

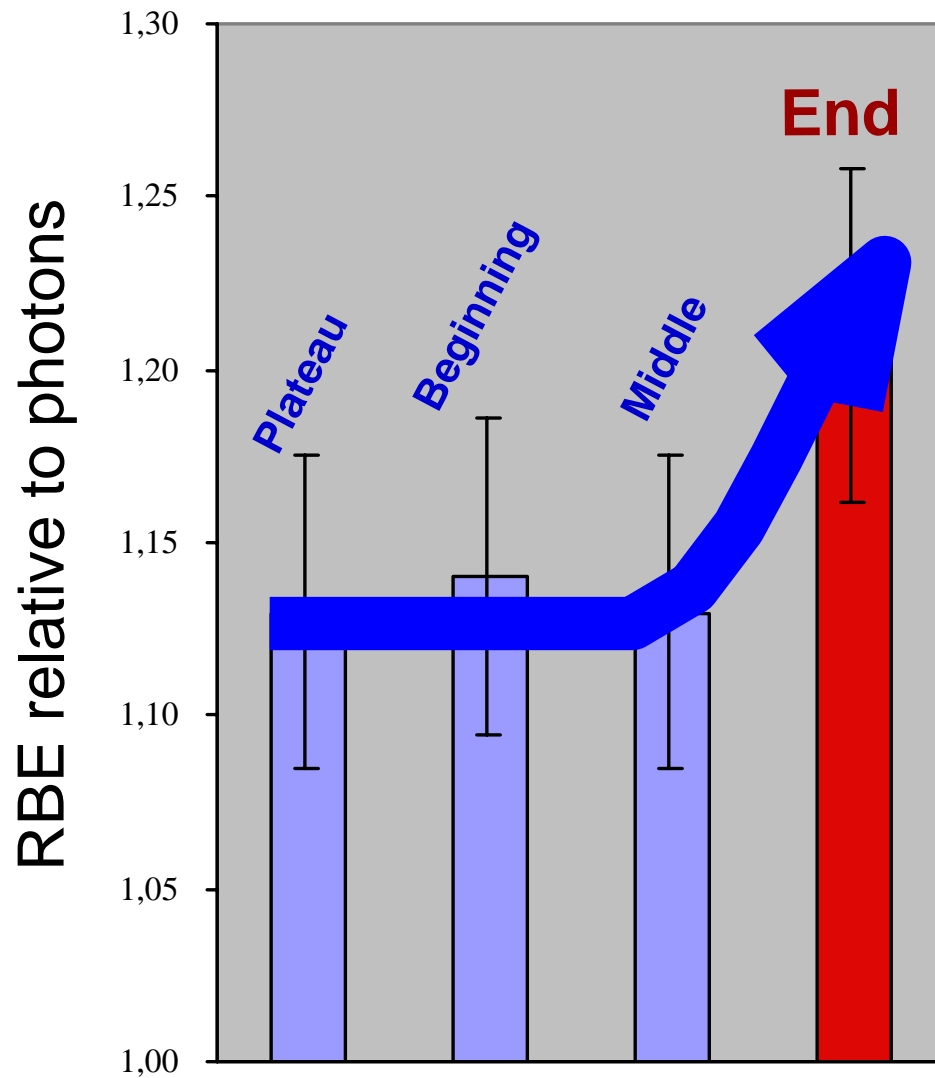
*Particle Therapy Co-Operative Group PTCOG-45, 2006
Houston (USA), October 7 - 11, 2006*

Increase in proton RBE in the last few millimeters of the SOBP as observed in intestine (preliminary results)

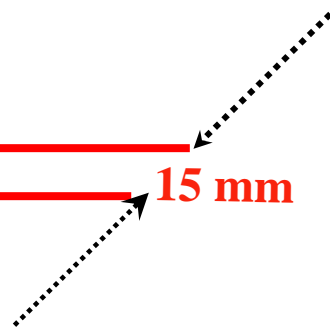
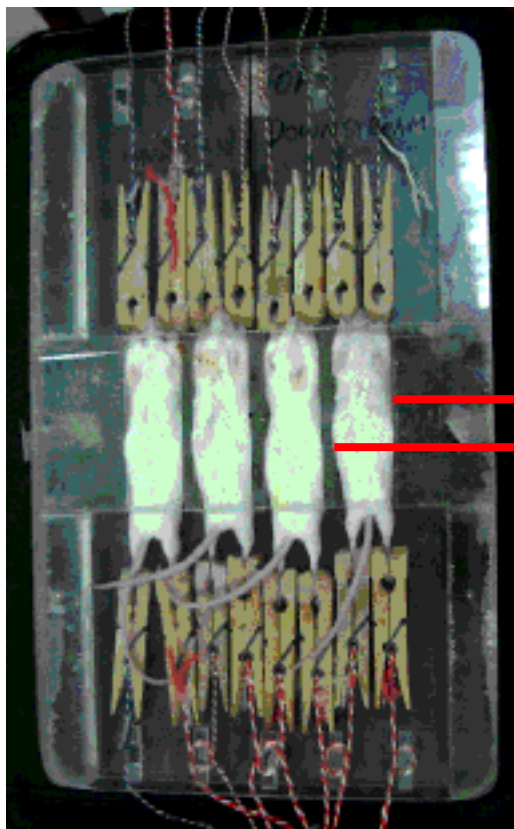
John Gueulette¹, Joël Martinez¹, Blanche-Marie De Coster¹,
Julyan Symons² and Jacobus Slabbert²

¹ *Université catholique de Louvain, Brussels, Belgium*

² *iThemba LABS, Somerset-West, South Africa*

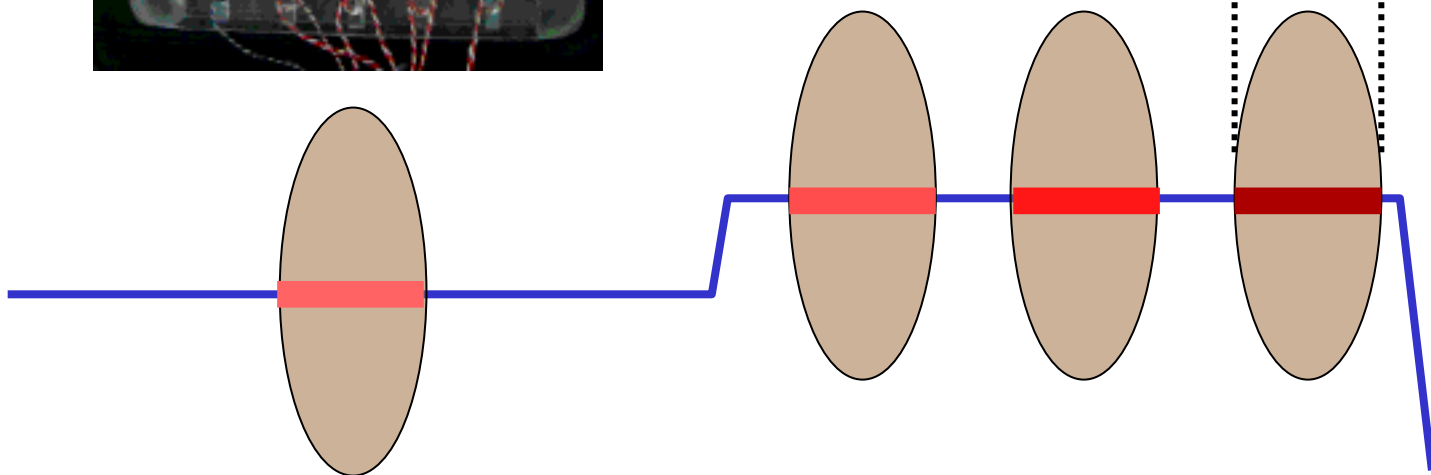


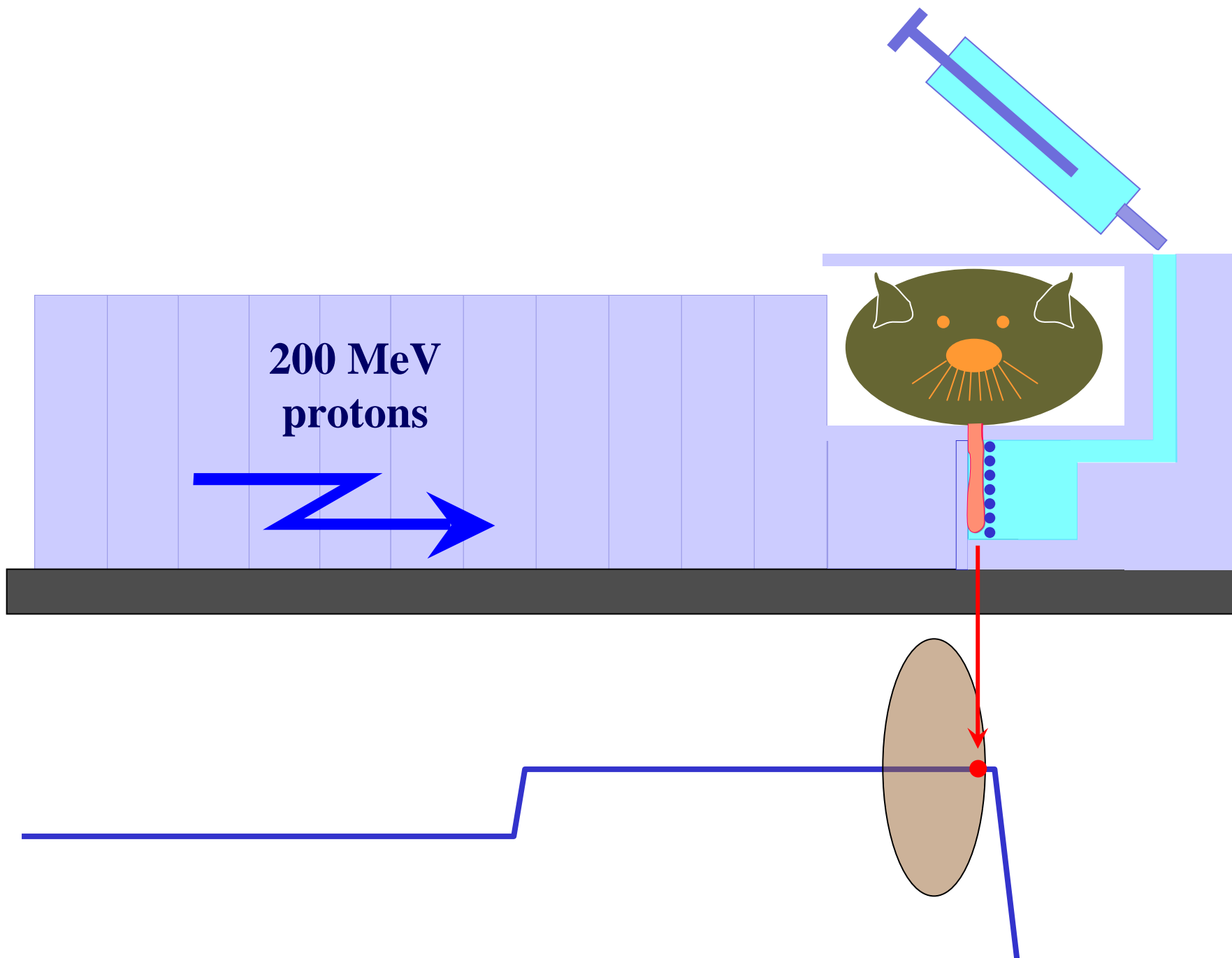
RBE increases suddenly by **6 - 10° %** from the **middle** to the **end** of the SOBP

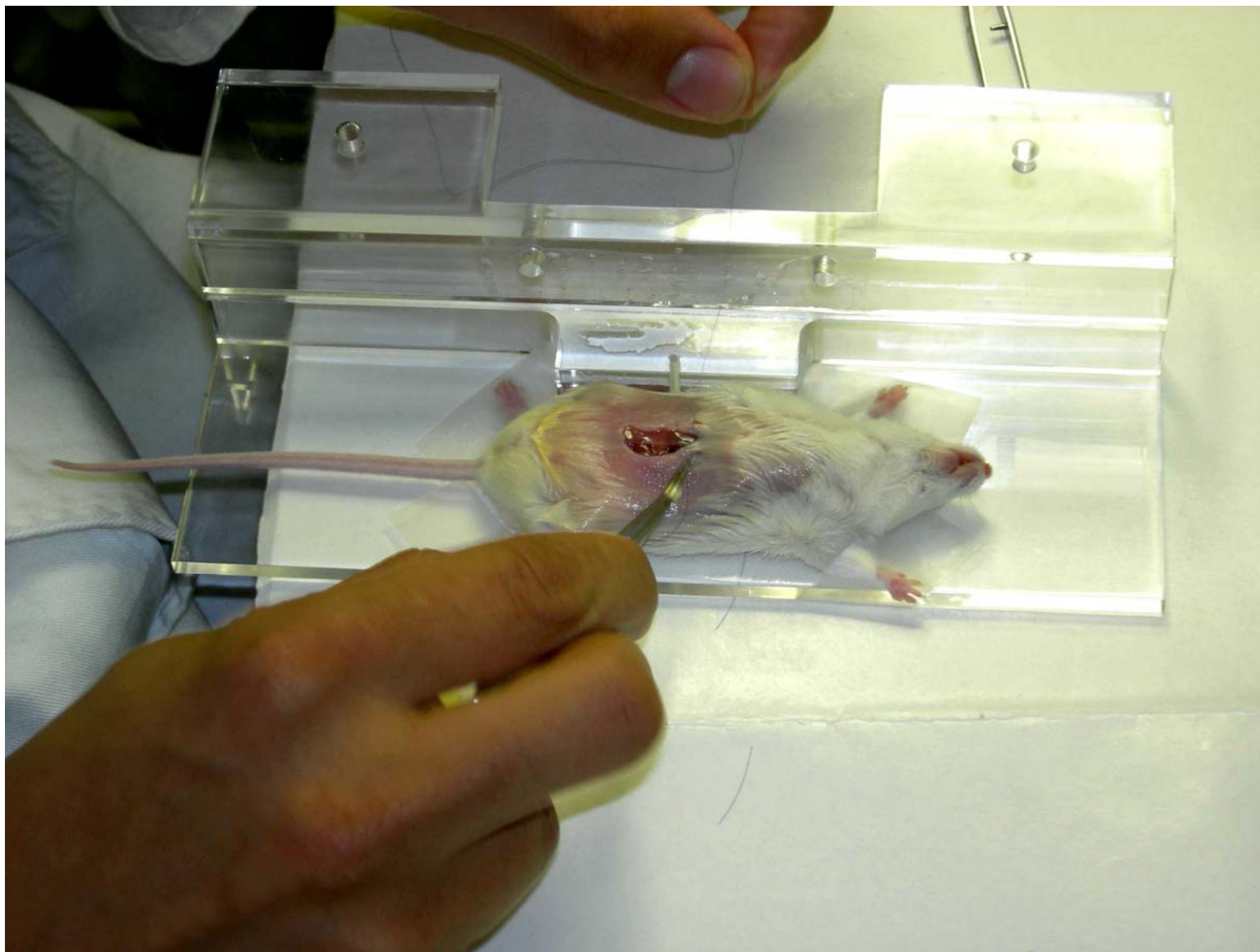


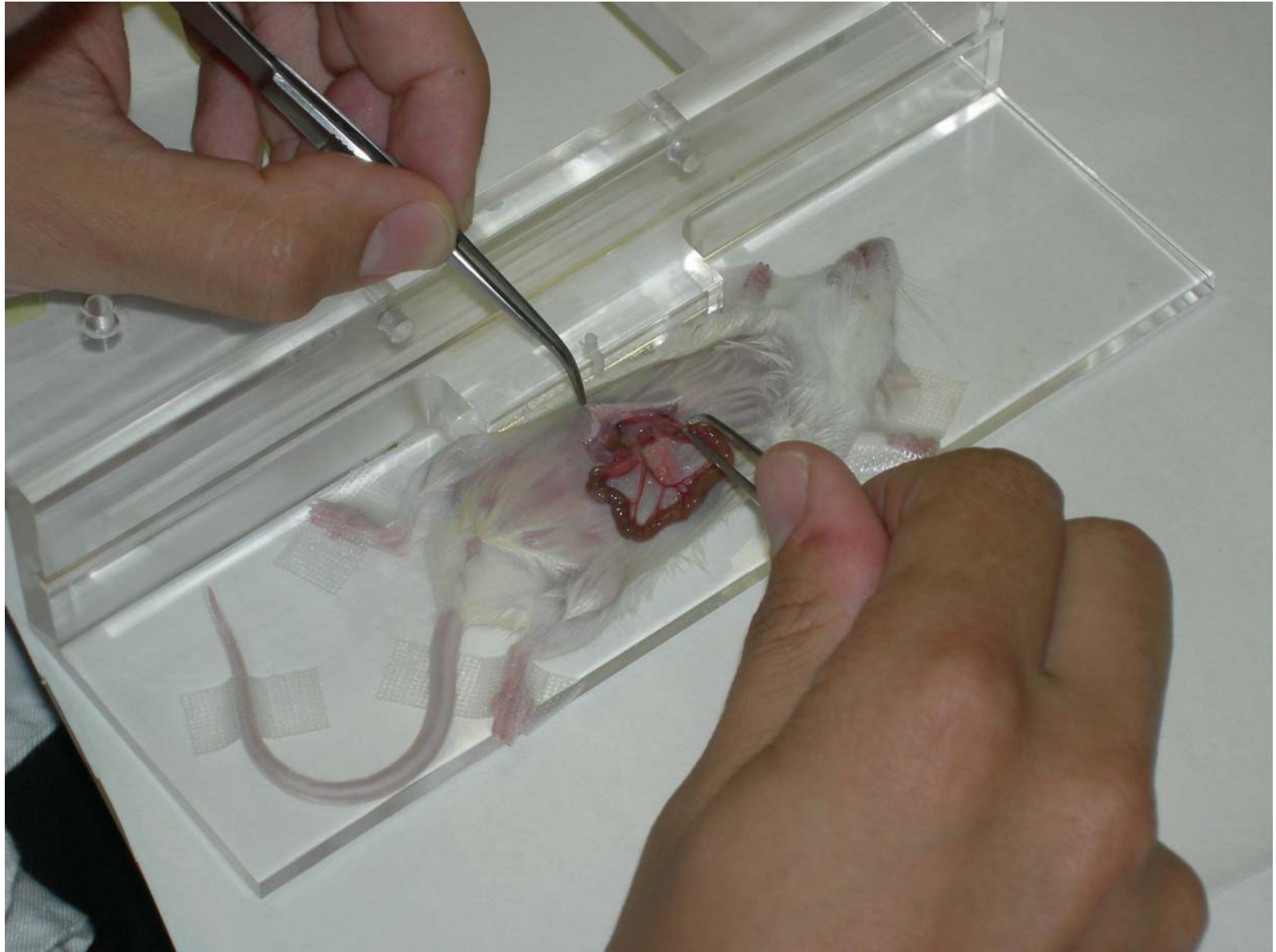
15 mm

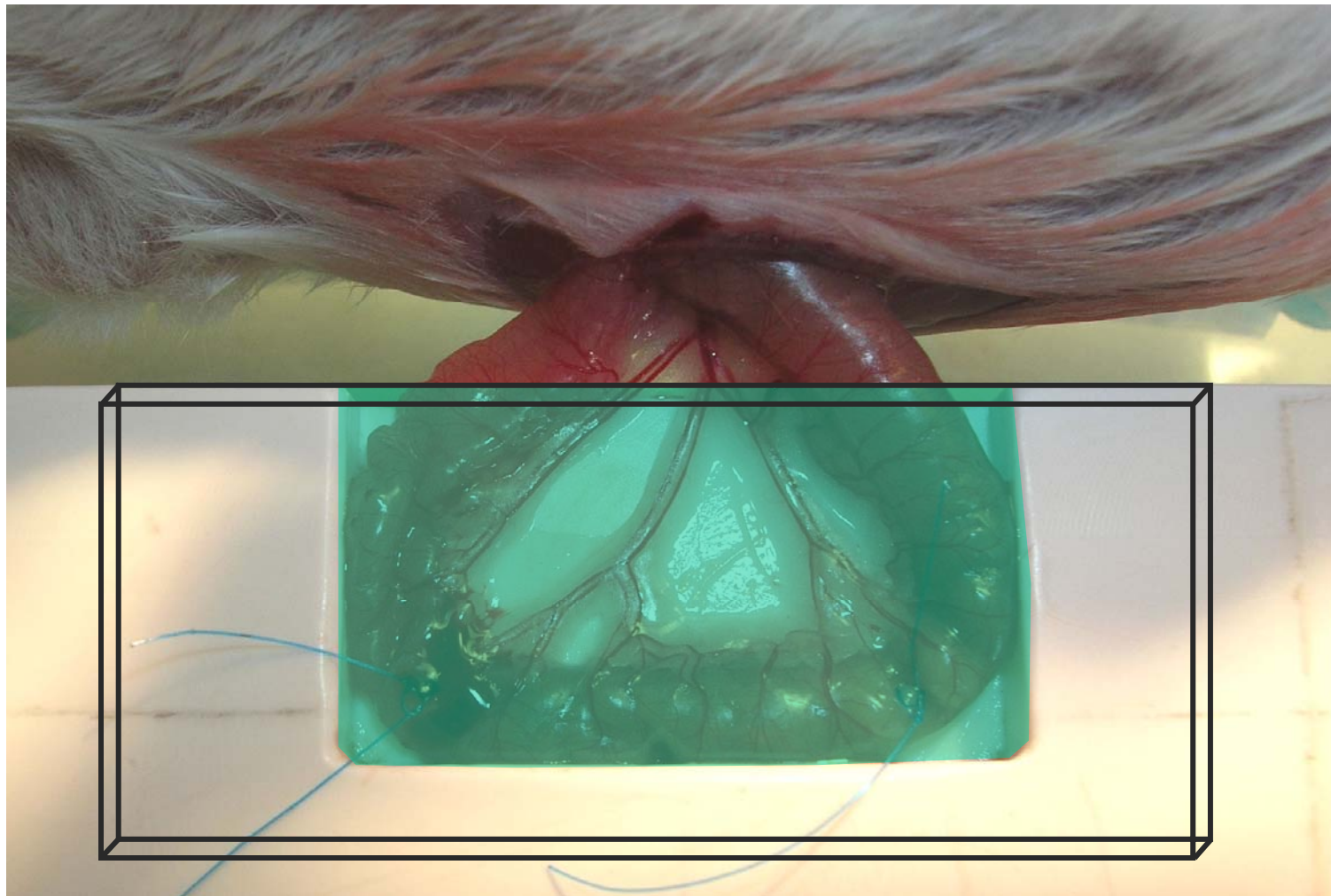
15 mm

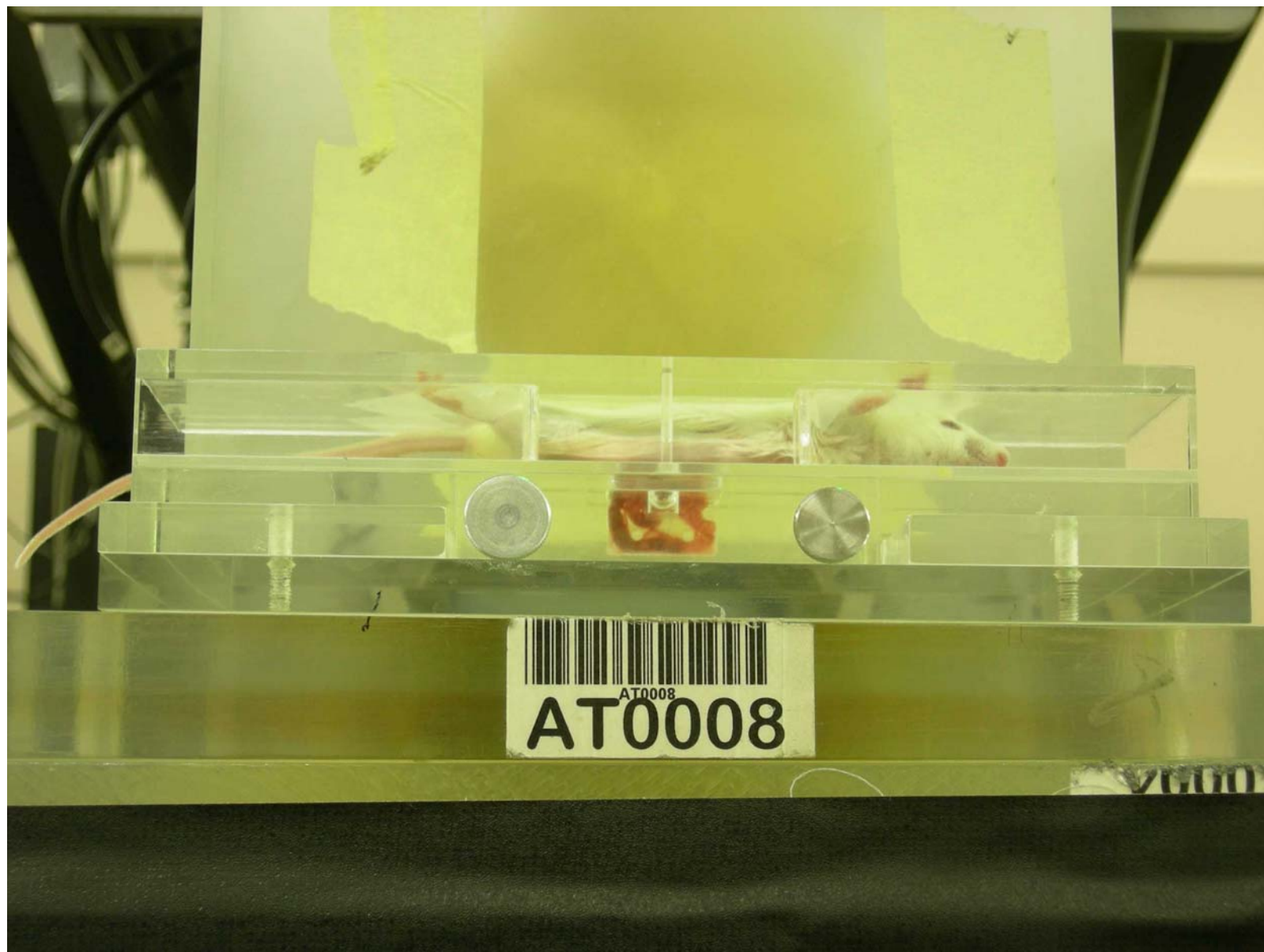














4 days

84 hours

Irradiation

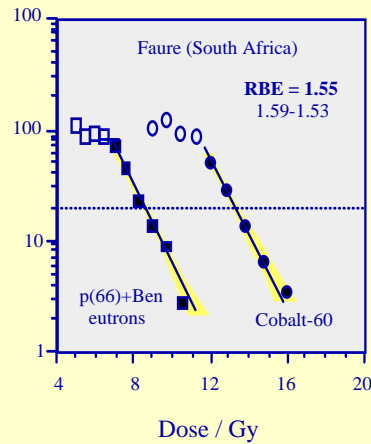
10 - 17 Gy (gamma equivalent)

Sacrifice

Fixation

Microtome

Histology

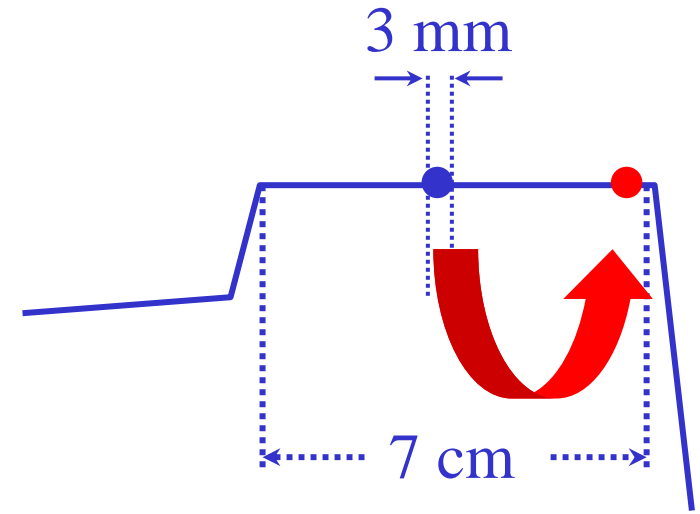
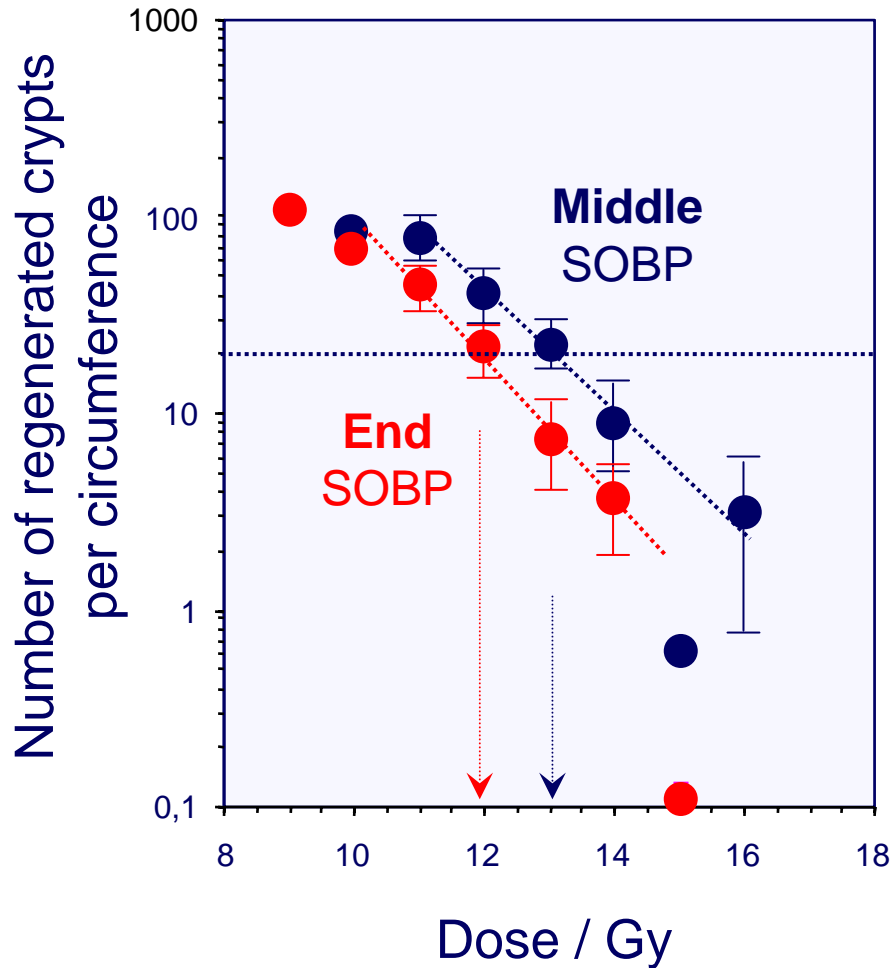


Dose-effect relationships

Counting of regenerated crypts (microscope)

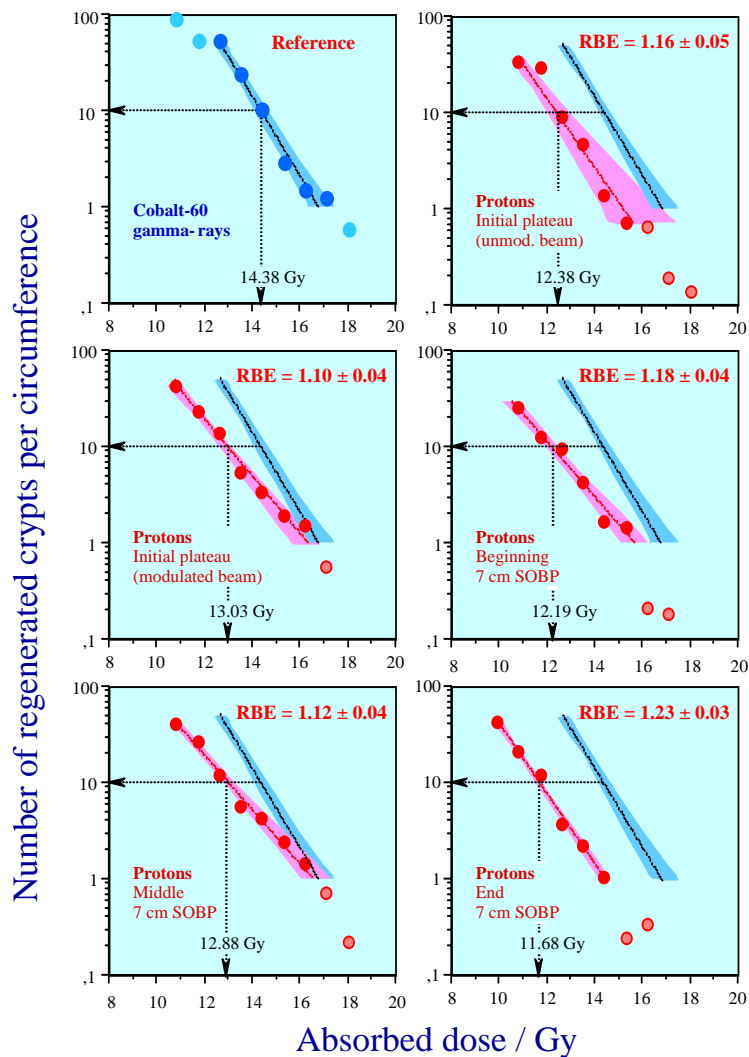
iThemba LABS (2006)

200 MeV protons, 7-cm SOBP

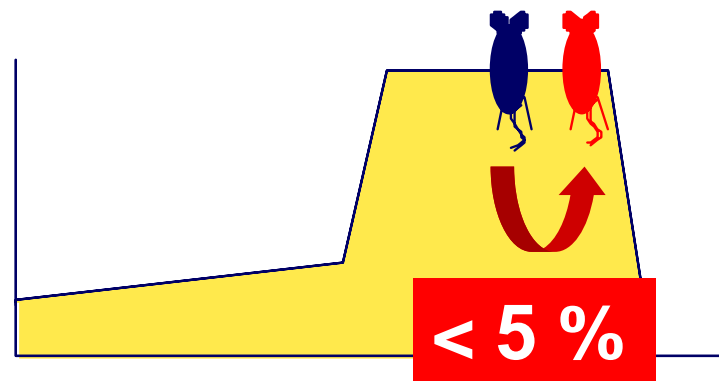
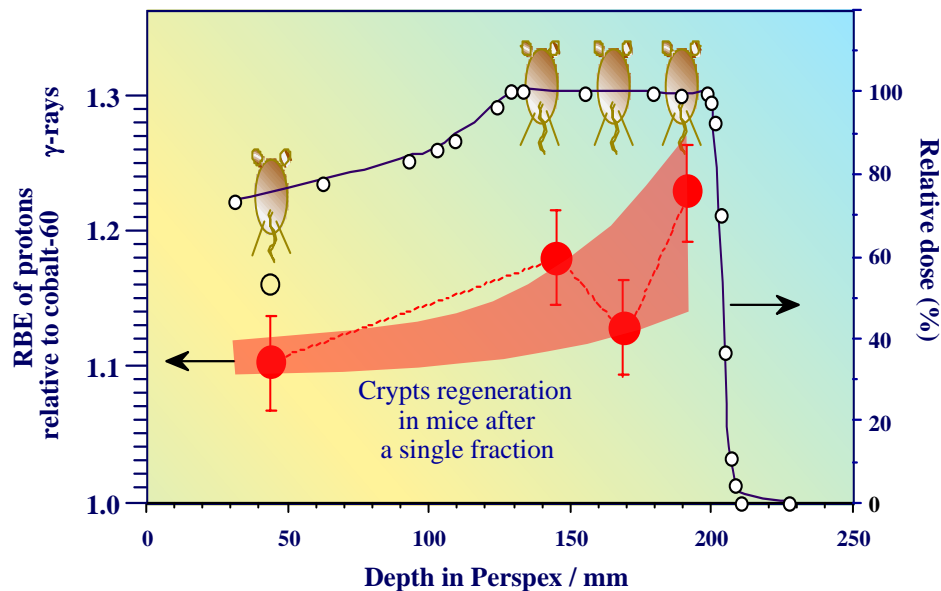


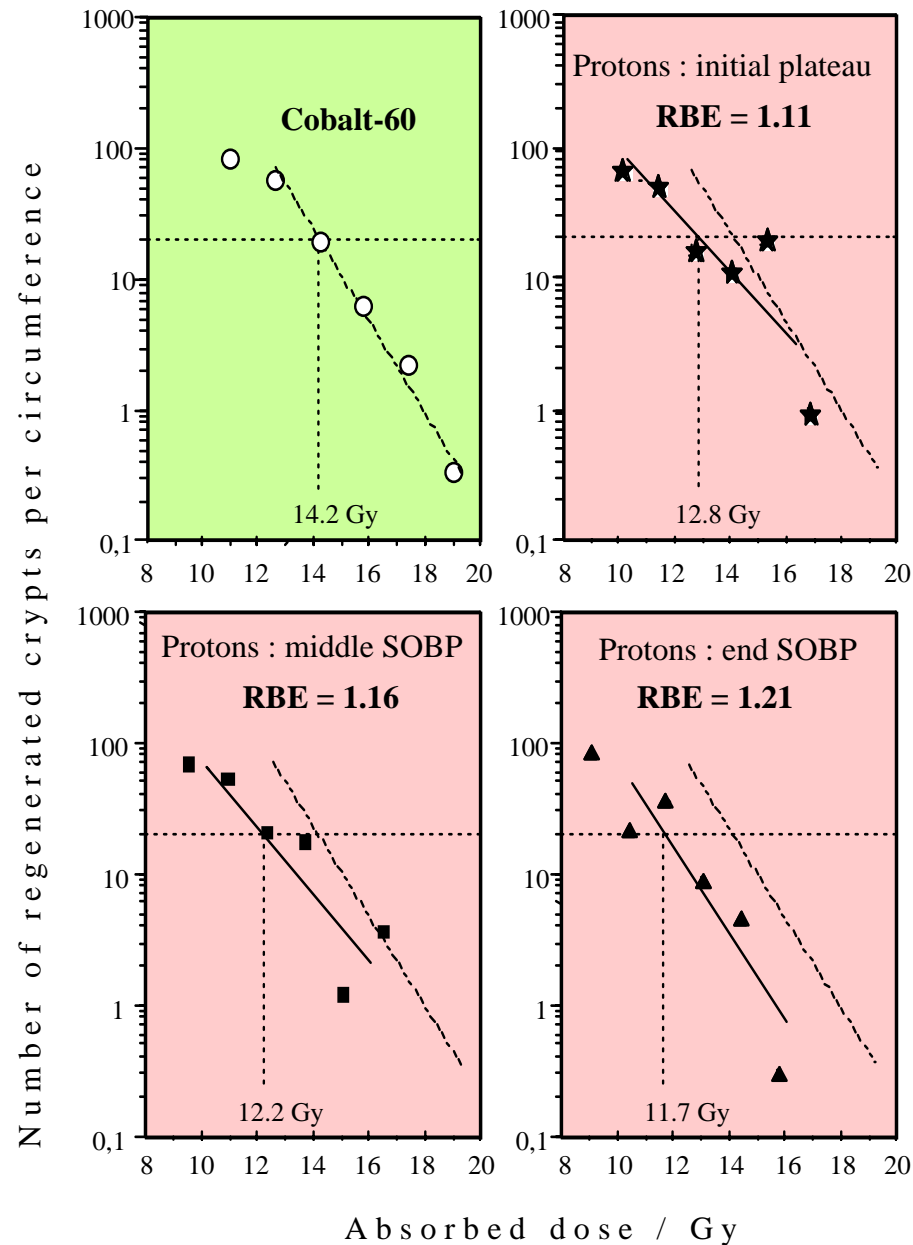
$$\frac{\text{RBE (end)}}{\text{RBE (middle)}} = 1.10$$

200 MeV protons NAC (Faure, South Africa)



200 MeV protons NAC (Faure) South Africa



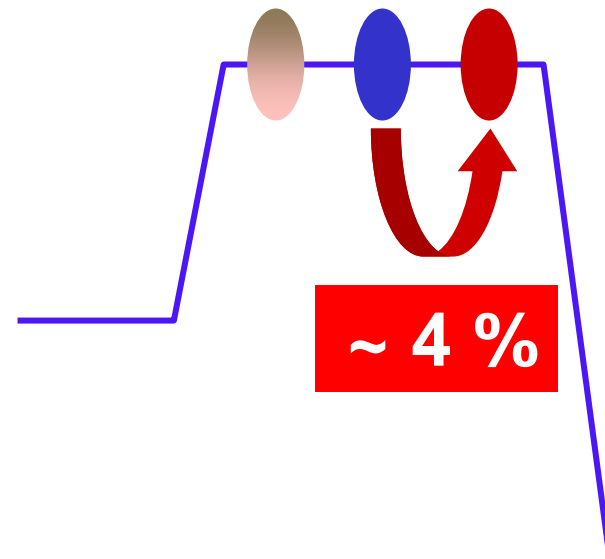


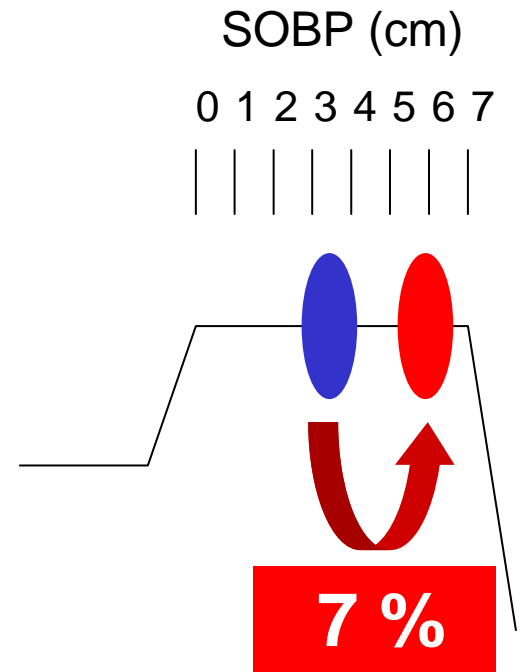
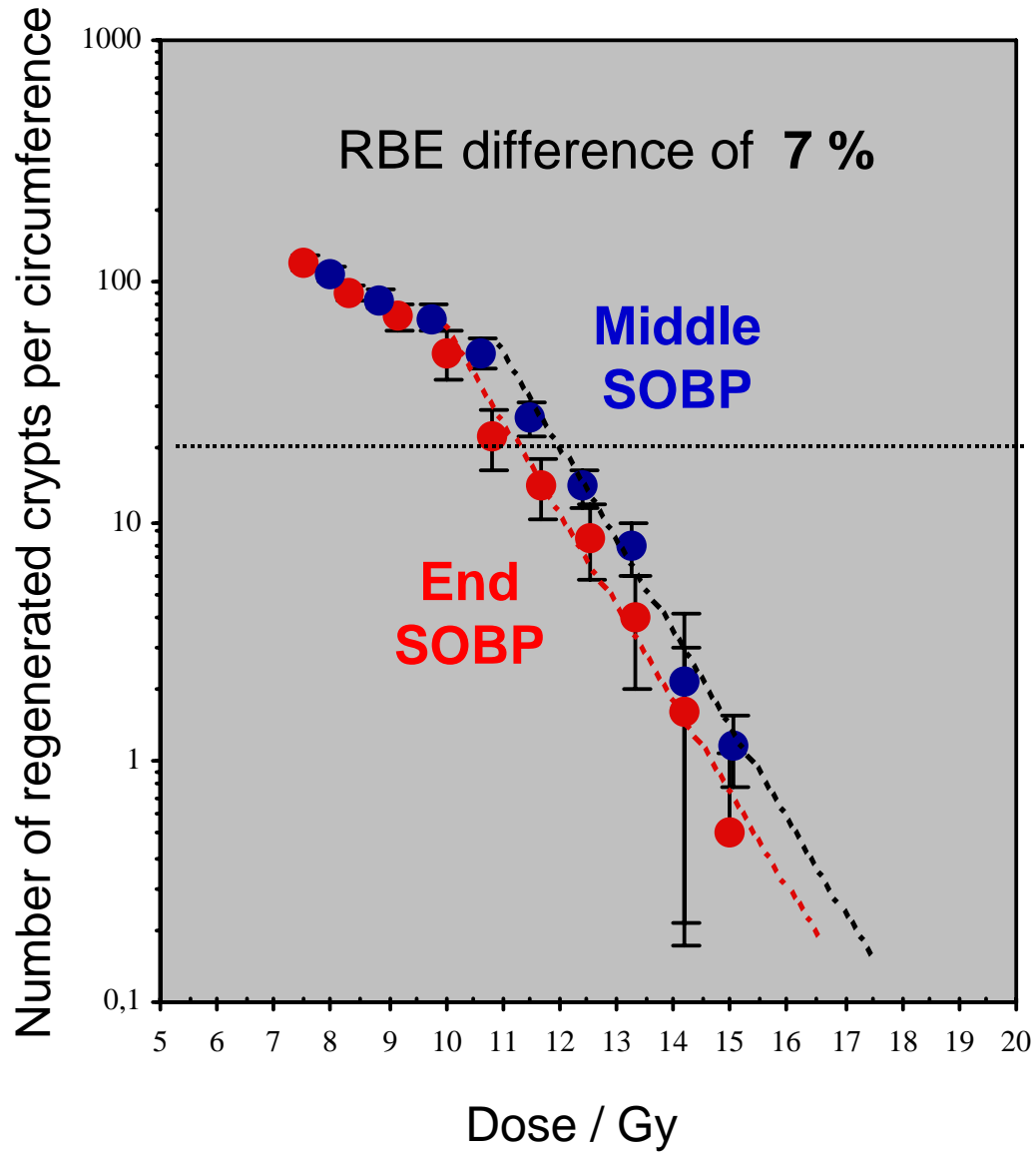
PSI

Spot scanning

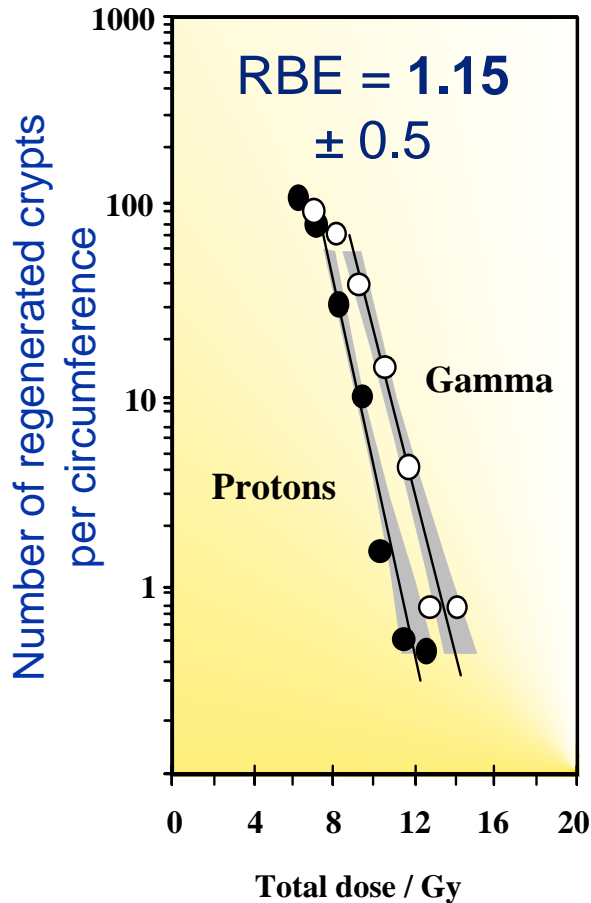
RBE =

1.11 1.16 1.21

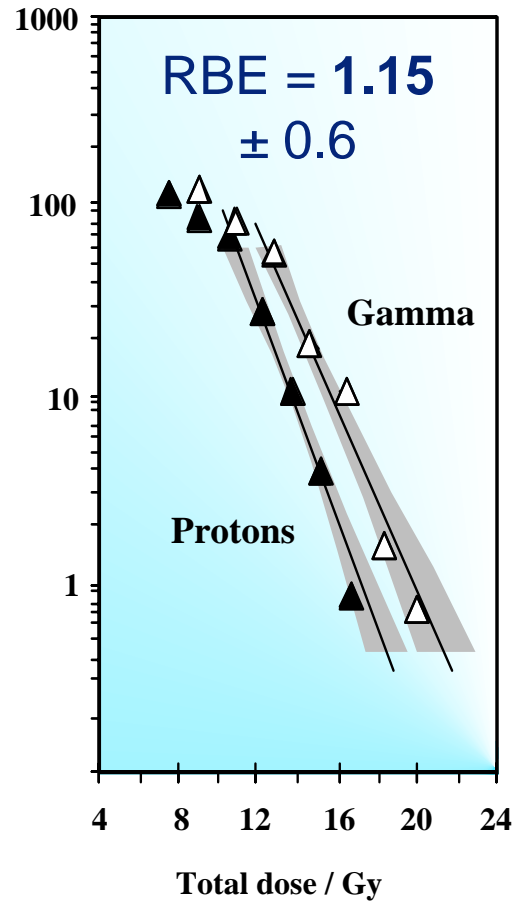




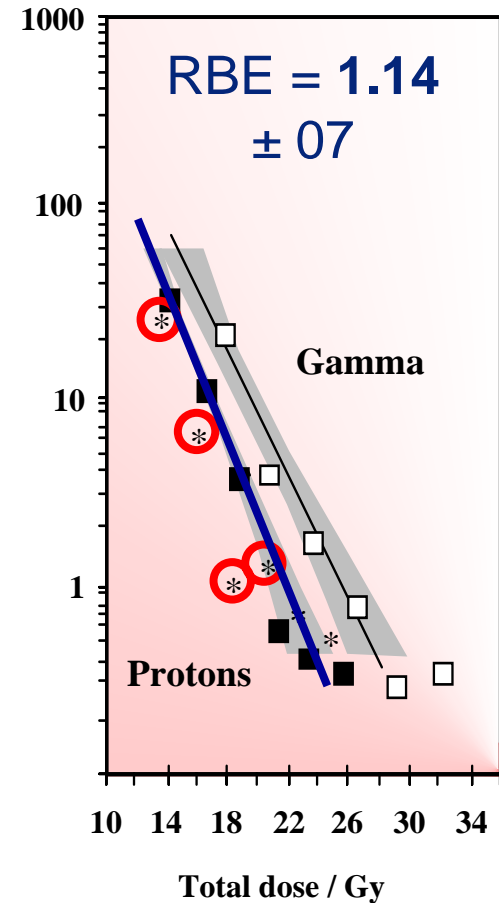
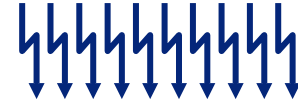
1 fract.



3 fract.



10 fract.



i = 4 h

Intestine (10 fractions)

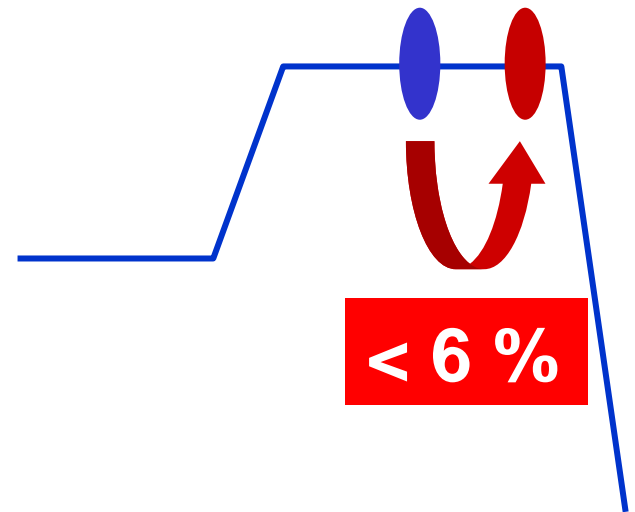
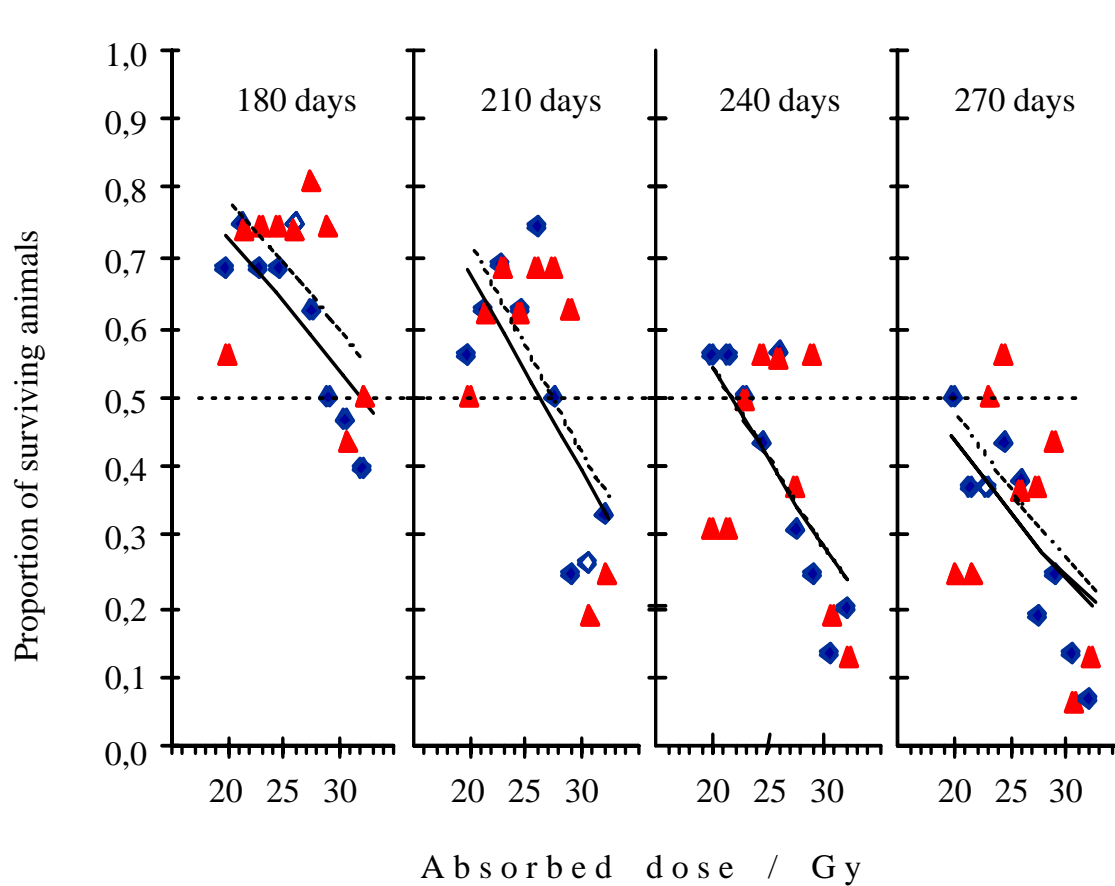
RBE (end) / RBE (middle)

~ 1.08

Selective thoracic irradiation *in mice*

Irradiation in 10 fractions ($i = 12$ h)

(middle vs **end** of the SOBP)

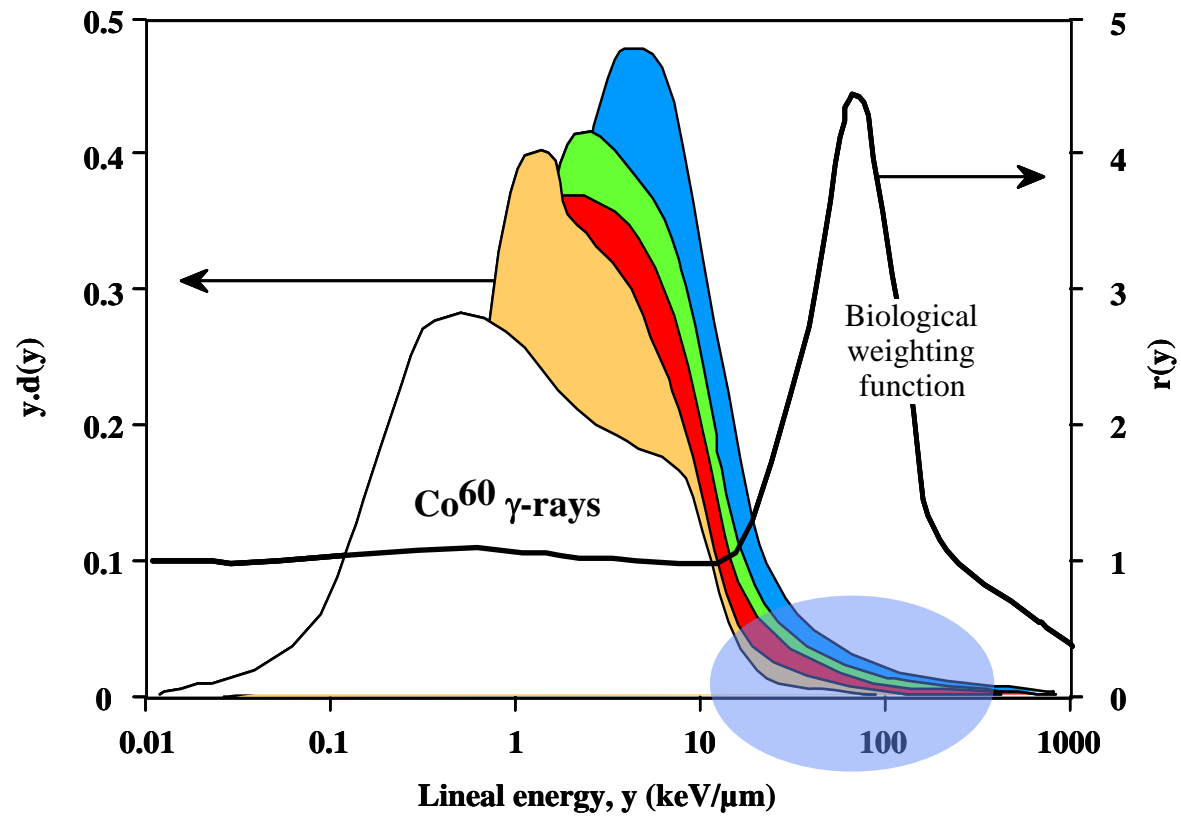
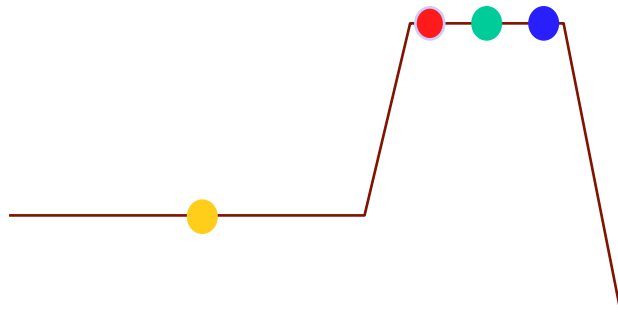


In vitro studies

- Blomquist E, Russell KR, Stenerlöv B, Montelius A, Grusell E, Carlsson J. Relative biological effectiveness of intermediate energy protons. Comparisons with ^{60}Co gamma-radiation using two cell lines. *Radiother. Oncol.* 1993; 28: 44-51.
- Courdi A, Brassart N, Herault J and Chauvel P. The depth-dependent radiation response of human melanoma cells exposed to 65 MeV protons. *Br. J. Radiol.*, 1994; 67: 800-804.
- Gueulette J, Grégoire V, Octave-Prignot M, Wambersie A. Measurements of radiobiological effectiveness in the 85 MeV proton beam produced at the cyclotron Cyclone of Louvain-la-Neuve (Belgium). *Radiation Research*, 1996; 145: 70-74.
- Wouters BG, Lam GK, Oelfke U, Gardey K, Durand RE, Skarsgard LD. Measurements of relative biological effectiveness of the 70 MeV proton beam at TRIUMF using Chinese hamster V79 cells and the high-precision cell sorter assay. *Radiat Res.* 1996; 146:159-70.

●

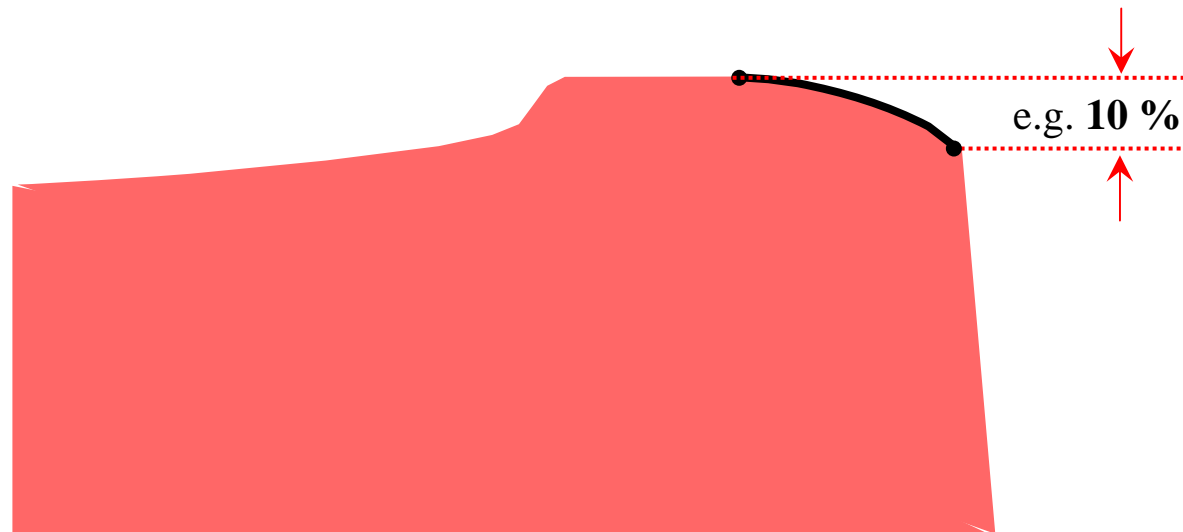
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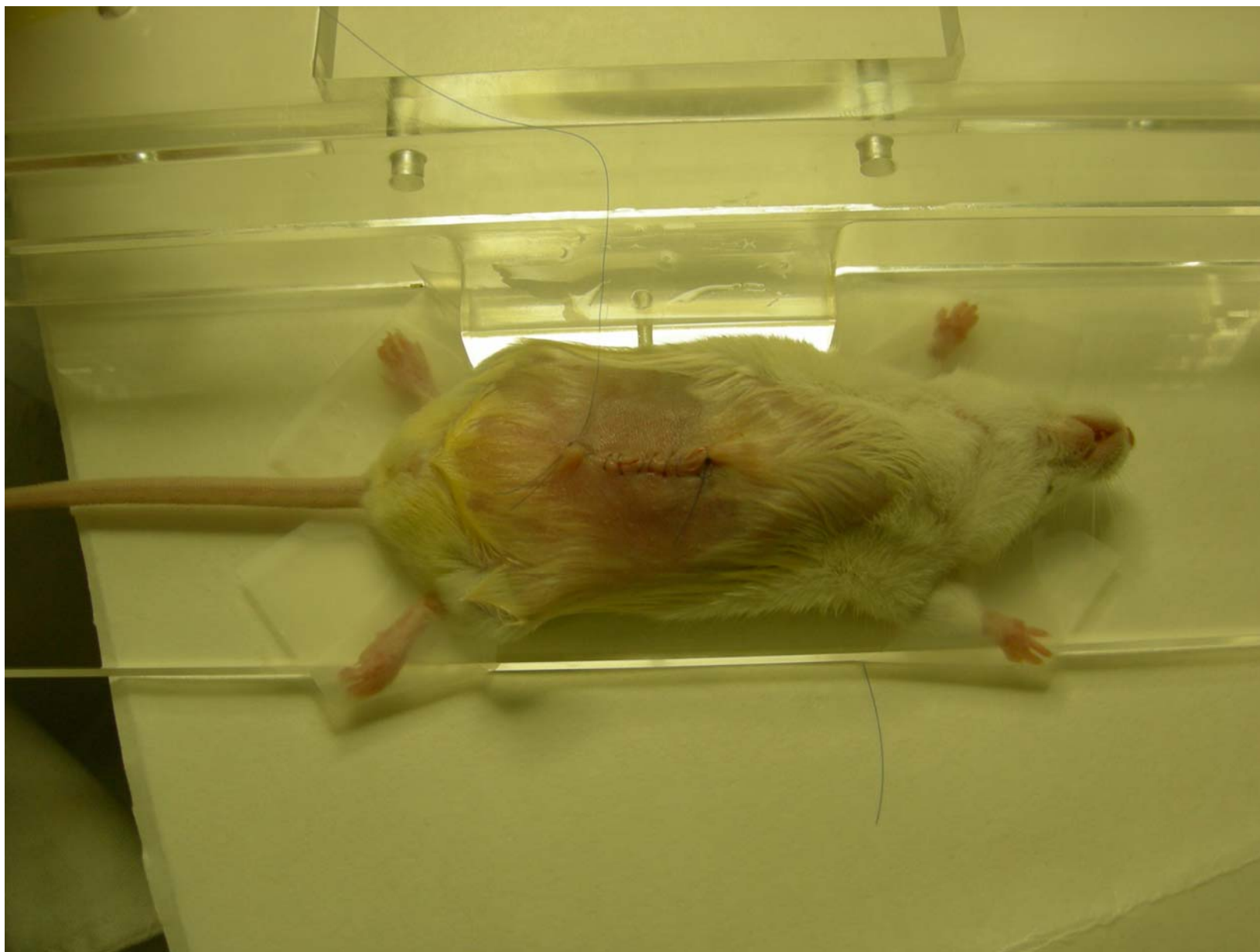


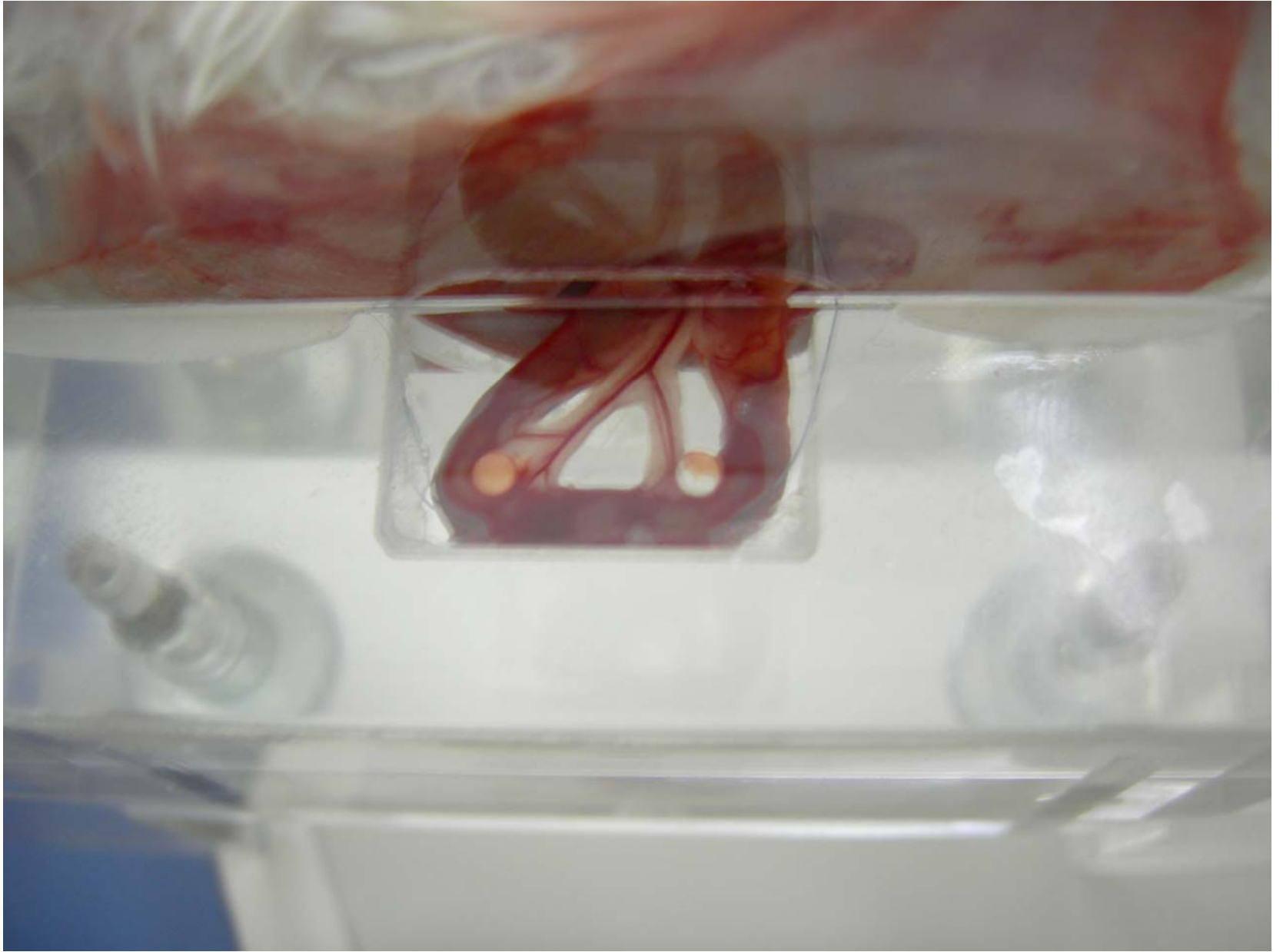
Conclusions

- Ex-vivo irradiations proved to be most workable and suitable to study the response of intestine in a restricted area.
- As an increase in RBE is observed at the end of the SOBP in all biological systems, **it is advisable to allow for it, and thus to shape the SOBP accordingly.**

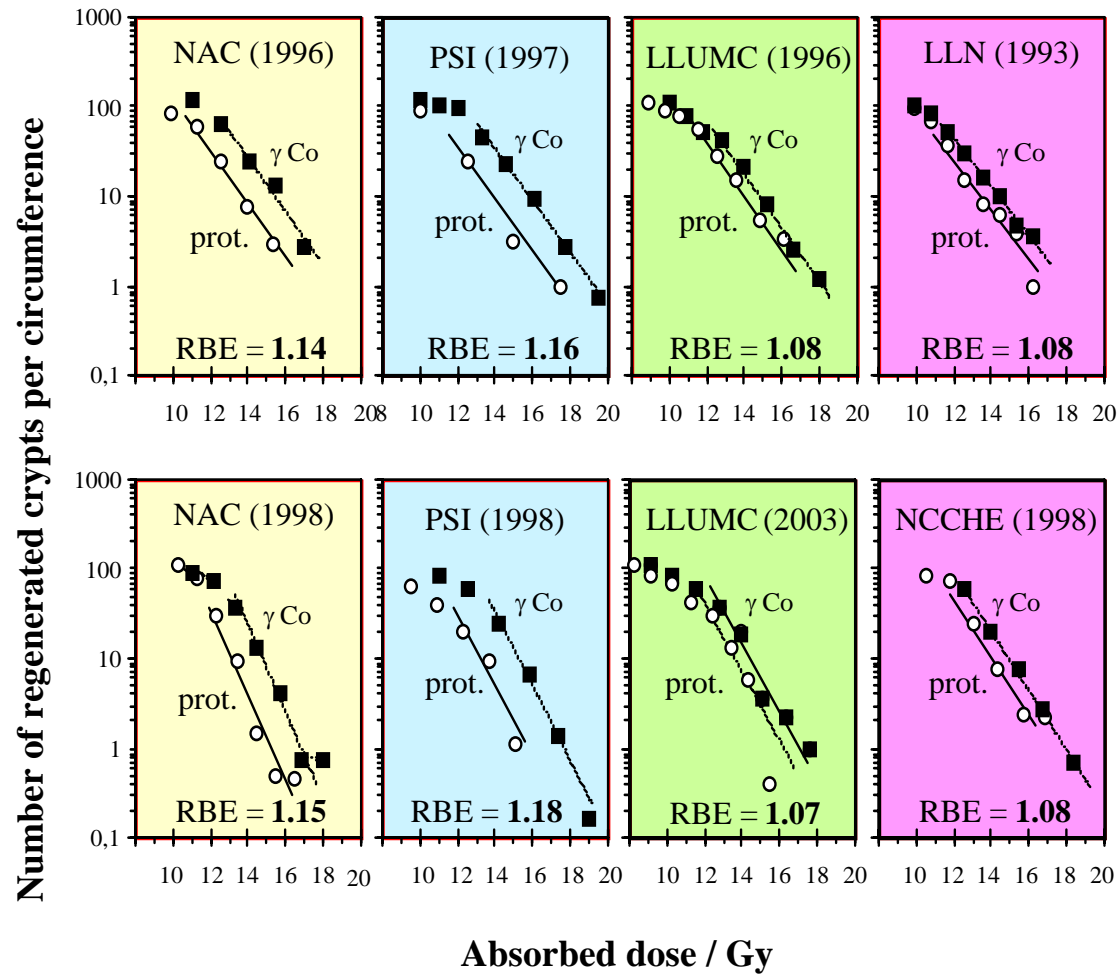
Decreasing progressively the dose from e.g. the middle to the end of the SOBP by $\sim 10\%$ would **compensate most of the RBE variations** and bring this region closer to **iso-effectiveness**



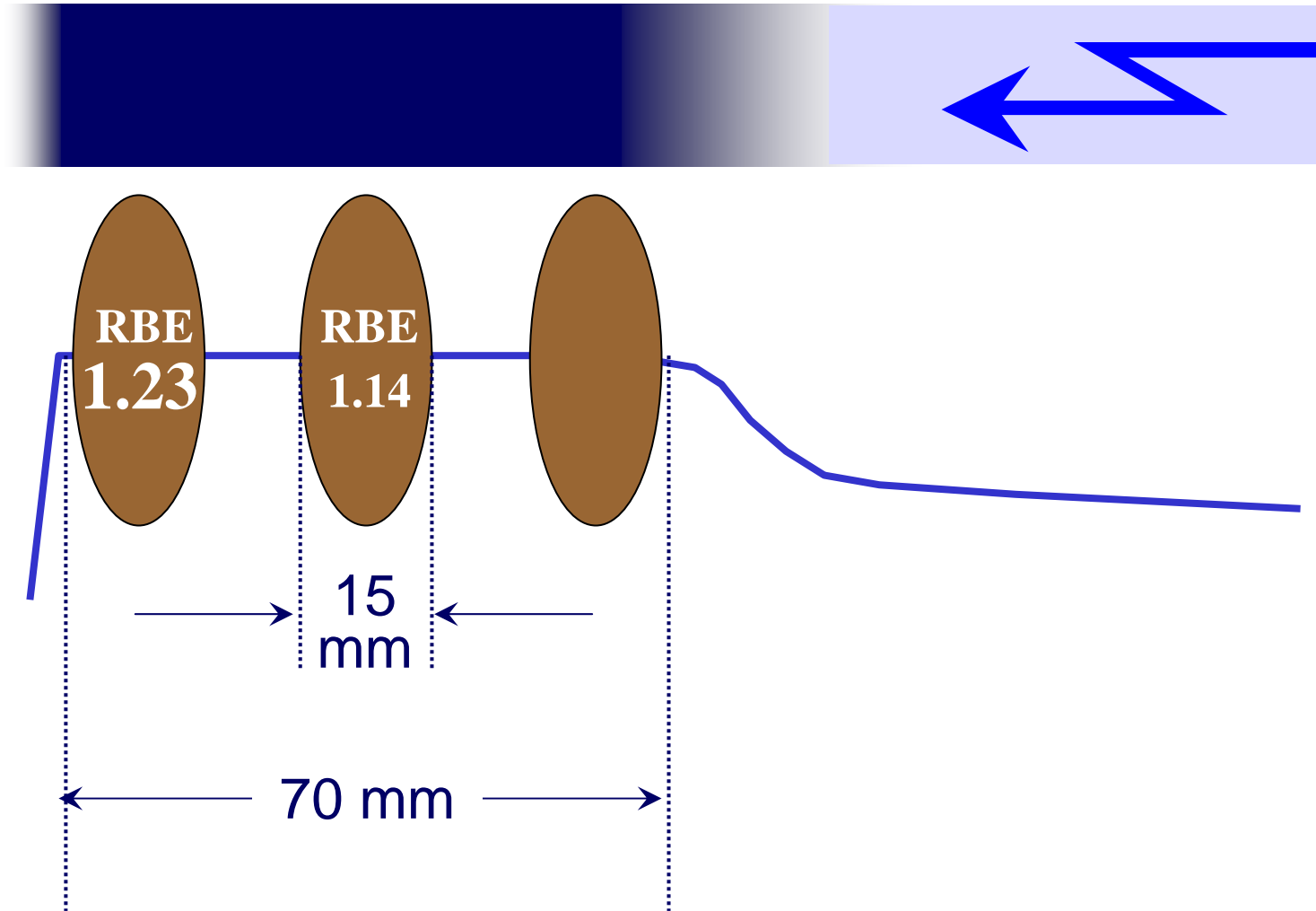




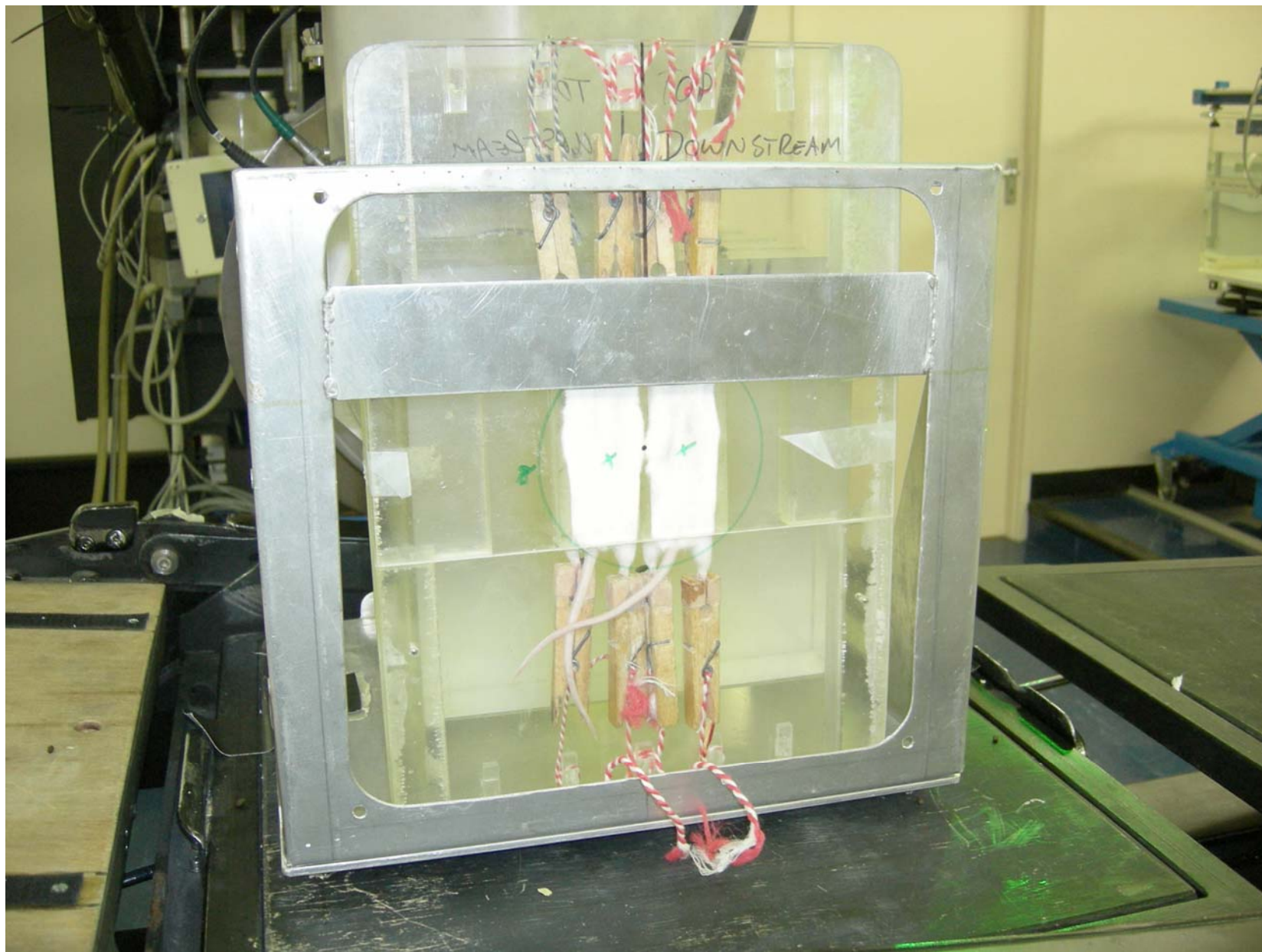
Intestinal crypt regeneration in mice after single dose irradiations



**200 MeV
protons**







Cells in vitro

Intestinal crypt
regeneration in mice

DL50 after thoracic
irradiation in mice