ComProj
System matrix evaluation for Compton imaging system

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Hello !

Hello, my name is Mehdi

2nd year PhD student in

SiMS team (LS2N/ECN)

Nuclear Oncology team (CRCI^{2}NA/CHU de Nantes).

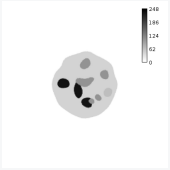
My PhD thesis

The main goal of my PhD is to combine

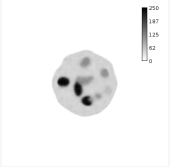
- PET imaging (cf. BIOSIM with Thomas Carlier);

$\Rightarrow$ Compton imaging (cf. Next slide)

to obtain **images** of radioactivity distribution through **photon detections**.



Emissions



Reconstruction

Credit: Y.Moussaoui

Compton imaging ...

... based on Compton scattering/effect

Compton effect is the **scattering** of photon after an interaction with an electron. It results in an **energy deposit**.

A bit of math

Let M be a decay source and assume that the photon will interact at **least twice** (CS, then CS or PE):

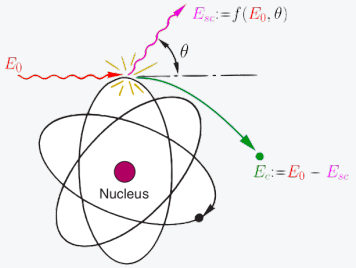
$$\textbf{Apex: } V_1;$$
$$\textbf{Axis: } \Delta = \overrightarrow{V_2V_1};$$
$$\textbf{Angle: } \theta = \arccos\left(1 - \frac{m_e c^2 E_1}{E_0(E_0 - E_1)}\right).$$

Property of Compton kinematic:

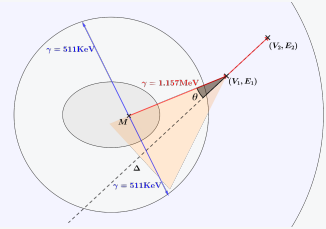
M lies on the **Cone of Response** (COR).

Compton Tomographic reconstruction:

By combining all the detected CORs, reconstruct an image of the radioactive distribution e.g. using ML based algorithms.



Compton Scattering - Adapted from: Cherry et al. [2012]



Problem formulation:

Direct model:

$$\boldsymbol{y}_n \sim \mathcal{P}(\bar{\boldsymbol{\lambda}}) \text{ with } \bar{\boldsymbol{\lambda}} := \sum_{j=1}^{J} A_j\left(\boldsymbol{y}_n\right) \lambda_j + \varepsilon_n$$

where:

- $\boldsymbol{y}_n$ is a measurement vector e.g. interaction coordinates, energy deposits, ...
- $\boldsymbol{\lambda} = (\lambda_j)_j$ is the radioactive distribution discretized in J voxel;
- ε_n is a hint of noise;
- $A_j\left(\boldsymbol{y}_n\right)$ is the system matrix i.e. the **probability** that an photon emission **occurring in voxel** j will be detected as a COR obtained with the **measurement vector** $\boldsymbol{y}_n$.

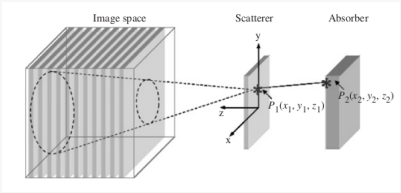
How to estimate $A_j\left(\boldsymbol{y}_n\right)$??

From literature ...

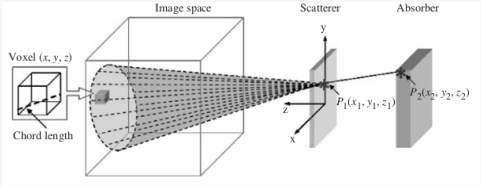
Two main approaches for $A_j\left(\boldsymbol{y}_n^k\right)$ estimation

COR based approach to evaluate the system matrix:

Ellipse-stacking method Wilderman et al. [1998]



Ray-tracing method Kim et al. [2007]



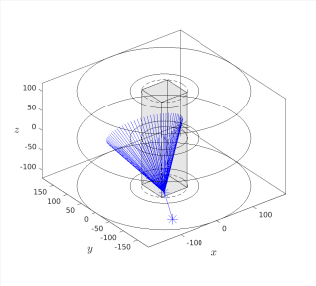
ESM method exploits the intersection of a COR with a plane, i.e. an ellipse;

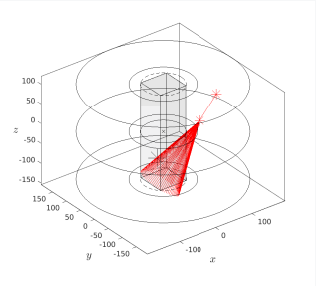
RTM method uses COR generatrix and a ray-tracing algorithm e.g. Siddon [1985].

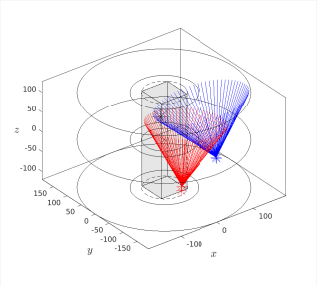
Aim of this Research Methodology project

To investigate existing methods to evaluate the intersection of a COR and voxels (in particular a multi-Siddon approach) and **...**

From literature to direct application







... the implementation of studied methods in POLLUX & ARIANE (), simulators of particle/matter interaction that we're developing (MATLAB) and based on computer graphics methods.

Thank you for your attention

Questions?

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Slides available on my website: mlatif.fr

ComProj: #Nuclear Oncology, #Inverse problem, #Computer graphics, ...

References i

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