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# NMSBA Seismic Imagery: Tribulations & Current Progress

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# Overview

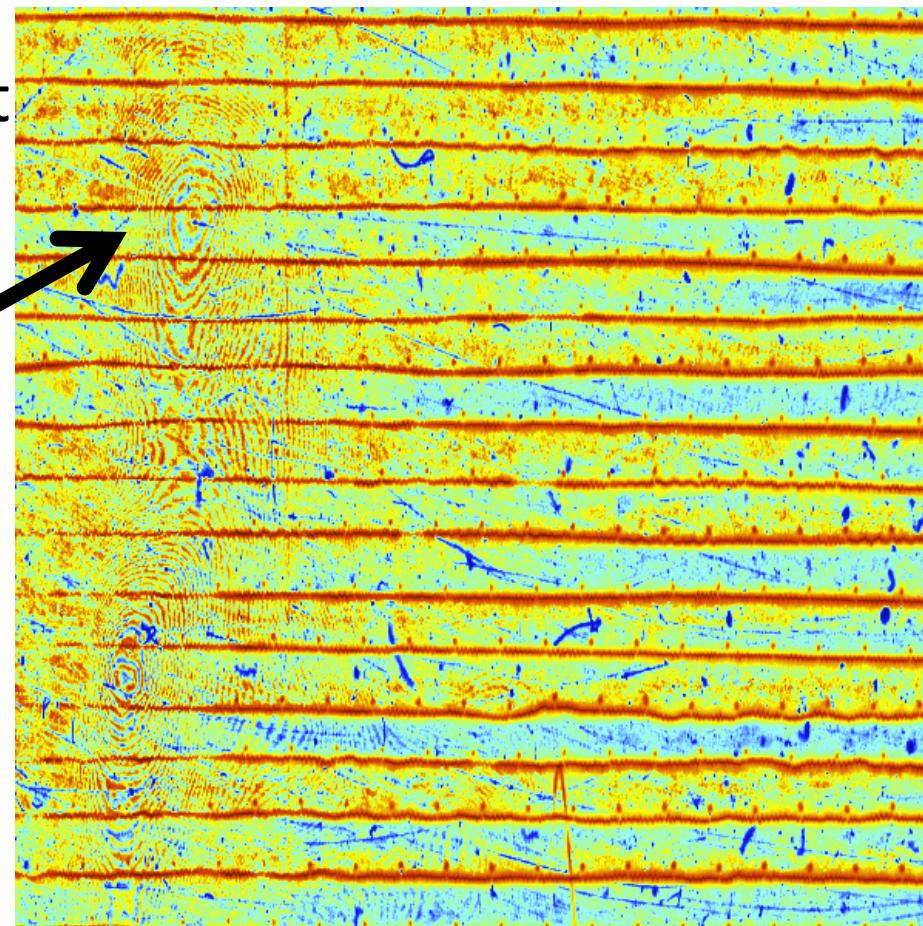
- Obvious issues
- Image timing mark results
- Proposed trace enhancement methods
- Future work and Conclusions
- Background Information

# Issues with Seismic Imagery

- Noise (Newton Rings)
- Scratches
- Timing Marks
- Uneven contrast / blotches
- Dimming Traces as activity increases
- Information Boxes / “dog tags” / Border

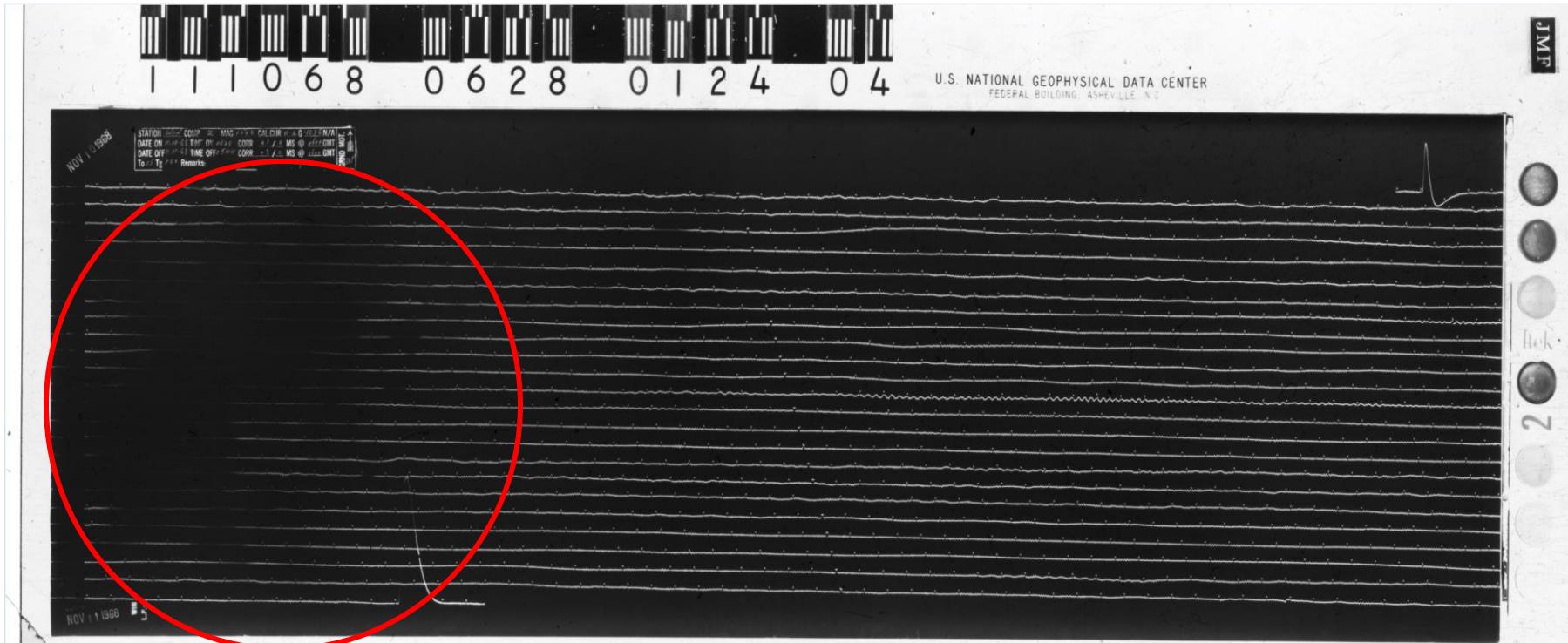
# Noise and Scratches

- Noise adds layer of complexity to trace detection algorithms. (Speckle)
- Scratches sometimes cut through traces
- Newton rings disrupt traces as well



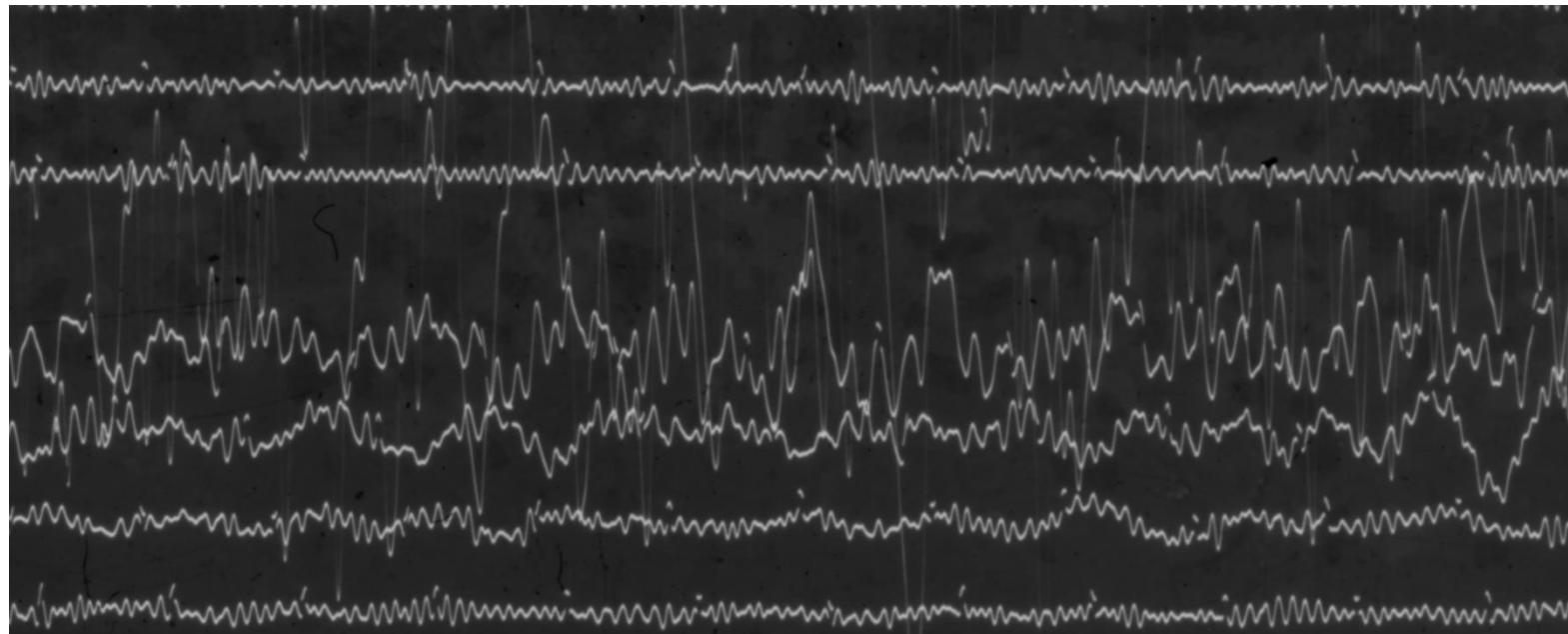
# Uneven Contrast

- Blotchy areas create uneven contrast
- Global thresholding is unreasonable



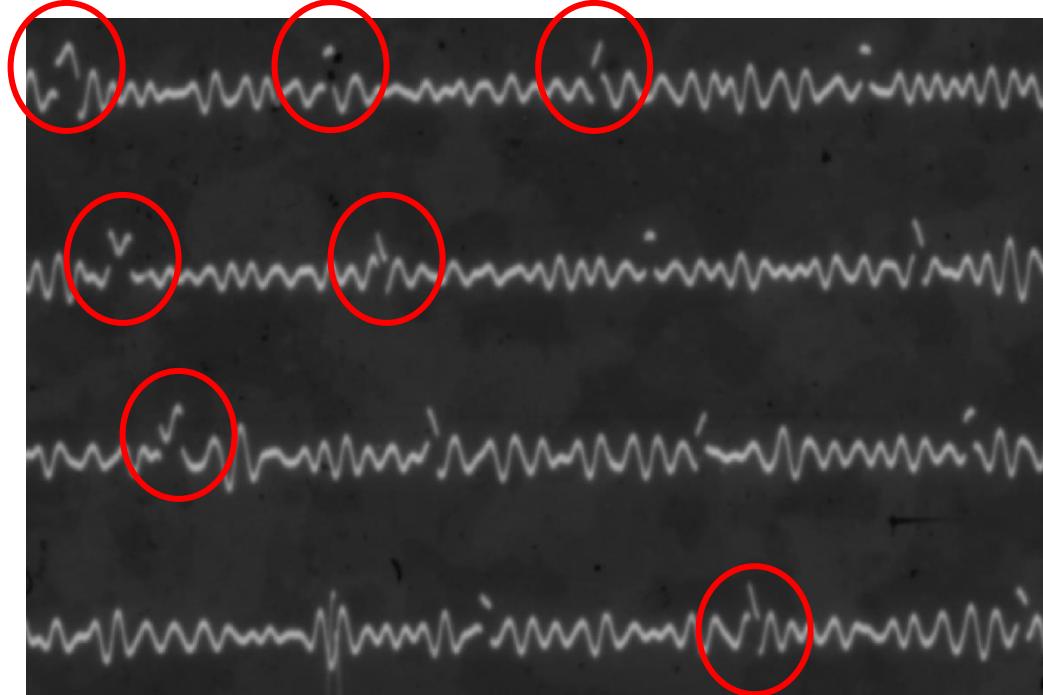
# Dim/Faint Traces

- Increasing activity results in dimmer traces.
- Proportional to trace slope



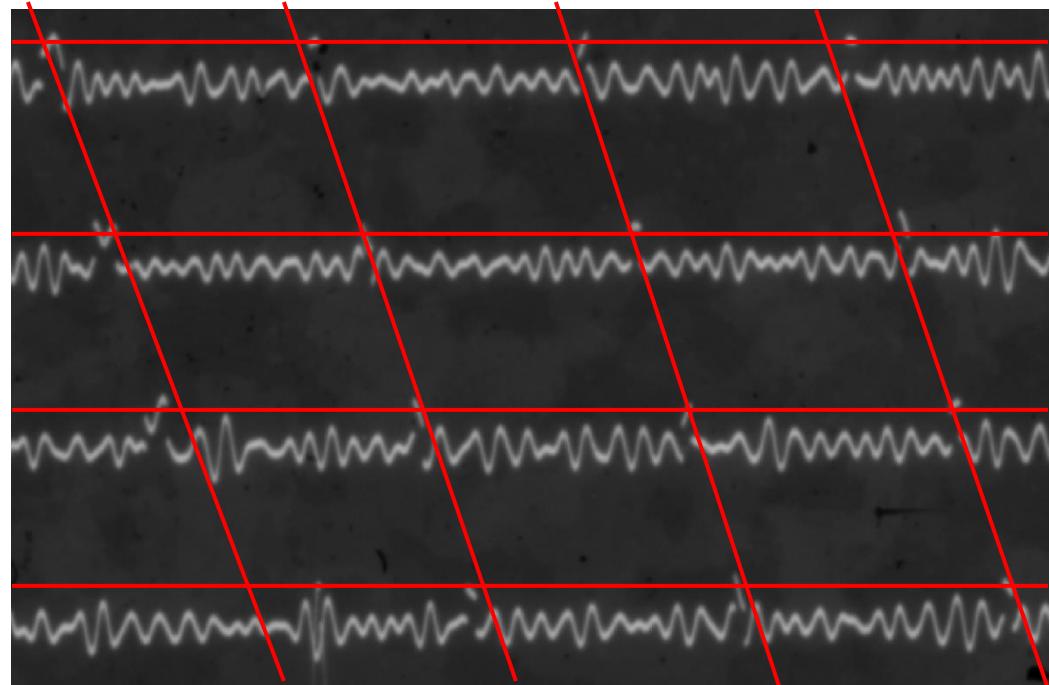
# Timing Marks

- Every set amount of time, markings are offsetted by a certain amount.
- They provide timing data as well as signal data



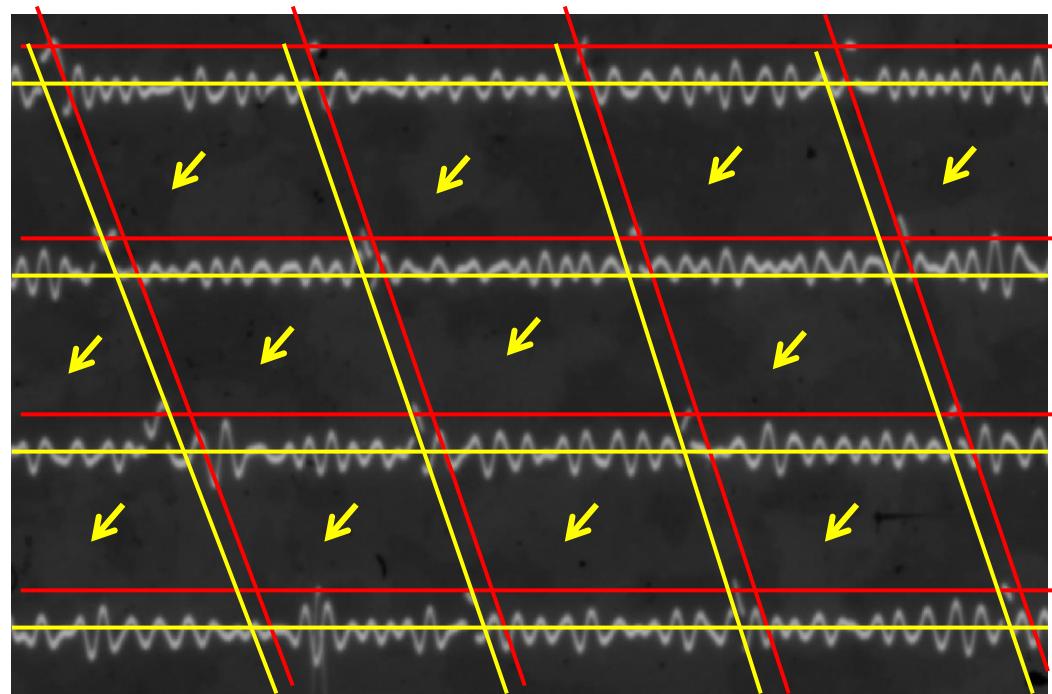
# Timing Marks

- Usually in a fairly uniform “lattice”



# Timing Marks

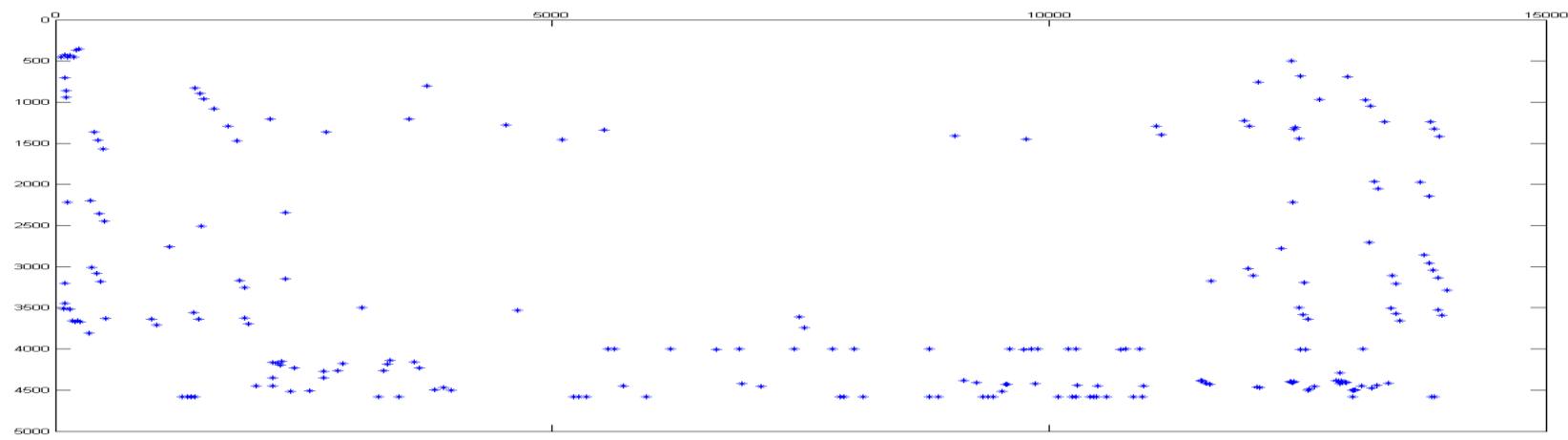
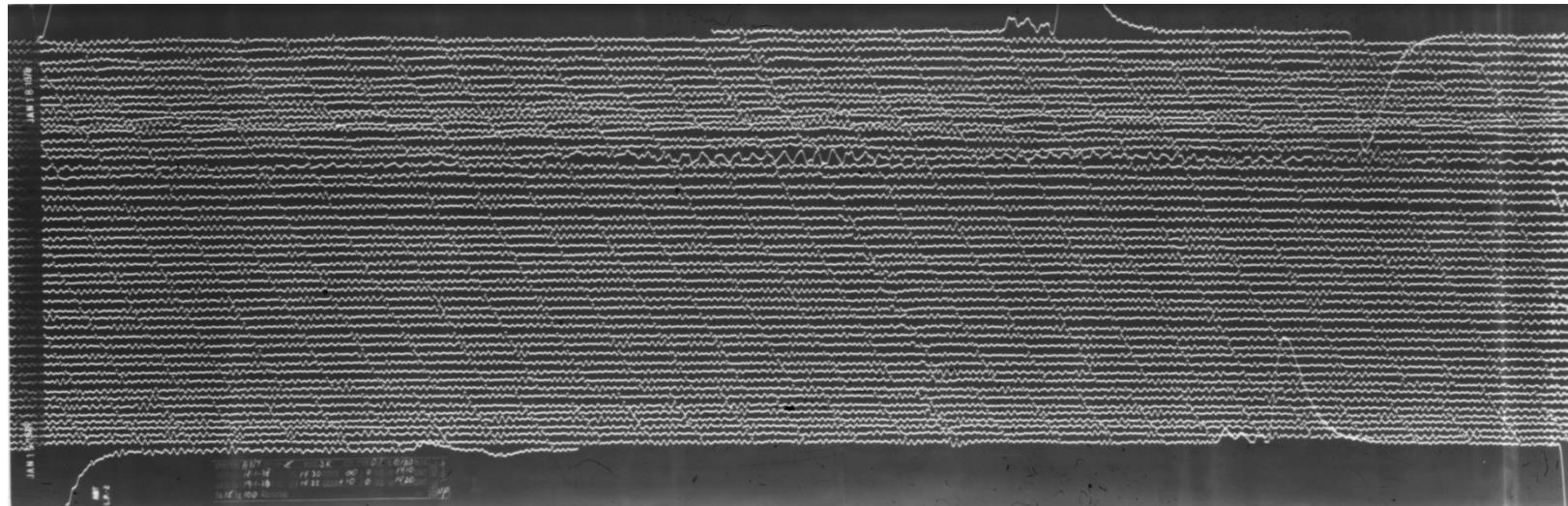
- Usually in a fairly uniform “lattice”
- Original thoughts were to model the lattice and extrapolate where unknown timing marks were based off of Known timing marks
- Then Shift the lattice down into rightful position



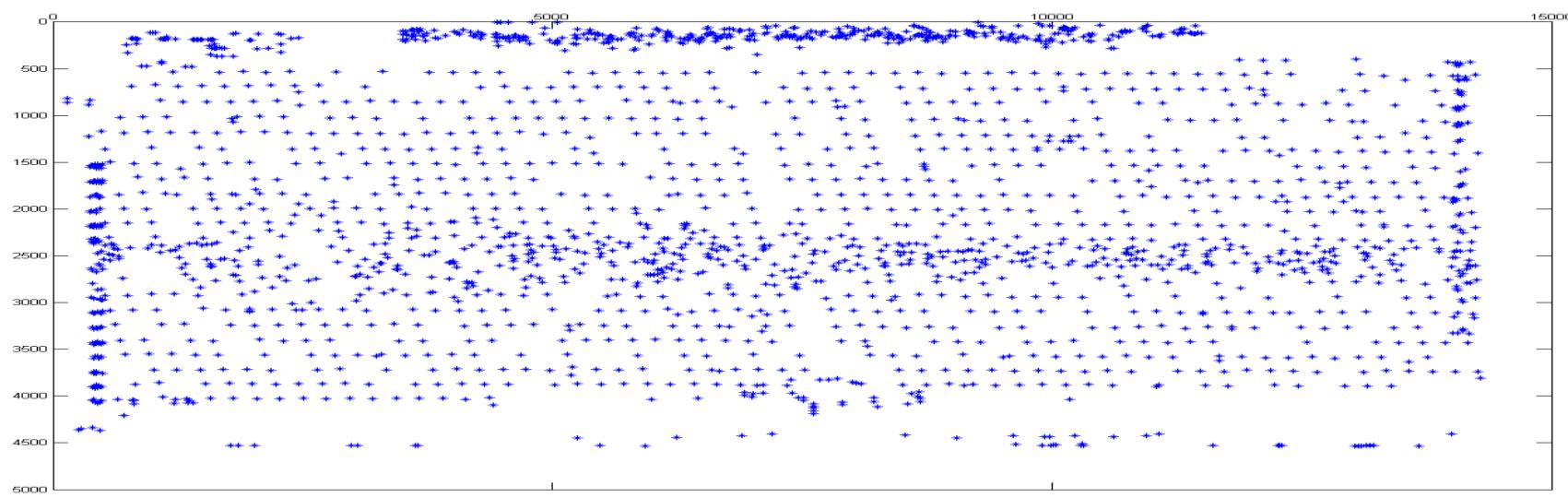
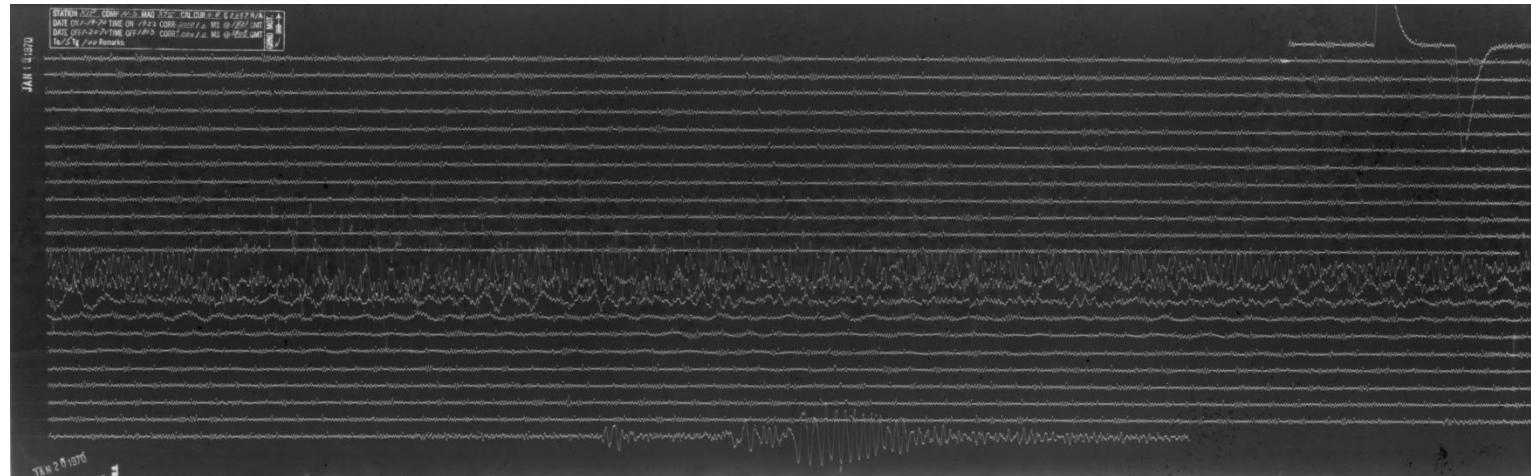
# Timing Mark Detection Algorithm

1. Cropping of the unimportant information (at this point in time) [\[4\]](#)
2. Bilateral filtering to reduce noise in the signal and bring out trace edges. (Worked better for noise reduction than detail enhancement) [\[1\]](#) [\[2\]](#)
3. Local binary conversion using block processing with Otsu's method. (Local adaptive methods work better than global) [\[3\]](#) [\[5\]](#)
4. Obtain binary clusters/connected components [\[6\]](#)
5. Using current threshold of [50, 150] pixels gets a “good” amount of timing marks in each image.
6. Find centroids of timing mark binary blotches

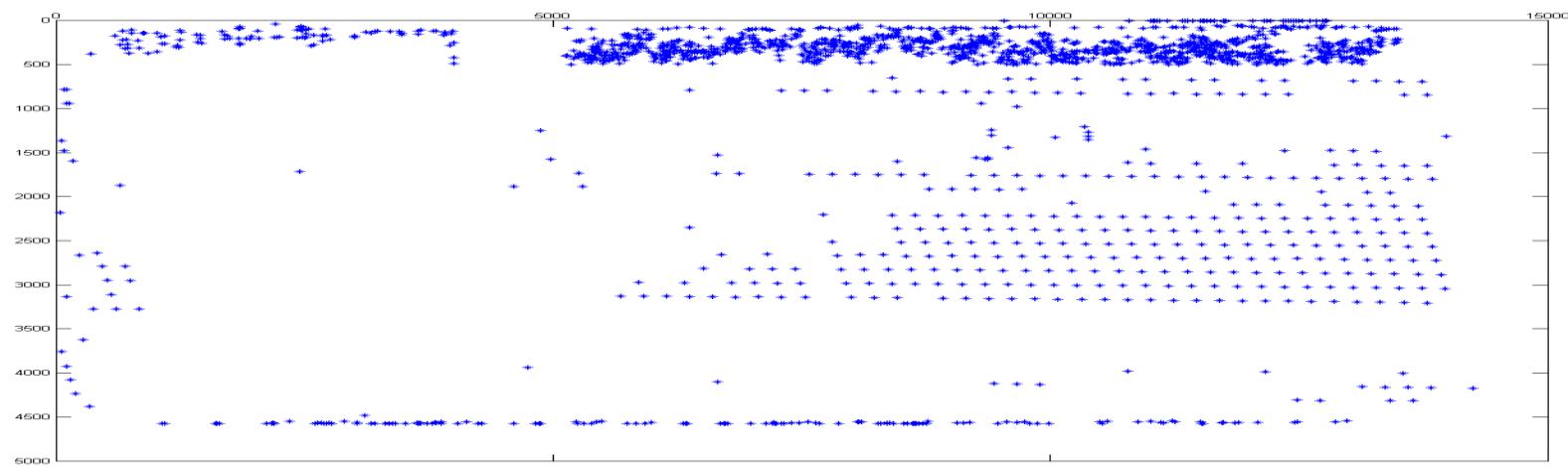
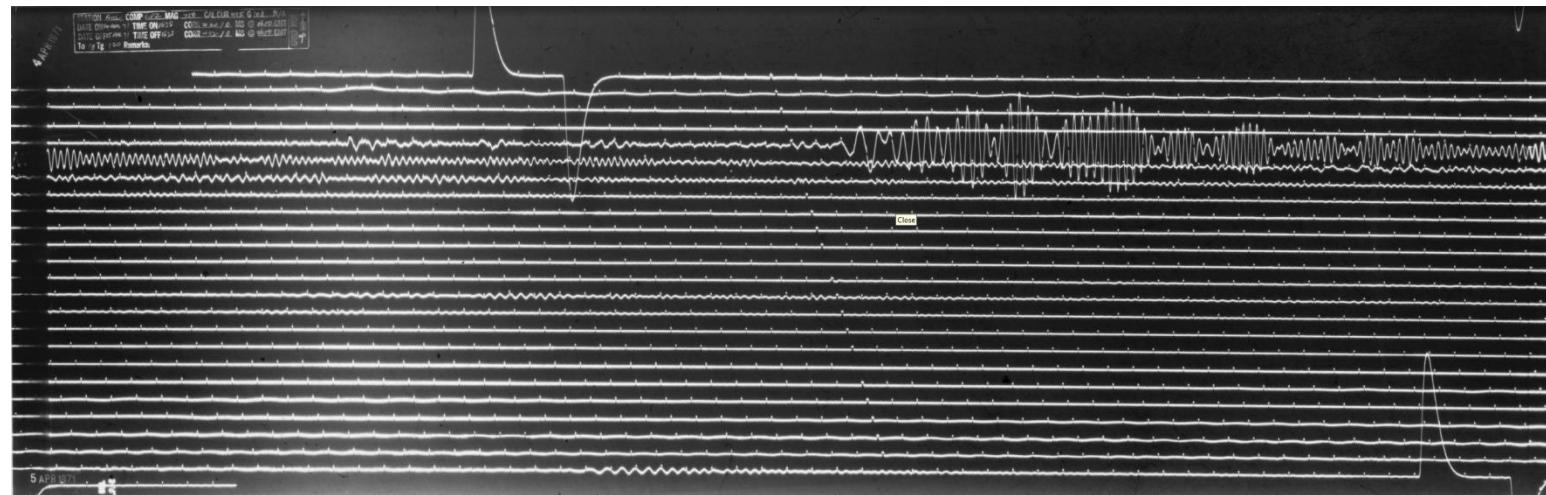
# Results 1 of 7



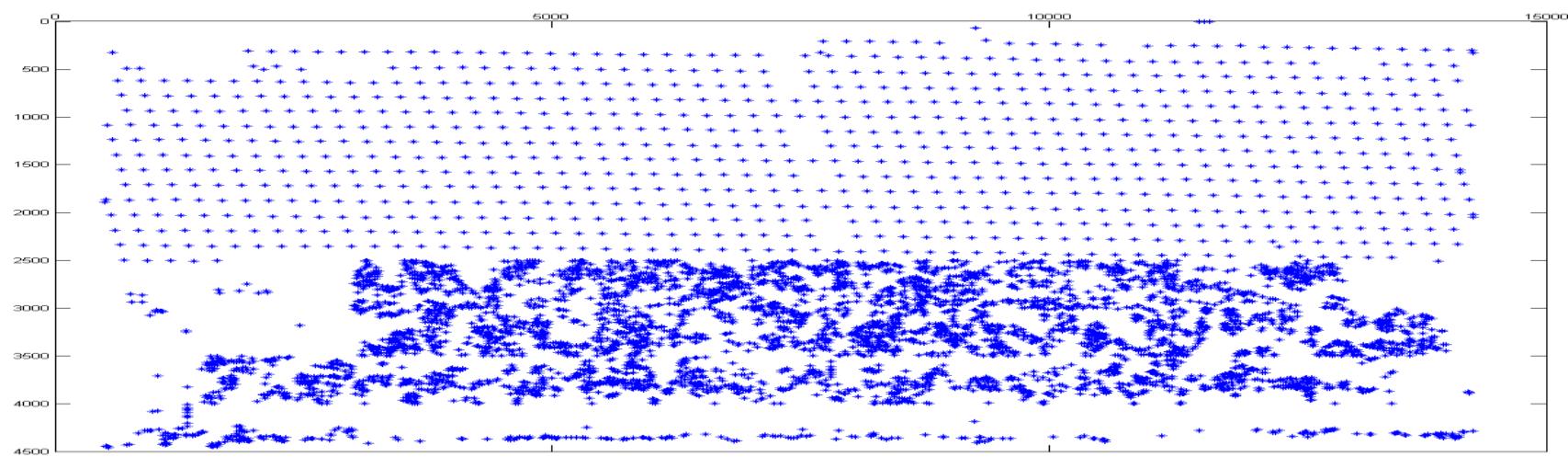
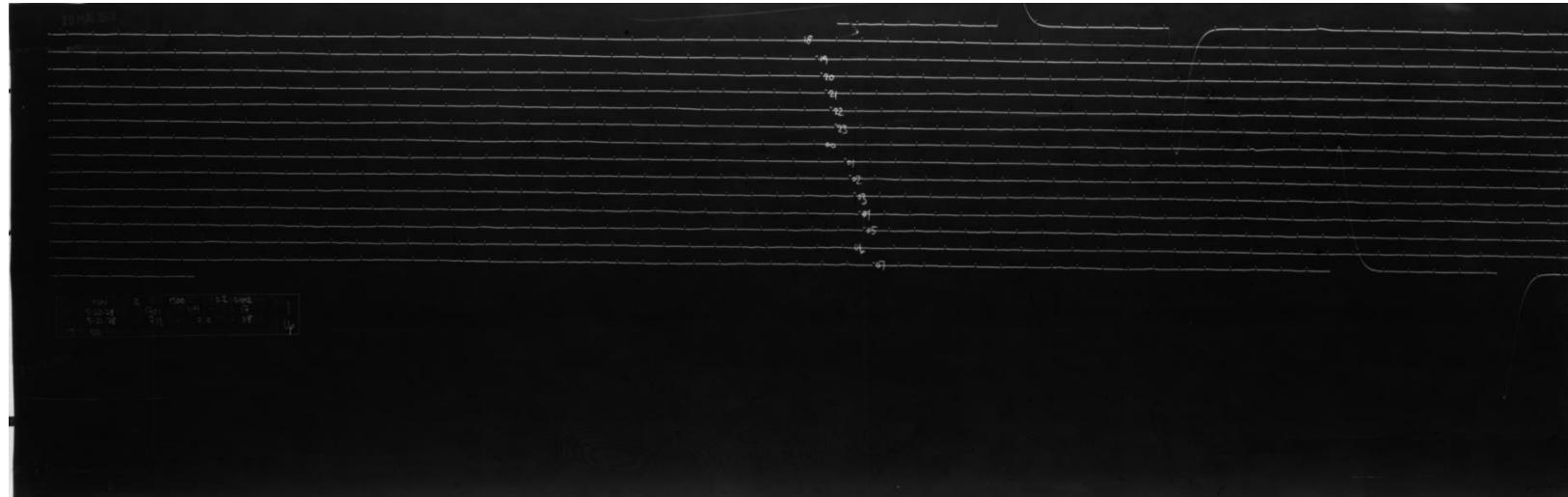
## Results 2 of 7



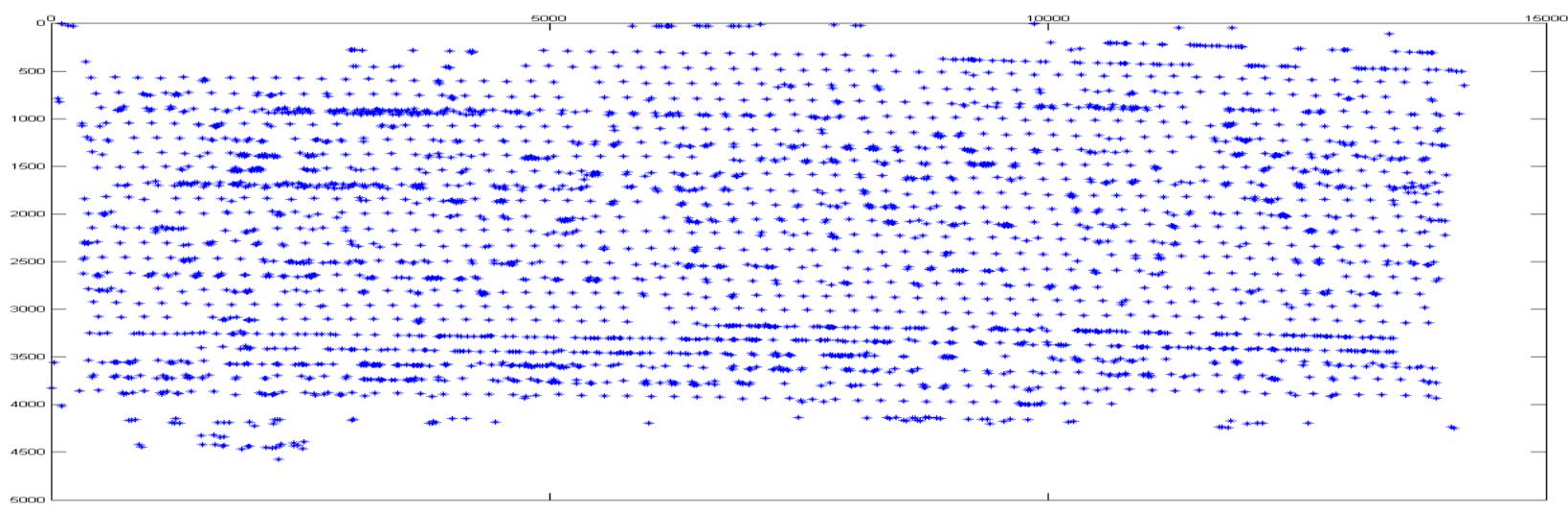
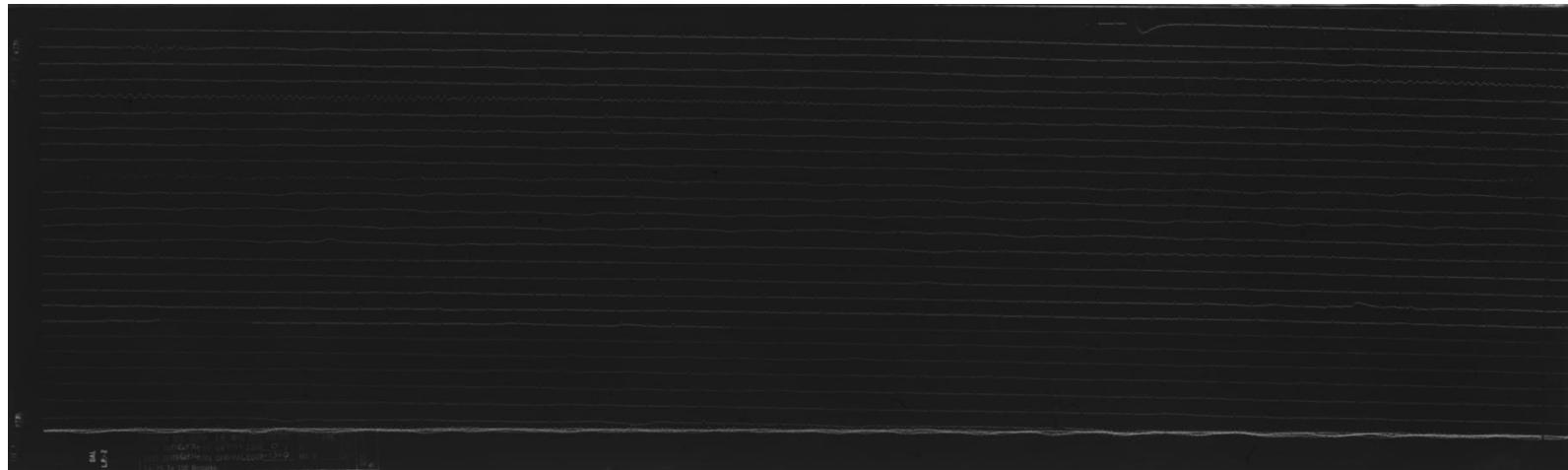
## Results 3 of 7



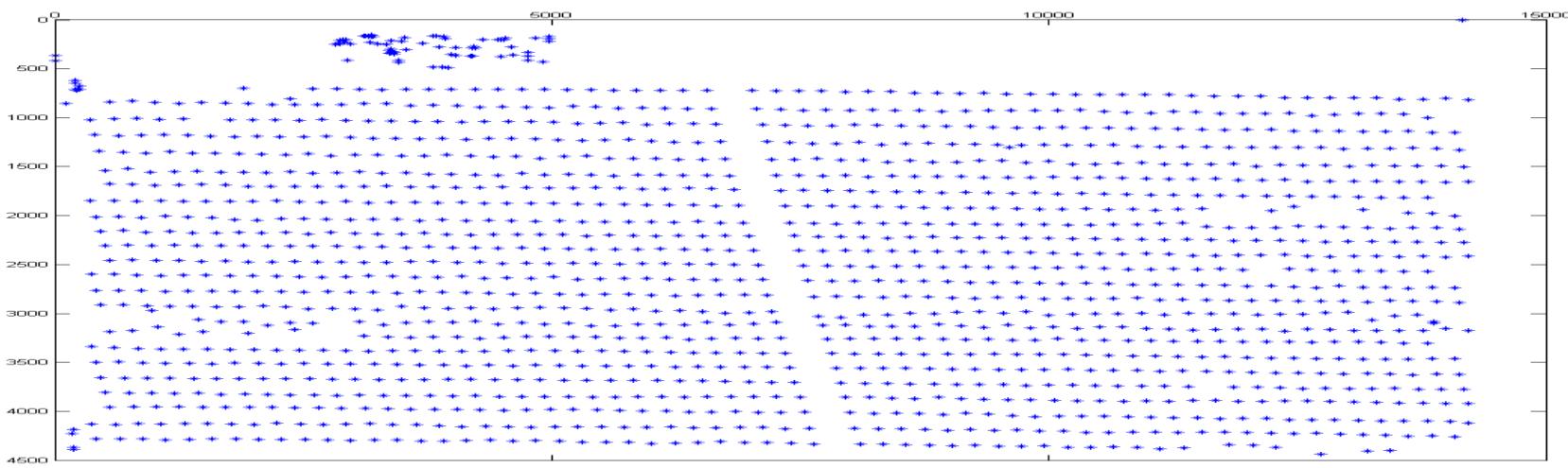
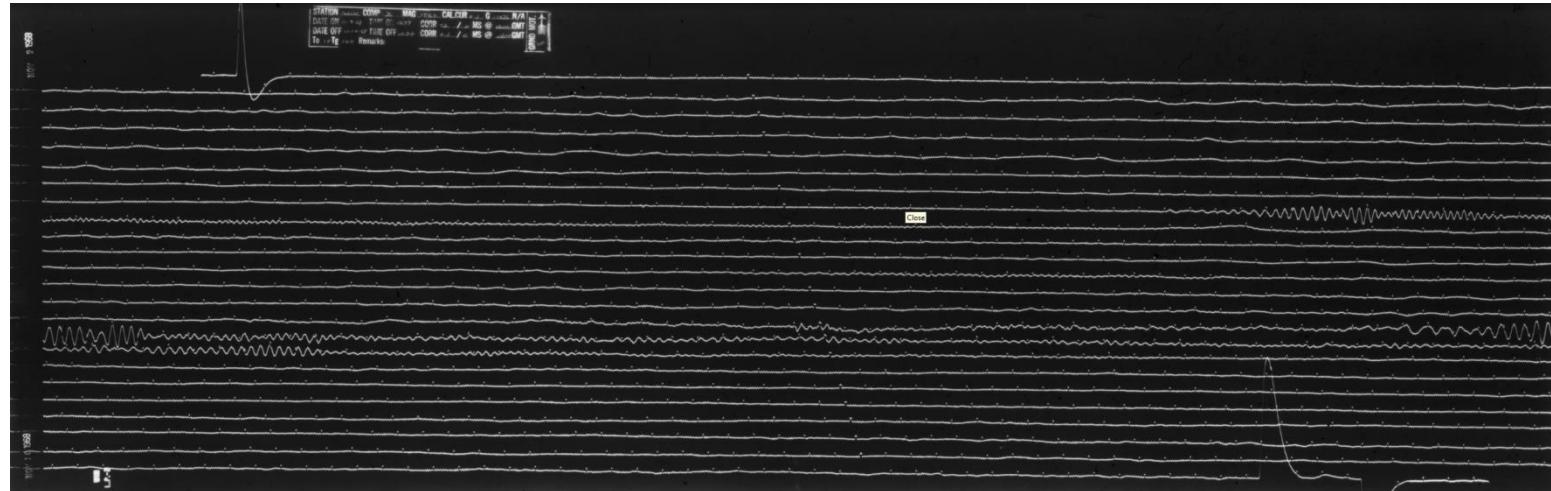
# Results 4 of 7



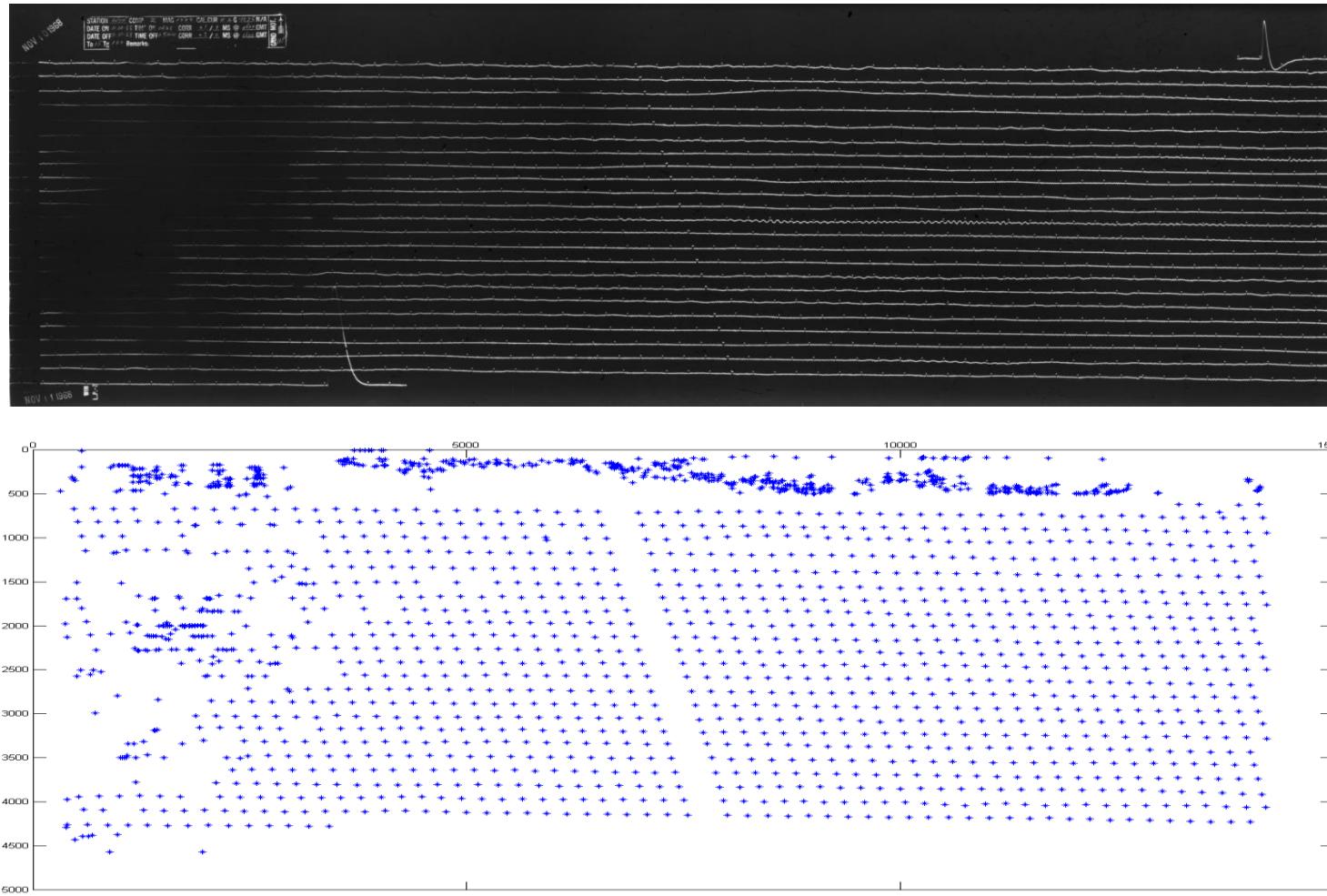
# Results 5 of 7



# Results 6 of 7



# Results 7 of 7

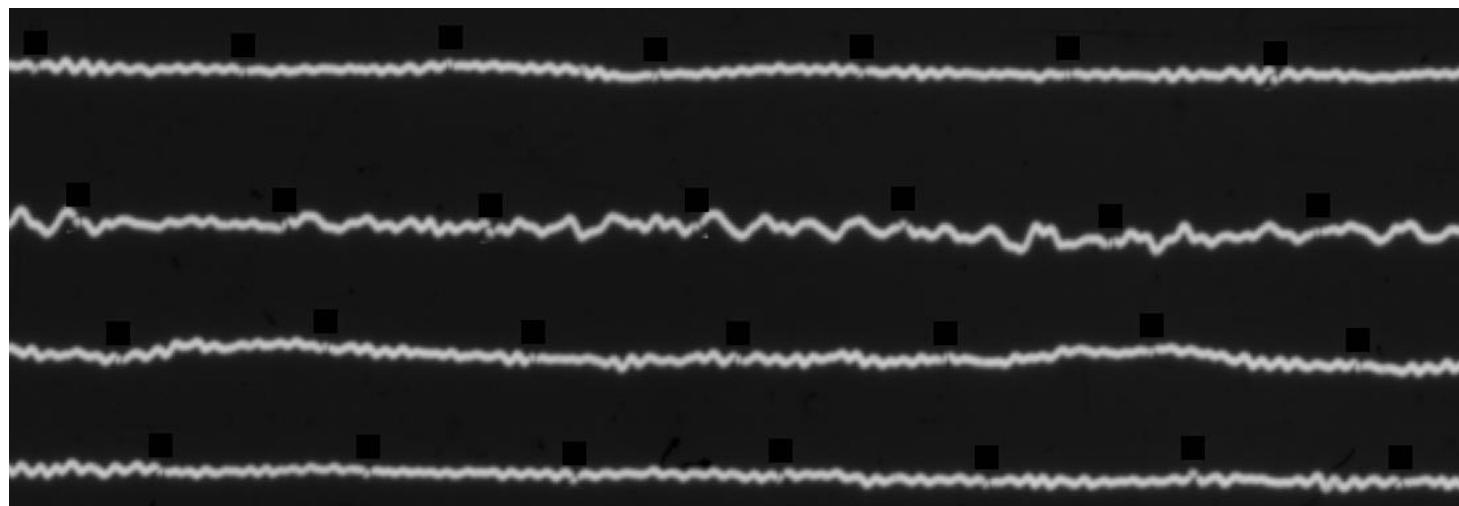
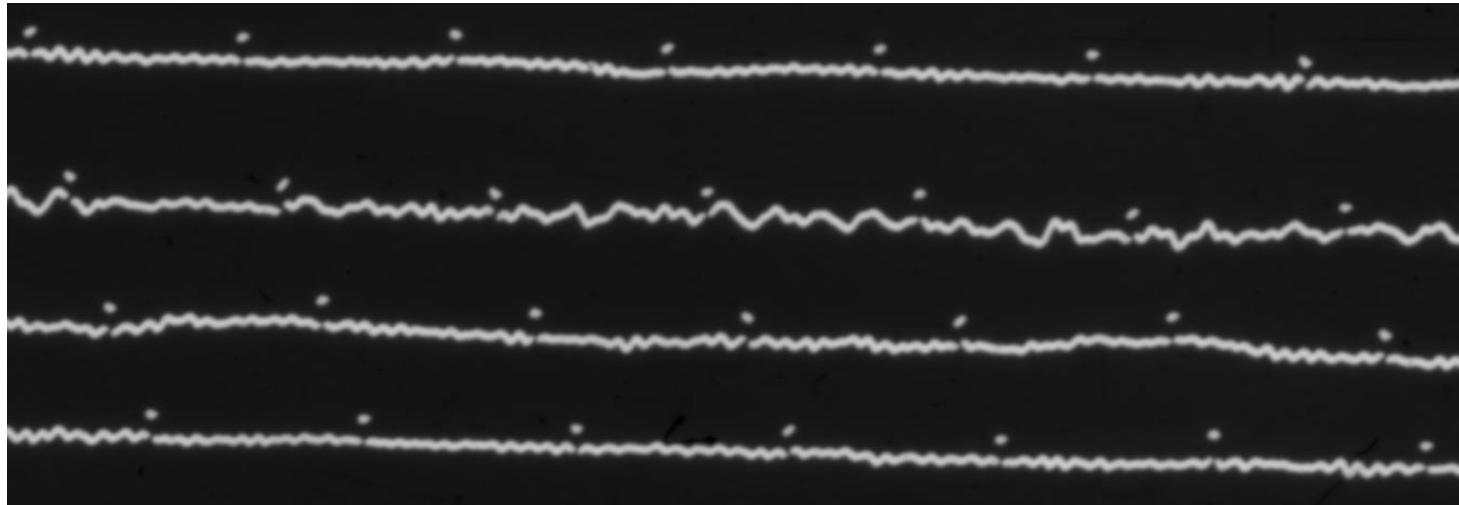


# “Chip” and Translate Method



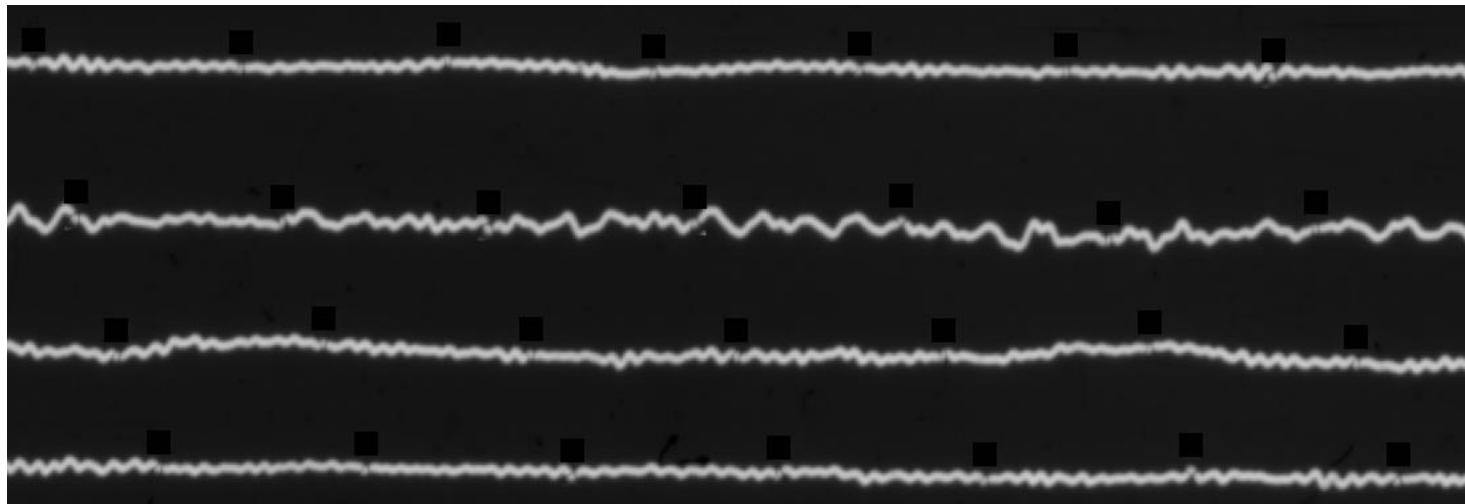
- “Chip” out the detected timing marks and translate the chip by an offset
- Offset is currently -35 pixels vertically
- For fused image, take maximum between chip and original signal being overlayed

# “Chip” and Translate Results



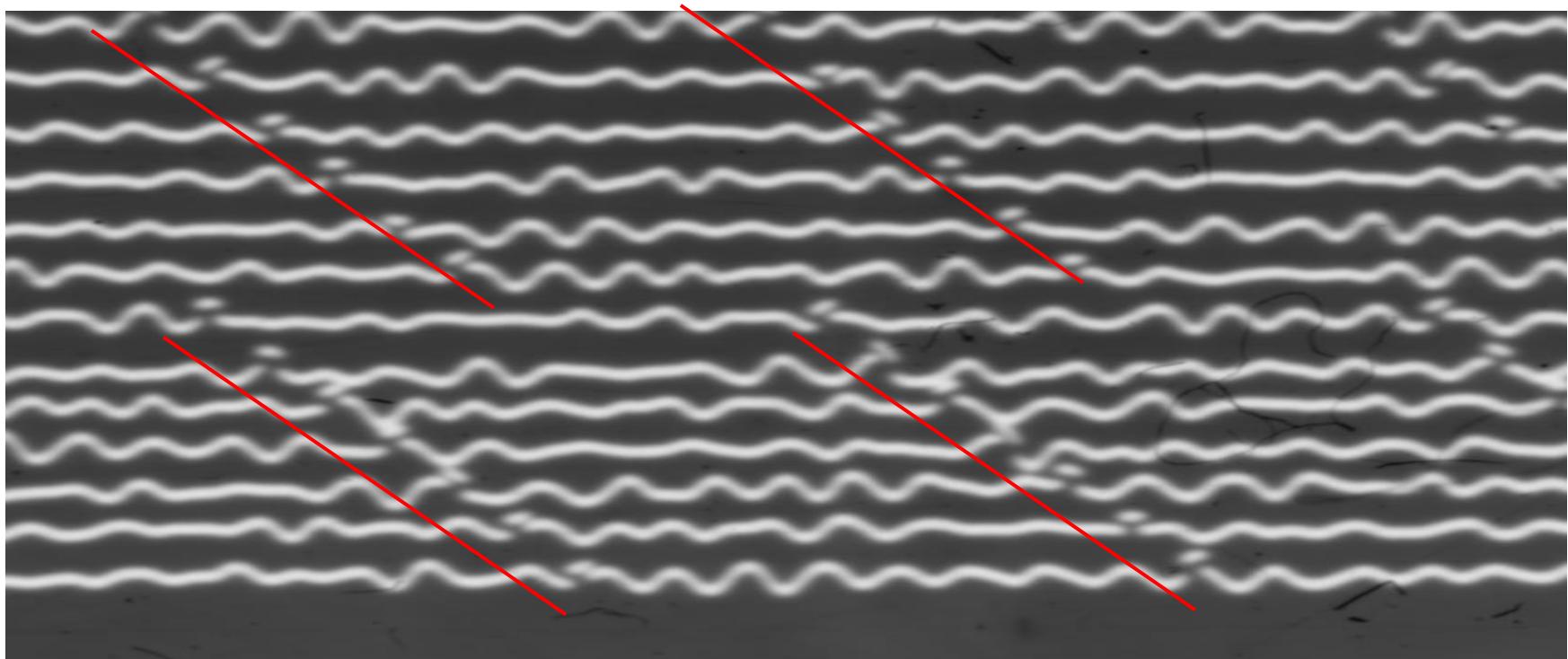
# “Chip” and Translate Results

- Works well where timing mark detection works well.
- Mixes well with original signal.
- **\*\*Idea\*\*** dilate and erode to find areas where signals are missing, then do an adaptive local translation per each timing mark for better results.



# Current Issue with “Lattice” translation method

- Offset lattices ([Image 1](#))



# Current Problems with “Lattice” translation method

- As activity increases, timing offset gets thrown forward or backward in time. ([Image 3](#)) [ratio between activity and timing mark time offset]
- Negative slope = negative in time
- Positive slope = positive in time



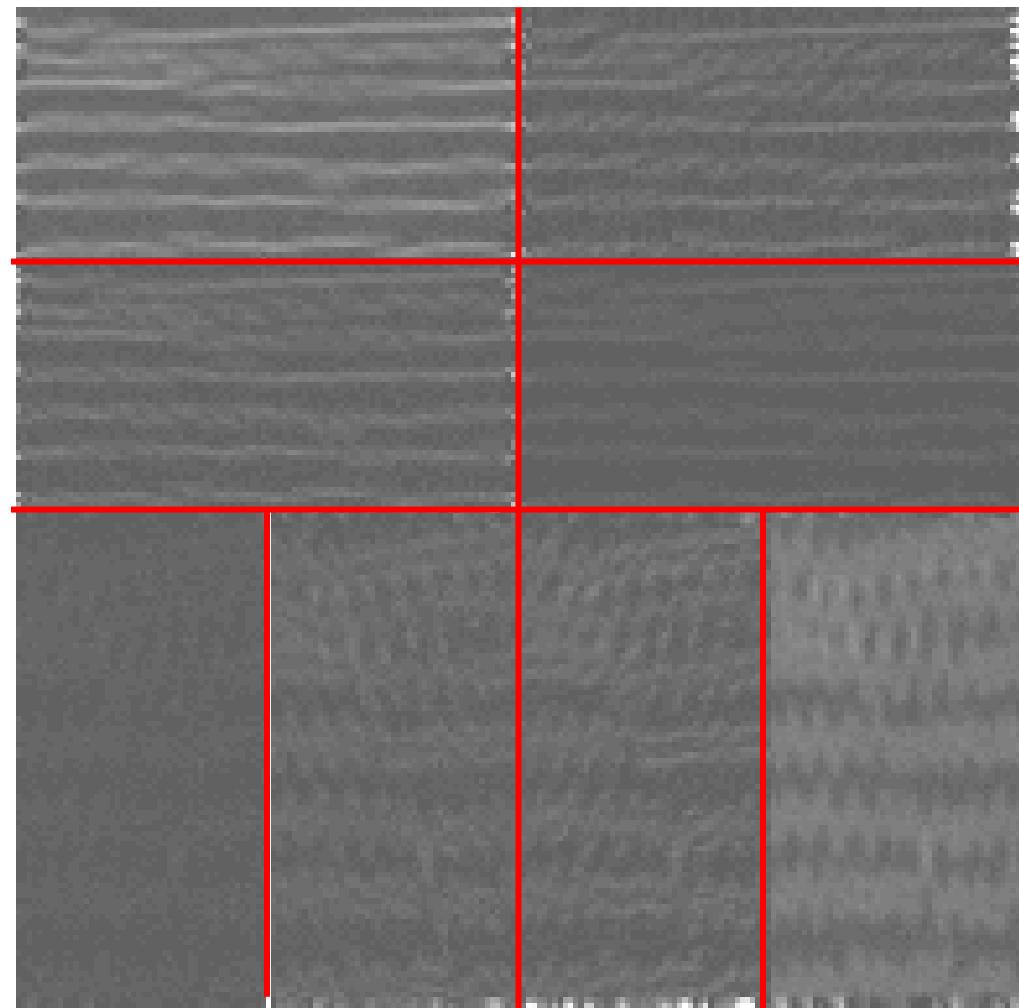
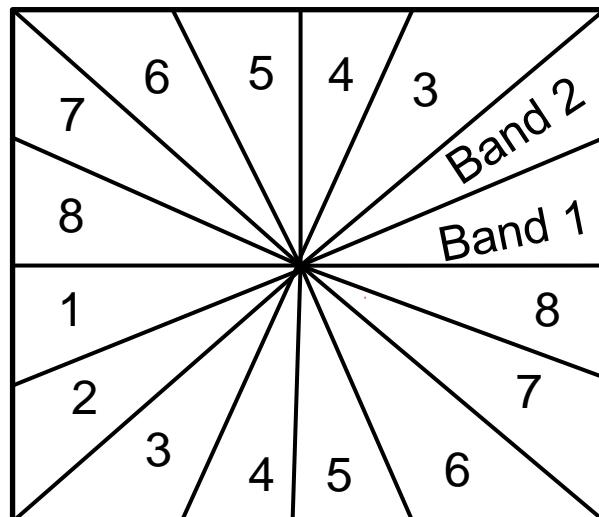
# Trace Enhancement with Contourlets



- Contourlet transform is a directional Multiresolution Image Representation [\[9\]](#) [\[10\]](#) [\[11\]](#) [\[13\]](#)
- Takes original Image and breaks up into  $2^n$  directional sub bands
- Noise level drops in sub bands by a factor of  $2^n$

# Contourlet Decomposition

- Bands in frequency domain relate to linear oriented features in spacial domain by 90°



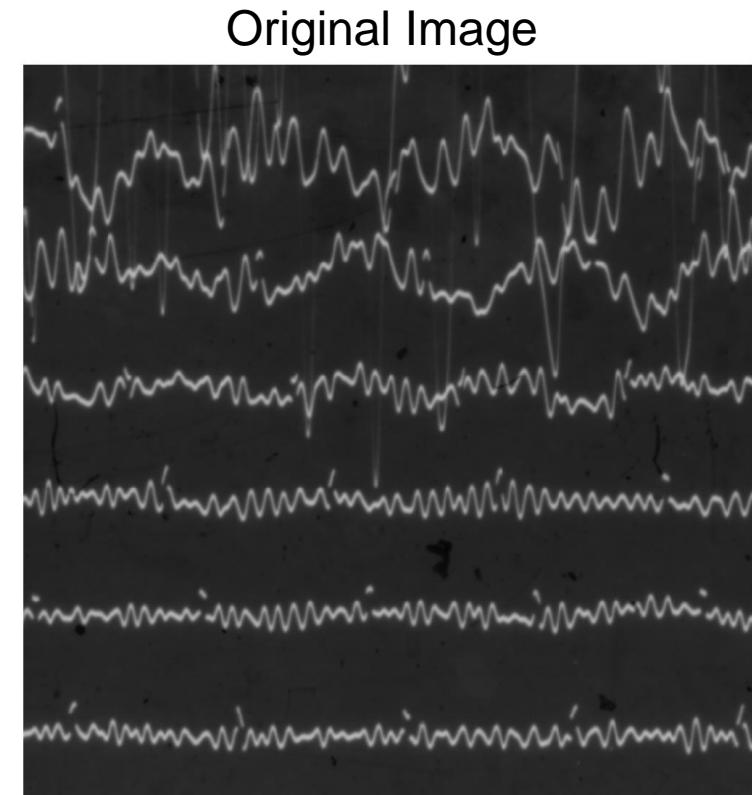
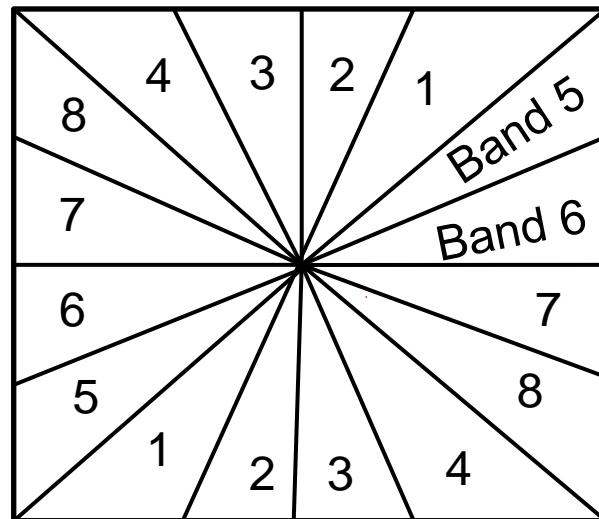
# Problems with Countourlet Transform

- Aliasing effects in the directional sub bands.
- Decreased resolution due to down sampling and decimation
- Non-uniform resolution across sub band images
- But...

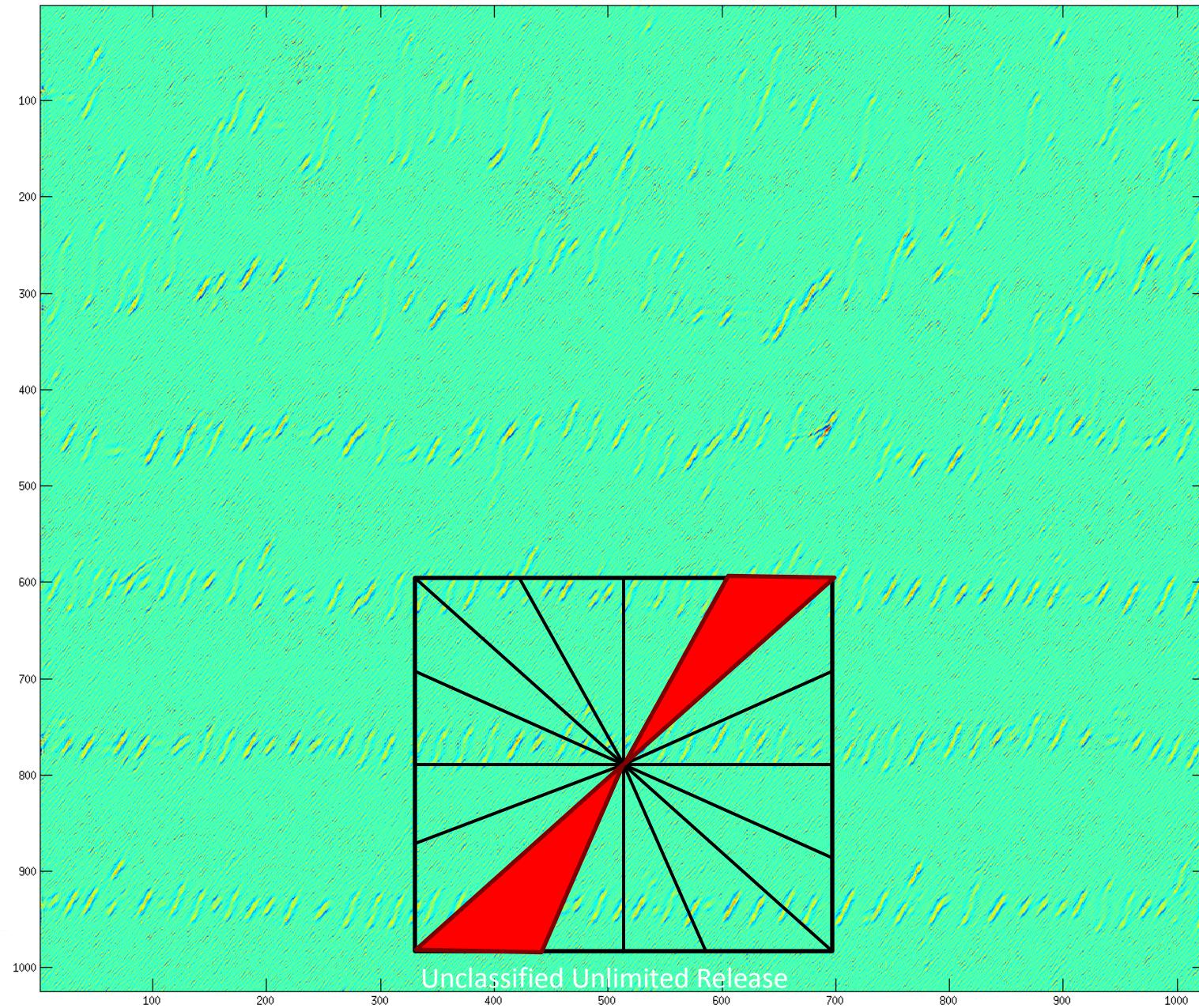
# Non-Subsampled Contourlet

## Decomposition

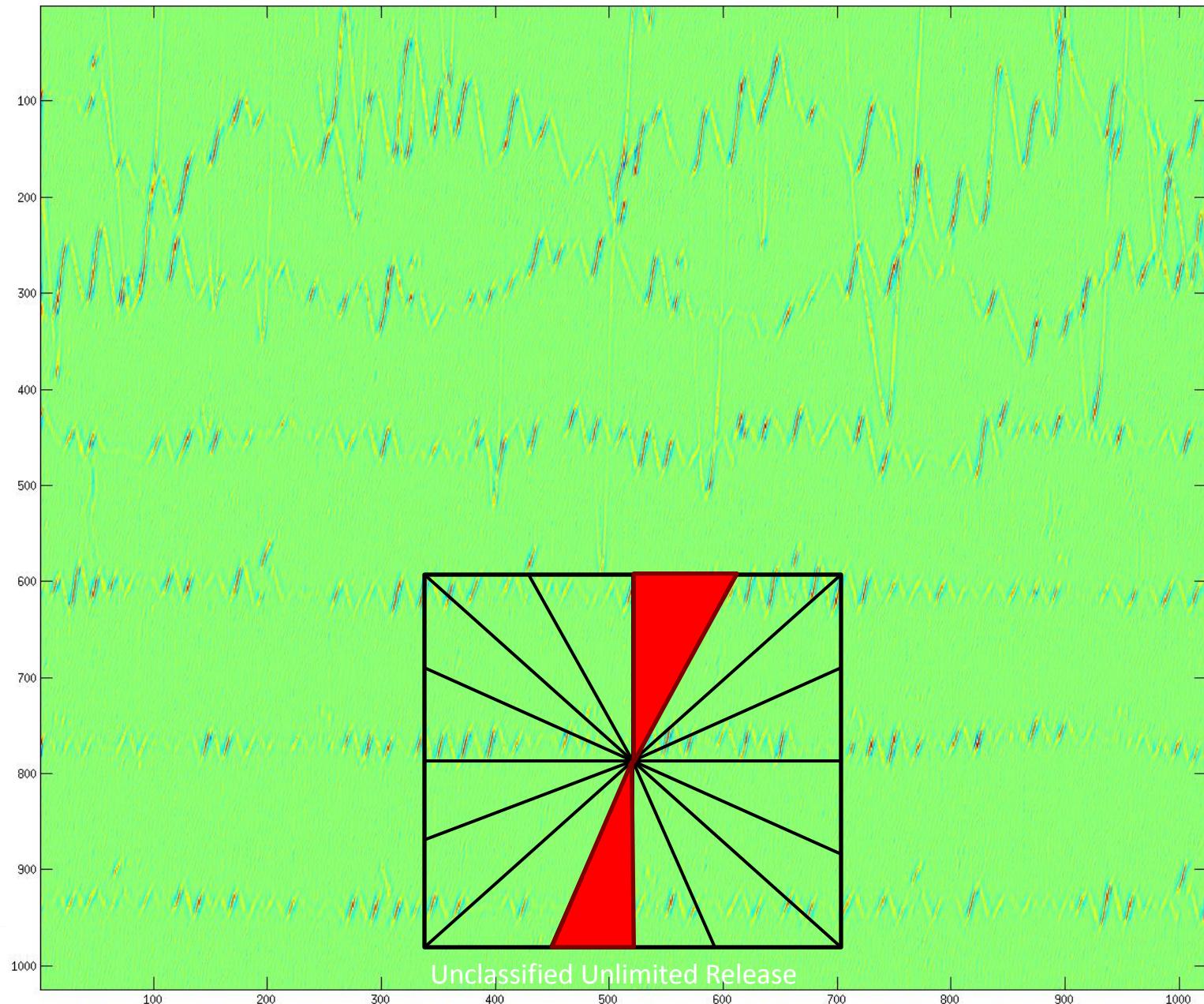
- No aliasing, sub bands are full resolution. [\[12\]](#) [\[14\]](#)



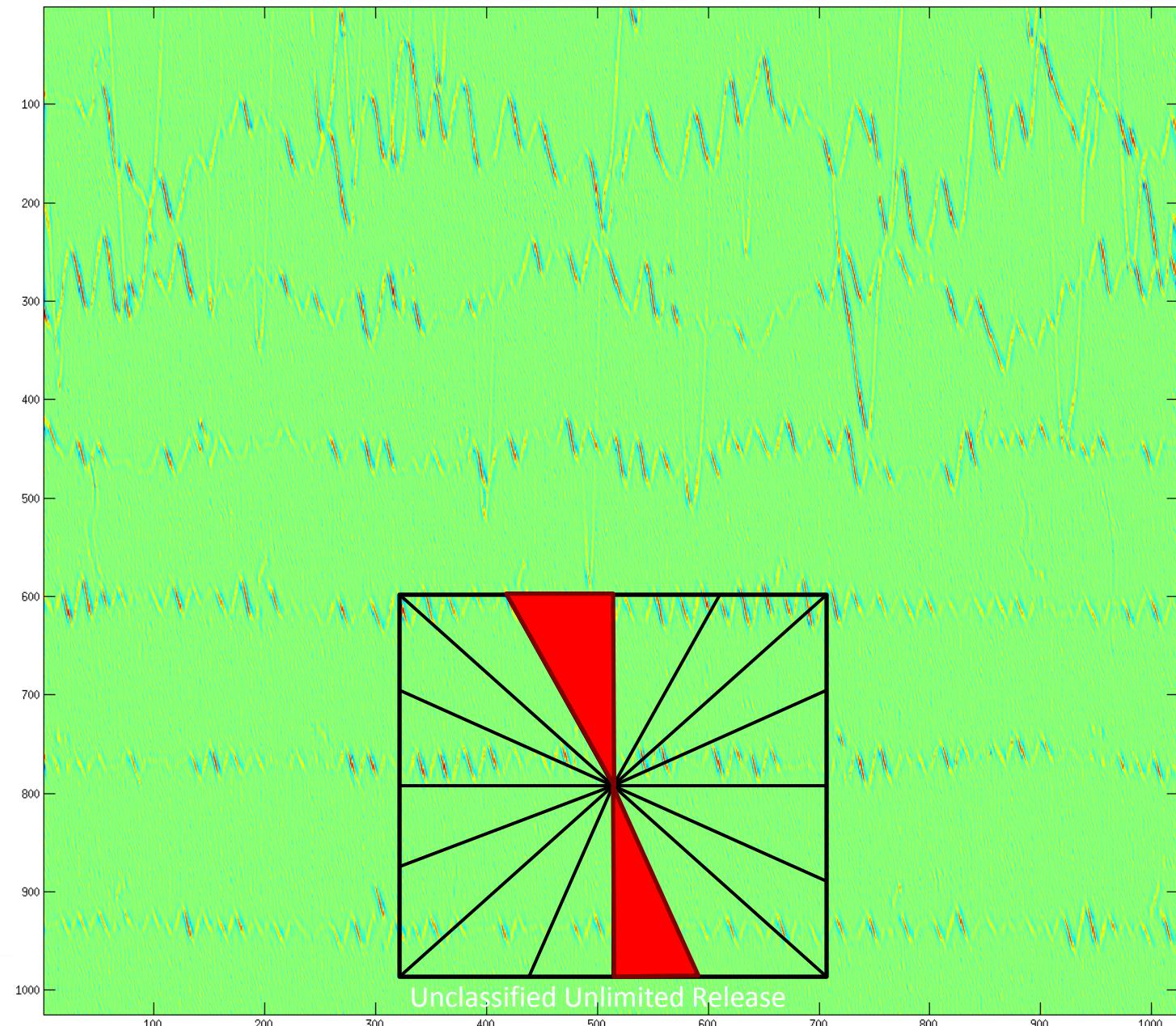
# Sub Band 1



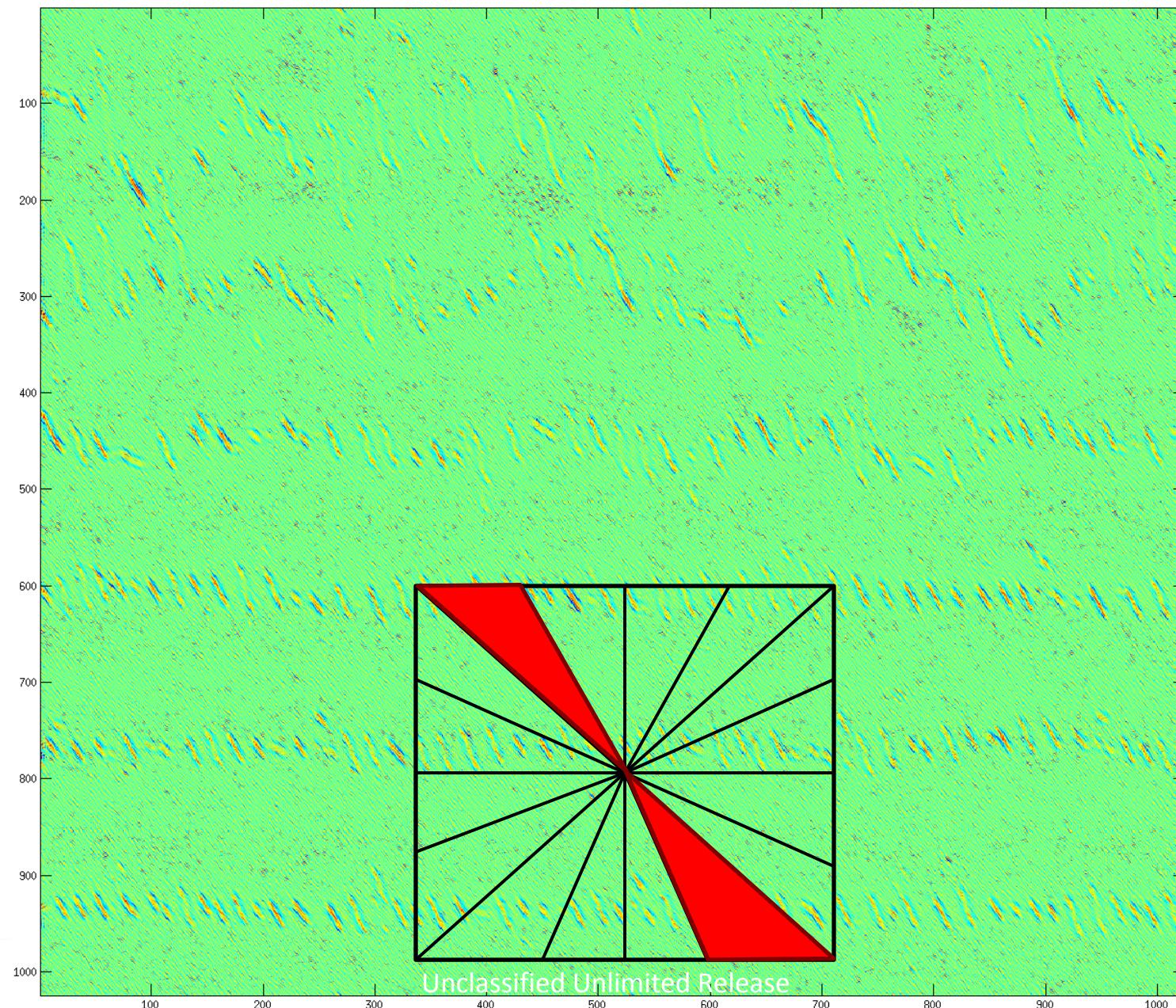
# Sub Band 2



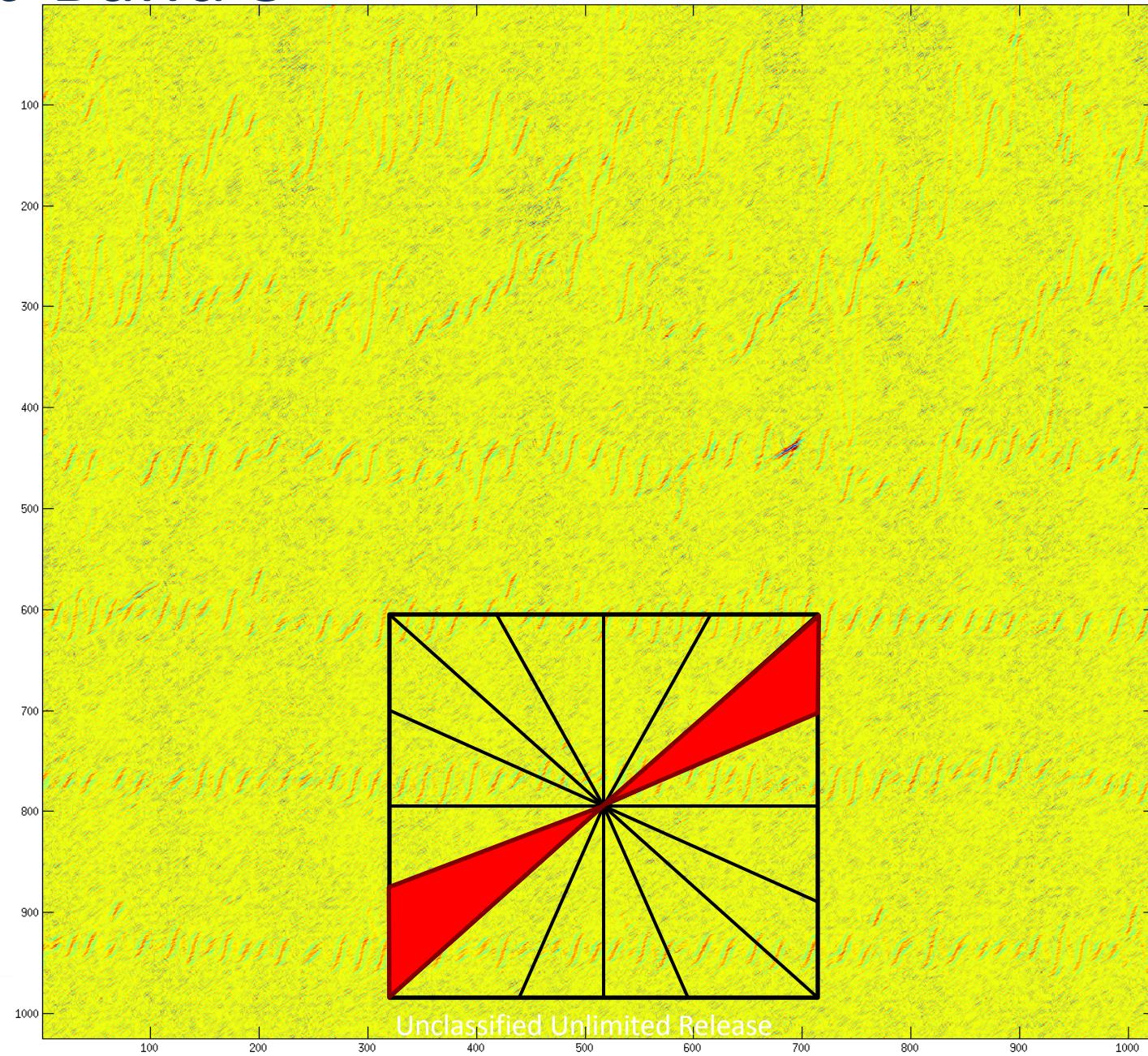
# Sub Band 3



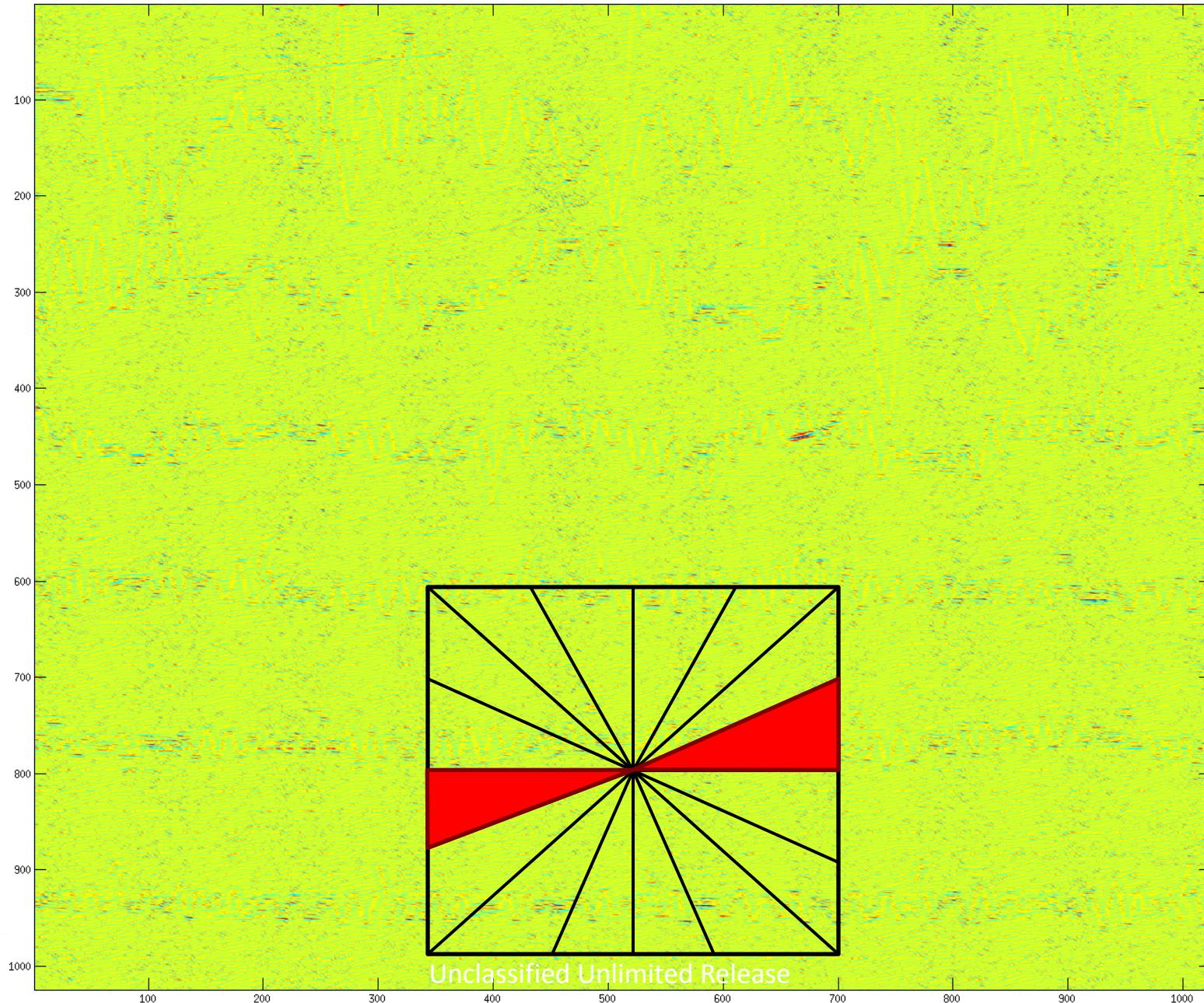
# Sub Band 4



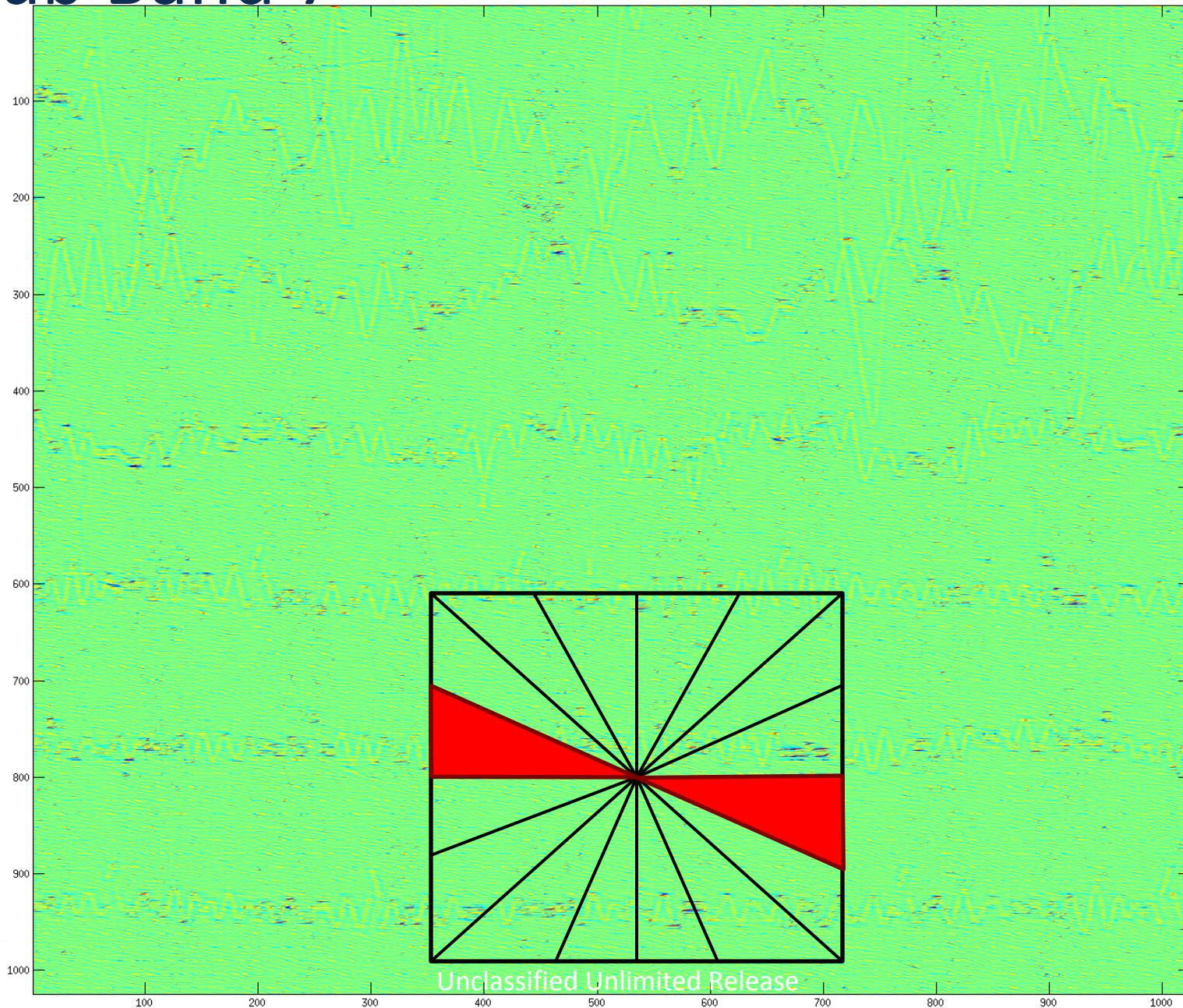
# Sub Band 5



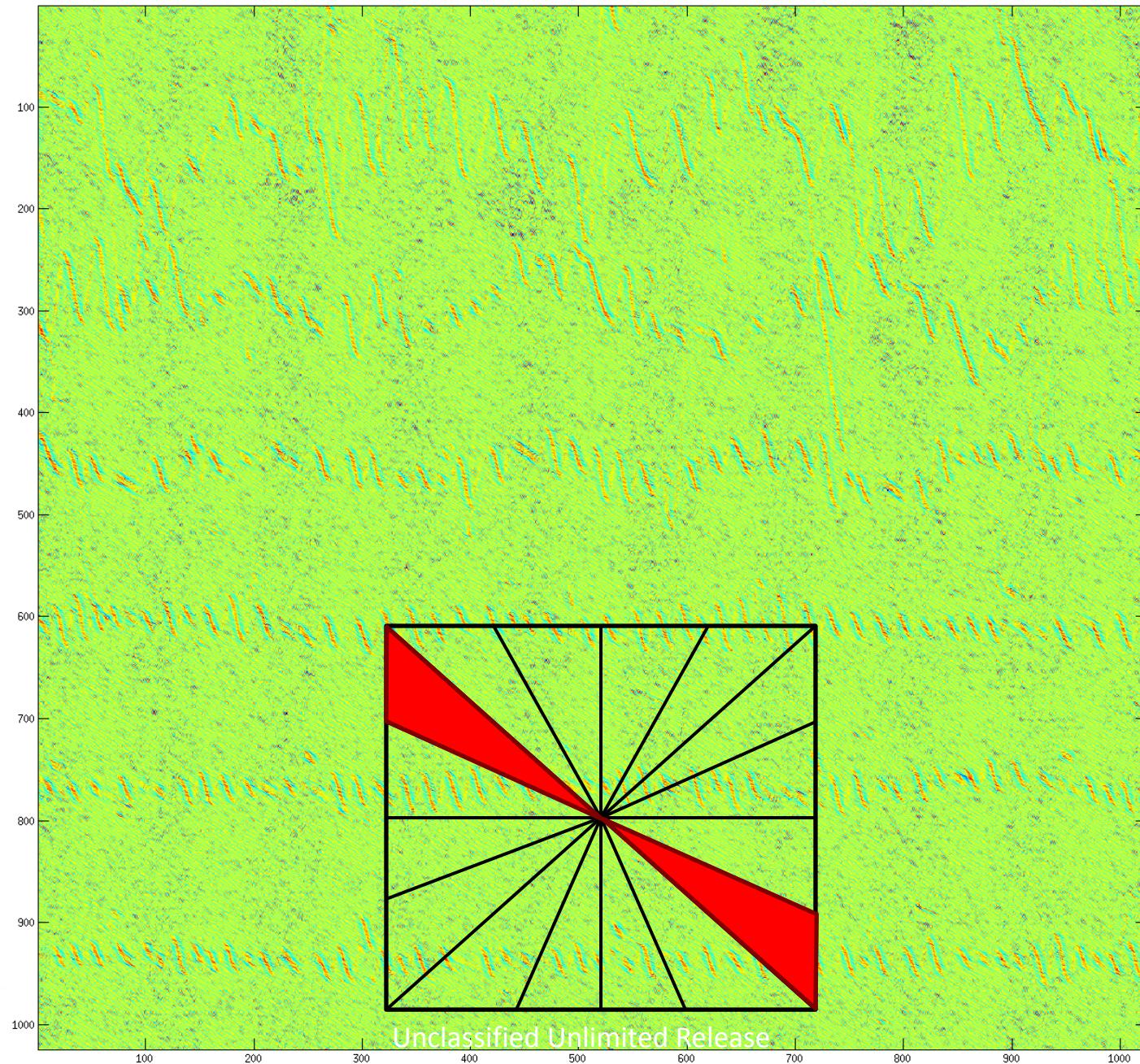
# Sub Band 6



# Sub Band 7



# Sub Band 8



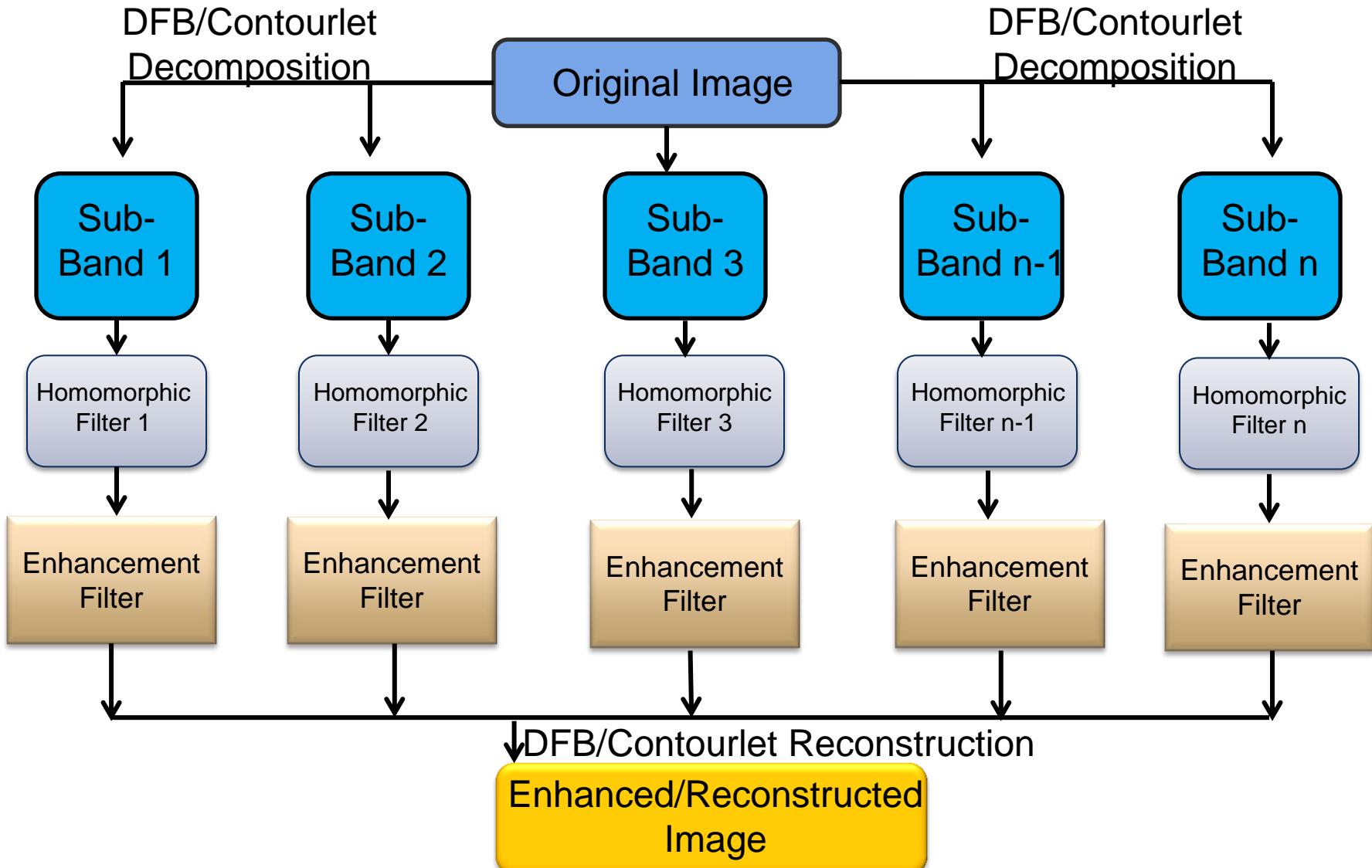
# Hessian Matrix/DFB Trace Enhancement



- Inspired by vessel and fingerprint image enhancement methods. [\[15\]](#) [\[16\]](#) [\[17\]](#) [\[18\]](#)

1. Directional decomposition of Image with Directional Filter Banks (DFB)
2. Homomorphic filtering
3. Rotated Hessian Eigenvalue Analysis across multiple sized Gaussian modeled traces
4. Trace detection
5. Enhanced directional Images
6. Image reconstruction

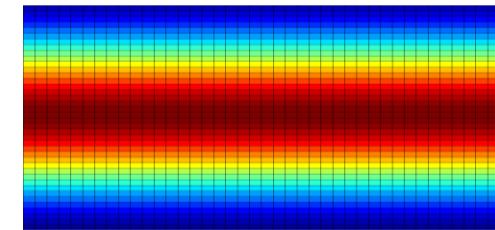
# Hessian Matrix/ DFB Trace Enhancement



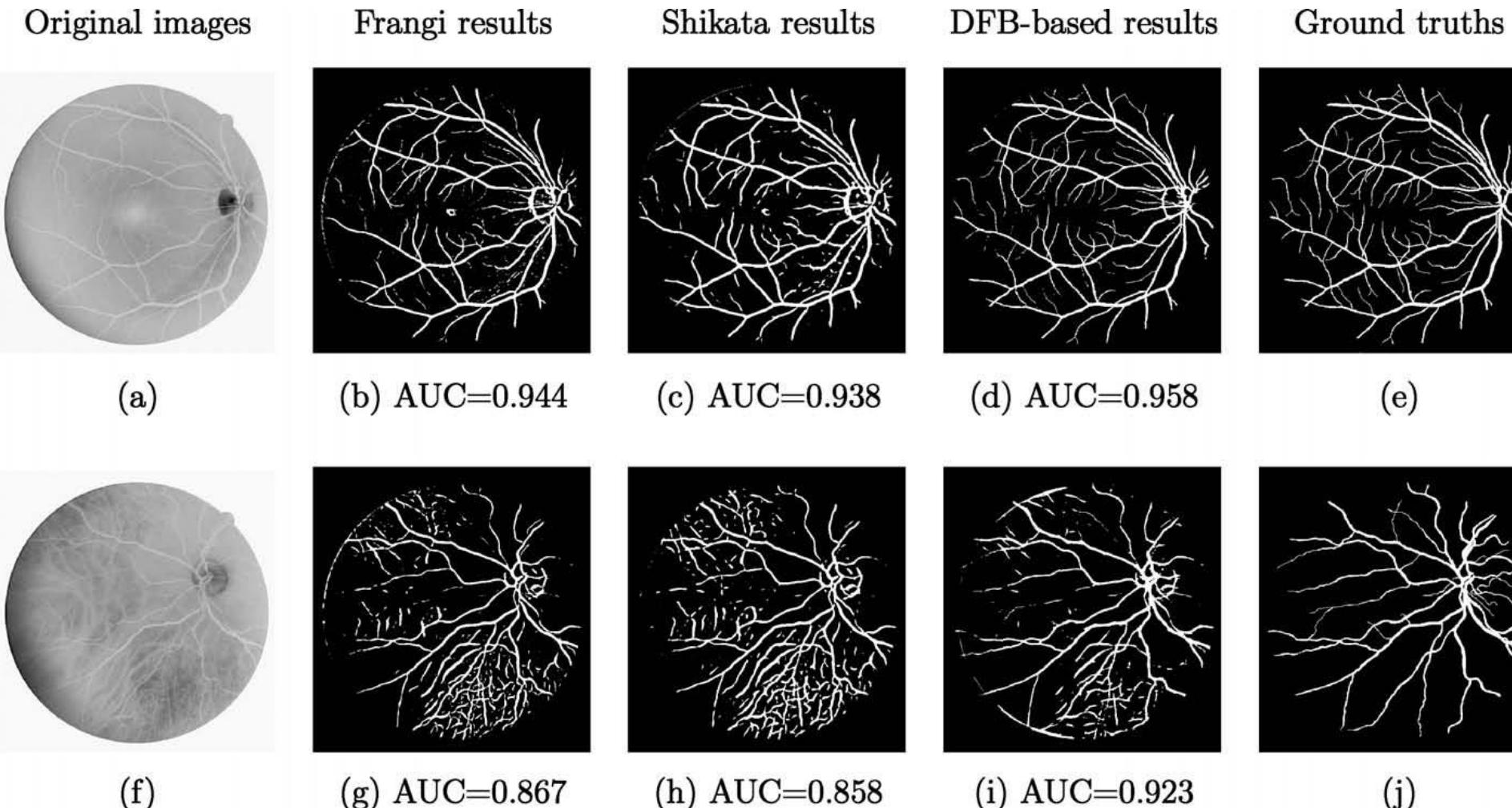
# Enhancement Filter [18]

Enhancement  
Filter

1. Calculate Rotated Hessian Matrix  $H(Ii_{(x, y)}, \sigma_j, \theta_i) = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$  for directional sub-band Image at each pixel. (Optimized noise sensitivity)
2. Model a Trace as a Gaussian with  $\sigma_j$
3. When  $R = \left| \frac{h_{11}}{h_{22}} \right| \ll 1 \quad \& \quad h_{22} < 0$  a trace is declared
4. Weighting equation is applied for pixels considered inside of trace.
5. Repeat multi-scale convolution for different scales  $\sigma$  in Range  $S$
6. Enhanced sub-band Image is the max of all calculated scales  $\sigma$



# Comparison of approaches [18]



# Advantages of Hessian/DFB Method



- Enhanced thin and weak traces.
- Ability to differentiate between noise and signal
- Iterative Tree Structure
- Accounts for different thickness/contrast signals

# Current pushing Issues I am working on {6/16/14}

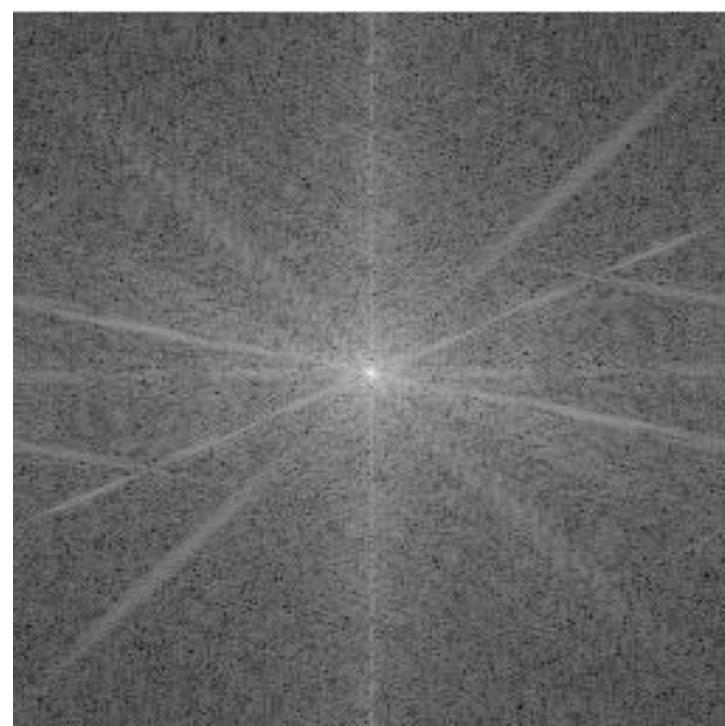


- Want a way to statistically calculate most uniform detected timing marks to use as a basis to interpolate/extrapolate.
- Looking at turning images on their side by the angle against the Y-Axis and the “slice” that majority of timing marks match up with
- Chipping out and moving select rows of timing marks (completed 6/18)
- Direction bank filters to pull out faint directional features. Countourlets{6/29}

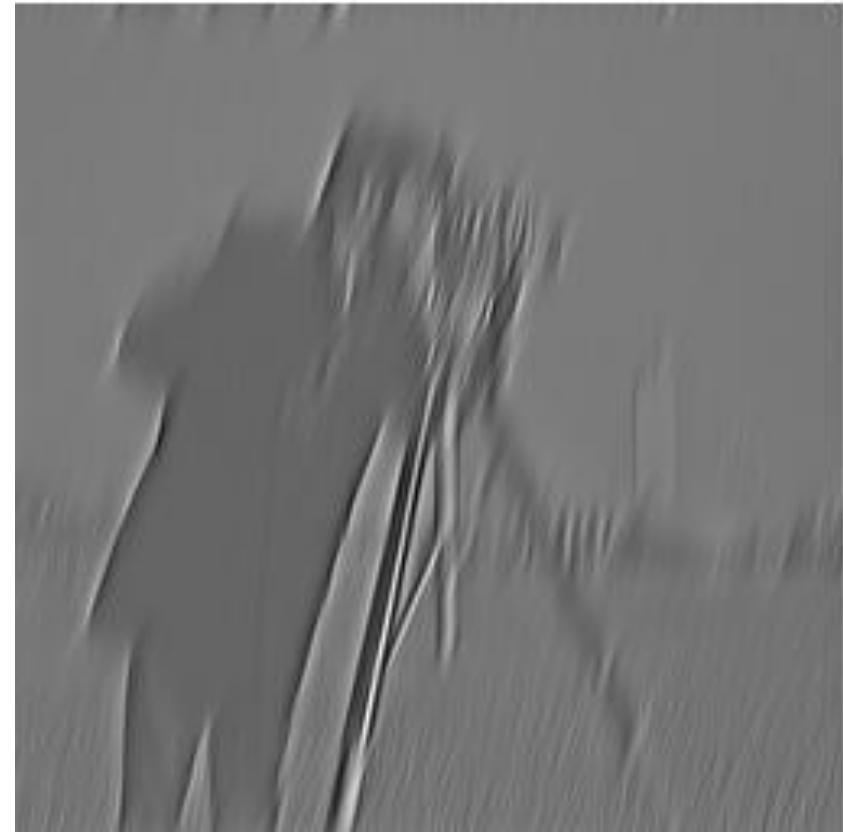
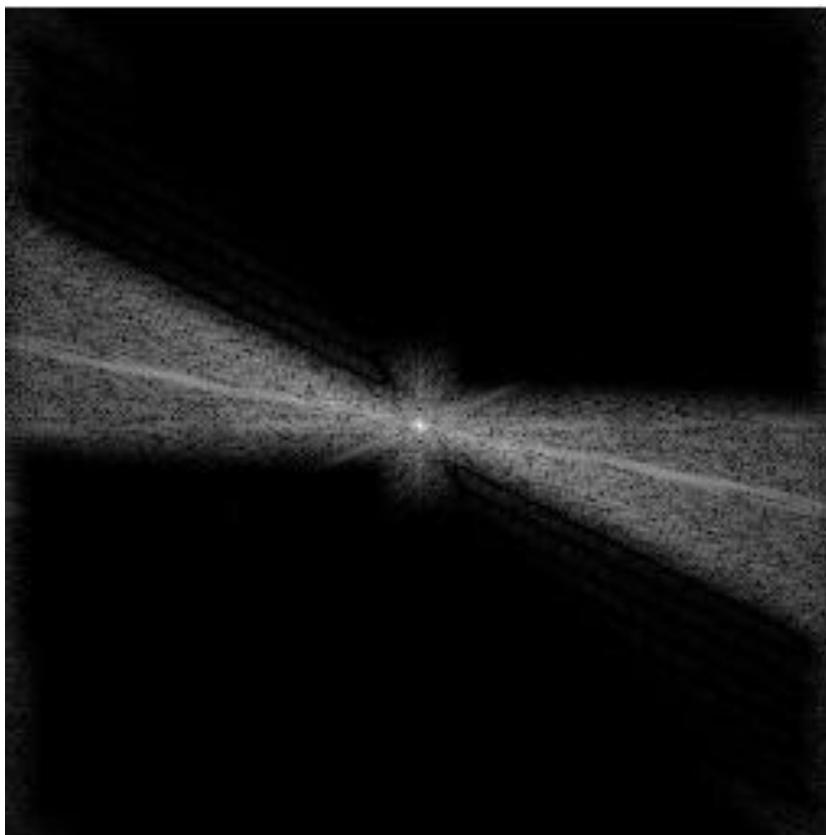
# Other Approaches taken

- Local Adaptive Histogram Equalization [\[7\]](#) [\[8\]](#)
- Evens out contrast well, sacrifices valuable data though.
  - Need to specify target histogram distribution. (not currently pursuing)
- Bilateral filtering takes out noise well, but does not exploit features as well as it claims. [\[1\]](#) [\[2\]](#)
  - Standard methods do not work well with thin traces
  - Possible customization of filter to use trace distribution for region differentiation

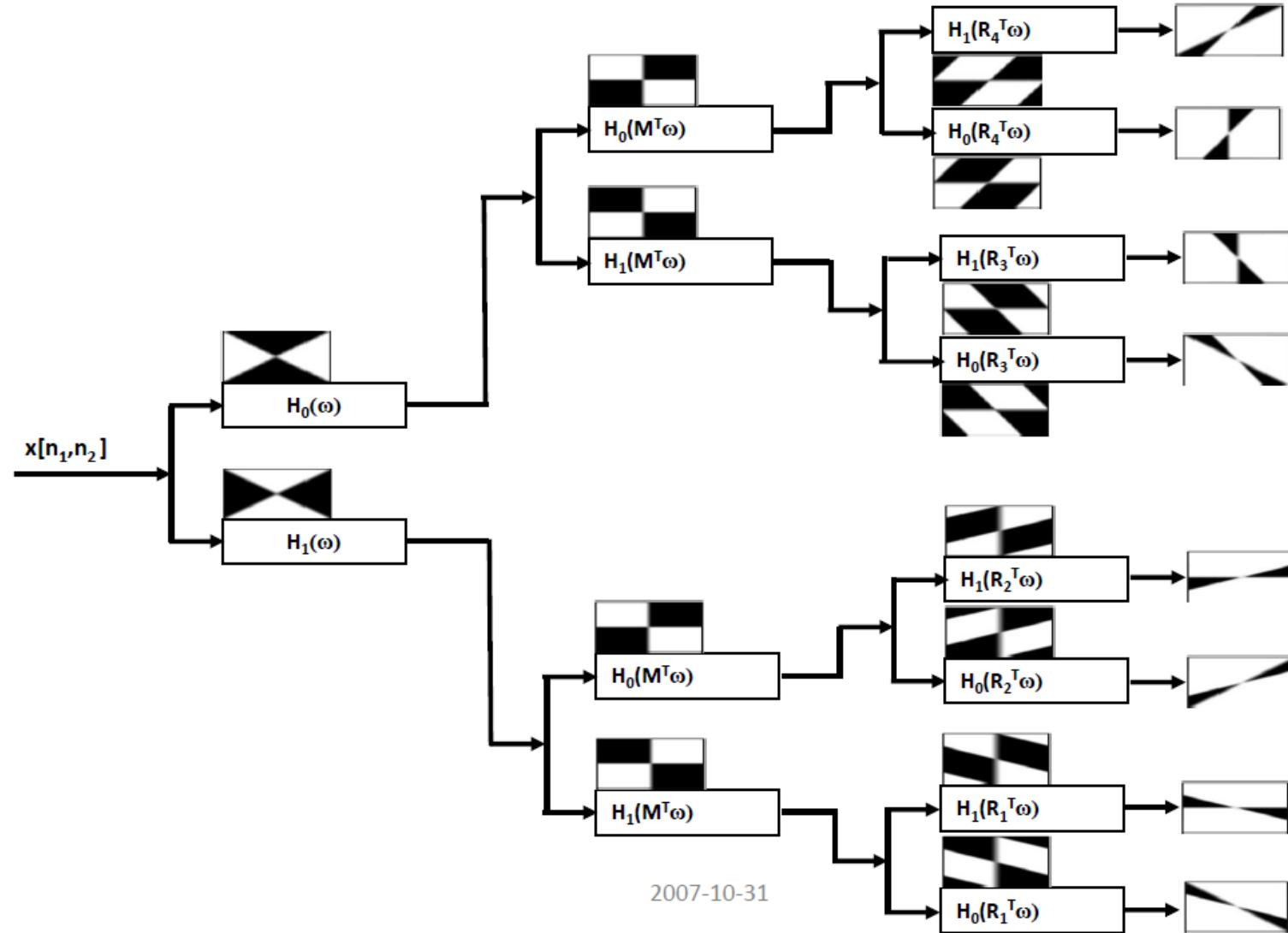
# DFB Background [19]



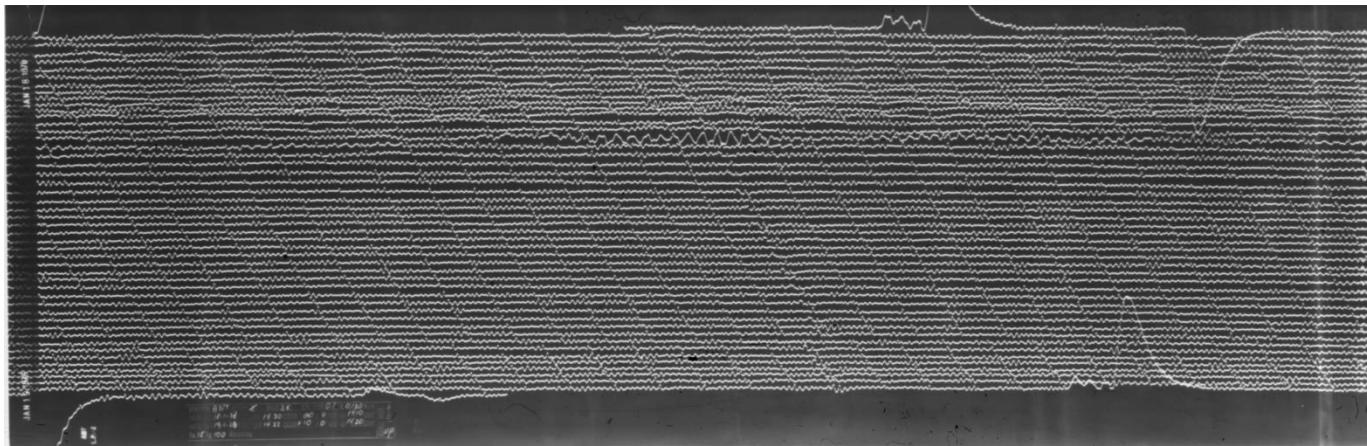
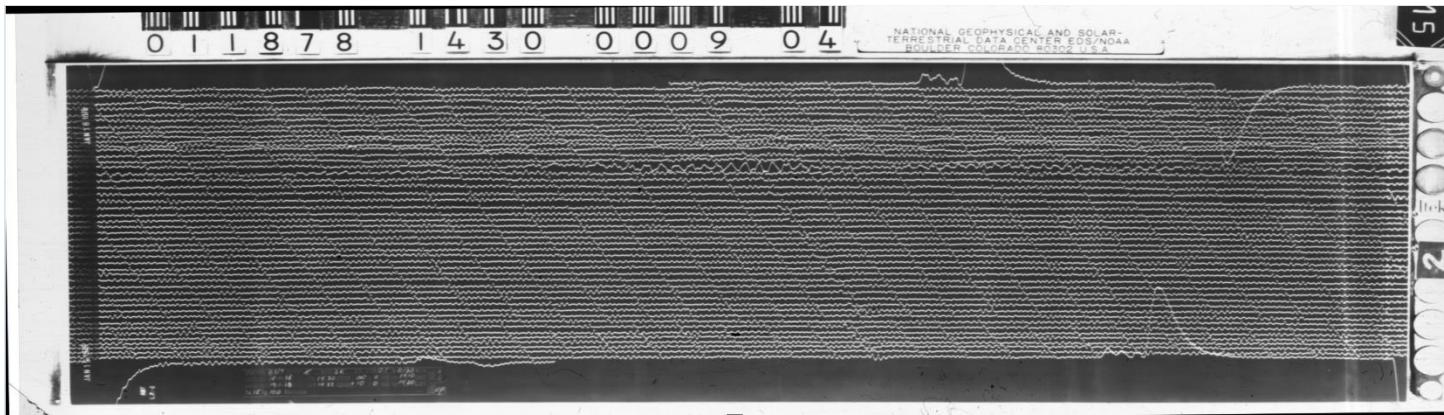
# DFB Background [\[19\]](#)



# DFB Structure [19]



# Cropping of Images (Extra)



# Image references

- Image 1 – 011878\_1430\_0009\_04.png
- Image 2 – 011970\_1922\_0053\_05.png
- Image 3 - 040471\_0638\_0023\_04.png
- Image 4 - 052078\_1701\_0055\_04.png
- Image 5 - 101776\_2121\_0032\_04.png
- Image 6 - 110968\_0639\_0124\_04.png
- Image 7 - 111068\_0628\_0124\_04.png