

# Quantitative PET/CT Radiomics

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*Thanks to Matthieu Hatt, Fei Yang, and U01CA148131*



IMAGING RESEARCH LABORATORY

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# Problems with reproducibility



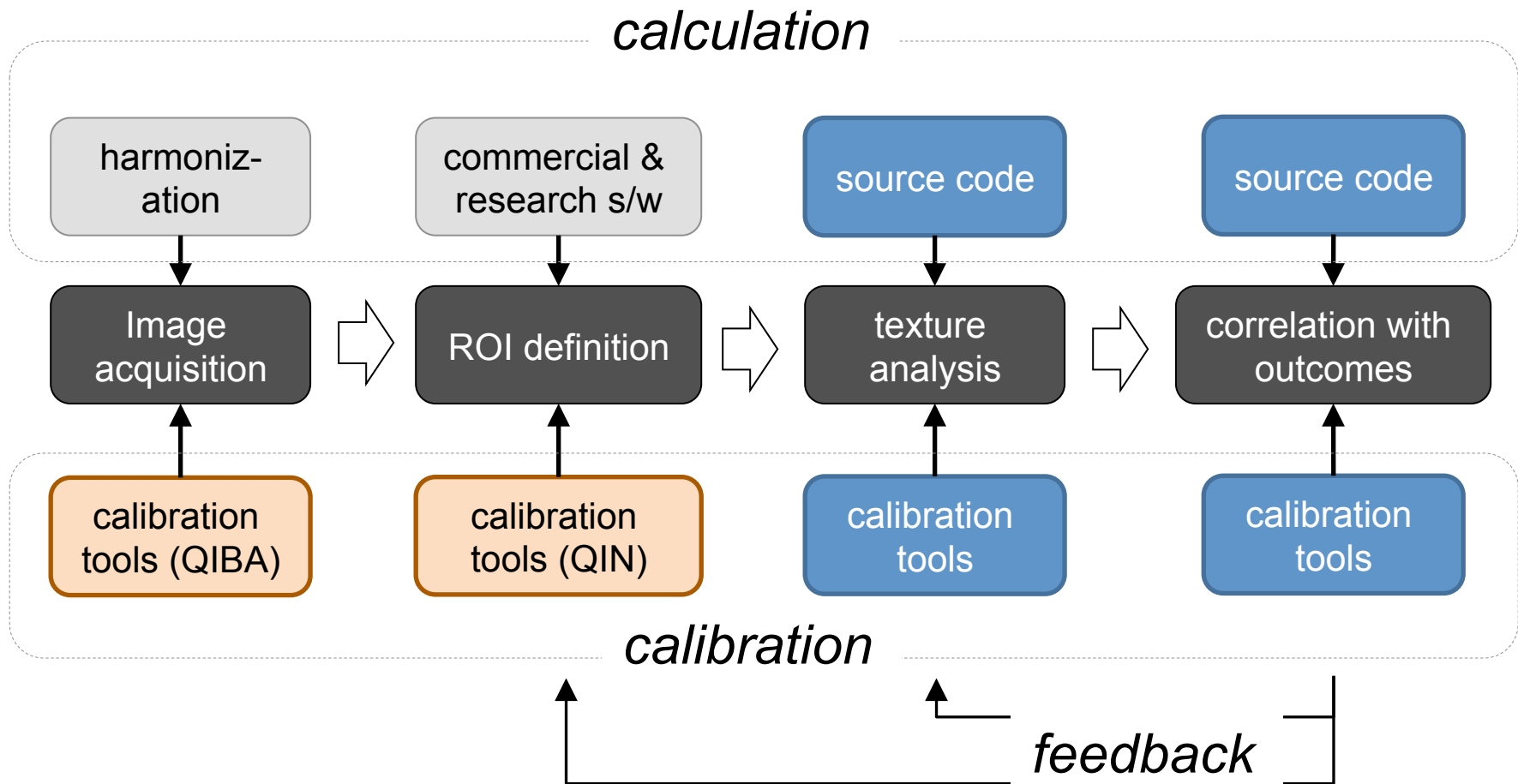
- Scientists at Amgen tried to replicate 53 studies considered landmarks in the basic science of cancer ... they were able to reproduce the original results in just 6
- Prinz and colleagues at Bayer HealthCare reported that they had successfully reproduced the published results in just a quarter of 67 seminal studies

*The Economist, October 2013*

- ... a greater than 85% loss, which implies that the dividends from tens of billions of dollars of investment in [biomedical] research are lost every year.

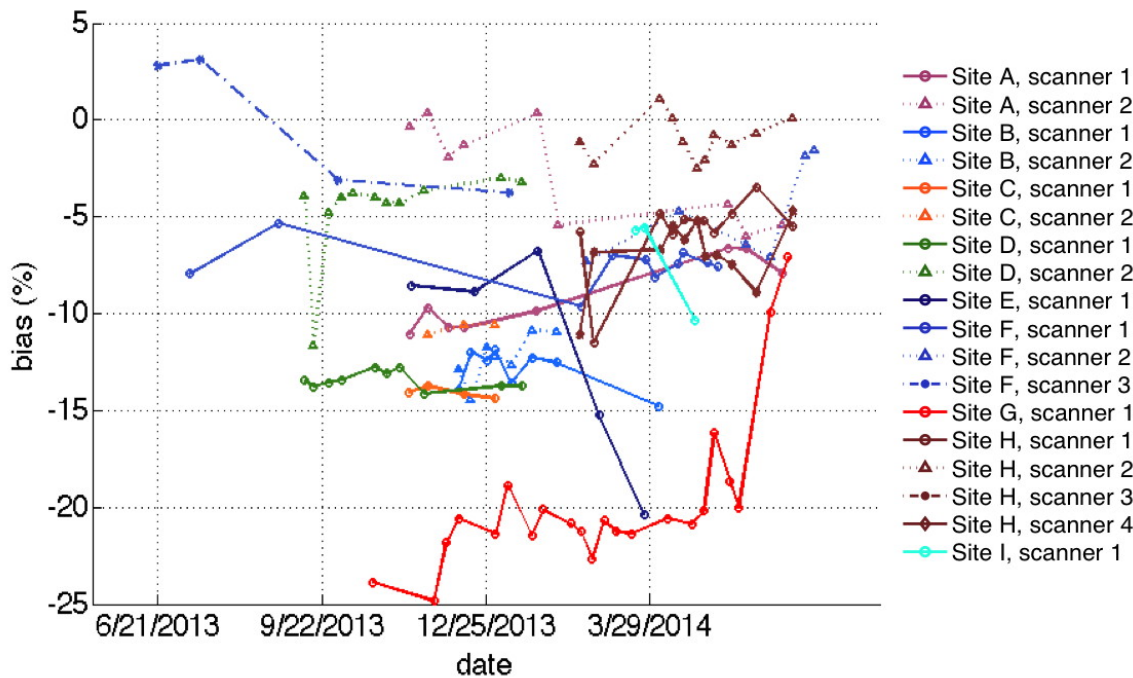
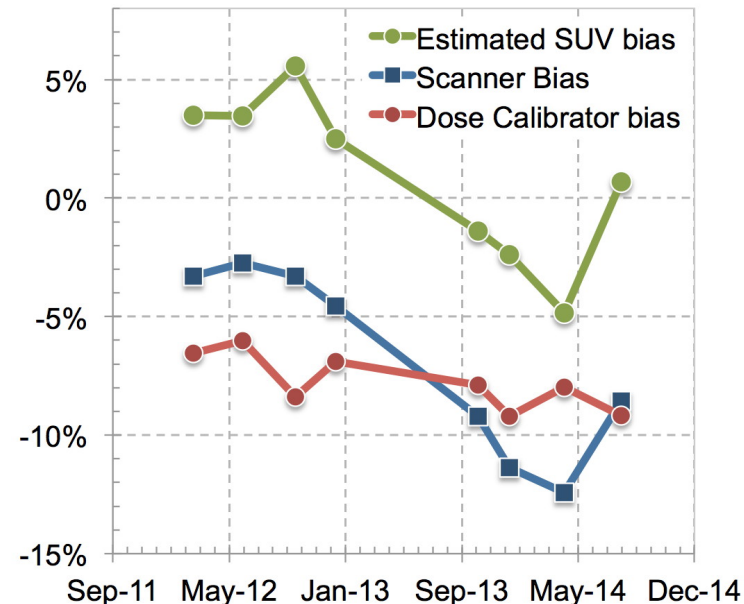
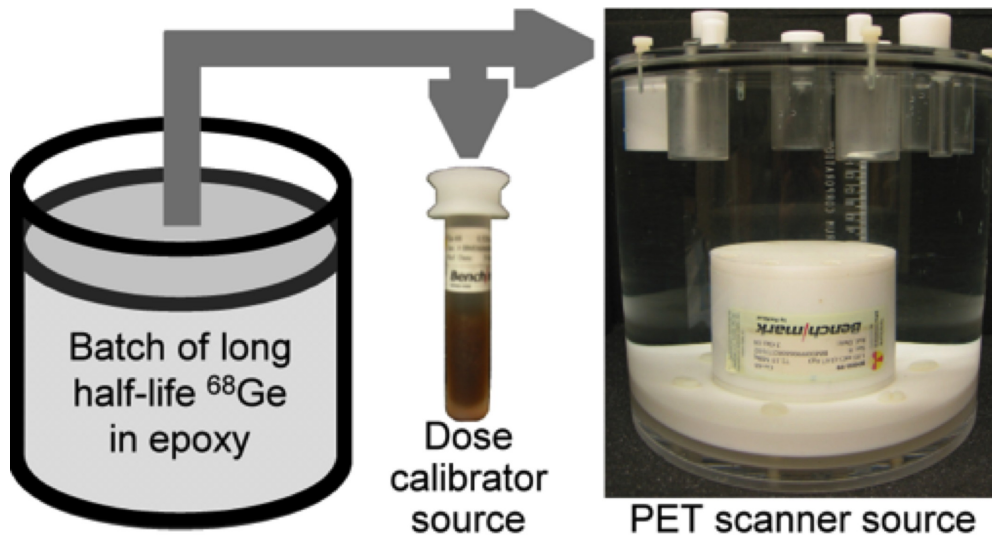
*Chalmers, Lancet 2009*

# Quantitative PET/CT Radiomics – a big picture



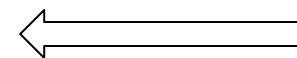
Despite years of research and hundreds of reports on tumor markers in oncology, the number of markers that have emerged as clinically useful is pitifully small *McShane JNCI 2005*

# Tracking PET/CT scanner calibration

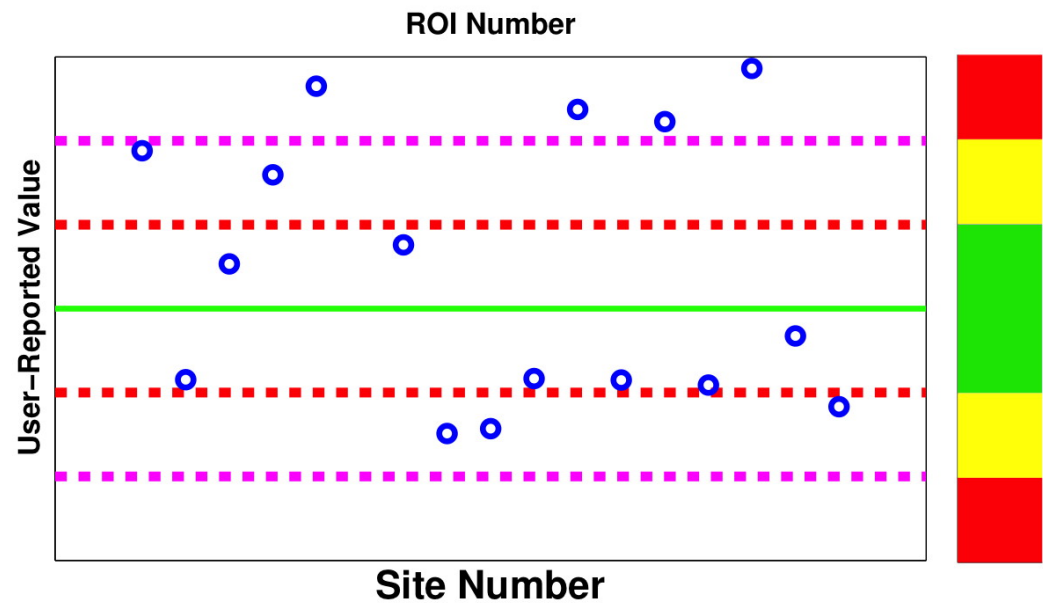
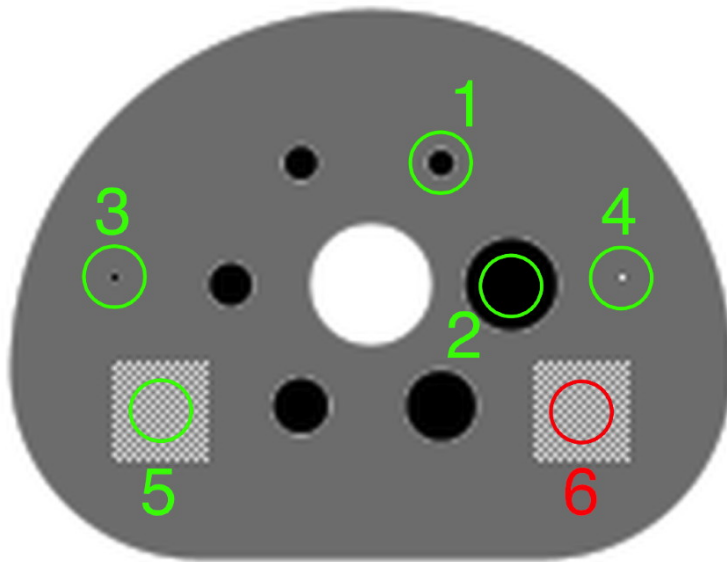


One scanner / site

14 scanners at 8 sites



# PET/CT Digital reference object (DRO)



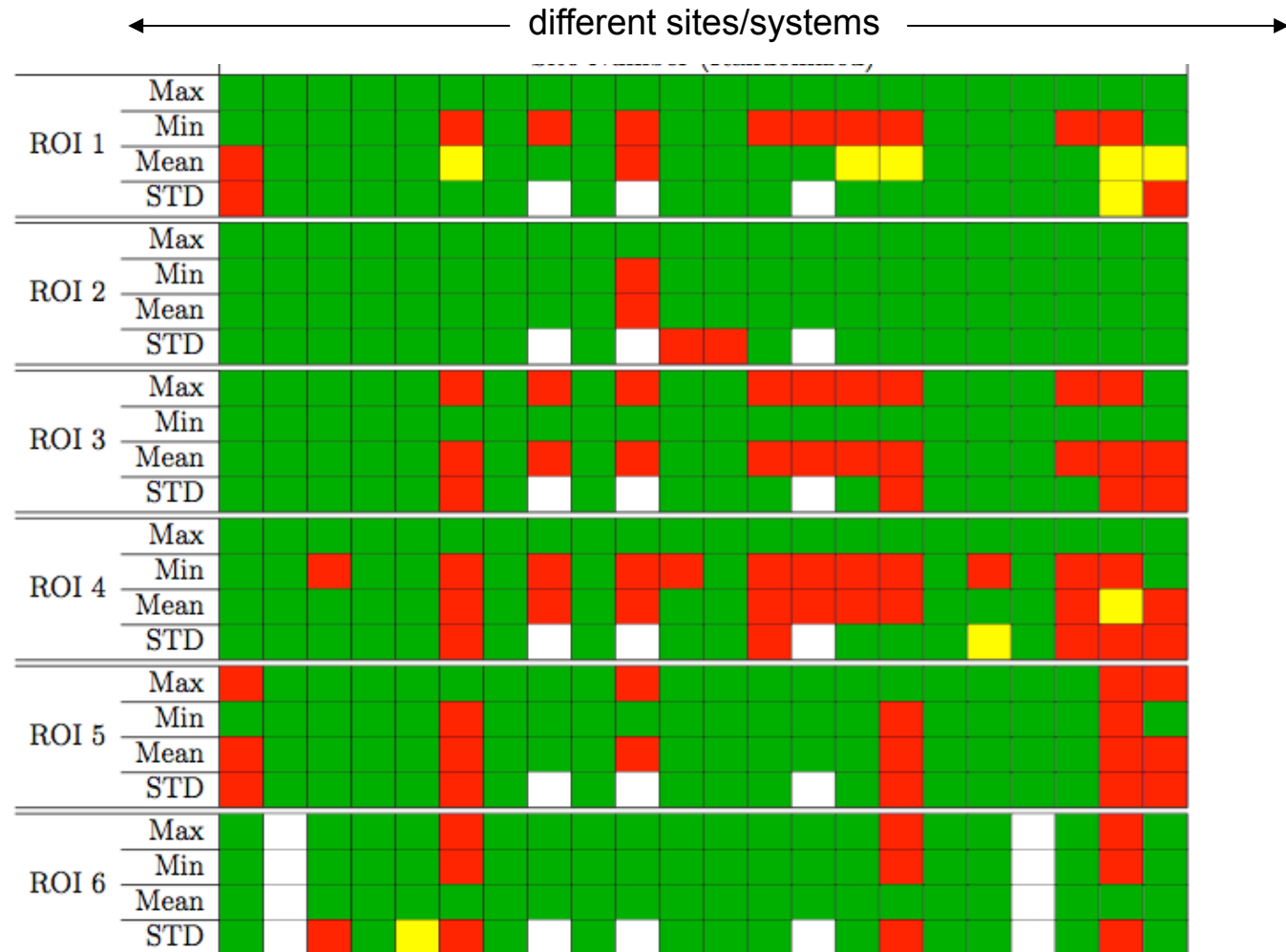
Evaluated at 16 sites using 21 analysis software packages (mostly expensive commercial clinical systems)

# Results: 13 sites, 21 different display systems



**green** = okay, **white** = ?, **yellow** = borderline, **red** = wrong

results  
for  
each  
of the  
6 ROIs

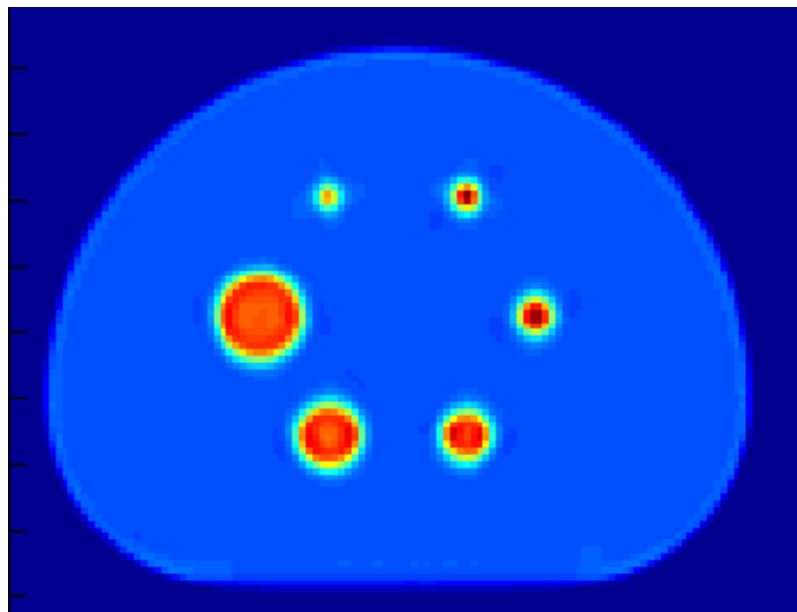


# Simulations for ground truth in texture analysis – effect of quantum noise



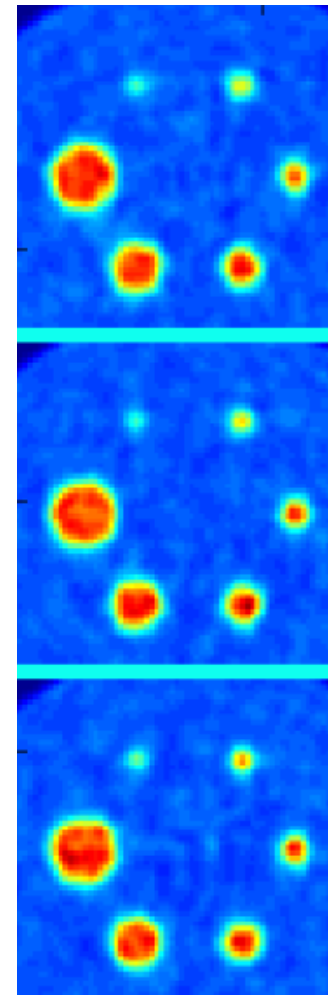
- Careful physics model of acquisition
- Uses scanner for reconstruction
- Produces images that closely match resolution and noise correlations in reality

Noise free realization



← 30 cm →

Examples from 3 of 50 realistic realizations

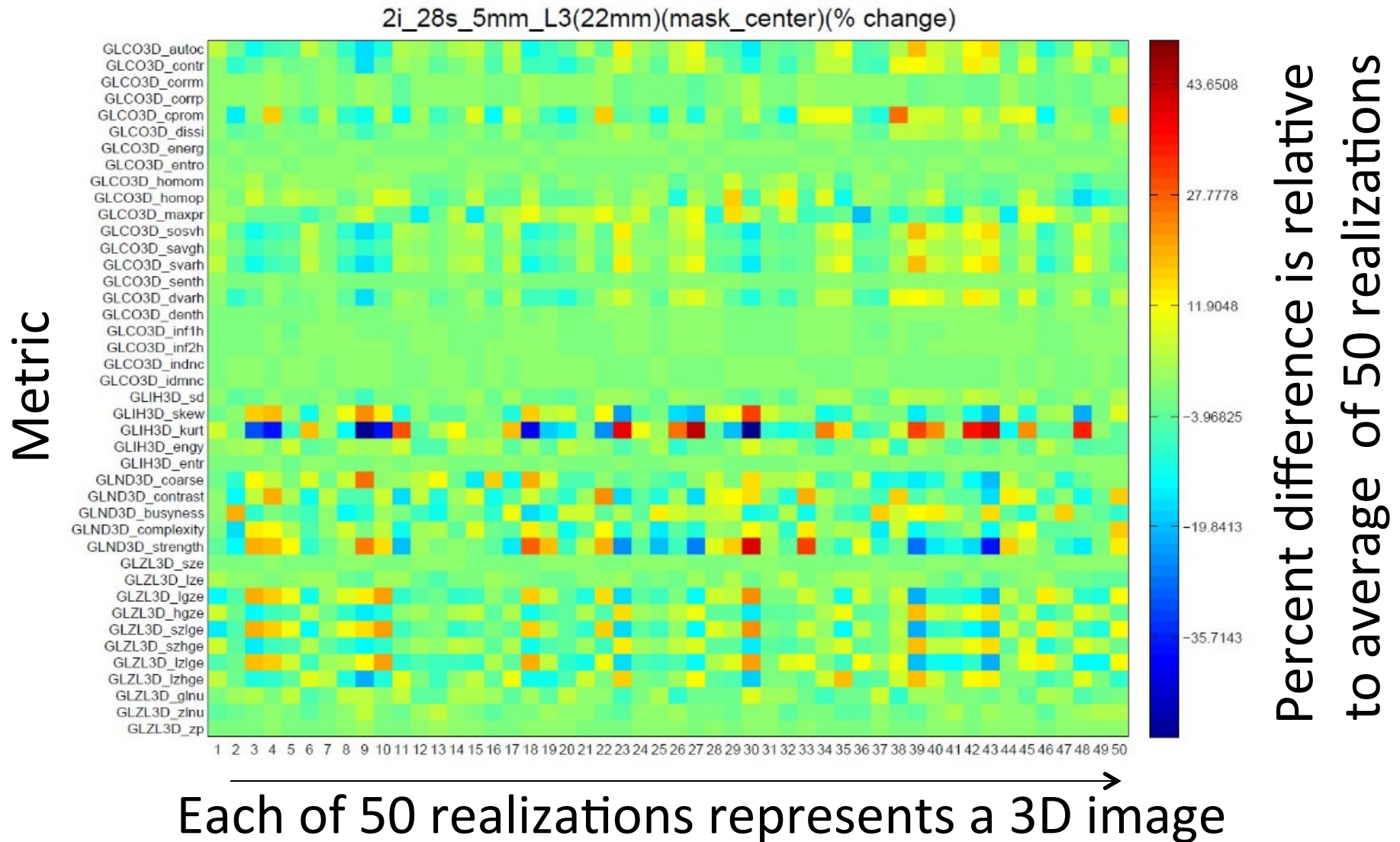


- Metrics:
  - GLCO: Gray level co-occurrence matrices (*Haralick 79*)
  - GLIH: Gray level intensity histogram
  - GLND: Gray level neighborhood-difference matrix (*Amadasun 89*)
  - GLZL: Gray level zone size
- Found multiple errors in the formulae and the code bases



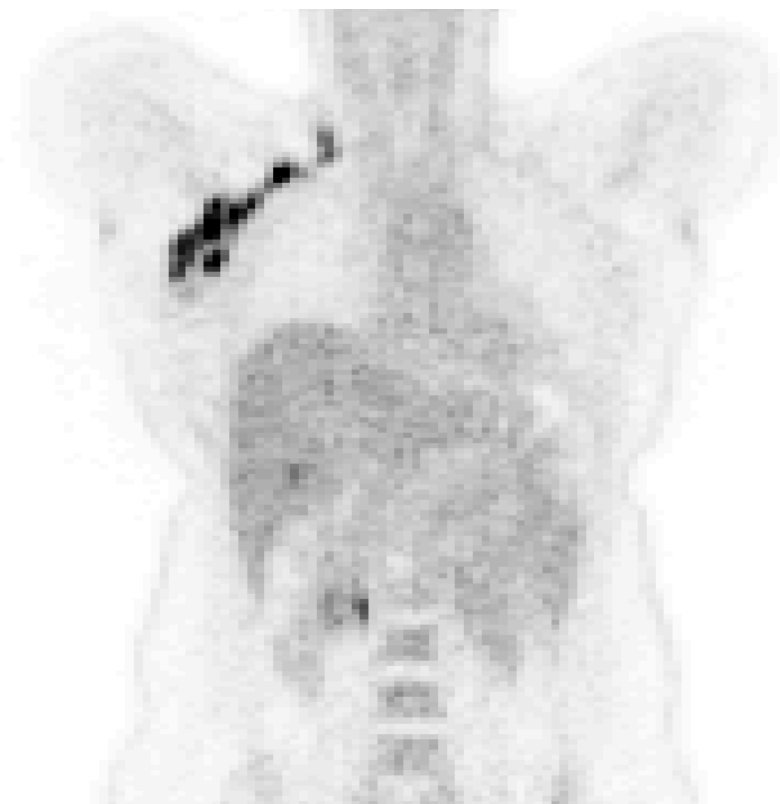
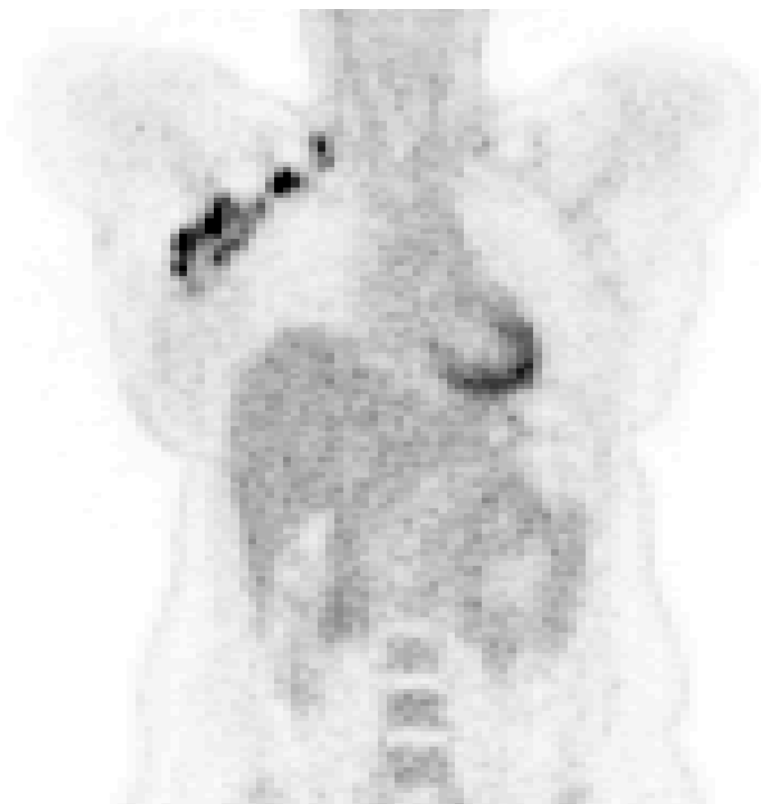
# Metric variability

# W

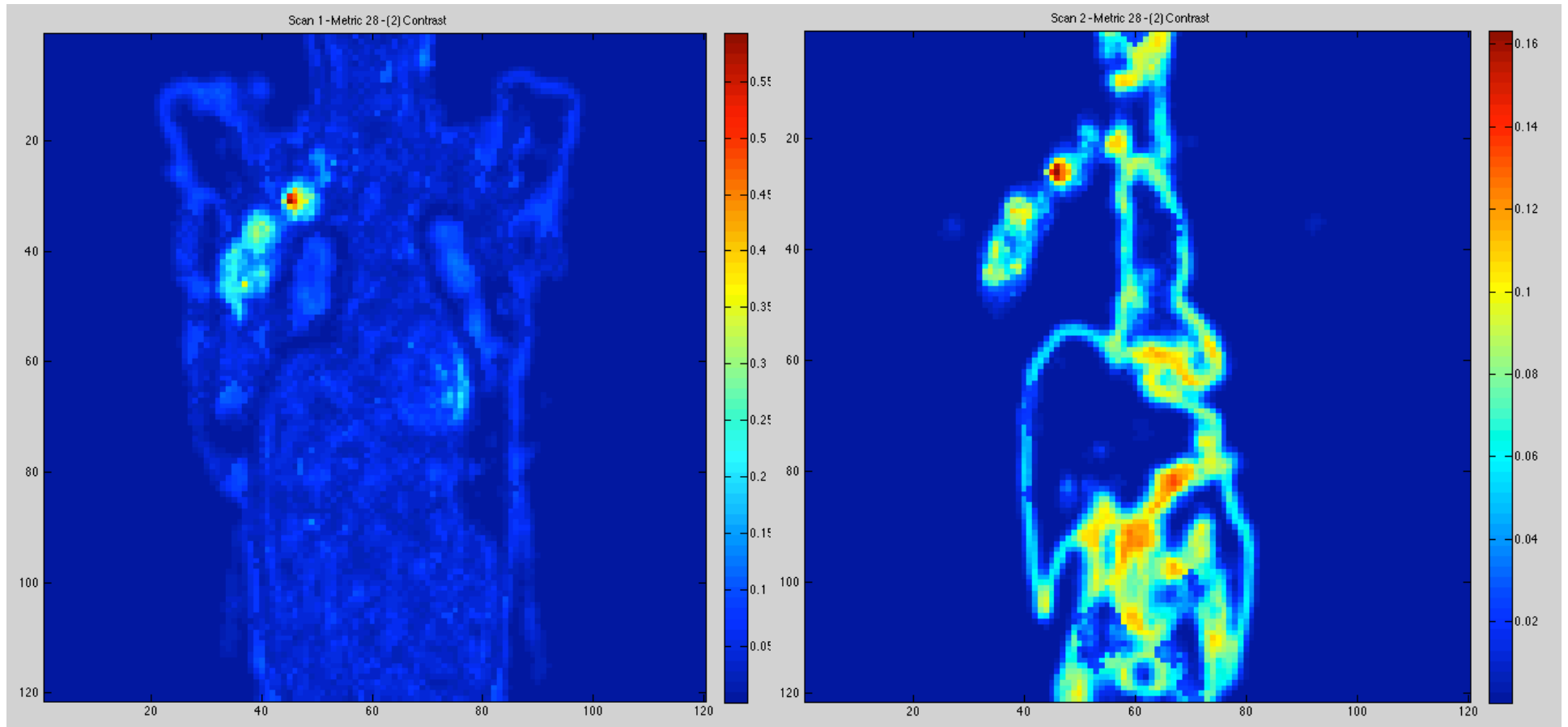


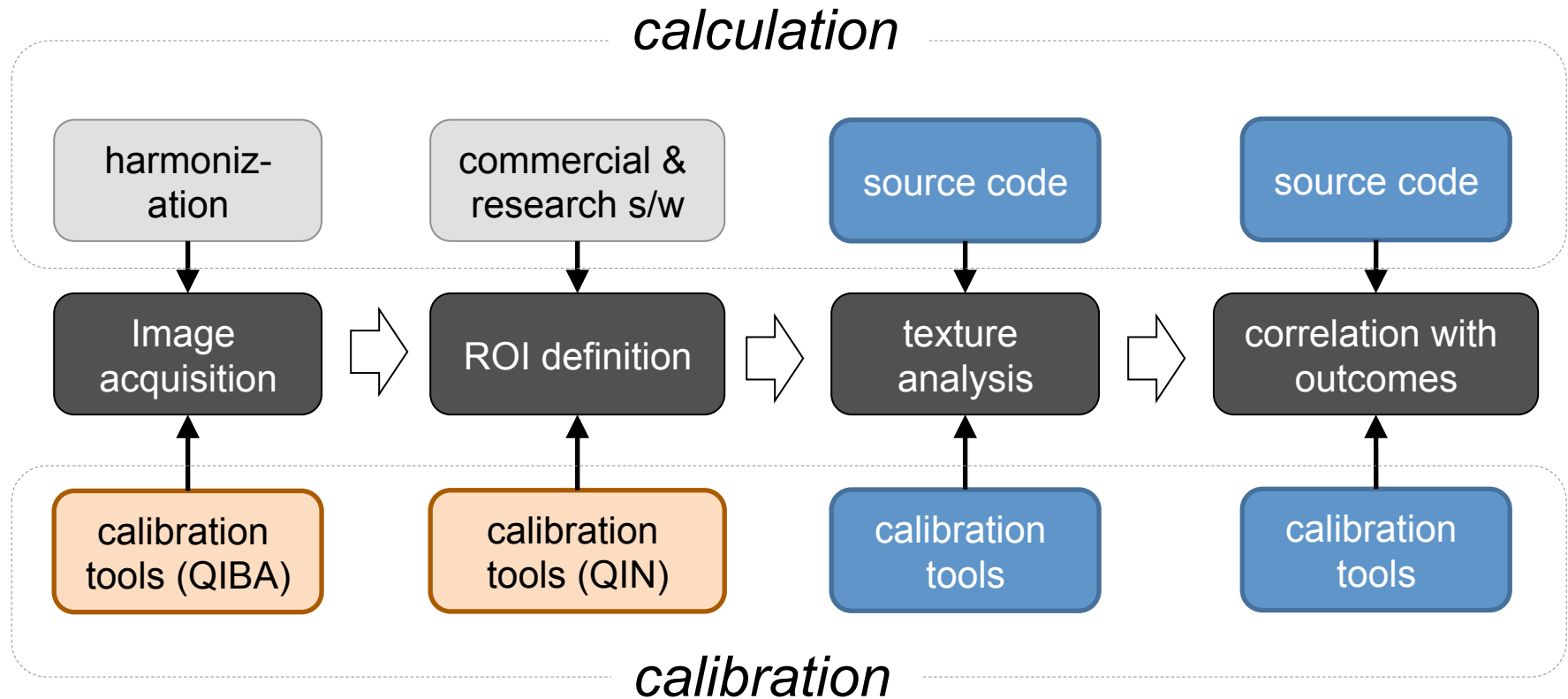
Nyflot, *Journal of Medical Imaging* 2015

# Patient 005 Test/Retest PET scans



# Neighborhood Graytone Difference





- Early days for radiomics research, likely many published results will not be reproducible
- Need for standards, tools, methodologies

# Radiomics Research



Reproducibility

