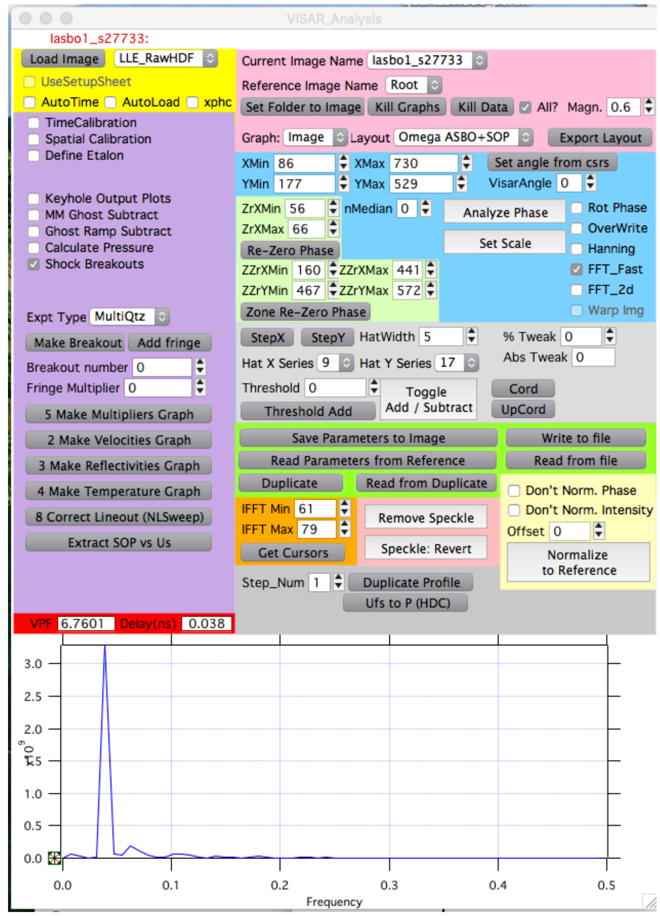
VISAR ANALYSIS

<u>This wiki is intended to provide a space to share code, report bugs and improvements to our VISAR and SOP analysis Igor code: AnalyzeVISAR</u>

Please Contact Marius Millot millot1@llnl.gov - with AnalyzeVISAR in the subject for request or questions.

Please take the time to log bugs and issues on the Bug Page !



<u>Terms of Use - Acknowledgments</u>

- This code was originally developed by Jon Eggert (JHE), includes algorithms and methods from Peter Celliers (PMC) and Damien Hicks (DH) and contributions by multiple people in the LLNL group, including Stewart MC Williams, Marius Millot (MM), Dayne Fratanduono, Suzanne Ali and others...
- I (MM) have been maintaining and updating it for a few years now ...
- This is an always evolving code.
    - Suggestions for improvements are very welcome.
    - Please report bugs and errors... it is likely others have had/ may experience similar issues.
- **If you use this code to analyze data , I would appreciate if you could acknowlede it in your papers, presentations, posters, ... for example using a sentence similar to**
    - **LLNL's AnalyzeVISAR code was used to analyze (Part of) the VISAR (and SOP) data.**

<u>Current Pages:</u>

- Getting started and Igor Routine Files
    - File lists
        - AV - Analyze Visar Change Log Page
        - Files for AV - Analyze Visar
- Keyboard Shortcuts
- Tutorials
    - Fit and Extrapolate Velocity in decaying shocks with vanishing reflectivity
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    - NIF Quartz Decaying Shock Tutorial
    - Use Make Reflectivities Graph
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- Understand the structure of the VISAR_Analysis Panel
    - Load an image
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    - Time Calibration
- Update Log
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Getting started and Igor Routine Files

AnalyzeVisar runs in Igor so that learning Igor basics is highly recommended. Igor has great documentation.

Igor runs in both Mac and PC environments, but used to run much better in Mac.

Most detailed file manipulation description on this wiki will be for Mac.

Windows procedure are at the bottom of the page

THE IGOR PROCEDURES AND RELATED FILES ARE AVAILABLE HERE or by navigating to Files for AV - Analyze Visar

Igor basics file structure and compiling.

- Do NOT put your own routines in the **Igor Pro X.x folder** it as it will get erased when you update Igor.
- Instead, put your files and AnalyzeVisar files in the other **User Files Folder** located in a **Wavemetrics** Folder in your **Documents** folder: For example **/Documents/WaveMetrics/Igor Pro 6 User Files**
- In this folder, you will find 4 folders **Igor Procedures, User Procedures, Igor Help Files** and **Igor Extensions**.
- When you open Igor, it will load all the procedures in the **Igor Procedures** folders and compile them.
- To open procedures within a current Experiment, you will need to **#include** command.

Mandatory Files and Initial Setup for MAC

You will need several procedures and files installed in the **User Files Folder** to run AnalyzeVisar.

1. Install Multipeak XOP: (**not necessary for Igor8**)
    1. Make an alias (Mac OS X) or shortcut (Windows) for the following file: **/Applications/Igor Pro 6.3 Folder/More Extensions/Curve Fitting/MultipeakFit.xop** or **/Applications/Igor Pro 7 Folder/More Extensions/Curve Fitting/Obsolete/MultiPeakFit.xop**
    2. Move the alias or shortcut into the **Igor Pro 6 User Files\Igor Procedures** folder
2. Install the HDF 4 Loader XOP (to read Omega data) :
    1. Get the file **HDF Loader.xop**
        1. If you use Igor 6 go to: **/Applications/Igor Pro 6.3 Folder/WaveMetrics Procedures/File Input Output/**
        2. If you use Igor 7 go to: http://www.igorexchange.com/node/8035
        3. If you use Igor 8 go to: **/Applications/Igor Pro 8 Folder/More Extensions (64-bit)/File Loaders/HDF Loader-64.xop**
    2. Make an alias and put the alias in the **Igor Pro XX User Files\Igor Extensions** folder
3. Install the HDF5 browser : See Igor Help (copy below)

Installing The HDF5 Package

Installing HDF5 requires activating two files - the HDF5 XOP file and the "HDF5 Browser" procedure file - by placing aliases (*Mac OS X*) or shortcuts (*Windows*) for them in special folders.

1. From the Help menu, choose "Show Igor Pro User Files".

   This displays the Igor Pro User Files folder on the desktop:

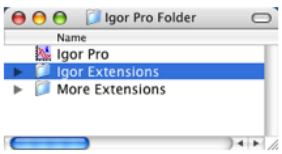
   

   You will be putting the aliases or shortcuts in the "Igor Extensions" and "Igor Procedures" folder, thereby activating them.

   If you are using IGOR64, the 64-bit version of Igor, you need to use the "Igor Extensions (64-bit)" instead of "Igor Extensions". If it does not already exist, manually create "Igor Extensions (64-bit)" in your "Igor User Files" folder. The rest of this section assumes you are using IGOR32.

2. From the Help menu, choose "Show Igor Pro Folder".

   This displays the Igor Pro Folder on the desktop:

3. Make an alias (*Mac OS X*) or shortcut (*Windows*) for the following file:

   Igor Pro Folder\More Extensions\File Loaders\HDF5.xop

   Move the alias or shortcut into "Igor Pro 6 User Files\Igor Extensions". This activates the HDF5 XOP which adds operations to Igor for interacting with HDF5 files.

   HDF5.xop contains within it the necessary HDF5 libraries so you do not need to install libraries from The HDF Group.

2. Make an alias (*Mac OS X*) or shortcut (*Windows*) for the following file:

   Igor Pro Folder\WaveMetrics Procedures\File Input Output\HDF5 Browser.ipf

   Move the alias or shortcut into the "Igor Pro 6 User Files\Igor Procedures" folder. This activates the procedure file that implements an HDF5 browser and adds a "New HDF5 Browser" menu item in the Data->Load Waves menu.

3. Restart Igor Pro and then read the HDF5 Guided Tour section below.

To uninstall the HDF5 package, delete the aliases or shortcuts created above and restart Igor.

For background information on special folders such as the Igor Extensions and Igor Procedures folders, see Special Folders.

HDF5 Package Compatibility

The current version of the HDF5Browser.ipf file requires HDF5 XOP 1.09 or later. If you get a compile error when compiling the HDF5Browser.ipf file, it may be because you are mixing a newer HDF5Browser.ipf with an older HDF5.xop. Always activate these files from the same installation of Igor to insure that they are compatible.

4. Copy the following files into your Igor Procedure folder **/Documents/WaveMetrics/Igor Pro XX User Files/Igor Procedures**
   1. **/Applications/Igor Pro 6.3 Folder/WaveMetrics Procedures/File Input Output/HDF Utilities.ipf (not needed for igor 8)**
   2. DataManipolation.ipf
   3. ChangeFolder.IPF
   4. Quick_Links5.ipf
5. Copy the following file to your User Files folder **/Documents/WaveMetrics/Igor Pro XX User Files**
   1. **-**EtalonsToAnalyzevisar.xlsx (**prior to March 2020)**
   2. EtalonsToAnalyzevisar2.xlsx **(after March 2020)**

6. Copy the following procedure files to your User Procedure folder **/Documents/WaveMetrics/Igor Pro XX User Files/User Procedures**
    1. Hamamatsu_SC.ipf
    2. KeyholeOutputs.ipf
    3. AV.ipf **(or AV8.ipf if you are running Igor 8)**
    4. AdjustImageColorOnly.ipf
    5. Image_Line_Profile_JEMM.ipf
    6. ConfidenceBands.ipf
    7. SmoothWaves.ipf
    8. FindSpots.ipf
    9. DuplicateCursorWaves.ipf
7. If you are running Igor with a version not later than Version: 8.04 (Build 34722), you need to move and overwrite the **Multi-Peak Fit 2.0** file in **C:\Program Files\WaveMetrics\Igor Pro 8 Folder\WaveMetrics Procedures\Analysis\Peak Fitting**

Mandatory Files and Initial Setup for Windows

Install Igor8

Locate the Igor folder in **Program Files** C:\Program Files\WaveMetrics\Igor Pro 8 Folder

Locate the Igor folder in **Documents** for example at C:\Users\millot1\Documents\WaveMetrics\Igor Pro 8 User Files

You will need several procedures and files installed in the User Files Folder to run AnalyzeVisar.

1. Install the HDF 4 Loader XOP (to read Omega data) :
    1. Get the file **HDF Loader.xop**
        1. If you use Igor 8 go to: **C:\Program Files\WaveMetrics\Igor Pro 8 Folder\More Extensions\File Loaders**
    2. Make a shortcut and put the shortcut in the **C:\Users\millot1\Documents\WaveMetrics\Igor Pro 8 User Files\Igor Extensions** folder
2. Install the HDF5 browser to read NIF data: See Igor Help: by executing in Igor **DisplayHelpTopic "Installing The HDF5 Package"**

    Installing HDF5 requires activating two files - the HDF5 XOP file and the "HDF5 Browser" procedure file - by placing aliases (Mac OS X) or shortcuts (Windows) for them in special folders.

    1. *Make a shortcut (Windows) for the following file:*

        C:\Program Files\WaveMetrics\Igor Pro 8 Folder\More Extensions (64-bit)\File Loaders\HDF5-64.xop

        *Move the shortcut into **/Documents/WaveMetrics/Igor Pro 8 User Files/Igor Extensions (64-bit)**".*
    2. *Make a shortcut (Windows) for the following file:*

        C:\Program Files\WaveMetrics\Igor Pro 8 Folder\More Extensions (64-bit)\File Loaders\HDF5.xop

        *Move the shortcut into **/Documents/WaveMetrics/Igor Pro 8 User Files/Igor Extensions**".*

    2. Make a shortcut (Windows) for the following file:

    C:\Program Files\WaveMetrics\Igor Pro 8 Folder\WaveMetrics Procedures\File Input Output\HDF5 Browser.ipf

    *Move the shortcut into the **/Documents/WaveMetrics/Igor Pro 8 User Files/Igor Procedures** folder. T*

    *3. **Restart Igor Pro***

3. Copy the following files into your Igor Procedure folder **/Documents/WaveMetrics/Igor Pro 8 User Files/Igor Procedures**

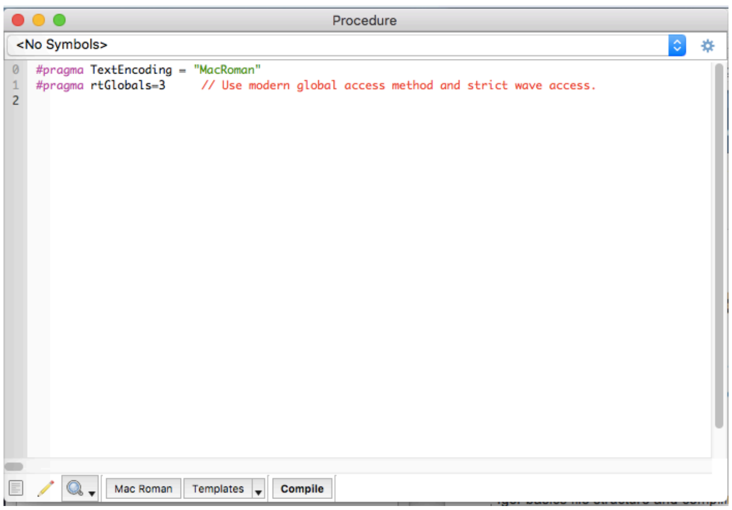
    1. **/Applications/Igor Pro 6.3 Folder/WaveMetrics Procedures/File Input Output/HDF Utilities.ipf (not needed for igor 8)**
    2. DataManipolation.ipf
    3. ChangeFolder.IPF
    4. Quick_Links5.ipf
4. Copy the following file to your User Files folder **/Documents/WaveMetrics/Igor Pro 8 User Files**
    1. **-**EtalonsToAnalyzevisar.xlsx (**prior to March 2020)**
    2. EtalonsToAnalyzevisar2.xlsx **(after March 2020)**
    3. EtalonsToAnalyzevisar3.xlsx **(after May 2020)**
5. Copy the following procedure files to your User Procedure folder **/Documents/WaveMetrics/Igor Pro 8 User Files/User Procedures**

    1. Hamamatsu_SC.ipf
    2. KeyholeOutputs.ipf
    3. **AV8.ipf**
    4. AdjustImageColorOnly.ipf
    5. AdjustImageColorOnlyMM.ipf (these are two slightly different versions of the same procedure)
    6. Image_Line_Profile_JEMM.ipf
    7. ConfidenceBands.ipf
    8. SmoothWaves.ipf
    9. FindSpots.ipf
    10. DuplicateCursorWaves.ipf

6. If you are running Igor with a version not later than Version: 8.04 (Build 34722), you need to move and overwrite the **Multi-Peak Fit 2.0** file in **C:\Program Files\WaveMetrics\Igor Pro 8 Folder\WaveMetrics Procedures\Analysis\Peak Fitting**

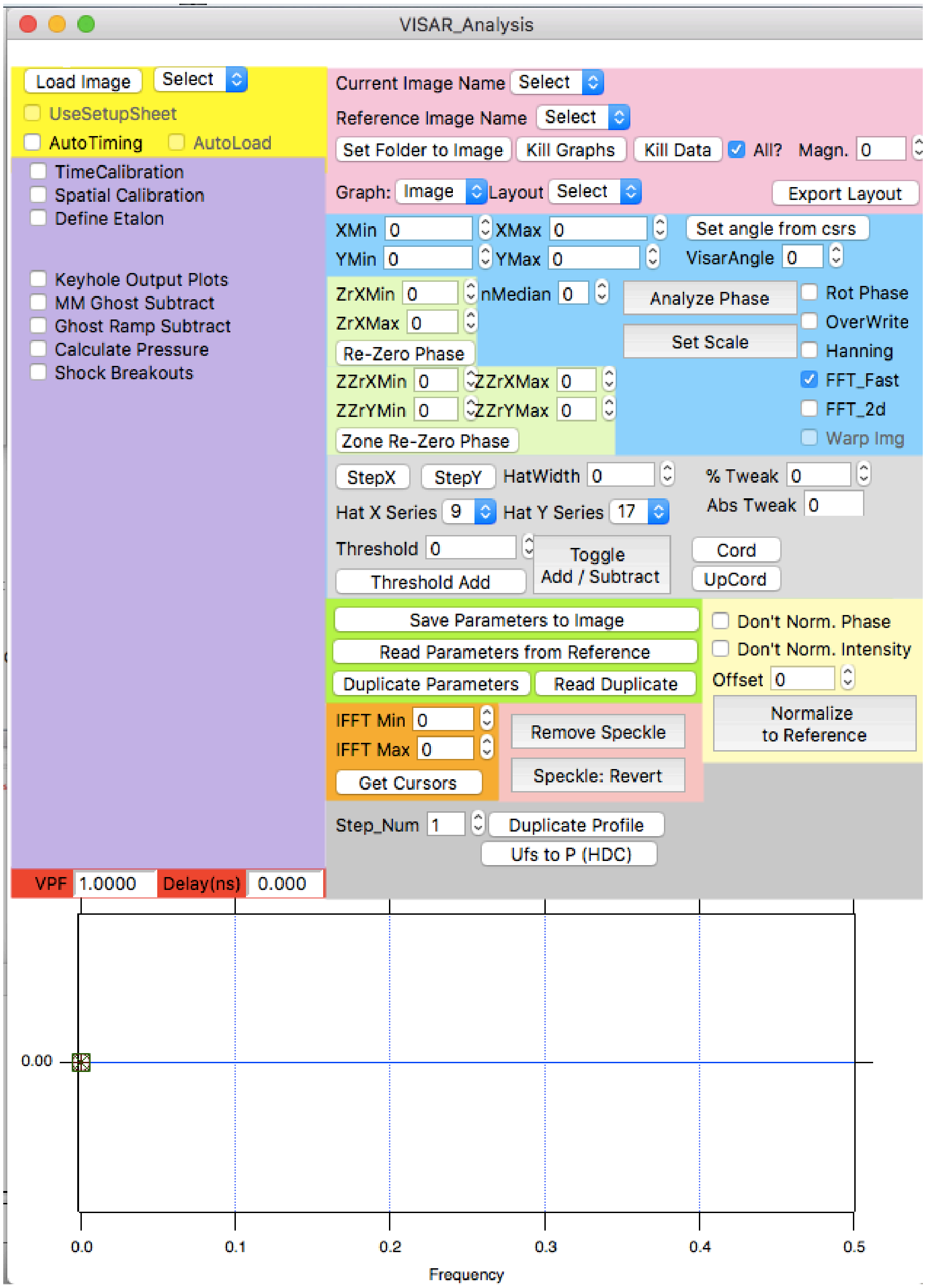
Launch Igor

- Cmd+M to launch the Procedure window
- Should look like:



- Type #include "AV" or AV8
- click on Compile at the bottom or do Macro-->Compile

- Macros--> Initialize_Variables_VISAR will create the AnalyzeVisar panel.



- There should not be any error up to this stage ...

AV - Analyze Visar Change Log Page

This pages provides comments and notes on AnalyzeVISAR AV8 changes.

Latest notes are on top.

<table>
<tr><th>Date</th><th>Notes</th></tr>
<tr><td></td><td></td></tr>
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<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td>2020-05-06</td><td>version 25 corrects a bug with Overwrite option in AnalyzePhase

Changed

```
If (OverWrite && waveexists(OUT_Phase))
WAVE OUT_Phase=$"Phase_"+imagenm
Duplicate/O Out_Phase, Out_Phase_Save
Else
Duplicate/O IN $"Phase_"+imagenm
WAVE OUT_Phase=$"Phase_"+imagenm
Duplicate/O Out_Phase, Out_Phase_Save
Out_Phase_Save=NaN
Endif
Endif
If (stringmatch(Flags, "*Amplitude*")) // Calculate Amplitude

If (OverWrite && waveexists(OUT_Amplitude))
WAVE OUT_Amplitude=$"Ampl_"+imagenm
Duplicate/O OUT_Amplitude, OUT_Amplitude_Save
Else
Duplicate/O IN $"Ampl_"+imagenm
WAVE OUT_Amplitude=$"Ampl_"+imagenm
Duplicate/O OUT_Amplitude, OUT_Amplitude_Save
OUT_Amplitude_Save=Nan
Endif
Endif


If (stringmatch(Flags, "*IFFT*")) // Calculate IFFT

If (OverWrite && waveexists(OUT_IFFT))
WAVE OUT_IFFT=$"IFFT_"+imagenm
Duplicate/O OUT_IFFT, OUT_IFFT_Save
```
</td></tr>
</table>

```
Else
Duplicate/O IN $"IFFT_"+imagenm
WAVE OUT_IFFT=$"IFFT_"+imagenm
Duplicate/O OUT_IFFT, OUT_IFFT_Save
OUT_IFFT_Save=NAN
Endif
Endif
```

into

```
If (OverWrite && waveexists($"Phase_"+imagenm))
WAVE OUT_Phase=$"Phase_"+imagenm
Duplicate/O Out_Phase, Out_Phase_Save
Else
Duplicate/O IN $"Phase_"+imagenm
WAVE OUT_Phase=$"Phase_"+imagenm
Duplicate/O Out_Phase, Out_Phase_Save
Out_Phase_Save=NaN
Endif
Endif
If (stringmatch(Flags, "*Amplitude*")) // Calculate Amplitude

If (OverWrite && waveexists($"Ampl_"+imagenm ))
WAVE OUT_Amplitude=$"Ampl_"+imagenm
Duplicate/O OUT_Amplitude, OUT_Amplitude_Save
Else
Duplicate/O IN $"Ampl_"+imagenm
WAVE OUT_Amplitude=$"Ampl_"+imagenm
Duplicate/O OUT_Amplitude, OUT_Amplitude_Save
OUT_Amplitude_Save=Nan
Endif
Endif


If (stringmatch(Flags, "*IFFT*")) // Calculate IFFT

If (OverWrite && waveexists($"IFFT_"+imagenm))
WAVE OUT_IFFT=$"IFFT_"+imagenm
Duplicate/O OUT_IFFT, OUT_IFFT_Save
Else
Duplicate/O IN $"IFFT_"+imagenm
WAVE OUT_IFFT=$"IFFT_"+imagenm
Duplicate/O OUT_IFFT, OUT_IFFT_Save
OUT_IFFT_Save=NAN
Endif
```

	`Endif`
2020-05-01	version 24 corrects a bug preventing the use of the two comb timing option. also change **HighP_Qtz** into **Precom_Qtz** to avoid the ambiguity: this is the model for the **precompressed** samples, based on **Brygoo,Millot 2015**.
2020-04-30	I added IM_MM_MonteCarlo_2019 which improves the 2017 version. In particular adding the high pressure model we developed to go beyond 16 Mbar in the Qtz: `new high P fit from 1. Fernandez-Pañella, A. et al. Shock Compression of Liquid Deuterium up to 1 TPa. Phys. Rev. Lett. 122, 255702 (2019).`
2020-04-29	v23: + Minor tweaks + addition of Absolute Calibration option for SOP based on Gregor 2016 RSI paper http://dx.doi.org/10.1063/1.4968023 + created a D2_L1014 Reference for SOP based on the D2 Hugoniot from the Kerley 1014 Table + added a modified QthermQuartz Reference for which the switch from power law to linear T(Us) behavior occurs around 20 km/ns seems to match the fit I based that model on (unpublished Omega Data)
2020-04-02	v22 A few more improvements and a new button + Marquee Operation: **Ramp Cleaner** to clean the phase map in regions of very fast increasing phase shift **Also renamed a button with a shorter string for compatibility with Igor 7**
2020-04-01	and a few more fixes to the reflectivity/temperature analysis v21
2020-03-30	A few more tweaks Now V20
2020-03-24	And a few more bug fixes on AV8. Now version 18. Including: Power spectrum of FFT in zero phase region now is updated when selected a new image, cursors as well My CheckProc fixed so that selecting new image does not force checkbox menu to change on the left of VISAR_Analysis Panel FIxed an error when calling the parameter wave table and opening multiple NIF images at once. I also added a section on how to use the new (and fast) **Timing option at Time Calibration**
2020-03-23	A few more bug fixes. Now Av8_15 I recommend selecting Watch on the top-right corner of this page. That way you can receive an email when new files are loaded
2020-03-19	New Updates - Covid19 Edition: This is now **Av8_14** I fixed a few bugs . In particular, you can now move your mouse around while loading several images at once and using the Fast Ref option I also recommend using the improved **QuickLinks5 v2 (see comment above)** You may need to update the version of **KeyholeOutputs** that you have. I also identified a bug in Multi-Peak Fit 2.0 (see above)

<table>
<tr><td>2020-03-18</td><td>New Updates -

This is Av8_11

Requires EtalonsToAnalyzevisar2.xlsx and update of AV8 and KeyholeOutputs

<code>//// This is version March2020- CovidEdition - by MM</code>

<code>//// Recent updates include</code>

<code>// Historical Fiducial timing info for Omega (both telescopes) and EP, by reading EtalonsToAnalyzevisar2.xlsx</code>

<code>// Write and Read Parameters wave to file - Handy to analyze multiple shots of a series each in its own .pxp experiment</code>

<code>// Fast Ref Button: Does all the clicks for you to do on the reference image the same analysis you have just done on your system shot image.</code>

<code>// Remove the use of the fGaussFit1WidthBL and automated the 1CombAuto timing comb fit with MultiPeakFit 2.0 functions (so much faster !, no need for deprecated functions)</code>

<code>// Improved Reflectivity and Temperature Panels for the MultiQtz case</code>

<code>// Improved Load Image to handle multiple images at once</code></td></tr>
<tr><td>2020-01-09</td><td>Av8_10 includes a few improvements to deal with multi quartz packages and a few bug fixes</td></tr>
<tr><td>2020-01-07</td><td>ust added Multi-Peak Fit 2.0 that fixes a bug for Igor 8
Version: 8.04 (Build 34722)

You should probably overwrite the existing file in Igor <=8.04 with this file, directly in the Igor folder in Applications</td></tr>
<tr><td>2020-03-19</td><td>QuickLinks5 v2 now adds two functions:

DeleteAllTables and

<code>BeforeExperimentSaveHook(rN,fileName,path,type,creator,kind) to create statements like this</code>

<code>******* Saved on Thu, Nov 14, 2019 at 6:10:19 PM into Macintosh HD:Users:millot1:Materials:Diamond_C:Diamond_Melt_2019_ICF:Diamond Refreeze XRD at Omega EP:Analysis:November2019:p30975_Nov.pxp</code>

see https://www.wavemetrics.com/node/21092#comment-19199

<code>REMEMBER: QuickLinks goes into IgorProcedure Folder (so that it is always open when opening Igor)</code></td></tr>
<tr><td>2019-11-04</td><td>AV8 version 9 implements the corrected function from Suzanne as well as an option to fit the timing combs with a polynomial instead of spline or linear.</td></tr>
<tr><td>2019-11-04</td><td>Version 8 implements a snippet from Suzanne Ali to use the top and bottom combs for timing at NIF, using the Locos delays

else //Use LOCOS Delay Values // Modified by S. Ali

print "Using LOCOS Delay Values"

redimension/n=(numpnts(TimeFiducialPosition1)+numpnts(TimeFiducialPosition2)) TimeFiducialRelativeTime, TimeFiducialPosition

redimension/n=(numpnts(TimeFiduDiffNorm1)+numpnts(TimeFiduDiffNorm2)) TimeFiduDiffNorm ,TimeFiduDiffPos

TimeFiduDiffNorm[numpnts(TimeFiduDiffPos2),numpnts(TimeFiduDiffPos)-1]=TimeFiduDiffNorm1[p-numpnts(TimeFiduDiffPos2)]

TimeFiduDiffPos[numpnts(TimeFiduDiffPos2),numpnts(TimeFiduDiffPos)-1]=TimeFiduDiffPos1[p-numpnts(TimeFiduDiffPos2)]

sort TimeFiduDiffPos,TimeFiduDiffPos,TimeFiduDiffNorm

wavestats/q TimeFiduDiffNorm

TimeFiduDiffNorm/=v_avg</td></tr>
</table>

```
variable S01Temp=Streak_Comb_Fixed_Delay_01, S10Temp=Streak_Comb_Fixed_Delay_10



// Check if there are deltatcomb offsets between the two comb timings: (there is probably a better way to do this…)
do
	if(S10Temp-S01Temp>=DeltatComb*1e-3)
		S10Temp -= deltatcomb*1e-3
	elseif (S01Temp-S10Temp>=DeltatComb*1e-3)
		S01Temp -= deltatcomb*1e-3
	endif

while (abs(S10Temp-S01Temp)>=DeltatComb*1e-3)



TimeFiducial2+=S10Temp
TimeFiducial1+=S01Temp
// Combine everything using Marius' code:
TimeFiducialPosition[0,numpnts(TimeFiducialPosition1)-1]=TimeFiducialPosition1
TimeFiducialPosition[numpnts(TimeFiducialPosition1),numpnts(TimeFiducialPosition)-1]=TimeFiducialPosition2[p-numpnts(TimeFiducialPosition1)]


 TimeFiducialRelativeTime[0,numpnts(TimeFiducialPosition1)-1]=TimeFiducial1
TimeFiducialRelativeTime[ numpnts(TimeFiducialPosition1),numpnts(TimeFiducialPosition)-1]=TimeFiducial2[p-numpnts(TimeFiducialPosition1)]
sort TimeFiducialPosition,TimeFiducialPosition,TimeFiducialRelativeTime


endif
```

Files for AV - Analyze Visar

Please see the AV - Analyze Visar Change Log Page for details on updates and changes

File	Modified
File AdjustImageColorOnly.ipf	2018-08-03 by Millot, Marius Adrien
File ConfidenceBands.ipf	2018-08-03 by Millot, Marius Adrien
File DuplicateCursorWaves.ipf	2018-08-03 by Millot, Marius Adrien
File FindSpots.ipf	2018-08-03 by Millot, Marius Adrien
File Image_Line_Profile_JEMM.ipf	2018-08-03 by Millot, Marius Adrien
File DataManipolation.ipf	2018-08-03 by Millot, Marius Adrien
File ChangeFolder.IPF	2018-08-07 by Krygier, Andy
File Hamamatsu_SC.ipf	2019-03-06 by Millot, Marius Adrien
Microsoft Excel Spreadsheet EtalonsToAnalyzevisar.xlsx	2019-06-03 by Millot, Marius Adrien
File AdjustImageColorMM.ipf	2019-06-03 by Millot, Marius Adrien
File asbo1_s30595.hdf	2019-06-03 by Millot, Marius Adrien
File asbo2_s30595.hdf	2019-06-03 by Millot, Marius Adrien
File AV.ipf	2019-07-11 by Millot, Marius Adrien
File IM_MM_MonteCarlo_2017.ipf	2019-08-14 by Millot, Marius Adrien
File AdjustImageColorOnlyMM.ipf	2019-10-25 by Millot, Marius Adrien
File Quick_Links5.ipf	2019-11-14 by Millot, Marius Adrien
PNG File Screen Shot 2019-11-14 at 6.15.15 PM.png	2019-11-14 by Millot, Marius Adrien
File Multi-peak Fitting 2.0.ipf	2019-12-10 by Millot, Marius Adrien
File KeyholeOutputs.ipf	2020-03-18 by Millot, Marius Adrien
Microsoft Excel Spreadsheet EtalonsToAnalyzevisar2.xlsx	2020-03-18 by Millot, Marius Adrien
PNG File Screen Shot 2020-04-02 at 9.24.40 AM.png	2020-04-02 by Millot, Marius Adrien
PNG File Screen Shot 2020-04-02 at 9.24.14 AM.png	2020-04-02 by Millot, Marius Adrien
PNG File Screen Shot 2020-04-02 at 9.22.03 AM.png	2020-04-02 by Millot, Marius Adrien
PNG File Screen Shot 2020-04-02 at 9.20.05 AM.png	2020-04-02 by Millot, Marius Adrien
PNG File Screen Shot 2020-04-02 at 9.24.26 AM.png	2020-04-02 by Millot, Marius Adrien
File IM_MM_MonteCarlo_2019.ipf	2020-04-30 by Millot, Marius Adrien
File AV8.ipf	2020-05-06 by Millot, Marius Adrien

Drag and drop to upload or browse for files

Download All

Keyboard Shortcuts

Useful Keyboard shortcuts:

cmd+1 Bring the Adjust Contrast / ColorScale panel to the front

cmd+2 Copy Phase Lineout to Make Velocity Graph

cmd+3 Copy Amplitude or Intensity Lineout to Make Reflectivity Graph

cmd+4 Copy SOP Lineout to Make Temperature Graph

cmd+5 Copy Phase Lineout to Make Multiplier Graph

cmd+6 Make Lineout by calling ImageLineProfile

cmd+7 Duplicate the wave having a cursor on it with DuplicateCsrWaves()

cmd+8 Copy the Lineout to calculate the Non Linear TimeScale Intensity correction with Correct Lineout

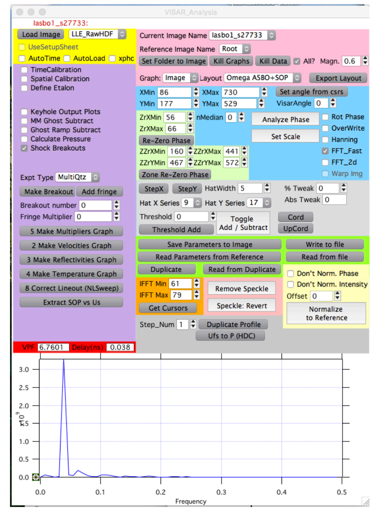
cmd+9 Bring the Data Browser panel to the front

Useful IGOR Keyboard shortcuts copied from http://cires1.colorado.edu/jimenez-group/wiki/index.php/Igor_Quick_Reference

- CTRL + J --> command window
  - CTRL + K --> clears command line
- CTRL + M --> brings the procedure window to the front
- CTRL + T --> in a graph or panel, enables or disables tools
- CTRL + I --> in a graph, enables cursors ("info") (*Graph -> Show Info*)
- CTRL + A --> in a table or in the command window: select all
  - --> in a graph: autoscale axes *Graph -> Autoscale Axes*
- Common Windows Commands
  - CTRL + S --> save experiment
  - CTRL + C, CTRL + X, CTRL + V --> copy, cut, paste
  - CTRL + F, CTRL + G --> find, find again (with shift, go the opposite direction)
  - CTRL + R --> search and replace
  - CTRL + P --> print
  - CTRL + Z --> undo (only one action)
  - CTRL + N --> new experiment

Understand the structure of the VISAR_Analysis Panel

This page describes the various blocks of the VISAR_Analysis Panel



- Yellow block : Load Images
    - **LOAD IMAGE Button** and associated Popup menu
    - AutoTime Checkbox (for Omega)
    - AutoLoad Checkbox (for Omega)
    - xphc Checkbox (for Omega)
- Purple block : Checking one of the checkboxes will bring up a series of options and buttons
    - TimeCalibration
    - Spatial Calibration
    - Define Etalon
    - Keyhole output plots: Generate standardized plots for NIF shock timing shots
    - MM Ghost Subtract: simple ghost subtraction method based on a heuristic guess of the ghost fringe pattern
    - Ghost Subtract: (Legacy) simple ghost subtraction method from DH and JHE
    - Calculate Pressure: (Legacy) a simple way to convert velocity history to pressure for selected materials
    - Shock Breakouts: Manually insert integer fringe jumps at breakouts or catch-up events to resolve the fringe jump ambiguities and calculate velocity, reflectivity and temperature
        - Multiplier Graph: Compare the phase lineouts from the two *Legs* or *Chan nels* to resolve fringe jump ambiguities
        - Velocity Graph: apply corrections to the apparent velocity history to generate a true velocity history. This is needed when not monitoring free surface velocities : reflecting shocks, windowed interface etc
        - Reflectivity Graph: use the amplitude or the intensity of the fringes to infer the reflectivity of the reflecting surface (e.g. shock front)
        - Temperature Analysis: use the SOP and the reflectivity analysis to determine temperature
        - Correct Lineout: Adjust the intensity/amplitude of the VISAR and SOP signal to account for the sweep rate non-linearity *i.e.* non constant dwell time
        - Extract SOP vs Us: Compare timing of SOP and VISAR to interpolate SOP(Us)
- Pink Block : select active image
    - Current Image Name Popup
    - Reference ImageName Popup
    - Set Folder to Image Button
    - Kill Graphs Button and associated CheckBox
    - Kill Data Button
    - Graph Magnification Control
    - Graph selection Popup
- Blue Block: Select fringe analysis region
    - xmin, xmax, ymin,ymax define the region where the phase analysis will be performed
    - Set angle from Cursors (Legacy)
    - VISARAngle (Legacy)
    - nMedian Control: apply nMedian filtering to the current VISAR image. Setting back to -1 resets to the raw image (need to redo/Space time calibrations)
    - AnalyzePhase Button: Analyze the fringes and perform the column-by-column 1D FFT to extract the phase and amplitude
    - SetScale Button: Adjust the Phase, Image, Amplitude and IFFT Graph to zoom on the fringe analysis region
    - Rot Phase Checkbox (Legacy)
    - Overwrite Checkbox
    - Hanning CheckBox
    - FFT Fast CheckBox
    - FFT 2D Checkbox (Legacy)
    - Warp Img (Legacy)
- Pale Green Block: Select Zero Phase Region
    - ZeroXmin and ZeroXmax Controls: delimitate the columns where the phase is zero
    - Re-Zero Phase Button: Subtract the average of the phase between the ZrXmin and ZrXmax columns to set the phase to Zero in that region
    - ZoneZeroXmin,ZoneZeroXmax, YMin, Ymax: Delimitate a region, within the fringe analysis region to be used as the "zero phase" reference. (Useful if the VISAR sweep window begins after initial fringe motion)
    - Zone Re-Zero Phase Button: Subtract the average of the phase in the region delimitated by the ZZrXmin,max,Ymin,max Controls to set the phase to Zero in that region
- Grey Block: Clean the phase map from spurious fringe jumps

    - StepX Button
    - Step Y Button
    - HatWidth Control
    - Hat X Series Control
    - Hat Y Series Control
    - % Tweak Control
    - Abs Tweak Control
    - Threshold Control
    - Threshold Toggle Add/ Subtract Button
    - Threshold Add / Threshold Subtract Button
    - Cord Button
    - Up Cord Button (Not working)
- Intense Green Block: Manipulate the Parameters Wave which stores all parameters for the analysis of one image
    - Save Parameters to Image Button
    - Read Parameters from Reference Button
    - Duplicate Read From Duplicate Button
    - Write to file Button
    - Read from file Button
- Orange Block: Define the FFT filter
    - IFFT Min Control
    - IFFT Max Control
    - Get Cursors
- Pale Pink Block: Speckle Removal (Based on Dave Erskine, coded by DEF)
- Yellow Block: Normalization using the Reference image
    - Don't Normalize Phase Checkbox
    - Don't Normalize Intensity Checkbox
    - Offset Control
    - Normalize to reference Button
- Dark Grey Block: Quick Save Profile
    - Step Number Control
    - Duplicate Profile Button
    - Ufs to P (HDC) Button: Convert the free surface velocity into pressure (Coarse approximation, useful for quick reference)

Load an image

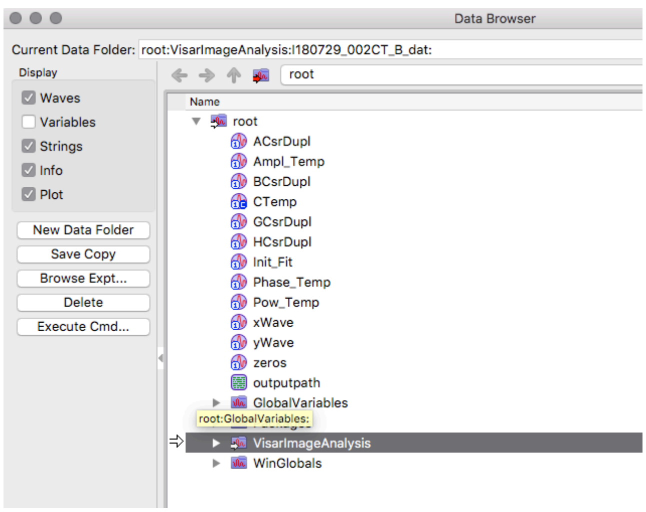
This page describe how to load images from various facilities.

Many users have written their own routines and tweaks are often necessary to adapt to changing instruments, file formats or naming conventions.

Feel free to suggest improvements and/or share your loading routines with others.

Load Image Button

- This button will load the image and create a folder in the VisarImageAnalysis folder where it will create a wave for the image and store some of the metadata that were extracted from the file



- Selecting multiple image file is generally permitted and will load multiple images at once

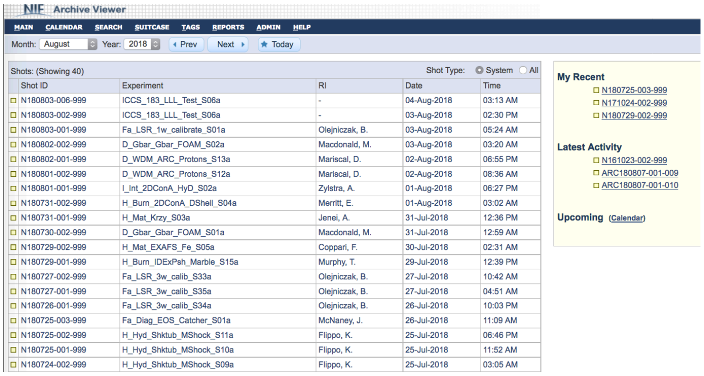
NIF

The archiving system at NIF is quite complex. Naming convention will be different depending on how you download your data.

NIF_H5 option for Load Image Button

This routine assumes that the files have been downloaded by

- going to NIF Archive Viewer https://nifit.llnl.gov/viewer/main.action, find and click on your system shot number NYYMMDD-00X-999 or shot name, or type https://nifit.llnl.gov/viewer/browseShot.action?shotId=NYYMMDD-00X-999



Shot ID	Experiment	RI	Date	Time
N180803-006-999	ICCS_183_LLL_Test_S06a	-	04-Aug-2018	03:13 AM
N180803-002-999	ICCS_183_LLL_Test_S06a	-	03-Aug-2018	02:30 PM
N180803-001-999	Fa_LSR_1w_calibrate_S01a	Olejniczak, B.	03-Aug-2018	05:24 AM
N180802-002-999	D_Gbar_Gbar_FOAM_S02a	Macdonald, M.	03-Aug-2018	03:20 AM
N180802-001-999	D_WDM_ARC_Protons_S13a	Mariscal, D.	02-Aug-2018	06:55 PM
N180801-002-999	D_WDM_ARC_Protons_S12a	Mariscal, D.	02-Aug-2018	08:36 AM
N180801-001-999	I_Int_2DConA_HyD_S02a	Zylstra, A.	01-Aug-2018	06:27 PM
N180731-002-999	H_Burn_2DConA_DShell_S04a	Merritt, E.	01-Aug-2018	03:02 AM
N180731-001-999	H_Mat_Krzy_S03a	Jenei, A.	31-Jul-2018	12:36 PM
N180730-002-999	D_Gbar_Gbar_FOAM_S01a	Macdonald, M.	31-Jul-2018	12:59 AM
N180729-002-999	H_Mat_EXAFS_Fe_S05a	Coppari, F.	30-Jul-2018	02:31 AM
N180729-001-999	H_Burn_IDExPsh_Marble_S15a	Murphy, T.	29-Jul-2018	12:39 PM
N180727-002-999	Fa_LSR_3w_calib_S33a	Olejniczak, B.	27-Jul-2018	10:42 AM
N180727-001-999	Fa_LSR_3w_calib_S35a	Olejniczak, B.	27-Jul-2018	04:51 AM
N180726-001-999	Fa_LSR_3w_calib_S34a	Olejniczak, B.	26-Jul-2018	10:03 PM
N180725-003-999	Fa_Diag_EOS_Catcher_S01a	McNaney, J.	26-Jul-2018	11:09 AM
N180725-002-999	H_Hyd_Shktub_MShock_S11a	Flippo, K.	25-Jul-2018	06:46 PM
N180725-001-999	H_Hyd_Shktub_MShock_S10a	Flippo, K.	25-Jul-2018	11:52 AM
N180724-002-999	H_Hyd_Shktub_MShock_S09a	Flippo, K.	25-Jul-2018	03:05 AM

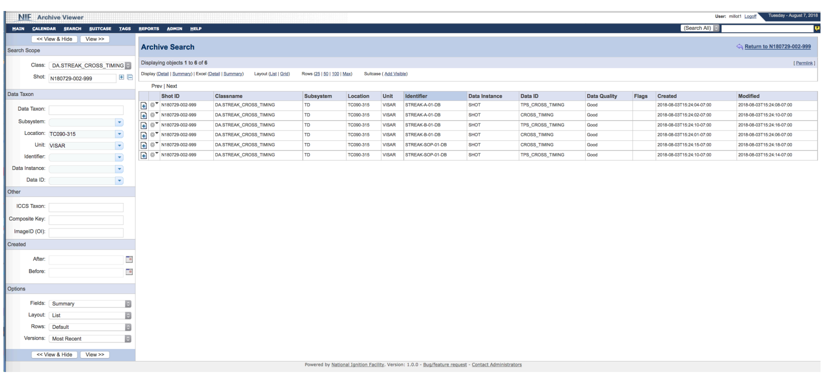
- Locate the VISAR Data

VISAR

TC090-315

STREAK_COMB_REMOVED	6
STREAK_CROSS_TIMING	6
STREAK_FIDU_COMB	18
TPS_WARP_CORR	3
BKGD_CORR	3
CCD_TEMPERATURE	3
COMBINED_IMAGE	3
FLATFLD_CORR	3
IMAGE_PREPROC_STATS	6
SATPIX_CORR	3
WARP_CORR	6
MULTI_COMB	3
SCOPE_CHANNEL	8
SCOPE_CHANNEL_SCALED	8
SCOPE_CHAN_SET	2
STREAK_CAMERA	3

- Click on Streak Camera for the Raw Images or Streak Crosstiming for the Cross timed and TPS Cross-timed images



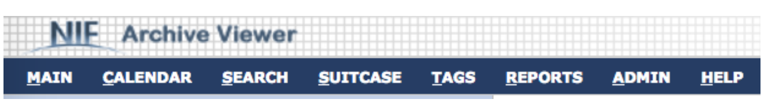
- Select the appropriate images and add them to the suitcase (**add visible**)

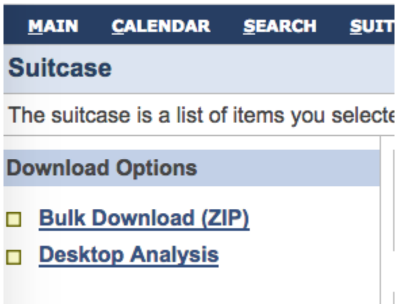
Archive Search

Displaying objects 1 to 6 of 6

Display (Detail | Summary) | Excel (Detail | Summary) Layout (List | Grid) Rows (25 | 50 | 100 | Max) Suitcase (Add Visible)

- Go to the suitcase and download it with bulk download





- Doing so will create files with names like TD_TC090-315_VISAR_STREAK-A-01-DB_SHOT_CROSS-TIMING_N180729-002-999.h5
- For NIF, you will need to load both the system shot image NYYMMDD-00X-999 and a reference image, usually the rod shot image NYYMMDD-00X-00Z where X is the shot number and Z is the rod shot number

NIF_Peter option for Load Image Button

- This option is designed to load images created by Peter Celliers Yorick code, in order to do a manual 10-comb dewarping for example
- The following naming convention is required: NYYMMDD-00X_legAdat_dw.h5 which means that you will need to modify Peter's file name legAdat_dw.h5 to insert NYYMMDD-00X_ so that the IGOR code can determine the shot number.

Omega and Omega EP

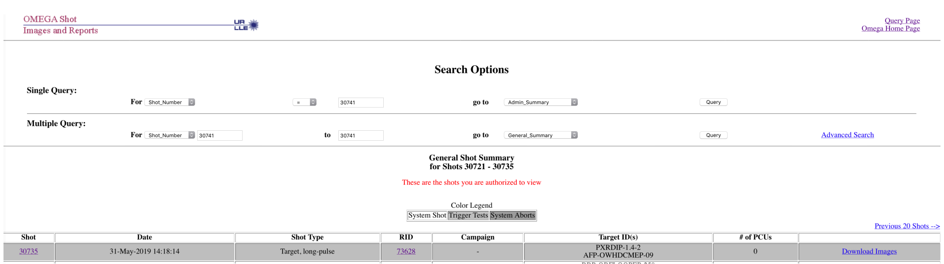
You will need to download the data as hdf from the Omega web portal:

https://omega-prod-informatics.lle.rochester.edu/#/piportal

or from LLE's website to go **Operations**

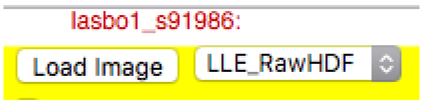
Then Click on **Shot Images and Reports**

Then from the **Query page**



you can download the data for a given shot by clicking (on the right) on **Download Images**

To load these into AV, select LLE_RawHDF and click on **Load Images**



- At Omega, the hdf files are raw images and do not contain timing information or spatial distortion corrections
- The VISAR/ASBO files contain a reference image acquired right prior to the system shot. It will be saved as _Ref
- The SOP files do not contain a reference
- This routine also opens XRPHC images (may need to tweak ROI for your needs)
- **You can download several images at once**, just select multiple files

Jupiter Laser Facility

At Jupiter, the streak Cameras are Hammamatsu.

The Timing is generally determined by using the factory determined calibration of the time vs pixel relationship for the various sweep speeds. The parameters have been included in several routines named by the serial number of the SC. (Legacy)

Use of timing combs is recommended!

MEC

At MEC, the streak Cameras are Hammamatsu.

Timing calibrations have been carried out and Dayne Fratanduono performed timing fits that are used in the MEC routine

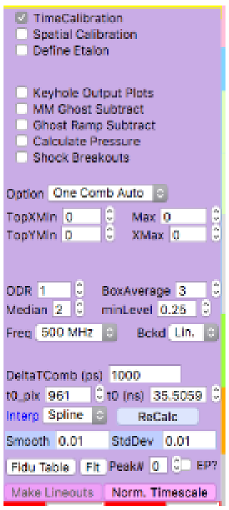
Time Calibration

This needs more work

Updated on March 24 2020 for AV8 more recent than version10

Summary

The Time Calibration options become available by checking the Time Calibration checkbox in the main AnalyzeVisar Panel



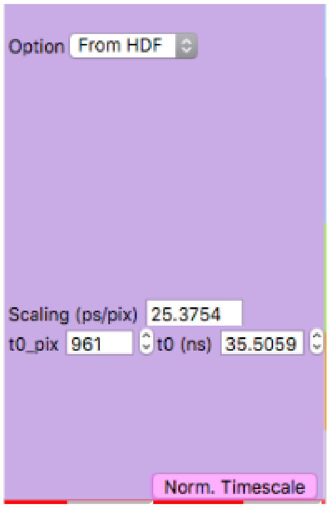
Selecting one option using the Option Popup Menu will enable/disables several fields below.

The options are

1. One Comb auto - This is now an automated version using the more modern, less user friendly Multipeak fit set of routines from Igor ~~This is the legacy routine from JHE fitting a timing comb with a fixed-width multi-gaussian fit~~.
2. Two Comb - Meant to treat the top and bottom combs at NIF - Need to be used with the polynomial fit option - Thanks to Suzanne Ali
3. From HDF - Use for NIF data which include a timing wave/vector in the HDF file.
4. One Comb Manual - Fits a timing comb with the more modern, less user friendly Multipeak fit set of routines from Igor

Use : From HDF for NIF Data

1. Select From HDF
   The menu will be very simplified



2. When you load NIF data using the NIF_H5 routine, some of the timing data generated by the automated analyis engine (SAVI) are read.
3. Specifically, AV reads the time/pixel relationship and stores it in Scaling in ps/pix
4. If the position of the fiducial is populated in the HDF file, AV sill store this as well into t0_pix and t0 (ns) which store the pixel for the fiducial and the corresponding time.
   If not found, t0_pix is set as 682 (center pixel) and t0_ns is read from the timing wave in the HDF file.
5. If you want to adjust the timing, set t0_pix and t0 (ns) to the appropriate values , then hit Norm. Timescale (meaning Normalize the Timescale) to adjust the time wave.
   Remember to save the parameters to store these values.

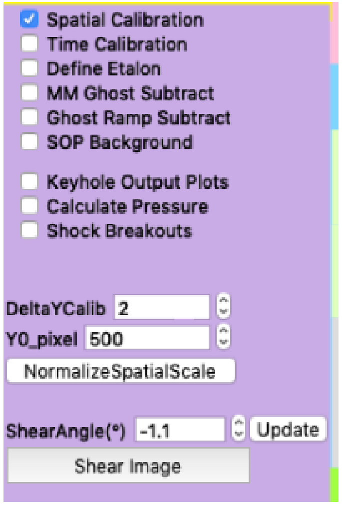
Use : One Comb auto for OMEGA Data

Here, to determine the relative timing, we need to manually select a region of the image where the streak camera recorded a series of blips or pulses generated by a very stable oscillator which provides us with a timing reference pattern: If the oscillator period is 2 ns then there should be 2 ns between two blips. Once we identify these blips, we do a lineout, then we fit this lineout to find the location in pixel of all the blips, then we assign a time to all these blip using the known period between those blips. Integrating this series of [time,pixel] values creates the time vs pixel wave that we need .

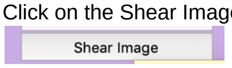
Then identifying the position of the absolute timing feature, "the 8-comb", we can determine the absolute timing.

1. Select one image with the **Current Image Name Popup**
2. You may want to **shear** the Image, a cheap way of correcting for the spatial distortion so that fringes are horizontal and isochrones are therefore vertical

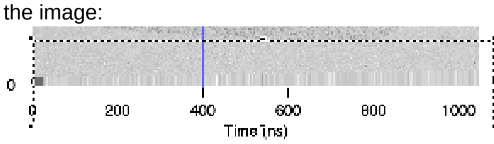
1. Check the **Spatial Calibration** box



2. Adjust the ShearAngle Value. I usually used the following values (most recent data suggest slightly different values may be needed.) Goal is to obtain fringes as perfectly horizontal as possible in the reference image (or in the early time, constant fringe pattern region of the shot image)
    1. for Omega 60:
        1. ASBO1 ShearAngle=-0.2
        2. ASBO2 ShearAngle=-1.2
        3. SOP ShearAngle=-0.2
    2. for OmegaEP
        1. ASBO1 ShearAngle=-1
        2. ASBO2 ShearAngle=+0.2
        3. SOP ShearAngle=-0.2
3. Click on the Shear Image button

    The image will be sheared and straightened(hopefully) and characteristic features (vertical lines) will appear at the bottom of the image:

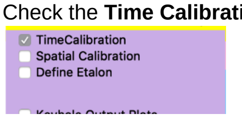
    

4. Now the Fringes should look "more horizontal"
5. Click to Save Parameters to Image to save the value of the ShearAngle
6. **You will also need to shear the Reference Image the same way. If you do not use FAST Ref (which does it for you)**

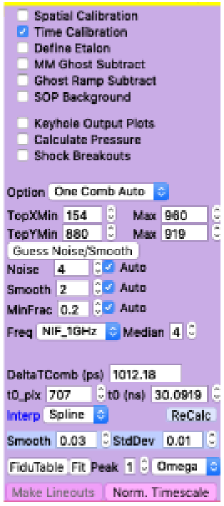
Before	After
(I changed the grid lines to red to see them better here)	

<u>NOTE:</u> Generally speaking, it is always better to do any dewarping or distortion corrections **<u>BEFORE</u>** doing timing calibration.

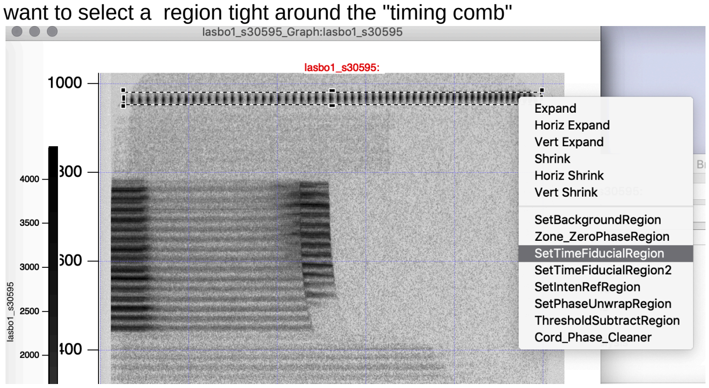
3. Check the **Time Calibration** box on the left

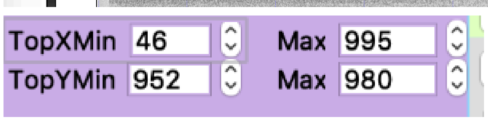


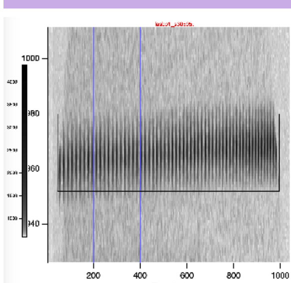
4. Select **One Comb Auto** in the Option popup menu. The buttons will simplify and will look like this



5. Using the mouse to draw a marquee and then right click, select **SetTimeFiducialRegion** will create a marquee region to delimit the location of the timing comb (at the top) which will populate the Top Xmin,max, Ymin,max values and draw a black rectangle. You want to select a region tight around the "timing comb"

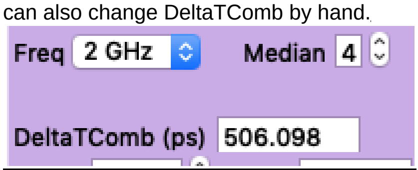






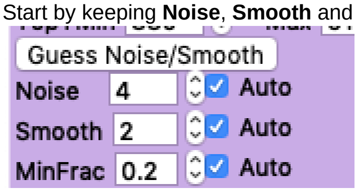
6. Set the median filtering level
    1. Median=N: Apply a Median filter of order N to the timing comb region of the image before taking the lineout. This is useful for noisy data. Larger N applies more smoothing. Median of 3-4 is good.

7. Select the Comb frequency. This info will come from the SRF or the shot report. Usually, at Omega it is 2GHz. On the sweeps longer than 27 ns, the 500 MHz comb is used.
   Note: If the timing comb looks similar to the "8-comb" then it is 2 GHz, otherwise it is likely 500 MHz
   Note: Selecting a Frequency in the Freq popup will fill the DeltaTComb variables which holds the comb period in picoseconds. You can also change DeltaTComb by hand.



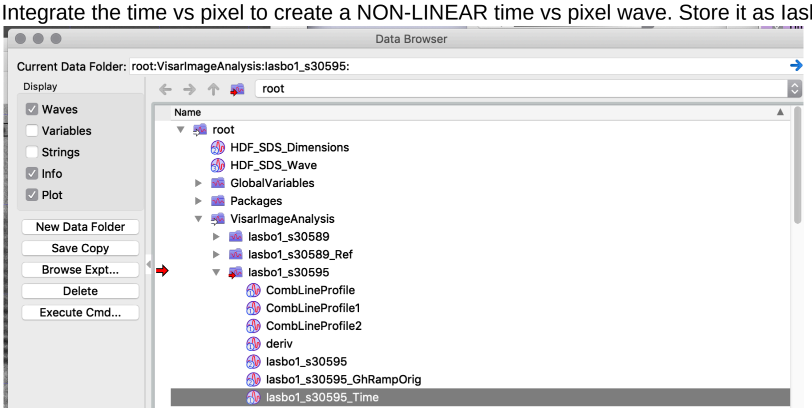
    1. .

8. Start by keeping **Noise**, **Smooth** and **MinFrac** in Auto mode (tick the Auto checkboxes)



    1. Noise and Smooth are two parameters that are used to locate the timing comb "peaks" in the lineout
    2. Min Frac sets the Minimum level (as a Fraction of the most intense peak) below which additional peaks are ignored. Default is 0.05.

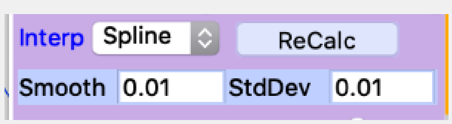
9. Click on **Norm. Timescale**. This will
    1. create the lineout.
    2. Plot it into a new window called TimeFidu_IAsbo1_s99999_Graph
    3. fit it with a multi-peak Gaussian fit routine + a cubic baseline
    4. Assign a time interval of DeltaTComb between two adjacent peaks
    5. Integrate the time vs pixel to create a NON-LINEAR time vs pixel wave. Store it as Iasbo1_s99999_Time.

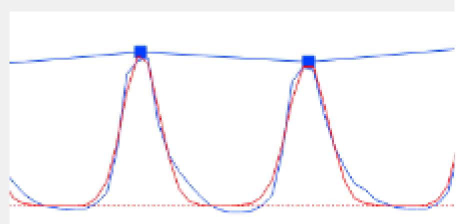
       THIS is the wave that contains the accurate timing information.
    6. Calculate a LINEAR approximation to the time vs pixel relationship and use that APPROX relationship to RESCALE the images into time. This is because we do not want to bother deforming the images.
       <u>**NOTE**</u>: Whenever we plot images of Omega Data, the timing will be approximate. The accurate timing information will only be shown when we plot lineouts and extracted observables as a function of the _Time wave.
       Using cursors on an image is NOT an accurate way to determine the time delay between two events on Omega.

10. The new window reports the results of the Timing calibration:

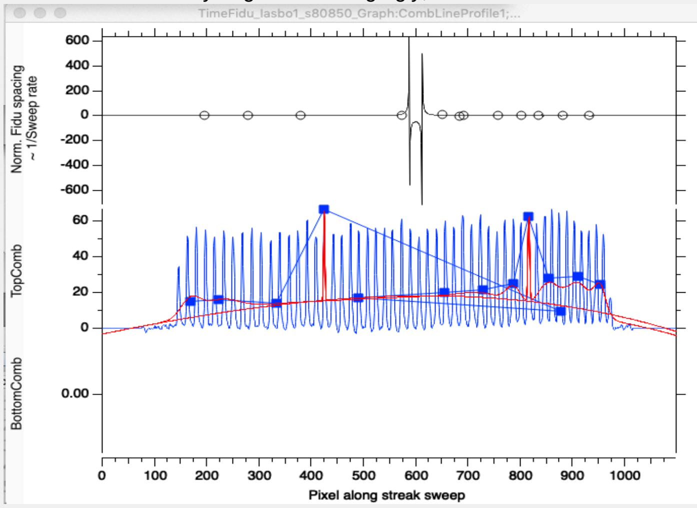
    1. **The bottom plots show the lineouts for the top (and bottom if using two combs like at NIF) combs in BLUE and the multi-gaussian fit result in RED. The baseline is dotted red.**
    2. **The squares are the positions of the center of the various gaussian peaks.**
    3. **The top plot reports**
        1. **the spacing between these fiducials, normalized by the average value (Circles).**
           This is inversely proportional to the sweep rate and proportional to the dwell time=the time photons are recorded on a given column of pixels in the timing dimension.
        2. **A line that is a Smooth&Spline of the circles. The parameters are Smooth and StdDev. Increasing those numbers smoothes out fast variations of the sweep rate. Linear and polynomial interpolation options are also available.**

        3. This line is then integrated to create the Iasbo1_s99999_Time wave. Using Recalc will adjust the timing without recalculating the multi-Gaussian fit.

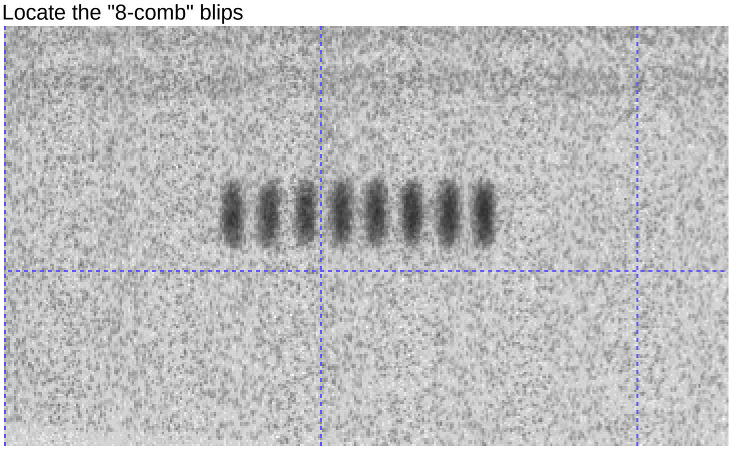


4. If instead of a nice fit you get something ugly, similar to:

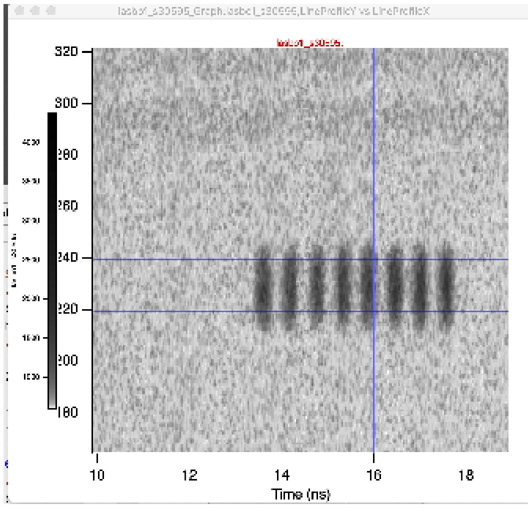


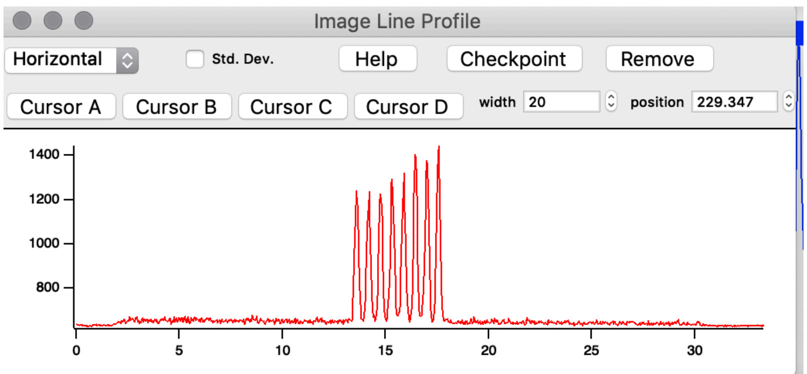
   1. You need to help the routine a bit
   2. Click on Guess Noise/Smooth. This will call the initial guess of the MultiPeak Fit routine and set the Noise and Smooth values
   3. Uncheck the Auto options and lower the values that seem high, or use trial and error before clicking again on **Norm. Timescale**
   4. For example reducing Smooth from the guessed value of 7 to 3 allowed the code to correctly fit the comb shown above
   5. If you cannot make the Auto Option work, there is always the Manual option

11. Locate the "8-comb" blips

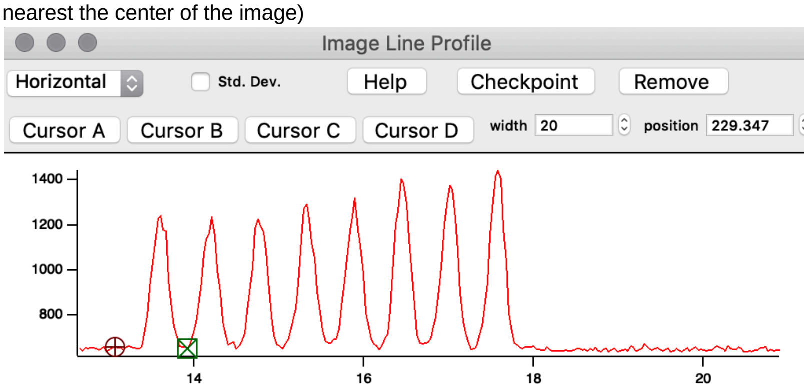


12. Zoom and use **Cmd+6** to create a horizontal lineout with a width of 20





13. Expand horizontally and position cursors around the first peak (or any other peak of your choice. **BEST Practice:** Use the peak nearest the center of the image)



14. Click on **Fit**

This will use a gaussian fit to locate the position of the center of the selected blip. The results will appear in the command window:

```
Coefficient values ± one standard deviation
 y0 =587.64 ± 15.8
 A  =6.4223 ± 0.936
 x0 =12.451 ± 0.00338
 B  =0.0092889 ± 0.00139
```

Here the center is found at 12.451 ns.

15. Select the number of the peak that was fit in **Peak #** (between 1 and 8, starting from the left/ in chronological order)
16. Select the facility/telescope option between **Omega, EP,** or the Omega Off-Axis Telescope : **OATEL**

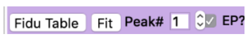
17. Click on **FiduTable. This will create a table with the Absolute timing values for the center of the selected peak within the 8-comb pattern**

1. This uses data from the LLE folks doing the timing calibration. Historical values are loaded into the **EtalonsToAnalyzevisar2 .xlsx** spreadsheet in your **Igor Pro 8 User Files Folder** and selected based on the shot number
2. If you used a common Trim Fiducial Delay optical fiber, select the timing values for each channel in the corresponding row.

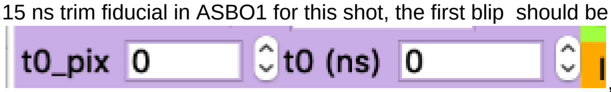
Fiducial_Table:FiduFiberDelay,FiduASBO1,FiduASBO2,Fid...

R0 | 0

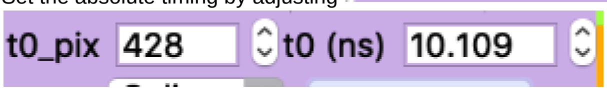
Point	FiduFiberDelay	FiduASBO1	FiduASBO2	FiduSOP
0	0	-0.041	-0.302	-0.256
1	3.05	3.009	2.748	2.794
2	6.23	6.189	5.928	5.974
3	6.26	6.219	5.958	6.004
4	6.55	6.509	6.248	6.294
5	7.1	7.059	6.798	6.844
6	7.12	7.079	6.818	6.864
7	10.15	10.109	9.848	9.894
8	10.33	10.289	10.028	10.074
9	12.19	12.149	11.888	11.934
10	13.46	13.419	13.158	13.204
11	14.3	14.259	13.998	14.044
12	14.99	14.949	14.688	14.734
13	15.23	15.189	14.928	14.974
14	20.23	20.189	19.928	19.974
15	25.31	25.269	25.008	25.054
16	25.77	25.729	25.468	25.514
17	81.51	81.469	81.208	81.254
18	81.53	81.489	81.228	81.274

For example, here for EP shot #30595, with these parameters 

and because we used a 10.15 ns trim fiducial in ASBO1 for this shot, the first blip should be at t=10.109 ns.

18. Set the absolute timing by adjusting 

, for example to



Now redoing the Fit of the 1st blip of the "8-comb" gives

```
y0 =567.59 ± 19.1
A  =7.2443 ± 1.12
x0 =10.103 ± 0.00326
B  =0.010243 ± 0.00156
```

Which is quite good (only 6 picoseconds off).
If necessary, t0_pix and t0 (ns) can be adjusted manually to non-integer values,

19. Click to Save Parameters to Image to save all these parameters. Clicking on ReCalc is also a good idea.
20. **NOTE**: One can also set the cross-timing between various images by assigning a reference time (say t=0) to a common feature (example a shock breakout)

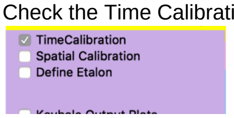
Description of the outdated option: One Comb auto for AV8 version 10 and lower - before 03/2020

Here, to determine the relative timing, we need to manually select a region of the image where the streak camera recorded a series of blips or pulses generated by a very stable oscillator which provides us with a timing reference pattern: If the oscillator period is 2 ns then there should be 2 ns between two blips. Once we identify these blips, we do a lineout, then we fit this lineout to find the location in pixel of all the blips, then we assign a time to all these blip using the known period between those blips. Integrating this series of [time,pixel] values creates the time vs pixel wave that we need .

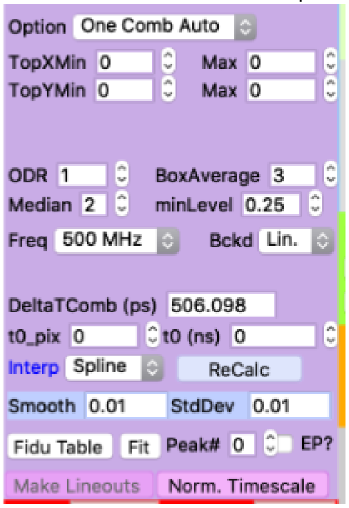
Then identifying the position of the absolute timing feature, "the 8-comb", we can determine the absolute timing.

1. Select one image with the Current Image Name Popup

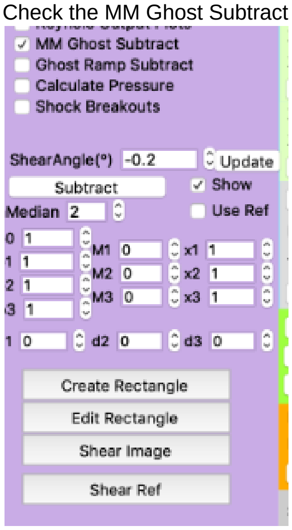
2. Check the Time Calibration box on the left



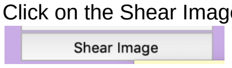
3. Select One Comb Auto in the Option popup menu. The buttons will simplify and will look like this

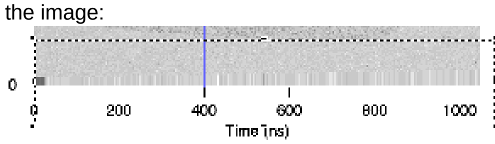
4. You may want to shear the Image, a cheap way of correcting for the spatial distortion so that fringes are horizontal and isochrones are therefore vertical
   1. Check the MM Ghost Subtract box

   2. Adjust the ShearAngle Value. I usually use the following values
      1. for Omega 60:
         1. ASBO1 ShearAngle=-0.2
         2. ASBO2 ShearAngle=-1.2
         3. SOP ShearAngle=-0.2
      2. for OmegaEP
         1. ASBO1 ShearAngle=-1
         2. ASBO2 ShearAngle=+0.2
         3. SOP ShearAngle=-0.2
   3. Click on the Shear Image button

      The image will be sheared and straightened(hopefully) and characteristic features (vertical lines) will appear at the bottom of the image:

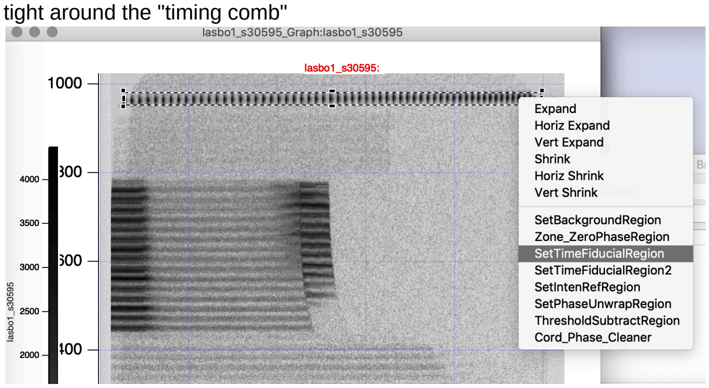
   4. Now the Fringes should look "more horizontal"
   5. Click to Save Parameters to Image to save the value of the ShearAngle
   6. **You will also need to shear the Reference Image the same way.**

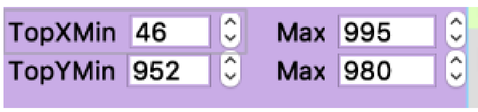
Before	After

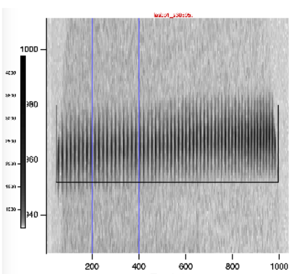
(I changed the grid lines to red to see them better here)

NOTE: Generally speaking, it is always better to do any dewarping or distortion corrections **BEFORE** doing timing calibration.

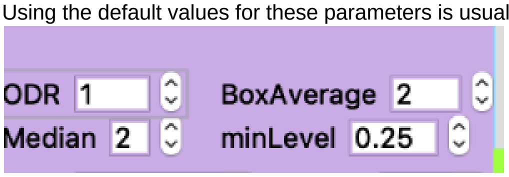
5. Using the mouse and right click, then select SetTimeFiducialRegion will create a marquee region to delimit the location of the timing comb (at the top) which will populate the Top Xmin,max, Ymin,max values and draw a black rectangle. You want to select a region tight around the "timing comb"





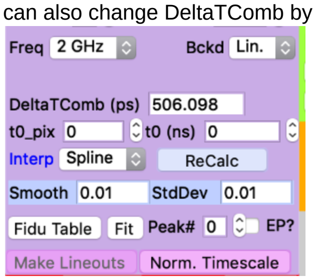


6. Using the default values for these parameters is usually ok



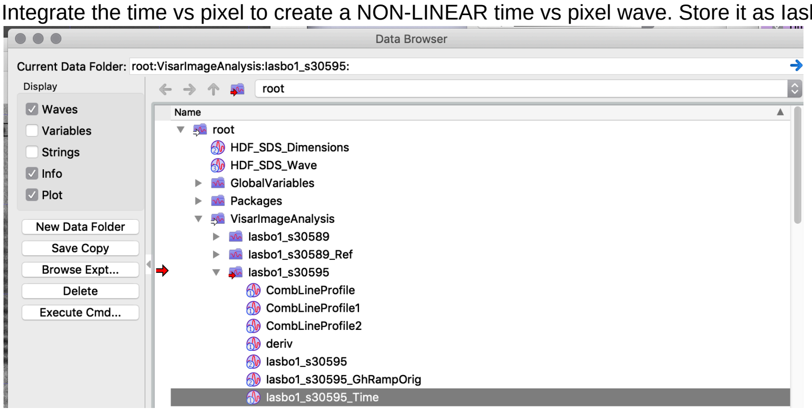
   1. ODR=N: ODR parameter for the multi-peak fit of the lineout
   2. Box Average=N: Apply a box average smoothing to the lineout before filtering
   3. Median=N: Apply a Median filter of order N to the timing comb region of the image before taking the lineout.
      NOTE: This is better than Box Average to clean out noisy data
   4. minLevel=x: Find only blips (that is peaks in the lineout) that are larger than x times the maximum value. x=0.25 is usually a good guess. Tweaking this value will usually help finding all the blips.

7. Select the Comb frequency and the Background shape(either linear of cubic). This info will come from the SRF or the shot report. Usually it is 2GHz. On the sweeps longer than 27 ns, the 500 MHz comb is used.
   Note: If the timing comb looks similar to the "8-comb" then it is 2 GHz, otherwise it is likely 500 MHz
   Note: Selecting a Frequency in the Freq popup will fill the DeltaTComb variables which holds the comb period in picoseconds. You can also change DeltaTComb by hand.



8. Click on Norm. Timescale. This will
   1. create the lineout.
   2. Plot it into a new window called TimeFidu_IAsbo1_s99999_Graph

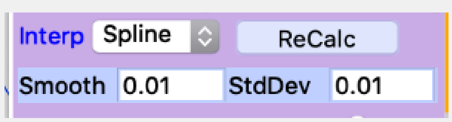
3. fit it with a (legacy routine from Igor6) multi-peak Gaussian fit which has fixed widths.
   NOTE: For some reason, this routine is VEEERY slow in Igor7 and above. So don't worry, if it takes a while, it's not you ;-)
4. Assign a time interval of DeltaTComb between two adjacent peaks
5. Integrate the time vs pixel to create a NON-LINEAR time vs pixel wave. Store it as lasbo1_s99999_Time.



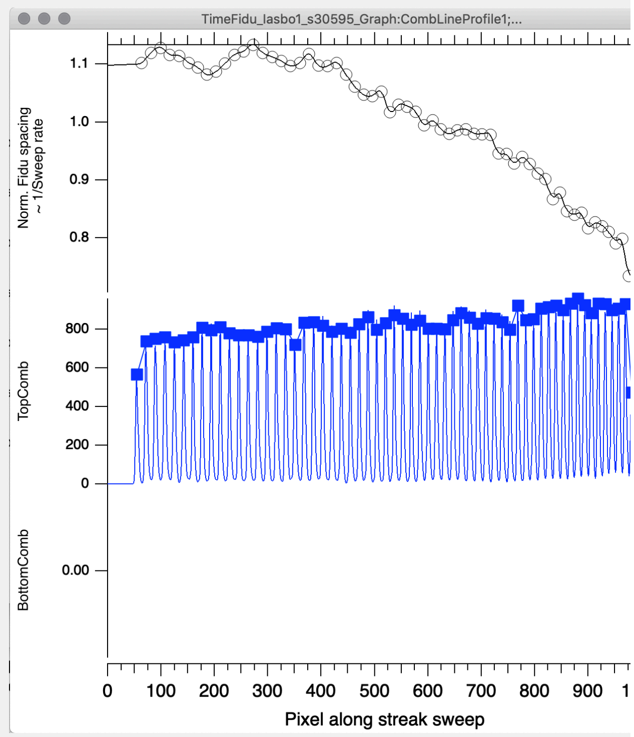
   THIS is the wave that contains the accurate timing information.
6. Calculate a LINEAR approximation to the time vs pixel relationship and use that APPROX relationship to RESCALE the images into time. This is because we do not want to bother deforming the images.
   NOTE: Whenever we plot images of Omega Data, the timing will be approximate. The accurate timing information will only be shown when we plot lineouts and extracted observables as a function of the _Time wave.
   Using cursors on an image is NOT an accurate way to determine the time delay between two events on Omega.

9. The new window reports the results of the Timing calibration:

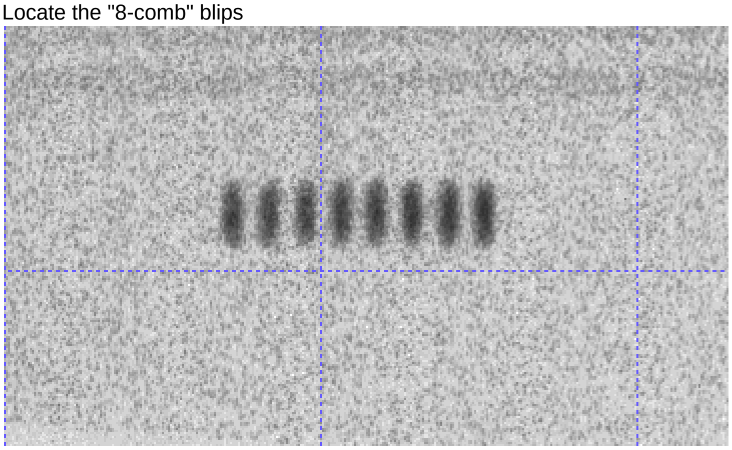
1. **The bottom plots show the lineouts for the top (and bottom if using two combs like at NIF) combs.**
2. **The squares are the positions of the center of the various gaussian peaks.**
3. **The top plot reports**
   1. **the spacing between these fiducials, normalized by the average value (Circles). This is inversely proportional to the sweep rate and proportional to the dwell time=the time photons are recorded on a given column of pixels in the timing dimension.**
   2. **A line that is a Smooth&Spline of the circles. The parameters are Smooth and StdDev. Increasing those numbers smoothes out fast variations of the sweep rate. A linear interpolation is also available.**



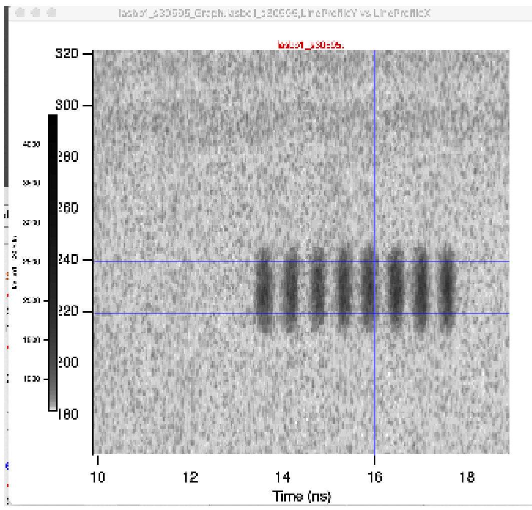
   3. This line is then integrated to create the lasbo1_s99999_Time wave. Using Recalc will adjust the timing without recalculating the (slow) multi-Gaussian fit.

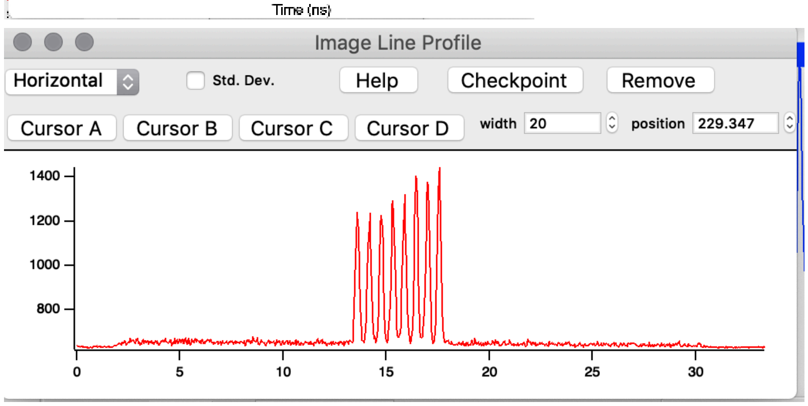


10. Locate the "8-comb" blips

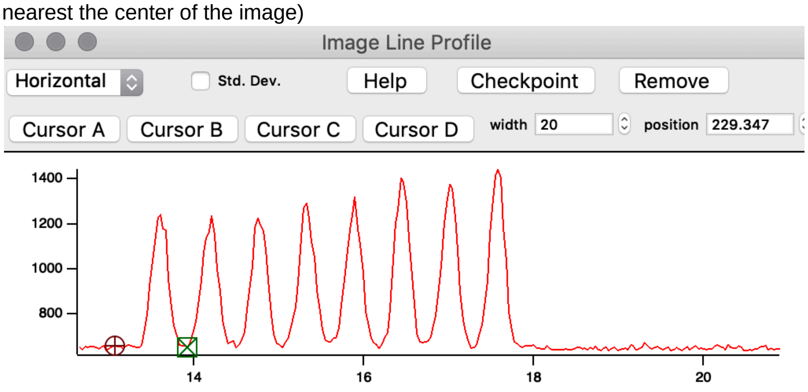


11. Zoom and use Cmd+6 to create a horizontal lineout with a width of 20





12. Expand horizontally and position cursors around the first peak (or any other peak of your choice. BEST Practice: Use the peak nearest the center of the image)



13. Click on Fit 

This will use a gaussian fit to locate the position of the center of the selected blip. The results will appear in the command window:

```
Coefficient values ± one standard deviation
 y0 =587.64 ± 15.8
 A  =6.4223 ± 0.936
 x0 =12.451 ± 0.00338
 B  =0.0092889 ± 0.00139
```

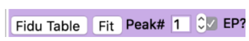
Here the center is found at 12.451 ns.

14. Select the number of the peak that was fit in Peak #, then check EP if analyzing data from Omega EP. Then click on FiduTable
This will create a table where the suggested value of the center of the selected peak appears.
This uses data from the Omega folks doing the timing calibration and is available for the various Trim Fiducial Delay optical fibers that were used during the shot.

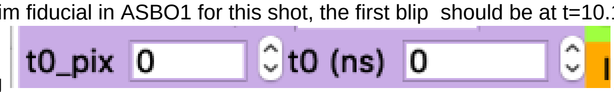
Fiducial_Table:FiduFiberDelay,FiduASBO1,FiduASBO2,Fid...

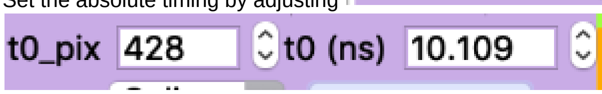
R0 | 0

Point	FiduFiberDelay	FiduASBO1	FiduASBO2	FiduSOP
0	0	-0.041	-0.302	-0.256
1	3.05	3.009	2.748	2.794
2	6.23	6.189	5.928	5.974
3	6.26	6.219	5.958	6.004
4	6.55	6.509	6.248	6.294
5	7.1	7.059	6.798	6.844
6	7.12	7.079	6.818	6.864
7	10.15	10.109	9.848	9.894
8	10.33	10.289	10.028	10.074
9	12.19	12.149	11.888	11.934
10	13.46	13.419	13.158	13.204
11	14.3	14.259	13.998	14.044
12	14.99	14.949	14.688	14.734
13	15.23	15.189	14.928	14.974
14	20.23	20.189	19.928	19.974
15	25.31	25.269	25.008	25.054
16	25.77	25.729	25.468	25.514
17	81.51	81.469	81.208	81.254
18	81.53	81.489	81.228	81.274

For example, here for EP shot #30595, with these parameters 

and because we used a 10.15 ns trim fiducial in ASBO1 for this shot, the first blip should be at t=10.109 ns.

15. Set the absolute timing by adjusting 

, for example to


Now redoing the Fit of the 1st blip of the "8-comb" gives

```
 y0 =567.59 ± 19.1
 A  =7.2443 ± 1.12
 x0 =10.103 ± 0.00326
 B  =0.010243 ± 0.00156
```

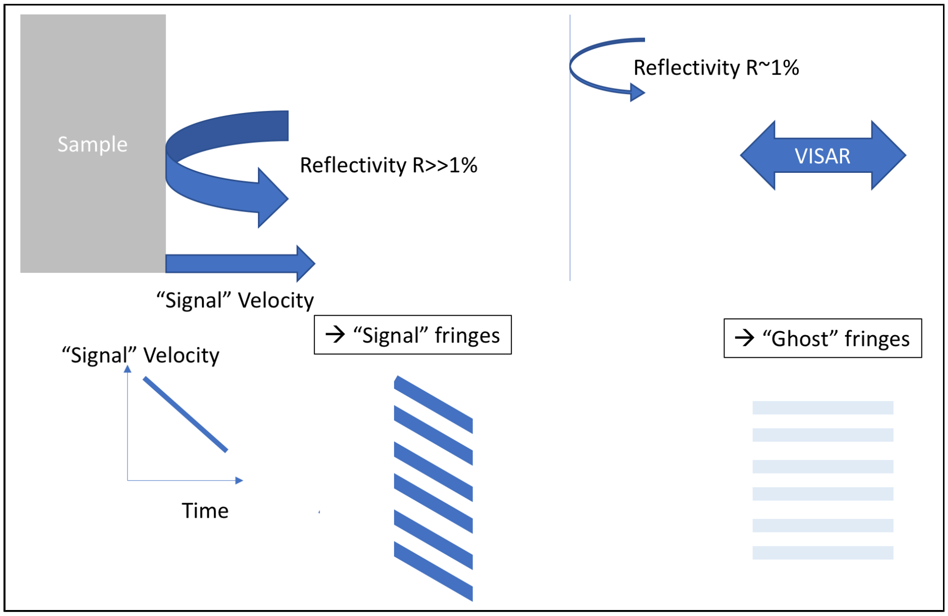
Which is quite good (only 6 picoseconds off).
If necessary, t0_pix and t0 (ns) can be adjusted manually to non-integer values,

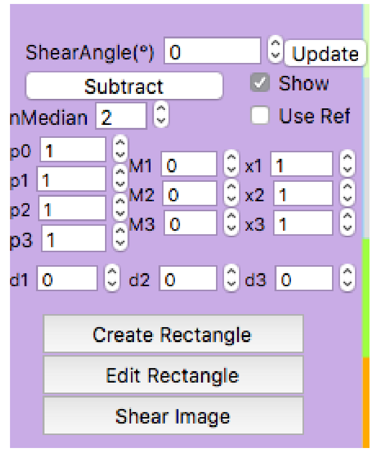
16. Click to Save Parameters to Image to save all these parameters. Clicking on ReCalc is also a good idea.
17. **NOTE**: One can also set the cross-timing between various images by assigning a reference time (say t=0) to a common feature (example a shock breakout)

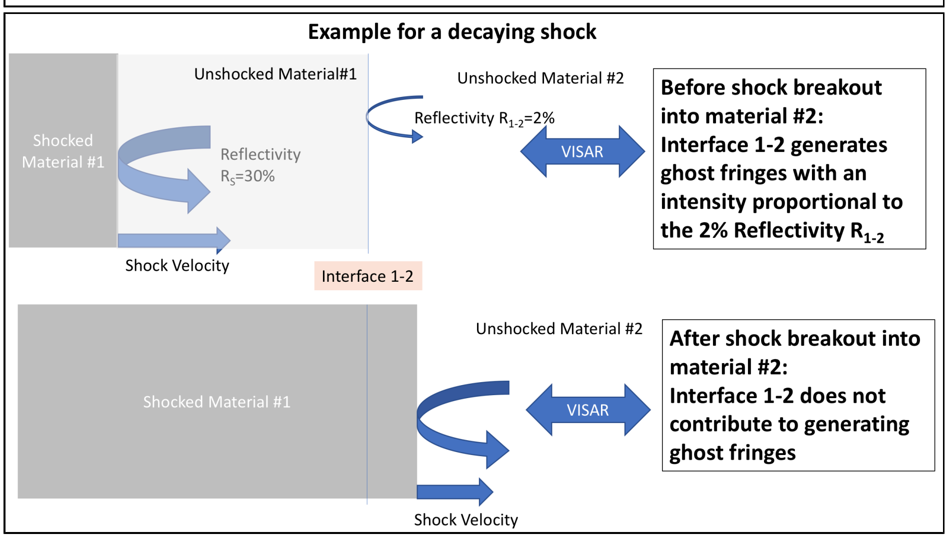
MM Ghost Subtract

This is simple, heuristic way to subtract ghost fringe signal.

The philosophy is to assume that ghost fringes will be stationary (no fringe shift) and that their intensity will likely be relatively constant over time as long as the interface they originate from remains on the VISAR path.





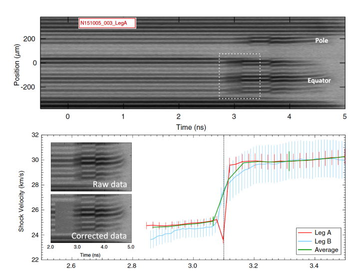


How to use this

1. Make sure your image has no shear or rotation that is stationary fringes will be parallel to the time axis.
    1. At NIF this is usually true
    2. At Omega,
        1. You might want to shear the images BEFORE doing the timing
        2. Start by setting a **Shear Angle** and clicking on **Shear Image**.
        3. Remember to also shear the **Reference image**

2. Click on Create rectangle. This wil create a green rectangle on your image.
    1. You can edit its size (keep it a rectangle) by clicking on it. Click on Cmd+T when you are done
    2. Clicking on Edit Rectangle will make it active again. (By setting the Active layer of the image to the one when the green rectangle is drawn)

Example:



    3. With the Green Rectangle , you want to select a region that has either just the ghost fringes (case of a reflecting shock with vanishing reflectivity) or stationary fringes at early time.
    4. The Ghost fringe algorithm will be applied ROW by ROW, in the spatial dimension delimited by the green rectangle.
3. Set the parameters: p0 to p3 and M1to M3.
    1. X1 to x3 =1 and d1 to d3 =0 are default.
    2. Need to fill in P0 to p3 as a monotoneous series of pixel positions along the time axis.
    3. This means you need to fill p2 and p3 with 1000 and 1001 for example even if you are really using only p0 and p1 to subtract ghost in one region.
4. Make sure you selected an image in **Current Image Name** Popup and the appropriate Reference in the **Reference Image Name** Popup
5. Click on subtract
    1. The algorithm performs a FFT in the green region and extracts a vertical lineout (representing the fringes)
    2. it then subtracts these fringes, multiplied by M_i for all rows withing the green rectangle, and between the pixels p_{i-1} and pi
    3. If xi is different from 1, the fringes between p_{i-1} and pi will be dilated by xi (to correct for pinching)
    4. If di is different from 0, the fringes between p_{i-1} and pi will be offset by d1 (to correct for pinching)

Tutorials

This section contains a few tutorials.

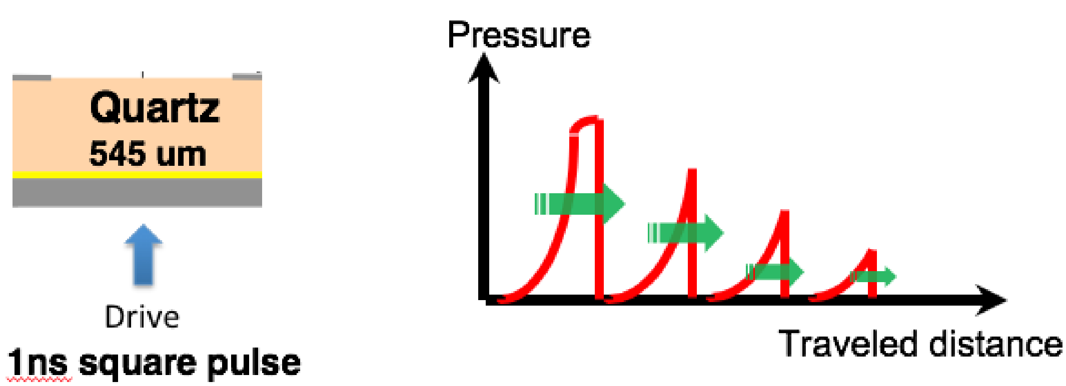
- NIF Quartz Decaying Shock Tutorial
    - Load image
    - obtain the Phase Map
    - create Breakout waves
    - use the Make Multipliers Graph to solve fringe jumps
- Use Make Velocities Graph
- A note about Impedance Matching fits and error bars
- Fit and Extrapolate Velocity in decaying shocks with vanishing reflectivity
- Use Make Reflectivities Graph
- Use Make Temperature Graph

NIF Quartz Decaying Shock Tutorial

-

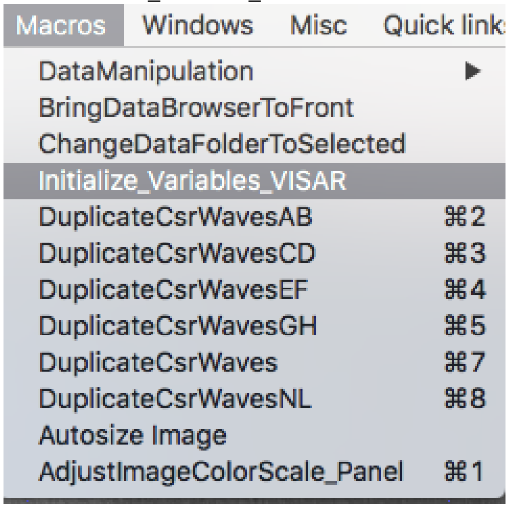
Notes on this tutorial

1. This tutorial uses a dataset corresponding to a decaying shock in quartz measured at the NIF. The pressure range is ~10 to 40 Mbar.
2. You can **Download the files** for N180702-002 either directly on the NIF Archive Viewer if you have appropriate credentials or directly here : N180702-002.zip



1. ## Get AV8 up and running
    1. **Start Igor and Verify you can compile** AnalyzeVisar (AV) and its companion routines or check Getting started and Igor Routine Files **without any error messages**
    2. **Launch AnalyzeVisar**
    3. Cmd+M to bring command window forward, type #include "AV" in the command window, then compile. If you are using Igor8, type #include "AV8" instead

4. MacrosInitialize_Variables_VISAR



This will create and declare many variables, waves, folders and strings and create the VISAR_Analysis Panel. Sometimes, if something bugs or goes wrong and the panel is modified, kill the panel and re-execute the Initialize_Variables_Visar macro

2. ## Load the images

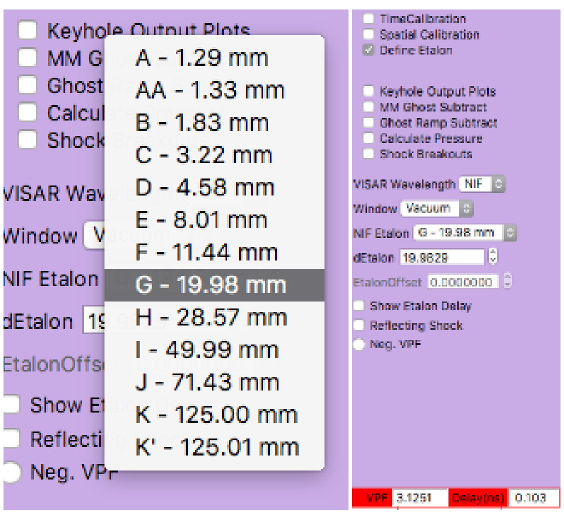
    1. More details about loading are on the Load an image page

3. ## Take care of the time calibration

    1. **Select the LegA image** in the Current Image Name Popup Menu
    2. **Time Calibration**: Because this is a NIF image that has been post processed by the SAVI engine, the timescale is actually quite linear, so you can skip the **Spatial Calibration** and **Time Calibration** steps
    3. More details on this step are on the Time Calibration page

4. ## Select the etalon,

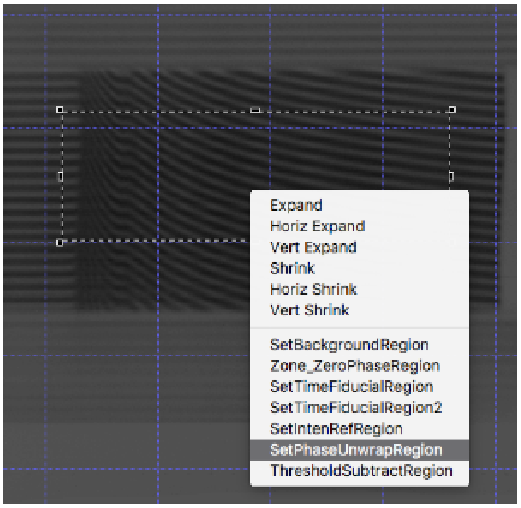
    1. check the **Define Etalon Checkbox**
    2. Select NIF in the **VISAR Wavelength Popup,** a vacuum window in the **Window Popup** and the appropriate etalon in the **NIF Etalon Popup**
        1. For this shot the Leg A had the 19.98 mm while leg B had the 8.01 mm



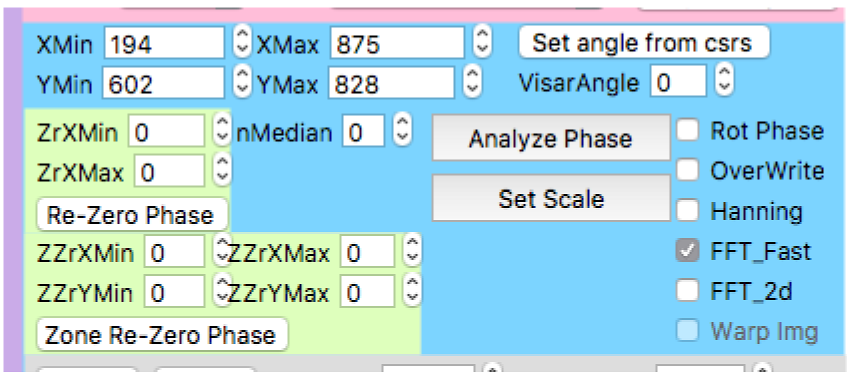
    3. **Notes:**
        1. List of etalons for **Omega 60** and **Omega EP** are also available. Select Omega or EP in the **VISAR Wavelength Popup**
        2. The velocity per fringe VPF will be populated in the red area below (in km/s = micron/ns), as well as the etalon delay in nanosecond
    4. Click Save Parameters to Image to save the etalon value in the **Parameters Wave** for the active image

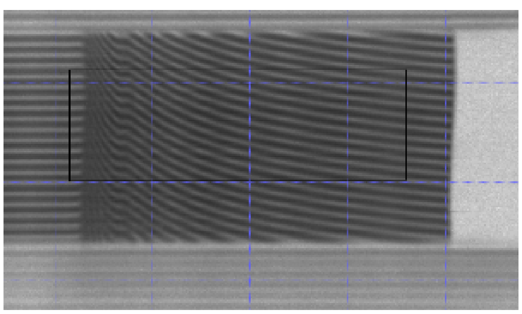
5. ## Select the Fringe Analysis Area

    1. by drawing a rectangle with the mouse (Left click), then right click in the active area and select **SetPhaseUnwrapRegion**



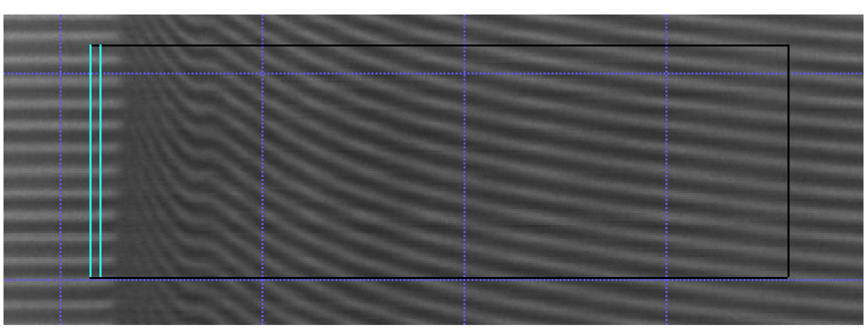
This will populate the **Xmin,Xmax ,Ymin,Ymax** Controls on the **Blue Block** and draw a black rectangle around this area

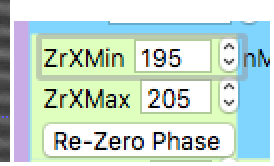




6. **<u>Set the Zero Phase Region</u>.**

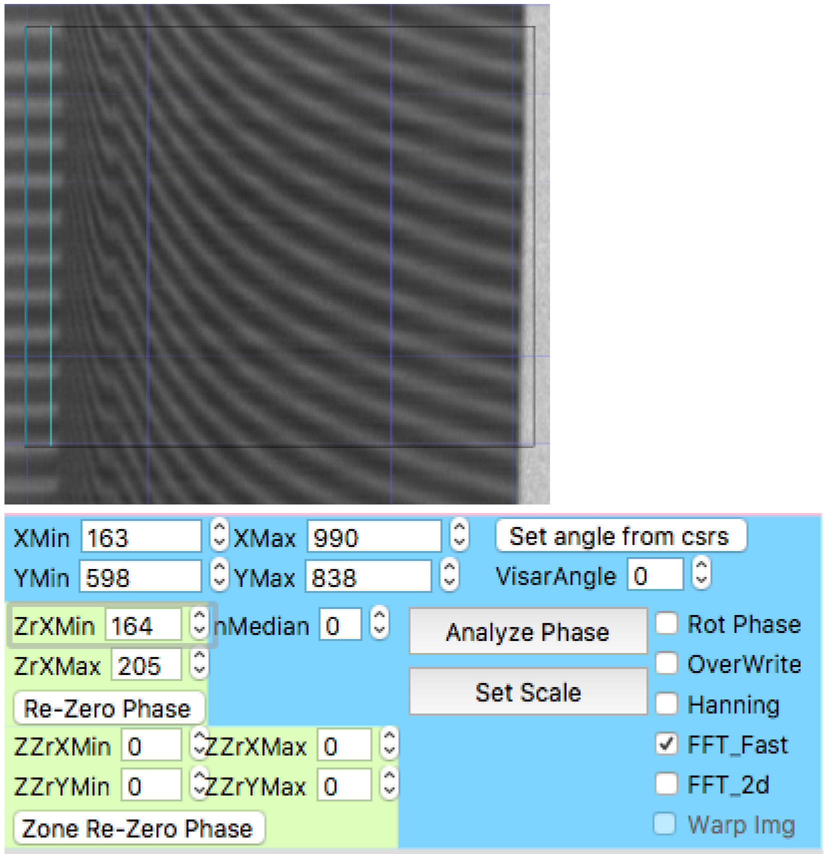
   1. Clicking and hitting Return or typing any number less than Xmin into ZrXMin in the green area will set this value to Xmin+1. Similarly, it will populate ZrXmax by ZrXmin+10 by default. Feel free to adjust these to select an appropriate region of initial fringe phase, that is zero fringe shift.





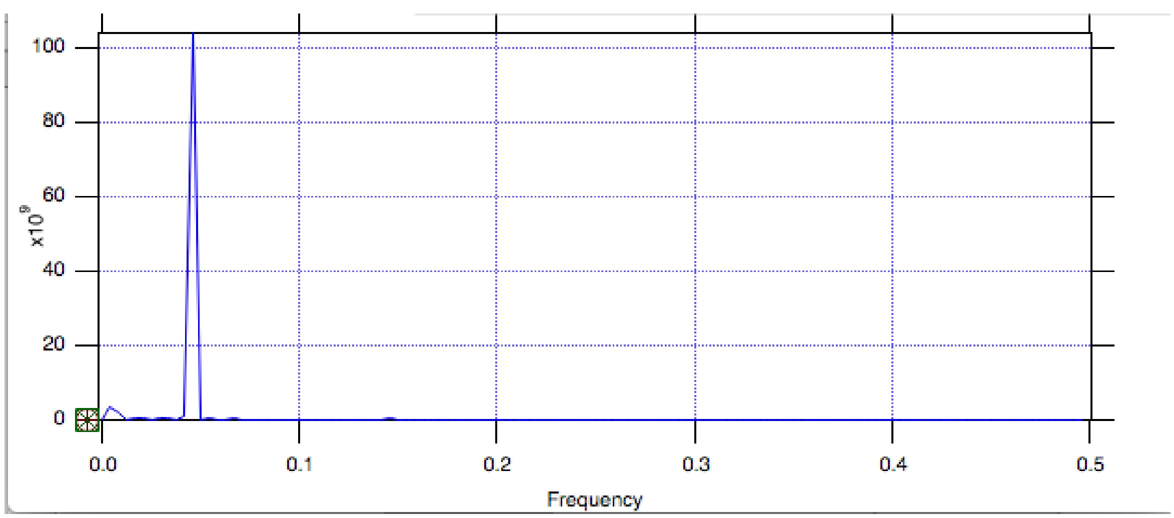
<u>Notes</u>:

1. Of course, because we will do a 1D FFT, you want to select an integer number of fringes between Ymin and Ymax.
2. You can adjust the Fringe Analysis Region boundaries using the Controls in the Blue Block of VISAR_Analysis Panel.
3. In this case, we are interested in the central region of the record, monitoring a strong, unsupported shock travel into a quartz crystal.

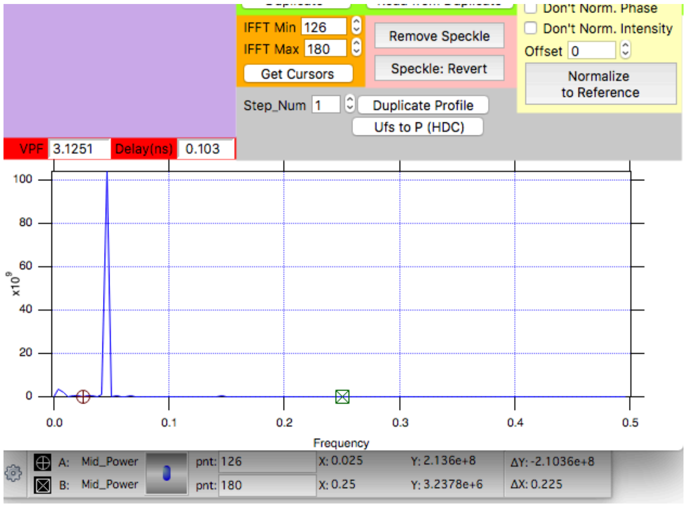


7. Analyze the phase

1. Click on Analyze Phase. This will take a second and modify the plot at the bottom of the VISAR_Analysis Panel. This graph shows the power spectrum of the 1D FFT in the ZeroPhase Region as a function of spatial frequency. Obviously, if you select a larger number of fringes, the resolution in spatial frequency will be higher.



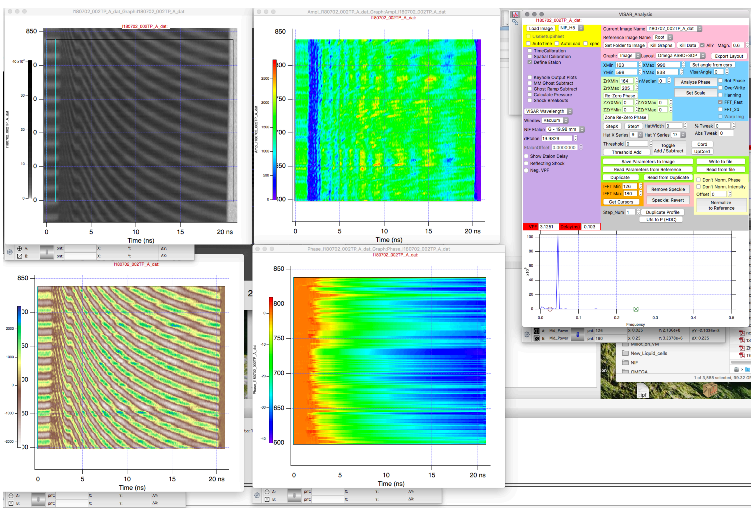
2. Adjust the FFT filter: position cursors to the left and to the right of the carrier frequency and click on Get Cursors to populate IFFT Min and IFFT Max



Note : The goal of this step is to filter out zero frequency contributions before extracting the fringe shift phase map and amplitude.

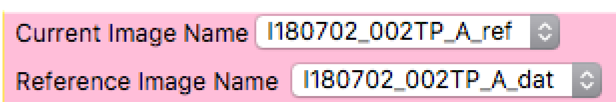
I usually set the IFFT Min near the minimum between the Zero Frequency peak and the carrier frequency peak. It is important to remember that using IFFT Min too close to the carrier Frequency maximum will cause a loss of information at low spatial frequency (that is slowly varying in real space). I usually set the IFFT Max near 0.25.

3. Click again in Analyze Phase, then on Set Scale to bring forward and adjust the zoom of the Phase, amplitude, and IFFT Images.

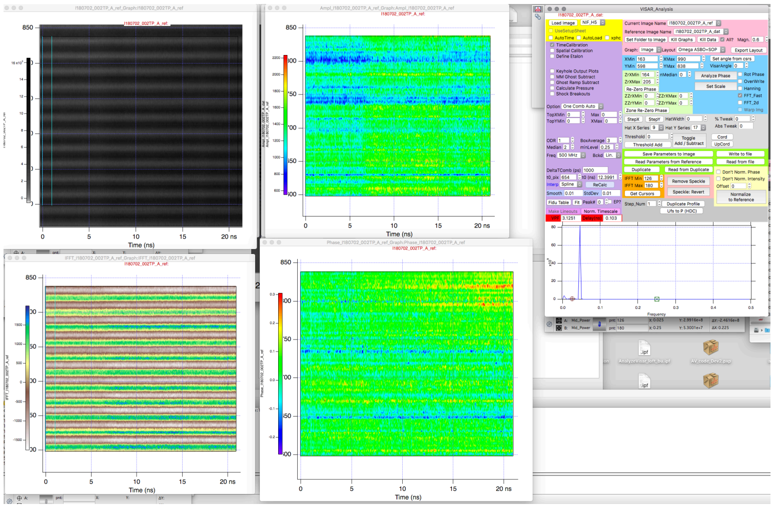


8. Analyze the Reference Image

1. Select the appropriate Reference Image in the Current Image Name Popup
2. Select the appropriate Shot Image in the Reference Image Name Popup



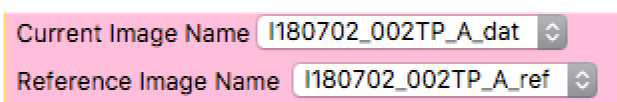
3. Click on Read Parameters from Reference : This will copy all analysis parameters.
4. Click on Analyze Phase, then on Set Scale to see the Images for the Reference Image



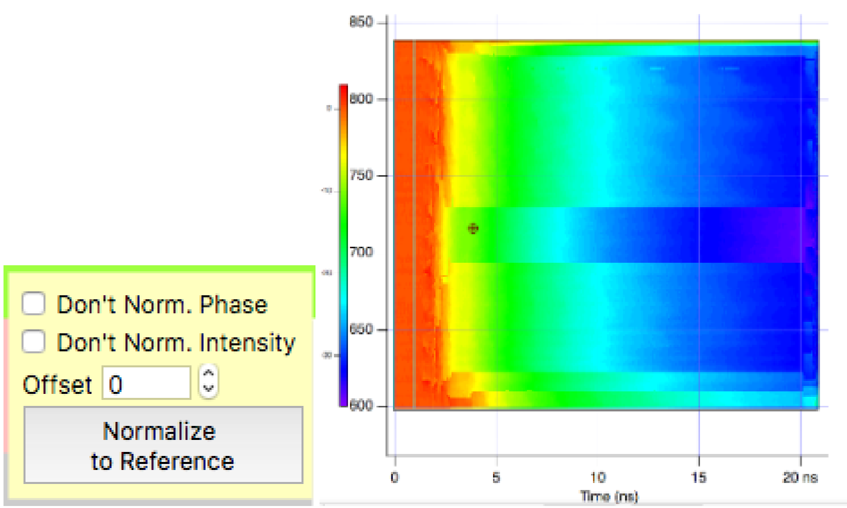
Notes:

1. The IFFT shows fringes very similar to the original Reference Image, the Amplitude and Phase maps are quite uniform (note that the color scales are usually set to automatic). Use Cmd+1 to adjust colors on any plot.
2. If the color scale for the phase map spans a range larger than the VPF, it is likely that some spurious fringe jumps need to be removed by *cleaning* the phase map using the tools in the Grey Block of the VISAR_Analysis Panel
3. Using the **Fast Ref Button** will do all of this in one click! This will:
    1. Swap the **Image** and **Reference** Images
    2. **Copy Parameters** from the Image
    3. Set **Median** to 3 for the **Ref**
    4. **Shear** the Ref to match the shear on the Image,
    5. **AnalyzePhase** for the Ref
    6. Apply **Cord** on the ref
    7. Swap the **Image** and **Reference** again

9. **Re-select the shot image and the reference images in the respective Popup Menus**



10. **Normalize the shot image phase and amplitude maps using the reference image.**
    1. Click on Normalize to Reference, with Don't Normalize Phase and Don't Normalize Intensity unchecked and Offset=0

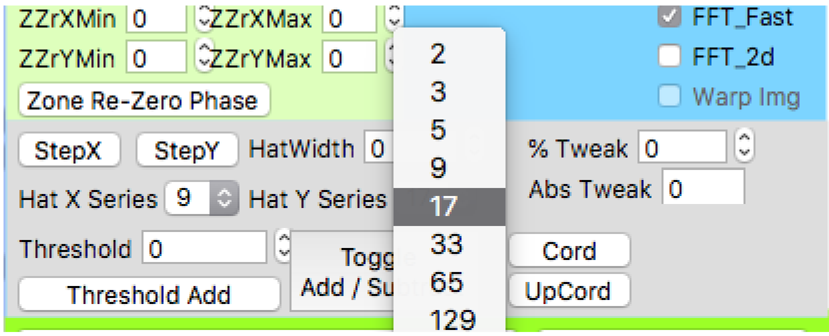


2. This is a simple way to correct for non-uniformities in the target illumination and camera sensitivity and remaining wedges between the fringes/ that is the "real" time axis and the abscissa of the images.
3. The amplitude graph color map should now extend over [0, ~1] instead of [0,~1000]

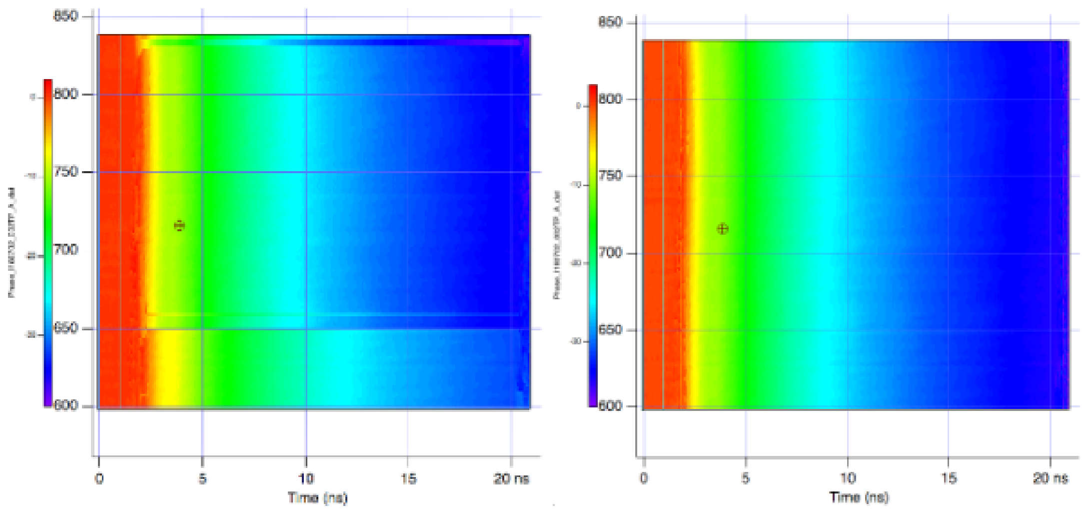
11. ## Clean the phase map

1. Goal is to remove the unphysical fringe jumps that were created because the phase unwrapping algorithm is not that smart.
2. **This can be tricky and tedious in most cases**
3. Here, **as an example** and for simplicity I recommend to start with

    1. **Hat Y** 17



    2. Then position the cursor A onto the image and hit **Cord**. This will copy on all raws the fringes shifts (or absence thereof) on the raw on which you position the Cursor A.

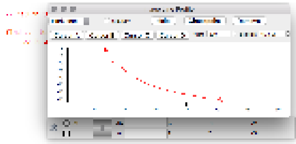


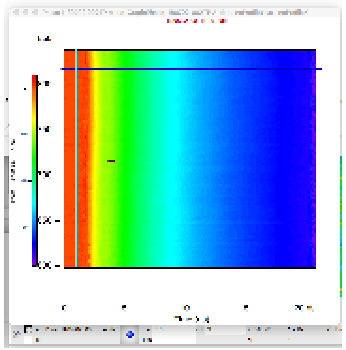
12. ## Re-Zero Phase:

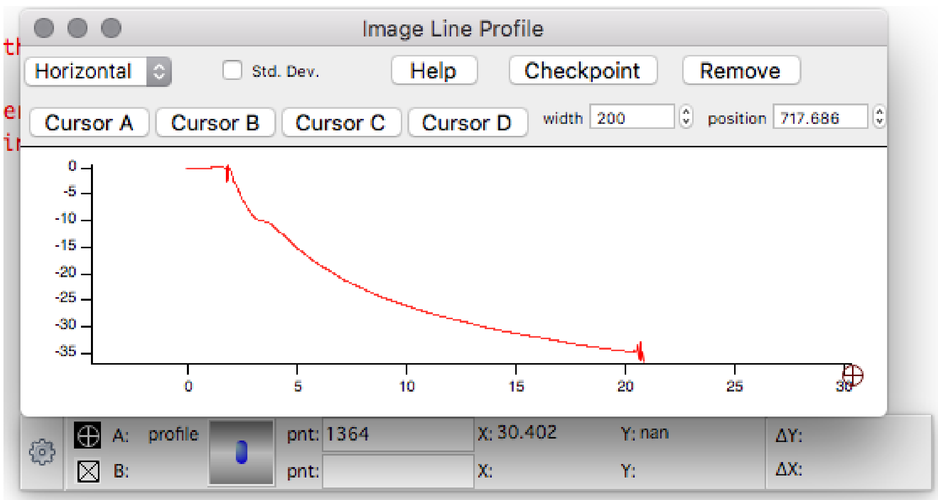
Click on Re-Zero phase to set the fringe shift to zero before the shock breakout.

13. ## Create the phase lineout for Leg A

1. At this time, you are ready to hit Cmd+6 to call the Image Line Profile routine. This will allow you to take an horizontal lineout of the phase map. You can select a wide region, here for example 200 pixel along the Y- axis and use the Position Control on the Image Line Profile Panel or move the blue lines with the mouse to obtain a spatially average phase shift history.

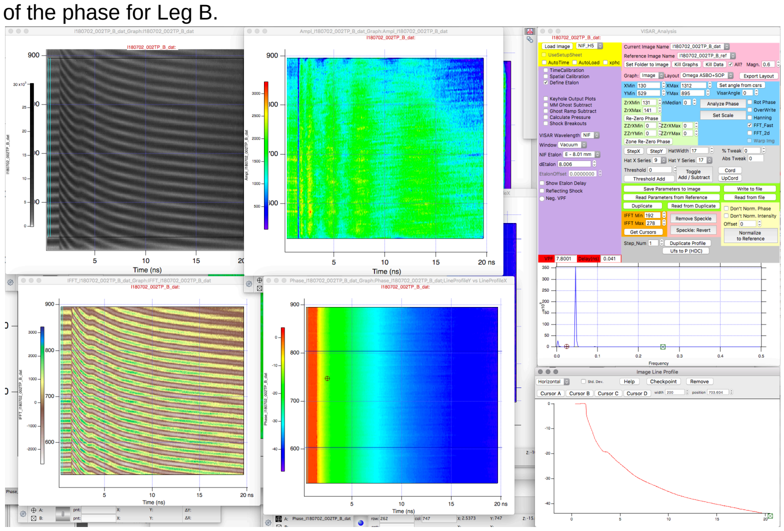






1. Clicking on Cursor A will put the cursor A on the Profile trace (at the last point of the trace).
2. Typing Cmd+5 will call the DuplicateCsrWaveGH routine and copy the Profile wave onto a new wave at the root directory call GCsrDupl.

14. **<u>Repeat all these operations and Create the phase lineout for Leg B</u>**

    1. Then clicking on Cursor B or placing the cursor B on the ImageLineProfile trace , this will create the HCSrDupl wave with a copy of the phase for Leg B.
    2. 

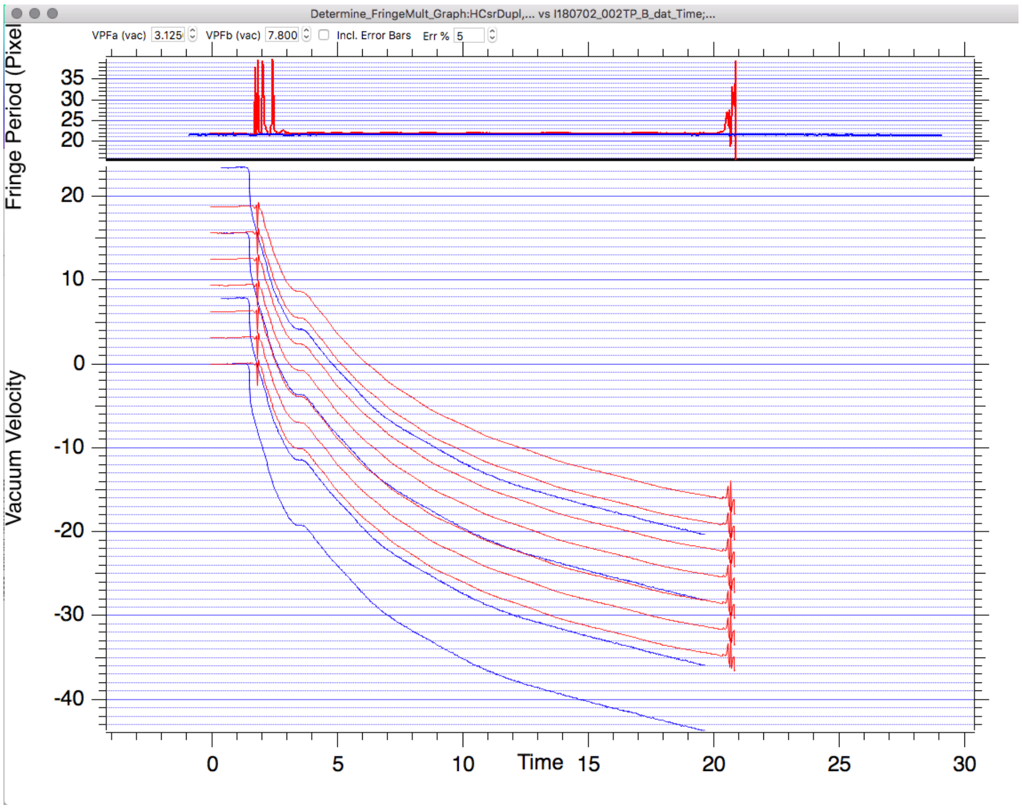
15. **<u>Make the Multiplier Graph</u>**

1. Check the **Shock Breakouts** in the Purple Box of VISAR_Analysis Panel and Click on **5 Make Multiplier Graph.** This will create the Multiplier graph to understand and resolve the 2-pi fringe jump ambiguities using the information from the 2 legs having different sensitivity.

   Note: The 5 in the button title is a reminder to use Cmd+5

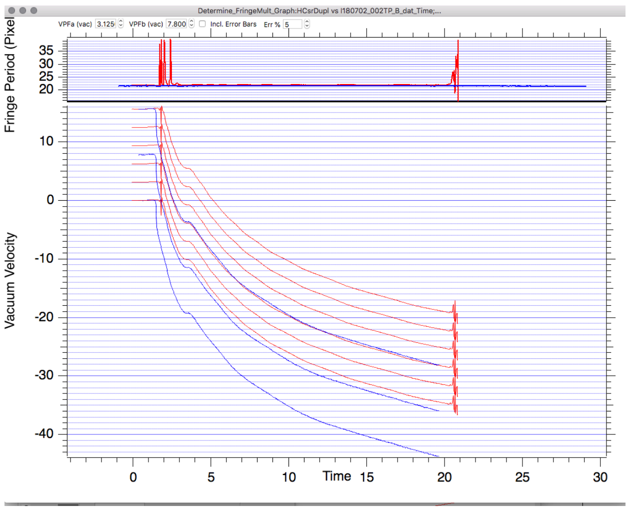
   The Multiplier Graph will initially look like this.

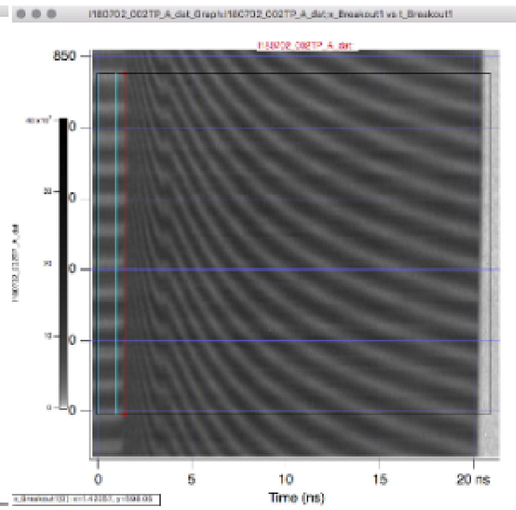
   Notes:
2. The bottom plot overlays the *GCstDupl* and *HCsrDupl* waves containing the copies of the phase lineouts.
3. Each of the two Leg phase profile is duplicated a few times and those duplicated waves are offset by 1 VPF on the graph.
4. These waves are plotted as a function of the NON-LINEAR time waves *I180702_002TP_A_dat_Time* and *I180702_002TP_B_dat_Time*. Here, because we did not modify the time calibration of the NIF images, this is not important here, but in most cases, the calculated implicit linear time scale of the waves/images will not be identical to the NON-LINEAR time scales waves LegXX_time.
5. The top part of the plot shows the fringe period from the FFT as a function of time for both the images and the references. This intends to indicate whether the fringe phase is meaningful (steady fringe period) or not (strong variations in the period).
6. It is good practice to check that the correct VPFs are reported for Leg A and Leg B on the top of the graph. (These are copied during the Cmd+5 action).



16. Simplify the Multiplier Plot.

1. Clicking on the VPFb Control and hitting enter will optimize the Multiplier graph by calculating the VPF ratio and plotting the relevant number of duplicated waves. Here because 5 times VPF A = 2 times VPF B, that is we used the standard 2/5 ratio between the VPFs, this will leave 6 (5+1) red traces and 3 (2+1) blue traces.

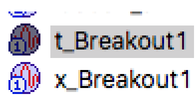


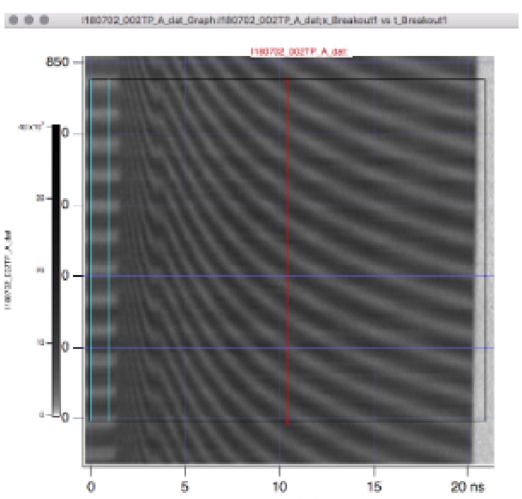


We are now ready to resolve the number of fringe jumps that occurred upon shock breakout into the quartz crystal near t=2 ns.

17. Create and adjust shock breakout waves

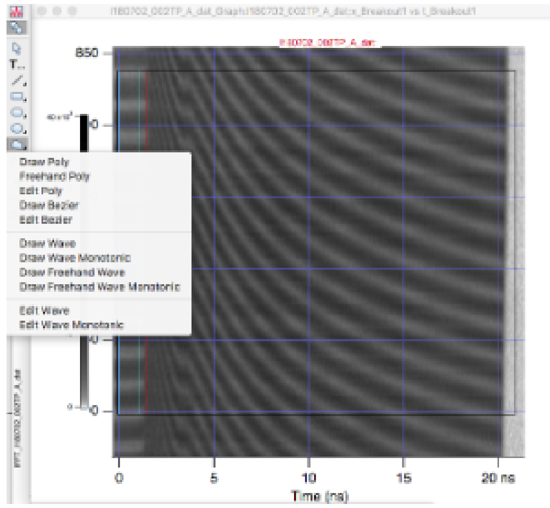
1. Select the Leg A image . Check the Shock Breakouts in the Purple Box of VISAR_Analysis Panel and Click on **Make Breakout.** This will create two waves in the current image folder named x_Breakout1 and t_breakout1 that will be shown as a red line on the shot image, phase, amplitude and IFFT maps.



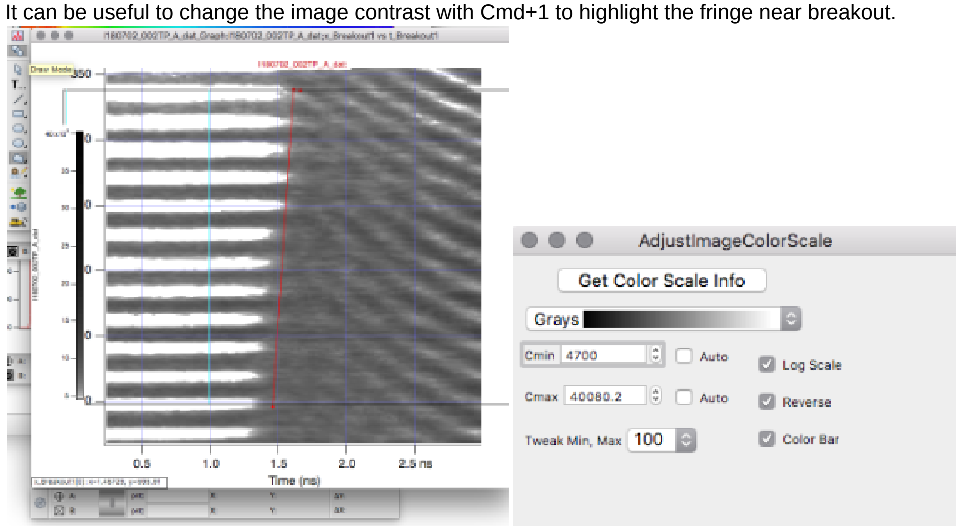


2. **Editing the shock breakout Waves**. We want to position the breakout wave to match the breakout event. For this you need to :
    1. click on the image
    2. call the tools with Cmd+T
    3. Select Edit Wave by
        1. on Igor 6 and 7 : Option+Click on the Polygon tool

2. on Igor 8 : Click and hold on the Polygon tool, select Edit Wave



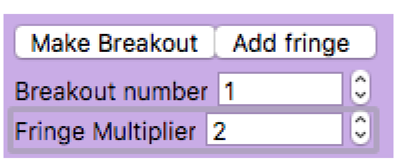
4. Move the red line onto the breakout event.
   1. Using shift and click will move a linear segment as a whole. Option and click will delete a point if there are more than 2.
   2. You might want to zoom. For this you need to escape the Tools mode with Cmd+T, zoom, then re-select the edit wave mode.
   3. It can be useful to change the image contrast with Cmd+1 to highlight the fringe near breakout.



Note: If necessary, we can create more than one breakout waves, they will be named x_Breakout2 etc

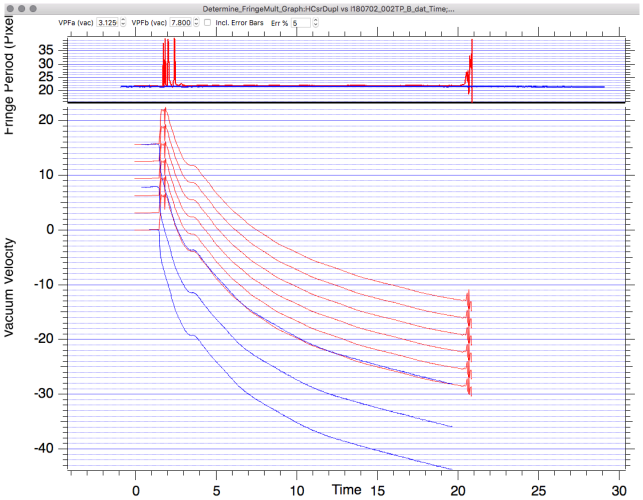
18. Add fringe jumps at the breakout to resolve the fringe jump ambiguities.

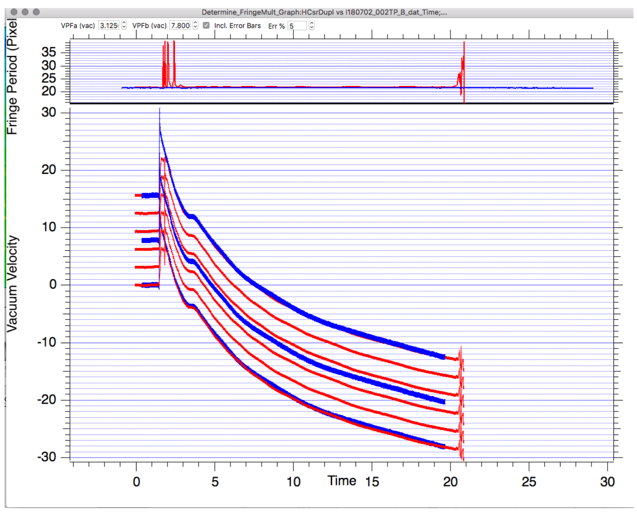
1. Going back to the VISAR_Analysis panel, select Breakout number #1 and type or use the tools to dial Fringe Multiplier to 2. Then click on add Fringes. You just added 2 VPFs on the phase map for Leg A, for all pixels to the right of the Breakout wave #1.



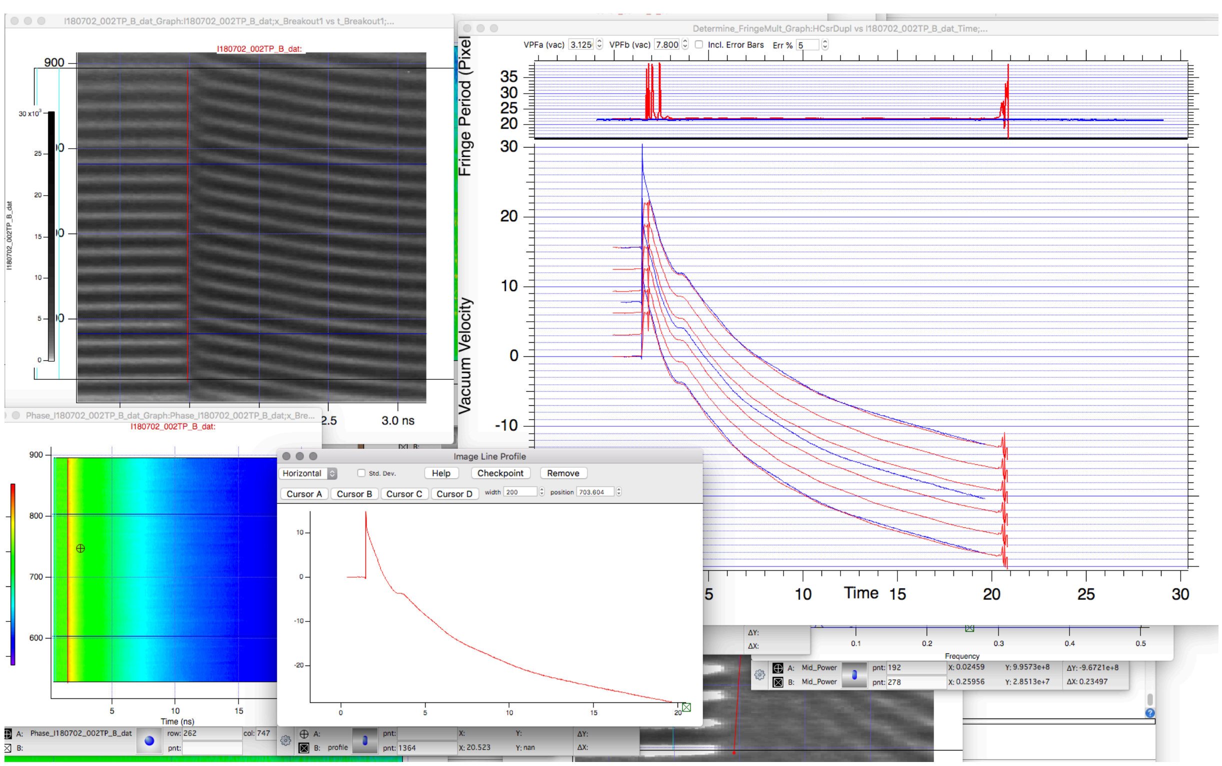
Click on the phase map for Leg A to activate it, then Cmd+6 to recall the lineout tool and actualize the lineout by either changing the width or position or clicking in one of these fields and hitting Return.

Now the phase lineout has changed and, selecting Cursor A for Leg A, we can update the Multiplier Graph by duplicating the current lineout with Cmd+5



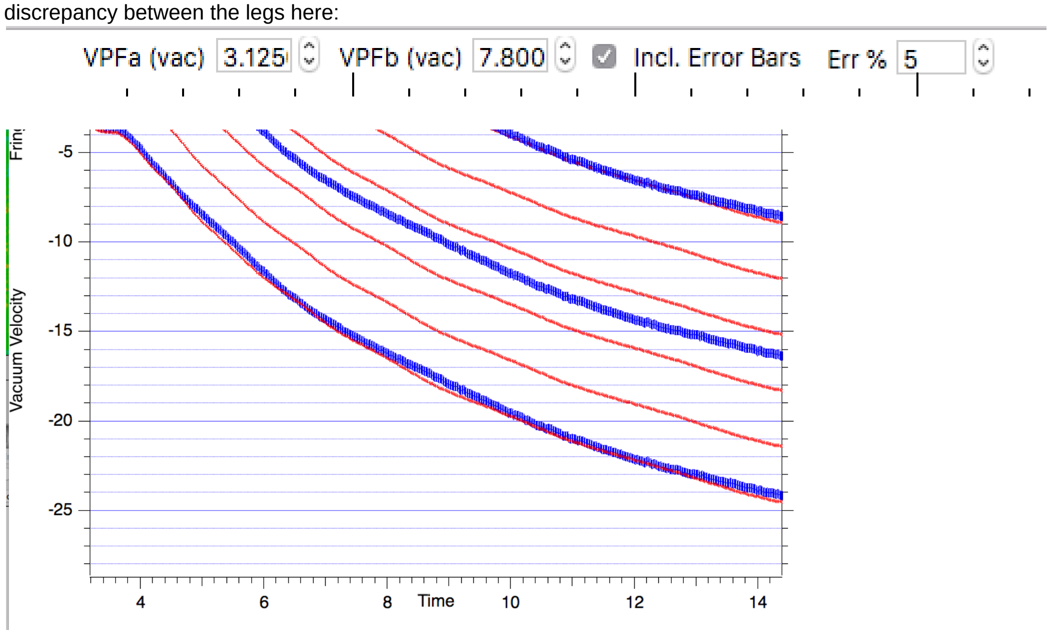


2. Repeat for Leg B. Add also 2 fringe jumps.



Now the Multiplier Graph shows that the two traces at the bottom overlap for most of the record (ignoring for now the wiggles near t=2 ns)

3. **You may want to Add phase uncertainty to the plot**:
    1. Checking the Include Error Bar checkbox will add an error bar to all curves that correspond to 5 % of the VPF. You can alter this value and uncheck-recheck to update the graph. This value is a rule-of-thumb, conservative estimate of the ability to resolve the fringe phase in VISAR images. For such a clean VISAR record, you can see that the true uncertainty at this level of analysis is about 3 %. In fact, ghost fringes are the cause for the residual oscillating discrepancy between the legs here:



19. Revise / Further Adjust the fringe jumps using additional information.

1. In most cases, this is done by trial and error until we figure out the solution that makes sense.

    So far we matched Leg A and Leg B, but obtained negative velocities. We now need to use additional information to determine the actual velocity history.

    Because we use etalons with an integer ratio, as we can see on the multiplier plot, we will now always add jumps by steps of one **repeat velocity, that is , with a 2/5 ratio: 2 * VPF_B= 5* VPF_A**

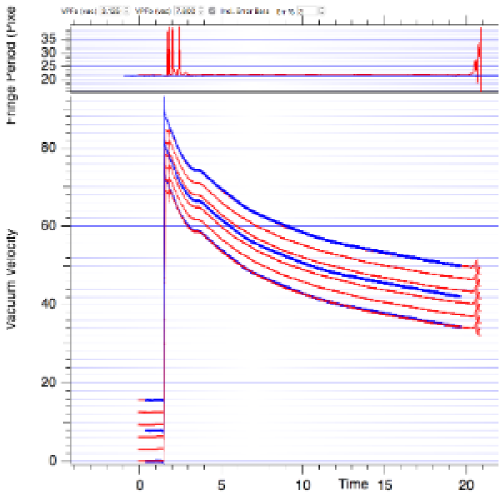
    We will use:

    1. the constraint that the shock velocity has to be positive at the end of the record
    2. the shock velocity has to be large enough to produce a strongly reflecting shock in quartz
    3. the shock velocity should match with the known thickness of the sample

        Notes:

        1. In some cases, we may need to consider several shots with similar targets but increasing laser power to fully understand the data.
        2. Looking at the SOP can also be very useful in some cases

    Here, the correct guess is to add 8 fringes to Leg B and 20 fringes top Leg A



To figure this out, we need to calculate the actual velocity, not the apparent velocity.

20. Calculate the corrected velocity as described in Use Make Velocities Graph

For each leg, re-calculate the phase lineout and call Cmd+2 to create ACsrDupl and BCsrDupl waves.

Use Make Velocities Graph

Once you have done timing, analyzed the phase and used the **Make Multipliers Graph** to determine the appropriate fringe jumps (**see detailed tutorial here)**, the **Make Multipliers Graph** tool helps you applying corrections to the VPF to determine the real velocity history.

- Start from the Multiplier Graph
- Create the velocity lineouts
- Make the Velocities graph
- Define the pixel/time region corresponding to the different layers
- Define Correction Values
- Optional: Provide Thicknesses
- Create the CorrectedVelocities wave
- Fit the velocity at Breakout 1 might want to check out Impedance Matching fits and error bars
- Fit the velocity at later Breakout events

If it has been a while, you may want to go back and check Peter's RSI VISAR paper and in particular the section IV :

A. Sample-dependent corrections

When the reflection originates at an interface viewed through a transparent shocked window, an additional correction factor must be applied, leading to the modified VPF expression[15]

$$VPF_w = VPF_0(1 + \Delta\nu/\nu_0)^{-1}. \quad (3)$$

Here, the term $\Delta\nu/\nu_0$ depends on the refractive index in the shock-compressed window. Correction terms have been empirically determined for several windows, including fused silica,[15,36] LiF,[37] sapphire,[15,36] alpha-quartz,[38] and poly (methylmethacrylate).[15]

When the reflected beam originates from a shock front in flight inside a transparent dielectric medium, the Doppler shift depends on the refractive index in the sample, and the sensitivity becomes

$$VPF_s = VPF_0 n_s^{-1}. \quad (4)$$

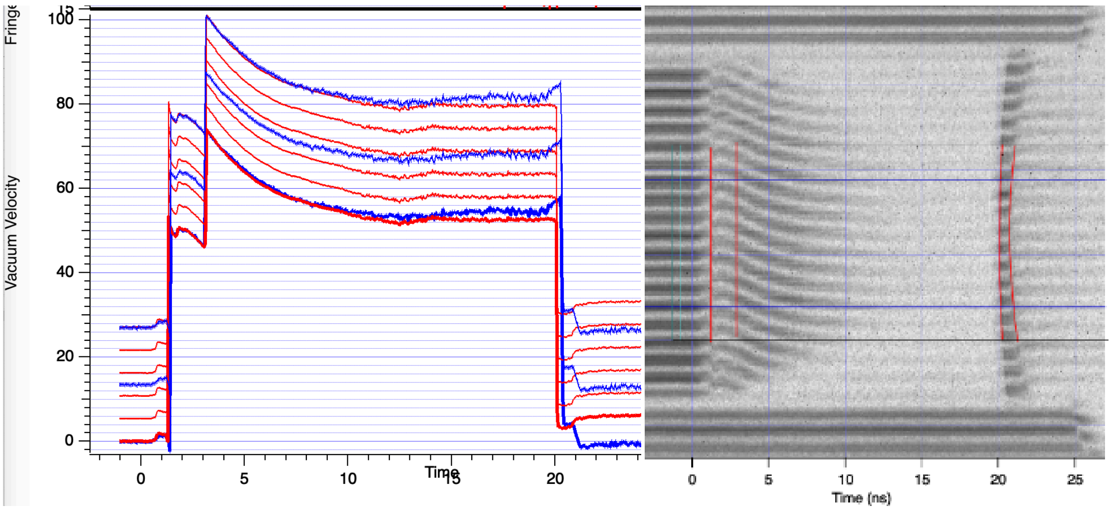
where n_s is the index of refraction of the *unshocked* material, just ahead of the shock front. This sensitivity formula can be derived using optical path difference arguments. We have tested this sensitivity formula directly by tracking the shock front in a transparent medium as it travels across a known thickness. Using the VISAR measurement one can compute the integral

$$X_v = \int_{t_0}^{t_1} VPF_s f(t)\,dt, \quad (5)$$

where $f(t)$ is the fringe count observed between the time t_0, when the shock enters the medium, and the time t_1, when it exits. The result X_v should match an independent measurement of the thickness of the sample. We have tested this equivalence in a variety of materials (liquid deuterium, water, alpha-quartz, and diamond), independent measurements of the sample thickness match X_v to within measurement uncertainties, thus providing an experimental verification of Eq. (4).[39]

1. Start from the Multiplier Graph

Assuming you have analyzed the phase created lineouts and used the Multipliers graph to determine the fringe jumps you need, the Multipliers plot should look like:



with the lowest red and blue traces overlapping as much as possible. This example is for a decaying shock in a Quartz/Diamond target in which we loose the reflectivity a bit after 10 ns (See raw image on the right).

2. Create the velocity lineouts

1. Go back to the phase map for ASBO1 or Leg A, update the lineout and use the Cursor A and Cmd+2 to duplicate the lineout into ACsrDupl wave.

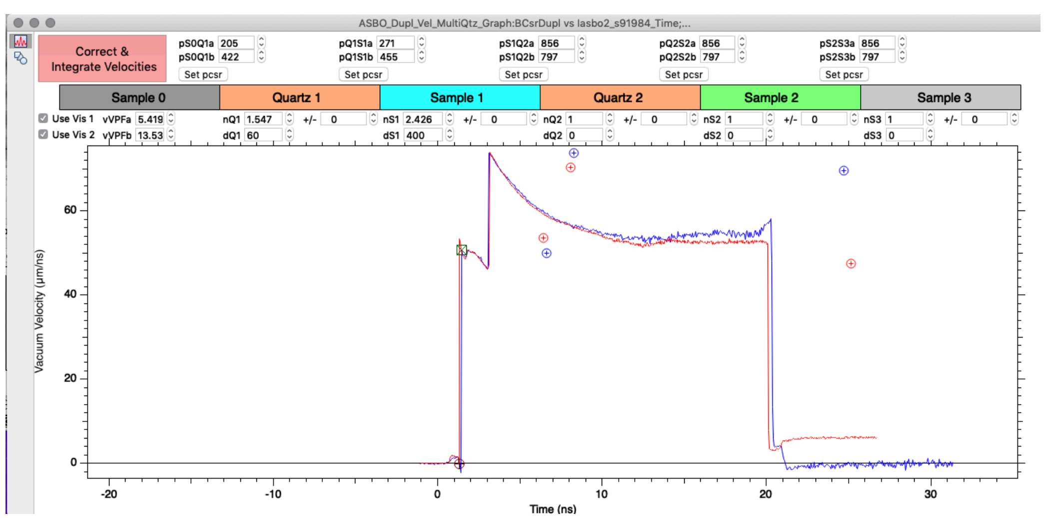
   Notes:

   1. This is similar to the step using Cmd+5 to create the lineout for the Multipliers graph.
   2. The 2 in the button title of 2 Make Velocities graph is there to remind you to use Cmd+2
2. Same as step 2 with ASBO2 or Leg B and the cursor B to create the BCsrDupl wave

3. Make the Velocities graph

1. Once you have created the two new waves containing the phase lineouts for the two channels, click on **Make Velocities graph**

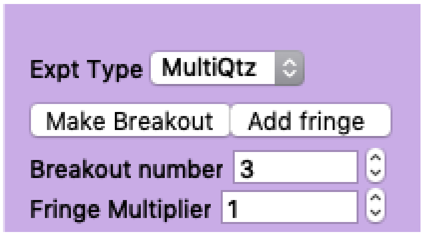
   A new graph window named ASBO_Dupl_Vel_MultiQtz will popup looking like this be created:



   Simply use Cmd+A to rescale and show the velocity traces in full. At this point, no corrections have been made.

   Notes:

   1. This assumes that you selected the default option for the **Experiment Type i**n the **Shock Breakouts** Menu : **MultiQ tz** (for Multi-Quartz)

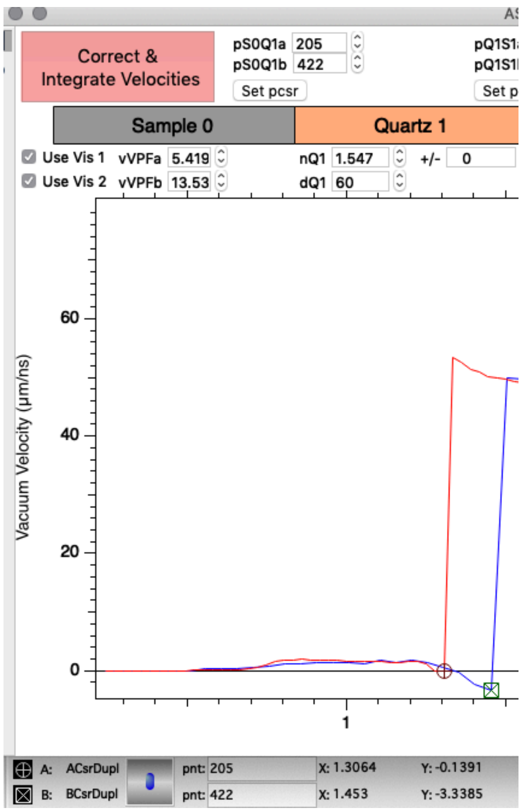


2. Other options are Keyhole (specific for keyhole shots) and DAC which follows the original routine by JHE.
3. The colored rectangles illustrate that this routine is written to treat VISAR data collected with a stack of various layers, with the drive on the Left and the VISAR diagnostic being to the right.

4. Define the pixel/time region corresponding to the different layers

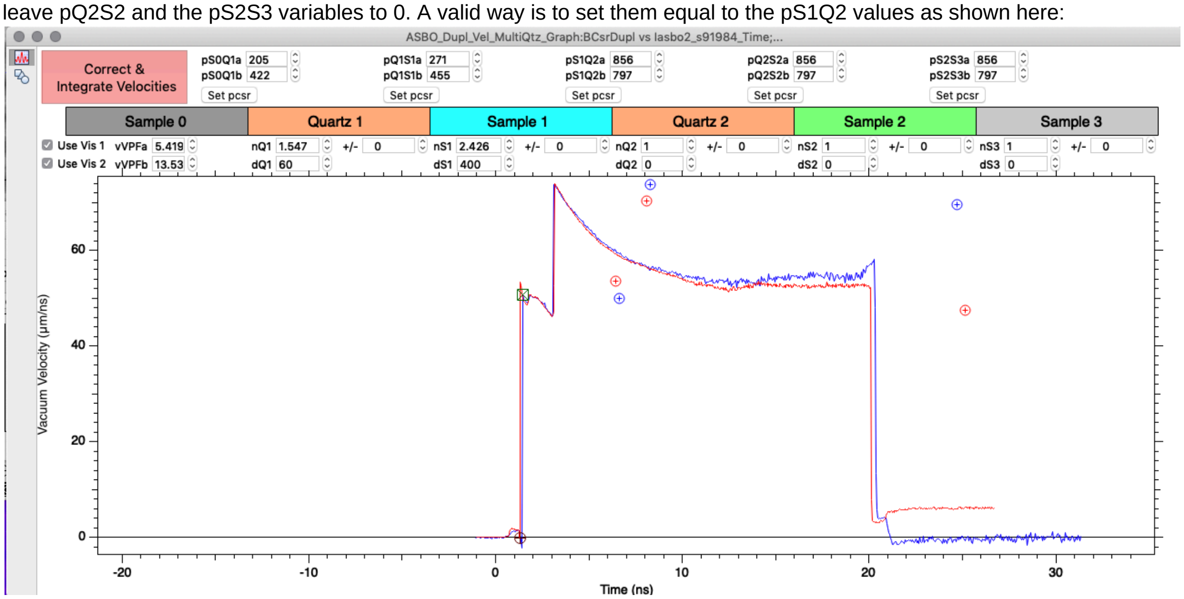
1. **Use the cursor A** on the VISAR1 (ACsrDupl) and cursor B(BCsrDupl) on the VISAR2 to locate the pixel(time) at which the shock goes from the Sample 0 into the Quartz 1 and click the **SetPcsr** button that is above the **Sample0/Quartz1** boundary.

   For example



   will set the values of pS0Q1a and pS0Q1b to 205 and 422 respectively.
2. Repeat and use SetPcsr for all the interfaces.
   For example, in the case described we can identify the breakout into the quartz near 1.5 ns, the BO into the diamond near 3 ns and the BO of the Diamond near 20 ns.

<u>Important Remark:</u> Even if there are no Quartz 2, Sample 2 and Sample 3 in my target for this shot, it is important to NOT leave pQ2S2 and the pS2S3 variables to 0. A valid way is to set them equal to the pS1Q2 values as shown here:



5. ## Define Correction Values

Next step is to assign a value for the correction to be performed for each layer. For a reflecting shock, Us=Us_apparent/n where n is the refractive index of the material at rest.

For example, here we just need to fill in with the value of the refractive index of quartz at 532 nm which is 1.547 according to the literature.

Similarly, we set nS1 to the value of the index of diamond and 532nm 2.426.

<u>Remark:</u>

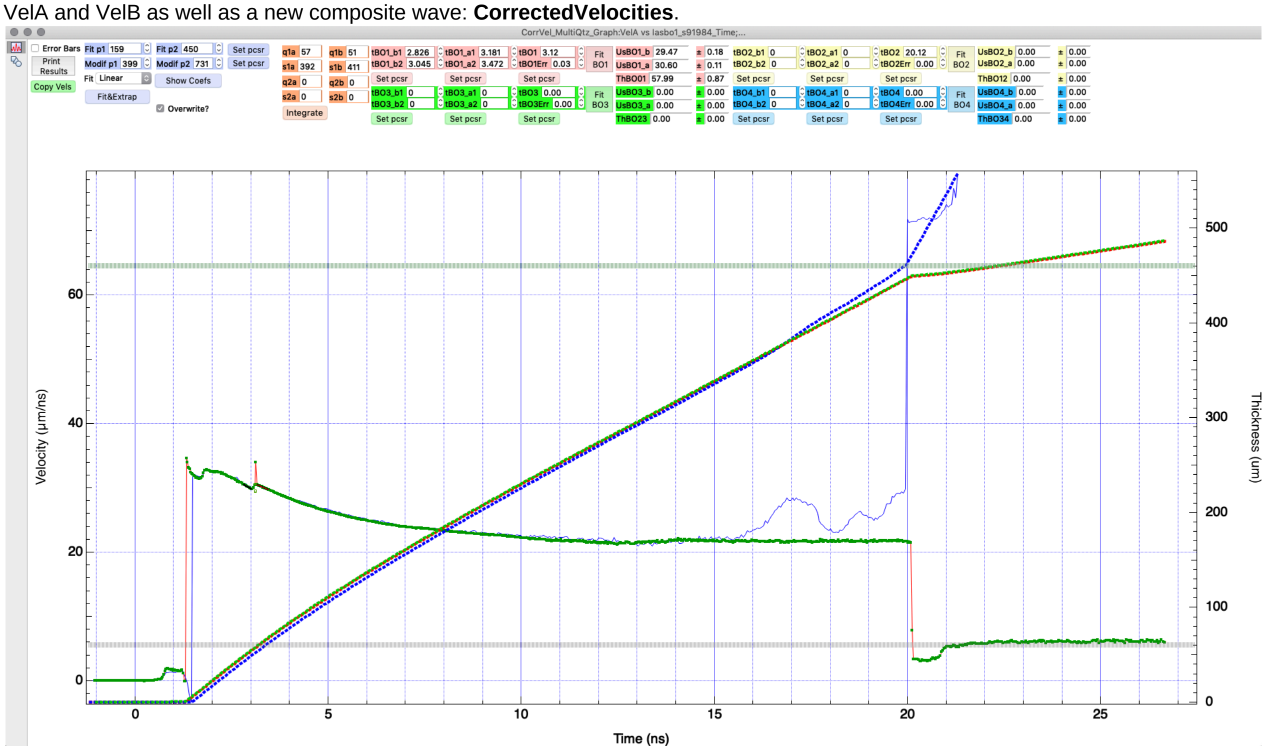
1. The default value which will leave the velocity uncorrected is to set the index to 1. Setting the index to 0 might cause errors by creating NaN values
2. If you are looking through a window, you might need to use **a window correction for up** instead.

6. ## Optional: Provide Thicknesses

If you want, you call also fill in the thickness in microns of the various layers to be compared with the integrated velocity. Here 60 and 400.

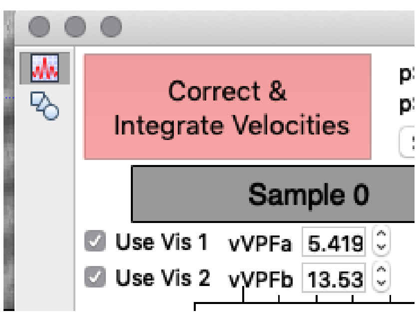
7. ## Create the CorrectedVelocities wave

Click on Correct and Integrate velocity which will open a new plot **CorrVel_MultiQtz_Graph** which will plot the Corrected Velocities VelA and VelB as well as a new composite wave: **CorrectedVelocities**.



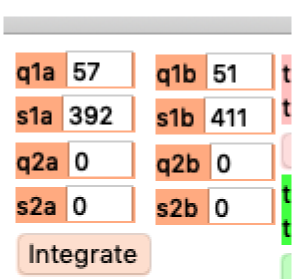
Remarks:

1. If you selected both VISAR 1 and VISAR 2 in the previous graph, the **CorrectedVelocities** wave will contain all the points from VelA and VelB sorted by increasing time. If you select only one or the other, **CorrectedVelocities** will be identical to VelA or VelB.



2. The right scale shows thicknesses. For each channel and the composite one shown in green, the integrated velocity=distance traveled by a reflecting shock. A thick line represents the thickness of the various layers dQ1, dS1 etc. This is a visual aid to verify that the integrated velocity during the shock transit in a given layer matches with the known thickness of that layer.
3. Another way to determine the integrated thickness for the various layer is to click on the Integrate button:

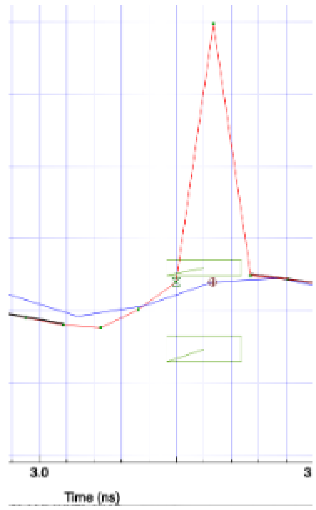
   The panel will report the **integrated thicknesses** in microns of the **different layers** for channel A and B : example Q1a== thickness of Quartz 1 according to channel A...



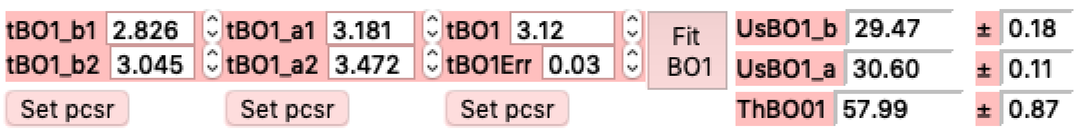
8. Fit the velocity at Breakout 1 might want to check out Impedance Matching fits and error bars

You are now ready to determine the velocity right before and right after a shock breakout (BO) event, for example when the shock goes from the quartz into the diamond.

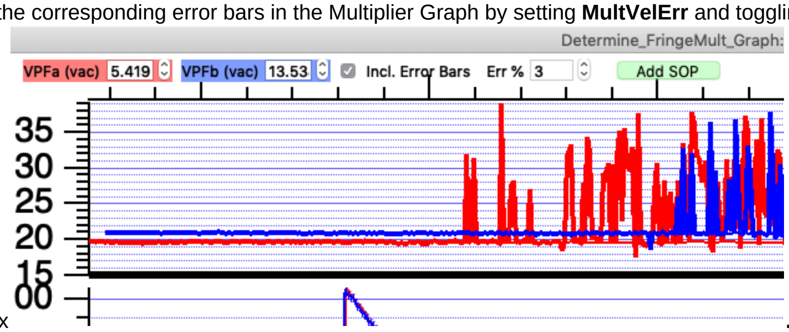
1. Zoom on the region of interest for the BO1
2. Position the cursors A and B to select the duration over which you want to fit the velocity **before** the BO event (on any curve, cursors will only pick-up the time). Click on **SetPcsr** to define the starting time **tBO1_b1** and the ending time **tBO1_b2**
3. Repeat to define **tBO1_a1** and **tBO1_a2** for the fit of the velocity **after** the BO1
4. Position cursor A at the best estimated time of BO. The time difference between the cursor A and the cursor B will define the



tBO1Err value when you click on the corresponding **Set Pcsr** button.



5. Click on Fit BO1 will fit linearly CorrectedVelocities between **tBO1_b1** and **tBO1_b2,** extrapolate to **tBO_1** and report the value in **UsBO1_b.** Similarly, it will fit linearly CorrectedVelocities between **tBO1_a1** and **tBO1_a2,** extrapolate to **tBO_1** and report the value in **UsBO1_a.** NOTE:
    1. Uncertainty including random error in the fit, error on n and the systematic uncertainty as a % of the VPF for each channel will be included in the error
    2. Instead of using the standard value of 5% of the VPF as an estimation of the VISAR sensitivity , you an choose a different value and show the corresponding error bars in the Multiplier Graph by setting **MultVelErr** and toggling the



Incl. Error Bars checkbox **.**If the VISAR 1 and VISAR 2 error bars overlaps, **MultVelErr** has a reasonable value. 5% is the default. 3% is reasonable on good recent datasets on Omega.

9. Fit the velocity at later Breakout events

Repeat the steps above as necessary for other BO events with similar sets of buttons for BO2, BO3 and BO4

Impedance Matching fits and error bars

WIP as of May 18 2020

- Fit each channel separately then combine measurements using appropriate weights to get an average Us1 and Us2 and determine their total uncertainty Us1Err and Us2Err
- Keep only the most resolving channel
- Fit both channel together,using appropriate weights to get an average Us1 and Us2 and determine their total uncertainty Us1Err and Us2Err

Should we use both VISARs? How to estimate error bars in Us_Ref , Us_Sample before doing the impedance match calculation?

Let's call Us_Ref ==Us1 and Us_Sample==Us2 and the two interferometer channels A and B

There are different schools of thought about this:

1. Fit each channel separately then combine measurements using appropriate weights to get an average Us1 and Us2 and determine their total uncertainty Us1Err and Us2Err

1. This is what we do for keyholes at NIF. I think this makes sense if the data quality is good.
2. To do this in AV8
    1. generate the CorrectedVelocities Plot checking only the checkbox for one channel at a time
    2. adjust the timing ranges for the linear fit, I usually use 200-300 ps on each side of the BO if possible
    3. adjust the Breakout time for that particular channel by looking at the raw image, finding the BO position and its uncertainty in pixels, then use the MakeMultiplier Graph to convert pixels into Time
    4. fit each channel, obtain Us1A , Us1AErr,Us2A , Us2AErr then Us1B , Us1BErr,Us2B , Us2BErr
    5. use for example a spreadsheet such as the ImpedanceMatching_Calculator_MM.xlsx to calculate the average and total uncertainties

2. Keep only the most resolving channel

1. This is what has been done in many papers, eg Z papers.
2. I used this for several papers
3. do as case 1, only for one channel

3. Fit both channel together,using appropriate weights to get an average Us1 and Us2 and determine their total uncertainty Us1Err and Us2Err

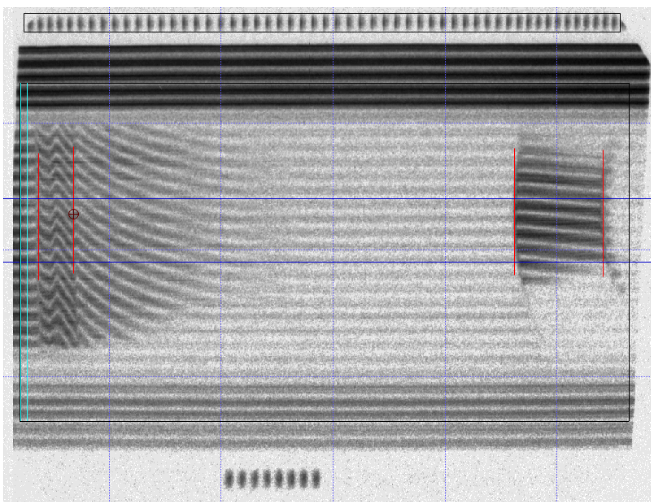
1. This is what is coded so far in AnalyzeVisar
2. check the two channels, use the fit button
3. Not my preferred choice: the contributions of the two channels are weighted appropriately in this fit. However, slight timing differences between the two legs could cause issues with the fidelity of the fit.

Fit and Extrapolate Velocity in decaying shocks with vanishing reflectivity

Description:

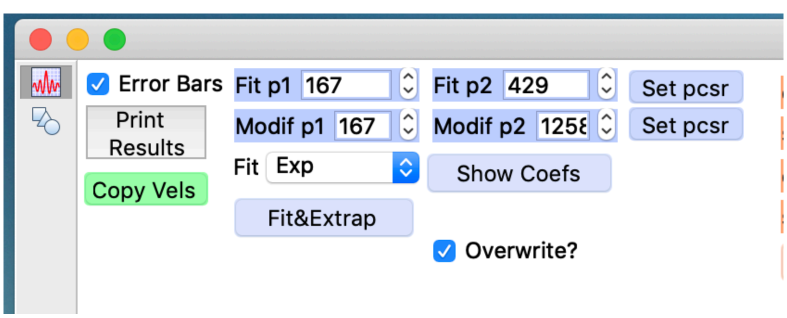
Sometimes, it can be useful to fit the **CorrectedVelocities** and extrapolate it to periods of the visar record where the fringe record does not allow us to obtain a good Us(t).

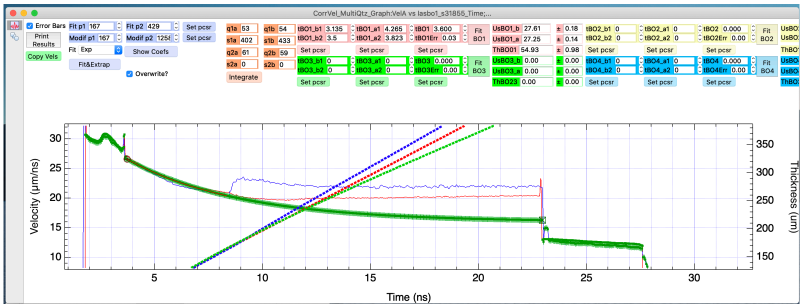
This is very useful for decaying shocks with vanishing shock front reflectivity and records similar to the example below for a shock in a Ablator /Au/Qtz/Sample/Qtz package.



There are a few simple options coded up in **AV8**: these are the Blue controls in the top left of the **CorrVel_MultiQtz_Graph**

These tools affects the CorrectedVelocities wave that is used for the Reflectivity and Temperature analysis





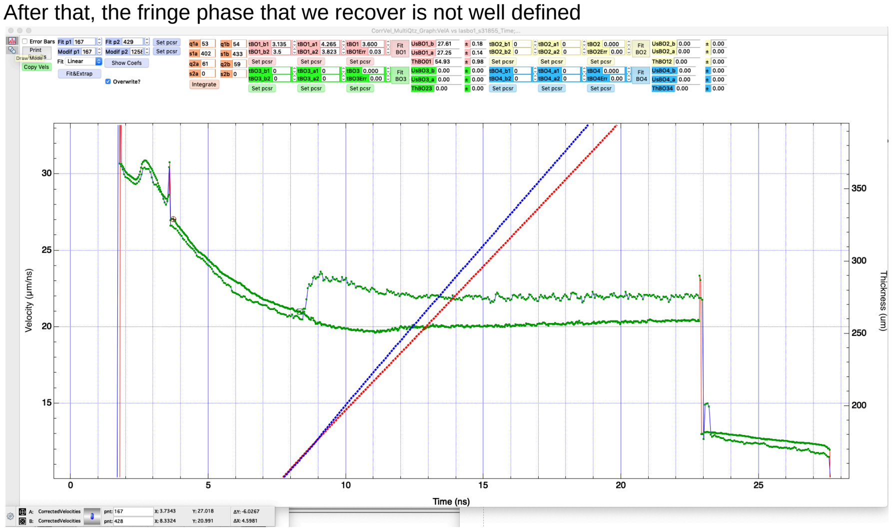
Example :

1. **Create the Corrected Velocities graph CorrVel_MultiQtz_Graph**

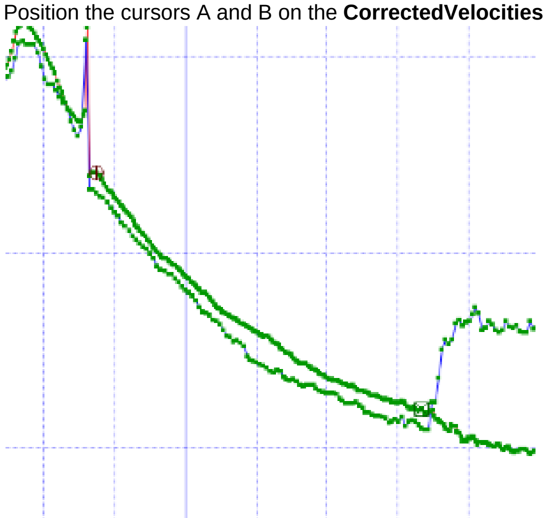
   (see Use Make Velocities Graph#CreatetheCorrectedVelocitieswave)

2. **Identify the region where you trust the fringe analysis**

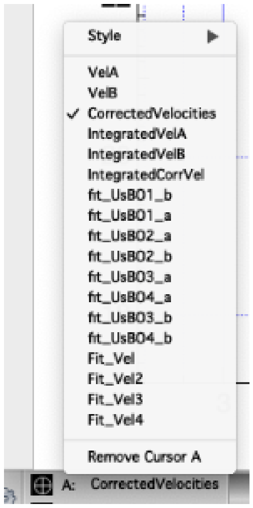
   In this example, the shock transit in the sample is followed well by the VISAR from ~3.5 ns up to ~ 8 ns
   After that, the fringe phase that we recover is not well defined



1. Position the cursors A and B on the **CorrectedVelocities** wave near 3.5 and 8 ns



2. Click on the **Set pcsr button** that is to the right of the **Fit p1** and **Fit p2** controls
   This will pick up the pixel number for the **CorrectedVelocities** wave that define the region where to fit: between p1 and p2
   REMARK:
   1. Make sure you put the cursor on the **CorrectedVelocities** wave!!
   2. To do that, a trick is to right click on the cursor and select the wave you want to put the cursor on:



3. Identify the region where you want to apply the fit

In this example, we may want to replace the **CorrectedVelocities** wave by the result of the fit only in the region where we do not have fringes, between ~8 ns and the breakout in the second quartz near 23 ns.

1. Position the cursors A and B on the **CorrectedVelocities** wave near 8 and 23 ns
2. Click on the **Set pcsr button** that is to the right of the **Modif p1** and **Modif p2** controls
   This will pick up the pixel number for the **CorrectedVelocities** wave that define the region where to apply the fit results: between p1 and p2

4. Select the Fit model

1. Linear
2. Exponential decay
3. Double-Exponential decay
4. Undo to reverse the fit and reset the **CorrectedVelocities**

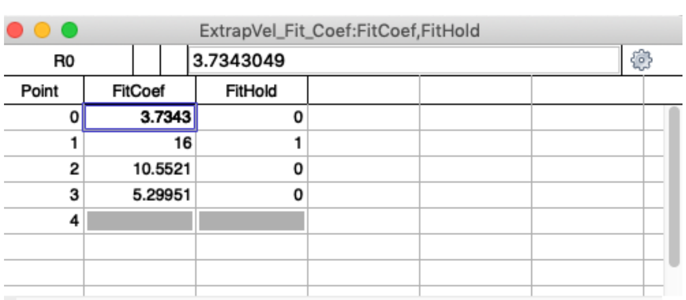
5. Apply the fit over a first portion of the record

Click on the **Fit& Extrap** button

This will fit **CorrectedVelocities** between **Fit p1** and **Fit p2** and replace its values by the results of the fit between **Modif p1** and **Mo dif p2**

1. It is better to uncheck Overwrite to start with, unless you want to perform a series of **Fit& Extrap** on multiple portions of the record
2. Use **Undo** to reverse the fit if needed
3. Adjust the fit parameters ... and repeat as needed

   1. Click on **Show Coefs** button



ExtrapVel_Fit_Coef:FitCoef,FitHold

R0 3.7343049

Point	FitCoef	FitHold
0	3.7343	0
1	16	1
2	10.5521	0
3	5.29951	0
4		

   This will open a table with two waves: **FitCoef** contains the fit coefficient , FitHold contains 0 and 1 to select which parameters to fix during the fit

2. Click on the **Fit& Extrap** button to see the new fit results

   Remark: If **Modif p1** < **Fit p2** , which means that you modify the portion where you fit, you may need to **Undo** before testing the fit again

6. ## Apply the fit over another portion of the record if needed

   1. Check Overwrite
   2. Use **Fit& Extrap** button again

Use Make Reflectivities Graph

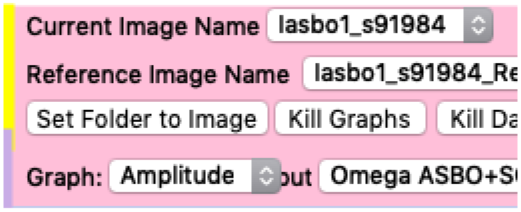
Once you analyzed the phase and obtained the velocity history with the Make Velocities plot, you are ready to work on the reflectivity analysis.

This tutorial is for the simple case of a reflecting shock as shown in the tutorial for the velocity.

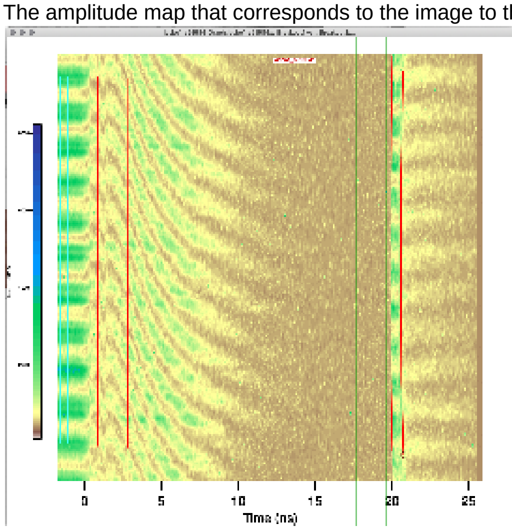
Notes:

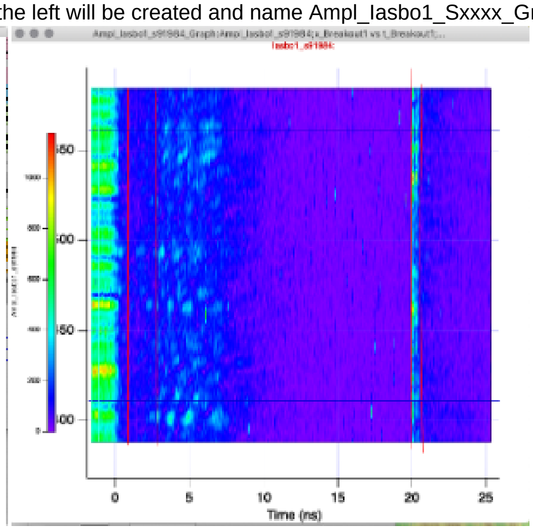
- Here I use the Amplitude of the VISAR fringes for the reflectivity
- The reflectivity is by far the most difficult thing to get out of line VISAR images
- The analysis described here uses horizontal lineouts over which we perform the analysis of the average reflectivity. More advanced analysis, for example matching pixel by pixel the velocity and amplitude similar to what P Celliers did in Celliers Science 2018 would require new code development.

1. Select the image for VISAR1, click on **Set Folder to Image** and get the Amplitude Graph

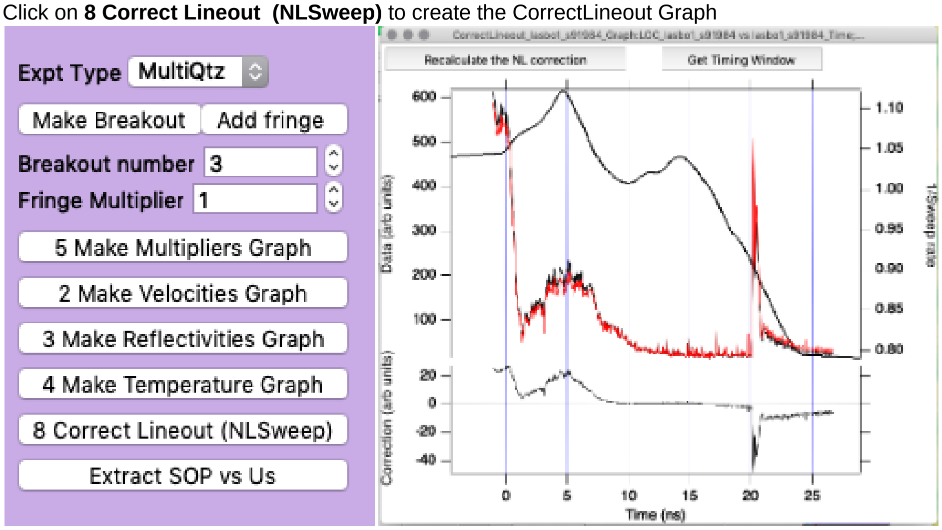
   The amplitude map that corresponds to the image to the left will be created and name Ampl_Iasbo1_Sxxxx_Graph for example

2. **Create a lineout** over the same region you analyzed the fringe history from with **Cmd+6**
3. **Create the CCsrDupl and DCsrDupl waves**:
   1. Quick analysis: Put **Cursor A** for VISAR1/Leg A and **Cursor B** for VISAR2/Leg B on the **profile** wave and do **Cmd+3** to call the **DuplicateCsrWavesCD** function.
   2. Refined analysis that corrects for the effect of sweep rate changes:
      1. Put Cursor A for any leg and call **Cmd+8** to Call **DuplicateCsrWavesNL** and create **NLCsrDupl**

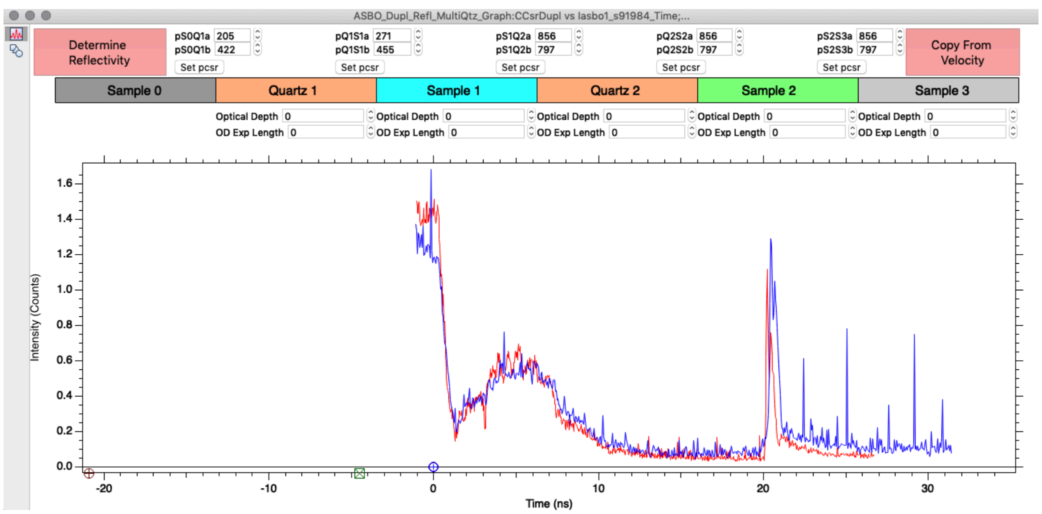
2. Click on **8 Correct Lineout (NLSweep)** to create the CorrectLineout Graph



The red curve is a copy of NLCsrDupl waven name LO_...(for LineOut), plotted versus time. The **Black curve** is the corrected wave named LOC_... (for LineOutCorrected) calculated as LO_.../ SweepRate. The difference is shown in the bottom panel. The Sweep rate is calculated from the Timing window.

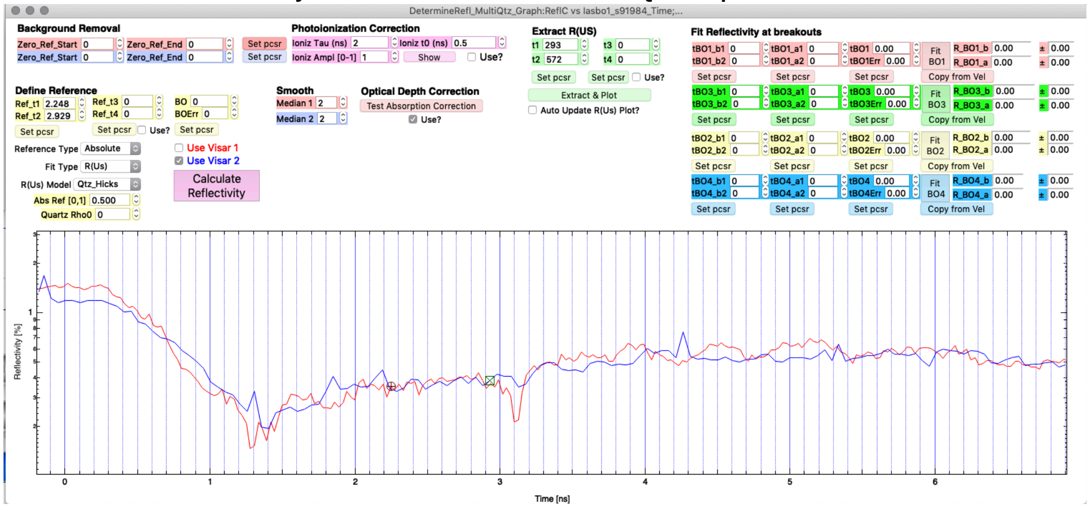
3. Put **Cursor A** for VISAR1/Leg A and **Cursor B** for VISAR2/Leg B on the **LOC_...** (Black) wave and do **Cmd+3** to call the **DuplicateCsrWavesCD** function.

4. **Repeat for second VISAR 2/ Leg B**
5. Click on **3 Make Reflectivities Graph**

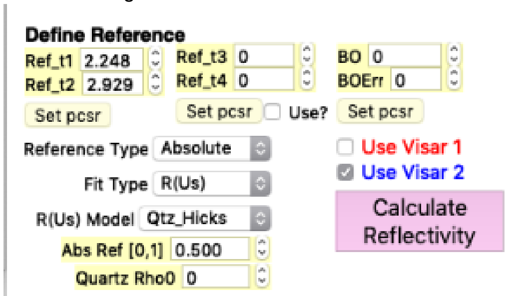


1. Identify the different regions of the sample and define **pS0Q1a, pS0Q1b etc.**
   <u>Remark</u>: You can copy the values defined for the velocity analysis by using the **Copy from Velocity Button**
2. Remember to fill in all values (do not leave 0s)

6. Click on **Determine Reflectivity** to create the **DetermineRef_MultiQtz_Graph**

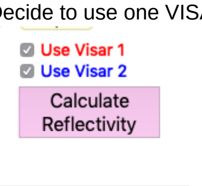


    1. Define the region to use as a reference.

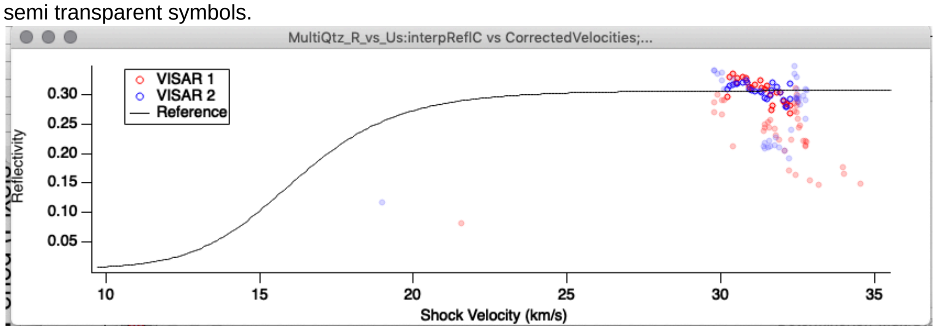


        1. Here we use the Quartz 1 region
        2. Position cursor A and B on any wave and use the **Set pcsr** button to define **Ref_t1** and **Ref_t2** variables

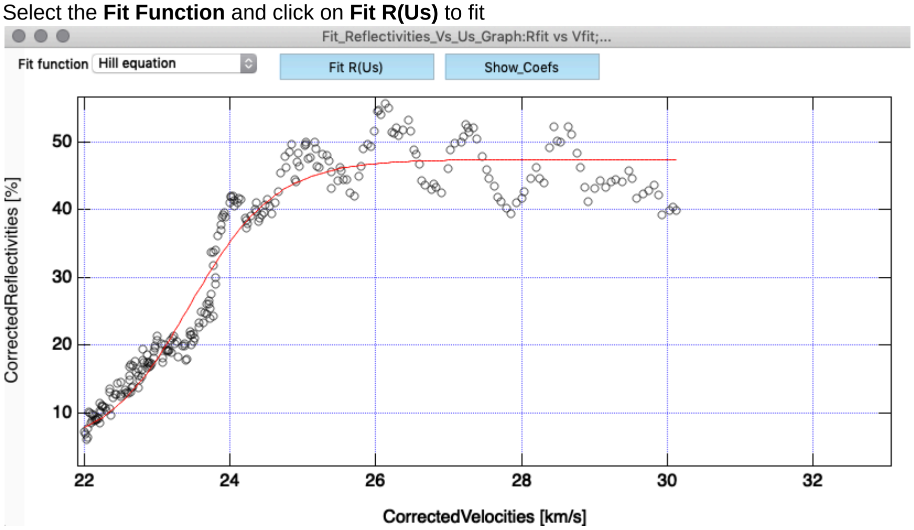
        3. If there was another quartz and we wanted to use it as well, we could also define **Ref_t3** and **Ref_t4** and Check the **Use?** CheckBox
    2. Select the **Reference Type In-Situ** or **Absolute** (for which you just need to set the **Abs Ref** variable)
    3. Select the **Fit Type**
        1. **R(Us)** to fit R as a function of Us the entire reference region
        2. **Linear** and **NoSlope** for which we linearly fit the Reflectivity and extrapolate to the breakout time (as for the velocity). This is what the DAC option does (JHE Legacy). Need to define the BO time and error: **BO** and **BOErr** Variables
    4. Select the R(Us) Model **Quartz_Hicks** (Ambient Pressure quartz, as in Hicks PRL2006) or **HighP_Qtz** (for DACs as in Brygoo JAP 2015, need to set Quartz Rho0 to appropriate value)
7. Decide to use one VISAR or both, then click on Calculate Reflectivity



    1. This creates the **CorrectedReflectivities** wave (similar to **CorrectedVelocities** wave, shown in Green)
    2. This also Modify **ReflC** and **ReflD** to become reflectivity values in % (Using the Quartz Calibration)
    3. This also creates a few plots including **MultiQtz_R_vs_Us** that shows the Reference curve and the values of ReflC and ReflD between **Ref_t1** and **Ref_t2** (and if used **Ref_t3** and **Ref_t4**) in solid colors, and the values in the Quartz1 Region as semi transparent symbols.



8. You can use a few options to refine these values:
    1. **Background Removal**
    2. **PhotoIonizationCorrection**
    3. **Smooth**
    4. **Optical Depth Correction**
9. **Extract R(US)** for the Sample
    1. Select the region of interest between **t1** and **t2** (and if needed **t3** and **t4)**
    2. Click on **Extract and Plot** to create **Fit_Reflectivities_Vs_Us.** This interpolates **CorrectedReflectivities** as a function of **CorrectedVelocities**
    3. Select the **Fit Function** and click on **Fit R(Us)** to fit



Use Make Temperature Graph

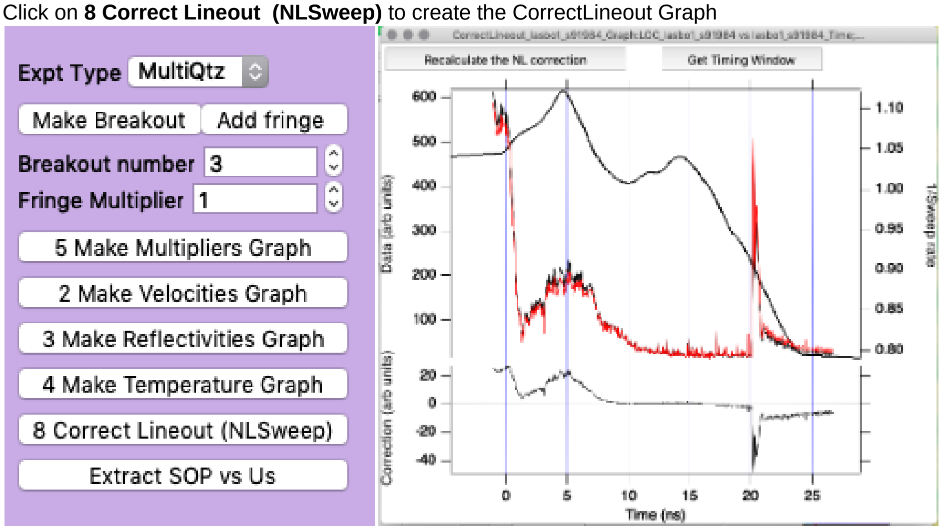
Once you analyzed the phase shift to get the velocity and the phase amplitude to get the reflectivity, you are ready to look at the SOP data

This quick tutorial is for the case of an internal quartz reference, using the newly develop method to use the SOP versus Us data during the transit through one or two quartz reference plates to infer the relationship between SOP and Temperature.

We use grey body approximation with the emissivity as 1-R. See for example Brygoo, Millot et al JAP

This is for Omega and Omega EP.

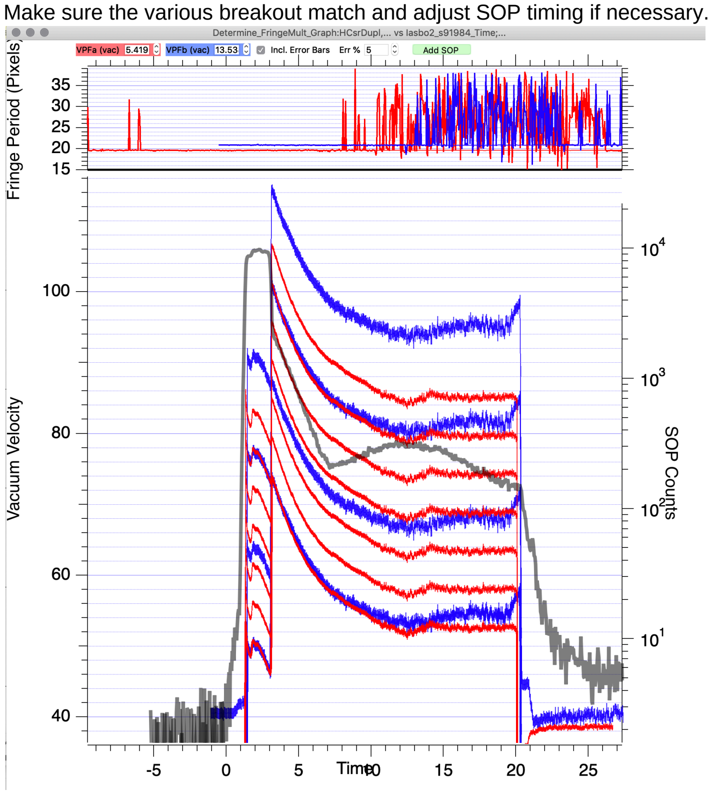
1. **Load** the SOP **image**, same procedure as for the VISAR images
2. Perform **timing** calibration, same procedure as for the VISAR images
3. Identify on SOP image the region over which you performed the velocity analysis (NOTE: The spatial magnification are not exactly the same),
    1. Use Cursor A and press **Cmd+8** to Call **DuplicateCsrWavesNL** and create **NLCsrDupl**
    2. Click on **8 Correct Lineout (NLSweep)** to create the CorrectLineout Graph

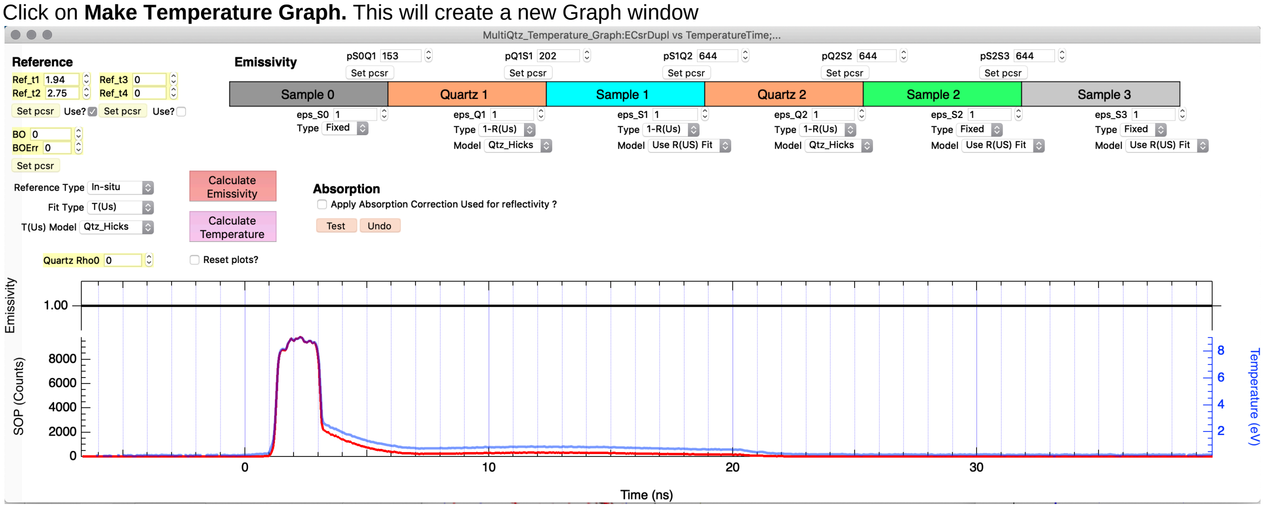
       The red curve is a copy of NLCsrDupl waven name LO_...(for LineOut), plotted versus time. The **Black curve** is the corrected wave named LOC_... (for LineOutCorrected) calculated as LO_.../ SweepRate. The difference is shown in the bottom panel. The Sweep rate is calculated from the Timing window.
    3. Put **Cursor A** on the LOC wave and press **Cmd+4** to create the **ECscrDupl** wave

4. Make sure that the co-timing between SOP and VISAR is good.
    1. Click again on **5 Make Multipliers Graph** to recall the Multiplier plot
    2. Click on Add SOP button on top right corner. This will add the ECsrDupl Wave, plotted against the SOP_..._Time wave , in black, (right scale) onto the VISAR traces.

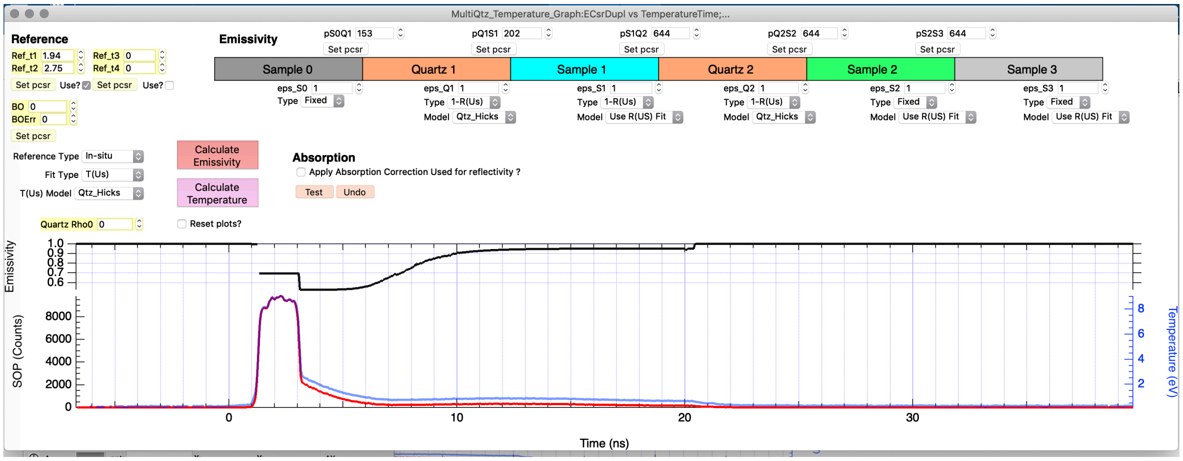
3. Make sure the various breakout match and adjust SOP timing if necessary.



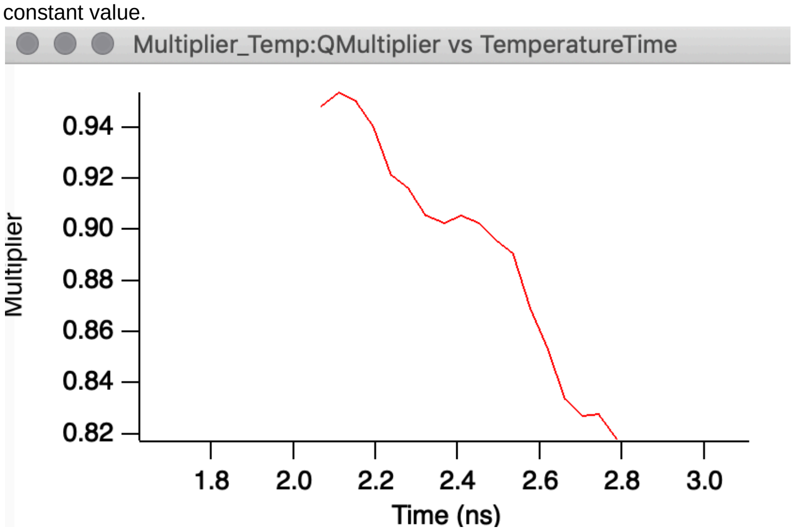
5. Click on **Make Temperature Graph.** This will create a new Graph window



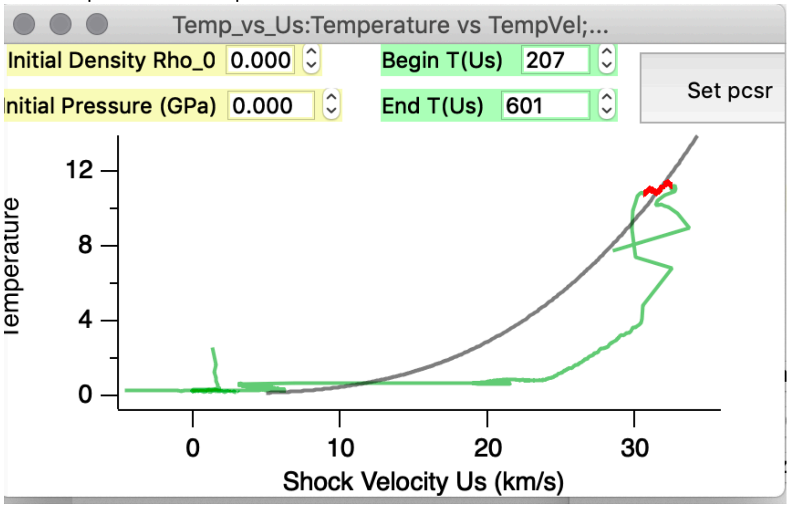
6. As for the Velocity and for the reflectivity analysis, use the Setpcsr buttons to **delimit** the different regions on the SOP lineout. Remember to not leave any to 0.
7. Once you have done this, you need to define the Emissivity as a function of time (**Note**: eps stands for epsilon). For each portion of the record, Sample0, Quartz1 etc, you need to select a type : **Fixed, 1-R(US) , or 1-R(t)**
   1. **Fixed**: Epsilon is directly defined by the user using the **eps_S0, eps_Q1** etc **SetVariables**
   2. **1-R(US)**: Epsilon is defined from a model and calculated as a function of **CorrectedVelocities**
      1. For the Quartz, Use **Qtz_Hicks. This is recommended**
      2. For the Sample, use **Use R(Us) Fit.** This will use the results and the model of the fit as performed in the **Extract R (US)** Graph. **This is recommended**
   3. **1-R(t)**: Epsilon is calculated directly as an interpolation of **CorrectedReflectivities**
   4. Click on **Calculate Emissivity** to update the **Emissivity** wave for all changes to be taken into account. Black curve on top Graph will be updated.

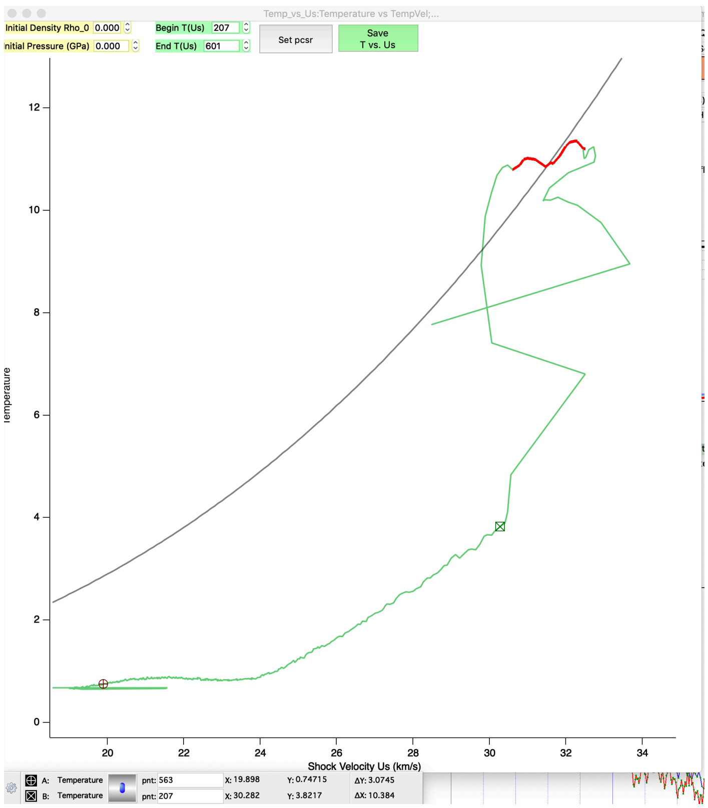


8. Now you are ready to specify the parameter for the Quartz Calibration
    1. Define the Time range you want to use as the reference. Use the SetPcsr buttons to define **Ref_t1** and **Ref_t2** variables. If there was another quartz and we wanted to use it as well, we could also define **Ref_t3** and **Ref_t4** and Check the **Use?** CheckBox
    2. Select Reference Type: **In Situ**
    3. Select Fit Type: **T(Us)**
    4. Select T(Us) Model:
        1. **Qtz_Hicks:** This is for **not precompressed** Quartz up to 25 km/s Hicks PRL 2006
        2. **QThermQuartz**: This is for **not precompressed** Quartz above 25 km/sUnpublished Millot. Mentioned in Millot Science 2015 SM
        3. HighP_Quartz: This is for **precompressed** Quartz . Brygoo 2015. Need to specify **QuartzRho0**
9. Click on Calculate Temperature. This (re)calculate the Temperature wave (Shown in Blue, right scale in eV)
    1. It will also create/update two plots:
        1. The Temperature Multiplier graph: Shows the calibration multiplier as a function of time. Ideally, this should be a constant value.



2. The Temperature Vs Us plot





3. The curve in black represents the model for the Quartz.
4. The Green curve is the interpolation of the **Temperature** wave versus **Corrected Velocities**
5. The portion in **Red** is the region used for the reference. Here, the agreement is not so great because the red region does not really follow closely the model.

10. Once you are happy with your analysis, use the **SetPcsr** buttons to select the portion of **T(Us)** to extract and click **Save T vs Us** to save as a text file