Physical characterization of biological experiments in Plasma Medicine

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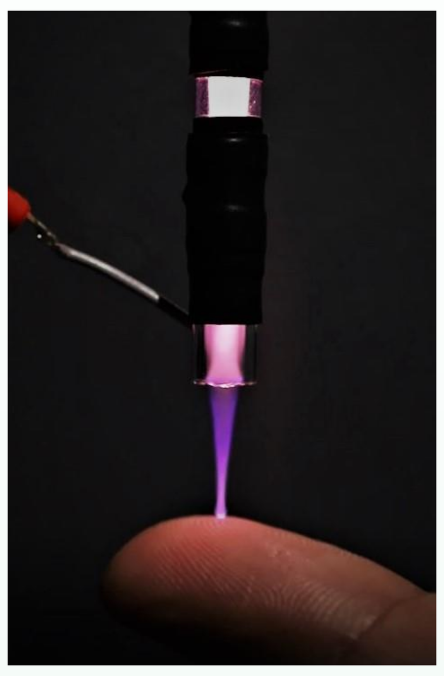
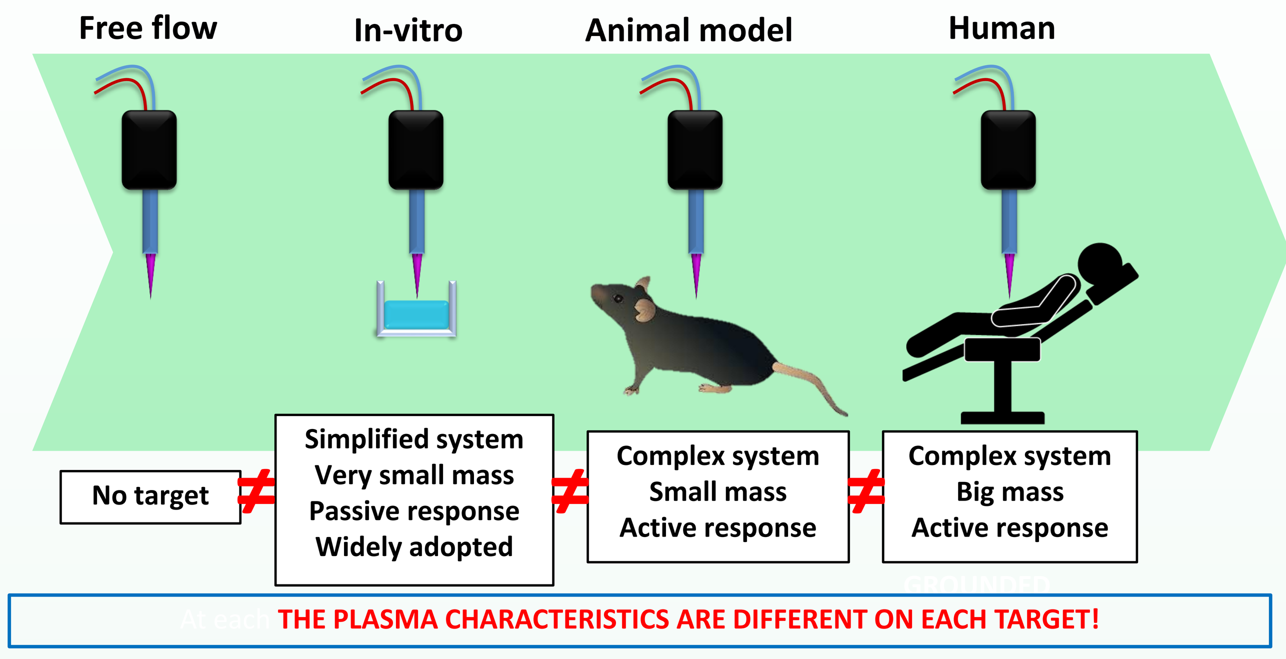
Abstract

Plasma jets are being intensively studied for biomedicine applications but their fine control remains challenging due to the mutual interactions between plasma and target.

In Plasma Medicine especially testing and validation range over very different targets making difficult to compare achieved results and to transit toward clinical trials.
Even considering perhaps one of the simplest scenario in a research laboratory, using a plasma jet to treat a 2D cells culture in a plastic multi-well plate, it is not known in detail how the physical environment of the micro-well influence the nature of the plasma jet treatment.

It is critical to undergo a physical investigation of the setups commonly adopted in biomedical research.



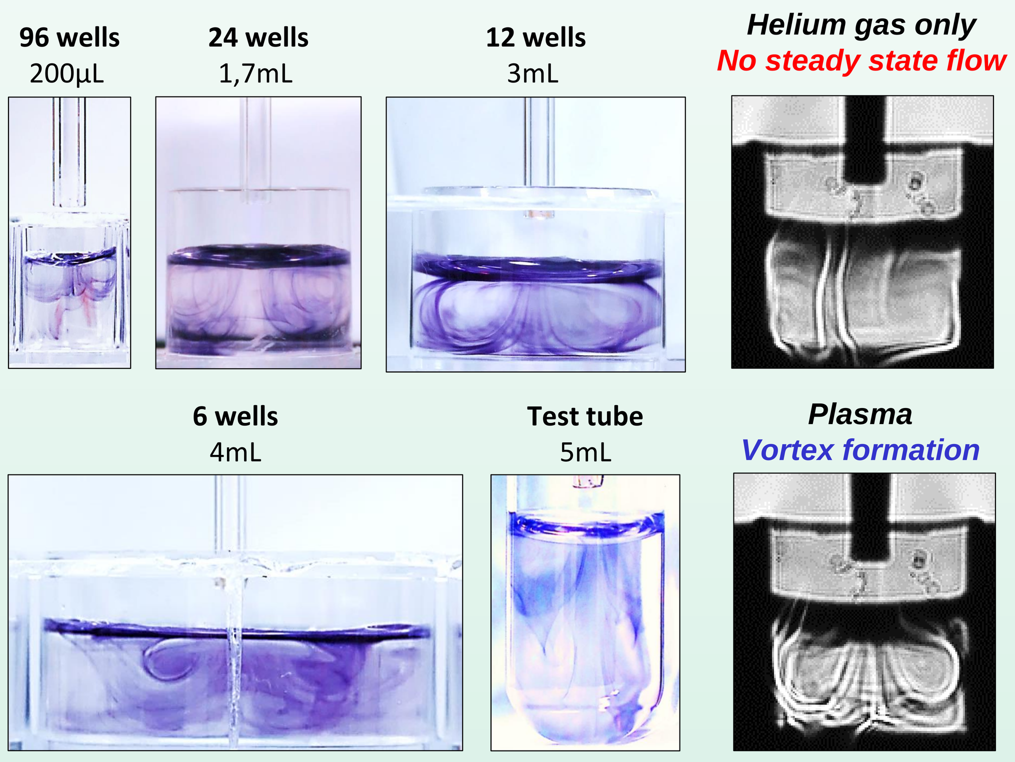


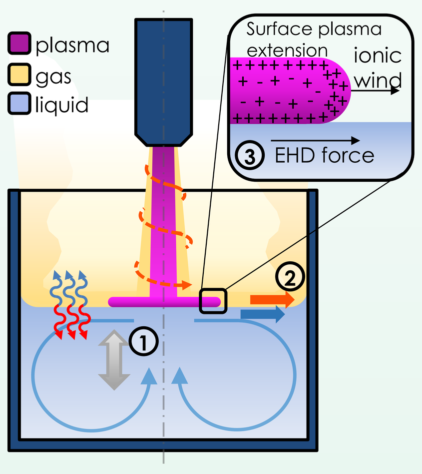
Thermo-fluid dynamic effects

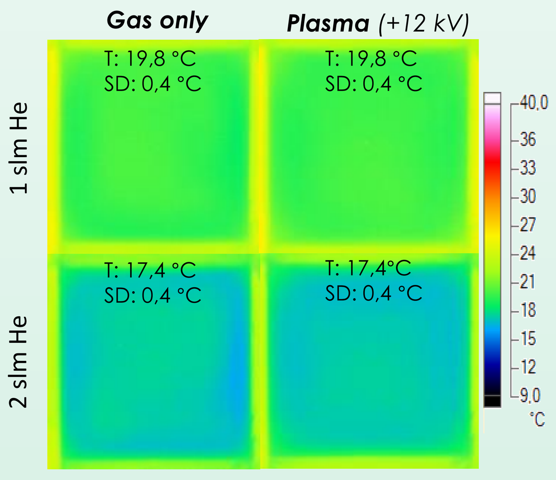
Mixing is critical to plasma jet applications as liquid transport can have a critical impact on the reaction kinetics. The configuration in which a plasma jet impinges on a liquid surface is widely adopted in plasma medicine.

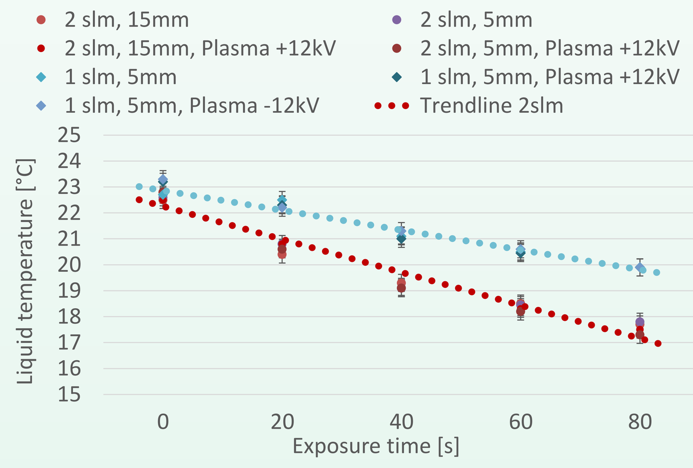
The impinging of a plasma jet can induce liquid recirculation in vessels commonly adopted for biomedical in vitro studies. The generated vortexes strongly affect the distribution of long-lived reactive species inside the liquid. Liquids treated for tens of seconds and used/analysed rightly after likely present a non-uniform distribution of reactive species.
Also temperature variations are observed and attributed essentially to the helium gas flow necessary for the operation of the plasma jet.

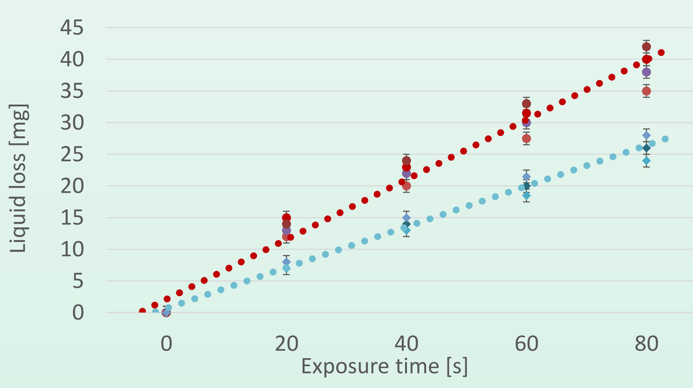
Ki and starch reagents and Schlieren technique for vortex visualisation









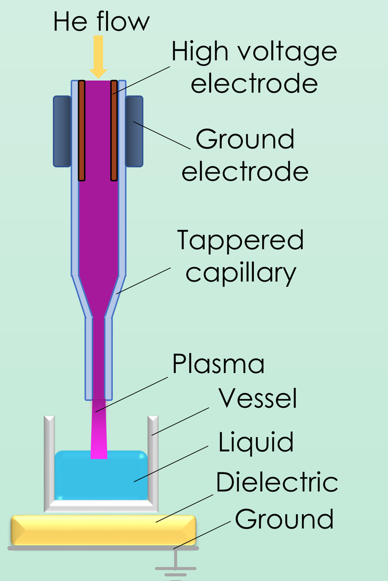


Target impedance

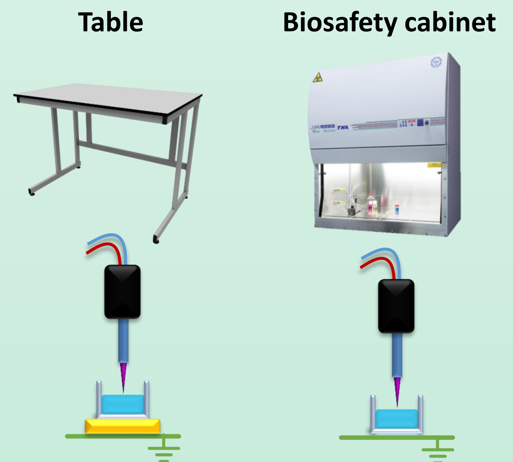
Plasma characteristics are greatly affected by the target total impedance. When the target is at floating potential, even the nature of the plate supporting the sample can influence the treatment.

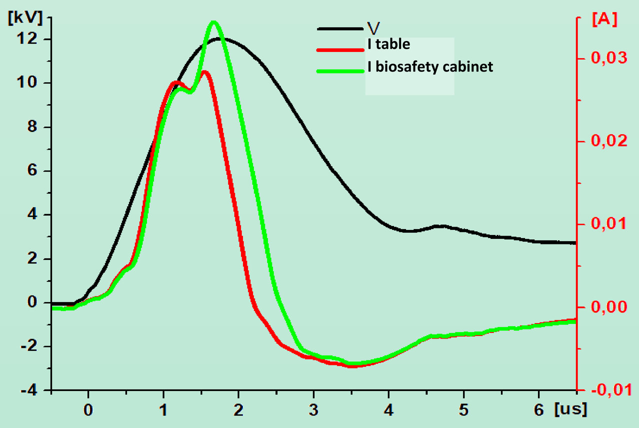
New Mehod – Mimicking the human body

By means of a basic and easy to implement electrical circuit **it is possible to "compensate" the electrical differences between in vitro models, mice and human body** and in such a way to reach more reproducible treatment conditions between in vitro and in vivo targets.

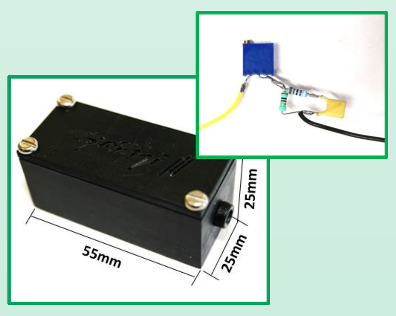


Where you do your experiments?

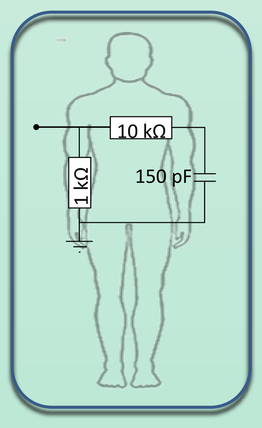


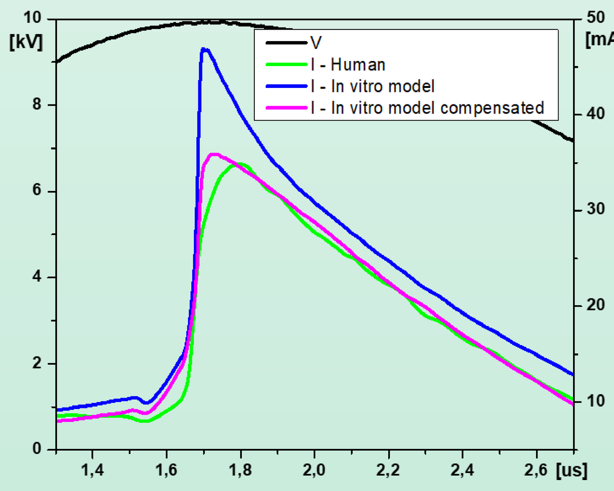


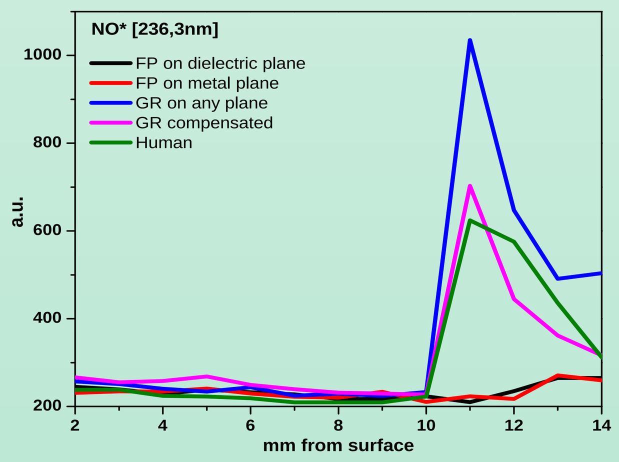
Compensation circuit for mimicking the human body



Equivalent electrical circuit for the human body
International Standard IEC 60601-1





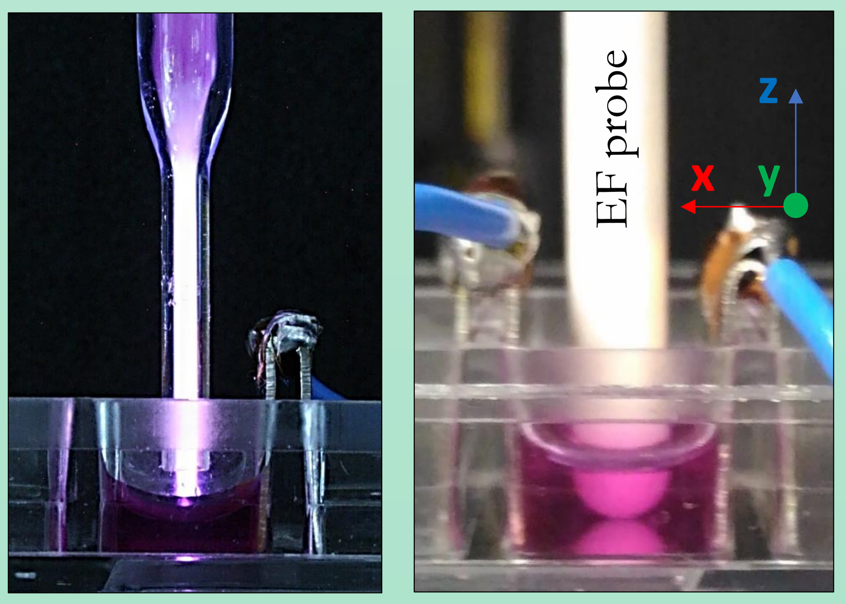


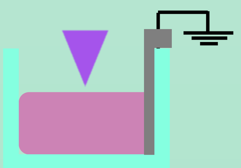
Electric field

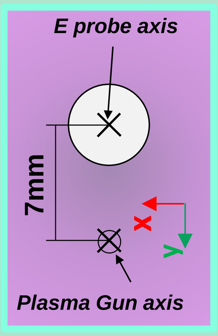
Electric field generated by the plasma discharge can potentially play a major role transiently increasing cell membrane permeability, a phenomenon commonly known as **"electroporation".**

Nowadays electroporation devices are widely used for several applications including gene transfection and electrochemotherapy.

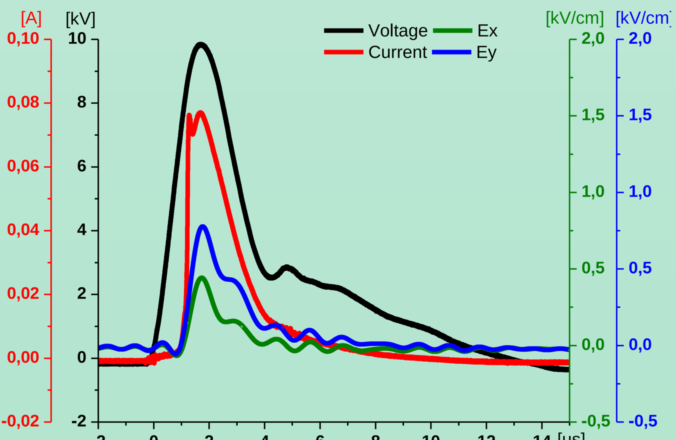
The measurement of the electric field potentially experienced by cells in Plasma Medicine experiment could help to explain some of the for observed biological responses induced by plasma treatments.



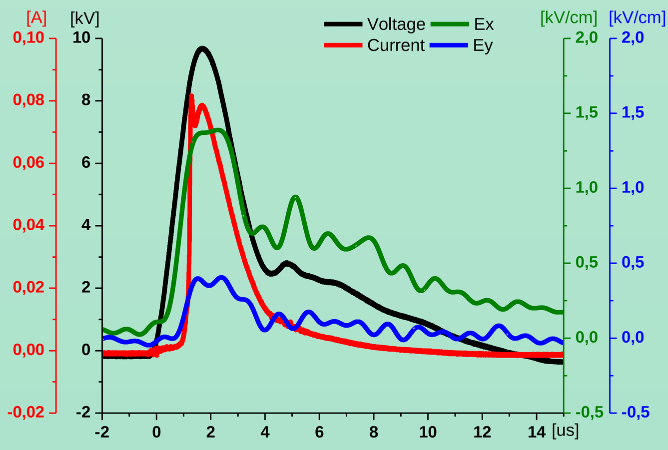




WATER
High purity deionized water
σ < 1µS/cm



SMEM
Spiner's modification of Eagle's minimum essential medium
σ = 12 mS/cm



References

- [1] E. Robert et al, Physics of Plasma, 22, 122007 (2015)
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