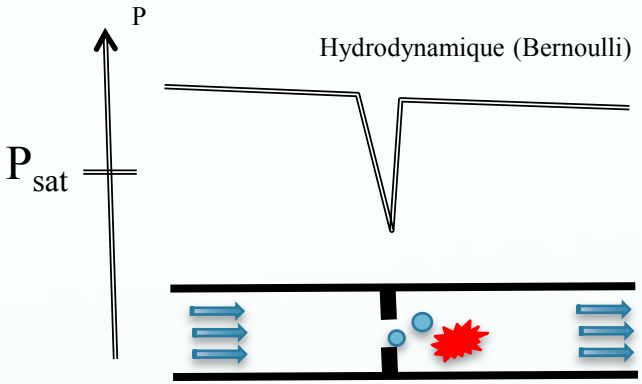
JSUP 2019

(Sono)luminescence et chimiluminescence en cavitation hydrodynamique ‘sur puce’

L. Perrin[a], D. Podbevsek[b], G. Ledoux[b], D. Colombet[a], N. Gondrexon[c], et F. Ayela[a]

[a] Laboratoire des Ecoulements Géophysiques et Industriels, Univ. Grenoble Alpes, CNRS.
[b] Institut Lumière Matière, Université Claude Bernard Lyon 1, CNRS.
[c] Laboratoire Rhéologie et Procédés, Univ. Grenoble Alpes, CNRS.

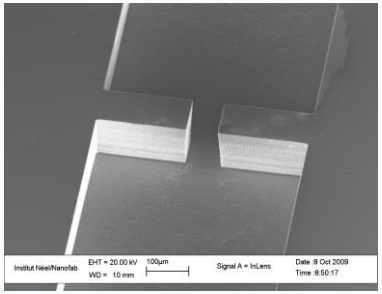
Cavitation hydrodynamique ‘sur puce’



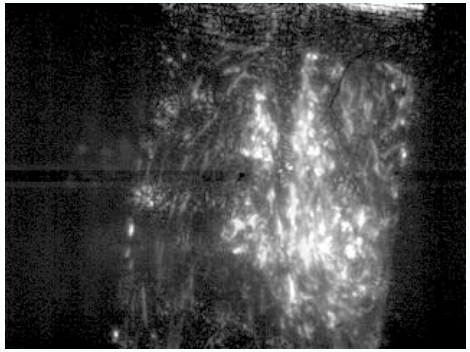
2005 : Y. Peles *et al.* : cavitation dans circuits microfluidiques (hydrodynamique)

2009 ---> : F. Ayela *et al.* : cavitation dans circuits microfluidiques (hydro + thermodynamique)

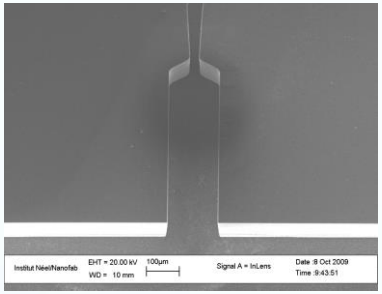
Différentes familles de réacteurs



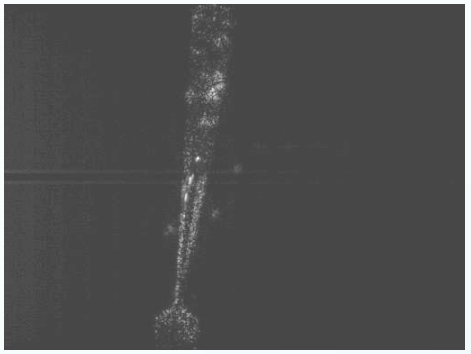
microdiaphragme

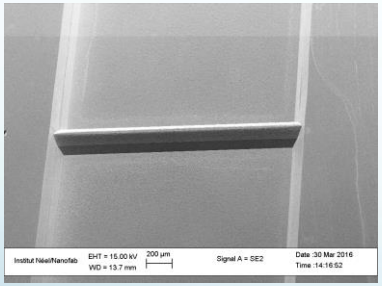


54000 fps

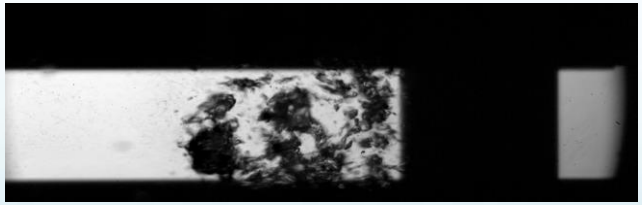


microventuri





micromarche



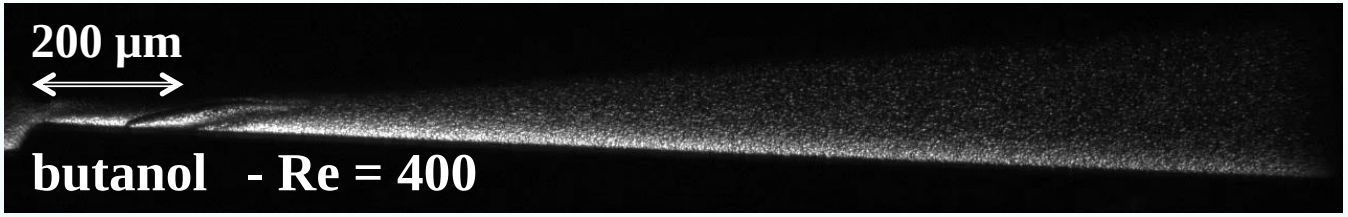
Ordres de grandeur : 5 bars < ΔP < 15 bars; 20 m/s < U < 35 m/s

Laboratoire sur puce

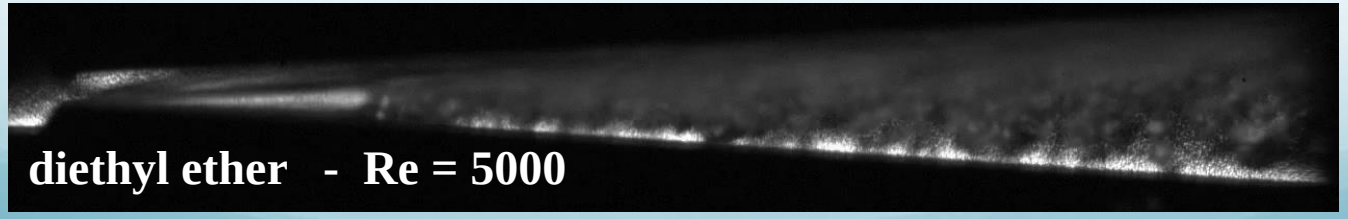
- **Expériences inaccessibles à macro-échelle**
- **Nouvelles perspectives pour cavitation hydrodynamique**

Condition pour cavitation en régime laminaire (Re < 2000) $\mathbf{D_h < \mu_l.Re/(2\rho_l P_{atm})^{1/2}}$

eau : $D_h < 140$ µm
butanol : $D_h < 630$ µm
éther : $D_h < 54$ µm



Total recording time : 4 ms 130000 frames / sec

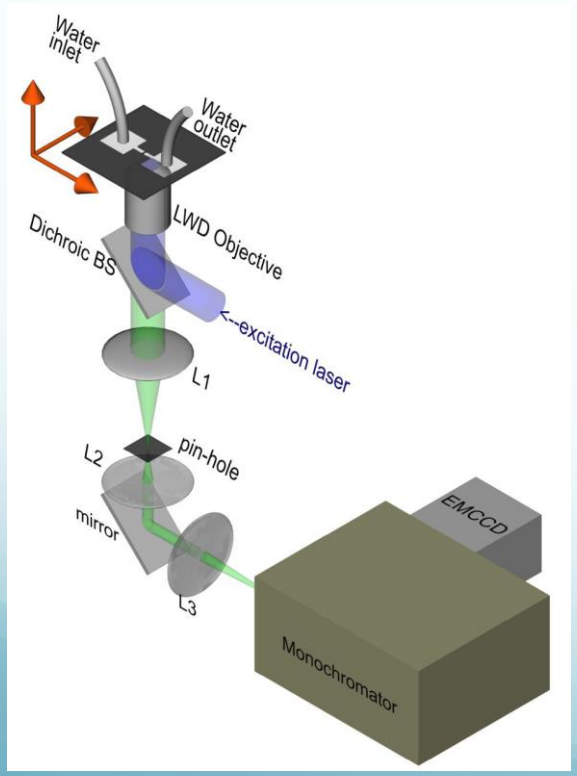


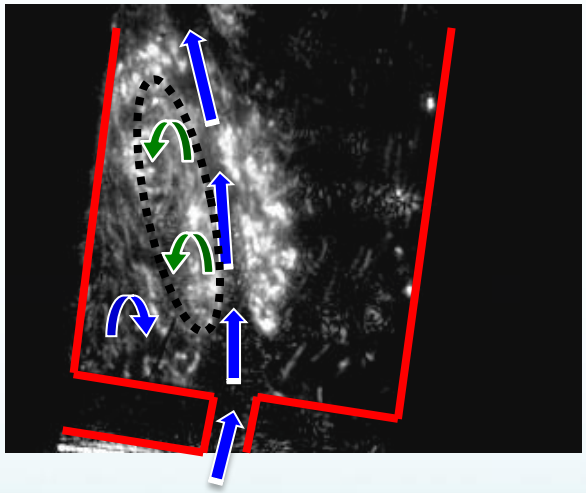
S. Mossaz et al. Exp. Therm. Fluid Sci. 80 (2017) 337-347

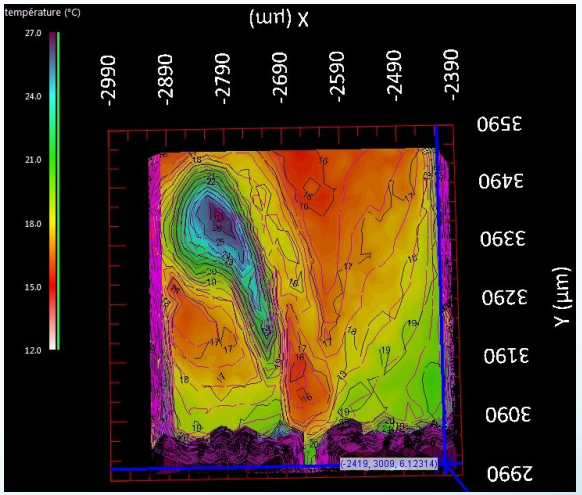
Laboratoire sur puce

- **Expériences inaccessibles à macro-échelle**
- **Nouvelles perspectives pour cavitation hydrodynamique**

→ Cartographie thermique par nanoparticules thermofluorescentes







F. Ayela et al., Phys. Rev. E **88**, 043016 (**2013**)

Luminescence & cavitation hydrodynamique

Peu de références

• 1964 : Jarman & Taylor : Light emission from cavitating water (venturi)
• 1967 : Peterson & Anderson : Light emission from hydrodynamic cavitation (venturi)
• 1970 : Knapp, Daily & Hammitt (stations hydroélectriques)
• 1986 : van der Meulen : corrélation entre bruit, érosion et luminescence
• 1999 : Weninger, Camara & Putterman : Energy focusing in a converging fluid flow : implications for sonoluminescence (venturi, xénon)
• 2003 : Leighton et al. : Cavitation luminescence from flow over a hydrofoil in a cavitation Tunnel
• 2011 : Farhat et al. : Luminescence from hydrodynamic cavitation (aile profilée)
• 2018 : Whitfield et al. : Cavitating flow luminescence as a potential source for analytical spectroscopy

Chimiluminescence & cavitation hydrodynamique

• 2016 : Schlender et al. : Sono-chemiluminescence in a high pressure double stage homogenization process
• 2018 : Podbevsek et al. : Observation of chemiluminescence induced by hydrodynamic avitation in microchannels

Production de radicaux OH° par cavitation hydrostatique ?

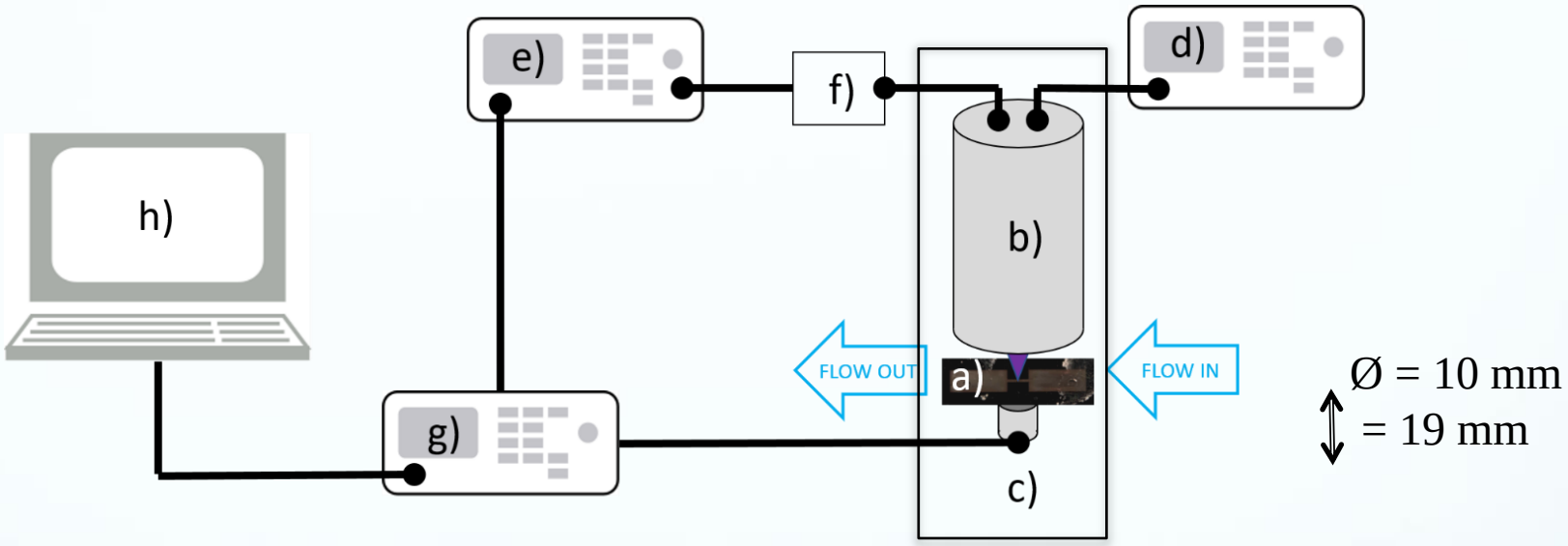
Luminol = fluide de travail (Renaudin 1994)

Comparaison luminescence et chimiluminescence

‘Laboratoire sur puce’ + luminol

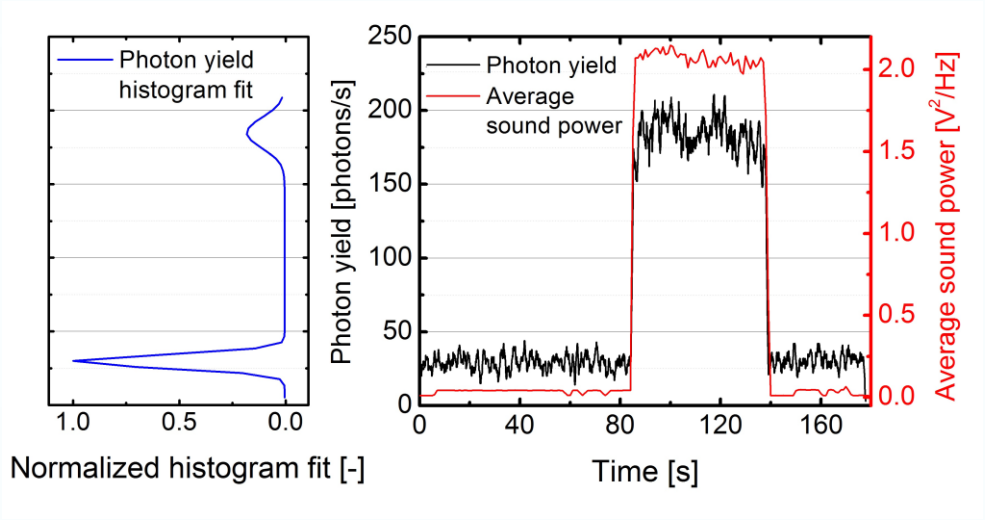
microdiaphragmes

ILM Lyon. Comptage de photons

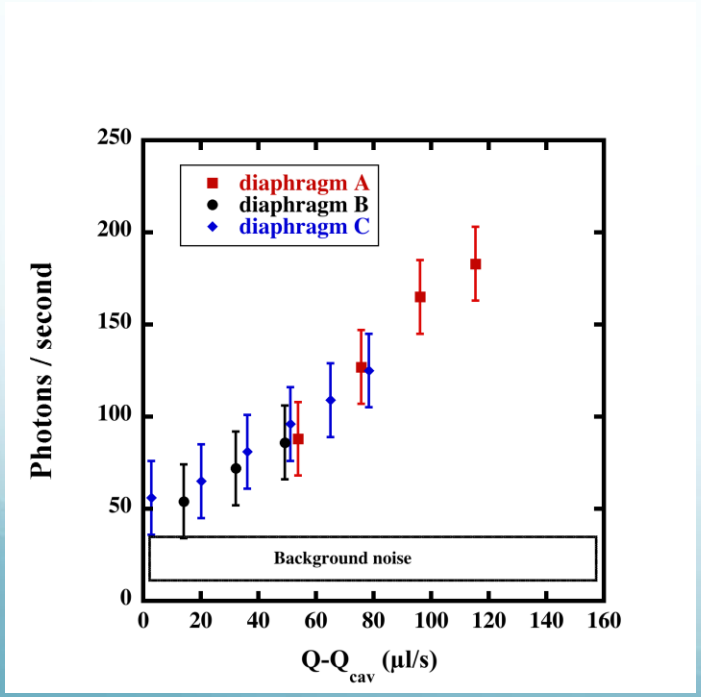


Experimental setup for the CL yield measurements via the photon counting technique. a) microchannel with the b) PMT placed on top and the c) microphone below. d) supplies the voltage to the PMT, f) preamplifier boosts the signal before the e) discriminator. Both signals are collected by the g) data acquisition card and sent to the h) computer.

Luminol 0,170 g /L ; ph = 11,6 (chimiluminescence)

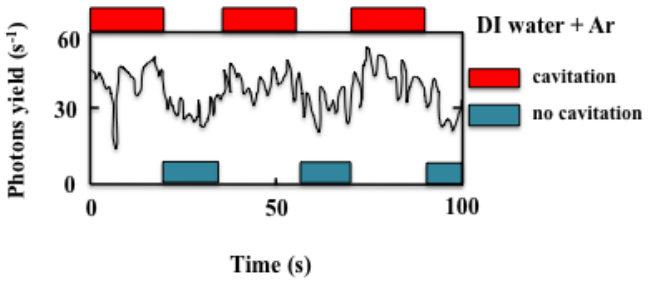


ΔP = 10bars



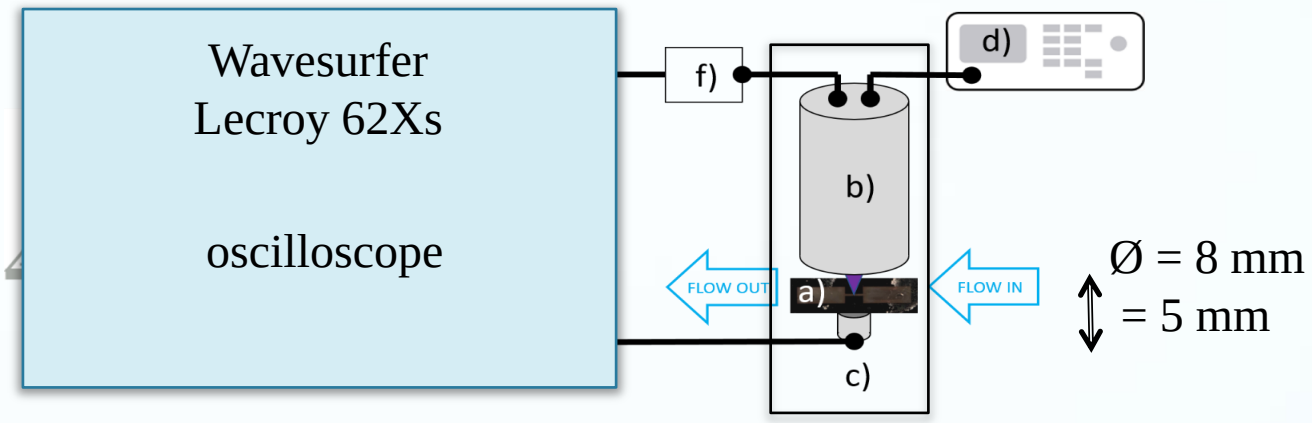
183 photons/s enregistrés < - > ≈ 75000 réels /s
1,36 L/h
1,6 10^{10} OH°/min/L

Luminescence : eau + Ar, $\Delta P = 10$ bars



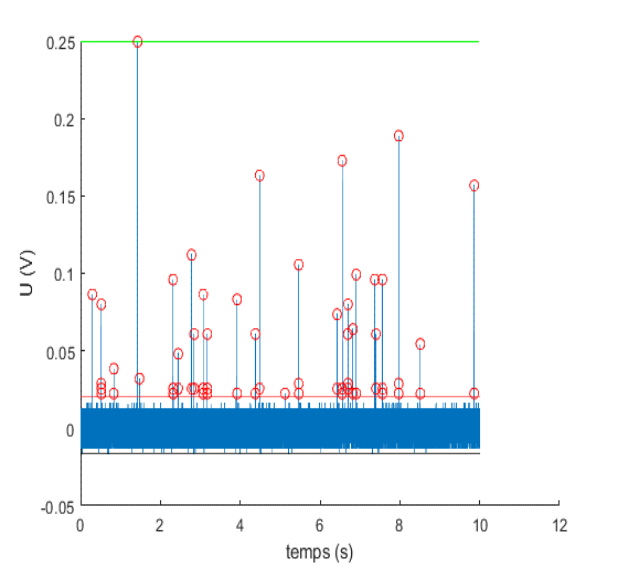
micromarche

LEGI Grenoble

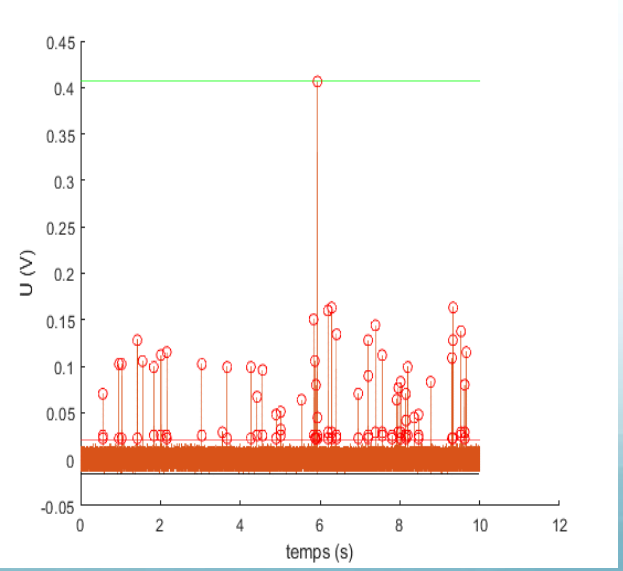


Cavitation à partir de ΔP = 5 bars, 10,8 L/h

Bruit électronique

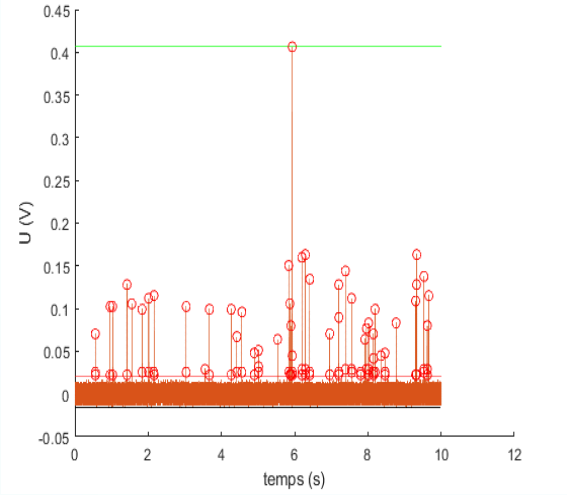


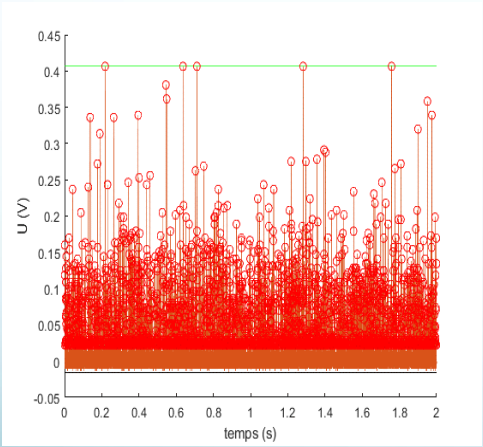
Ecoulement non cavitant



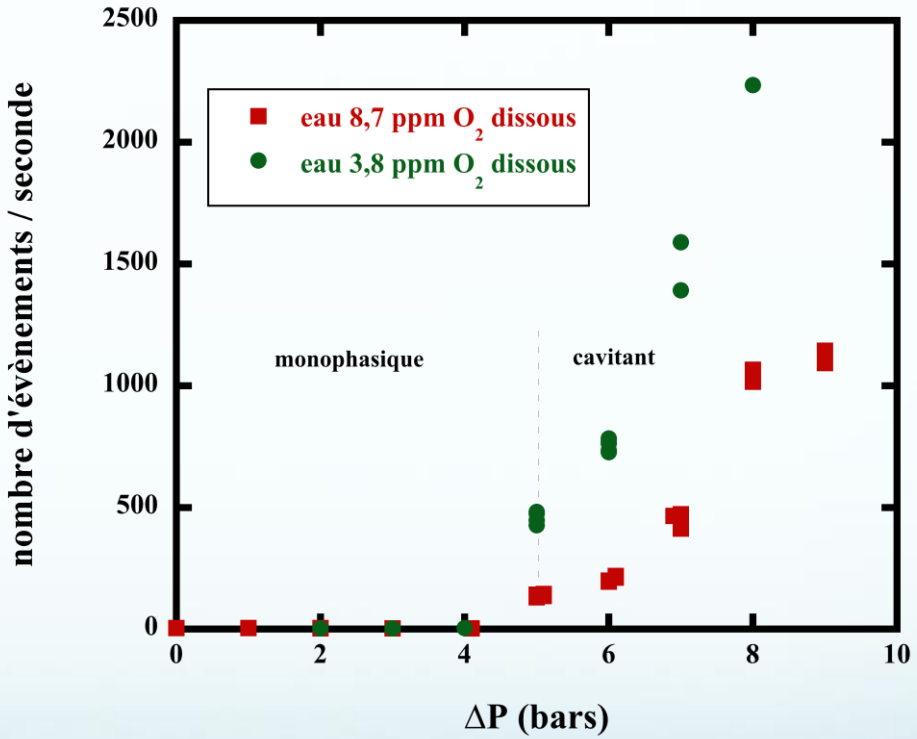
luminescence

Ecoulement non cavitant

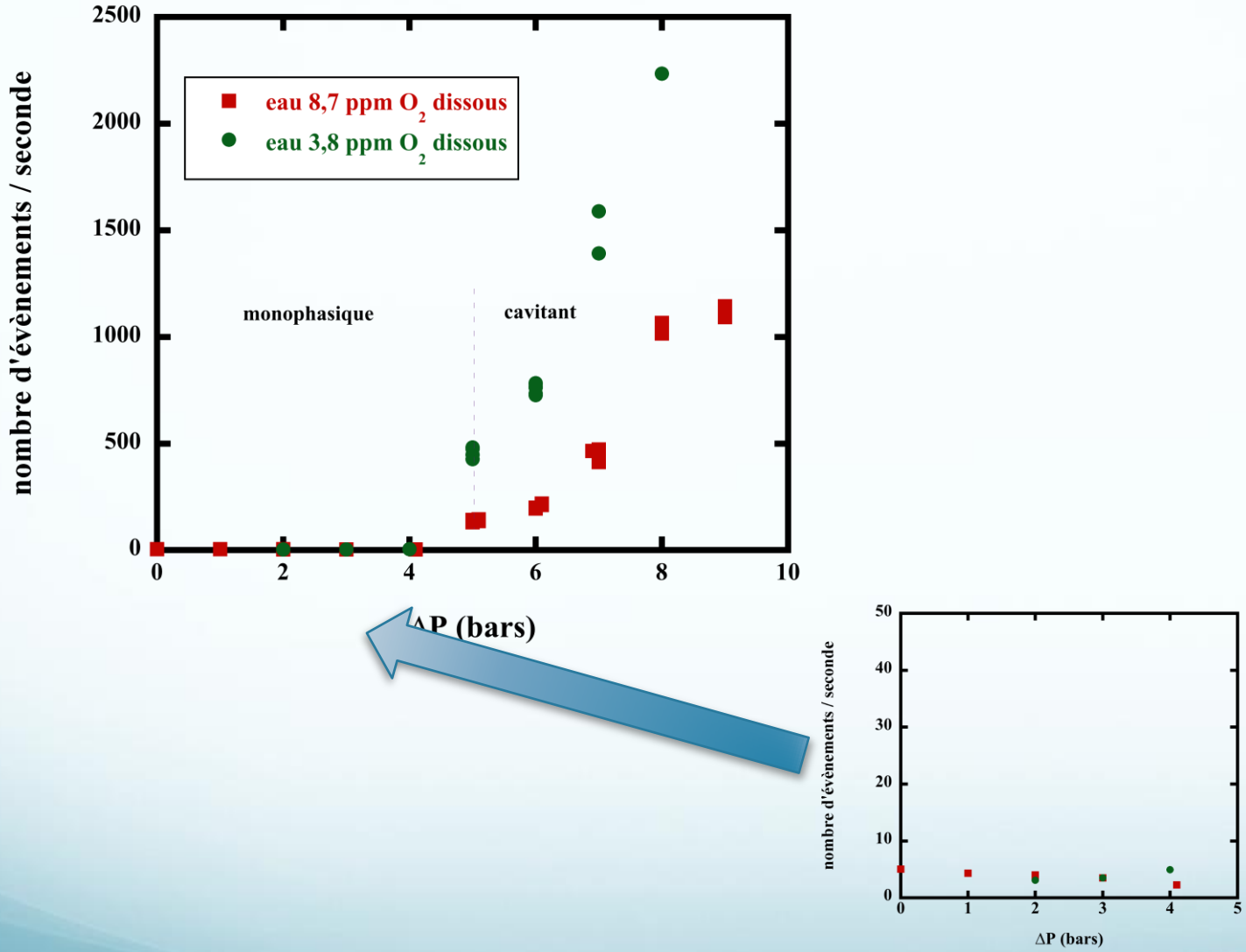




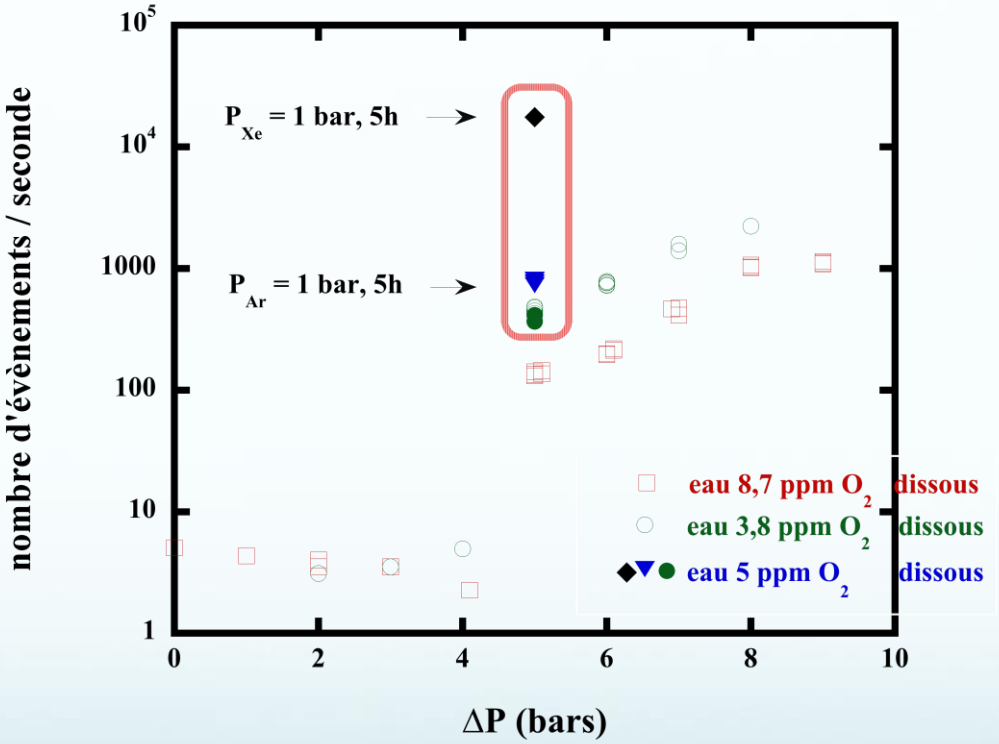
Ecoulement cavitant
ΔP = 9 bars; Q = 14,4 L/h



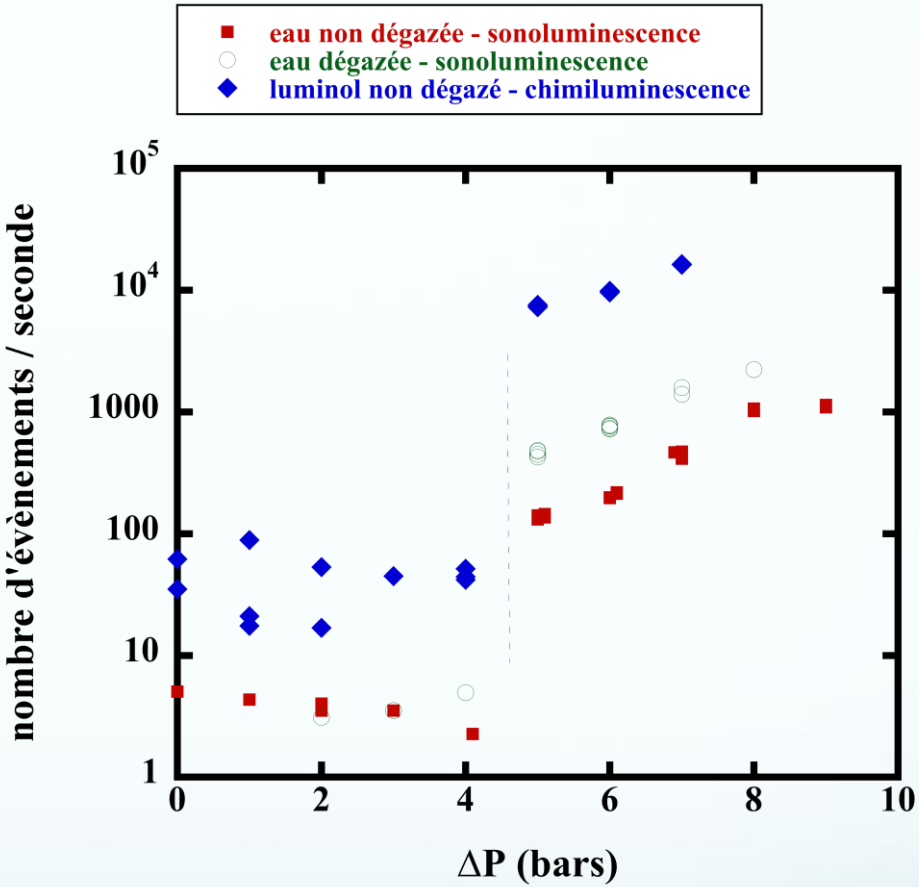
luminescence



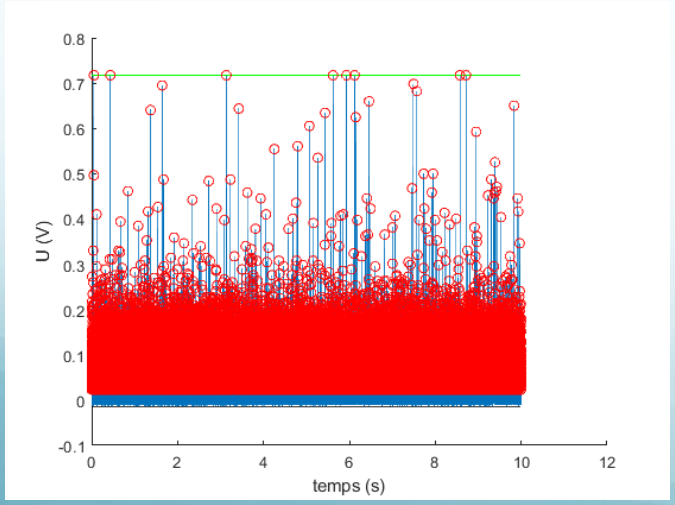
luminescence



Chimiluminescence du luminol



Mesures 14/05/19



Conclusion

- **2 expériences ≠ avec 2 µcanaux ≠ :**

luminol -> chimiluminescence

- **Observation luminescence et chimiluminescence**

sur une géométrie d'écoulement fixée

- **Futures actions :** **comparaison avec cavitation acoustique**

  influence facteurs d'aspect

  détermination production OH°

Remerciements : C.N.R.S. (PEPS) & TECXXI