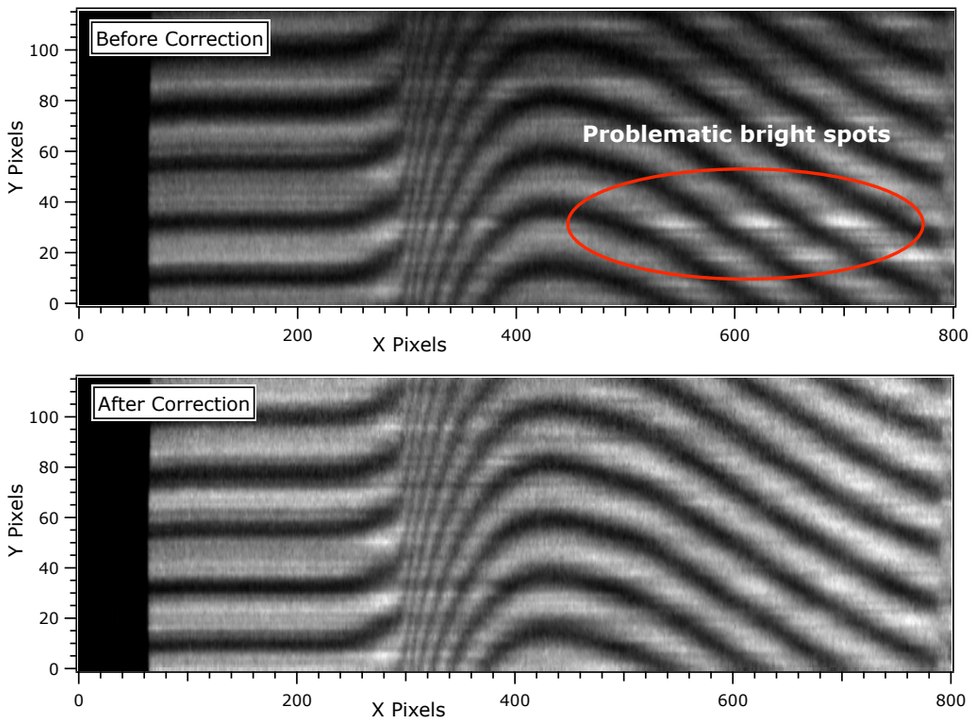
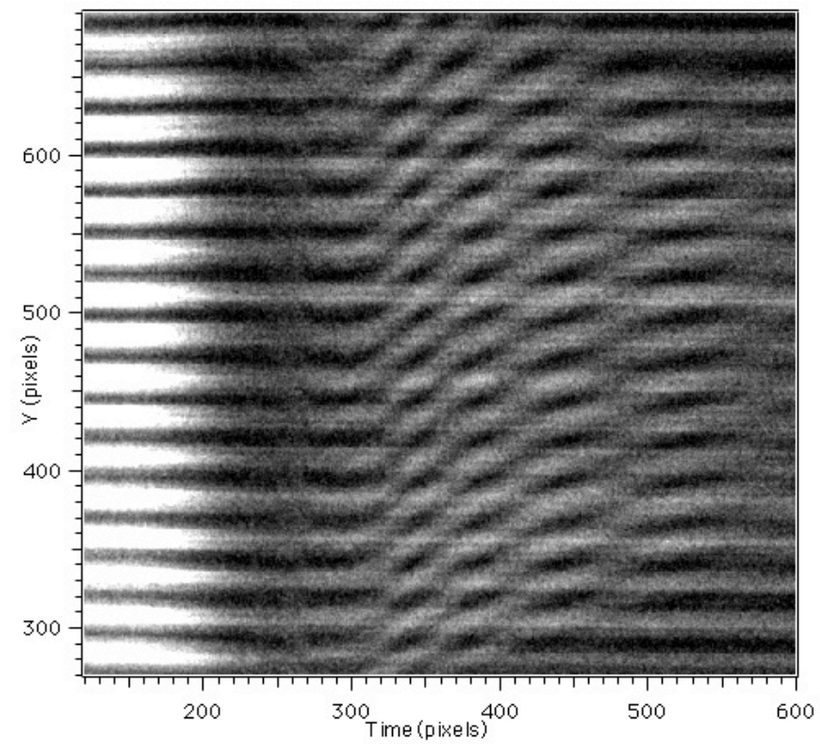
Advances in VISAR Interferogram Analysis: Speckle-Adaptive & Ghost Fringe Removal Techniques

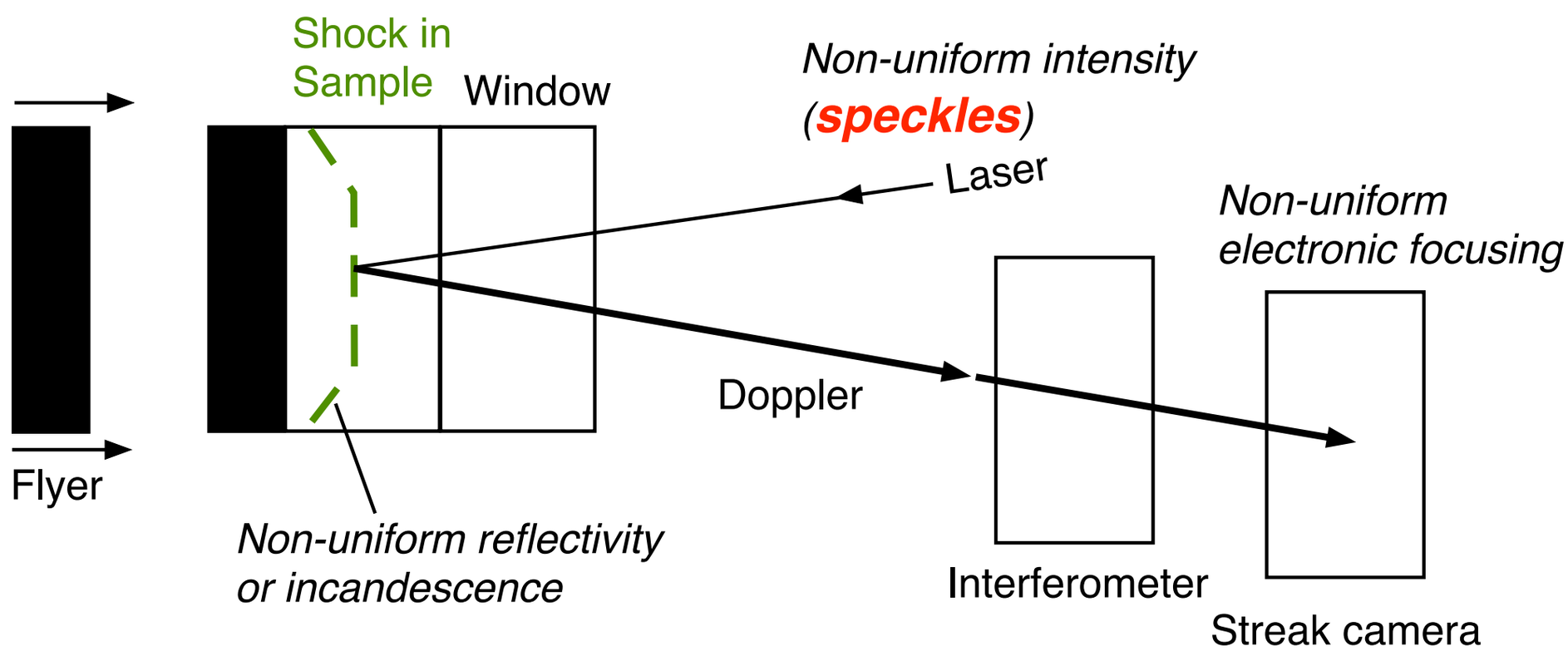


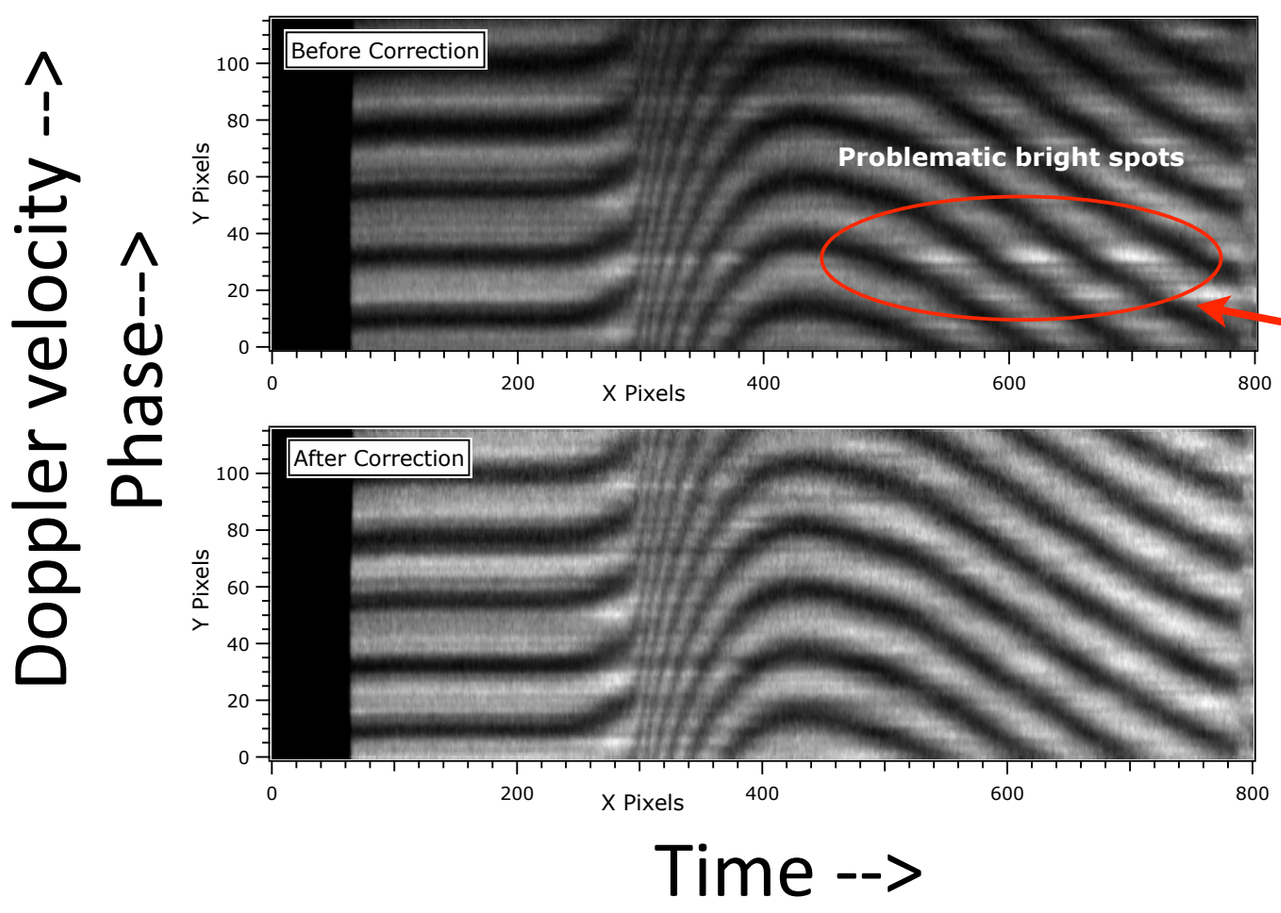


David Erskine (LLNL)

19th Signal & Imaging Sciences Workshop (CASIS)
May 13, 2015, LLNL

Speckle-Adaptive VISAR Analysis Algorithm

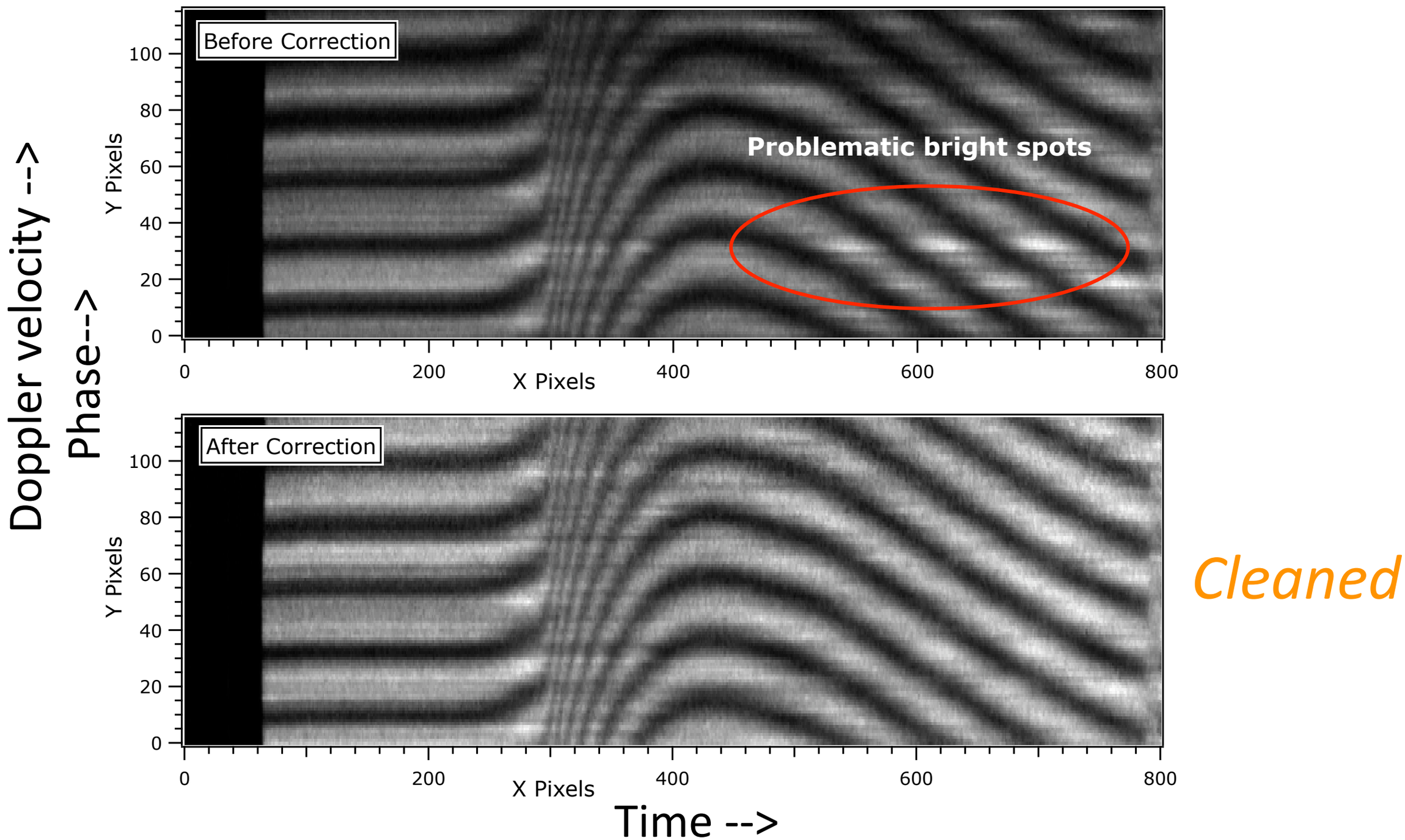




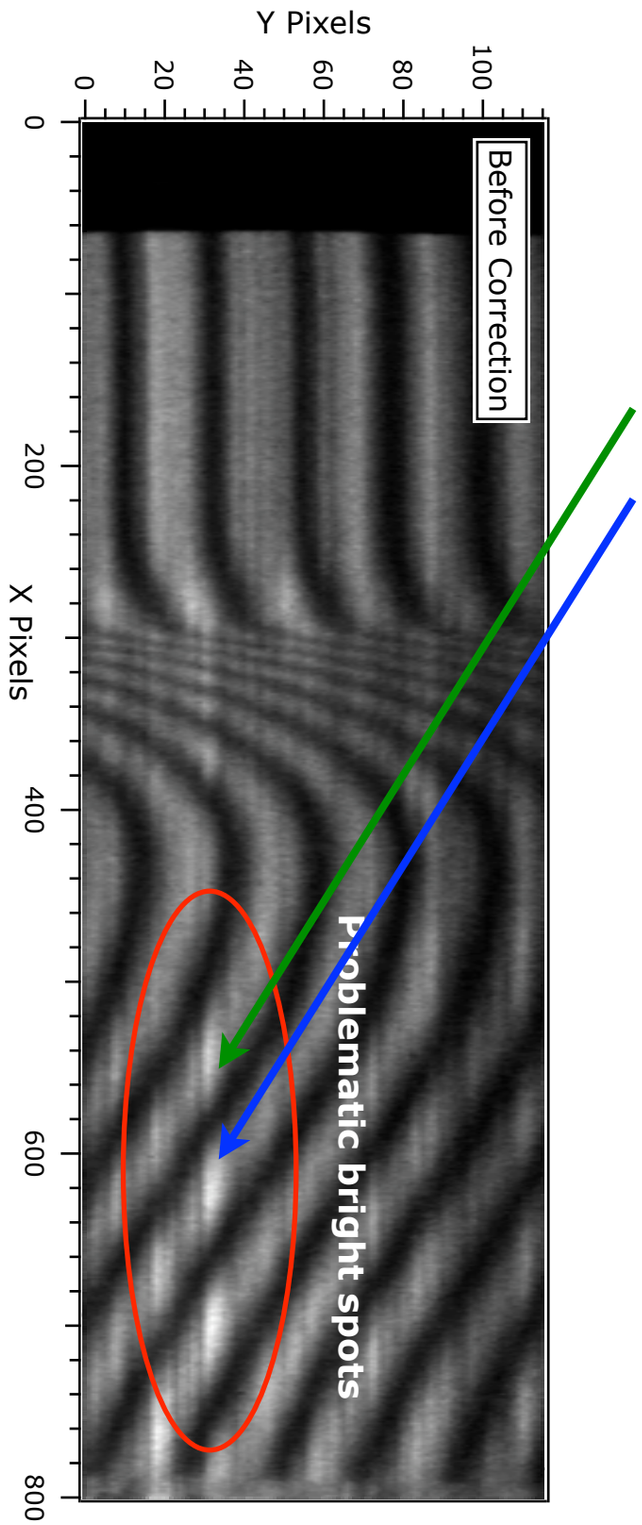
Problematic bright spots

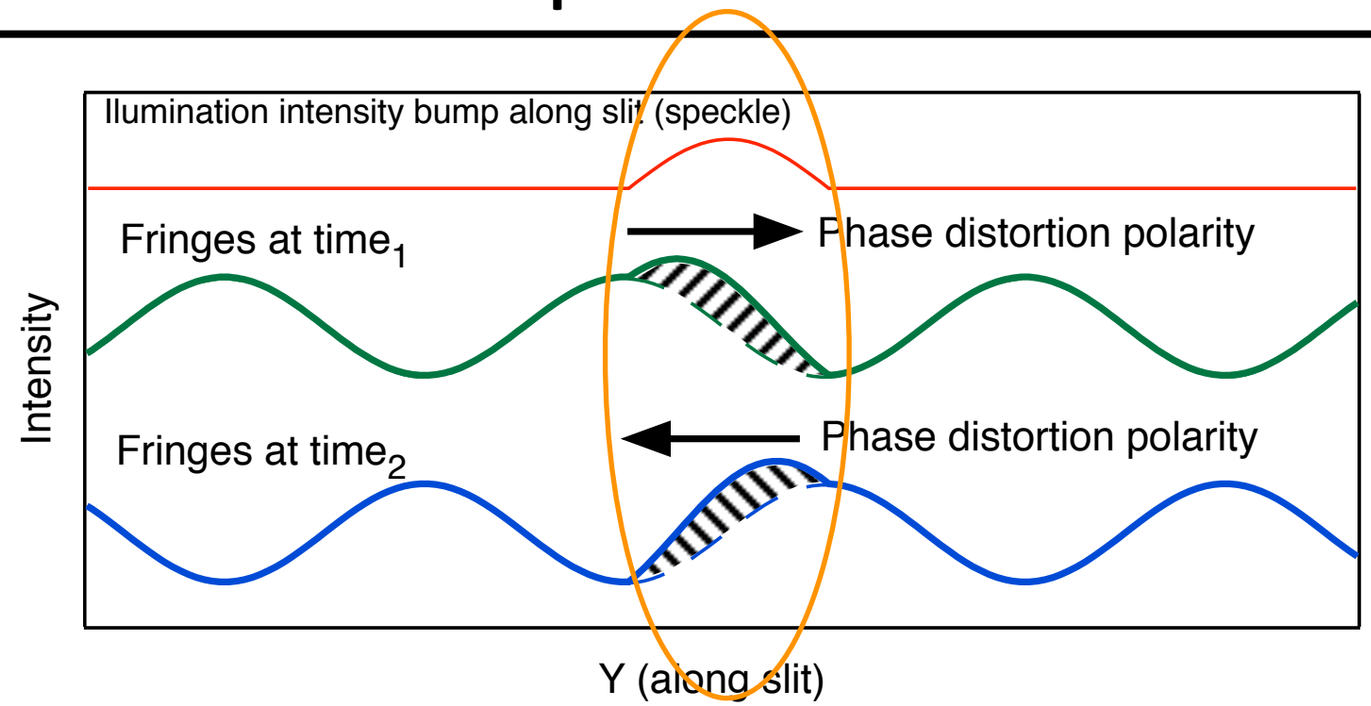
Speckle-Adaptive VISAR Analysis Algorithm

"Speckle" means any Y-irregularity: intensity, phase, visibility

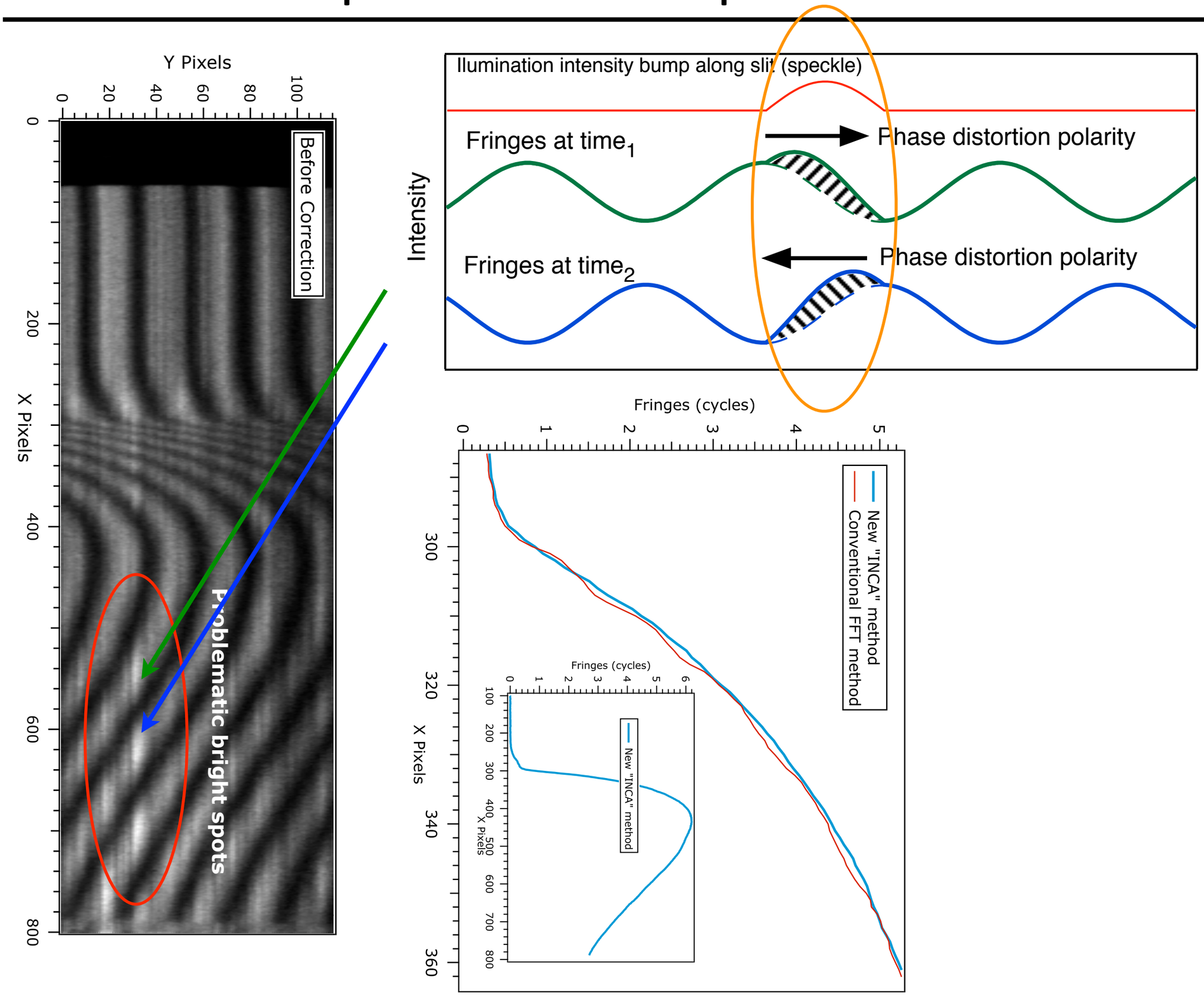


Motivation: Speckle creates phase errors

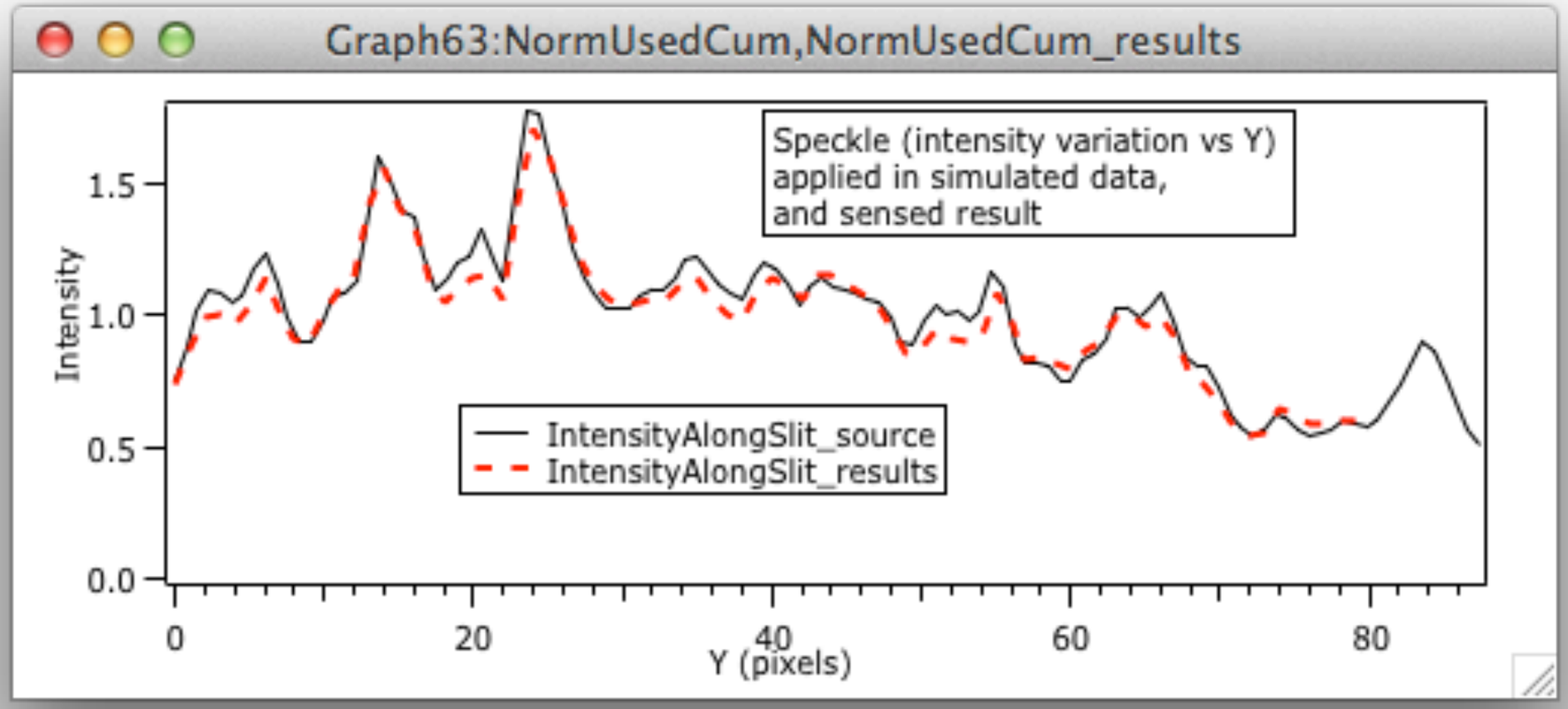




Motivation: Speckle creates phase errors

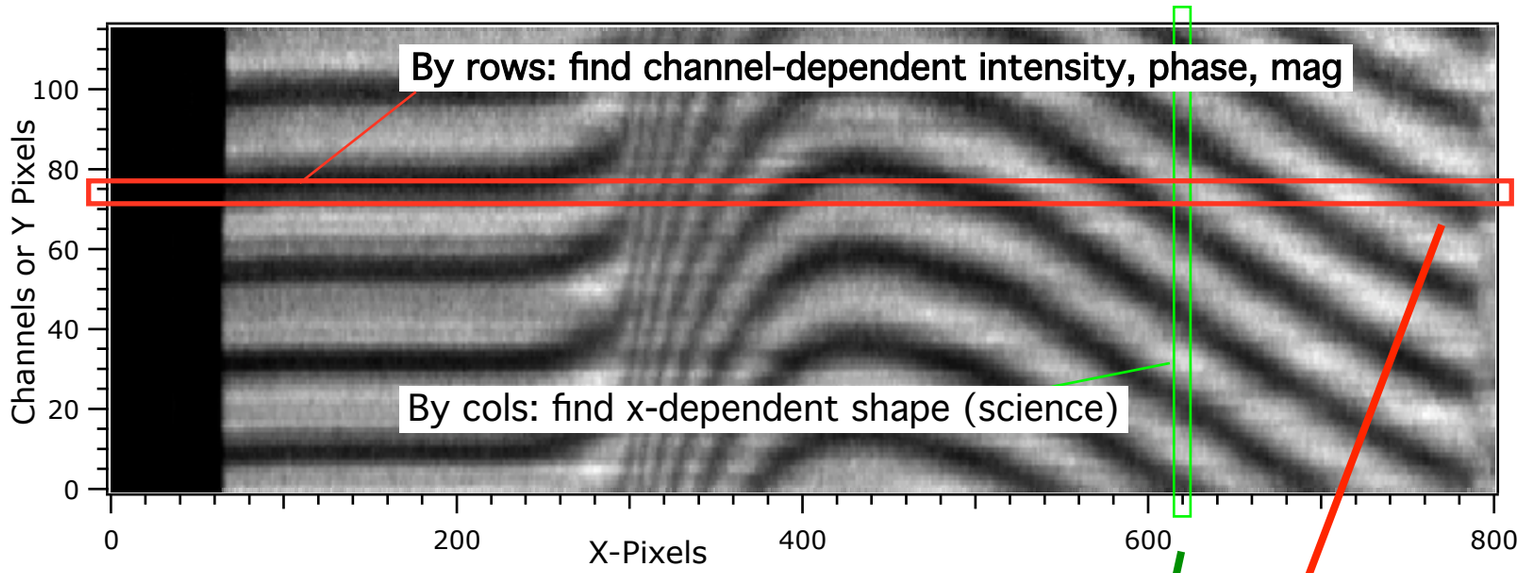


Speckle is found, then normalized from data

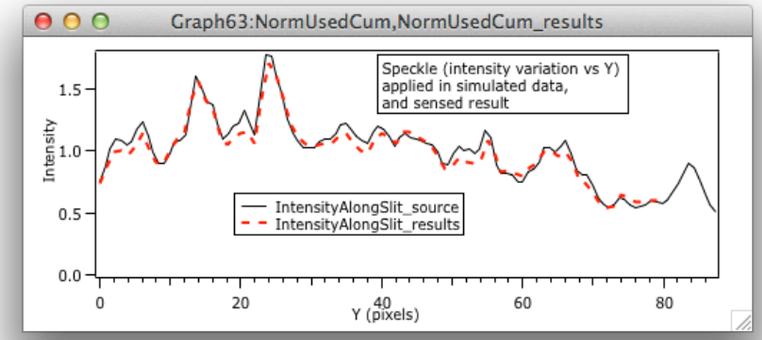


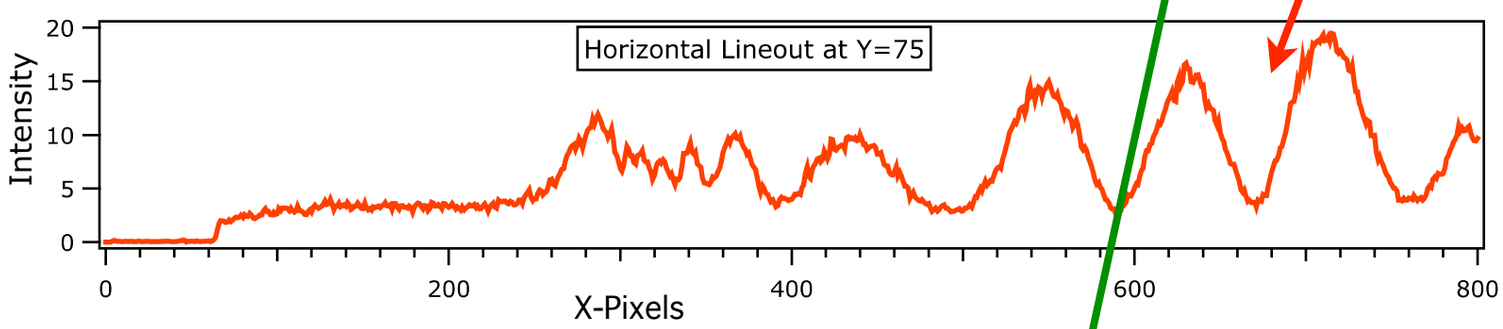
then data reprocessed
to yield a cleaner result

We **alternate** iterating between seeking the Y-dependence, and seeking the X-dependence

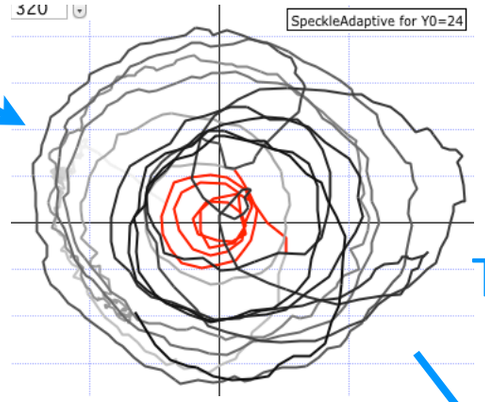


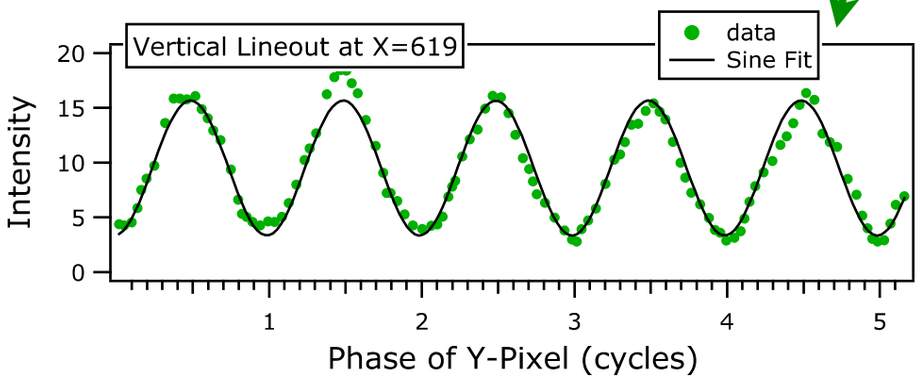
"Speckle" vs Y



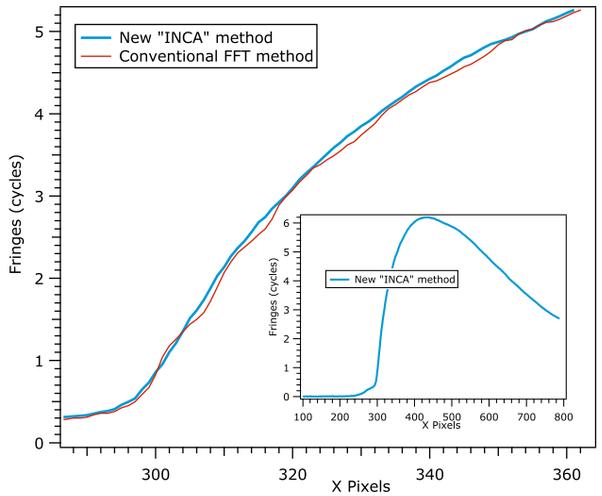


Lissajous: Im vs Re

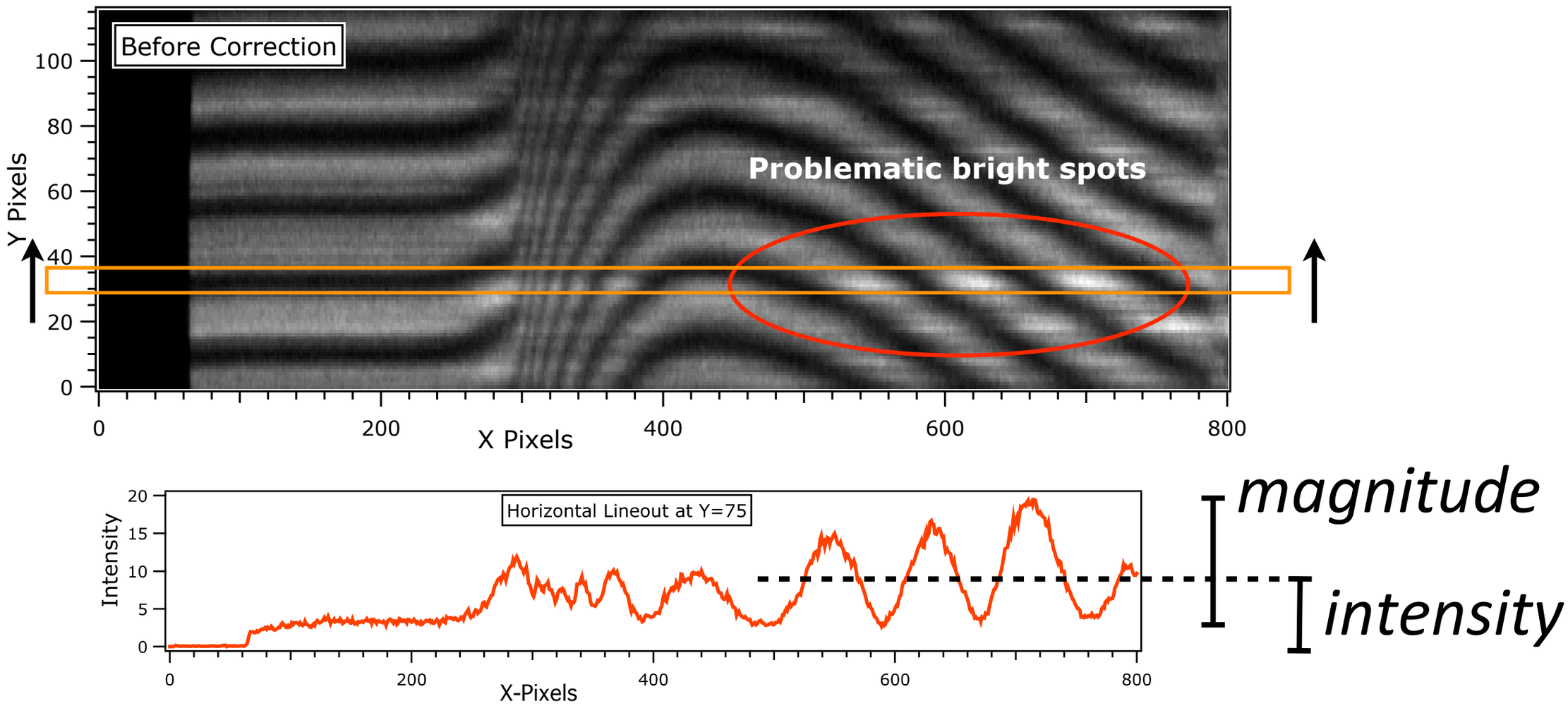




Take arctangent to yield phase

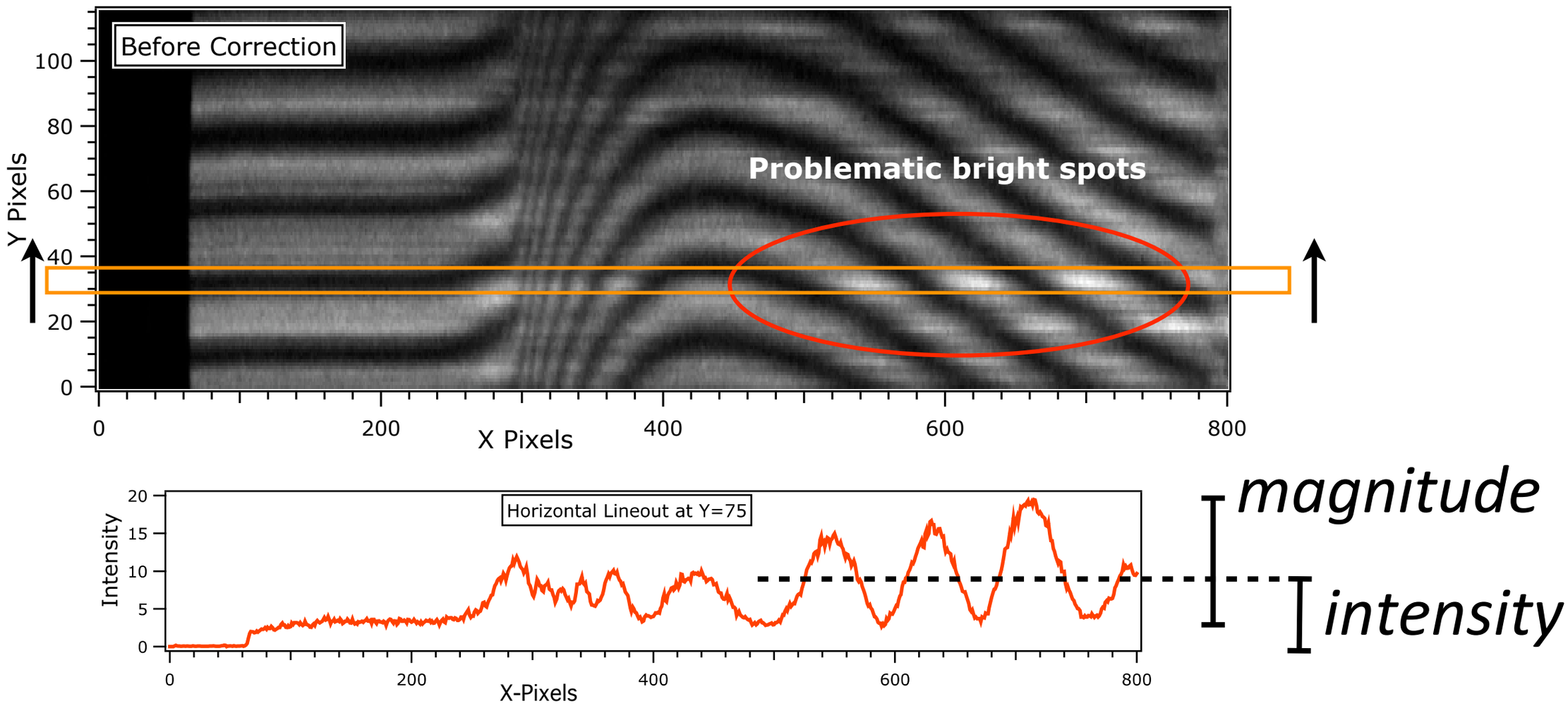


Row-by-row decomposition to find speckle params vs Y



The 3 speckle parameters of a row can be determined if the science shape is provisionally known

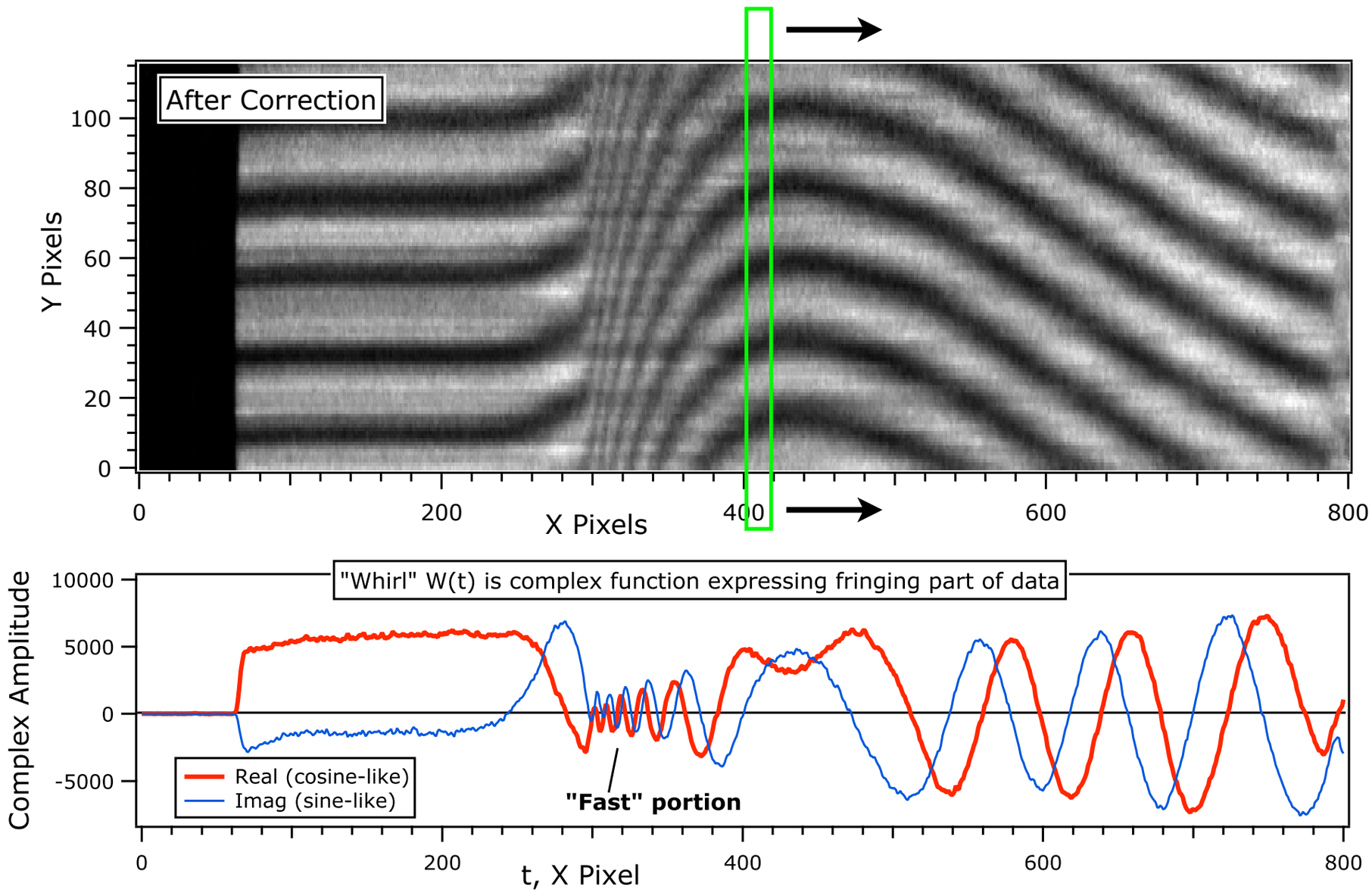
Row-by-row decomposition to find speckle params vs Y



I(x) = **A***Nonfringing(x) + **B***FringingReal(x) + **C***FringingImag(x)

If we know the three "basis functions", and they are approximately orthogonal, we can solve for coefficients **A**, **B**, **C**.

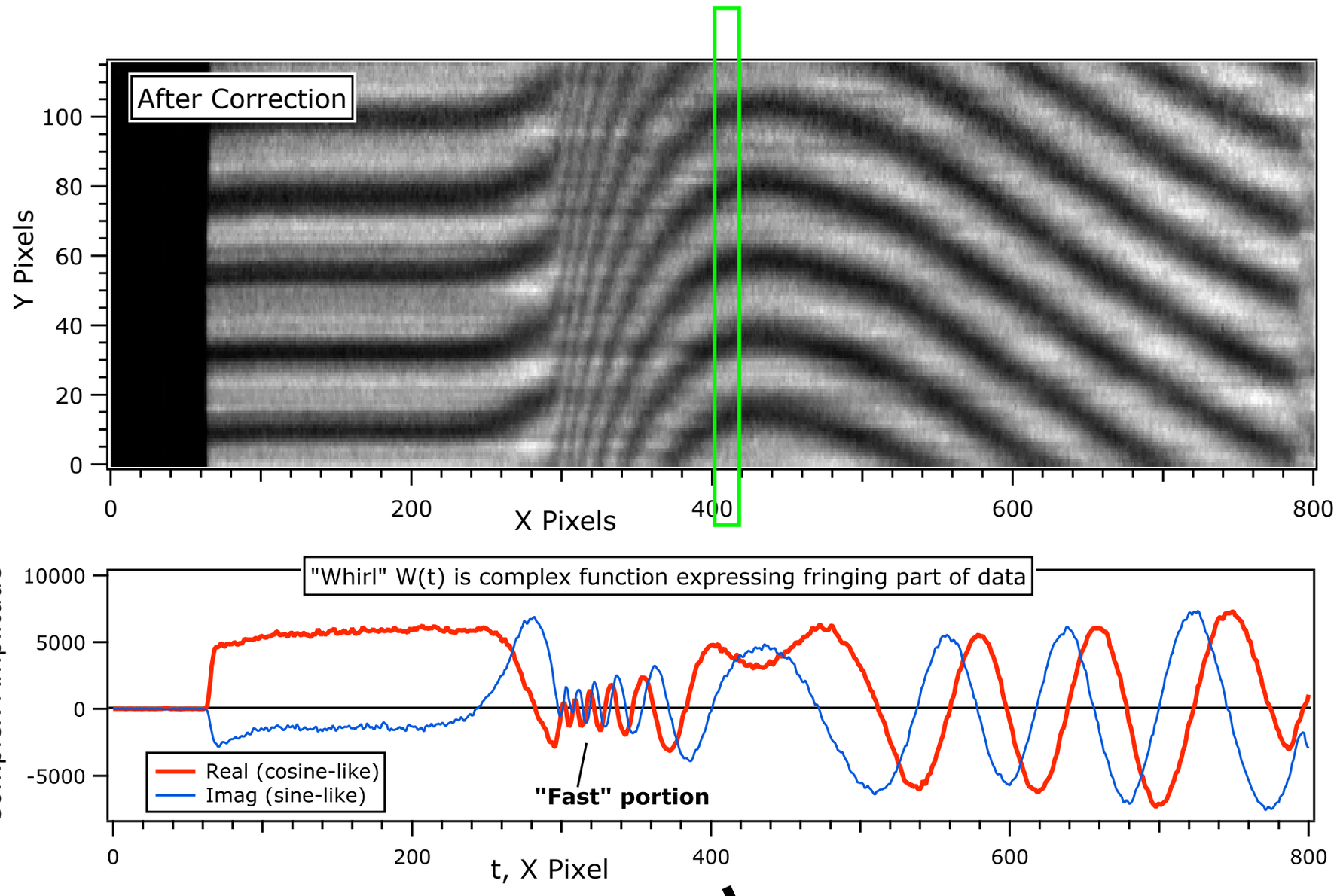
Col-by-col to find science shape vs t



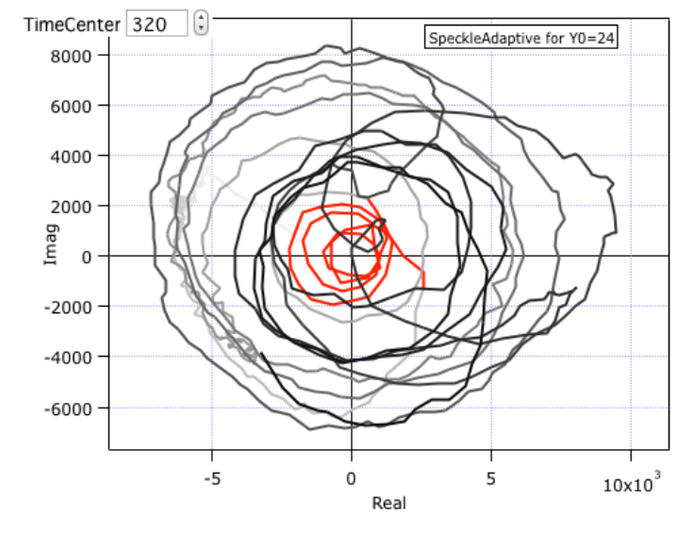
Science shape vs time,
described by real and imaginary parts

and a nonfringing shape (not shown)

Col-by-col to find science shape vs t

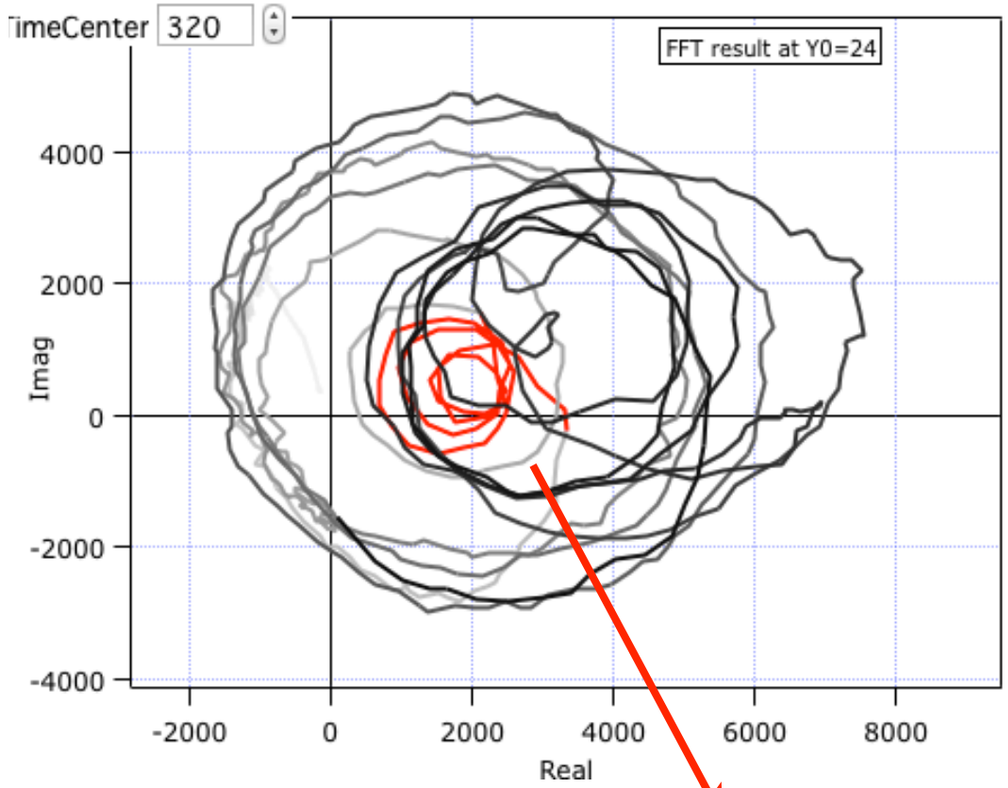


Lissajous presentation

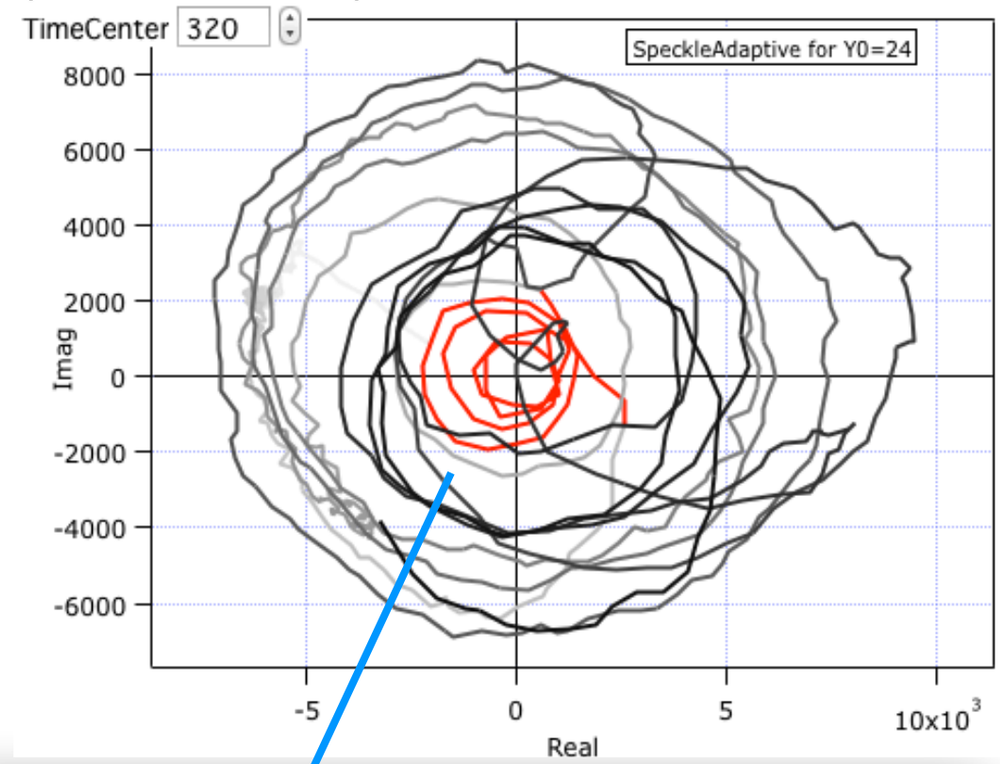


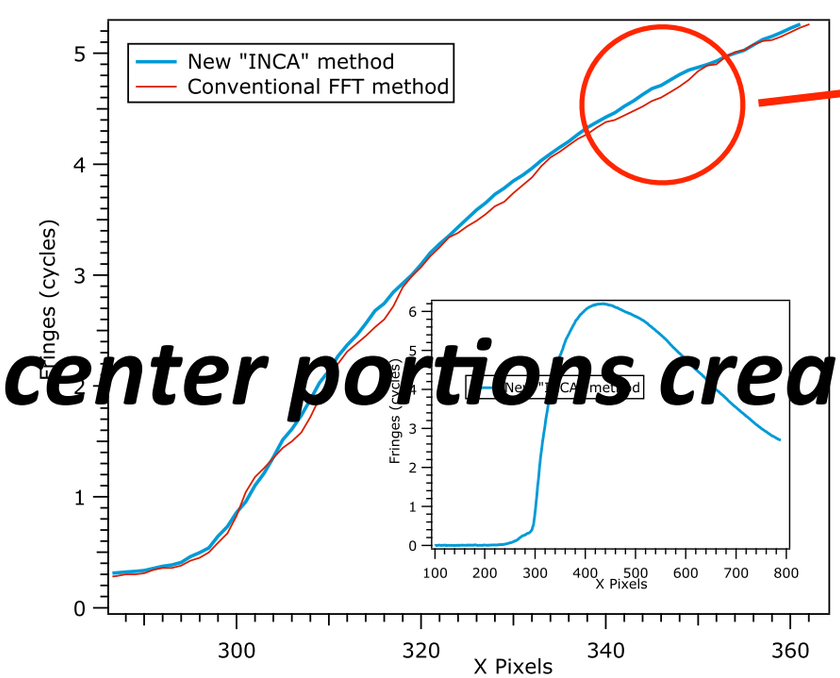
Centration critical to accurate velocity result

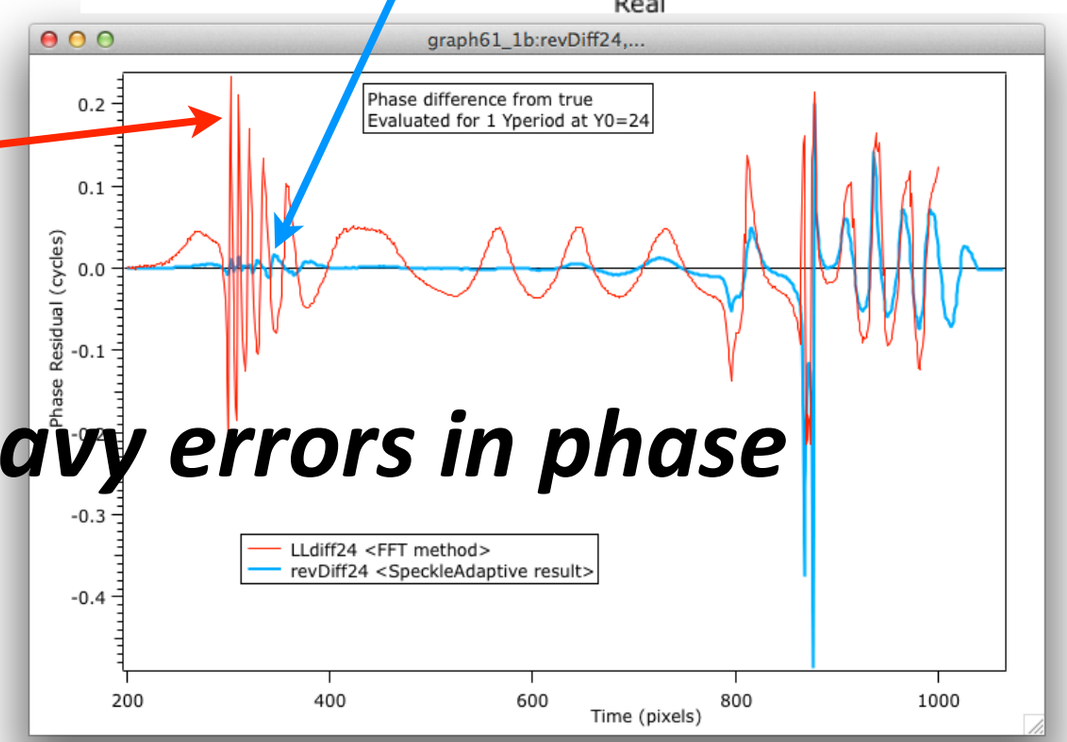
FFT method: worse centration



SpeckleAdaptive: better centration



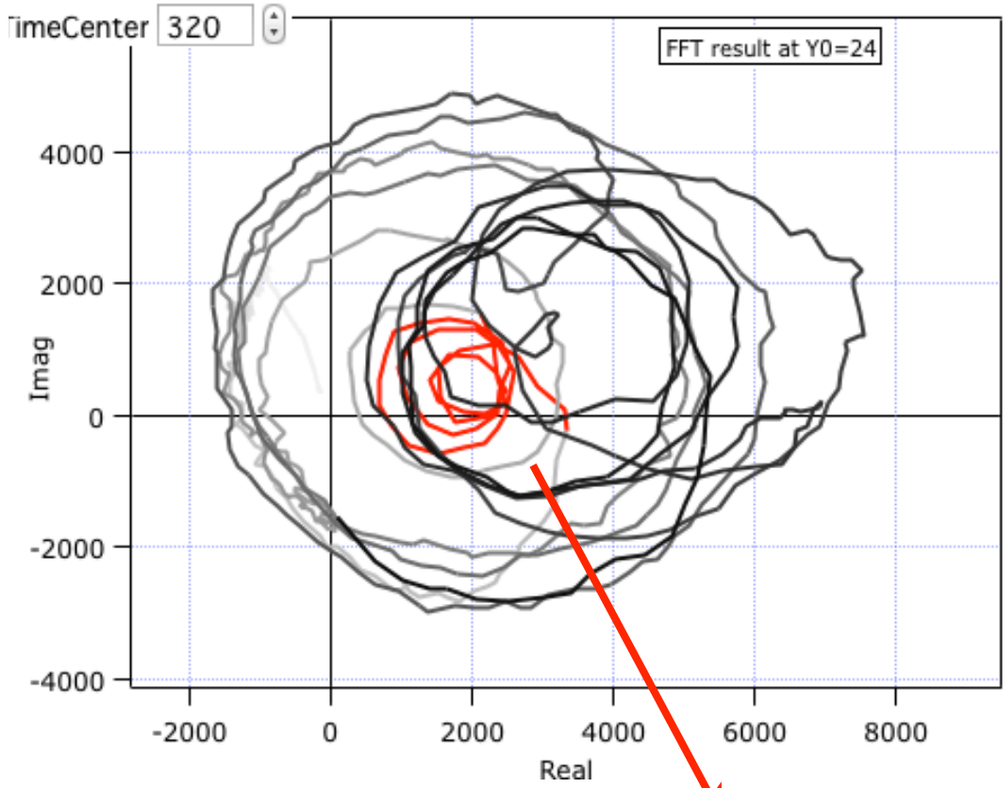




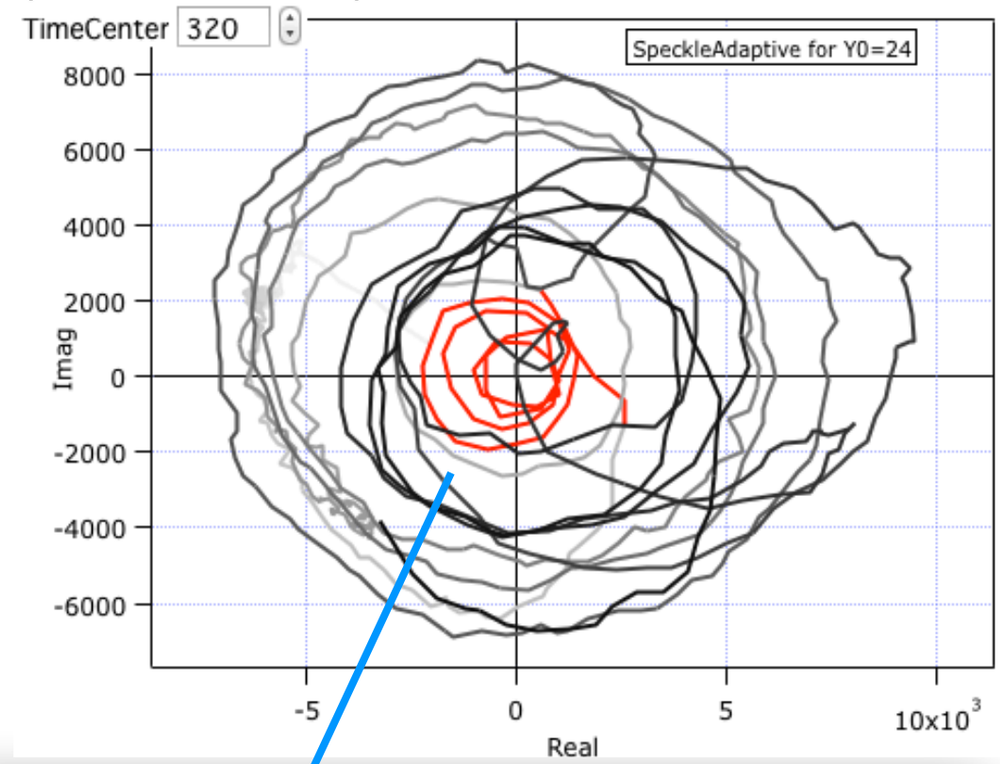
Off center portions create wavy errors in phase

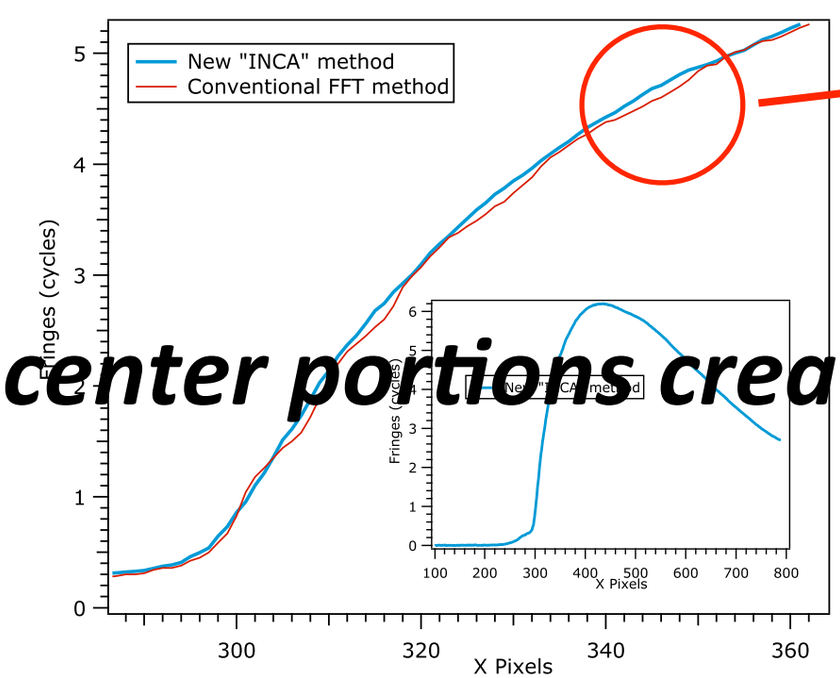
SpeckleAdaptive shows better centration than FFT

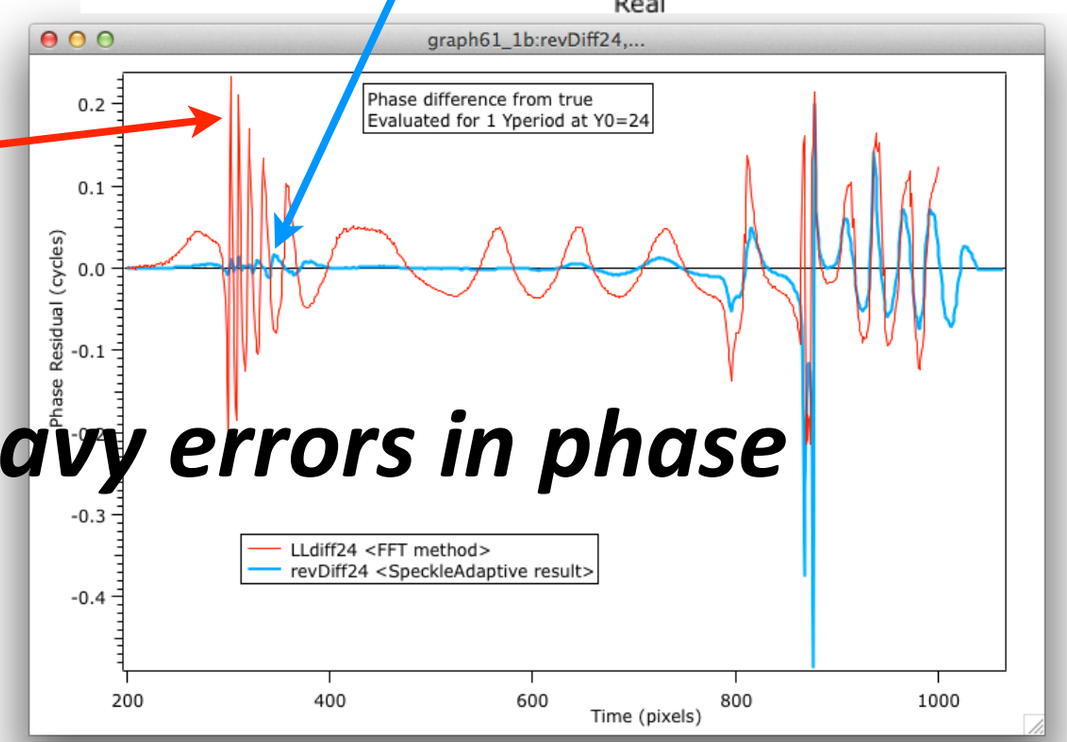
FFT method: worse centration



SpeckleAdaptive: better centration



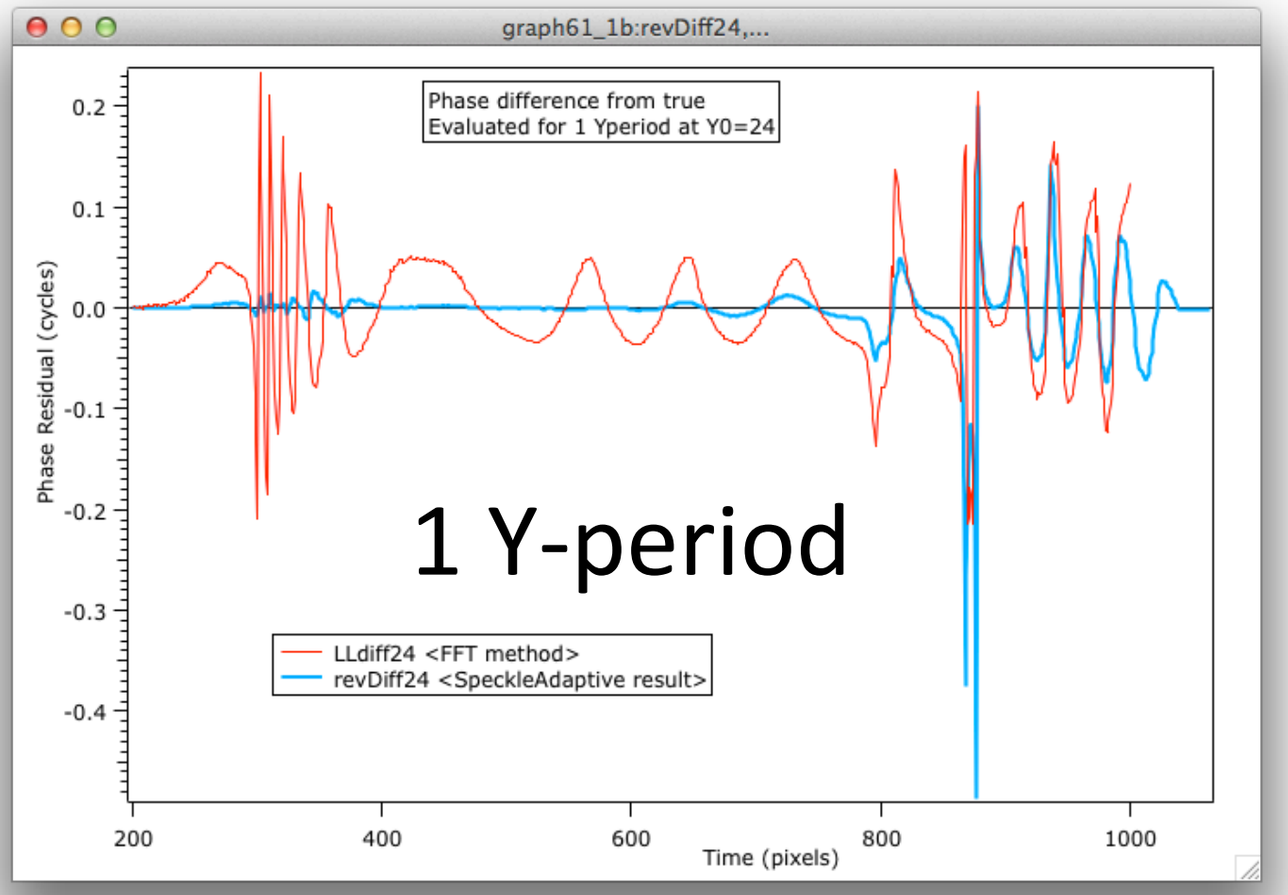


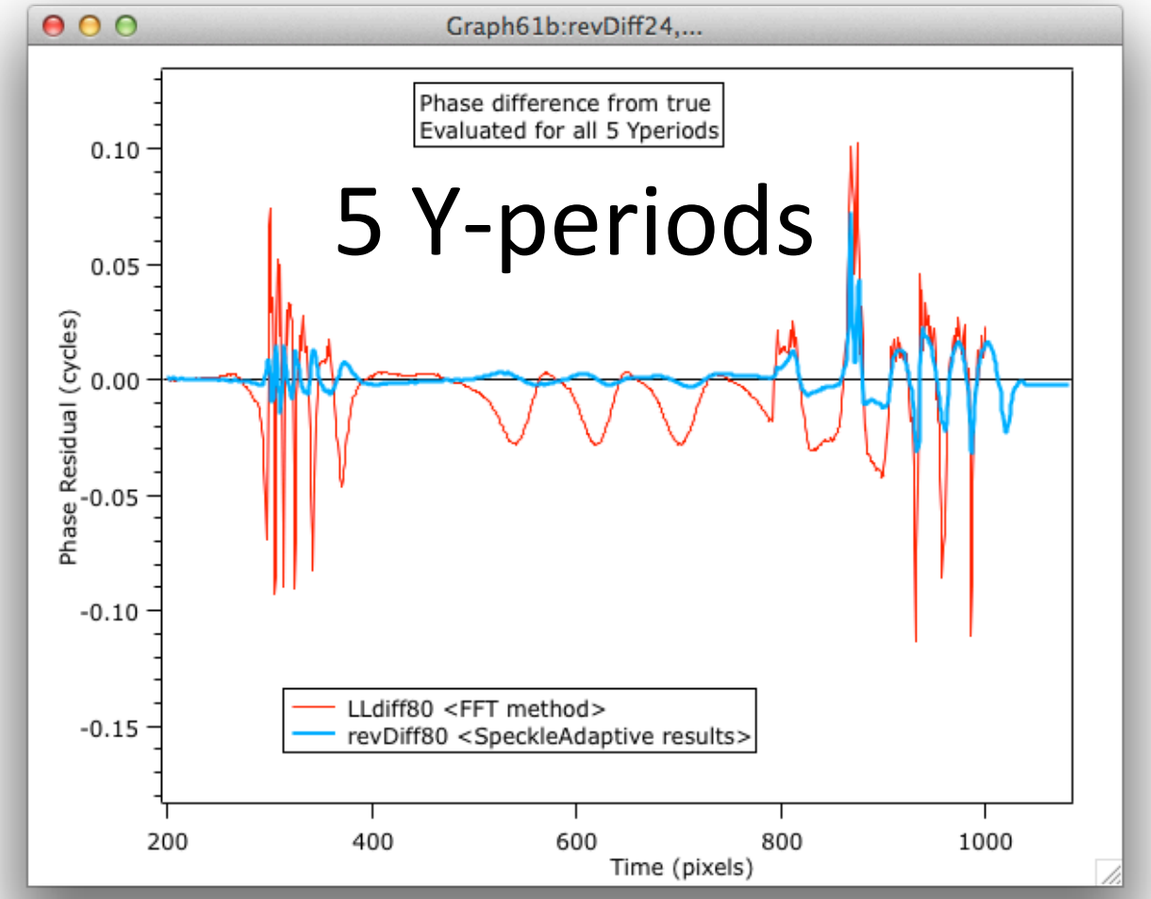


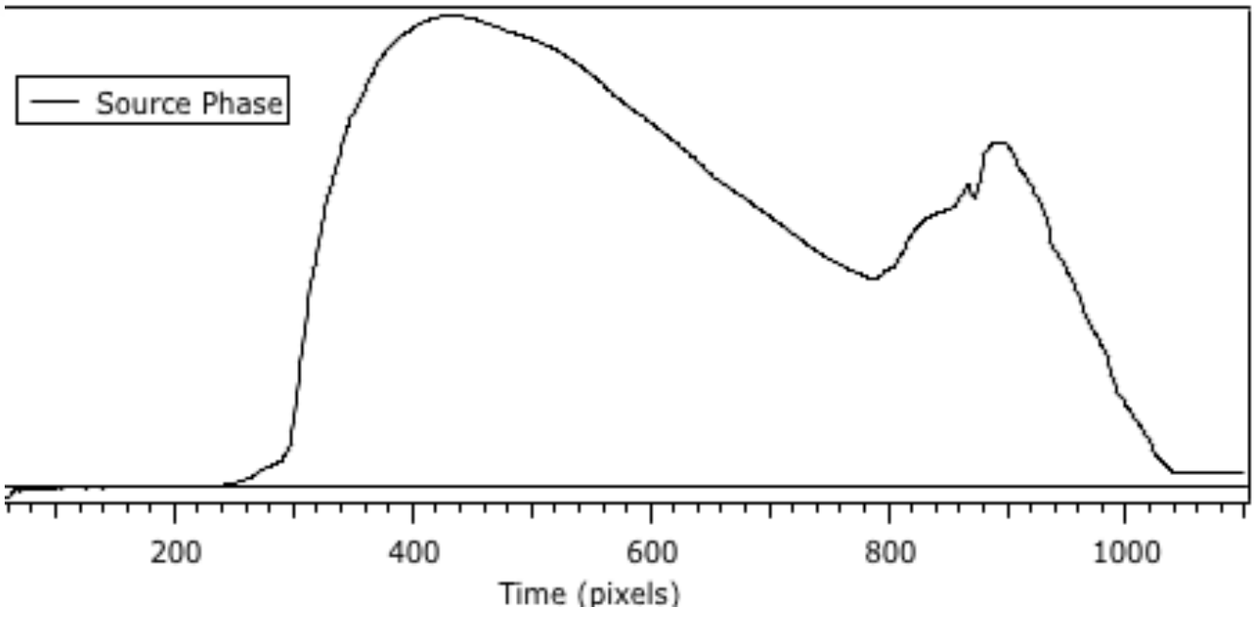
Off center portions create wavy errors in phase

Comparison to FFT technique (simulated data)

Blue: SpeckleAdaptive Red: FFT







Use on *actual* data indicates it can handle noisy and **difficult** data well

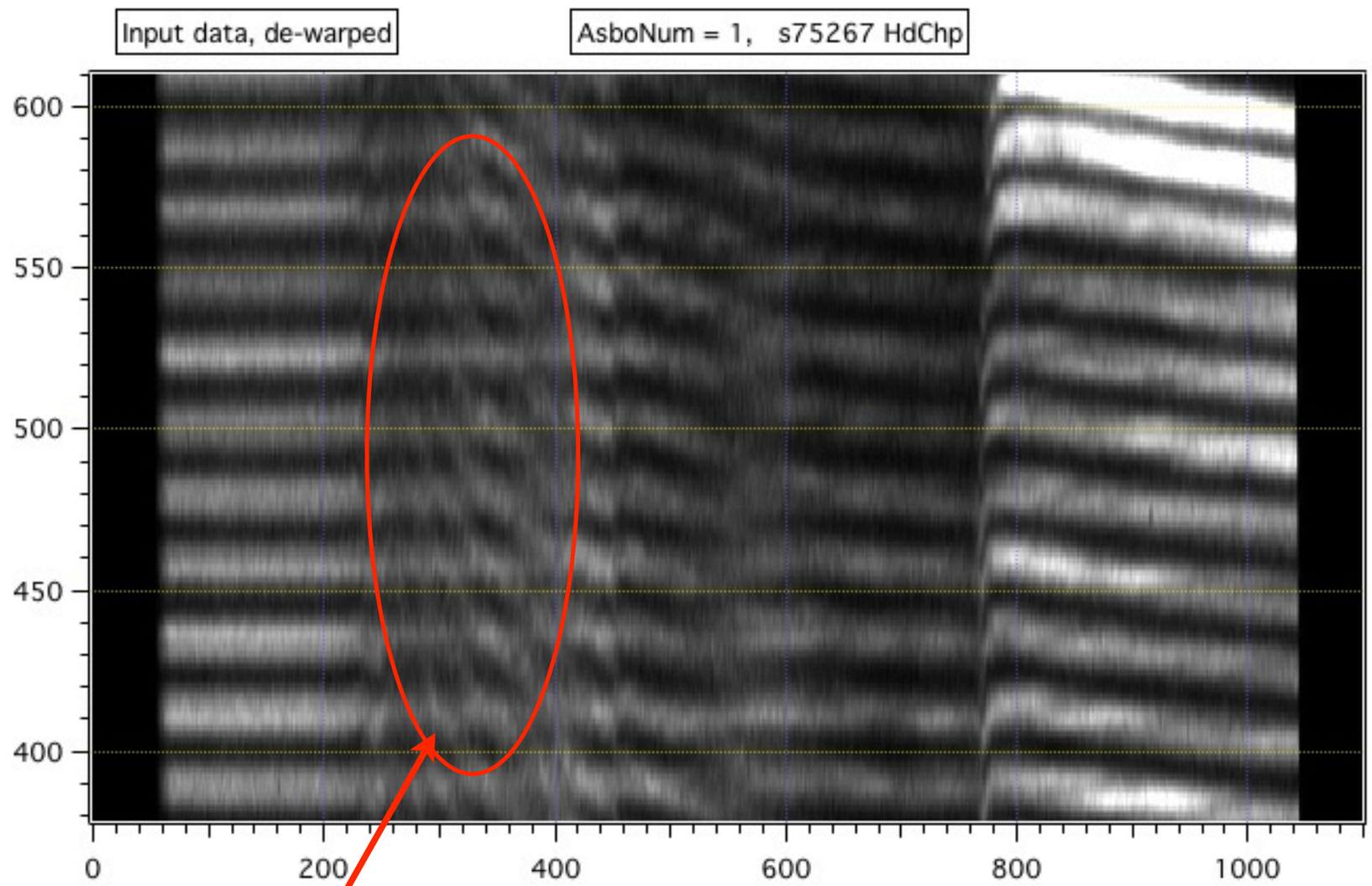
Having drop-outs or limited available Y-cycles

In worst case, the SpeckleAdaptive is same accuracy as FFT, i.e. you can't hurt yourself by using it

(Starting assumptions of constant visibility etc are equivalent to FFT method)

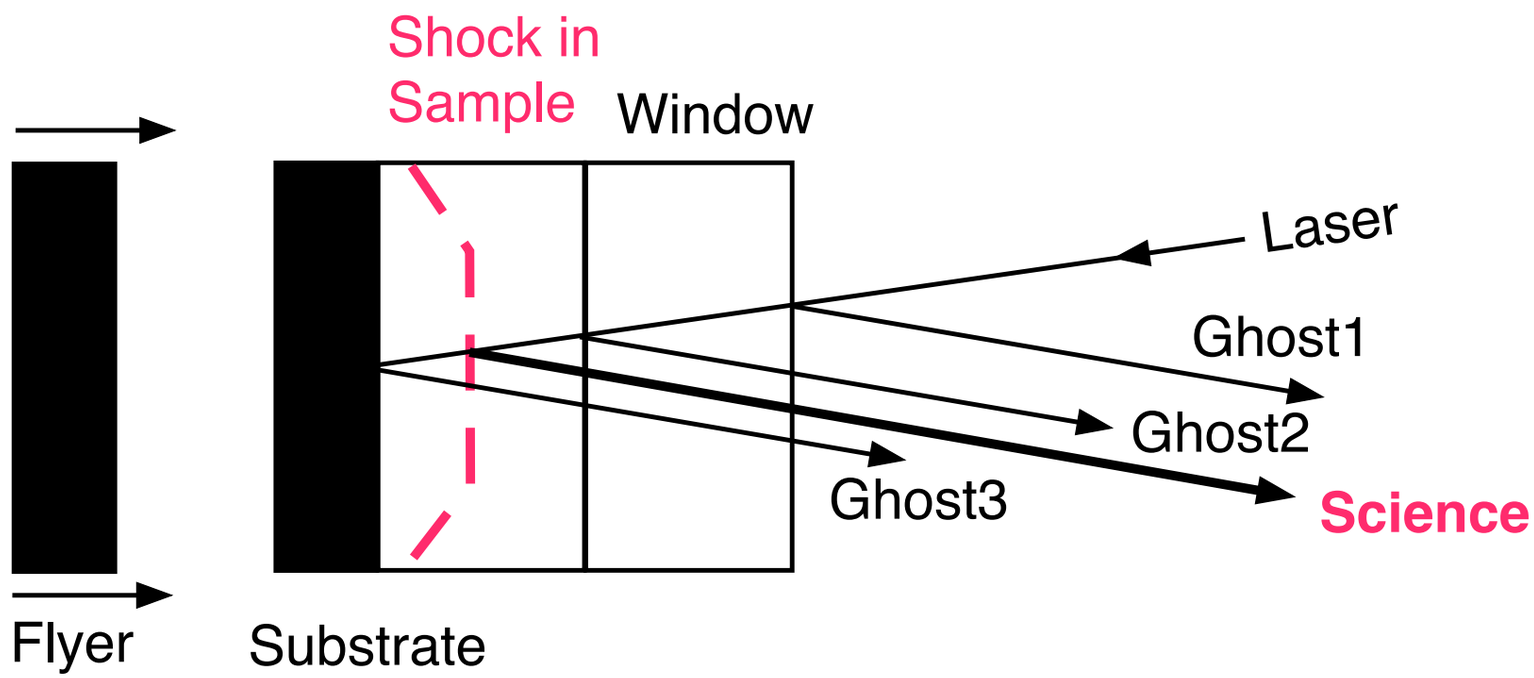
Switch topics

Ghost artifact reflection subtraction crucial for accurate VISAR analysis

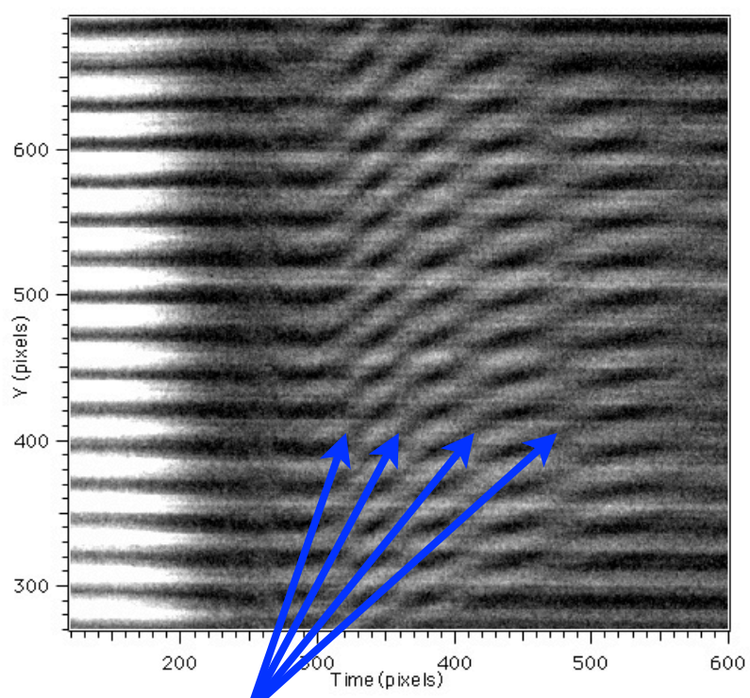


Signal (sloping portion) is weaker than ghost (steady portion)

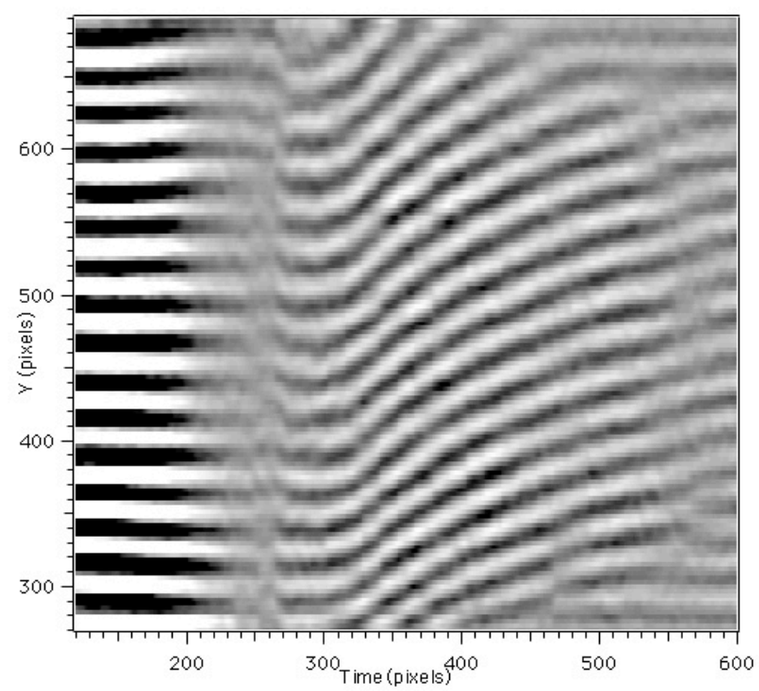
Ghost artifact removal on VISAR data: Vector Offset method



Raw data



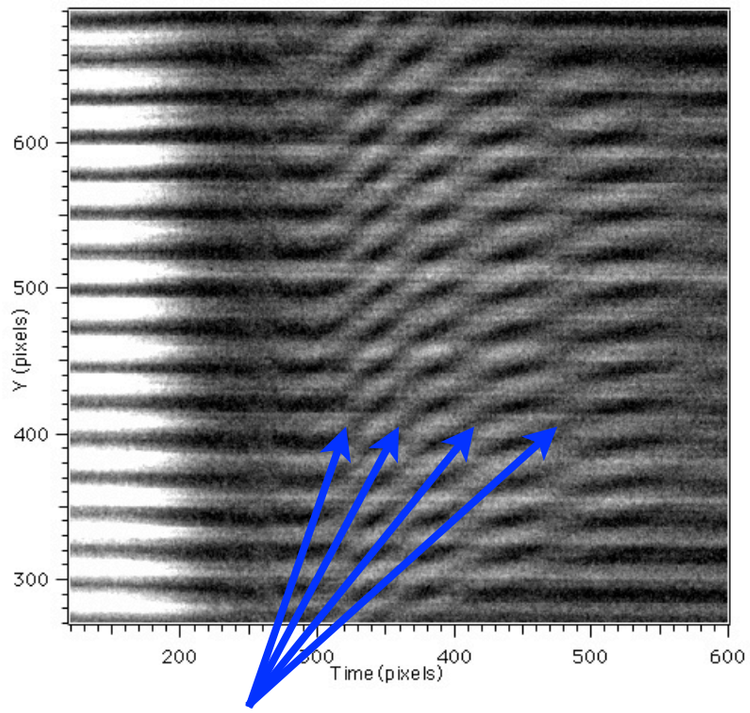
Ghost removed



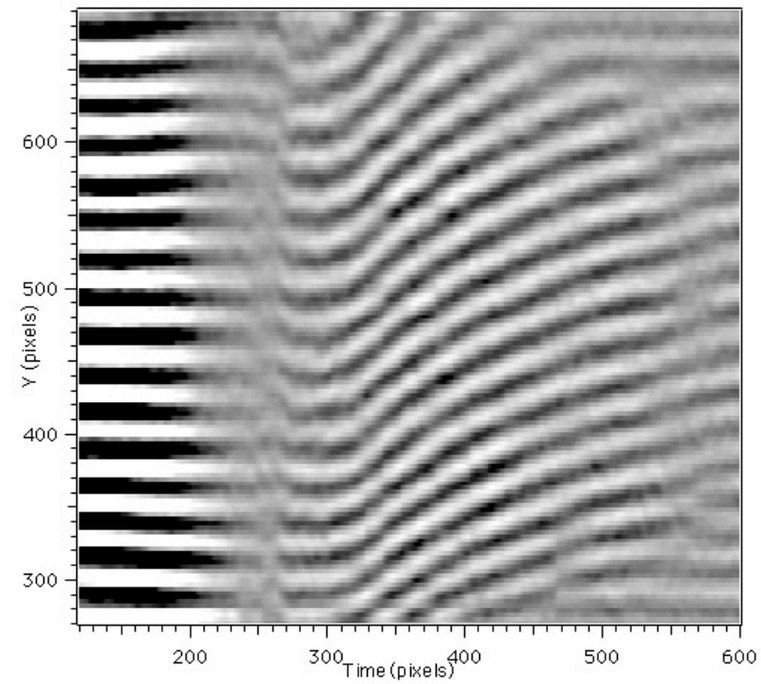
Beats between stationary and changing fringes

Vector Offset presentation most useful

Raw data

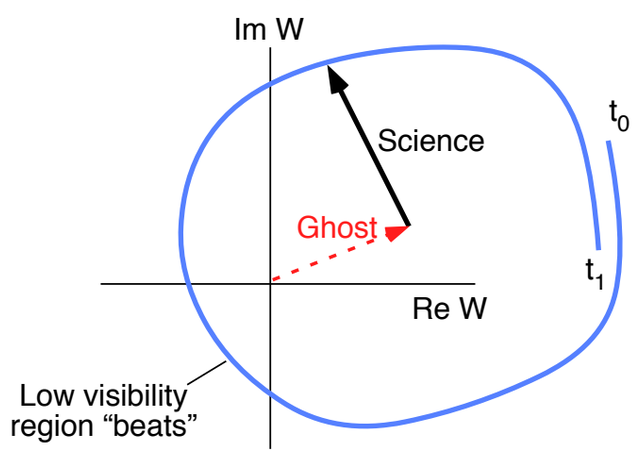


Ghost removed

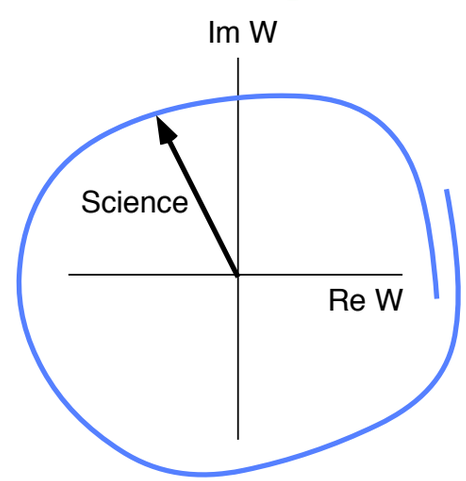


Beats indicate ghost presence

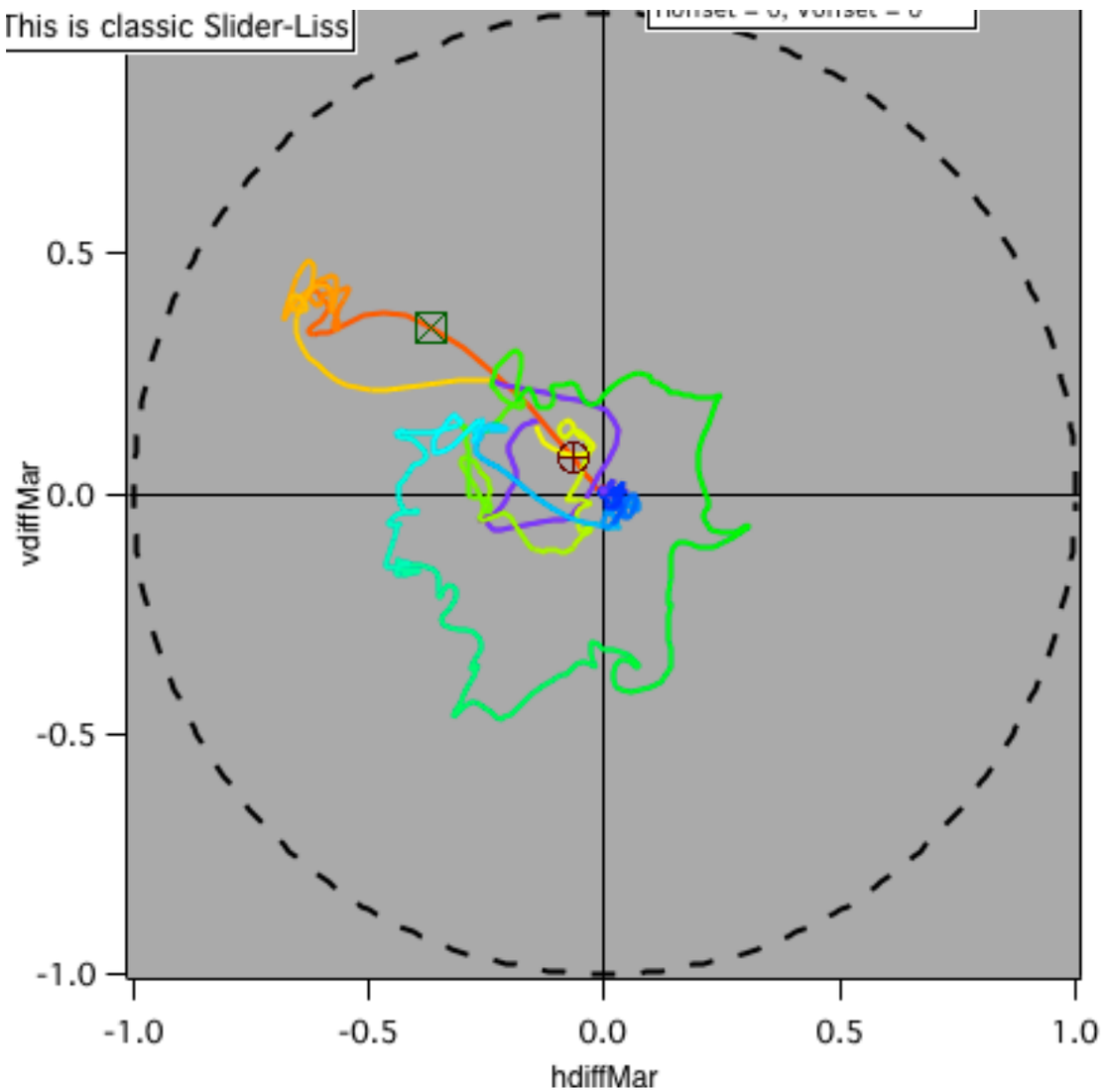
Lissajous offcentered due to ghost



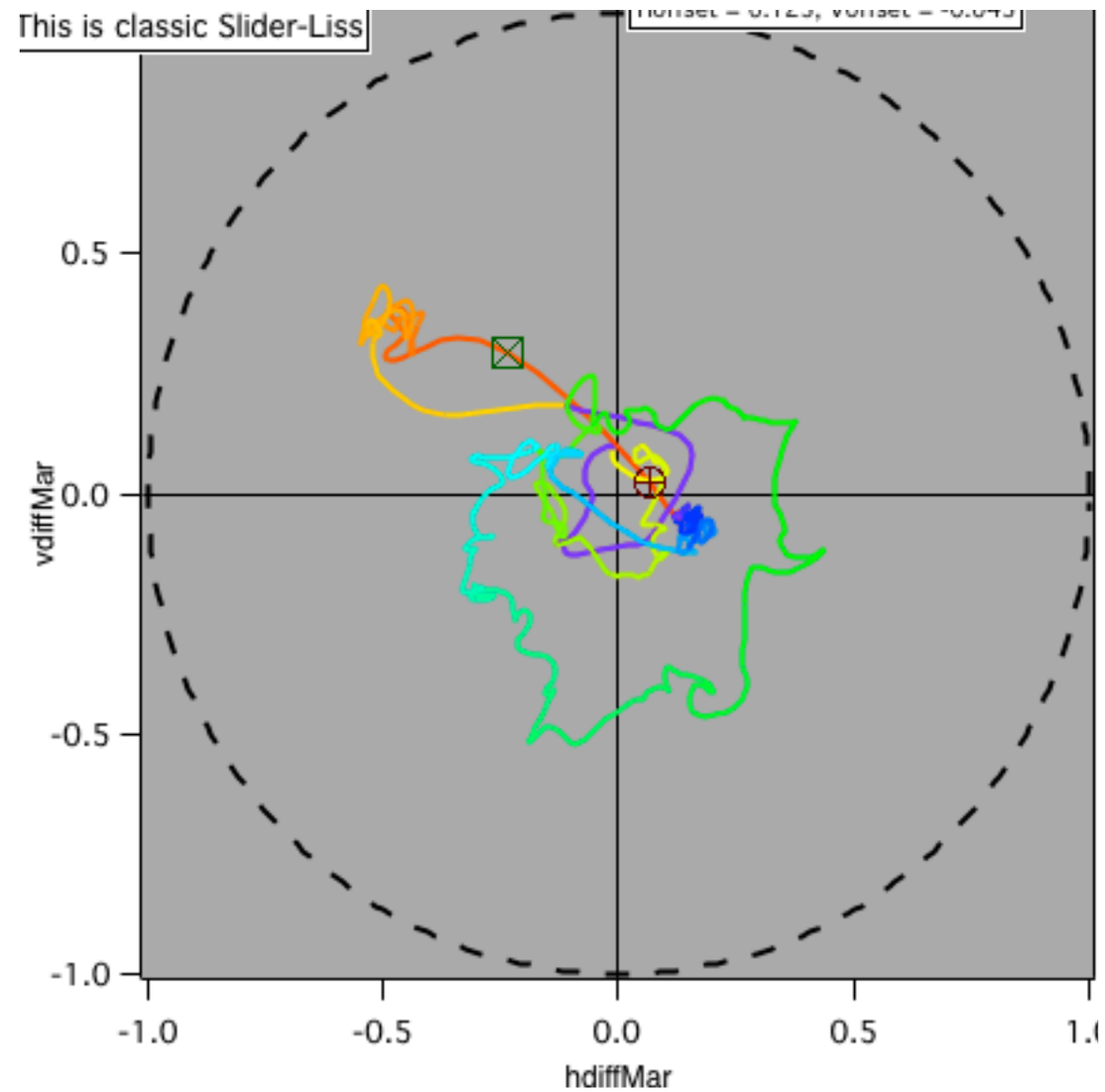
Shifting the Lissajous removes ghost



Original
(purple loop not centered)

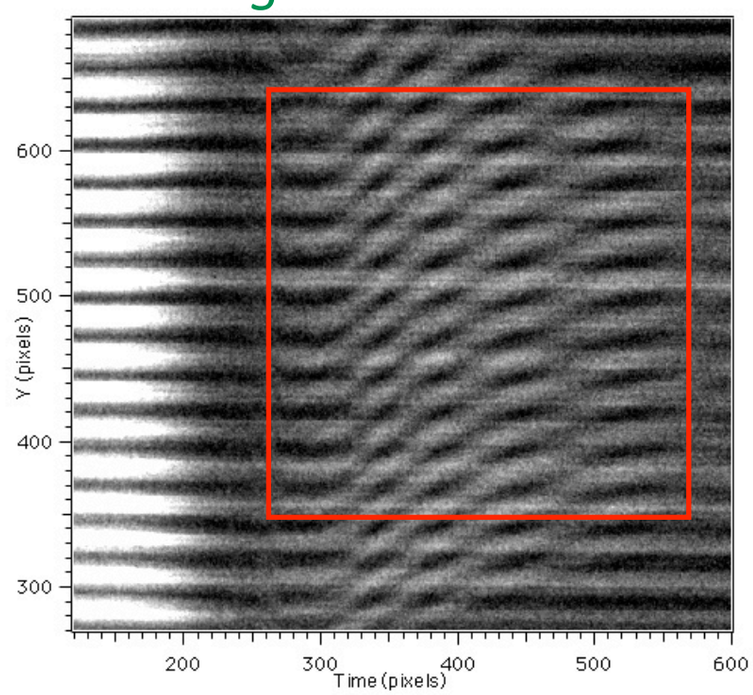


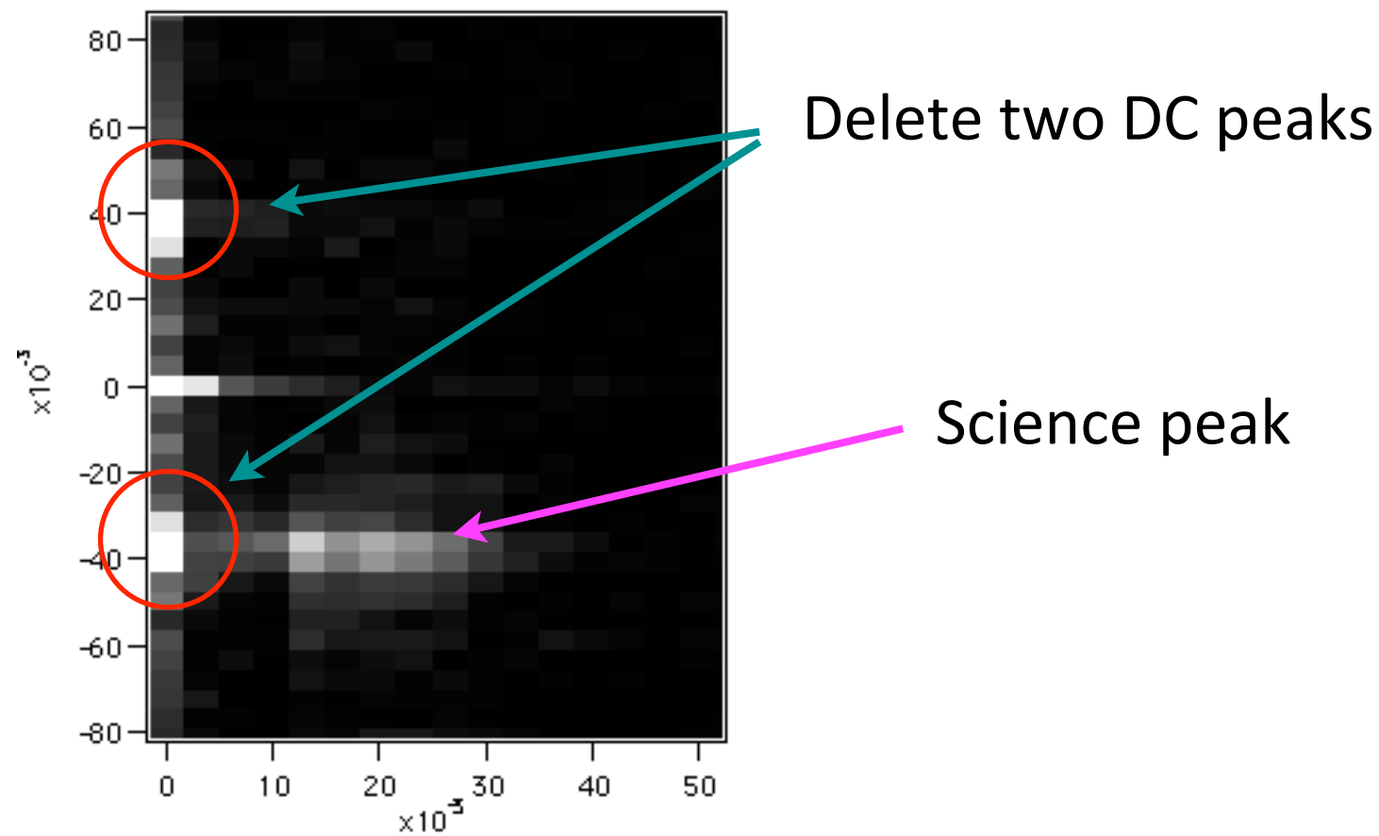
After offset



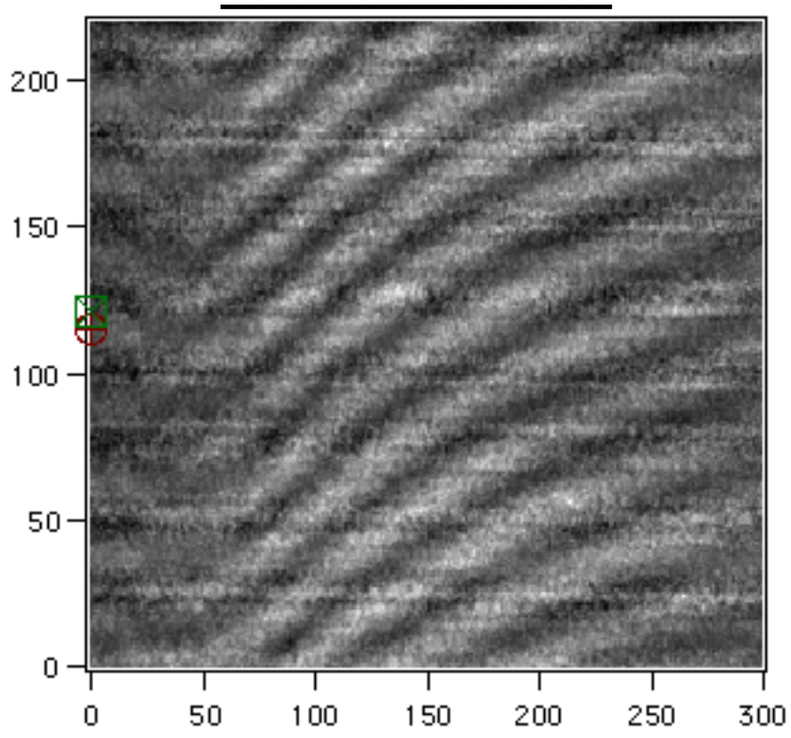
Prior Method: Deletion of stationary peaks in FFT

Large etalon VISAR



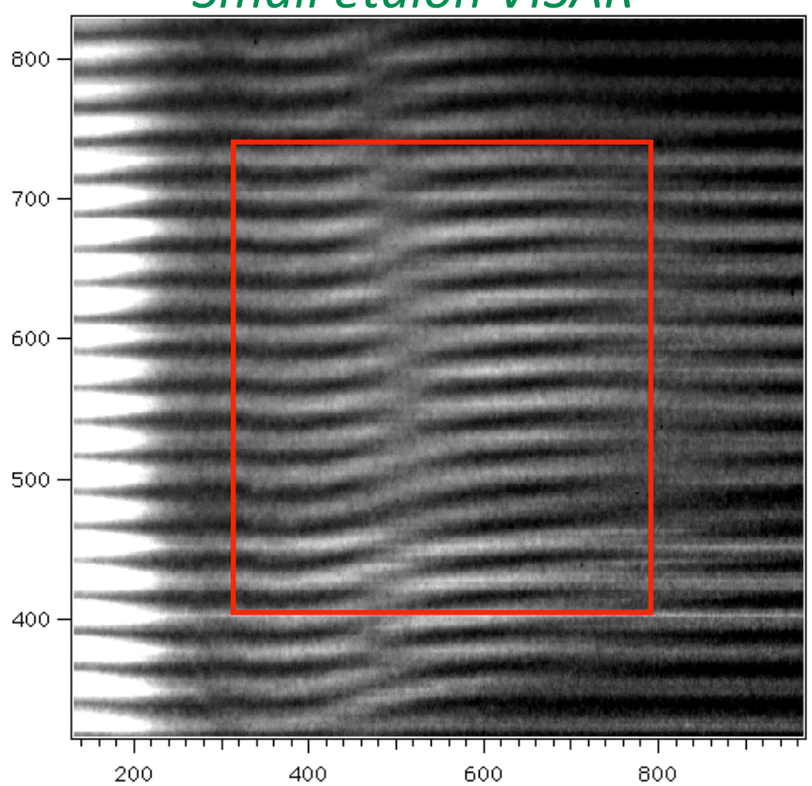


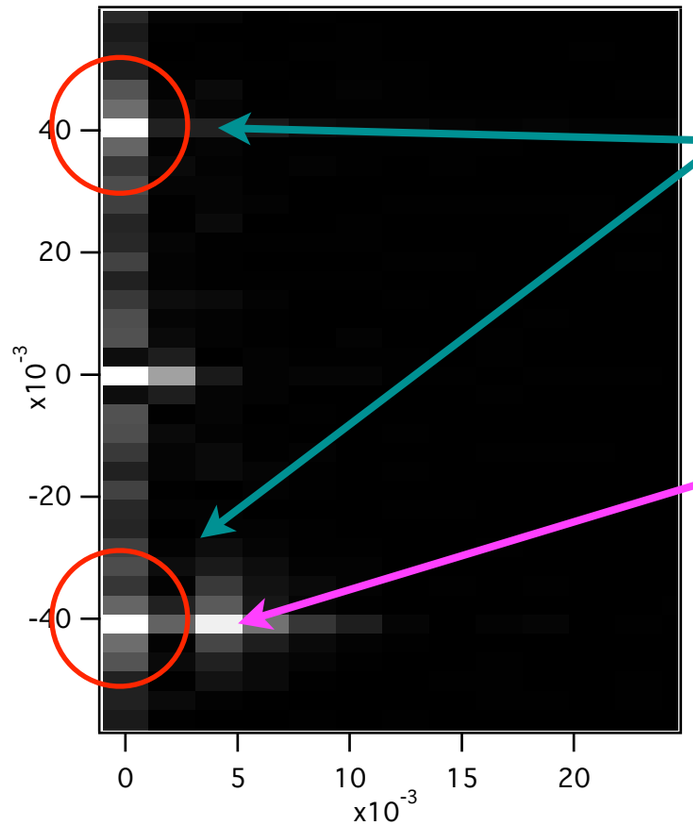
Cleaned result



Imperfect deletion: slower changing science signal

Small etalon VISAR

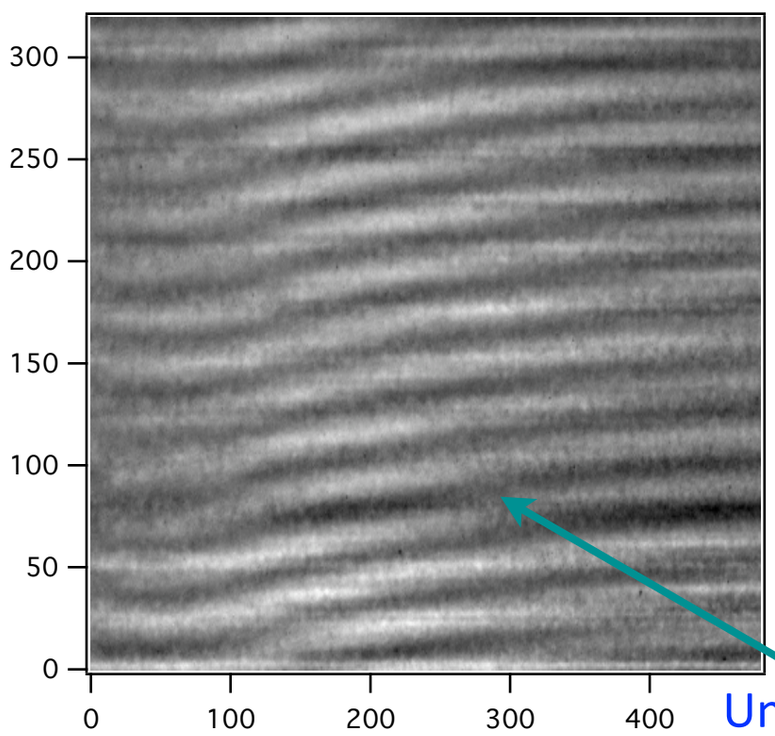




Delete two DC peaks

Science peak

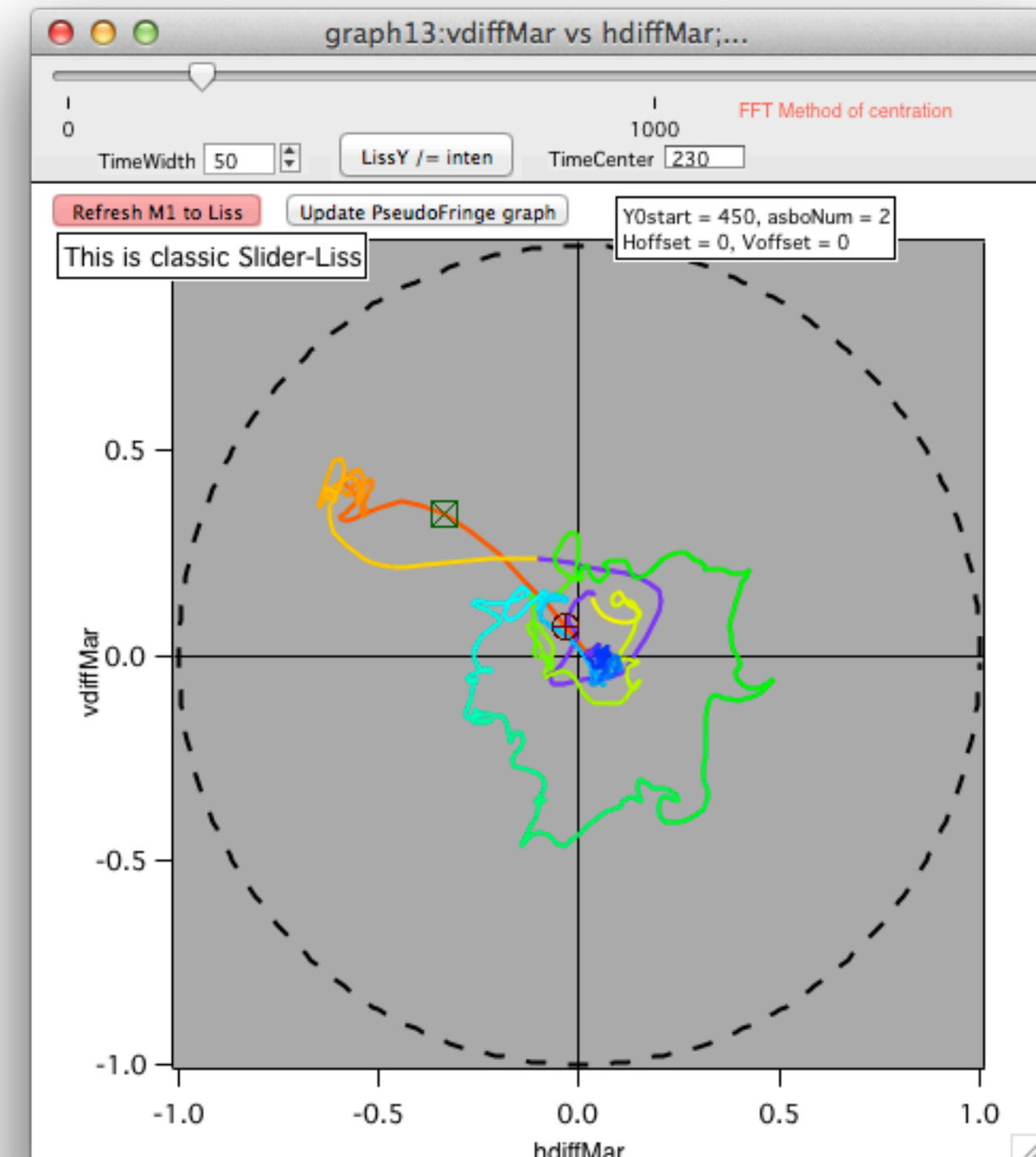
Cleaned result: so-so



Unevenness

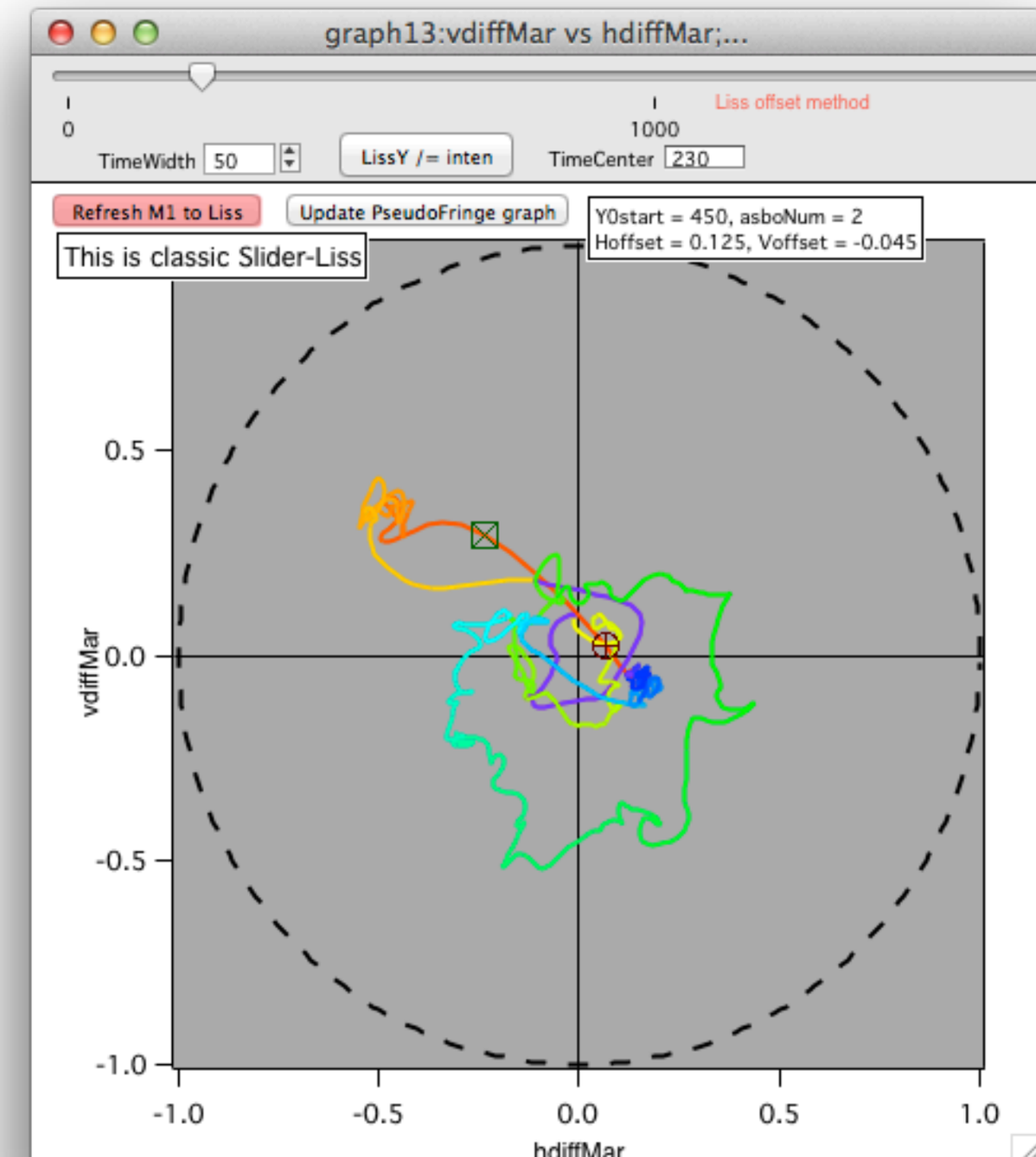
Problem2: FFT not quite the same as offsetting

FFT deletion of low freqs

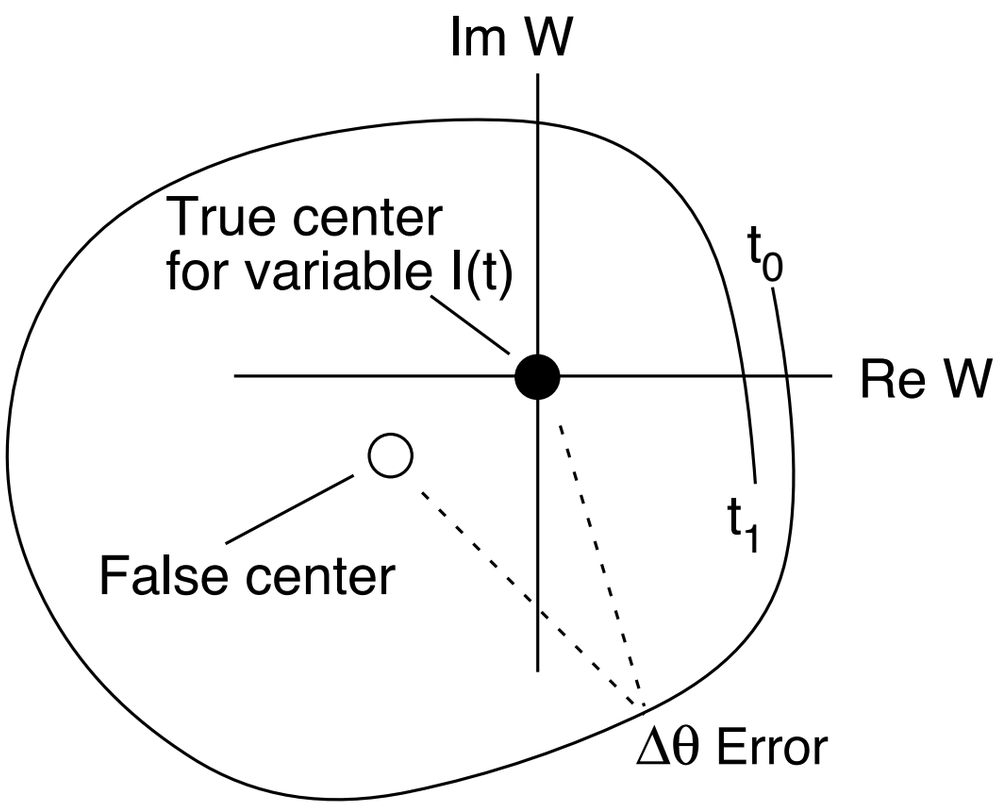


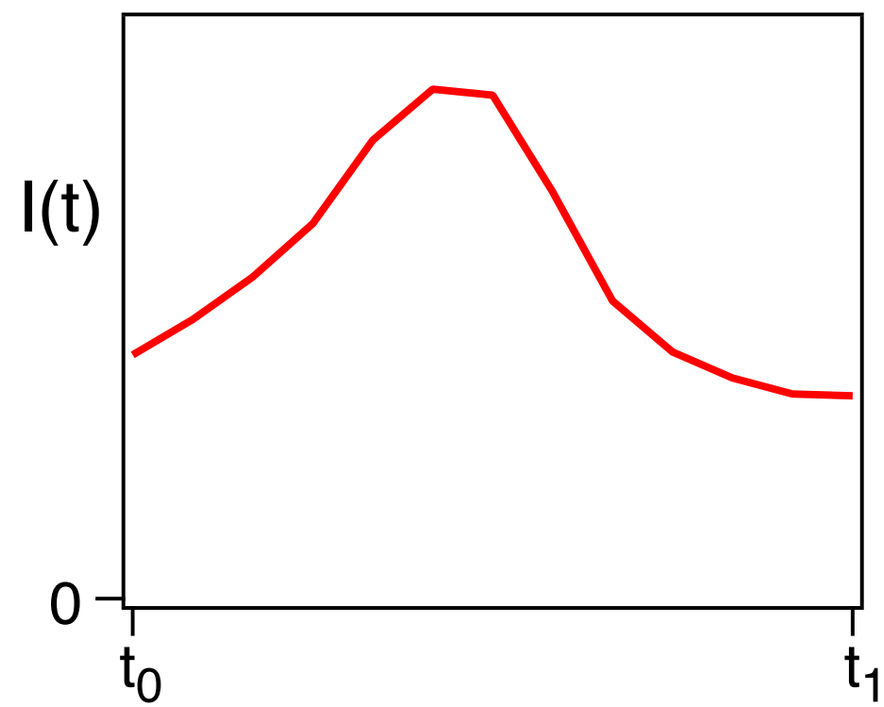
Problem2: FFT not quite the same as offsetting

Offset method



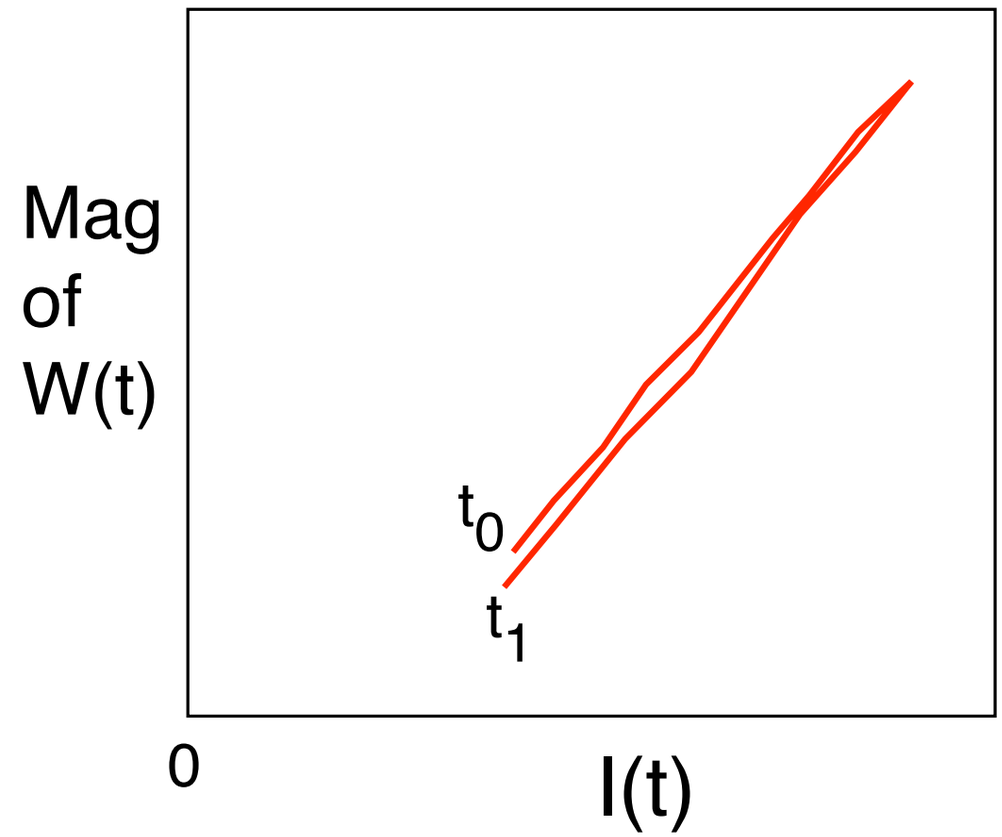
Problem3: changing reflectivity or laser intensity distorts average position (false center)

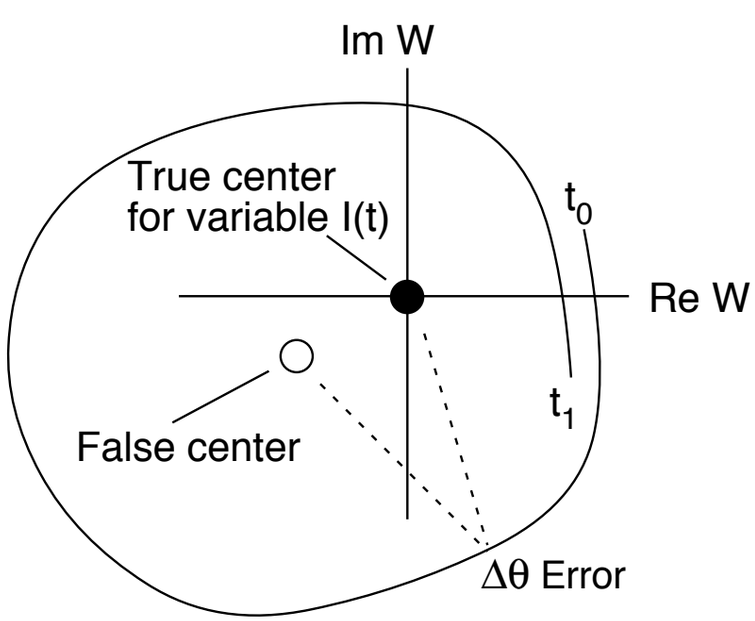


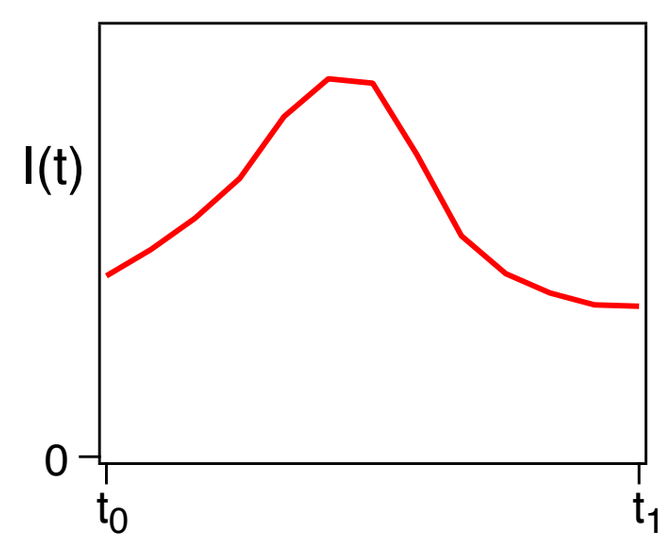


Solution: **require visibility vs intensity to be linear**

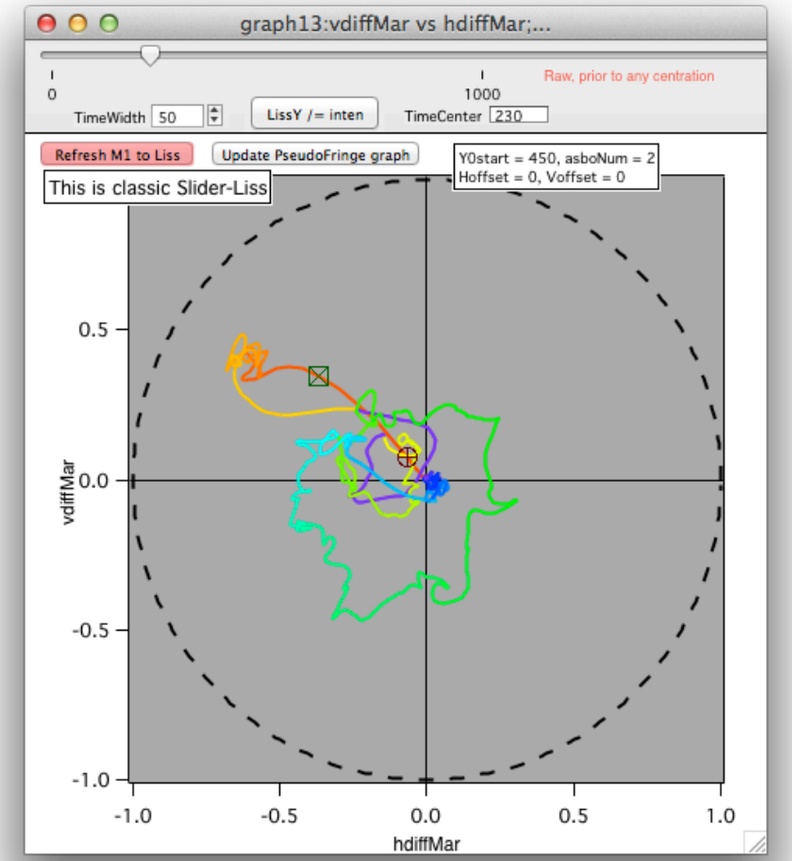
The true center is found by **maximizing linearity** between Lissajous magnitude vs intensity as various vector offsets are tried



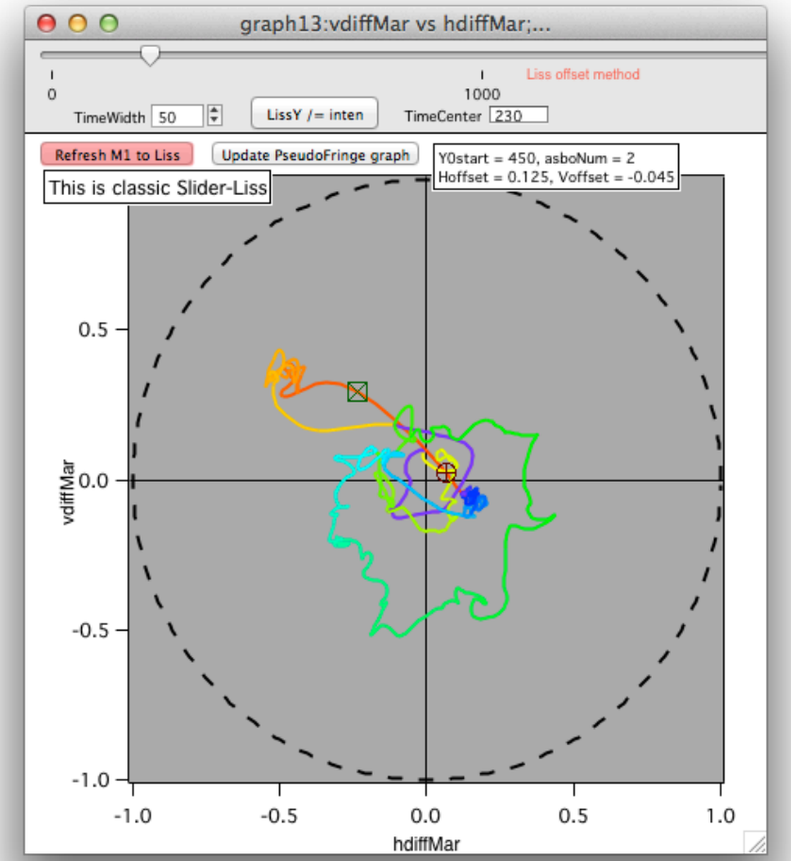


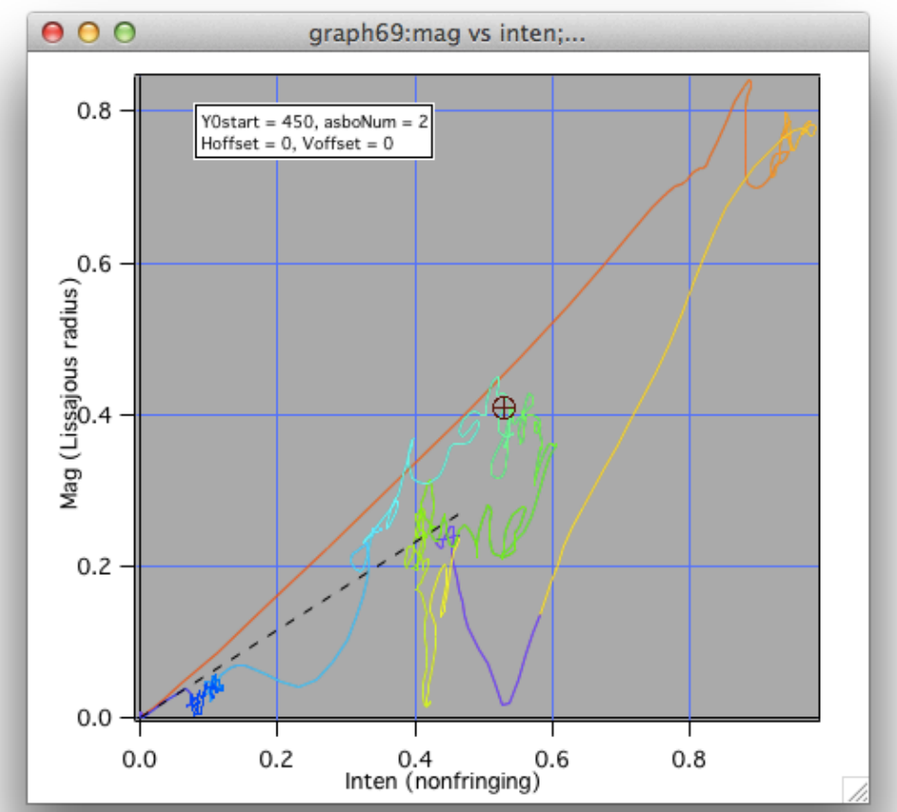


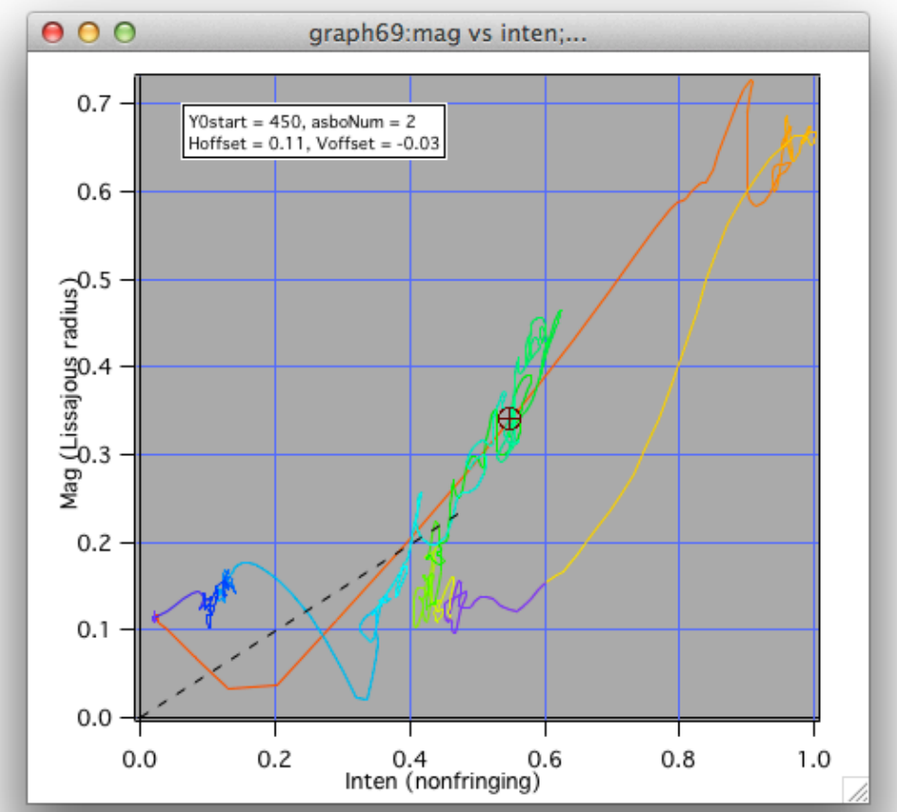
Original with ghost



After vector offset



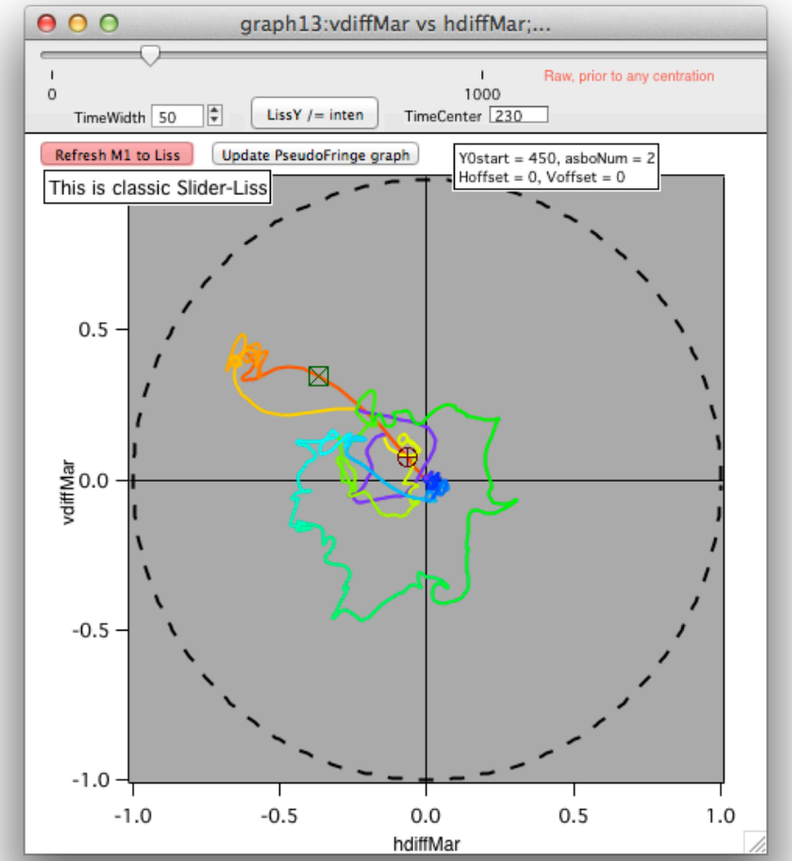




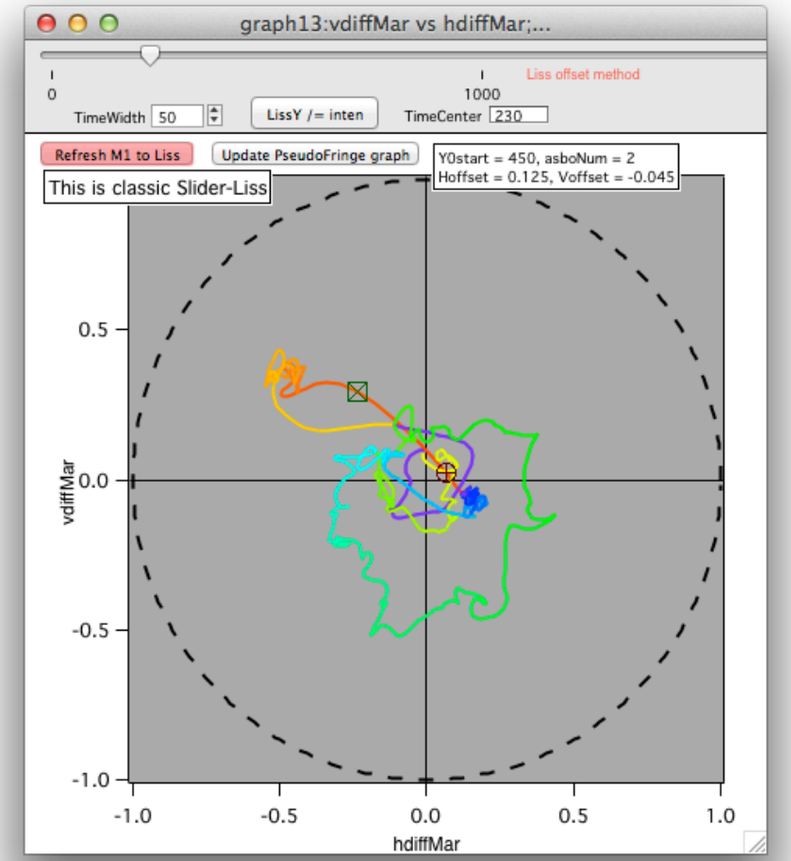
Green and purple sections now either follow along a line, or have tight Y-deviation, indicating good centration.

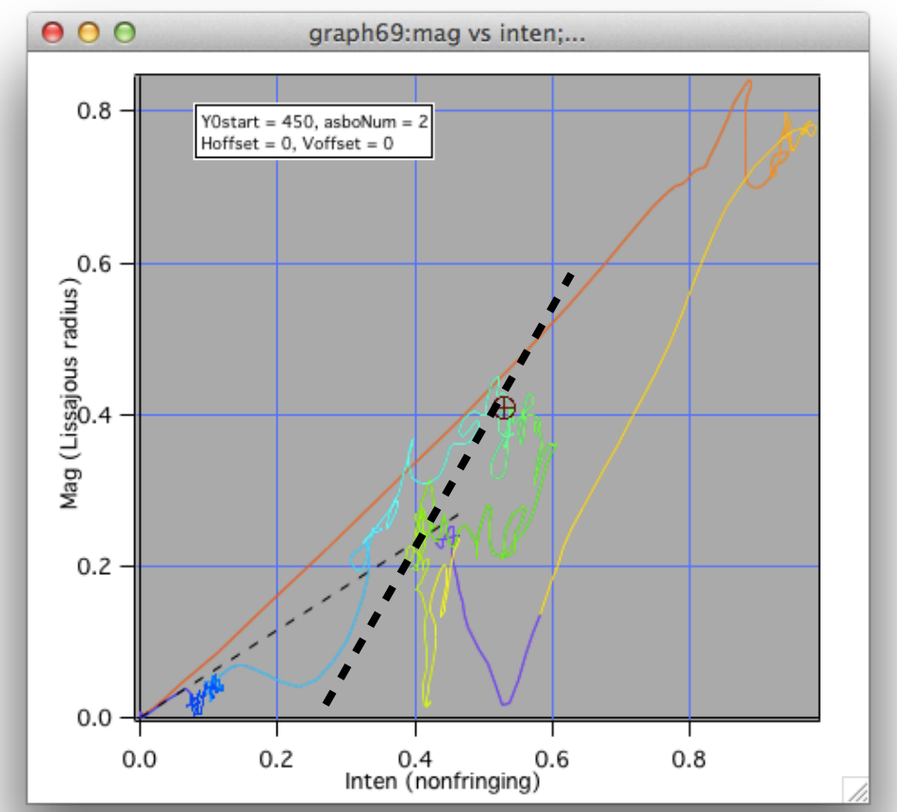
X-offsets can be due to target incandescence

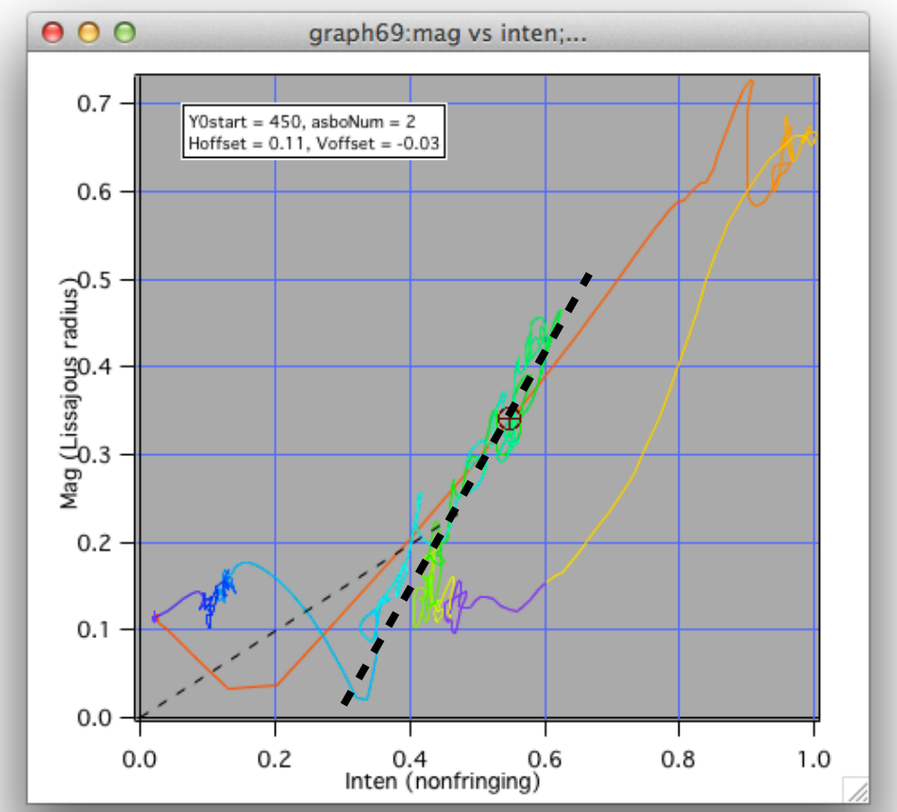
Original with ghost



After vector offset



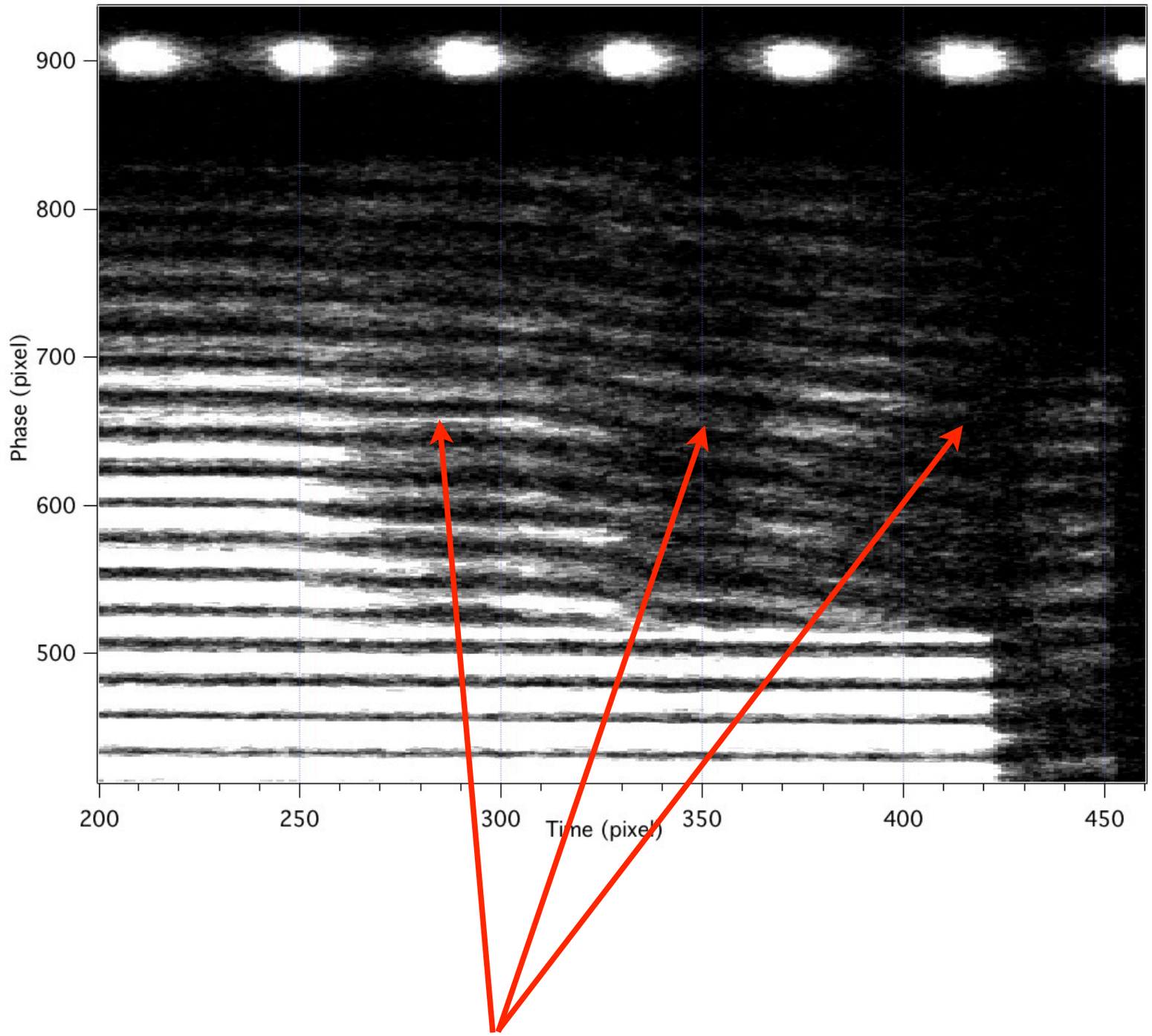




Green and purple sections now either follow along a line, or have tight Y-deviation, indicating good centration.

X-offsets can be due to target incandescence

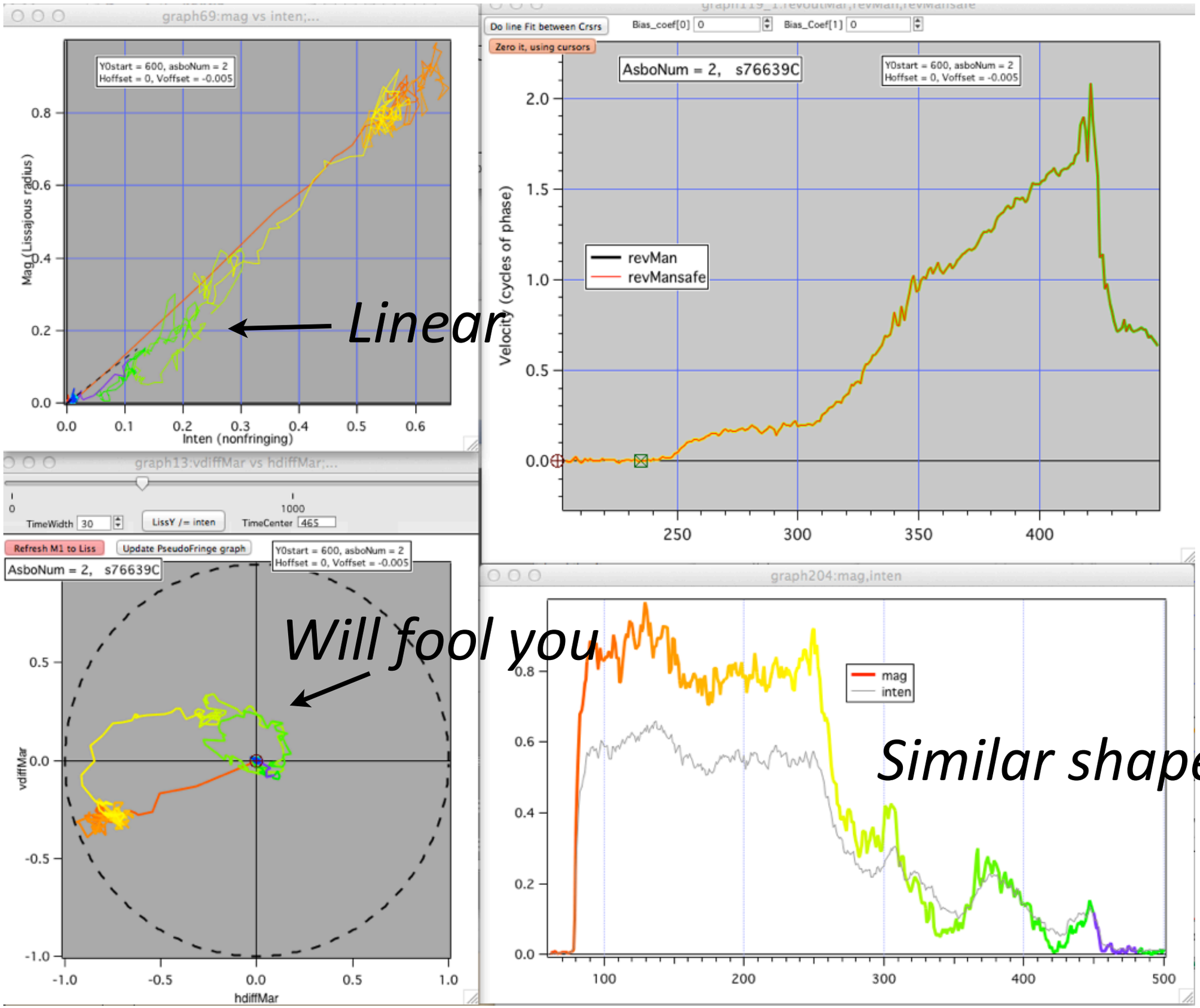
Example data that can confuse FFT method



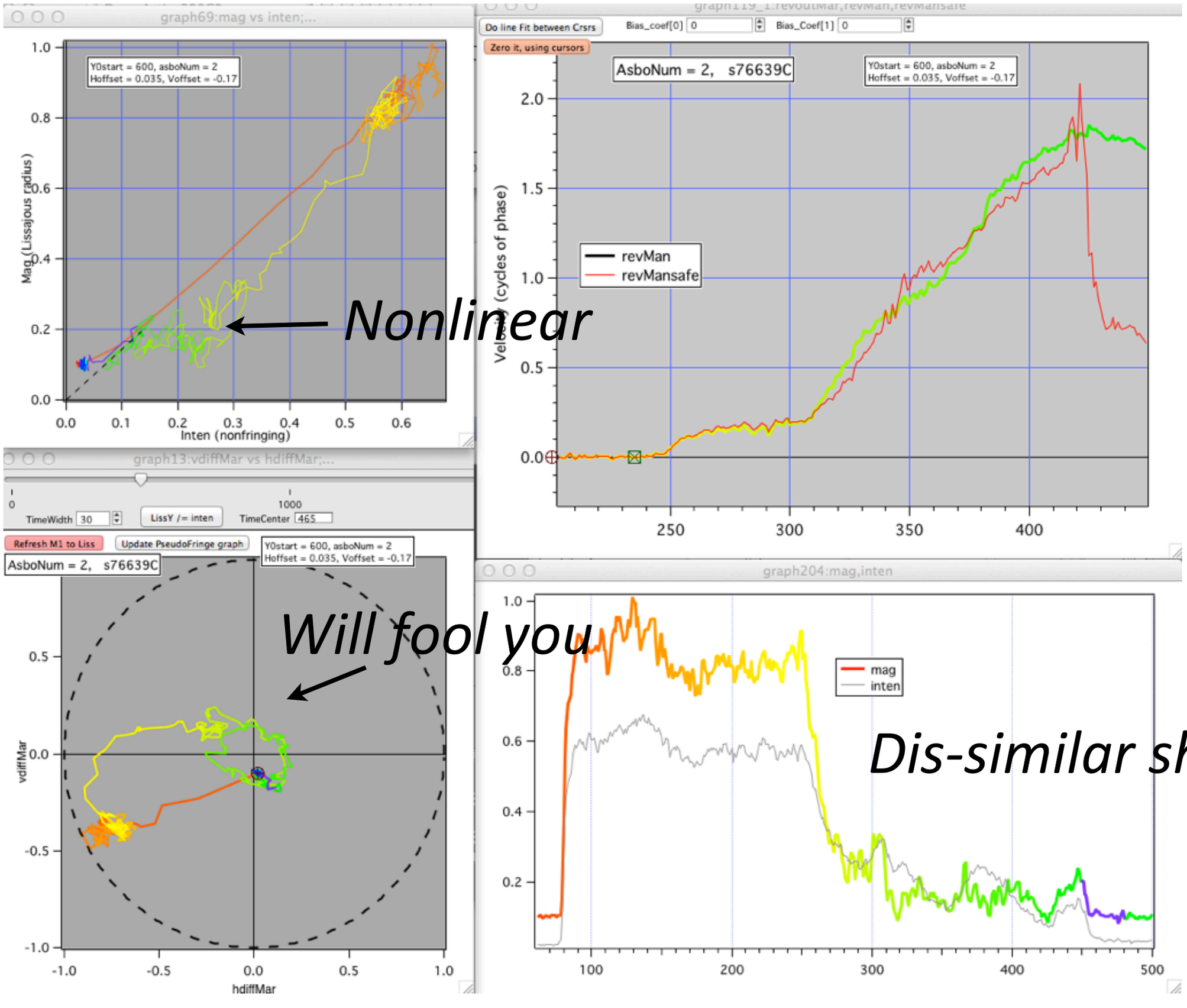
We see beats, right?

As found, "Centered" (although it doesn't look it)

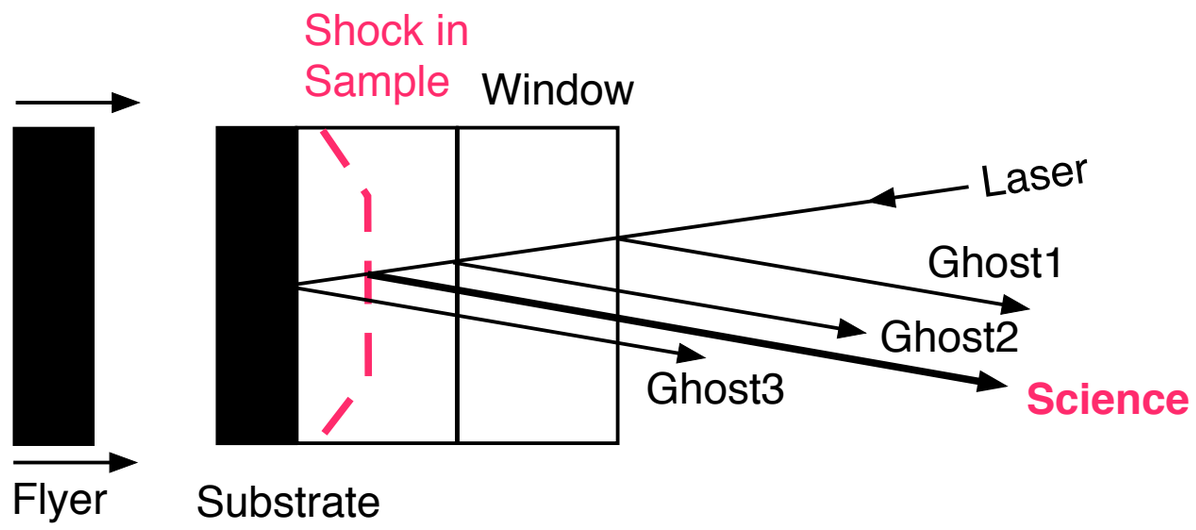
No ghost present!



“Centering” the loop would be wrong, in this case

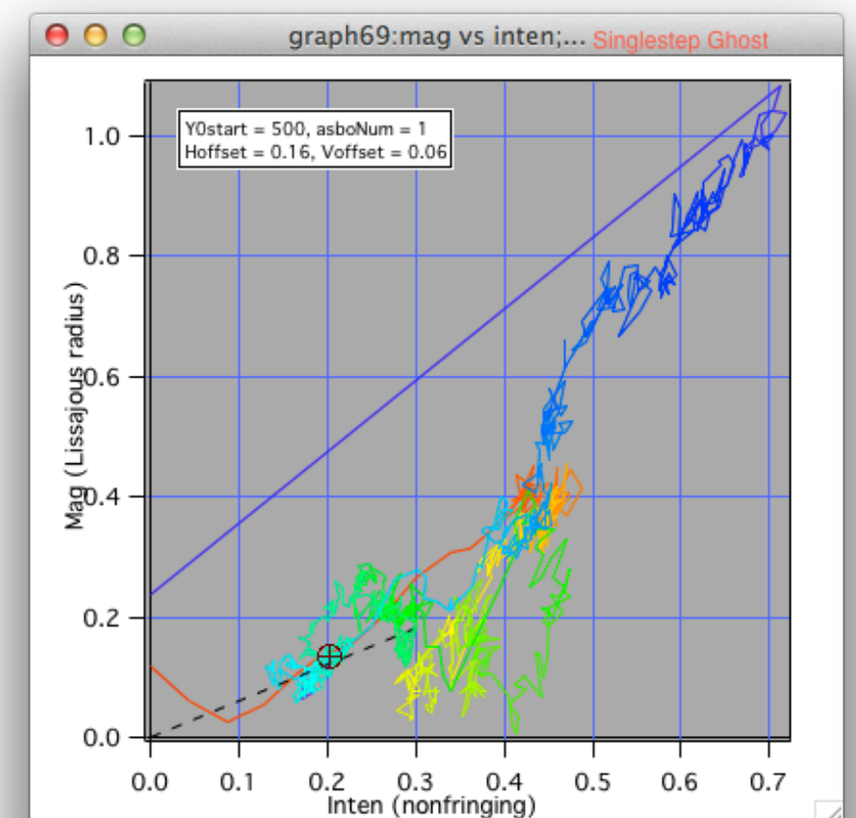


Multi-layered targets can have multiple ghost reflections

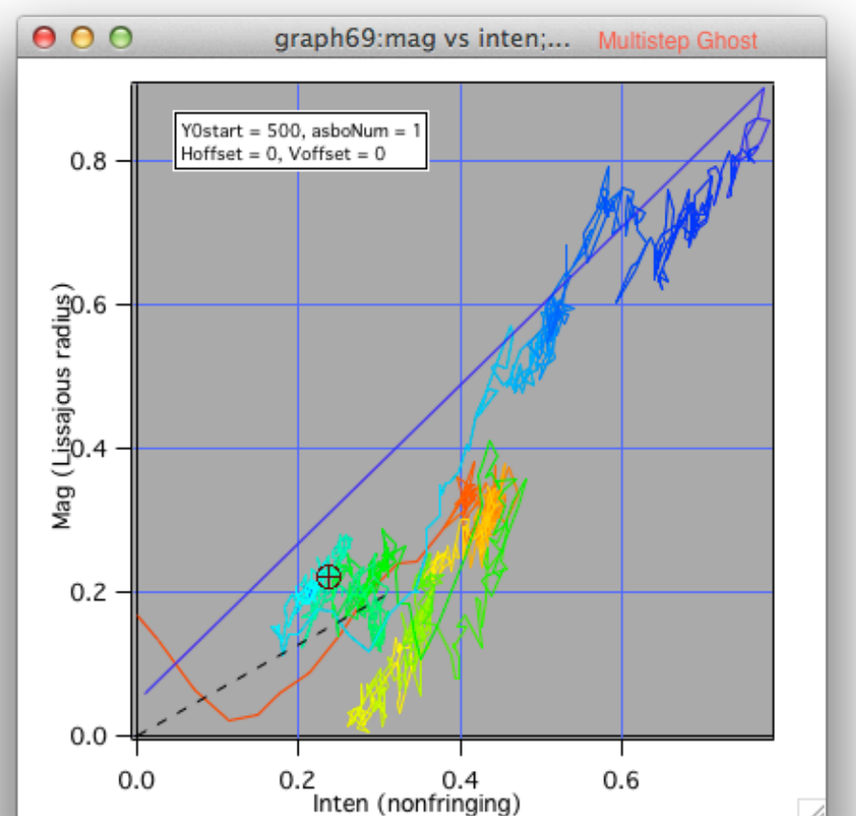


Shock turns off different reflections at different times

Single offset

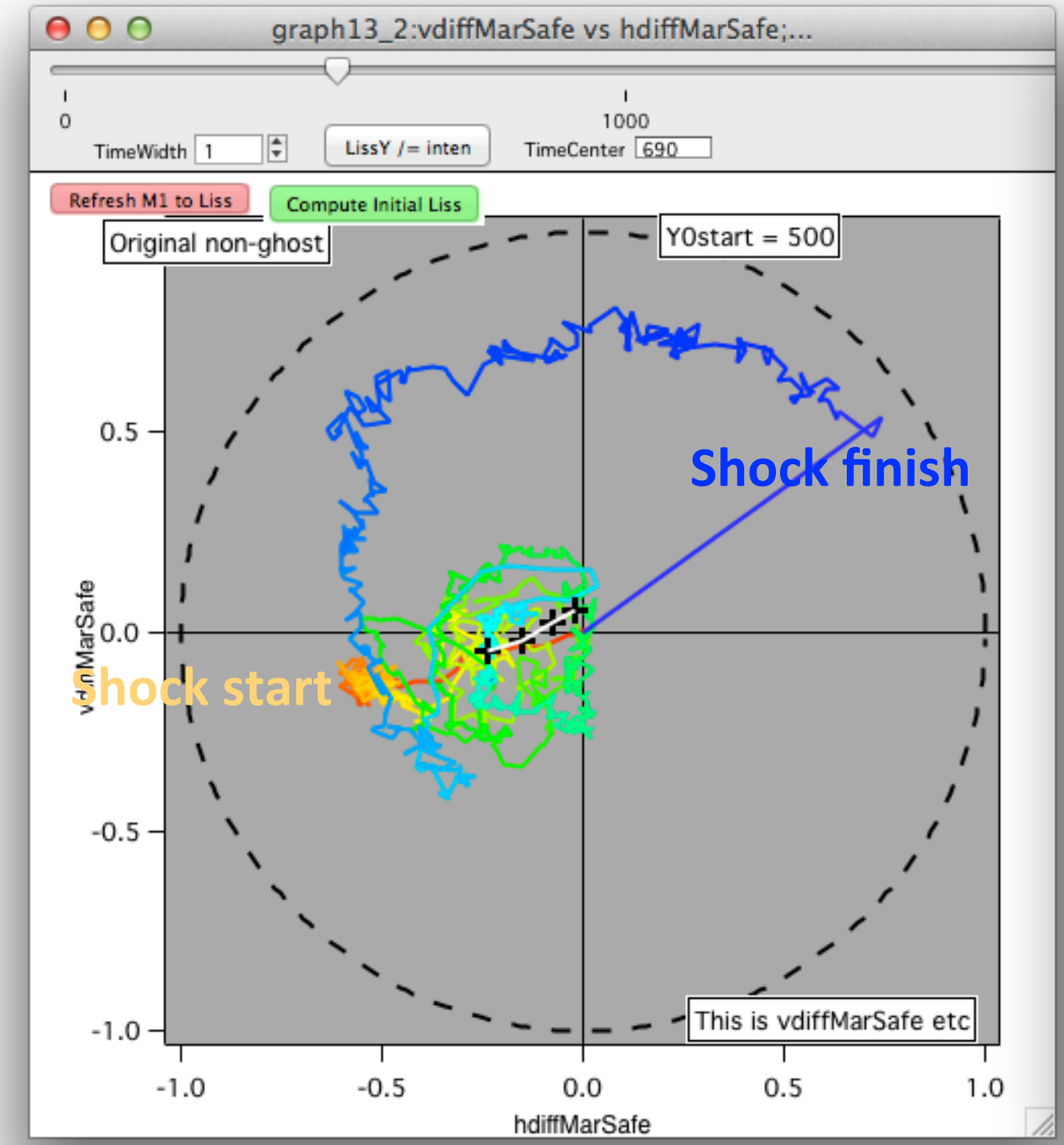


Multiple offset

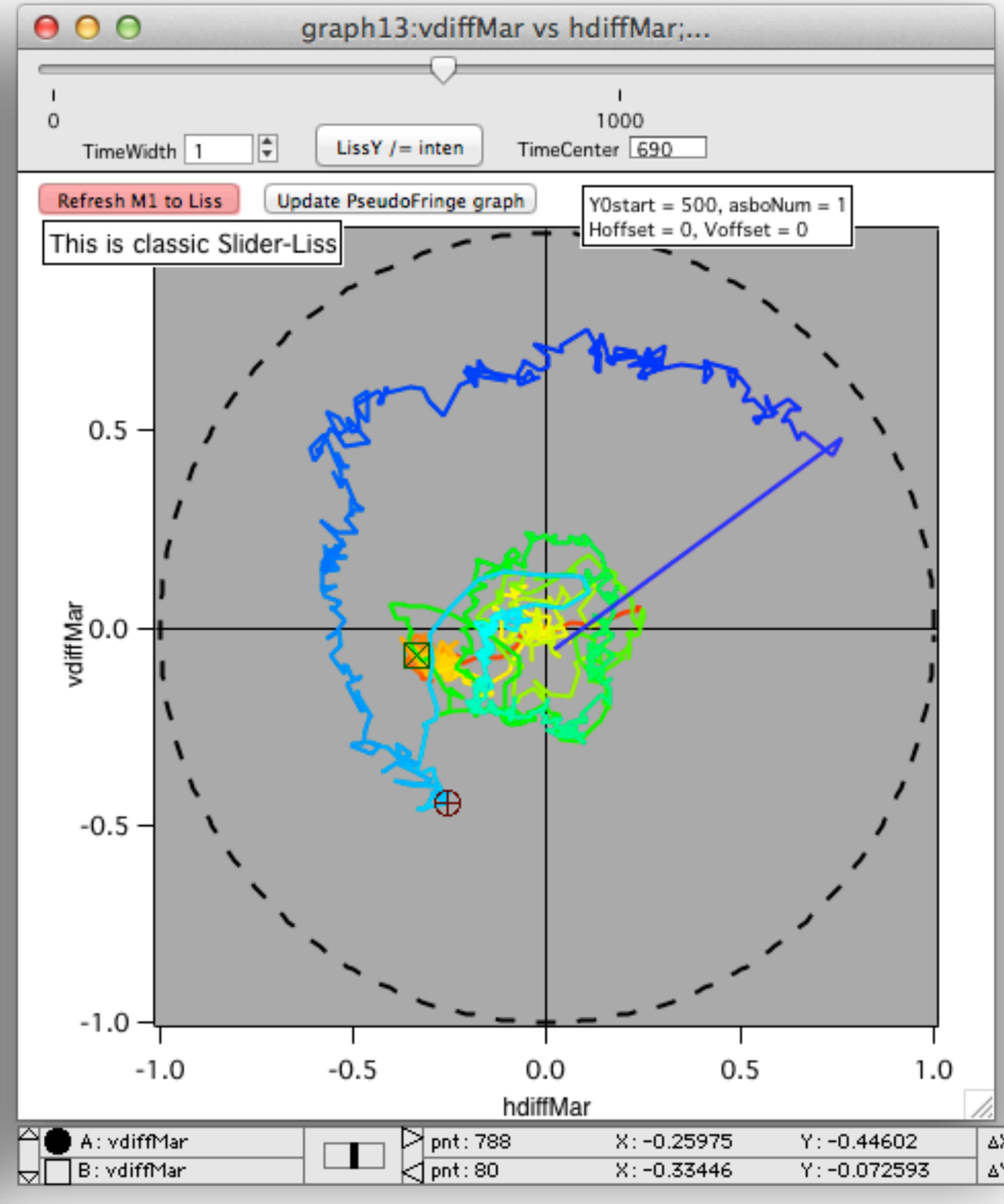


Multi-step offsetting sometimes needed.
Shock turns off different reflections at different times

Before



After



End