Positrons are obtained from weak radioactive sources of 22-Na. In porous systems, positronium as bound state between a positron and an electron can be formed. Para-positronium (p-Ps), as the singlet state (opposite spins) annihilates in 125 ps and does not carry any information about the host system. However, 75% of the positronium is generated as ortho-positronium (triplet state) with parallel spins. The lifetime in vacuum is 142 ns. In a pore, o-Ps will be bounced between the pore walls. At the wall, o-Ps can exchange the electron of the parallel spin to an electron of opposite spin, and thus form p-Ps, which annihilates very fast. This process is called pick-off annihilation. It may shorten the positronium lifetime to values between 0.7 and 142 ns depending on the pore size. Thus, Ps lifetime spectroscopy can be used for porosimetry in the range from 0.5 to about 50 nm. From a possible distribution of the lifetimes, also the pore size distribution can be reconstructed. The method can be applied for open- and closed-pore systems. Typical applications are the investigation of open volume between polymer chains and molecules of ionic liquids; porous membranes and powders, such as zeolites; and porous layers (100 nm … 5 µm). Also thin porous layers (< 1 µm) can be characterized.

The positron lifetime is measured as time difference of the appearance of the 1.27 MeV "Birth"-quantum and the 0.511 MeV annihilation quanta. The source must be weak enough so that the simultaneous appearance of two positrons is highly unlikely.

You are welcome to join our workshop at HZDR in September!