生醫工程實驗, Spring 2017
Lab3 超音波醫學影像分析 (Ultrasound)

第五組 蔡承佑 許博竣 許秉鈞

May 24, 2017

1 HW1-Point Spread Function(PSF)

1.1 實驗目的

了解超音波醫學影像的原理，並學習操作儀器測量仿體，量測各種不同模式下所觀測到的影

1.2 實驗原理

超音波係利用電壓訊號經由壓電材料轉換成超音波，再感測反彈的超音波轉換成電訊號，藉由不同的組織會有不同的聲阻抗，導致不一樣的反射係數，來進行感測，利用接收反射波的時間為距離的兩倍除以速度來推算物體的遠近。超音波可分為數種模式:A mode、B mode、M mode、Color Doppler Mode。A mode 是將反射波強度以振幅顯示;B mode 是將反射波強度以亮度表示;M mode 則是可以記錄連續時間下空間的變化;Color Doppler Mode 是利用都卜勒效應來量測移動物體的移動速度，並利用顏色的方式呈現。而由於需要對於特定的區域達到良好的解析度，需要聚焦射出的超音波，對於陣列感測器而言，可利用不同時間發射超音波的方式，藉由相互干涉達成聚焦亦或是轉向的目的，稱為 beamformation。而接收反射時，在訊號中加入 delay 及 weighting 再相加，利用調整兩參數達成動態聚焦的效果，以加大高解析度的範圍。

1.3 實驗步驟

1. 用 B mode，比較在 res 與 pen 模式，不同 B mode gain 之標的物大小。
2. 用 B mode，比較在 res 與 pen 模式，不同 B mode gain 下的雜訊。
3. 用 B mode，比較在 res 與 pen 模式下的 CNR。
4. 用都卜勒模式測量人體的大動脈，截取其跳動影像及速率影像。

1.4 實驗數據

a) Estimate PSF size for In-focused and Out-focused targets
以下用 5.7cm, 7.1cm 深度、pen/res 模式來測量

b) Repeat (a) under different B-mode gain

- **5.7cm/high gain/pen**

Row	Lateral	Axial
In Focus	5.33333333333333	3.4125
Out Focus	6.39285714285715	3.70196078431373

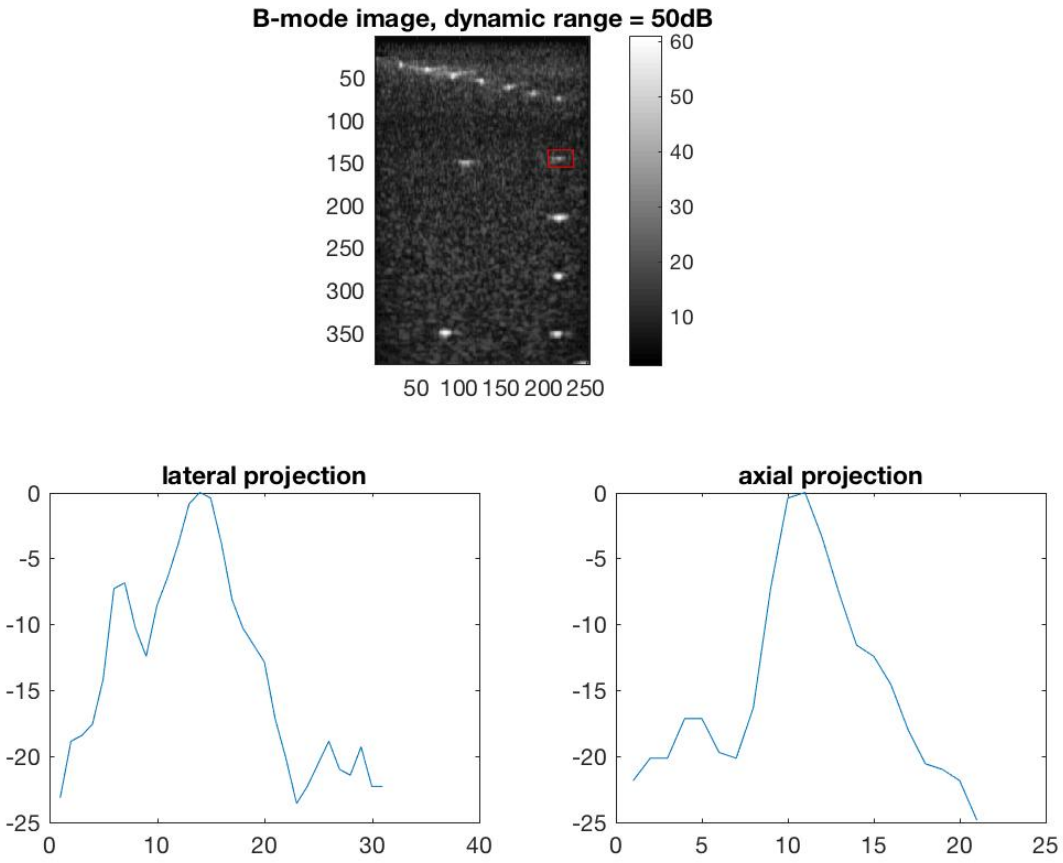

Figure 1: 57-high-pen(In Focus)

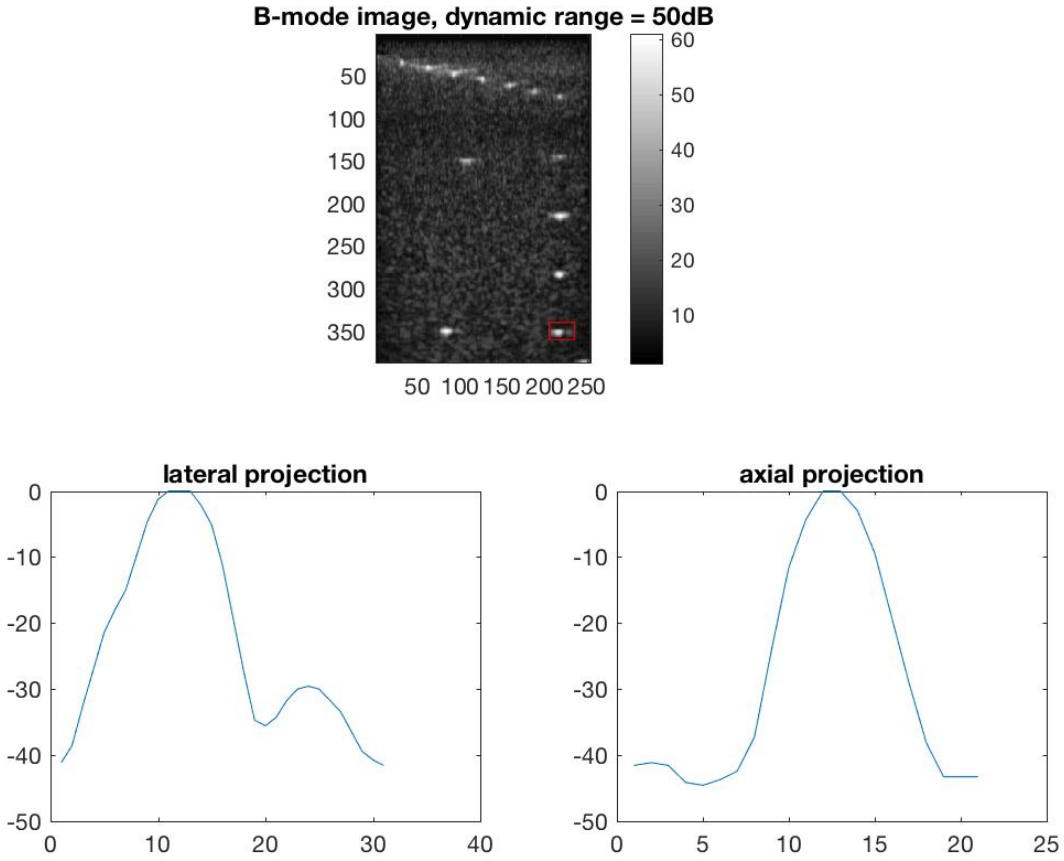

Figure 2: 57-high-pen(Out Focus)

- **5.7cm/high gain/res**

Row	Lateral	Axial
In Focus	4.53560606060606	2.22025641025641
Out Focus	6.53194444444444	2.55023148148148

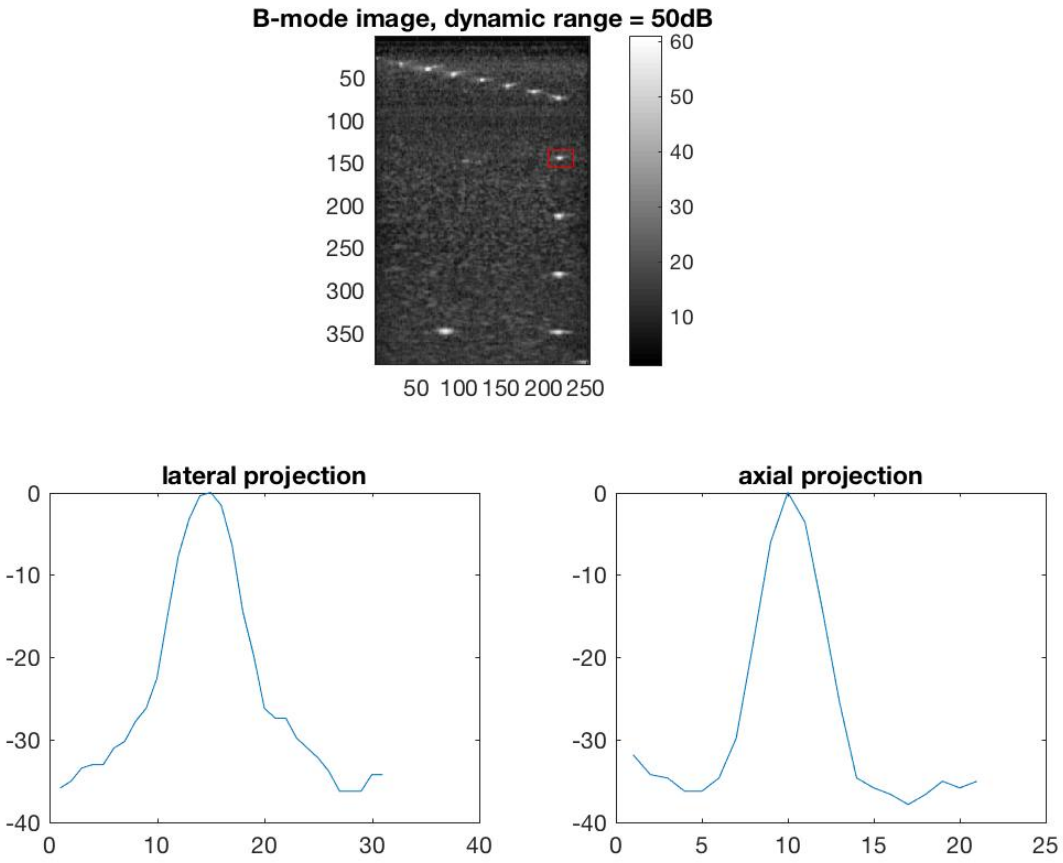

Figure 3: 57-high-res(In Focus)

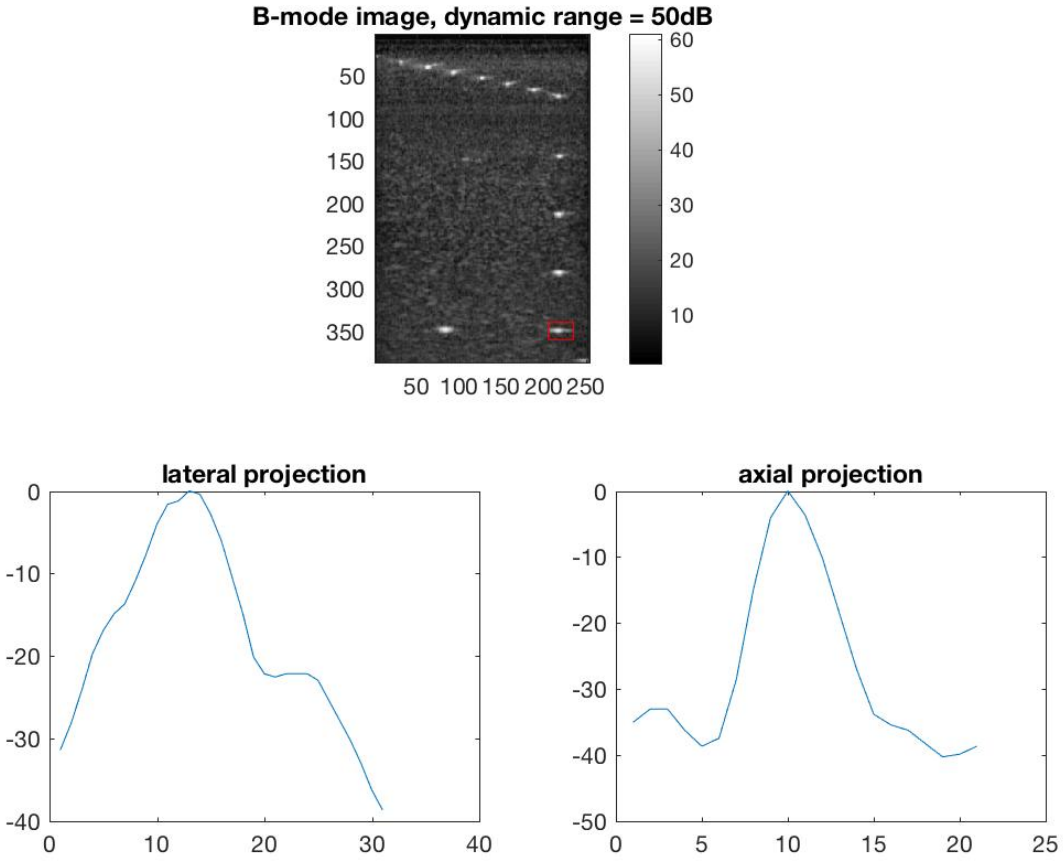

Figure 4: 57-high-res(Out Focus)

- **5.7cm/low gain/pen**

Row	Lateral	Axial
In Focus	3.08181818181818	2.64646464646465
Out Focus	2.09	3.41608187134503

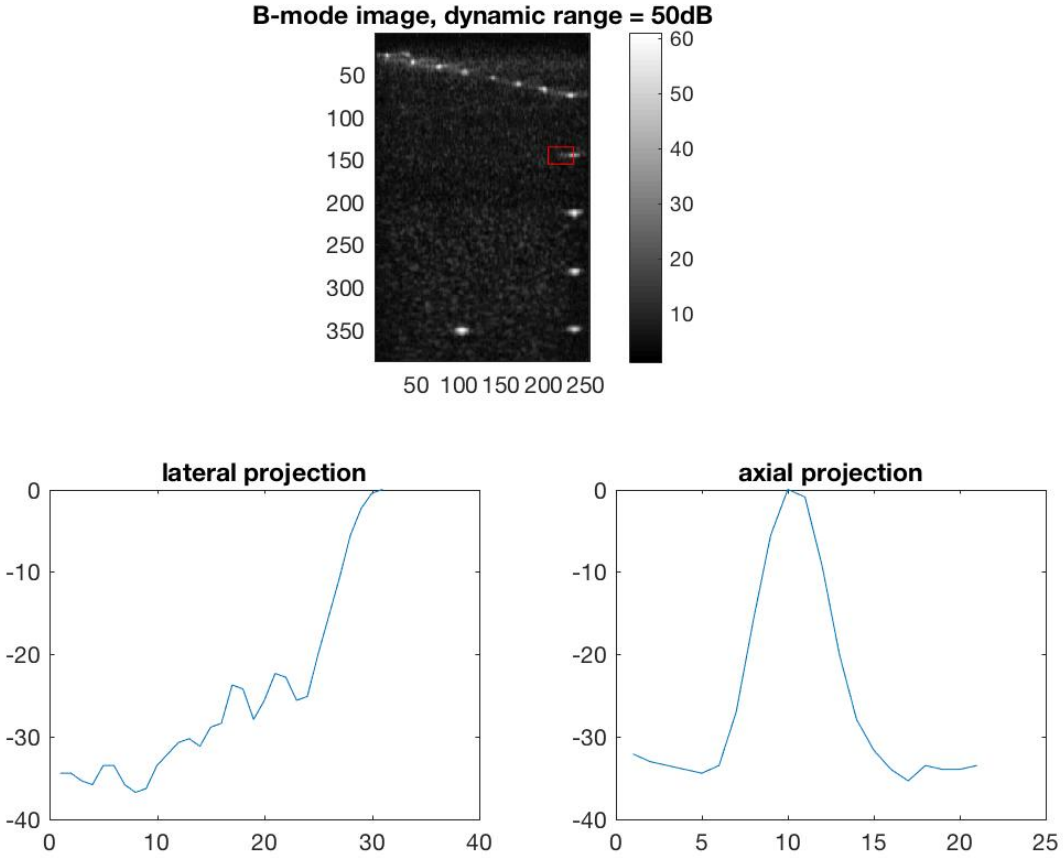

Figure 5: 57-low-pen(In Focus)

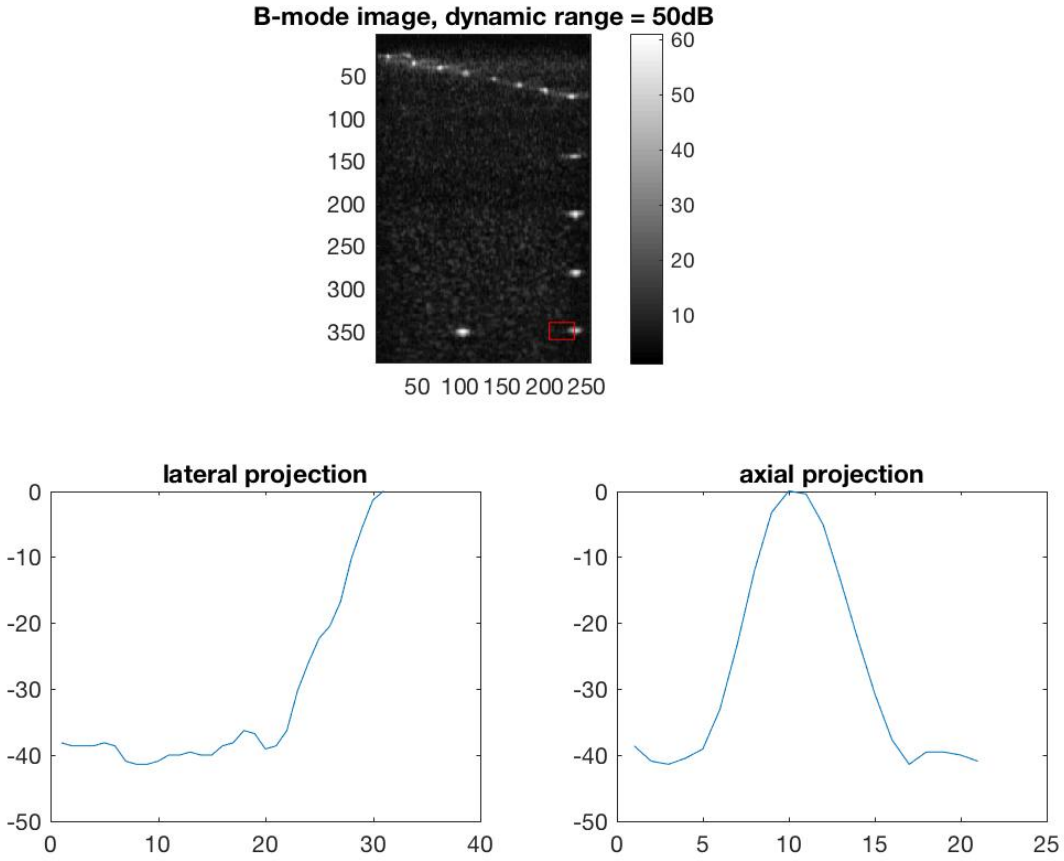

Figure 6: 57-low-pen(Out Focus)

- **5.7cm/low gain/res**

Row	Lateral	Axial
In Focus	4.11666666666667	2.22727272727273
Out Focus	6.36607142857143	2.77944862155388

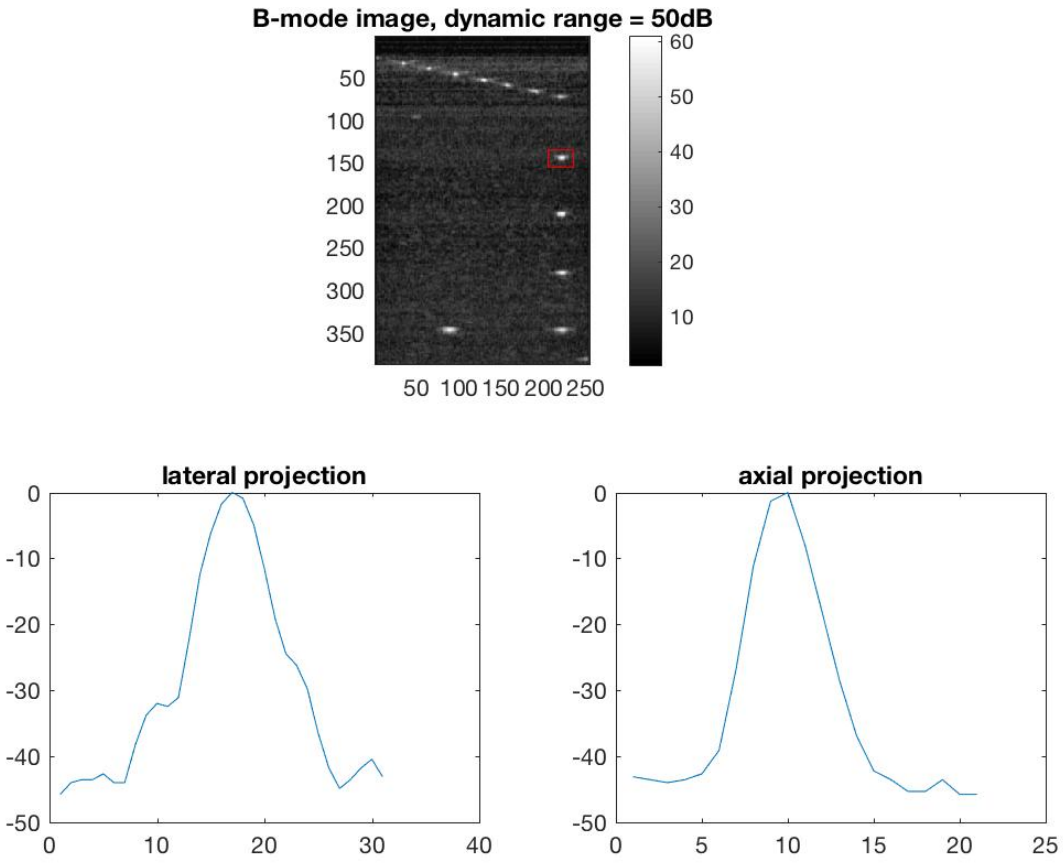

Figure 7: 57-low-res(In Focus)

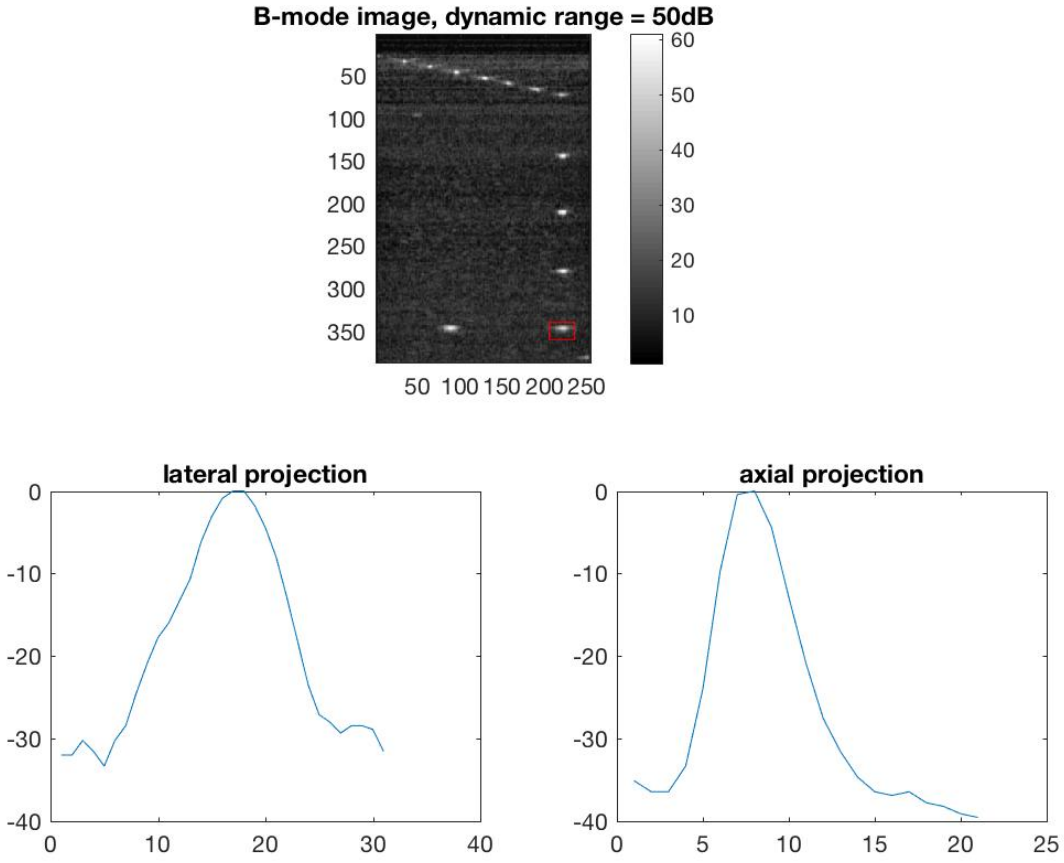

Figure 8: 57-low-res(Out Focus)

- **7.1cm/high gain/pen**

Row	Lateral	Axial
In Focus	8.51111111111111	2.55514874141877
Out Focus	5.25238095238095	2.75944444444444

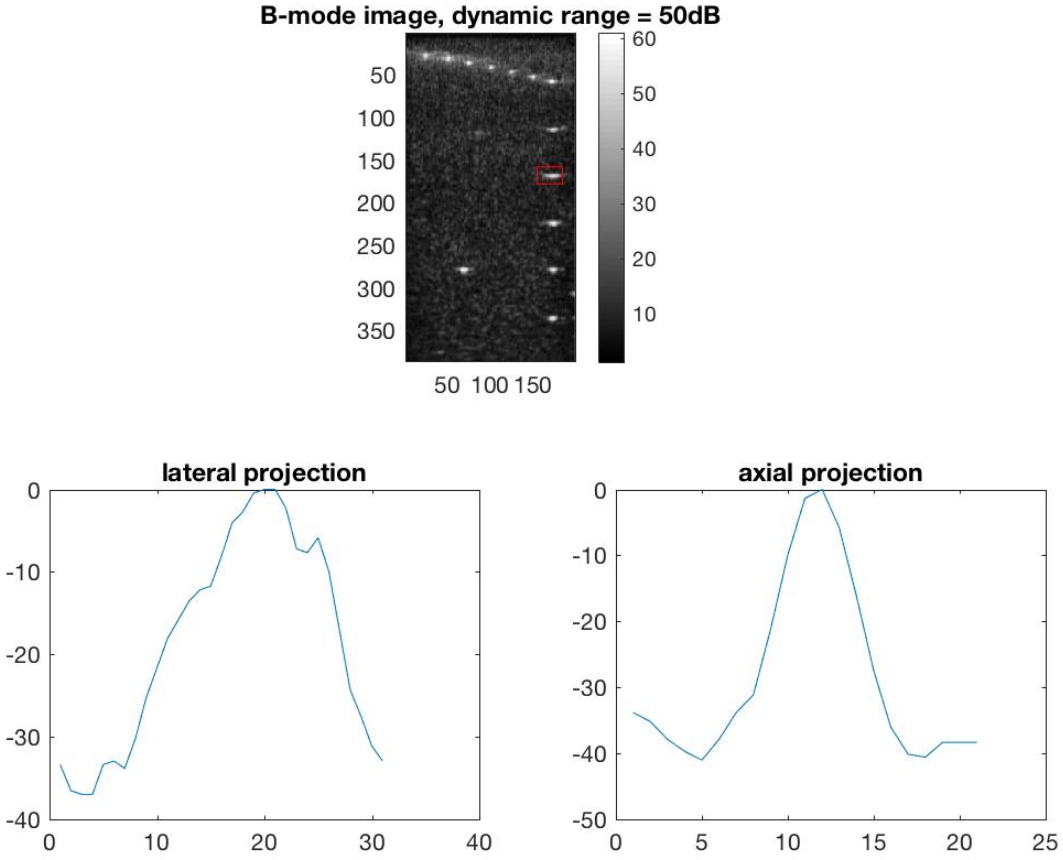

Figure 9: 71-high-pen(In Focus)

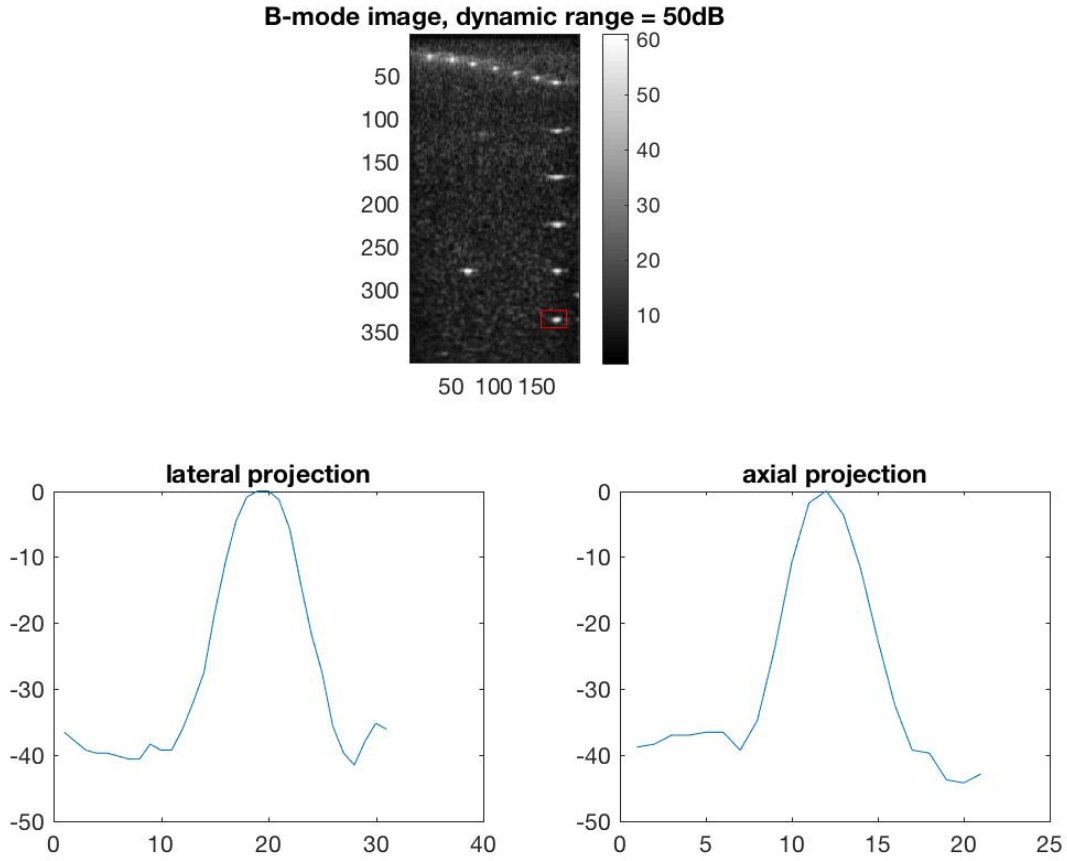

Figure 10: 71-high-pen(Out Focus)

- **7.1cm/high gain/res**

Row	Lateral	Axial
In Focus	4.05	2.24559915164369
Out Focus	5.62637362637362	2.42131578947368

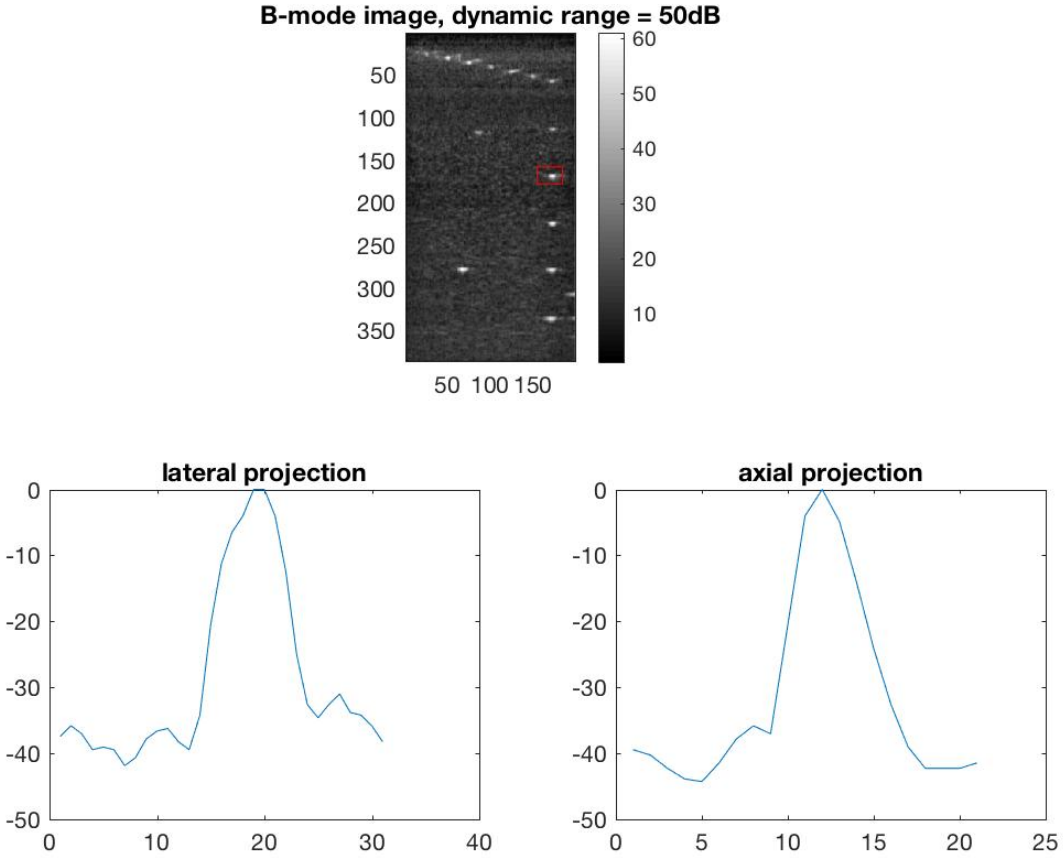

Figure 11: 71-high-res(In Focus)

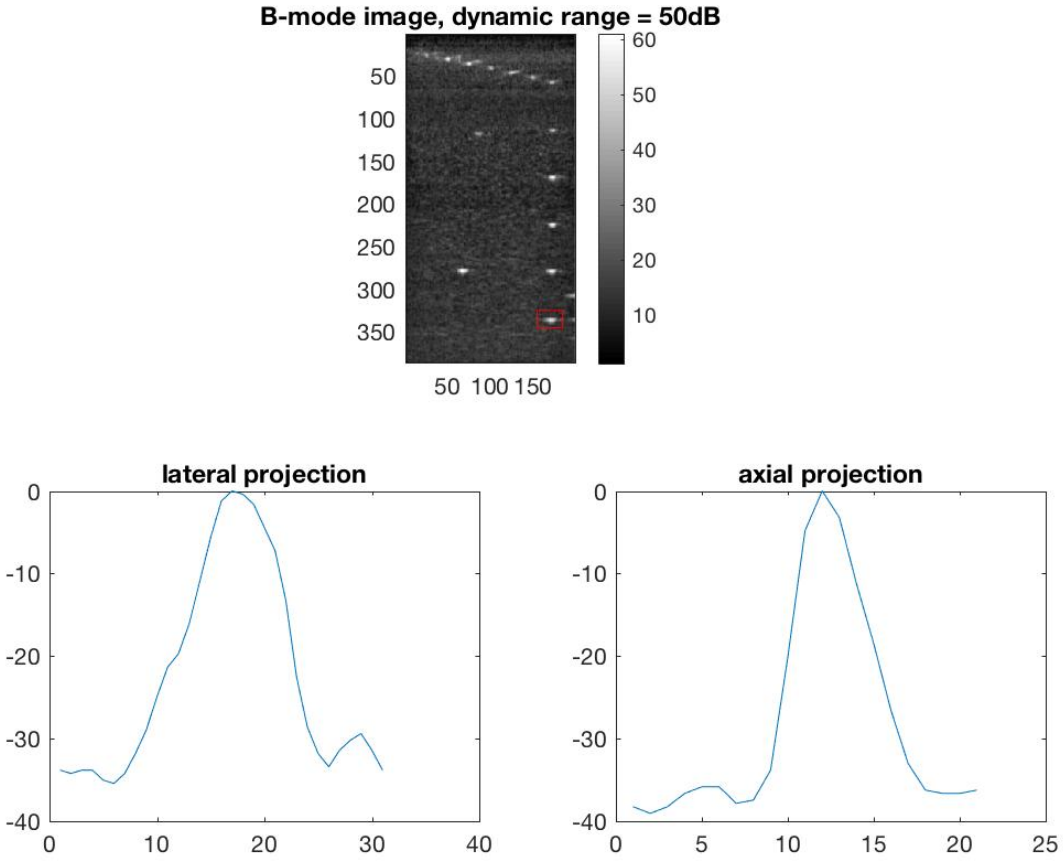

Figure 12: 71-high-res(Out Focus)

- **7.1cm/low gain/pen**

Row	Lateral	Axial
In Focus	6.74999999999999	2.37085020242915
Out Focus	4.29166666666667	2.5

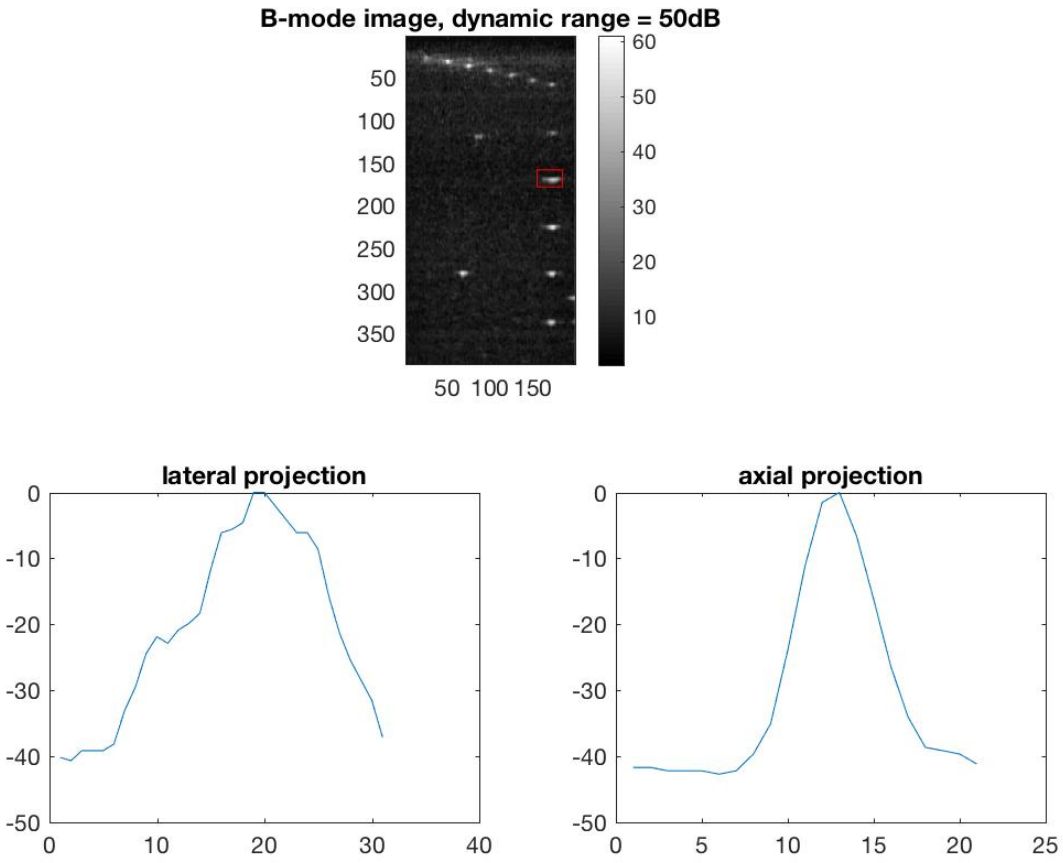

Figure 13: 71-low-pen(In Focus)

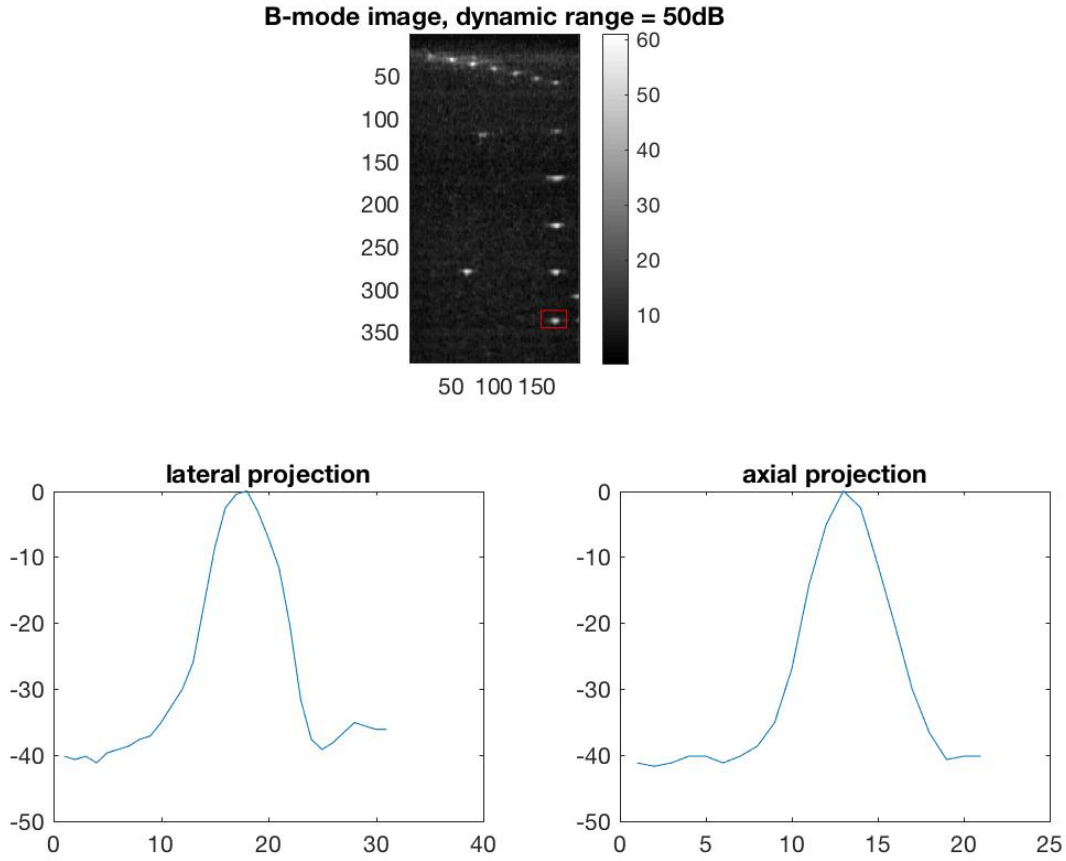

Figure 14: 71-low-pen(Out Focus)

- **7.1cm/low gain/res**

Row	Lateral	Axial
In Focus	3.44047619047619	1.94301470588235
Out Focus	5.78571428571428	2.33981481481482

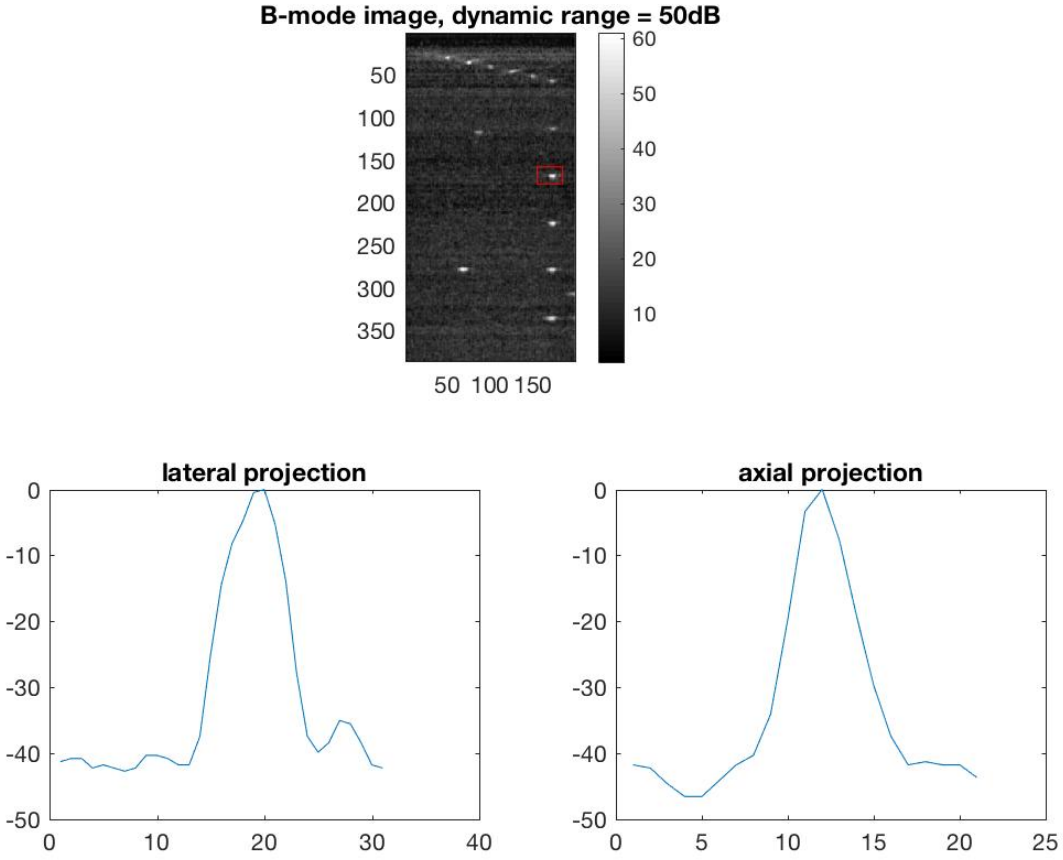

Figure 15: 71-low-res(In Focus)

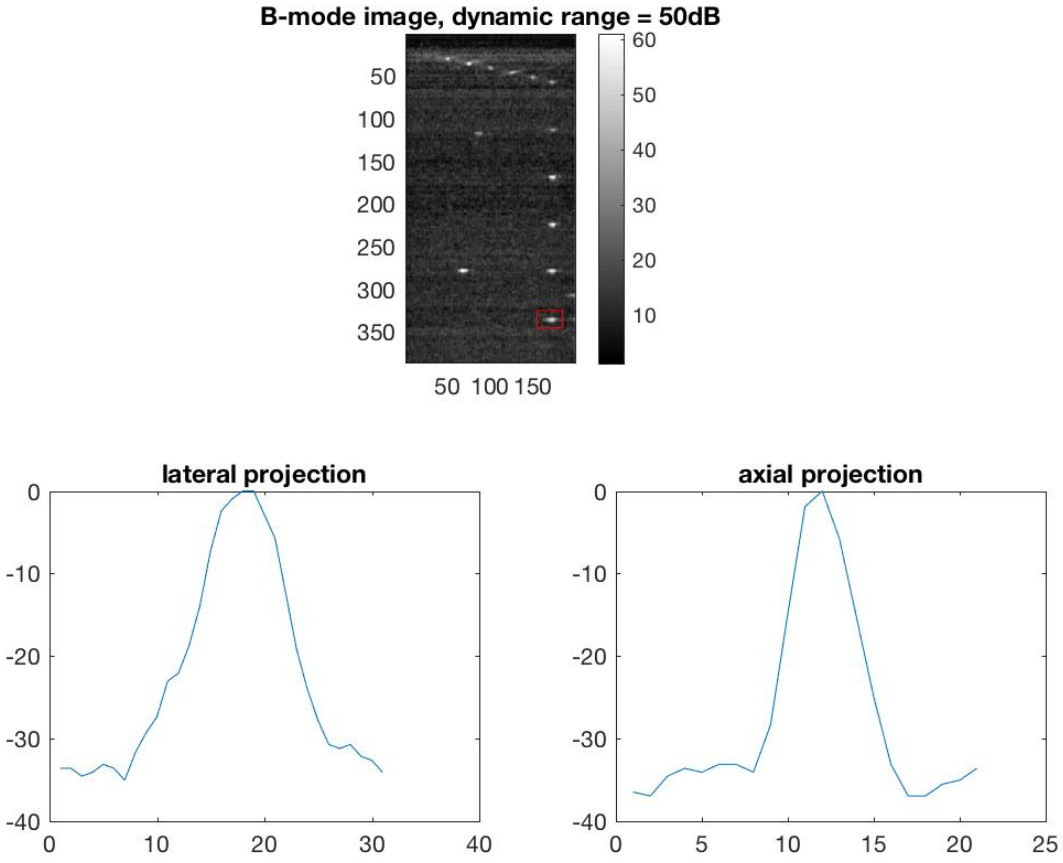

Figure 16: 71-low-res(Out Focus)

HW1 CONCLUSION

大部分情況，In-focused 的大小都比 Out-focused 來的小，符合我們的預期，除了少數情況之外，因為我們有些圖其實量的有些不清楚，可能造成在找 6dB 點的時，其真正範圍與觀測範圍不太一樣。

2 HW2-Speckle Statistics

在 B mode 下，分別以探頭可測最大深度 5.7cm 及 7.1 cm，量測在 high gain 及 low gain 下，比較 pen 與 res 時，in-focused 及 out-focused 的 standard variation，並作出 speckle intensity distribution 及 speckle amplitude distribution。

- **5.7cm/high gain/pen**

Row	speckleStd
In Focus	2.62093209070806
Out Focus	2.95600552442126

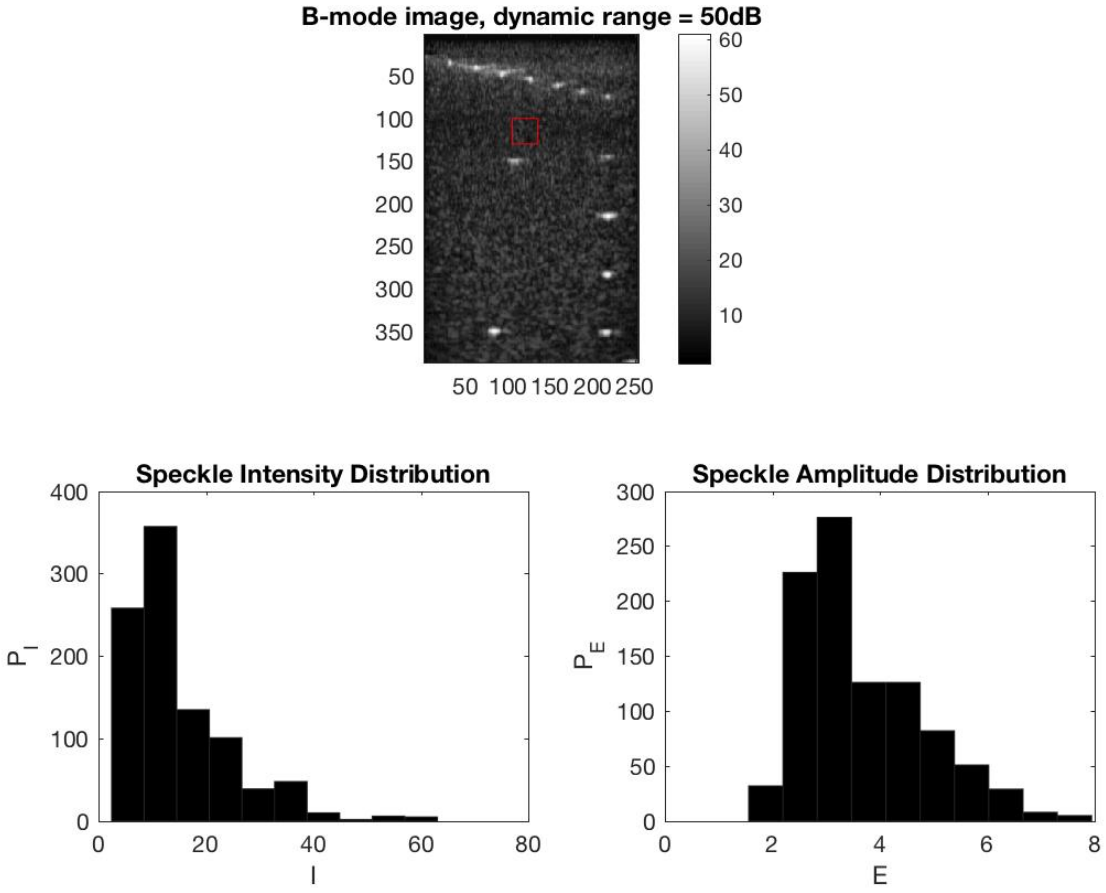

Figure 17: 57-high-pen(In Focus)

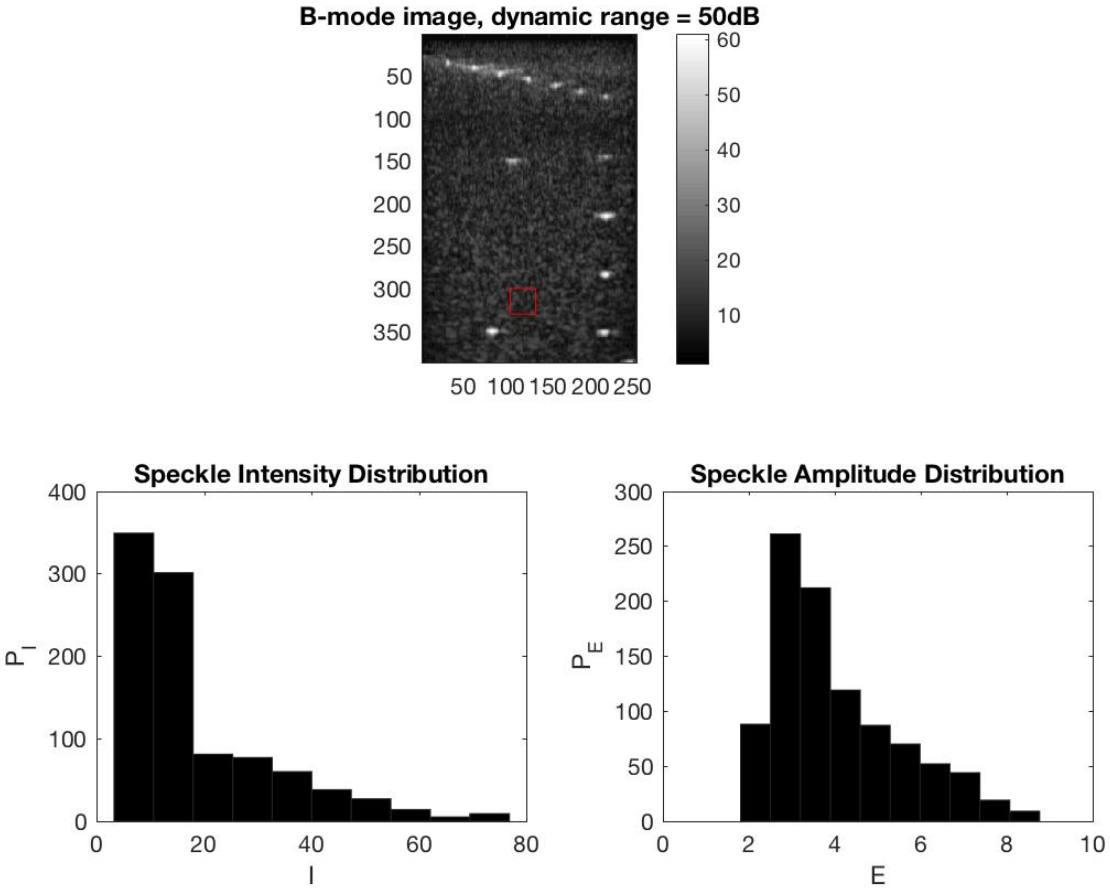

Figure 18: 57-high-pen(Out Focus)

- **5.7cm/high gain/res**

Row	speckleStd
In Focus	2.18850670168981
Out Focus	2.3659751129719

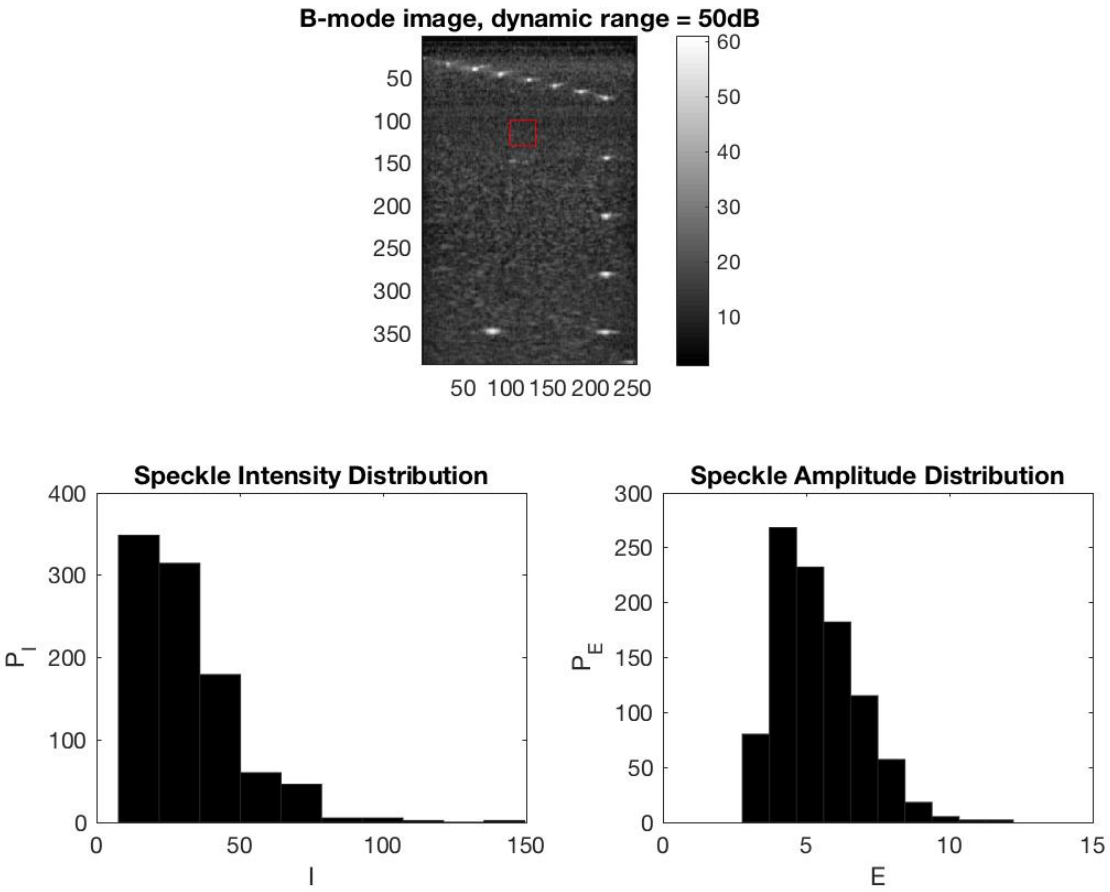

Figure 19: 57-high-res(In Focus)

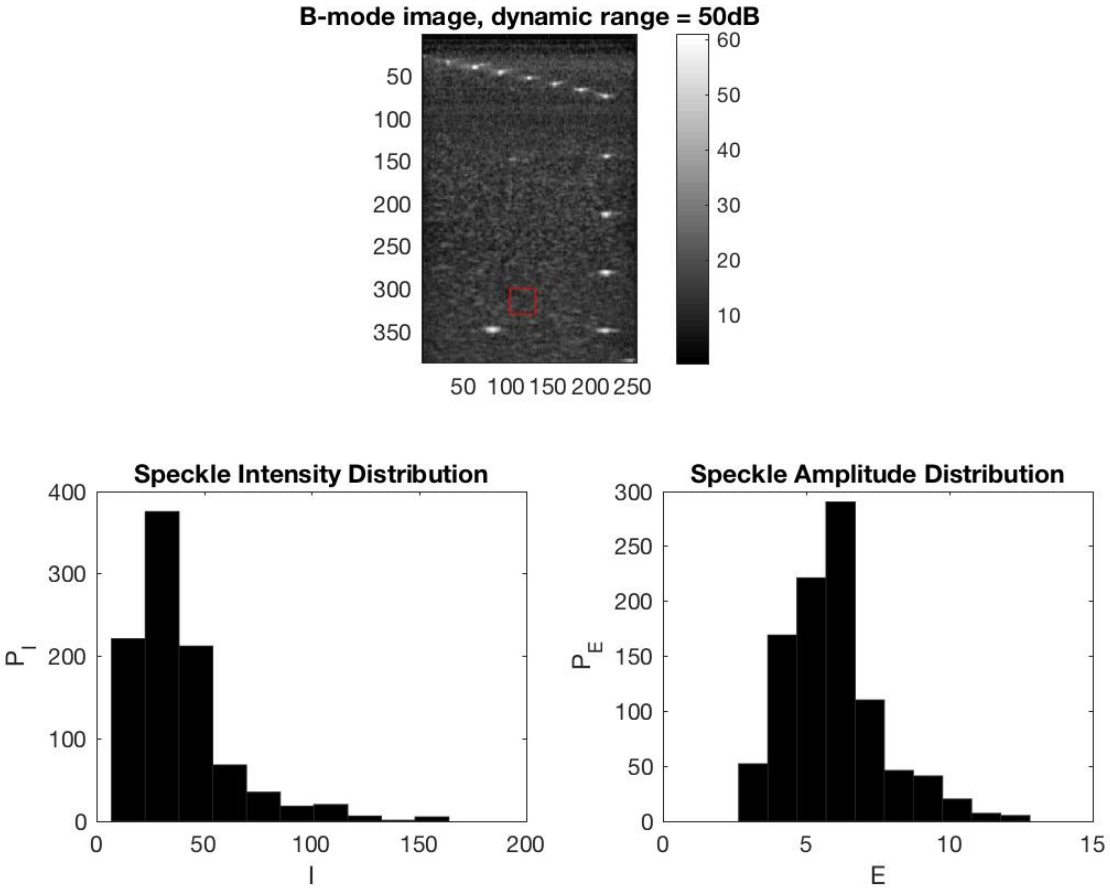

Figure 20: 57-high-res(Out Focus)

- **5.7cm/low gain/pen**

Row	speckleStd
In Focus	1.85955350077375
Out Focus	1.87701624088202

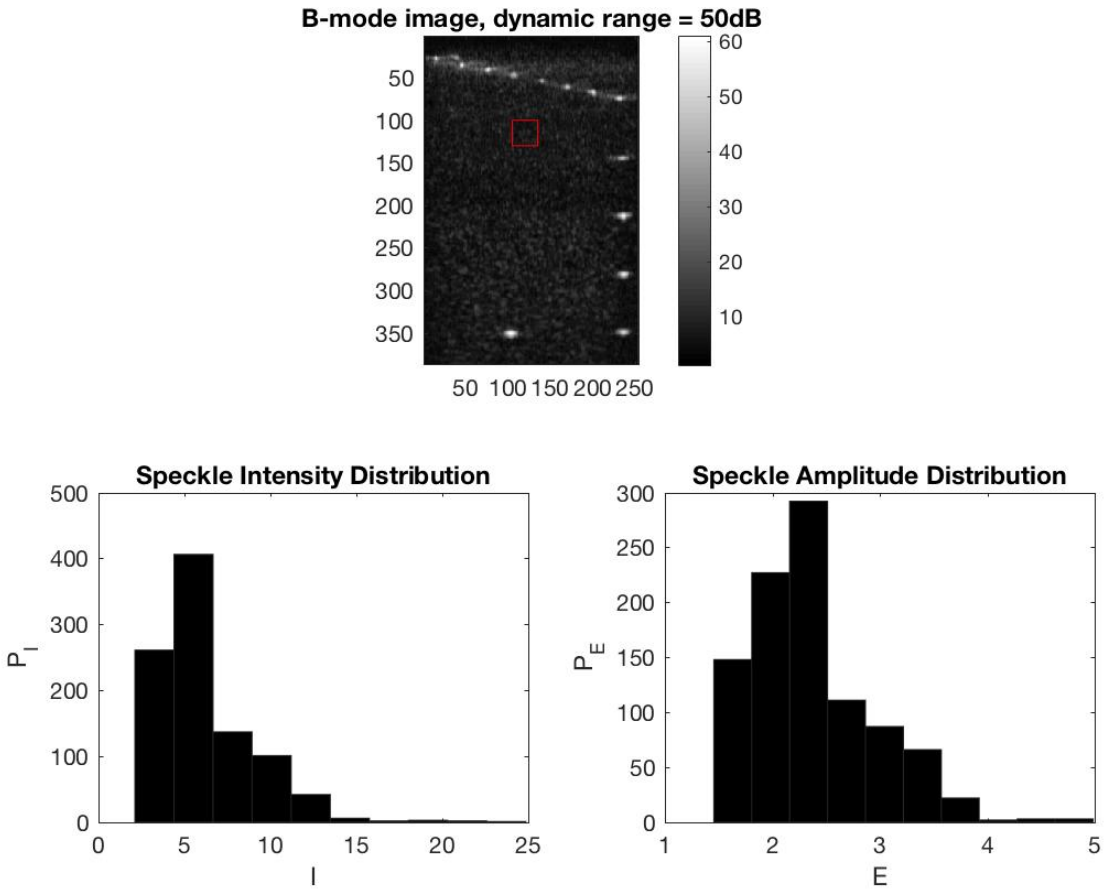

Figure 21: 57-low-pen(In Focus)

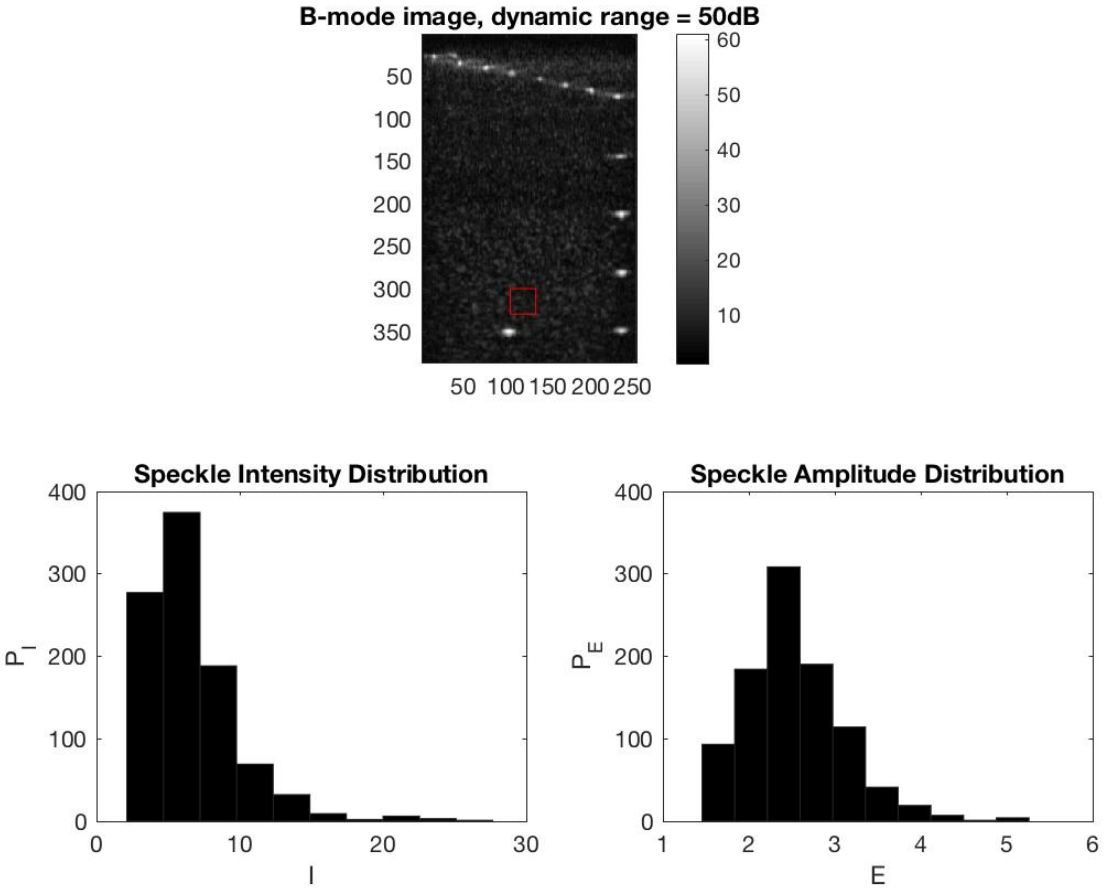

Figure 22: 57-low-pen(Out Focus)

- **5.7cm/low gain/res**

Row	speckleStd
In Focus	2.0591363015756
Out Focus	2.09933948396461

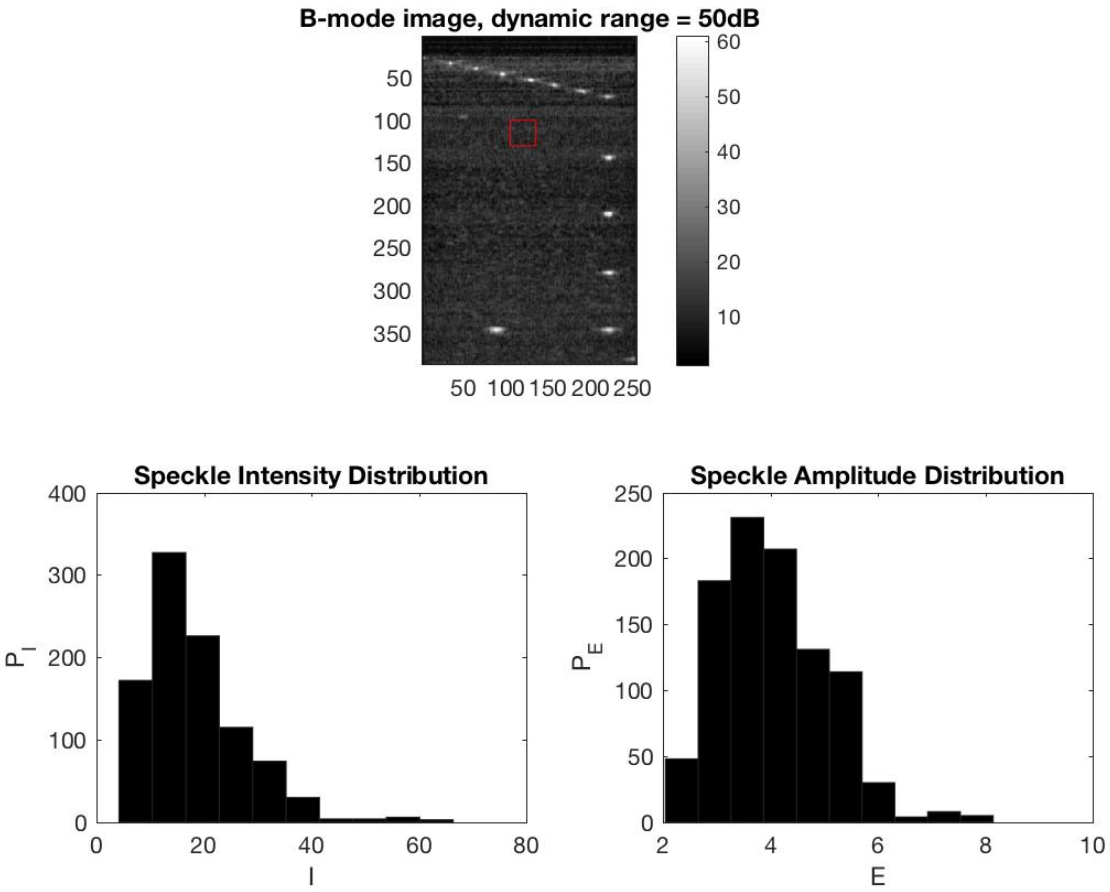

Figure 23: 57-low-res(In Focus)

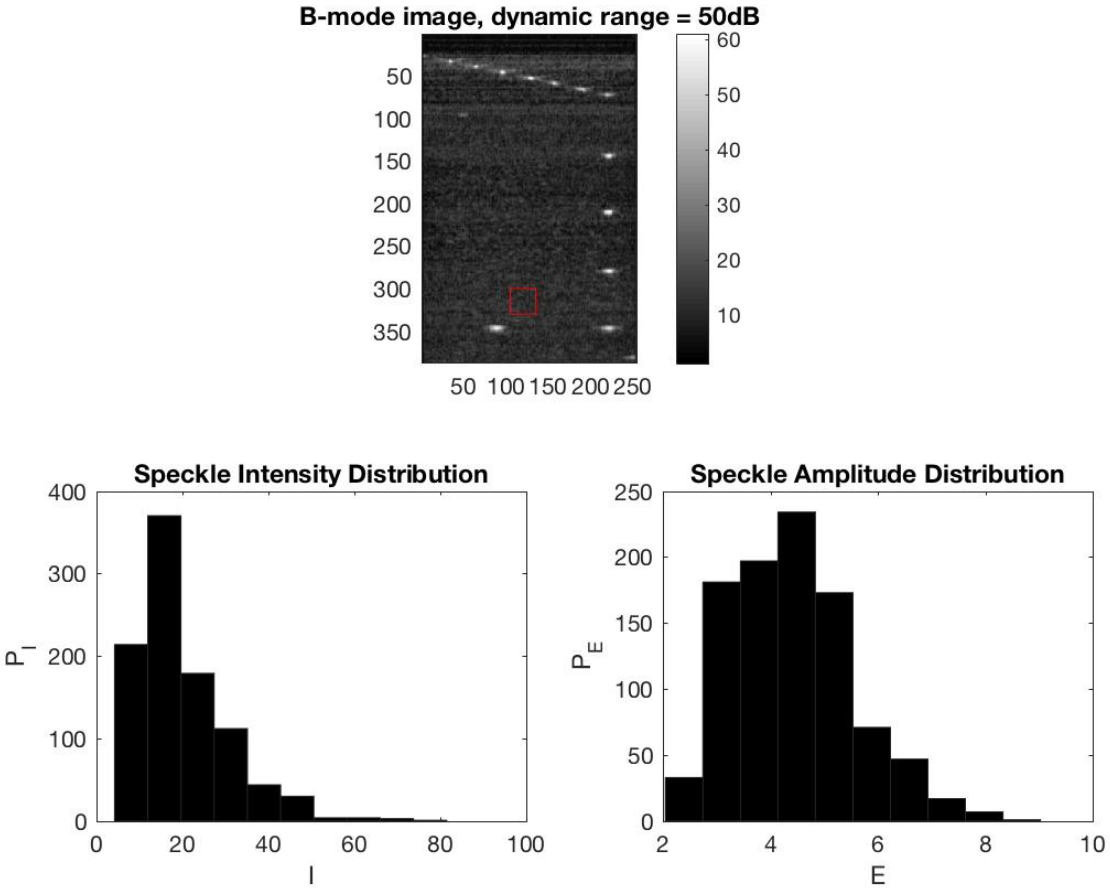

Figure 24: 57-low-res(Out Focus)

- **7.1cm/high gain/pen**

Row	speckleStd
In Focus	2.52223087523631
Out Focus	2.8006540657354

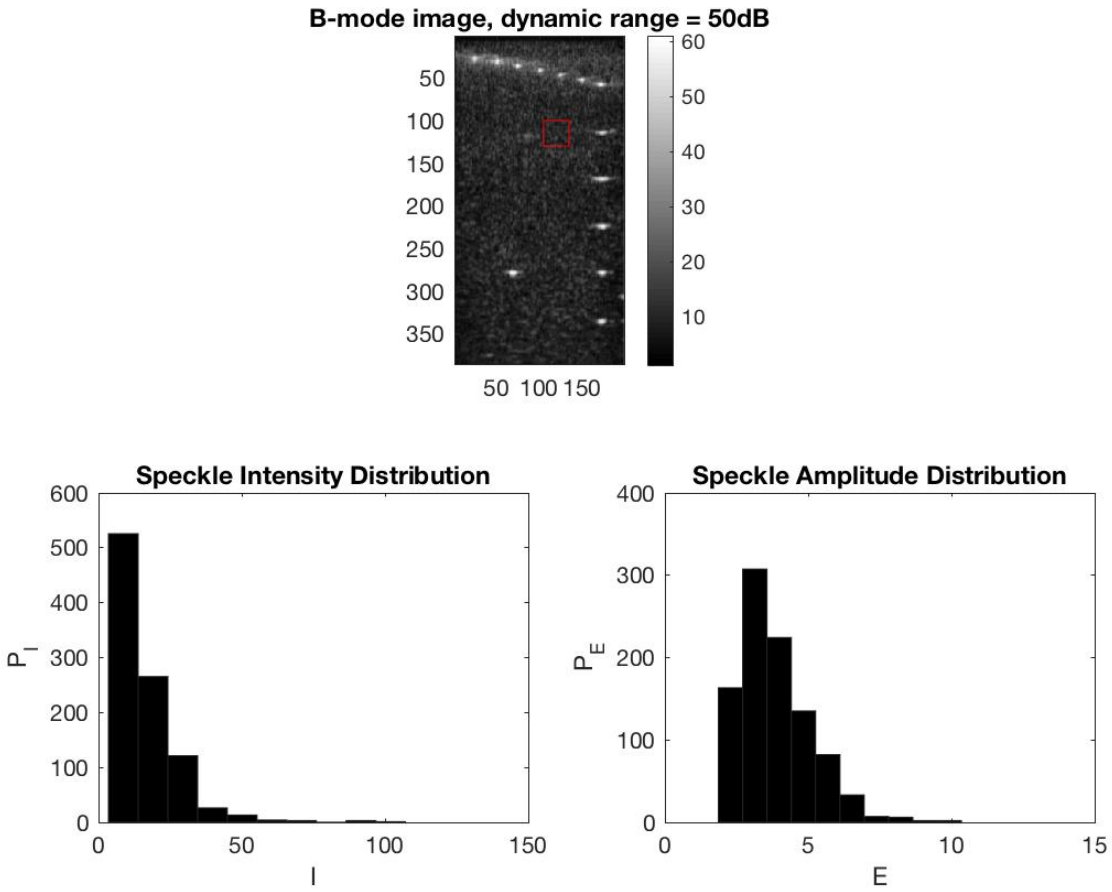

Figure 25: 71-high-pen(In Focus)

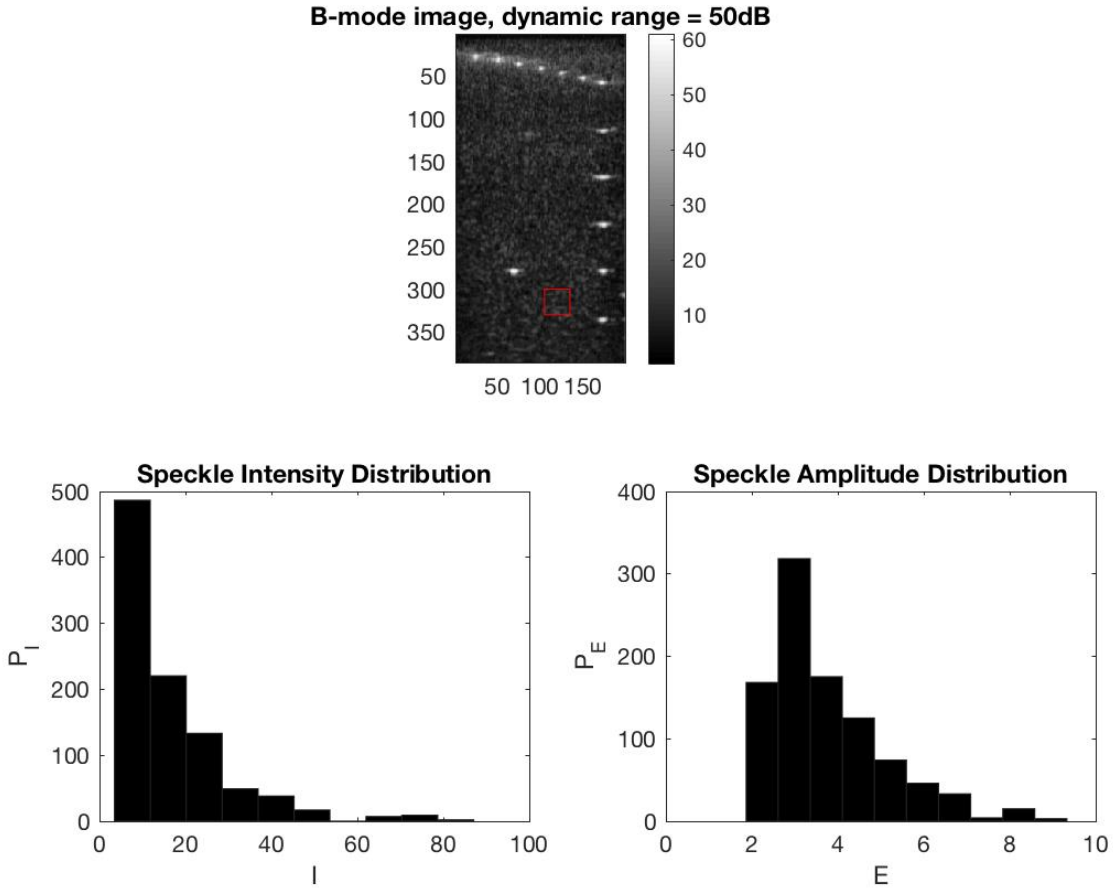

Figure 26: 71-high-pen(Out Focus)

- **7.1cm/high gain/res**

Row	speckleStd
In Focus	2.30119717391589
Out Focus	1.95521979312996

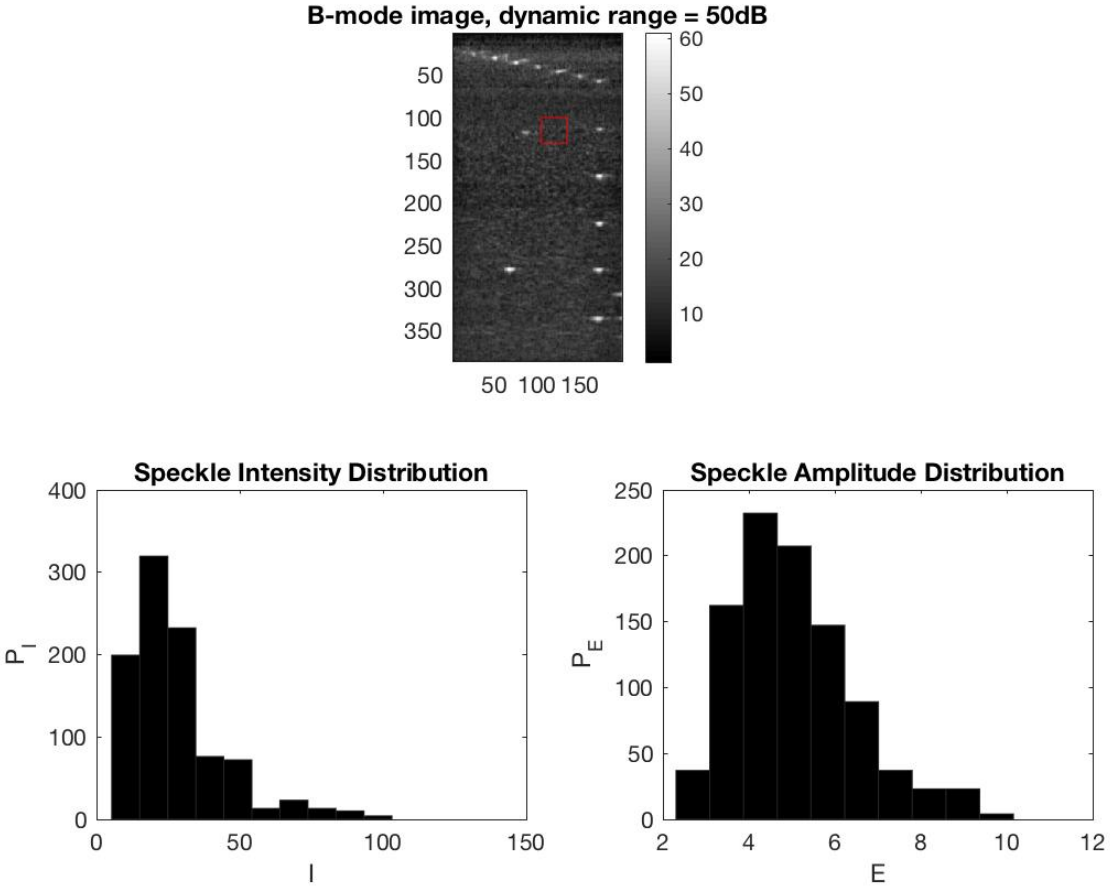

Figure 27: 71-high-res(In Focus)

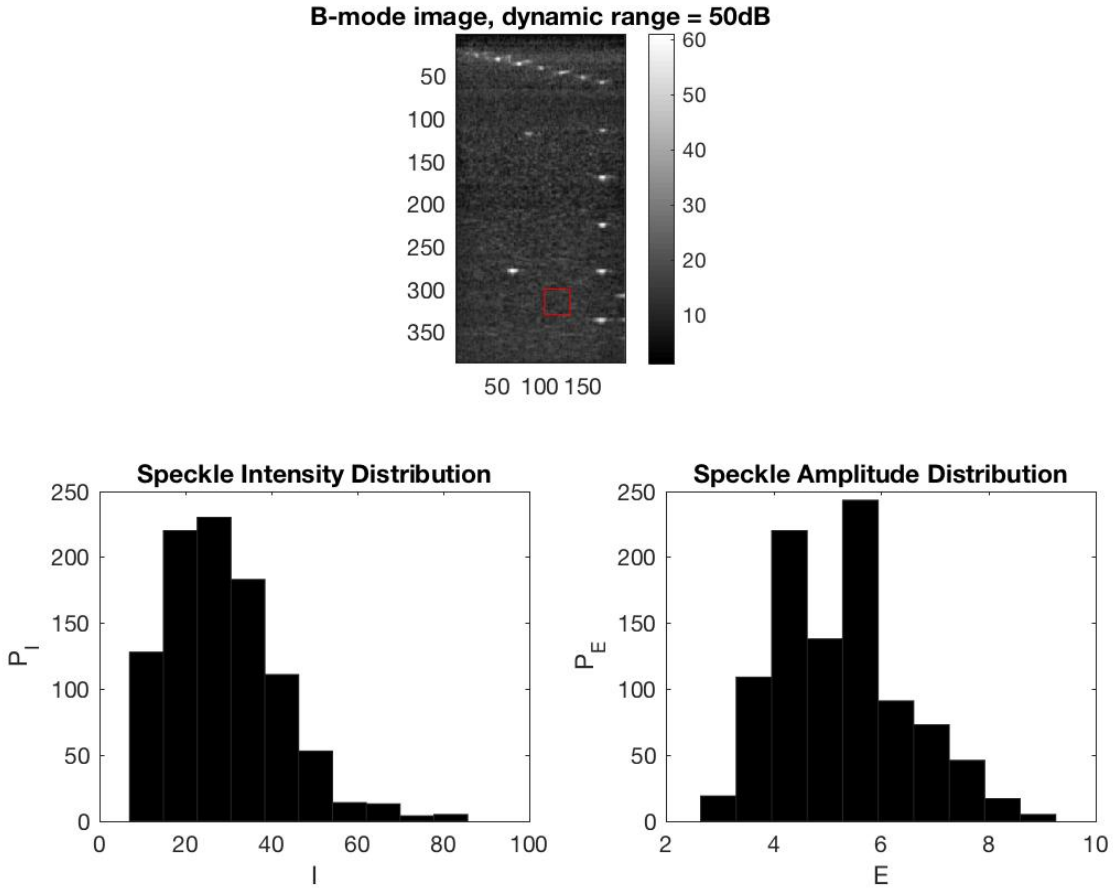

Figure 28: 71-high-res(Out Focus)

- **7.1cm/low gain/pen**

Row	speckleStd
In Focus	1.85806436047414
Out Focus	1.46467184032543

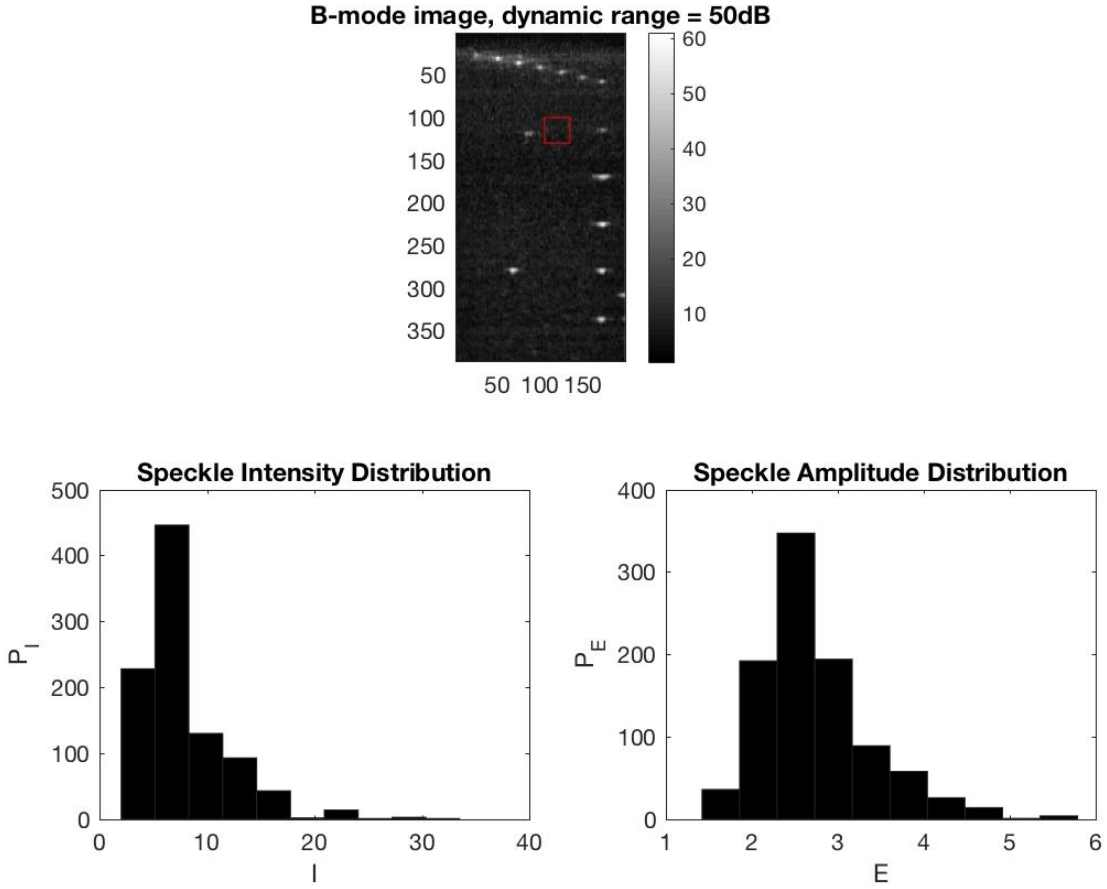

Figure 29: 71-low-pen(In Focus)

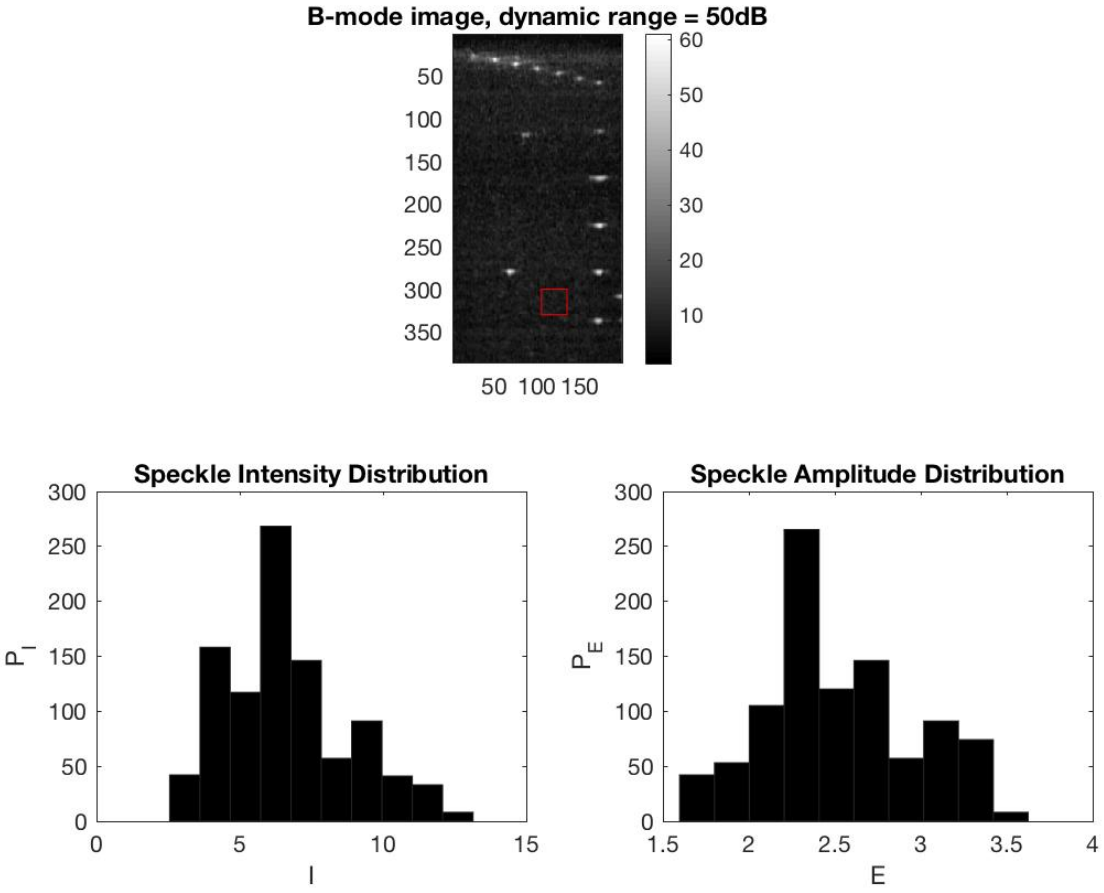

Figure 30: 71-low-pen(Out Focus)

- **7.1cm/low gain/res**

Row	speckleStd
In Focus	2.46031687510177
Out Focus	2.15699941892348

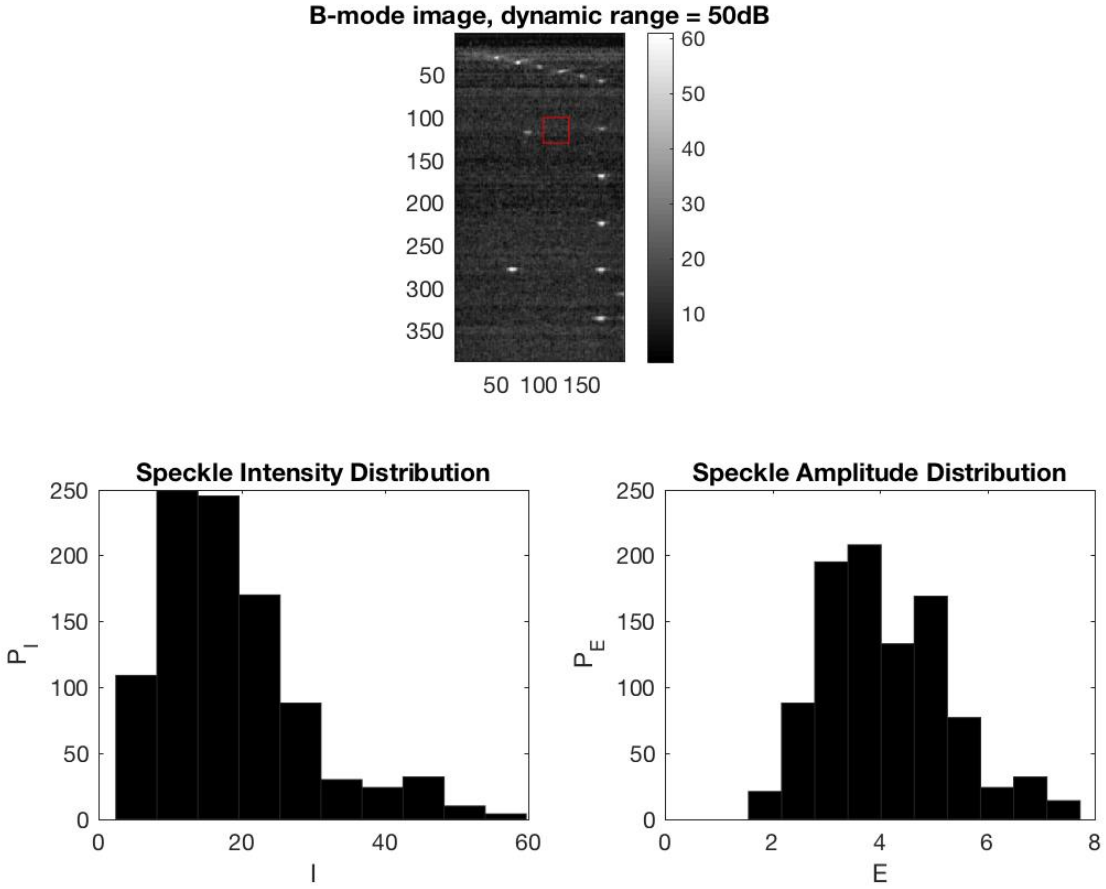

Figure 31: 71-low-res(In Focus)

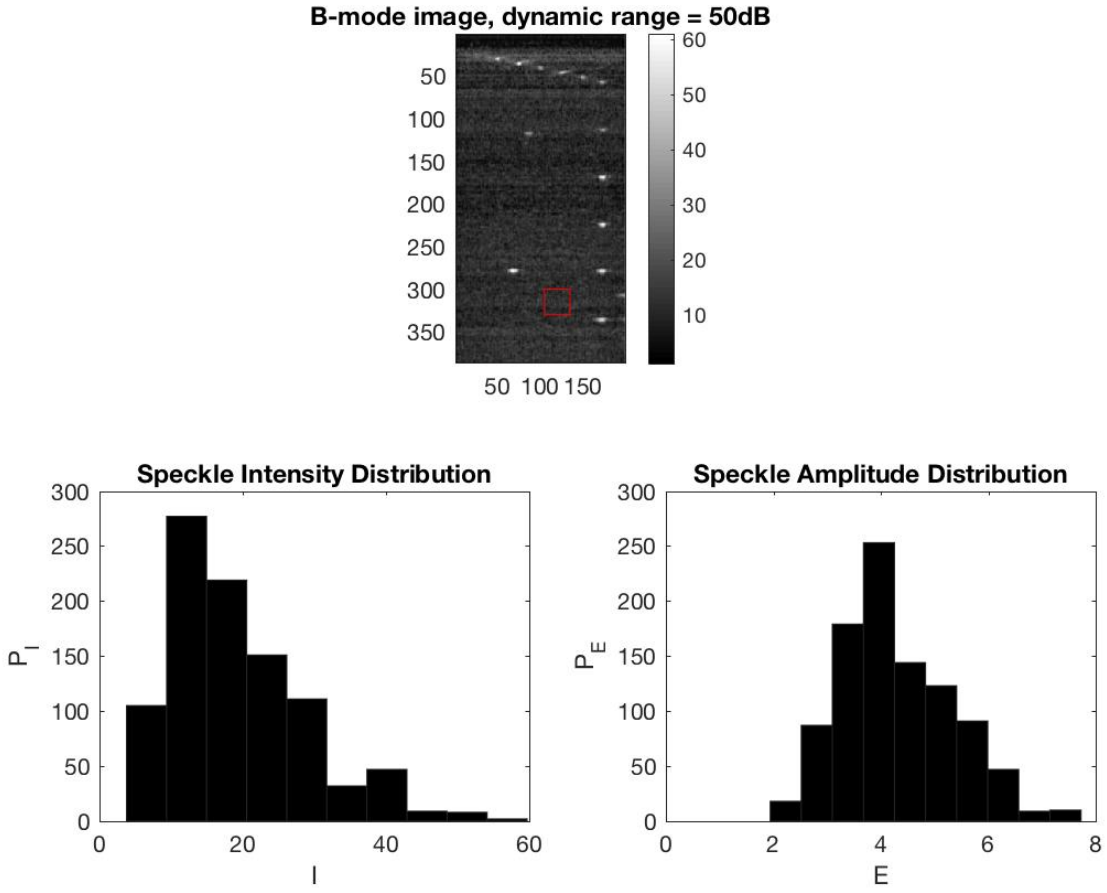

Figure 32: 71-low-res(Out Focus)

HW2 CONCLUSION

由圖可以發現，intensity 跟 amplitude 大都符合理論的分布，standard deviation 也在理論範圍附近!

3 HW3-Contrast To Noise Ration(CNR)

3.1 實驗原理

用於決定影像解析度高低的基準。強度可被視為訊號而標準差則為噪音。CNR 的定義為

$$CNR = |\frac{I_{in} - I_{out}}{std_{in} - std_{out}}|$$

3.2 實驗數據

a) Estimate CNR at in-focused region and out-focused region
在 B mode 下，分別以 high gain 及 low gain，量測 pen (in-focused) 及 res (out-focused) 的個點，並計算出其 CNR。

- **high gain/pen**

Row	負 15dB 和負 6dB	負 3dB 和正 3dB	正 6dB 和正 15dB
CNR	1.50773574773114	0.0480413687620145	0.601431009913864

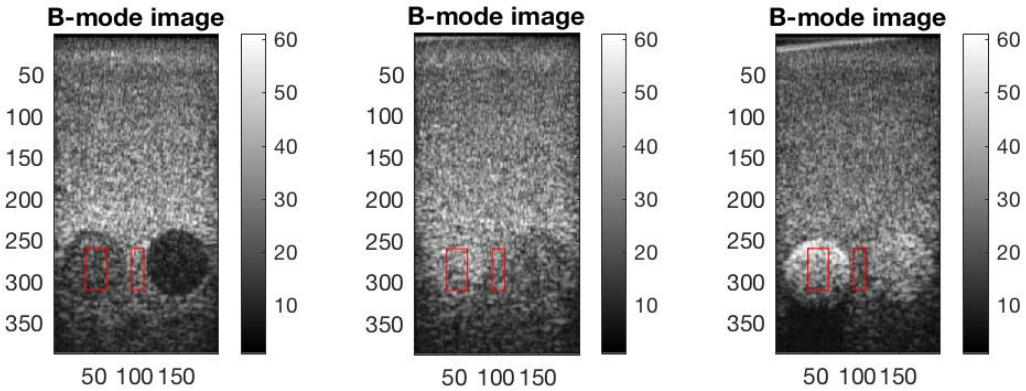

Figure 33: high-pen

- **high gain/res**

Row	負 15dB 和負 6dB	負 3dB 和正 3dB	正 6dB 和正 15dB
CNR	2.21680669412347	0.544271341232453	0.193607102083192

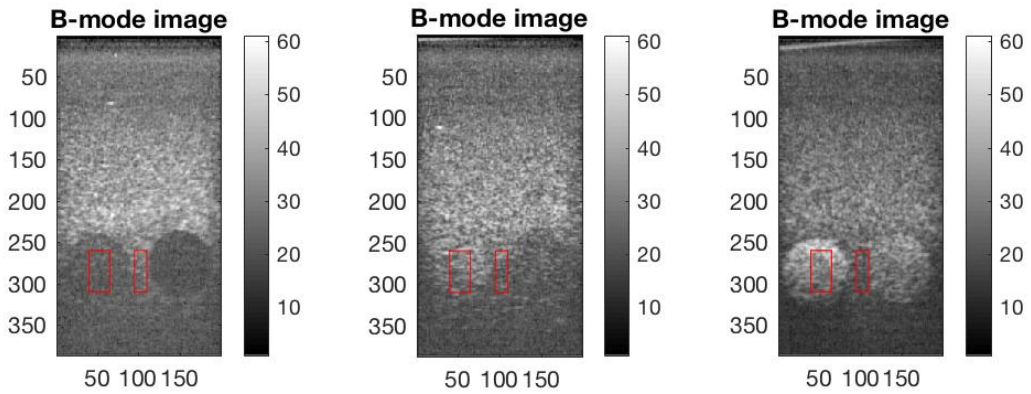

Figure 34: high-res

- **low gain/pen**

Row	負 15dB 和負 6dB	負 3dB 和正 3dB	正 6dB 和正 15dB
CNR	0.2284280195117	1.25356417018746	1.06455157861478

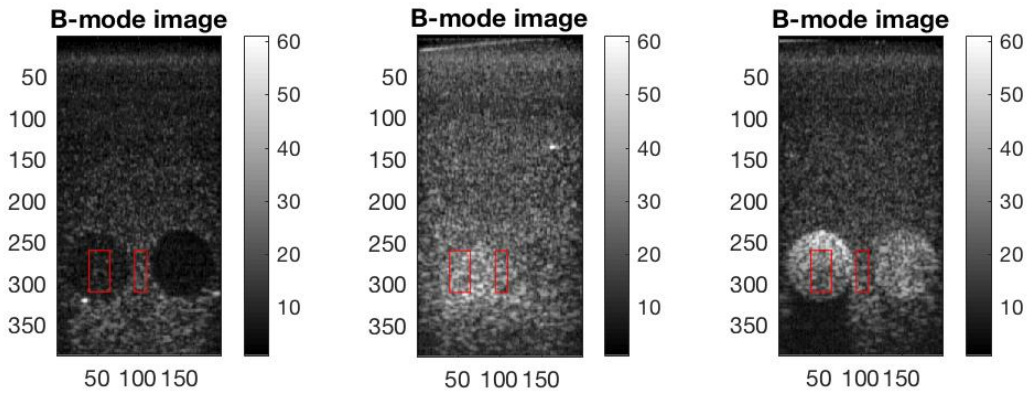

Figure 35: low-pen

- **low gain/res**

Row	負 15dB 和負 6dB	負 3dB 和正 3dB	正 6dB 和正 15dB
CNR	0.0913893761403897	0.838694640276527	1.23049646412891

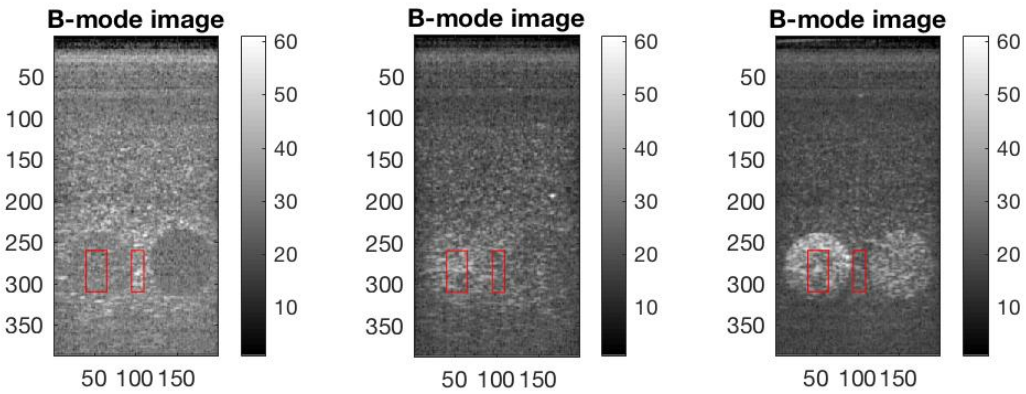

Figure 36: low-res

4 HW4-Doppler

4.1 實驗原理

在都卜勒模式下，以探頭測量頸動脈的血流，並擷取其 Color Doppler 及 PW 影像。

4.2 實驗步驟

a) Carotid color Doppler and PW images
受測者: 蔡承佑

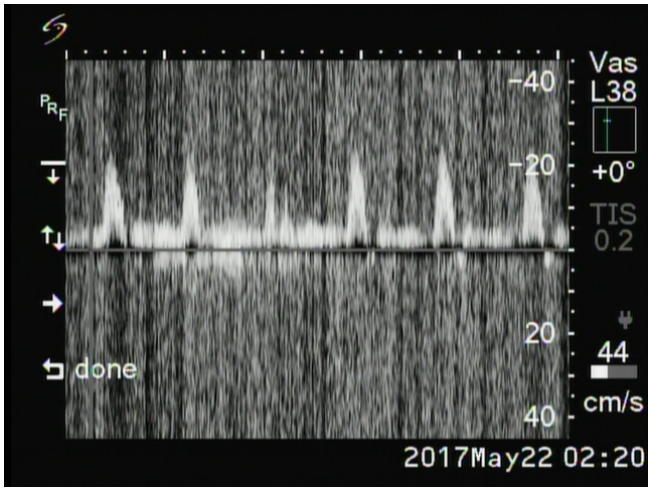

Figure 37: CPD

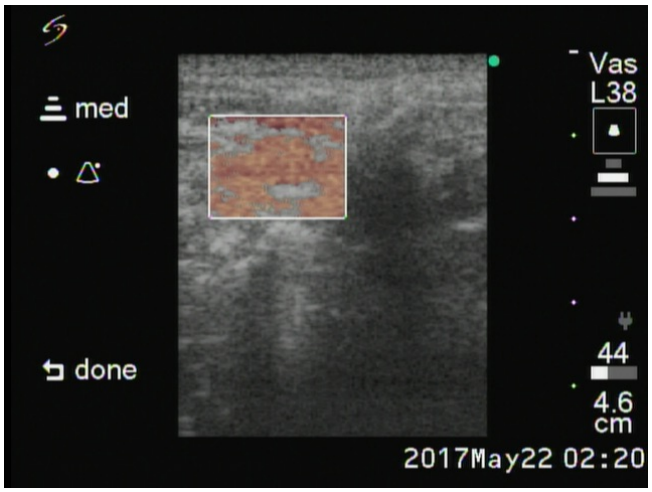

Figure 38: CPD2