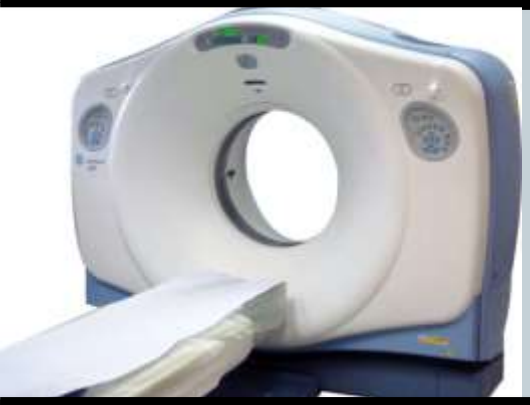
PAEDIATRIC CT PROTOCOL OPTIMISATION OF THE ABDO-PELVIC REGION

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VERVIEW

- Paediatric radiologist's concerns
- Objectives of the study
- Data collection procedure and tools
- Data analysis techniques
- Current situation of scanners
- Scanner results post-optimisation
- Limitations and problems encountered
- Recommended actions
- Summary

Radiologist's concerns

- Current situation in Leeds:
  - **Siemens Definition 64 slice CT scanner** ("*OPTIMISED" scanner)
    - 3 paediatric protocols (100kV, weight dependent variable current, 32cm phantom)
  - **GE Lightspeed VCT 64 slice CT scanner**
    - 9 colour-coded paediatric protocols (80 – 120kV, fixed current/tube current modulation, 16/32cm phantom)

- Radiologist's concerns of the GE scanner compared to the Siemens scanner:
  - GE radiation doses are much higher than Siemens doses for large paediatric patients (22.5 – 55 kg)
  - Images for small paediatric patients on the GE scanner are much noisier

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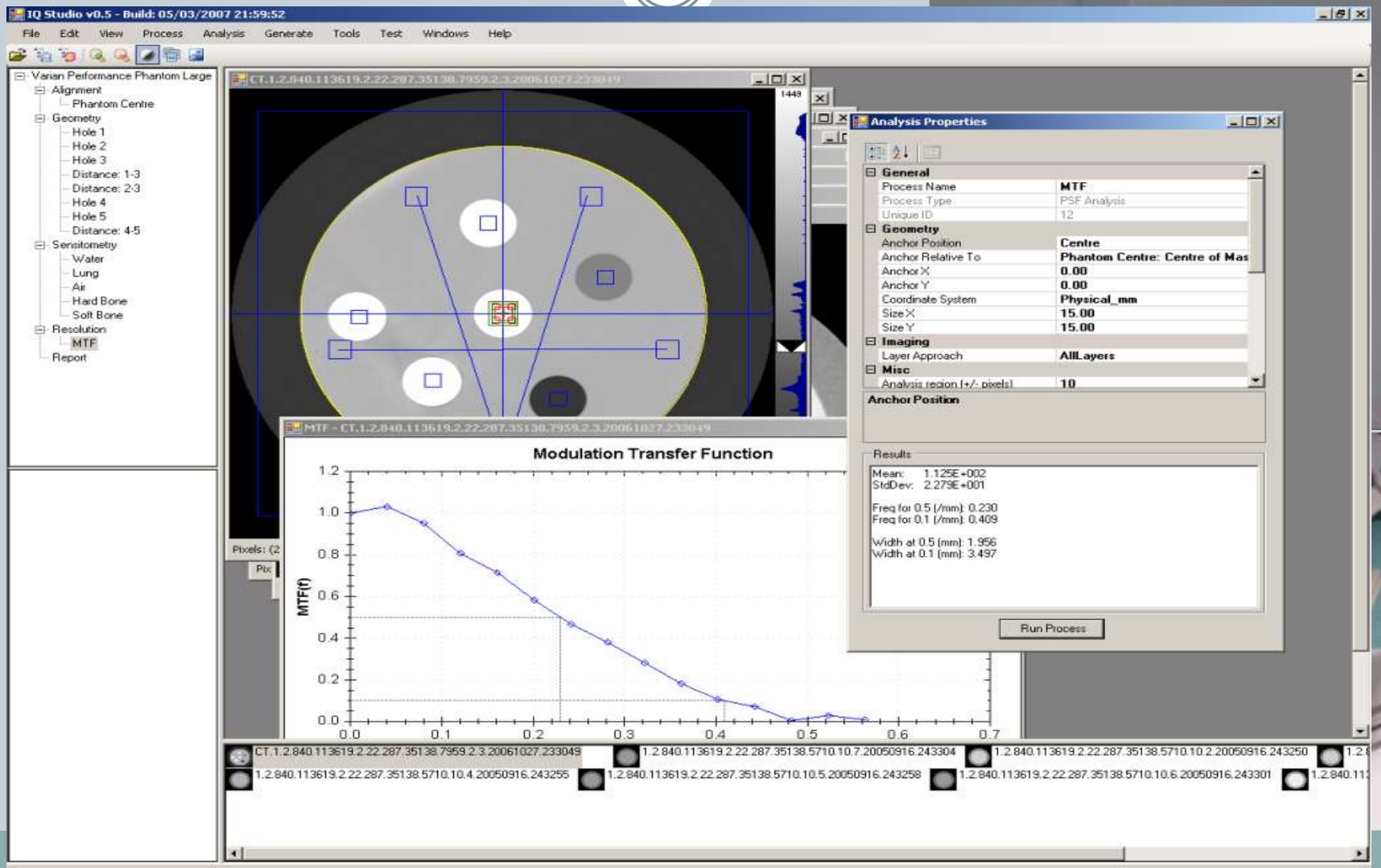
OBJECTIVES OF THE STUDY

- Identifying appropriate image quality indicators (Contrast-to-noise ratio (CNR), noise and Modulation Transfer Function (MTF)).
- Measuring and comparing the image quality indicators and dose measurements between the reference (Siemens) and the GE scanner.
- Adjusting the exposure and reconstruction parameters on the GE scanner to optimise the image quality whilst keeping radiation doses to a minimum, according to radiologist's concerns.

DATA COLLECTION PROCEDURE



DATA COLLECTION TOOLS

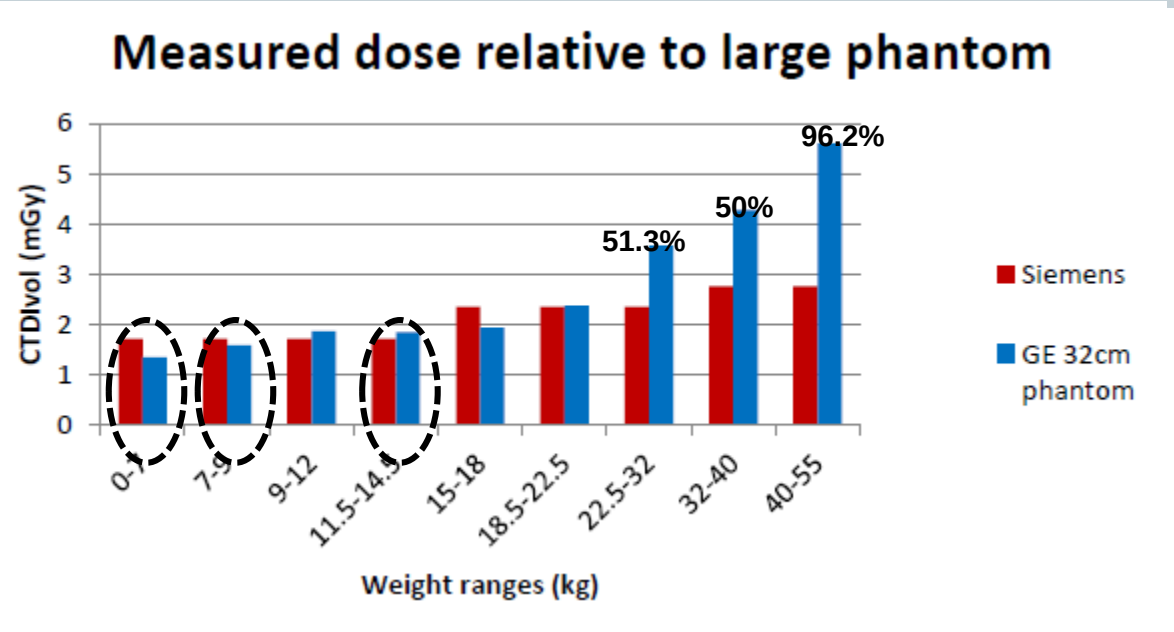
- 32cm diameter CTDI phantom + 100mm long pencil ionisation chamber
- TLDs in anthropomorphic phantoms **(NOT IDEAL)**
- Circular CTDI phantoms chosen
- Elliptic CTDI phantoms (Dong, Davros, Pozzuto, & Reid, 2012)
- Catphan 500 comprised of four modules, each produces a specific image quality indicator
- IQworks
- MATLAB **(COMPLEX)**

DATA ANALYSIS TECHNIQUES

- Dose reduction
  - mA reduction in protocols – Linear reduction in dose
  - kV reduction in protocols – matching GE protocols
- Image Quality variation
  - mA reduction in protocols – noise α $\frac{1}{\sqrt{mA}}$; $\mathrm{CNR} = \frac{\text{contrast}}{\text{new noise}}$
- CNR objective analysis
  - Using 3rd module of Catphan (0.3%, 0.5%, 1% contrast targets)
  - New analysis tree for module 3 (IQworks)

Scanners' Current Situation (Radiation Dose)

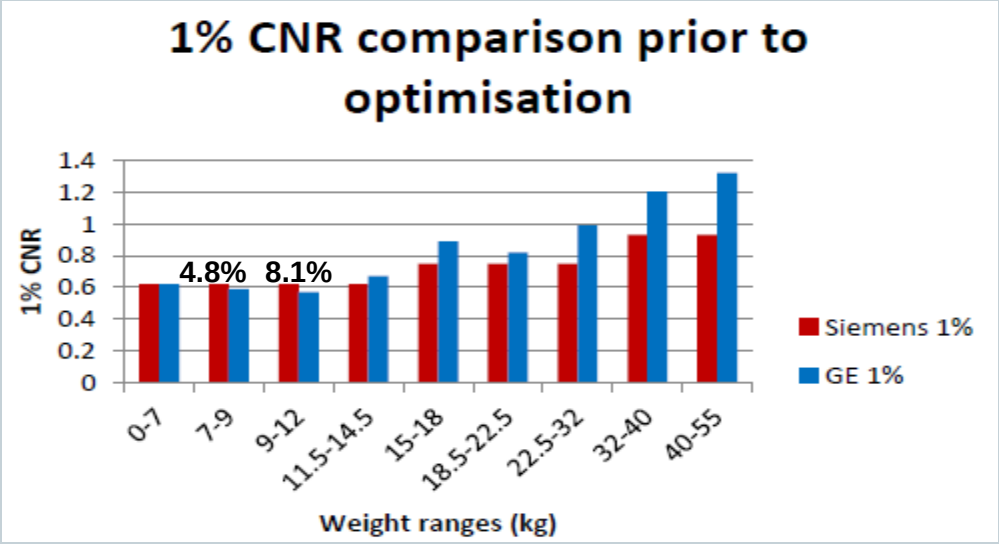
- Paediatric radiologist's dose concern (displayed doses)
- Comparison of measured doses relative to 32cm CTDI phantom (conversion factors or using measured data)
- GE doses within **96.2%** of Siemens doses (overall range of **4.25mGy** for GE)



Scanners' Current Situation (Image Quality)

- Comparing measured noise between two scanners
  - **137% noise difference** on GE
  - **4.36HU maximum difference** between Siemens and GE
- Paediatric radiologist's noise concern for children weighing between 0 -12 kg

- Comparing 1% CNR (new analysis tree) between two scanners
  - All GE protocols except 7-9 kg and 9-12 kg had higher or similar CNR than Siemens

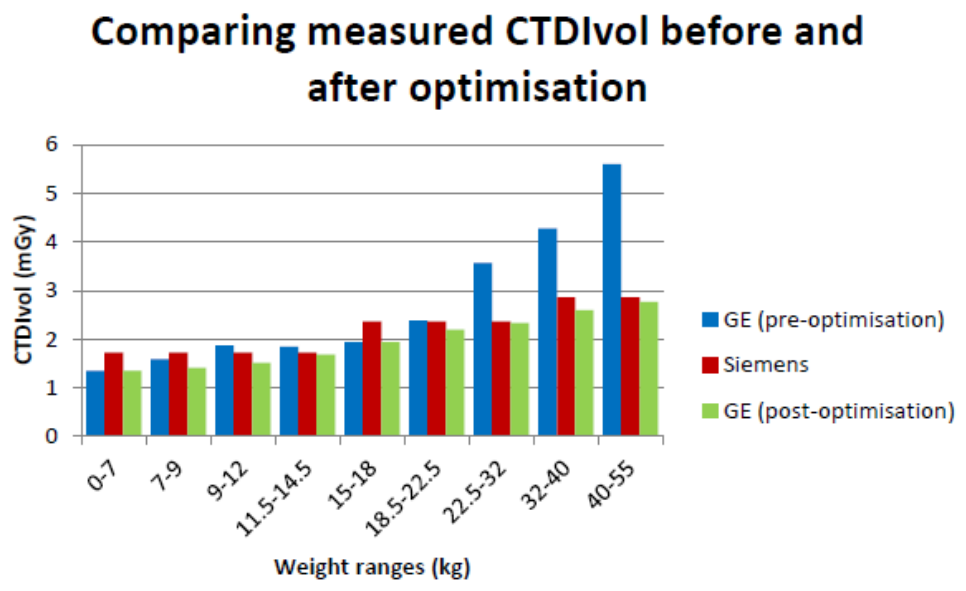


Optimisation Steps

	Original Parameters	Optimised Parameters
PINK (0 – 7kg)	80kV, 150mA, Ped body, std 20%	80kV, 150mA, Ped body, soft 20%
RED (7 – 9kg)	80kV, 180mA, Ped body, std 0%	80kV, 160mA, Ped body, soft 20%
PURPLE (9 – 12kg)	80kV, 210mA, Small body, std 0%	80kV, 170mA, Ped body, soft 20%
YELLOW (11.5 – 14.5kg)	100kV, 110mA, Ped body, std 20%	100kV, 100mA, Ped body, soft 20%
WHITE (15 – 18kg)	100kV, 115mA, Small body, std 30%	100kV, 115mA, Small body, soft 30%
BLUE (18.5 – 22.5kg)	100kV, 120mA, Med body, std 30%	100kV, 120mA, Small body, std 40%
ORANGE (22.5 – 32kg)	120kV, 140mA, Small body, std 30%	100kV, 140mA, Small body, std 40%
GREEN (32 – 40kg)	120kV, 150mA, Med body, std 30%	100kV, 130mA, Med body, std 40%
BLACK (40 – 55kg)	120kV, 180mA, Med body, std 30%	100kV, 140mA, Med body, std 40%

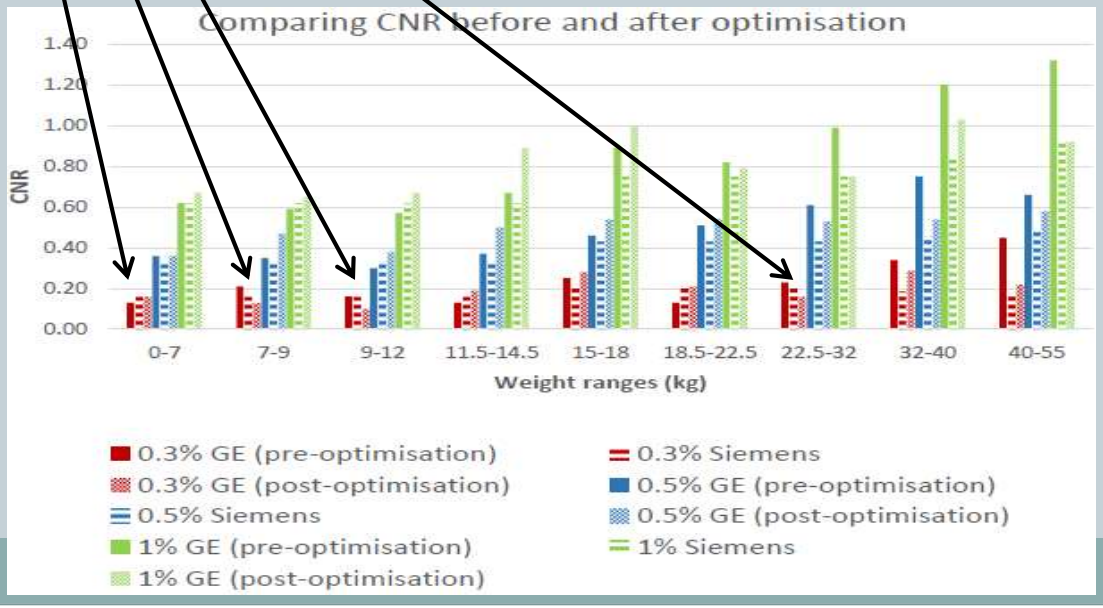
Results after Optimisation (Radiation Dose)

- **DOSE SAVINGS OF 34.7% TO 50.5%** for paediatric patients weighing between 22.5 – 55 kg
- GE doses post-optimisation are within **21.65%** of Siemens doses with a range of 1.42mGy (compared to 96.2% and 4.25mGy range)
- More gradual increase in doses as weight increases
- Dose reduction contributing to collective dose
- Dose data from this study lower than diagnostic reference levels, locally and foreign



Results after Optimisation (Image Quality)

- Noise range decreased to **39.3%** from 137% (or 4.36HU to 0.9HU)
- More gradual reduction in noise as weight increases
- The reductions in 0.3% CNR could be improved by further increasing the tube current
- The 0.5% and 1% CNR improved for all GE protocols (less variation between protocols). Only BLACK resulted in a 1.1% reduction for the 1% CNR from Siemens



Results after Optimisation (Image Quality)(2)

- Where the ASIR level was increased, the noise decreased by **6.2% – 7.9%** and the 1% CNR improved by **7.4% – 8.2%**
- This study achieved similar results to Protik et al.'s study where the noise decreases by **26% and 25.2%** and the CNR improves by **41% and 33.9%** when **30% and 50% ASIR** are respectively used
- Overall performance was further improved, with a maximum increase of **55.9%** from the Siemens scanner and ~9% from the same GE scanner, pre-optimisation

Limitations & Problems

- Catphan is not a true representation of paediatric clinical practice.
- A small number of radiologists is needed for subjective assessment of the clinical images.
- Three scanners were available with one of them being replaced in the February – March period, so only two CT scanners were clinically available
  - collecting of data during out of hours (evening)
  - trying to acquire some of the data before the scanner is removed from service
- The clinical paediatric abdomen pelvis protocols are helical, but the CTDI was defined for axial scans.
  - new axial scan protocols were set up and the CTDI was measured under these conditions

Recommended Actions

- Clinical practice
  - First checking new protocols on anthropomorphic phantoms before implementing them in clinical use
  - Change in workflow
  - Lowering the volume of iodinated contrast agent
  - Radiologists and operators need to be informed and aware of paediatric risks
- Future research
  - More than one Catphan size
  - Protocols based on effective diameter
  - Studying other body regions
  - Study based on new Siemens Definition AS+ scanner system (Automatic kV selection)

Summary

- Paediatric radiologist's concerns regarding radiation dose and image quality
- Setup of 32cm CTDI phantom and Catphan 500 together with the tools used to collect the data
- Dose savings up to 50.5% on GE scanner
- 4.36HU maximum noise difference between Siemens and GE reduced to 0.9HU post-optimisation
- Improvement in all GE protocols for 1% CNR except BLACK which only decreased by 1.1% from Siemens
- GE scanner overall performance compared to the Siemens scanner was further improved by 7% post-optimisation
- **The GE scanner offers better image quality and performance at reduced or similar radiation doses than the Siemens scanner**

References

- Alessio, A. M., Kinahan, P. E., Manchanda, V., Ghioni, V., Aldape, L., & Parisi, M. T. (2009). Weight-based, low-dose pediatric whole-body PET/CT protocols. *Journal of nuclear medicine : official publication, Society of Nuclear Medicine*, *50*(10), 1570–7. doi:10.2967/jnumed.109.065912

- Brady, Z., Ramanauskas, F., Cain, T. M., & Johnston, P. N. (2012). Assessment of paediatric CT dose indicators for the purpose of optimisation. *The British journal of radiology*, *85*(1019), 1488–98. doi:10.1259/bjr/28015185

- Dong, F., Davros, W., Pozzuto, J., & Reid, J. (2012). Optimization of kilovoltage and tube current-exposure time product based on abdominal circumference: an oval phantom study for pediatric abdominal CT. *AJR. American journal of roentgenology*, *199*(3), 670–6. doi:10.2214/AJR.10.6153

- Miglioretti, D. L., Johnson, E., Williams, A., Greenlee, R. T., Weinmann, S., Solberg, L. I., … Smith-bindman, R. (2013). The Use of Computed Tomography in Pediatrics and the Associated Radiation Exposure and Estimated Cancer Risk, *95616*(8), 700–707. doi:10.1001/jamapediatrics.2013.311

- Protik, A., Thomas, K., Babyn, P., & Ford, N. L. (2012). Phantom study of the impact of adaptive statistical iterative reconstruction (ASiR ™) on image quality for paediatric computed tomography, *2012*(December), 793–806.

- Siegel, M. J., Hildebolt, C., & Bradley, D. (2013). Effects of Automated Kilovoltage Selection Technology on, *268*(2). doi:10.1148/radiol.13122438/-/DC1

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