



# Spectral and spatial shaping of a laseraccelerated proton beam for radiation biology applications

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### Acknowledgments

B. Vauzour, L. Pommarel, O. Delmas, D. Levy, M. Cavallone



F. Schillaci, F. Romano, V. Scuderi, G. A. P. Cirrone

E. Bayart (now at LOA), F.Megnin-Chanet, E. Deutsch, F.Goujil, C. Nauraye



Inserm



#### **SAPHIR** project



25 september 2017

EAAC 2017

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# Why radiation biology



Page 3 of 18 V. Ponette et al, Int. J. Radiat. Biol. (2000)

# **Temporal scale of radiation damage**

Scale	Process		Timescale
Atom	Energy	Excitation Ionization	ns
Molecule	H <sup>+</sup> e <sup>-</sup> OH- hydroxide H H <sup>+</sup> hydrogen ion H O <sup>0</sup> neutral hydroxide	Radical production Radiolysis Breaking chemical bonds	s
Cell	necrosis apoptosis death	DNA strand brakes Cell damages	day
Being		Somatic and hereditary diseases	y ear

#### Radiation biology: needs for in vitro



(O. Lund)



#### Repeatability

shot to shot, day to day, month to month (year to year).

#### **Integrated dose**

acceptable doserate  $\rightarrow$  dose per shot

#### Wide irradiation surface

**Online dosimetry** 

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#### **SAPHIR** laser



#### **SAPHIR** interaction area



# **TNSA** performances



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#### **PMQs** transport line





#### **Transport** beamline





### **Ionization chamber**

Transmission ionization chamber

- wide diameter (15cm)
- low energy footprint: 110 $\mu$  H<sub>2</sub>O



- Non-linear energy response
- Recombination and saturation effects



## **Dosimetry protocol**



Pommarel et al. PRAB 2017

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#### **Proton transport!**



#### Proton transport on the target



### **Irradiation conditions**

0 0.4 0.8 1.2 1.6 2 2.4 2.6 2.8 cm



Stable irradiation conditions

- 0.7Gy/shot for in vitro 2D
- stability : 6 % rms
- uniformity : 20 % rms
- duration :  $\sim$ ns
- peak doserate :  $10^8 \text{ Gy/min}$
- repetition rate : 1/1.5s (quasi-automated)





# **Application to radiation biology**



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#### **Differential effect on HCT116**



(average doserate: 2.1 Gy/min)

Pommarel et al., PRAB 2017

### **Conclusions and perspectives**

- Transport and dosimetry on laser-accelerated proton beam
- Conditions for radiation biology: 0.7 Gy/shot, 1/1.5 Hz, 2 cm<sup>2</sup>
- 2D *in vitro* studies

- Stability and uniformity
- Room for more advanced dose-deposition profiles (eg. *in vitro* 3D)
- Improvement needed on dosimetry (error bars, proper diagnostic)