Event-driven Motion Compensation in clinical PET

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- Patient movements during PET investigations are problematic and unavoidable
  - ➢ PET images represent „long exposure pictures“ (minutes ... hours)
  - ➢ Motion compromises qualitative and quantitative integrity of PET images (image artifacts, incorrect time-activity-curves (TAC), kinetic parameters, SUV, ...)
- Improving scanner resolution increases problem
- Different motion compensation techniques exist

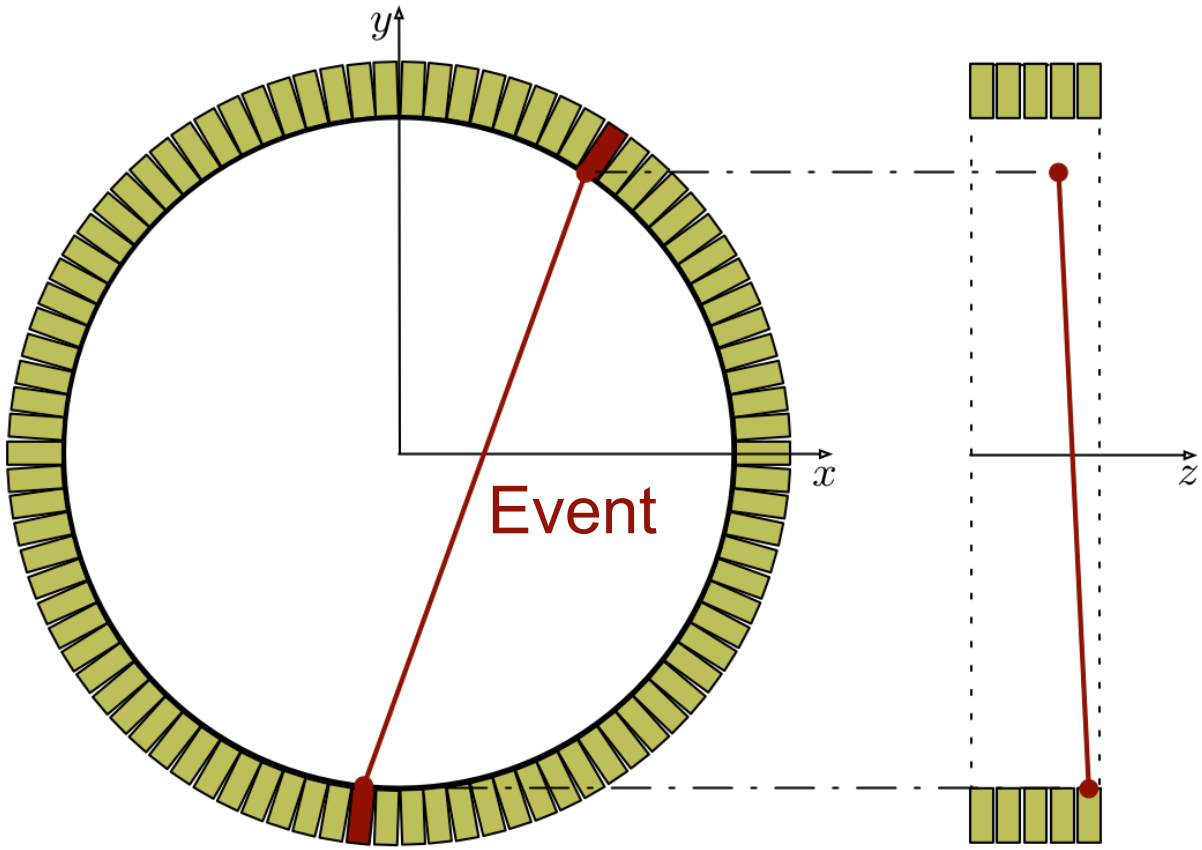
  own development of event-driven motion compensation technique:

  - Bühler, P., et al. IEEE Med. Imaging. 2004; 23(9): 1176-1185
  - Langner, J., et al. Z. Med. Phys. 2006; 16(1):75-82.
  - Langner, J., et al. IEEE MIC 2008; Oct 22 - Oct 25, Dresden
  - Langner, J., et al. DGN 2006-2010

Aim

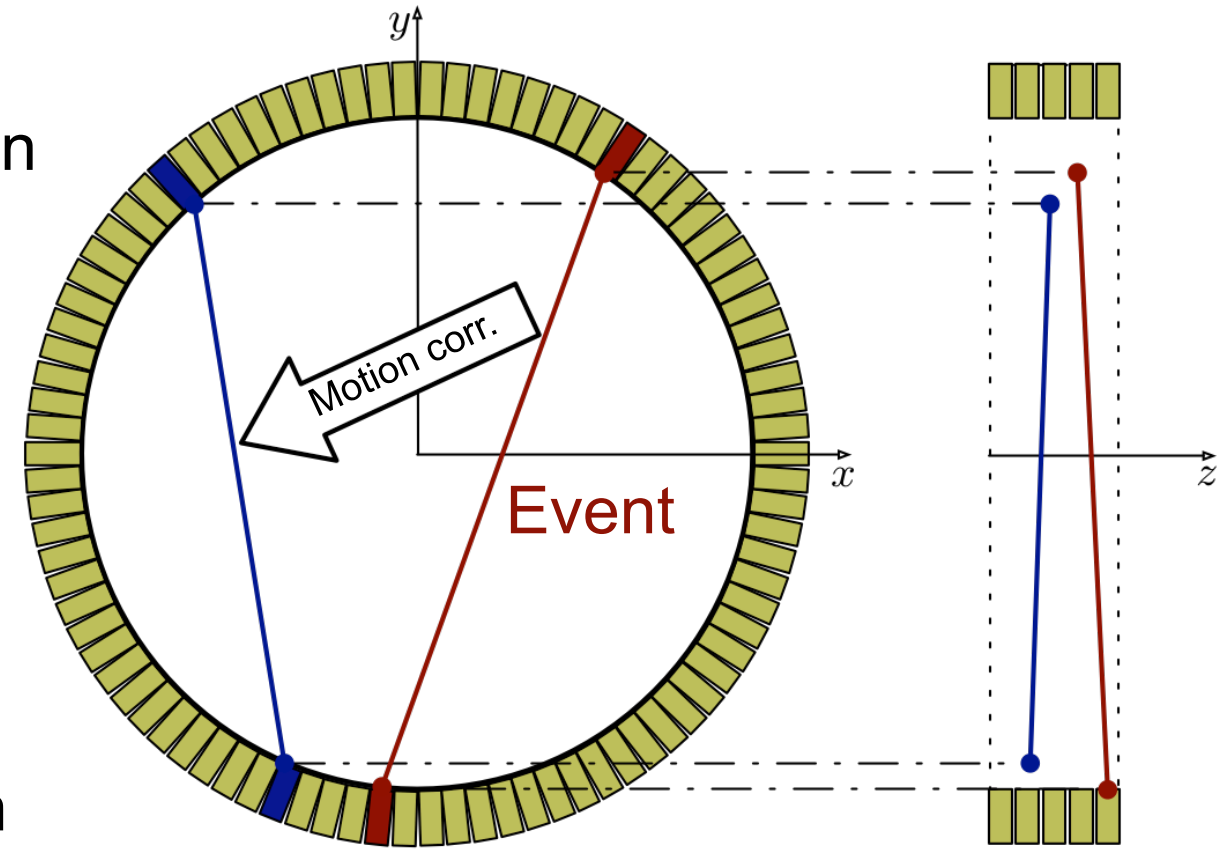
- Analysis of the qualitative and quantitative effects on a large clinical patient collective

- Acquisition in *List-mode* data format (raw data)
  >> Registration of each coincidence event



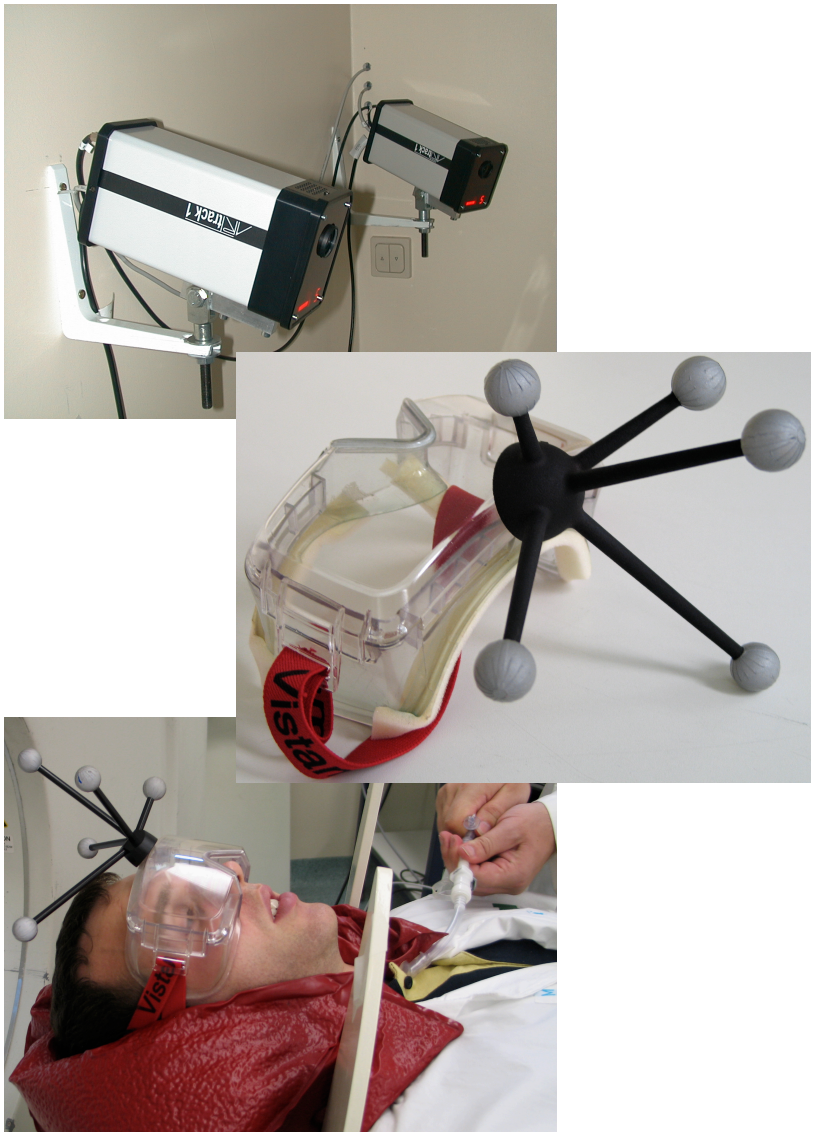
- Acquisition in *List-mode* data format (raw data)
  >> Registration of each coincidence event

1. Spatial transformation of all reg. events
2. Binning of events into sinogram
3. Use of standard image reconstruction



Method – Patient Motion Acquisition

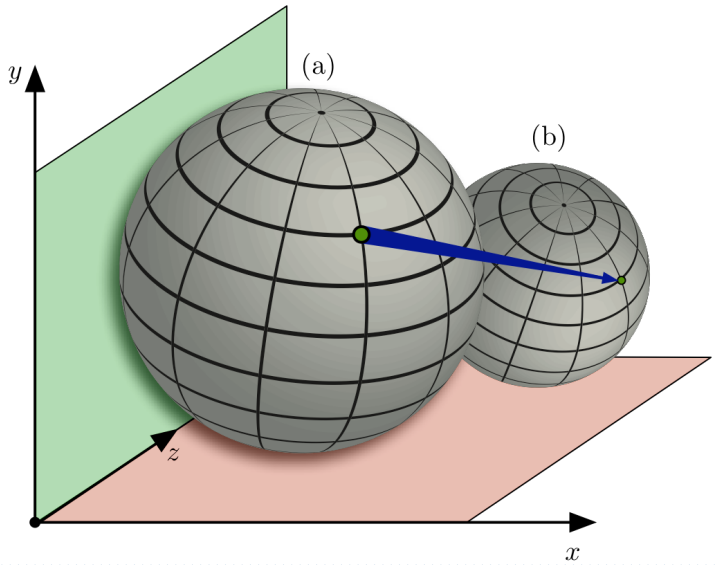
- External motion detection via optical tracking system
- Integrated infrared flashes
- passive marker system
- Max. sampling rate 60Hz, < 1 mm resolution
- Output:
  - 3 translation parameter
  - 3 rotation parameter



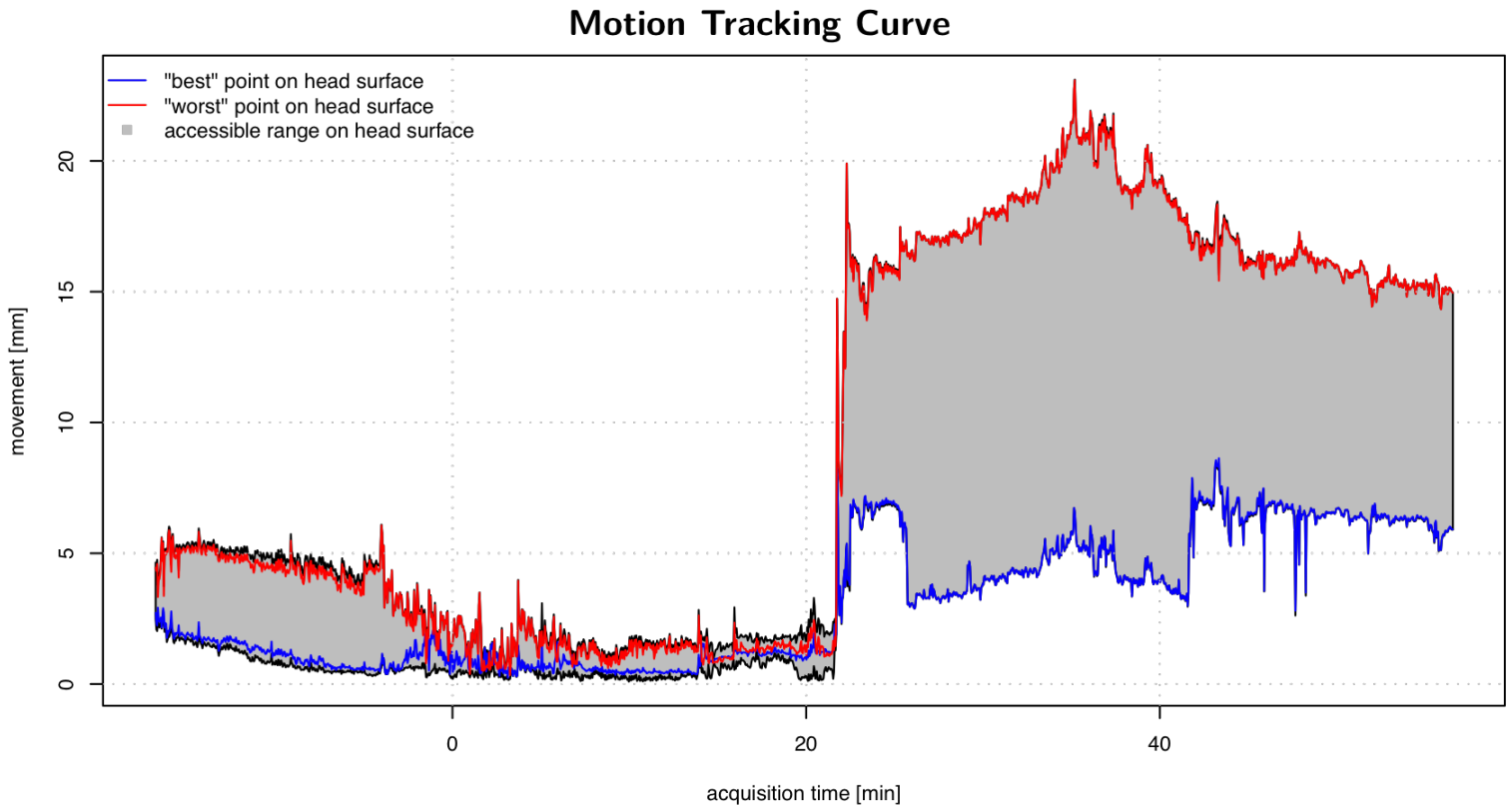
- Problem: significance of motion can not be directly derived from motion parameters (rotation dependence)

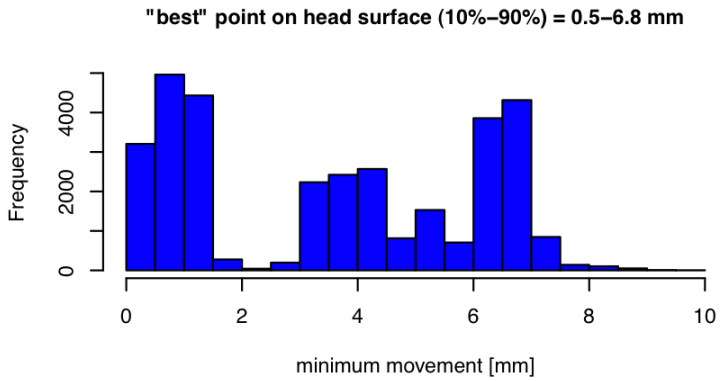
1. Application of motion parameters to the anatomical structure that is analysed (e.g. surface of a sphere as an approx. head)

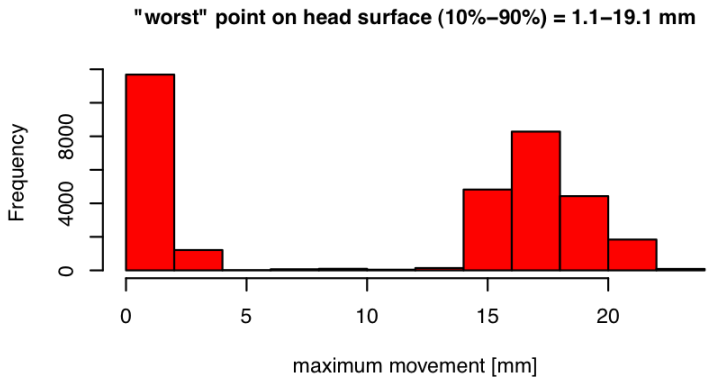
2. Calculation of the euclidean distance for selected points on the structure to their origin (for thresholding)



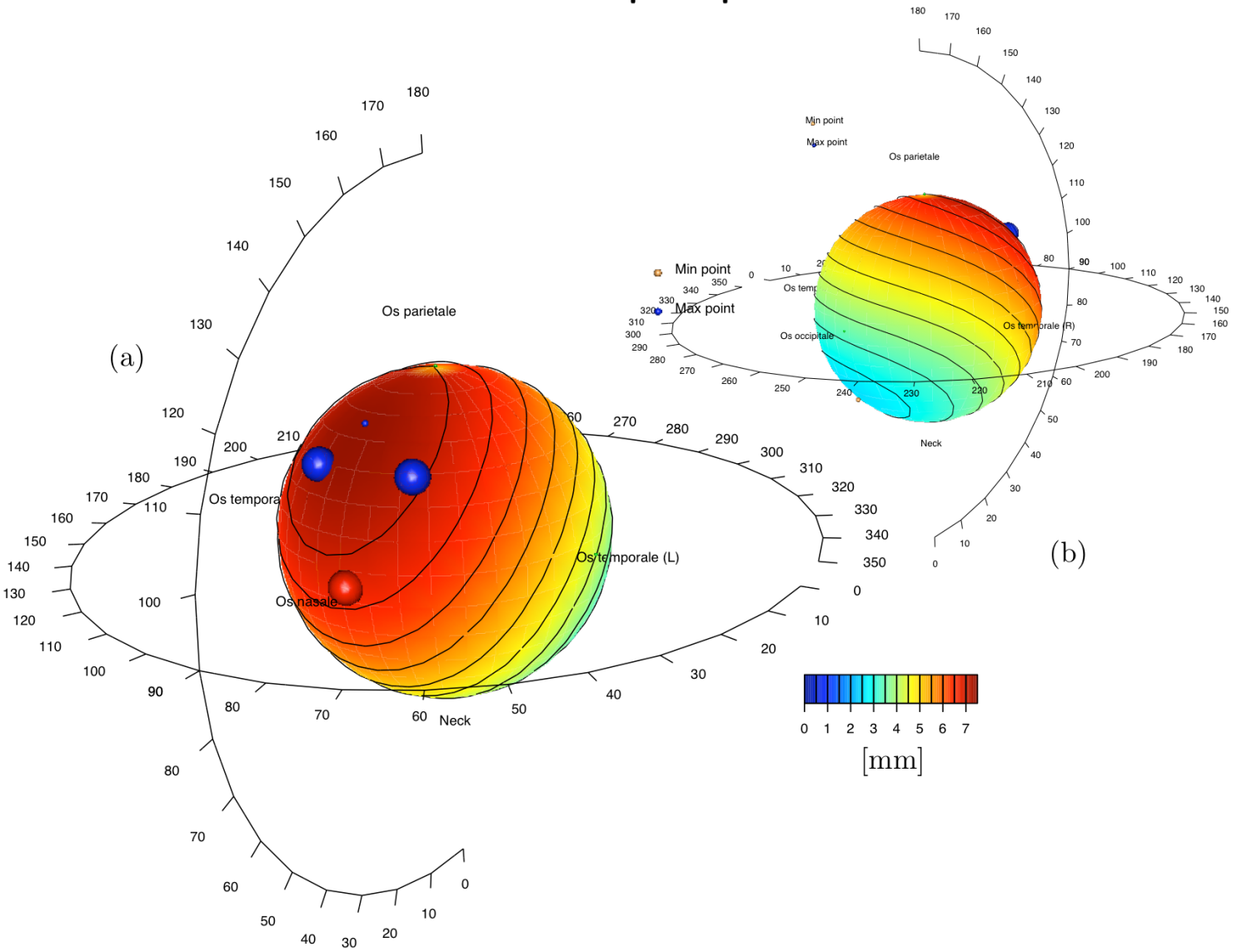
Method – Motion Quantification - Example



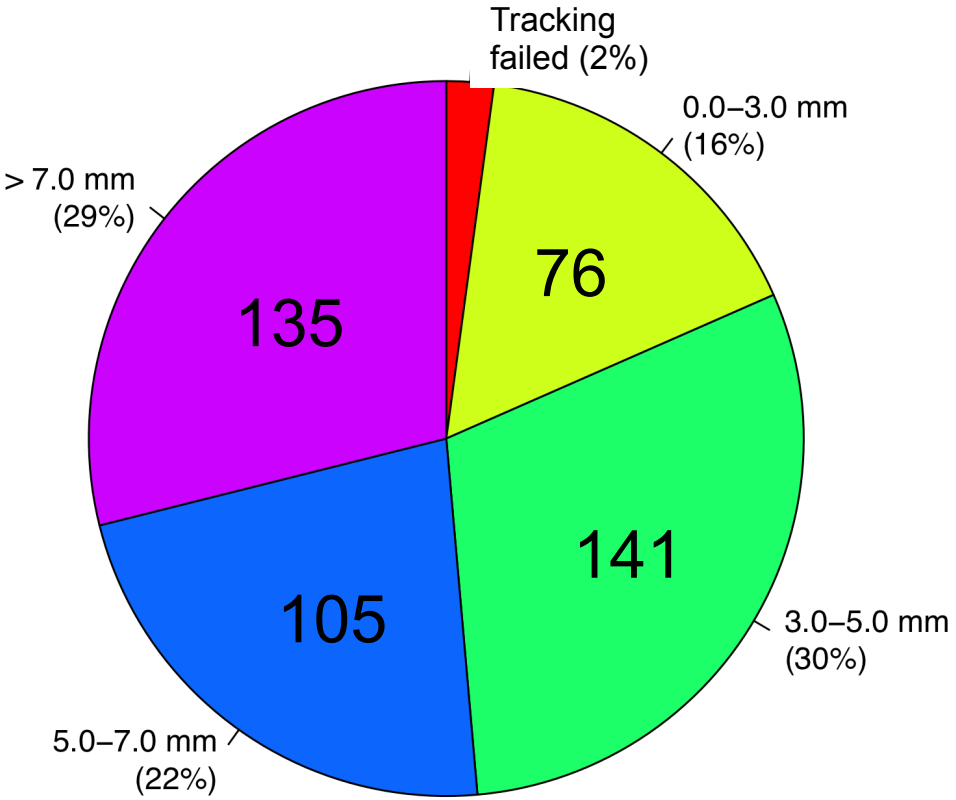


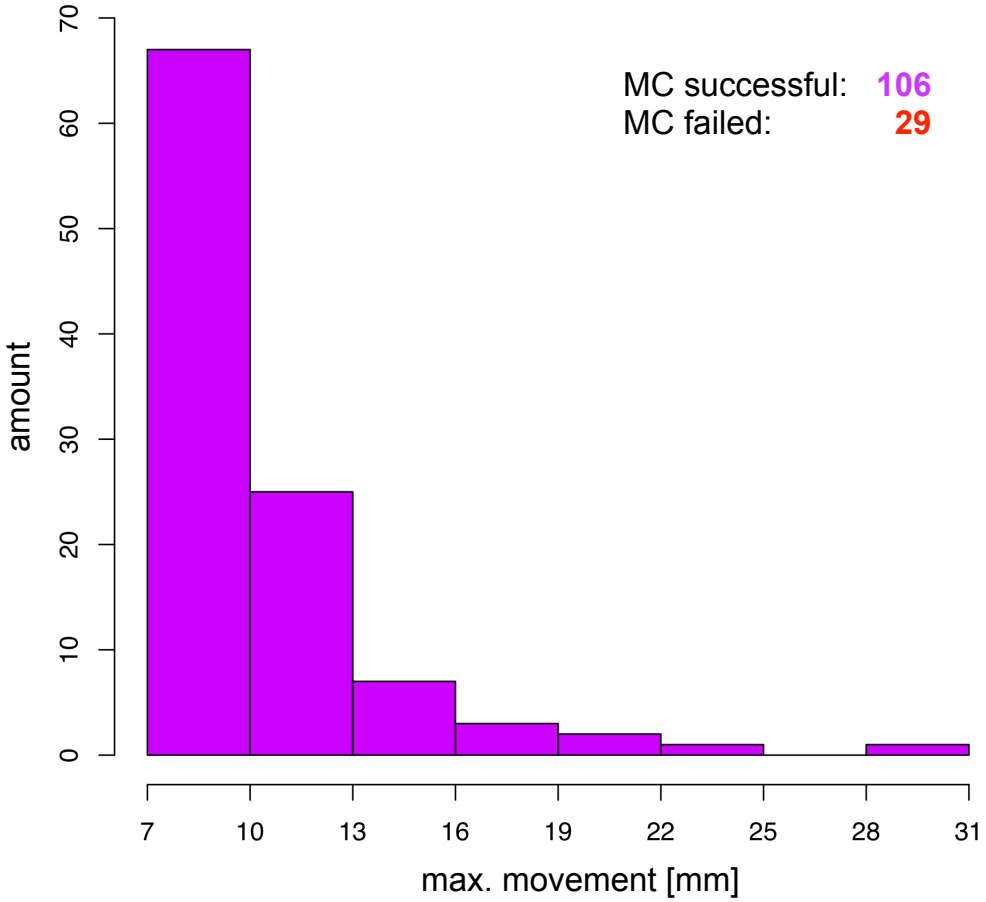


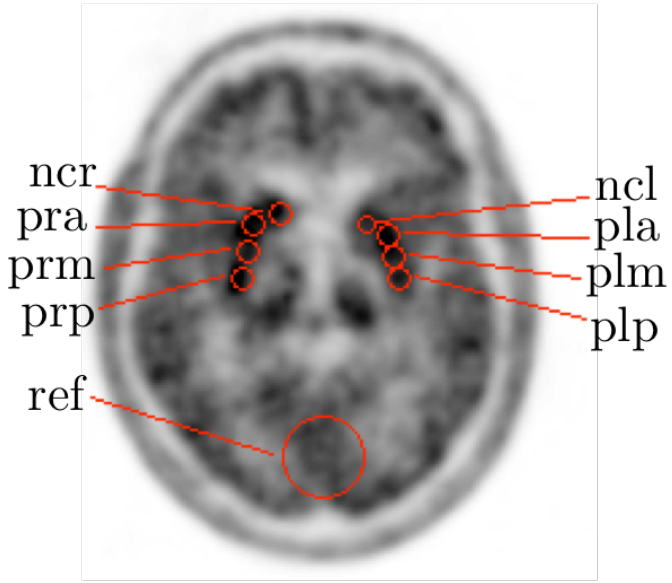
Method – Motion Quantification - Example



- 467 [18F]DOPA examinations (DD *M. Parkinson*)
  - 55 min 3D-Listmode, 27 frames, ECAT Exact HR+
    266 male, 201 female, avg. age: 61.5 ± 11.8 (sd)
- For 29% movement > 7 mm found







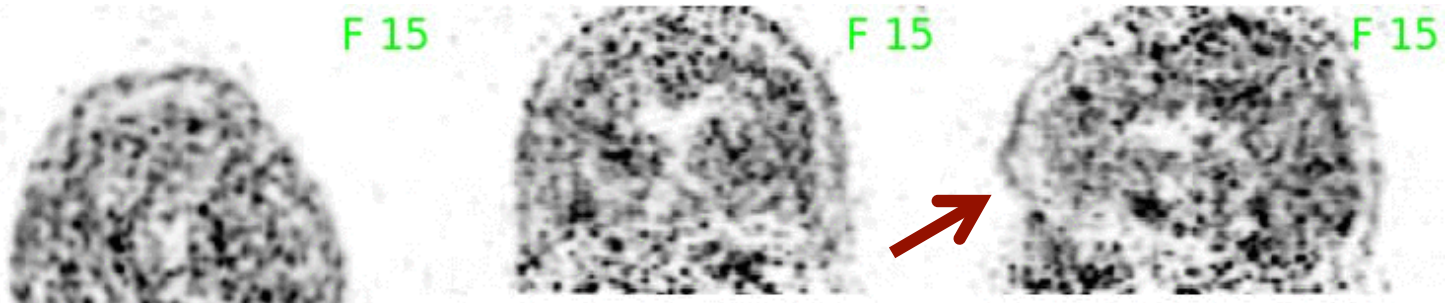
Transaxial

	ncr	Nucleus caudatus right
	ncl	Nucleus caudatus left
pr	pra	Putamen right anterior
	prm	Putamen right medius
	prp	Putamen right posterior
pl	pla	Putamen left anterior
	plm	Putamen left medius
	plp	Putamen left posterior
	ref	Reference ROI

- 8 ROI (3D) within striatum + 1 ROI as reference tissue occipital (independent positioning before and after MC)
- Comparison of time-activity-curves (TAC) and input rates (R_0k_3) of a two compartment reference tissue model (Patlak analysis)

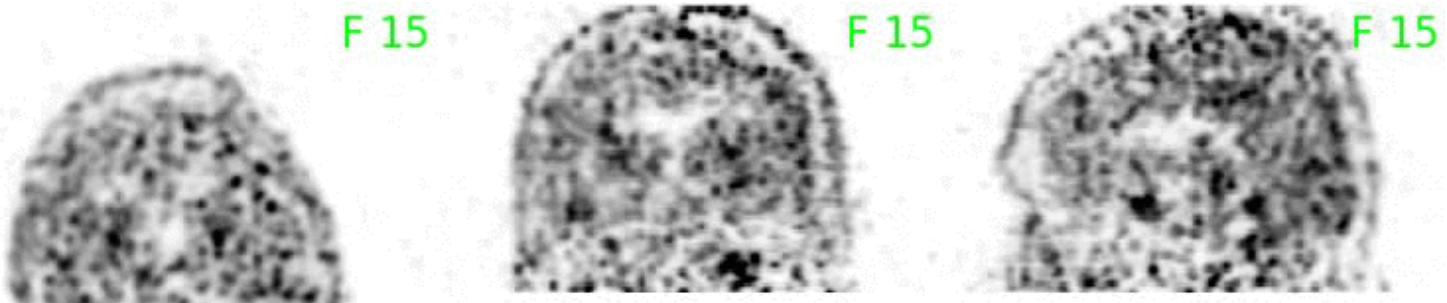
Results – Example

Uncorrected
Frame 15-27

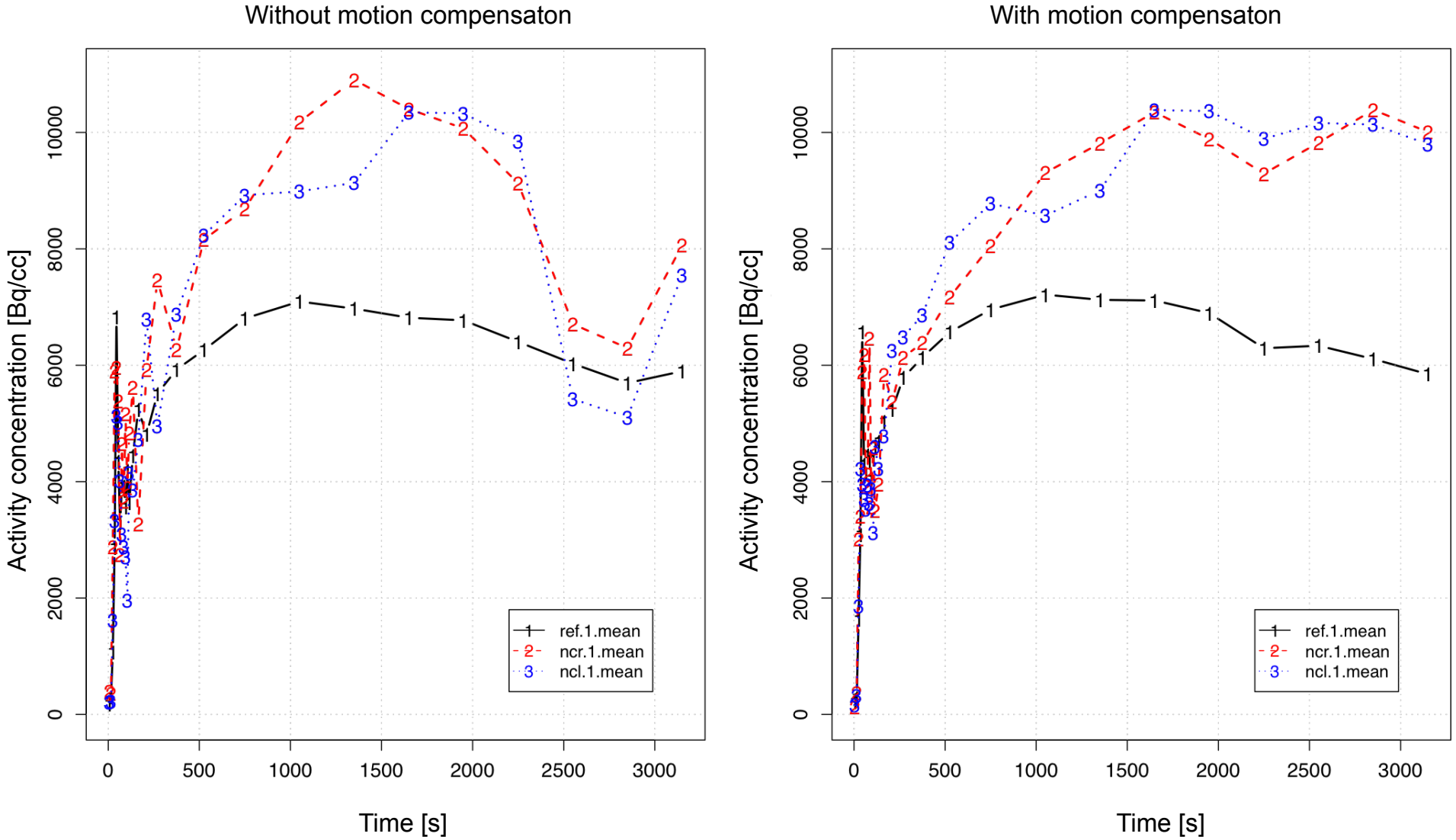


max. movement: 2.7 – 24.2 mm
motion blurring: ± 8.3 mm

Corrected
Frame 15-27

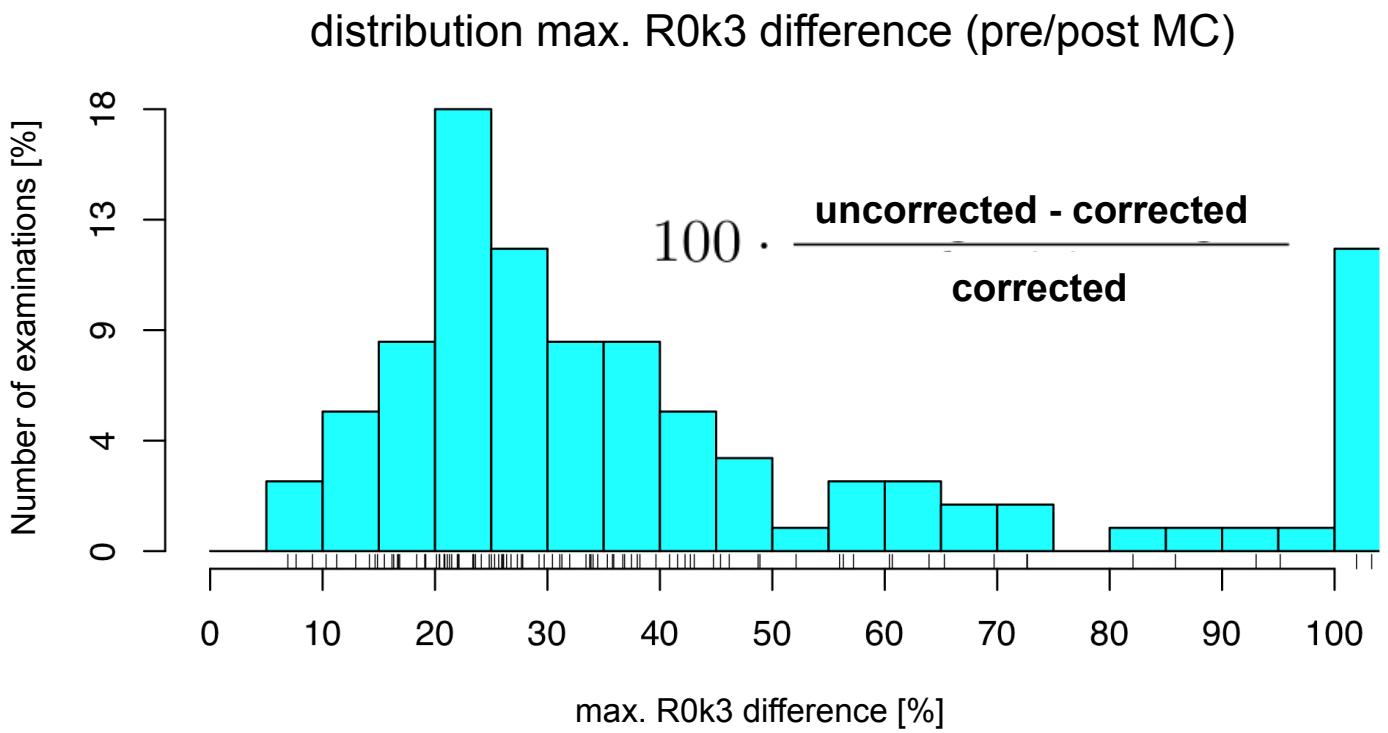


Results – Example – TAC



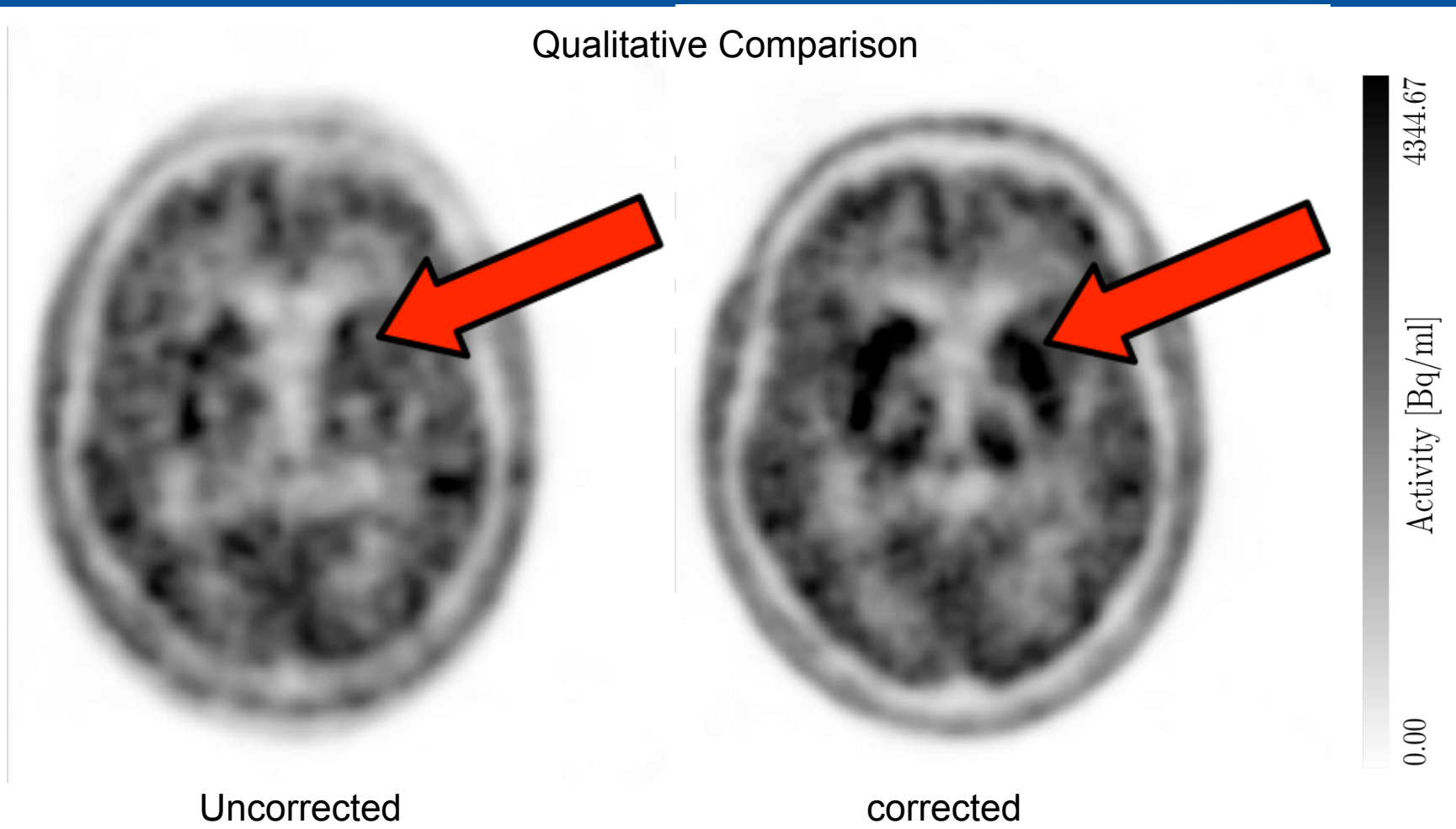
- Large differences in TAC before/after MC

Results – all patients



Number exams	max. R0k3 diff [%]
18 (17%)	0 – 20%
60 (57%)	20 – 50%
28 (26%) 13 (12%)	> 50% > 100%

Results – qualitative analysis



- Improvement of image contrast
- Reduction of image artifacts

Summary

- Patient movements can have a large impact on PET examinations
- > 50 % of all analysed studies showed motion larger than resolution of current PET systems (4 – 5 mm)
- Severe effects on quantification parameters (TAC, SUV, etc.) also for small motions visible
- 8 – 10 % of the examinations had to be repeated in case no MC would have been available (-> increased radiation dose)

- ➢ Monitoring and Compensation of patient motion highly adviseable
- ➢ Improving resolution suggests motion compensation to be one of the limiting factors for the success of future PET systems
- ➢ MR-based multi modality systems (PET/MR) require to think about MC for MR data as well.