Research and networking activities at the LNL laboratories

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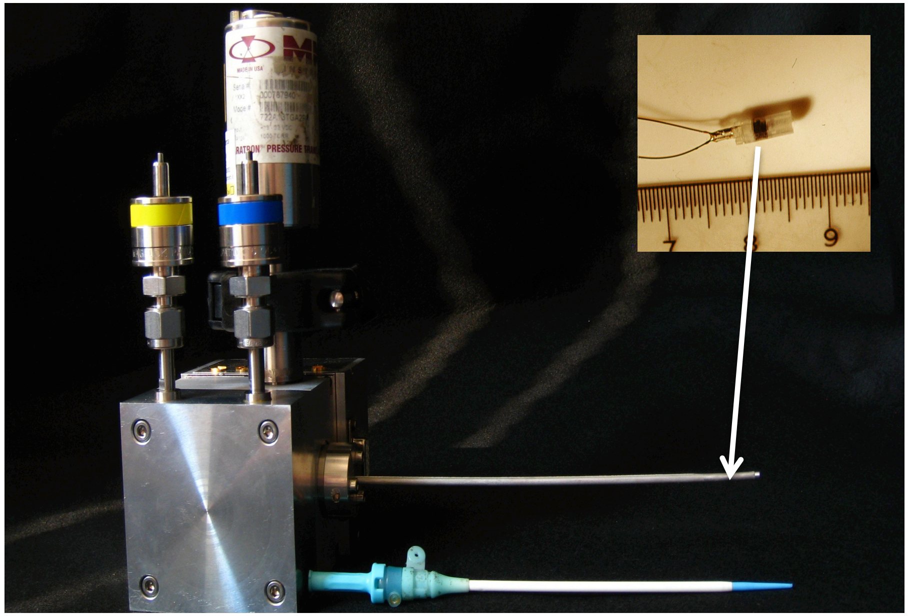
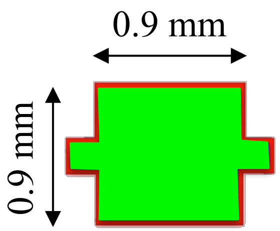
MidiNet task 2. Mid term meeting
Београд, 12-14 March 2018

Microdosimetric Study with the CNAO **Active-Scanning** Carbon-Ion Beam doi:10.1093/rpd/ncx217

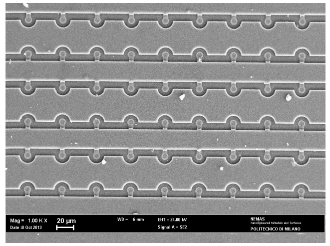
Two detectors were used



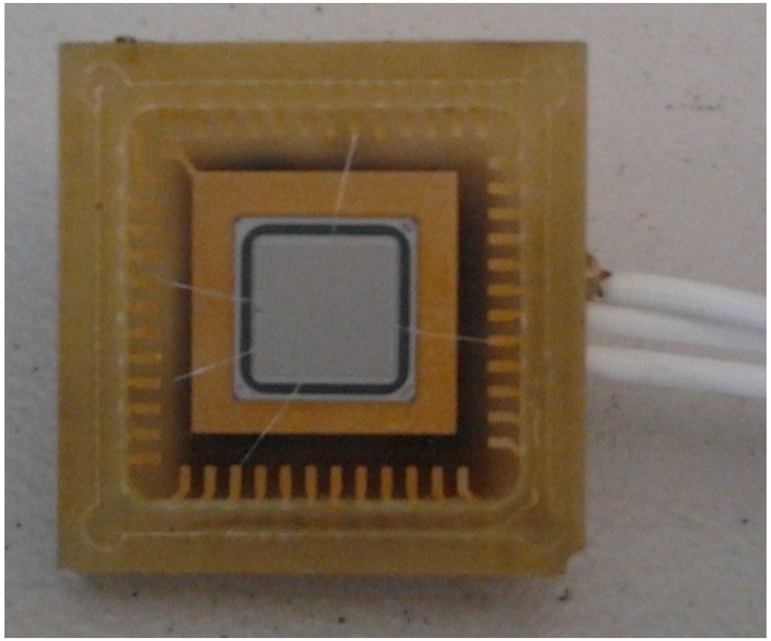
The mini Tissue-Equivalent Proportional Counter (mini-TEPC). LNL-INFN



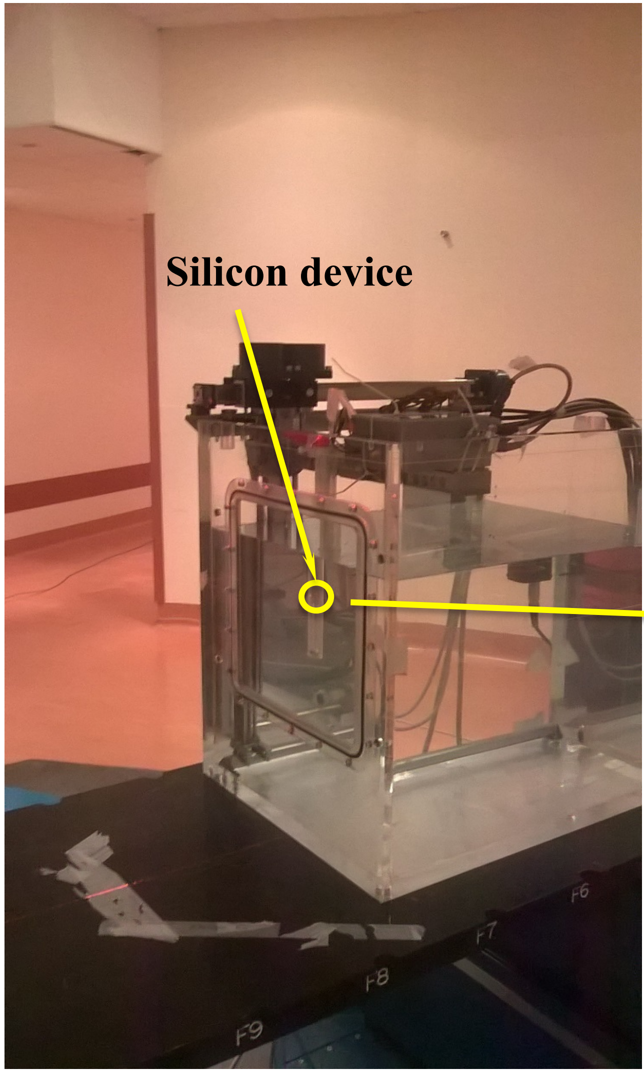
The silicon microdosimeter. Politecnico of Milano



More than 7000 pixels are connected in parallel to give an effective detection area of the ΔE stage of about 0.3 mm^2

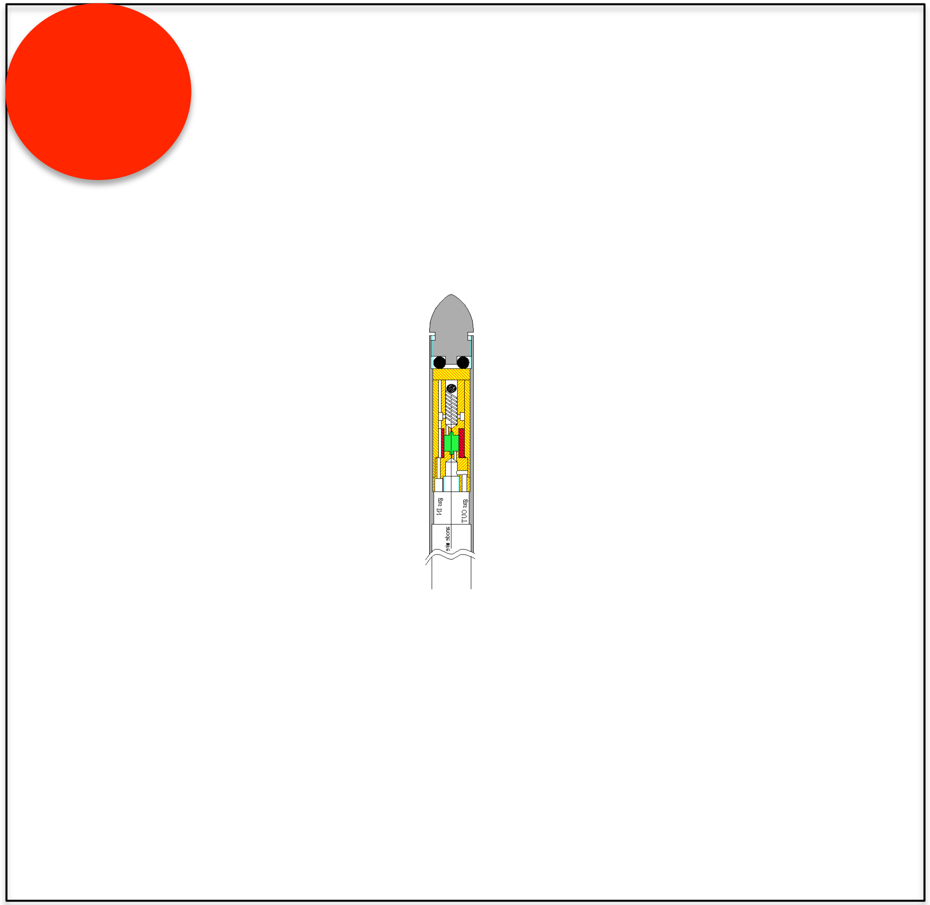


Measurements were performed inside a water phantom



ACTIVE SCANNING: 225 beam spots of 6 mm of diameter uniformly fill the area

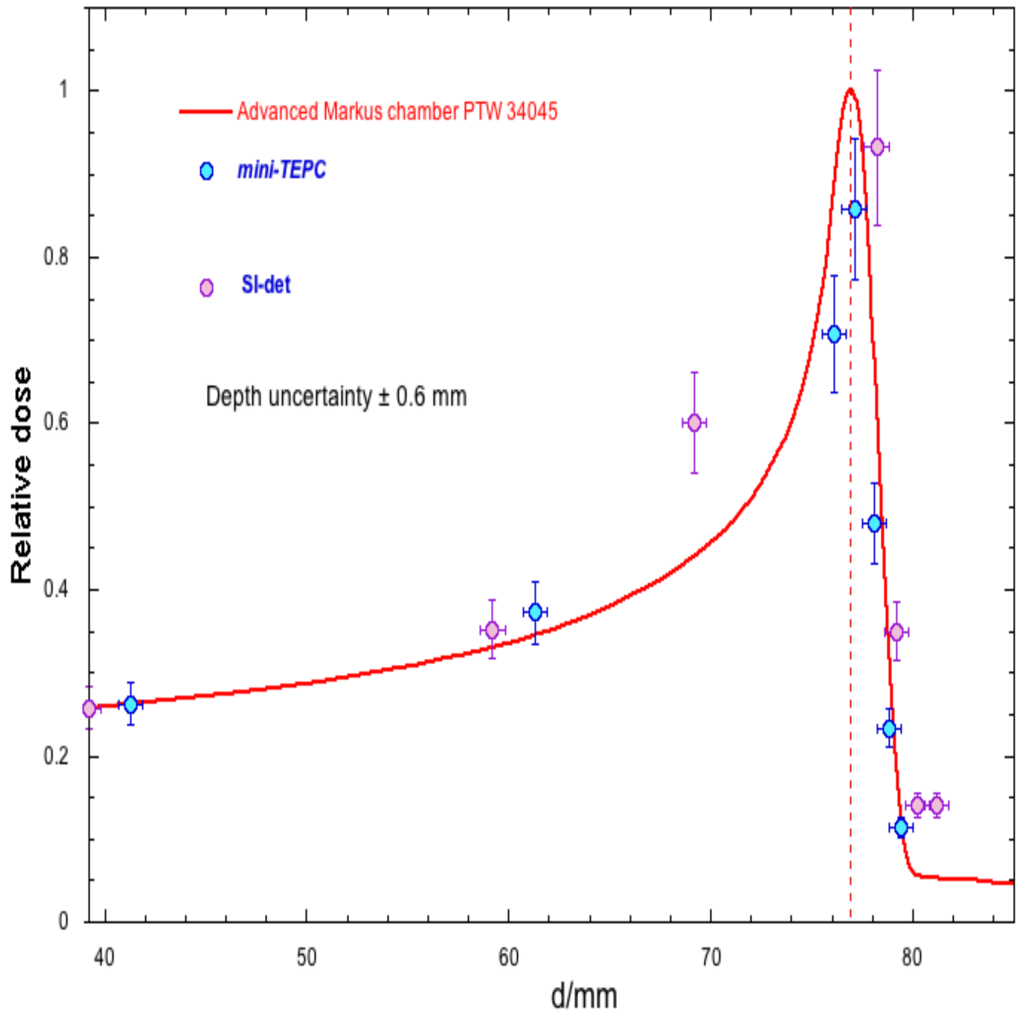
30 mm



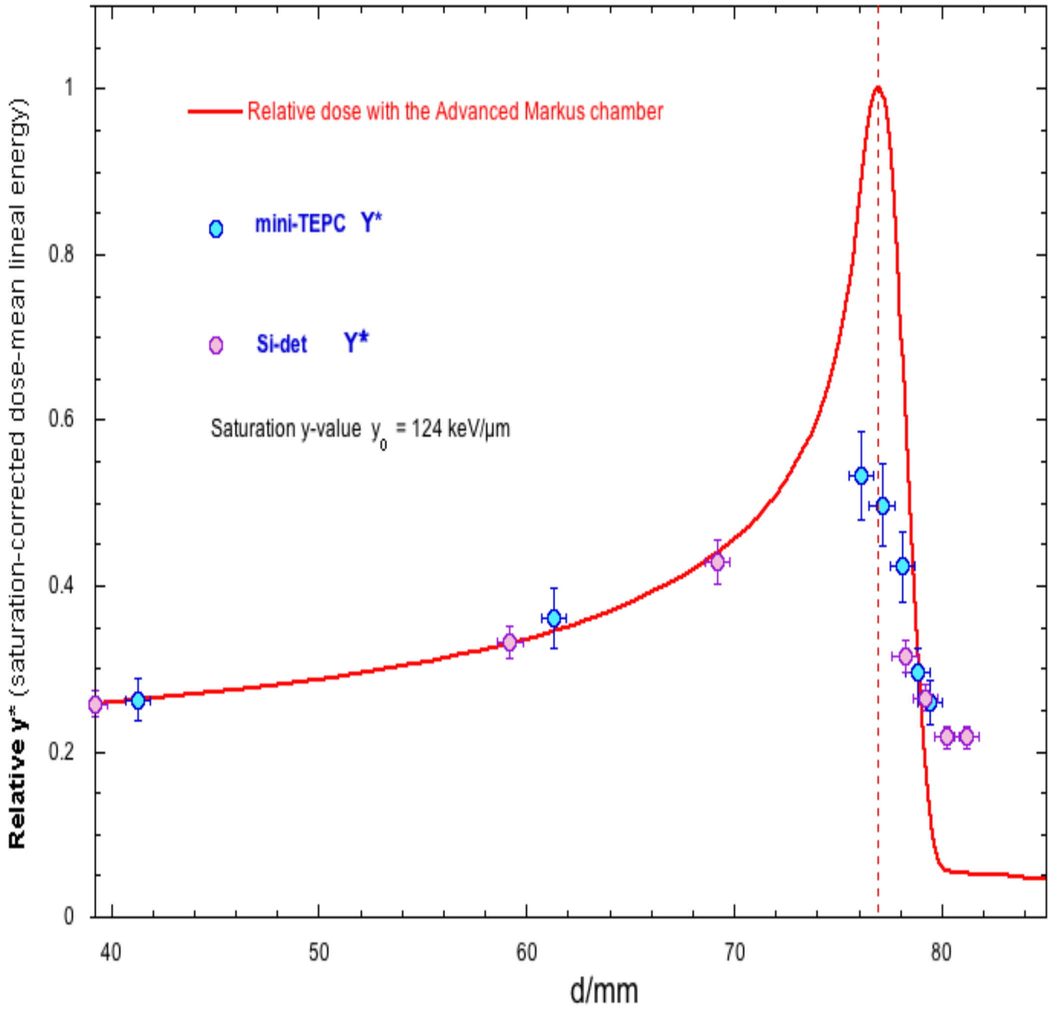
30 mm

Relative mean values comparison: relative dose

$$D = \frac{k}{\rho \cdot d^2} \cdot N \cdot \overline{y}_F$$



Relative mean values comparison: saturation-corrected $\bar{y}_D$

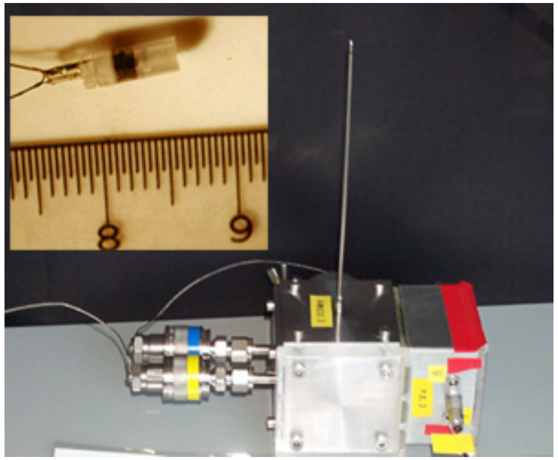


$$y^* = y_0^2 \cdot \int [1 - e^{-(y/y_0)^2}] \cdot f(y) \cdot dy \, / \int y \cdot f(y) \cdot dy$$

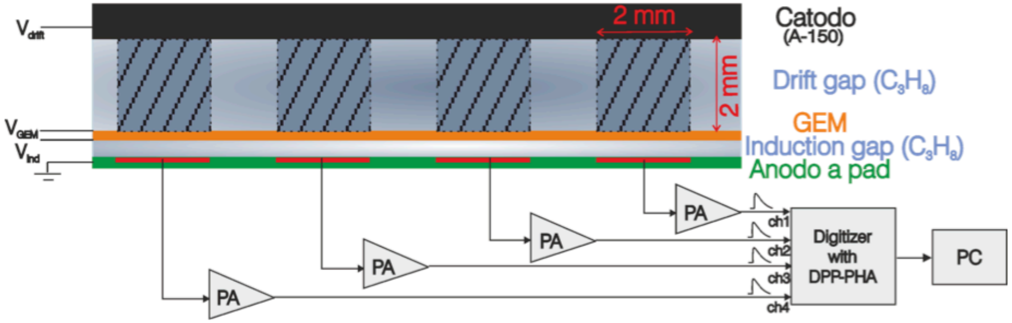
ICRU report 36. 1983

Microdosimetric inter-comparison with the 62 MeV/u carbon-ion beam of Catania

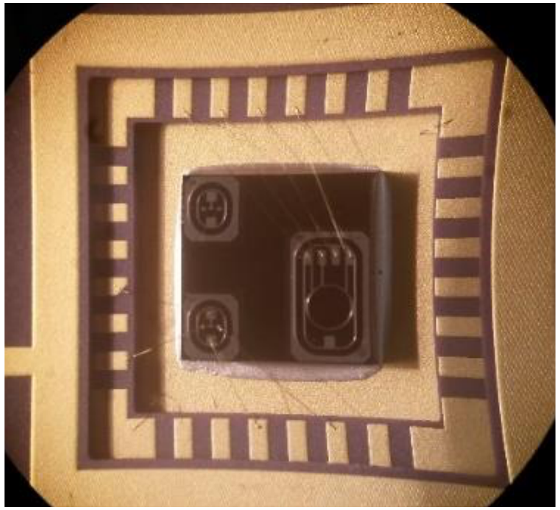
submitted to Physica Medica

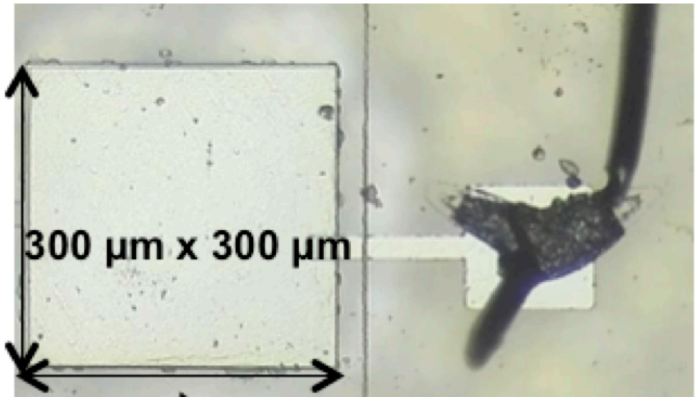


Mini-TEPC ***LNL-INFN***



GEM detector ***PD-INFN***

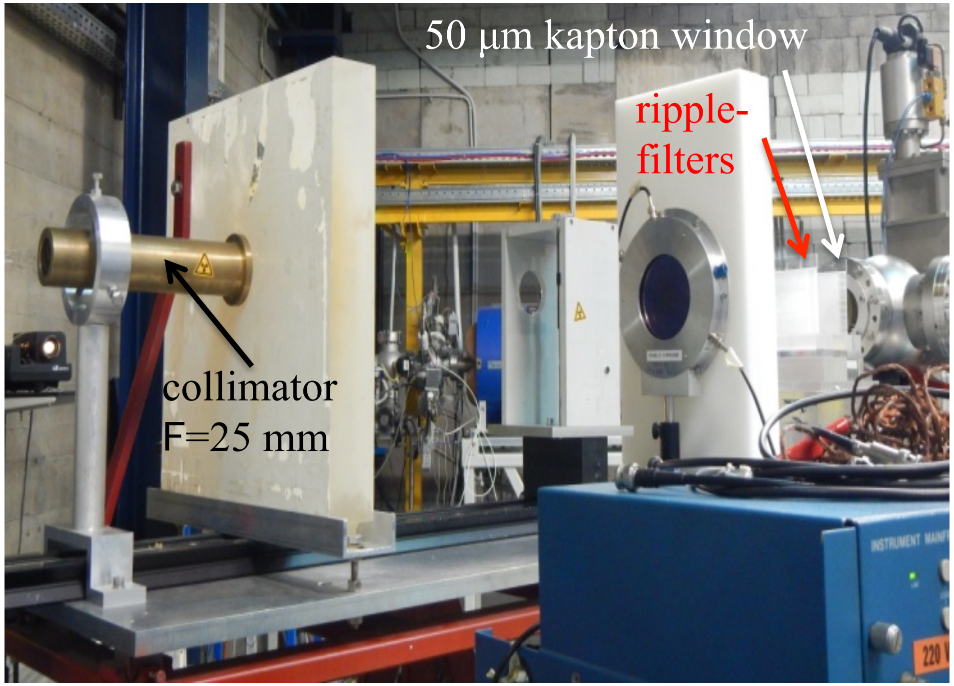


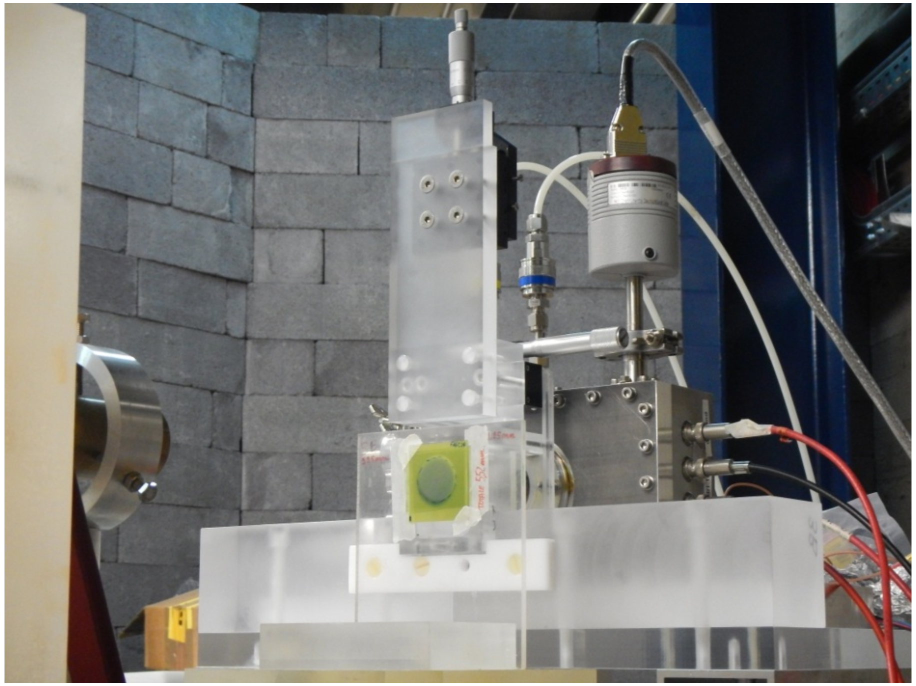


Diamond detector ***Roma2-INFN, MedAustron***

Silicon detector ***Polimi***

The beam line of LNS laboratory and the PMMA phantom





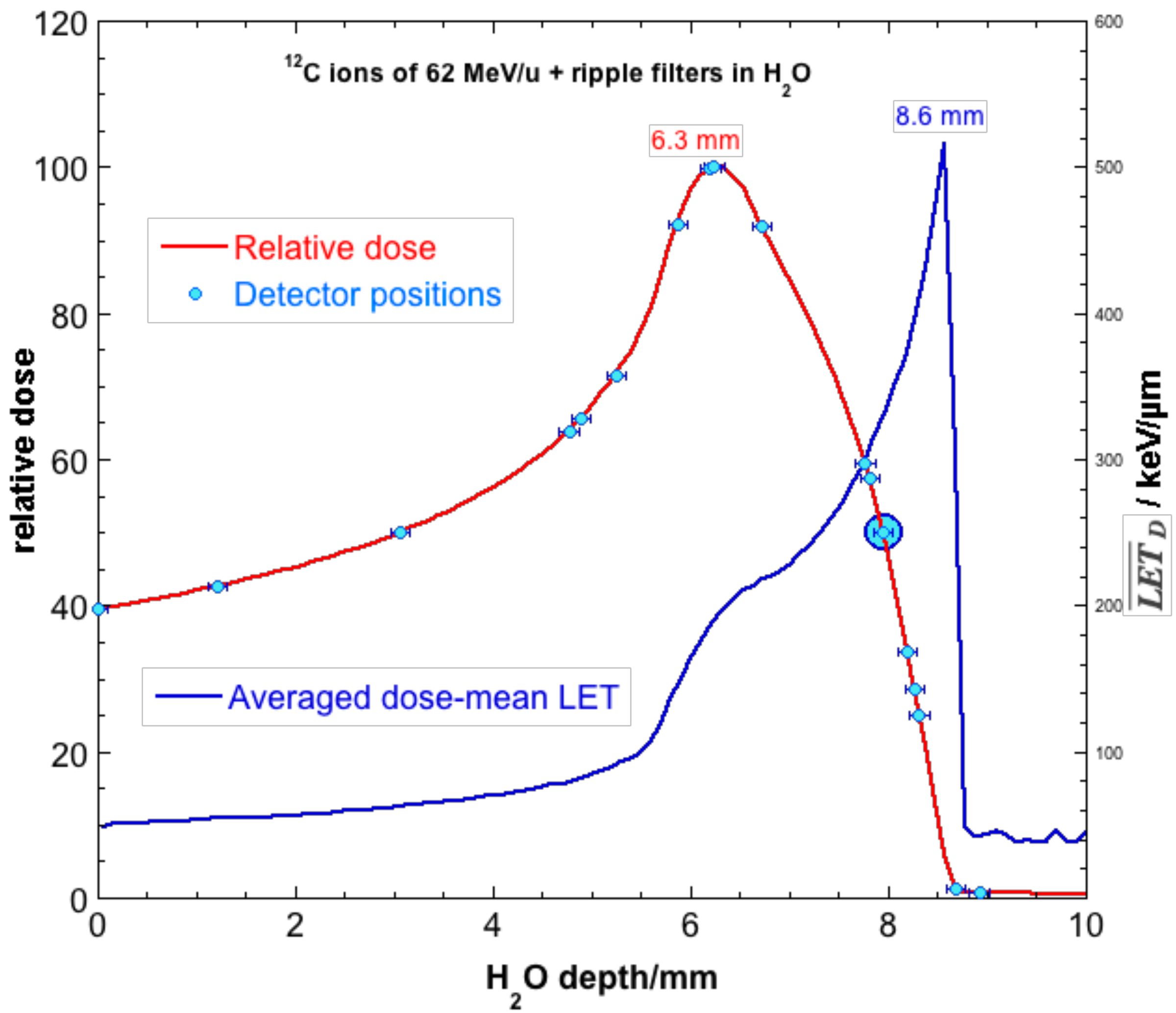
Relative dose, points of the measurements and averaged dose-mean LET

$$\overline{LET}_D(z) = \frac{\sum_{j=1}^{n}\int_0^{\infty}(S_{el}^j(E))^2\varphi_E^j(z)\,dE}{\sum_{j=1}^{n}\int_0^{\infty}S_{el}^j(E)\varphi_E^j(z)\,dE}$$

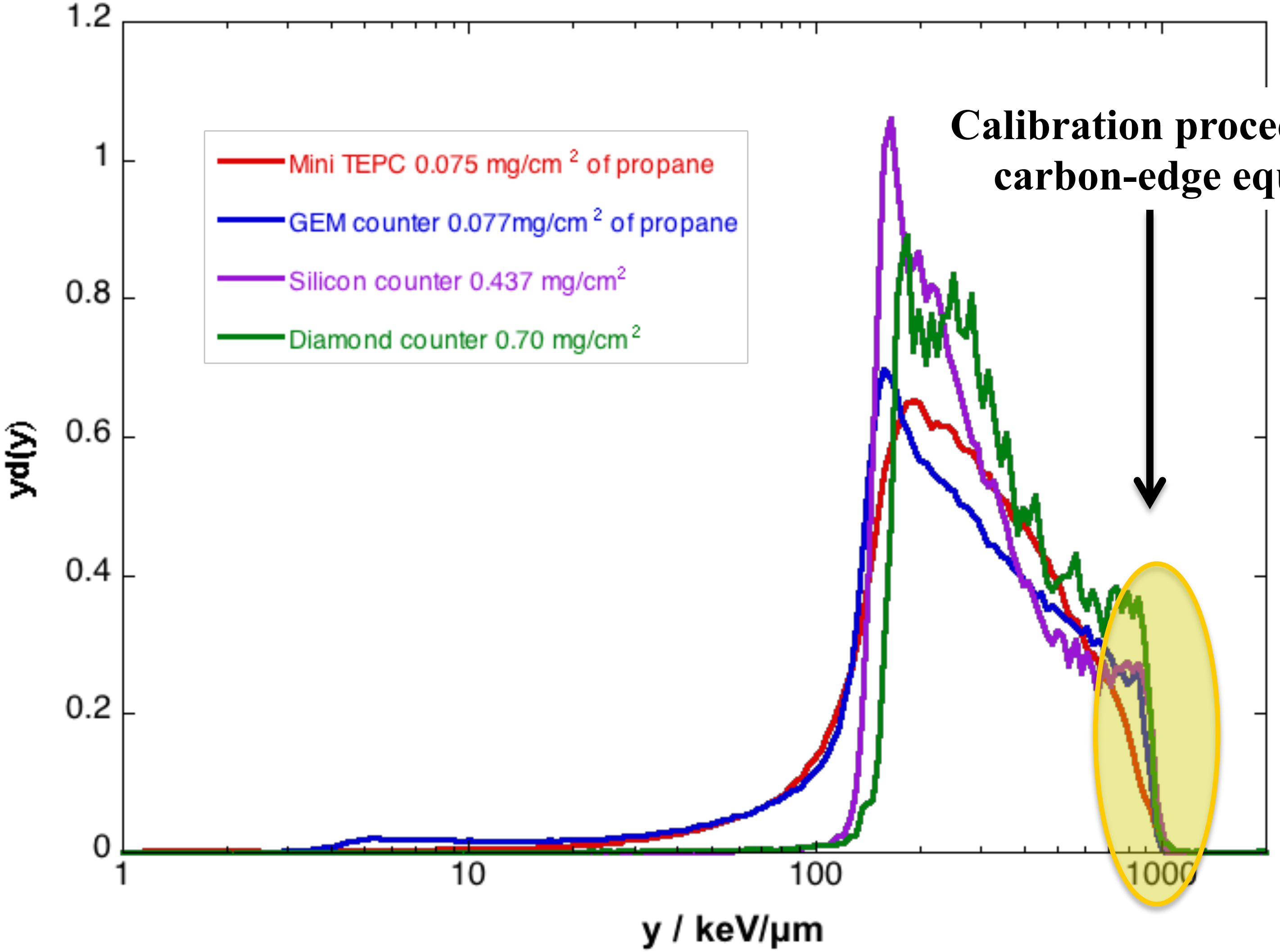
S^j_{el} LET of j particle of energy E

$\varphi_E^j(z)$ spectrum of j particle at z depth

F. Romano et al. PMB 2014: 59,2863

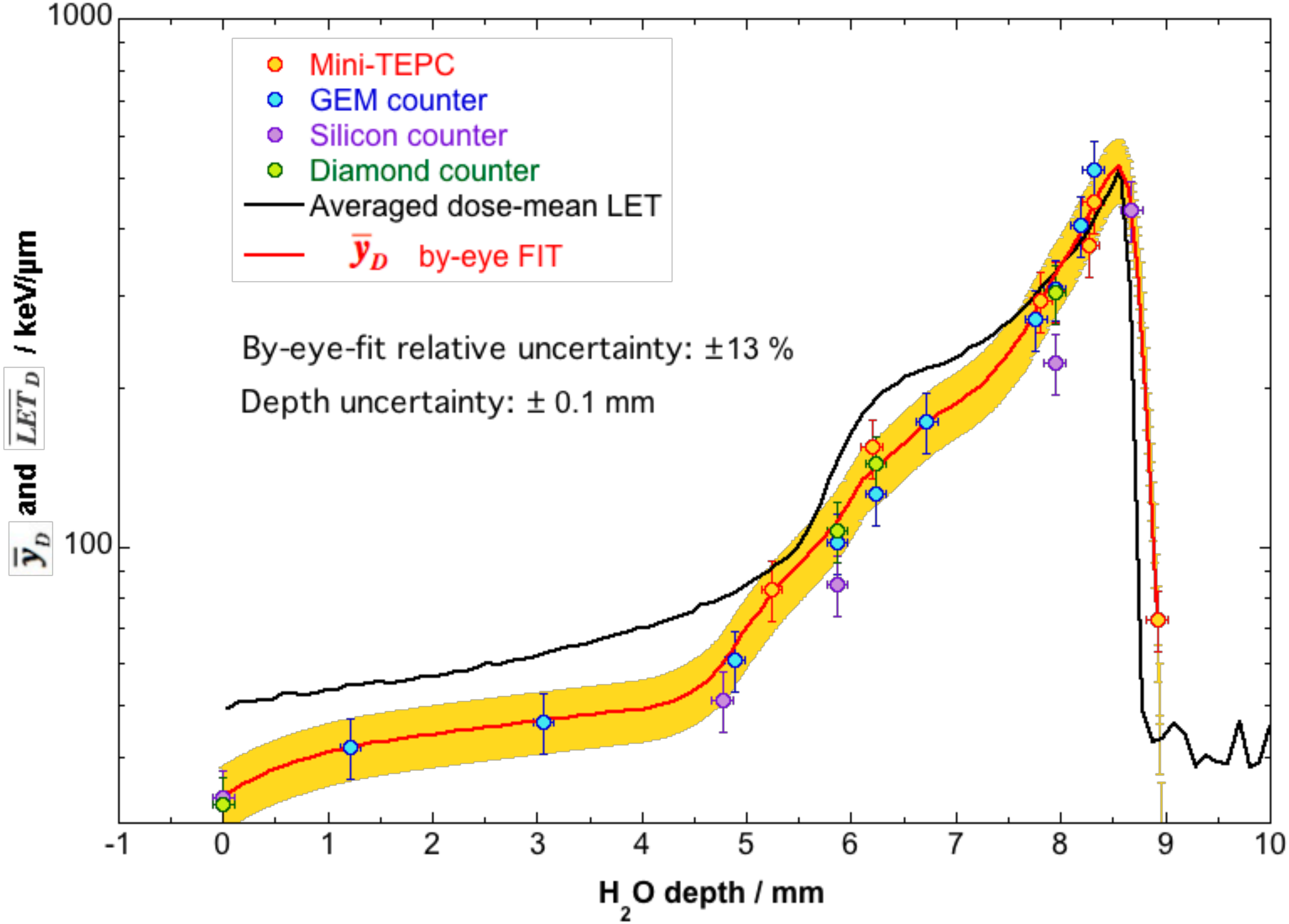


The response of the four detectors at 7.9 mm of water-equivalent depth

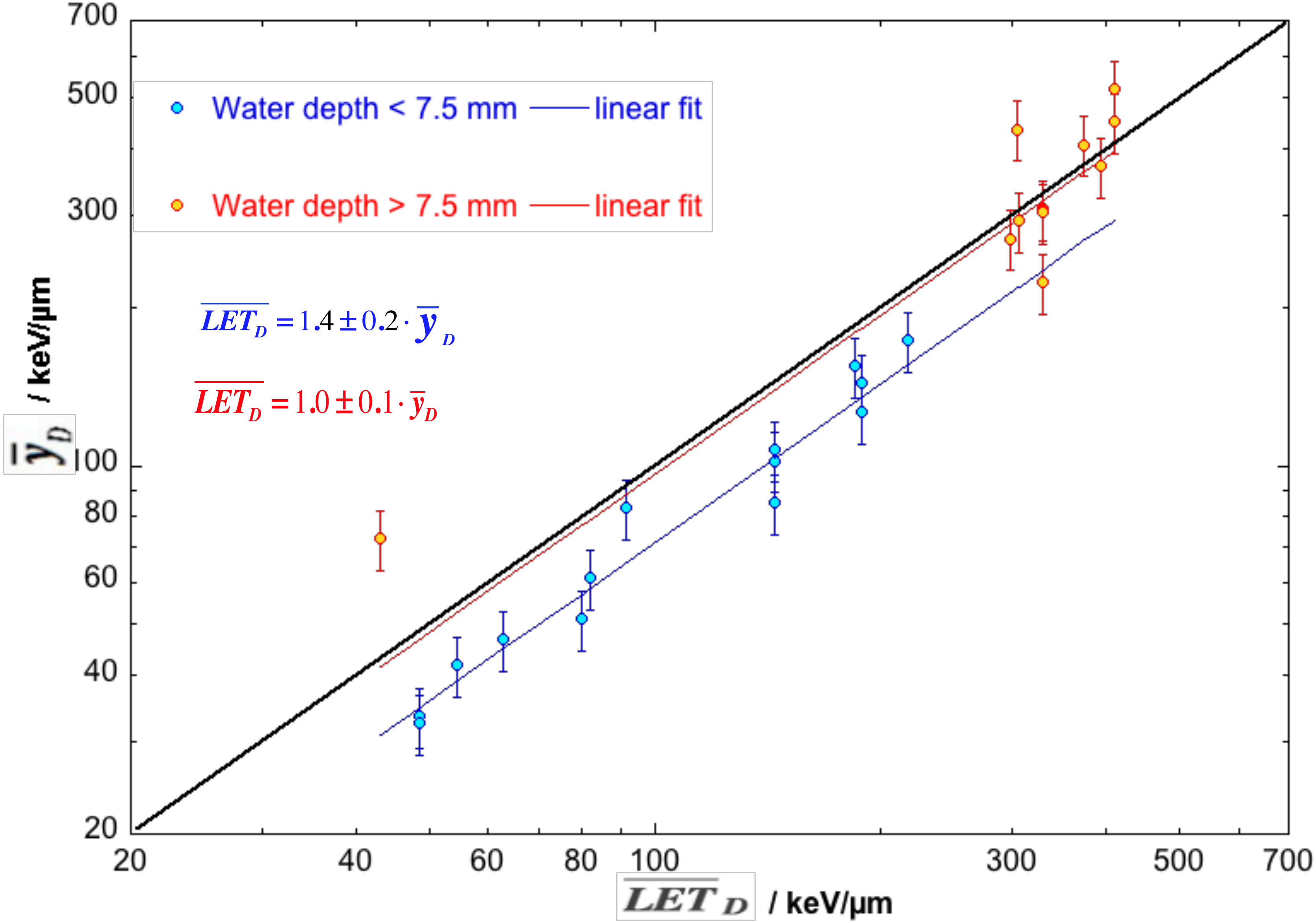


Calibration procedure: carbon-edge equal LET_{water}^{max}

$\overline{y}_D$-values inter-comparison and $\overline{LET}_D$



$\overline{y}_D$ against $\overline{LET}_D$ at different depths



The microdosimeter is a LET counter only as a first approximation,

In a mixed-radiation field different particle tracks have different LET (L) values. They give rise to the distribution ***t(L)***, which is different from the ***f(y)*** distribution. However, the respective momenta are proportional when the particles cross randomly the detector in CSDA:

$$\overline{y^n} = \frac{\overline{l^n}}{\bar{l}^{\,n}} \cdot \overline{L^n}$$

Therefore for any detector:

$$\bar{y}_F = \bar{L}_F \qquad \text{and} \qquad \bar{y}_D \neq \bar{L}_D$$

If we consider the energy straggling, we have:

$$\bar{y}_D = \frac{\overline{l^2}}{\bar{l}^{\,2}} \cdot \bar{L}_D + \frac{\bar{E}_w}{\bar{l}}$$

Where $\bar{E}_w$ is the weighted mean of the collision spectrum

A.M.Kellerer in Second Symposium on Microdosimetry EUR 4452 d-f-e-, 107-135

CONCLUSIONS

The scientific collaboration is continuing with:

1. **INFN laboratories of Catania, Italy**
2. **INFN section of Padova, Italy**
3. **Politecnico of Milano, Italy**
4. **University of Roma 2, Italy**
5. **MedAustron, Austria**
6. **FCK•CEN of Mol, Belgium**
7. **University of Hasselt, Belgium**
8. **ELI-Beamlines. Dolní Břežany, Czech Republic.**
9. **ELI- National Physical Laboratory, Teddington, UK.**
10. **CNAO, Pavia, Italy**

With the aim of constructing reliabile microdosimeters operative in the clinic environment.

The microdosimeter is also, as a first approximation, a LET counter

In a mixed-radiation field different particle tracks have different LET (L) values. They give rise to the distribution *t(L)*, which is different from the f(y) distribution. In CSDA, when the particles cross randomly the detector :

$$\overline{L^n} = \frac{\bar{l}^{\,n}}{\overline{l^n}} \cdot \overline{y^n}$$

Therefore:

$$\bar{L}_F = \bar{y}_F$$

and

$$\bar{L}_D \neq \bar{y}_D$$

If we include the energy straggling of the particle:

$$\bar{L}_D = \frac{\bar{l}^{\,2}}{\overline{l^2}} \cdot \bar{y}_D - \frac{\bar{l}}{\bar{l}_2} \cdot \bar{E}_w$$

A.M.Kellerer in Second Symposium on Microdosimetry EUR 4452 d-f-e-, 107-135