

RSNA-QIBA COMPARISON OF SHEAR WAVE SPEED ESTIMATION IN VISCOELASTIC PHANTOMS

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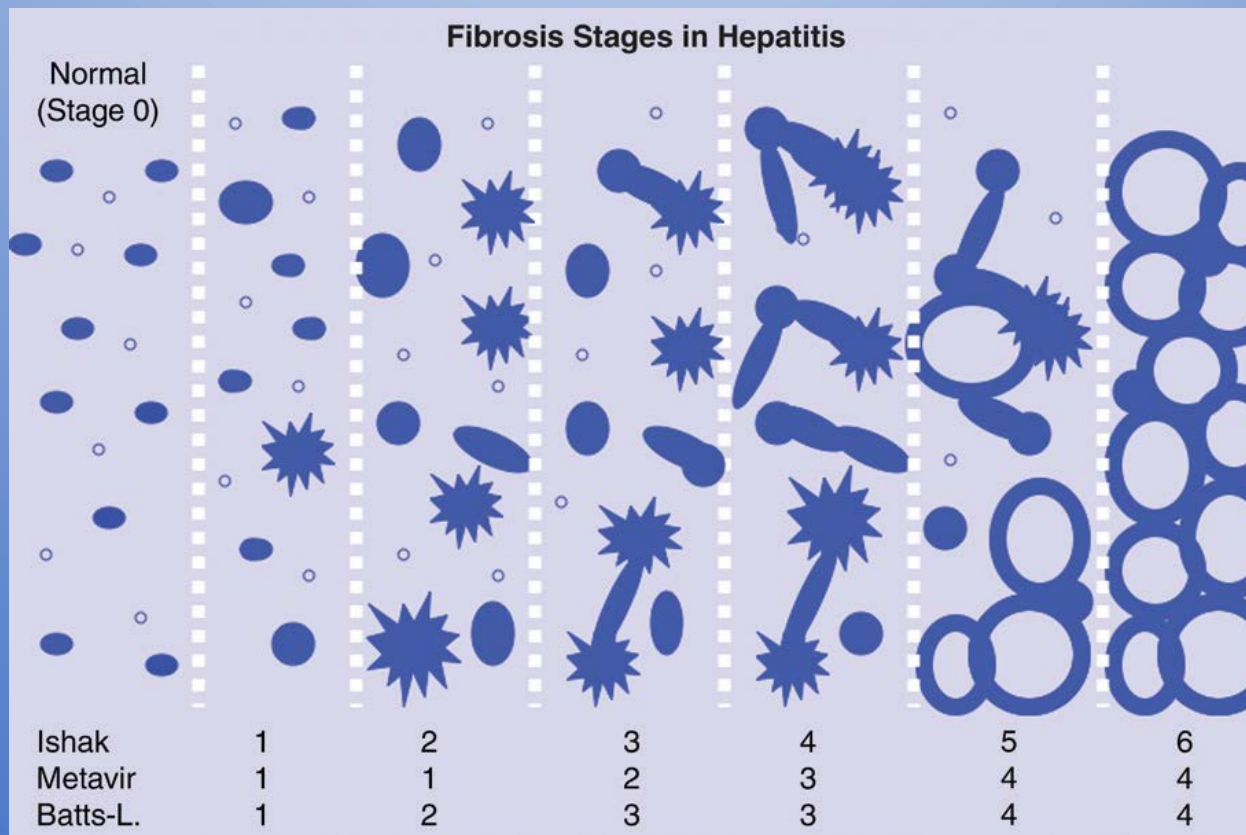
Thanks!

- This is an international effort involving many groups
 - Industry
 - Academics
 - Clinicians
 - Government agencies
 - Pharma
 - Over 200 participants
- Special thanks to Mark Palmeri (Duke University) and Jun Chen (Mayo Clinic, Rochester, MN) for many of the slides/plots included here

Clinical Motivation

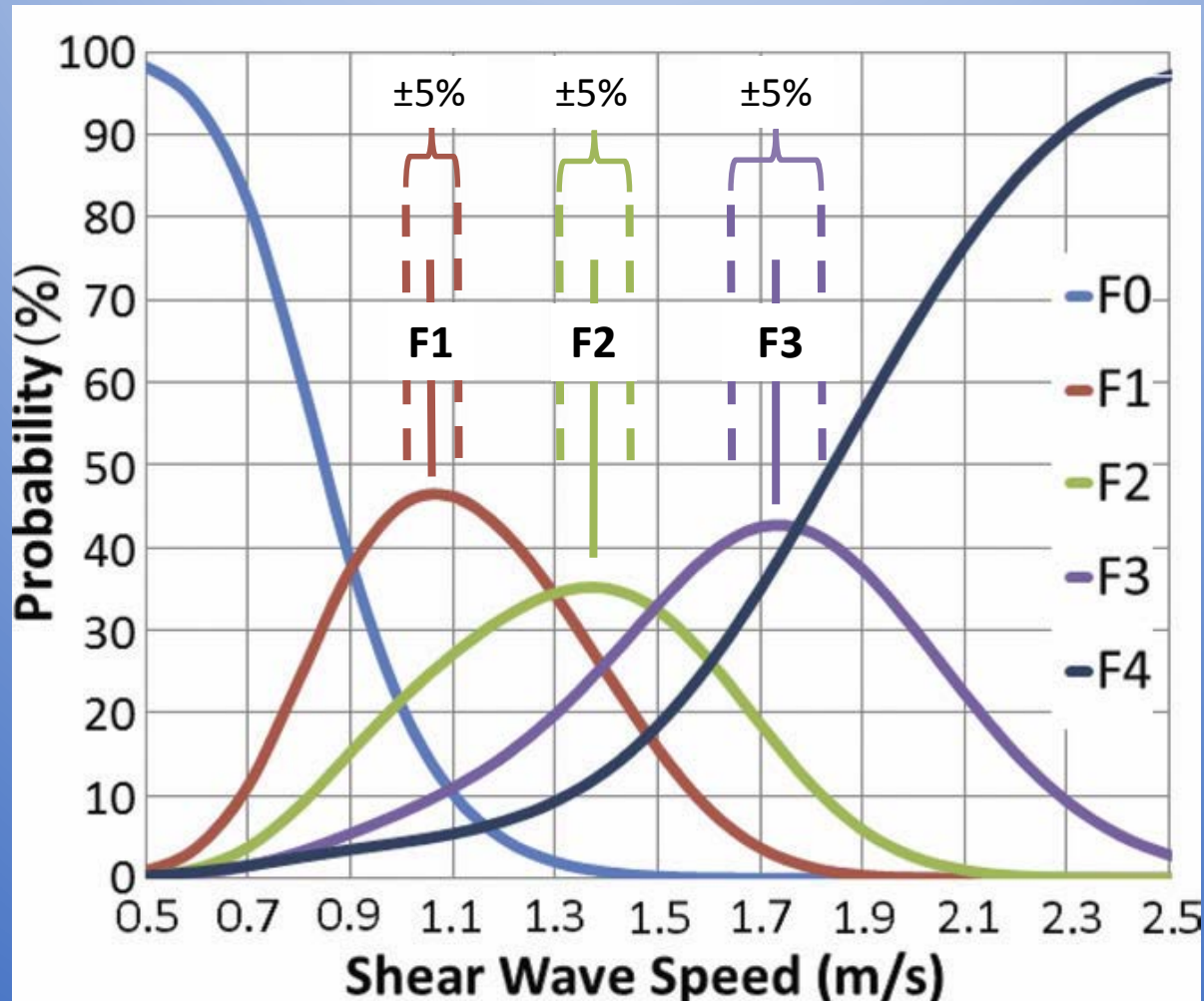
- Clinical guidelines
 - EFSUMB Ultrasound Elastography Guidelines
 - JSUM Ultrasound Elastography Practice Guidelines
 - WFUMB Guidelines and Recommendations for Clinical Use of Ultrasound Elastography
 - SRU Elastography Assessment of Liver Fibrosis Consensus Statement
- Guidelines and clinical literature cite differences in SWS for liver fibrosis staging
- Need controlled datasets and imaging environments to characterize and delineate sources of SWS bias and variation

Liver Fibrosis Stages



Stars represent periportal fibrosis, lines represent bridging fibrosis, and circles represent nodularity

Meta-analysis: SWS vs. METAVIR Score



Barr et al. "Elastography Assessment of Liver Fibrosis: Society of Radiologists in Ultrasound Consensus Conference Statement", Radiology 276(3):845-861, 2015.

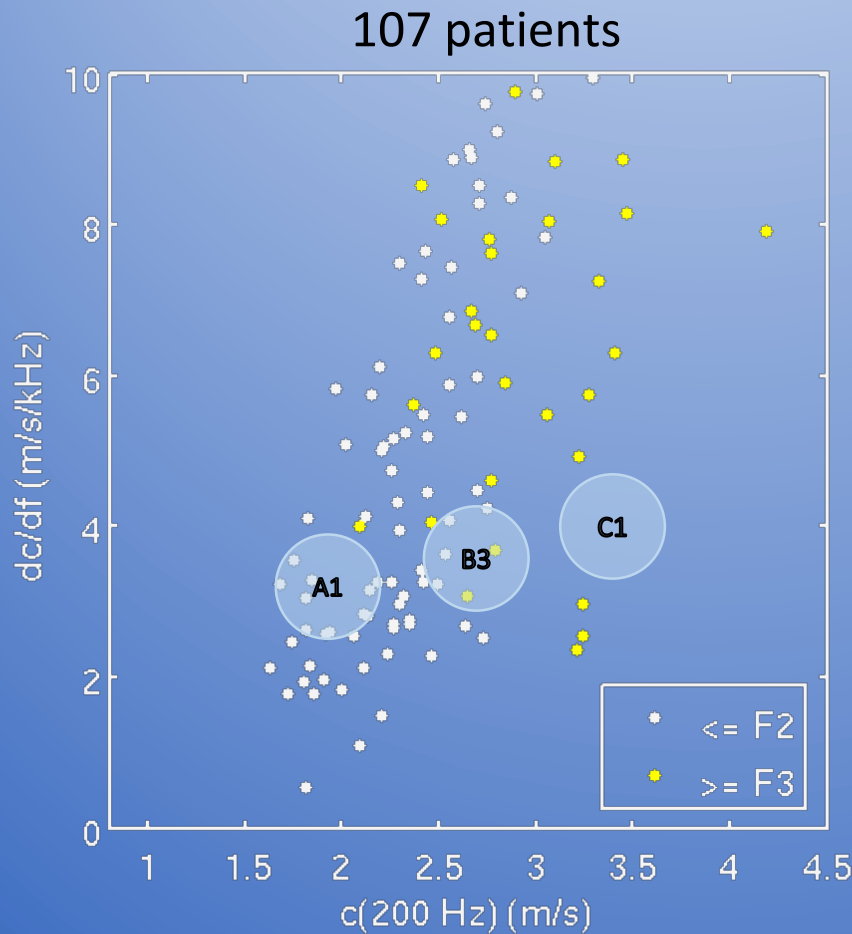
Friedrich-Rust et al. "Performance of acoustic radiation force impulse imaging for the staging of liver fibrosis: a pooled meta-analysis", J Viral Hep 19(2), 2012.

Systems Involved in the Phase II Study

Most were blinded from knowing the results obtained by others prior to their data acquisition

- GE Logiq E9 - C6-1
- Hitachi
- Mindray/Zonare ZS3
- Philips EPIQ - C5-1
- Philips iU22 - C5-1
- Samsung/Medison RS80A
- Siemens S3000 - 6C1
- Siemens S2000 - 6C1
- Siemens SC2000 - 4C1
- Supersonic Imagine Aixplorer - 6C1
- Toshiba Aplio-500 - PVT
- Verasonics
- Duke custom implementation

VE Phantoms Chosen to Match Human Liver Data (Healthy-Fibrotic)



Three phantoms from CIRS

-- A1

-- B3

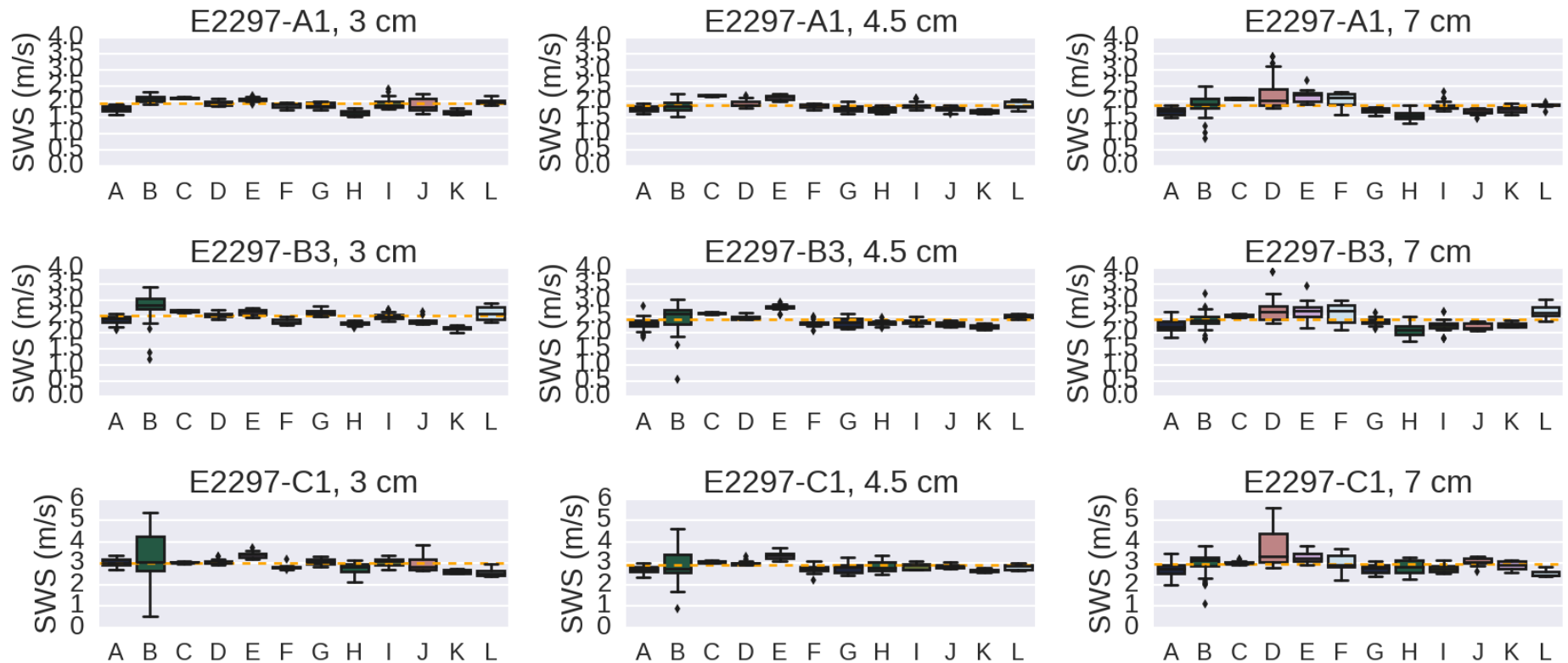
-- C1

(oil-in-polyacrylamide dispersions)

Increasing stiffness and dispersion

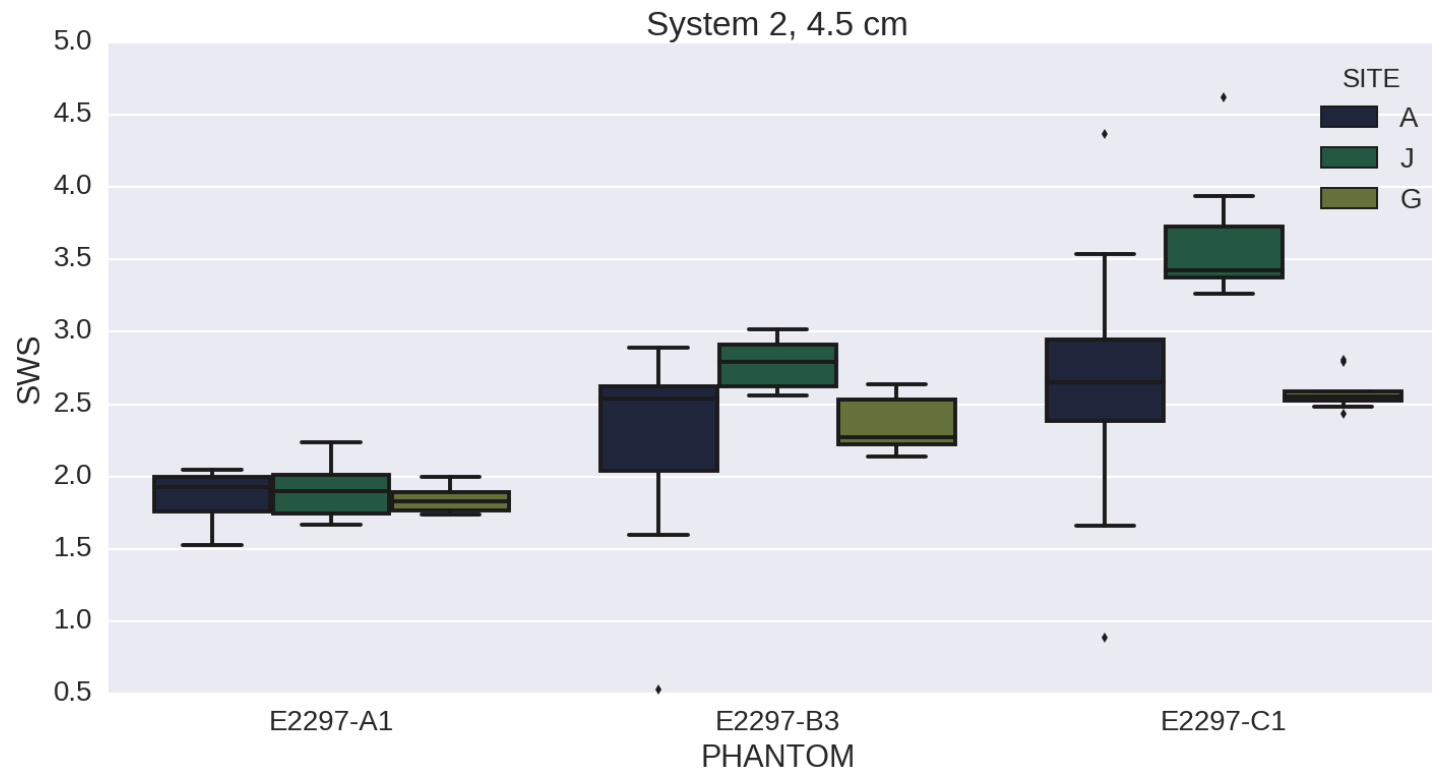
Demonstrates a need for more dispersive phantom materials

Phase II Results



3 Phantoms (A1, B3, C1), 3 depths (3.0, 4.5, and 7.0cm), and 11 systems

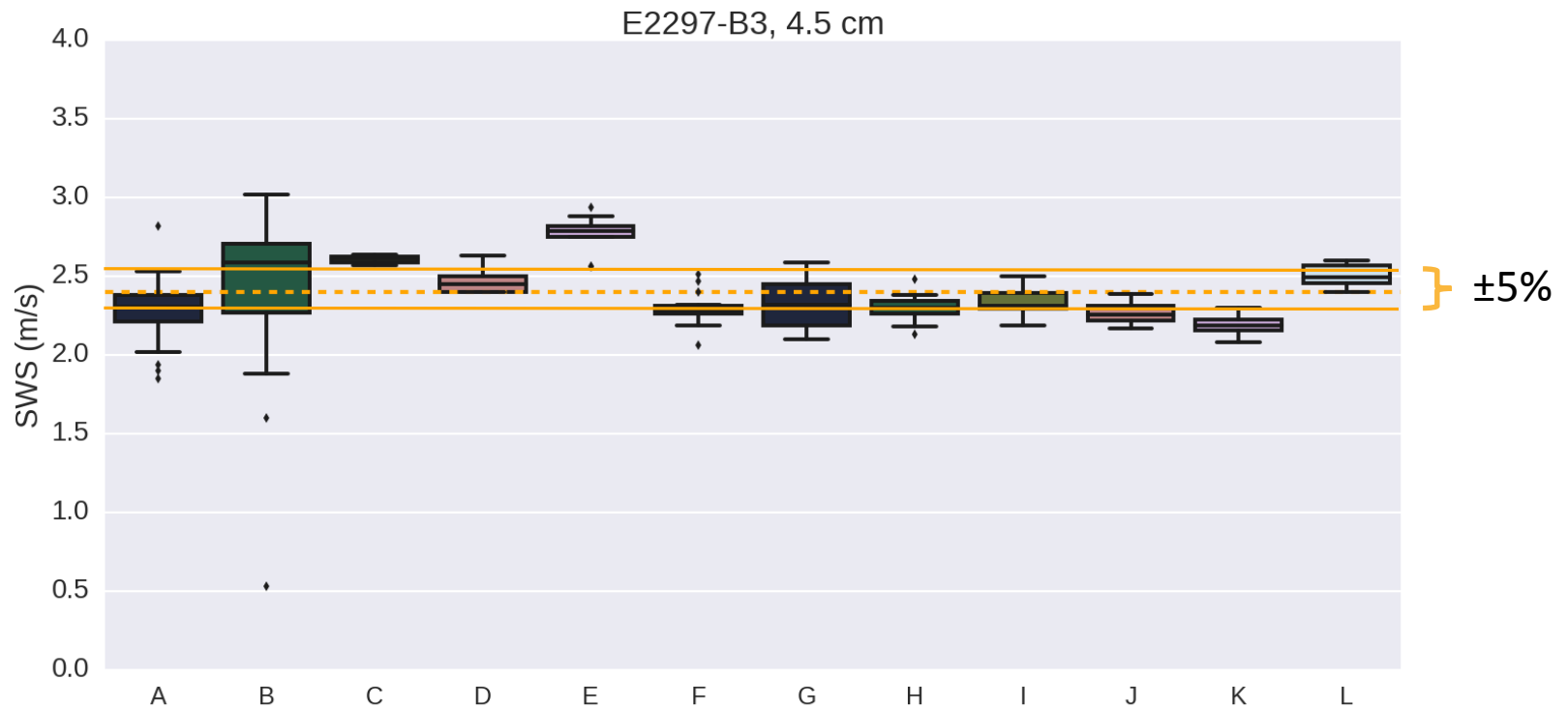
Phase II Results



Reproducibility

3 Phantoms (A1, B3, C1), 1 depth, and 1 system at 3 sites

Phase II Results



Bias? Comparison with a 'consensus mean'

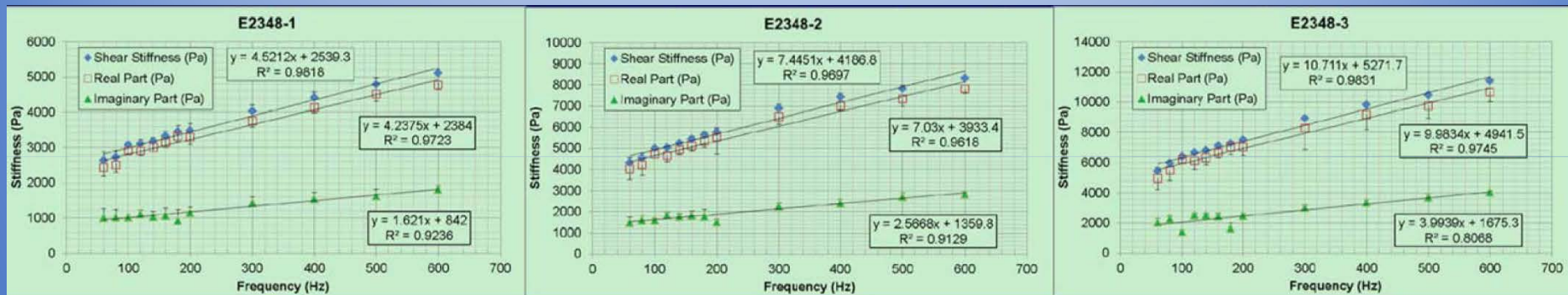
1 Phantom, 1 depth, and 11 systems

Phantom Material Properties

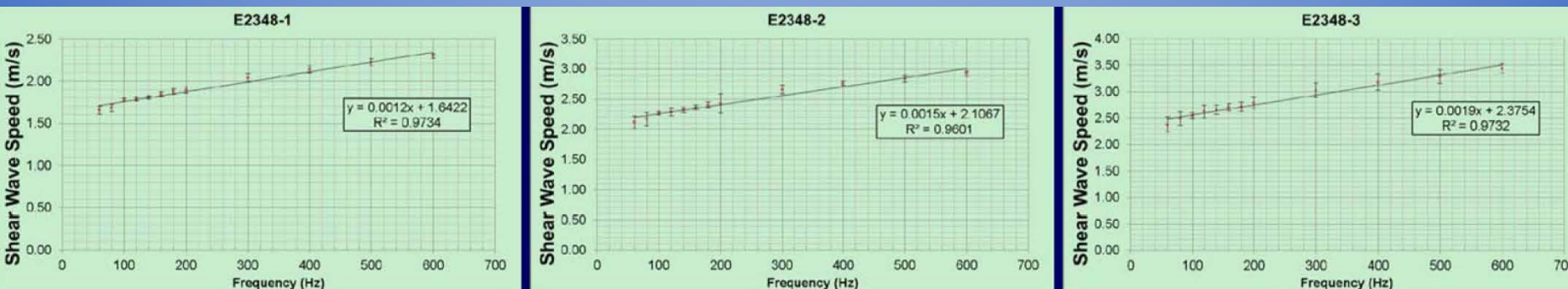
- What is ground truth?
- What are the viscoelastic properties of these materials?
- What is the (shear wave) frequency dependence of those properties?
- ***How can we determine estimate bias lacking ground truth?***

Use MRE Estimates as a Reference

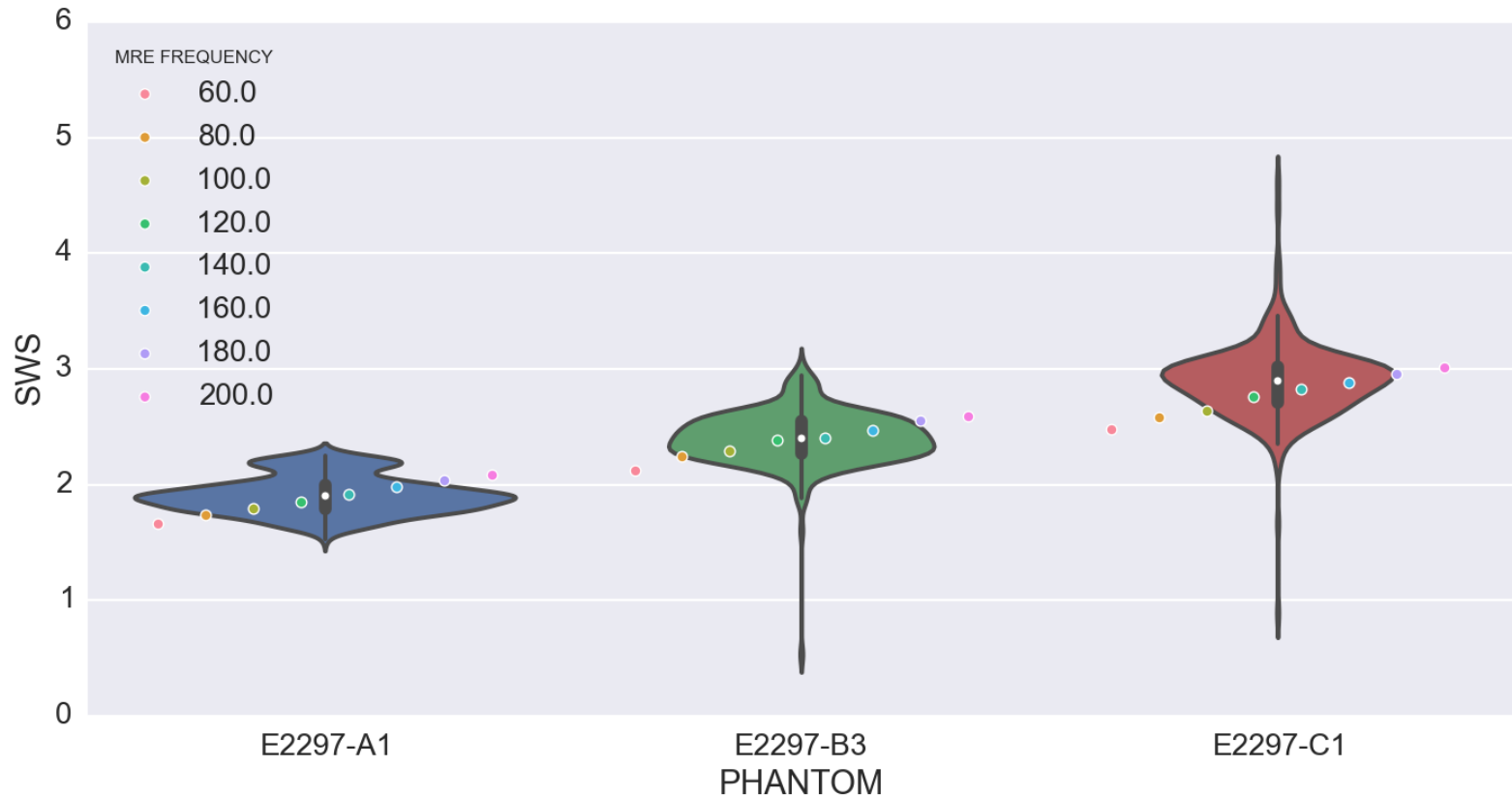
MRE complex modulus estimates



MRE estimates converted to equivalent SWS



Compare SWS to MRE Estimates



Digital Phantom Study Parameters

- **Curvilinear Probe Parameters**

- Radius of curvature: 60 mm
- Element Height: 14 mm
- Element Pitch: 0.477 mm (0.007 mm kerf)
- Center Freq: 3.0 MHz
- Frac. Bandwidth: 100%
- Elevation Focus: 50 mm

- **ARF Excitation Parameters**

- Frequency: 3.0 MHz
- $F/\# = 2, 3.5$
- 500, 1000 cycles
- Focal Depths: 30, 50, 70 mm (F/2 for all configurations)

- **Acoustic Material Properties**

- Attenuation: 0.45 dB/cm/MHz
- Linear

- **Elastic Material Properties**

- Poisson's ratio: 0.495
- Shear modulus: [1.0, 2.0, 5.0, 10.0] kPa

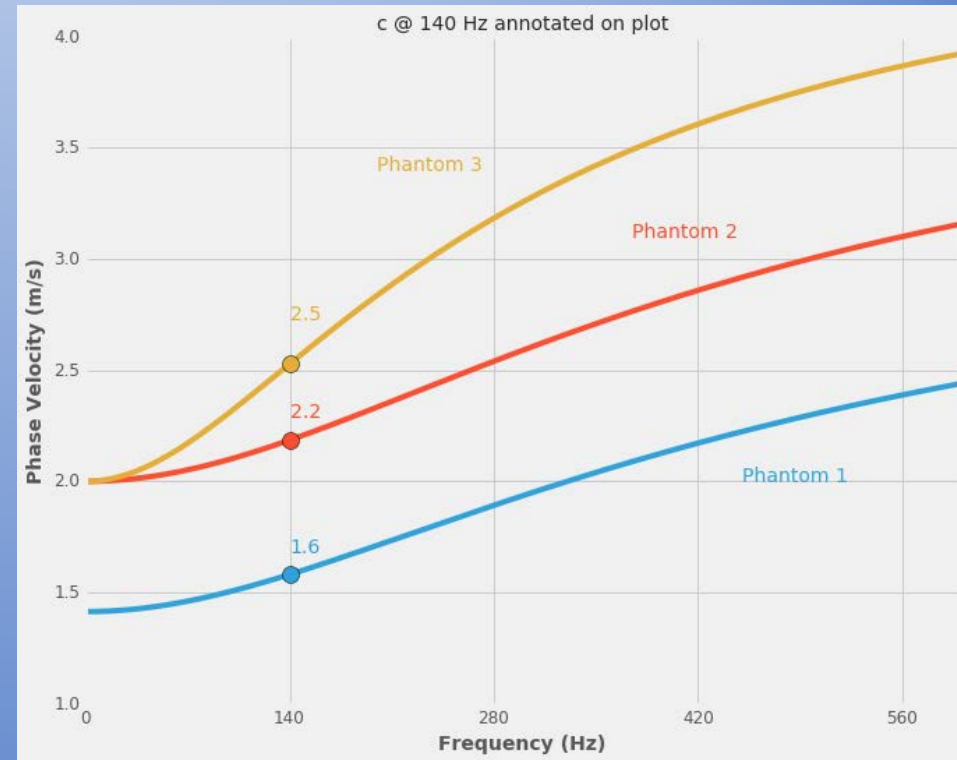
- **Viscoelastic Material Properties**

- Match Phase II phantoms
- Fewer focal configurations

VE Digital Phantoms

$$G(t) = G_{\infty} + (G_o - G_{\infty})e^{-\beta t}$$

	Go (kPa)	G ∞ (kPa)	B (s-1)
Phantom 1	10	2	6667
Phantom 2	15	4	5500
Phantom 3	20	4	4000



Simulation Setup Code Hosted on GitHub

<https://github.com/RSNA-QIBA-US-SWS>

Search GitHub

Explore Gist Blog Help

mlp6

RSNA Quantitative Imaging Biomarker Alliance (US SWS)

Ultrasound Shear Wave Speed Biomarker

http://qibawiki.rsna.org/index.php?title=Ultrasound_SWS_tech_ctte

Filters Find a repository... + New repository

QIBA-DigitalPhantoms

Python ★0 1

RSNA QIBA Digital Phantom Studies

Updated 3 days ago

fem

Python ★0 3

forked from mlp6/fem

Finite Element Modeling (FEM) Code: Python Tools, Field II Intensity Field Solution, LS-DYNA Pre/Post Processing

Updated 4 days ago

People

2 >

- mlp6 Mark Palmeri
- qiangbo Bo Qiang

Invite someone

Teams

1 >

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Audit log

7 events happened in the past two weeks.

This repository Search

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RSNA-QIBA-US-SWS / QIBA-DigitalPhantoms

Unwatch 1 Star 0 Fork 1

RSNA QIBA Digital Phantom Studies — Edit

21 commits 1 branch 0 releases 2 contributors

branch master QIBA-DigitalPhantoms / +

Merge remote-tracking branch 'qiba/master'

mlp6 authored 3 days ago latest commit 474010b708

- dyna add ls-dyna input deck and cluster run scripts 3 days ago
- field fix syntax for nodeLoad*.mts generation 3 days ago
- mesh extend axial dim to 3 cm beyond focal depth 3 days ago
- .gitignore ignore dyna input deck files 4 days ago
- LICENSE Initial commit 27 days ago
- README.md Merge remote-tracking branch 'qiba/master' 3 days ago

README.md

QIBA-DigitalPhantoms

RSNA QIBA Digital Phantom Studies (http://qibawiki.rsna.org/index.php?title=Ultrasound_SWS_tech_ctte)

This repository contains the parameters and simulation configuration files used for the digital phantom datasets that will be circulated to all of the manufacturers.

Curvilinear Probe Parameters

- Radius of curvature: 60 mm
- Element Height: 14 mm
- Element Pitch: 0.477 mm (0.007 mm kerf)
- Center Frequency: 2.0 MHz

SSH clone URL: g1t@github.com:RS

You can clone with HTTPS, SSH, or Subversion

Download ZIP

Quantitative Imaging Data Warehouse (QIDW)

<http://qidw.rsna.org>
(US SWS Digital Phantoms)

The screenshot displays the QIDW web interface. At the top left is the logo for the Quantitative Imaging Biomarkers Alliance (RSNA). A search bar and an 'Upload' button are located at the top right. On the left side, there is a navigation menu with options: Communities, My folders, Users, Feed, Explore, Advanced search, and Curation Dashboard. The main content area shows the 'US-SWS-Digital-Phantoms' community page, which includes a description: 'Finite element (FE) and finite-difference method simulation datasets of elastic and... More »'. Below the description are tabs for 'Data', 'Feed', 'Info', and 'Shared with members'. A table lists the files in the 'CIRS_Elastic_FEM_Data' folder:

Name	Size	Modified	
Private	--	8 months ago	
Public	--	8 months ago	
CIRS_Elastic_FEM_Data	--	7 months	
CIRS_Elastic_FEM_Data.txt	8.7 KB	7 months	
CIRS_Elastic_FEM_Data.zip	524.4 MB	7 months	
LICENSE	0.6 KB	7 months	
README	0.8 KB	7 months	

On the right side, there are sections for 'COMMUNITY ACTIONS' (Manage, Send invitation, Create a top-level folder, Leave the community), 'SELECTED FOLDER' (View, Download, Share, Create a new Folder, Upload here, Edit, Move, Permissions, Delete), and 'INFO' for the 'CIRS_Elastic_FEM_Data' folder:

CIRS_Elastic_FEM_Data
Created 08/09/2014
Last Updated 08/09/2014
Size 524.4 MB

At the bottom of the page, it says 'Midas Platform 3.2.20 - © 2015 Kitware - Report bug'.

Conclusions

- Most commercial ultrasound systems agree quite well with a 'consensus mean' SWS in uniform phantoms
 - Some outliers (systems), but that can be corrected
- Calibration against MRE at ultrasound SWS-relevant frequency (e.g., 140 Hz for liver) provides a consensus 'target SWS' for a particular phantom
- Simulated data provides a basis for determining sources of bias in SWS estimation for each individual implementation
- Highly possible to minimize bias and reduce variance to about $\pm 5\%$ among systems in uniform media
- Better phantom materials and calibration methods are needed