Monitoring of water imbibition of a particular porous pavement structure by impulse and step-frequency radar

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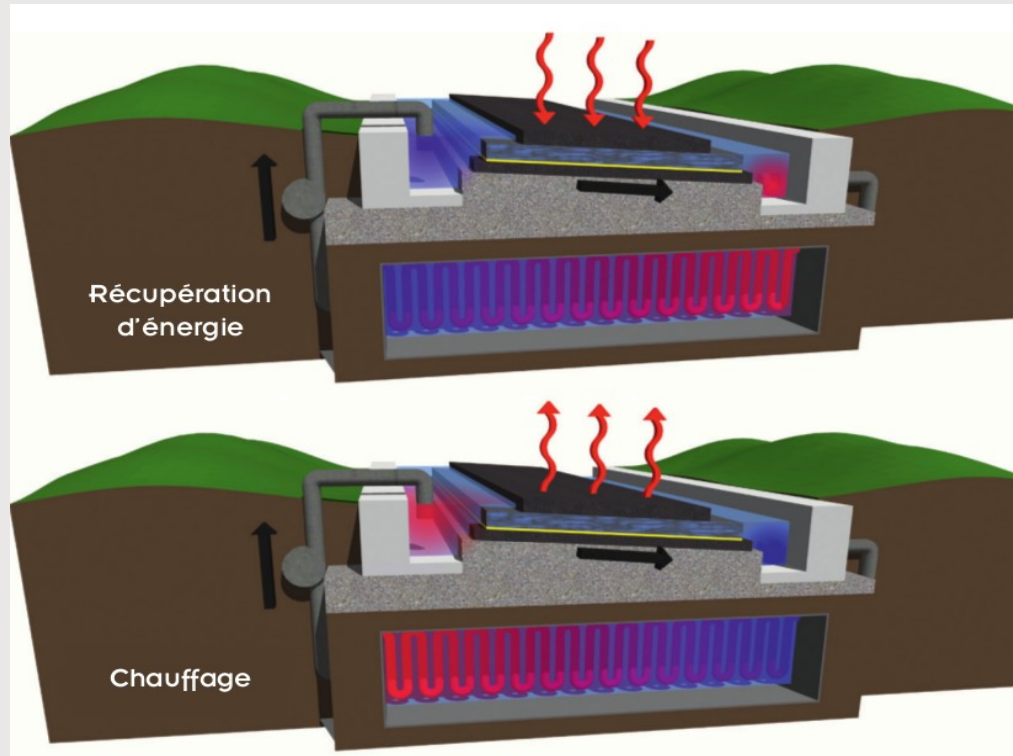J.N. Gaudin**, S. Todkar* **, F. Bernardin**

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> Objectives

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Objectives

Frame: Geothermic energy storage from solar energy

Test site objective: Heat transfert efficiency from fluid flow through a drainage asphalt layer

Egletons test site

Road test site configuration
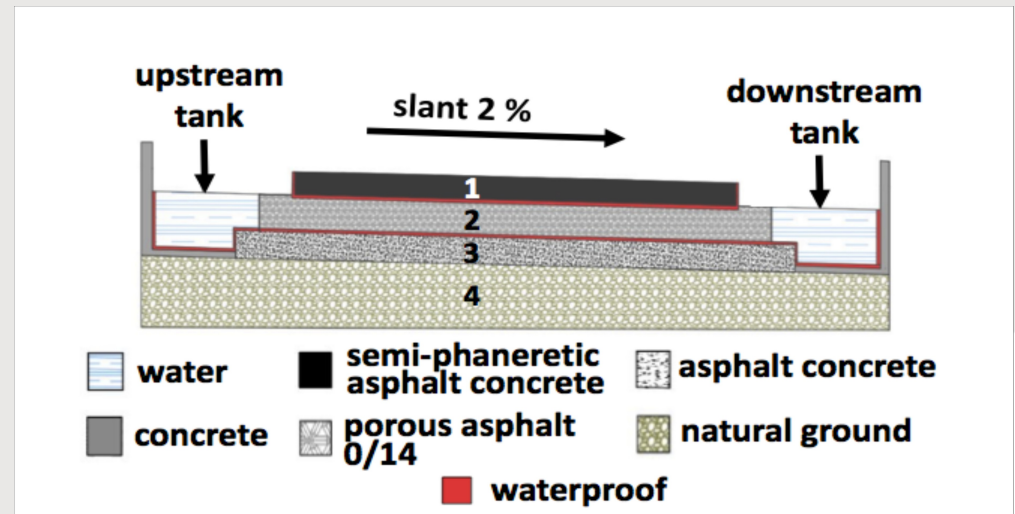

Dim : ~ 4 m * 3,3 m

ACL (WL) 6 cm

PAL (0/14) 8 cm

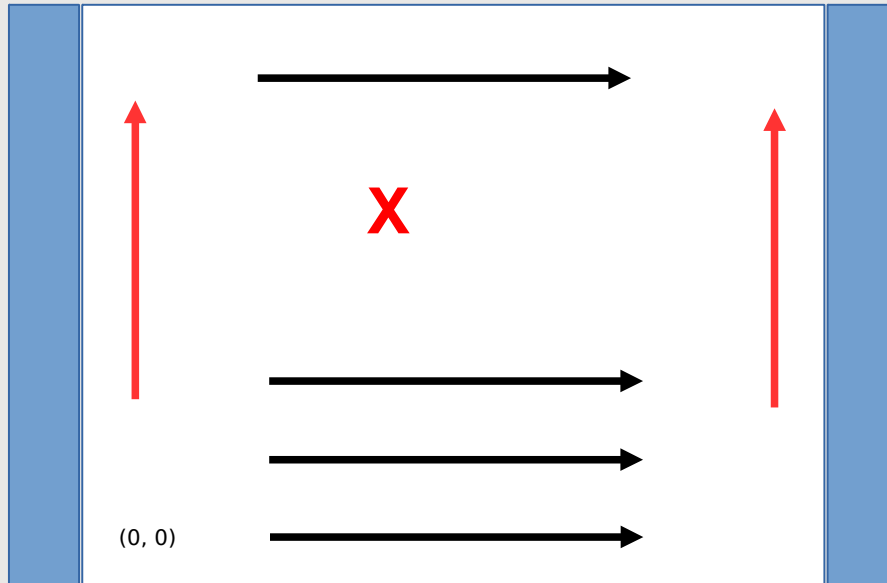ACL 5 cm

GPR/SFR Objectives :

- Water front detection ?
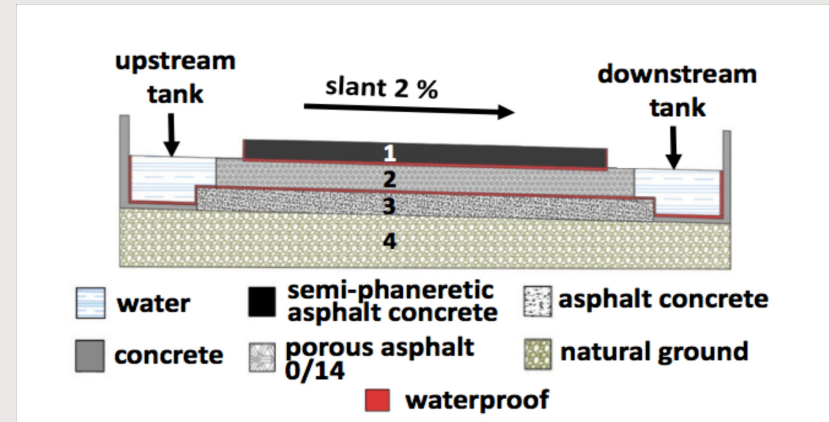
- Possible air lens ?

Radar protocols

GPR – 2.6 GHz on 9 transversal / 2 long. profiles

SFR – [800 – 3000 MHz] : static & continuous meas.

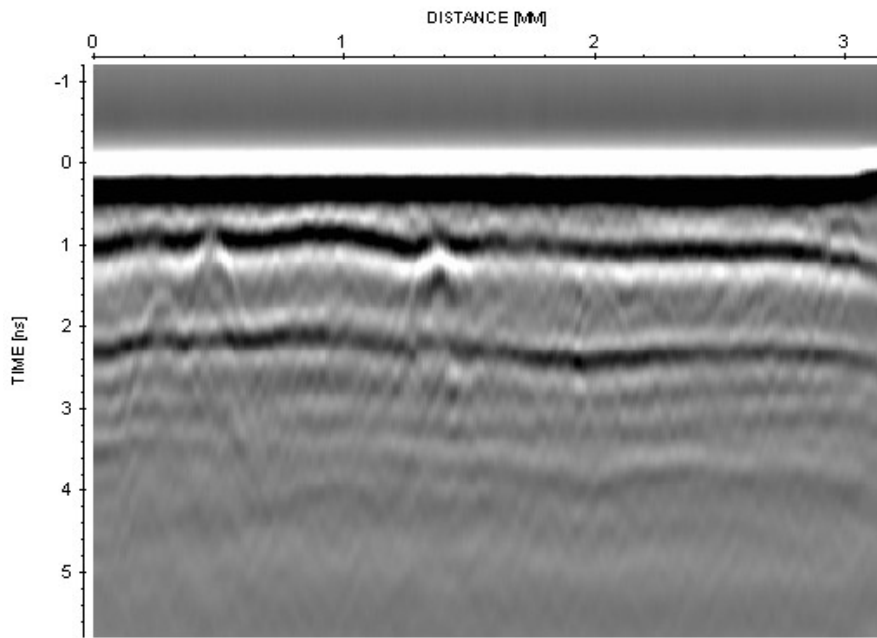(0, 0)

X

$\Delta t = 7'$

am : 24 cycles / pm : 17 cycles

upstream tank   slant 2 %   downstream tank

1
2
3
4

water	semi-phaneretic asphalt concrete	asphalt concrete
concrete	porous asphalt 0/14	natural ground
	waterproof	

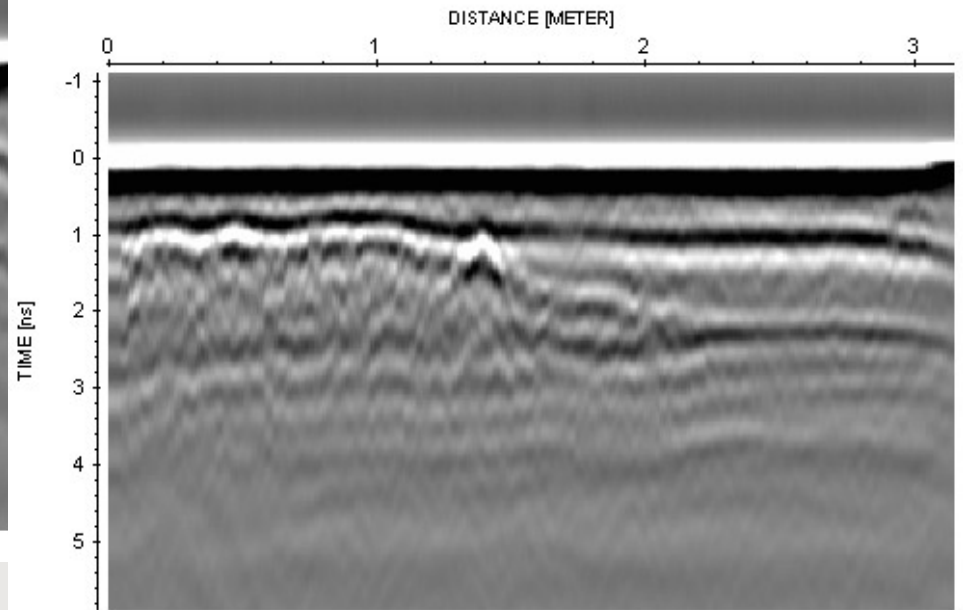# Radar measurements (video)

GPR 2.6 GHz – Line 3

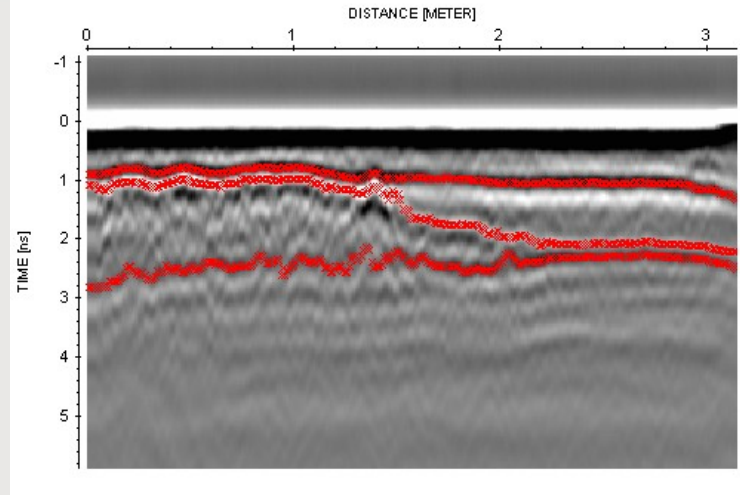T_0 (before imbibition)

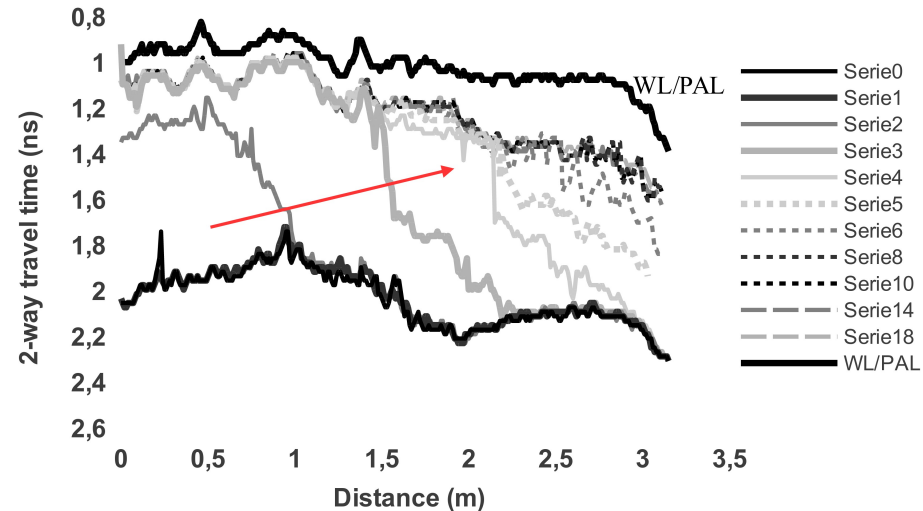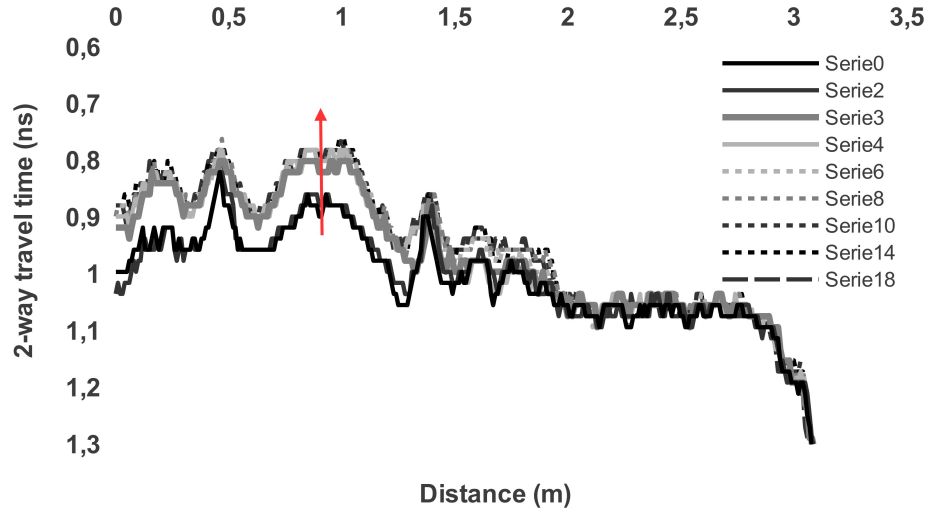T_3 (16' imbibition)

GPR 2.6 GHz peaking – Ligne 3

Peaking at T_3 (16'):

WL/PAL interface

Water front flow
PAL/ACL interface

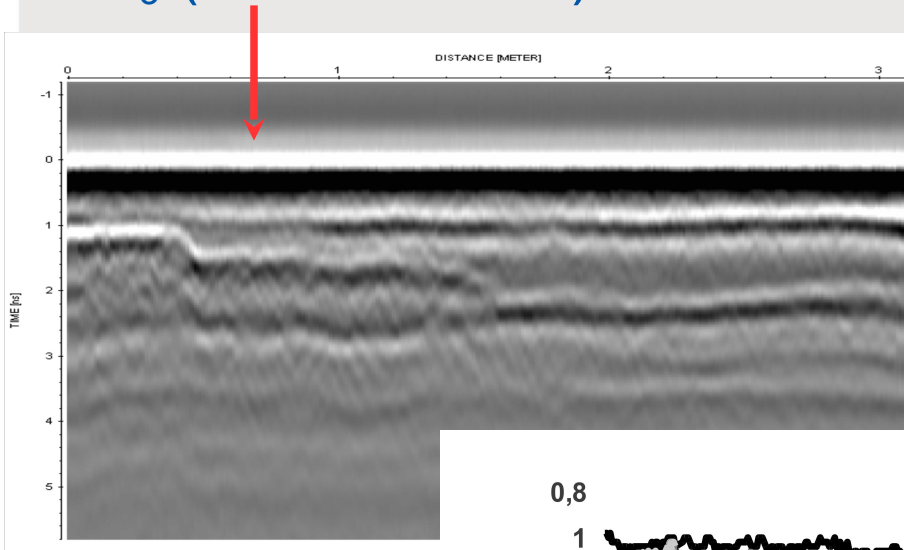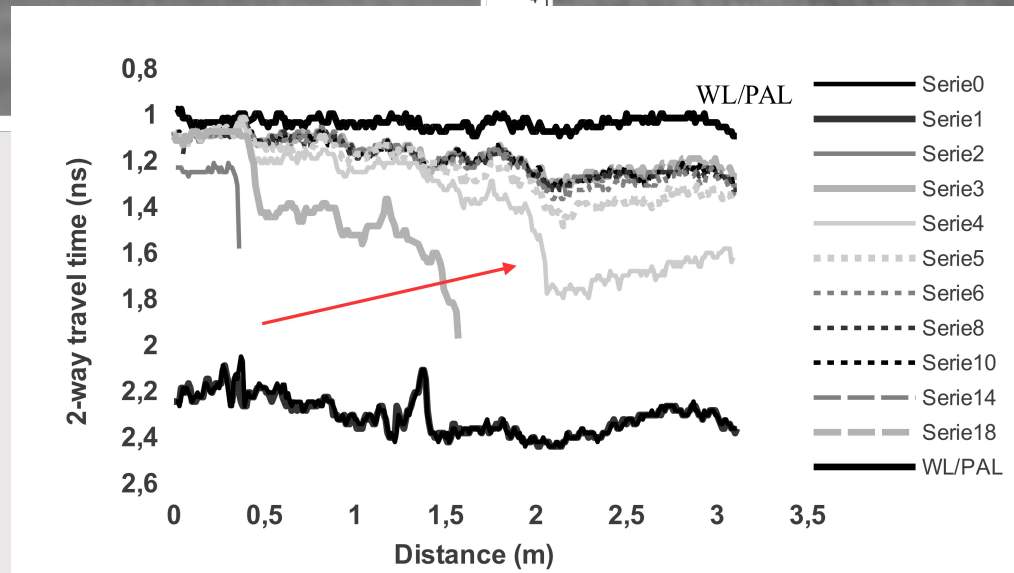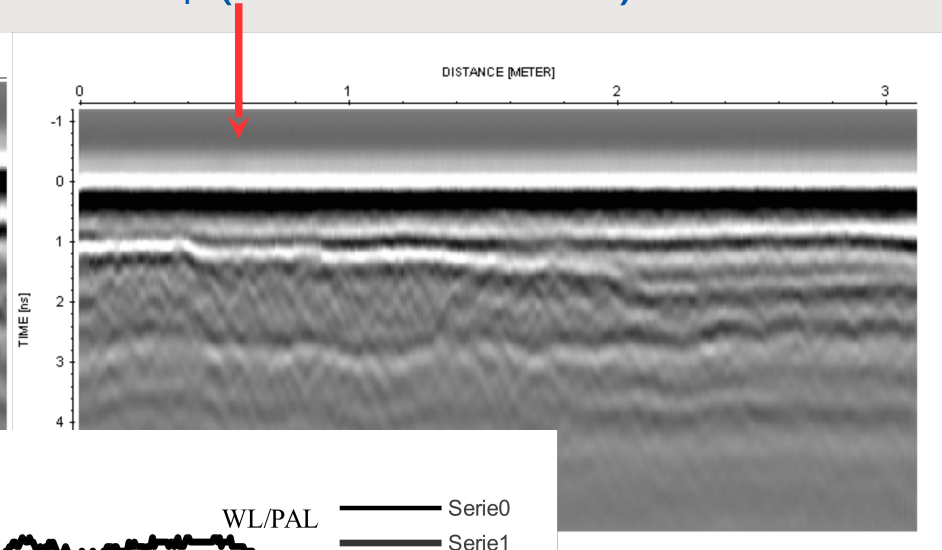## WL/PAL interface

Water front flow

GPR 2.6 GHz – Line 6
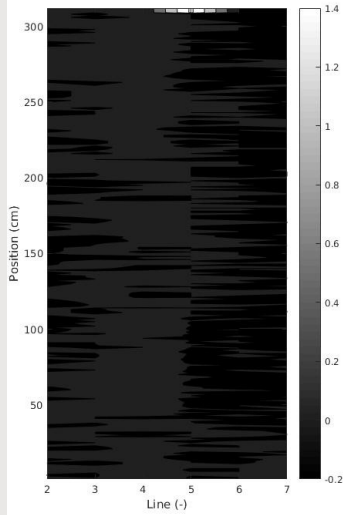
T_3 (16' imbibition):

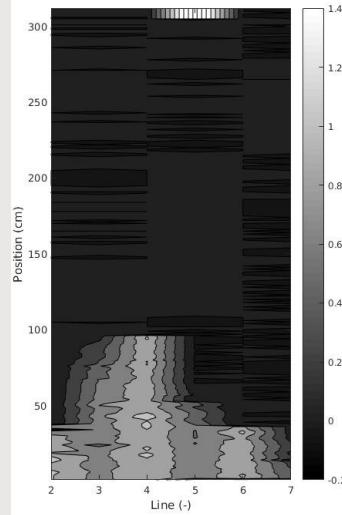T_4 (22' 'imbibition):

GPR 2.6 GHz – Line 3

From T_0 to T_{24} (2h55')
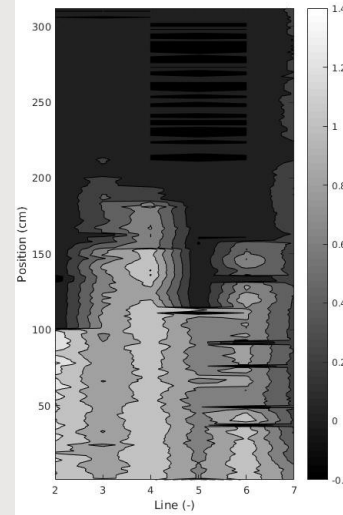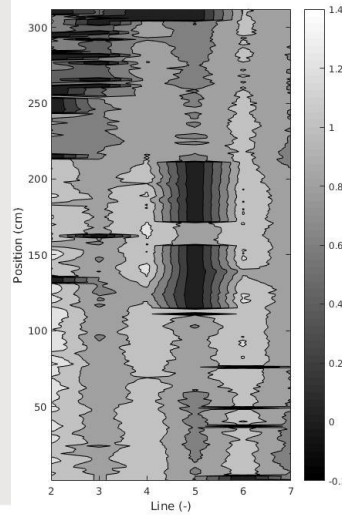
Water front mapping monitoring
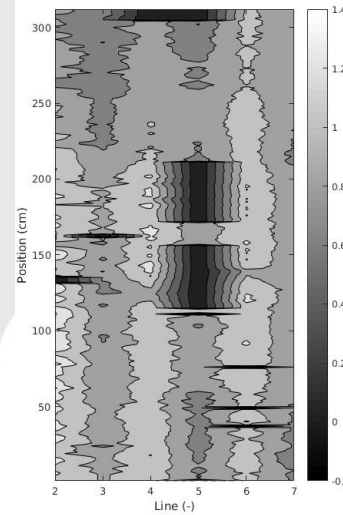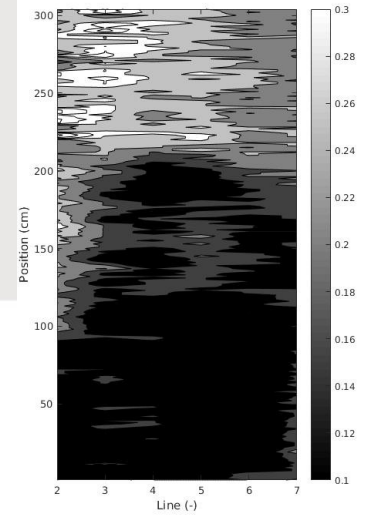

T0-T1

T0-T2

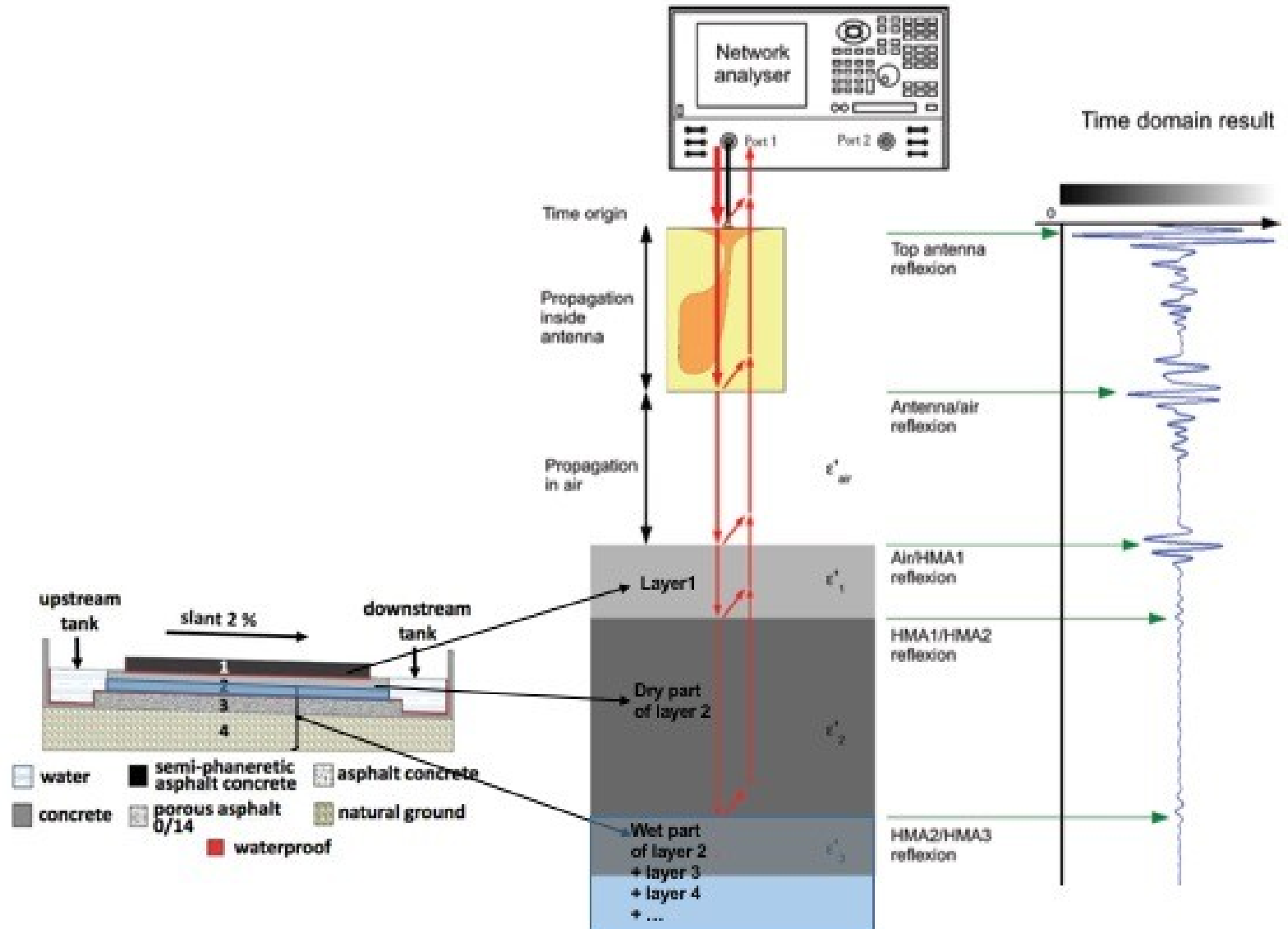
T0-T3

T0-T4
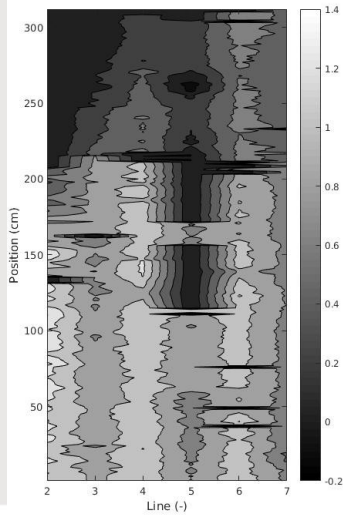
T0-T6

T0-T8

W/PAL(T8)

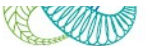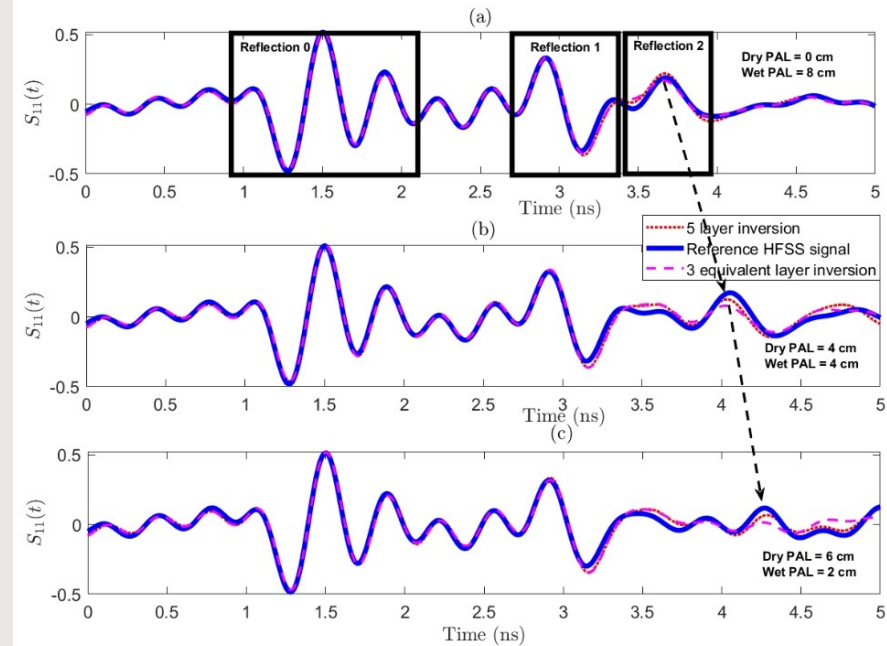# Step-frequency radar principle [800 – 3000 MHz]

SFR direct modelling

=> Analytical model:

Air-coupled dipole behavior (LF) / Green 's functions / Multi-layer

=> Numerical simulation (5 – 3 layers-eq)
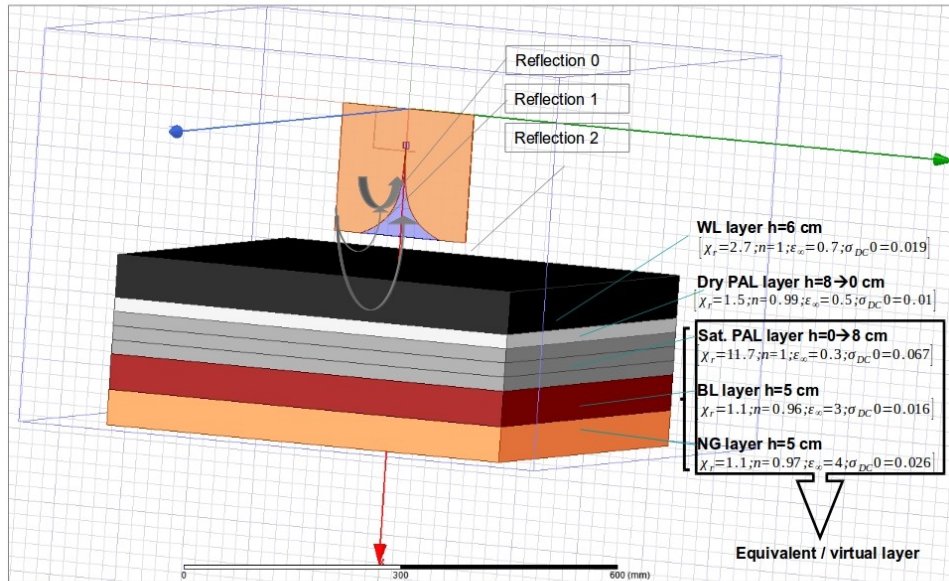
SFR Measurement example (T_0)
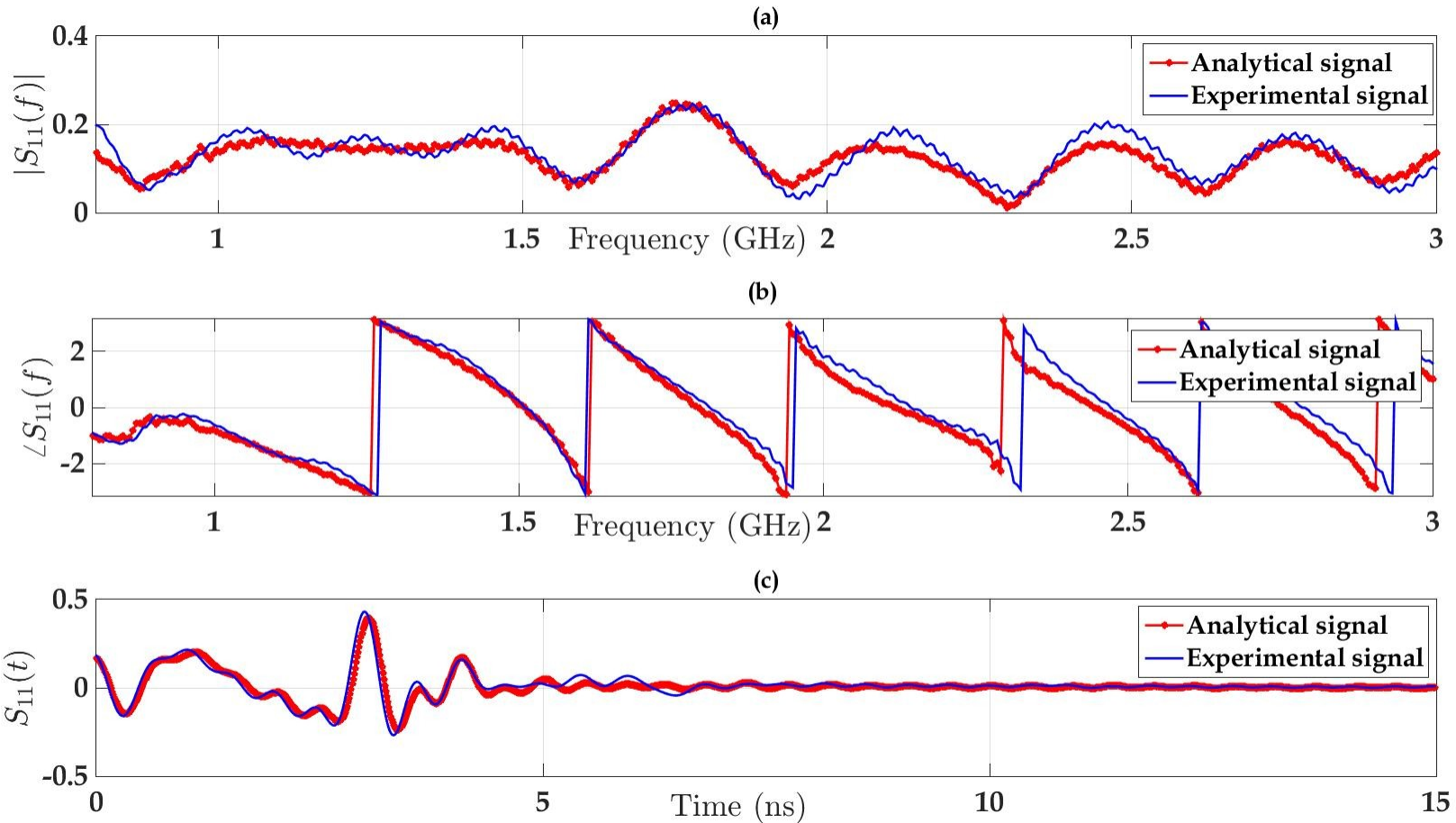
=> Analytical model (3 layers-eq):

Air-coupled dipole behavior (LF) / Green 's functions / Multi-layer

Full-wave form inversion
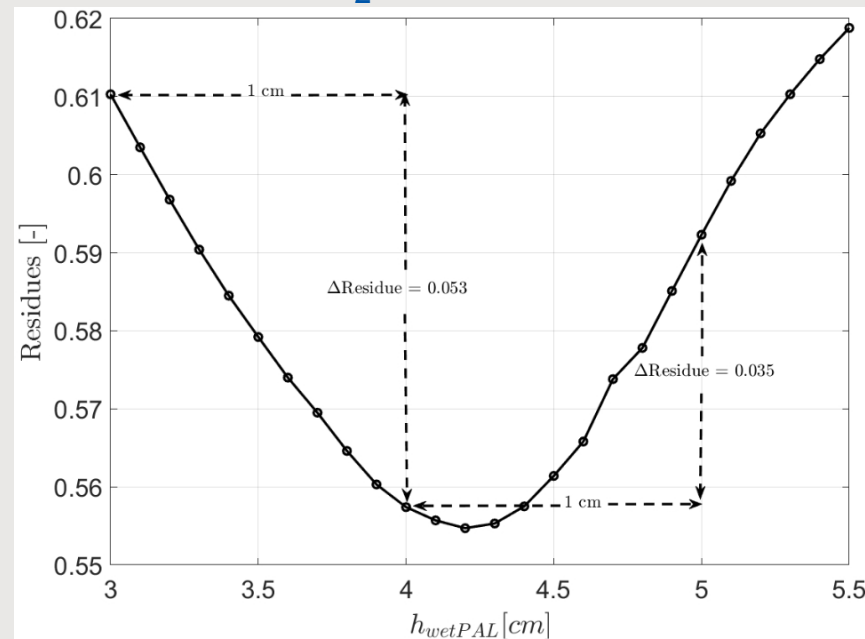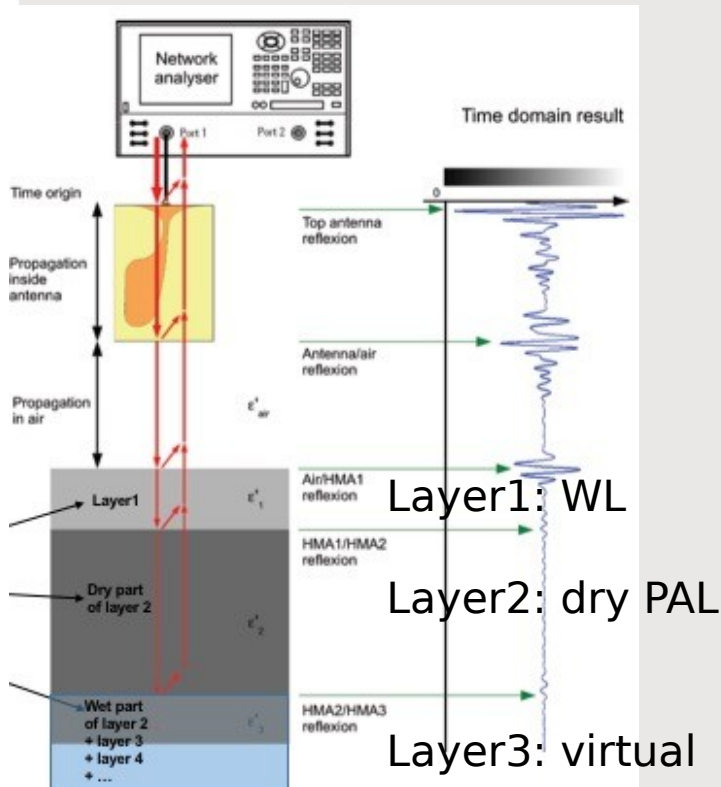

Layer1: WL

Layer2: dry PAL

Layer3: virtual

FWFI: Cost function minimization (genetic algorithm)

Time T_0: ε_i calculated (12 unknowns)

Time T_i: ε_i & h_1 fixed

h_2 calculated (1 unknown)

SFR inversions

Permittivities (T_0) :

Dry PAL thickness:

(a)

χ_r=3.5, n=1.0, ϵ_∞=0.9, σ_{DC}=0.002, h=6.5 cm

χ_r=2.9, n=0.98, ϵ_∞=0.6, σ_{DC}=0.02, h=∞

χ_r=2.7, n=0.94, ϵ_∞=0.0, σ_{DC}=0.0, h=8 cm

Re(ϵ_r)

Layer No.1
Layer No.2
Layer No.3

f(GHz)

(b)

Layer No.1
Layer No.2
Layer No.3

Im(ϵ_r)

f(GHz)

Dry part of layer 2 thickness (cm)

Saturated state

Imbibition time (min)
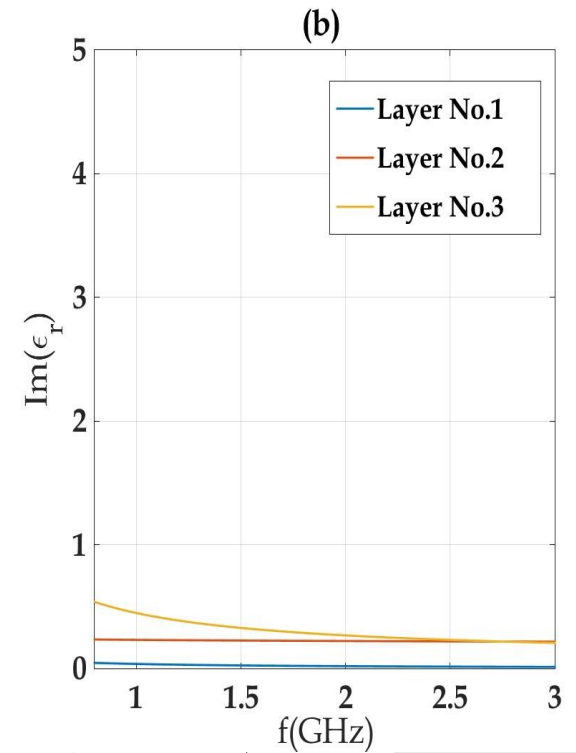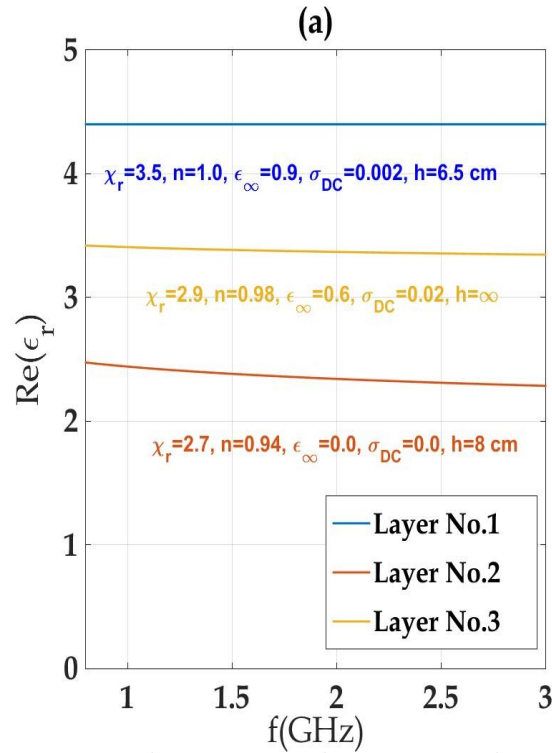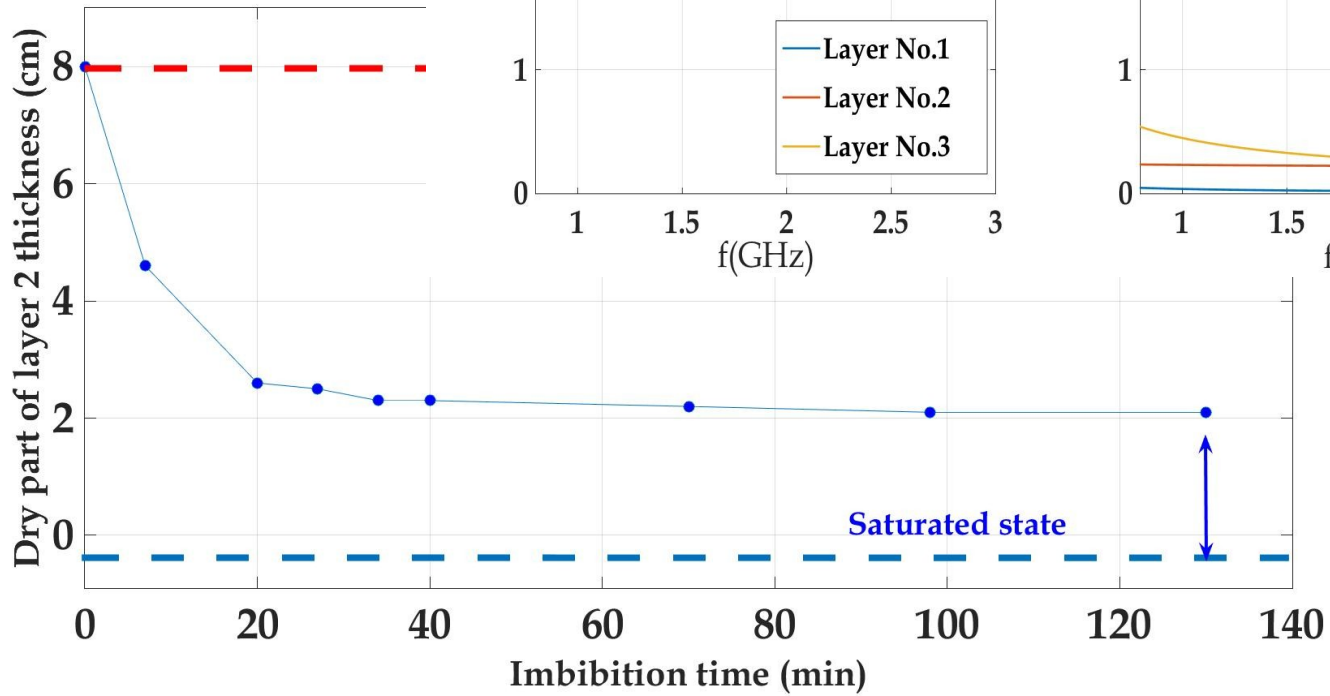
Conclusions / Perspectives

> GPR

    Water front detection - imbibition (purge): Yes (No)

    Air lens detection: ~ OK

> SFR / FWFI:

    Inversions stable vs. Time

    Simplified config. (virtual Layer3): consistent results

    > 4-layer FWFI to be tested...

Merci pour votre attention

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