Department of Medical Physics
UNIVERSITY OF WISCONSIN
SCHOOL OF MEDICINE AND PUBLIC HEALTH

STUDENT RESEARCH POSTER SYMPOSIUM

JANUARY 16, 2025 | 4:00-6:00 PM
HEALTH SCIENCES LEARNING CENTER ATRIUM

Adedamola Adeniyi
Title: iQID – Advanced Digital Autoradiography for RPT Investigations
Abstract: The ionizing Quantum Imaging Detector, or iQID, a scintillation-based autoradiography device designed to image biological tissue samples containing radionuclides, has proven highly useful in the spatial detection of α-particles in ex-vivo murine samples. The device's high resolution (~19.5µm) and particle detection efficiency (>95%) provides the framework for the development of an equivalent standardized workflow of RPT detection that has previously been established for betas and γ-ray radioisotopes.[1] A preliminary workflow has already been established in which digital scintillation maps of activity obtained from tissue samples are overlayed with microscopy images registered to shadowgraphs also produced on the iQID. The result is a cohesive distribution of highlighted activity reflected in the autoradiograph correlated to physical biological structures provided by the microscope image which can be enhanced by the aforementioned immunohistochemistry and biochemical stains to provide the level of insight necessary to understand how α-particle RPT affects the tumor microenvironment. The use of radioisotopes in cancer therapy treatment has had great clinical significance for patients whose cancers are otherwise untreatable. As immunological effects due to radiotherapy present a two-pronged treatment approach by which radionuclides can be used to treat tumor development, detection of the location of key α-particle pharmaceuticals is critical in observing how and why these changes are induced. The iQID, through use in clinical research involving α-particle RPT will help to provide the framework to develop a workflow that better correlates dose deposition from α-particles with immunological effects which can be translated into clinical practice.

Mervat Alharbi (Advisor: Dr. Wes Culberson)
Title: BEAMCHECKER™ AS DAILY OUTPUT CHECK FOR THE MOBETRON® ULTRA-HIGH DOSE RATE BEAM
Abstract: The Standard Imaging QA BeamChecker™ Plus is a device used for clinical linear accelerator daily quality assurance (QA) tasks, such as output checks in electron and photon beams. It includes 1.5 cm of inherent buildup, eight parallel chambers with 1.4 cm diameter, and a 0.4 cm separation. This work investigates the nonstandard use of the BeamChecker™ Plus for daily output checks of ultra-high dose rate (UHDR) electron beams. The Intraop® Mobetron® is an electron linear accelerator that is capable of delivering both conventional and UHDR beams. The BeamChecker™ was carefully positioned at 170 cm extended SSD and used to acquire output baselines for 5 and 10 pulses on a 9 MeV UHDR beam on the Mobetron®. The change output as measured by the BeamChecker™ was observed, as a function of time over a few months, as well as the number of pulses delivered. Additionally, measurements were acquired for different pulse widths, frequencies, and SSDs. The BeamChecker™ results indicated a stable output over time. The device also shows linearity between the number of pulses delivered and the output at 30Hz and 1.2 microseconds. When the output variation was investigated with different SSDs, the change in output was less than ± 2%.
Conclusions: BeamChecker™ shows potential to be an effective daily constancy output verification check for an UHDR beam. There was not an observable change in the output with the change in SSD.

Carly Allen (Andy Alexander)
Title: Cartesian MPnRAGE for Efficient Simultaneous Multi-Contrast and Quantitative Relaxometry Imaging
Abstract: Quantitative T1 (qT1) values may be useful for diagnosing and examining progression of disease and characterization of brain development, yet long scan times diminish use in clinic and research settings. Therefore, a faster qT1sequence with accurate fitting would have great benefit. The goal of this project was to create a sequence that provides multiple image contrasts suitable for diagnostic evaluation and produces accurate qT1 maps in a short scan time. We accomplished this by creating a novel 3D Cartesian MPnRAGE sequence with 10 inversion times and under sampling to obtain qT1 values across the whole brain in less than 5 minutes. This method generated 10 high quality T1-weighted images across the inversion recovery curve, and a B1 and inversion efficiency corrected quantitative T1 map with high accuracy.

Dalton Bermudez (Wally Block)
Title: Enhanced Sulci Mapping Using bSSFP MRI for Improved Pre-Surgical Planning of Brain Therapies
Abstract: Accurate sulci mapping is critical for pre-surgical planning of intraparenchymal brain therapies, such as convection-enhanced delivery (CED) of neurotherapeutics. Sulci serve as low-resistance pathways that guide infusion distributions and must be precisely identified to optimize catheter placement and therapy outcomes. This study investigates the utility of high flip angle, 3D balanced steady-state free precession (bSSFP) imaging compared to traditional FLAIR MRI for sulci mapping. Volunteer scans were performed on a 3T GE Premier scanner, acquiring 5-minute 3D bSSFP (0.5 mm isotropic resolution) and 11-minute 3D FLAIR (0.7 × 0.7 × 1 mm resolution) images. Sulci maps were generated using maximum intensity projections (MIPs) for bSSFP and minimum intensity projections (MinIPs) for FLAIR, with additional binary segmentations processed for comparison. Results show that bSSFP imaging, with its positive contrast and higher spatial resolution, depicts sulci networks with greater detail than FLAIR, even after resolution matching. Structural similarity index (SSIM) analysis further highlights significant discrepancies, demonstrating the limitations of FLAIR in capturing intricate sulci details. The findings suggest that bSSFP imaging could enhance pre-surgical planning for gene therapies and other intraparenchymal interventions by providing faster, higher-resolution sulci maps. Future work will explore multi-flip angle approaches to mitigate partial voluming effects at sulci interfaces.

Liliana Berube (Advisor: Dr. Randall Kimple)
Title: Exploring Cellular and Molecular Dynamics in Cetuximab-Sensitive and Resistant Head and Neck Cancer Patient-Derived Xenografts
Abstract: Cetuximab, an anti-EGFR monoclonal antibody, has shown limited efficacy in treating head and neck squamous cell carcinoma (HNSCC) due to the emergence of resistance. To better understand the underlying mechanisms, we performed single-cell RNA sequencing on patient-derived xenografts (PDXs) from cetuximab-sensitive and resistant HNSCC models under control and cetuximab-treated conditions. This study focuses on characterizing the cellular heterogeneity within the tumor microenvironment, identifying distinct cell populations and their roles in drug response. Comprehensive gene expression profiling is employed to uncover genes and transcriptional programs associated with sensitivity and resistance. Furthermore, pathway enrichment analyses aim to reveal key signaling networks altered in response to cetuximab treatment. By integrating insights from cellular composition, gene expression, and pathway activity, this work seeks to deepen our understanding of cetuximab resistance and to identify potential therapeutic targets to improve outcomes for HNSCC patients.

Brecca Bettcher (Advisor: Dr. Bradley Christian)
Title: [18F]-FE-DPN 6-O-(2-[18F]fluoroethyl)-6-O-desmethyl-diprenorphine with Dynamic PET Imaging for Brain μ-Opioid Receptors in Nonhuman Primate Models
Abstract: The opioid system, consisting of μ, κ, and δ-opioid receptors, plays a central role in hedonic processing and addiction. [18F]FE-DPN is an opioid antagonist with high affinity for μ-opioid receptors. Previous human PET investigations of [18F]FE-DPN have been conducted demonstrating its variable imaging characteristics validating methods for quantitative measurement of ligand-receptor binding. The goal of this work was to examine the binding

characteristics of [18F]FE-DPN in rhesus macaques and evaluate this model for investigation of the μ-opioid receptor system. Dynamic PET images of three anesthetized monkeys were acquired on a Focus 220 microPET. Macaques were administered a bolus injection of ~5 mCi [18F]FE-DPN (82.75 ng/kg) and scanned for 90 min. One macaque underwent an additional blocking study with naltrexone administration (10mg/kg, IM) followed by [18F]FE-DPN. Reconstructed images were denoised and normalized to an MRI template with ROIs from a rhesus atlas. Time activity curves (TACS) were extracted in regions of high opioid density, including the thalamus, amygdala, frontal cortex (fc) as well as the cerebellar gray matter (cbm) as a reference region. DVR was computed using Logan Graphical Analysis as an index of specific binding. TACS from the blocking study were to determine reductions in target region binding and to evaluate binding in the cbm. The highest binding was exhibited in the thalamus and amygdala and lower uptake in the fc, with target to reference signal plateauing at ~80 min and 40 min, respectively. Average DVR values of 4.07 ±± 0.41 in the thalamus and 3.73 ±± 0.56 in the amygdala were observed, with t*=40 min (no K−2K-2). DVR remained stable with the truncation of select scan durations from 40-90 to 40-70 min. Naltrexone blocking revealed near complete reduction in target region binding with DVR values of 1.05, 0.84, and 0.87 in the thalamus, amygdala, and fc, respectively. A comparison of cbm TACs revealed a lower late-frame SUV, suggesting ~25% of baseline cbm signal is due to receptor specific binding (i.e. displaceable). [18F]FE-DPN has favorable binding characteristics in the rhesus monkey with similar patterns of radiotracer binding reported in human studies. Specific binding of [18F]FE-DPN was detected in the cbm which, depending on experimental design, may limit its use for reference region analysis in this model.

Molly DeLuca (Advisor: Dr. Jonathan Engle)
Title: Production of 45Ti in a Solution Cyclotron Target
Abstract: 45Ti is a positron-emitting radiometal with several decay characteristics (t1/2 = 3.08h, 84.8% β+, E<β+> = .439 MeV, <1% concomitant gamma emissions) which render it compelling for high-resolution positron emission tomography (PET) imaging. It can be produced via the natSc(p,n)45Ti reaction with a cross-section that is maximized between 10-14 MeV, an energy regime accessible to low-energy cyclotrons. The Sc target material is a solid at room temperature (m.p. = 1540° C). However, most PET radiopharmaceuticals rely on the [18O]H2O(p,n)18F or 68ZnNO3(p,n)68Ga reactions. Therefore, cyclotrons typically found in clinical settings do not have the infrastructure to handle solid targets. As an alternative to solid target 45Ti production, Sc compounds can be dissolved in water or acid and irradiated in a solution cyclotron target. We describe our experiences irradiating solutions of dissolved ScCl3 in a solution cyclotron target. 45Ti yields of up to 330(50) MBq/μA were produced during 10-minute irradiations of dissolved ScCl3 solutions with 11 MeV protons in a solution cyclotron target. Currently, 45Ti production from irradiation of dissolved ScCl3 solutions is limited by precipitation of target material during irradiation and deterioration of system components.

Caroline Doctor (Advisor: Dr. Kevin Johnson)
Title: Correcting the Effects of Patient Bulk Motion on DENSE Scans in the Brain
Abstract: Cardiac-gated Displacement Encoding through Stimulated Echoes (DENSE) has been shown to measure sub-millimeter brain tissue displacements non-invasively through MR. DENSE has been applied to multiple cohorts consisting of young, healthy participants; however, significant variability is observed when applying these methods to aging studies. Due to the very small displacement encoding required to be sensitive to these sub-millimeter displacements, DENSE scans are more sensitive to patient bulk motion than other motion encoded scans. Disentangling bulk motion from desired measures of brain motion is particularly challenging as the motion may mimic motion of brain. A prospective study was performed in healthy participants (N=6, ages 25-34 yrs), using a 2D spiral DENSE sequence and a 48-channel head coil, imaging three slice positions in the superior portion of the brain. Inclusion of both encode rejection and polynomial subtraction steps in the post-processing pipeline visibly removes both the intensity variations and the phase wrap artifacts seen in the individual displacement maps and demonstrates the greatest effect on motion-reduction (R-squared from 0.50 to 0.95, RSS from 0.15 to 0.01). Overall, the utilized motion-correction pipeline substantially improved the correspondence of DENSE measures acquired during induced motion.

Kai Flores (Advisor: Dr. Paul Ellison)
Title: Radiosynthesis and Characterization of [18F]FET for Preclinical Imaging of Glioblastoma in Animal Models

Abstract: Accurate imaging of brain cancers remains a significant challenge despite advances in magnetic resonance imaging techniques, particularly when it comes to accurate tumor delineation and characterization. A promising alternative is amino acid PET imaging, with [18F]fluoroethyltyrosine ([18F]FET) being of particular interest for glioblastoma (GBM) due to its targeting of the L-type amino acid transporter 1 (LAT1); however, issues persist due to its limited commercial availability and the lack of a standardized radiosynthesis protocol. This study presents a manual radiosynthesis and formulation protocol developed based on methods developed by Telix Pharmaceuticals. Courtesy of Professor Jonathan Engle, fluorine-18 was produced using the University of Wisconsin's GE PETtrace cyclotron via the O "# (p, n) F "# reaction, employing enriched 18O water as target medium. It was then isolated from the irradiated target water via anion exchange chromatography by use of a quaternary methyl ammonium (QMA) cartridge eluted with a $K\$\$\$$ and $K\$CO\%$ solution. After azeotropic drying, labeling of the precursor (2S)-O-(2-tosyloxyethyl)-N-trityl-tyrosine-tert-butyl ester (TET) and subsequent hydrolysis reaction were performed. Various parameters were tested for all three of these processes in order to optimize the conditions. After synthesis, the final [18F]FET product was isolated using preparative high performance liquid chromatography and its composition was analyzed via thin-layer chromatography. Additionally, preliminary positron emission tomography imaging of a Rag2-null rat with induced GBM demonstrated successful uptake of [18F]FET and thus the ability to utilize this compound for tumor identification and delination. We propose this standardized manual radiosynthesis protocol as a reliable method for producing [18F]FET for further animal studies, with promising outlooks for future automation and use of PET for GBM imaging.

Garrett Fullerton (Advisor: Dr. Scott Reeder)
Title: Saturation Recovery Chemical Shift-Encoded T1 Mapping of the Liver
Abstract: T1 mapping shows promise as a diagnostic tool for liver fibrosis and inflammation, but conventional methods face challenges with fat-related bias, variability, and lengthy acquisition times. While our previously developed 2D saturation recovery-based chemical shift-encoded (SR-CSE) technique enables rapid, confounder-corrected T1 mapping, it is limited by relatively low signal-to-noise ratio (SNR) and restricted slice coverage. We address these limitations through two key developments: 1) mathematical optimization of acquisition timing parameters and flip angle modulation schemes to improve SNR performance, and 2) implementation of simultaneous multi-slice (SMS) acquisition to expand coverage. Our optimization framework considers T1 accuracy, SNR performance, and k-space profile flatness to determine optimal saturation times and flip angle schemes. Results demonstrate that the optimized acquisition significantly improves T1 measurement precision while maintaining accuracy compared to reference methods. The addition of SMS enables whole-liver coverage (27 slices) within a single 20-second breath-hold, representing a substantial improvement over conventional single-slice-per-breath-hold approaches. This technical advancement improves the clinical viability of confounder-corrected T1 mapping for liver disease assessment by providing robust whole-liver coverage with improved measurement precision in a clinically feasible scan time.

Campbell Haasch (Dr. Bryan Bednarz)
Title: Quantitative Cherenkov Luminescence Imaging for Pre-clinical Targeted Radiopharmaceutical Therapy Dosimetry
Abstract: Targeted radiopharmaceutical therapy (TRT) using isotopes such as 90Y and 225Ac have shown promise in both pre-clinical and clinical trials. Estimating the dose to the tumor volume and organs-at-risk is difficult with novel 90Y and 225Ac radiopharmaceuticals at the preclinical stage as imaging these agents with uSPECT/uPET is challenging. Cherenkov luminescence imaging (CLI) has previously been used to image the redistribution of 90Y and 225Ac agents, however, no methodology for in vivo activity quantification using CLI has been developed. In this work, 86Y-NM600 is used as a model isotope to develop a CLI quantification methodology that can be applied to 90Y, 225Ac, and other difficult to image isotopes at the preclinical stage.
A well plate phantom containing varying amounts of 86YCl3 (0-100 µCi) covered with varying depths of an intralipid/blood mixture to create a calibration curve of Cherenkov radiance as a function of both activity and tissue depth. Four athymic nude mice were injected with 100 µCi of 86Y-NM600 and imaged with both CLI and PET at time

points 1, 24, and 48 hours post injection. Relevant organs were removed, imaged ex vivo, and the activity of each organ was measured in a γ-well counter. Cherenkov spread kernels (CSK) were generated using Geant4. A deconvolution-reconvolution scheme was implemented to isolate the contribution of Cherenkov radiance to only the organ of interest. CLI and PET images showed correlated uptake of 86Y in skeletal system and kidney. At early timepoints, the agreement between CLI and PET measured activates was 10.95% in the kidneys and 8.02% in the femurs. At later timepoints percent error increased due to low sensitivity of the measurement. CLI and PET measured activity agreed with 10 kBq for all measurements.

Jonathan Hale (Advisor: Dr. Ivan Rosado-Mendez)

Title: Acoustic and optical characterization of polymer-based imaging windows for a ultrasound/optical multiscale scope

Abstract: The Rosado-Mendez and Eliceiri labs are working together towards developing ultrasound-based biomarkers of collagen remodeling to evaluate collagen-rich fibrosis non-invasively. Collagen is the most abundant protein in the body and critical in normal and diseased processes. During several physiological or pathophysiological processes, collagen microstructure (fiber density and organization) changes drastically. Evaluation of biomarker performance [Raunig 2016] requires assessing bias, which needs ground truth knowledge of collagen microstructure. To assist in biomarker development, a multiscale imaging system combining an ultrasound scanner and a Second Harmonic Generation (SHG) collagen imaging microscope will be used to register the ultrasound and SHG images, allowing for a co-registered analysis of ultrasound biomarkers and quantitative features describing collagen microstructure. However, the ultrasound image quality obtained is currently degraded by large reflections at the glass optical microscopy window. We seek to identify a new optical window material that reduces ultrasound reflections compared to glass without significantly affecting the quantitative optical assessment of collagen microstructure. The search was restricted to optically clear thin film materials that are currently used in optics manufacturing. The acoustic reflection coefficients of the materials were measured through an immersion-based, pulse-echo broadband technique using a 30MHz single-element ultrasound transducer. A planar reflector with known acoustic reflection coefficient was used to correct for system-dependent factors and diffraction. The effect of the optical window material on quantitative assessment of collagen architecture was assessed by imaging a rat tail tendon through the window and quantifying collagen alignment with a lab developed collagen analysis software called CurveAlign. Five polymers were identified as suitable candidates for the optical window. These were polymethyl pentene (PMP), polymethyl methacrylate (PMMA), cyclin olefin copolymer (COC), polycarbonate (PC), and polyethylene terephthalate (PET). These materials, respectively, had measured reflection coefficients of 0.074+-0.007, 0.362+-0.002, 0.2453+-0.0004, 0.2902+-0.0002, and 0.3647+-0.0002. However, only COC provided CurveAlign alignment estimates that had less than 5% percent error. COC has the best performance optically of the 5 polymers tested and has performance like glass. TPX has the best acoustic reflection coefficient but results in unacceptably high percent errors of measured collagen alignment. We are doing more investigations to see if the ultrasound/SHG scope can be adapted to use COC optical windows instead of glass.

Jeremy Hallett (Advisor: Dr. Brian Pogue)

Title: Cherenkov Emission in Realistic Optical Body Phantoms to Study Effects from Melanin Level and Delivery Technique

Abstract: During the delivery of external beam radiation therapy, high energy secondary electrons interact with tissue matter, producing the emission of low intensity Cherenkov light that can be visualized using an intensified scientific complementary metal oxide semiconductor (iCMOS) camera time gated to acquire images only during the pulse delivery of the linac. Most optical photons escaping the patient are created at a depth between 0-5mm of the skin surface due to the attenuation of Cherenkov light from hemoglobin and melanin. Therefore, varying melanin concentrations are expected to lead to different levels of Cherenkov detection. The goal of this study was to simulate various concentrations of melanin in anthropomorphic skin phantoms to determine the spatial accuracy of Cherenkov detection as a function of melanin and treatment type. Six silicone phantoms were produced, each with a layer of silicone paint applied to the surface with varying levels of dark skin tone and black pigment to simulate varying concentrations of melanin to visually replicate the skin tones listed in the Fitzpatrick skin scale (skin type I-VI). A CT simulation was performed on all phantoms and 3 breast treatment plans were developed for each phantom: tangent beams, field-in-

field, and VMAT. After treatment delivery, the imaged Cherenkov signal was compared against the expected Cherenkov visualization calculated from the treatment planning system. It was shown that the Dice similarity scores for skin types I-V were above 90%, suggesting excellent geometric accuracy and light detection. This was true for all three plan types. However, when the darkest skin tone phantom was imaged (skin type VI, melanin index ~120), the Dice score dropped slightly for the tangent and field-in-field plan, and even more significantly for the VMAT plan. However, the score was still nearly 80%, suggesting that even in the range of the darkest skin tones, Cherenkov imaging is a viable technique for beam recognition. Despite the lack of diverse patient Cherenkov data, studies can still be conducted to ensure quality care for all patients using anthropomorphic phantoms.

Andrea Houck (Advisor: Dr. Diego Hernando)
Title: Optimizing acquisition and post-processing pipeline for motion-robust diffusion weighted imaging of the liver
Abstract: Diffusion weighted imaging (DWI) in MRI is useful for detecting lesions and characterizing tissue. Cardiac and respiratory motion complicate DWI, especially in the left lobe of the liver, causing localized signal dropouts that lead to bias in quantitative parameters like the apparent diffusion coefficient (ADC). Several acquisition- and postprocessing-based methods have been proposed to address these artifacts and improve the quantitative performance of ADC, but the combination of these methods has not been evaluated. We evaluated multiple diffusion acquisitions with increasing levels of motion sensitivity and different signal averaging methods during post-processing. Our results show that acquisitions with higher motion sensitivity are more prone to signal dropout, but weighted averaging methods partly mitigate this effect. ADC measurement variability was larger in the left lobe than the right lobe for most acquisitions and post-processing methods. The combination of motion robust acquisition and weighted averaging post-processing techniques reduce bias between ADC values in the left and right lobe. Overall, this study finds that diffusion acquisitions with low motion sensitivity combined with weighted averaging is optimal. This improved quantification may enhance the detection, staging, and treatment monitoring of liver disease.

Timothy Houston (Advisor: Oliver Wieben)
Title: Cardiac Function and 4D Flow in a Swine Model of Isolated Post-Capillary Hypertension
Abstract: Left heart failure (LHF) often results in pulmonary hypertension (PH), which leads to poorly understood pulmonary vascular and right ventricular changes caused by increased pulmonary venous pressures. Surgical, non-occlusive pulmonary vein banding of swine was performed to induce isolated post-capillary pulmonary hypertension (Ipc-PH) without damage to the left heart. Cine bSSFP and 4D Flow MRI were performed at 0, 8, and/or 16 weeks to assess cardiac function and hemodynamics. Invasive right heart cath measures (mean pulmonary artery pressure (mPAP) and PVR) were obtained within hours of each exam. At week 16, mPAP and PVR were elevated in banded swine compared to shams, while having preserved left ventricular ejection fraction (LVEF). Superior pulmonary vein (SPV) flow increased over time in banded animals, compensating for reduced IPV flow. Main pulmonary artery flow shifted from higher in shams at week 8 to higher in banded swine at week 16. This banding model mimics progressive PH independent of LHF, providing insights into disease progression and its impact on cardiopulmonary hemodynamics. Hemodynamic changes suggest compensatory mechanisms in response to elevated mPAP and PVR. This model offers potential for studying therapies targeting PH progression.

Shujie Jin (Advisor: Guang-Hong Chen)
Title: Physics-driven and data consistency-constrained sinogram completion using a denoising diffusion probabilistic model for limited-angle reconstruction
Abstract: Our work addresses the challenge of limited-angle tomographic reconstruction, a common issue in medical and industrial imaging caused by hardware constraints or deliberate trade-offs to enhance temporal or spectral resolution. The incomplete sinograms resulting from these limitations often fail to satisfy the data sufficiency condition required for accurate image reconstruction. To overcome this, we propose a physics-driven and data consistency-constrained sinogram completion framework utilizing a conditional Denoising Diffusion Probabilistic Model (DDPM). The framework incorporates two key techniques: (1) a conjugate ray completion step that leverages the geometric

symmetry of divergent beam CT to fill missing sinogram regions, significantly improving the performance of DDPM; and (2) a data consistency condition that enforces intrinsic consistency within the completed sinogram. These techniques ensure that the sinogram reconstruction is both physically plausible and consistent with the original acquisition process. By effectively addressing the challenges of incomplete data, this approach enables robust and accurate image reconstruction in limited-angle scenarios, offering significant potential for advancing medical and industrial imaging applications.

Marlin Keller (Advisor: Mike Speidel)
Title: In silico study of quantitative digital subtraction angiography (qDSA) blood velocity measurements
Abstract: Quantitative digital subtraction angiography (qDSA) is a method for measuring blood velocity from 2D x-ray sequences during interventional procedures. Previous studies in swine models and phantoms compared qDSA blood velocity estimations to MRI or ultrasound measurements. We report a computational fluid dynamics (CFD) simulation platform for controlled investigations of qDSA behavior. Iodine injections into arterial blood flow and the turbulent mixing of the two liquids were simulated with OpenFOAM. Simulations were repeated for different catheter geometries (0-45° angle, 0-180° rotation) and blood velocities. X-ray projections were derived from CFD volumes, and qDSA was applied to these projections to obtain blood velocity estimations. This study performed a comparison between the known CFD velocity fields and the qDSA outputs. We found qDSA was linearly related to downstream CFD velocity. Furthermore, this study shows catheter orientation changes between simulations under controlled fluid conditions resulted in 5% standard deviation in qDSA output.

Peyton Lalain (Advisor: Dr. Larry DeWerd)
Title: Comparison of Triple-to-Double Coincidence Ratio Liquid Scintillation Counting Activity Determinations of Co60 Using FPGA and List-Mode Acquired Data
Abstract: Triple-to-double coincidence ratio (TDCR) liquid scintillation counting (LSC) is a primary method for the measurement of activity. TDCR is particularly suited to measuring activity for beta and positron emitters, since their relatively low LET leads to lower counting efficiency. A three-photomultiplier tube (PMT) system is used, with an LS vial containing activity and LS solution placed in the center, and emitted scintillation light collected by the PMTs. Logic circuitry is used to record the collected light as a triple coincidence (light pulse detected by all three PMTs) or a double coincidence (light pulse collected by two PMTs). The ratio of triple coincidence and double coincidence count rates is the TDCR, which allows an absolute measurement of the collection through a free-parameter efficiency model. Using various filters, the efficiency of light collection is manually changed to provide a range of TDCR values. Currently, NIST employs two modes of data collection in their TDCR system: a field programmable gate array (FPGA) based system that has been used in the past, and list-mode acquired data collected using a newly implemented Caen 5724 digitizer. In this work, TDCR activity measurements were performed for a 60Co source using these two different methods of data collection. Activity calculations were done using both TDCR data sets in addition to two different MICELLE2 TDCR simulations. The two MICELLE2 simulations differed in the beta spectrum of 60Co used: one using the classical 60Co spectra and the other using the BetaShape calculated spectrum from Kossert et al (2018). Using MICELLE2 simulated TDCR and efficiency values, a plot of the efficiency versus the TDCR was made, and a linear fit was applied. This fit equation and the experimental TDCR values were used to solve the double coincidence counting efficiency. This efficiency and the experimentally measured count rate were used to get the value of the activity in becquerel. Comparisons were made between the activity computed using both TDCR data sets to assess differences in the data acquisition methods.

Hong Beom Lee (Advisor: Paul Ellison)
Title: Preclinical Studies for Novel Theranostic Radiopharmaceutical 3-[76Br/77Br]bromo-pHPG
Abstract: Positron-emitting 76Br (t1/2 = 16.2 h, β+ = 21.5%) and Auger electron-emitting 77Br (t1/2 = 57.0 h) have great potential for radiolabeling small-molecule radiopharmaceuticals. This study developed 3-[76Br/77Br]bromo-p-hydroxyphenethylguanidine (3-[76Br/77Br]Br-pHPG) targeting norepinephrine-transporter-overexpressing malignancies such as neuroblastoma. Phenethylguanidine, a norepinephrine analog, demonstrates faster tumor localization and

higher retention than benzylguanidine analogs, with 3-[18F]F-pHPG PET showing superior lesion detection and spatial resolution over [123I]mIBG scintigraphy. Bromine-76 and 77Br were produced via 13 MeV proton irradiation of Co76/77Se, followed by isolation using dry distillation and trapping on a bicarbonate-form QMA cartridge. Radiosynthesis was achieved through electrophilic radiobromination resulting in high radiochemical conversion (RCC) (96 ± 1 %, n = 7 for 77Br; 98 %, n = 1 for 76Br), radiochemical yield (RCY) (58 ± 6 %, n = 9 for 77Br; 53 %, n = 1 for 76Br) and molar activity (70 ± 22 MBq/nmol for 77Br; 48 MBq/nmol for 76Br). Additionally, the compound only suffered 10% debromination across two weeks in 4 – 8 MBq/mL saline. In vitro cytotoxicity assays on SK-N-SH neuroblastoma cells revealed a 50% effective concentration (EC50) of 0.476 ± 0.008 MBq/mL (7.884 nM) for 3-[77Br]Br-pHPG and 1.287 ± 0.144 mM for 3-natBr-pHPG, demonstrating radiotoxic efficacy. In vivo positron emission tomography imaging in BALB/c nu/nu mice with subcutaneous SK-N-SH tumors indicated rapid renal clearance with limited tumor uptake (standard uptake value = 0.07 ± 0.02 at 6 hours). Despite promising synthesis and in vitro results, initial in vivo data highlight the need for further optimization, including in vitro uptake studies and testing alternative neuroblastoma cell lines with higher norepinephrine transporter expression.

MJ Lindsey (Advisor: Reinier Hernandez)

Title: Dual Radiopharmaceutical-Senolytic “One-Two Punch” Therapy

Abstract: The senescent phenotype is a terminal, radioresistant state that a cell may enter following sub-lethal irradiation. Senescence halts neoplastic replication and triggers an acute inflammatory response, both of which have been shown to be therapeutic. However, prolonged senescence is associated with increased risk for metastasis and recurrence. The senolytic drug class selectively targets senescent cells and upregulates apoptotic pathways. The so-called “One-Two Punch” combination therapy of radiation and a senolytic agent aims to initially induce the therapeutic effect of acutely radio-generated senescent cells and subsequently clear these cells with the senolytic. This study seeks to characterize the potential of a dual radiopharmaceutical-senolytic therapy (RPT-S). Determination of half-max inhibitory concentration (IC50) of senolytic agent Navitoclax was performed via treatment titration for metastatic prostate cancer (mPC) cell lines: PC3-PIP, LNCaP, and 22Rv1. Navitoclax synergy with external beam radiation (EBR) and 177Lu was determined via in vitro combinations over a range of radiation absorbed doses and drug concentrations for the PC3-PIP cell line. Representative bright-field microscopy images were taken of non-colony-forming PC3-PIP cells following 14-d incubation with the combination treatment. Results: In PC3-PIP cells treated with EBR or 177Lu, the addition of Navitoclax at ≥1.0 μM showed statistically relevant ($q < 0.003$) reduction in cell culture vitality when compared to radiation treatment alone. Bright-field imaging corroborated these findings. These early results demonstrate the potential of RPT-S to enhance the therapeutic landscape of RPT for mPC. Moreover, it is reasonable to assume that these findings may be relevant for other tumor types where an RPT agent exists. Further work will explore in vivo potential and optimization of RPT-S.

Yi-Hsuan Lo (Advisor: Paul Ellison)

Title: Accelerator production of 71As from metal germanium targets and radiolabeling of SCN-TT-Glu-Ser-RM2

Abstract: We report the cyclotron production, radiochemical isolation, and radiolabeling methods for of 71As-Glu-Ser-RM2, a gastrin-releasing peptide receptor (GRPR) antagonist for targeting cancer. 70Ge(m) was irradiated with 15 – 35 μA, 8 MeV deuterons, producing 71As with radionuclidic purity >98% and the experimental physical yield is 0.143±0.02 mCi·μA-1·h-1. The irradiated target was dissolved with aqua regia at 100 °C. Anion exchange (AX) chromatography isolated 71As from germanium in 0.1 M HCl with Ge decontamination factor of ~103 – 104 and overall yield 52±8%. For radiolabeling, SCN-TT-Glu-Ser-RM2 (50 – 100 nmol) was deprotected and reacted with mercaptoacetic-acid-reduced 71As(III). The radiolabeling efficiency was 97± 7% (n=5) with 92% stability in phosphate buffered saline (PBS) over 96 h. Two cell lines, PC3 human prostate cancer (high GRPR expression) and TP53/BRCA2 knock out ID8 murine ovarian cancer (with unknown GRPR expression) were selected for in vitro studies. The cellular uptake after 2 h incubation with 3.4-4.5 nM 71As-Glu-Ser-RM2 was 0.55±0.09 and 0.36±0.06 amol/cell at in PC3 and ID8, respectively. Irradiation of 70Ge targets produced effectively produced 71As which was isolated by AX chromatography with acceptable yield and purity. 71As-

TT-Glu-Ser-RM2 showed good uptake in the two cell lines, motivating PET studies on mice bearing heterotopic syngeneic ovarian cancer.

Kelly McElvain (Advisor: Larry DeWerd)
Title: Radiological characterization of water-equivalent solid phantom materials for dosimetry in low to medium x-ray energy applications
Abstract: Accurate dosimetry is fundamental in radiation therapy, with protocols such as AAPM TG-61 relying on water phantoms for dose measurements across specified energy ranges. Solid water-equivalent phantoms serve as practical alternatives to liquid water for relative dosimetry in low to medium x-ray energy applications. This study evaluates the dosimetric water equivalence of several commercial solid phantom materials using photon beams between 50 and 250 kVp. Preliminary relative measurements demonstrated agreement with water within 1.0±1.0% across the entire energy range, confirming their suitability for radiation dosimetry. Characterization of solid phantoms relative to water prior to use for radiation dosimetry applications is recommended to ensure the material accurately mimics radiological interaction properties.

Bujar Mehmeti (Advisor: Dr. Guang-Hong Chen)
Title: A review of the pulse formation process and polarization effect on semiconductor-based Photon Counting Detectors (PCDs) with preliminary simulation and experimental results
Abstract: Photon Counting Detectors (PCDs) have emerged as a transformative technology in X-ray imaging, enabling precise energy-resolved photon detection, improved imaging capabilities, and reduced radiation dose. This poster presents a review of the pulse formation process and the effects of polarization in semiconductor-based PCDs, supported by theoretical, simulation, and experimental findings. Pulse formation is analysed using the mirror method to simulate the dynamics of charge transport, diffusion, and trapping. The simulations illustrate how charge clouds evolve, with factors such as charge-sharing and repulsion playing a significant role in influencing energy resolution and detection efficiency. Figures generated from these simulations provide insights into the pulse formation process on the detector under different simulation parameters. Polarization, a phenomenon where the internal electric field within the detector material is distorted due to the accumulation of trapped charges, is investigated as a potential limitation to PCD performance. This effect arises during prolonged irradiation as the continuous flux of charge carriers leads to charge trapping at defect sites, altering the field distribution and reducing the detector's ability to efficiently collect generated charges. Over time, this dynamic can degrade the uniformity of charge collection and impact both the count rate and energy resolution. Experimental measurements on a benchtop PCD exposed to continuous irradiation demonstrated a reduction in photon counts, even after corrections for X-ray tube drift, underscoring the implications of polarization on detector performance and its operational stability. This review provides valuable insights into the pulse formation process and polarization effects, paving the way for improved PCD performance and reliability in various imaging applications.

Grace Minesinger (Advisor: Dr. Martin Wagner)
Title: Automating swine liver segmentation for FE image registration in CBCT guided histotripsy
Abstract: Histotripsy is an ultrasound-based focal tumor therapy that was approved by the FDA to treat liver tumors in October 2023. Despite this promising advance in cancer care, histotripsy is currently guided by diagnostic ultrasound which fails to adequately depict the tumor or surrounding anatomy for approximately 50% of the liver. To overcome such visualization limitations, C-arm cone beam CT (CBCT) guided histotripsy is being developed, where treatment planning (i.e., localizing targets and critical structures) is performed during the procedure using an intraprocedural CBCT. To facilitate treatment planning in advance of the procedure, a finite element (FE) elastic model of the liver was developed to register preprocedural images and contours to intraprocedural anatomy. The FE model relies on liver and gallbladder segmentations, which are currently defined manually. Deep learning networks for automatically segmenting human CTs are available but not generalizable to swine, where image registration algorithms are often developed and evaluated. This study investigated transfer learning from human to swine anatomy by training a set of nnU-Nets to

segment swine liver and gallbladder from CTs. Automatic and manual segmentations were used to generate FE models and perform image registration. Their performance was evaluated by comparing registration accuracy and anatomical similarity between automatically and manually registered images. This automatic swine liver segmentation network will expedite and facilitate further development of image registration for CBCT guided histotripsy.

Rachel Minne (Advisor: Dr. Randall Kimple)

Title: Evaluating the Theranostic Potential of a Novel Shark VNAR Antibody to Target MET in NSCLC

Abstract: The mesenchymal epithelial transition (MET) factor receptor plays a crucial role in driving cell motility, proliferation, and angiogenesis. Mutations or amplifications in MET lead to pathway upregulation, which contributes to tumorigenesis and metastasis. MET amplification (METamp) is observed in 6% of non-small cell lung cancers (NSCLC), while MET mutations, including the most common MET exon 14 skipping mutations (METex14), occur in 3%. FDA-approved tyrosine kinase inhibitors, such as Capmatinib, Crizotinib, and Teopotinib, serve as first-line treatments for NSCLC patients harboring MET mutations. Despite this, drug response varies across different MET alterations, and treatment options remain scarce for patients who develop resistance. This underscores the critical need to identify alternative therapeutic strategies for NSCLC patients with MET mutations. We sought to develop a novel variable domain new receptor (VNAR) shark antibody with strong binding affinity to MET that could be used to deliver conjugated treatment payloads to MET expressing cancers. From a panel of shark antibodies, we identified a VNAR clone termed 2H4 that displayed high affinity for human MET and was cross-reactive with MET across multiple species. Flow cytometry and immunofluorescence imaging of 2H4-Fc with METamp and METex14 human cell lines was performed to assess the nanobodies MET targeting abilities in vitro. Western blotting and cell proliferation were used to assess 2H4-Fc's effect on downstream signaling and cell viability respectively. We conjugated 2H4-Fc with Zr89 and assessed tumor uptake in mouse xenografts bearing METamp and METex14 tumors with PET/CT imaging and ex vivo biodistribution analysis. Additionally, we conjugated 2H4-Fc with Lu177 and assessed tumor uptake and anti-cancer effects with SPECT imaging and tumor volume measurements in mouse xenografts bearing METamp tumors. When expressed as a bivalent human Fc fusion protein, 2H4-Fc was found to selectively bind to both METamp and METex14 human cell lines by flow cytometry and immunofluorescence imaging and did not inhibit downstream signaling nor effect cell viability. [89Zr]Zr-2H4-Fc and demonstrated rapid localization and high tumor uptake in both xenograft with a calculated %IA/g in the tumor to be 30.2% and 20.0% for METex14 and METamp respectively at 96 hr post injection. Additionally, [177Lu]Lu-2H4-Fc has demonstrated similar pharmacokinetic behavior with rapid attenuation in METamp tumors within 24 hours post injection. Tumor uptake was calculated to be approximately 15 %IA/g at 120 hr post injection and delay in tumor growth was observed up to 21 days post injection. MET shark antibody, 2H4-Fc, demonstrated high binding affinity and accumulation in MET altered tumors and minimal surrounding tissue cytotoxicity, highlighting it's potential application as a successful theranostic agent.

Zahra Alyani Nezhad (Advisor: Tim Szczykutowicz)

Title: A Physics-Based Correction for Contrast-Enhanced CT to Mitigate the Effects of Beam Hardening and Acquisition Energy

Abstract: A retrospective study was done on 55 patients who received CT-pulmonary angiography over a 1-month period. Beam energies were set to 80, 100, or 120 kV depending on patient weight. We measured Quantitative Iodine Contrast Enhancement (Q-ICE) of the pulmonary artery (PA). To eliminate the influence of beam energy on Q-ICE, relative iodine enhancement normalization factors from the literature were used to normalize Q-ICE measurements to 120 kV. Beam hardening correction factors were determined using measurements of iodine enhancement in a phantom model of varying size. Unpaired two-tailed Student's t-test was performed to evaluate the difference in mean PA Q-ICE between weight bins in both pre- and post-corrections. Correlation of PA Q-ICE values across patient weight were assessed using linear regression. Before correction, the mean PA Q-ICE enhancement for (40-60)/(61-80)/(81-100)/(101-120)/(>120) kg patients was 756/565/327/310/275 HU respectively; a range of 481 HU over patient size. After correction, the mean PA Q-ICE enhancement for (40-60)/(61-80)/(81-100)/(101-120)/(>120) kg patients was 416/386/275/297/320 HU respectively; a range of 141 HU over patient size. Before corrections, PA Q-ICE changed when

moving from 40-60 to 61-80 weight bin (p=0.0357) for un-corrected PA Q-ICE while post correction there was no change (p=0.4108). PA Q-ICE with patient weight showed a negative slope of -5.97/-2.52 /-1.59 for uncorrected, beam energy corrected, and beam energy plus beam hardening corrected cohorts respectively. After beam energy and beam hardening correction, there was less variation in PA Q-ICE across patients. By removing patient size and beam energy effects from iodine enhancement optimization, one can focus on other factors like: exam timing, contrast bolus, flow rate, and saline flush parameters. Our work is being used at our clinic to allow for more informed contrast prescription optimization.

Aubrey Parks (Advisor: Dr. Brian Pogue)
Title: Small Field intensity and spatial trends between dose and Cherenkov imaging
Abstract: Cherenkov imaging of radiotherapy beams allows for treatment visualization and verification, however decreased signal from highly modulated treatments that leverage small beams presents a challenge for treatment monitoring. Beam profiles with a constant dose at depth for field sizes varying laterally between 0.5 and 15cm were created using RayStation Treatment Planning System. Cherenkov emission from an aqueous quinine solution was captured using an intensified CMOS camera, and intensity was mapped to dose using a 3%/3mm gamma analysis. Additional treatment plans were imaged in a tissue-like phantom to evaluate the impact of optical absorption on Cherenkov detection from small beams. The gamma analysis showed a strong spatial agreement between dose and Cherenkov signal in the buildup region for all field sizes. Normalized Cherenkov intensity diverges from dose at small field sizes, remaining within 5% until the 2.5x5cm field, but declining to 61% for the smallest field in the aqueous quinine solution. Tissue optics cause further divergence between Cherenkov emission in dose with the normalized Cherenkov intensity from the tissue phantom within 5% of the dose until the 3x5cm field and dropping to 38% for the smallest field.

Gabriela Pazin Tardelli (Advisor: Dr. Ron Wakai)
Title: Prognostic Value of Fetal magnetocardiography in Ebstein's anomaly
Abstract: Ebstein's anomaly and tricuspid valve dysplasia (EA/TVD) are congenital heart defects associated with very high perinatal mortality (~45%). Fetal echocardiography is the primary tool for predicting outcomes, but the role of electrophysiologic indicators has not been investigated. In this regard, fetal magnetocardiography (fMCG) offers a more precise and comprehensive assessment of fetal heart rate and rhythm, including conduction, repolarization, cardiac time intervals, and fetal heart rate variability. In this study, we used fMCG to characterize the electrophysiology of 17 fetuses with EA/TVD. The fetal rhythm, waveform intervals, and fetal heart rate and activity patterns were obtained and compared against data from normal fetuses. The most prominent fMCG features of fetuses with EA/TVD were tall, wide P-waves and wide QRS complexes. The degree of QRS prolongation was remarkable, and 4 of 6 fetuses that died showed QRS with Z scores> 4. Lastly, 4 fetuses that died showed flat heart rate tracings and low or abnormal heart rate reactivity. In conclusion, fMCG identified conduction and rhythm abnormalities in EA/TVD that are not detectable in echocardiography. The abnormalities were strongly associated with perinatal demise and can serve as useful prognostic indicators.

Karen Rex Pius Vincent (Advisor: Dr. Larry DeWerd)
Title: Absolute measurement of HDR Ir-192 using an Exradin A3 Known Volume Chamber
Abstract: Absolute measurements are often employed to establish primary standards because they do not require calibration coefficients and provide higher metrological quality. However, for the HDR Ir-192 brachytherapy source, only an interim primary standard currently exists to measure the air-kerma strength. This standard requires using an ionization chamber with a calibration coefficient interpolated between two NIST-traceable beams (M250 and Cs-137) to approximate the effective energy of HDR Ir-192 (397 keV). The calibrated chamber is then used in a technique known as the seven-distance method to determine the air-kerma strength. Known-volume chambers offer an alternative approach to measure this quantity. In this work, the air-kerma strength was determined using an Exradin A3 ionization chamber

with a precisely determined collecting volume, obtained via microCT. In addition, several parameters and correction factors for this chamber were determined through either previous literature data or EGSnrc monte carlo. The air-kerma strength obtained from the known-volume chamber was compared to the value measured from using the interpolation-based calibration coefficient method. The percentage difference between the two techniques was 0.070%.

Chase Ruff (Advisor: Dr. Carri Glide-Hurst)

Title: Development of a Population-Based Coronary Artery Habitat Model Using CCTA for Cardiac-Spared Treatment Planning

Abstract: Increased dose to coronary arteries during thoracic radiotherapy is correlated with worse patient outcomes following treatment. Decreasing coronary artery dose is advantageous but is complicated by complex coronary artery trajectories and resolution limits of routine radiotherapy datasets, thus making patient-specific models impractical. We propose a robust population-based coronary artery habitat model using high resolution CTCA to better define potential high-risk regions. Ten diagnostic multi-detector CTCA scans (end-inhalation, mid-diastole, deep-learning reconstructed motion-corrected) were delineated for the left anterior descending (LADA), right (RCA), circumflex (LCX), and left main (LMCA) coronary arteries, and whole-heart (WH). Twenty additional cases had contours generated via a state-of-the-art nn-UNET deep learning model. Labels were manually adjusted and verified by a radiologist. A template case was selected based on average heartrate, BMI, heart volume, and image intensity (HU). Hybrid contour-based intensity-based deformable image registration was used to transfer all data to the template. Registration results were quantitatively evaluated via the Dice Similarity Coefficient (DSC) and visually verified. Cases with a whole heart DSC > 95% and within the 95th percentile of coronary artery volumes were included for analysis. Population habitats for each artery were defined via Euclidian-based clustering and conformal boundaries around the final points. Five cases were tested for final habitat verification. Corrected nn-UNET predicted coronary artery volumes for the population were 1.10-5.06 mL, 0.87-4.37 mL, 0.15-0.84, mL and 0.56-4.96 mL for RCA, LADA, LMCA, and LCX, respectively. The corresponding predicted habitats defining these arteries accounted for 14.0%, 5.3%, 5.7%, and 0.6% of the total heart volumes. Predicted habitats successfully contained 86.4%-96.0% of ground-truth coronary artery labels. Greatest variability was observed near the apex of the heart and aorta. We have demonstrated feasibility of developing a population-based coronary artery habitat model from CTCA. After confirmation in a larger cohort, future work includes integration into cardiac-spared treatment planning.

Aria Salyapongse (Advisor: Tim Szczykutowicz)

Title: Assessing Iodine Quantification Errors with Partial Iodine Voxel Content During Iodine-Water Basis Pair Material Decomposition

Abstract: Iodine quantification is an important CT based biomarker in quantitative CT imaging. This study quantifies sources of errors in quantitative spectral CT. This work examines the theoretical relationship between linear attenuation coefficients, material decomposition basis pairs, and material quantification. Voxels are simulated using the spektr MATLAB package with clinically appropriate volume fractions of iodine and tissue backgrounds. Voxel linear attenuation coefficients were calculated using the National Institute of Standards and Technology (NIST) XCOM database. Then the voxels' contents are decomposed onto an iodine-water basis pair and the iodine volume fraction was calculated. This value was then compared with the known iodine volume fraction as a percent error. Quantification errors are also demonstrated experimentally using a clinically relevant phantom with known iodine and background density inserts. For a voxel of some background material and iodine with the choice of a water-iodine material basis pair for material decomposition of iodine in the range of 0.2-2.0 mg/mL, the error in iodine density 0 mg/mL for a water background, 0.03 to 0.05 mg/mL for muscle, lung, soft tissue, and blood backgrounds, -0.23 mg/mL for an adipose tissue background, and 6.92 mg/mL for a bone background. A negative mass difference means the calculated iodine mass was underestimated, and a positive mass difference means the calculated iodine mass was overestimated. We derive two new understandings: (1) iodine-water material decomposition is never accurate in vivo, and (2) for error free material decomposition a voxel must only consist of the basis decomposition vectors. Our work demonstrates material quantification is fundamentally limited when measured in vivo. To define CT derived biomarkers, the errors we

demonstrate should either be avoided or built into uncertainty bounds. Improving error bounds in quantitative CT, specifically in iodine quantification, could further the development of CT biomarkers.

Sebastian Salgado (Advisor: Robert Jeraj)
Title: PET Predicts and Tumors Persist: Leveraging Molecular Imaging in PRRT to Foresee Metastatic Lesion Outcomes and Guide Selective SBRT
Abstract: Patients with metastatic neuroendocrine tumors (mNETs) often undergo peptide receptor radionuclide therapy (PRRT), where lesion response heterogeneity is ubiquitous. Image features in somatostatin receptor (SSTR) PET/CT have been shown to be reasonable predictors of progression free survival and overall survival, i.e., patient-level outcome. This study investigates whether image-based quantitative features from SSTR PET/CT can predict lesion-level outcome and guide selective locoregional therapy after PRRT. A retrospective analysis of 13 mNET patients treated with [177Lu]Lu-DOTA-TATE and imaged with [68Ga]Ga-DOTA-TATE was conducted. Lesions were segmented and matched across baseline (BL), short-term post-treatment (PT), and long-term (LT) scans to extract longitudinal features (BL-PT matched SUV metrics). Models predicting LT persistence were trained using BL, PT, and longitudinal features, and performance was evaluated via AUC, sensitivity, and specificity. The best-performing model was compared to a PERCIST-based approach to assess its impact on selecting persistent lesions for treatment and avoiding irradiation of disappearing lesions. In all models, one feature matched across timepoints (longitudinal feature) maximizes model performance (highest performance: 0.85 AUC, 77% sensitivity, 90 specificity). Longitudinally informed models have an average of 0.81 AUC (0.83 - 0.80, 95%CI), significantly higher ($p < 1e-10$) than only PT models 0.72 (0.74 - 0.70, 95%CI), and only BL models with 0.66 (0.69 - 0.64, 95%CI) ($p = 0$). Finally, selecting lesions with our model led to more persistent lesions treated, and less disappearing lesions irradiated (an average of 6 and 2 respectively). SSTR PET/CT is informative for predicting lesion persistence. This approach offers a method for identifying lesions that may benefit from locoregional ablative therapies (e.g. stereotactic body radiation therapy), ultimately improving individualized treatment strategies for mNET patients.

Alma Spahic (Advisor: Oliver Wieben)
Title: Motion Characterization of Cranial MRI during Exercise
Abstract: Cardiovascular MRI studies conducted while exercising can elucidate pathologies that are obscured under resting conditions1–5. There is motivation to conduct similar studies on cerebral blood flow to probe the effects of exercise on cerebrovascular and cognitive health6,7. However, these studies pose several challenges, such as requiring MR-compatible equipment and managing additional motion artifacts. In this study, we use rapid 2D sequences to characterize cranial motion patterns during rest and at different exercise intensities. Knowledge of the motion patterns will help characterize the requirements for motion correction schemes to conduct reliable and accurate quantitative MRI studies during exercise.

Jiayi Tang (Advisor: Dr. Diego Hernando)
Title: MRI-based Fat Quantification with Improved Motion-Robustness and Cross-Vendor Usage
Abstract: Excessive liver fat deposition (steatosis) is highly prevalent (1.5 billion worldwide) and can lead to further liver injury, liver failure, and liver cancer. Non-invasive methods are needed for accurate, reliable and widely available liver fat quantification, for detection, staging, and treatment monitoring of liver steatosis. Conventional MRI-based methods require breath-holds and fail in the presence of physiological motion. For these reasons, there is an urgent clinical need for a method that enables motion-robust liver fat quantification. 2D sequential chemical-shift encoded MRI with flip-angle modulation (FAM) is a promising method for quantifying liver fat deposition noninvasively, with robustness to respiratory motion and excellent quantitative performance in preliminary studies. Our recent work focuses on improving the FAM method itself, as well as broadening the adoption of FAM. To improve the FAM method, we implement bipolar readouts in the FAM sequence. Bipolar readouts increase motion robustness by reducing the temporal footprint of an acquisition. Also, bipolar readouts shorten echo times, which we show improves performance in patients and phantoms

with high R2*. To broaden adoption of FAM, we implement FAM in the vendor-neutral platform Pulseq. This allows us to acquire FAM in systems of three major MR vendors, at three field strengths. We show the results of Pulseq-FAM validation in a cross-site, cross-vendor phantom study and a single-site in vivo study. Overall, this work advances motion-robust quantitative MRI to address a major clinical need in the evaluation of liver disease.

Manasa Tatavarthy (Advisor: Dr. Wes Culberson)
Title: Calibration of radionuclides with gamma spectroscopy
Abstract: The accurate determination of radionuclide activity is crucial in the context of radiopharmaceutical therapy (RPT), where precision in dosimetry ensures effective treatment plans while minimizing adverse effects. Gamma spectroscopy, with its ability to interpret the energy and intensity of gamma radiation emitted by radionuclides, plays a pivotal role in this domain. This study focuses on using gamma spectroscopy to verify unsealed radionuclide activity, addressing the challenges of calibration and standardization in clinical settings. This study will focus on improving the accuracy of radionuclide activity measurements by addressing critical factors that influence results, like the impact of detector efficiency, geometric dependency of radionuclides, and limitations in traditional calibration techniques. Discrepancies caused by varied sample geometries, container materials, and radionuclide-specific calibration factors are also examined, emphasizing the need for precise and reliable measurement approaches. By employing NIST-traceable standard radionuclides we try to build traceability and standards, there is research that highlights the critical role of traceability and standardization in enhancing the reliability of clinical measurements. This study emphasizes the necessity of integrating secondary standards laboratories, like ADCLs, into the calibration process for unsealed sources, bridging existing gaps and establishing consistent practices. The goal of this research work is to get precise measurements of radionuclide activity, through well-calibrated gamma spectroscopy systems, which can significantly improve patient outcomes in RPT by delivering accurate Doses. This study will explore the potential for developing a secondary standards lab for radionuclides that follows a similar framework that ADCL employs for dosimetry.

Zach Welchel (Advisor: Dr. Larry DeWerd)
Title: Impact of Beam Energy and Symmetry on the Radial Profile Correction Factor for FFF Beams
Abstract: Conventional linear accelerator-based photon radiotherapy therapy utilizes a flattening filter in the treatment head to achieve increased dose uniformity. However, removing the flattening filter can significantly enhance delivery efficiency by increasing the dose rate. In flattening filter-free (FFF) beams, the intrinsic characteristics of megavoltage photon production result in a “peaked” beam profile, with maximum intensity occurring along the central axis for symmetric beams. Due to this spatial variance near the central axis, one must be aware of the degree of signal averaging that occurs over the ion chamber’s volume when performing reference dosimetry. This necessitates a radial profile correction factor (PrpPrp) that corrects the ion chamber reading for volume averaging. This study investigates how variations in photon beam energy and symmetry influence the radial profile correction factor. PrpPrp values were calculated for Farmer-type chambers by integrating a function fitted to measured and simulated profile data. Results indicate that the correction factor increases with photon beam energy. However, changes in PrpPrp were minor within the sampled range of beam symmetry.

Yuhao Yan (Advisor: Dr. Carri Glide-Hurst)
Title: Evaluation of a Novel Quantitative Multiparametric MR Sequence for Radiation Therapy Treatment Response Assessment
Abstract: Multi-parametric MRI has shown great promise to rapidly derive multiple quantitative imaging biomarkers for treatment response assessment. A novel Deep Learning-enhanced MUlti-PArametric MR sequence, DL-MUPA, was evaluated for treatment response assessment for two prospective clinical studies of brain metastases and head-and-neck (HnN) cancer patients. DL-MUPA derives quantitative T1 and T2 relaxation time maps from a single 4-6-minute scan

using dictionary fitting. DL-based reconstruction was used to reduce noise. Longitudinal DL-MUPA data were acquired on a 1.5T MR-simulator (pre-treatment (PreTx) and every ~3 months post-treatment (PostTx) in brain, PreTx, 2-3 weeks mid-tretament (MidTx) and 3-month PostTx in HnN). Changes in mean T1 and T2 values were calculated to evaluate treatment response of gross tumor volumes (GTVs) and parotids (HnN). Uninvolved normal tissue (normal appearing white matter in brain and spinal cord in HnN) were evaluated for within-subject repeatability. Uninvolved normal tissue values were consistent (absolute ΔT1mean<65ms/5% and ΔT2mean<4ms/6%), suggesting reliability in longitudinal study. Considerable changes were observed in brain metastases (ΔT1mean=155ms/14%, ΔT2mean=12ms/19% at 4-month PostTx for one resolution, ΔT1mean>214ms/18%, ΔT2mean>7ms/9% comparing 6-month to 3-month PostTx for two necrosis) and one resolved HnN tumor (PostTx ΔT1mean=-340ms/-26%, ΔT2mean=-11ms/-18%). Another HnN patient with the left parotid abutted to GTV exhibited longitudinal T1 enhancement (MidTx ΔT1mean=52ms/6%, PostTx ΔT1mean=93ms/10%), coincided with a patient's reported outcome of persistent severe dry mouth, while the right parotid remained stable (absolute ΔT1mean<43ms/5%), suggesting potential of identifying endpoints for functional organ sparing in HnN adaptive radiation therapy. Preliminary results suggest promise of applying DL-MUPA in treatment response assessment for tumor and functional organs to be confirmed in a larger cohort with corresponding outcome information.

Linying Zhan (Advisor: Dr. Guang-Hong Chen)

Title: The Color of Clarity: X-ray Energy and Its Impact on Spatial Resolution in Photon Counting CT

Abstract: Photon counting detector computed tomography (PCD-CT) is widely acclaimed for its superb spatial resolution. This study extends beyond traditional comparisons with energy integrating detector CT (EID-CT) to examine a novel aspect of PCD-CT technology: the significant influence of x-ray energy on spatial resolution. This parameter can be analogously described as the 'color' of x-rays, introducing a color dimension to spatial resolution analysis. The study also aims to pinpoint whether the noted improvements in spatial resolution with PCD-CT are predominantly attributable to the photon counting mechanism or to a sophisticated interaction with the spectral characteristics of x-ray energy. Pre-sampling edge response function and MTF of a CdTe-based direct conversion PCD (0.1 mm pixel pitch) were experimentally measured at 13 different energy thresholds ranging from 5 to 60 keV. At each threshold, the measurement was repeated 1000 times to establish uncertainty range. The obtained experimental data served as validation for a detector model capable of estimating MTF across arbitrary energy thresholds. By eliminating low energy thresholding and applying photon energy-based weighting, the detector model effectively simulates the transformation of the PCD into a direct conversion EID with matching sensor thickness, bias voltage, and pixel pitch. Subsequently, we measured the MTF of this simulated EID and compared it against the MTF of the original PCD.