Theranostics and Personalized Therapies in Nuclear Medicine

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What is Nuclear Medicine?

What is Nuclear Medicine?

- Medical Specialty used to
  - Diagnose
  - Treat

SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

- Allows to gather medical information that may otherwise:
  - Require Surgery
  - Require more expensive and invasive diagnostic exams

- It can identify abnormalities very early in the progression of the disease (even before they are apparent with other diagnostic tests)
  - Earlier treatment -> higher chances of a better prognosis

Radioactivity in Medicine

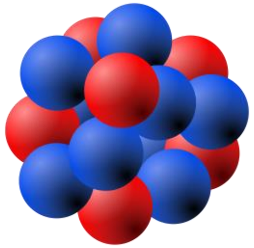
Generate images of an organ	• Radioactive tracers are injected into the patient
	  • Planar (2D)
	  • Tomographic (3D)

Therapy	• Radioactive tracers are injected into the patient to deliver energy and hopefully kill cancer cells (tumors).

Why is it called “Nuclear”?

A medicine attached to a small quantity of radioactive material

Pharmaceutical + Radioisotope = Radiopharmaceutical



Radiopharmaceuticals

- Link between physics (radio) and biochemistry (tracer)
- Is a substance that is labeled with a radioisotope, that decays allowing us to determine its location
- Inside the patient, it has a spatial/temporal distribution that provides useful information (e.g. For diagnosis)
  - The distribution or uptake depends on the biochemical properties of the tracer, not the fact that is radioactive
    - Necrotic tissue does not have tracer uptake
    - Uptake shows tissue function
- Nuclear medicine falls below the “functional imaging” category. It does not show anatomy or structure.

Tracers and Radioisotopes

PET Isotopes (Positron Emitters)		
Half-life	**Rmean (mm)**	**Isotope**
110 min	0.6	^{18}F
68 min	3.5	^{68}Ga
20.4 min	1.2	^{11}C
78.4 h	1.3	^{89}Zr

Therapy Isotopes (Beta emitters)			
Half-life	**Rmean (mm)**	**Gamma emissions [keV]**	**Isotope**
6.7 days	0.5	113 (6.2) 208 (10.3)	^{177}Lu

Small molecules
(Deoxyglucose)

Peptides and derivatives
(DCFPyL)
(PSMA-617)

Monoclonal antibodies
(Rituximab)

Role of Physics in Nuclear Medicine

- Underlying physics is not changing

- But the technology is changing
  - Production of radioisotopes (with the radiochemist)
  - New detectors, new configurations

- Methods for accurately quantifying concentrations of radionuclides within the patient

- Improvement of the models used for radiation dosimetry

- Physics plays a role in providing high-quality, cost-effective, quantitative, reliable, and biologically safe assays in Nuclear Medicine.

Nuclear Medicine can help in

- Determining if an organ is functioning well, or if there is any disease.
- Establishing if the physiology and/or metabolism has been altered?
- Providing information about treatment efficacy.
- Drug development
- Classification of disease
- Reporting of gene expression
- … and many more

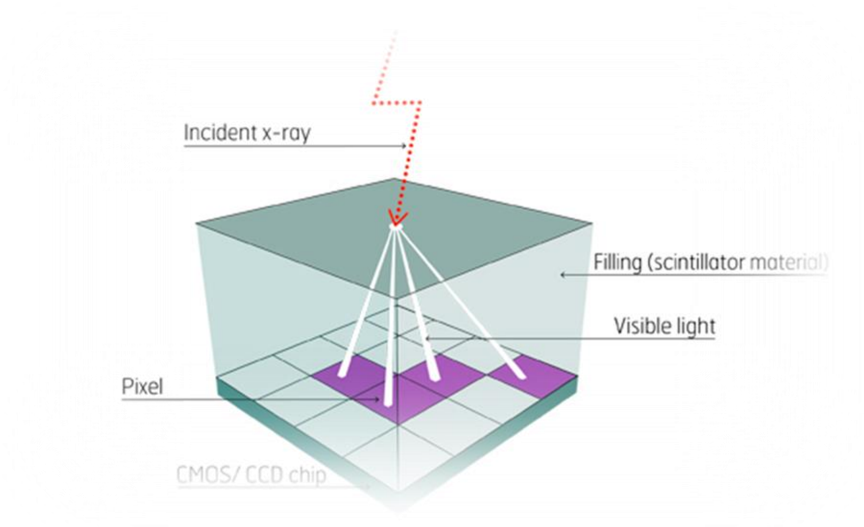
Emission Detection

Groups of Radiation Detectors

We are interested in detecting gammas emitted by radiopharmaceuticals to generate images

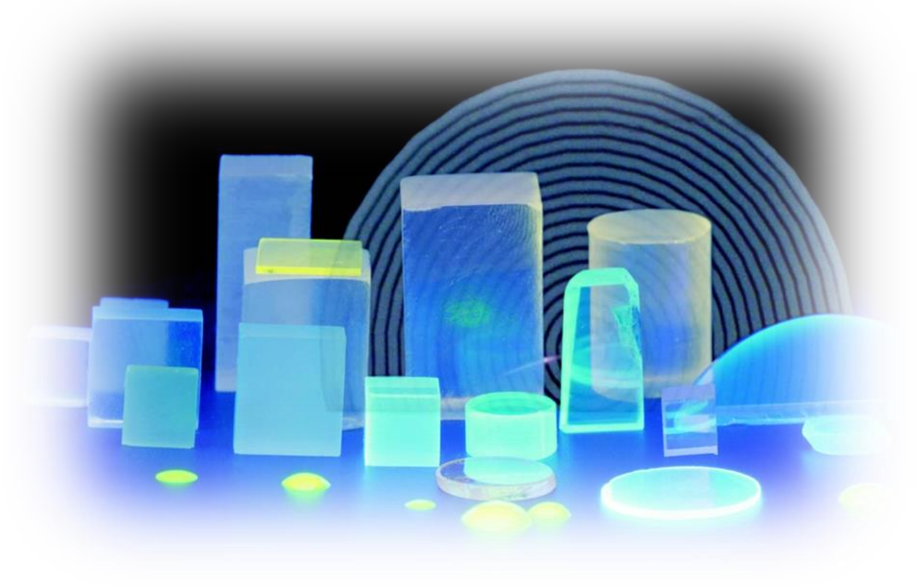
The processes of photon interaction with matter result in production of energetic electrons that transfer their energy to the medium by ionization and excitation		
Charge carriers **Gas detectors**	Electrons and holes **Semiconductor detectors**	Emission of light **Scintillators**

Scintillators



- Some materials emit light when they interact with ionizing radiation

- Scintillators can be plastic, organic or inorganic crystals, liquids or gases.



Scintillator Detectors

Inorganic ionic crystals are the most important in Nuclear Medicine

- High density and Z
- Fast response and high light yield
- Large crystals can be grown

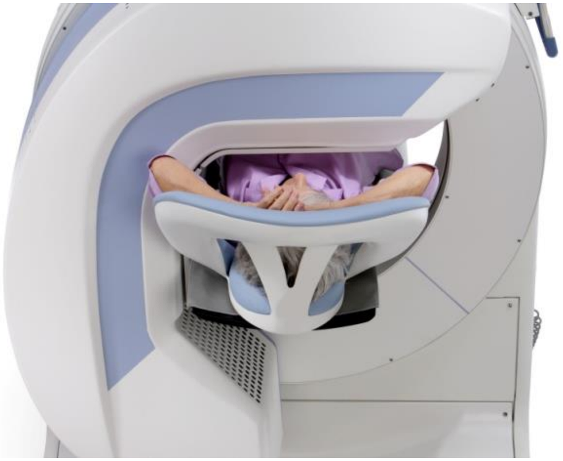
Important property of scintillators

- **Amount of light produced after the interaction with a particle is proportional to the energy deposited by the particle in the scintillator.** In the NM energy range, the amount of light is very small.

Scintillator Detectors

Scintillator	Light Yield (photons/MeV)	Density (g/cm3)	Hydroscopic?	Decay constant (ns)	Energy resolution (%)	Max emission wavelength (nm)
NaI	41000	3.7	Yes	230	7	410
BGO	9000	7.1	No	300	21	480
LSO	26000	7.4	No	40	12	420
LYSO	26000	7.3	No	50	13	420
GSO	8000	6.7	No	60	14	440
BaF2	1400	4.9	No	0.8	10	225

The Gamma Camera



Single Photon Emission Computed Tomography (SPECT)

The Gamma Camera

- Detection of gammas from single photon emitting radioisotope
    - Energy of gammas typically within 70-400 keV. (Tc-99m -> 140 keV)
    - The energy depends on the isotope

- Statistics → Record as many photons as possible

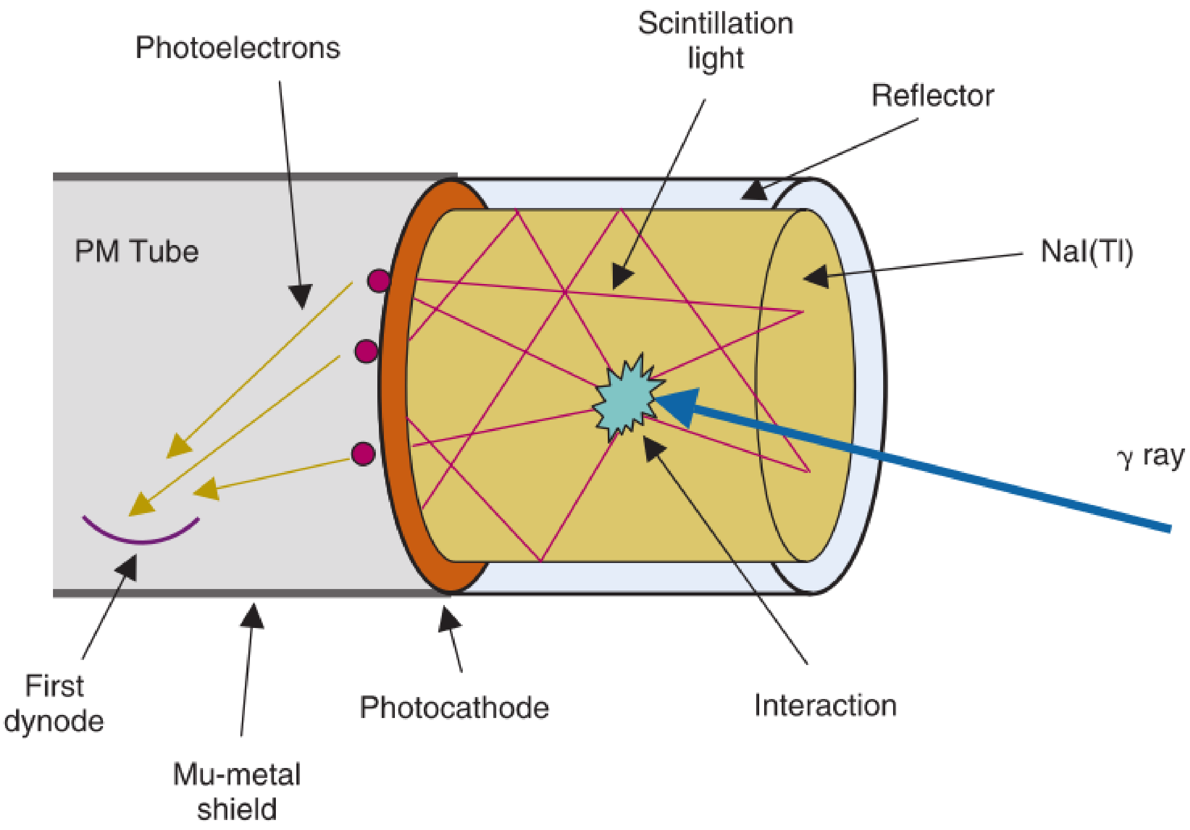
- Spatial resolution → localization of photons during detection

- Energy resolution → reject events that do not correspond to the source.

- Isotope identification

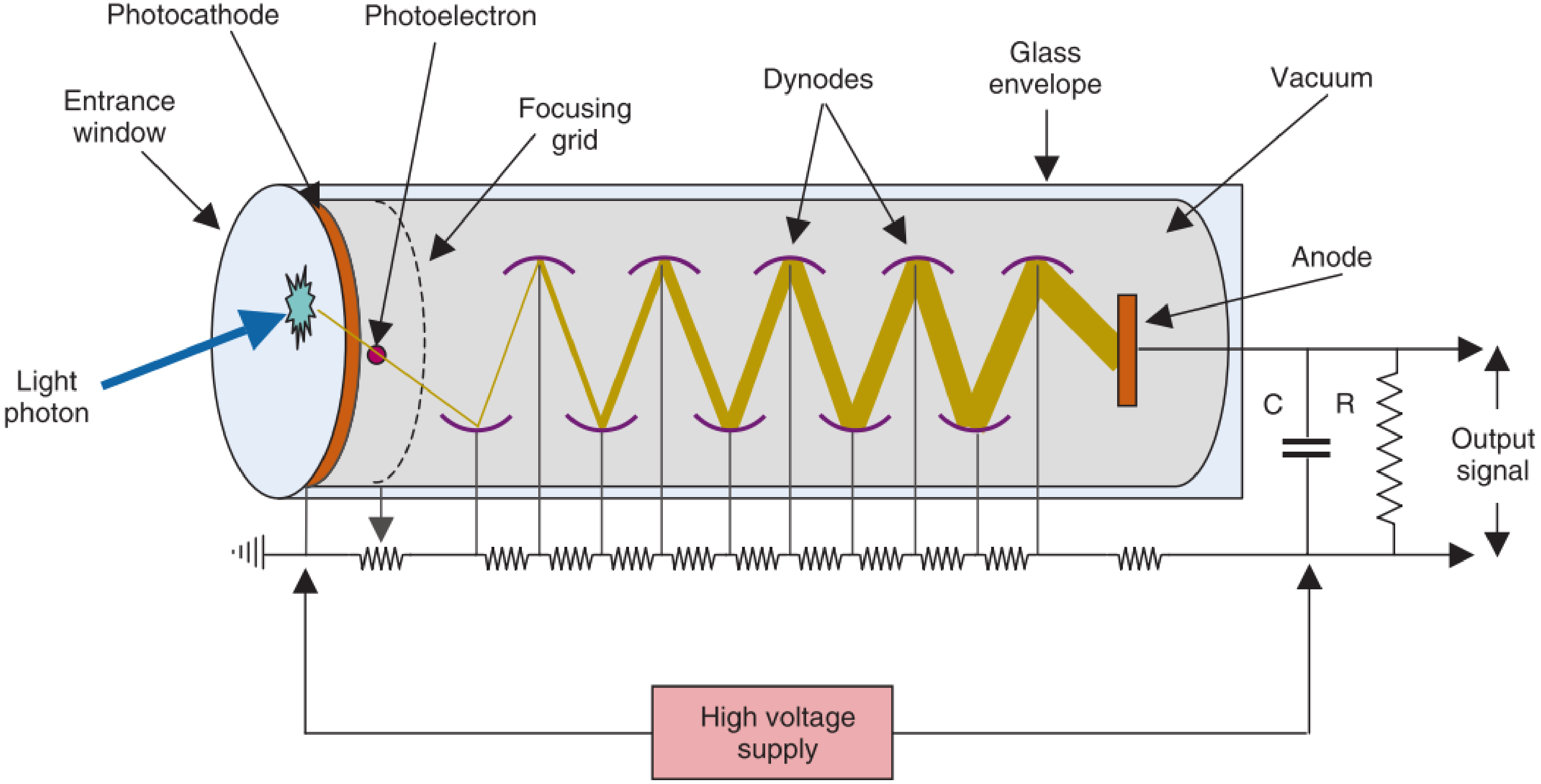
- The direction from which the photons reach the detector matters

The Gamma Camera



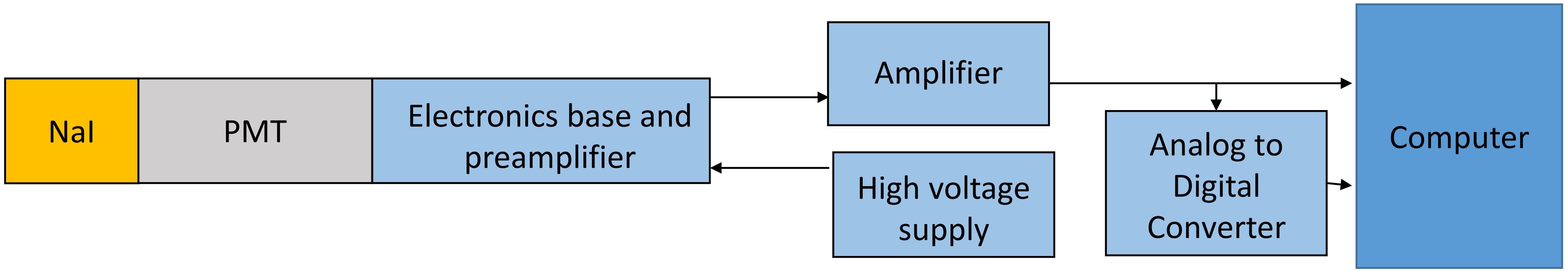
Cherry, Physics in Nuclear Medicine

The Gamma Camera

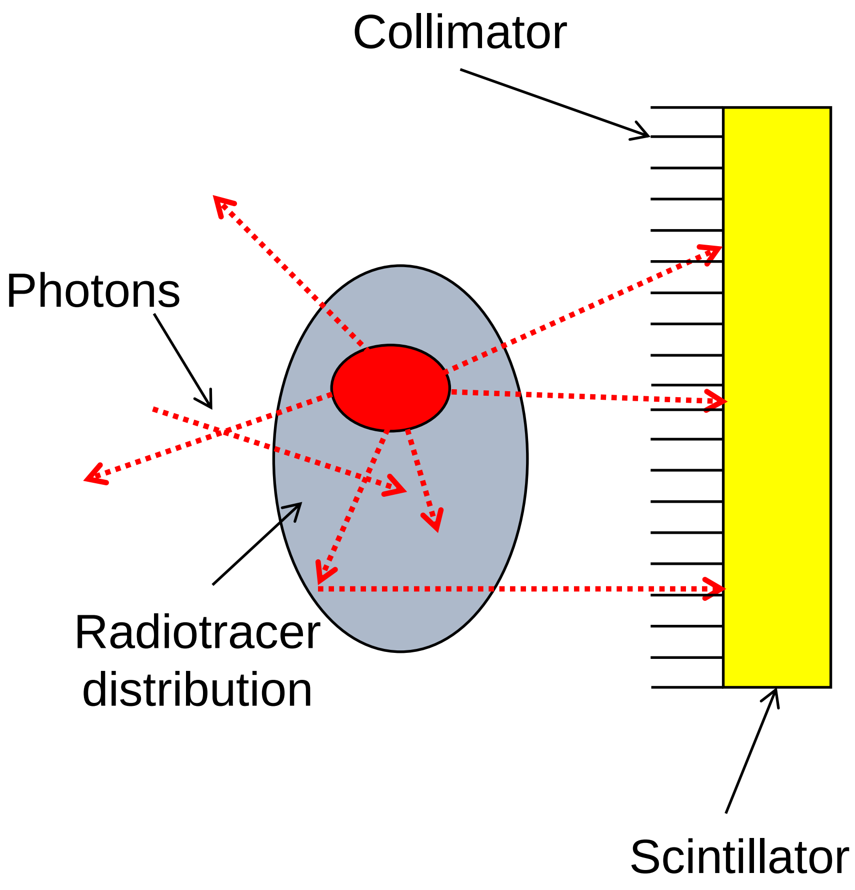


Cherry, Physics in Nuclear Medicine

The Gamma Camera



Absorptive Collimation



Gamma rays cannot be focused with lenses as it is done in cameras

Collimators allow only those photons travelling along certain directions to reach the detector

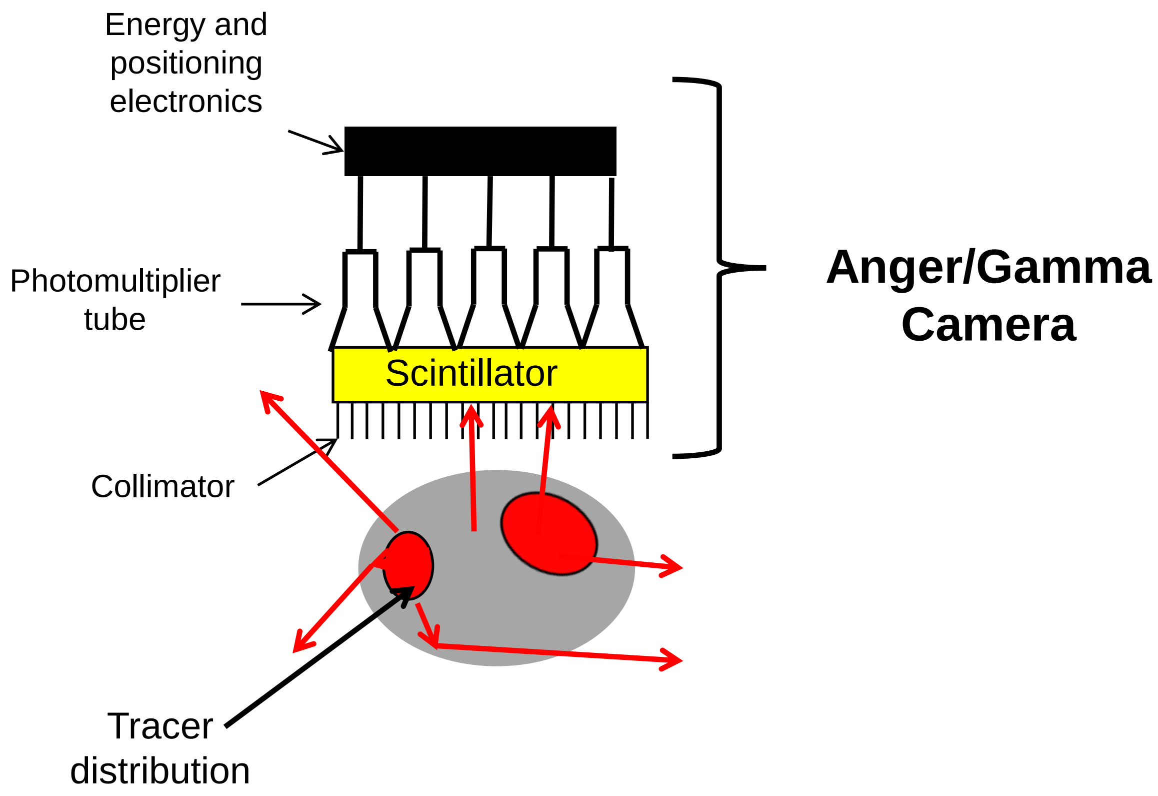
Without a collimator, we don't know the direction of the incoming photon

Absorptive Collimation

Requirements for collimator material:

1. High attenuation coefficient μ at energy E of the emissions.
2. Should produce very few scatter photons.

Planar Imaging (2D)



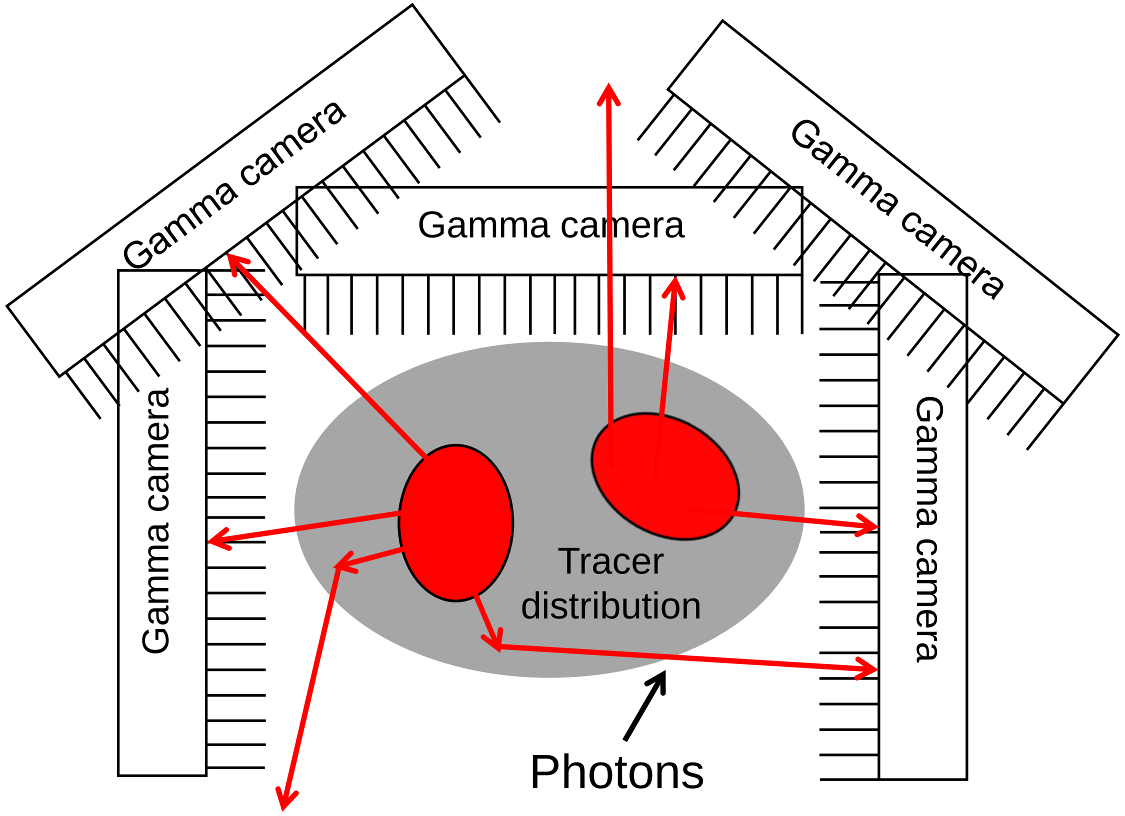
- Gamma camera is used to detect gammas emitted from single-photon-emitting radionuclides

Planar Imaging (2D)

Anterior

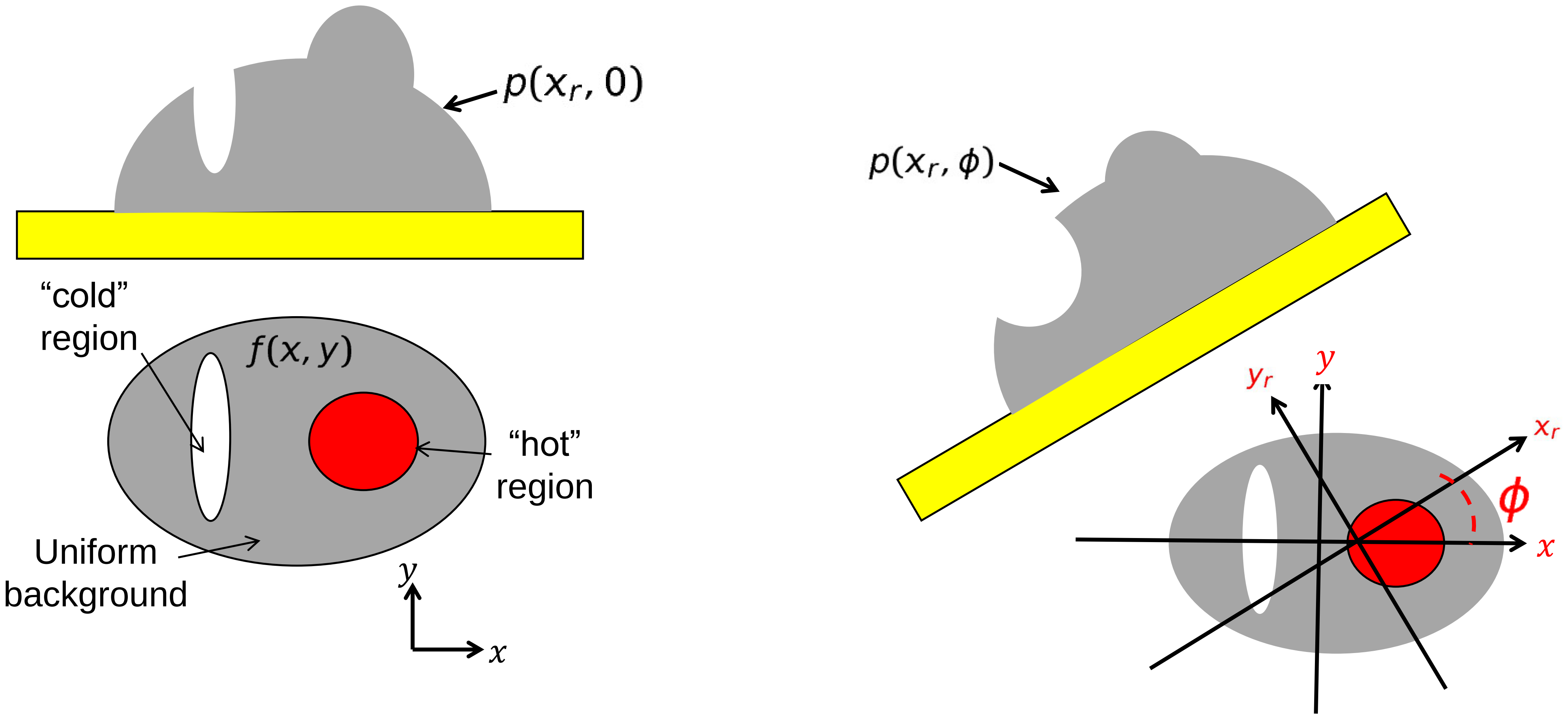
Posterior

Tomographic Imaging

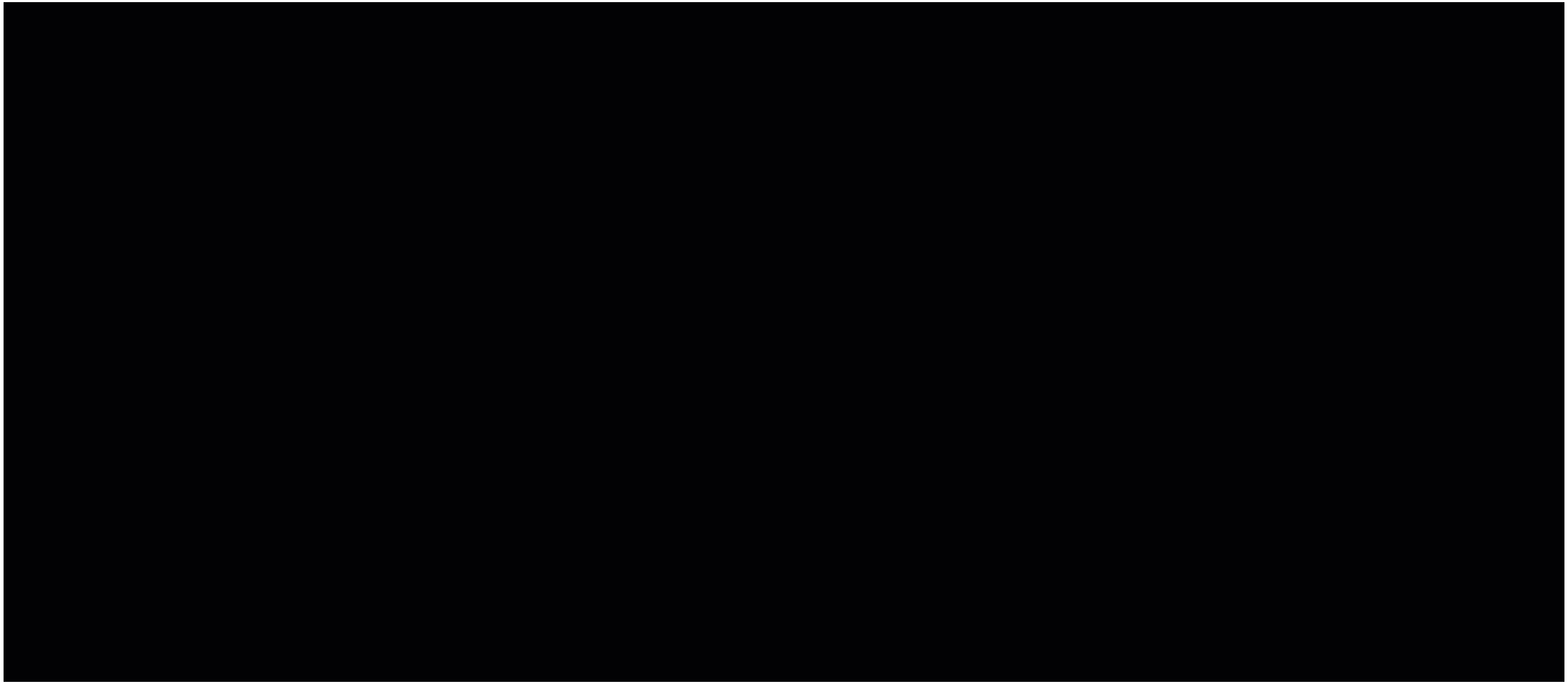


Camera is rotated to acquire *projections* at many angles enabling 3D imaging

Tomographic Imaging

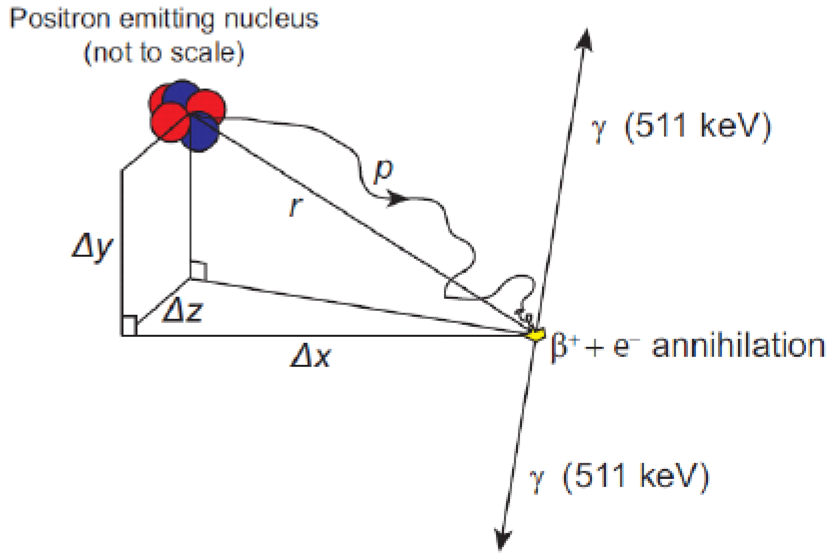


Tomographic Imaging SPECT

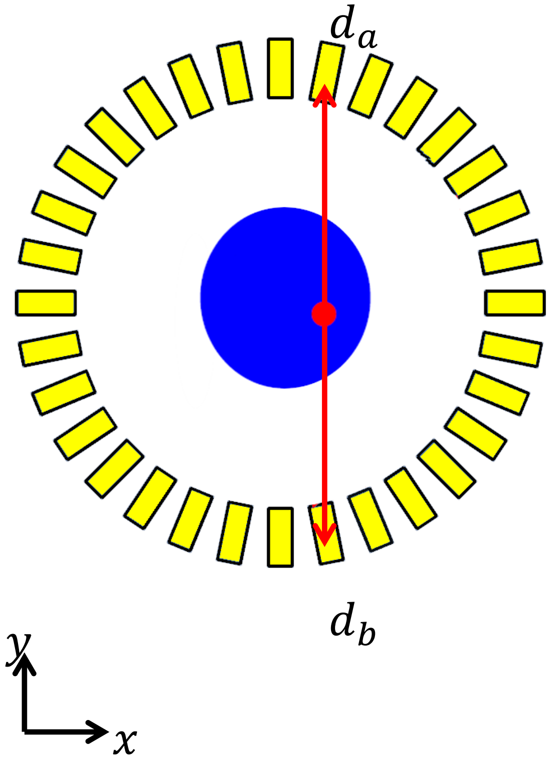


Positron Emission Tomography (PET)

- Nuclei undergoes β^+ decay
- The positron travels for a few mm and interacts with an electron in tissue
- An annihilation event occurs
- The annihilation produces two photons that travel in opposite directions

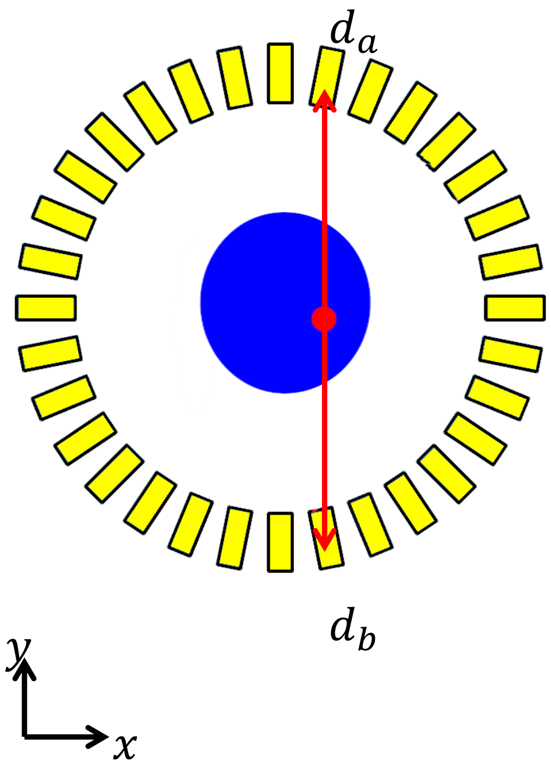


Positron Emission Tomography (PET)



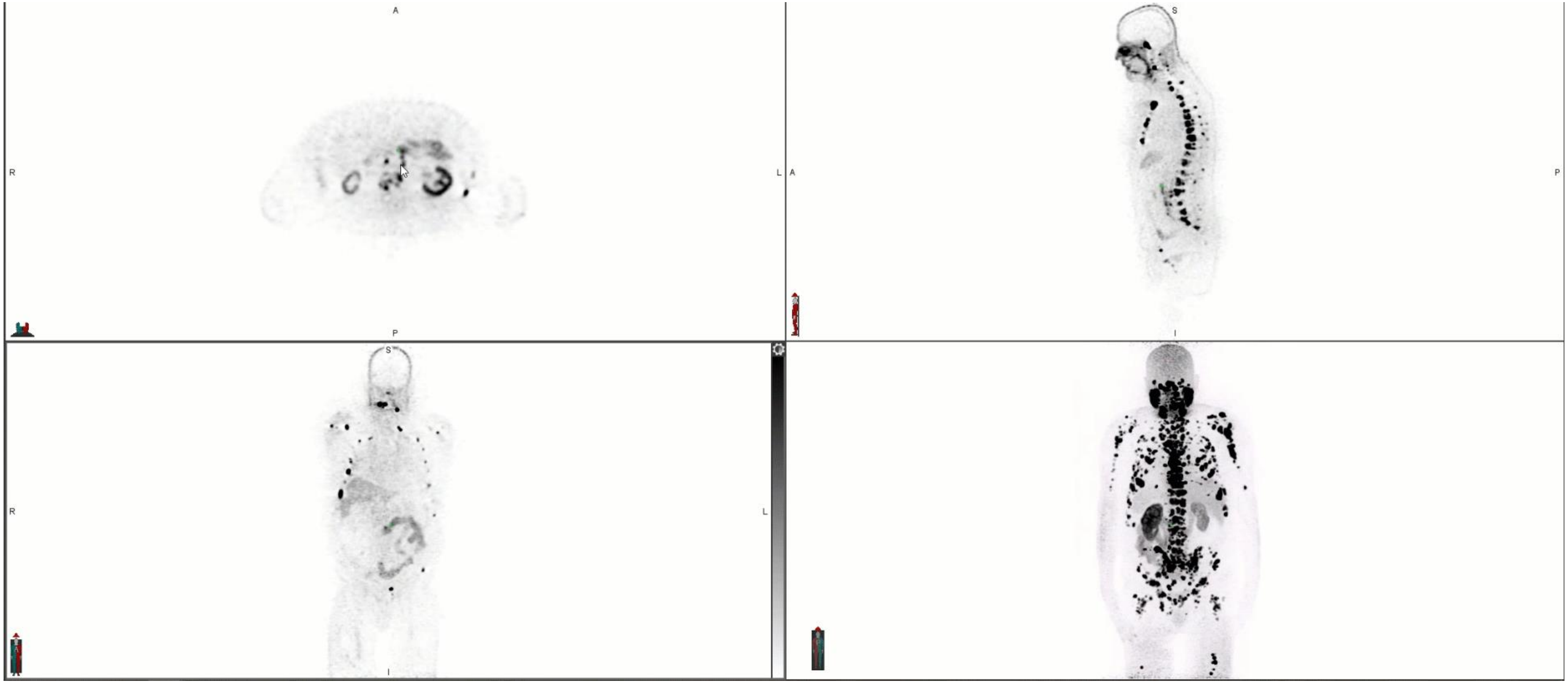
- Measure electrical pulses from pairs of detectors
- Timing pulses are triggered when the voltages exceed predefined thresholds

Positron Emission Tomography (PET)

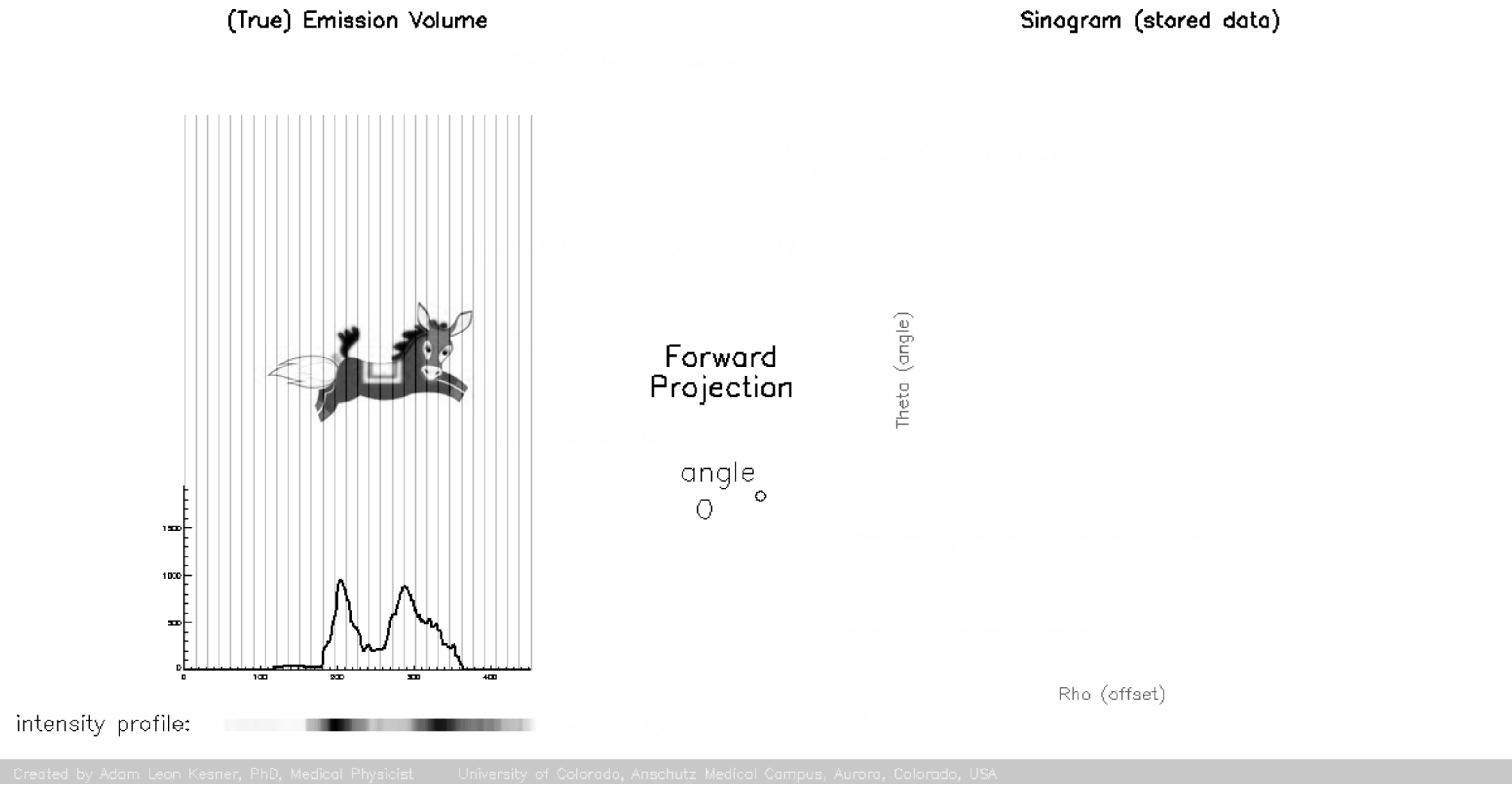


- The detector ring detects both of the 511 keV annihilation photons
- If the two events are detected within a small time difference (typically 6-12 ns) they are assumed to come from the same annihilation event
- The line of response passes through the point of annihilation
- No need for a collimator

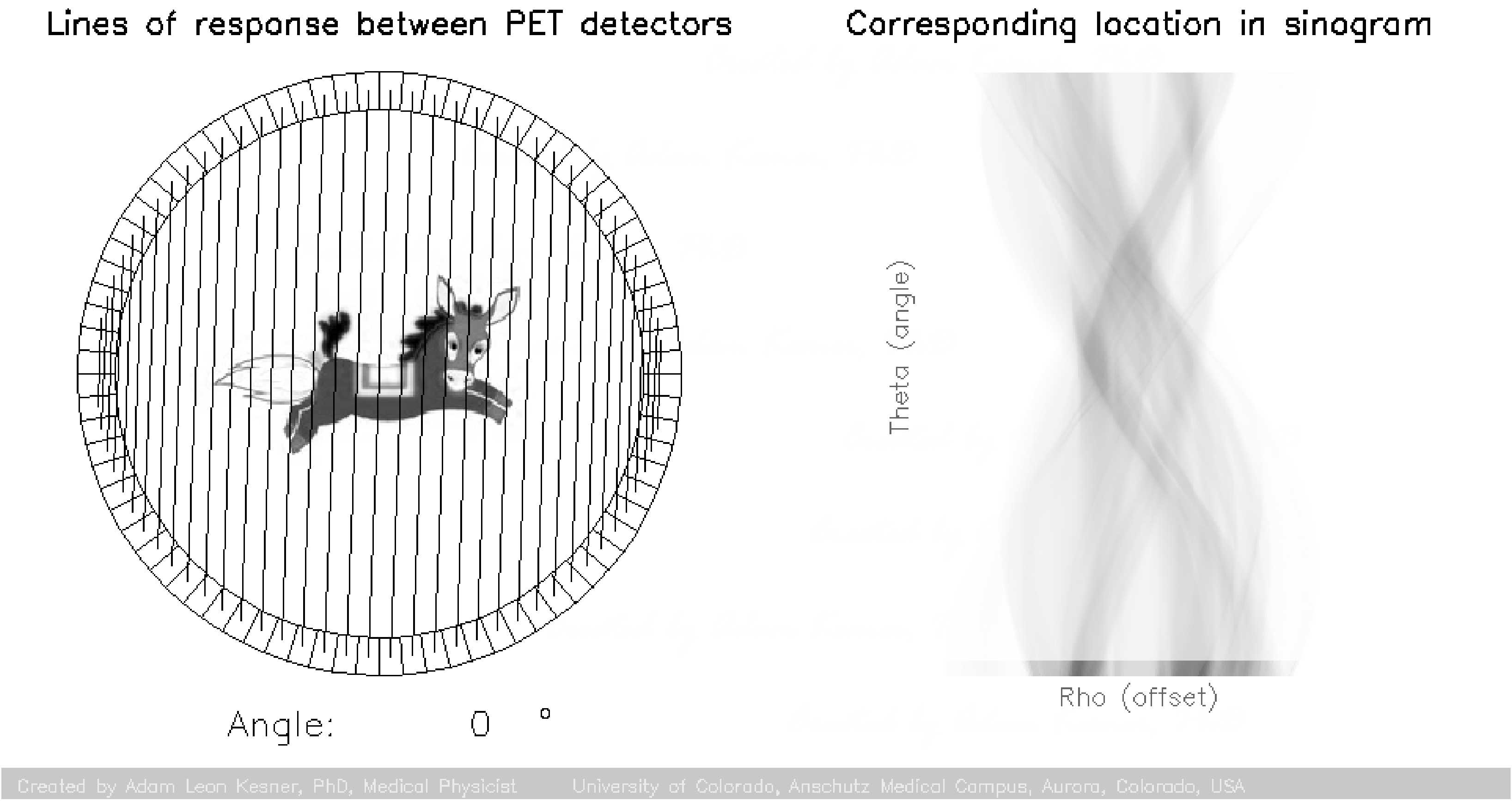
Tomographic Imaging PET



Tomographic Imaging



Tomographic Imaging PET



Tomographic Imaging PET

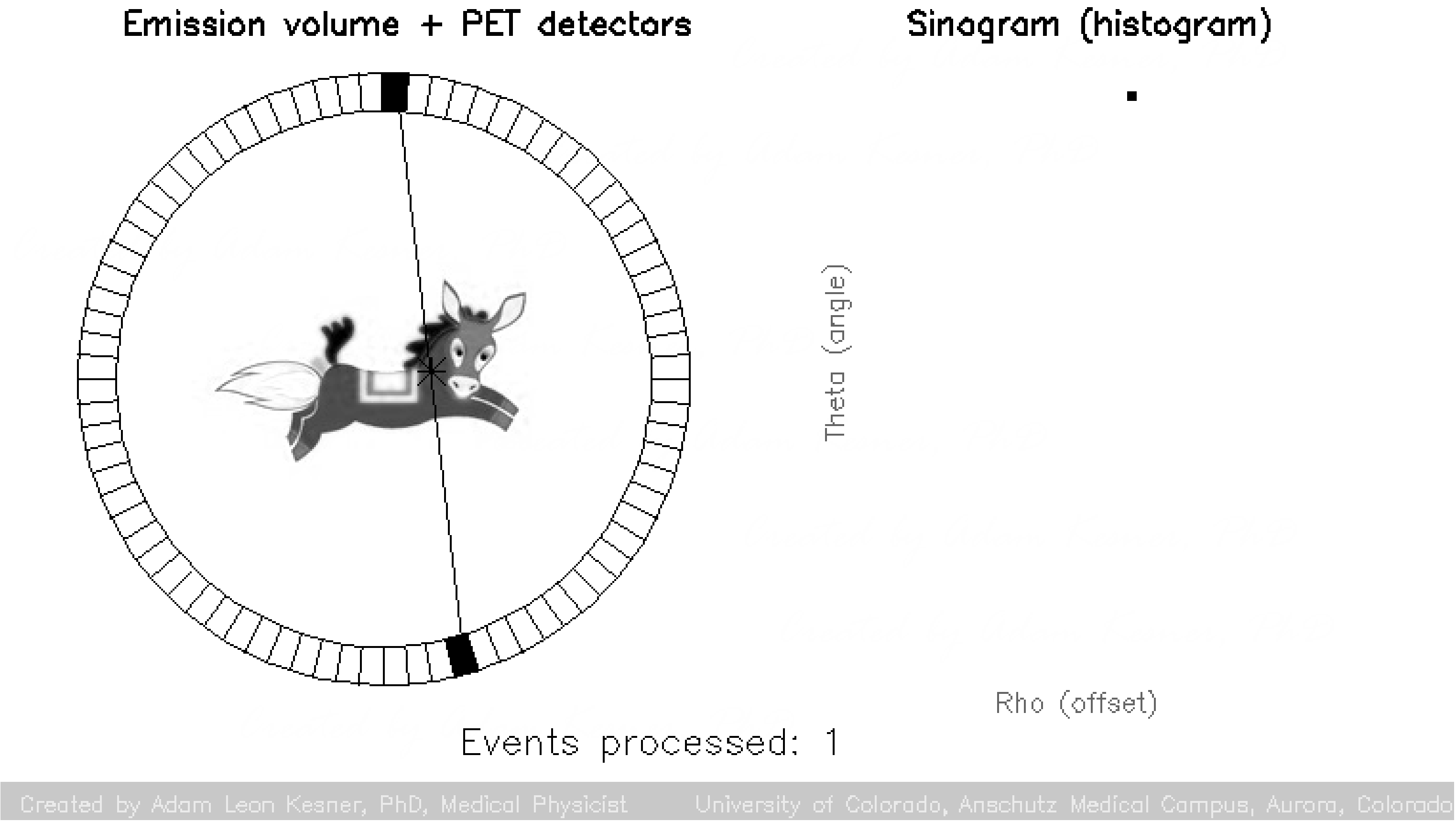
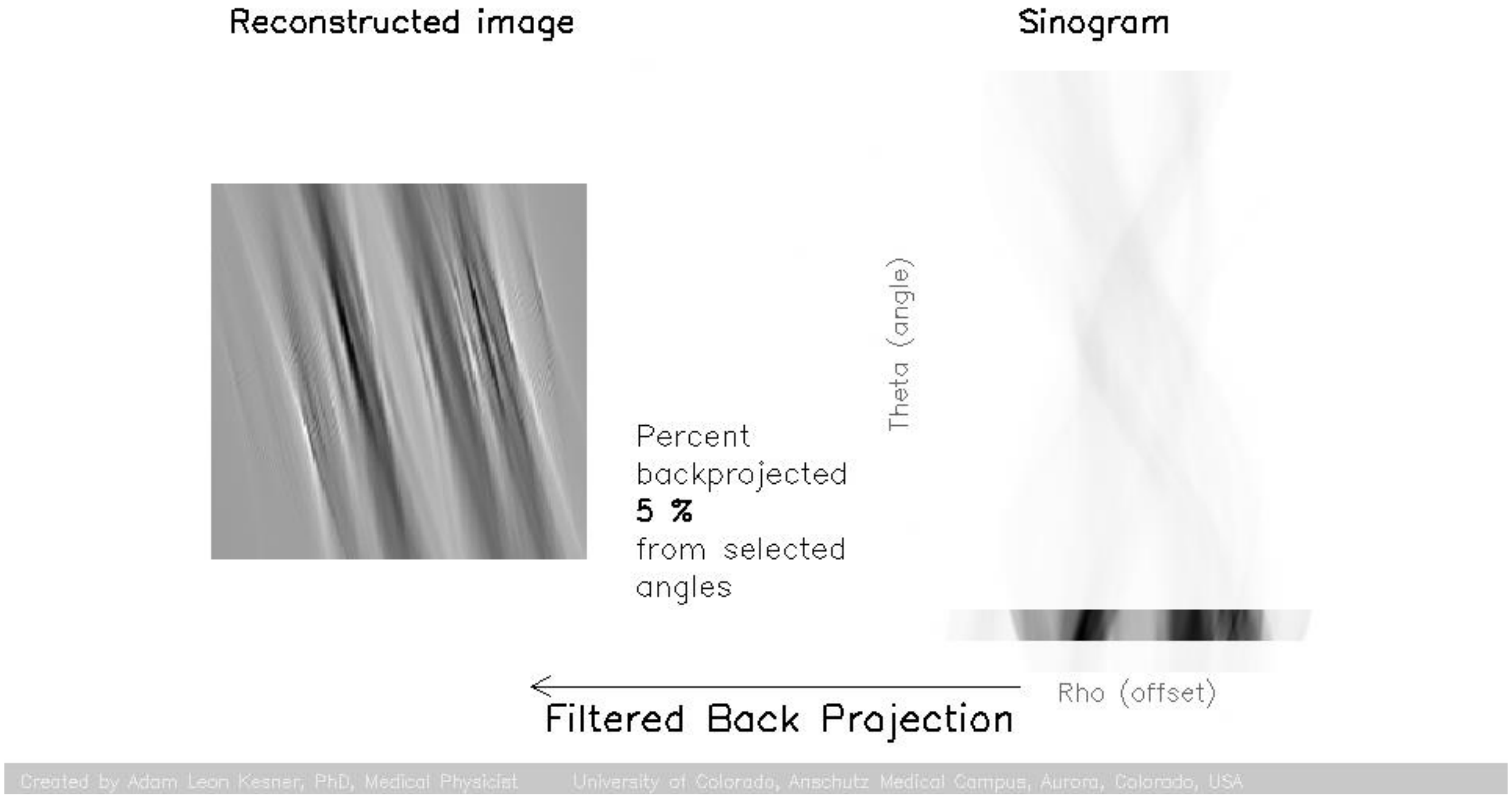
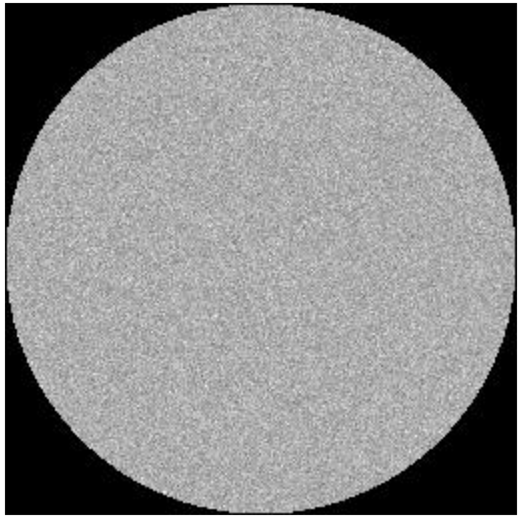


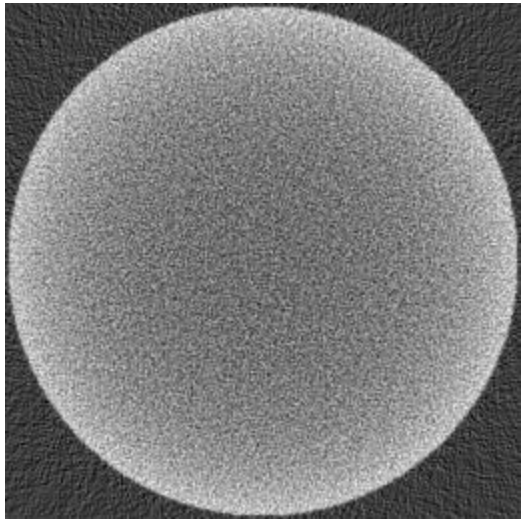
Image Reconstruction



Anything wrong with this image?



$f(x, y)$

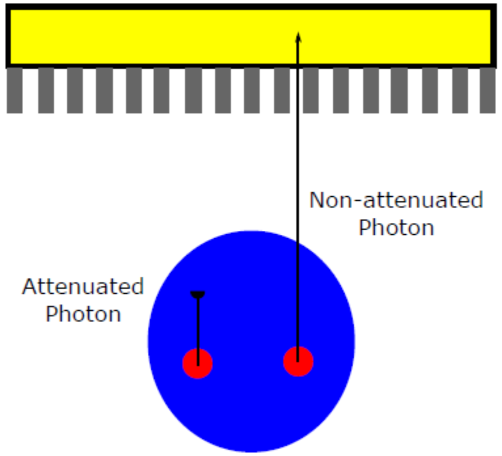


Reconstructed image

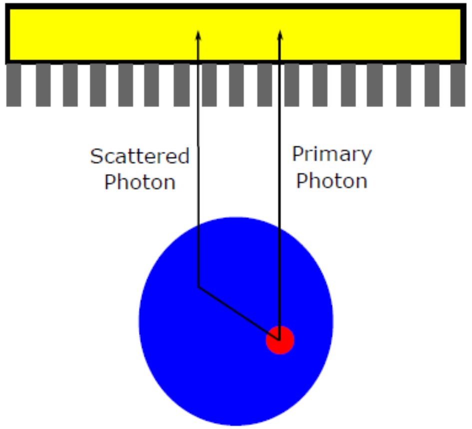
Disk with uniform activity concentration

Quantitative Imaging

Image Degrading Effects SPECT

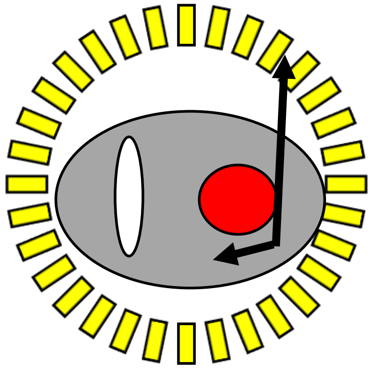


Attenuation

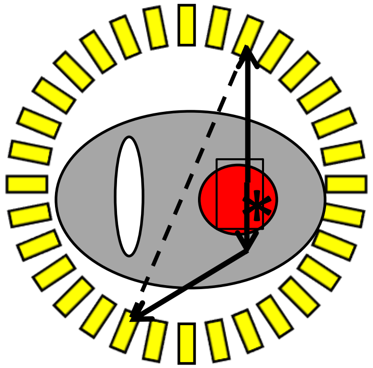


Scatter

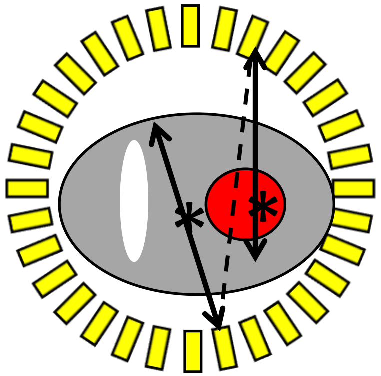
Image Degrading Effects PET



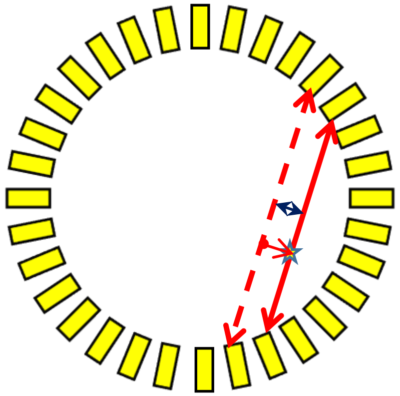
Attenuation



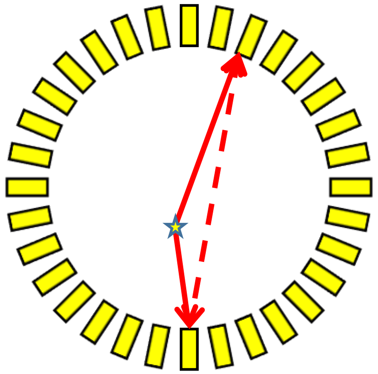
Scatter



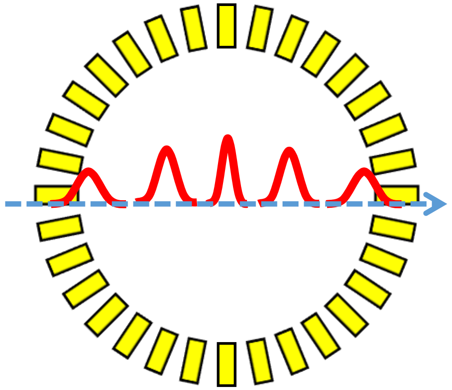
Randoms



Positron range

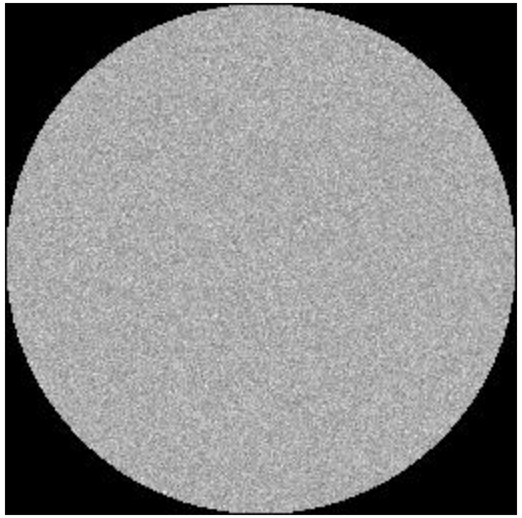


Positron non-colinearity

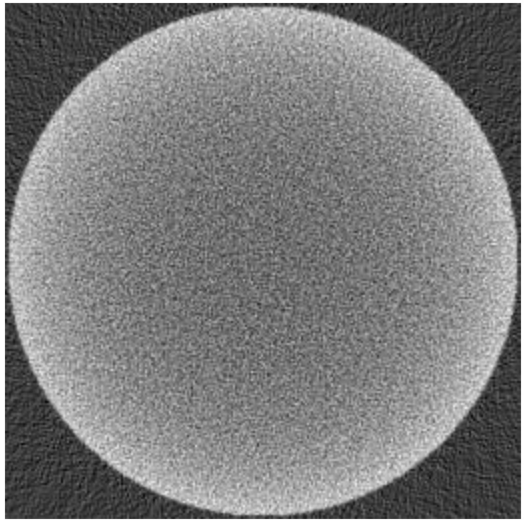


Depth of interaction

But there's a problem…



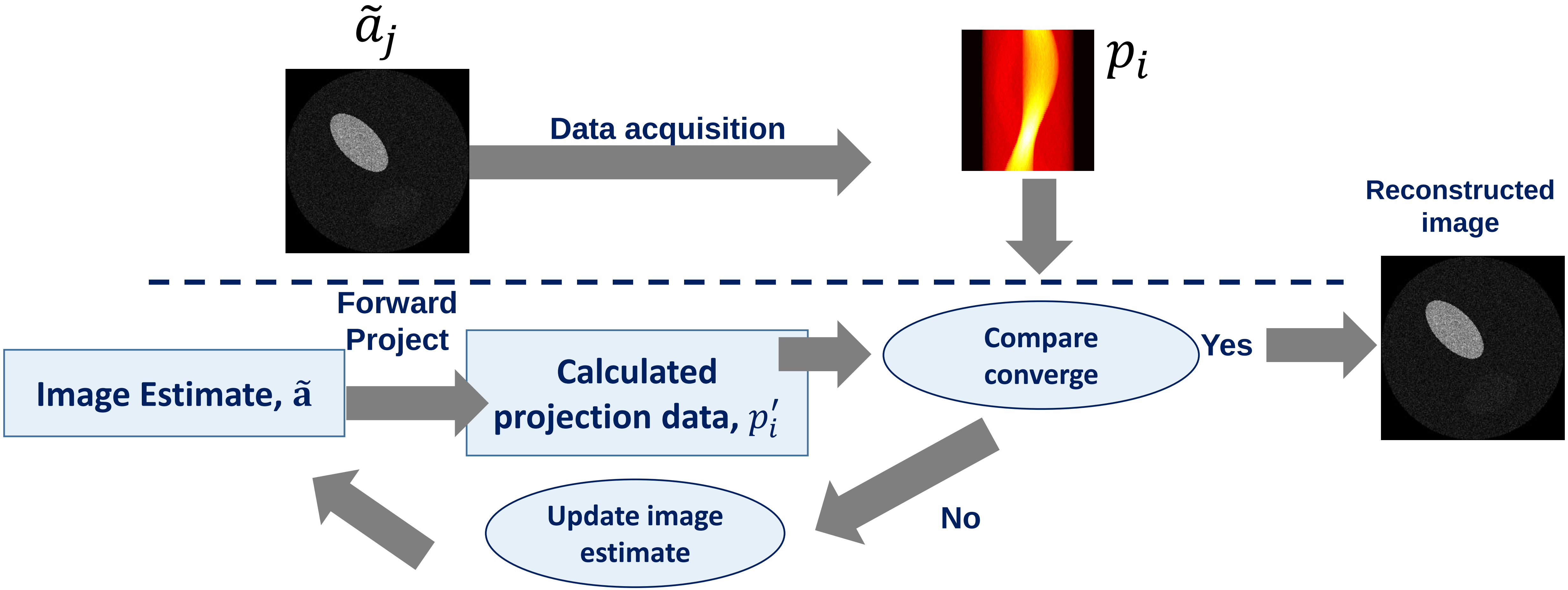
$f(x, y)$



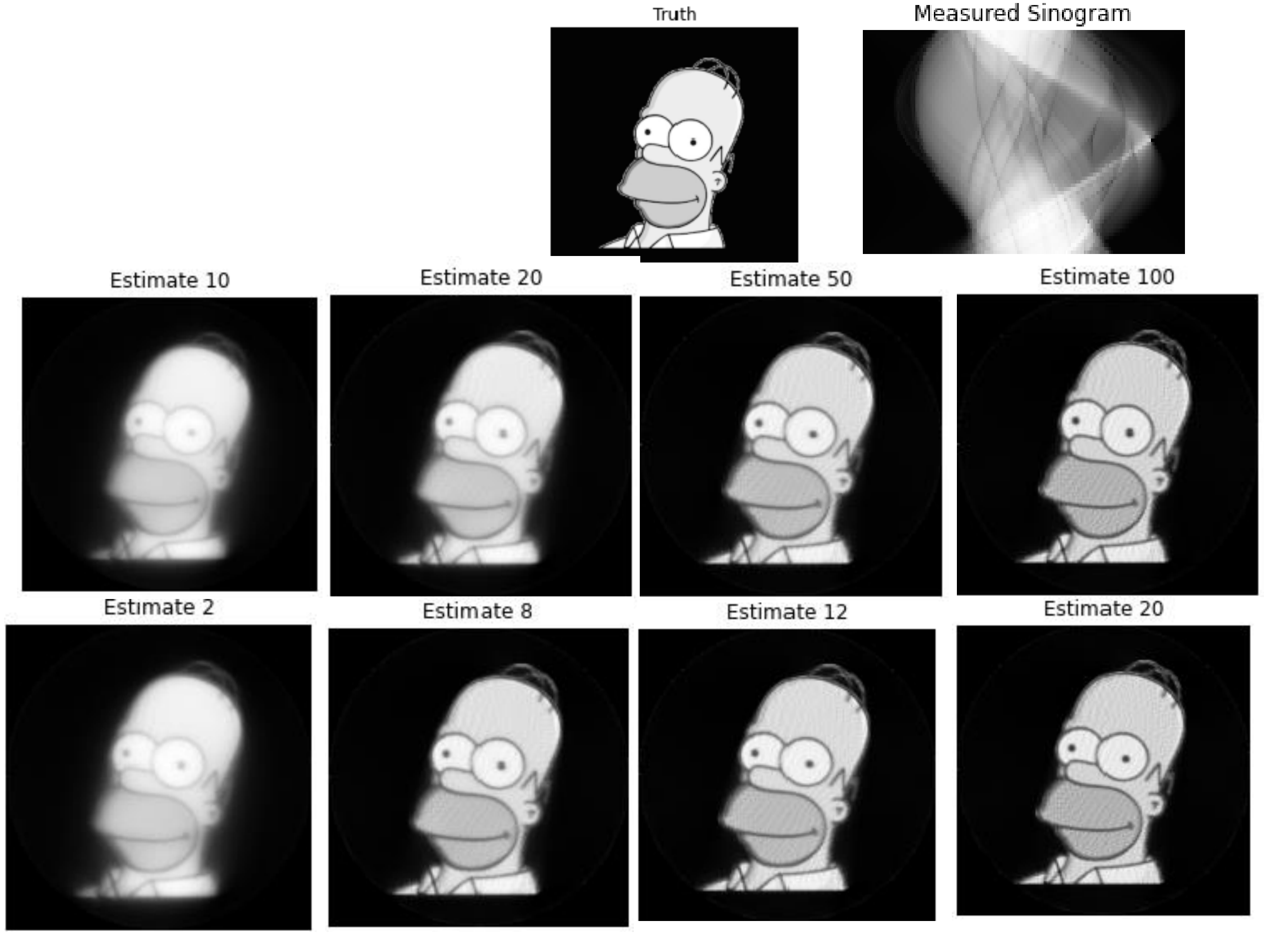
Reconstructed image

Disk with uniform activity concentration

Iterative reconstruction algorithms

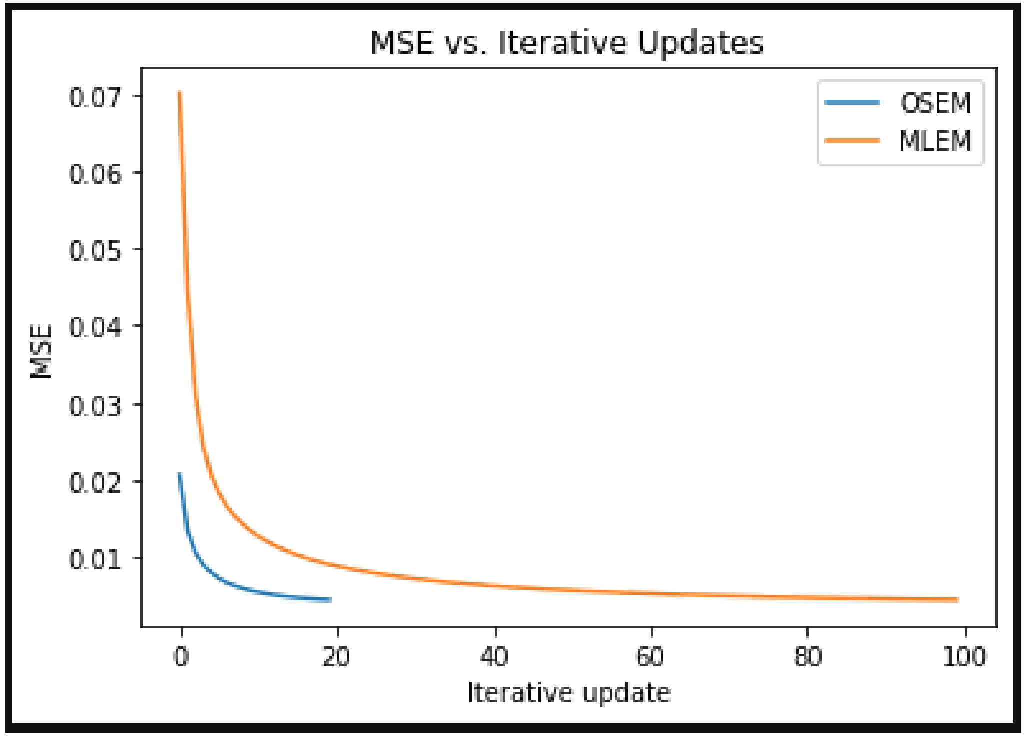


Iterative reconstruction algorithms



MLEM

OSEM



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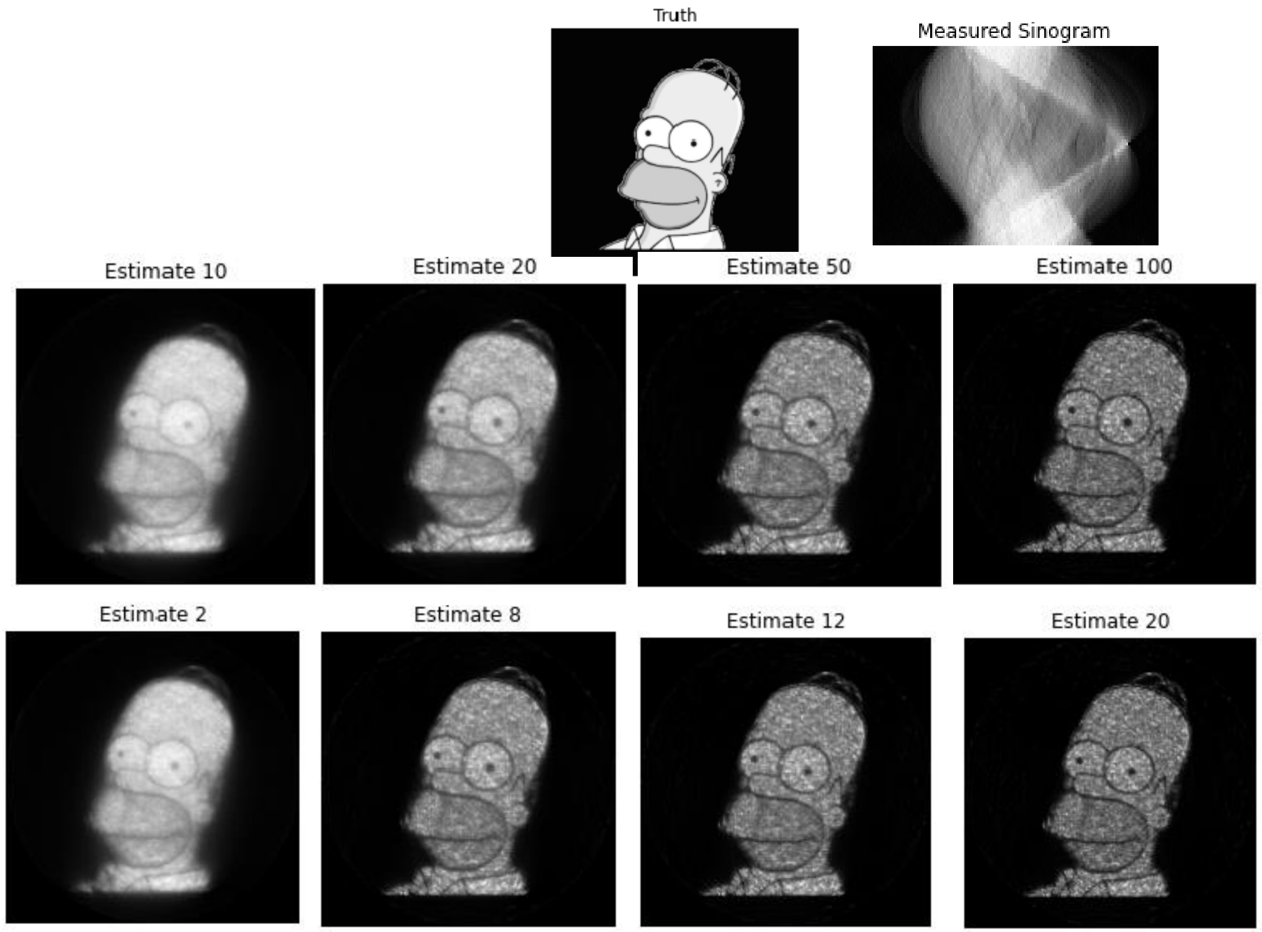
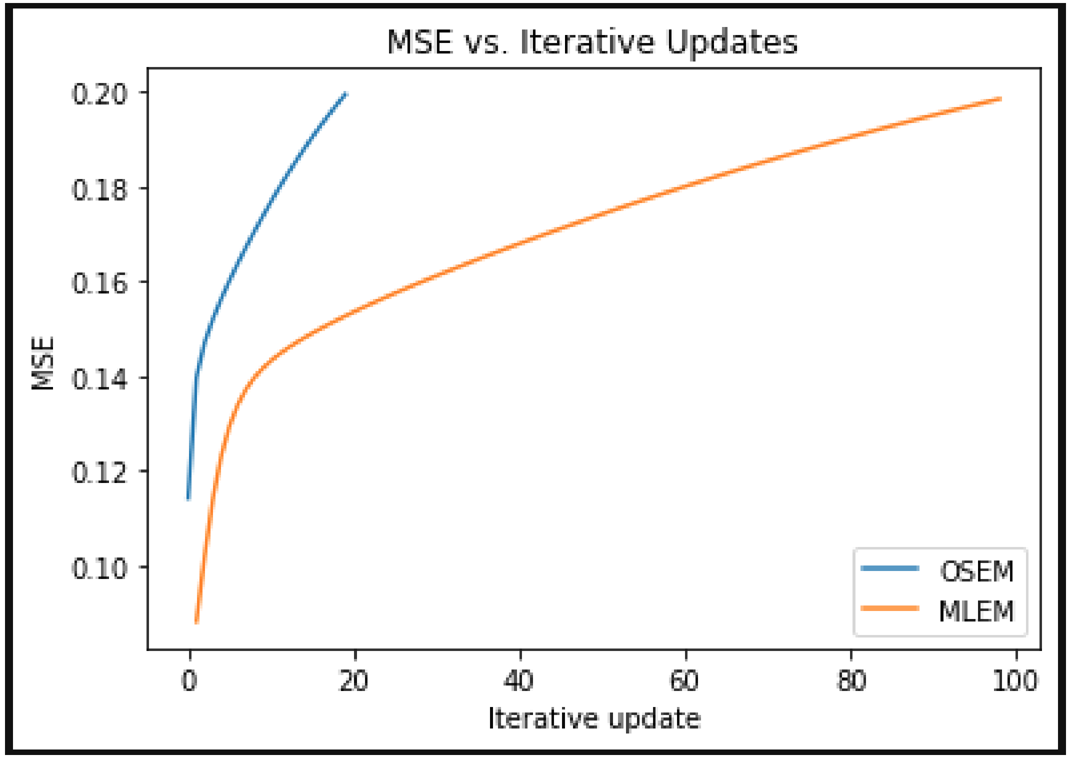


MLEM

OSEM



https://github.com/carluri/nucmed_physics_examples/tree/master/Lab2

Quantitative Imaging

- If SPECT and PET images are **corrected for degrading effects**, then the image should contain information about the primary photons originating inside the patient

- **The images now have the correct number of photons in each pixel**

- However, a calibration factor is still required in order to convert the counts into activity or activity concentration values

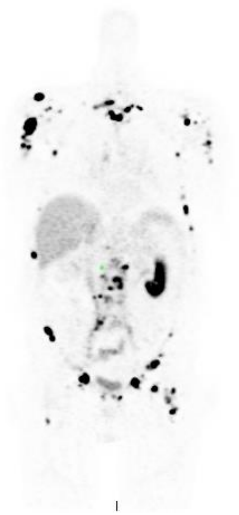
- In order to obtain it, a scan of a perfectly known activity, with all the corrections is performed.

Quantitative Imaging

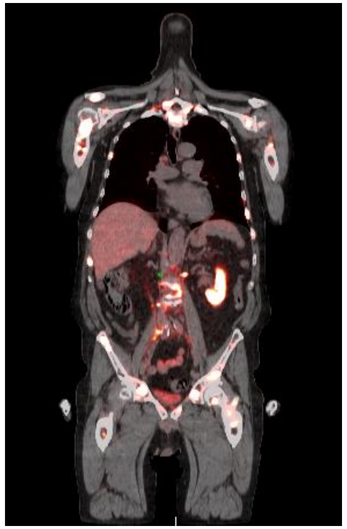
PET
No
Corrections

SPECT
No
Corrections

CT



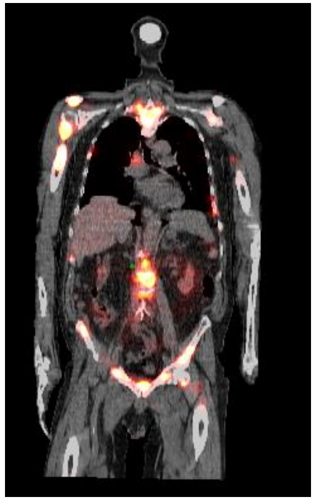
PET Corrected



Fused Image

CT

SPECT Corrected



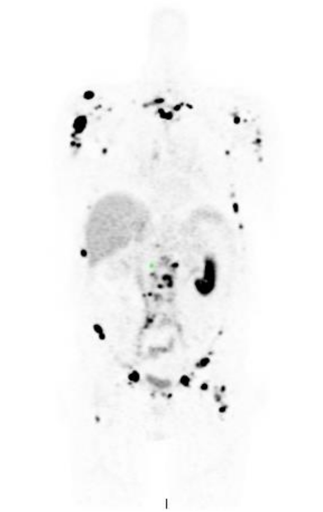
Fused Image

Quantitative Imaging

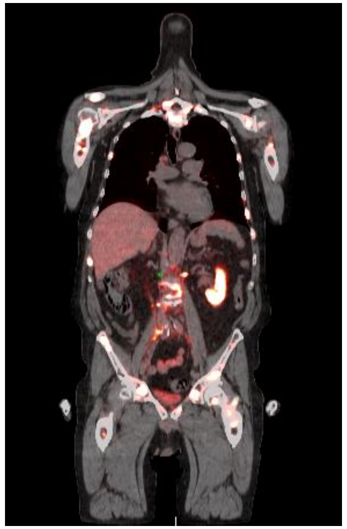
PET
No
Corrections

SPECT
No
Corrections

CT



PET Corrected



Fused Image

CT

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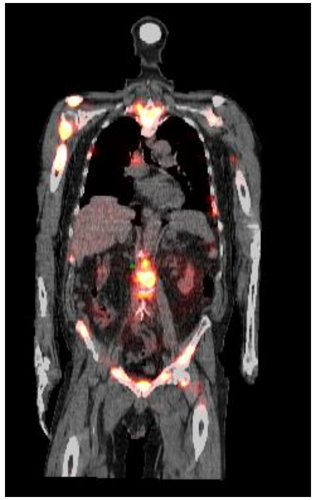
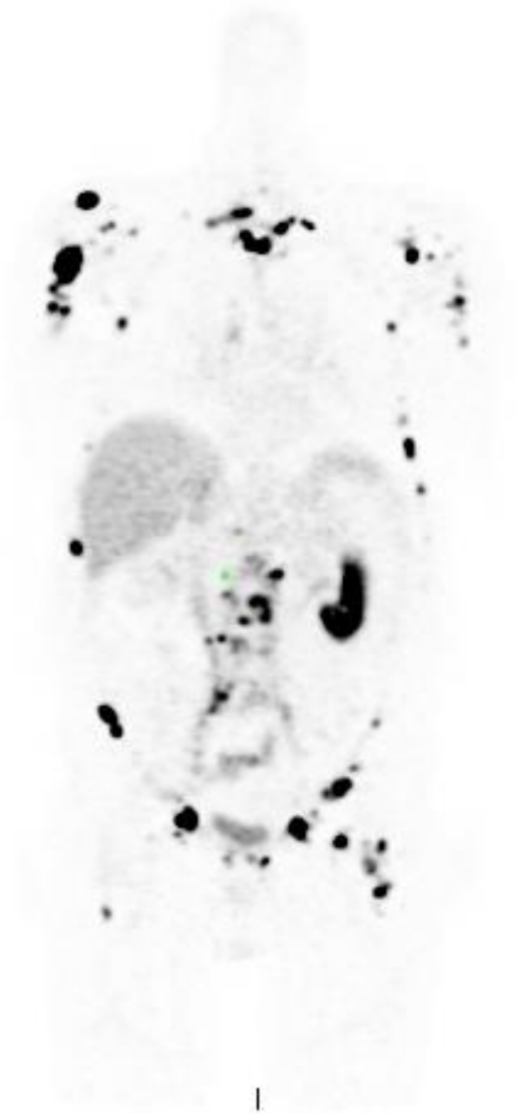


Fused Image

Theranostics

PET and SPECT scans



PET	SPECT
[^{68}Ga]Ga-PSMA-11	[^{177}Lu]Lu-PSMA617

PET Isotopes (Positron Emitters)

Half-life	Rmean (mm)	Isotope
110 min	0.6	^{18}F
68 min	3.5	^{68}Ga
20.4 min	1.2	^{11}C
78.4 h	1.3	^{89}Zr

Therapy Isotopes (Beta emitters)

Half-life	Rmean (mm)	Gamma emissions [keV]	Isotope
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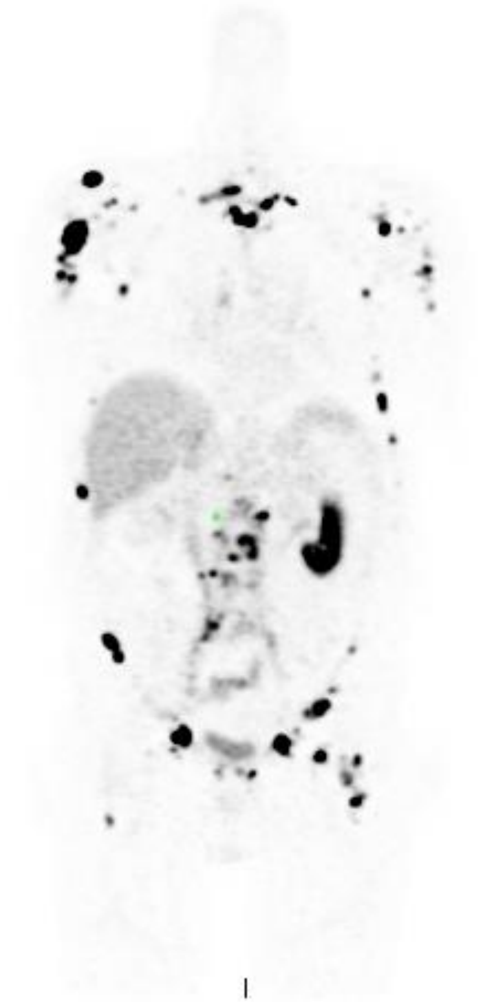
PET and SPECT Scans



Diagnostic Scan

PET	SPECT
[^{68}Ga]Ga-PSMA-11	[^{177}Lu]Lu-PSMA617

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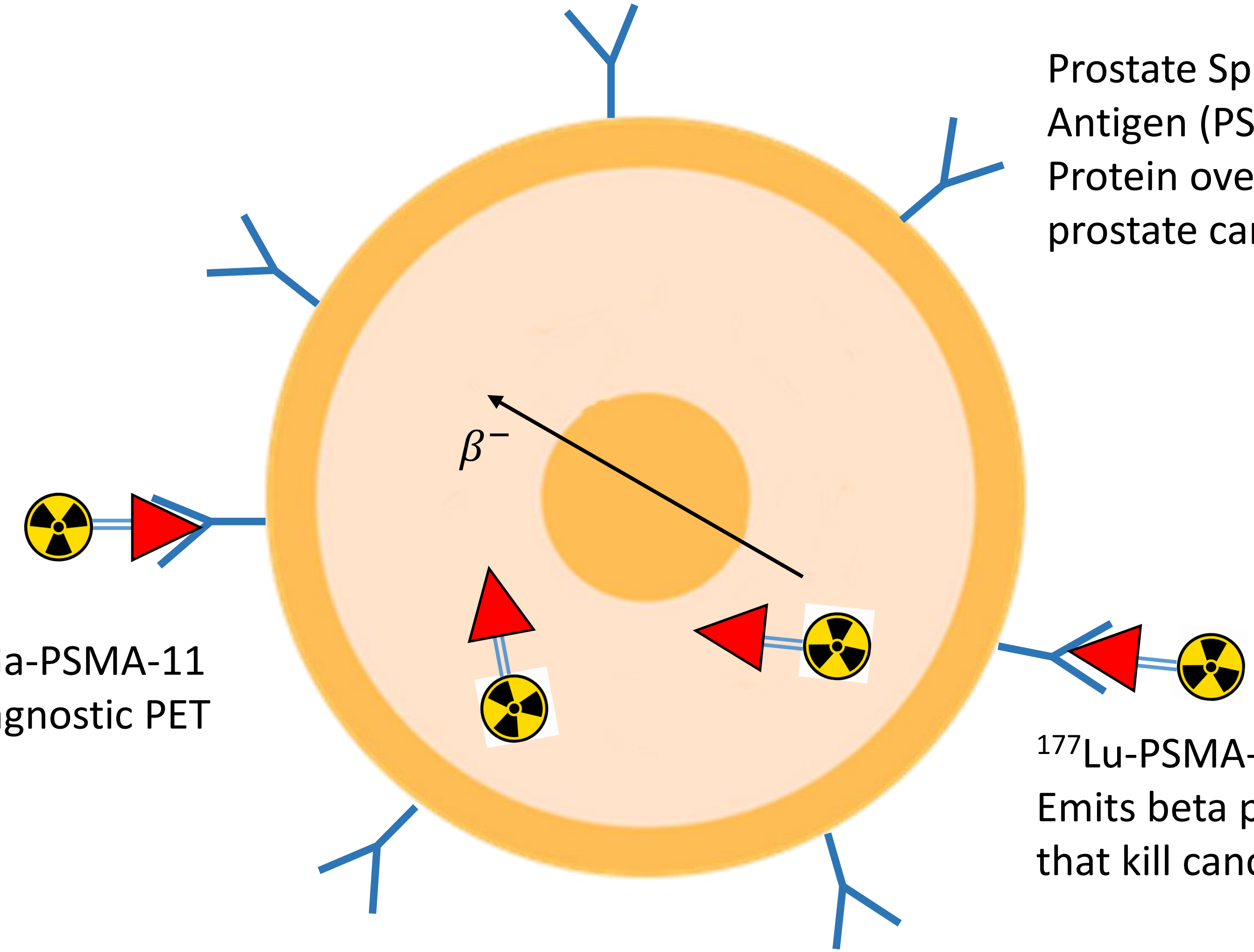
Therapy Scan

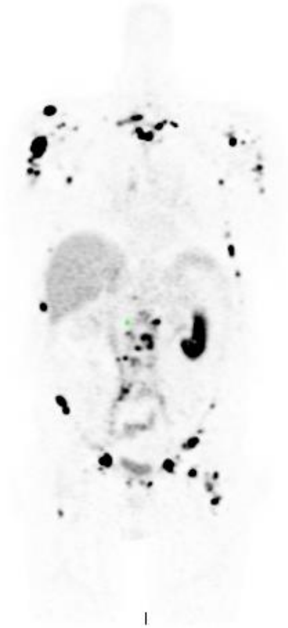
Theranostics



Prostate Specific Membrane Antigen (PSMA):
Protein overexpressed in prostate cancer cells

^{68}Ga-PSMA-11
Diagnostic PET

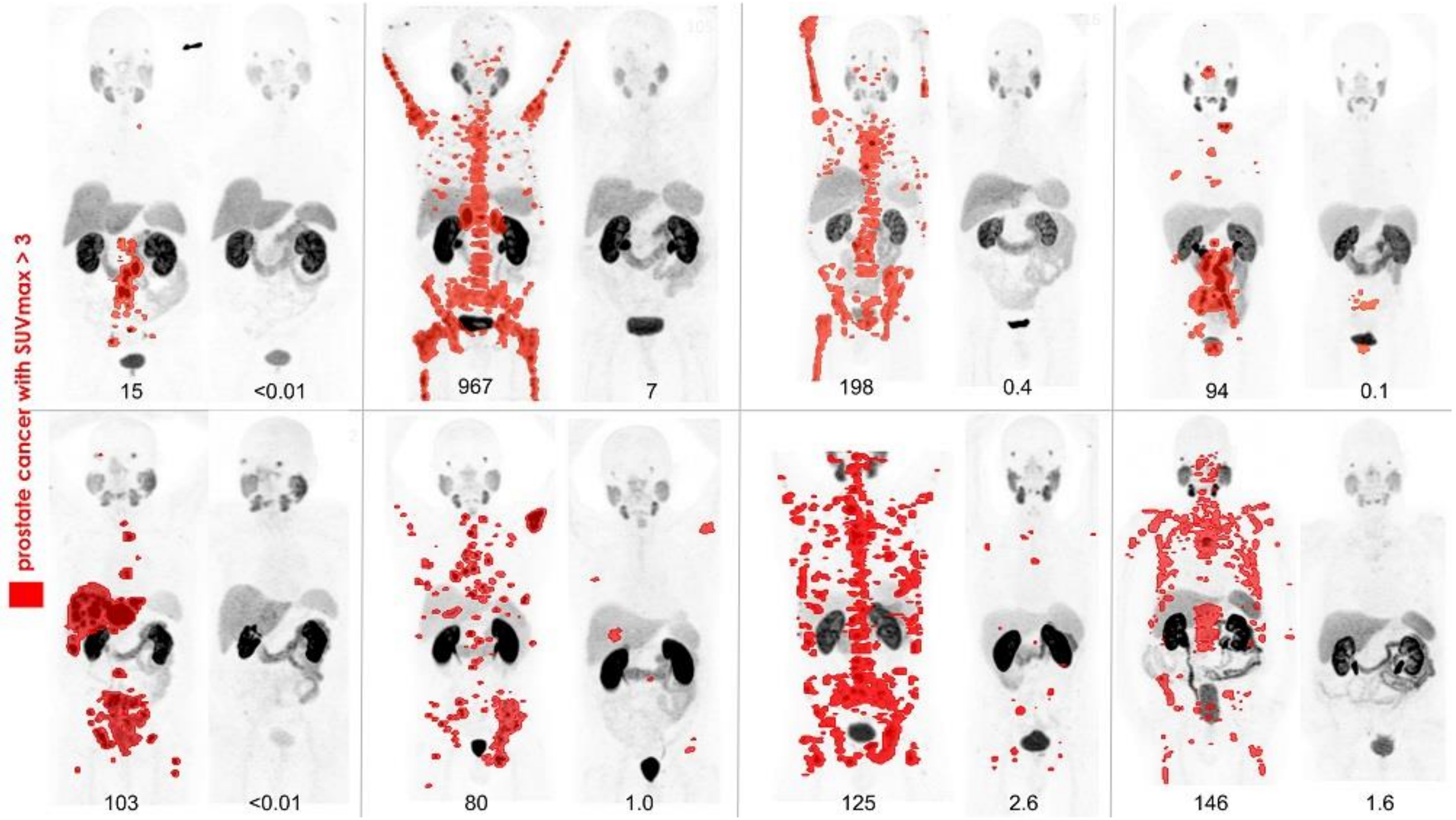
^{177}Lu-PSMA-617
Emits beta particles that kill cancer cells



Diagnostic Scan

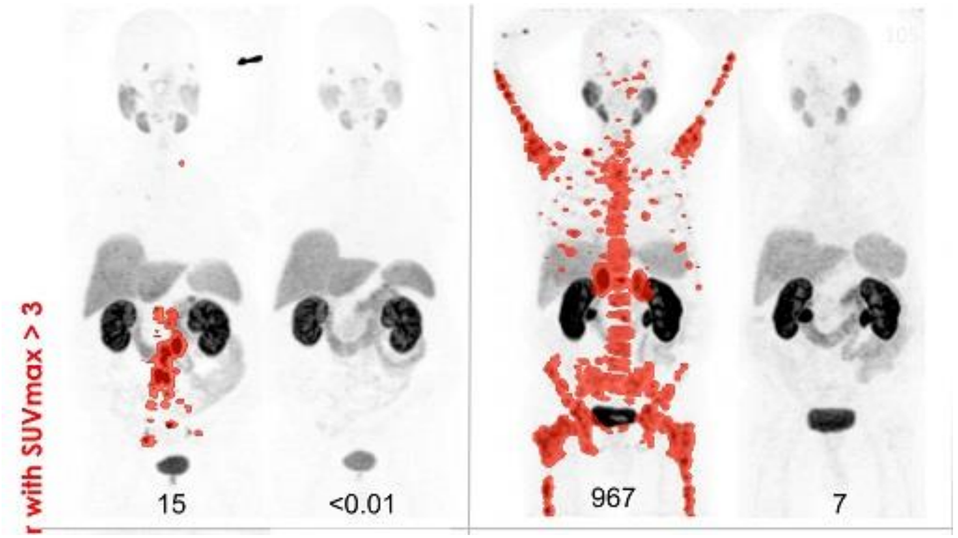
Therapy Scan

Theranostics - PSMA



Hofman, et al. "[177Lu]-PSMA-617 Radionuclide Treatment in Patients with Metastatic Castration-Resistant Prostate Cancer (LuPSMA Trial): A Single-Centre, Single-Arm, Phase 2 Study." *The Lancet Oncology* 19 (6): 825–33. 2018

Radiopharmaceutical Therapies (RPT)



Currently RPTs follow an empiric approach in which

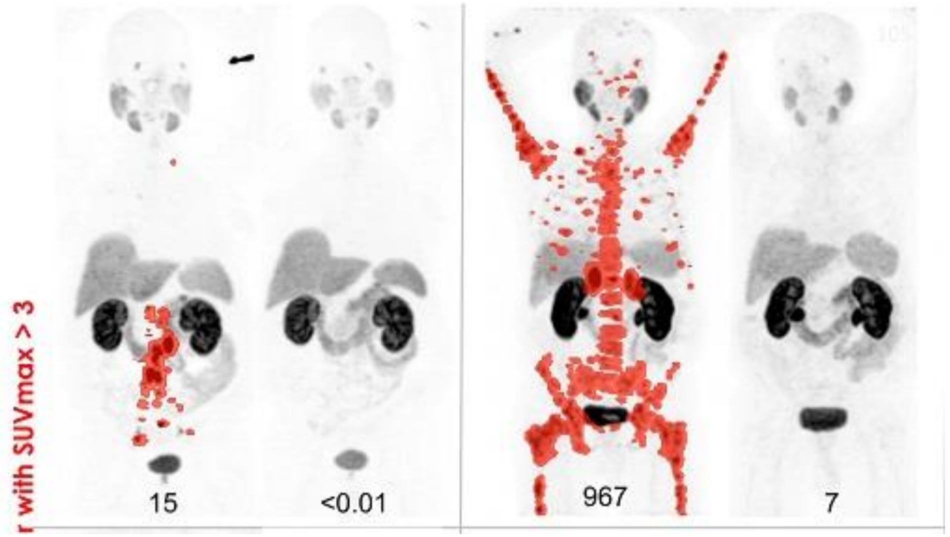
- All patients are injected the same amount of radioactivity
- This approach limits the radiation toxicity to the population. Is posible that many patients are "under-treated".
- Many of them can propably tolerate a higher radiation doce.

Personalized RPTs

If we perform personalized dose assessments (as is routine in external beam radiation therapy):

We could optimize treatment response by:

- Delivering maximum possible dose to tumors
- While sparing healthy organs by keeping dose levels below toxic.



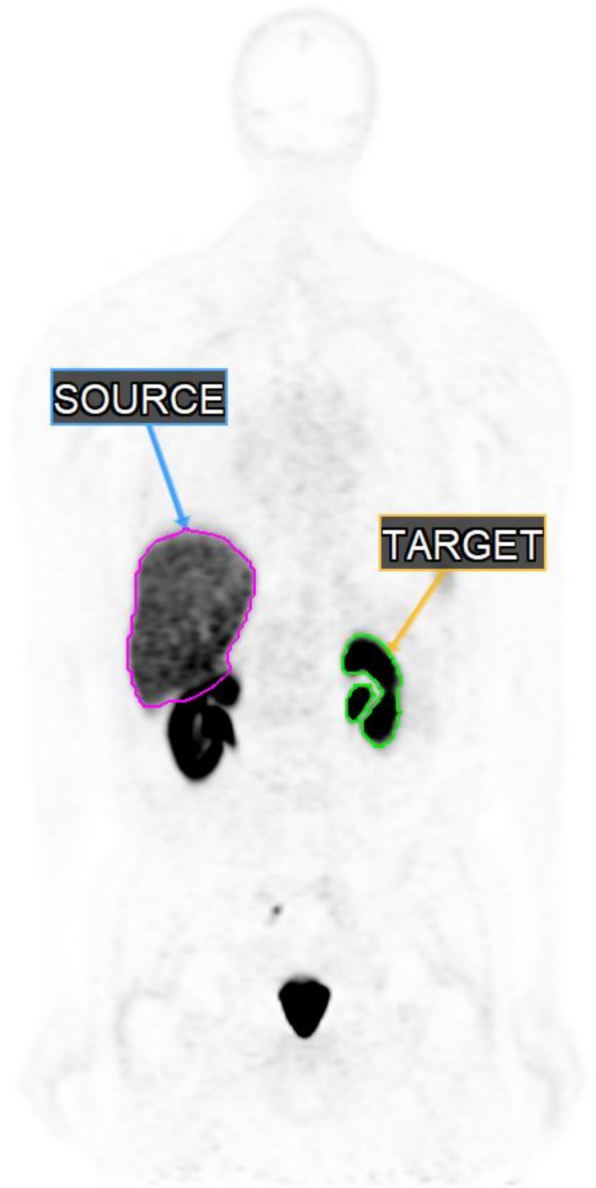
Internal Dosimetry

Dose

- Dose is defined as the energy deposited in a target region (e.g. organ or tumor) per unit mass

$$D = \frac{E}{M}$$

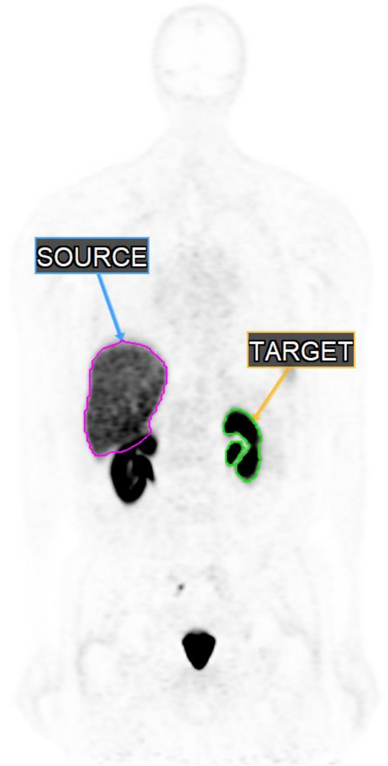
- SI units of absorbed dose is the joule per kilogram which has been named gray (1J/kg = 1 Gy).



Internal Dosimetry

- To calculate dose in nuclear medicine procedures we need to have information from the radioactive emissions of the radiopharmaceutical

$$S(r_t \leftarrow r_s) = \sum_i \frac{n_i E_i \phi_i(r_t \leftarrow r_s)}{M_t}$$



  - Different decay modes of radionuclide of interest
    - Abundance (n_i) and energy (E_i) of each emission
- Absorbed fraction, $\varphi_i(r_T \leftarrow r_S)$
- M_t mass of the target

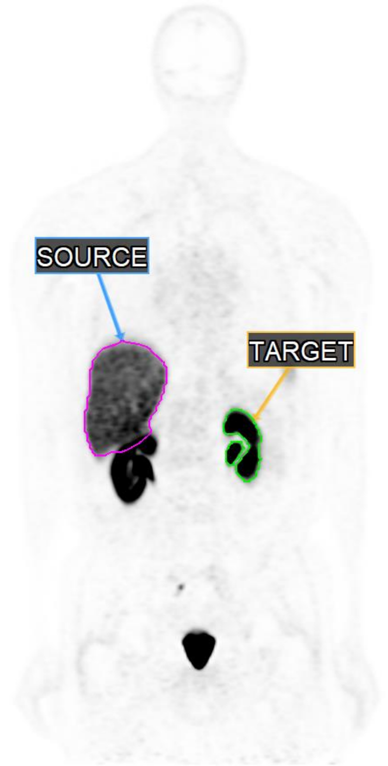
Internal Dosimetry

$$S(r_t \leftarrow r_s) = \sum_i \frac{n_i E_i \phi_i(r_t \leftarrow r_s)}{M_t}$$

- The S-factor provides the dose absorbed by the target per decay in the source
- How many decays in total within the source?
- $A = \frac{dN}{dt} = A_0 e^{-\lambda t}$
- $N = \int A_0 e^{-\lambda t} dt$

???

- Biological processes (e.g. sweat, urine, etc)
- We need to incorporate a "biological half-life" that accounts for the rate at which the isotope is removed from the body

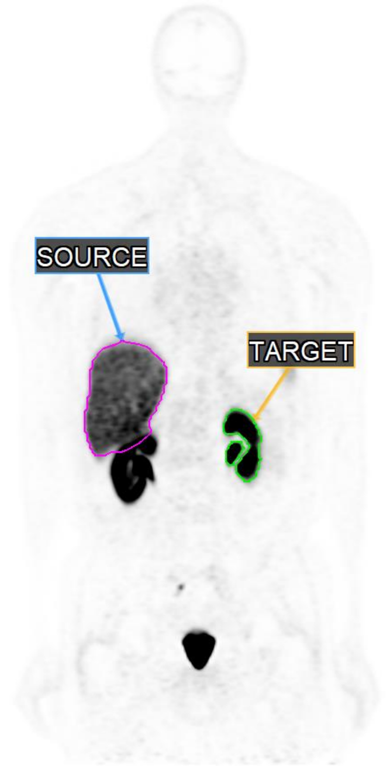


Internal Dosimetry

$N = \int A_0 e^{-\lambda_{eff} t} dt = \tilde{A}$ Time Integrated Activity (TIA)

$$S(r_t \leftarrow r_s) = \sum_i \frac{n_i E_i \phi_i (r_t \leftarrow r_s)}{M_t}$$

$$D(r_t \leftarrow r_s) = \tilde{A}(r_s) S(r_t \leftarrow r_s)$$

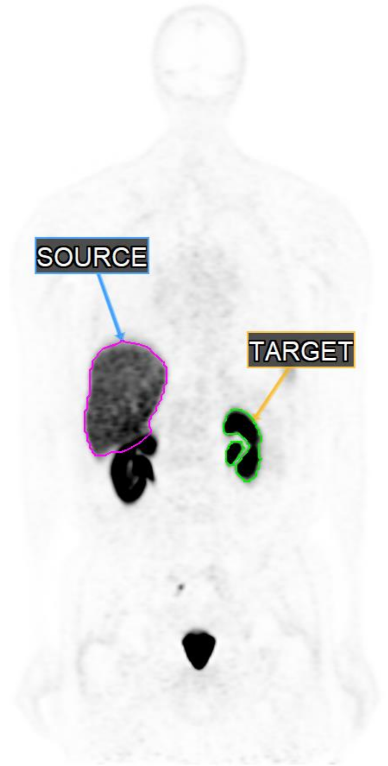


Internal Dosimetry

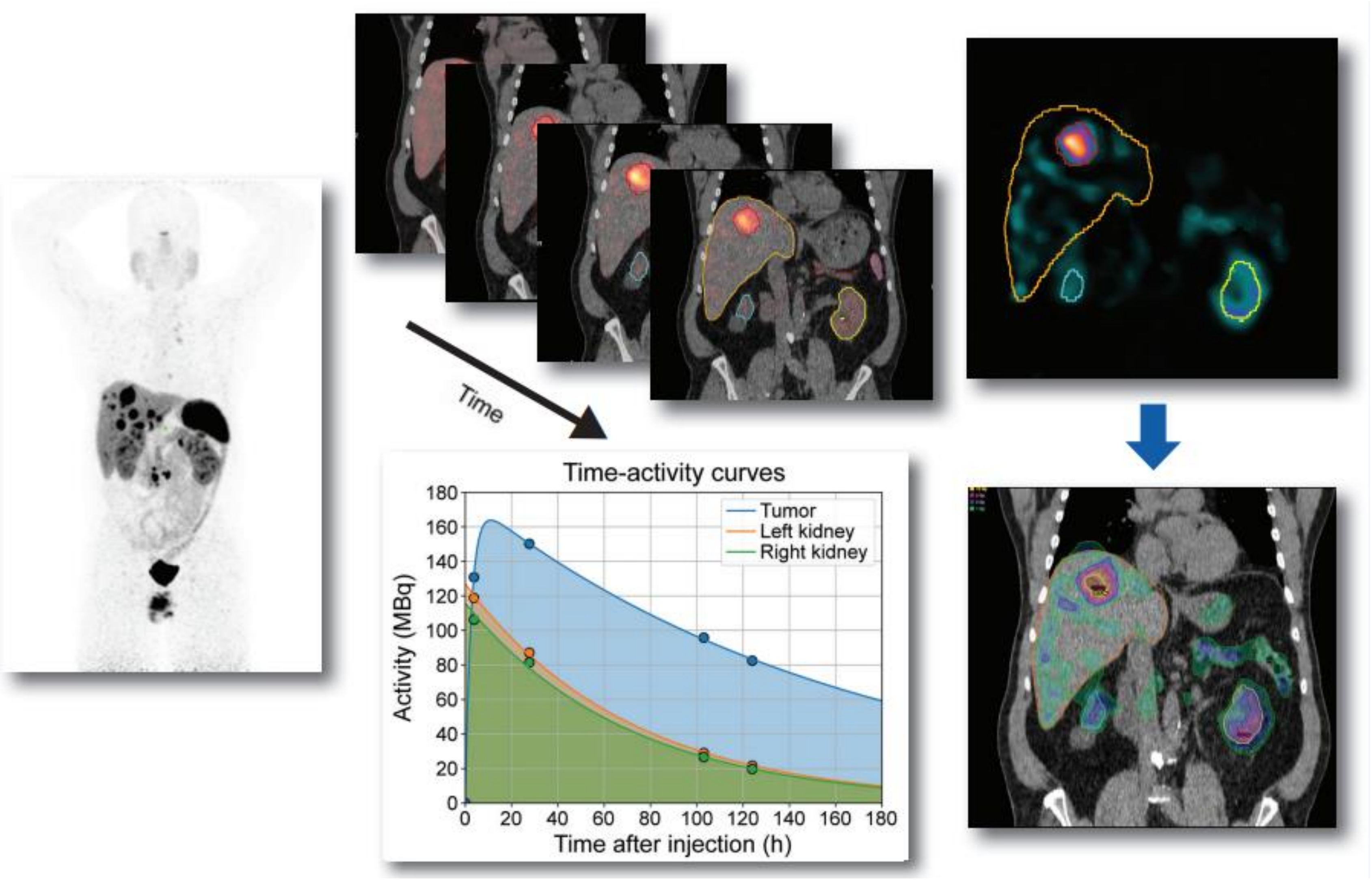
Biologic distribution data (we don't know it; we must measure it)

- $D(r_t \leftarrow r_s) = \tilde{A}(r_s)\, S(r_t \leftarrow r_s)$

Details about physical properties of the radionuclide.
Method for combining biologic data with physical data to obtain Dose estimate



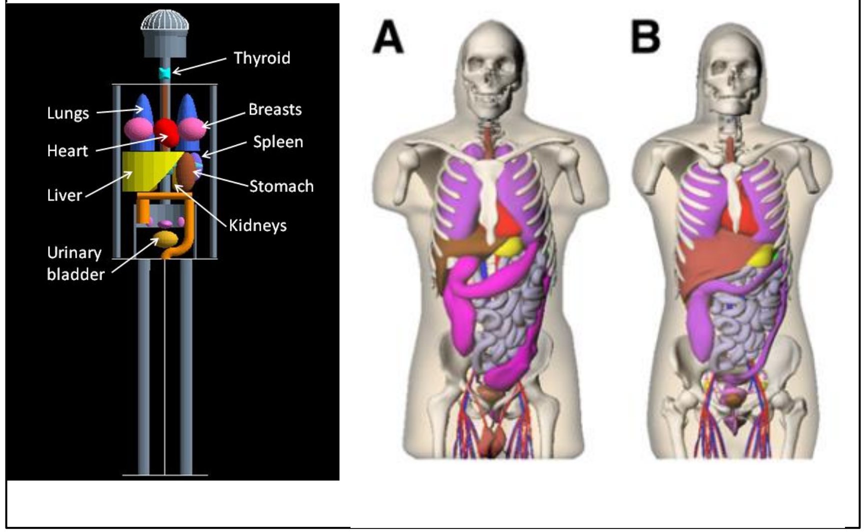
Dosimetry Workflow



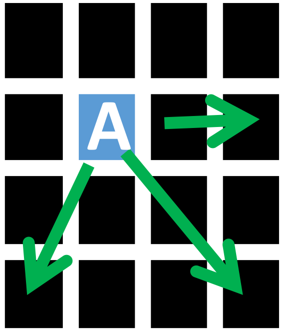
Dose Estimation Techniques

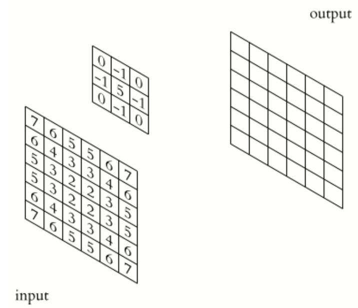
$$D(r_t \leftarrow r_s) = \tilde{A}(r_s)\, S(r_t \leftarrow r_s)$$

- Organ Level Approaches
  - Uses organ level S values
  - Dose to reference phantom

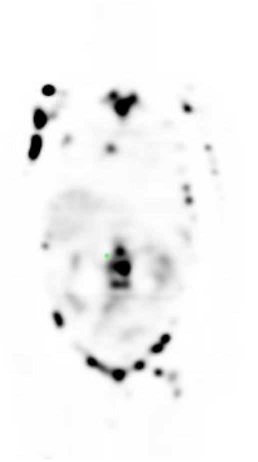


- Voxel S value approaches
  - Can deal with heterogeneous activity distributions
  - Precalculated dose distribution at voxel level
  - Homogeneous tissue





- Full Monte-Carlo
  - Uses patien’s CT and 3D activity distribution
  - Simulates radiation transport of particles through media



Challenges

- Need quantitative image reconstruction

- Multiple measurements
  - When to measure?
  - How many times to measure?
  - Can the patient tolerate it?
  - Do we have enough resources?

- Image registration
  - We acquire images at different times. How do we know that one voxel in one image does correspond to another one in another image?

Challenges

- Image segmentation
  - How can we be sure that what we are segmenting is the truth?
  - What's the mass? What's the activity?

- How accurate is the used dosimetry model?
  - Can we report values with an uncertainty?

- Some of these procedures are very time consuming and need too many resources.
  - How can we simplify them? Make it easier to make the standard of care?

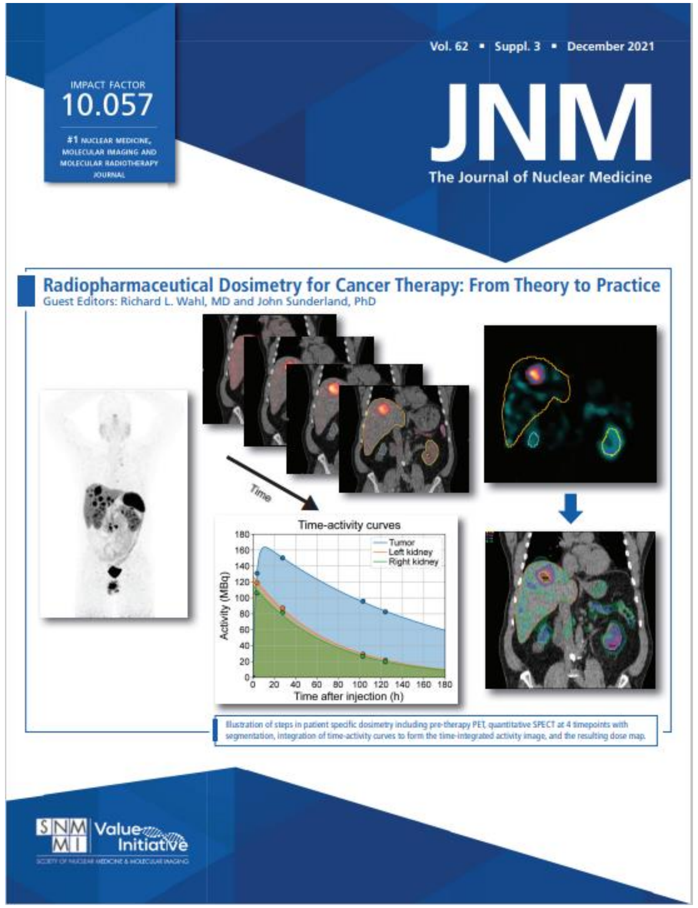
Challenges

- Despite a large number of clinical trials, considerable uncertainties still remain regarding the optimization of this therapeutic approach. The vital question still remains

- What is the dose-response relationship that could guide us in planning personalized treatments?

Our Vision and Efforts

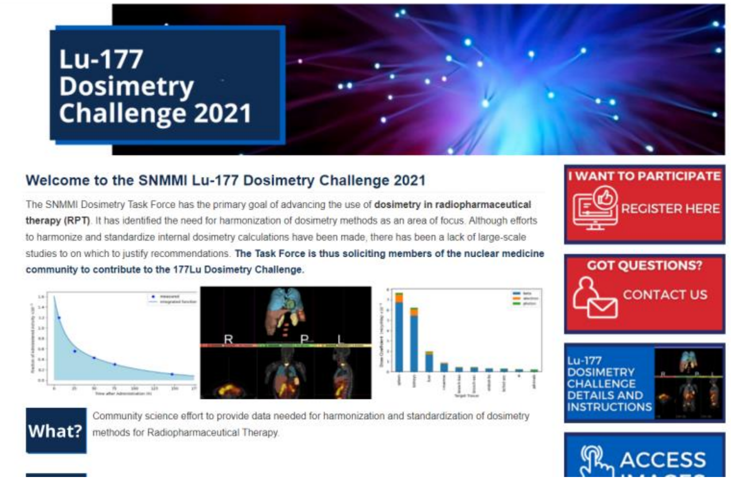
Standardizing Dosimetry Protocols



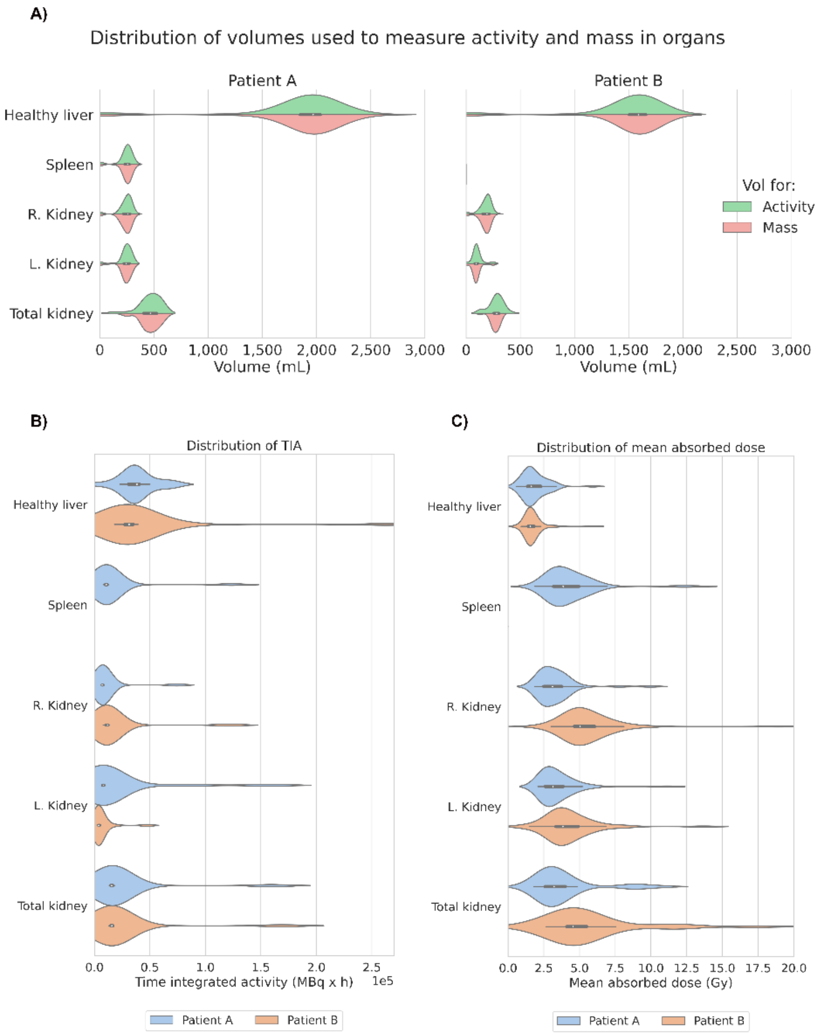
An International Study of Factors Affecting Variability of Dosimetry Calculations, Part 1: Design and Early Results of the SNMMI Dosimetry Challenge

Carlos Uribe[1,2], Avery Peterson[3], Benjamin Van[3], Roberto Fedrigo[4], Jake Carlson[5], John Sunderland[6], Eric Frey*[7,8], and Yuni K. Dewaraja*[3]

[1]Functional Imaging, BC Cancer, Vancouver, British Columbia, Canada; [2]Department of Radiology, University of British Columbia, Vancouver, British Columbia, Canada; [3]Department of Radiology, University of Michigan Medical School, Ann Arbor, Michigan; [4]Department of Integrative Oncology, BC Cancer Research Institute, Vancouver, British Columbia, Canada; [5]U-M Library, University of Michigan, Ann Arbor, Michigan; [6]Department of Radiology, University of Iowa, Iowa City, Iowa; [7]Radiological Physics Division, Johns Hopkins University, Baltimore, Maryland; and [8]Rapid, LLC, Baltimore, Maryland



[Dosimetry Challenge (snmmi.org)](#)



SNMMI SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

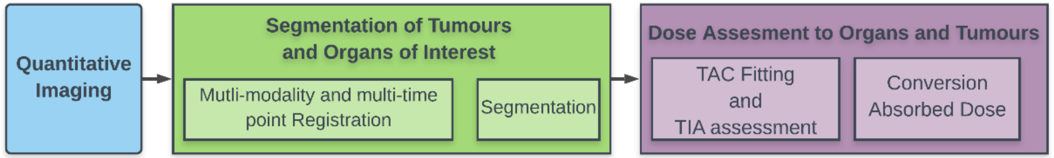
[JNM Supplement Addresses Radiopharmaceutical Dosimetry for Cancer Therapy - SNMMI](#)

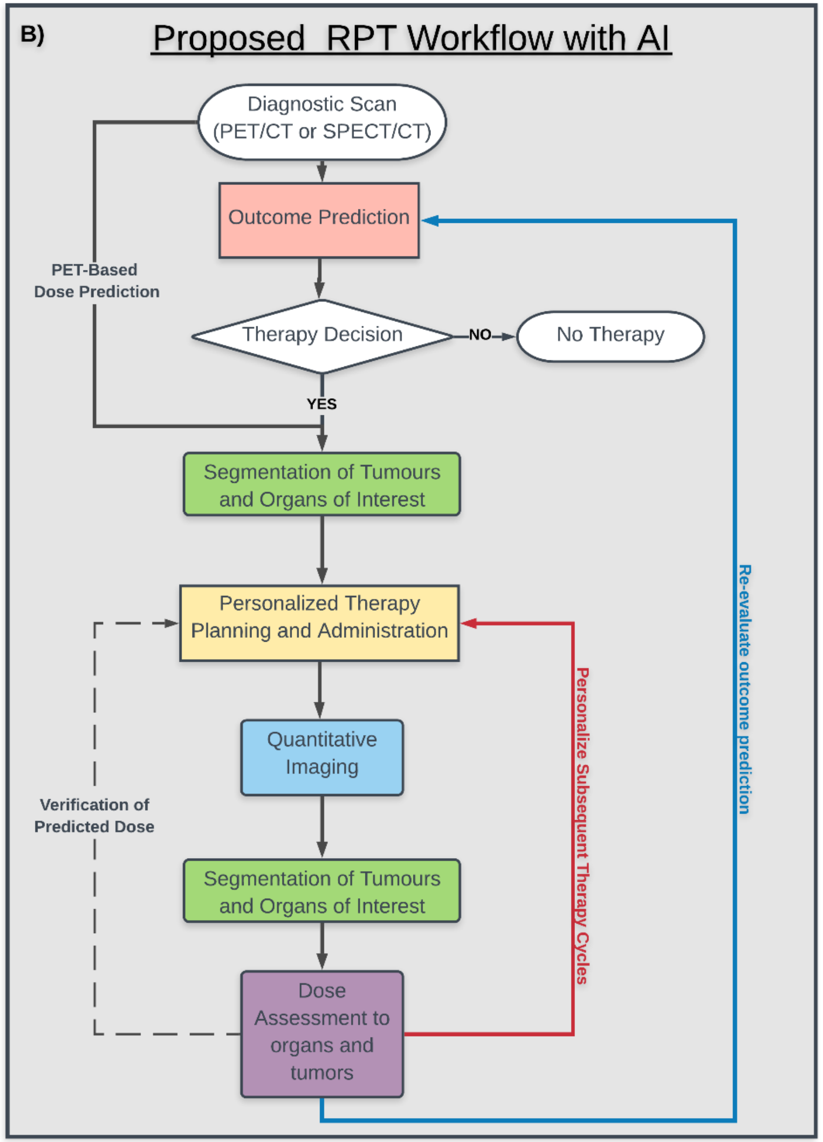
AI is a powerful tool

Role of Artificial Intelligence in Theranostics:
Toward Routine Personalized Radiopharmaceutical Therapies

Julia Brosch-Lenz, PhD[a], Fereshteh Yousefirizi, PhD[a],
Katherine Zukotynski, MD, PhD, FRCPC[b],
Jean-Mathieu Beauregard, MD, MSc, FRCPC[c,d], Vincent Gaudet, PhD, PEng[e],
Babak Saboury, MD, MPH, DABR, DABNM[f,g,h],
Arman Rahmim, PhD, DABSNM[a,i,j], Carlos Uribe, PhD, MCCPM[i,k,*]

Brosch-Lenz, J. *et al. PET Clinics* **16**, 627–641 (2021).





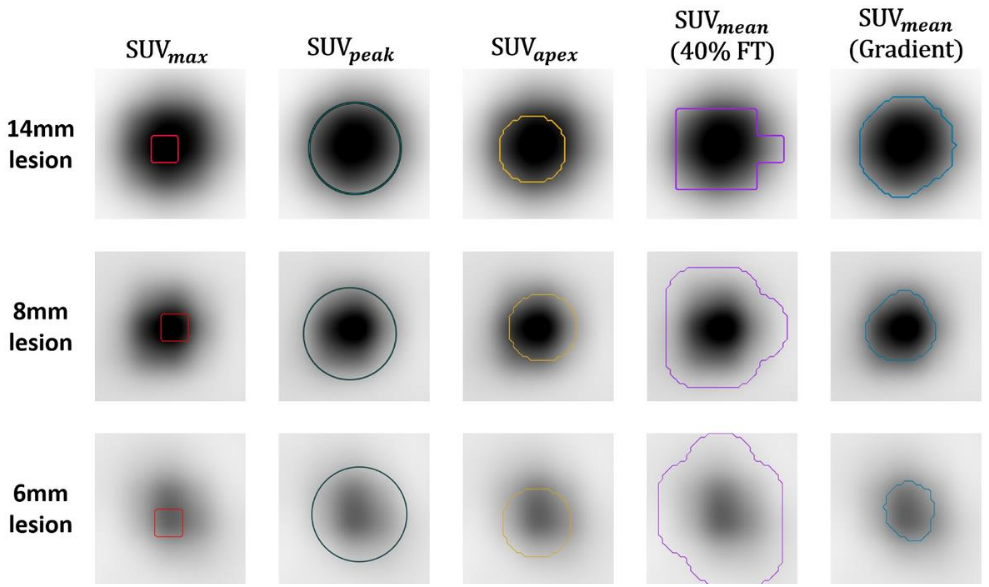
Quantitative Imaging PSMA

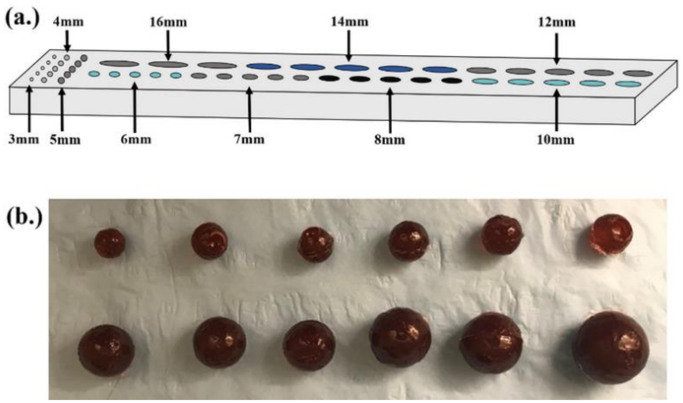
ORIGINAL RESEARCH

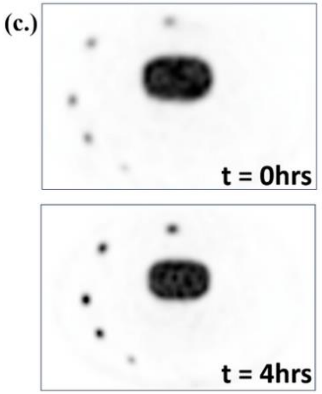
Quantitative Evaluation of PSMA PET Imaging using a Realistic Anthropomorphic Phantom and Shell-less Radioactive Epoxy Lesions

Roberto Fedrigo, Dan J. Kadrmas, Patricia E. Edem, Lauren Fougner, Ivan S. Klyuzhin, M. Peter Petric, François Bénard, Arman Rahmim, Carlos Uribe

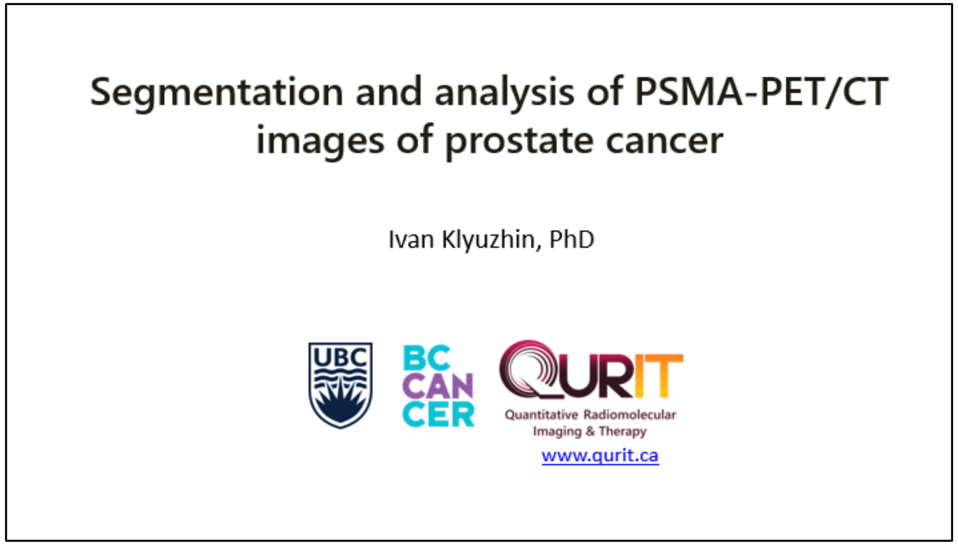
DOI: 10.21203/rs.3.rs-801202/v1 Download PDF







Automatic Segmentation PSMA



Segmentation and analysis of PSMA-PET/CT images of prostate cancer

Ivan Klyuzhin, PhD

Quantitative Radiomolecular Imaging & Therapy

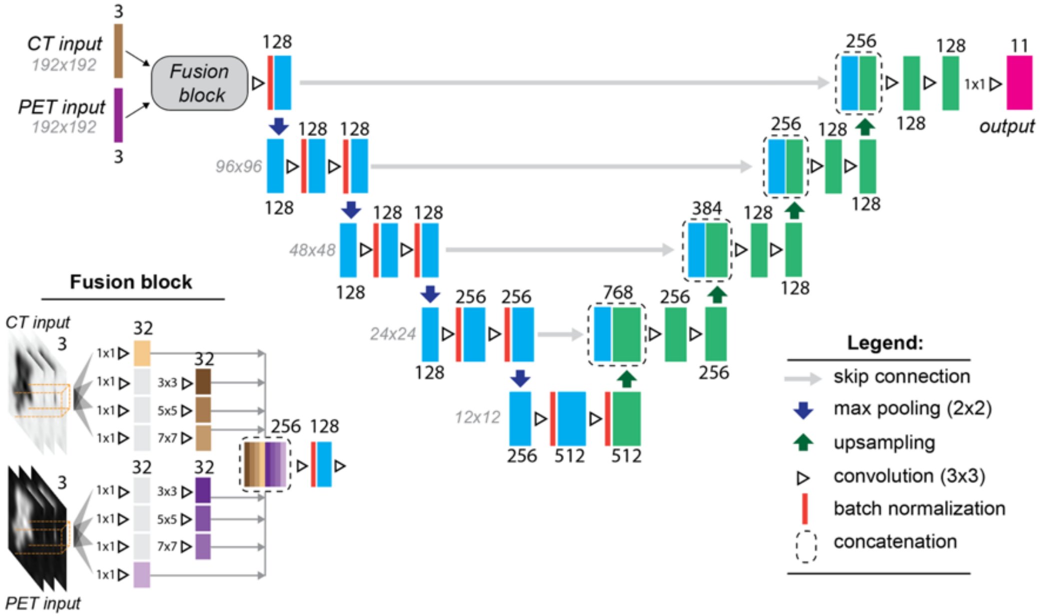
www.qurit.ca

Measuring the tracer uptake in healthy organs can be used to optimize the drug dose and effectiveness on a personalized level.
[*Violet et al., J Nucl Med., 2019*]

- Manual segmentation of organs is very labor-intensive and subject to operator variability.

Our goal is to develop a fully-automated and robust method for healthy organ segmentation in PSMA PET/CT images.

Neural net architecture ("PSMA-Hornet")



Implementation:
Tensorflow/Keras

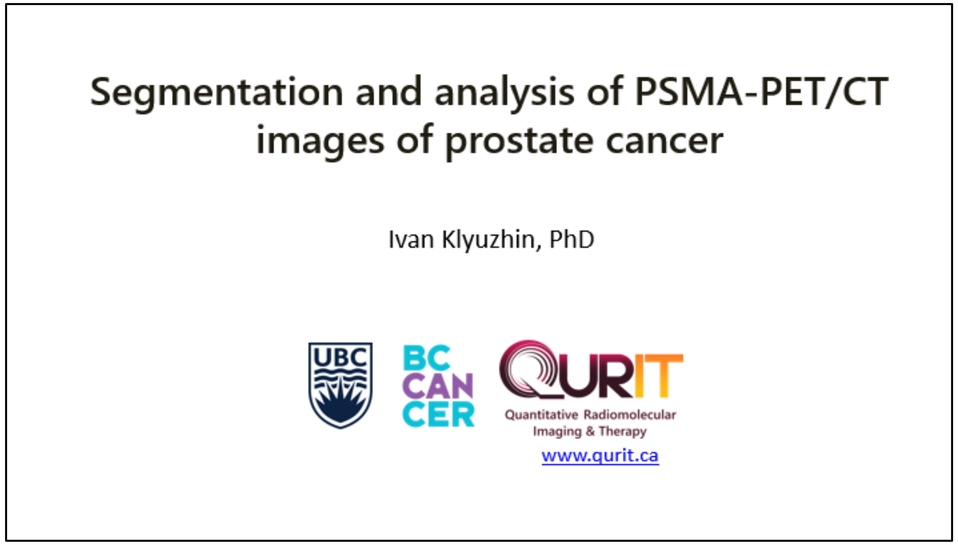
Activations:
leaky ReLU
sigmoid (output)

Total number of trainable parameters:
9,373,003

No dropout

Parameters per target:
937,300

Automatic Segmentation PSMA



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[*Violet et al., J Nucl Med., 2019]*

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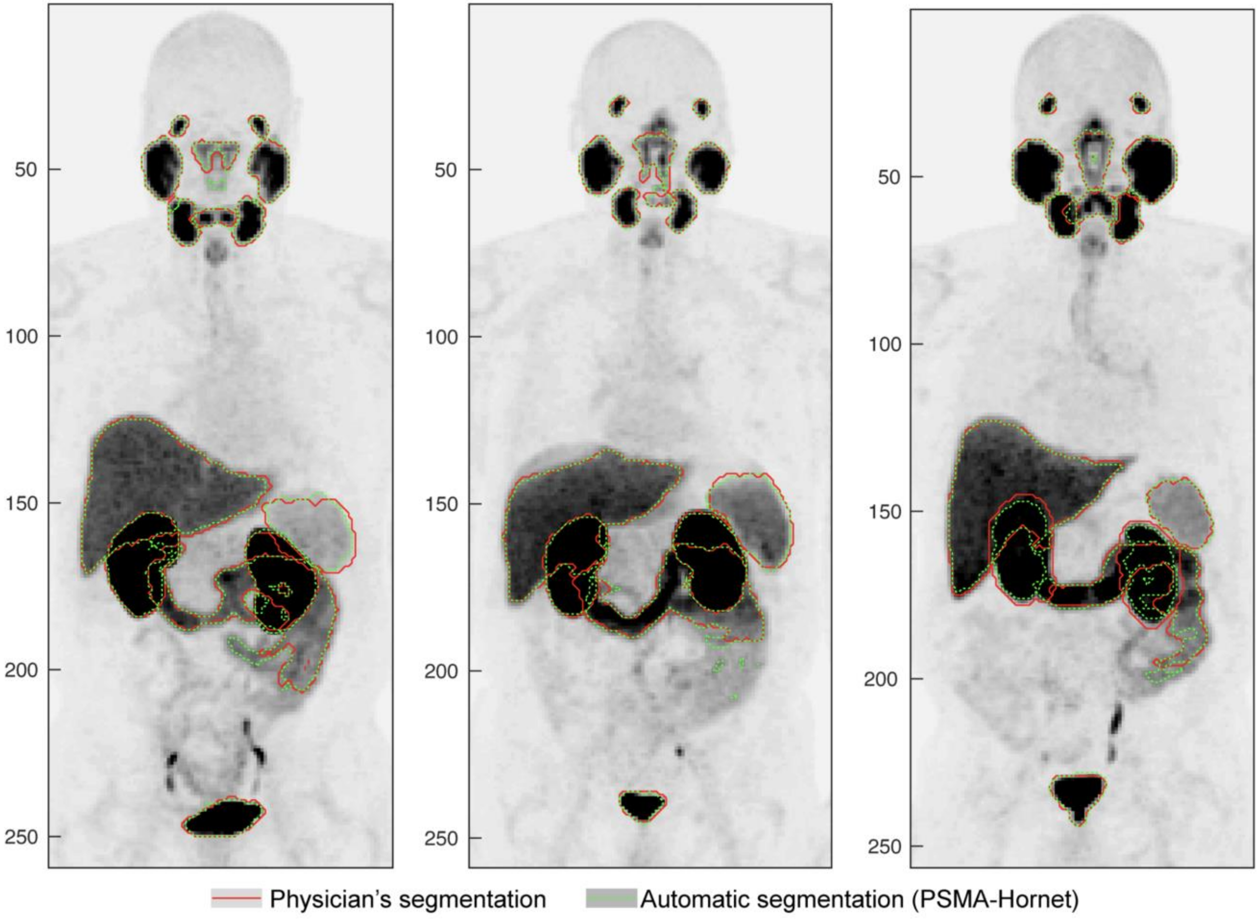
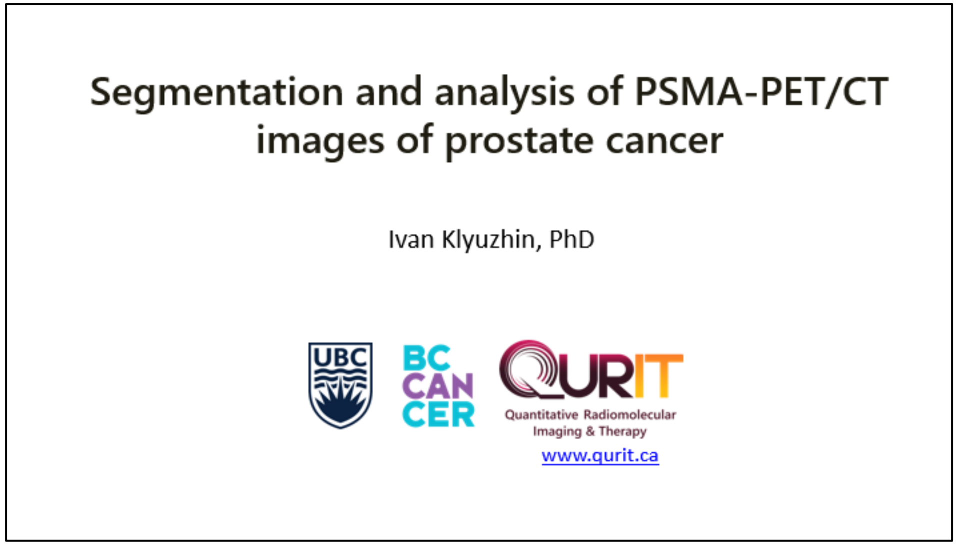
PSMA-Hornet

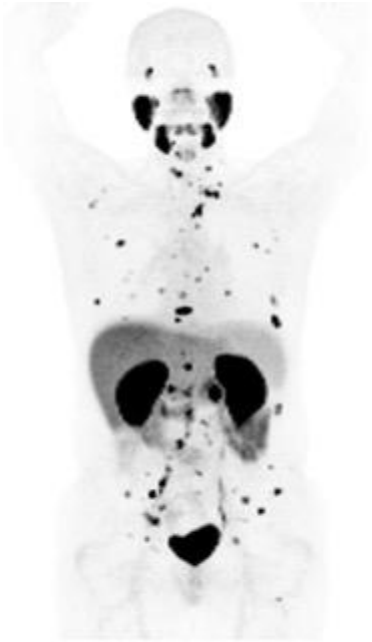


Automatic Segmentation PSMA



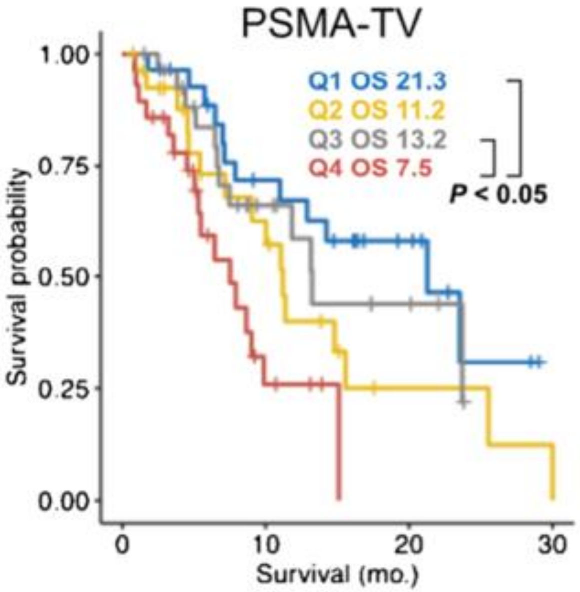
Total lesion volume (TV) was found to be significantly associated with prostate cancer survival – can be used to adjust therapy.

We are developing models and methods for <u>fully-automated detection and segmentation</u> of metastatic prostate cancer lesions.



PSMA Tracer: ^{18}F-DCFPyL

Schwarzenboeck et al., JNM, 2017



PSMA total tumor volume (TV) predicts survival.

Seifert et al., EJNMMI, Sep 2020

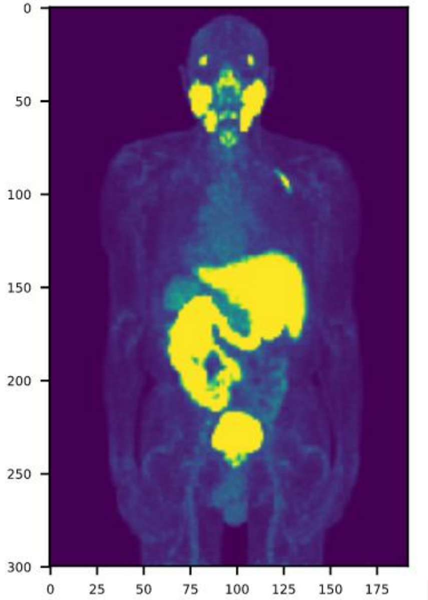
Automatic Segmentation PSMA

Segmentation and analysis of PSMA-PET/CT images of prostate cancer

Ivan Klyuzhin, PhD

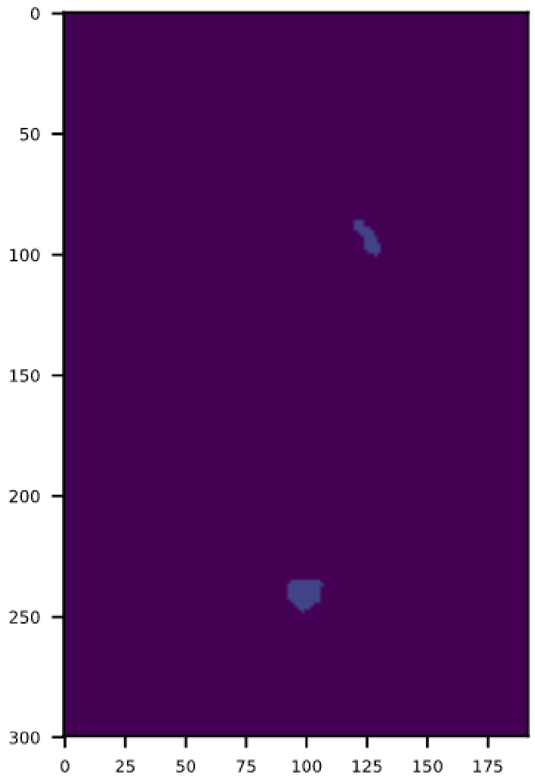
UBC BC CANCER QURIT Quantitative Radiomolecular Imaging & Therapy
www.qurit.ca

PET

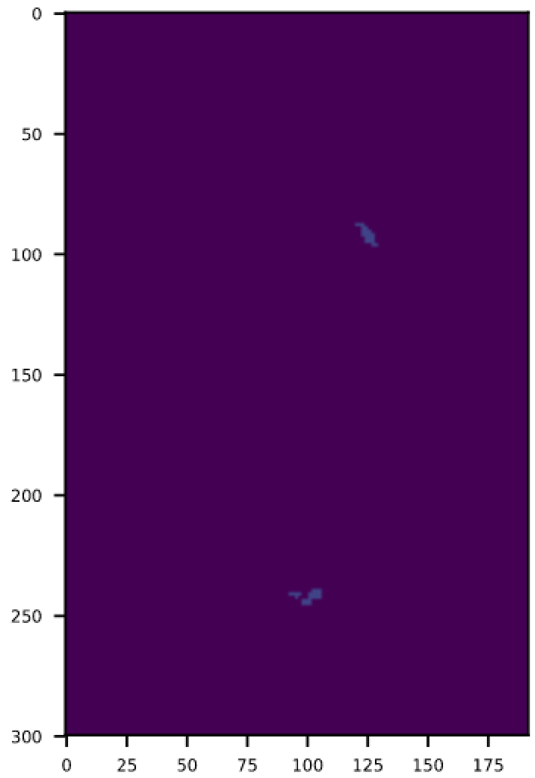


Lesion segmentation examples (U-net)

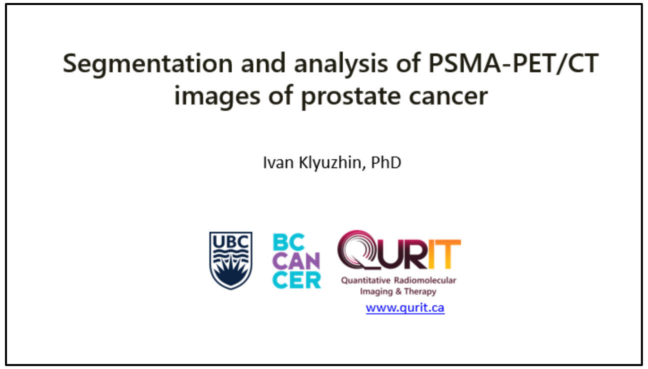
Ground truth

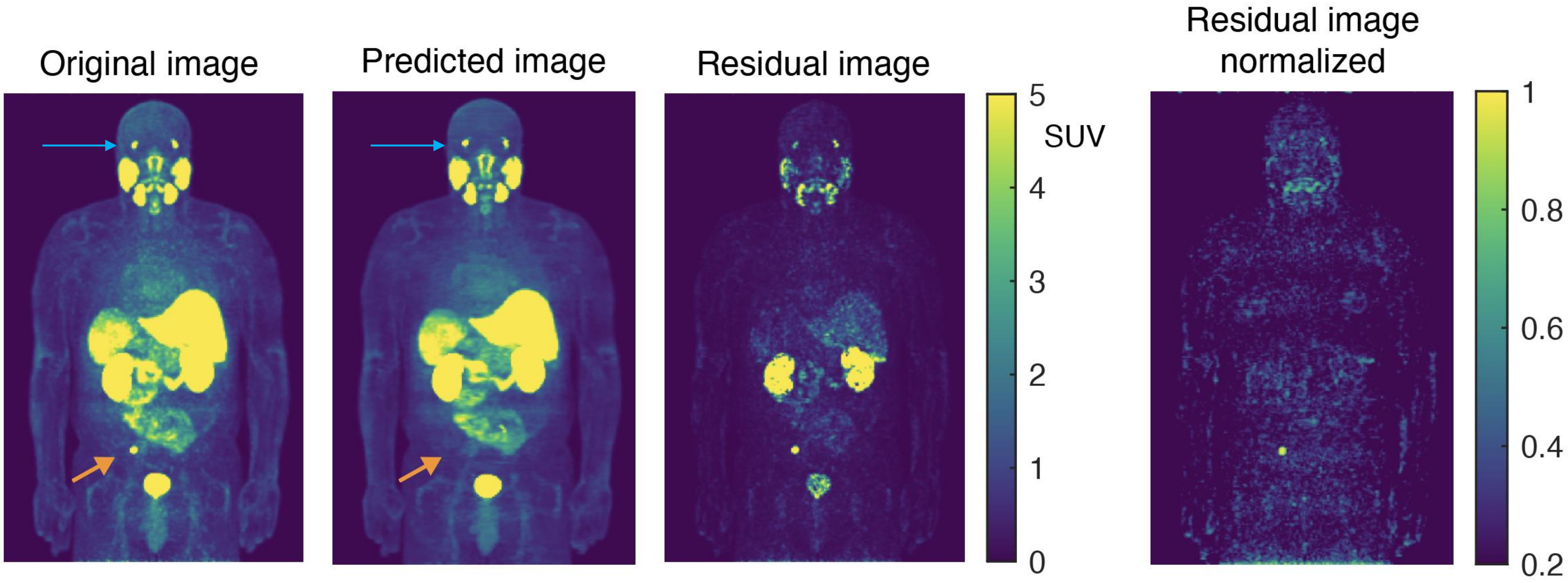


Prediction



Automatic Segmentation PSMA





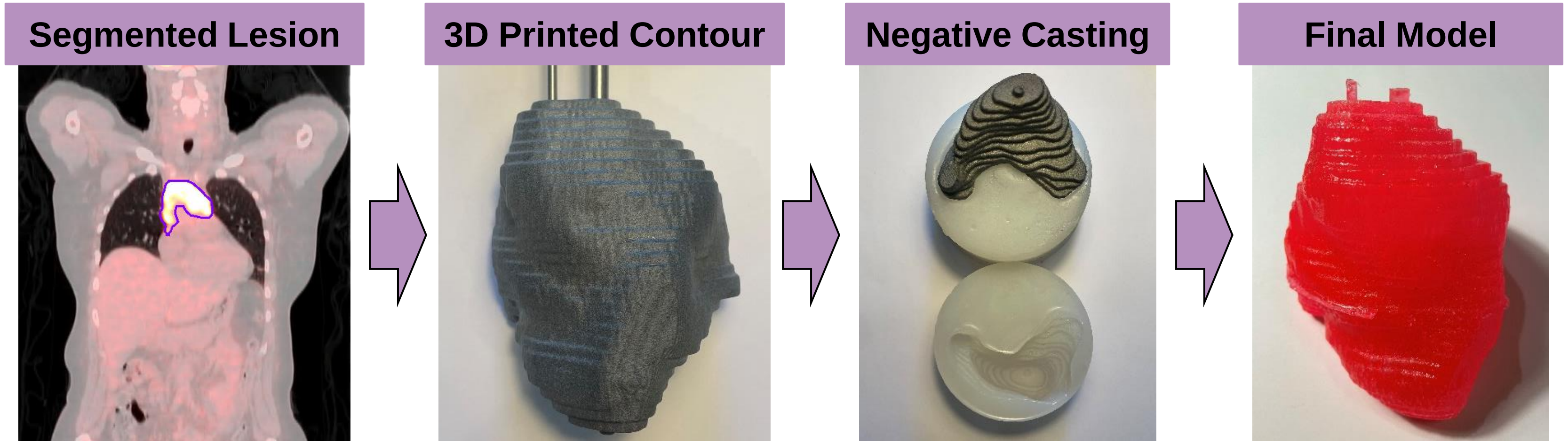
$$\frac{(\text{original} - \text{predicted})}{(\text{predicted})}$$

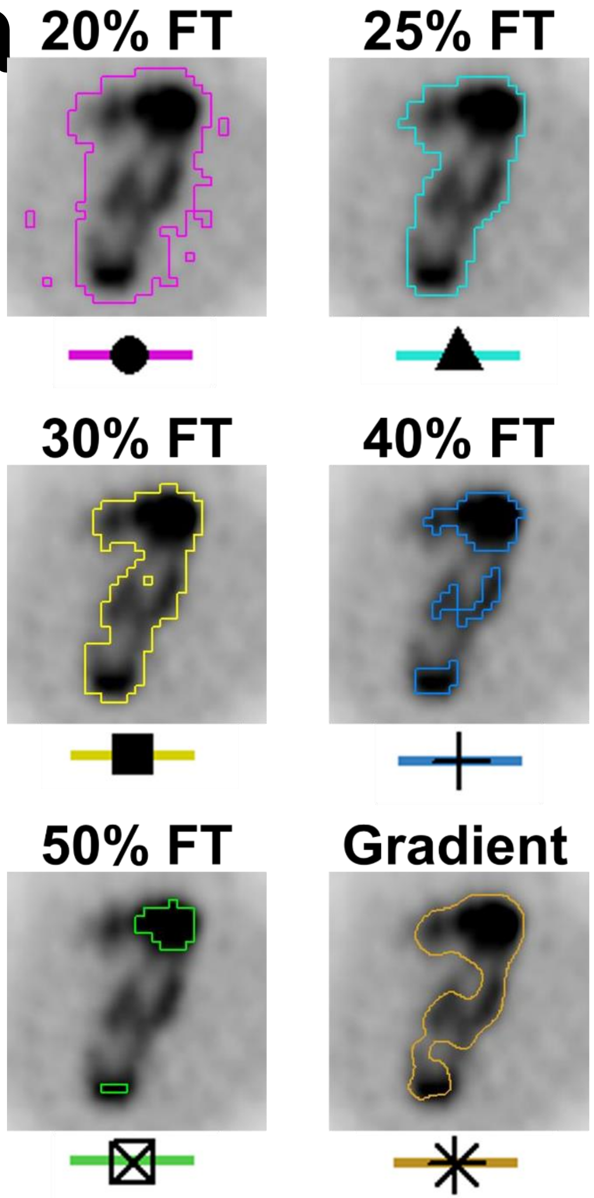
Quantitative Imaging Lymphoma

Negative-Cast Modelling for Oncology (NCMO)

Realistic Tumour Modelling for Nuclear Medicine

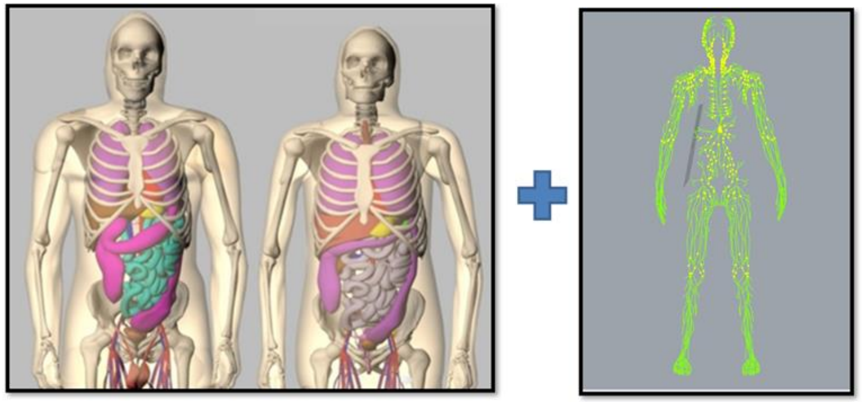
- NCMO used to simulate bulky, heterogeneous tumours based on example cases from lymphoma patients

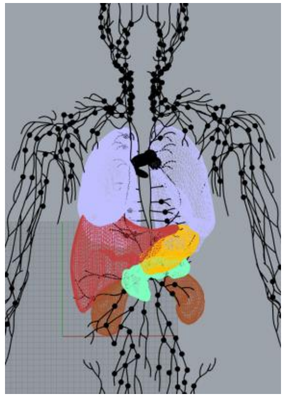




Roberto Fedrigo, Masters Student

Quantitative Imaging Lymphoma



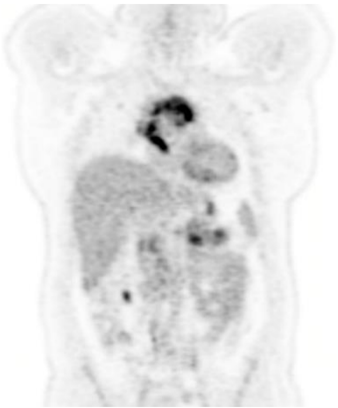


Development of the Lymphatic System in the 4D XCAT Phantom for Improved Multimodality Imaging Research

Roberto Fedrigo[1,2], Paul Segars[3], Patrick Martineau[4], Kerry J. Savage[4], Carlos Uribe[2,4], Arman Rahmim[1,2,4]
[1]BC Cancer Research Institute, [2]University of British Columbia, [3]Duke University, [4]BC Cancer

BC CANCER · QURIT Quantitative Radiomolecular Imaging & Therapy · UBC · Duke

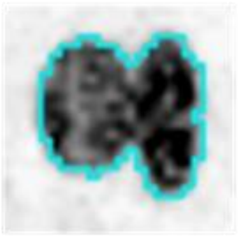
Patient | **XCAT Simulation**



Roberto Fedrigo, Masters Student

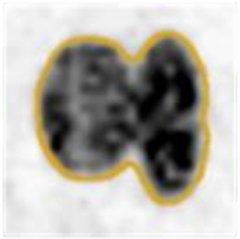
Best for Volume:

25% FT

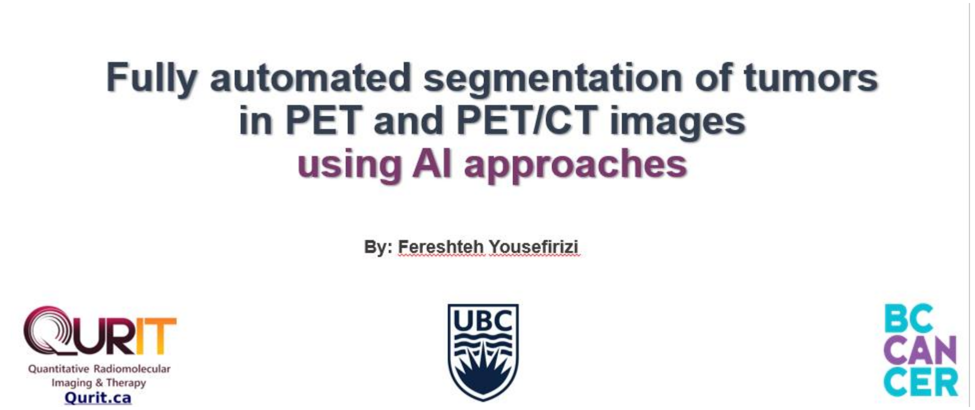


Best for Activity:

Gradient

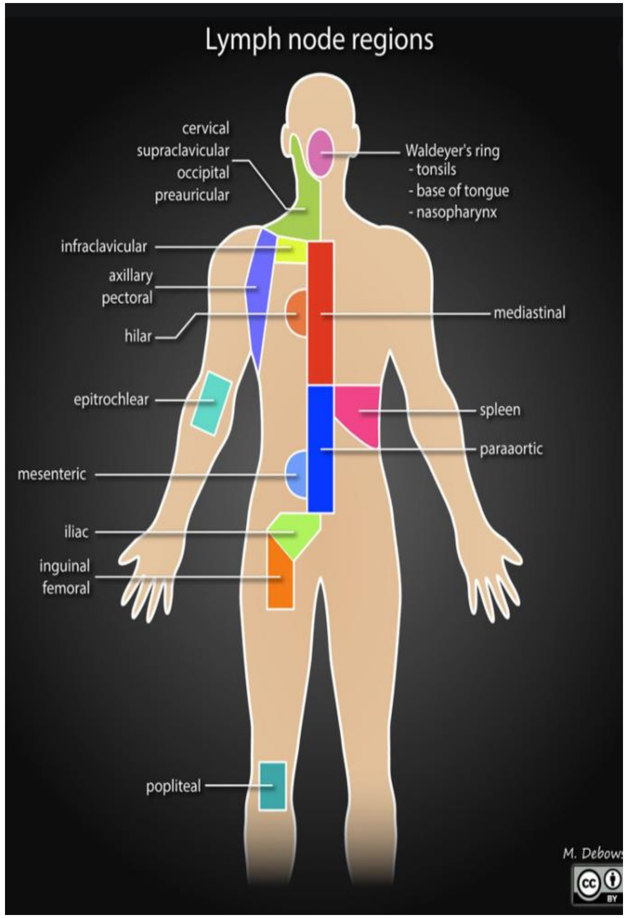


Segmentation Lymphoma



- Heterogeneous Presence:
  - lymphoma can be present in any of the over 500 lymph nodes
  - other lymphatic organs such as the bone marrow and spleen.
- Vast range of Treatments:
  - chemotherapy and radiation to newer immunotherapies

It is difficult to identify the patients who will not respond to therapy or the non responder patients



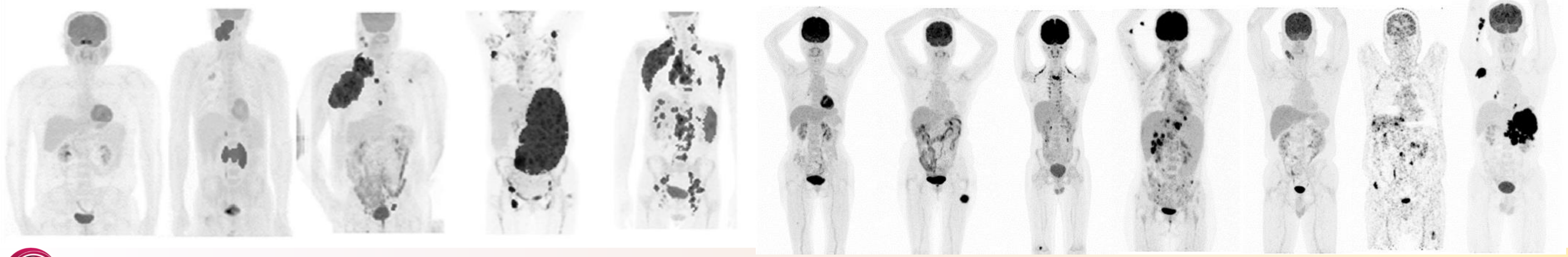
Segmentation Lymphoma

Fully automated segmentation of tumors in PET and PET/CT images using AI approaches

By: Fereshteh Yousefirizi

Quantitative Radiomolecular Imaging & Therapy
Qurit.ca

- Lymphoma lesion segmentation is a challenging task:
  - **Varied number, size, site and shape of lesions**
  - **Heterogeneity and different degrees of glucose metabolism**
  - **The high rate of false positive by normal organs (i.e. brain & bladder)**



Segmentation Lymphoma

Fully automated segmentation of tumors in PET and PET/CT images using AI approaches

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Quantitative Radiomolecular Imaging & Therapy
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- Convolutional neural network with a hybrid loss function for fully automated segmentation of lymphoma lesions in FDG PET images, SPIE2022

- A cascaded deep network for automated tumor detection and segmentation in clinical PET imaging of diffuse large B-cell lymphoma, SPIE2022.

- Automated segmentation of diffuse large B cell lymphoma (DLBCL) lesions in $[^{18}F]$FDG-PET/CT images using Transfer learning, PILM2021

Segmentation Lymphoma

Fully automated segmentation of tumors in PET and PET/CT images using AI approaches

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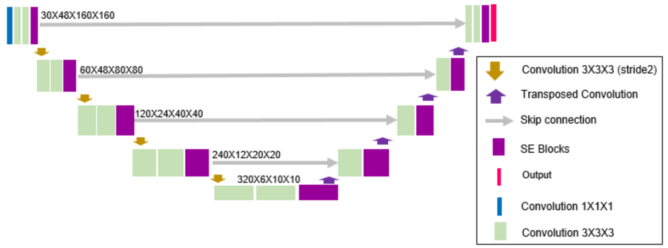

The **cross-entropy** loss and **Dice** loss or a combination of them are mainly used for semantic segmentation.

Three main **categories** of loss functions that have been used for **medical image segmentation**

Region-Based	Distribution-Based	Boundary-based
Dice	Cross entropy (Binary, Weighted, Balanced)	Mumford-Shah
Tversky	Focal	ACWE
Focal Tversky	Distance Map derived	HD
Sensitivity-Specificity		Shape-aware
Log-Cosh		
Matthews Correlation Coefficient		

$$Loss = L_{Distribution} + L_{Region} + L_{Boundray}$$

Segmentation Lymphoma

Fully automated segmentation of tumors in PET and PET/CT images using AI approaches

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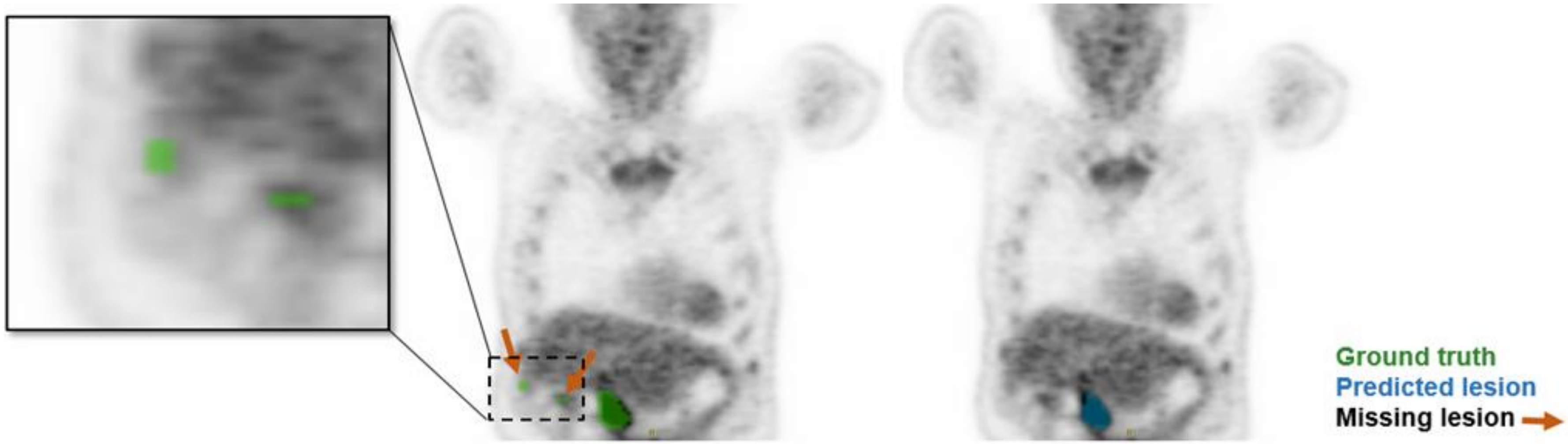
Loss function	Hyper-parameters	Dice	HD
Region	-	0.68 ± 0.21	24.6 ± 27.3
Distribution	α=0.25, γ=2	0.72 ± 0.24	28.7 ± 19.2
Region + Distribution	α=0.25, γ=2	0.75 ± 0.16	31.2 ± 21.9
Distribution + Region + Boundary	λ=0.5, δ=0.6, γ=0.5, $\beta=10^{-7}$	0.77 ± 0.08	16.5 ±12.5

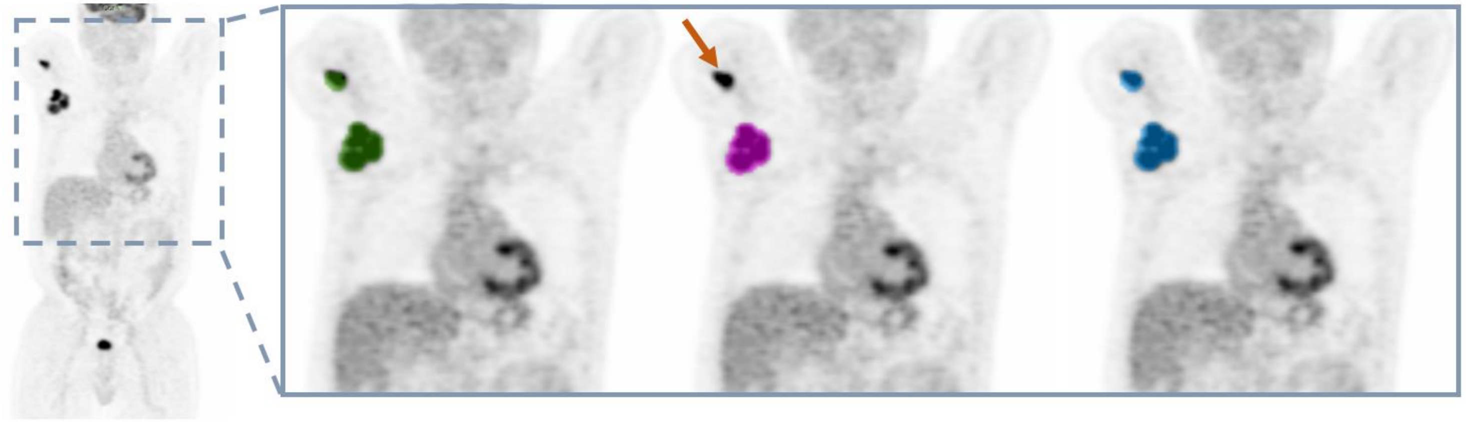


Segmentation Lymphoma

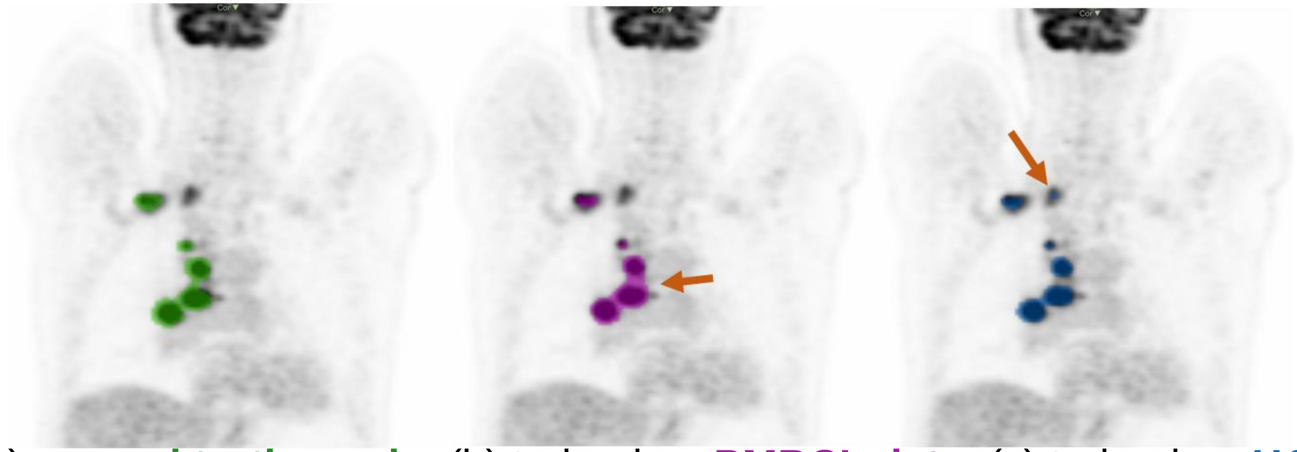
Fully automated segmentation of tumors in PET and PET/CT images using AI approaches

By: Fereshteh Yousefirizi

Approach1: Automated segmentation of diffuse large B cell lymphoma (DLBCL) lesions in [18F]FDG-PET/CT images using Transfer learning



(a) Original PET image **(b)** **ground truth mask** **(c)** trained on **PMBCL data** **(d)** trained on **H&N data**



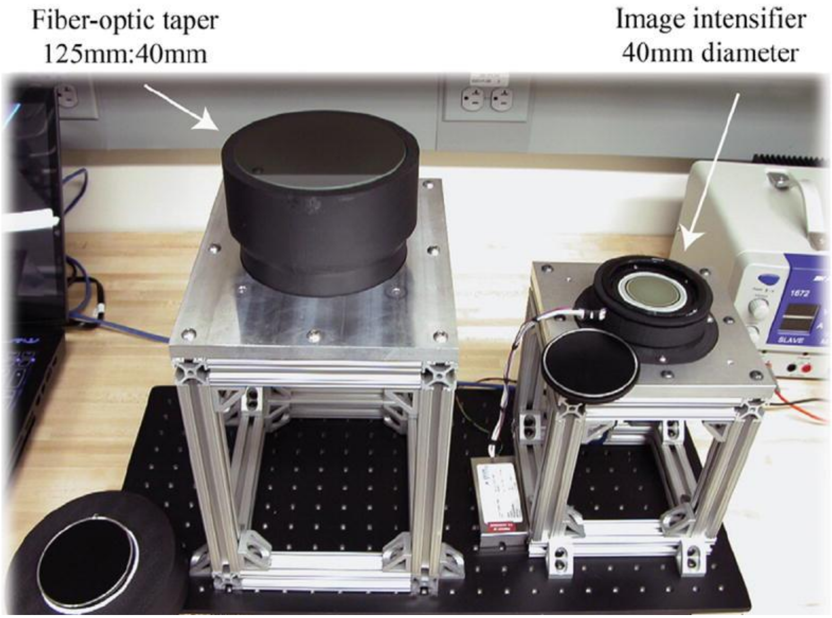
(a) **ground truth mask** (b) trained on **PMBCL data** (c) trained on **H&N data**

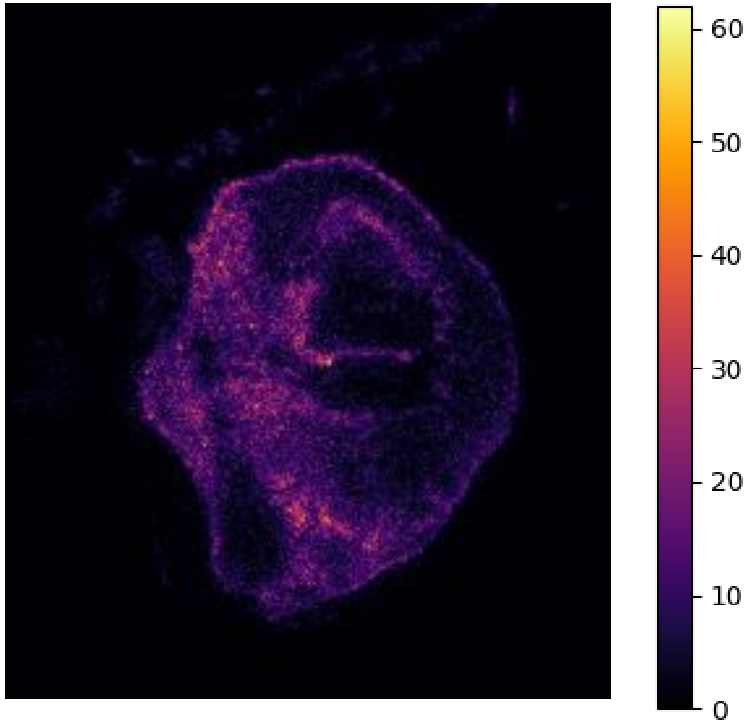
Model	DSC (mean ± std)
trained on H&N	0.71±0.14
trained on PMBCL	0.54±0.08

Multiscale Dosimetry

Quantitative Ex Vivo Imaging of ^{225}Ac with the iQID Alpha Camera

Cassandra Miller[1,2], Julie Rousseau[3], Jason Crawford[4], Brian Miller[5,6], François Bénard[3,8,9], Arman Rahmim[1,2,8], Carlos Uribe[7,9]





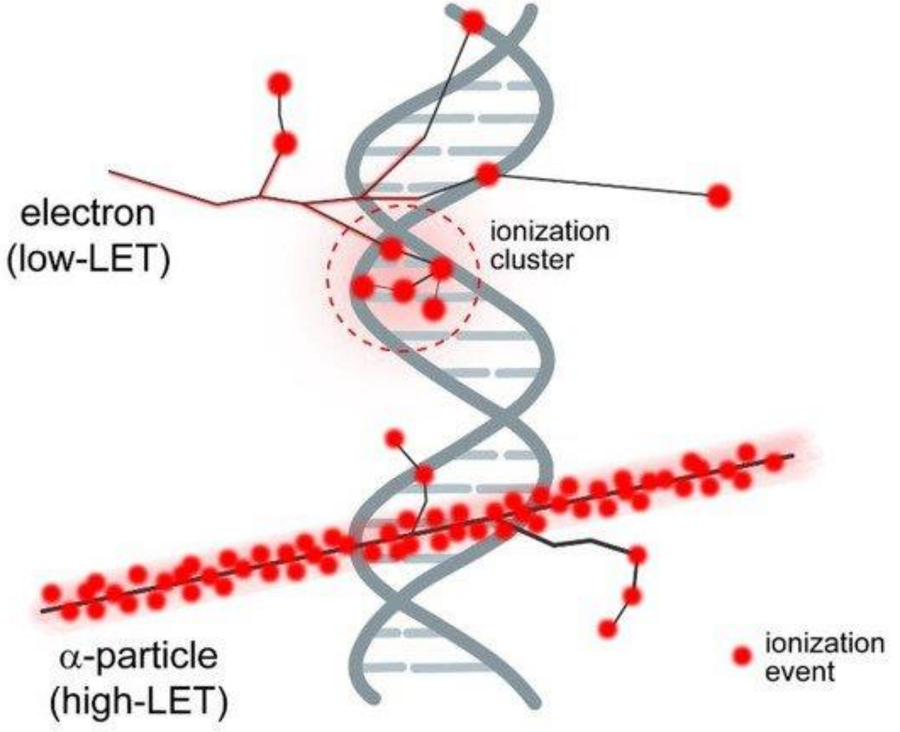
Intratumoural distribution of an ^{225}Ac labelled antibody in mouse tissue section

Multiscale Dosimetry

The Impact of Cell Shape on the Doses Delivered to the Nucleus from ^{177}Lu-labelled Radiotracers

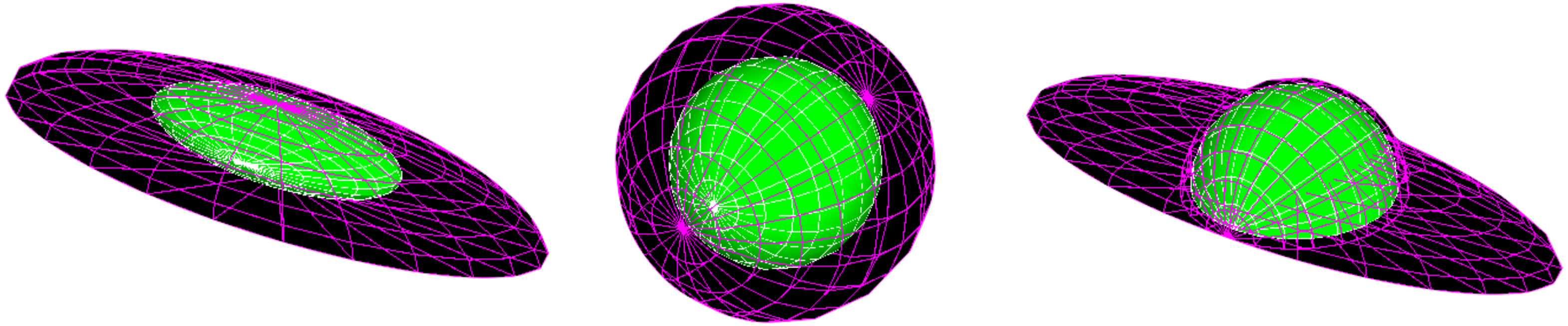
Cassandra Miller[1,2], Guillaume Chaussé[3], Julia Brosch-Lenz[1,4], François Bénard[3,5,6], Arman Rahmim[1,2,6], and Carlos Uribe[3,6]

[1]Department of Integrative Oncology, BC Cancer Research Institute, Vancouver, BC, Canada, [2]Department of Physics, University of British



Macroscopic dosimetry **omits** the physics & biology that occurs on the **microscopic** and **cellular** level

- There are microscopic variations in absorbed doses between radioisotopes and pharmaceuticals which may not be seen at the organ-level



Multiscale Dosimetry

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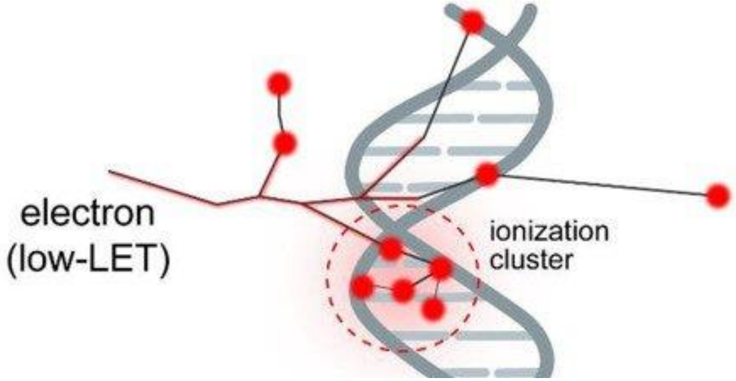

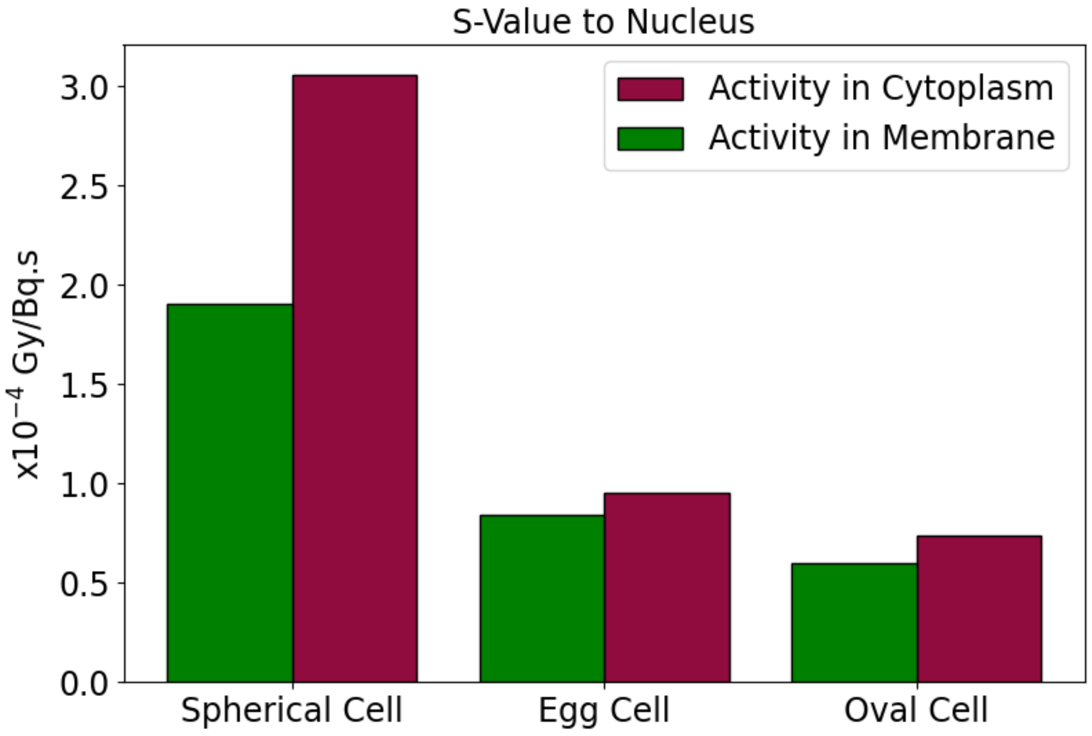

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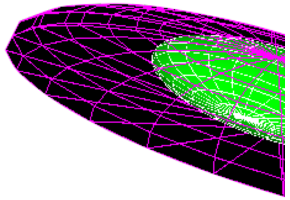
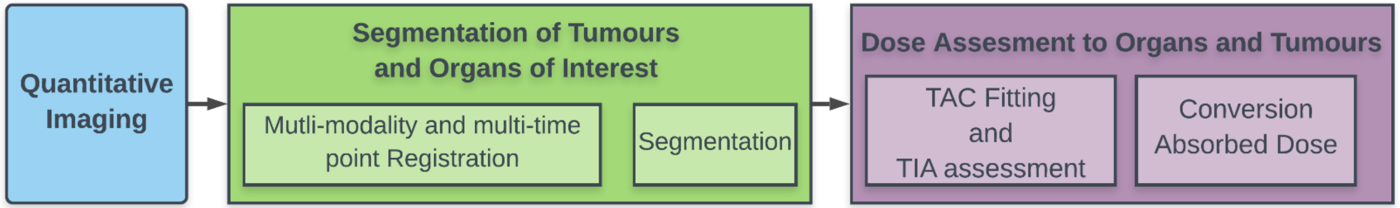
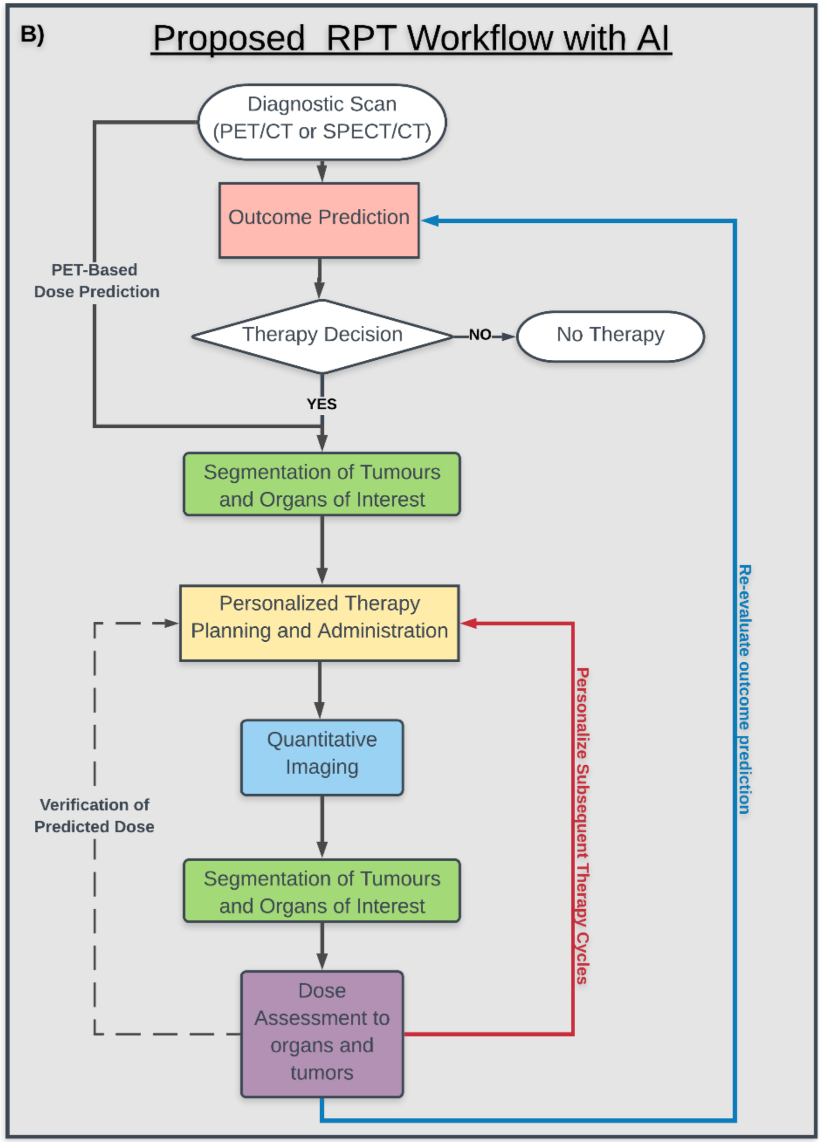


Conclusions and Acknowledgements

Conclusions



- Nuclear medicine detectors (i.e. PET and SPECT) allow us to gather information of
- Quantitative imaging is needed for accurate dosimetry and outcome prediction
- AI is a powerful tool that can help us with the different steps of the dosimetry workflow to make personalized dose assessments routine in clinical practice



Acknowledgements

BC CANCER

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NSERC
CRSNG

SNMMI
SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

Thank you!

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