ORIGIN

optical fibre dose imaging for adaptive brachytherapy

"Delivering more precise and effective brachytherapy for cancer treatment"

SUMMARY

The ORIGIN project addresses the urgent need to deliver more precise and effective brachytherapy for prostate and gynaecological oncology, through the introduction of novel optical fibre technology. The project expands on the successful development of two innovative single point optical fibre dosimeters based on radio-luminescence using inorganic scintillating materials for High Dose Rate (HDR)- and Low Dose Rate (LDR)-brachytherapy (BT). The ORIGIN system prototype integrates an array of such sensors with a common acquisition system to provide real-time patient dose imaging of the target area and nearby organs at risk, which is currently unavailable. The high temporal resolution of the sensor system (0.1 sec) provides the ability to further monitor the location of the radiation sources during treatment with 0.5mm spatial resolution for HDR-BT and 3mm for LDR-BT.

OBJECTIVES

System Design

- *Design and fabricate 16 point sensor array for LDR/HDR - BT*
- *Develop a control and data acquisition system*
- *Develop algorithm for 3D dose imaging of the tumour and OARs*
- *Devise localisation strategies to monitor radiation sources*

Clinical Development

- *Demonstrate the clinical validity of the ORIGIN system in clinical prostate and gynaecological phantoms*
- *Develop a protocol for integrating ORIGIN with existing treatment planning software*
- *Integrate the ORIGIN system within a commercial brachytherapy afterloader*

Manufacturability

- *Modify the sensing tip design to provide an increase in optical efficiency*
- *Optimise sensor design for high-throughput cost effective mass-manufacturability*
- *Undertake market and regulatory assessments to provide a clear path to market beyond the project*

Brachytherapy

Radiotherapy is the use of ionizing radiation for the treatment of cancer and 50 – 60 % of patients require radiotherapy at some point during their treatment . It is delivered in the form of external beam radiotherapy (EBRT), using linear accelerators (linacs), or internally, known as brachytherapy (BT). Brachytherapy is further divided into Low Dose Rate (LDR), where the radioactive sources, known as seeds, remain implanted permanently, and High Dose Rate (HDR), where higher activity radiation sources are temporarily implanted.

High Dose Rate (HDR) Brachytherapy

Single radiation source attached to wire – driven by afterloader
Iridium-192 or cobalt-60
Source removed at end of treatment

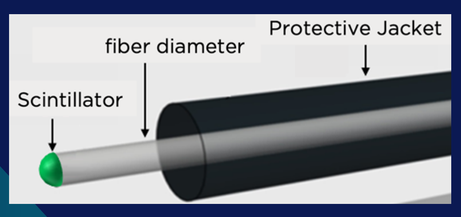
Low Dose Rate (LDR) Brachytherapy

Typically, 60 – 80 "seeds" permanently inserted
Iodine-125
Primarily used for prostate cancer

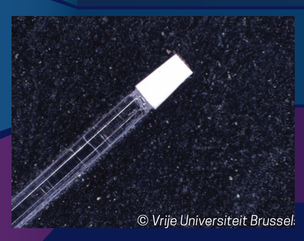
ORIGIN brings together a highly multidisciplinary consortium of leaders in their respective fields, including photonics, engineering, medical physics, oncology and medical devices.

SYSTEM DEVELOPMENT & CLINICAL INTEGRATION

1. Sensor Optimisation & Fabrication



The design of the optical fibre sensor tip, which holds the scintillator, has been optimised. Two sensor types, using different scintillators, have been developed: LDR: Gd2O2S:Tb (Gadox) & HDR: 4YVO4:Eu+1Y2O3:Eu (YVO).



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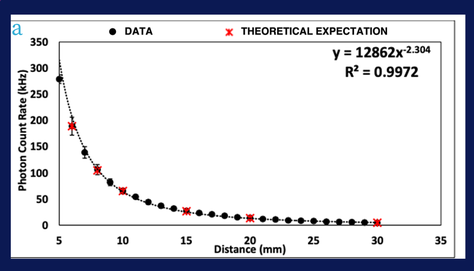
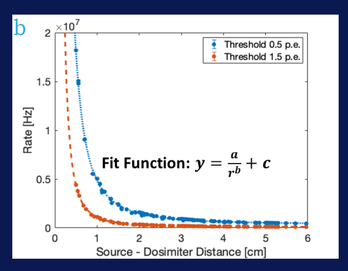
2. 16-Channel Detector System Development

A multi-fiber module has been developed using 16 fiber sensors, 16 SiPMs (1x1 mm2), with front-end readout based on a CITIROC1A ASIC and a CAEN FERS board.

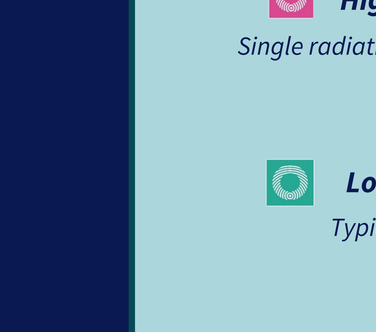




Silicon Photomultiplier (SiPM) response for LDR (a) and HDR (b) sensors as a function of the source to sensor distance. The sensors are capable of monitoring the radiation dose at distances compatible with brachytherapy.

Initial evaluation of the 16-Channel system, with sensors placed surrounding the Ir-192 Source. The source is lowered from a height 10cm from above the sensors to parallel to the sensors (0cm) and the optical signal monitored accordingly.

3. Dose Mapping & Source Localisation



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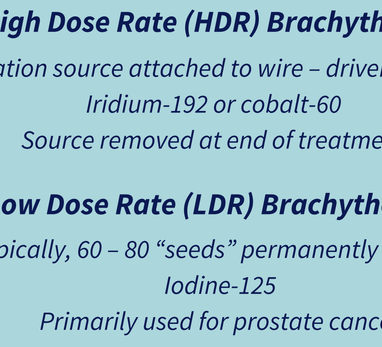

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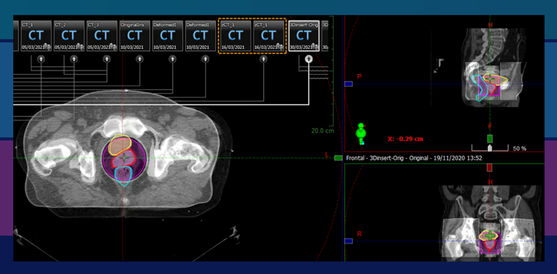
3D plot of dose map for accumulation of 62 Iodine seeds (a), overlayed on a DICOM (TRUS) image-set (b); 3D surface plot indicating seed coordinates (c).

4. Phantom Development for System Evaluation



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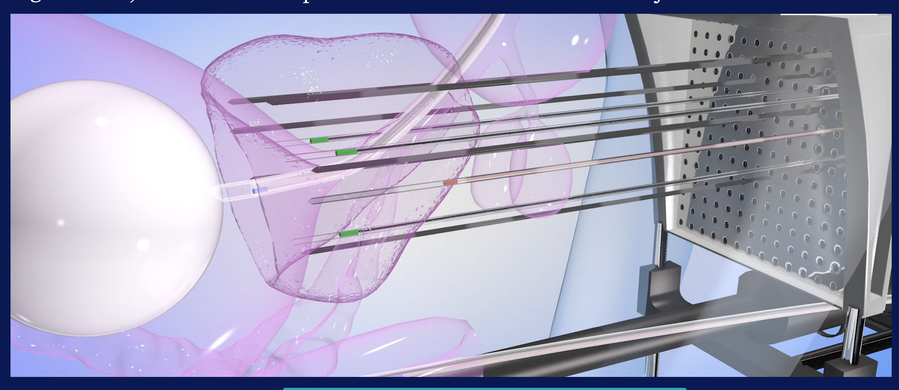
3D printed phantom prototypes were developed to provide semi-anatomical phantoms for use in the evaluation of the dosimetry system.

5. Integration with Clinical Systems

The ORIGIN system is being developed as a standalone system compatible with existing treatment planning systems and also fully integrated with the BEBIG SagiNova® HDR afterloader. The sensors record a dose related to the insertion of every new seed (LDR) or source movement (HDR). This dose is then compared with the time-integrated dose fraction planned by the TPS. A position shift of one or more seeds will lead to a difference in dose distribution with respect to the planned dose. When the difference is significant, the treatment plan can be re-evaluated and adjusted if needed.



IMPACT

ORIGIN will result in significant impacts on:

- Society: with improved patient outcomes, reduced treatment risks, reduced hospital stays and thereby increasing patient treatment numbers
- Industry: establishing Europe at the fore of brachytherapy system development and photonics manufacturing
- European economy: reducing the economic burden of cancer and costs associated with treatment errors and increasing employment owing to photonics-enabled products

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

The ORIGIN project is an initiative of the Photonics Public Private Partnership (www.photonics21.org) and has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement no 871324.

More Info

ORIGIN@ul.ie
www.origin2020.eu
@ORIGIN2020