Hull University Teaching Hospitals NHS Trust

# Where do we go from here? Insights from the 2018 IPEM Dose survey and opportunities for quality improvement 20th November-2019

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# Acknowledgements


- Thanks go to:
  - Tim wood for providing slides from the “First UK survey of doses from radiotherapy CT scans”
  - Annie Tonks for her work on an internal RT CT dose audit.
  - Gill Millen for inviting me to give this talk.

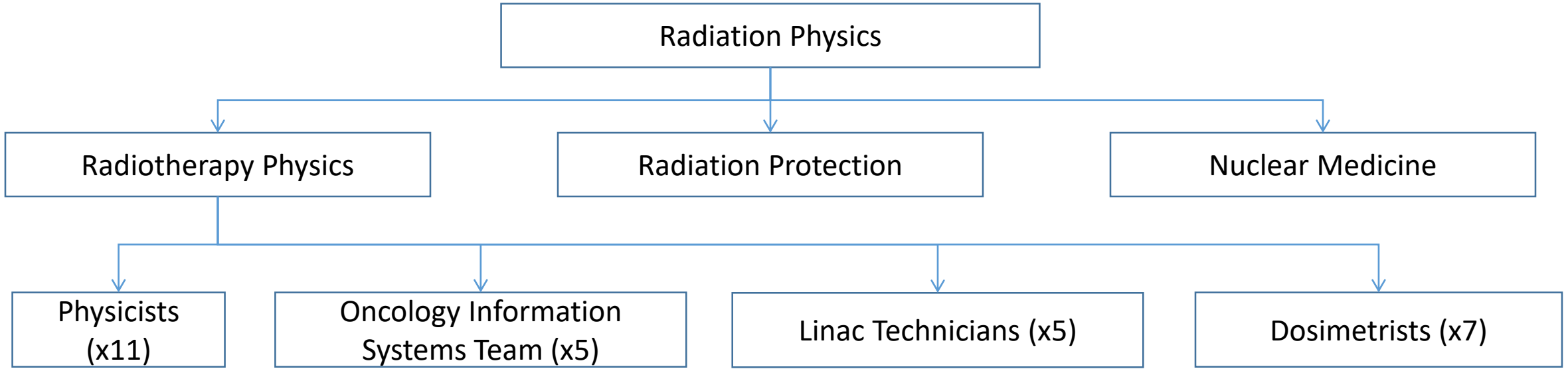
# Castle Hill Hospital Radiotherapy Team

http://www.hullrad.org.uk/

# RADIOTHERAPY EQUIPMENT

- Six Varian Linacs, two Clinac iX systems, three Truebeam systems and a state of the art Halcyon system, all with portal MV imaging and kV CBCT imaging. Varian Real-time Position Management (RPM) system.
- Nucletron Flexitron-HDR unit
- Xstrahl 200 Superficial Therapy X-Ray (SXR) Unit
- Ariane Papillon 50 Contact Therapy X-Ray Unit
- 2 Philips Brilliance Big Bore 16-slice CT Scanners
- Varian Eclipse treatment planning system for external beam therapy and Oncentra Masterplan for brachytherapy
- IBA Compass pre treatment verification system

# Our Department



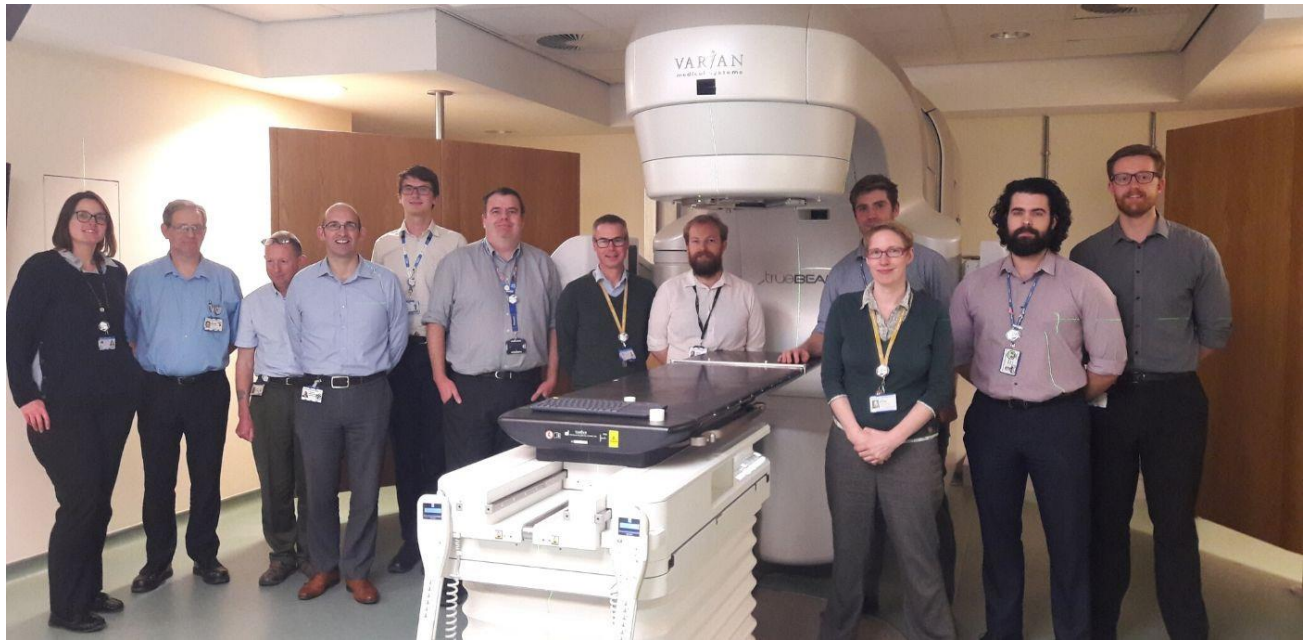
# National first for MPACE accreditation

Already compliant with **ISO9001** accredited by BSI.

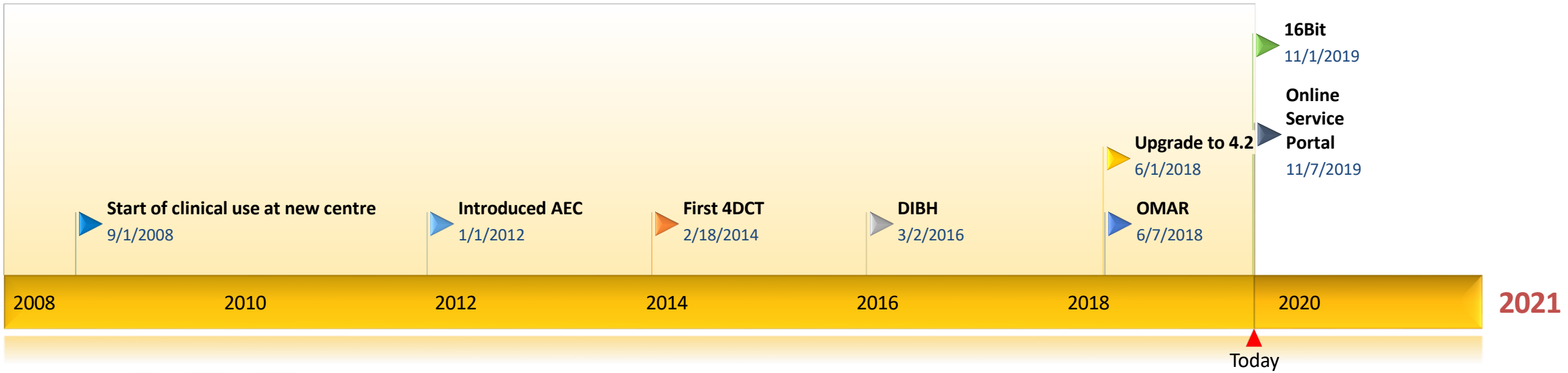
Now accredited for **BS70000** which is a new standard specific to Medical Physics and Clinical Engineering services.

UKAS MEDICAL
10317

**Accredited to**
**BS 70000:2017**



# Where we are coming from



IPEM Institute of Physics and Engineering in Medicine

NHS Hull University Teaching Hospitals NHS Trust

# The first UK survey of doses from radiotherapy treatment planning CT scans for adult patients

**Tim Wood**, Anne Davis, James Earley, Sue Edyvean, Una Findlay, Rebecca Lindsay, Rosy Plaistow, Andrew Nisbet, Antony Palmer, Matt Williams

Working party of Radiotherapy & Diagnostic Radiology Special Interest Groups

# The aims of the working party

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- To fill in the ‘gap’ by facilitating sharing and comparison of dose information for radiotherapy imaging

- Or specifically…

# The aims of the working party

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- To undertake an audit of typical imaging doses for a range of common X-ray imaging procedures undertaken in Radiotherapy departments
  - This includes planning CT scans, on treatment CBCT imaging and tomotherapy (may also consider planar X-ray and fluoroscopy)
- To publish a range of typical ‘doses’ for common procedures
  - Like PHE do with national reference doses in diagnostic imaging
  - If data is good enough, this should allow adoption as national reference doses for RT imaging
- Make data available to the UK Radiotherapy community that will enable better optimisation of imaging
  - Including direct feedback to participating centres
- Identify best practice that will ultimately benefit patients

# The ‘grand plan’

- Aim for at least two peer-reviewed publications in PMB
  - **Planning CT doses**
    (out now: http://iopscience.iop.org/article/10.1088/1361-6560/aacc87/meta)
  - **CBCT doses/tomotherapy**
    (data collection soon, aiming for publication in 2019)

- Want to include a simple evaluation of **image quality** to go alongside the assessment of doses
  - Later, follow-up work if there is time for the working party

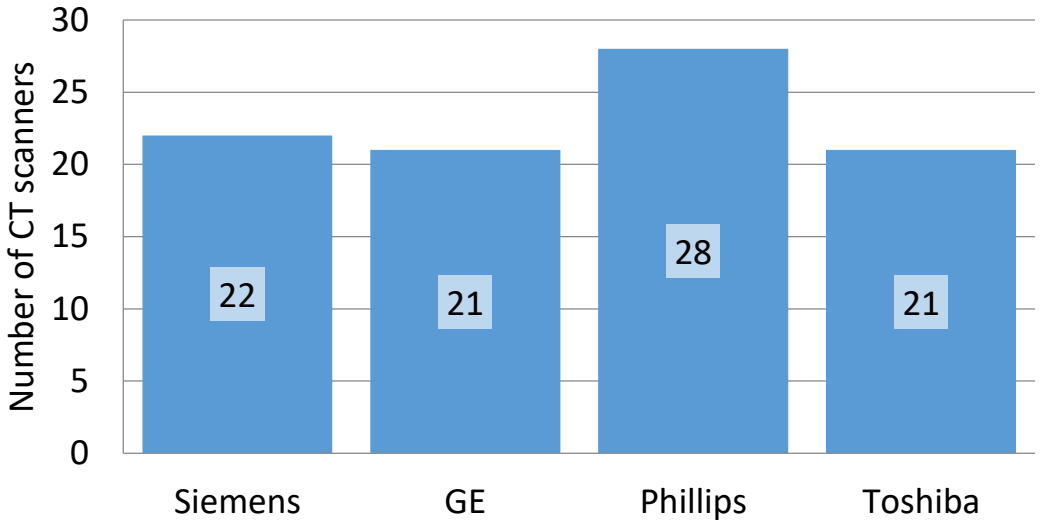
# CT planning scans

- Launched data collection in February 2017, and final dataset came in September 2017

- For each patient:
  - CT Dose Index ($CTDI_{vol}$)
  - Dose-length product (DLP)
  - Scan length
  - Patient weight (if available)

# Pre-data collection questionnaire

- With regards to **CT planning scan equipment and protocols**;
  - In the 59 UK centres to submit data, there are a total of 92 CT scanners currently ‘in use’
  - Fairly evenly split between four vendors
  - The seven proposed ‘clinical protocols’ were used by the majority of centres
  - There was no common ‘other’ protocol suggested for audit
  - *Note*, no nodes was selected for audit due to more standardised protocols (scan lengths) being used



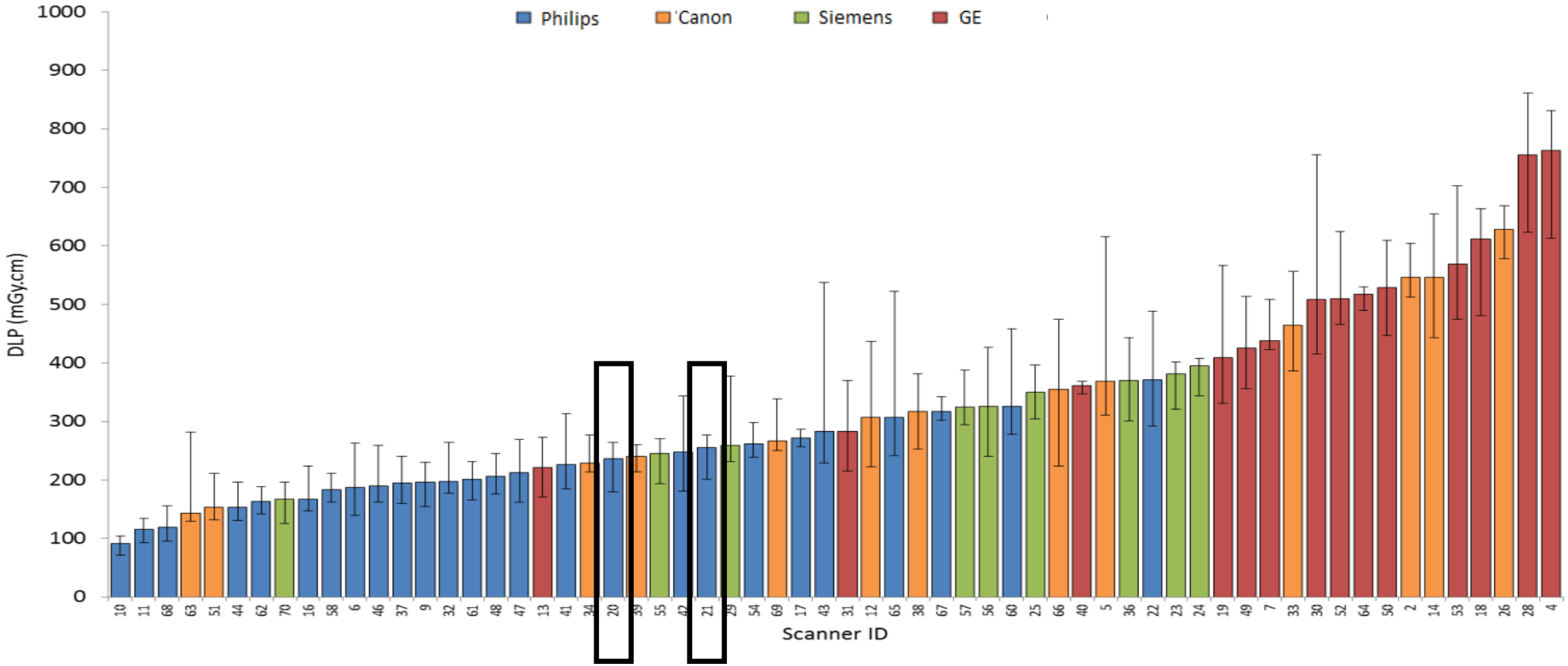

| CT Protocol | N | % of centres |
|---|---|---|
| Breast (no nodes) | 57 | 96.6 |
| Prostate (no nodes) | 56 | 94.9 |
| Gynae (no nodes) | 46 | 78.0 |
| Lung 3D | 53 | 89.8 |
| Lung 4D | 48 | 81.4 |
| Brain | 44 | 74.6 |
| Head and neck | 54 | 91.5 |

# Data analysis

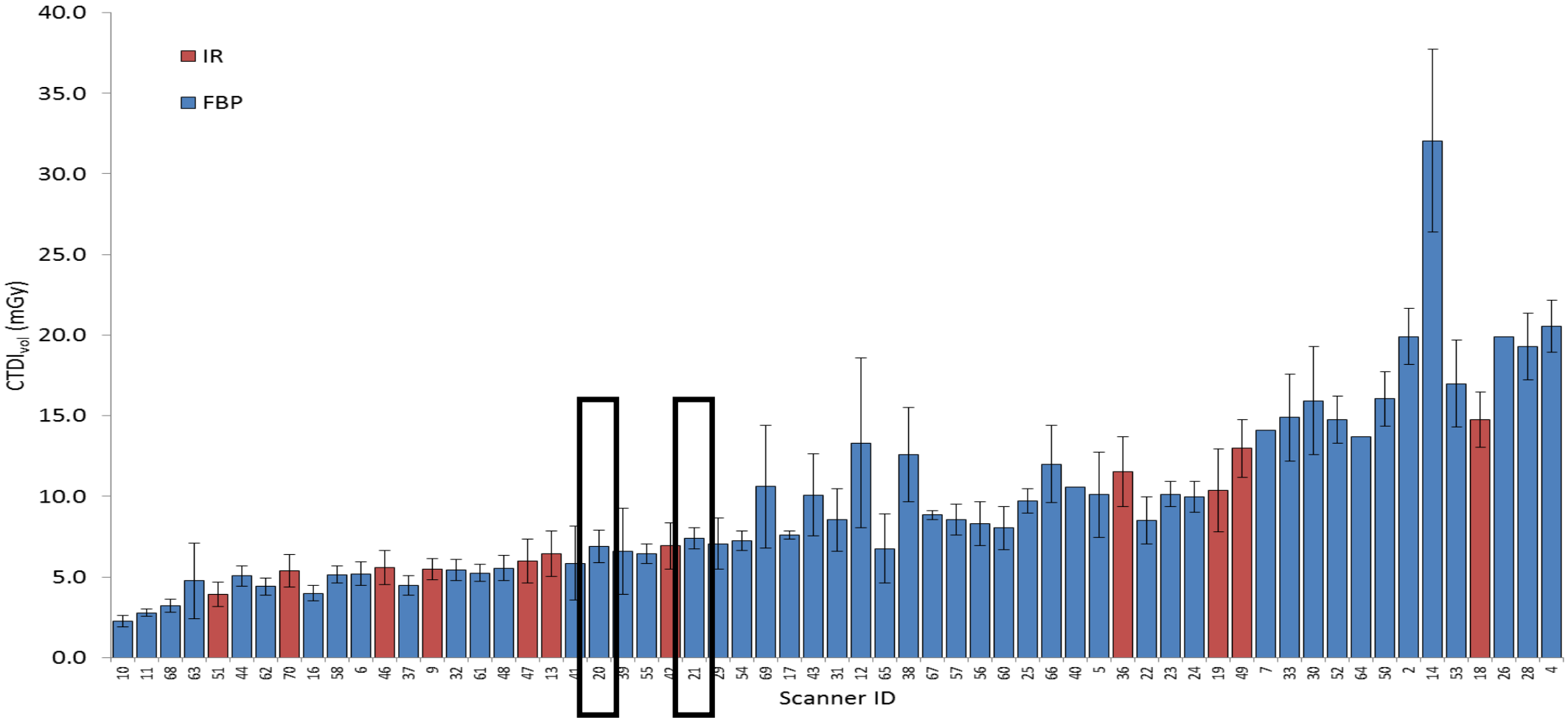
- For this study, **median** from each scanner was used to define scanner average $CTDI_{vol}$, DLP, scan length (not mean)
  - More robust against outliers e.g. very obese patients
  - In accordance with draft guidance from the ICRP on '*Diagnostic Reference Levels in Medical Imaging*' and is also a widely used technique in many centres
  - For data plots, error bars are the 95% confidence intervals

- **Third quartile** ('national reference') and **median** ('achievable') of the **scanner median data** were calculated in Excel

# Breast – DLP


Philips
Canon
Siemens
GE
DLP (mGy.cm)
1000
900
800
700
600
500
400
300
200
100
0
10 11 68 63 51 44 62 70 16 58 6 46 37 9 32 61 48 47 13 41 34 20 39 55 42 21 29 54 69 17 43 31 12 65 38 67 57 56 60 25 66 40 5 36 22 23 24 19 49 7 33 30 52 64 50 2 14 53 18 26 28 4
Scanner ID

# Breast – FBP vs iterative



# Breast – Scan length

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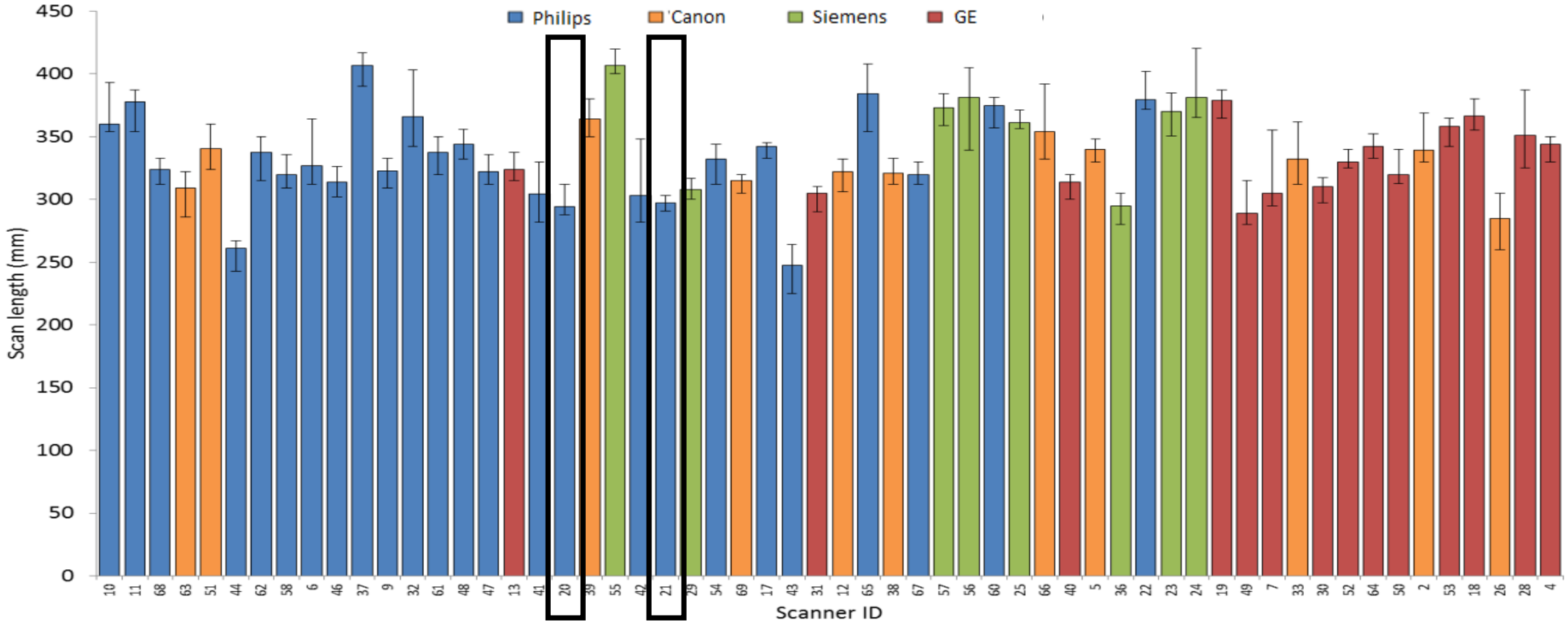
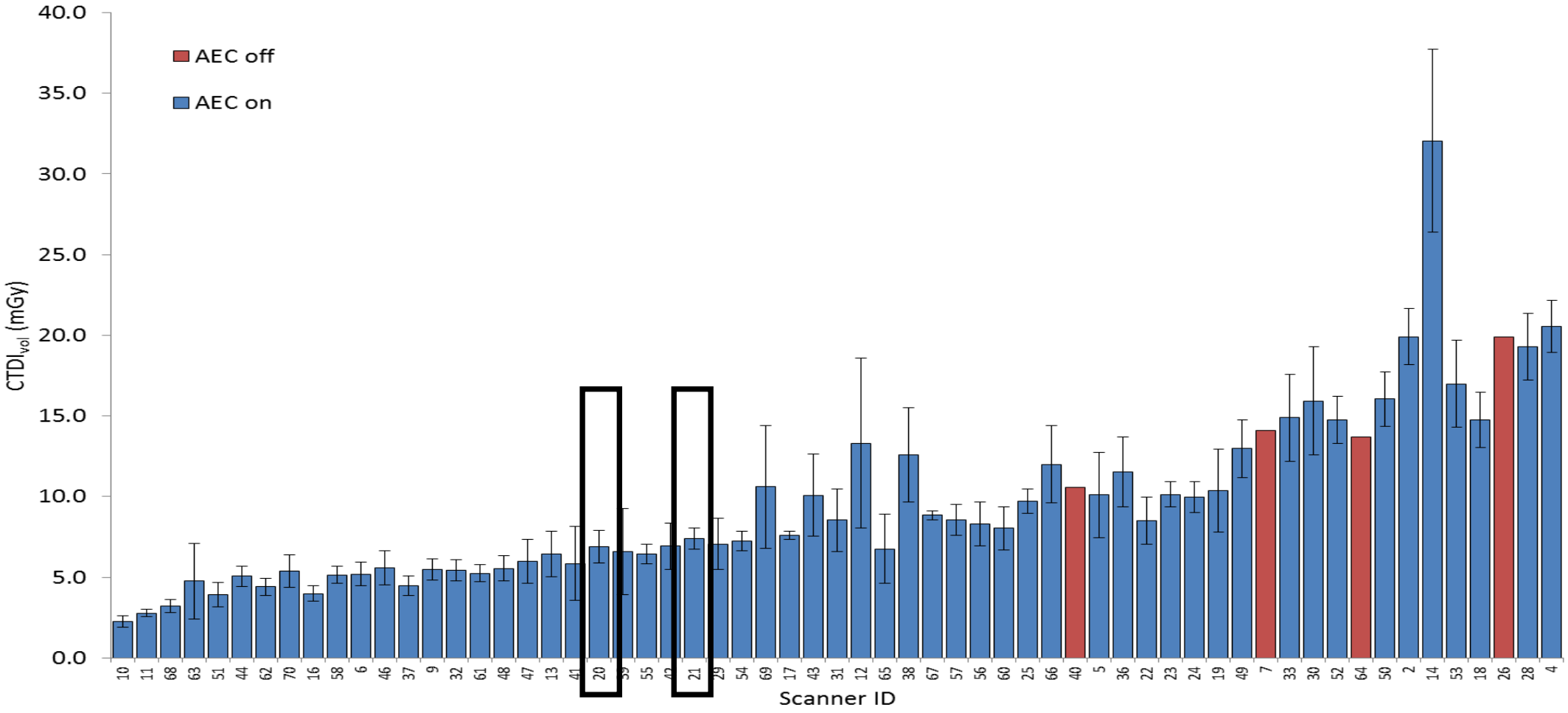
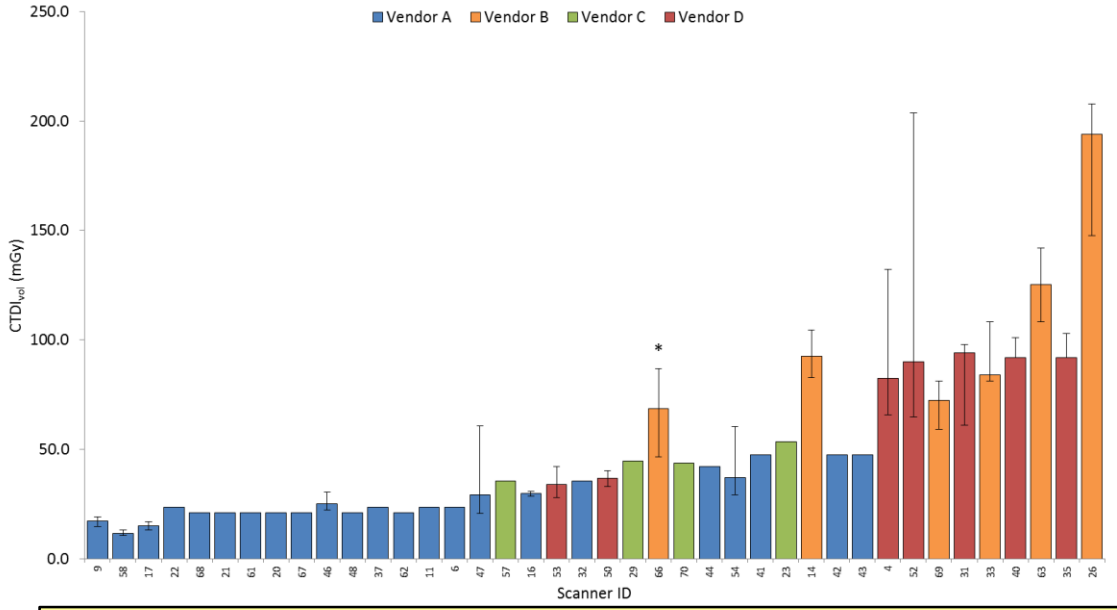


# Breast – AEC vs fixed mAs



# Lung 4D

- Relatively small data set
  - 41 DLP scanner medians
  - 40 $CTDI_{vol}$ scanner medians (39 excluding max CTDI systems)
  - 36 scan length medians
- Very wide range of doses
  - Factor of 18.6 between min and max DLP
  - Factor of 16.7 between min and max $CTDI_{vol}$
- Very strong vendor dependence
  - Different approaches to 4D CT data acquisition and processing?




* Indicates maximum CTDI on older Toshiba scanners using AEC

# Proposed reference levels

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## CT Planning scans – Reference Values

($3^{rd}$ quartile)

| Examination | Phantom diameter (cm) | $CTDI_{vol}$ (mGy) | DLP (mGy.cm) | Scan length (mm) |
|---|---|---|---|---|
| Breast | 32 | 10 | 390 | 360 |
| Gynaecological | 32 | 16 | 610 | 400 |
| Lung 3D | 32 | 14 | 550 | 390 |
| Lung 4D | 32 | 63 | 1750 | 340 |
| Prostate | 32 | 16 | 570 | 340 |
| Brain | 16 | 50 | 1500 | 290 |
| Head and neck | 16 | 49 | 2150 | 420 |

## CT Planning scans – Achievable values

(Median)

| Examination | Phantom diameter (cm) | $CTDI_{vol}$ (mGy) | DLP (mGy.cm) | Scan length (mm) |
|---|---|---|---|---|
| Breast | 32 | 8 | 280 | 330 |
| Gynaecological | 32 | 12 | 510 | 390 |
| Lung 3D | 32 | 10 | 410 | 370 |
| Lung 4D | 32 | 36 | 1170 | 330 |
| Prostate | 32 | 13 | 420 | 310 |
| Brain | 16 | 42 | 1110 | 250 |
| Head and neck | 16 | 26 | 1080 | 400 |

# Standard Practice

- Local annual dose audit

# Local annual dose audit

- Patient data was collected automatically via the OpenREM dose management system from an approximate six month period (end of July 2018 to January 2019), detailing the $CTDI_{vol}$, DLP and scan length for each patient examination across two radiotherapy treatment planning CT scanners, CT1 and CT2, at CHH.

- The data was collected and reviewed in Microsoft Excel and categorised into the seven examination protocols of breast, gynaecological, lung 3D, lung 4D, prostate, brain and head and neck, as per the NDRLs and with an additional examination protocol for DIBH breast. The median values for $CTDI_{vol}$, DLP and scan length were then calculated alongside deviations from the NDRL values for each of the two Philips machines.

- Additional achievable levels were proposed in the IPEM report based on the median of the scanner median distributions of the 68 radiotherapy CT scanners included in the audit

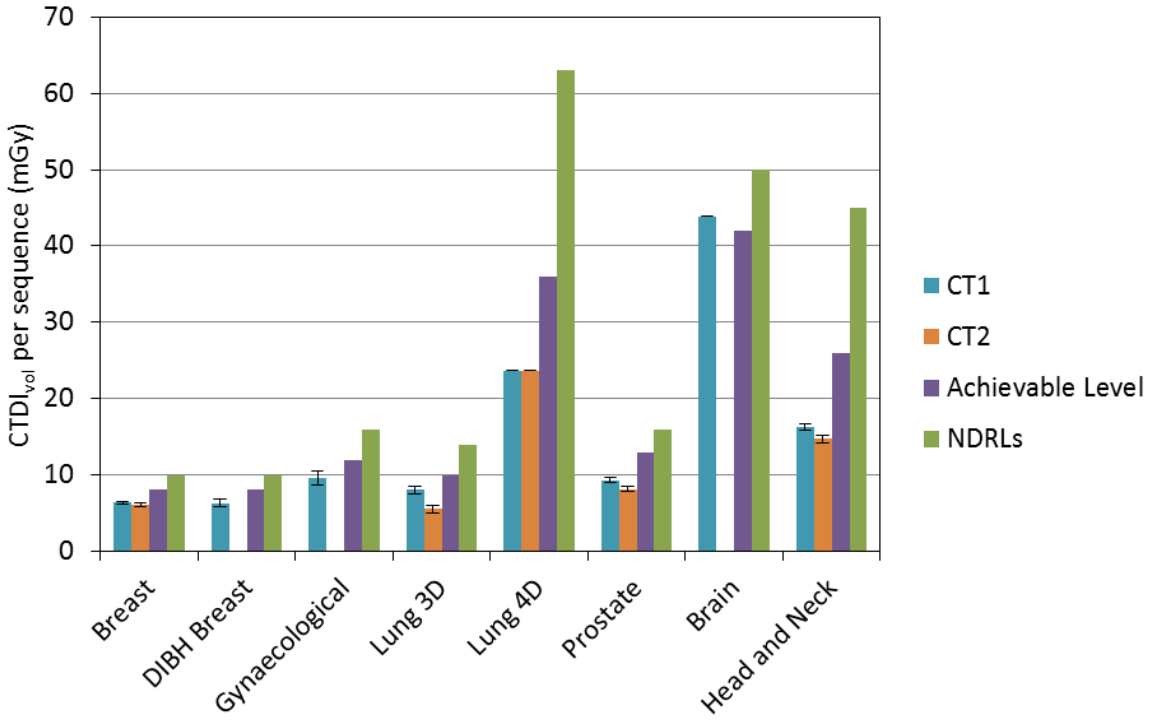



**Figure 1:** Patient dose audit data for the $CTDI_{vol}$ for the eight examination protocols. Each protocol includes a measure for each of the two machines, CT1 and CT2, with the relevant NDRL and achievable level for comparison. Note: the brain and head and neck examination protocol values for $CTDI_{vol}$ and DLP have been scaled to match the 16 cm phantom used for the NDRLs.

Credit to Annie Tonks for conducting this audit

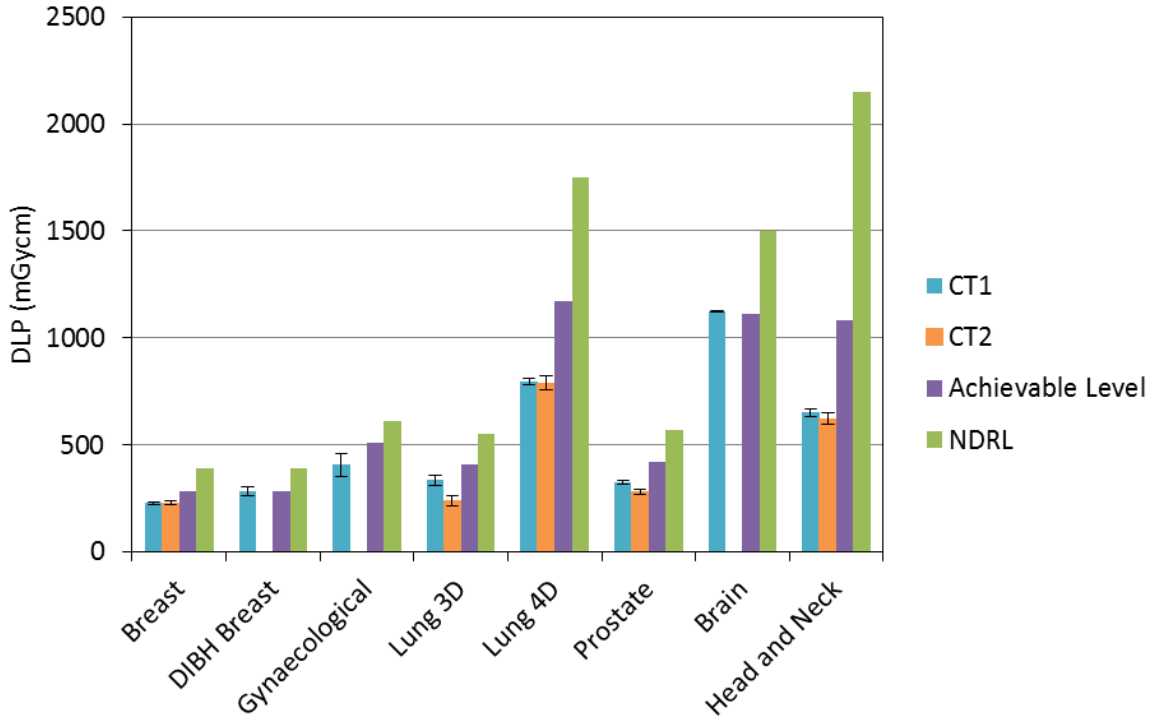



**Figure 2:** Patient dose audit data for the DLP for the eight examination protocols. Each protocol includes a measure for each of the two machines, CT1 and CT2, with the relevant NDRL and achievable level for comparison. Note: the brain and head and neck examination protocol values for $CTDI_{vol}$ and DLP have been scaled to match the 16 cm phantom used for the NDRLs.

Credit to Annie Tonks for conducting this audit

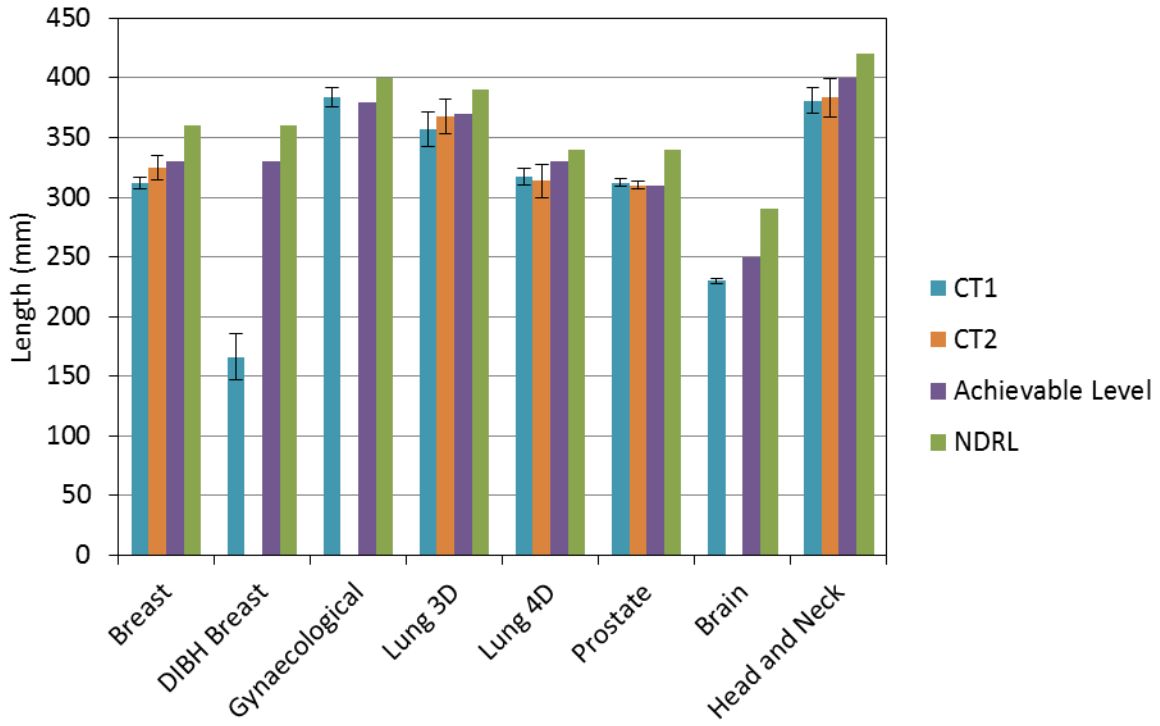



**Figure 3:** Patient dose audit data for the scan length measurements for the eight examination protocols. Each protocol includes a measure for each of the two machines, CT1 and CT2, with the relevant NDRL and achievable level for comparison. Note: the brain and head and neck examination protocol values for $CTDI_{vol}$ and DLP have been scaled to match the 16 cm phantom used for the NDRLs.

Credit to Annie Tonks for conducting this audit

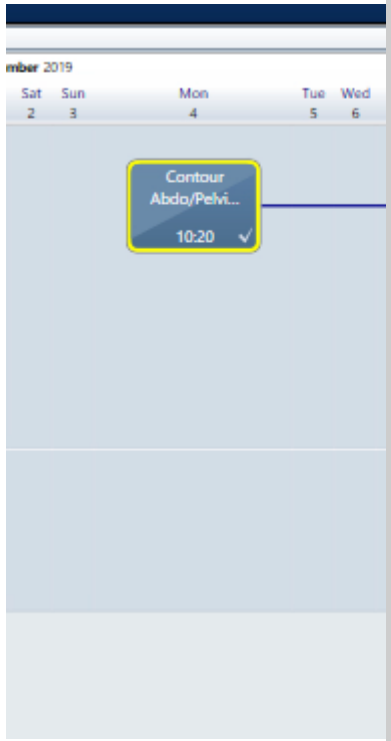
**Table 1:** Local DRL values based on the 32 cm diameter phantom (size used for all protocols on the scanners).

| Examination | $CTDI_{vol}$ LDRL (mGy) | DLP LDRL (mGycm) | Scan Length LDRL (mm) |
|---|---|---|---|
| Breast | 7 | 230 | 330 |
| Gynaecological | 10 | 410 | 390 |
| Lung 3D | 8 | 340 | 370 |
| Lung 4D | 24 | 800 | 320 |
| Prostate | 10 | 330 | 320 |
| Brain | 22 | 590 | 230 |
| Head and Neck | 8 | 320 | 390 |

# Reception of Images

- What do our doctors actually think of image quality.
- What can we do to improve?

# Reception of Images




Activity : 'Volume and Prescribe Urology IMRT' for Patient 'Prostate, Nonclincial1 (RAProstate1)' - Activity Status : 'Completed' - Proce...

Patient Status: Test Patient
Hospital: Castle Hill Hospital
Department: RadiotherapyCHH
Patient I/O Status: Outpatient
Course:
Payor:
Prim. Oncologist:
Covering Provider:

Related Diagnoses

| Related | Type | Onset Date | Code | Clinical Description | Sequence | Ran... |
|---|---|---|---|---|---|---|
| ☑ | Primary | 31/03/2019 | C61 | Malignant neoplasm of prostate | 1 | 1 - ... |
| ☑ | Primary | 02/02/2017 | Referral_1 | Referral received date for Course 1 | 2 | 1 - ... |

Procedure Code Details

| | Qty | Procedure Code | Account Number | Exportable | Code Modifier | Completed by | Date of Service ... | Grou |
|---|---|---|---|---|---|---|---|---|
| ☐ | 1 | HEY-TP-068 - High quality image | | ☐ | | Carl Horsfield | 12/11/2019 10:2... | Onc |
| ☐ | 1 | HEY-TP-069 - Acceptable image | | ☐ | | Carl Horsfield | 12/11/2019 10:2... | Onc |
| ☐ | 1 | HEY-TP-070 - Low quality image | | ☐ | | Carl Horsfield | 12/11/2019 10:2... | Onc |
| ☐ | 1 | HEY-TP-071 - Rejected image | | ☐ | | Carl Horsfield | 12/11/2019 10:2... | Onc |

Fill Account Numbers | Add More Procedure Codes

Additional Activity Attributes

Image Quality Problem

Help | Previous Patient | Next Patient | Save Edits | Cancel Edits

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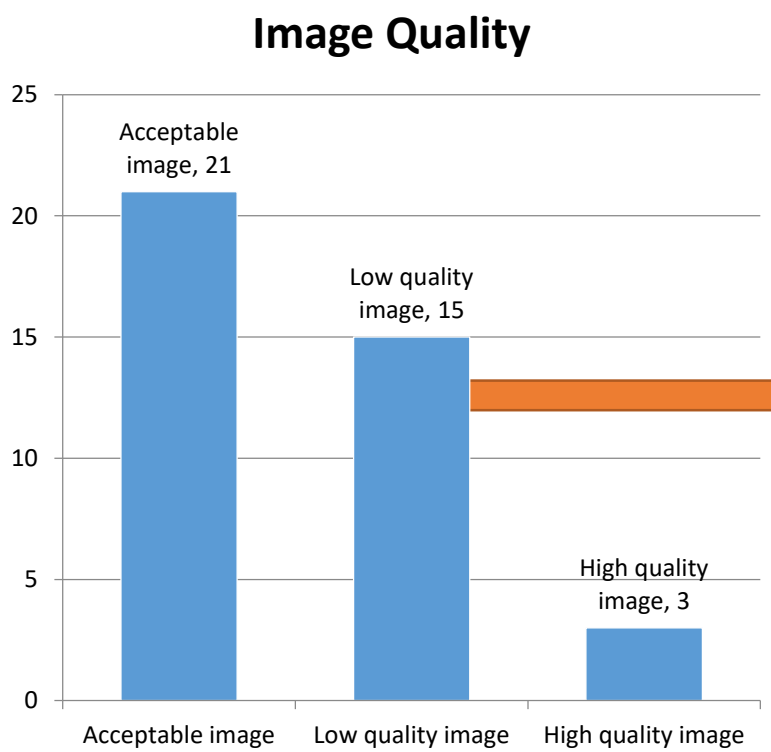
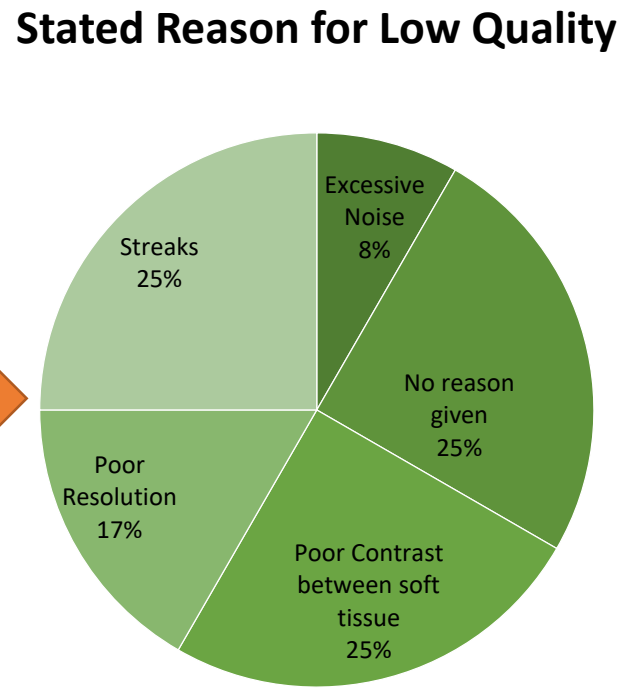
Remarkable people.
Extraordinary place.

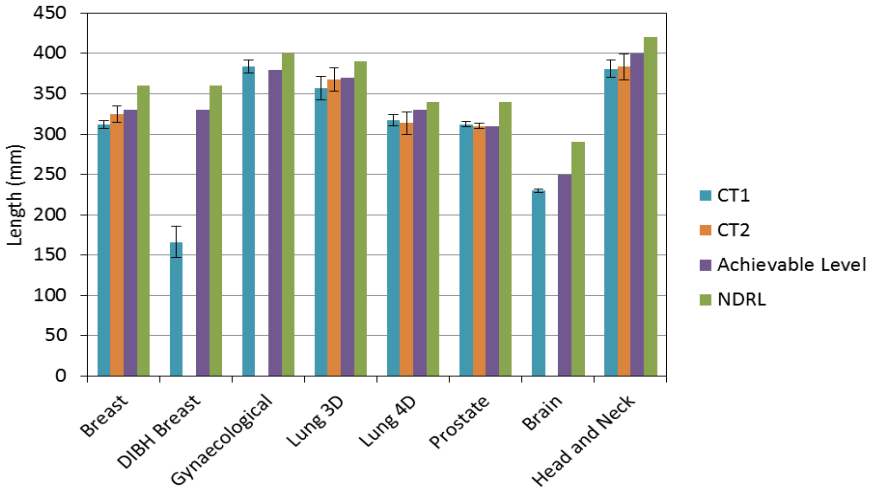
# Reception of Images



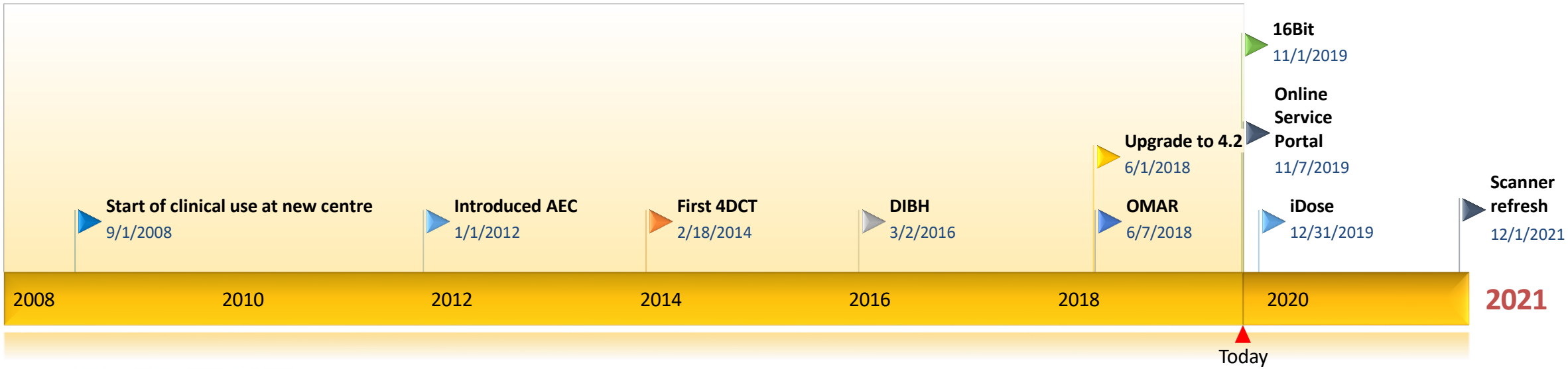



# Reception of Images

- There is some work to be done.
- We could increase dose to help with Streaks, and noise. But Urology are already close to the Reference Level.



# Where we going to?



# Any Questions?