BLIN4: Spectral and spatial shaping of laser-driven proton beams using a pulsed high-field magnet beamline.

F. Brack[1,2], F. Kroll[1], L. Gaus[1,2], C. Bernert[1,2], E. Beyreuther[1,3], T. Cowan[1,2], L. Karsch[1,3], S. Kraft[1], L. Kunz-Schughart[3], E. Lessmann[1], J. Metzkes-Ng[1], J. Pawelke[1,3], M. Rehwald[1,2], H.-P. Schlenvoigt[1], U. Schramm[1,2], M. Sobiella[1], E. Rita Szabo[4], T. Ziegler[1,2], and K. Zeil[1]

1 Helmholtz-Zentrum Dresden – Rossendorf, 01328 Dresden, Germany

2 Technische Universität Dresden, 01062 Dresden, Germany

3 OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, TU Dresden

4 Attosecond Light Pulse Source, ELI-HU Nonprofit Ltd., Szeged, Hungary

Intense laser-driven proton pulses, inherently broadband and highly divergent, pose a challenge to established beamline concepts on the path to application-adapted irradiation field formation, particularly for three-dimensional cases. In this presentation we show the successful implementation of a highly efficient (50% transmission) and tunable dual pulsed solenoid setup to generate a homogeneous volumetric dose distribution (cylindrical volume of 5mm diameter and 5 mm penetration depth in water) via multi-energy slice selection from the broad input spectrum. Uncertainties of dose prescription and spatial homogeneity (lateral and in depth) was minimized to a level of less than +/- 5%. Dose delivery of more than 10 Gy per single shot is demonstrated allowing for investigating dose rate effects. The experiments were conducted at the Petawatt beam of the Dresden Laser Acceleration Source Draco and were aided by a predictive simulation model verified by proton transport studies. With the characterized beamline we studied manipulation and matching of lateral and depth dose profiles to various desired applications and radiobiological samples (e.g. tumour tissue spheroids, zebrafish embryos or small tumours grown on mice ears). Concurrent operation of laser accelerator, beam shaping, dosimetry and irradiation procedure of volumetric biological samples was established.

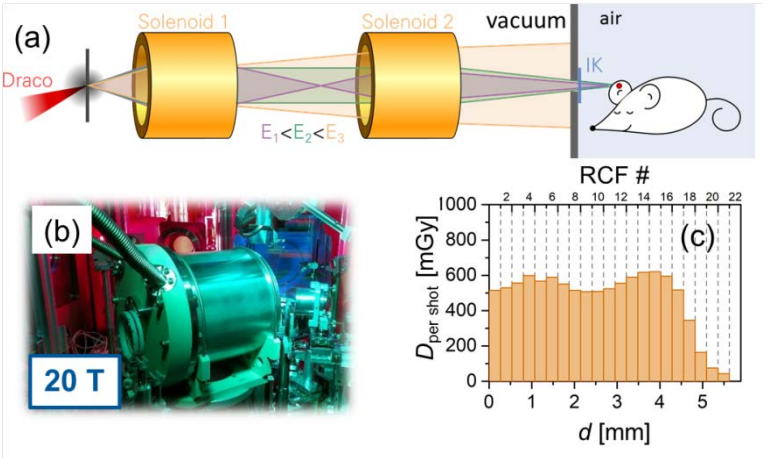

Figure 1: (a) Schematic setup of the dual-solenoid beamline developed at HZDR. (b) Picture of the in-vacuum solenoid which can be operated at up to 20 T. (c) Homogenized depth dose profile measured with a stack of RCF, generated by two different energy bands (E_1 and E_2) focused at the irradiation site.