



## 2<sup>nd</sup> European Advanced Accelerator Concepts Workshop La Biodola, Isola D'Elba 13-19 September 2015

# The ELIMED transport and dosimetry beamline for laser-driven ion beams

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<u>Hadrontherapy</u>: one of the most advanced and pioneering treatment modalitie (more than 40 facilities nowadays in operation)



Limitations to the hadrontherapy spread: huge dimensions complexity high costs (70 - 150 M€)

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# The ELIMED idea





#### ELIMAIA: ELI Multidisciplinary Applications of laser-lon Acceleration

ELIMED (ELI MEDical applications): the ELIMAIA section dedicated to the transport and dosimetry



### **Experimental area: basement**

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## Laser-driven beams peculiarities

#### • Wide angular distributions

med



Large energy spread



 Extremely high dose rate per pulse 10<sup>7</sup>-10<sup>9</sup> Gy/min (vs 10-50 Gy/min)



New paradigms for beam dosimetry

Istituto Nazionale

di Fisica Nucleare



## **ELIMED** beam line layout





Graphics by G. Gallo



# 5 PMQs Hybrid array

L.Y.

Inner Halbach trapezoidal sectors Two external hybrid arrays

Bore 36 mm (net bore 30 mm)
Outer diameter: 325 mm
Lengths: 1x160mm; 2x120mm; 2x80mm

#### Magnetic field features:

- 3 main magnetization directions
- Gradients: ≈ 100 T/m
- Gradient uniformity < 2% @ R = 12 mm (80% bore)
- Integrated gradient uniformity < 0.3% @ R = 12 mm (80% bore)</li>

High Br - Low Hc

Low Br - High Hc

Stainless Steel

Screen

The tender procedure started in August

**Courtesy of F. Schillaci** 





#### Beam selection and transport: Energy Selection System

med





#### **Energy Selection System**







#### **Beamline Optics: 60 MeV proton**

**Quadrupoles** 

2

2

Position (m)

20 10

-10 -20

-30

30 20 10 € 0 -10 -20

-30 -



Input beam: Monochromatic Source size r = 20µm 10° Divergence (half-angle) *Uniform distribution in space and angle* 

#### **Courtesy of F. Schillaci**





Position (m)

5

5

**Energy selection** 

Output beam: Monochromatic Beam spot size: 10mmx30mm Uniform distribution in space and angle Divergence ≤ 0.3° (half- angle)

## **ELIMED test beamline @ INFN-LNS**

e

med



#### 40° LNS beamline





## **ELIMED R&D (prototypes)**







## **ELIMED R&D (dosimetry)**





![](_page_15_Picture_0.jpeg)

## Multi-gap chamber prototype

![](_page_15_Picture_2.jpeg)

![](_page_15_Figure_3.jpeg)

![](_page_15_Picture_4.jpeg)

In collaboration with INFN section of Turin

![](_page_15_Picture_6.jpeg)

#### **Tested at LNS**

- > 62 MeV protons (accelerated by CS)
- pulsed beam (chopper used), 500
   µs and 10 µs pulse duration
- Data analysis in progress

![](_page_16_Picture_0.jpeg)

## **ELIMED R&D (dosimetry)**

![](_page_16_Picture_2.jpeg)

An innovative Faraday Cup optimized for high pulsed ion beams has been designed and realized at INFN-LNS

![](_page_16_Figure_4.jpeg)

New solutions to optimize the charge collection efficiency

![](_page_16_Figure_6.jpeg)

![](_page_16_Picture_7.jpeg)

See next talk by Dr. G. Milluzzo for results...

![](_page_17_Picture_0.jpeg)

## **ELIMED MonteCarlo activity**

![](_page_17_Picture_2.jpeg)

- **Design** of the application for the final **ELIMED** beamline completed in April 2015
- Simulations of the beam transport systems carried out (quadrupoles and energy selector):
  - Magnetic elements simulated and tested (geometry and field for tracking)
  - Grid map for magnetic fields simulation implemented (benchmark with reference analytical transport codes)
  - Simulation outputs compared with experimental data
- Simulation of the dosimetric system prototypes carried out
  - Faraday cup fully simulated (electric field implemented and secondary electron emission studied)

![](_page_17_Figure_10.jpeg)

![](_page_18_Picture_0.jpeg)

## **Geant4 simulations benchmark**

![](_page_18_Picture_2.jpeg)

![](_page_18_Figure_3.jpeg)

![](_page_18_Figure_4.jpeg)

![](_page_19_Picture_0.jpeg)

## **ELIMED realization time schedule**

![](_page_19_Picture_2.jpeg)

#### April 2015

- Feasibility study of the PMQs system
- Code design of the Monte Carlo Geant4 application for transport and dosimetry June 2015
- Design of the ELIMED relative and absolute dosimetry system

#### September 2015

- Feasibility study and design of the energy selection system (ESS)
- Preliminary Monte Carlo results

#### March 2016

- Collection system realization
- In-vacuum/in-air beam-line design

#### September 2016

- ESS realization
- October 2017
- ELIMED beam-line delivery and assembled @ ELI-Beam-lines

# done

# Thank you for your attention