



COST Action TU1208

“Civil Engineering Applications of Ground Penetrating Radar”

Training School on Electromagnetic modelling techniques for GPR

**E²GPR – Edit your geometry, execute gprMax
and Plot the Results!**

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E²GPR - Introduction

What is E²GPR ?

E²GPR stands for **E**dit your geometry, **E**xecute **G**prMax and **P**lot the **R**esults (**EEGPR**). This tool was developed by **Daniele Pirrone** under the supervision of Lara Pajewski (Sapienza & Roma Tre University, Italy), as a contribution to COST Action TU1208. It is a set of Server/Client scripts, conceived to facilitate the use of gprMax through a user-friendly interface, as well as to shorten the execution time by allowing parallelized and distributed analysis on multi-core machines or computer networks.

The main scripts are:

- **CAD** to build the model (*Client-side*)
- **PROCESS** to enable parallelisation/cluster (*Server-side*)
- **PLOTTER** to open the output file and show results (*Server/Client-side*)



E²GPR - Introduction

To use gprMax, a user has to:

1. Write an **input file**, describing media properties, geometry, antennas, ...
2. Execute gprMax
3. Check if the geometry is correct, by opening the geometry files generated by gprMax (for example by using **Paraview** or suitable **MatLab procedures**)
4. Once the execution is completed, plot the results stored in the output file generated by gprMax (for example by using **Paraview** or suitable **MatLab procedures**)



E²GPR – gprMax CAD

Writing an input file can be complicated

For simple models the input file can be easily created.

...but...



- for more complicated scenarios **creating the model is not so straightforward**
- it would be very useful to have the possibility to **check the geometry in real time**, while creating a model. In this way, it would be much easier to check whether the model is correct and fix errors.
- with gprMax it may be difficult to modify an already existing model, in order to add new objects or change the existing ones.



E²GPR – gprMax CAD

Solution: Develop a **CAD** to help the user

➤ What is a Computer-Aided Design (CAD)?

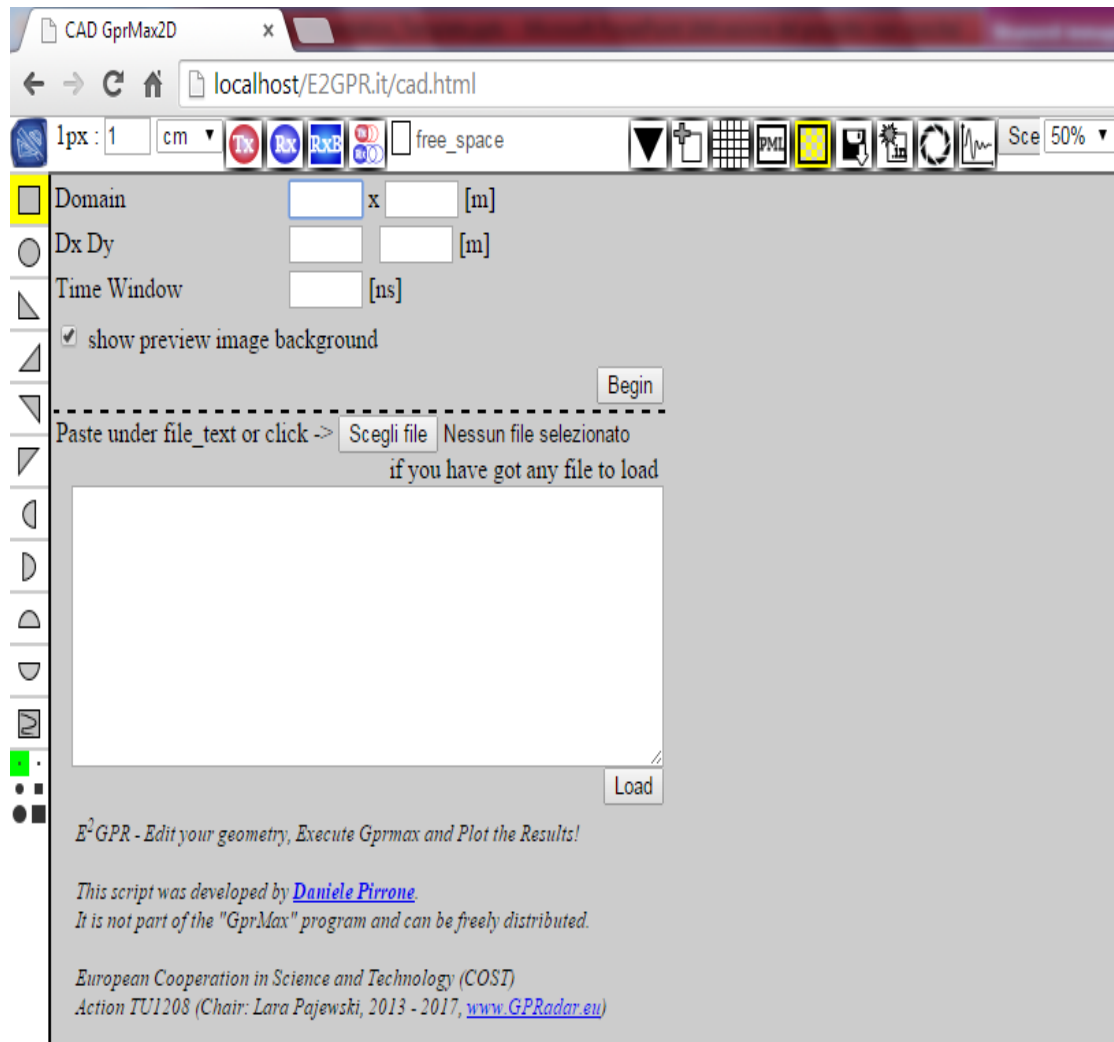
- CAD is the use of computer systems to assist in the creation, modification, analysis, or optimisation of a model
- It allows to describe the shape and size of an object by using devices different from the keyboard (mouse, touch-screen).

➤ Requirements

- Compatibility across different Software / Hardware platforms
- The developed CAD has to create an input file for gprMax



E²GPR – gprMax CAD



Our **CAD** is written in:

- **HTML**
- **JAVASCRIPT**

so it runs on any device such as:
Notebooks, Tablets,
Smartphones, PCs, MACs, ...

To start, the user has to define
the main features:

- *Domain size* : x y
- *Spatial discretisation* : x y
- *Time window* : t

Then press the button «**Begin**».

Else, it is possible to load an
already existing input file by
pressing the button «**Load**»



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E²GPR – gprMax CAD

The screenshot displays the CAD GprMax2D software interface. The main workspace shows a circular element being edited on a grid. The element's coordinates are displayed as $x = 0.299 \text{ m}$ and $y = 0.122 \text{ m}$. The interface includes a toolbar with various tools, a command panel on the right, and a status bar at the bottom.

Command Panel:

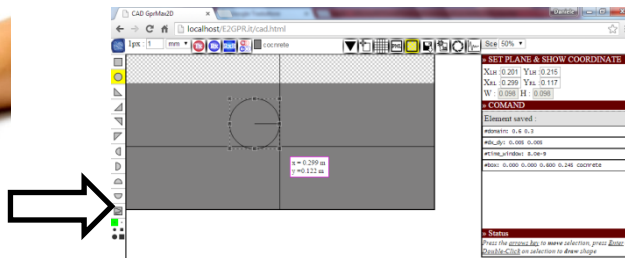
- SET PLANE & SHOW COORDINATE**
 - XLH : 0.201 YLH : 0.215
 - XRL : 0.299 YRL : 0.117
 - W : 0.098 H : 0.098
- COMAND**
 - Element saved :
 - #domain: 0.6 0.3
 - #dx_dy: 0.005 0.005
 - #time_window: 8.0e-9
 - #box: 0.000 0.000 0.600 0.245 concrete
- Status**
 - Press the *arrows key* to move selection, press *Enter* or *Double-Click* on selection to draw shape



E²GPR – gprMax CAD

Some CAD features, for 2D models:

- Objects can be copied, deleted, shifted, resized, ...
- Different media can be defined and associated to different colours
- It is possible to load a background picture!
- Basic shapes are available (cylinder, square, triangle, ...) and arbitrary shapes can be hand-drawn!
- The receiving and transmitting antennas can follow an arbitrary path!



Element saved :

```
#domain: 0.6 0.3
#dx_dy: 0.0025 0.0025
#time_window: 8.0e-9
#box: 0.0980 0.1340 0.2720 0.2500 pec
```

```
#domain : 0.6 0.3
#dx_dy : 0.0025 0.0025
#time_windows : 8.0e-9
#box: 0.0980 0.01340 0.2720 0.25 pec
.....
```



E²GPR - Parallelised and distributed execution of gprMax

Sophisticated models take a lot of time to be run...

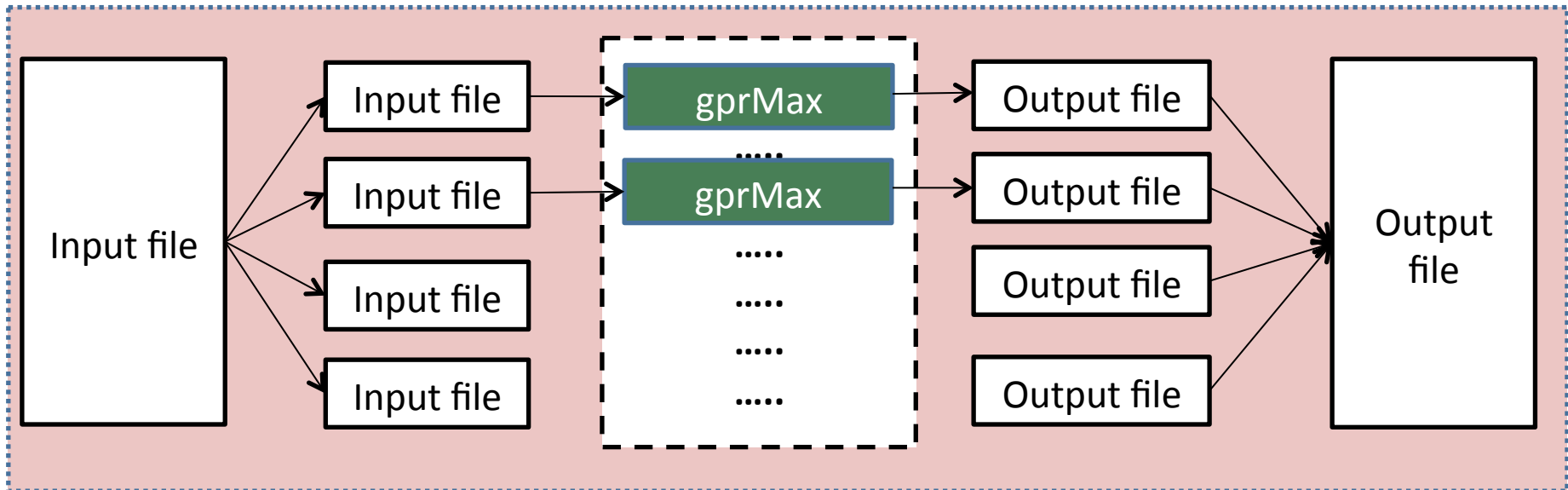
Solution: the new version of gprMax has been parallelized. Moreover, we developed a tool to facilitate the simultaneous execution of different traces of a model on different available cores (on multi-core machines or networks of computers) and be able to follow in real time the process.



E²GPR - Parallelised Analysis

If N traces have to be calculated, the input file is automatically splitted by E²GPR in N input files and their execution is allocated to the available cores.

As soon as a core completes a trace, it receives a new input file to be executed. Finally, all the output files are combined in a **xml** file.



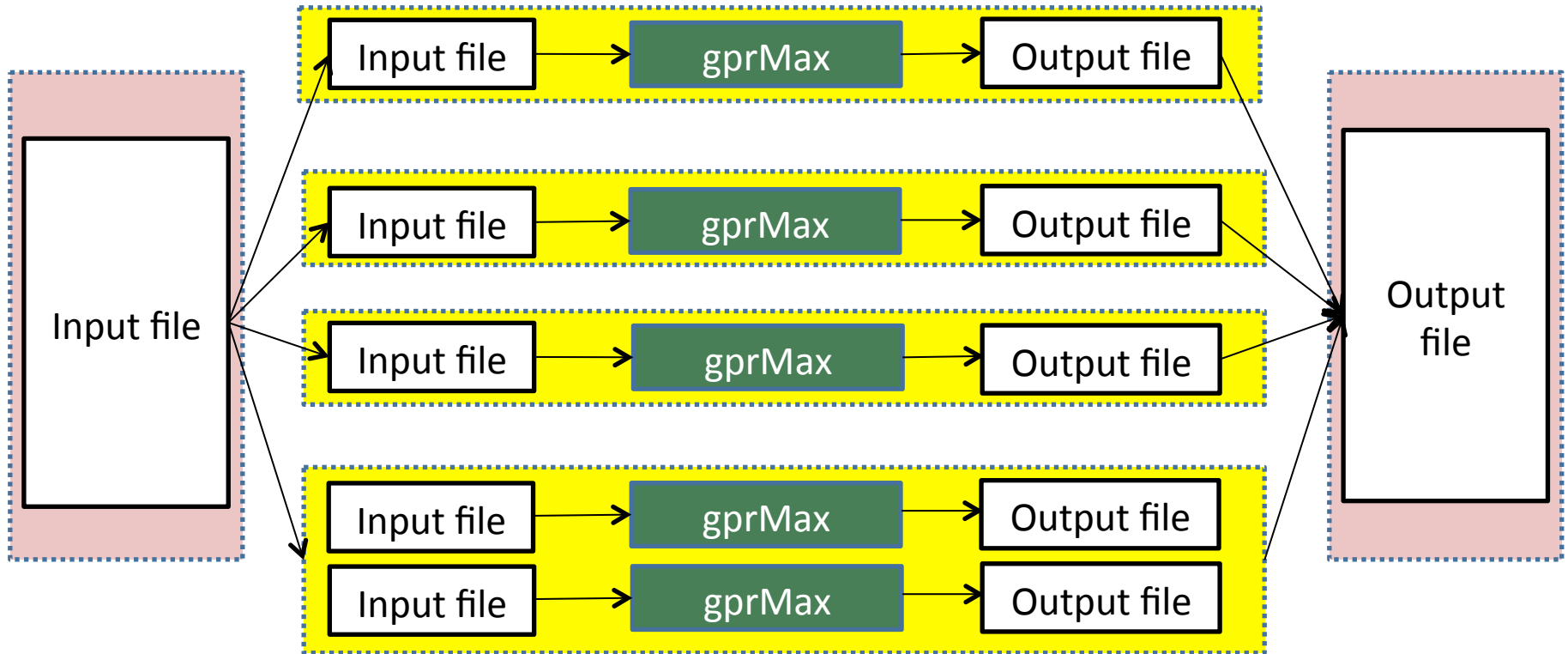
xml is a markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable.



E²GPR - Distributed Analysis

Further E²GPR scripts allow to simultaneously execute different traces on a network of multi-core machines

Different computer/server machines connected within a LAN or WAN



E²GPR - Distributed Analysis

The user can monitor how the process is going on.

Ip : localhost
Cpu's number : 2

These tracks are runned to GprMax2D

Analysis #1 100%	Analysis #10 100%	Analysis #13 100%	Analysis #14 100%	Analysis #17 FnEx%	Analysis #18 0%	Analysis #2 0%	Analysis #21 0%
Analysis #22 0%	Analysis #25 0%	Analysis #26 0%	Analysis #29 0%	Analysis #30 0%	Analysis #33 0%	Analysis #34 0%	Analysis #37 0%

1.out 10.out 13.out 14.out

Ip : localhost
Cpu's number : 2

These tracks are runned to GprMax2D

Analysis #11 100%	Analysis #12 100%	Analysis #15 100%	Analysis #16 100%	Analysis #19 11%	Analysis #20 FnEx%	Analysis #23 0%	Analysis #24 0%
Analysis #27 0%	Analysis #28 0%	Analysis #3 0%	Analysis #31 0%	Analysis #32 0%	Analysis #35 0%	Analysis #36 0%	Analysis #39 0%

These tracks will be sent at main node

12.out sent 11.out sent 15.out sent 16.out sent

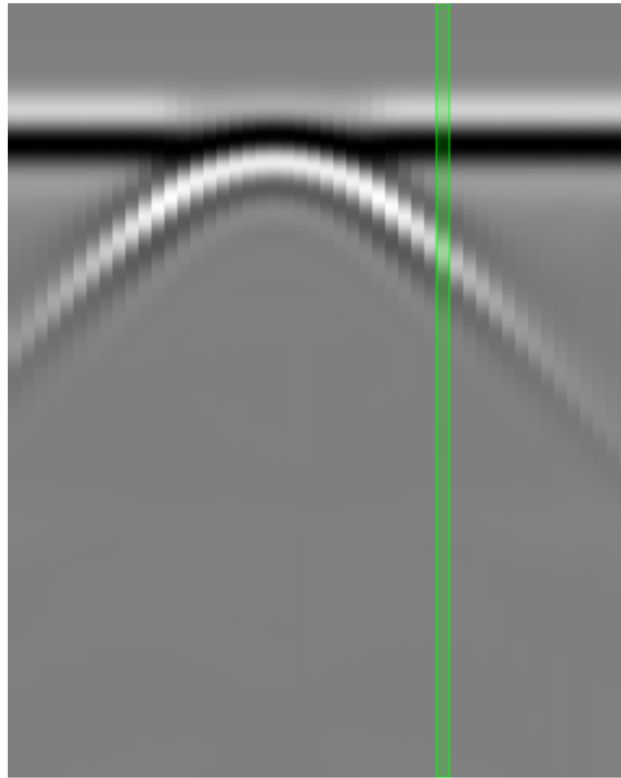
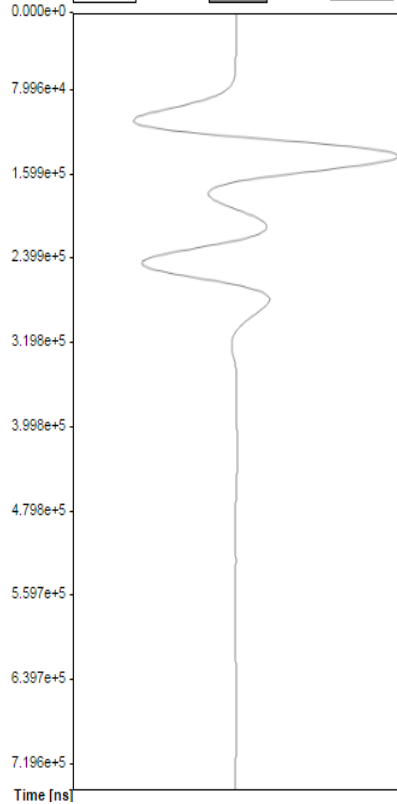


E²GPR - Plotting the results

A-SCAN trace number : Field : Scale :

Elaboration start 27/02/2015 11:30:59 end 27/02/2015 11:32:14

Ez [V/m]



The **Plotter** is written in:

- **HMTL**
 - **JAVASCRIPT**
- (same as the CAD).

It takes data from the **xml** file and automatically plots A-scans and B-scans.

The user can choose the number of the trace to be plotted (for A-scans) and the scale (for both A- and B-scans).

Both the electric and magnetic fields can be visualised.



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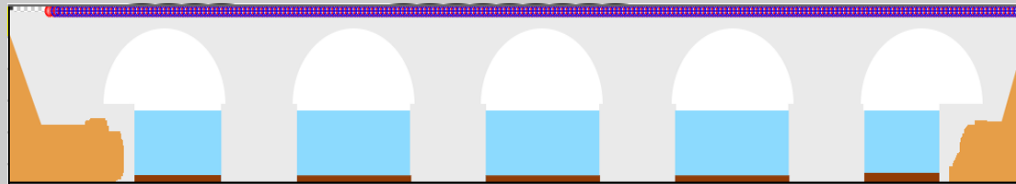
E²GPR - Examples

Sant'Angelo Bridge in Rome

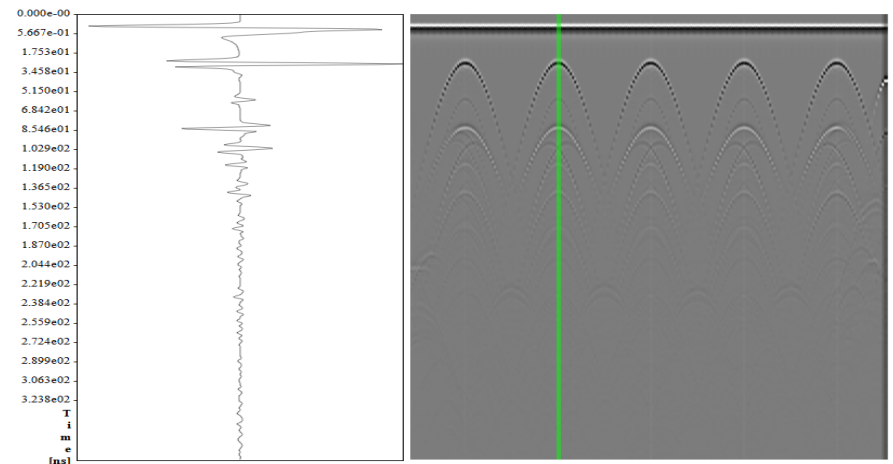
A)



B)



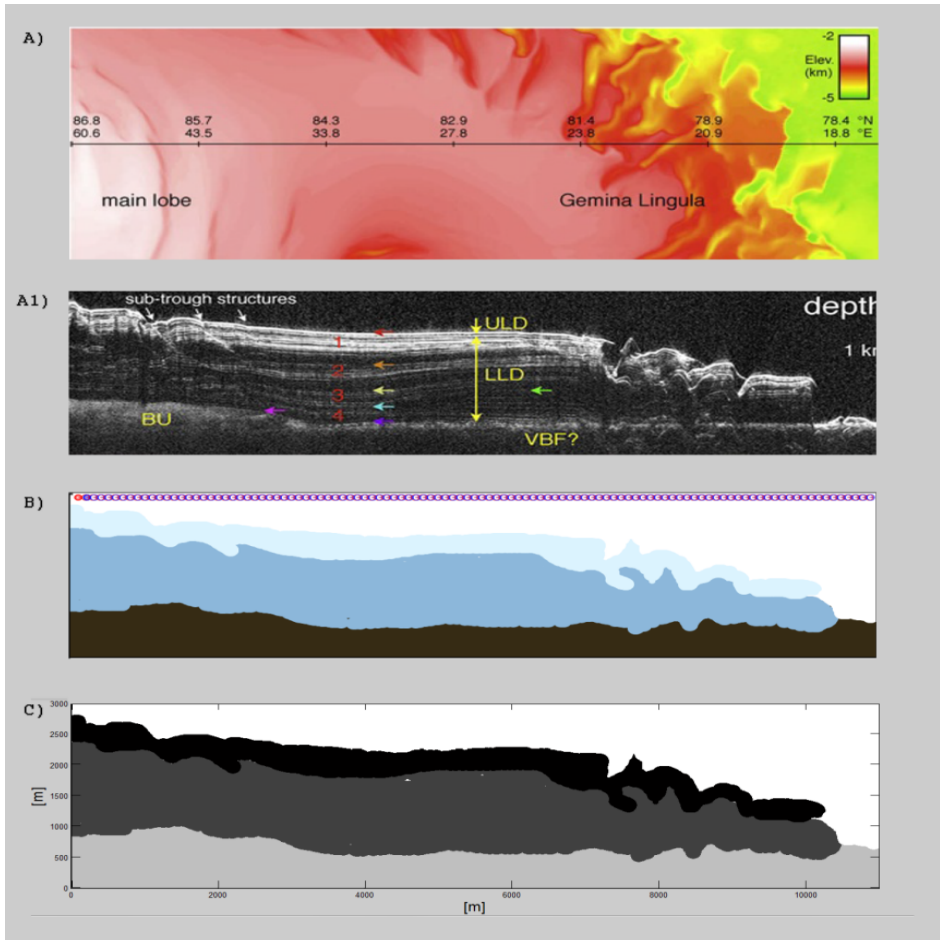
A-SCAN trace number: [69] | Field: [Ez] | zoom x [1]



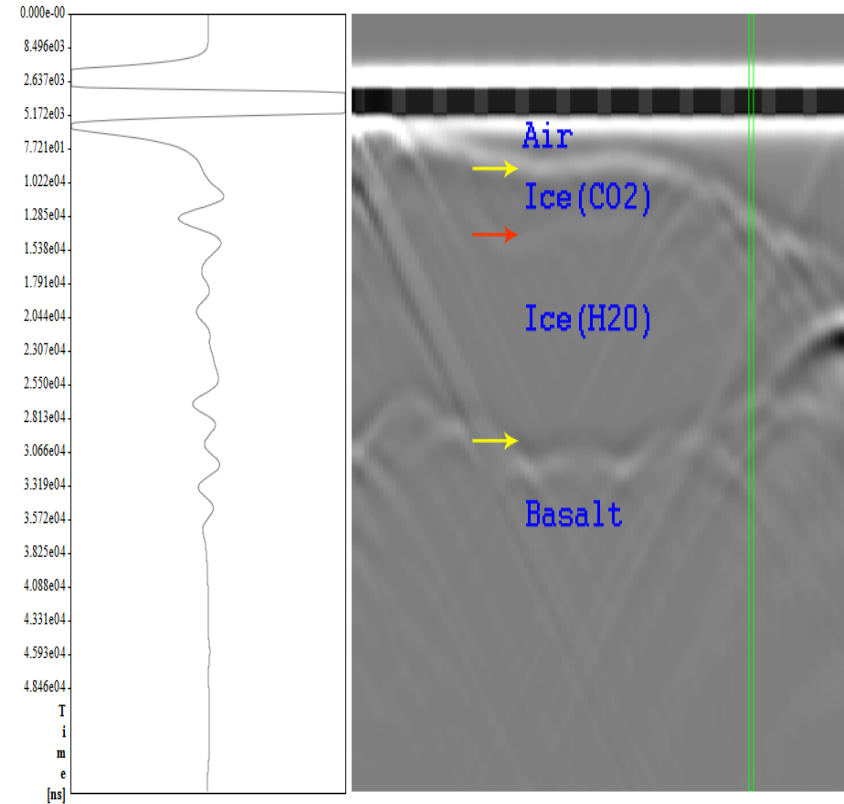
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E²GPR - Examples

South pole of Mars



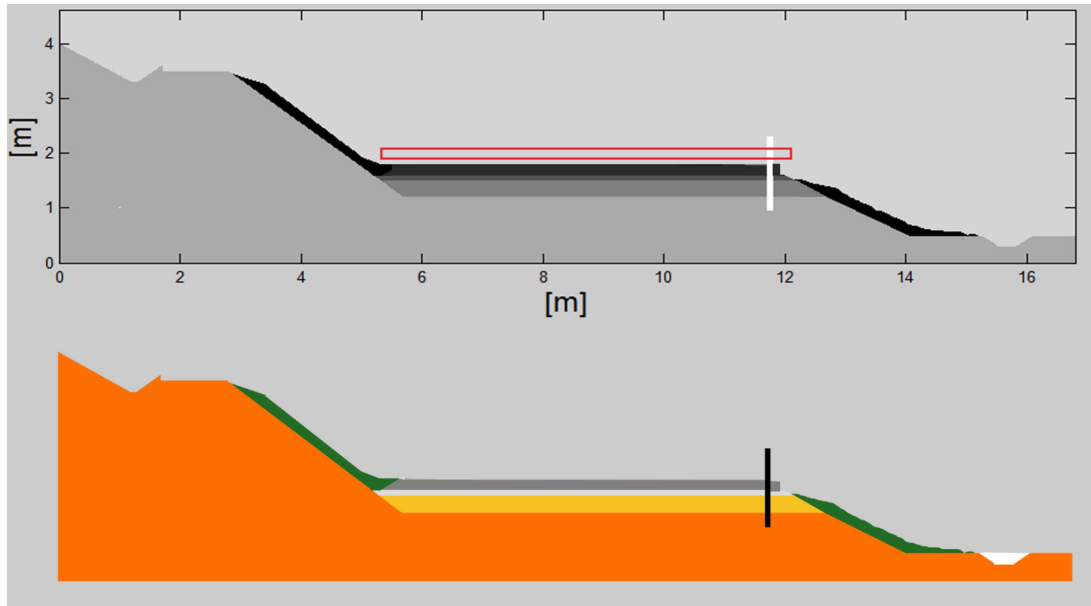
A-SCAN trace number: 88 | Field: Ez | zoom x 4



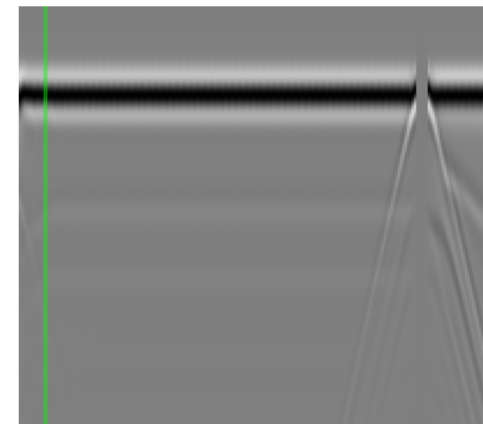
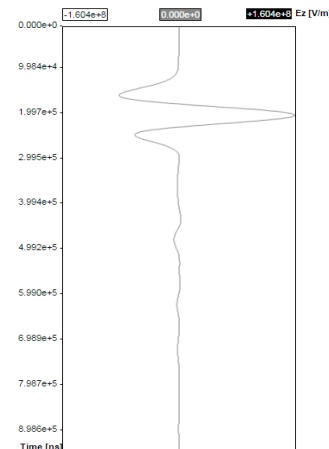
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E²GPR - Examples

Road pavement



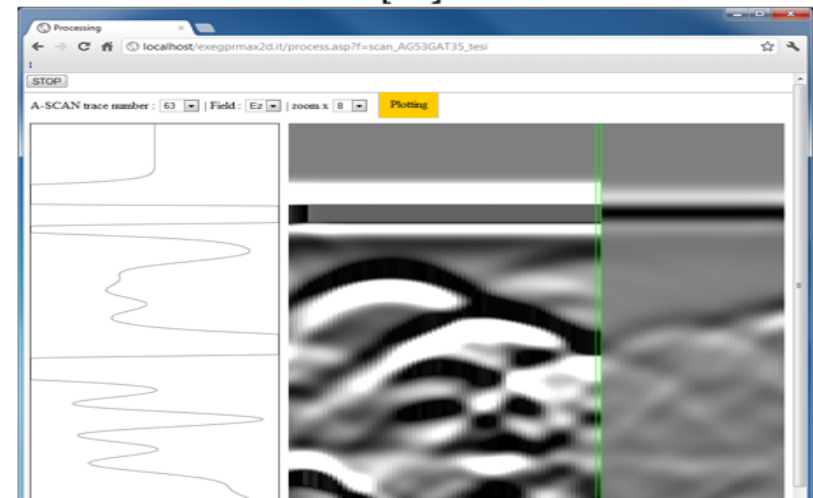
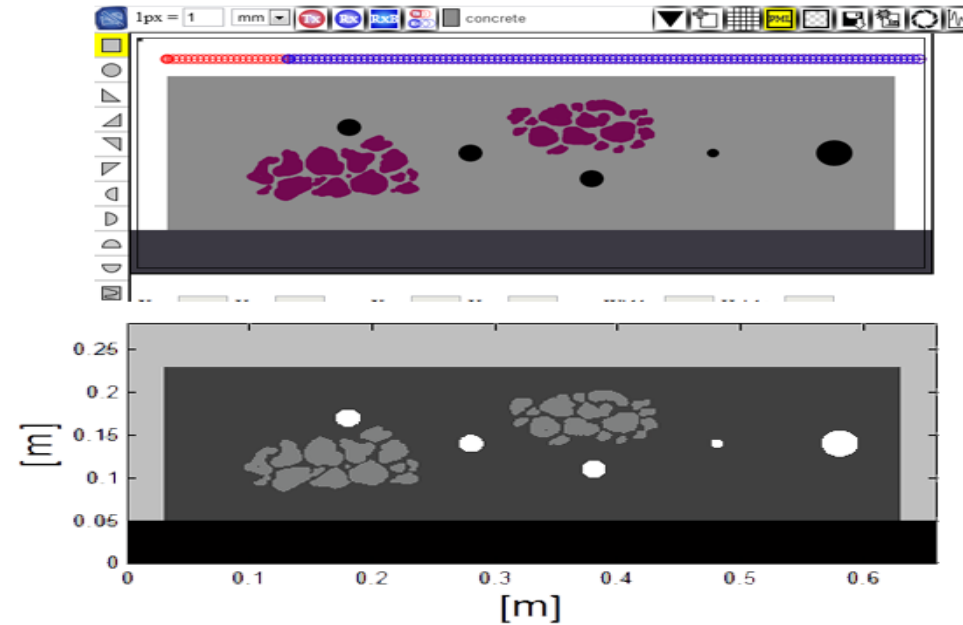
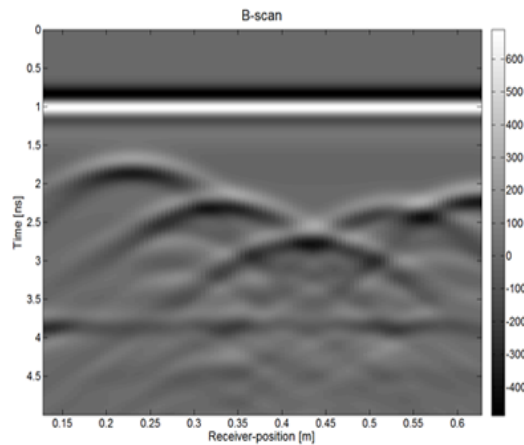
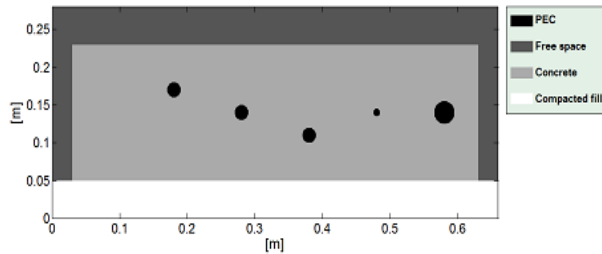
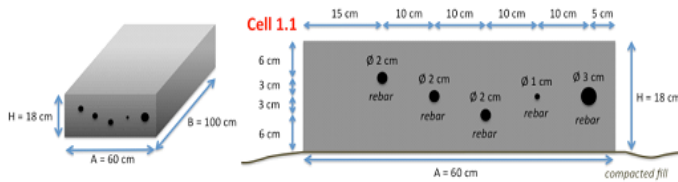
A-SCAN trace number : 12 | Field : Ez | Scale : 1:1 | Save Plotting
Elaboration start 24/02/2015 21:15:35 and 25/02/2015 02:54:21



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E²GPR - Examples

Modifying an existing model: aggregates in concrete cells



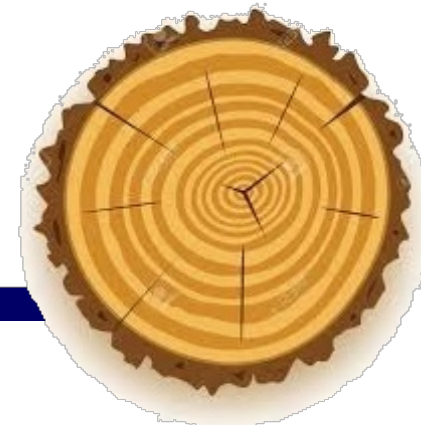
E²GPR - Examples

Tree trunk

The screenshot displays the E2GPR software interface. The main window shows a circular cross-section of a tree trunk with concentric rings representing different wood layers. The layers are color-coded: dark red for the cortex, orange for sapwood, and yellow for heartwood. A legend on the right lists the layers: free_space, pec, cortex, sapwood_16, sapwood_14, sapwood_12, sapwood_9, and heartwood. The interface also includes a toolbar with various tools, a status bar at the bottom, and a command console on the right showing the current element saved and its coordinates.

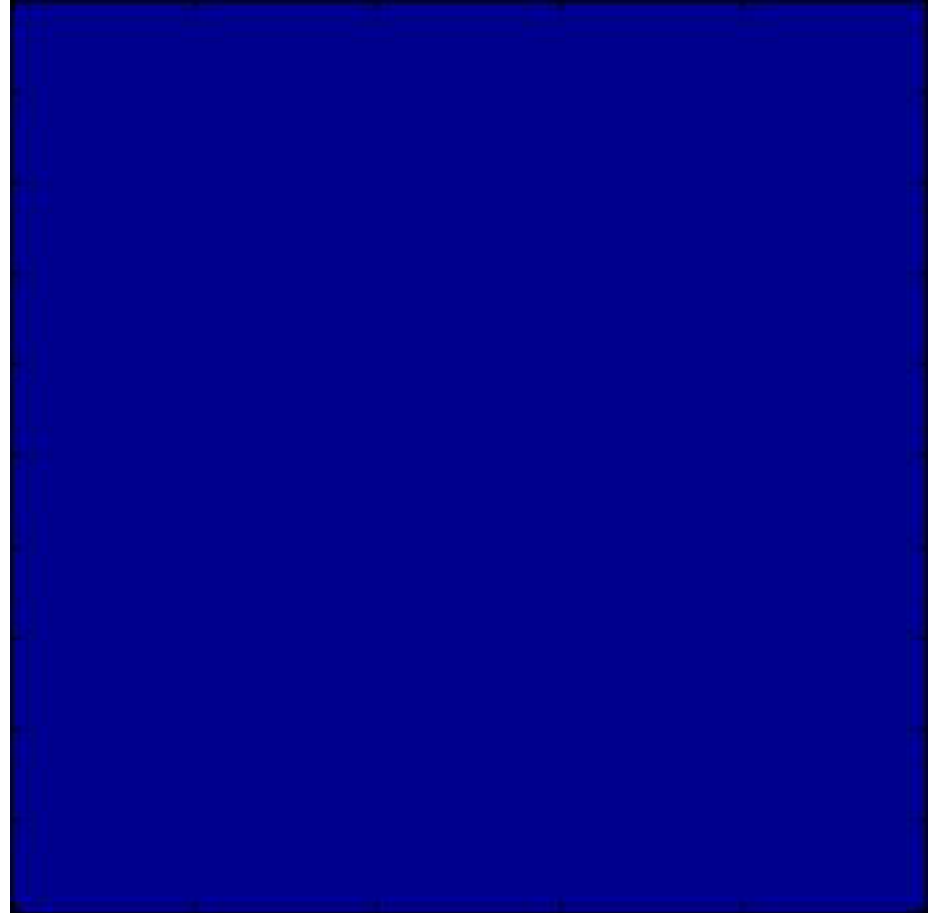
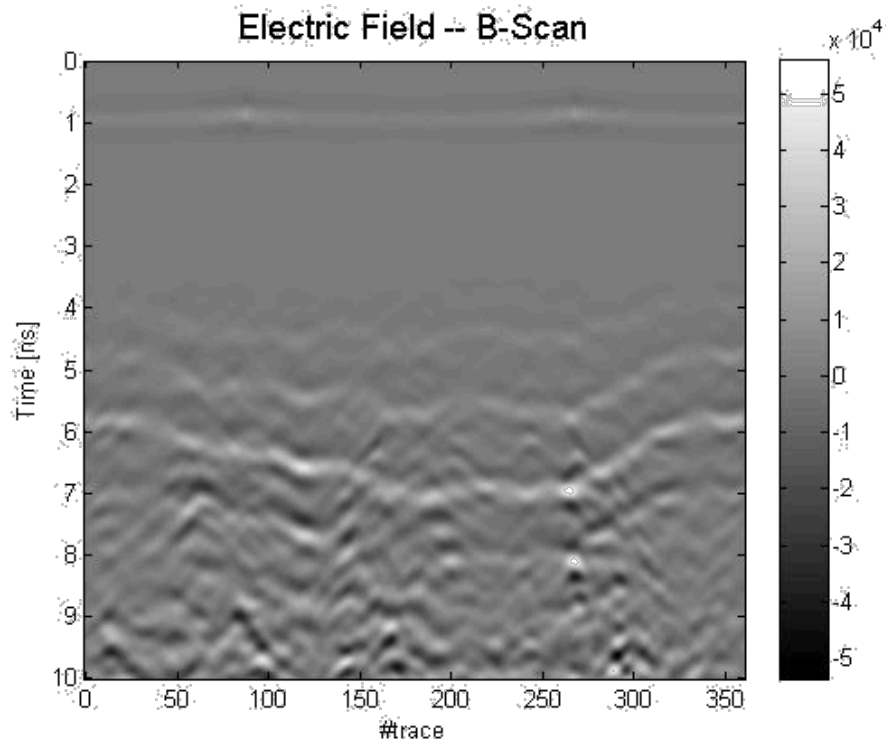
free_space
pec
cortex
sapwood_16
sapwood_14
sapwood_12
sapwood_9
heartwood

Resize
» SET PLANE & SHOW COORDINATE
XLH: 0.214 YLH: 0.774
XRL: 0.782 YRL: 0.206
W: 0.568 H: 0.568
» COMAND
Element saved :
#cy11nder: 0.525 0.498 0.082 sapwood_9
#cy11nder: 0.507 0.503 0.033 heartwood
#cy11nder: 0.515 0.507 0.034 heartwood
#cy11nder: 0.523 0.507 0.033 heartwood
#cy11nder: 0.520 0.497 0.028 heartwood
#Ex: 1.073 0.496 0.0 10.0e-9
#Ex: 0.783 0.496 0.0 10.0e-9
#rx: 0.783 0.521
#pm1: 12
» Status
Double-Click on selection to draw shape



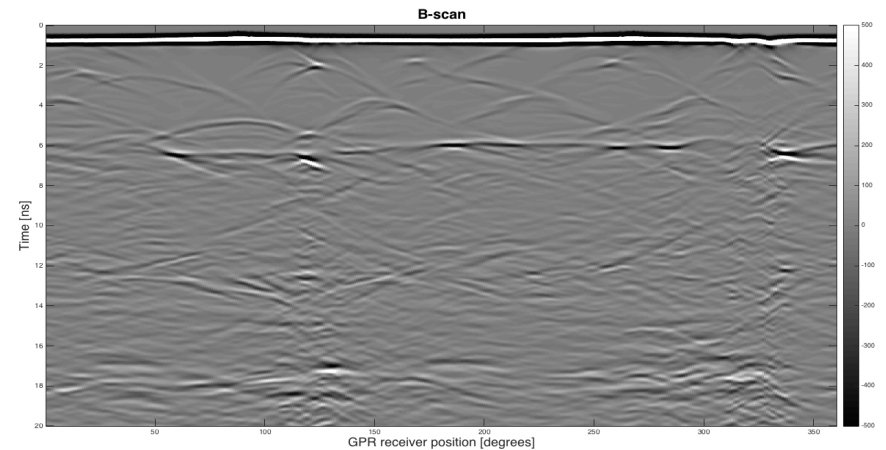
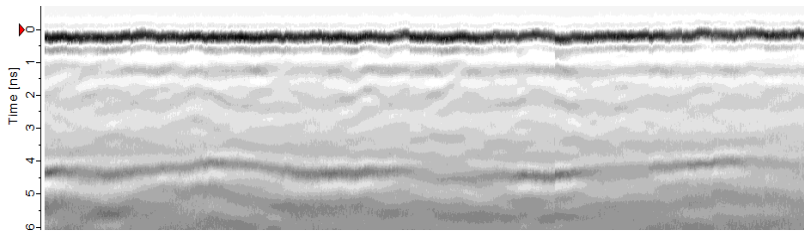
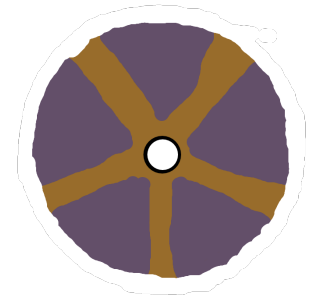
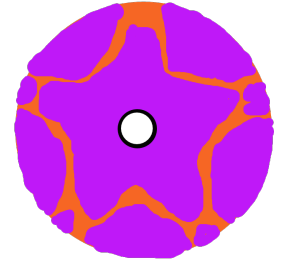
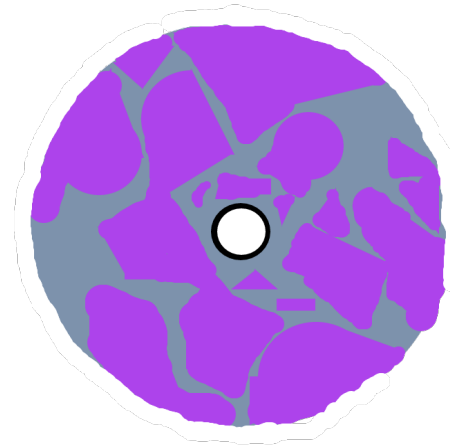
E²GPR - Examples

Tree trunk



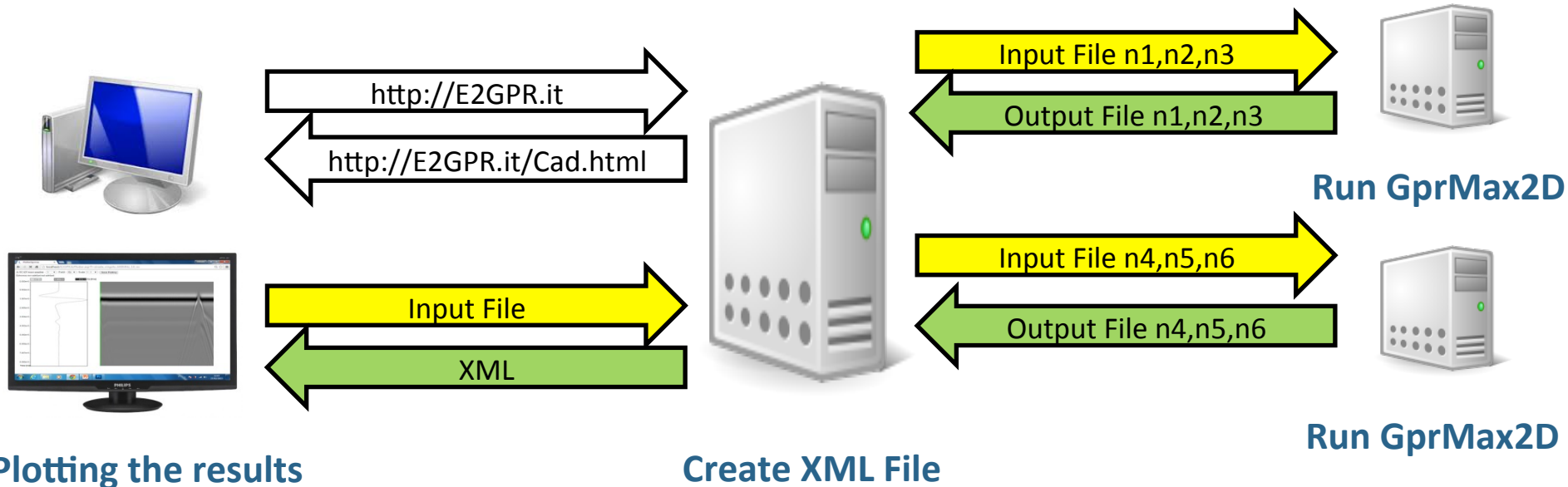
E²GPR - Examples

Column of the St Paul Hospital in Barcelona



E²GPR - Conclusions

E²GPR (Edit your geometry, Execute GprMax and Plot the Results) is a set of Server/Client scripts, developed to facilitate and extend the use of gprMax through a user-friendly interface, as well as to shorten the execution time by allowing parallelised and distributed analysis on multi-core machines or computer networks. **It is distributed for free to both academic and commercial users.**



Plotting the results

Create XML File

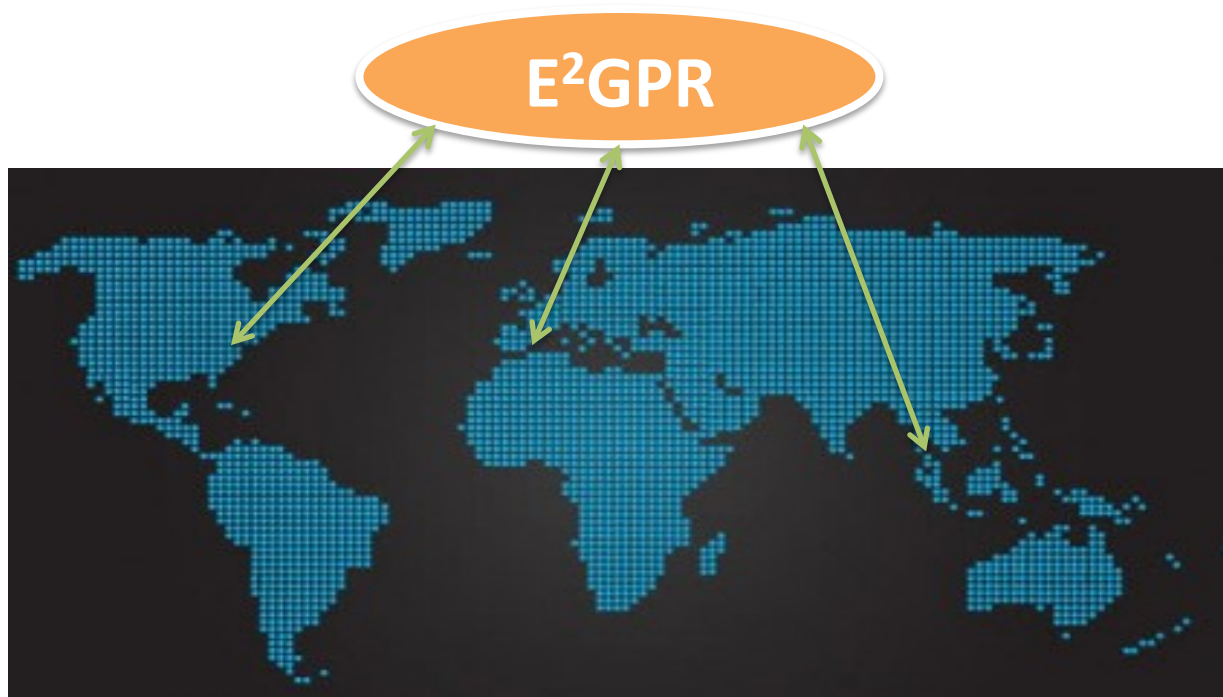
Run GprMax2D



E²GPR - Work in progress

A user guide for E²GPR is being written.

A dedicated server network is being set up: Action Members from Inclusiveness Countries will be able to remotely use it, in order to execute their gprMax models on our machines.



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Thank you!

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