



## Méthodes d'examen des tissus biologiques en lumière polarisée

Anabela Da Silva  
[anabela.dasilva@fresnel.fr](mailto:anabela.dasilva@fresnel.fr)

# DiMABio

Responsable: Carole Deumié

## Permanents

- Anabela Da Silva (CR CNRS)
- Carole DEUMIE (PR ECM)
- Gaëlle GEORGES (MCF – ECM)
- Laure SIOZADE (MCF – AMU)



## Doctorants

- Susmita SRIDHAR (Erasmus Mundus)



## IR CDD

- Charles HANDSCHIN (SATT-SE)
- Christophe RIEDINGER (SATT-SE)
- Laurent ESTEVE (AMIDEX)



# Méthodes de Sondages optiques multi-échelle

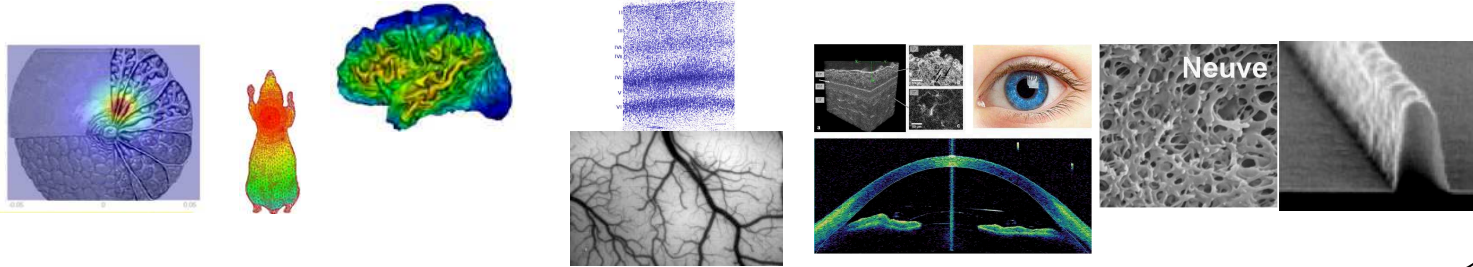
Macroscopique [cm]

Mésoscopique [mm]

Microscopique [ $\mu\text{m}$ ]



Applications

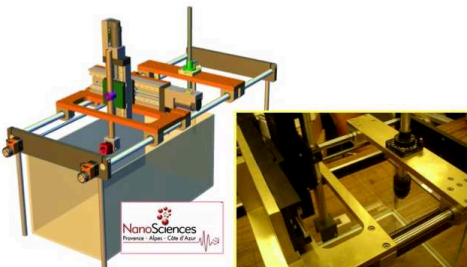


Partenaires



Techniques instrumentales

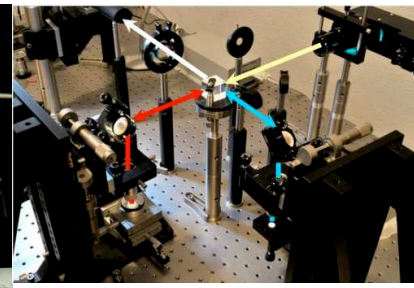
DOT. Tomographie photoacoustique



Imagerie de polarisation



OCT

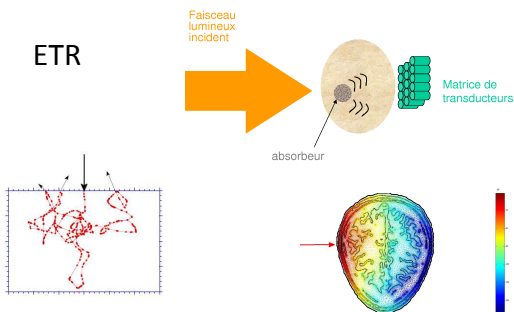


Diffusomètre  
Ellipsomètre

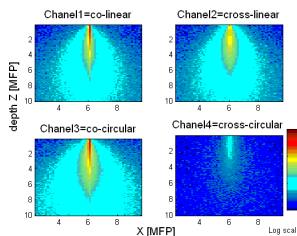


Théorie

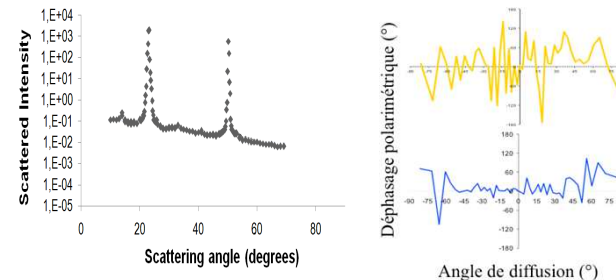
ETR



ETRV, Eq. Maxwell



Equations de Maxwell



Financements



# Examen des tissus biologiques en lumière polarisée

Interaction lumière polarisée/tissu

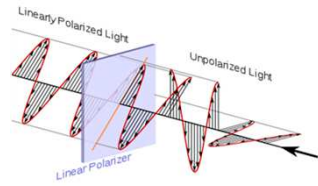
Applications en clinique

Imagerie sub-surfacique résolue en profondeur



# Polarisation

Un mécanisme de filtrage



Sans filtre polarisant



Avec filtre polarisant



Ciel plus bleu

Eau plus transparente

<https://www.polarization.com/water/water.html>

forum.nikonpassion.com

# Interaction lumière polarisée/tissu

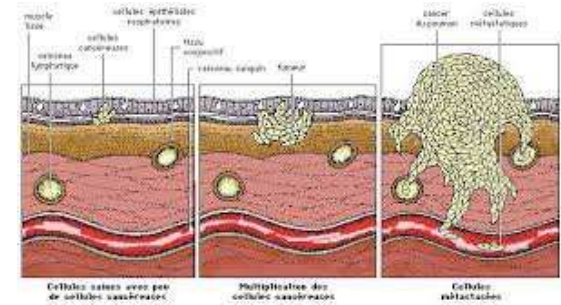
## Propriétés optiques des tissus

### Tissu

- Propriétés de polarisation (molécules, fibres...): réfléchissant en surface, biréfringents...

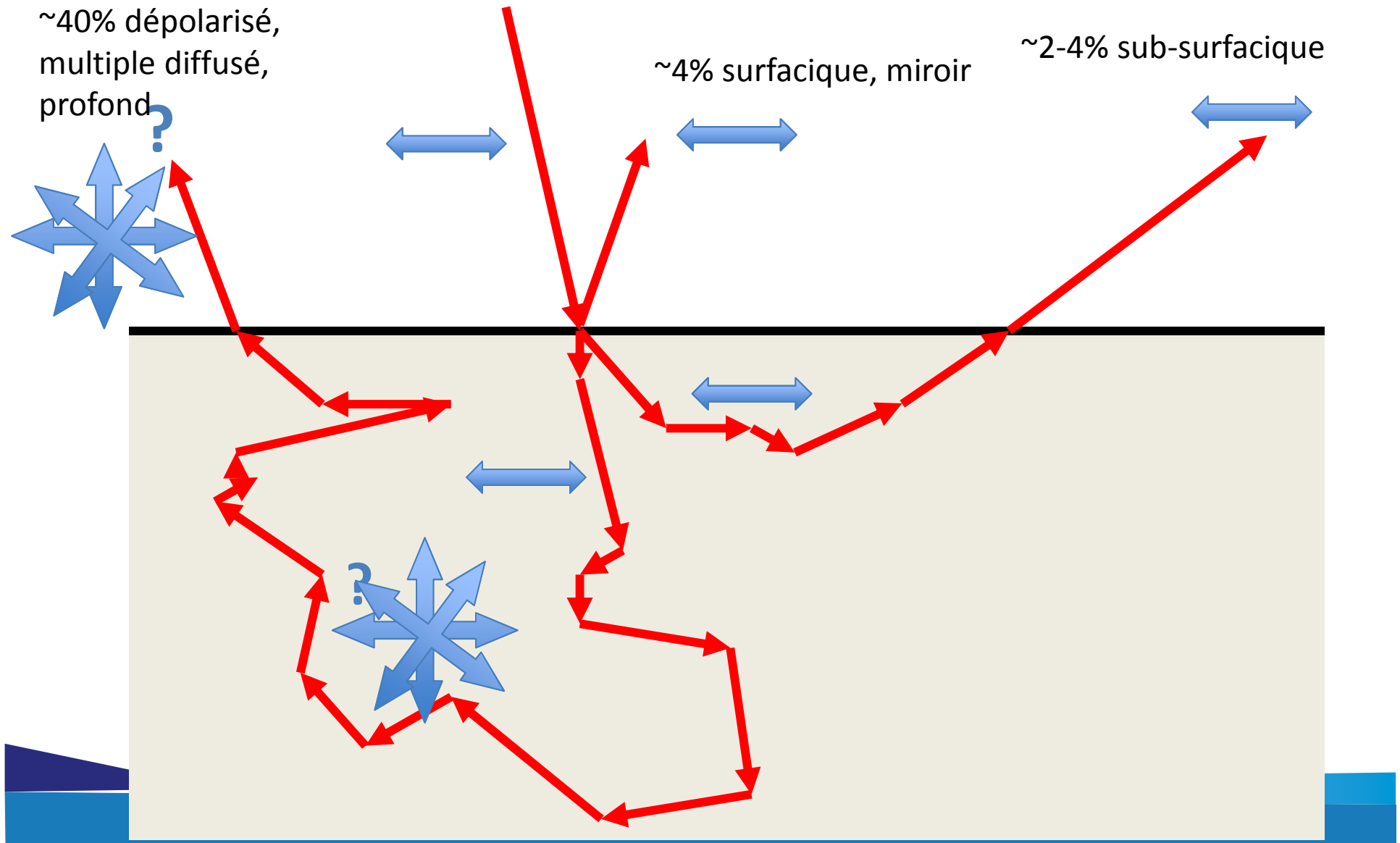
### MAIS

- Diffusant (=dépolarisant) en surface et en volume
- Absorbant, sauf dans le **rouge, proche IR**



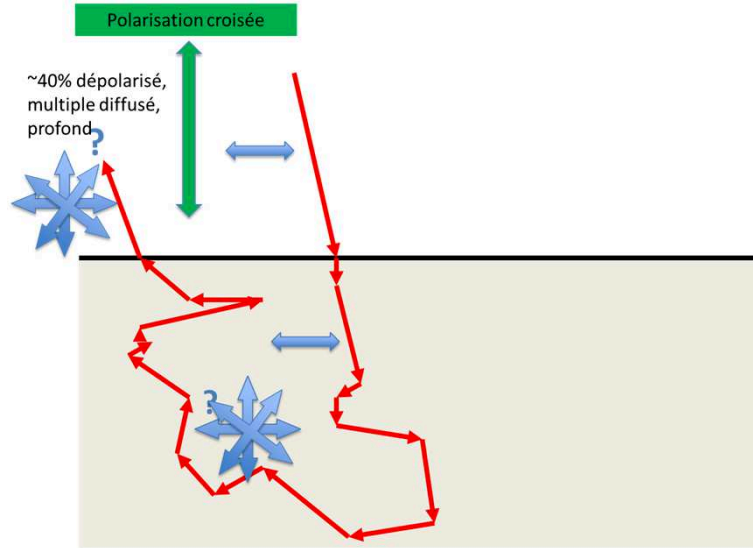
# Interaction lumière polarisée/tissu

Imagerie des structures profondes, surfaciques et sub-surfaciques



# Applications en clinique

## Imagerie des structures profondes



Phlébologie



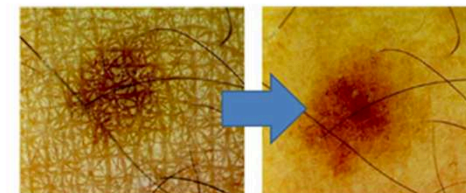
Société SyrisScientific



Dermatologie



Dermatoscope numérique à lumière polarisée  
Firefly DE350 sans fil (Import USA) 399 €

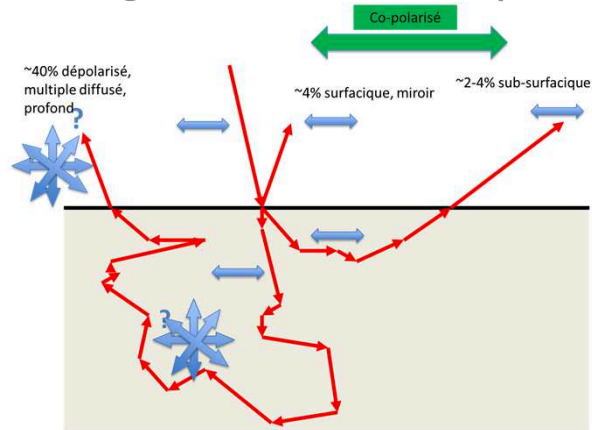


Applying Polarizer



# Applications en clinique

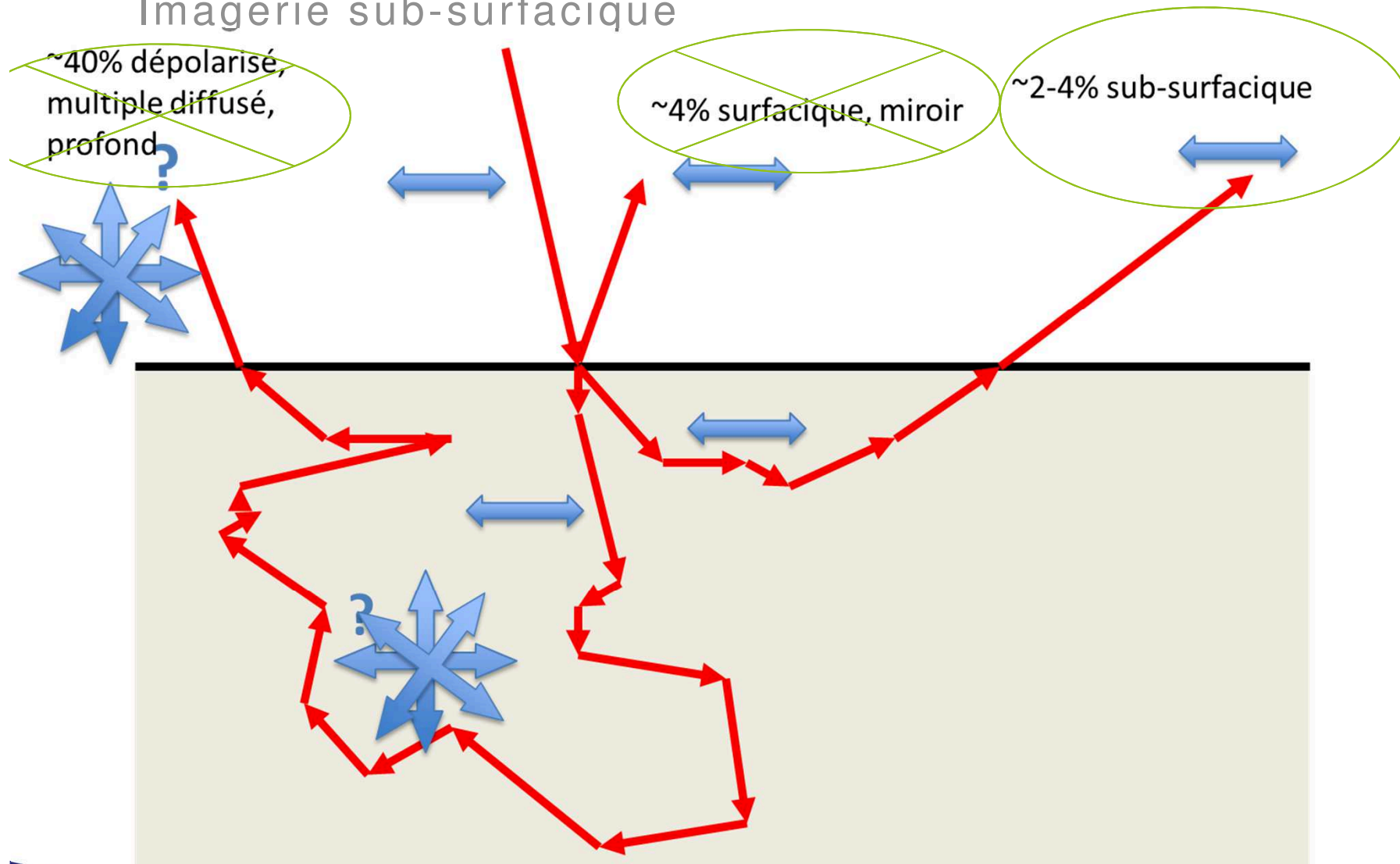
## Imagerie surfacique: Exaltation de la surface



- Mesure en co-linéaire
- **Exaltation** du relief surfacique
- Signature de la rugosité
- Applications: industries des cosmétiques et du rendu visuel
- Cancer de la peau

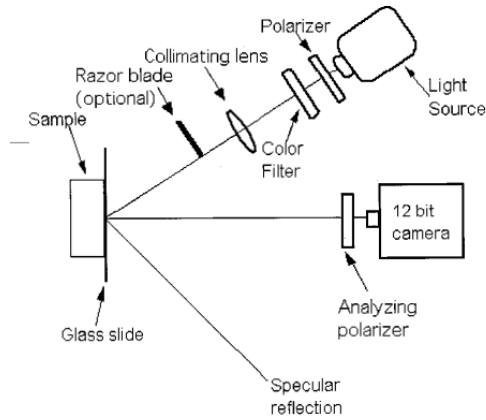
# Interaction lumière polarisée/tissu

## Imagerie sub-surfacique



# Applications en clinique

## Imagerie sub-surfacique: Dermatologie



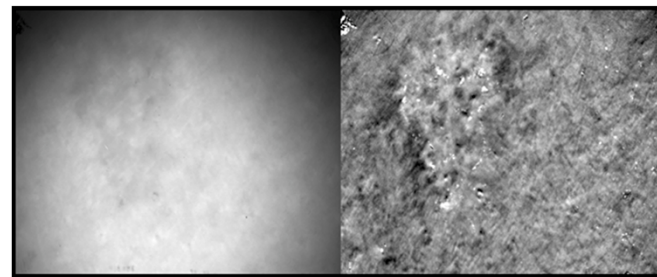
$$\text{Image polarisée} = \frac{\text{par} - \text{per}}{\text{par} + \text{per}}$$

← Superficiel + Profond  
← Profond

*Steven Jacques, JBO 7(3), 2002*

Basal-Cell Carcinoma

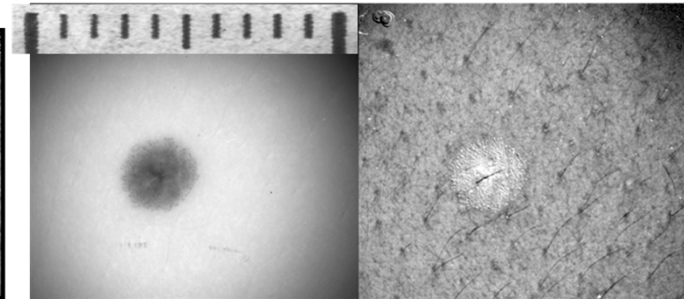
compound nevus



Unpolarized

Polarized

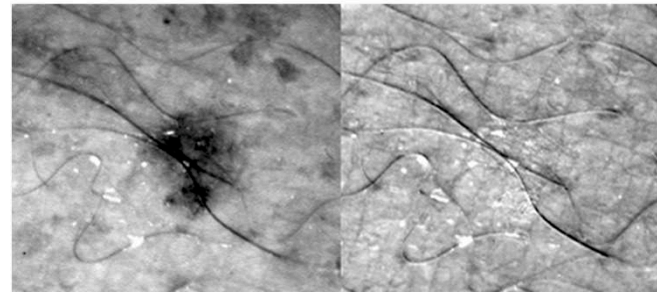
freckle



Unpolarized

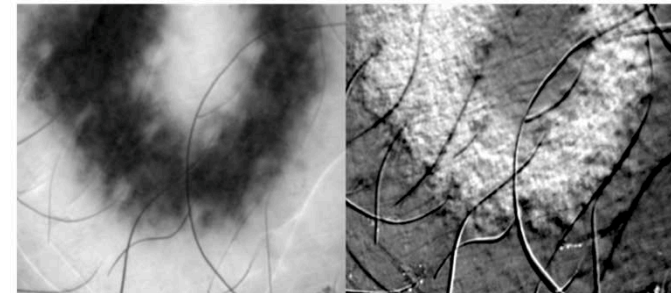
Polarized

tattoo



Unpolarized

Polarized



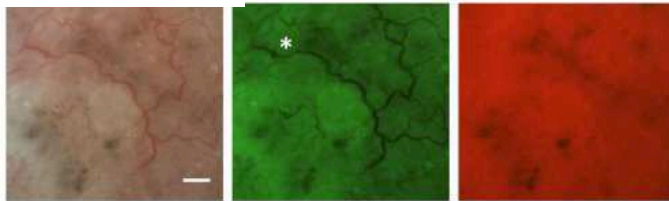
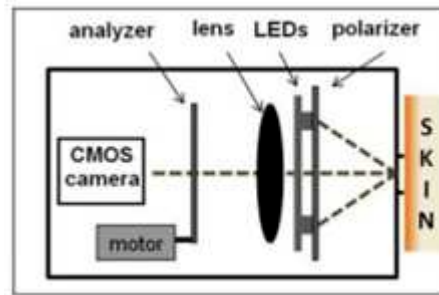
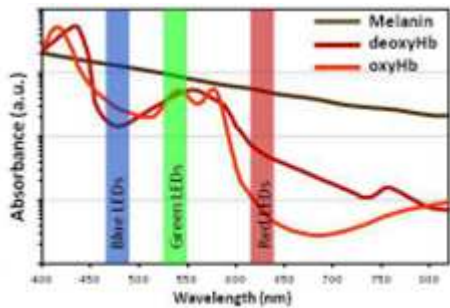
Unpolarized

Polarized

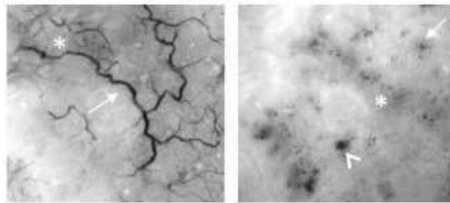
# Applications en clinique

Imagerie sub-surfacique + spectral  
Composition, Vascularisation

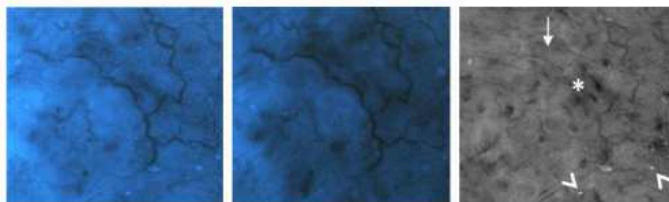
Francesco S. Pavone



a) Dermoscopic      b) Green90      c) Red90



d) Blood Contrast      e) Melanin Contrast

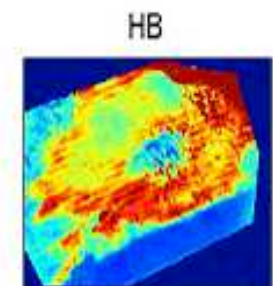
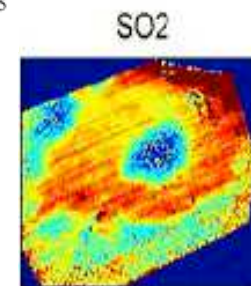
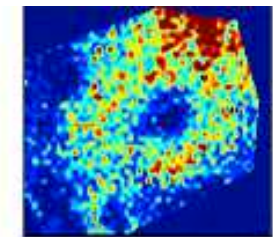


f) Blue0      g) Blue90      h) Scattering Contrast

$$\text{Scattering Contrast} = \text{Blue0} - \text{Blue90} = \text{Blue0}^s + \text{Blue0}^m - \text{Blue90} = \text{Blue0}^s$$

$$\text{Blood Contrast} = \frac{\text{Green90} - \text{Red90}}{\text{Green90} + \text{Red90}}$$

$$\text{Melanin Contrast} = \frac{\text{Red90}^{\text{ch}} - \min(\text{Red90}^{\text{ch}})}{\max(\text{Red90}^{\text{ch}}) - \min(\text{Red90}^{\text{ch}})} \cdot 255$$



# Applications en clinique

Imagerie sub-surfacique+spectral+miniaturisation  
Endoscopie, oncologie, gynécologie

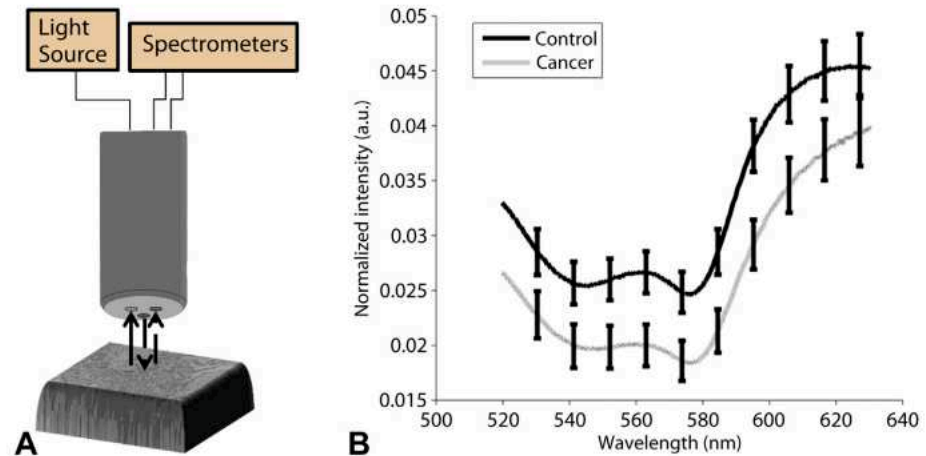
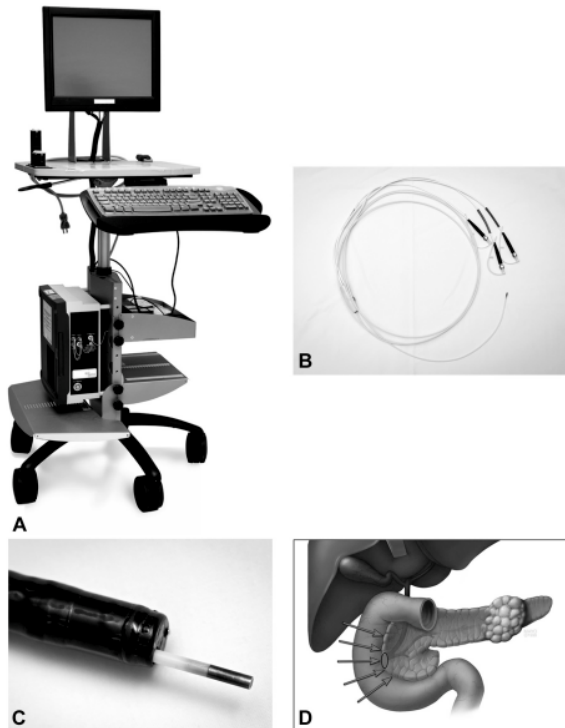


Figure 1. Schematic of the polarization-gated probe (A) and representation of data acquisition graph (B).

## Polarization gating spectroscopy of normal-appearing duodenal mucosa to detect pancreatic cancer

Mihir Patel, MD, MSc,<sup>1</sup> Andrew Gomes, PhD,<sup>2</sup> Sarah Ruderman, MS,<sup>2</sup> Darla Hardee, RN,<sup>1</sup>  
Sergio Crespo, MD,<sup>1</sup> Massimo Raimondo, MD,<sup>1</sup> Timothy Woodward, MD,<sup>1</sup> Vadim Backman, PhD,<sup>2</sup>  
Hemant Roy, MD,<sup>3</sup> Michael Wallace, MD, MPH<sup>1</sup>

Jacksonville, Florida; Evanston, Illinois; Boston, Massachusetts, USA

# Applications en clinique

Imagerie sub-surfacique

Imagerie 2D

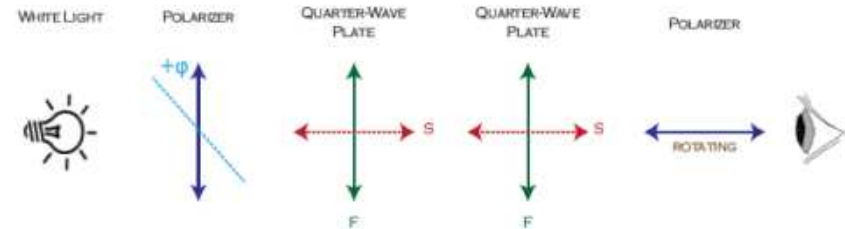
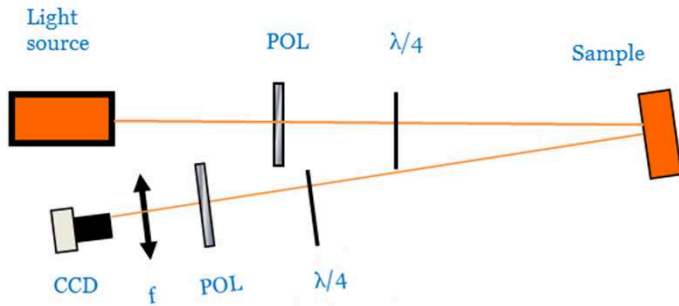
Information en profondeur?

→ utilisation de la polarisation elliptique

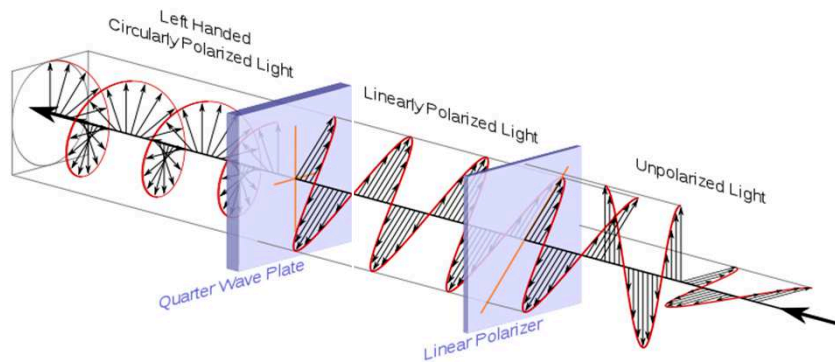
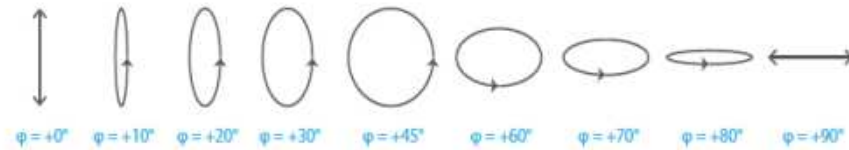


# Imagerie sub-surfacique

Polarisation linéaire, circulaire, elliptique

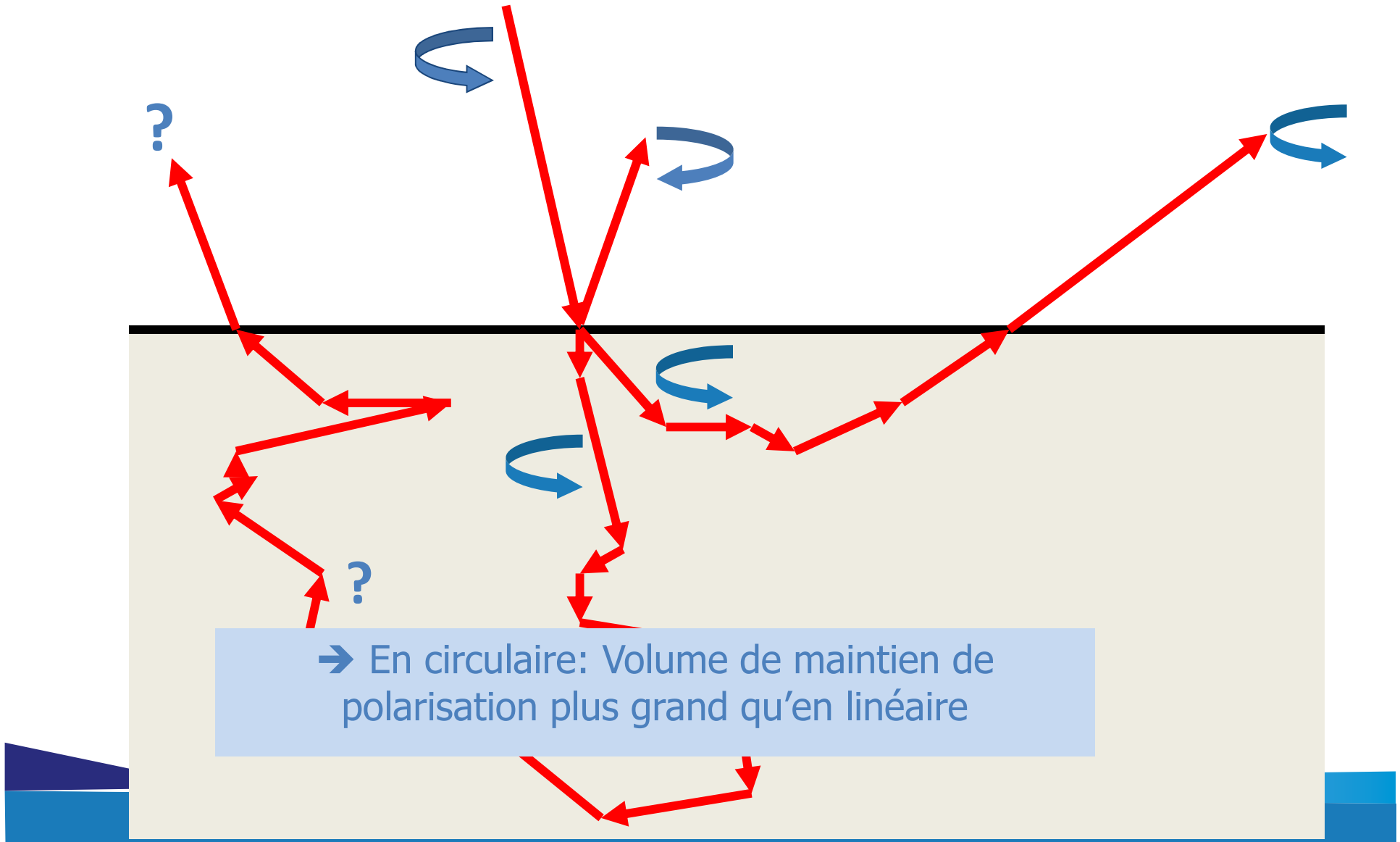


ELIPSES OF POLARIZATION



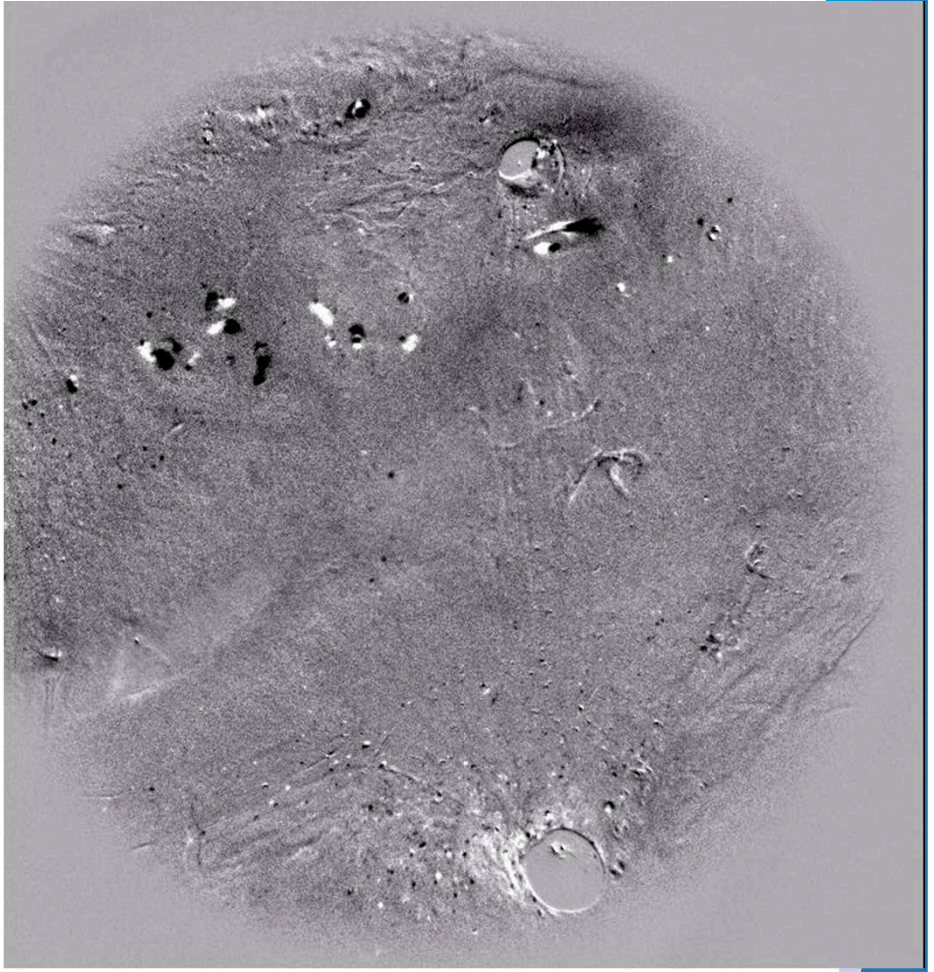
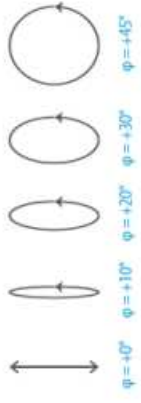
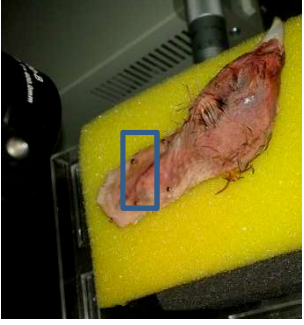
# Imagerie sub-surfacique

Propagation de la polarisation elliptique dans les tissus





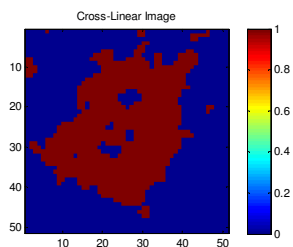




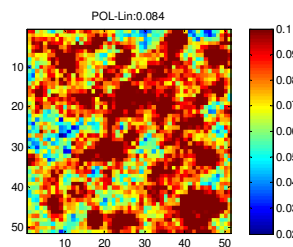
# Hand of a volunteer: mole



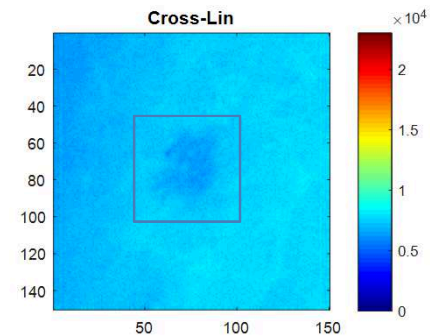
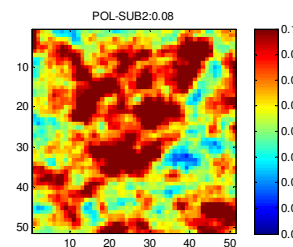
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



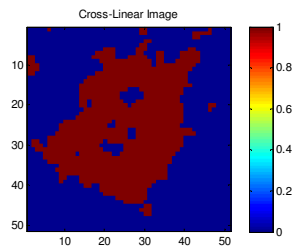
$$\varphi = +10^\circ$$



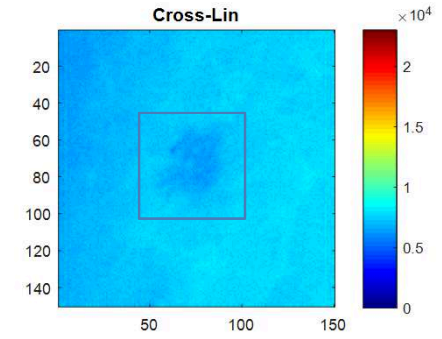
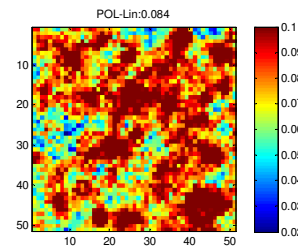
# Hand of a volunteer: mole



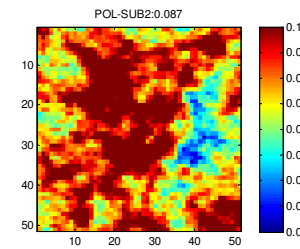
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



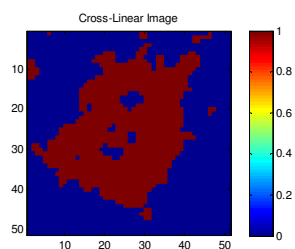
$$\varphi = +20^\circ$$



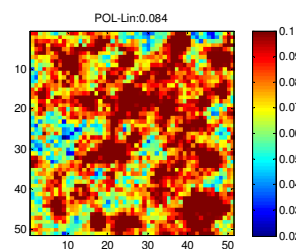
# Hand of a volunteer: mole



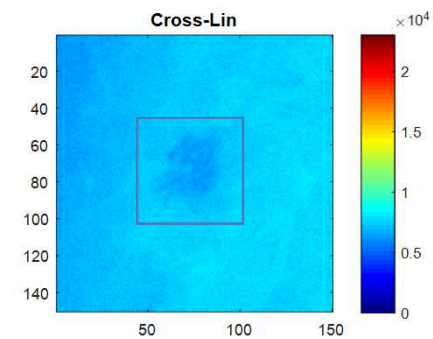
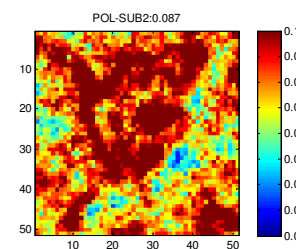
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



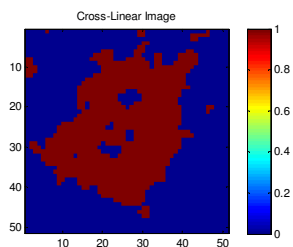
$$\varphi = +30^\circ$$



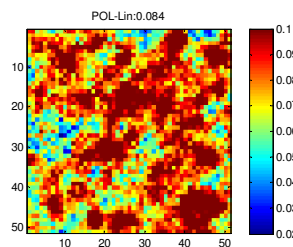
# Hand of a volunteer: mole



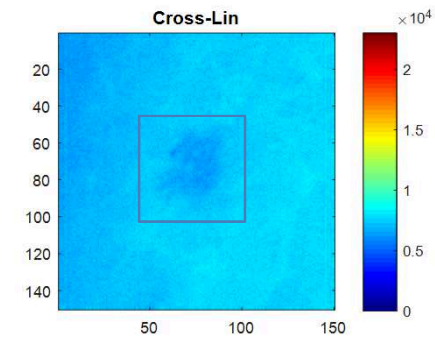
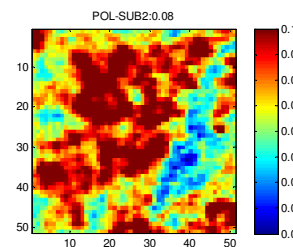
$\varphi = +90^\circ$



$\varphi = 0^\circ$



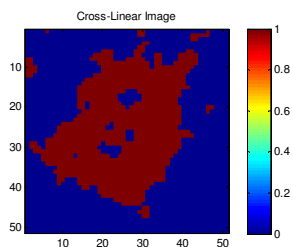
$\varphi = +40^\circ$



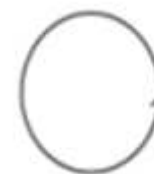
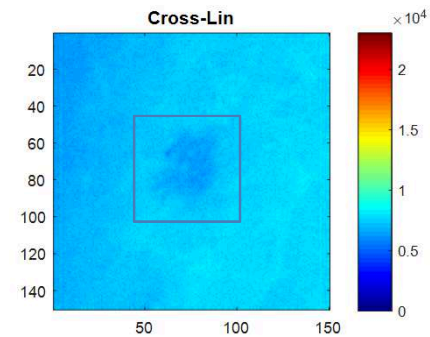
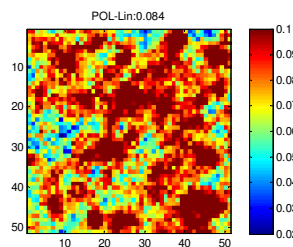
# Hand of a volunteer: mole



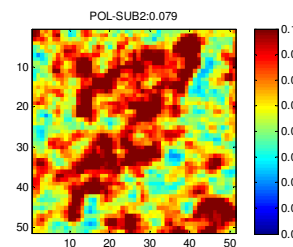
$$\varphi = +90^\circ$$



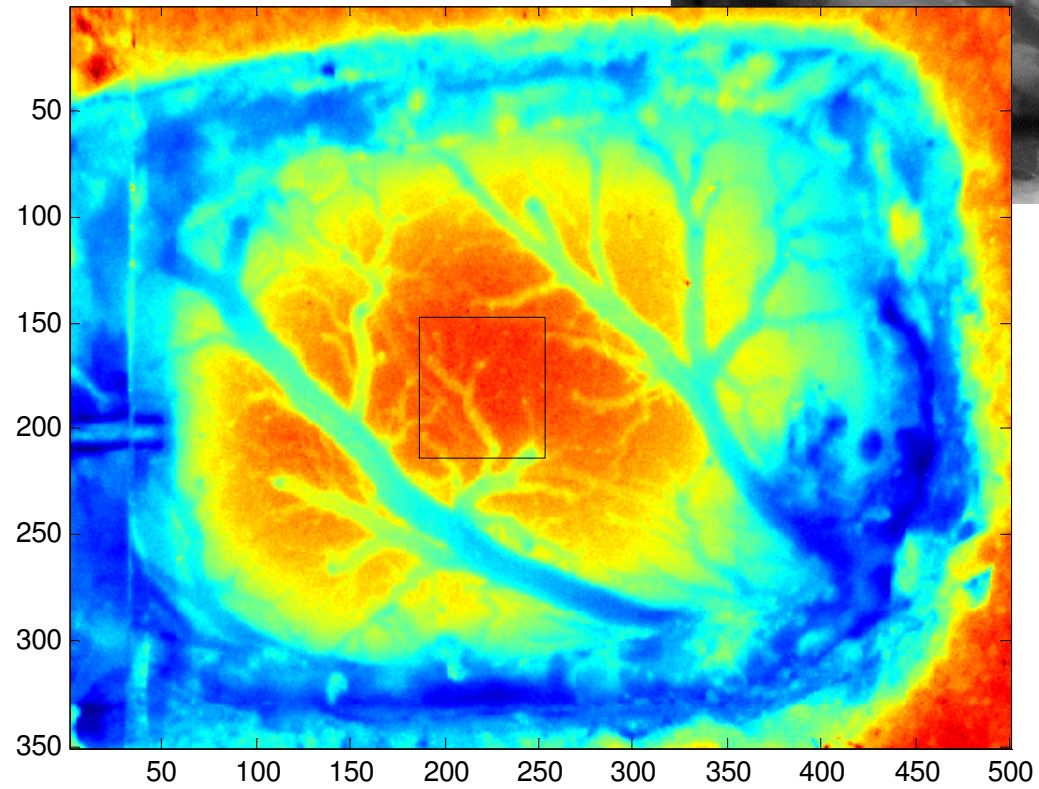
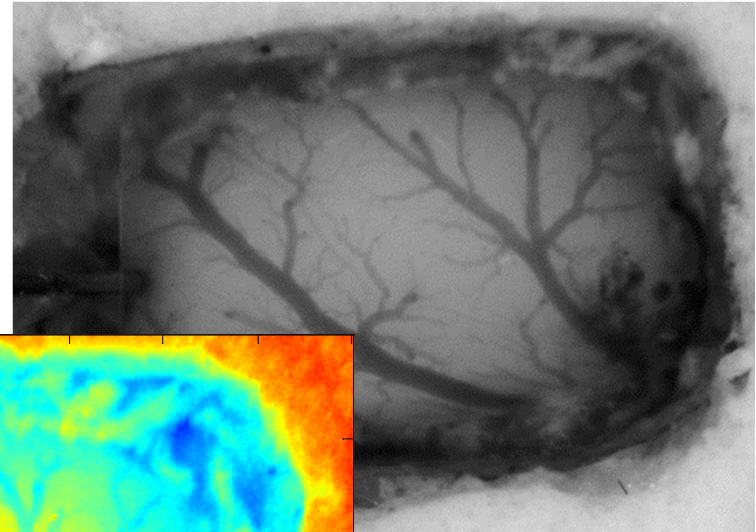
$$\varphi = 0^\circ$$



$$\varphi = +45^\circ$$



# Rat cortex



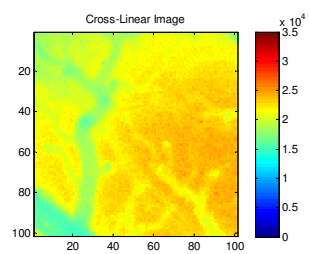
Ivo Vanzetta



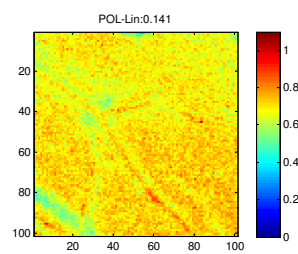
# Rat brain



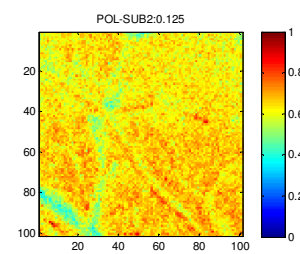
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



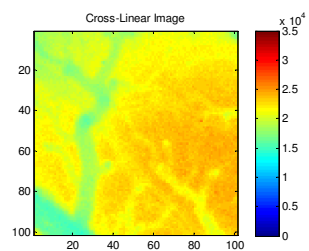
$$\varphi = +10^\circ$$



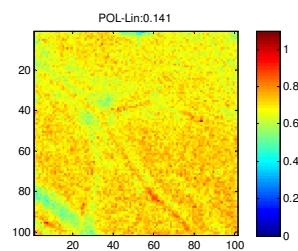
# Rat brain



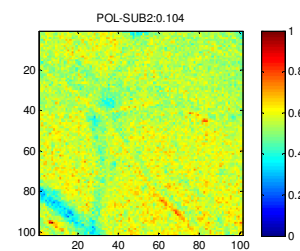
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



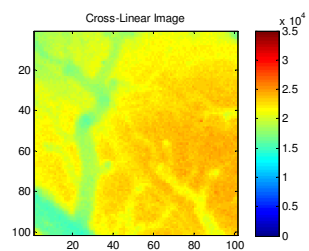
$$\varphi = +20^\circ$$



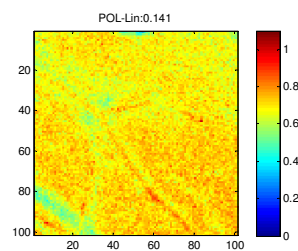
# Rat brain



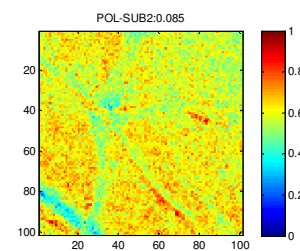
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



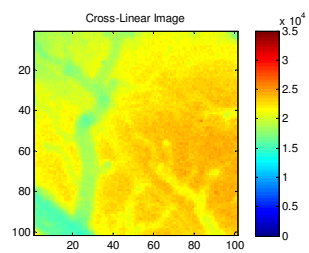
$$\varphi = +30^\circ$$



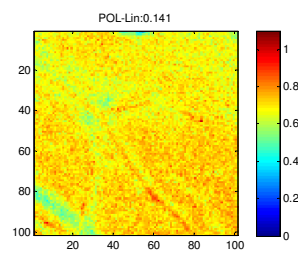
# Rat brain



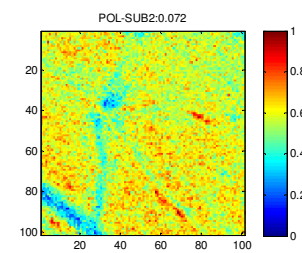
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



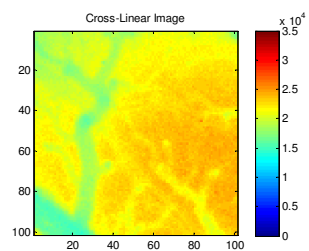
$$\varphi = +40^\circ$$



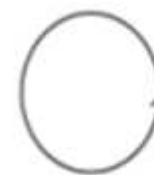
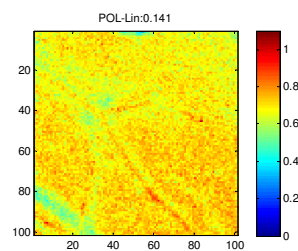
# Rat brain



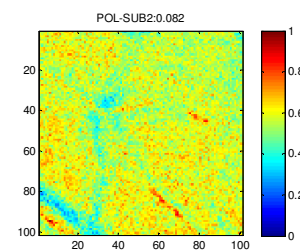
$$\varphi = +90^\circ$$



$$\varphi = 0^\circ$$



$$\varphi = +45^\circ$$



# Imagerie sub-surfacique

## Conclusion

Difficulté: Qualité des images (opérations sur plusieurs images)

- ← Amélioration des systèmes: Dynamique, Rapidité des mesures (acquisition d'images en parallèle, automatisation, cellules à cristaux liquides, modulateurs photoélastiques, snapshot)
- ← Traitement de l'image: Correction du bougé, Contrastes, Textures

- ⇒ Sondage en polarisation **elliptique**: examen continu en profondeur
- ⇒ Volumes sondés spécifiques

Tissus actifs en polarisation: indicateur polarimétrique  
Résolution spectrale



MERCI!



Anabela Da Silva  
Susmita Sridhar

Anne Planat-Chrétien  
Michel Berger  
Jean-Marc Dinten

Ivo Vanzetta  
Pierre Stahl

Claudia Valdès-Escobar  
Turgut Durduran

