ANALYZING SUB-POISSONIAN NOISE IN QUANTUM CORRELATED IMAGES

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Uses

- Sending information securely
- Increasing sensitivity of interferometry
- Increasing precision of transmission and reflection measurements
- Increasing resolution of images

Photon Statistics

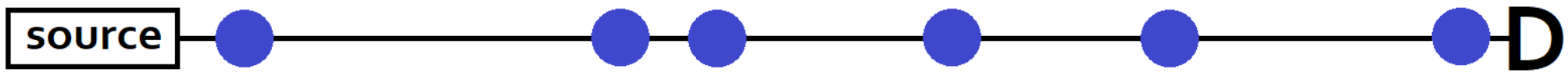
Photon Detector

Mean Value $\overline{n}$

Variance $(\Delta n)^2$

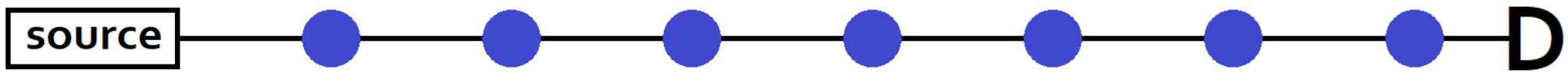
Classification of Light by Photon Statistics

	Super - Poissonian	**Poissonian**	**Sub - Poissonian**
Form of Light	Classical	Classical	Quantum
Relationship	$(\Delta n)^2 > \overline{n}$	$(\Delta n)^2 = \overline{n}$	$(\Delta n)^2 < \overline{n}$

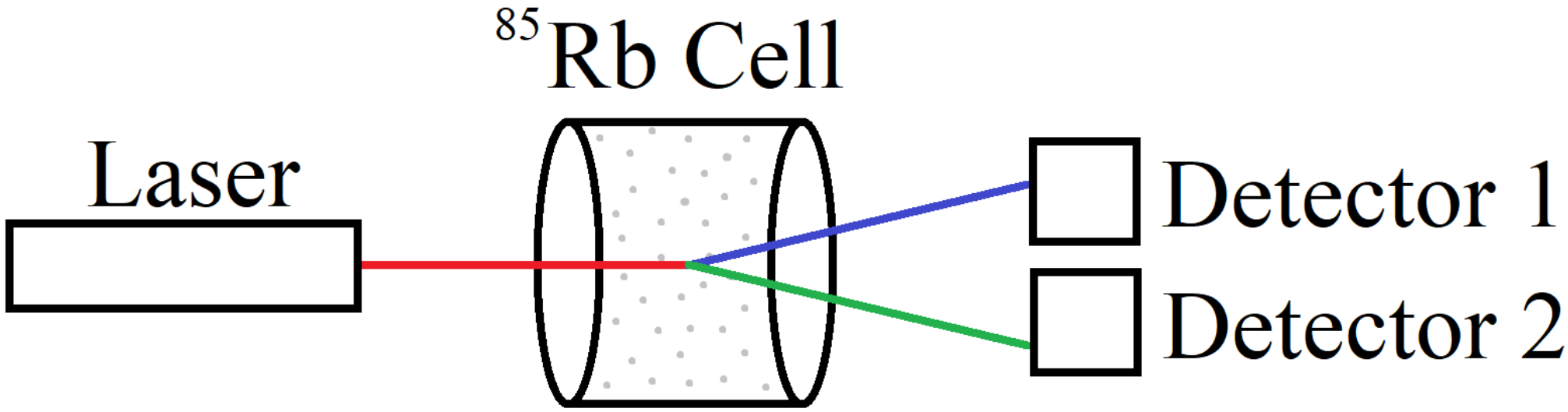


POISSONIAN (COHERENT)

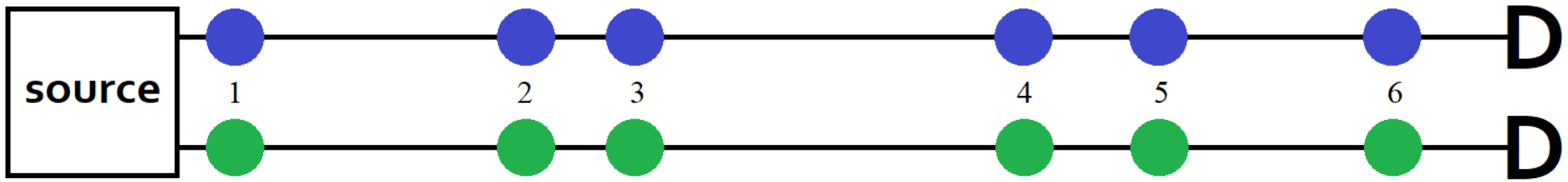
SUPER-POISSONIAN (BUNCHED)



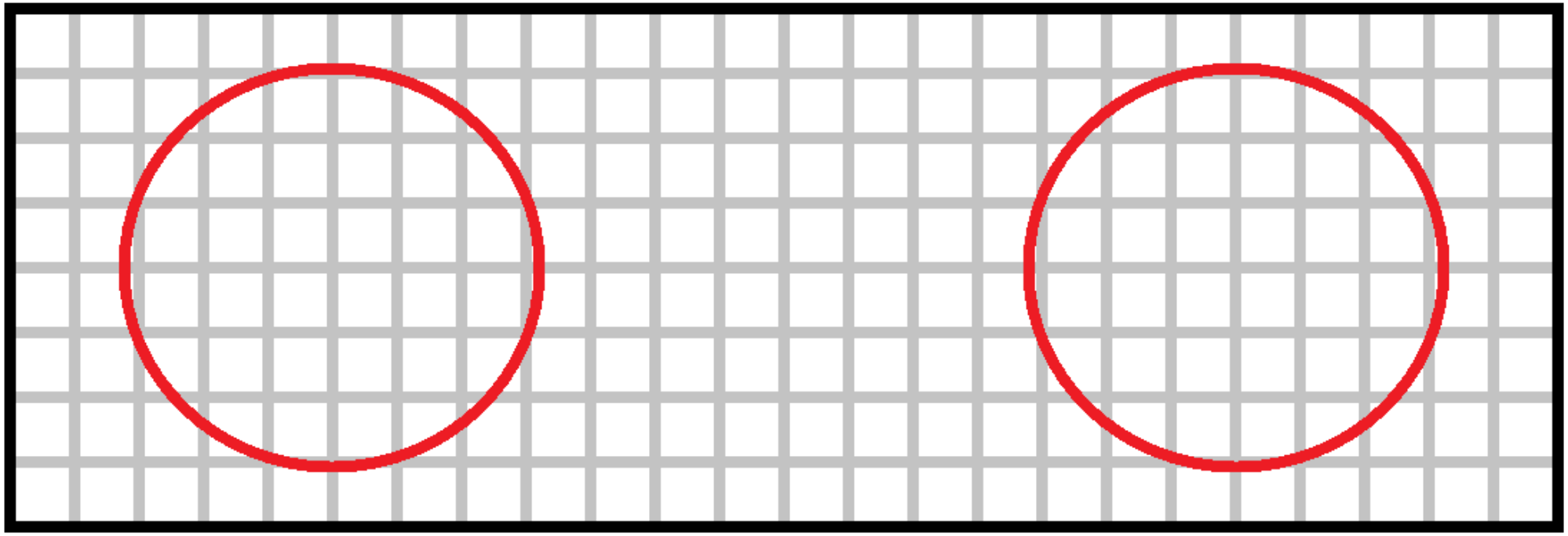
SUB-POISSONIAN (ANTI-BUNCHED)



APPARATUS DIAGRAM



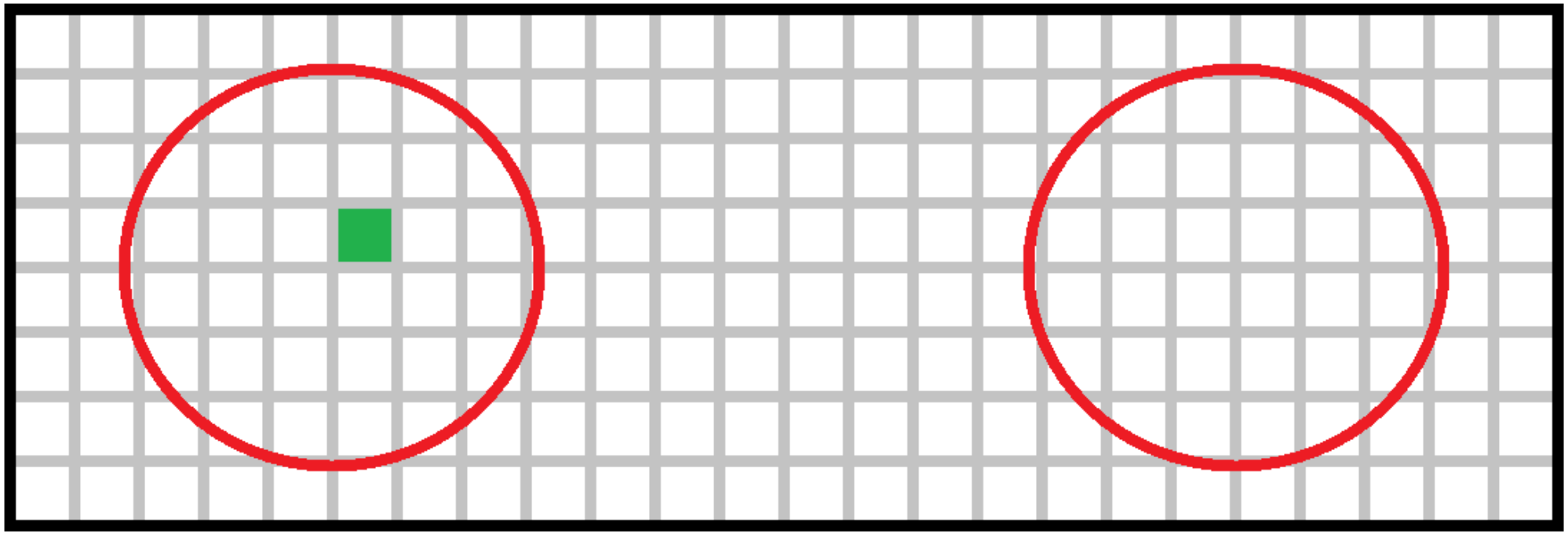
TEMPORALLY CORRELATED



Left

Right

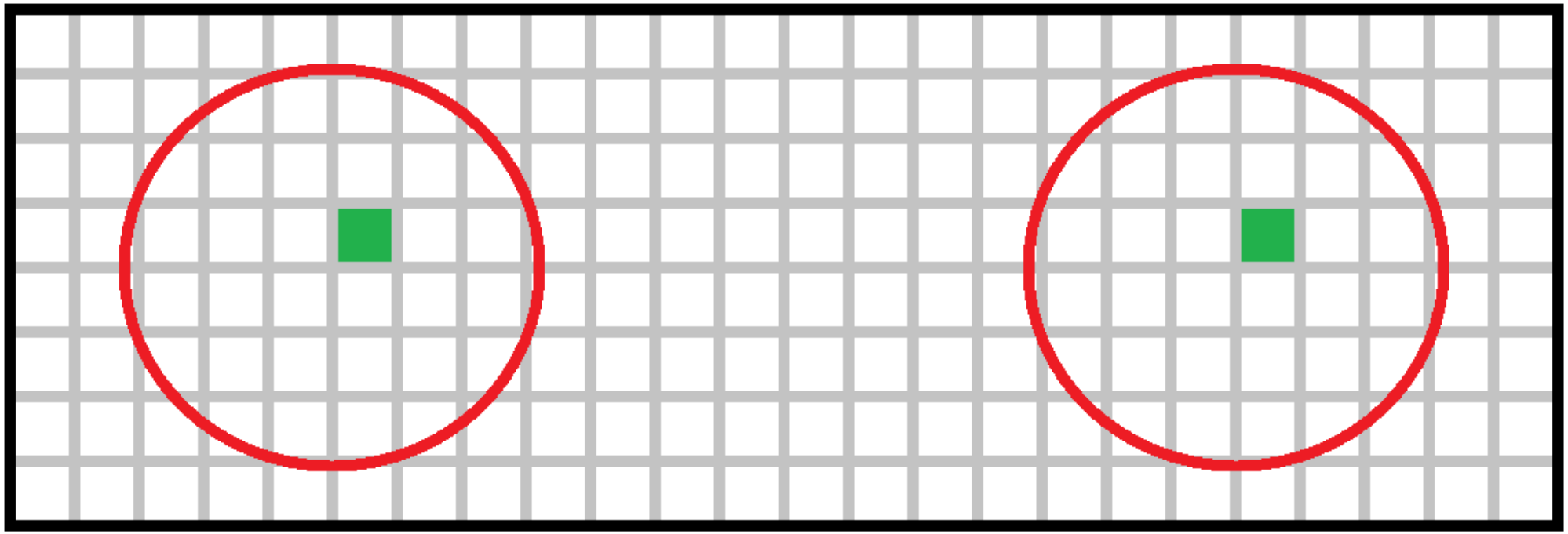
SPATIALLY CORRELATED



Left

Right

SPATIALLY CORRELATED



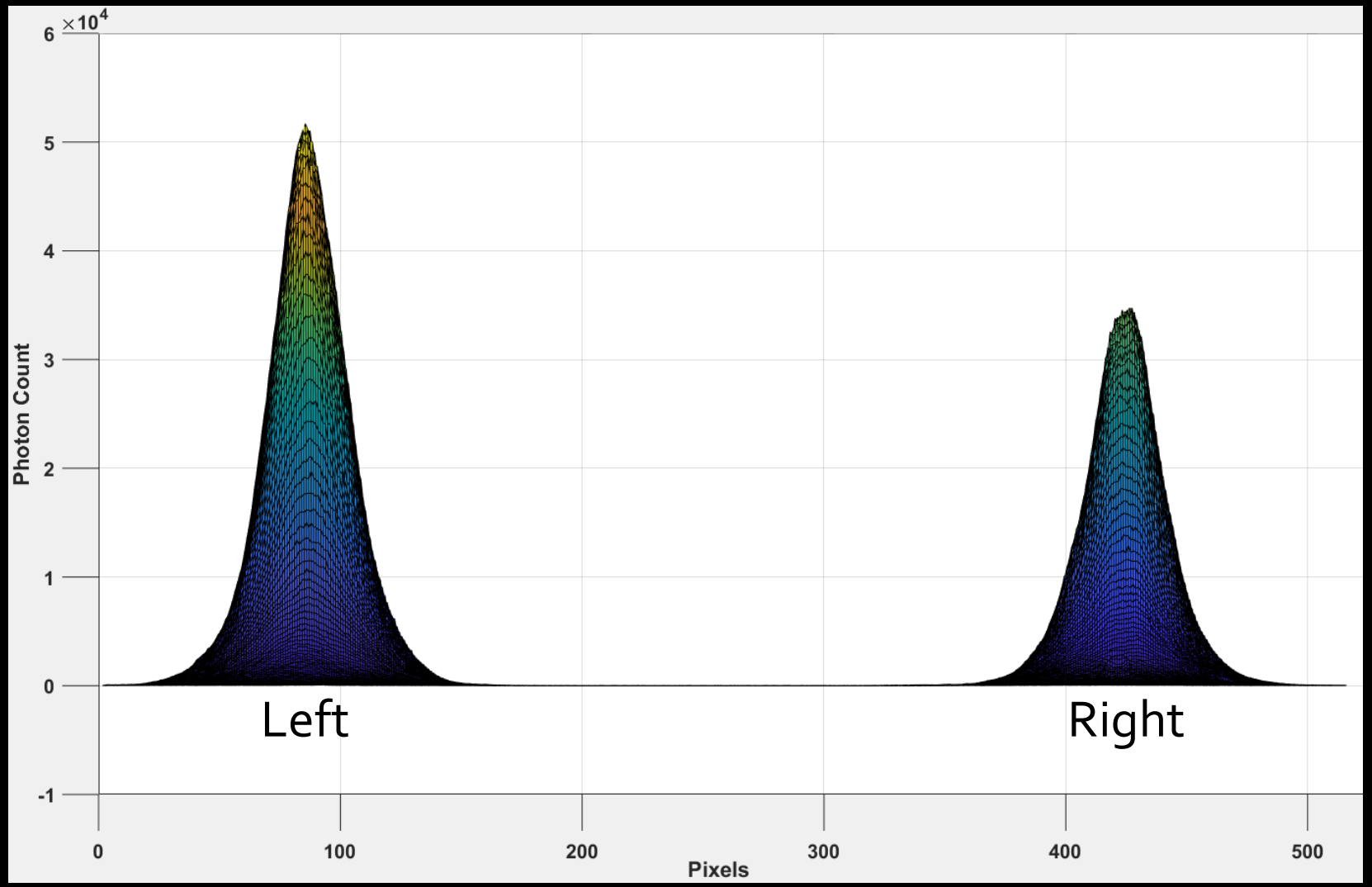
Left

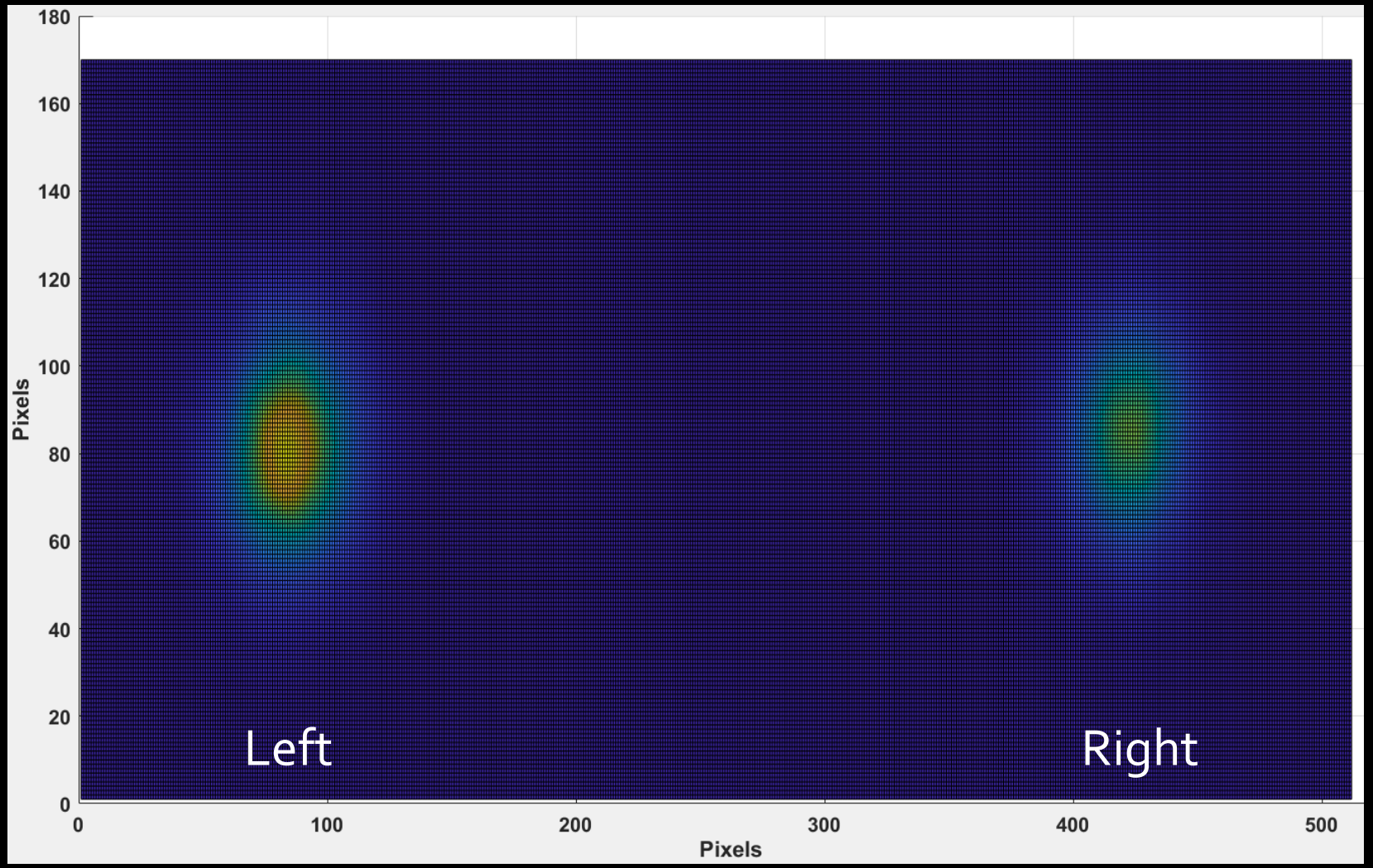
Right

SPATIALLY CORRELATED

Uploading Images

Side view



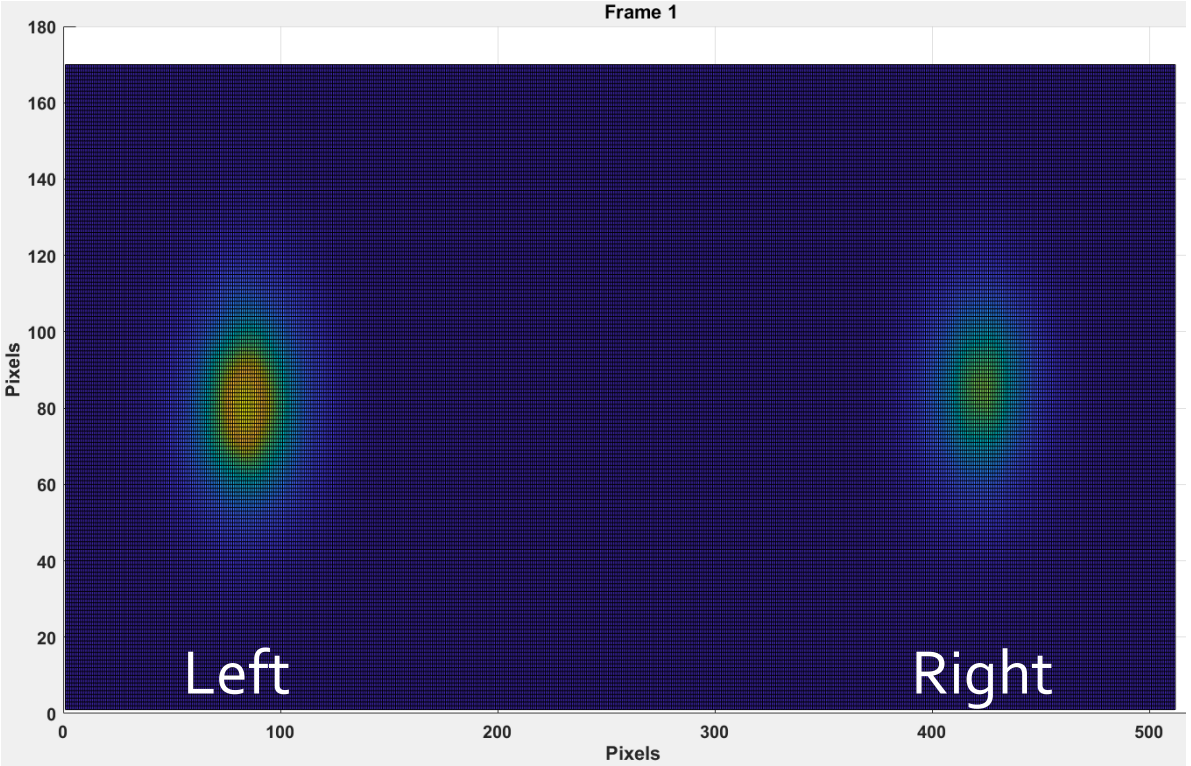


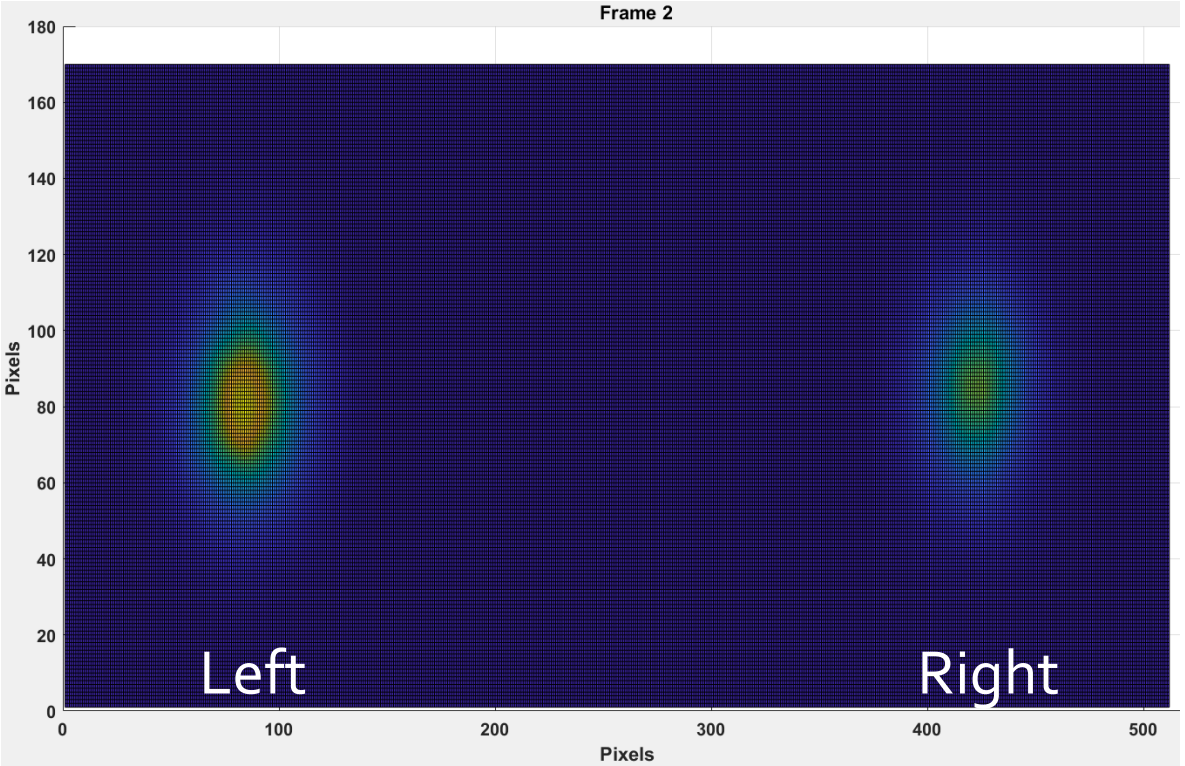
Uploading Images

Top down view

Correcting Images

- Subtract background noise
- Separate beams into two separate images
- Crop out unimportant areas
- Align images

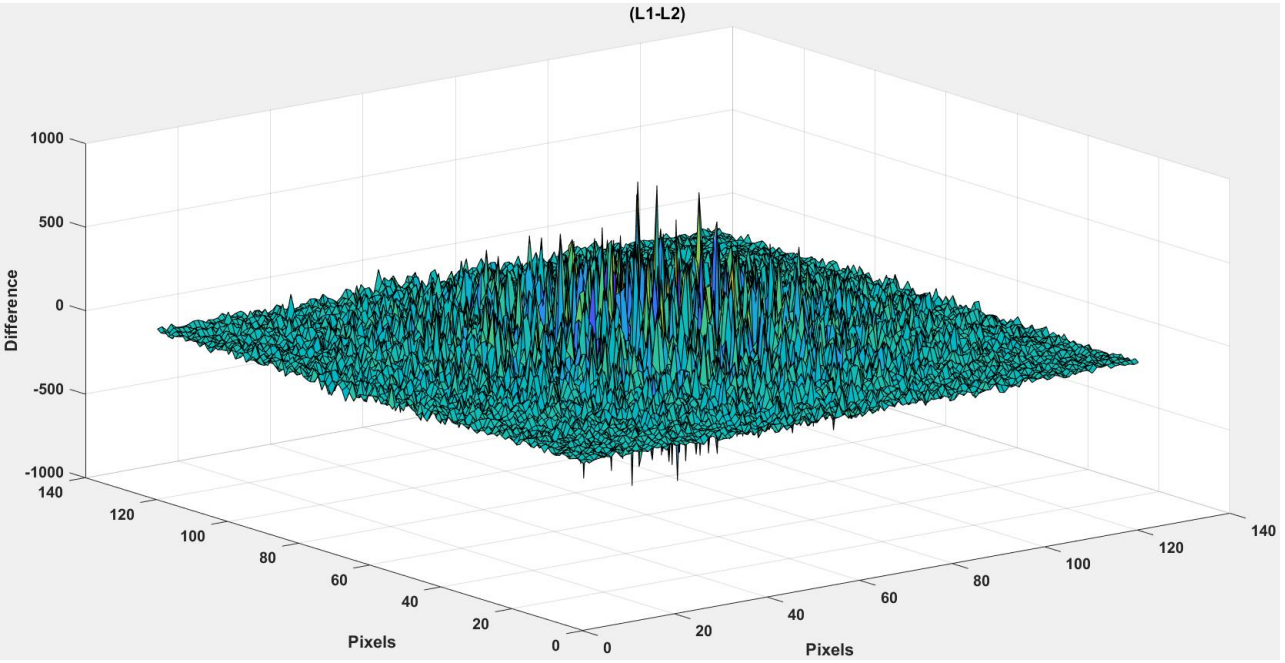




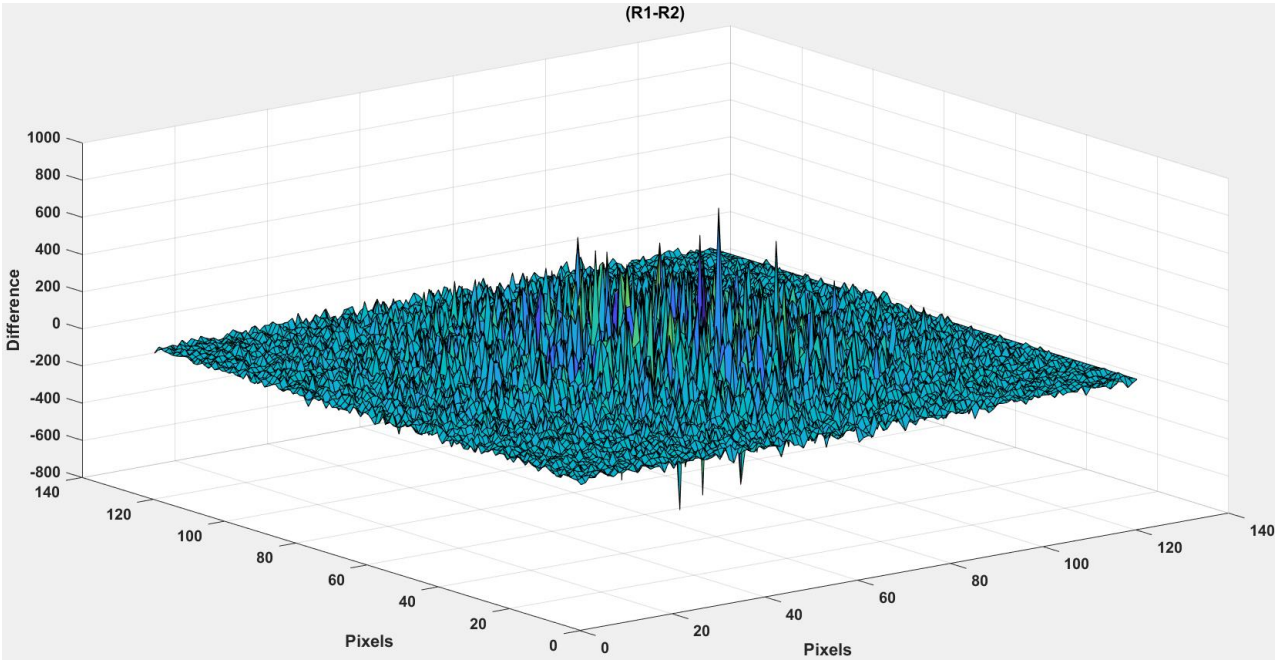
2 FRAMES PER IMAGE

Subtracting Frames

- Gets rid of classical noise
- Looks at fluctuations only

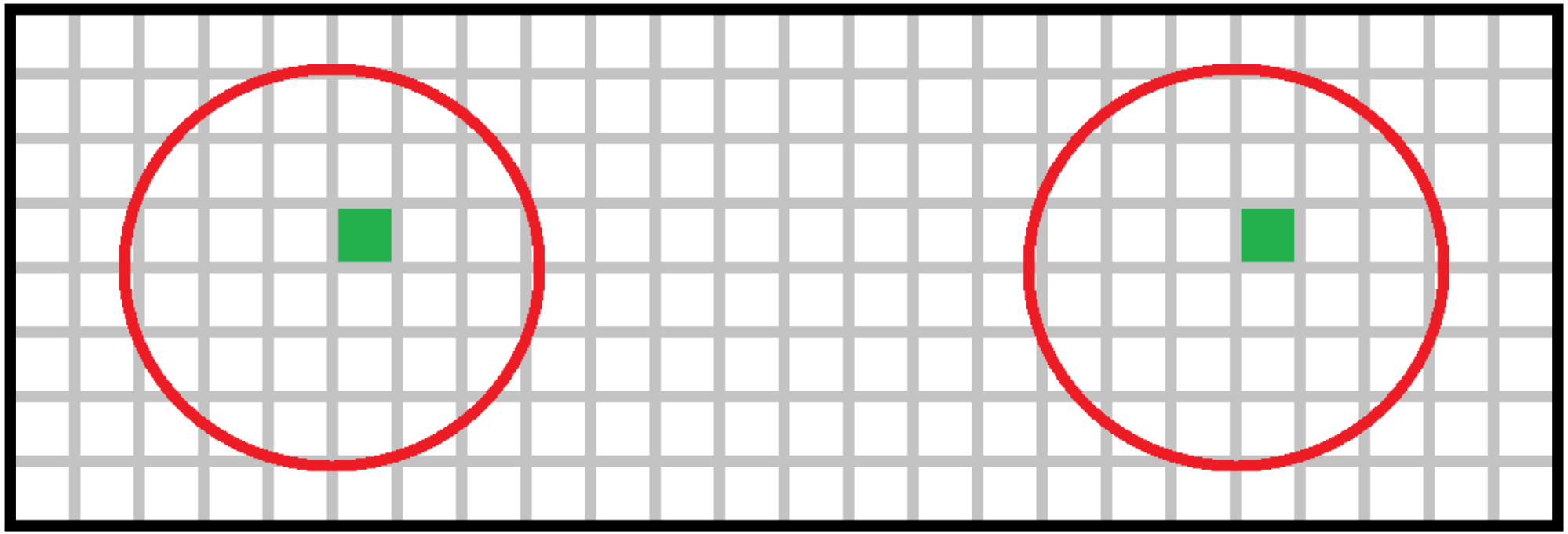


Left

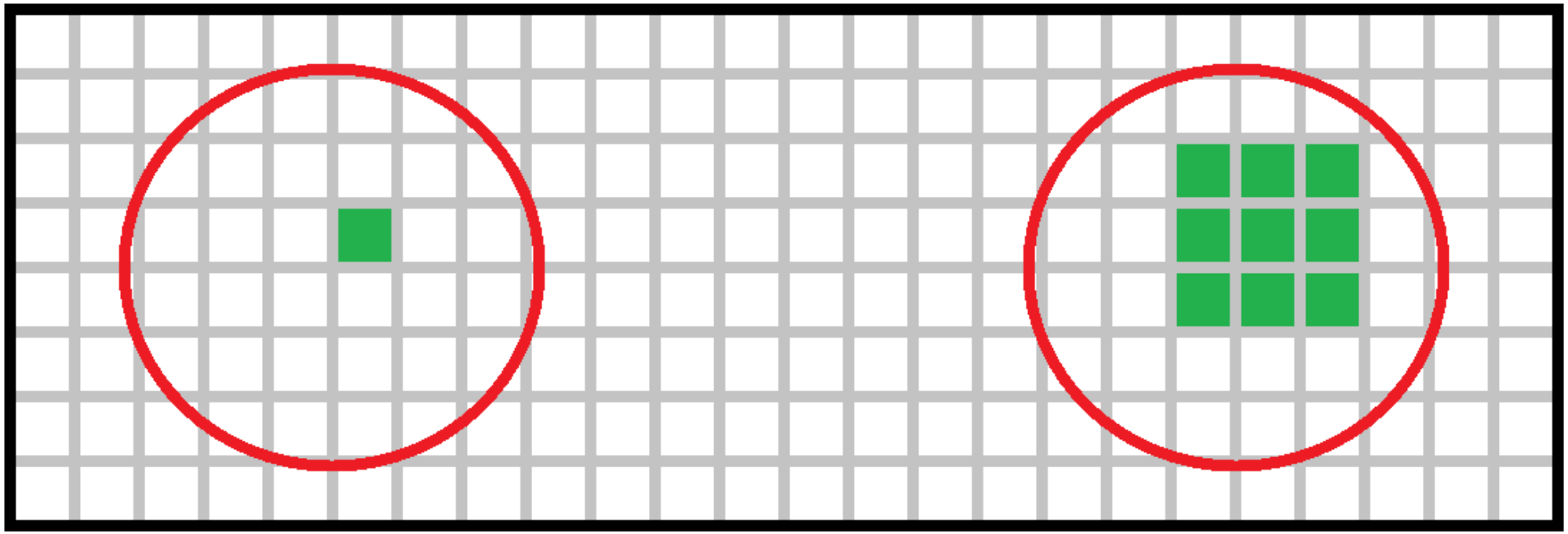


Right

SUBTRACTED FRAMES



COHERENCE AREA



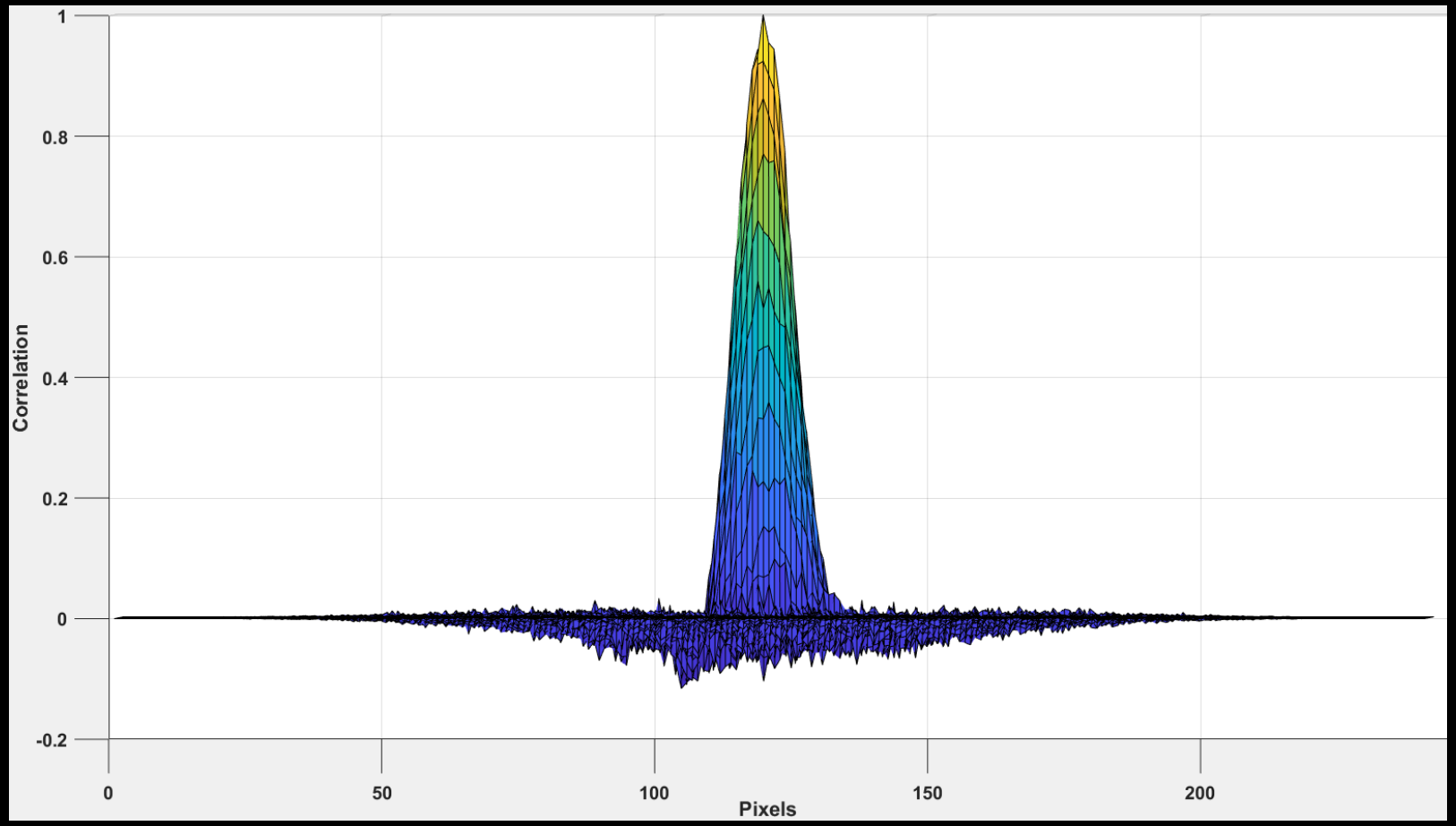
Left

Right

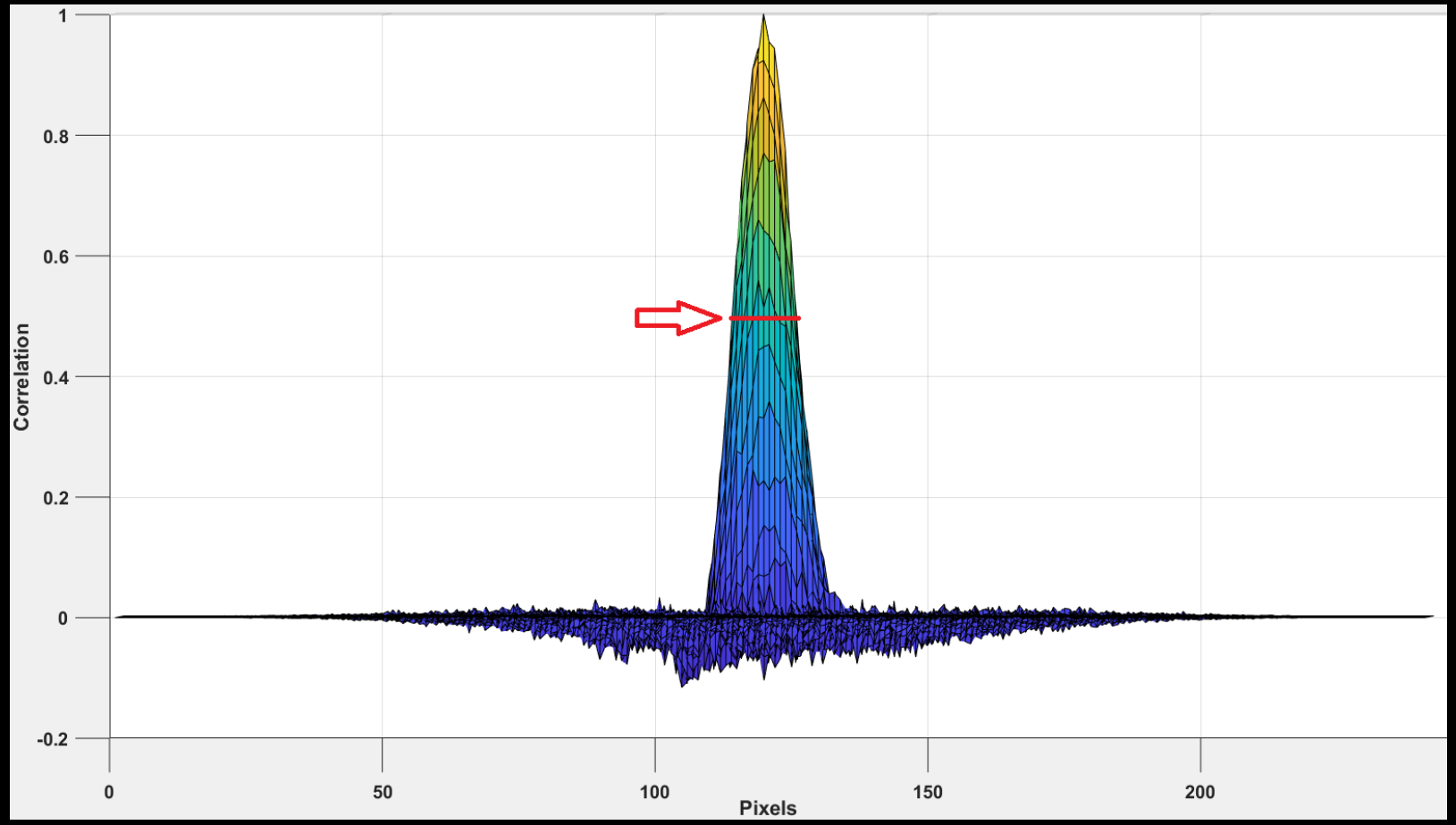
COHERENCE AREA

Cross Correlation

(L1-L2) vs (R1-R2)



Cross Correlation

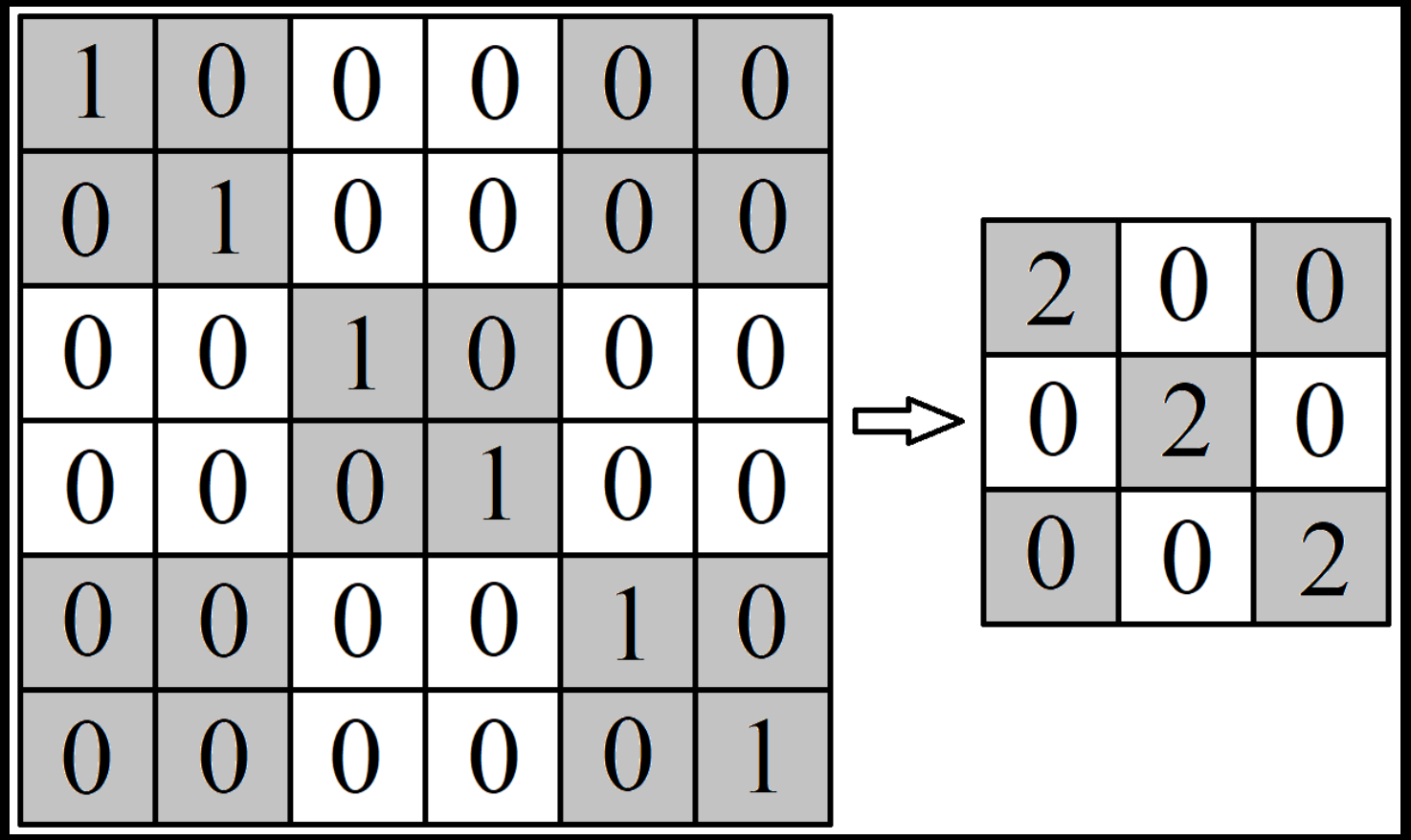


(L1-L2) vs (R1-R2)

Binning

1	0	0	0	0	0
0	1	0	0	0	0
0	0	1	0	0	0
0	0	0	1	0	0
0	0	0	0	1	0
0	0	0	0	0	1

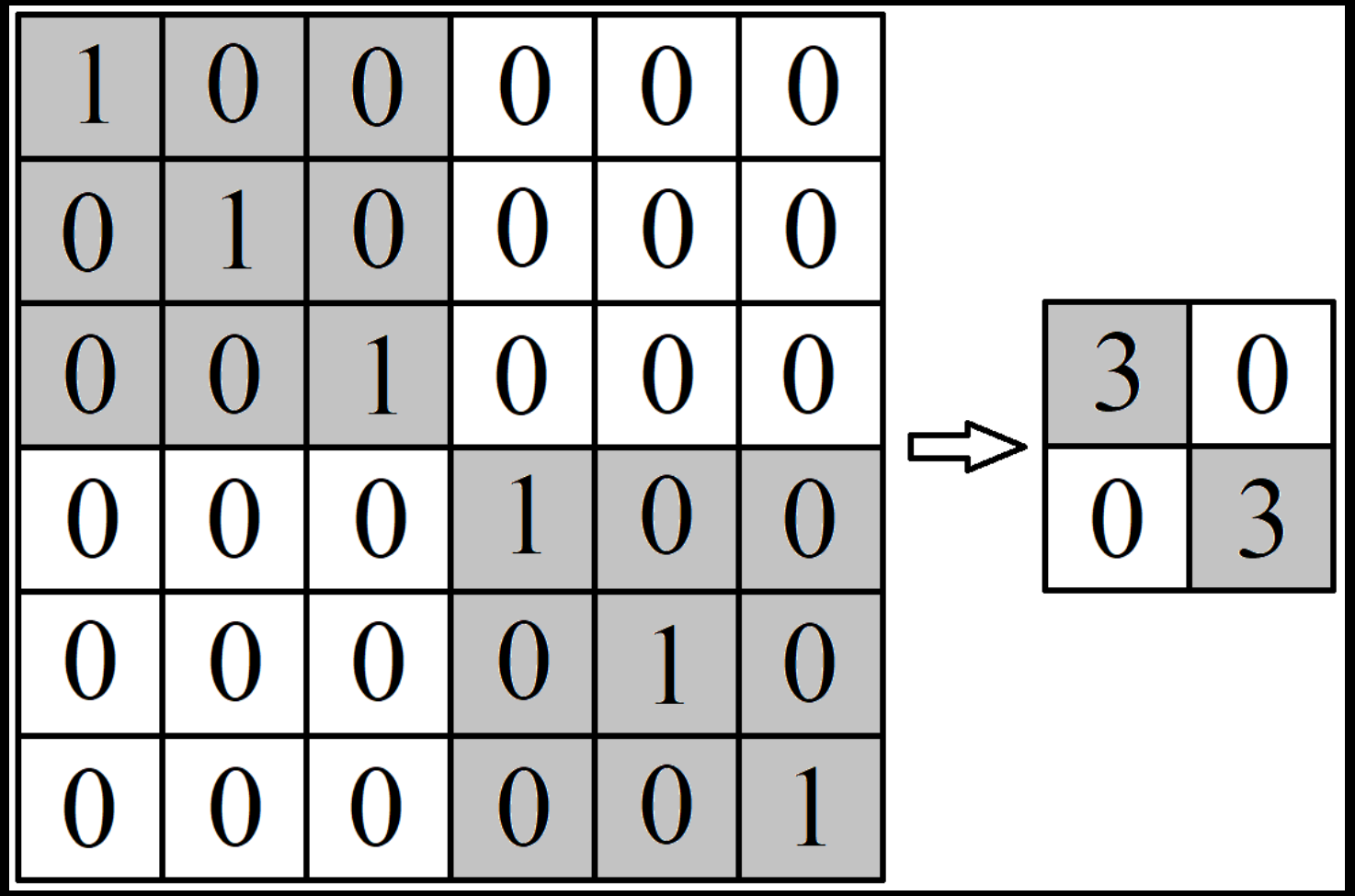
Binning

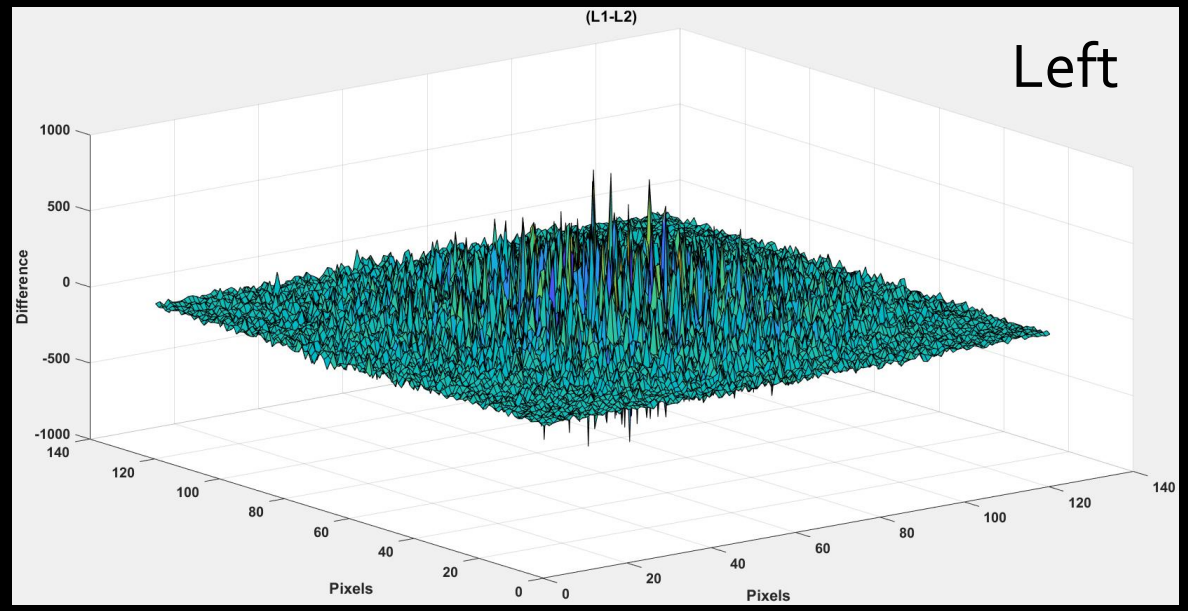


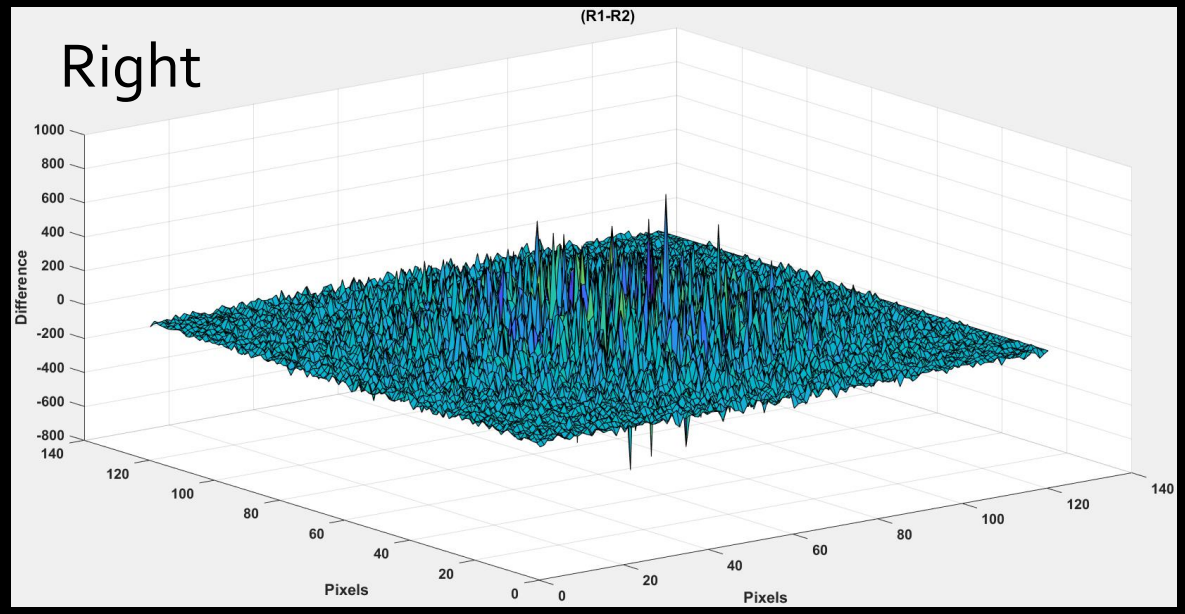
By 2

Binning

By 3







$$Noise\ Reduction\ Factor = \frac{var\left((L_1 - L_2) - (R_1 - R_2)\right)}{mean(L_1) + mean(L_2) + mean(R_1) + mean(R_2)}$$

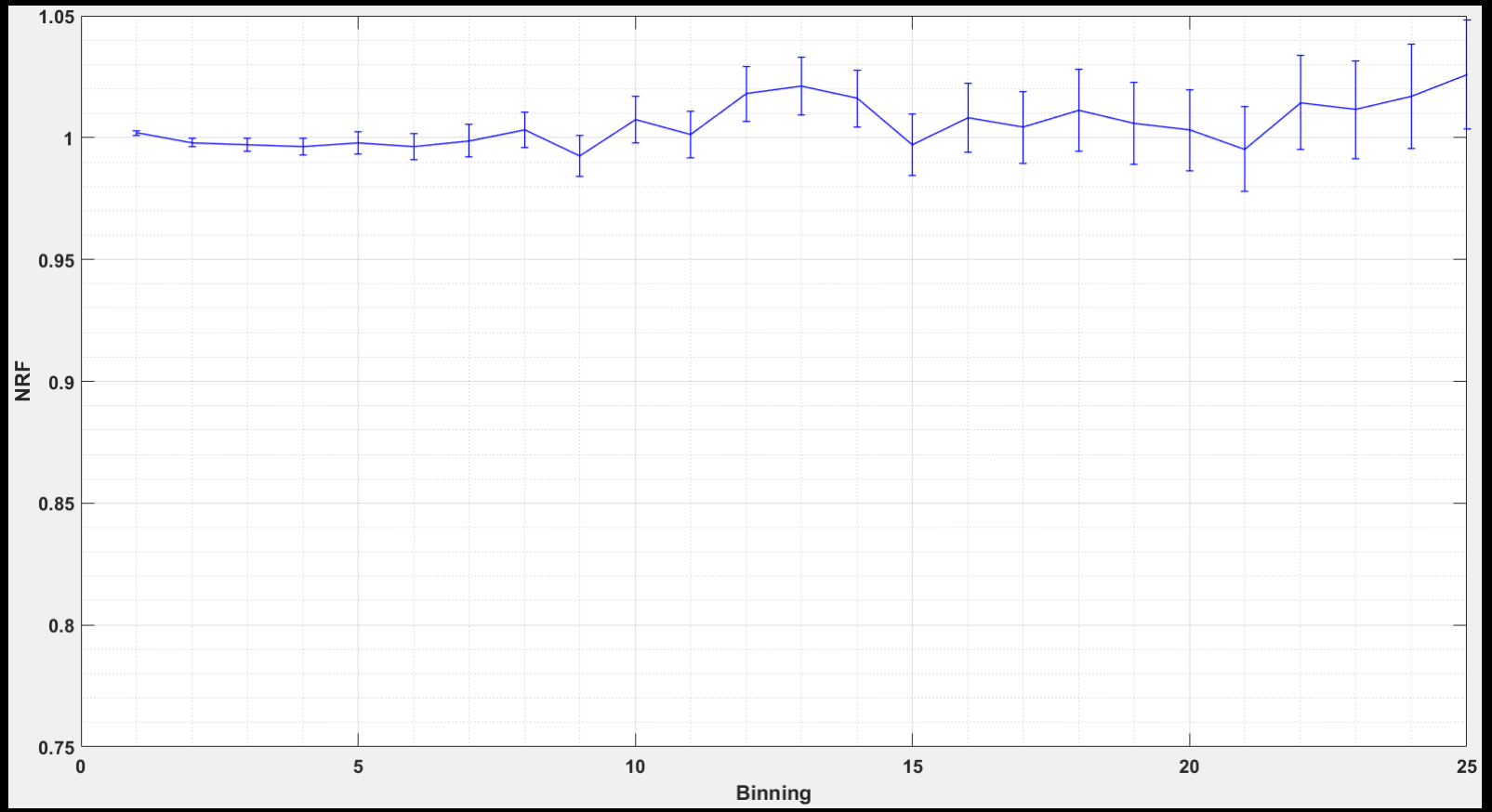
Noise Reduction Factor

> 1 : Super-Poissonian

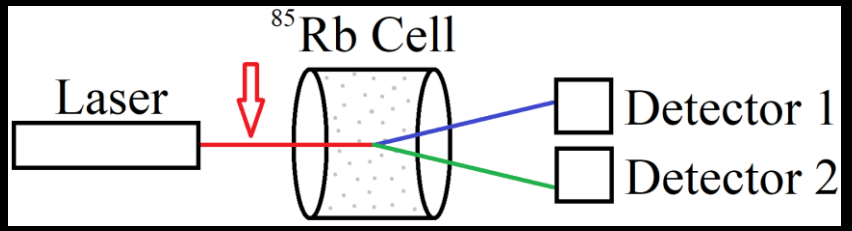
= 1 : Poissonian

< 1 : Sub-Poissonian

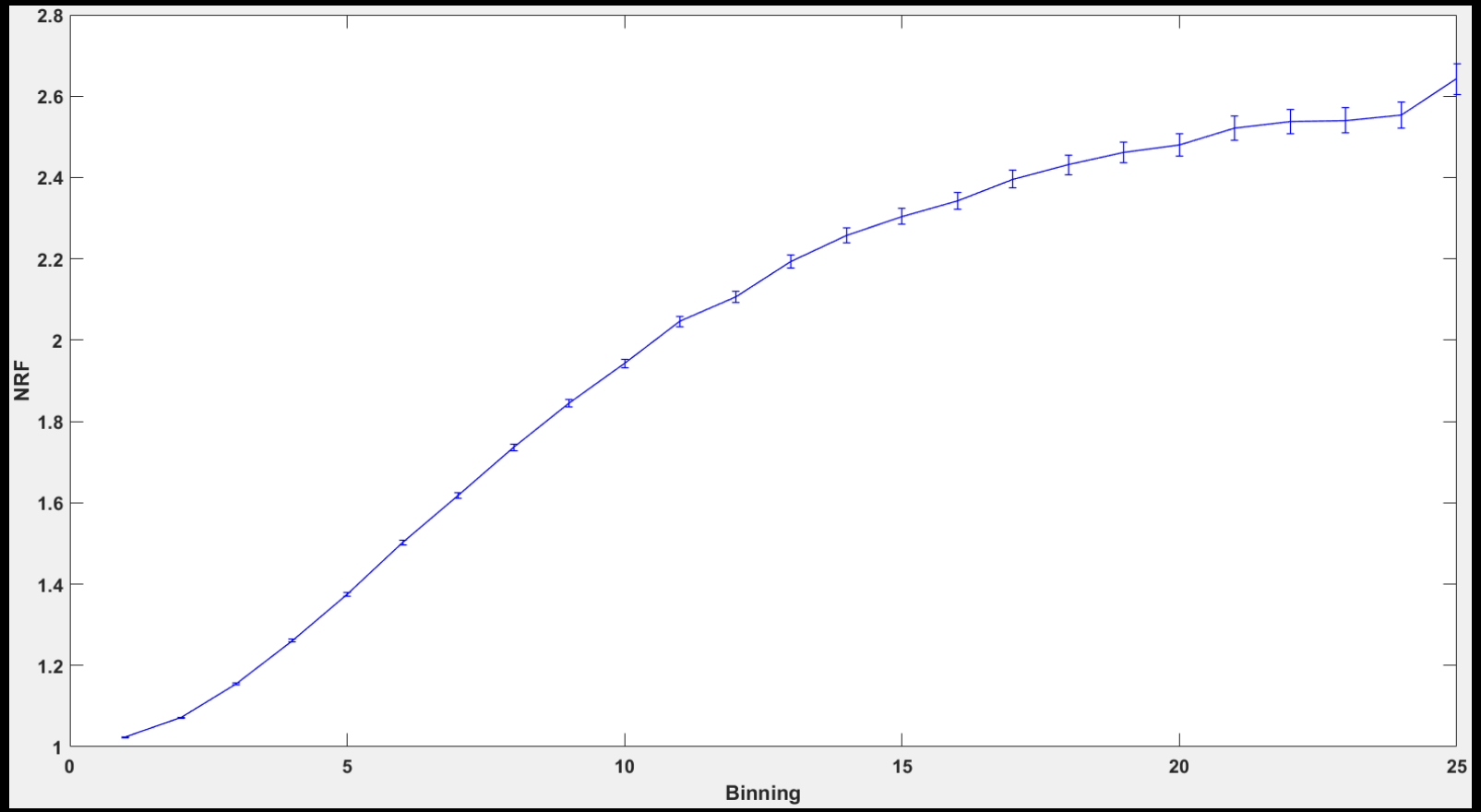
Noise Reduction Factor vs Binning



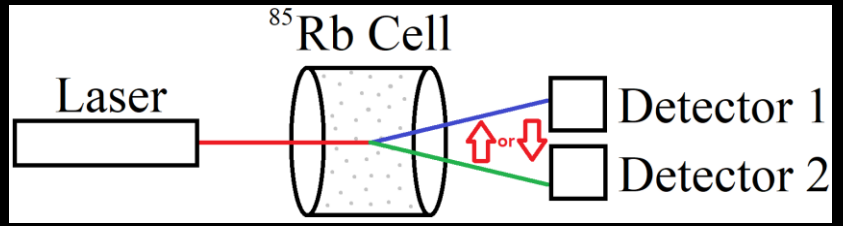
Poissonian



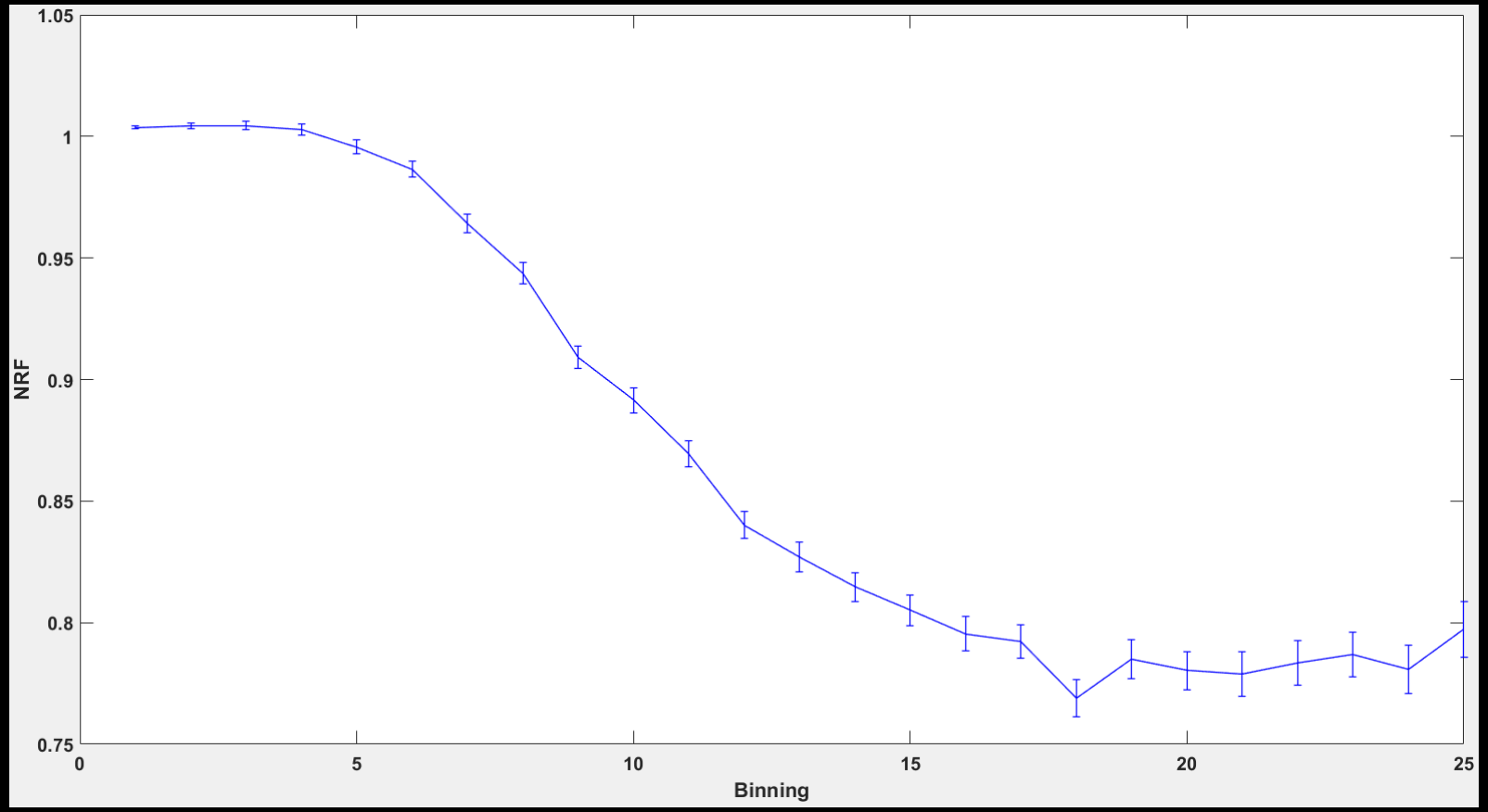
Noise Reduction Factor vs Binning



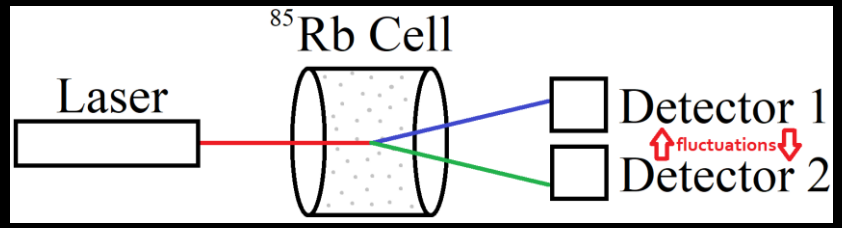
Super-Poissonian



Noise Reduction Factor vs Binning



Sub-Poissonian



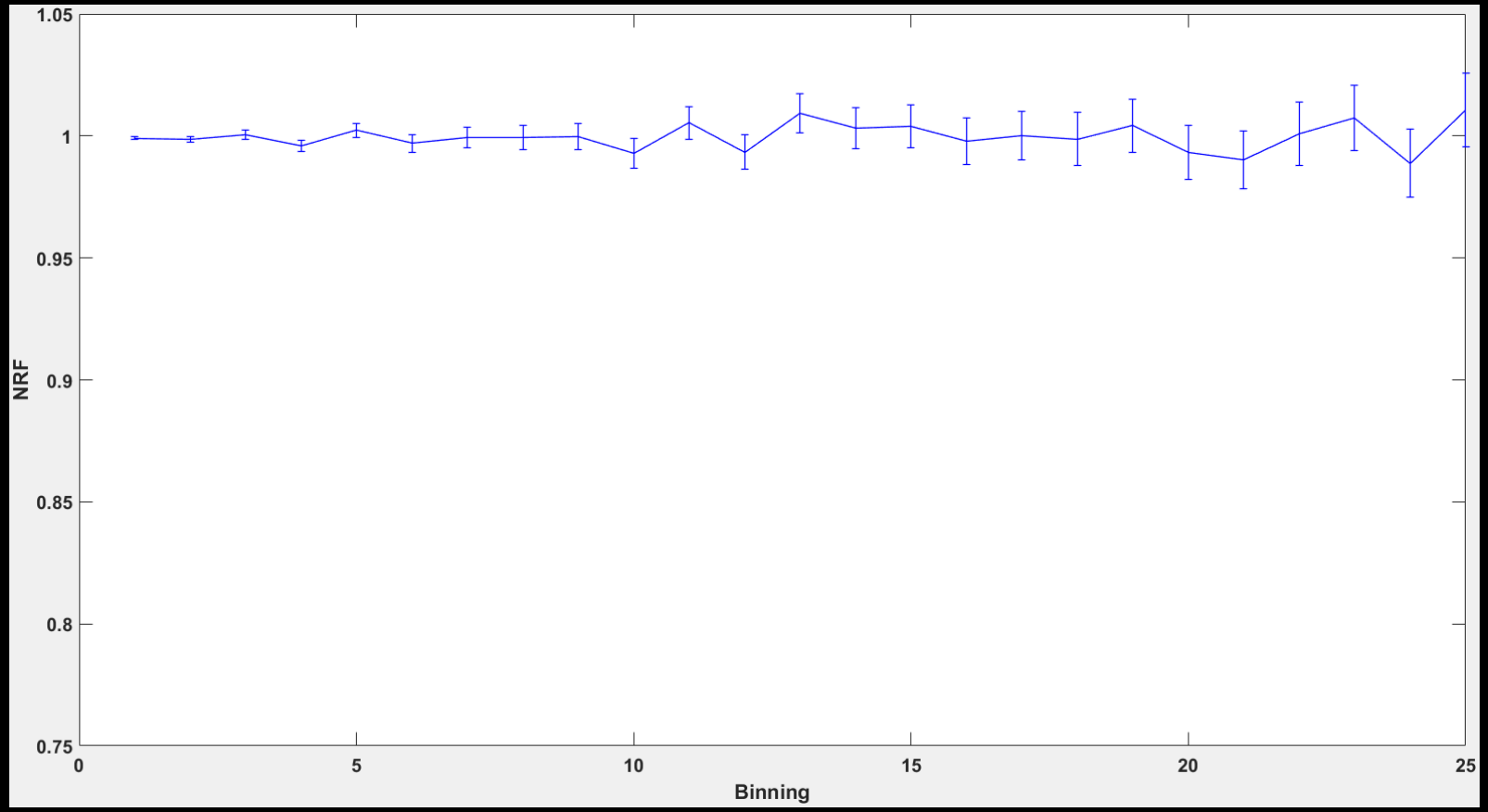
Summarized

- Classification of Light
- Two correlated beams
- Using MATLAB, interpret and correct images
- Subtract one frame from the other
- Binning and Noise Reduction Factor

Next Steps

- Characterizing correlations better
- Pixel-Pixel correspondence by taking into account the cross-correlation function
- Obtain subshot noise reduction

Noise Reduction Factor vs Binning



Poissonian

QUESTIONS