

# Dosimetric impact of respiratory motion compensation in radioembolization

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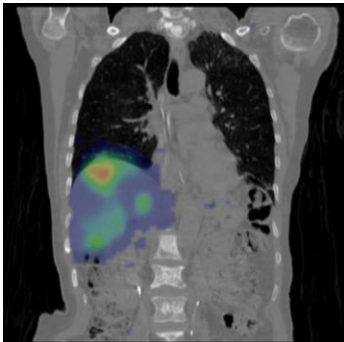
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# Radioembolization

## Pre-treatment

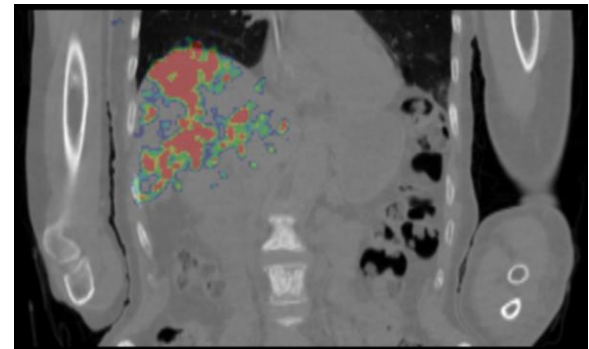
- Treatment planning
- $^{99m}\text{Tc}$ -MAA injection
- SPECT/CT acquisitions of gamma photons (140 keV)
- $^{99m}\text{Tc}$ -MAA biodistribution is a prediction of  $^{90}\text{Y}$  microspheres biodistribution



**Optimisation of the treatment  
for each patient**

## Post-treatment

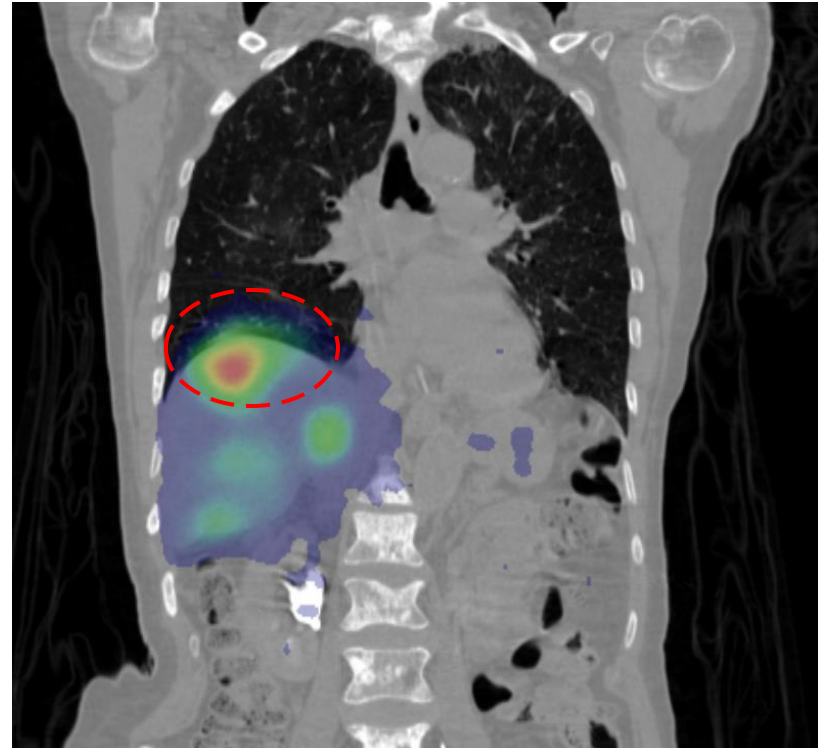
- Verification of treatment
- Injection of  $^{90}\text{Y}$  microspheres
- PET/CT acquisition



# SPECT/CT acquisition

- Approximately 15 minutes of acquisition time
- Liver movements related to respiratory movements
- Artifact ("blur") in tomographic reconstruction

**What is the dosimetric impact of respiratory movement?**



# Respiratory movement correction

**Several methods can be used:**

- External device [Beach and al., IEEE NSS, 2005]
- Fluoroscopic images in addition to nuclear images [Dietze and al., Physics in Medicine and Biology, 2021]
- **Data-driven approaches** [Sanders and al., IEEE Transactions on Medical Imaging, 2016 ; **Robert and al.**, IEEE Transactions on Radiation and Plasma Medical Sciences, 2021]

**Correction applied mainly for myocardial perfusion** [Kortelainen and al., Annals of Nuclear Medicine, 2019 ; Kovalski and al., Journal of Nuclear Medicine, 2007]

The dosimetric impact of respiratory movement was assessed **only on phantoms not on real data** [Bastiaannet and al., Medical Physics, 2017]

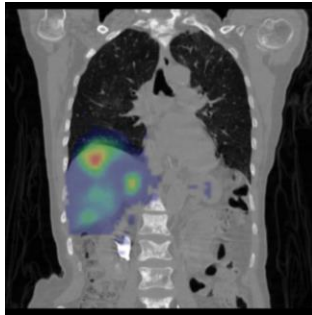
This evaluation was performed **only on post-processing PET imaging** [Osborne and al., Nuclear Medicine Communications, 2018]

# Reconstruction algorithms

Three SPECT reconstruction algorithms:

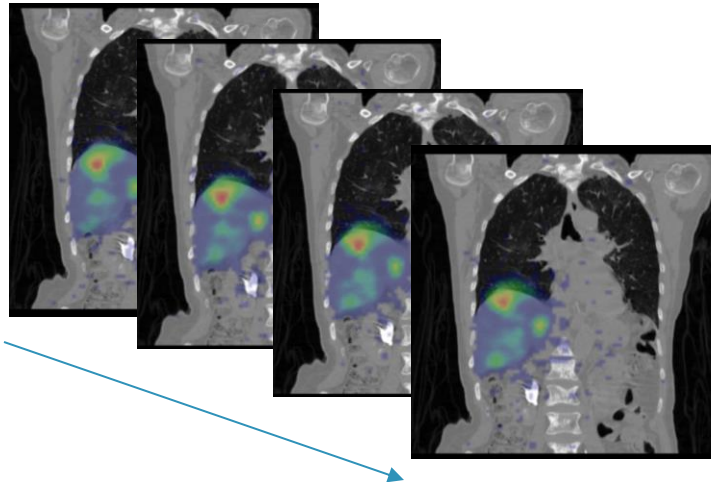
## 3D Reconstruction

[Robert and al., IEEE Transactions on Radiation and Plasma Medical Sciences, 2021]



## 4D Reconstruction

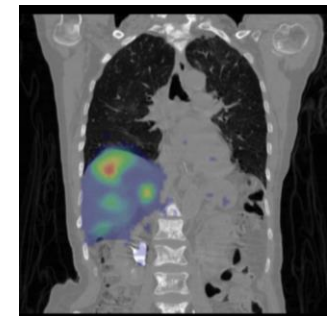
[Robert and al., IEEE Transactions on Radiation and Plasma Medical Sciences, 2021]



8 phases (1 reconstruction / phase)

## 3D motion compensated Reconstruction

[Robert and al., Fully 3D Image Reconstruction, 2021]



Compensation on one of the phases

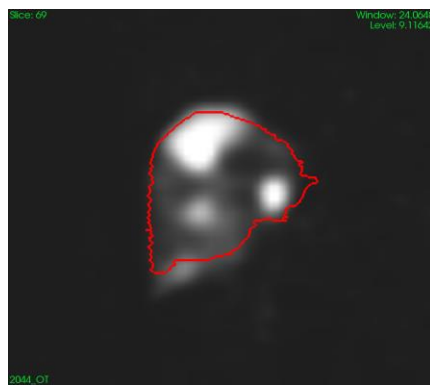
# Motion amplitude

## Limitation:

- No 4D CT available (attenuation correction)

## Methodology:

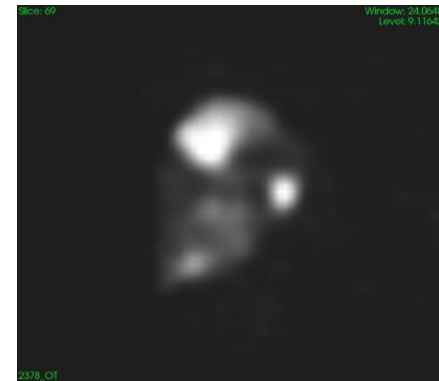
Registration of 3D compensated reconstructions on the extreme phases



**Phase 0  
compensated**



Local rigid  
registration



**Phase 4  
compensated**

# Patient data

**31 treatments** received by **29 patients**  
(14 women and 15 men)

## Pathologies

- Hepatocellular carcinoma (HCC): **10/29**
- Cholangiocarcinoma: **3/29**
- Metastasis of colorectal cancers: **3/29**
- Metastasis of breast cancer: **7/29**
- Other: **6/29**

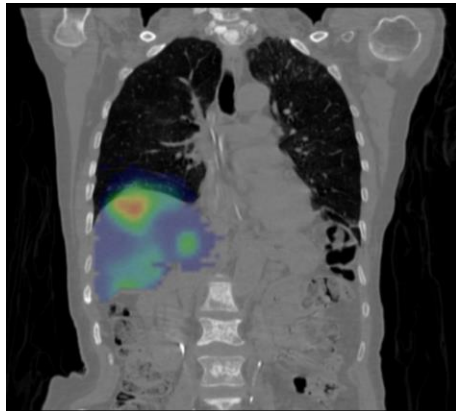
## Microspheres

- SIR-Sphères®: **11/29**
- ThéraSphères®: **18/29**

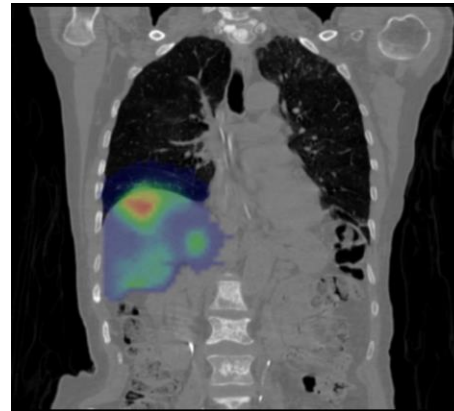
# Volumes of interest

- Contours of **liver, lungs and lesions** on CT
- **Perfused Liver** = intersection between the liver and 5% of maximum SPECT
- For other contours, use of Boolean operations:
  - **Healthy Liver** = Liver - Lesions
  - **Healthy Perfused Liver** = Perfused Liver - Lesions
  - **Hepatic reserve** = Liver - Perfused Liver - Lesions

# Dosimetry



**Monte Carlo  
simulation:  
1 MBq of  $^{90}\text{Y}$   
during 1s**



**Dose rate map (Gy/s)**

**Scaling to actual  
injected activity**

**Volume-wide average  
dose rate**

**Integration taking into account  
only the radioactive decay  
= Dose**

**SPECT normalisation of  
activity to that present in  
the liver and lungs =  
distribution**

# Lung Shunt Fraction (LSF) and TN ratio

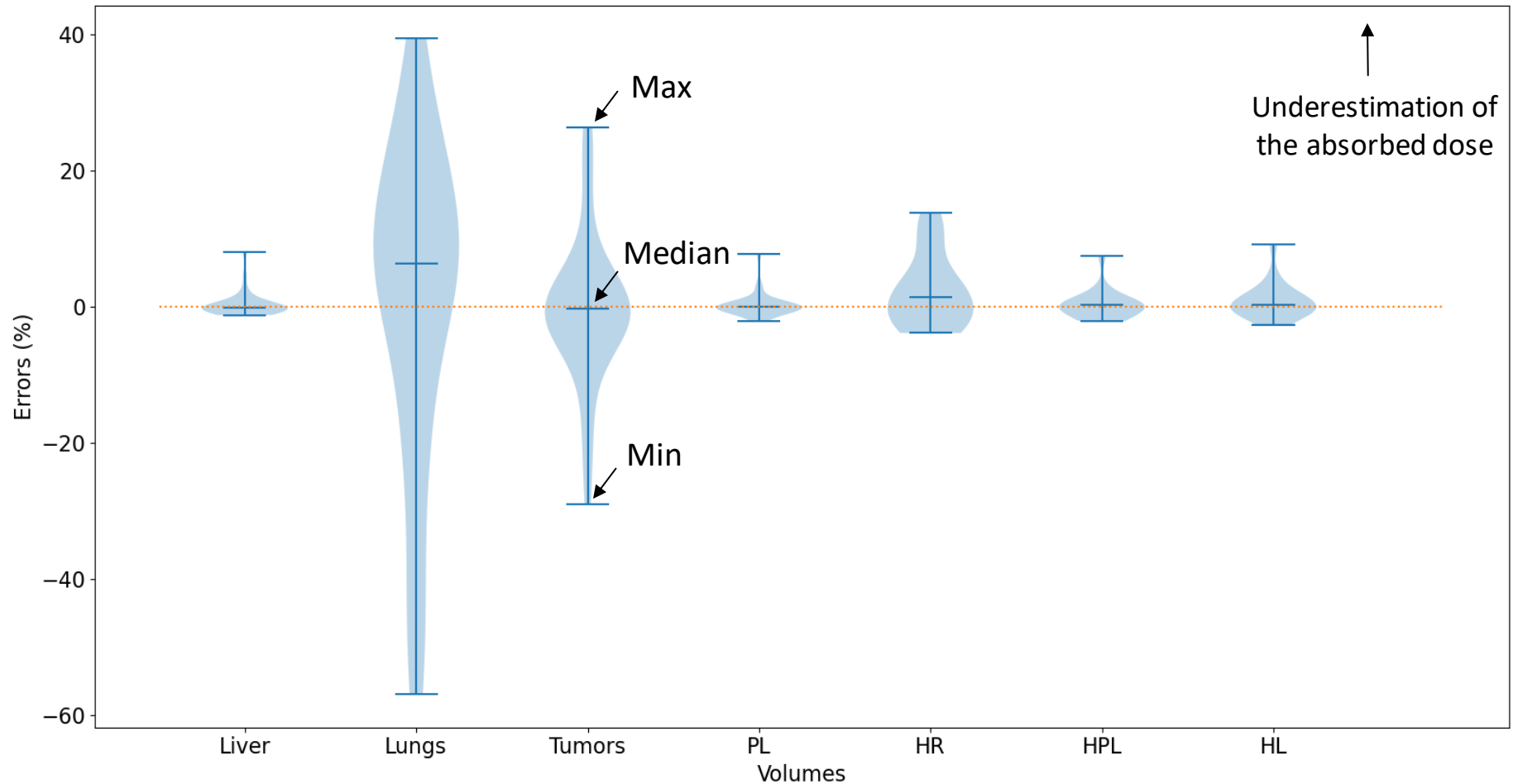
LSF formula [Levillain et al., European Journal of Nuclear Medicine and Molecular Imaging, 2021]:

$$LSF[\%] = \frac{C_{Lungs}}{C_{Lungs} + C_{Liver}} \times 100$$

TN formula [Levillain et al., European Journal of Nuclear Medicine and Molecular Imaging, 2021]:

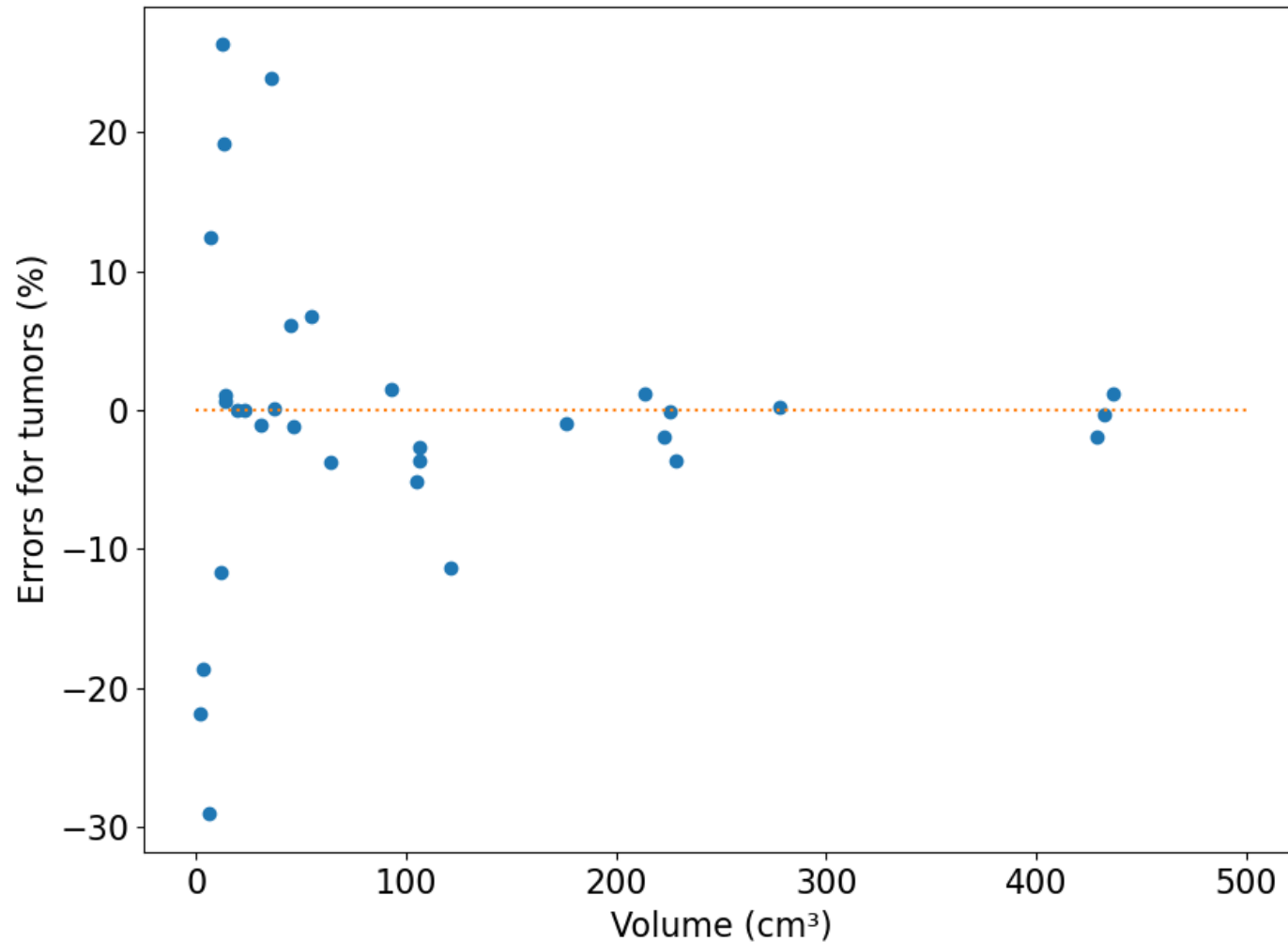
$$TN = \frac{C_{Tumor}/V_{Tumor}}{C_{HealthyLiver}/V_{HealthyLiver}}$$

# Absorbed dose differences



PL: Perfused Liver, HR: Hepatic Reserve, HPL: Healthy Perfused Liver, HL: Healthy Liver

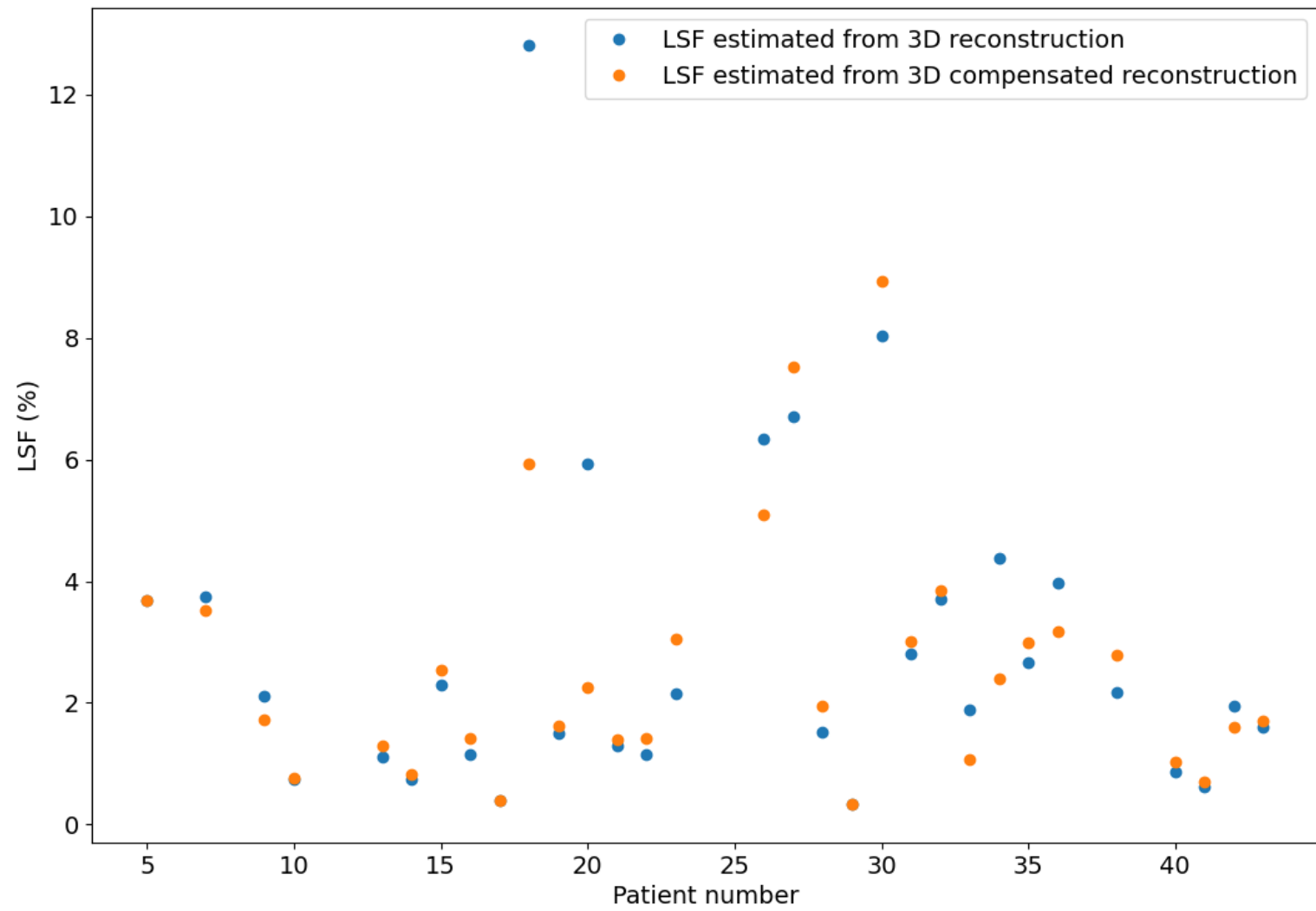
# Dose differences and volumes



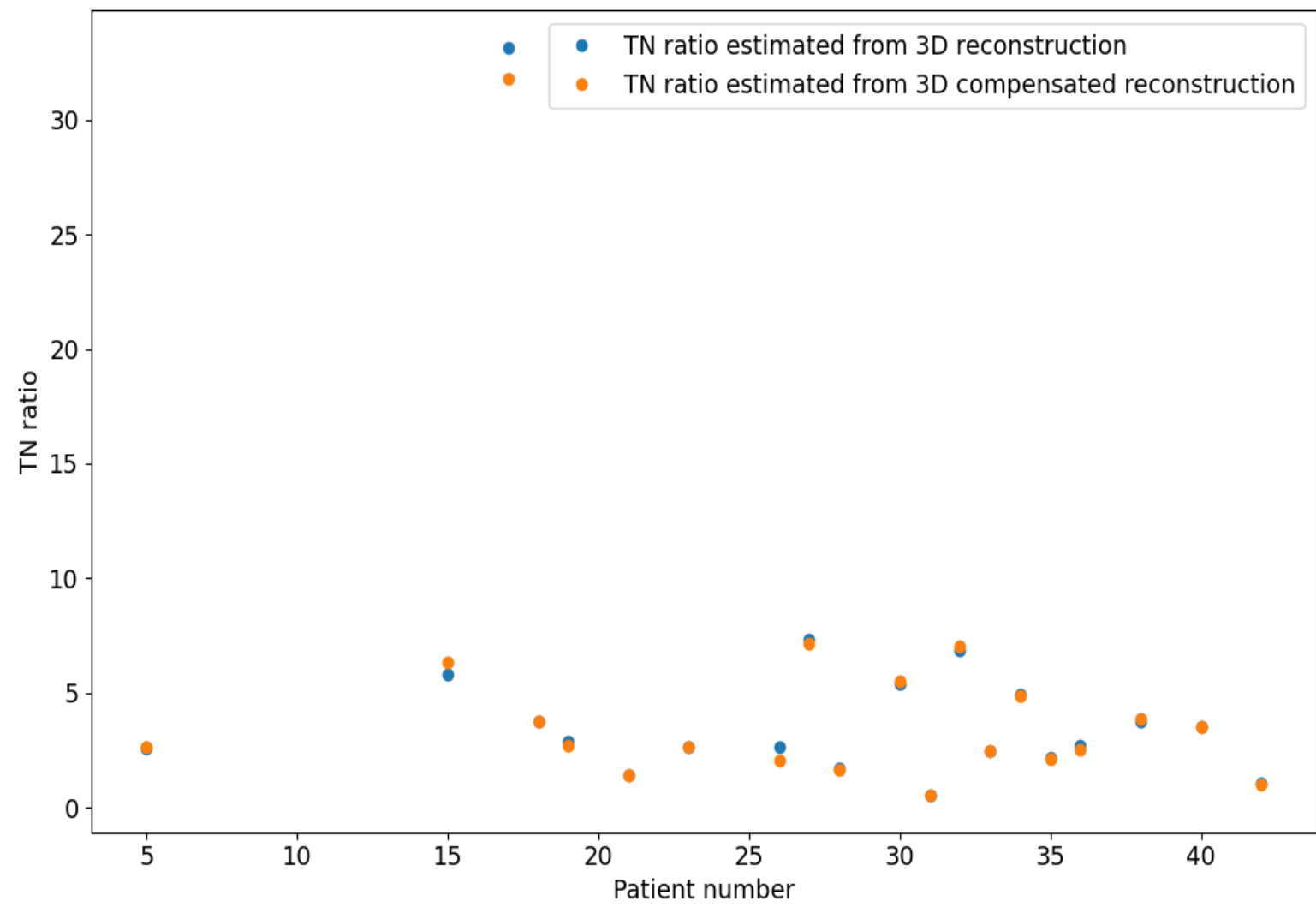
Volume < 122mL  
High variability of errors

Volume > 122 mL  
PDD close to 0

# LSF



# TN ratio



# Conclusion and perspectives

- 3D vs 3D compensated: no significant absorbed dose systematic differences
- However, for some tumors, differences can be important ( $> 10\%$ )
- For lesions with a volume  $< 122$  mL

## Perspectives:

- How to detect when motion correction is needed?
- Does correction of respiratory movement have an impact on  $^{90}\text{Y}$  prescription?

# Acknowledgements

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