Mervat Alharbi (Advisor: Dr. Tomy Varghese)
Title: Matching radiochromic film measurements with parallel plate chamber for conventional electron beam
Abstract: Ultra-high dose rate (FLASH) involves the delivery of radiation in microseconds and represents a promising treatment method that enhances the efficacy of radiation treatments for cancer cells while minimizing the potential side effects of normal cells.

Liliana Berube (Advisor: Dr. Randall Kimple)
Title: Impact of Serial Passage on Head and Neck Cancer Patient-Derived Xenografts
Abstract: Patient-derived cancer models offer crucial insights into therapeutic responses and resistance mechanisms. To optimize translational value, researchers must recognize their models’ strengths and limitations. Breast cancer and T cell acute lymphoblastic leukemia studies reveal shifting clonal dynamics and selection in xenografts over serial passage. This is critical information for researchers as these changes could influence the interpretation of experimental results. Still, the impact of serial passaging on head and neck cancer (HNC) xenografts remains unknown. Our study addresses this gap, examining tumor biology, clonal evolution, and therapy responses in serially passaged HNC patient-derived xenografts. We will present preliminary data on the impact of serial passage on HNC xenografts.

Brecca Bettcher (Advisor: Dr. Bradley Christian)
Title: Predictability of Amyloid-PET Status with Plasma PTau217 in Down Syndrome Adults
Abstract: Efficient blood-based biomarkers capable of detecting Aβ pathology could serve as a costeffective and noninvasive screening to incorporate participants with Down syndrome (DS) in antiamyloid clinical trials. Previous work (Janelidze, 2022) has found a strong correlation between plasma and PET biomarkers using pTau217 and [ 11C]PiB. This work looks to expand on the analysis of plasma pTau217 in predicting PET amyloid positivity with [ 11C]PiB and [ 18F]florbetapir in adults with DS.

Laura Castañeda Martínez (Advisor: Dr. Ivan Rosado-Mendez)
Title: Quantitative microstructural evaluation of the neonatal brain
Abstract: This abstract is part of an ongoing research project that aims to use Quantitative Ultrasound (QUS) to assess early microstructural changes in the neonatal brain due to acute damage. Previous studies showed that acoustical parameters can potentially detect anesthesia induced...
microstructural brain changes in non-human primates. However, their accuracy and precision depend on accurate compensation for the attenuation between the transducer and the tissue of interest. Conventional QUS methods suffer from neglecting the piecewise variability of tissue properties with depth. This limitation is addressed in regularized QUS methods, like ALGEBRA (AnaLytic Global rEguArized BackscatteR quAntitative ultrasound). ALGEBRA has been shown to reduce bias and variance of QUS features. As a first step, this study focused on evaluating the inter- and intra-subject variability of QUS parameters in six healthy newborns. The study revealed that ALGEBRA reduces intersubject variability in attenuation measurements, particularly with higher regularization weights, and maintains agreement in attenuation over time. Although preliminary results are promising, these methods assume isotropic scattering sources, which may not be accurate for brain tissue. This motivated a new research line, which aims to implement a novel technique for the microstructural anisotropy assessment of the neonatal brain using a 2D matrix array transducer. Preliminary results of a 2D matrix array transducer characterization will be presented.

Molly DeLuca (Advisor: Dr. Jonathan Engle)
Title: Cyclotron Production of 45Ti: A Novel PET Radiometal
Abstract: The titanium radioisotope $^{45}$Ti undergoes $\beta^+$ decay with a 3.08h half-life and high positron branching ratio (84.8%), emitting a low energy positron ($E_{av} = 0.439$ fJMeV) and <1% gamma emissions apart from the two 511 keV photons associated with positron annihilation. Taken as a whole, these decay characteristics render $^{45}$Ti a compelling candidate for positron emission tomography (PET) imaging. Moreover, $^{45}$Ti can be produced from proton bombardment of naturally monoisotopic $^{45}$Sc, eliminating a need for enriched materials and reducing coproduction of radionuclidic impurities. The high cross section of the $^{45}$Sc(p,$n$)$^{45}$Ti reaction (320-350 mb) in the 10-15 MeV energy range renders $^{45}$Ti production accessible to the low energy cyclotrons typically available in clinical settings. We explore cyclotron production of $^{45}$Ti for incorporation in molecular imaging agents with the goal of optimizing physical and radiochemical yields while considering infrastructure requirements that constrain clinical radionuclide production. Sc presents a versatile target material; development of cyclotron targetry included solid Sc foils spot-welded onto tantalum backings and a liquid target filled with a solution of dissolved ScCl3 in hydrochloric acid. Physical $^{45}$Ti yields from both production routes were characterized. A chemical separation for extracting $^{45}$Ti from bulk Sc using a hydroxamate-based extraction resin was optimized to maximize $^{45}$Ti radiochemical yields and minimize final elution volumes. This chemistry was subsequently automated using a GE Fastlab to facilitate integration of $^{45}$Ti based radiopharmaceuticals into a clinical workflow.

Caroline Doctor (Advisor: Dr. Kevin Johnson)
Title: Brain Tissue Displacement and Strain Measures in an Alzheimer’s Disease Cohort using DENSE
Abstract: Prior research has provided evidence for arterial stiffening, increased pulsatile pressure, and a loss of brain tissue biomechanical integrity with increased age and also with the onset of Alzheimer’s disease (AD). Higher pulsatile pressure of the blood entering the capillaries may result in
increased displacement of the brain tissue over the cardiac cycle and increase mechanical forces to brain tissue leading to neuronal damage. The goal of this research was to provide preliminary results on the success of measuring the displacement and strain of brain tissues due to Cardiac Arterial Pulsations (CAPs) using DENSE (Displacement ENcoding with Stimulated Echoes) in patients with AD and age-comparable controls. DENSE scan data from a sample of 133 volunteers was processed and evaluated for trends in the derived displacement and strain information. High variability was found in the displacement measures, and future work is needed to determine the confounding factors behind the variability and to what degree those factors can be minimized going forward.

Miguel Flores (Advisor: Dr. Wes Culberson)
Title: CORRELATION OF THE EXRADIN W2 SCINTILLATOR RESPONSE WITH CURRENT BEAM TRANSFORMERS
Abstract: Exradin W2-scintillator provide a solution to real-time response for ultra-high dose rate (UHDR) beams. Real-time response of detectors in clinical settings is relevant to determine the absorbed dose. The nanoseconds response of the W2-scintillator makes it ideal for UHDR irradiations. Despite this advantage, W2-scintillator response to UHDR beams has not been fully addressed.

Garrett Fullerton (Advisor: Dr. Scott Reeder)
Title: Saturation recovery-based chemical shift-encoded T1 mapping in the liver
Abstract: Quantitative MRI methods are increasingly used to non-invasively diagnose, stage, and monitor various chronic liver diseases. T1 mapping is a valuable tool for quantitatively assessing liver fibrosis, but current T1 mapping methods suffer from high variability and bias, limiting its clinical implementation. This is often a result of confounders such as the presence of fat and B1+ inhomogeneities. To improve the variability of T1 mapping in the liver, we propose a multi-echo chemical shift-encoded MRI sequence with an optimized preparation pulse, optimized flip angle-modulation readout scheme, centric encoding, and joint parameter estimation. The proposed acquisition scheme enables rapid, simultaneous mapping of water-specific T1 (T1w), proton density fat fraction, and R2* without the need for additional B0 calibration. Our acquisition scheme and reconstruction method improve the overall performance of T1w estimation in the presence of confounding factors, ultimately helping to advance T1 mapping as a clinically viable diagnostic tool.

Jonathan Hale (Advisor: Dr. Ivan Rosado-Mendez)
Title: Acoustic Multiple Scattering as a Potential Imaging Biomarker for Assessing Collagen Remodeling
Abstract: Collagen is the most abundant protein in the body. During several physiological or pathophysiological processes, like cervical ripening during pregnancy and fibrosis, respectively, collagen fiber density and organization changes drastically. We seek to develop a quantitative ultrasound method to assess collagen fiber topology and non-invasively monitor collagen remodeling. Current imaging methods to assess collagen remodeling either lack penetration to favor
resolution or are not sensitive enough. Being able to monitor changes in collagen density and organization non-invasively using ultrasound will give us insight into the specific structural tissue changes during collagen remodeling and will give us early warning to abnormalities. Collagen contributes a significant portion of the received ultrasound signal due to the large acoustic scattering cross section of collagen compared to other extracellular matrix proteins. Thus, the received signal contains information about the collagen microstructure that we hope to extract. To track collagen remodeling, we rely on the analysis of multiple acoustic scattering, which provides descriptors of the interaction of ultrasound waves with tissue microstructure, like collagen fibers. The acoustic scattering mean free path is a parameter extracted from this analysis by fitting ultrasound signals to radiation transport theory models. It is related to the average distance between scatterers in a medium. The higher the density of scatterers, the shorter the scattering mean free path. Recently, the acoustic scattering mean free path has been used to evaluate the concentration of air-filled alveoli in the lung. We seek to use the same method to evaluate collagen remodeling. As a first step, the technique will be tested on collagen gel phantoms with varying collagen densities, alignments, and cross-linking concentrations. Using second harmonic generation microscopy as the ground truth, we will evaluate the sensitivity and specificity of the mean free path to predicting these different collagen properties. The algorithm to measure the acoustic scattering mean free path has been implemented in Matlab and tested on five ultrasound tissue-mimicking phantoms with varying scattering cross-sections. Results indicate that phantoms with larger scattering cross-sections produce higher rates of multiple scattering.

Jeremy Hallett (Advisor: Dr. Brian Pogue)
Title: Computational Methods for Improved Cherenkov Imaging
Abstract: Cherenkov imaging during radiotherapy provides a real time visualization of beam delivery on patient tissue, which can be used dynamically for incident detection or to review a summary of the delivered surface signal for treatment verification. There are several sources of noise and blurring which degrade the overall quality of these images such as sensor noise and photon intensifier blurring. This work has focused on removing or suppressing noise via image postprocessing and implementing new data acquisition techniques to produce fine image resolution. Total variation minimization (TV-L1), non-local means (NLM), block-matching 3D (BM3D), and alpha (adaptive) trimmed mean (ATM) algorithms were surveyed to quantify their denoising effectiveness. Each method was applied to Cherenkov images acquired using a BeamSite camera (DoseOptics). The standard denoised images were tested for SNR, noise power spectrum (NPS) and image sharpness. The signal-to-noise ratio (SNR) was measured to be 18.2 in Cherenkov and 7.3 in the background. TV-L1 processing increased these SNR values by 55% and 198%, respectively, which was the best improvement out of all the algorithms. This approach also produced minimal blurring and the lowest NPS curve. Additionally, a super resolution imaging technique was developed and implemented with a cooled CCD Pimax 4 camera to demonstrate the possible resolution improvements that could be implemented in clinical Cherenkov imaging or QA. It was demonstrated that individual photons could
be isolated and statistically sorted to determine their specific 2D pixel location. Future experiments will implement this technique with the BeamSite camera and analyze improvements in resolution.

Andrea Houck (Advisor: Dr. Diego Hernando)
Title: Smart averaging in diffusion MRI of the liver
Abstract: In diffusion weighted MRI, multiple repetitions are acquired in each diffusion direction. The signal from each repetition is then combined to obtain a final image. Abdominal diffusion weighted imaging is complicated by cardiac and respiratory motion. The compressive motion in the liver tissue in the presence of diffusion gradients leads to a localized dephasing of the signal. Due to these motion artifacts, some repetitions have localized signal dropout especially in the left lobe of the liver. These signal dropouts lead to bias in quantitative diffusion parameters, such as the apparent diffusion coefficient (ADC). We aim to optimize the method for combining the repetitions by investigating different averaging methods during the postprocessing stage. By reducing the impact of signal dropout artifacts, we hope to improve the reproducibility and accuracy of quantitative imaging biomarkers like ADC. This is important in a clinical setting to detect and characterize tumors and other tissues.

Peyton Lalain (Advisor: Dr. Larry DeWerd)
Title: Development of In-House Molecular Deposition Plating Procedure for Lanthanides and Chemically Similar Radiopharmaceutical Therapy Radionuclides Y-90 and Lu-177
Abstract: In nuclear spectroscopy measurements, having knowledge of plated radioactivity sources, including the diameter and homogeneity of plated material, is crucial to the quality of measurements. Sources received from manufacturers can suffer from lack of homogeneity, plating off-center on the substrate, irregularity in the shape/size of the plated material, etc. In addition to these manufacturer limitations, there is uncertainty associated with imaging methods that are used to determine the diameter and homogeneity of manufacturer plated substrates. Further, when dealing with lower energy sources such as beta and positron emitters, homogeneity of the plated sources is needed to reduce selfattenuation in the source and prevent poor measurement resolution. A proposed solution to these concerns is developing an in-house method for source preparation using molecular deposition plating, which, if successful, will allow for control of the shape and homogeneity of plated sources. The overall goal of this work is to have a reliable and reproducible method for plating commonly used beta emitters in radiopharmaceutical therapy (RPT). To this end, plating trials have been done using the stable lanthanide Holmium, stable Yttrium-oxide, radioactive Yttrium-86, and radioactive Yttrium-90. These trials involved the testing of the effects of different electrolytes, sources, substrates, applied currents/voltages, etc. on the outcome of the plated sources. In addition to some preliminary tests of source adhesion and homogeneity, this poster includes a map for future experiments to be done in order to solidify a final protocol for in–house plating.
Lisette LeMerise (Advisor: Dr. Andy Alexander)
Title: Superior Longitudinal Fasciculus: The Connection with Language in Fragile X and Autism
Abstract: A comprehensive study was performed for group differences between two neurodevelopmental disorders: Fragile X syndrome (FXS) and autism spectrum disorder (ASD). These populations have overlapping behavior that previously showed no statistically significant group differences when looking at the superior longitudinal fascicle (SLF), the arcuate fascicle (AF), and tracks of the striatum. However, little has still been done to characterize differences between these populations and find neural markers. This is important since these groups share similar behaviors, but FXS is a single gene disorder with known etiology, while it is unknown whether ASD has a genetic cause.

Diffusion MRI (dMRI) is a beneficial technique used to extract information about the diffusion of water in the brain. As water follows the path of a white matter track, its diffusion properties can indicate the track’s integrity. Hence, dMRI and white matter tractography are often used to obtain values from the diffusion tensor to derive parameter maps for properties of white matter microstructure. Parameters include axial diffusivity (AD), radial diffusivity (RD), mean diffusivity (MD), and fractional anisotropy (FA). A separate model called noddi-watson was also applied, as it is more sensitive to myelin-based metrics and handling errors from crossing fibers. Following previous analysis on three tracks showing no statistically significant differences between the two groups and then applying Tract-Based Spatial Statistics (TBSS) and statistical analysis with FSL’s PALM, significant tracks were highlighted elsewhere in the brain. Therefore, white matter tracks of the midbrain and outward became the focus of additional work. Tracks of interest include: parieto-occipital pontine (POPT), superior cerebellar peduncle (SCP), commissure anterior (CA), middle cerebellar peduncle (MCP), striato-fronto-orbital (ST_FO), and the uncinate fascicle (UF).

Yi-Hsuan Lo (Advisor: Dr. Paul Ellison)
Title: Accelerator production of 71As from metal germanium targets and radiolabeling of SCN-TT-Glu-Ser-RM2
Abstract: The positron emitting radioisotope of arsenic, 71As (t1/2 = 65 h, EAvgβ+ = 350 keV), has theranostic potential when paired with β–-emitting therapeutic 77As or, potentially due to homologous chemistry, the very promising Meitner-Auger-electron-emitter 119Sb. We report our metallic germanium coin targets for cyclotron irradiation and radiochemical isolation of 71As and radiolabeling of TT-Glu-Ser-RM2, a gastrin-releasing peptide receptor antagonist for prostate and breast cancer. The target was irradiated with 15 – 35 µA, 8 MeV deuterons and/or 16 MeV protons (to produce a 69Ge tracer), producing 71As with radionuclidic purity >99% and the experimental physical yield is 0.165 mCi·µA-1·h-1. The irradiated target was dissolved with aqua regia at 100 °C. This solution was filtered, and the filter rinsed with H2O and H2O2, trapping 71As. After stripping from the filter with NaOH, the 71As was diluted and loaded onto an anion exchange (AX) column, and rinsed with NaOH, NH4OH, and H2O, and 71As was eluted with 0.1 M HCl. This separation procedure effectively removed bulk germanium and the overall yield of 71As was 49 ± 6%. For radiolabeling, the SCN-TT-
Glu–Ser–RM2 was deprotected, then 71As solution was reduced and combined with the deprotected compound. The radiolabeling efficiency determined by high performance liquid chromatography was 60–80% depending on concentration. In conclusion, the irradiated 70Ge targets showed consistent 71As physical yield. Most of germanium was removed in loading and base solution fraction. In radiolabeling, we successfully radiolabeled TT-Glu-Ser-RM2 and will access 71As-TT-Glu-Ser-RM2 in vitro/vivo studies and PET studies on mice bearing breast cancer in future.

Max McLachlan (Advisor: Dr. Brad Christian)
Title: PiB PET demonstrates early, elevated amyloid striatal binding compared to florbetapir in Down syndrome
Abstract: Individuals with Down syndrome (DS) carry a genetic risk for Alzheimer’s Disease (AD) influenced by the elevated production of amyloid precursor protein. PET amyloid [11C]PiB imaging of the DS population has revealed early detection of β amyloid plaques (Aβ) in the striatum, similar to autosomal dominant forms of AD. This work compares [11C]PiB and [18F]florbetapir (FBP) striatal uptake relative to the cortex in DS.

Yadira Medina (Advisor: Dr. Reinier Hernandez)
Title: Theragnostic Approach for Targeted Radionuclide Therapy in Triple-Negative Breast Cancer
Abstract: Triple-negative breast cancer (TNBC) represents a highly aggressive subtype with a poor prognosis, lacking targeted endocrine or anti-HER-2 therapies. Heterogeneous responses to chemotherapeutic treatments further complicate the clinical management of TNBC. In response to these challenges, theragnostic strategies have emerged as a promising avenue for personalized treatment. In this study, we investigated a novel theragnostic approach utilizing a tumor-targeting alkylphosphocholine (NM600) radiolabeled with lutetium-177 (177Lu) for single-photon emission computed tomography (SPECT) imaging and actinium-225 (225Ac) for targeted radionuclide therapy (TRT). SPECT imaging and biodistribution studies in mouse models demonstrated in vivo selective tumor uptake and retention of 177Lu-NM600, validating its potential for non-invasive imaging in TNBC. Initial toxicity assessments encompassing complete blood counts, blood chemistry, and histopathology of major organs established the safety profile of 225Ac-NM600. Mice bearing 4T1-cell TNBC tumors and treated with 225Ac-NM600 exhibited significant tumor growth inhibition, leading to an extended survival rate. These findings underscore the potential of the proposed theragnostic approach as a valuable tool for TNBC management, offering both diagnostic insight through SPECT imaging and therapeutic efficacy through targeted radionuclide therapy. The successful preclinical application of 177Lu-NM600 and 225Ac-NM600 paves the way for further exploration and translation of this strategy into clinical trials, holding promise for improved outcomes in patients with TNBC.
Grace Minesinger (Advisor: Dr. Mike Speidel)

Title: FEM Deformable Liver Registration to Facilitate CBCT Guided Histotripsy

Abstract: Histotripsy is an emerging focal tumor therapy that utilizes focused ultrasound (US) to mechanically destroy tissue. Cone beam CT (CBCT) guidance has been developed to overcome limitations of diagnostic US for visualizing and targeting tumors. The existing workflow for CBCT-guided histotripsy requires live treatment planning during the procedure because targeting is based on an image acquired at the patient’s current position. To provide a framework for planning liver tumor treatments in advance, a biomechanical, nonrigid model is proposed to predict volumetric liver deformations between a pre-procedural diagnostic image and the intraprocedural CBCT. In the proposed registration approach, the liver, gallbladder (GB), and hepatic blood vessels were segmented from CBCT images acquired at two different points of motion. Segmented structural surfaces were registered using a rigid iterative closest point algorithm followed by deformable registration (demons algorithm). These internal and external hepatic structural surface registrations were used as boundary conditions for a finite element model (FEM) to determine internal liver deformations. Four FEM models were constructed: the liver alone (L-FEM), liver and GB (LG-FEM), liver and vessels (LV-FEM), and liver, GB, and vessels (LGV-FEM). Registration accuracy was measured as the Euclidean distance between manually annotated vessel bifurcations. Bifurcation error was 3.5±3.5mm for LGV-FEM, a 52% improvement from L-FEM (7.4±6.1mm). Including vessels and GB in the model both individually reduced bifurcation error compared to corresponding models excluding those structures. FEM-based liver registration guided by internal and external hepatic structures is a feasible method to facilitate CBCT-guided histotripsy treatment planning.

Rachel Minne (Advisor: Dr. Randall Kimple)

Title: Assessing The Theragnostic Value of a Met-directed Camelid Nanobody in Non-small Cell Lung Cancer

Abstract: Background The mesenchymal epithelial transition (MET) factor receptor is responsible for promoting cell motility, proliferation, and angiogenesis. When mutated or amplified, the upregulation of the MET pathway stimulates tumorigenesis and metatasssis. MET is amplified in 6% of non-small cell lung cancers (NSCLC) and mutated in 3% with MET exon 14 skipping mutations being the most common. Current FDA approved chemotherapy agents that act as tyrosine kinase inhibitors include Capmatinib, Crizotinib, and Teopotinib and is the first line of treatment for lung cancer patients with MET mutations. However, response to these drugs vary among MET alteration types, and there are limited alternative treatment methods available to patients once resistance inevitably develops. Hence there exists a significant demand to identify alternative options for NSCLC patients bearing MET mutations.
Tarun Naren (Advisor: Dr. Oliver Weiben)

Title: Feasibility of a 2D Radial Simultaneous Multi-Slice Phase Contrast MRI sequence for Aortic Pulse Wave Velocity Measurements

Abstract: Pulse wave velocity (PWV) refers to the speed of blood pressure waves as they propagate through the vasculature [1]. PWV is inversely related to arterial stiffness and has emerged as a useful tool for diagnosis and risk stratification of cardiovascular disease [2]. Aortic PWV can be determined non-invasively using 2D Phase-Contrast (2DPC) MRI by measuring the time-shifts between flow waveforms at 2+ points along the aorta and vessel pathlengths between them [1]. However, accuracy of the calculated PWV depends highly on the temporal synchronization of the 2DPC scans which is affected by changes in heart rate and blood pressure. To overcome synchronization issues and enable the acquisition of 2DPC datasets with a high separation distance, we introduced a Simultaneous Multi-Slice (SMS) radial free-breathing 2DPC sequence. We compare this approach to 2 sequentially acquired single-slice radial 2DPC datasets in a small cohort of elderly subjects. The SMS sequence produced higher quality 2DPC images with fewer undersampling artifacts within the same scan time as a single sequential sequence while still having identical physiological gating. In the aortic arch, the SMS scans produced a mean PWV (11.86m/s, SD=3.28) significantly higher than the sequential scans (9.47m/s, SD=4.63). Mean Global-PWV was also significantly higher for SMS (8.69m/s, SD=1.48) compared to the sequential sequences (6.79m/s, SD=2.40), although differing path lengths makes comparison difficult. Additionally, a few subjects’ sequential scans had temporal inconsistencies between planes leading to extremely small time-shifts and unrealistically large PWVs, an issue that did not affect the SMS scans.

Alex Niver (Advisor: Dr. Brian Pogue)

Title: Optimizing scintillator signal in scintillator imaging dosimetry for TBI

Abstract: Objective. To determine the optimal pairing of scintillators, wavelength shifters, and camera photocathodes to maximize the scintillator signal in non-contact scintillator dosimetry for TBI. Maximizing the available signal would allow for utilization of non-contact scintillator dosimetry for TBI in conditions with greater ambient light. Approach. 9 fast-response scintillators, 3 wavelength shifters, and 2 photocathodes were systematically tested to find the optimal combination. Effects of room lights on the scintillator signal and the background signal were characterized. Main Results: The EJ-262 scintillator combined with the QE-Green photocathode produced the greatest available scintillator signal and is able to image scintillators with ambient illuminance in excess of 500 lux, but rejected background Cherenkov useful for Cherenkov Imaging Dosimetry in other radiotherapy setups. A middle ground option which retained the Cherenkov signal but produced less available scintillator signal was found using the EJ-260 scintillator and the QE-Red photocathode. It was also determined that ambient light under 50 lux does not significantly affect the scintillator signal. Significance: This work shows that under a variety of lighting conditions non-contact scintillator dosimetry for TBI can be performed with the proper pairing of scintillators and camera photocathodes.
Aubrey Parks (Advisor: Dr. Brian Pogue)
Title: Monte Carlo Modeling of Cherenkov Emission Effects from Tissue due to Beam, Particle, Incidence, and Detector Variations
Abstract: Cherenkov radiation induced from external beam radiation therapy is dependent on beam parameters, and its emitted spectrum provides key insights on beam-tissue interaction, tissue composition, and Cherenkov emission from the body. Using MCmatlab, an open-source optical Monte Carlo package, investigation of spectral generation of Cherenkov upon altering beam energy, particle type, orientation, and field size has been performed. Emitted Cherenkov spectra were generated for 6, 10, 18MV photon beams, 6MeV electron beams, 6MV entrance and exit orientations, and 3x3cm, 6x6cm, 10x10cm, 15x15cm, 30x30cm, and 40x40cm 6MV field sizes. The change in spectral intensity was quantified through comparison of the quantum efficiency of two photocathodes, one which is optimized for red to near-infrared (NIR) wavelengths and the other optimized for blue-green wavelengths. Findings conclude that there is a decrease in emitted intensity for both NIR and blue-green wavelengths upon increasing energy, and exit intensity when compared to entrance. There is minimal change in intensity between thicker tissue exit orientations. There is a large increase in emitted intensity for electron beams when compared to photon beams, and a gradual increase in intensity when increasing field size. Energy and particle results were experimentally validated. Results conclude there is little benefit altering camera hardware based upon beam energy, type, incidence, or field size.

Autumn Rasmussen (Advisor: Dr. Larry DeWerd)
Title: Low dose rate verification for UAMS Cs-137 irradiator
Abstract: This study emphasizes the critical role of in-vivo dose monitoring in assessing chronic low dose rate radiation impact. Traditional approaches to chronic LDR rely on models designed for health physics applications and indirect measurements. This research focuses on characterizing a Cs-137 source by employing a large-volume NIST ionization chamber and determining in-vivo doses delivered to mice using waterproofed TLD100 microcubes. Using TG-21 and ICRU47 formalism, the resulting dose was determined to range from 0.08 to 0.82 Gy per week ± 0.5%, contingent on the attenuator selected. Additionally, the study explores the potential fading of TLD100 chips when exposed to Cs-137 and incubated at body temperature, revealing a signal fade of approximately 8% at 37°C with an uncertainty of 4%. The findings demonstrate the adaptability of measurement tools, traditionally used in higher dose rate applications, such as ion chambers and TLDs, for chronic low dose rate radiobiology. The study underscores the apparent need to characterize TLD responses under temperature conditions relevant to the experiment, with plans for further investigation into these preliminary results.

Karen Rex Pius Vincent (Advisor: Dr. Larry DeWerd)
Title: Collecting Volume Determination of an Exradin A3 Ionization Chamber
Abstract: Absolute measurements offer the highest metrological quality. Moreover, absolute measurements of air kerma rate can be determined with a free air chamber a known volume
ionization chamber. Known volume chambers offer advantages over free air chambers in that it can measure a higher air kerma rate for higher energy photons (above 300 keV). The volume determination of cavity ionization chambers, however, requires characterizing the electric field near the guard region of the chamber, which can be challenging. Additionally, nominally listed volumes of cavity ionization chambers vary among manufacturers and individual detector types. Therefore, the collecting volume determination of cavity ionization chambers has been confined to primary standards labs. In this work, the collecting volume of an Exradin A3 ionization chamber (S/N: XR230512) was determined using micro-CT and COMSOL Multiphysics. First, the ionization chamber volume was scanned using micro-CT. From this scan, a threshold value to distinguish the chamber material from inner air volume was calculated. This threshold value was then used to segment the scan to determine the raw volume. Next, the electric field lines near the guard region were simulated in COMSOL Multiphysics to correct the raw chamber volume to the effective chamber volume. Finally, the magnification of the micro-CT scanner was determined by scanning a bone mineral density phantom and taking the ratio of the imaging length and diameters to that of calipers. The resulting magnification correction yielded the final collecting volume of the Exradin A3 ionization chamber.

Chase Ruff (Advisor: Dr. Carri Glide-Hurst)
Title: Deducing Respiratory and Cardiac Motion Using a Novel 5D MRI Workflow
Abstract: Cardiotoxicity is a devastating complication of thoracic cancer treatment. However, defining margins to spare the heart and cardiac substructures is complicated by cardiac and respiratory-induced intra-fraction motion and the inability to decouple sources of uncertainty. Herein we describe a novel, flexible 5D MRI workflow to address this unmet need.

Alma Spahic (Advisor: Dr. Oliver Weiben)
Title: Cerebrovascular Flow and White Matter Microstructural Integrity in the Presence of Amyloid and Tau Biomarkers
Abstract: Recent studies suggest potential interactions between cerebrovascular disease (CVD) and Alzheimer’s disease (AD) pathology, by investigating correlations between AD biomarkers, hypoperfusion1, white matter hyperintensity (WMH) burden2, and WM abnormalities3. However, hypoperfusion and WMH are not specific to CVD pathology4, limiting the potential to identify CVD and AD interaction pathways. More specific CVD markers, such as intracranial vessel flow rates and velocities, can be quantified using 4D flow MRI. Our study examines correlations between CVD markers and WM microstructure across the AD clinical spectrum, utilizing 4D flow MRI and neurite orientation dispersion and density imaging (NODDI)5. This research aims to bridge existing knowledge gaps by examining the connections between CVD, AD, and WM alterations.

Jiayi Tang (Advisor: Dr. Diego Hernando)
Title: Optimization, Deployment, and Clinical Translation of MRI-based Motion-Robust Fat Quantification
**Abstract:** 2D sequential chemical-shift encoded MRI with flip-angle modulation is a recently proposed method for quantifying fat deposition noninvasively, with excellent robustness to respiratory motion and higher SNR than previously achieved with 2D sequences. My work has focused on increasing access to FAM in several complementary directions:

- Using parallel imaging to further improve the motion-robustness of FAM to make it available to more patients, while using the available magnetization more efficiently to increase SNR.
- Improving access to FAM at more clinical sites by implementing and validating it in a cross-vendor framework.
- Deploying FAM through the innovative clinical care pathway at UW Health, clinical partners at Cincinnati Children’s Hospital, research partners at UCSD, with a view to disseminate widely as a GE HealthCare prototype.
- Leading a BME undergrad team to develop and share a repeatable, convenient method for quantifying the motion robustness of FAM through an open-source motion phantom.

**Jordan Teague (Advisor: Dr. Tobey Betthauser)**

**Title:** Validation of sampled iterative local approximation for individualized estimates of tau PET onset age

**Abstract:** Quantifying the time course of AD amyloid and tau pathology is essential to identifying optimal disease treatment and secondary prevention windows. Sampled iterative local approximation (SILA) is a temporal modeling method validated for amyloid PET and provides person-level estimated amyloid onset age. The goal of this work is to validate SILA to model longitudinal tau PET trajectories and generate person-level estimated tau onset age (ETOA)

**Andrew White (Advisor: Dr. Wes Culberson)**

**Title:** Overresponse of TLD-100 to Varian OBI and Elekta XVI CBCT Protocols

**Abstract:** Thermoluminescent dosimeters (TLDs) are passive solid-state dosimeters used clinically to verify patient dose from external beam radiation therapy. Dose verification is valuable to confirm in-field target dose, as well as to monitor out-of-field dose to medical devices such as pacemakers. Because TLD-100 is made of LiF, which is not a water equivalent material, there is an associated energy dependence that becomes significant in mixed energy deliveries. An overresponse of up to 1.4x has been reported for diagnostic x-rays (kV) when TLDs are calibrated to an MV beam. Clinical workflows utilize cone beam computed tomography (CBCT) imaging to precisely align patients prior to treatment. Therefore, TLDs placed on patients prior to treatment will overresponse relative to the MV calibration, producing an error in the reported absorbed dose. This work aimed to provide a lookup table that reports the over responding imaging dose from various CBCT protocols when calibrated to MV beams. The resulting imaging dose can be subtracted from the total reported dose to provide a more accurate therapy dose verification.
Yuhao Yan (Advisor: Dr. Carri Clide-Hurst)
Title: 'Deep Learning-based Synthetic CT for Low-field Brain MR-guided Adaptive Radiation Therapy
Abstract: Purpose: MR-guided Radiation Therapy (MRgRT) enables online adaptation to address intra- and inter-fractional changes. Yet, high-fidelity synthetic CT (synCT) is required to facilitate robust dose calculation. To address this need, we developed a conditional generative adversarial network (cGAN) for synCT generation from low-field MRI in the brain.

Linying Zhan (Advisor: Dr. Guang-Hong Chen)
Title: Revisiting Noise Variance-mAs Relationship in Photon Counting Detector CT
Abstract: For half a century, the inverse proportionality of CT noise variance to tube current-time product (mAs) has been documented in standard textbooks. This relationship is essential in optimizing clinical CT protocols to reduce radiation exposure while maintaining diagnostic efficacy. The emergence of whole-body photon counting detector CT (PCD-CT) holds the potential to offer superior patient care with minimized radiation risks, given that protocols are optimized. Such protocol optimization requires a precise noise-mAs relationship. Owing to the technical intricacies of photon counting detectors, this noise-mAs relationship may undergo modifications, necessitating a thorough reevaluation. The objective of this study is to introduce a novel noise-mAs relationship and to provide simulation and experimental validation of this relationship for PCD-CT.

Due to the finite deadtime ($\tau$) of the PCDs, the statistical distribution of detector counts departs from the ideal Poisson distribution, becoming dependent on the deadtime. By analyzing the modified Poisson distribution of output photon counts for non-paralyzable PCDs, the variance of post-log sinogram projection data can be derived. A cascaded systems analysis was applied to link the noise variance of a CT image with the variance of the sinogram data. Moreover, a comparative analysis was performed for PCD-CTs with pile-up corrections. The theoretical analysis shows that in the non-paralyzable counting mode of PCD-CTs, as found in current clinical systems, CT image noise dependence on mAs is modified in two ways: 1) without pile-up correction, $\sigma^2$ is altered by a multiplicative factor, and 2) with pulse pile-up correction, $\sigma^2$ is changed by an additive factor. The proposed $\sigma^2$ (mA, $\tau$) models comply well with both simulation data and experimental data acquired from a CdTe-based clinical PCD-CT system.