# Use of lead shielding for foetal dose reduction in CTPA

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# A clinical issue?

- CTPA scanning on the increase
- Pregnant patients often scanned
- Should foetus be protected during CTPA?
- Literature is unclear
- Local Departments do different things

# Different use of lead shielding

- Surveyed seven hospitals
  - 1 didn’t do CTPA scans – scanner too slow
  - 1 didn’t scan pregnant patients
  - 1 didn’t use Pb shielding – thought it would increase foetal dose
  - 1 used 0.35mm Pb front and back – for patient reassurance only
  - 3 used 0.7mm Pb front and back

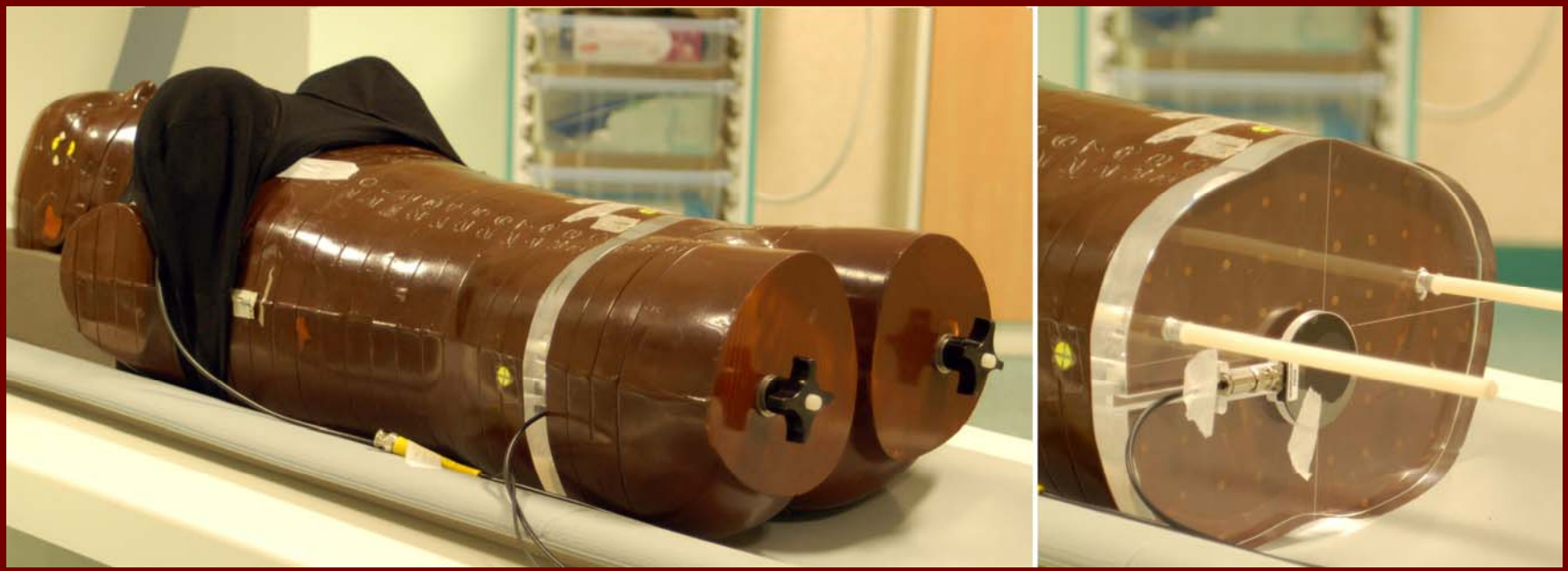
# Methods

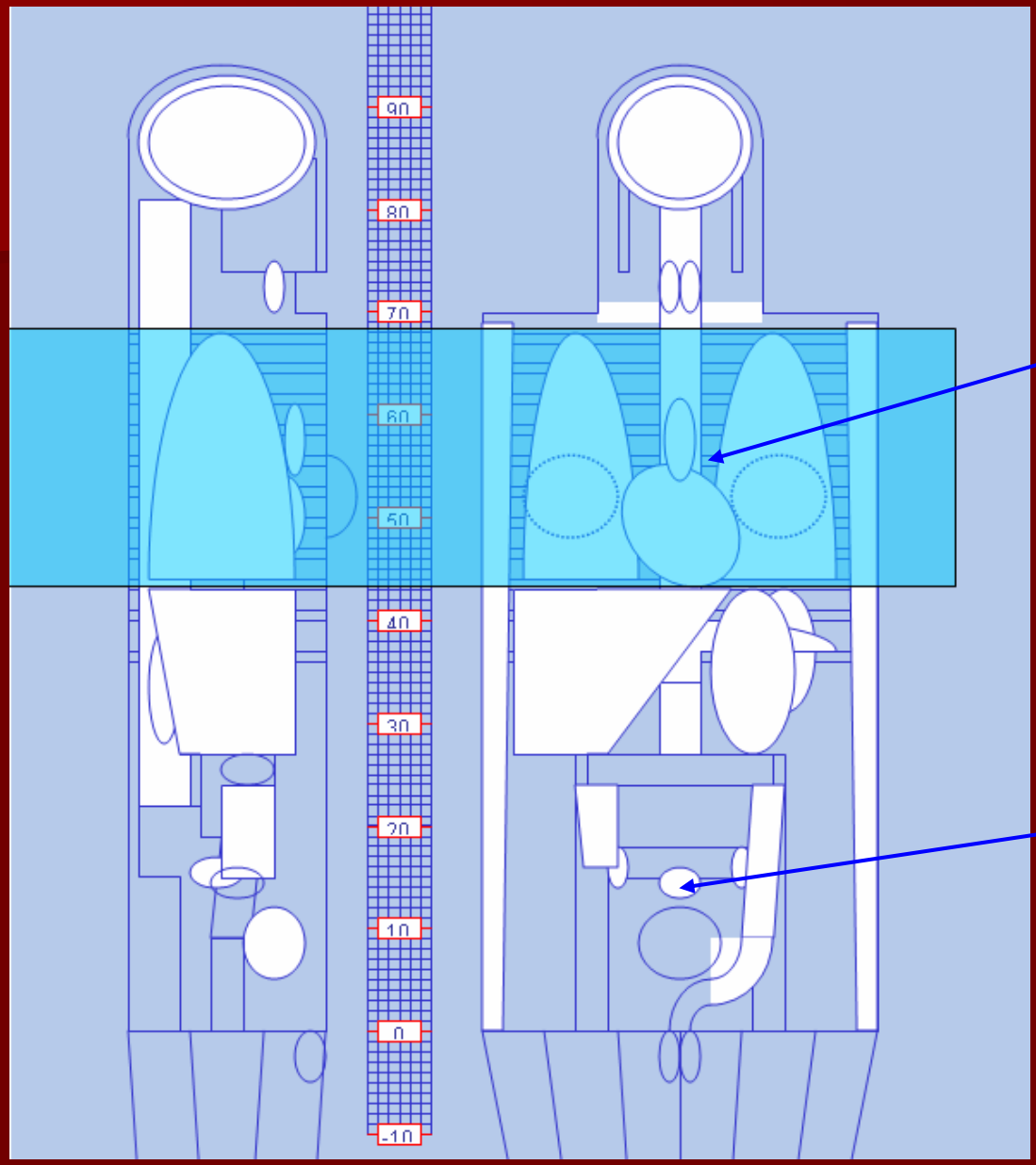
- Measure uterus (foetal) dose with ion chamber in RANDO phantom
- Identify slice corresponding to top of uterus
- Determine uterus position within slice from anatomical images
- Manufacture replacement slice from Perspex
- Attach to phantom & insert ion chamber

# Methods

- Attach breast mimics (double bagged water balloons!)
- Measure breast dose with ion chamber (double bagged)
- Use Pb coats from CT Department as abdominal shields

# Phantom set-up



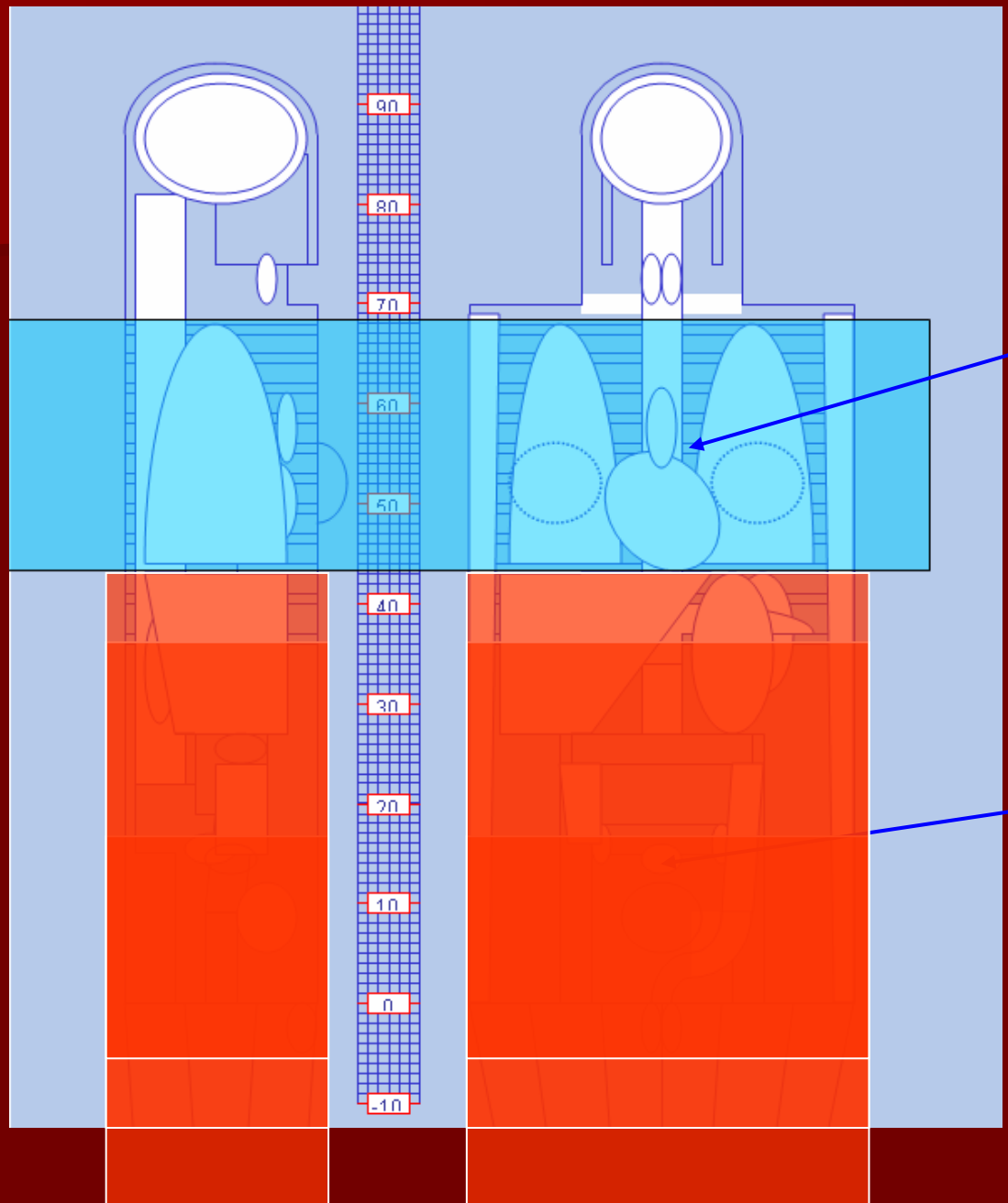

CTPA scan volume
Uterus

# Standard protocol

- Siemens Sensation 16 scanner
  - 100kVp
  - 140 eff mAs
  - 16x0.75mm collimation
  - 0.5s rot time
  - 10mm feed/rot (pitch = 0.83)
- CARE Dose switched off
- 0.7mm Pb shielding used

# Range of parameters

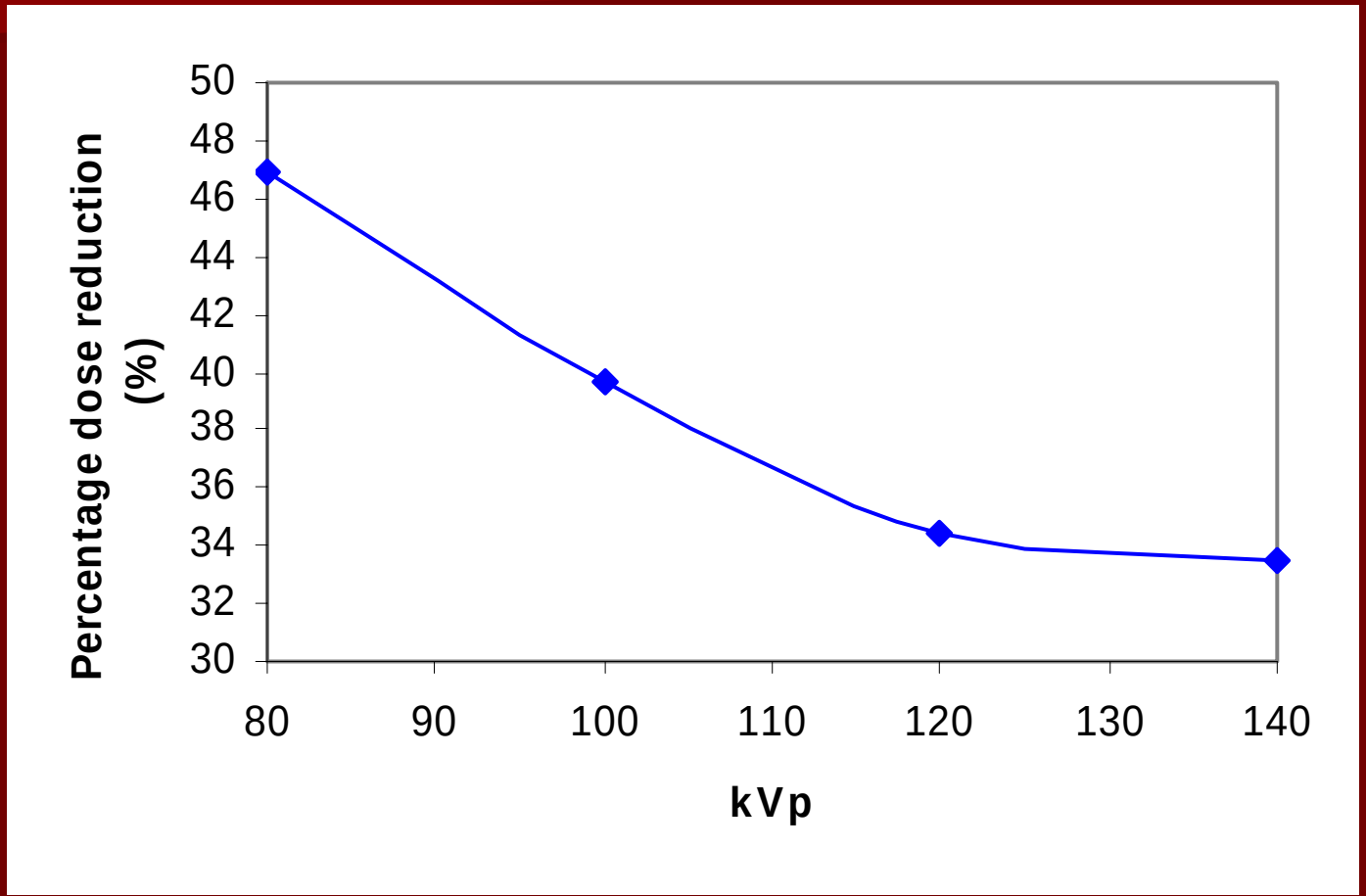
| Parameter | Range tested |
|---|---|
| kV | 80 – 140 |
| Effective mAs | 25 – 200 |
| Rotation time (s) | 0.42 – 0.75 |
| Pitch | 0.5 – 1.5 |
| Collimation (mm) | 16x0.75 – 16x1.5 |
| Pb thickness (mm) | 0.25 – 2.2 |
| Pb position | Uterus – bottom of scan volume |
| Scan length (cm) | 30 – 52 (std - ~uterus) |
| Scan position | |


CTPA scan volume
Uterus

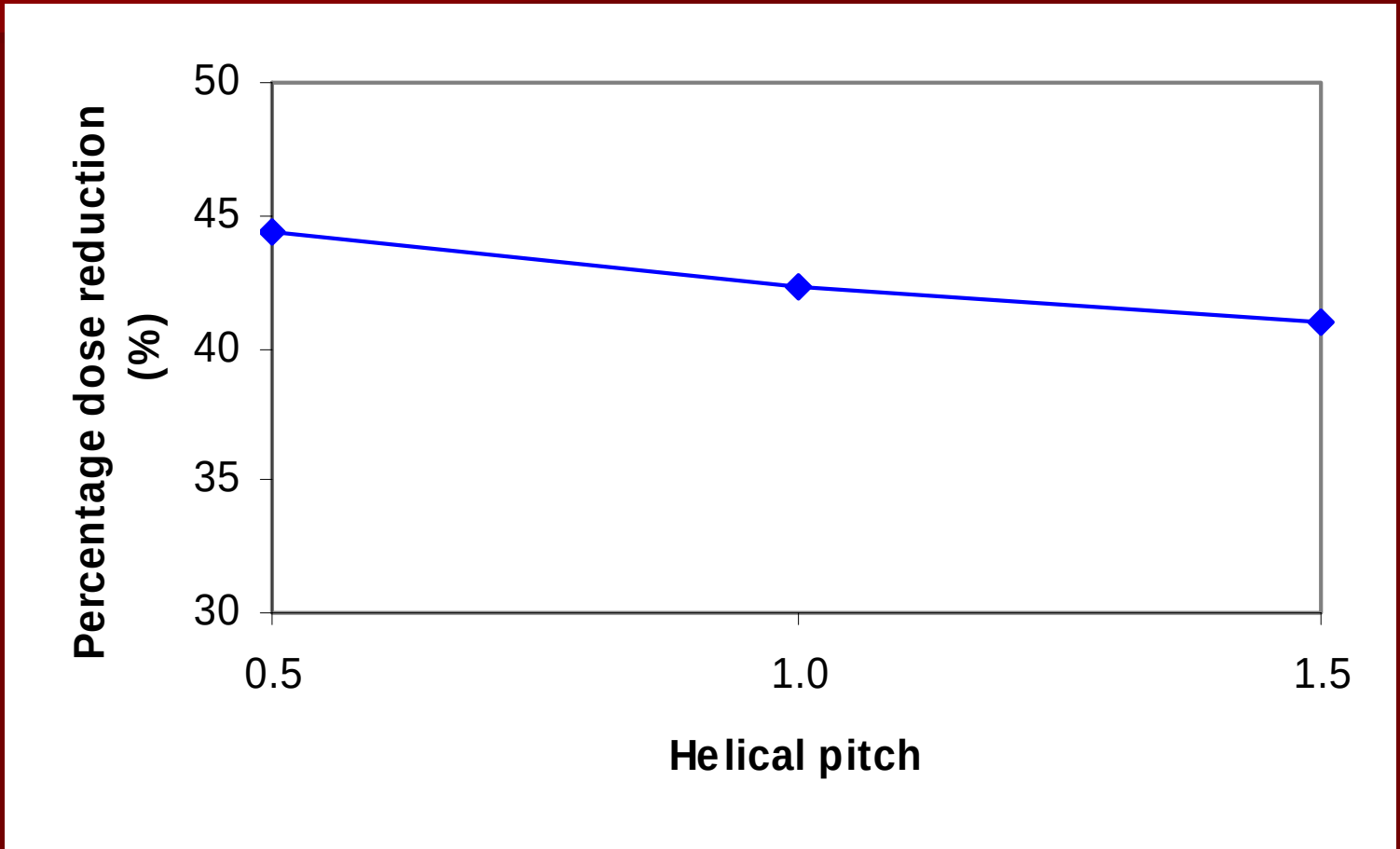
# Results

For standard protocol unless otherwise stated

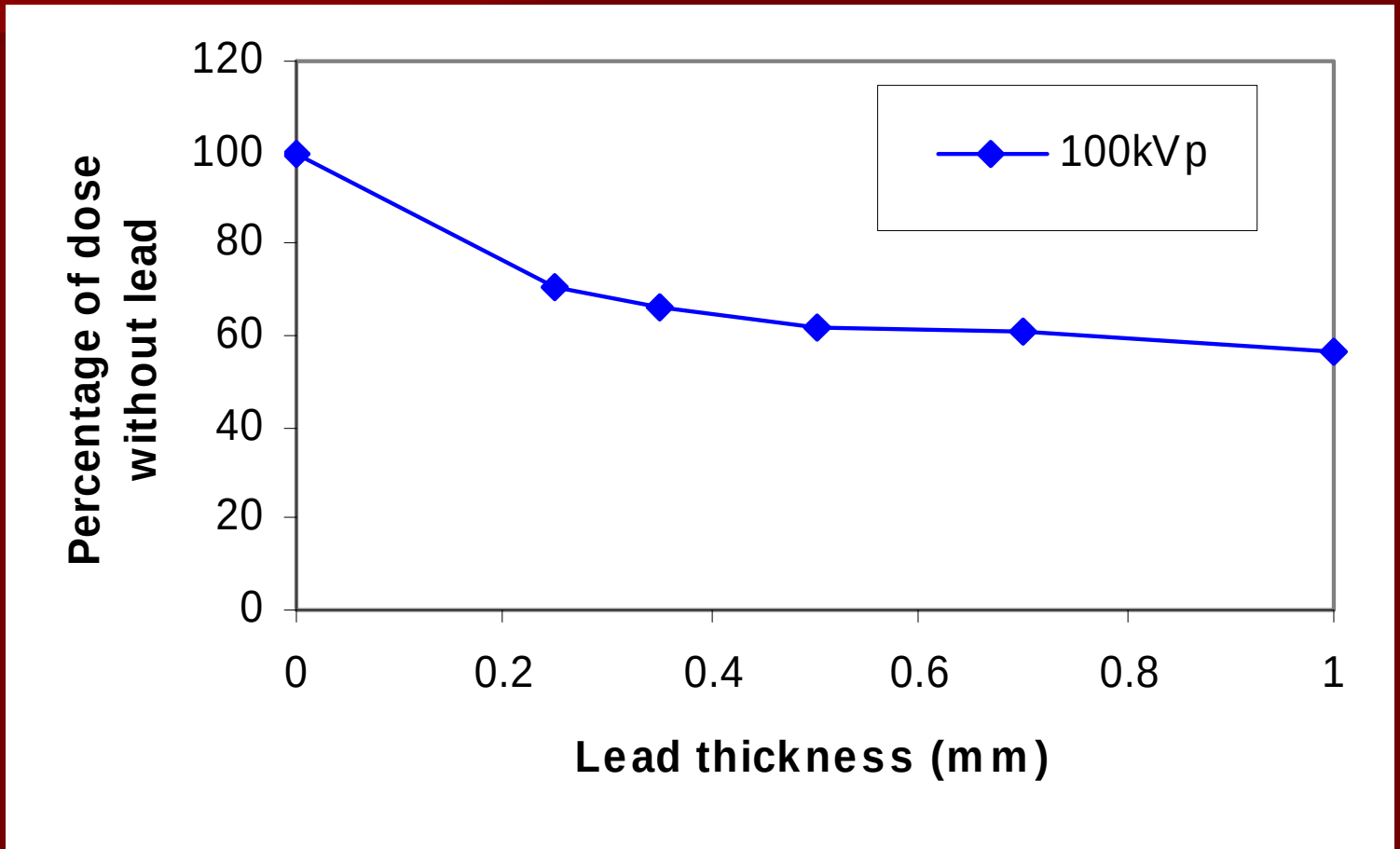
# Effect of kV


Percentage dose reduction (%)
50
48
46
44
42
40
38
36
34
32
30
80
90
100
110
120
130
140
kVp

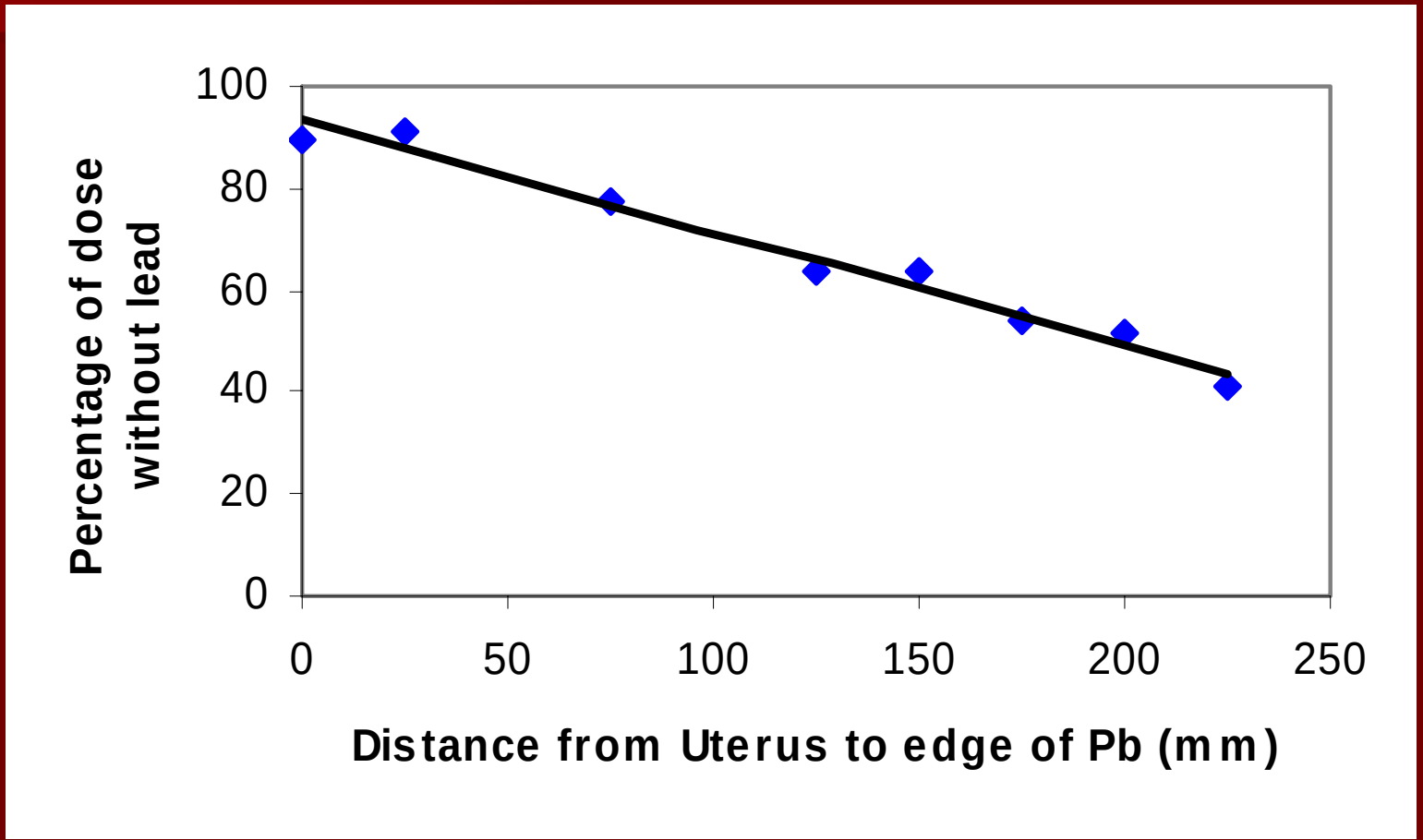
# Effect of pitch



# Effect of lead thickness



# Effect of position of lead



# Comparison of % dose reduction between scanners

| Pb Thickness (mm) | GE 8 slice | Siemens 16 slice | Average |
|---|---|---|---|
| 0.35 | 23.9 | 30.8 | 27.3 |
| 0.7 | 28.3 | 34.6 | 31.5 |

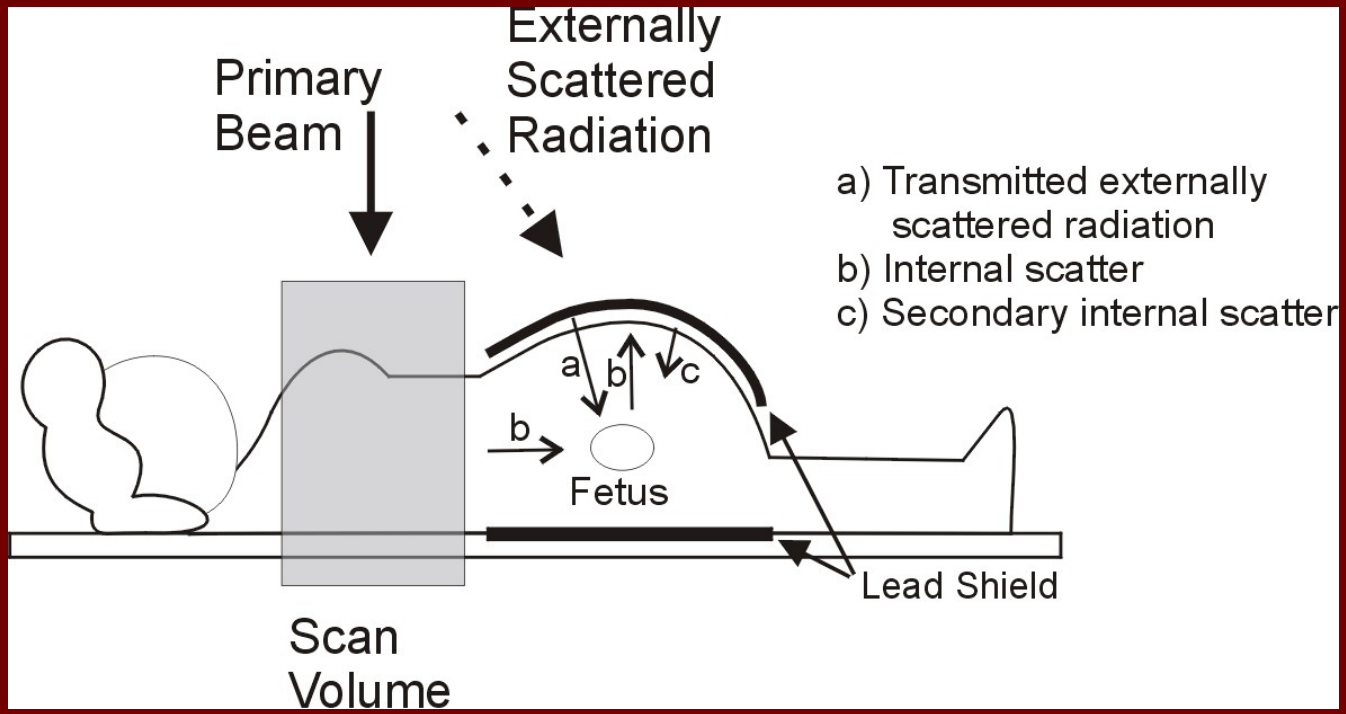
- At 140kVp
- Good agreement between different manufacturers
- Better agreement found at lower kVp settings

# Protocol for use of lead shields

- Use 0.7mm Pb apron below and on top of patient (front & back of 0.35mm apron)
- Cover up to inferior edge of scan volume
- If patient cannot tolerate 0.7mm Pb on the abdomen add more Pb behind the patient and a thinner amount on abdomen

- Applies to all CT Thorax

# Sources of foetal dose



# The model

$$\text{Foetal Dose} = C + [I_o e^{-\mu_{Pb} T_{Pb}} \times e^{-\mu_t T_t}] + [I_i \times (1-(e^{-\mu_{Pb} T_{Pb}})) \times e^{-\mu_t T_t}]$$

C = Internal scatter (constant)

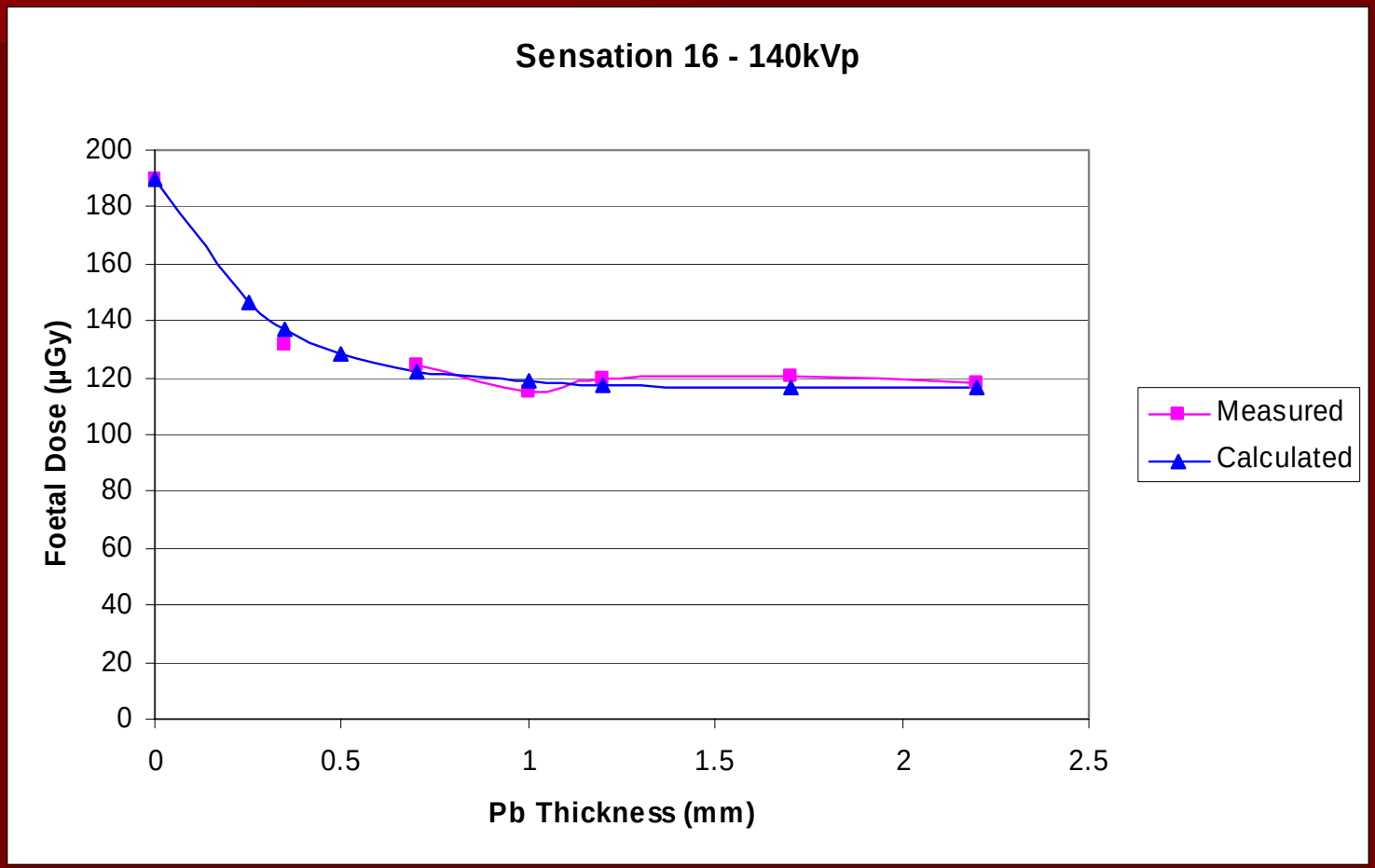
$I_o$ = intensity incident upon phantom surface

$I_i$ = intensity incident upon inside of Pb shield

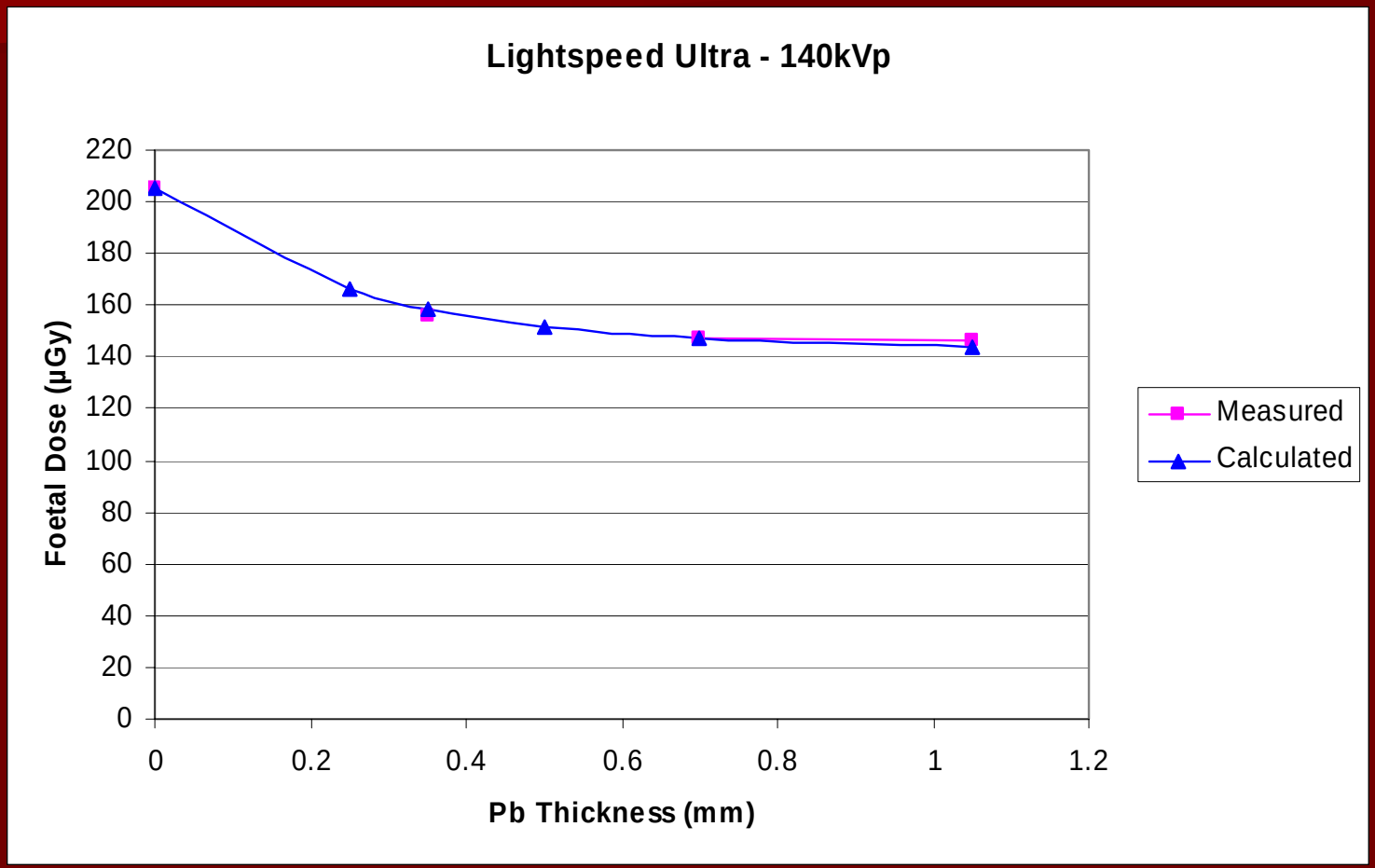
μ = linear attenuation coefficient (Pb = lead, t = tissue)

T = thickness (Pb = lead, t = tissue)

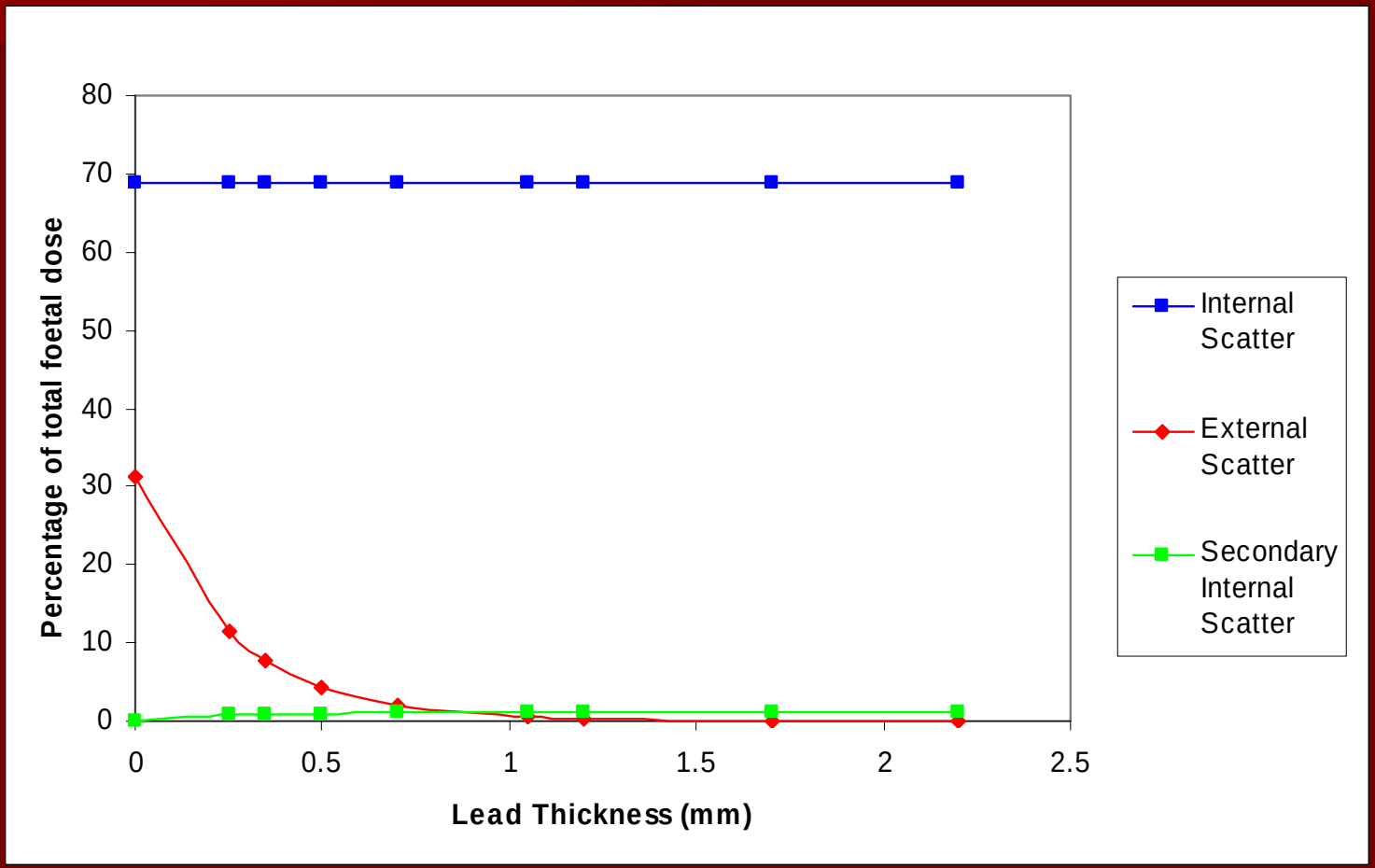
# Model vs Measured data



# Model vs Measured data



# Relative contributions



# The dreaded stats...

- Tests performed for full model & simplified model (no secondary internal scatter)
- Spearman Rank Correlation
  - RS = 0.98 for full model
  - RS = 0.98 for simple model

# Problems with coverage

# Problems

- Lead coats can leave unshielded gaps around the patient
- Coats get damaged
- Because each apron has a front and back they can be unwieldy
- Aprons cover further down the body than is needed – unnecessary weight

# Solution?

- Design a custom built shield
- 1mm Pb shield laid on the couch
- 0.35-0.5mm Pb attaches over patient
- Shaped to cope with small and large “bumps”
- Easier for Radiographers to move?
- Prototype being manufactured
- Clinical trial envisaged

# Custom shield v1.0

# Acknowledgments


- CT Department at St James' University Hospital
- Superintendent Radiographer: Penny Dutton
- Consultant Radiologist: Dr Bobby Bhartia