Group 3: Medical applications
Part 1
MEDICAL APPLICATIONS

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The importance of teaching modern physics in high school

- Students should know about the latest discoveries and the big questions challenging the physicists today

- Students must understand that particle physics is not a mystery, it is very close to reality, it’s in our everyday life
Students who physically experience scientific concepts understand them more deeply.

Our idea was to make particle physics more approachable.

Two projects:

1. Using the power of the computer and smart phones: plan for an app for learning about PET scanning (even programming the app).

2. Learning by doing: building a simple model to perform an experiment that will illustrate the Bragg Peak.
What do students learn during these activities?

- particle accelerator, tracer
- radioactivity; beta+ decay; half-time
- matter- antimatter; electron-positron
- collisions; energy stored in mass
- annihilation
- detectors
- the difference between PET Scanning and other imaging techniques
PET BASIS

- A tracer is administered as an intravenous injection usually labelled with F-18 in a glucose molecule:
  
  18-fluorodeoxyglucose (FDG).

- The accumulation of FDG allows measurement of the rate of consumption of glucose because in these areas, glucose is used as the primary source of energy.
ANNIHILATION

- Momentum conservation requires $\theta=180^\circ$
- $m = 2m_e$  $\quad$ $E = 2m_e c^2$  $\quad$ $E = 2 \cdot 511$ keV
COINCIDENCE DETECTION

When a decay occurs within the field of view of the detector, **two 511 keV** photons are produced at **180°**.
DETECTORS

The scintillation process involves the conversion of high-energy photons into visible light via interaction with a scintillating material, and consists of the following steps:

1) A photon incident on the scintillator creates an energetic electron, either by Compton scattering or by photoelectric absorption.
2) As the electron passes through the scintillator, it loses energy and excites other electrons in the process.

3) These excited electrons decay back to their ground state, giving off light as they do so.

4) Light is transformed into a electrical signal.
PET offers detailed imaging because:

- Gamma rays that do not arrive in pairs are ignored.
- A computer works out the position of source by “drawing lines” between gamma rays that arrive at the same time (within nanoseconds of each other).
S’Cool Lab PET workshop

\[ e^+ + \nu_e \rightarrow \gamma (1275 \text{ keV}) \]

\[ ^{22}_{10}\text{Ne} \rightarrow ^{22}_{10}\text{Ne}^* \rightarrow ^{22}_{11}\text{Na} \]

Photon energy in keV

Photon number
S’Cool Lab’s PET workshop
RADIATION

Radioactive Source: $^{22}\text{Na}$

Activity / Date: 74 KBq (15/07/2.14)

RP #: 4613 RP

RADIATION PROTECTION, PHONE 73171
S’Cool Lab’s PET Scanner
Method 1
Method 2
Model PET Scanner

- Taking a different point to fix one detector...
Model PET Scanner

- Taking a third different fixed point to fix one detector.
CASSYlab 2 Software

![Graphical User Interface](image)
Very very nice gadget ;-)

Very very expensive (20 000 €)
Virtual lab on the PC...
...or on smartphone and tablet
How would this look like?
Ingredients:

1 brain

2 movable detectors

1 360° protractor

1 red button
The task:
Locate the tumor inside!
Additional features

Theoretical introduction:

- $\beta^+$-decay
- annihilation
- conservation of momentum
- compton-scattering...

Showing different methods of moving the detectors

What happens if the body moves during the measuring process?

What happens if you change the angular accuracy?

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