

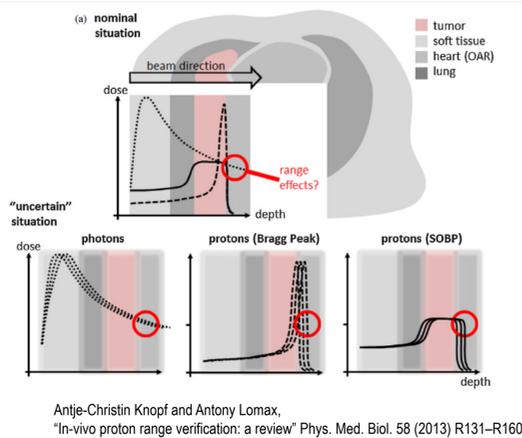
# THE INSIDE BIMODAL SYSTEM FOR RANGE MONITORING IN PARTICLE THERAPY TOWARD CLINICAL VALIDATION

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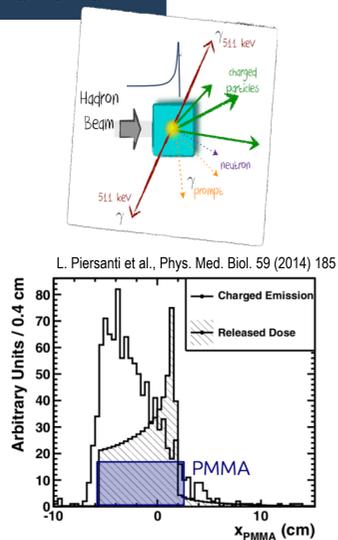
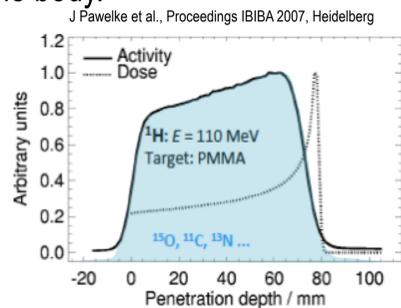
## Motivation

Particle therapy is highly sensitive to range uncertainties. Particle range (PR) in patients needs to be predicted as accurately as possible in the treatment planning and delivery process.



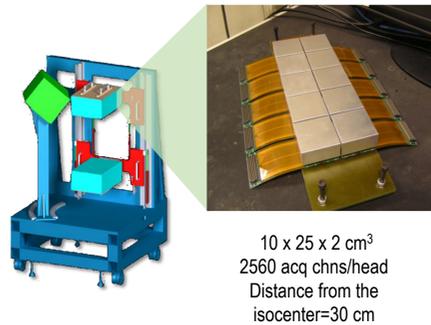
## In-vivo range verification

Safety margins could potentially be reduced with routine *in vivo* range monitoring. One takes advantage from the nuclear interactions of the beam in the body.

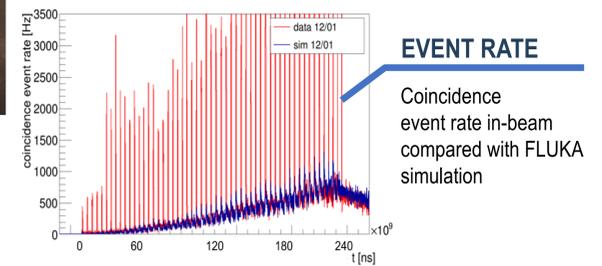


Detect the signals exiting from the patient and correlate them with the PR

## In-beam PET

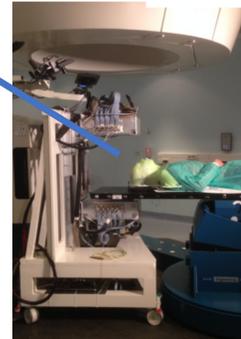


**PET DETECTOR**  
256 LFS pixel crystals (3x3x20mm<sup>3</sup>) coupled one to one to MPPCs (Hamamatsu Multi Pixel Photon Counters, SiPMs).

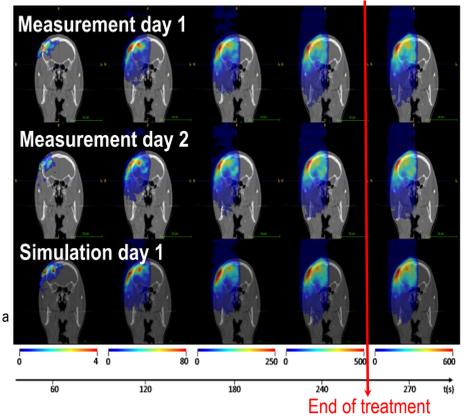


## CLINICAL TEST

First clinical test patient suffering of a carcinoma of the lacrimal gland. Treated with 3.7 \* 10<sup>10</sup> protons [66.3, 144.4] MeV/u (28-29)/30 fractions, 2.2 GyE Monitored for two consecutive days (1 and 2 /12/2016) Compared with FLUKA simulations



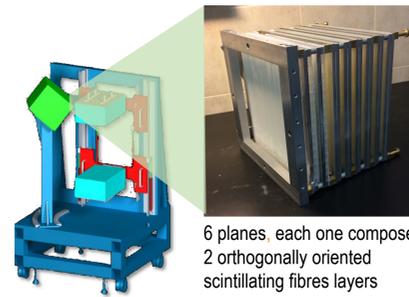
After 120 s average activity contour distance < 1 mm



Ferrero V, Fiorina E, Morrocchi M, Pennazio F, et al. Online proton therapy monitoring: clinical test of a silicon-photodetector-based in-beam pet. Scientific Reports 2018;8(1):4100.

Fiorina E, Ferrero V, Pennazio F, et al. Monte Carlo simulation tool for online treatment monitoring in hadrontherapy with in-beam PET: A patient study. Physica Medica EJMP 2018; in press, DOI: <https://doi.org/10.1016/j.ejmp.2018.05.002>

## Dose Profiler



## CNAO TEST BEAM

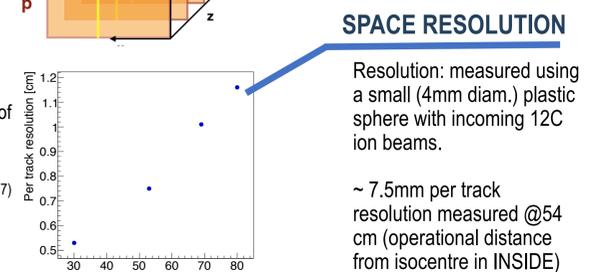
Single 12C pencil beam (PB) shot inside rando phantom (centre) at different ranges (energies).



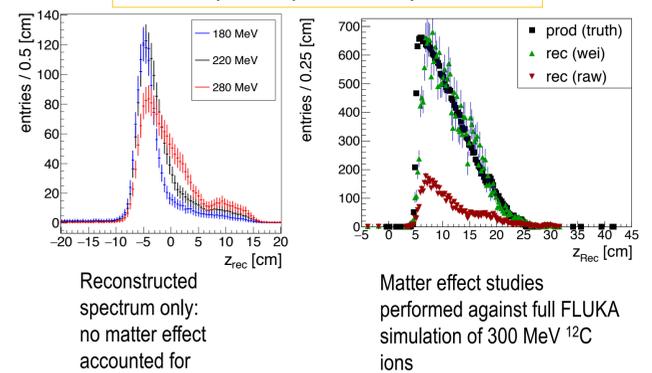
Statistics: 10<sup>6</sup> ions ~ 1cm<sup>2</sup> area. 10-20 PB summed up

A. Sarti, University Sapienza and INFN Roma1

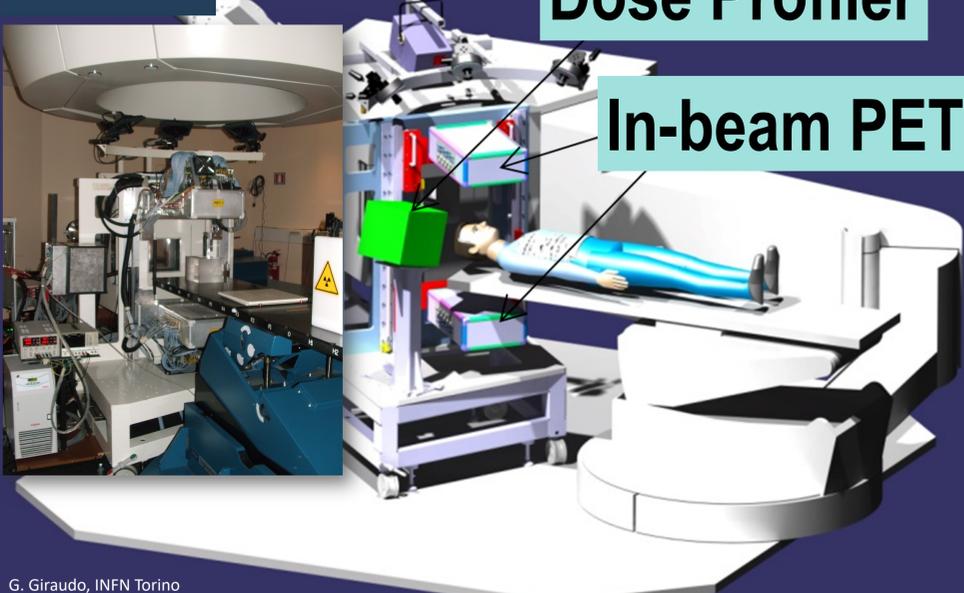
**FIBER TRACKER**  
Fibers Saint Gobain BCF-12 Double cladding layer (4%) Trapping efficiency 7.2% 2 plastic scintillator layers for energy measurement



See also poster presented by E. Gioscio



## INSIDE



## Dose Profiler

## In-beam PET

G. Girauco, INFN Torino

Frontier Detectors for Frontier Physics  
14<sup>th</sup> Pisa meeting on advanced detectors  
La Biodola • Isola d'Elba • Italy  
27 May - 2 June, 2018



N. Belcari  
M. G. Bisogni  
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Arianna Serra

Maria Vittoria Livraga  
Giuseppe Venchi  
Francesca Valvo  
Viviana Vitolo  
Sara Tampellini

M. Scalise and F. Pennazio, INFN Torino

## Upgrade

The system is being upgraded to allow clinical validation. 20 patients affected by 4 different cancer pathologies and treated with proton and carbon ions will be monitored by INSIDE during their treatments.

**Goal:** evaluate the impact of the INSIDE range monitoring system on the CNAO patient management and treatment quality assurance

Project INSIDE2 funded by CNAO  
Project PETRA funded by Tuscany region, CNAO and INFN

