



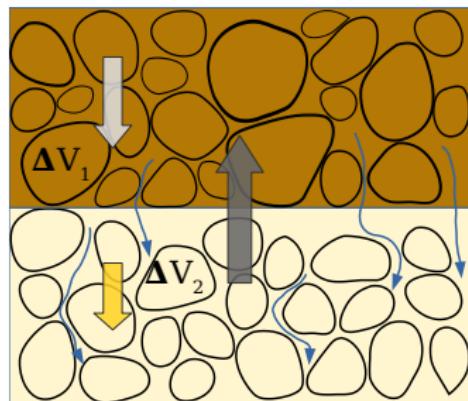
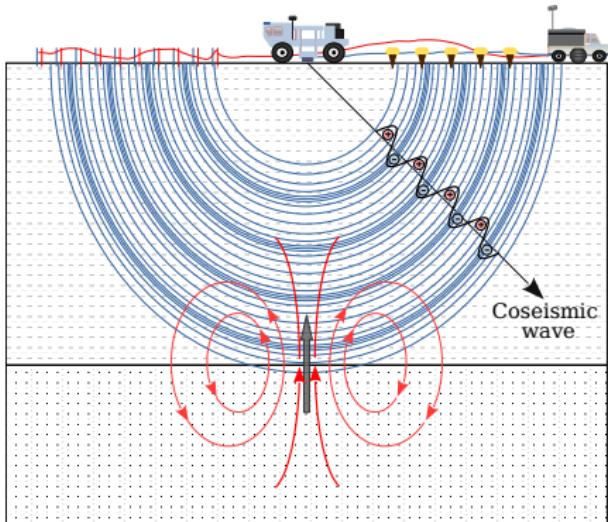
Thesis Report of the: Ongoing experimental research on seismo-electromagnetic fields generated at saturated porous media interfaces

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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

Physical properties : Porosity (ϕ), Permeability (k_0), Bulk modulus (K_s, K_f, K_{fr}), frame's Shear modulus, densities (ρ_s, ρ_f), fluid's electrical conductivity (σ), fluid's viscosity (η), molarity, temperature, solid and fluid's relative permittivity and tortuosity.

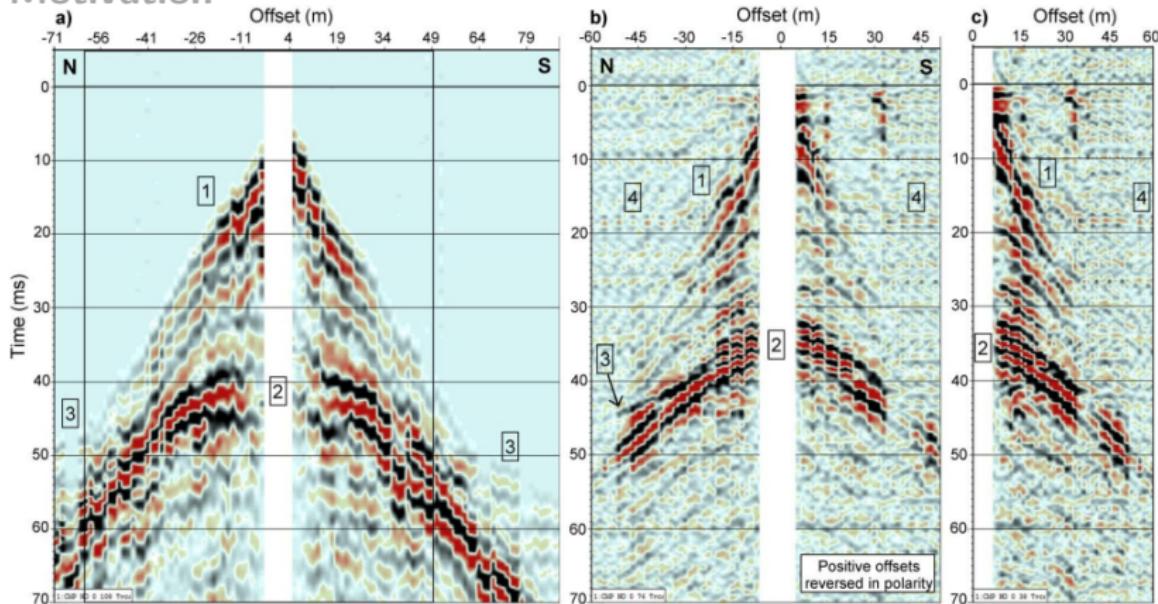
Introduction

Motivation

- ▶ Hydrocarbon
- ▶ Bedrock
- ▶ Water
- ▶ Water table
- ▶ CO₂ storage
- ▶ Borehole and surface

Introduction

Motivation



Butler et al., 2018

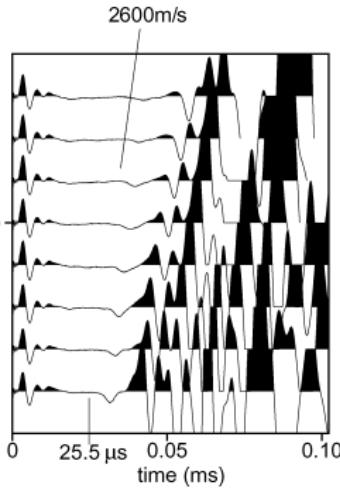
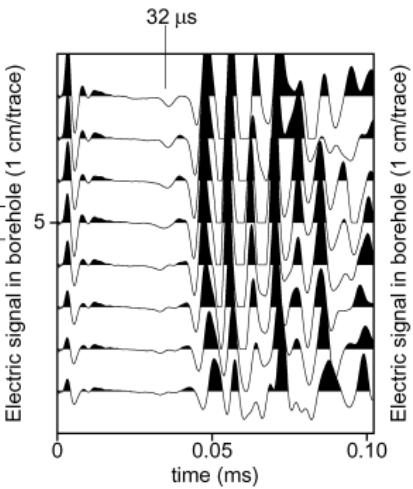
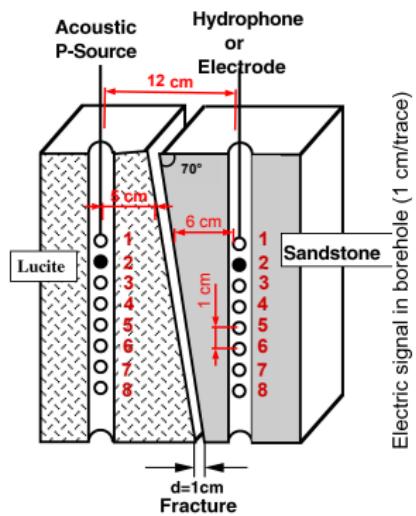
Experiments: What has been done

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

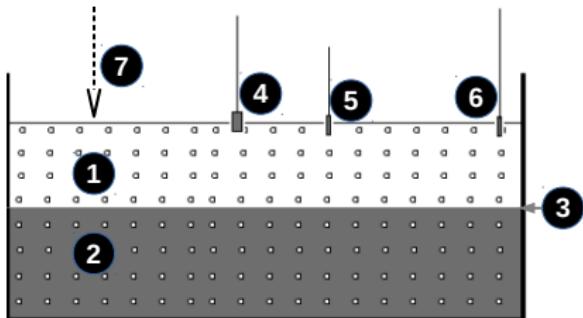
Zhu and Toksöz (2003)



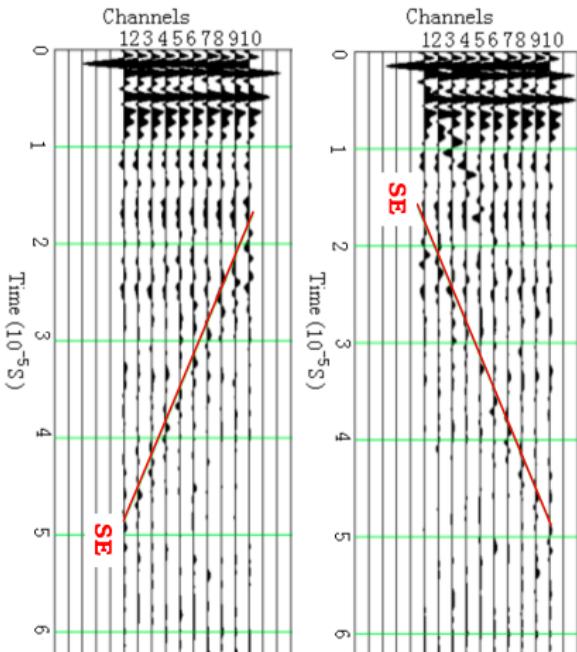
- ▶ Crosshole w/ water filled fracture
- ▶ Study fracture aperture vs amplitude
- ▶ Geometrical parameters of dipping fractures

Experiments: What has been done

Chen and Mu (2005)

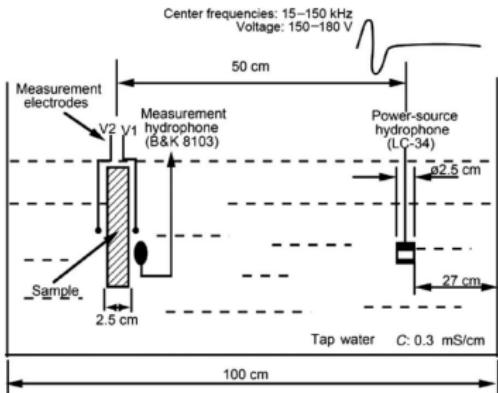


- ▶ NaCl-saturated sand
- ▶ Salt-water/Water/Oil saturated layers
- ▶ Conductivity behaviour
- ▶ converted EM is sensitive to Oil/salt-water

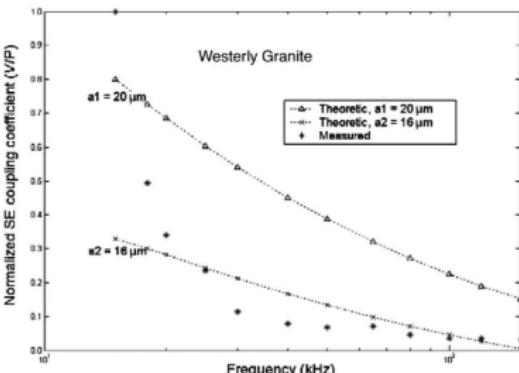
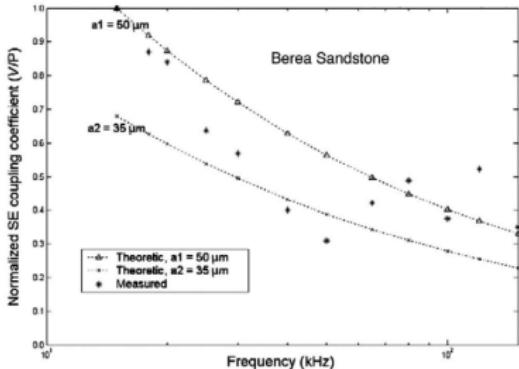


Experiments: What has been done

Zhu et al. (2008)

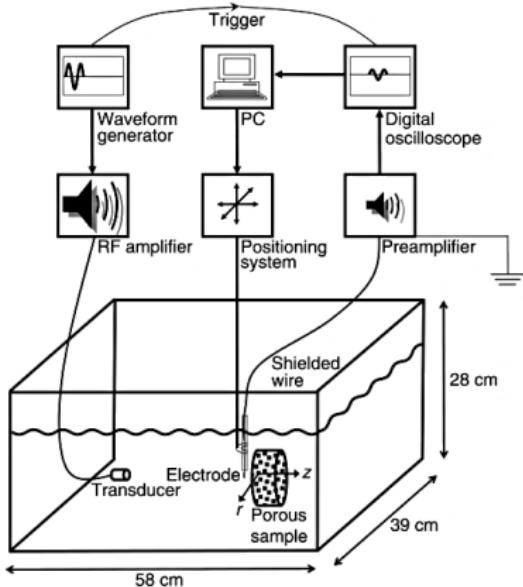


- ▶ Sandstone and Granite
- ▶ Coup Coef for 15 – 150 kHz
- ▶ Coup Coef for Capillary model
- ▶ Similar in frequency
- ▶ Converted energy \propto Permeability and Porosity

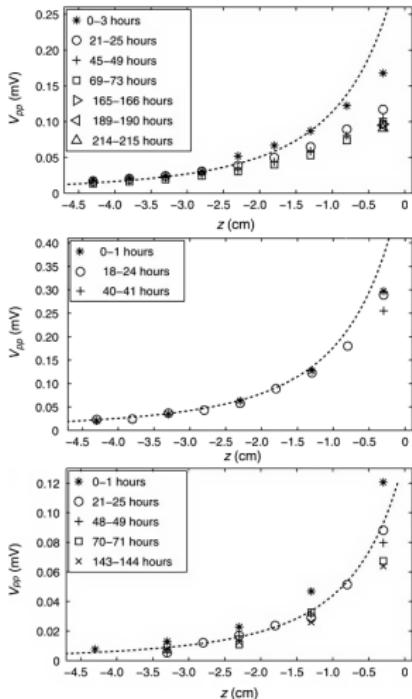


Experiments: What has been done

Schakel et al. (2011)

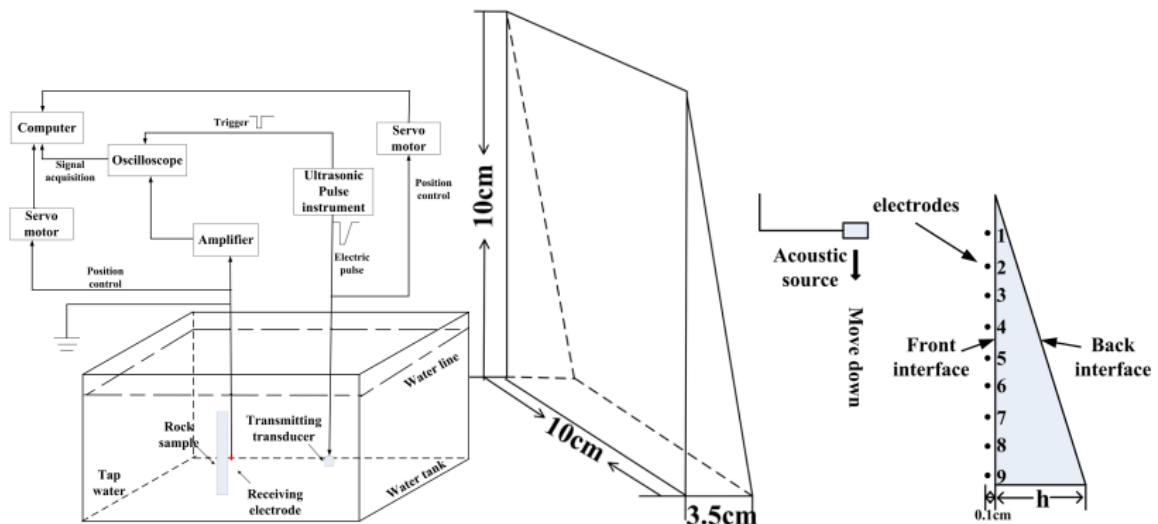


- ▶ Amp vs. Conductivity
- ▶ $\sigma = 1.27\text{e-}3$ (up), $1.20\text{e-}2$ (middle), $1.01\text{e-}1$ (bottom)



Experiments: What has been done

Peng et al. (2017)

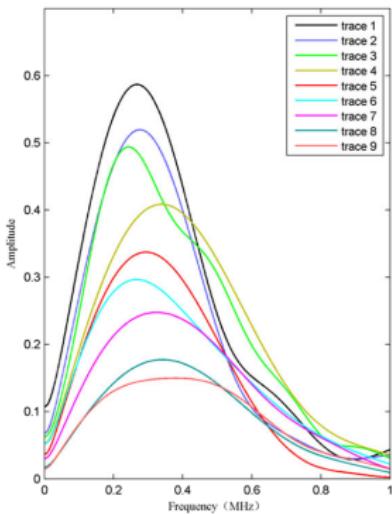
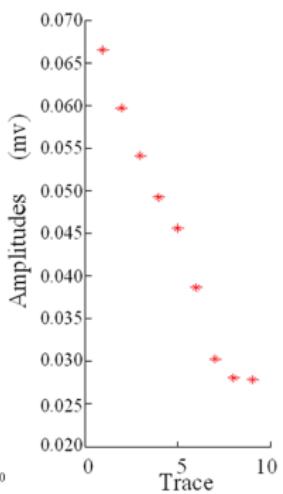
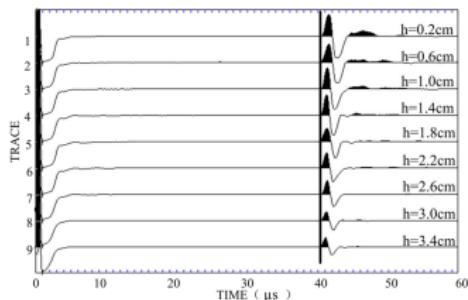


► $\lambda=0.9\text{cm}$

Experiments: What has been done

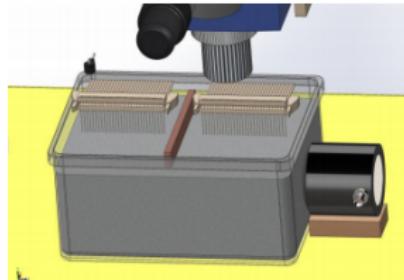
Peng et al. (2017)

Continue :



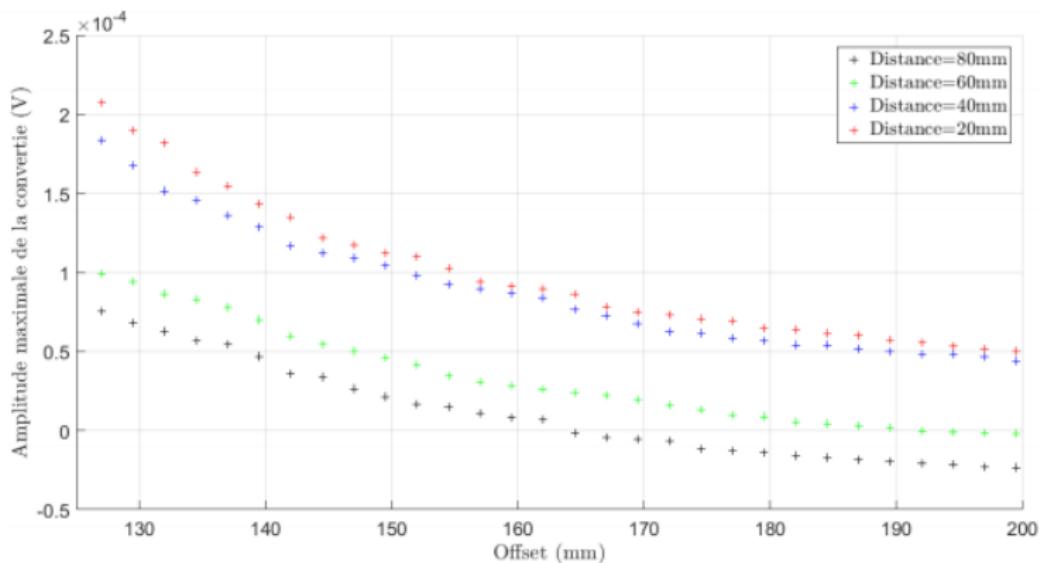
- ▶ Experimentally confirmed that thin-layers can enhance the interface response.

- ▶ 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



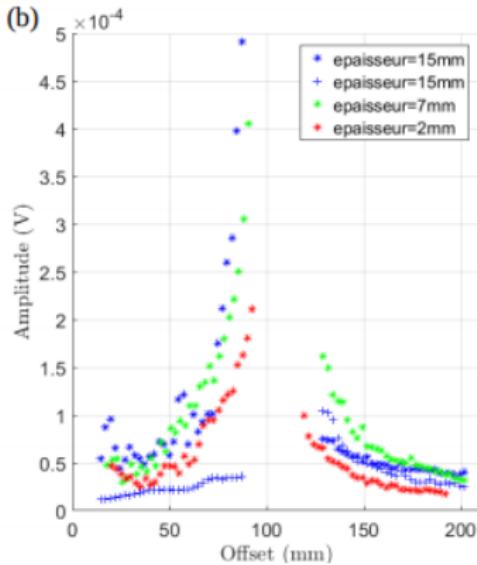
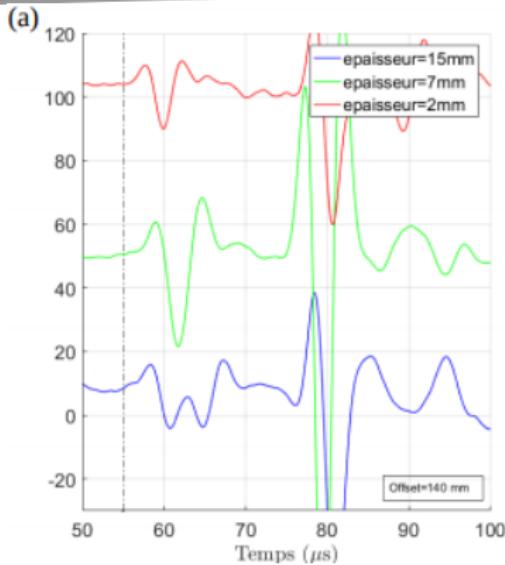
Experiments: What has been done

Ellouz (2017)



Experiments: What has been done

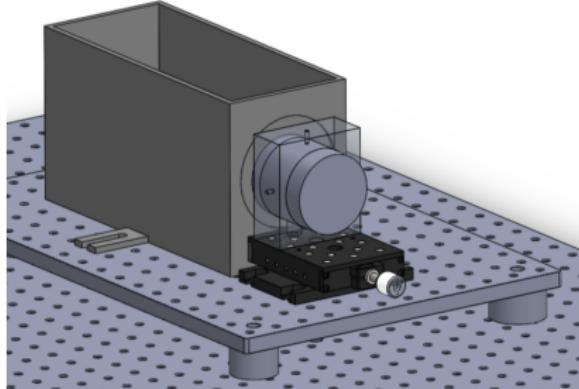
Ellouz (2017)



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

New experimental set-up

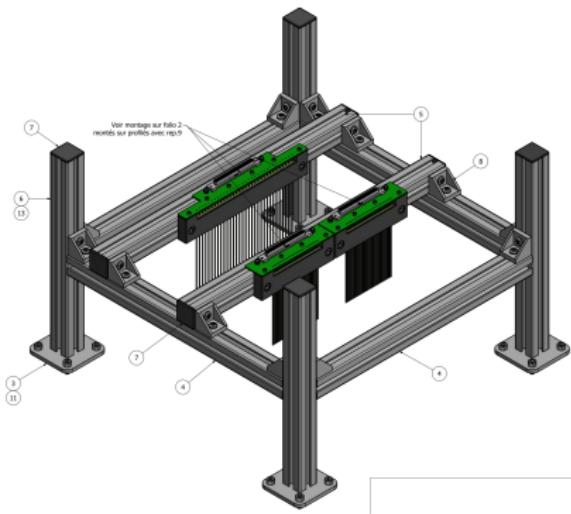
Acoustic-related



- ▶ Thorlabs equipments
- ▶ Support for Piezo
- ▶ Sandbox

New experimental set-up

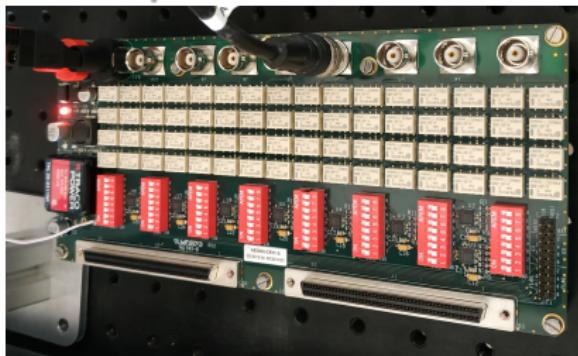
EM-related



- ▶ Thicker and longer electrodes
- ▶ More rigid -> Better positioning
- ▶ Metallic support for moving

New experimental set-up

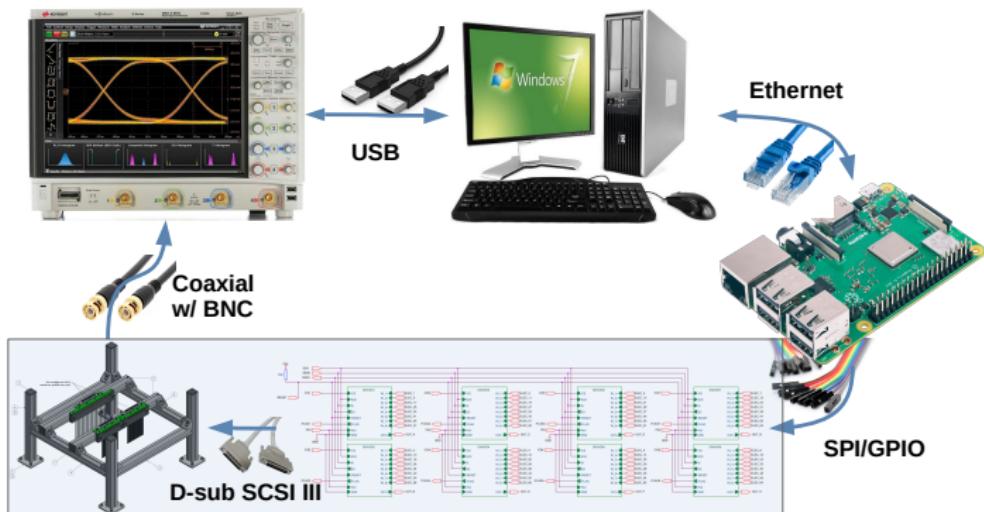
EM Acquisition-related



- ▶ Easily make measurements manually or in an automated way using SPI
- ▶ Faster acquisitions
- ▶ Less human influence

Automation – general view

Schema

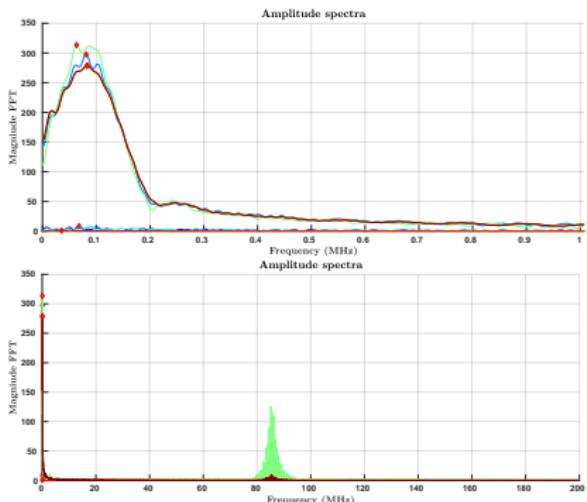
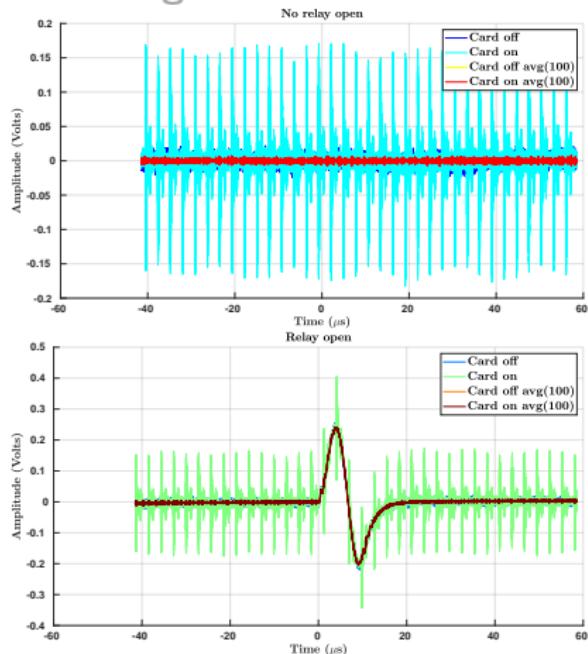


Automation – general view

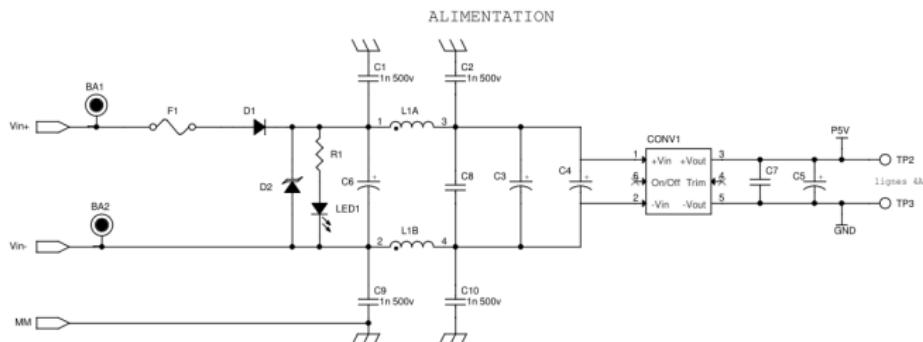
Main points

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

Testing the card



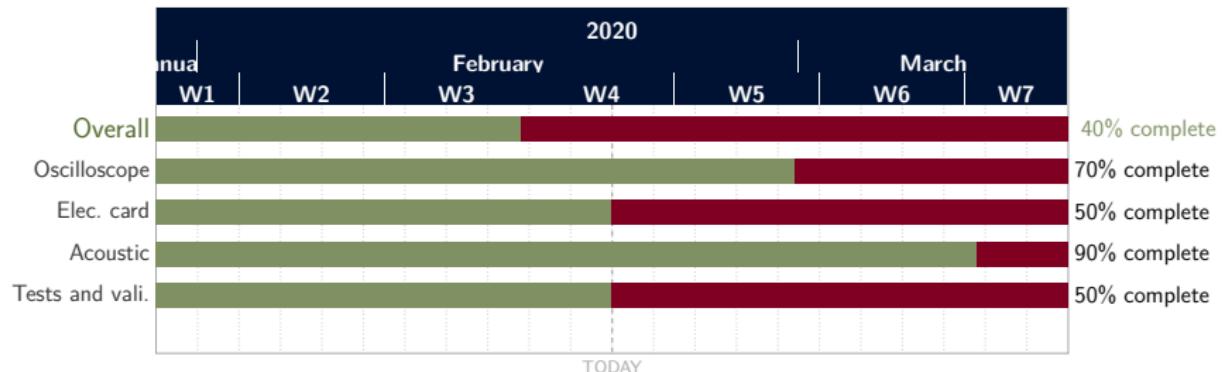
Testing the card



- ▶ Problem in switching regulator
- ▶ Solution: remove it

Automation Planning

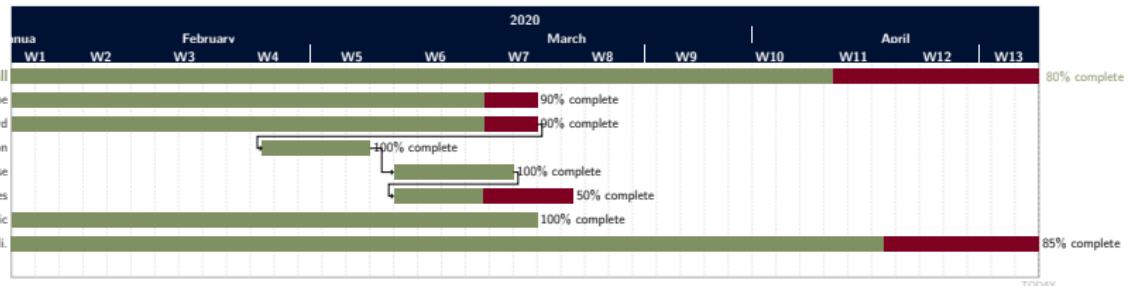
From : 2020-01-30 until 2020-03-13



► 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!

