SAR Processing

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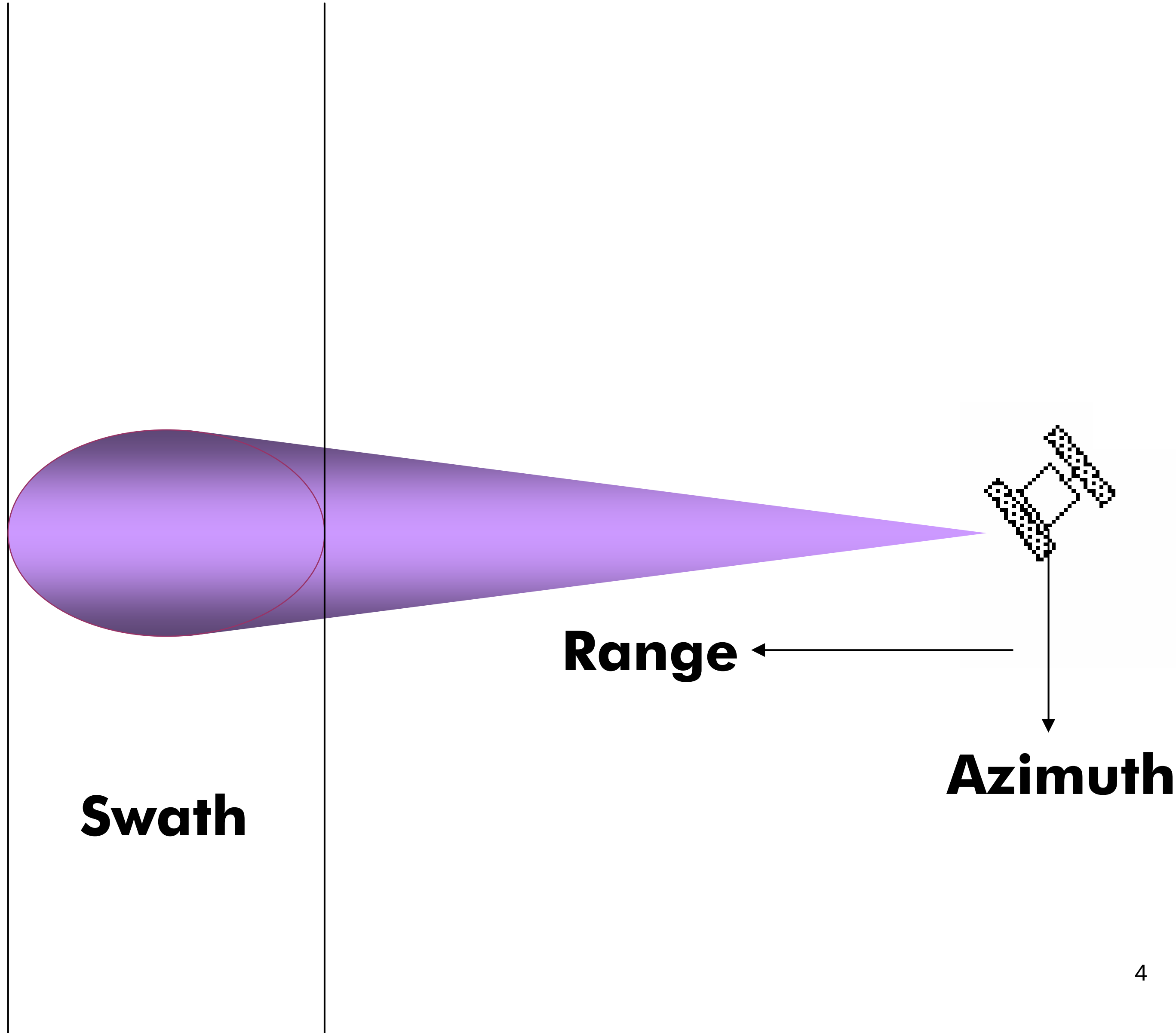
Outline

- Sonar Echoes
- Definitions
- What do we measure?
- Target detection
- Convolution
- Range compression
- Azimuth Compression

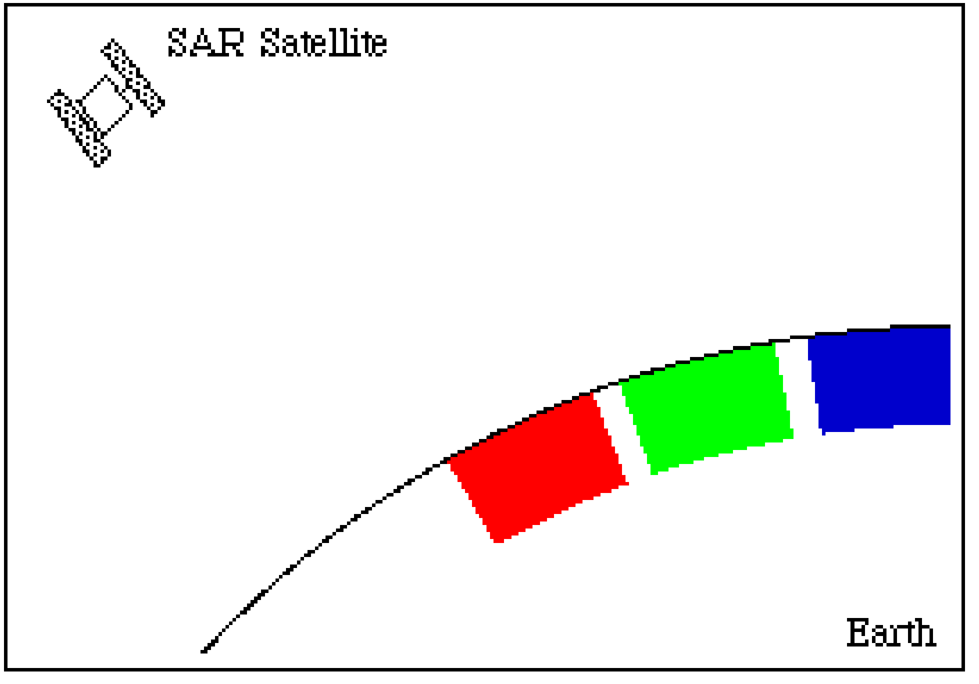
Sonar Echoes

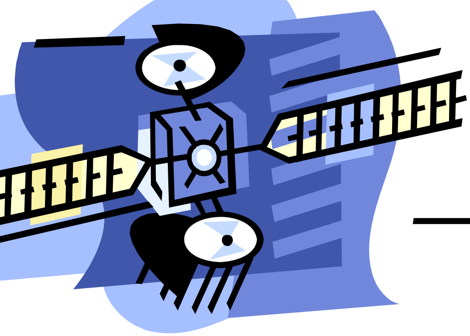
Some definitions



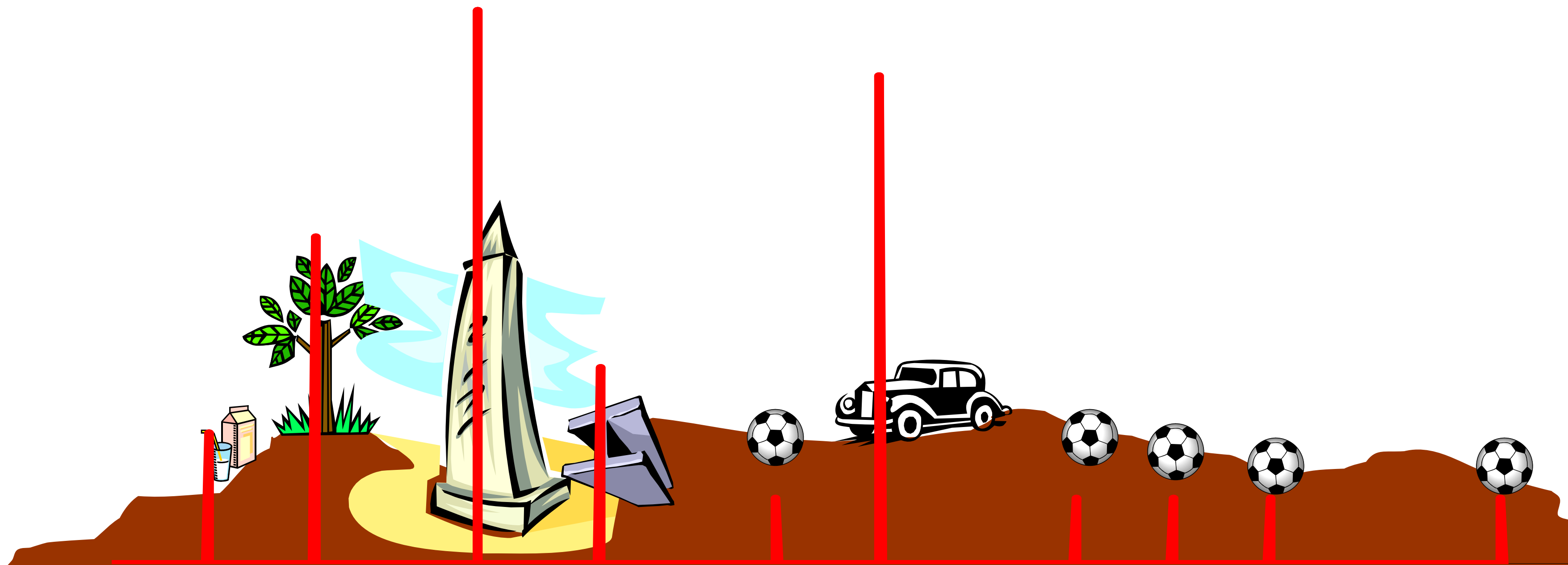
What do we measure?

- At the satellite
  - Radar signal strength as a function of time
- After processing
  - Radar Cross Section per piece of dirt

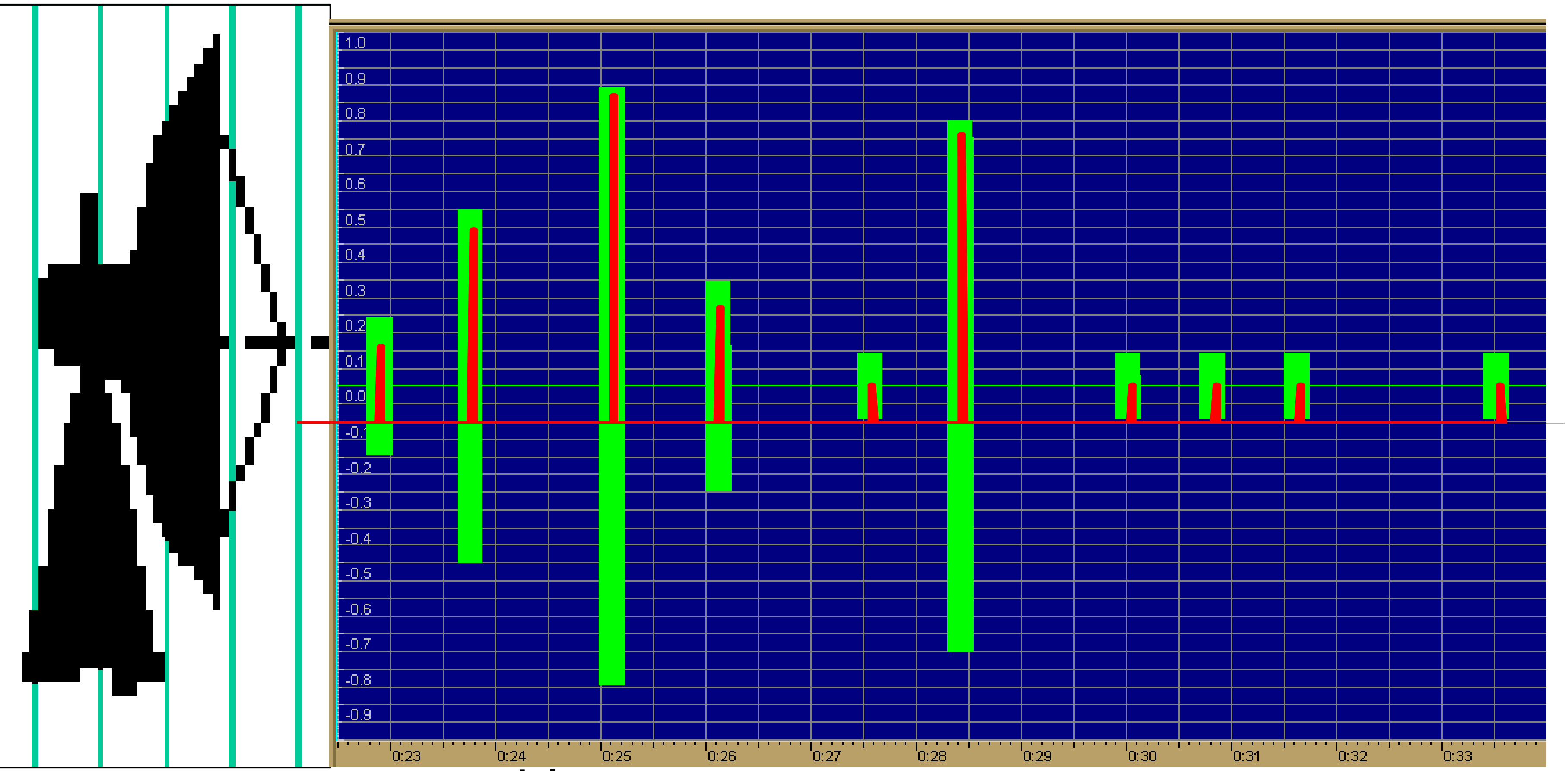




Target detection

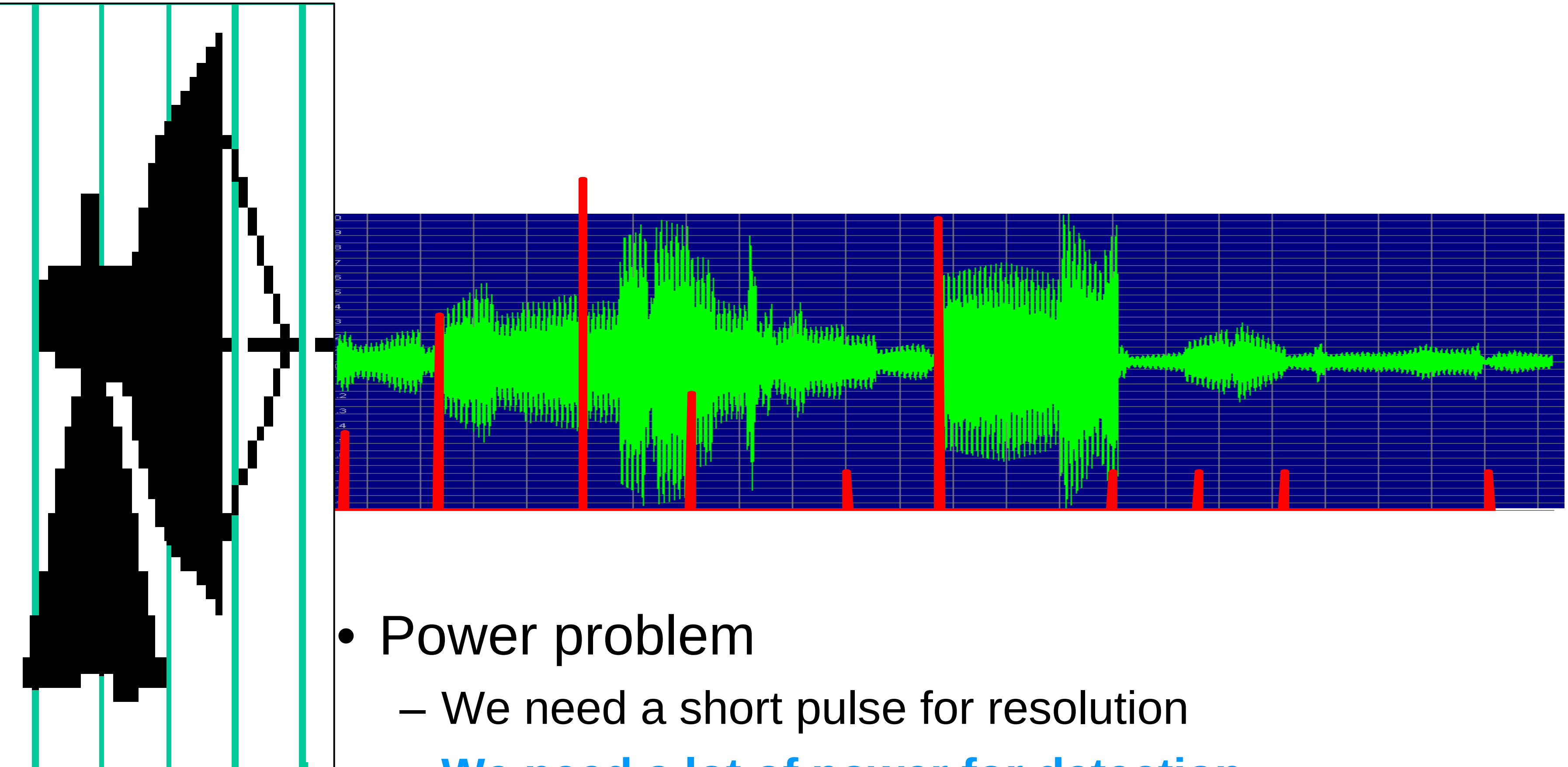


Target detection: Short pulse



- Power problem
  - We need a short pulse for resolution
  - We need a lot of power for detection

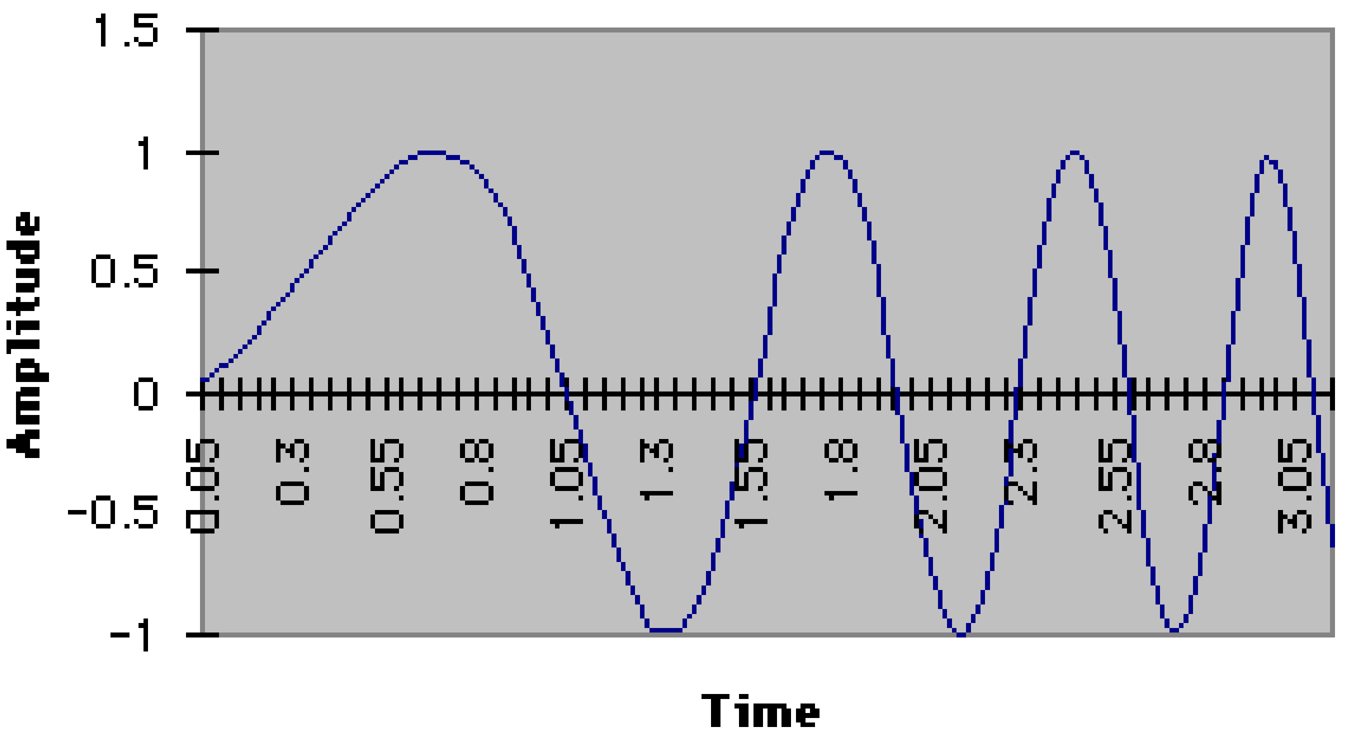
Target detection: Long pulse



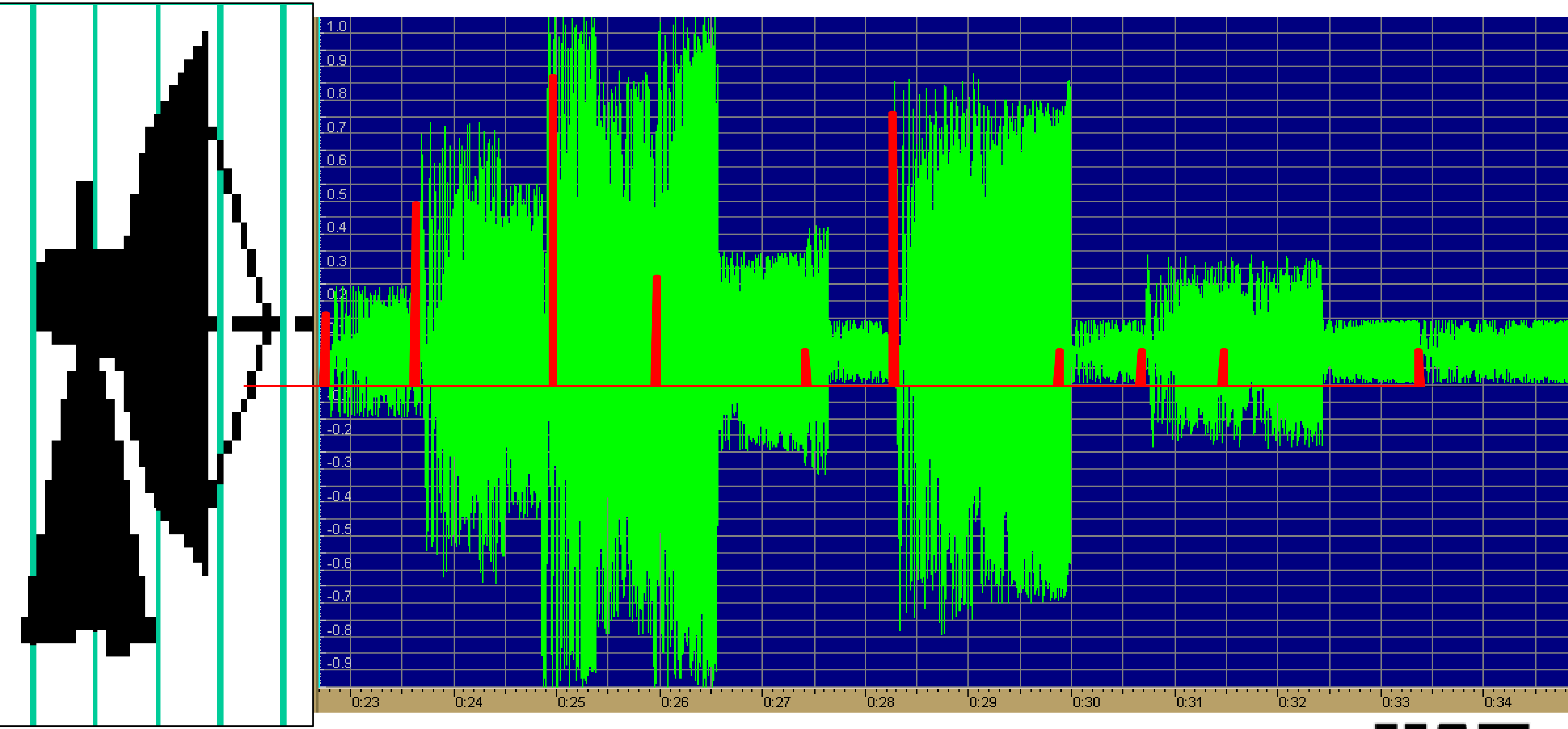
- Power problem
  - We need a short pulse for resolution
  - **We need a lot of power for detection**

Target detection: Chirp

- Can go from low to high or high to low frequency
- Can be much more complicated



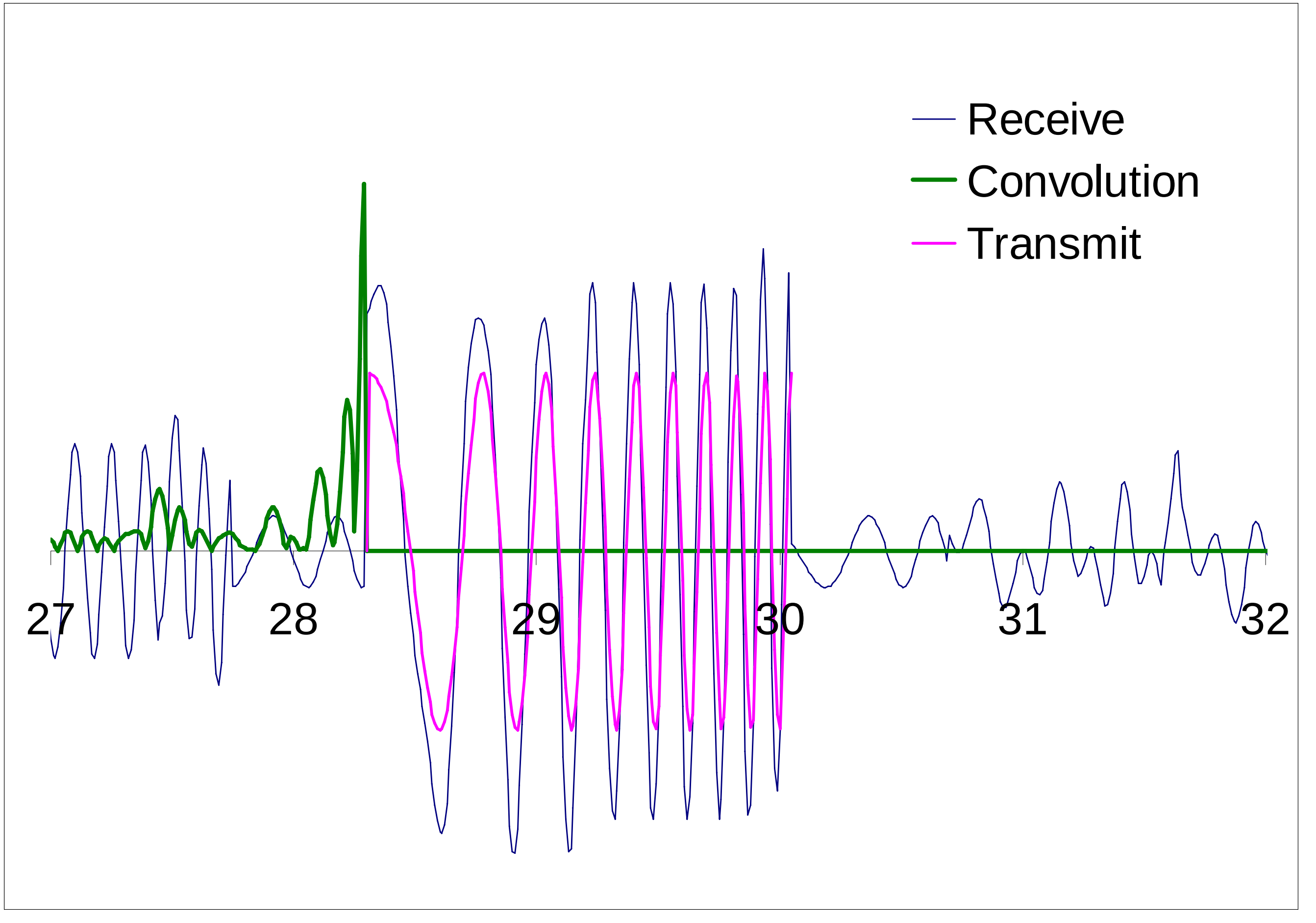
Target detection: Chirp pulse



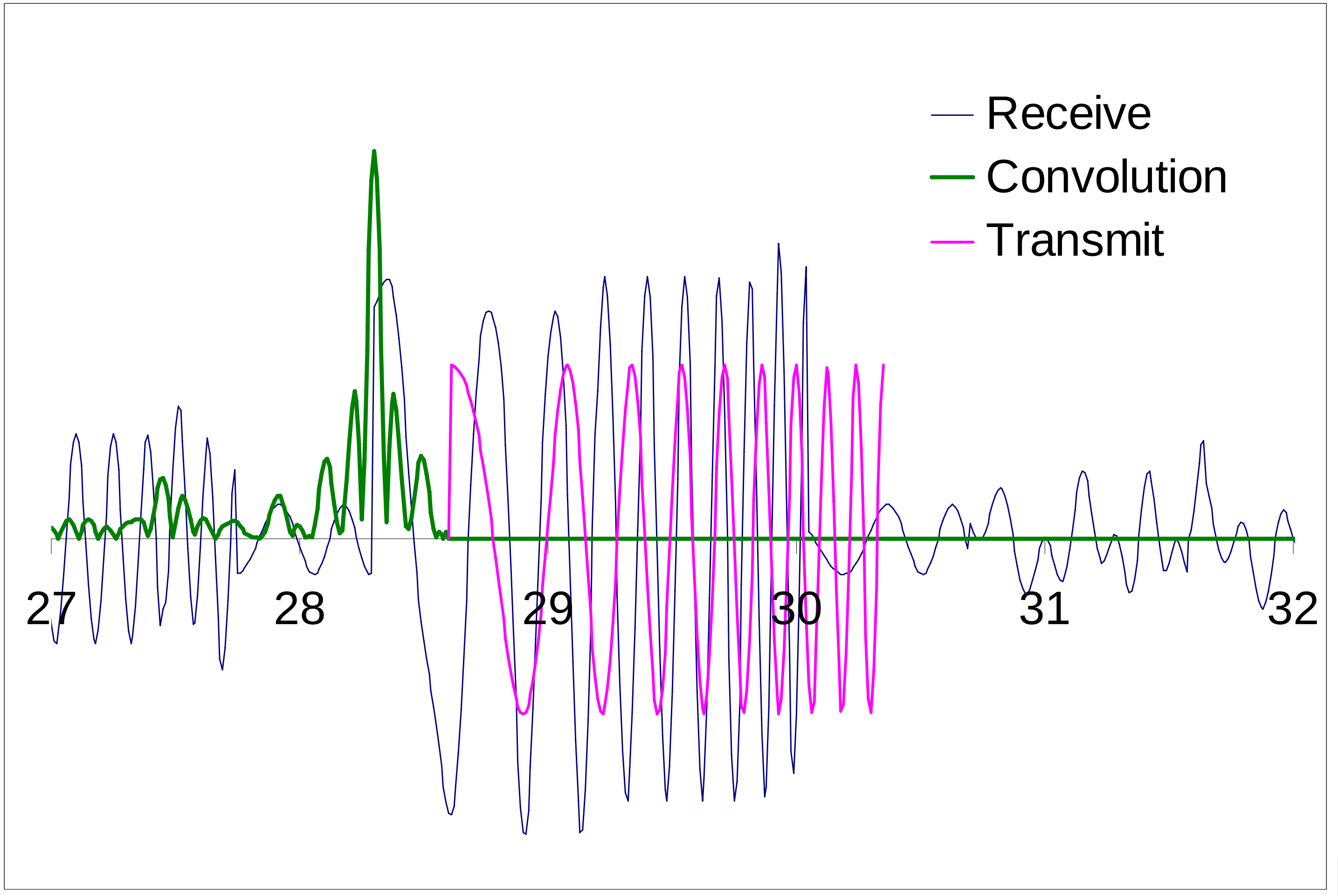
Convolution

- Run simulation

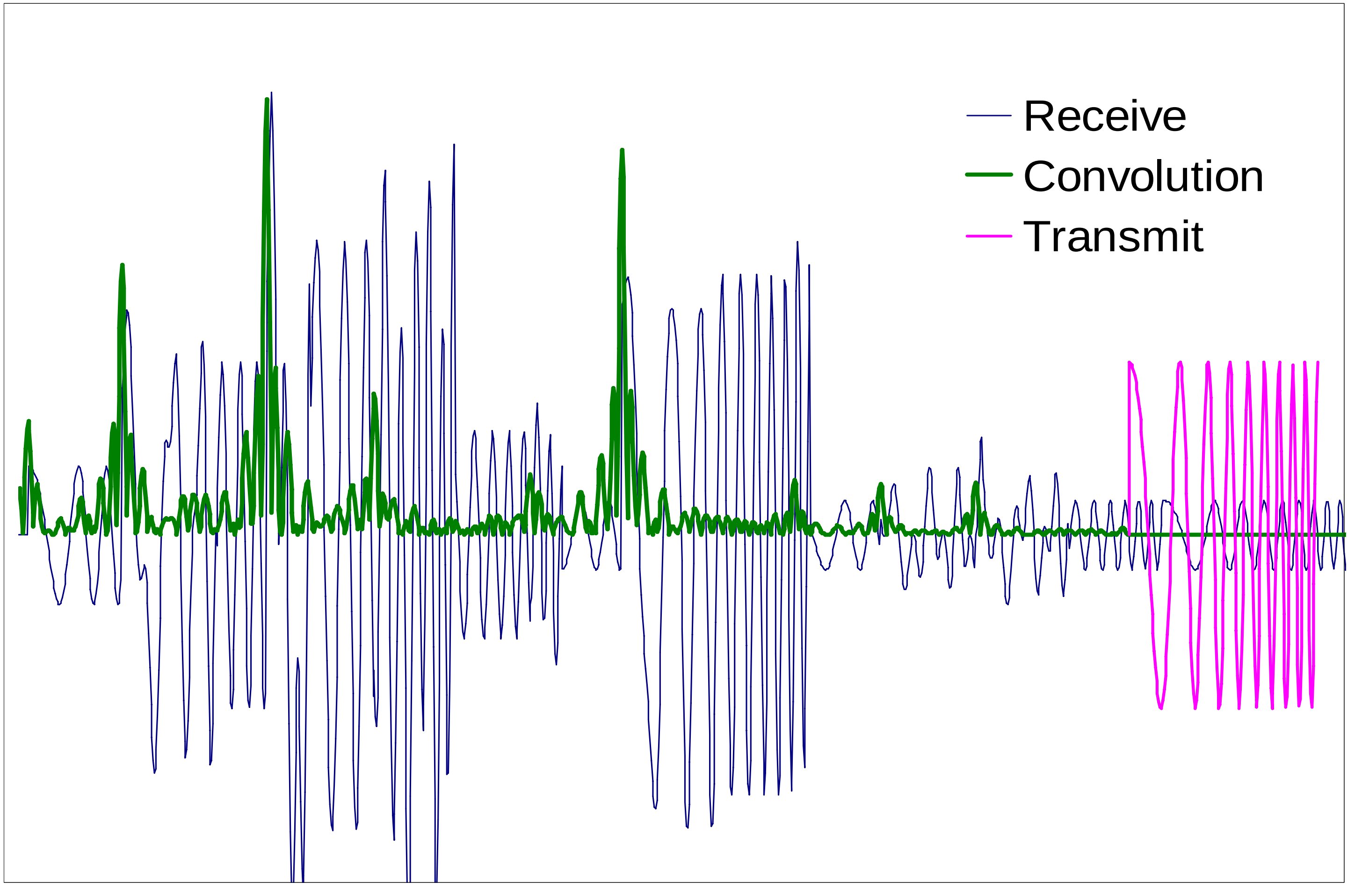
Convolution: Constructive interference



Convolution: Destructive interference

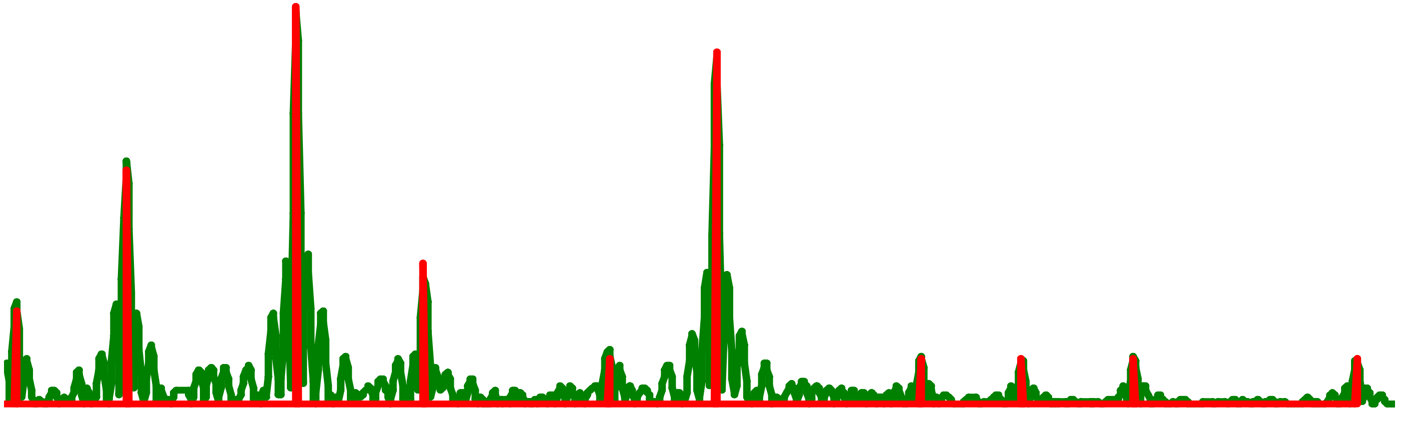


Convolution



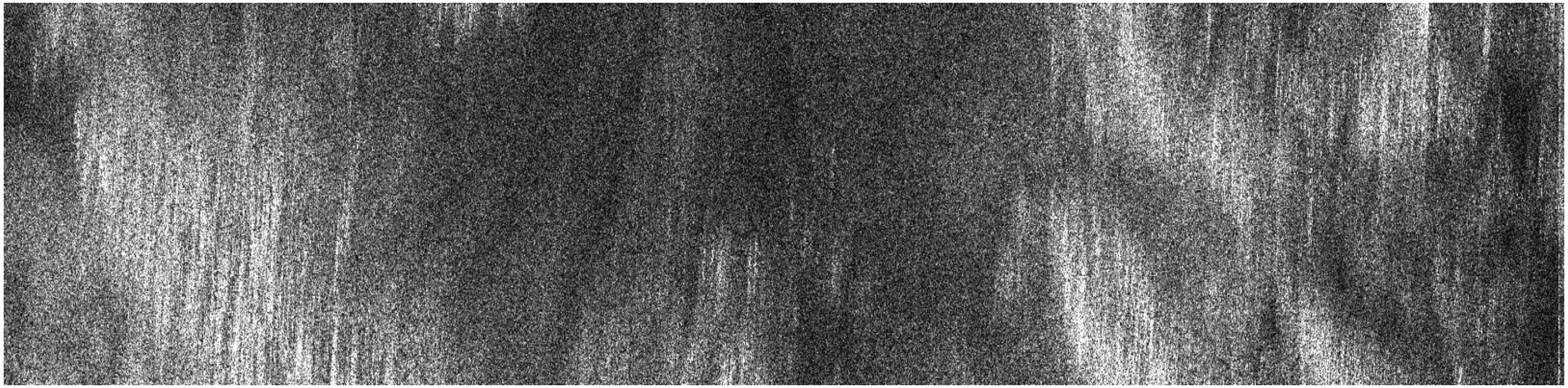
Range Compression

- Convolve the received range signal with the chirp you sent out.
- Range line looks similar to that of a short pulse – We have “compressed” the chirps in the signal to short pulses.



Azimuth:
Real Aperture Radar

- Good resolution in range, poor resolution in azimuth



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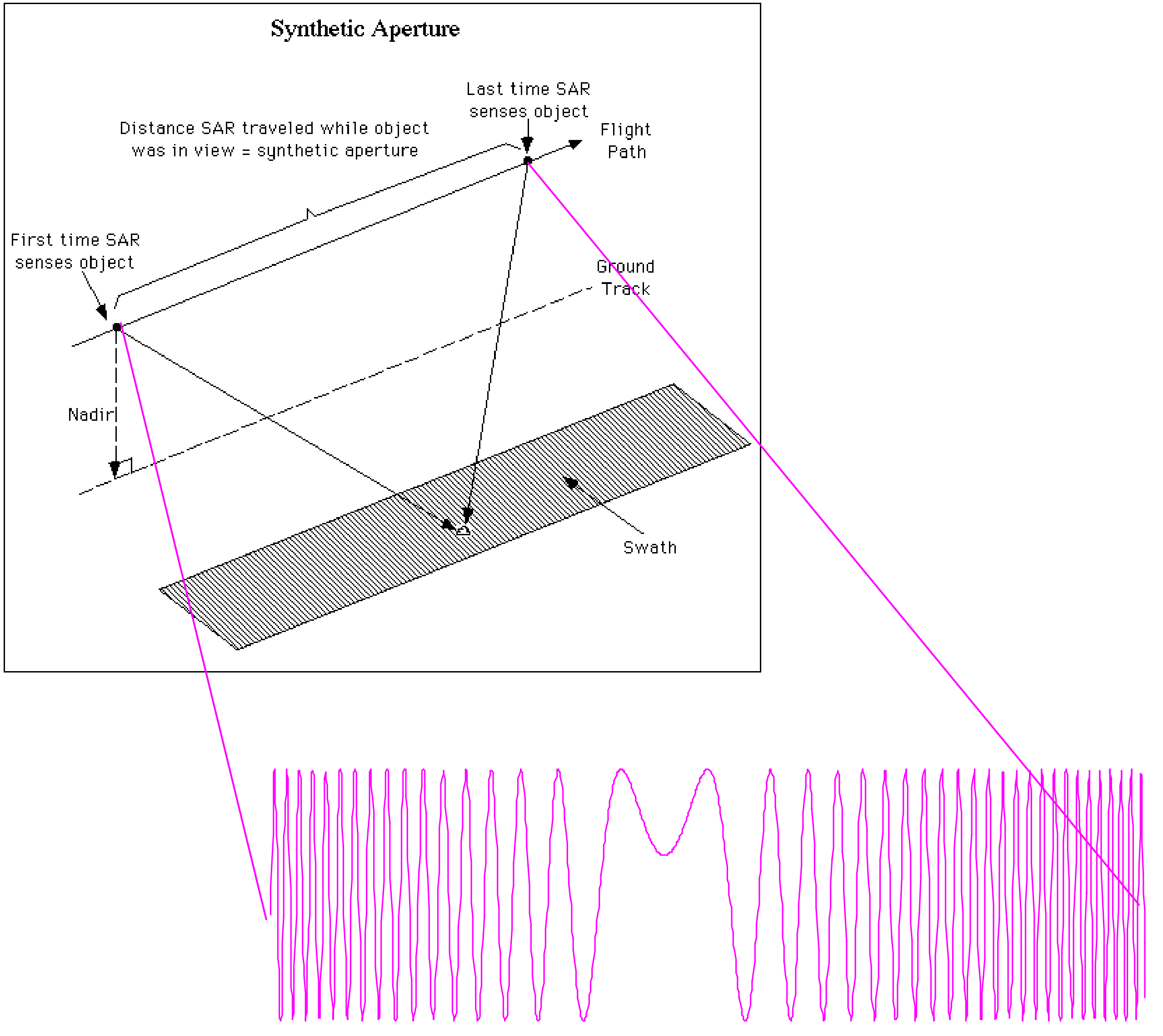
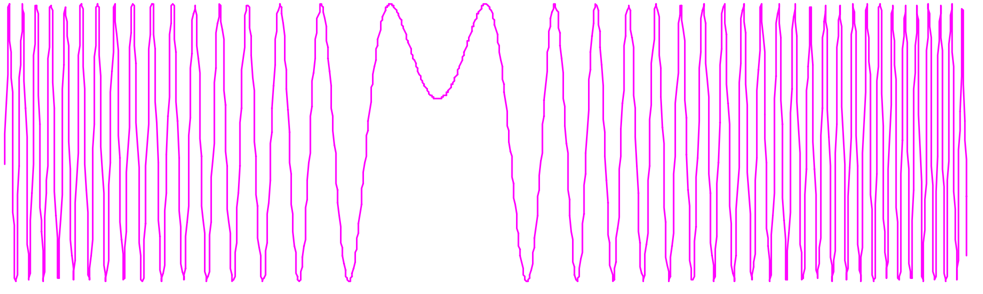
Azimuth: The Doppler effect

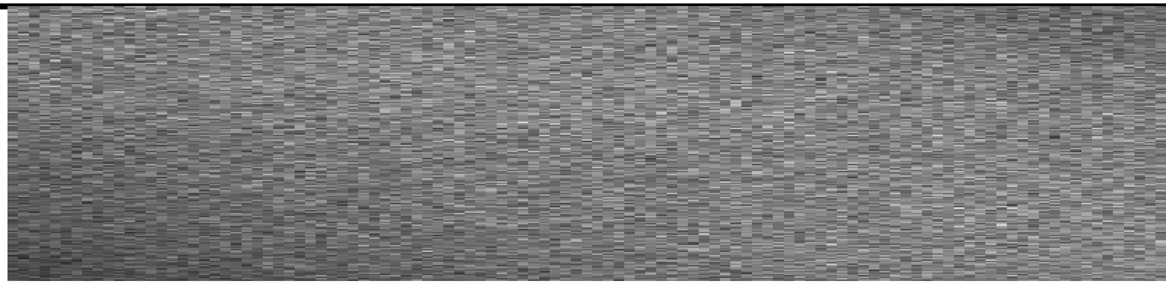


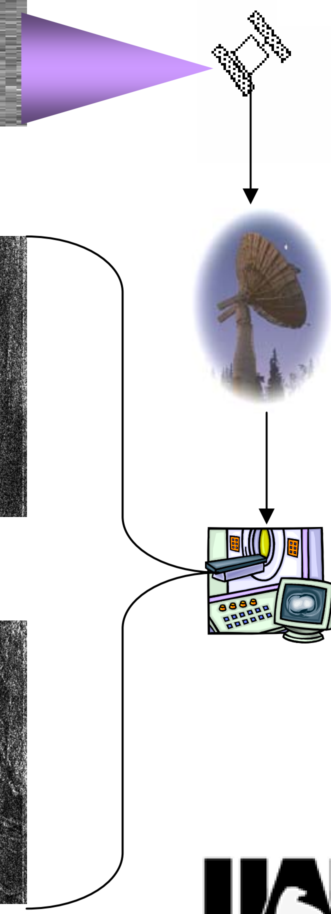
Azimuth compression

- Carl Wiley, in 1951, observed that two point targets at different azimuth positions, will have distinct Doppler frequency shifts. [Curlander, McDonough, 1991]
- We can compress the pulse in azimuth in the same fashion we compressed it in range.
- Convolve an azimuth line with the azimuth reference function:

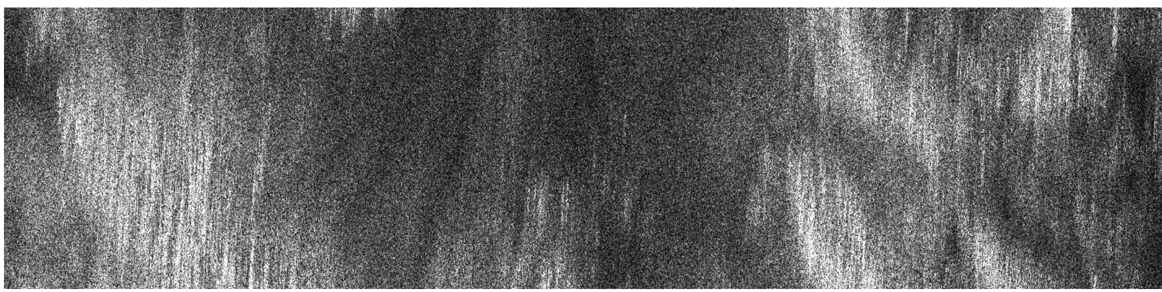


Synthetic Aperture Radar

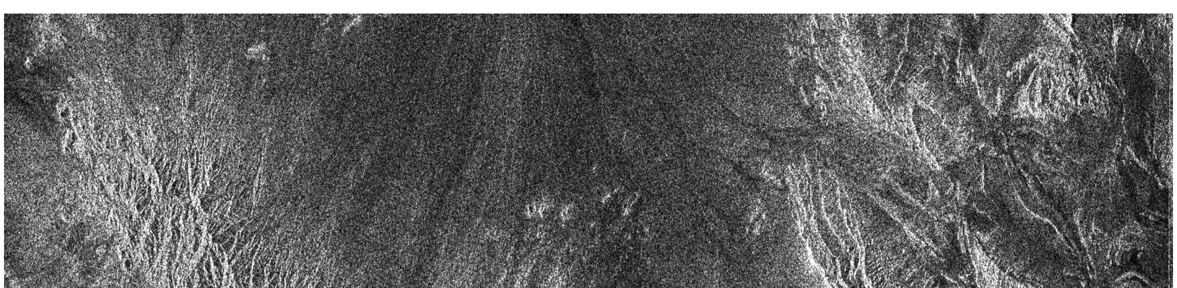




- Raw data

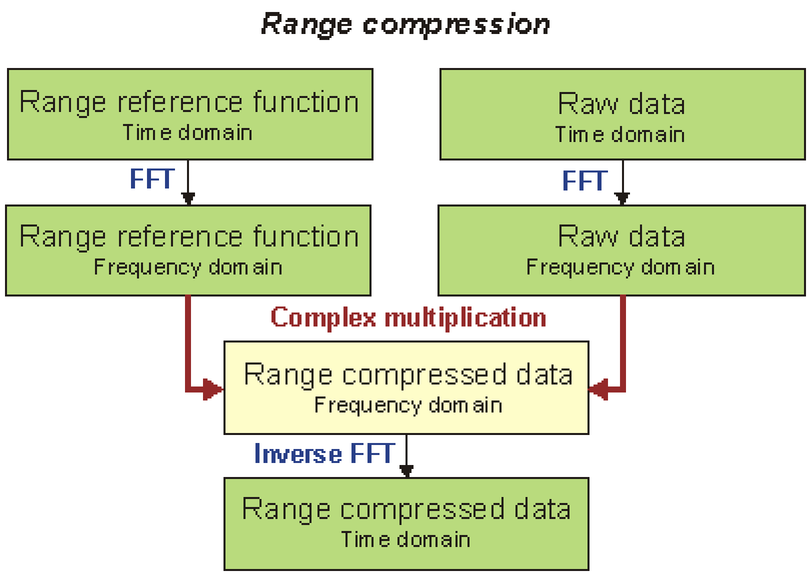


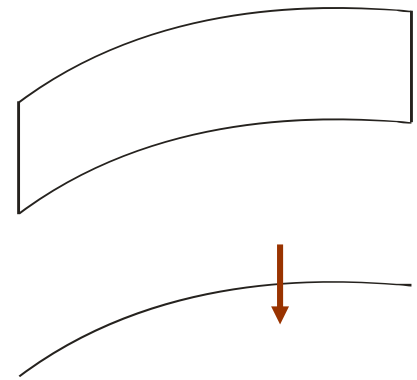
- Range compressed



- Azimuth compressed

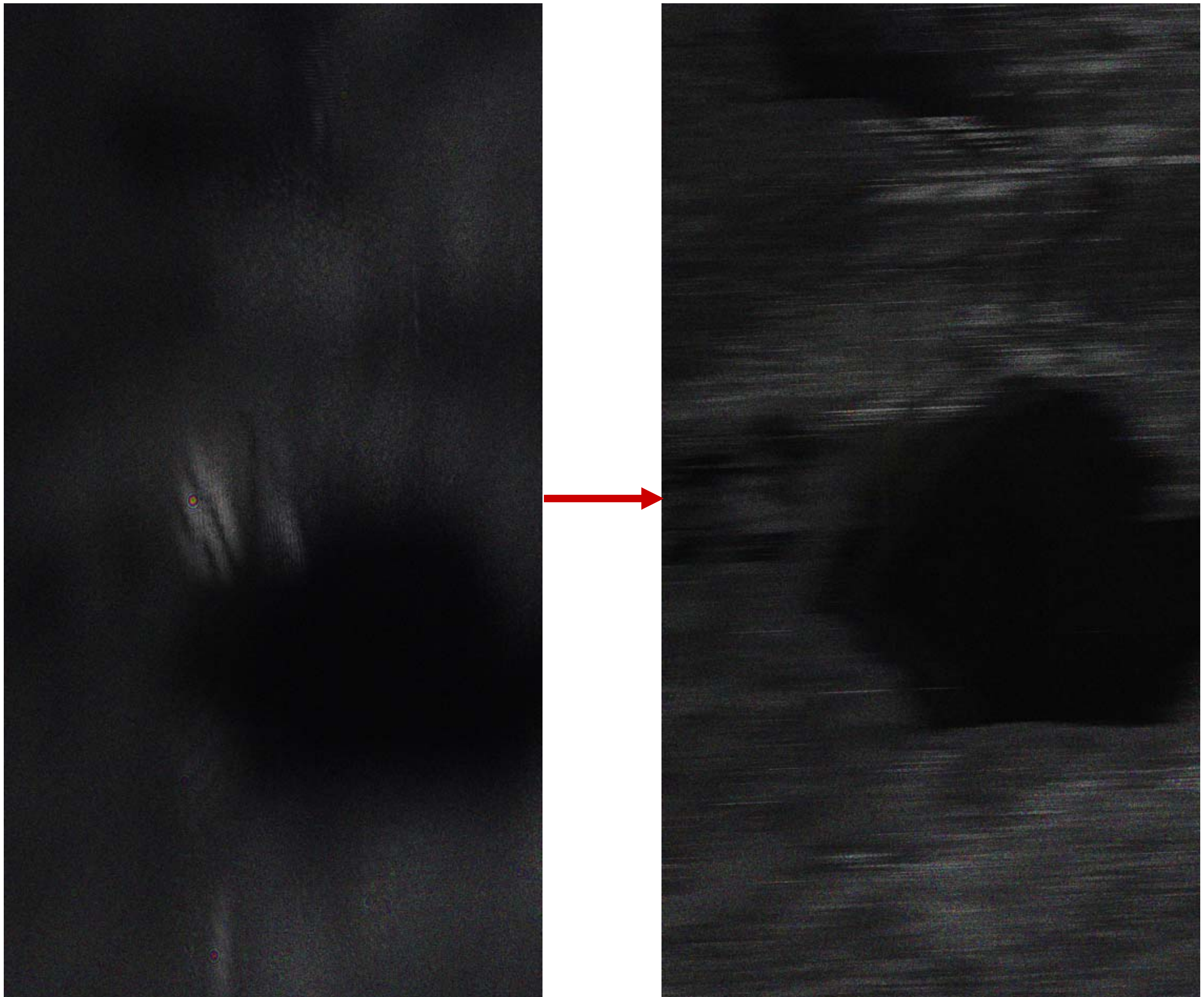
Range compression



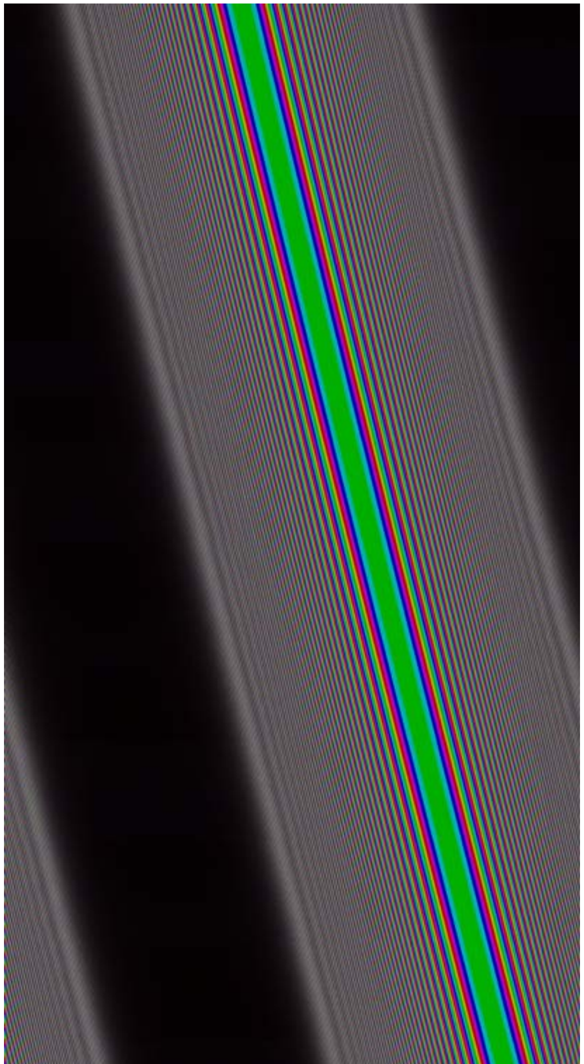


- each element of the raw data is multiplied by the complex conjugate of the corresponding element of the range reference function

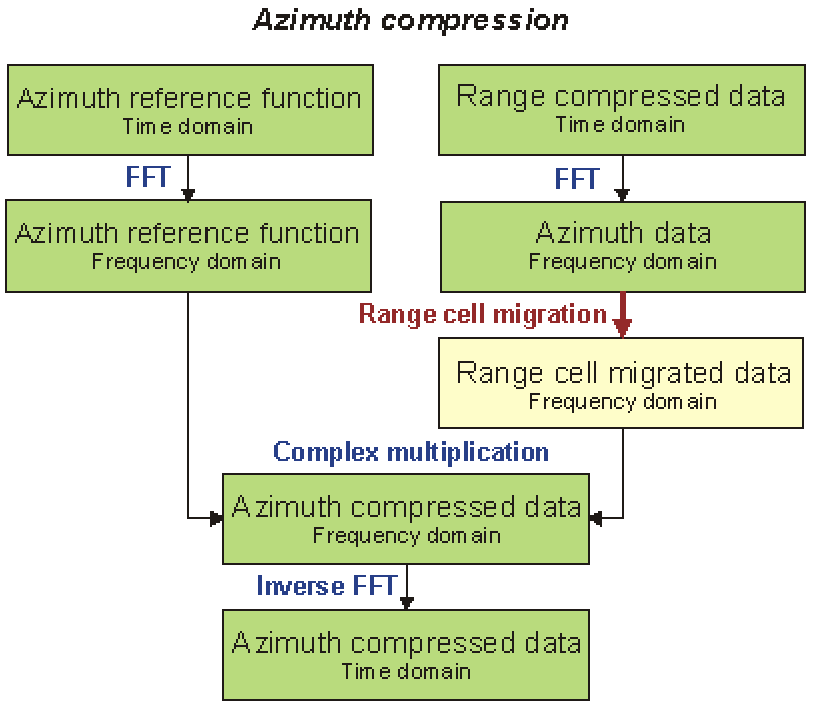
Range compression

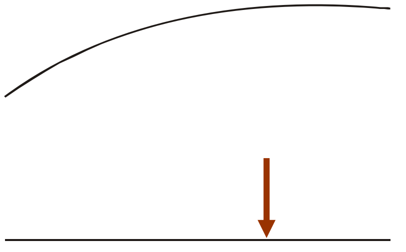


Azimuth reference function



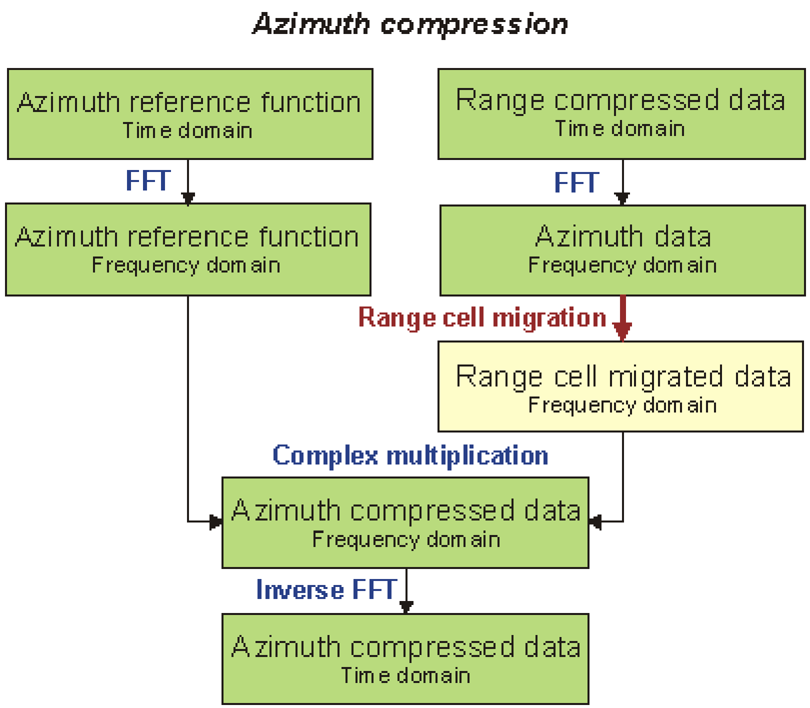
Range cell migration





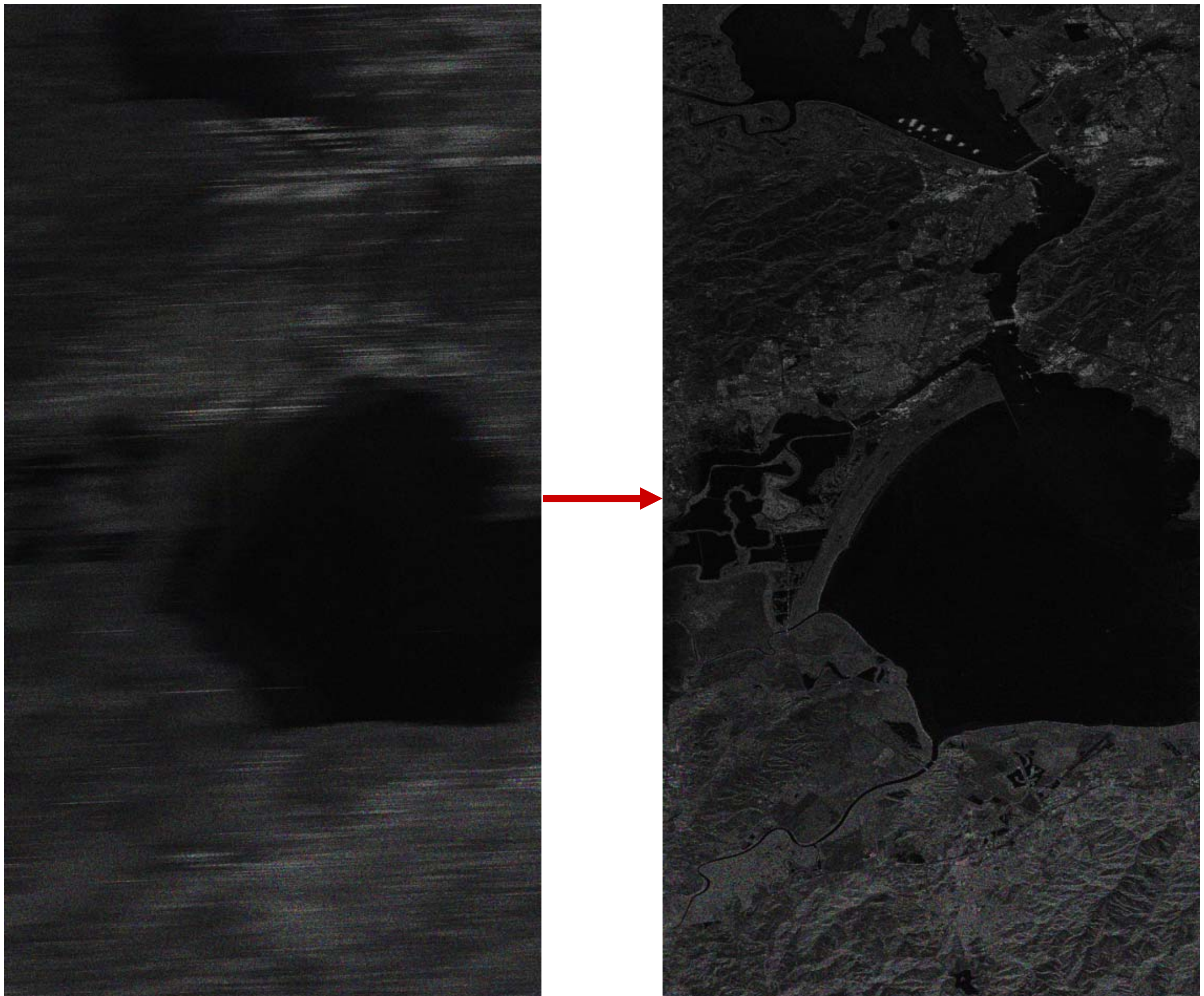
- range cell migration realigns all the returns for a single target into an appropriate single line of data

Azimuth compression

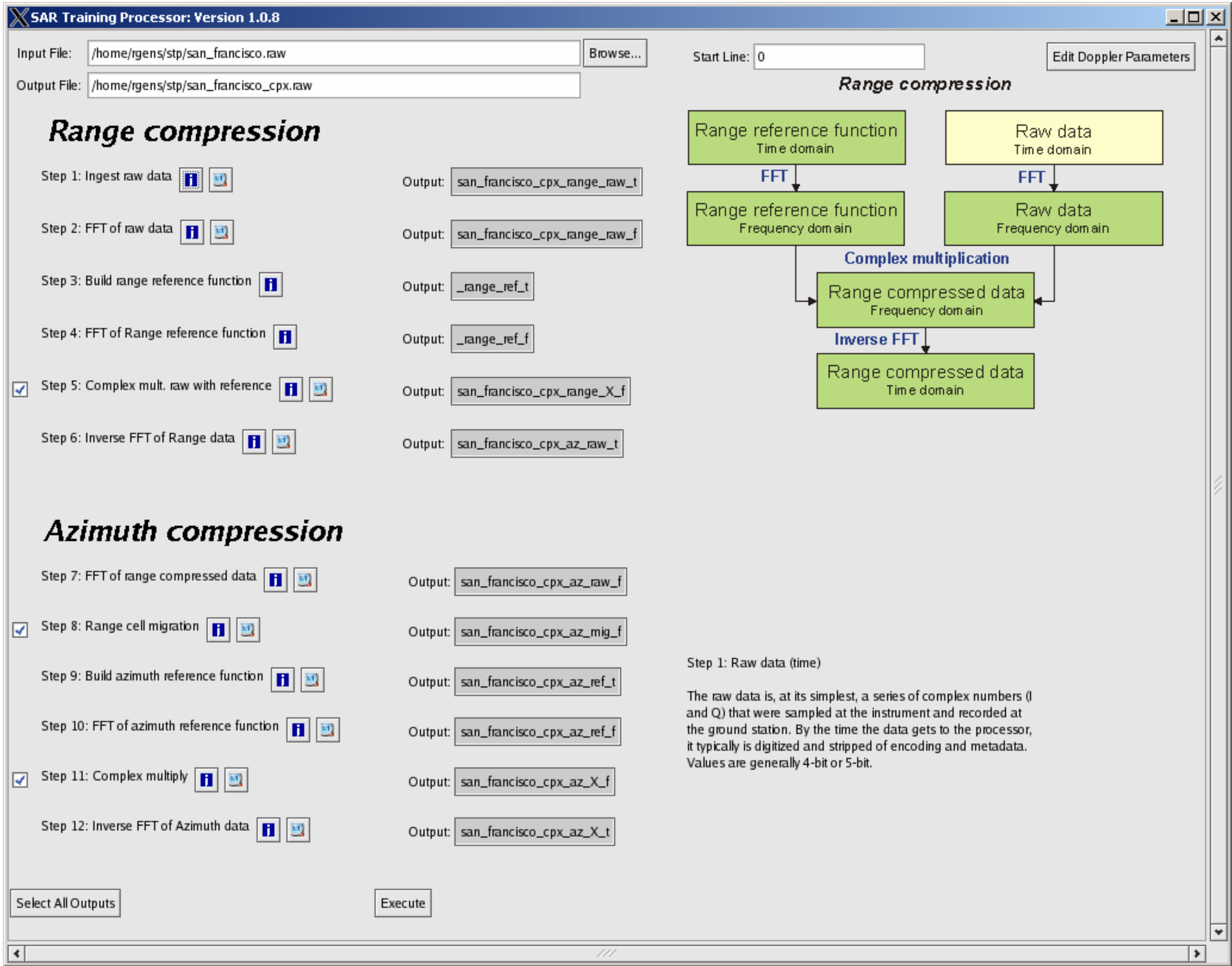


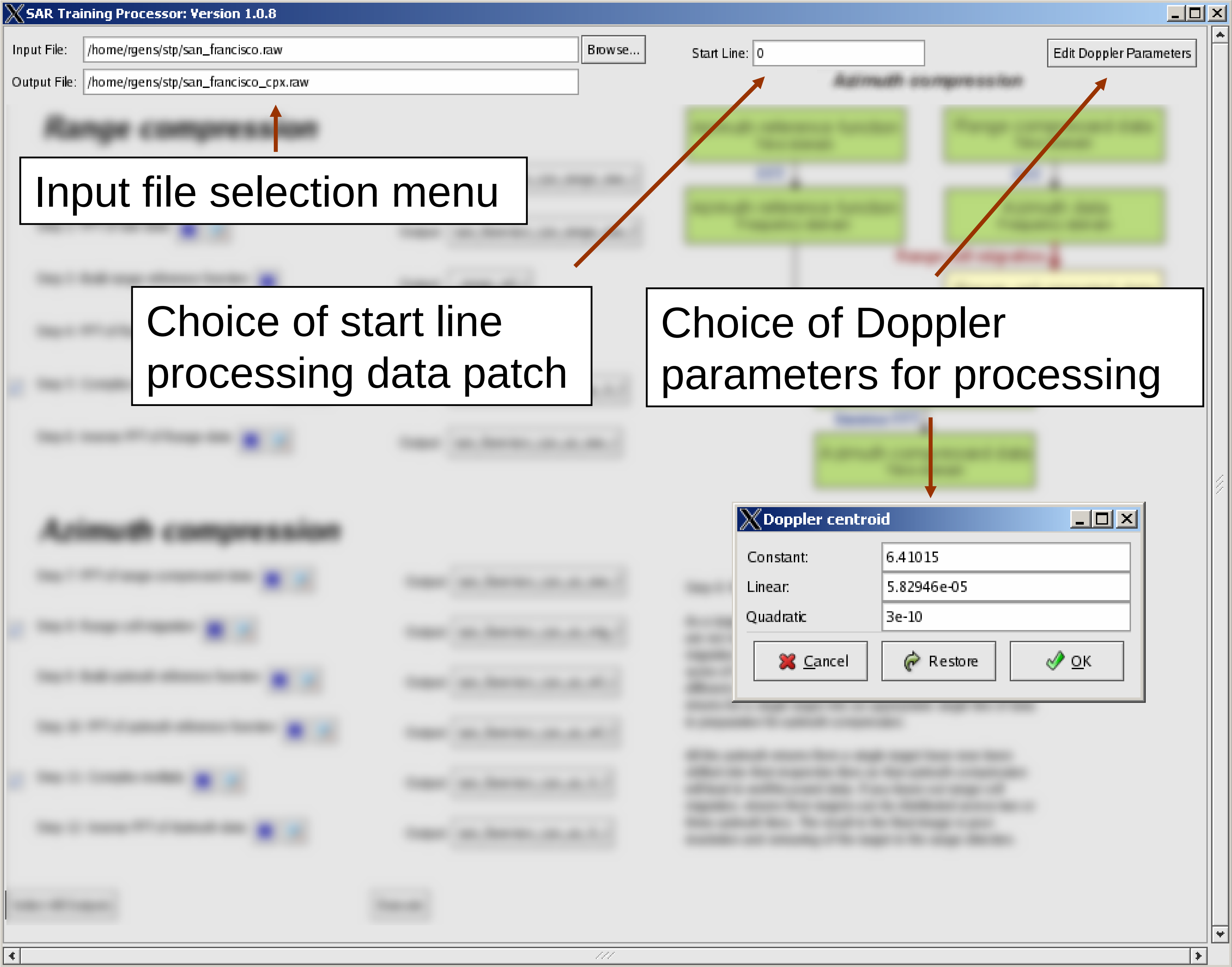
- each element of the data is multiplied by the complex conjugate of the corresponding element of the azimuth reference function

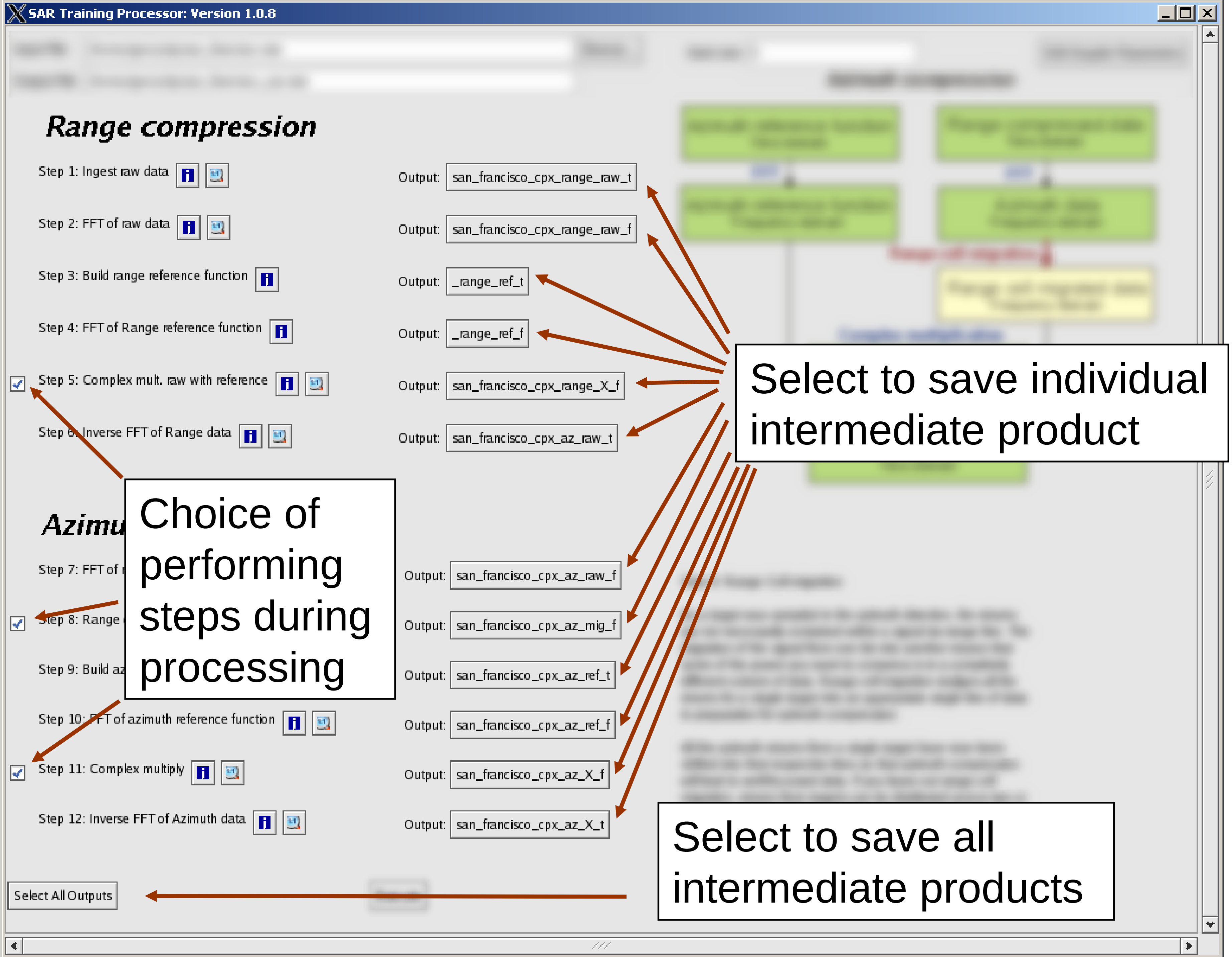
Range compression

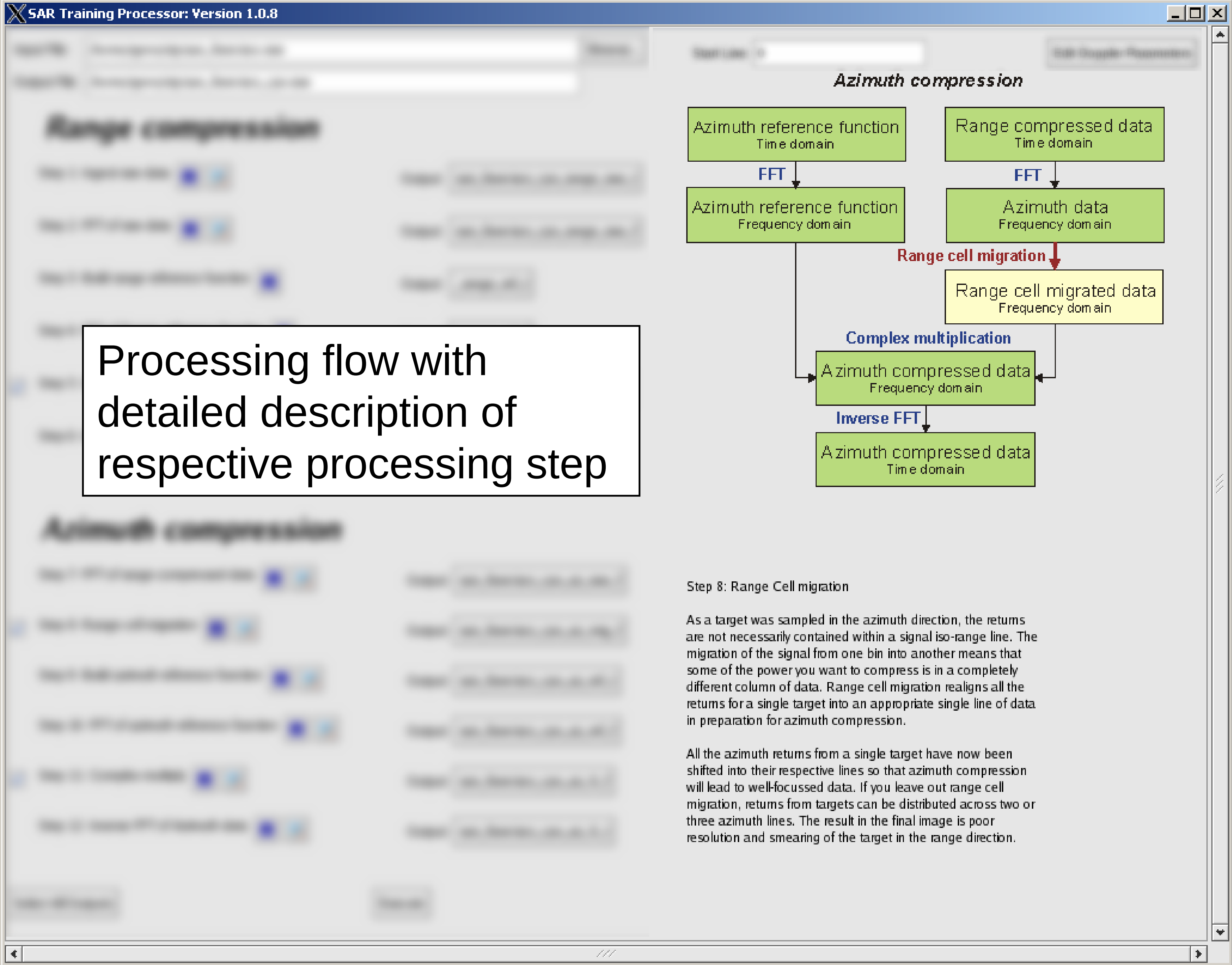


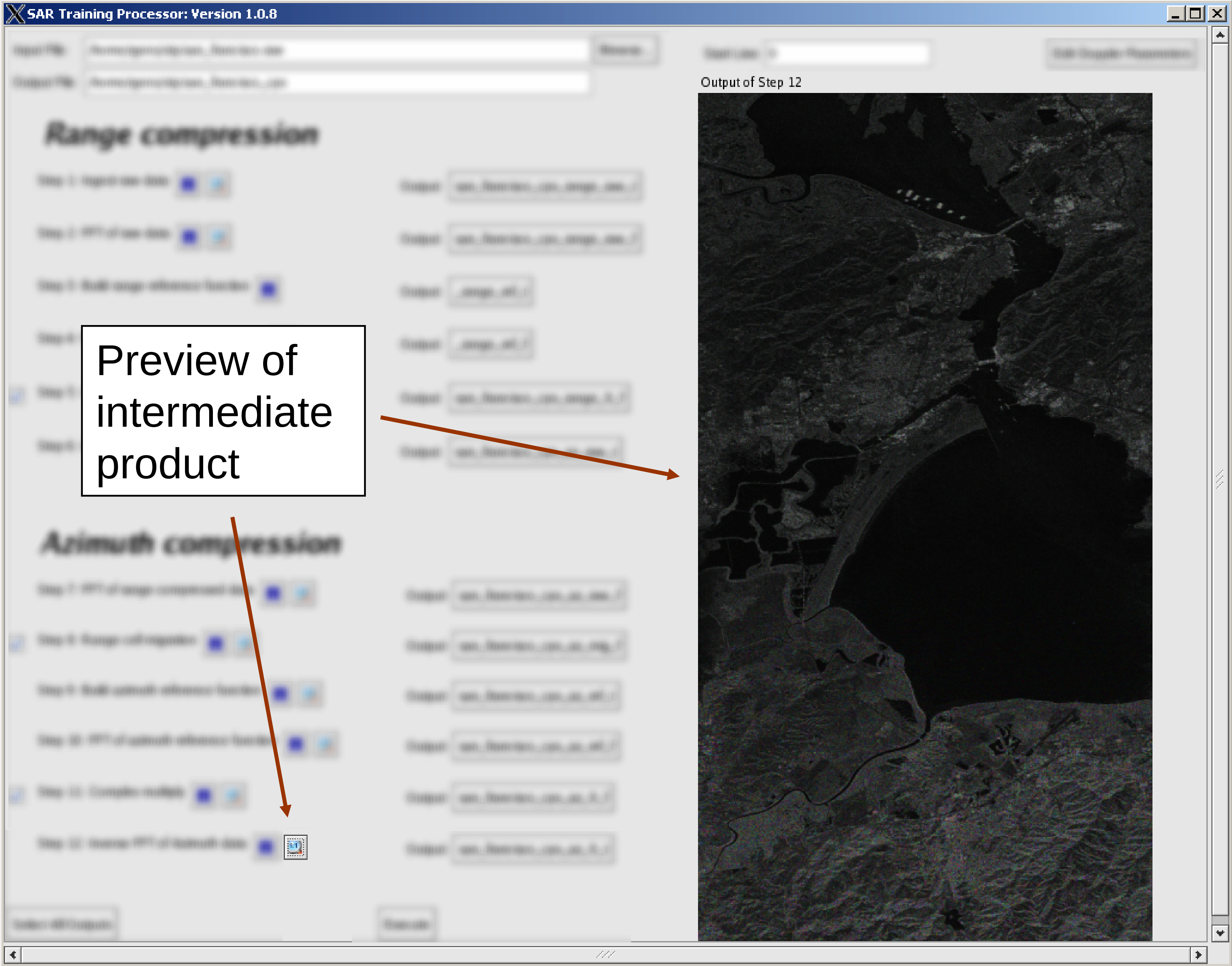
SAR training processor




SAR Training Processor: Version 1.0.8
Input File:
/home/rgens/stp/san_francisco.raw
Browse...
Output File:
/home/rgens/stp/san_francisco_cpx.raw
Start Line:
0
Edit Doppler Parameters
Input file selection menu
Choice of start line processing data patch
Choice of Doppler parameters for processing
Doppler centroid
Constant:
6.41015
Linear:
5.82946e-05
Quadratic
3e-10
Cancel
Restore
OK


SAR Training Processor: Version 1.0.8
Range compression
Step 1: Ingest raw data
Output: san_francisco_cpx_range_raw_t
Step 2: FFT of raw data
Output: san_francisco_cpx_range_raw_f
Step 3: Build range reference function
Output: _range_ref_t
Step 4: FFT of Range reference function
Output: _range_ref_f
Step 5: Complex mult. raw with reference
Output: san_francisco_cpx_range_X_f
Step 6: Inverse FFT of Range data
Output: san_francisco_cpx_az_raw_t
Azimu
Step 7: FFT of
Output: san_francisco_cpx_az_raw_f
Step 8: Range
Output: san_francisco_cpx_az_mig_f
Step 9: Build az
Output: san_francisco_cpx_az_ref_t
Step 10: FFT of azimuth reference function
Output: san_francisco_cpx_az_ref_f
Step 11: Complex multiply
Output: san_francisco_cpx_az_X_f
Step 12: Inverse FFT of Azimuth data
Output: san_francisco_cpx_az_X_t
Select All Outputs
Select to save individual intermediate product
Choice of performing steps during processing
Select to save all intermediate products


SAR Training Processor: Version 1.0.8
Processing flow with detailed description of respective processing step
Azimuth compression
Azimuth reference function
Time domain
Range compressed data
Time domain
FFT
FFT
Azimuth reference function
Frequency domain
Azimuth data
Frequency domain
Range cell migration
Range cell migrated data
Frequency domain
Complex multiplication
Azimuth compressed data
Frequency domain
Inverse FFT
Azimuth compressed data
Time domain
Step 8: Range Cell migration
As a target was sampled in the azimuth direction, the returns are not necessarily contained within a signal iso-range line. The migration of the signal from one bin into another means that some of the power you want to compress is in a completely different column of data. Range cell migration realigns all the returns for a single target into an appropriate single line of data in preparation for azimuth compression.
All the azimuth returns from a single target have now been shifted into their respective lines so that azimuth compression will lead to well-focussed data. If you leave out range cell migration, returns from targets can be distributed across two or three azimuth lines. The result in the final image is poor resolution and smearing of the target in the range direction.


SAR Training Processor: Version 1.0.8
Output of Step 12
Range compression
Preview of intermediate product
Azimuth compression