# Experimental techniques in particle physics. PBL1

The first Danish astronaut, Christer Fågelsång, is a member of the next crew on the space shuttle Discovery. He and his fellow crew members had an after work beer in downtown Houston the other day, the last one before the launch in December. To Fågelsångs satisfaction they served what was probably the best beer in the world. They discussed lively the upcoming trip. Fågelsång described the “carry on experiment” that he had been permitted to perform during the mission.

During his long training in high energy physics, successfully ended with a PhD and several stays at CERN, Fågelsång had many times heard about light sensations, like flashes, that astronauts experience on space flights. The fellow astronauts never saw the same flash so it was clearly something happening inside the astronaut.

Fågelsångs teachers were never really able explain the origin of these sensations. They could very well propose several explanations with cosmic rays interacting with the eyeball that could in principle cause the effect but as physicists they were never really sure that the eye was sensitive enough to see the interaction. Now, Fågelsång wanted to be quantitative in the studies to learn about what is the radiation, what interaction does it make and what is the energy?

What had puzzled Fågelsång further, was that low energy particle beams were nowadays used to treat tumors in the eyeball and although the energy deposit by such particles was much larger than by high energy cosmic rays, he had not seen any reports that patients had observed similar light flash phenomena. So, it seemed as if the effect has to do with the fact that the cosmic particles are very fast, actually in many cases faster than light, Fågelsång concluded.

The commander of the crew, who after a couple of beers always got pissed by listening to the “conceited ass” Fågelsång, argued that he had never heard such bullshit. “Faster than light”, he said. Everybody knows there is nothing faster than light. And low energy particles put more energy in than high energy ones. That sounds just as stupid as it is. And you have a PhD in physics? Good luck with your experiment! You need it!

Well, Fågelsång was used to these discussions and he didn’t care about arguing back, since all the others knew that if there is anything that he is familiar with from his years in experimental particle physics research, it is particles interacting with matter.

**Literature list:**

| Author | Title |
|---|---|
| Fernow | Introduction to experimental Particle physics |
| Knoll | Radiation Detection and Measurement |
| Wigmans | Calorimetry |
| Ferbel | Experimental techniques in High Energy Nuclear and Particle Physics. |
| Flyckt | Photomultiplier tubes and applications |
| Leo | Techniques for Nuclear and Particle Physics experiments |
| Särtryck | Review of Particle properties, Phys. Lett |
| Green | The physics of particle detectors |
| Bock & Vasilescu | The partcile Detector Briefbook |
| Kleinknecht | Detectors for Particle Radiation |
| Littauer | Pulse Electronics |
| Grupen | Particle detectors (blå paper cover) |

**Teachers instructions:**

The text is correct in the sence that the first Swedish Astronaut, Christer Fuglesang was on his long awaited first space mission in december 2006. Fuglesang has a PhD in particle physics and he had a “carry on experiment” with he purpose of studying the sparking sensations that astronauts and high altitude aircraft pilots experience. The phenomena, which occur quite frequently are believed to be due to Cherenkov light produced by relativistic particles from the cosmic radiation passing the eyeglobe.

The basic idea is to regard the eyeglobe as a detector. The discussion about the tumor treatment in the eye (which is also basically correct but simplified) brings about the low energy aspect of radiation in matter, the Bethe Bloch formalism and radiation in biological matter

**Detailed learning goals in key words.**

Particle interaction with matter,
- Interactions in bulk matter
  - Bethe-Bloch formula

- Range-energy relation
- Electromagnetic: ionization, excitation, Cherenkov, transition radiation, coulomb scattering
- Strong: nuclear collisions, elastic scattering (neutrons)

Detector materials-extracting a signal

- Gaseous medium
  - Electrons-ions
  - Drift by ions and electrons in E-Field
  - Avalanche multiplication
- Semiconductor medium
  - Electrons and holes in pn-junction
  - Reverse biased silicon diode
  - Radiation damage
- Scintillator medium
  - Light collection
    - Surface reflection
    - Light guides
    - Optical fibers
  - Light detection
    - Photomultiplier
    - Photodiode

Particle identification at low energies

- ΔE-E techniques, direct application of B-B formula

Loss of resolution during passage

- Multiple scattering reduces momentum resolution
- Secondary hadronic interactions limits energy measurement
- Vacuum chamber and He-bag to reduce effects

Radiation safety

- Units of dose, Grey, Sivert
- Radiation damage of electronics