# Positrons for modelling PET processes and analysing plasma damage

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Positrons provide a unique tool to explore a number of physical processes. The development of the Surko buffer gas trap has enabled new exploration of positon-molecule interactions, as well as a new approach to the use of positrons for materials analysis. This talk will describe the development of the ANU positron facility, which addresses both these issues. The measurement and use of positron cross sections for medical physics will be described, along with the role positrons play in analysing plasma damage of tungsten, an important material in the construction of the ITER fusion reactor.

## 1. Introduction

Positrons were the first antiparticle to be predicted and discovered, after Dirac's work on a relativistic formulation of quantum mechanics [1,2]. Since then, experimental techniques have been developed to allow for the use of positrons in a wide range of research, from fundamental atomic and molecular processes to applied studies, such as materials analysis. They have also become an imaging tool of choice in medicine, with Positron Emission Tomography (PET) becoming widespread in hospitals throughout the world. Research progress has been somewhat limited by the relative scarcity of positrons, and various different experimental schemes have been developed to provide the tools required to pursue positron studies. The development of the Surko trap and beam system, at the University of California, San Diego, provided a leap forward in positron technology, making available a high energy resolution positron beam, comparable to the best electron beams, for the first time [3]. In turn, this opened up new possibilities for the detailed study of low energy positron interactions.

## 2. The ANU positron beam facility

At the Australian National University, we have constructed two positron beamline experiments, based on the Surko trap technique. One is dedicated to studies of atomic and molecular physics [4], and the other to materials analysis [5]. The atomic and molecular physics experiment produces a pulsed beam, with an energy resolution of around 50 meV and tuneable between 1 and 200 eV. This has been used for a wide range of scattering experiments from targets such as the noble gases and a wide range of molecules. The second beamline is configured to provide a high temporal resolution pulse, of less than 1 ns, which is the injected into materials at energies up to 20 keV. Positrons annihilate inside the material, producing characteristic 511keV gamma rays, emitted back-to-back. Fast detection of these gamma rays allows for the measurement of the positron lifetime inside the material. Through using Positron Annihilation Lifetime Spectroscopy (PALS), we can then obtain information about vacancies and voids within the structure of the material. Again, measurements have been performed for a wide variety of systems. The operation of both beamlines will be outlined during this talk.

## 3. Positron transport in the human body

One focus of our research program is to better understand positron transport and damage in the human body, related to the use of PET. To that end, we have made a study of positron interactions with a variety of relevant molecules, and this data is then used in transport calculations as part of a broad collaboration in this area. Relevant data will be presented, along with the approaches taken to modelling positron transport and damage, using Monte Carlo simulations and modified swarm physics calculations.

## 4. Positron analysis of plasma damage

The final part of this talk will explain the use of positrons for analysing plasma damage to tungsten. Tungsten is an important material for the plasma facing walls of the divertor region of the ITER reactor, and we have analysed samples exposed to a range of conditions simulating the damage that will occur over the lifetime of the machine.

## 5. References

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