ORIGIN

optical fibre dose imaging for adaptive brachytherapy

ORIGIN Newsletter **VOL 3** **DEC 15, 2023**

Welcome to the latest edition of the ORIGIN'newsletter!

Here you can find out more about:

- The project - get the latest news and updates on ORIGIN activities and watch our new video!
- The team - meet our clincial partners in Queens University Belfast, Blackrock Heath Galway Clinic and Central University Hospital of Asturias
- The stats - get a snapshot of current ORIGIN progress
- What's next - check out upcoming ORIGIN events and activities

ORIGIN'S TECHNICAL VIDEO!

The ORIGIN project is an initiative of the Photonics Public Private Partnership (www.photonics21.org), and has received funding from the European Union's 2020 research and innovation programme under grant agreement No. 871324

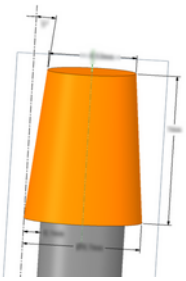
PHOTONICS 21

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

The latest ORIGIN Research

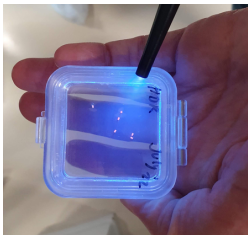
SYSTEM DEVELOPMENT & MANUFACTURABLITY

The method of fabrication of the optical fibre sensors has been optimised and a final batch of 64 LDR-BT and 65 HDR-BT probes have been delivered to the clinics. The final sensor tip has a truncated cone design. This design was chosen as it achieves the best optical performance and also supports the fabrication and assembly process.



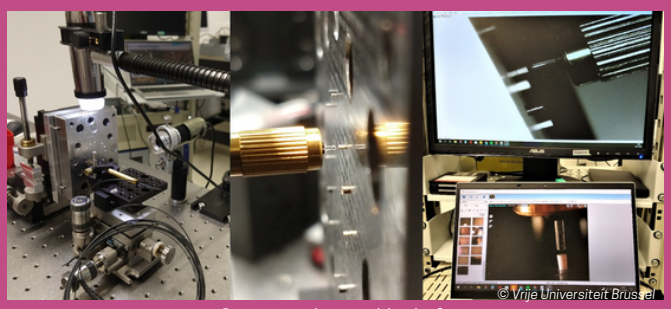
Sensor tip design

The scintillating tips are fabricated by means of a two-step process using hot embossing and compression moulding to first manufacture a substrate from which the tips are made using a transfer moulding tool. The tips are then attached to the polished facet of the polymer optical fiber.



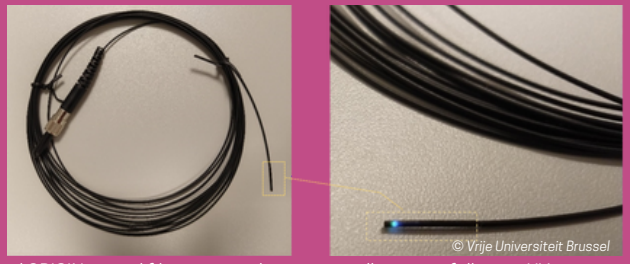
R; Sample HDR sensor tips composed of an inorganic scintillator fluorescing upon exposure to UV light

A customised assembly platform was developed to mount the the sensor tips to the fibre. This enabled the gluing of the scintillating tip to the polymer optical fibre facet with considerable alignment accuracy and speed.



Customised assembly platform

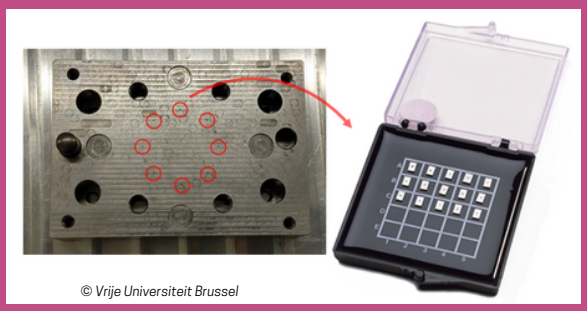
In total, 317 optical fibre sensors have been fabricated, demonstrating small-scale repeatable fabrication within acceptable tolerance limits.



Final ORIGIN optical fibre sensor showing scintillating tip following UV excitation

Although the scintillating material differs for LDR-BT and HDR-BT, the design of the probes are identical. Therefore the same fabrication process and equipment can be used, increasing the manufacturing efficiency and decreasing costs.

While the fabrication process developed within the project is sufficient for small scale production, the ability to scale up to larger quantities requires the incorporation of some automated steps. The automated assembly of the optical fibre sensors would significantly increase throughput to medium scale manufacturing. A “pick and place” automated assembly of the tips to the fibre is currently being trialed as a proof-of-concept on a pilot line by FiconTec, a photonics automated assembly and testing company .

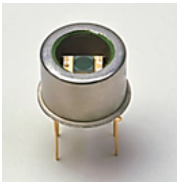


Pick and place automated assembly

The multi-channel detector system employs silicon photomultiplier (SiPM) technology which enables the detection or “counting” of single photons. This provides both the sensitivity and range required for different brachytherapy treatments.

When exposed to ionising radiation the scintillating tip of the sensor emits photons of light which travel along the optical fibre to the detector system. The photon count rate (PCR) is measured, which is the signal generated above the dark count rate (DCR) due to the scintillation. The HDR detector system has been finalised and delivered to the clinics. However, due to the sensitivity required for LDR-BT at the larger distances a modificaton to the LDR detector system is required.

Thermo-electric (TE) cooled SiPMs where the DCR is strongly reduced by operating the detector at -20oC have been employed. In addition, an optical focusing system was designed to focus the emitted light on the sensor surface to further increase the sensitivity of the system.



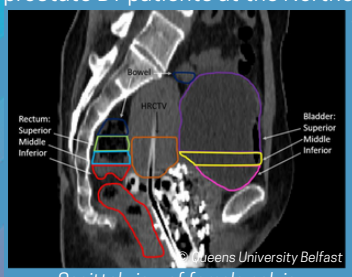
TE cooled SiPM

Optical focusing system

The latest ORIGIN Research

CLINICAL INTEGRATION

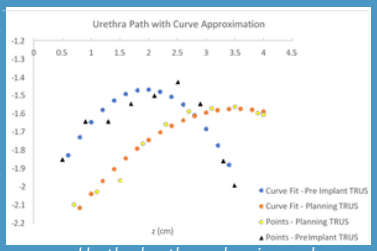
A protocol for the integration of the ORIGIN system with existing treatment planning systems is currently being developed. An important aspect of this is examining the clinical need for in vivo dosimetry and determining the optimal position of the sensors to monitor the radiation dose in real-time. Treatment planning studies were performed on image datasets of HDR gynaecological BT and LDR prostate BT patients at the Northern Ireland Cancer Centre Belfast.



Sagittal view of female pelvis

The assessment of 20 consecutive HDR cervical BT patients concluded that organs at risk such as the bladder, rectum and bowel, move between treatment fractions and can necessitate a reduction in the dose prescribed.

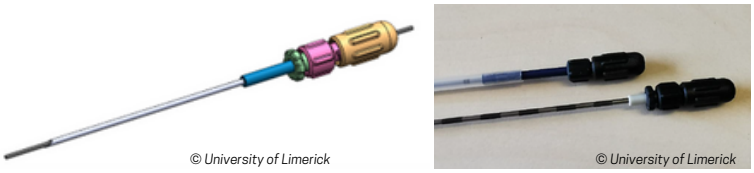
30 patient's undergoing two-step LDR BT were examined for positional differences between the planning ultrasound and implant procedure. A significant difference in the curvature of the urethra led to an increased number of cases exceeding dose constraints to the urthetra.



Urethral path on planning and pre-implant ultrasound

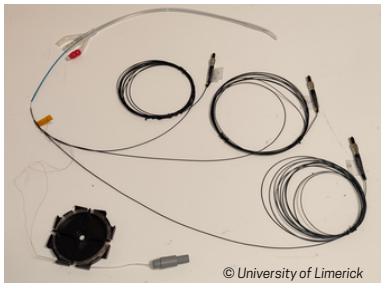
There is a need for in vivo dosimetry due to the potential for organ movement.

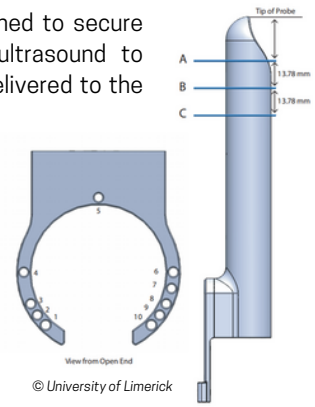
A careful consideration of the ORIGIN system development has been to ensure it is compatible with existing clinical practice and equipment. Several custom made devices have been designed to enable the ORIGIN sensors to be secured within existing brachytherapy applicators.



Fibre securement device to fix the optical fibre sensor within the brachytherapy needle

A rectal probe accessory has been designed to secure multiple sensors around a transrectal ultrasound to enable monitoring of the radiation dose delivered to the rectum during the treatment.





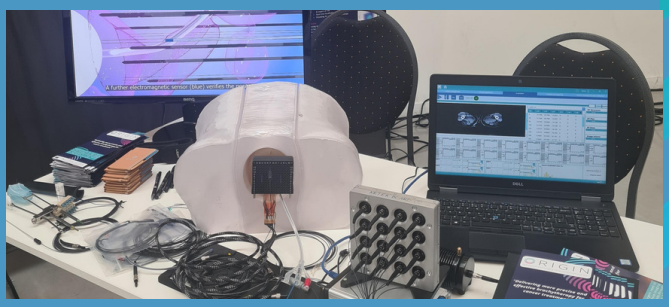
Rectal probe

A urethra bundle has been designed to place the sensors within a Foley catheter such that they are optimally positioned to monitor the radiation dose to the urethra and bladder.

The ORIGIN software integrates the hardware modules with the source localisation and 3D dose mapping algorithms through a central graphical user interface. The software provides real-time data on the accumlated dose, the dose-rate, and the source position. The real-time availabiliy of this data provides the user with vital information througout the treatment and crucially, allows the treatment to be adjusted or halted, greatly decreasing the incidence of grave errors.

The software has been developed such that it can be used with any treatment planning system and is user-friendly, ensuring that it will be easily integrated into existing clinical workflows. The software is currently being tested and validated in the clinics.

ORIGIN SYSTEM PROTOTYPES



ORIGIN prototype exhibited at EWOFS 2023

The first fully integrated Standalone ORIGIN Prototypes for High Dose Rate (HDR) and Low Dose Rate (LDR) brachytherapy have been assembled. They are currently undergoing clinical testing in the hospitals. Prostate and gynaecological anthropomorphic phantoms which closely mimic the human body are being 3D printed to provide clinically relevant testing environments.

R; Demo of prostate HDR BT procedure with ORIGIN sensors placed within the target, urethra and rectum.

ORIGIN Team

MEET THE TEAM AT QUB

L-R; Dr Conor McGarry, Prof. Kevin Prise, Prof. Suneil Jain, Mr Owen McLaughlin, Dr Orla Houlihan, Prof Alan Housell, Ms Monica Byrne, Mr Sergio Esteve and Dr Geraldine Workman

The team at Queen's University Belfast leads workpackage 5 which covers clinical system evaluation and validation of the Origin Project. The team is multidisciplinary consisting of clinical oncologists, clinical physicists, medical physicists and radiobiology researchers. Together they have been testing the Origin system under clinical conditions relevant to HDR and LDR brachytherapy treatments in collaboration with colleagues at the Galway Clinic (GC) and the Central University Hospital of the Asturias (HUCA). A key task has been undertaking treatment planning studies to define the clinical parameters for in vivo dosimetry with the Origin system and also developing clinical protocols for its eventual clinical use.

Tell us about your hospital department and the types of patients you treat?

The Northern Ireland Cancer Centre is based in Belfast and is a large treatment facility, with 10 linear Accelerators and HDR/LDR Brachytherapy treatment equipment and associated imaging and treatment planning facilities. Approximately 4,400 external beam and 175 brachytherapy patients are treated per year. Within brachytherapy both gynaecological and prostate cancers are treated.

Why did you want to get involved in the ORIGIN project?

Within the radiotherapy process there are constant strides to ensure the radiation treatment is safe and effective. For brachytherapy this is particularly important as the use of radioactive sources internally means that the accuracy of placement of these sources is a crucial element of the procedures to ensure the prescribed dose is delivered to the target volume and the dose to radiosensitive organs is below accepted tolerance levels. The purpose of the ORIGIN work to develop and test in vivo dosimeters and sensors with the aim of verifying the dose distribution at the time of dose delivery is an exciting project. It would have real impact in the clinical workflow, by ensuring the treatment is safe and effective, leading to better clinical outcomes for target coverage and reduced toxicities for radiosensitive organs.

What do you most like about working on ORIGIN?

Working in a multidisciplinary team, with both research and clinical colleagues. The chance to work with international teams, either in university, industry or hospital settings has been interesting and rewarding. Being part of a project that will benefit brachytherapy patient treatments is a great opportunity.

MEET THE TEAM AT GC

Galway Clinic, part of Blackrock Health, is the leading provider of private cancer care in the West of Ireland. It has 120 Consultants across 60 specialties. The Galway Clinic is also an affiliated teaching hospital to the Royal College of Surgeons in Ireland (RCSI) and National University of Ireland Galway (NUIG).
One of the main aims of the Galway Clinic was to introduce Cancer Care services to the West of Ireland. The Galway Clinic introduced vital services such as Oncology treatment and Cardiac services in 2004. We also provide the widest range of treatment for Prostate Cancer in the West of Ireland.

L-R; Mr Keith Scully, Research Medical Physicist, Mr Peter Woulfe, Chief Medical Physicist and Prof. Frank Sullivan, Consultant Radiation Oncologist

What is your role within ORIGIN?

The Galway Clinic is responsible for leading the clinical development, integration and validation of the ORIGIN system for LDR prostate brachytherapy. The goal is to develop a novel optical fibre based sensor system to deliver more precise and effective BT and improve patient outcomes. Optical fibre based sensors have the small size required for insertion into BT needle applicators/catheters, allowing for potential in-vivo measurements during a procedure.

Why did you want to get involved in the ORIGIN project?

The novel dosimetry solution developed within the ORIGIN project can be translated into other radiotherapy departments within the Blackrock Health group, since the system has been designed such that it is compatible with existing clinical equipment (e.g. needle applicators, catheters, etc.), allowing for it to be easily implemented within existing clinical environments. This system will provide radiation oncologists with the tools required for real-time adaptive brachytherapy for their patients, enabling more consultants to safely incorporate this treatment within their practice. Brachytherapy is a highly complex procedure in a live theatre environment and the implant is performed and adapted on the day. Currently, the only guidance for the Consultant is a software program to visually indicate where the sources are implanted in the prostate. ORIGIN will give the Consultant the real-time information that they require to verify treatment accuracy, enhance patient safety and improve patient outcomes.

ORIGIN Team

How will ORIGIN impact the future of Brachytherapy?

The ORIGIN optical fibre based sensor system developed in this work, and characterised using a custom water-phantom system, was employed to obtain precise optical fibre sensor measurements for applications in LDR prostate BT. Radiation dosimetry measurements obtained agreed with theoretical expectation with unprecedented accuracy. It is also worth noting that the ORIGIN system employs a multi-point sensing configuration, comprised of 16 optical fibre sensors. The use of multiple sensors, and flexibility in terms of where each sensor can be placed, allows for both the localisation of individual radioactive sources and the ability to visual radiation doses in 3D (both dose to the target area and organs at risk). Furthermore the ORIGIN system is designed such that it is compatible with existing clinical equipment (e.g. needle applicators, catheters, etc.), allowing for it to be easily implemented within the existing clinical environment. The initial results obtained by the ORIGIN team demonstrate the potential for the novel ORIGIN dosimetry solution to be employed during a clinical procedure. This will provide for optimised dose-led, patient-oriented, personalised treatment plans leading to improved patient outcomes and prevention of treatment errors, with the potential to reduce the overall risk of treatment error by 55%.

SERVICIO DE SALUD
DEL PRINCIPADO DE ASTURIAS
HOSPITAL UNIVERSITARIO CENTRAL DE ASTURIAS
Unidad de Radiofísica
Servicio Radiofísica y P.R.

MEET THE TEAM AT HUCA

Central University Hospital of Asturias, Oviedo, Spain

Annually, our department treats approx. 2,300 patients with external radiotherapy using the most advanced techniques (IMRT, VMAT, SBRT, SRS, STAR,...) with the four linacs installed. All linacs have the SunCHECK platform that allows us to perform in vivo dosimetry using the linac flat panel in each patient and each treatment. Thus, we can check the coincidence of the planning with the actual treatment. We also have two HDR machines with Co-60 sources with which we annually perform about 400 patients of all types of brachytherapy, although the majority are prostate and gynecological. In the case of the prostate (LDR and HDR) we use real time with the use of ultrasound for placement and planning. Since 2014 we have been performing in vivo dosimetry in prostate treatments with the detectors incorporated in the HDR machine. Currently, we have made more than 400 determinations. Three years ago we started using breast IORT with a portable accelerator, treating more than 40 patients to date.

Why did you want to get involved in the ORIGIN project?

The development of in vivo dosimetry in brachytherapy has always been behind that of external beam radiotherapy. Brachytherapy is a considerably less automated modality than external RT and therefore much more likely to make treatment errors. Over the years since we have incorporated in vivo dosimetry we have been able to verify the need to deviate from the planned treatment. However, the technology we use does not offer the precision required. When we learned about the ORIGIN project, we immediately realized that the technology that was being developed in the project was a considerable step forward. And, for us, it was a wonderful opportunity to contribute our clinical experience to its development.

Why is it important for hospitals to be involved in research?

When looking back at the development of radiotherapy we can realize that the research comes mainly from industry. There are examples of external RT treatment techniques that began to be used on a massive scale without taking clinical experience into account, and whose use was subsequently discouraged in the absence of other image verification technologies. One of the most notable aspects of the ORIGIN project is its interrelationship between hospitals and development centers. In this way, the functionality of the technology developed will be the best and most reliable from the beginning.

How will ORIGIN impact the future of brachytherapy?

Once the development of ORIGIN is finished, it will be one of the most accurate and reliable systems for the verification of treatments. In radiotherapy it has always been assumed that the planned treatment is the one provided at the time of irradiation. But unfortunately, this is not always the case. In fact we believe that the precision of the treatments currently achieved will be difficult to improve, but safety has a wide margin for improvement. The most important part of this improvement in safety will be the use of in vivo dosimetry systems, such as ORIGIN, in all brachytherapy patients and treatments. Not only will it notify us of random and systematic errors, but it will also do so in real time. This aspect is very important because correcting an error in a brachytherapy treatment is very difficult.

Prof. José Fernández
Chief Medical Physicist

Dr Daniel R. Latorre
Medical Physicist

Dr Silvia Fernández
Medical Physicist

Mr Ignacio Iglesias
Research Fellow

Dr Zahara Martín
Medical Physicist

Dr Lulzime Daci
Medical Physicist

ORIGIN at key events

Invited Speaker

ORIGIN's coordinator Dr Sinéad O'Keeffe was recently invited to present her work on optical fibre sensors at the renowned European workshop. Dr O'Keeffe described the urgent clinical need for in vivo dosimetry in brachytherapy and explained how optical fibre sensors are uniquely positioned to meet this need.

Invited speaker Dr Sinéad O'Keeffe presenting "Optical Fibre Sensors for Radiotherapy Dosimetry"

ORIGIN Exhibit

ORIGIN was delighted to have the opportunity to exhibit at EWOFS and was the only research project among the many industry exhibitors throughout the four day event. An interactive display with 3D printed semi-anatomical phantoms guided visitors through a typical LDR prostate brachytherapy procedure and how the ORIGIN system can be employed to monitor the radiation dose and map the position of the radiation sources throughout the treatment.

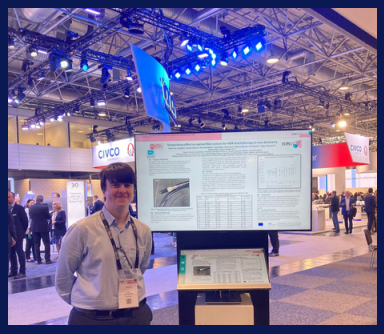
Dr Sinéad O'Keeffe and Dr Jennifer Hanly demonstrating the ORIGIN system to EWOFS attendees

Conference dinner held at the beautiful Chateau de Beloeil

ESTRO 2023
From Innovation to Action
12-16 May 2023
Vienna, Austria

In May, the clinical team from QUB, along with our industry partner Bebig Medical, attended Europe's largest industry exhibition in radiation oncology. The current theme of the congress "From Innovation to Action" perfectly aligns with ORIGIN's focus on translating research into clinical practice.

With five posters accepted and an invite for a poster discussion, ESTRO 2023 was a fantastic platform to share the results of ORIGIN and highlight the need for in vivo dosimetry in brachytherapy amongst the radiation oncology community.



L; ORIGIN researcher Mr Owen McLaughlin presenting "Temperature effect on optical fibre sensors for in vivo dosimetry in HDR BT"

R; Dr Orla Houlihan discussing "The effects of simulated systematic applicator displacement"

L; ORIGIN partner BEBIG Medical showcasing the latest radiation technology products

R; QUB ORIGIN team enjoying a relaxing evening with colleagues after a busy few days at ESTRO 2023

ORIGIN Consortium Meetings

UNIVERSITÀ DEGLI STUDI DELL'INSUBRIA

29-30 Sep 2022, Como, Italy

VUB B-PHOT BRUSSELS PHOTONICS

22-23 Mar 2023, Brussels, Belgium

Thank you to our hosts!

Download the ORIGIN factsheet

Conferences and Events

PROSTATE BRACHYTHERAPY
UK & Ireland
Conference 2022

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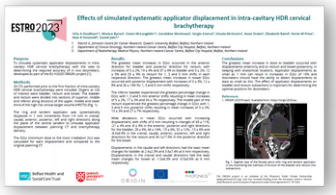

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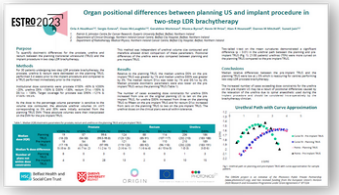

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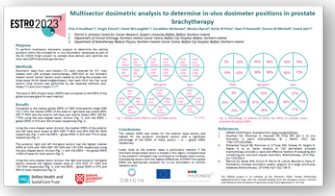
ESTRO 2023
From Innovation to Action
12-16 May 2023
Vienna, Austria
#ESTRO2023
ANNUAL ESTRO CONGRESS



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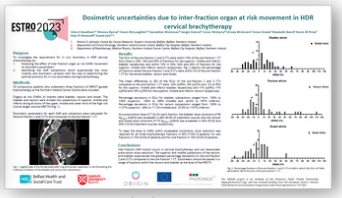

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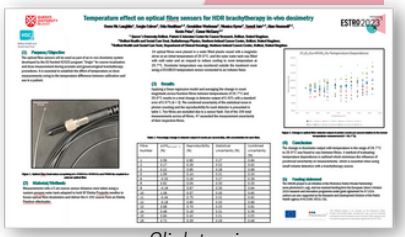

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FLANDERS MAKE
DRIVING INNOVATION IN MANUFACTURING

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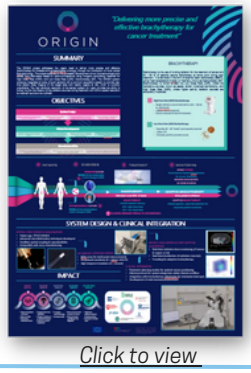

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8º CONGRESO CONJUNTO
24 SEFM | SEPR 19
OVIEDO 2023 UVIÉU

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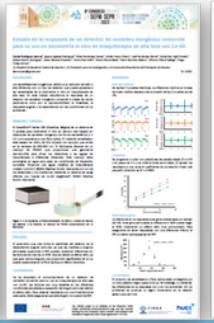

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ORIGIN STATS

07 Partners

37 Researchers

45 Months

35 Deliverables

16 Milestones

02 Prototypes

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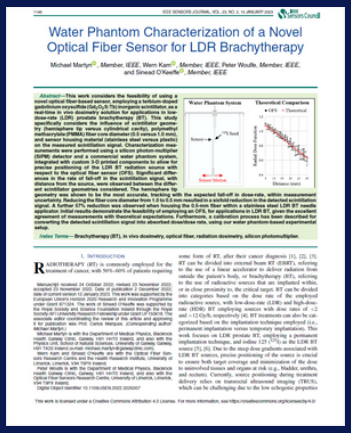
ORIGIN news

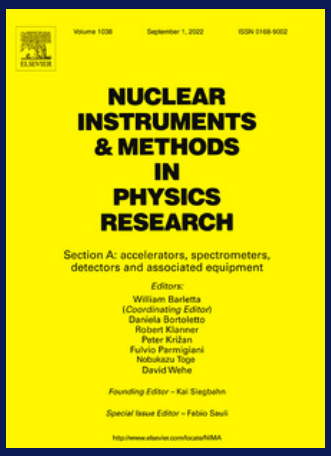
ORIGIN PUBLICATIONS

The latest ORIGIN research was published in the esteemed journals below, with a number of other manuscripts in preparation.



Martyn, M., Kam, W., Woulfe, P., O'Keeffe, S. (2023) **Water Phantom Characterization of a Novel Optical Fiber Sensor for LDR Brachytherapy.** *IEEE Sensors Journal* Vol 23 (2).

This paper describes the characterization of a novel optical fibre sensor which employs a terbium-doped inorganic scintillator as an in-vivo dosimeter for use in LDR brachytherapy. A custom water-phantom system-based experimental design is employed to perform the extensive testing. The results clearly demonstrate the feasibility of scintillation-based optical fibre sensors as dosimeters in LDR brachytherapy.



Giaz, A., Galoppo, M., Ampilogov, N., Cometti, S., Hanly, J., Houlihan, O., Kam, W., Martyn, M., Mc.Laughlin, O., Santoro, R., Workman, G., Caccia, M., O'Keeffe, S. **ORIGIN, an EU project targeting real-time 3D dose imaging and source localization in brachytherapy: Commissioning and first results of a 16-sensor prototype** (2023) *Nuclear Instruments and Methods in Physics Research Section A* Vol 1048

The design, characterisation and laboratory validation of the first 16 channel ORIGIN prototype is presented here. An array of 16 scintillation-based sensors coupled to an SiPM detection system provides single photon sensitivity and demonstrates the spatial resolution and precision required to meet the clinical needs.

AWARD

Congratulations to our clinical partner the Galway Clinic who won the Blackrock Health group "commitment to research" award in recognition of their innovative research within the ORIGIN project.

ORIGIN REVIEW

ORIGIN was delighted to receive a very enthusiastic assessment from our EU review panel at our technical review in Sep 2022. Our ability to overcome many challenges including the impact of Covid 19, changes to our consortium and recruitment difficulties was commended. The concerted efforts and close working relationships between all of our partners was notably highlighted as the key enabler for our success to date 😊

EXTERNAL ADVISORY BOARD MEETING

In March 2023, ORIGIN met with its expert panel of independent advisors. This was a fantastic opportunity to receive constructive feedback from our respected peers, who were impressed with our technical accomplishments to date and provided some suggestions of focus for the coming months.

Many thanks to our advisory board members for their time and to the Galway Clinic who kindly hosted the meeting.