Public Health England

Protecting and improving the nation's health

The Abdus Salam International Centre for Theoretical Physics

IAEA International Atomic Energy Agency

DRLs and exposure monitoring in CT:

quantities, procedures, methods, international experience

Sue Edyvean

ICTP-IAEA Workshop on Establishment and Utilization of Diagnostic Reference Levels in Medical Imaging Imaging (smr3333):
18-22 November 2019 **Trieste, Italy**

Senior Scientific Group Leader
Medical radiation Dosimetry, CRCE
Public Health England
Didcot, Oxon. OX11 0RQ, UK

Outline

- CT Scanner
  - Fundamentals, Dose distribution
- Considerations for dose audit in CT
  - Dose index data (CTDI, DLP, SSDE)
  - How to get the data (manual ….. dose monitoring systems)
  - Selection of exams
  - Selection of patients (size and numbers)
  - Relevant information to collect
    - Automatic Exposure control
    - Iterative reconstruction
    - Other things to consider – SPR, contrast monitoring
- UK data

sue.edyvean@phe.gov.uk

CT Doses

CT procedures deliver approximately 50% of the collective effective dose from medical and dental exposures in many countries, due to the relatively high-dose nature of CT procedures compared with other diagnostic imaging modalities (NCRP, 2009).

This contribution is increasing.

ICRP 135

sue.edyvean@phe.gov.uk

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Search

Departments Worldwide How government works Get involved
Policies Publications Consultations Statistics Announcements

Research and analysis

Ionising radiation exposure of the UK population: 2010 review

From: Public Health England
First published: 15 April 2010
Part of: Radiation: PHE-CRCE report series

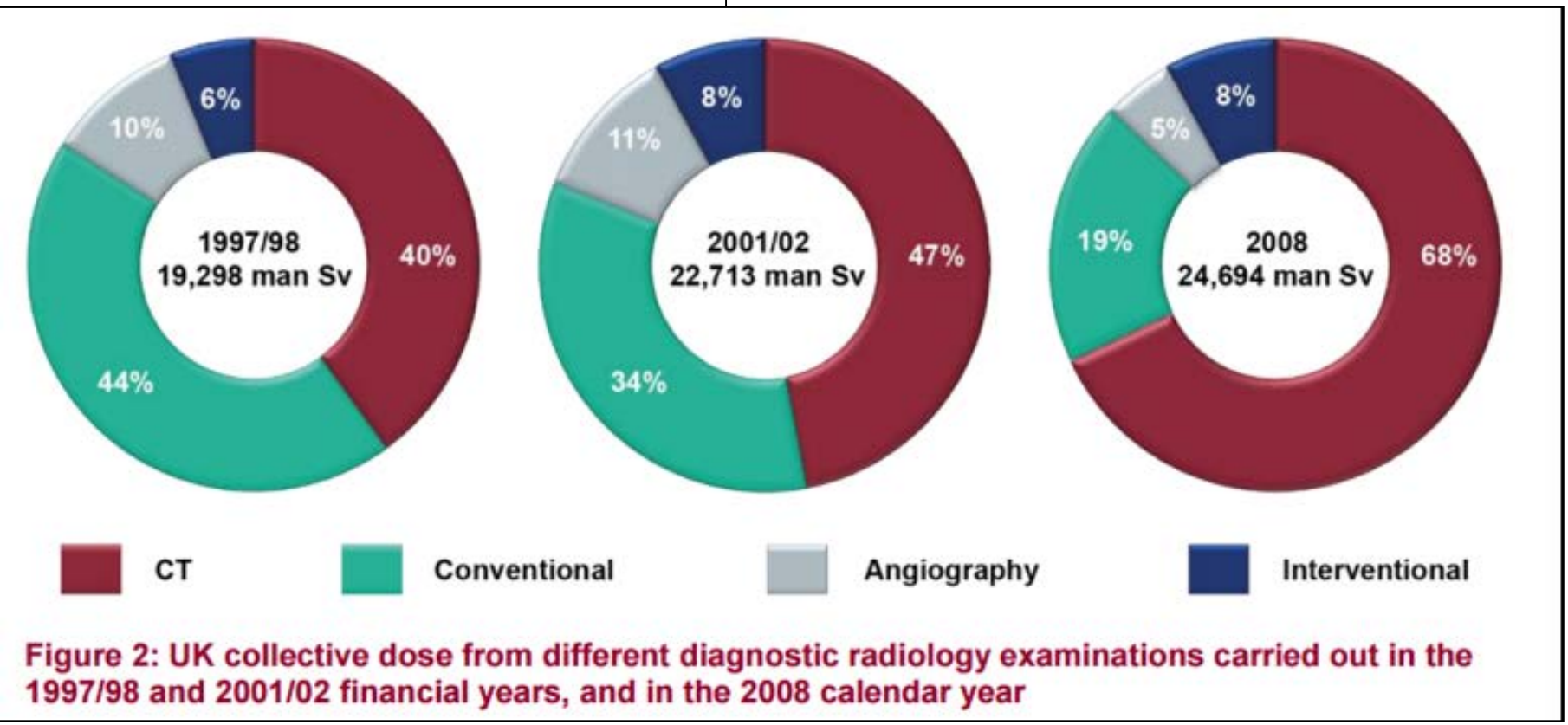


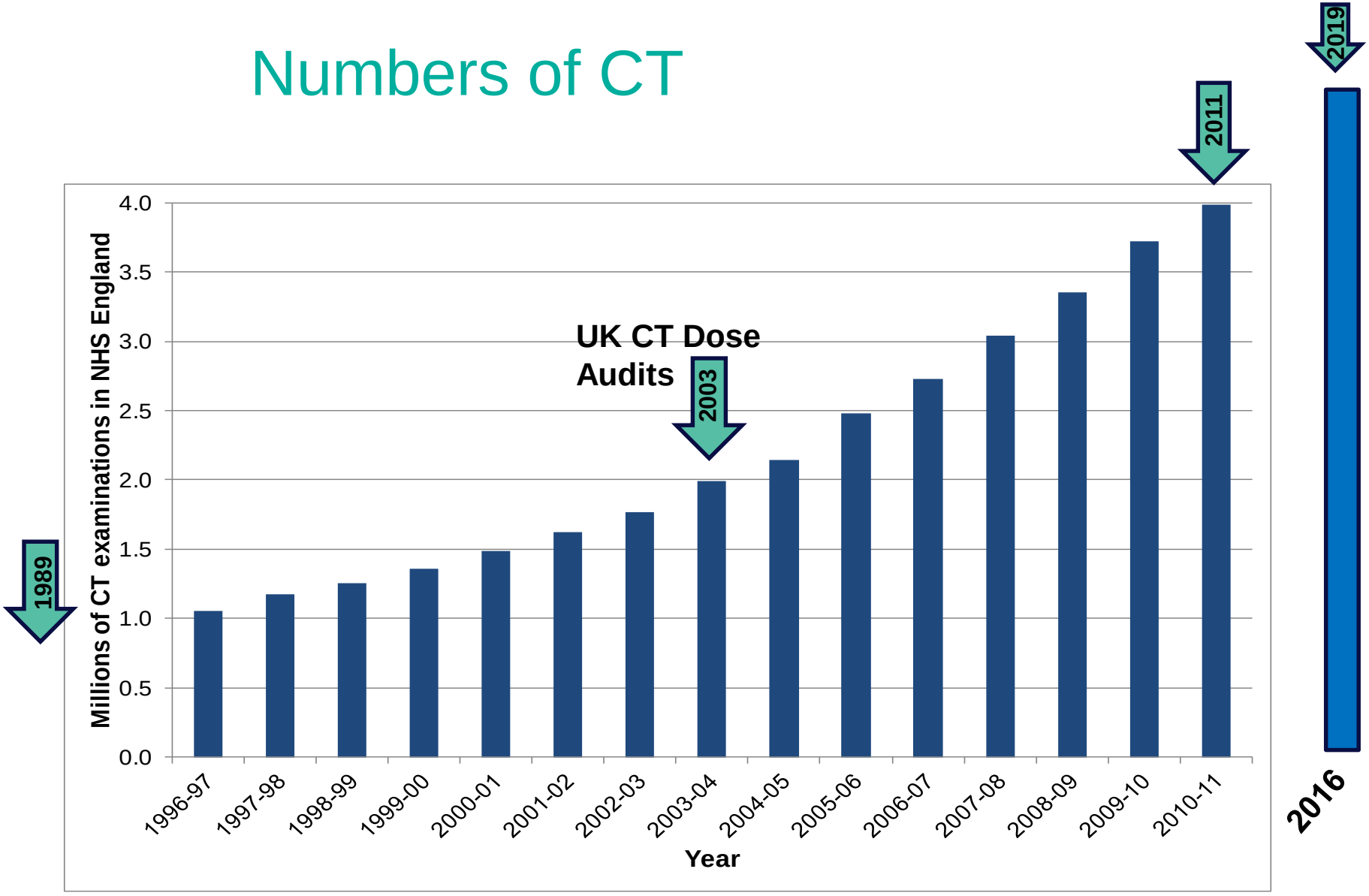
Figure 2: UK collective dose from different diagnostic radiology examinations carried out in the 1997/98 and 2001/02 financial years, and in the 2008 calendar year

CT accounted for 68% of dose for radiology examinations in 2008

This is affected by level of dose and numbers of examinations

sue.edyvean@phe.gov.uk

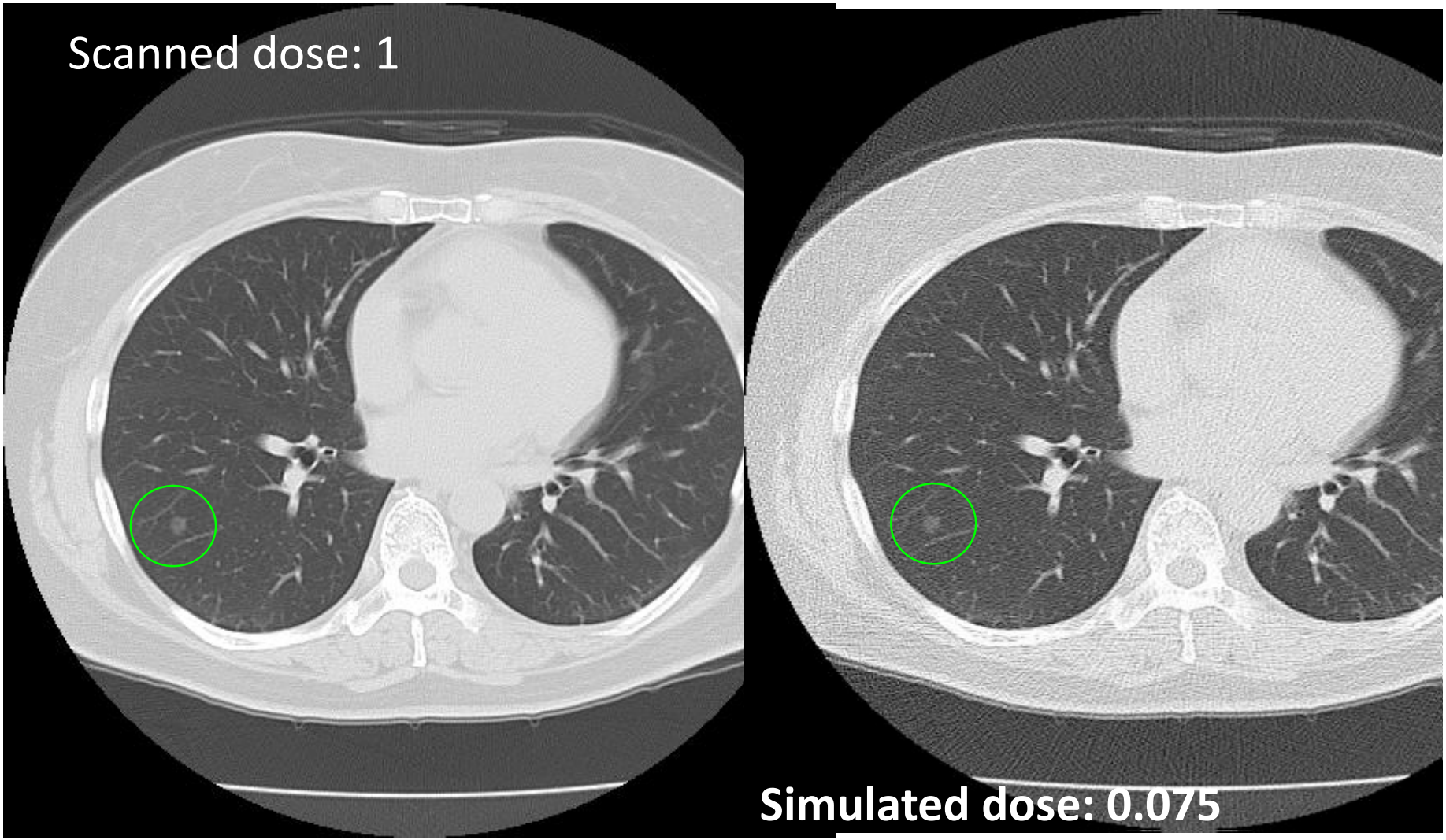
Numbers of CT



Annual numbers of CT examination performed in the NHS in England (Department of Health, 2011) *(NHS England 2016)*

sue.edyvean@phe.gov.uk

Image Quality in CT gets better and better with more dose



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Images courtesy Y. Muramatsu, NCC Tokyo

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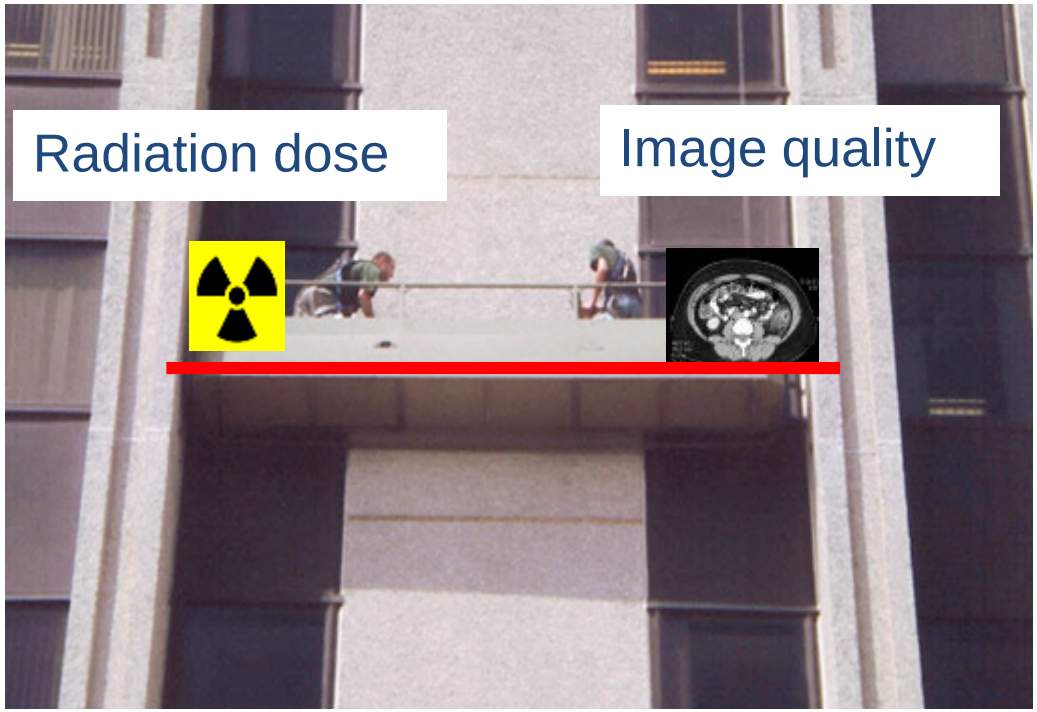
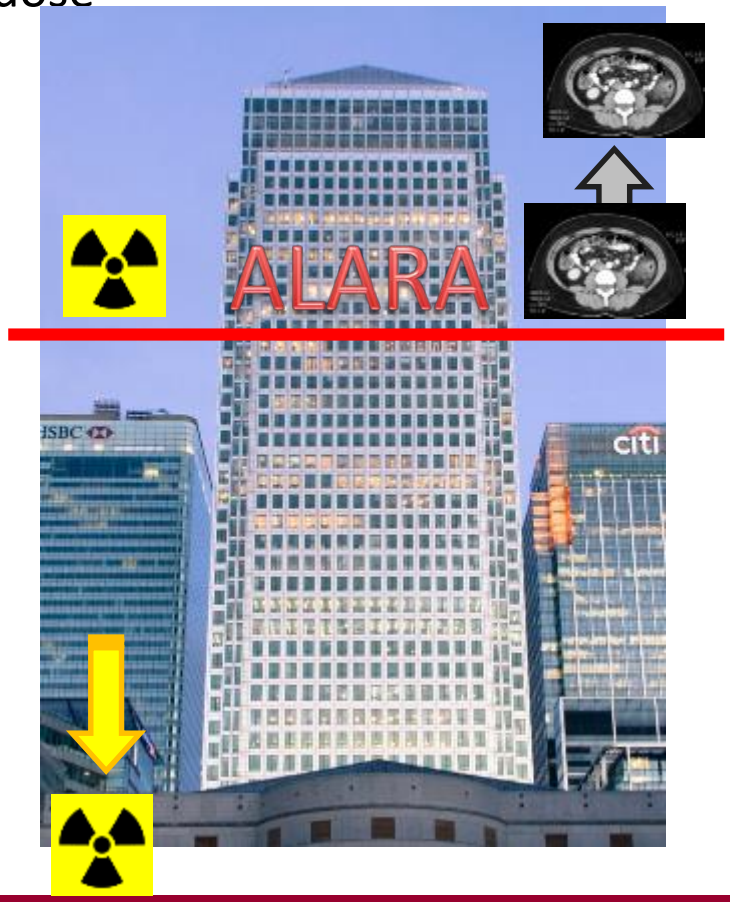
CT Scanners – digital systems

- Detectors have high dynamic range –
- unbounded higher image quality for higher dose





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Diagnostic Reference Levels

- All about ..

BENCHMARKING DOSES….

- From …

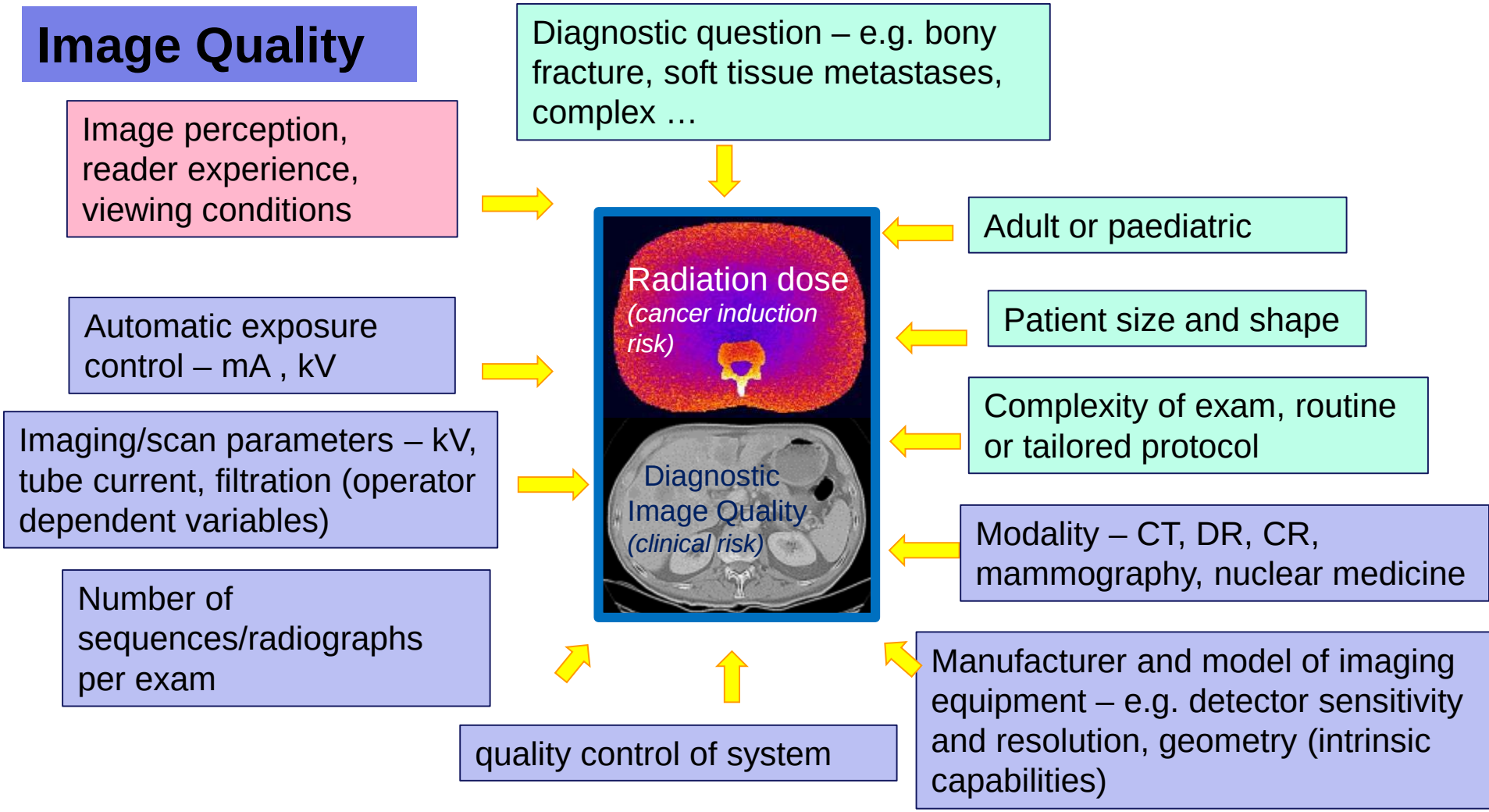
Dose Audits

- Using

STANDARD CONDITIONS AND BASIC STATISTICS

Factors influencing dose (and image quality)

A diagnostically acceptable image is the basic premise for DRLs



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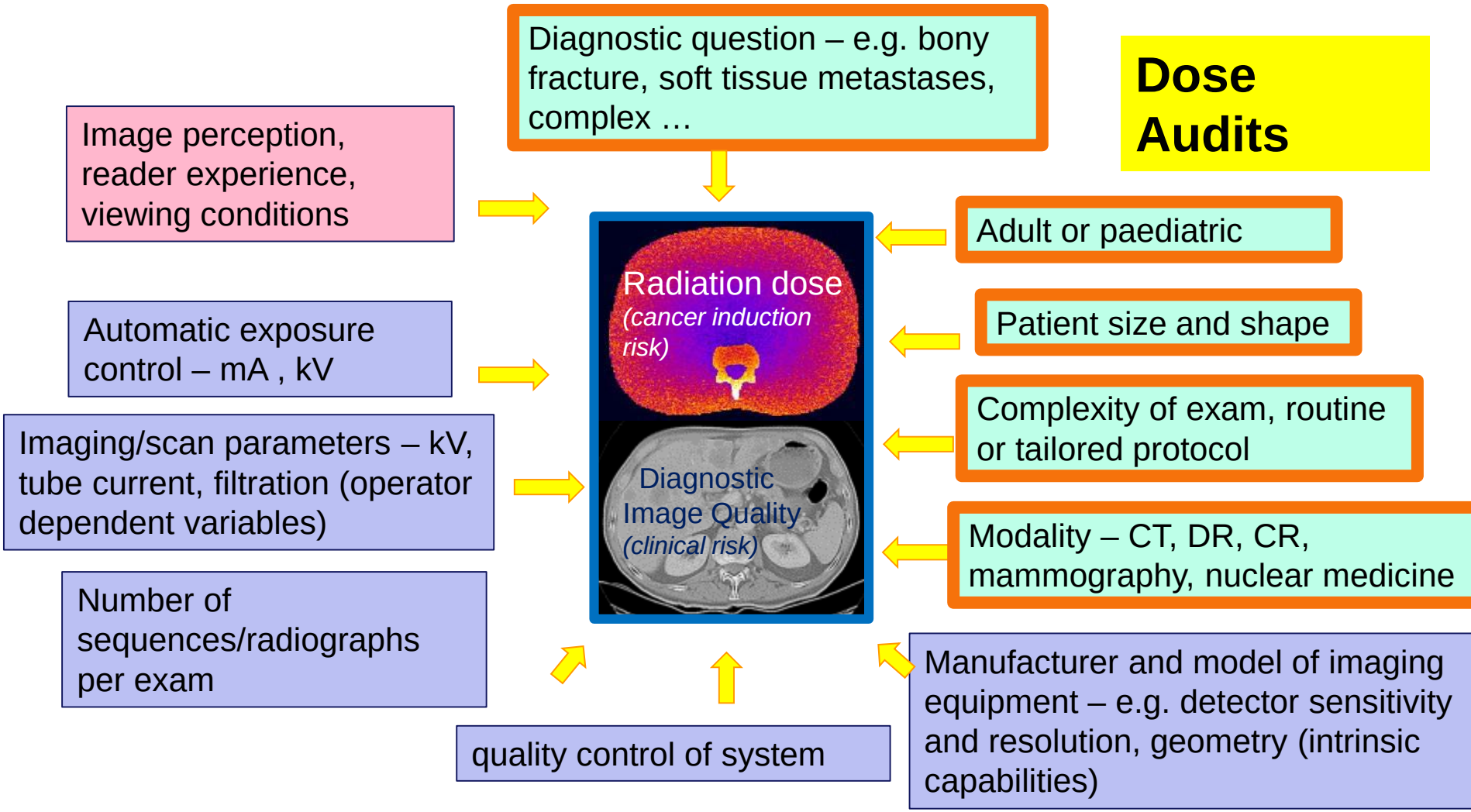
Factors influencing dose (and image quality)

For DRLs – some standardisation is required for a meaningful result …



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Dose Audits for DRLS

- Dose indicator (e.g. DAP,ESD or CTDI,DLP)
  - common examinations (e.g. chest CT) or high dose
  - Sample of standard size/weight patients

- Calculate the median^ value for each x-ray system, each exam

- ^UK previously used mean. UK currently ask for both: for retrospective comparison, and continue to future with median.

sue.edyvean@phe.gov.uk

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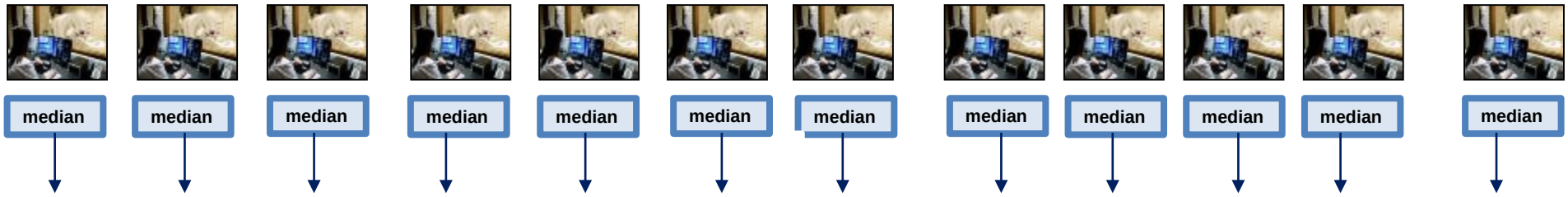
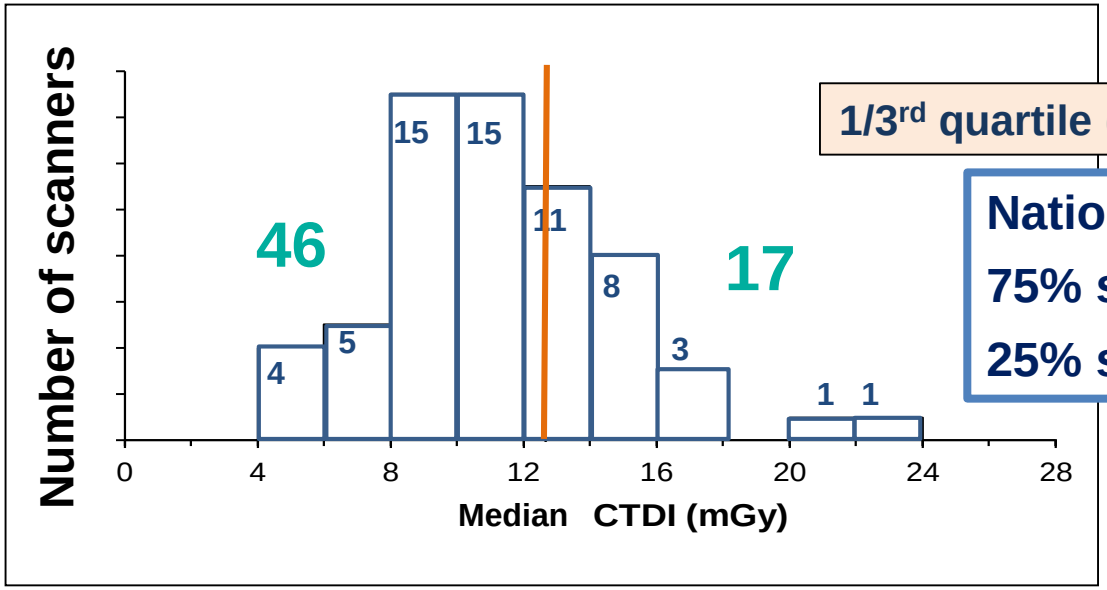
Two distributions of data

Distribution of Median Values from all scanners



Total of 63 scanners



1/3rd quartile (75%) dose = NDRL

National DRL(dose):

75% scanners below NDRL

25% scanners above NDRL

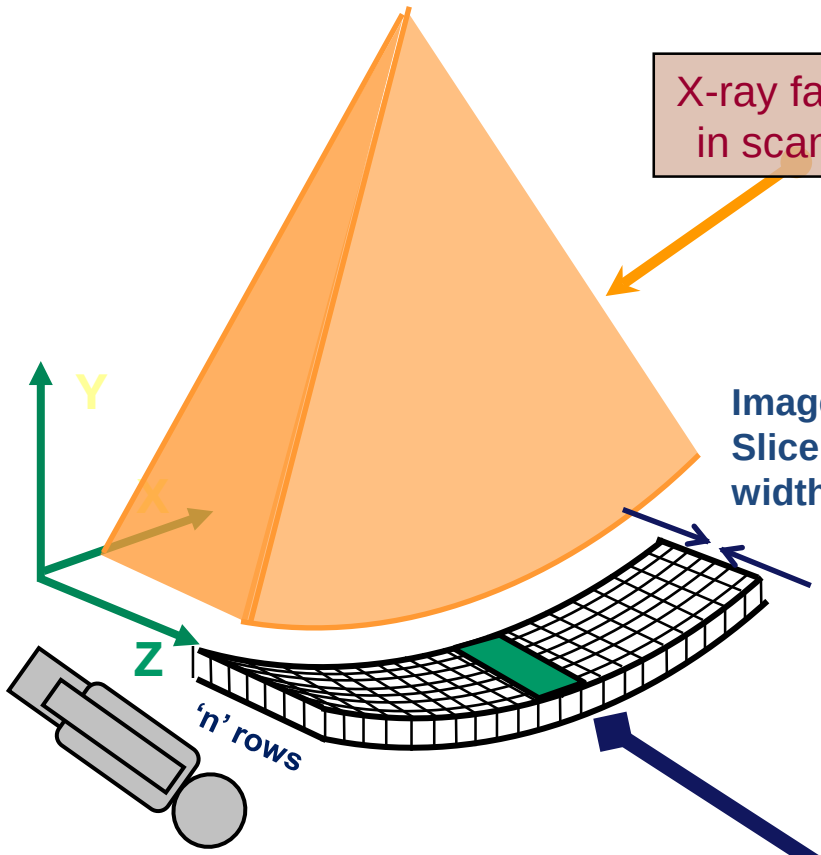
sue.edyvean@phe.gov.uk

Exam A

Technology

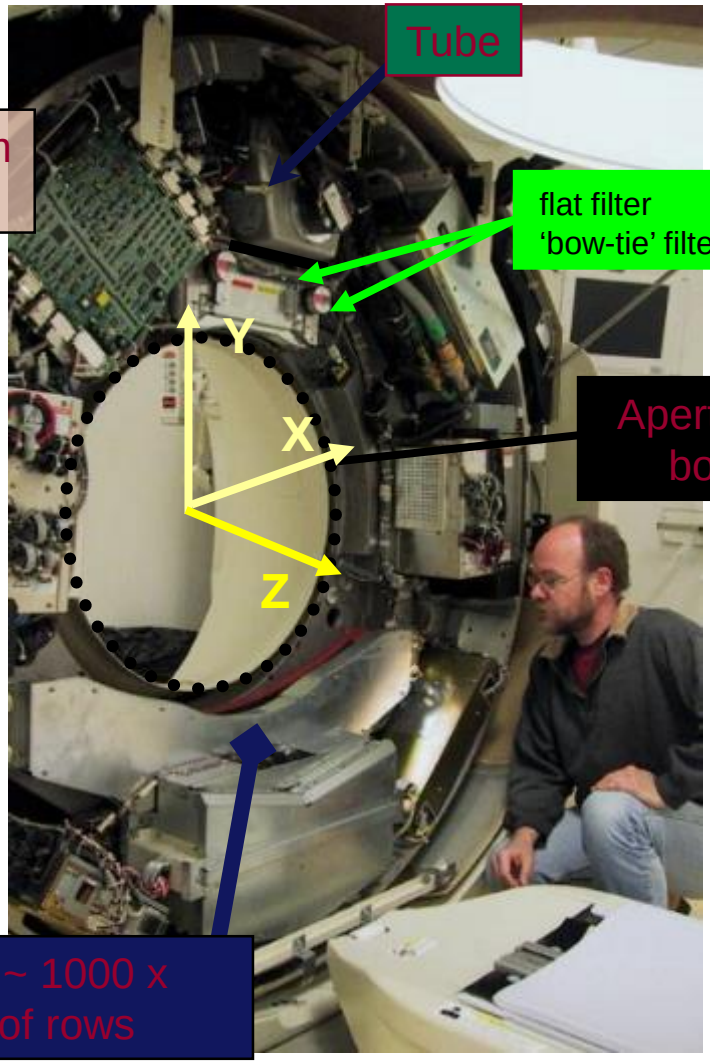
sue.edyvean@phe.gov.uk

The Conventional MSCT Scanner



X-ray fan beam in scan plane

Image Slice width



Detectors ~ 1000 x number of rows

Typical detector array length:

~ 40 mm (20 - 160 mm)

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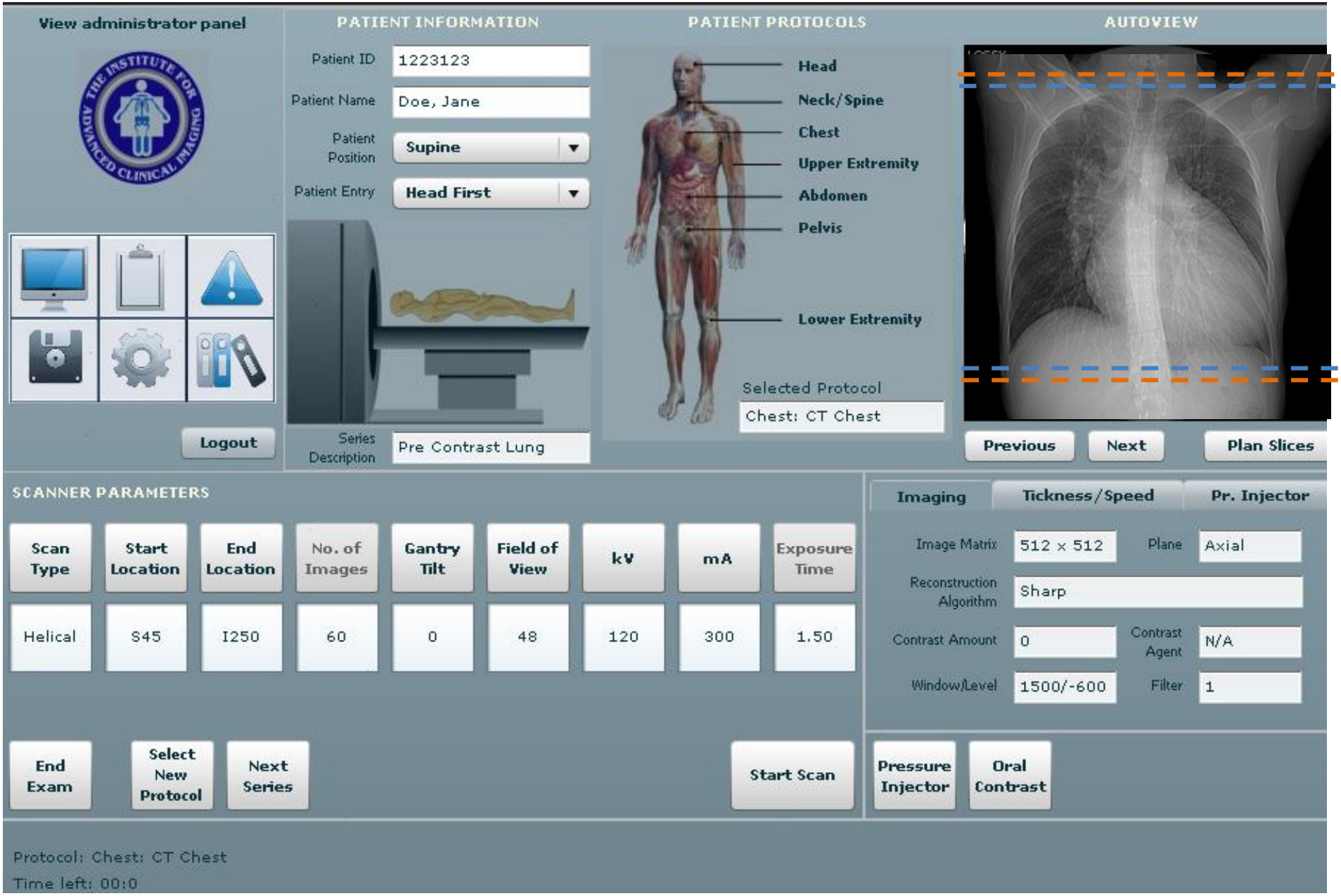

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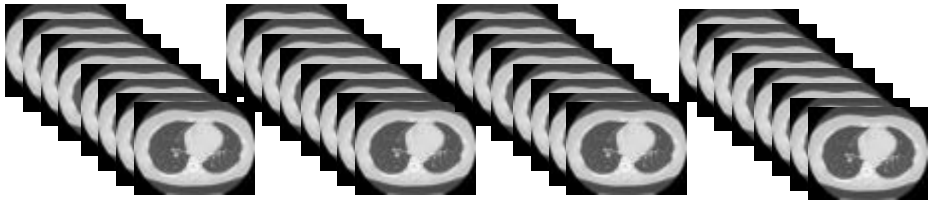
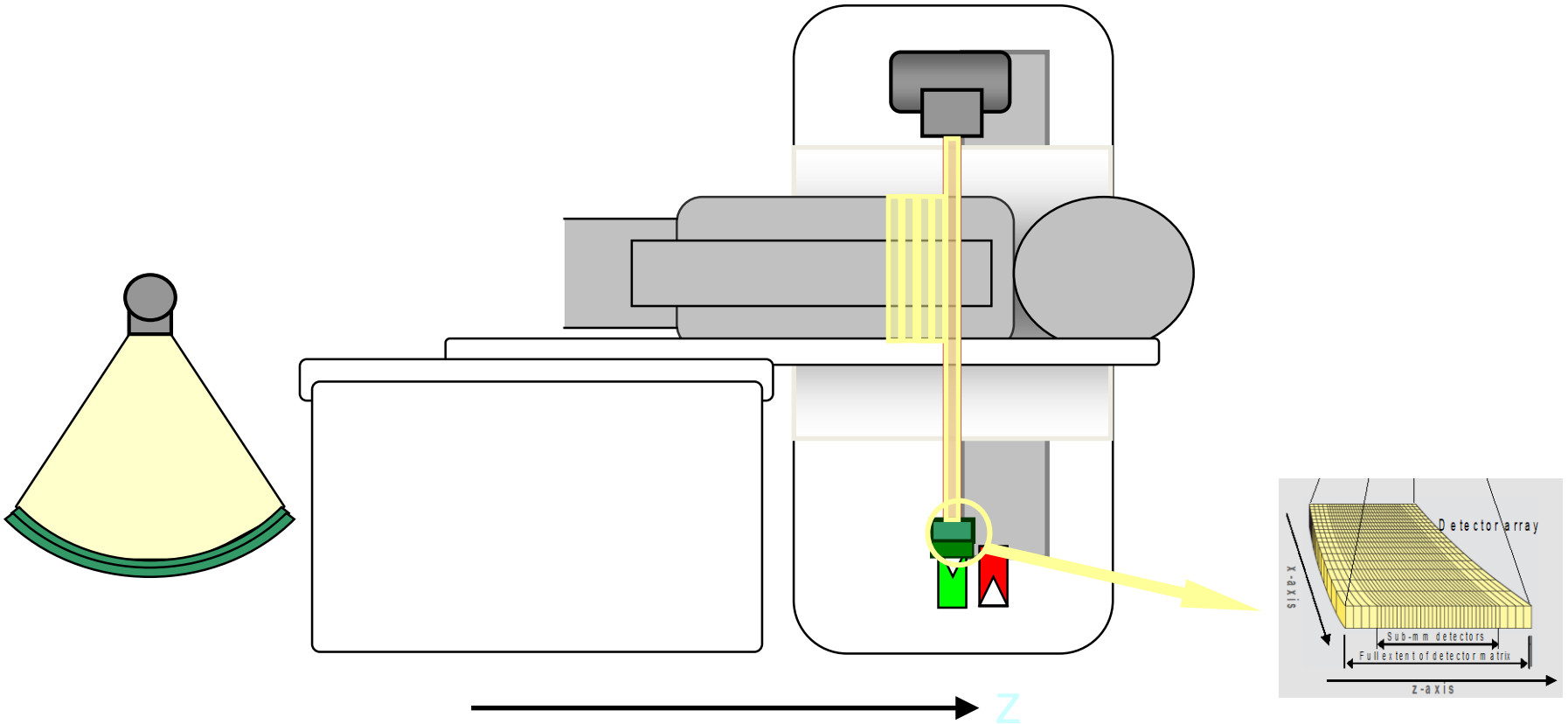
http://www.iacionline.com/skins/userfiles/image/CTScanner_ScreenShot.png

Axial scanning – ‘step and shoot’

– Also known as sequential scanning





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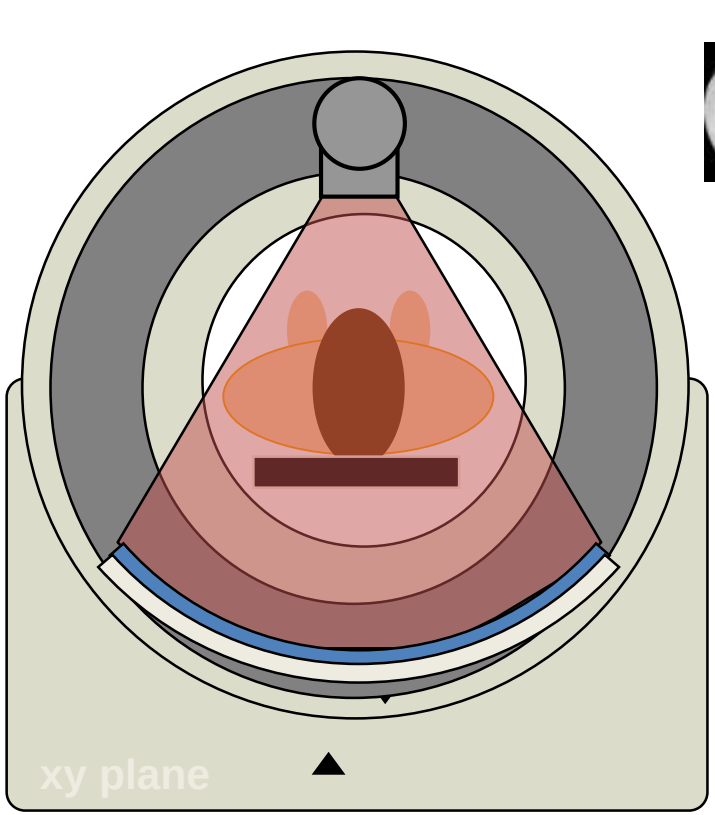
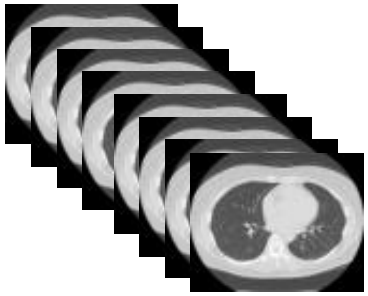
Helical (spiral) scanning

- Continuous gantry rotation + continuous table feed
- Multi-slice helical data used to form axial images





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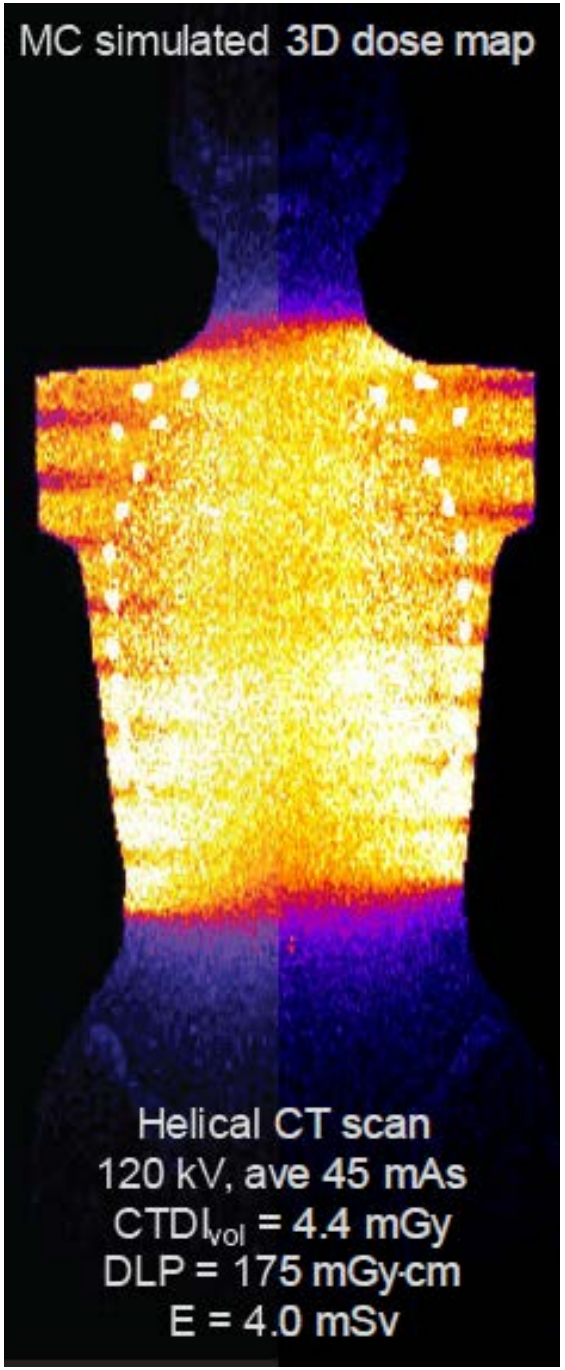
N. Keat, ImPACT

MSCT Examination - Dose Distribution in Z-Axis

Complex dose distribution

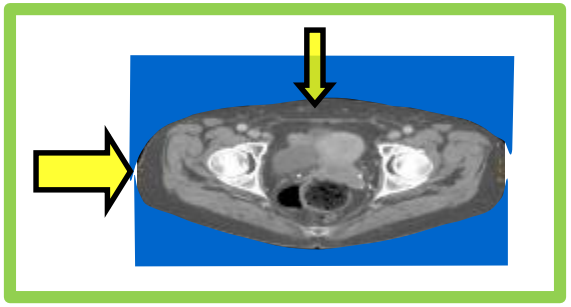
MC simulated dose map for a helical scan

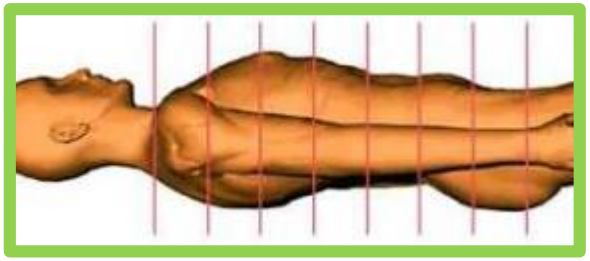


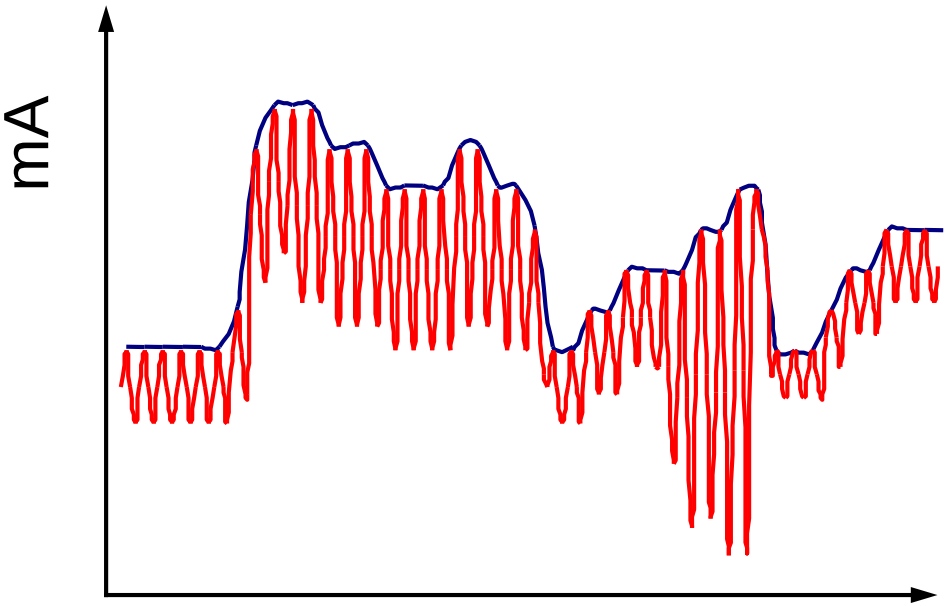
Courtesy Mika Kortesienmi

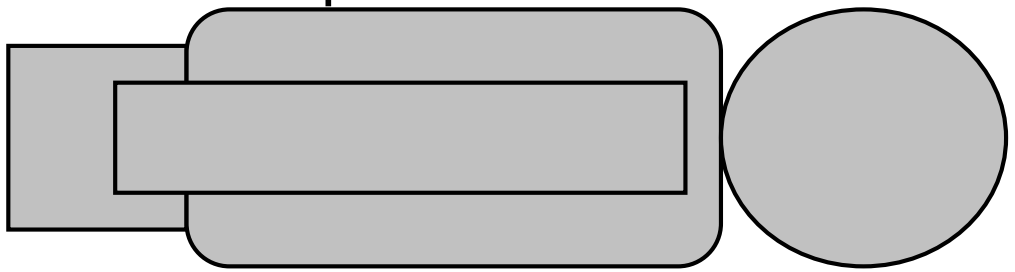
sue.edyvean@phe.gov.uk

Automatic Exposure Control (AEC)









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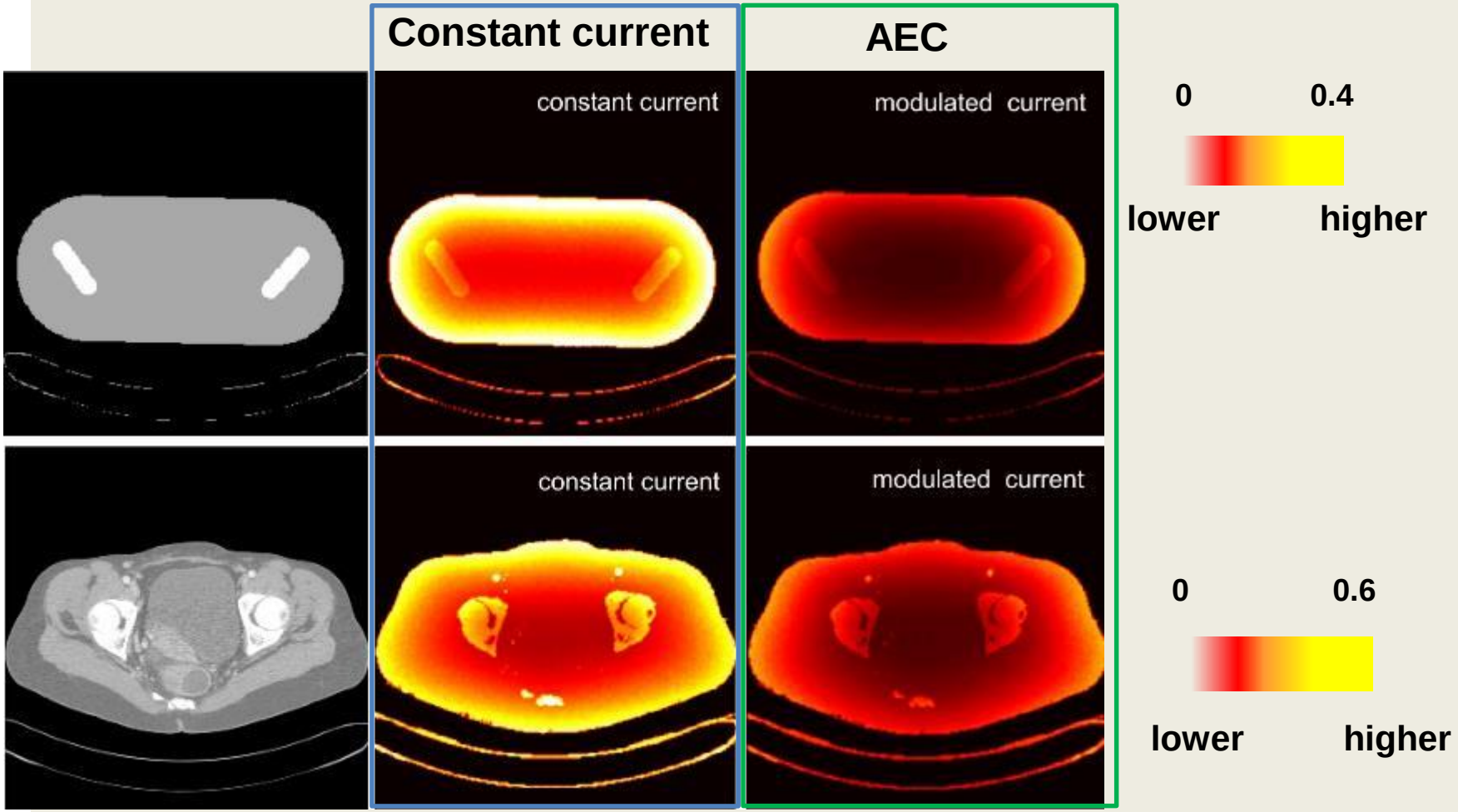
MSCT dose distribution in Scan Plane



Dose Metrics (Indicators) in MSCT

- CTDI^ mGy Computed Tomography Dose Index
- *$MSAD_L$ mGy Multi-slice Average Dose (≡ $CTDI_L$)*
- $D_0(L)$ mGy Cumulative dose = $MSAD_L$
- SSDE mGy Size Specific Dose Estimate
- DLP mGy.cm Dose Length Product
- ED mSv Effective Dose

$CTDI_{vol}$ and DLP used for setting DRLs
SSDE may be used to aide optimisation

^

$CTDI_{air}$
$CTDI_{100}$
$CTDI_{w}$
$CTDI_{vol}$
$CTDI_{IEC}$
$CTDI_{300}$
$CTDI_{\infty}$

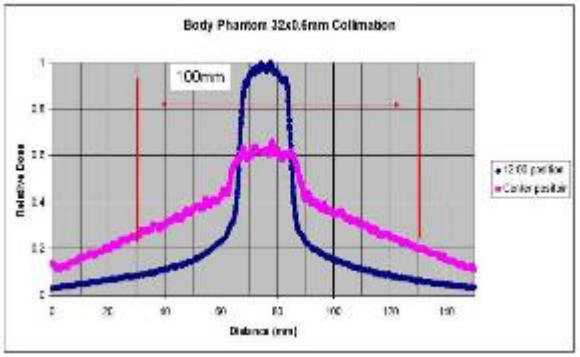
sue.edyvean@phe.gov.uk

Quantities suitable for setting DRLs in CT

Quantity	Recommended symbols	Recommended unit	Closely similar quantity	
Volume computed tomography dose index	CTDIvol	mGy	Volume CT air kerma index	(C_{vol})*
Dose-length product	DLP	mGy.cm	Air kerma-length product	(P_{KL})*

IAEA Web page

CTDI - general



A descriptor telling about the type of CTDI
(integration length, or medium measured in)

The dose profile

$$CTDI_L = \frac{1}{(N \times T)} \int_{-L/2}^{+L/2} D(z)\, dz$$

The nominal beam width

Integral limits – how much dose we collect from the dose profile

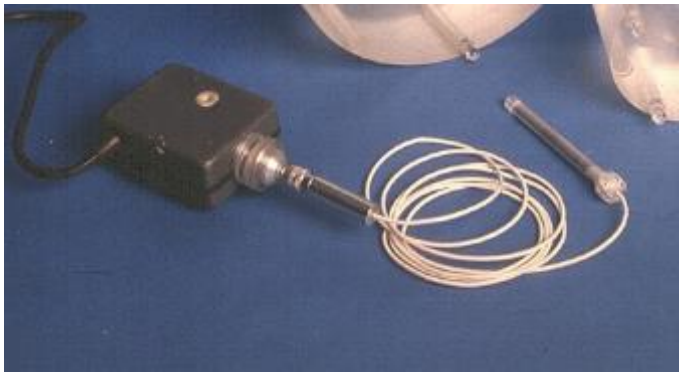
sue.edyvean@phe.gov.uk

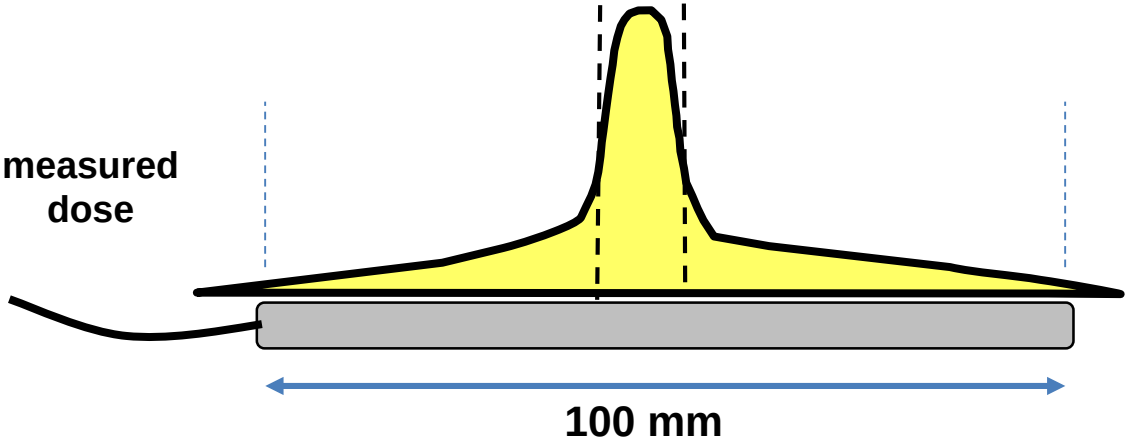
$CTDI_{100}$

- 100 mm long ion chamber used
- **Scan one rotation - one 'dose slice'**
- Dose from the profile is collected over 100 mm
- **$CTDI_{100}$ is calculated:** integral dose / nominal beam width

$$CTDI_{100} = \frac{1}{(N \times T)} \int_{-50}^{+50} D(z)\, dz$$

$$CTDI_{100} = \frac{\text{integral dose 100 mm}}{\text{nominal beam width}}$$





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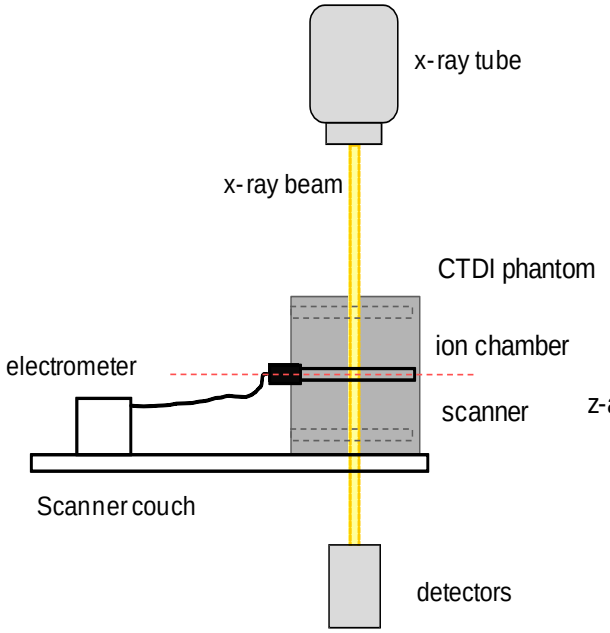
Weighted CTDI ($CTDI_w$)

- $CTDI_{100}$ measured in a Perspex phantom (quoted as dose to air)
  - 32 cm or 16 cm diam. (body, head)
  - Centre and periphery positions
- Cross-sectional average: $CTDI_w = 1/3\ CTDI_{100c} + 2/3\ CTDI_{100p}$



Manuf. data - tolerances 10–40%

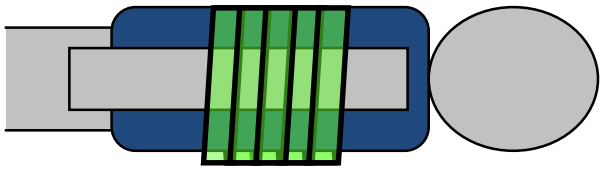
sue.edyvean@phe.gov.uk

Volume CTDI ($CTDI_{vol}$)

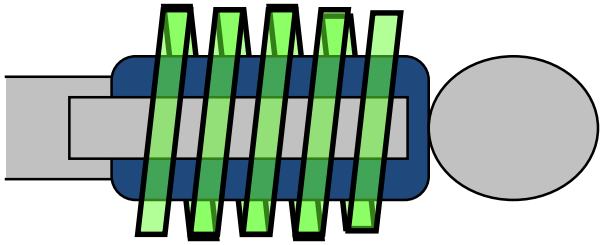
- $CTDI_{vol}$ takes account of exposure variation along z-axis
  - Accounting for pitch in the scan protocol

$$CTDI_{vol} = CTDI_w / pitch$$

- $CTDI_{vol}$ (axial scans) = $CTDI_w$ x packing factor
- $CTDI_{vol}$ ~represents average absorbed dose (x,y,z)



Pitch = 1
$CTDI_{vol} = CTDI_w$

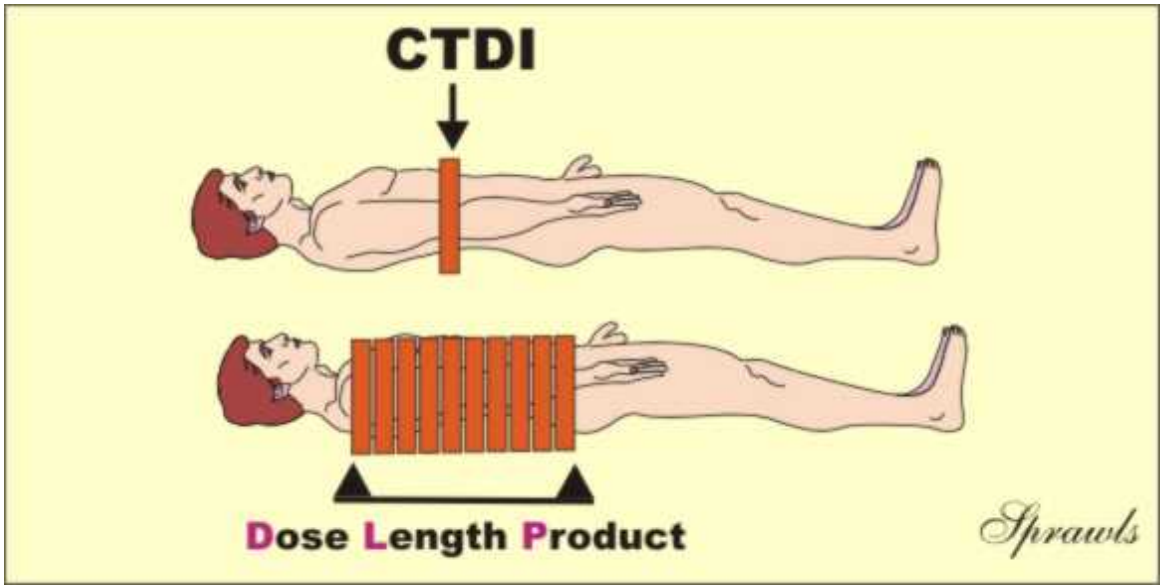


Pitch = 2
$CTDI_{vol} = CTDI_w/2$

sue.edyvean@phe.gov.uk

Dose length product (DLP)

- Dose descriptor used to indicate total absorbed dose
- Relates to risk
- DLP (mGy.cm) = $CTDI_{vol}$ x scanned length (L).



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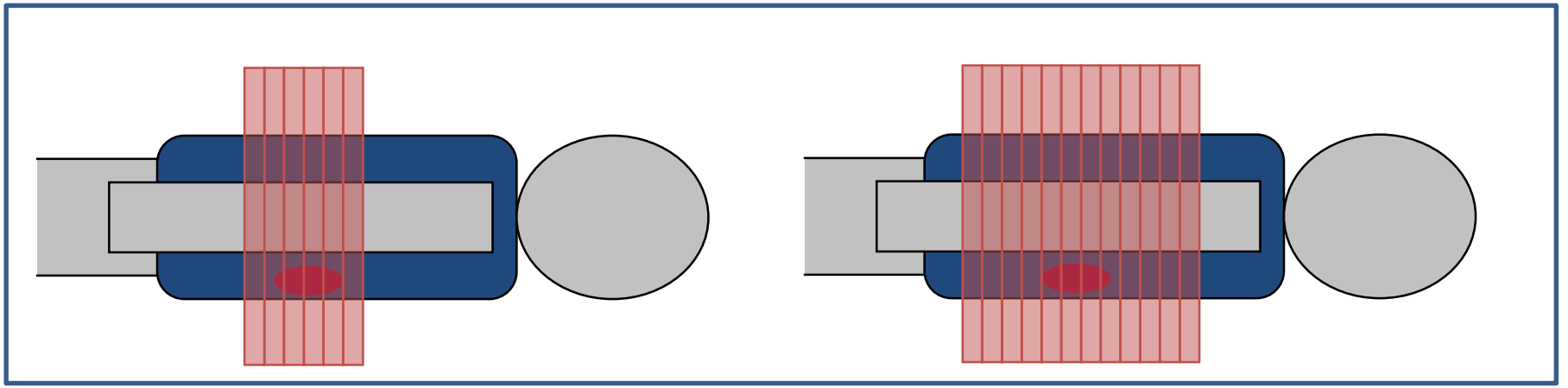
Double imaged length – same mAs

$CTDI_{vol}$ = same

DLP = x 2



e.g. **$CTDI_{vol}$ = 10 mGy**
DLP = 200 mGy.cm

$CTDI_{vol}$ = 10 mGy
DLP = 400 mGy.cm

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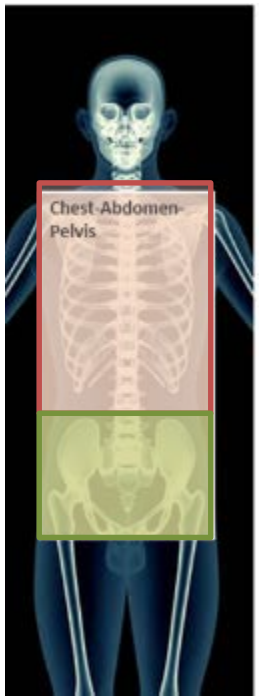
CTDI and DLP – Dose Audits

- CTDI relates to cross-sectional scan parameters
  - Suitable for each sequence
  - DLP relates to clinical input wrt length of scan
    - Suitable for total exam, and each sequence if available

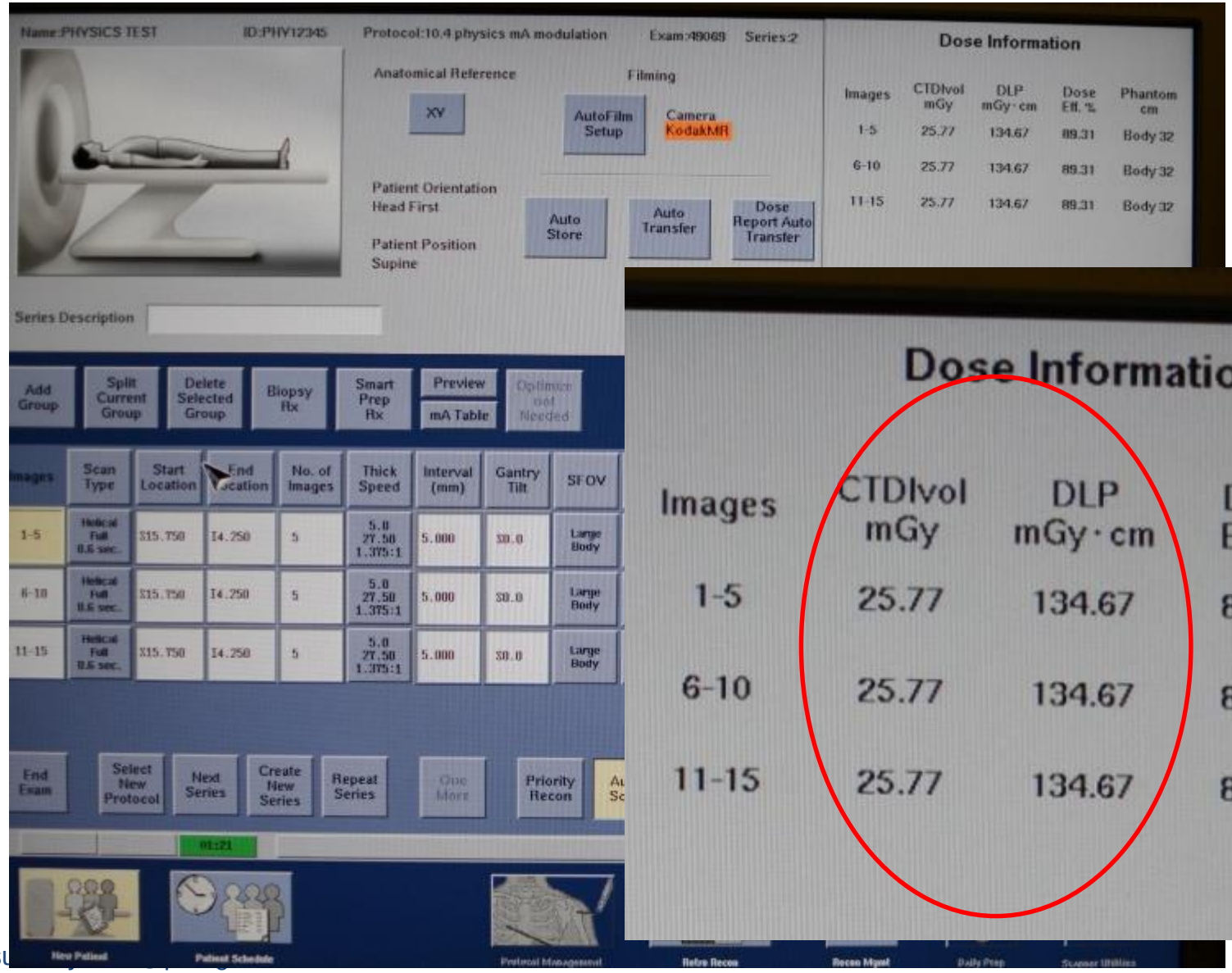
These may have
- same or similar CTDIvol,
- but will have different DLP



Each sequence:
- different average CTDIvol

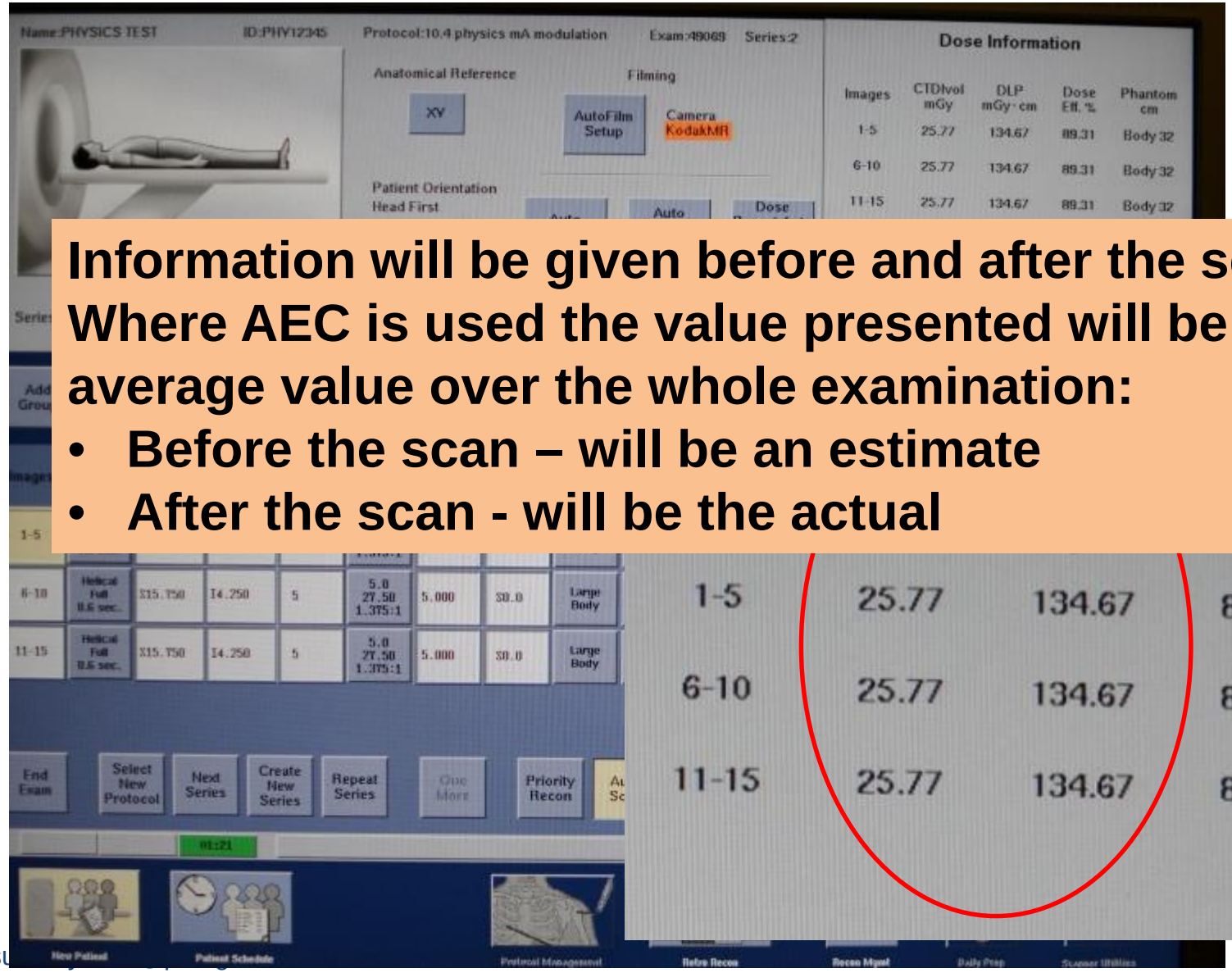
sue.edyvean@phe.gov.uk

$CTDI_{vol}$ and DLP are indicated on the scanner



GE Scanner

$CTDI_{vol}$ and DLP are indicated on the scanner



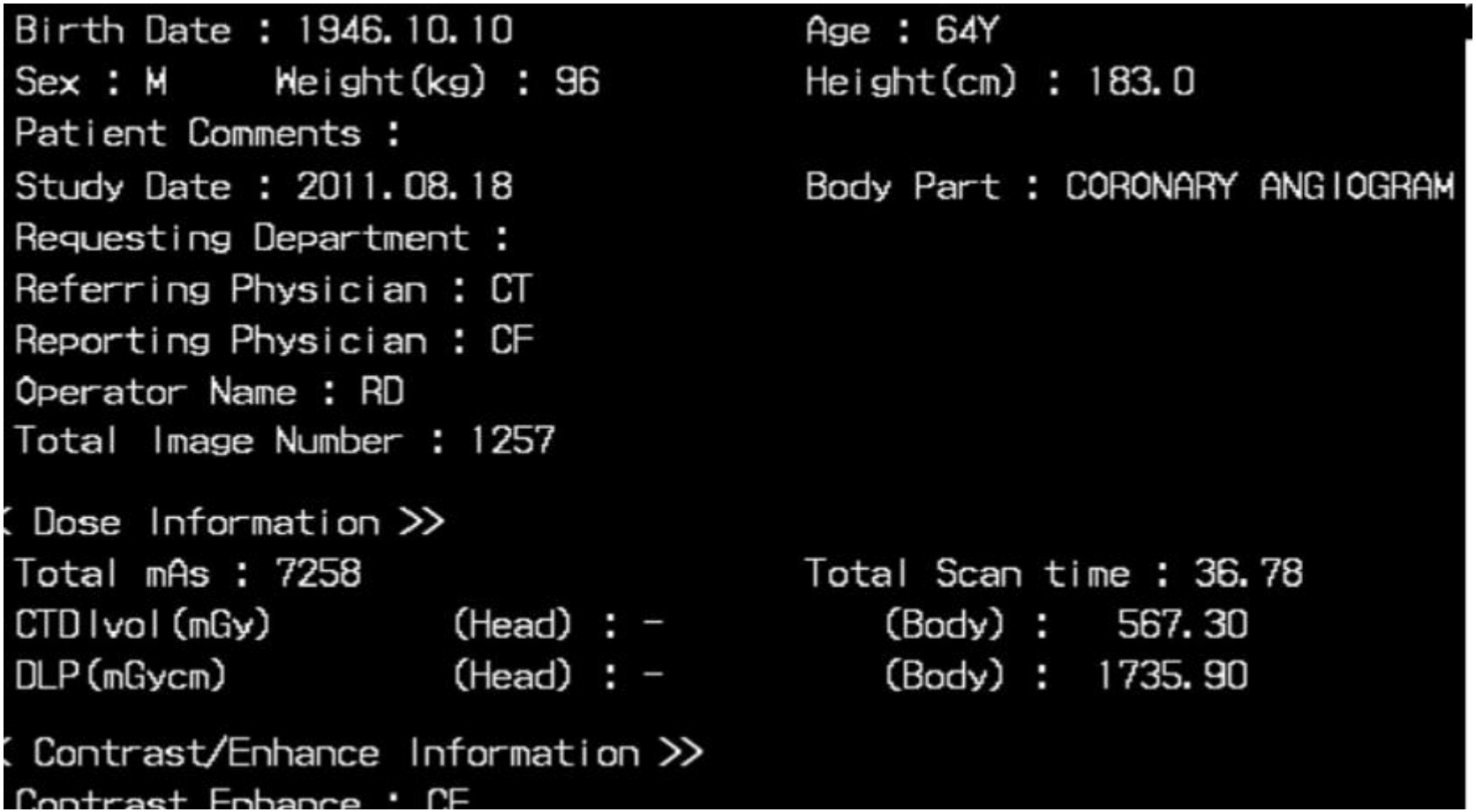
GE Scanner

Information will be given before and after the scan
Where AEC is used the value presented will be the average value over the whole examination:

- **Before the scan – will be an estimate**
- **After the scan - will be the actual**

$CTDI_{vol}$ and DLP are indicated on the scanner

- Dose Report/Dose page – stored as an image



sue.edyvean@phe.gov.uk

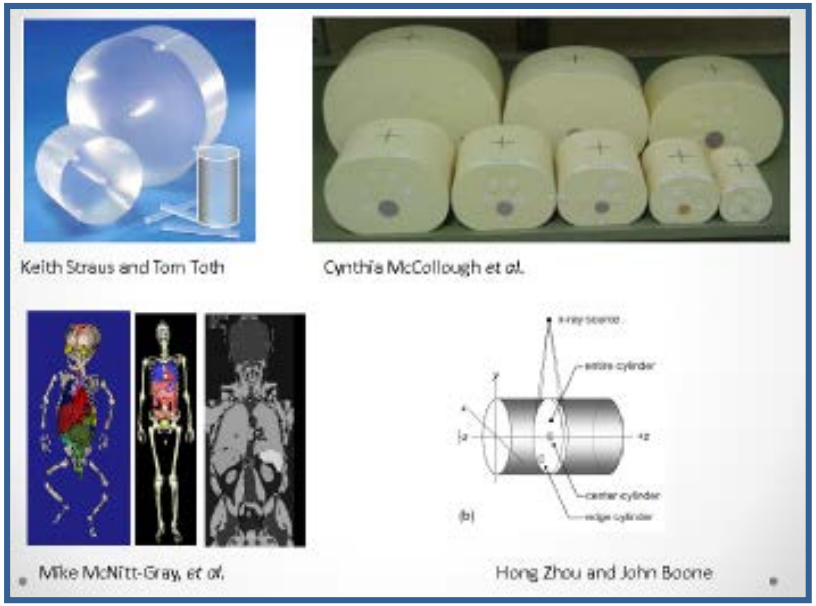
Size Specific Dose Estimate (SSDE)

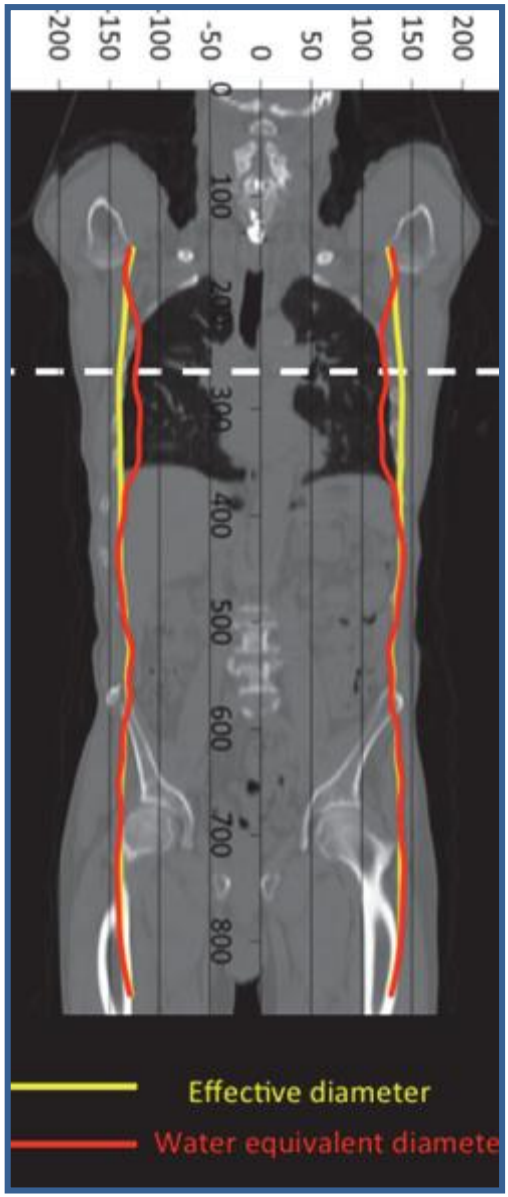
- Effective diameter (AAPM 204)
- Water Equivalent Diameter (D_w) (AAPM 220)
- $SSDE = CTDI_{vol} \times f$

SSDE a dose index or estimate more representative for the patient size

Table 1D

Dw (cm)	Conversion Factor
8	2.76
9	2.66
10	2.57
11	2.47
12	2.38
13	2.30
14	2.22
15	2.14
16	2.06
17	1.98
18	1.91
19	1.84
20	1.78
21	1.71
22	1.65



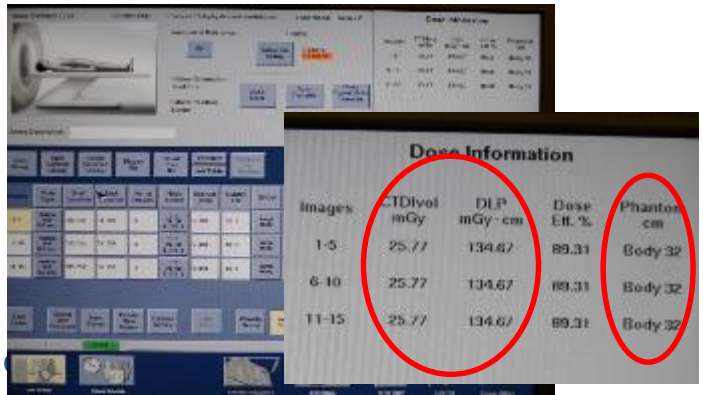


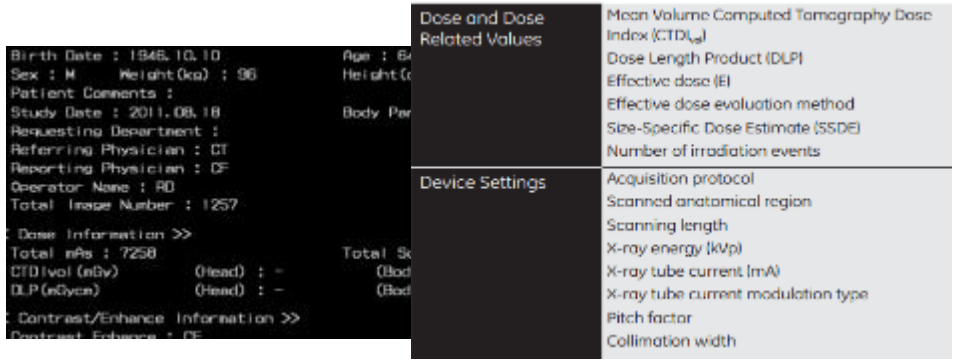
sue.edyvean@phe.gov.uk

AAPM Report 220

Dose Data - where is it?

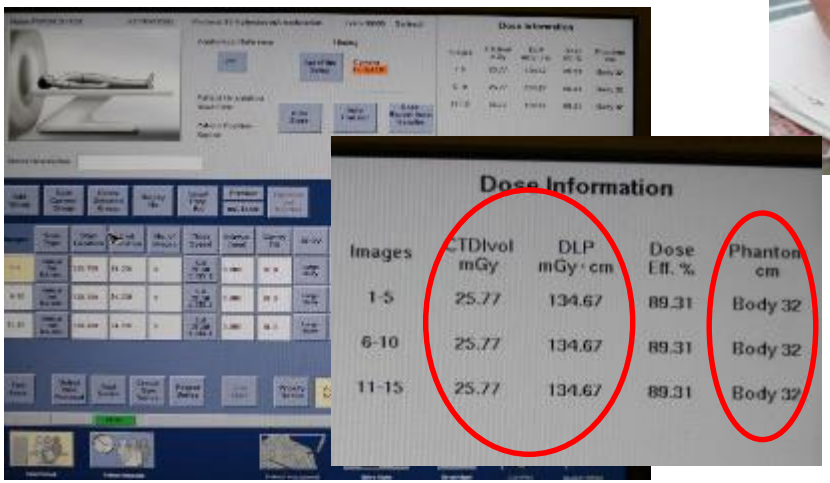
- Scanner
  - On the screen
  - Dose page (get as image or as digital data: optical character recognition (OCR))
  - In DICOM information: Radiation Dose Structured Report (RDSR)
- PACs (from dose page or DICOM RDSR)
- Dose Management System (from scanner or PACS, or RIS)
- RIS - dose input manually from scanner (at the time of exam or after) (RIS – Radiology Information System)

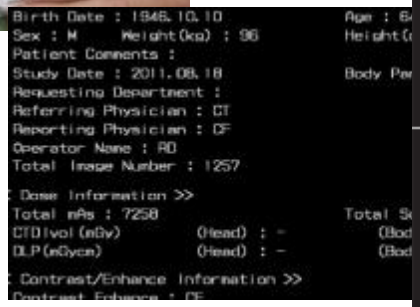




Dose Data – How to get it ?

- Write / type into Excel
- Export electronically from: PACS, RIS, DMS
- Web based systems – type info in



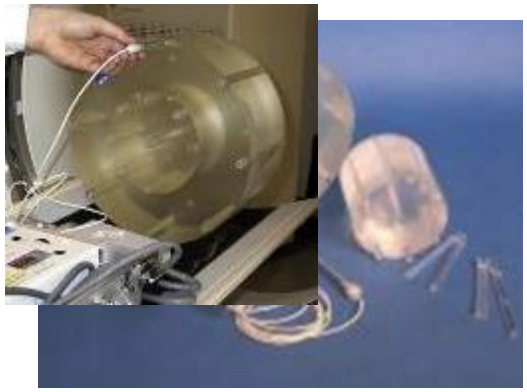


Dose and Dose Related Values	Mean Volume Computed Tomography Dose Index ($CTDI_{vol}$)
	Dose Length Product (DLP)
	Effective dose (E)
	Effective dose evaluation method
	Size-Specific Dose Estimate (SSDE)
	Number of irradiation events
Device Settings	Acquisition protocol
	Scanned anatomical region
	Scanning length
	X-ray energy (kVp)
	X-ray tube current (mA)
	X-ray tube current modulation type
	Pitch factor
	Collimation width

sue.edyvean@phe.gov.uk

Importance of CTDI phantom Size

- For same mAs:
  - CTDI head phantom =~ twice CTDI body:
  - $CTDI_{vol32cm} = 0.54\ CTDI_{vol16cm}$ (AAPM 2014)
- Important especially for
  - Paediatrics
  - cervical spine (neck scans)



Check phantom size used for CTDI value

American Association of Physicists in Medicine (AAPM). *Use of water equivalent diameter for calculating patient size and size specific dose estimates (SSDE) in CT (task group 220)*. Maryland, USA: AAPM; 2014.

sue.edyvean@phe.gov.uk

CTDI IEC standards, Phantom size

IEC 60601-2-44 Ed 3.1:
All bodies (adult and paediatric) 32 cm phantom
All heads (adult and paediatric) 16 cm phantom

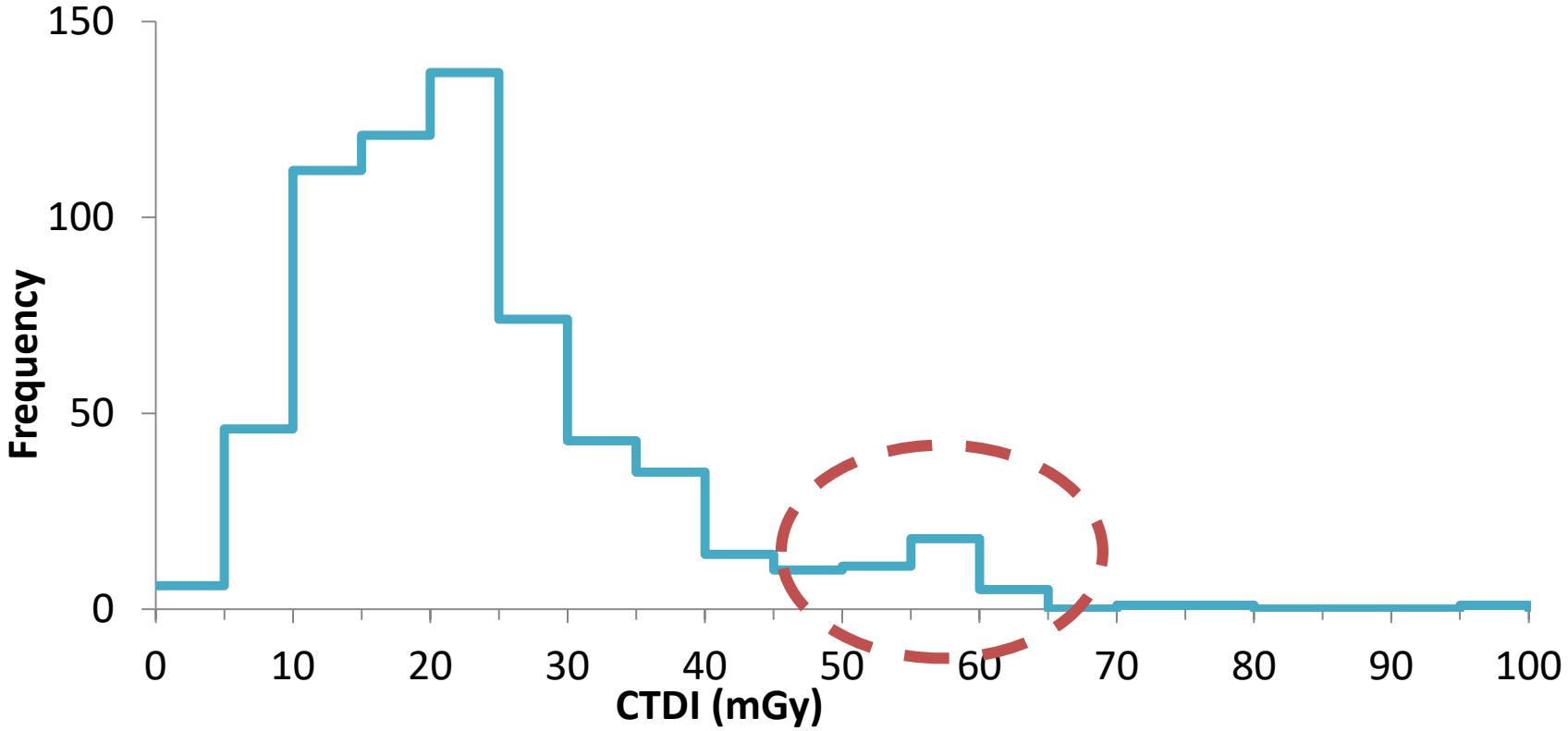
Paediatric phantom specification given – Ed. 3.1 onwards
SSDE to be introduced

CT Dose Display and Recording Requirements in IEC 60601-2-44						
IEC 60601-2-44 edition	**date of standard**	**clause**	**Dose metrics to be displayed prior to scan**	**Dose metrics to be displayed after the scan**	**Dose Metrics to be recorded in RDSR**	**Accuracy of Dose display and recording**
Ed. 2.0	June, 2001	29.1.103.3	CTDIw	n/a	n/a	n/a
Ed. 2.1	November, 2002	29.1.103.4	CTDIvol	n/a	n/a	n/a
Ed. 3.0	February, 2009	203.112	CTDIvol, DLP, phantom type (diameter)	CTDIvol, DLP, phantom type (diameter)	CTDIvol, DLP, phantom type (diameter)	n/a
Ed. 3.1	August, 2012	203.112	CTDIvol, DLP, phantom type (diameter)	CTDIvol, DLP, phantom type (diameter)	CTDIvol, DLP, phantom type (diameter)	The accuracy of the displayed and recorded values of CTDIvol and DLP shall be specified in the user manual.

sue.edyvean@phe.gov.uk

C-Spine (Fracture): Distribution of Scanner Median CTDI values

(PHE CT 2011 Survey Report)



CTDI values for 7 scanners

CT Scanner		GE LIGHTSPEED VCT (64)	
Scanner ID	No of patients	Average CTDI	Median CTDI
1	20	**43.2**	**41.6**
2	20	17.2	16.4
3	20	18.5	18.2
4	20	16.4	15.7
5	5	15.1	16.1
6	20	**32.4**	**30.6**
7	20	16.2	16.2

J. Holroyd, PHE (data from PHE CT 2011 Survey)

Importance of CTDI phantom Size

- Cervical spine (neck)
  - Head and neck protocol – 16 cm
  - Neck and body scan – 32 cm
- Recent UK survey found both in use
  - and that most scanners use 32 cm. But the same model may be utilised differently (even in the same organisation)

Table 2. Choice of CTDI phantom used to calculate CTDI measurements by the scanners included in this survey

CTDI phantom	Number of scanners
16 cm head	4
32 cm body	69

CTDI, CT dose index.

Holroyd JR, Edyvean S. Doses from cervical spine computed tomography (CT) examinations in the UK. *Br J Radiol* 2018; **91**: 20170834

sue.edyvean@phe.gov.uk

BJR

Received: 03 November 2017 | Revised: 09 February 2018 | Accepted: 13 February 2018
https://doi.org/10.1259/bjr.20170834
Cite this article as:
Holroyd JR, Edyvean S. Doses from cervical spine computed tomography (CT) examinations in the UK. Br J Radiol 2018; 91: 20170834.

FULL PAPER

Doses from cervical spine computed tomography (CT) examinations in the UK

JOHN R HOLROYD, BSc, MRes and SUE EDYVEAN, BSc, MSc

Centre for Radiation, Chemical and Environmental Hazards (CRCE), Public Health England, Chilton, Didcot, Oxfordshire, UK

Address correspondence to: John R Holroyd
E-mail: John.Holroyd@phe.gov.uk

Table 9. Summary of cervical spine CT NDRLs in the UK: existing and proposed

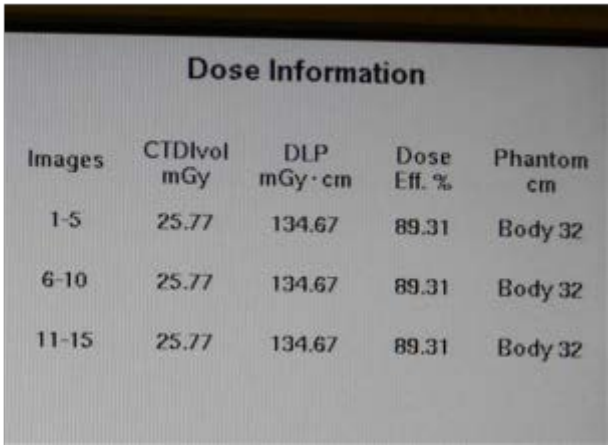
UK national DRLs	Quoted for 32 cm phantom		Quoted for 16 cm phantom	
	CTDIvol (mGy)	DLP (mGy cm)	CTDIvol (mGy)	DLP (mGy cm)
Existing	(15)	(324)	28	600
Proposed	20	440	(37)	(815)

AAPM, American Association of Physicists in Medicine; CTDI, CT dose index; DLP, dose–length product; DRL, diagnostic reference level; PHE, Public Health England.

Current value taken from the 2011 PHE CT survey is published for a 16 cm phantom. The actual proposed value from this study will be given for the 32 cm phantom. The conversion to the other phantom in each case is given in brackets, using the 0.54 factor from AAPM (2014).

Calibration / Verification of CTDI

- Manufacturers Specifications – accuracy of actual CTDI
  - IEC +/- 20% or even 40%
- Values on the screen may be representative of that model, or made on the actual scanner at the factory.
- Only one collimation and set of scan parameters may have been be measured at subsequent tests
  - Other values obtained using specification correction factors for collimation, tube current, kV etc



sue.edyvean@phe.gov.uk

Calibration details – PHE Survey

Calibration Data (only if available)

Last measured $CTDI_{vol}$ for this or a similar protocol (mGy):	
mAs used for the CTDI measurement above:	
Displayed $CTDI_{vol}$ for the CTDI measurement above (mGy):	

Calibration / Verification of CTDI

PHE 2017 Cervical Spine (Neck) CT Survey

- In this survey, information was requested on the latest CTDIvol measurement made on the CT scanner.
  - Details were requested on the measured and reported CTDIvol values for the standard cervical spine protocol, or for the most similar protocol. See table 4 for results.
- As data were not corrected for error in the previous PHE CT dose survey, it was decided not to correct the data for this single exam survey.
  - However, analysis performed, without those scanners with a discrepancy greater than 10%, showed no significant effect on the final results, and therefore, this aspect did not need to be considered for the application of the final reference values.

- Table 4 summarises the information received.
  - The vast majority of scanners had CTDI values measured within a few percent of the displayed values,
  - with only four scanners having an error greater than ± 10%.

Table 4. Summary of CTDI calibration data provided

Number of scanners	27
Average error (%)	0
Standard deviation (%)	6
Minimum error (%)	−13
Maximum error (%)	17

CTDI, CT dose index.

sue.edyvean@phe.gov.uk

Holroyd JR, Edyvean S. Doses from cervical spine computed tomography (CT) examinations in the UK. *Br J Radiol* 2018; **91**: 20170834

Public Health England

Current UK National Patient Dose Audits






Endorsed CPD Now

X-ray & Fluoro Pilot

UK Adult: plain X-ray; simple IR/fluoro surveys

Pilot

17th April 2019

Mid-2018 | 2019 | April | July | Sept | 2020

Pilot

20th March 2019

UK 4th CT survey (adult) pilot

UK 4th CT survey (adult)

Computed Tomography

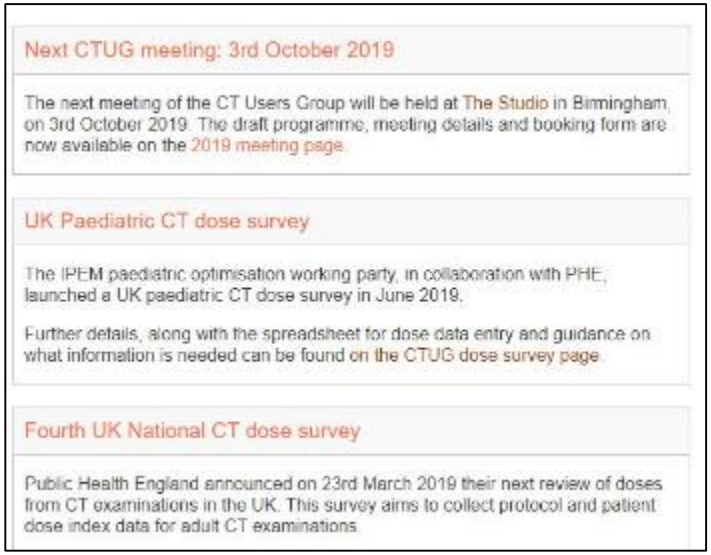
6th June 2019

IPEM/PHE

UK 4th CT survey (paediatric)

Data collection survey

- By Excel spreadsheet, familiar design
  - PHE cervical spine CT audit
  - IPEM SPECT/PET CT and radiotherapy audits
- Distributed via
  - CTUG mailing list (ctug.org.uk)
  - UK Medical-Physics-Engineering mail list
  - SCoR (Society and College of Radiographers) website and newsletter



Next CTUG meeting: 3rd October 2019

The next meeting of the CT Users Group will be held at The Studio in Birmingham on 3rd October 2019. The draft programme, meeting details and booking form are now available on the 2019 meeting page.

UK Paediatric CT dose survey

The IPEM paediatric optimisation working party, in collaboration with PHE, launched a UK paediatric CT dose survey in June 2019.

Further details, along with the spreadsheet for dose data entry and guidance on what information is needed can be found on the CTUG dose survey page.

Fourth UK National CT dose survey

Public Health England announced on 23rd March 2019 their next review of doses from CT examinations in the UK. This survey aims to collect protocol and patient dose index data for adult CT examinations.

SoR

Home | Public and Patient | About radiography | About us | Being a member | Learning | Career progression | Practice

Home > News > Participants urgently needed for PHE's CT dose survey

Participants urgently needed for PHE's CT dose survey

22 July, 2019

More responses are urgently needed for Public Health England's (PHE) Fourth National CT Dose Survey.

SCoR members are encouraged to submit data for any of the 13 examinations or other adult examinations that are routinely performed and/or have the highest doses.

"It has been decided to extend the deadline date for submitting data until the end of September 2019 to give participants additional time. If you have data ready to submit, please do so as soon as you can which will help us with processing," says PHE.

The data collection form and scanner help sheets are available on the CT users group website at http://www.ctug.org.uk/ctsurvey.html

For any queries and to submit data please email medicalradiationdoses@phe.gov.uk

Endorsed CPD Now

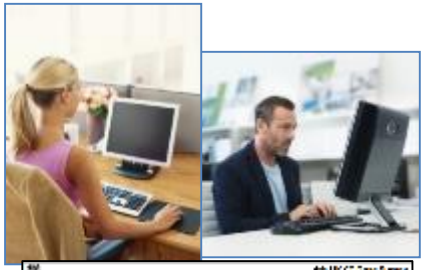
Public Health England

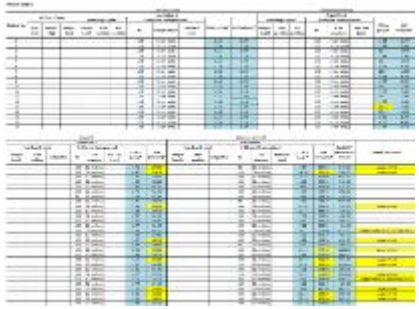
Survey Process

Contributors

PHE

Information from Scanner, Dose Management system, RIS, PACS





Submitting department (physics or radiology)

Quality Assurance Data examined for consistency/ obvious errors

Queries back to site for clarification

Data into standard format if necessary

Rogue data eliminated

Checking of submitted data

Data transferred into Access or into Master Excel workbook

Queried by Access/Excel interface

Results

Report

sue.edyvean@phe.gov.uk

Public Health England

Patient Selection - Examination

- Selection of Exams for National Audit
  - High frequency (most common)
  - High dose
- Specify:
  - Anatomical region
  - Clinical reason for scan

Public Health England

PHE UK Dose Audits – Selection of Exams

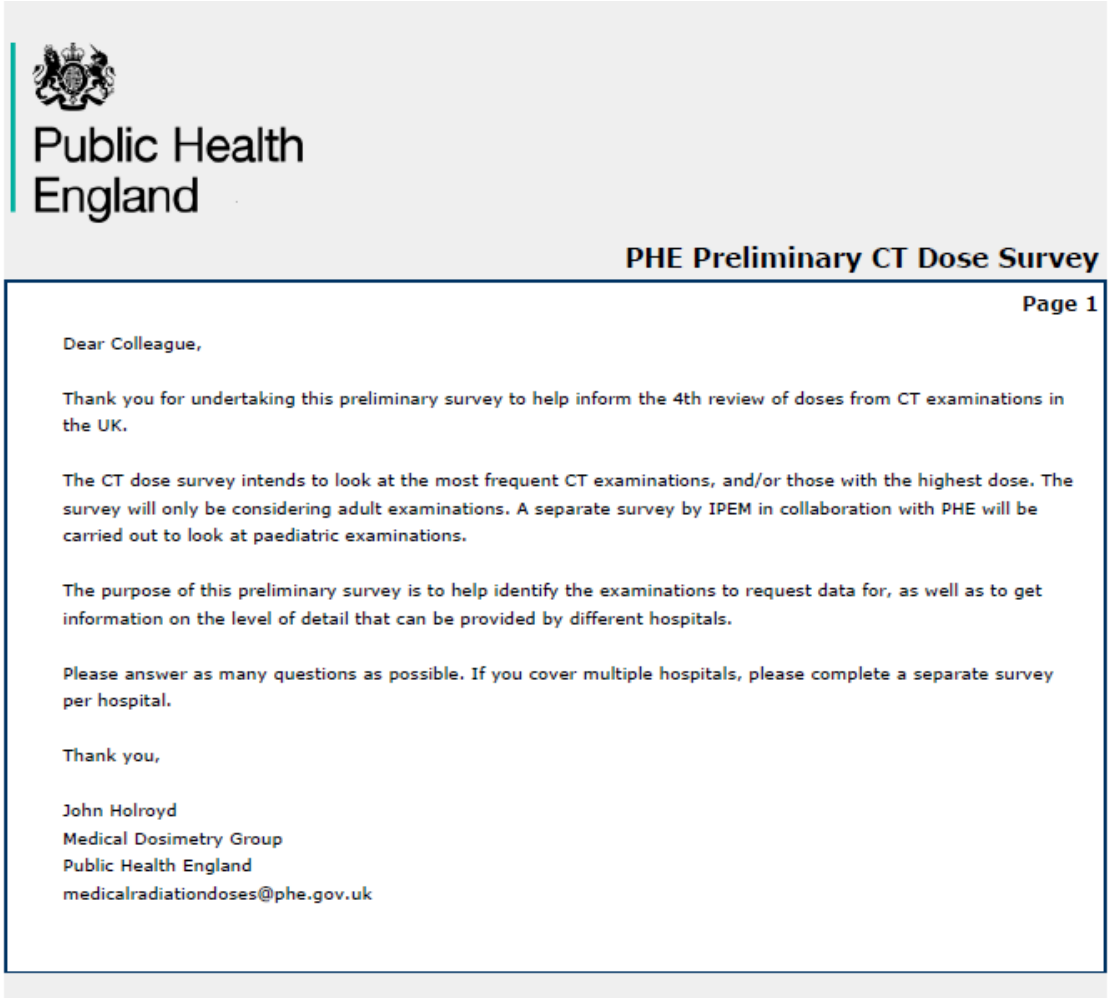
- Selection of Exams for National Audit
  - High frequency
  - High dose

NHS Digital | Diagnostic Imaging Dataset

- Diagnostic Imaging dataset (NHS Digital/NHS England)
  - SNOMED-CT and/or NICIP RIS codes

SNOMED-CT Code Title	Count 2016	% of all exams
Computed tomography of entire head (procedure) (408754009)	1,209,740	26.1%
Computed tomography of thorax, abdomen and pelvis with contrast (procedure) (433761009)	539,640	11.6%
Computed tomography of abdomen and pelvis with contrast (procedure) (432370003)	434,450	9.4%
Computed tomography angiography of pulmonary artery (procedure) (419225001)	193,225	4.2%
Computed tomography of urinary tract (procedure) (419084009)	153,895	3.3%
Computed tomography of chest (procedure) (169069000)	151,370	3.3%
Computed tomography of thorax with contrast (procedure) (75385009)	144,820	3.1%
Computed tomography of thorax and abdomen with contrast (procedure) (429864007)	114,295	2.5%
Computerised tomography of chest with high resolution (procedure) (315941000000105)	101,755	2.2%

Preliminary survey



Public Health England

PHE Preliminary CT Dose Survey

Page 1

Dear Colleague,

Thank you for undertaking this preliminary survey to help inform the 4th review of doses from CT examinations in the UK.

The CT dose survey intends to look at the most frequent CT examinations, and/or those with the highest dose. The survey will only be considering adult examinations. A separate survey by IPEM in collaboration with PHE will be carried out to look at paediatric examinations.

The purpose of this preliminary survey is to help identify the examinations to request data for, as well as to get information on the level of detail that can be provided by different hospitals.

Please answer as many questions as possible. If you cover multiple hospitals, please complete a separate survey per hospital.

Thank you,

John Holroyd
Medical Dosimetry Group
Public Health England
medicalradiationdoses@phe.gov.uk

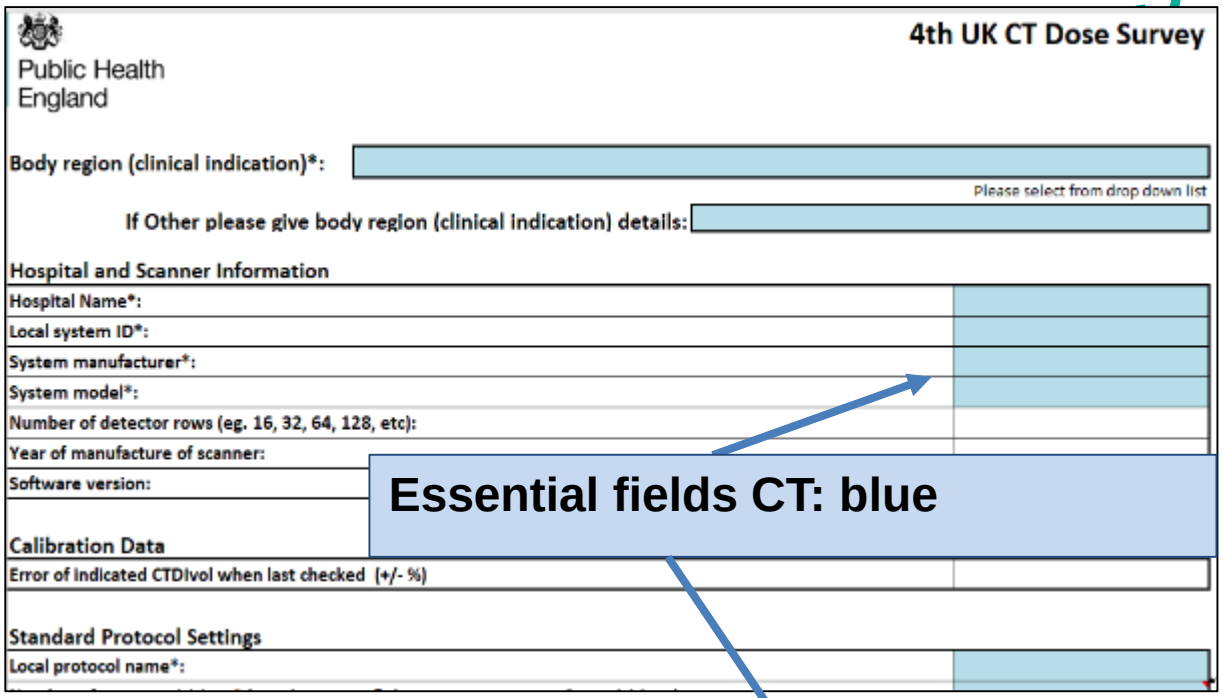
Preliminary survey results

Parameter	Automatic (%)	Manual (%)
Age	84	79
Patient diameter	15	33
Height	5	8
Weight	7	8
Size specific dose estimate (SSDE)	27	23
Water equivalent diameter, D_w	24	34

Could people supply us with this information?
- and whether they had to obtain it manually (by weighing, or dimensions from images) or from a dose management/PACs/RIS system

CT Survey Workbooks: Colour coding

Public Health England



Public Health England

4th UK CT Dose Survey

Body region (clinical indication)*:

Please select from drop down list

If Other please give body region (clinical indication) details:

Hospital and Scanner Information

Hospital Name*:	
Local system ID*:	
System manufacturer*:	
System model*:	
Number of detector rows (eg. 16, 32, 64, 128, etc):	
Year of manufacture of scanner:	
Software version:	

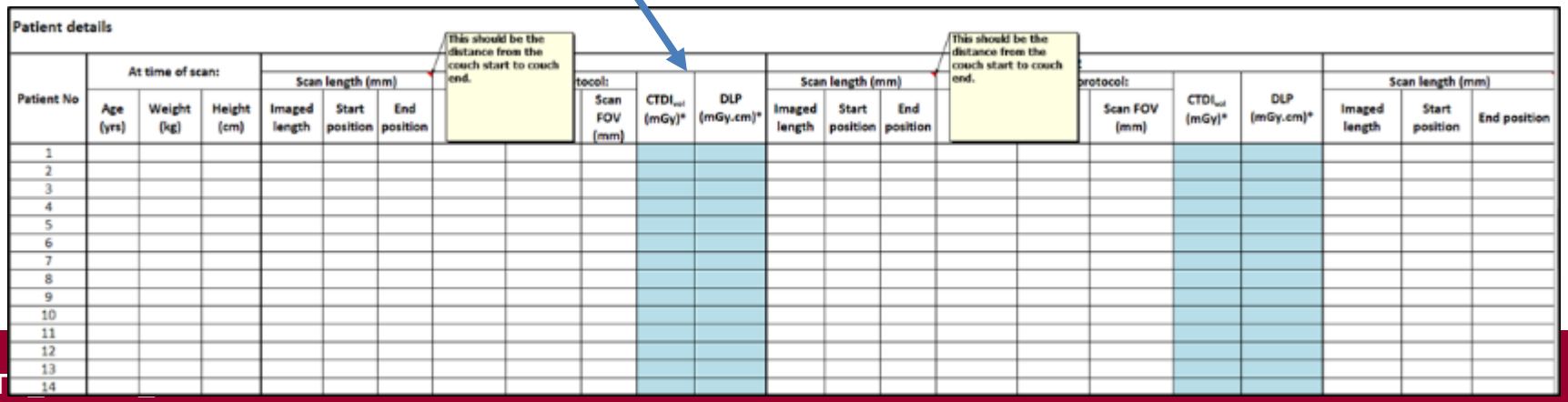
Calibration Data

Error of indicated CTDIvol when last checked (+/- %)	

Standard Protocol Settings

Local protocol name*:	

Essential fields CT: blue



Patient details

Patient No	At time of scan:			Scan length (mm)			This should be the distance from the couch start to couch end.			tocol:	CTDI$_{vol}$ (mGy)*	DLP (mGy.cm)*	Scan length (mm)			This should be the distance from the couch start to couch end.			protocol:	CTDI$_{vol}$ (mGy)*	DLP (mGy.cm)*	Scan length (mm)		
	Age (yrs)	Weight (kg)	Height (cm)	Imaged length	Start position	End position				Scan FOV (mm)			Imaged length	Start position	End position				Scan FOV (mm)			Imaged length	Start position	End position
1																								
2																								
3																								
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12																								
13																								
14																								

Public Health England

PHE UK Dose Audits – Selected Exams

Examination	Clinical indication	Suggested scan justifications that may use a similar exposure setup
Head	Acute stroke	head trauma, onset of headaches/facial pain, visual disturbances, aura/migraine, atypical seizure. Confusion, vomiting, slurred speech, limb weakness/worsening mobility. Existing aneurism. Previous surgery: CVA, evacuation of haematoma, biopsy
Paranasal sinuses	**Sinus disease**	**Tumour, infection**
Cervical spine (C-spine)	Fracture	head and neck injury. Fall/trauma/polytrauma. Previous vertebral tension. Neck pain or tenderness. RTC. Contact sports neck related injury
Neck, chest, abdomen and pelvis	**Query Cancer**	**Query Lymphoma, lymphadenopathy, nodal disease**
Chest	Query Lung cancer	Query cause of shadowing. Query lymphadenopathy. Previous lymph node enlargement. Bulky hilum (that persist on plain film). Abnormal CXR, pleural effusion
Chest – high resolution	Interstitial lung disease	Severe breathlessness, hypoxia, query parenchymal involvement. Subpleural ground-glass opacity
Chest and abdomen	Query Lung cancer	chest mass, abnormal CXR, shadowing, pleural effusion
Chest-abdomen-pelvis (CAP)	Query Cancer	Night sweats, weight loss, sepsis
CT pulmonary angiography (CTPA)	Pulmonary embolism	Pleuritic chest pain, decreased saturations, breathlessness. Sudden onset SOB. Previous surgery/PE
Abdomen and pelvis	Abscess	abdo pain, acute abdomen, weight loss, sepsis
Colonography/Virtual colonoscopy (VC)	Polyps/tumour	Anaemia, change of bowel habit, (do not include bowel cancer screening)
Kidney-ureters-bladder (KUB)	Stones/colic	Colicky pain, vomiting, previous calculus, haematuria
Urogram	Stones/colic or tumour	Query urological injury. Colicky pain, vomiting, previous calculus, haematuria. Query Urothelial tumour

Not included (but which were in 2011 survey): CT Angiography, Abdomen, Enteroclysis

Public Health

Protocol names

StudyDescription	Short_Name	RPID
CT HEAD SURGICAL PLANNING WO CONTRAST	CT HEAD WO IVCON	RPID22
CT HEAD W/O	CT HEAD WO IVCON	RPID22
CT HEAD WO CONT	CT HEAD WO IVCON	RPID22
CT HEAD WO CONTRAST	CT HEAD WO IVCON	RPID22
CT Head Scan wo Contrast	CT HEAD WO IVCON	RPID22
CT Head w/o Con	CT HEAD WO IVCON	RPID22
CT Head w/o Con/Mag/AI	CT HEAD WO IVCON	RPID22
CT NEEDLE GUIDE BIOPSY NEURO	CT HEAD WO IVCON	RPID22
CT ORBIT EAR WO CONTRAST	CT HEAD WO IVCON	RPID22
CT ORBITS,SCREEN FOR MRI	CT HEAD WO IVCON	RPID22
CT Orb/Ear w/o	CT HEAD WO IVCON	RPID22
CT Orbit/Sinus MR Screen	CT HEAD WO IVCON	RPID22
CT Orbits or Ear wo Contrast	CT HEAD WO IVCON	RPID22
HEAD CT	CT HEAD WO IVCON	RPID22
HEAD WO	CT HEAD WO IVCON	RPID22
TCT HEAD	CT HEAD WO IVCON	RPID22
TCT HEAD W/O	CT HEAD WO IVCON	RPID22
TCT HEAD WO CONTRAST	CT HEAD WO IVCON	RPID22
TCT Head Scan wo Contrast	CT HEAD WO IVCON	RPID22
TCT Head wo Con	CT HEAD WO IVCON	RPID22
TCT Head wo Con/Mag/AI	CT HEAD WO IVCON	RPID22
TCT Orbits or Ear wo Contrast	CT HEAD WO IVCON	RPID22

List of the 19 exam names used at one institution for noncontrast head CT

PHE CT protocol
Head
Paranasal sinuses
Cervical spine (C-spine)
Neck, chest, abdomen and pelvis
Chest
Chest – high resolution
Chest and abdomen
Chest-abdomen-pelvis (CAP)
CT pulmonary angiography (CTPA)
Abdomen and pelvis
Colonography/Virtual colonoscopy (VC)
Kidney-ureters-bladder (KUB)
Urogram

P

Public Health England

Clinical Reason for Scan

Data is requested for the examinations listed below. See the 'scan regi

PHE CT protocol	Clinical indication
Head	Acute stroke
Paranasal sinuses	Paranasal sinuses
Cervical spine (C-spine)	Fracture
Neck, chest, abdomen and pelvis	Query Cancer
Chest	Query Lung cancer
Chest – high resolution	Interstitial lung disease
Chest and abdomen	Query Lung cancer

Introduction | Guidelines | **Protocol guidance** | Scan Regi

sue.edyvean@phe.gov.uk

PHE UK CT Protocols for National CT Dose Audit (Adults)

PHE CT protocol	Clinical indication
Head	Acute stroke

Clinical Reason for Scan

Other similar reasons

Suggested scan justifications that may use a similar exposure setup
head trauma, onset of headaches/facial pain, visual disturbances, aura/migraine, atypical seizure. Confusion, vomiting, slurred speech, limb weakness/worsening mobility. Existing aneurism. Previous surgery: CVA, evacuation of haematoma, biopsy

Key words for RIS or dose management search

Keywords for electronic searches (eg. on a RIS or dose management system)
Stroke, CVA, haemorrhage

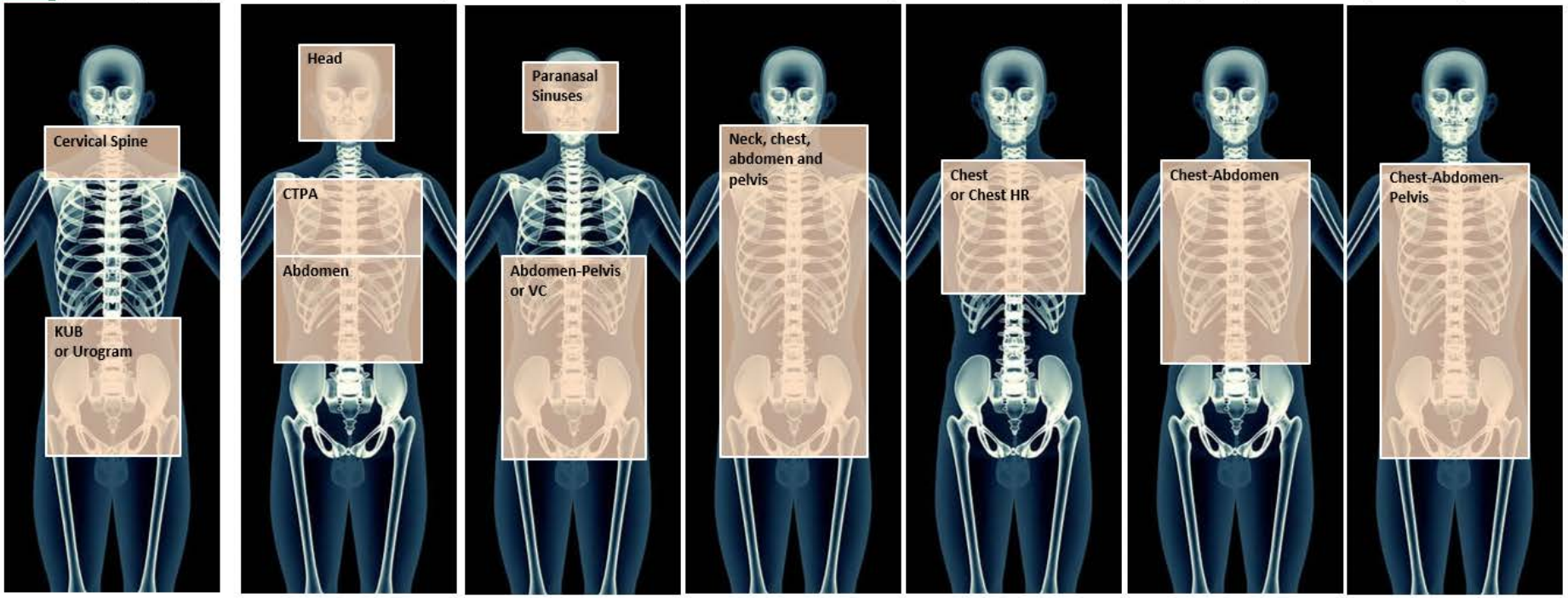
sue.edyvean@phe.gov.uk

Anatomical Scan Region Guidance

Public Health England

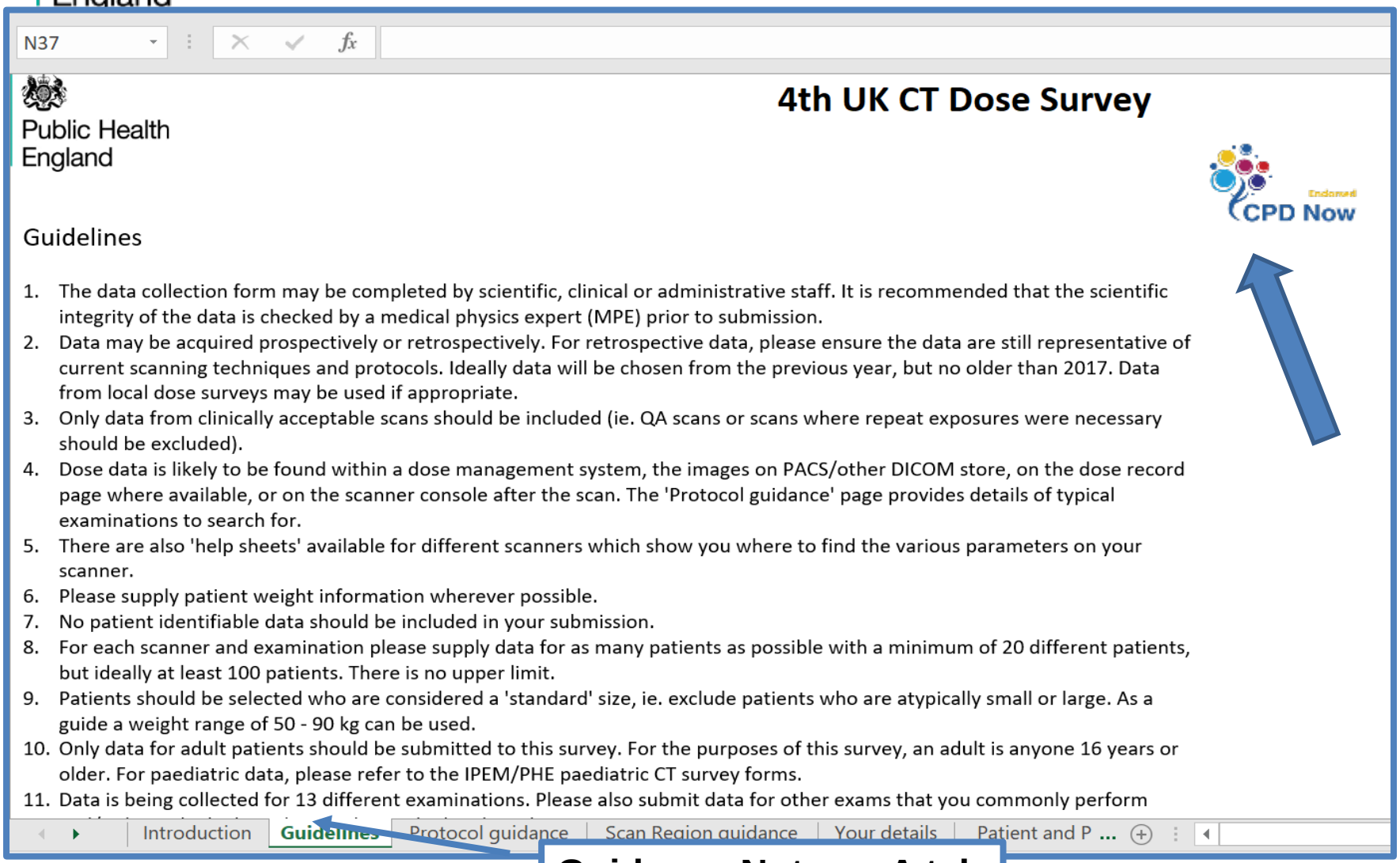
4th UK CT Dose Survey

The images below give an approximation of the start and end positions for the 13 examinations requested for this dose survey. These should be used as a guide only - please provide data for your clinical practice.



Introduction | Guidelines | Protocol guidance | **Scan Region guidance** | Your details | Patient and P ...

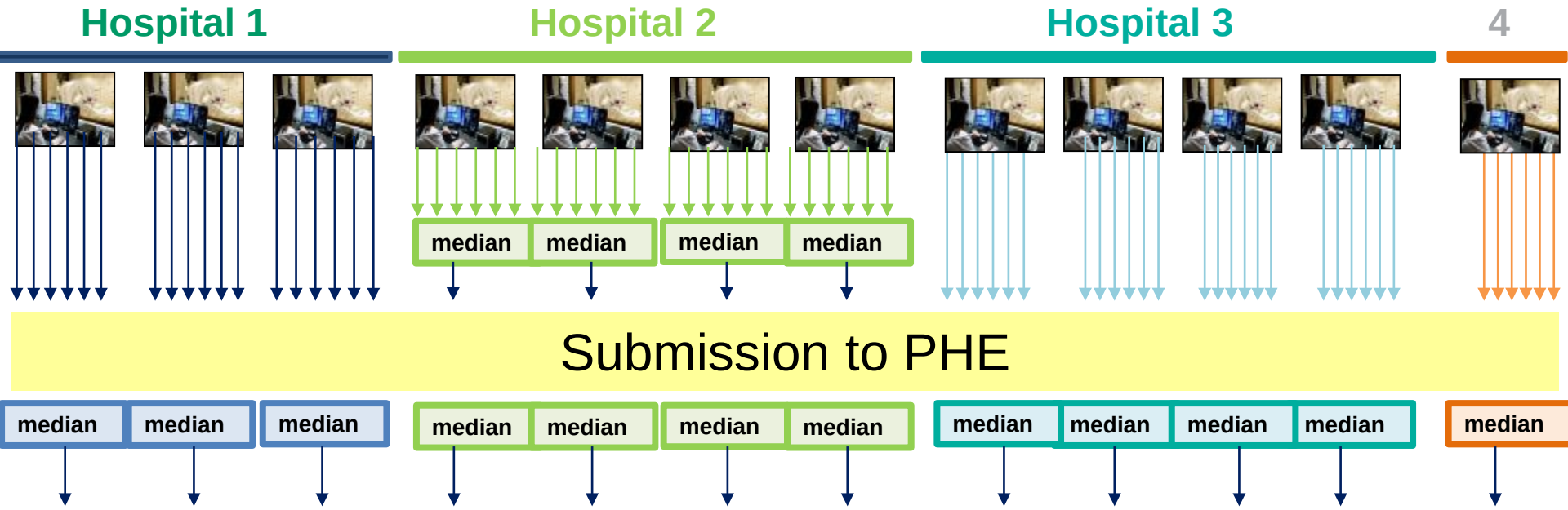
Guidance Notes



Guidance Notes - A tab in each Excel file

UK National DRLS

- Hospitals send either
  - Individual patient data or
  - Summary mean and median^ data from own audit



^asked for mean (for retrospective comparison), and median (ICRP recommended approach) for this and future surveys

sue.edyvean@phe.gov.uk

PHE 4th UK Survey – patient data

Essential fields (blue)

Public Health England

4th UK CT Dose Survey

Body region (clinical indication)*:

Please select from drop down list

If Other please give body region (clinical indication) details:

Hospital and Scanner Information

Hospital Name*:	
Local system ID*:	
System manufacturer*:	
System model*:	
Number of detector rows (eg. 16, 32, 64, 128, etc):	
Year of manufacture of scanner:	
Software version:	

Calibration Data

Error of indicated CTDIvol when last checked (+/- %)	

Standard Protocol Settings

Local protocol name*:	
Number of scan acquisitions* (e.g. 1 contrast & 1 non-contrast scan = 2 acquisitions):	

Acquisition 1 details

CTDI phantom size (cm) (i.e. 16 cm head or 32 cm body)*:		
Is Automatic Exposure Control (AEC) used?^		
AEC name (e.g. AutomA, ZDOM, CARE Dose 4D, SureExpose):		
AEC setting type (e.g. ref noise index, reference mAs, etc):		
AEC setting value (e.g. SD 7.5, ref mAs 200):		
minimum mA for AEC (where applicable):		
maximum mA for AEC (where applicable):		
mA where AEC is not used:		
Is iterative reconstruction used?*		
Iterative recon type (e.g. ASIR, SAFIRE, iDose, AIDR):		
Iterative recon value (e.g. ASIR 40%, SAFIRE 3, iDose level 4):		
Radiation beam collimation	- Collimated beam width (mm):	
	- Number of slices:	
	- Detector size (mm) (e.g. 0.625,0.6):	
Is Automatic tube voltage selection used? (eg. CarekV)		
If no, Fixed Tube voltage (kV):		
Tube rotation time (s):		
Primary image slice thickness (mm):		
Scan field of view (SFOV) (mm):		
Reconstruction field of view (DFOV) (mm):		
Axial or helical?		
Pitch (where applicable):		
Primary Reconstruction algorithm or kernel (e.g. B30; FC17; Std)		
Is contrast used?		

Patient details

Patient No	At time of scan:			Scan length (mm)			This should be the distance from the couch start to couch end.			Scan protocol:	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	Scan length (mm)			This should be the distance from the couch start to couch end.			Scan protocol:	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	Scan length (mm)		
	Age (yrs)	Weight (kg)	Height (cm)	Imaged length	Start position	End position				Scan FOV (mm)			Imaged length	Start position	End position				Scan FOV (mm)			Imaged length	Start position	End position
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Submit by patient (no ID info)

PHE 4th UK Survey – local audit data

Summary dose data from local audit

No of Patients	Mean Age at time of scan (yrs)	Mean Body Mass (kg)	Mean Total DLP* (whole scan)	Median Total DLP* (whole scan)	Comments on the data collection method (eg. inclusion criteria, data analysis method)

Acquisition 1									
Mean $CTDI_{vol}$ (mGy)*	Standard deviation	Median $CTDI_{vol}$ (mGy)*	25th Percentile	75th Percentile	Mean DLP (mGy.cm)*	Standard deviation	Median DLP (mGy.cm)*	25th Percentile	75th Percentile

Acquisition 2									
Mean $CTDI_{vol}$ (mGy)*	Standard deviation	Median $CTDI_{vol}$ (mGy)*	25th Percentile	75th Percentile	Mean DLP (mGy.cm)*	Standard deviation	Median DLP (mGy.cm)*	25th Percentile	75th Percentile

Or by summary data from local audit – for each system

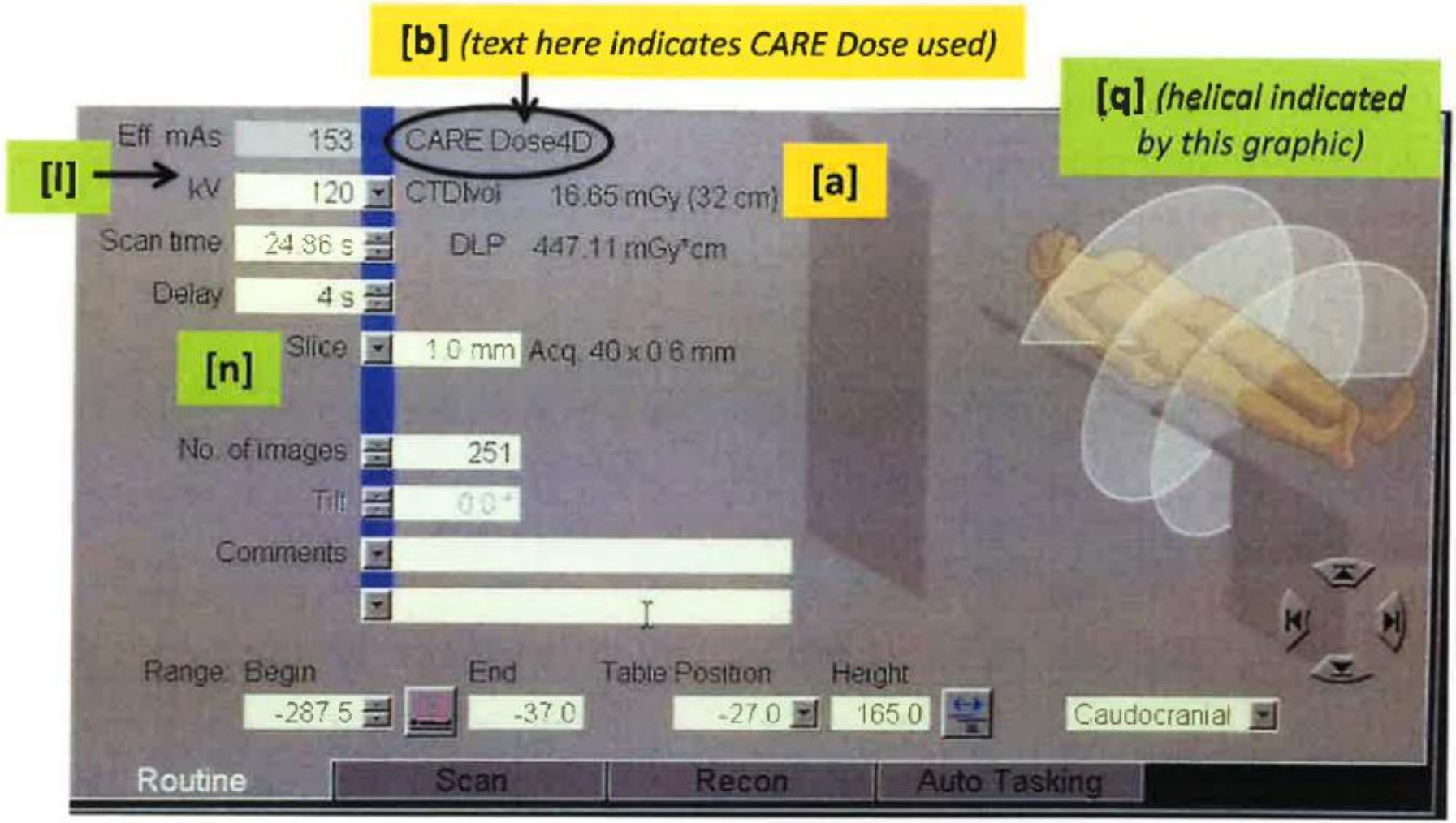
Protocol details: scan details

Acquisition 1 details

See notes on scanner specific help sheet

CTDI phantom size (cm) (i.e. 16 cm head or 32 cm body)*:			[a]
Is Automatic Exposure Control (AEC) used?*			[b]
AEC name (e.g. AutomA, ZDOM, CARE Dose 4D, SureExpose):			[c]
AEC setting type (e.g. ref noise index, reference mAs, etc):			[d]
AEC setting value (e.g. SD 7.5, ref mAs 200):			[e]
minimum mA for AEC (where applicable):			[f1]
maximum mA for AEC (where applicable):			[f1]
mA where AEC is not used:			[f2]
Is iterative reconstruction used?			
Iterative recon type (e.g. ASIR, SAFIRE, iDose, AIDR):			[g]
Iterative recon value (e.g. ASIR 40%, SAFIRE 3, iDose level 4):			[h]
Radiation beam collimation	**- Collimated Beam width (mm):**		[i]
	- Number of slices:		[j]
	- Detector size (mm) (e.g. 0.625,0.6):		[k]
Is Automatic tube voltage selection used? (eg. CarekV)			
If no, Fixed Tube voltage (kV):			[l]
Tube rotation time (s):			[m]
Primary image slice thickness (mm):			[n]
Scan field of view (SFOV) (mm):			[o]
Reconstruction field of view (DFOV) (mm):			[p]
Axial or helical?			[q]
Pitch (where applicable):			[r]
Reconstruction algorithm or kernel (e.g. B30; FC17; Std)			[s]
Is contrast used?			
Anatomical landmarks for start and	**Start point (e.g. base of skull)**		
end points	**End point (e.g. vertex)**		

Siemens scanner - help sheet



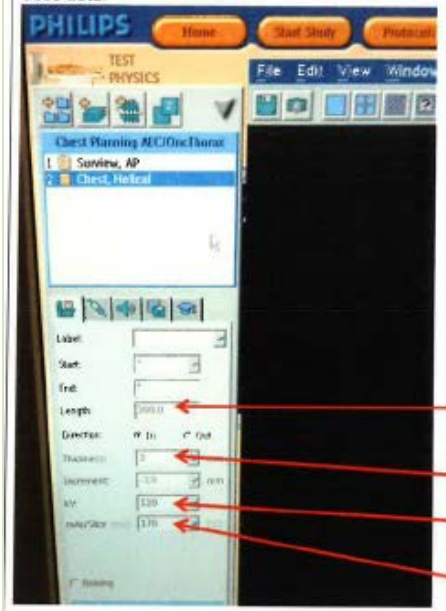
sue.edyvean@phe.gov.uk

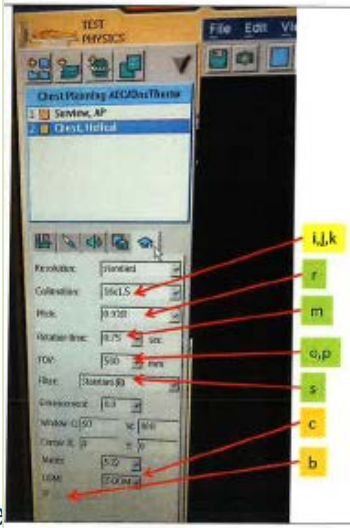
Philips CT scanners – help sheet

These instructions are based on an older Brilliance Big Bore scanner. New software versions may vary from guidelines.

Prospective data collection (during patient scan):

On the protocol settings panel, the first and last tab can be used to obtain a lot of dose data.

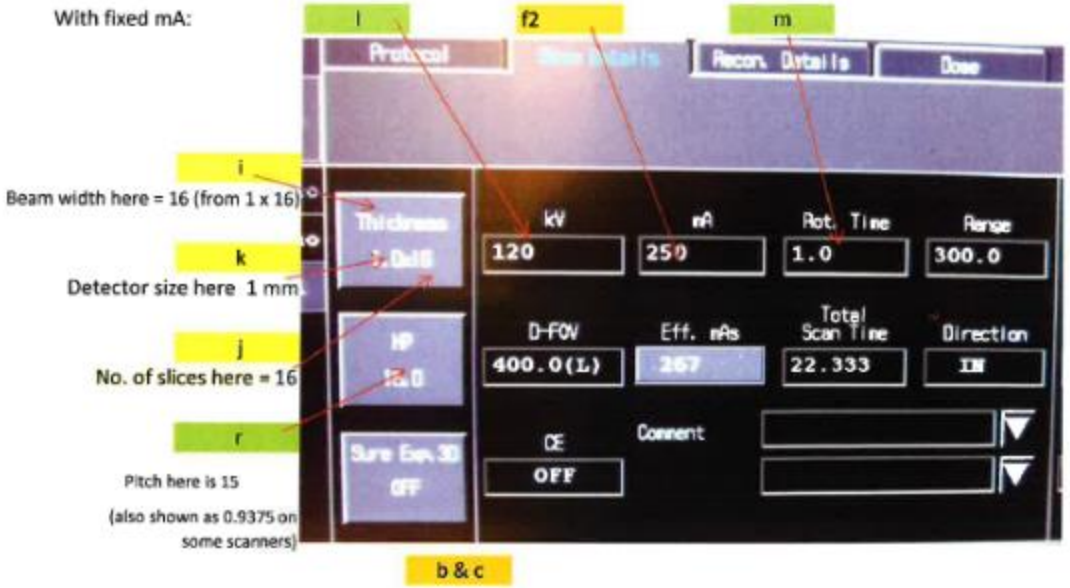




Canon / Toshiba scanners - help sheet

This is based on an old Toshiba LB. Newer scanners may look different but terms should be the same or similar.

With fixed mA:



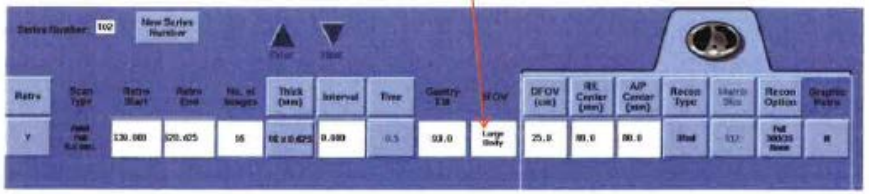
f auto mA is switched on:

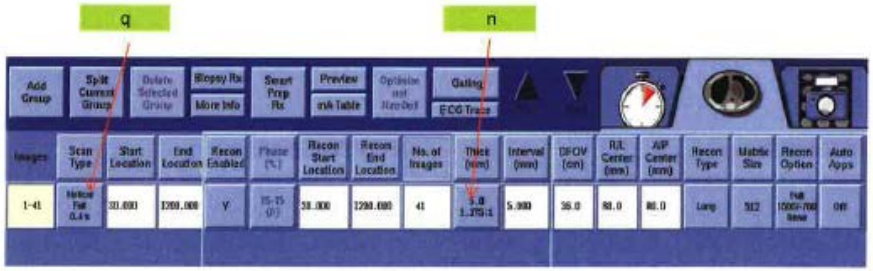
d
AEC setting type is Noise Index

e

GE scanners - help sheet

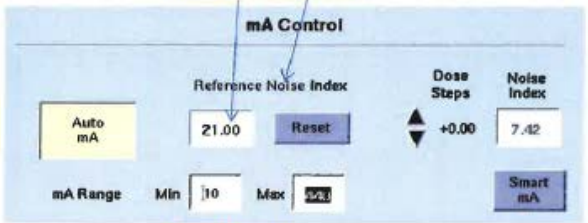
o



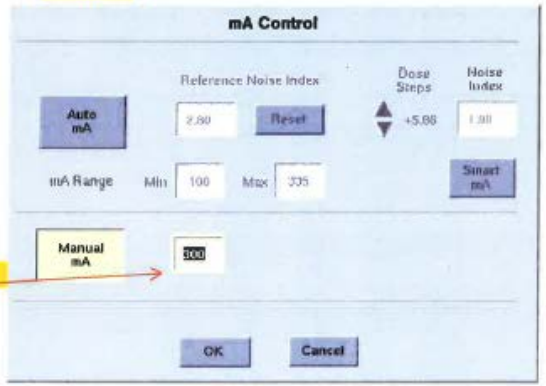


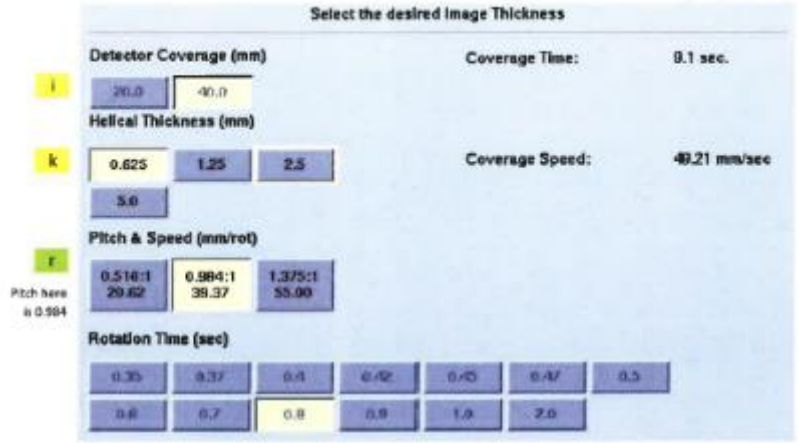
If auto mA

e d

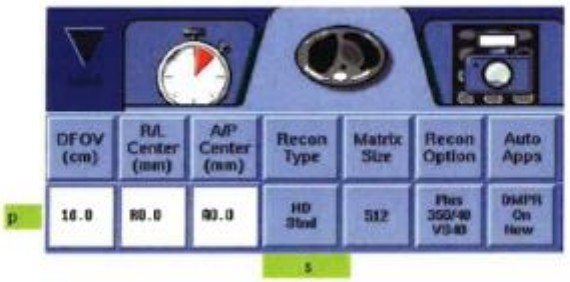


f1





m



Example dose report showing delivered dose for, in this case, two axial scans

Patient Name: Exam no: 24
Accession Number: Nov 08 2011
Patient ID: Dose SR Discovery CT750 HD
Exam Description:

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Axial	50.000-557.500	93.37	560.24	Head 16
1	Axial	560.000-1135.000	63.88	511.06	Head 16
			Total Exam DLP:	1071.30	

Total mAs if available & switched on will be shown on the dose report. (Not shown here)
If not available leave this part of the data sheet blank.

a

sue.edyvean@phe.gov.uk

Patient Selection – size and numbers of patients

- Size of patient in sample
- Numbers of patients in sample

sue.edyvean@phe.gov.uk

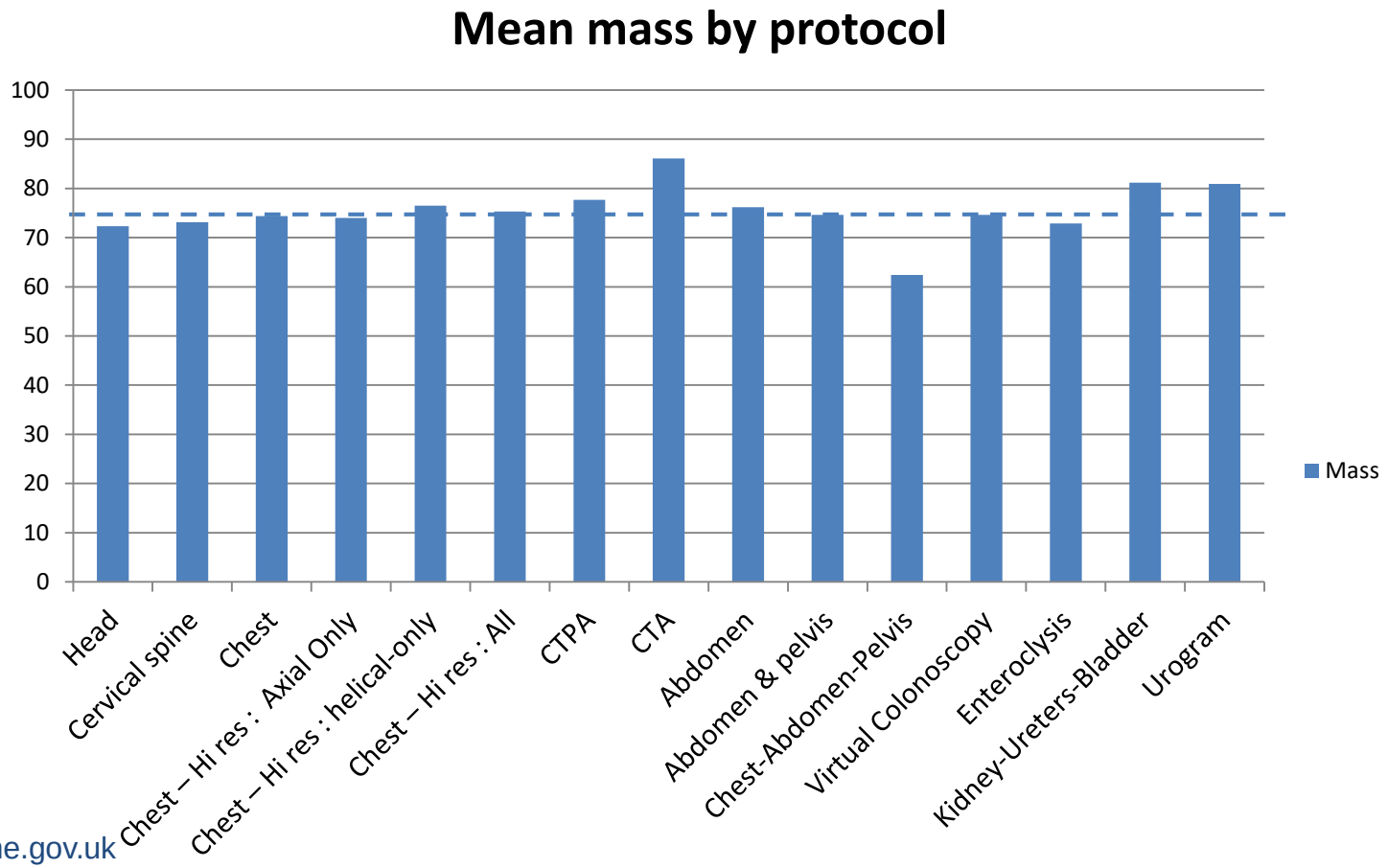
Dose Audits - Patient size

- Usually/previously specify data collected from
  - 70 kg +/- 20 kg (ie 50 – 90kg)
- So that the mean value of the weight is
  - 70 kg +/- 10 kg (or even +/- 5 kg)
- Of course – standard weight is not 70 kg …..
- Weight often not available
- Now ICRP not so specific - ‘standard’
  - Causes problems for inter-comparison of DRLs
  - Good reason to have weight based DRLs in the future

sue.edyvean@phe.gov.uk

PHE 2011 Survey Data - Individual Patients

- Mean mass = 75 kg
- Max: CTA = 86 kg, Min: CAP = 62 kg



sue.edyvean@phe.gov.uk

Dose Audits – Numbers of data and patient size

- (227) If data collection is via paper forms, the number of patients will be limited, but should be at least 20–30. With restricted numbers, information on patient sizes should be recorded, if possible, or at least the range of sizes should be restricted, with very large and very small patients being excluded.
- This is not a concern when an automated data collection system is used.

ICRP 135

A general accepted approach with large scale data sets is to remove the top 5% and bottom 5% of doses values

sue.edyvean@phe.gov.uk

Large Scale Data – all weights

- **E.g. from Radiology Information system (RIS) (with manual dose index data input), or PACs or Dose management systems**
- **Outliers can be removed easily – e.g. removing top and bottom 5% of data**

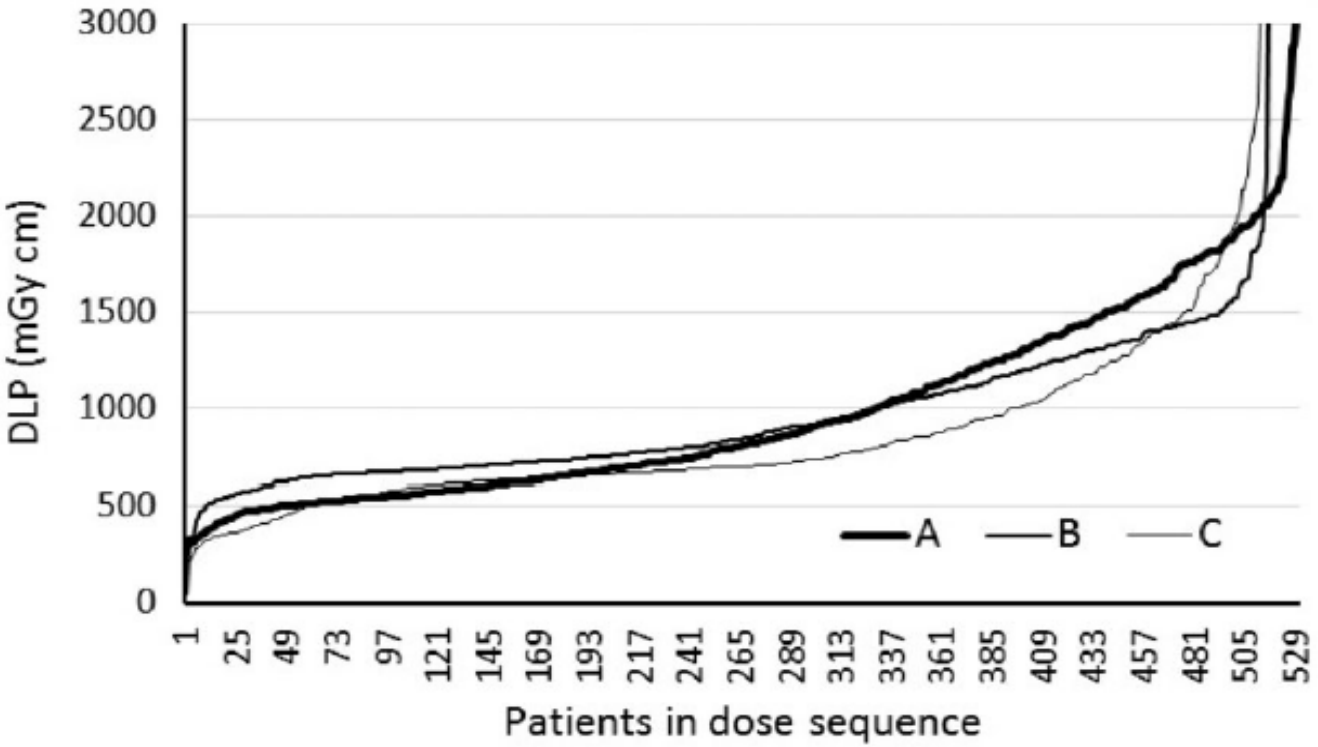


Fig. 2.1. Examples of data on dose–length product (DLP) for chest–abdomen–pelvis scans on three computed tomography (CT) scanners operating under automatic tube current modulation plotted sequentially in terms of increasing DLP (Martin, 2016). Outliers can be identified readily and omitted from the data analysis.

Martin 2016, and ICRP 135

Radiation Protection Dosimetry (2012), Vol. 150, No. 4, pp. 427–433
Advance Access publication 16 November 2011
doi:10.1093/rpd/ncr434

VALIDATION OF A LARGE-SCALE AUDIT TECHNIQUE FOR CT DOSE OPTIMISATION

T. J. Wood[1,*], A. W. Davis[1], C. S. Moore[1,2], A. W. Beavis[1,2,3] and J. R. Saunderson[1,4]
[1]Radiation Physics Department, Hull and East Yorkshire Hospitals NHS Trust, Queen's Centre for

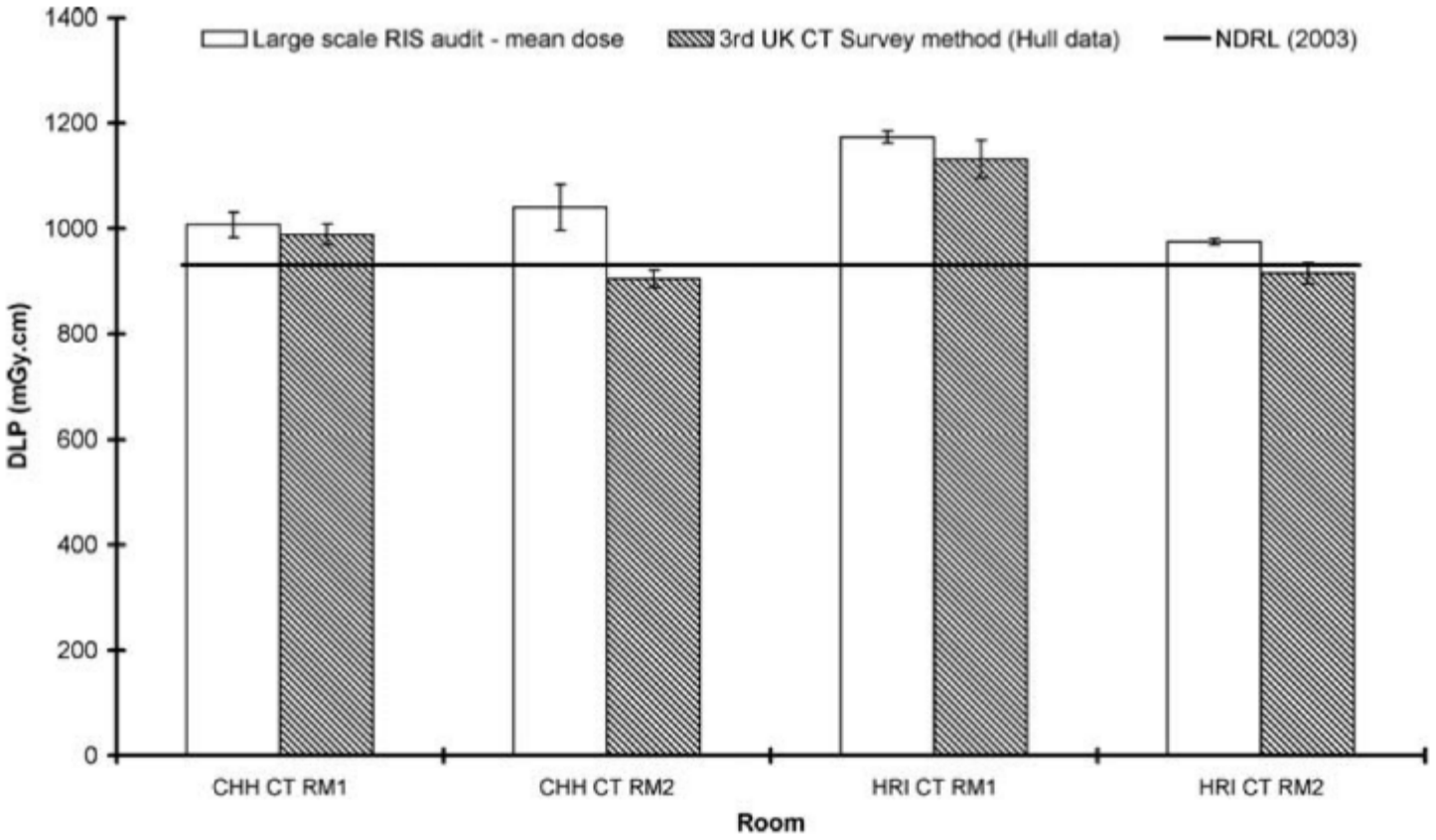


Figure 1. A comparison of the mean CT head DLPs determined using Dosalyzer with the third UK CT survey data, for each of the four radiology CT scanners in the Hull and East Yorkshire Hospitals NHS Trust. Error bars are defined by two times the SEM[8], and the national DRL is indicated by the solid line (derived from the 2003 review of CT doses[13]).

sue.edyvean@pne.gov.uk

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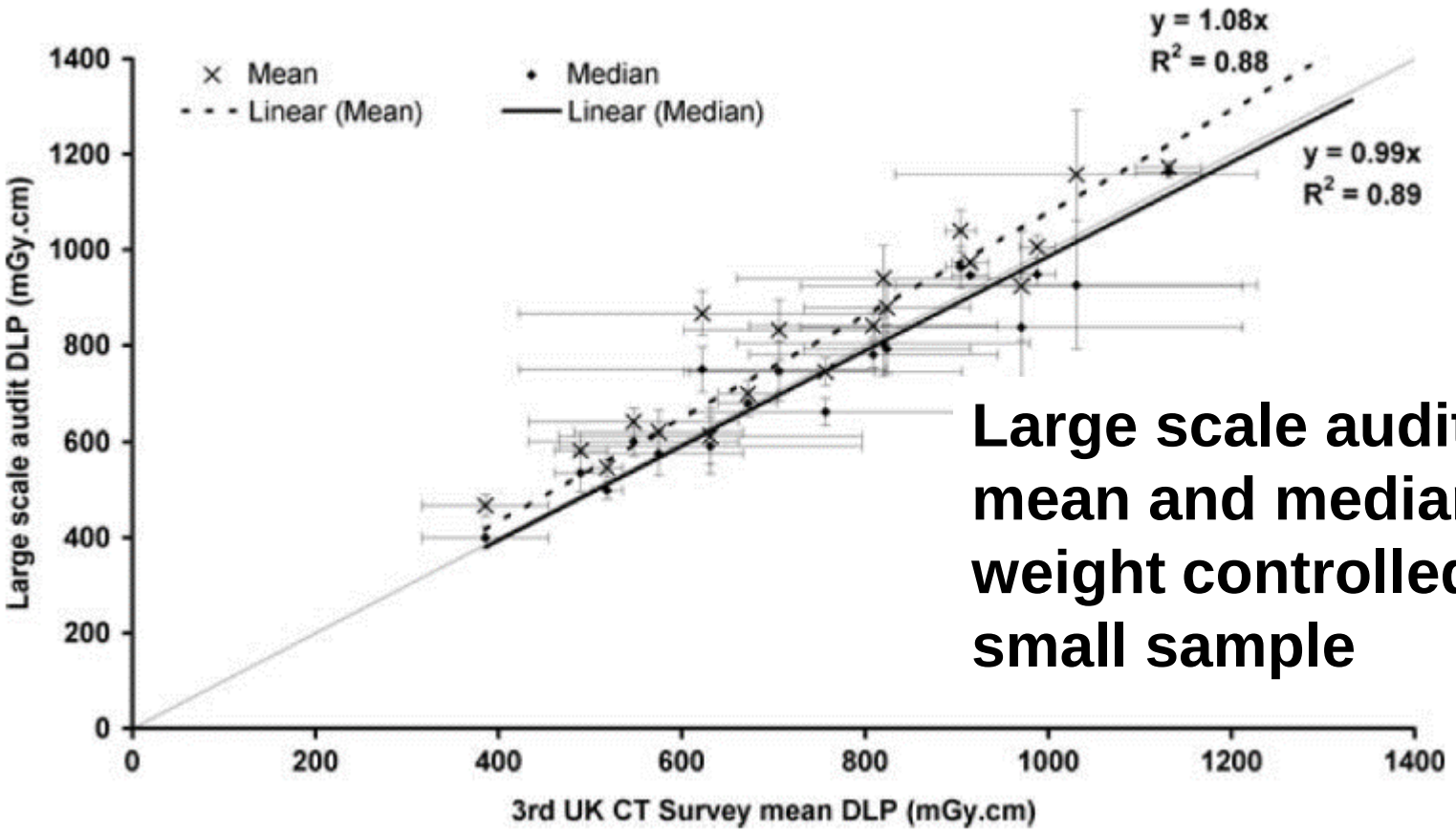


Large scale audit: mean and median vs weight controlled small sample

sue.edyvean@phe.gov.uk

Public Health
England

ESTABLISHING LOCAL AND REGIONAL DRLs BY MEANS OF ELECTRONIC RADIOGRAPHICAL X-RAY EXAMINATION RECORDS

P. Charnock*, B. M. Moores and R. Wilde
Integrated Radiological Services Ltd, Unit 188 Century Buildings, Tower Street, Brunswick Business Park, Liverpool L3 4BJ, UK

*Corresponding author: paulcharnock@irs-limited.com

Received December 31 2012, revised April 12 2013, accepted April 16 2013

The objective of the paper is to demonstrate that patient dose audits may be undertaken at the local and regional levels by employing electronic examination records contained in Radiology Information Systems (RISs) that have been collected, analysed and managed by modern IT systems. The resulting mean and third quartile values obtained may then be used to establish local and regional dose reference levels (DRLs) as part of an optimisation strategy. The method involved the collection of roughly 1.3 million radiographical examination records stored in hospital RIS over a 3-y period from 10 hospital sites in the north of England. These were analysed according to the process employed in the national patient dose (NPD) audits undertaken every 5 y in the UK. Data processing and analysis methods are described that are suitable for handling very large data sets quickly and efficiently. Because RIS data involve manual data entry it may be susceptible to data entry errors. Therefore, a comparison of results obtained from both RIS and DICOM generated data was first of all undertaken in order to 'calibrate' the RIS-based method and demonstrate its accuracy. The results obtained from this comparison indicate that the RIS-based examination records provide patient dose distributions with an equivalent statistical accuracy compared with those employing DICOM data and, therefore, may be employed in patient dose audits in order to establish both local and regional DRLs for use in patient dose management and optimisation strategies.

sue.edyvean@phe.gov.uk

RIS (Radiology Information system)

- Example of summary Data
  - Total exam and DLP only

PHE CT Protocol	RIS Name	Scanner	No of Patients	Mean Age at time of scan (yrs)	Mean Total DLP* (whole scan)	Median Total DLP* (whole scan)	Standard deviation
Abdomen and pelvis (Abscess)	Abdomen and pelvis (Abscess)	CT	34	51.38	510.3	489	222.29
Cervical spine (C-spine) (Fracture)	Cervical spine (C-spine) (Fracture)	CT	341	58.10	166.3	153	69.48
Chest (Lung cancer)	Chest (Lung cancer)	CT	69	57.13	247.6	222.8	106.93
Chest-abdomen-pelvis (CAP) (Cancer)	Chest-abdomen-pelvis (CAP) (Cancer)	CT	133	57.71	566.0	509	224.60
CT pulmonary angiography (CTPA) (Pulmonary embolism)	CT pulmonary angiography (CTPA) (Pulmonary embolism)	CT	54	57.17	267.2	264	69.12
Head (acute stroke)	Head (acute stroke)	CT	2246	55.60	830.7	818.4	132.85
Other	CT Brain Volume (allegro)	CT	717	50.08	900.3	947	213.62
Other	CT Spine Lumbar	CT	464	54.77	211.7	184.5	107.70
Other	Angio Intracranal/Venogram Cerebral	CT	573	52.38	728.2	744.2	88.45

Usually only get DLP data and total exam information from RIS

In the UK – since IRMER 2000 (UK law) radiographers input dose index data into RIS system

sue.edyvean@phe.gov.uk

Public Health England

PHE 2019 survey - CT submissions to date

	This survey	2011 survey
Number of Hospitals	60	127
Number of Scanners	115	182^
Number of local audit spreadsheets	677	189
Number of patient spreadsheets	421	682
Number of patients	413,257	46,938

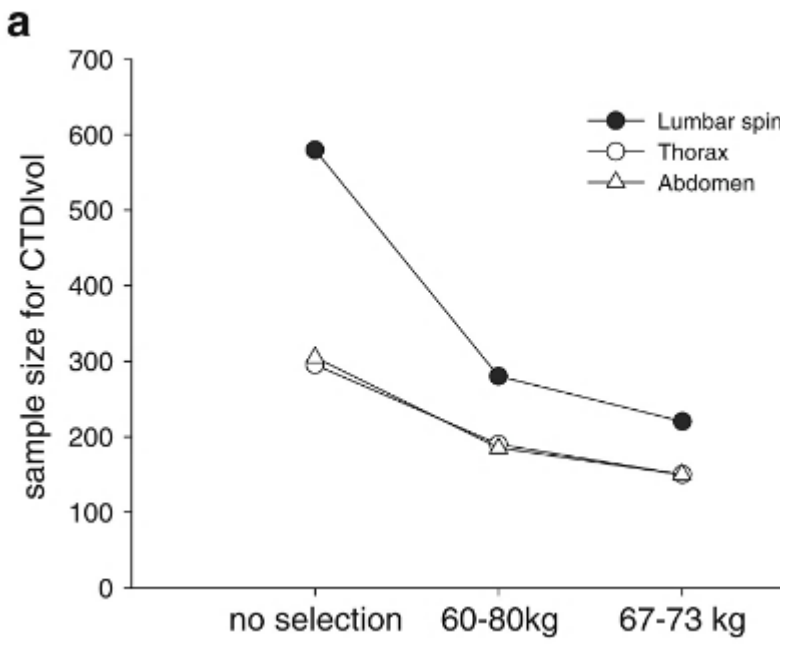
^30% of installed base

Eur Radiol (2017) 27:365–373
DOI 10.1007/s00330-016-4333-3

COMPUTED TOMOGRAPHY

CT dose survey in adults: what sample size for what precision?

Stephen Taylor[1] · Alain Van Muylem[2] · Nigel Howarth[3] · Pierre Alain Gevenois[4] · Denis Tack[5]



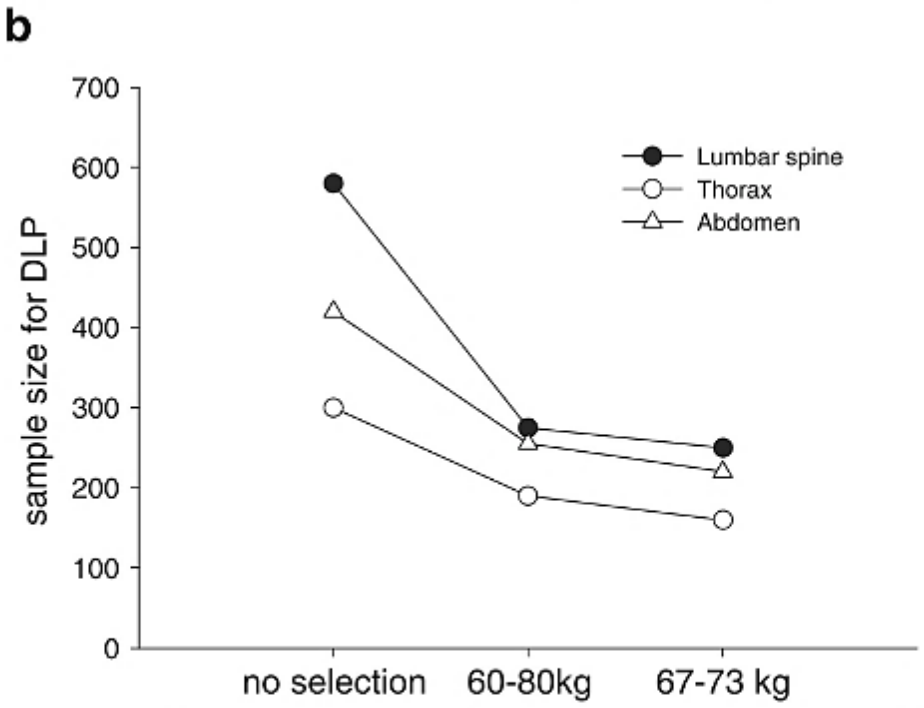


Fig. 3 **a** and **b** show the effect of body weight selection on the sample size required in center A to achieve CI95/med < 10 % for the thorax, abdomen and lumbar spine when using CTDIvol and DLP as the data sources, respectively

sue.edyvean@phe.gov.uk

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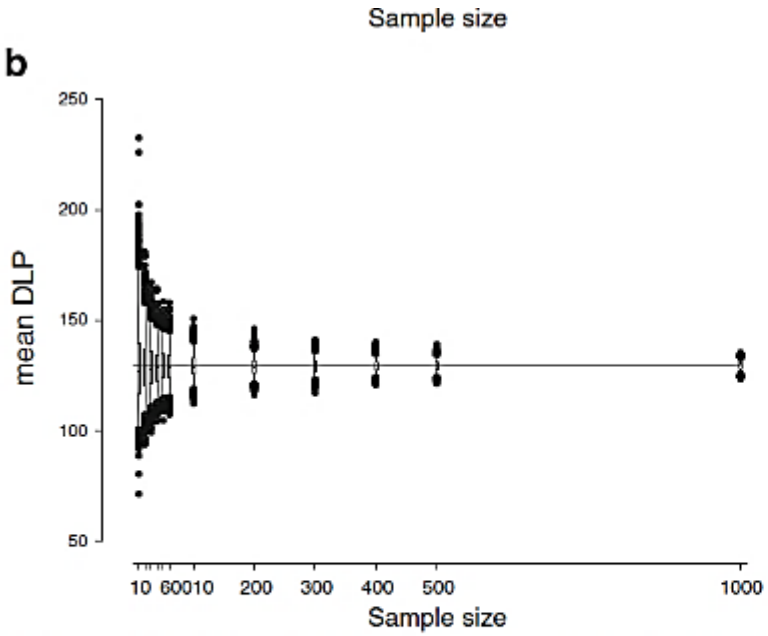


Fig. 1 a–b. show the sampled distribution of mean CTDIvol and DLP, respectively, for acquisitions in the thorax (2000 samples) as a function of sample size. For each sample size, the *box* represents the inter-quartile range and the *whiskers* represent the 95 % confidence interval; the *closed circles* are the values above percentile 97.5 and under percentile 2.5. Inside each *box*, the *horizontal line* is the median. The *dashed horizontal line* is the CTDIvol or DLP mean of the whole population of CT

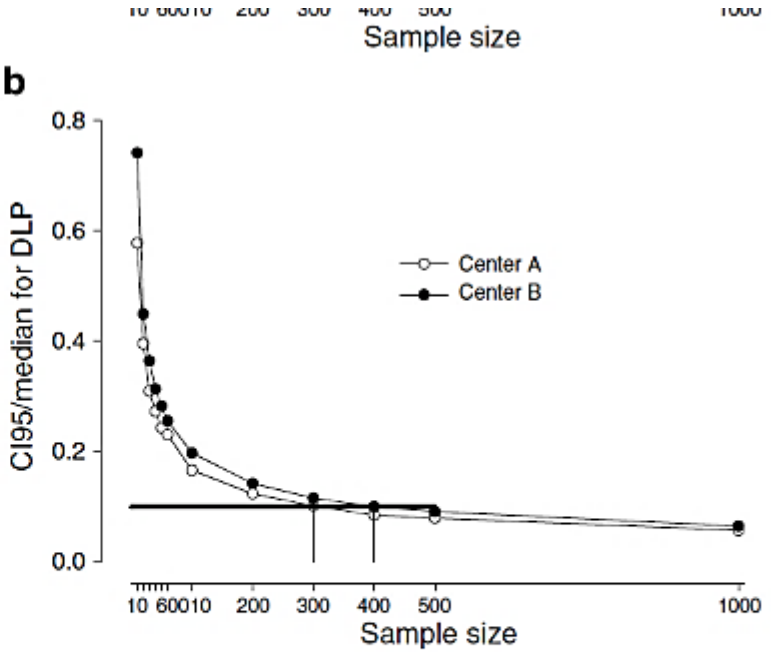


Fig. 2 Thorax - a and b show the 95 % confidence interval for center A (*open circles*) and center B (*closed circles*) in percentage of the median as a function of the sample size, using CTDIvol and DLP as the data sources, respectively. *Vertical lines* corresponds to the sample sizes ensuring CI95/med < 10 %

sue

PHE 4th UK CT Survey

Public Health England

4th UK CT Dose Survey

Guidelines

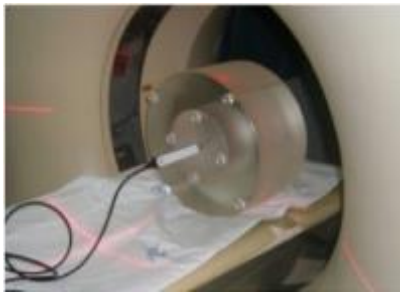
1. The data collection form may be completed by scientific, clinical or administrative staff. It is recommended that the scientific integrity of the data is checked by a medical physics expert (MPE) prior to submission.
2. Data may be acquired prospectively or retrospectively. For retrospective data, please ensure the data are still representative of current scanning te
from local dose sur
3. Only data from clini
should be excluded
4. Dose data is likely t
page where availab
examinations to sea
5. There are also 'help
scanner.
6. Please supply patie
7. No patient identifia
8. For each scanner ar
but ideally at least 1
9. Patients should be s
guide a weight range of 50 - 90 kg can be used.
10. Only data for adult patients should be submitted to this survey. For the purposes of this survey, an adult is anyone 16 years or older. For paediatric data, please refer to the IPEM/PHE paediatric CT survey forms.

5. Please supply patient weight information wherever possible.
6. No patient identifiable data should be included in your submission.
7. For each scanner and examination please supply data for as many patients as possible with a minimum of 20 different patients, but ideally at least 100 patients. There is no upper limit.
8. Patients should be selected who are considered a 'standard' size, ie. exclude patients who are atypically small or large. As a guide a weight range of 50 - 90 kg can be used.

sue.edyvean@phe.gov.uk

Dose Audits – Numbers of data and patient size

- Small data sample (manual methods of data collection):
  - 20 – 30 samples
  - Record and standardise patient size
- Large sample (automatic systems of data collection):
  - median size generally prevails



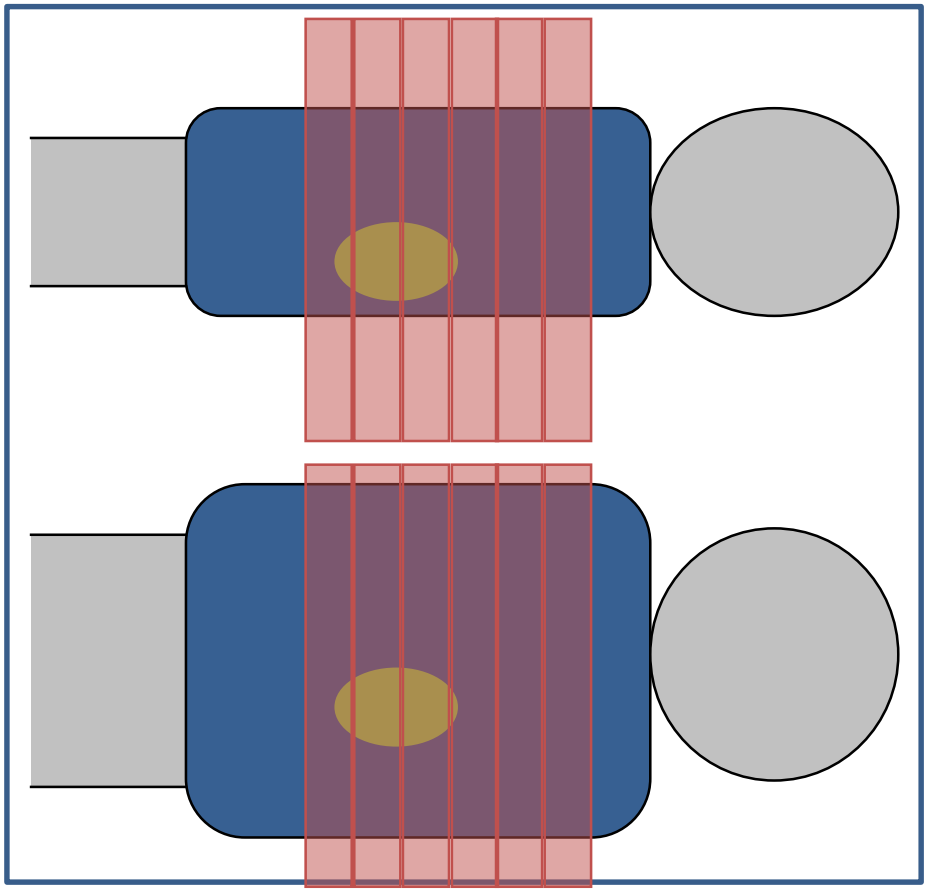
High ‘dose’ (CTDI) value may just mean you have scanned large patient,

It does not necessarily mean *high dose* to the patient

sue.edyvean@phe.gov.uk

Larger Patient Size – same CTDI

- Same mAs, same scan length



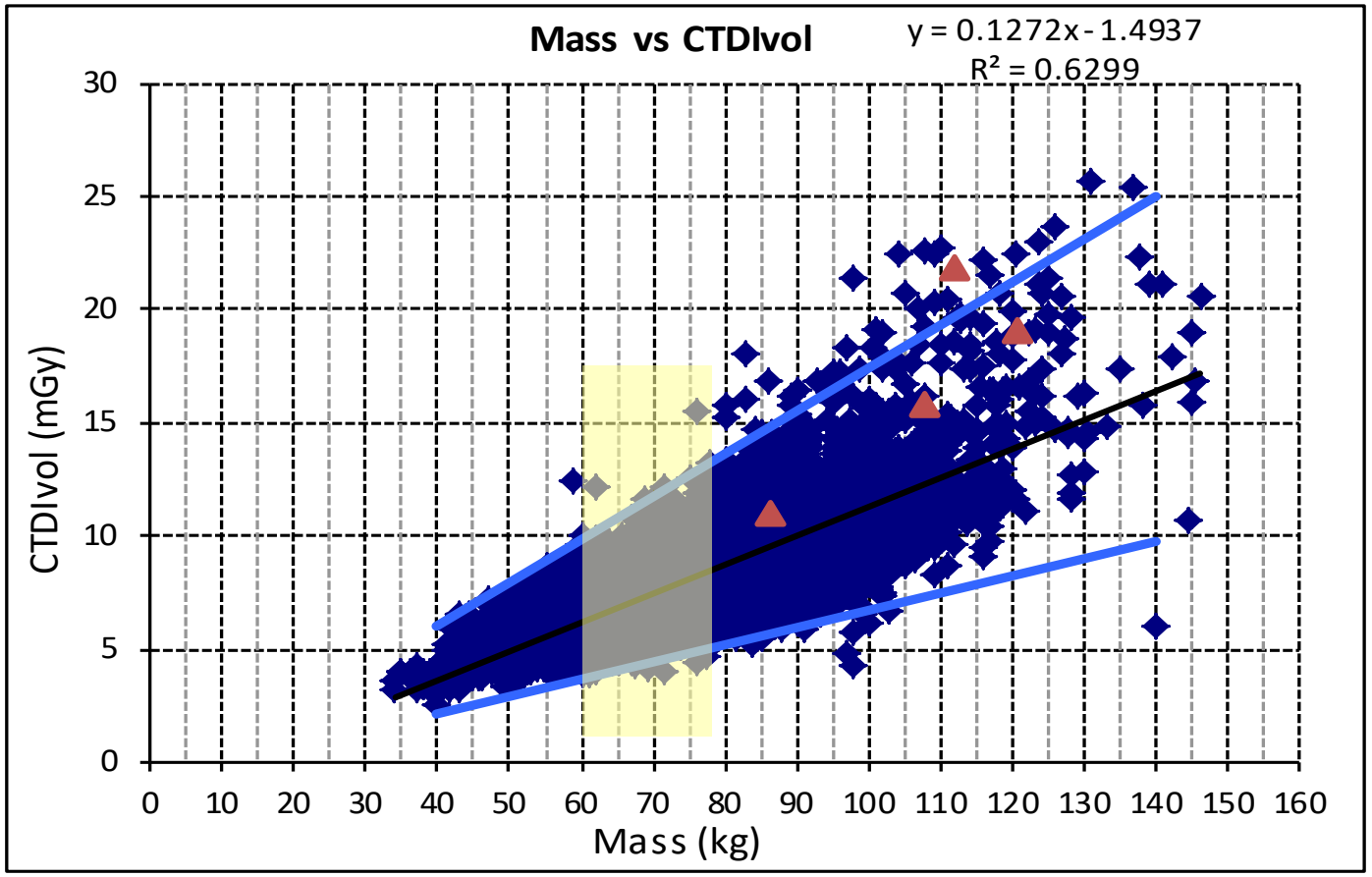
- CTDIvol same
- DLP same

Absorbed dose to organ lower

sue.edyvean@phe.gov.uk

Dose Audits - Patient size

- CTDIvol at 70 kg =~ 8 mGy
- Great uncertainty if take only a few data points from any weight
- If only a few data samples (even 20 – 30) – standard weight more important



sue.edyvean@phe.gov.uk

Courtesy E. Castellano, Royal Marsden, London

Dose Audits - Patient size Indicators

- Weight
- BMI (weight / (height x height)
- Lateral and AP dimensions, Effective diameter
- Professional judgement - ‘standard size’, ‘too large’, ‘too small’ (Sutton BJR 2014, Palorini Eur Radiol 2014,Moorin JRP 2013)
- Water equivalent diameter (used in estimating SSDE) (IEC soon)

Paediatrics: body imaging : weight not age (EU RP185)

sue.edyvean@phe.gov.uk

Dose Audits - Patient size Indicators

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Paediatrics: body imaging : weight not age (EU RP185)

sue.edyvean@phe.gov.uk

Setting DRLs for a range of sizes ?

- Differences in the operation of tube current modulation systems affect the relationship between patient dose and size in different ways, so that translating tube current modulation settings in scanning protocols between CT scanners is not straightforward
- Relationships between the DRL quantities and patient size vary on different CT scanners
- Setting DRL values for different size ranges may be appropriate

(manual methods not practical)

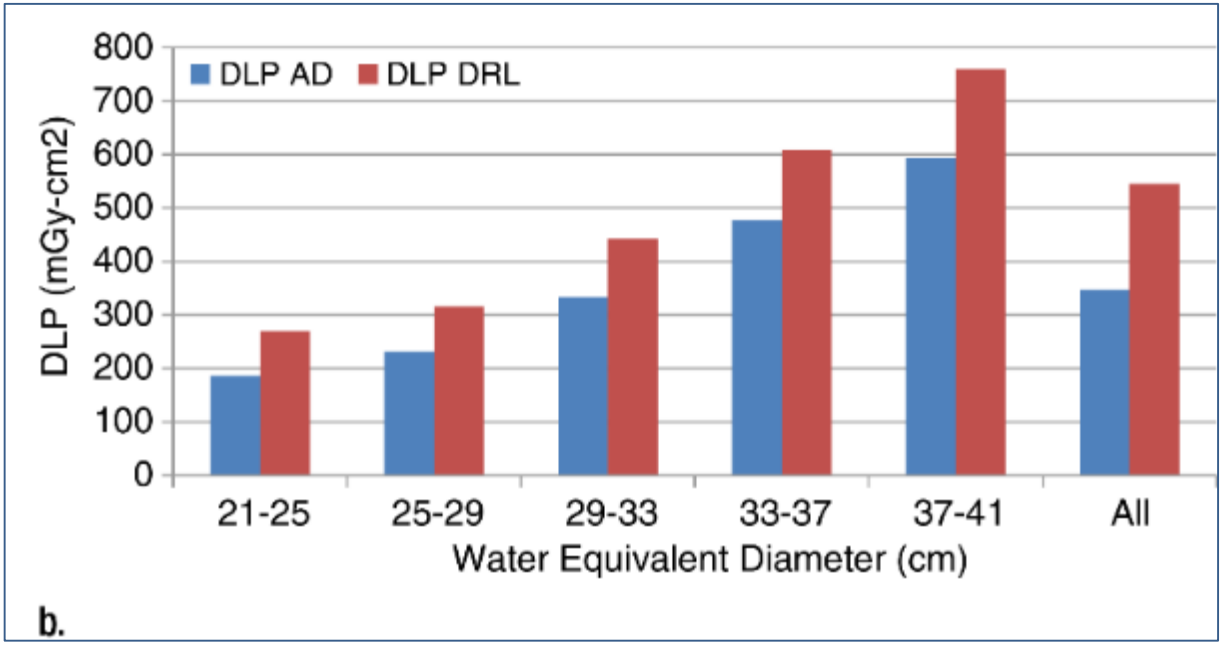
ICRP 135

sue.edyvean@phe.gov.uk

Size based DRLs

Figure 3. Graphs show abdomen and pelvis achievable doses (ADs) and diagnostic reference levels (DRLs). ..

(b) AD and DRL for abdomen and pelvis without contrast material—dose-length product (DLP



radiology.rsna.org • **Radiology:** Volume 284: Number 1—July 2017

Original Research
Medical Physics

Free Access

U.S. Diagnostic Reference Levels and Achievable Doses for 10 Adult CT Examinations

Kalpana M. Kanal, Priscilla F. Butler ✉, Debapriya Sengupta, Mythreyi Bhargavan-Chatfield, Laura P. Coombs, Richard L. Morin

sue.edyvean@phe.gov.uk

What information to collect?

- How much of the scan protocol information should be collected?
  - kV, mA, scan time, recon algorithm, AEC
  - FBP or IR (and their parameters)
- Should it be …
  - Just the exam name and dose index values ?

A compromise between too little information and too much – bearing in mind how you will process the information, and the people submitting data

ICRP 135: where information may give rise to key separation of system types this is important

sue.edyvean@phe.gov.uk

What information to collect? ICRP

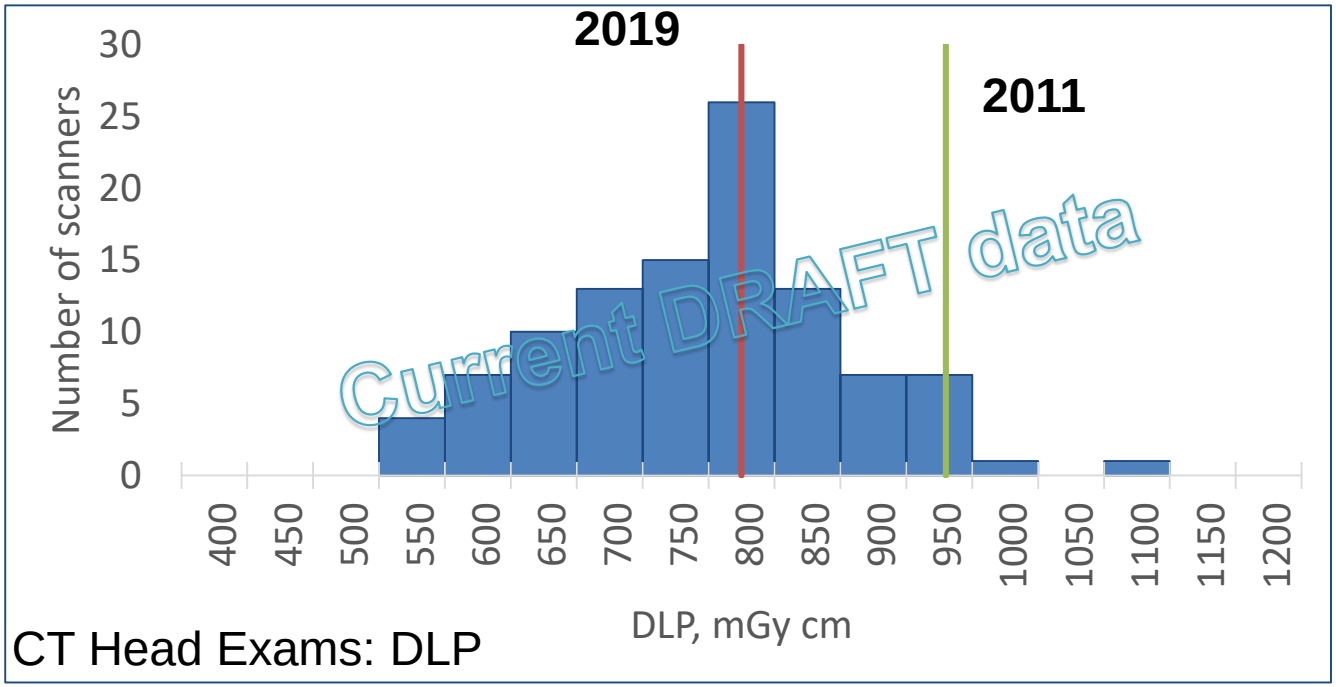
- It is important that the data set in patient dose surveys for developing DRL values for CT includes:
  - detector technology
  - detector configuration
  - image reconstruction algorithm (FBP vs IR)
- So that differences between detector types and reconstruction algorithms are identified correctly.
- It may be useful to develop different DRL values locally for different CT technologies (e.g. single- vs multi-slice scanners, filtered back projection vs iterative reconstruction), even for the same procedure.

ICRP 135 (para. 214)

sue.edyvean@phe.gov.uk

CT – Preliminary Results

- In general:
  - 10-30% reductions of proposed NDRL across the range of exams
  - >90% use AEC; 60 – 70% use IR



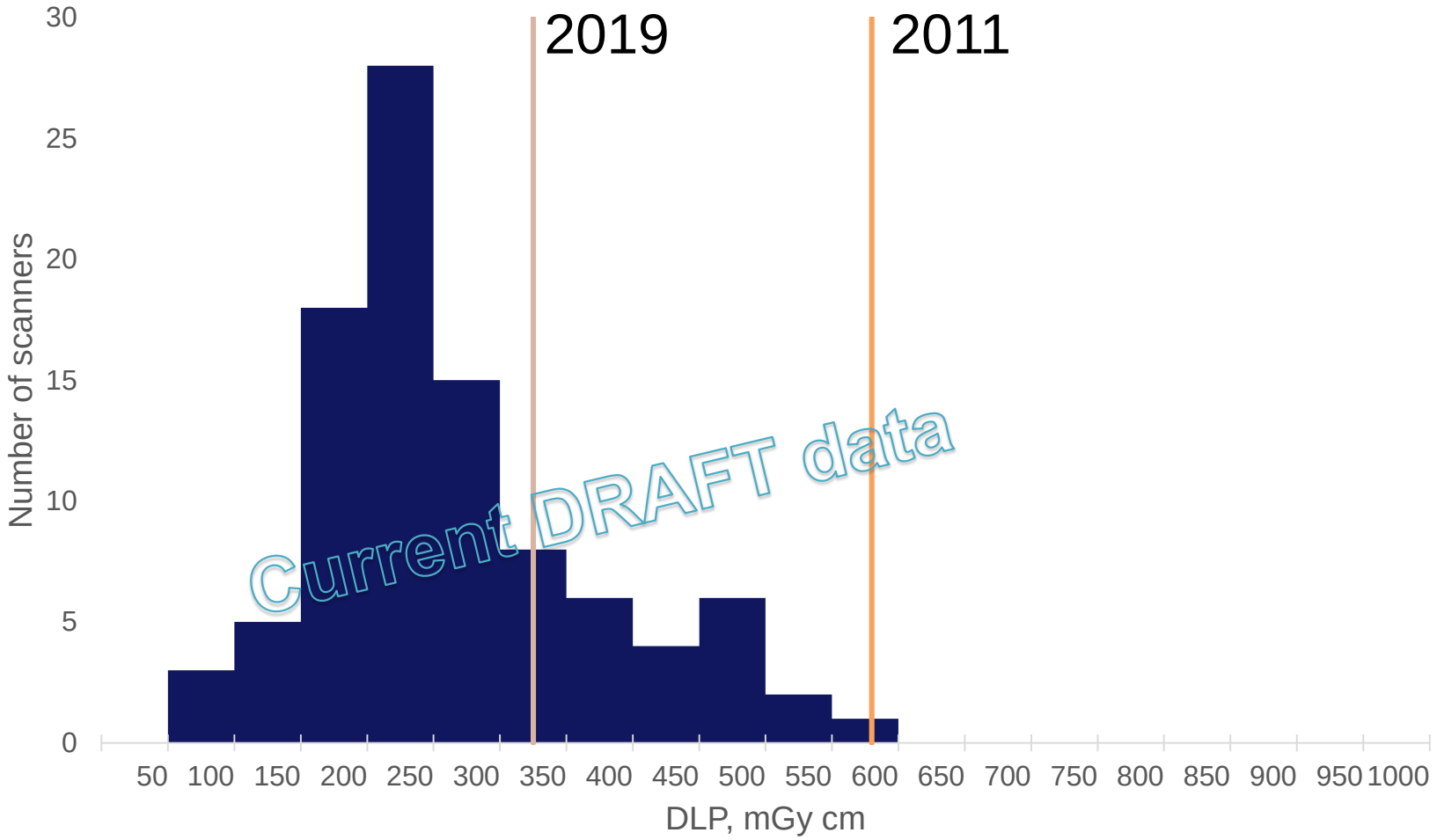
CT Head Exams: DLP

CTUG 3rd
October 2019

4th UK CT Dose Survey Sept 2019 (Adult) - JH

sue.edyvean@phe.gov.uk

Chest exams: DLP



Separate dose by reconstruction technique

Examination	IR		FBP		% Difference	
	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP
Head	43.9	815	52.8	838	-17	-3
Paranasal sinuses	8.0	167	13.1	177	-39	-5
Cervical spine (C-spine)	15.2	431	22.0	492	-31	-12
Neck, chest, abdomen and pelvis	12.0	944	14.3	1060	-16	-11
Chest	8.8	290	10.7	374	-18	-22
Chest – high resolution	*10.5*	*341*	*7.2*	*356*	*47*	*-4*
Chest and abdomen	10.5	516	15.2	583	-31	-11
Chest-abdomen-pelvis (CAP)	11.1	734	14.6	754	-24	-3
CT pulmonary angiography (CTPA)	9.6	347	10.5	393	-8	-12
Abdomen and pelvis	12.8	640	14.0	670	-9	-5
Colonography/Virtual colonoscopy (VC)	6.0	842	8.0	835	-24	1
Kidney-ureters-bladder (KUB)	**7.0**	**319**	**10.8**	**474**	**-35**	**-33**
Urogram	9.4	974	9.2	966	3	1

sue.edyvean@phe.gov.uk

DRLs for new technology

Evidence of dose saving in routine CT practice using iterative reconstruction derived from a national diagnostic reference level survey

P THOMAS, PhD, A HAYTON, MAppSc, BSc, T BEVERIDGE, PhD, P MARKS, BAppSc and A WALLACE, MAppSc, MSc

Medical Imaging Section, Australian Radiation Protection and Nuclear Safety Agency, Melbourne, VIC, Australia

Address correspondence to: Dr Peter Thomas
E-mail: *Peter.Thomas@arpansa.gov.au*

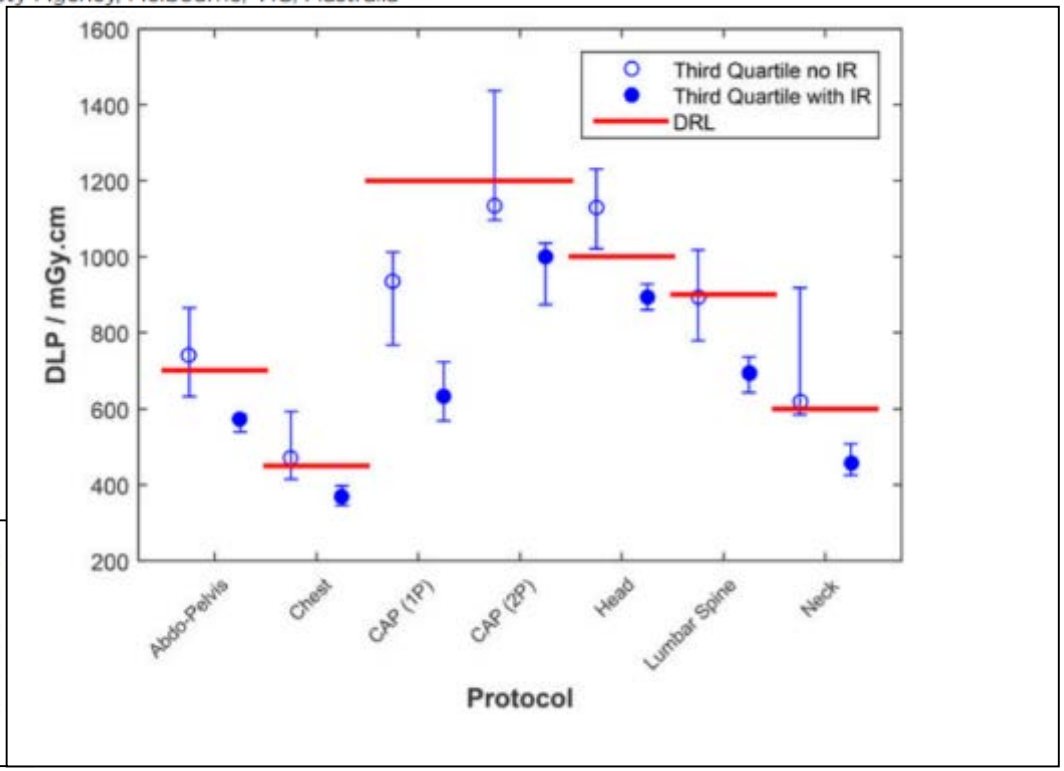


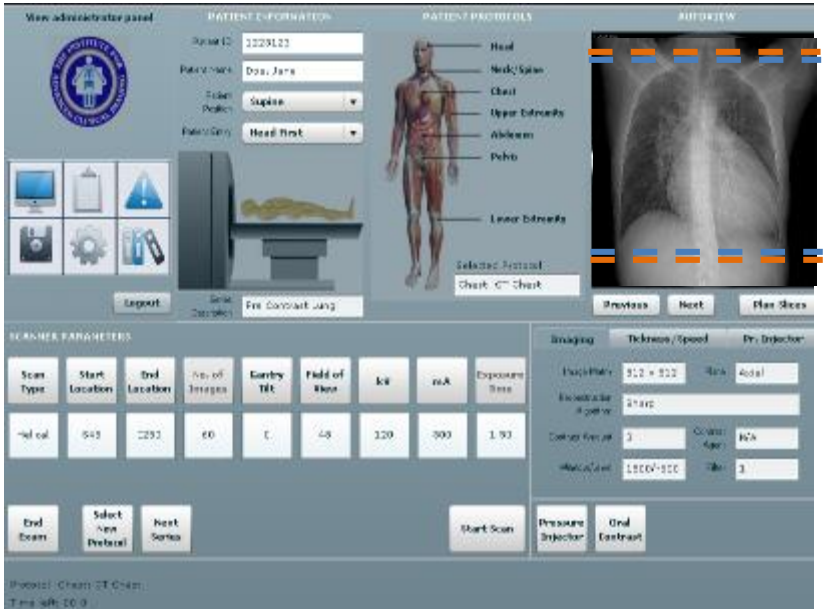
Figure 1. Third quartile dose–length product (DLP) for adult surveys in 2013–14 by protocol, phases and iterative reconstruction (IR) with 95% confidence intervals in comparison with the established diagnostic reference levels (DRLs). Abdo, abdomen; CAP (1P), chest–abdomen–pelvis (single phase); CAP (2P), chest–abdomen–pelvis (two phase).

Thomas P, Hayton A, Beveridge T, Marks P, Wallace A. Evidence of dose saving in routine CT practice using iterative reconstruction derived from a national diagnostic reference level survey. *Br J Radiol* 2015; **88**: 20150380.

Public Health England

Key Questions we had

- Include the scan projection radiograph ?
- Contrast monitoring scans



SPR = scan projection radiograph
= ‘Scoutview’, ‘Topogram etc’

sue.edyvean@phe.gov.uk

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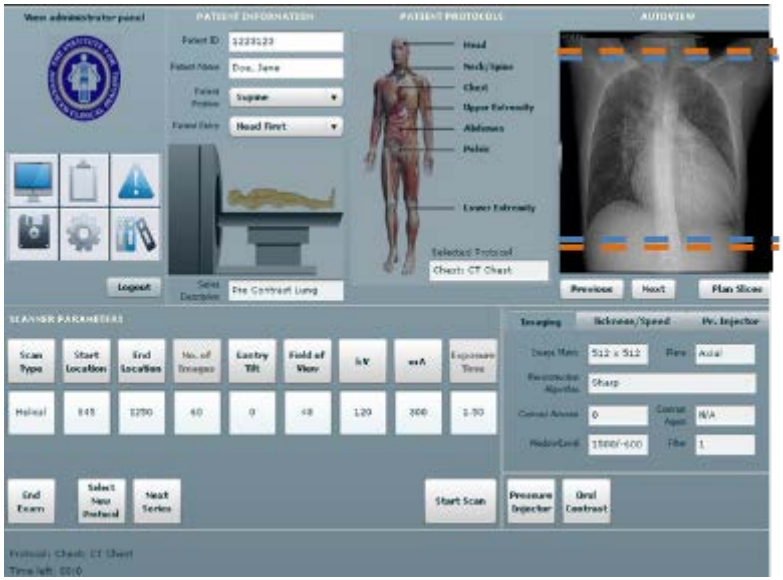
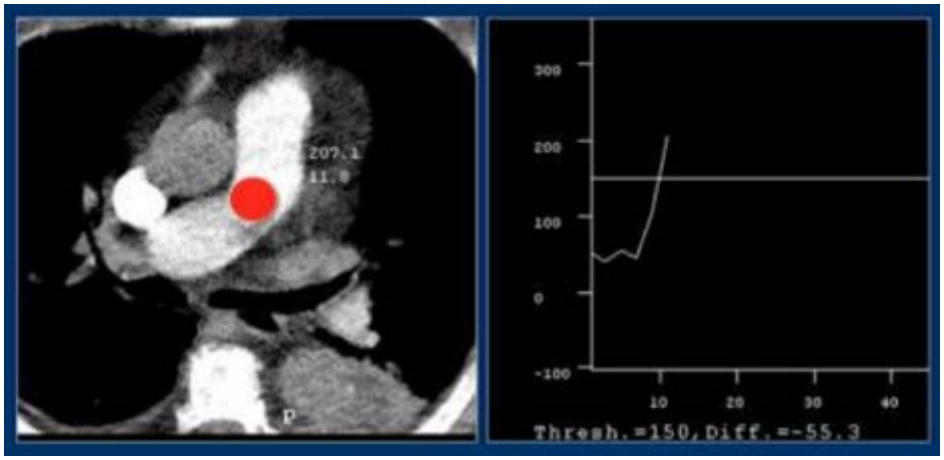
SPR and Bolus Tracking

- Exclude from the individual sequence data.
- Bolus tracking scans should be included in the total exam DLP
- SPRs may or may not be in total DLP (we ask if they are or aren't)



PHE Survey



SPR = scan projection radiograph
= 'Scoutview', 'Topogram etc'

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Example Scan – Chest and Abdomen (Lung cancer)

- CCC_CHEST_ABDO_CONTRAST workflow:

	Sequence	CTDI	DLP	Exam
a.	Topogram (typical value)		7.96	
b.	Pre-contrast monitoring	1.16	1.20	
c.	Contrast monitoring (no IR)	1.16	1.20	
d.	Thorax CT(IR)	3.83	131.30	
e.	Abdomen CT (IR)	7.56	222.20	
	Exam	?	Total = 363.9	364.00 from scanner

- **Need a consistent strategy as to how to quote CTDI for whole exam**
- Should it be
  1. Exclude contrast and SPR, and give an average only of diagnostic image scans? Or
  2. Not quote CTDI for whole exam at all?
- PHE survey: Bolus tracking scans should be included in the total exam DLP
- PHE survey: SPR may or may not be given in total exam DLP (regardless – it is only a small percent dose) (we want to know if they are or aren't)

sue.edyvean@phe.gov.uk

CT Planning scans in Radiotherapy

Physics in Medicine & Biology

IPEM Institute of Physics and Engineering in Medicine

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PAPER

IPEM topical report: the first UK survey of dose indices from radiotherapy treatment planning computed tomography scans for adult patients

Tim J Wood[1,2,3], Anne T Davis[1,4,5], James Earley[1,6], Sue Edyvean[7], Una Findlay[8], Rebecca Lindsay[1,9], Andrew Nisbet[1,5,6], Antony L Palmer[1,4,5], Rosaleen Plaistow[1,10] and Matthew Williams[1,11]

[1] Radiotherapy and Diagnostic Radiology Special Interest Groups, Institute of Physics and Engineering in Medicine, Doses to patients from x-ray imaging in radiotherapy working party York, United Kingdom
[2] Radiation Physics Department, Queen's Centre for Oncology and Haematology, Castle Hill Hospital, Hull & East Yorkshire Hospitals NHS Trust, Castle Road, Hull, HU16 5JQ, United Kingdom
[3] Faculty of Science, University of Hull, Cottingham Road, Hull, HU6 7RX, United Kingdom
[4] Medical Physics Department, Portsmouth Hospitals NHS Trust, Portsmouth, PO6 3LY, United Kingdom
[5] Faculty of Engineering and Physical Science, Department of Physics, University of Surrey, Guildford, United Kingdom
[6] Department of Medical Physics, Royal Surrey County Hospital NHS Foundation Trust, Guildford, United Kingdom
[7] Radiation Dosimetry Department, Centre for Radiation Chemicals and Environmental Hazards, Public Health England, Chilton, Oxon, OX11 0RQ, United Kingdom
[8] Medical Exposure Department, Centre for Radiation Chemicals and Environmental Hazards, Public Health England, Chilton, Oxon, OX11 0RQ, United Kingdom
[9] Medical Physics Department, St James's Institute for Oncology, Leeds, LS9 7TF, United Kingdom
[10] Medical Physics Department, Cambridge University Hospitals NHS Foundation Trust, Cambridge CB2 0QX, United Kingdom
[11] Medical Physics, Velindre NHS Trust, Velindre Road, Whitchurch, Cardiff, CF14 2TL, United Kingdom

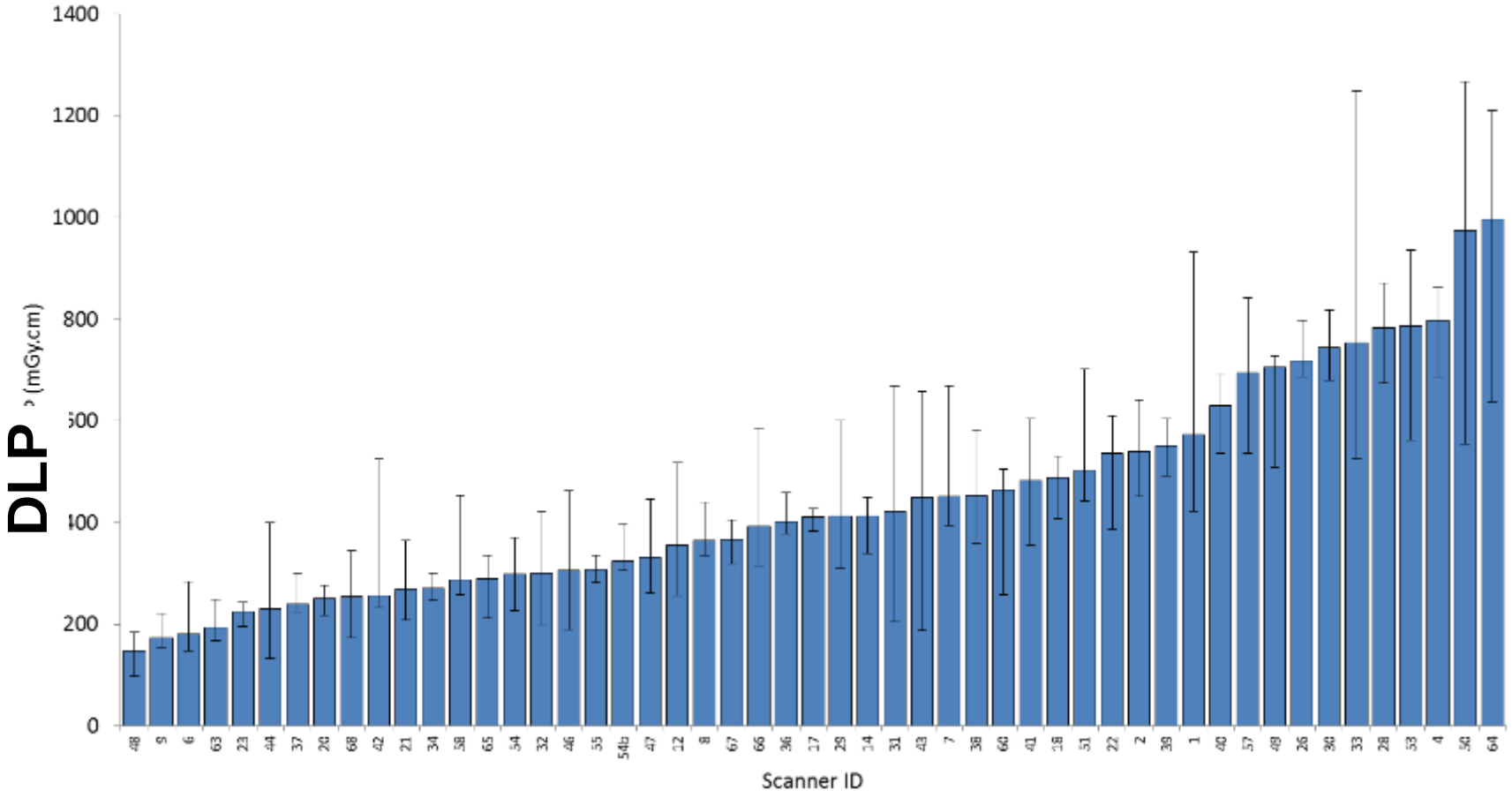
E-mail: tim.wood@hey.nhs.uk

Toshiba $CTDI_{vol}$

- For software version 4.63 or earlier, Toshiba scanners display maximum $CTDI_{vol}$, not average like all other vendors
  - *Typically* corresponds to scanners from before 2013
  - Scanners on later versions of software give average value
- For protocols **that use the AEC system** this will result in overestimation of the dose and may skew the national reference values for $CTDI_{vol}$
  - Does not affect DLP (based on average $CTDI_{vol}$)
- All centres with Toshiba scanners installed prior to 2013 were asked to confirm the software version of their scanner
- If the data was from v4.63 or earlier;
  - The average $CTDI_{vol}$ was excluding from the calculation of national reference values (DLP and scan length were left in)
  - $CTDI_{vol}$ still included in plots for further discussion

(Tim Wood, Hull, UK. IPEM, CT in RT survey)

Lung 3D median DLP



(Tim Wood, Hull, UK. IPEM, CT in RT survey)

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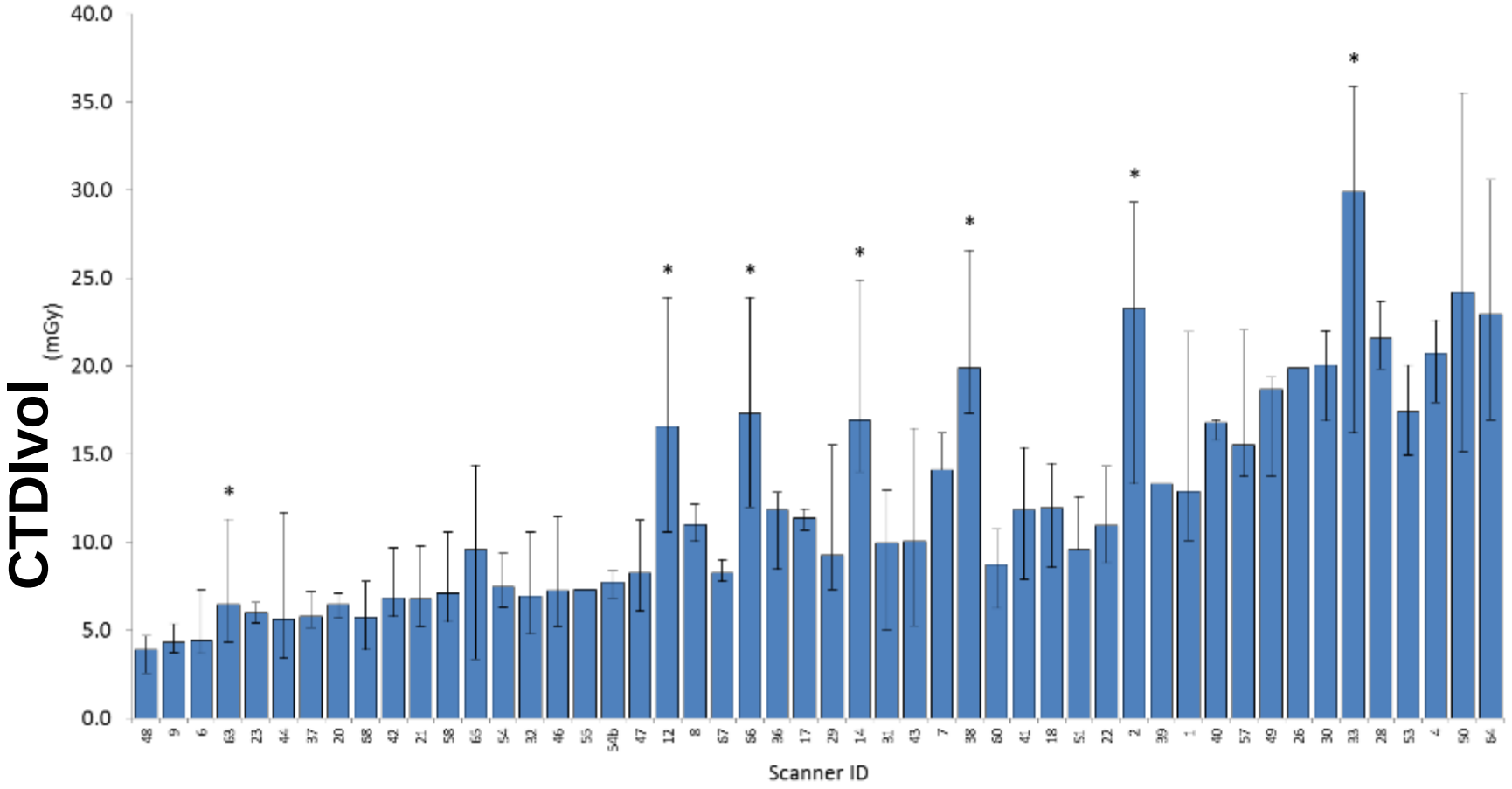
Lung 3D median $CTDI_{vol}$



*** Indicates maximum CTDI on older Toshiba scanners using AEC**

(Tim Wood, Hull, UK. IPEM, CT in RT survey)

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High resolution chest CT

- Toshiba axial sequences – appear to give CTDIw not CTDIvol
- 3 scanners with axial sequences, 1 mm beam width

Scanner	"$CTDI_{vol}$"	DLP
Aquilion CX	43	51
Aquilion One	50	60
Aquilion Prime	33	83

- Current CTDIvol NDRL is ~ 4 mGy
- The average $CTDI_{vol}$ from other axial sequences in this study (n=11) is ~ 2 mGy
- Other manufactures appear to correct for step between scans, Toshiba do not

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Dose Audits for DRLS

- Dose indicator (e.g. DAP,ESD or CTDI,DLP)
  - common examinations (e.g. chest CT) or high dose
  - Sample of standard size/weight patients

- Calculate the median^ value for each x-ray system, each exam

- ^UK previously used mean. UK currently ask for both: for retrospective comparison, and continue to future with median.

sue.edyvean@phe.gov.uk

DRL: distribution of mean vs. median

Examination	DRL from distribution of					
	Mean doses		Median doses		% Difference	
	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP
Head	48.7	821	48.0	797	-1	-3
Paranasal sinuses	12.0	173	11.6	165	-3	-4
Cervical spine (C-spine)	17.6	473	17.6	443	0	-6
Neck, chest, abdomen and pelvis	12.1	1026	10.0	904	-17	-12
Chest	9.3	327	8.4	292	-10	-11
Chest – high resolution	8.5	346	8.0	331	-5	-4
Chest and abdomen	11.0	539	9.3	464	-15	-14
Chest-abdomen-pelvis (CAP)	11.3	740	9.0	656	-20	-11
CT pulmonary angiography (CTPA)	10.0	358	9.9	317	-2	-11
Abdomen and pelvis	13.6	652	11.6	548	-15	-16
Colonography/Virtual colonoscopy (VC)	7.2	857	6.8	820	-6	-4
Kidney-ureters-bladder (KUB)	7.5	370	6.8	309	-10	-17
Urogram	9.9	1010	8.9	913	-10	-10

Note: this from well run dose audits. Errors may be greater for results of poorly run audits

Mean versus Median – Simple tutorial

sue.edyvean@phe.gov.uk

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Mean versus Median

Mean	Median
Average of values	Same number of data points above and below (50th percentile)
More affected by outliers	Less affected by outliers
Less robust for skewed distributions	More robust for skewed distributions

Nine numbers: 7 9 11 6 13 6 6 3 11			
Put in order	3 **6 6 6** 7 9 11 11 13	Mode	6
Put in order	3 6 6 6 **7** 9 11 11 13	Median	7
Add all	7+9+11+6+13+6+6+3+11 = 72 There are 9 numbers: 72 ÷ 9 = **8**	Mean (average)	8

sue.edyvean@phe.gov.uk

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Mean versus Median

Mean	Median
Average of values	Same number of data points above and below (50th percentile)
More affected by outliers	Less affected by outliers
Less robust for skewed distributions	More robust for skewed distributions

If highest value is 130 not 13:

Nine numbers: 7 9 11 6 130 6 6 3 11			
Put in order	3 **6 6 6** 7 9 11 11 130	Mode	6
Put in order	3 6 6 6 **7** 9 11 11 130	Median	7
Add all	7+9+11+6+130+6+6+3+11 = 189 There are 9 numbers: 189 ÷ 9 = **8**	Mean (average)	21

sue.edyvean@phe.gov.uk

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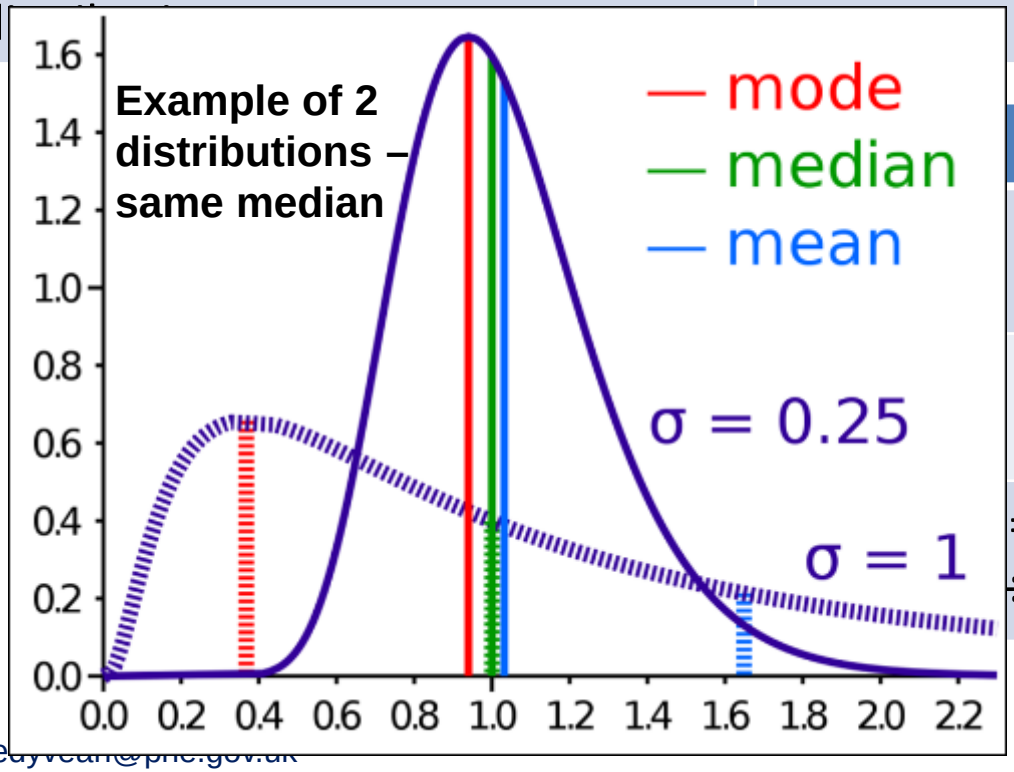
Mean versus Median

Mean	Median
Average of values	Same number of data points above and below (50th percentile)
More affected by outliers	Less affected by outliers
Less robust for skewed d	More robust for skewed distributions



Nine numbers: 7 9 11 6 13 6 6 3 11

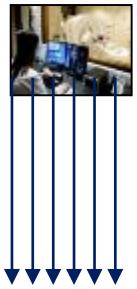
	Mode	6
	Median	7
= 72 ÷ 9 = **8**	Mean (average)	8

sue.eadyvean@phe.gov.uk

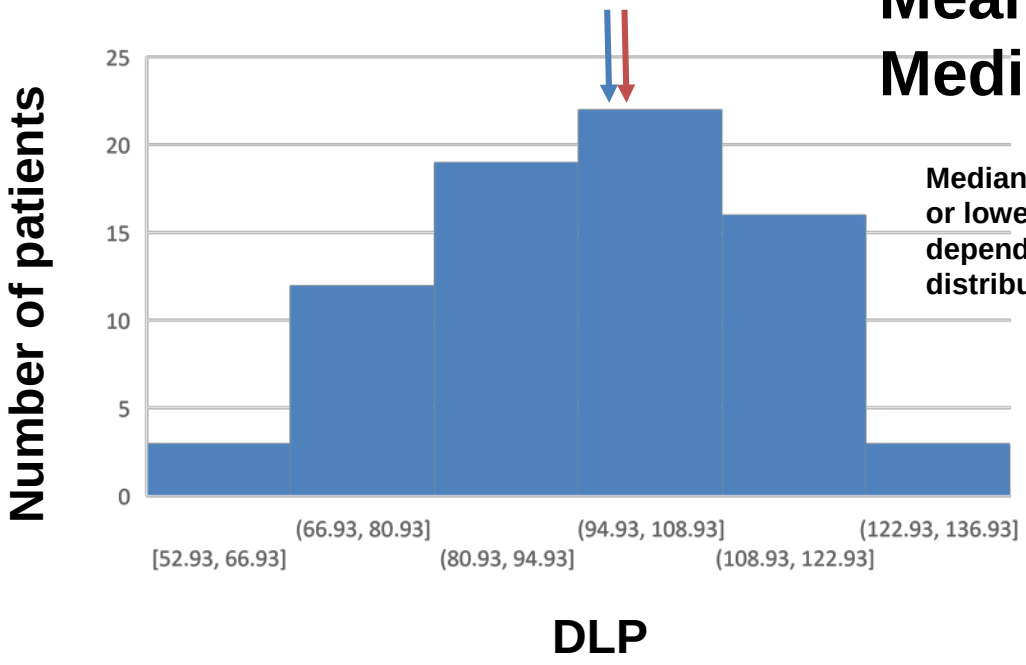
Distribution of data – mean and Median

1. Distribution of one scanner's patient data / exam
   - Small data sample (standard weight)
   - Large data sample (no weights necessary if not available)

Hospital 1
Scanner 1



median

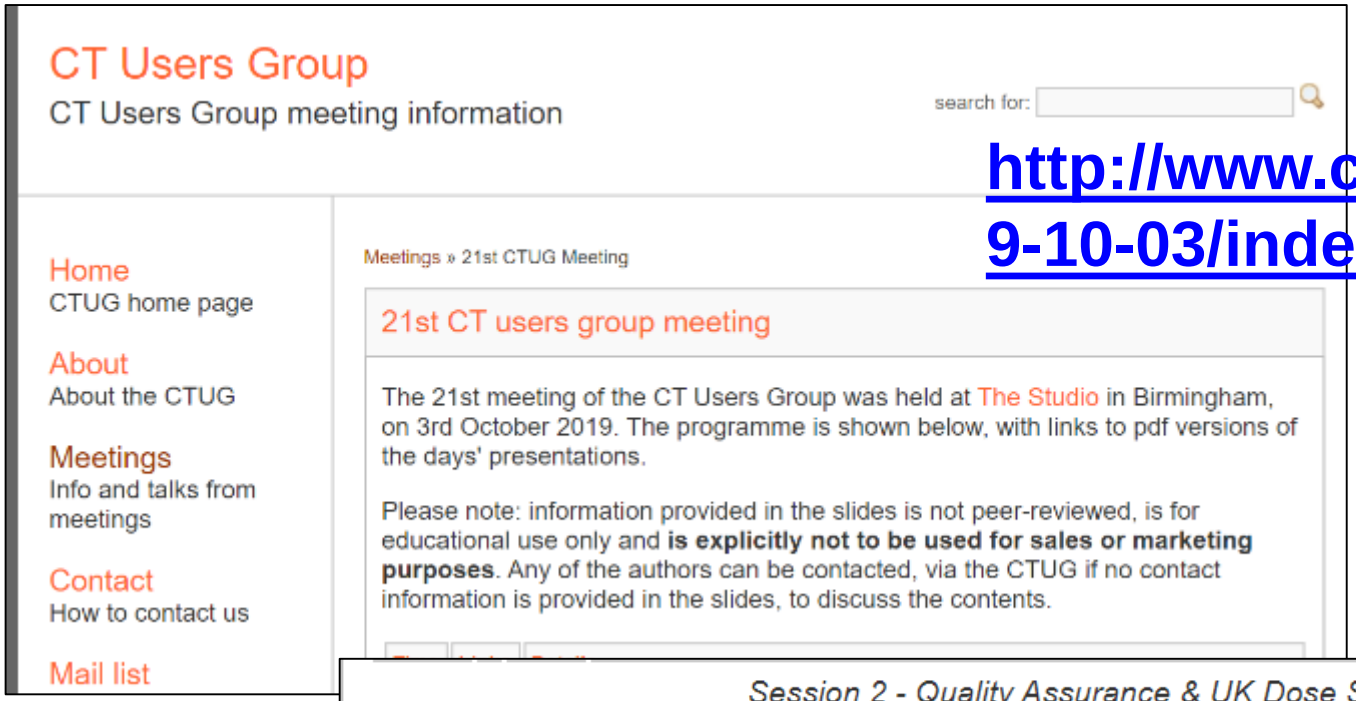


Mean = 95.2
Median = 96.4

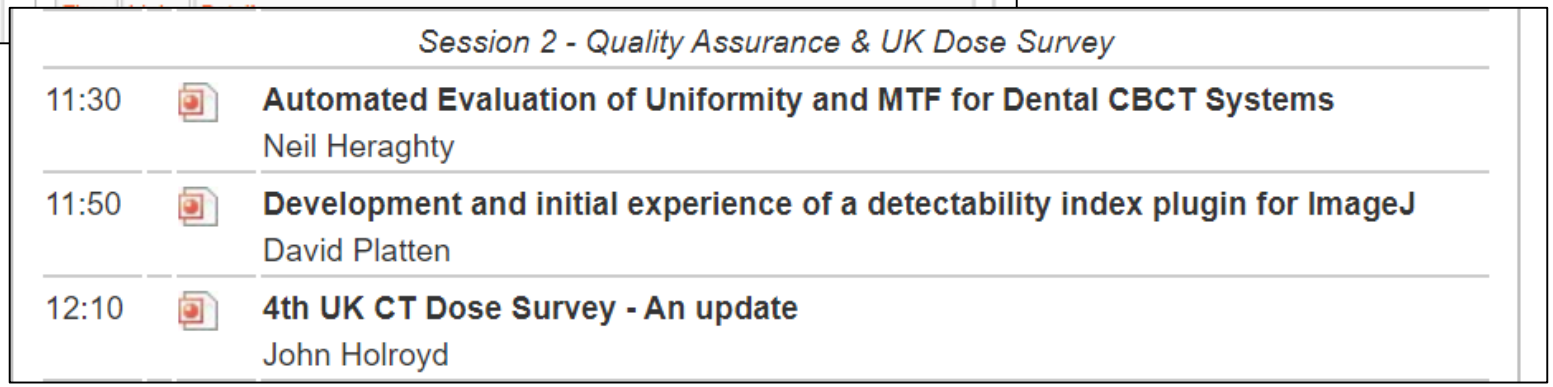
Median may be higher or lower than mean depending on shape of distribution

sue.edyvean@phe.gov.uk

Update talk on 4th UK CT Survey



http://www.ctug.org.uk/meet19-10-03/index.html



(Lots of talks on physics and CT : www.ctug.org.uk)

sue.edyvean@phe.gov.uk

Same Spreadsheet - same generic info asked for

Protocol details: scanner details

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4th UK CT Dose Survey

Body region (clinical indication)*:	**Abdomen and pelvis (Abscess)**
	Please select from drop down list
If Other please give body region (clinical indication) details:	domen and Pelvis (Nausea, Weight loss, abdo Pelvis Pain, Lethar

Hospital and Scanner Information

Hospital Name*:	xxxxBridge
Local system ID*:	Diagnostic CT
System manufacturer*:	Siemens
System model*:	Definition Edge
Number of detector rows (eg. 16, 32, 64, 128, etc):	64 (128 slices with flying focal)
Year of manufacture of scanner:	2018
Software version:	Syngo CT VA84A

Calibration Data

Error of indicated CTDIvol when last checked (+/- %)	6%

Standard Protocol Settings

Local protocol name*:	CCC_ABDO_PELV_CONTRAST
Number of scan acquisitions* (e.g. 1 contrast & 1 non-contrast scan = 2 acquisitions):	1

Scanner/Protocol Comments

Please include any other details and descriptions of your scan protocol

Protocol details: scout view details

Scout view details

Number of scout views:	
Does the total DLP (provided opposite) include the DLP from scout views?*	
Typical total DLP for all scout views (mGy.cm):	
Tube voltage (kV):	
Tube current (mA):	
Tuber current time (mAs):	
Imaged scan length (mm):	

Scout view details

Number of scout views:	1
Does the total DLP for each patient (below) include the DLP from scout views?*	No
Typical total DLP for all scout views (mGy.cm):	average 6.5
Tube voltage (kV):	120
Tube current (mA):	35
Tube current time (mAs):	
Imaged scan length (mm):	Average 480

Protocol details: scan details

Acquisition 1 details			See notes on s
CTDI phantom size (cm) (i.e. 16 cm head or 32 cm body)*:		32 cm body	[a]
Is Automatic Exposure Control (AEC) used?*		No	[b]
AEC name (e.g. AutomA, ZDOM, CARE Dose 4D, SureExpose):		-	[c]
AEC setting type (e.g. ref noise index, reference mAs, etc):		-	[d]
AEC setting value (e.g. SD 7.5, ref mAs 200):		-	[e]
minimum mA for AEC (where applicable):		-	[f1]
maximum mA for AEC (where applicable):		-	[f1]
mA where AEC is not used:		13	[f2]
Is iterative reconstruction used?*		No	
Iterative recon type (e.g. ASIR, SAFIRE, iDose, AIDR):		-	[g]
Iterative recon value (e.g. ASIR 40%, SAFIRE 3, iDose level 4):		-	[h]
Radiation beam collimation	- Collimated beam width (mm):	10	[i]
	- Number of slices:	1	[j]
	- Detector size (mm) (e.g. 0.625,0.6):	10	[k]
Is Automatic tube voltage selection used? (eg. CarekV)		No	
If no, Fixed Tube voltage (kV):		120	[l]
Tube rotation time (s):		1.5	[m]
Primary image slice thickness (mm):		10	[n]
Scan field of view (SFOV) (mm):			[o]
Reconstruction field of view (DFOV) (mm):		300	[p]
Axial or helical?		Axial	[q]
Pitch (where applicable):			[r]
Primary Reconstruction algorithm or kernel (e.g. B30; FC17; Std)		B30s	[s]
Is contrast used?		None	
Anatomical landmarks for start and end points	Start point (e.g. base of skull)	Carina	
	End point (e.g. vertex)	Carina	
Comments		Pre-monitoring scan	

Protocol details: scan details

Split scan protocol settings (if applicable)		
Acquisition 2 (if applicable)		
CTDI phantom size (cm) (i.e. 16 cm head or 32 cm body)*:		32 cm body
Is Automatic Exposure Control (AEC) used?*		No
AEC name (e.g. AutomA, ZDOM, CARE Dose 4D, SureExpose):		-
AEC setting value (e.g. SD 7.5, ref mAs 200):		-
mA where AEC is not used:		13
Is iterative reconstruction used?*		No
Iterative recon value (e.g. ASIR 40%, SAFIRE 3, iDose level 4):		
Radiation beam collimation	- Collimated beam width (mm):	10
	- Number of slices:	1
	- Detector size (mm) (e.g. 0.625,0.6):	10
Is Automatic tube voltage selection used? (eg. CarekV)		No
If no, Fixed Tube voltage (kV):		120
Tube rotation time (s):		1.5
Primary image slice thickness (mm):		10
Scan field of view (SFOV) (mm):		
Reconstruction field of view (DFOV) (mm):		300
Axial or helical?		Axial
Pitch (where applicable):		
Primary Reconstruction algorithm or kernel (e.g. B30; FC17; Std)		B30s
Is contrast used?		IV
Anatomical landmarks for start and end points	Start point (e.g. base of skull)	Carina
	End point (e.g. vertex)	Carina
Comments		Contrast monitoring scans

Protocol details: scan details

Comments		Contrast monitoring scans
Acquisition 3 (if applicable)		
CTDI phantom size (cm) (i.e. 16 cm head or 32 cm body)*:		32 cm body
Is Automatic Exposure Control (AEC) used?*		Yes
AEC name (e.g. AutomA, ZDOM, CARE Dose 4D, SureExpose):		CARE Dose4D
AEC setting value (e.g. SD 7.5, ref mAs 200):		Quality reference mAs 65
mA where AEC is not used:		
Is iterative reconstruction used?*		Yes
Iterative recon value (e.g. ASIR 40%, SAFIRE 3, iDose level 4):		SAFFIRE strength 2
Radiation beam collimation	- Collimated beam width (mm):	38.4
	- Number of slices:	64
	- Detector size (mm) (e.g. 0.625,0.6):	0.6
Is Automatic tube voltage selection used? (eg. CarekV)		Yes
If no, Fixed Tube voltage (kV):		
Tube rotation time (s):		0.5
Primary image slice thickness (mm):		
Scan field of view (SFOV) (mm):		
Reconstruction field of view (DFOV) (mm):		
Axial or helical?		
Pitch (where applicable):		
Primary Reconstruction algorithm or kernel (e.g. B30; FC17; Std)		
Is contrast used?		
Anatomical landmarks for start and end points	Start point (e.g. base of skull)	
	End point (e.g. vertex)	
Comments		Thorax CT

PHE 4th UK Survey – patient data

Essential fields (blue)

Public Health England

4th UK CT Dose Survey

Body region (clinical indication)*:

Please select from drop down list

If Other please give body region (clinical indication) details:

Hospital and Scanner Information

Hospital Name*:	
Local system ID*:	
System manufacturer*:	
System model*:	
Number of detector rows (eg. 16, 32, 64, 128, etc):	
Year of manufacture of scanner:	
Software version:	

Calibration Data

Error of indicated CTDIvol when last checked (+/- %)	

Standard Protocol Settings

Local protocol name*:	
Number of scan acquisitions* (e.g. 1 contrast & 1 non-contrast scan = 2 acquisitions):	

Acquisition 1 details

CTDI phantom size (cm) (i.e. 16 cm head or 32 cm body)*:		
Is Automatic Exposure Control (AEC) used?^		
AEC name (e.g. AutomA, ZDOM, CARE Dose 4D, SureExpose):		
AEC setting type (e.g. ref noise index, reference mAs, etc):		
AEC setting value (e.g. SD 7.5, ref mAs 200):		
minimum mA for AEC (where applicable):		
maximum mA for AEC (where applicable):		
mA where AEC is not used:		
Is iterative reconstruction used?*		
Iterative recon type (e.g. ASIR, SAFIRE, iDose, AIDR):		
Iterative recon value (e.g. ASIR 40%, SAFIRE 3, iDose level 4):		
Radiation beam collimation	- Collimated beam width (mm):	
	- Number of slices:	
	- Detector size (mm) (e.g. 0.625,0.6):	
Is Automatic tube voltage selection used? (eg. CarekV)		
If no, Fixed Tube voltage (kV):		
Tube rotation time (s):		
Primary image slice thickness (mm):		
Scan field of view (SFOV) (mm):		
Reconstruction field of view (DFOV) (mm):		
Axial or helical?		
Pitch (where applicable):		
Primary Reconstruction algorithm or kernel (e.g. B30; FC17; Std)		
Is contrast used?		

Patient details

Patient No	At time of scan:			Scan length (mm)			This should be the distance from the couch start to couch end.			Scan protocol:	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	Scan length (mm)			This should be the distance from the couch start to couch end.			Scan protocol:	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	Scan length (mm)		
	Age (yrs)	Weight (kg)	Height (cm)	Imaged length	Start position	End position				Scan FOV (mm)			Imaged length	Start position	End position				Scan FOV (mm)			Imaged length	Start position	End position
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								
13																								
14																								

Submit by patient (no ID info)

Patient details and dose

Patient No	At time of scan:			Acquisition 1								Total DLP* (whole scan) mGy.cm
				Scan length (mm)			If different from protocol:					
	Age (yrs)	Weight (kg)	Height (cm)	Imaged length	Start position	End position	kV	CTDI phantom	Scan FOV (mm)	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	
1												
2												
3												
4												
5												

Patient details

	Pre-monitoring										Contrast monitoring							
				Acquisition 1										Acquisition 2				
				Scan length (mm)			If different from protocol:				Scan length (mm)			If different from protocol:				
Patient No	At time of scan: Age (yrs)	Weight (kg)	Height (cm)	Imaged length	Start position	End position	kV	CTDI phantom	Scan FOV (mm)	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	Imaged length	Start position	End position	kV	CTDI phantom	Scan FOV (mm)	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*
1							120	32 cm body		1.16	1.20				120	32 cm body		2.31	2.30
2							120	32 cm body		1.16	1.20				120	32 cm body		5.78	5.80
3							120	32 cm body		1.16	1.20				120	32 cm body		10.41	10.40
4							120	32 cm body		1.16	1.20				120	32 cm body		3.47	3.50
5							120	32 cm body		1.16	1.20				120	32 cm body		10.41	10.40
6							120	32 cm body		1.16	1.20				120	32 cm body		9.25	9.30
7							120	32 cm body		1.16	1.20				120	32 cm body		11.57	11.60
8							120	32 cm body		1.16	1.20				120	32 cm body		9.25	9.30
9							120	32 cm body		1.16	1.20				120	32 cm body		3.47	3.50
10							120	32 cm body		1.16	1.20				120	32 cm body		11.57	11.60
11							120	32 cm body		1.16	1.20				120	32 cm body		5.78	5.80
12							120	32 cm body		1.16	1.20				120	32 cm body		11.57	11.60
13							120	32 cm body		1.16	1.20				120	32 cm body		4.63	4.60
14							120	32 cm body		1.16	1.20				120	32 cm body		17.35	17.30
15							120	32 cm body		1.16	1.20				120	32 cm body		10.41	10.40
16							120	32 cm body		1.16	1.20				120	32 cm body		9.25	9.30
17							120	32 cm body		1.16	1.20				120	32 cm body		4.63	4.60
18							120	32 cm body		1.16	1.20				120	32 cm body		3.47	3.50

	Thorax CT								Abdomen-pelvis CT									
	Acquisition 3								Acquisition 4									
	Scan length (mm)			If different from protocol:					Scan length (mm)			If different from protocol:						
Imaged length	Start position	End position	kV	CTDI phantom	Scan FOV (mm)	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	Imaged length	Start position	End position	kV	CTDI phantom	Scan FOV (mm)	$CTDI_{vol}$ (mGy)*	DLP (mGy.cm)*	Total DLP* (whole scan) mGy.cm	Patient comments
			100	32 cm body		4.71	167.80				80	32 cm body		7.14	367.60	549.00	Large patient
			100	32 cm body		6.42	214.50				120	32 cm body		14.03	763.20	996.00	Large patient
			100	32 cm body		3.45	118.30				100	32 cm body		8.07	404.90	544.00	
			100	32 cm body		4.04	129.20				100	32 cm body		8.62	397.90	542.00	
			100	32 cm body		2.96	98.70				100	32 cm body		9.43	404.80	525.00	
			100	32 cm body		2.76	92.20				100	32 cm body		4.28	195.70	308.00	
			80	32 cm body		2.73	93.80				100	32 cm body		5.44	259.70	376.00	
			100	32 cm body		3.45	103.70				80	32 cm body		7.29	410.40	536.00	
			100	32 cm body		5.03	154.30				100	32 cm body		11.05	554.30	722.00	Large patient
			100	32 cm body		4.96	129.10				100	32 cm body		11.82	585.10	736.00	
			100	32 cm body		2.92	82.00				100	32 cm body		7.51	369.30	468.00	
			100	32 cm body		3.61	131.40				100	32 cm body		8.49	439.10	594.00	
			100	32 cm body		2.97	82.30				100	32 cm body		6.18	333.00	431.00	
			100	32 cm body		2.68	80.70				100	32 cm body		6.03	309.60	419.00	Large number of monitoring scans
			100	32 cm body		2.83	107.50				100	32 cm body		6.62	323.70	453.00	
			100	32 cm body		4.47	163.10				100	32 cm body		8.89	459.50	643.00	Large patient
			100	32 cm body		4.34	144.90				80	32 cm body		6.79	336.20	496.00	
			120	32 cm body		8.55	250.30				100	32 cm body		14.45	747.10	1010.00	Large patient
			100	32 cm body		3.53	141.20				100	32 cm body		5.91	305.50	469.00	
			100	32 cm body		6.55	191.00				100	32 cm body		14.74	762.50	967.00	Large patient
			100	32 cm body		5.32	147.60				120	32 cm body		17.02	906.50	1074.00	Large patient
			100	32 cm body		2.81	93.80				100	32 cm body		5.05	248.60	359.00	
			100	32 cm body		4.02	116.10				120	32 cm body		19.42	1038.30	1173.00	Large patient
			100	32 cm body		4.01	121.20				100	32 cm body		6.62	356.90	505.00	Large number of monitoring scans
			100	32 cm body		2.74	91.60				100	32 cm body		6.18	311.40	425.00	
			100	32 cm body		5.16	158.80				100	32 cm body		9.11	480.60	663.00	Large patient
			100	32 cm body		5.65	166.80				100	32 cm body		11.22	666.50	858.00	Large patient
			100	32 cm body		7.31	198.30				100	32 cm body		12.70	674.90	892.00	Large patient
			100	32 cm body		4.34	145.20				100	32 cm body		12.38	608.50	773.00	

PHE 4th UK Survey – local audit data

Summary dose data from local audit

No of Patients	Mean Age at time of scan (yrs)	Mean Body Mass (kg)	Mean Total DLP* (whole scan)	Median Total DLP* (whole scan)	Comments on the data collection method (eg. inclusion criteria, data analysis method)

Acquisition 1									
Mean $CTDI_{vol}$ (mGy)*	Standard deviation	Median $CTDI_{vol}$ (mGy)*	25th Percentile	75th Percentile	Mean DLP (mGy.cm)*	Standard deviation	Median DLP (mGy.cm)*	25th Percentile	75th Percentile

Acquisition 2									
Mean $CTDI_{vol}$ (mGy)*	Standard deviation	Median $CTDI_{vol}$ (mGy)*	25th Percentile	75th Percentile	Mean DLP (mGy.cm)*	Standard deviation	Median DLP (mGy.cm)*	25th Percentile	75th Percentile

Or by summary data from local audit – for each system

Summary of Local audit - details and

If Other please

Hospital and Scanner Information

Hospital Name*:
Local system ID*:
System manufacturer*:
System model*:
Number of detector rows (eg. 16, 32, 64, 1
Year of manufacture of scanner:
Software version:

Calibration Data

Error of indicated CTDIvol when last checke

Standard Protocol Settings

Local protocol name*:
Number of scan acquisitions* (e.g. 1 contras

Scanner/Protocol Comments

Please include any other details and descri

Scout view details

Number of scout views:	1
Does the total DLP (provided opposite) include the DLP from scout views?*	Yes
Typical total DLP for all scout views (mGy.cm):	8.5
Tube voltage (kV):	120
Tube current (mA):	35
Tuber current time (mAs):	NA
Imaged scan length (mm):	512

Acquisition 1 details

See notes on scanner specific he

CTDI phantom size (cm) (i.e. 16 cm head or 32 cm body)*:		32 cm body	[a]
Is Automatic Exposure Control (AEC) used?*		Yes	[b]
AEC name (e.g. AutomA, ZDOM, CARE Dose 4D, SureExpose):		CareDose4D	[c]
AEC setting type (e.g. ref noise index, reference mAs, etc):		Quality ref mAs	[d]
AEC setting value (e.g. SD 7.5, ref mAs 200):		180	[e]
minimum mA for AEC (where applicable):		NA	[f1]
maximum mA for AEC (where applicable):		NA	[f1]
mA where AEC is not used:		NA	[f2]
Is iterative reconstruction used?		Yes	
Iterative recon type (e.g. ASIR, SAFIRE, iDose, AIDR):		SAFIRE	[g]
Iterative recon value (e.g. ASIR 40%, SAFIRE 3, iDose level 4):		Strength 1	[h]
Radiation beam collimation	- Collimated Beam width (mm):	NA	[i]
	- Number of slices:	128	[j]
	- Detector size (mm) (e.g. 0.625,0.6):	0.6	[k]
Is Automatic tube voltage selection used? (eg. CarekV)		Yes	
If no, Fixed Tube voltage (kV):			[l]
Tube rotation time (s):		0.5	[m]
Primary image slice thickness (mm):		5	[n]
Scan field of view (SFOV) (mm):		NA	[o]
Reconstruction field of view (DFOV) (mm):		300	[p]

Summary of Local audit - details and doses

Public Health England

4th UK CT Dose Survey

ody region (clinical indication)*: Chest-abdomen-pelvis (CAP) (Cancer)

Please select from drop down list

If Other please give body region (clinical indication) details:

ospital and Scanner Information

ospital Name*: XXXburn hospital

Summary dose data from local audit

No of Patients	Mean Age at time of scan (yrs)	Mean Body Mass (kg)	Mean Total DLP* (whole scan)	Median Total DLP* (whole scan)	Comments on the data collection method (eg. inclusion criteria, data analysis method)
3132	67.18295019		560.01724	514.5	

Summary dose data from local audit

No of Patients	Mean Age at time of scan (yrs)	Mean Body Mass (kg)	Mean Total DLP* (whole scan)	Median Total DLP* (whole scan)	Comments on the data collection method (eg. inclusion criteria, data analysis method)
3132	67.18295019		560.01724	514.5	

Summary of Local audit - details and doses

Public Health England

4th UK CT Dose Survey

ody region (clinical indication)*:	Chest-abdomen-pelvis (CAP) (Cancer)
	Please select from drop down list
If Other please give body region (clinical indication) details:	

ospital and Scanner Information

ospital Name*:	XXXburn hospital
ocal system ID*:	RBC1
ystem manufacturer*:	Siemens
ystem model*:	Definition AS
umber of detector rows (eg. 16, 32, 64, 128, etc):	128

Summary dose data from local audit

No of Patients	Mean Age at time of scan (yrs)	Mean Body Mass (kg)	Mean Total DLP* (whole scan)	Median Total DLP* (whole scan)	Comments on the data collection method (eg. inclusion criteria, data analysis method)
3132	67.18295019		560.01724	514.5	

Acquisition 1									
Mean C (mG	Standard deviation	Median $CTDI_{vol}$ (mGy)*	25th Percentile	75th Percentile	Mean DLP (mGy.cm)*	Standard deviation	Median DLP (mGy.cm)*	25th Percentile	75th Percentile

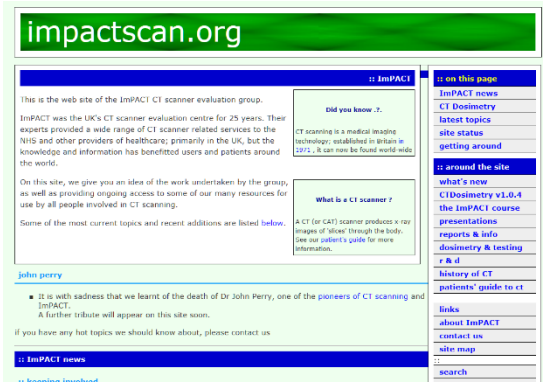
Generally only get total Exam DLP data

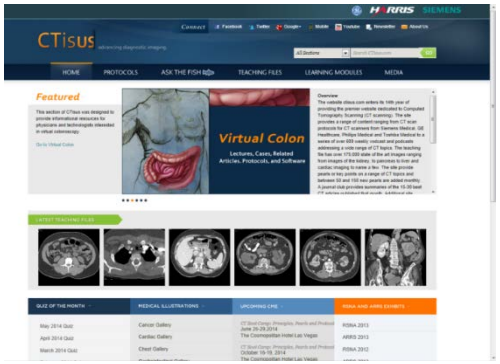
Summary dose data from local audit

No of Patients	Mean Age at time of scan (yrs)	Mean Body Mass (kg)	Mean Total DLP* (whole scan)	Median Total DLP* (whole scan)	Comments on the data collection method (eg. inclusion criteria, data analysis method)
3132	67.18295019		560.01724	514.5	

Teaching material

- Basic CT
  - www.impactscan.org
- Physics UK Group
  - www.ctug.org.uk
- CTISUS.org





Public Health England

Protecting and improving the nation's health

IAEA International Atomic Energy Agency

DRLs and exposure monitoring in CT:

quantities, procedures, methods, international experience

Sue Edyvean

ICTP-IAEA Workshop on Establishment and Utilization of Diagnostic Reference Levels in Medical Imaging Imaging (smr3333):
18-22 November 2019 **Trieste, Italy**

Senior Scientific Group Leader
Medical radiation Dosimetry, CRCE
Public Health England
Didcot, Oxon. OX11 0RQ, UK

Reports on Cardiac CT

BJR

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REVIEW ARTICLE

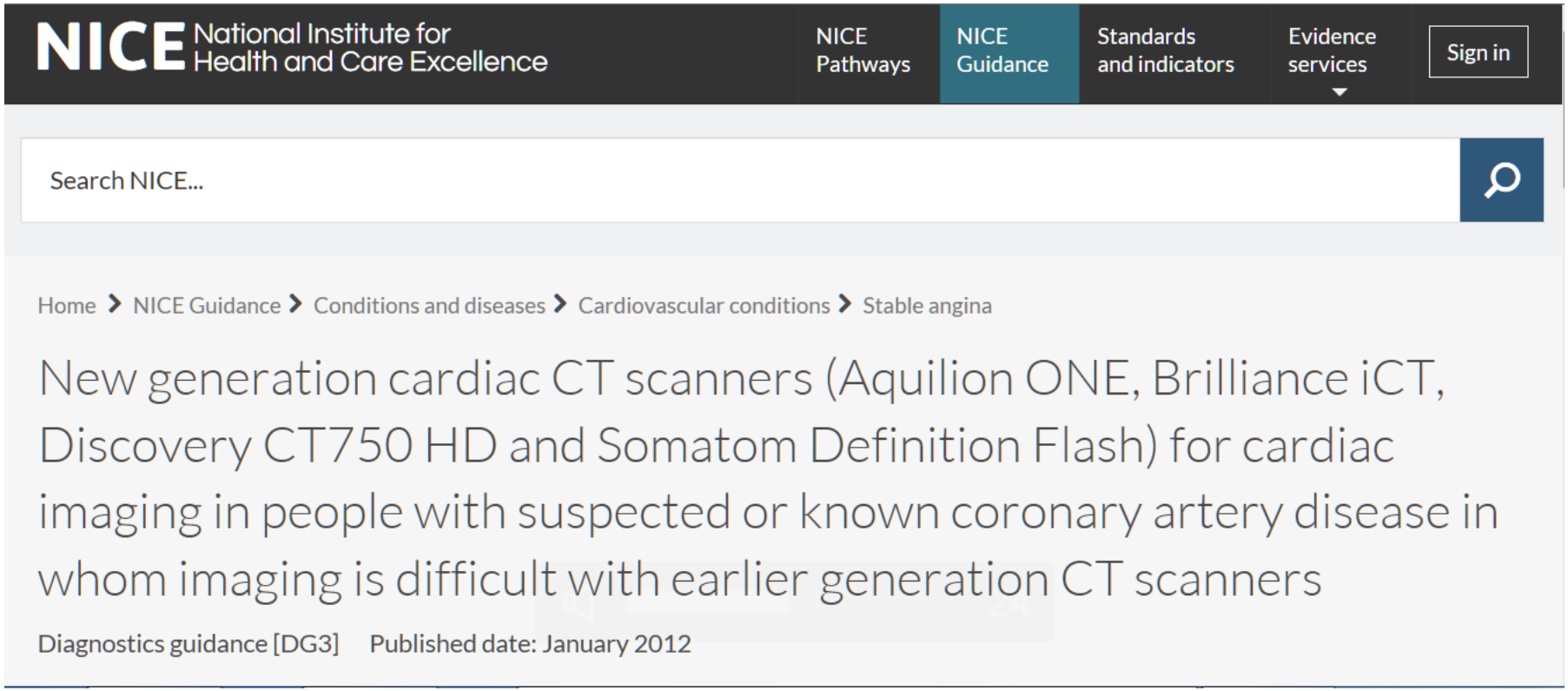
Selecting a CT scanner for cardiac imaging: the heart of the matter

[1]MARIA A LEWIS, MSc, [2,3]ANA PASCOAL, PhD, MIPEM, [1,2,4]STEPHEN F KEEVIL, PhD, FIPEM and [2,3]CORNELIUS A LEWIS, PhD, FIPEM

[1]Department of Medical Physics, Guy's and St Thomas' NHS Foundation Trust, London, UK
[2]King's Technology Evaluation Centre (KiTEC), King's College London, London, UK
[3]Department of Medical Engineering and Physics, King's College Hospital NHS Foundation Trust, London, UK
[4]Division of Imaging Sciences & Biomedical Engineering, King's College London, London, UK

Address correspondence to: Mrs Maria Anna Lewis
E-mail: *maria_anna_lewis@yahoo.co.uk*

Reports on Cardiac CT



Cardiac CT

- Cardiac CT - BIR webinar 9 May 2016
  (http://www.bir.org.uk/webinars-on-demand)
- Market review: Advanced CT scanners for coronary angiography

  CEP10043, March 2010

http://www.impactscan.org/reports/CEP10043.htm

Advanced CT scanners for coronary angiography. CEP10043, Mar-10

This market review is intended to help prospective purchasers make informed choices and achieve best value from investment in high-end CT systems for Coronary CT Angiography applications. It should be read in conjunction with CEP's buyer's guide to multi-slice CT scanners (CEP08007) and the associated comparative specification reports (CEP08027, CEP08028).

Electronic access to a PDF version of this report is available from the CEP website.