Dose (how low can you go) – ultra low dose CT for PET-CT

Nicholas Keat

GlaxoSmithKline Clinical Imaging Centre

Imperial College - London

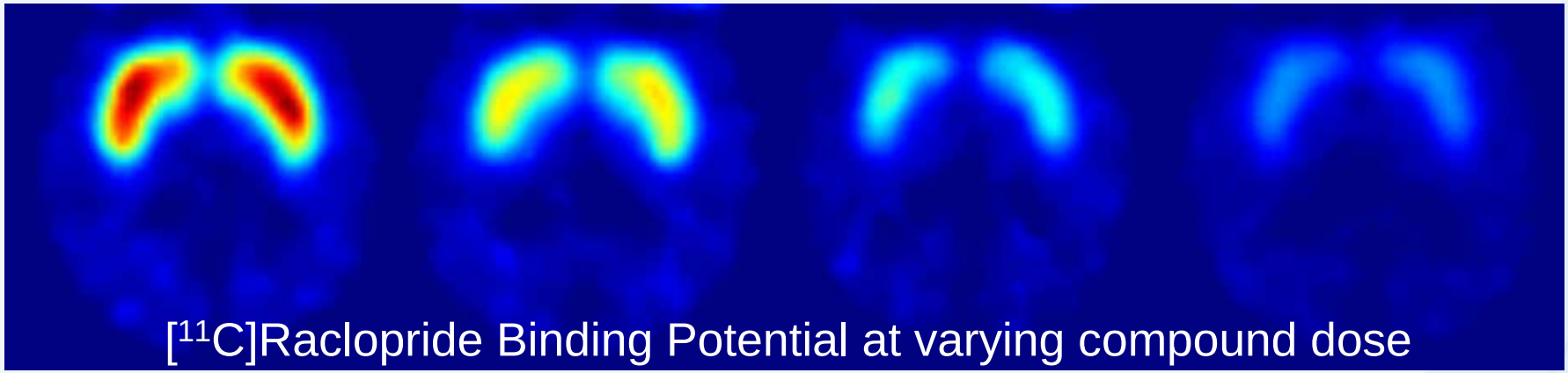
Overview

- Background
- Experimental work
- Results
- Context
- Conclusions

GSK clinical imaging centre – by night

Background (1)

- PET-CT used at CIC for range of studies
  - Receptor occupancy
  - Kinetics and dynamics of drug metabolism
  - Biomarkers for disease progression
  - Dosimetry of new PET ligands
- Mostly C-11 based scanning
  - Flexible chemistry
  - 20 minute half life ~ ¼ of F-18 dose per MBq



[^{11}C]Raclopride Binding Potential at varying compound dose

Background (2)

- Studied group is often healthy volunteers
  - No direct benefit to individual from scan
- CT for attenuation correction only
  - Rarely for any diagnostic purpose
  - Extra radiation dose to healthy volunteer
  - Low dose protocol – 130 kV, 30 mAs*
- Typical 10 mSv total dose constraint for a study
  - May include up to 3 PET-CT scans
- Effective dose from CT per scan
  - Approx. 1.5 mSv for body
  - 0.2 mSv for head

* All CT mAs values in this talk are 'effective mAs', taking pitch into account

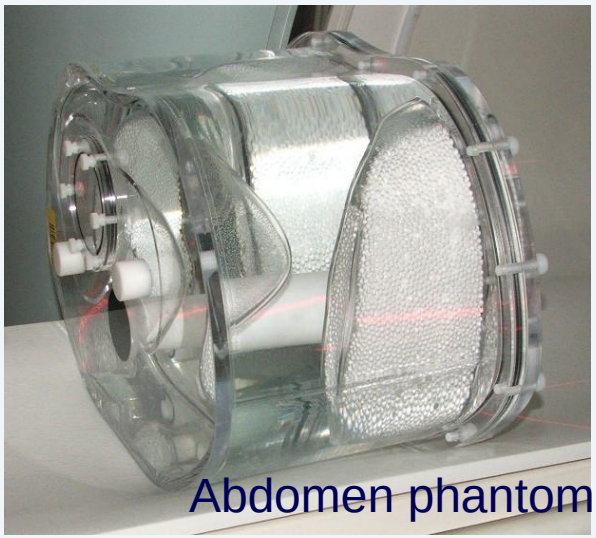
Experimental questions

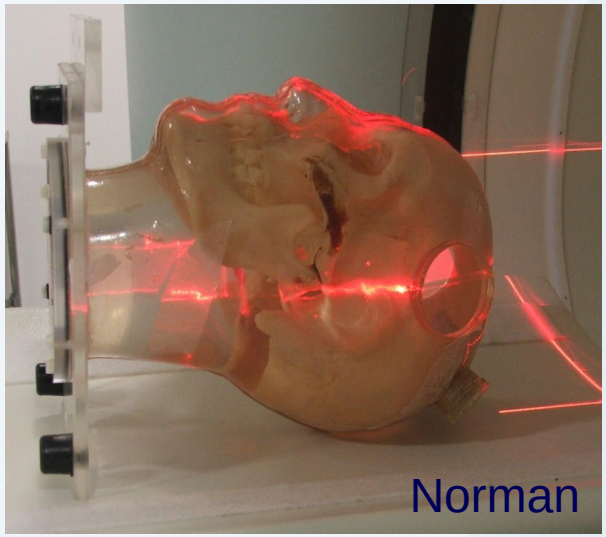
- Dose (how low can you go)?
  - How low can we turn the CT dose?
- What is the effect of reduced CT dose on PET IQ?
  - Change in PET pixel values?
  - Change in PET image noise?
- Is there a minimum limit on CT technique?
- How does dose reduction by changing kV and mAs compare?

Experimental setup (1) - Equipment

- Siemens Biograph 6 TruePoint / TrueView
  - LSO crystals, 216 mm axial FOV, 6 Slice 'Emotion' scanner
- Abdomen phantom with spine, lungs, liver
  - Add on Teflon 'arm' bone
- Skull phantom 'Norman' (thanks to RMH, Sutton)


Biograph 6


Abdomen phantom

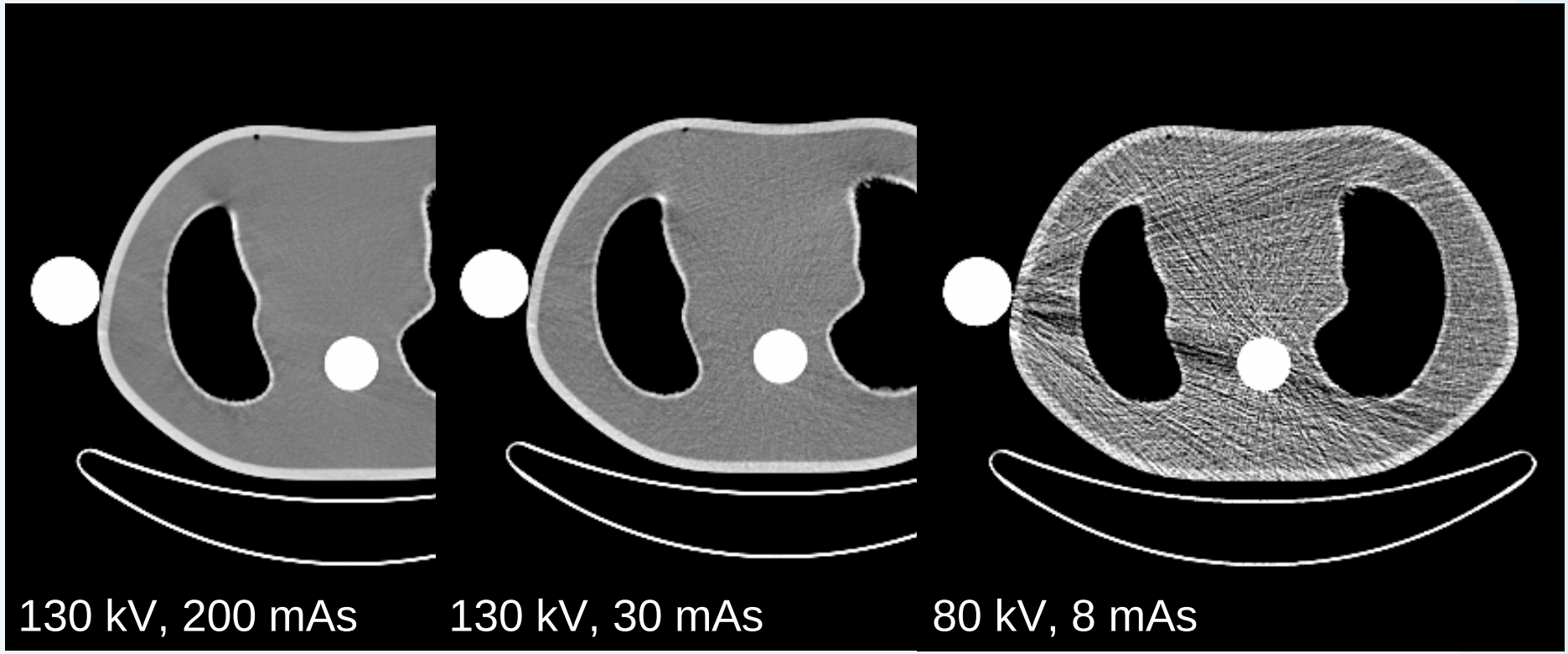

Norman

Experimental setup (2) - Scanning

- CT at different kV / mAs settings
  - 80, 110, 130 kV
  - 8, 10, 15, 20, 30, 200 mAs
  - Siemens standard is 130 kV, 30 mAs
    - Pitch 1.5, 6 x 3 mm collimation, 5 mm slice, B19
- Acquire list mode PET images of phantom (1 hour)
  - Reconstruct using each CT acquisition for attenuation correction

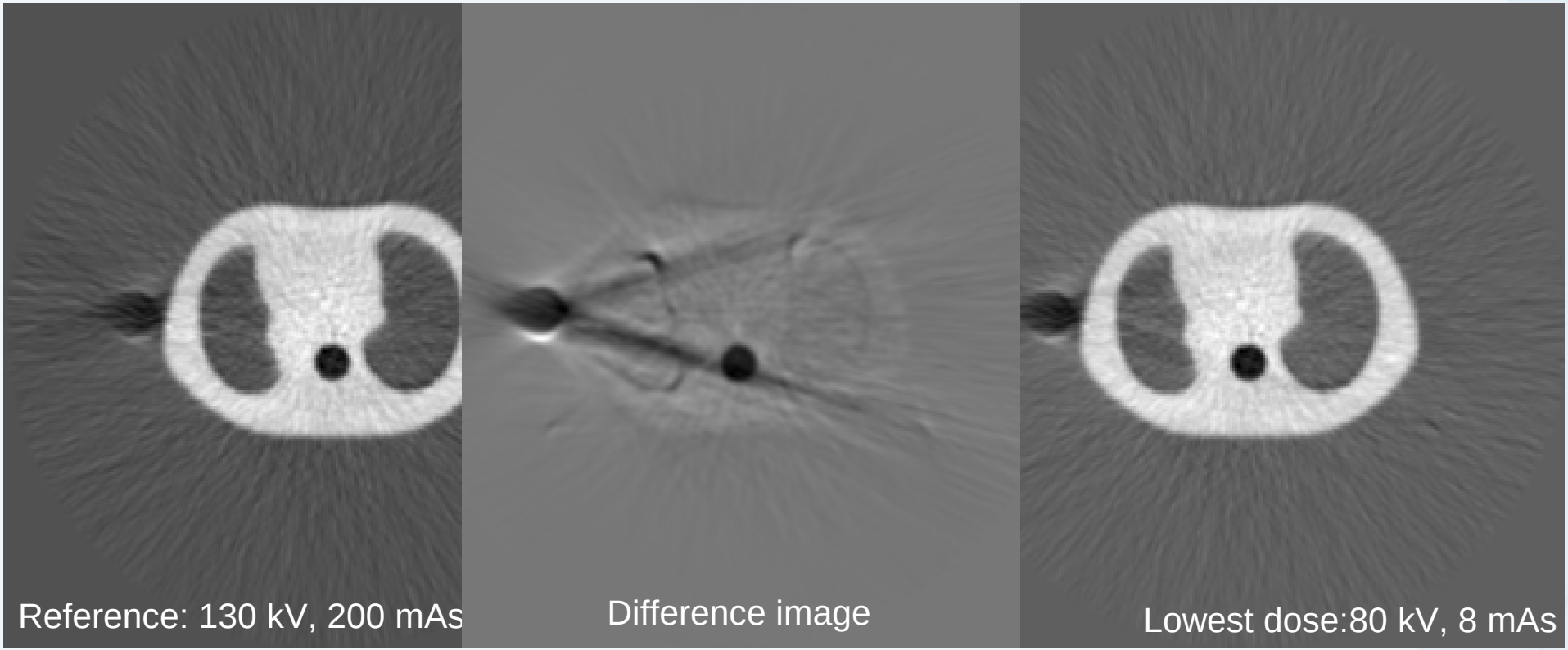
Results (1) – CT images

- CT images at 'reference', standard and lowest setting



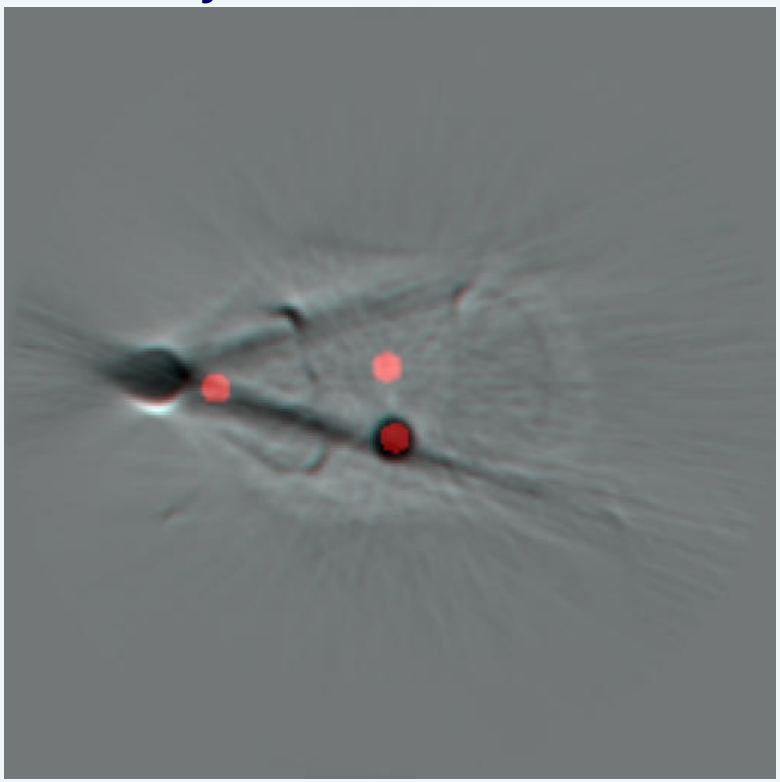
Results (2) – PET images

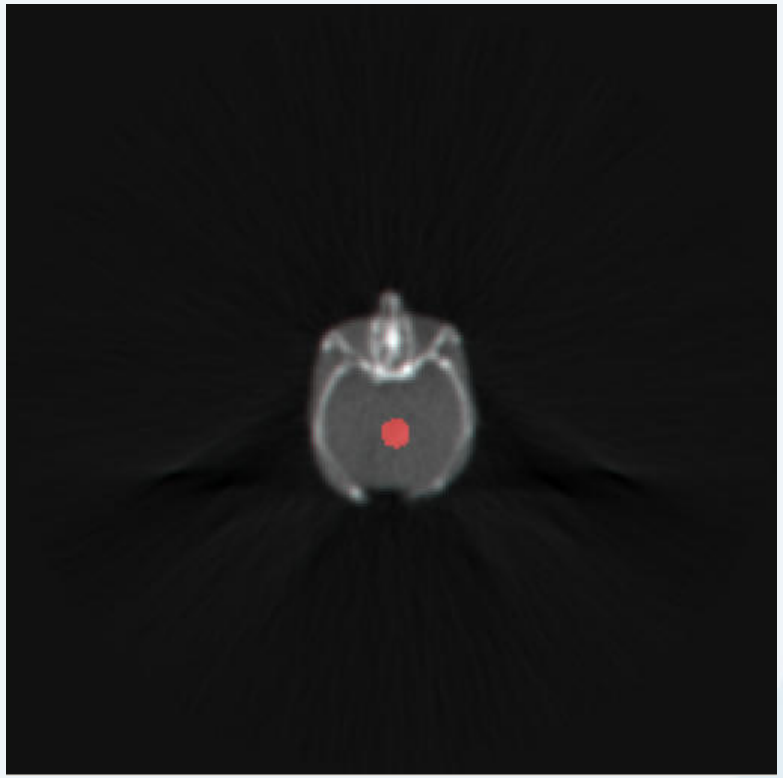
- PET images at same point from 1 hour scan
  - FBP reconstruction, 5mm Gaussian filter
- Spot the difference?



Results (3) - Analysis

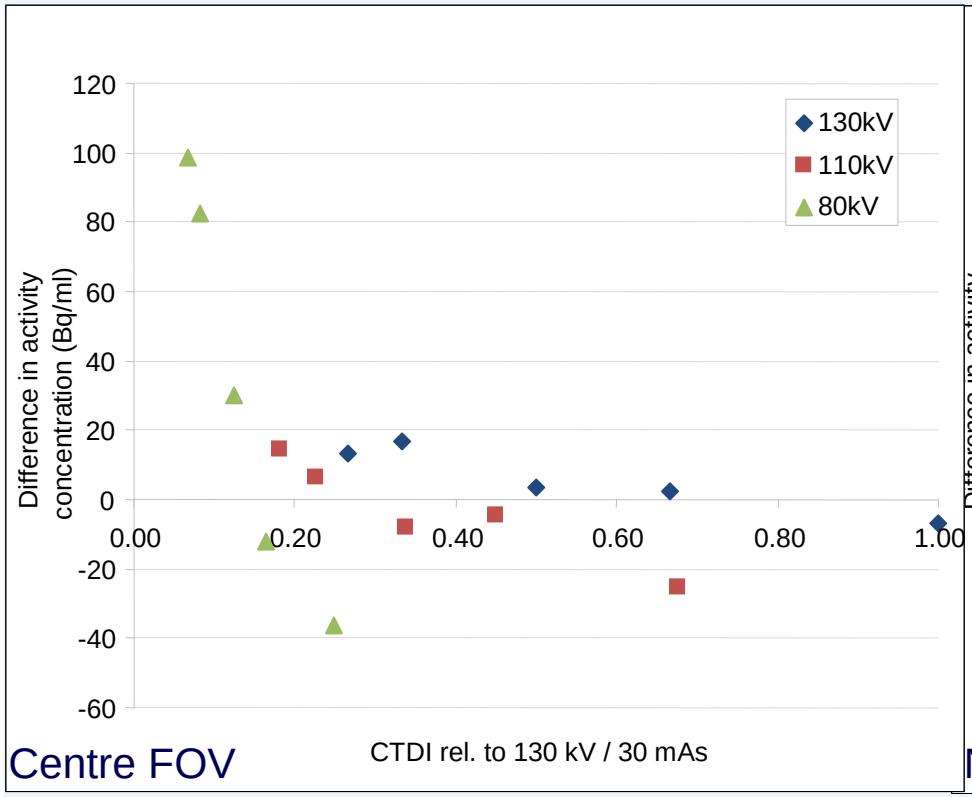
- ROIs – centre phantom, + near arm and in spine for body
  - Calculate mean and SD for each ROI
  - Mean of 20 (10 in head) images in middle of phantom
  - Analysis for each PET data set



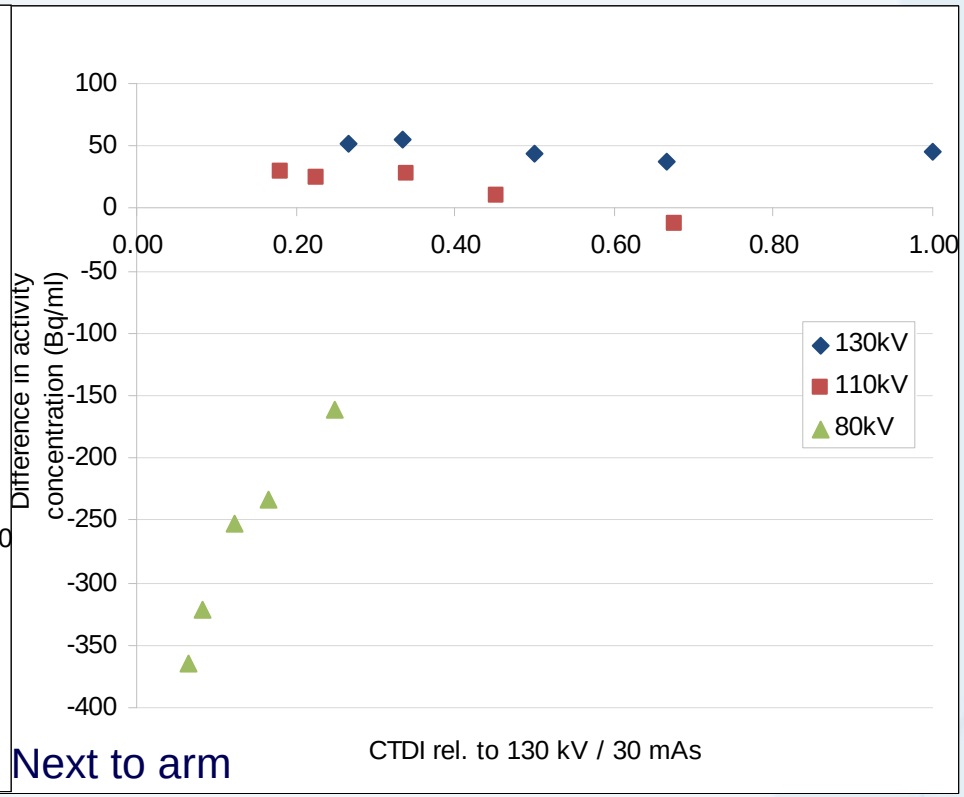


Results (4) Difference in pixel value vs. rel. CTDI

- Compared to 130 kV / 200 mAs (mean ~ 7000 Bq/ml)
  - Difference < 100 Bq/ml at centre FOV
  - Difference up to 400 Bq/ml next to arm, due to artefact



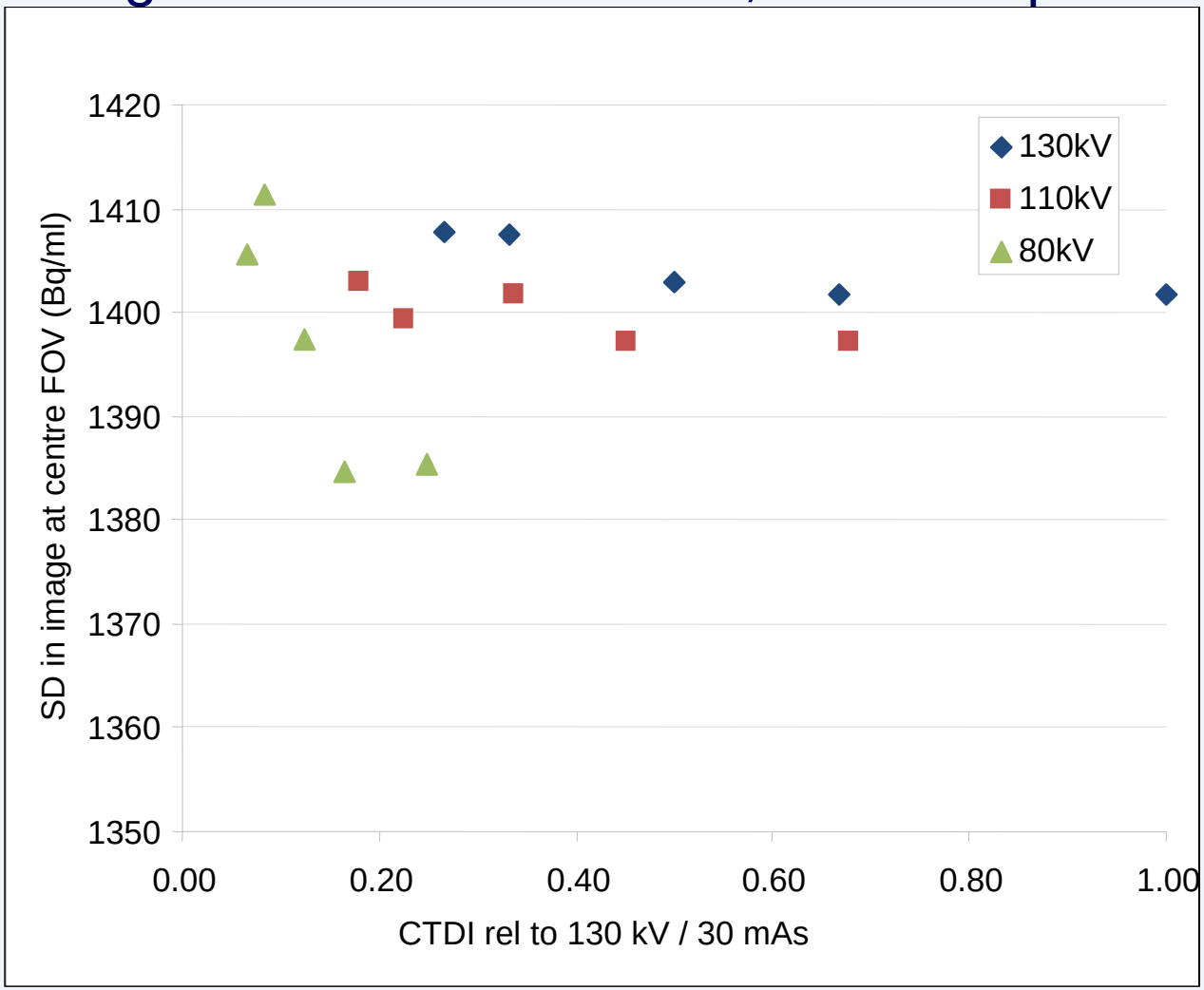
Centre FOV



Next to arm

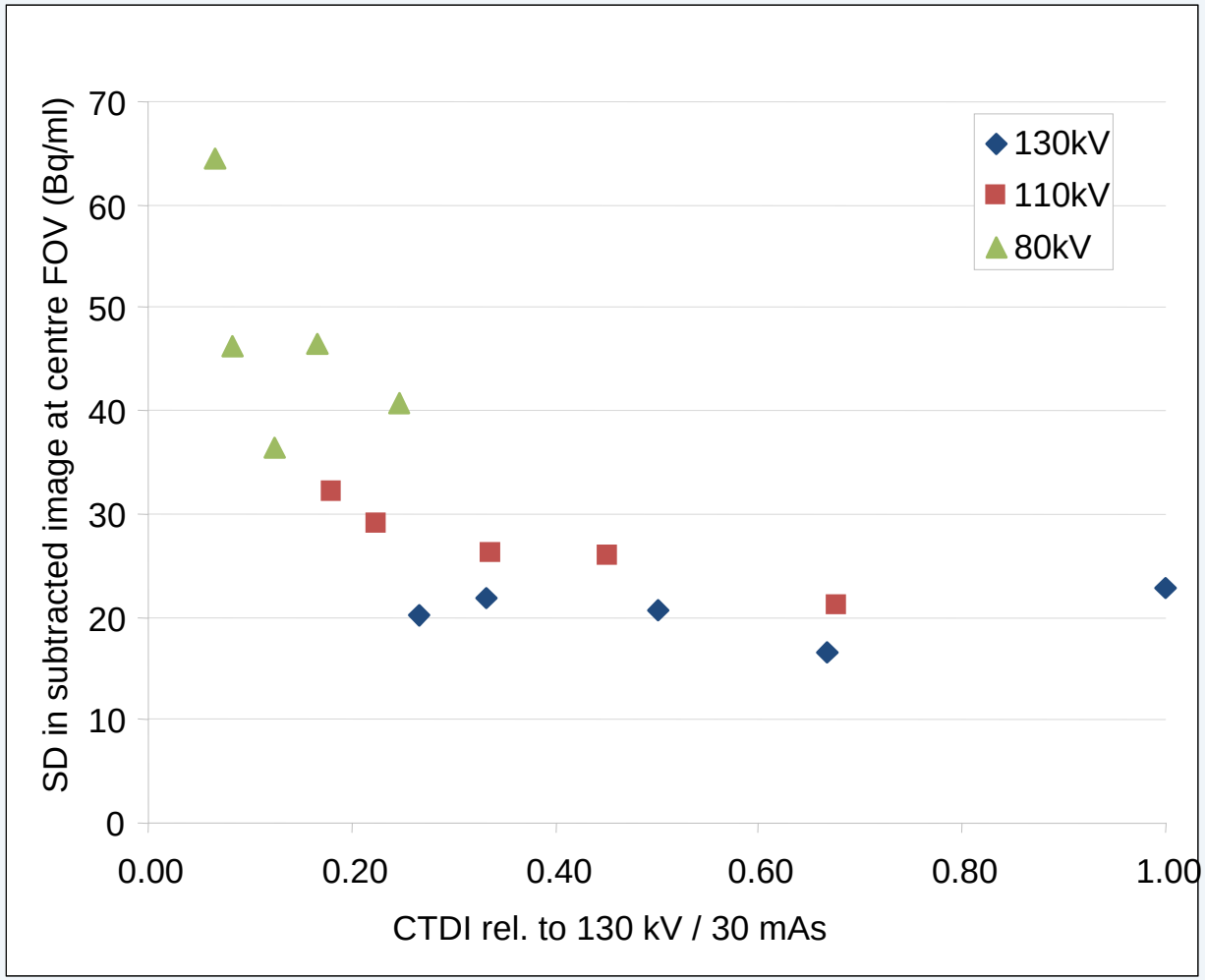
Results (5) – SD vs. rel. CTDI

- PET image SD vs relative CTDI, 5 min acquisition



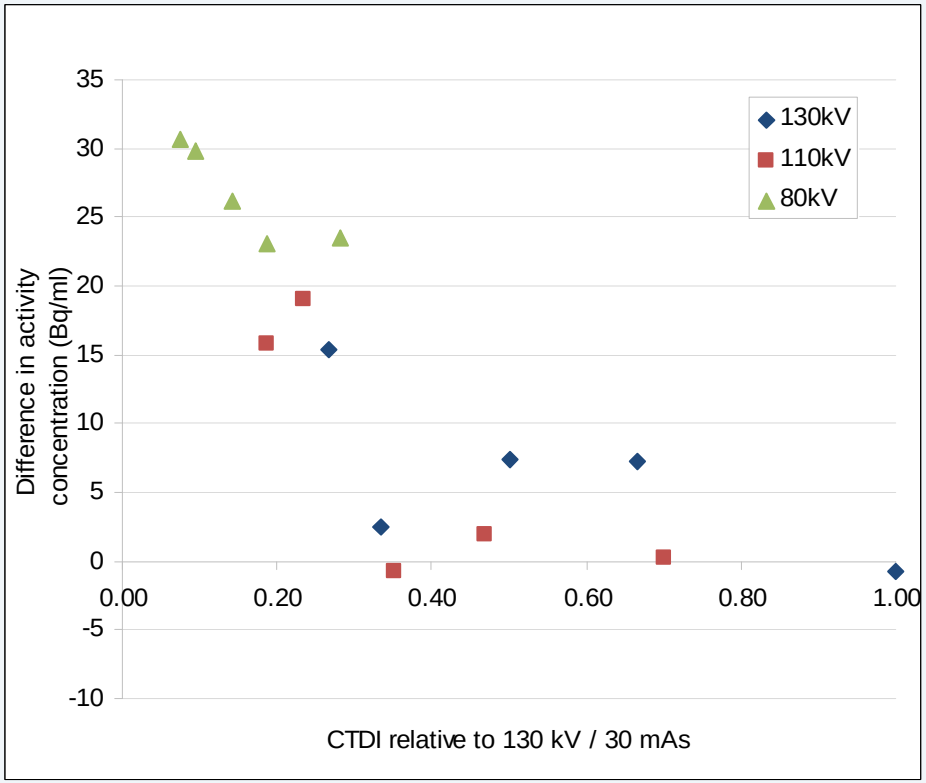
Results (6) – SD vs. rel. CTDI (subtracted)

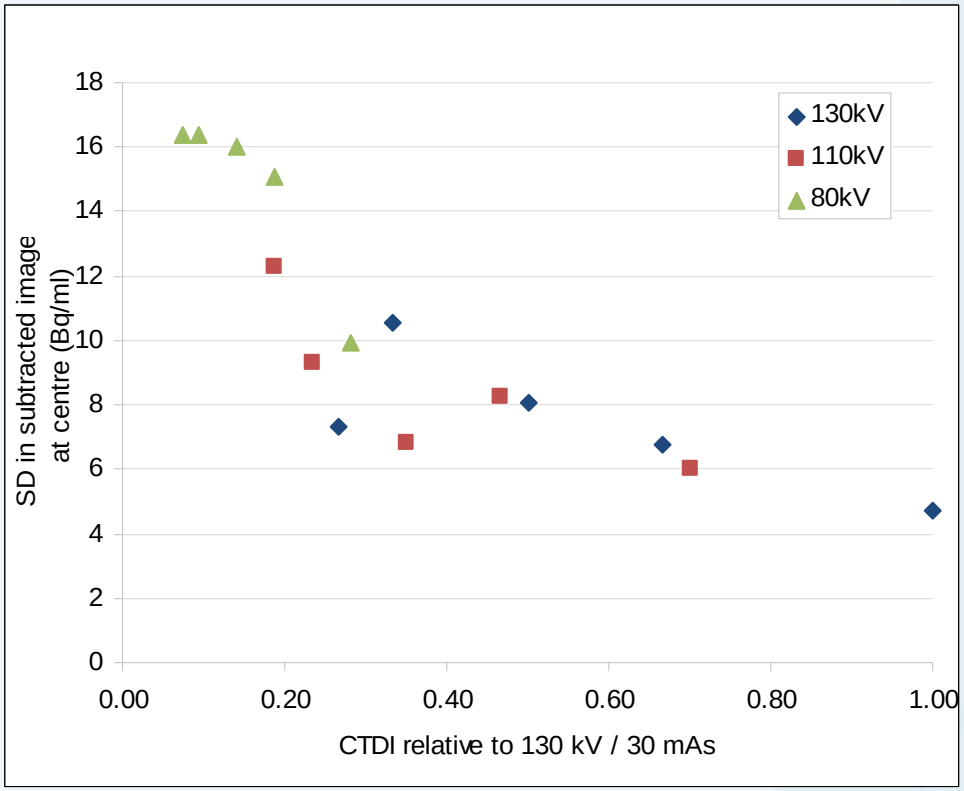
- PET image SD vs relative CTDI
  - images subtracted from 130 kV / 200 mAs reference scan



Results (7) – Head images

- Pixel value difference and SD from reference images vs. relative CTDI
  - Difference and SD smaller than in body





Results (8) – Trends between SD and CTDI

- Correlation between SD in subtracted PET images and relative CTDI

	Body (centre)	**Head**
All kVs	-0.73	-0.82
80 kV only	-0.96	-0.93
110 kV only	-0.97	-0.80
130 kV only	-0.48	-0.79

Context (1) – Effective Dose reduction

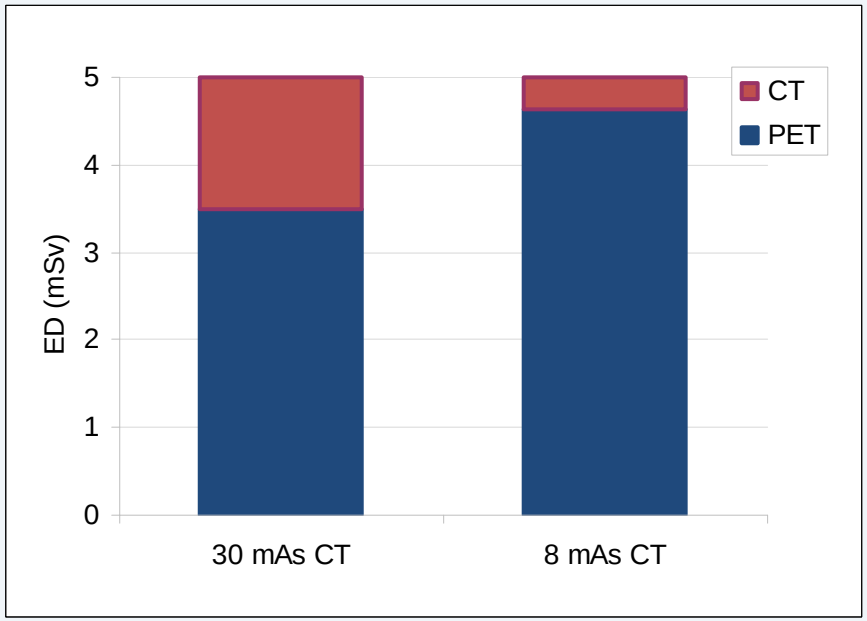
Effective mAs	Relative ED
8	0.27
15	0.50
30	1.00

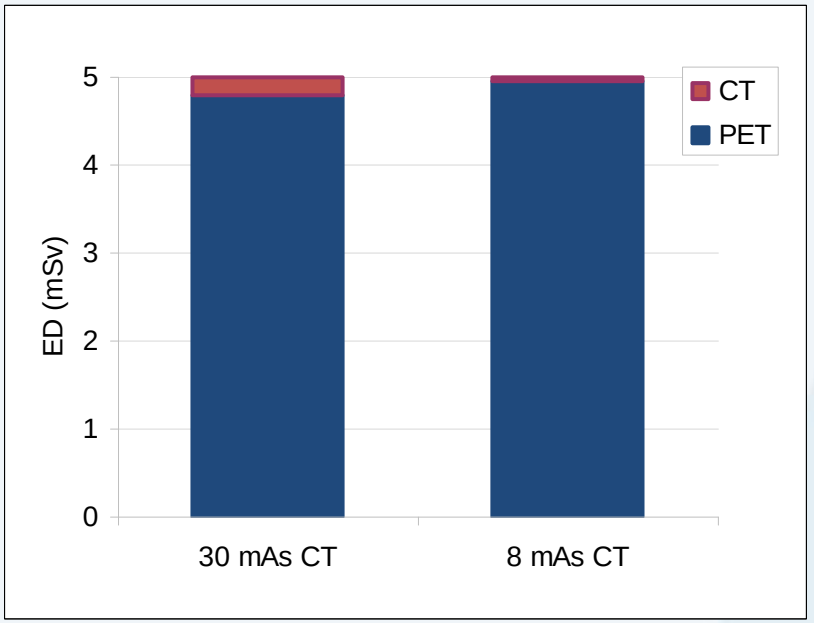
Abdomen	ED (mSv) @ 30mAs	Relative ED
80 kV	0.34	0.24
110 kV	0.89	0.64
130 kV	1.4	1.00

Head	ED (mSv) @ 30 mAs	Relative ED
80 kV	0.15	0.42
110 kV	0.31	0.86
130 kV	0.36	1.00

Context (2) – Effect on dose constraints

- CT Dose savings of ~ 75% by reducing mAs alone
  - 1.1 mSv for body, 0.15 mSv for head
- Could 'spend' reduced CT dose on increased PET activity
  - 30% increase for body (2 scan study)
  - 3% for head





Conclusions

- Mean PET value affected by changing kV
  - Little effect from changing mAs
- PET SD increased at reduced CT technique (kV and mAs)
  - Effect smaller for head
  - Due to less attenuation correction in smaller cross section?
- Effective Dose reduction from low dose CT is much more significant for body scanning

- Change attenuation scan technique to 130 kV, 8-10 mAs
  - Look into reducing kV, but do so with caution
- Results valid for Siemens scanners only
  - No way of knowing what happens with GE / Philips