Initial assumptions for the initial biological proof-of-principle experiment, BioPoP-1

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1 Introduction

The LhARA collaboration has embarked on the development of a proof-of-principle demonstration system that will allow radiobiological investigations using laser-driven proton beams and the commissioning and test of prototype equipment. The vision is that the demonstration system will be developed incrementally on the SCAPA facility at the University of Strathclyde. A schematic of the demonstration system, BioPoP, in SCAPA Bunker B is shown in figure 1a.

The first step in the development of the demonstrator will be the implementation of a minimal capture and focusing system that can be used for first *in-vitro* exposures (BioPop-0, see figure 1b. To expedite the implementation of the system it is assumed that the system will be implemented using permanent magnet quadrupoles.

This document sets out initial assumptions that will be used to develop the full specification for BioPoP-0

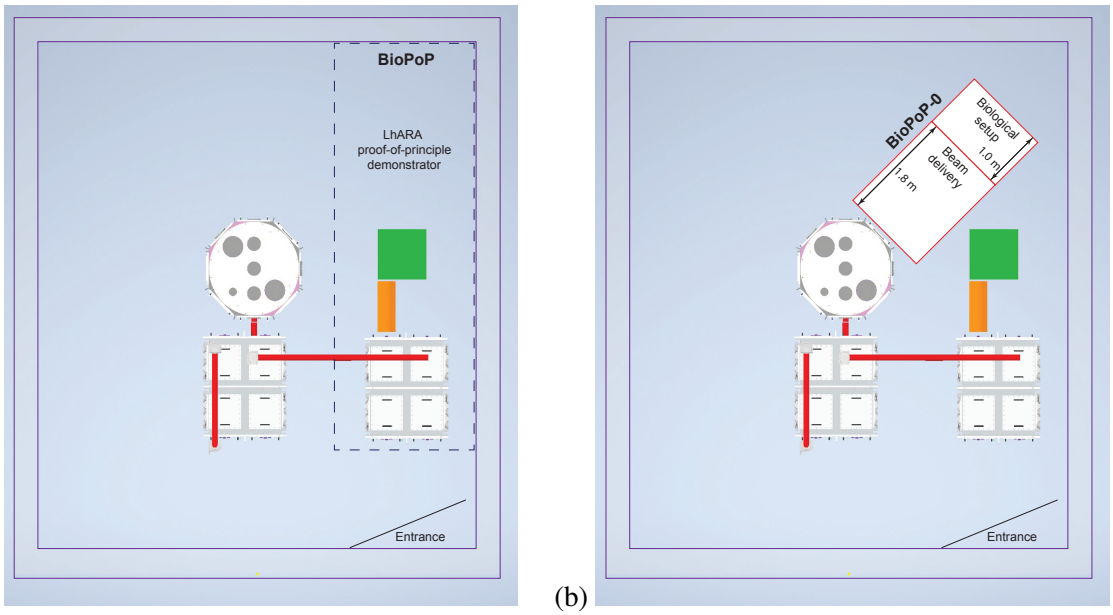

Figure 1: Schematic diagrams of the layout of Bunker B on the SCAPA facility. The present laser transport and octagonal target and experimental chamber is shown in the centre of the figures. The laser enters the octagonal vacuum vessel from the bottom of the figures. The location proposed for the incremental development of the LhARA proof-of-principle demonstration system (BioPoP) is indicated in (a). The space in which it is proposed to implement BioPoP-0 is indicated in (b).

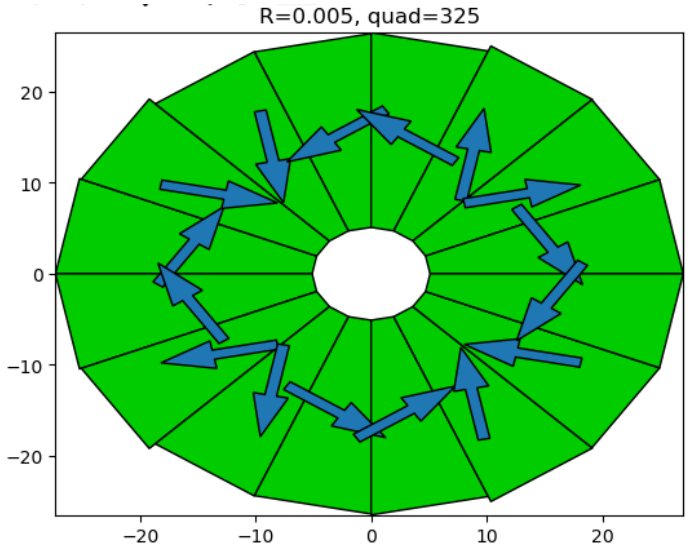

Figure 2: Sketch of the Halbach array configuration for the permanent magnet quadrupole design provided by B. Shepherd (DL).

2 Outline of BioPop-0 in SCAPA Bunker B

A permanent-magnet quadrupole doublet, or triplet, will be installed in the octagonal vacuum chamber to capture and focus protons produced in the laser-target interaction. An evacuated beam pipe will be coupled to one side of the octagonal chamber. The layout allows for a maximum drift of 1.8 m from the surface of the octagonal vacuum chamber to the biological sample holder. A region of length 1 m is reserved for the installation of supports and sample handling systems for the radiobiology experiments.

2.1 Permanent magnet quadrupoles

In an initial discussion, B. Shepherd (DL) provided a design for a permanent magnet quadrupole with an bore of 10 mm and a field gradient of 325 T/m. A sketch of the Halbach array is shown in figure 2.

Initial studies of the detailed layout of the beam line will assume a quadrupole doublet or triplet based on the design shown in figure 2. The length of the quadrupoles will initially be assumed to fall within the range 1 cm – 4 cm. The parameters of the permanent magnet quadrupoles as well as their positions and lengths will be varied to allow the collection and transfer efficiency of the beam line to be optimised.

3 Biological sample handling

The layout of the two floors of the SCAPA facility are shown in figure 3. A biological preparation laboratory has been identified on the floor 2. The floor area of the biology preparation laboratory is $3.7 \times 3\,\mathrm{m}^2$. The Laboratory is presently equipped with 2 biosafety cabinets and an incubator.

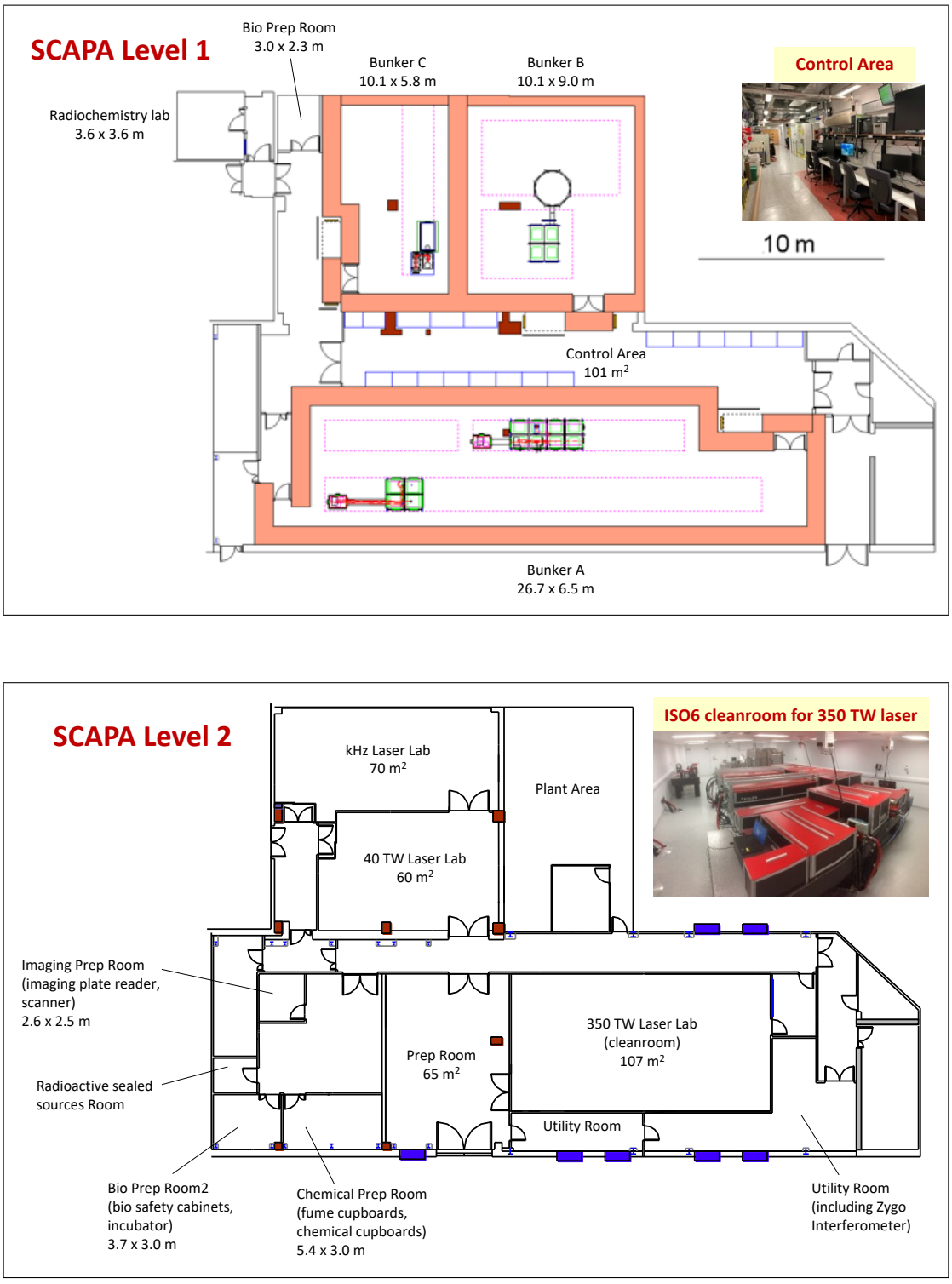

Figure 3: Layout of the two floors of the SCAPA facility. The bunkers used for experiments are shown in the top panel. The laser laboratory, control room and other facilities are shown in the bottom panel. The biological preparation laboratory is indicated at the bottom left-hand corner of the Level 2 schematic.