

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

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

## 1. 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 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 reported in [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]

## 2. CULTIVATION CONDITIONS AND FIELD EXPOSURE

Methods of cultivation of the moss *Physcomitrella patens* has already been published [5]; basic cultivation conditions are used. Seven days old plants cultivated on agar medium have been exposed to the experimental EMF conditions in 5 cm plastic Petri dishes.

## 3. APPLICATION OF PHOTOSYNTHESIS FLUORESCENCE MEASUREMENTS TO *P. PATENS*

Electromagnetic fields are thought to affect biological membrane integrity in a very complex way [6, 7]. Any slight membrane structure disturbance could potentially lead to detectable physiological effects. The photosynthetic apparatus of plants is located in a membrane complex (thylakoid) that has been extensively studied. Photosystem II (PSII) is the primary step in the electron transfer that follows light absorption. PSII is a multiproteic, multifunctional complex which is an integral part of the membrane; modifications of the molecular arrangement can be detected by studying the fluorescence kinetics following light absorption [8, 9]. 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>).

## 4. 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.

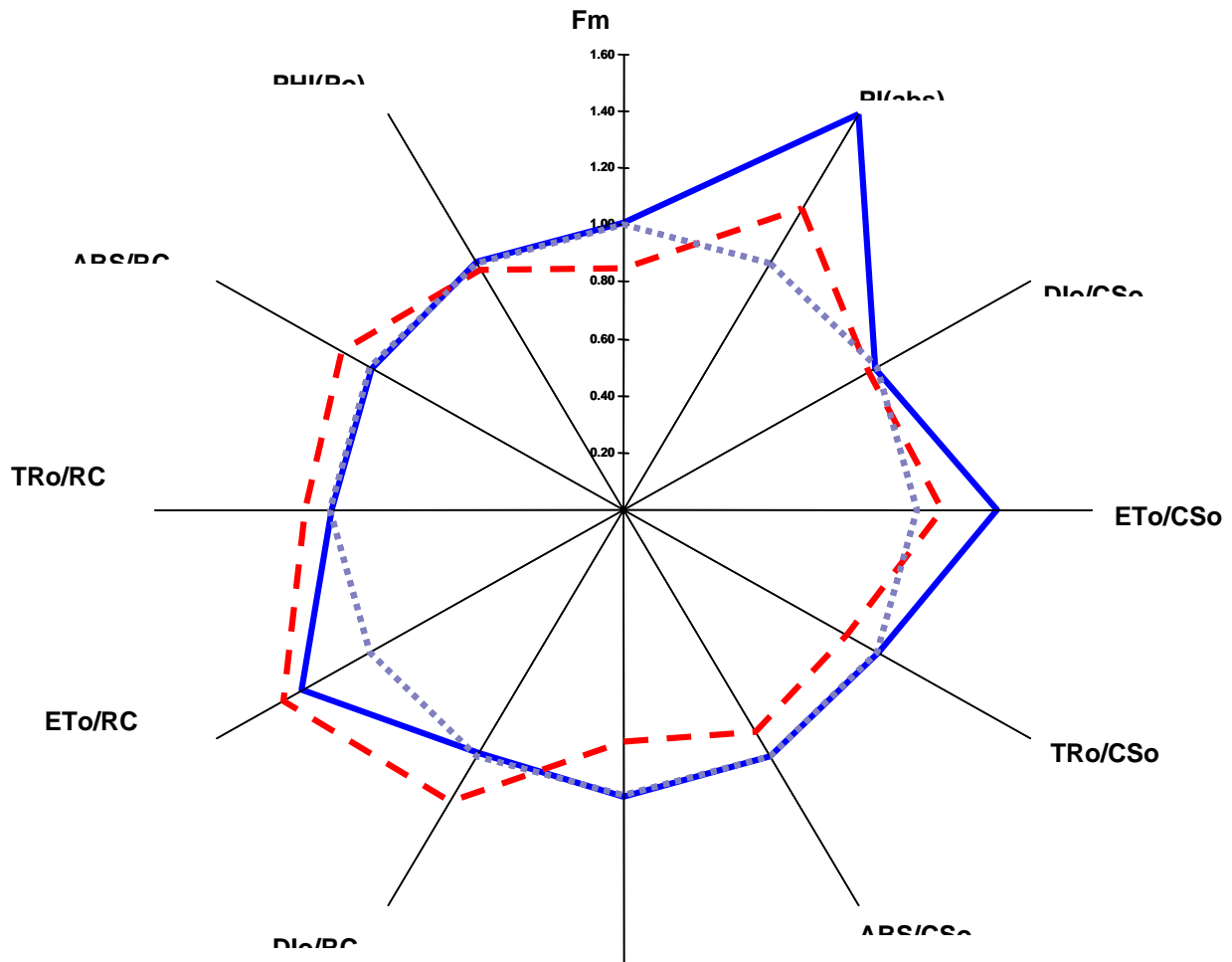
Fig. 1 shows the results of such an experiment; for the moment these are only preliminary results but they show that the analysis of fast fluorescence transients can be successfully used for an evaluation of the influence of the electromagnetic fields.

Spider plot graphic of the fluorescence kinetics of moss plants

**Control**

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

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**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

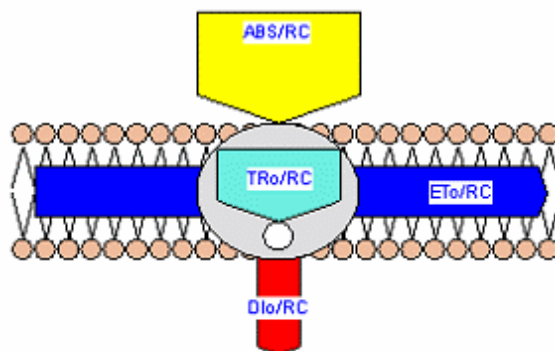
**Specific fluxes or specific activities (per active reaction center) :**

**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 [9] for detailed information on calculations). This indicates an alteration of the complex membrane structure. These results should be confirmed by further experiments.



## 5. CONCLUSION

The results presented in this paper shows that an analysis based on 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 from the preliminary results that 900 MHz EMF do induce some perturbations in the photosynthetic membrane albeit at very large field intensities (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.

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