

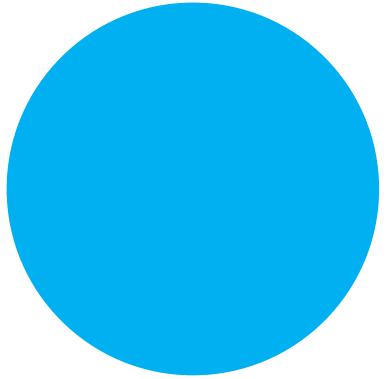


An **iXblue** product line

IPGP-Journée Géodésie 06/09/2018 - Frédéric Guattari

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- About rotational seismology
- Our next product dedicated to OBS



# About iXblue

# iXblue at a glance

An international high technology company

iXblue is an **independent French industrial group**,  
recognized worldwide for high-tech equipment devoted to:

- **Navigation**
- **Positioning**
- **Underwater imaging**



**600+**  
employees



**100+ M€**  
turnover



# iXblue, from FOG to vertical and horizontal development

Complete mastery of technology through [vertical integration](#)

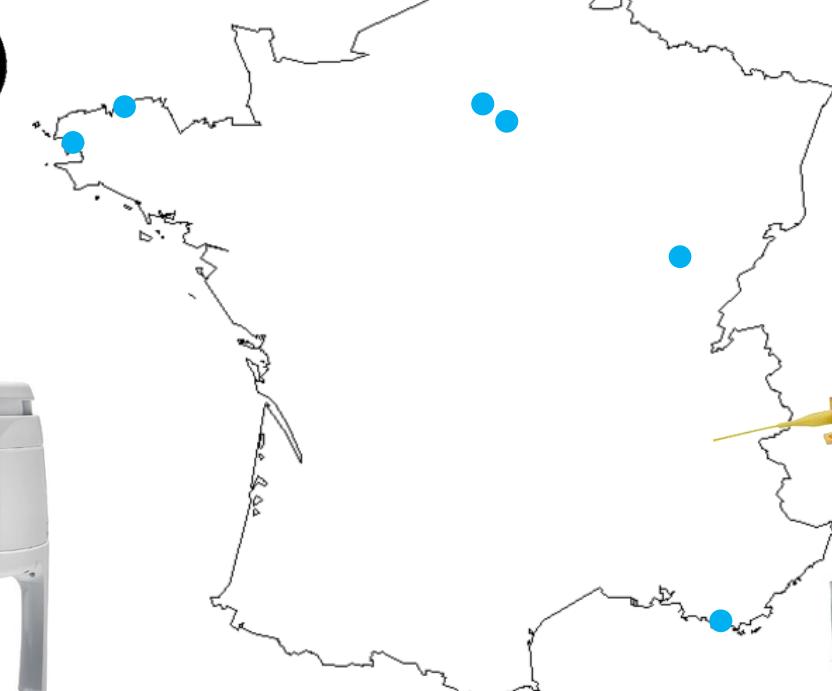
## 3 markets :

- Civil
- Defense
- Exploration



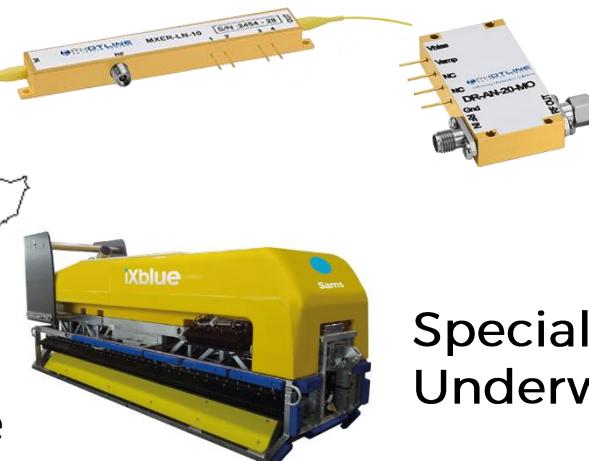
Navigation and positioning from submarine to satellite

Specialty fiber  
Optical components



Calibration table,  
pan-tilt

Acoustic  
release,  
transponders,  
and  
positioning



Specialty sonars,  
Underwater imaging

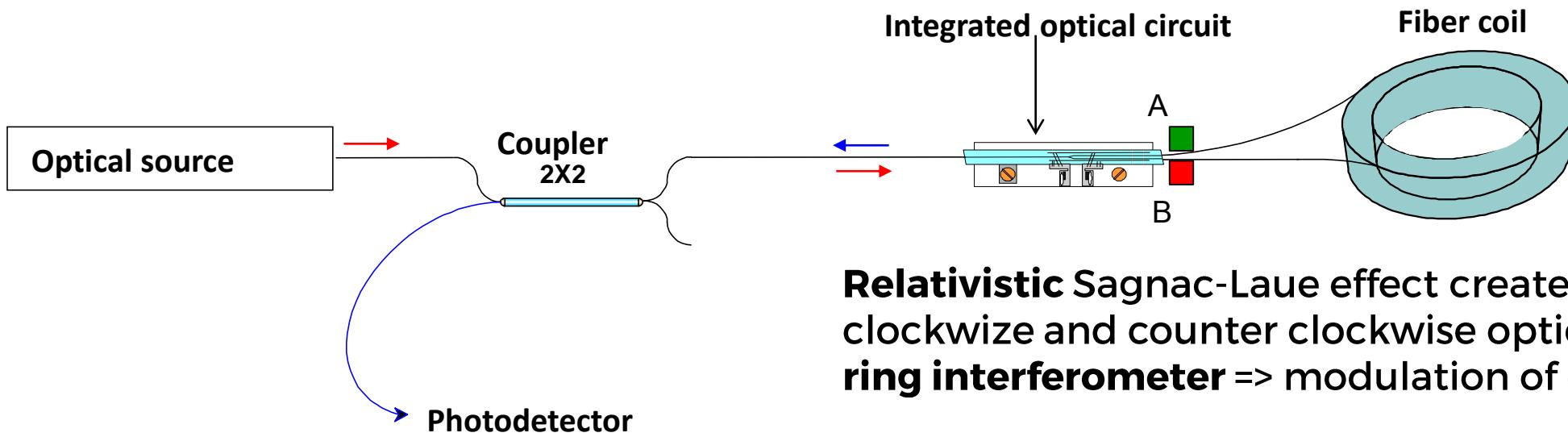


Optical circuit,  
RF driver

6 centers of excellence in France

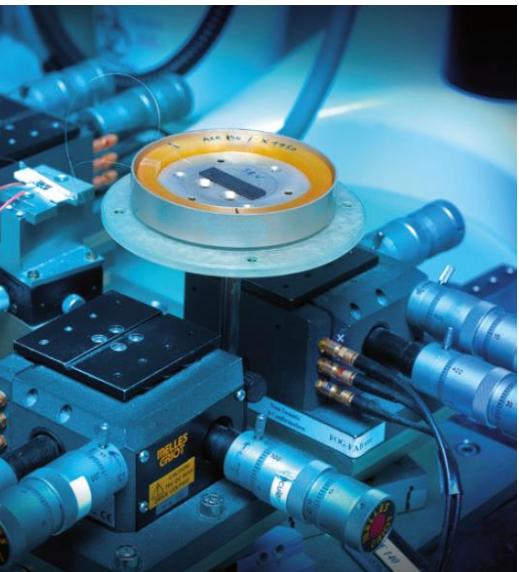
# A unique expertise recognized worldwide for high grade FOG

## Fiber-Optic Gyroscope (FOG)



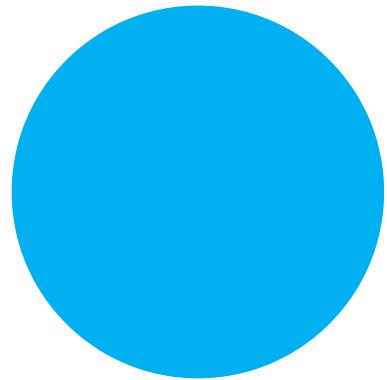
Integrated optical circuit

Fiber coil



**Relativistic Sagnac-Laue effect** creates a **delay** between clockwise and counter clockwise optical wave inside **ring interferometer** => modulation of optical intensity

- By using **massless particles** (photons) for the measurement, Fiber-Optic Gyroscope is entirely **insensitive to linear accelerations** and **no cross coupling** can happen.
- Moreover, there is **no moving part** except photons, it allows **maintenance free** and **small environment sensitivity**



# About rotational seismology

# blueSeis, a turning point in rotational seismology

Why is rotational seismology so crucial?

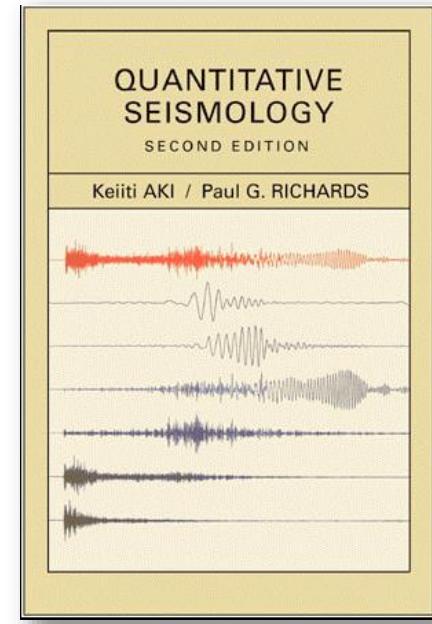
(1980)

“ The state-of-the-art **sensitivity** of the general rotation sensor is **not yet enough** for a useful geophysical application. ”

(2002)

“ [...] **note the utility** of measuring rotation near a rupturing fault plane [...] **but as of this writing seismology still awaits a suitable instrument** for making such measurements. ”

Aki and Richards, Quantitative Seismology



(2017)



**Rotational seismometer** product line,  
To make rotational seismology happen **on the field**,  
To allow **new sciences** and discoveries in **seism understanding**

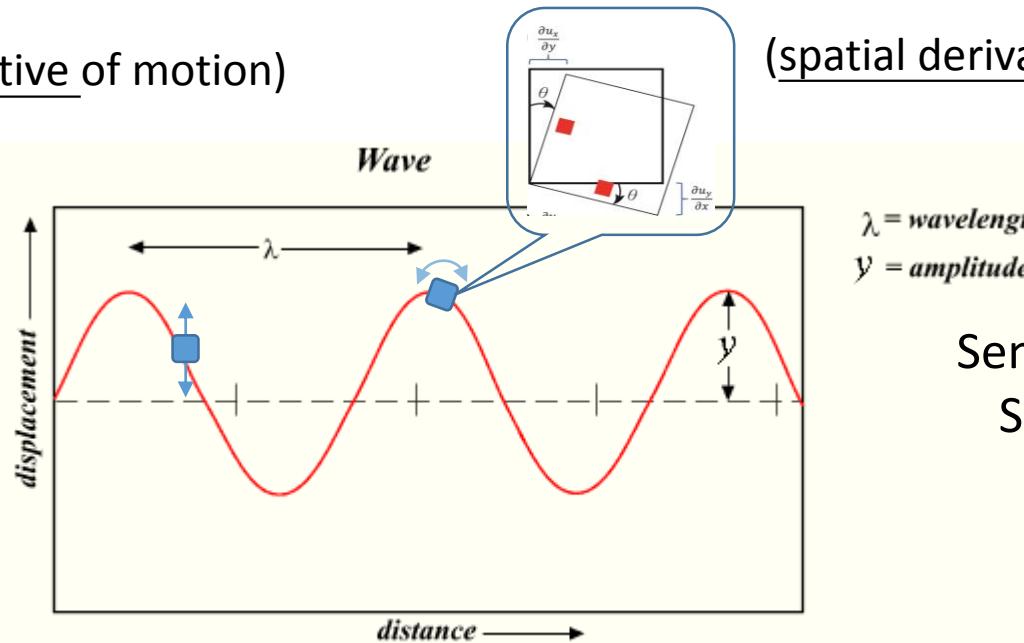
# Seismometer vs. rotation/strain



Sensitive to all wave types  
Sensitive to rotations  
(tilt-seismometer coupling)

$$\text{Seismometer} = \frac{\partial x}{\partial t}$$

**translation**  
(time derivative of motion)



Combine both information of seismometer and rotation we get **phase velocity**  $\frac{\partial s}{\partial t}$

$$\text{Rotation/strain} = \frac{\partial x}{\partial s}$$

(spatial derivative of motion)

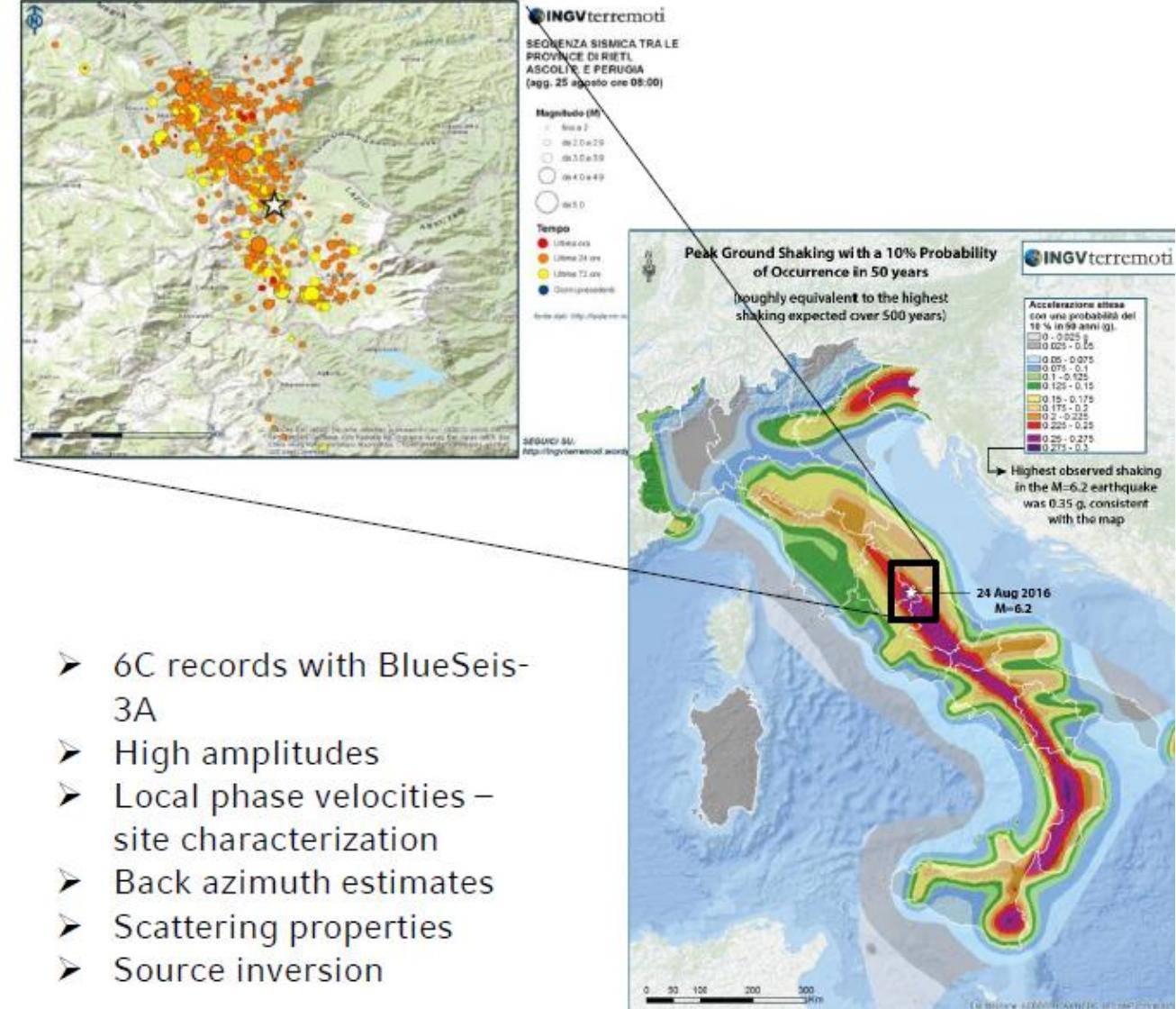
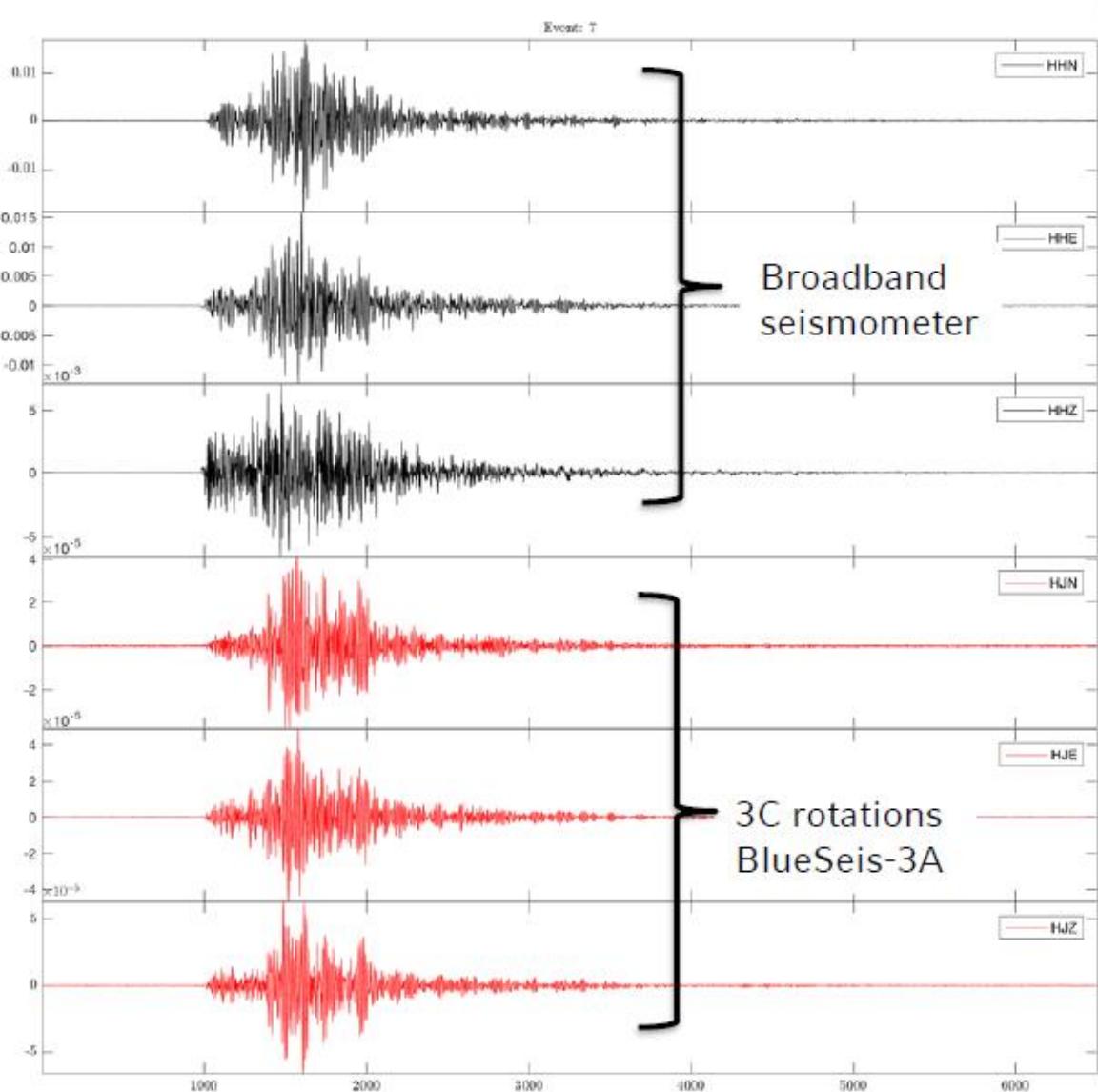
$\lambda$  = wavelength  
 $y$  = amplitude

Sensitive to S waves only (inside Earth)  
Separates Love and Rayleigh at the surface

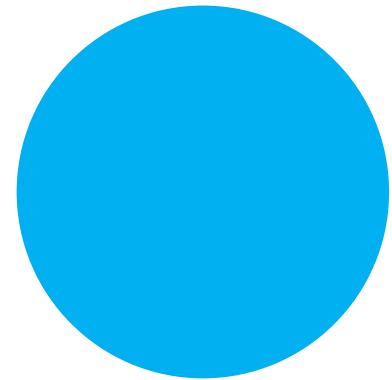


# Seismology : near-field earthquakes and volcanoes

blueSeis-3A makes the difference when you get close



- 6C records with BlueSeis-3A
- High amplitudes
- Local phase velocities – site characterization
- Back azimuth estimates
- Scattering properties
- Source inversion

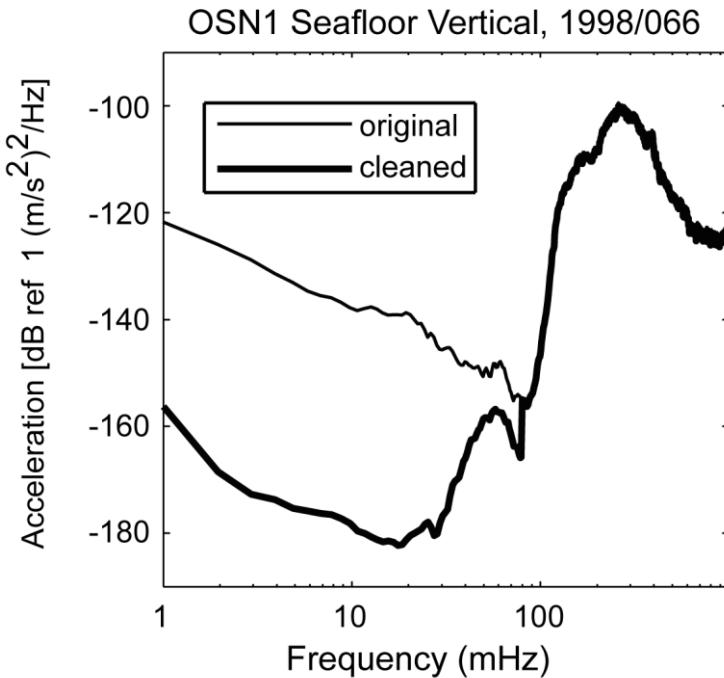


**Our next product  
dedicated to OBS**

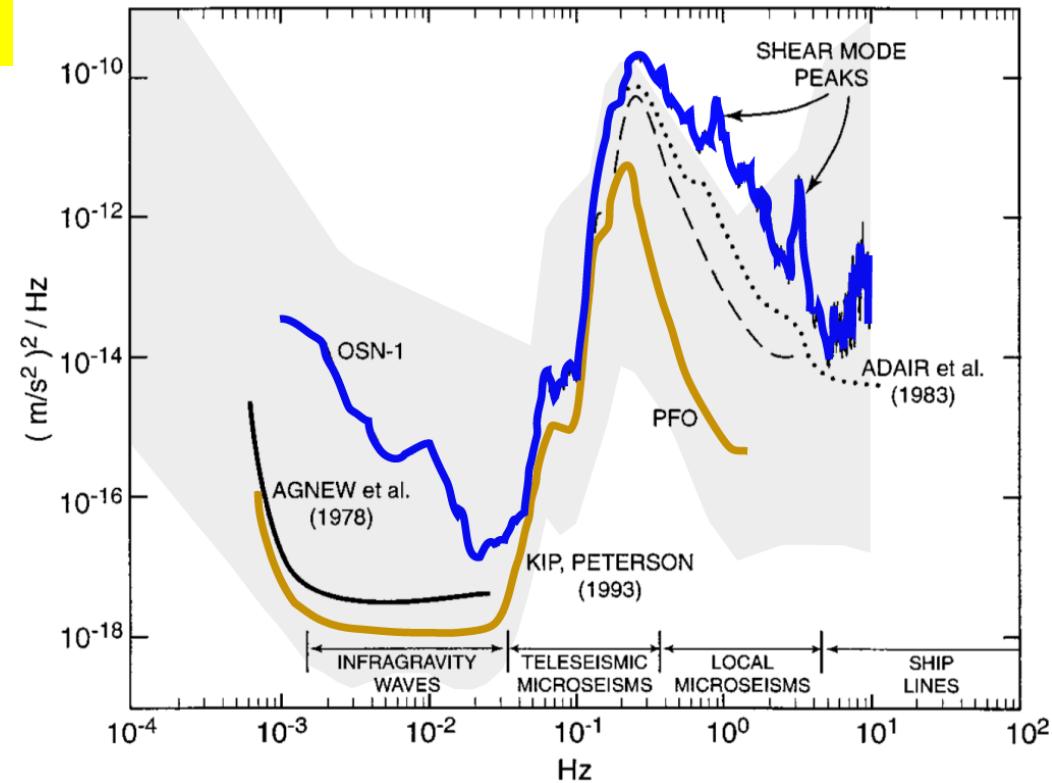
# Pour quel besoins

## Sismomètre fond de mer :

- Vertical  $\approx$  sol
- Horizontaux >> 35dB plus fort



La voie verticale peut être « nettoyé » en utilisant les informations de pression et des voies horizontales. Site OSN-1 océan Pacifique (modifié de Crawford et al, 2006).

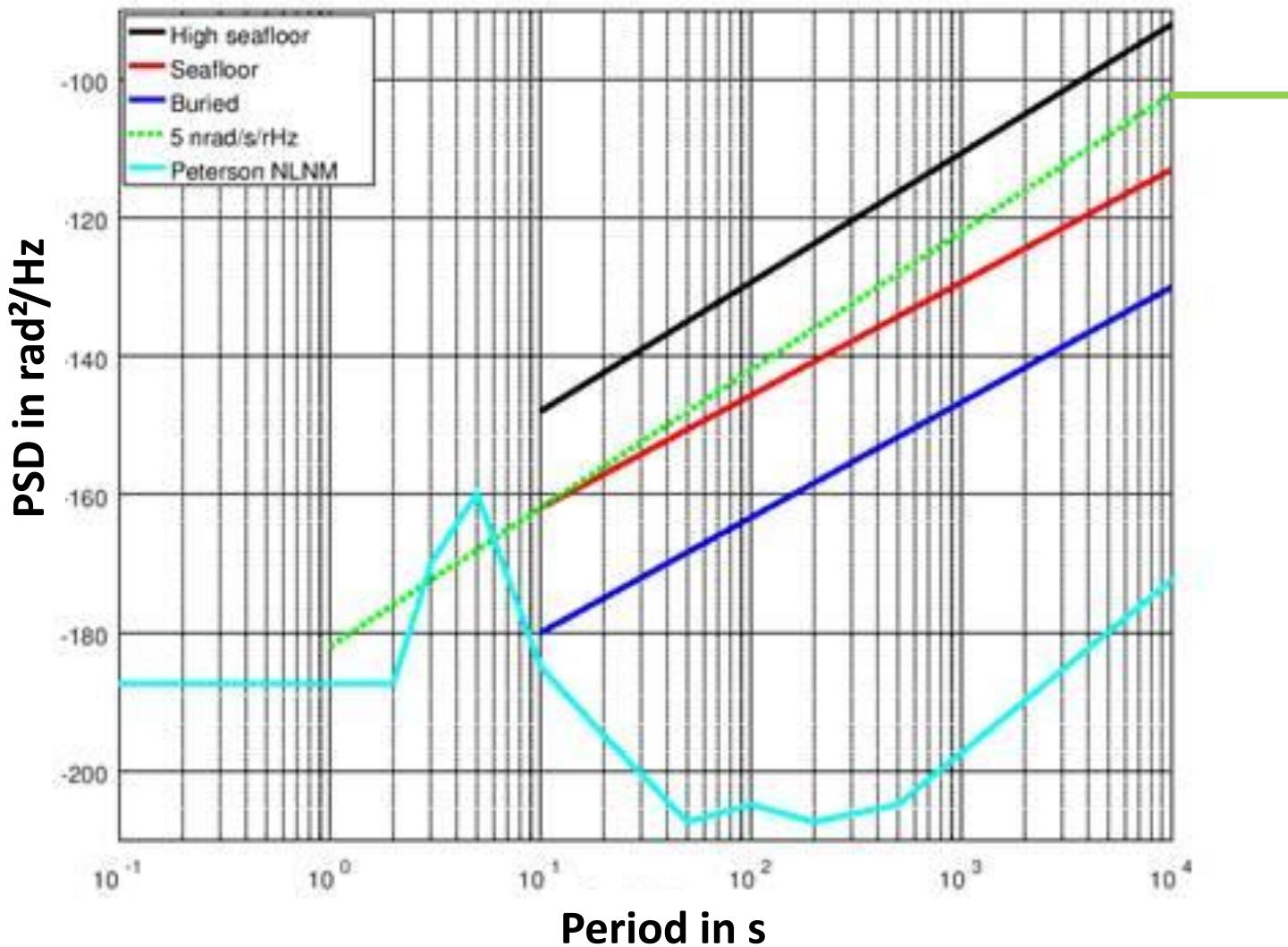


Bruit typique sur la voie verticale d'un sismomètre fond de mer large-bande (ligne bleu) comparé à celui d'une station terrestre silencieux (ligne marron) et les limites de bruit enregistrés sur des stations terrestres (fond gris).

Modifié de Webb [1998].

Pour nettoyer les composantes horizontales, il faut des mesures de rotation

# Quelle réponse proposée



**First prototype (on-going dev) :**  
DC to 10Hz  
 $<5\text{nrad/s/Hz}$  @ [10Hz; 100s]  
3.5W (*too much, but will be improved*)  
35cm diamètre

# Ils nous font confiance

- ISAE supaero
- ETHz
- Switzerland seismic ...
- Postdam
- Bochum
- LMU
- TUM
- Academia Sinica
- CEA (chine)
- CEA (France)
- UNAM
- USGS
- ...



UNAM

RUHR  
UNIVERSITÄT  
BOCHUM



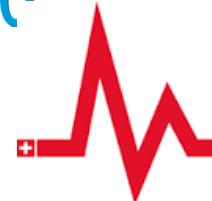
**ETH** zürich



中国地震局  
CHINA EARTHQUAKE ADMINISTRATION



中央研究院  
ACADEMIA SINICA



Schweizerischer Erdbebendienst  
Service Sismologique Suisse  
Servizio Sismico Svizzero  
Swiss Seismological Service



恒达新创  
hengda century



Technische  
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**Thank you for your attention!**

