USE OF THE PHOTOSYNTHESIS PERFORMANCE INDEX TO ASSESS THE EFFECTS OF HIGH FREQUENCY ELECTROMAGNETIC FIELDS ON THE MEMBRANE INTEGRITY OF THE MOSS P. PATENS

E. Alasonati[1], E. Comino[1], A. Giudice[1], M. Ianoz[2], F. Rachidi[2], Y. Saidi[3], J.P. Zryd[3], P. Zweiacker[2]

1 Turin Polytechnics, Dip. Georisorse e Territorio, Torino, Italy.
2 Swiss Federal Institute of Technology, EMC Group, Lausanne, Switzerland.
3 University of Lausanne, Institute of Ecology, Lausanne, Switzerland.

Abstract - This paper describes the use of photosynthesis efficiency parameters obtained from fluorescence kinetics to analyze the plant *Physcomitrella patens (Bryopyhtae)*. The plants have been illuminated by a high frequency electromagnetic field (900 MHz) using TEM cells. The results are analyzed and discussed in relation with a possible effect of high intensity high frequency electro magnetic fields on biological membrane integrity.

I. INTRODUCTION

No clear conclusion about possible effects of electromagnetic fields on health could be clearly put into evidence by epidemiological studies or in vitro experiments on tissues or cells. Recently, the Food and Drug Administration backed by the CTIA (Cellular Telephone Industry Association) emphasized the need to work on simple animal, plants and cellular systems [1]. The two biological organism chosen for this research study is well suited in this respect: *Physcomitrella patens* is a moss whose genetics and development is well studied and therefore is the object of several programs of functional genomic (e.g. [2]).
Preliminary results on the effect of 50 Hz magnetic fields on *Physcomitrella patens* have been published in the last EMC Europe Symposium [3]. We have also used a method based on fractal dimension to quantify the effect of electromagnetic field on the growth of *Physcomitrella patens* and on the mobility of the nematode *Caenorhabditis elegans* [4]

II. CULTIVATION CONDITIONS AND FIELD EXPOSURE

Methods of cultivation of the moss *Physcomitrella patens* has already been published basic cultivation conditions are used [6,]. Plants have been exposed to the experimental conditions on agar medium in 5 cm plastic Petri dishes.

III. APPLICATION OF PHOTOSYNTHESIS FLUORESCENCE MEASUREMENTS TO P*. PATENS*

Electromagnetic fields are thought to affect biological membrane integrity in a very complex way [5, 6]. Any slight membrane structure disturbance could potentially lead to detectable physiological effects. The photosynthetic apparatus of plants is located to a membrane complex that has been extensively studied. Photosystem II (PSII) is the primary step in the electron transfer that follows light absorbtion. PSII is a multiproteinic, multifunctional complex which is an integral part of the membrane; modifications of the molecular arrangement can be detected by the studying the fluorescence kinetics following light absorbtion [7, 8]. We present here a first attempt to test the available methods using the Hansatech® PEA (plant efficiency analyzer) fluorometer and the Biolyzer© program to analyze the results (http://www.unige.ch/sciences/biologie/bioen/bioindex.html) .

IV. EXPOSURE OF *PHYSCOMITRELLA PATENS* TO HIGH FREQUENCY MAGNETIC FIELDS

The behavior of *Physcomitrella patens* is investigated under a 900 MHz field produced by a TEM cell in order to test the use of fluorescence transients (i.e. the O-J-I-P fast fluorescence induction curves) for the estimation of biological

membrane integrity. At day 0 and after 1 day of electromagnetic field exposures, the physiological status of moss colonies was measured with PEA fluorometer.

Fig. 1 shows the results of such an experiment; for the moment these are only preliminary results but they show that the analysis of fast fluorescence transients can be successfully used for an evaluation of the influence of the electromagnetic fields.

VI. CONCLUSION

The results presented in this paper shows that an analysis based fluorescent measurements of intact plants is a powerful tool to indicate variations in the moss *Physcomitrella patens* physiological changes resulting from the application of an electromagnetic field. We could infer form those preliminary results that 900 MHz EMF do induce some perturbations in the photosynthetic membrane albeit at very high field value (1000 V/m). The advantages of the method used are that it is not invasive, that it has already been used to test the biological effect of environmental stress and that it is very simple and cost effective.

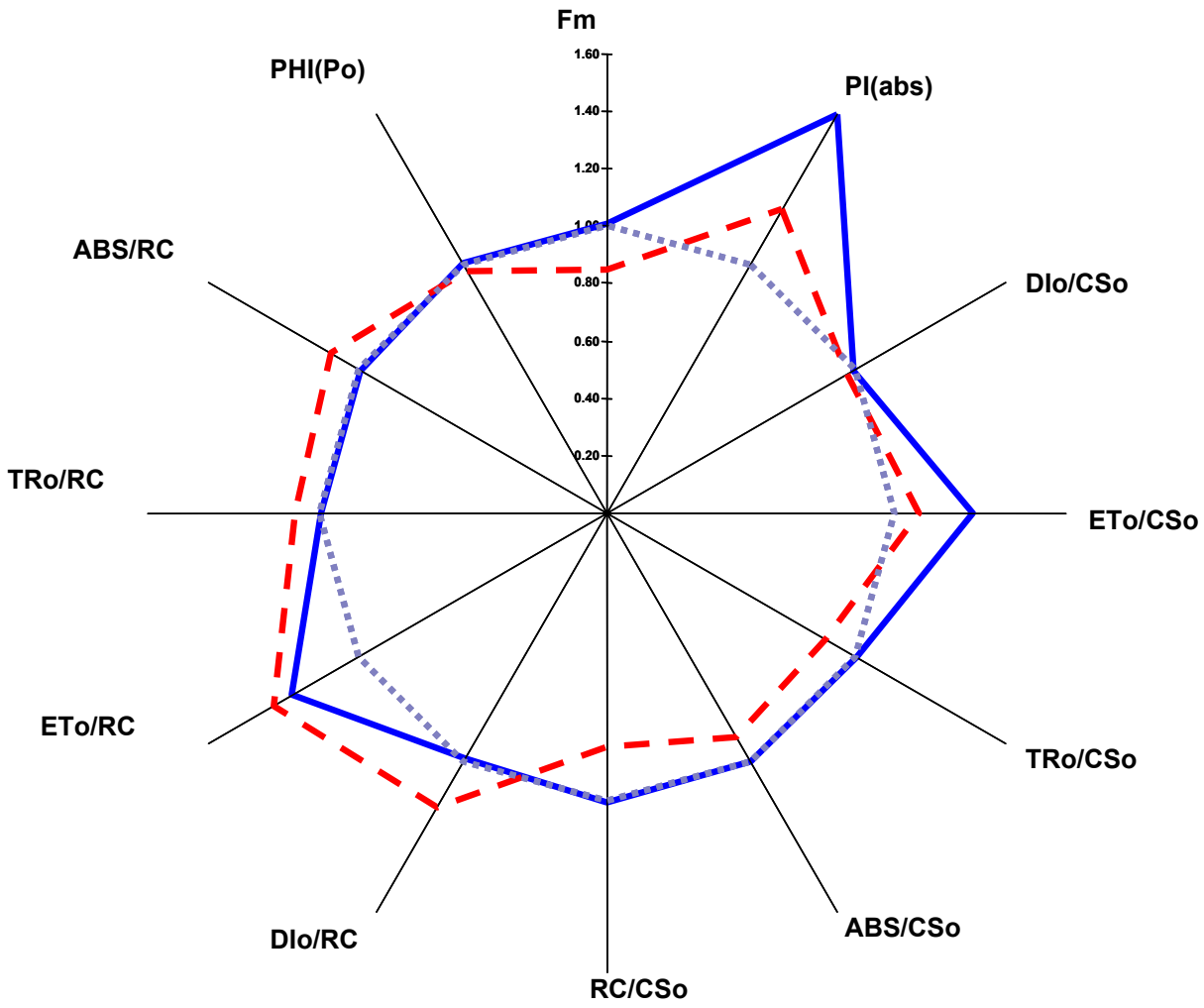
As the behavior of living organisms is a complex issue, more experiments are needed before a conclusion on biological or possible health effects can be drawn.

Acknowledgments – Financial Support from Electrical Utilities Research Fund (CREE-RDP) and Sustainable Mobile Communication Fund are acknowledged. We thanks Prof. Reto Strasser for his help and fruitful discussions

Spider plot graphic of the fluorescence kinetics of moss plants

Control

EMF 24h exposure at 900 MHz, 1000 V/m



Legend of the test parameters obtained from data of the fast fluorescence transient :

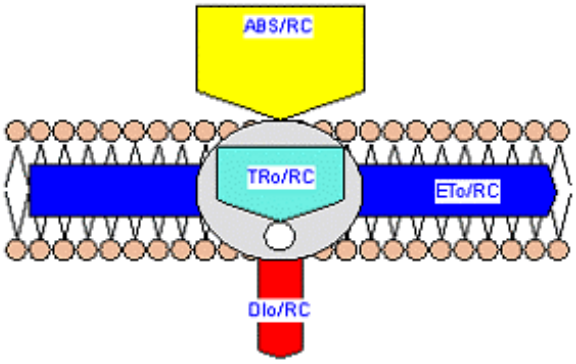
Fm : Maximal fluorescence intensity
PHI(P0) : Maximum quantum yield of primary photochemistry
PI (ABS): Performance index based on equal absorption

Specific fluxes or specific activities (per active reaction center) :
ABS/RC : Energy flux absorbed
TR0/RC : Energy flux trapped
ET0/RC : Electron transport flux
DI0/RC : Energy dissipation

Phenomenological fluxes or phenomenological activities (per excited cross-section) :

ABS/CS0 : Energy flux absorbed
TR0/CS0 : Energy flux trapped
ET0/CS0 : Electron transport flux
DI0/CS0 : Energy dissipation
RC/CS0 : Density of active reaction centers

This simplified functional model of a photosynthetic membrane (thylakoid) illustrates the various flux parameters that are measured and calculated (legend is as above). A part of the energy flux (**ABS/RC**) is trapped (**TRo/RC**) and transmitted to the electron transport system (**ETo/RC**) of photosynthesis; the remaining energy is dissipated as fluorescence energy (**DIo/RC**) and heat. Our results show that in plants submitted to EMF, energy dissipation is increased with a depressing effect on the performance index (see reference [8] for detailed information on calculations). This indicates an alteration of the complex membrane structure. These results should be confirmed by further experiments.



VII. REFERENCES

1. *Cells and Cell Phones.* Science, 2000. **289**: p. 845.
2. Schaefer, D.G. and J.P. Zryd, *The moss Physcomitrella patens, now and then.* Plant Physiology, 2001. **127**(4): p. 1430-1438.
3. Zryd, J.-P., et al. *Influence of 50 Hz magnetic fields on the moss Physcomitrella patens*. in *4th European Symposium on Electromagnetic compatibility*. 2000. Brugge: EMC 2000.
4. Alasonati, E., et al. *Use of fractal dimension for the analysis of biological effects of electromagnetic field on the moss P.patens and the nematode C. elegans*. in *International Symposium on Electromagnetic Compatibility*. 2002. Sorrento (Italy).
5. Leszczynski, D., et al., *Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: Molecular mechanism for cancer- and blood-brain barrier-related effects.* Differentiation, 2002. **70**(2-3): p. 120-U1.
6. Kotnik, T. and D. Miklavcic, *Second-order model of membrane electric field induced by alternating external electric fields.* IEEE Transactions on Biomedical Engineering, 2000. **47**(8): p. 1074-81.
7. Strasser, R.J. and A.D. Stirbet, *Estimation of the energetic connectivity of PSII centres in plants using the fluorescence rise O-J-I-P - Fitting of experimental data to three different PSII models.* Mathematics and Computers in Simulation, 2001. **56**(4-5): p. 451-461.
8. Strasser, R.J., A. Srivastava, and M. Tsimilli-Michael, *The fluorescence transient as a tool to characterize and screen photosynthetic samples*, in *Probing Photosynthesis: Mechanism, Regulation and Adaptation*, M. Yunus, U. Pathre, and P. Mohanty, Editors. 2000, Taylor and Francis: London. p. 443-480.