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Serendipidous Holography of Shocked Surfaces using Ultrashort Pulse-Pair 2d-Velocimetry

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May 21, 2014

Signal & Image Sciences Workshop (CASIS)
Livermore, CA, United States
May 21, 2014 through May 21, 2014

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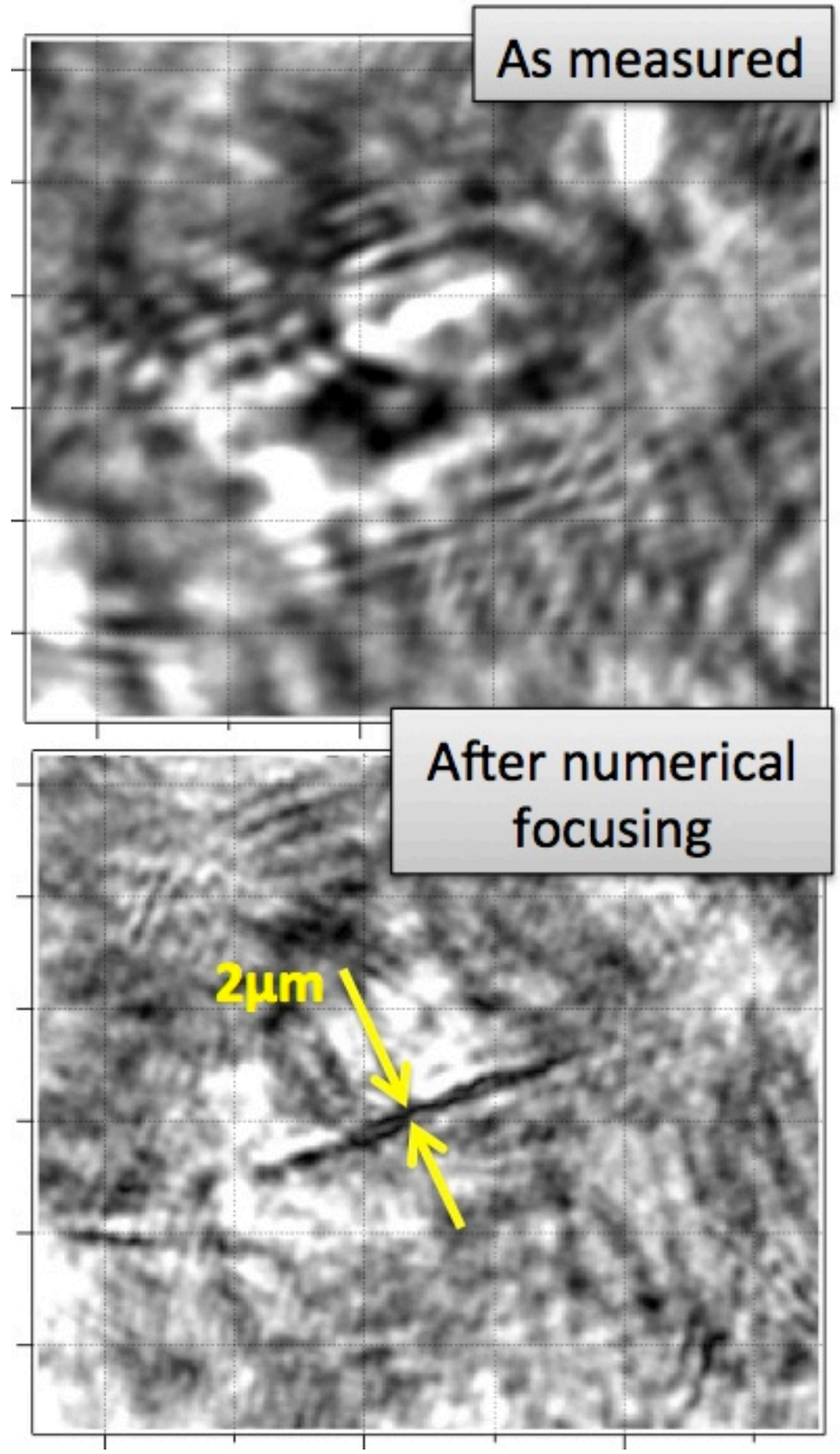
Serendipitous Holography of Shocked Surfaces using Ultrashort Pulse-Pair 2d-Velocimetry

David J. Erskine, LLNL

CASIS Talk

LLNL, May 21, 2014



Colleagues

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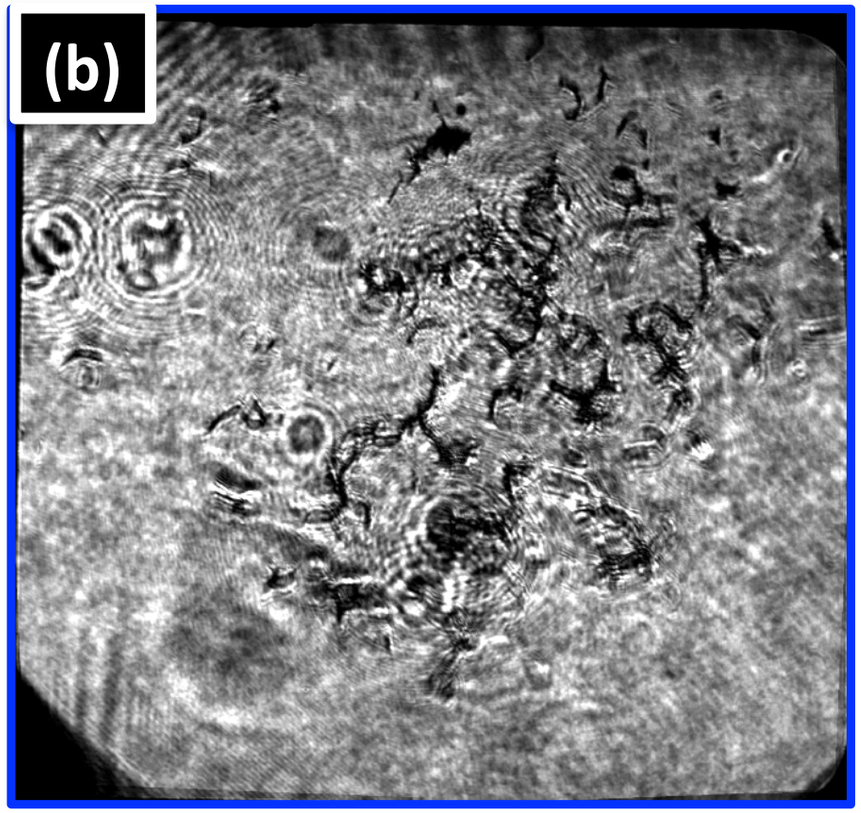
Suzanne Ali (UCB)

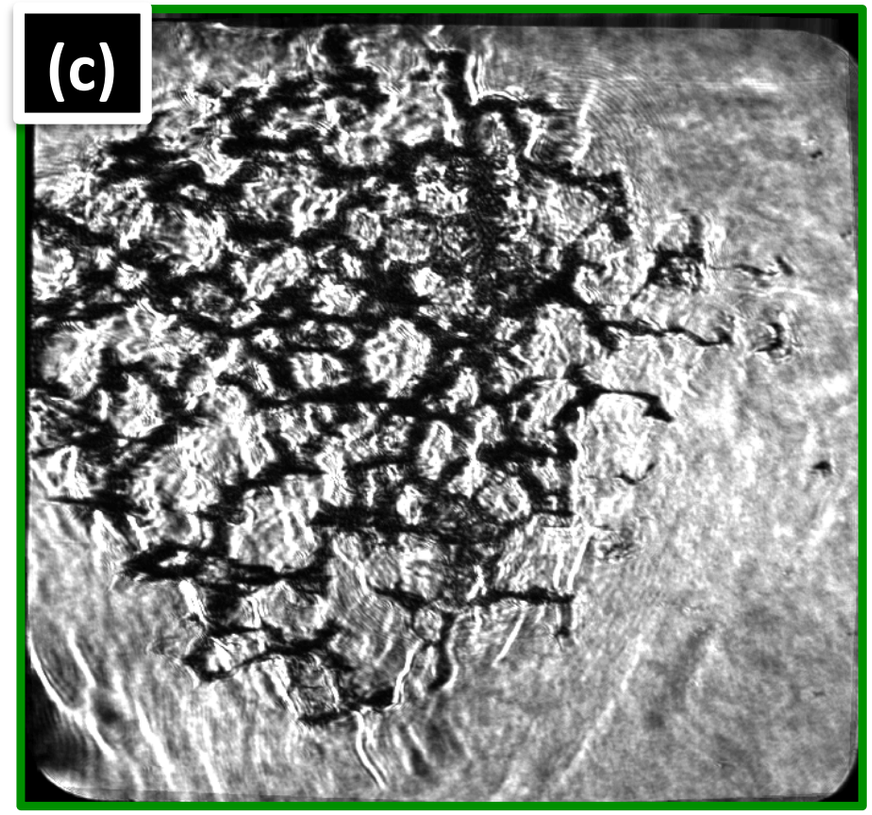
Peter Celliers

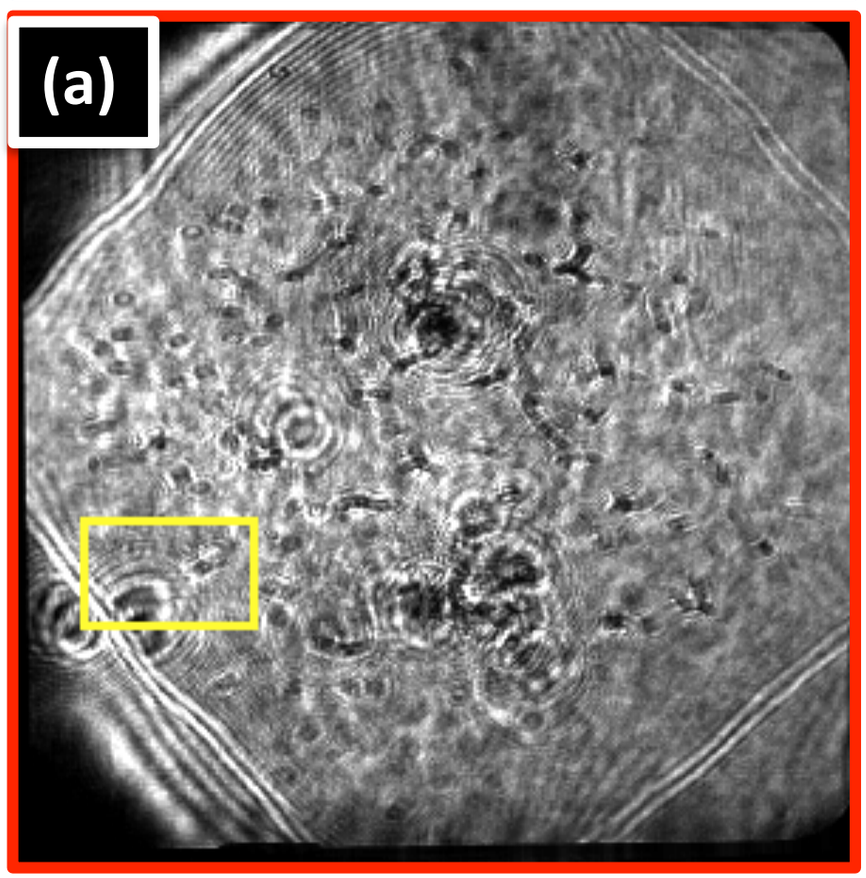
Gilbert Collins

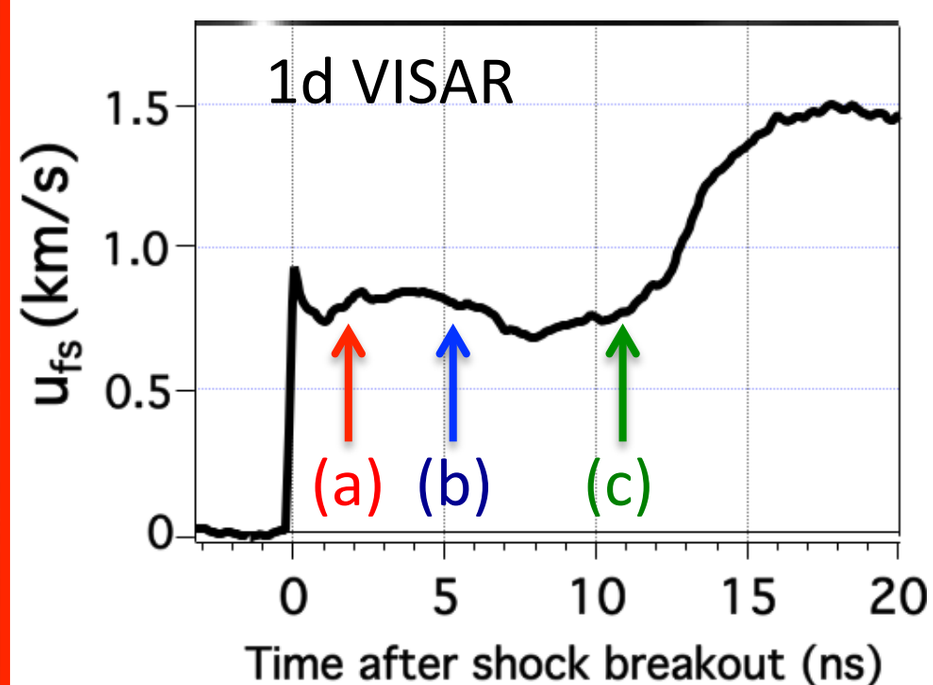
Prepared by LLNL under Contract DE-AC52-07NA27344

Untamped Si target strobed at 3 ps

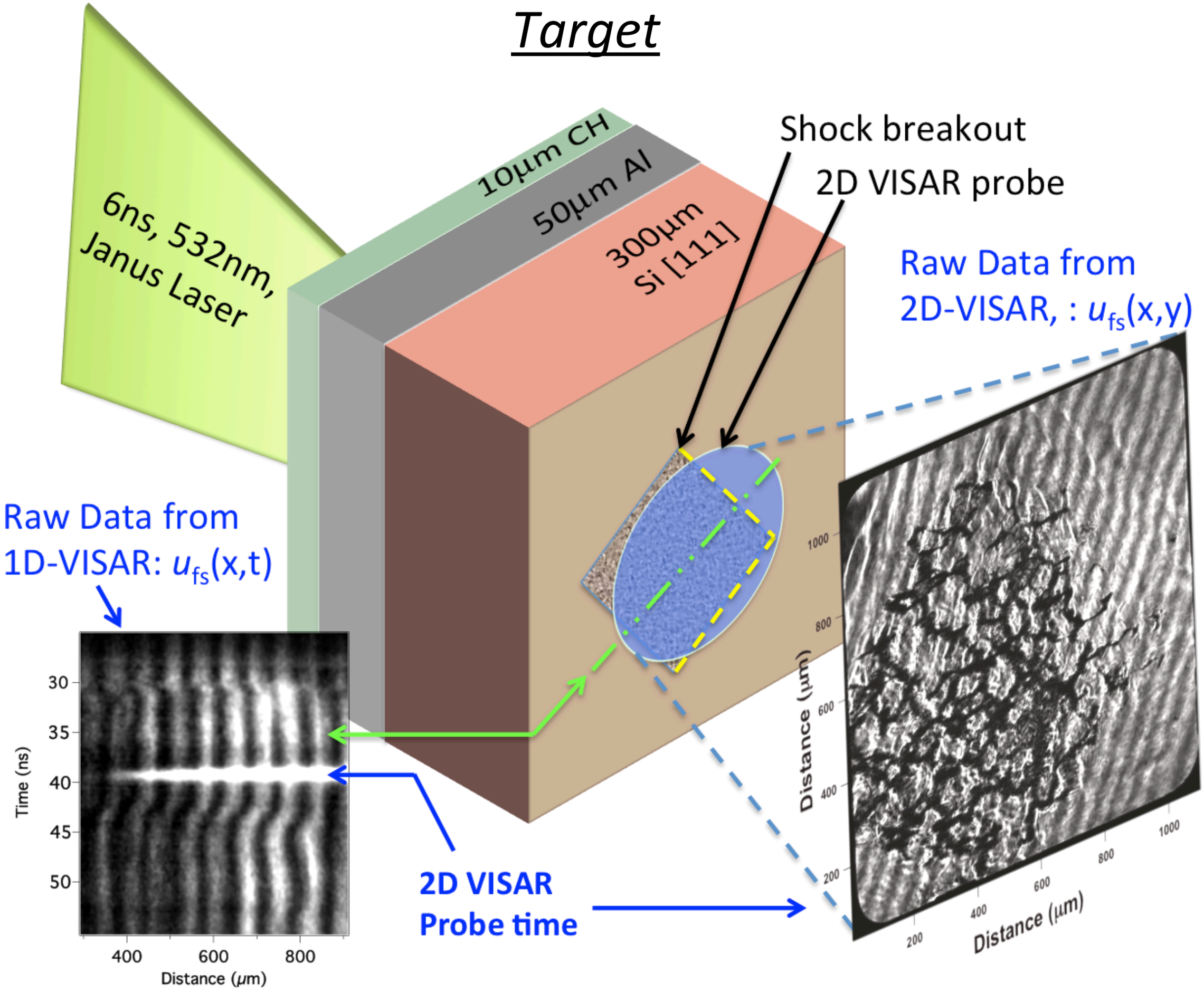




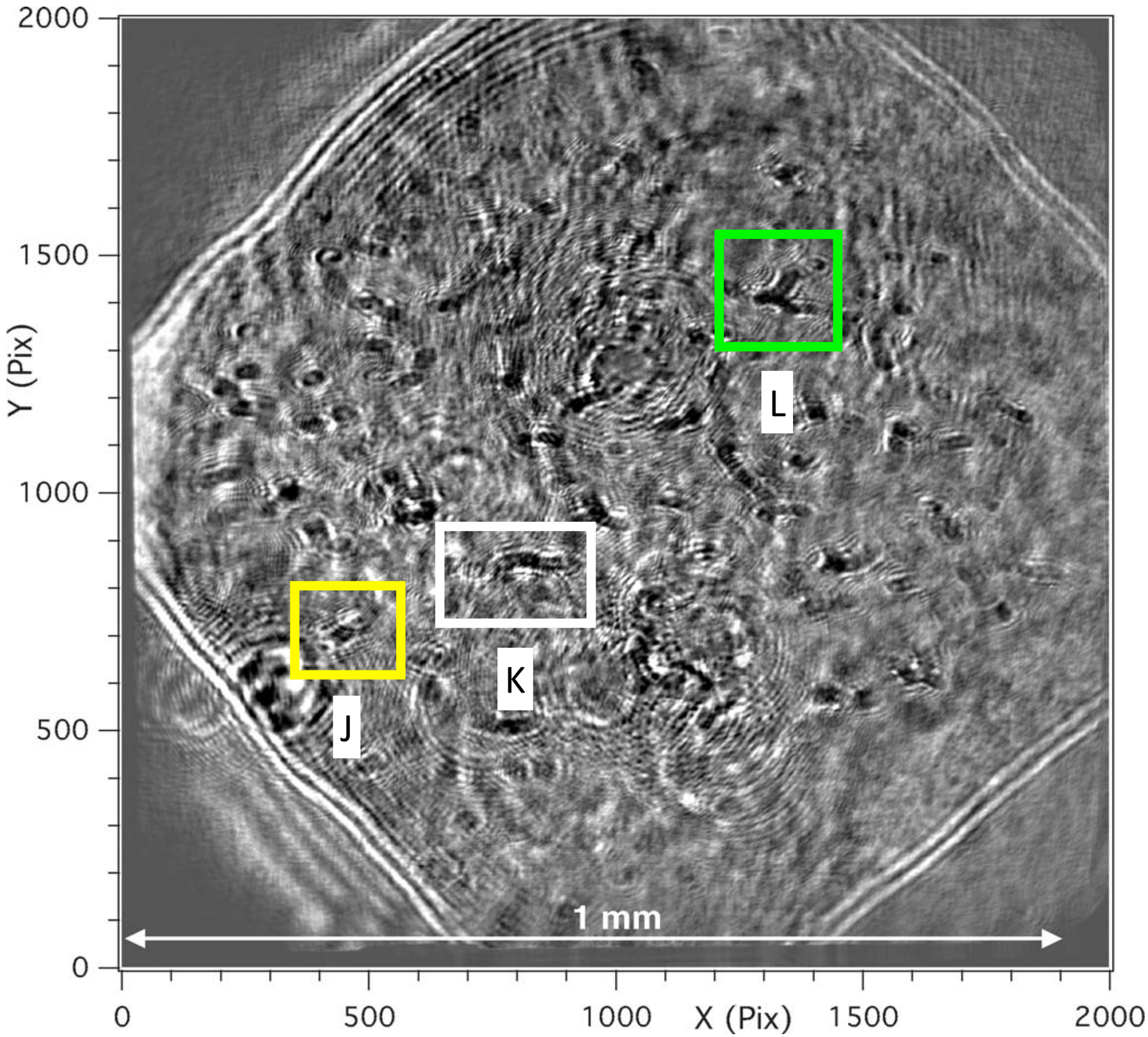




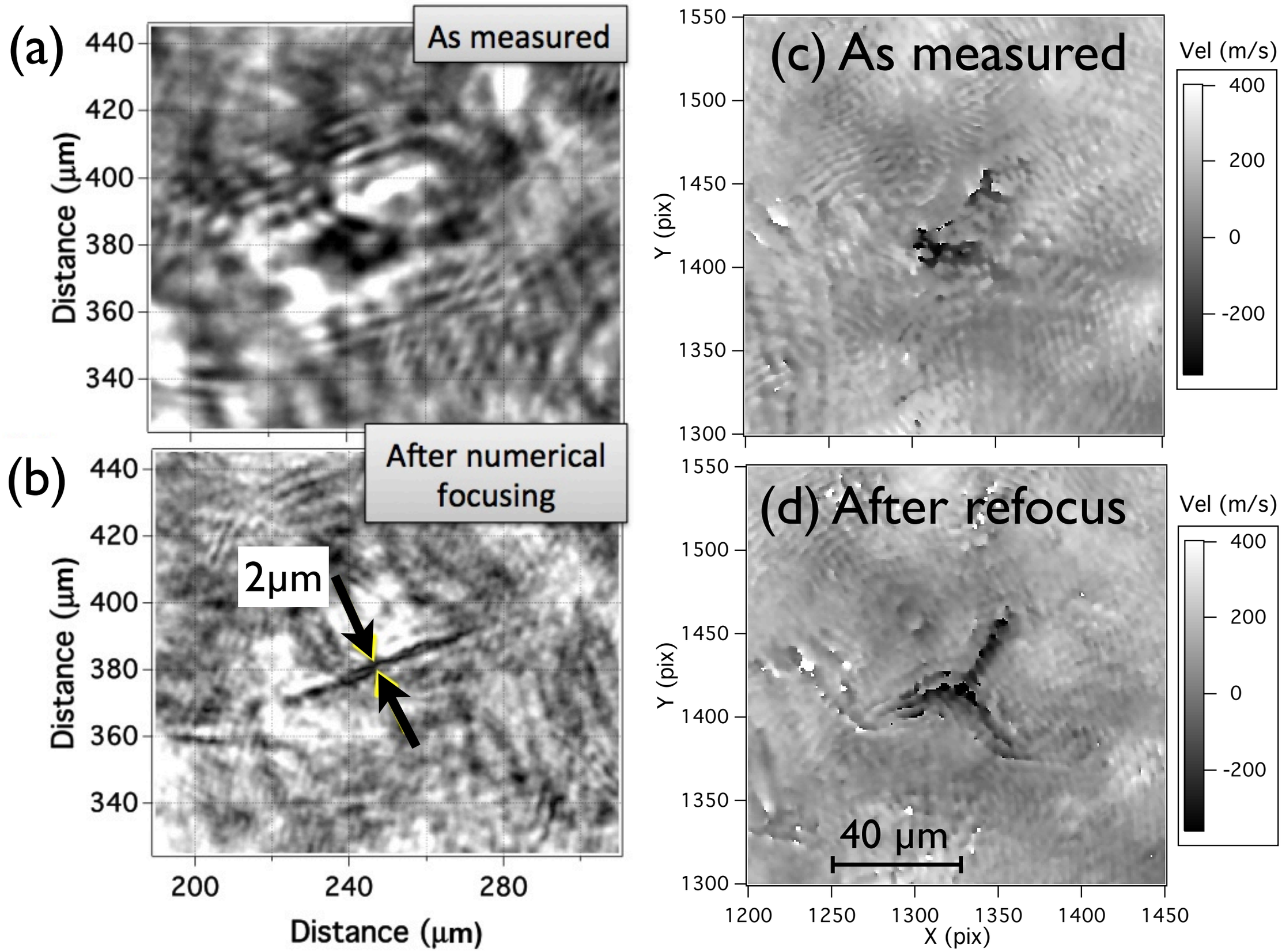
Target


6ns, 532nm,
Janus Laser
10μm CH
50μm Al
300μm
Si [111]
Shock breakout
2D VISAR probe
Raw Data from
2D-VISAR, : $u_{fs}(x,y)$
Raw Data from
1D-VISAR: $u_{fs}(x,t)$
Time (ns)
30
35
40
45
50
400
600
800
Distance (μm)
2D VISAR
Probe time
Distance (μm)
200
400
600
800
1000

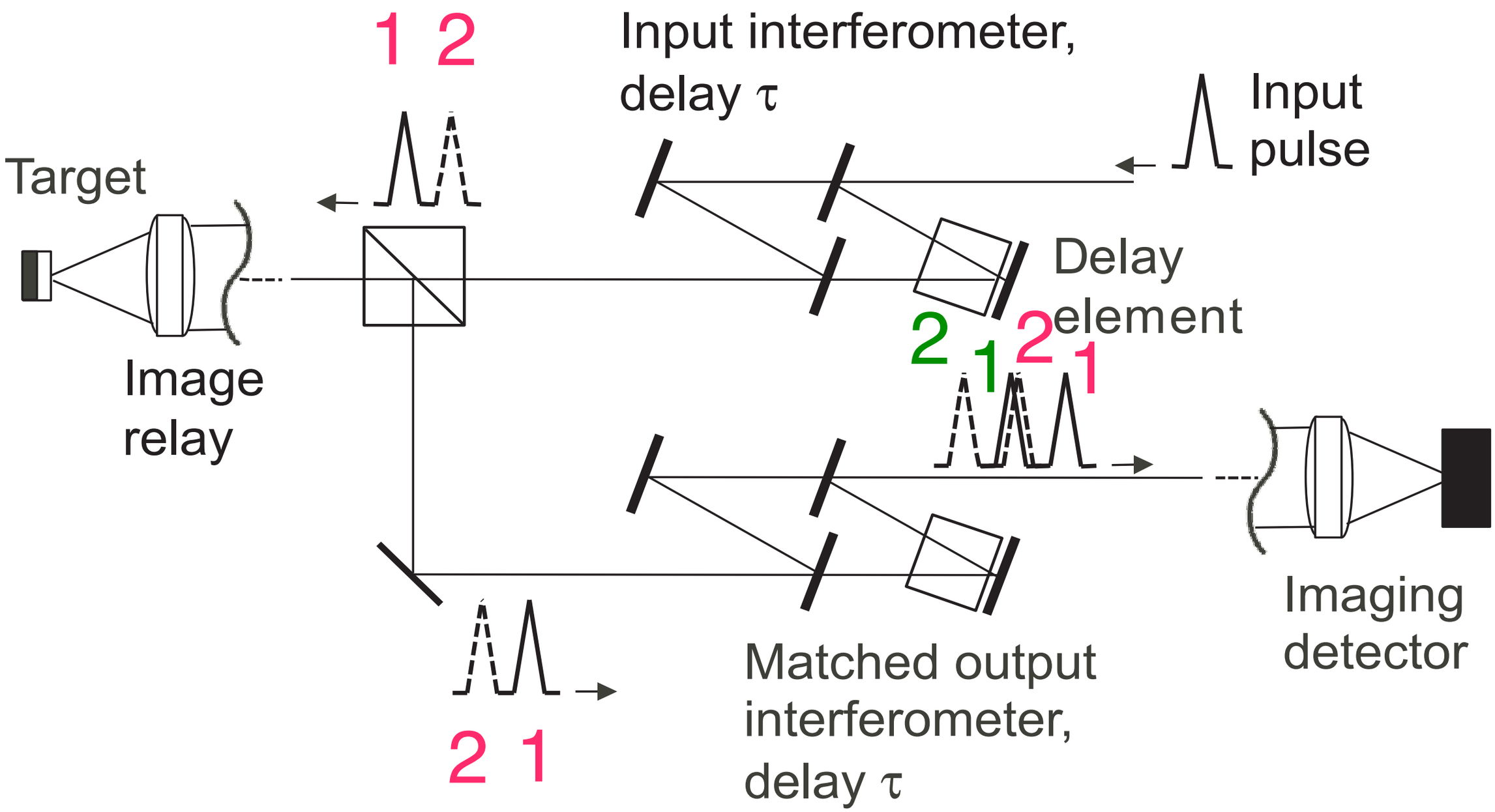
As-taken, accidentally out of focus



Refocusing done numerically post-shot



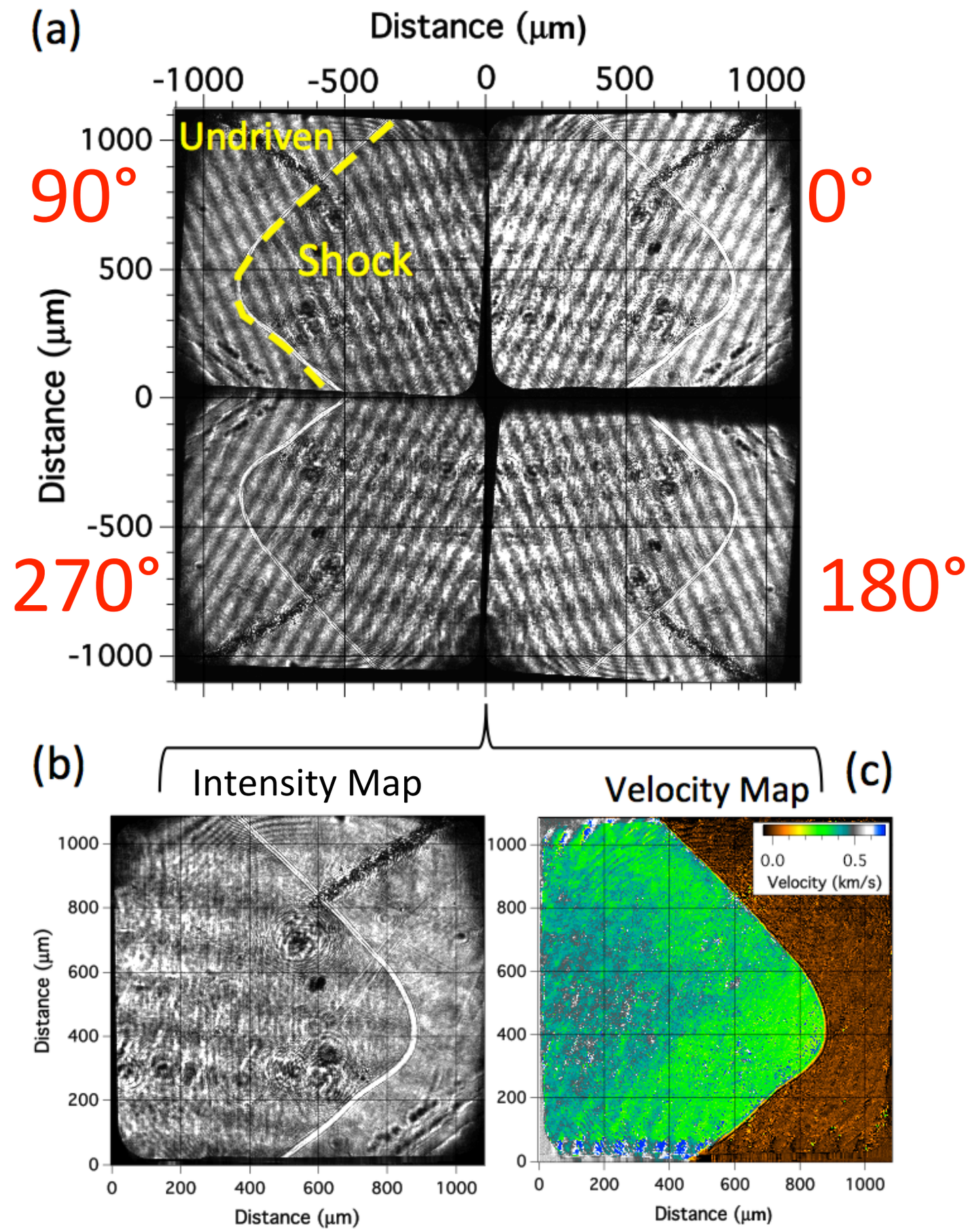
Need to use a pair of pulses, for velocimetry (detect position twice, over an interval)

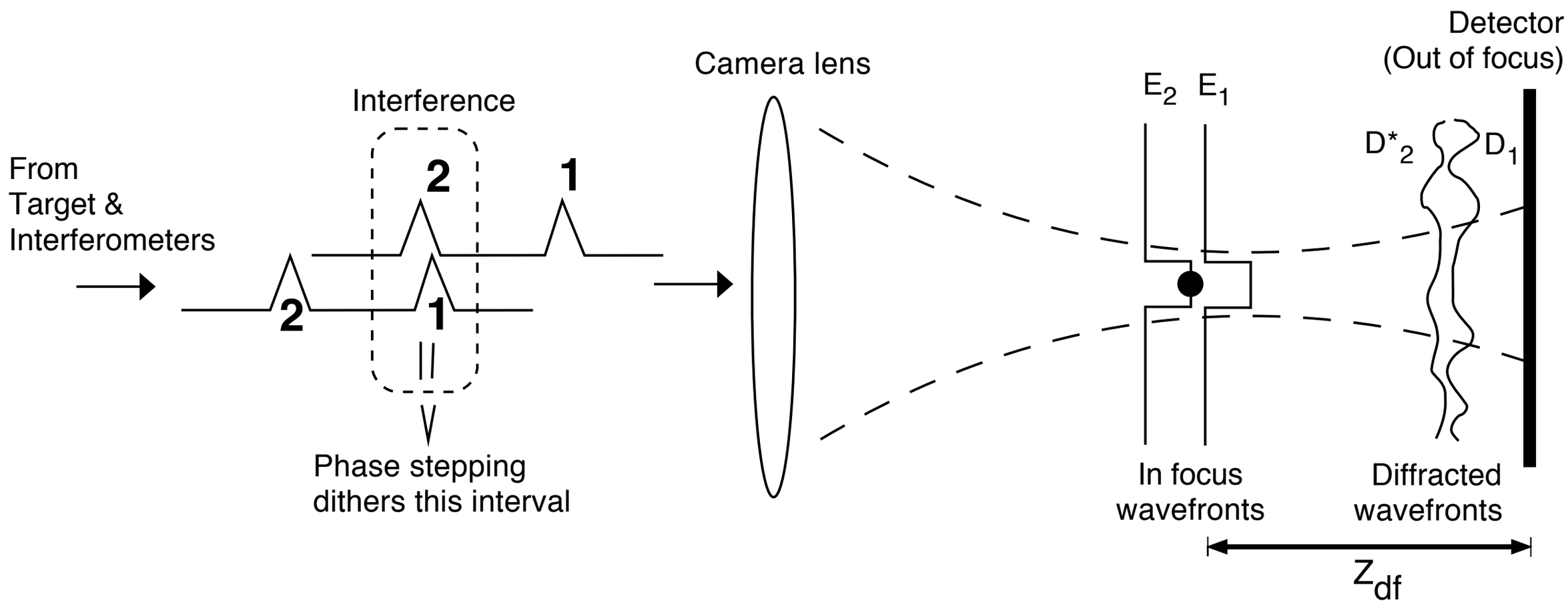


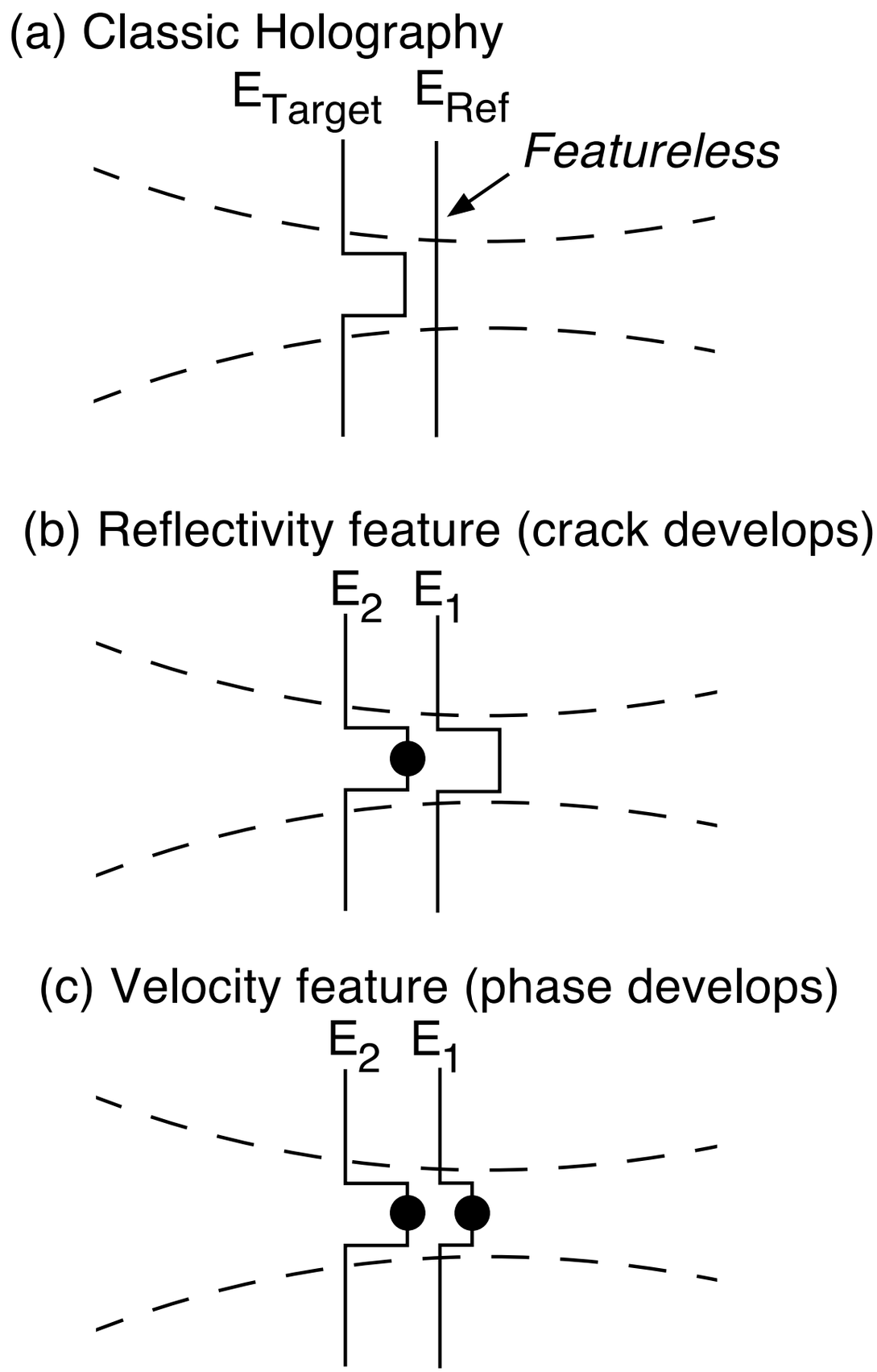
Phase-stepped recording

Phase & Magnitude recovered

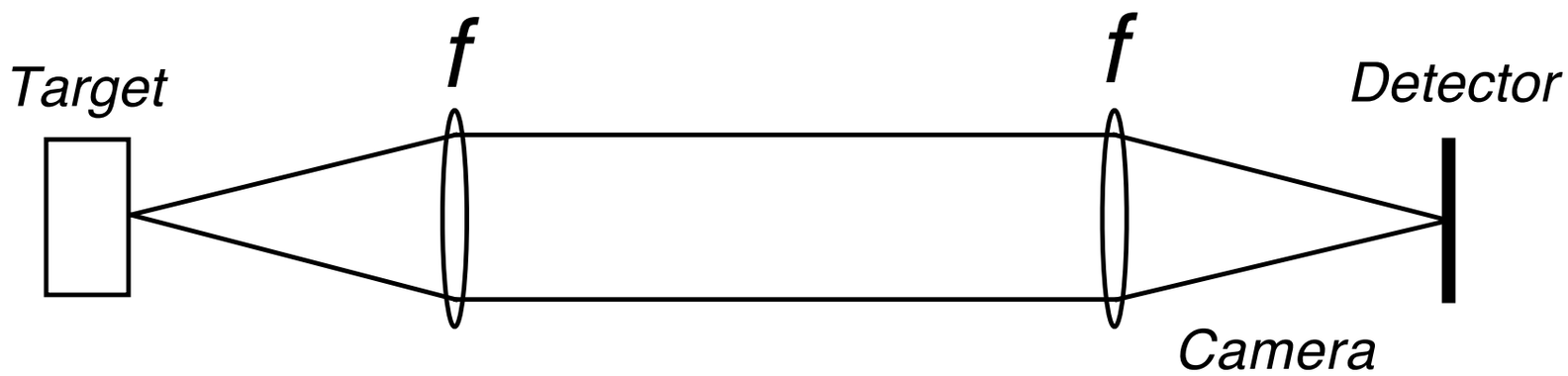
Fringing & nonFringing separable

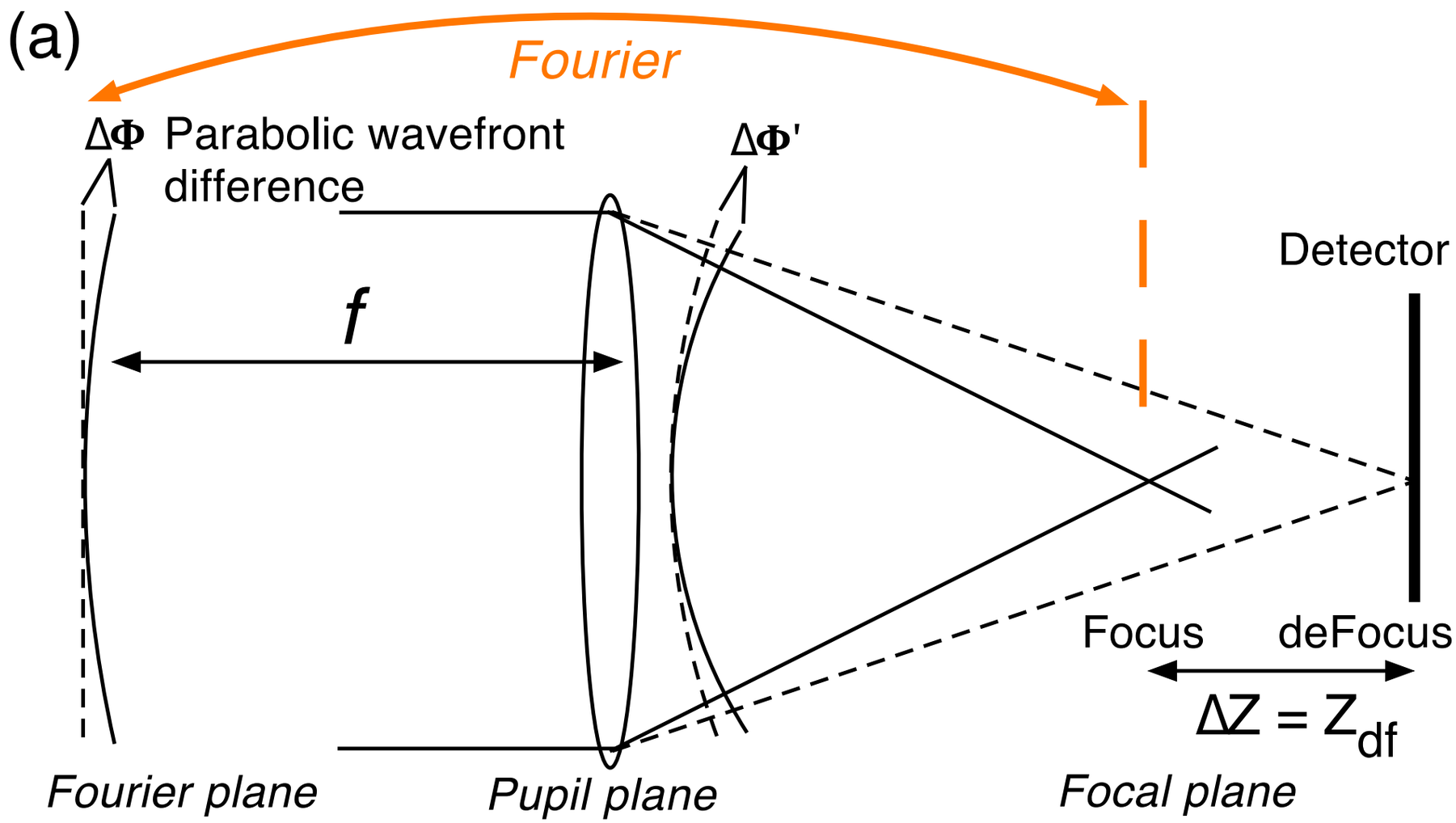



Detector
(Out of focus)
Camera lens
Interference
From
Target &
Interferometers
2
1
2
1
Phase stepping
dithers this interval
E2 E1
D*2
D1
In focus
wavefronts
Diffracted
wavefronts
Zdf

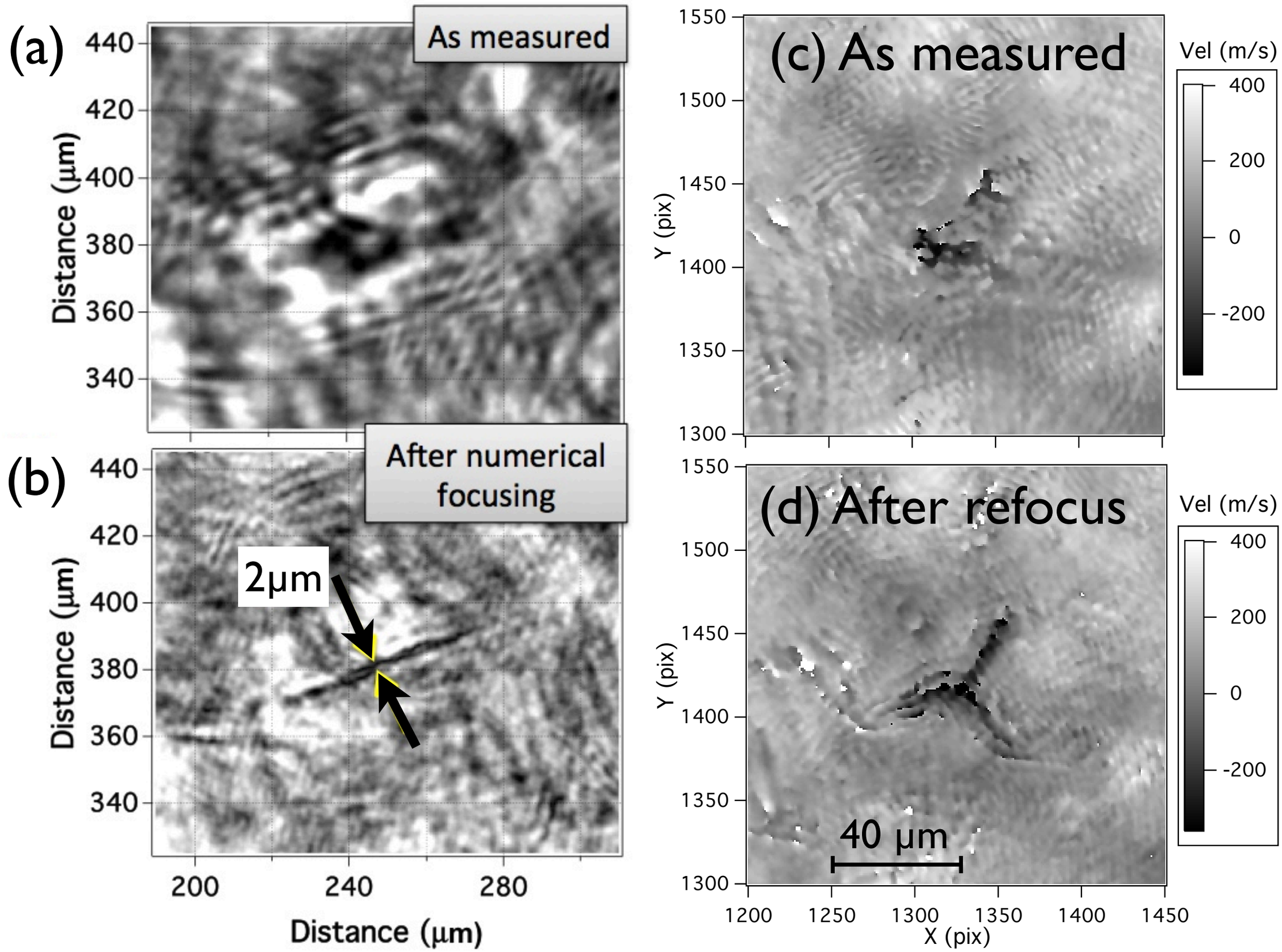

(a) Classic Holography
E_Target
E_Ref
Featureless
(b) Reflectivity feature (crack develops)
E_2
E_1
(c) Velocity feature (phase develops)
E_2
E_1

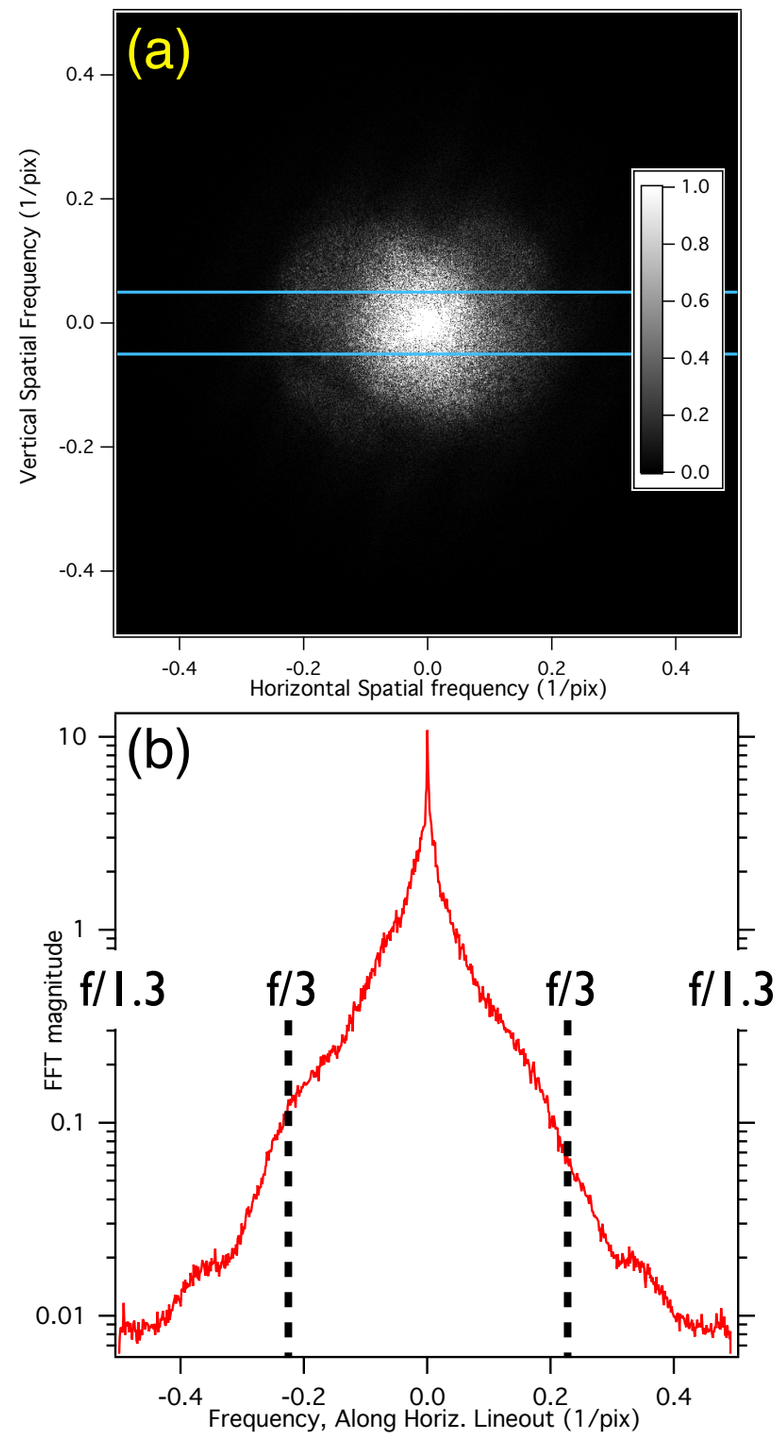
(b)

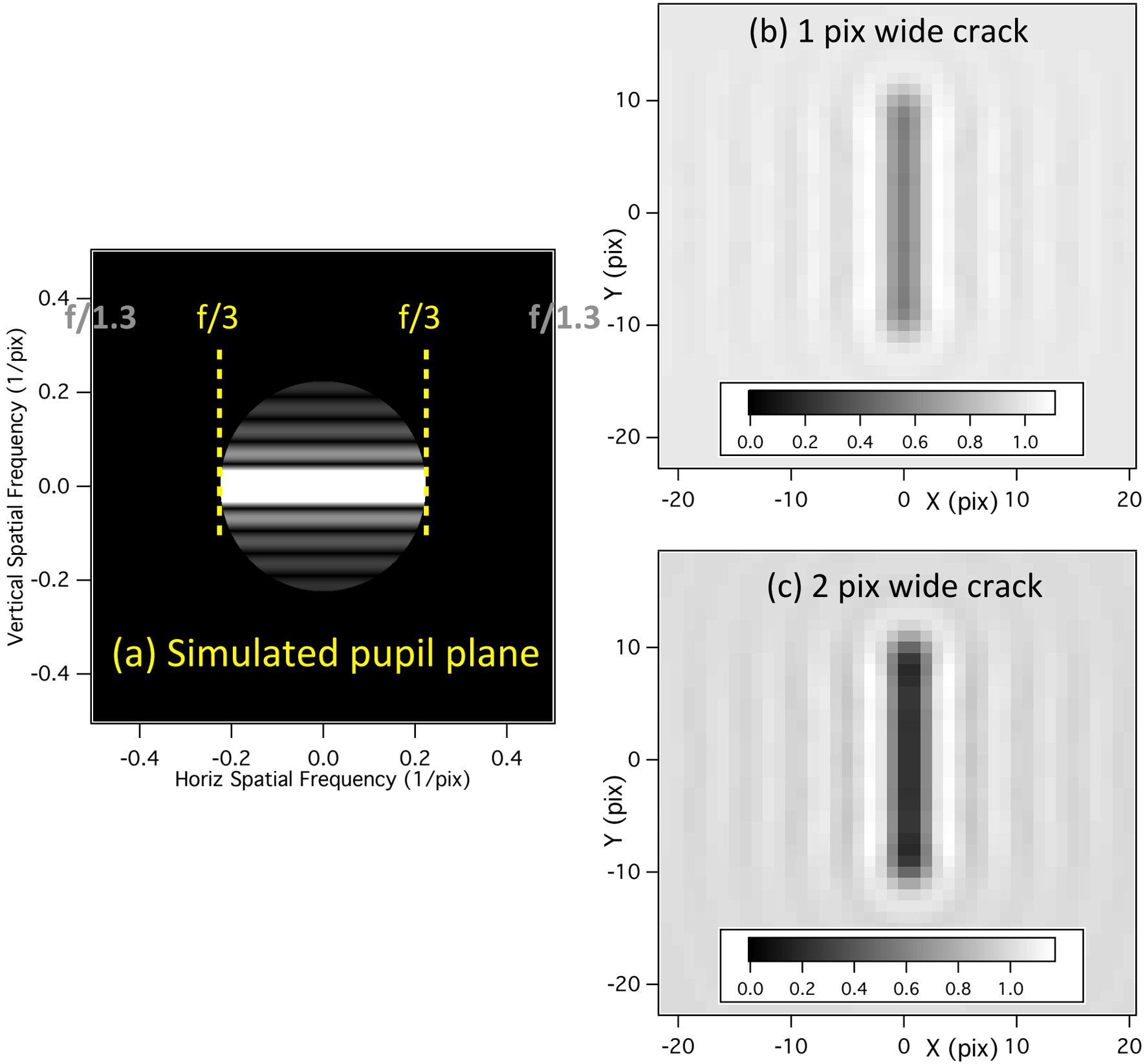



(a)
Fourier
ΔΦ
Parabolic wavefront difference
ΔΦ'
Detector
f
Focus
deFocus
ΔZ = Z_df
Fourier plane
Pupil plane
Focal plane

Refocusing done numerically post-shot



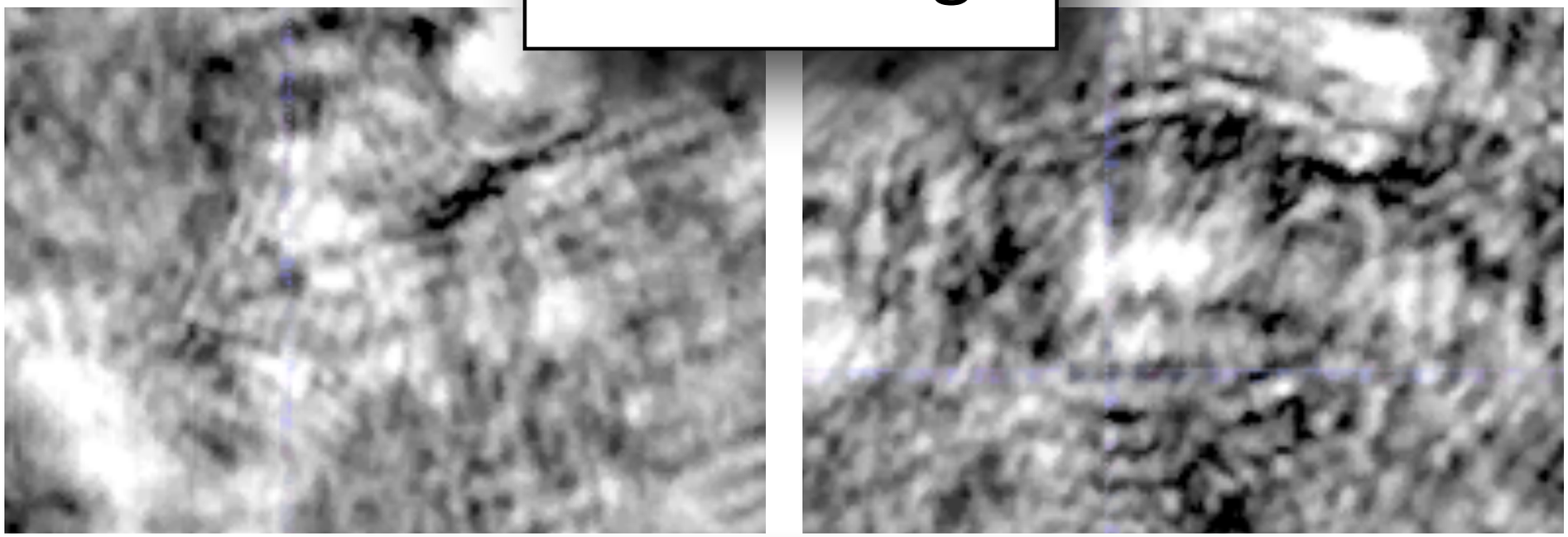

(a)
Vertical Spatial Frequency (1/pix)
Horizontal Spatial frequency (1/pix)
0.4
0.2
0.0
-0.2
-0.4
1.0
0.8
0.6
0.4
0.2
0.0
(b)
FFT magnitude
10
1
0.1
0.01
f/1.3
f/3
f/3
f/1.3
Frequency, Along Horiz. Lineout (1/pix)


f/1.3
f/3
f/3
f/1.3
(a) Simulated pupil plane
Vertical Spatial Frequency (1/pix)
Horiz Spatial Frequency (1/pix)
0.4
0.2
0.0
-0.2
-0.4
(b) 1 pix wide crack
(c) 2 pix wide crack
Y (pix)
X (pix)
10
0
-10
-20
20
0.0
0.2
0.4
0.6
0.8
1.0

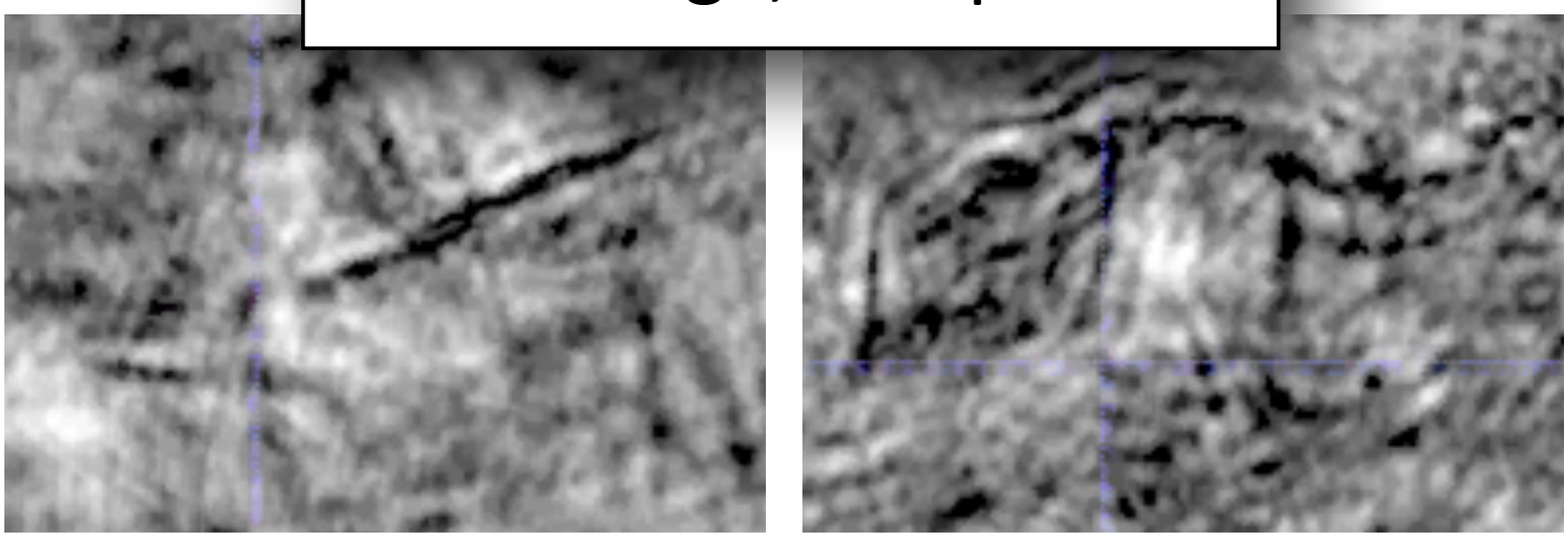
Place J

Ghost image

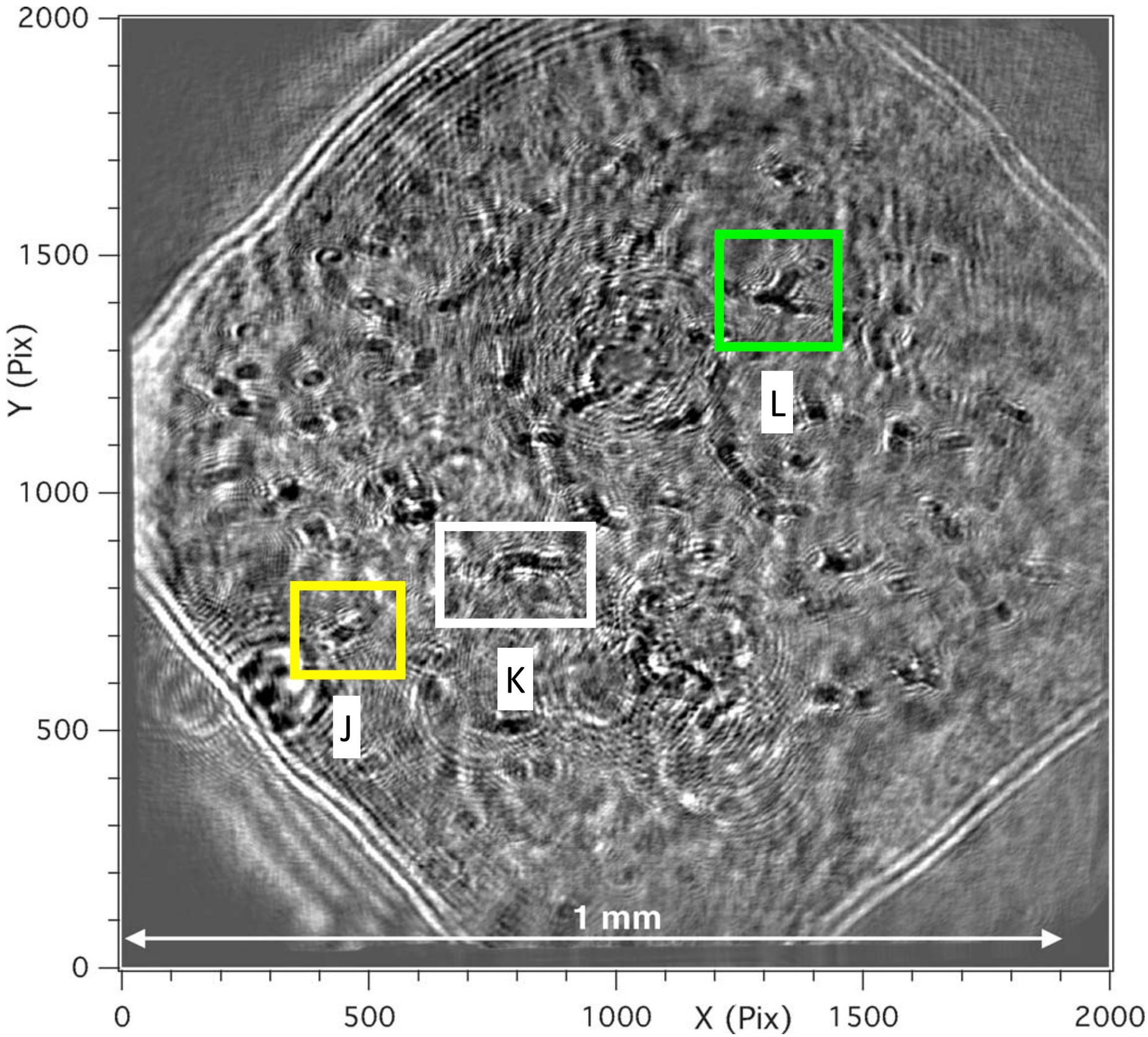
Place K



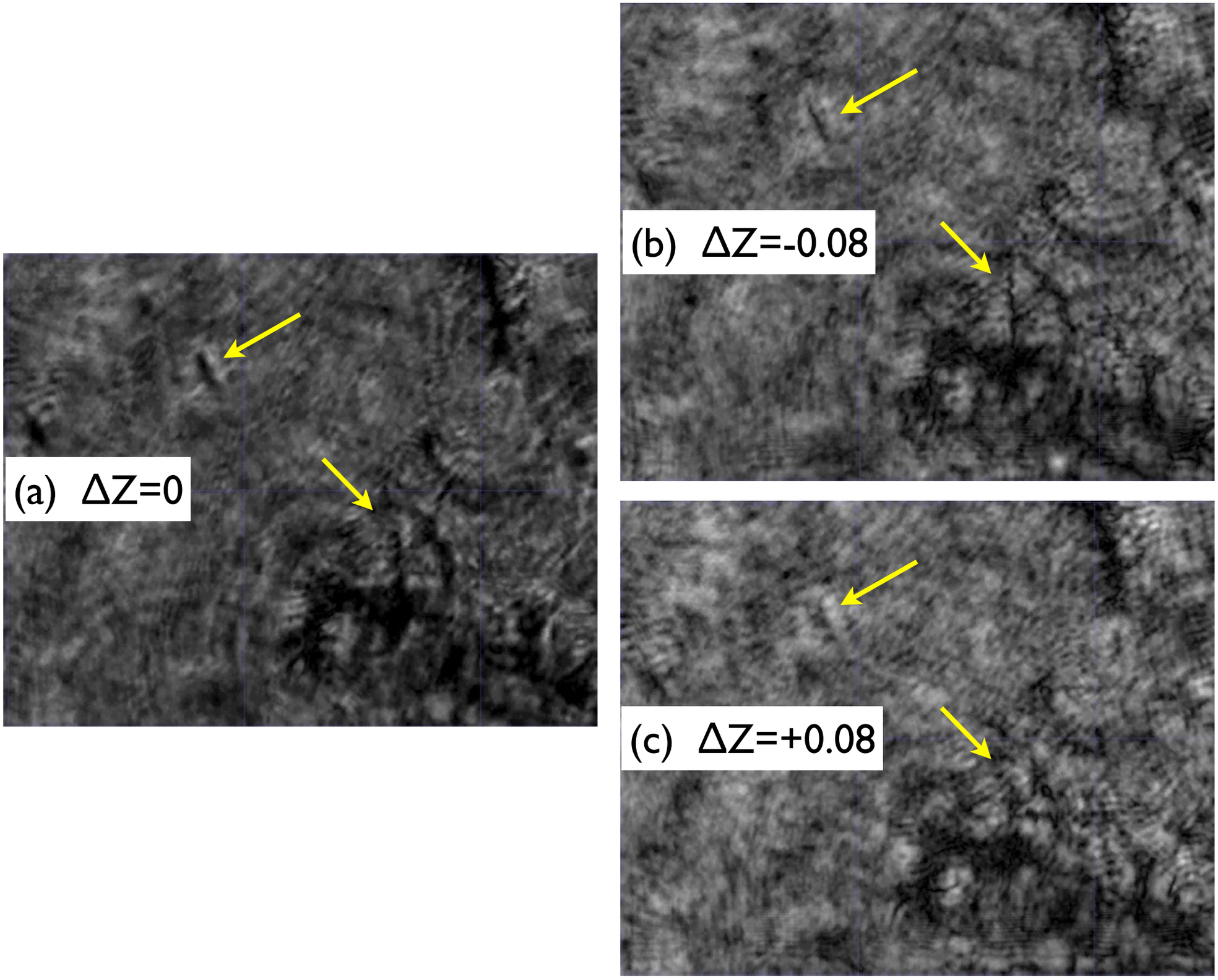
Main image, 268 ps later



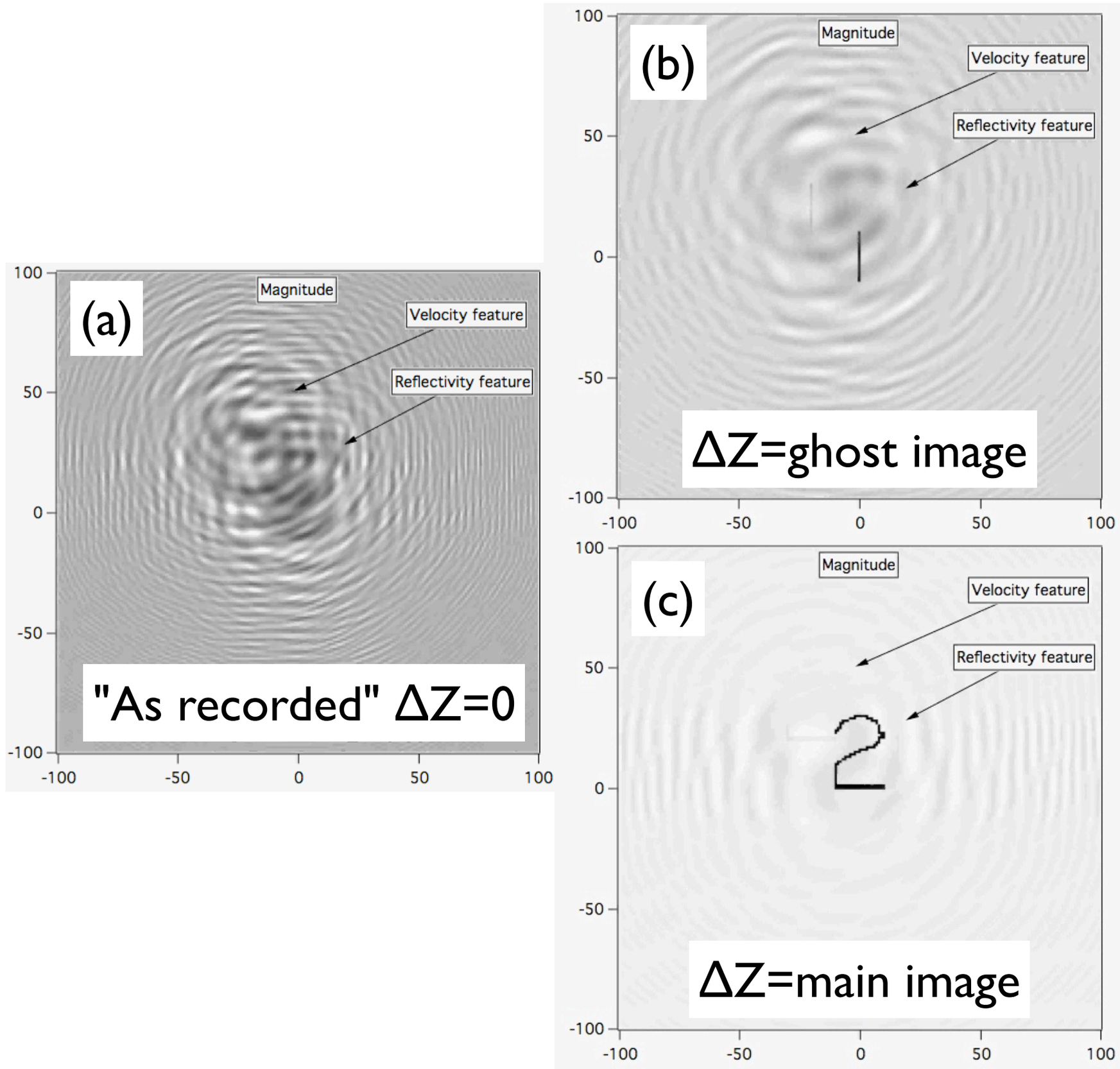
As-taken, accidentally out of focus



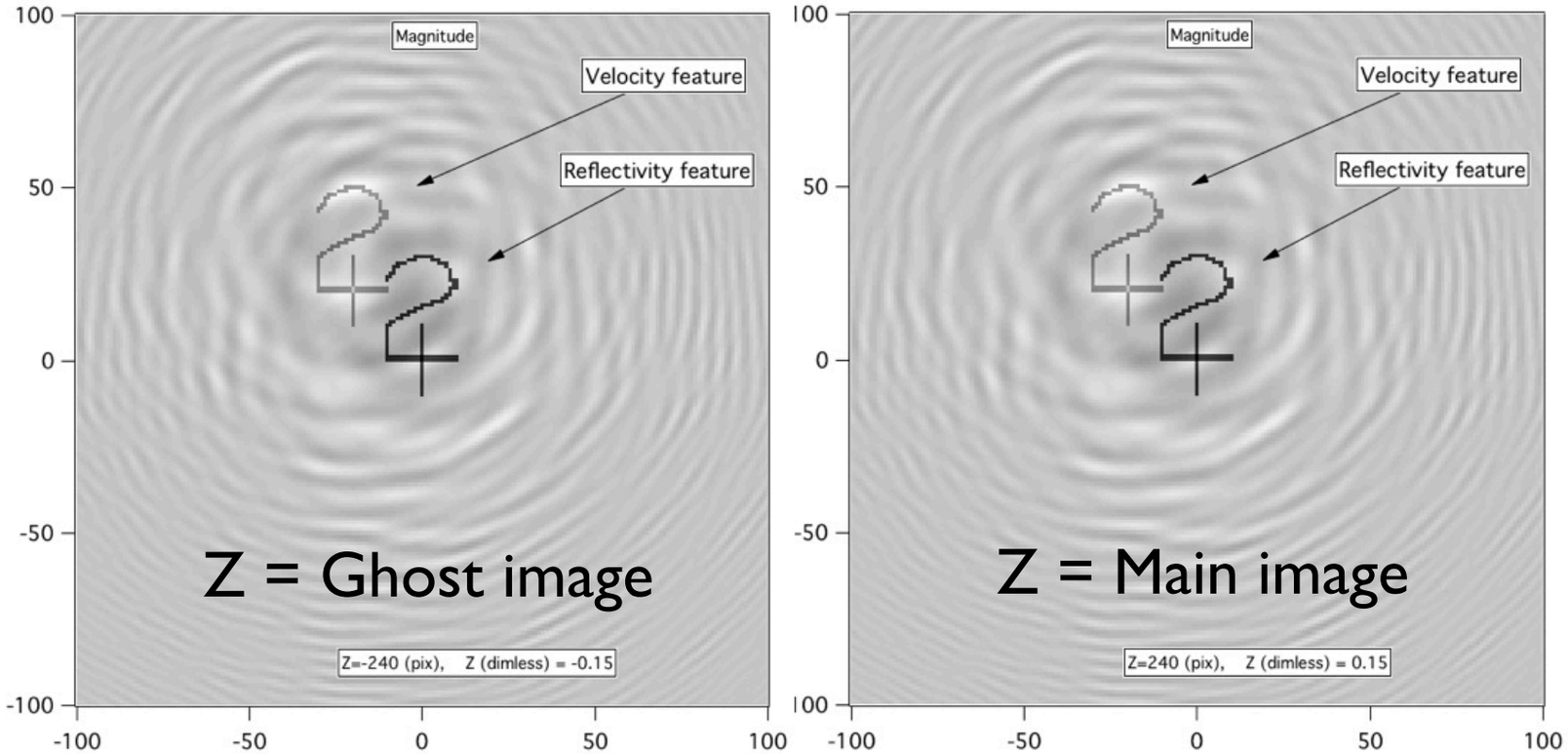
Also seen on another shot, so its not a fluke



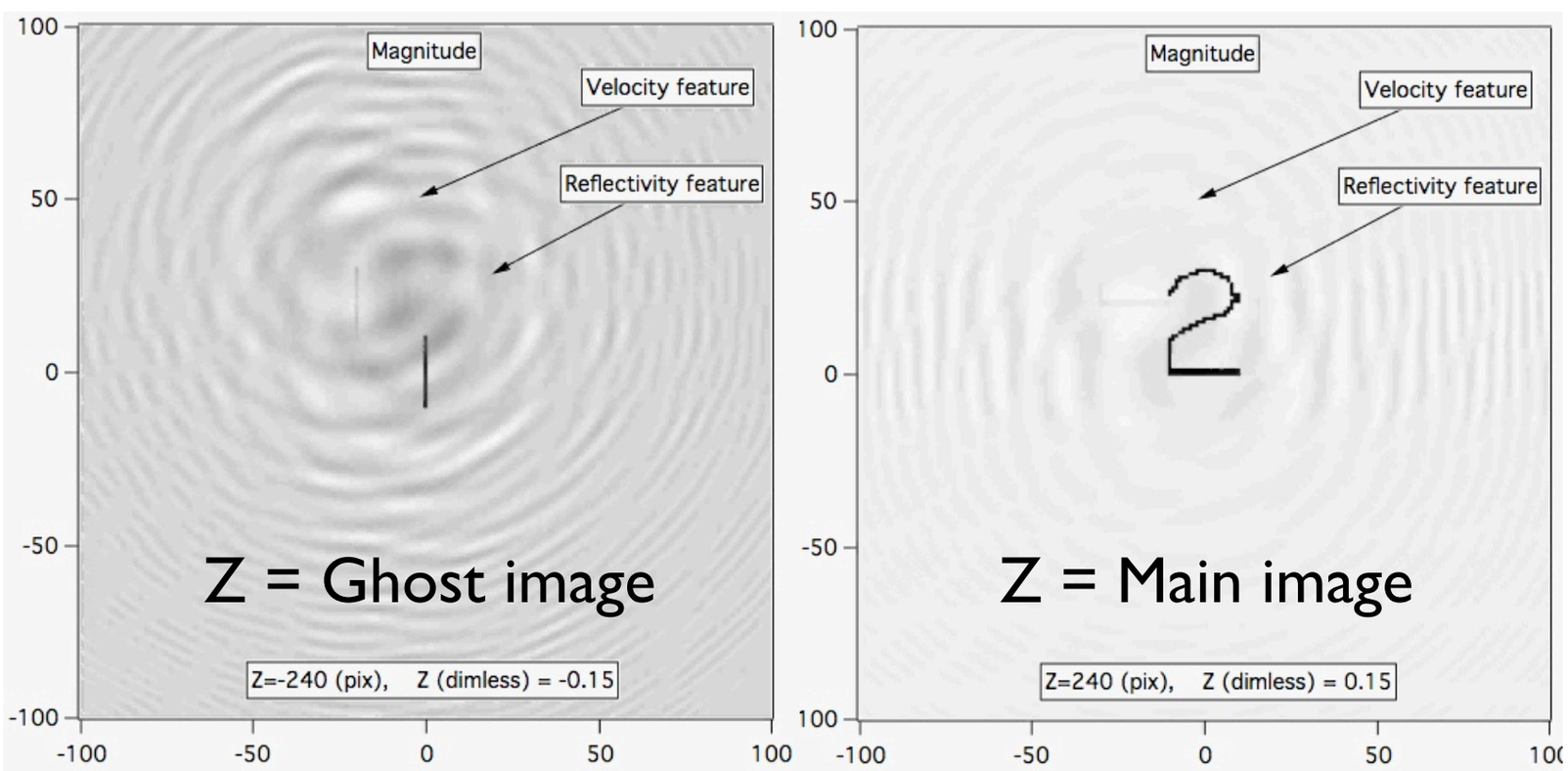
Simulations predict two-frame movie ability



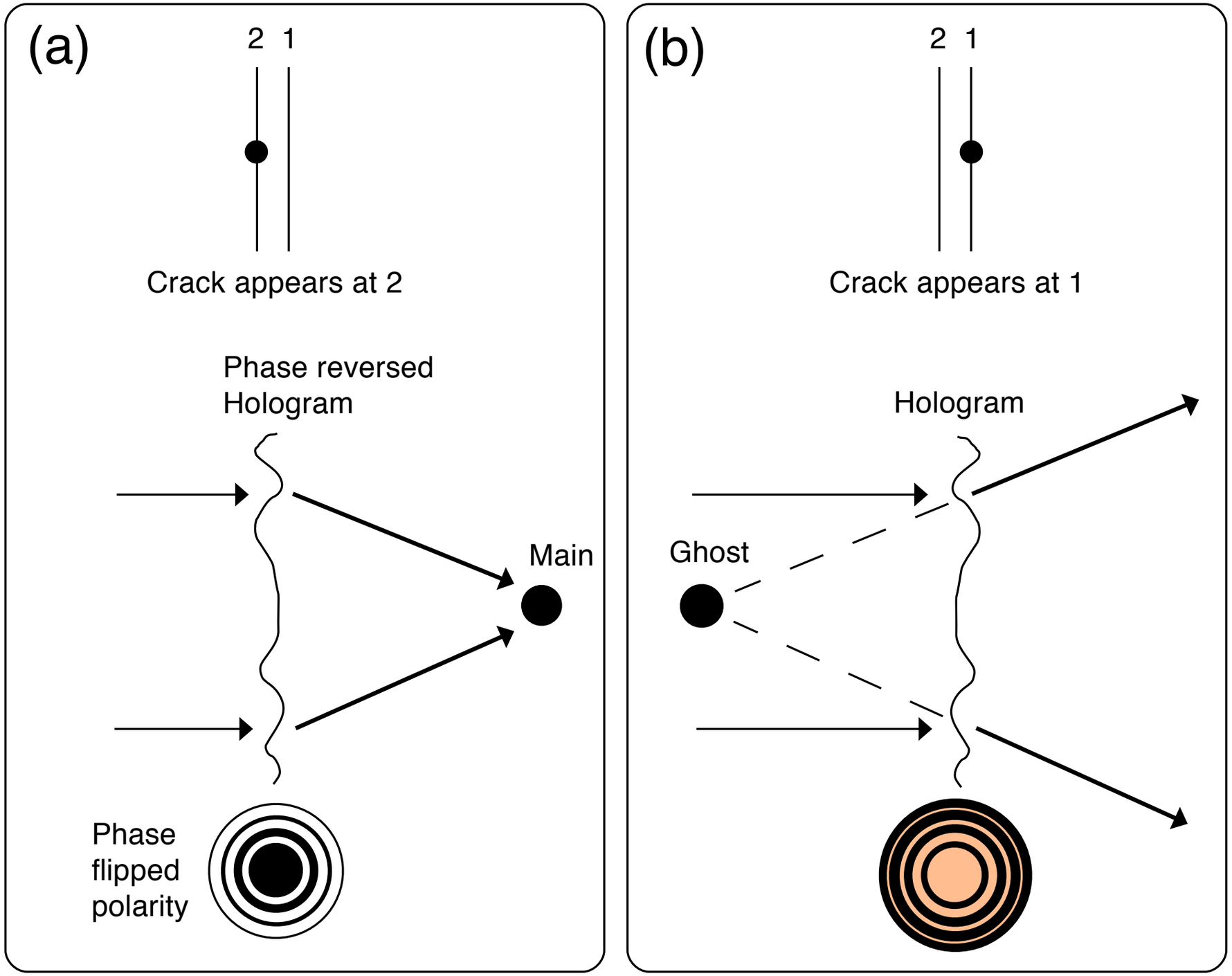
(A) No phase stepping

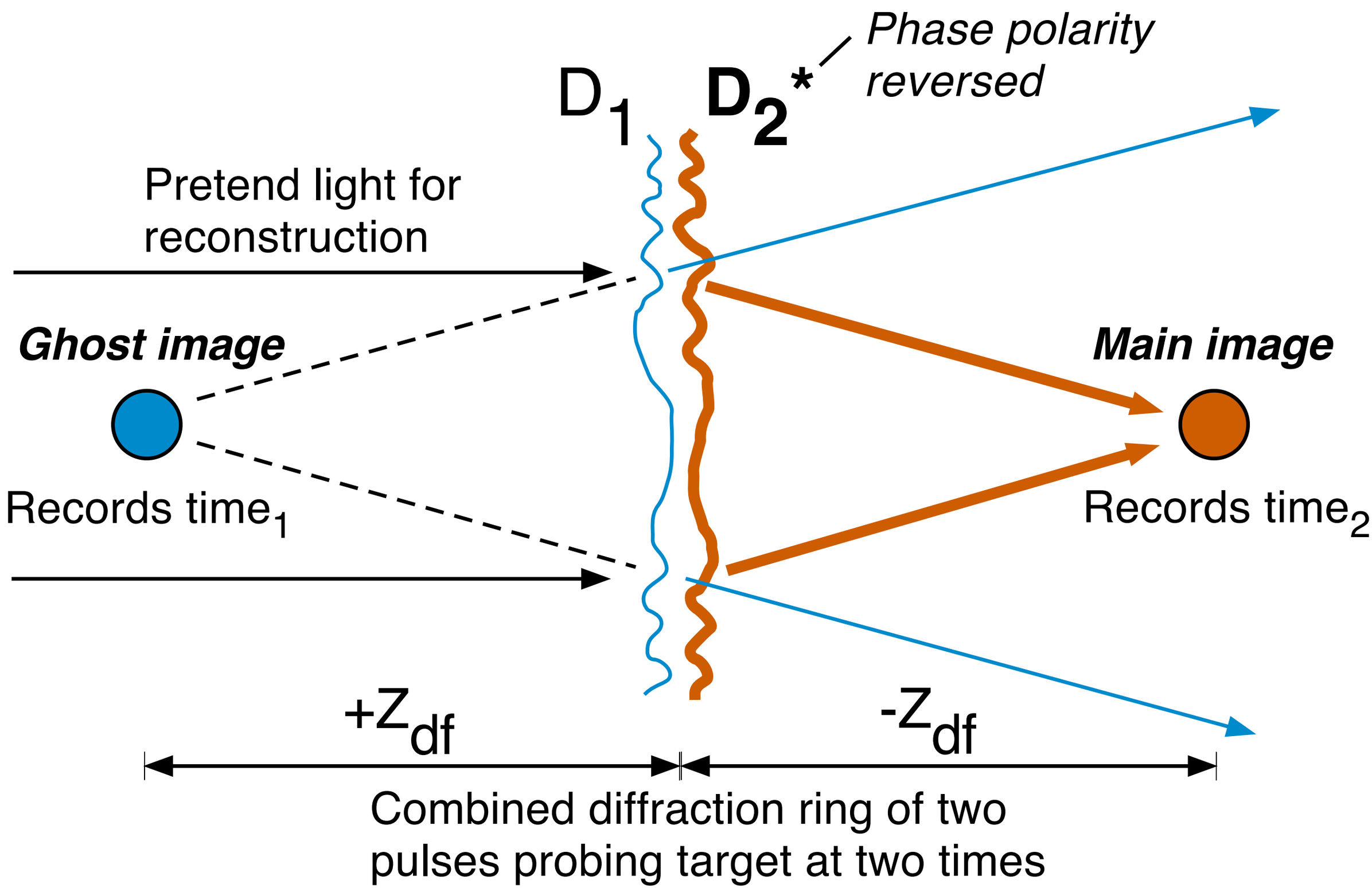


(B) Yes phase stepping



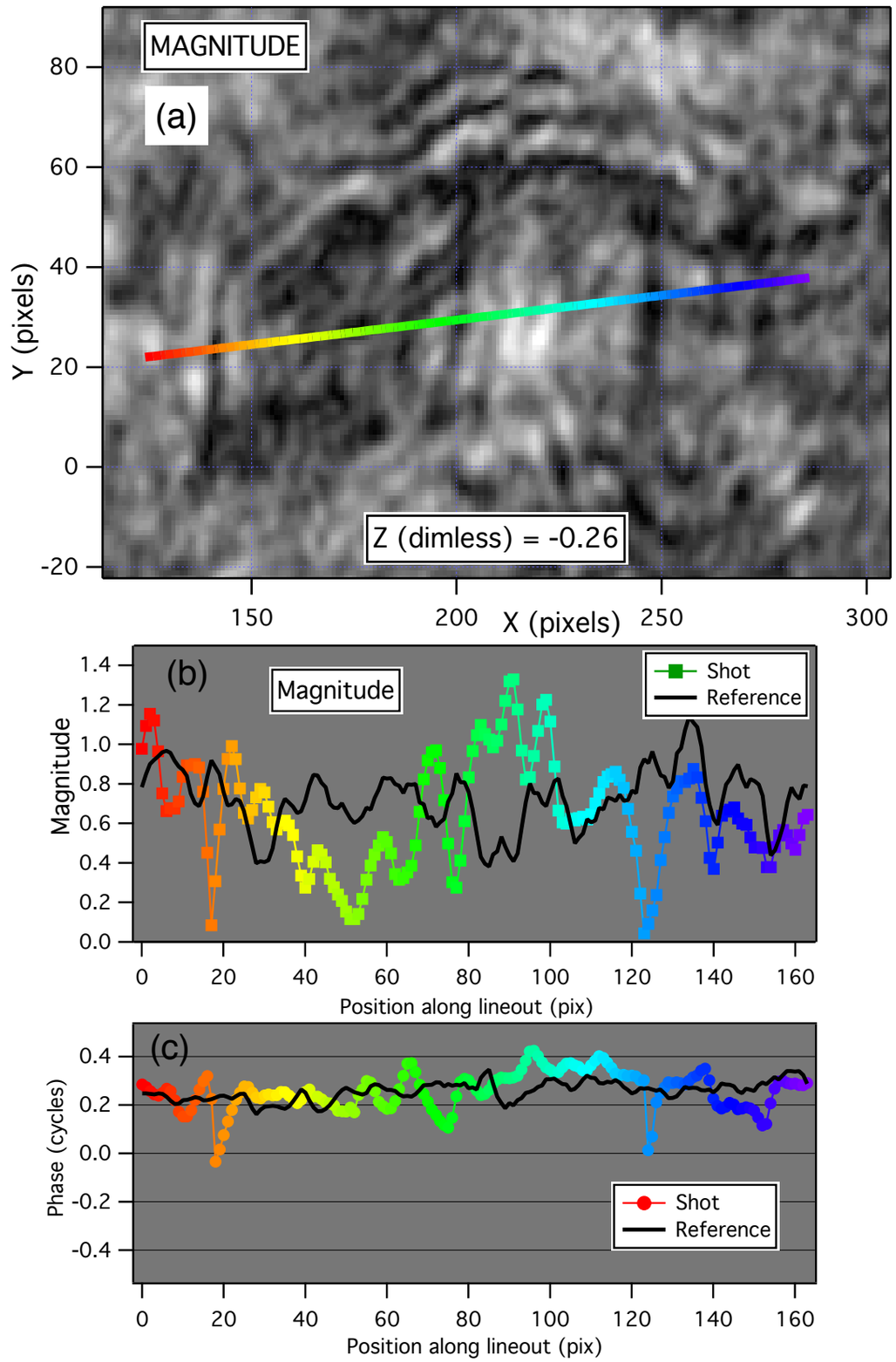
Arrow of time sets polarity of phase in rings

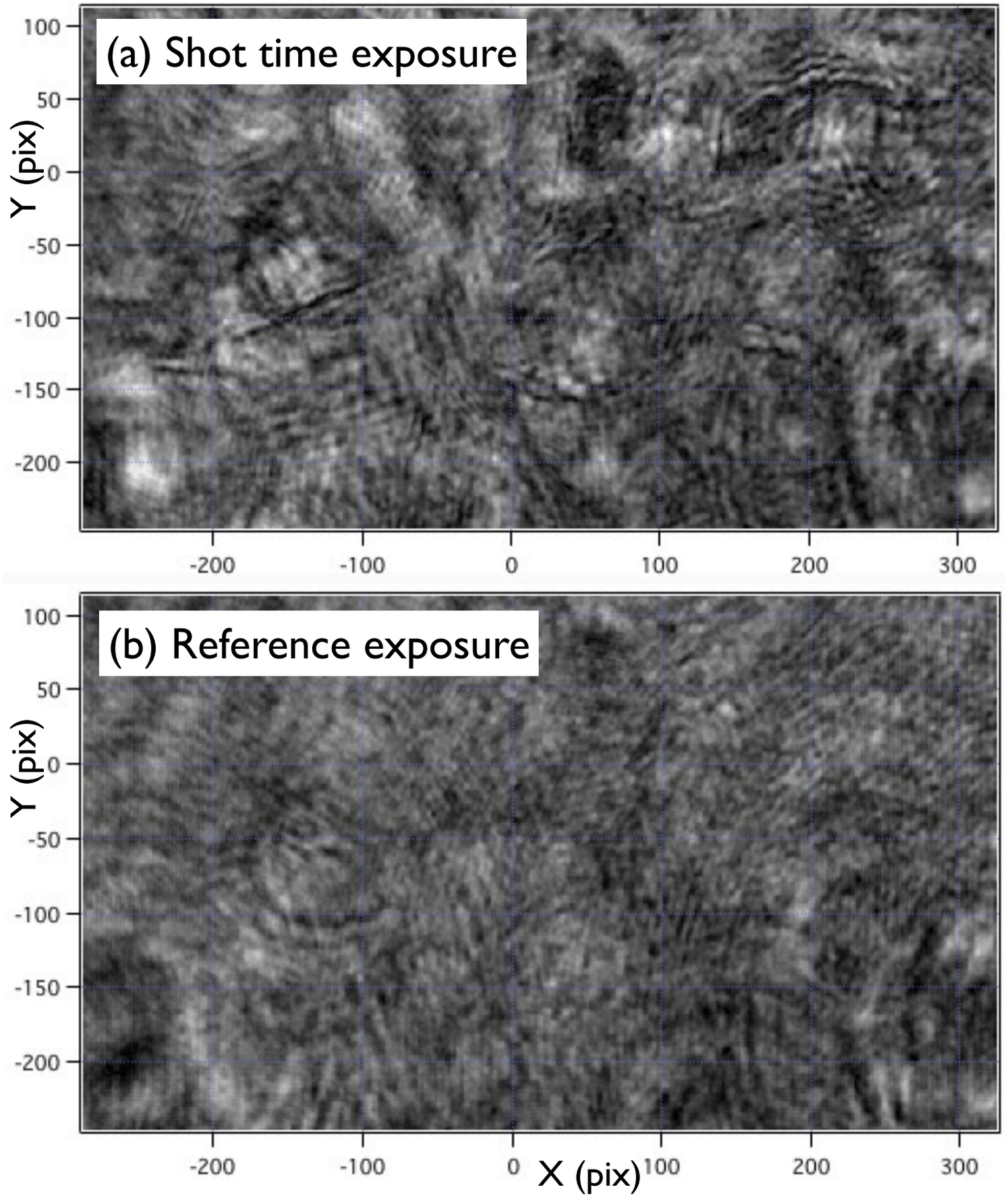


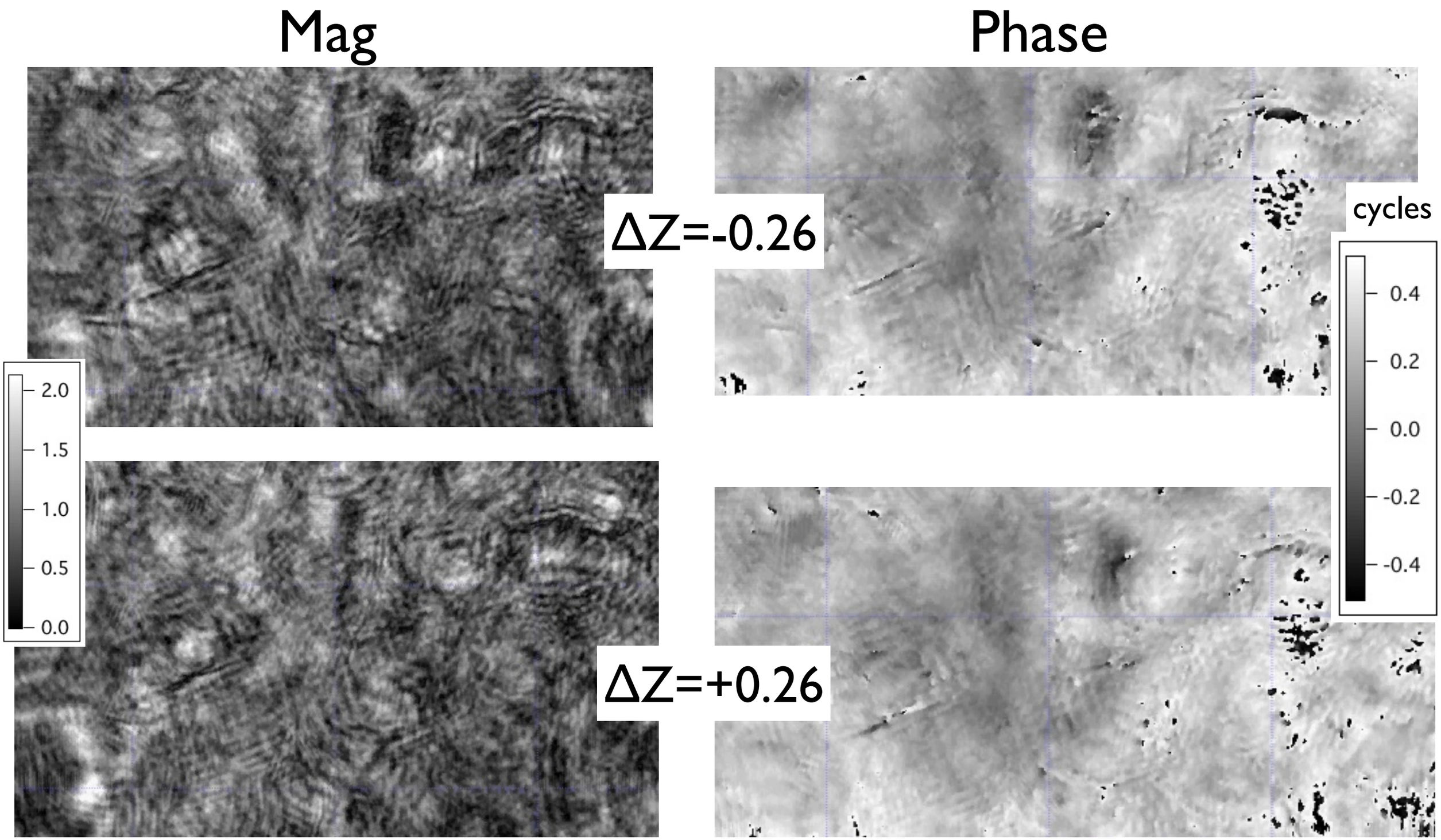

Phase polarity reversed
D1
D2*
Pretend light for reconstruction
Ghost image
Main image
Records time1
Records time2
+Zdf
-Zdf
Combined diffraction ring of two pulses probing target at two times

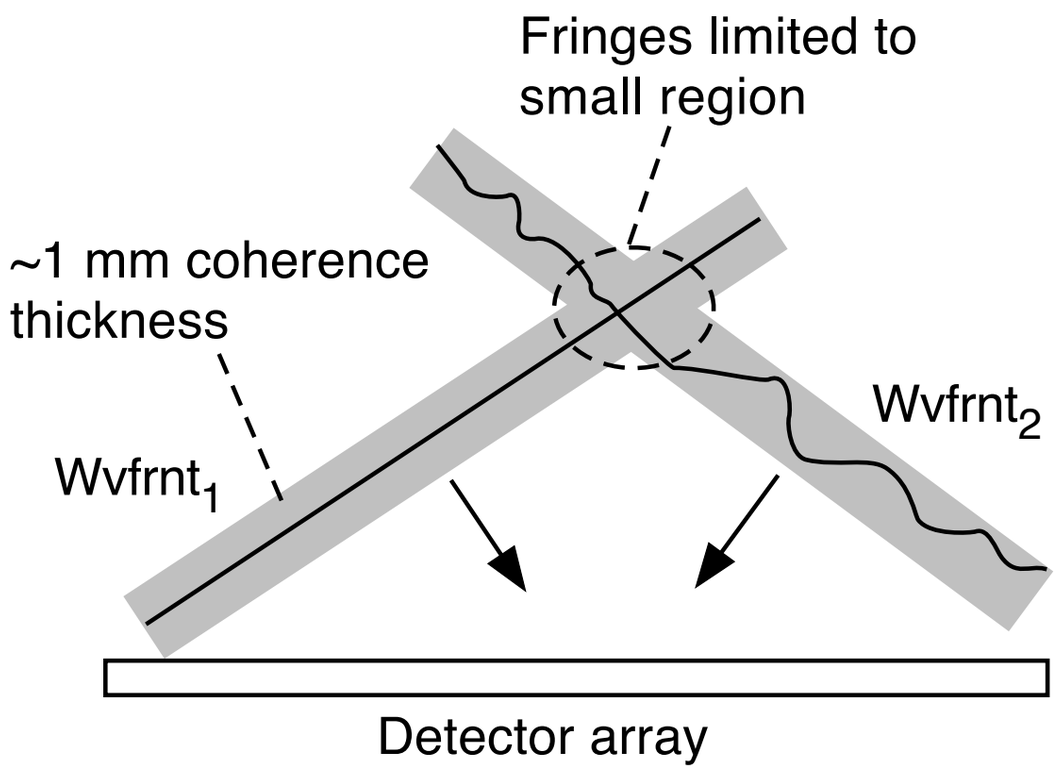
The End

Garage of possible slides could use


MAGNITUDE
(a)
Z (dimless) = -0.26
Y (pixels)
X (pixels)
(b)
Magnitude
Shot
Reference
Position along lineout (pix)
(c)
Phase (cycles)
Shot
Reference
Position along lineout (pix)


(a) Shot time exposure
(b) Reference exposure
Y (pix)
X (pix)
100
50
0
-50
-100
-150
-200
-200
-100
0
100
200
300

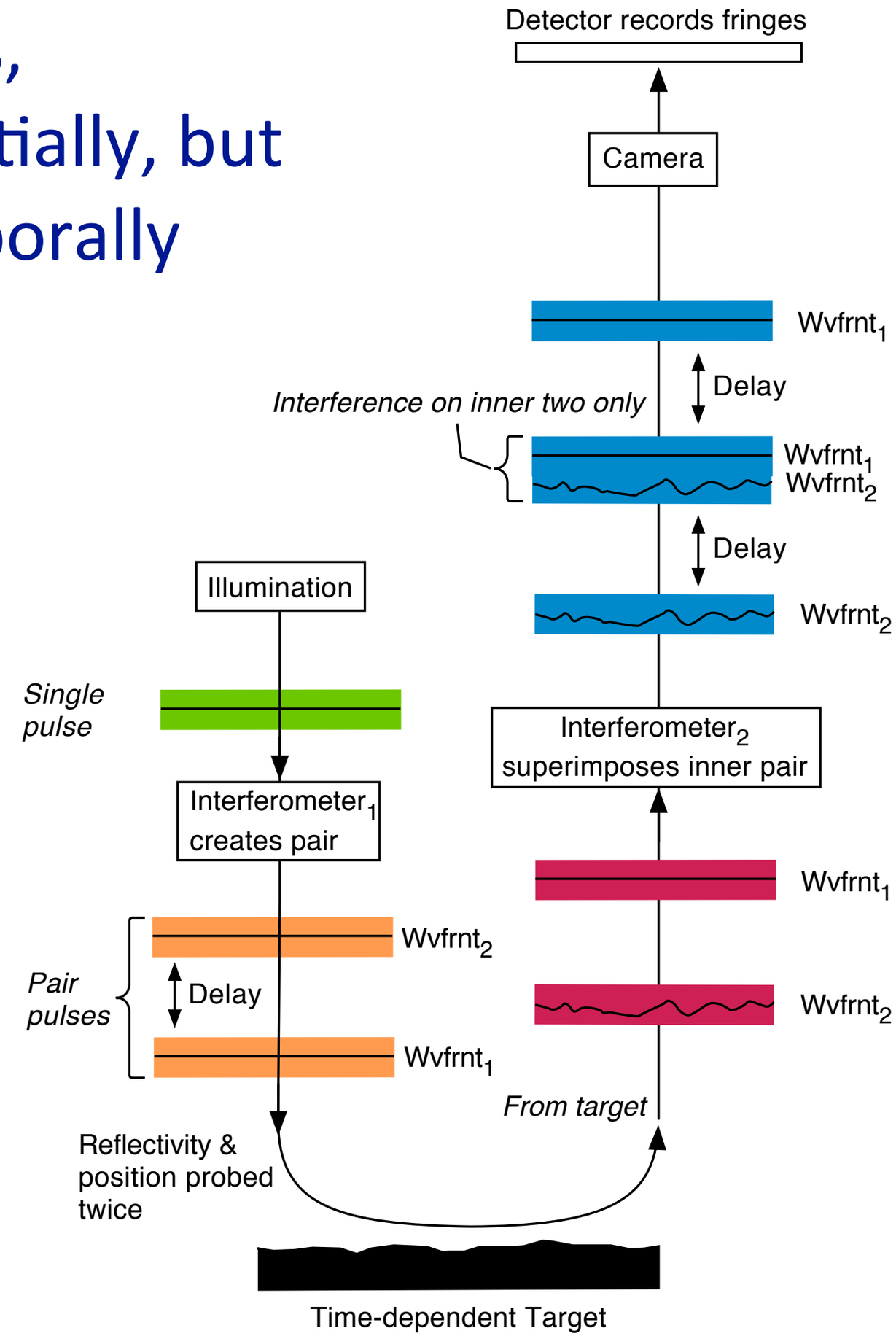

Mag
Phase
ΔZ=-0.26
ΔZ=+0.26
cycles
2.0
1.5
1.0
0.5
0.0
0.4
0.2
0.0
-0.2
-0.4


Fringes limited to
small region
~1 mm coherence
thickness
Wvfrnt$_2$
Wvfrnt$_1$
Detector array

Two wavefronts,
overlapped spatially, but
separated temporally

Fringes result

Time-dependence of target sensed

Velocity

Reflectivity changes