FLORIDA STATE UNIVERSITY

Broader Impacts - 2

Collaboration with Mayo Clinic Florida

Sergio Almaraz-Calderon

NSF Site Visit, John D. Fox Laboratory, Florida State University

Collaboration between Mayo Clinic and FSU

FACULTY

KEITH M. FURUTANI, PH.D.

Location
Jacksonville, Florida

Contact
Furutani.Keith@mayo.edu

Clinical Profile

Consultant, Department of Radiation Oncology
Vice Chair, Division of Medical Physics, Department of Radiology

Resident - Medical Physics
Cancercenter Manitoba

Postdoctoral Fellowship
Canadian Natural Sciences and Engineering Research Council

Ph.D. - Nuclear Physics
University of Manitoba

BSc (Hons) - (Honours) Physics
University of Manitoba

FACULTY

CHRIS J. BELTRAN, PH.D.

Location
Jacksonville, Florida

Contact
Beltran.Chris@mayo.edu

Clinical Profile

Consultant, Department of Radiation Oncology
Chair, Division of Medical Physics, Department of Radiation Oncology

Resident
Radiation Oncology Medical Physics Program, Programs in Rochester, Mayo School of Graduate Medical Education, Mayo Clinic College of Medicine

Ph.D. - Accelerator/Nuclear Physics
Indiana University, Bloomington

BS - Physics and Mathematics
New Mexico State University

https://www.mayo.edu/research/faculty/furutani-keith-m-ph-d/bio-00092546
https://www.mayo.edu/research/faculty/beltran-chris-j-ph-d/bio-00092647

Collaboration between Mayo Clinic and FSU

Started with a visit by Keith Furutani to the J.D. Fox lab at FSU in *May 2023*

- Mayo Clinic Florida is currently building an advanced cancer radiotherapy center in Jacksonville, FL.
- This facility will include a first-in-America carbon ion clinical beam.

American Association of Physicists in Medicine
Journal of Applied Clinical Medical Physics

J Appl Clin Med Phys. 2020 Dec; 21(12): 6–9. PMCID: PMC7769388
Published online 2020 Dec 14. doi: 10.1002/acm2.13133 PMID: 33319499

We are ready for clinical implementation of Carbon Ion Radiotherapy in the United States

Chris Beltran,[1] Richard A. Amos,[2] and Yi Rong[3]

Figure by K. Furutani.

Collaboration between Mayo Clinic and FSU

Mayo Clinic Florida has developed a new microdosimetric kinetic model for fast and accurate calculations of linear energy transfer (LET) for heavy ions aimed at cancer radiotherapy treatment planning with accelerated carbon ions.

A collaboration between the John D. Fox laboratory at FSU and Mayo Clinic for the experimental validation of the microdosimetric simulations.

International Journal of Molecular Sciences MDPI

Int J Mol Sci. 2022 Oct; 23(20): 12491. PMCID: PMC9604502
Published online 2022 Oct 18. doi: 10.3390/ijms232012491 PMID: 36293348

The Mayo Clinic Florida Microdosimetric Kinetic Model of Clonogenic Survival: Application to Various Repair-Competent Rodent and Human Cell Lines

Alessio Parisi,* Chris J. Beltran, and Keith M. Furutani

As part of the collaboration, FSU grad student Eilens Lopez-Saavedra led the experimental project at FSU and participated in an internship program at Mayo clinic.

Full support of FSU (M. Riley - Dean of Graduate School, E. Pritchard - Provost Office) **and Mayo Clinic** (C. Johnson – Director Strategic Alliances) **administrations**.

Collaboration between Mayo Clinic and FSU

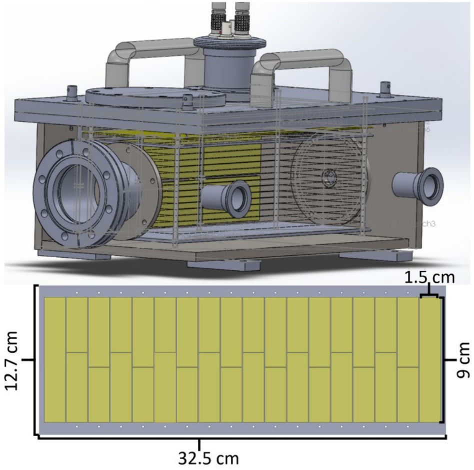
- Eilens Lopez-Saavedra did An internship at Mayo Clinic Florida working with the radiation oncology group.

- Setup and initial tests of Encore. Encore was filled with methane-based tissue-equivalent gas mixture. Needed to operate at much lower pressures than those usually used in nuclear physics experiments.

- Experiments with Heavy ions from the Tandem accelerator at the John D. Fox laboratory. Special focus in the 'Bragg peak' of the distribution.

- Data Analysis on Linear Energy Losses for understanding the interaction of Carbon ions with tissue-equivalent materials at a micrometer scale.

- Validation of Microdosimetric Model for Radiotherapy Applications.



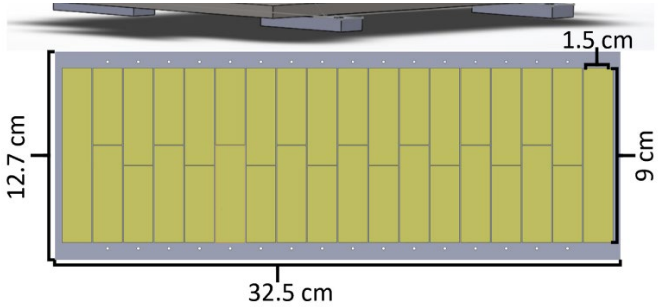
Collaboration between Mayo Clinic and FSU

Table IV.2
Elemental Composition (percent by weight), components (percent by partial pressure) of tissue equivalent gases and (pl)/kP.cm*

	Elemental Composition				Components				$(pl)_c$
	H	C	N	O	CH_4	C_3H_8	CO_2	N_2	
Methane based	10.2	45.6	3.5	40.7	64.4	0	32.5	3.1	74.6
Propane based	10.3	56.9	3.5	29.3	0	55	39.6	5.4	43.7

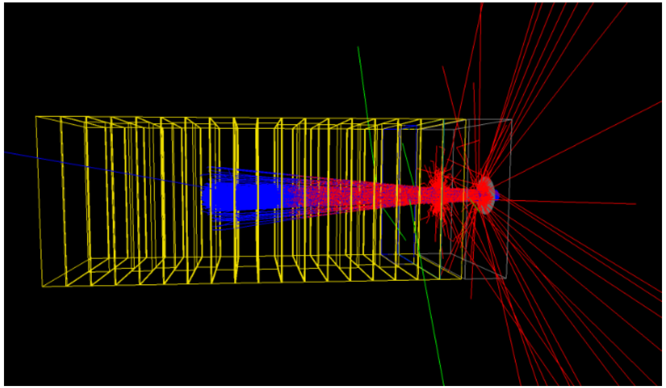
*Product of pressure (torr) and distance (cm) in the gas that is equivalent to 1 micrometer of tissue.

H.H. Rossi and M. Zaider. Microdosimetry and Its Applications, 2012.



Encore's anode structure.

50 Torr of methane-based tissue equivalent gas mixture in Encore for 1 μm of tissue per strip!



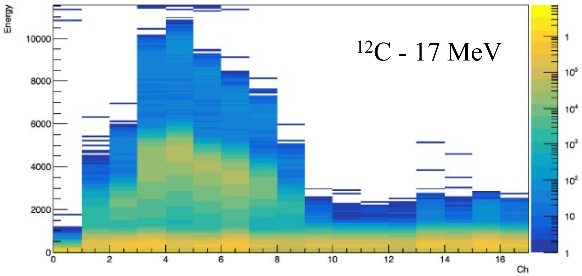
TOPAS Simulation of a 25 MeV ^{12}C beam passing through Encore's active region filled with methane-based tissue equivalent gas.

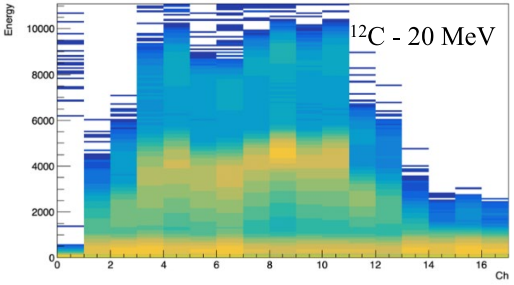
Collaboration between Mayo Clinic and FSU

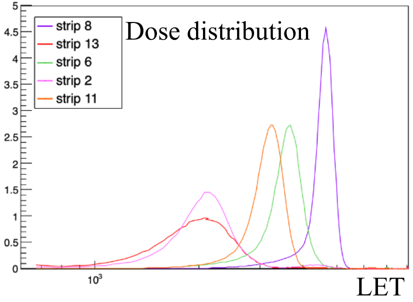
The scope of the experiments was expanded, we measured energy losses of ^{12}C, ^{16}O and ^{28}Si beams at several energies.
Protons and alphas were not measured.

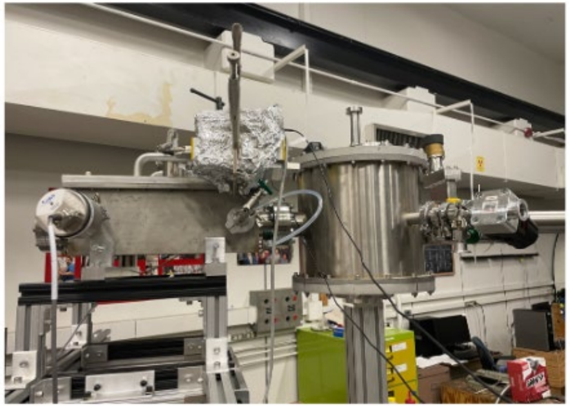
Table 2: Summary of experimental data runs

Runs #	Beam	Energy (MeV)	Pressure (torr)
58	^{12}C	20	55
60	^{12}C	40	55
62	^{12}C	17	55
66	^{16}O	30	55
68	^{16}O	40	55
69	^{16}O	25	55
70	^{16}O	25	55
71	^{16}O	20	55
88	^{16}O	54	55
90	^{28}Si	45	55
92	^{28}Si	50	55
94	^{28}Si	55	55









Experimental Setup in TR1. Encore was filled with 50 Torr of methane-based tissue-equivalent gas mixture.

The results of this collaboration are included in Eilens' PhD dissertation.

Collaboration between Mayo Clinic and FSU

Moving forward …Proposal **by the Mayo Clinic**

Florida HEALTH

1.Significantly expand cancer research capacity in Florida.
2.Improve both research and treatment through greater pediatric and adult participation in clinical trials networks.
3.Reduce the impact of cancer on disproportionately impacted individuals

Bankhead-Coley Cancer Biomedical Research Program

James and Esther King Biomedical Research Program

Live Like Bella Pediatric Cancer Biomedical Research Program

The following types of grants are available to pursue the above seven research priorities. Applications for Research Infrastructure grants that are reviewed and assigned exceptional scientific merit will be considered for preferential funding.

Bankhead-Coley/James and Esther King Research Programs

Grant Mechanism	Maximum Amount (Including direct and indirect costs)	Maximum Duration
Discovery Science	$600,000	36 Months
High-Risk, High-Reward Discovery Science	$300,000	36 Months
Research Infrastructure	$1,500,000	36 Months
Clinical Trials/ Socio-behavioral Interventions	$1,500,000	48 Months
High-Risk, High-Reward Clinical Research	$750,000	48 Months
Bridge	$100,000	6 months
Equipment	$100,000	12 months
Non-typical Clinical Trials/Socio-behavioral Research	$250,000	36 months
New Investigator Research (NIR)	$300,000	36 months

Advancing Cancer Therapy and Space Radiation Research: Building Infrastructure for High-LET Biological Experiments

"This proposal aims to establish the infrastructure at FSU to conduct high-LET based biological experiments with a platform dedicated to studying the biological effects of charged heavy particles in both the context of radiotherapy and space radiation protection."

Research with heavy ions is needed to precisely characterize healthy tissue responses and optimize tumor cell killing … There is "currently" no facility in Florida capable of facilitating biological experiments with high-LET radiation beams.

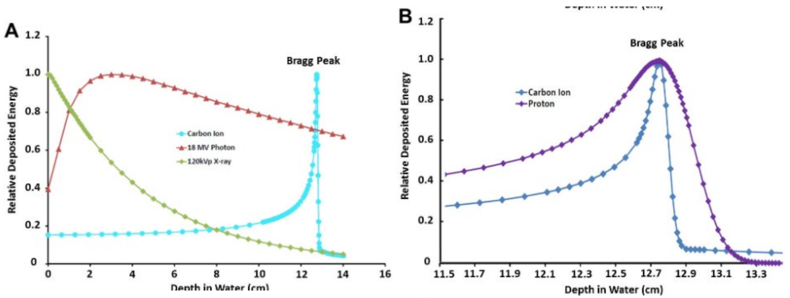
Collaboration between Mayo Clinic and FSU

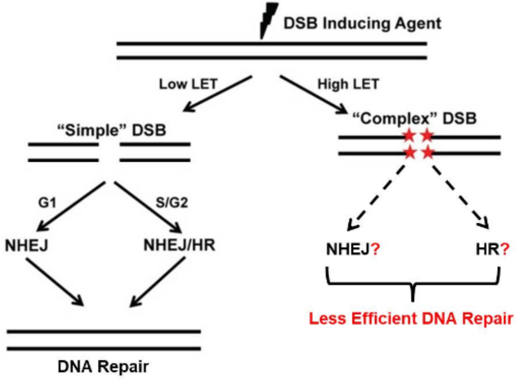
Advancing Cancer Therapy and Space Radiation Research: Building Infrastructure for High-LET Biological Experiments

- Dedicated radiobiology lab space will be created at FSU for biology-driven studies.

- Establish a state-wide network of cross-disciplinary expertise in nuclear physics, ion beam delivery, (micro)dosimetry, and radiation biology to support vigorous validation of experimental parameters for radiobiological assays.

- Benchmark studies to ensure accurate cell targeting, with biological assays including DNA damage repair and cell survival to evaluate successful radiation delivery.





cancers

MDPI

Review

Carbon Ion Radiotherapy: A Review of Clinical Experiences and Preclinical Research, with an Emphasis on DNA Damage/Repair

Osama Mohamad, Brock J. Sishc, Janapriya Saha, Arnold Pompos, Asal Rahimi, Michael D. Story, Anthony J. Davis † and D.W. Nathan Kim *,†

Collaboration between Mayo Clinic and FSU

Advancing Cancer Therapy and Space Radiation Research: Building Infrastructure for High-LET Biological Experiments

What does it mean for the John D. Fox lab?

Several technical adjustments will be made to the existing accelerator facility to establish the necessary infrastructure for radiobiological experimentation.

1. In the ion source area, beam production and delivery will be upgraded with the addition of a multi-cathode ion source.
2. A beam line in target room 2 will be dedicated to cell irradiation.
3. The beams from the accelerators need to be extracted to atmosphere from the vacuum tube used for beam transport. A two-chamber setup will be built for this purpose.
4. A fast beam deflector is needed to stop the beam and ensure proper dose delivery to the cells as well as vacuum integrity through all other beam components of the laboratory.
5. Dedicated data acquisition as well as detectors for beam and dose monitoring will be available for this project.

Collaboration between Mayo Clinic and FSU

Advancing Cancer Therapy and Space Radiation Research: Building Infrastructure for High-LET Biological Experiments

What does it mean for the John D. Fox lab?

Several technical adjustments will be made to the existing accelerator facility to establish the necessary infrastructure for radiobiological experimentation.

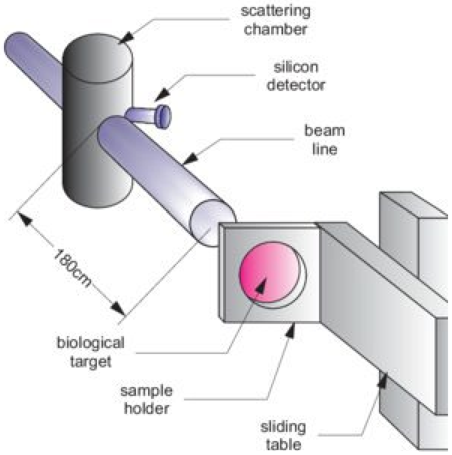
1. In the ion source area, beam production and delivery will be upgraded with the addition of a multi-cathode ion source.
2. A beam line in target room 2 will be dedicated to cell irradiation.
3. The beams from the accelerators need to be extracted to atmosphere from the vacuum tube used for beam transport. A two-chamber setup will be built for this purpose.
4. A fast beam deflector is needed to stop the beam and ensure proper dose delivery to the cells as well as vacuum integrity through all other beam components of the laboratory.
5. Dedicated data acquisition as well as detectors for beam and dose monitoring will be available for this project.

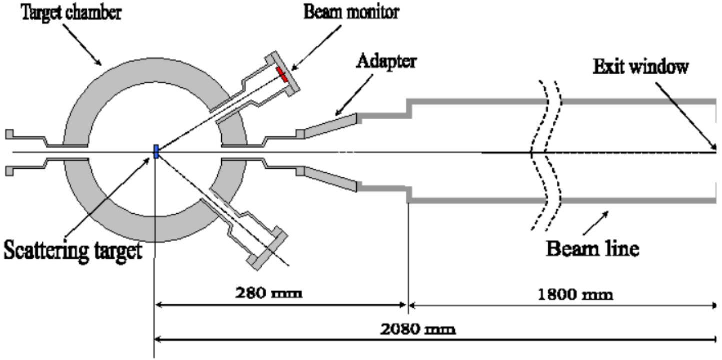
Collaboration between Mayo Clinic and FSU

Advancing Cancer Therapy and Space Radiation Research: Building Infrastructure for High-LET Biological Experiments

What does it mean for the John D. Fox lab?

3. The beams from the accelerators need to be extracted to atmosphere from the vacuum tube used for beam transport. A two-chamber setup will be built for this purpose.





Set up for cell irradiation at Warsaw cyclotron.

Beam control and monitor, accurate dose delivery, 3D remote control of the sample, keep vacuum integrity.

Summary

- We have established a collaboration with Mayo Clinic Florida to experimentally validate microdosimetric models for carbon therapy.

- Experiments were carried out at the John D. Fox lab to measure energy losses around the Bragg peak for ^{12}C, ^{16}O and ^{28}Si beam from the tandem accelerator in the Encore detector which was filled with a methane-based tissue-equivalent gas mixture, operated at 50 Torr.

- A proposal **submitted by Mayo Clinic** to create a research infrastructure at FSU to perform high-Linear Energy Transfer (LET) biological experiments with a platform dedicated to studying the biological effects of charged heavy particles for radiotherapy was submitted to FDH.

- Strong support from FSU and Mayo Clinic administrations.

Thank you!