Challenges for Quantitation of Emphysema in the Screening Setting

Anthony P. Reeves
Vision and Image Analysis Group
School of Electrical and Computer Engineering
Cornell University

Presentation to Lung Cancer Workshop, May 2, 2013

Screening for COPD and Emphysema

Why screen?

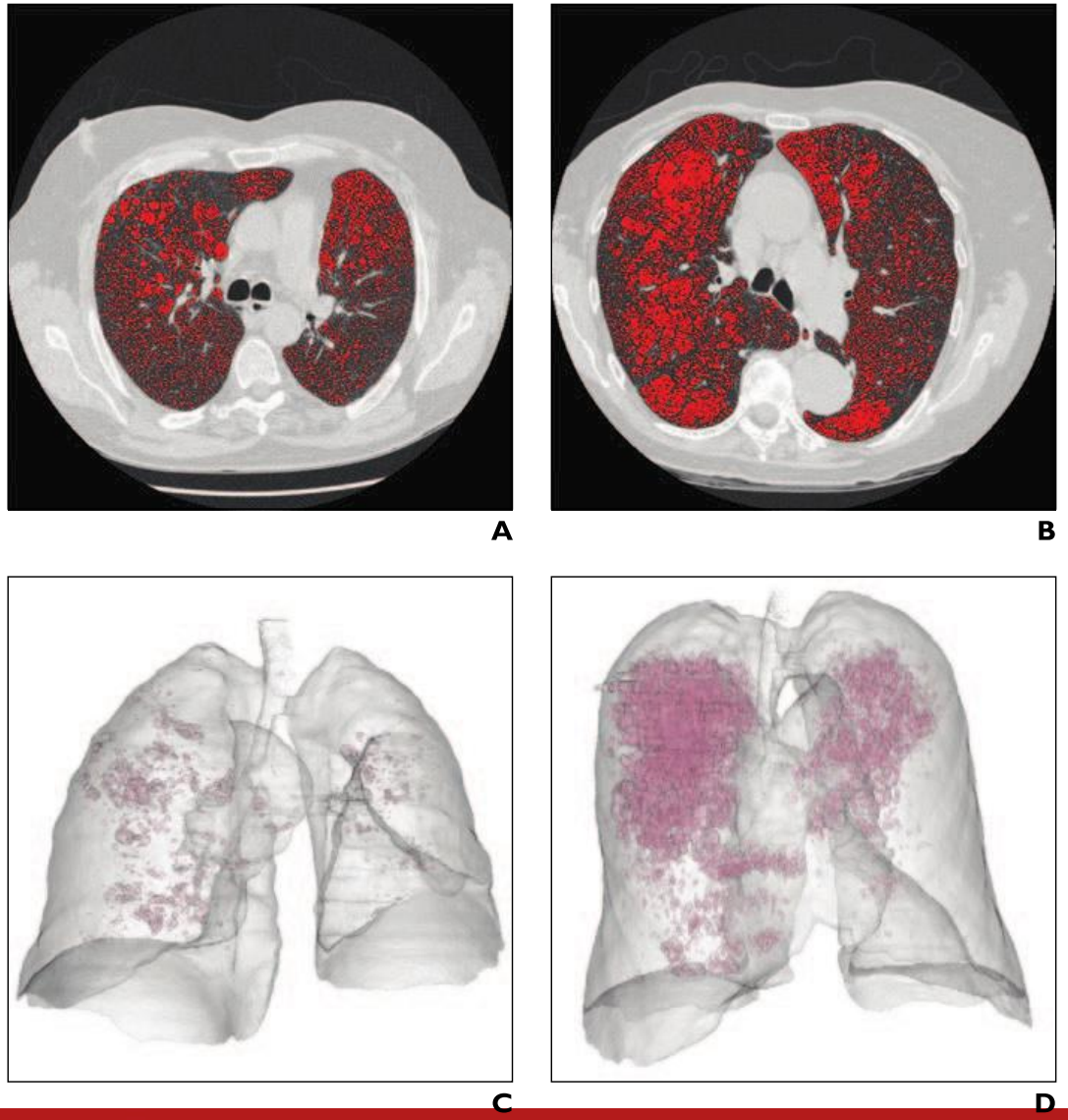
1. Identify early stage disease
   - Asymptomatic: fixed protocol
2. Monitor disease progression and response to therapy
   - Symptomatic: adaptive protocol

What to screen for?

- **Emphysema**
- Small airway disease: air trapping
- Large airway disease
- Other lung diseases (dense image structures)

CT Emphysema Index Measure

- Emphysema Index EI_{-950}, EI_{-910}
- Fraction (percentage) of lung parenchyma below intensity threshold



Emphysema Measures

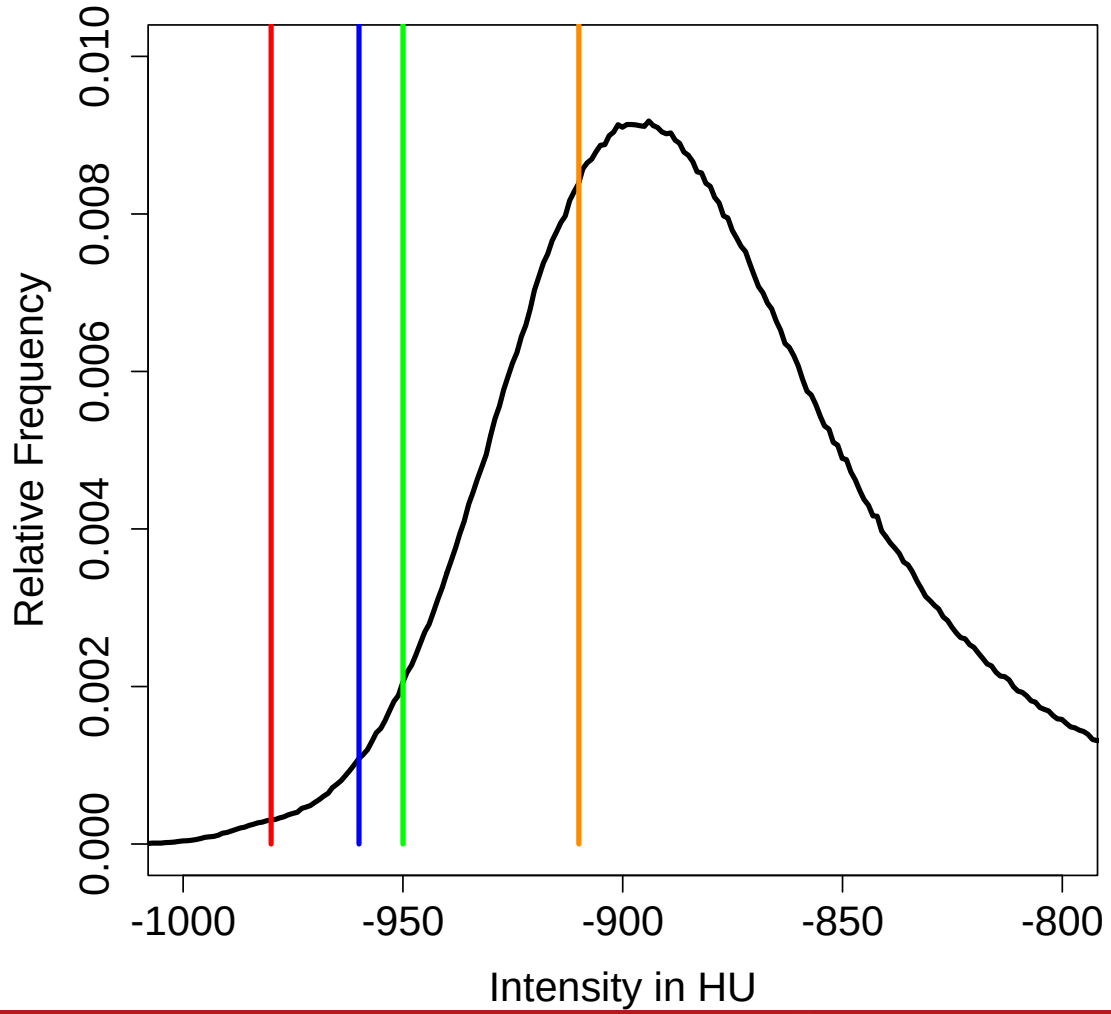
- **Emphysema Index** $EI_{-950,}$ EI_{-910}
  - Fraction (percentage) of lung parenchyma below intensity threshold
  - Poor correlation with FEV_1/FVC
- Mean Lung Density MLD
  - Mean lung image intensity in HU
- 15^{th} Percentile Intensity 15PI
  - Image intensity at the 15^{th} percentile level in the histogram
- Fractal Dimension Measure FD

Challenges with screening (CT imaging)

- Low-dose regimen
  - Noisy images: challenge for measurement of Emphysema
  - Multiple-scans required for airway trapping measurement
  - Noise limits the depth to which airways can be measured
- Calibration
  - Image calibration is important for Emphysema measurement
- Changes in CT scanner settings
  - Dose (KVp,mAs), slice thickness, and recon filter affect EI measures
  - Changes in technology e.g. model based reconstruction
- Inspiration Level

EI Thresholds

Histogram for Lung region

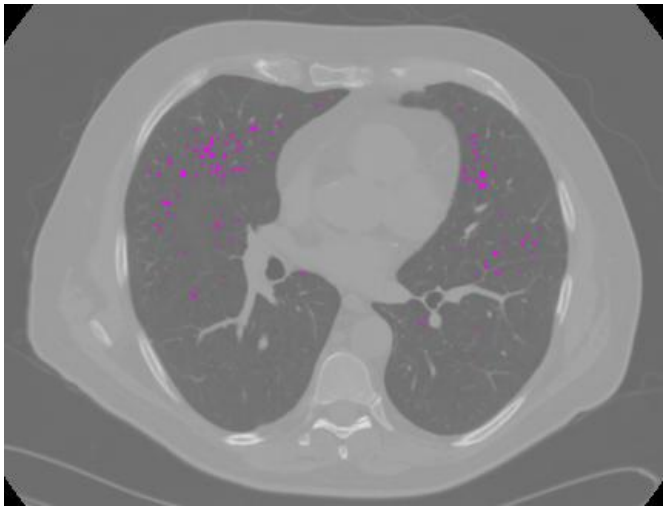


EI_{-910} = 23.8%

EI_{-950} = 2.5%

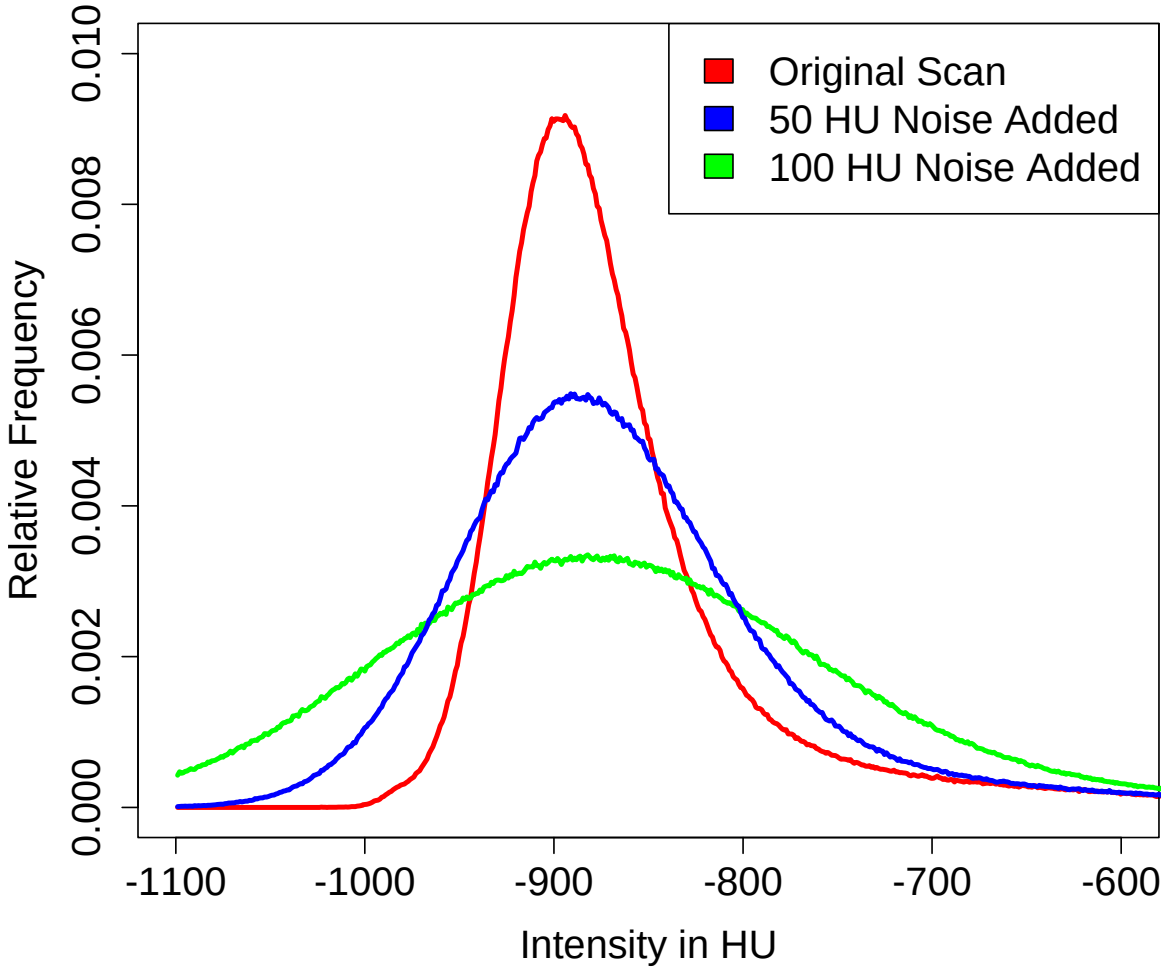
EI_{-960} = 1.1%

EI_{-980} = 0.1%



Effect of Image Noise

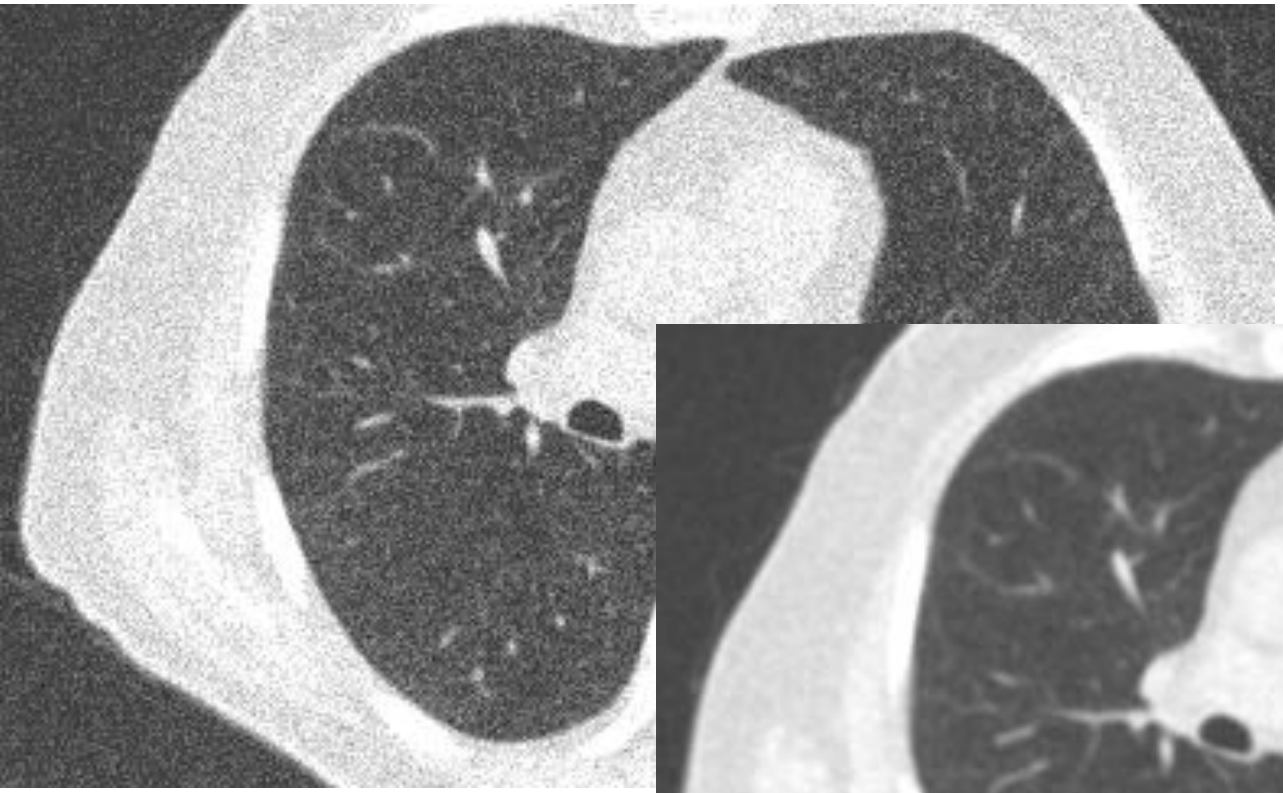
Histogram for Lung region



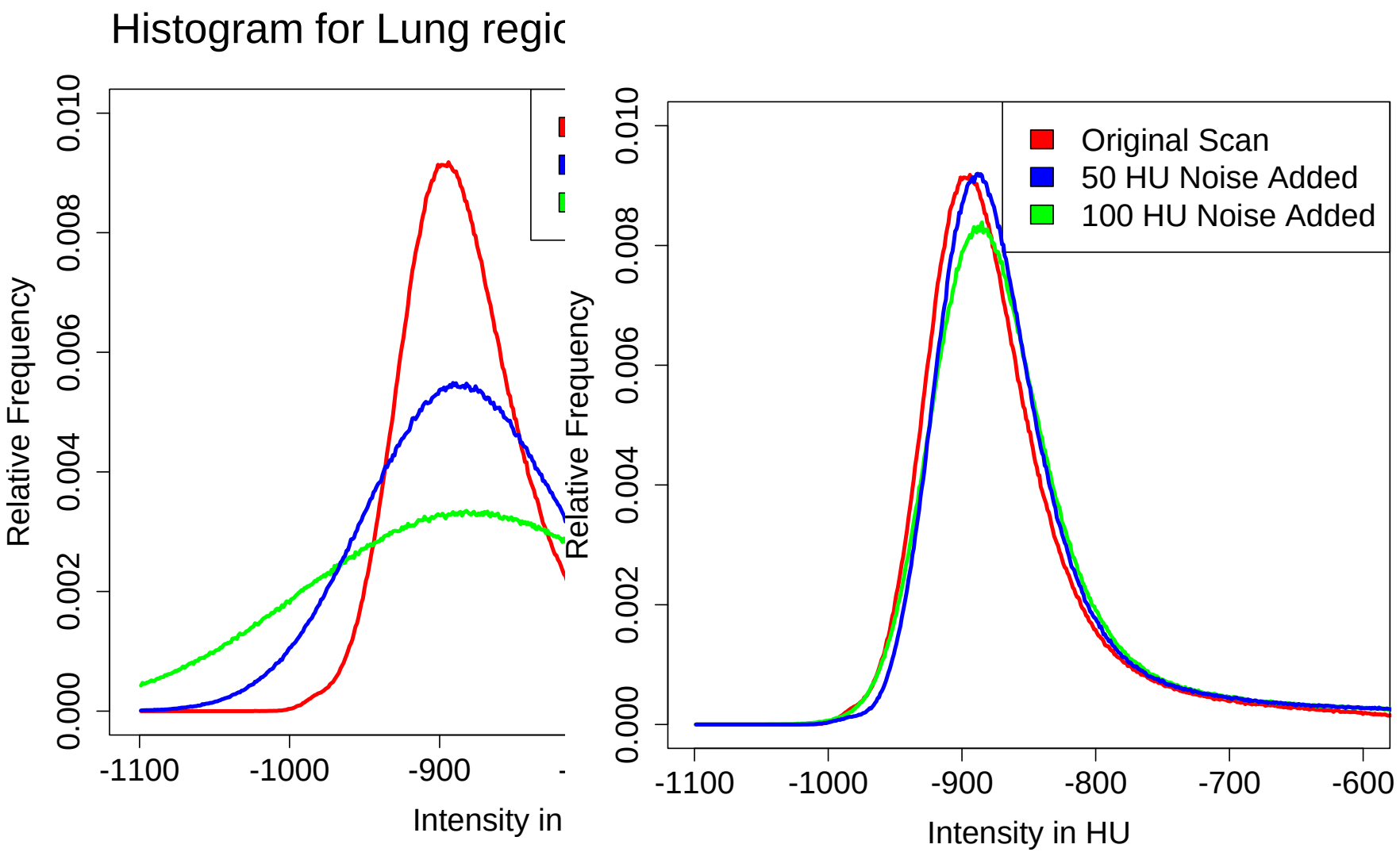
The effect of adding Gaussian noise of SD 50 and 100 HU

LIDC
120 kVp
198 mAs
1.25 mm
16 MDCT

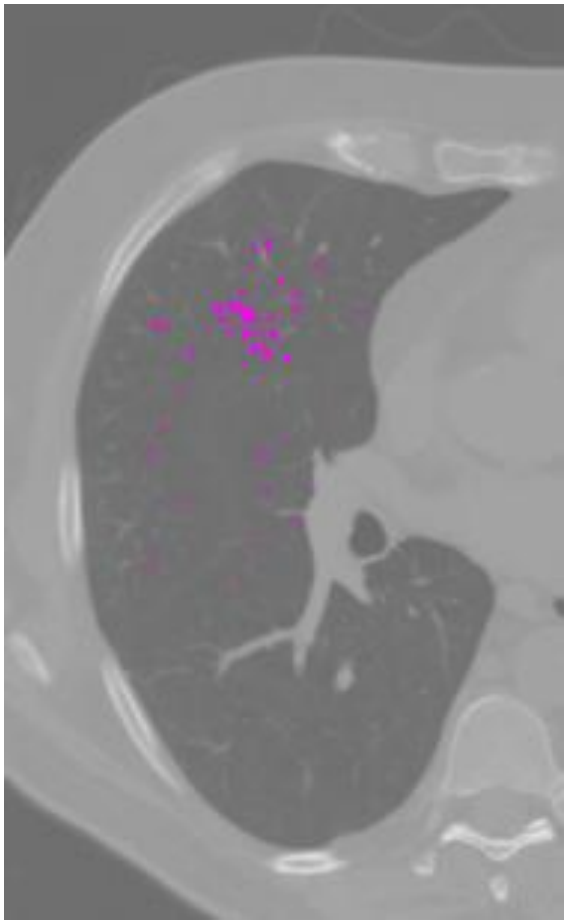
Image Noise Filtering



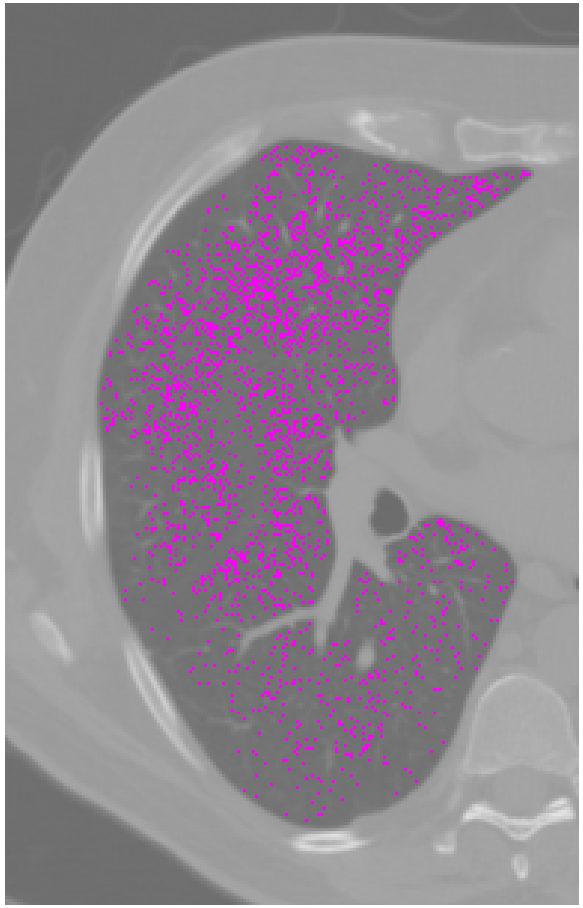
Effect of Noise Filtering



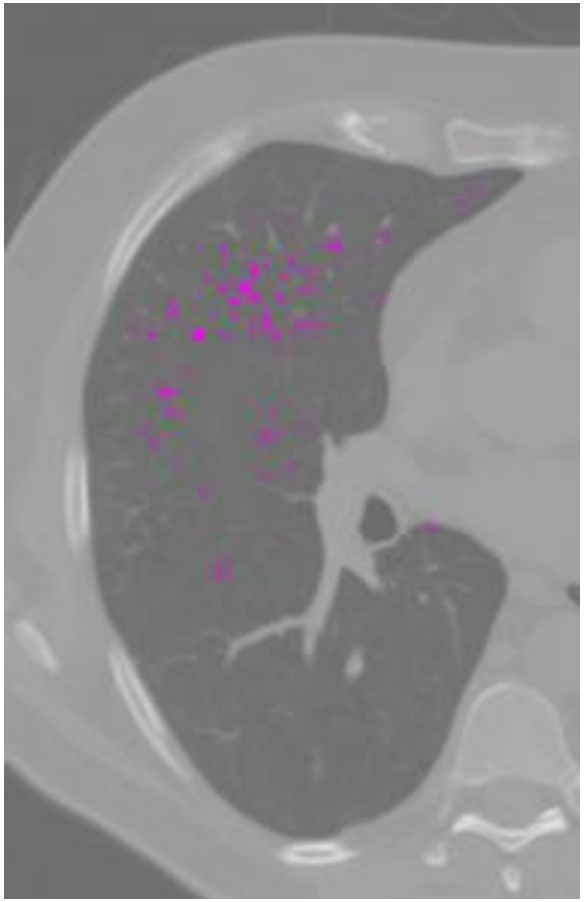
Effect of Noise on Emphysema Index



EI (-950) for original scan



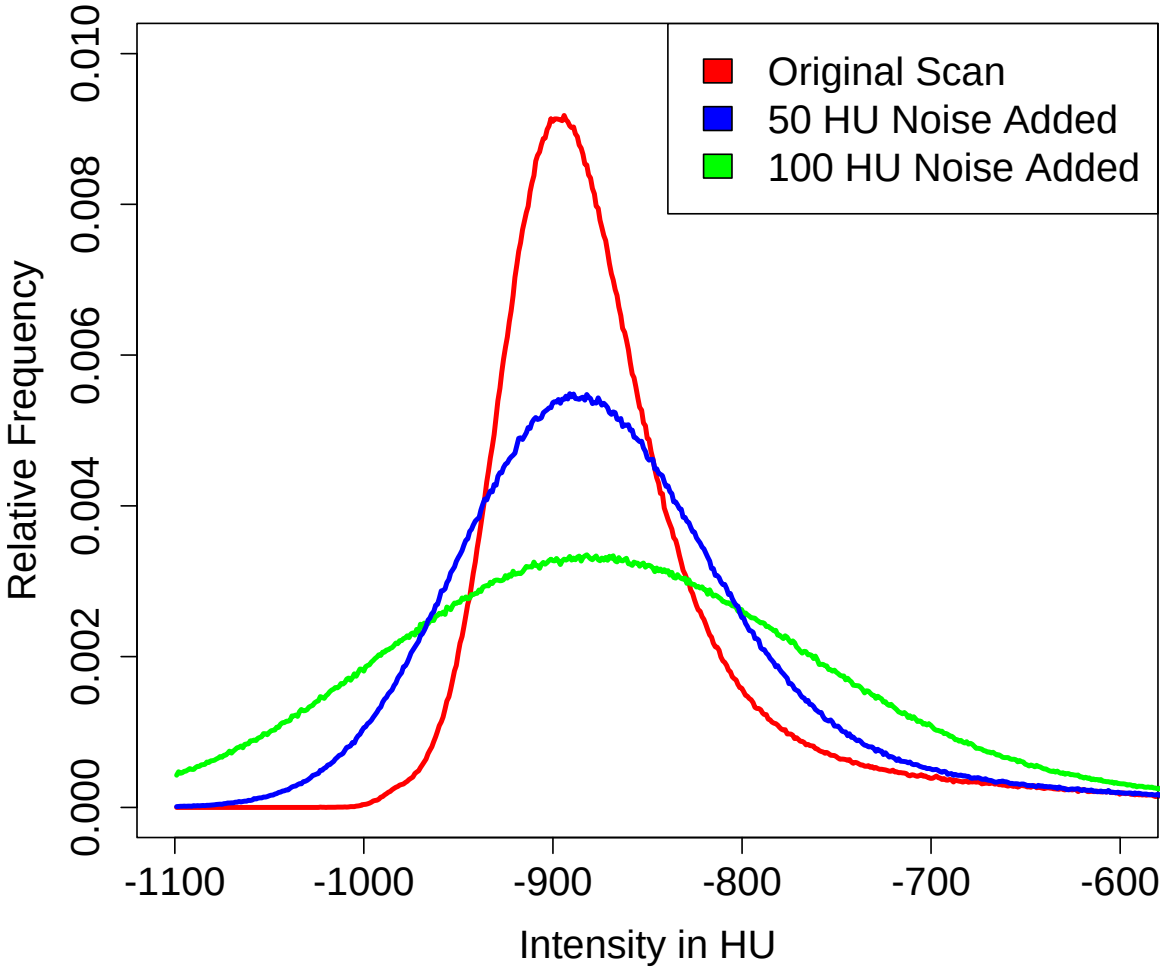
+50 HU noise



After noise filtering

Effect of Image Noise

Histogram for Lung region



The effect of adding Gaussian noise of SD 50 and 100 HU

Before Filtering

EI_{-950} = 2.6%

EI_{-950} = 13.0%

EI_{-950} = 24.1%

After Filtering

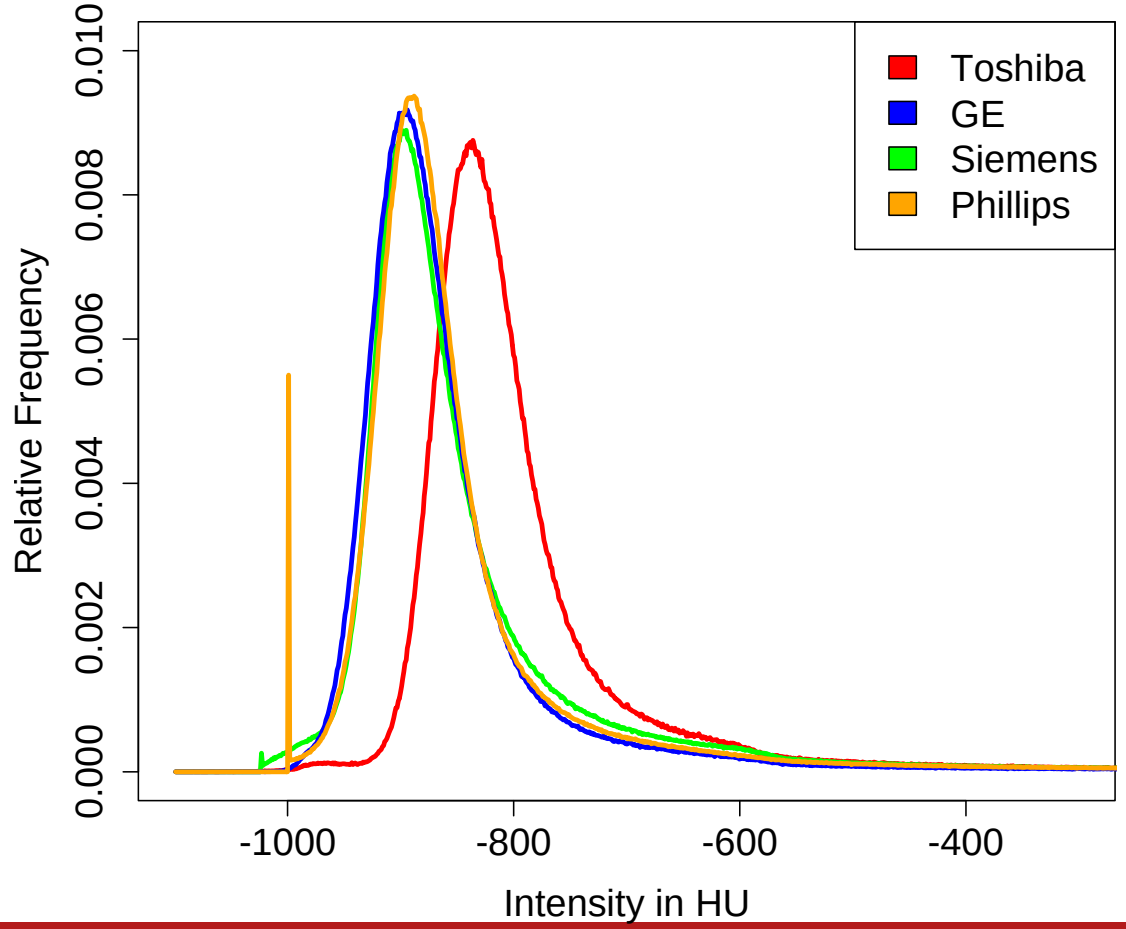
EI_{-950} = 1.3%

EI_{-950} = 2.6%

Manufacturers Low Cutoff

Example scans from 4 different Manufacturers

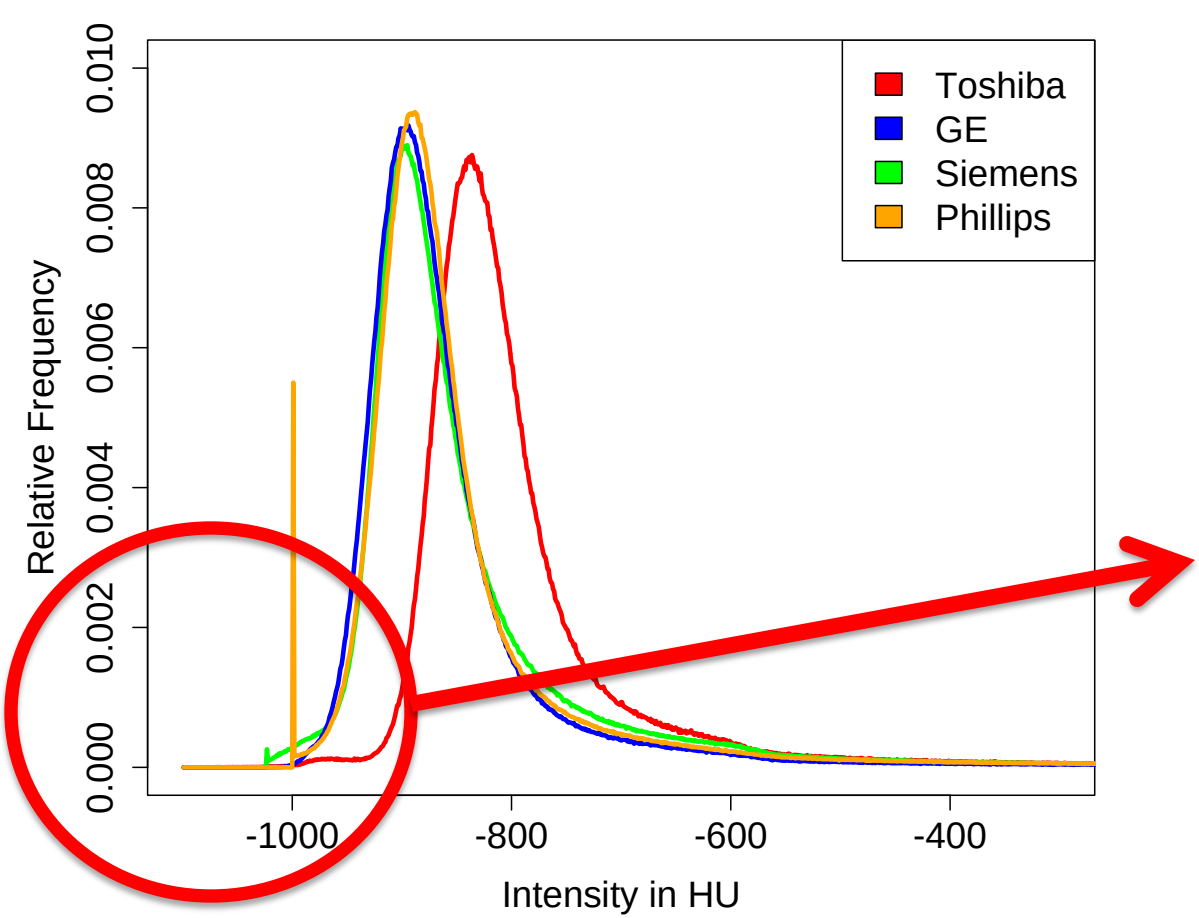
Histogram for Lung region

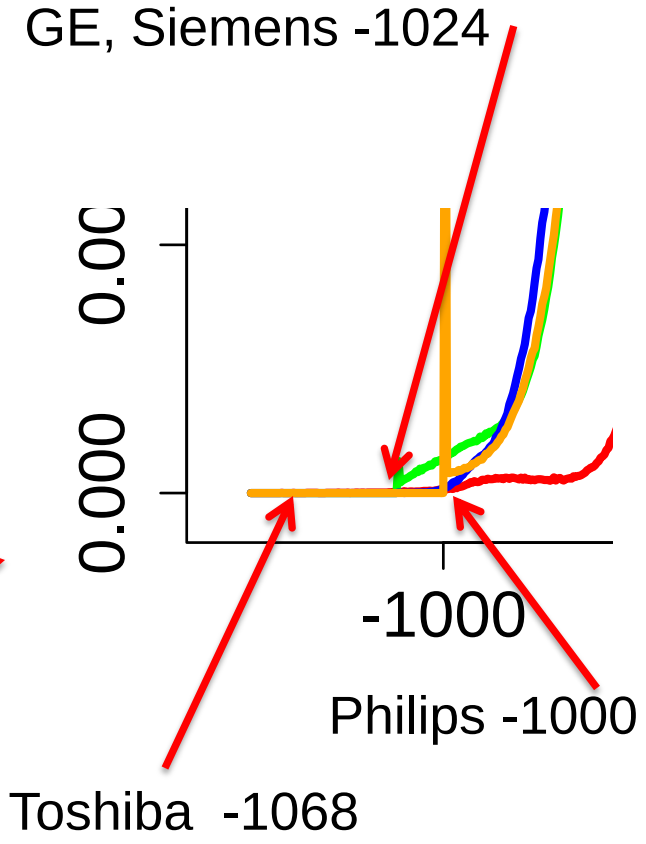


Manufacturers Low Cutoff

Example scans from 4 different Manufacturers

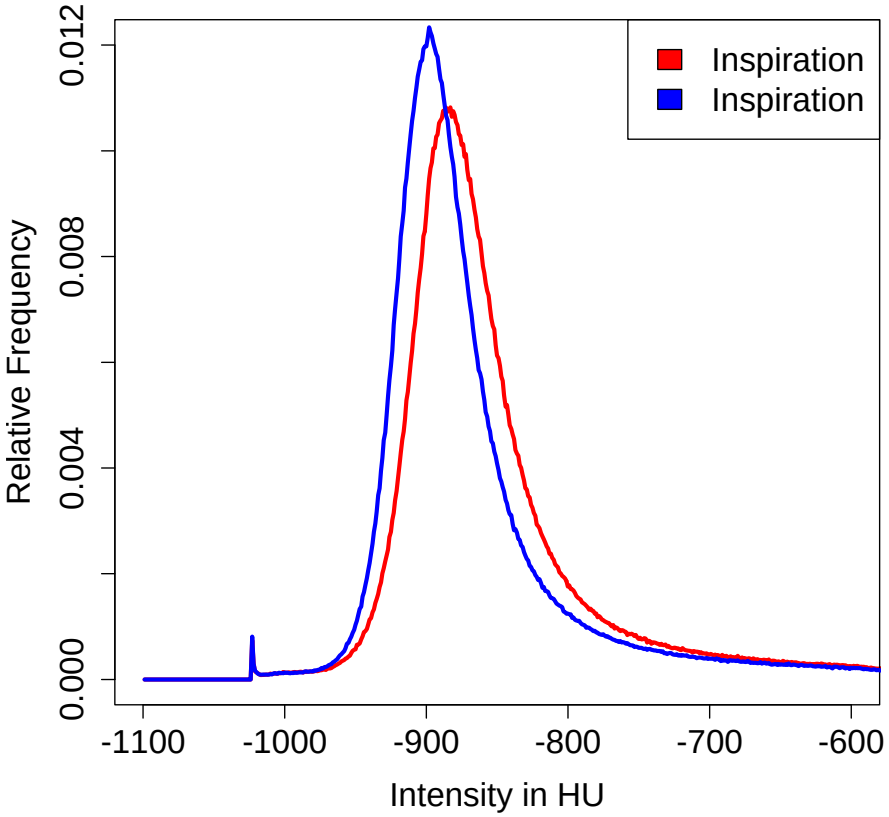
Histogram for Lung region



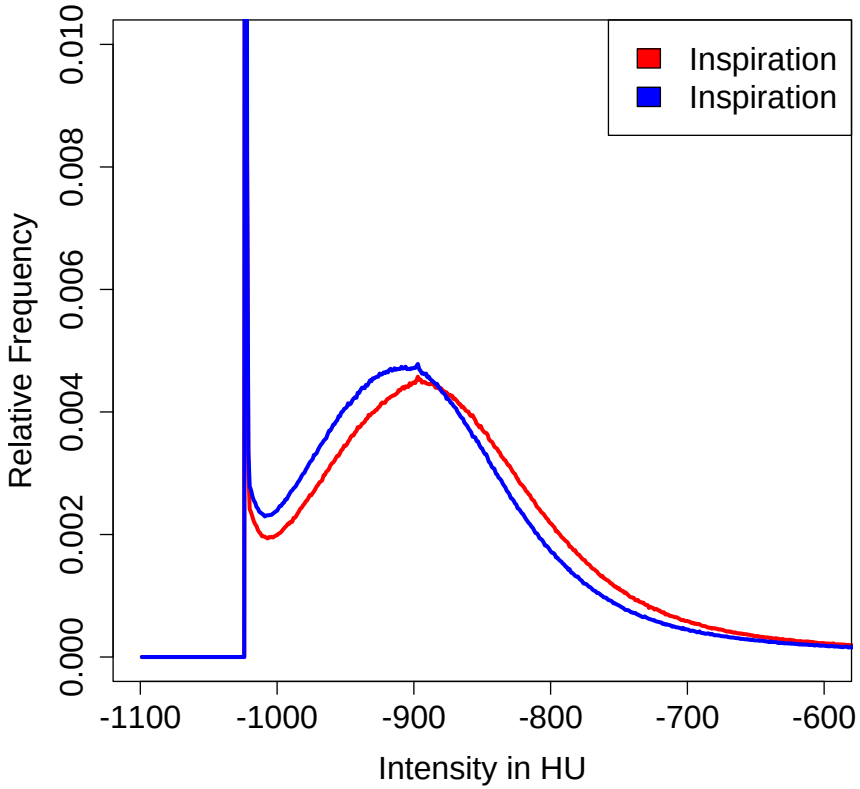


Example: Difference in inspiration (9%)

Histogram for Lung region



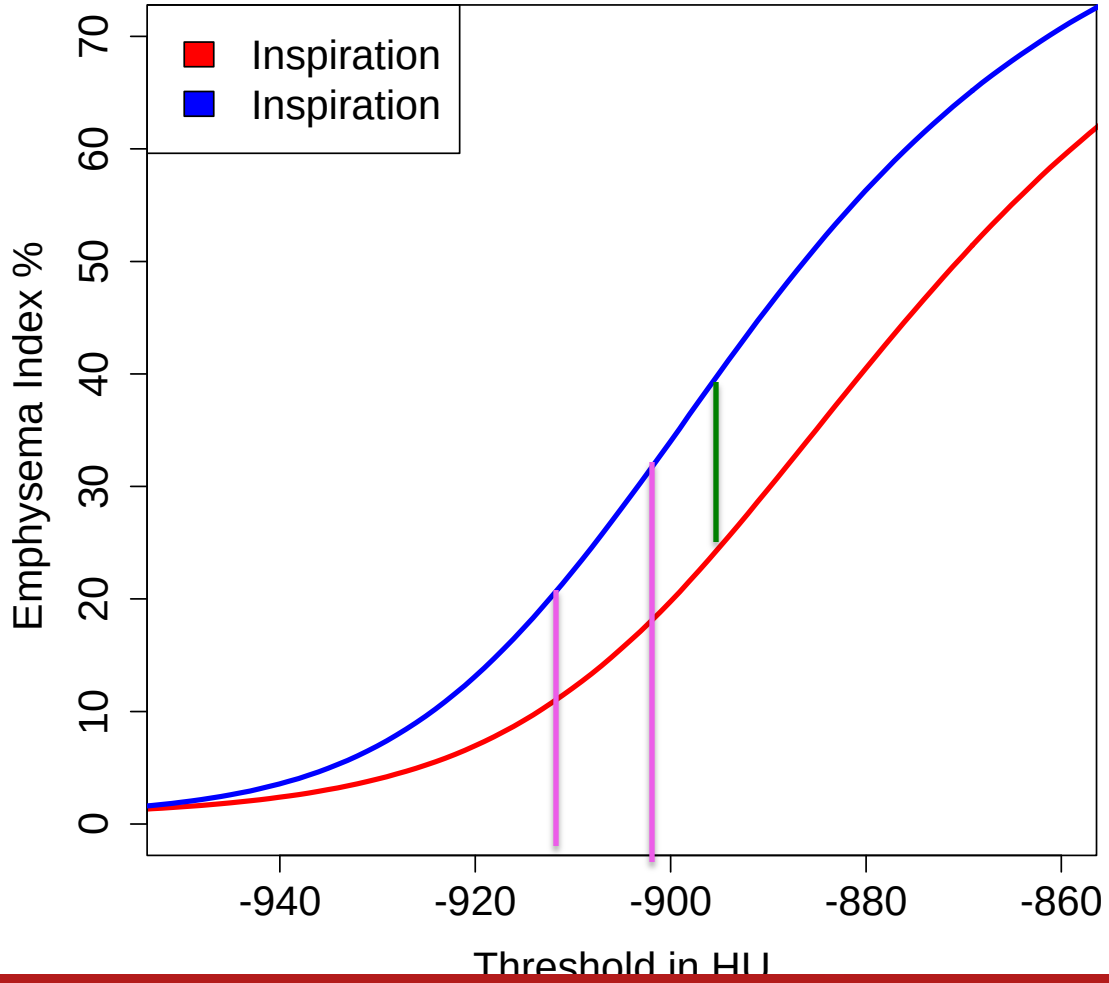
Slice thickness 5 mm



Slice Thickness 1.0 mm

Effects of inspiration and calibration

- Lung histogram



10% change in EI due to inspiration change

10% change in EI due to 10 HU “calibration” change

Conclusion

- Challenges
  - Image noise
  - Subject inspiration level
  - Scanner parameter settings
  - Poor correlation with conventional function tests
- Opportunities
  - Low-cost (in the context of LC screening) evaluation of COPD and emphysema
  - Simple automated implementation
  - The importance of early diagnosis of COPD