Opportunities for radiobiology at DONES

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World Cancer Research Fund International

18,094,716 new cases in 2020

9,342,957 men (lung-15.4% / prostate-15.1% / colorectal-11.4%)

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types of cancer → patients of cancer → individualization of treatments → personalized medicine

more than half of cancer patients undergo radiotherapy

high-energy X-rays, electrons, protons, heavy-ions

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- energy deposited in matter by ionizing radiation per unit mass
- fundamental magnitude to determine the radiation effects
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How can absorbed dose and biological effects be (unambiguously) related?

fundamental question for treatment individualization

absorbed dose ⟷ biological effects

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relative biological effectiveness (RBE)

ratio between absorbed doses delivered with two radiation qualities that result in the same effect in a given biological system, under identical conditions.

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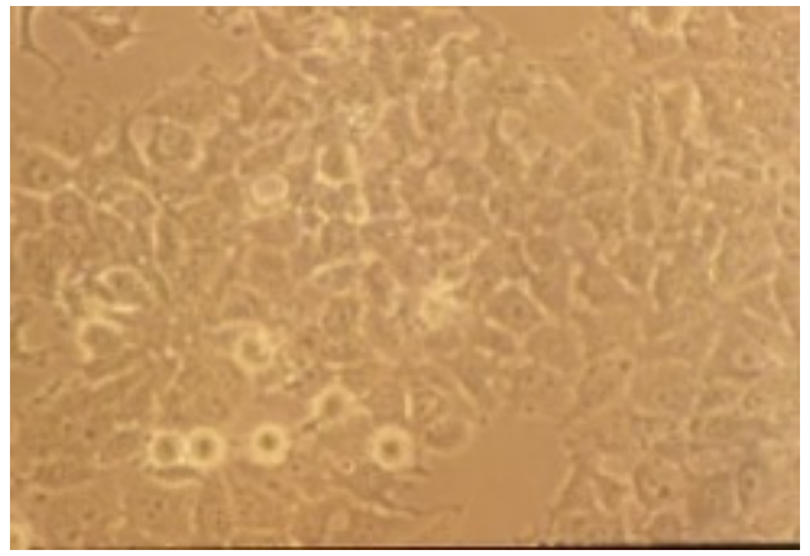
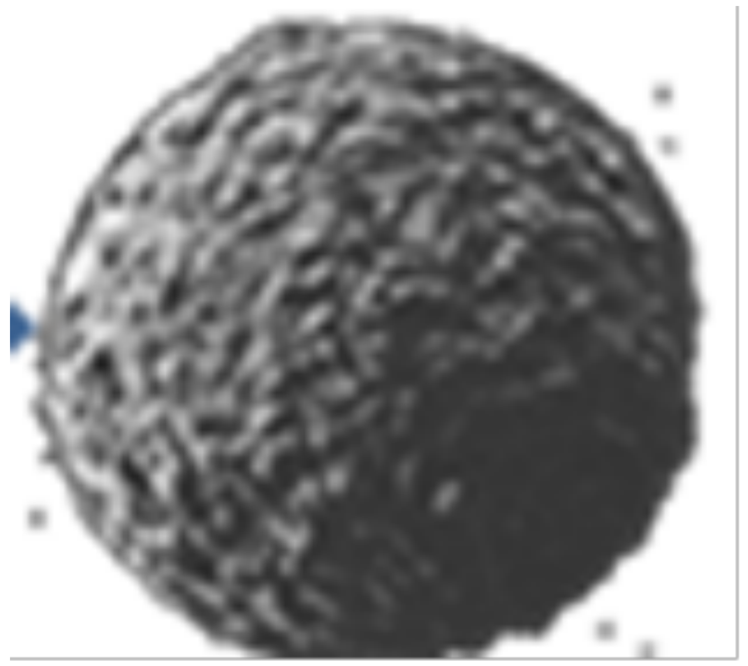
not only cell type or radiation quality





importance of the end points

- cell survival (monolayer / spheroids / matrigel)
- chromosomal aberrations
- molecular damage to DNA (simple- / double-strand breaks)
- other molecular end-points (tumor microenvironment / metastases)

what about neutrons?

radiation protection

- for workers and general public
- extremely relevant at DONES

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equivalent dose in tissue T, H_T

$$H_T = \sum_R w_R D_{T,R}$$

Table 1. Radiation weighting factors[1]

Type and energy range[2]	Radiation weighting factor, w_R
Photons, all energies	1
Electrons and muons, all energies[3]	1
Neutrons, energy < 10 keV	5
10 keV to 100 keV	10
> 100 keV to 2 MeV	20
> 2 MeV to 20 MeV	10
> 20 MeV	5
(See also Figure 1)	
Protons, other than recoil protons, energy > 2 MeV	5
Alpha particles, fission fragments, heavy nuclei	20

ICRP Publication 60 (1991)

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chosen by ICRP

- $w_R = 1$ for low LET radiations
- w_R for other radiations according to RBE

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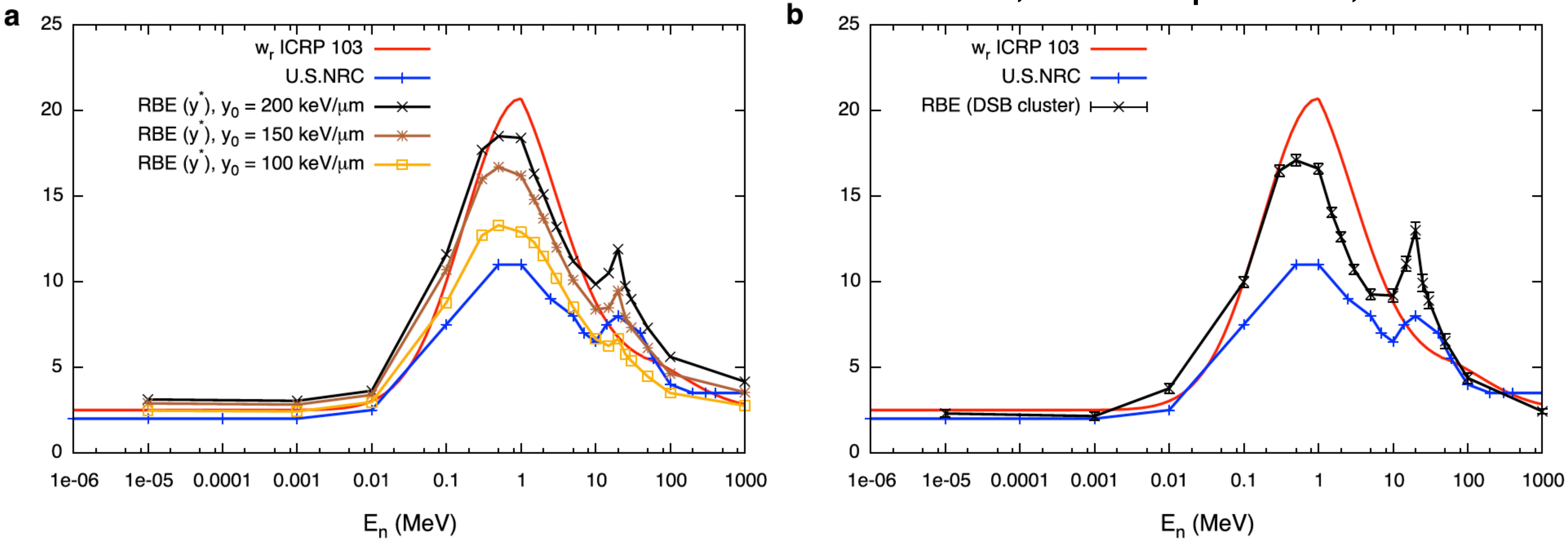
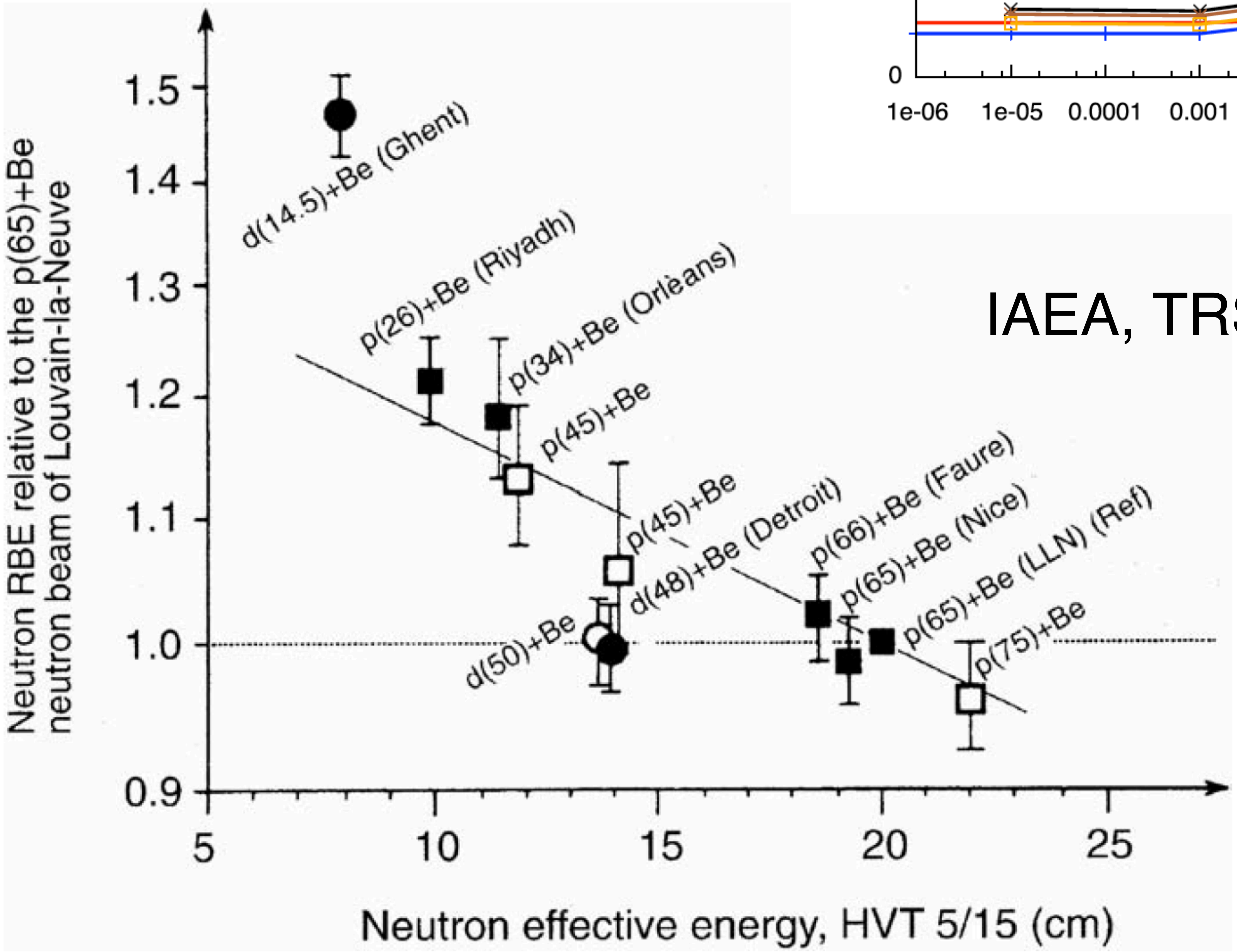
RBE of neutrons

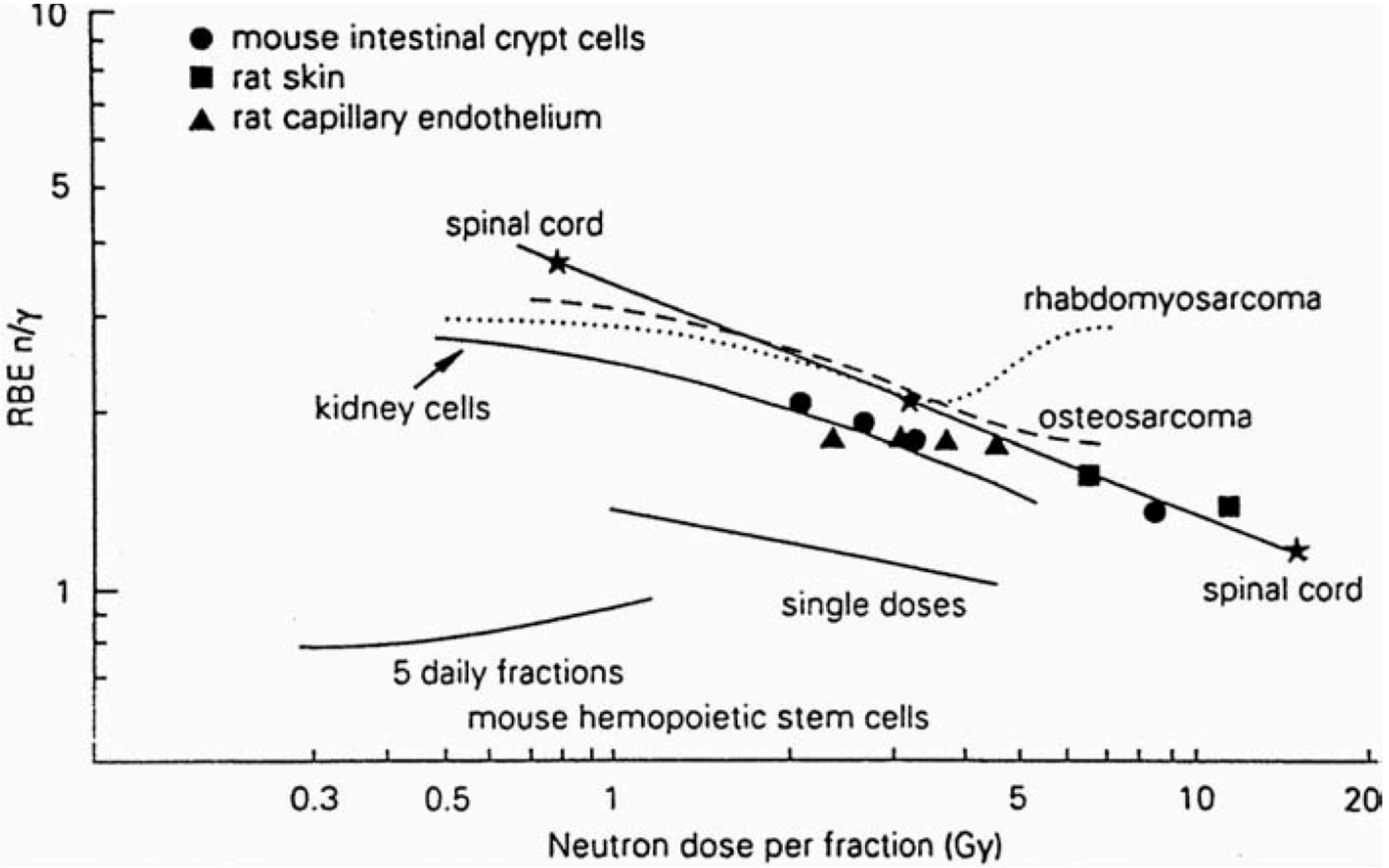
Baiocco et al., Sci. Rep. 2016;6:34033

- •energy dependent
- •large uncertainties
- •strong end-point dependence





IAEA, TRS-461, 2008



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- X-ray machines up to 12-15MV are used, but hadrontherapy

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- minimal equipement required:

-laminar flow cabinet
-vacuum pump
-CO_2 incubator (with pH-meter)
-inverted phase constrast microscope
-basics elements for maintaining and manipulating cell cultures
-cell culture media, consumables, …

-TLD dosimetry system

conclusions

- the response of cell cultures to irradiation provides valuable information that can be transferred to clinical and radiation protection practices.
- measurement of different endpoints is required.
- neutron (and deuteron) beams available at IFMIF-DONES will open the possibility of analyzing situations never investigated before.
- the new beams would complete the radiobiological information obtained by using the electron clinical accelerators of the nearby hospitals and the X-ray irradiation facilities available at CNA or CIC-UGR

- IFMIF-DONES is an excellent opportunity to expand our knowledge about neutron RBE and to study the cell response to both neutrons and deuterons at the energies that will be available.