Complementing BioQuaRT goals: the INFN Project MITRA on advanced microdosimetry of ion beams

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REG(INFN)

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Summary of participation in work packages

(WP leader in bold)

WP1	Microdosimetry	**NPL**, IRSN, IST, PoliMi, REG (INFN)
WP2	Nanodosimetry	**PTB**, NCBJ, PoliMi, REG (INFN)
WP3	Indirect Effects	**NPL**, IST, PTB
WP4	Biology	**ENEA**, IRSN, IST, PTB
WP5	Multi-scale Model	**IRSN**, ENEA, IST, NPL, PTB
WP6	Creating Impact	PTB, ENEA, IRSN, IST, NPL, NCBJ, PoliMi, INFN
WP7	Manag. & Coordination	PTB, ENEA, IRSN, IST, NPL, NCBJ, PoliMi, INFN

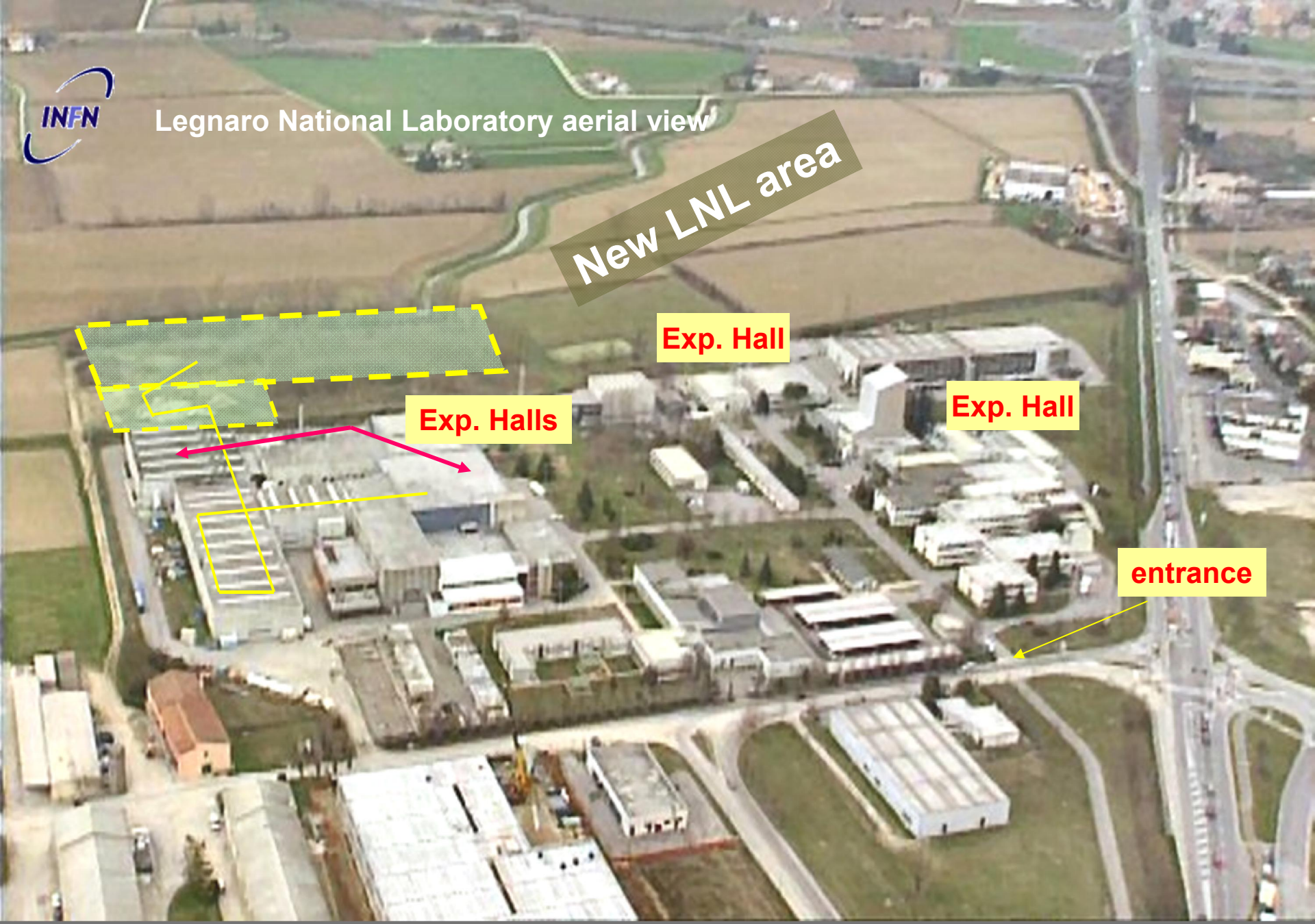
Overview of the WP1 and WP2 aims

WP1

To develop micro-calorimeters for directly measuring energy deposition spectra and to compare them with tissue-equivalent proportional counters and silicon based microdosimeters

WP2

To develop improved techniques for measuring ionising-particle track structure and its characteristics with nanometre resolution. This will allow a multi-scale characterisation of the radiation qualities used in WP4


Legnaro National Laboratory aerial view
New LNL area
Exp. Hall
Exp. Hall
Exp. Halls
entrance

MITRA

MIcrodosimetria e struttura di TRAccia

A complete approach for improving the hadron therapy

Research Coordinator:

Paolo Colautti, Laboratori Nazionali di Legnaro, INFN

MITRA Participants

INFN – LNL

Politecnico of Milano

University of Padova

University of Roma “Tor Vergata”

IOV (Istituto Oncologico Veneto)
(Venetian Oncological Institute)

MITRA Scientific Aims

I. to develop methods and innovative instruments for characterizing, with accuracy, the radiation fields generated by the hadron-therapeutic beams

II. to find solutions that could be exploitable in the clinical practise

- By integrating microdosimetry and nanodosimetry
- By developing new innovative microdosimeters for measuring at nanometric level

- Developing new detectors that are more strong, cheaper and easy to use

The response functions of these detectors will be studied and compared to that one obtained from mini-TEPC

MITRA is structured into 7 WPs

NANODOSIMETRY

WP1: Track Structure Nanodosimetry
LNL-INFN

WP2: Microdosimetry at nanometric level
Politecnico of Milano

MICRODOSIMETRY

WP3: Microdosimetry with mini TEPC
LNL-INFN

WP4: Microdosimetry with Si-based detectors
Politecnico of Milano

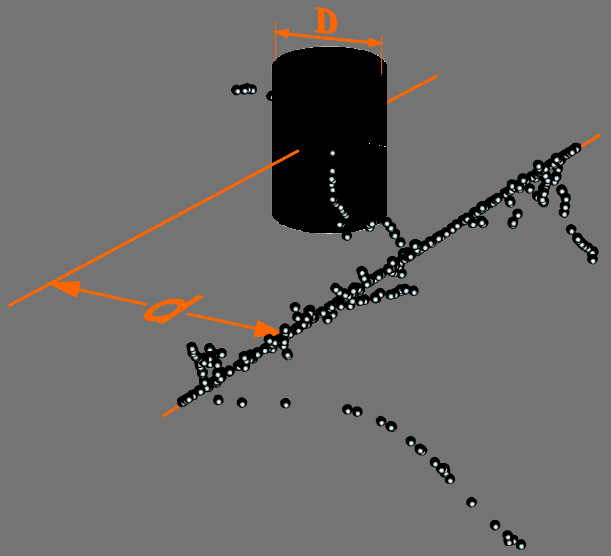
WP5: Microdosimetry with Diamond-based detectors
University of Roma "Tor Vergata"

WP6: Microdosimetry with GEM-TEPC
University of Padova

WP7: Comparison and analysis of the experimental data
IOV
(Venetian Oncological Institute)

WP1 @ INFN-LNL

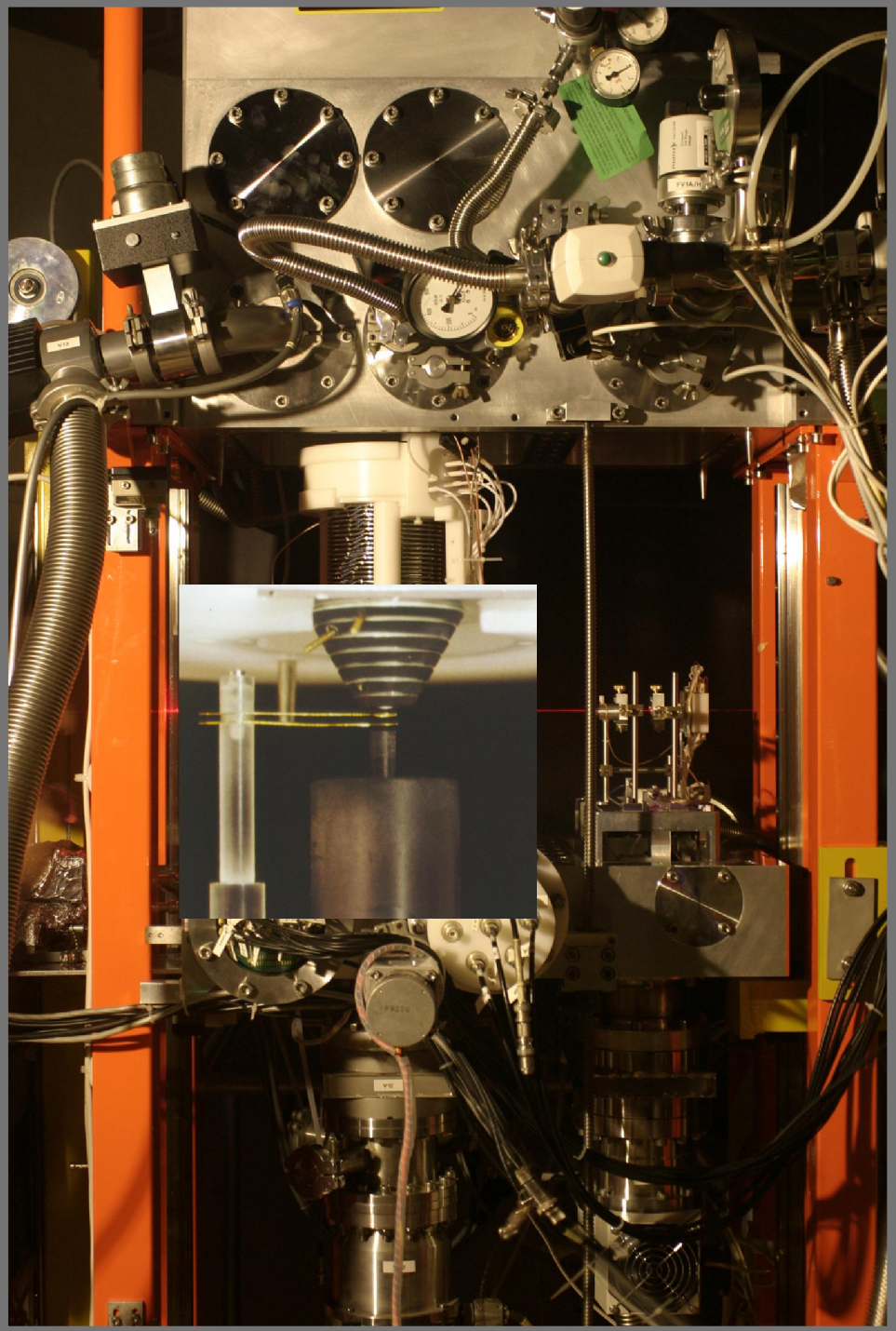
Track Structure: measurements and MC simulations



Track Structure measurements of different light ion beams with the nanodosimeter called STARTRACK (@ LNL-INFN)

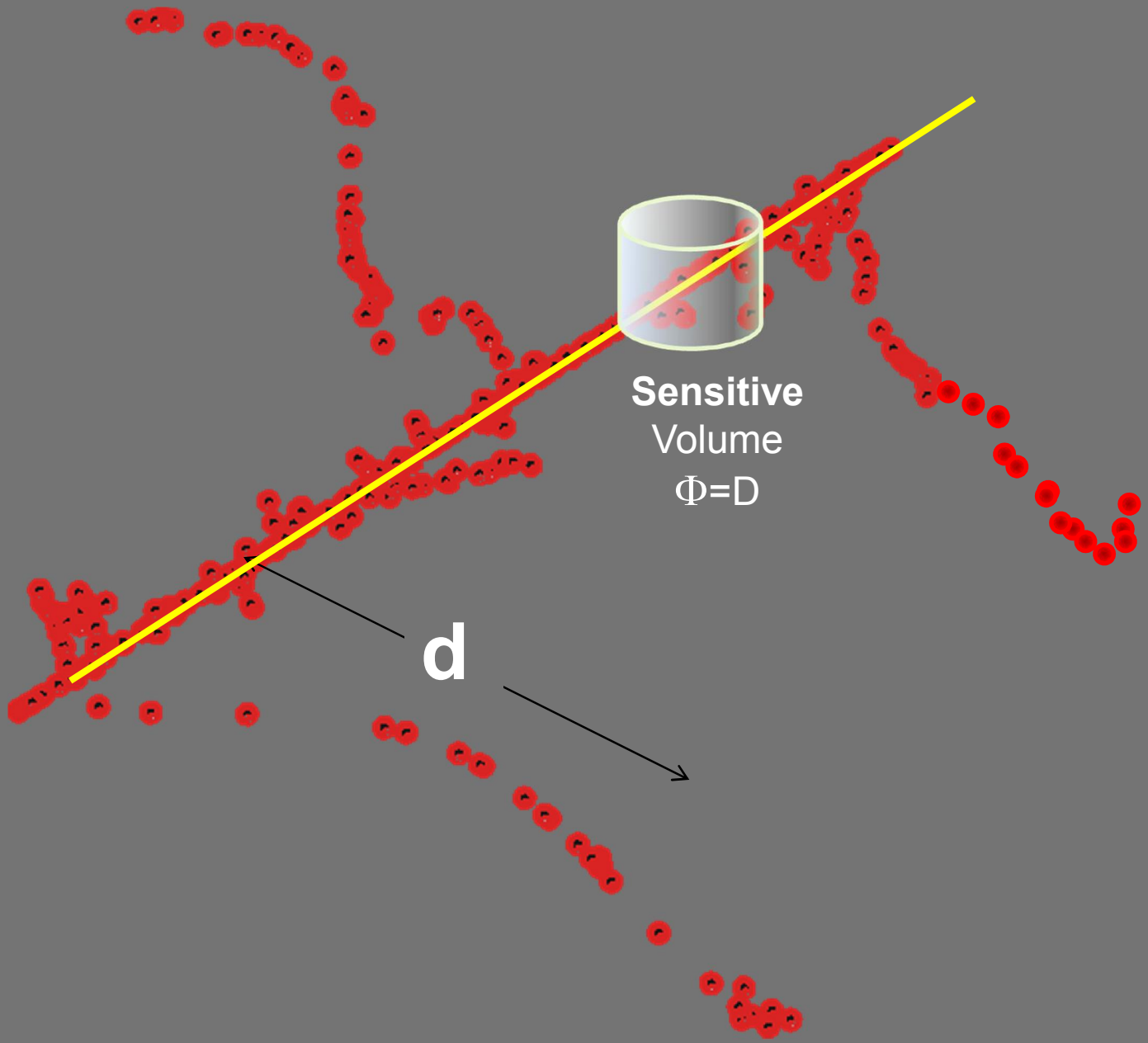
MC simulations will be perfomed thanks to the scientific collaboration with Bernd Grosswendt.

STARTRACK



Apparatus

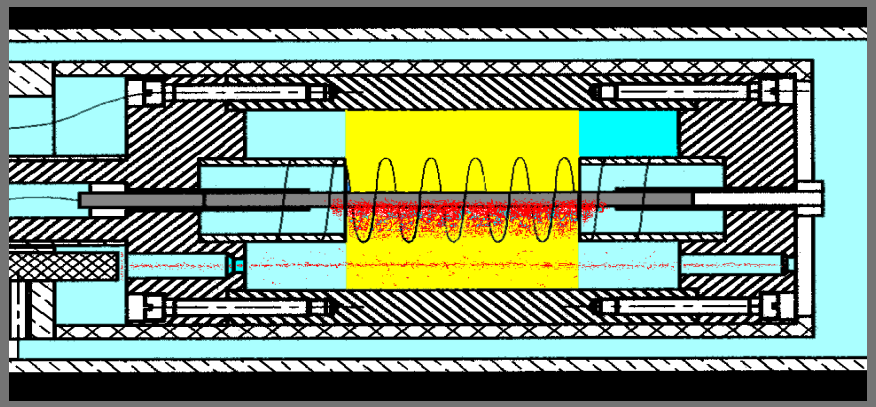
STARTRACK in outline



WP2 @ PoliMi

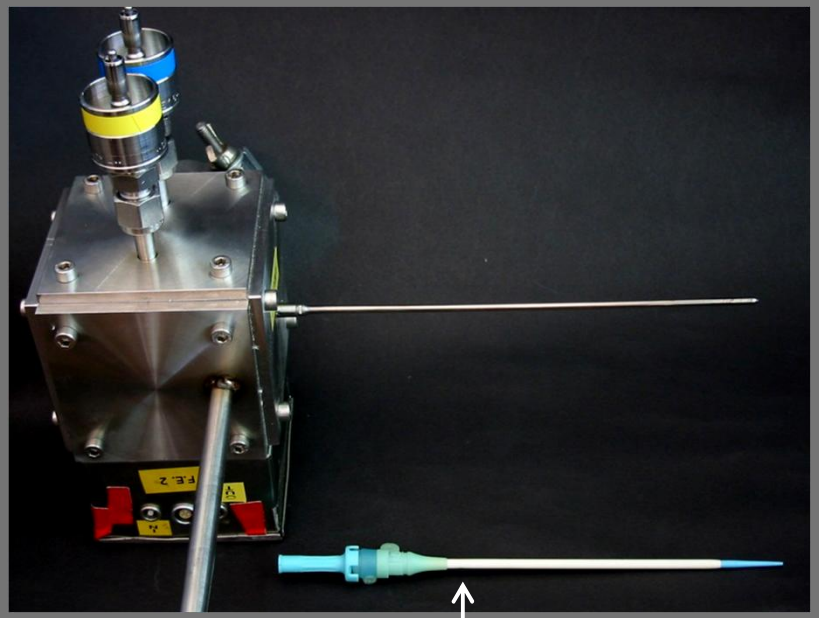
Microdosimetry at nanometric level

Development of an avalanche confinement TEPC able to measure down to about 25 nm (with good resolution) up to 1µm.



WP3 @ INFN-LNL

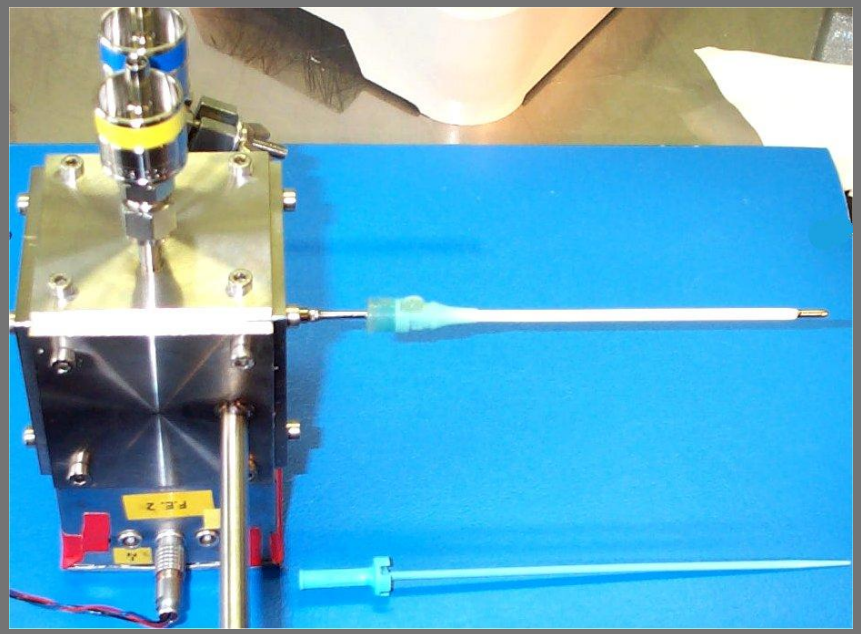
Microdosimetry with mini TEPCs



8 French cannula
for mini invasive surgery

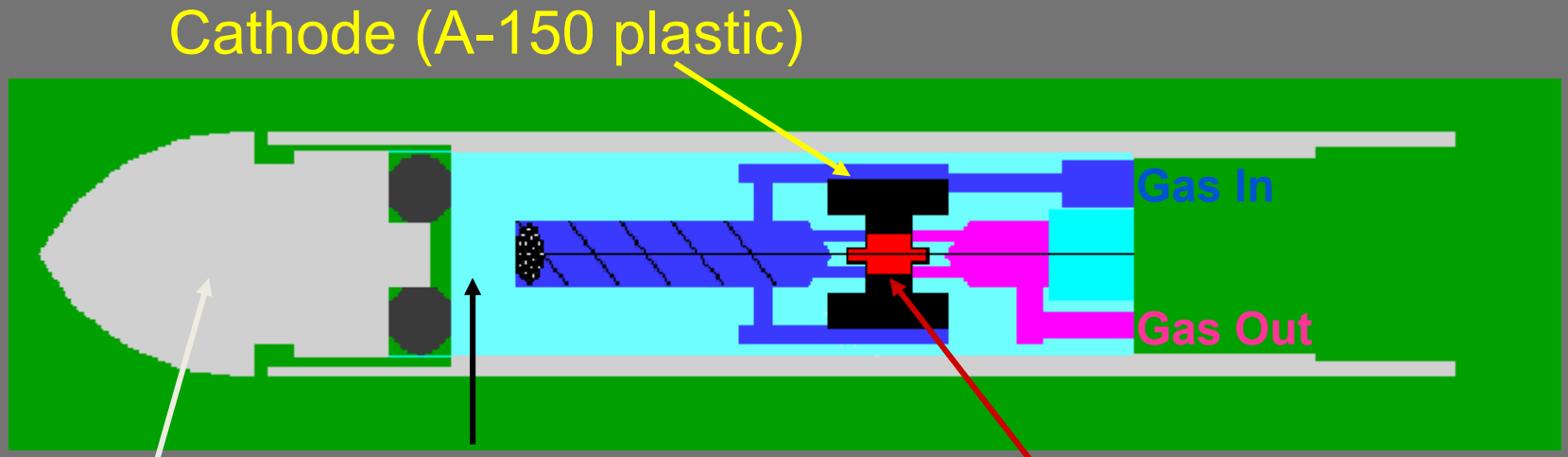
External dimensions:
diameter of 2.7 mm

(to fit 8 French cannula)



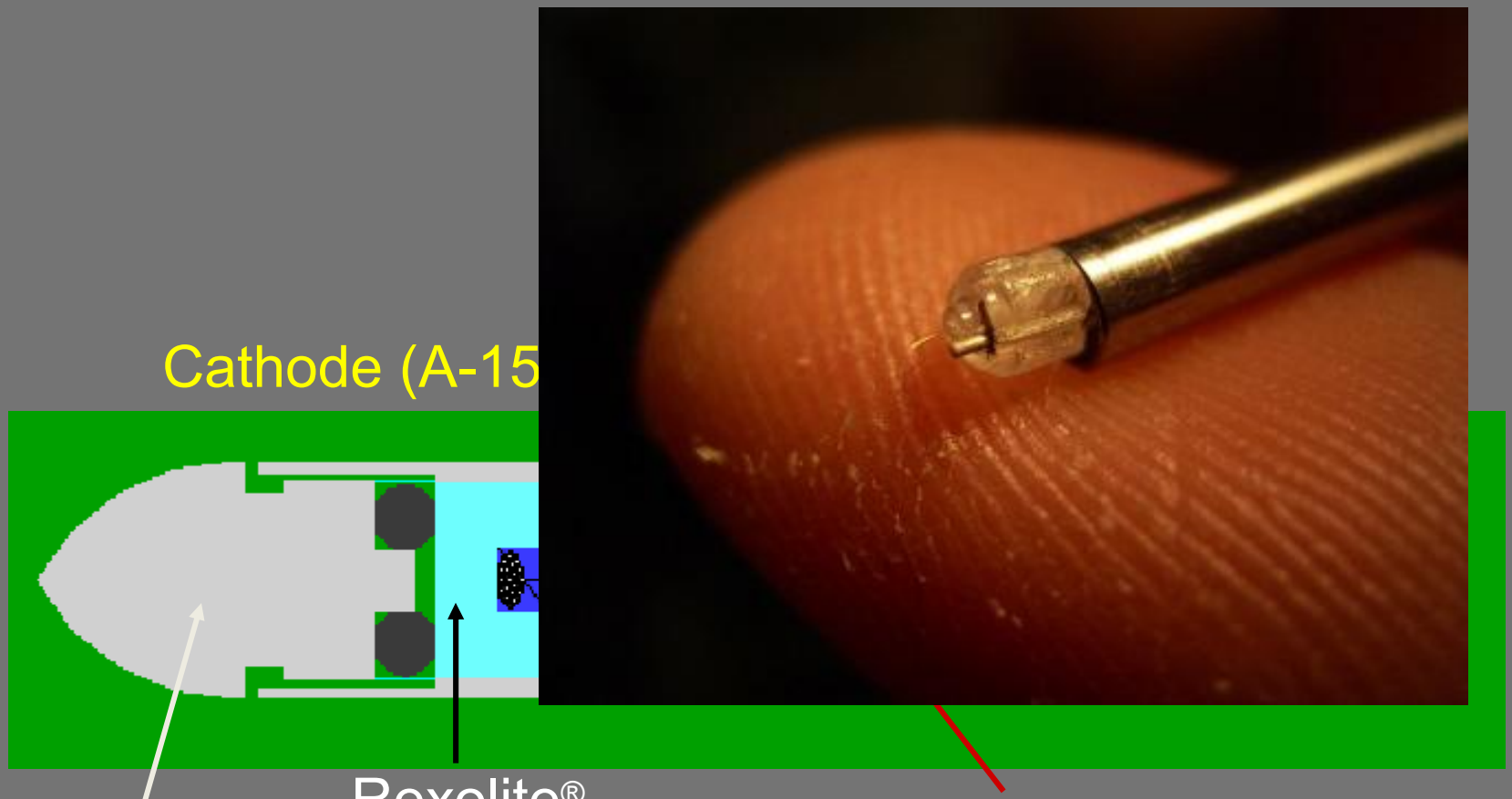
WP3 @ INFN-LNL

Microdosimetry with mini TEPCs



WP3 @ INFN-LNL

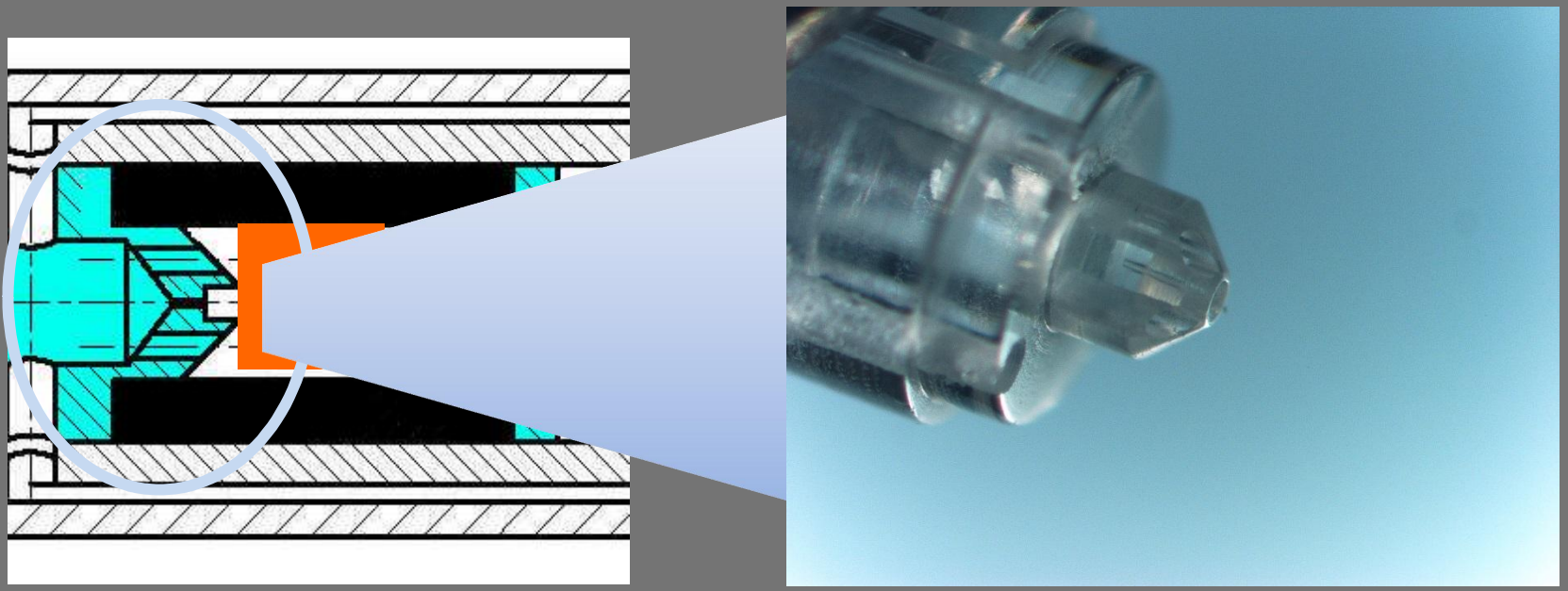
Microdosimetry with mini TEPCs



WP3 @ INFN-LNL

New mini TEPCs

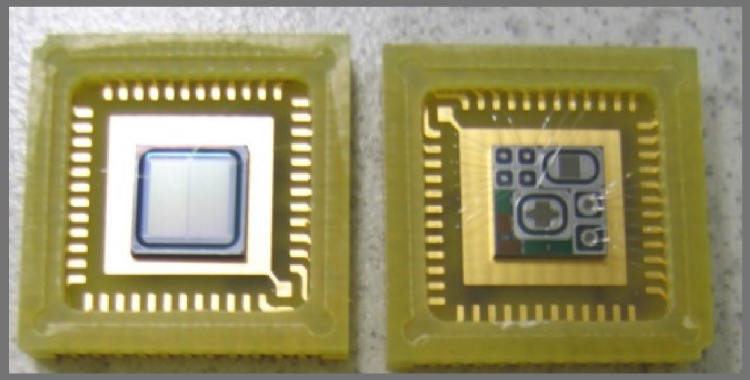
Mini TEPCs demonstrated to work properly both in proton and neutron fields. However, in BNCT fields they showed an underestimation of the high lineal energy events (Li events y_{max} = 660keV/μm). This could be due to the polarization of the insulators that should distort the sensitive volume at high energy events. Therefore cone shaped insulators have been planned in order to reduce these effects.

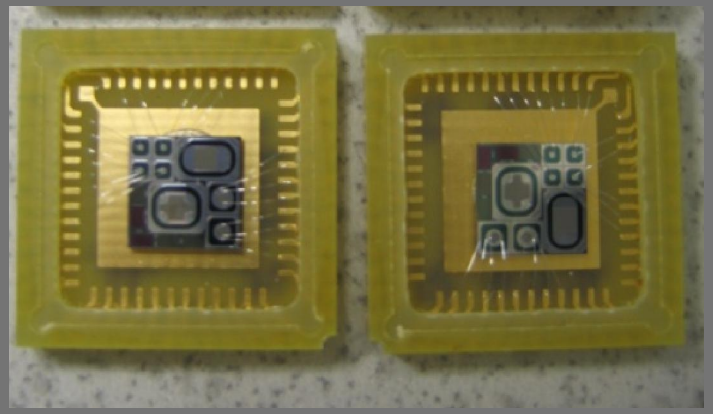


WP4 @ PoliMi

Microdosimetry with Si-based detectors

The main aim of this WP is to make a systematic comparison of the microdosimetric spectra of light ion beams obtained both with the Si-based microdosimeter and the mini-TEPC. Measurements will be carried out in phantom.

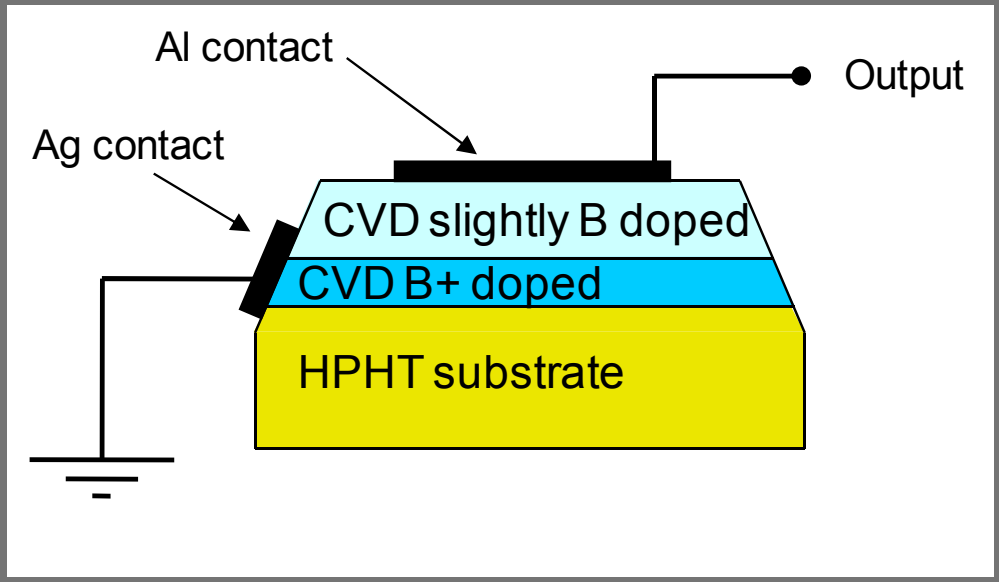




WP5 @ University of Rome

Microdosimetry with Diamond-based detectors

The main aim of this WP is to develop a Diamond-based microdosimeter able to measure energy deposition in sensitive volume of 1-2μm equivalent tissue diameter. A deep characterization of the device will be done.

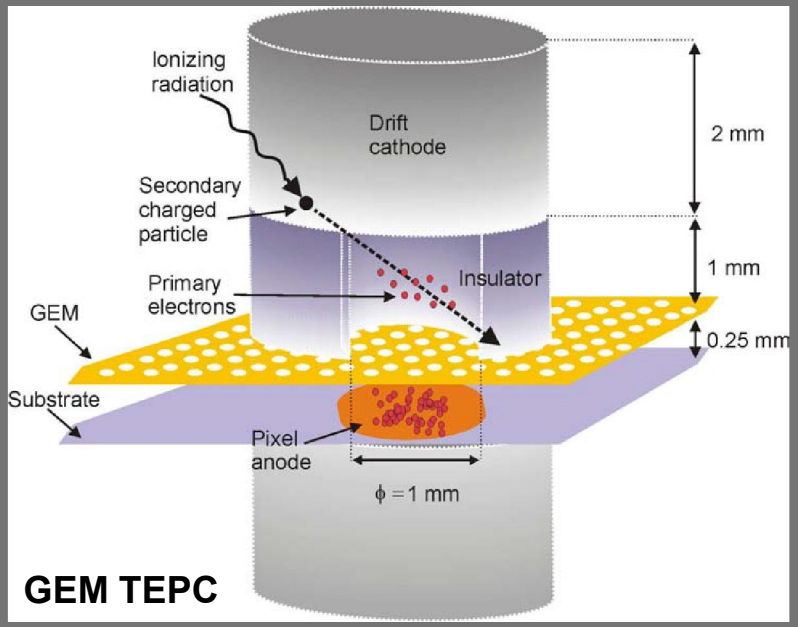


Example of Diamond-based microdosimeter

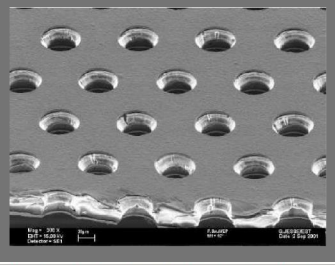
WP6 @ University of Padova

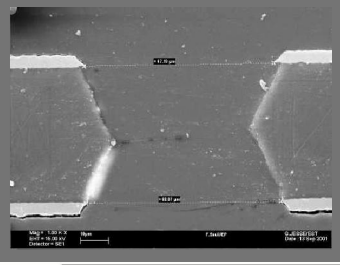
Microdosimetry with GEM-TEPC

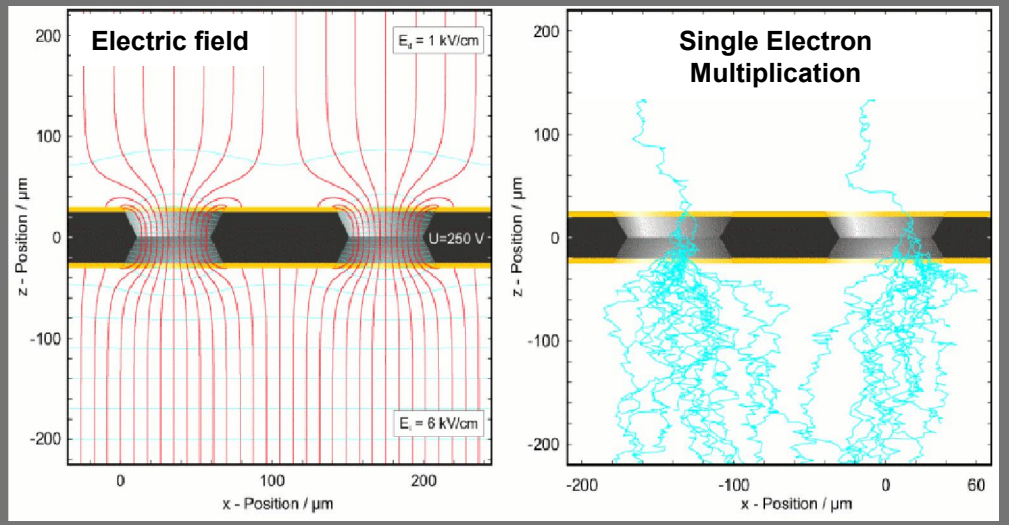
The main aim of this WP is to develop a multiple microdosimeter based on GEM for making a 2D-map of an hadronic therapeutic beam.



Courtesy of dr. A.J.J. Bos, Delft University of Technology







WP7 @ IOV

Comparison and analysis of the experimental data

Scientific Aims

- To analyse, compare and interpret the results both of microdosimetric and track structure measurements, in the light of the radiotherapeutic clinical experience
- To study the applicability of a microdosimetric system into the clinical practise of hadrontherapy
- To identify significant physical quantities that could improve the radiotherapeutic plans

CONCLUSIONS

BioQuaRT impact is mainly in the field of metrology

while

MITRA is more connected to the application in clinical practise.

The two research projects have some topics and detectors that are the same but the aims are different.

So, it can be say they have complementing goals.