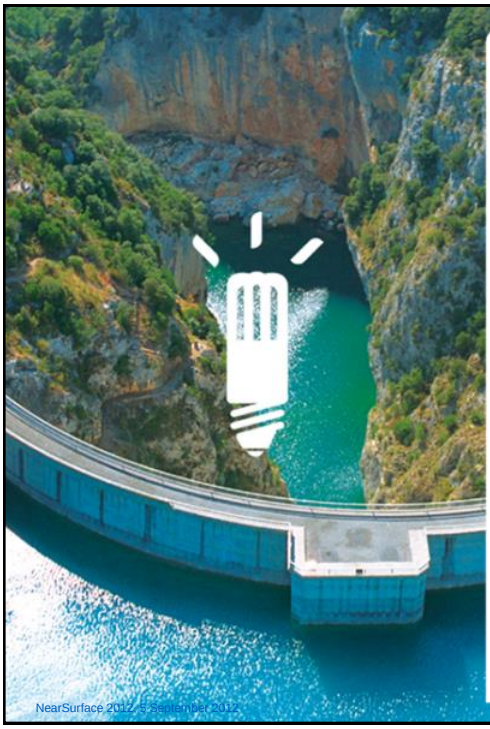


Detection of ground movement using the shape of Brillouin spectrum

NearSurface 2012,

PARIS, France, September,3-5, 2012

Edouard BUCHOUD, Sylvain BLAIRON, Jean-Marie HENAULT, Guy D'URSO, Alexandre GIRARD*
Jerome MARS**,
Valeriu VRABIE ***,

* EDF R&D
** GIPSA-LAB
*** CRESTIC

Context

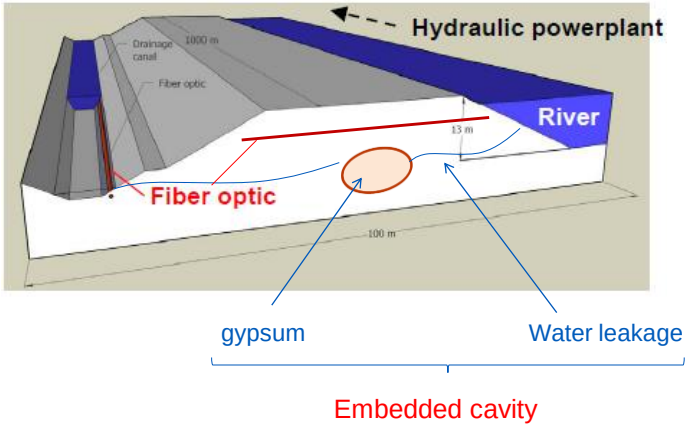
- EDF:
  - European energy leader: hydroelectric fleets (440 hydroelectric plants, 220 dams)
  - Geotechnical structures: earth dams and earth dikes

- Crucial issues:
  - Estimate durability and stability of structures
  - Safety, maintenance optimization

- Solution:
  - Monitoring of structures with fiber optic sensors

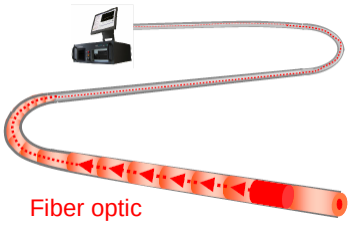
Monitoring earth dikes :

- Detection of embedded cavities



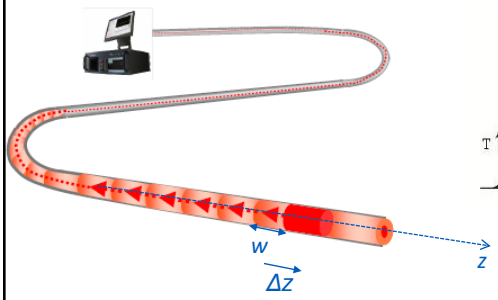
Fiber optic sensors:

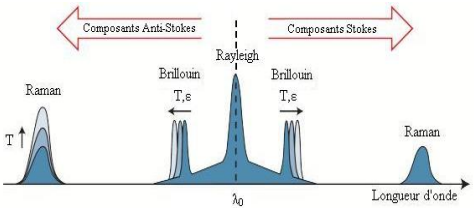
- Relative strain and temperature sensitive interrogators:
  - **Requirement:**
    - **High spatial resolution (<1m)**
    - **Distance range (> 5km)**



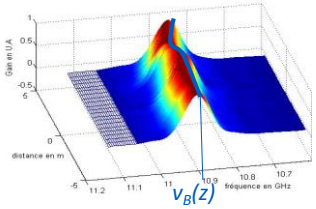
- Rayleigh : centimeter spatial resolution but a distance range <70m
- Brillouin : meter spatial resolution and a distance range up to 25km

  - **Improvement of Brillouin sensor**





- Etude de l'algorithme interne de l'interrogateur Brillouin
  - Acquisition des matrices de données brutes : Spectres Brillouin



Profil de fréquences Brillouin en fonction de la distance

Temperature and strain measurement

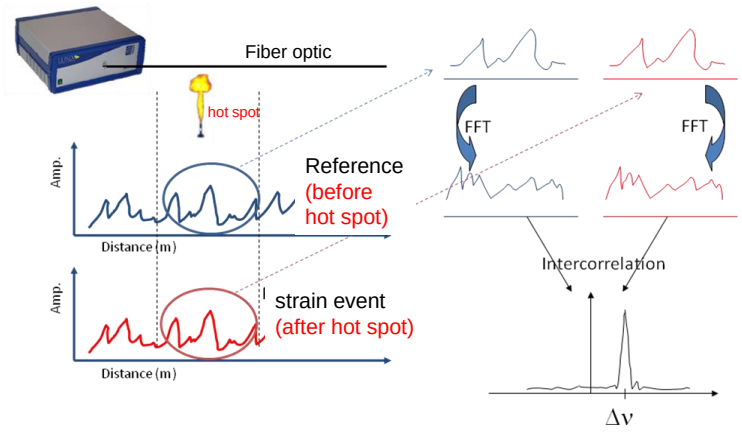
- Relative frequencies depending on relative strain and temperature

$$\Delta\nu(z) = C_T \Delta T(z) + C_\varepsilon \varepsilon(z)$$

- $\Delta\nu(z)$ relative frequency profile between two states of the fiber
- $\Delta T(z)$ temperature between two states of the fiber
- $\varepsilon(z)$ strain between two states of the fiber
- C_T and C_ε transducer coefficients depending on temperature and strain

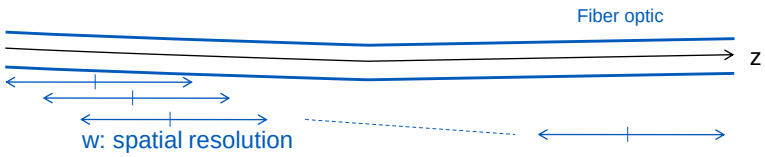
Rayleigh technology

- Intercorrelation of OTDR profiles:

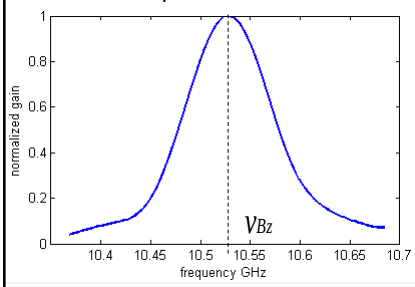


Brillouin technology

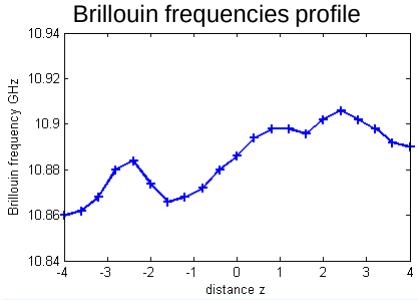
- Brillouin spectra and frequencies:



Brillouin spectrum, z fixed



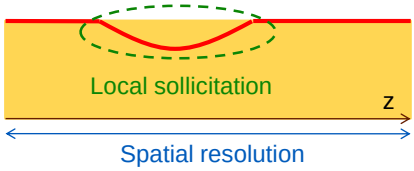
Brillouin frequencies profile



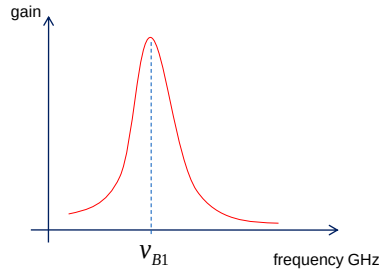
Brillouin distortion

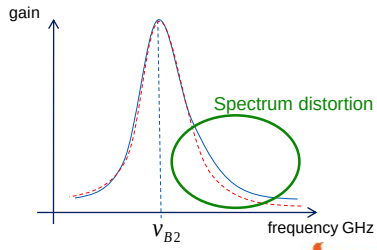
Uniform strain within spatial resolution

Non uniform strain within spatial resolution



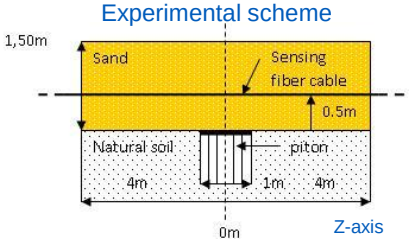
Brillouin spectrum





Experimental structure : underground cavity generation

Experimental scheme



Positionning jacks

Ref Blairon FMGM 2011

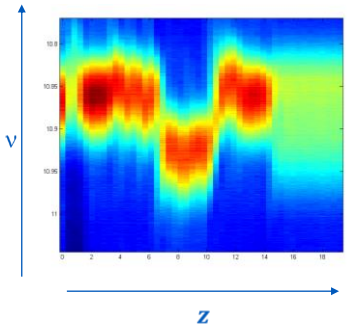
Cables installation

Ref Blairon FMGM 2011

Number of displacements	Displacements mm
0	0 mm (reference profile)
1	0 mm
2	0 mm
3	2 mm
4	4 mm
5	6 mm
6	8 mm
7	10 mm

Estimation du spectre surrésolu :

Spectres mesurés



$$\boldsymbol{G}(\nu, \boldsymbol{z}) = \boldsymbol{W_z} *_{\boldsymbol{x}} \boldsymbol{s}(\nu, \boldsymbol{x})$$

On recherche s mesurant G et sachant que W_z est un opérateur de moyenne.

Δz = 41 cm et on désire un Δx de 5 cm.