Microdosimetry at nanometre level

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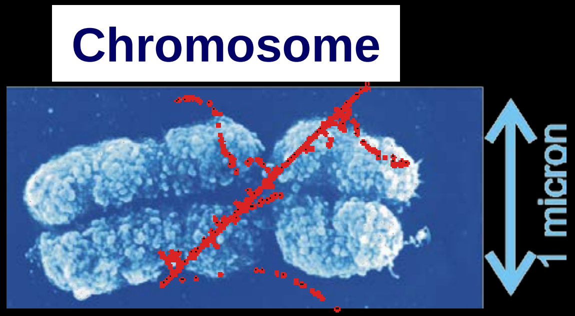
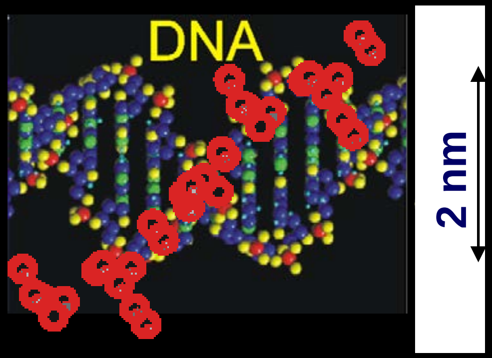
Introduction

Biological damage initiates at DNA level.

Classical microdosimetry measures at micrometre level (chromosomes).



Nowadays, investigation at nanometre level is experimentally feasible. However, the experimental set-up is very complex and cannot be employed in clinical radiation fields.



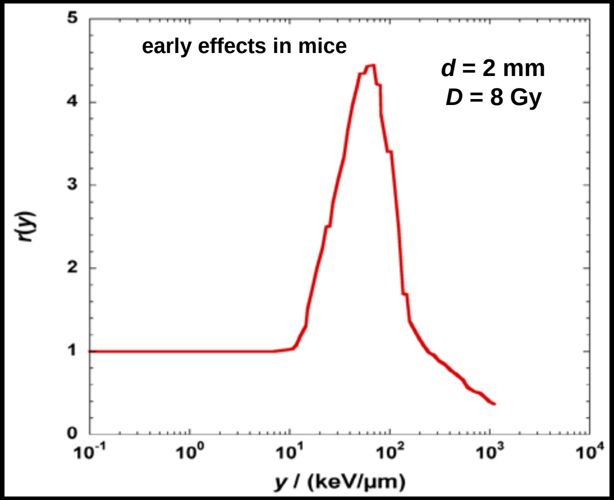
Is it possible to use TEPCs at nanometre level?

The advantage of performing TEPC measurements at nanometre level

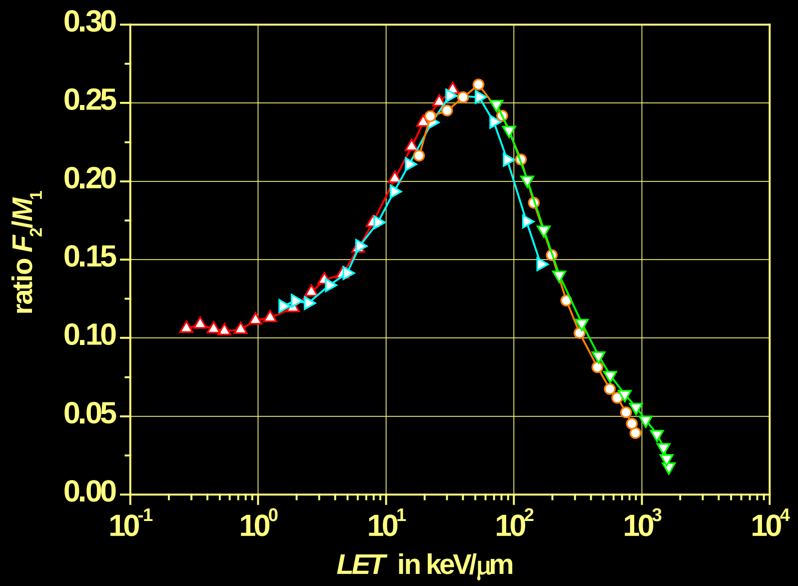
TEPCs data processing at nanometre level could take advantage from all recent track structure findings.

At nanometric level, the TEPC saturation function could be invariant with respect to radiation fields.

That invariance is reasonable, since the interaction is measured in the same site size where the initial biological damage occurs



P. Pihet et al., *Radiat. Prot. Dosim.* 31 (1990) 437



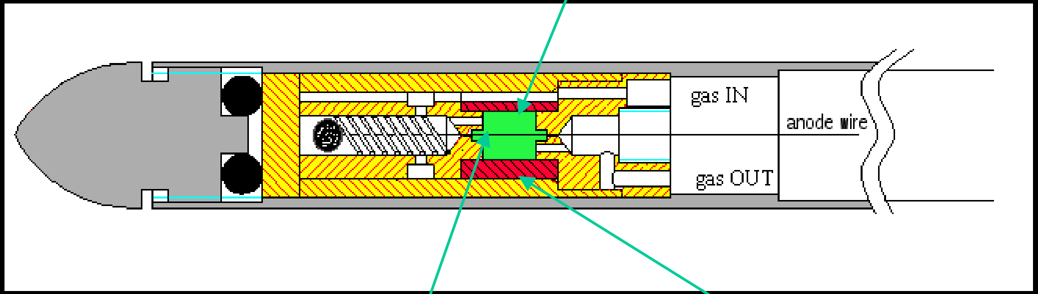
Courtesy of Bernd Grosswendt

Mini TEPCs are single-wire gas proportional counters

Sensitive volume
0.9 mm in diameter and length

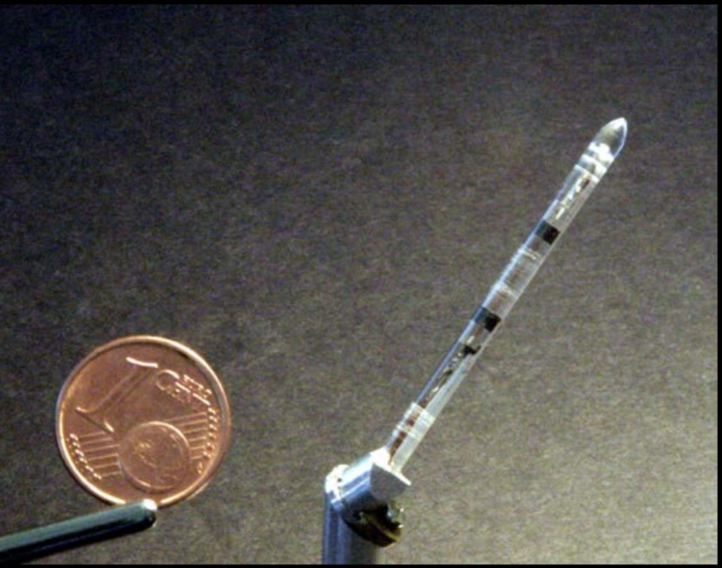
Ti stem 170 mm in length

2.7 mm

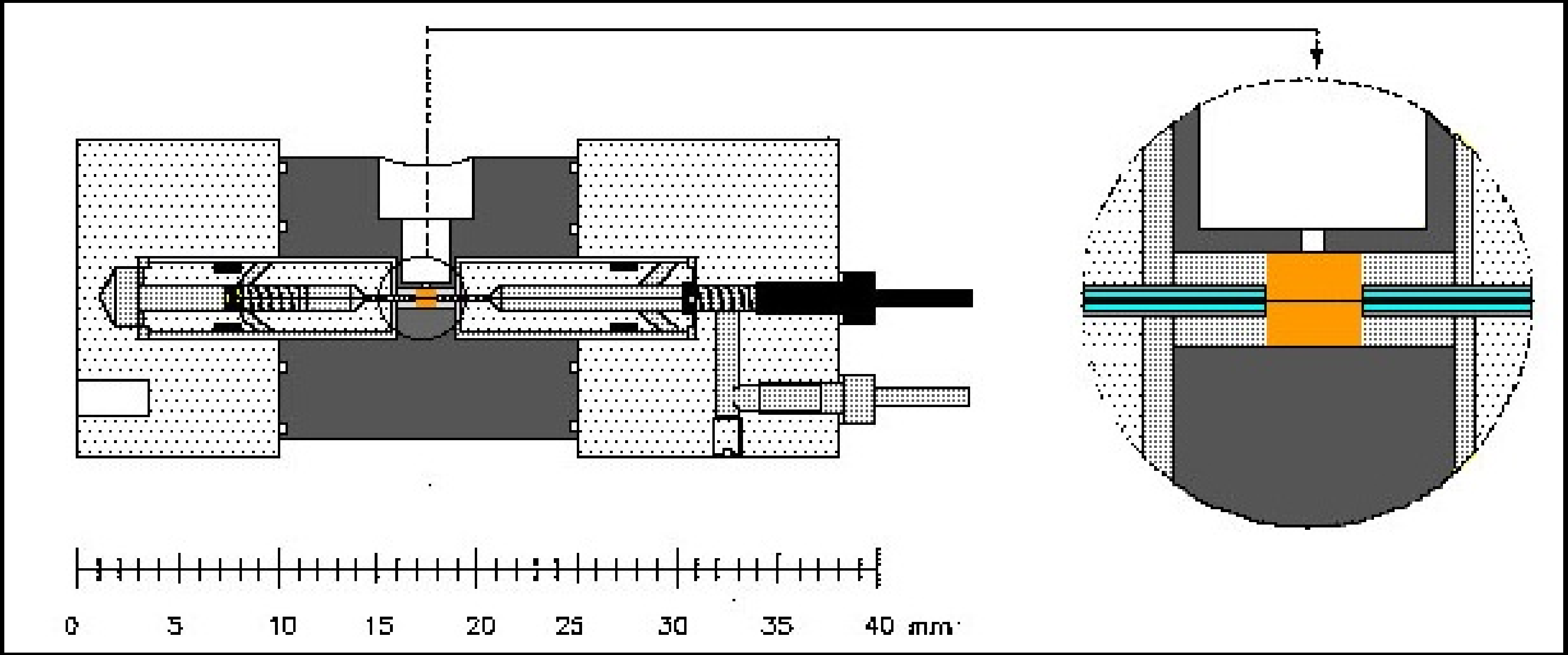


Gold-plated tungsten anode
10 μm in diameter

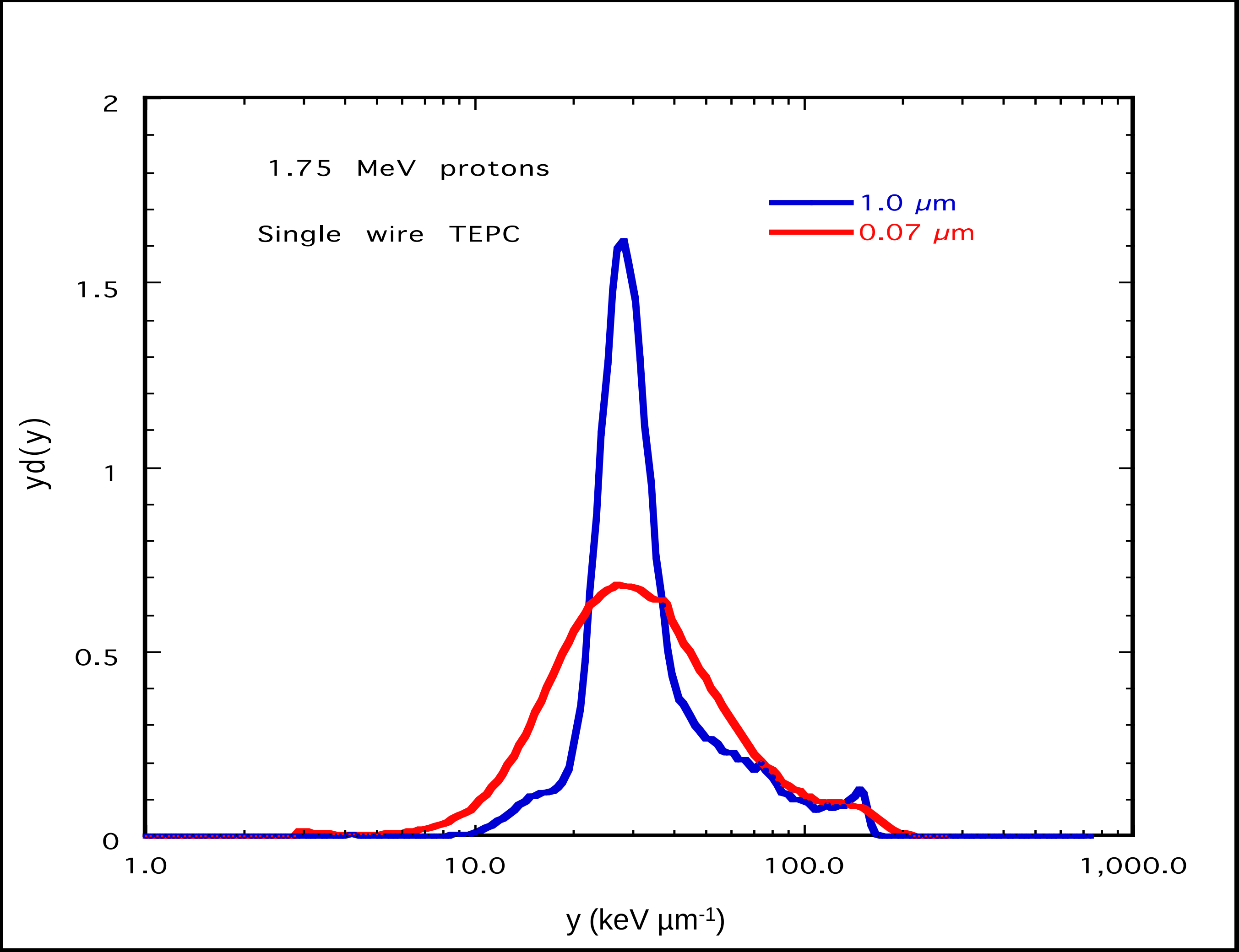
A-150 cathode
0.35 mm in thickness



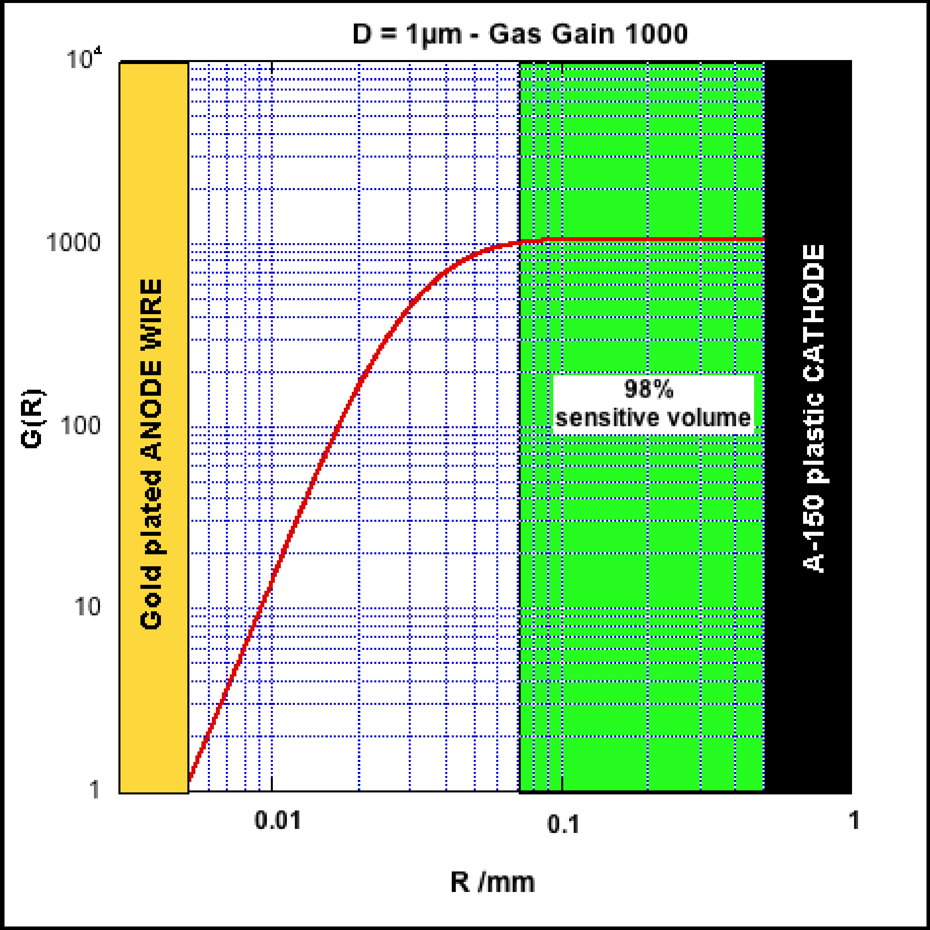
Mini TEPCs are single-wire gas proportional counters

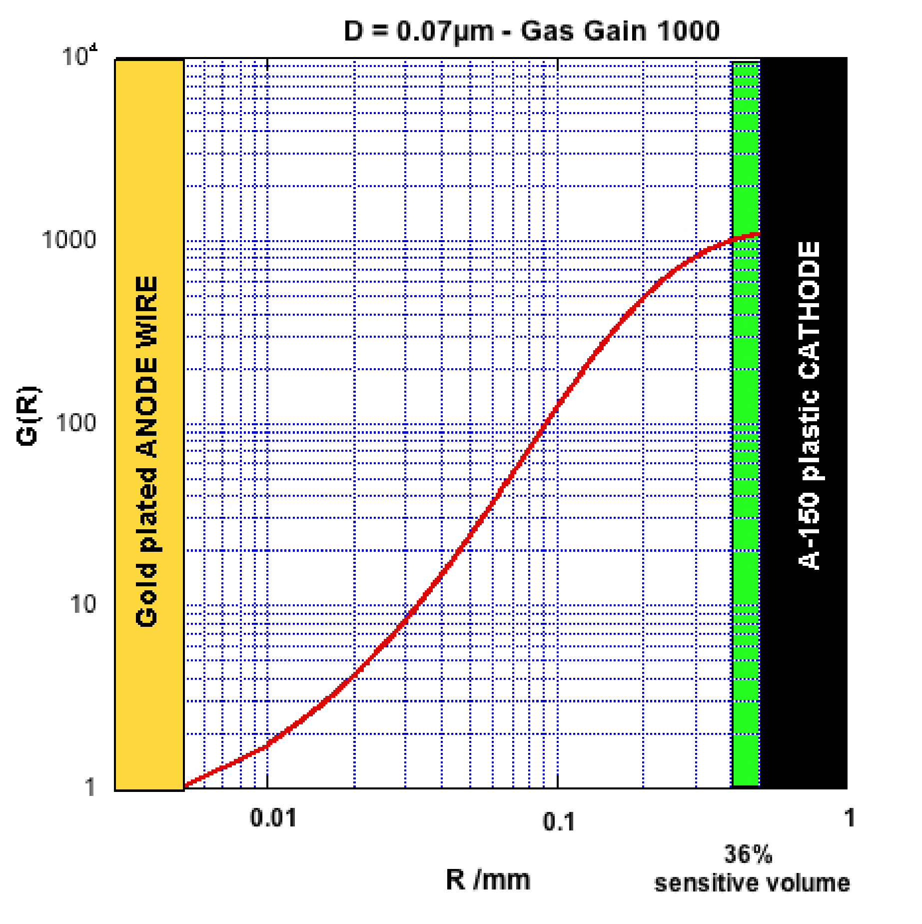


Mini TEPCs cannot measure at nanometre level



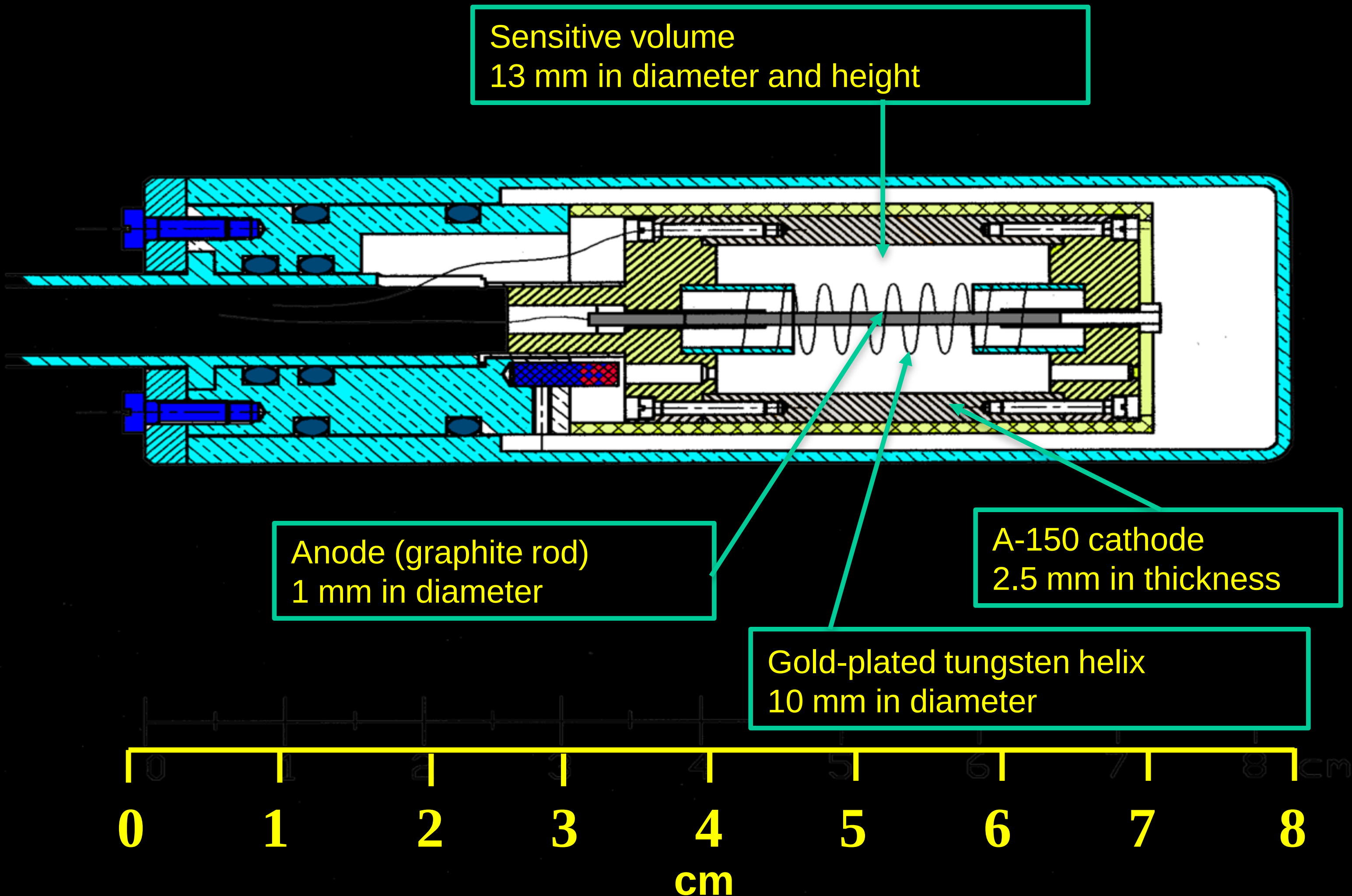
Electronic avalanche profile inside the mini TEPC



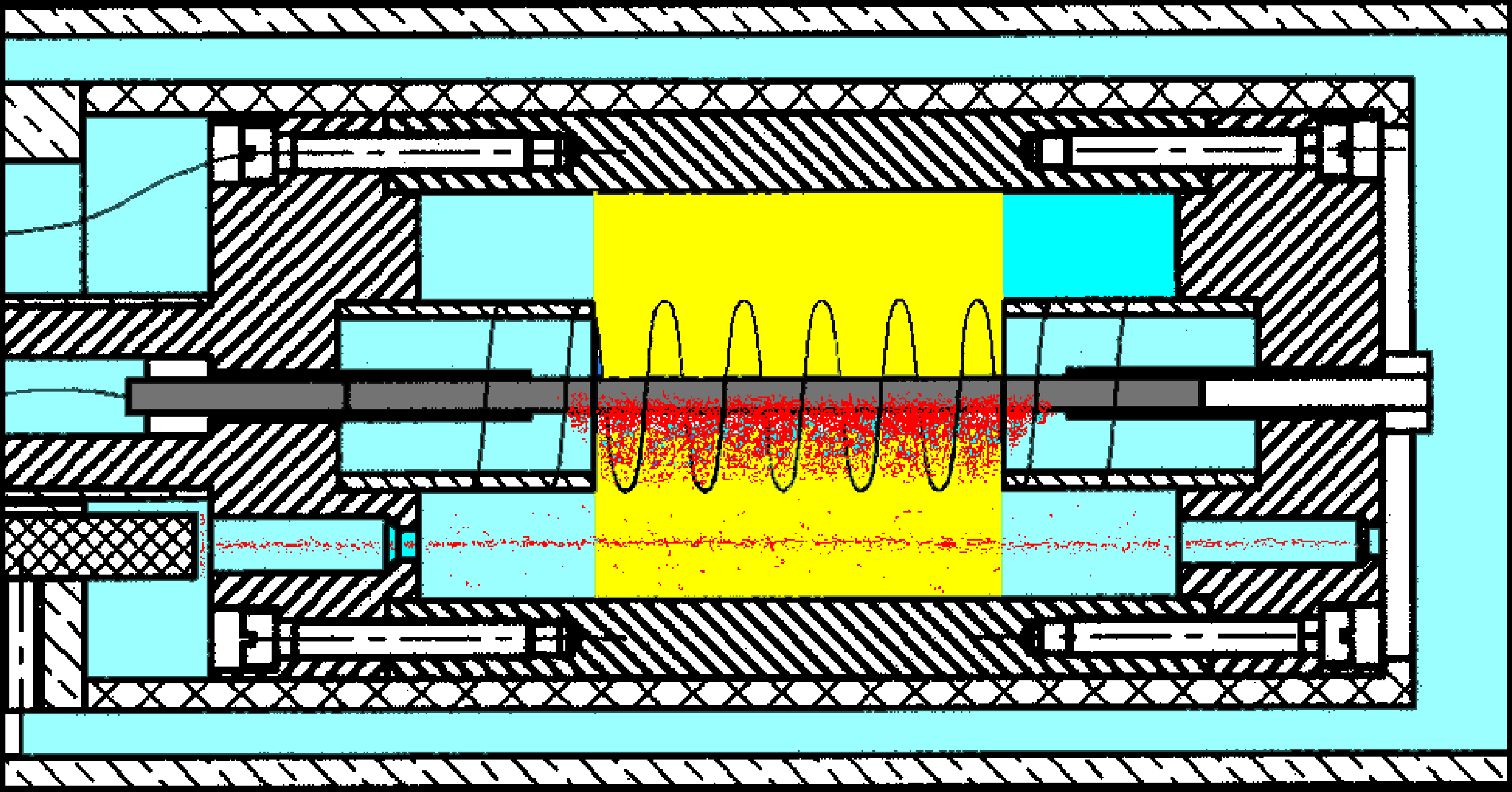


P.Segur, P.Olko and P.Colautti. Radiation Protection Dosimetry 61, 323-350 (1995).

Microdosimetric Measurements In Nanometric Sites With The Avalanche Confinement TEPC

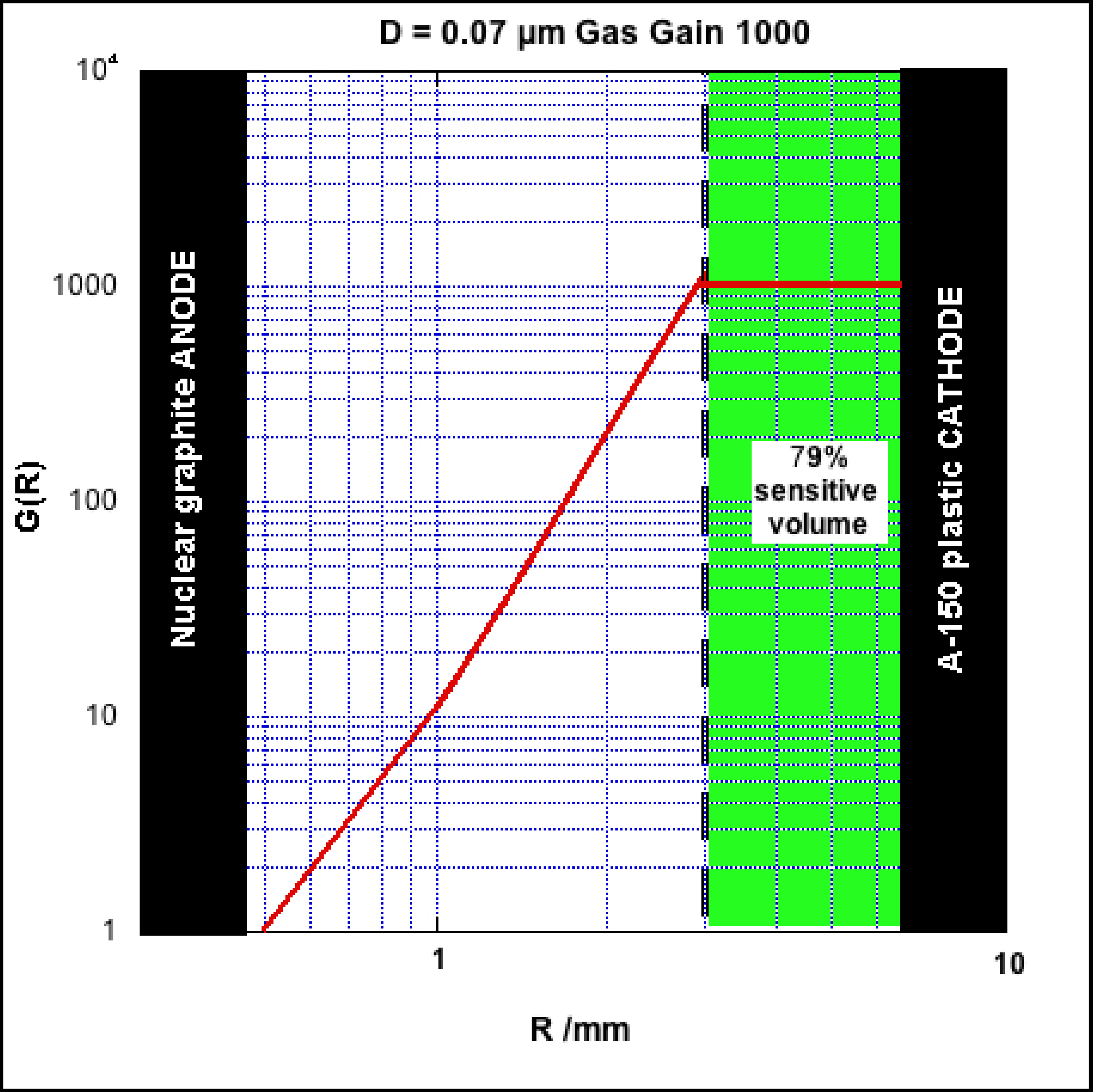


The avalanche-confinement TEPC forces the electronic avalanche inside the helix volume

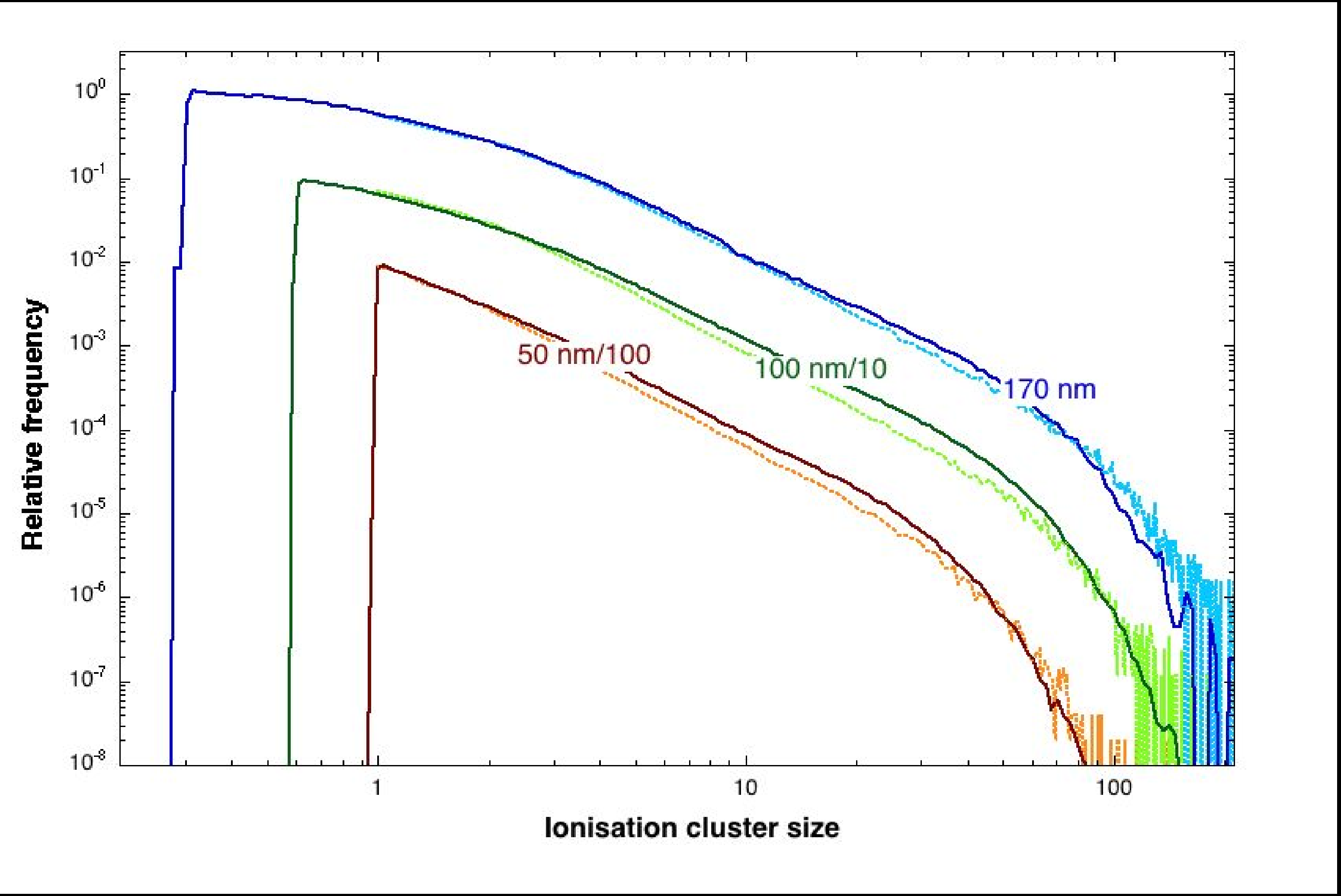


Gas pressure was set by using (at 0 °C) a ratio of 0.244 nm/Pa for the C_3H_8-TE mixture and a ratio of 0.258 nm/Pa for DME

Electronic avalanche profile inside the avalanche confinement TEPC

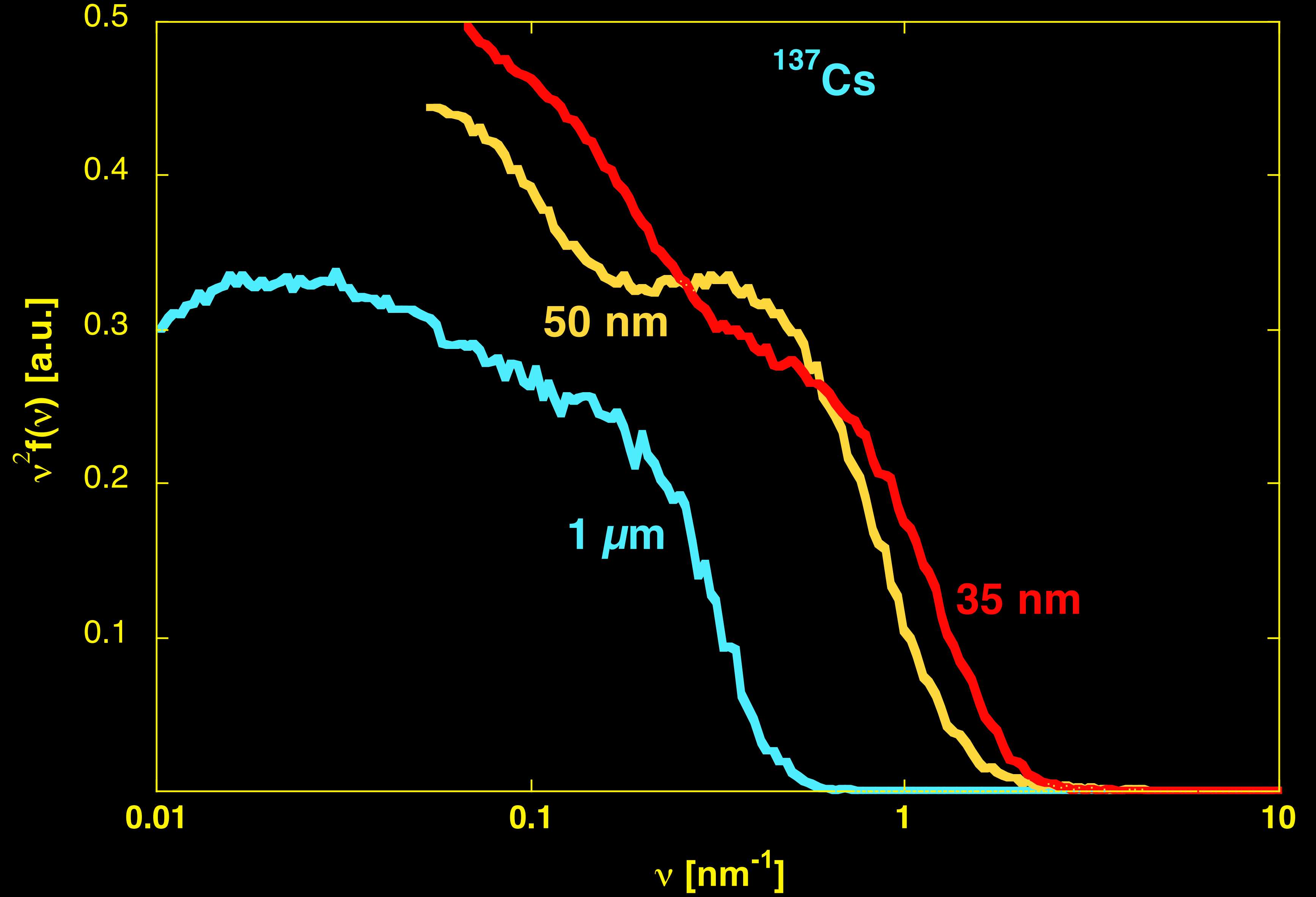


Comparison experimental and MC data
Gamma rays from a ^{137}Cs source

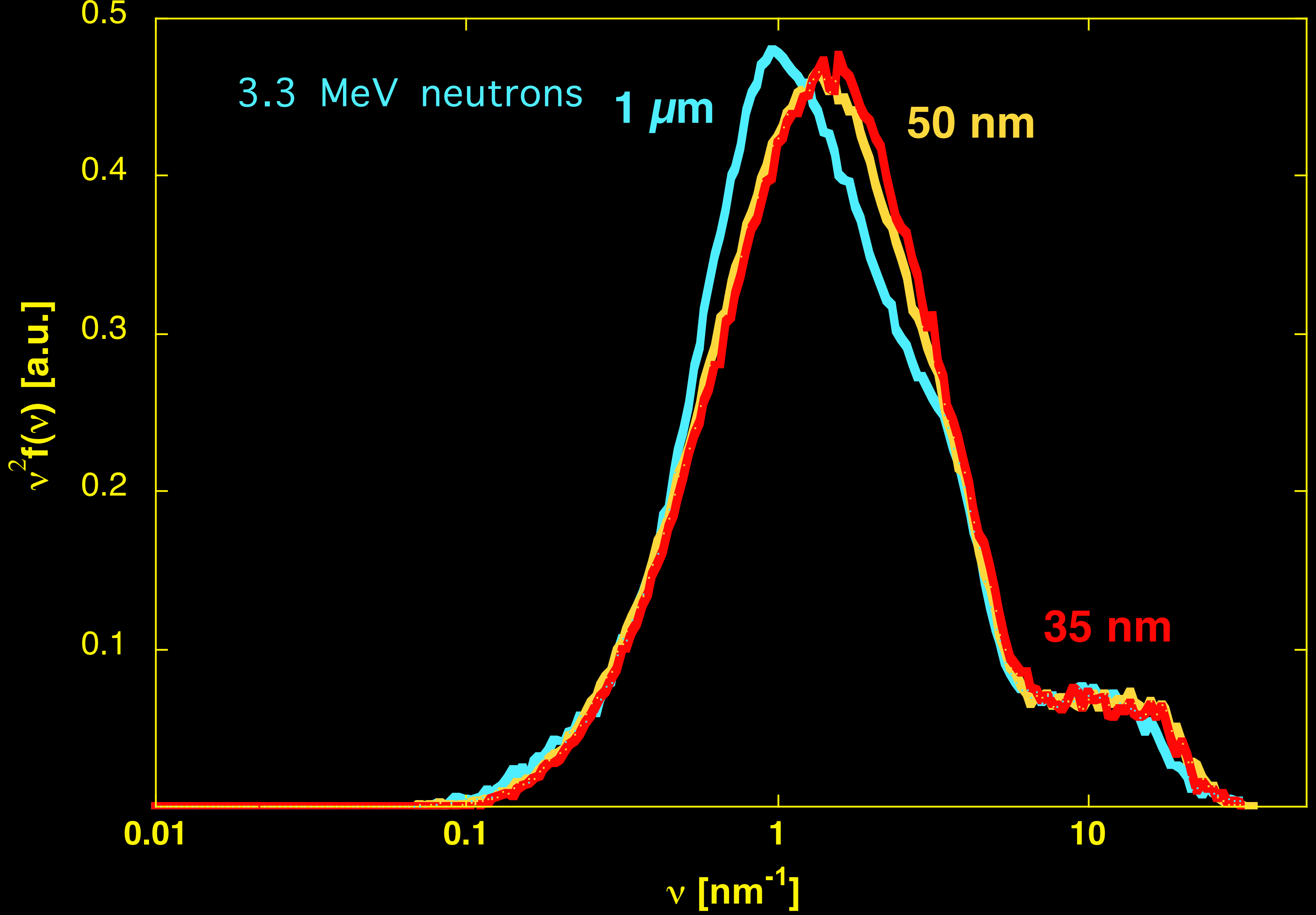


V.Cesari et al. Rad.Prot.Dosim. 99, 337-342, 2002

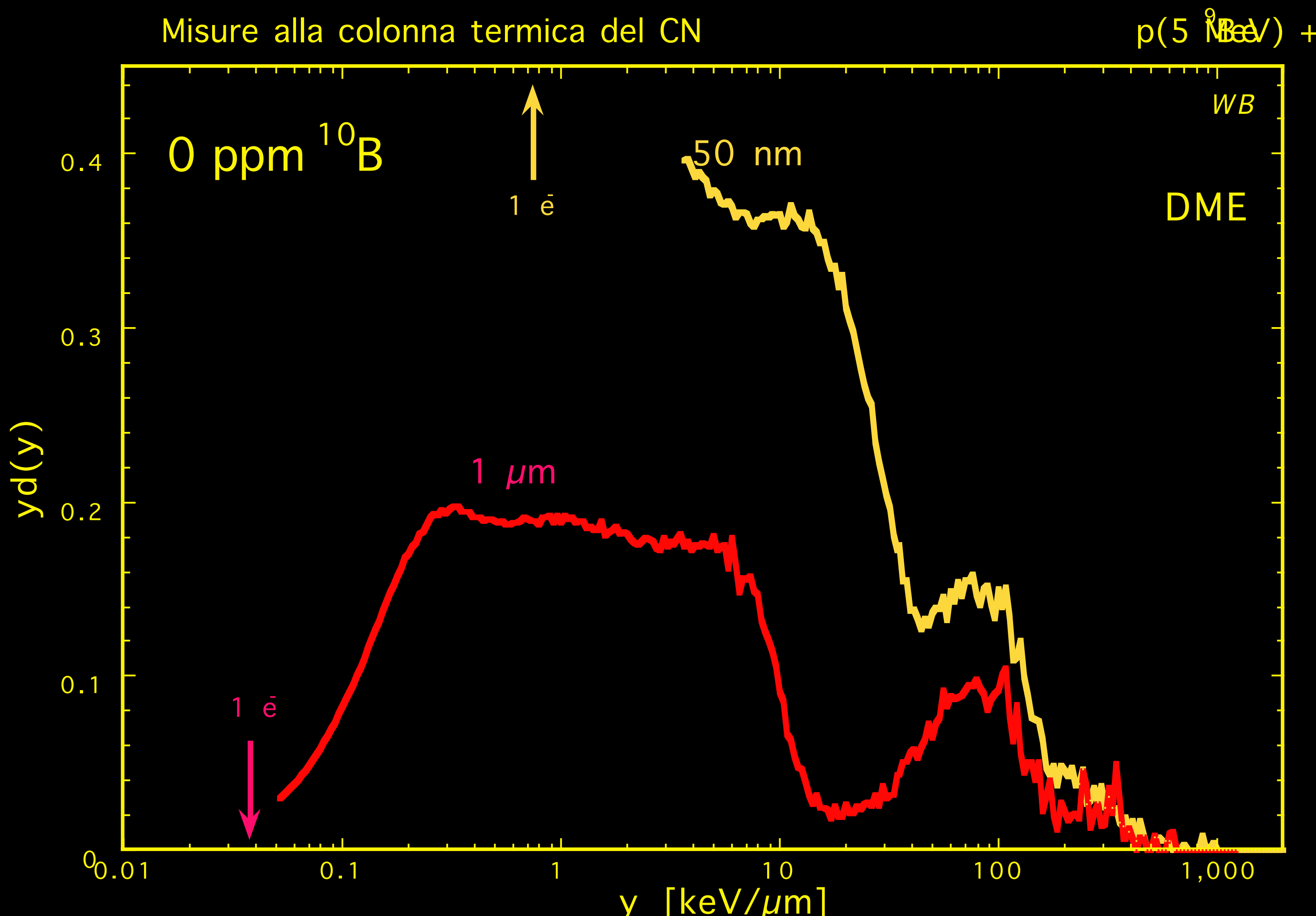
Photon microdosimetric spectra against the average ionisation density at different simulated site sizes



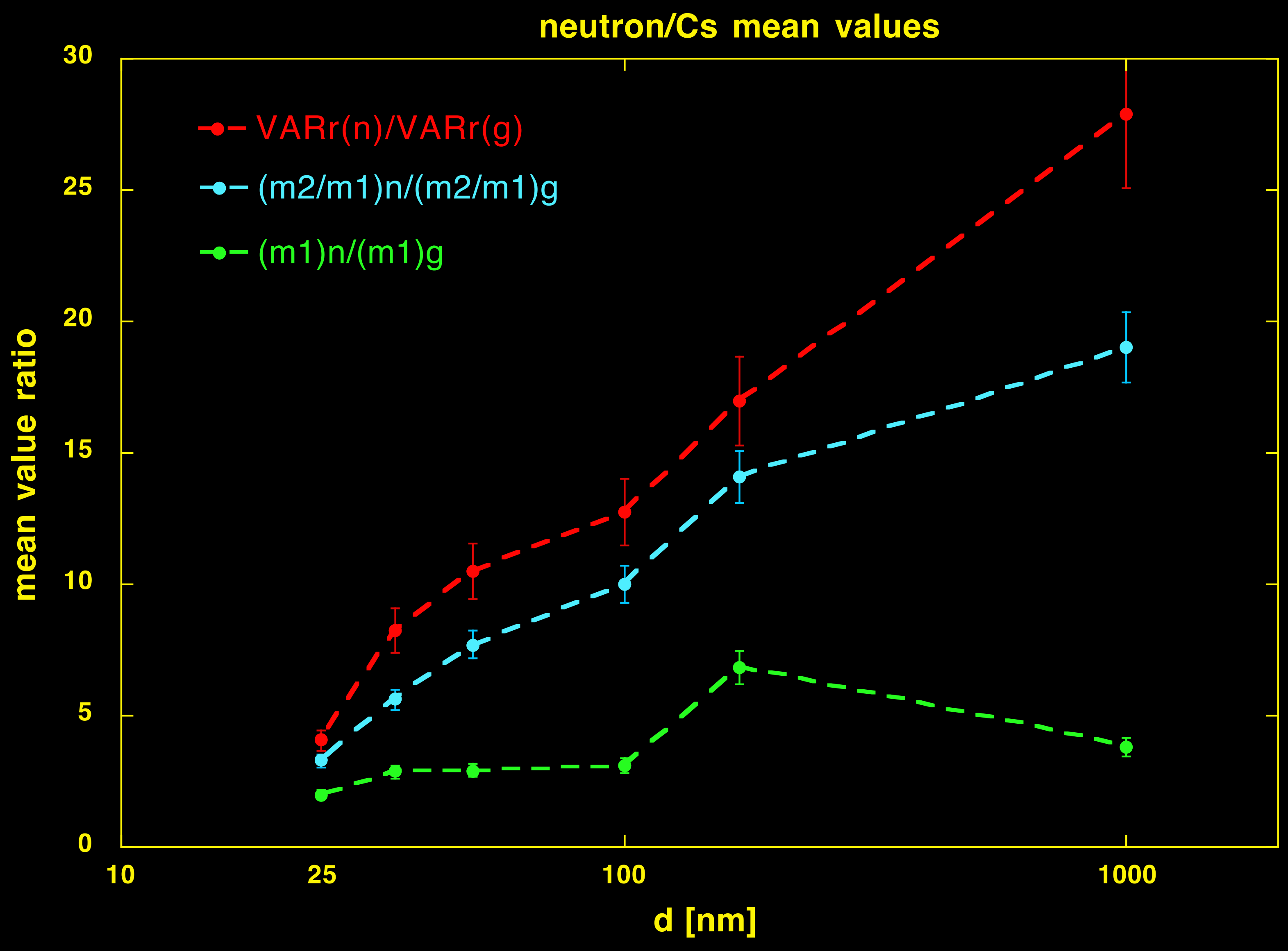
Neutron microdosimetric spectra against the average ionisation density at different simulated site sizes



Neutron microdosimetric spectra against the average ionisation density at different simulated site sizes

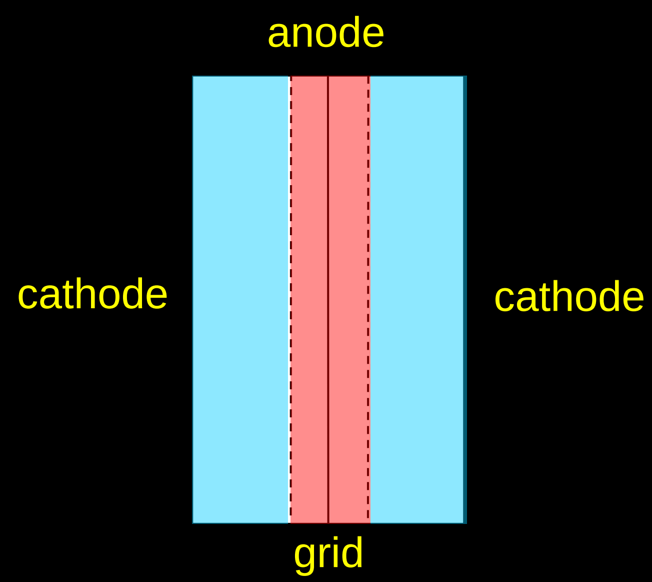


At nanometre diameters mean value ratios approach RBE value



Avalanche-confinement TEPC

Principle of operation: two variables and two parameters



Form factor

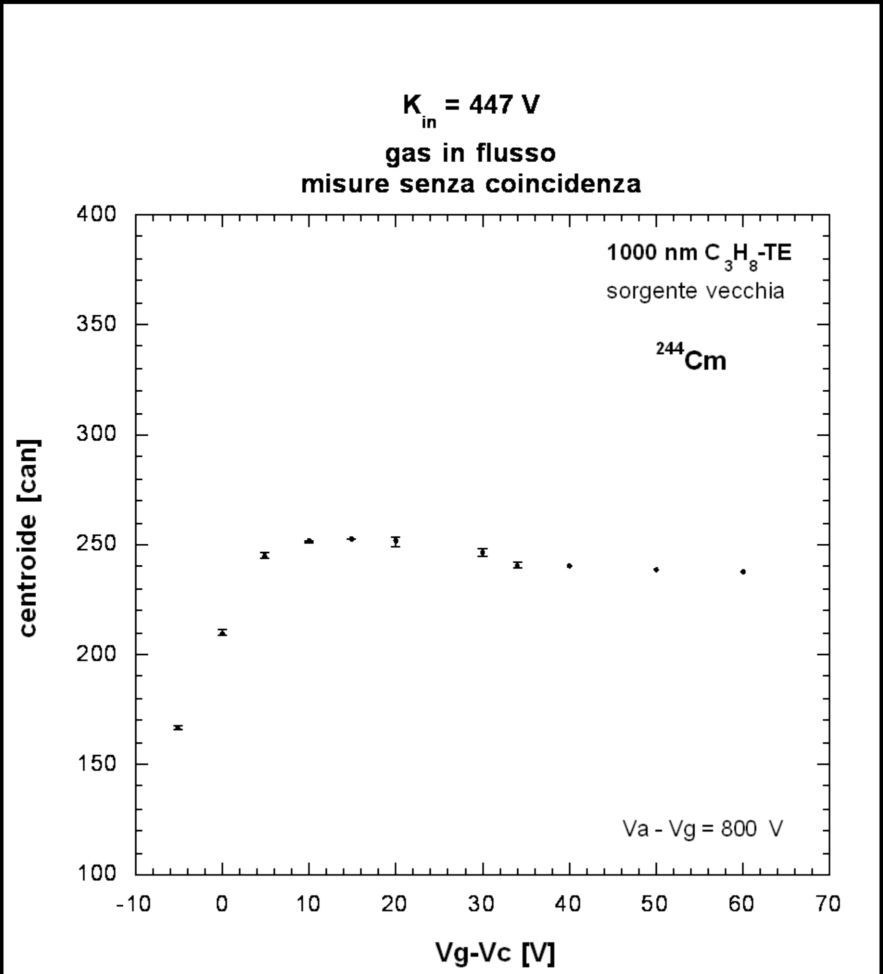
$$K_{in} = \frac{1}{\ln \frac{r_g}{r_a}} \cdot \Delta V_{a-g}$$

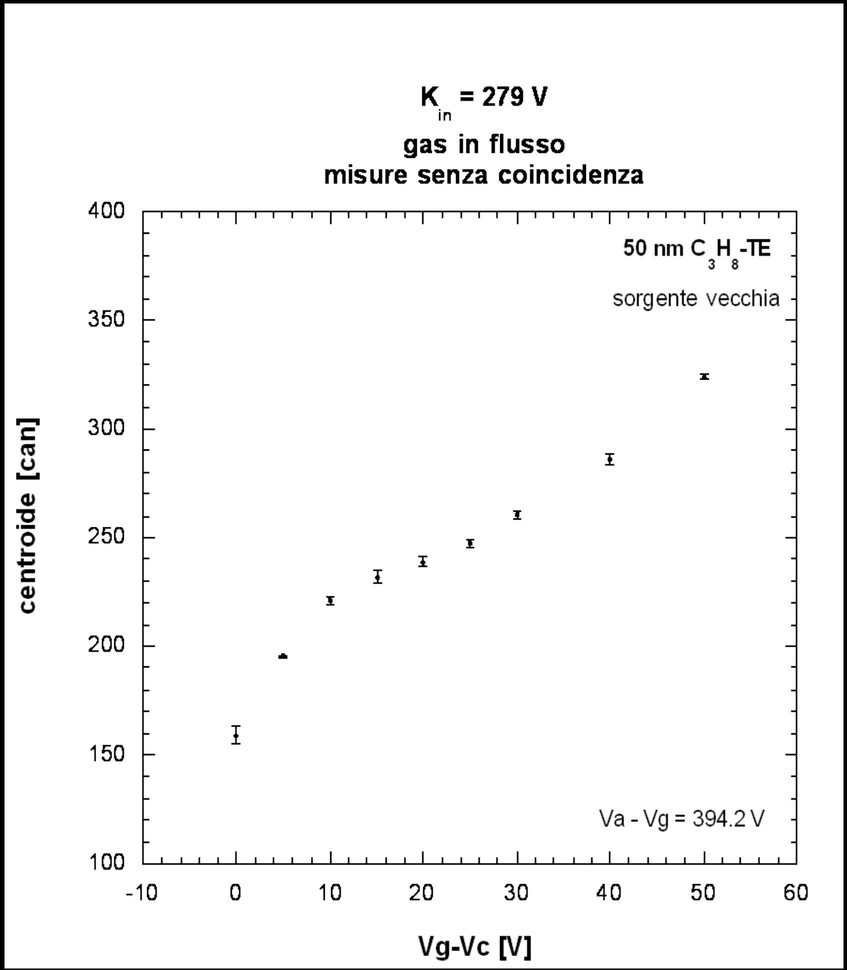
Form factor

$$K_{out} = \frac{1}{\ln \frac{r_c}{r_g}} \cdot \Delta V_{g-c}$$

Avalanche-confinement TEPC

Setting the V_g-V_c values giving a quasi-constant amplitude of the signal from an α source





Avalanche-confinement TEPC

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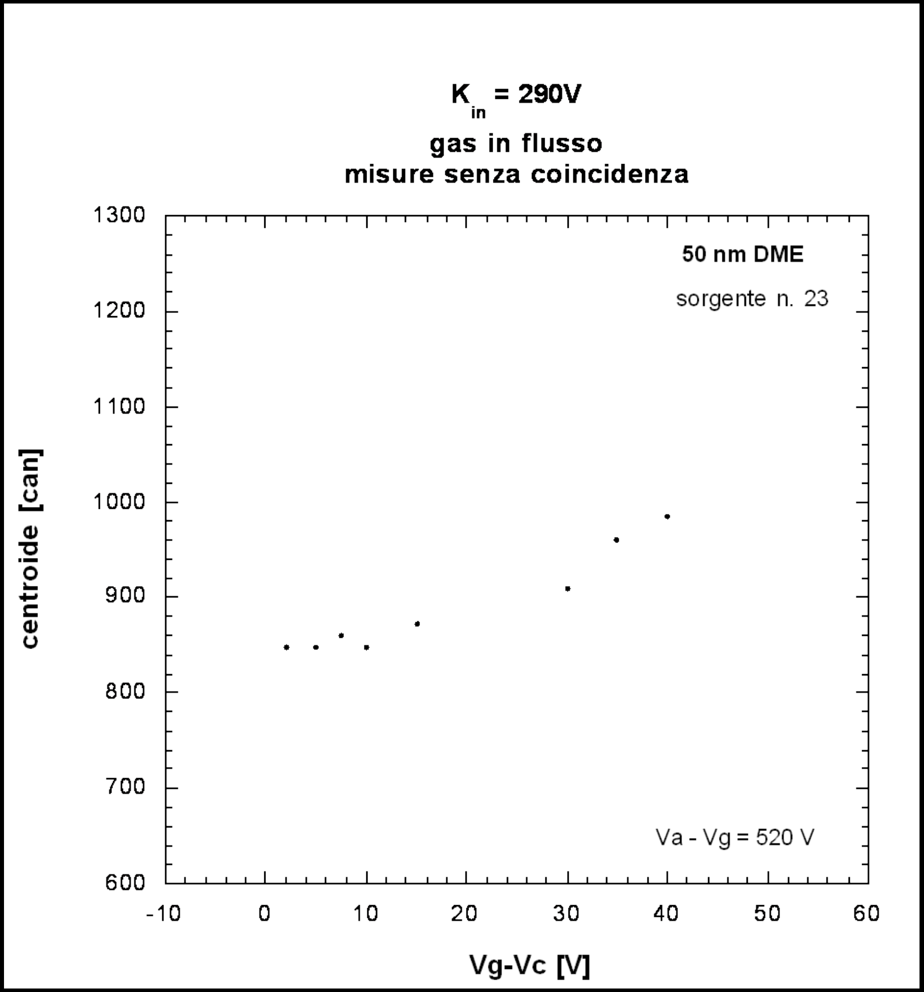
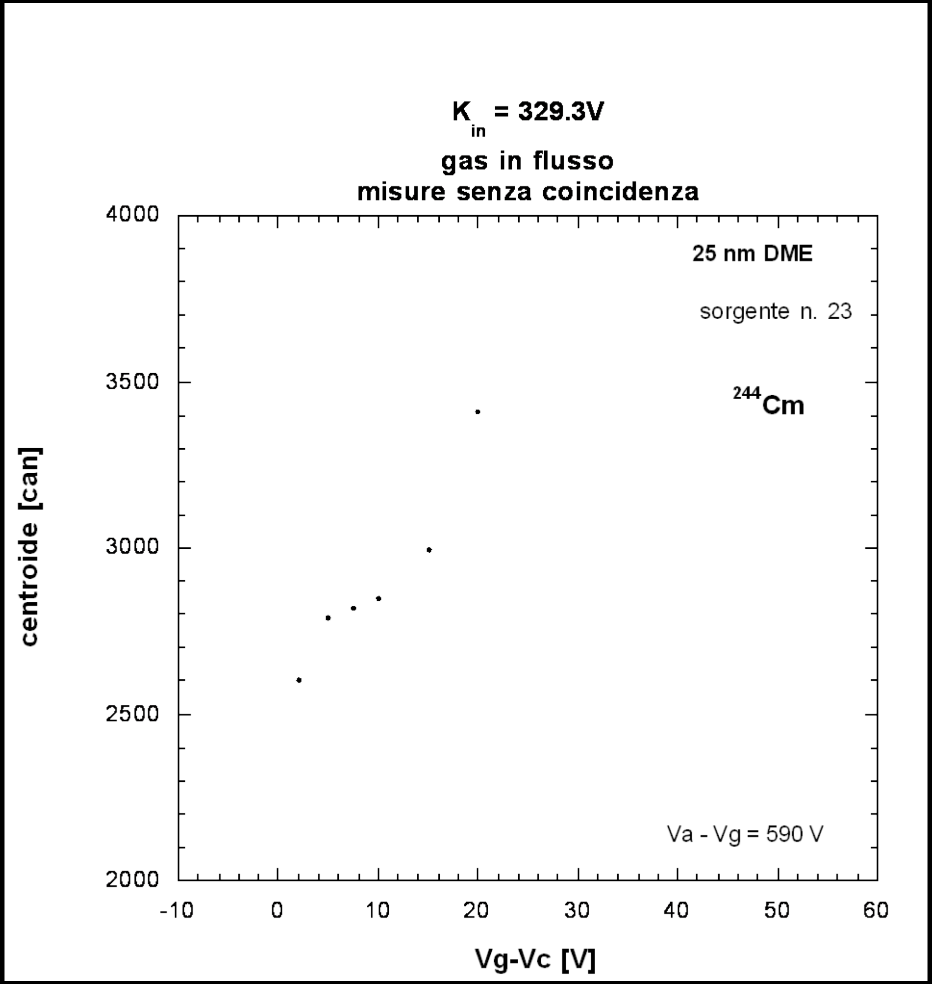
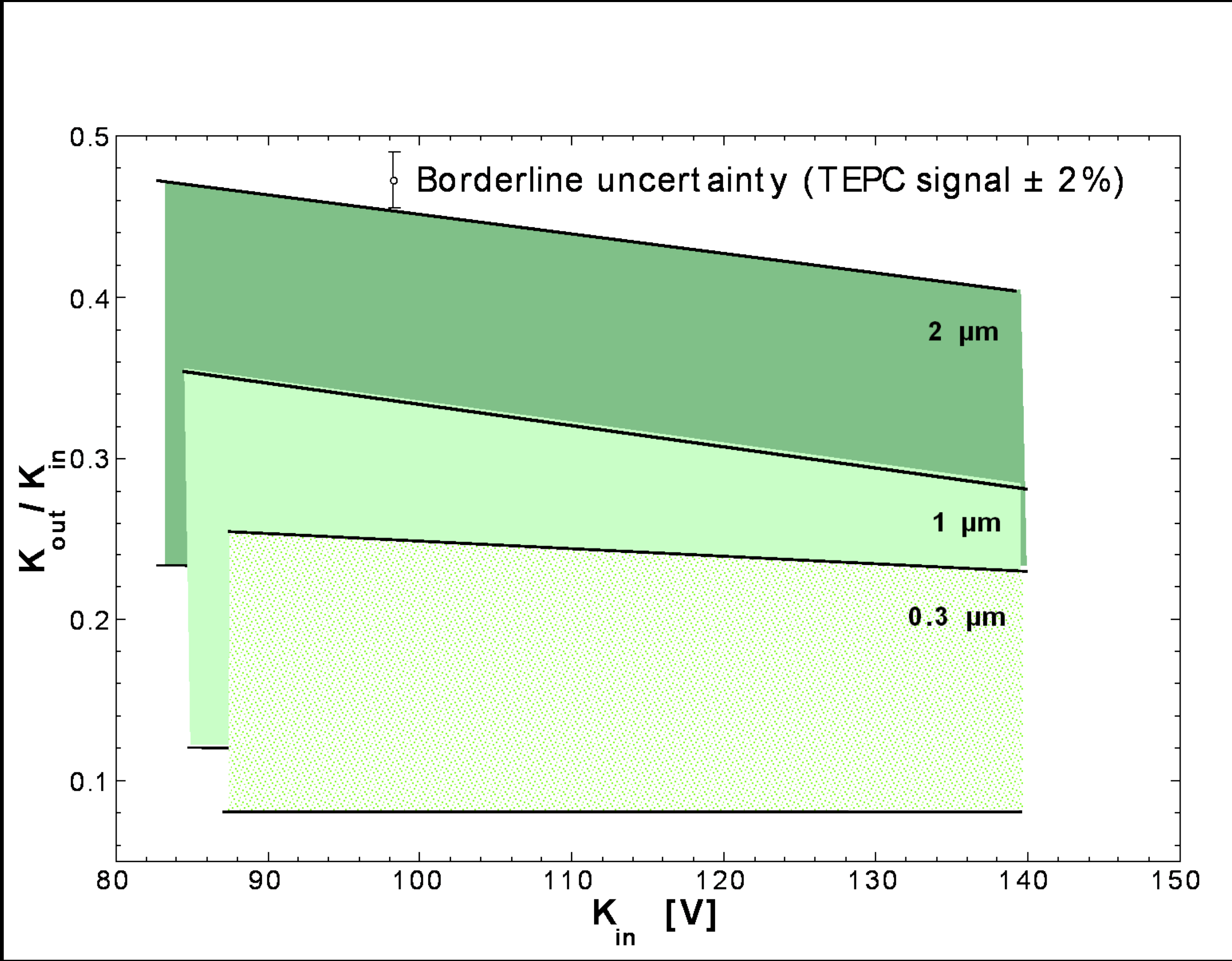




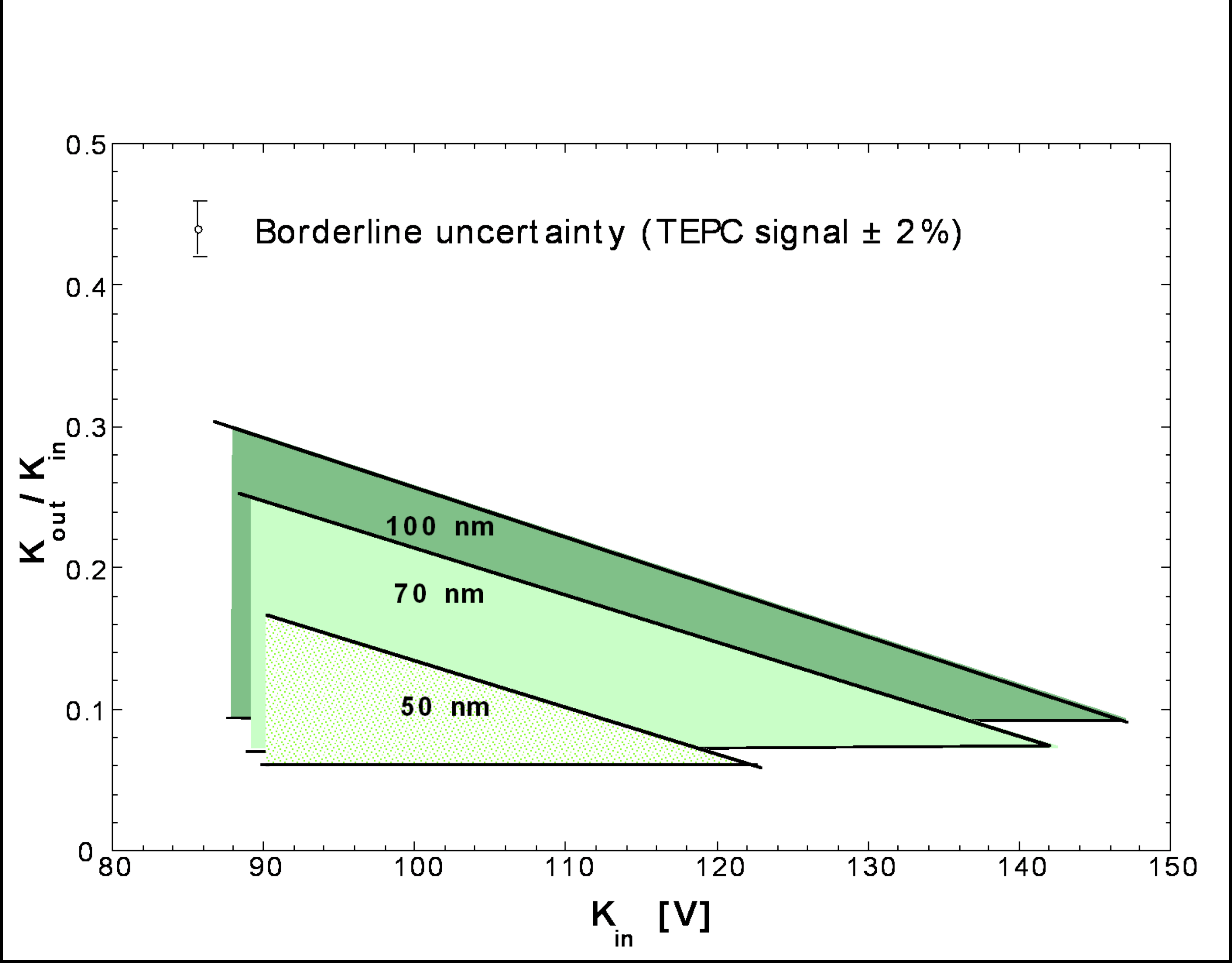
Working window

The avalanche is confined inside the windows



Working window

At low pressure, the window shrinks for high K_{in} values, thus limiting the maximum gain.



Future Research

- A new avalanche confinement TEPC is being constructed. Measurements will be performed in ion beams and results will be analysed on the basis of track-structure properties assessed with LNL track-nanodosimeter.

- Main goals:
- Decrease sensitive site size.
- Develop a portable nanodosimeter