Crowd-Sourcing Quality in Imaging

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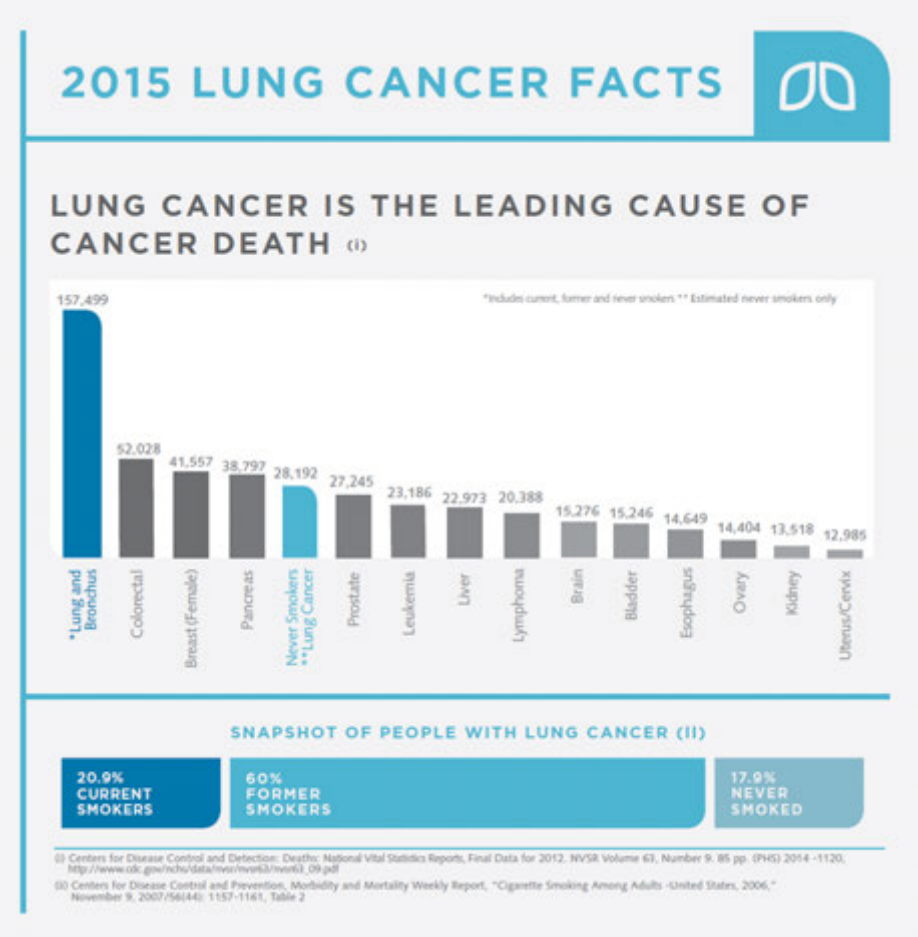
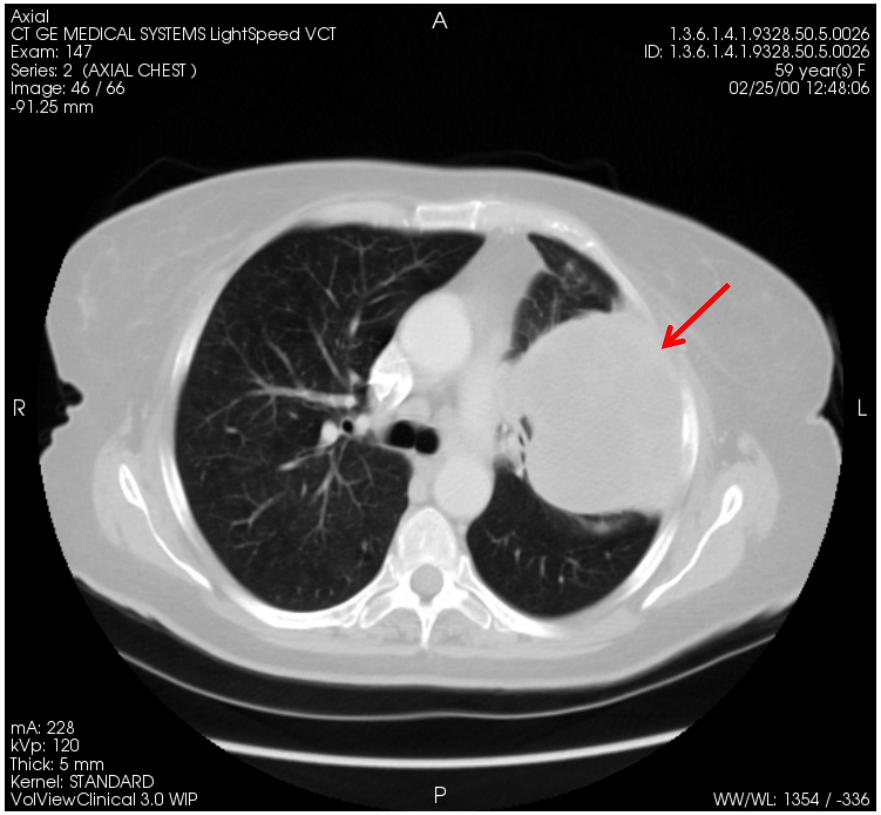
Image Quality For Lung Cancer Screening



Since 2015:
Annual Low Dose CT Screening is Reimbursed For Individuals at High Risk

Lung Cancer Screening

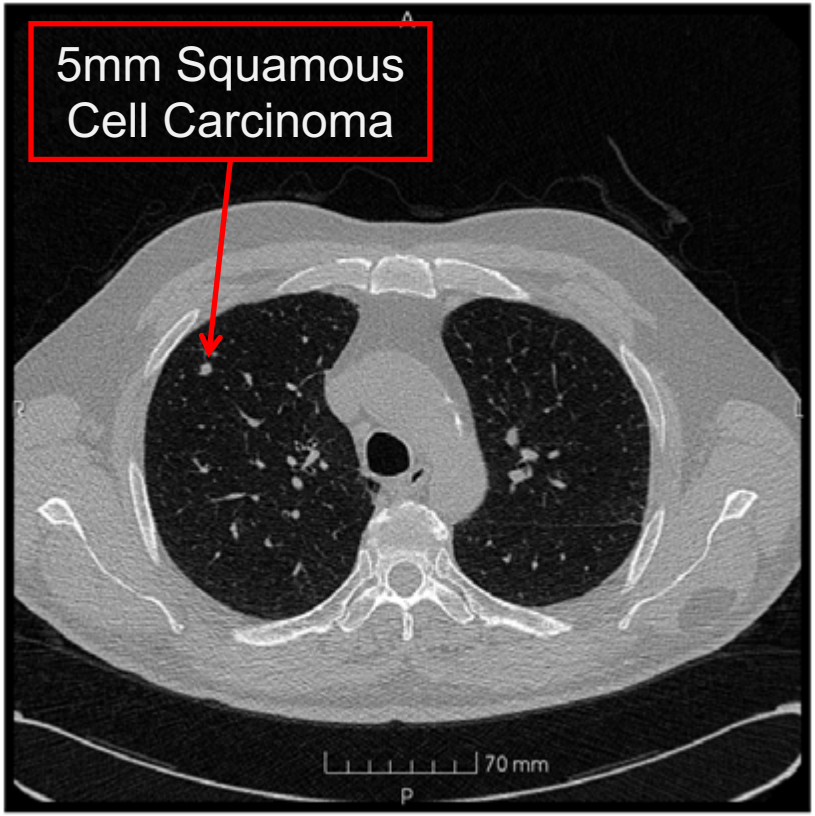
Late-Stage Lung Cancer



[R. Gottlieb, Roswell Park Cancer Institute]

~5% five year survival

Early Lung Cancer

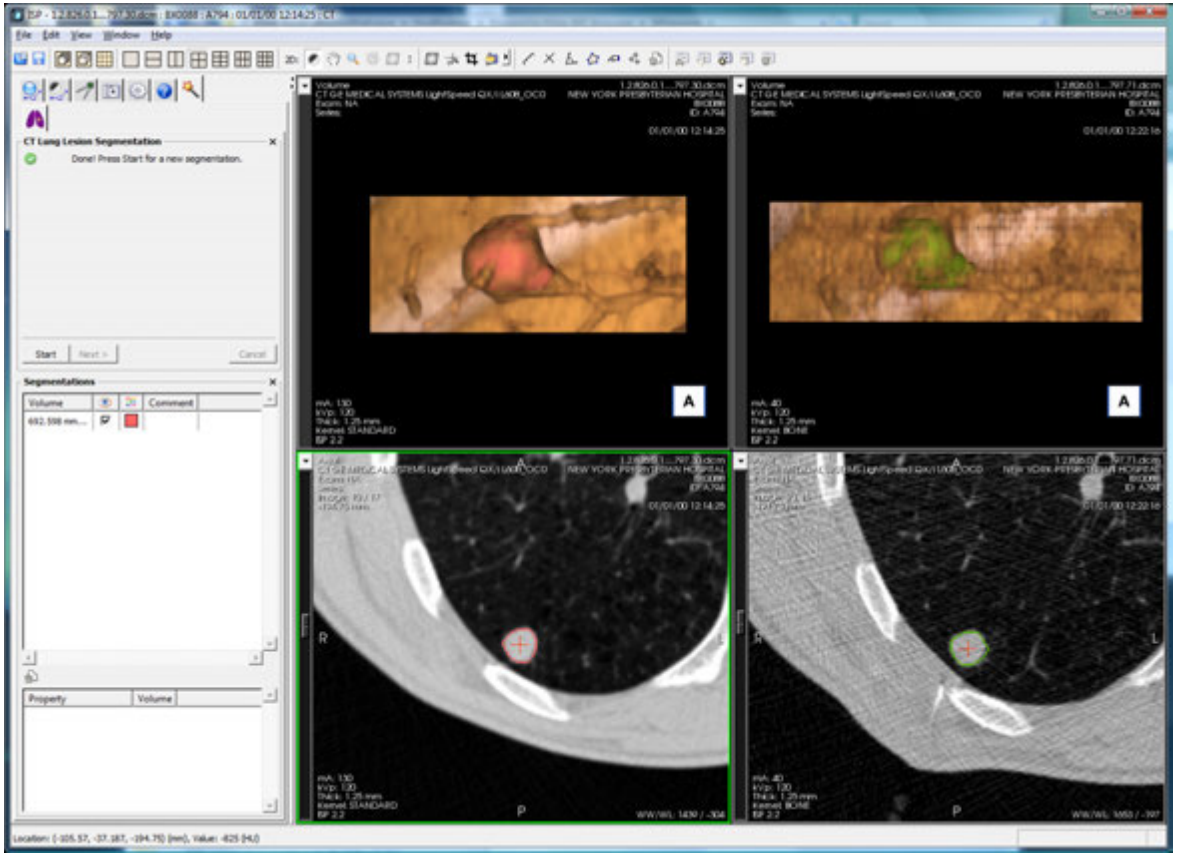


[Dr. Javier Zulueta, University of Navarra]

~85% five year survival

Pulmonary Nodules

Time 1 Time 2

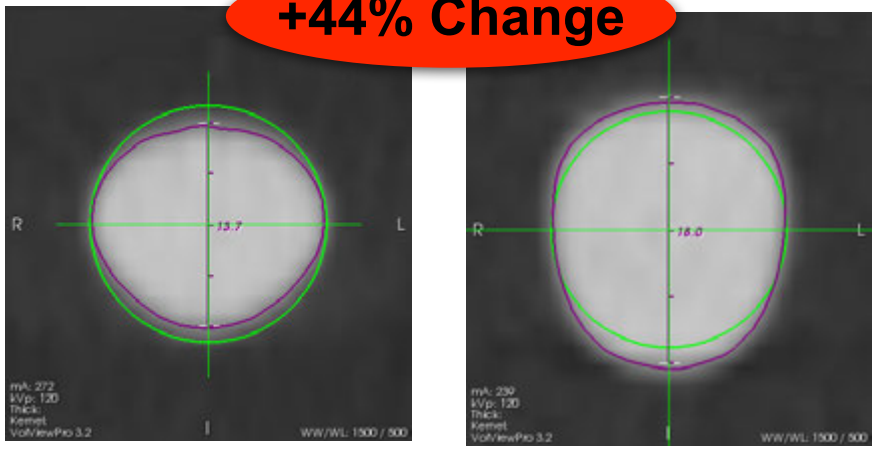


= 668 mm^3 T2 = 661 mm^3

ΔV = No Change

2010: Roche ABIGAIL Study

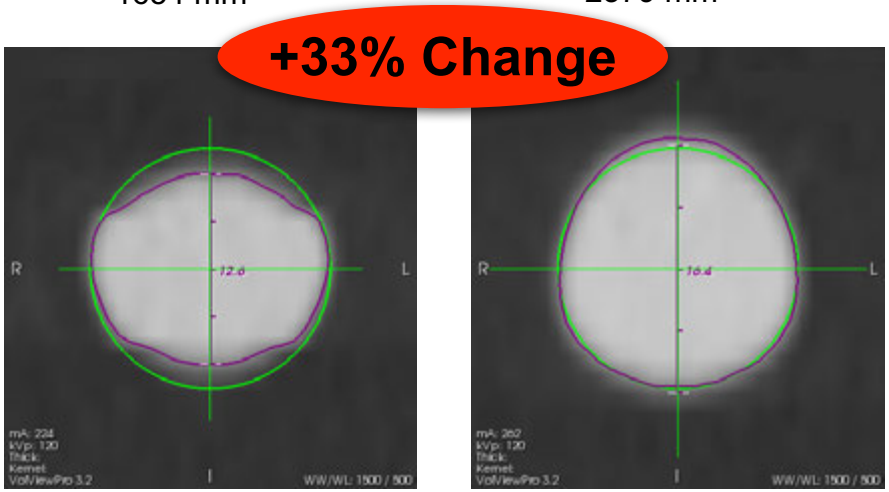
Model A
Site 1



1654 mm^3

2379 mm^3

Model A
Site 2

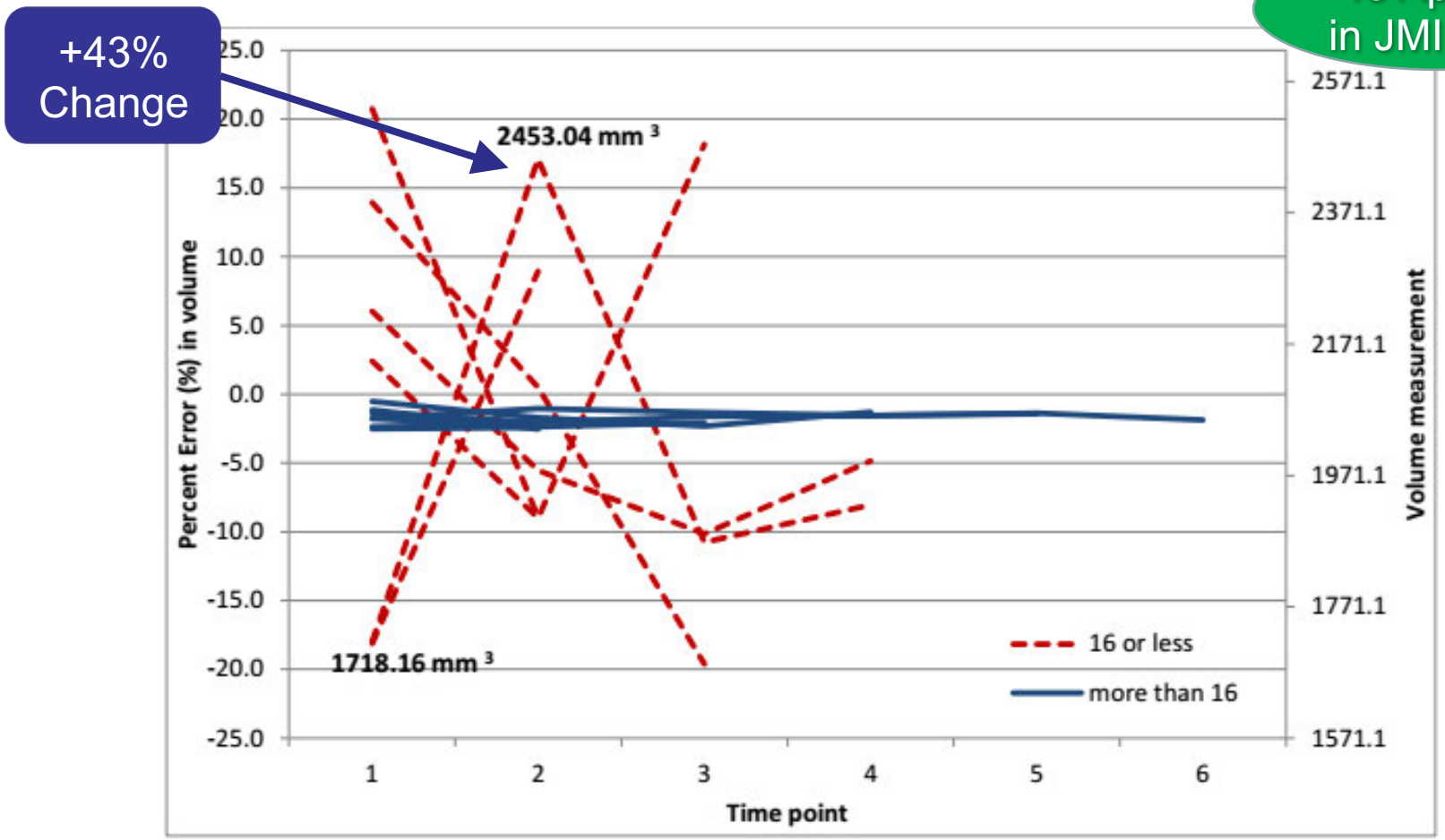


1601 mm^3

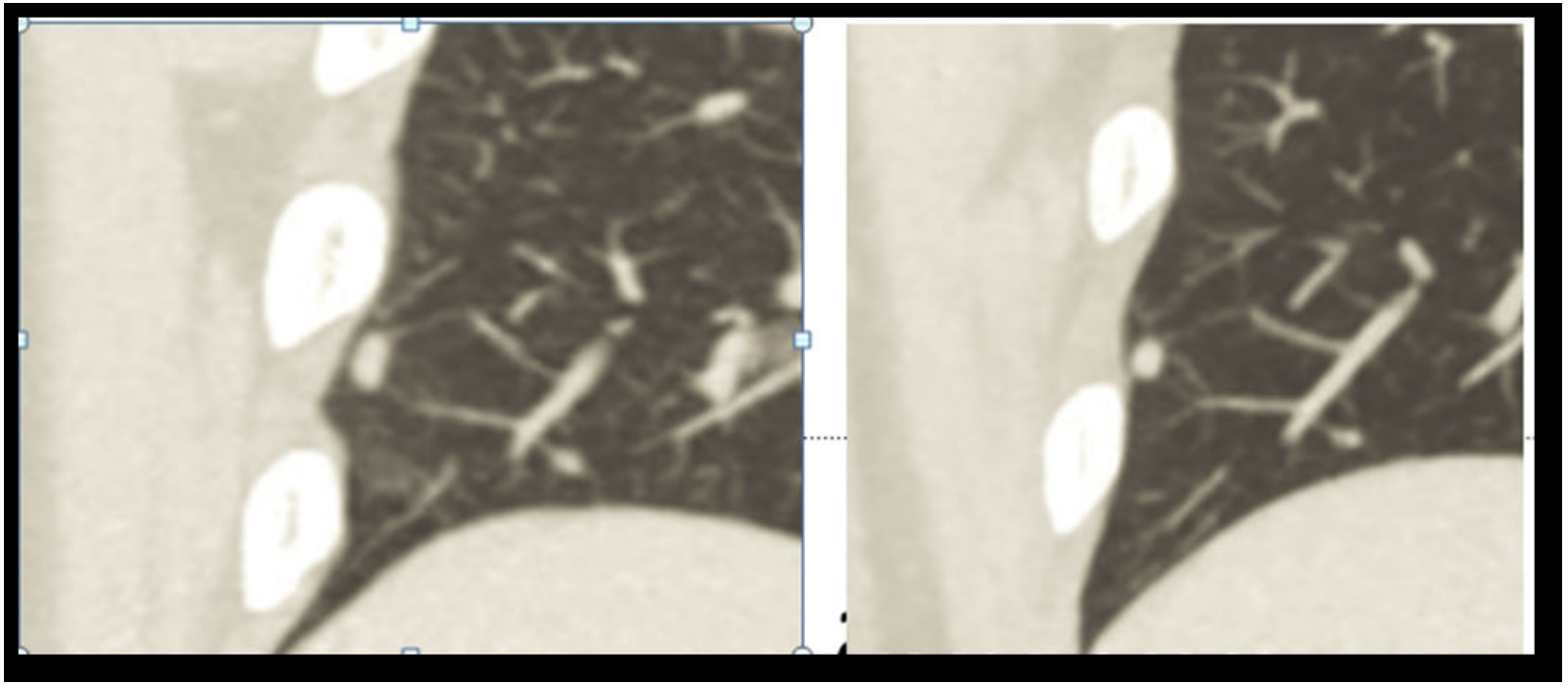
2127 mm^3

Volume Measurements Over Time

To Appear in JMI 2016



Periodic Z Warping



2016 CT Lung Cancer Screening Protocol Challenge

- **Goal**
  - To quantitatively determine the most effective lung cancer screening CT scanners and protocols using an ultra-low cost, crowd-sourced approach.
  - In addition, to identify the best protocols for combined lung cancer and COPD screening.

Team

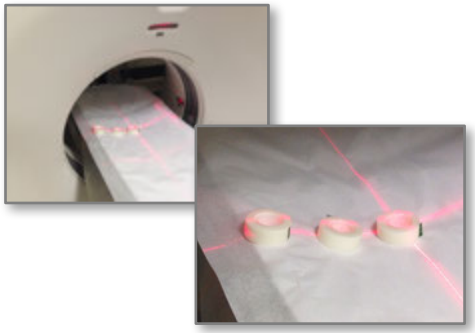
- Accumetra
  - Challenge Leadership
  - Image Assessment Technology
- Prevent Cancer Foundation
  - National Cancer Patient Advocacy
  - Lung Cancer Workshop XIII
- Lung Cancer Alliance
  - National Cancer Patient Advocacy
  - > 300 Framework Sites
- I-ELCAP
  - Largest Ongoing International Lung Cancer Screening Study
- COPD Foundation
  - National COPD Patient Advocacy

Free CT Image Quality Report

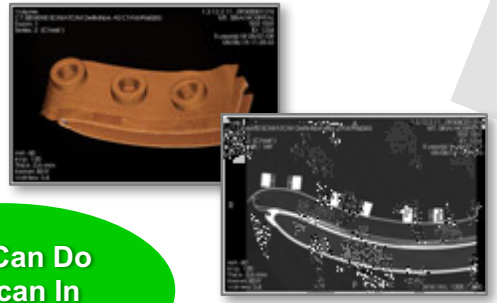
Can Be Replaced With Calibrated Object

Accumetra.com

Email



Upload



Tech Can Do The Scan In < 5 Minutes

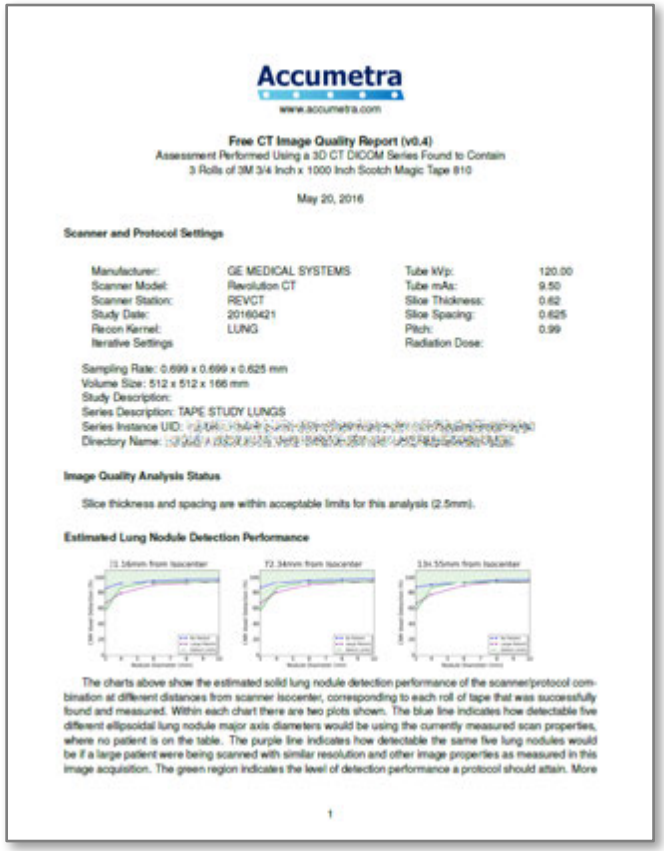
Optimize

Radiology Focused Image Quality Reports

Protocol Settings

Analysis Status

Lung Nodule Detection



Accumetra

www.accumetra.com

Free CT Image Quality Report (v0.4)

Assessment Performed Using a 3D CT DICOM Series Found to Contain 3 Rolls of 3M 3/4 Inch x 1000 Inch Scotch Magic Tape 810

May 20, 2016

Scanner and Protocol Settings

Manufacturer:	GE MEDICAL SYSTEMS	Tube kVp:	120.00
Scanner Model:	Revolution CT	Tube mAs:	9.50
Scanner Station:	REVCT	Slice Thickness:	0.62
Study Date:	20160421	Slice Spacing:	0.625
Recon Kernel:	LUNG	Pitch:	0.99
Iterative Settings		Radiation Dose:	

Sampling Rate: 0.699 x 0.699 x 0.625 mm
Volume Size: 512 x 512 x 166 mm
Study Description:
Series Description: TAPE STUDY LUNGS
Series Instance UID:
Directory Name:

Image Quality Analysis Status

Slice thickness and spacing are within acceptable limits for this analysis (2.5mm).

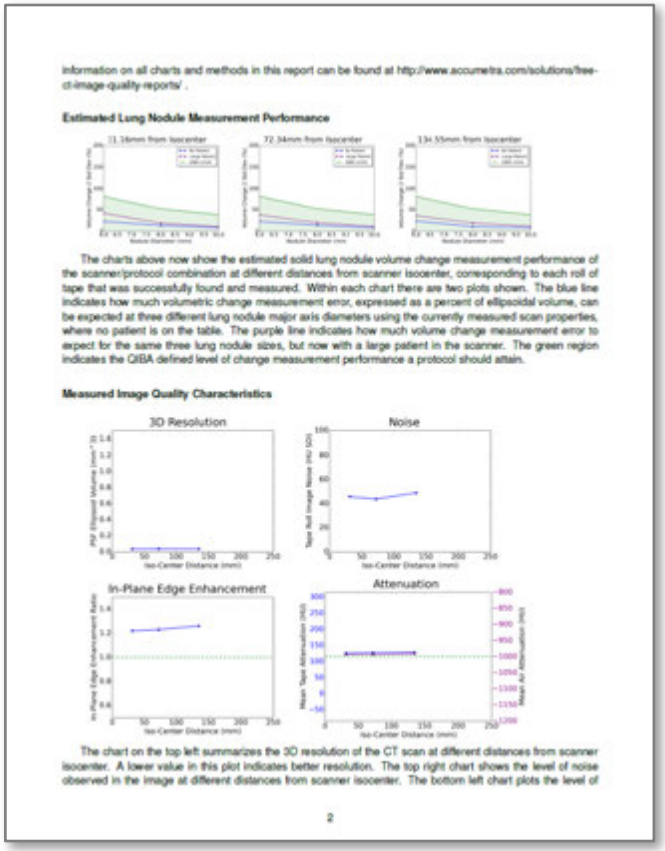
Estimated Lung Nodule Detection Performance

The charts above show the estimated solid lung nodule detection performance of the scanner/protocol combination at different distances from scanner isocenter, corresponding to each roll of tape that was successfully found and measured. Within each chart there are two plots shown. The blue line indicates how detectable five different ellipsoidal lung nodule major axis diameters would be using the currently measured scan properties, where no patient is on the table. The purple line indicates how detectable the same five lung nodules would be if a large patient were being scanned with similar resolution and other image properties as measured in this image acquisition. The green region indicates the level of detection performance a protocol should attain. More

1

Lung Nodule Δ Measurement

Fundamental Properties



information on all charts and methods in this report can be found at http://www.accumetra.com/solutions/free-ct-image-quality-reports/ .

Estimated Lung Nodule Measurement Performance

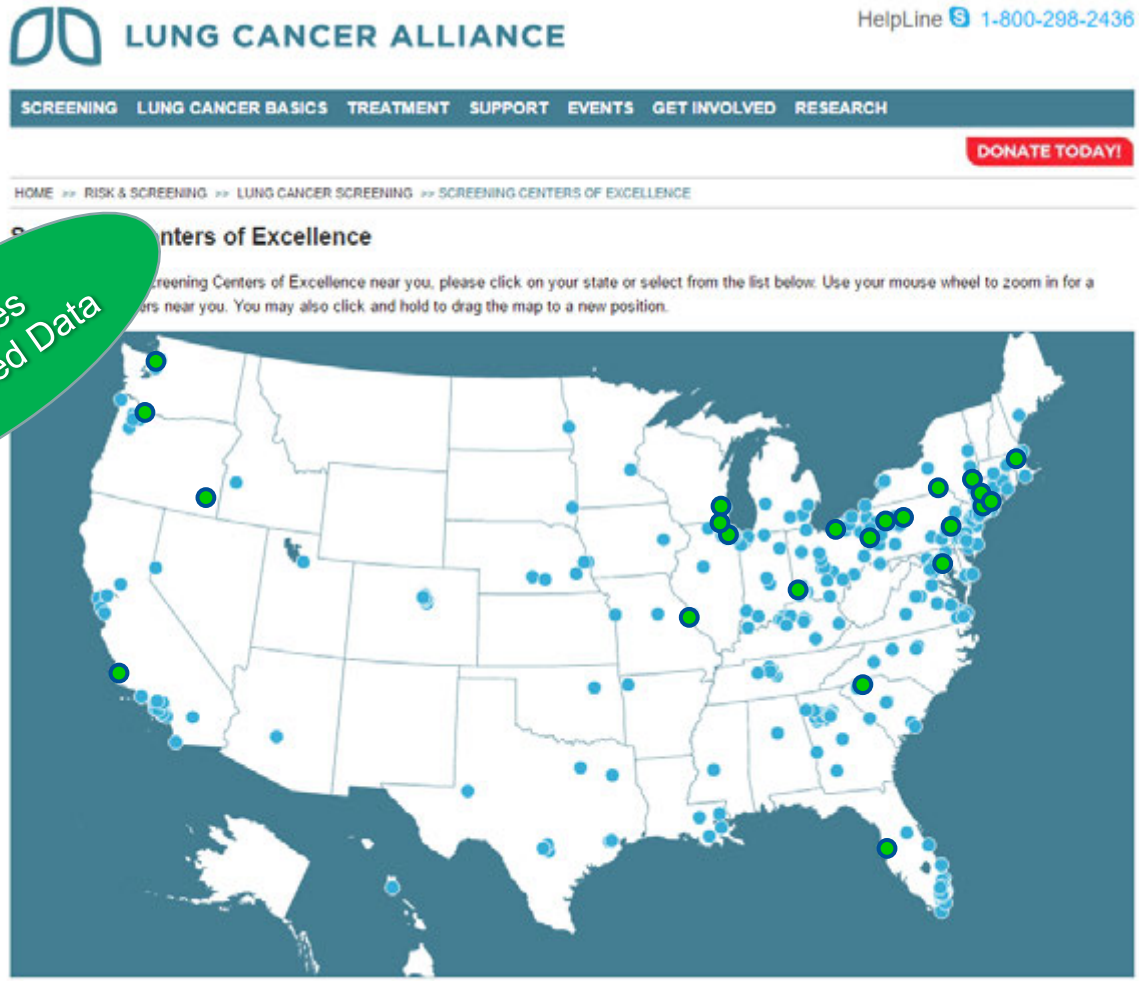
The charts above now show the estimated solid lung nodule volume change measurement performance of the scanner/protocol combination at different distances from scanner isocenter, corresponding to each roll of tape that was successfully found and measured. Within each chart there are two plots shown. The blue line indicates how much volumetric change measurement error, expressed as a percent of ellipsoidal volume, can be expected at three different lung nodule major axis diameters using the currently measured scan properties, where no patient is on the table. The purple line indicates how much volume change measurement error to expect for the same three lung nodule sizes, but now with a large patient in the scanner. The green region indicates the QIBA defined level of change measurement performance a protocol should attain.

Measured Image Quality Characteristics

The chart on the top left summarizes the 3D resolution of the CT scan at different distances from scanner isocenter. A lower value in this plot indicates better resolution. The top right chart shows the level of noise observed in the image at different distances from scanner isocenter. The bottom left chart plots the level of

2

CT Scanning Site Participants



27 Sites Submitted Data

- China
- Spain (2)
- Israel
- Switzerland

CT Scanners (26 sites)

GE (19% = 10/53)	BrightSpeed8	8	1
	LightSpeed VCT	64	5
	Discovery CT750 HD	128	2
	Revolution CT	256	2
Siemens (50% = 27/53)	Sensation 16	16	2
	Biograph40	40	1
	Sensation64	64	4
	SOMATOM Definition	64	4
	SOMATOM Definition AS	40, 64, 128	6
	SOMATOM Definition AS+	128	4
	Definition AS+ 128	128	1
	Definition Edge 128	128	1
	SOMATOM Definition Flash	256	4
Philips (23% = 12/53)	Brilliance64	64	4
	IngenuityCT	128	5
	iCT 256	256	3
Toshiba (8% = 4/53)	Aquilion	64	1
	Aquilon ONE	320	3
4 Manufacturers	18 Models		53 CT Scanners

CT Lung Screening Protocol Guidelines

	CT Acquisition			
	Detectors >=	Thickness <=	Spacing <=	Kernel
2016 RSNA/QIBA Small Nodule Profile (19% to 42%)	16	1.25	1.25	Highest Res.
2016 I-ELCAP Guidelines	64	1.25	1.25	Highest Res.
2015 European Society of Radiology	16	1.0	0.7	No Pref.
2015 American College of Radiology (10 Pillars Publication)	16	2.5, 1.0 pref.	No Pref.	No Pref.
2016 AAPM Lung Cancer Screening Protocols	16	2.5, 1.0 pref.	2.5, 1.0 pref.	Range, Not Easy

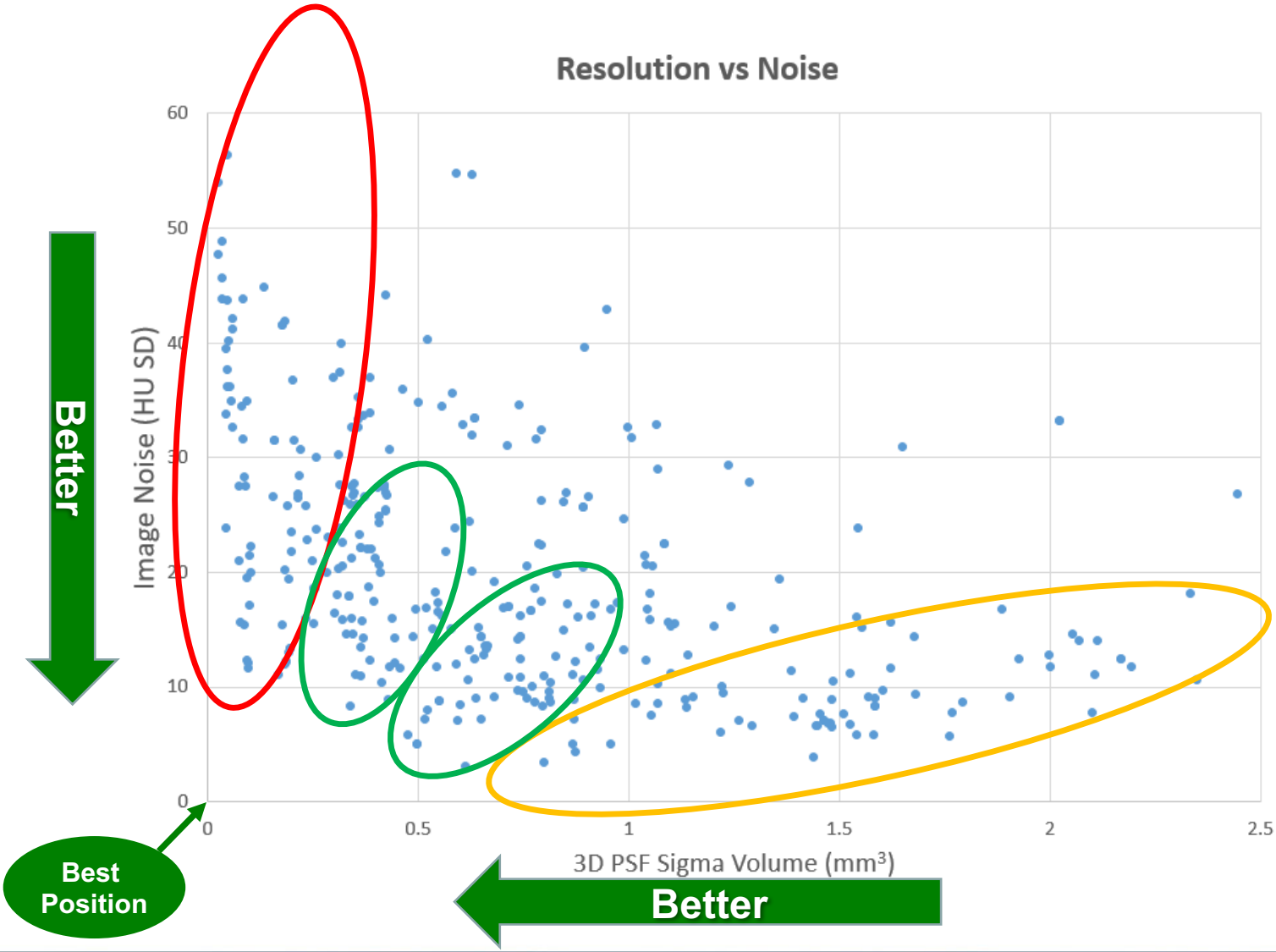
Our Specification: >= 16 detector rows, <=1.25 thickness , <=1.25 spacing

Detection Slice Thickness & Recon Kernel

Slice Thickness	Sites	Soft Recon	Medium Recon	Edge En. Recon
<= 0.625	4 (15%)	0	3	1
0.8, 1.0, 1.25	12 (46%)	6	2	4
>= 1.5	10 (38%)	6	3	1

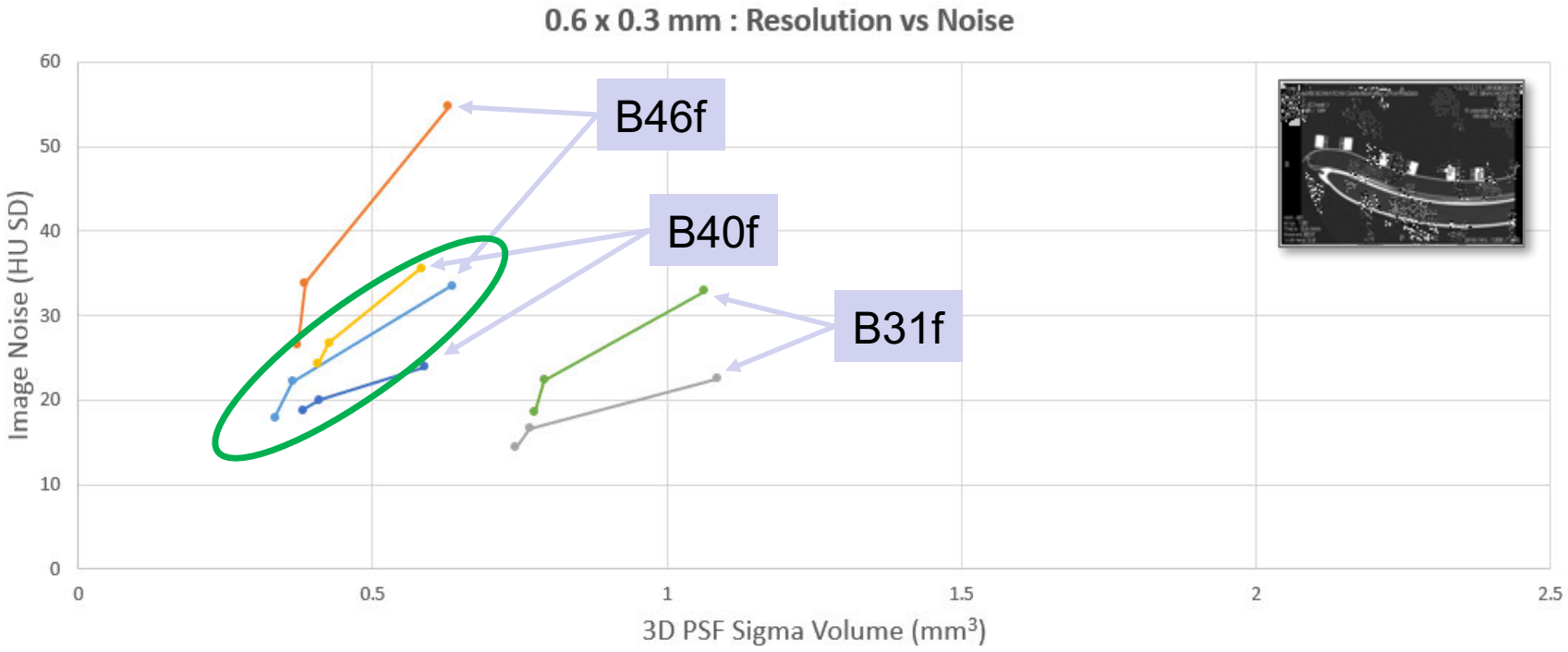
3 used 2mm ST & 1mm spacing

All Data


Resolution vs Noise
Image Noise (HU SD)
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3D PSF Sigma Volume (mm³)
Better
Better
Best Position

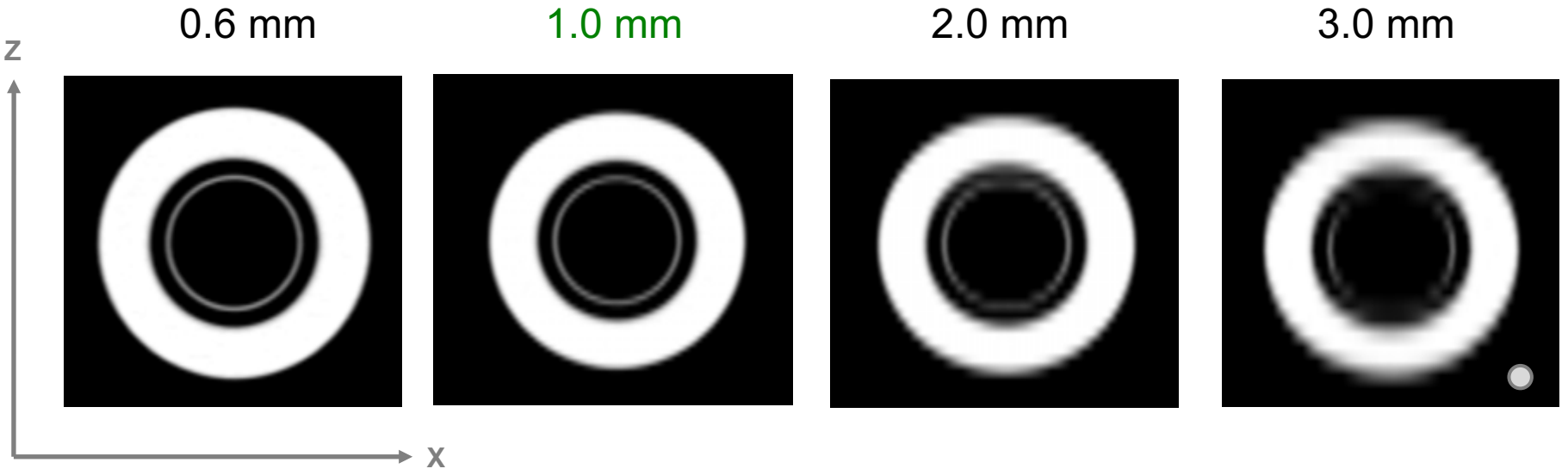
0.6 mm Slice Thickness x 0.3mm Slice Spacing

1000 Slices!
Outside Guidelines



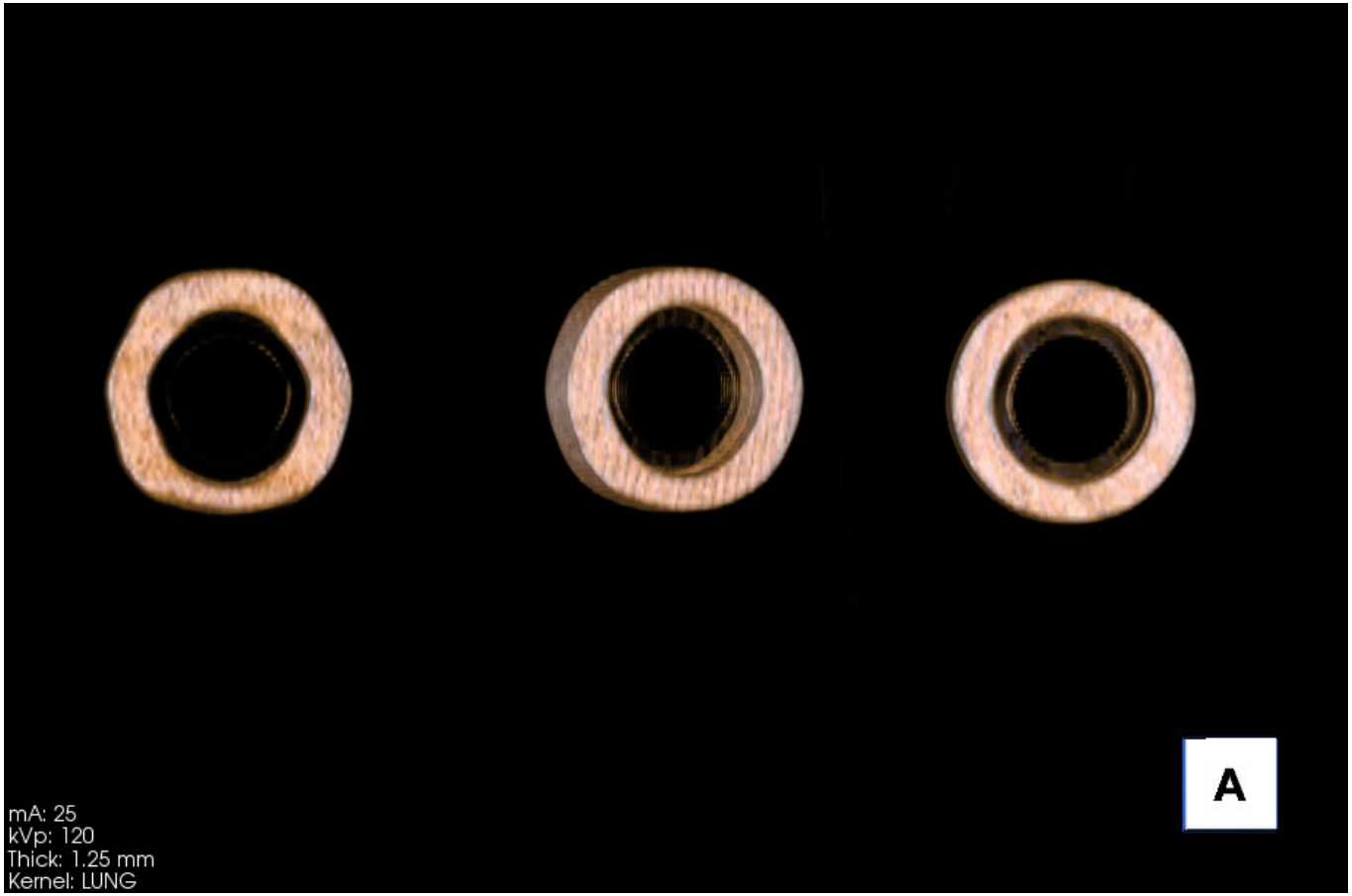
All Data from One **Siemens SOMATOM Definition** CT Scanner
Pitch 0.8, 0.5s/rotation, 120 kVp, 21 or 64 mA

CT Slice Thickness



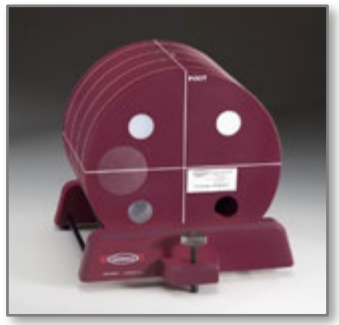
WW = 1000
WL = - 400

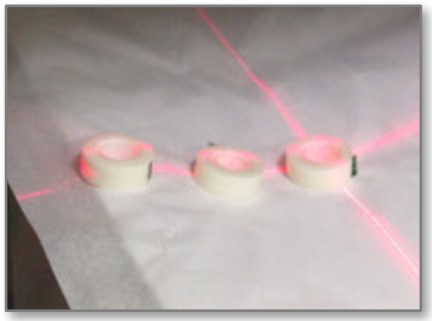
Crowd-Sourced Data

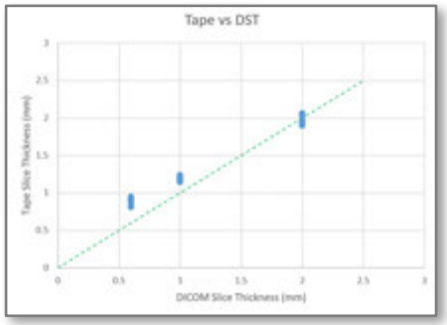


Validation Studies

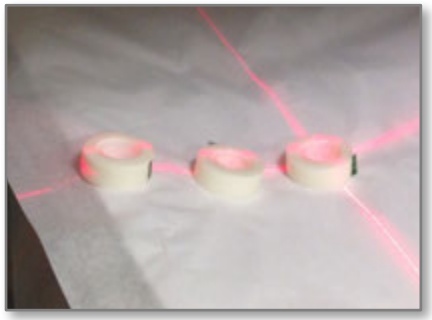
- ACR Phantom and Tape Comparison

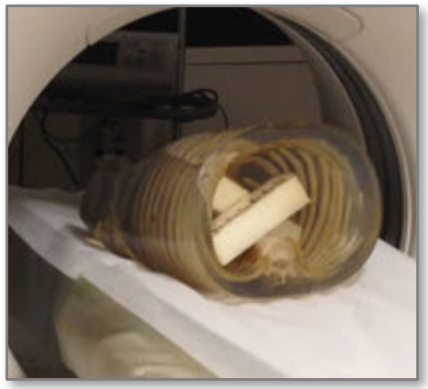


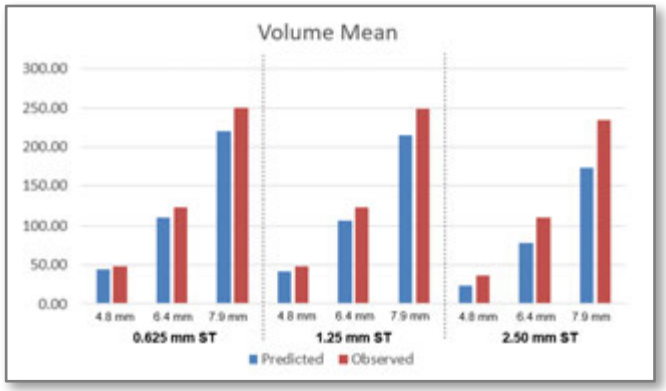




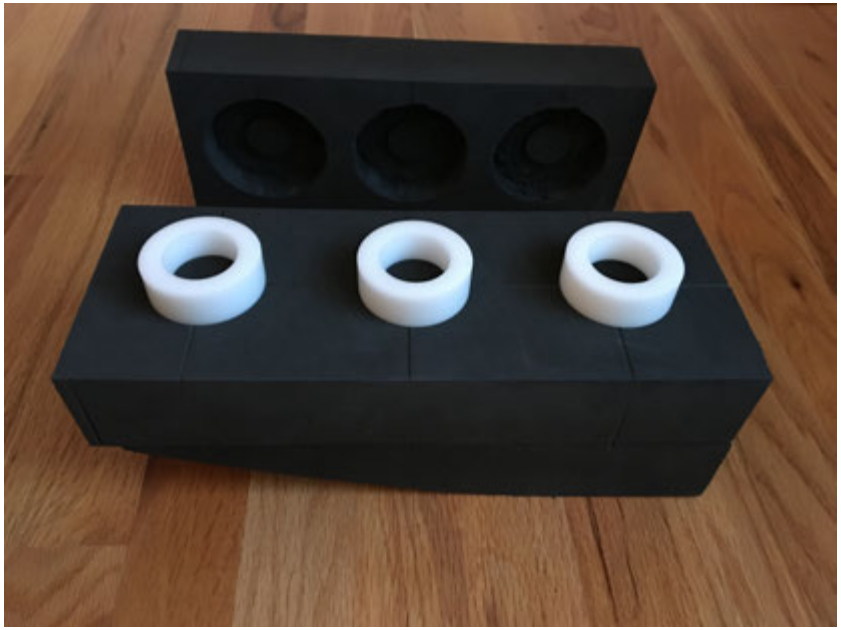
- Clinical Task Prediction Performance

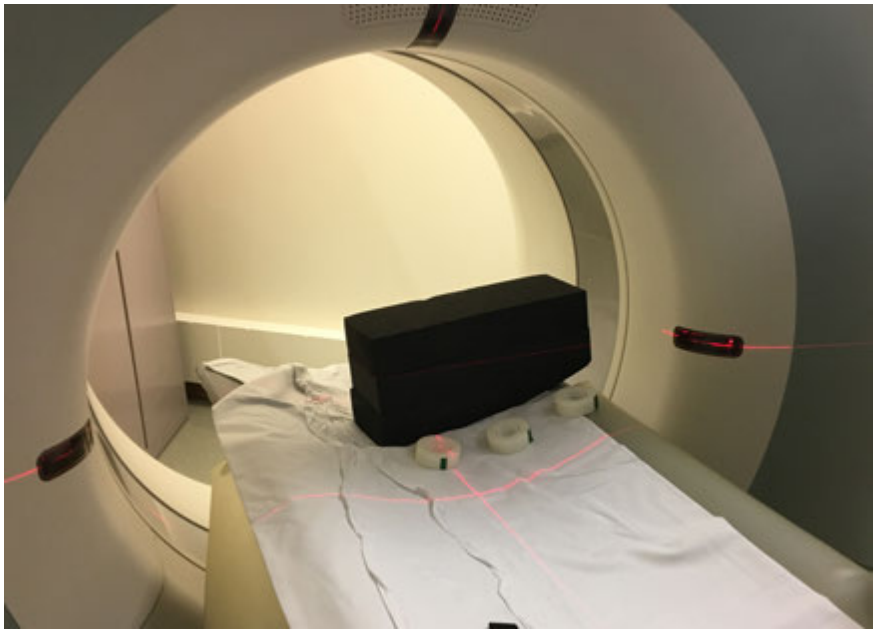


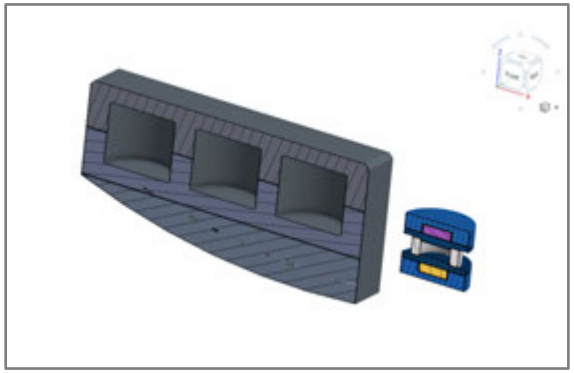


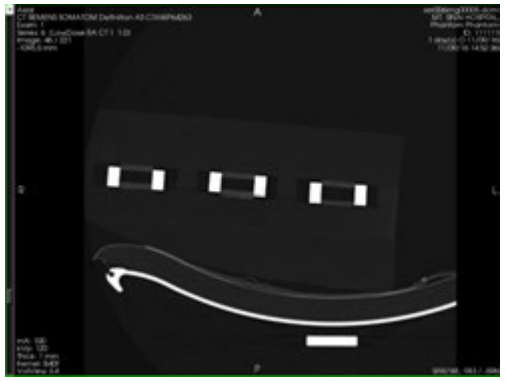


New Low Cost CT IQ Phantom





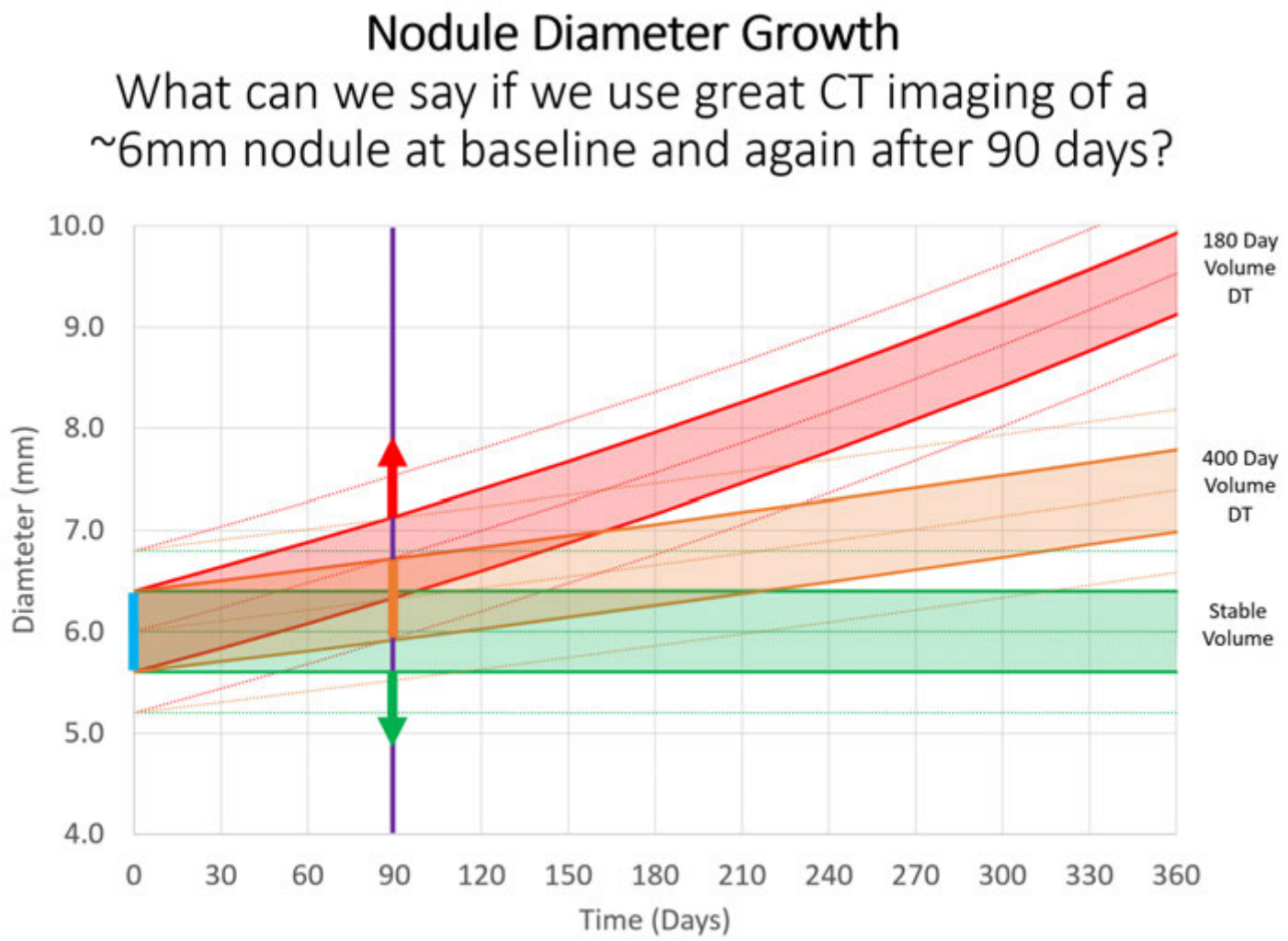




2017 Lung Screening Protocol Challenge

- We will continue our crowd-sourcing study
- Clinical sites will scan scotch tape and some will use the new low cost phantom
- The goal will be to globally optimize CT scan protocols and provide guidance on minimum time needed to distinguish malignant nodule size change

Nodule Diameter Growth



International Image Quality Monitoring

- We have tested a highly efficient and scalable image quality monitoring infrastructure
  - Ultra-low cost CT phantoms requiring <= 5 min to scan
  - Web-based Calculator(s)
  - Running on the Amazon Web Services (AWS) cloud

Summary

- For the First Time, We Can Help International Screening Sites Rapidly Optimize Protocols For Lung Cancer Screening Using Crowd-Sourcing and Cloud Computing
- In the Future Sites Will Be Able To See Their Performance Versus Other Sites with Similar Equipment
  - Am I an Outlier?
- Supports Monitoring of Advancement (or Setbacks) of CT Scanner Technology Over Time
- We Are Now Working to Establish Standards and an International Infrastructure For Screening Image Quality

Thank You