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THE TERAHERTZ BEAMLINE AND TISSUE CULTURE FACILITY ON THE ALICE ACCELERATOR AT THE DARESBURY LABORATORY

A description is given of the terahertz beamline and tissue culture facility that is being commissioned on the ALICE accelerator at the Daresbury laboratory.
Keywords: terahertz**,** epithelial cells, keratinocytes, nerve cells, stem cells.

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КАНАЛ ТЕРАГЕРЦЕВОГО ИЗЛУЧЕНИЯ И УСТАНОВКА ДЛЯ ИССЛЕДОВАНИЯ КУЛЬТУР ТКАНЕЙ НА УСКОРИТЕЛЕ ALICE В ЛАБОРАТОРИИ ДАРСБЕРИ

Описываются канал терагерцевого излучения и установка для исследования культур тканей, запускаемая на ускорителе ALICE в лаборатории Дарсбери.
Ключевые слова: терагерцевый, клетки эпителия, кератиноциты, нервные клетки, стволовые клетки.

A Terahertz (THz) beamline and tissue culture facility (TCF) is currently being commissioned on the ALICE accelerator at the Daresbury laboratory in the UK (Fig. 1). ALICE is an energy recovery linear accelerator [1], based on superconducting technology, that was originally developed as the prototype for the UK fourth generation light source, 4GLS [2–5]. The 4GLS project has now been subsumed into the UK NLS proposal and ALICE has become a development facility for accelerator technology.

However although ALICE is not a user facility and is not intended for scientific research it has been possible to construct the THz beamline and TCF with funding from the UK North West Development Agency (NWDA) and the University of Liverpool. In addition the UK Engineering and Physical Science Research Council has funded a programme of scientific research concerned with testing the controversial Frohlich hypothesis concerning the mechanisms of biological organisation [6–8].

The key feature of the ALICE accelerator that makes it an ideal source of THz radiation is that as an energy recovery system the electron bunches circulate round the machine only once and this makes it possible to keep the bunches small. As a result when the electron bunch traverses a magnetic field one obtains coherent emission at wavelengths longer than the bunch length [9]. ALICE is designed to have

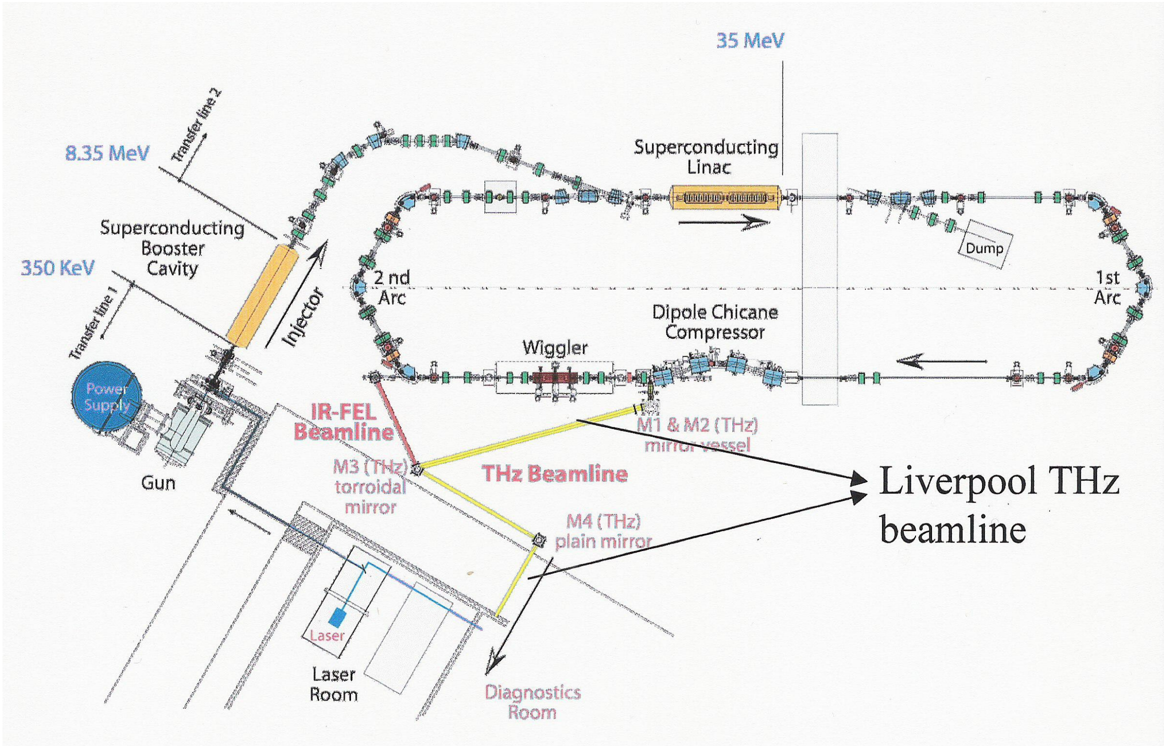

Fig. 1. The ALICE energy recovery linear accelerator at the Daresbury Laboratory

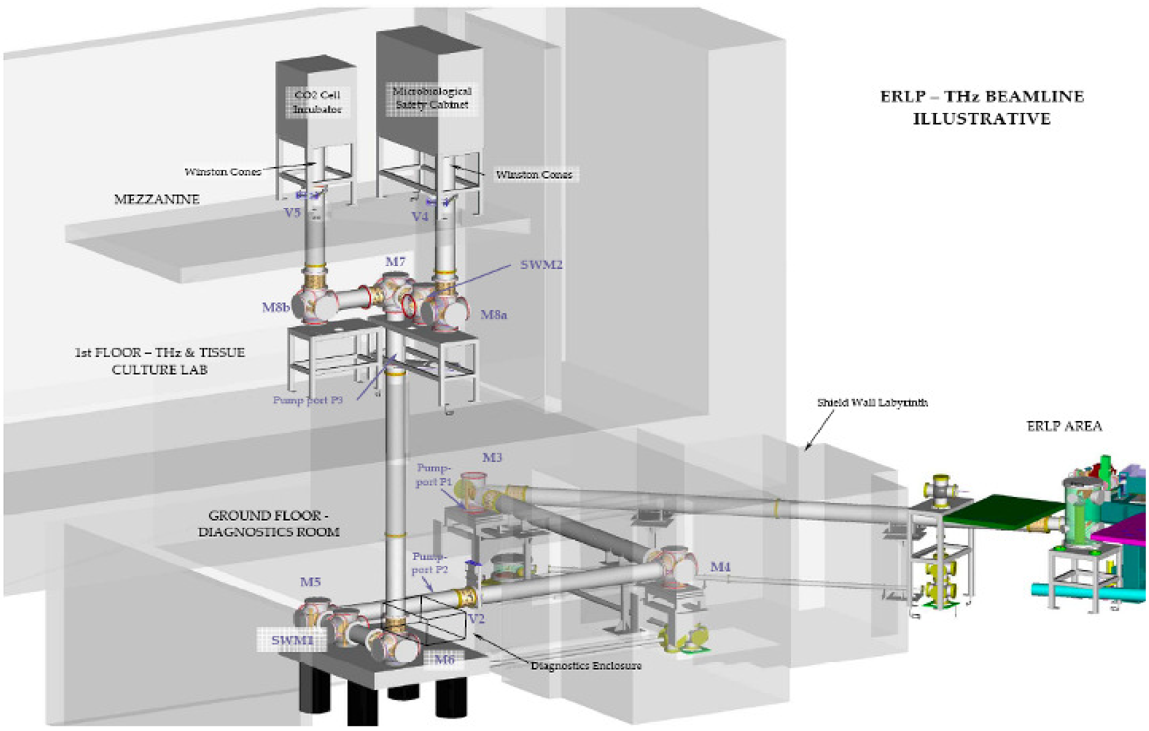

Fig. 2. The beamline on ALICE that directs THz radiation from the accelerator to the tissue culture facility

Fig. 3. The tissue culture facility established on the THz beamline. One THz line can be seen entering through the floor of the laboratory and into the bottom of the CO_2 incubator in the centre of the photograph. A second THz line enters through the bottom of the microbiological safety cabinet on the left. The THz output from the beamline can be switched between these lines for the radiation of live human tissue

Table 1: Comparison of design and current operating parameters for the ALICE accelerator as of September 2010

	Design	Operating
Accelerator Energy (MeV)	35	27.5
Bunch Charge (pC)	80	40
Bunch repetition rate (MHz)	81	81
Max Macro bunch length (μsecs)	100	100
Max Number of Bunches/Train	8125	8125
RMS Bunch length (ps)	0.6	0.8
Bunch train repetition rate (Hz)	20	10

a bunch length of 0.6 ps with the result that coherent emission is expected to be observed for radiation of frequencies up to ~ 1 THz. The THz radiation from ALICE is extracted from a mirror located in the accelerator which directs the radiation out through a diamond window and into the beamline (Fig. 2). The beamline directs the THz radiation into a diagnostics room and then up to the tissue culture facility which is on the next floor (Fig. 3). The tissue culture facility satisfies the requirements for work on cancerous tissue and is equipped with a CO_2 incubator and a microbiological safety cabinet. A switch mirror in the beamline makes it possible to direct the THz radiation through the base of either of these units for the direct irradiation of biological material in the conditions needed to maintain it in a healthy state.

Energy recovery was achieved on ALICE in December 2008. Measurements of the THz intensity with a power meter at the diamond window gave results that are consistent with the expected performance. In addition the THz intensity varies linearly with the length of the bunch train at a constant bunch charge and quadratically with the bunch charge at a constant train length. These are the expected characteristics of coherent emission [10]. Table 1 shows a comparison between the theoretical and current operating parameters of the ALICE beamline confirming the expected performance of the accelerator.

Commissioning experiments are continuing on optimising the performance of ALICE and in directing the THz radiation into the beamline efficiently. In parallel with the programme of commissioning the THz beamline experiments are being conducted in a temporary CO_2 incubator that has been set up inside the accelerator shield wall and taking THz radiation in a direct line with the diamond window. These experiments are concerned with the exposure of corneal epithelial cells, retinal pigment epithelial and stem cells to high intensity THz radiation with a view to establishing the safe limits of human exposure to this radiation.

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