

# FUNCTIONAL AND STRUCTURAL IMAGING WITH MICROBUBBLE CONTRAST AGENTS

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*College*  
**LONDON**

# Overview

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- Methods to improve quantitative measure of microbubble contrast:
  - attenuation correction
  - non-linear artifact correction
- A different approach to bubble counting.
- Method to reveal fine structural detail in the vasculature (beyond the diffraction limited system resolution).

Tang, M. X., *et al.* (2011). Quantitative contrast-enhanced ultrasound imaging: a review of sources of variability. *Interface Focus*, 1(4), 520-539.

# Attenuation Compensation



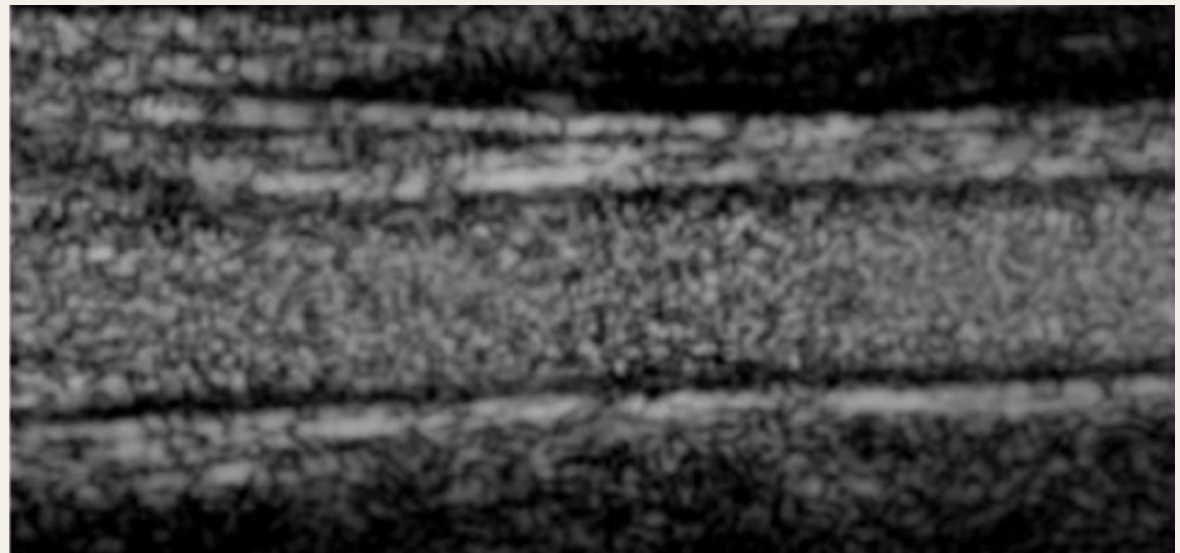
Assume uniform  
intensity in lumen.

Remove effects of  
speckle

Rescale and  
normalise tissue  
region below lumen

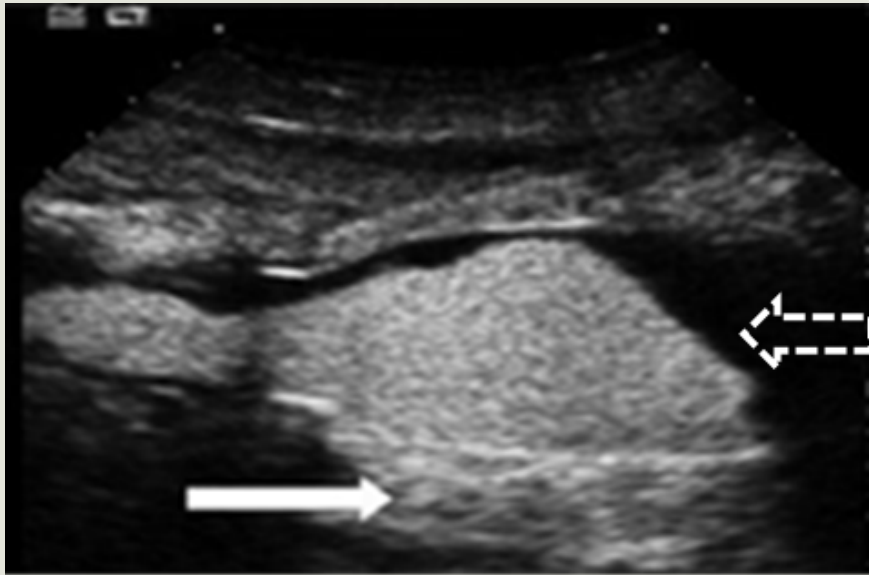
Attenuation correction  
and normalisation for  
quantification of contrast  
enhancement in  
ultrasound images of  
carotid arteries.

Cheung *et al*  
(ACCEPTED in *Ultrasound  
in Medicine and Biology*  
21/02/2015)

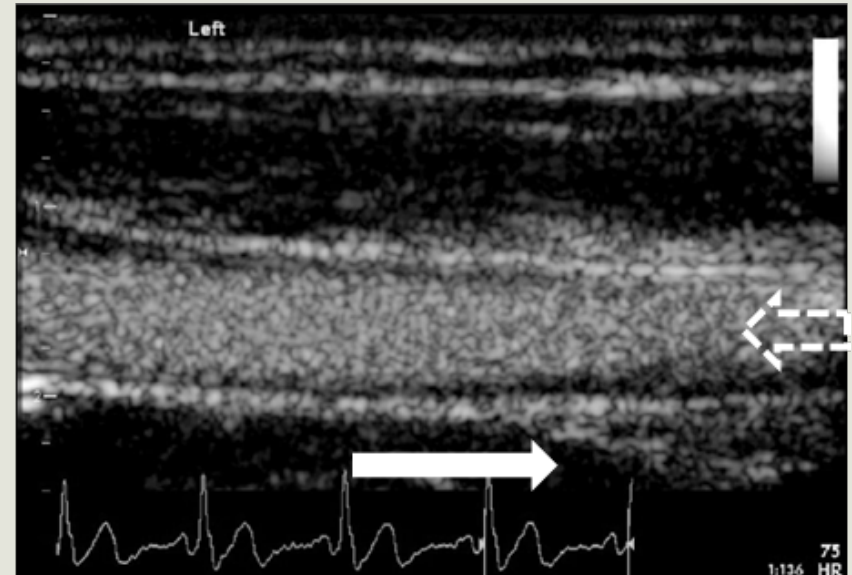




# Nonlinear propagation artefact in contrast US



Courtesy of Prof. David Cosgrove



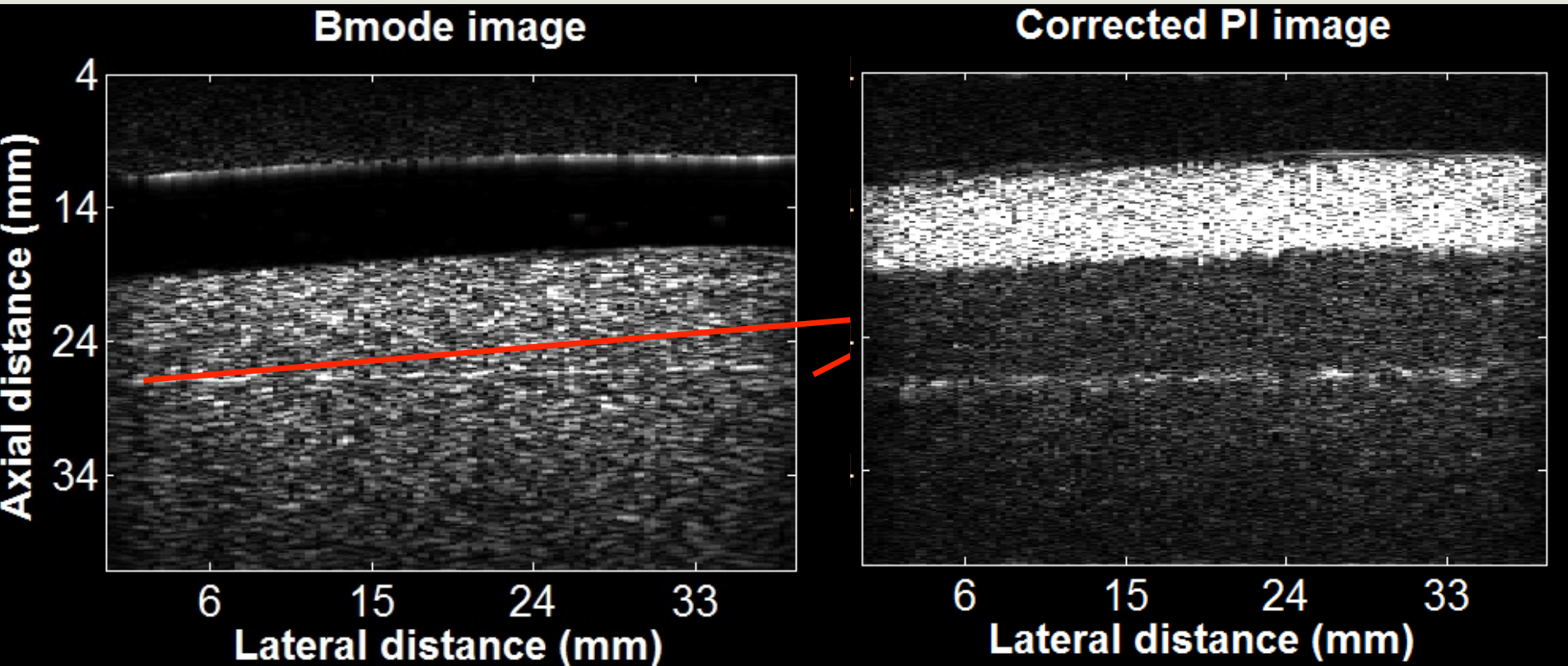
Courtesy of Prof. Roxy Senior

- Nonlinear propagation causes qualitative (misclassification of tissue) and quantitative (error in concentration estimation) artefacts

Tang, M.-X., N. Kamiyama, and R.J. Eckersley, *Effects of Nonlinear Propagation in Ultrasound Contrast Agent Imaging*. *Ultrasound in Medicine & Biology*, 2010. **36**(3): p. 459-466

Tang, M.X. and R.J. Eckersley, *Nonlinear propagation of ultrasound through microbubble contrast agents and implications for Imaging*. *IEEE Transactions on Ultrasonics Ferroelectrics and Frequency Control*, 2006. **53**(12): p. 2406-2415

# Correction of non-linear propagation: *In-vitro* demonstration



MI = 0.3, Concentration = 0.5 mL/L & 0.2 mL/L of SonoVue  
Transmit centre frequency = 4MHz

# In-Vivo Velocity Mapping

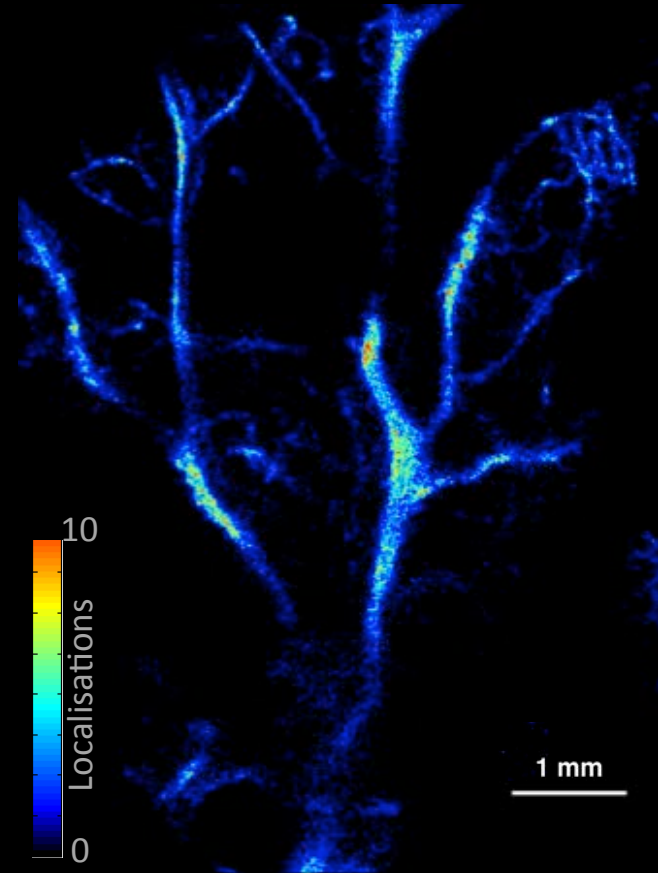


Fig 1. Super-resolution image of mouse ear microvasculature

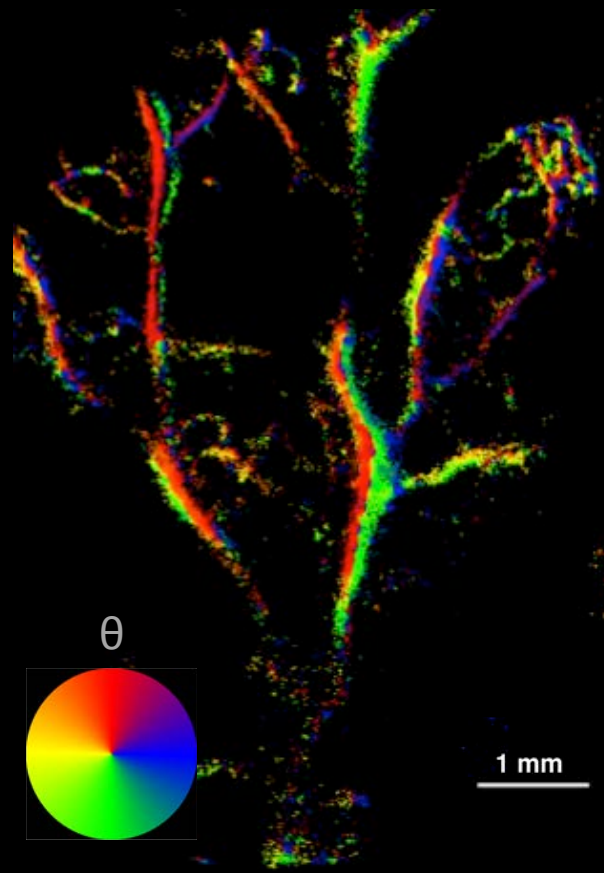


Fig 2. Image of the directional component of velocity.

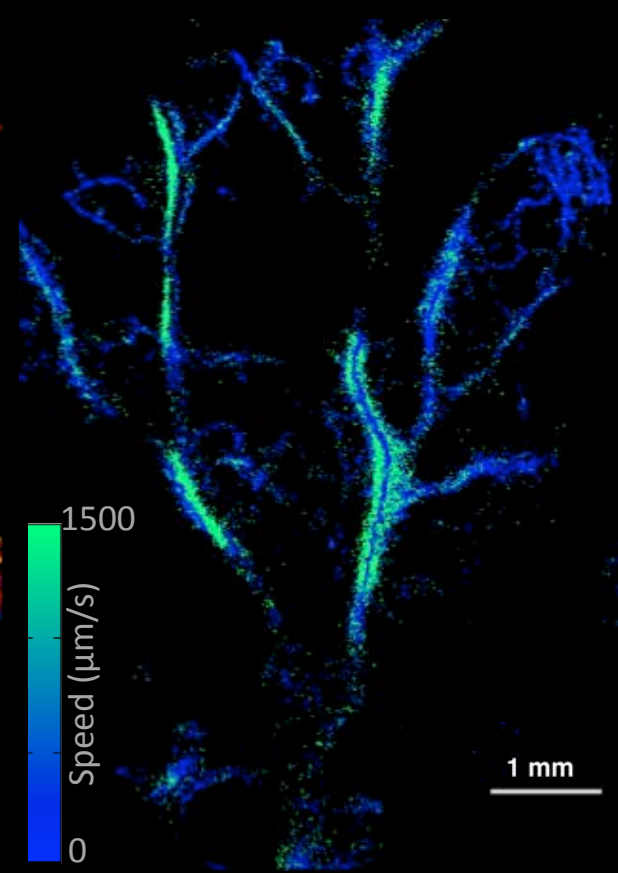
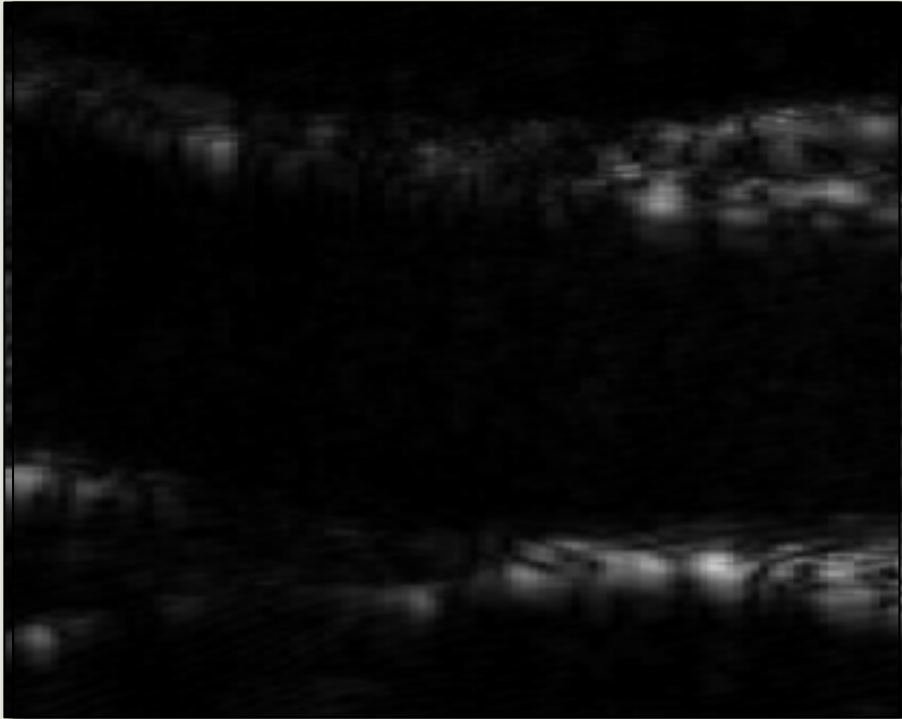


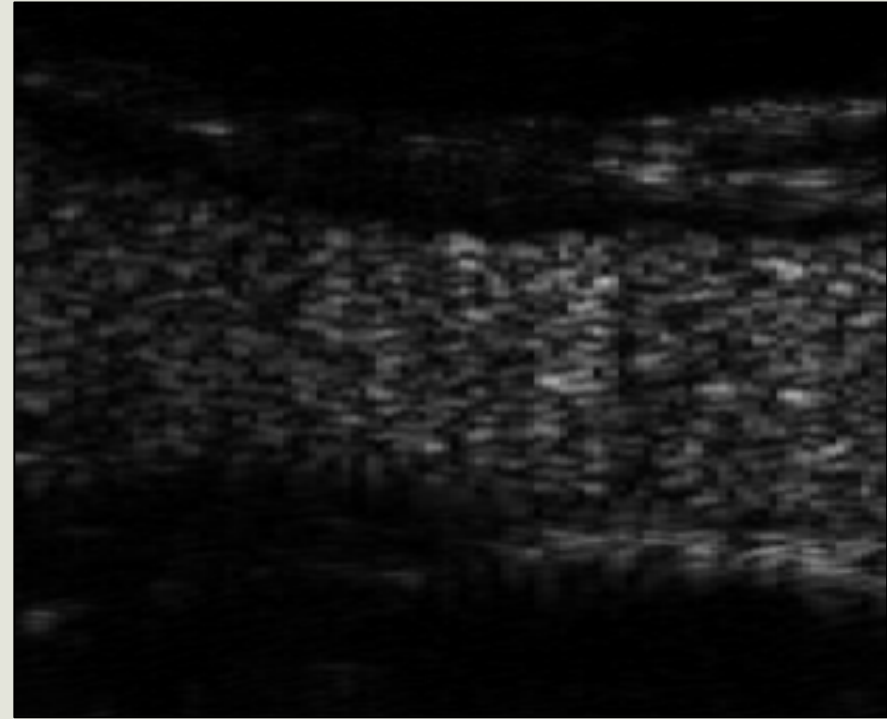
Fig 3. Image of the speed of bubble flow.

# Correction of non-linear propagation: *In-vivo* demonstration

Estimated tissue artefact image



Corrected PI image

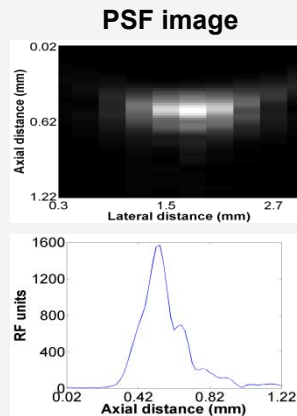
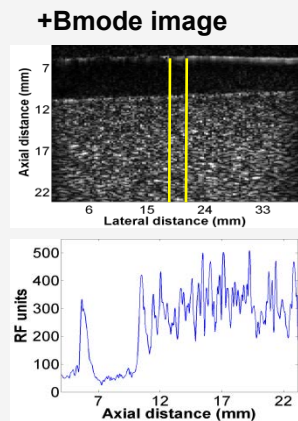


Correction of nonlinear propagation artifact in contrast enhanced ultrasound imaging of carotid arteries: methods and in vitro evaluation. Yildiz *et al* 2015.

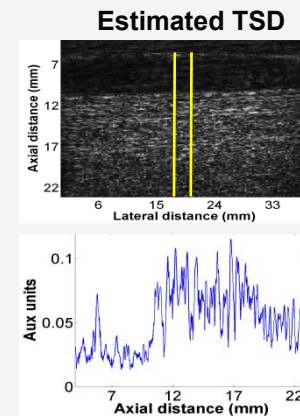
(ACCEPTED 11<sup>th</sup> March 2015 for publication in *Ultrasound in Medicine and Biology*)



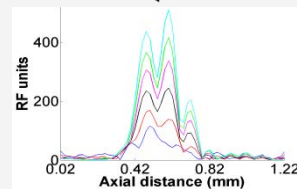
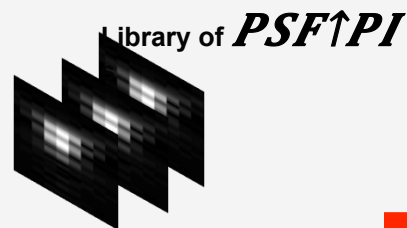
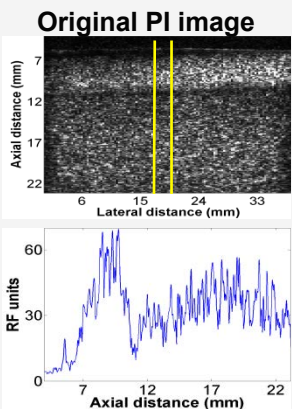
## TSD estimation



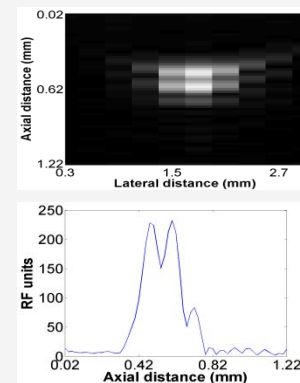
*TSD*



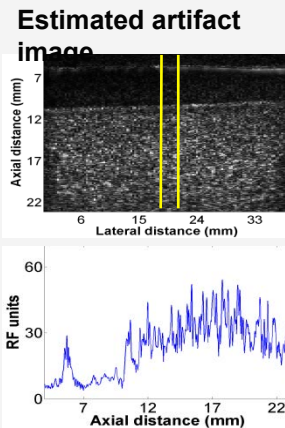
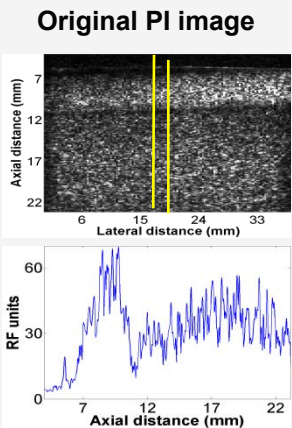
## PI PSF estimation



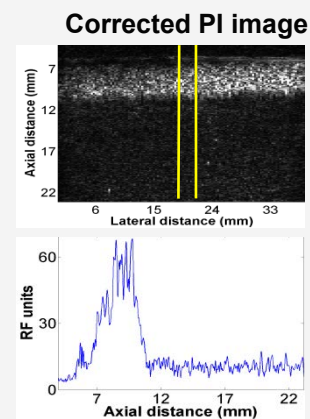
*PSF $\uparrow$ PI*



## Correction

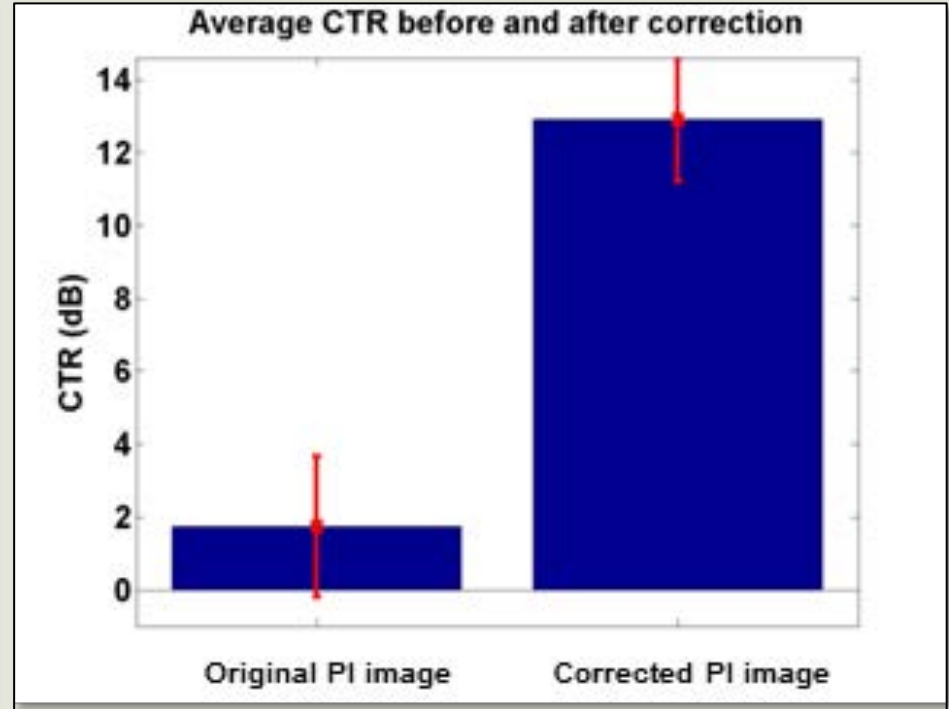
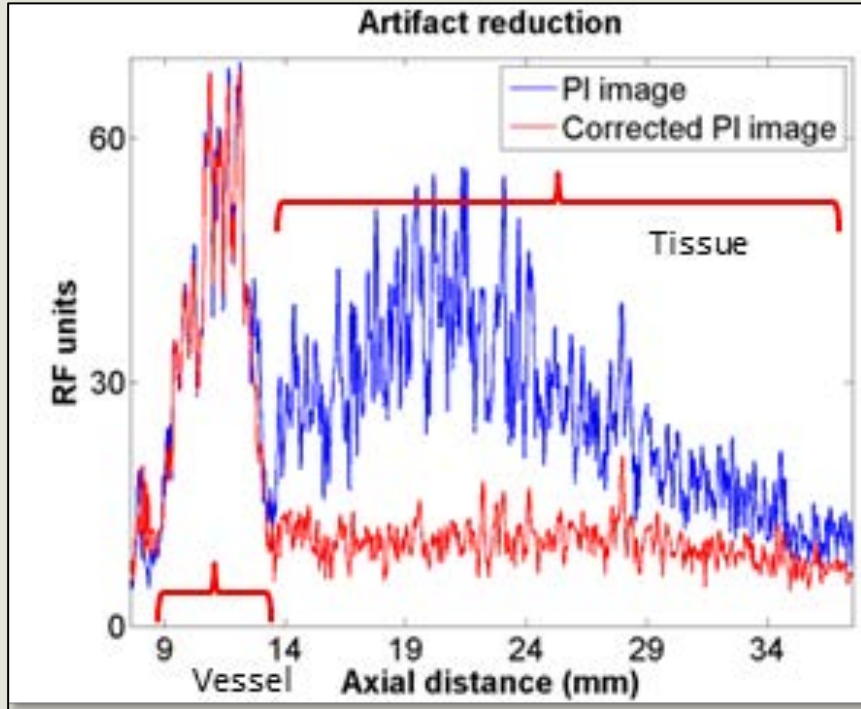


*I*





# In vitro results

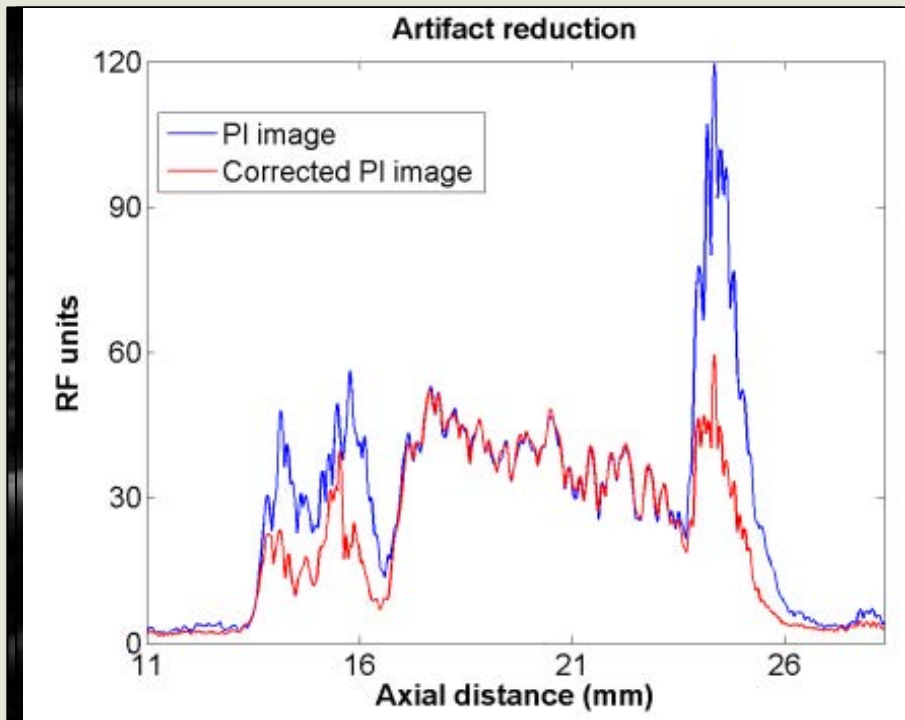


*Demodulated RF data averaged over ten central columns in the original versus corrected PI image*

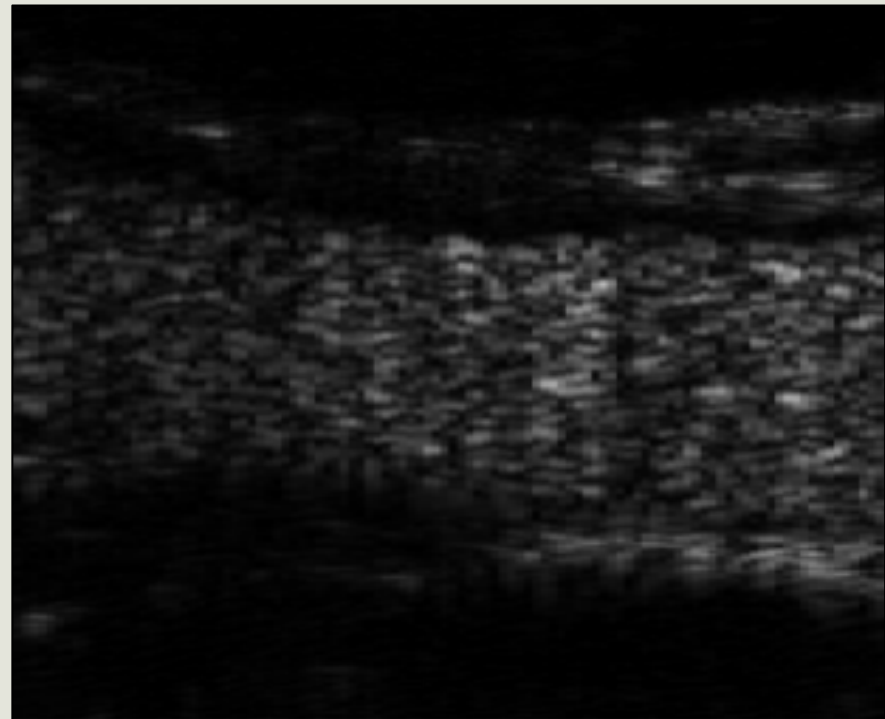
*Contrast to Tissue Ratio(CTR) for the original and corrected images. CTR increases significantly after correction.*

# Correction of non-linear propagation: *In-vivo* demonstration

Estimated tissue artefact image



Corrected PI image



Correction of nonlinear propagation artifact in contrast enhanced ultrasound imaging of carotid arteries: methods and in vitro evaluation. Yildiz *et al* 2015.

(ACCEPTED 11<sup>th</sup> March 2015 for publication in *Ultrasound in Medicine and Biology*)