GCNR_ Example usage

Bob Dougherty
OptiNav, Inc.
June 5, 2026

In a certain in-vivo medical ultrasound dataset representing a transverse view of a carotid artery, the lumen of the artery should be featureless and therefore should appear dark. Speckle and sidelobe beamforming artefacts contaminate the image, reducing the contrast. A beamforming method depending on a parameter ν is supposed to increase the contrast for $\nu > 1$. To test this, one ROI is a circle inside the lumen and the other is an annular region concentric with but fully outside the artery. The gCNR metric is robust against changes to the display brightness, so a change in gCNR with ν demonstrates a real effect.

Generalized Contrast to Noise Ratio

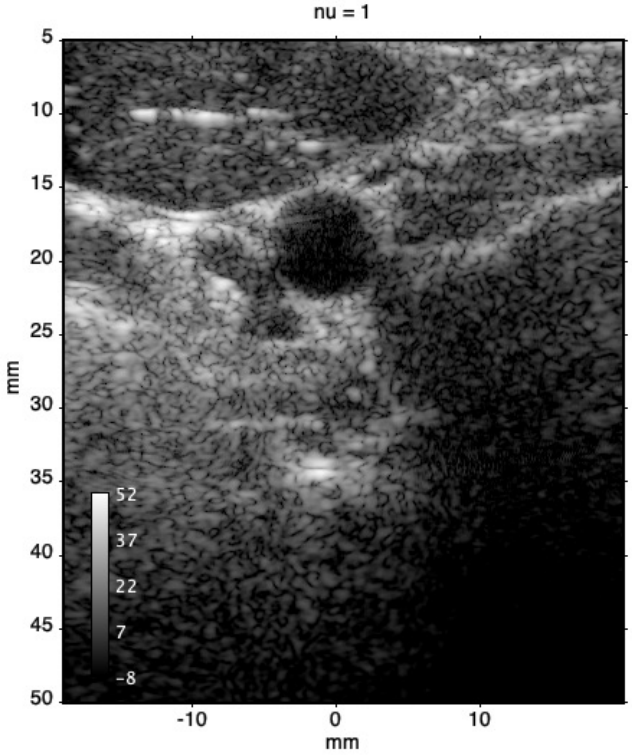
$$\mathrm{gCNR} = 1 - \sum_{i=1}^{N} \min\left(P_{\mathrm{in}}(i), P_{\mathrm{out}}(i)\right)$$

Where P_{in} and P_{out} are the **normalized histograms** (each summing to 1.0) calculated from your two chosen regions of interest (ROIs) [1].

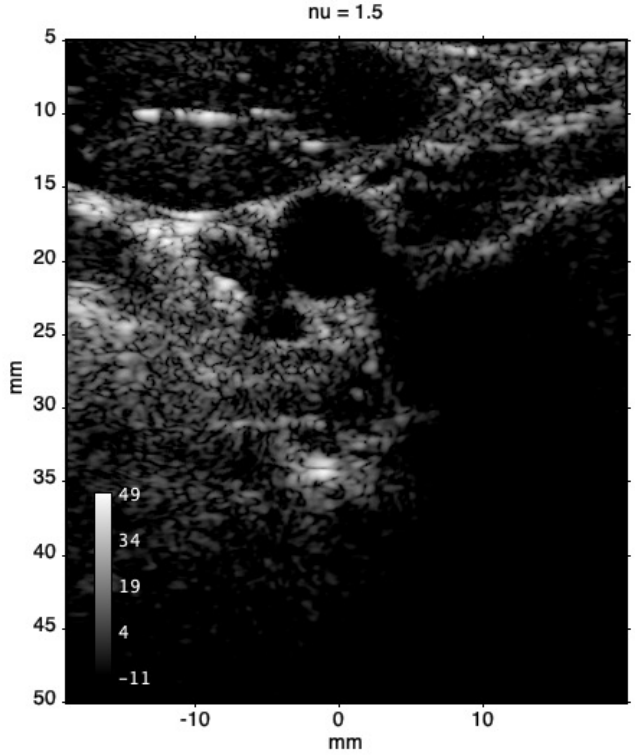
1. Rodriguez-Molares, A., Rindal, O. M. H., D'hooge, J., Måsøy, S. E., Austeng, A., Bell, M. A. L., & Torp, H. (2020). The generalized contrast-to-noise ratio: a formal definition for lesion detectability. *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, 67(4), 745–759. doi.org

PICMUS[2] Transverse carotid artery in-vivo dataset Functional Beamforming[3]

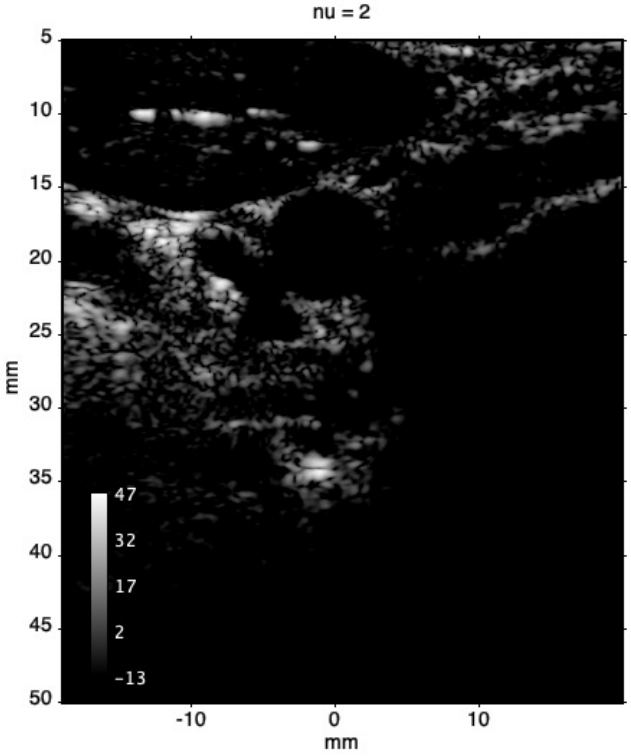
$\nu = 1$ (DAS)



$\nu = 1.5$



$\nu = 2$



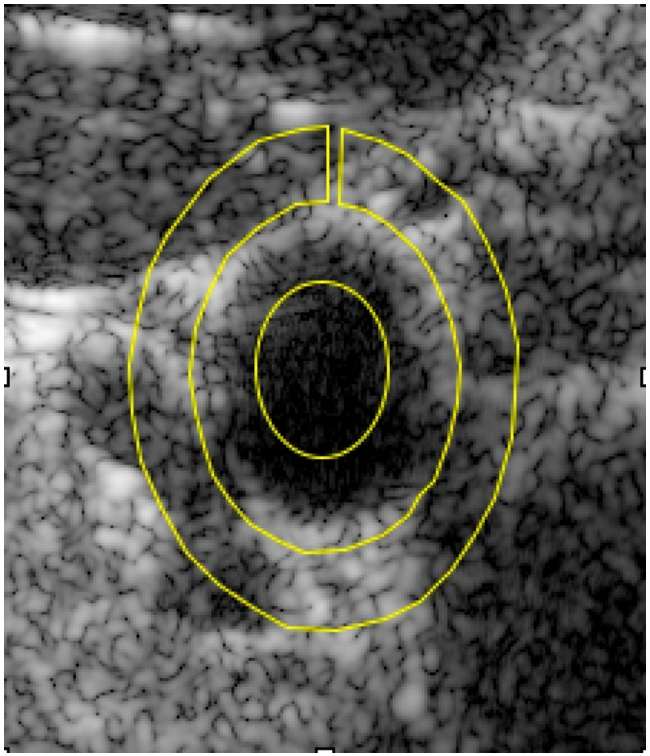
60 dB plot

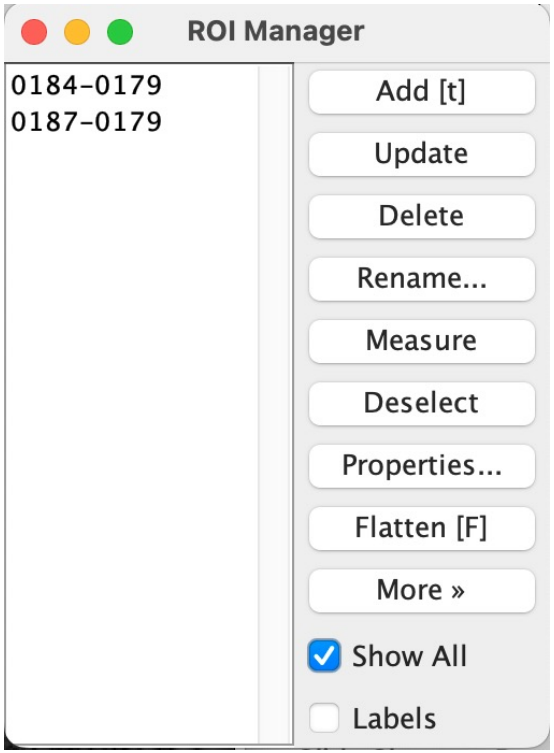
2. Liebgott H, Rodriguez-Molares A, Cervenansky F, Jensen JA, Bernard O. Plane-wave imaging challenge in medical ultrasound. In2016 IEEE International ultrasonics symposium (IUS) 2016 Sep 18 (pp. 1-4). IEEE.

3. Dougherty, R.P. "Active Functional Beamforming", Berlin Beamforming Conference (BeBeC) June 2026

OptiNav

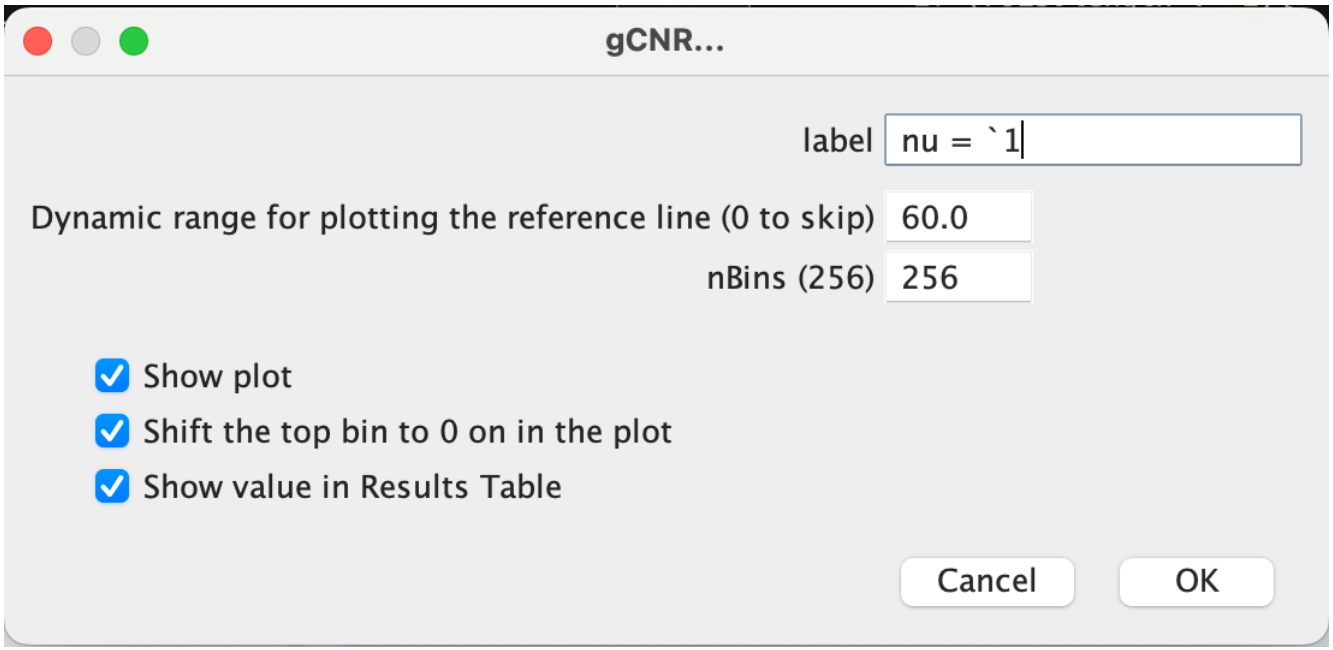
The beamforming grid has rectangular pixels, so the artery appears distorted from its true circular shape in the raw images. The previous slide shows the full scanning grid with three values of ν, scaled for square pixels and a 60-dB Brightness and Contrast range. The following slides show application of the ImageJ plugin GCNR_ on the raw images where the 32-bit data lives.

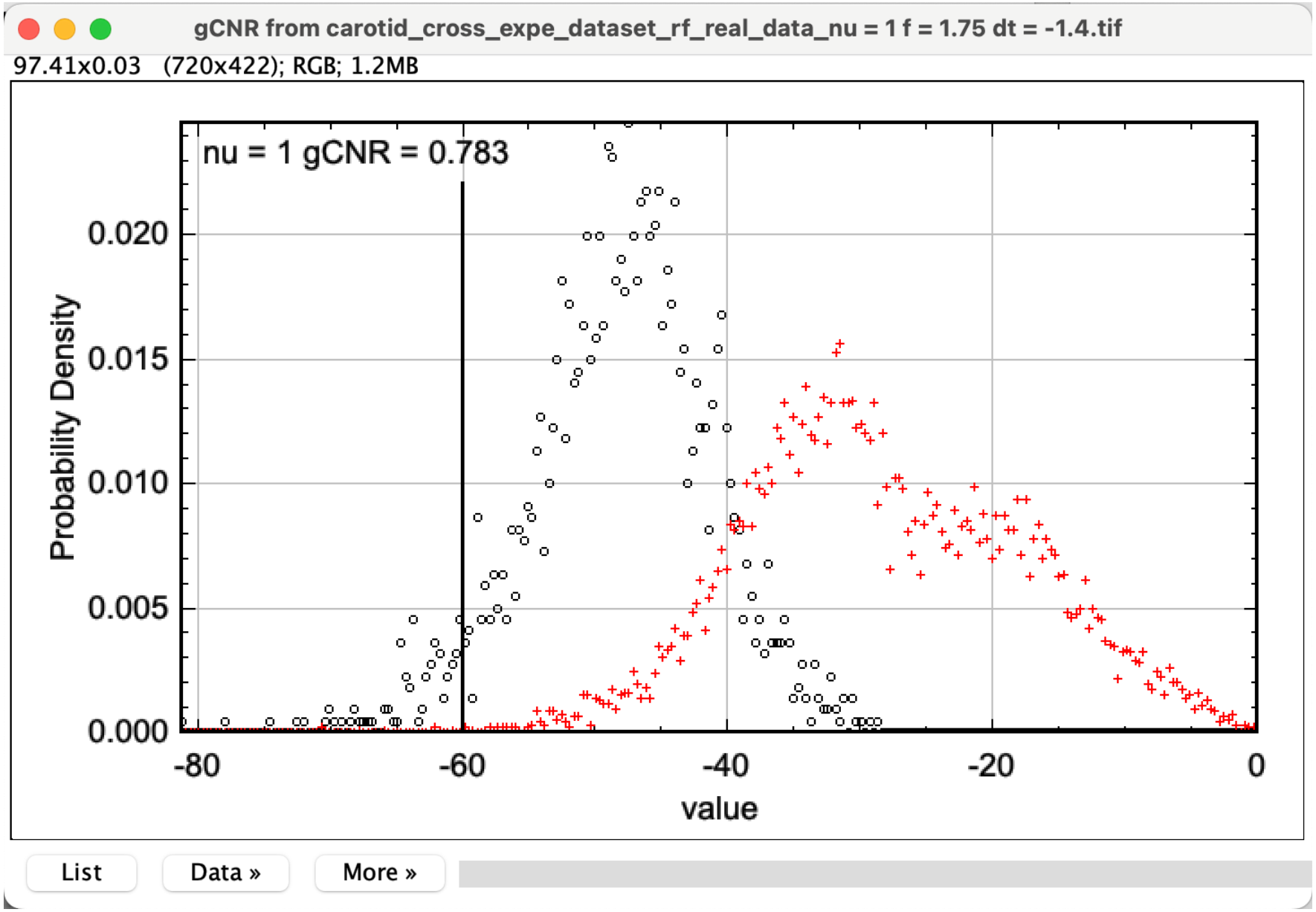


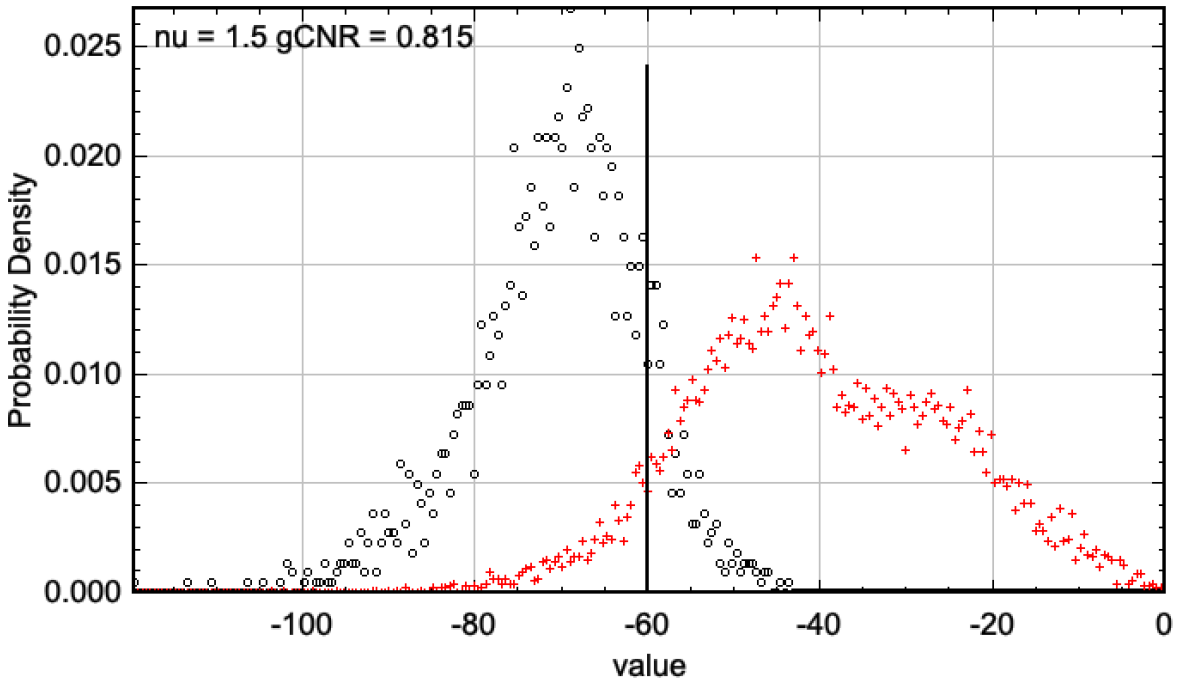


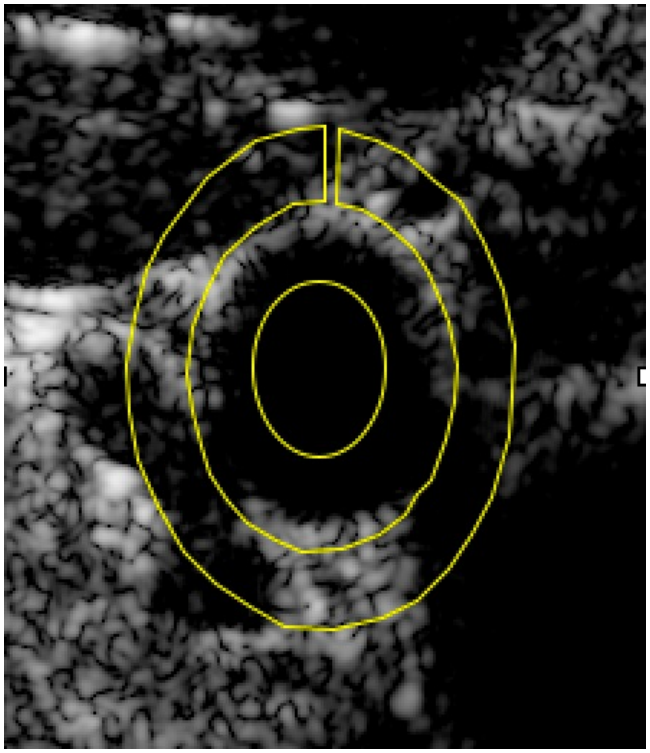
ROI Manager needs to have exactly 2 ROIs

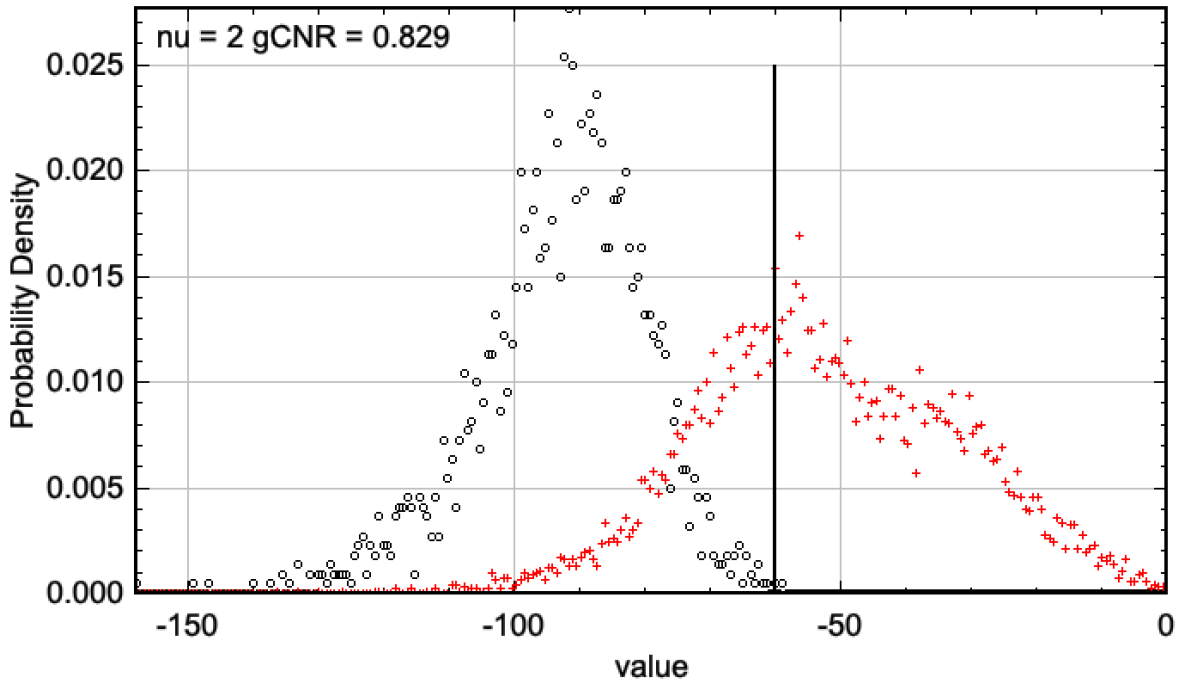
"Show All" shows the ROIs on the image. It does not matter whether the image has a selection. GCNR_ looks to ROI Manager for its ROIs.

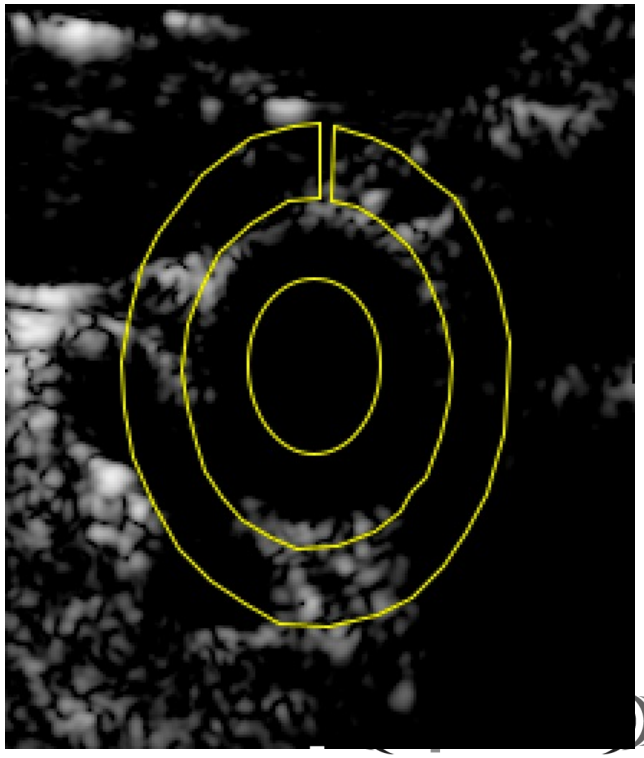



gCNR from carotid_cross_expe_dataset_rf_real_data_nu = 1 f = 1.75 dt = -1.4.tif
97.41x0.03 (720x422); RGB; 1.2MB
nu = 1 gCNR = 0.783
Probability Density
0.020
0.015
0.010
0.005
0.000
-80
-60
-40
-20
0
value
List
Data »
More »


nu = 1.5 gCNR = 0.815
Probability Density
0.025
0.020
0.015
0.010
0.005
0.000
-100
-80
-60
-40
-20
0
value



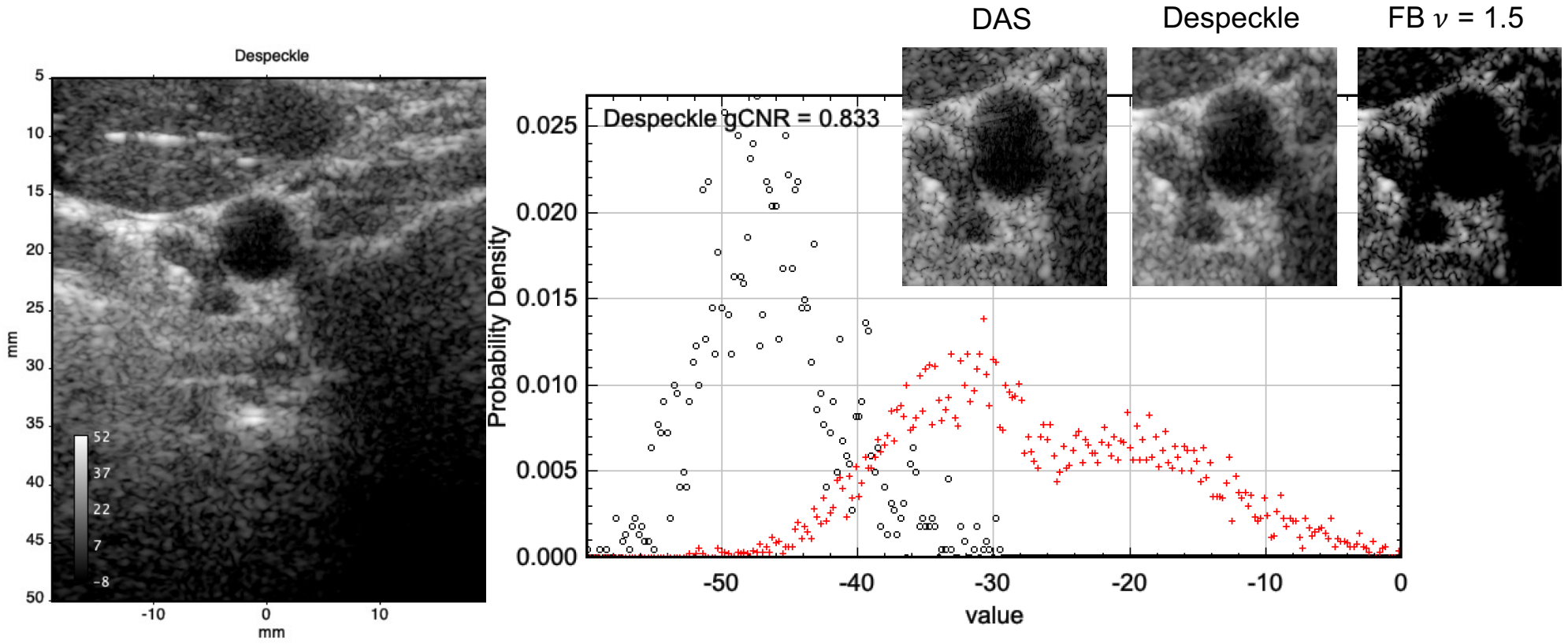

nu = 2 gCNR = 0.829
Probability Density
0.025
0.020
0.015
0.010
0.005
0.000
-150
-100
-50
0
value



Despeckle

Instead of changing the beamforming used to create an ultrasound image, for example by using Functional Beamforming, another way to manipulate speckle and change gCNR is to perform image processing on the ultrasound output.

ImageJ has a built-in speckle reducing plugin: Process/Noise/Despeckle.



Note about another dataset: I've noticed that a 3-pixel Gaussian blur applied to the DAS images from PICUMS experimental contrast dataset increases the gCNR between the phantom areas. In this case, Functional Beamforming does not change the gCNR because FB is designed to reduce speckle relative to non-speckle echogenerators, and this data is almost entirely composed of speckle.