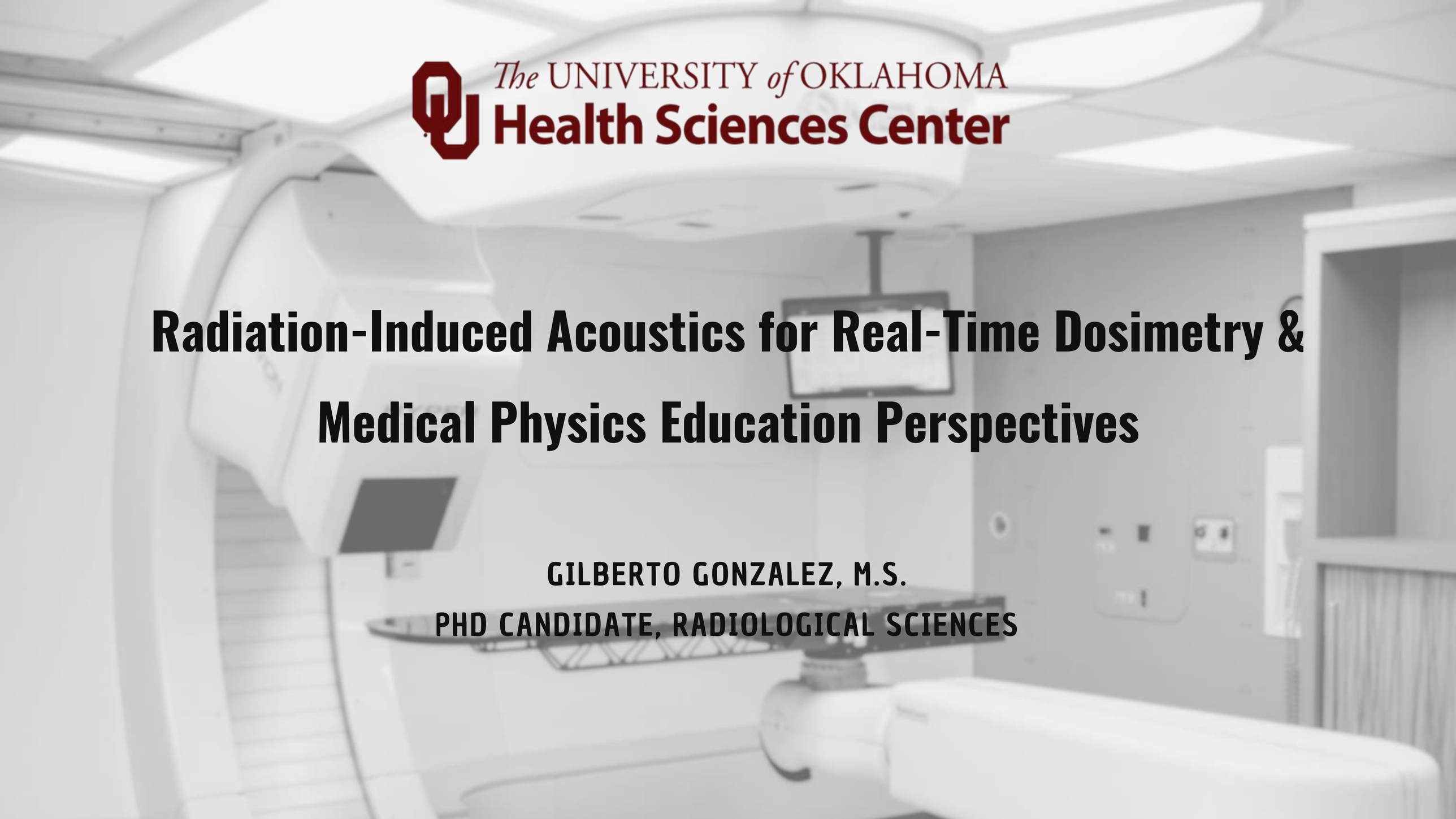


The UNIVERSITY of OKLAHOMA
Health Sciences Center

Radiation-Induced Acoustics for Real-Time Dosimetry & Medical Physics Education Perspectives

GILBERTO GONZALEZ, M.S.
PHD CANDIDATE, RADIOLOGICAL SCIENCES

OUTLINE

I. PERSPECTIVES OF MEDICAL PHYSICS: MEXICO, GERMANY, USA

- Education and programs
- Residency
- Certifications (ABR, Fachkunde, IOMP)
- About OUHSC

II. RADIATION-INDUCED ACOUSTICS FOR DOSE MONITORING

- Goal of Adaptive Radiotherapy
- Radiation- Induced Acoustic (RIA) Imaging
- Studies with Linac and Synchrocyclotron
- OUHSC research
- Questions

Disclaimer

- All what is shared in this presentation are personal experiences and **may not necessarily** represent the interest of OUHSC, AAPM, nor other organizations mentioned.

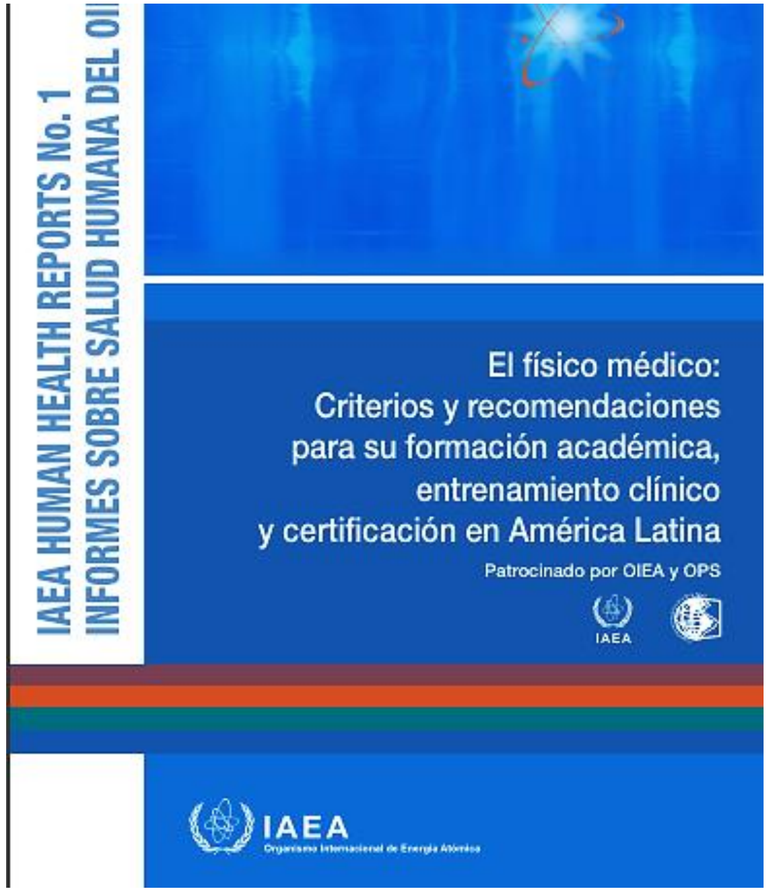
- All **presented research** was performed between OUHSC and UCI under a NIH grant.

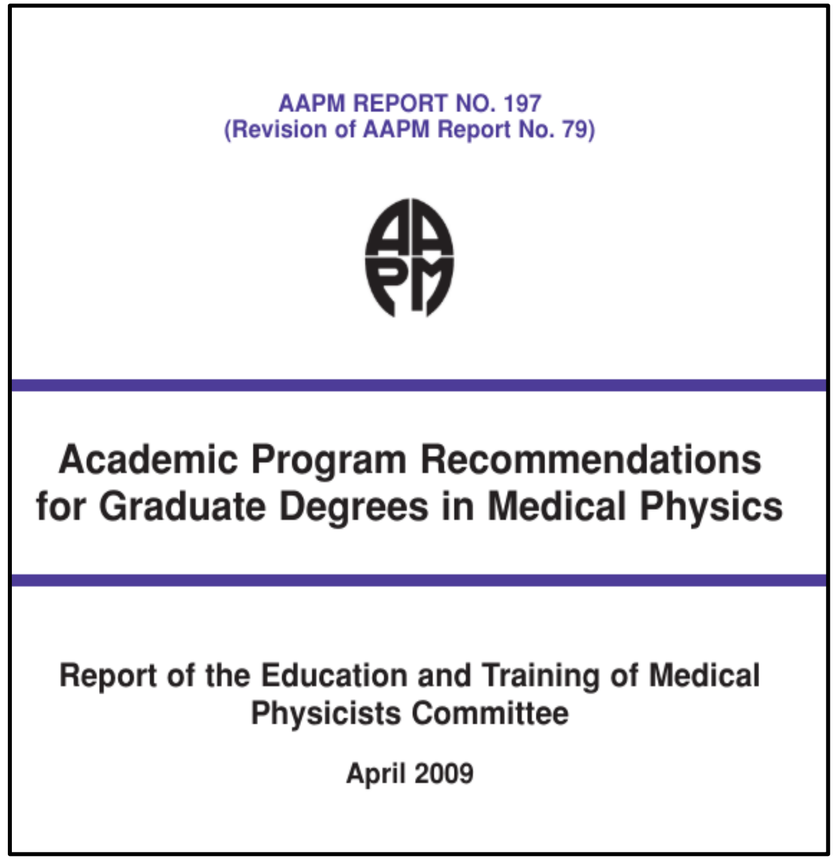
EDUCATION AND PROGRAMS

TYPICAL PATHWAY?

WHERE CAN I STUDY?

WHAT BACKGROUND IS REQUIRED?





QUALIFIED MEDICAL PHYSICIST

IAEA: profesional with a degree on physics, engineering or related, + 2 to 4 years of additional formation in medical physics (MS? PhD?) and Clinical training.

AAPM: MS or PhD in medical physics, or equivalent from an accredited school + board certification (ABR).

EDUCATION AND PROGRAMS

TYPICAL PATHWAY?

WHERE CAN I STUDY?

WHAT BACKGROUND IS REQUIRED?

CNSNS
COMISIÓN NACIONAL DE SEGURIDAD NUCLEAR Y SALVAGUARDIAS

HOSPITAL GENERAL de MÉXICO
DR. EDUARDO LICEAGA

INCMNSZ

REQUIREMENT FOR CLINICAL TRAINING

6 Months:

Treatment Planning, daily QA, Linac output, CT Simulation, Shielding

Mandatory requirement for License of Operation

EDUCATION AND PROGRAMS

TYPICAL PATHWAY?

WHERE CAN I STUDY?

WHAT BACKGROUND IS REQUIRED?

DGMP

Deutsche Gesellschaft für Medizinische Physik e.V.

Participation of the DGMP in granting specialist qualifications in radiation protection for medical physics experts

When granting specialist licenses for medical physics experts (MPE) in Bavaria, Baden-Württemberg and Hesse, the DGMP is included as an expert in accordance with Section 20 of the Atomic Energy Act.

https://www.dgmp.de/de-DE/977/studiengaenge-in-medizinischer-physik-fuer-das-mpe-qualifikationsniveau/

https://www.dgmp.de/de-DE/506/fachkunde-mpe/

REQUIREMENT OF FACHKUNDE (GERMANY)

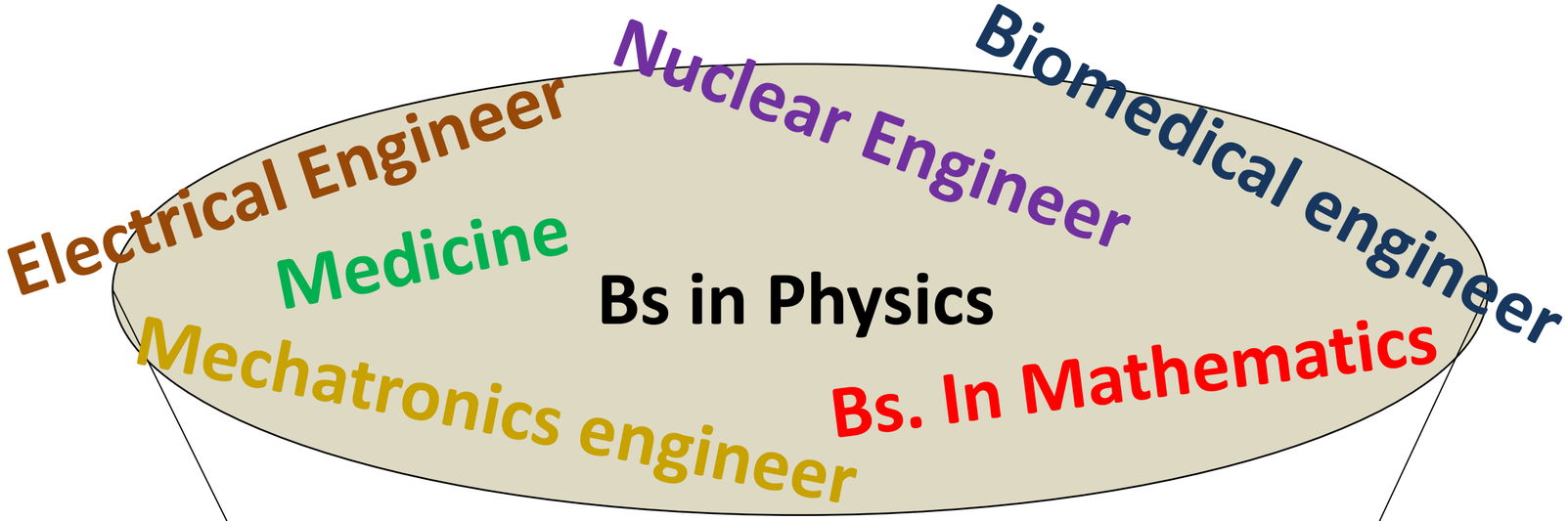
1. Adequate" education MS or PhD + **Technical interview in german with DGMP**
2. **Exam or proof of practical experience** which demonstrates knowledge and duration of practical training (Fachkunde), 2 years?
3. **Participate** in approved courses on Radiation safety

EDUCATION AND PROGRAMS

TYPICAL PATHWAY?

WHERE CAN I STUDY?

WHAT BACKGROUND IS REQUIRED?



CAMPEP Accredited Graduate Programs in Medical Physics

MS, PhD

CAMPEP Accredited Residency Programs in Medical Physics

ABR | American Board of Radiology **Part 1 Exam**

RESIDENCY PROGRAMS

TYPICAL PATHWAY?

WHERE CAN I STUDY?

WHAT BACKGROUND IS REQUIRED?

PROGRAMS AVAILABLE THRU "THE MATCH"

SEPTEMBER 2023: Residency Virtual Fair for AAPM Student members

OCTOBER -NOVEMBER 2023: Registration, payment, apply to vacancies

JANUARY 2024: First preliminary interviews for selected candidates

FEBRUARY – MARCH 2024: Final interviews (1- 2 rounds) for candidates

20 MARCH 2024: Deadline to submit the Ranking List

27 MARCH 2024: Result, 1 Match

1 JULY 2024: Start of Residency

HOW TO STAND-OUT?

- **Clinical experiences:** PSQA, Linac calibration, Treatment Planning, CT Sim
- **MS vs PhD**: Publications and conferences
- **Personal experiences and volunteering**

CERTIFICATION EXAMS

TYPICAL PATHWAY?

WHERE CAN I STUDY?

WHAT BACKGROUND IS REQUIRED?

ABR | AMERICAN BOARD OF RADIOLOGY

International Organization for Medical Physics

IOMP

BOARD EXAMS

ABR Part 1: Remote 8h, Divided in General and Clinical

During your PhD, or during your Residency.

ABR Part 2: Remote 5h. By specialty: Therapy, Diagnostic, Nuclear Medicine

Right after Residency

ABR Part 3: Oral exam 3h, by specialty.

First years in your job

RESEARCH AT OUHSC

MS Program
(2 years)

PhD Program
(At least 4 years)

OU Health
Stephenson Cancer Center

RADIATION ONCOLOGY

10 Physicians, 9 Qualified Medical Physicists, 4 Physics Residents

4 Linear Accelerators, 1 Pencil beam Proton Therapy

1 HDR Brachytherapy, 1 Gammaknife SRS

RESEARCH TOPICS

Radiation-induced acoustics (Collaboration with Uni of California Irvine)

Proton FLASH - RT

Monte Carlo modelling (TOPAS software)

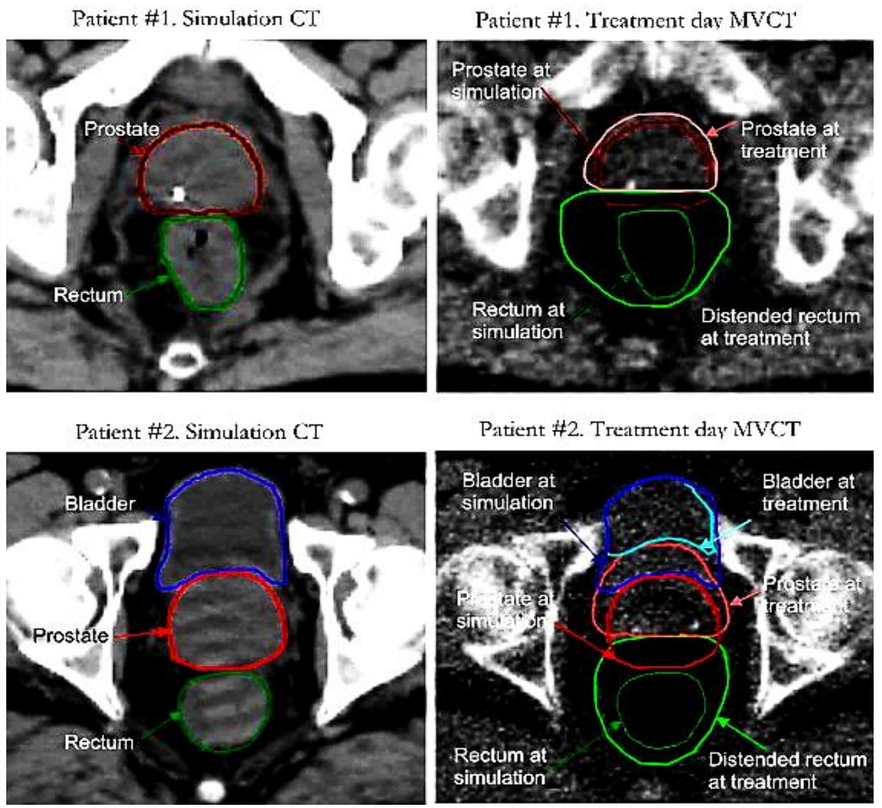
GOAL OF RADIOTHERAPY

TOWARDS PRECISION RT

Conventional IGRT:
pre-treatment target localization.

Patient specific QA:
pre-treatment dose verification.

Not **real-time** checks.



Kupelian, P. et al. Seminars in radiation oncology. 18.1 (2008)

Alshareef, J. Radiation physics and chemistry (2021)

ADAPTATIVE MODALITIES

MRI-LINAC AND ETHOS

Online workflows for **intrafraction motion**, allowing real-time treatment adjustments.

However, Ethos relies on x-ray imaging dose, whereas MRI imaging adds considerable time to the treatment.

REAL-TIME DOSIMETRY

IN-VIVO DETECTORS

Initially, TLDs offered point measurements, but lacked **real-time read-out.**

Silicon diodes, while giving instant readout, are limited to skin dose.

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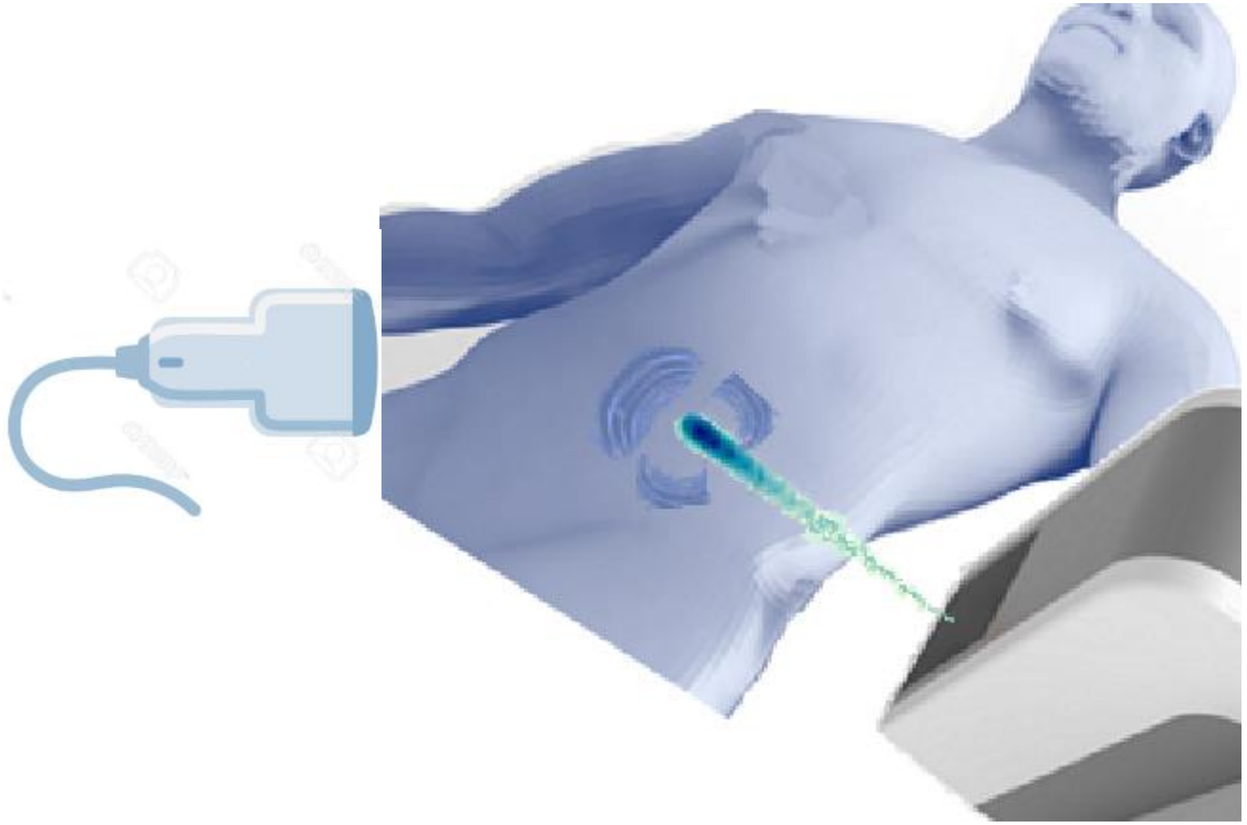
A NOVEL SOLUTION

WHAT IF WE COULD “LISTEN” TO RADIATION?

Acoustic-based technology offers dynamic imaging.

There is promise for real-time dosimetry, alongside diagnostic ultrasound.



RADIATION-INDUCED ACOUSTICS

BASIC PRINCIPLE

Pulsed energy deposition causes localized heating, generating a rapid irradiated tissue expansion.

This expansion produces acoustic waves that can be picked up by transducers.

PULSED RADIATION

LINACS (X-RAY, ELECTRON)
SYNCHROCYCLOTRONS (PROTON)

Given a short pulse (less than a few microseconds), the acoustic signals reflect sharply the dose distribution.

.

RECENT STUDIES

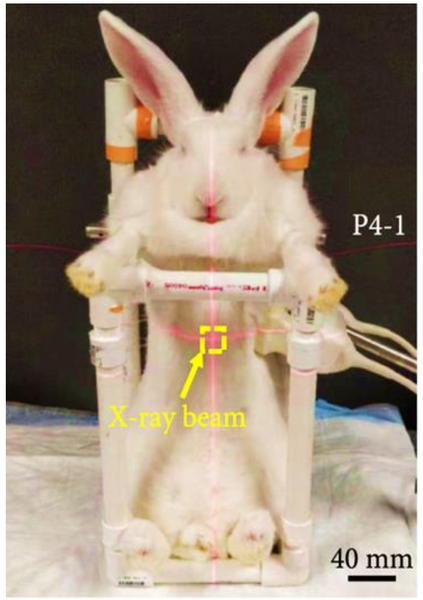
X-RAY ACOUSTIC COMPUTED TOMOGRAPHY (XACT)

Dual modality with ultrasound imaging on in-vivo rabbit.

PROTOACOUSTICS

Submillimeter ionoacoustic range determination for protons in water at a clinical synchrocyclotron.

Both limited to high-averaging (pulses)



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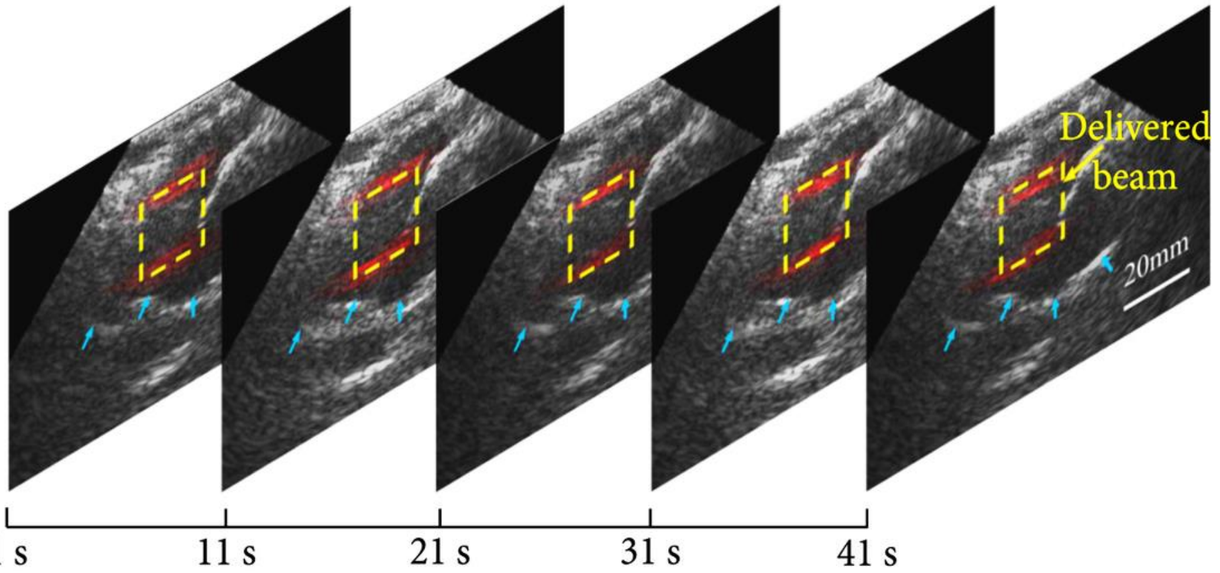
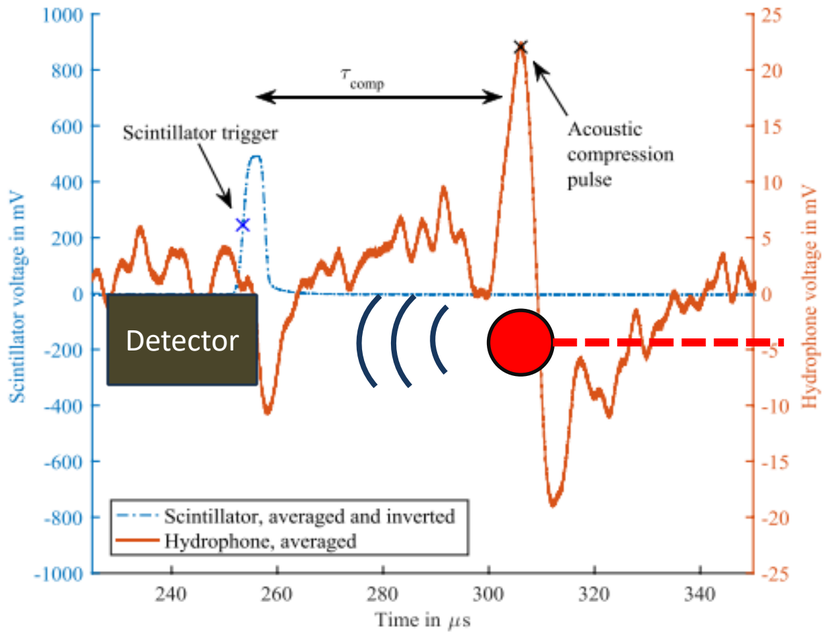
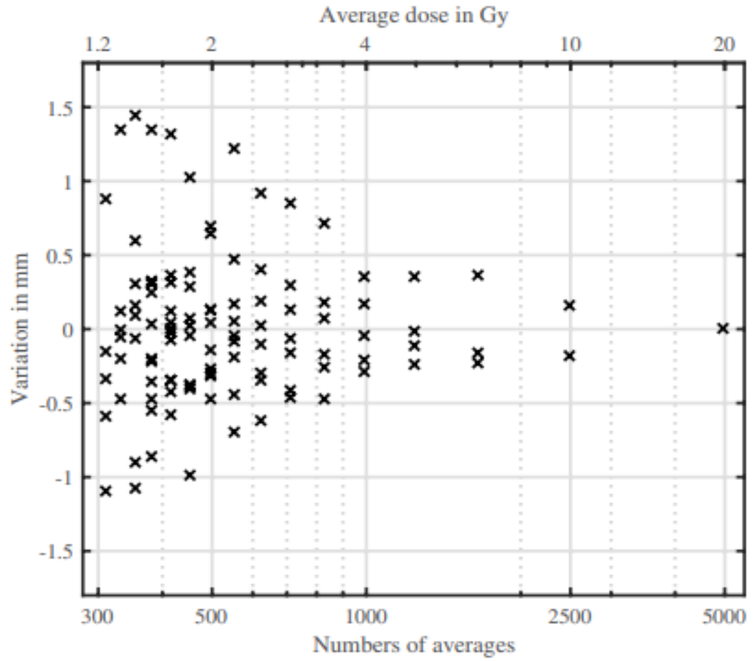


(b)

Zhang, W., et al. BME Frontiers, Volume 2020, Article ID 9853609, 10 pages



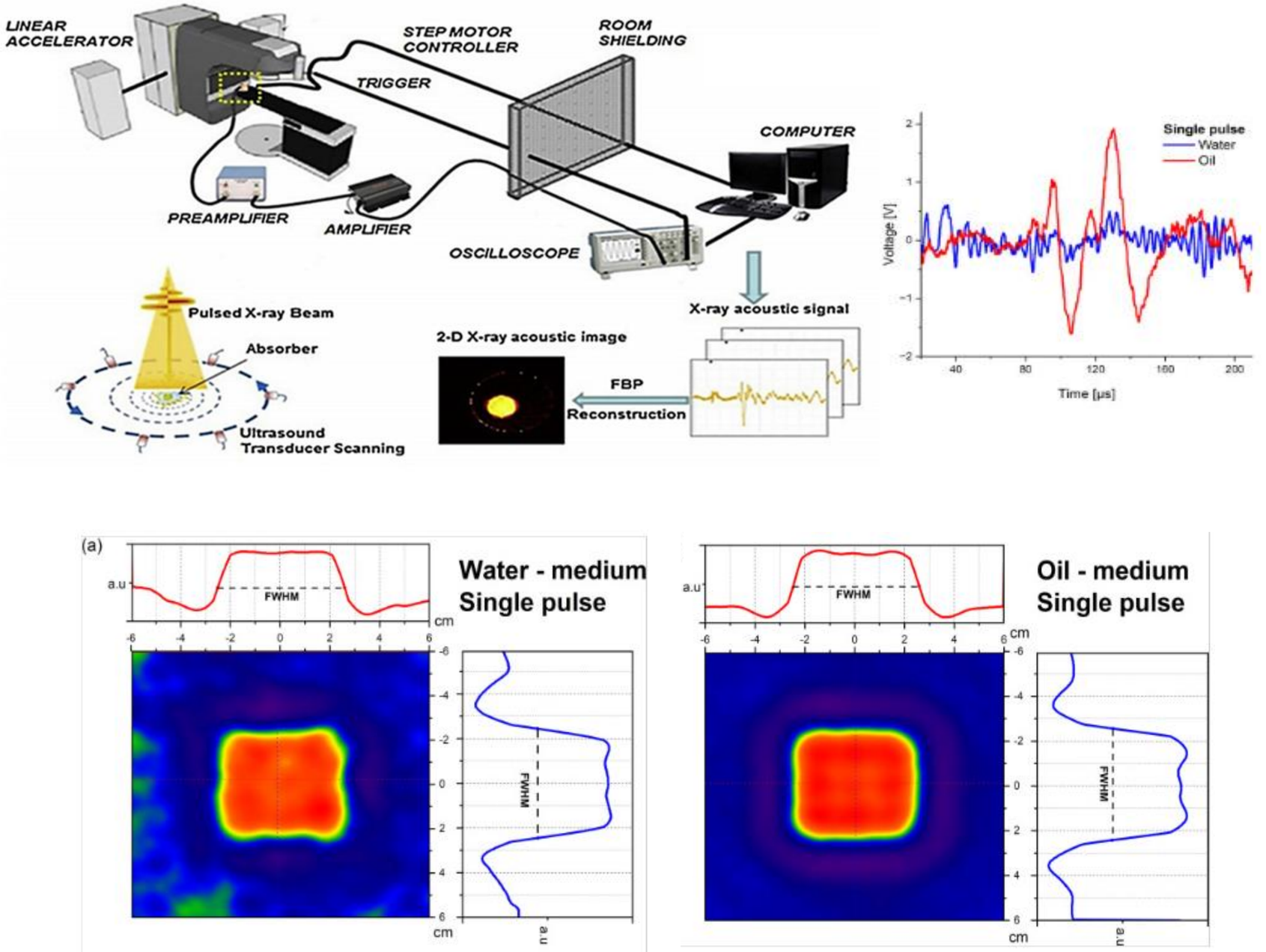


Lehrack, S., et al, Physics in medicine and biology vol. 62,17 L20-L30. 18 Aug. 2017

SINGLE-PULSE XACT

Goal: To overcome the poor SNR for image reconstruction of a LINAC x-ray field.

Conclusion: To achieve single pulse, multiple factors must contribute: Grüneisen parameter, filter and amplifier gain, transducer sensitivity, dose per pulse.

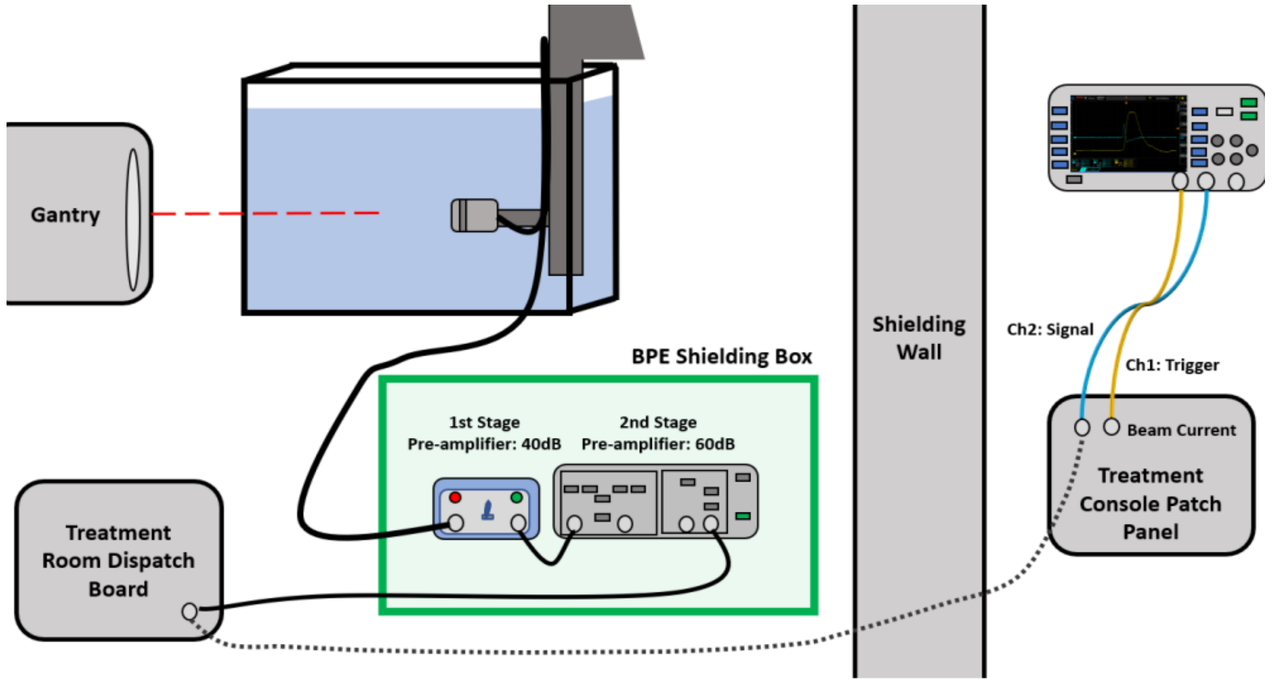


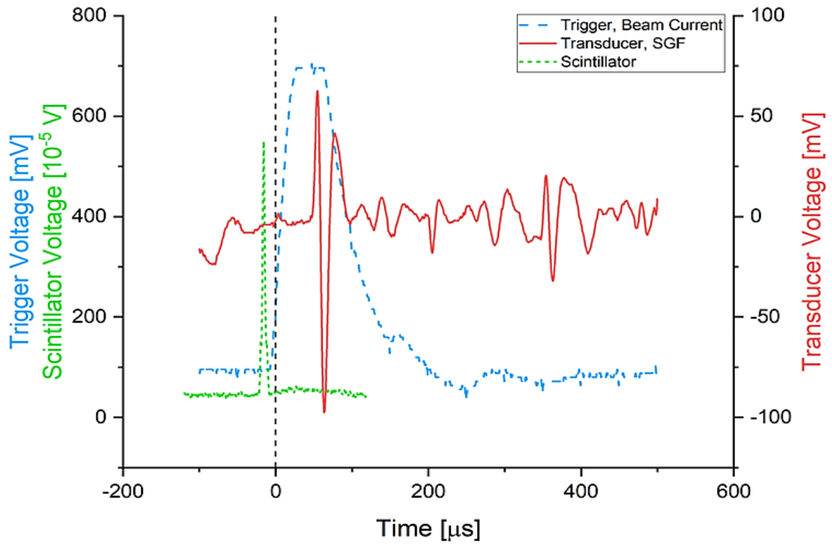
Gonzalez, G., *Prather, K., Pandey, P.K., Ahmad, S., Xiang, L., Chen, Y.. Advances in Radiation Oncology (2023)*

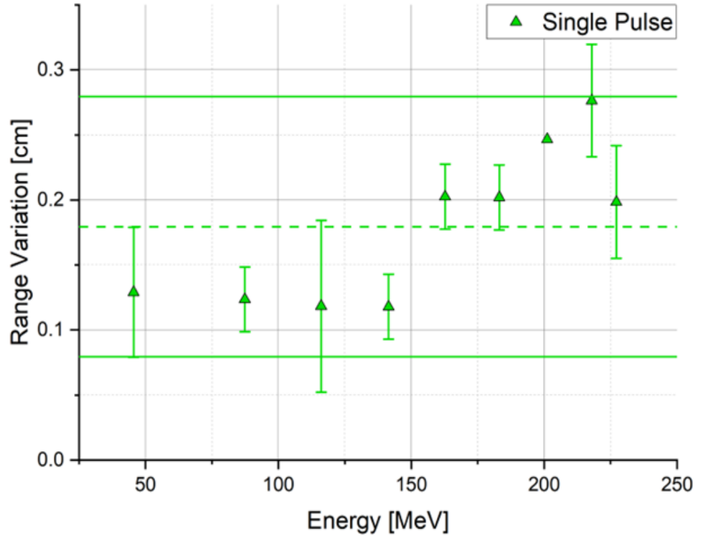
SINGLE-PULSE PROTOACOUSTICS

Goal: To achieve proton range verification using single-pulse protoacoustic detection.

Conclusion: Across all clinical proton energies of our synchrocyclotron, the estimated range was within <3mm variation for single pulse.





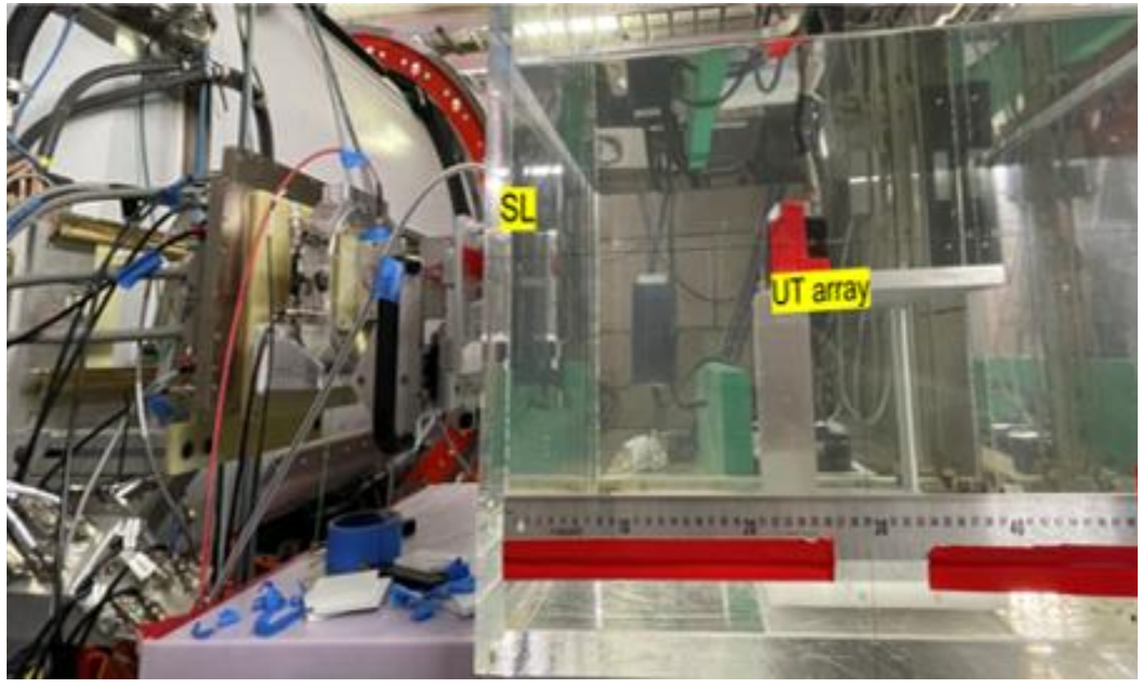


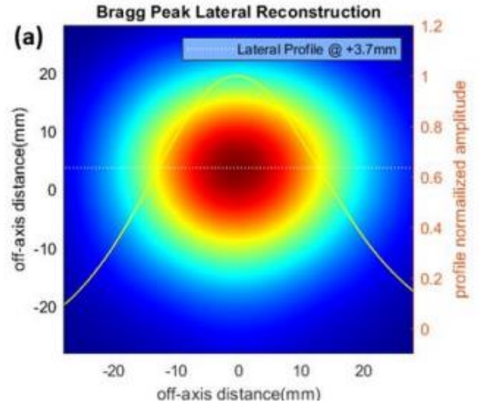
Caron, J,. ***Gonzalez, G.****, Pandey, P. K., Wang, S., Prather, K., Ahmad, S., Xiang, L., Chen, Y. Physics in medicine and biology vol. 68 (2023)*

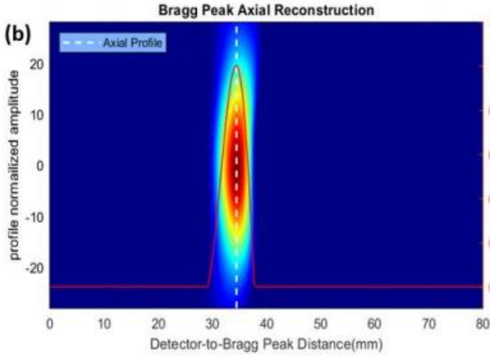
TOWARDS 3D PROTON FLASH DOSIMETRY

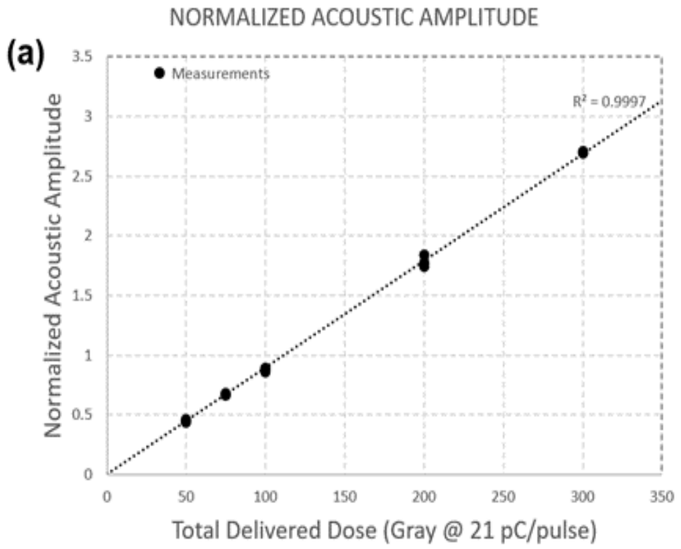
Goal: To demonstrate viable linearity across conventional and FLASH dose rates for a clinical synchrocyclotron.

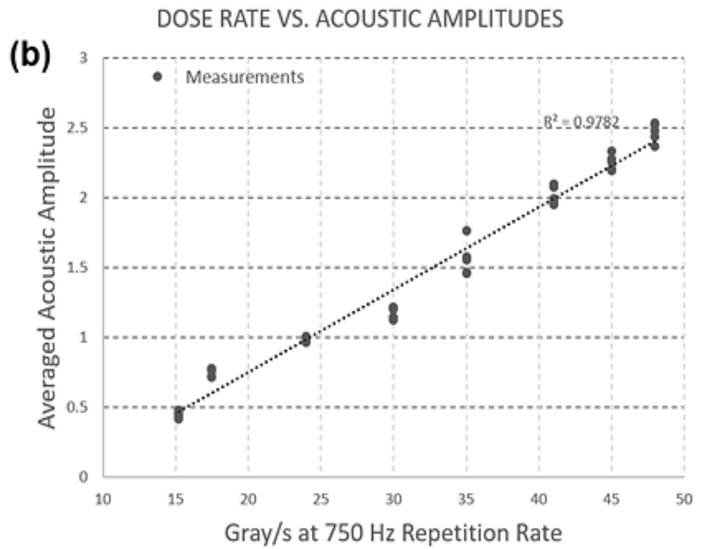
Conclusion: This 2D array demonstrated accurate measurement of proton dose rates across conventional to FLASH and provided a 3D visualization of the Bragg Peak.











Wang, S. and **Gonzalez, G*.,** Owen, D. R., Sun, L., Liu, Y., Zwart, T., Chen, Y., Xiang, L. Medical Physics (2024)*

CLINICAL FEASIBILITY

Nature journal showcasing RIA Imaging with a 2D Transducer for real-time visualization of a prostate Treatment with linac.

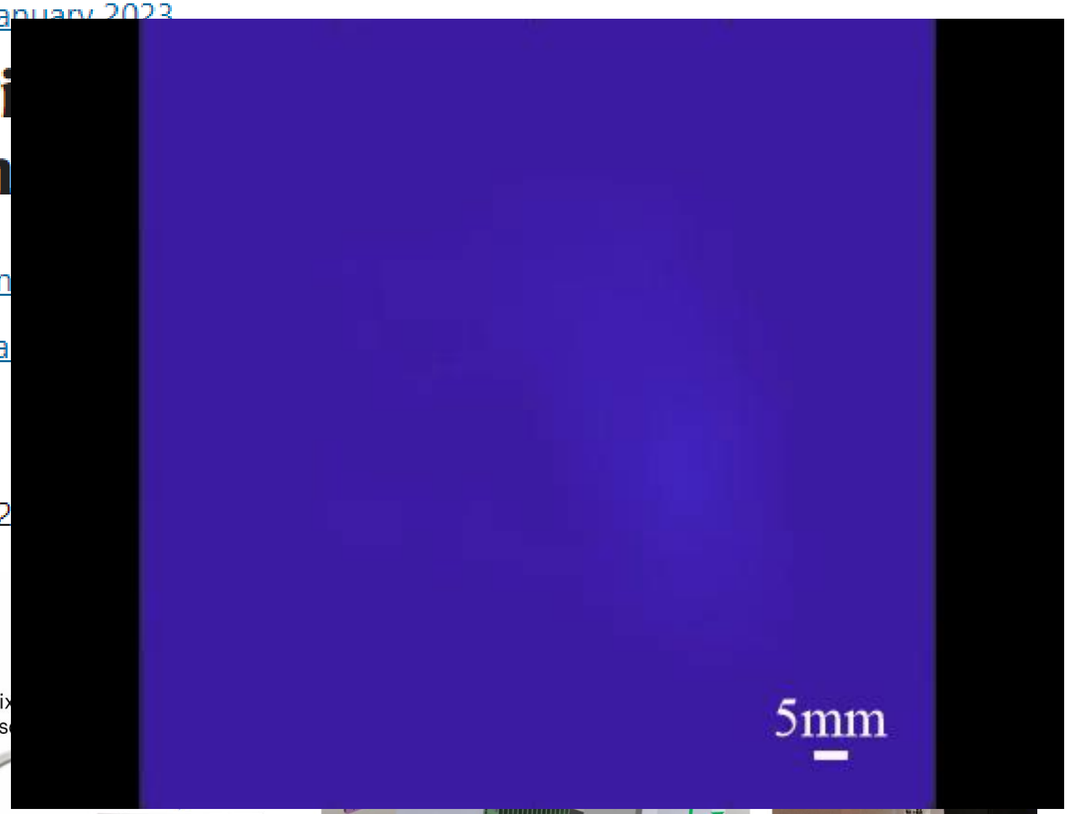
C-shape IMRT test.

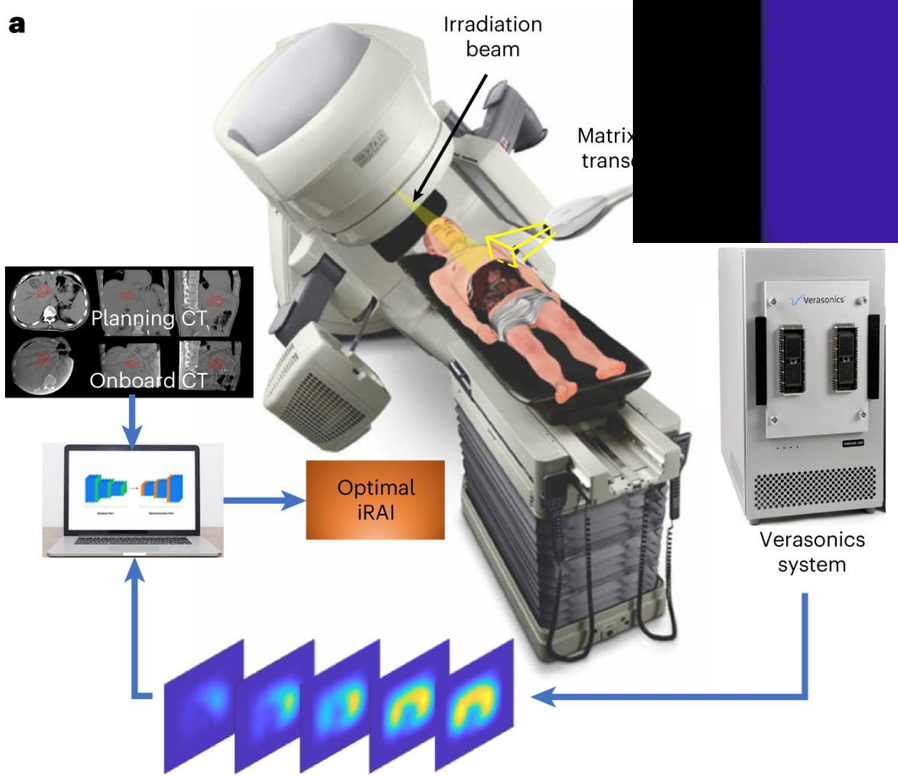
Article | Open access | Published: 02 January 2023

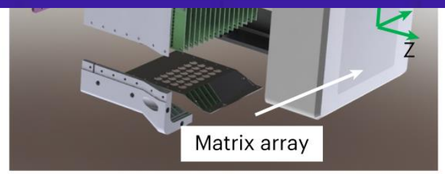
Real-time, volumetri… delivery deep into th…

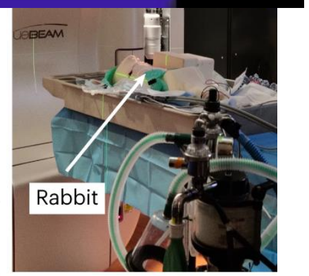
Wei Zhang, Ibrahim Oraiqat, Dale Litzen… Matuszak, Christopher J. Tichacek, Edua… Issam El Naqa

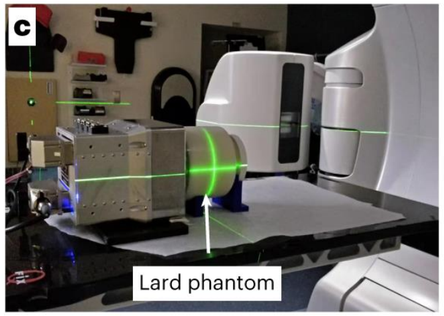
Nature Biotechnology **41**, 1160–1167 (2…

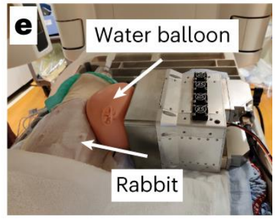






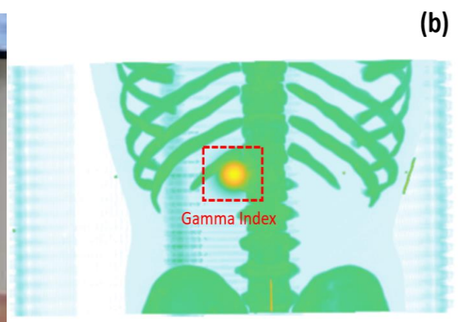


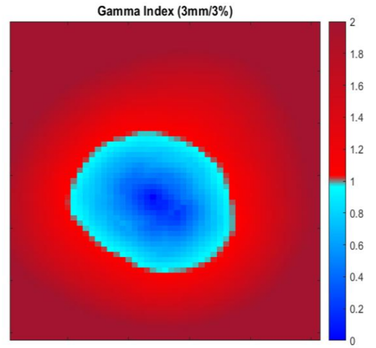


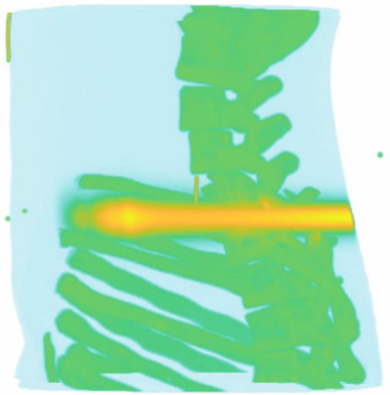


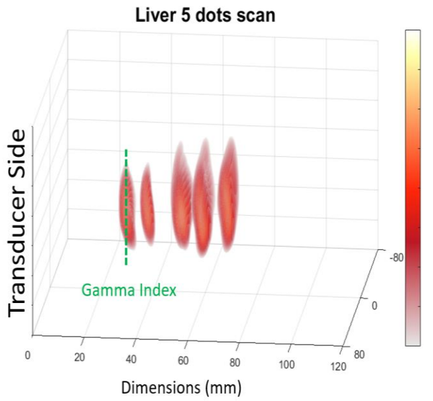
SUMMARY

TAKE HOME MESSAGES









- **Currently, RIA shows promising results in initial-stage water tank experiments. Groups are transitioning to human phantom tests.**

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Siqi Wang, PhD
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GRACIAS

Questions?

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