9th Annual Loma Linda Algorithm Workshop
31.07.2023-02.08.2023

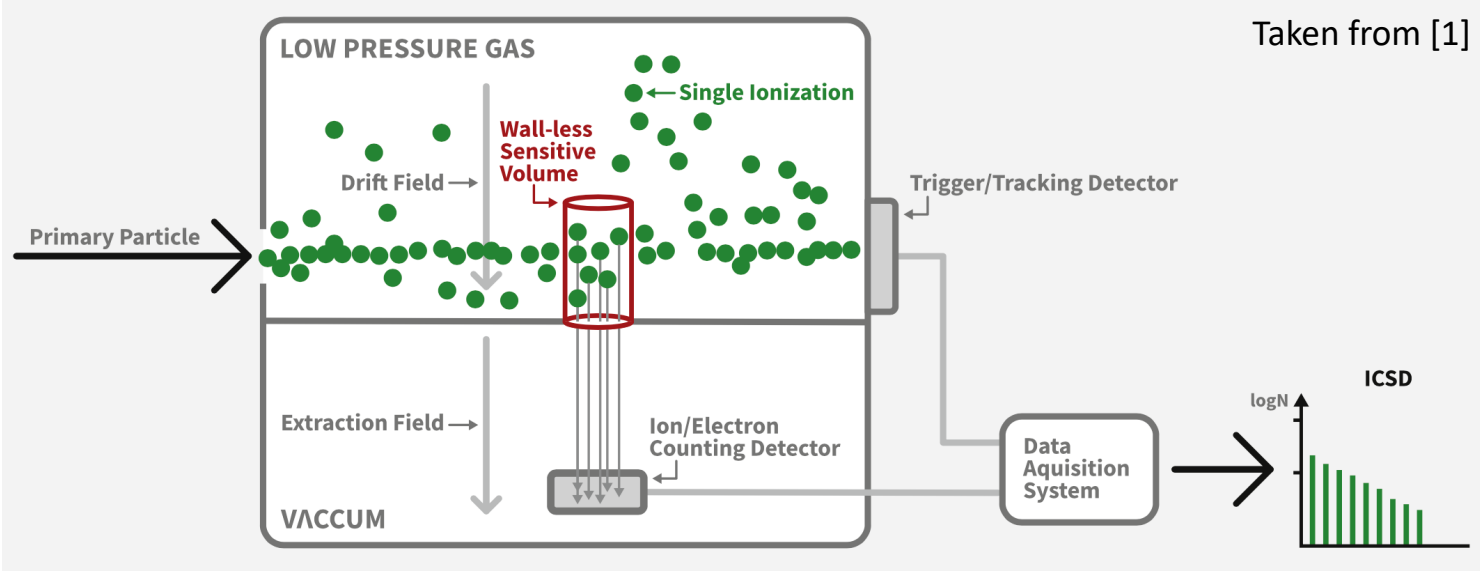
A short introduction to experimental nanodosimetry in the 2020s

Victor Merza
Center of Nuclear Sciences and Technology
Instituto Superior Técnico (University of Lisbon)

Funding: Fundação para a Ciência e a Tecnologia (FCT), research grant PRT/BD/153748/2021.

Nanodosimetry

- Radiation exposure: ionization clusters overlap with DNA → damage
- Cluster sizes and frequencies correlate with biological effectiveness, cancer risk
- Nanodosimeters: measurements in tissue-equivalent gasses with nanometer-equivalent resolution → direct assessment of biological effectiveness

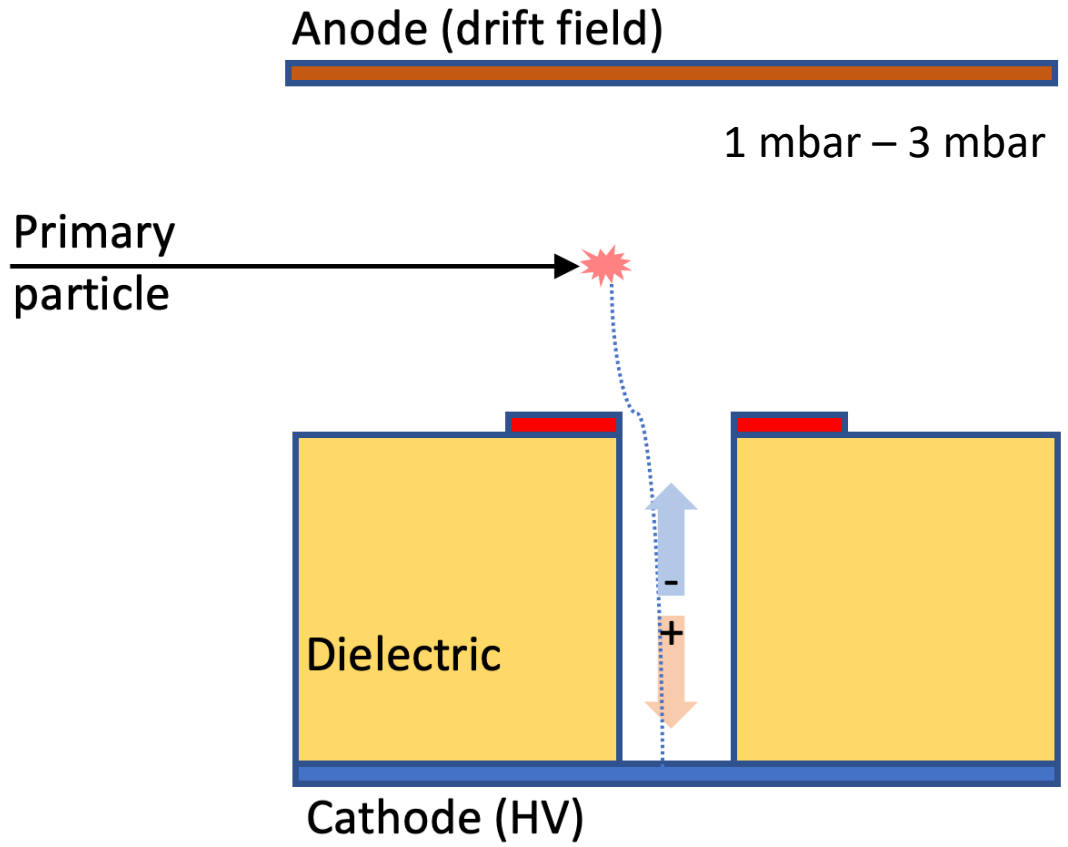


(1-100) nm length, (1-20) nm diameter in low pressure gas

(3.4-7.8) nm DNA segments or 1-2 helical turns

THGEM-based nanodosimeters

- “THGEM”: Thick Gas Electron Multiplier, here: reverse polarity
- Primary particle ionizes gas molecules, extraction of ions from the sensitive volume
- drift & acceleration towards hole
  → impact ionizations of gas molecules
  → charge avalanches
- detection of electron avalanche at the top of the hole
- Pros: compact and portable design possible, high gain
- Cons: low efficiency



Potential future applications of THGEM-based nanodosimeters

- Space dosimetry: wide range of different particles with various energies
- Patient Quality Assurance (QA) in treatment planning systems
- Assessment of low-dose risks (low-fluence radiation fields) in radiation protection

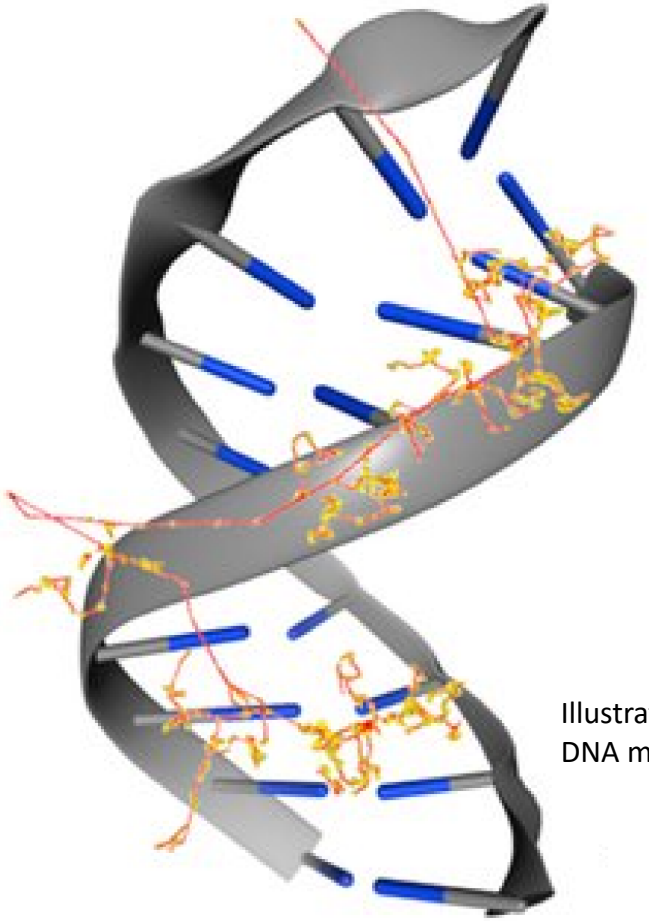


Illustration of energy deposition on a DNA molecule. Taken from [8].

Thank you for your attention!
Thanks for the organisation!

… time for questions,
comments or complaints

Contact:
victor.merza@tecnico.ulisboa.pt

Literature

[1] Rucinski A et al 2021 Applications of nanodosimetry in particle therapy planning and beyond *Phys. Med. Biol.* **66** 24TR01
[2] Brenner D.J. and Ward J.F. 1992 Constraints on energy deposition and target size of multiply damaged sites associated with DNA double-strand breaks *Int. J. Radiat. Biol.* **61** 737e748
[3] V.A. Bashkirov, R.F. Hurley, R.W. Schulte 2009 A Novel Detector for 2D Ion Detection in Low-Pressure Gas and its Applications, *IEEE Nuclear Science Symposium Conference Record (NSS/MIC)*, pp. 694-698
[4] Casiraghi M, Bashkirov V, Hurley F and Schulte R 2014 A novel approach to study radiation track structure with nanometer-equivalent resolution *Eur. Phys. J. D* **68**: 111
[5] M. Casiraghi, V.A. Bashkirov, R.F. Hurley, R.W. Schulte 2015 Characterisation of a track structure imaging detector, *Radiat. Prot. Dosim.* 166 223–7
[6] F. Vasi, M. Casiraghi, V. Bashkirov, U. Giesen, R.W. Schulte 2016 Development of a single ion detector for radiation track structure studies, *J. Instrum.* 11 C09021–09021
[7] Vasi F et al 2016 Development of a single ion detector for radiation track structure studies *JINST* **11** C09021
[8] Chatzipapas K et al 2020 Ionizing Radiation and Complex DNA Damage: Quantifying the Radiobiological Damage Using Monte Carlo Simulations *Cancers* 12(4):799