



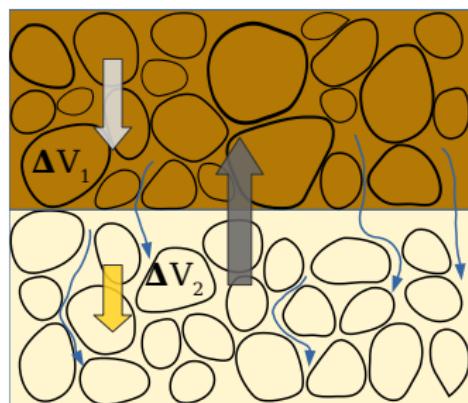
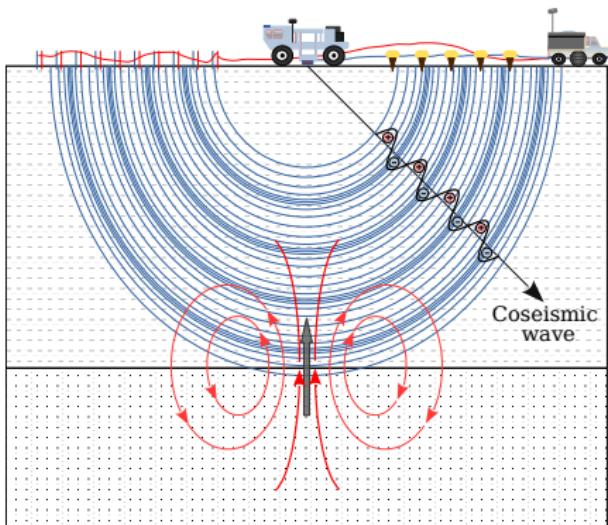
# Thesis Report of the: Ongoing experimental research on seismo-electromagnetic fields generated at saturated porous media interfaces

Victor MARTINS GOMES

Daniel BRITO (PhD supervisor)  
Hélène BARUCQ (PhD co-supervisor)

# Introduction

## Seismo-electromagnetic phenomena



# Introduction

## Interface response :

- ▶ Synchronous
- ▶ Arrival time is equal to travel time of P-wave to the interface
- ▶ Max amplitude in receivers while offset is equal to help the interface depth
- ▶ Different polarity in source sides

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**Physical properties :** Porosity ( $\phi$ ), Permeability ( $k_0$ ), Bulk modulus ( $K_s, K_f, K_{fr}$ ), frame's Shear modulus, densities ( $\rho_s, \rho_f$ ), fluid's electrical conductivity ( $\sigma$ ), fluid's viscosity ( $\eta$ ), molarity, temperature, solid and fluid's relative permittivity and tortuosity.

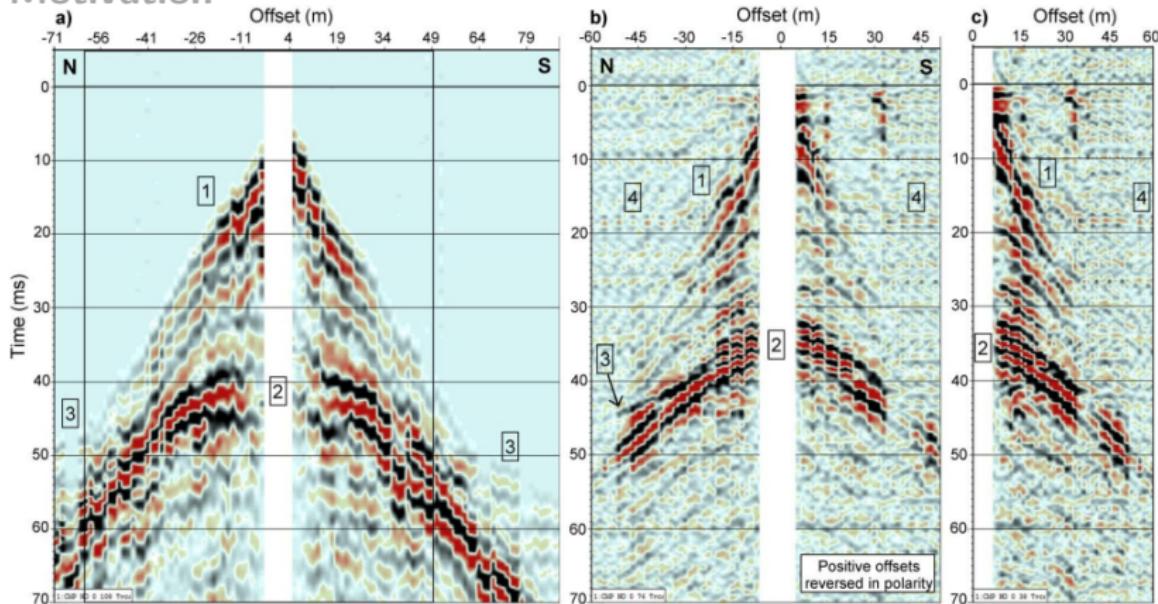
# Introduction

## Motivation

- ▶ Hydrocarbon
- ▶ Bedrock
- ▶ Water
- ▶ Water table
- ▶ CO<sub>2</sub> storage
- ▶ Borehole and surface

# Introduction

## Motivation



Butler et al., 2018

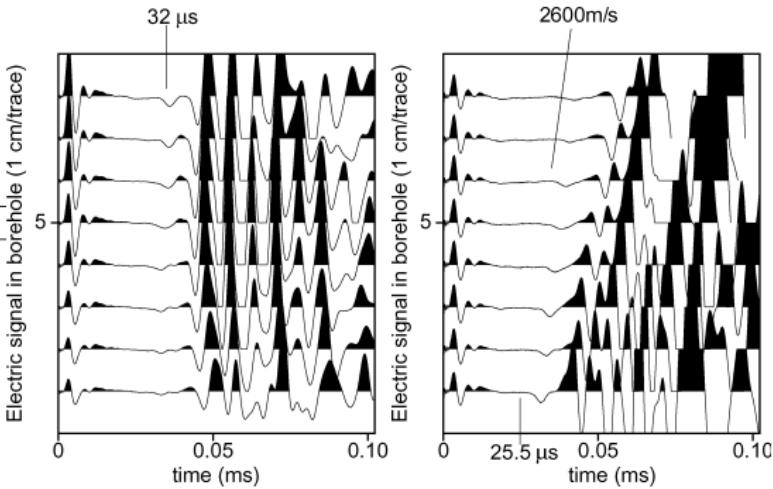
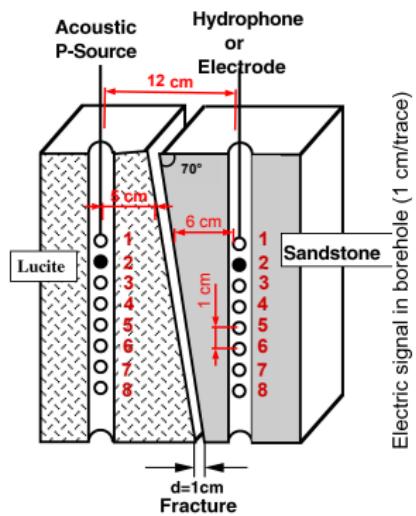
# Experiments: What has been done

## Summary

1. Zhu and Toksöz (2003)
2. Chen and Mu (2005)
3. Zu et al. (2008)
4. Schakel et al. (2011)
5. Peng et al. (2017)
6. Ellouz (2017)

# Experiments: What has been done

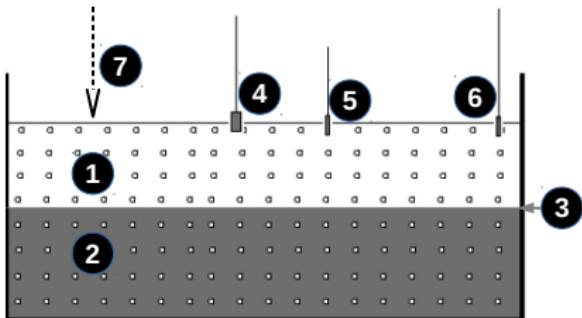
## Zhu and Toksöz (2003)



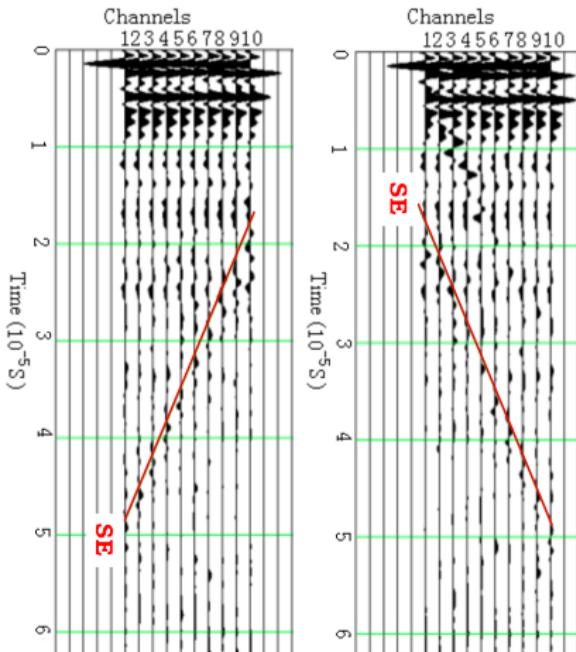
- ▶ Crosshole w/ water filled fracture
- ▶ Study fracture aperture vs amplitude
- ▶ Geometrical parameters of dipping fractures

# Experiments: What has been done

Chen and Mu (2005)

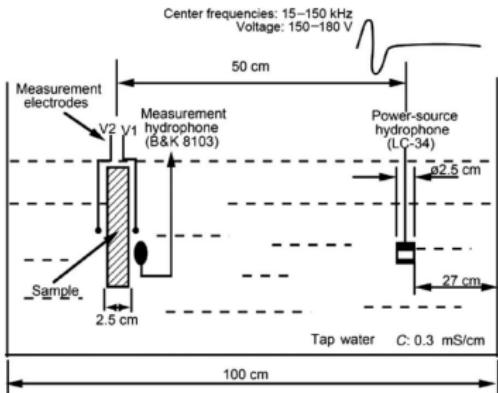


- ▶ NaCl-saturated sand
- ▶ Salt-water/Water/Oil saturated layers
- ▶ Conductivity behaviour
- ▶ converted EM is sensitive to Oil/salt-water

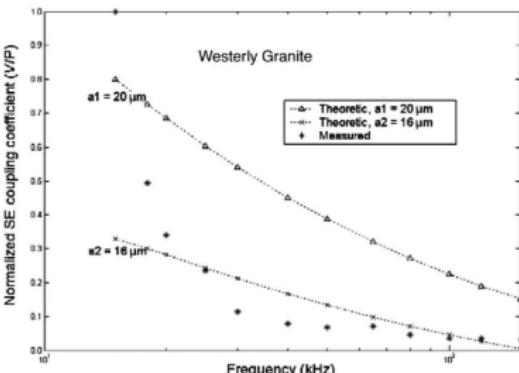
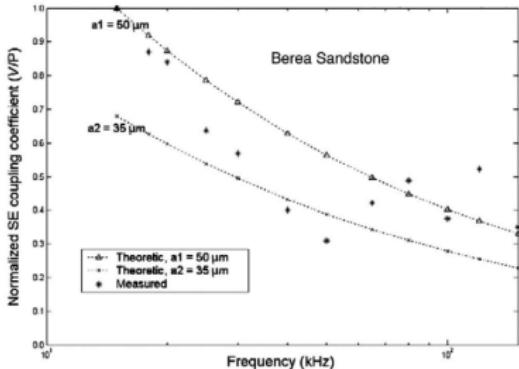


# Experiments: What has been done

## Zhu et al. (2008)

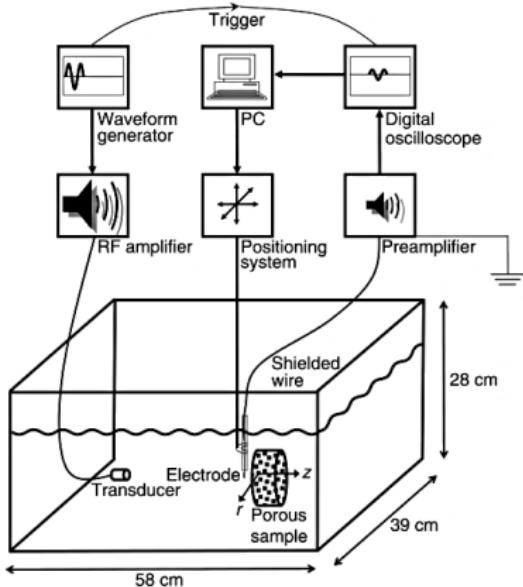


- ▶ Sandstone and Granite
- ▶ Coup Coef for 15 – 150 kHz
- ▶ Coup Coef for Capillary model
- ▶ Similar in frequency
- ▶ Converted energy  $\propto$  Permeability and Porosity

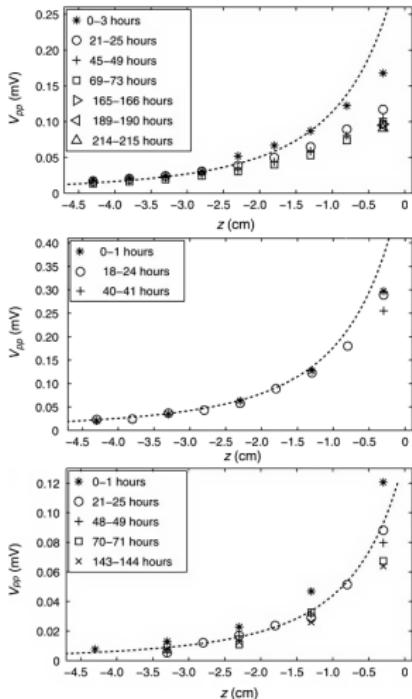


# Experiments: What has been done

Schakel et al. (2011)

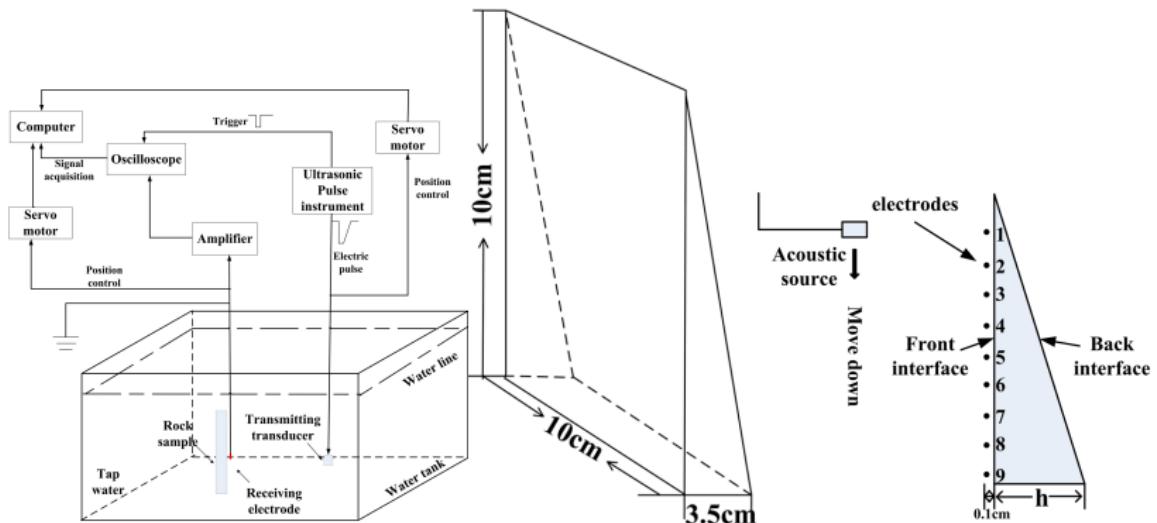


- ▶ Amp vs. Conductivity
- ▶  $\sigma = 1.27e-3$  (up),  $1.20e-2$  (middle),  $1.01e-1$  (bottom)



# Experiments: What has been done

Peng et al. (2017)

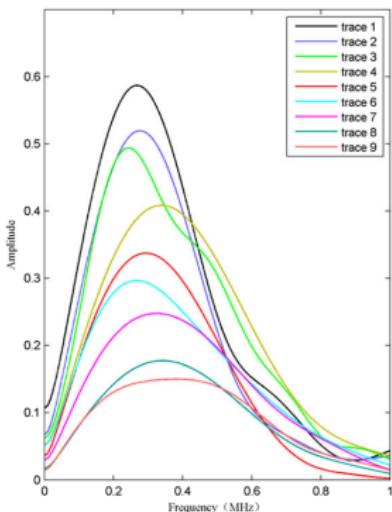
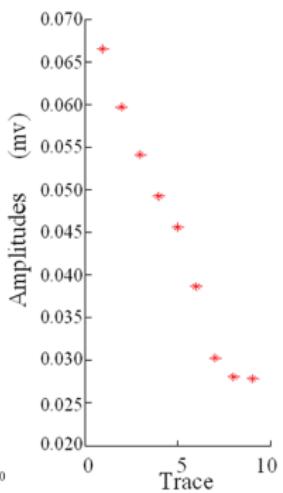
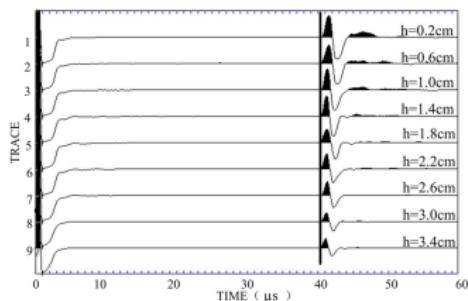


►  $\lambda=0.9\text{cm}$

# Experiments: What has been done

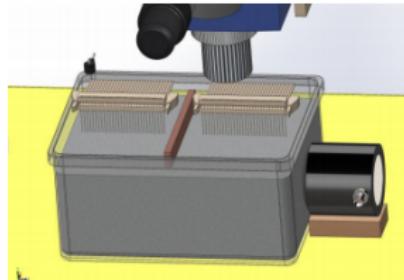
Peng et al. (2017)

Continue :



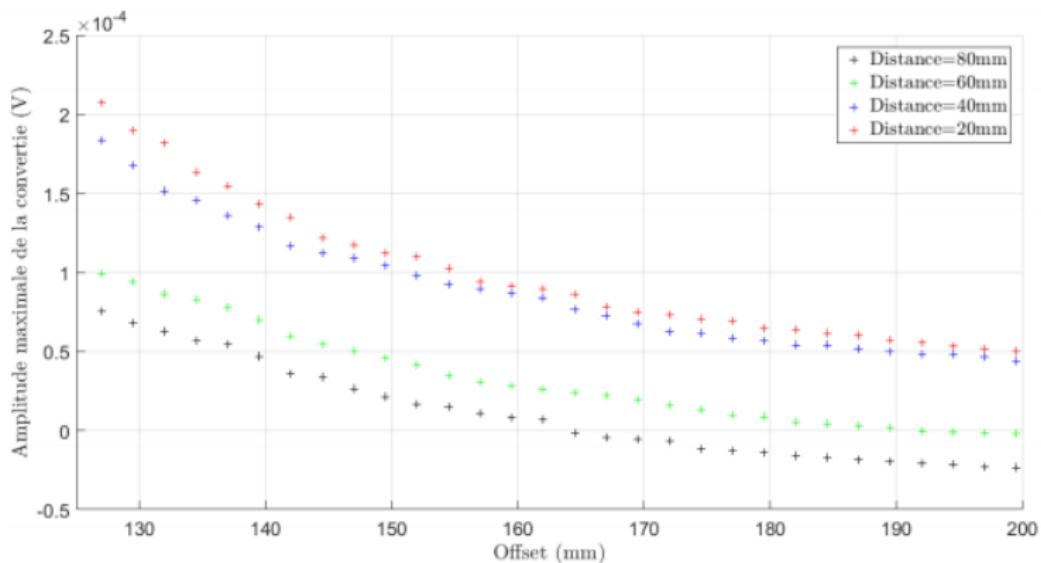
- ▶ Experimentally confirmed that thin-layers can enhance the interface response.

- ▶ Investigated the effect of various acquisition and geometry-related model parameters to amplitude of converted-EM:
  - ▶ Thickness
  - ▶ Electrode distance to layer
  - ▶ Excitation frequency
- ▶ Layer with widths as small as  $\lambda/6$  could be identified



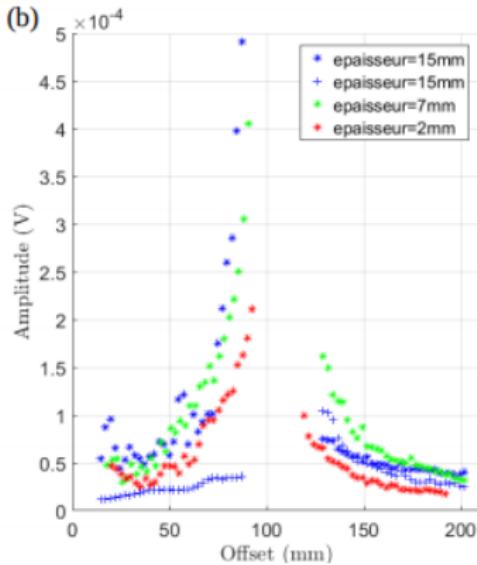
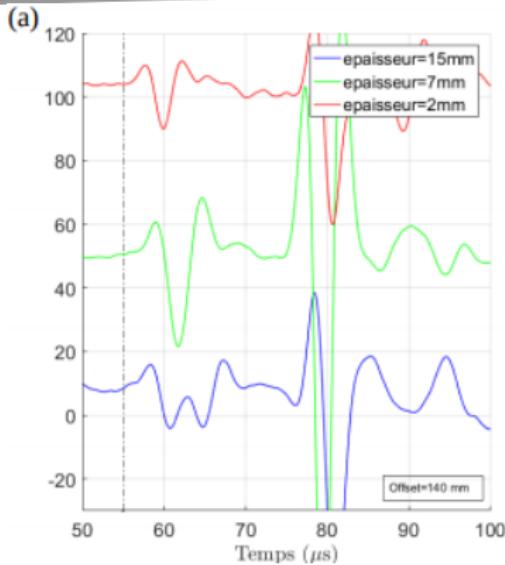
# Experiments: What has been done

## Ellouz (2017)



# Experiments: What has been done

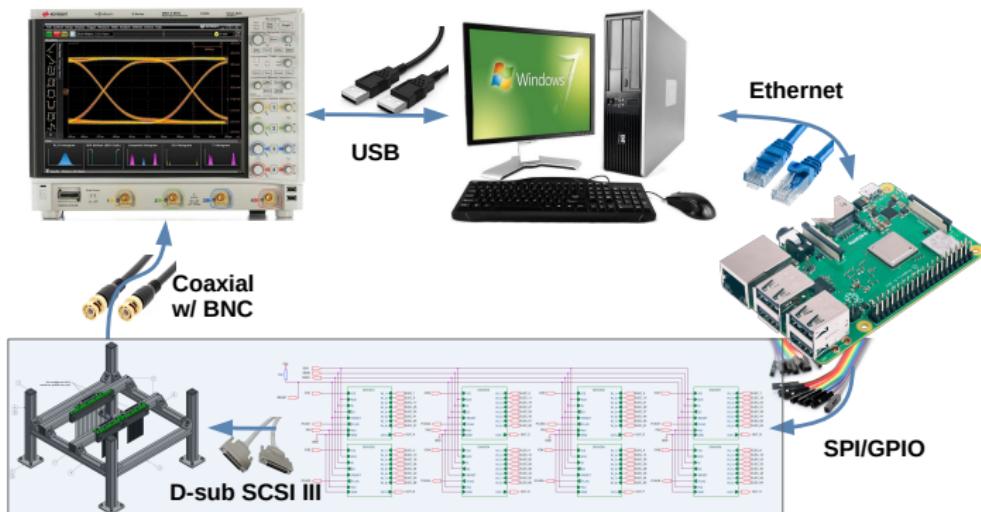
## Ellouz (2017)



- ▶  $\lambda \approx 7\text{mm}$
- ▶ Thin-layer amplitude enhancement was not seen for 2mm thickness

# Automation – general view

## Schema



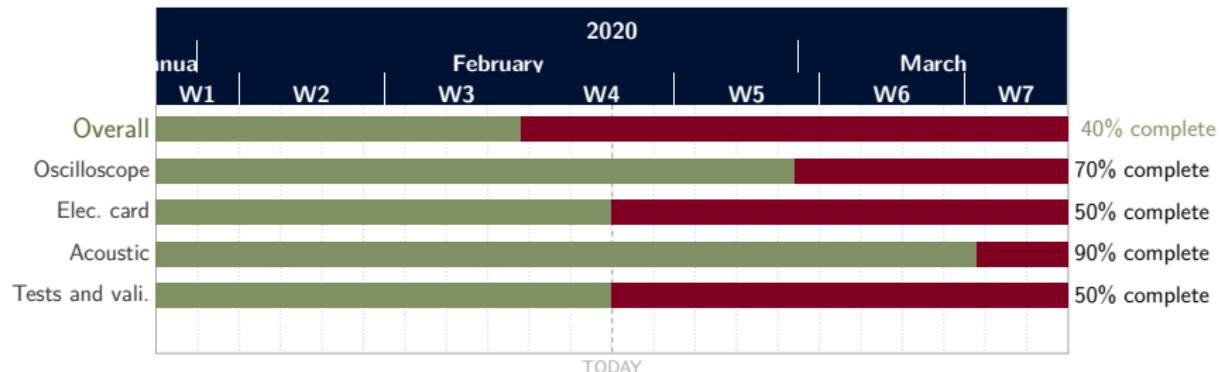
# Automation – general view

## Main points

- ▶ Python-based routines and interface to control the electric acquisition
- ▶ Quicker and simpler acquisition
- ▶ Less human interaction
- ▶ Towards reproductibility

# Automation Planning

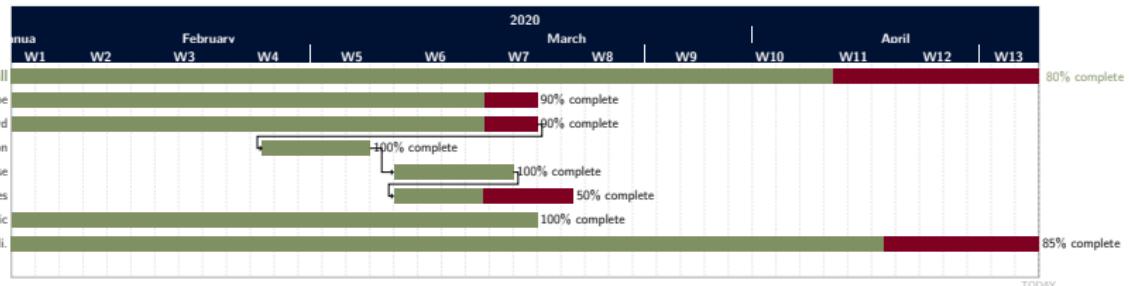
From : 2020-01-30 until 2020-03-13



► Proposed at 2020-02-20

# Automation Planning

## Today



# Automation Planning

## Points :

- ▶ Oscilloscope connection has no easy-to-use user interface.  
Possibility of bugs I have not yet seen.
- ▶ Control over GPIO pins works but SPI is not quite clear.
  - ▶ The right cable config.
  - ▶ What 8-bit message do I send to change drivers/relays.
- ▶ Oscilloscope control could be done with LabView to make it easier.

## Tests to be performed

- ▶ Check if all relays work properly - **DONE**
- ▶ Test box attenuation/plastic velocity/etc **ONGOING**
- ▶ Water-filled box with dipole source to check electrodes' behaviour to electromagnetic sources
- ▶ Sand-filled box
- ▶ Sensitivity to the Layer response

# Perspectives to new experimentl setup

## General :

1. Greater SNR;
2. Faster acquisition
3. Greater spatial precision of electric measurements due to more rigid electrodes;
4. Ensure repeatability;
5. More precision when studying the converted wave.

# Thank you for your attention!

