



## Background information on PET and Cyclotrons

### The revolution of PET?

PET – Positron Emission Tomography – is an exciting innovative and powerful medical imaging system which is revolutionising the treatment of cancers. This is achieved through quicker and more accurate disease diagnosis, early detection and initiation of advanced, tailor-made treatment plans. Thousands of patients who could benefit from PET don't because of a shortage of facilities. This is due to cost, highlighted in the current debate between Federal and State governments regarding the Medicare rebate for PET procedures which in turn affect State funding to build new PET facilities.

PET uses a radioactive tracer (radiopharmaceutical) and a PET scanner to allow doctors to study how disease is affecting the body. This is done by analysing radiation signals sent by the tracer to the PET scanner which in turn produces 3D images of high resolution which lets the doctors clearly see where disease is in the patient.

The initiative by ANSTO and Siemens is likely to reduce the cost of the radioactive tracer and enable hospitals to use their capital investment for PET scanners rather than cyclotrons

### What is a PET Scanner?

A PET scanner is a body scanner with a computer. The scanner records the position of radioactive tracers when 'positrons' meet 'electrons' in the body, creating radiation that can be detected outside the body.

### How does a PET scan work?

A patient receives an injection of a radioactive tracer which is comprised of a typical chemical prevalent in the body such as glucose.

The tracer moves through the body and is processed by the organ being studied or the area receiving treatment by the targeted pharmaceutical. The PET scanner detects the radioactivity and this comes up as a full-colour image on a computer screen. The higher the concentration signal revealed, the higher the activity of the disease or take up of the pharmaceutical.

### What is FDG (Fluoro – deoxy - glucose)?

FDG is a glucose compound most commonly used in PET imaging. When injected this is taken up by high-glucose-using cells located in areas like the brain, kidney and cancer. After FDG is injected into the patient the PET scanner forms images of the distribution of FDG in the body. These images are then assessed to provide a disease diagnosis. The fluorine in the FDG molecule is chosen to be the positron-emitting radioactive isotope fluorine-18, to produce FDG.

FDG is made in a cyclotron and only has a short life span - a half-life of 110 minutes - before the activity level diminishes and cannot be utilised. It is therefore necessary for a cyclotron to be near transport infrastructure and major PET facilities.

**What is a half-life?**

Half-life is the time taken for the activity level in a compound to drop to half of its starting level.

**What is a cyclotron?**

A cyclotron produces positron-emitting isotopes for use in PET medical imaging. The machine itself is a type of particle accelerator which accelerates charged particles at high-frequency and alternating voltage. The particles go around in a circle due to a magnetic field which causes them to re-encounter the accelerating voltage many times.

Cyclotron beams bombard specific atoms introduced into the accelerator to create the short-lived PET isotopes needed for PET imaging. They can also be used to penetrate the body and kill tumours by radiation damage, while minimising damage to healthy tissue along its path eg. Proton therapy.

**How does a cyclotron work?**

Electrodes are placed in a flat vacuum chamber, in a narrow gap between the two poles of a large magnet. A high-frequency alternating voltage applied across the electrodes alternatively attracts and repels charged particles. These accelerate only when they pass through the gap between the electrodes. The perpendicular magnetic field forces the particles to travel in a circle. This is because a current of electrons, or ions, flowing perpendicular into a magnetic field experiences a similar force. In the vacuum the charge particles move freely so they follow a circular path.

**Cyclotrons in Australia**

There is only one commercial facility in Australia which produces TGA (Therapeutic Goods Association) approved FDG and follows good manufacturing practice, based in Victoria and has two cyclotrons. Others are based at Royal Prince Alfred Hospital (NSW) (x2), Peter MacCallum Cancer Institute (VIC), Austin Health and Medical Imaging Australia (VIC), Royal Brisbane Hospital (QLD), Wesley Hospital (WA), Sir Charles Gairdner Hospital (WA).

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