CT AEC Techniques in PET/CT scanning

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CT in PET

- CT introduced into PET ~2000
- CT used for:
  - attenuation correction
  - attenuation correction & localisation
  - radiotherapy planning
  - diagnosis
- Range of image quality and dose

Lack of current dose data

- Some protocol information from UK PET SIG survey 2005 – old scanners
- French survey 2011[1]
  - Eyes-thighs scans
  - Attenuation correction & localisation

	Average	National DRL
CTDIvol (mGy)	6.6	8.0
DLP (mGycm)	628	750

1. Cecile Etard et al, National survey of patient doses from whole body FDG PET-CT examinations in France in 2011, Radiation Protection Dosimetry, 2012

Collaborative project

- Two PET/CT scanners in Leeds
  - GE Discovery 690
    - Run by Leeds Trust
  - Philips Gemini TF
    - Run by Alliance Medical
- One PET/CT scanner in Central Manchester Trust
  - Siemens Biograph mCT
- All are current 64 slice models

GE scan protocols

	GE default	Clinical
kV	120	120
Detector coverage (mm)	40	40
AEC settings	NI = 25 30-210 mA Auto & SmartmA	NI = 35 30-450 mA Auto & SmartmA
Pitch	1.375	1.375
Rot time (s)	0.5	0.5
Primary image width (mm)	3.75	3.75

Philips scan protocols

	Recommended
kV	140
Detector coverage (mm)	40
AEC settings	Fixed 50mAs/slice with D-DOM
Pitch	0.829
Rot time (s)	0.5
Primary image width (mm)	4

- “Don’t use Z-DOM if scanning whole body”
  - May modulate too low in places
- “D-DOM poor in pelvis”

Changes needed

- Clinicians wanted more contrast in images
- Very bad images for large patients
- Developed weight based protocols[1]

144kg, 1.55m, BMI=59.9, arms down
– 120kV, 90mAs/slice, DDOM on

1. Livingstone, Pradip, Dinakran, Srikanth "Radiation doses during chest examinations using dose modulation techniques in multislice CT scanner", Indian J Radiol Imaging. 2010 May; 20(2): 154–157

Weight based protocols

Weight (kg)	kV	mAs/slice	D-DOM
40-60	120	72	On*
61-80	120	80	On*
81-110	120	90	On*
110+	140	80	Off
110+ arms down	140	120	Off

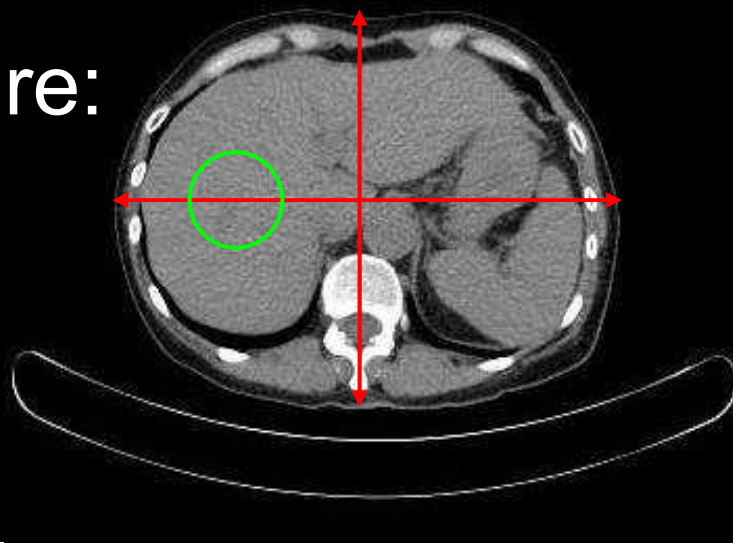
* Off for “round” and arms down patients. “DDOM scaling of abdominal mAs will be inappropriate with non-standard body shapes.”

Siemens protocols

	Siemens default/clinical
kV	120
Beam collimation (mm)	16*1.2
AEC settings	Q.Ref mAs = 30 CARE Dose 4D Average/Average
Pitch	1.5
Rot time (s)	0.5
Primary image width (mm)	4

Dose & image quality methods

- For “eyes to thighs” scans only
- Record:
  - CTDIvol & DLP from dose report
  - Patient weight
- At mid point of liver measure:
  - AP & lateral dimensions
  - Liver noise



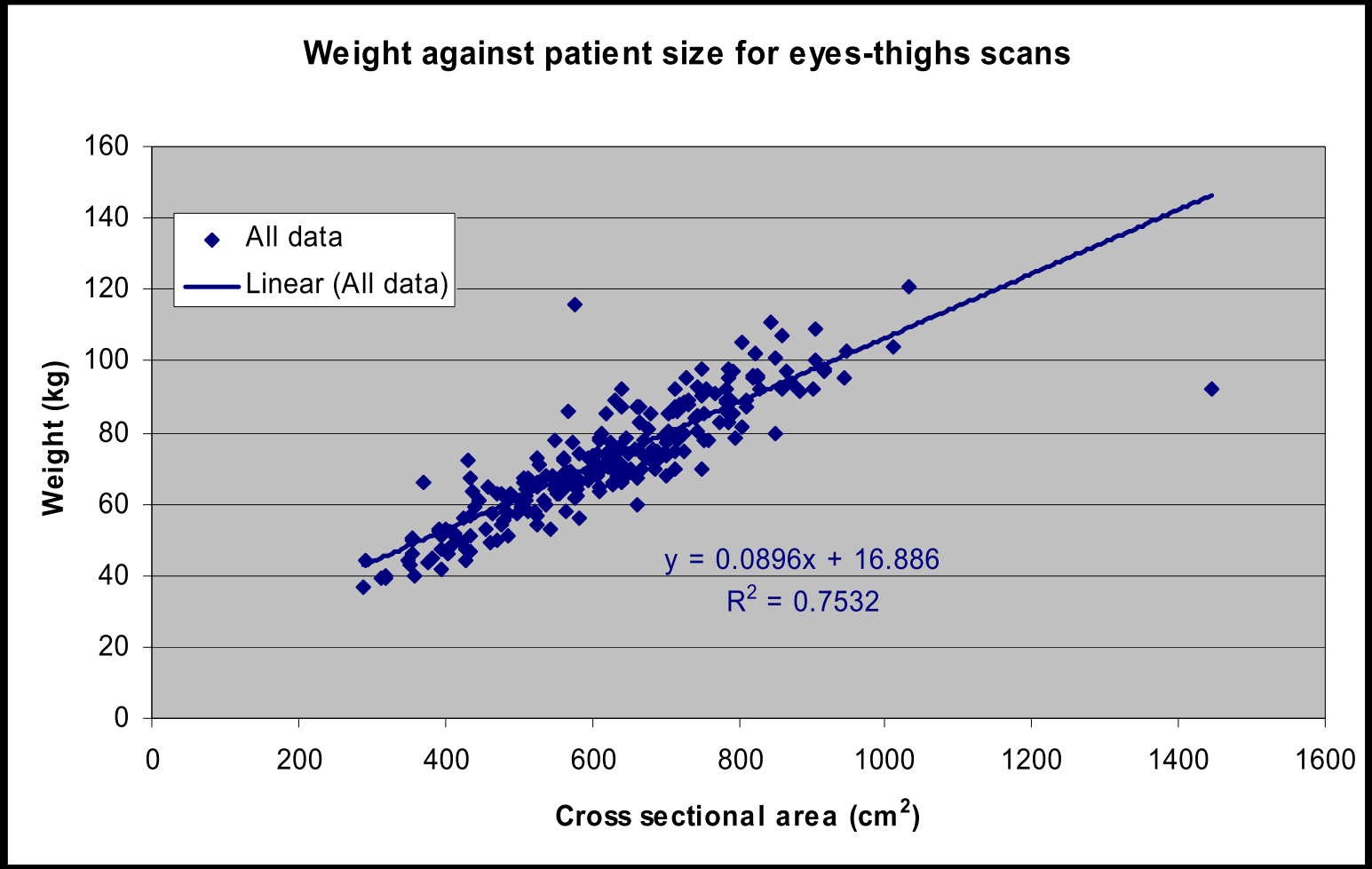
Katie Howard et al – CTUG 2008

3rd UK CT dose survey

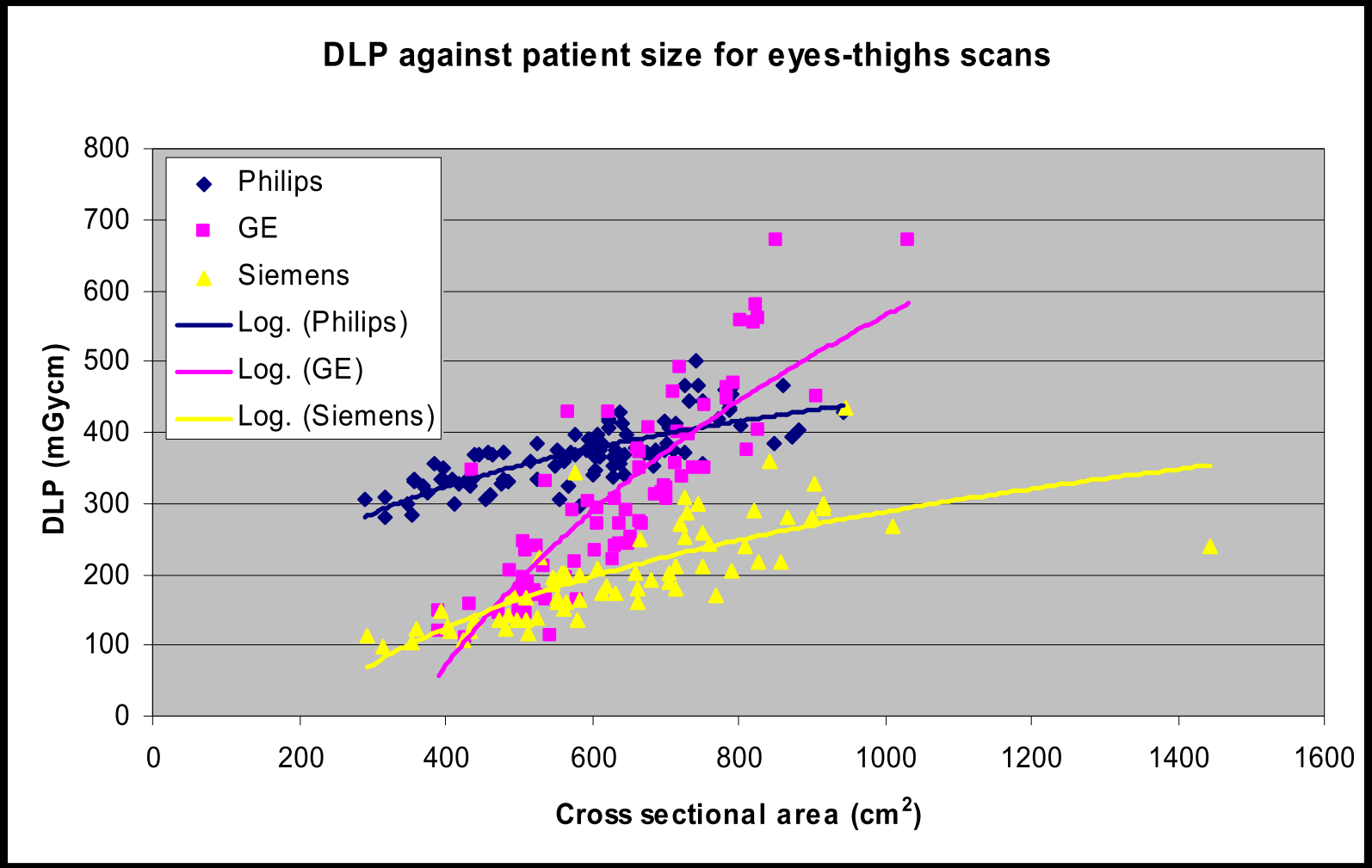
Sample statistics

	GE	Philips	Siemens
Sample size	73	103	71
Weight (kg)	76 (52-121)	69 (37-107)	75 (39-116)
Age	60 (20-82)	65 (16-89)	64 (15-86)
Gender	M: 38 F: 35	M: 49 F: 54	M: 42 F: 29

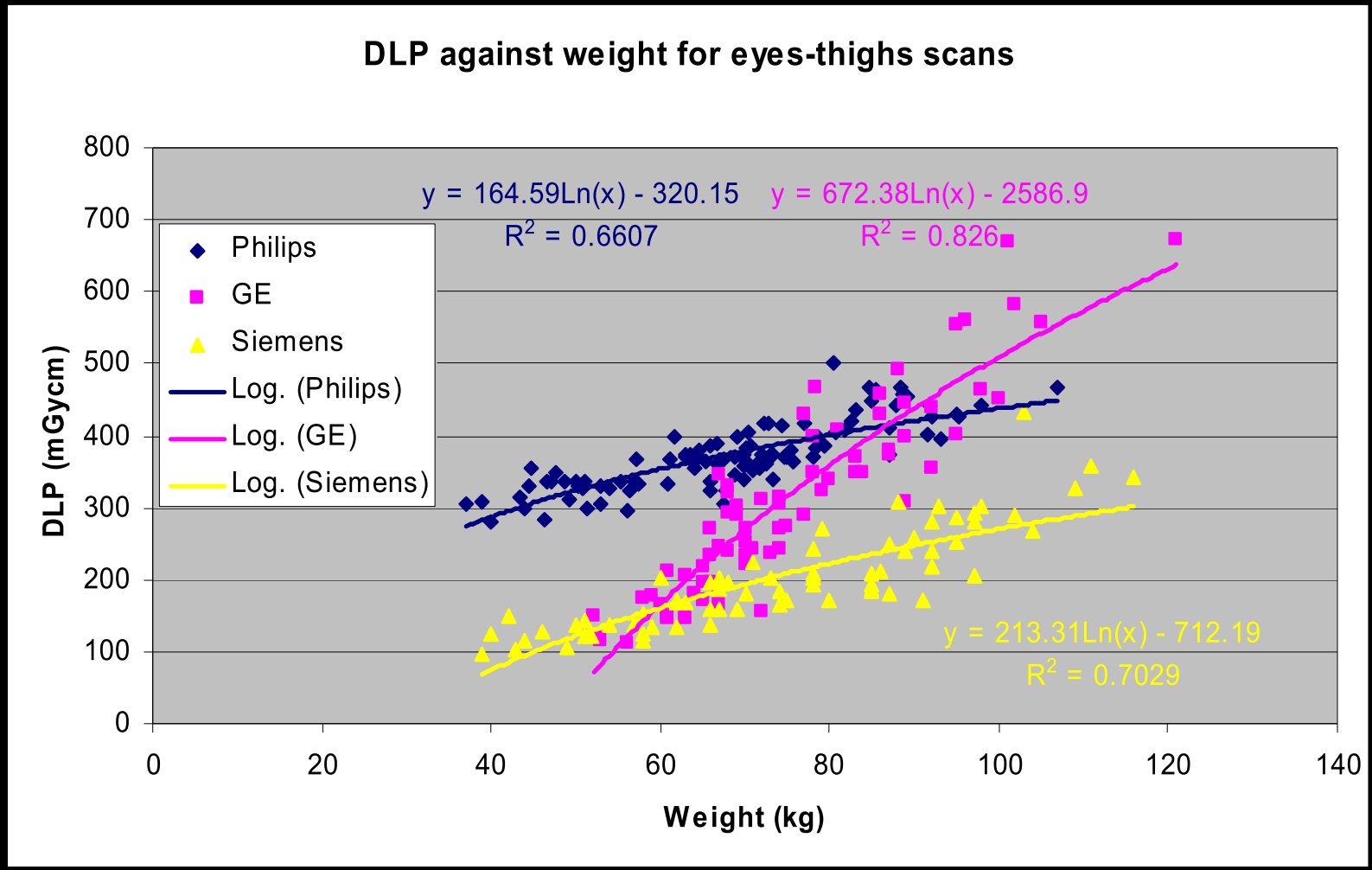
Size or weight?



Dose vs. patient size



Dose vs. weight



Relative dose vs. weight

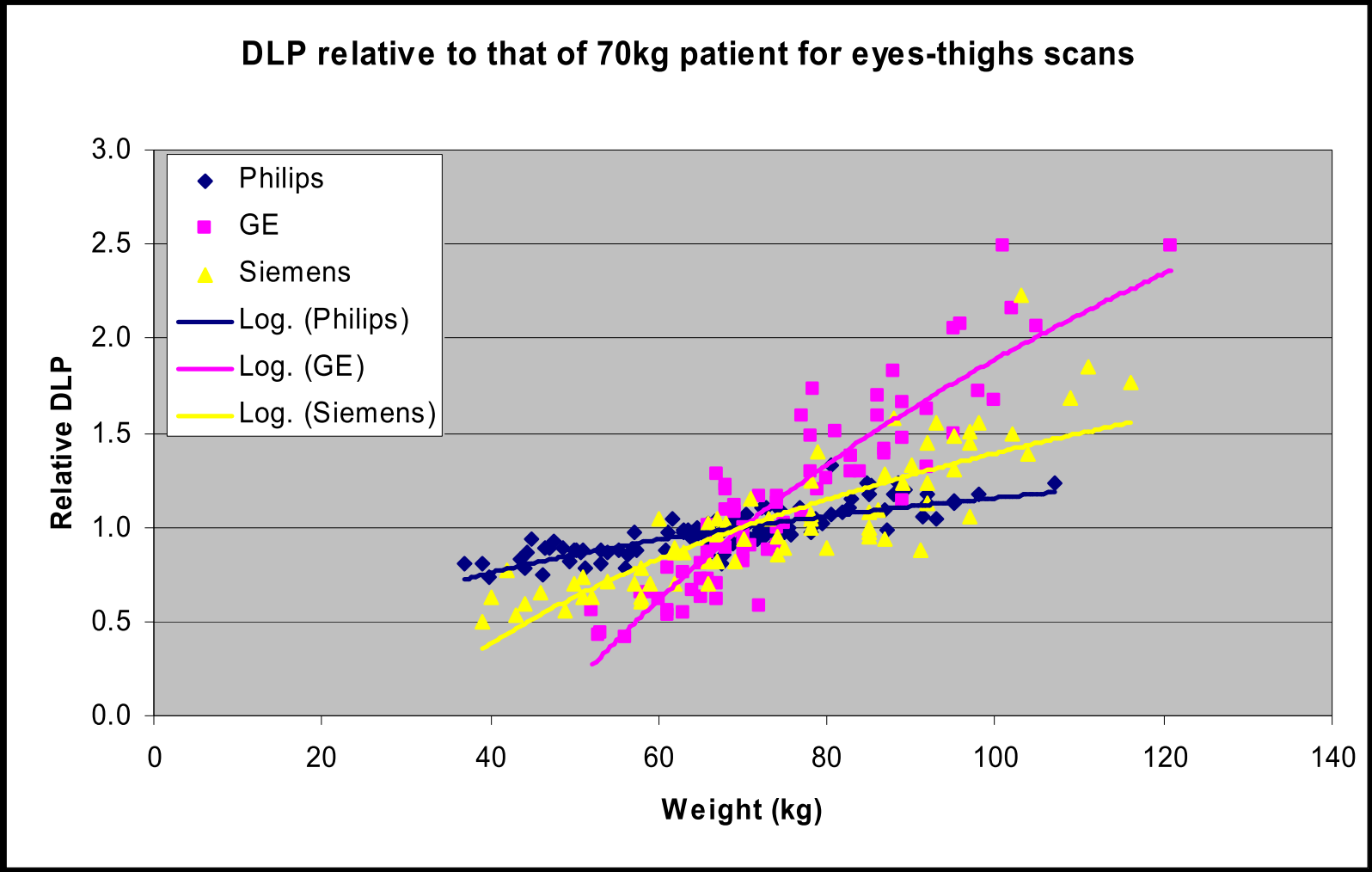
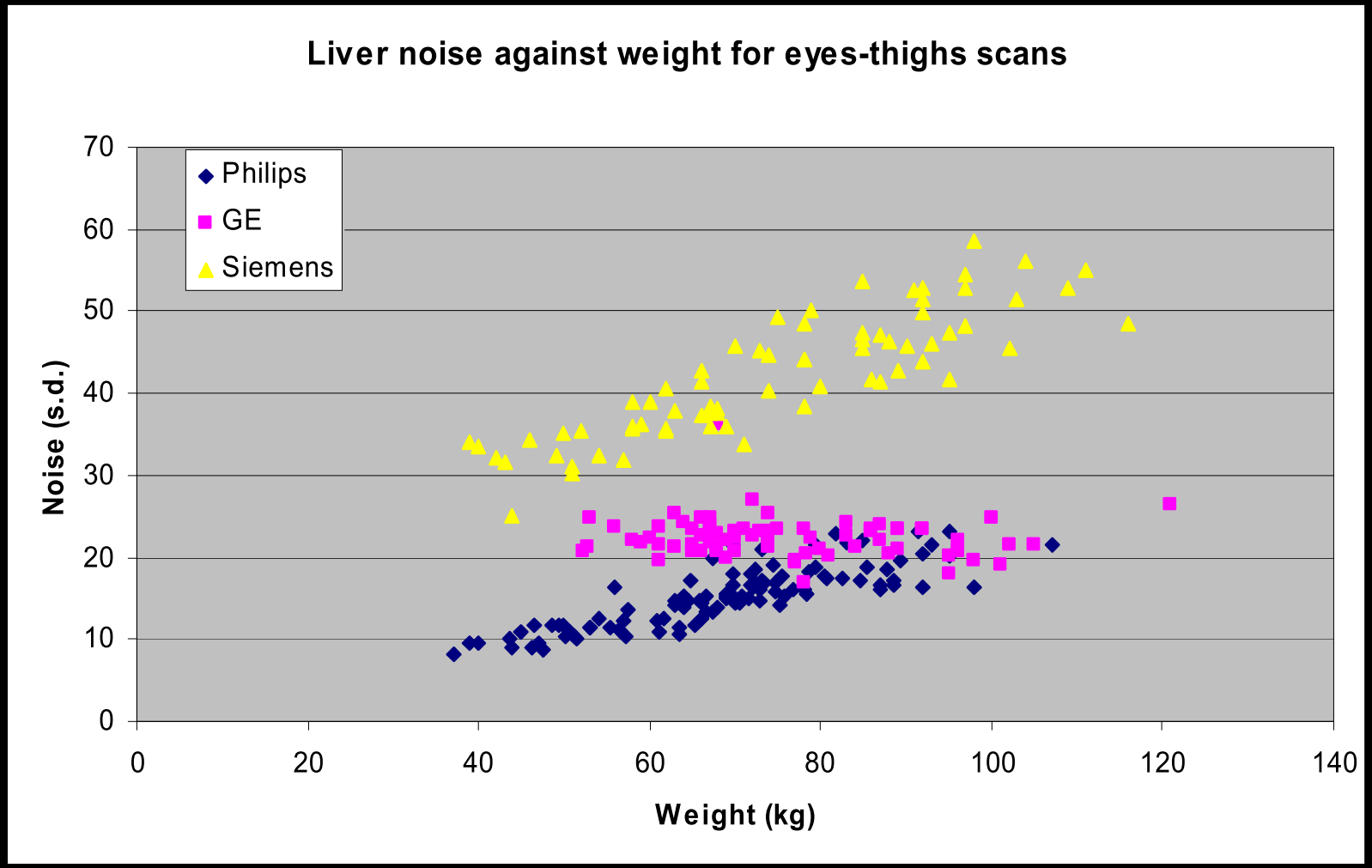


Image noise vs. weight



Dose and IQ comparisons

Mean DLP (mGycm)	GE	Philips	Siemens*	French data
60-80 kg	261	370	186	-
50-100 kg	293	379	197	628
Mean liver noise	22.4	15.2	42.1	-

- Comparable data much lower than French data
- Philips doses much higher than GE
- Image quality very different

*Siemens is attenuation correction only, hence lower doses

Patient data summary

- Dose variation on Philips mainly due to weight based protocols
  - D-DOM makes no adjustment for weight/size
- GE adjusts dose much more rapidly with weight than Siemens system
  - Both performed as expected
- Very good correlation between DLP and weight

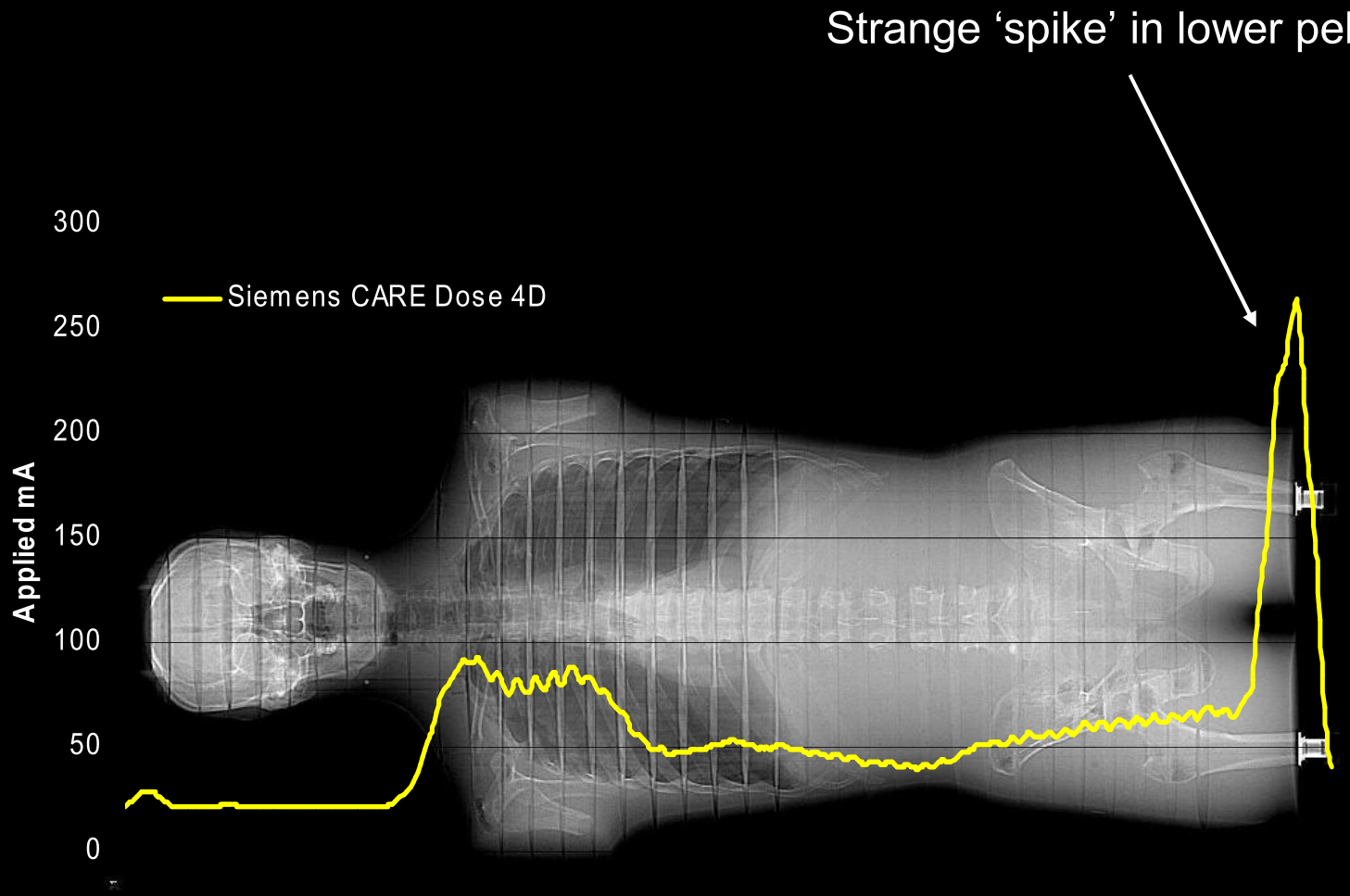
Patient data summary

- Potential for optimisation – especially for two scanners on same site
- Need to know how tube current varies along patient/phantom
- What could be changed to optimise the protocols?

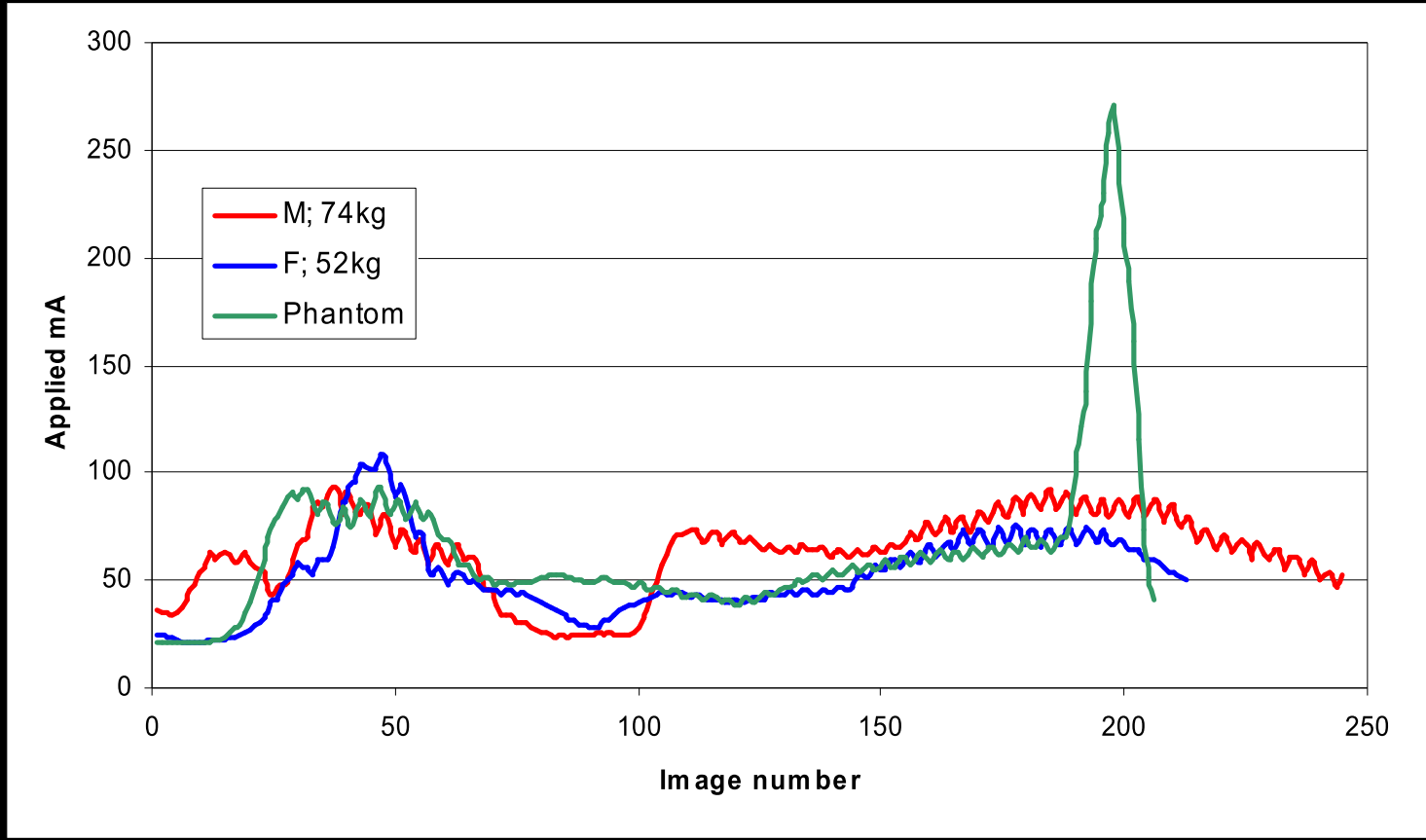
Rando phantom methods

- Scan on clinical protocols
  - Record CTDIvol and DLP
  - Extract mA values from DICOM headers
  - Adjust AEC settings and repeat

Initial Siemens results

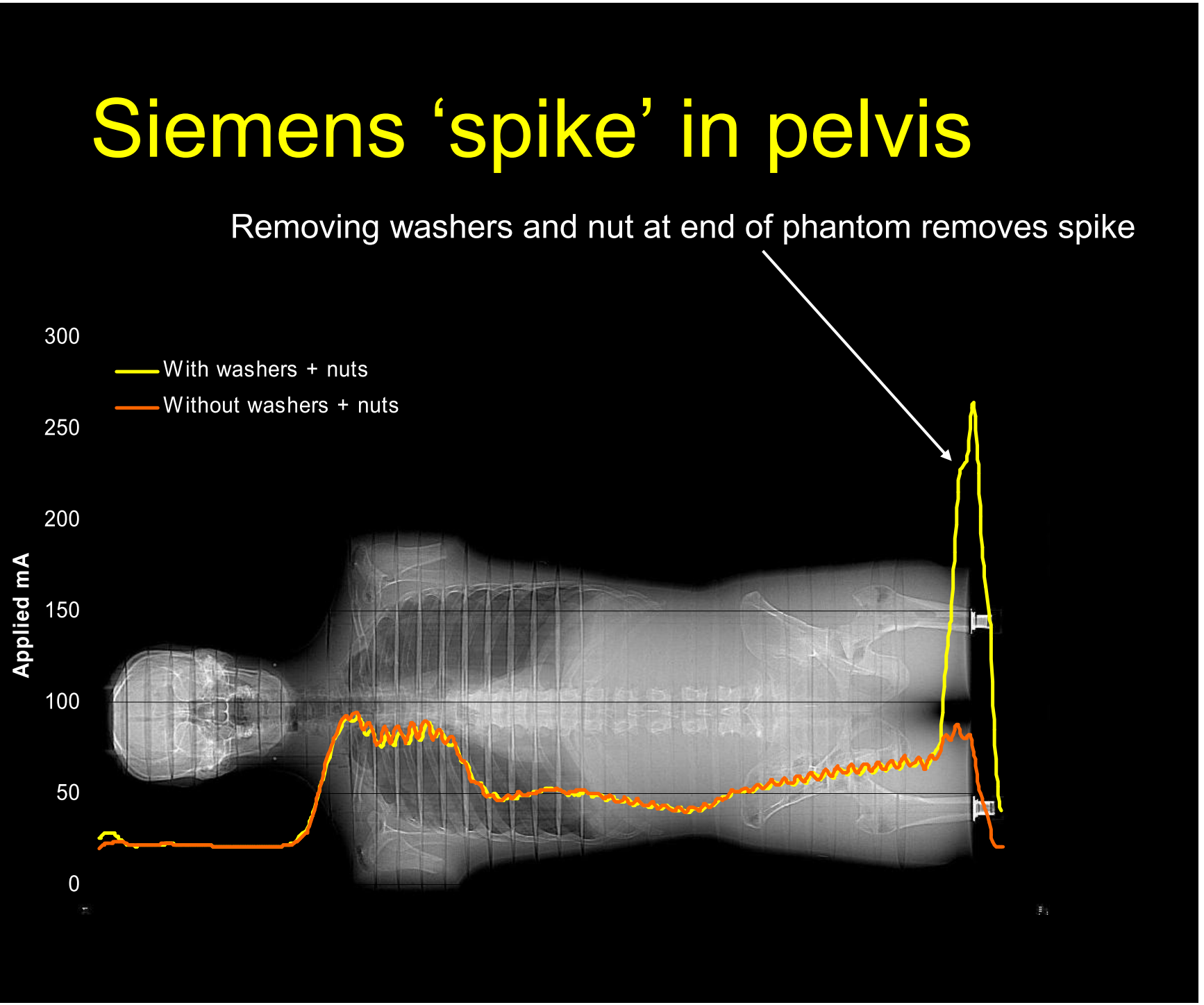


Not present on patients




The offending articles…
Biograph mCT
H2
H1
0
F1
F2
F3
F4

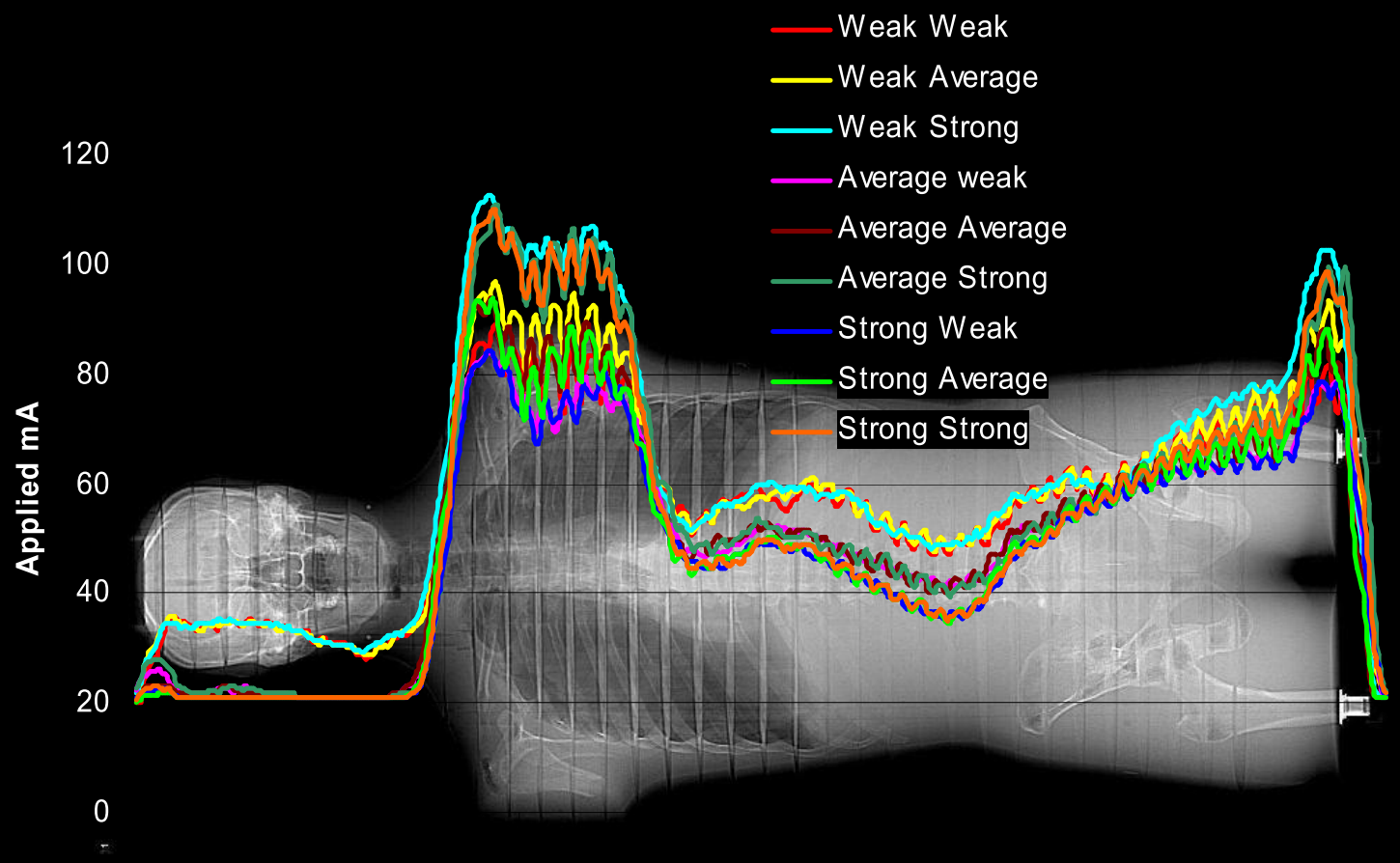
Siemens ‘spike’ in pelvis



Siemens options

CARE Dose 4D is x-y and z modulation

Vary adaptation strength settings

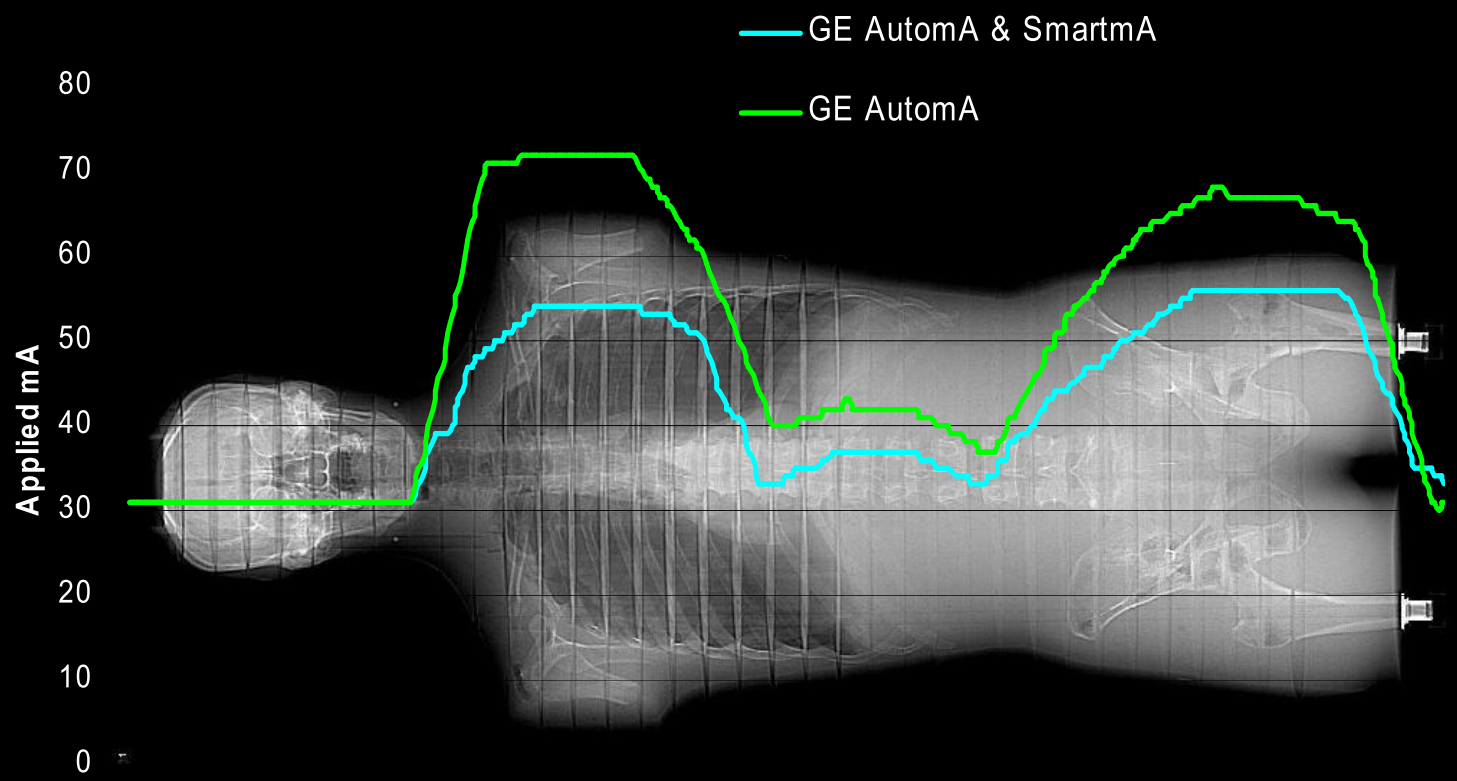


weak/strong 24% higher DLP than average/average; strong/weak 9% lower

GE options

x-y and z modulation used clinically

Test z axis only



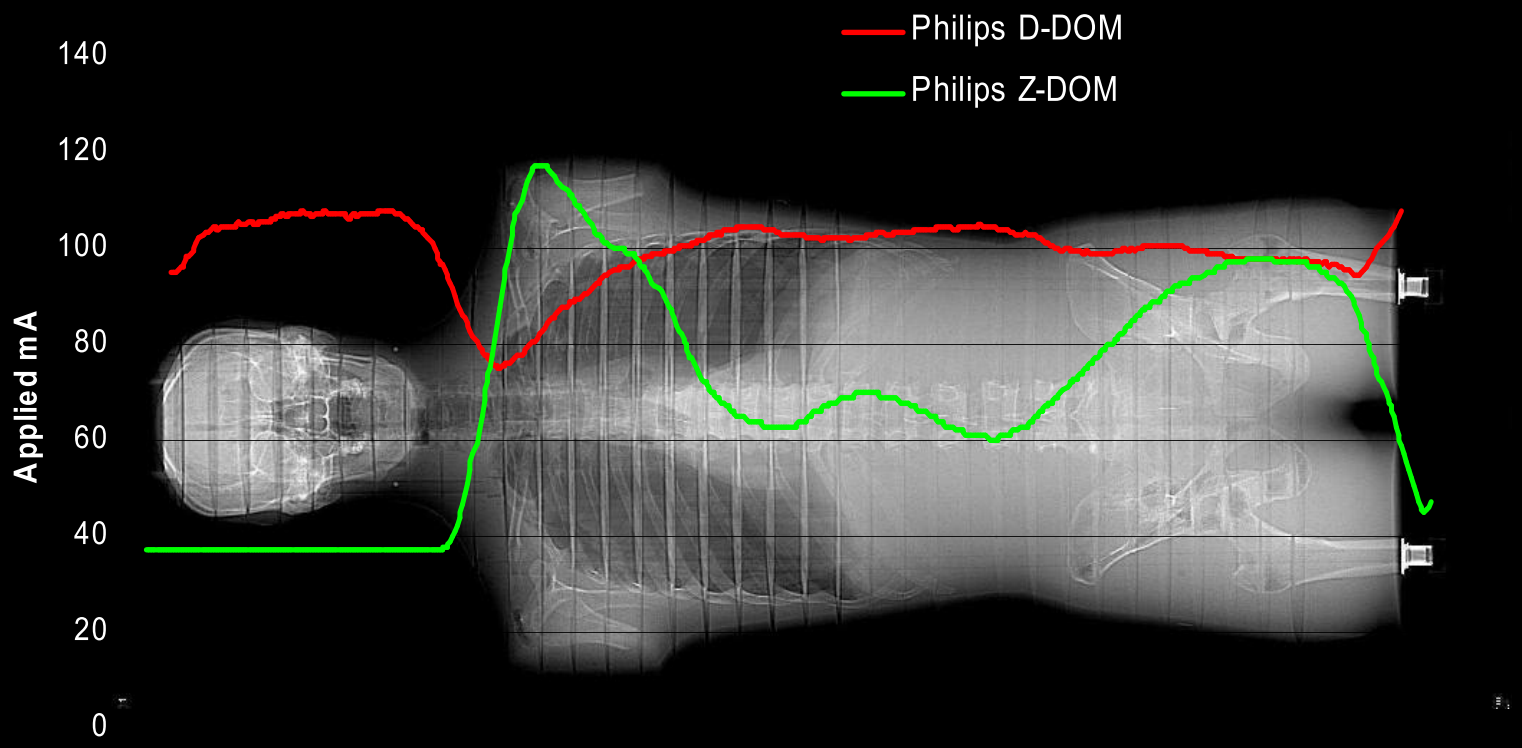
14% reduction in DLP with SmartmA included

Philips options

D-DOM set to 72mAs/slice

Set reference image at fixed 72mAs/slice

After repeat surview ACS suggested 72mAs/slice, then activate Z-DOM



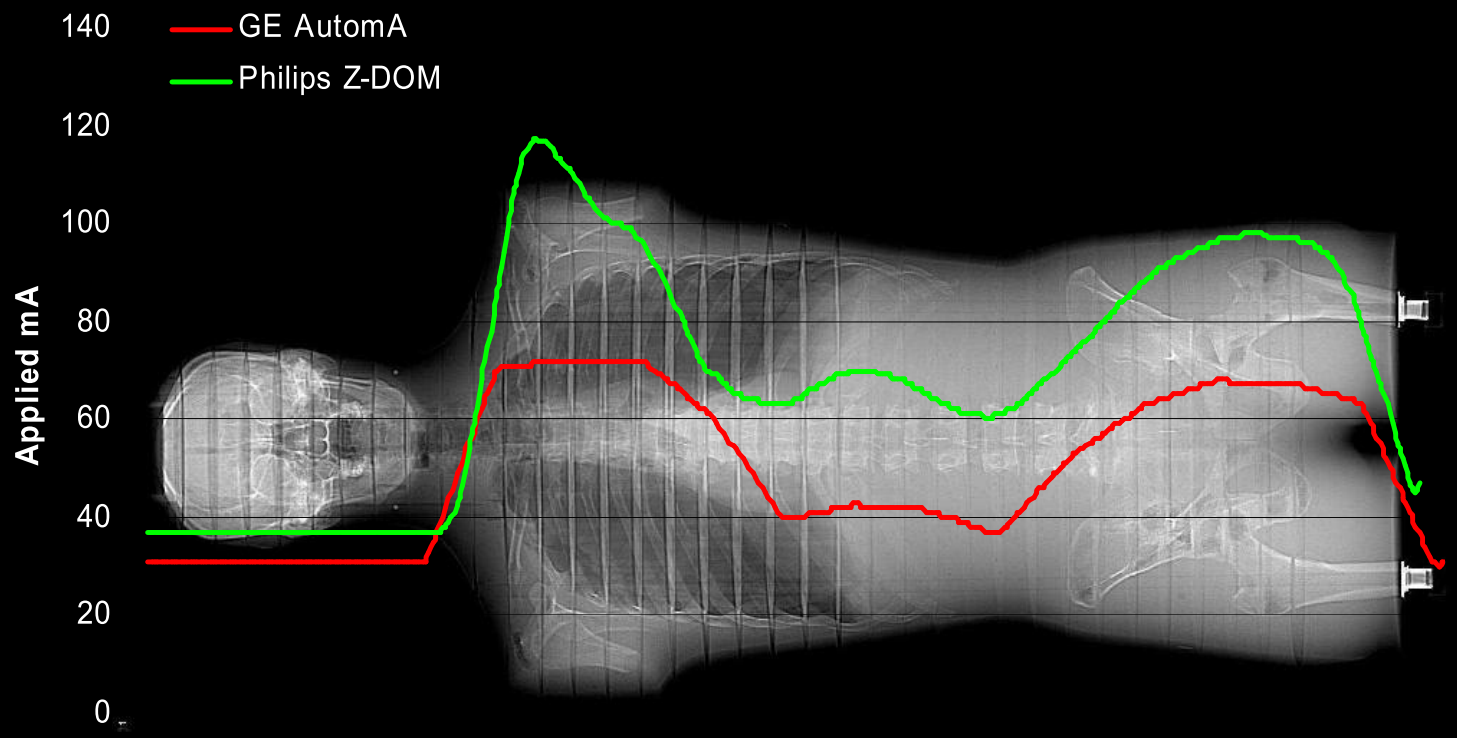
24% reduction in DLP with Z-DOM

Z-axis modulation only

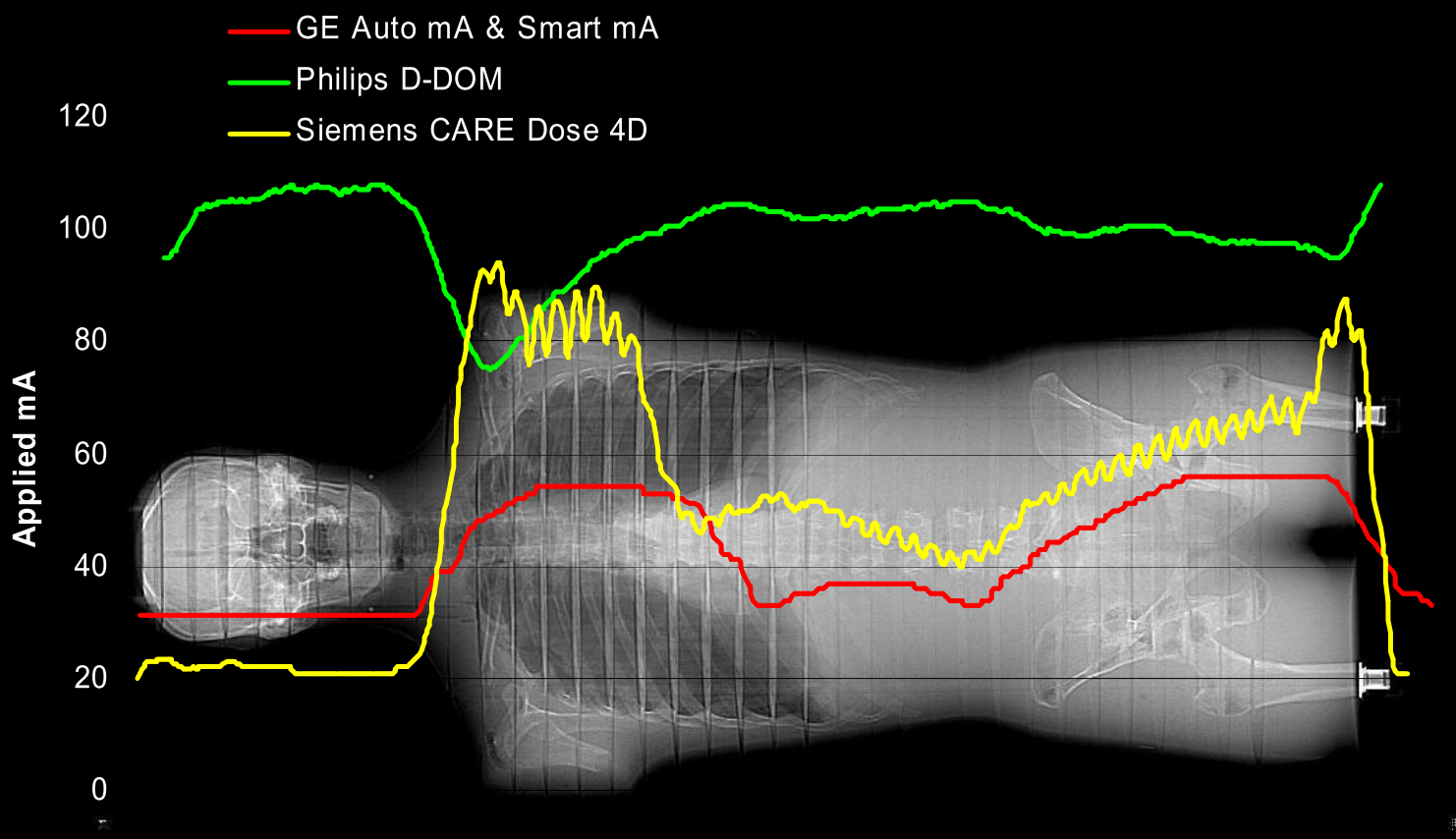
Overall shape very similar!

Philips values higher due to high mAs/slice setting on reference images

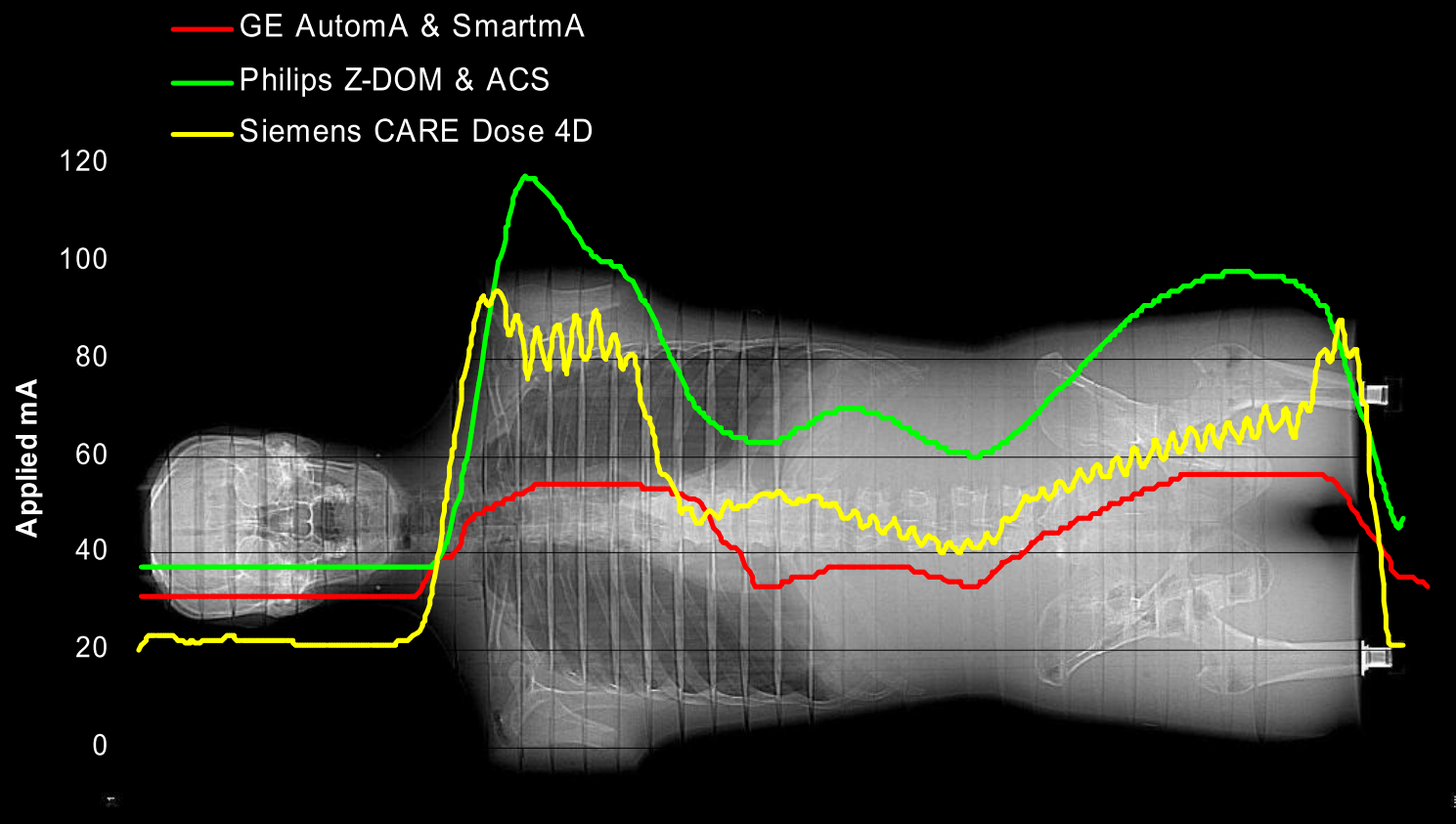
Overall shape is most important thing



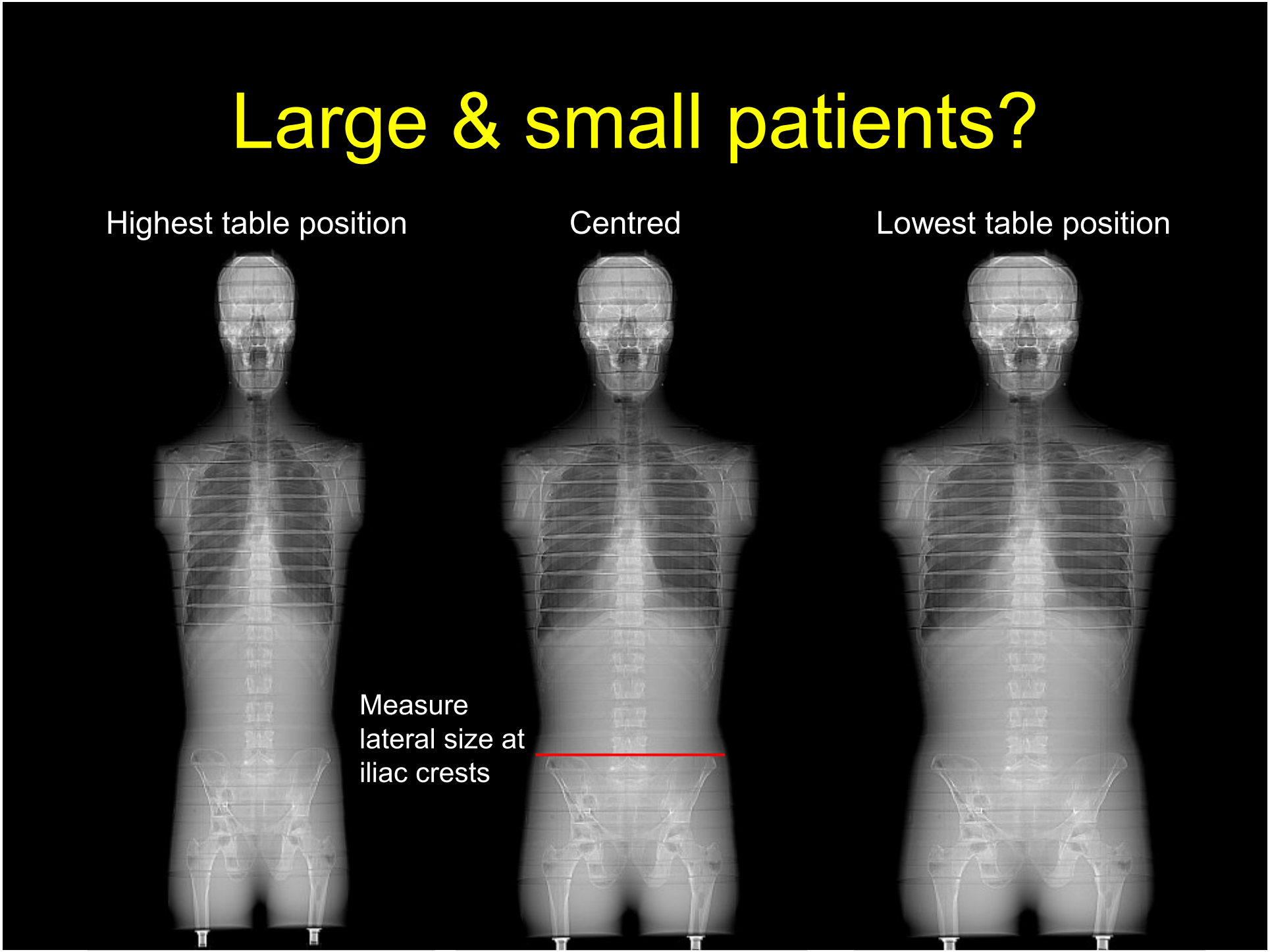
Current clinical protocols



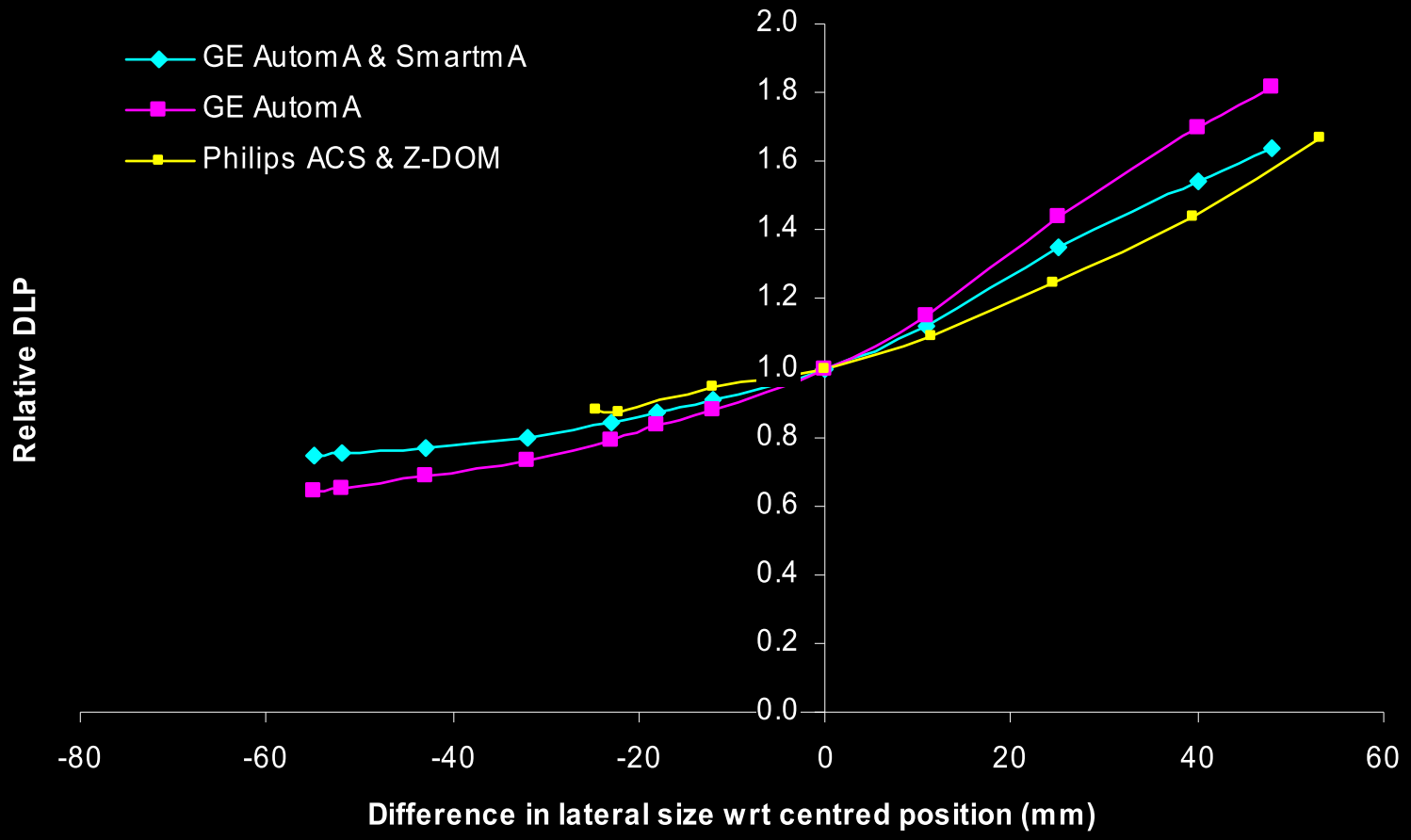
“Best” modulation techniques?



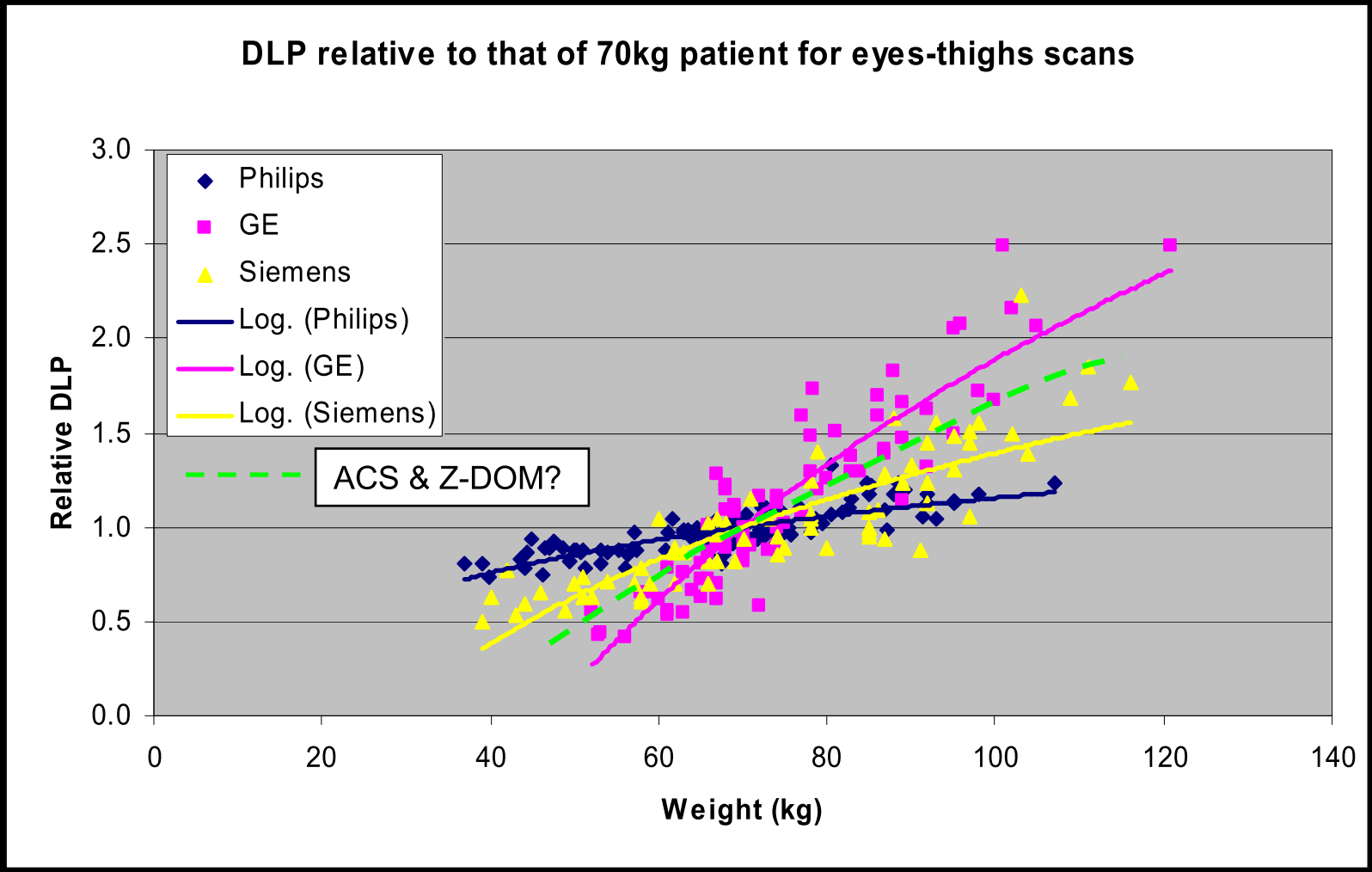
Large & small patients?



Dose variation with lateral size



Relative dose vs. weight?



Rando phantom summary

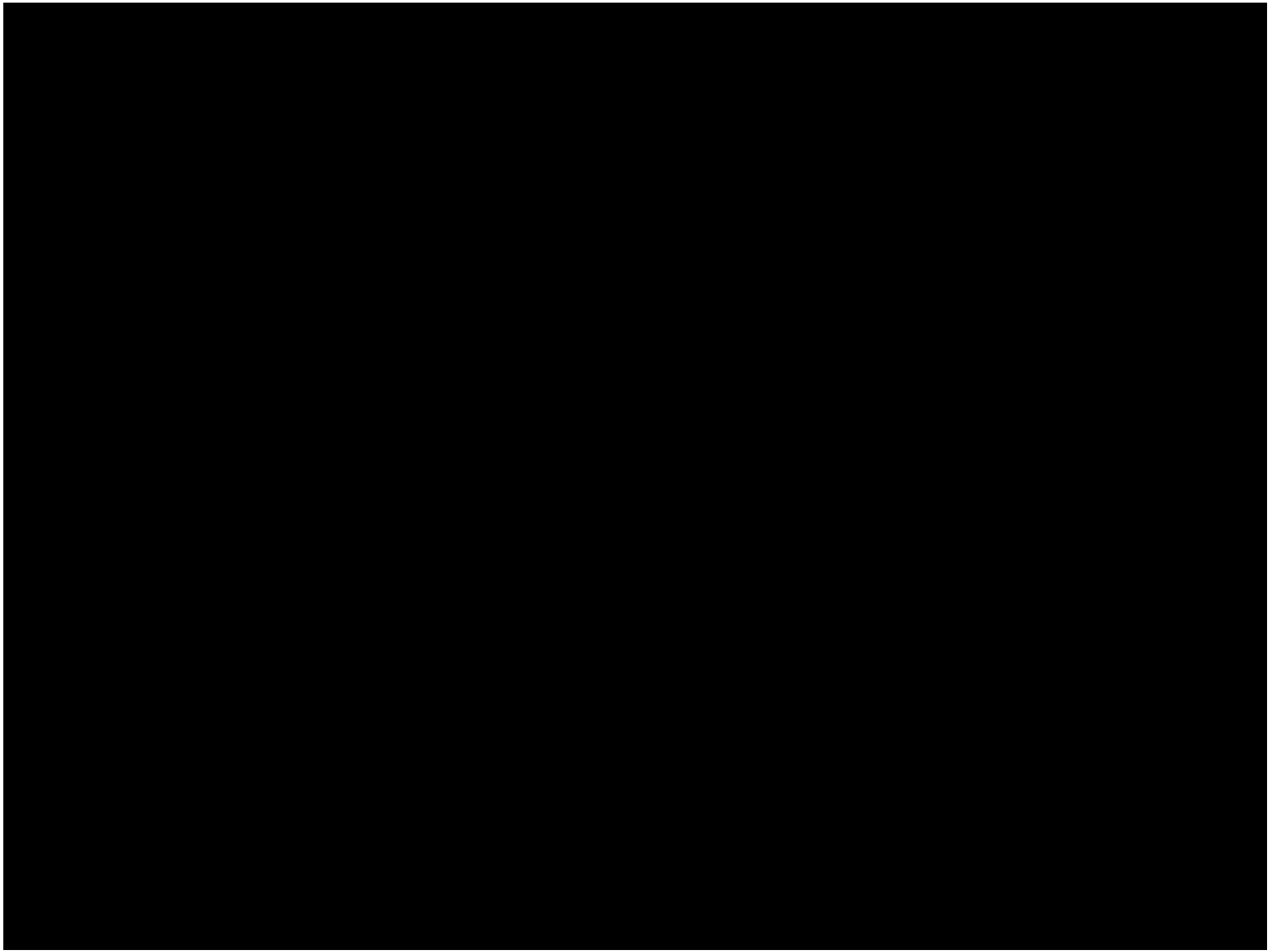
- Can adjust AEC settings to achieve similar modulation patterns
- Philips: Z-DOM and ACS much better than D-DOM
- Dose change with size via table height adjustment

Conclusions

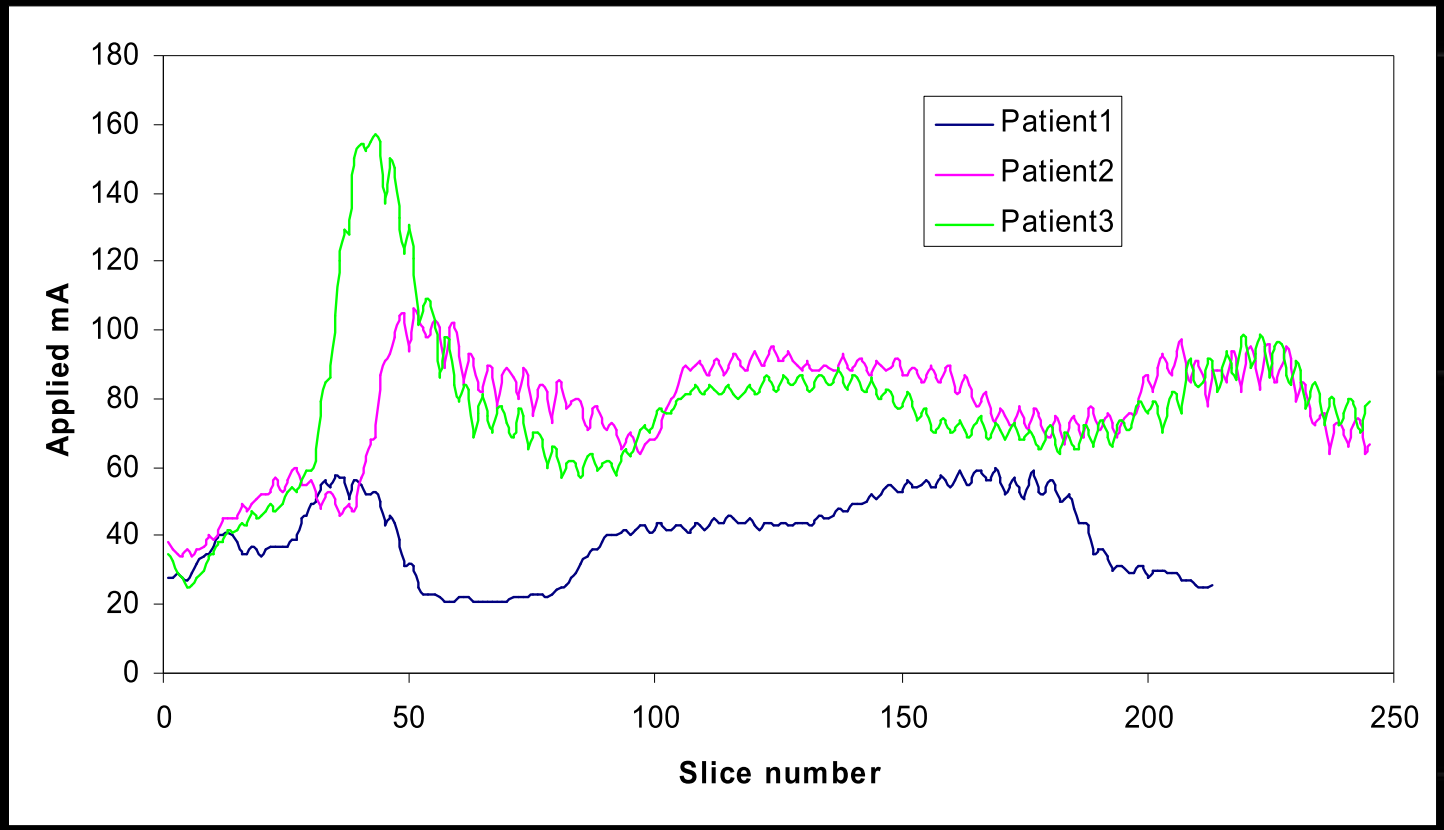
- All AEC systems can modulate adequately
- Some are easier to set than others…
  - Know your system!
  - **Cannot** achieve equal dose for all patient sizes on all scanners with a single scan protocol
- Must make sure patient is set up centrally
- Hybrid imaging reference doses are needed

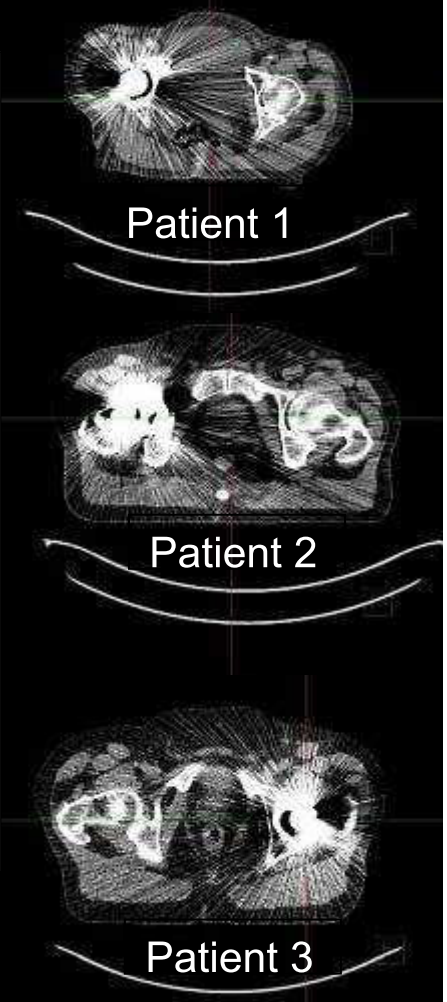
Our thanks to…

- PET/CT staff in:
  - Central Manchester University Hospitals
  - Leeds Teaching Hospitals
  - Alliance Medical Ltd
- Tim Wood for advice on the Philips system



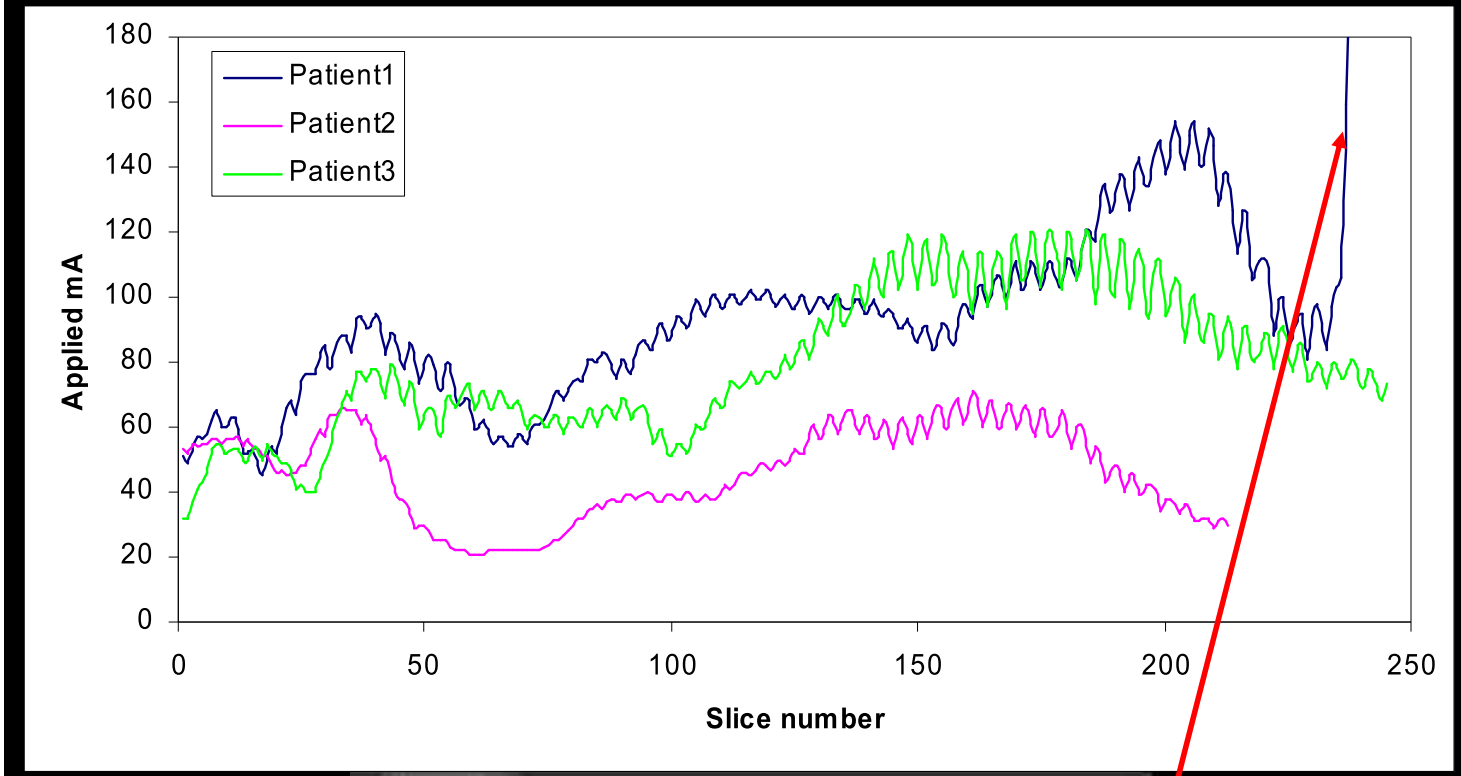
Patients with prosthetic hips

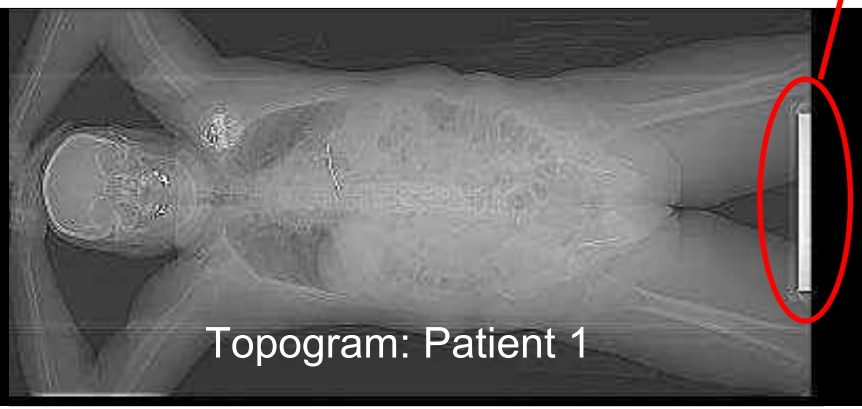




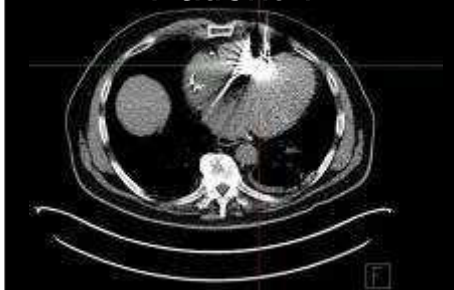
No mA spike present in region of implant

Patients with pacemakers

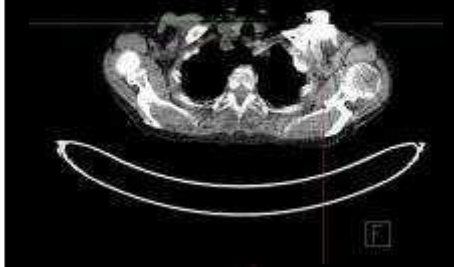




Patient 1



Patient 2



Patient 3

Philips dose saving vs. lateral/AP ratio