DEXA

Transforming carcase grading

Honor Calnan

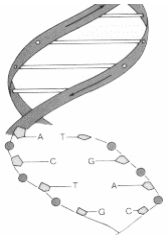
Outline

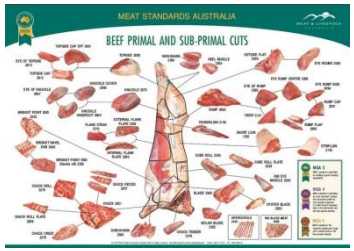
- Carcase measurement – the status quo
- Project to accelerate tech development
  - Beef, pork and lamb industries
- Systems to integrate data from new tech.
- DEXA for carcase composition

Precision measurement

from paddock/pen to plate

- Predict quality and amount of final product





Conception — Value — Live Animal — Value — Carcase — Value — Retail Cuts — Value — Cooked Product

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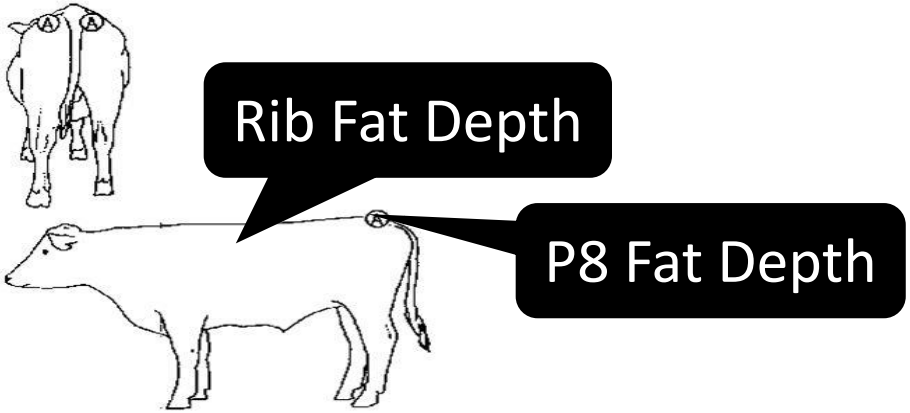
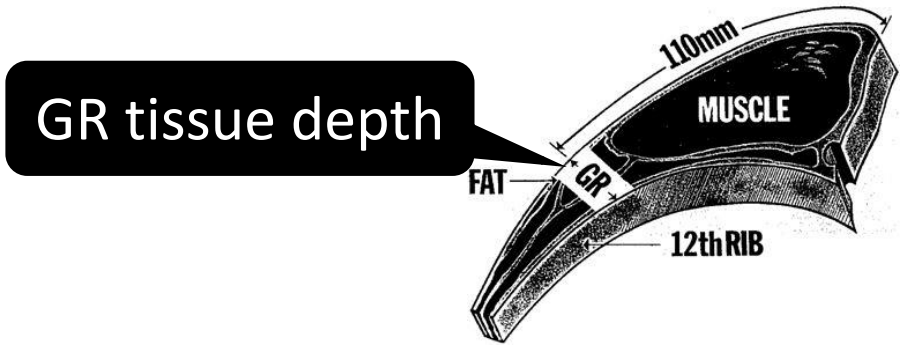
Trading beef and lamb

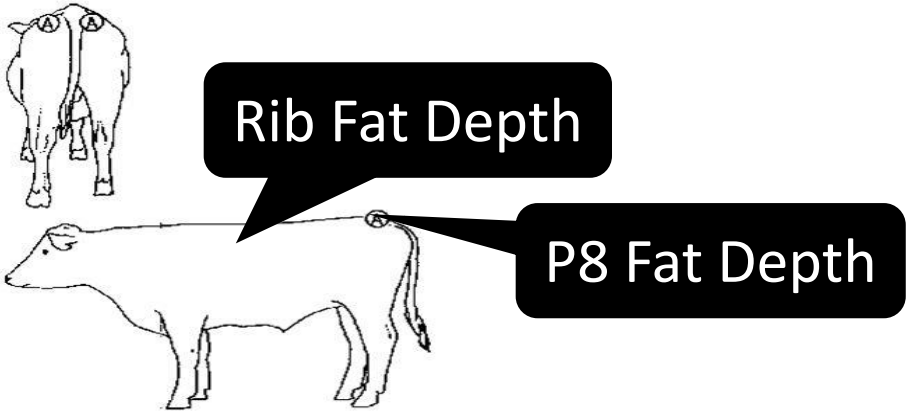
- Traded largely on carcase weight
- Fat penalties only at the extremes

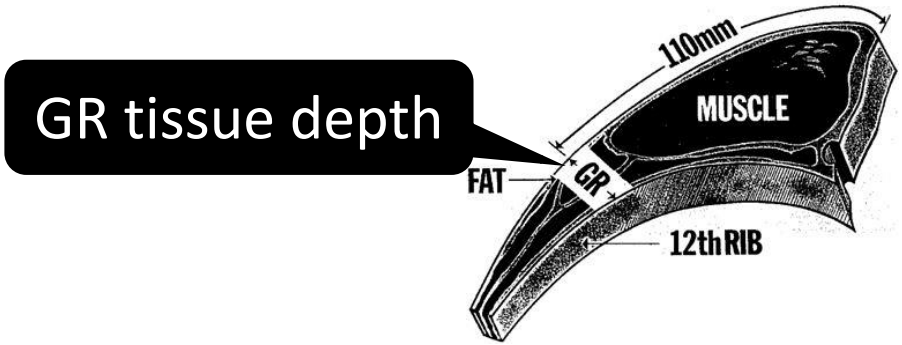




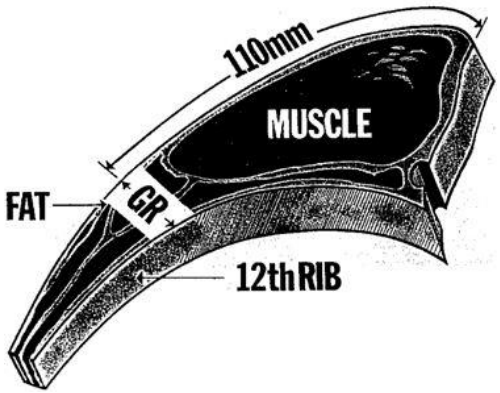
Lean meat yield (LMY)

= lean meat : fat & bone



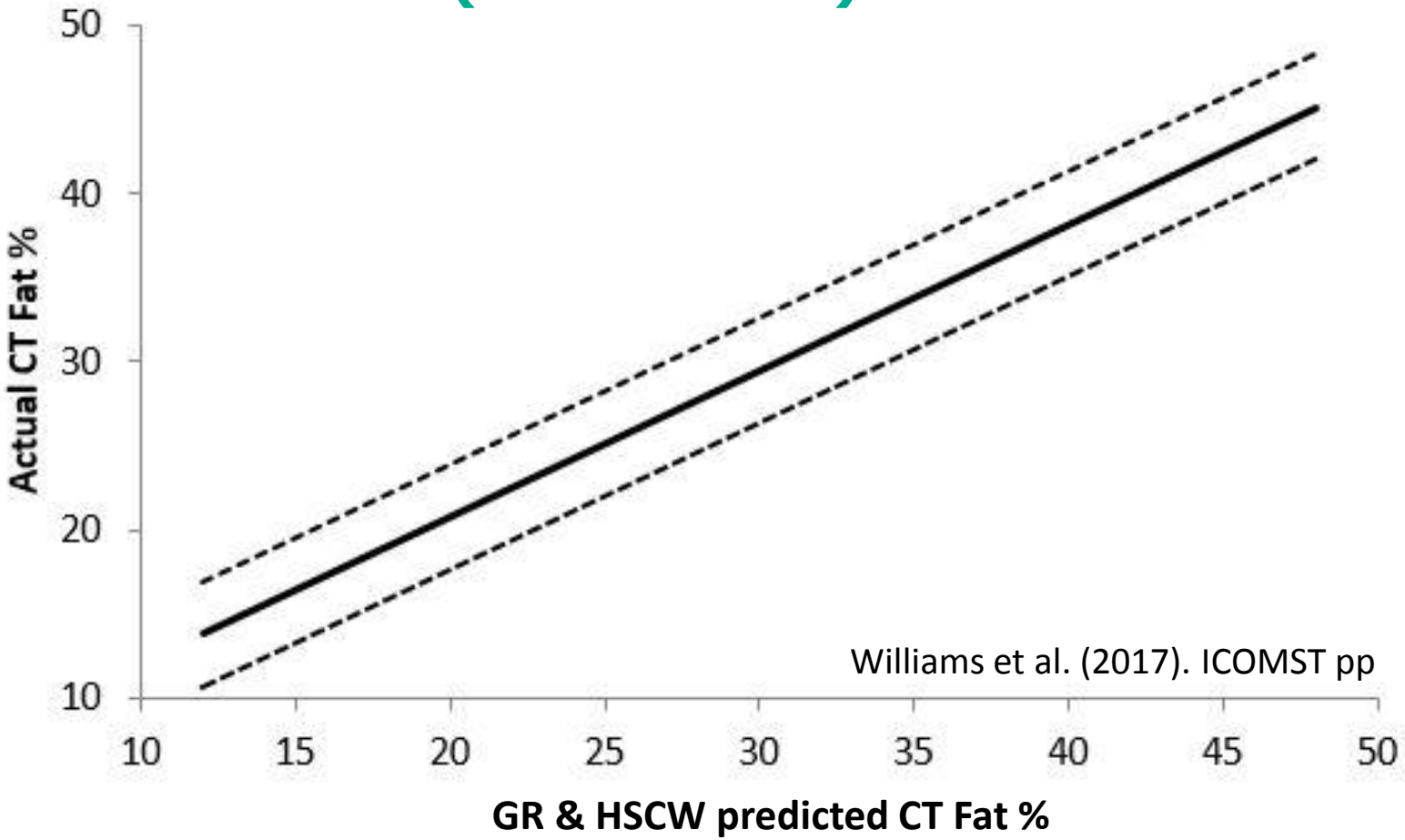


How well do the existing measures work?

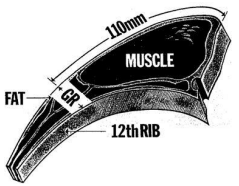


GR and HSCW

(28 data sets)



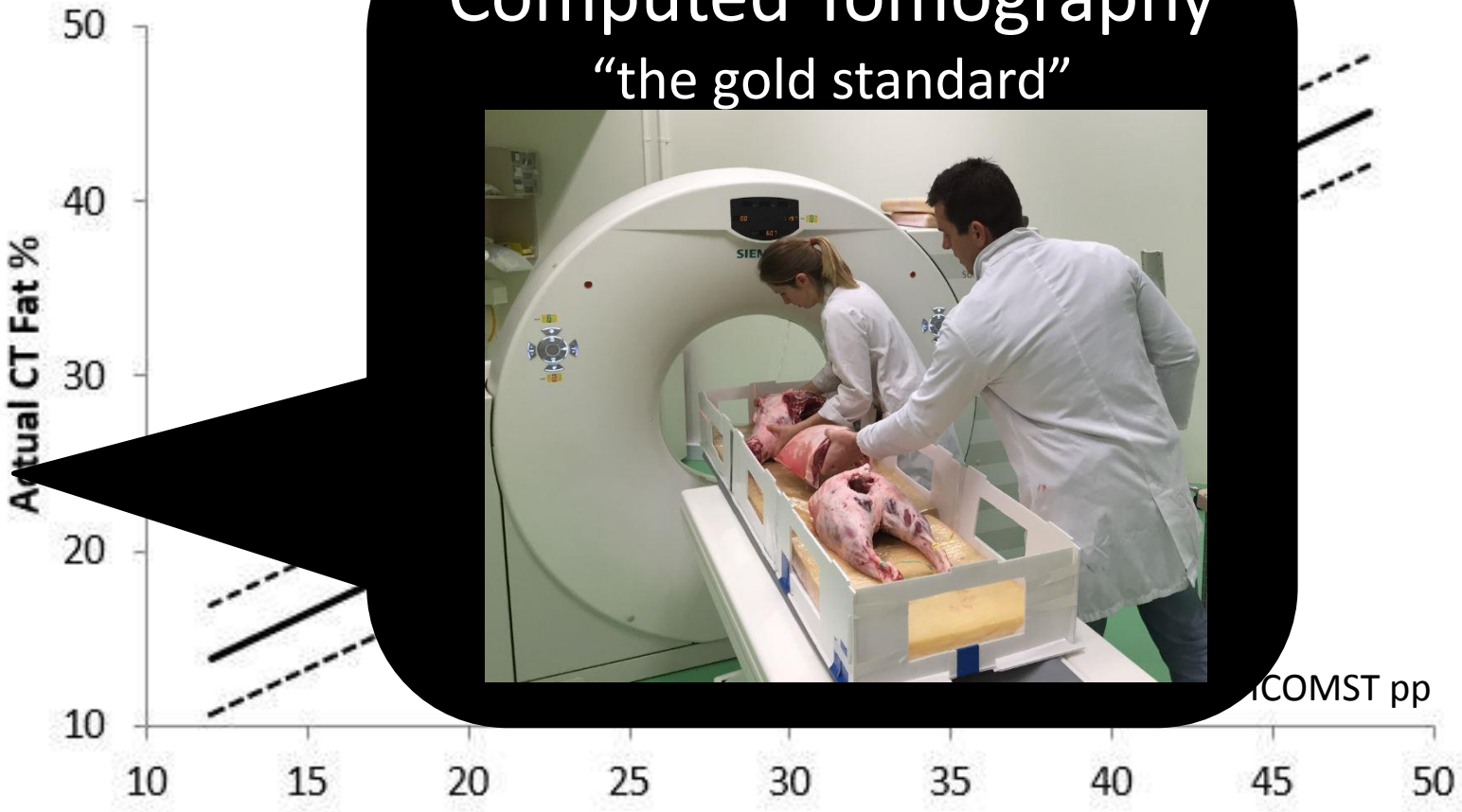
Williams et al. (2017). ICOMST pp



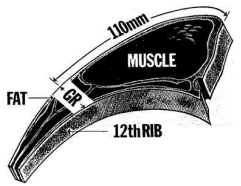
GR and HSCW

Computed Tomography

"the gold standard"



ICOMST pp



GR and HSCW

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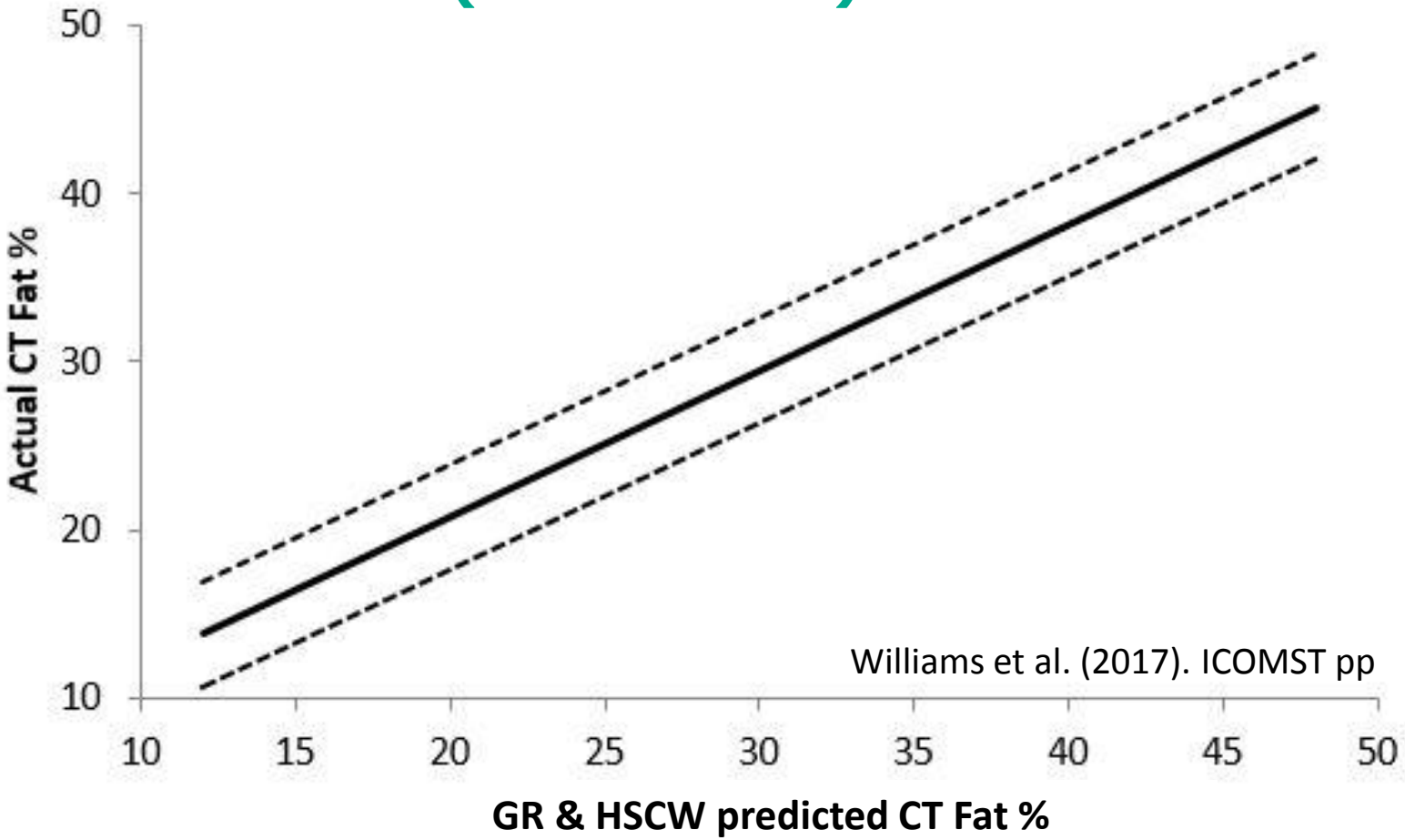
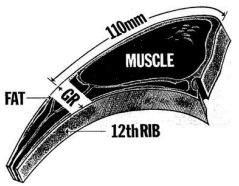


Williams et al. (2017). ICOMST pp



GR and HSCW

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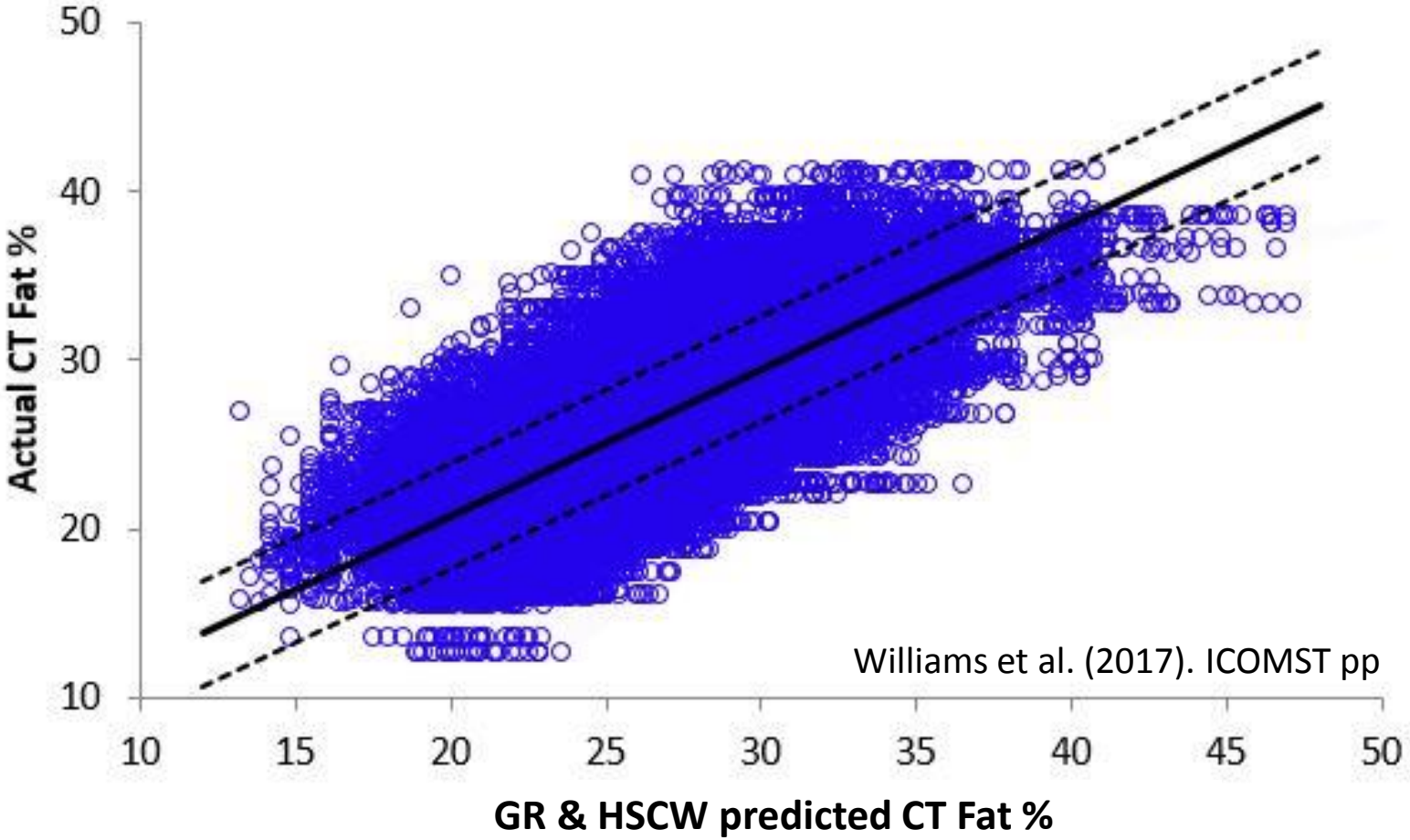
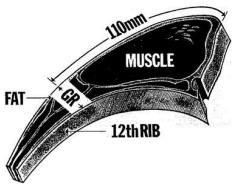


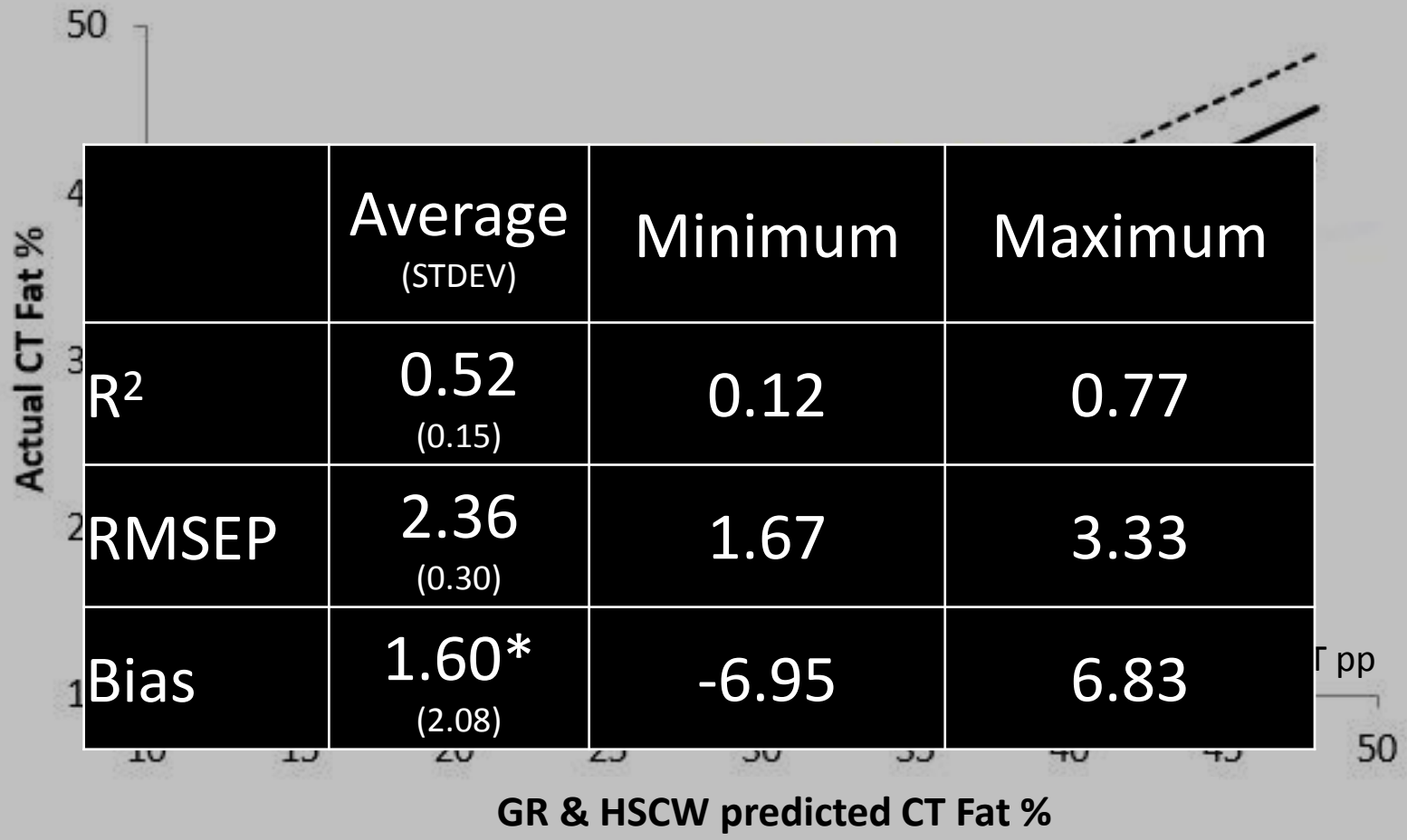
Williams et al. (2017). ICOMST pp



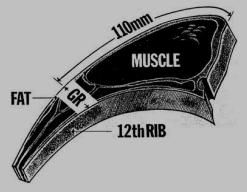
GR and HSCW

(28 data sets)

	Average (STDEV)	Minimum	Maximum
R^2	0.52 (0.15)	0.12	0.77
RMSEP	2.36 (0.30)	1.67	3.33
Bias	1.60* (2.08)	-6.95	6.83



*Average of the absolute values of Bias



GR and HSCW

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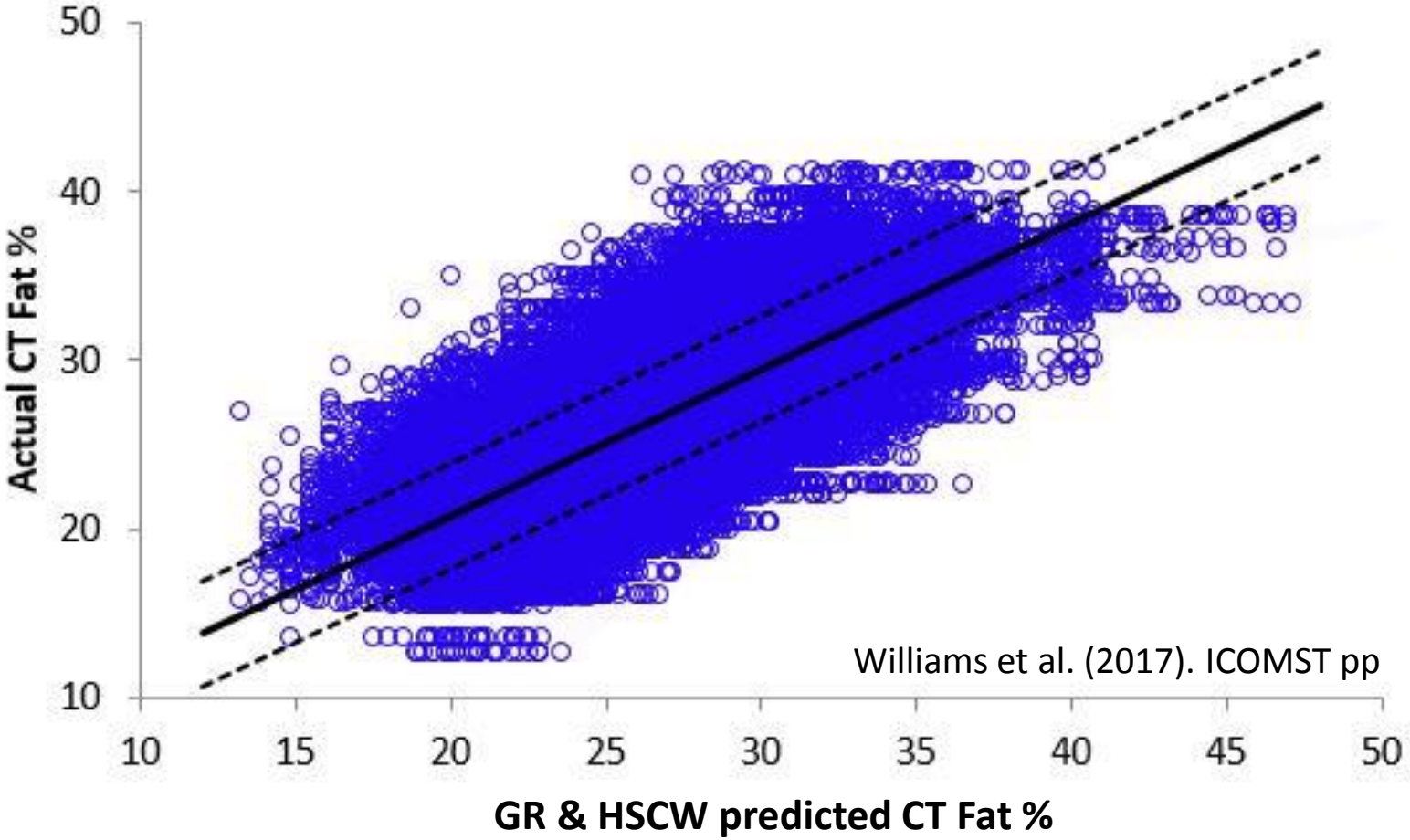
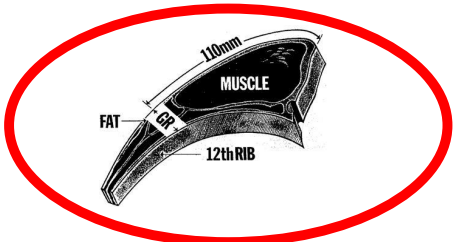
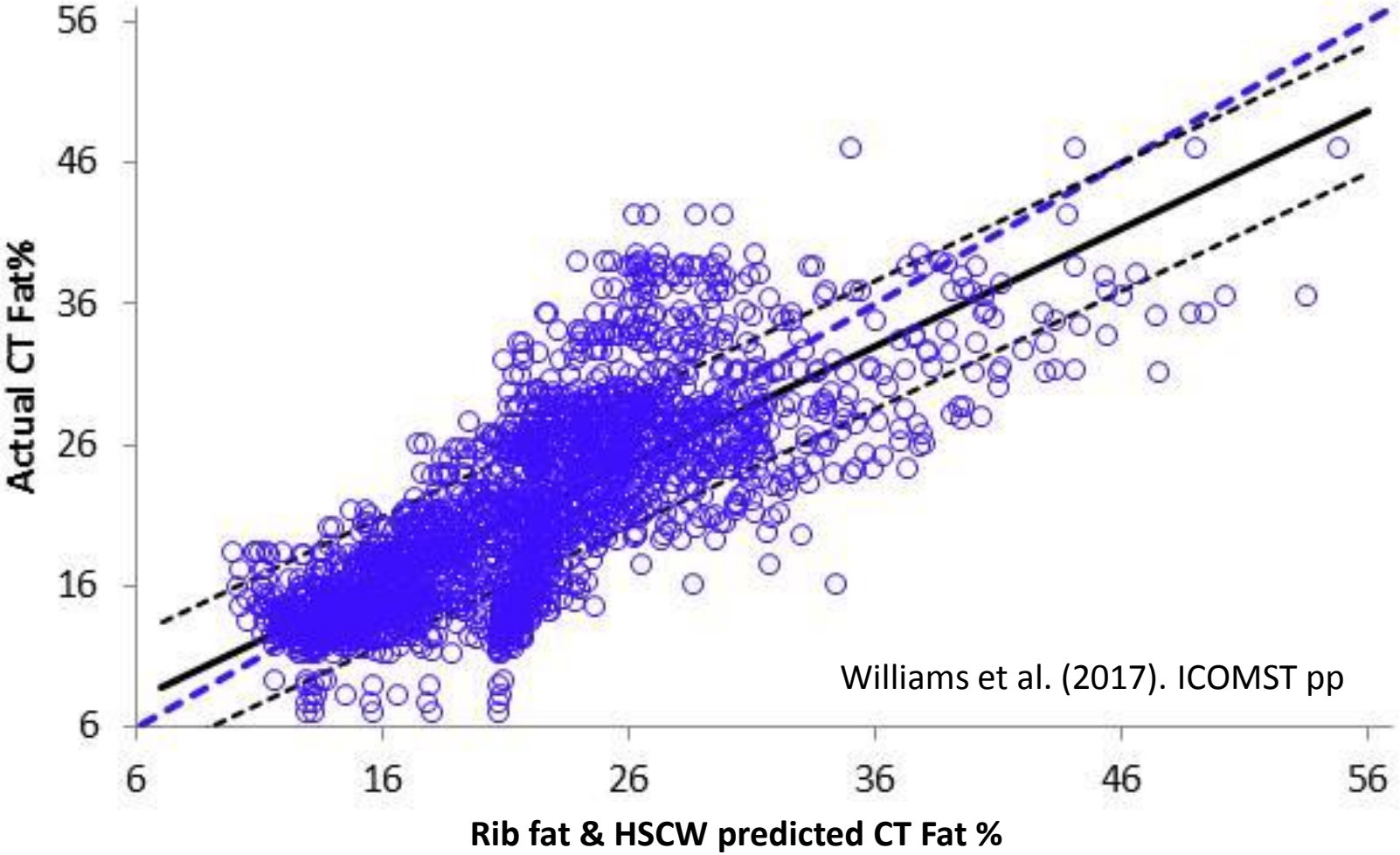


Williams et al. (2017). ICOMST pp



Rib Fat and HSCW

(6 data sets)



Williams et al. (2017). ICOMST pp

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Eating Quality

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Trading on Eating Quality

Meat Standards Australia eating quality model

Description	Format	Name	Input	?
Estimated % Bos Indicus	% or X if doubt	EPBI	0	
Animal Sex Type	M/F	Sex	F	
mone Growth Promotent	Y or ? / N	HGP	n	
MilkFedVealer	Y/N	MFV	n	
SaleYard	Y/N	SlYrd	n	
Rinse/Flush	Y/N	RnFl	n	
Hot Std Carcase Weight	Weight in Kg	HSCW	350	
HangMethod	T/TS/TL/TC/XT	Hang	at	
Hump Height	mm	Hump	63	
Ossification USDA	USDA measure	uoss	290	
Marbling USDA	USDA measure	umb	300	
RibFat	mm	RbFt	10	
Ultimate pH	Metered pH	UpH	5.5	
Loin Temp at Grade	Metered Temp C	Utmp	9	
Days of Ageing from Kill	Days Aged	Age	5	

Aged

cut	muscle	GRL	RST	SFR	TSL	SCT	CRN
spinalis	SPN081	79	69	79	75		
tenderloin	TDR034	82		76			
tenderloin	TDR062	78	77	80	74		
tenderloin	TDR063	73					
cube roll	CUB045	62	62	62	64		
striploin	STA045	55	56	58	58		
striploin	STP045	53	54	57	57		
oyster blade	OYS036	67	64	69	72		
blade	BLD095			43			
blade	BLD096	53	57	58	59	59	
chucktender	CTR085		49	51	53	59	
rump	RMP131	51	59	56	62	54	
rump	RMP231	54	62	61	60		
rump	RMP005	59		67	67		
rump	RMP032			64	68		
rump	RMP087		52	57	55	56	
knuckle	KNU066	46	59	54	58	47	
knuckle	KNU098			54	59	56	
knuckle	KNU099	36	47	44	51	52	
knuckle	KNU100			60	62	55	
outside flat	OUT005		40	43	56	59	52
outside flat	OUT029			54	61	55	
eye round	EYE075	40	44	42	45	46	45
topside	TOP001	39		51	53	50	
topside	TOP033	40		53	58	60	
topside	TOP073	34	43	43	56	52	
chuck	CHK068			48	53	65	
chuck	CHK074	63	56	61	67	72	
chuck	CHK078	56	57	58	62	69	
chuck	CHK081			60	64	75	
chuck	CHK082			52	56		
thin-flank	TFL051			58		58	
thin-flank	TFL052			67	59	64	
thin-flank	TFL064			61	58	60	
rib-blade	RIB041			48			
brisket	BRI056			44	58	60	38
brisket	BRI057			41	49	64	
shin	FQshin					57	
shin	HQshin					60	
intercostal	INT037			57			

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Trading on Eating Quality

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Aged

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shin	HQshin					60	
intercostal	INT037			57			

Doesn't exist for lamb!

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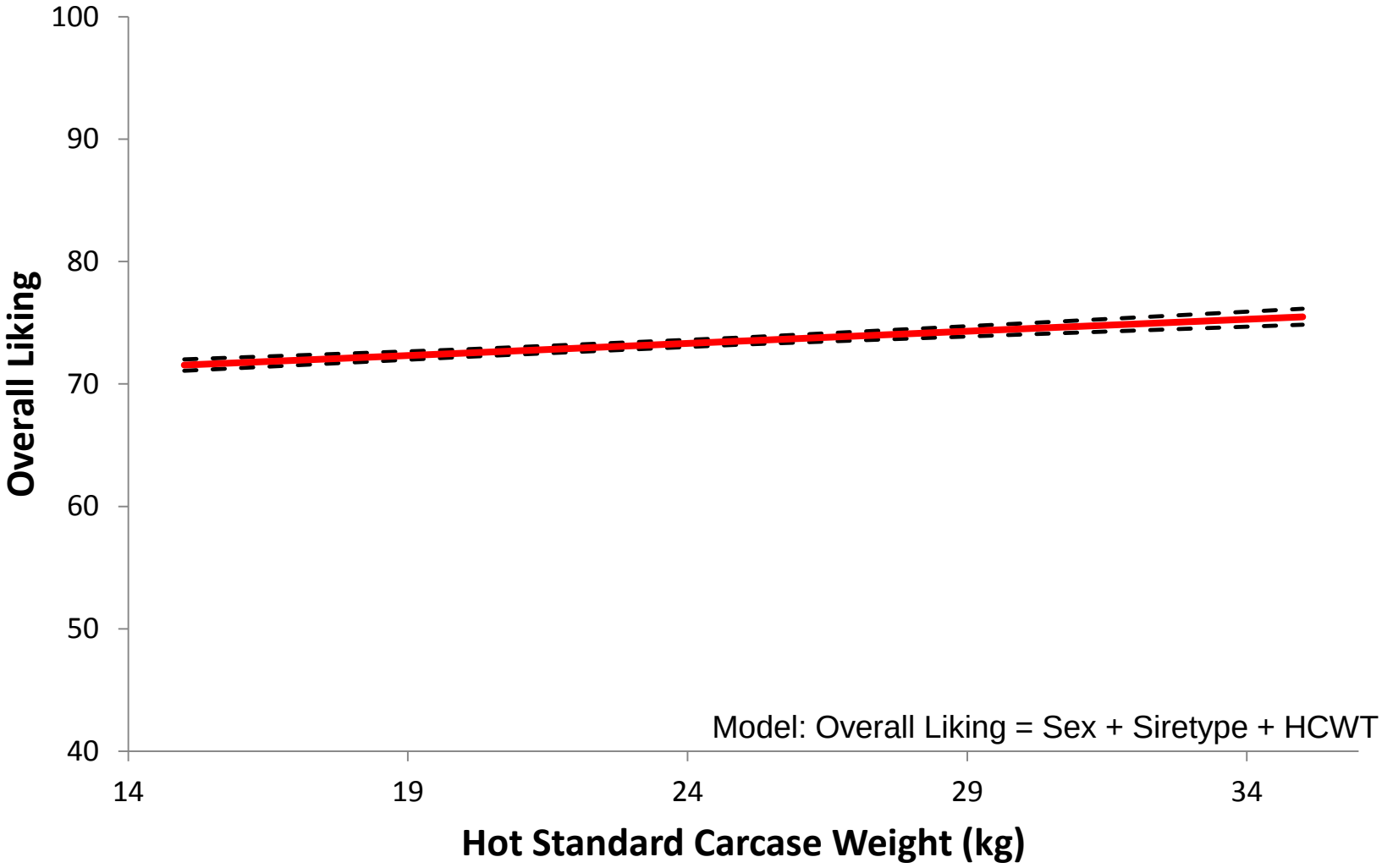
Loin Eating Quality and HSCW



mla MEAT & LIVESTOCK AUSTRALIA

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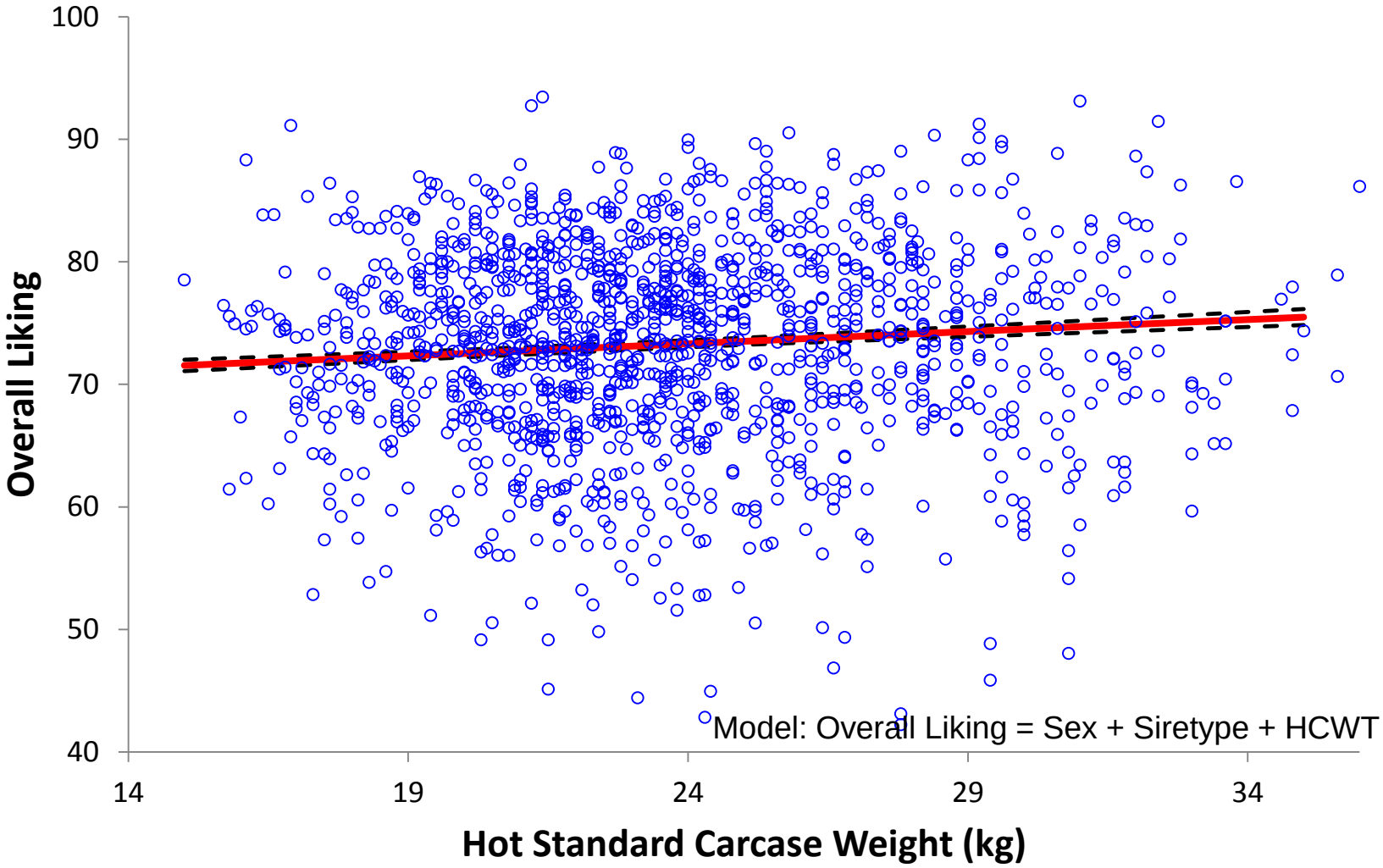
Loin Eating Quality and HSCW



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MEAT & LIVESTOCK AUSTRALIA
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Variability in these traits has a cost!

- Variability can be managed with…
  - carcase sorting (prior to fabrication)
  - cut sorting for cut size and EQ, assuming its traceable…

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Variability in these traits has a cost!

- Variability can be managed with…
  - carcase sorting (prior to fabrication)
  - cut sorting for cut size and EQ, assuming its traceable…

If we can predict it!

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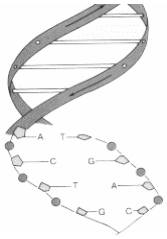
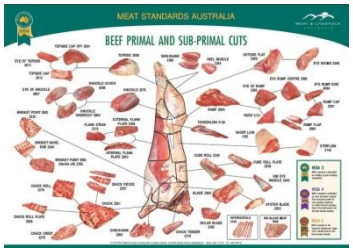
Precision measurement

from paddock/pen to plate

- Predict quality and amount of final product





Conception | Live Animal | Carcase | Retail Cuts | Cooked Product

Value | **Value** | **Value** | **Value**

Trading lacks transparency?

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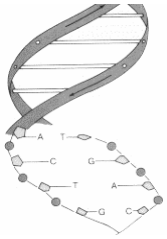
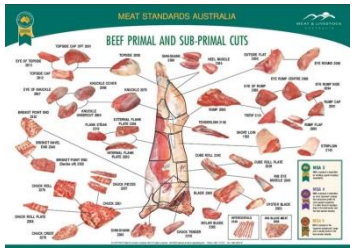
Precision measurement

from paddock/pen to plate

- Predict quality and amount of final product





Conception | Live Animal | Carcase | Retail Cuts | Cooked Product

Value | **Value** | **Value** | **Value**

Senate inquiry

Trading lacks transparency?

= political impetus for change!

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Australian Government

Department of Agriculture and Water Resources

Advanced Livestock Measurement Technologies

This project is supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit programme in partnership with Research & Development Corporations, commercial companies, state departments and universities

AMPC

AUSTRALIAN Pork

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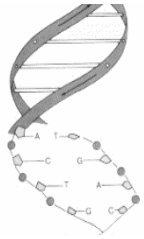
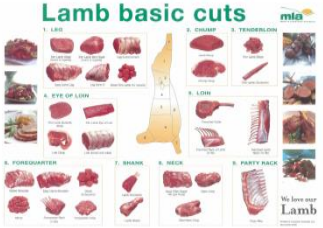
Precision measurement

from paddock/pen to plate

- Predict quality and amount of final product





Conception | Live Animal | Carcase | Retail Cuts | Cooked Product

Value | Value | Value | Value

LMY:

3D Imaging

DEXA

3D Imaging

Eating Quality:

Hyperspectral

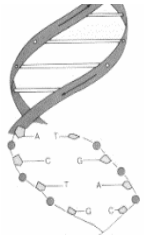
NIR

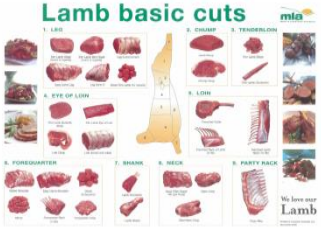
Synergy with Automation

Precision measurement

from paddock/pen to plate

- Predict quality and amount of final product





Conception | Live Animal | Carcase | Retail Cuts | Cooked Product

Value | Value | Value | Value

New Breeding Values

Systems to improve compliance

Price Grid

Enhanced Beef MSA

Benchmarking systems

Cut wt prediction systems

Enhanced Producer Feedback

Cuts-based Lamb MSA

Profit functions to optimise carcase use $

True value of the carcase

Carcase value ($)

=

Wt retail cuts (kg)

X

Value of the cuts ($/kg)

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Lean Meat Yield

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Technologies to predict LMY

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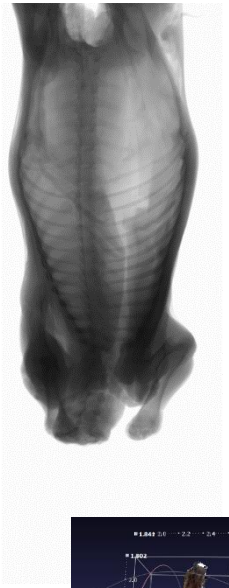
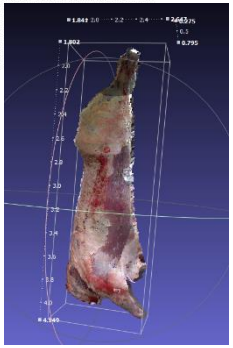


Hyperspectral camera

3D Imaging



Microwave

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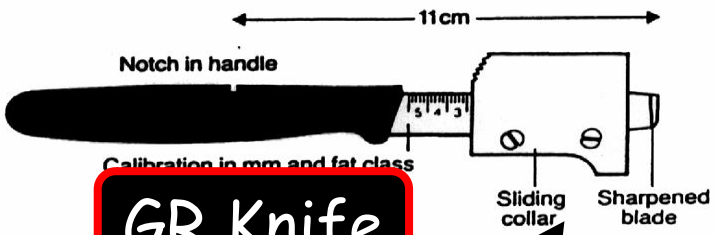
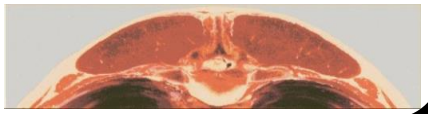
Point measures for prediction

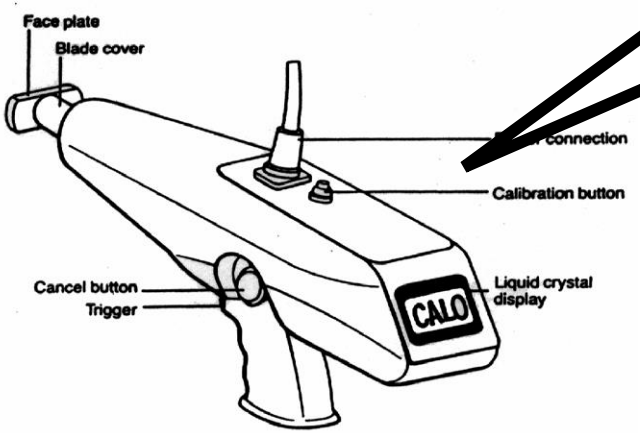
Ultrasound



GR Knife

Devices for yield measurement





Sheep Probe

Hyperspectral Camera

Redistribution of muscle

+ 5%

- 5%

Measured here!

PEMD

+8%

Anderson et al (2015). Meat Science 108:145–154.

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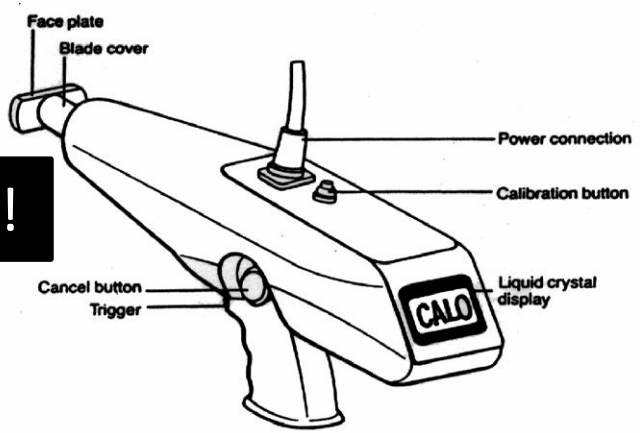
Redistribution of muscle

+ 5%

- 5%

Measured here!



+8%

Anderson et al (2015). Meat Science 108:145–154.

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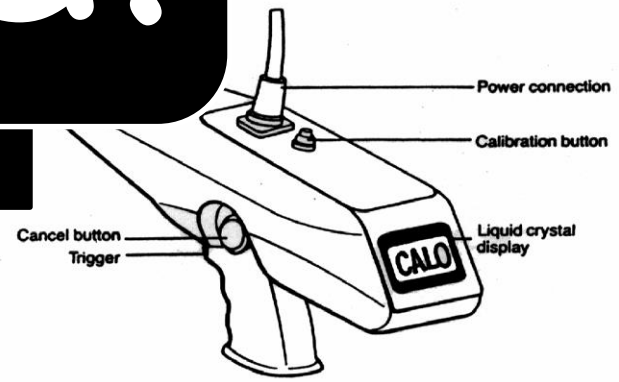
Redistribution of muscle

Biased!

+ 5%

- 5%

Measured here!



+8%

Anderson et al (2015). Meat Science 108:145–154.

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Need to move towards systems that measure whole carcase lean!

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DEXA

SCOTT®

JBS

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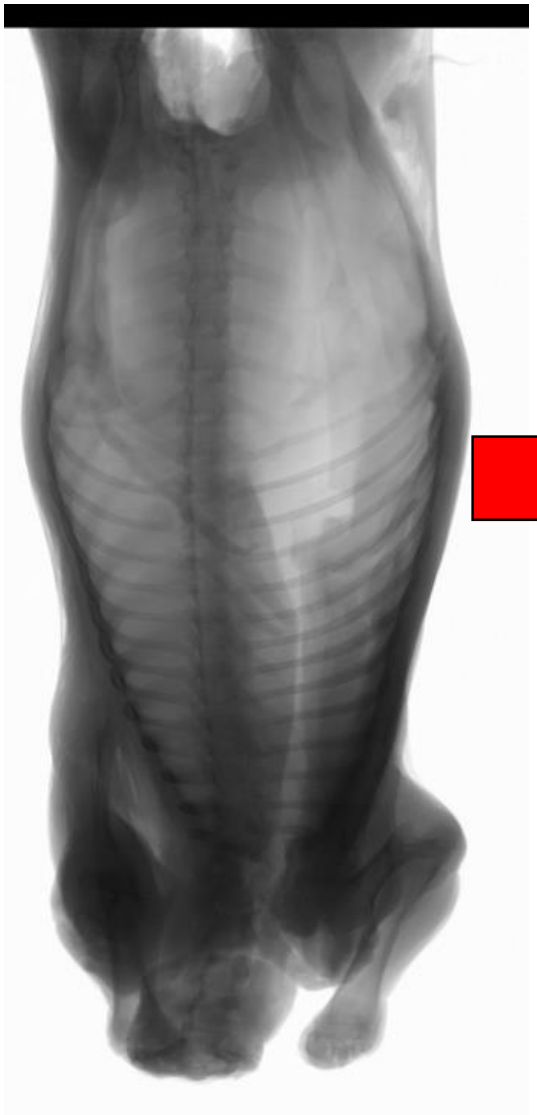
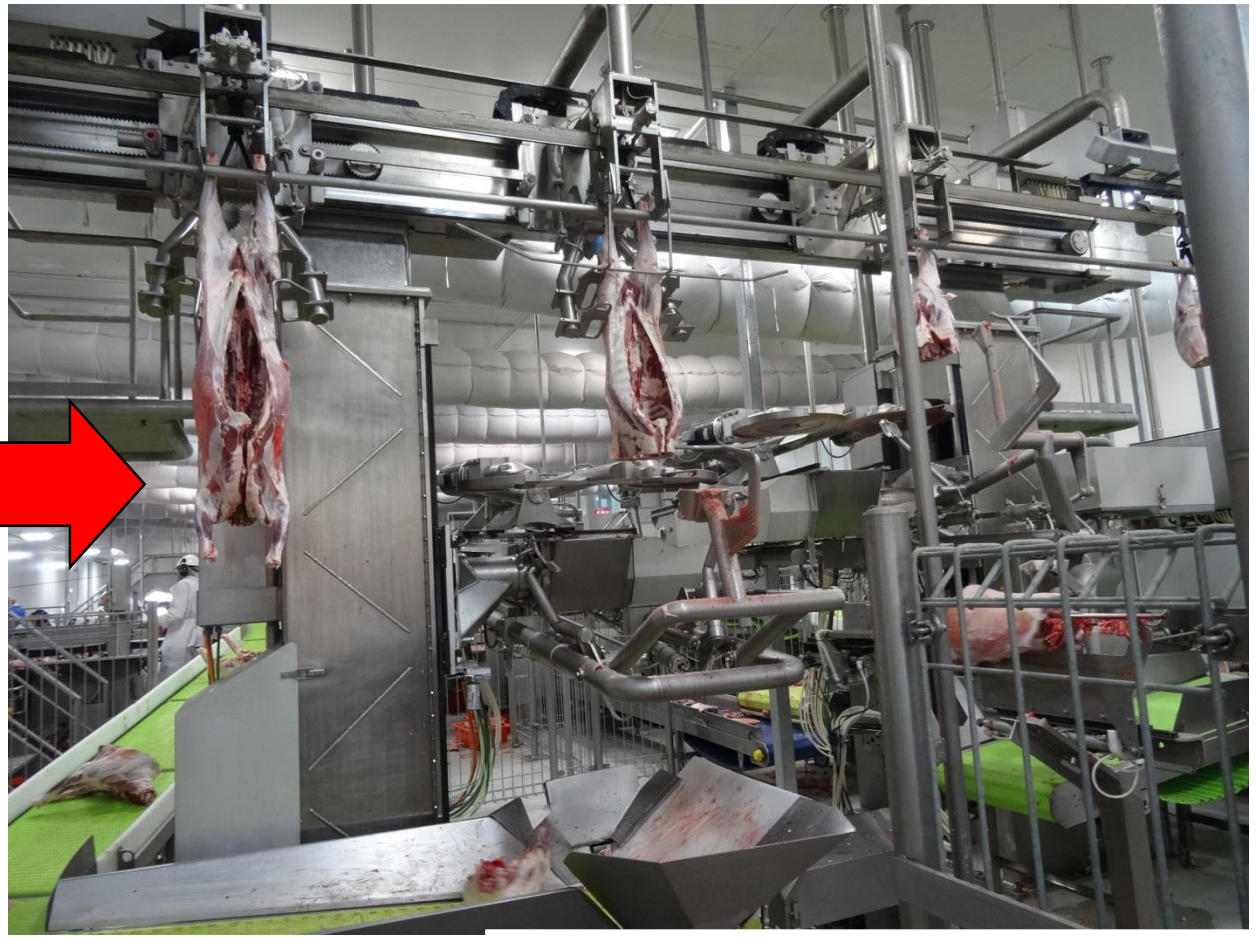
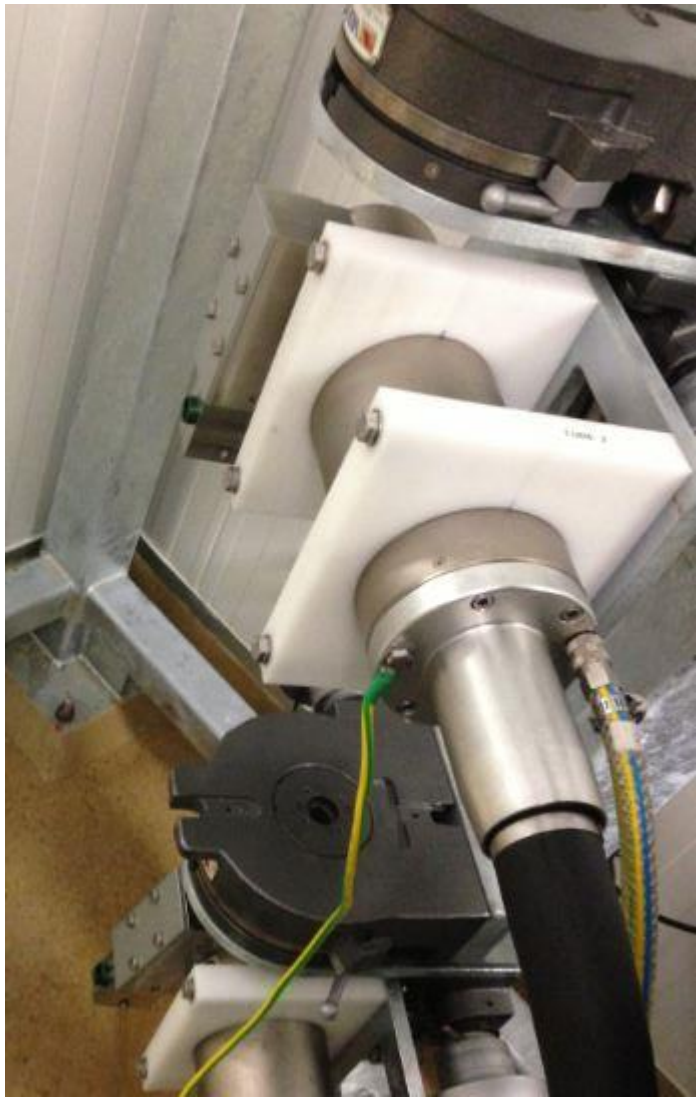
X-Ray for driving robots

SCOTT®

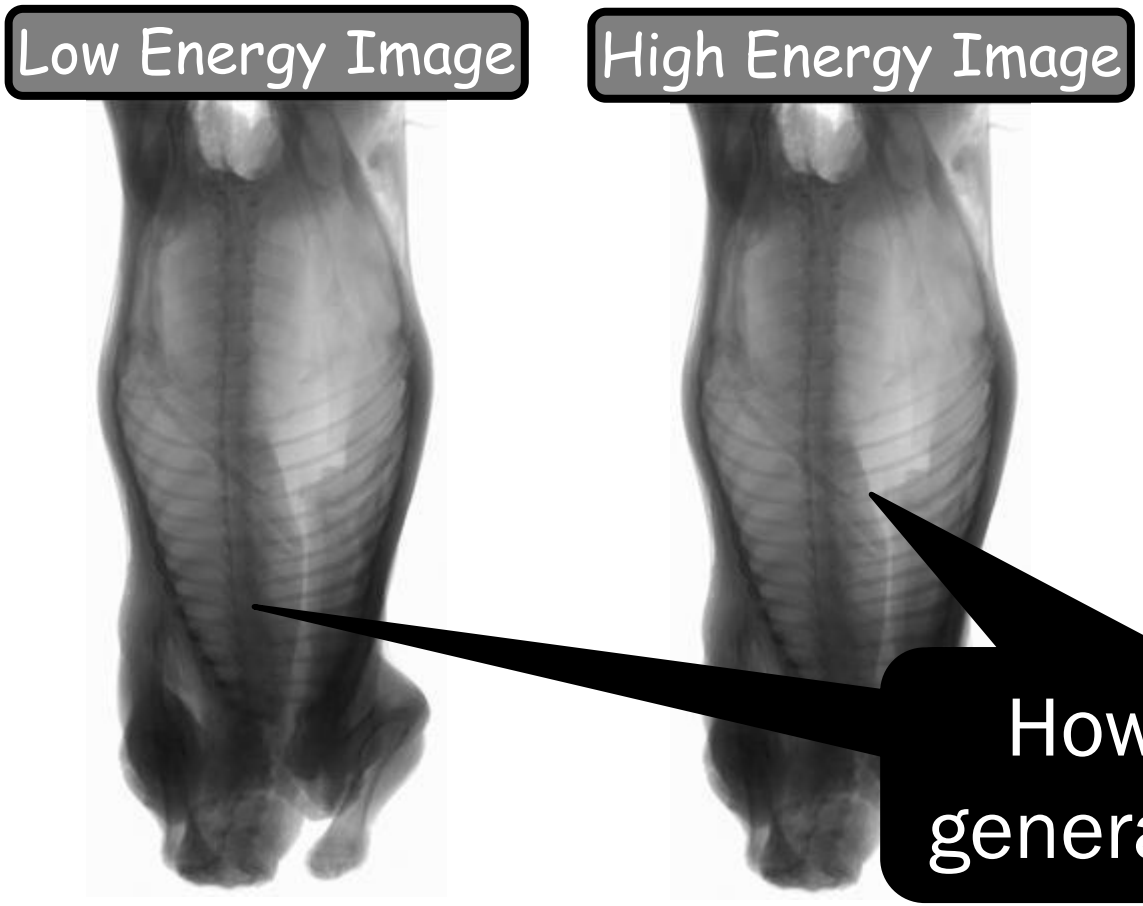




Adapt existing X-ray hardware



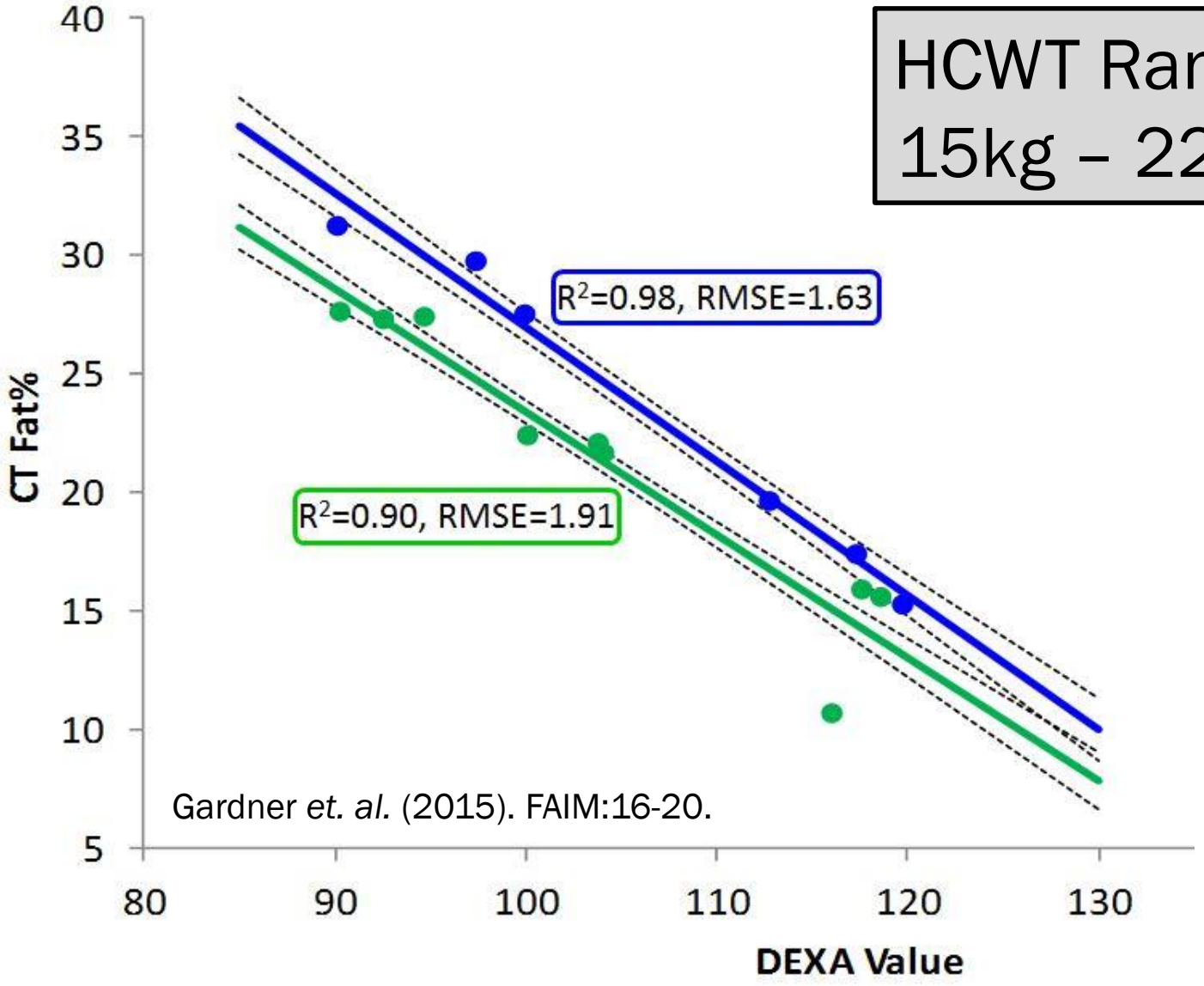
Dual Energy Images



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

NZ DEXA Results – Fat%

HCWT Range
15kg – 22kg



Gardner *et. al.* (2015). FAIM:16-20.

Calibration

To drive industry adoption of yield measurement and payment

1 Kirby Nucleus Flock

600 lambs

Agistment, SA

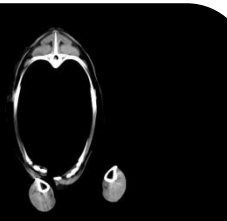
DEXA

JBS Bordertown, SA

400 lambs (24kg)

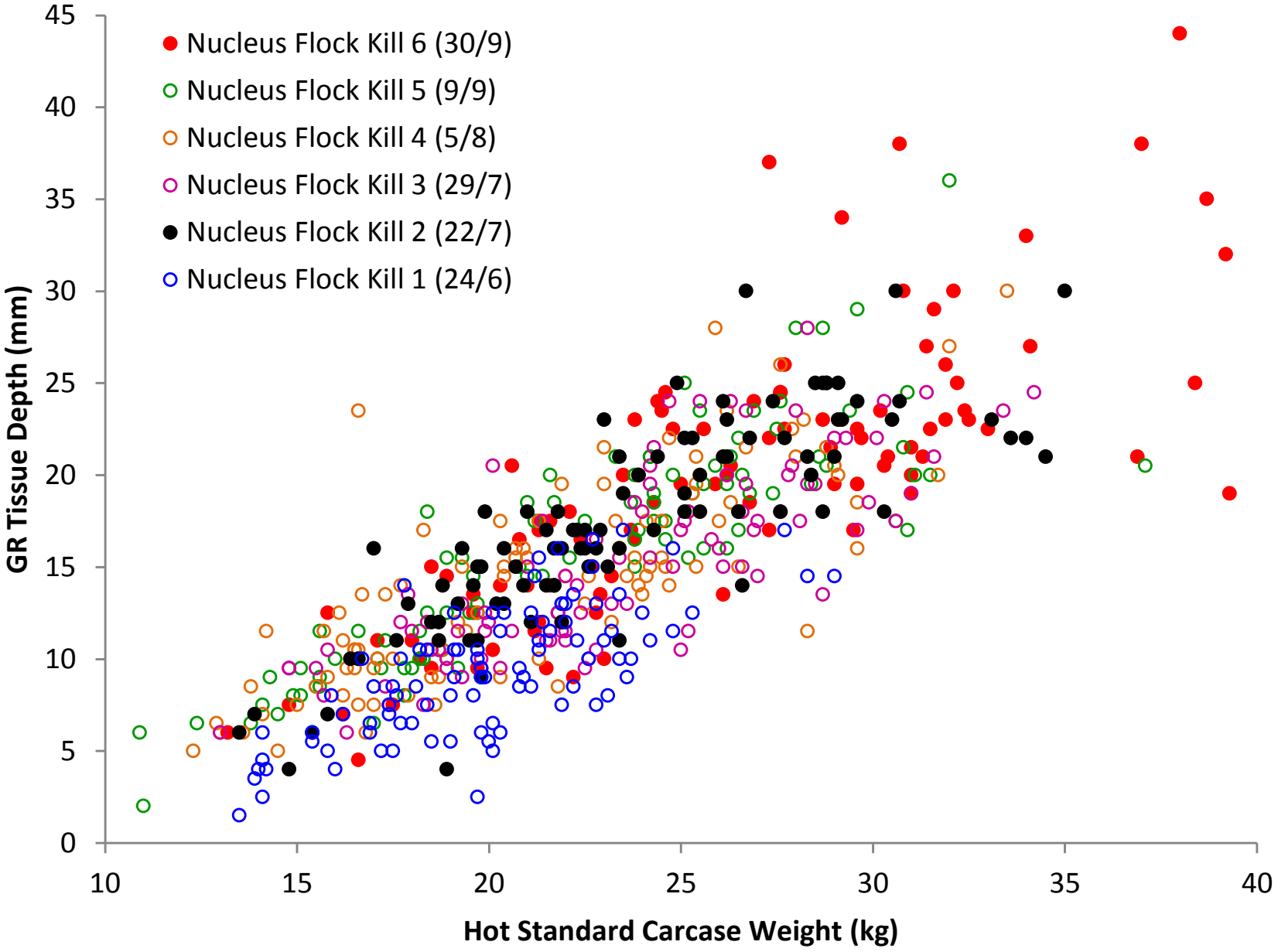
100 lambs (24kg)

100 lambs (29kg)

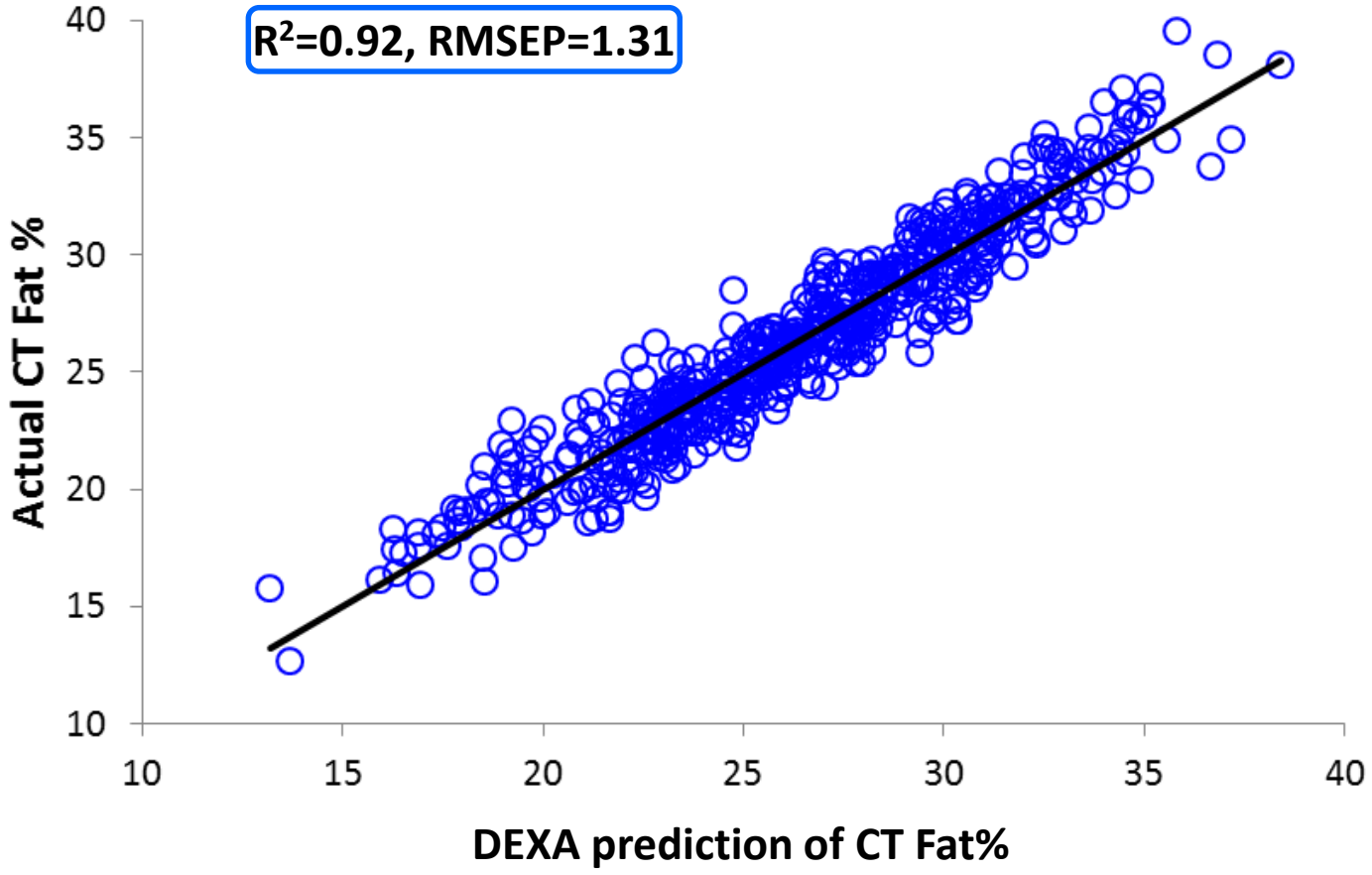


CT Scanning

Nucleus Flock/DEXA



DEXA predicting CT



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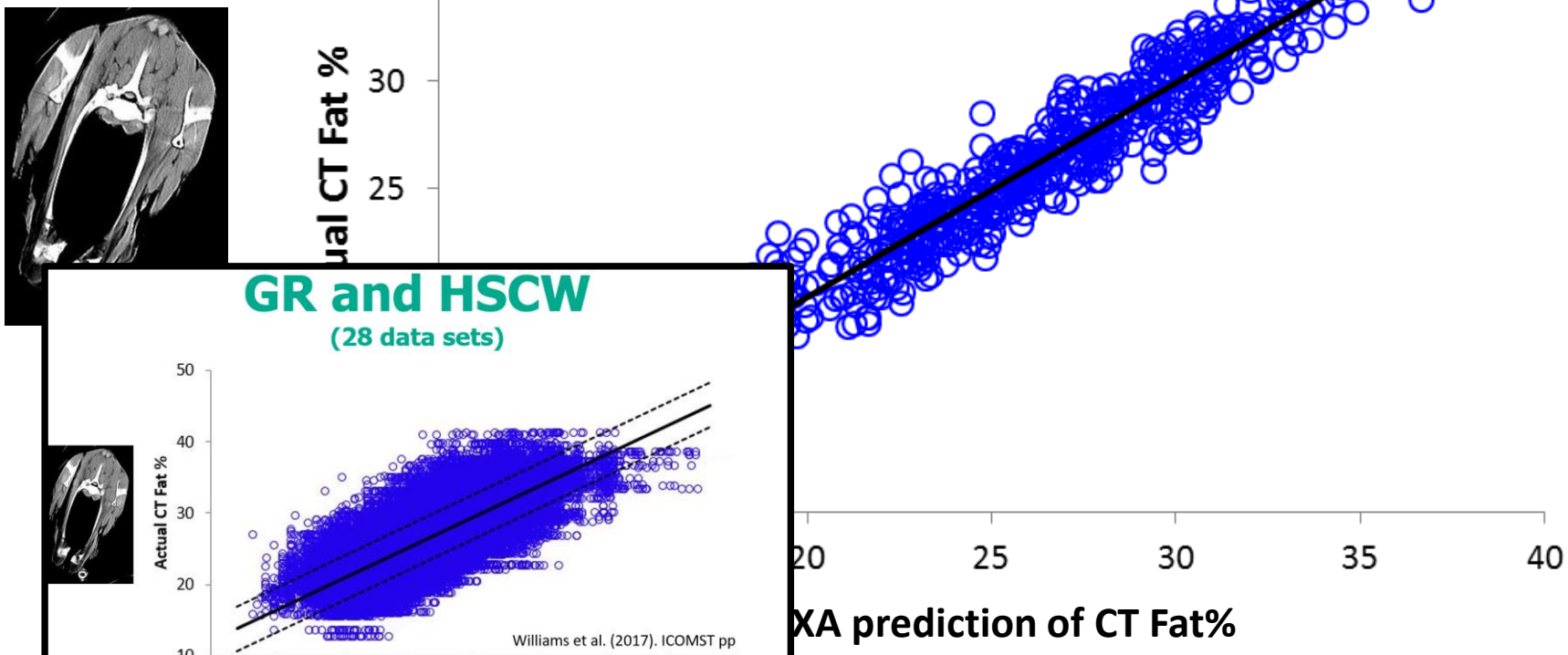
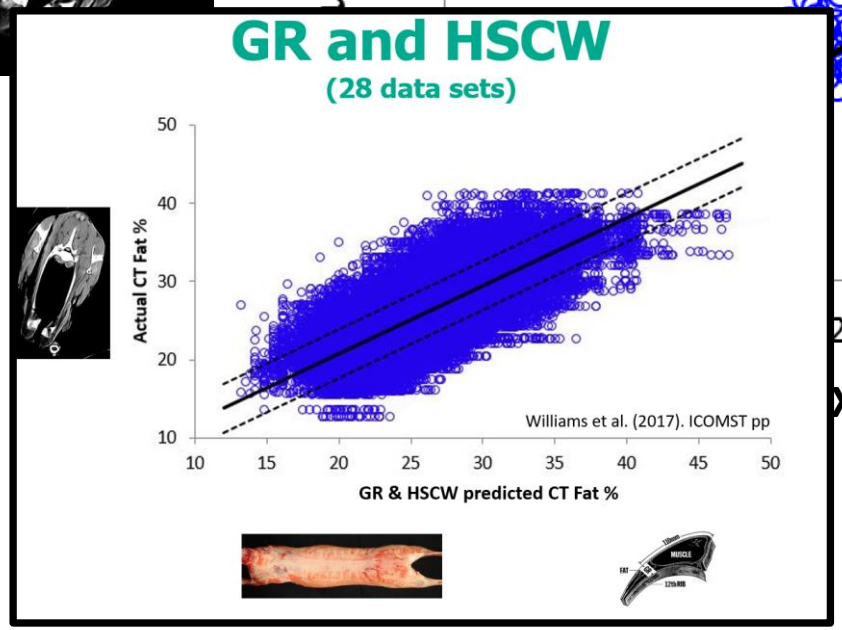
DEXA predicting CT





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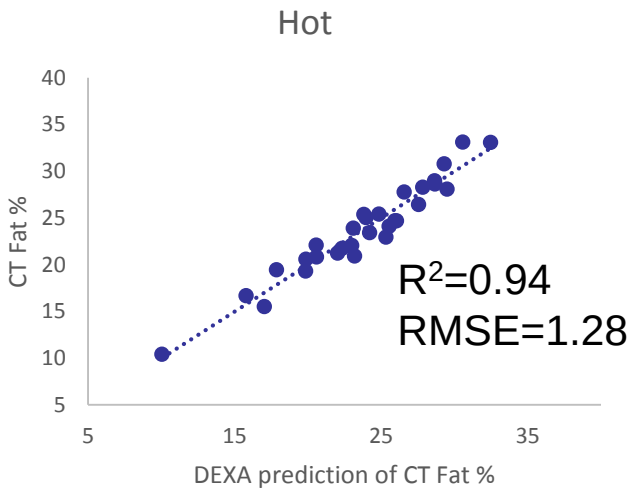
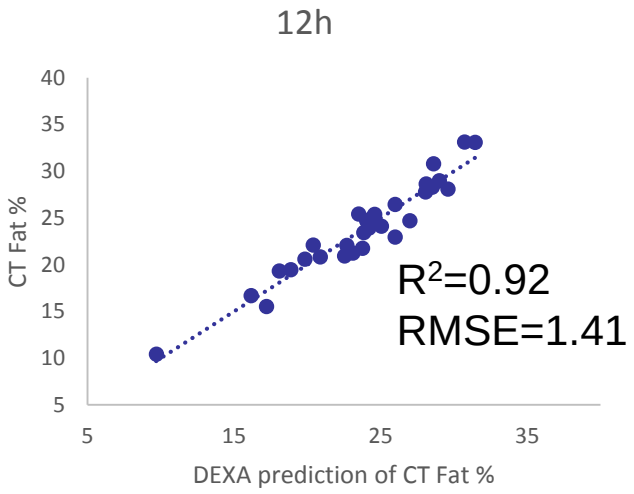
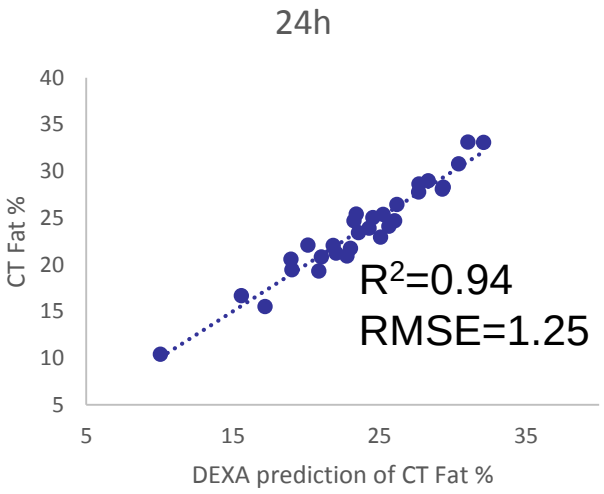
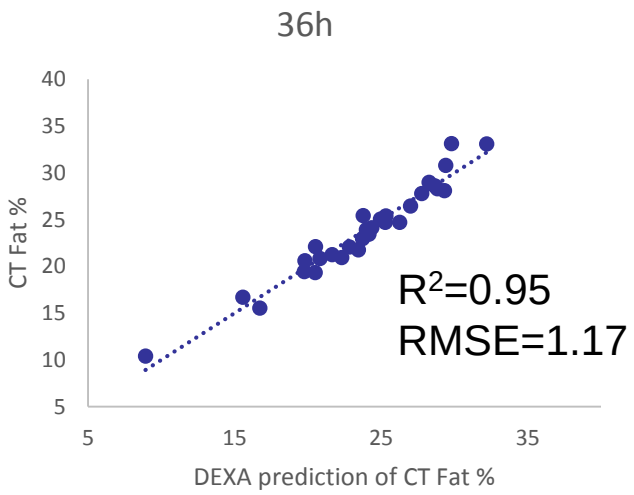
DEXA repeatability

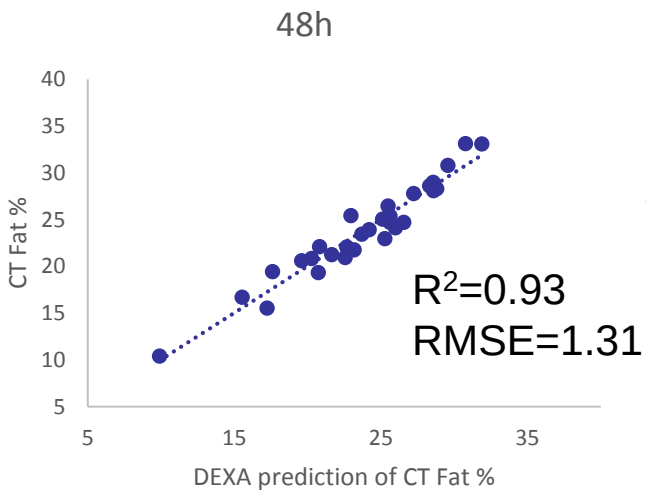
Carcases over time (72h)

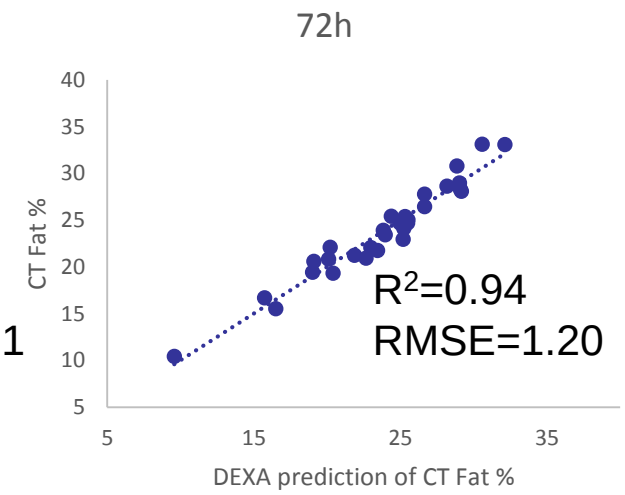






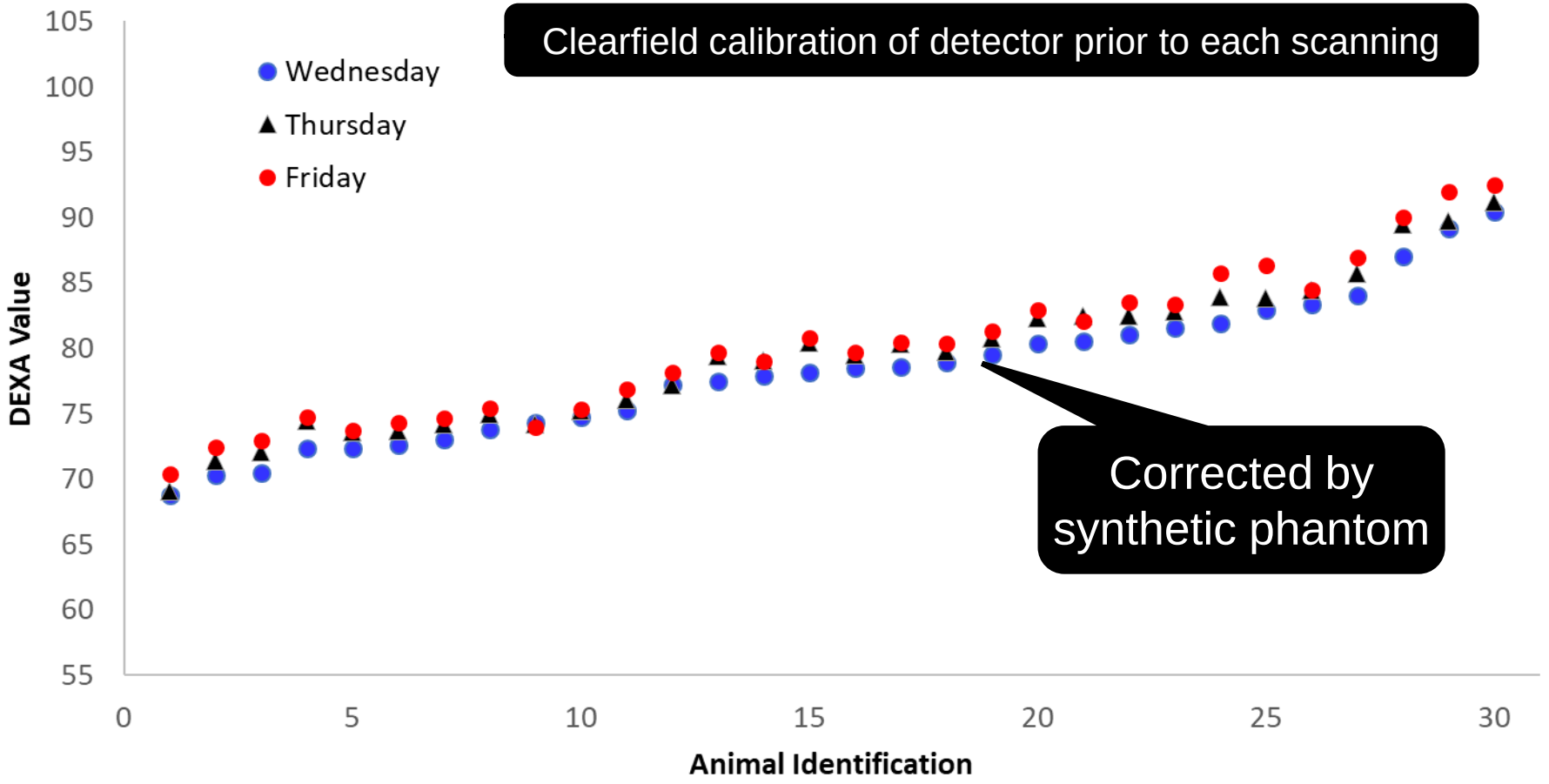






Repeatability

(30 carcases repeat scanned)



Influence of abattoir factors?

- Spray chilling
- Carcase orientation (180 degree turn)
- Carcase temperature
- Time post mortem (no Δ in precision)

Connaughton et al. (2018). ICOMST pp

Estimating cut weight using DEXA

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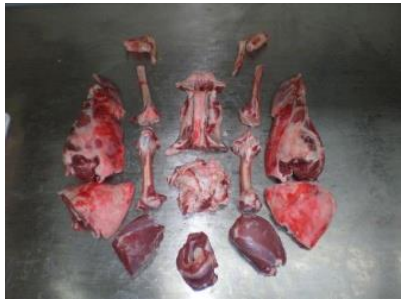
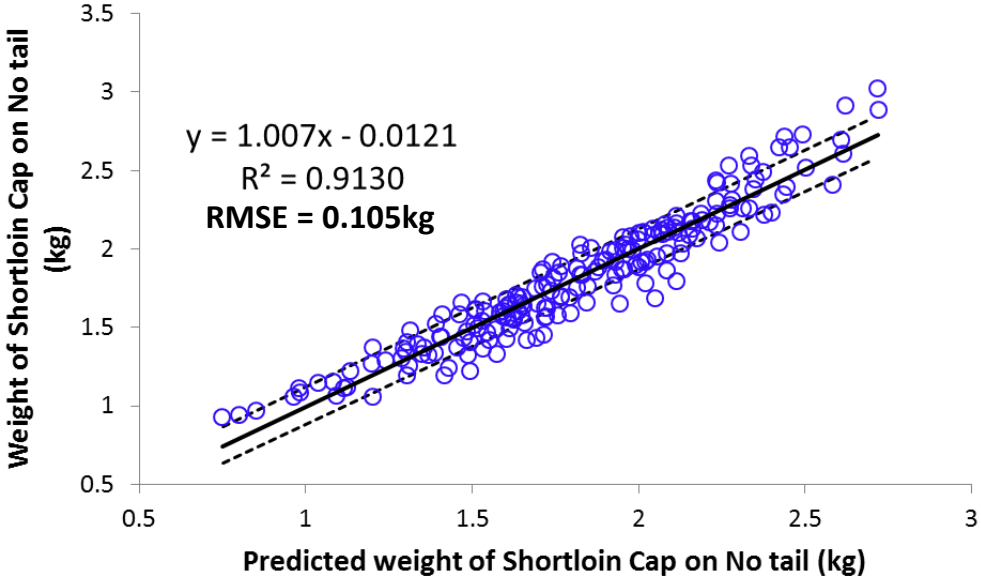
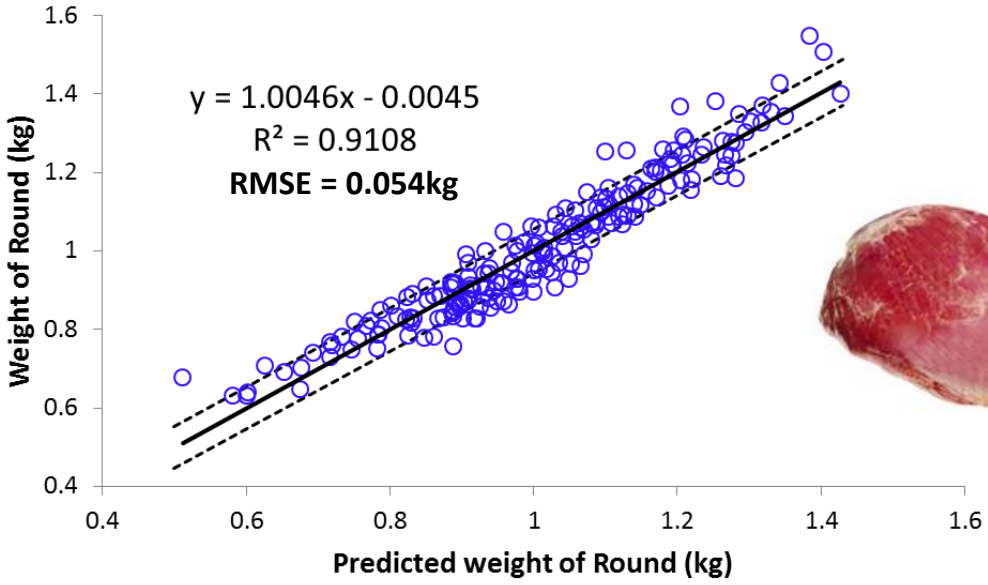
DEXA to predict cut weights



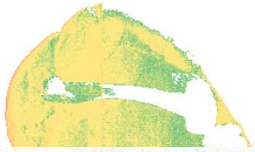
Predicting round & shortloin wt

using HCWT plus DEXAfat value





Carcase Calculator



Primal Weight Estimates

Trade: Over the Hooks. X-Breed Av. GR: 14.1mm Av. HCW: 23 kg Shrinkage: 2.5 %

Total Retail Valu	$221.54

Carcase Gross Prof	$35.55	16.0%

Back to Main Menu

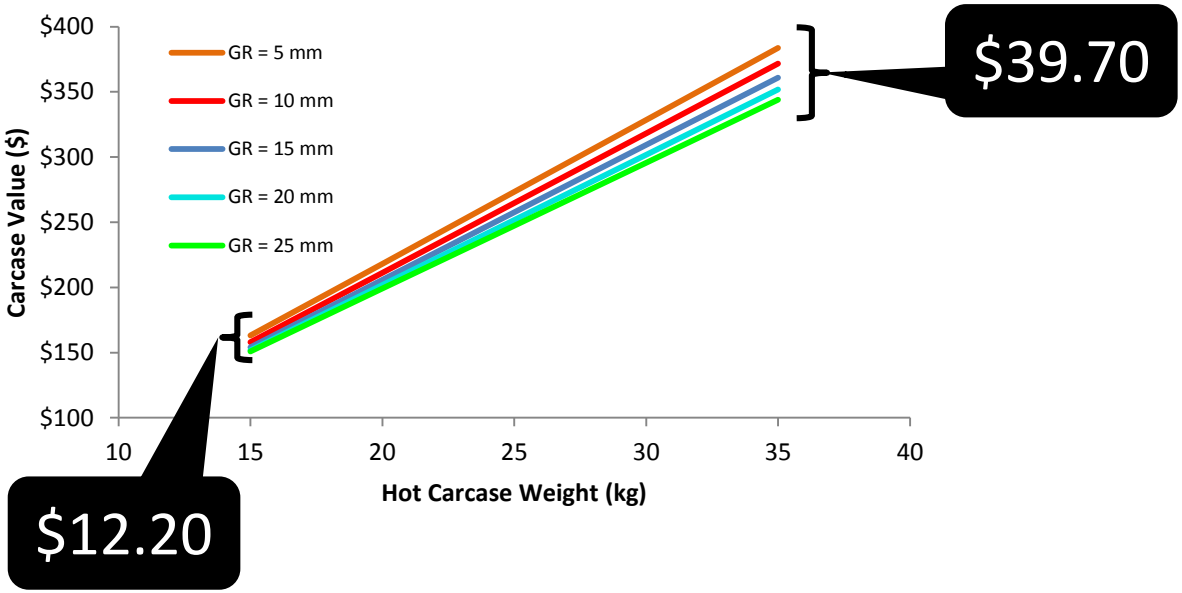
DEXA Lean Value = 52

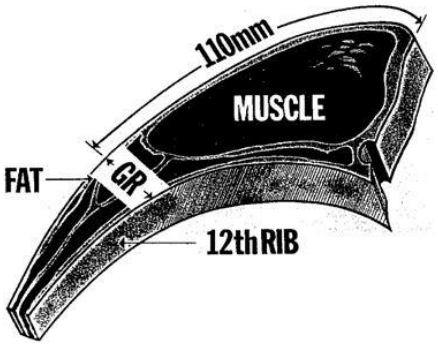
DEXA Lean Value = 48

DEXA Lean Value = 59

	Weight Kg	Weight Kg	Weight Kg	Weight Kg
Forequarter 4 Rib	Square Cu Shoulder Wholesale			Eye of Shoulder 0.349
				Boneless Shoulder 2.140
	Fore shank not tipped	Fore shank Tipped		Fore shank Trim 0.787
	Breast			Breast Trim 0.197
	Neck	Trimmed Neck		Neck Meat 0.325
Loin	Short Loin		Short Loin No Tail	Eye of Shortloin 0.726
				Tenderloin Butt 0.165
	Rack (8 Rib) 75 mm tail	Rack Trimmed (6mm trim)	USA Rack Cap Off (8 Rib) Frenched 50mm	Eye of Rack 0.625
	Flap	Boneless Flap (untrimmed)		Trimmed Boneless Flap 85cl 1.461
Leg	Leg Chump Tipped (6		Boneless Leg Chump on Shank Off	Topside 1.254
				Round 0.915
				Silverside 0.497
				Rump 0.524
				Butt Tenderloin 0.119
Total Lean 0.979			Hind Shank B/I	Hind Shank B/O 0.687

What does extra precision mean for the carcase calculator?





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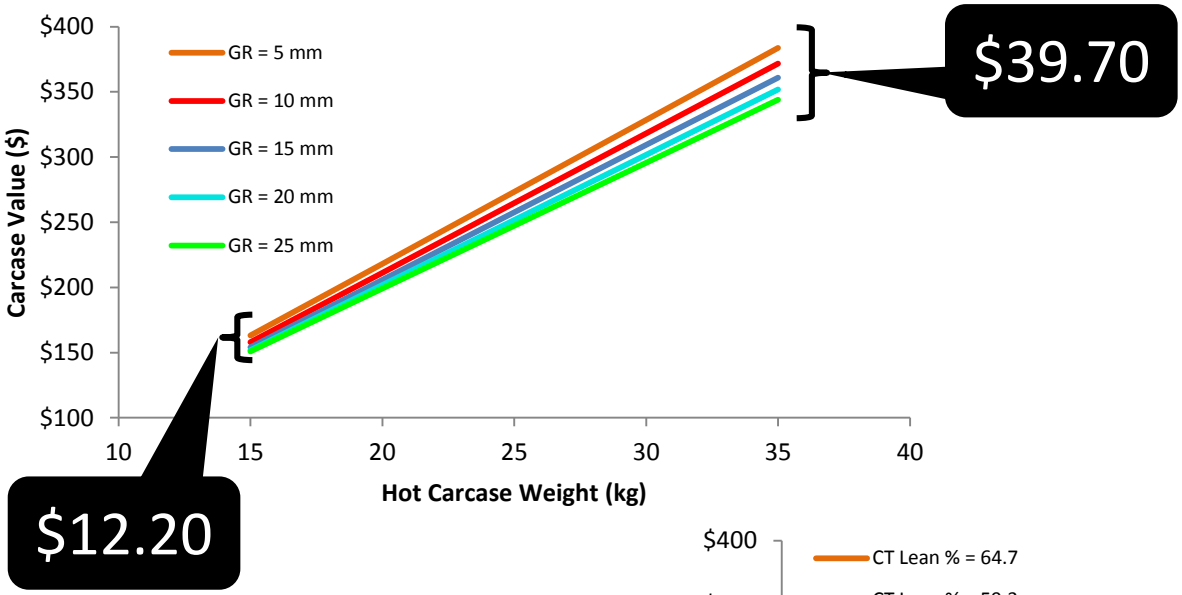
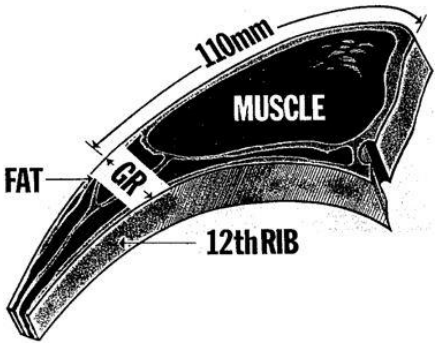
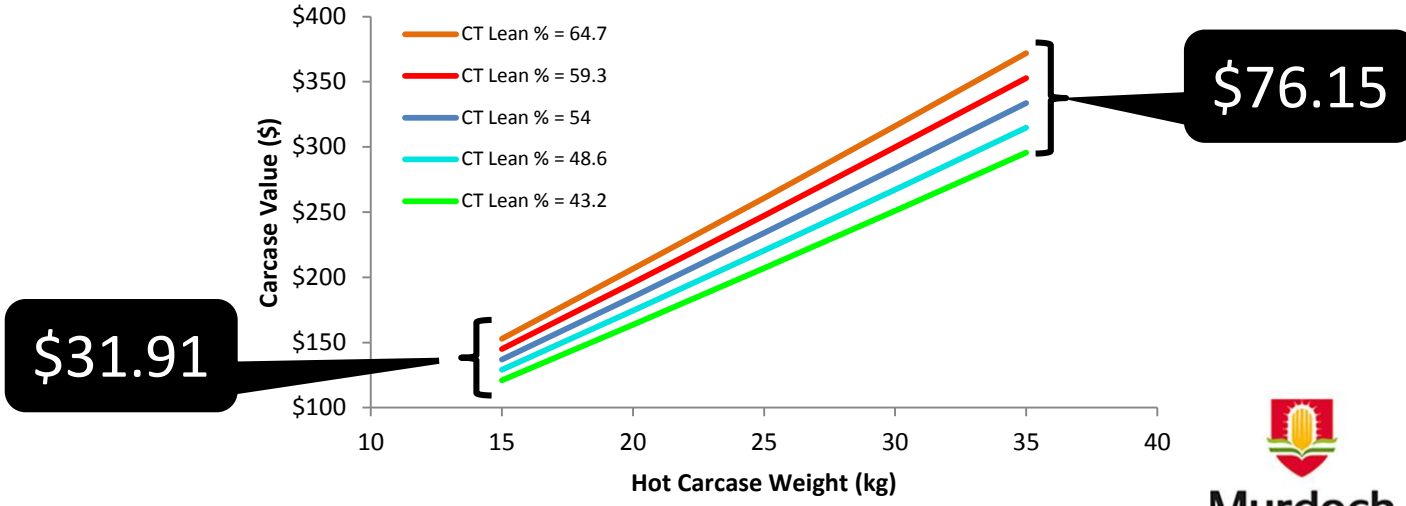
What does extra precision mean for the carcase calculator?







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Optimise carcase usage

Wt & DEXA & EQ

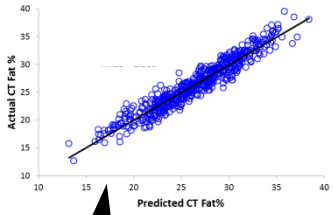
Bone out cost

Cut Retail Values

Grid Ref - Week:		7												Valid For Kills: 24/2/14-28/2/14
XB Lambs														
Grade	Fat mm	Dent	-14	14.1-16.0	16.1-18.0	18.1-20.0	20.1-22.0	22.1-24.0	24.1-26.0	26.1-28.0	28.1-30.0	30.1-32.0	32+
S1	0 - 5	0	$1.30	$2.10	$3.30	$4.70	$4.70	$4.70	$4.70	$4.70	$4.70	$4.70	$4.20
S2	6 - 10	0	$1.60	$2.40	$3.60	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$4.50
S3	11 - 15	0	$1.60	$2.40	$3.60	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$4.50
S4	15 - 20	0	$1.60	$2.40	$3.60	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$4.50
S5	20 +	0	$1.60	$2.40	$3.60	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00	$4.50

Cut wt by retail value

Adj for cut market volume

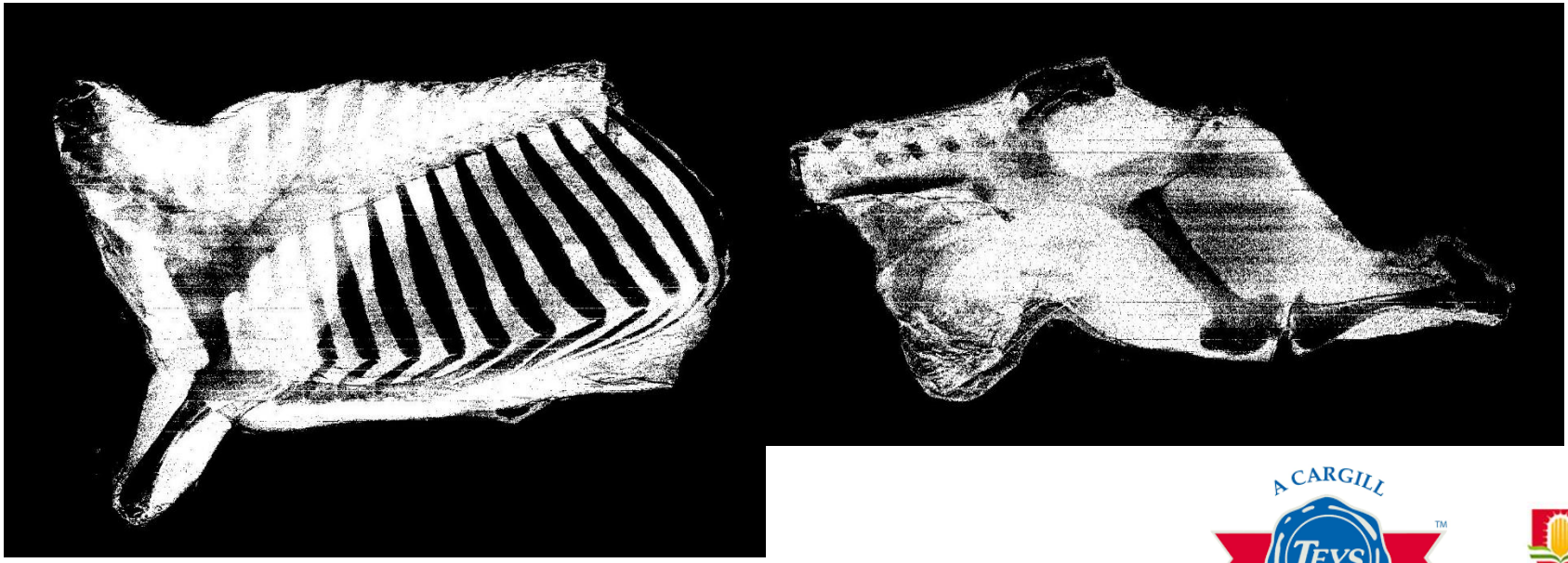


Characterise carcase grades

Optimised profit

Carcase descisions to optimise profit

Beef DEXA



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A CARGILL TEYS AUSTRALIA JOINT VENTURE

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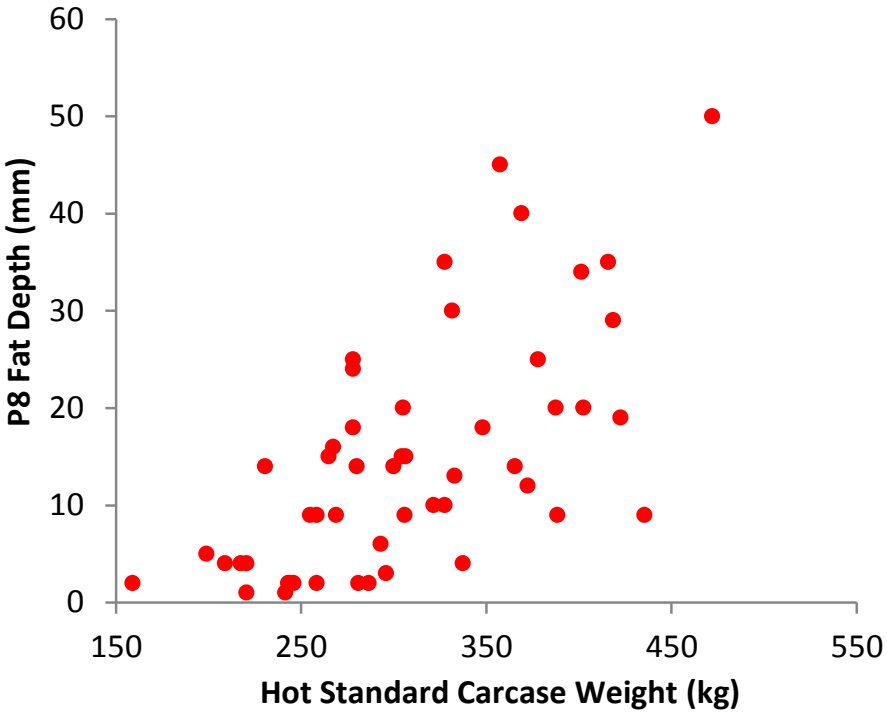
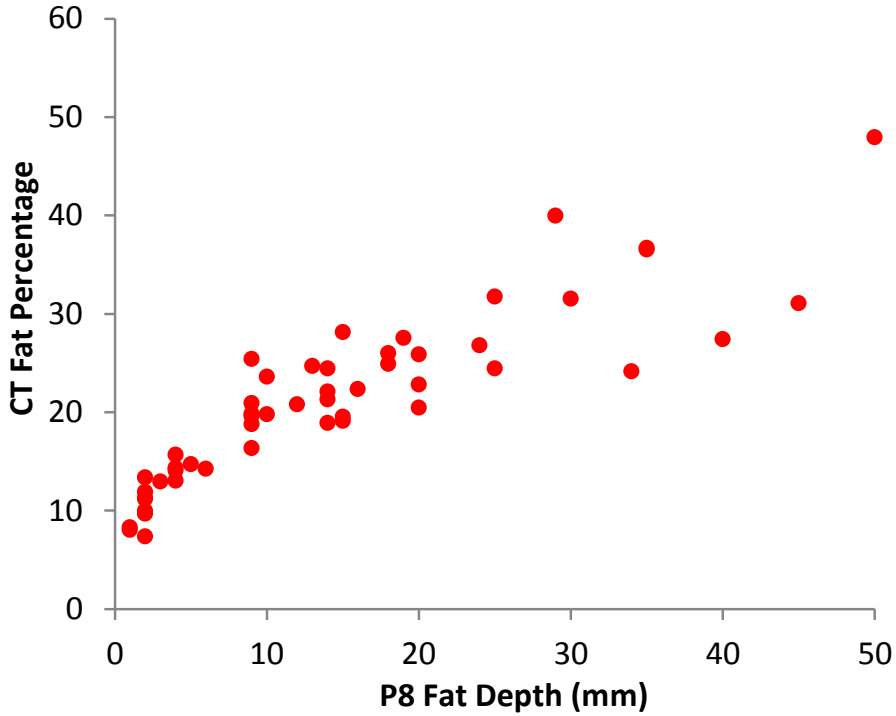
Beef DEXA– Carcase Data





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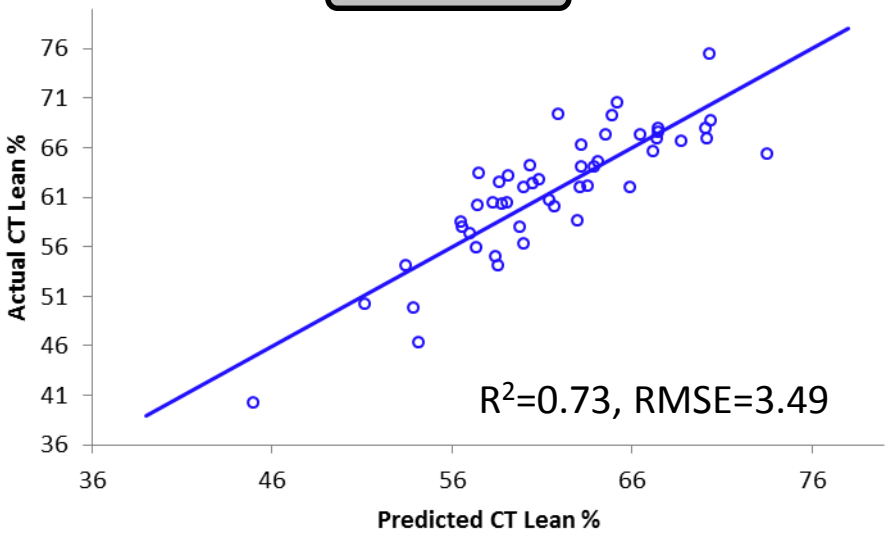
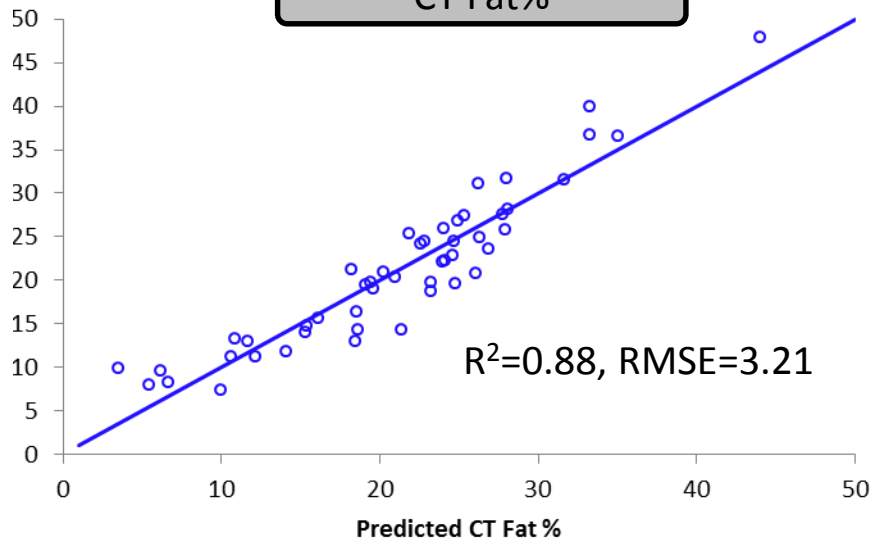
Predicting CT composition in Beef

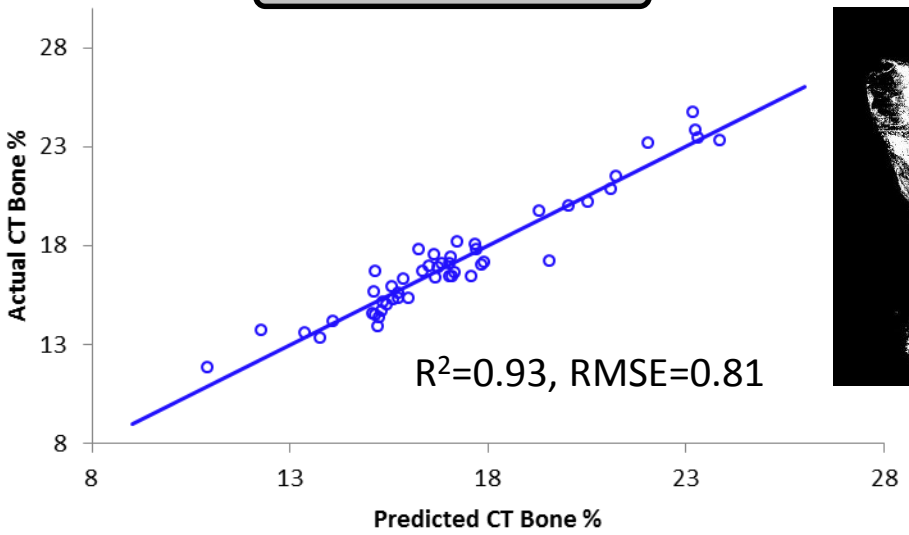
CT Lean%

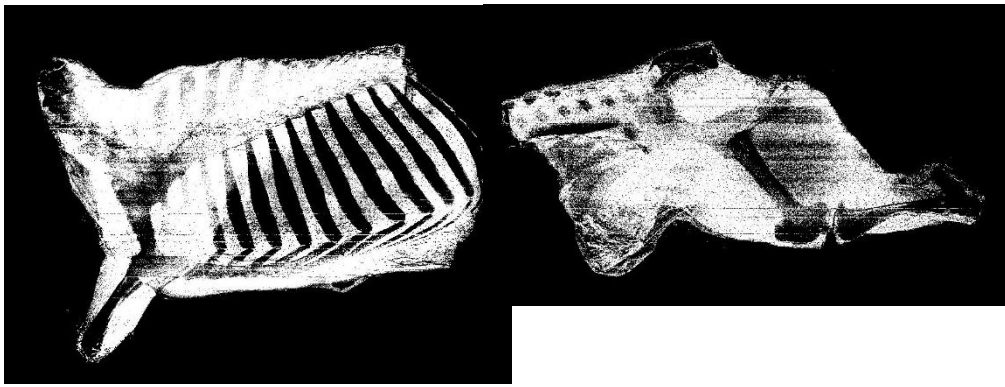


CT Fat%



CT Bone%





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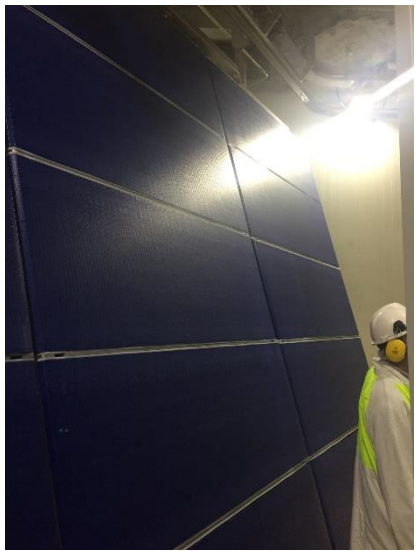
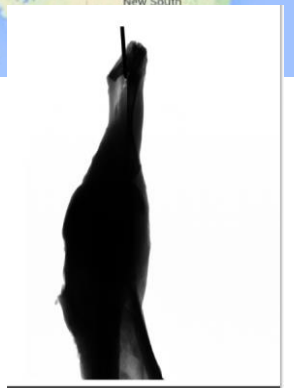
Beef DEXA: Teys Rockhampton

- Hardware adapted from lamb
  - 2 tubes, 2 detectors
  - Sides scanned separately
- Calibration work commenced
- CT in 2019





Is DEXA relevant to MSA?

MEAT STANDARDS AUSTRALIA GRADED

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Is DEXA relevant to MSA?

Meat Standards Australia eating quality model

Description	Format	Name	Input	?
Estimated % Bos Indicus	% or X if doubt	EPBI	0	
Animal Sex Type	M/F	Sex	F	
mone Growth Promotent	Y or ? / N	HGP	n	
MilkFedVealer	Y/N	MFV	n	
SaleYard	Y/N	SIYrd	n	
Rinse/Flush	Y/N	RnFl	n	
Hot Std Carcase Weight	Weight in Kg	HSCW	350	
HangMethod	T/TS/TL/TC/XT	Hang	at	
Hump Height	mm	Hump	63	
Ossification USDA	USDA measure	uoss	290	
Marbling USDA	USDA measure	umb	300	
bFat	mm	RbFt	10	
pH	Metered pH	UpH	5.5	
de	Metered Temp C	Utmp	9	
Days of ll	Days Aged	Age	5	

Aged

cut	muscle	GRL	RST	SFR	TSL	SCT	CRN
spinalis	SPN081	79	69	79	75		
tenderloin	TDR034	82		76			
tenderloin	TDR062	78	77	80	74		
tenderloin	TDR063	73					
cube roll	CUB045	62	62	62	64		
striploin	STA045	55	56	58	58		
striploin	STP045	53	54	57	57		
oyster blade	OYS036	67	64	69	72		
blade	BLD095			43			
blade	BLD096	53	57	58	59	59	
chucktender	CTR085		49	51	53	59	
rump	RMP131	51	59	56	62	54	
rump	RMP231	54	62	61	60		
rump	RMP005	59		67	67		
rump	RMP032			64	68		
rump	RMP087		52	57	55	56	
knuckle	KNU066	46	59	54	58	47	
knuckle	KNU098			54	59	56	
knuckle	KNU099	36	47	44	51	52	
knuckle	KNU100			60	62	55	
outside flat	OUT005		40	43	56	59	52
outside flat	OUT029			54	61	55	
eye round	EYE075	40	44	42	45	46	45
topside	TOP001	39		51	53	50	
topside	TOP033	40		53	58	60	
topside	TOP073	34	43	43	56	52	
chuck	CHK068			48	53	65	
chuck	CHK074	63	56	61	67	72	
chuck	CHK078	56	57	58	62	69	
chuck	CHK081			60	64	75	
chuck	CHK082			52	56		
thin-flank	TFL051			58		58	
thin-flank	TFL052			67	59	64	
thin-flank	TFL064			61	58	60	
rib-blade	RIB041			48			
brisket	BRI056			44	58	60	38
brisket	BRI057			41	49	64	
shin	FQshin					57	
shin	HQshin					60	
intercostal	INT037			57			

Yield indicators

Carcase Wt

IMF

Rib Fat

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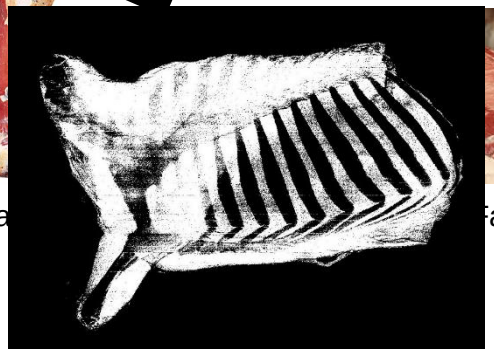
Is DEXA relevant to MSA?

Computed Tomography
"the gold standard"

Yield indicators



Carca fat

DEXA

ards Australia eating quality model

ne	Input	?
Bl	0	
x	F	
P	n	
V	n	
xd	n	
	n	
	350	
	at	
	63	
	00	
lb	300	
Ft	10	
bH	5.5	
tmp	9	
Days of	Days Aged	Age 5

Aged

CT as calibrating standard

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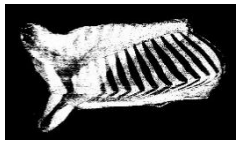
CT as calibrating standard

A common trait for all devices



DEXA

Predict

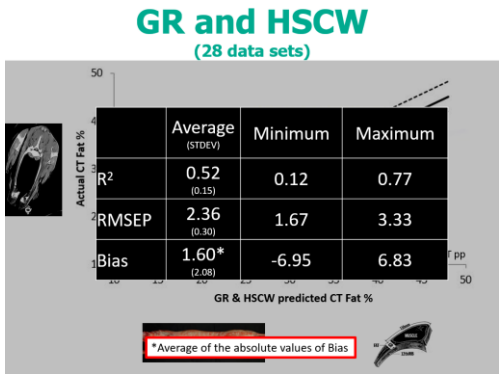
3D imaging

Predict

VIAScan

Predict

Validate



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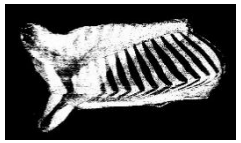
CT as calibrating standard

A common trait for all devices



DEXA

Predict

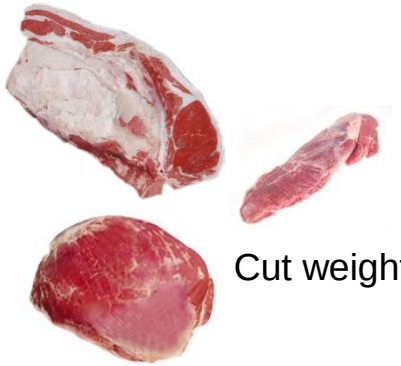
3D imaging

Predict

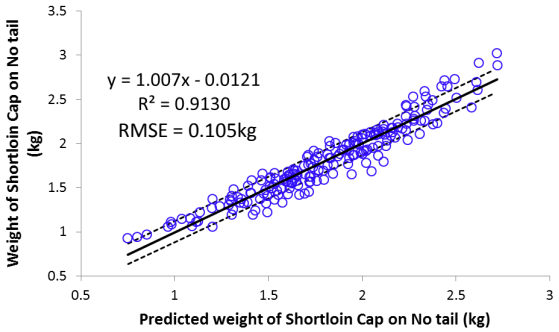
VIAScan

Predict

Validate

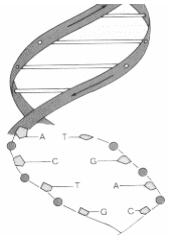


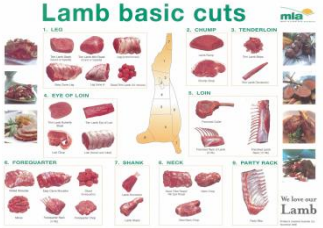
Cut weights



CT as the calibrating standard

- Supply chain information

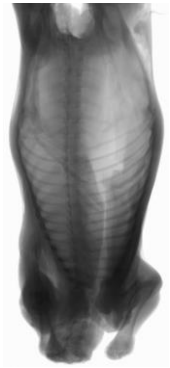




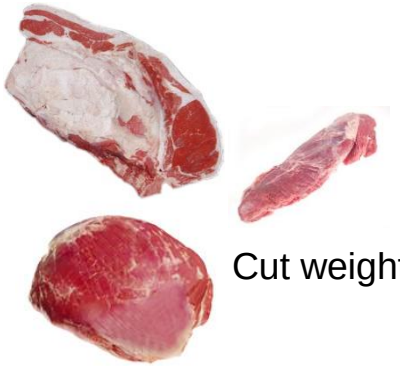
Conception — Live Animal — Carcase — Retail Cuts — Cooked Product

Value — Value — Value — Value

Wt of carcase
bone, muscle, fat



DEXA



Cut weights

Conclusion

- Existing carcase measurement is poor
- ALMTech will accelerate development
  - Beef, lamb, pork industries
- Integrative systems to use DEXA info
- DEXA lamb carcase composition
- Beef DEXA promising

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Supporting partners

Australian Government

Department of Agriculture and Water Resources

Rural Research and Development for Profit Programme

Keeping Australian farmers at the cutting edge

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Keeping Australian farmers at the cutting edge

Radiation mitigation

In people?

- We get ~ 3mSv per year via 'background' radiation
  - + 1.5 at higher altitude
  - + 0.05 for a flight across Australia
- Human DEXA scan delivers ~ 0.001 mSv (equiv 3 hrs!)
- Continuous exposure?
  - Lead shielding in walls of the tunnel

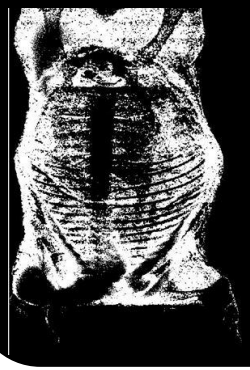
In food?

- Food Irradiation – safe & effective
  - FSANZ code – >1 kGy fruit, >30 kGy herbs & spices
  - Irradiation of imported foods (DAWR)

Australian Government
Department of Agriculture and Water Resources

Rural Research and Development for Profit Programme
Keeping Australian farmers at the cutting edge

Industry led initiative



MEAT & LIVESTOCK AUSTRALIA

Project 150

DEXA into 90 beef/lamb abattoirs

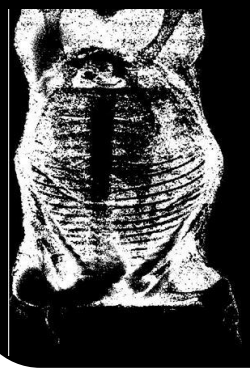
Producer Rep.s

Processor Rep.s

Industry led initiative

Auditor

Regulator



Project 150

DEXA into 90 beef/lamb abattoirs

Industry calibration working group

Objective Measurement Taskforce

Producer Rep.s

Processor Rep.s

Auditing
DEXA

Murdoch
UNIVERSITY

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Sets air attenuation at **4095**

Acquire images

Low energy

High energy

Clearfield

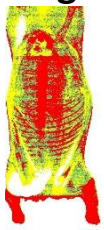
Air_{Atten}

Calc. R values

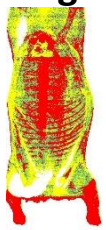
$$R = \frac{\ln(I_{Low}/Air_{Atten})}{\ln(I_{High}/Air_{Atten})}$$

Adjust for Synthetic Phantom

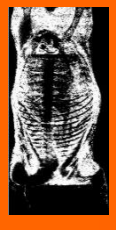
Calibrated Image



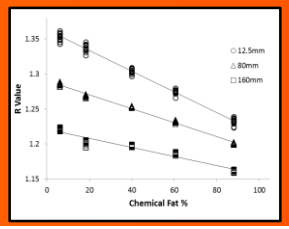
Calibrated Image



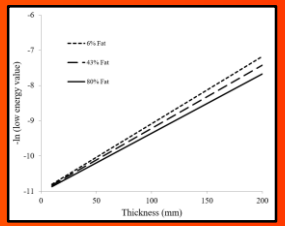
Threshold bone



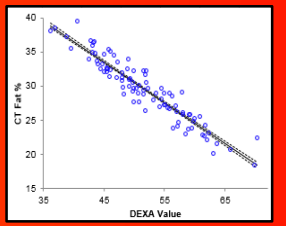
Convert to Tissue%



Wt'd pixel depth



Convert to CT lean, fat, bone



Company Specific Algorithm

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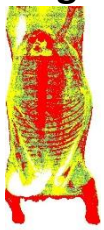


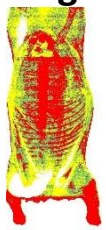
Calibration point

AUS-MEAT Limited Auditor

Synthetic Phantom

Routine auditing ensures calibrated image

Calibrated Image



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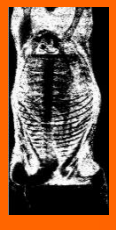

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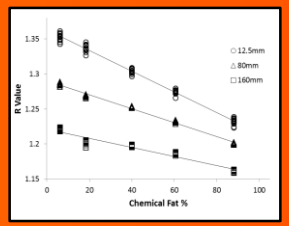
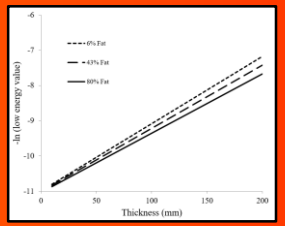


Wt'd pixel depth



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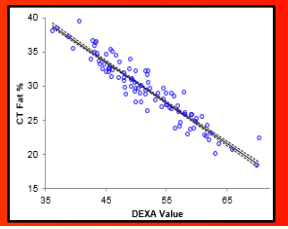

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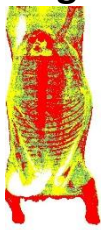
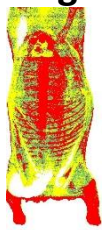


CT validation required when:

1. New DEXA hardware
2. Altered company algorithm
3. Disputes

Calibration point

Calibrated Image



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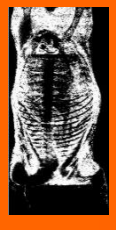

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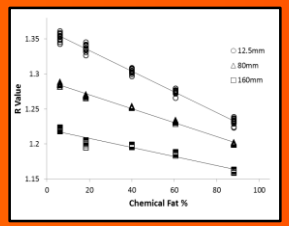

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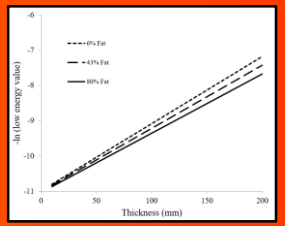

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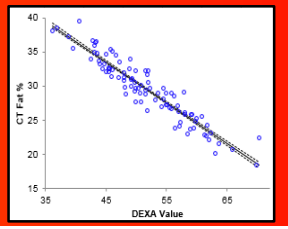
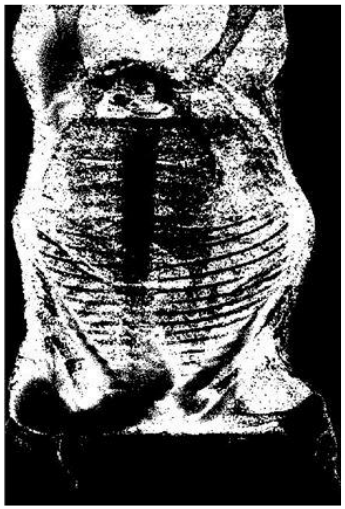
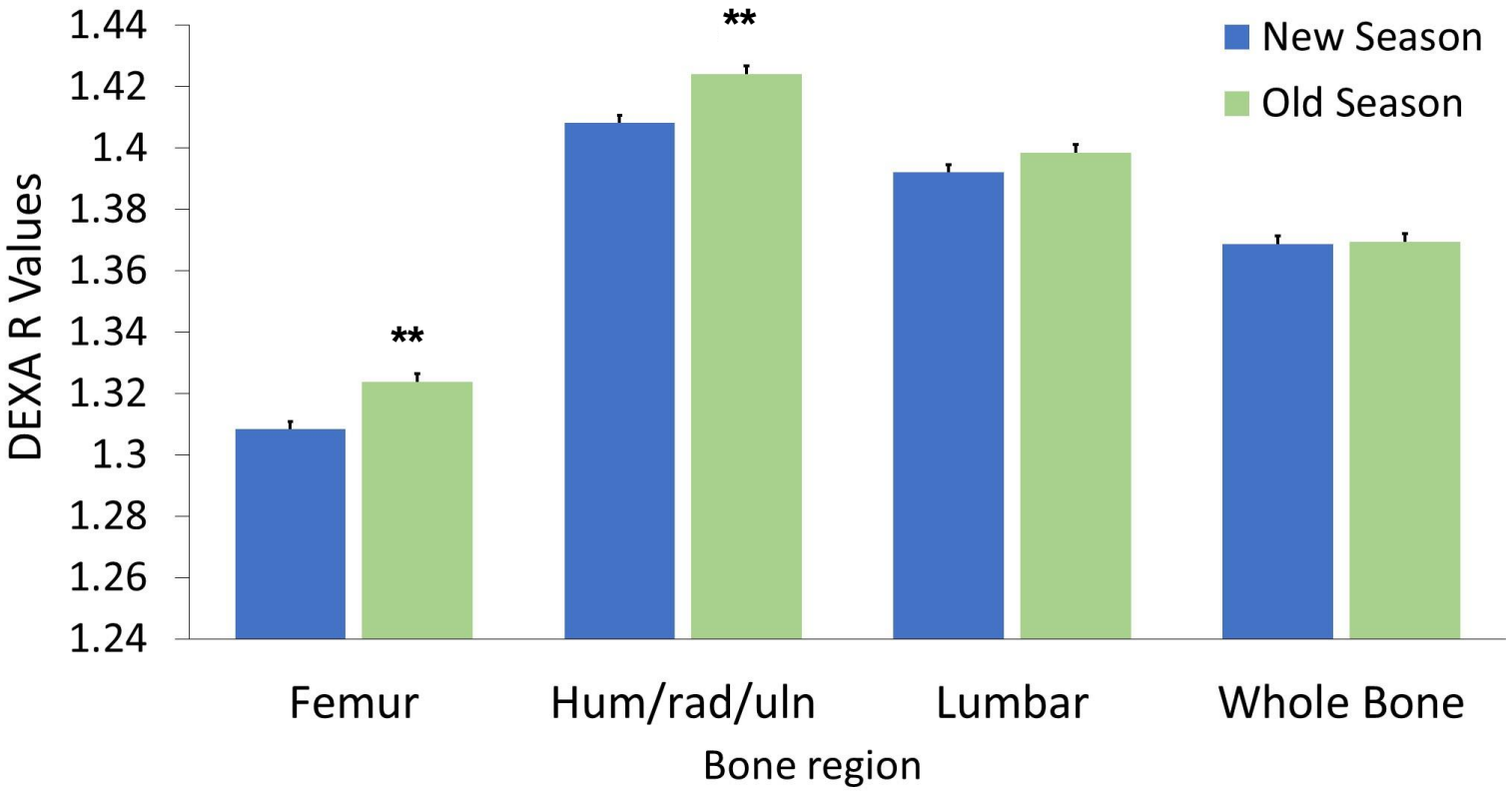


Company Specific Algorithm

DEXA prediction of age/maturity

DEXA to determine age





Payne et al. (2018). ICOMST pp

DEXA to determine age

	R-Value
Element	R
Hydrogen	1.0891
Carbon	1.2199
Nitrogen	1.3043
Oxygen	1.4167
Sodium	1.9045
Magnesium	2.0963
Phosphorus	2.7418
Sulfur	2.918
Chlorine	3.151
Potassium	3.4536
Calcium	3.5422

Mobile CT Scanner

Needs to be mobile!

1. Prove synthetic phantoms
2. Industry proof of concept data sets
3. Site comparisons
4. Genetic diversity
5. Spot check trouble spots
6. New technologies
7. New boneouts
8. $$$ Keep product in supply chain

DEXA bias analysis

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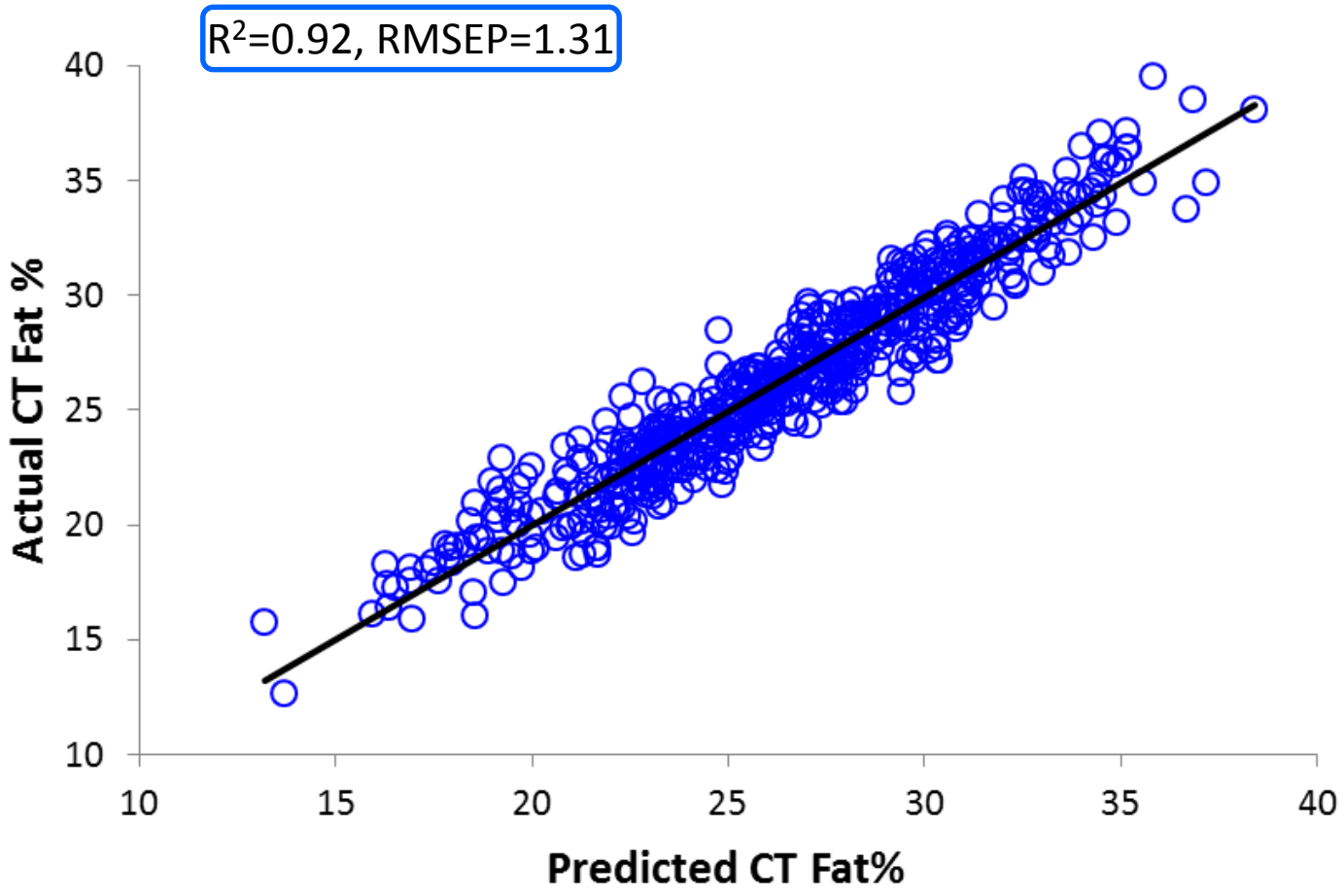
DEXA predicting CT



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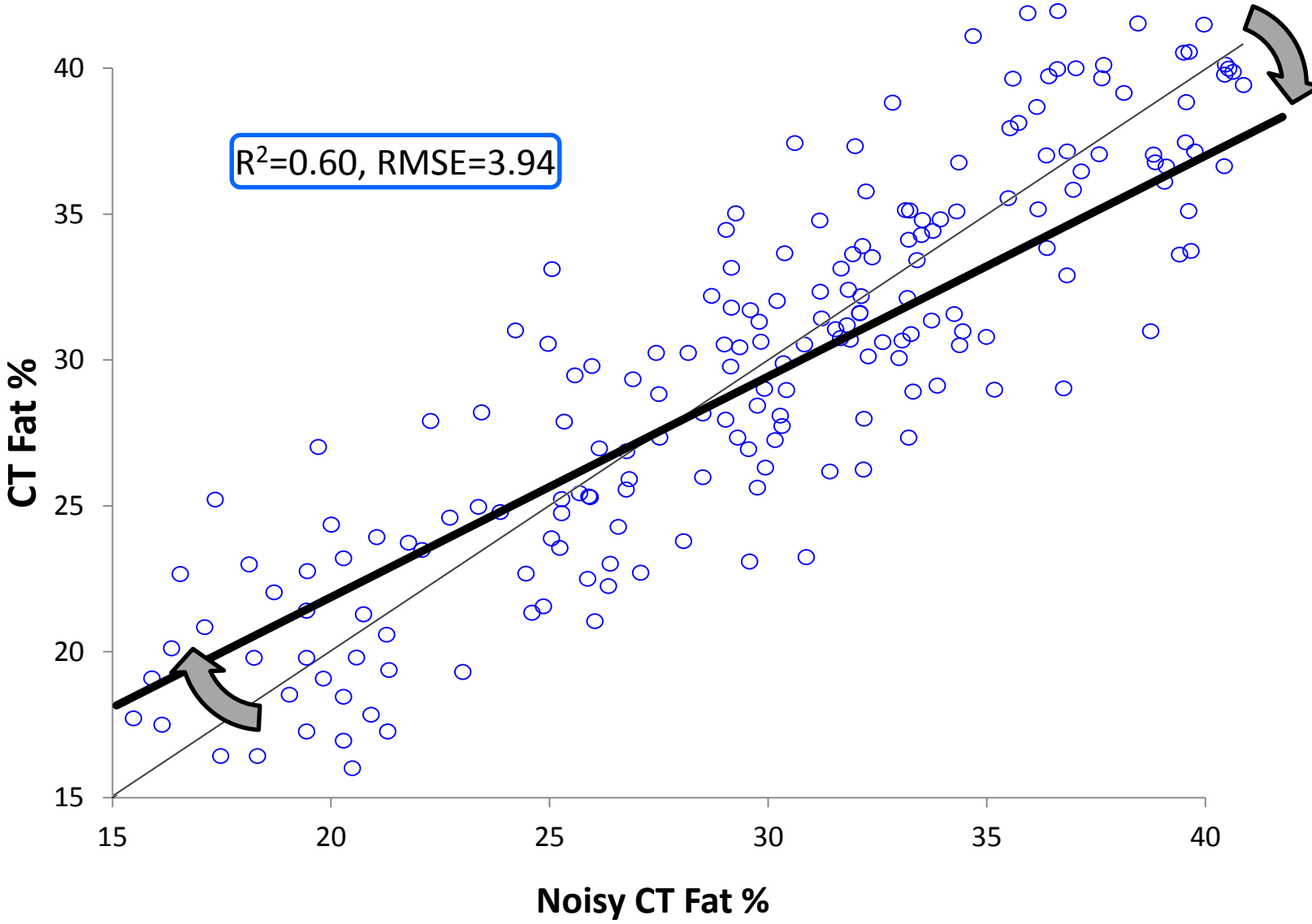
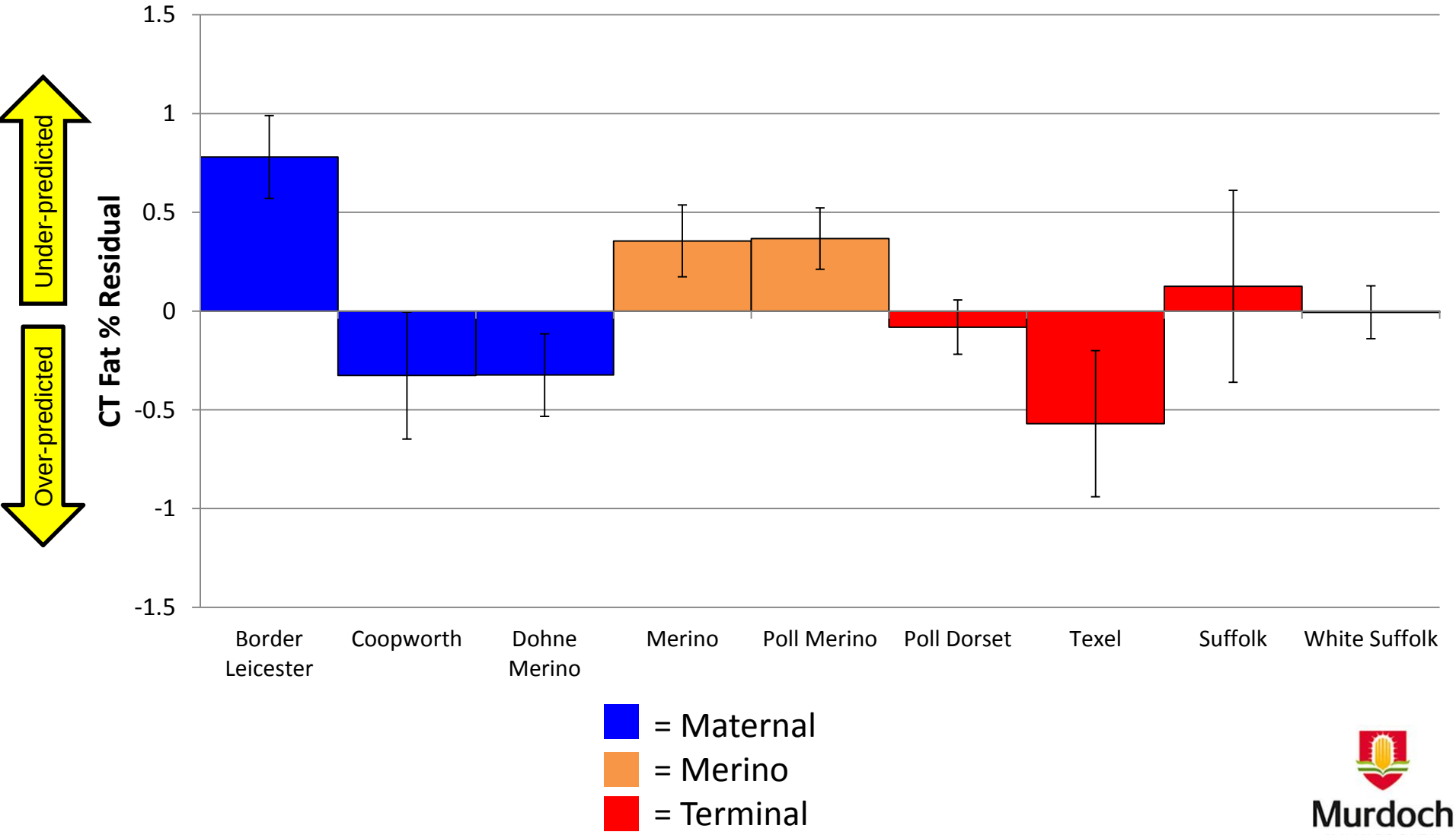
Noisier measure of CT Fat%



DEXA accuracy for breeds and sire types

Residual = Difference between DEXA predicted CT fat % and actual CT fat %



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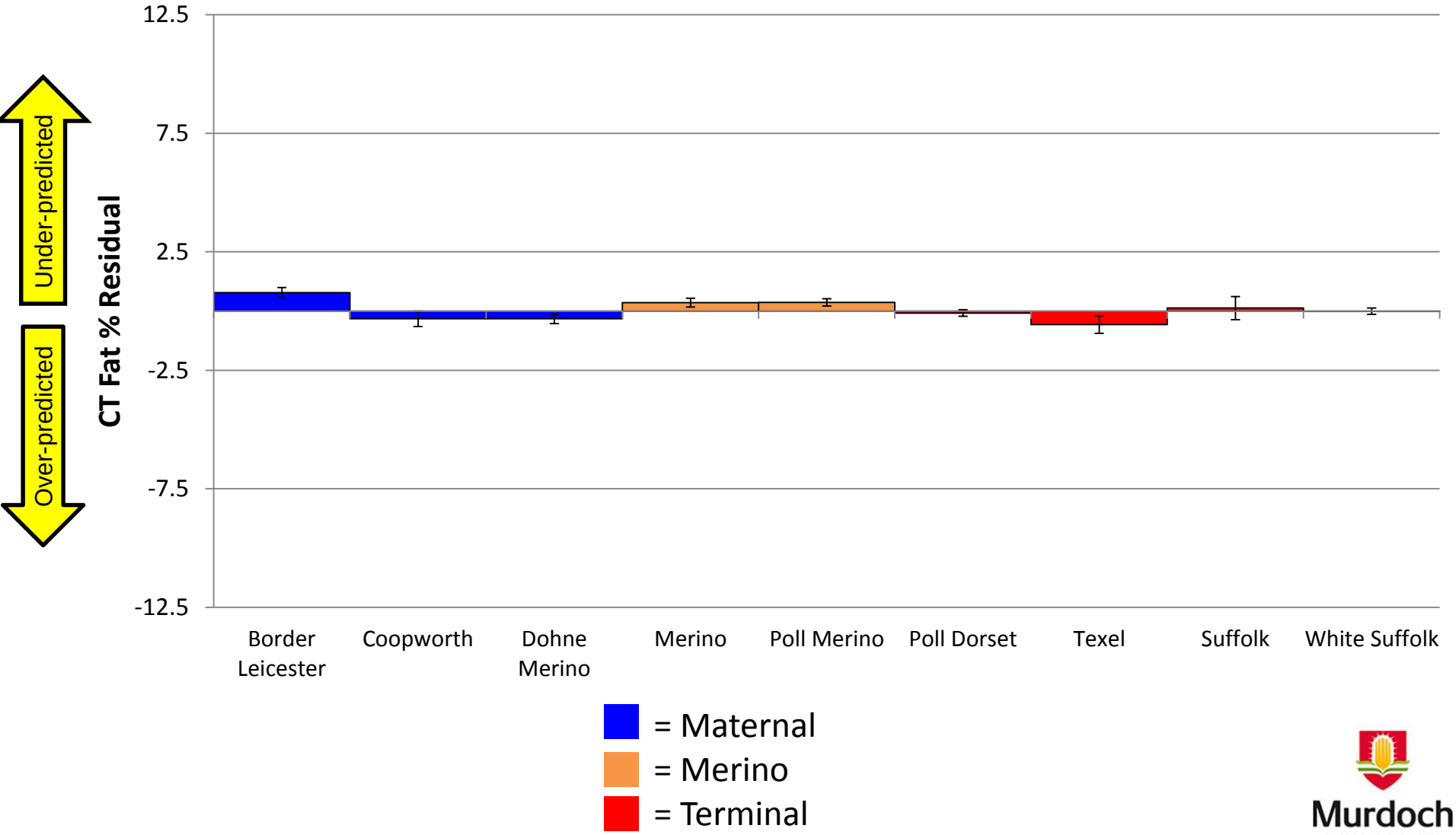

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DEXA accuracy across divergent genetics

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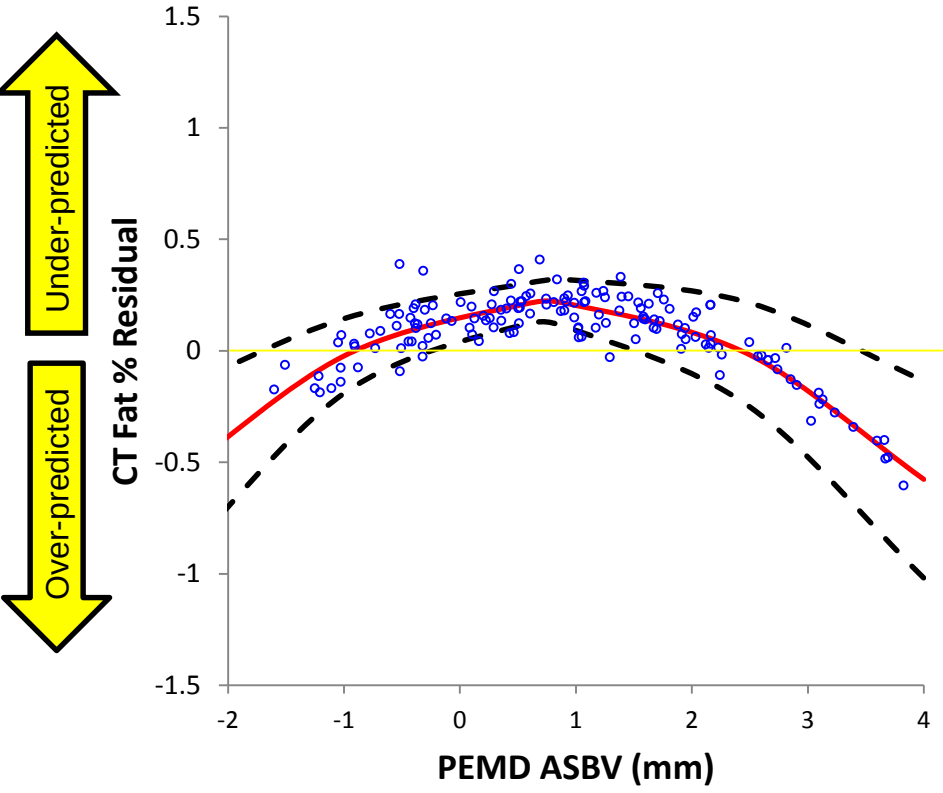

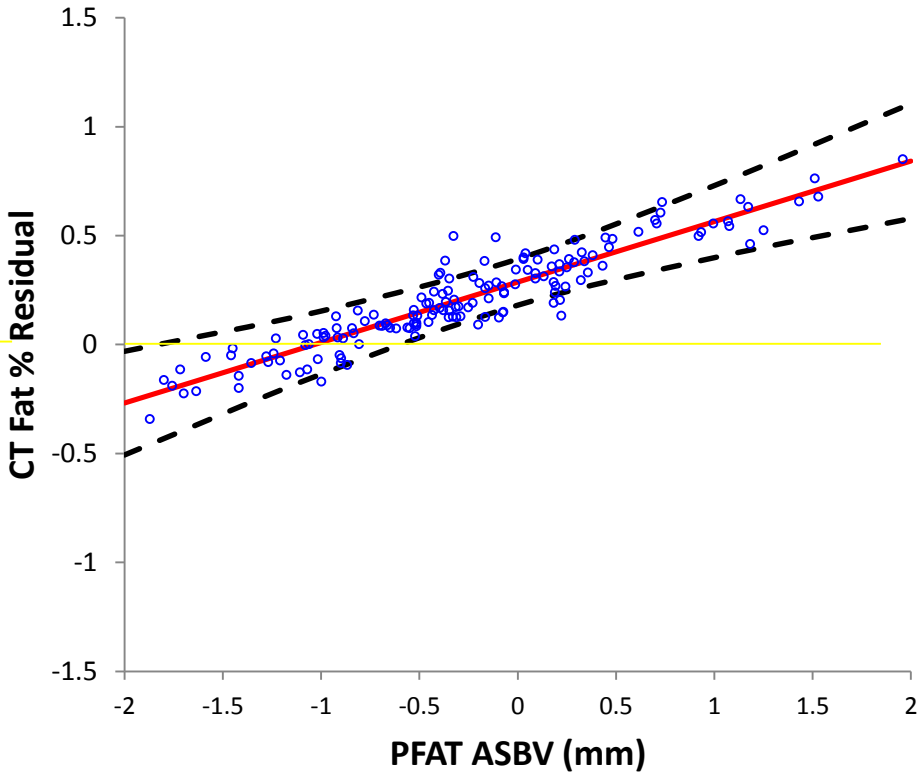

Note: Range of fatness in sample population was 15-40%

Connaughton et al. (2017). ICOMST pp

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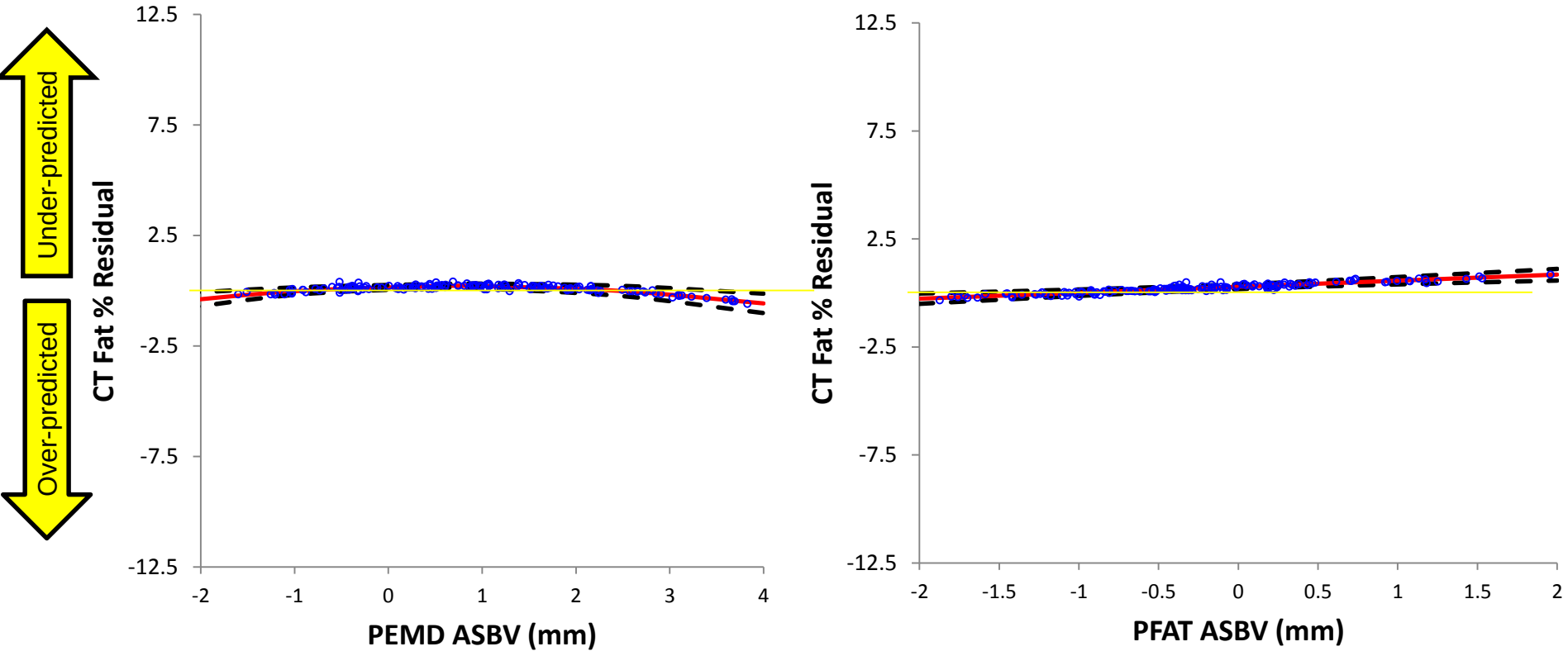

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