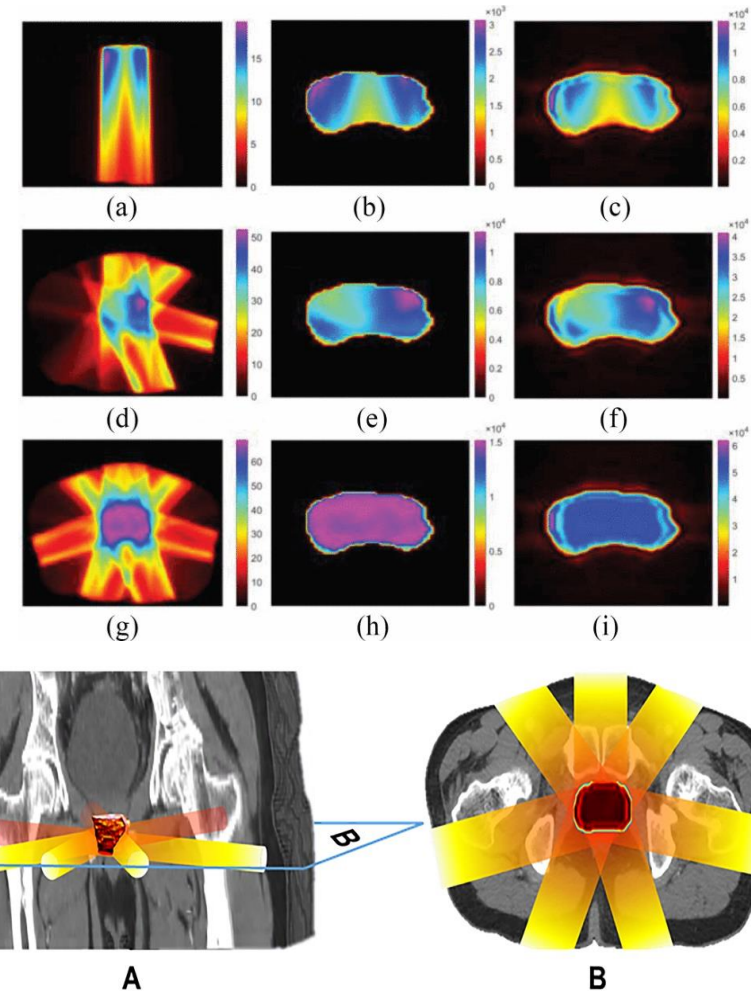


Flow chart

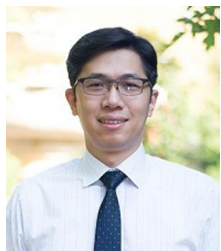
Yue Zheng, *et al.* X-ray Induced Acoustic Computed Tomography for Guiding Prone Stereotactic Partial Breast Irradiation: A Simulation Study, **Medical Physics**, 19 May (2020).



Prostate radiotherapy



Dose monitoring



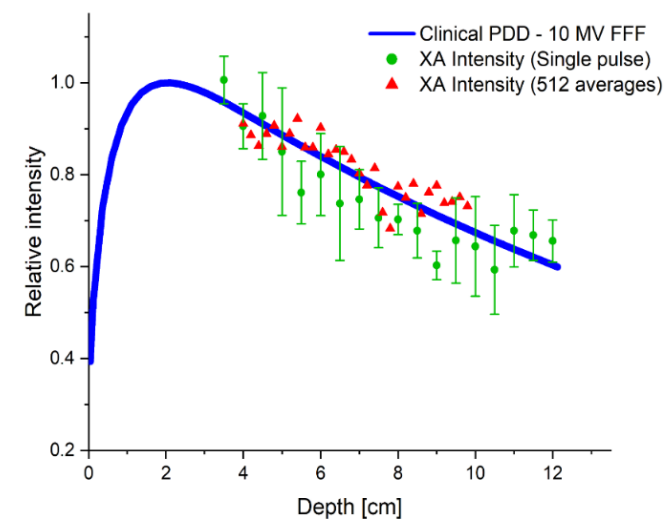
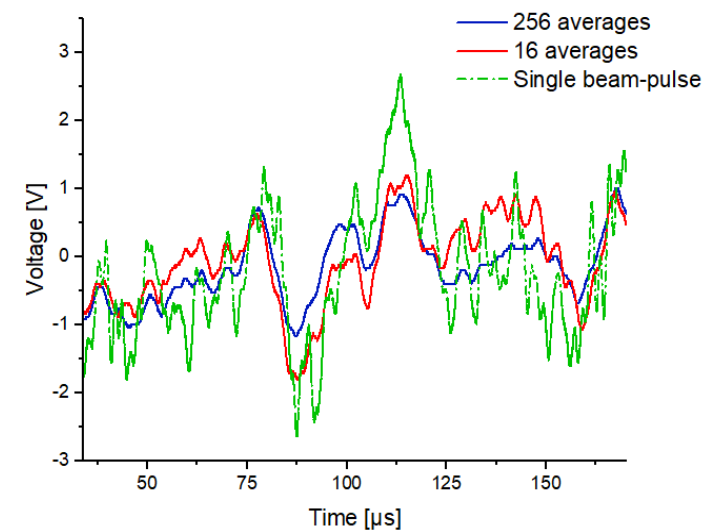
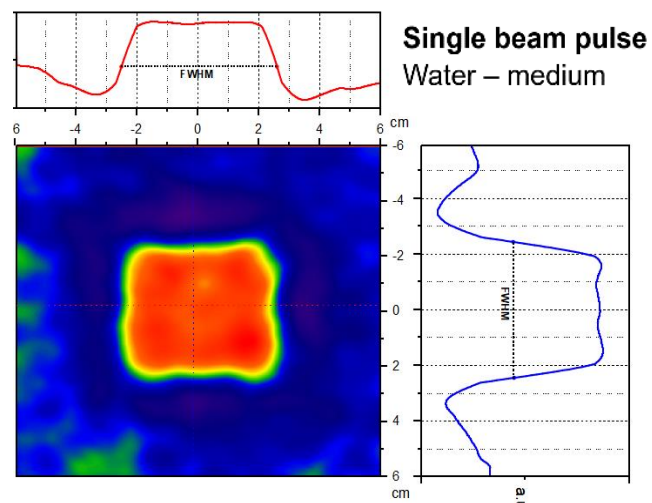
Yong Chen, Ph.D. DABR

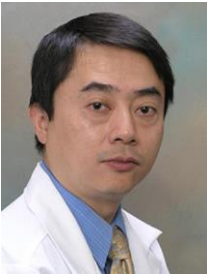


Gilberto Gonzalez

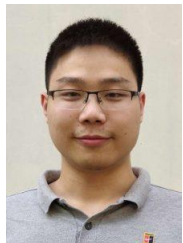


Kiana Prather





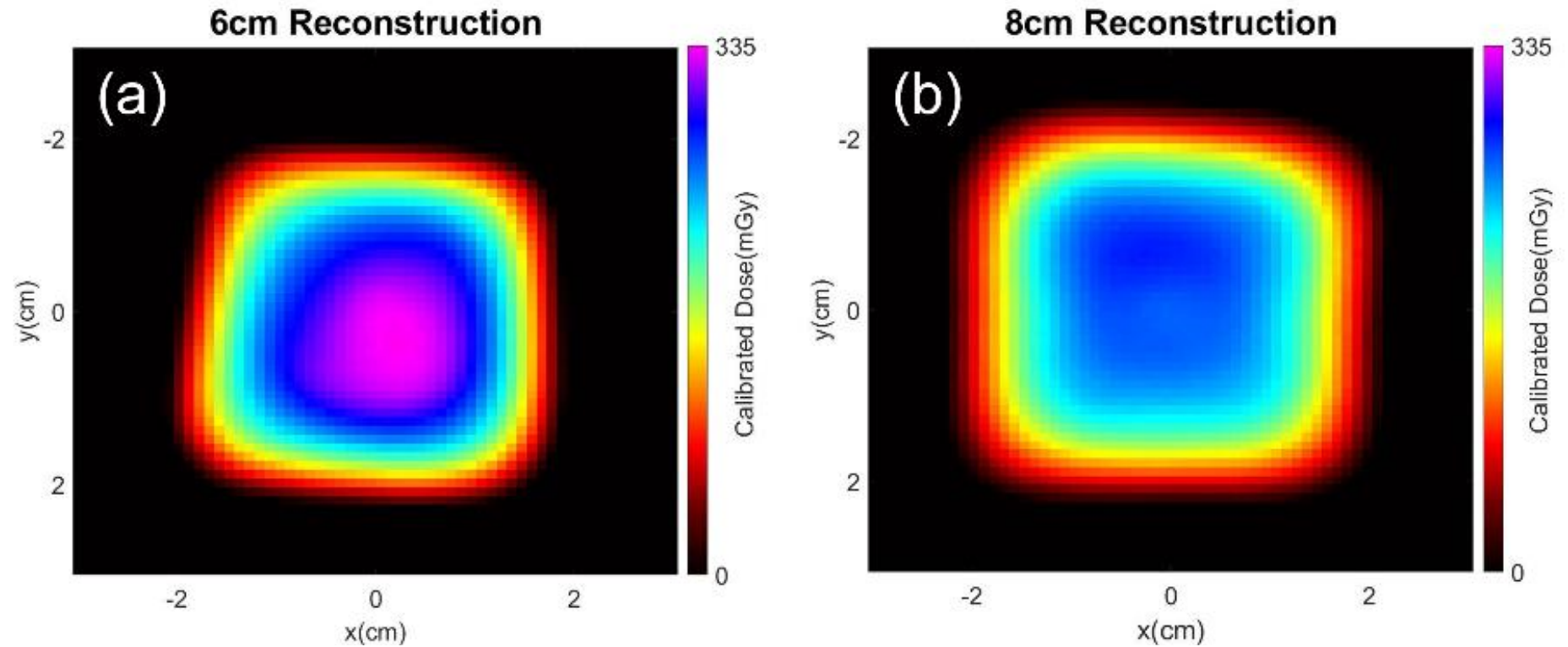
An Liu, Professor and Director
Division of Radiation Physics



Leshan Sun



Kristina Bjegovic



Leshan Sun, *et al.* Towards Quantitative Intraumoral Dosimetry Using XACT. **Medical Physics**, under review (2022).



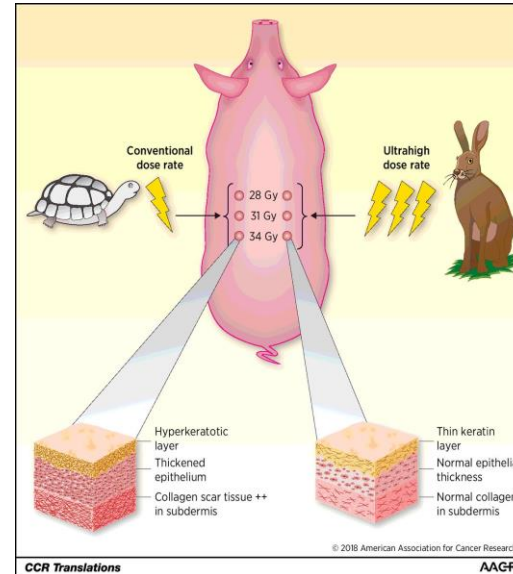
Charles Limoli, Ph.D.



Vozenin Marie-Catherine, Ph.D.

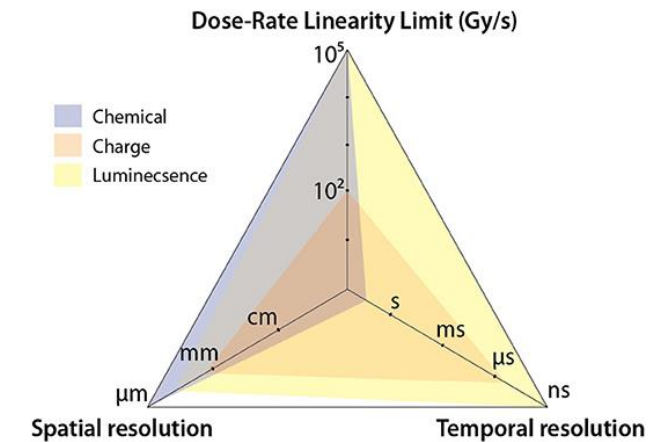
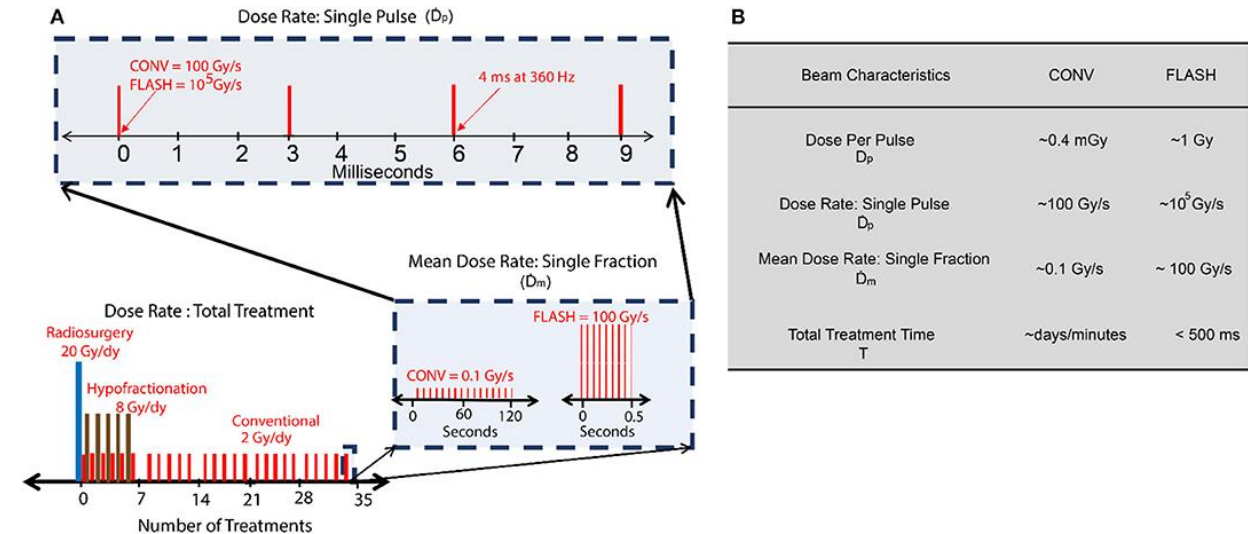


Rick van Bergen

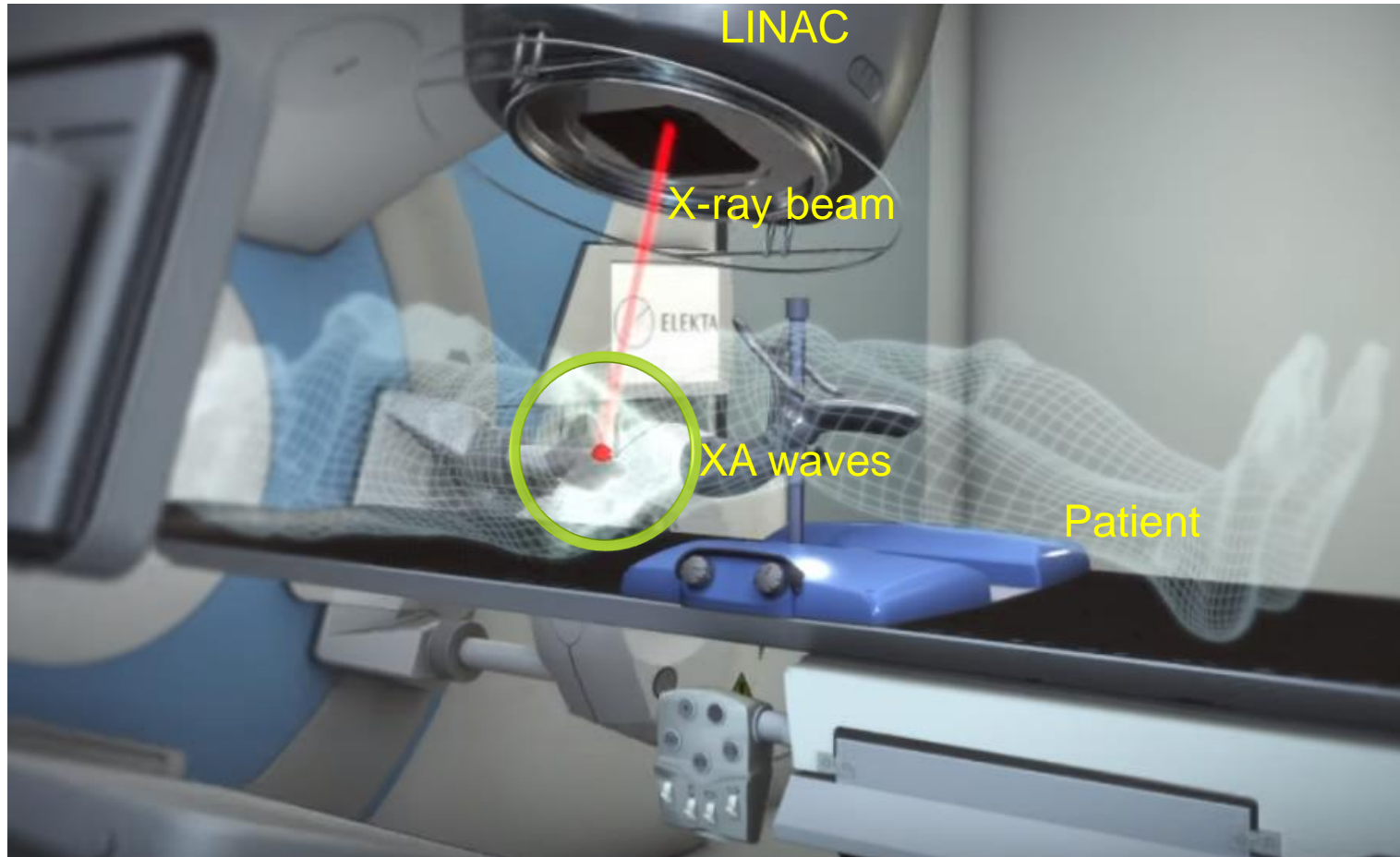


FLASH-RT

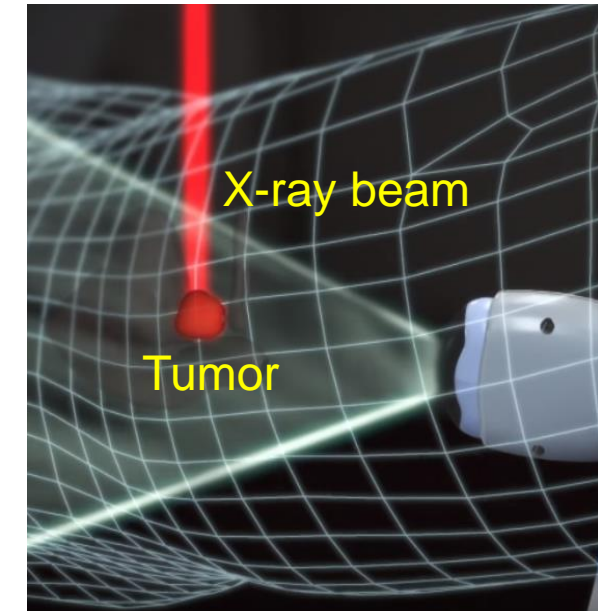
Kevin J. Harrington. Ultrahigh Dose-rate Radiotherapy: Next Steps for FLASH-RT, **Clin Cancer Res**; 25(1) January 1, 2019.



Ashraf, Muhammad Ramish, et al. "Dosimetry for FLASH radiotherapy: a review of tools and the role of radioluminescence and Cherenkov emission." *Frontiers in Physics* 8 (2020): 328.



External radiation therapy for prostate cancer



Treat the cancer precisely !



Wilhelm Conrad Röntgen



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*First clinical use of x-rays
by physicians*

Don't talk to me about
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Thomas Edison, whose assistant died from X-ray exposure

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First CT scan



CT Scanner

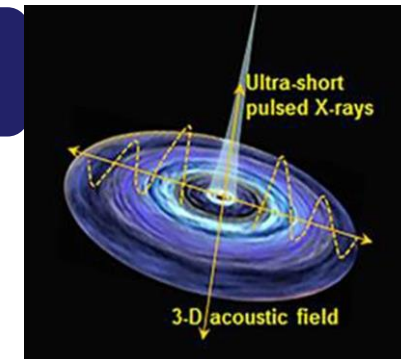
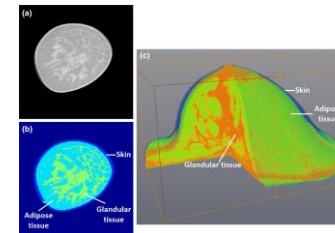
Godfrey N. Hounsfield Allan M. Cormack

1960



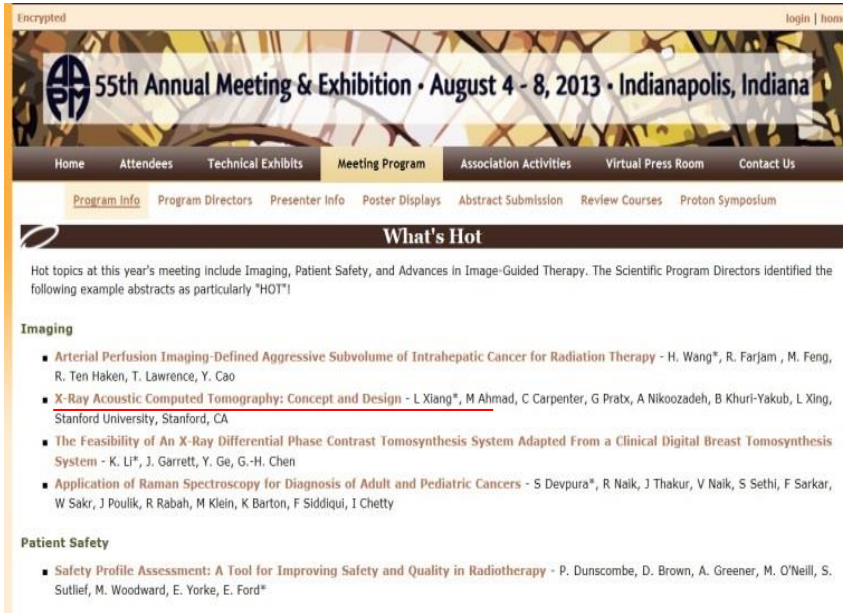
2016

XACT imaging for DR



1990

2020

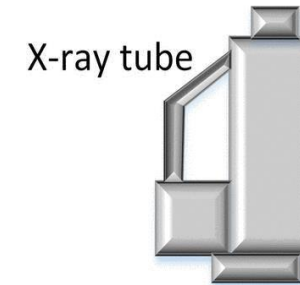
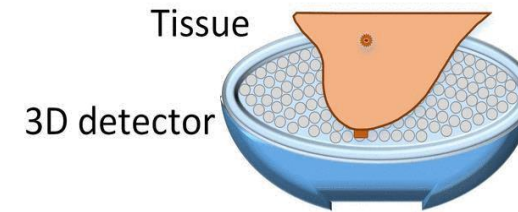


Hot Topic

- Measure density of the material.

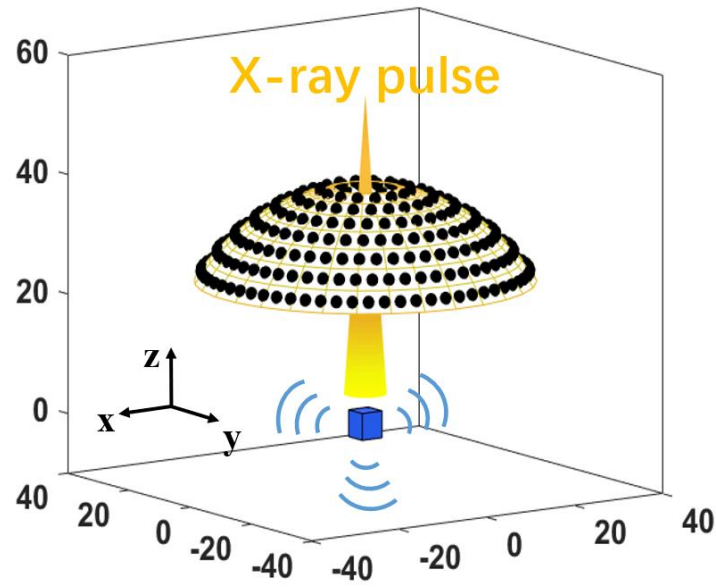


RSNA Award 2015

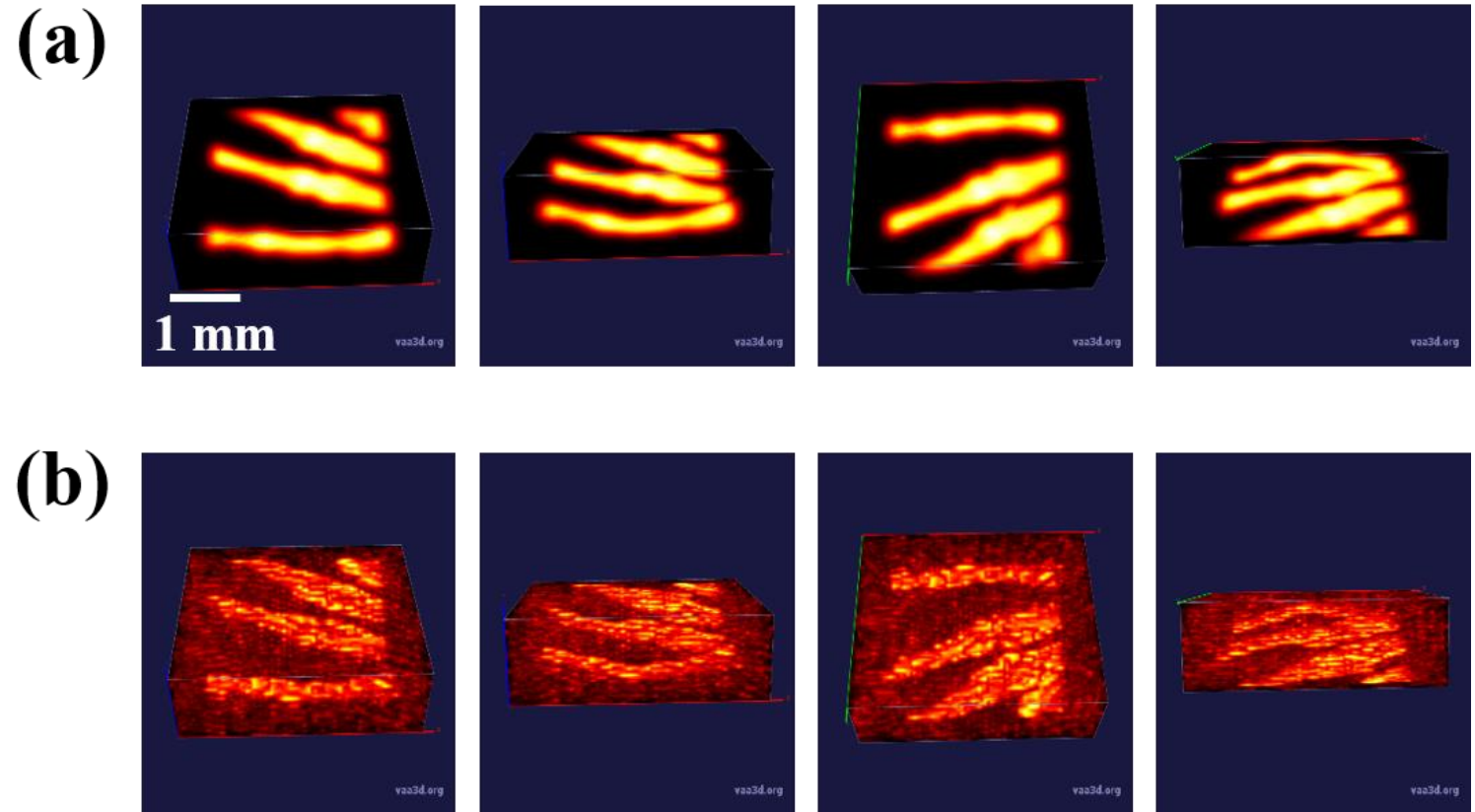


$$p_0 = \Gamma \mu F = \frac{\Gamma \eta_{th}}{\tau_p} \rho D$$

3D XACT Imaging



Schematic drawing of XACT scanner for bone imaging

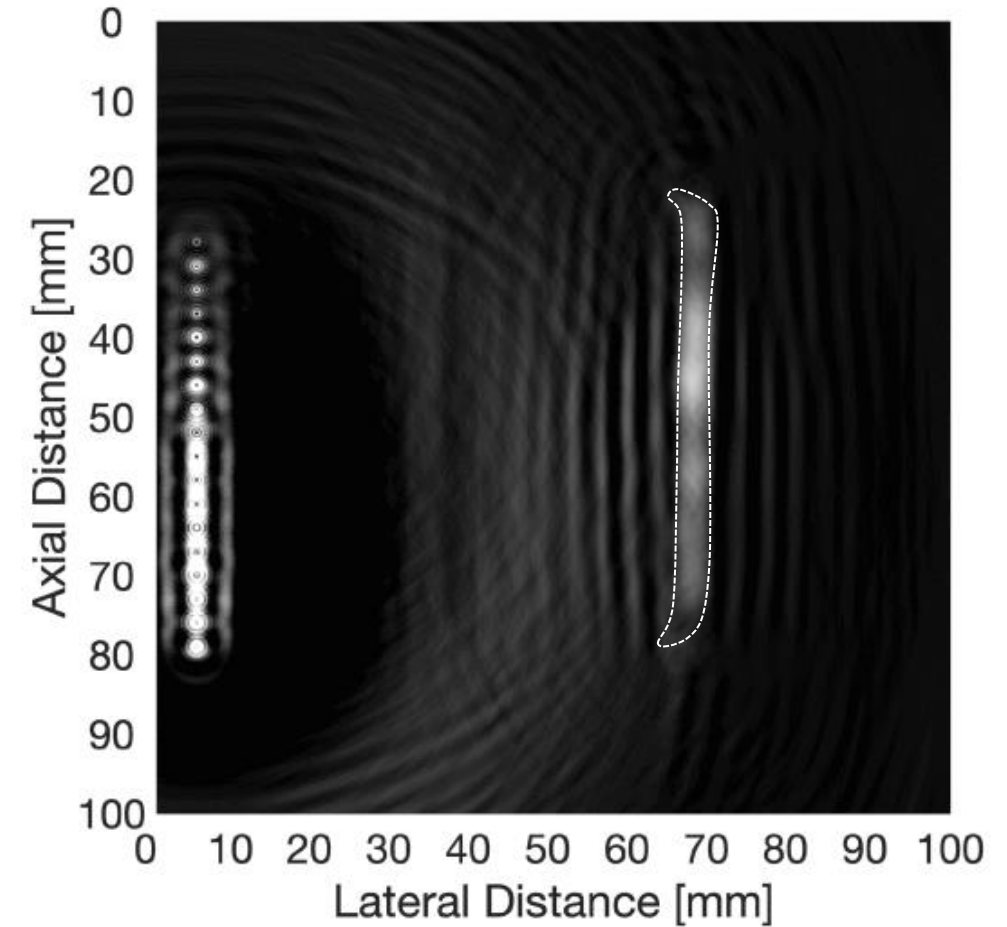
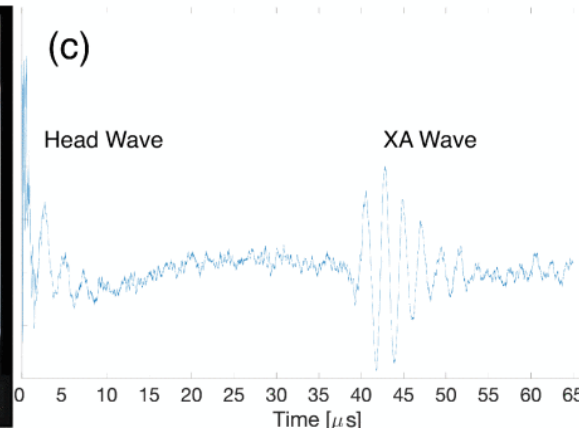
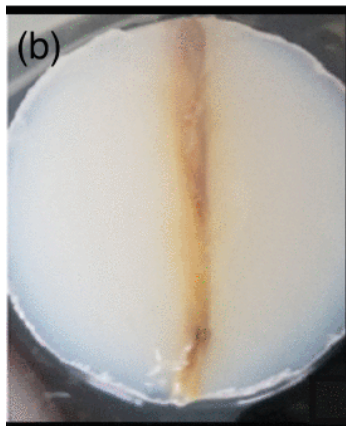
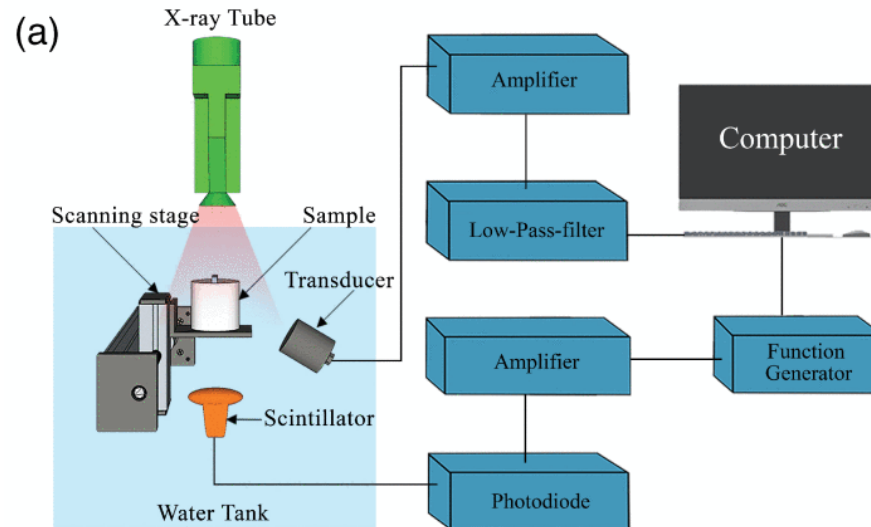


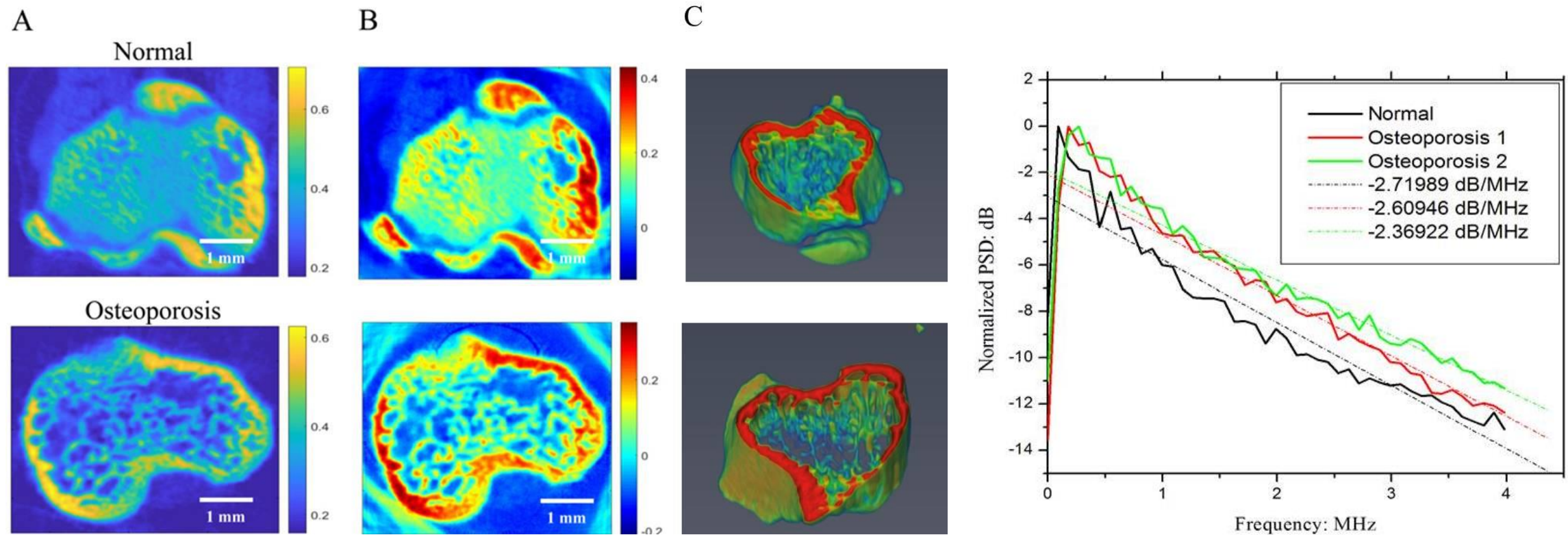
3D XACT imaging reconstruction on a mouse paw

Yang Li, *et al.* 3D X-ray-induced Acoustic Computed Tomography with a Spherical Array: A Simulation Study on bone imaging, **Transactions on Ultrasonics, Ferroelectrics, and Frequency Control**, 06 April (2020).

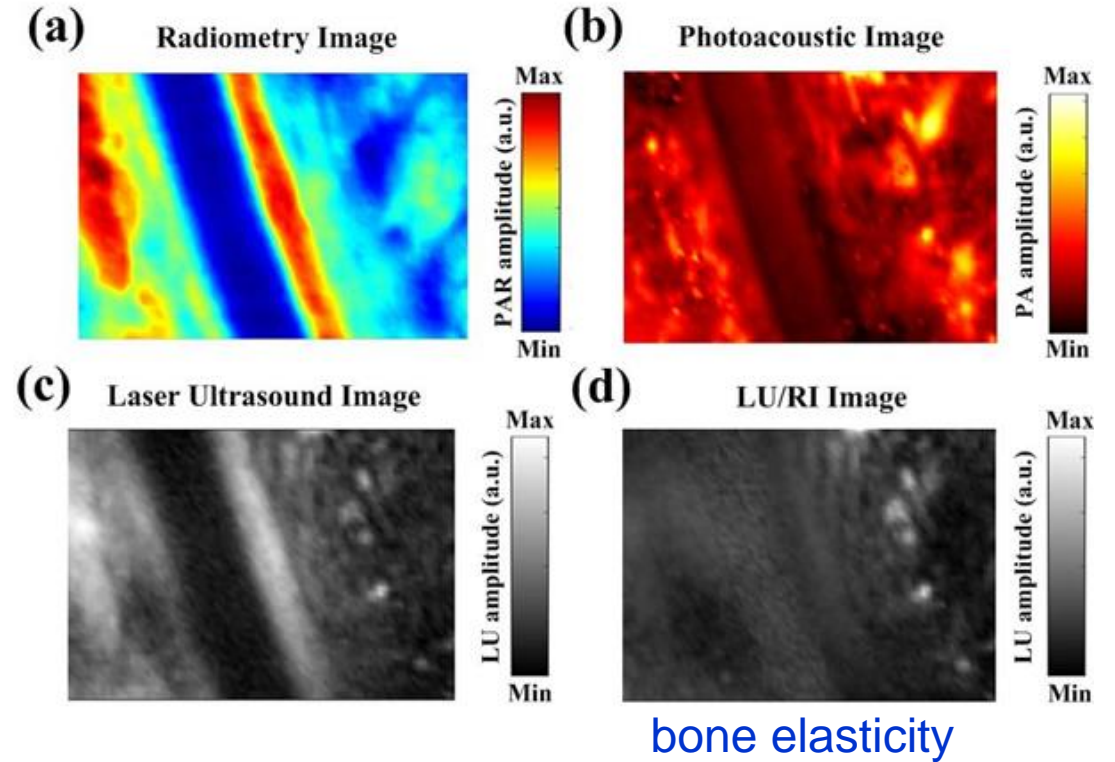
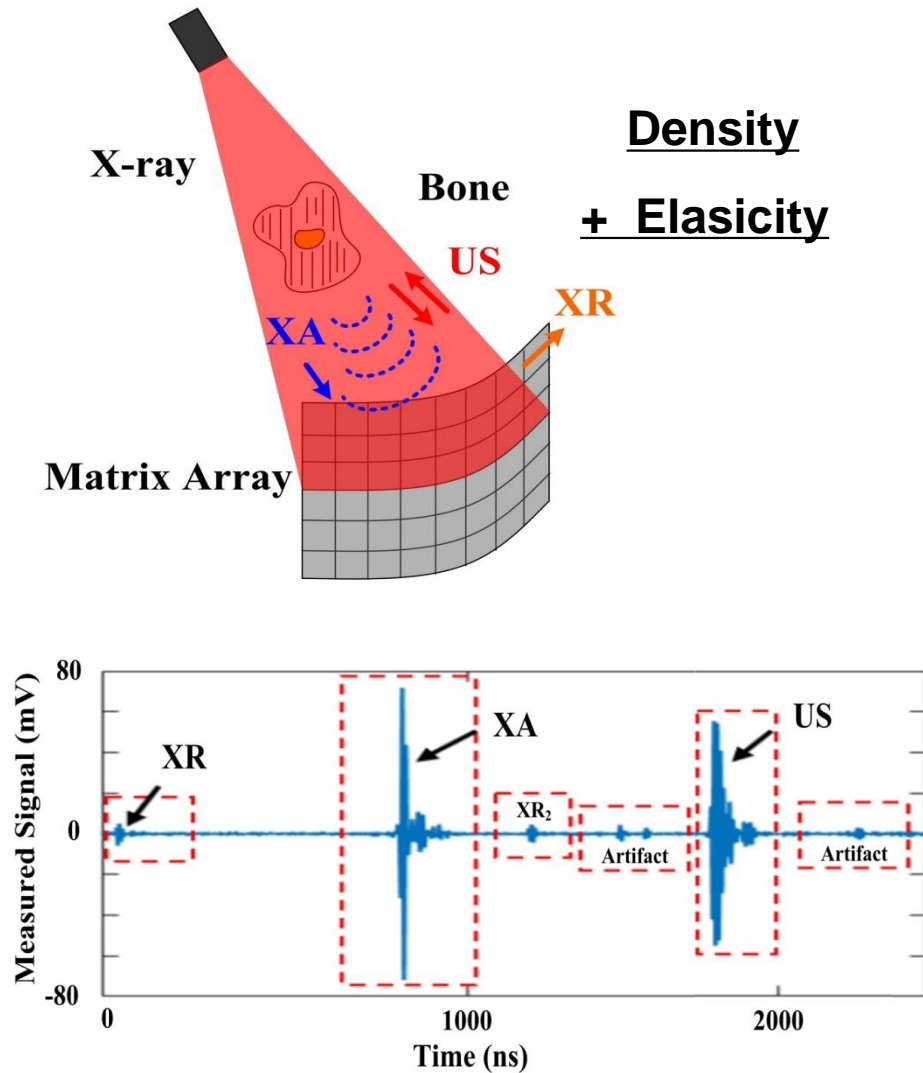


Elijah Robertson





Yizhou Li, *et al.* The feasibility study of X-ray acoustic computed tomography for characterizing osteoporosis, **Medical Physics**, Accepted (2022).



Yue Zhao *et al.* Triplex radiometric, photoacoustic and ultrasonic imaging based on single-pulse excitation. **Optical Letters**, February (2020).



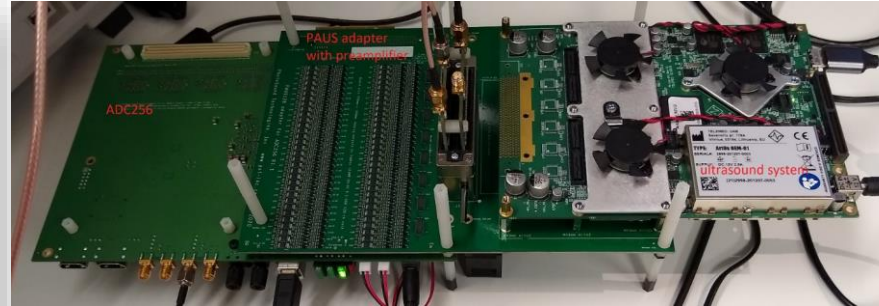
Vassili Ivanov, Ph.D.



Siqi Wang



Siqi Wang, Vassili Ivanov, Prabodh Kumar Pandey, Liangzhong Xiang. X-ray-induced acoustic computed tomographic imaging with single-shot nanosecond X-ray, **Applied Physics Letters**, 119, 183702 (2021).

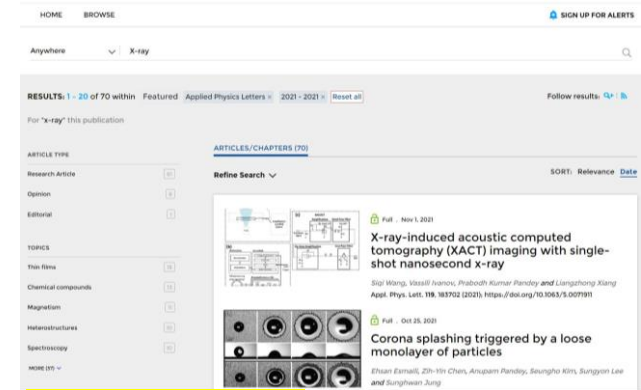


Dedicated Pre-amplifiers



Dual modal XACT/US imaging system

AIP AIP Publishing



Featured by AIP

AIP Scilight

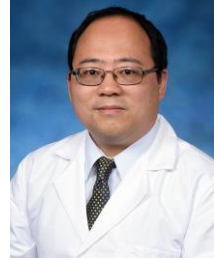


Scilight by AIP

Siqi Wang, *et al.* X-ray-induced acoustic computed tomographic imaging with single-shot nanosecond X-ray, **Applied Physics Letters**, Accepted (2021).



Dr. Prabodh Pandey



Lei Ren, PhD



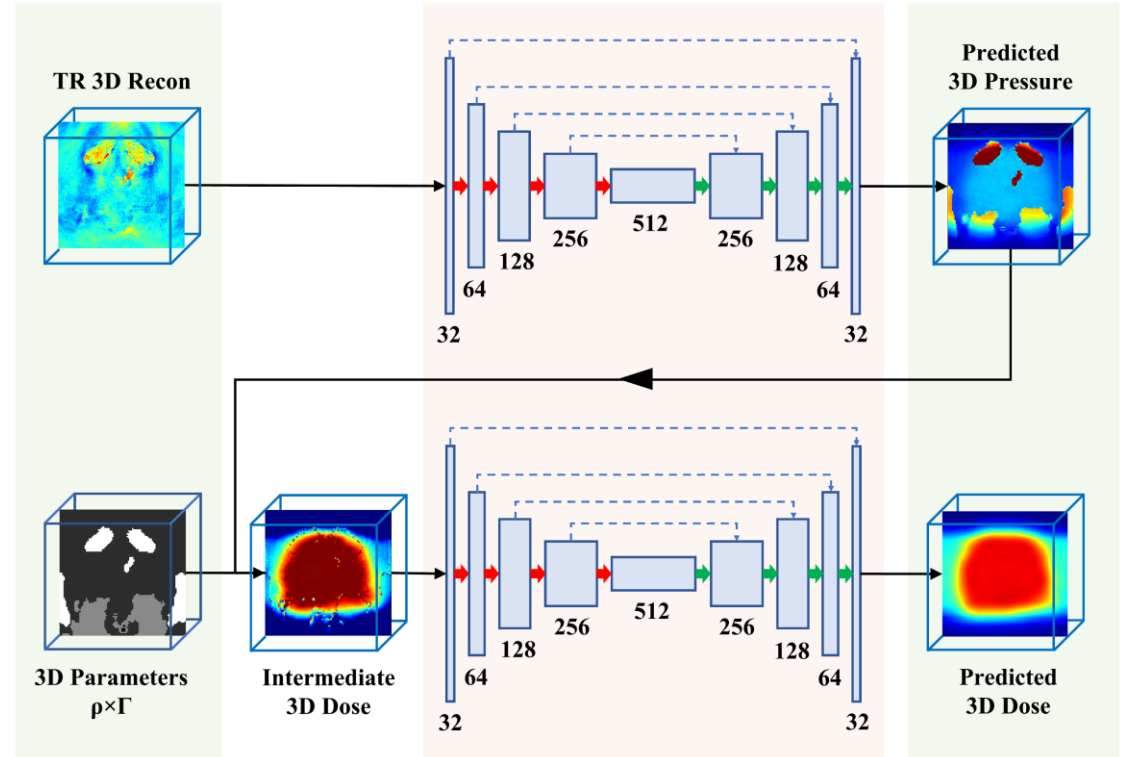
Zhuoran Jiang

Algorithm 1 Matrix-free computation of the product of model-matrix \mathbf{M} with an arbitrary vector \underline{u}

```

1: procedure COMPUTING  $\underline{p} = \mathbf{M}\underline{u}$ 
2:    $\underline{p} = []$  (Initialization by null-vector)
3:   for  $i_d = 1$  to  $N_d$  do
4:      $\underline{e} \leftarrow \hat{\mathbf{E}}\{i_d\}; \underline{t} \leftarrow \hat{\mathbf{T}}\{i_d\}; \mathbf{N} \leftarrow \hat{\mathbf{N}}\{i_d\}$ 
5:      $\mathbf{R} \leftarrow t(\underline{e}, :)$   $\triangleright$  global node numbers (in the columns) for all the contributing spatial elements
6:      $\mathbf{H} \leftarrow \underline{u}(\mathbf{R})$   $\triangleright$  values of  $\underline{u}$  at the indices contained in  $\mathbf{R}$ 
7:      $\mathbf{V} \leftarrow \mathbf{N} * \mathbf{H}; \underline{J} \leftarrow \sum_{i=1}^3 \mathbf{V}(:, i)$   $\triangleright$  row-wise summation
8:      $\underline{I} \leftarrow \text{sparse}(1, \underline{t}, \underline{J}, 1, N_t)$   $\triangleright$  assembly of the integral vector using MATLAB's sparse function
9:      $\underline{p} \leftarrow \left[ \underline{p}^T, \frac{I(2:N_t), 0] - [0, I(1:N_t-1)]}{2} \right]^T$ 
10:   end for
11:   return  $\underline{p}$ 
12: end procedure
  
```

Model Inputs



Prabodh Kumar Pandey, *et al.* Model based X-ray Induced Acoustic Computed Tomography, **IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control**, 2021 Jul 26 (2021).

Zhuoran Jiang *et al.* Intratumoral Dose Verification in Prostate Proton Therapy with Deep Learning-based 3D Proton-acoustic Imaging, **Physics in Medicine & Biology**, submitted (2022).



Wilhelm Conrad Röntgen



1895

X-Rays Discovered

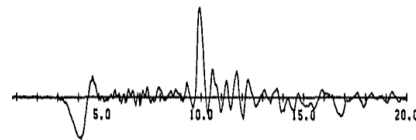


1908

Radiation therapy

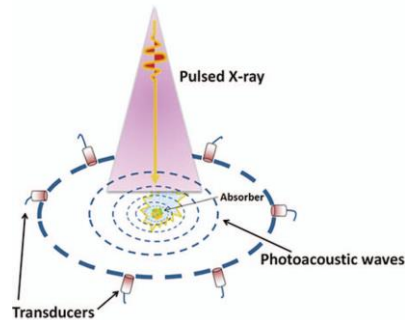


Emil Grubbe



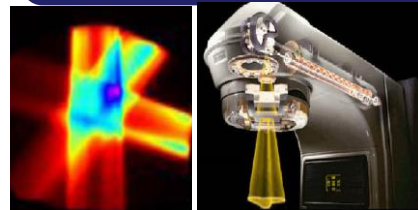
1983

X-ray acoustics



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LINAC

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First clinical use of x-rays by physicians

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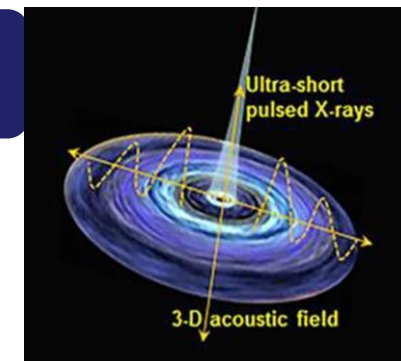
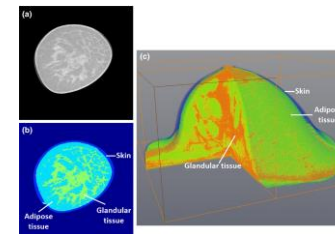
Allan M. Cormack

1960



2016

XACT imaging for DR



2020

Scientist/ Postdocs:



Dr. Prabodh Pandey



Dr. Taehoon Kim

Lab Alumni



Pratik Samant



Kiana Prather



Shanshan Tang



Jesse Echeverry



Elijah Robertson

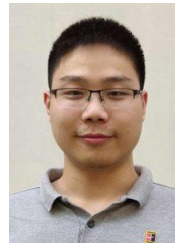
Graduates:



Siqi Wang



Kristina Bjegovic



Leshan Sun



Kaitlyn Kim



Yifei Xu



Salile Khandani



Yuchen Yan



Rick van Bergen

Medical physicist/MD:



Gilberto Gonzalez



Kiana Prather



Joe Caron

Undergraduates:



Chloe Chua



Michelle Simon



Raymond Liu



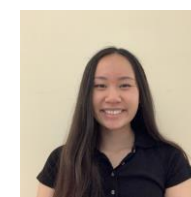
Ryan Johnson



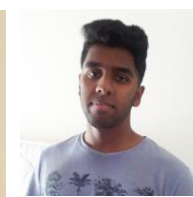
Noah Bailey



Gerald Lee



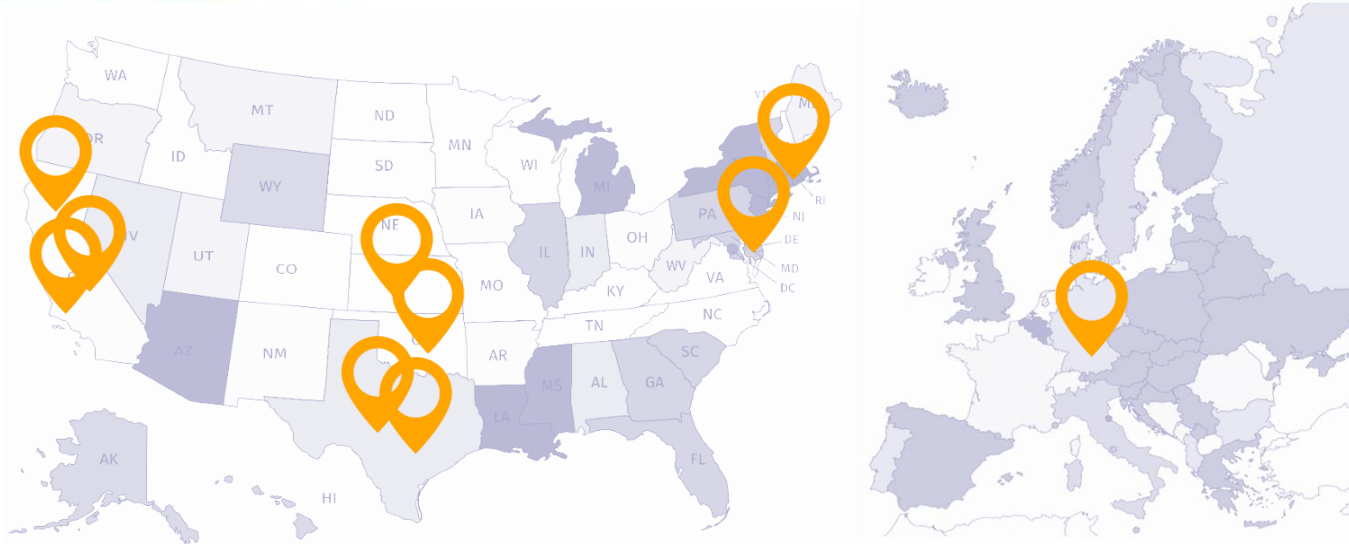
Kathy Duong



Sujal Bobba



Sean Crowley



➤ **University of Maryland:**

- Lei Ren, Ph.D. (Radiation Oncology)

➤ **Mevion:**

- Townsend Zwart, Ph.D. (VP)

➤ **Switzerland:**

- Vozenin Marie-Catherine, Ph.D.

➤ **UC Irvine :**

- Charles L Limoli, Ph.D. (Radiation Oncology)
- Thomas Milner, Ph.D. (Beckman Laser)
- Zhongping Chen, Ph.D. (BME)
- Vahid Yaghmai, MD, MS, FSAR. (Radiology)

➤ **City of Hope:**

- An Liu, Ph.D. (Radiation Oncology)

➤ **Lawrence Berkeley National Laboratory:**

- Tobias Ostermayr, Ph.D. (Physicist)
- Jeroen van Tilborg, Ph.D.(Physicist)

➤ **OUHSC :**

- Yong Chen, Ph.D. (Medical Physics)
- Salahuddin Ahmad, Ph.D.(Medical Physics)

➤ **Kansas Medical Center:**

- Hao Gao, Ph.D.
- Yuting Lin, Ph.D.

➤ **PhotoSound Technologies, Inc.:**

- Sergey Ermilov, Ph.D. (CEO)
- Vassili Ivanov, Ph.D. (CTO)

- **NIH/NCI**

R37 CA240806: XACT for RT



**NATIONAL
CANCER
INSTITUTE**

- **NIH/NHLBI**

R01HL163582: photoacoustics



National Heart, Lung,
and Blood Institute

- **ACS** | American Cancer Society
Cancer Research Scholar Grants : XACT for RT



- **UCI fund**

UCI

University of California, Irvine

- Dr. Liangzhong (Shawn) Xiang has an equity interest in Medical Mind Inc. Medical Mind Inc. develops XACT/US devices. The research findings on XACT imaging presented here are not related to any products or services currently provide by Medical Mind Inc.

Lab website: <https://truelab.som.uci.edu/>



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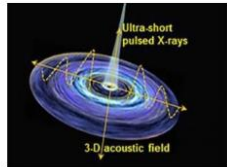
Home



Radiation-induced acoustics just like relay games

< Next >

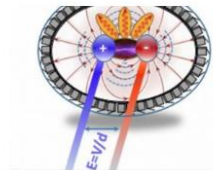
Seeing the Invisible Radiations via Ultrasound Emission



X-ray-induced acoustic computed tomography (XACT)



Proacoustic Tomography (PAT)



Electroacoustic Tomography (EAT)

JOB OPENINGS:

- 1 Postdoctoral
- 2 Predoctoral



Thank you!