Institut Fresnel

UMR 6133

Équipe MOSAIC

2006-2010

Moyens Humains

8 Permanents

6 CNRS (-1+1)

1 UPCAM

1 Univ Provence (+1)

11 Doctorants

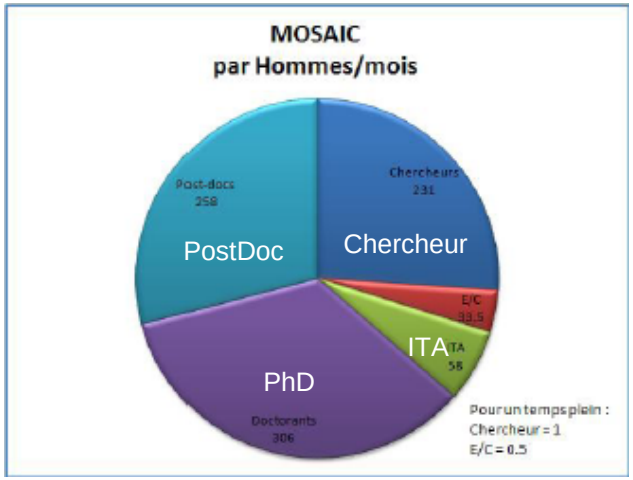
5 Post-Doctorants

Pour les 4,5 ans considérés pour l'évaluation

= 22 ETPR

Soit 4,9 ETPR / an

en moyenne



MOSAIC

Entre Optique et Biologie

Biophotonique: l'étude de problématiques liées aux sciences du vivant et utilisant des méthodes, outils et techniques relevant de l'optique et de la (nano) photonique.

- Centre d'Immunologie de Marseille Luminy (CIML) (équipe Didier Marguet et Hai-Tao He)

-l'Institut de Biologie du Développement de Marseille Luminy (IBDML) (Equipe de Pierre-François Lenne).

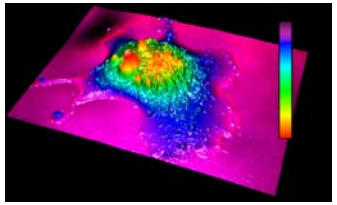
-AXE 1: Biophotonique et Imagerie

- Contrastes moléculaires
- Résolution spatiale
- Ordre moléculaire
- Manipulation cellulaire
- Dynamique et organisation membranaire
- Force corticales et embryogénèse

-AXE 2: Nano (Bio) Photonique

- Contrôle et Exaltation des contrastes moléculaires
- Ultra-résolution
- Détection moléculaire

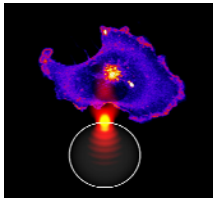
Thèmes de Recherche



- Axe 1 : **Biophotonique et Imagerie**

PI: P. Ferrand	*Th1-1 : La spectroscopie de corrélation de fluorescence (FCS) et ses développements.*
PI: H. Rigneault / S. Brasselet	*Th1-2 : Les contrastes nonlinéaires (CARS, SRS, SHG, TPEF) et leur étude polarimétrique.*
PI: S. Brasselet	*Th 1-3 : Le contrôle de la phase spectrale : la mise en forme temporelle d'impulsions pour un contraste optimal en microscopie non linéaire.*
PI: S. Monneret	*Th1-4 : Le contrôle et l'étude de la phase spatiale pour la manipulation et l'imagerie.*
PI: S. Monneret	*Th1-5 : Ultra-résolution optique.*
PI: P.-F. Lenne	*Th1-6 : Forces corticales et adhésion cellulaire dans les tissus.*

Thèmes de Recherche



- Axe 2 : **Nano (Bio) photonique**

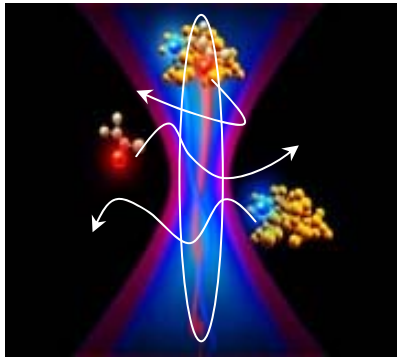
PI: J. Wenger
- *Th2-1 : Nano-ouvertures individuelles pour exalter les signaux moléculaires.*

PI: J. Wenger
- *Th2-2 : Microsphère diélectriques pour exalter les signaux moléculaires.*

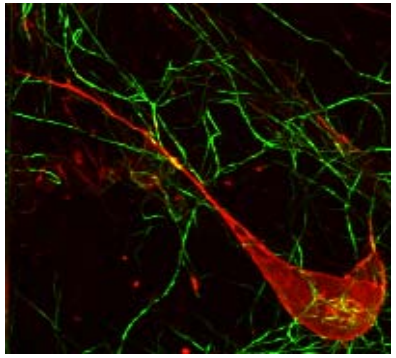
PI: H. Rigneault
- *Th2-3 : Miroirs et Microcavités planaires pour exalter les signaux moléculaires .*

Biophotonique et Imagerie

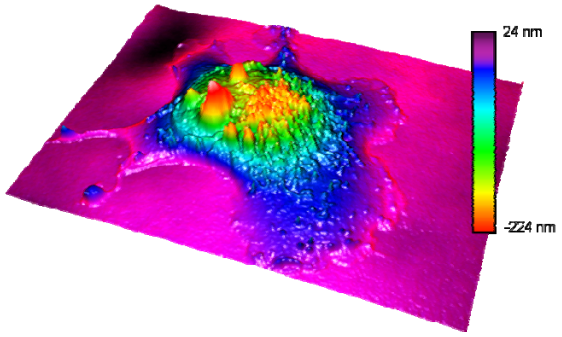
Collaboration: PHYTI –: 1 publication commune – SEMO 4 publications communes



FCS for cell membrane analysis



Nonlinear Microscopy



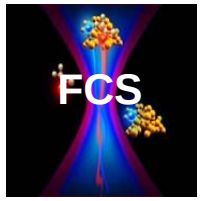
Phase Microscopy

P. Ferrand
P.-F. Lenne
J. Wenger
C. Favard
H. Rigneault

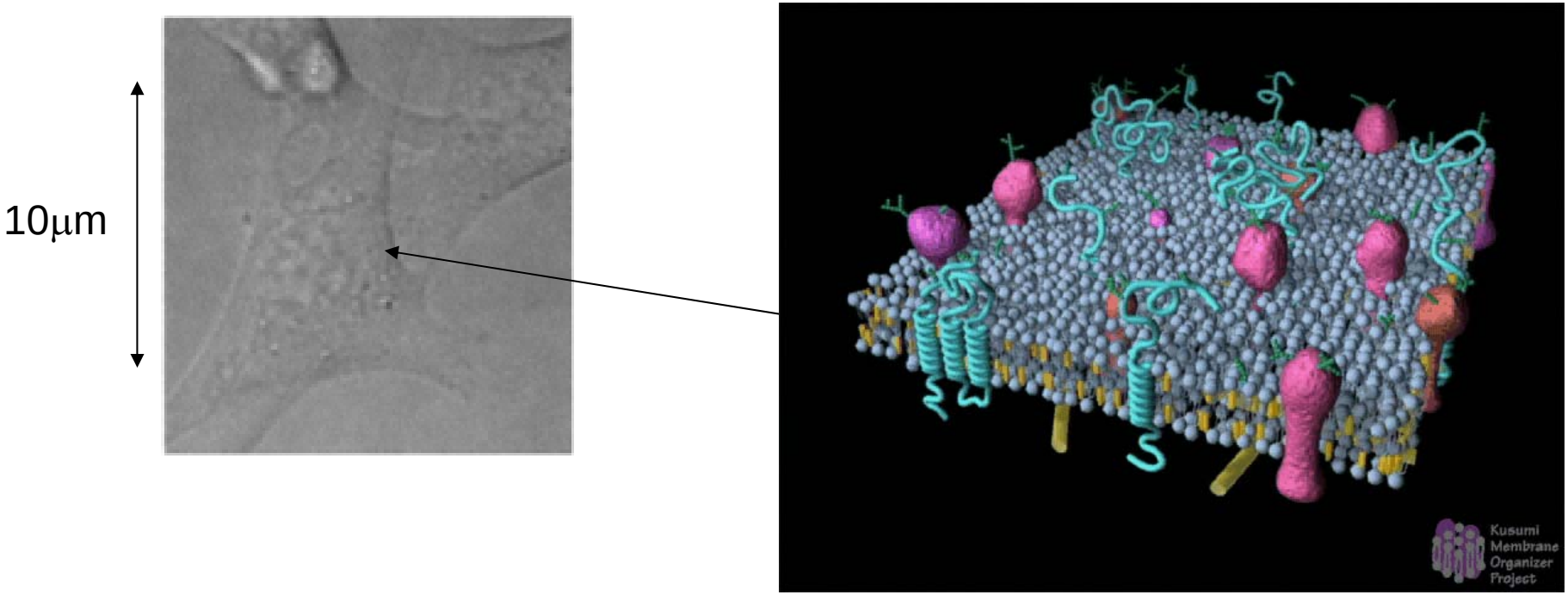
S. Brasselet
P. Ferrand
H. Rigneault

S. Monneret

Cell membrane dynamics



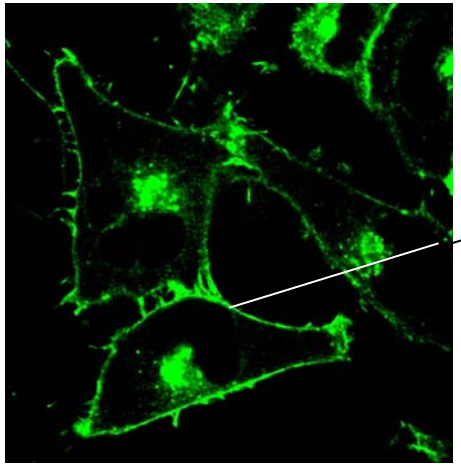
How to get new insights into membrane heterogeneities?



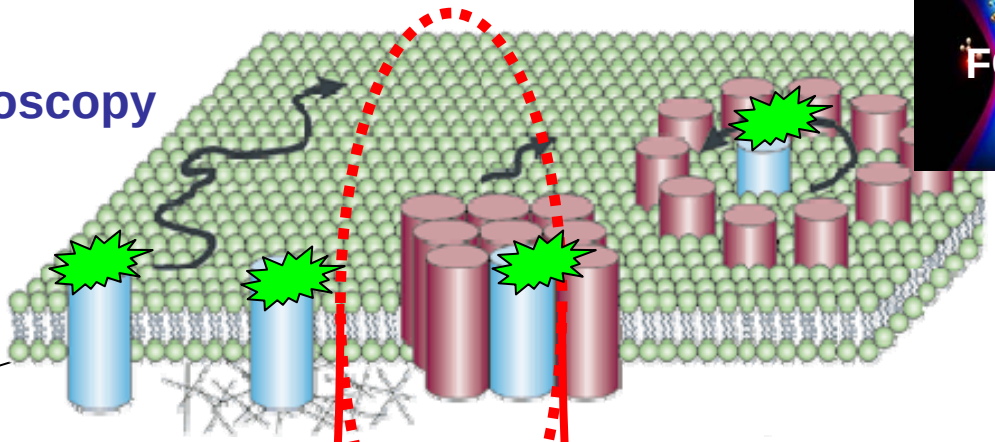
Technique: Fluorescence Correlation Spectroscopy - FCS

Method: FCS diffusion laws

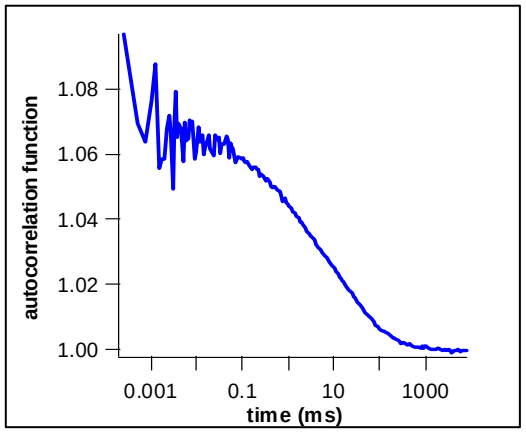
FCS:
Fluorescence Correlation Spectroscopy

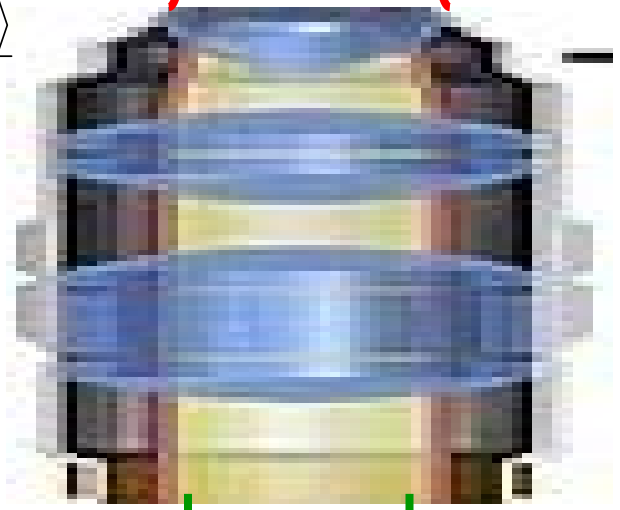


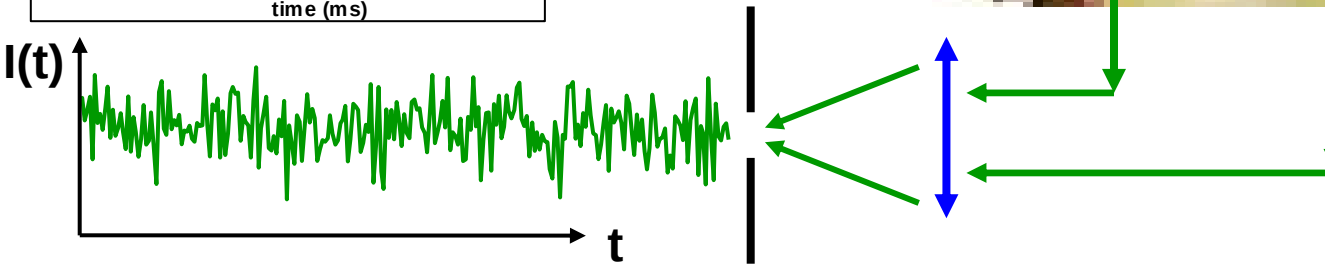
3 nm



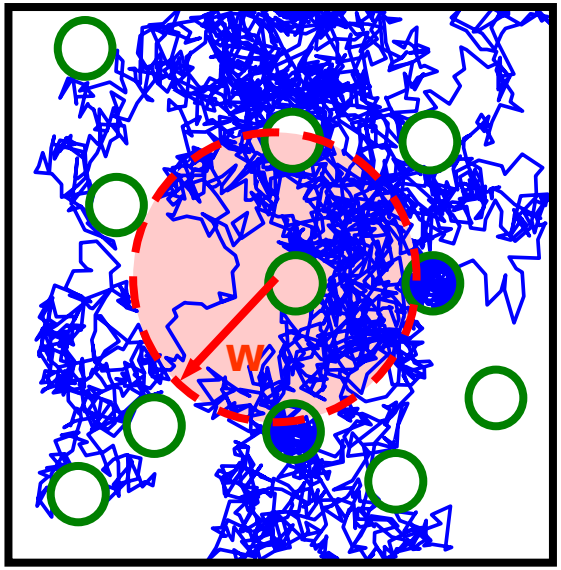
Autocorrelation function $g^{(2)}(\tau) = \frac{\langle I(t)\, I(t+\tau)\rangle}{\langle I(t)\rangle^2}$

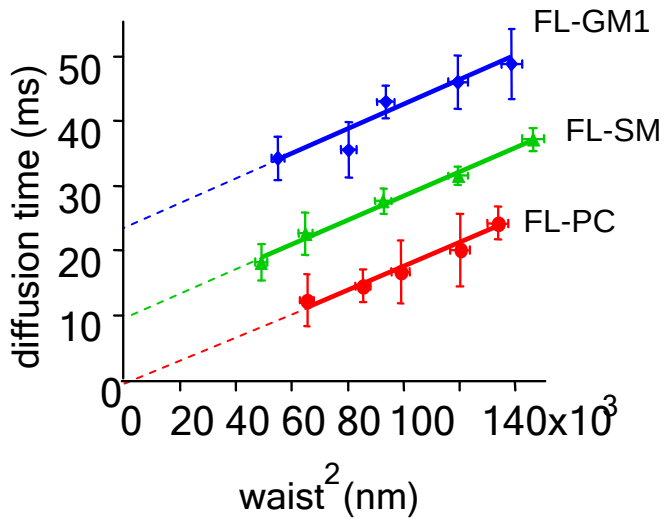




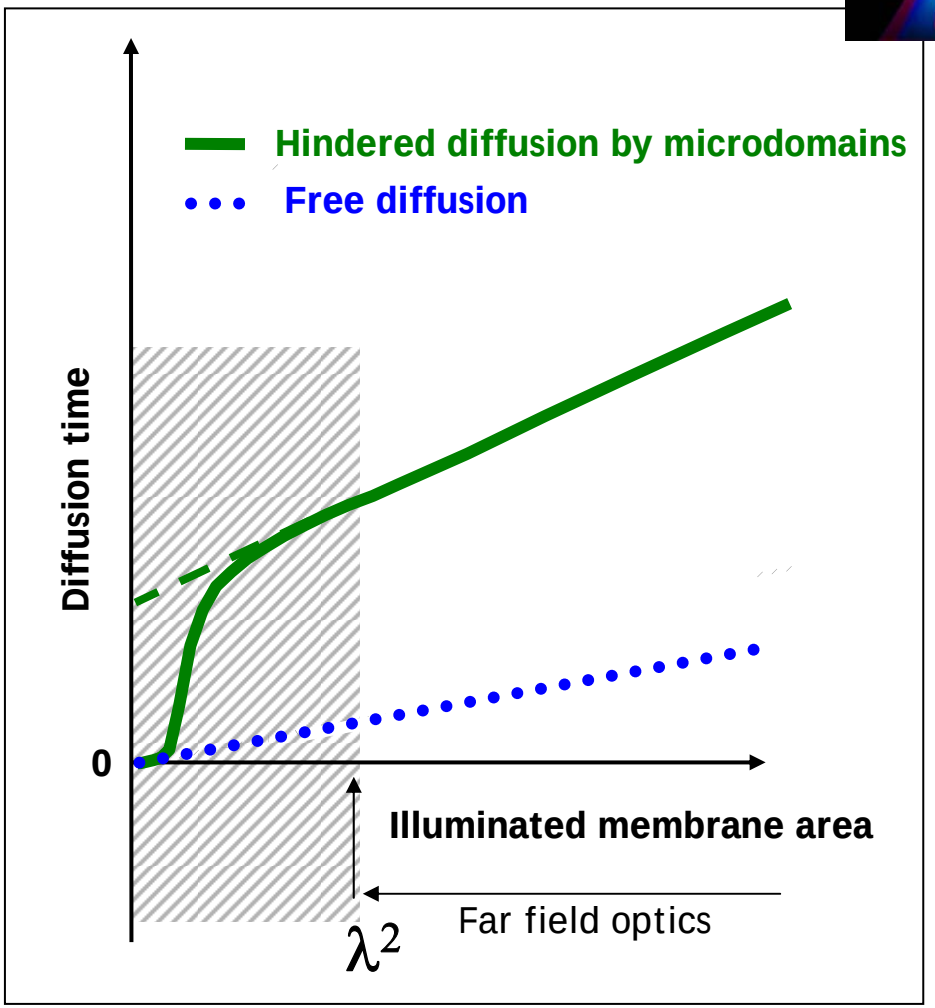


FCS Diffusion Laws



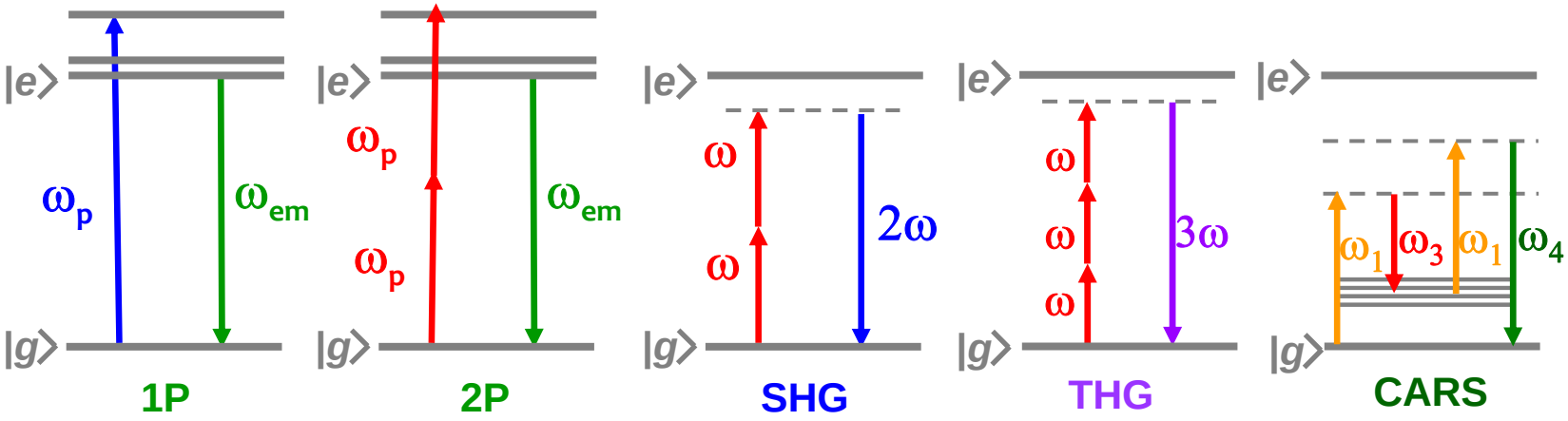


Extension to lipid mixture dynamics
C. Favard



P.-F. Lenne et al, EMBO J. 25 , 3245-3256 (2006)
D. Marget et al, EMBO J. 25 (15):3446-3457 (2006)
C. Favard et al, Biophys J., in press (2011)

Contrast Mechanisms



$$\mathbf{P}^{(p)}(\omega_\sigma) = \epsilon_0 \boldsymbol{\chi}^{(p)}(-\omega_\sigma; \omega_1, \ldots, \omega_p) : \mathbf{E}(\omega_1) \ldots \mathbf{E}(\omega_p)$$

Induced Polarization

- Radiation pattern
- Optical resolution

Molecular information

- Molecular specificity
- Non Resonant / Resonant
- Orientation - molecular order

Reading fields

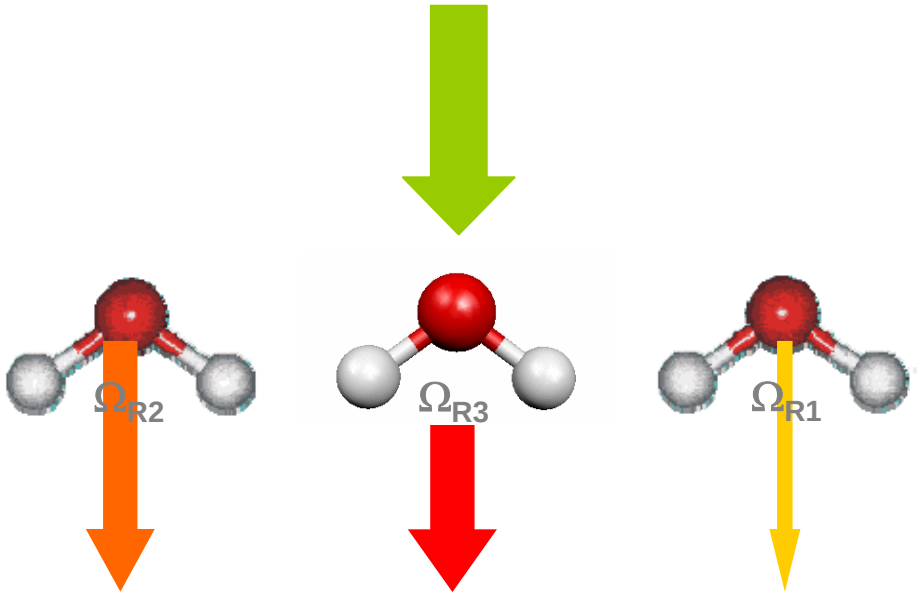
- Order process
- Polarization tuning

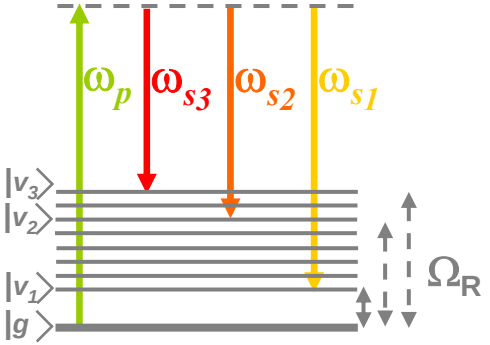
Molecular Spectroscopy

Molecular Imaging

One Example: Coherent Raman Scattering

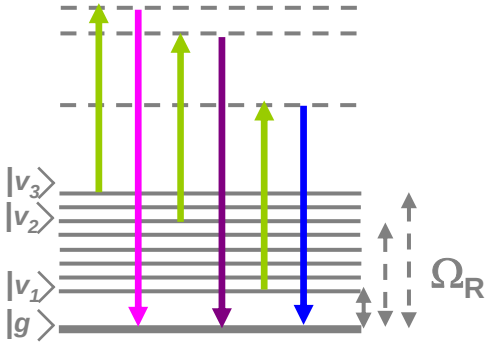
Spontaneous Raman Scattering (linear optics)



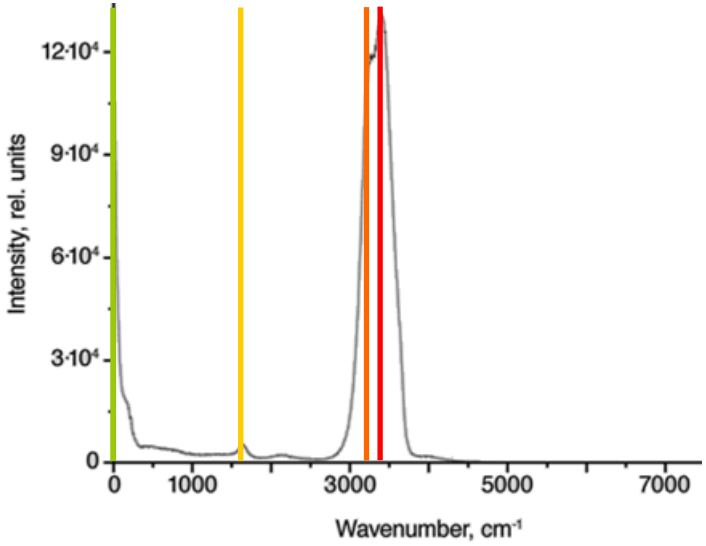


Stokes scattering

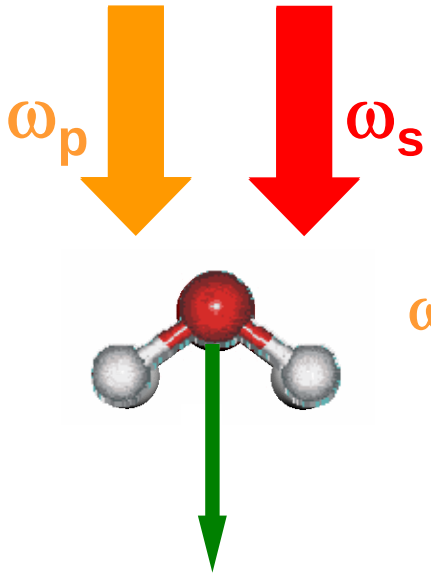
$$\omega_p - \omega_{s1} = \Omega_{R1}$$
$$\omega_p - \omega_{s2} = \Omega_{R2}$$
$$\omega_p - \omega_{s3} = \Omega_{R3}$$



Anti-Stokes scattering

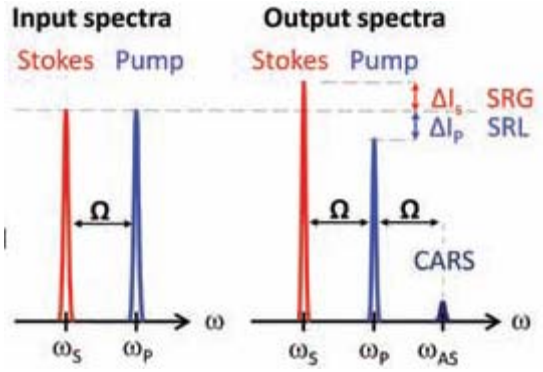


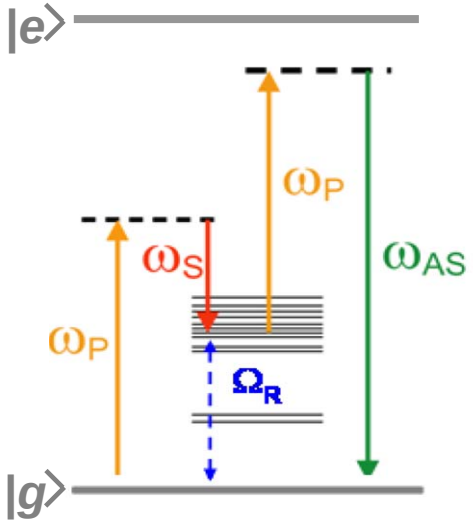
- **Coherent Raman Scattering (nonlinear optics)**

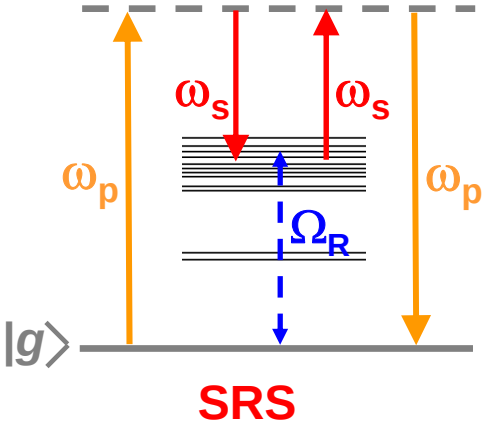


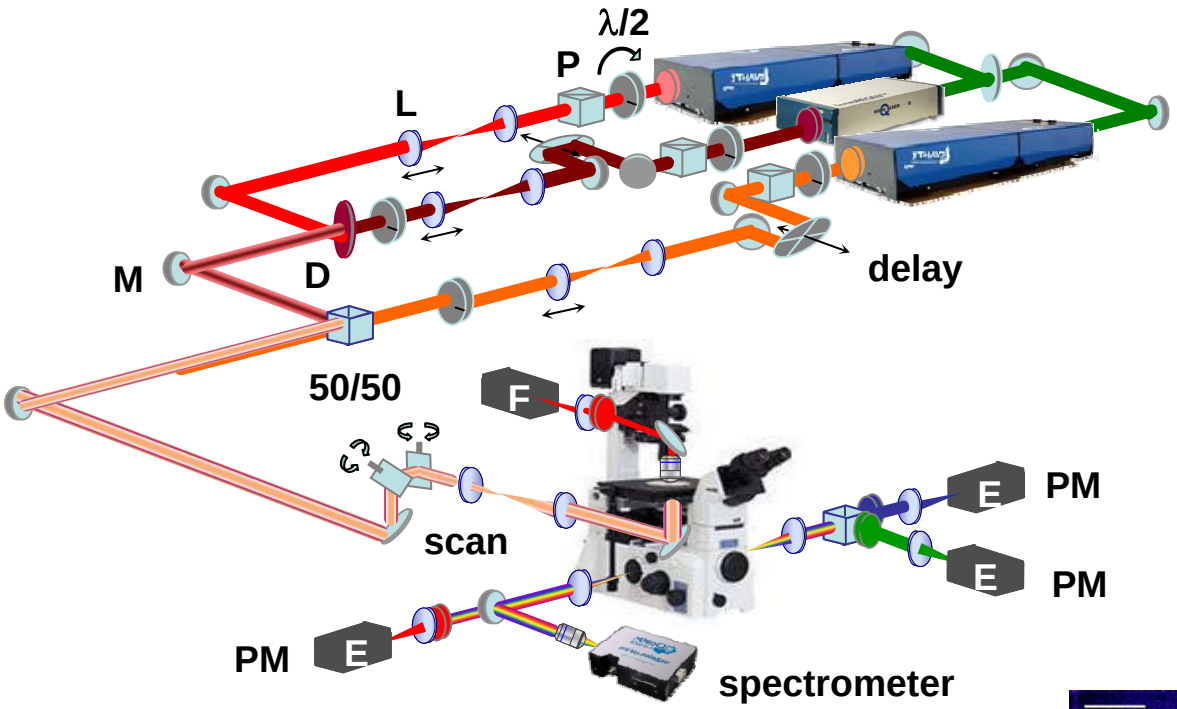
$$\omega_p - \omega_s = \Omega_R$$

$$\omega_{as} = 2\omega_p - \omega_s$$

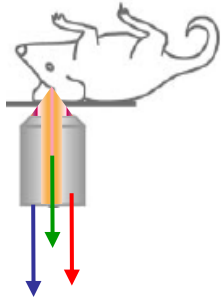




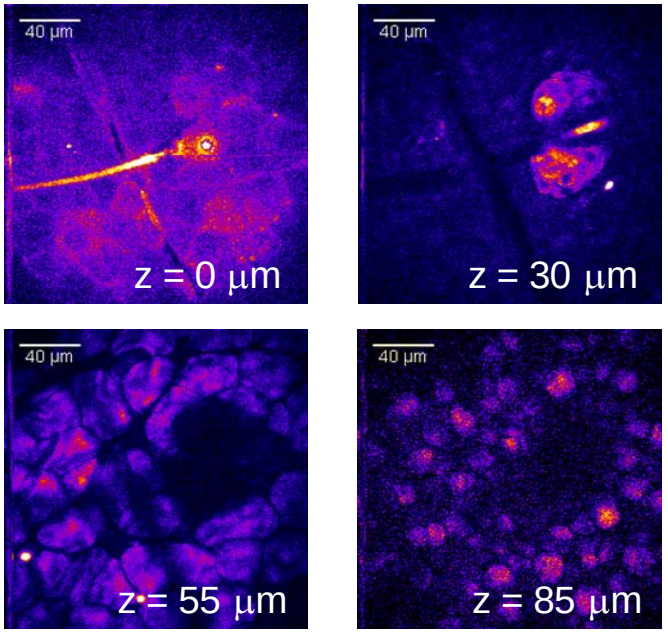




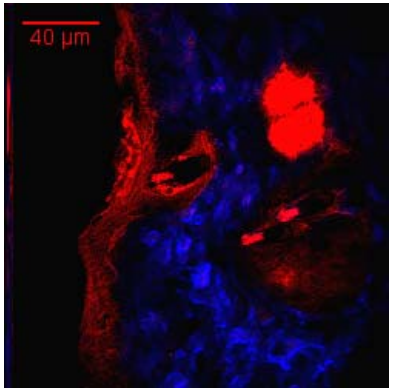
Optical Parametric Oscillators



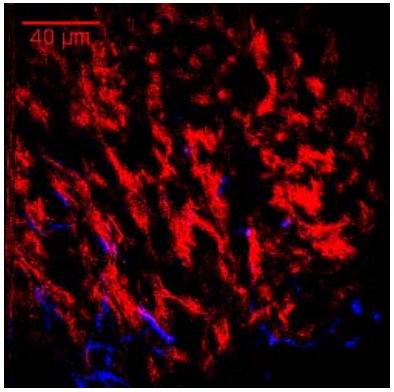
Mouse ear
CH2 2845cm^{-1}



Normal tissue



Cancerous tissue

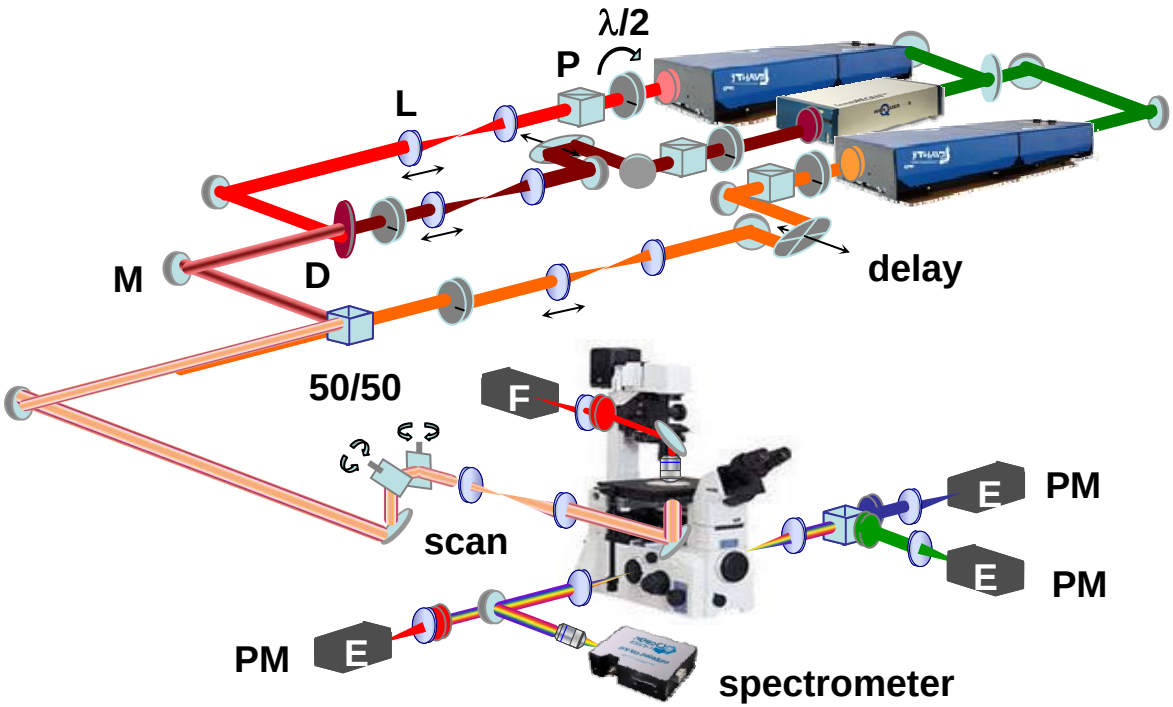


F-CARS (R-NR) – CH 2845cm^{-1}
E-SHG

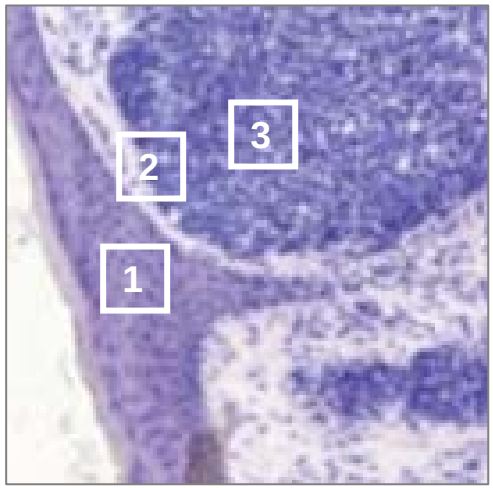
CARS Explorer

SEVENTH FRAMEWORK PROGRAMME

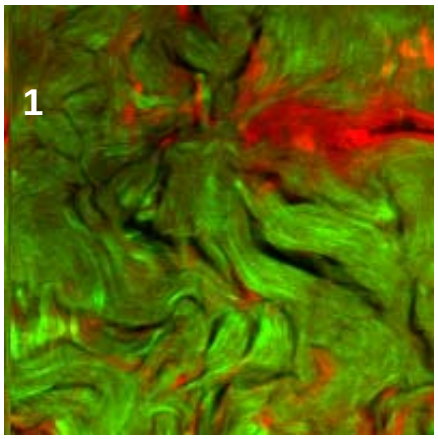
Brustlein et al. J. Biophys. Opt. Fev 2011



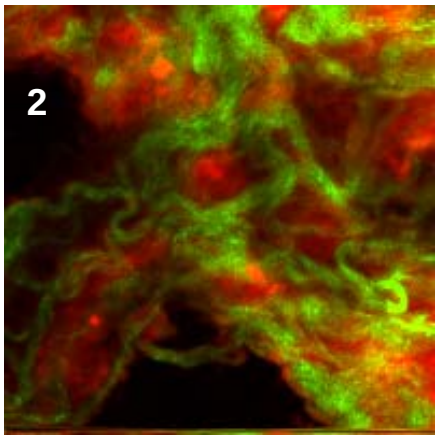
Optical Parametric Oscillators



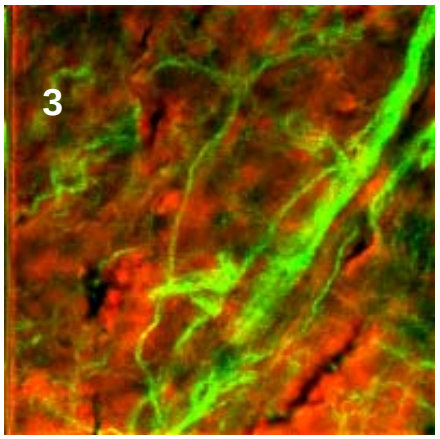
60x60µm



60x60µm



60x60µm



CARS Explorer

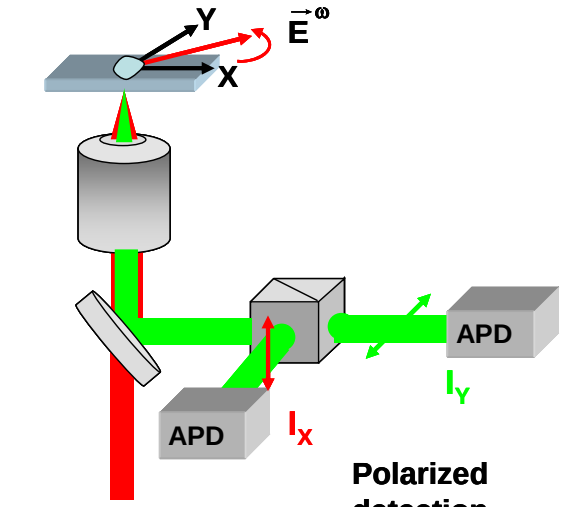
SEVENTH FRAMEWORK PROGRAMME

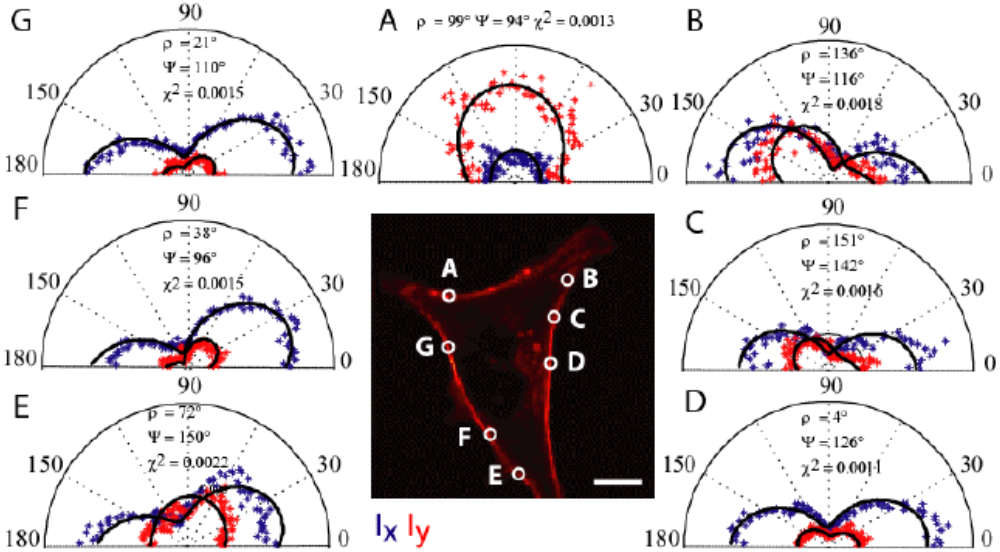
SHG : **Auto-fluorescence (2 photon TPEF)**

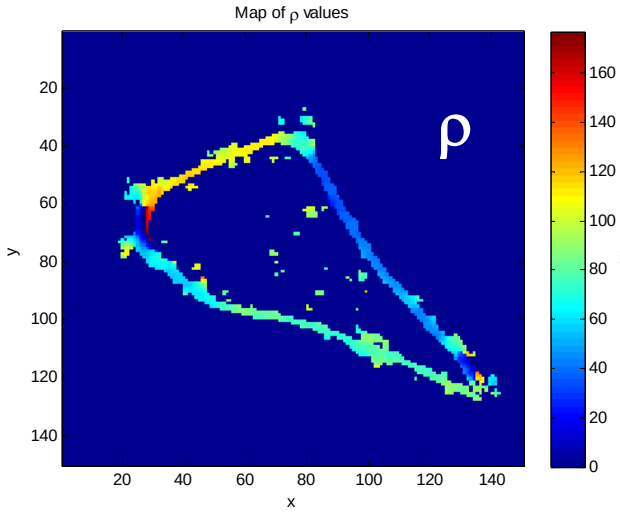
Exc 800nm, SHG 400nm, TPEF 525nm

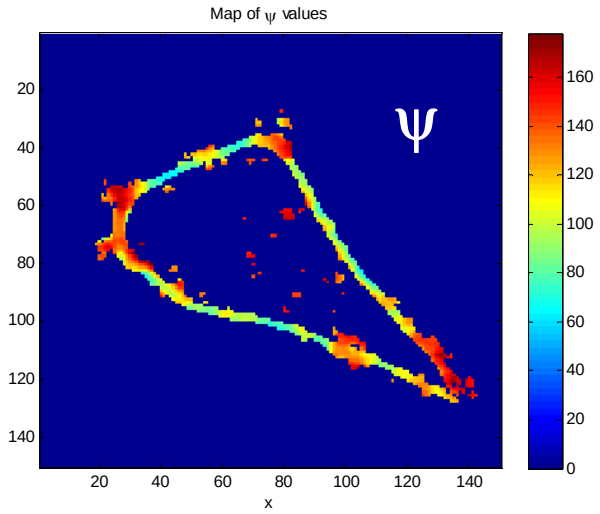
Microscopy resolved in polarization: Molecular order

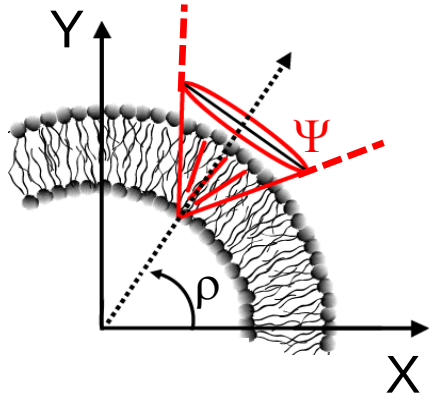
Example in 1P with ANEPPQ inserted in cell membrane







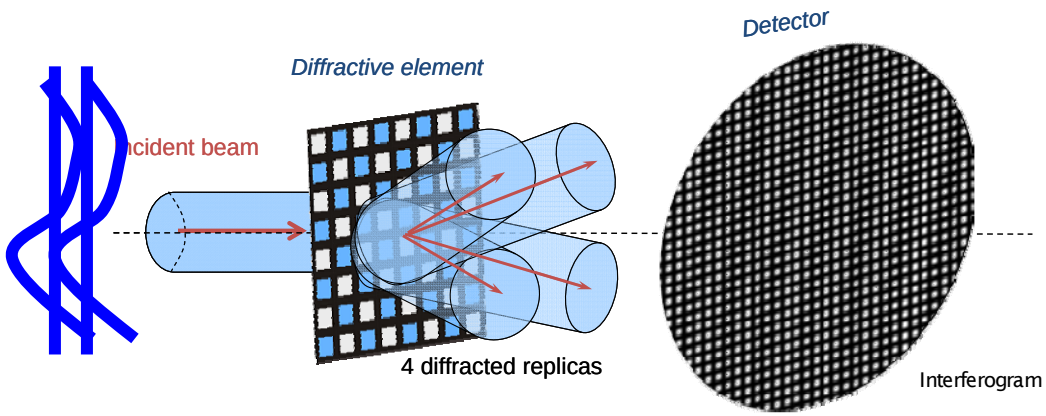


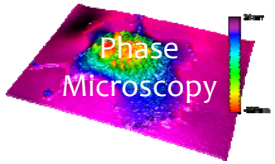


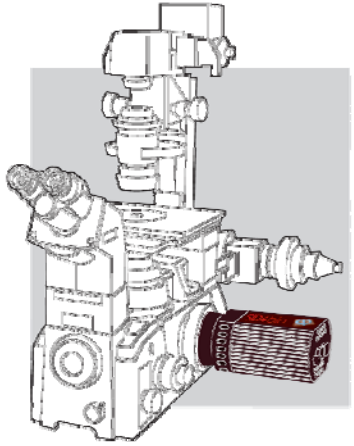
Gasecka et al. Biophys. J. 2009, Gasecka et al. J. Phys. Chem. B 2009, Kress et al. Soumis

Wave Front Analysis

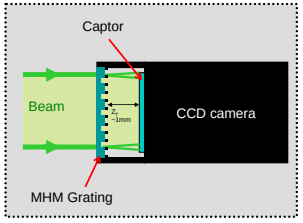
PHASICS
the phase control company

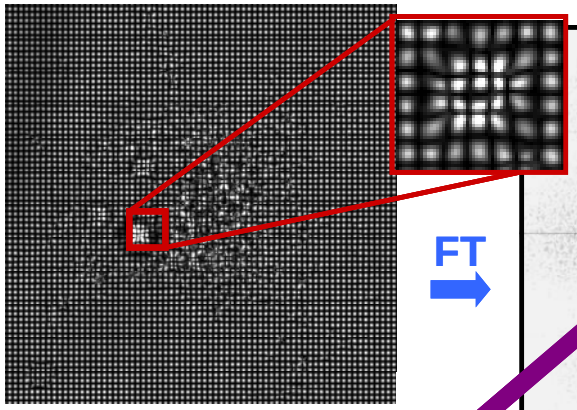






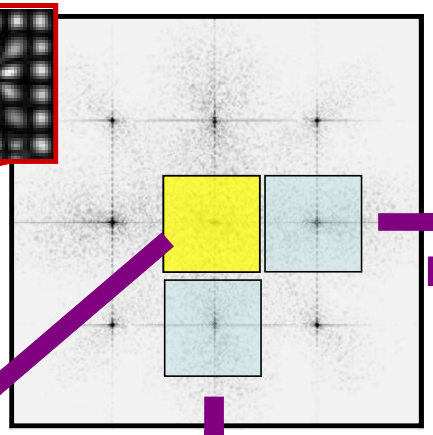
SID4Bio



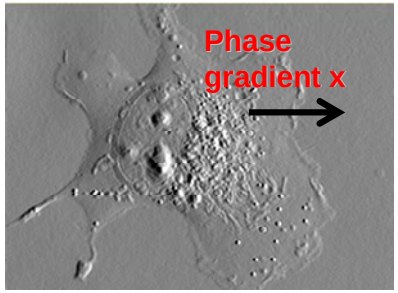


Interferogram obtained in the presence of a cell

FT



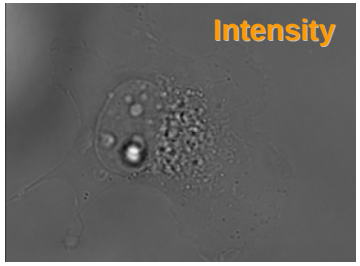
FT^{-1}

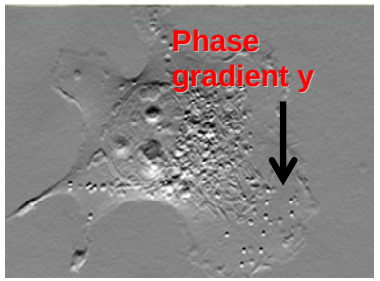


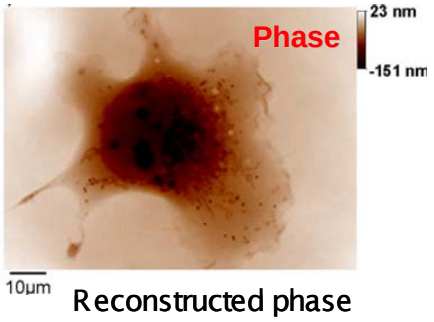
Integration

FT^{-1}

FT^{-1}

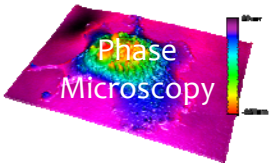


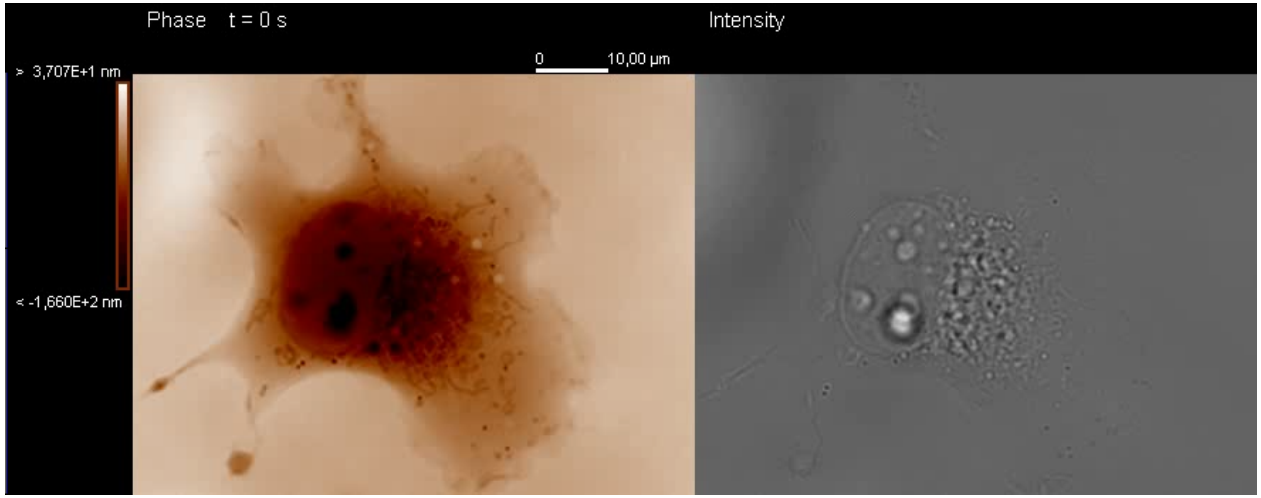


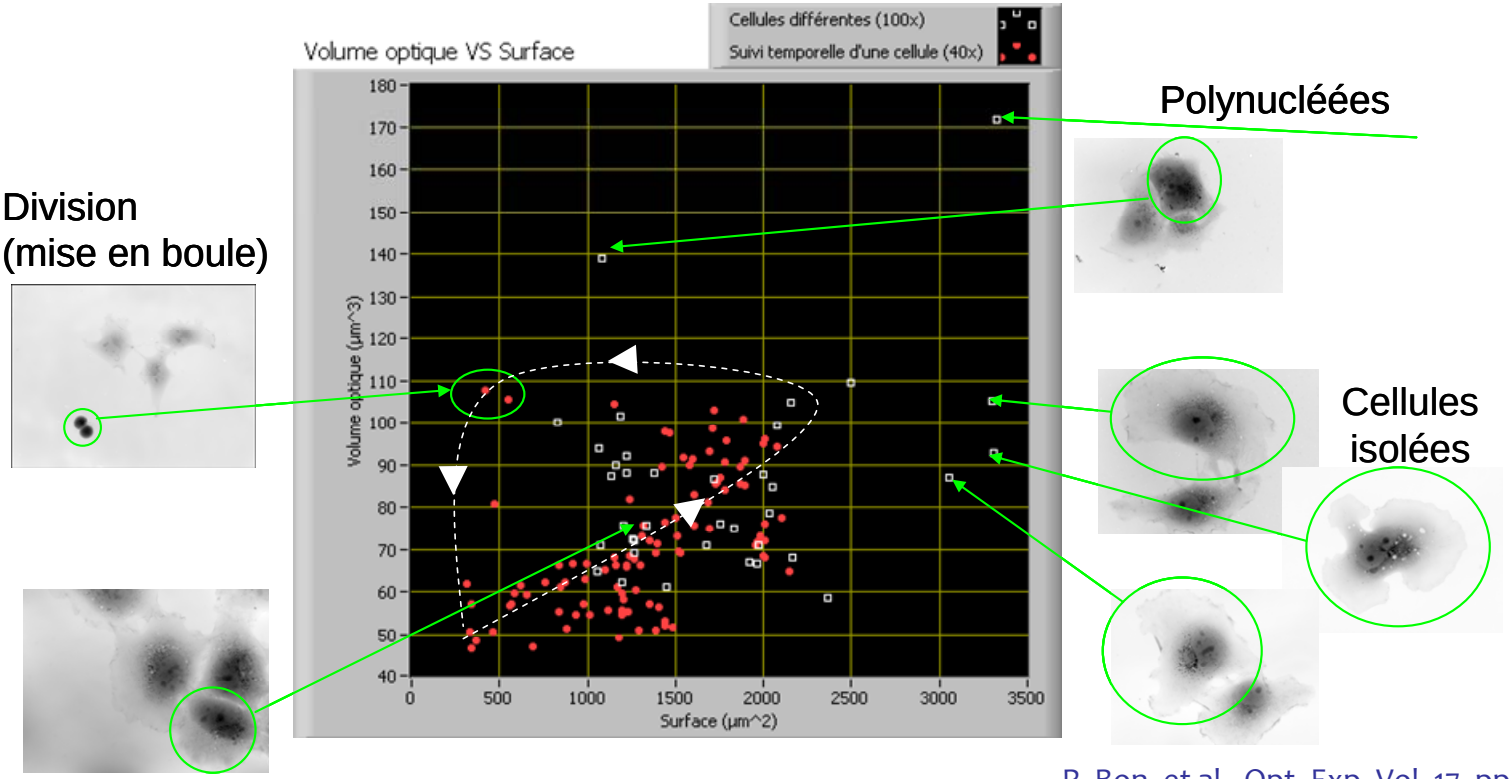


Reconstructed phase

Cell Imaging





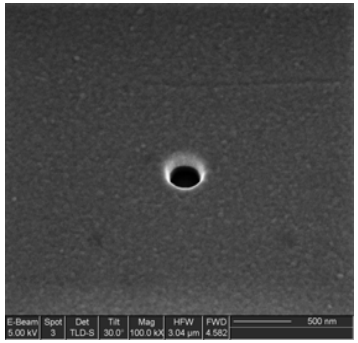


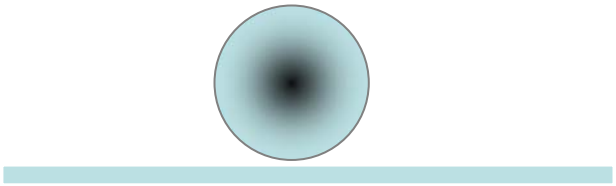
P. Bon, et al., Opt. Exp. Vol. 17, pp.13080 (2009)

Nano (Bio) Photonique

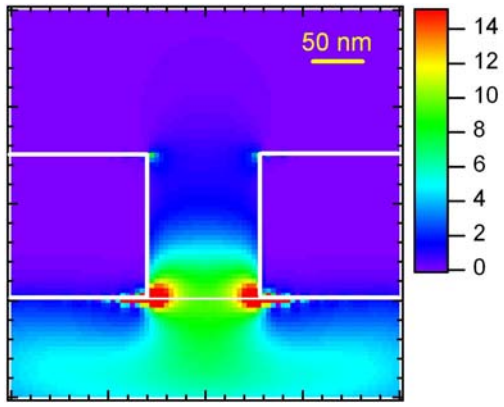
Collaboration: CLARTE – Modélisation : 10 publications communes

J. Wenger
S. Brasselet
P. Ferrand
P.-F. Lenne
H. Rigneault

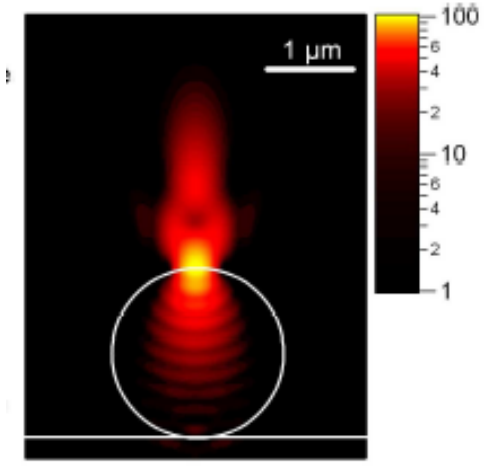


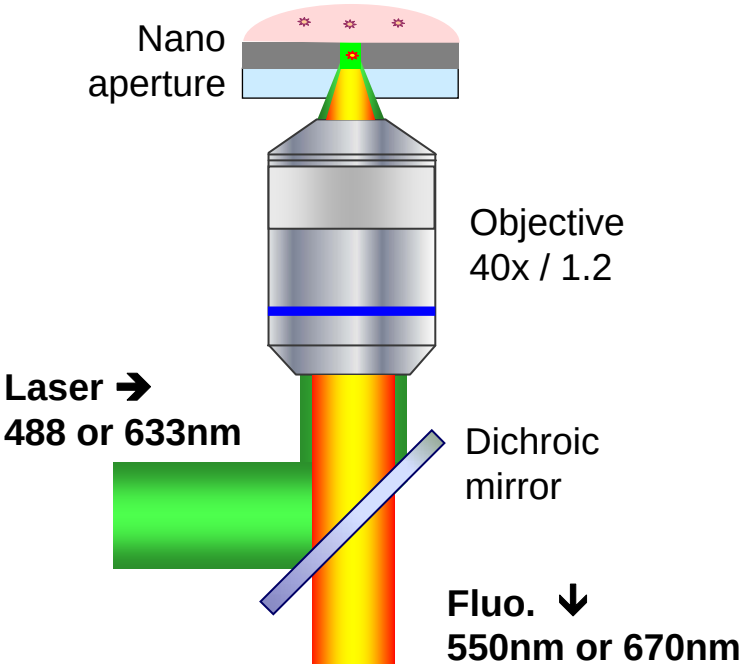


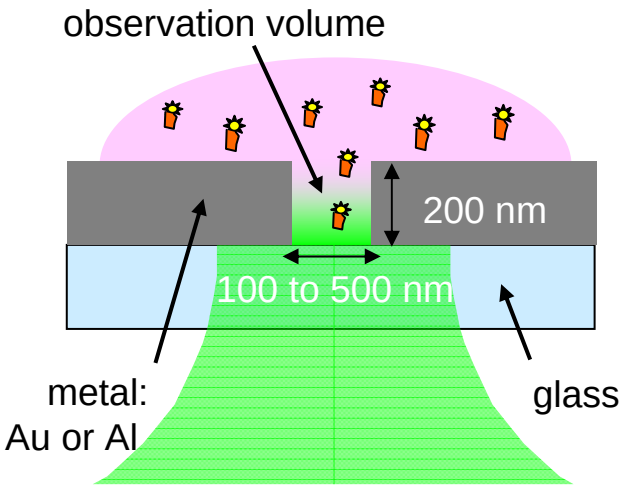
Nanohole in metal film

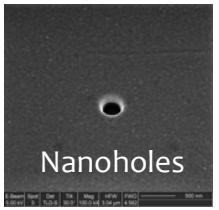


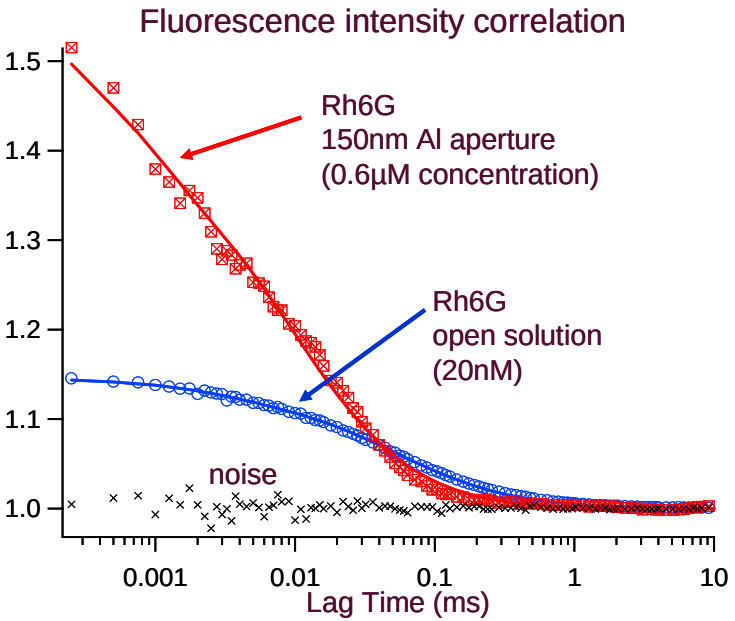
Dielectric Microbeads



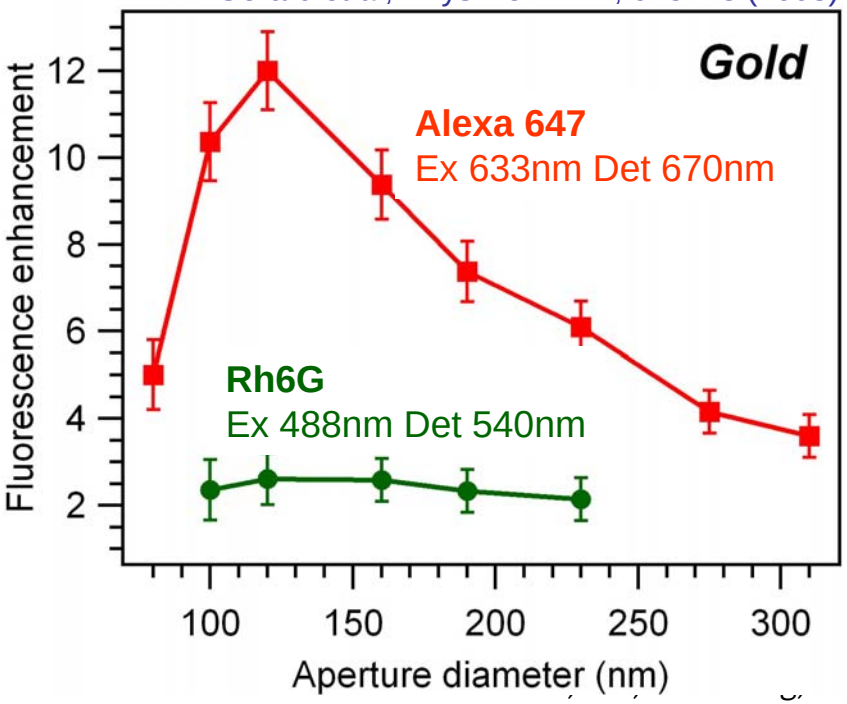




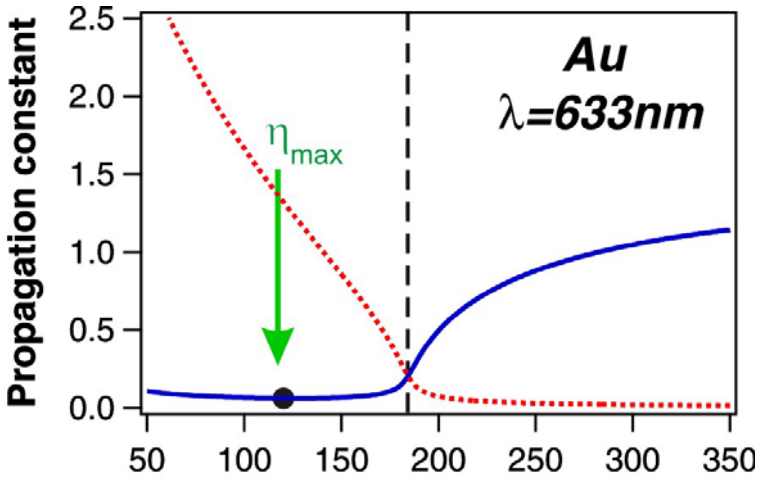




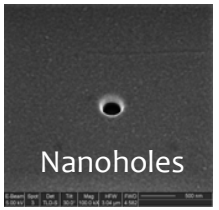
Gérard *et al*, Phys Rev B **77**, 045413 (2008)



Fundamental



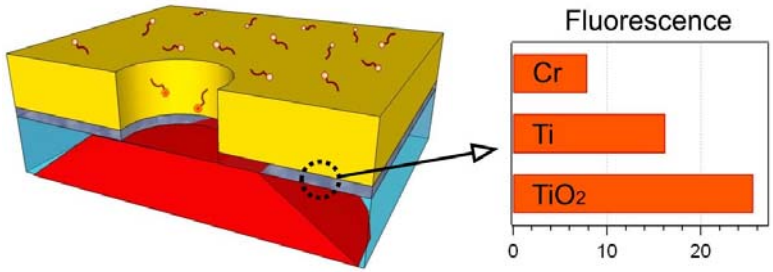
Nanoaperture ⟺ Waveguide

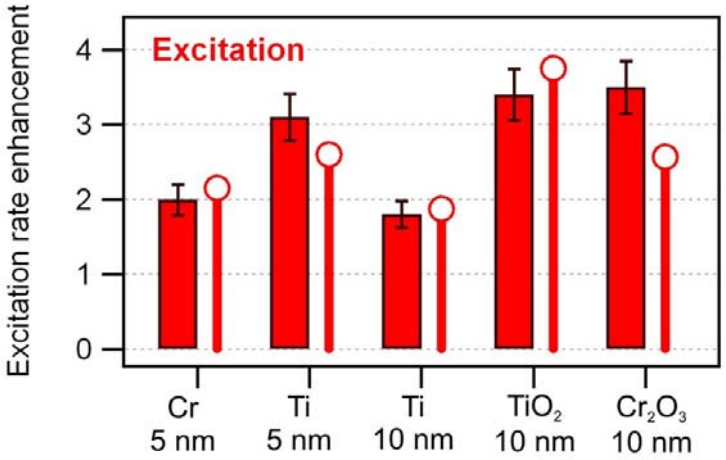


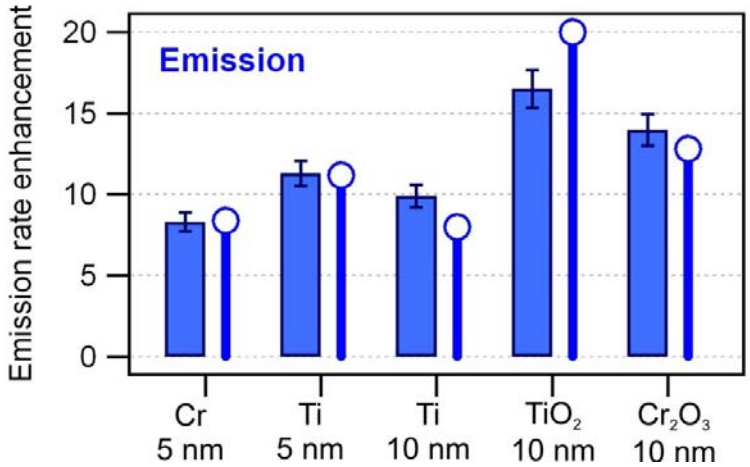
Propagation constant of the guided mode inside the aperture

Dashed lines = cut-off position
Black dots = minimum of the group velocity

Adhesion Layer

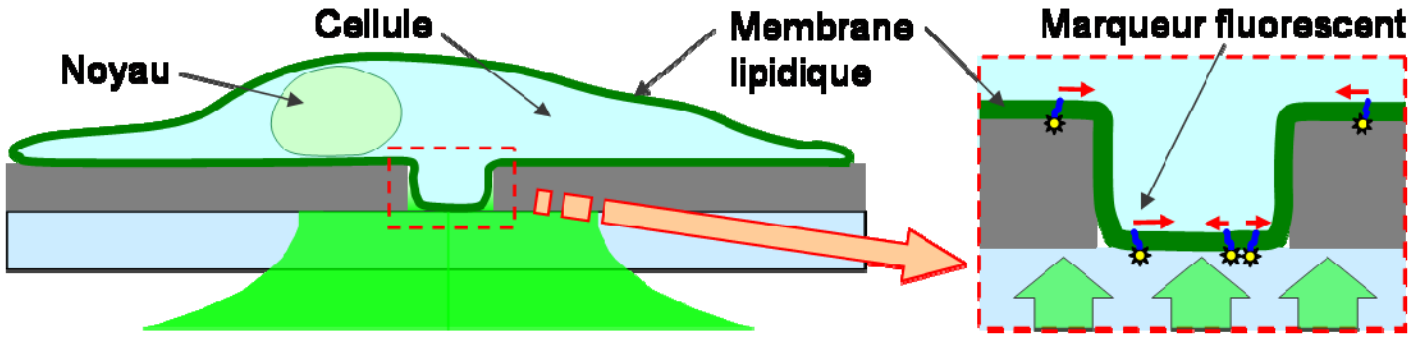


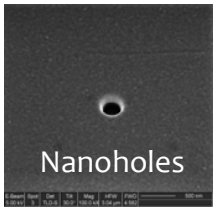


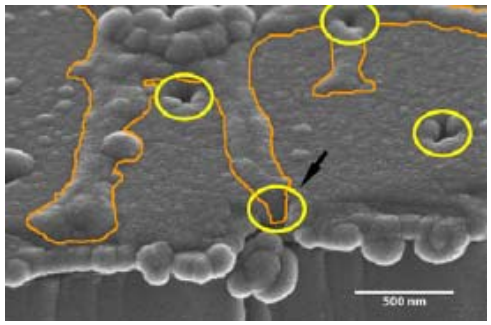


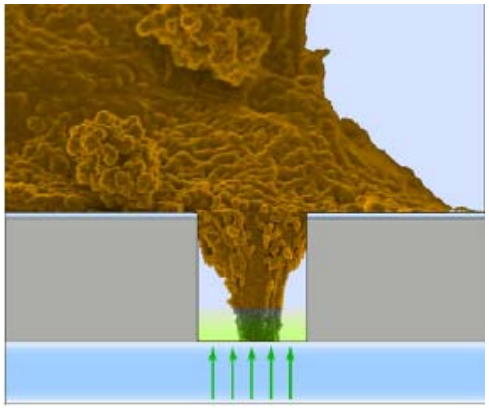
H. Aouani et al., ACS Nano, 3, 2043–2048, (2009)

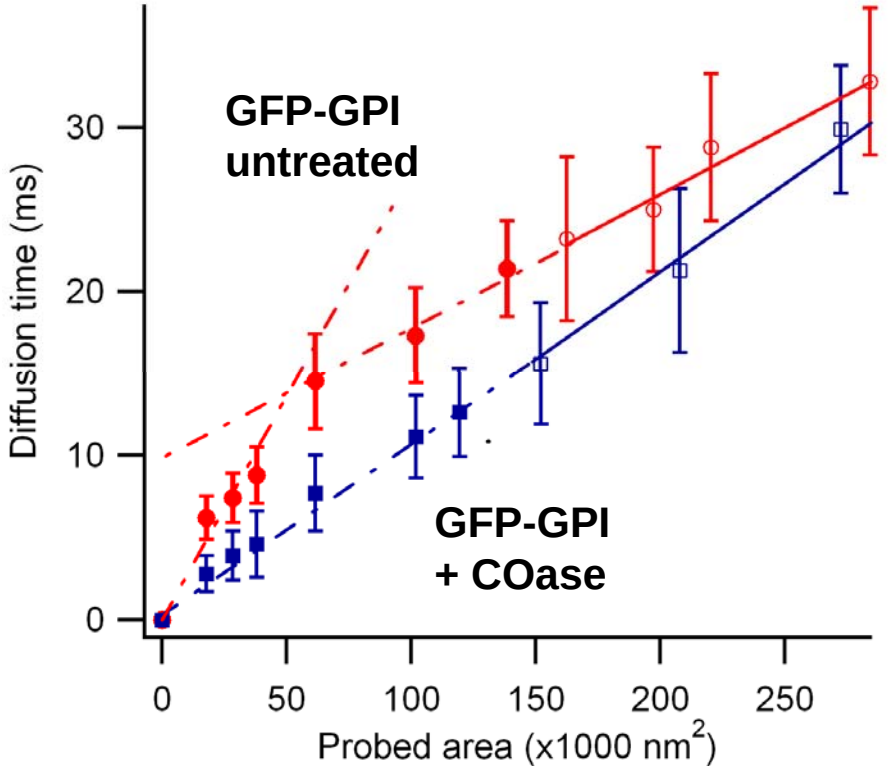
Cell membrane dynamics at nanoscale





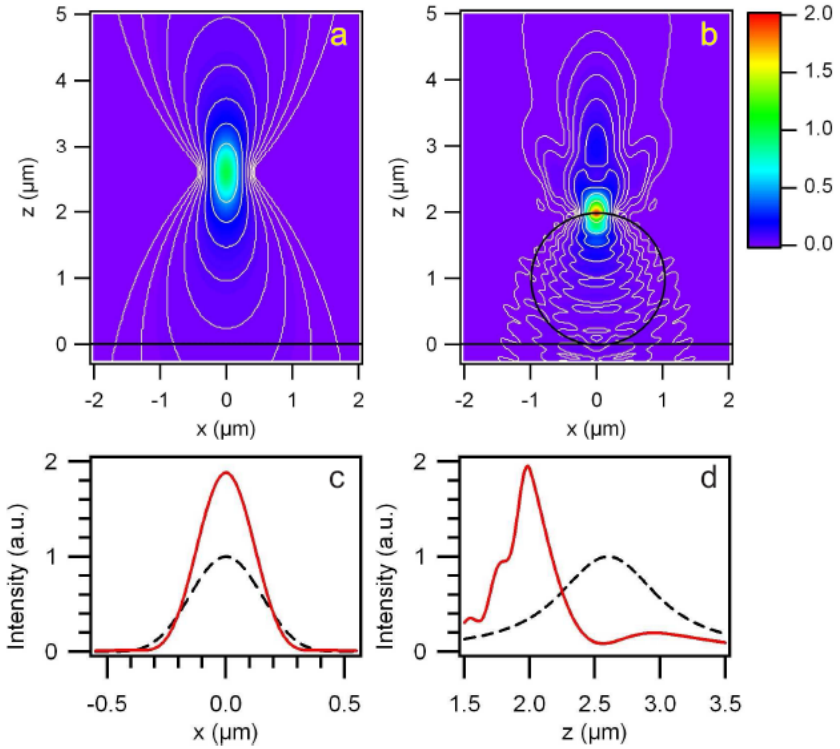


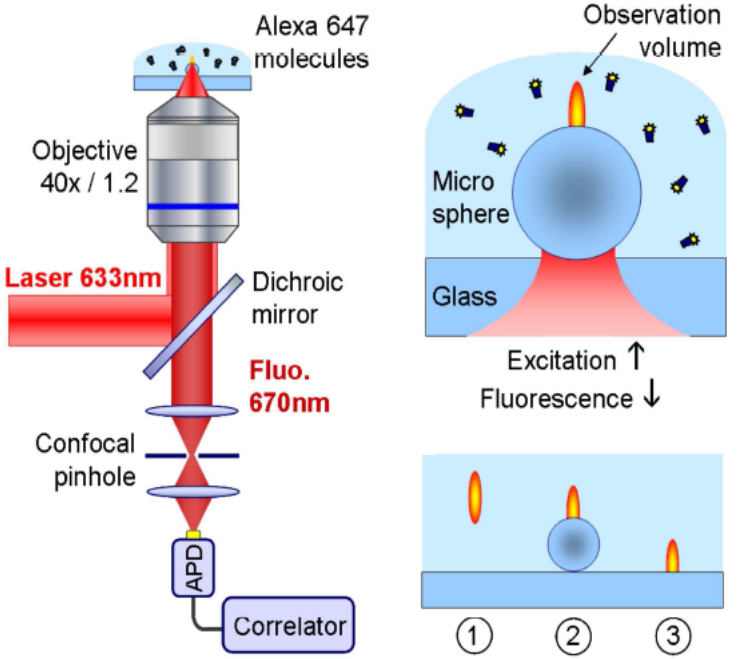


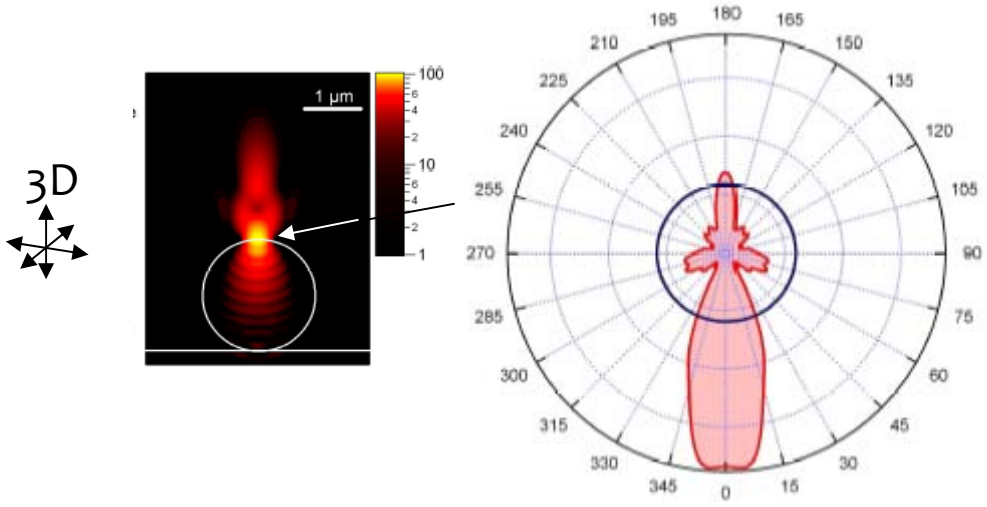


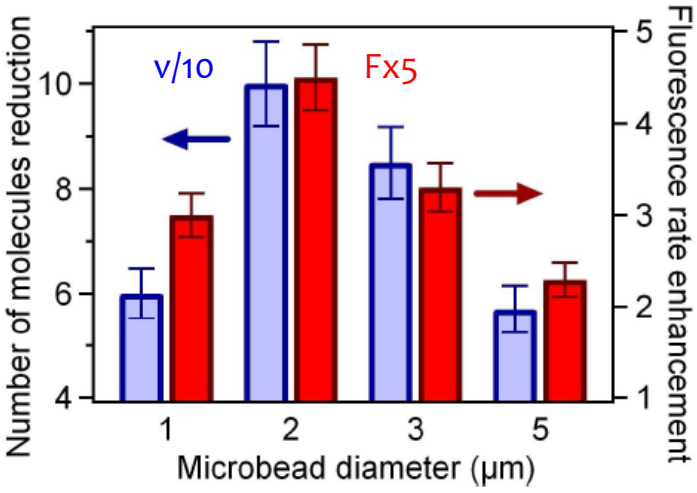
Wenger *et al*, Biophys J **92**, 913 (2007)

Enhanced molecular detection with microsphere



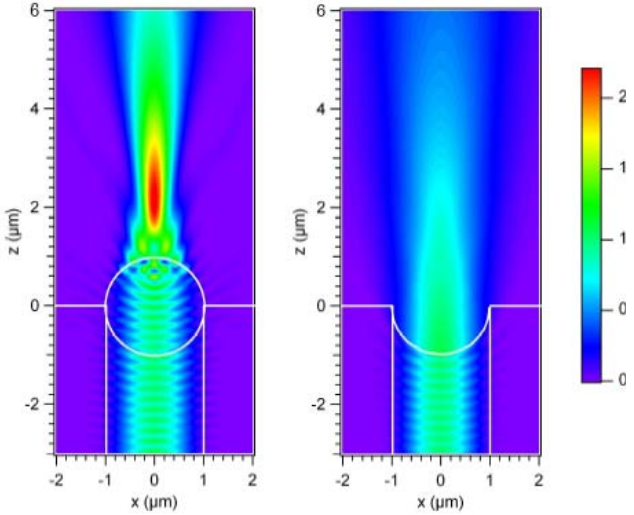


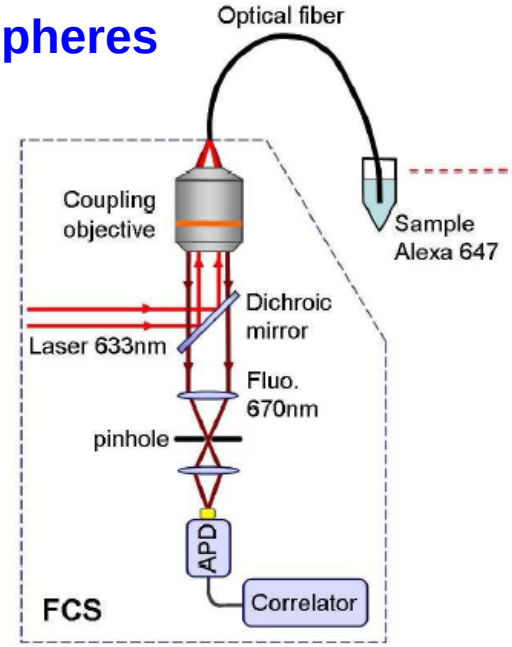


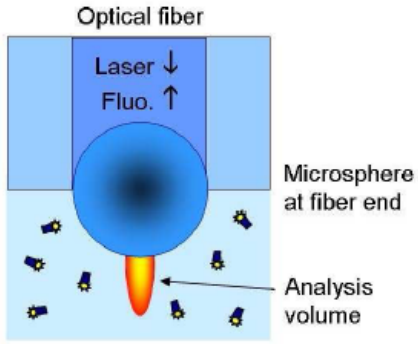


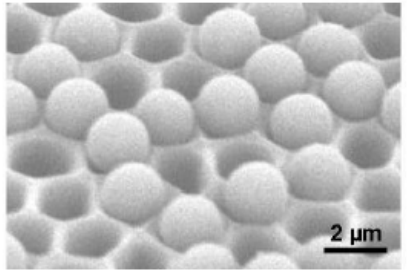
Gérard *et al*, Opt Express **16**, 15297 (2008)
Gérard *et al*, JOSA B **26**, 1473 (2009)
Brevet CNRS 852487 /FR

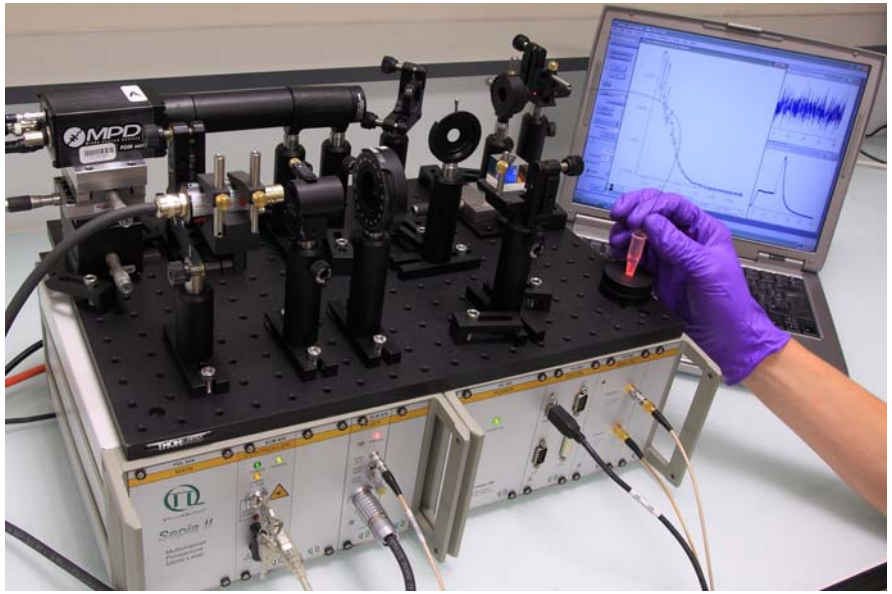
Remote molecular detection with microspheres



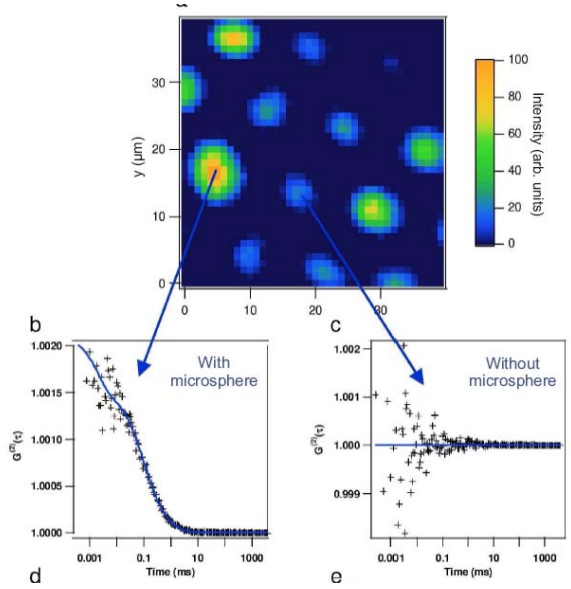








Collaboration with Neso Sojic ENSCP Bordeaux



Aouani, Opt Expr 17,18912(2009)
Brevet CNRS 107045/FR

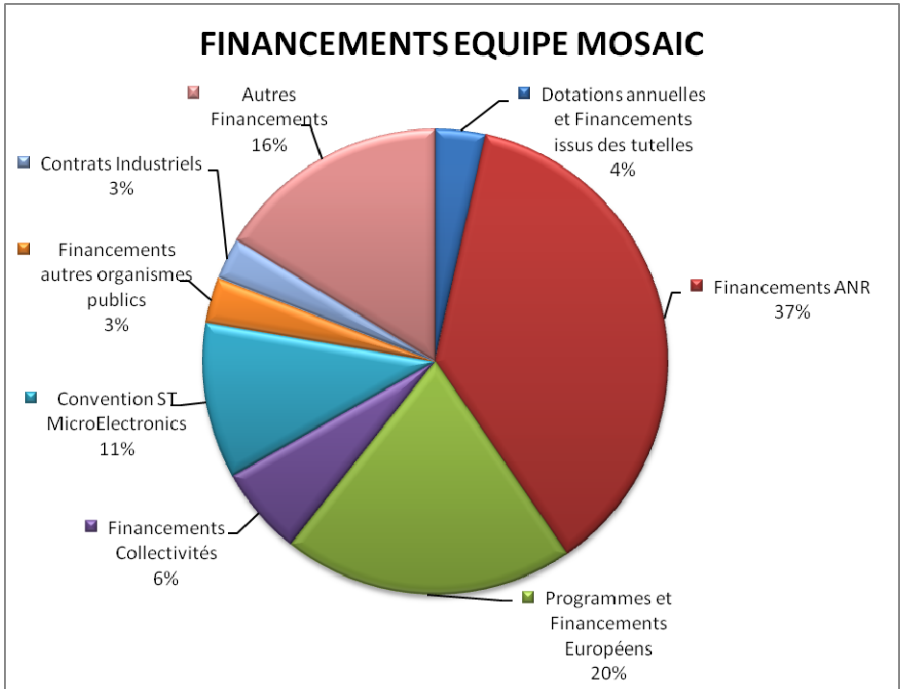
Production Scientifique

• **ACL**	*(Articles dans revues internationales ou nationales avec comité de lecture)*	**75**
• **ASCL**	*(Articles dans revues internationales ou nationales sans comité de lecture)*	**2**
• **INV**	*(Conférences données à l'invitation du Comité d'organisation)*	**50**
• **ACTI**	*(Communications avec actes dans congrès international)*	**9**
• **COM**	*(Communications orales sans actes dans congrès international ou national)*	**122**
• **OS**	*(Ouvrages scientifiques - ou chapitres de ces ouvrages -)*	**4**
• **AP**	*(Autre Production ou Média)*	**1**
• **B**	*(Brevets, Licences, Logiciels)*	**10**

Recettes

Récapitulatif des Financements

Dotations Annuelles et Financements issus des Tutelles	**119 004 €**
Financements ANR	1 251 741 €
Programmes et Financements Européens	687 346 €
Financements Collectivités	209 274 €
Financements Autres Organismes Publics	107 640 €
Contrats Industriels	98 282 €
Autres Financements	551 183 99 €
TOTAL	**3 391 645 €**



Financeurs principaux

Collaborations

- **14 Collaborations nationales**
  - Centre d'Immunologie de Marseille Luminy (CIML) – (Europe FP7 / ANR / INCA / Région PACA / Industrie)
  - Institut de Biologie de Développement de Marseille Luminy (IBDML) – (Europe FP7 / ANR/ Human frontier)
  - LPQM Cachan – (CNRS Weizmann NaBi LEA)
  - ISIS Strasbourg – (ANR)
  - ENS Lyon – (ANR)
  - ENSCP Bordeaux – (Valor Aquitaine)
  - UTT Troyes – (ANR)
  - ICB Dijon – (ANR)
  - FemtoST Besançon – (ANR / PEPS CNRS)
  - LTM Grenoble – (ANR)
  - Univ Paris VI et Paris VII – (ANR)
  - LPN Marcoussis – (ANR)
  - LP3 Marseille – (Région PACA / PEPS CNRS)
- **5 Collaborations internationales**
  - *Weizmann Institut of Sciences – Israel* - (CNRS Weizmann NaBi LEA)
  - *Univ Stuttgart – Allemagne – (Europe FP7)*
  - *Univ Bath – Royaume Uni – (Europe FP7)*
  - *Univ Seoul – Korée – (EGIDE)*
  - *Univ Salt Lake City Utah – USA – (CNRS DRI)*
- ***5 Collaborations industrielles***
  - *ST Microelectronics – (Région PACA)*
  - *L'Oreal – (ANR)*
  - *Genewave –(ANR)*
  - *Phasics – (FUI)*
  - *Amplitude Systèmes – (ANR)*

Rayonnement

ORGANISATION DE CONFERENCES NATIONALES ET INTERNATIONALES

2 conférences nationales et 1 Ecole pré-doctorale

(Ecole prédoctorale 'Interactions Lumière Matière' – Les Houches / Journées GDR Ondes et Microscopie)

3 conférences internationales et 1 Ecole doctorale

-'Porquerolles Summer School on Plasmonics' en collaboration avec CLARTE, 13-17 Sept 2009

-'International Japanese American French Workshop on nanobiophotonics'

- '12th Carl Zeiss sponsored workshop on FCS and related methods'

-IESC Cargese France, 'MicroCARS : Raman and CARS microscopy'

PRIX ET DISTINCTIONS

P.-F. Lenne Feulgen prize 2009, Society for Histochemistry

OSEO Emerges 2009– Michael Maurin (PostDoc) -Federico Belloni(PostDoc) – Projet PixinBio

MEMBRES DE COMITES

Observatoire des Micro et Nano Technologies (OMNT) (2007-2010) (J. Wenger, S. Brasselet)

ANR comité de sélection (H. Rigneault)

Comité National section 08 (S. Monneret)

CNU 30 (S. Brasselet)

CS Univ UPCAM (P. Ferrand)

HdR – Thèses – Devenir Doctorants

- **Habilitations à diriger des Recherches soutenues : 1 (14/02/2007)**

Pierre-François Lenne (chercheur 2000-2008) dirige l'équipe "'Physical approaches to cell dynamics and tissue morphogenesis" à l'IBDML

P.-F. Lenne

- **Thèses en cours : 9**
- **Thèses soutenues entre 2006 et 2010 : 3**

THESARD

David GACHET (2008) – Maître de conférences à l'université de la Méditerranée (Marseille)

Matteo RAUZI (2009) – Post Doc EMBL Heidelberg – Allemagne

Martina PIANTA (2008) – Ingénieur R&D Entreprise d'énergie renouvelable (Eoliennes) - Bruxelles

Peter Schoen (2007-2010), Ingénieur R&D chez Carl Zeiss, Göttingen

POSTDOC

Federico BELLONI (2006 – 2009) – Créateur d'entreprise PixinBIO (startup émanant de l'équipe Mosaic)

Franck BILLARD (2006-2008) – Ingénieur de recherche au CNRS (IICB Dijon)

Benoit CLUZEL (2006-2007) – Maître de conférences Université Bourgogne

Davy GERARD (2006-2008) – Maître de conférence UTT Troyes

Sébastin MICHEL (2008-2009) – Ingénieur Bertin SA – Aix les Milles

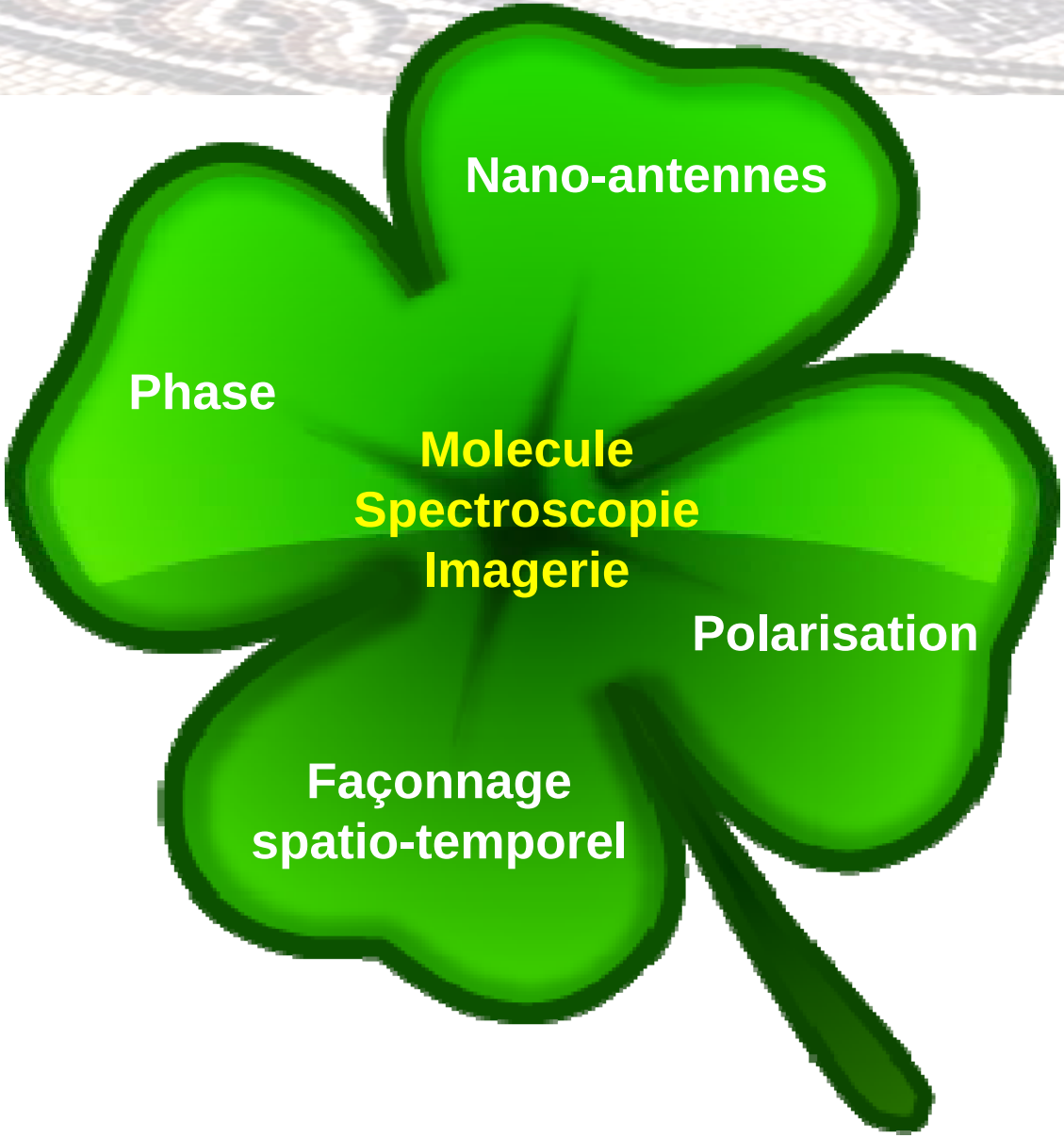
Michael MAURIN (2006-2009) – Responsable plateforme Biotechnologique GIGA Bruxelles

Pascale VERANT (2006-2007) – Professeur Agrégée en classe préparatoire – Marseille

Nadia DJAKER (2008-2009) – Maître de conférences à l'université Paris XIII

Richard Hostein (post-doc 2010) – Maître de conférences à l'université Pierre et Marie Curie - Paris VI

PROJET MOSAIC



PROJET MOSAIC

Nanophotonique et applications en biologie

J. Wenger

- Nano-antennes / guides et résonateurs plasmoniques pour exalter et contrôler la fluorescence

Aouani, NanoLetters (2011)

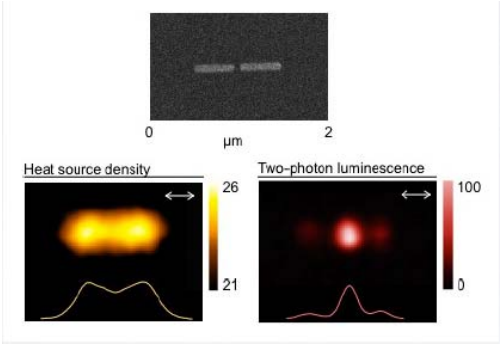
S. Brasselet

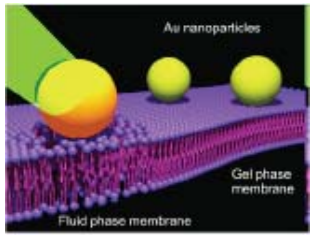
- Nano-particules metalliques pour génerer/exalter les signaux nonlinéaires et moléculaires

Shoen, Opt. Lett. 35, 4063 (2010)

G. Baffou

- Nano-particules metalliques pour contrôler la température localement





G. Baffou, Phys. Rev. Lett. (2010)

PROJET MOSAIC

Biophotonique et Imagerie

S. Brasselet

- Façonnage temporel d'impulsion pour l'imagerie et la spectroscopie non linéaire

P. Shön et al, Phys Rev A (2010)

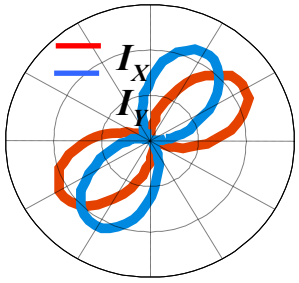
P. Ferrand

- Imagerie de fluorescence résolue en polarisation
- Microscopie à résolution isotrope (ISO)

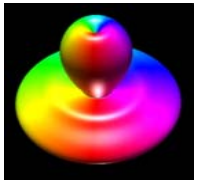
A. Kress et al, Biophys J soumis (2010)
E. Mudry et al, PRL (2010)

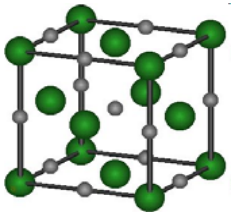
J. Duboisset

- Imagerie et spectroscopie non linéaire résolue en polarisation « De l'ordre moléculaire à l'ordre macroscopique »



$$\propto \left| \sum_{i_1 \ldots i_p} \chi^{(p)}_{I_0 \ldots I_p}(-\omega_\sigma; \omega_1, \ldots, \omega_p) E_{I_1}(\omega_1) \ldots E_{I_p}(\omega_p) \right|^2 \quad f(\Omega)$$





$\chi^{(p)}_{i_0 \ldots i_p}$

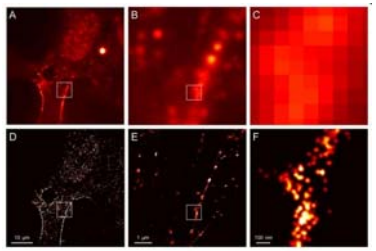
J. Duboisset at al., J. Phys. Chem B (2010)

PROJET MOSAIC

Biophotonique et Imagerie

S. Monneret

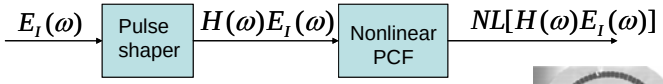
- Imagerie de phase pour la biologie — P. Bon et al, Opt. Expr. (2009)
- Ultra-résolution optique en champ large: d-STORM



direct **S**tochastic **O**ptical **M**icroscopy

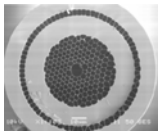
H. Rigneault

- Façonnage d'impulsion non linéaire pour la microscopie



E. Andressen et al, Opt. Expr. soumis (2010)

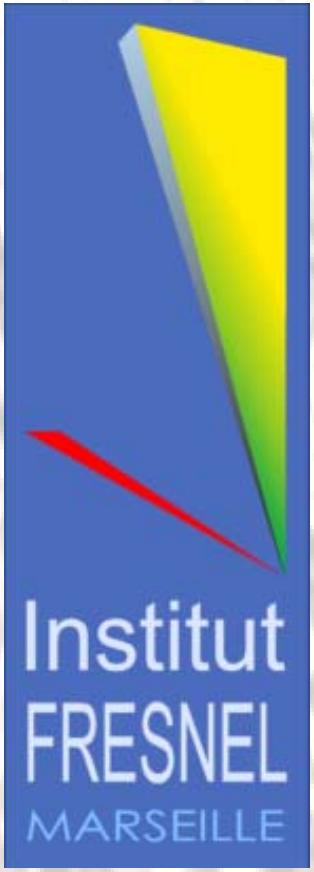
- Endoscopie non linéaire



S. Brustlein et al, PNAS soumis (2010)

P. Réfrégier

- Optimisation: Façonnage d'impulsion
- Traitements statistiques pour l'imagerie polarimétrique et l'ultra-résolution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