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Cloud chamber contamination from Roma Tre University

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Summary. — What if a community of physics researchers and students has the opportunity to always have at their fingertips the traces left by the particles around us thanks to a historic detector left always in operation? To celebrate the 25th anniversary of the INFN Division of Roma Tre, we have placed a cloud chamber right at the entrance of the university building that houses the Roma Tre physics degree course.

1. – Introduction

The cloud chamber is an instrument for detecting ionizing charged particles. It was conceived by Charles Wilson in 1899 and later refined to a larger and more complex instrument.

Cloud chambers played a key role in the development of particle physics during the first half of the last century. Using a cloud chamber, in 1932 American physicist Carl Anderson discovered the positron, the antiparticle of the electron. Also through the cloud chamber, a few years later Neddermeyer and Anderson discovered the muon, and in 1946 Rochester and Butler discovered the kaon instead.

The cloud chamber not only has enormous relevance to the history of particle physics, but still plays a leading role in making the invisible world of particles easily perceived. In fact, although modern experiments in the field of particle physics nowadays use a different type of detectors, the cloud chamber is still a very useful tool in the field of education and dissemination. In fact, there are some guides and resources that explain how you can build a do-it-yourself cloud chamber with an affordable price [1-4]. There are also nowadays some commercial versions of cloud chambers that can be purchased at a cost that, although high, is far less than that of a modern detector. This therefore makes it possible to use these scientific instruments even within exhibitions or museums, allowing non-experts in the field to experience the fascination of the invisible.

Indeed, the cloud chamber is a fascinating instrument that manages not only to capture the attention and imagination of the viewer, but it also conveys a strong emotion that helps even the non-expert to get a sense of being constantly immersed in a sea of invisible particles.

Just for this reason, taking advantage of the celebration of the 25th anniversary of the INFN Division of Roma Tre, we decided to place a cloud chamber at the entrance of the university building, which is also the headquarters of the INFN Division. We opted to place the detector at the entrance so that it would be clearly visible not only to the 400 regular visitors (including students and university and INFN staff), but also to any visitor to the university campus, which has unrestricted access and is not subject to access control. From 1 May 2023, the cloud chamber was turned on and remained in operation until 14 November 2023. This allowed everyone who accessed the building during this period to freely observe what it was revealing in real time. Near the cloud chamber we also placed an informative LED display that provided passersby with some basic information and clues to try to recognize some of the most frequent traces that appeared in the detector.

2. – How our cloud chamber works

Our cloud chamber is a diffusion cloud chamber built to be a museum exhibit by a specialized company.

This type of chamber, unlike expansion cloud chambers, is continuously sensitized to radiation. The space inside the chamber is filled with alcohol vapor, which, through special temperature conditions, reaches the condition of an over-saturated gas. The passage of a charged particle causes ionization of atoms in the gas, which then electrically attracts nearby alcohol molecules (which have polar characteristics), increasing the density of molecules at the points where the particle has passed. The molecules then join together causing a transition from vapor to liquid and the formation of small droplets along the particle's path in the cloud chamber.

In this way, the trajectory of any charged particle becomes visible in the form of a trail of droplets caused by gas condensation.

The charged particles that produce tracks in the cloud chamber are mainly electrons, positrons, muons and α particles. The traces left behind depend on the type of particle and their energy. In this way, an expert in the field can trace the type of particle that passed through the gas in the cloud chamber, just as an experienced hunter recognizes the passage of a particular animal from the footprints it left on the ground even though he was unable to see the animal. This is what scientists studying particles with large detectors do even today: from the traces they leave in the detectors, researchers can go back to the particle that left them, though without seeing the actual particle.

In addition to being generated by environmental radioactivity, some of these particles, such as muons, are due to the existence of cosmic rays. Cosmic rays are high-energy particles and atomic nuclei that, moving at a speed close to the speed of light, strike the Earth from all directions. These particles, which have galactic or extragalactic origins, interact at high altitudes (15–20 km) with the atoms that make up the atmosphere. As a result of these violent interactions, secondary particles are produced that can in turn interact (or spontaneously decay) and produce still more particles. Much of this "secondary" radiation is absorbed in the atmosphere, but a small fraction reaches the ground in the form of a mixture of particles of different types: photons, electrons, positrons, muons and neutrinos, but also pions, kaons. At sea level, each of us is traversed by a hundred particles per second, mostly muons and, to a lesser extent, electrons and positrons.

With our cloud chamber we can then also detect these cosmic rays.

3. – Learning to observe

During the months when we had the cloud chamber set up at the entrance, students and researchers developed a habit of taking breaks near this detector.

Young physics students are just starting to establish themselves as physicists. They have little experience, but it is through experience that they grow, define themselves, and realize their potential. Let us support them in inhabiting their universe, teaching them to perceive with their senses (aided by the detector in this case), to sense what is happening around them, to observe, and then to think. While we believe this sensitivity is innate in students, we must cultivate it to help them grow and discover the world around them.

Even before the creative moment comes the ability to see, an action we often take for granted, but it is not at all. Consider this example: if we look at a painting from many meters away, we will get a general impression of the arrangement of shapes and colors and appreciate its beauty, but it will be difficult to truly perceive the brush strokes. Only when we get closer do the brush strokes become clearer. This is why it is particularly useful to have a cloud chamber continually operating at the entrance of a physics department. Gaining experience is not just about experiencing, but about learning from those experiences to read situations and find solutions.

Acquiring experience takes time, and this is something we, as trainers, must provide. We need to listen to students' questions and offer the right stimuli at the right time. Students have an innate curiosity that drives them to investigate their surroundings and guides them in learning. We can leverage this curiosity to teach them to understand what they see, hear, and touch.

One of our main goals was to get students to pause and observe what the cloud chamber reveals. By observing it for extended periods, they gain overall impressions, discover details, compare their observations with prior knowledge, reflect and classify, and come up with creative ideas and personal insights. Discovery, play, and self-constructive learning are fundamental steps in gaining knowledge.

Simply standing still and observing the cloud chamber with a friend or colleague can help them develop the ability to observe deeply and for prolonged periods, leading to the discovery of details that might not be noticed at first glance. They will learn that even the simplest things, when observed with curiosity, can become fascinating.

4. – Discussion and conclusion

The positive influence was evident: appreciating the beauty of the traces left by particles in our detector proved to be a wonderful way to celebrate the first 25 years of the INFN Division of Roma Tre. From 1 May to 14 November 2023, our cloud chamber was accessible to all regular visitors to the building housing both the Physics Degree Course and the INFN Division of Roma Tre. Word soon spread about the opportunity to independently observe this historic detector in action, and its fascinating operation attracted several outside visitors. Additionally, some school groups visiting for university orientation activities were able to observe the detector in operation through guided tours.

The entrance to the university became a lively spot where researchers and students could chat about physics. They didn't just study; they shared insights! They exchanged remarks and asked probing questions, much like friends in a pub, discussing not only particle physics but also experiment procedures, detector construction, and many other topics.

Since December 2023, the cloud chamber has been temporarily moved to MUSE in Trento for the INFN exhibition "Quanto. La rivoluzione in un salto." It will return to its place at Roma Tre at the conclusion of the exhibition, scheduled for the end of June 2024. Given the overwhelmingly positive experience, the University has requested to keep the cloud chamber permanently active at the entrance of the building even beyond the INFN celebration period.

The contamination certainly worked!

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REFERENCES

[1] https://www.scienceinschool.org/article/2010/cloud/.
[2] https://www.asimmetrie.it/particelle-nella-nebbia.
[3] https://lab2go.roma1.infn.it/doku.php?id=fisica:esperimenti_a_casa:camera_a_nebbia.
[4] http://www.lnf.infn.it/edu/openlabs/2018/images/content/maker-lab/Brochure_raggi.pdf.