FACE

Free Air CO2 Enrichment

Alessandro Zaldei
Carolina Vagnoli
CNR IBE

Increase in levels of atmospheric CO2 and its possible consequence -Global Warming- gave rise to a lot of interesting questions about how natural ecosystems will respond to this, rather un-natural, phenomenon. Especially the response of trees and tree communities might be important, given their role as a possible 'carbon sink'.

Despite their importance, we still now only a little about how agro eco-systems will behave in a world of elevated CO2. This is due to their size, lifespan and the complexity of relationships and interactions that exist in every agronomical or forest ecosystem.

FACE is one of only a handful of projects which aim at assessing the influence of rising atmospheric CO_2 levels on a agro ecosystem. In particular, the objective of this experiment, realized in collaboration with the Agricultural Institute -Centre for Agricultural Research (HSA) in Martonvásár (Hungary), is to determine the functional responses of different varieties of cereals to actual and future CO_2 concentrations and to assess its potential for carbon sequestering.

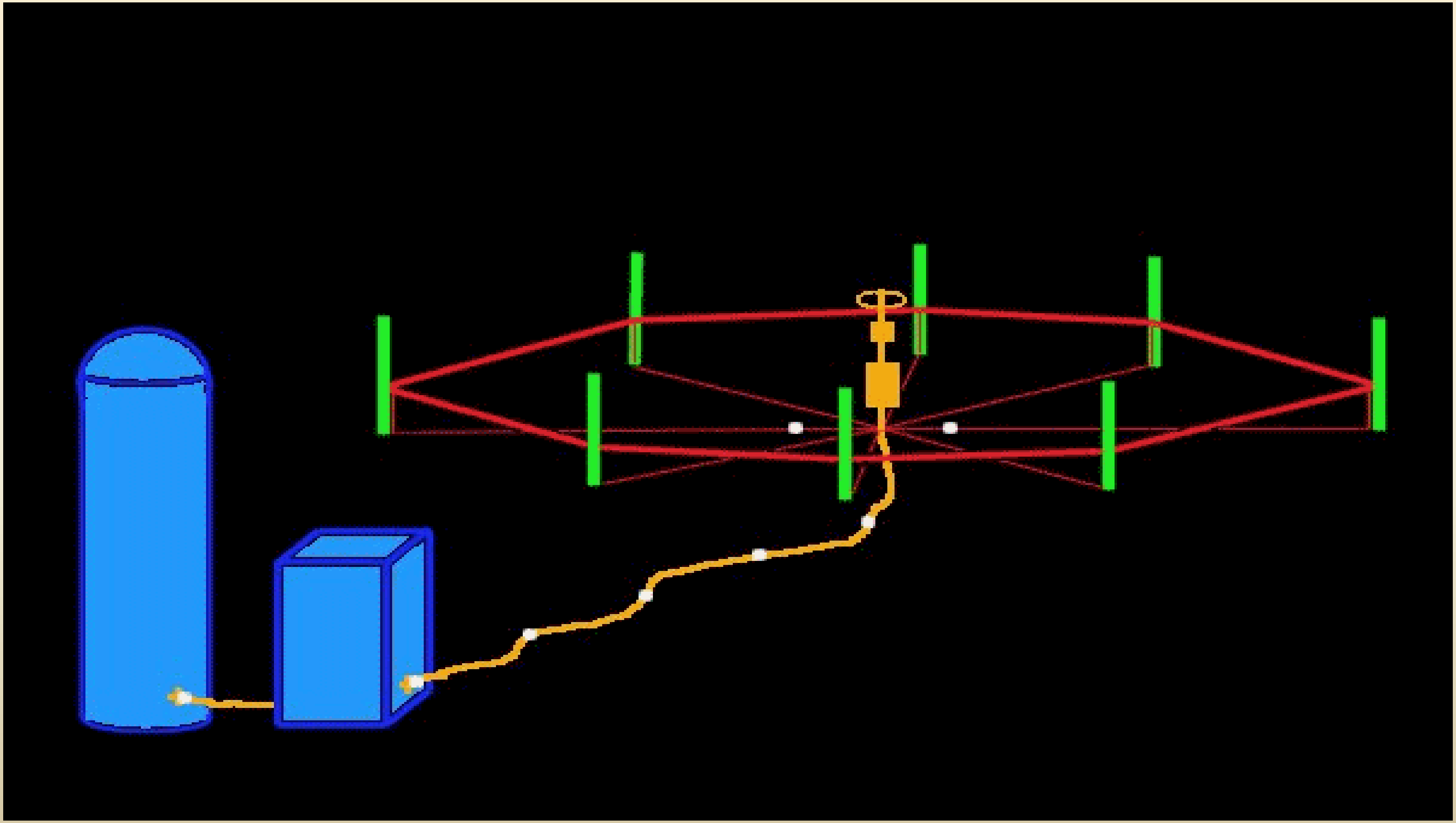
With the development of the improved FACE technology within the FACE Ungheria project, the concentrations of CO_2 and other trace-gases can be stably maintained at levels expected to prevail in the mid- to late twenty-first century.

The FACE facility installed in Hungary represent the state of the art of technology for the FACE system.

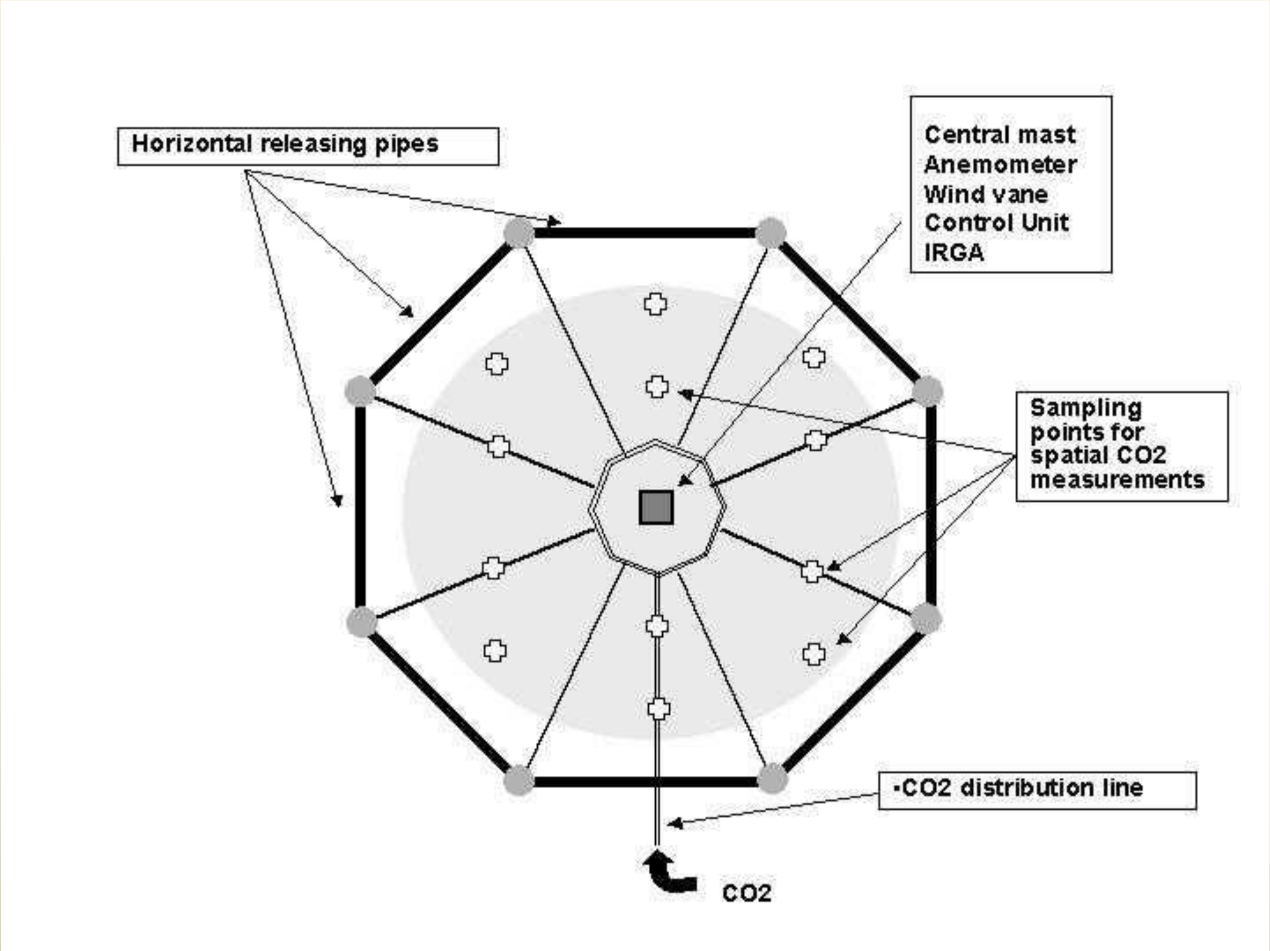
The objective is to ensure that the CO_2 concentration inside the study area (RING) is at least 80% of the time within a deviation of less than 20% from a given target set: in our case 570 ppm during the daylight hours.
To do this, a system FACE needs a directional control and a CO_2 pressure control, due to a industrial PC designed for this application.

In the experimental field of Martonvásár, we opted for the construction of 3 octagonal FACE rings with a diameter of 17 meters, each one with his own control unit.

Each ring is constituted by a control unit and a series of 8 laser drilled pipes to release CO2. The release system is made by one storage tank holding the supply of liquid CO2 at -180° C, radiators bringing the gas to ambient temperature and a vaporizer that ensures non-interrupted supply of CO2 to the rings through underground pipes.

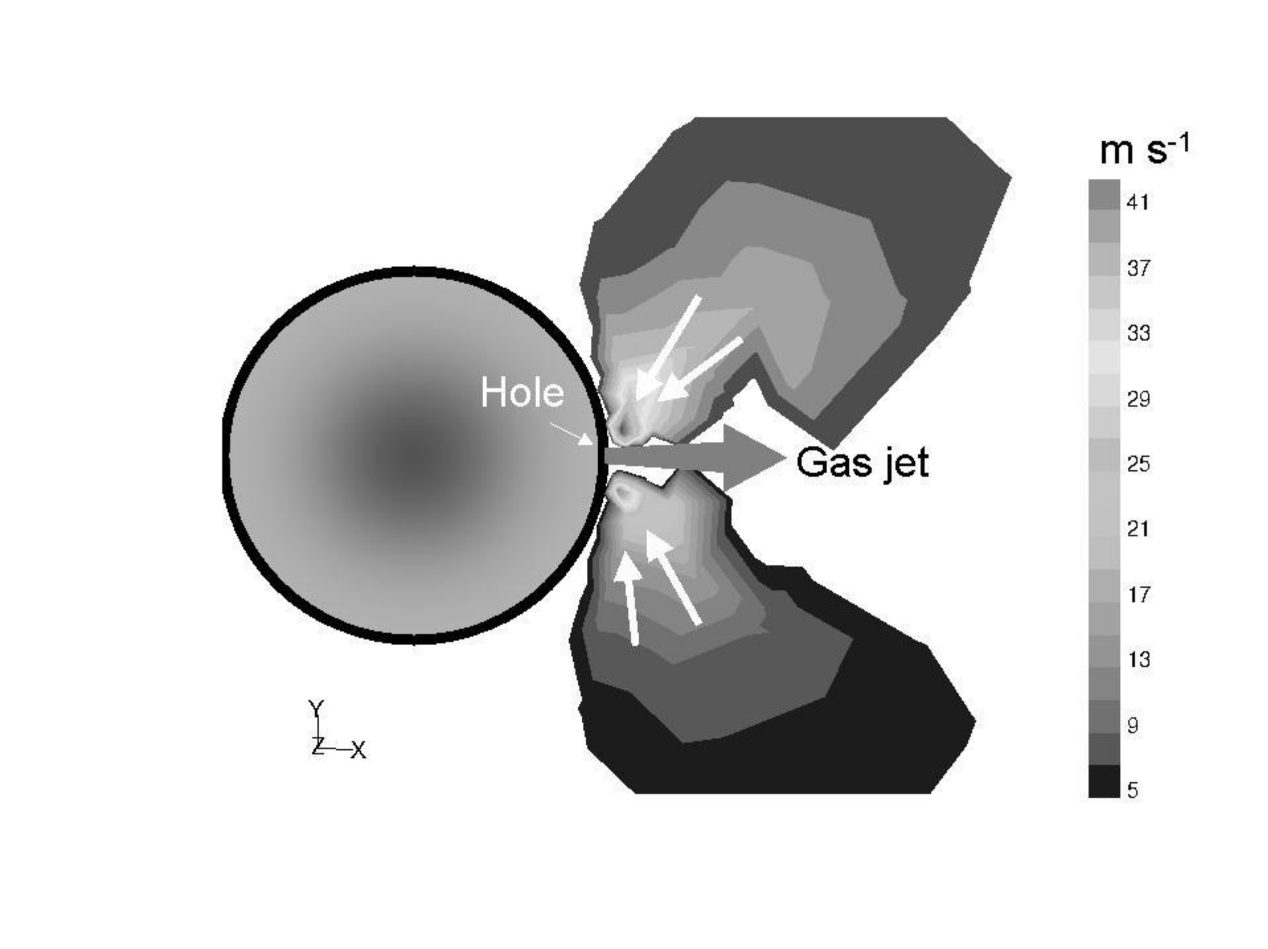


FACE SPATIAL DISTRIBUTION TEST

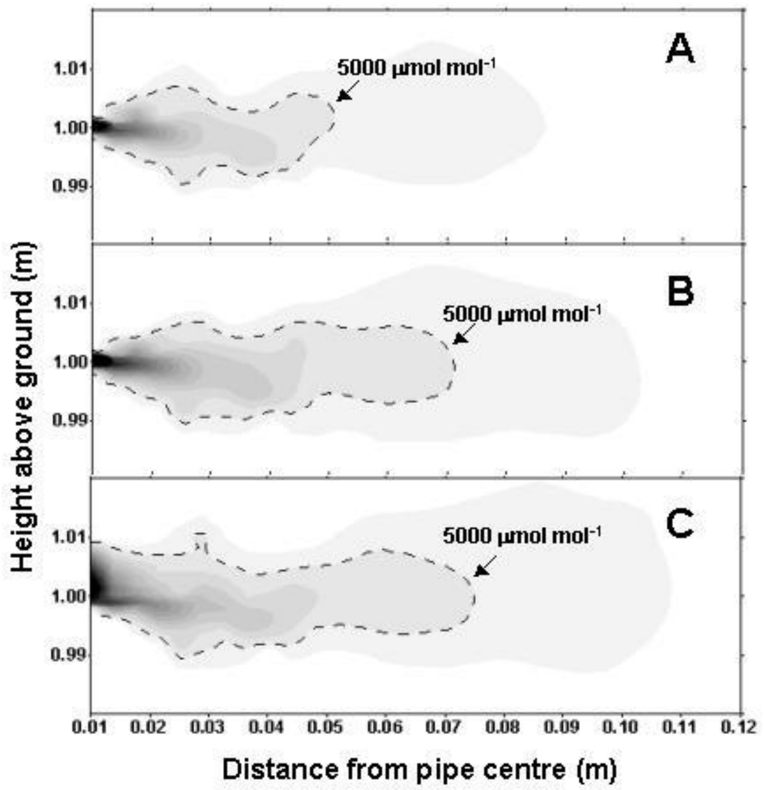


The "shock-wave effect" of sonic jets

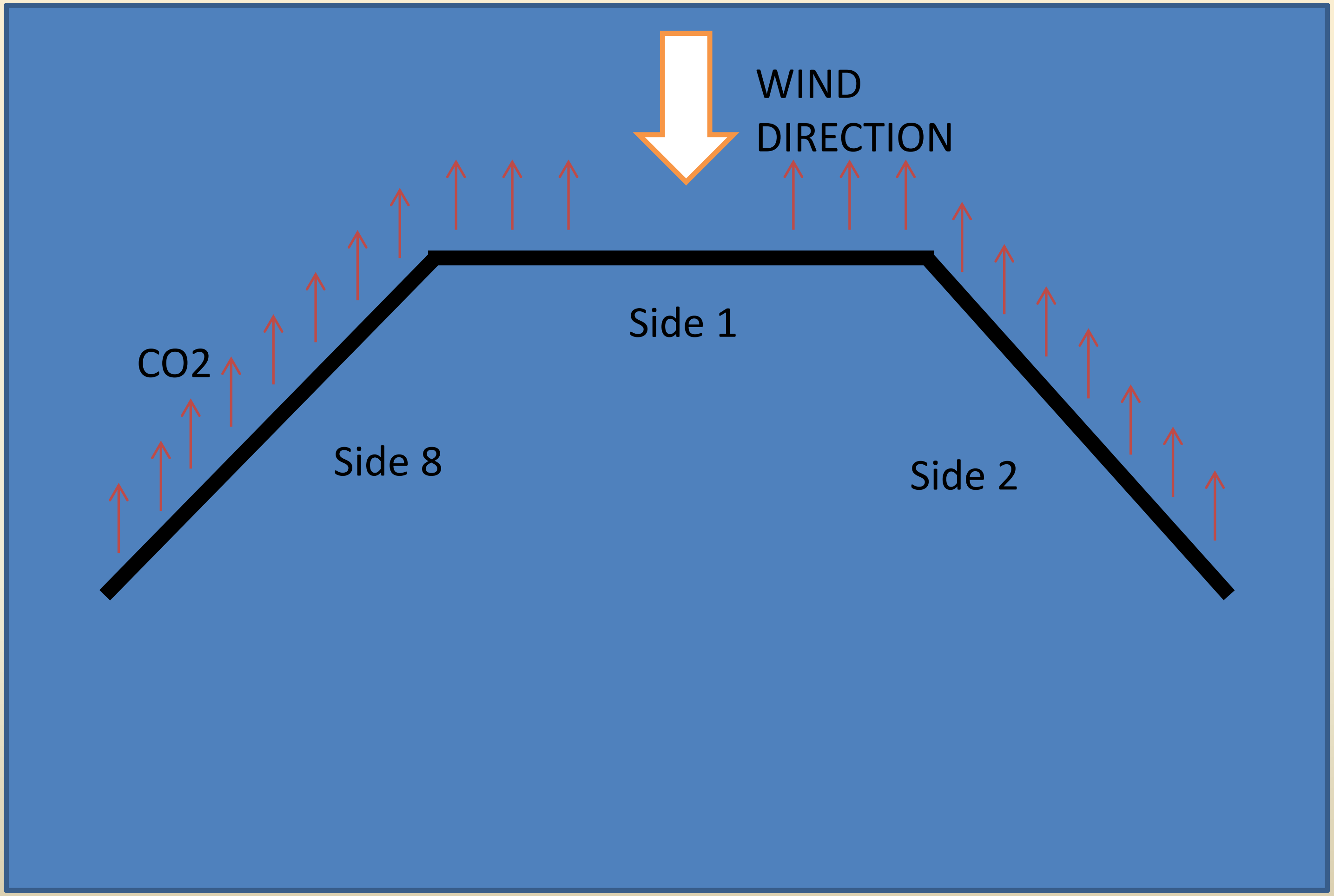
Direction and speed of the air flow calculated by the CFD model in the proximity of the CO2 releasing jet. The open arrows point to the direction of the air flow and the iso-surface indicate its velocity



Contour plots of CO_2 concentrations simulated by the CFD model downwind of a CO_2 releasing jet. The three frames refers to three separate simulations made by varying the absolute pressure inside the pipe. The dotted line indicates the isoline at 5000 mmol mol^{-1}.



Furthermore, the microscopic holes (0.2mm diametr) laser-drilled into the outer circumference of these pipes, allow CO2 to be ejected out at sonic speed against the incoming air mass to maximise mixing of CO2 with ambient air.

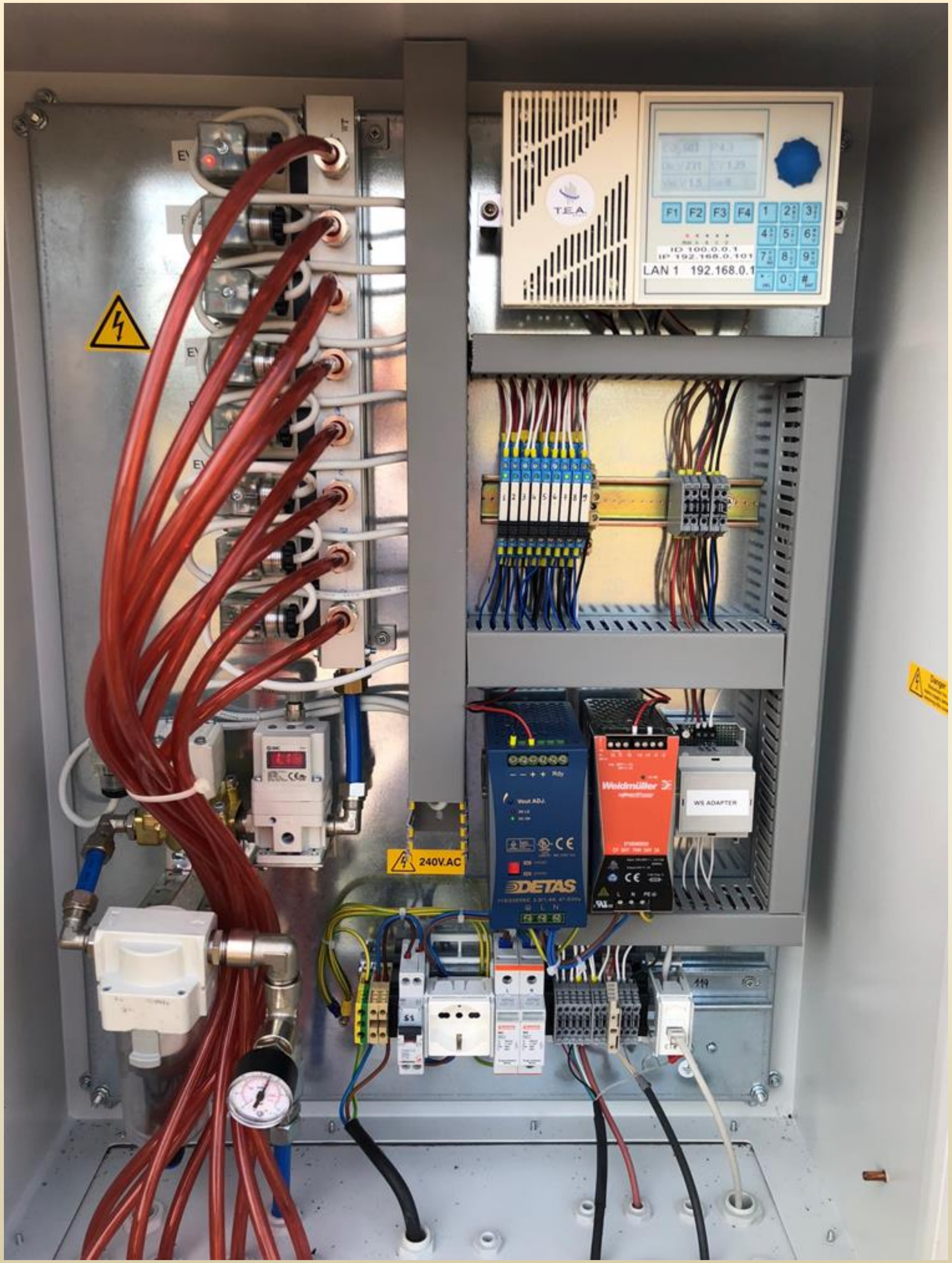


The container of CO_2 and the system of heating and vaporization

The release of CO_2 is controlled through a system of valves connected to the 8 laser drilled pipes forming the sides of the ring itself.
The pipes are installed on adjustable supports, which allow to raise the ring during the vegetation growth.

The CO2 reading is obtained using an infrared open path gas analyzer Vaisala model Carbocap.

Control Unit, placed on one of the support of the horizontal masts, is also provided with an anemometer to control wind speed and direction (needed to adjust the amount of CO2 released) and a soil temperature probe..



The heart of the control unit is a CPU that control and display the ring functionality and its regulation.

The CPU is connected to the network using optical fiber interface, this allow a remote control, data downloading and firmware updating of the system.

HYDRAULIC CO2 DISTRIBUTION CIRCUIT

MICROPROCESSOR CONTROL UNIT

Each control system is connected to a server that automatically collect data and allow a remote control of the systems installed in the field. The network also include a first class weather station to monitor the environmental conditions. This allowed a constant monitoring of the FACE system and rapid response on the occurrence of problems.