DEXA for carcase measurement

Dr Graham Gardner

Outline

- Existing Xray Infrastructure
- DEXA background
- Development of a new DEXA
- Calibration against CT composition

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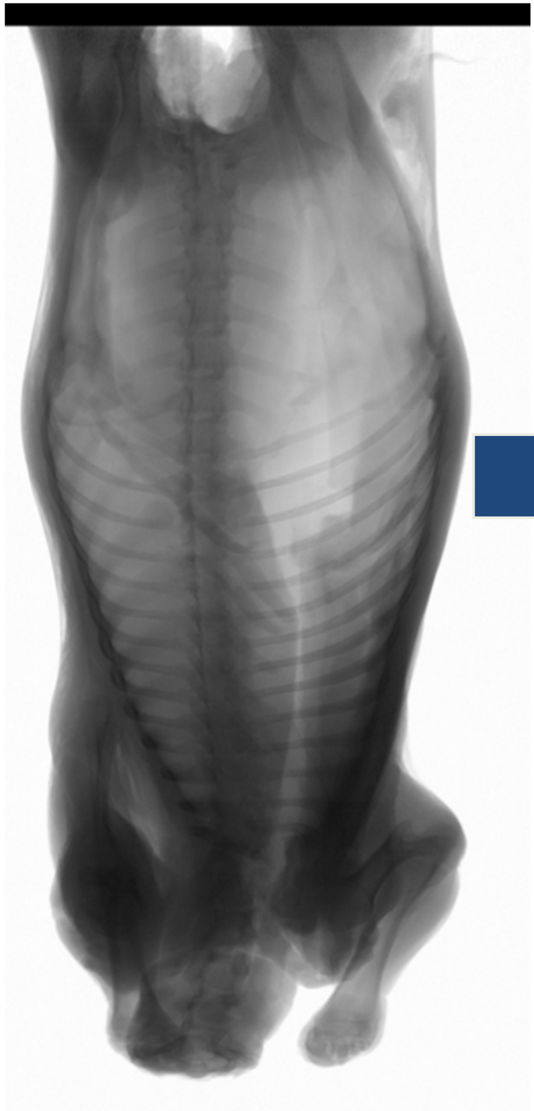
X-Ray for driving robots

Scott Technology



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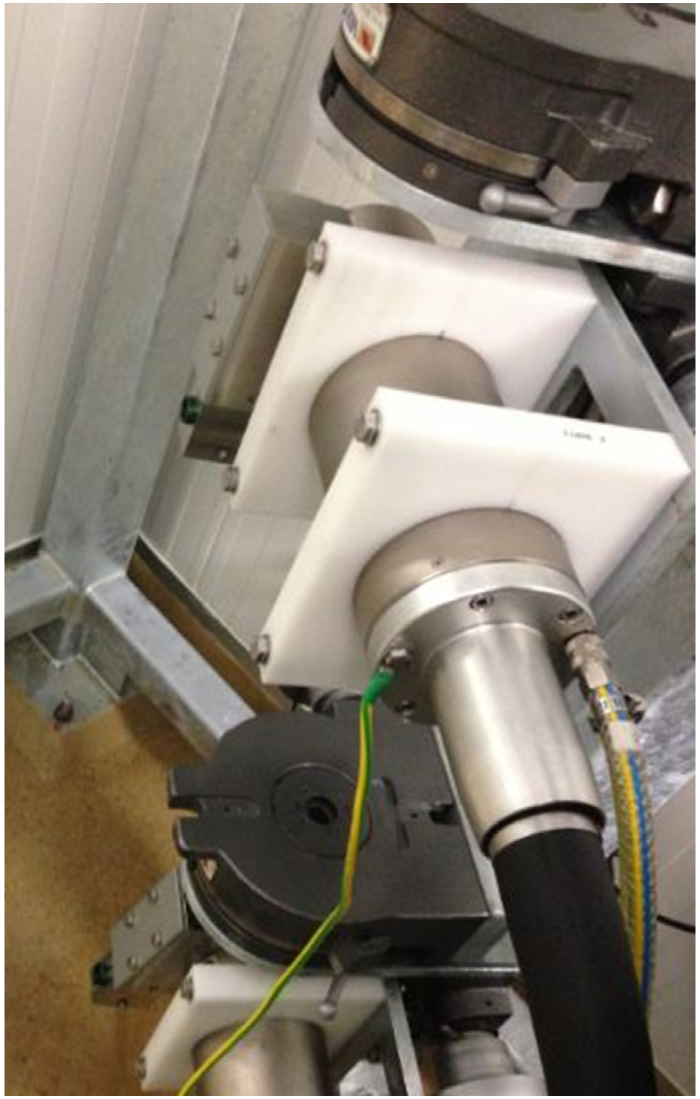
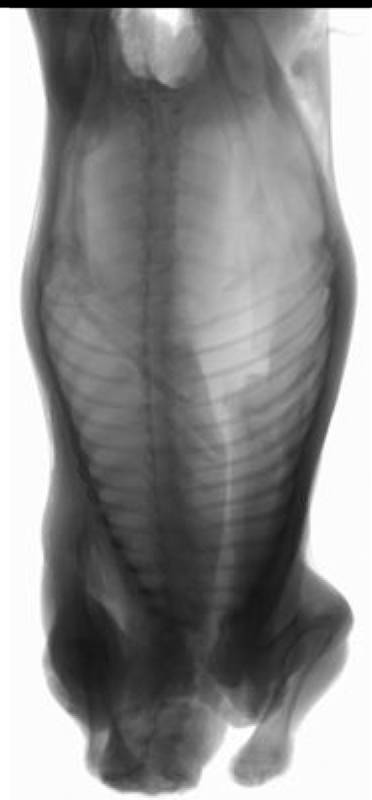
Adapt existing 2D Xray hardware



Dual Energy Images

Low Energy Image



High Energy Image

R value = $\ln(I/I_0)_{LowEnergy}/\ln(I/I_0)_{HighEnergy}$

Mass attenuation coefficients at 40 keV and 70 keV and R values

	Mass attenuation coefficient		R-Value
Element	40keV	70keV	R
Hydrogen	0.3458	0.3175	1.0891
Carbon	0.2047	0.1678	1.2199
Nitrogen	0.2246	0.1722	1.3043
Oxygen	0.2533	0.1788	1.4167
Sodium	0.3851	0.2022	1.9045
Magnesium	0.4704	0.2244	2.0963
Phosphorus	0.7784	0.2839	2.7418
Sulfur	0.9507	0.3258	2.918
Chlorine	1.1	0.3491	3.151
Potassium	1.484	0.4297	3.4536
Calcium	1.792	0.5059	3.5422

11 main elements in animals

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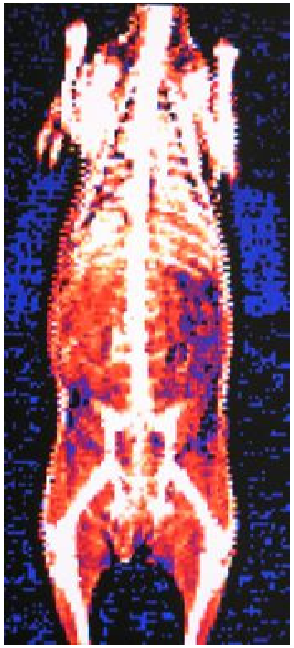
DEXA predicts composition



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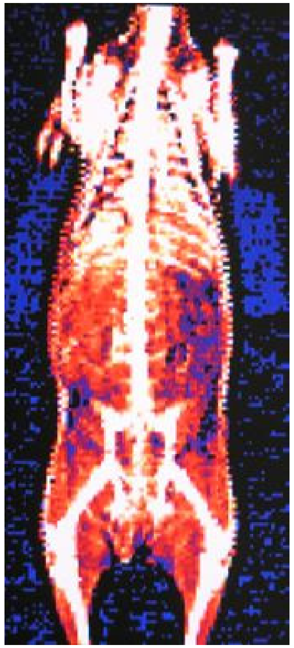
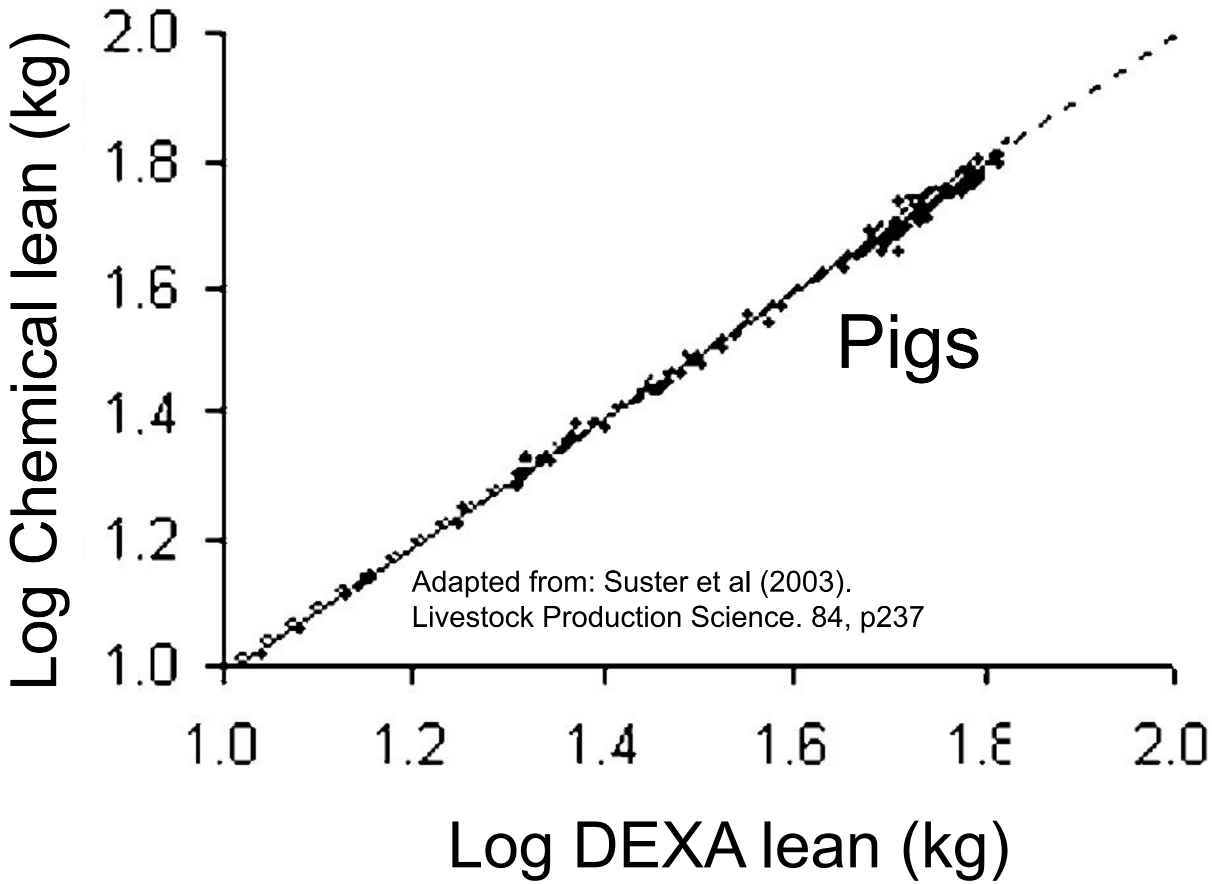
DEXA predicts composition





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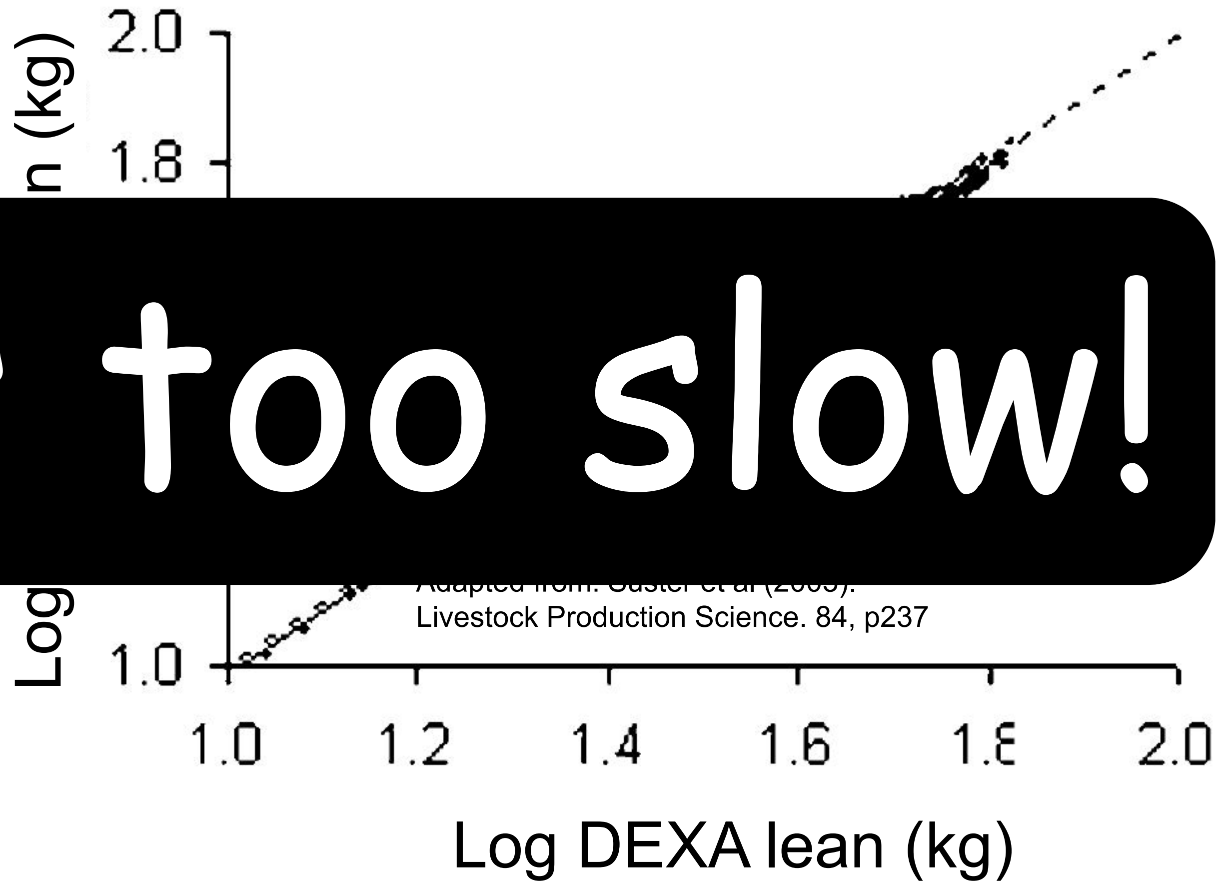
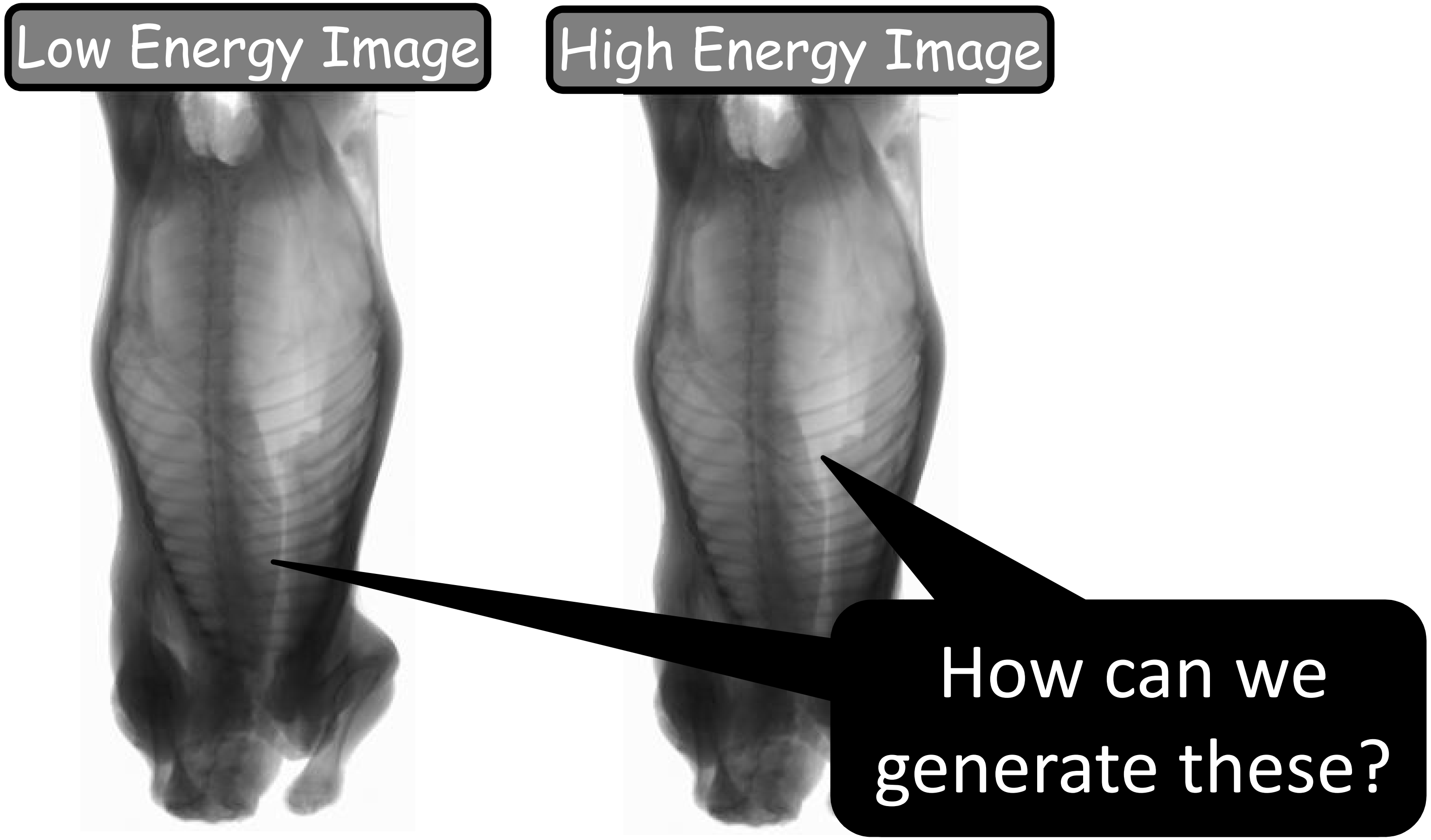
DEXA predicts composition



It's too slow!

Dual Energy Images



R value = $\ln(I/I_0)_{LowEnergy} / \ln(I/I_0)_{HighEnergy}$

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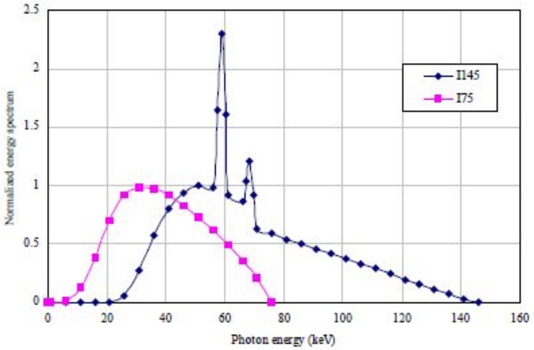
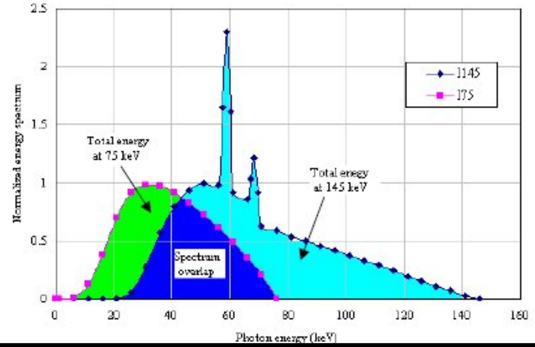
Dual Energy Generation

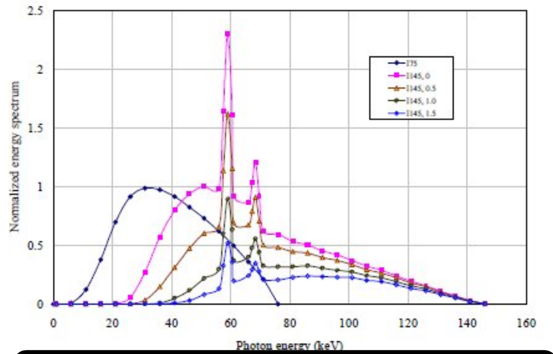
- Pulse the tube - in this case at 75keV & 145keV



Dual Spectra



Spectra over-lap degrades contrast



Filter with copper to optimise

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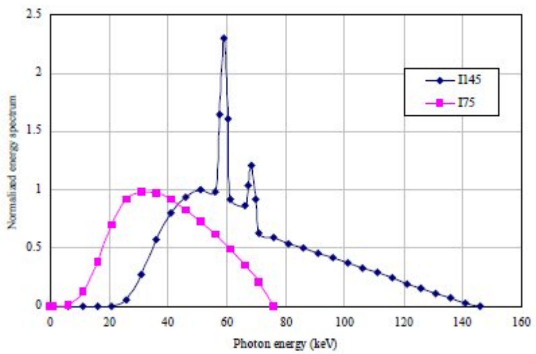
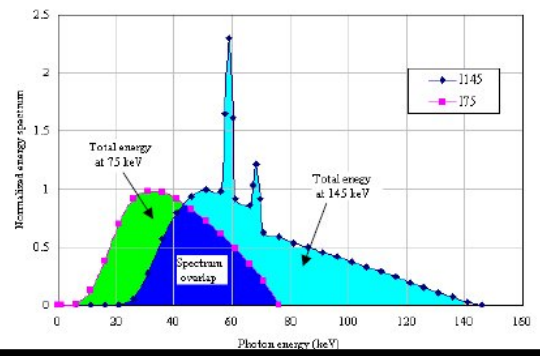
Dual Energy Generation

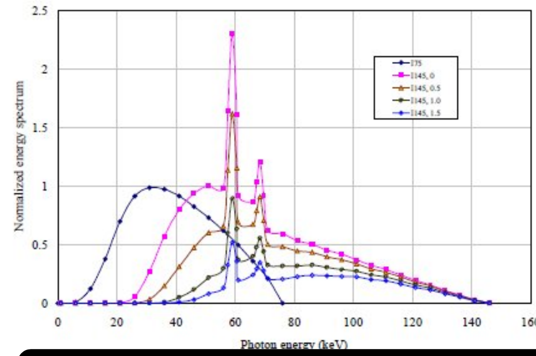
- Pulse the tube - in this case at 75keV & 145keV



Dual Spectra

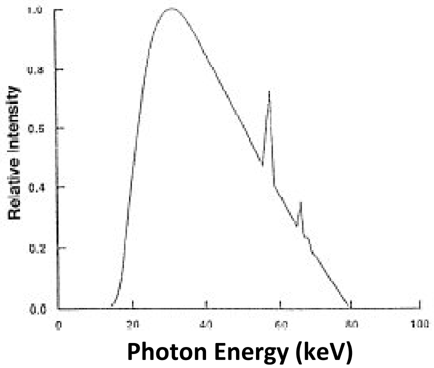


Spectra over-lap degrades contrast

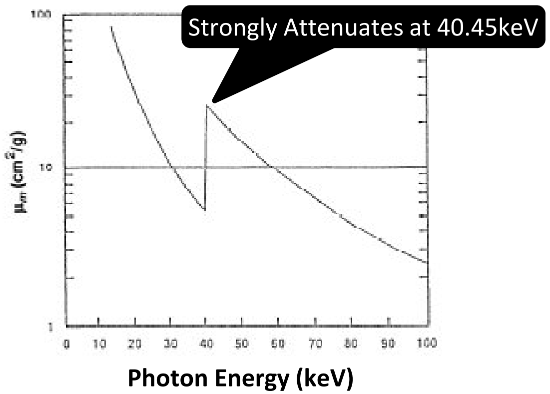


Filter with copper to optimise

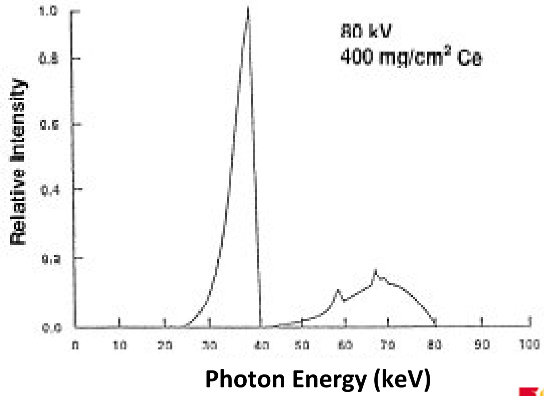
- K-edge filter - Cerium (Ce) or Samarium (Sm)



Single Spectra



Filter with Cerium



Resulting Spectra

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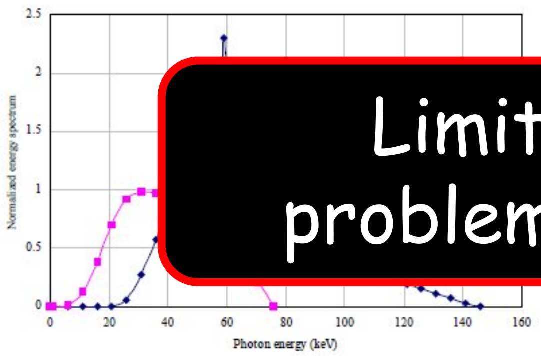
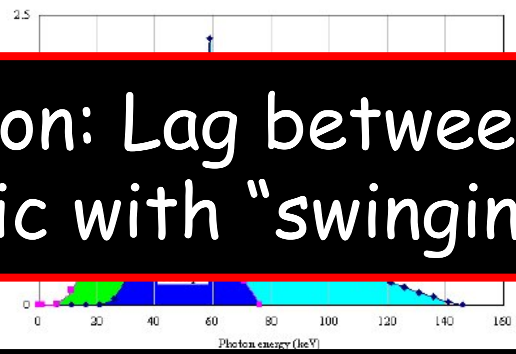
Dual Energy Generation

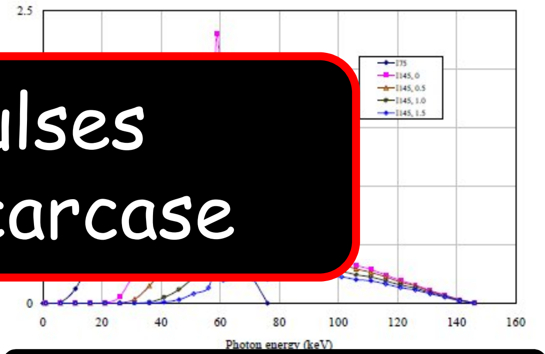
- Pulse the tube - in this case at 75keV & 145keV



Dual Spectra



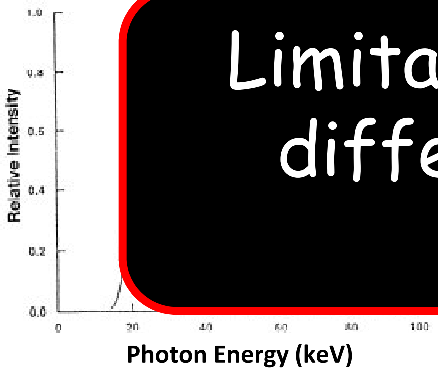
Spectra over-lap degrades contrast



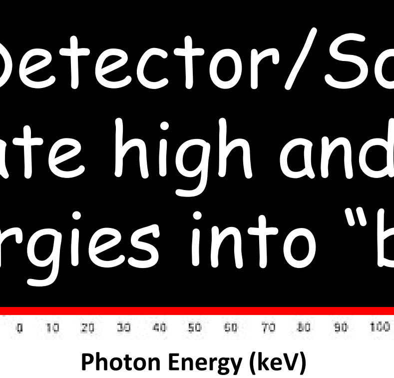
Filter with copper to optimise

Limitation: Lag between pulses problematic with "swinging" carcase

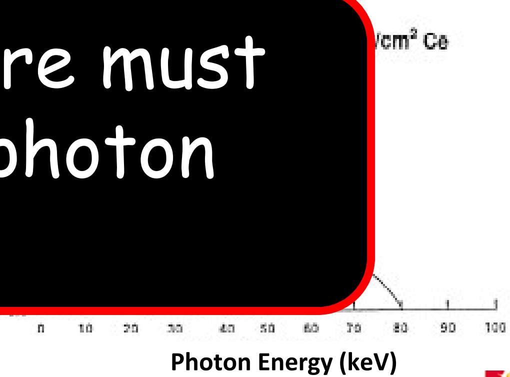
- K-edge filter - Cerium (Ce) or Samarium (Sm)



Single Spectra



Filter with Cerium



Resulting Spectra

Limitation: Detector/Software must differentiate high and low photon energies into "bins"

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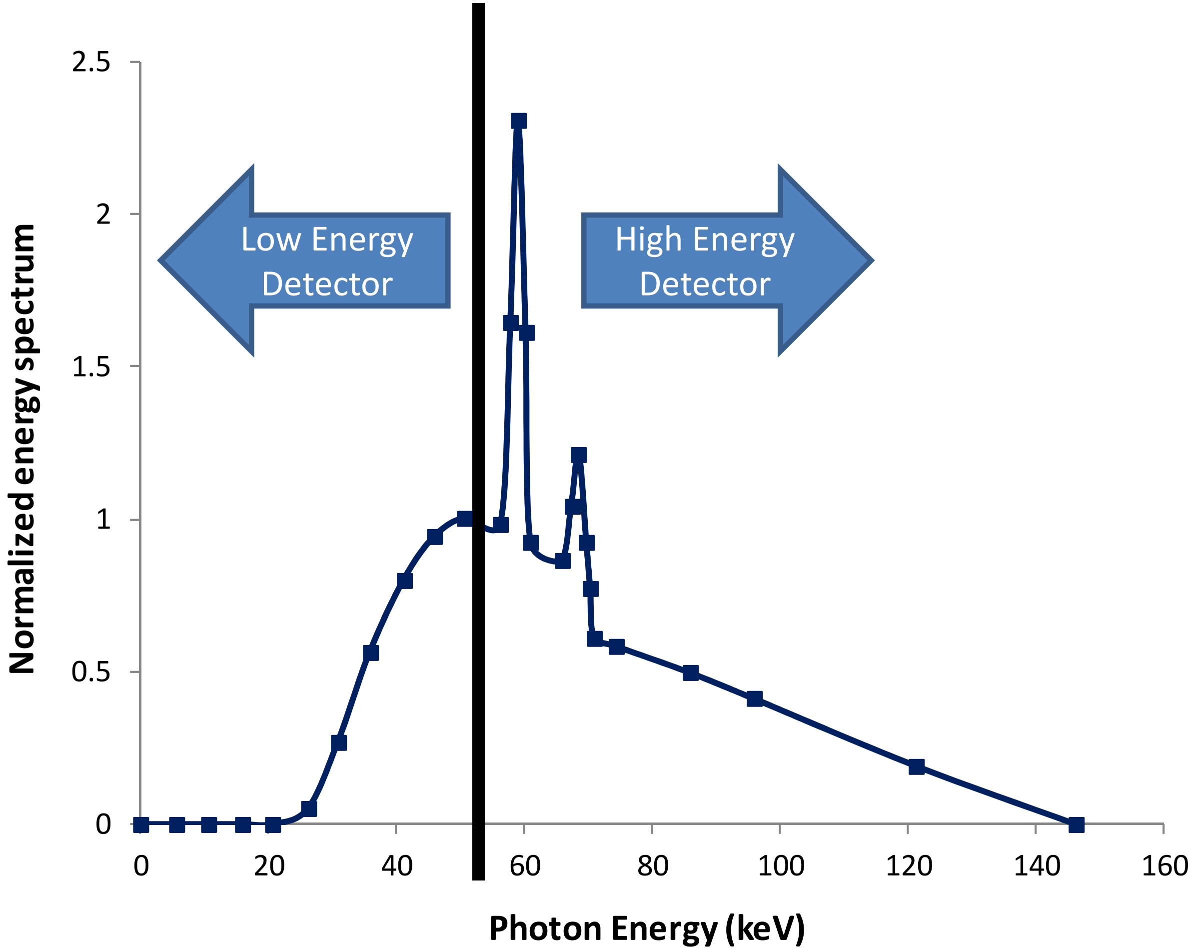
Dual Energy Generation

- What about detectors?

-Can we use detectors sensitive to different parts of the photon spectra



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Dual Energy Generation

• What about detectors?

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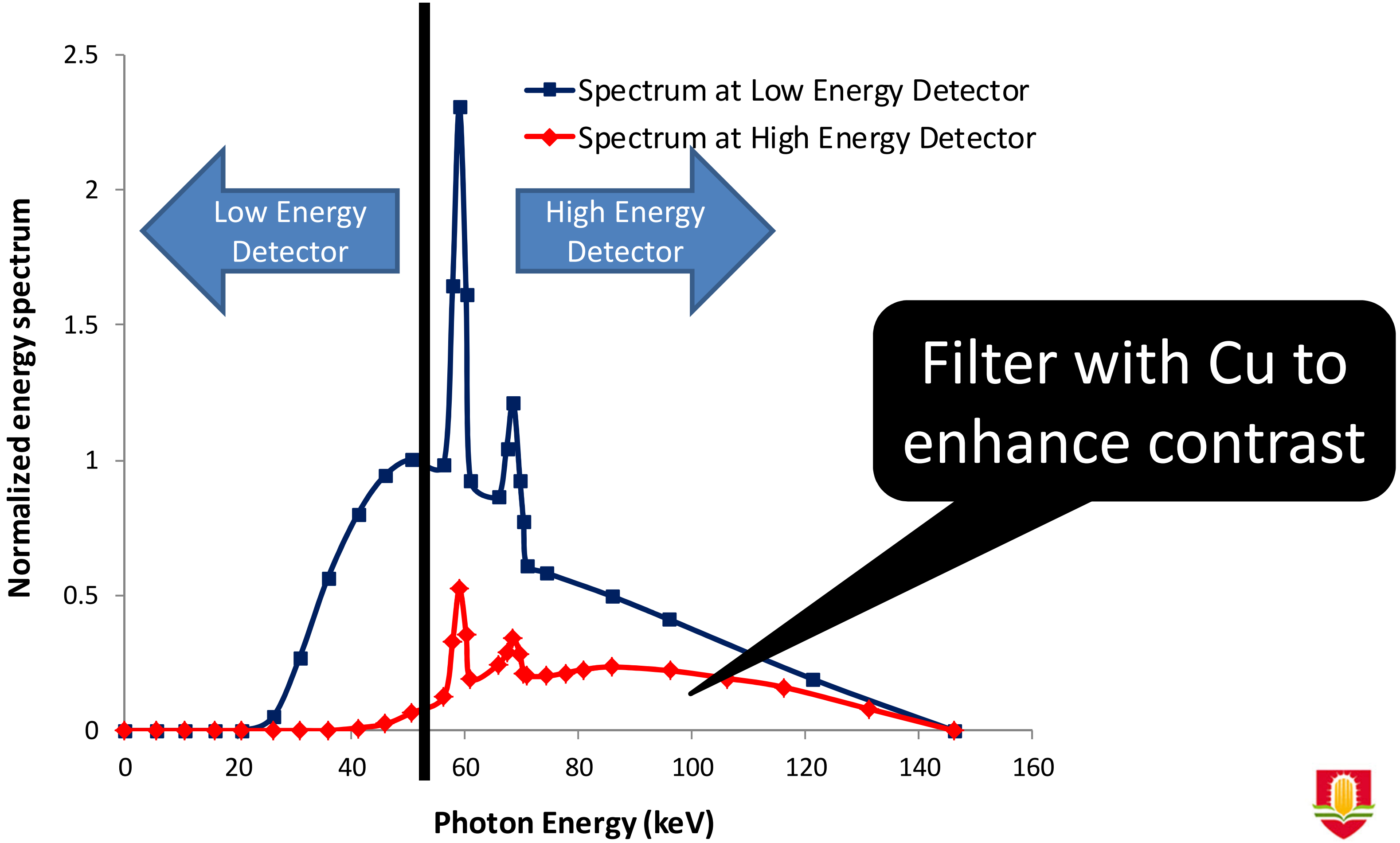

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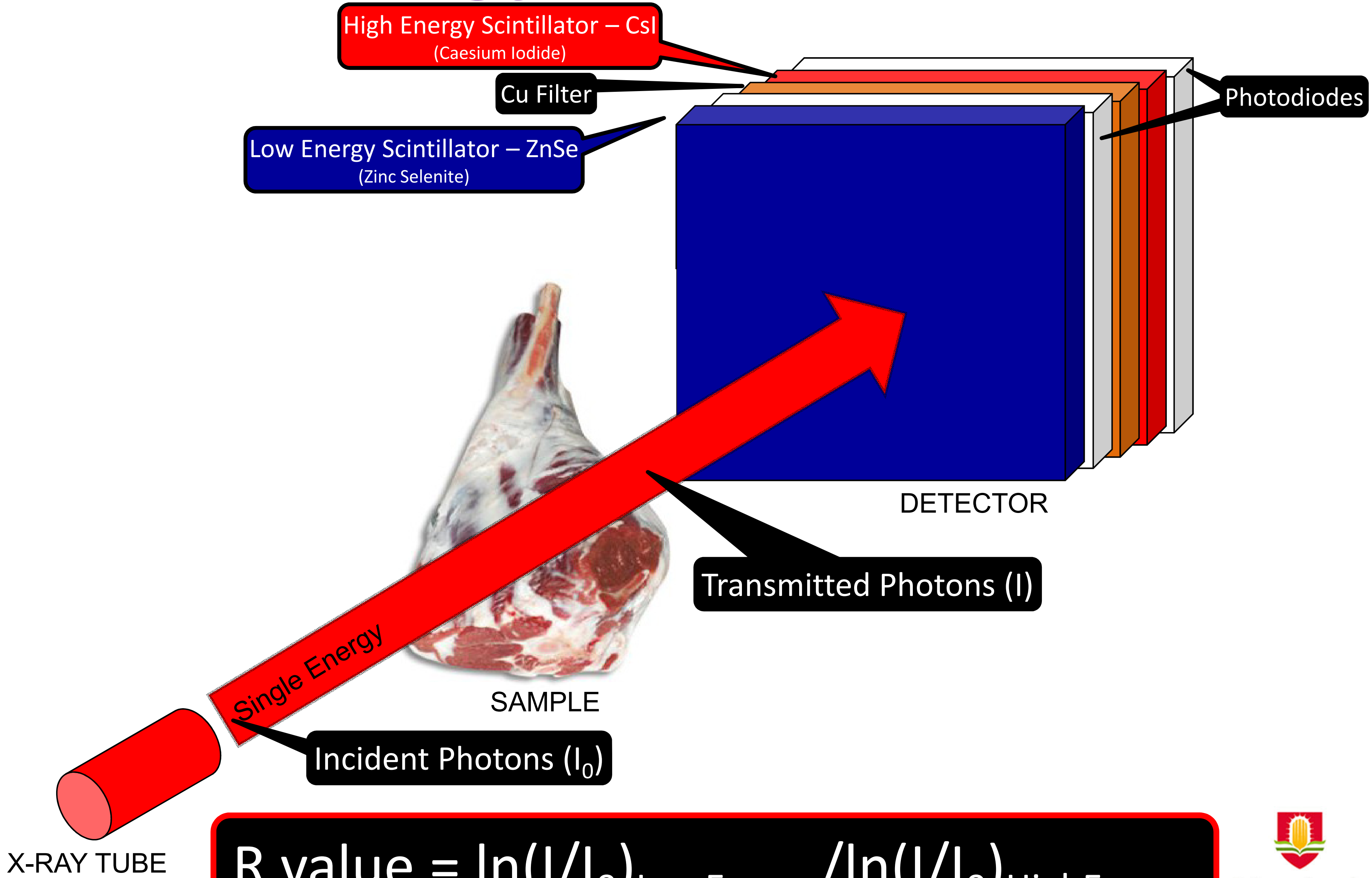
Dual Energy Detectors – ZnSe & CsI



$$R \text{ value} = \ln(I/I_0)_{LowEnergy} / \ln(I/I_0)_{HighEnergy}$$

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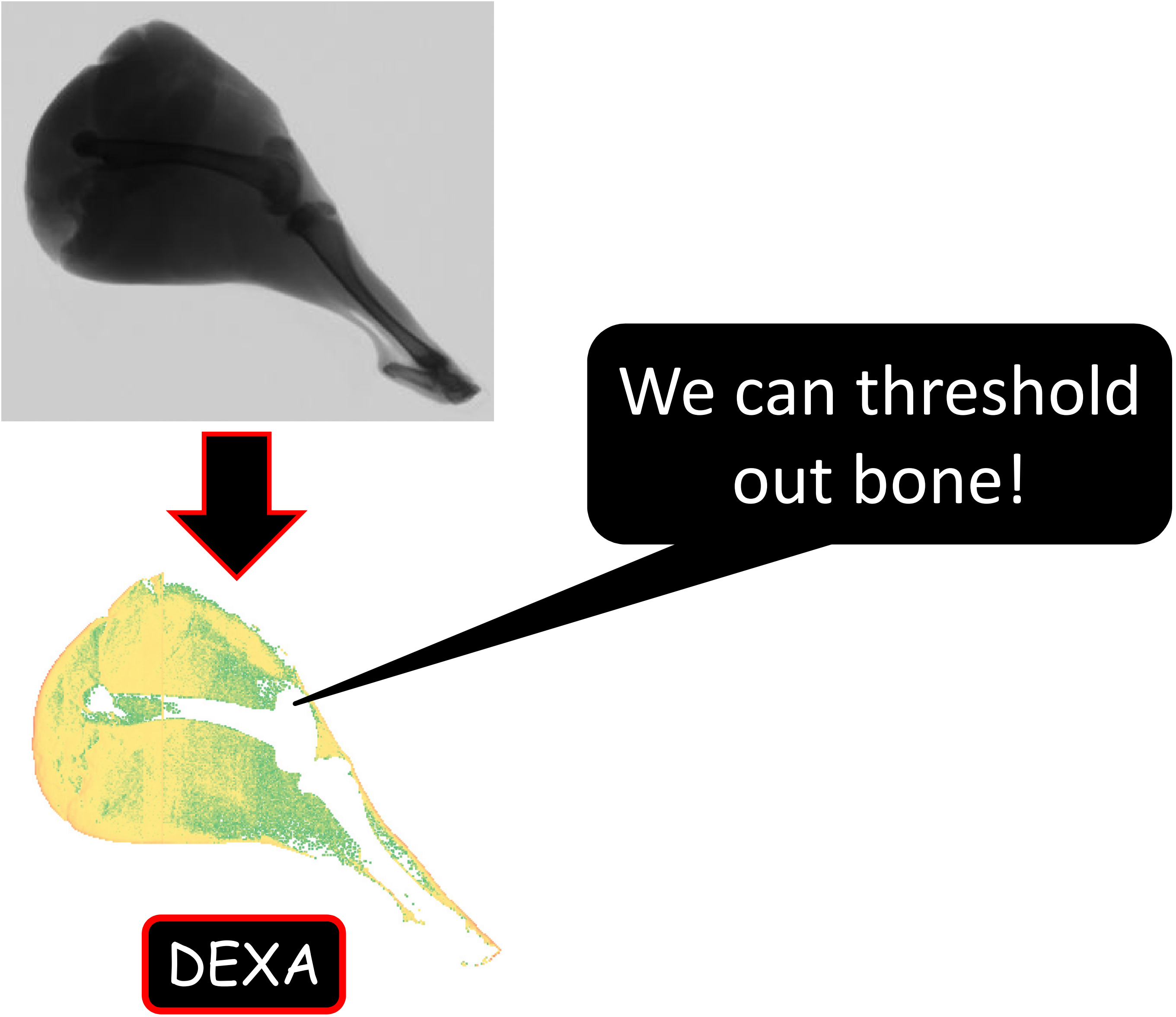
Dual Energy Detectors – ZnSe & CsI



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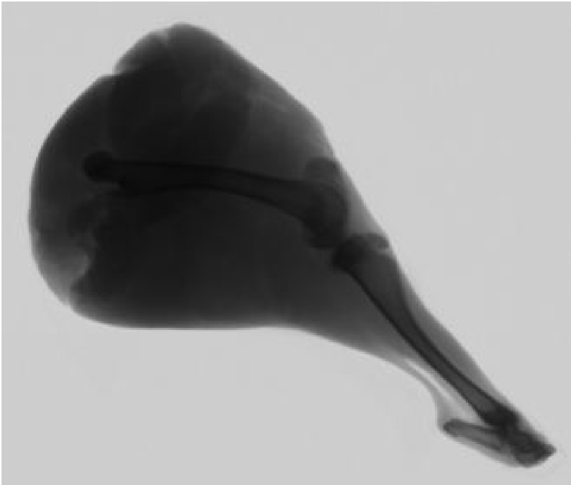
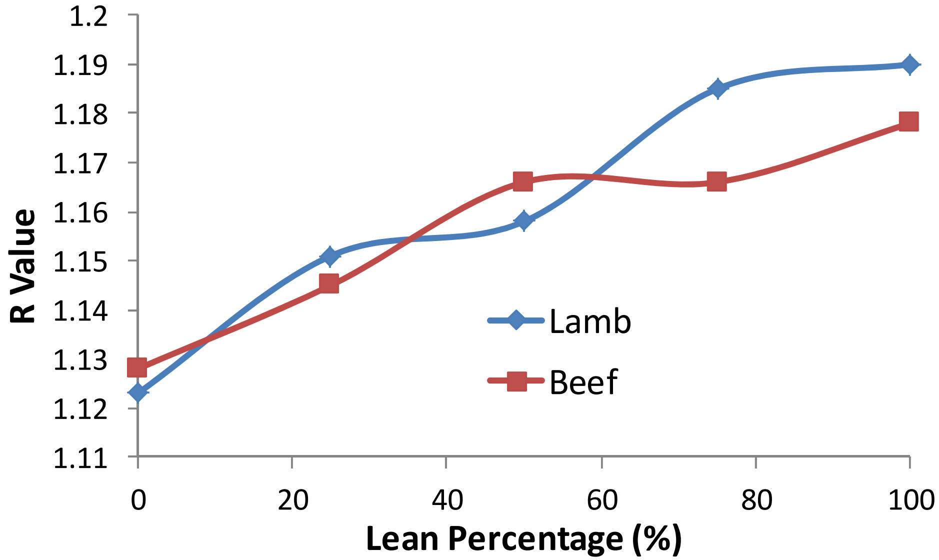
Dual Energy Detectors – ZnSe & CsI



DEXA



Differentiates Fat from Lean!

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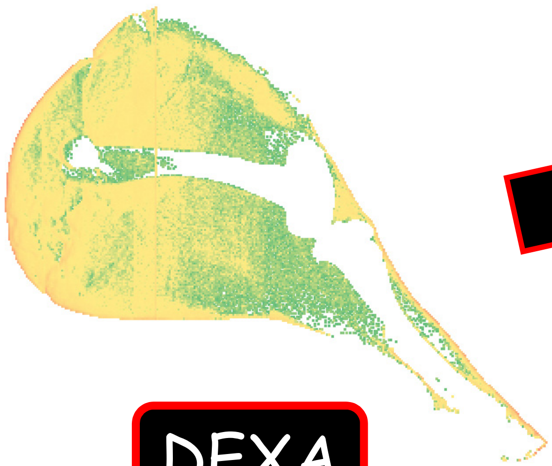
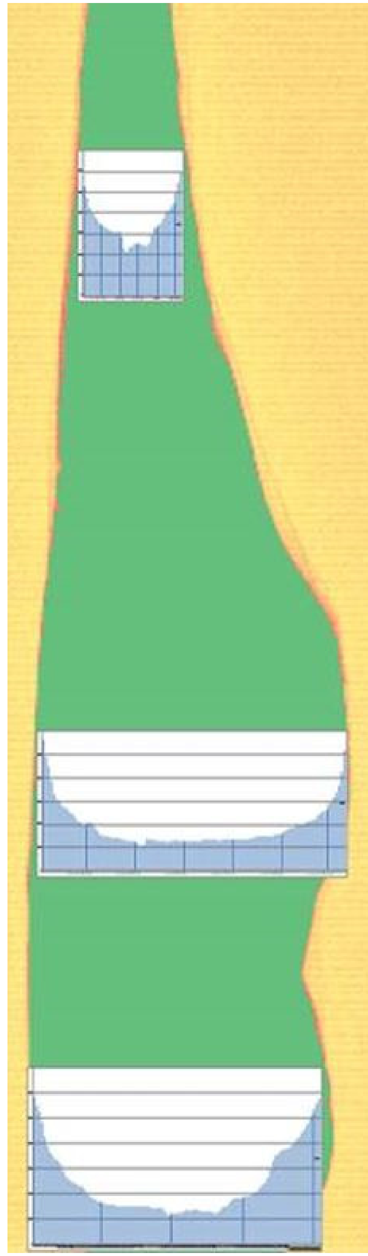
Made more precise with knowledge of volume?

Can we determine tissue depth profiles?



DEXA



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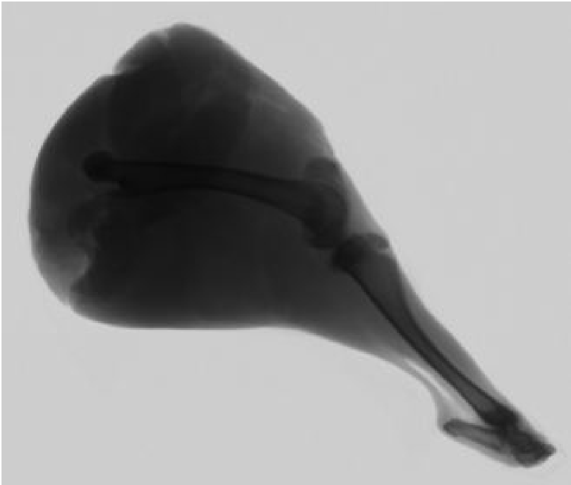
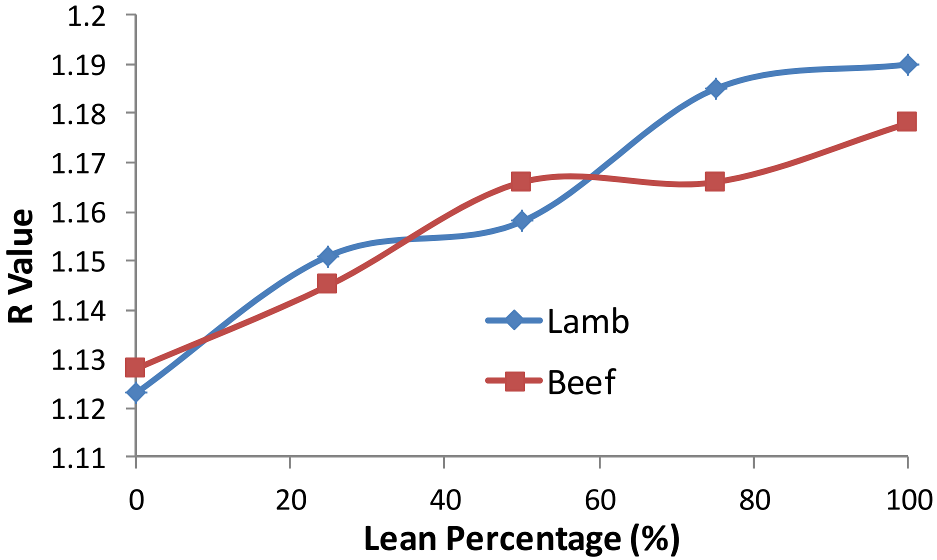
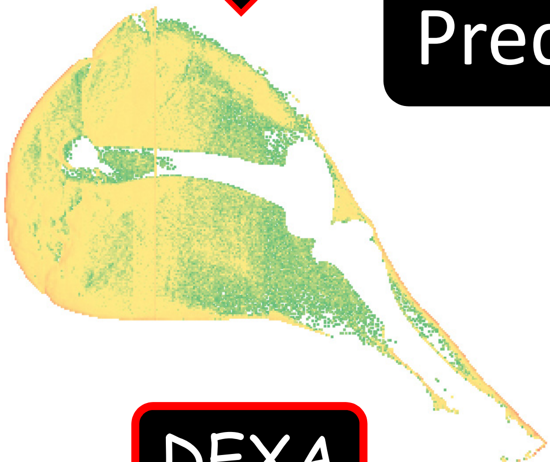
Dual Energy Detectors – ZnSe & CsI





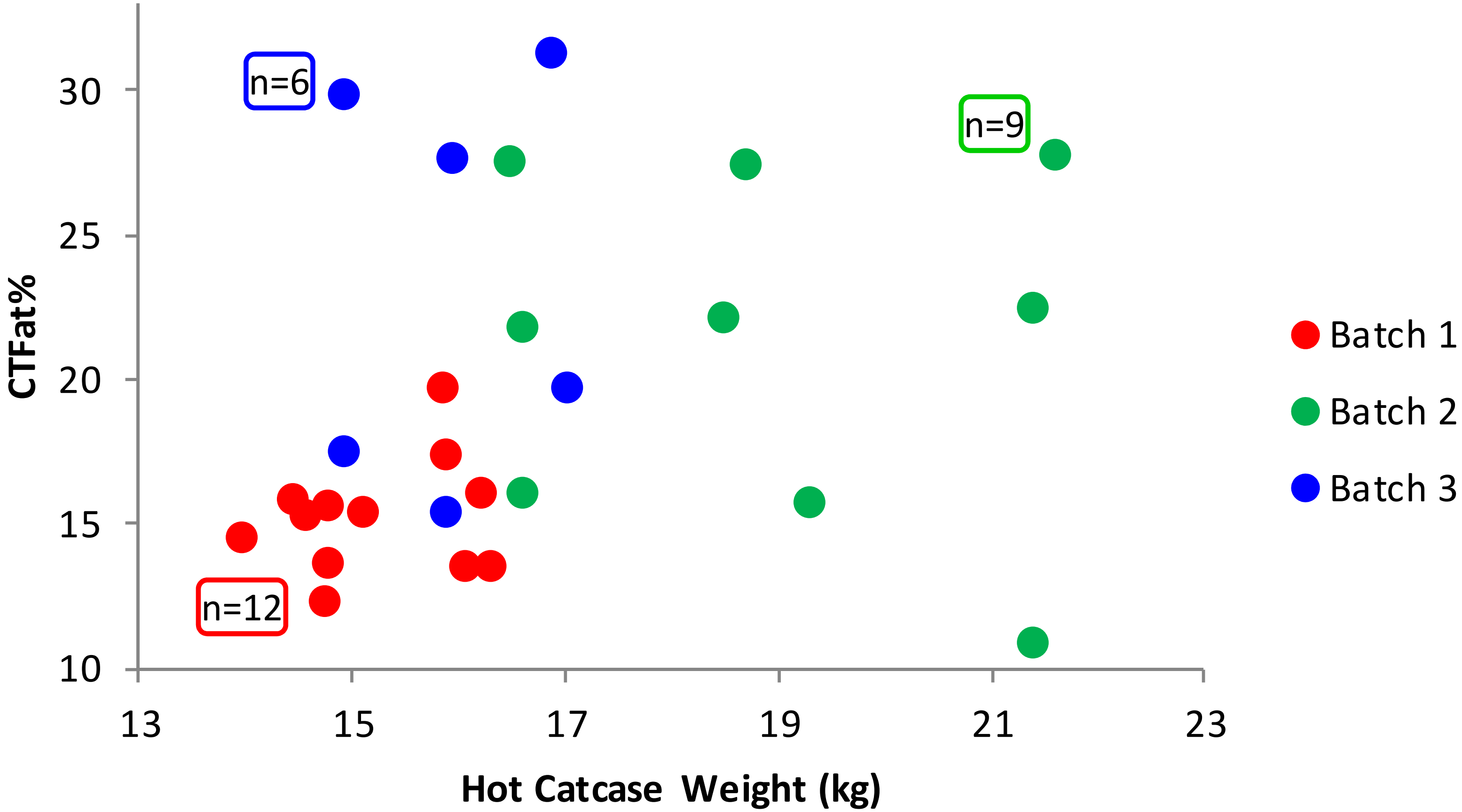


DEXA

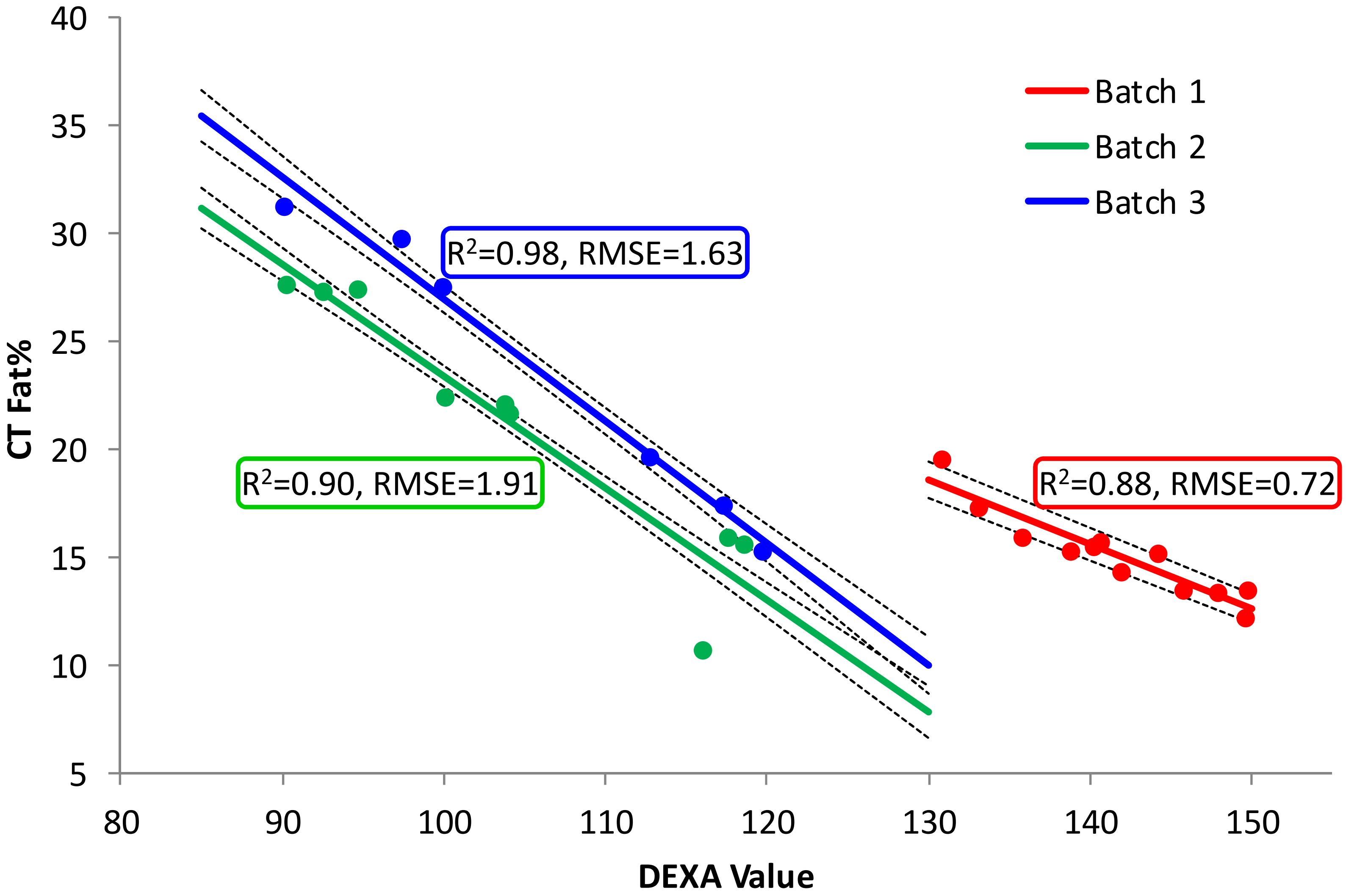
Predict CT Lean!

Computed Tomography (CT)

DEXA Results – Fat



DEXA Results – Fat



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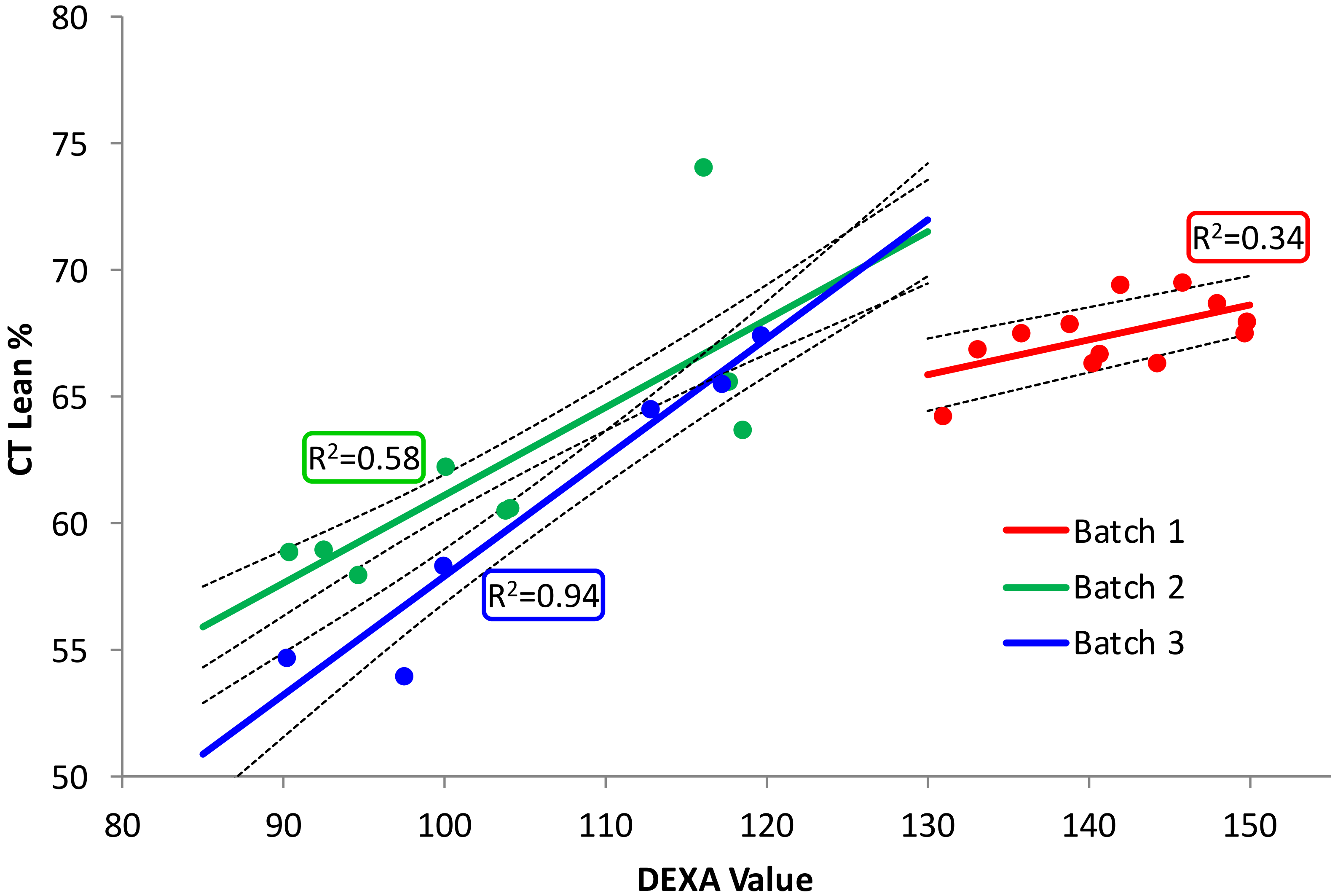
DEXA Results – Lean



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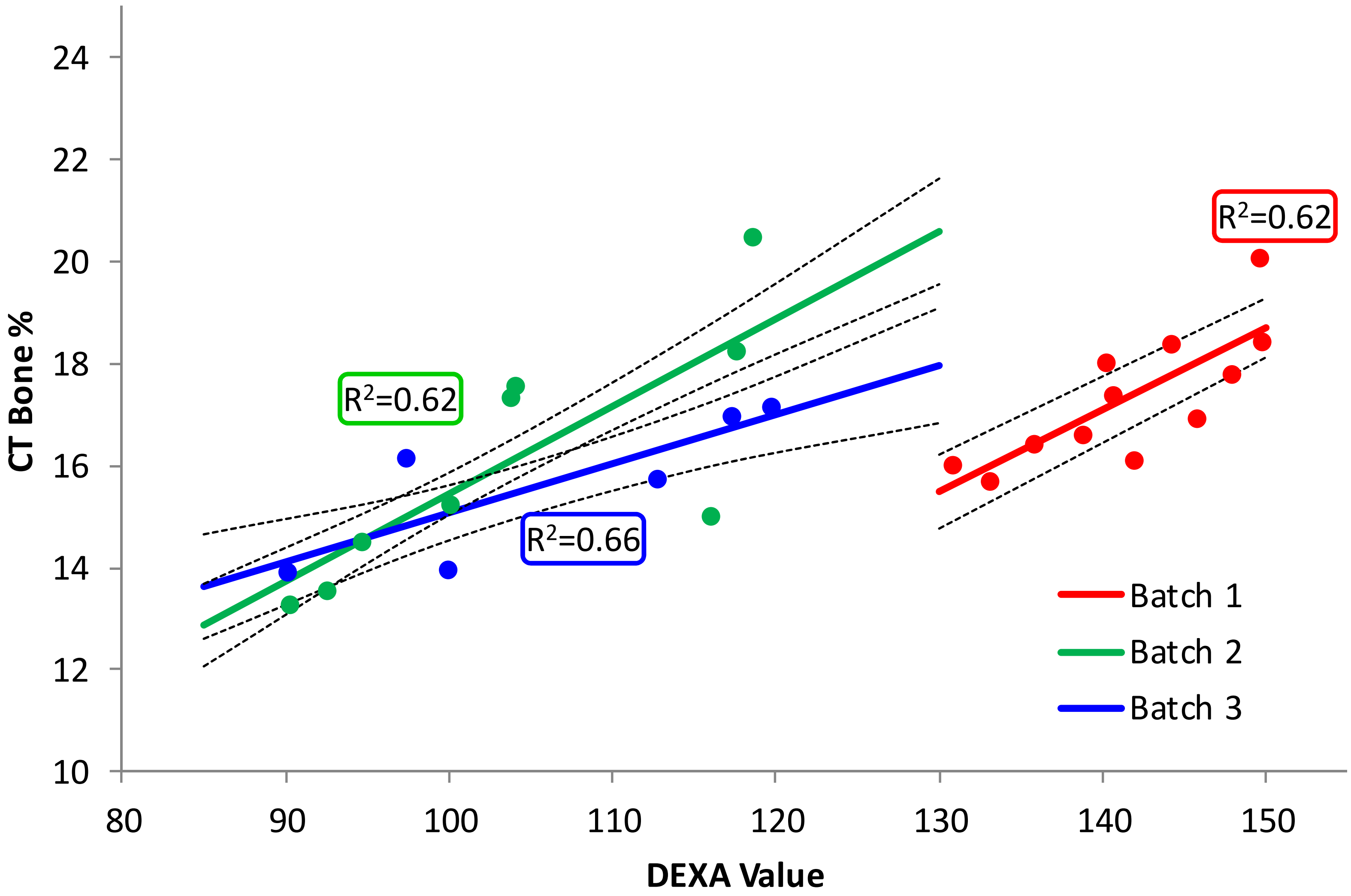
DEXA Results – Bone



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So where to next…?

- More data! (500 carcases)
- Composition within regions
- Further hard-ware development

Summary

- Dual Energy system developed – single x-ray source and dual detectors
- Successfully threshold bone
- Predicts CT composition

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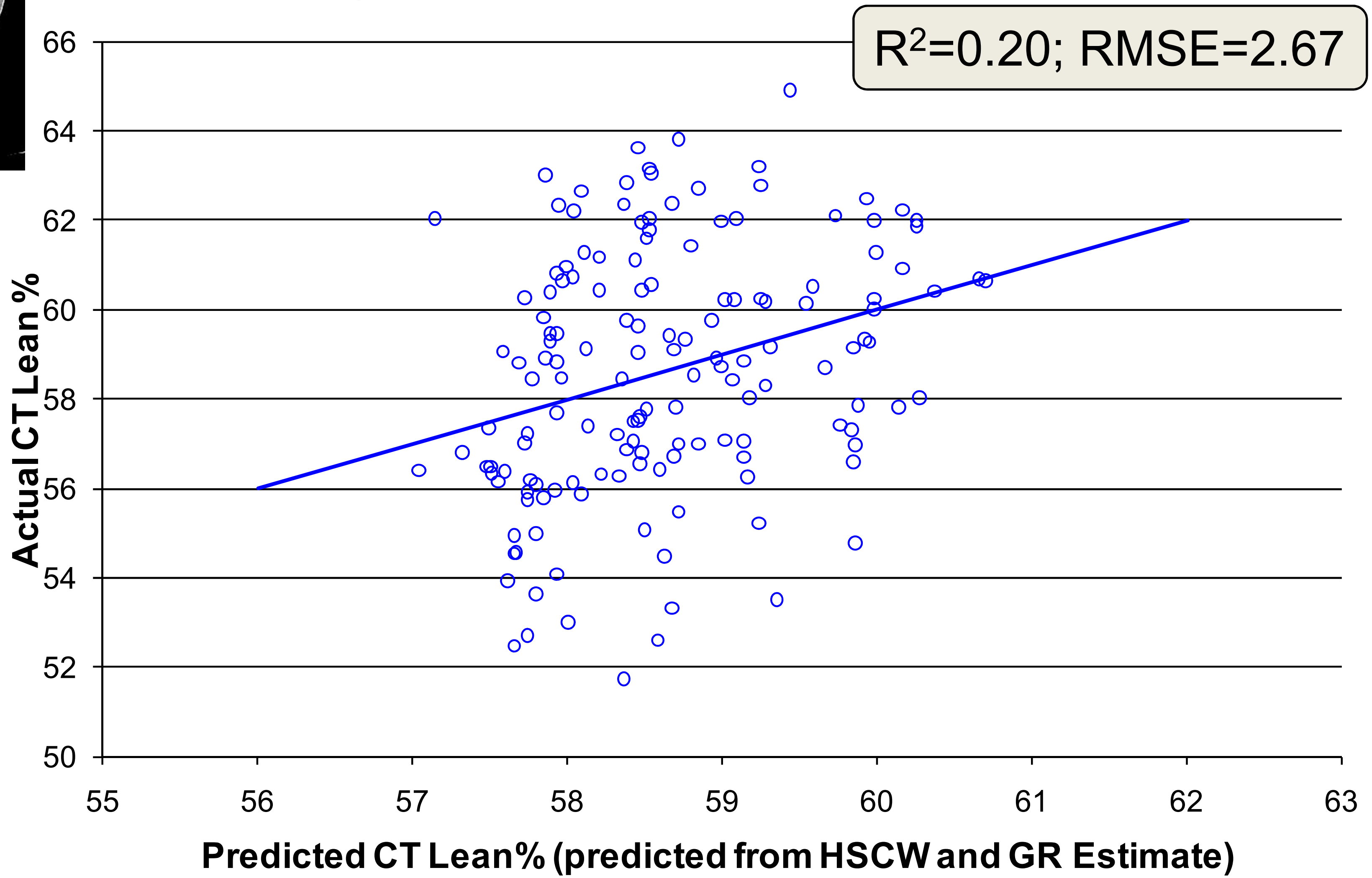
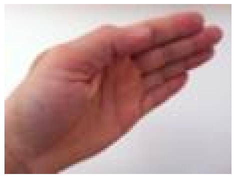
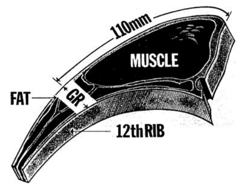
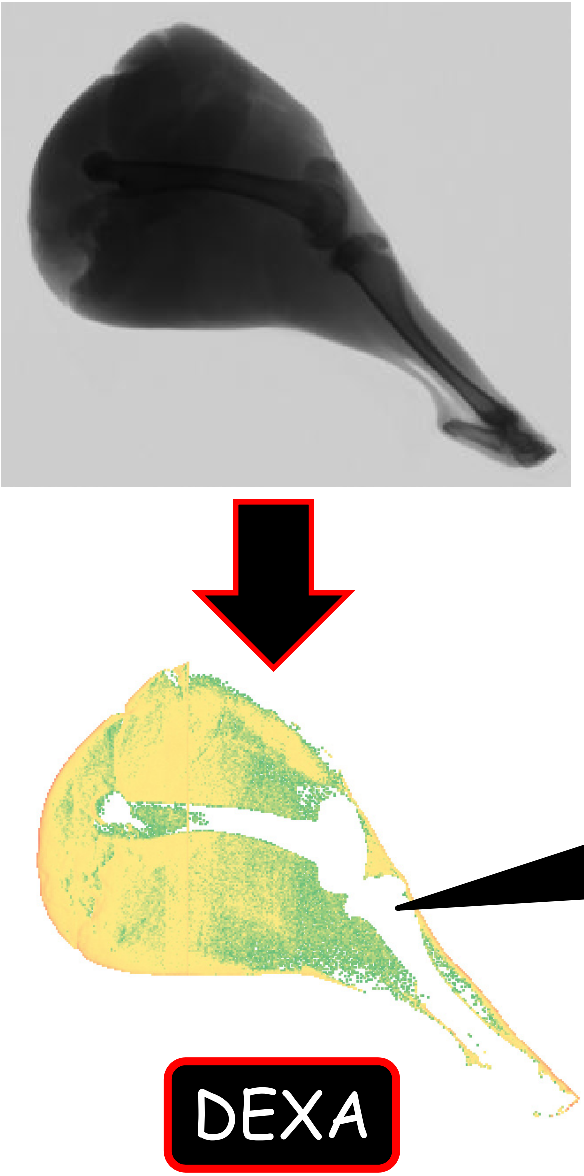
Palpated GR and HSCW







What about pixels containing bone?



Can we make further use of this tissue to enhance precision?

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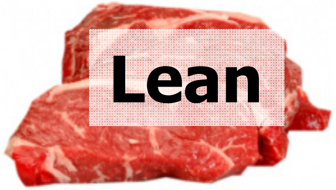

Redistribution of muscle

PEMD = more lean...
In the Saddle!

+ 4.9%

- 4.8%

+4.2%

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Need to move towards systems that measure whole carcase lean!

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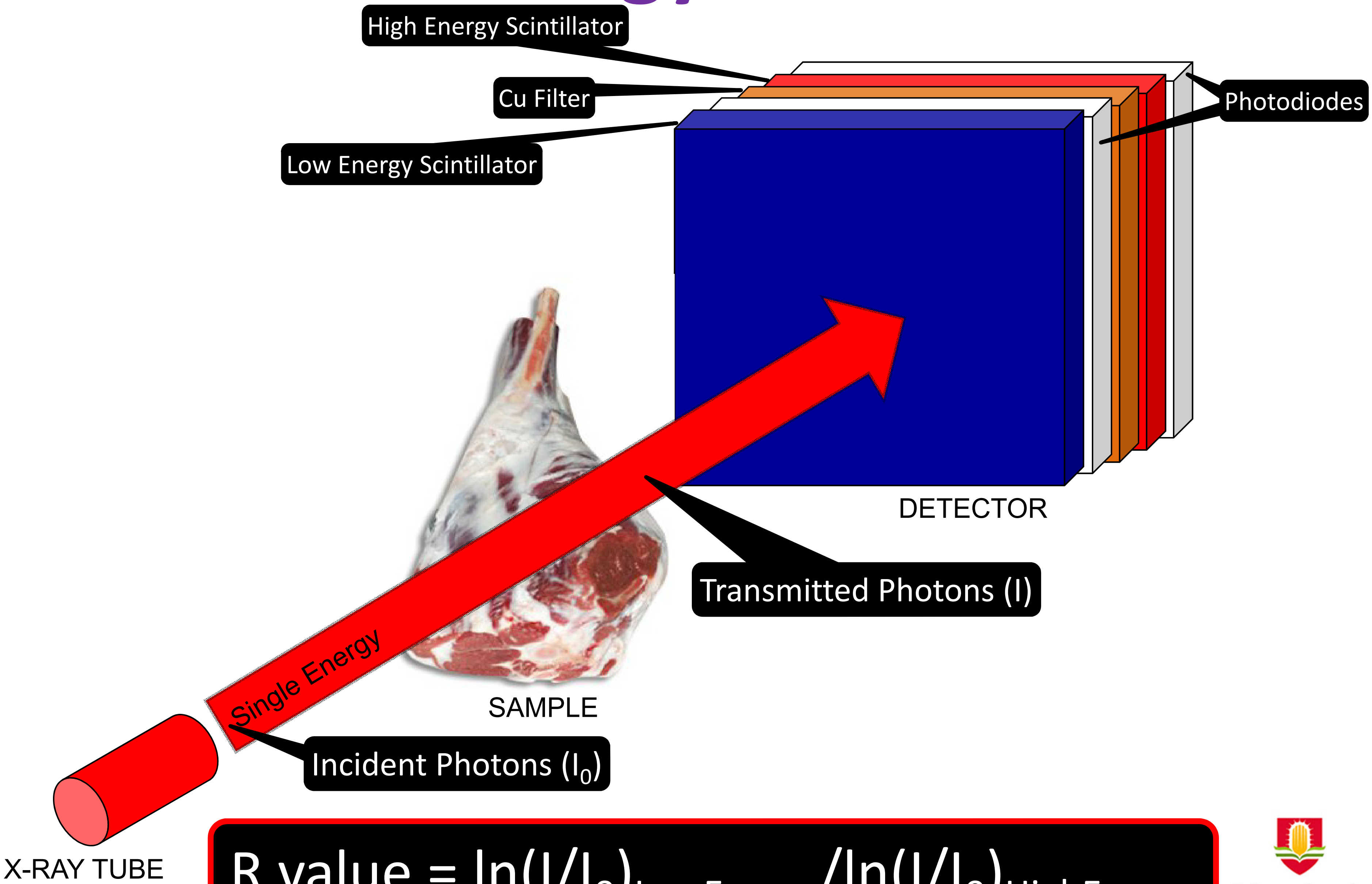
Dual Energy Detectors



$$R\ value = \ln(I/I_0)_{LowEnergy} / \ln(I/I_0)_{HighEnergy}$$

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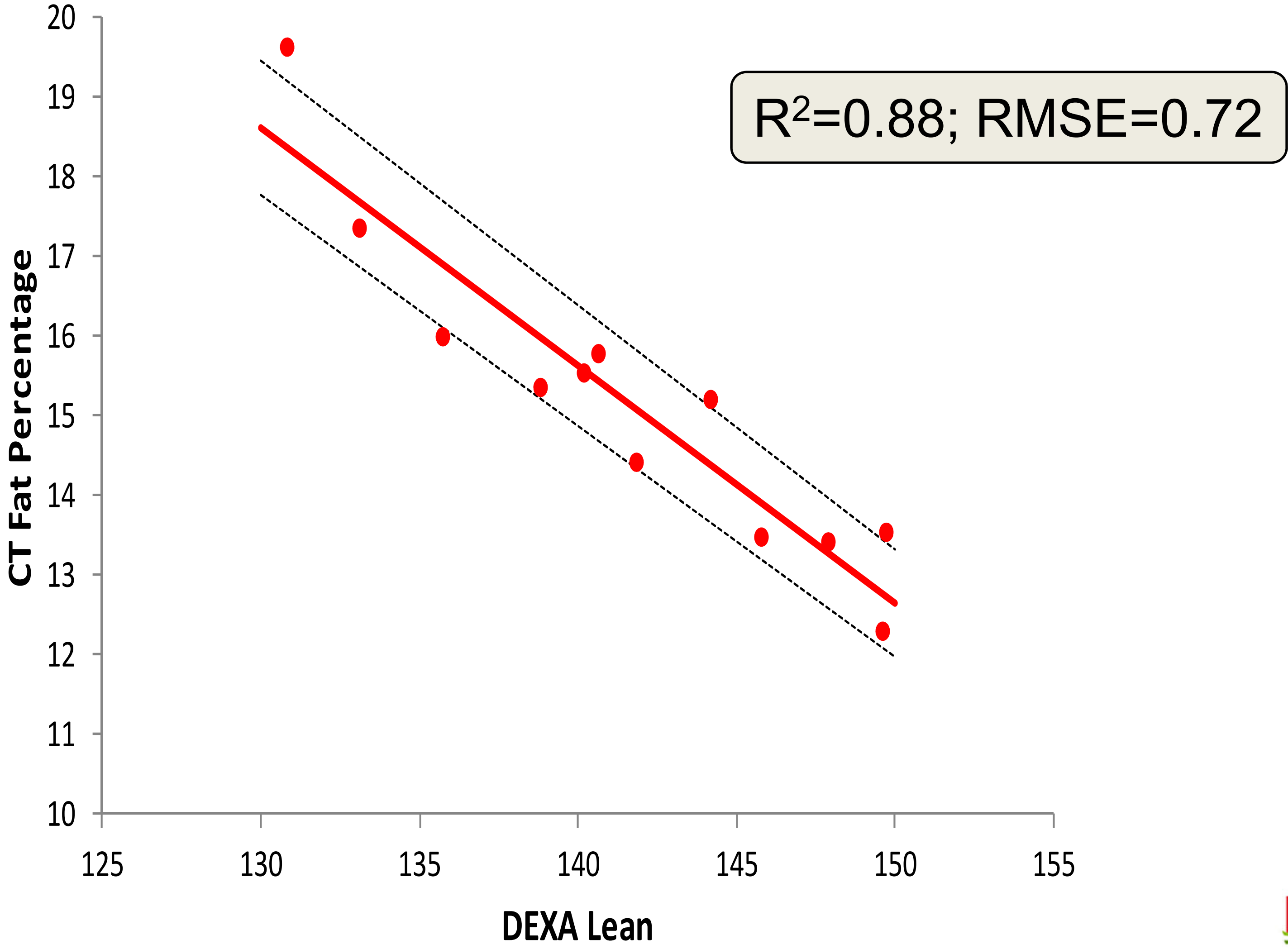
DEXA Results – Preliminary Test 1



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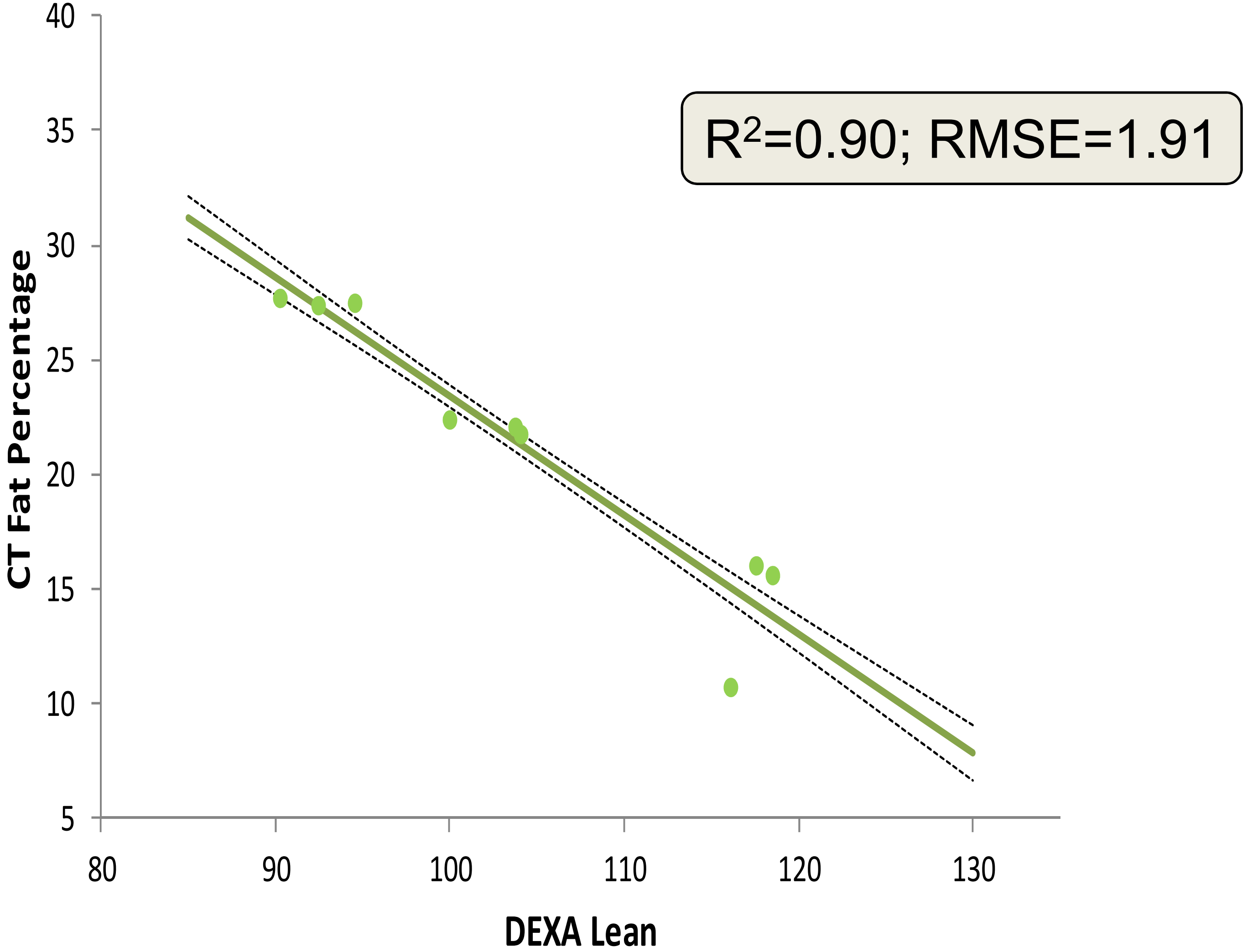
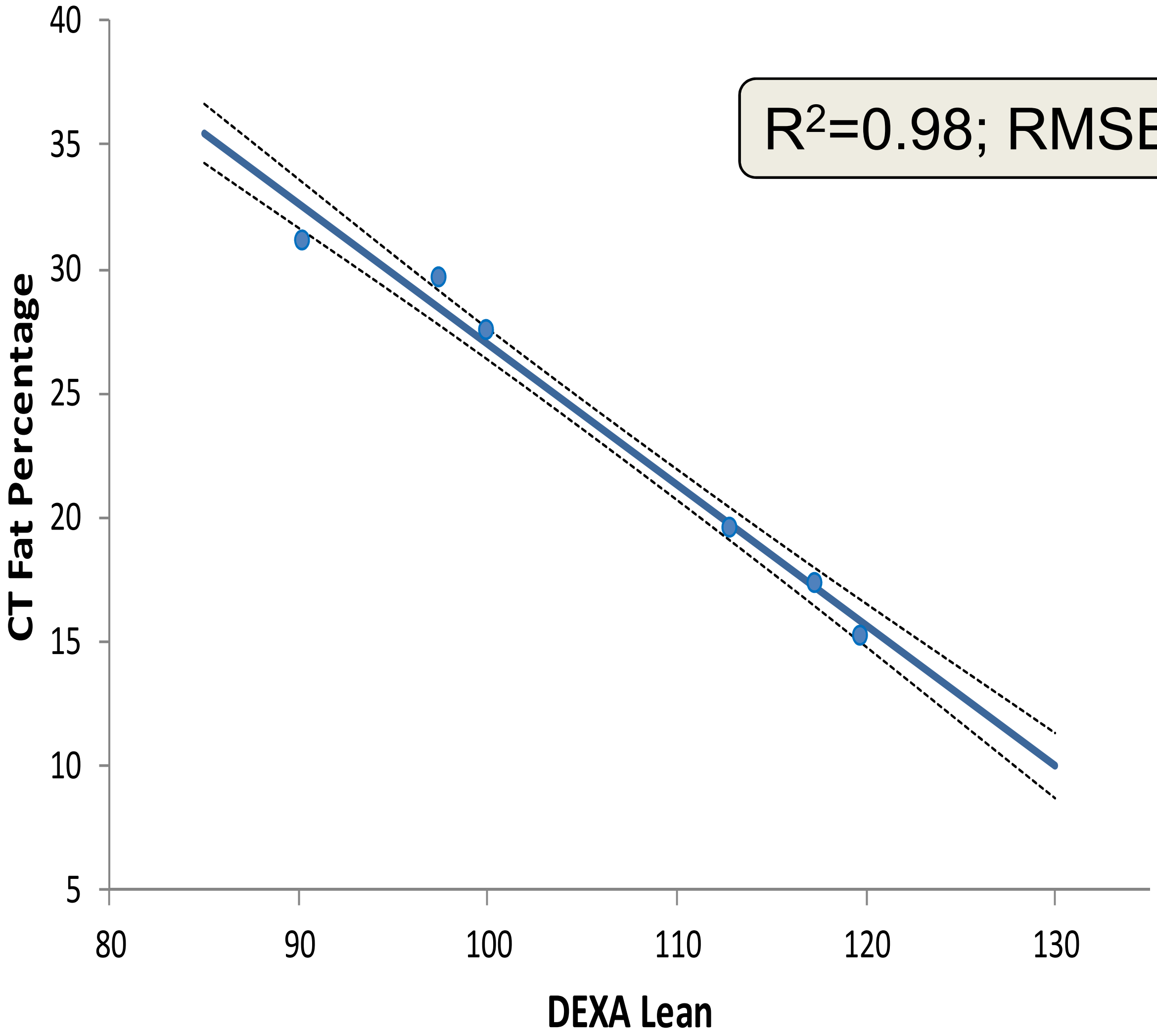
DEXA Results – Preliminary Test 2



DEXA Results – Preliminary Test 3



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Mass attenuation coefficients at 40 keV and 70 keV and R values

	Mass attenuation coefficient		R Value
Component	40keV	70keV	R
Fatty Acids	0.228	0.188	1.215
Triglycerides	0.228	0.187	1.218
Protein	0.236	0.183	1.291
Glycogen	0.238	0.183	1.301
Water	0.264	0.194	1.357
Extracellular fluid	0.267	0.195	1.374
Intracellular fluid	0.271	0.196	1.386
Soft tissue minerals	0.769	0.282	2.721
Bone mineral	0.904	0.316	2.862
Calcium hydroxyapatite	0.963	0.328	2.934

Main body components in animals

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