Comparative CTDI measurements in Perspex and water equivalent dosimetry phantoms

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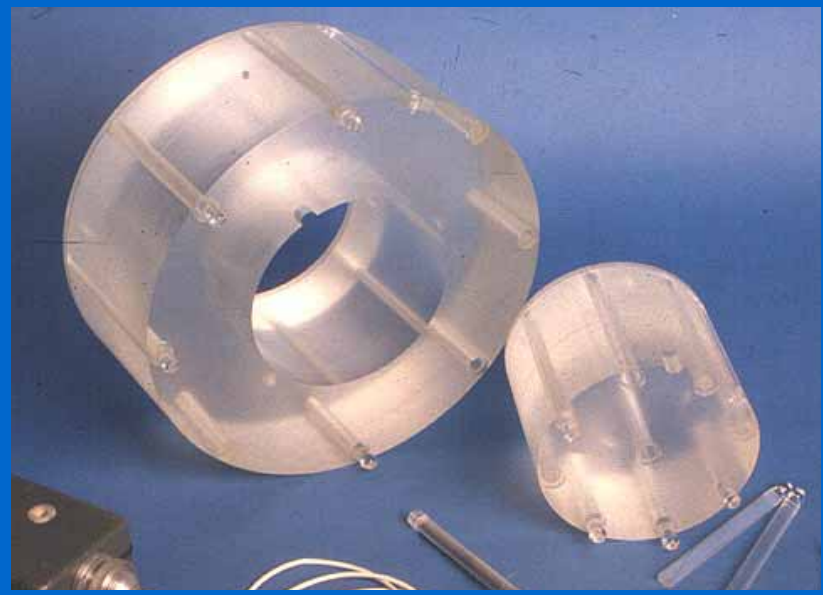
Aim

To determine if PMMA (Perspex) is a suitable material for CTDI measurements

Why Perspex?

PROS

- readily available
- reproducible composition
- homogenous
- easy to machine



CONS

- not tissue equivalent

Water equivalent phantoms

- Polyurethane resin with additives for water equivalence
- Same basic design & dimensions as Perspex phantoms
- Manufactured by QRM*
- Cost ~£1500 for set

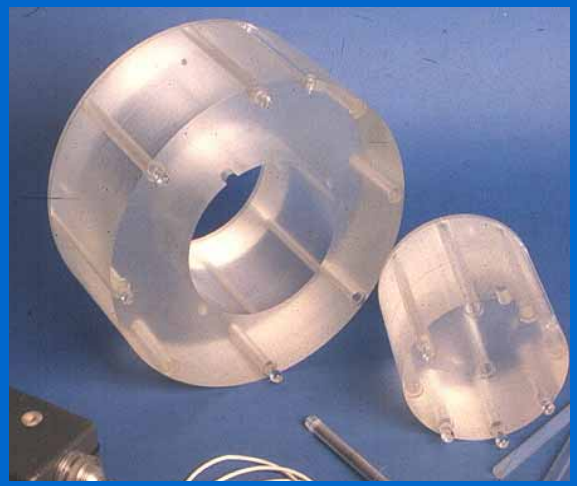
*Quality Assurance in Radiology and Medicine, GmbH, Dorfstrasse 4, 91096 Möhrendorf, Germany
Marketed by Scanditronix

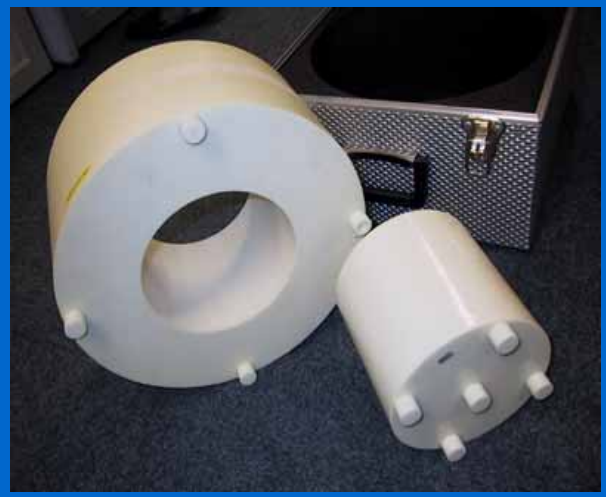
Properties of phantom materials

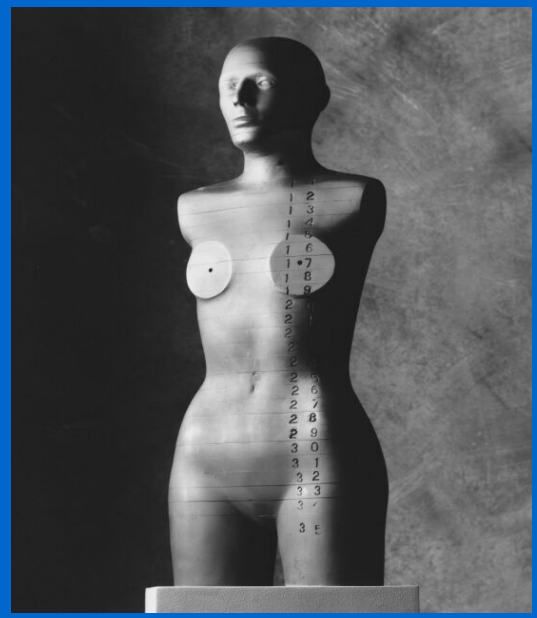
Material	Effective atomic number Z_{eff}	Density $g.cm^{-3}$	Mass attenuation coefficient* cm^2g^{-1}	Linear attenuation coefficient* cm^{-1}
Water	7.42	1.0	0.1945	0.1945
Perspex	6.48	1.19	0.1836	0.2184
Water-equivalent resin	7.5	1.0		

* at 70 keV

Patient equivalent?







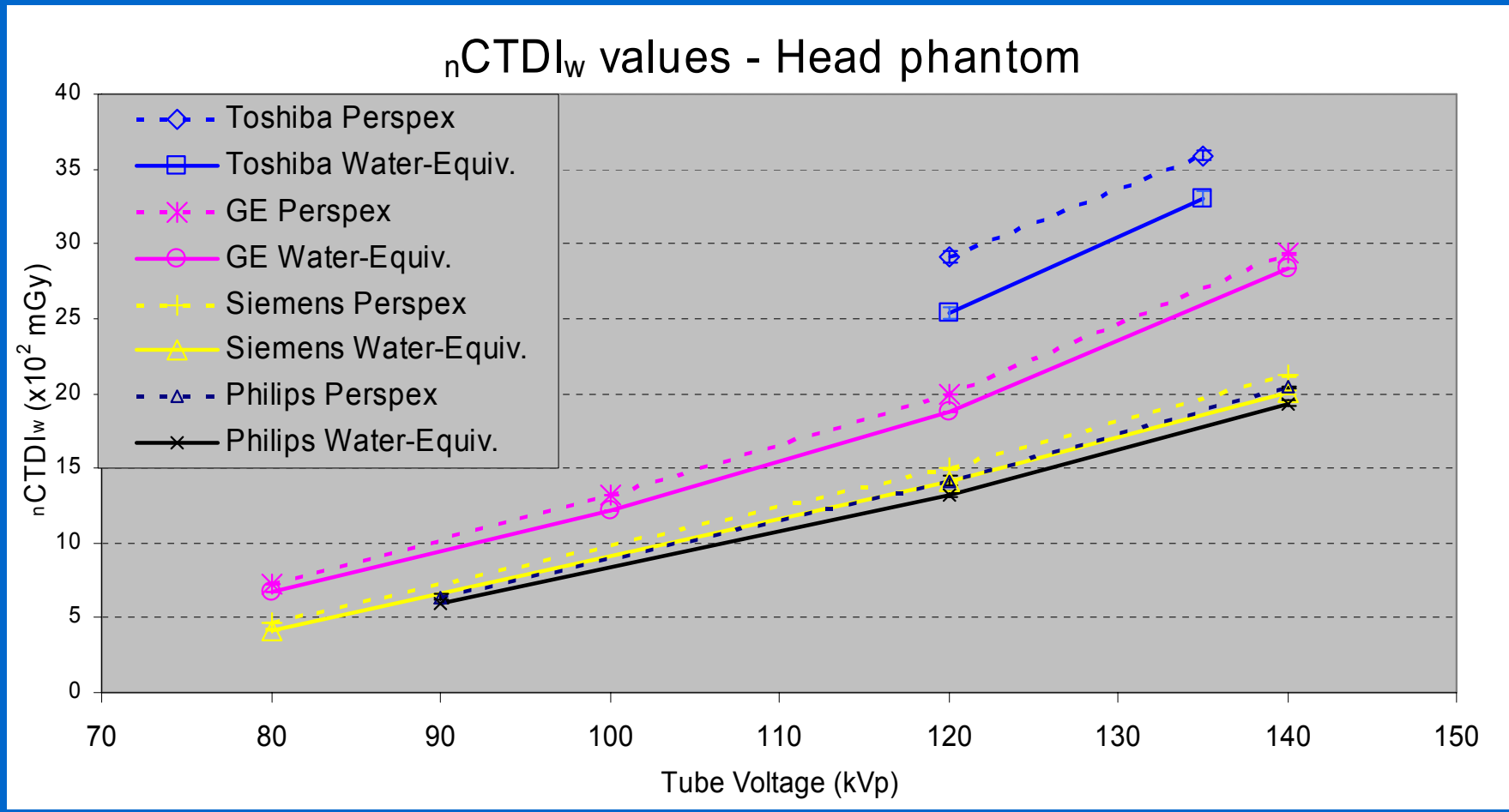
Method

- CTDI measurements at centre and periphery of head and body phantoms
- 10 cm pencil ionisation chamber
- 10 mm (or nearest available) collimation

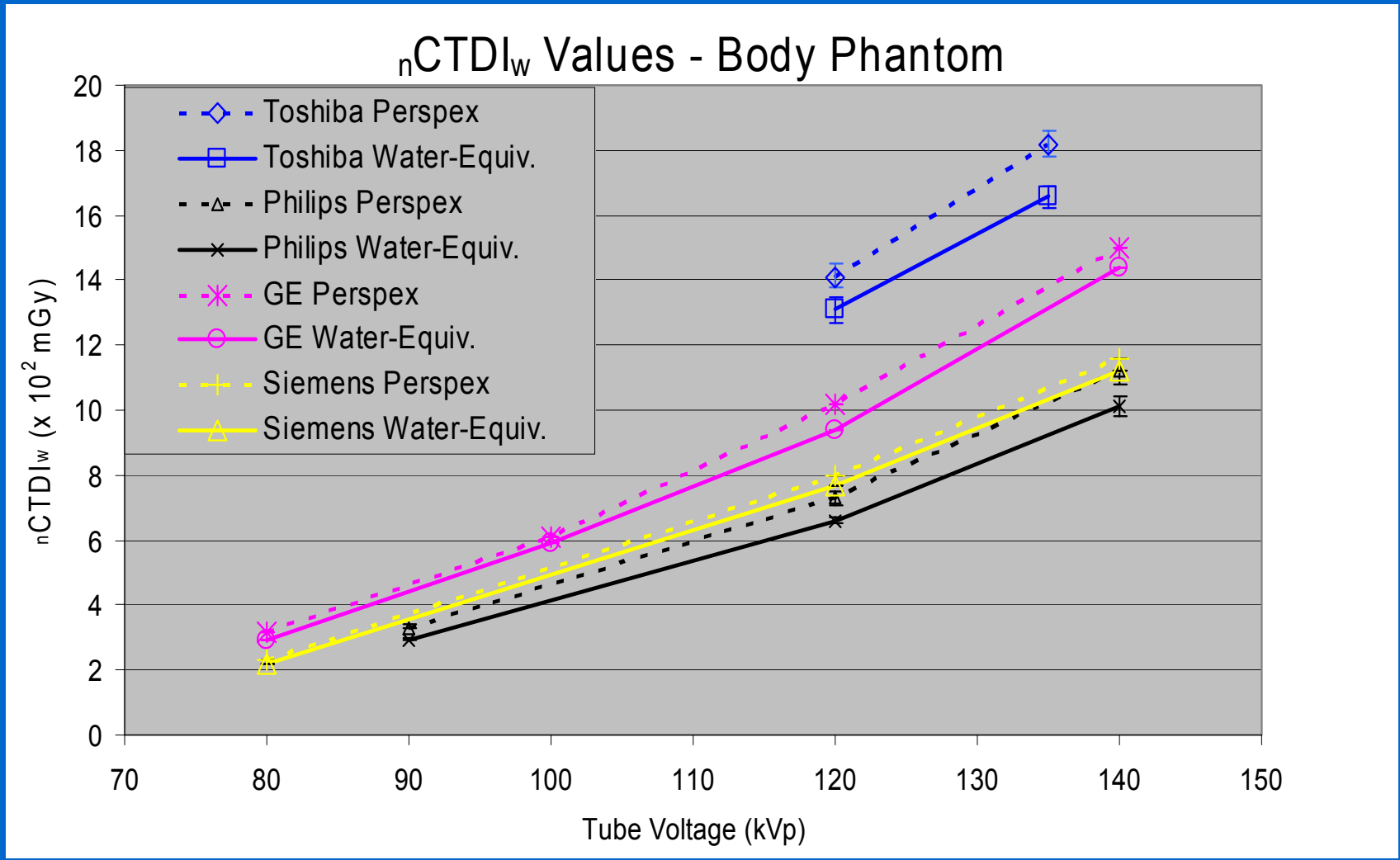
Measurements made on:

Siemens Somatom Plus 4	1-slice
Toshiba Asteion Dual	2-slice
GE LightSpeed Ultra	8-slice
Philips MX8000 IDT	16-slice

Head phantom results



Body phantom results



Why higher doses in WE resin?

- WE resin has higher linear attenuation coefficient i.e. more interactions per cm
- Faster decrease of dose with depth, but more scattered radiation
- Higher ratio of scattered radiation has been verified by Monte Carlo simulations[1]

1. Evaluation and Comparison of Water-equivalent CTDI Dosimetry Phantoms, J Erb, M Schmidt, B Schmidt, WA Kalender, QRM, Internal publication

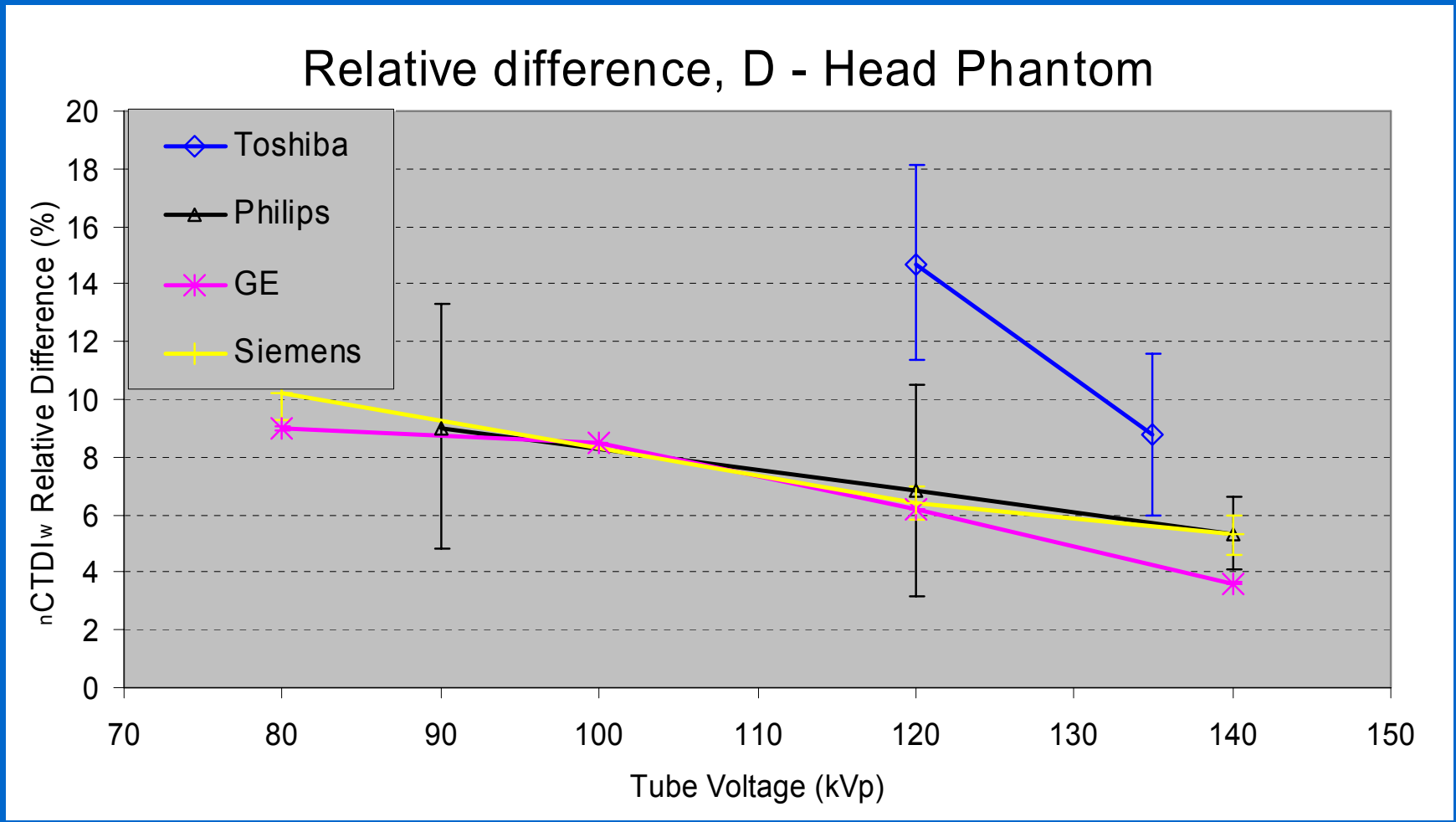
What we really want to know

- Does the difference in CTDI remain constant with:
  - kV
  - scanner model

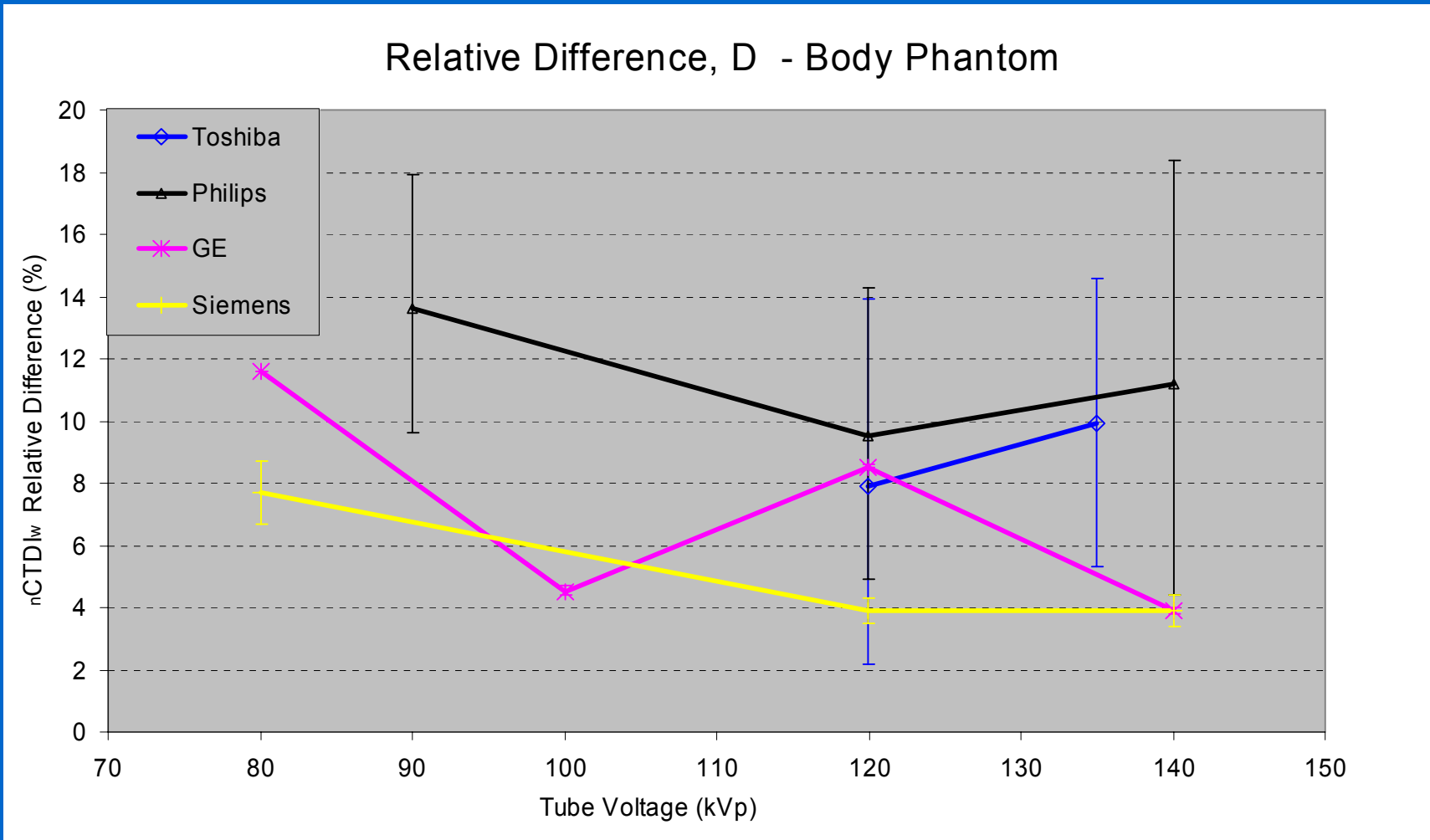
Relative difference:

$$D = \frac{CTDI_{Px} - CTDI_{WE}}{CTDI_{WE}}$$

Head phantom results

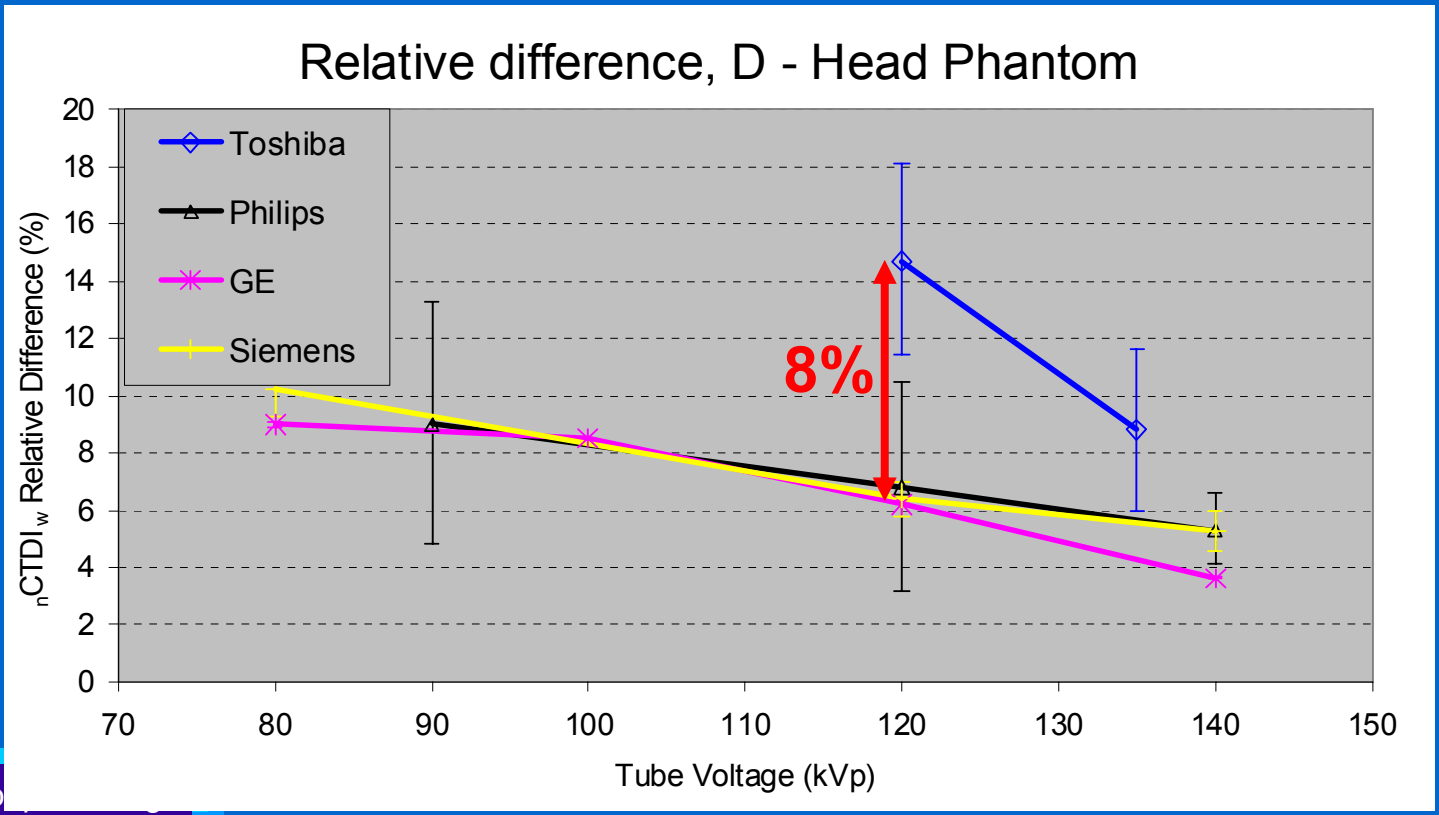


Body phantom results



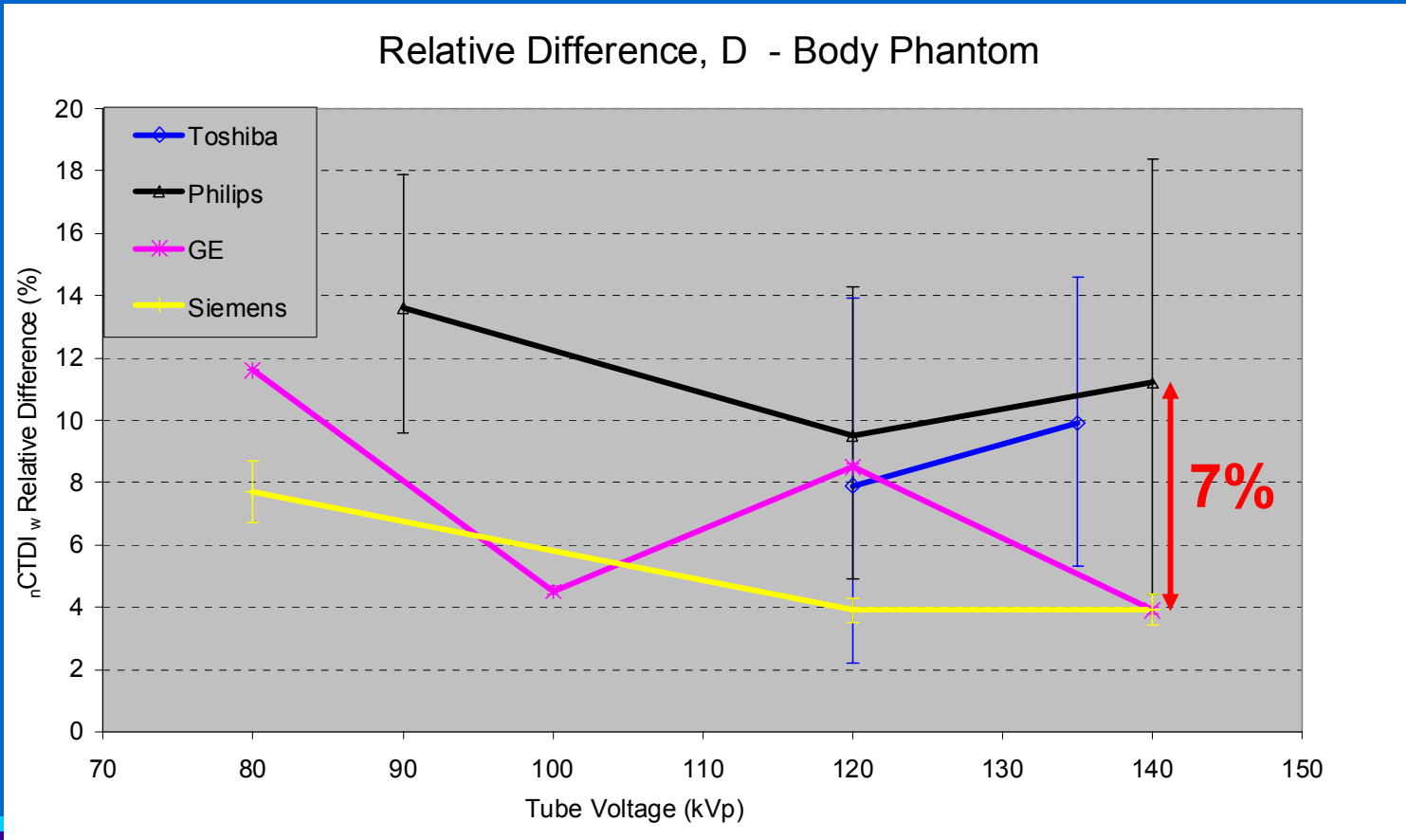
What is the range in D?

- Head
  - 5% between 80 kV and 140 kV for GE, Philips & Siemens
  - 8% at 120 kV between Toshiba & others



What is the range in D?

- Body
  - variable, but never >10%



Comments

- Large variations in CTDI on some scanners due to fluctuations in readings
- Mainly due to variable tube start position & slight overscan
- To obtain definitive correction factors, repeat with higher number of readings to improve statistics

Conclusions

Is it OK to use Perspex CTDI phantoms?

- Depends on the purpose of measurement
- Fine for acceptance and QA
- Probably OK for DRLs
- May not be satisfactory for precise comparisons of scanner models