Newsletter #1

Editorial

Dear reader,

Best Wishes for 2024 !

As the TITANS project reached its first year, it is nice to step back a moment from the excitement of starting new experiments and modelling, and shift our perspective towards the scientific objectives to come. Thanks to the dynamic and efficient bond created among the teams during TRANSAT, collaboration could get off to a flying start, as was needed due to the ambitious program planned and expected by the community. Eight deliverables have been submitted already, and although some delays have to be reported due to specific technical or internal organizational mishaps, there is no risk of impacting the project continuation. The mid-year videoconference discussion and the in-person annual meeting in the splendid Pavia University were amazing opportunities to share the various advances and first results in all workpackages, and engage to prepare the next steps. High-level presentations were carried out and discussed, with a very valuable perspective from our Scientific Advisory Committee. We are very grateful to benefit from such a wide range of expertise from international experts, and will do our best to carry on our research with their suggestions in mind.

A first webinar on permeation barriers took place on October 3rd, with contributions from various perspectives and promising discussion. Finally, preparation for the third Tritium School is underway : after a previous edition held remotely, we are thrilled to welcome all tritium-curious participants at Pharo in the beautiful city of Marseille, from March 18th to 22nd, 2024, to share expertise and discussion and hopefully attract more and more young researchers for future studies. Registration will open soon, with limited availability for a ITER visit on the last day of the school : stay tuned !

It is my first editorial as TITANS' coordinator and I hope you will enjoy this newsletter: please, feel free to get in touch with us through our website or ResearchGate for any question or update.

Elodie Bernard,

Third Tritium School

The TITANS project invites you to the Third Tritium School, that will be held in Marseille, France, from 18th to 22th March 2024.

The Third Tritium School is a continuation of the successful First and Second Tritium Schools, which were organized within the TRANSAT project (TRANSversal Actions for Tritium) and received great appreciation from the community.

The school will consist of four days of tutorial lectures, while a visit to the ITER site will be organized on the fifth day. Experts in the field of fusion, fission, waste management, biology applied to toxicology and dosimetry from all over the world will give lectures on various topics related to tritium. The topics addressed are highly multidisciplinary and will range from tritium detection, management, control, retention and waste to radiotoxicity, ecotoxicity and dosimetry of tritium in organisms. Both PhD students and young generation of researchers working in fusion and fission research and development are strongly encouraged to participate.

The list of invited speakers is already available on the school's website.

Registrations for the school are open and accessible just below.

Find out more!

Permeation Barriers Webinar

A webinar was organized within the TITANS project on 3rd of October 2023. The main topic of the webinar was the tritium permeation barrier, which is an important research area in both fusion and fission research.

The webinar started with an introduction by the organizer, Sabina Markelj (JSI) and a word from the TITANS coordinator Elodie Bernard (CEA). The webinar consisted of four talks given by experts in the field.

The first presentation was given by Ion Cristescu (KIT) with the title “Strategy for validation of tritium permeation through DEMO relevant materials”. He gave an overview of the options and requirements for the tritium permeation barriers for the DEMO fusion power plant.

The second presentation was given by Fabio Di Fonzo (IIT), entitled “Ceramic permeation barriers in contact with PbLi eutectic”, who gave an overview of the status of ceramic permeation barriers and their operating principle and then focused on the Al2O3 permeation barrier, discussing the barrier properties and how it behaves in contact with the PbLi.

After a coffee break, a presentation entitled “Sputtering fabrication of alternative coatings to act as corrosion and tritium permeation barriers”, was given by Raquel Gonzalez Arrabal (UPM). She gave an overview of the current status of the alternative coatings for corrosion and permeation barriers and how they behave under different conditions.

The last presentation was given by Marta Malo (CIEMAT) with the title “Facilities for the evaluation of permeation barriers under fusion-relevant conditions”. She presented the facilities used and being developed under Eurofusion and TITANS projects to study permeation barriers under different exposure conditions.

The presentations lasted 45 minutes including discussion. The webinar ended with a lively half an hour discussion on permeation barriers and current issues in their development and performance. The webinar attended more than 30 participants.

Check out the Event!

Computational dosimetry methods applied to the in vitro exposure of lung cells to tritiated particles

The radiotoxicological and radiobiological consequences of tritium contamination strongly depend on the speciation of tritiated products. Tritium commonly occurs as tritiated water (HTO) or organically-bound tritium (OBT), but can also exist in many other forms, including tritiated particles of different nature and sizes produced during dismantling operations of nuclear power facilities. Furthermore, different exposure pathways are possible under accidental exposure scenarios (i.e., inhalation, skin absorption and/or ingestion). Overall, the chemical speciation determines, for a given exposure pathway, both the kinetics associated with the distribution of tritiated products at the organ/tissue level (including clearance) and the associated distribution at the cellular and subcellular levels, which can be highly inhomogeneous.

Considering the average range of beta (β) electrons emitted by tritium decays in biological tissue (0.5 µm, corresponding to an average decay energy of 5.7 keV), it is clear that both the distribution of energy deposited at the subcellular level and the cumulative energy (“dose”) deposited in target cells will vary substantially when different tritiated products with different distributions are considered. Both these two pieces of information are necessary to correctly assess tritium dosimetry.

As a thorough experimental characterization of tritium dose to single cells and to the whole cell population is difficult (if not impossible!) to achieve, we need to rely on computational methods as radiation transport simulations. In the framework of the former TRANSAT and on the current TITANS projects, we apply such methods to understand how much energy is deposited to cells, with the purpose of building “dose-response” correlations, hence measuring the biological effect as a function of radiation dose.

Considering tritiated steel particles of micrometric size administered to lung cells cultured *in vitro*, we have recently performed calculations to assess such dose levels at different particle concentration. At first, a software model of the cell has to be built, using geometrical parameters representative of cell dimensions that can be measured with confocal microscopy. An important information obtained with microscopy is the distribution of radioactive particles: for the human bronchial epithelial cell line (BEAS-2B) cultured in adherent conditions, we have verified that steel particles do not penetrate the cell membrane, possibly as a consequence of their dimensions (average radius of 2.35 µm), but rather deposit on the cell surface, creating in some cases some sort of “depression” in the membrane due to their weight. As above-

mentioned, this has a big impact on the dosimetry, in particular concerning the energy deposited to cell nuclei, where the genotoxic effect takes place due to DNA damage by tritium radiation.

In a measurement campaign conducted by the *Biomarkers, Environment and Health Unit* of the IMBE Marseille, partner of the TRANSAT and TITANS project, concentrations of tritiated steel particles as high as 100 µg/ml were administered to BEAS-2B cells for 24 hours. Our simulations revealed that, at such concentration level, only ~40% of cells are expected to be reached by electrons released by tritium decays directly from the particles. On average, this leads to a cumulative dose to the cell population of a few cGy. However, different cells experience a highly varying exposure level: if cells are hit by decays by tritium released by steel particles in the extracellular environment, the dose is only of few mGy; on the contrary, if a radioactive particle lies on the cell surface directly on top of the nucleus, the dose to the nucleus can reach 20 cGy.

These considerations have important consequences when interpreting biological measurements: indeed our results suggest that measuring an average damage to the cell population in this experimental setup can be misleading, as this average will be the outcome of very different single-cell dose levels, hence mixing cells with a different “fate”. Taking such dose inhomogeneity into account in the data analysis can be very difficult, but, we need to recall that both the fraction of damaged cells and their dose (and hence, damage) levels are essential for carcinogenesis implications: highly damaged cells are less prone to survive, while lower damage levels might more easily result in misrepair leading to mutation, but preserving clonogenic potential, which can initiate the cancer. An approach based on computational dosimetry therefore sets the basis for a better-informed risk management for human exposure to radioactive particles.

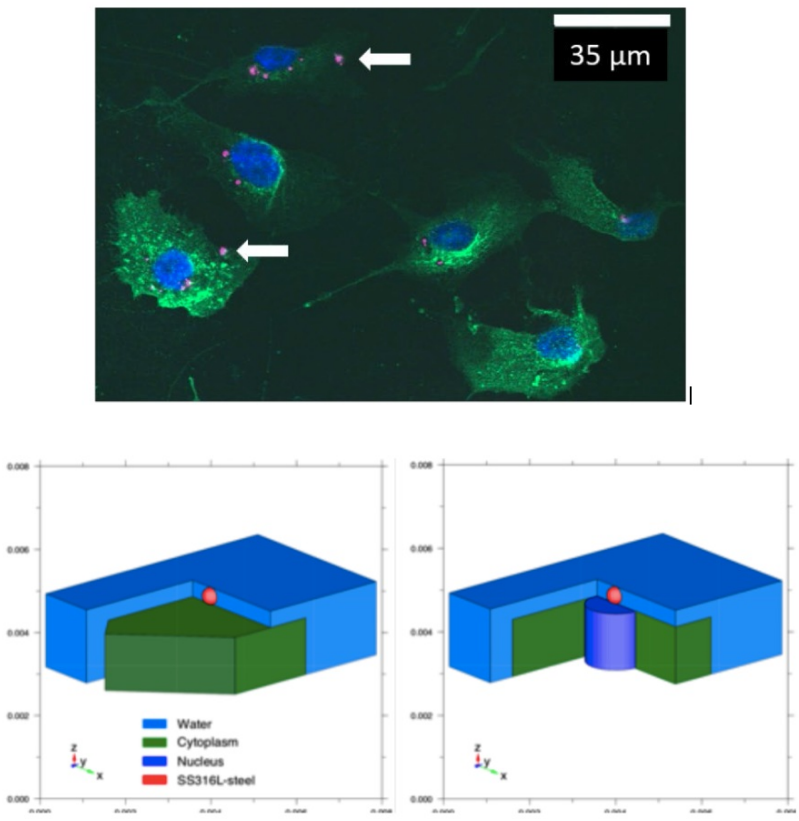

Figure: top panel, confocal microscopy image of BEAS-2B human bronchial epithelial cells (cytoplasm stained in green, nuclei in blue) after exposure to steel particles (in pink); bottom panel: computational dosimetry is performed with the code PHITS, the image shows a software model of a single cell, with average dimensions, the cell is the green volume, and a cross-sectional view reveals the inner nucleus (in blue), with a single radioactive particle (pink) positioned on the top of it. The light blue volume is the surrounding cell culture medium, in which the cell is immersed.

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