An example of computational dosimetry in BNCT

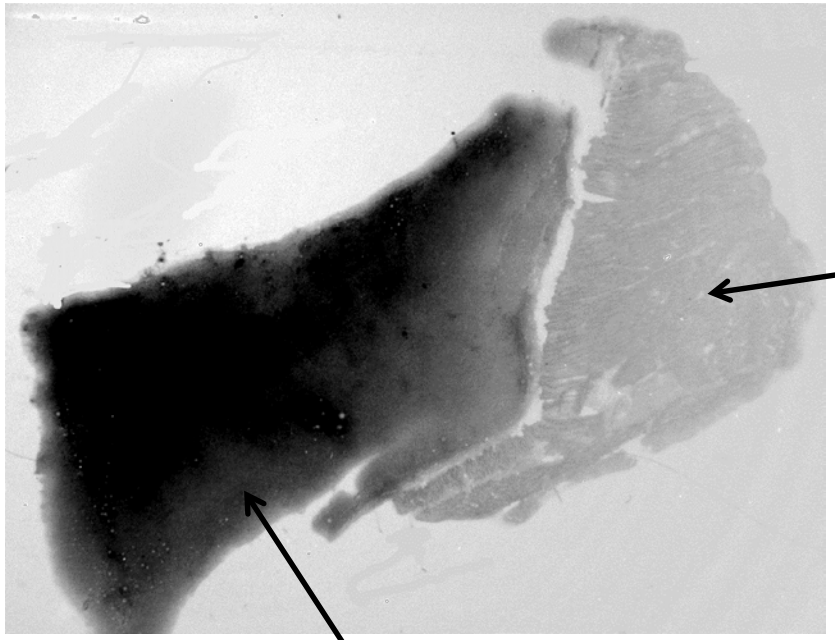
S. Bortolussi, I.Postuma, S.J. González, L. Provenzano, N.Protti, S. Fatemi, C. Magni, and S. Altieri

1

10° Edición de las Jornadas del CUIA en Argentina

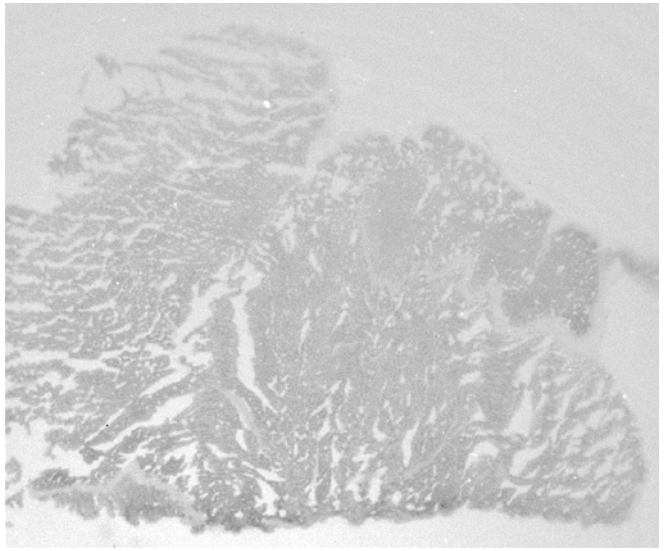
Boron uptake (BPA)

- Rat model with OS, induced by UMR-16
- BPA administration, intra-peritoneal, 4 hours
- Neutron autoradiography + charged particle spectrometry

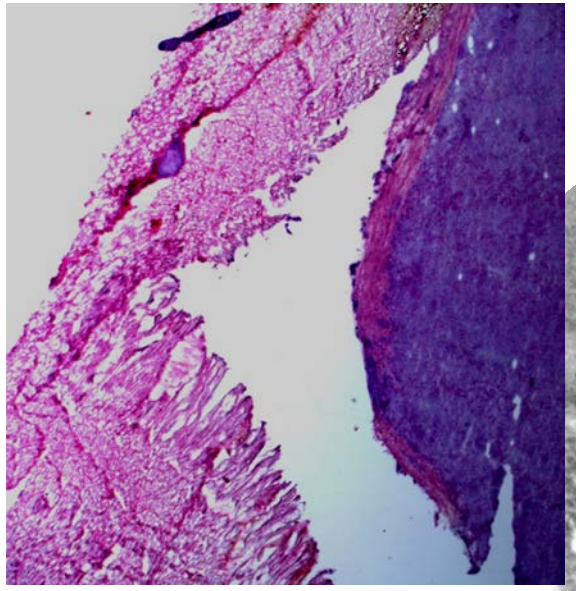


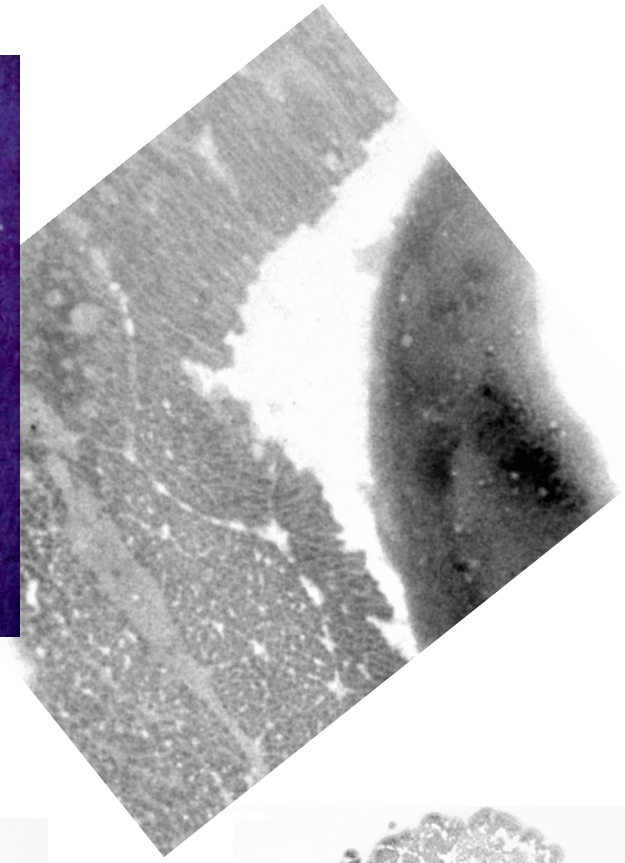
Tumor with necrotic areas, low proliferation, B concentration about 18 ppm

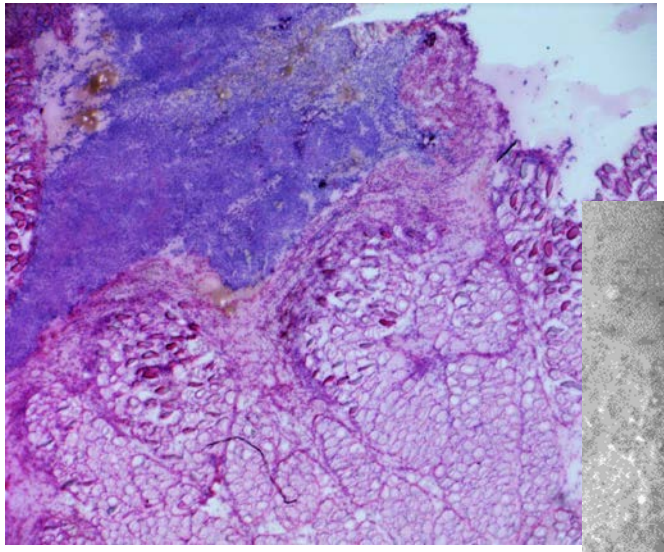
Active tumor
high proliferation
B concentration
about 62 ppm

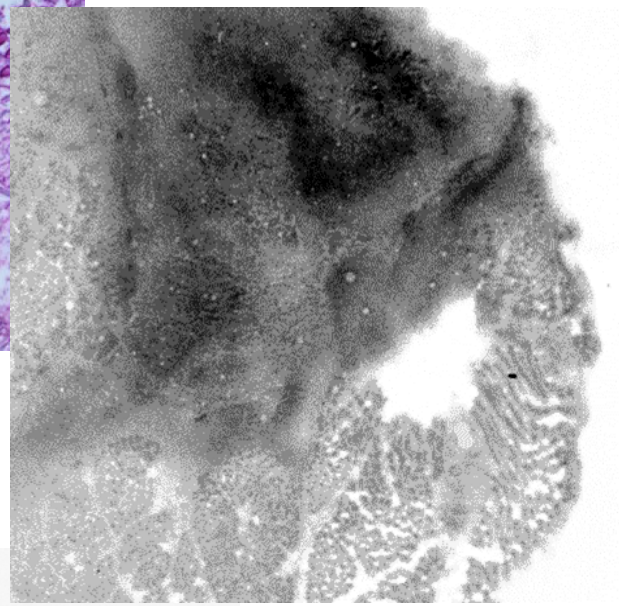


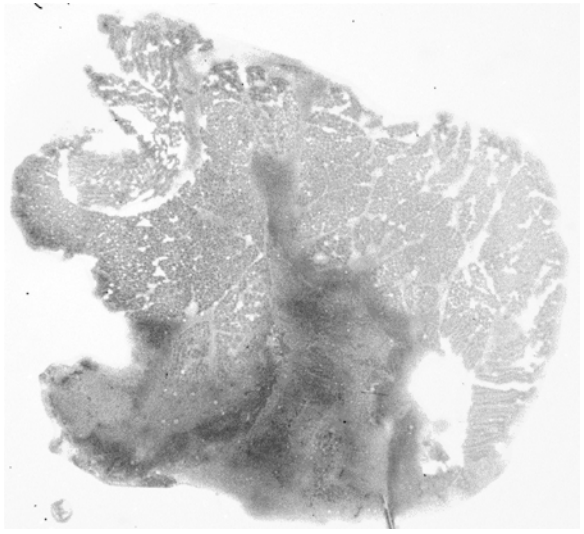
Normal muscle
B concentration
about 15 ppm

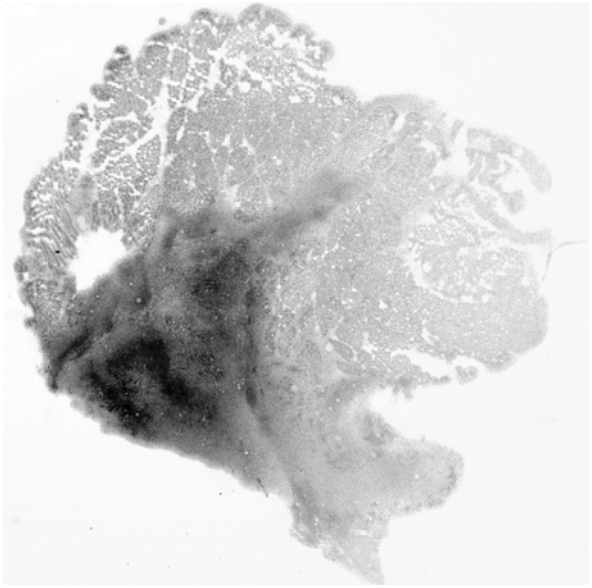


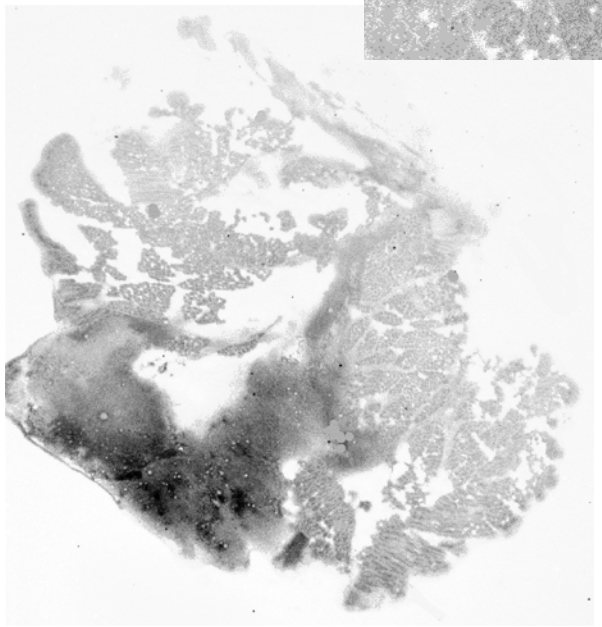












Normal Tissues

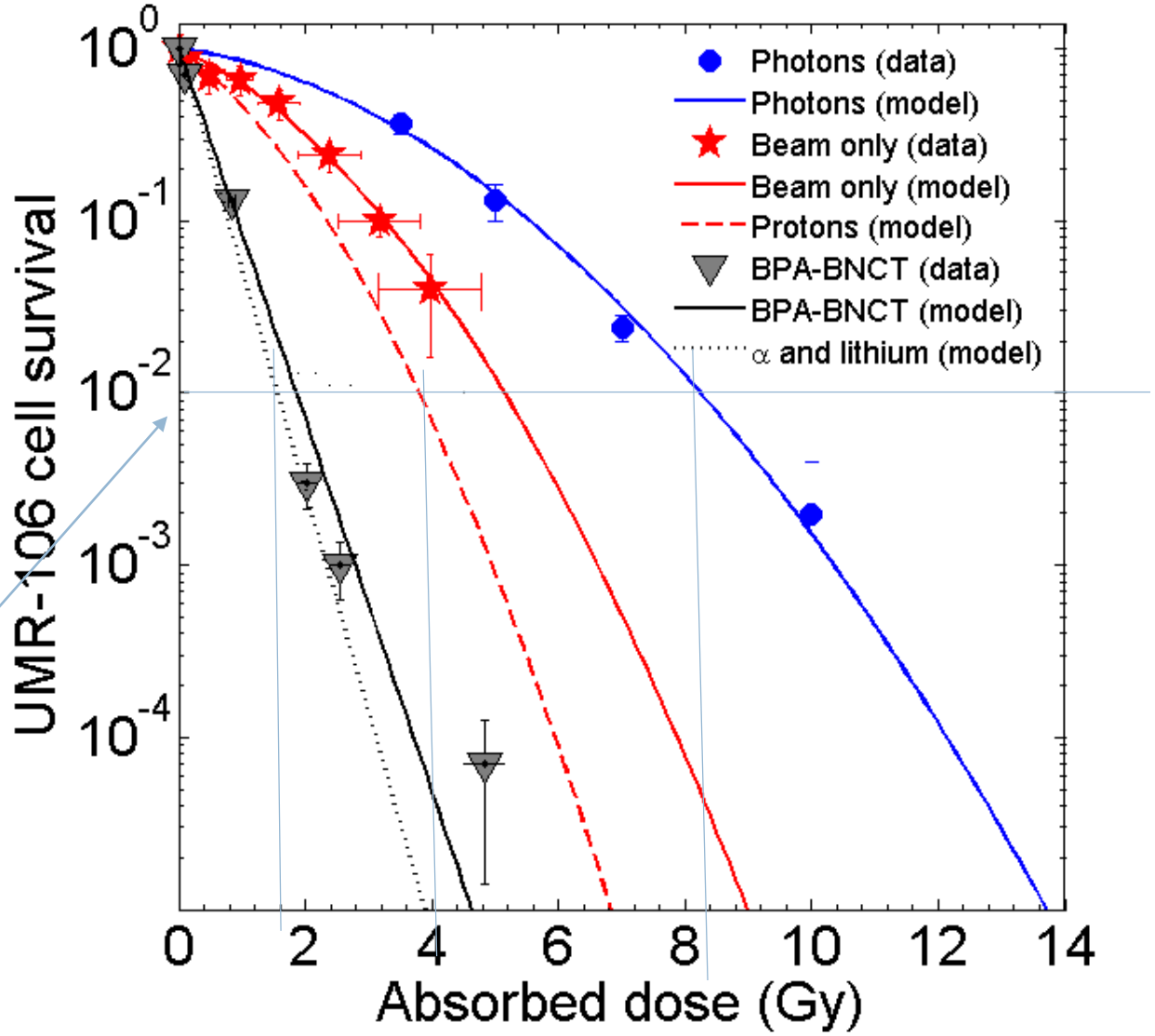
- **Normal muscle** has been chosen for healthy reference because the measurement techniques require sectioning of the tissues.

- ICP measurements (Argentina), neutron autoradiography and alpha spectrometry suggest that **normal bone** **uptakes the same boron concentration** as other normal tissues.

- **Skin**: 1.5 times the concentration in normal muscle (previous experience)

In vitro studies

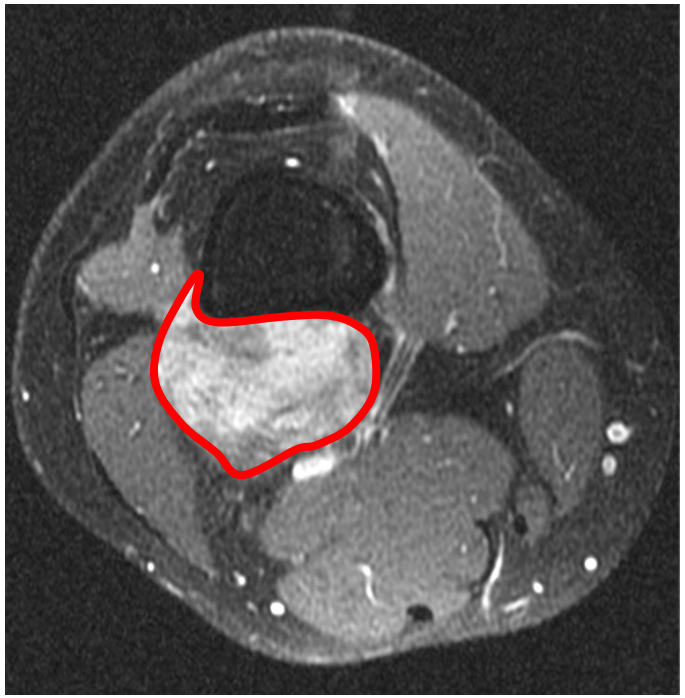
- UMR-106 cell line
- BPA, 80 ppm in medium for 4 hours
- Irradiation @different fluences with and without boron, and with ^{60}Co
- Dosimetry by MCNP calculation, transport of charged particles in cell layer



1% survival level
RBE = 2.2 ± 0.5
CBE = 5.3 ± 1.5

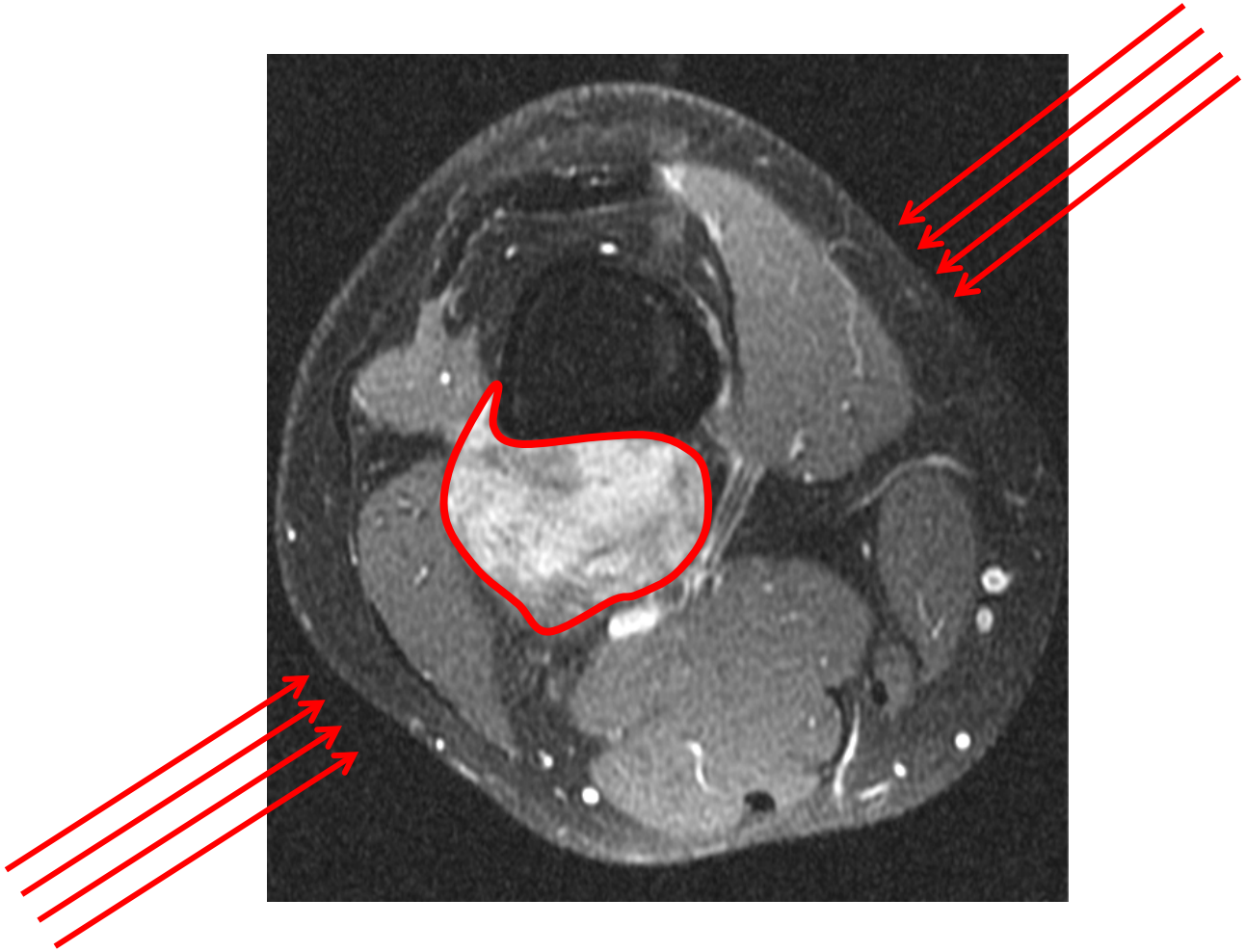
Optimal beam for Osteosarcoma

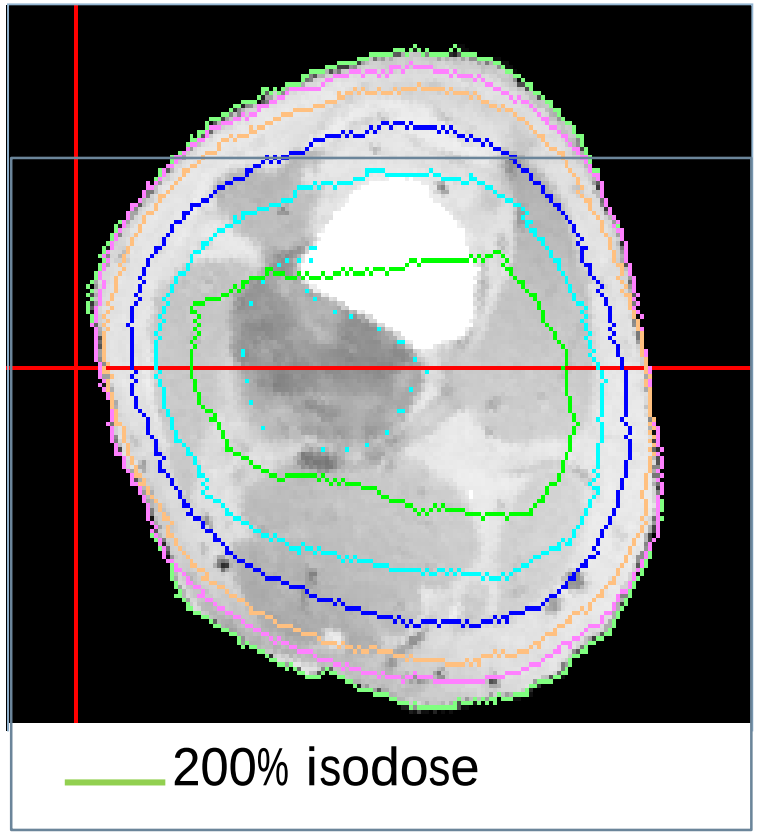
- Treatment Planning calcs with NCTPlan
- Ideal monoenergetic, monocromatic neutron beam, 1 or 2 beam ports
- Different energies: 2 eV, 1 keV, 10 keV



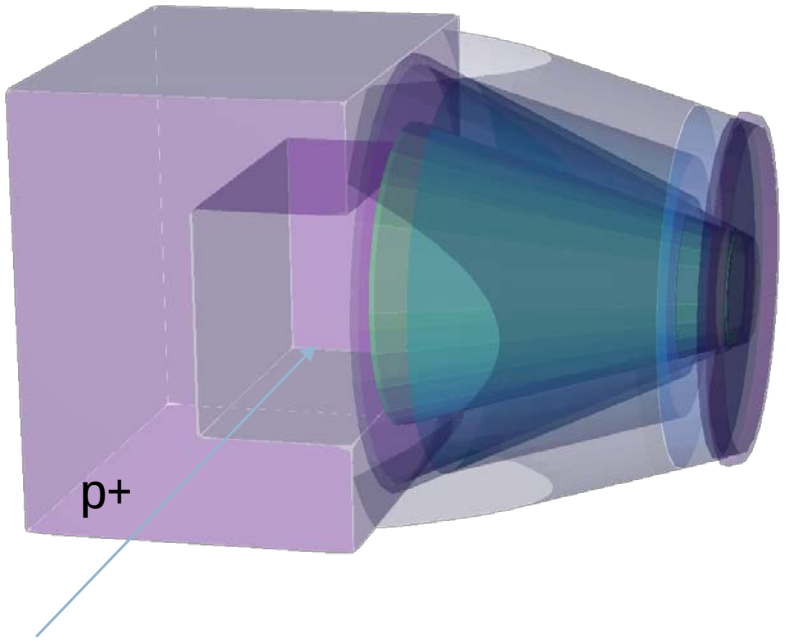
^{10}B concentration (ppm)	
Osteosarcoma	60
Healthy muscle/bone	15
Skin	22.5
RBE/CBE	
Osteosarcoma – boron	5.5
Healthy tissues – boron	2.2
Skin – boron	2.5
Protons	3
Photons	1
PRESCRIPTION	
Max dose to skin	22 Gy-Eq

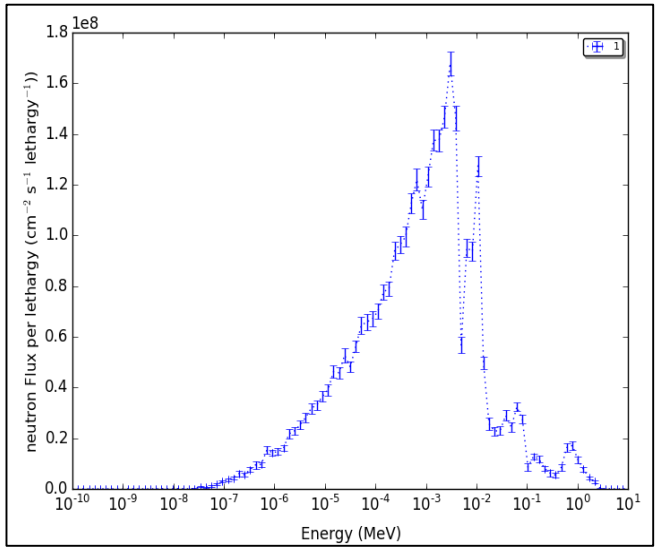
Best results with 1 keV, 2 beam ports

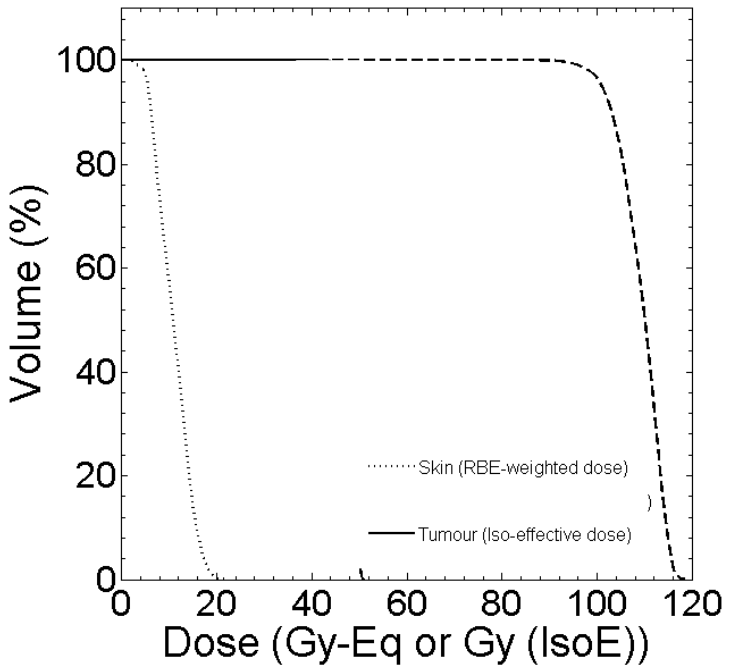




Tailoring of a neutron beam around 1 keV



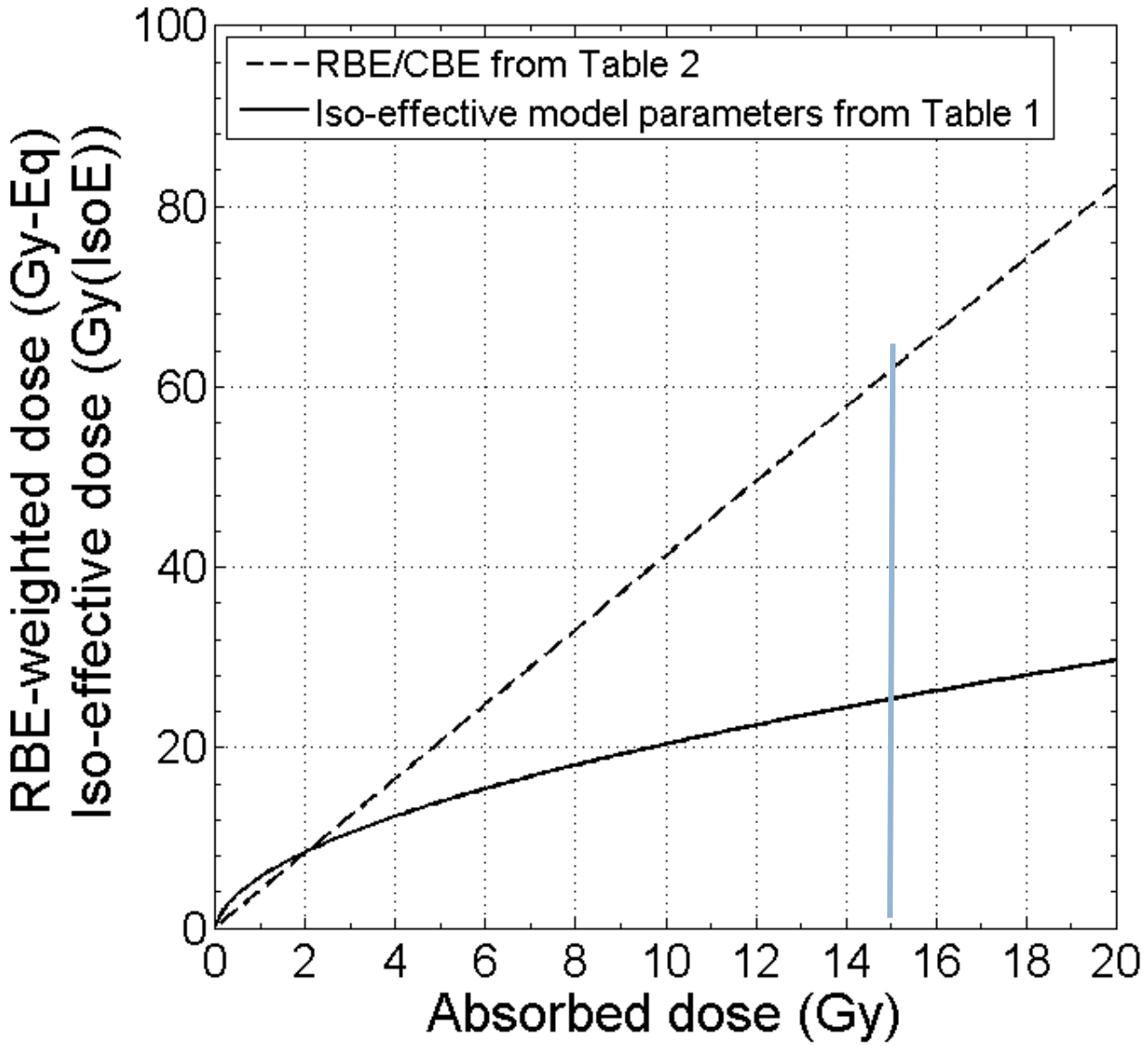




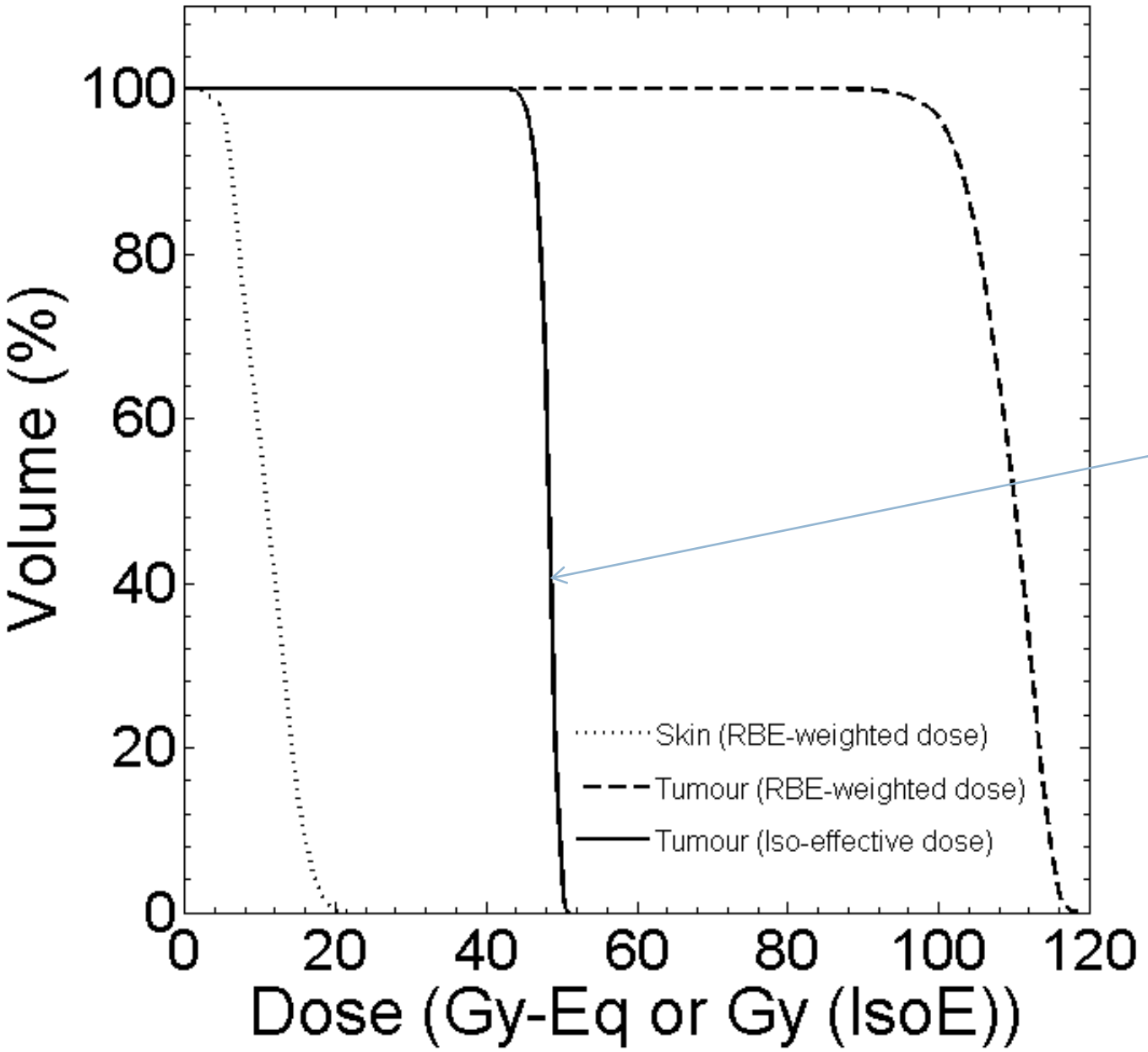
The prescription of 22 Gy_Eq to skin, leads to a minimum dose to tumour of 87 Gy_Eq, a maximum dose of 118.4 Gy_Eq, with a good uniformity in all the tumour volume.

Treatment time: 47 minutes

Photon isoeffective dose



For osteosarcoma, 15 Gy of absorbed dose correspond to RBE-dose of 66 Gy-Eq but to 27 Gy (IsoE).



The prescription of 22 Gy_Eq to skin, leads to a minimum dose to tumour of 43.2 Gy_IsoE, a maximum dose of 51.0 Gy_IsoE, with a good uniformity in all the tumour volume.

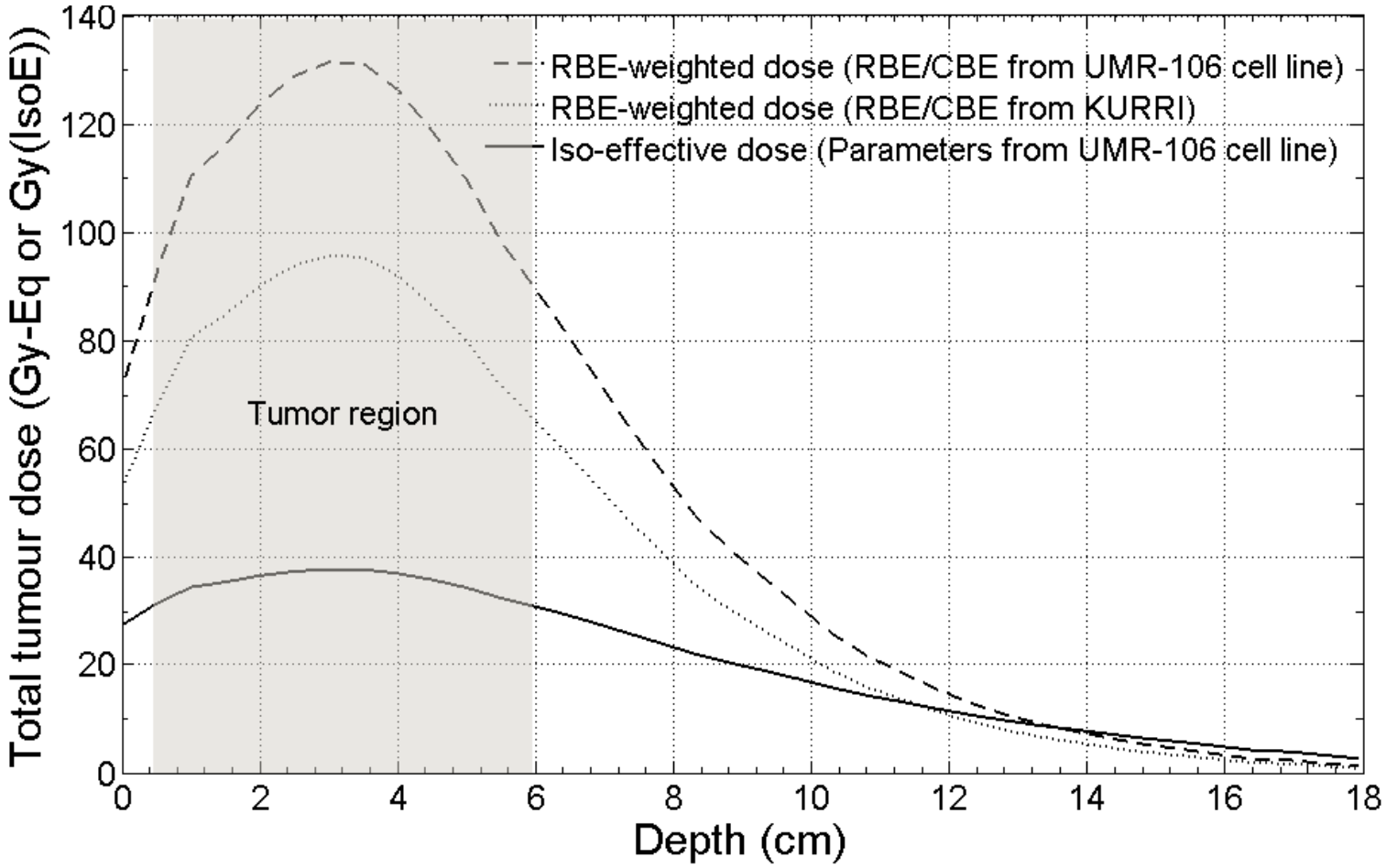
Treatment time: 47 minutes

Questions:

- Preclinical work: BPA ensures a selective uptake in OS
- Treatment planning simulations: dose to tumour significatively high
- Photon isoeffective model: IsoE values are half the standard RBE-dose.

- Would this be therapeutically significant?
- First clinical case of BNCT for OS of the skull

Retrospective dose calculation



- Max doses are similar to those obtained in the limb osteosarcoma with the accelerator.
- Max IsoE dose is about 40 Gy, similar to the MINIMUM IsoE dose obtained in the limb OS.

Conclusions

- Boron concentration measurements in rat osteosarcoma demonstrate selective boron uptake in tumour
- Preliminary in vivo irradiation show tumour destruction even if the set-up was not optimized for leg irradiation
- Computational dosimetry with a accelerator-based epithermal beam shows high minimum dose in tumour and uniform dose distribution prescribing 22 Gy_Eq to skin
- Isoeffective dose proved to be around half the RBE-weighted dose in tumour
- Comparing dosimetry of a successful clinical case with limb osteosarcoma we conclude that BNCT of limb osteosarcoma with these premises is feasible

SILVA BORTOLUSSI
Researcher
Secretary General of ISNCT

UNIVERSITY OF PAVIA- Dept of Physics
INFN - National Institute of Nuclear Physics - Unit of Pavia

Via Bassi 6 - 27100 Pavia Italy
silva.bortolussi@pv.infn.it
+39 0382 98 76 35
+39 320 921 50 01
http://www.bnct.it
http://www.isnct.net

¡Gracias!