

GATE simulated phantom studies on Positrono's NeuroLF, Siemens' Biograph Vision and Quadra

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Outline

- Motivation
- Methodology
 - Simulated PET Scanners: NeuroLF, Biograph Vision, Vision Quadra
 - Reconstruction software:
 - e7Tools (Siemens)
 - STIR (open-source)
- Results
 - Hoffman phantom NeuroLF vs Vision (STIR)
 - ^{89}Zr NEMA IQ phantom Vision vs Quadra (e7)
 - Tübingen group (Quantification, XCAT)
- Conclusions

Motivation

- Use GATE to support our PhD research questions related to
 - 1) Dual Tracer (Zekai)
 - 2) Zirconium (Philipp)
 - 3) Dedicated Brain PET imaging (Viet)
- Simulate F-18 and Zr-89 to investigate dual tracer methodology
- Investigate 909 gamma of Zr-89
- Motion correction for BrainPET
- Set up a simulation and reconstruction pipeline
- Now: NEMA IQ, Hoffman. Later: XCAT, patient data

Simulated scanners

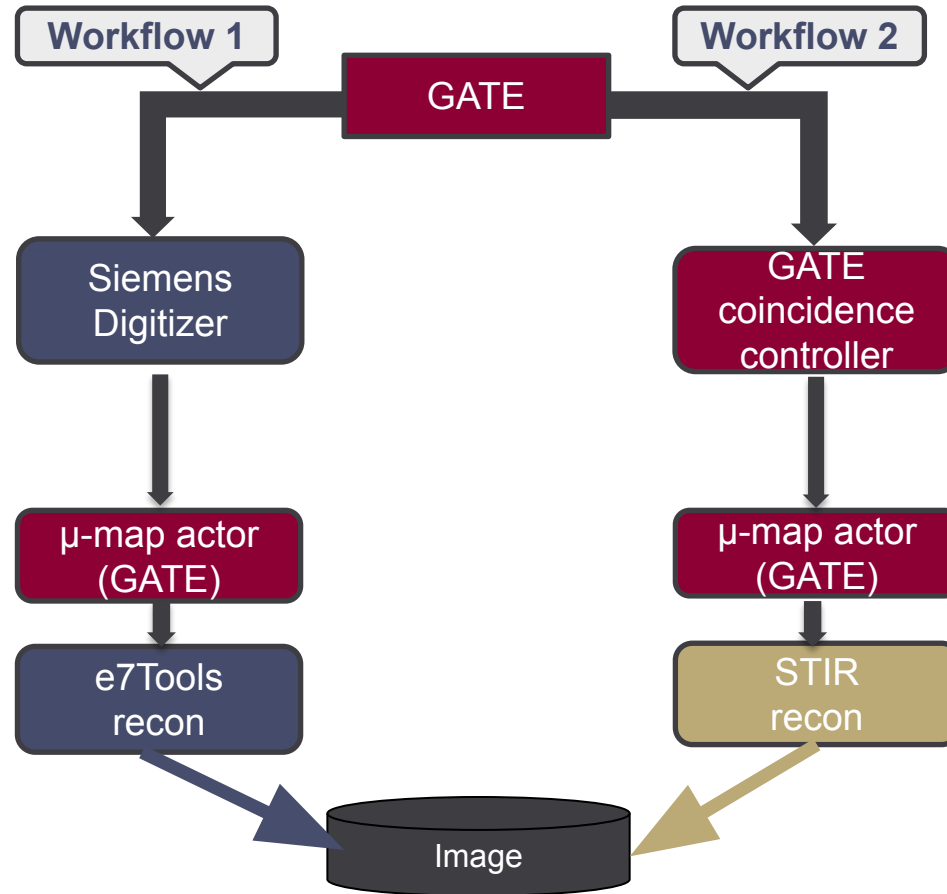


	Vision	Quadra	NeuroLF
diameter (cm)	78	78	26.5
aFOV (cm)	26.3	106.5	15.0
number of crystals (rings x crystals)	60800 80 x 760	245480 323 x 760	12288 48 x 256

Vision and Quadra simulated using Gate 9.0 and Gate 9.2, respectively
 NeuroLF simulated with Gate 9.2

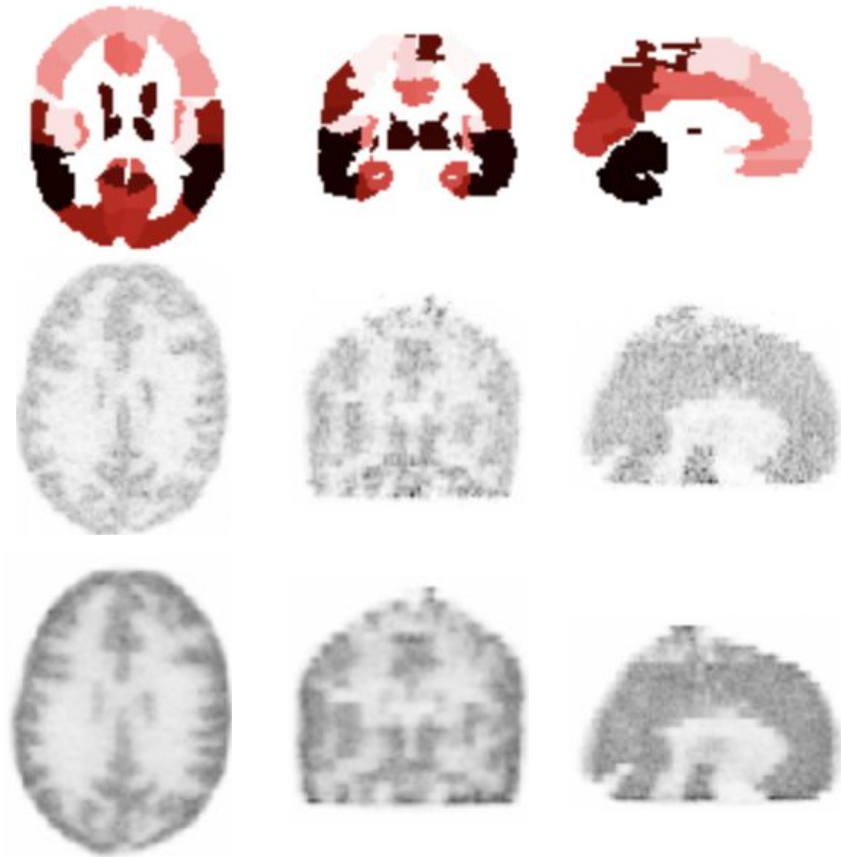
From .root to image

- e7 simulation:
 - lower energy threshold of 60 keV
 - save singles for input to e7tools offline digitizer
- e7 recon:
 - PSFTOF 4i5s
 - all corrections (attenuation, scatter, normalization, random)

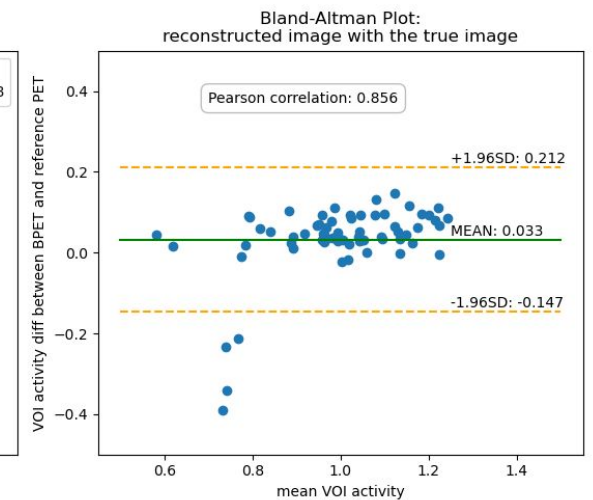
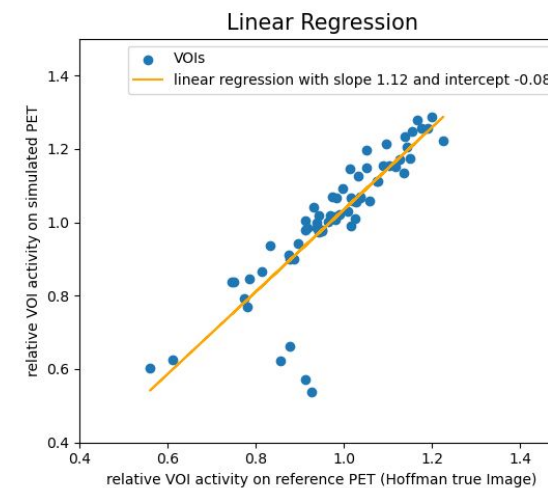
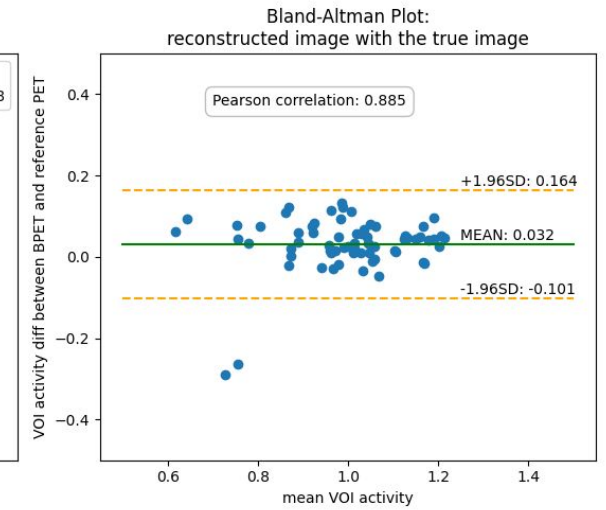
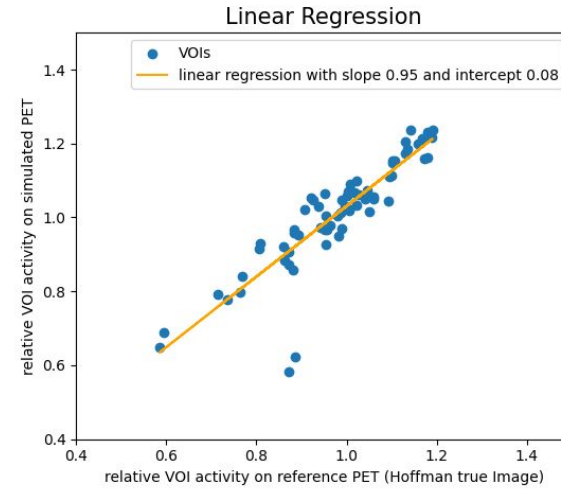


- STIR simulation:
 - normal energy window of 435 to 585 keV
 - save Coincidences, using GATE coincidence sorter
- STIR recon:
 - True coincidences
 - no TOF (yet!)

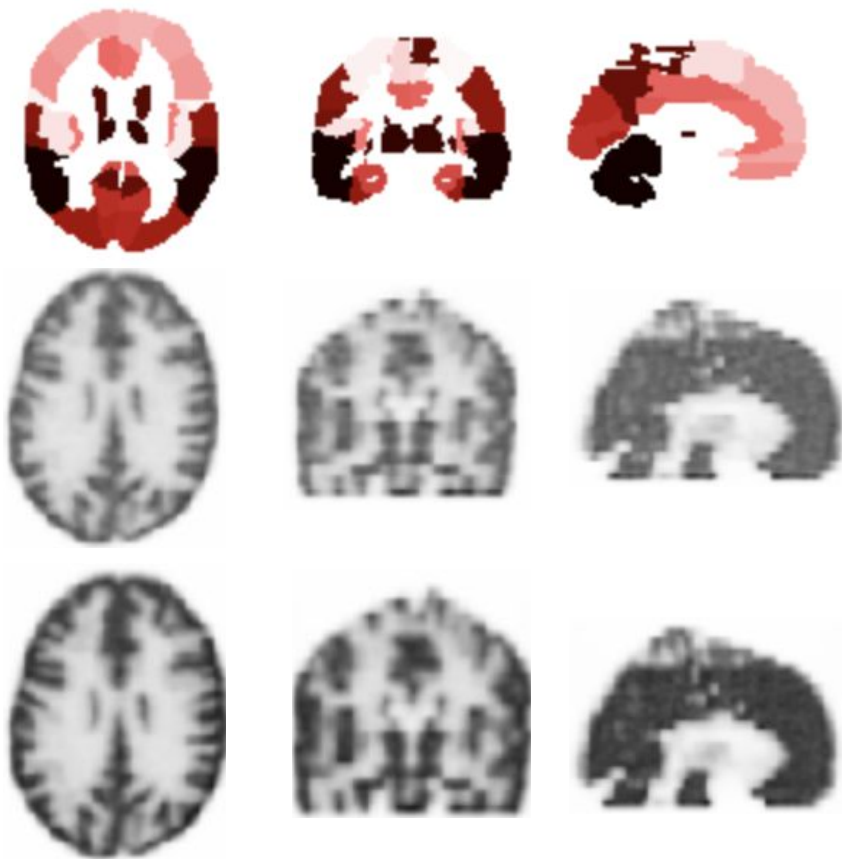
Results: Hoffman phantom NeuroLF vs Vision (STIR nonTOF)



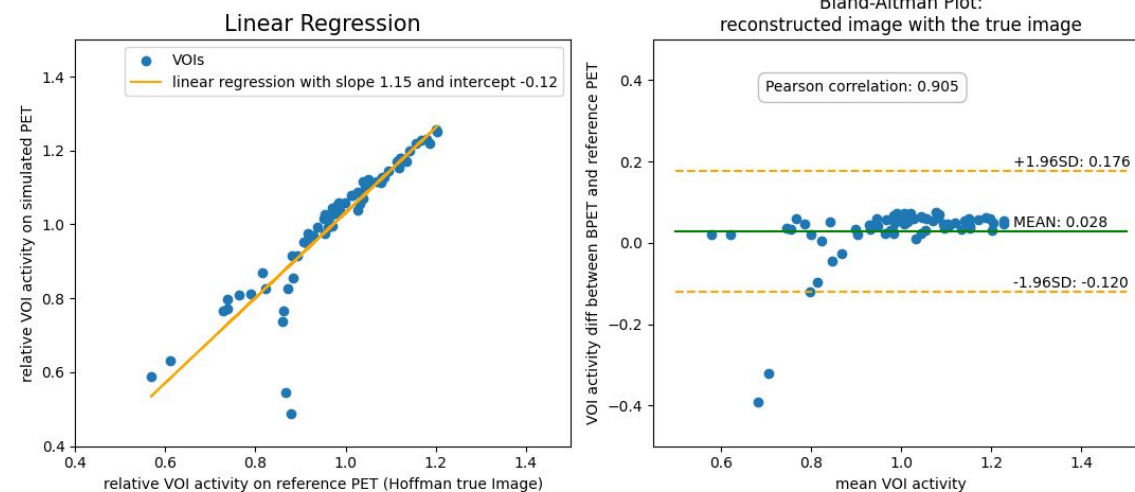
NeuroLF



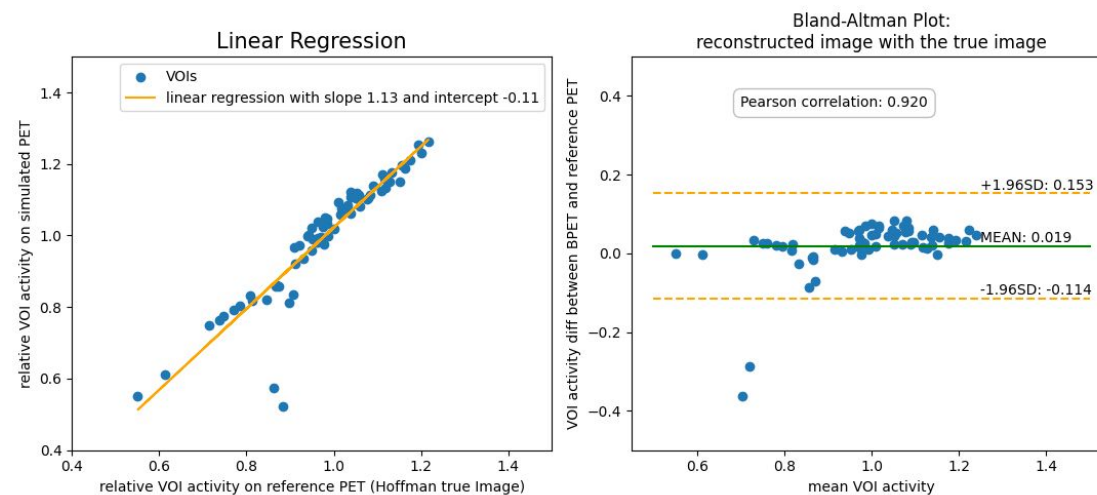
Results: Hoffman phantom Vision vs Quadra (e7)



Vision



Quadra

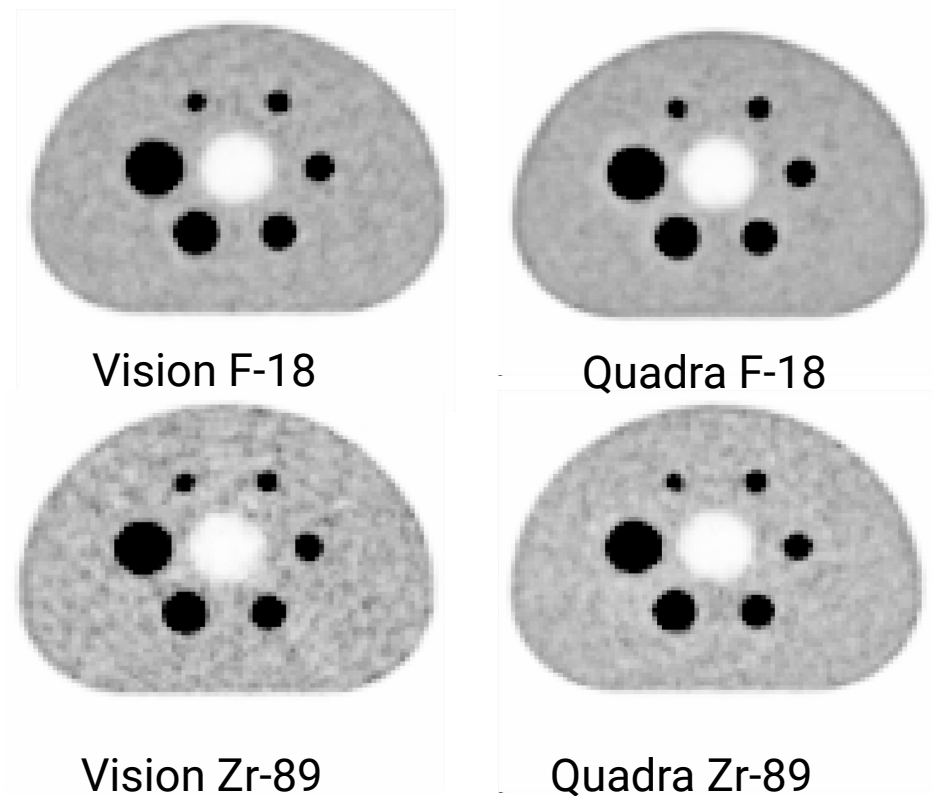


NEMA IQ simulation statistics

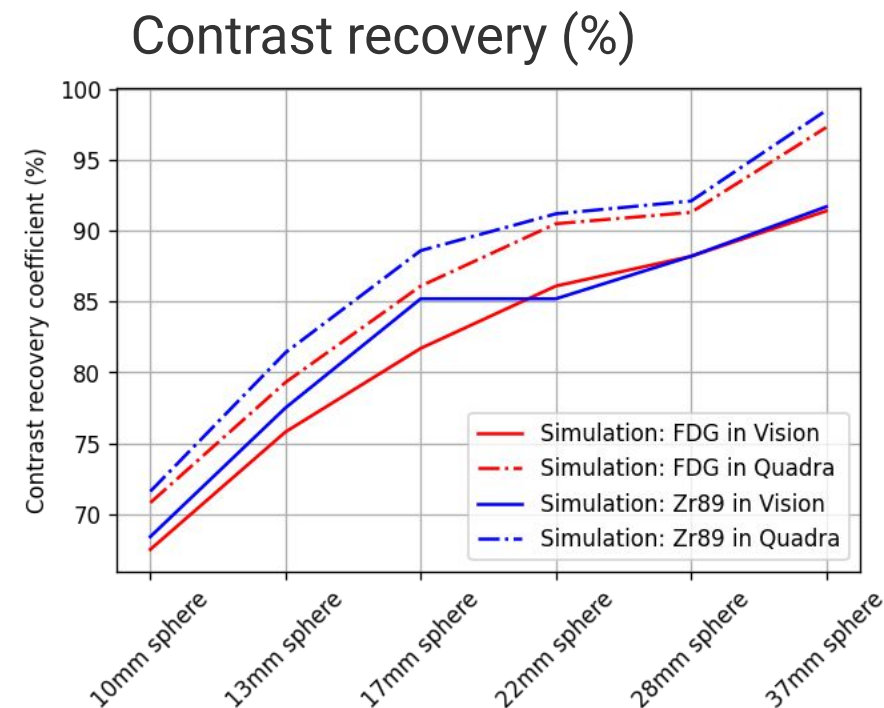
5 min NEMA IQ phantom with 20 kBq/cc in spheres and 2 kBq/cc in background for F-18 and Zr-89

Scanner	Vision		Quadra	
Nuclide	F-18	Zr-89	F-18	Zr-89
CPU hours	685	343	1750	1361
ROOT file size				
- e7 settings (including Singles, > 60 keV)	200 Gb	47 Gb	675 Gb	397 Gb
- STIR settings (only coincidences, 435 - 585 keV)	3.5 Gb	0.9 Gb	17.1 Gb	4.4 Gb
Coincidences (435-585 keV)				
- total	40M	9.7M	198M	48.9M
- true	23M	5.5M	103M	24.4M

NEMA IQ Zr-89 and F-18



Zr-89 simulated as positron + gamma source, due to problems with Zr-89 ion source implementation



COV(%) in 3 cm sphere in BG

	Vision	Quadra
FDG	8.51%	6.35%
Zr89	17.9%	11.8%

Two different digitization and analysis workflows



Christian Pommranz



Fabian Schmidt



Wenhong Lan



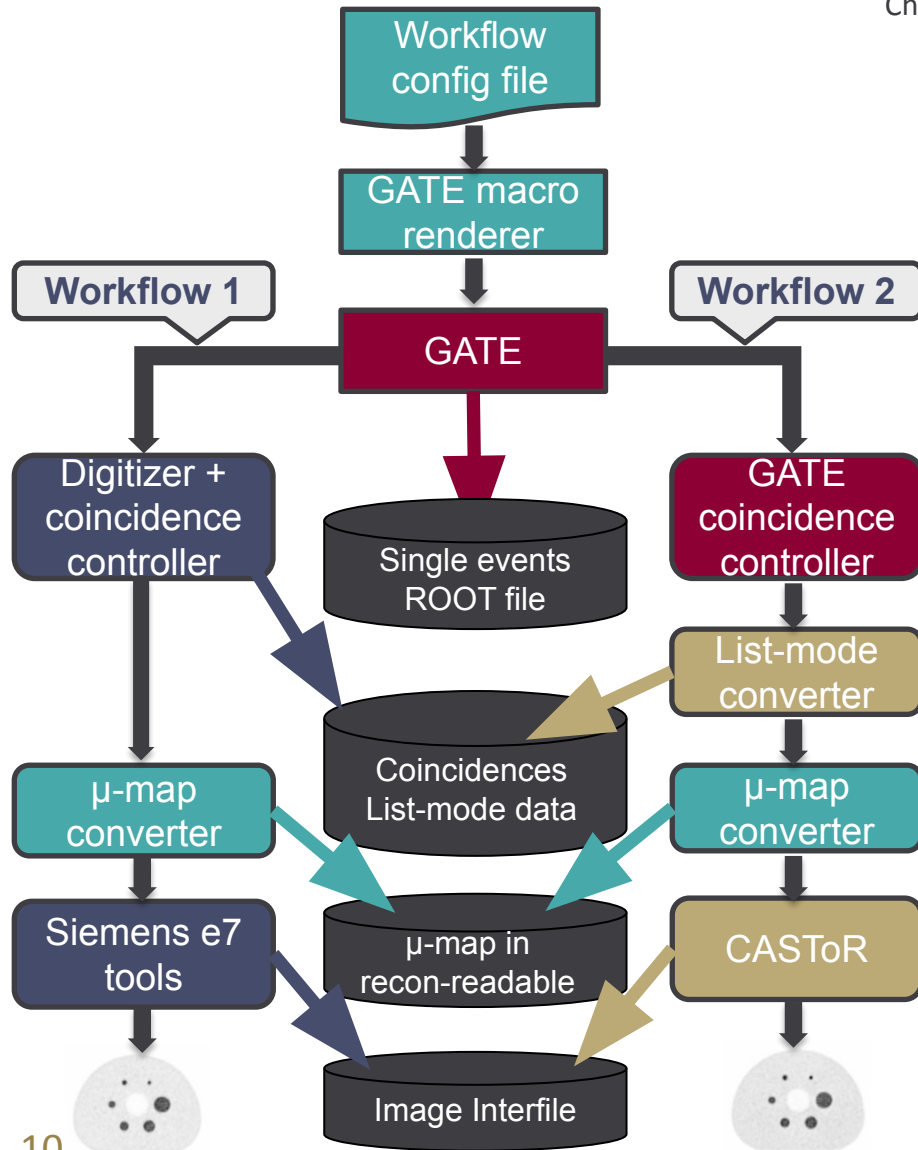
Ezzat Elmoujarkach



Jorge Cabello



UNIVERSITÄT ZU LÜBECK



Workflow 1

- GATE model + accurate coincidence processor + scanner reconstruction software (e7 tools)
- **Try to produce simulation data as close as possible to measurements**
- Attenuation map, listmode file headers etc. must be adjusted to be processed by e7 tools

Workflow 2

- GATE digitization and coincidence sorter + CASToR reconstruction software with a CASToR Quadra model
- **Very flexible workflow based on open-source software. Useful for “what-if” scenarios.**
- Less precise, but allows to simulate adaptations of the Quadra scanner (Geometry, PET inserts, etc.)



GATE in version 9.1



CASToR in version 3.1,
customized conversion tools



Siemens tools



Custom software

Workflow 1 initial results

- Quantification

Same normalization matrix as the real scanner, only calibration factor adapted for simulations

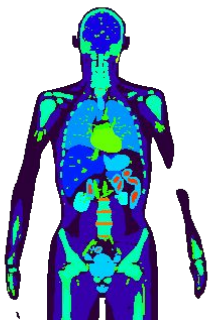
	Mean in Bq/ml	Ref. in Bq/ml	Diff. in %
Cylinder	5958	6000	0.7
IEC Phantom	5453	5472	0.3
Tube 100 cm	3005	3000	0.2

- Image Quality 60 seconds

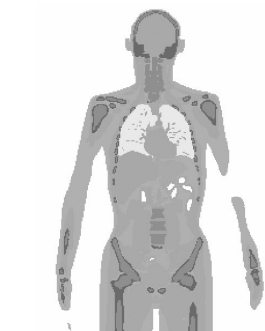
Measurement	Simulation	Sphere Diameter [mm]
		10
		13
		17
		22
		28
		37

SBR 4:1		SBR 8:1	
Simulation	Experiment (NEMA)	Simulation	Experiment (NEMA)
CRC [%]		CRC [%]	
55.5	55.7	65.9	59.3
69.2	62.4	73.2	68.5
74.4	77.3	78.7	79.3
79.0	80.9	81.2	82.1
83.5	79.2	84.0	78.6
87.3	85.3	88.0	85.3
Lung Residual Error [%]		Lung Residual Error [%]	
4.7		6.3	5.5

- XCAT phantom simulations



Look-up table with IDs and material compositions

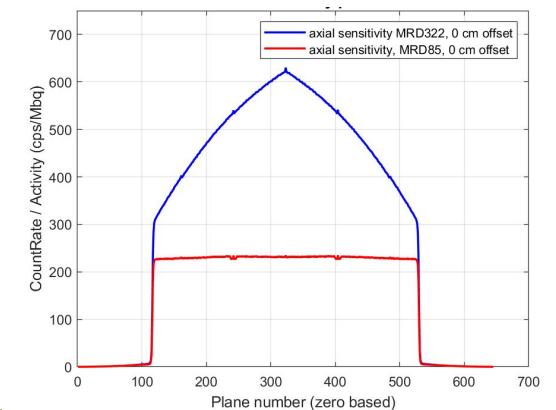


GATE attenuation map at 511 keV



20 seconds FDG, e7 tools recon

- Axial sensitivity profiles



Conclusions & Future Work

Conclusions:

- Powerful cluster is needed
- Large data for Quadra simulations

Problems with Gate:

- Zr-89 ion source bug
- Coincidence sorter offline
- Voxelized source overwrites detectors

Future Work:

- TOF reconstruction in STIR for Vision and Quadra
- Implement Vision/Quadra in GATE 10 (Python)
- Simulate Dual tracer, XCAT and motion, potentially kinetics

Thank you for your attention

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