

Passive elastography: a shear wave tomography of the human body

Stefan Catheline

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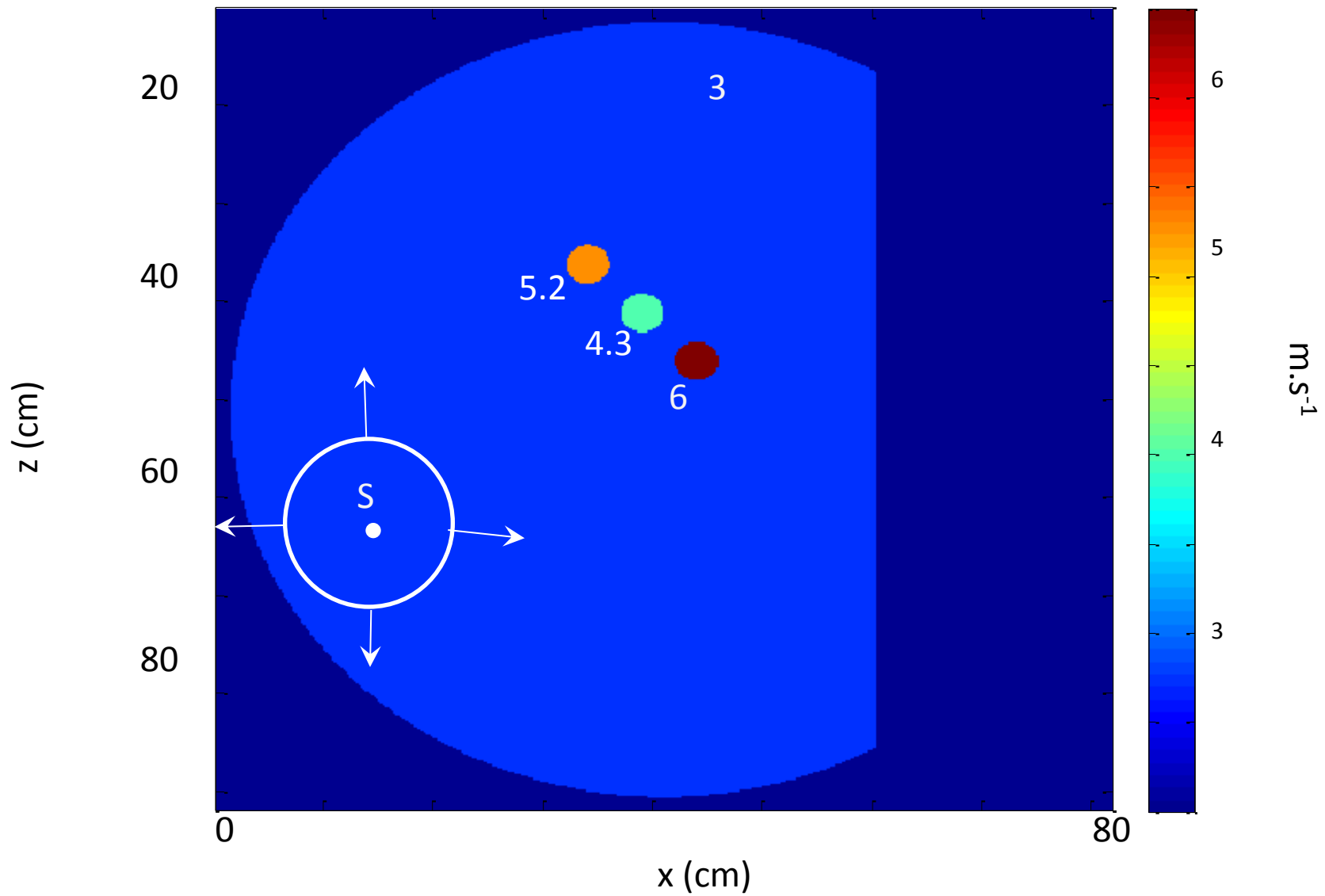
Institut des Sciences de la Terre (Grenoble), M.Campillo

LAU (Montevideo) C.Negreira

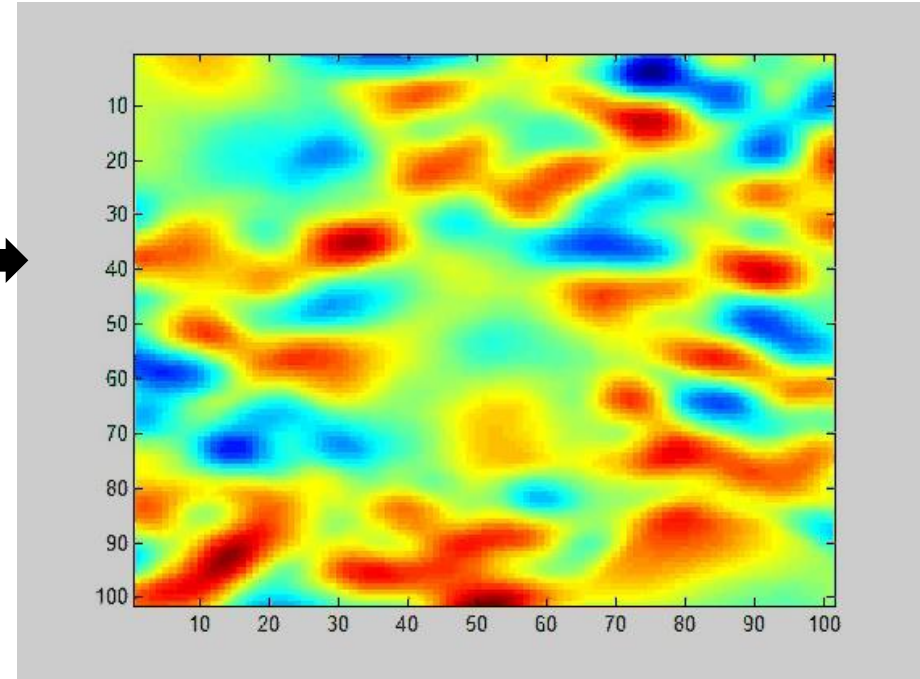
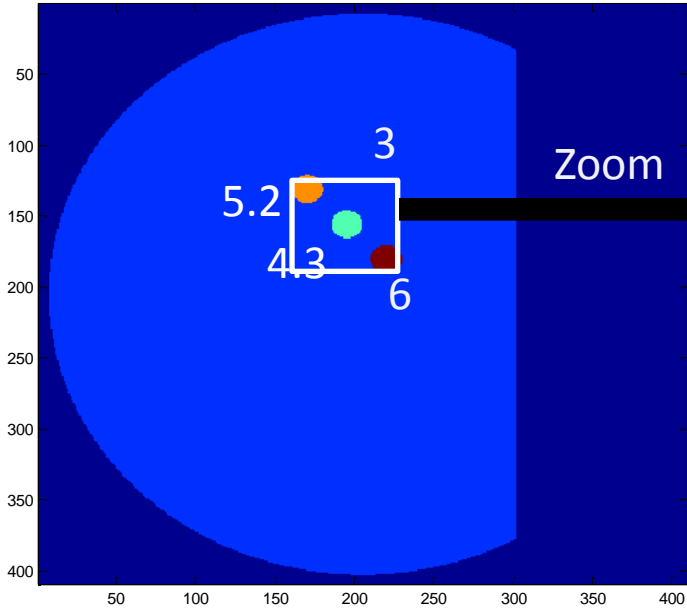
Institut Langevin (Paris) M.Fink

Ultrasound demo

The diffuse field approach: finite difference simulation

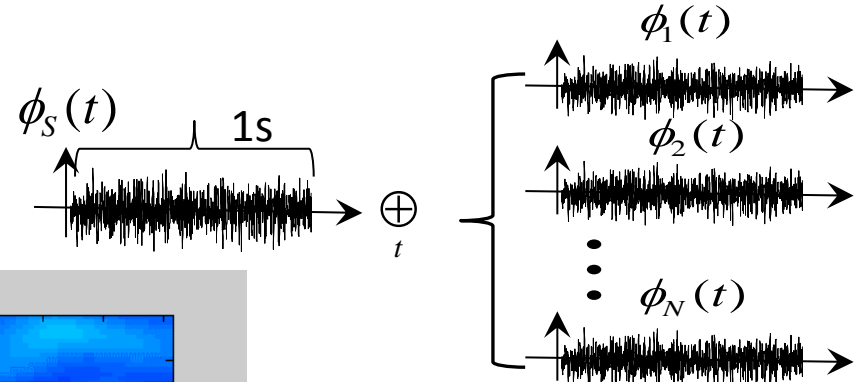
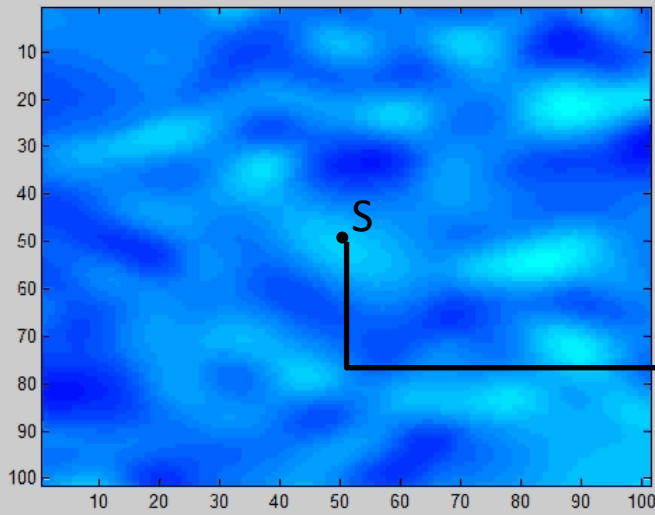


The diffuse field approach

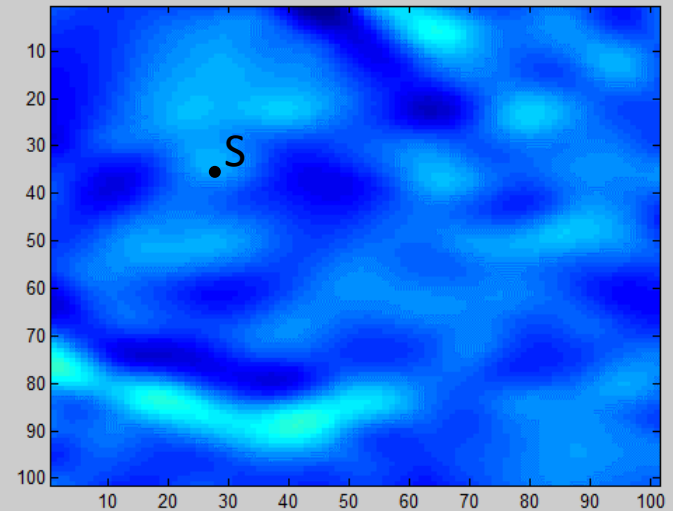
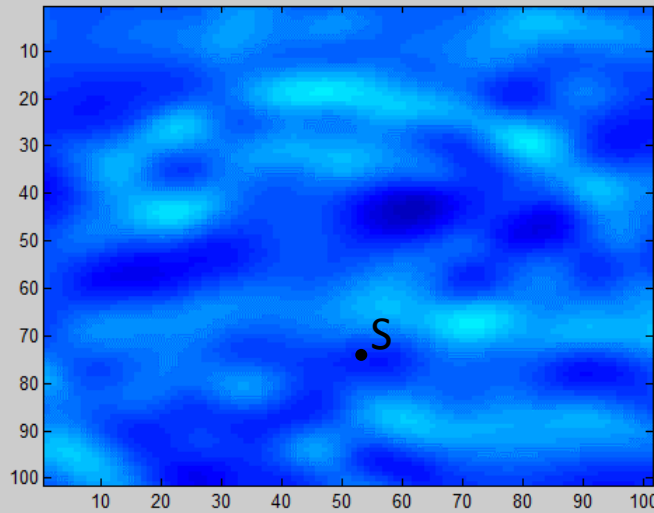


Time reversal/correlation

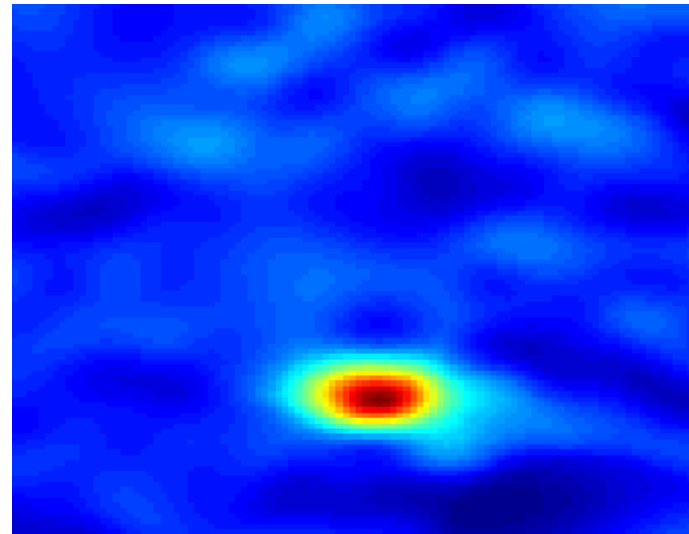
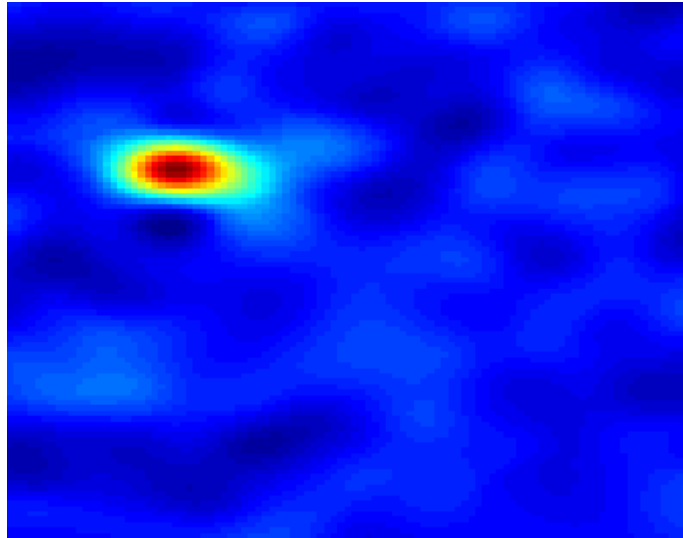
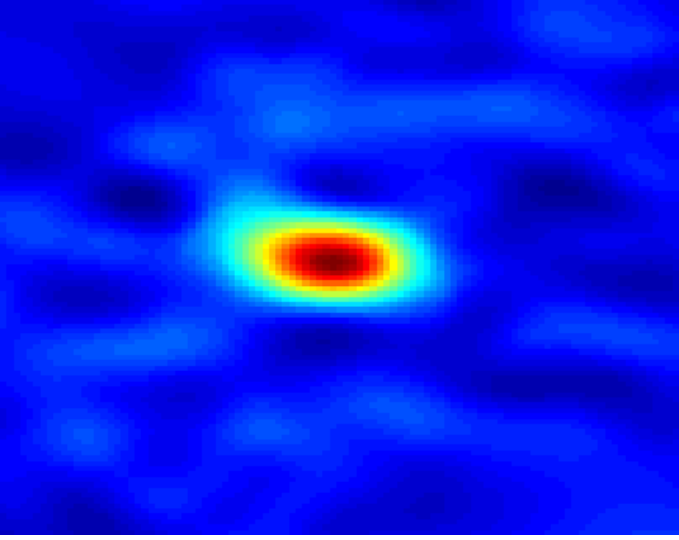
Key for speed extraction=TR
TR=spatio-temporal correlation
(coda wave interferometry)



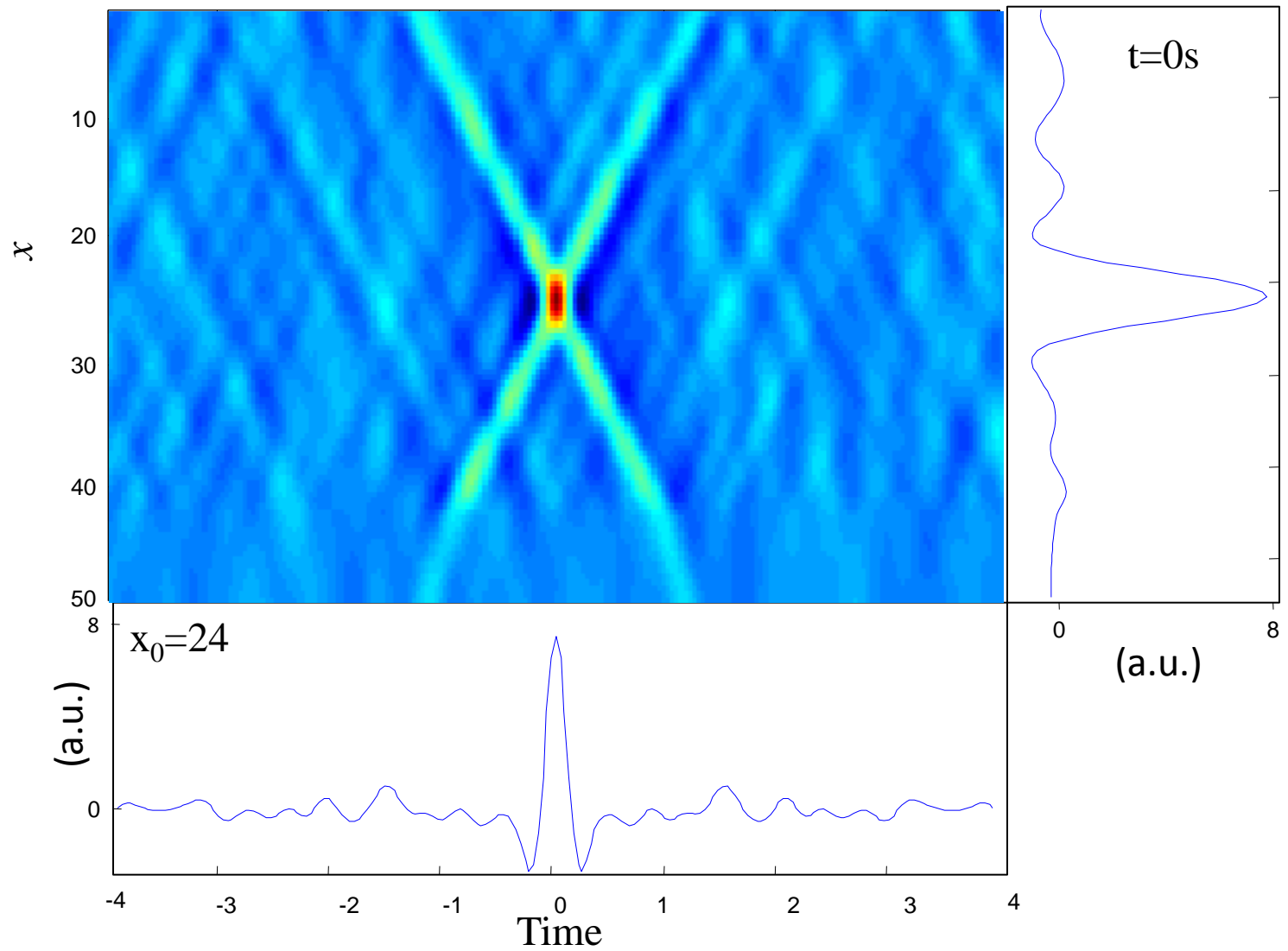
$$\phi_S(t) \otimes_t \phi_i(-t) \propto \psi^{RT}(\vec{r}, t)$$

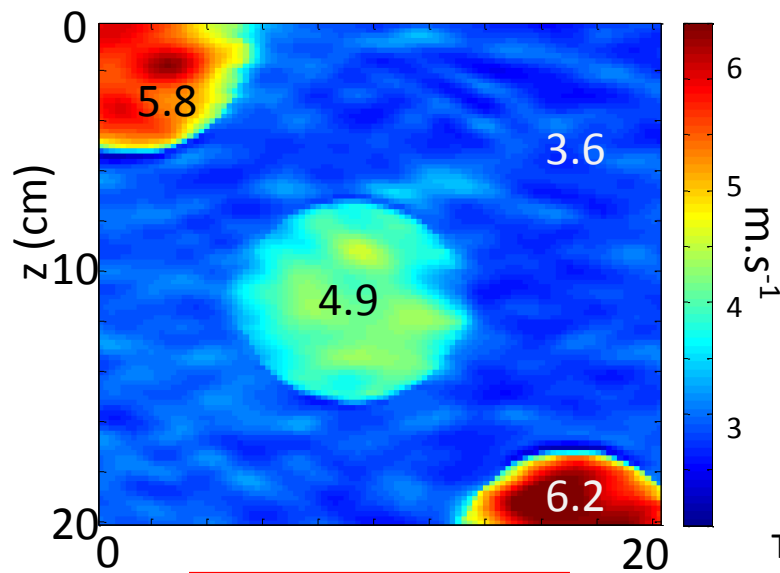
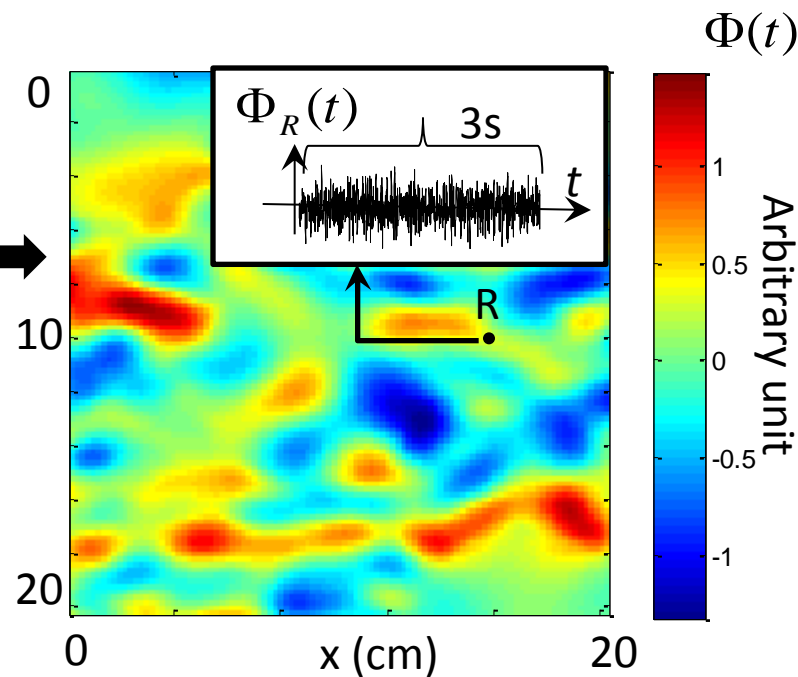
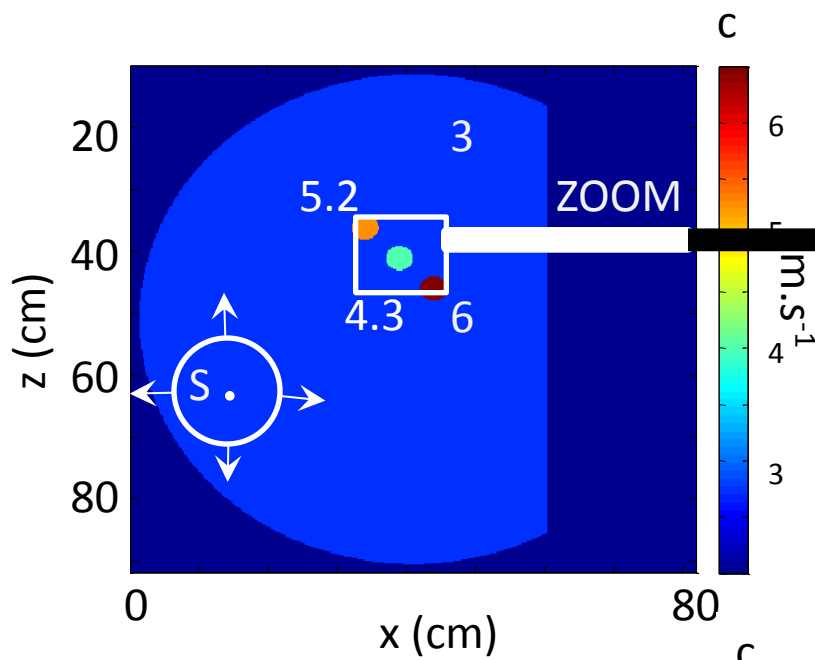


Time reversal focal spot



Over sampling





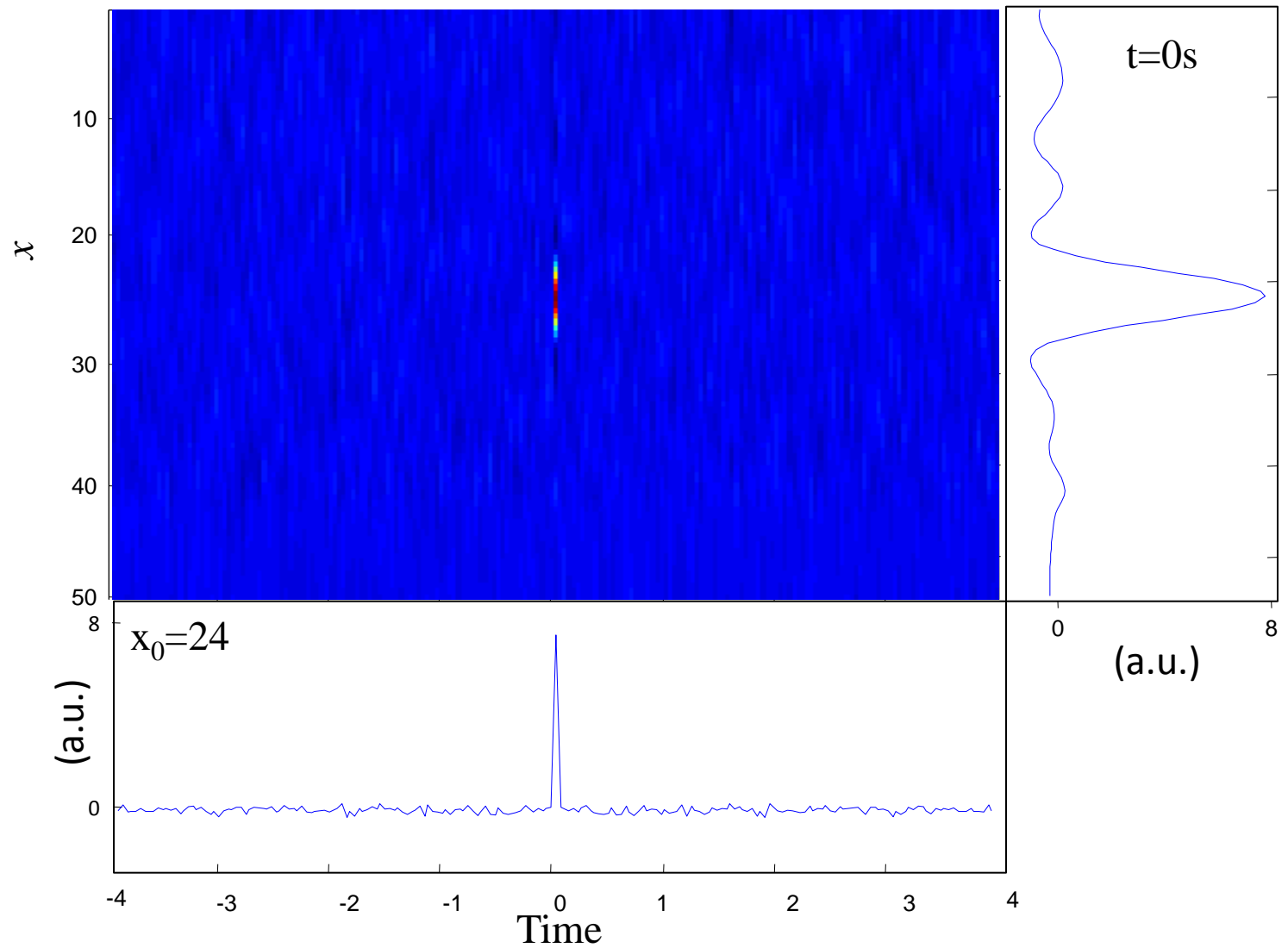
$F_{\text{sampling}} = 1000\text{Hz}$

$F_{\text{sampling}} = 25\text{Hz} ?$

$$c = \frac{\omega}{\text{Re}(k)} = \sqrt{\frac{V^{RT}}{\xi^{RT}}}$$

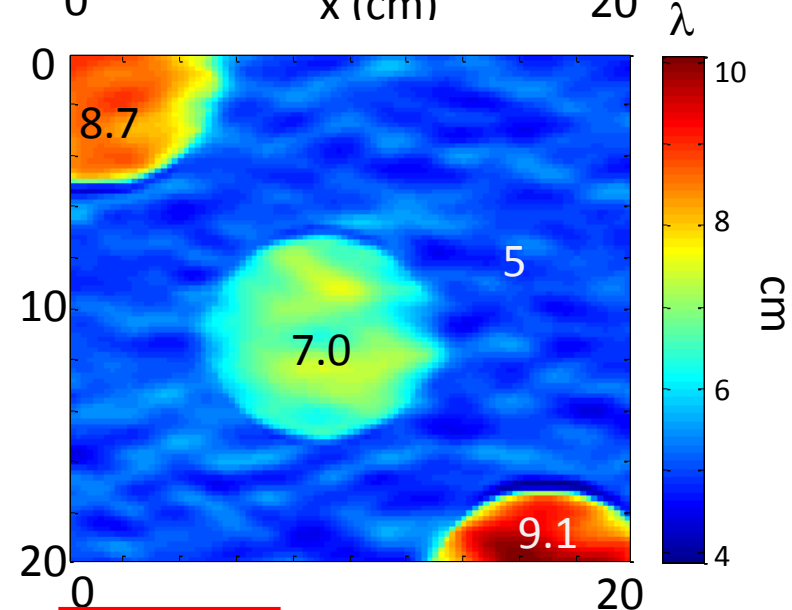
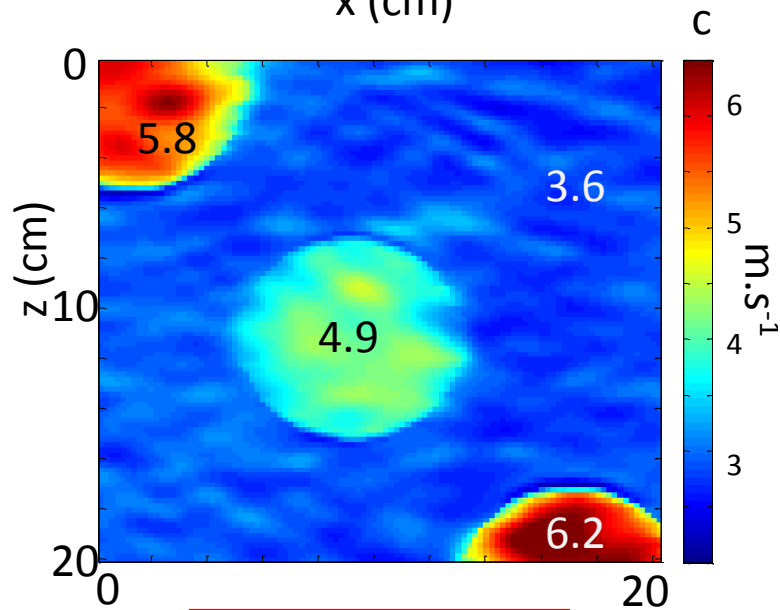
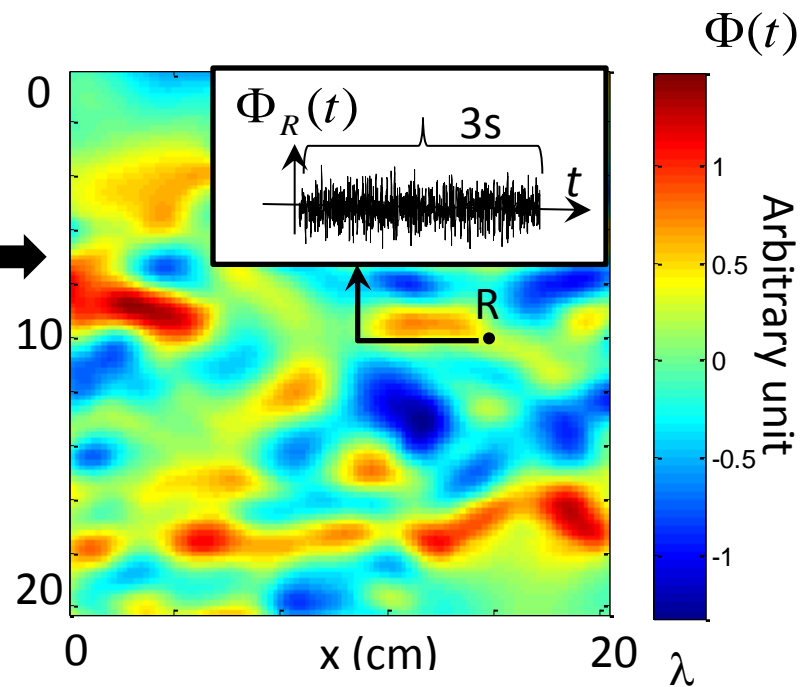
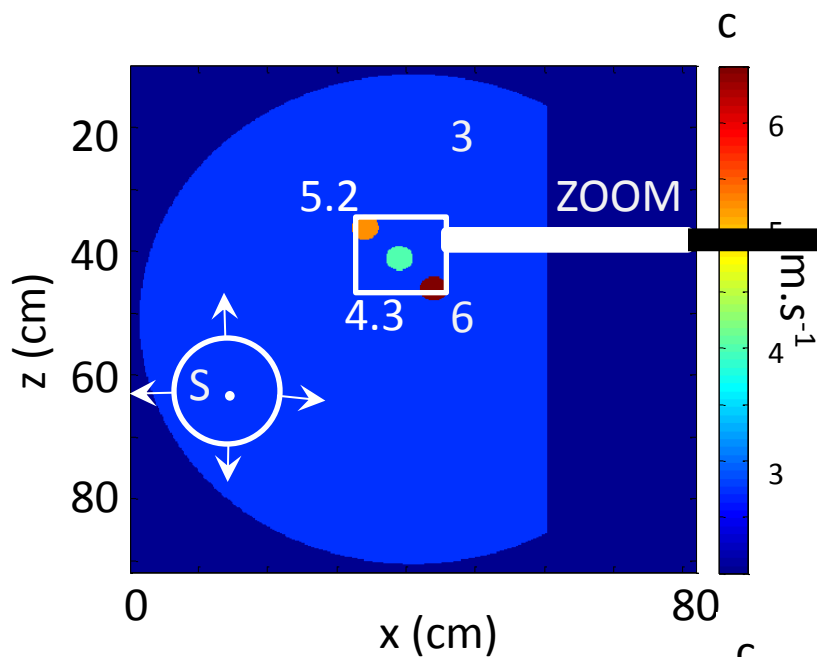
T.Gallot, S. Catheline, P. Roux, J. Brum, N. Benech, C. Negreira
 Passive elastography: Shear wave tomography from
 physiological noise correlation in soft tissues
 IEEE Transactions on UFFC, vol. 58, no. 6, June 2011.

Under sampling



$$C(\vec{r}_0, \vec{r}; 0) = \int_0^T \psi_z(\vec{r}_0, \tau) \cdot \psi_z(\vec{r}, \tau) d\tau.$$

$$C_\phi(\vec{r}_0, \vec{r}; 0) = \int_0^T \psi_z(\vec{r}_0, \phi(\tau)) \cdot \psi_z(\vec{r}, \phi(\tau)) d\tau.$$

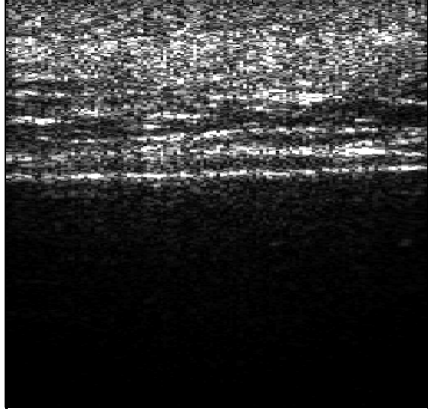


$$c = \frac{\omega}{\text{Re}(k)} = \sqrt{\frac{V^{RT}}{\xi^{RT}}}$$

$$k = \sqrt{\frac{\xi^{RT}}{\psi^{RT}}}$$

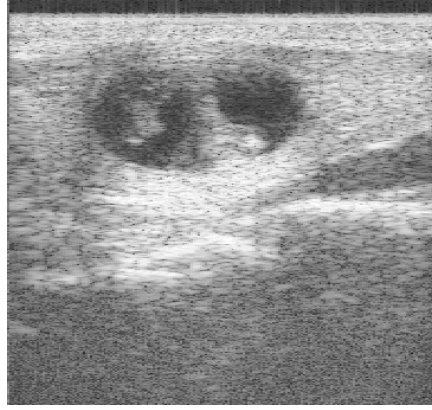
Ultrafast Ultrasounds

In vivo Human Liver



Ultralow Ultrasounds

In vivo human thyroid



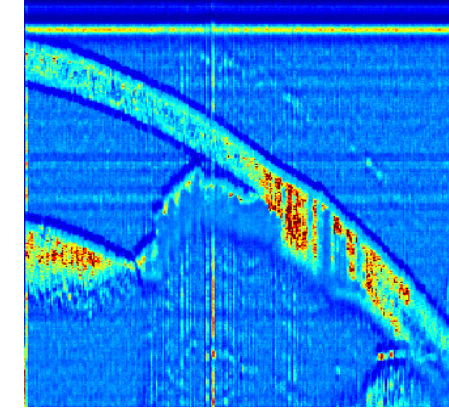
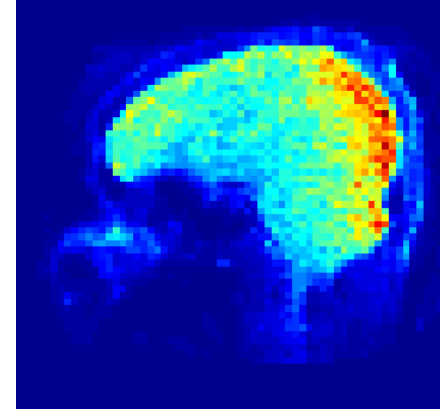
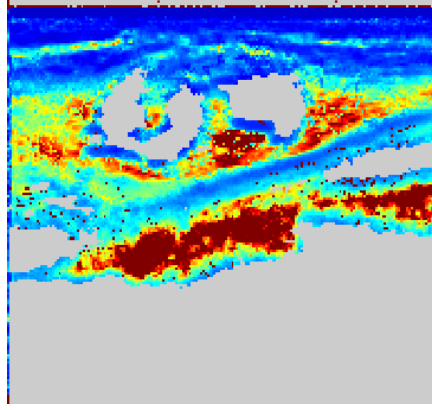
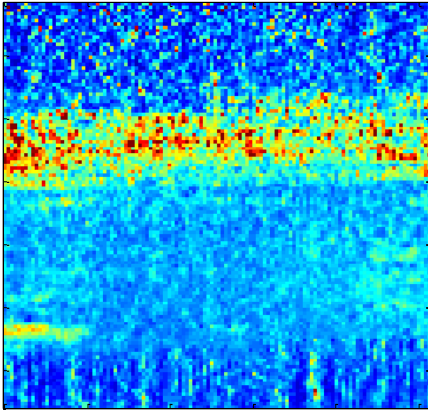
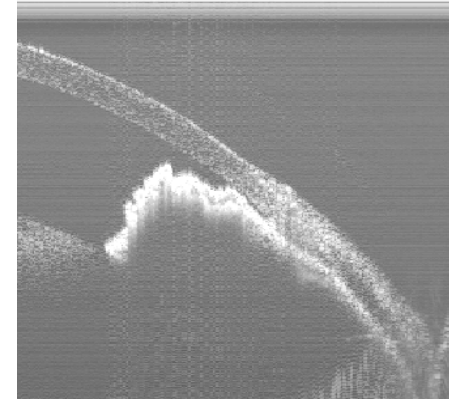
MRI

In vivo human brain



Optical Coherent Tomog.

In vivo rat cornea



T.Gallot, S. Catheline, P. Roux, J. Brum, N. Benech, C. Negreira, IEEE Transactions on UFFC, 58, 6 (2011).

A. Zorgani, C. Zemzemi, L. Daunizeau, S. Belabhar, R. Souchon, S. Catheline, submitted JASA (2017).

S. Catheline, R. Souchon, M. Rupin, J. Brum, A. H. Dinh, J-Y Chapelon
Appl. Phys. Lett. 103, 014101 (2013)

A. Zorgani, R. Souchon, A. Hoang-Dinh, J-Y Chapelon, J-M Ménager, S. Lounis, O. Rouvière, and S. Catheline
PNAS, **112** (42) 12917-12921, (2015).

T.M Nguyen, A.Nahas, A.Zorgani, S. Catheline, C. Boccara, M. Fink
J. Biomed. Optics, **21**(12), 126013 (2016).