MICRODOSIMETRY OF LOW DOSE RADIATION FIELDS IN THE FRAMEWORK OF THE DISCOVER22 PROJECT

A. Bianchi[1], A. Selva[1], P. Morciano[2,3], G. Baiocco[4,5], V. Dini[6,7], A. Sgura[8,9], V. Conte[1]

[1]Laboratori Nazionali di Legnaro (INFN), Legnaro (PD), Italy, [2]Laboratori Nazionali del Gran Sasso (INFN), Assergi (AQ), Italy, [3]Dipartimento di Medicina clinica, sanità pubblica, scienze della vita e dell'ambiente, Università degli Studi dell'Aquila, L'Aquila, Italy, [4]Dipartimento di Fisica, Università degli Studi di Pavia, Pavia, Italy, [5]INFN Pavia, Pavia, Italy, [6]Centro Nazionale di Tecnologie Innovative in Sanità Pubblica, Istituto Superiore di Sanità, Rome, Italy, [7]INFN, Sezione di Roma1, Rome, Italy, [8]Dipartimento di Scienze, Università degli Studi Roma Tre, Rome, Italy, [9]INFN, Sezione di Roma3, Rome, Italy

INFN LNL
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

Absorbed dose and its limits...

$$D = \frac{\Delta E}{\Delta m}$$

ΔE: energy deposited in a volume of matter
Δm: mass of that volume

Unit: **gray [Gy]**

$$1\ \mathrm{Gy} = 1\ \frac{\mathrm{J}}{\mathrm{kg}} = 0.00024\ \frac{\mathrm{kcal}}{\mathrm{kg}}$$

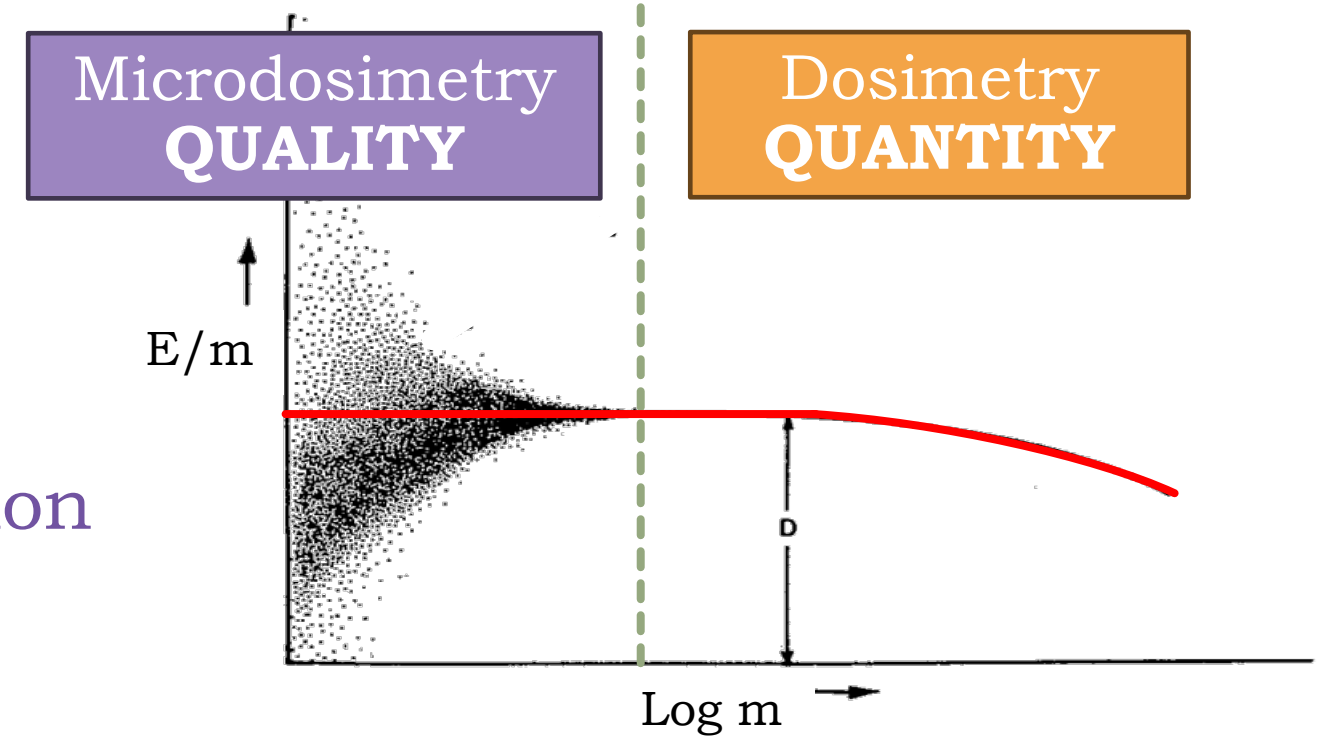
Considering a person weighting 80 kg:
10 Gy absorbed dose (lethal) -> 0.2 kcal absorbed energy

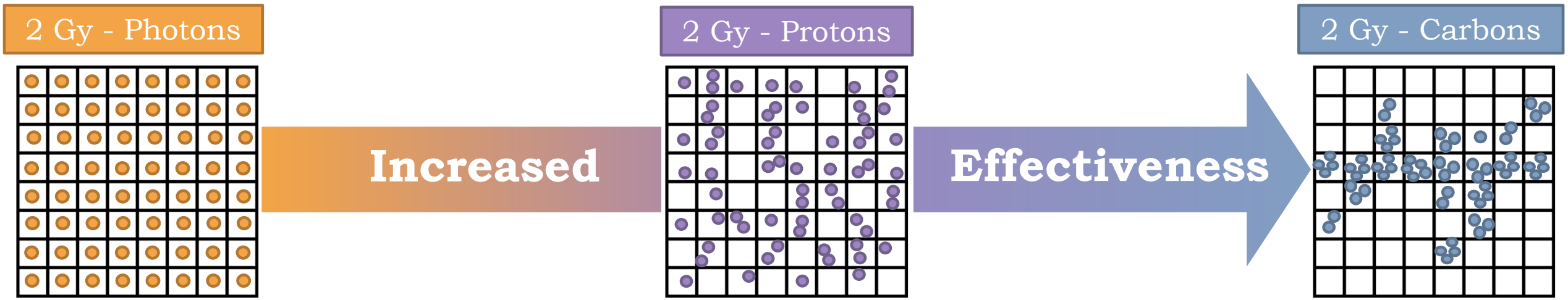
The (macroscopic) energy release in matter is not enough to understand radiation damage

...Microdosimetry

What is microdosimetry?

- Stochastic of energy deposition process event by event





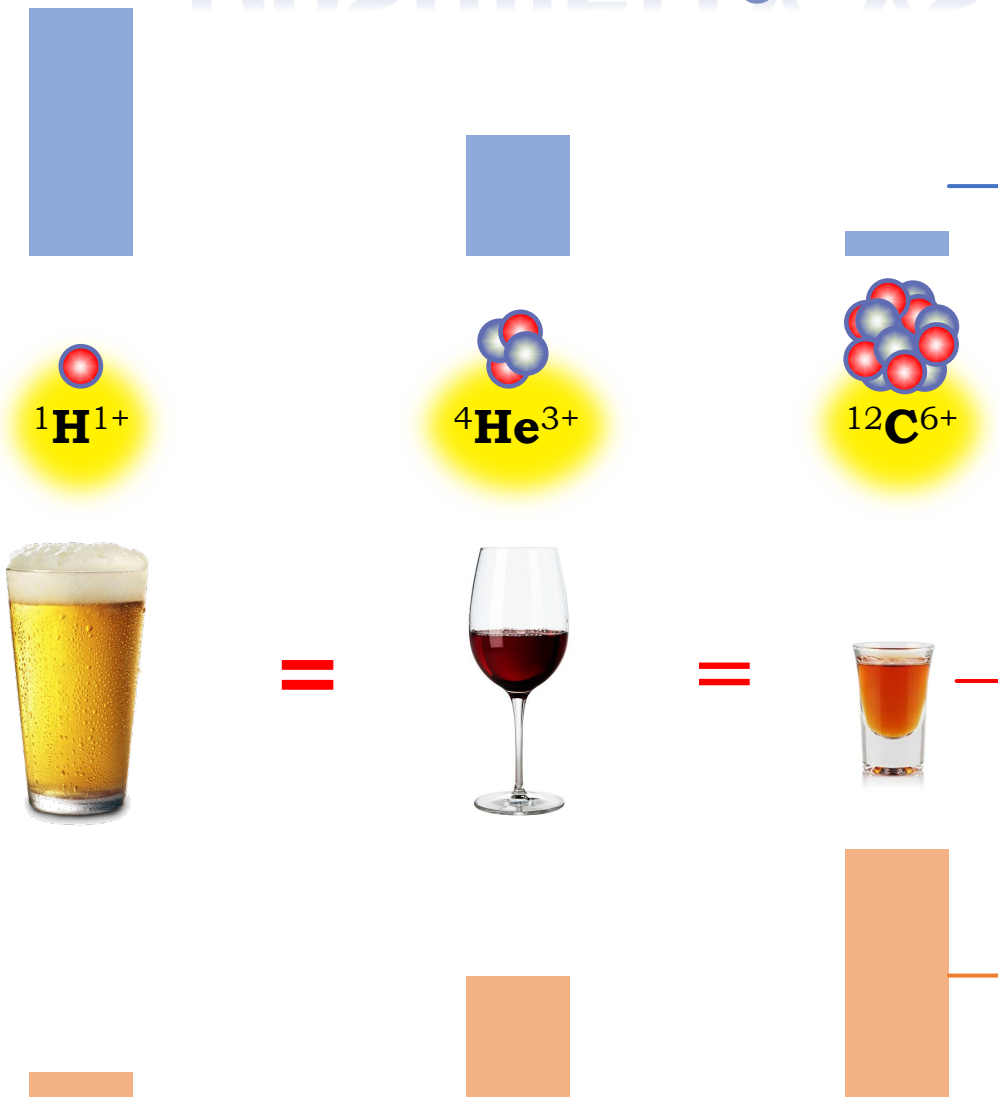
Dosimetry vs Microdosimetry

Dosimetry: volume

Microdosimetry: alcoholic concentration

Biological effect: alcohol content

Dosimetry vs Microdosimetry



The **absorbed dose**

$$D = \frac{\bar{\varepsilon}}{m}$$

Measures the quantity of radiation (drink volume)

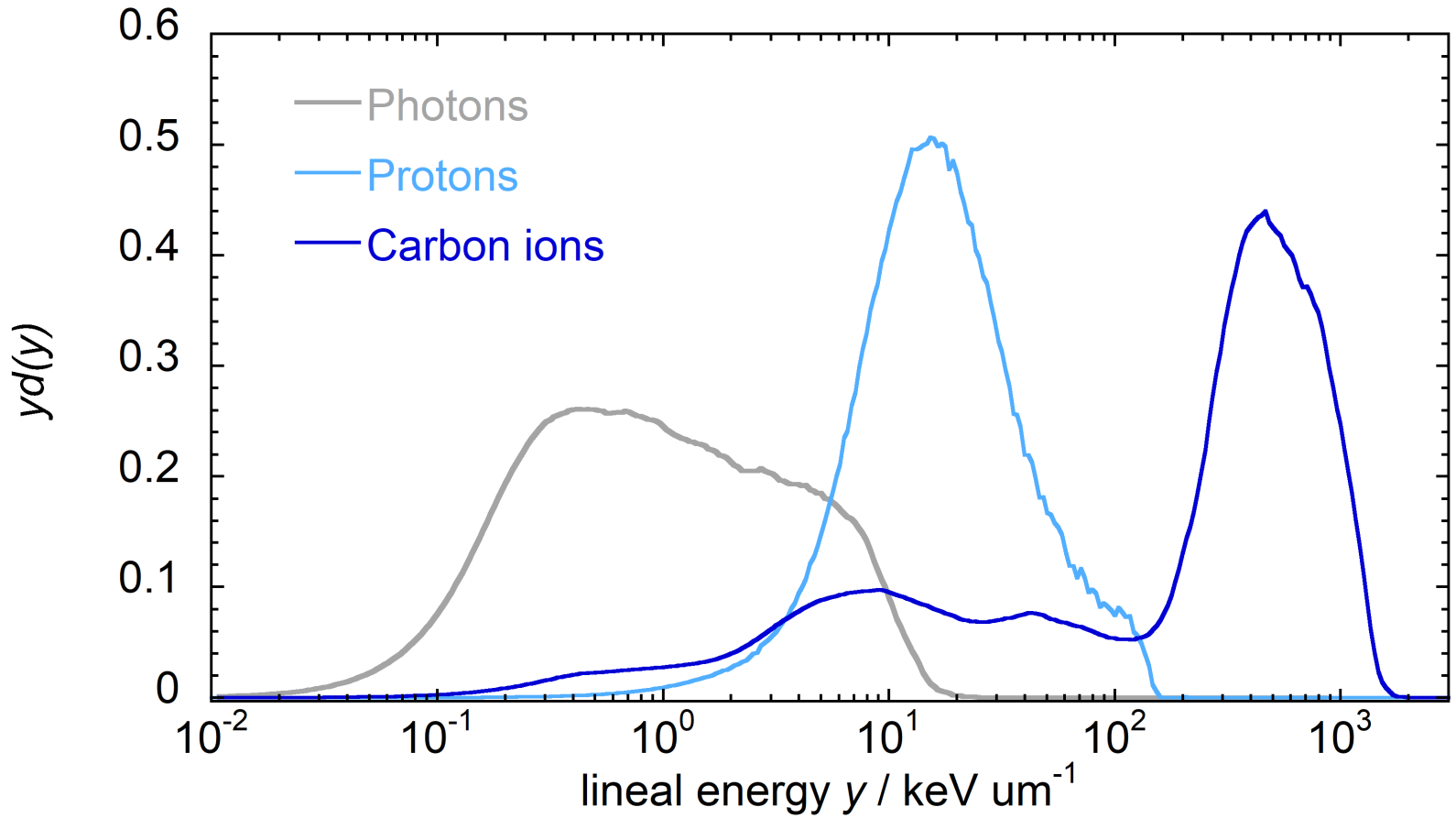
Equal biological effect (alcohol content)

The **lineal energy**

$$y = \frac{\varepsilon_1}{\bar{l}}$$

$f(y)$ + $d(y)$

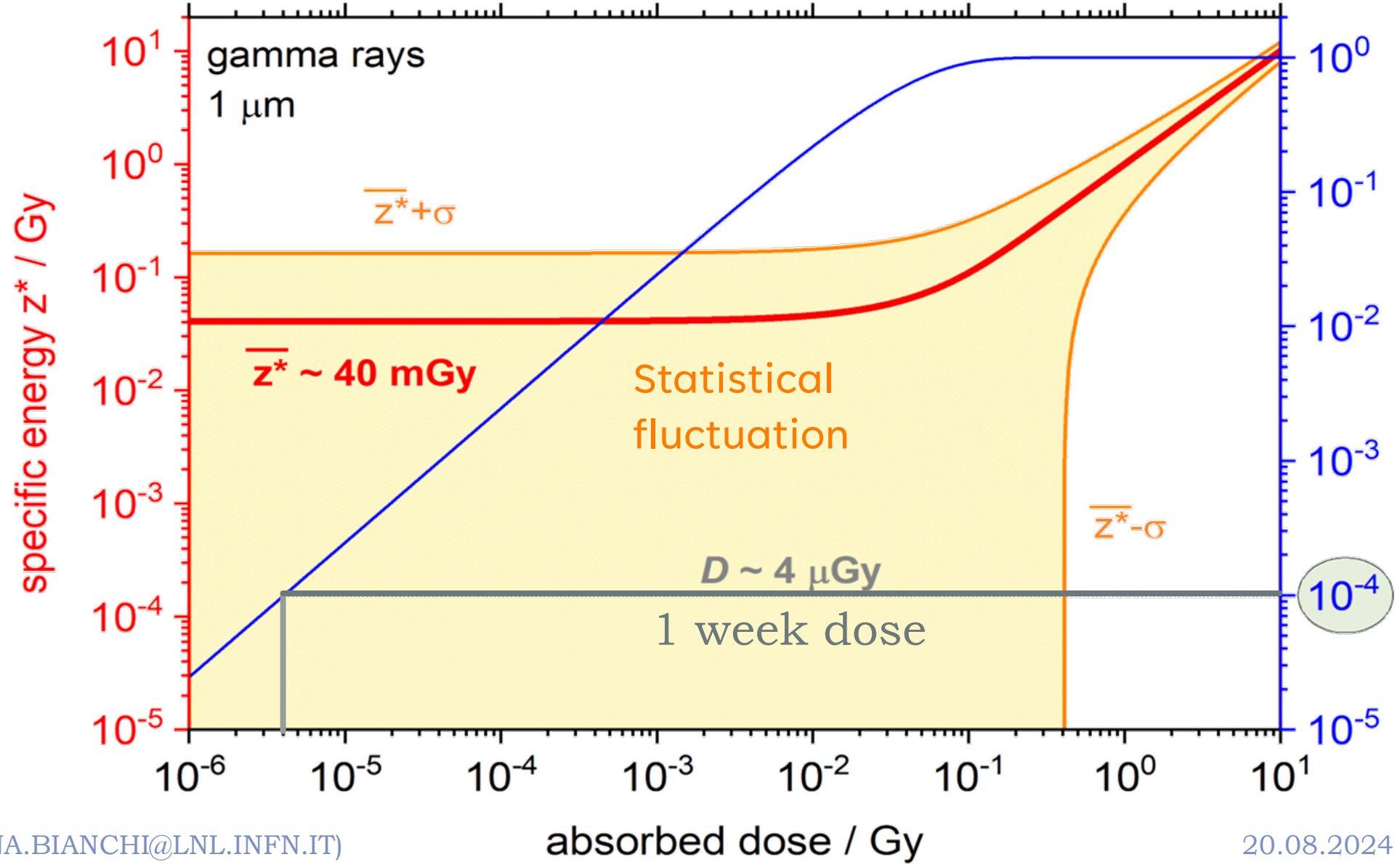
Measures the radiation quality (alcoholic concentration)



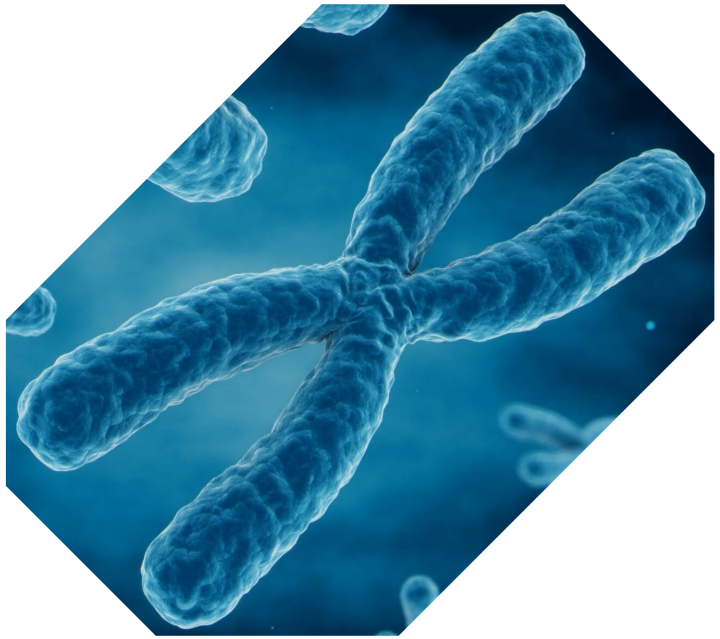
Increase in the radiation effectiveness

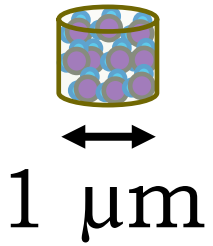
Stochastic is important at low doses!

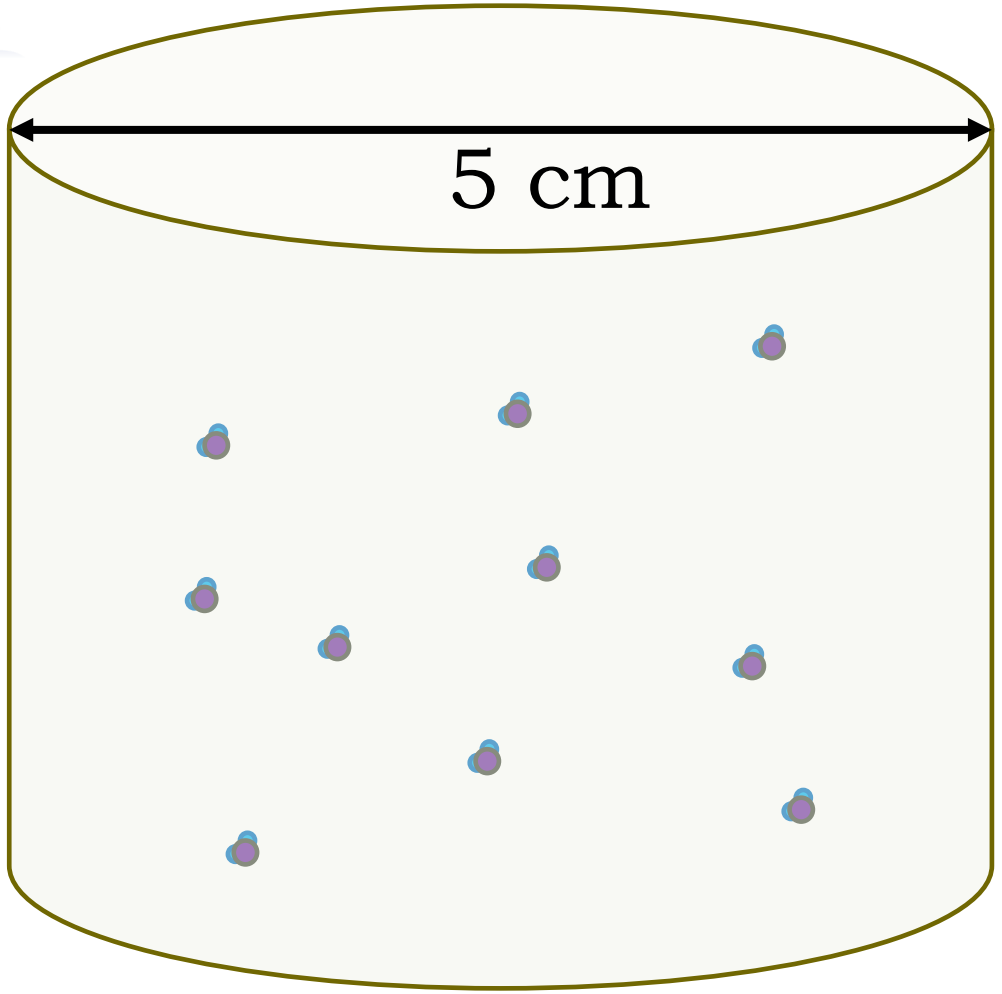
$$z = \frac{\varepsilon}{m}$$



How do we measure in micrometric sites?

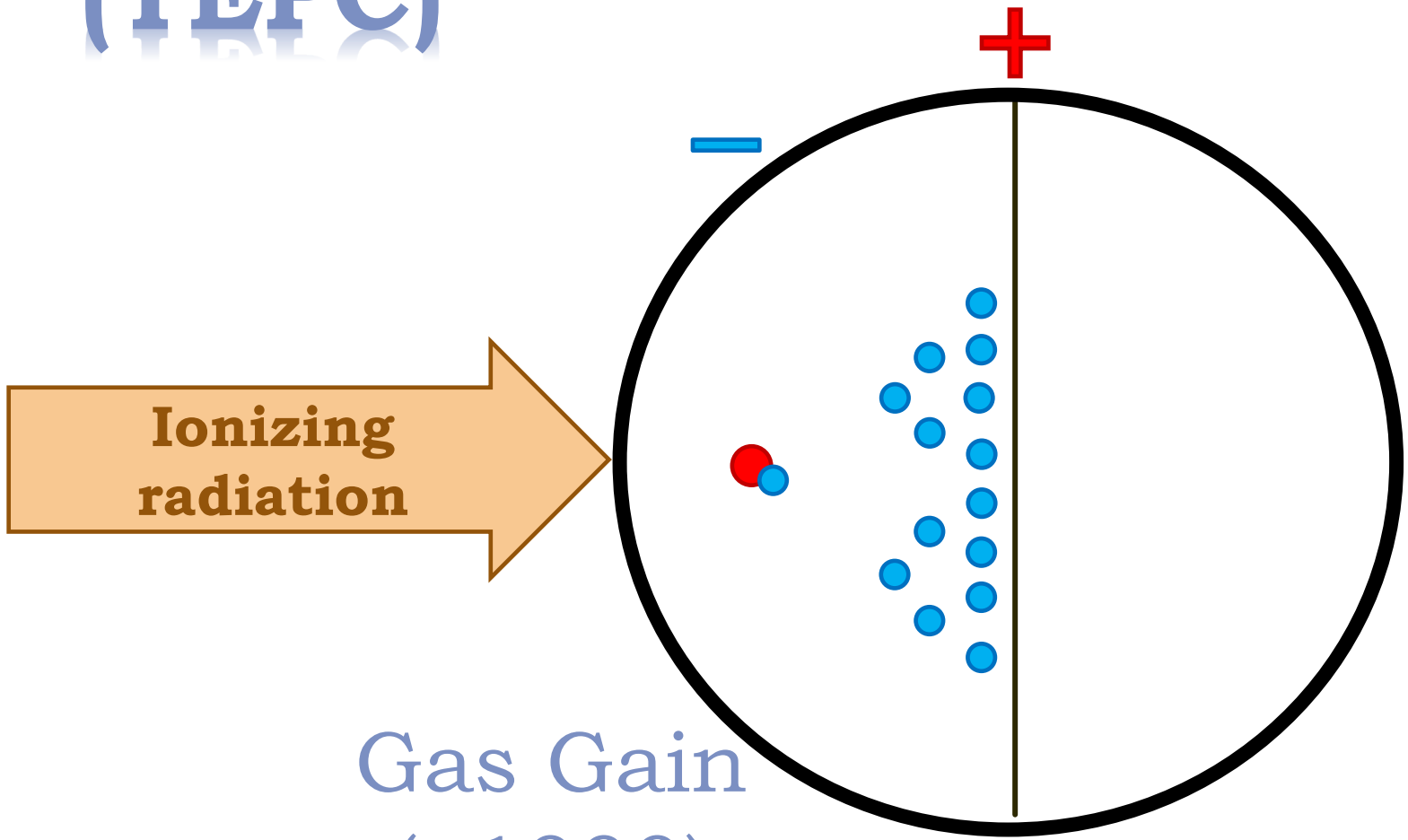






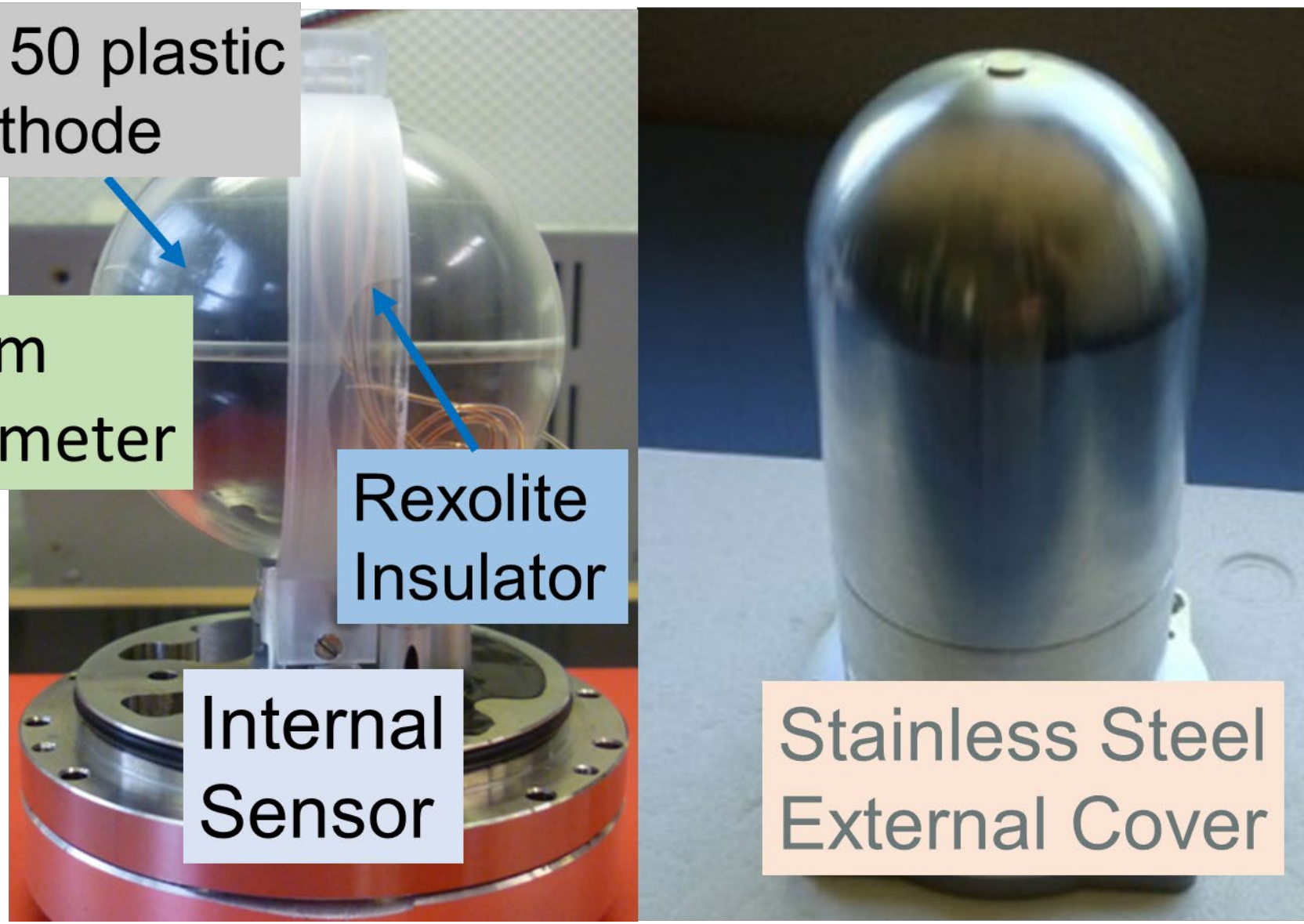
Tissue Equivalent Proportional Counters (TEPC)

Spherical configuration ensures isotropic response



Gas Gain (>1000)

The EuTEPC



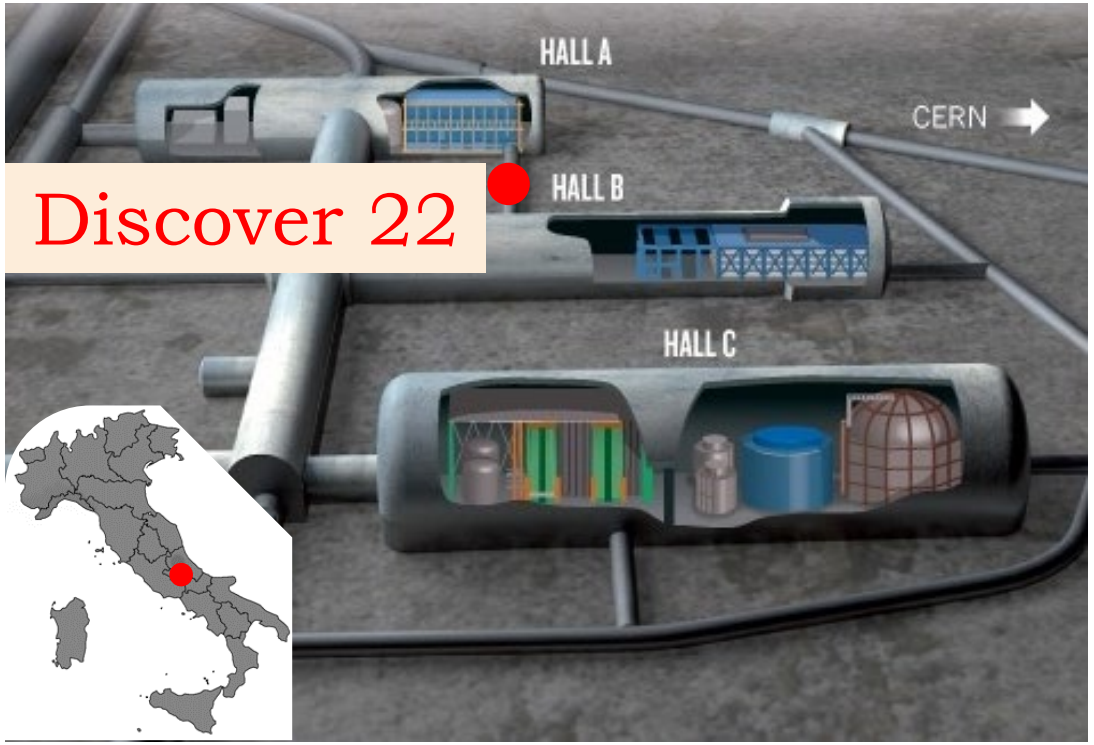
Filled with pure propane

DISCOVER22

DNA Damage and Immune System COoperation in VEry low Radiation environment

Where?

Gran Sasso underground laboratory



Why?

- Radiation Reduced Environment

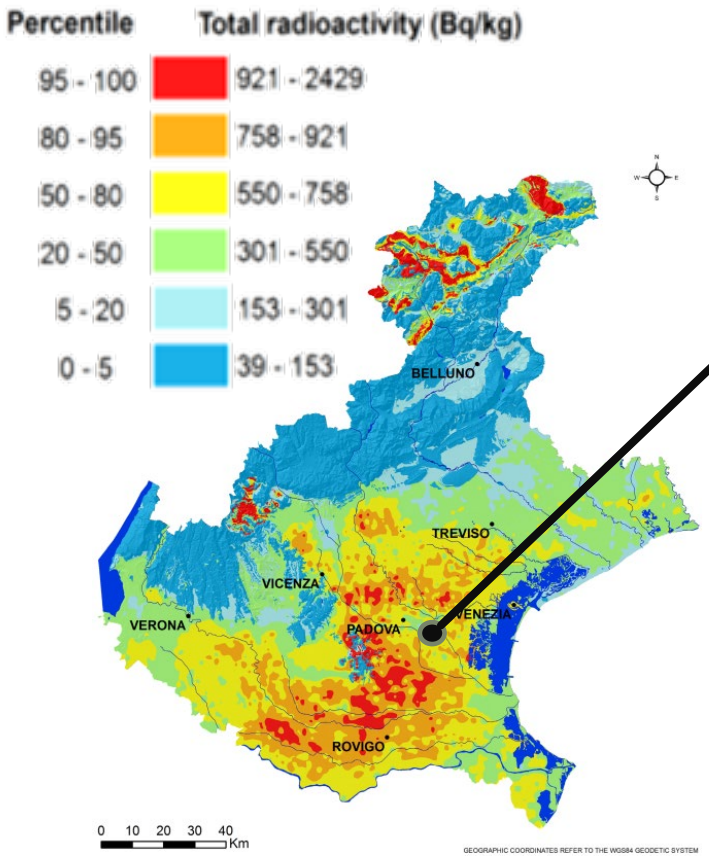
	Gamma dose (nSv/h)	Total Dose (nSv/h)
External Laboratory	31.6	67.0
Underground laboratory	24.7	28.1

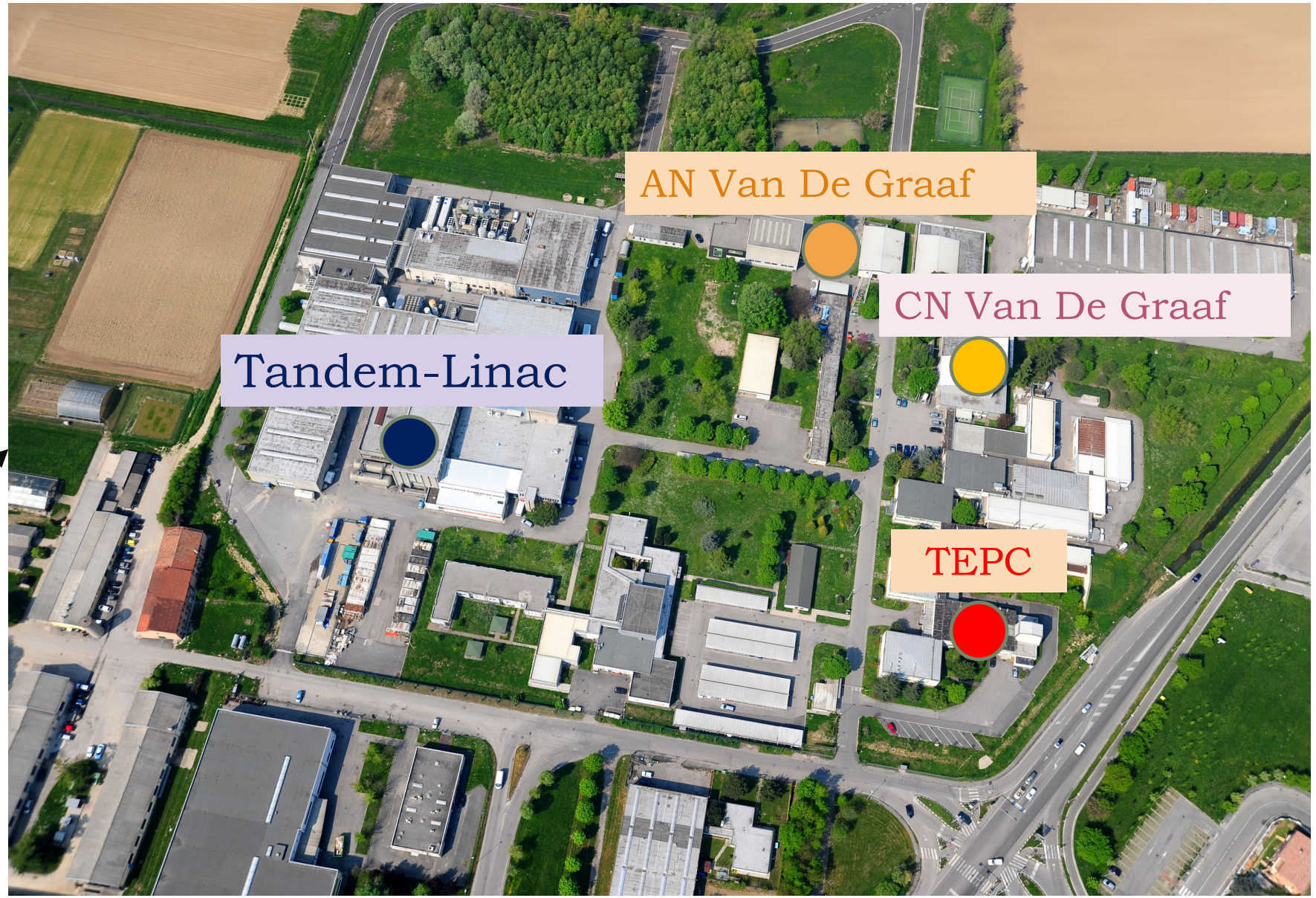
- Variability of the radiation field

How?

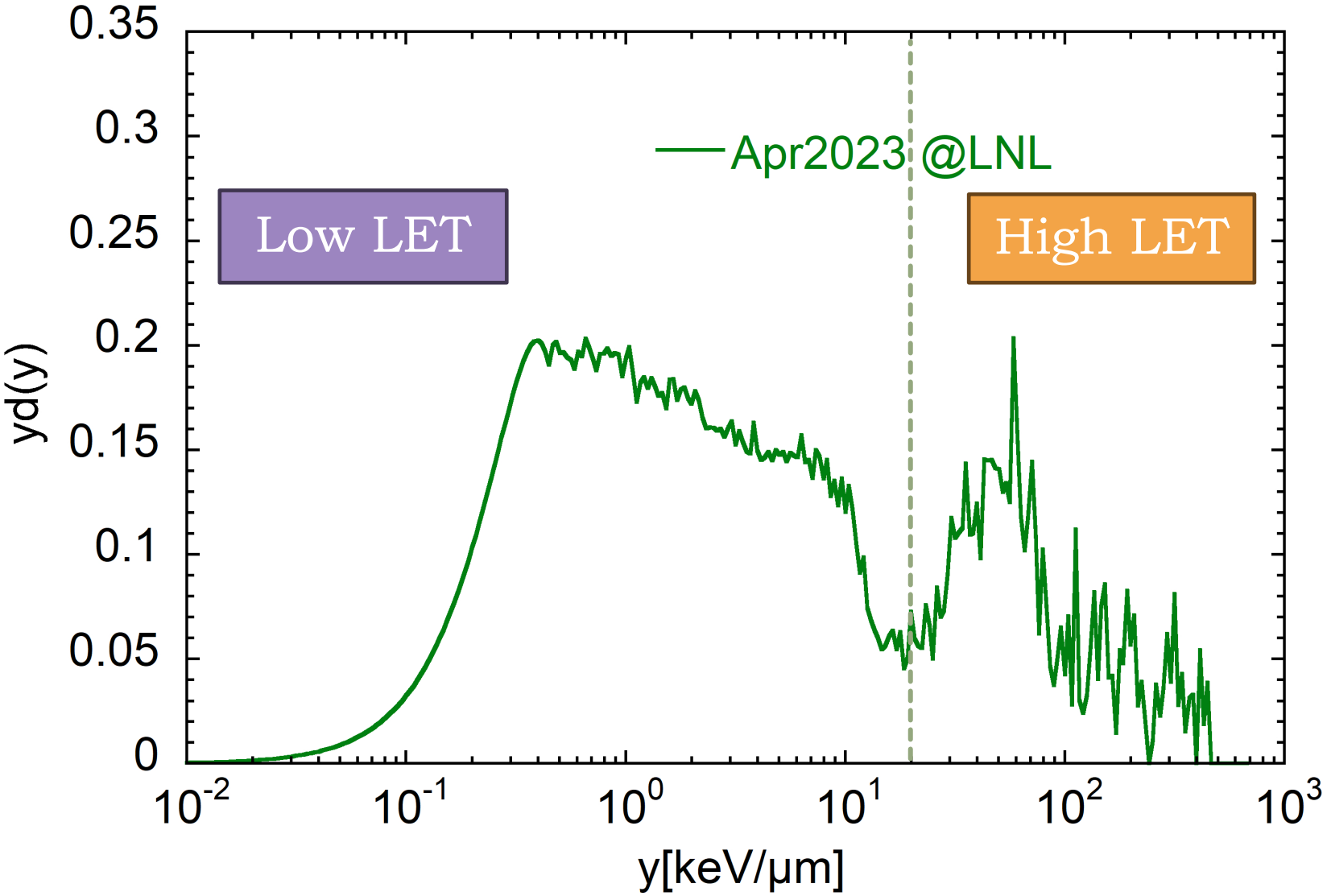
Microdosimetric Monitoring

Background @LNL





April 2023 @LNL



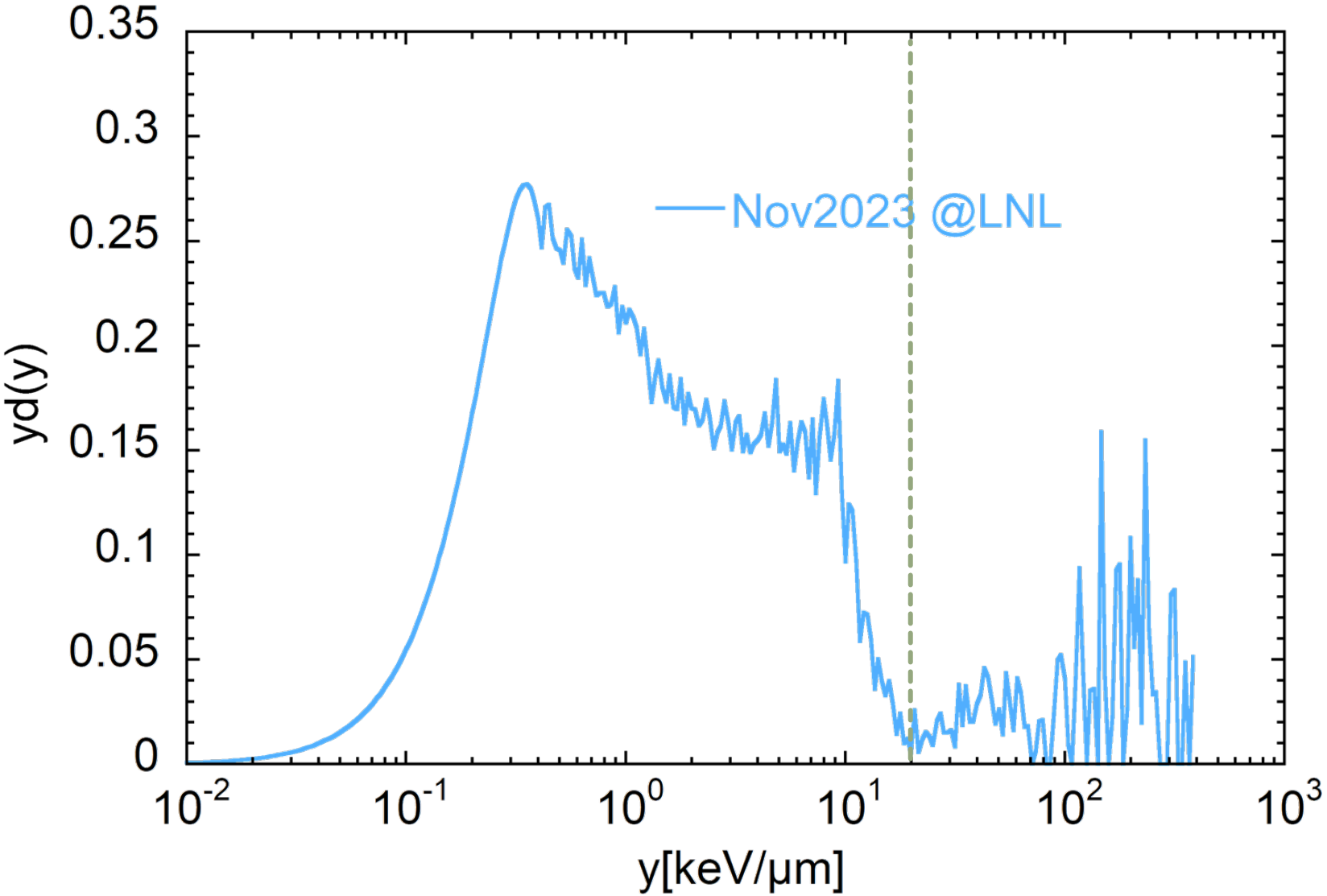
$\bar{y}_F = 0.69 \pm 0.05$

$\bar{y}_D = 24 \pm 1$

High LET fraction: 23%

RBE_μ = 1.52

November 2023 @LNL



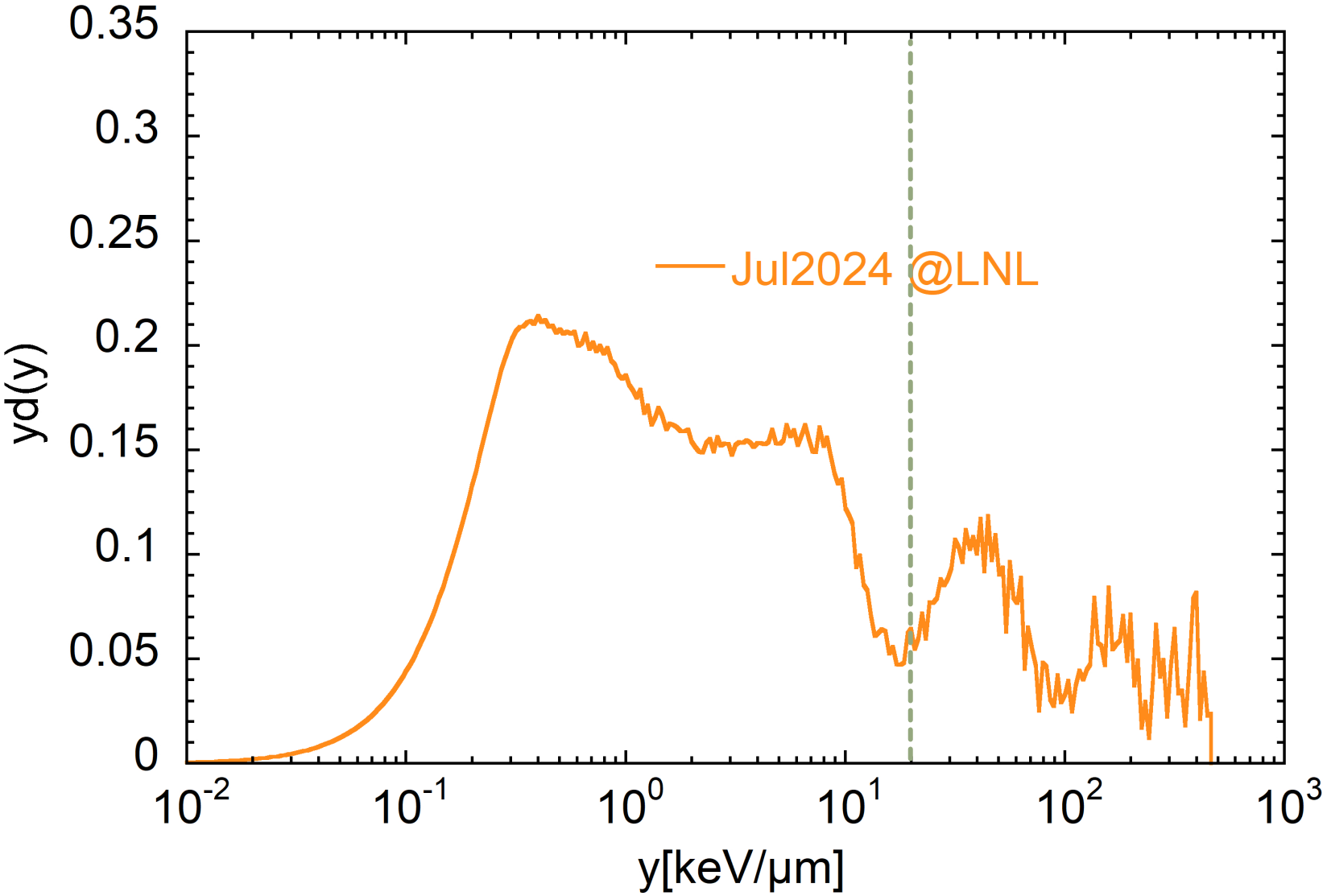
$\bar{y}_F = 0.47 \pm 0.03$

$\bar{y}_D = 15.8 \pm 0.8$

High LET fraction: 9.5%

RBE_μ = 1.18

July 2024 @LNL



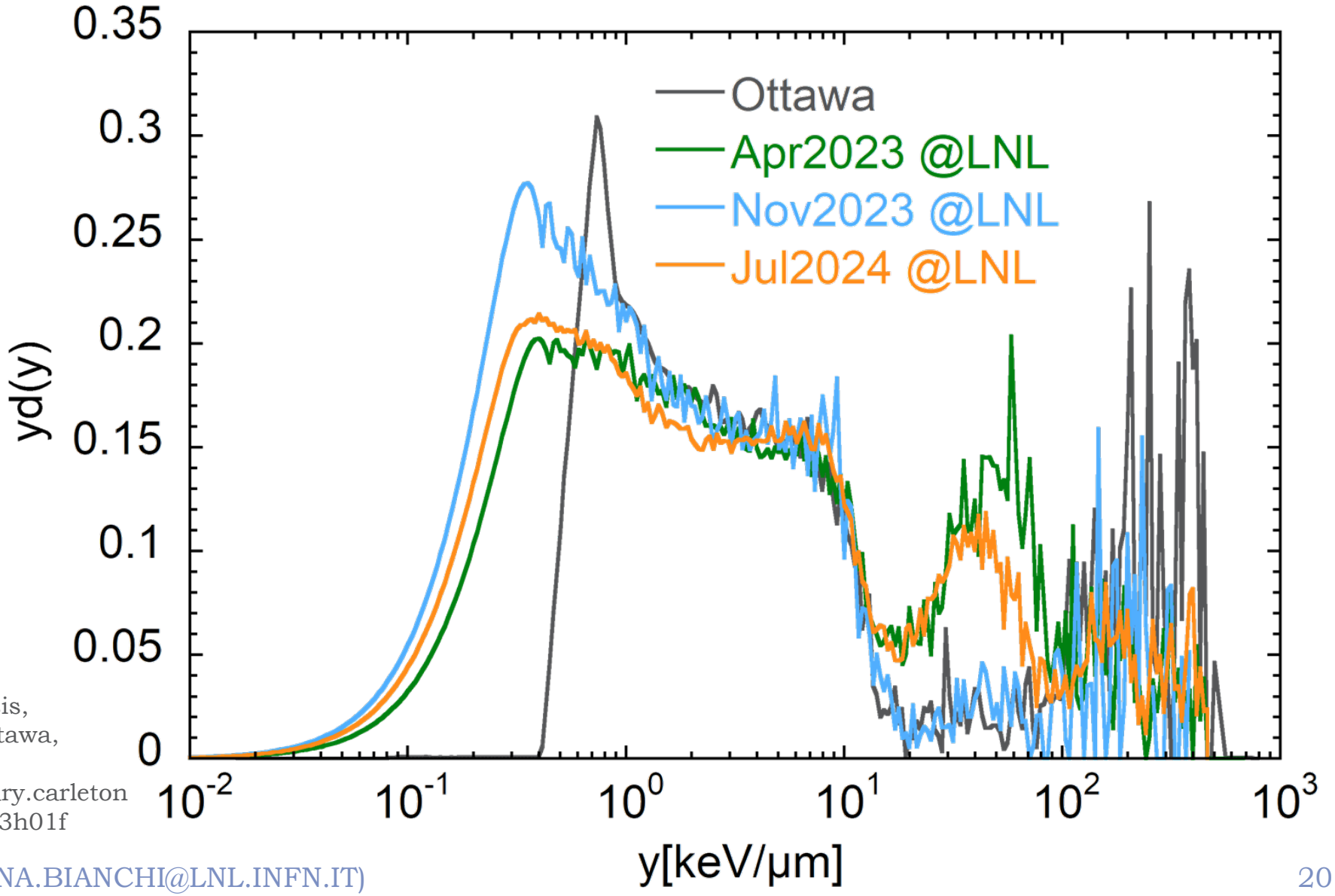
$\bar{y}_F = 0.57 \pm 0.04$

$\bar{y}_D = 24 \pm 1$

High LET fraction: 19%

RBE_μ = 1.39

Comparison with literature



Adapted from MsC thesis, Carleton University, Ottawa, Canada
https://repository.library.carleton.ca/concern/etds/6t053h01f

Conclusions

- We have demonstrated the high variability of the background radiation.
- Dose is not enough!
- High LET component influences biological effect.

Next steps…

- Measurements in the underground laboratory.
- Measurements above ground.
- Analysis in correlation to biological data.

Thank you!

Anna Bianchi

anna.bianchi@lnl.infn.it

INFN LNL
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro