TECHNICAL CONSIDERATIONS FOR AN OPTIMIZED JOINT PROTOCOL

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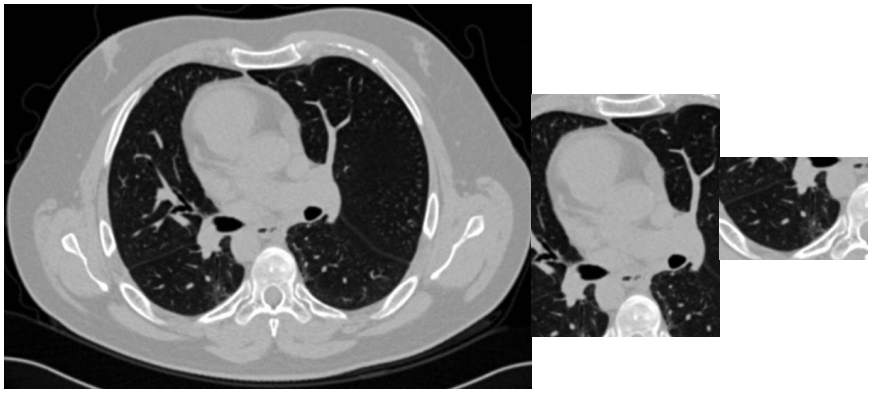
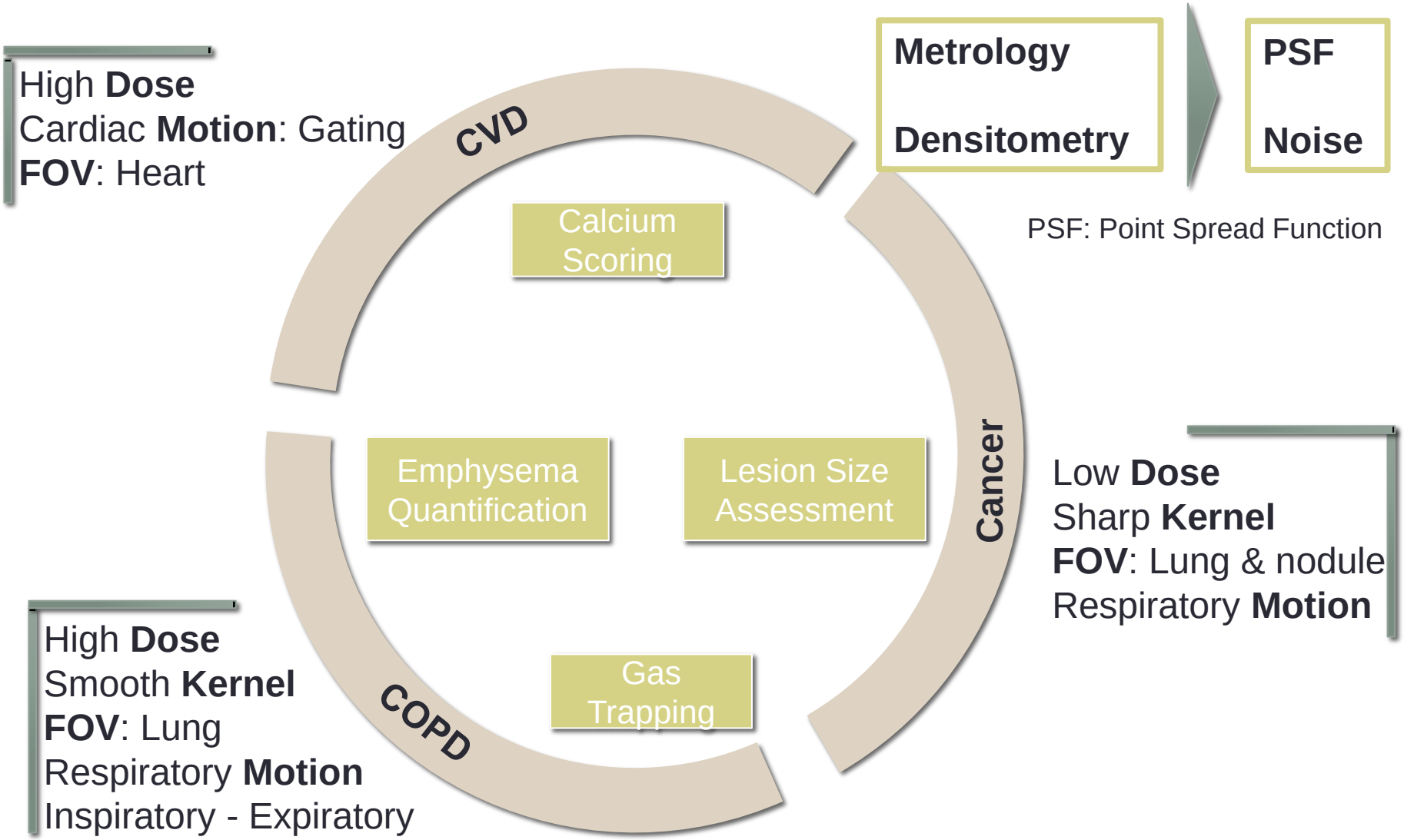
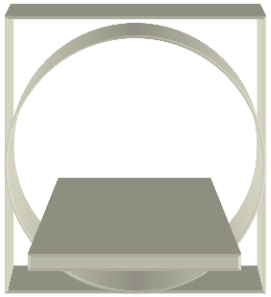
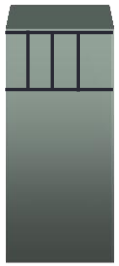


Introduction: The compromise of a joint protocol



The nature of the challenge





Software of the scanner

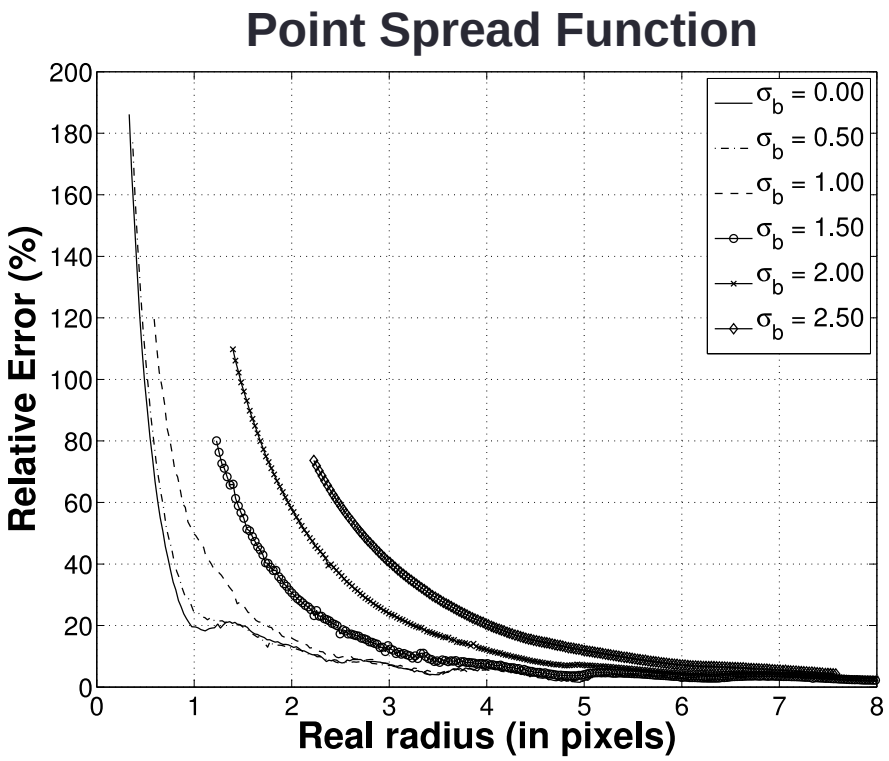
Physics of the scanner

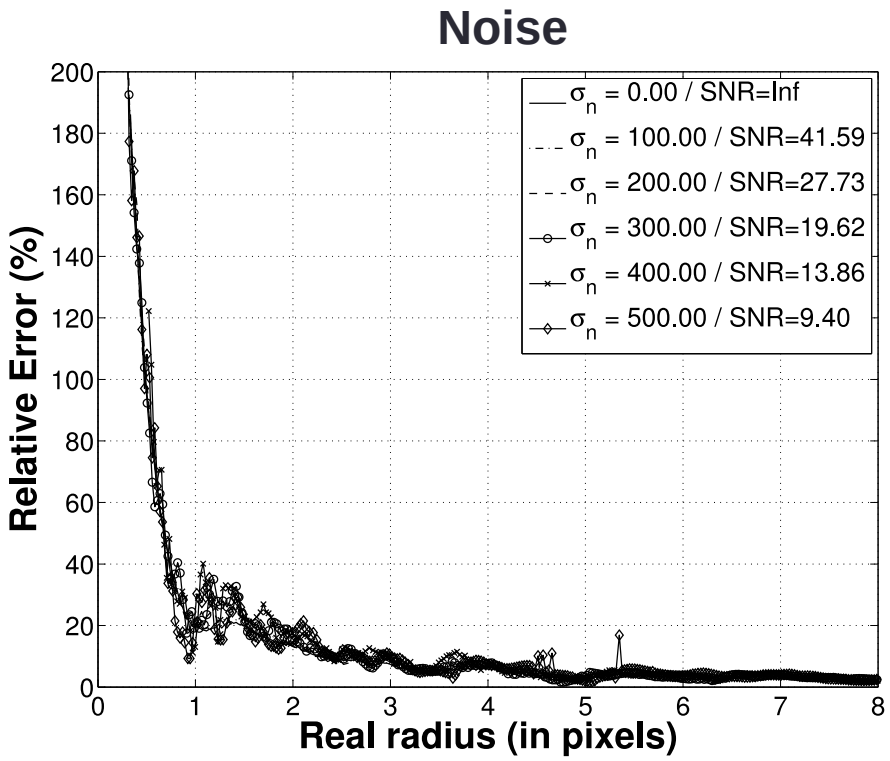
Scanner Configuration Tube current (dose) Table centering	
Current Modulation Reconstruction software • Recon Kernel • Iterative Approaches • Slice Thickness	**Noise** **PSF + Noise** **PSF**

Minimize Risk
Maximize Quality

Recon vs. Tube Current: What is critical?

- *Metrology*





Recon vs. Tube Current: What is critical?

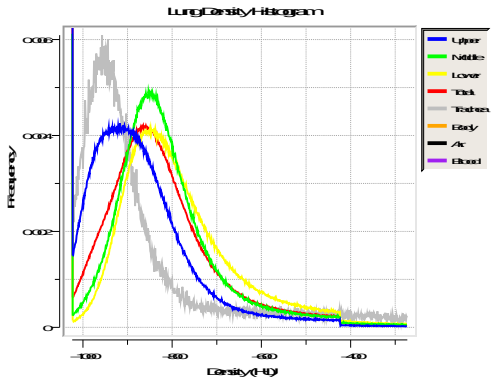
- *Densitometry*

Point Spread Function

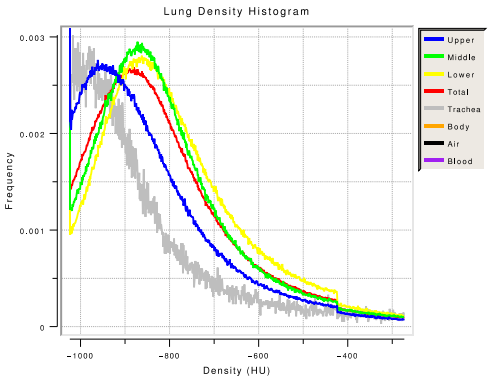
Noise

Reconstruction Technique

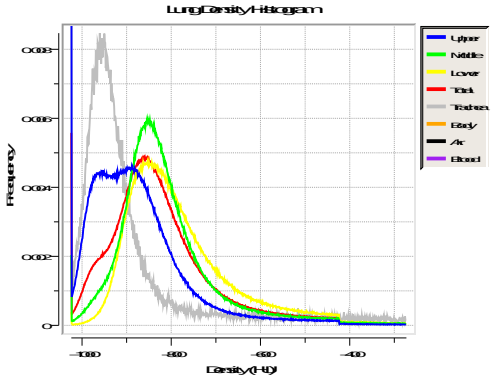
FBP: STANDARD Kernel



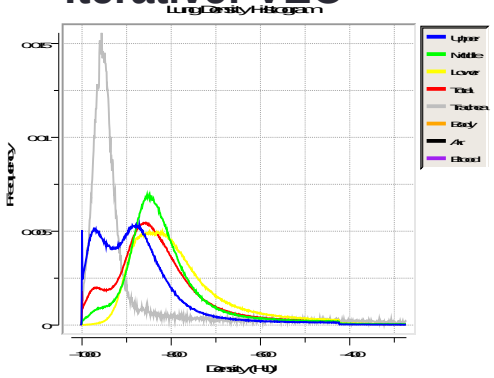
FBP: LUNG Kernel



Iterative: ASIR 70



Iterative: VEO

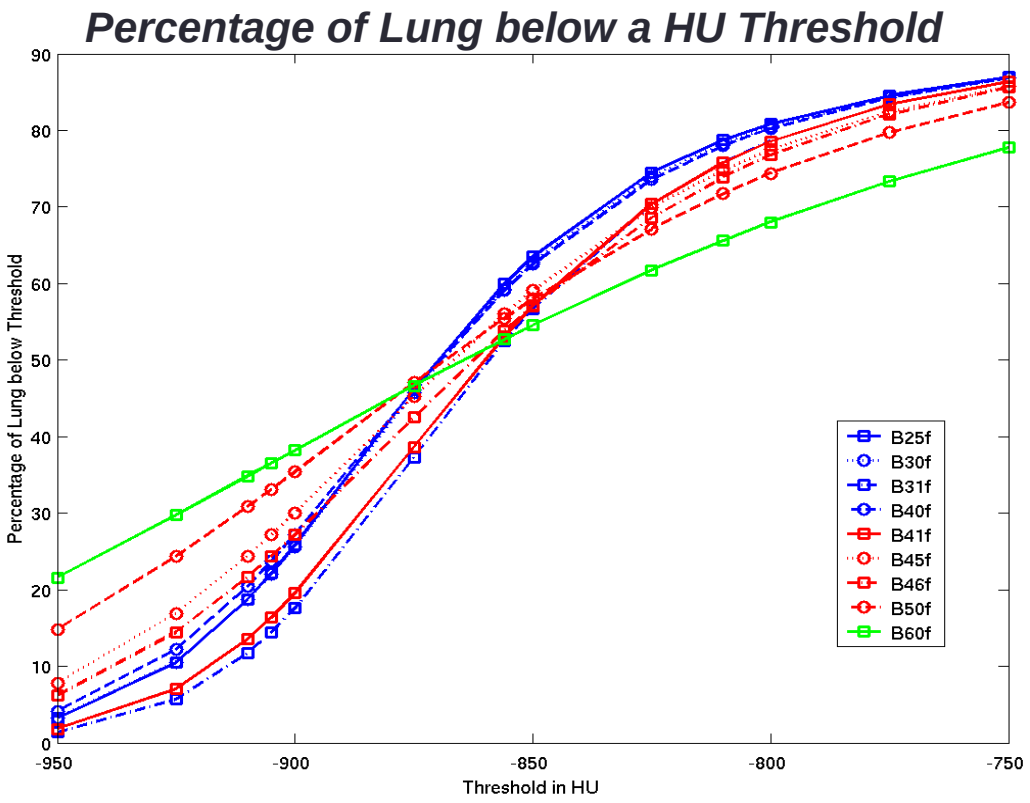


Recon vs. Tube Current: What is critical?

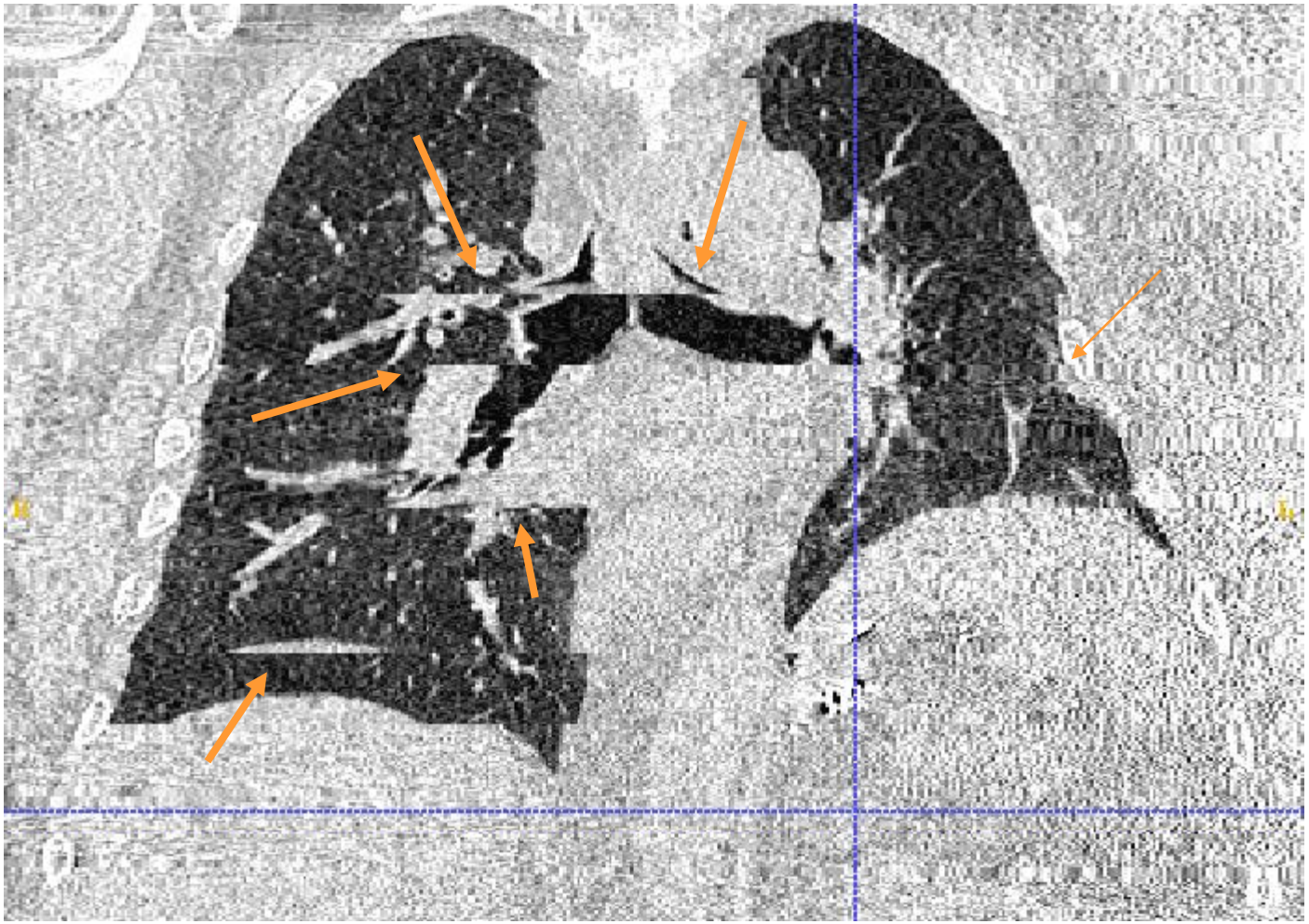
- *Densitometry*

Point Spread Function **Noise**

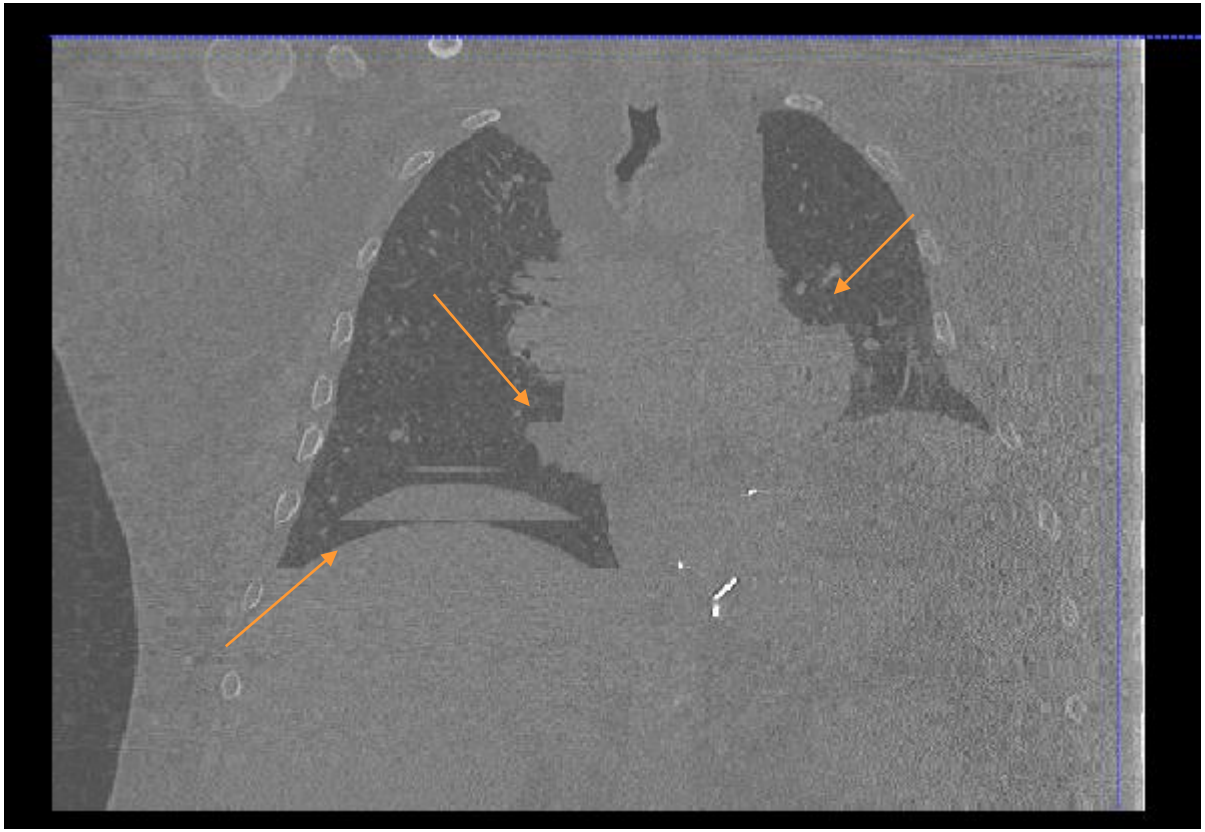
Reconstruction kernel



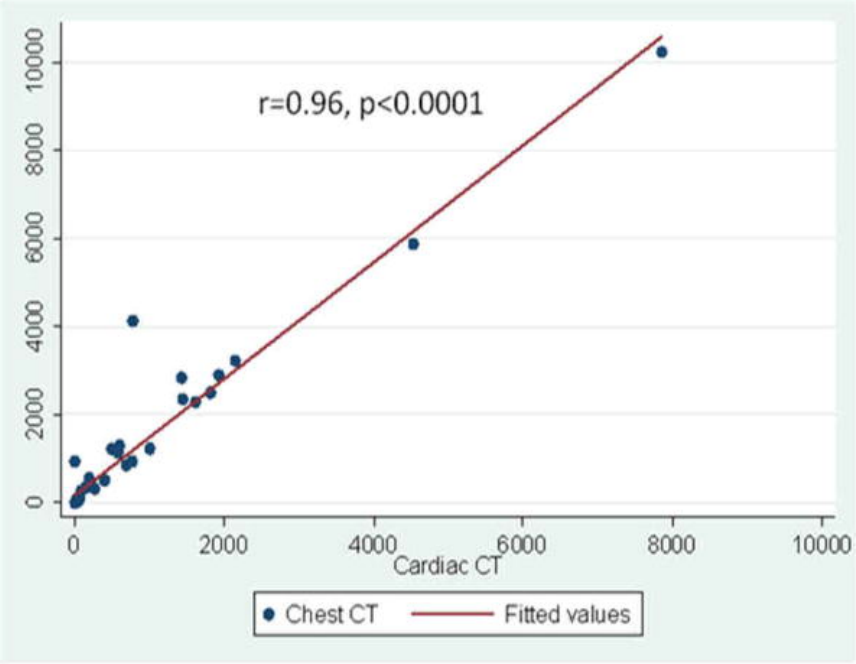
Motion: Two frequencies and one finite beam



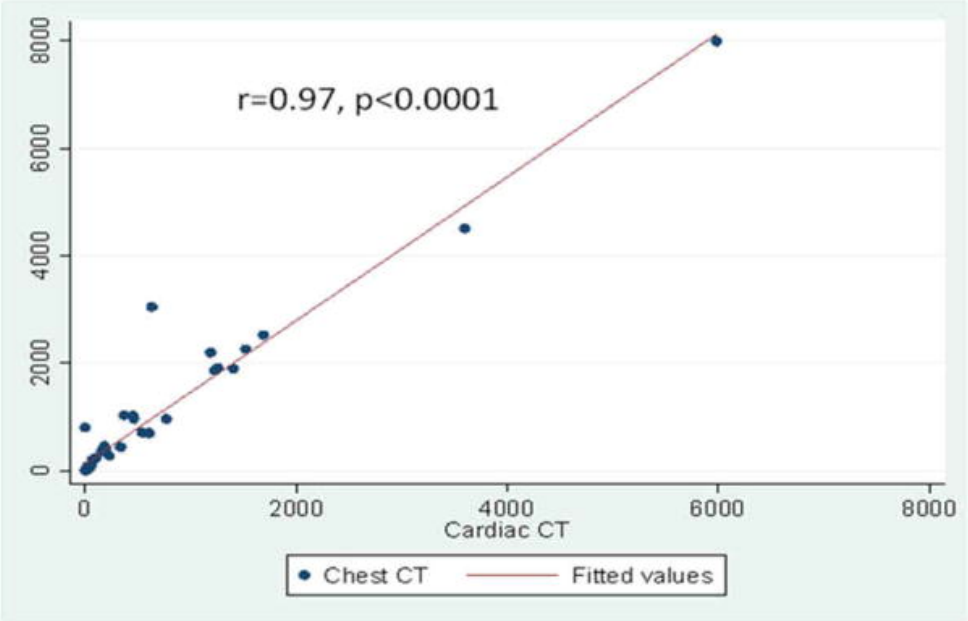
Reasons for Failure



Cardiac Motion: Is Gating needed?



Agatston Protocol



Volumetric Protocol

Budoff, M.J. et al., 2011. *Journal of cardiovascular computed tomography*,

Where are we now?: NLST Protocol

Scanner Configuration				
Scanner Make	**GE**		**Siemens**	
Scanner Model	**Light Speed 16**	**VCT(64)**	**Sensation 16**	**Senstation 64**
Rotation Time (s)	0.5	0.5		
Det. Configuration	16x1.25	64x0.625	16x0.75	32x0.6
Pitch	1.375	0.984	1.5	1
Speed (mm/rot)	27.5	39.37	18	19.2
kVp	120	120	120	120
mAs	40	25	75	50
Dose Modulation				
Reconstruction				
Algorithm	Standard	Standard	B30	B30
Thickness (mm)	2.5	2.5	2	2
Interval (mm)	2	2	1.8	1.8
DFOV (cm)				

Where are we now?: COPDGene Protocol

Scanner Configuration					
Scanner Make	**GE**		**Siemens**		
Scanner Model	**Light Speed 16**	**Discovery HD750**	**Definition**	**Definition AS+**	**Definition Flash**
Rotation Time (s)	0.5	0.5	0.5	0.5	0.5
Det. Configuration	16x0.625	64x0.625	64x0.6	128x0.6	128x0.6
Pitch	1.375	1.375	1.1	1	1
Speed (mm/rot)	13.75	13.75	13.2	38.4	38.4
kVp	120	120	120	120	120
mAs	200	200	200	200	200
Dose Modulation	Auto-mA Off	Off	CARE Dose 4D Off	CARE Dose 4D Off	CARE Dose 4D Off
Reconstruction					
Algorithm	Standard	Standard	B31f	B31f	B31f
Thickness (mm)	0.625	0.625	0.75	0.75	0.75
Interval (mm)	0.625	0.625	0.5	0.5	0.5
DFOV (cm)	Lungs	Lungs	Lungs	Lungs	Lungs

Where are we now?: CAC Protocol

Parameter	Scanner						
	Imatron (Electron-Beam)	LightSpeed Plus	MX8000	Volume Zoom	Volume Zoom	Aquilion	Sensation 64
Acquisition mode	Sequential	Sequential	Sequential	Sequential	Spiral	Sequential	Spiral
Electrocardiographic synchronization	Prospective	Prospective	Prospective	Prospective	Retrospective	Prospective	Retrospective
Peak voltage (kVp)	130	120	120	120	120	120	120
Rotation time (sec)	0.1 (scanning time)	0.5	0.5	0.5	0.5	0.5	0.33
Tube current–time product (mAs)*	63 (fixed)	25, 70, 145	10, 30, 65	20, 55, 135	20, 50, 115	20, 45, 90	20, 70, 145
Detector configuration (mm)	1 × 3	4 × 2.5	4 × 2.5	4 × 2.5	4 × 2.5	4 × 3	64 × 0.6
Section thickness (mm)	3	2.5	2.5	2.5	3	3	3
Table feed (millimeters per rotation)	3	10	10	10	3.75	12	3.84
Pitch	1	1	1	1	0.375	1	0.2
Reconstruction algorithm	Sharp	Standard	B	B35f	B35f	FC01	B35f
Effective dose (mSv)†	1.0	1.7	0.6	1.1	2.5	1.4	5.25

McCollough, Coronary Artery Calcium: A Multi- institutional, Multimanufacturer International Standard for Quantification at Cardiac CT Radiology, 2007

Emphysema: One marker for three protocols

COPDGene

N=4059
Mean FEV1%:
97.40 ±11.51%

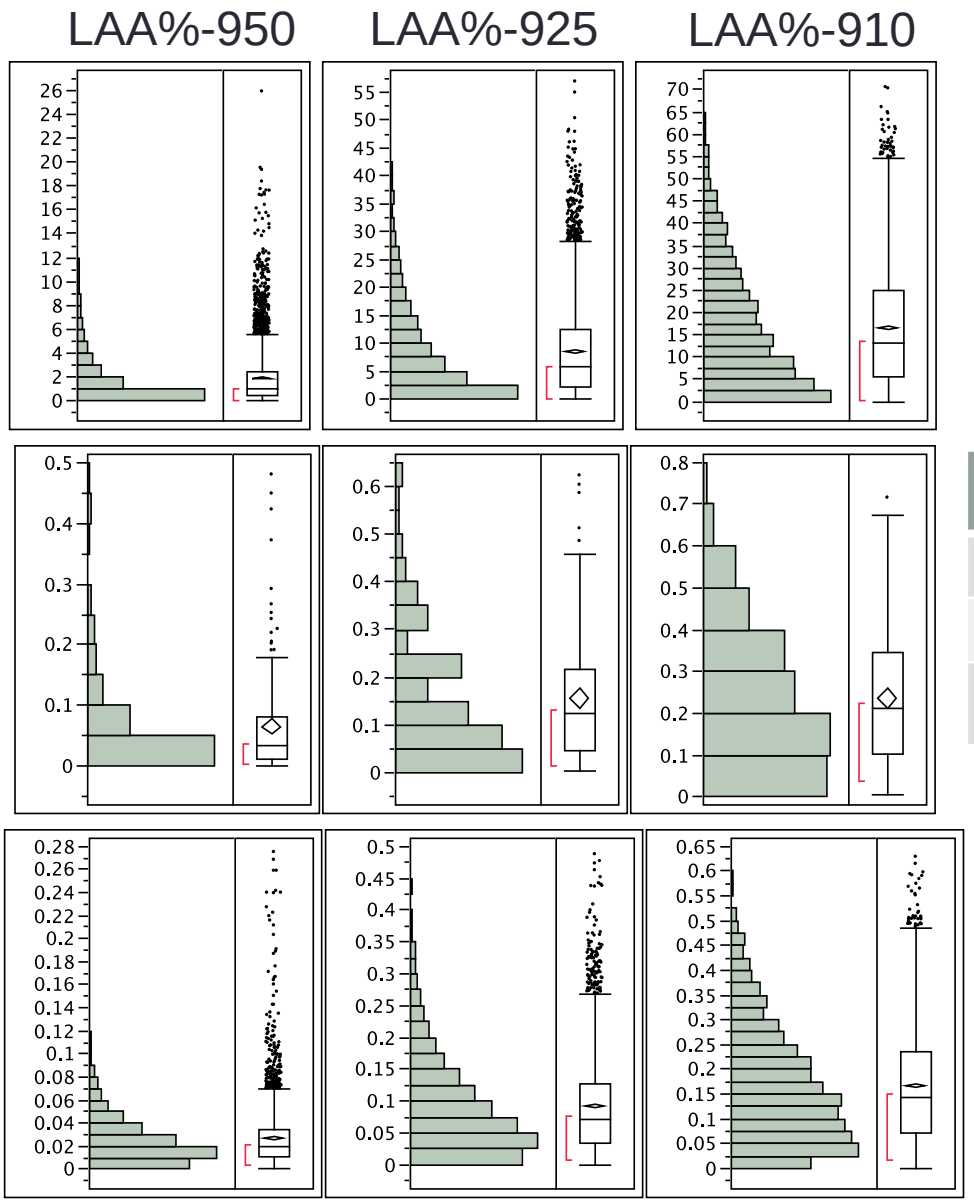
NLST

Dransfield et al, Chest, 2007

N=359
Mean FEV1%:
74±18%

FHS Cardiac

N=3409



Median Value

	LAA%-950	LAA%-925	LAA%-910
COPDGene	0.95%	5.65%	13.32%
NLST	3.5%	12.6%	24.8%
FHS Cardiac	2.0%	7.1%	14.27%

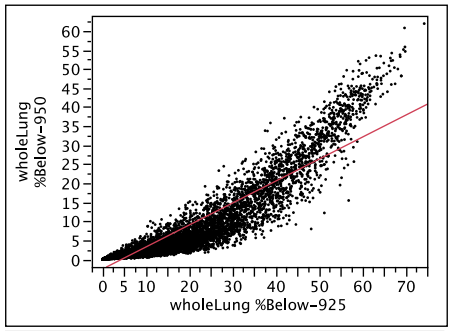
The effect of multiple thresholds

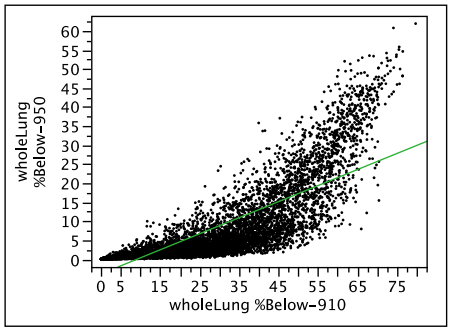
LAA%-950 vs LAA%-925

LAA%-950 vs LAA%-910

COPDGene

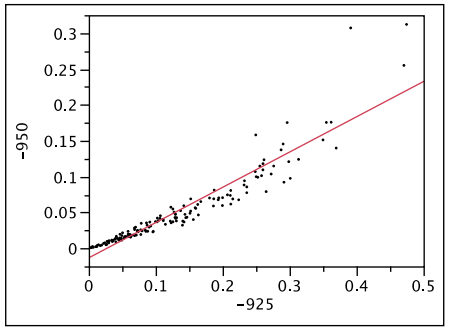
N=4059

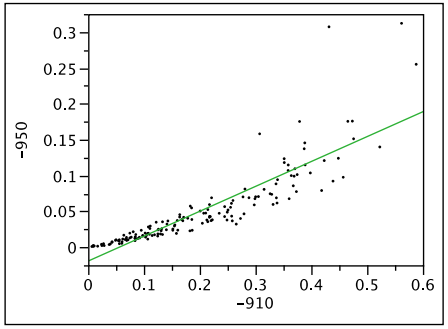




NLST

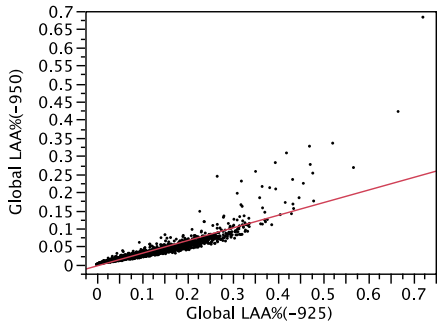
N=359

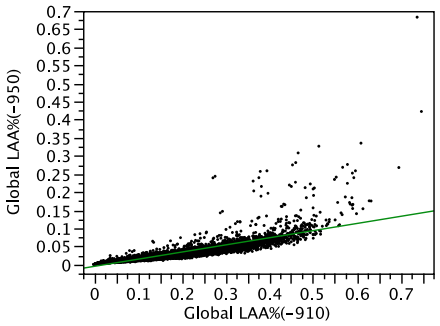




FHS Cardiac

N=3409

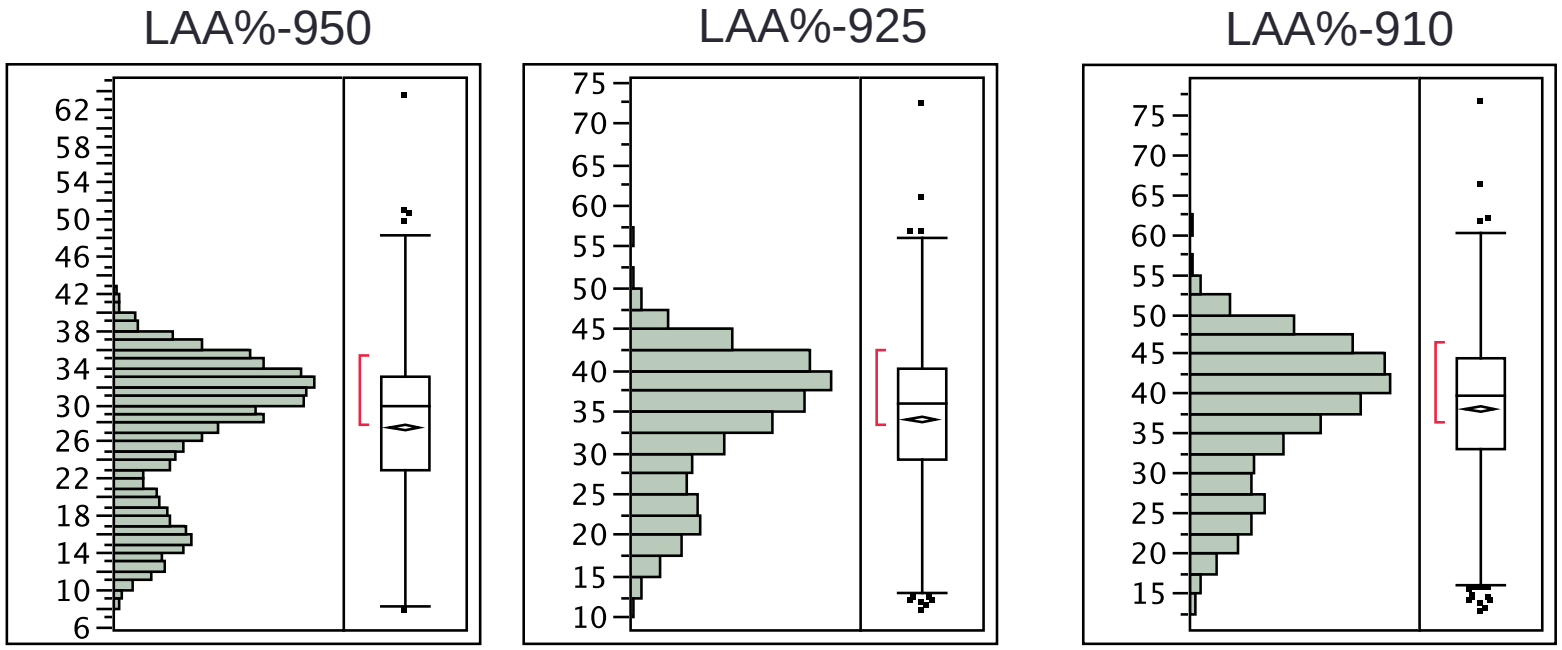




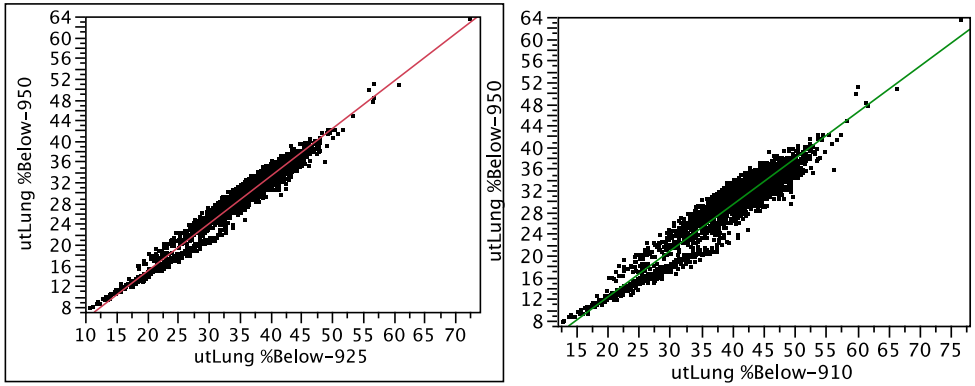
FHS: One attempt to a join protocol

	Heart Scan	**Full Lung Scan**
Manufacturer	GE Light Speed Ultra	GE Discovery STE
Voltage (kV)	120	120
Dosage (mAs)	**104.32**	**68.1**
Slice Width	**2.5**	**0.625**
Reconstruction	**STANDARD**	**LUNG**

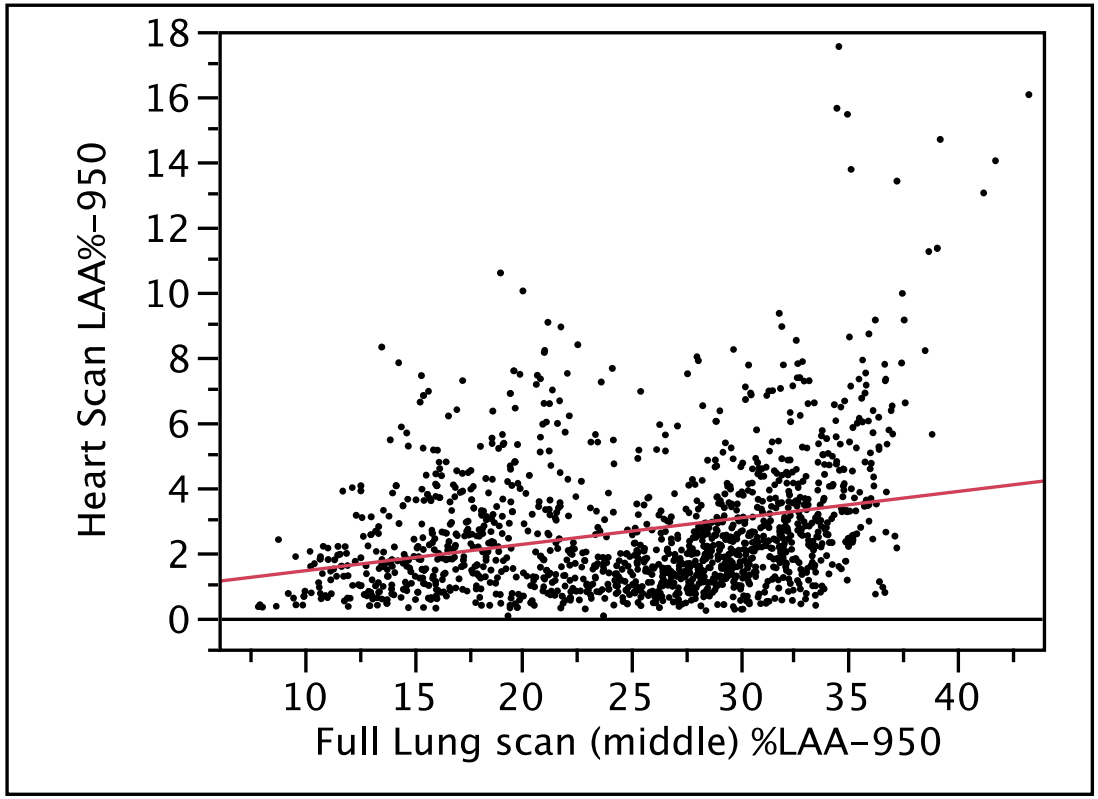
Emphysema in Full Lung Scan



N=2795
Median: 29.8% 35.91% 39.80%



Heart Scan vs Full Lung Scan with Gating



N=1433

Conclusions

- Effects of reconstruction overpowers the effects of dose
  - Standardized reconstruction protocols that balances the trade-offs
  - Iterative reconstructions need to be validated
- Gating is an imperfect solution
- Quantitative markers need to be adapted to exploit invariances across scanning protocols and scanner generations