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## MOBILE COMPTON CAMERA BASED ON TIMEPIX3 TECHNOLOGY FOR MONITORING THYROID GLAND CANCER TREATMENT

Imaging the Unseen













## THE CURRENT STATUS AND ITS DIFFICULTIES



## DIFFICULTIES

- **Therapeutic** dose the high-intensity of radiation (saturation).
  - Imaging decrease of activity in the body.
- Low spatial resolution small remnants.
- Non-personalized dose 3 or 7 GBq.





- Imaging of high therapeutic activities of the radiopharmaceutical in the target volume for treatment verification.
- Ability to detect high photon fluxes.
- High spatial resolution imaging that cannot be achieved with current generation gamma cameras that use a collimator.
- Reduction of applied diagnostic activities due to high detection efficiency.
- Reduction of data acquisition time due to high detection efficiency.
- Combination of planar and tomographic scanning (2D and SPECT).
- Mobile camera concept.

GOAL

Development of the mobile robotic gamma camera of new generation for thyroid gland imaging by the nuclear medicine methods.



- HW and SW for the system control, data colection, reconstruction, and analysis.
- Colaborative robotic arm

**Detection unit** – configuration of two hybrid pixel detectors working in Compton camera mode.

Colaborative robotic arm





**Double-layer Compton camera** configuration





### Imaging configuration

- Gamma camera imaging using collimators
  - (low energy, local diagnostics) TPX3.
- Compton camera imaging
  - (high energy, single or double layer) TPX3.

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Gamma camera module



#### Gamma camera unit

- Small gamma camera close to the patient body (robotic arm).
- Suitable for the examination where current cameras are not usable.
- Low energy, low weight.
- MiniPIX TPX3 flex version (1mmCdTe).
- Pinhole collimator and sensor config. low efficiency → long measurement.
- Multipinhole colimator SW tools for reconstruction.







## **COMPTON CAMERA UNIT**

## Principle

- SPECT method without the use of a collimator → higher detection efficiency
- Principle: Utilization of Compt. scattering in the first detector layer (second absorption layer) → information about time and energy → the original direction of the photon can be reconstructed → source localization

Imaging module with the laser



Double-layer Compton camera

Why we choose the double layer Compton camera?

- Lower detection efficiency angle, thickness, material.
- Better spatial resolution → energy resolution.
- Regulation of the data flux.
- Easier data reconstruction.
- Non random coincidental events.

AdvaPIX TPX3 Quad Flex

parameters

Quad Electronics – Two modules fully synchronized

Compton camera unit and its

- Max hit rate: 10 Mhits/S
- Detectors configuration:
  - First layer: 1 mm Si
  - Second layer: 1 mm CdTe ~\*

## COMPARISON OF IMAGING PROPERTIES OF SLCC AND DLCC





## **RESULTS – RECONSTRUCTION METHODS SIMULATION**

- IMAGING based on the reconstruction → development and optimization
- Optimization of the reconstruction
  - Simple back projection projection of the cones into the space
  - LM-MLEM iterative reconstruction, easier implementation, more accurate





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- <sup>131</sup>I in the form of 3 balls 1mm, 1mm and 2mm
- Scanning parameters: 360°, 72 projections
- 1200 coinc. events
- Reconstruction volume is 50x50x50mm
- No postprocessing (filter, gamma correction etc.).
- Reconstruction duration
  - 13,1 s Back projection
  - 43,6 s LM-MLEM





## **MEASUREMENTS WITH <sup>131</sup>I**

## Liquid <sup>131</sup>I and iodine capsules.

- 2 capilars of inner diameter 5mm.
- Liquid iodine.
- Filled to high 20 mm.
- Distance between capilars was 23 mm.
- Measurement at different angles.
- Fixed distance of Com.Cam was 25 mm from the center of sample.
- Scanning parameters: 360°, 72 projections, 60 s
  one projection.
- Activity: 35 MBq.







The energy intervals marked with light color correspond to the emerging Compton products. The intervals marked with a darker color represent the energy applied during the reconstruction





## **MEASUREMENTS WITH 131**

#### Department of Nuclear Medicine and Endocrinology at Motol Faculty of Medicine

#### CUTS

### Liquid <sup>131</sup>I and iodine capsules.

- 4 capsules of different aktivity 2x 25 MBq, 1x 10 MBq, 1x 7.5 MBq.
- Glued to plastic cylinders to cover the real scanning volume.
- Dimensions: Inner cylinder: 50mm, External cylinder: 90 mm.
- **Duration of the acqusition**: 100 s 360 dg po 5 st.
- Reconstruced volume: 10x10X10 cm.





#### PROJECTIONS

x (mm

-21

100



40 20 0 -20 z (mm)



3D visualization using gamma correction and thresholding.

# **RESULTS – RECONSTRUCTION METHODS EXPERIMENT**

- Anthropomorphic phantom ELVIS with inserts.
- Insert with cylindrical focus.
- <sup>133</sup>Ba.
- One projection processed one measuring position.







Evaluation of performer test – Elvis with remnants simulated insert.

ICES

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- Clinical tests on patients.
- Comparative tests with the current modalities.
- Certification of the ThyroPIX as a medical device.
- AdvaPIX TPX4 evaluation Timepix3 replacement. 485 MED/C
- Optimization of reconstruction time.

