2020
Report Stage

Laboratori Nazionali di Legnaro

Dell'istituto nazionale di fisica nucleare

INFN LNL Report 260

Foreword

INFN LNL host 23 students from 11 Italian high schools located in Veneto and Lombardia for a two weeks stage not in presence. Four colleagues teach about nuclear physics and detectors, accelerators, physics applied to medicine (radio isotope) and materials. After two hours, students ask questions to the speaker.

Students work in group on six different themes: they produce six scientific-technological articles, included in this internal report. All the groups organize the work with video conference instruments. They are extremely independent and well organized, without the tutors' intervention. Tutors are really astonished about the results obtained. It is a great pleasure working with students highly motivated and curious.

All the proposed covers are in the appendix.

Students demonstrate the capability to follow the interdisciplinary approach: this is the key point of LNL stage.

Tutors hope that some of them will work in our laboratories in the near future, maybe for a thesis.

INFN LNL people appreciate the supports of teachers and school staff and will keep the contact for other Third Mission (public engagement) events.

Now it's time to read about accelerators, Rutherford's experiment, information technology, material surface treatments, ion source for accelerators, safety at work, and many other topics!

Andrea Gozzelino

Responsible of LNL Service Library and Documentation

Contact person for Third Mission at LNL

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High School Introduction on Particle Accelerators and Simulation Project for a New Branch of the ACTAR Line

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INTRODUCTION

Particle accelerators are complex machines that accelerate particles following a precise trajectory with the purpose of reaching a determined kinetic energy. Only 5% of the particle accelerators are used by researchers of particle physics, the others are medical accelerators, industrial accelerators or accelerators for the ion implantation. Nowadays at least ten particle accelerators are involved in studies of COVID-19. Generally, particle accelerators are composed of different components: a particle source, a line of transport, radiofrequency cavities, magnetic quadrupoles or radiofrequency quadrupoles, diagnostic elements, dipoles. All these components are essential for the particle beam to reach a very high velocity following the design nominal trajectory. In particular the particle accelerators use the concepts of electric and magnetic fields to transport the particle beam; a charged particle in an electric field has an acceleration due to the Coulomb force, instead a charged particle in a magnetic field is turned because of the Lorentz force so the particle beam can follow a trajectory and remain focused.

PARTICLE SOURCE

Electrons and protons, the most commonly used particles in accelerators, can be found in all materials, but for an accelerator the appropriate particles must be separated out, otherwise they cannot be accelerated because neutral. Electrons are usually produced in a device known as an “electron gun”. The gun contains a cathode (negative electrode) in a vacuum, which is heated so that electrons break away from the atoms in the cathode material. The emitted electrons, which are negatively charged, are attracted towards an anode (positive electrode), where they pass through a hole. The voltage between the cathode and the anode in an electron gun is typically 50,000–150,000 volts.

As with electrons, there are protons in all materials, but only the nuclei of hydrogen atoms consist of single protons, so hydrogen gas is the source of particles for proton accelerators. In this case the gas is ionized -the electrons and protons are separated in an electric field- and the protons escape through a hole. In large high-energy particle accelerators, initially protons are often produced in the form of negative hydrogen ions. These are hydrogen atoms with an extra electron, which are also formed when the gas, originally in the form of molecules of two atoms, is ionized. Negative hydrogen ions prove easier to handle in the initial stages of large accelerators. They are later passed through thin foils to strip off the electrons before the protons move to the final stage of acceleration [1].

ACCELERATING CAVITY

The accelerating cavity is the part of the accelerator responsible for the velocity increase of the charged particles. In a LINAC (LINear ACcelerator), designed for the first time by Wideroe[2], the accelerating force is provided by a sinusoidal electric field. The path that the particles follow is divided in drift tubes of progressive length. The tubes are conductor, so inside them there’s no electric field, the particles continue their motion at the same speed. In the gap between two drift tubes the particles are caught between a cathode (the negative-charge conductor) and an anode (the positive-charge one) and they are accelerated. While they go on in the following tube, the electric field changes direction and in the second gap they are subjected to another acceleration. Because of the sinusoidal variation of the field this structure is called radiofrequency cavity. This is the equation of the potential difference between the tubes depending on time:

$$V(t) = V_0 \cos(\omega t)$$

The sinusoidal evolution of the electric field allows the grouping of the particles which are not in phase with the nominal synchronised particle: indeed, the particles which are behind the right place are subjected to a stronger acceleration, while the ones which are ahead receive a weaker acceleration. In this way they are assembled in bunches.

DIAGNOSTIC ELEMENTS

Diagnostic elements measure the parameters of a beam in a specific position. These tools are used to adjust the particle beam and to improve the accelerator performance. One of the diagnostic devices is, for example, the diagnostic box, a steel cell where sensors are arranged to measure the position and the width of the beam.

To collect information about the beam barycentre a Beam Position Monitor (BPM) is often employed. In a linear accelerator this instrument measures the trajectory of the beam and corrects it, while in a circular accelerator the BPM checks the beam orbit. The goal in an accelerator is to keep the beam in the centre of the vacuum tube, so a BPM detects the deviation of the beam from the pipe centre. The measurements in a BPM are made with electrodes located in the beam tube. These electrodes measure the charge distribution in the pipe: if the distribution is exactly uniform, the beam is situated in the centre of the tube, while if there is an unequal distribution, the beam is displaced from the centre position.

Another important measurement is the beam current. This data is necessary to optimize the accelerator operations: without the optimization less energy would arrive to the experiment. The instrument used to collect this information is called Beam Current Transformer (BCT). It has the shape of a ferromagnetic toroid that acts like a transformer and allows to determine the beam current and charge [3].

STRONG FOCUSING AND MAGNETIC QUADRUPOLES

Strong focusing is one of the most important principles on which modern particles accelerators are based and constructed. Since its discovery in 1950 by Ernie Courant, Hartland Snyder and Stan Livingston [4], it changed the way accelerators were designed and built, giving the possibility of smaller apertures for the particle beams. A magnetic quadrupole implements strong focusing as an optic lens on one plane, directing particle beams towards the centre. However, due to Earnshaw's theorem [5], focusing in both directions at the same time is impossible, so on the other plane particle beams are defocused.

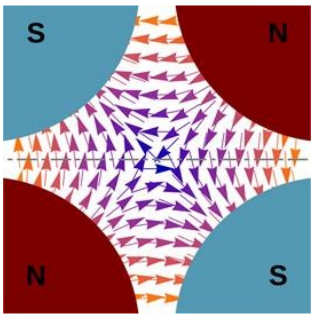

Fig. 1. [6] represents a focusing (by definition, on the x-axis) magnetic quadrupole and its magnetic field (going from north poles to south poles). As Lorentz force is represented by the formula

$$\vec{F} = q\vec{v} \times \vec{B}$$

and the particle trajectory is perpendicular to the plane represented here, force vectors point inwards on the x-axis, focusing the particle beams; while on the y-axis force vectors point outwards. As described with the following formulas, where *g* is the gradient parameter, force increases linearly as a function of distance to the magnet centre:

$$F_x = -g \cdot x \quad F_y = g \cdot y$$

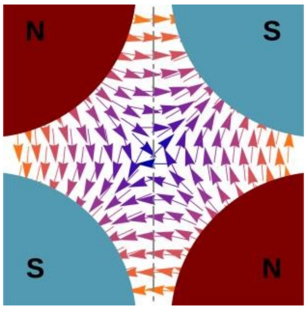

Fig. 2. [6] represents instead a defocusing magnetic quadrupole and its magnetic field. It can be obtained by inverting north and south poles: field lines run through the opposite direction, thus on the x-axis particle beams are defocused. In this case, signs are inverted in the formulas for force on both axes:

$$F_x = g \cdot x$$

$$F_y = -g \cdot y$$

Therefore, in order to keep particles as close to the centre as possible, focusing quadrupoles have to be alternated with defocusing quadrupoles, both separated by a line without focusing or defocusing elements (called drift). It is possible to demonstrate that a net effect is obtained on both planes: this structure is called FODO [7].

LINE OF TRANSPORT

About a linear accelerator, the line of transport is formed by an outer tube that separates and isolates an internal cavity and by a sequence of drift tubes of increasing length where the beam runs. Actually the beam is not inside the outer tube, but inside the drift tubes which in turn are contained by the outer tube. While the outer tube is usually made of steel and it must imprison the electromagnetic field, the drift tubes are made of copper or superconducting materials (that at a temperature of few Kelvin have very low resistance) and we must ensure that the energy transferred by the collisions of particles with the tubes or by the emitted radiations don't deform or damage the drift tubes. Speaking about a cyclotron instead, particles run along a spiral from the centre and, accelerating, enlarge the radius of their trajectory until they can exit when they have reached a sufficient radius. Speaking about a synchrotron there is a circular structure in which particles travel with points where the acceleration occurs. A communal need is the creation and maintenance of vacuum inside the accelerator because the presence of air molecules would prevent the acceleration of the particles due to collisions that would happen. For this aim vacuum pumps which decrease the pressure (up to 10^{-12} mbar) and create the ultra-high vacuum are used. In particular the ranges of vacuum are: 1013 - 10^{-3} mbar for low vacuum; 10^{-3} -10^{-8} mbar for the high vacuum; 10^{-8}-10^{-12} mbar for the ultra-high vacuum.

DIPOLES

Magnetic dipoles are used in accelerators to curve the particle beams. The magnetic field is set up by induction when current passes through coils of copper, and it is perpendicular to the beam direction. Charged particles that go through the field begin a circular motion of radius directly proportional to particles rigidity (momentum divided by charge) and inversely proportional to the magnetic field B, so, the higher the particles energy get, the higher the magnetic field must be to curve the beam. Since B<2T using conductors (but it can be more than four times higher using superconductors), long circular accelerators are built to reach very high energies.

A beam that passes through a dipole is focalised on the x axis, but not on the vertical one. To solve this problem the poles are shaped as shown in figure 3:

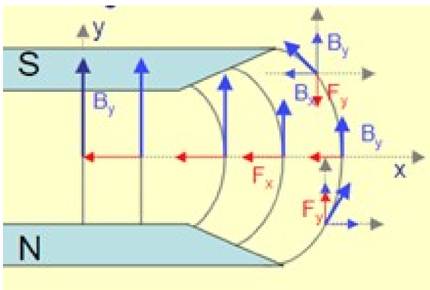

Fig. 3. Dipole with field vectors.

Particles don’t change their energy due to Lorentz force because it is always perpendicular to their motion, but they emit synchrotron radiation [8] while moving into a magnetic field. However, the loss of energy is negligible if accelerated ions are much heavier than a proton.

SIMULATION

For this simulation we used a software called TraceWin [9]. Our goal was to plan a new branch for the ACTAR line, a very novel cast detector concept where the gas constitutes both the target and the detection medium [10]. This project aims to bring a beam of $^{58}Ni^{12+}$ ions (A/Q=4.8) into a future experiment, ALPI uses particle beams with 1<A/Q<7[11]. For the simulation, we used 1000 ions with an average kinetic energy of 544.4 MeV (Bρ = 2.1373164 Tm). It is necessary to underline that the obtained measurements are valid only for low energetic spread. The number of particles was restricted by the TraceWin software type of licence for education.

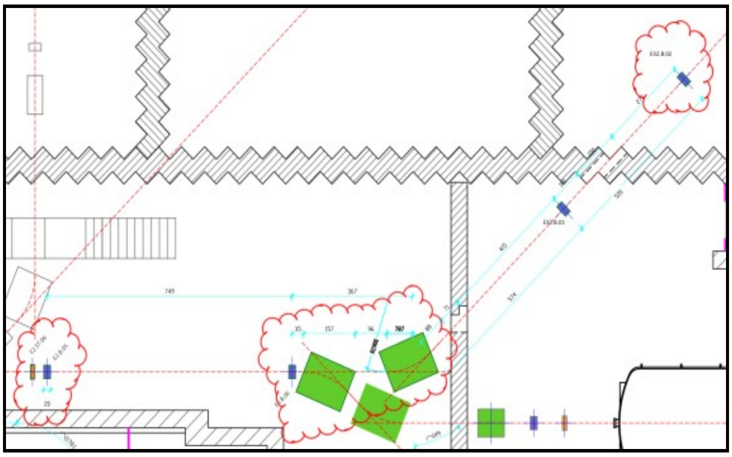

Fig. 4. Project in CAD format.

The branch starts in the diagnostic box E2.B.05 and runs straight up to the diagnostic box E2.B.06. In order to stabilize the particle beam, we placed between them two triplets of magnetic quadrupoles (E2.3Q.01 and E2.3Q.02). The line then passes through a turned-off dipole (used for sending the beam to the GARFIELD experiment [12]) and turns 45° thanks to an active magnetic dipole (E2.D.01). Before arriving into the diagnostic box E22.B.01, the beam runs into a doublet of magnetic quadrupoles (E22.2Q.01). Another triplet (E22.3Q.01) is placed before the last diagnostic box, E22.B.02. Arranging elements was limited due to the presence of two walls. Our main objective is find the position of the magnets correctly and adjust the values of the gradient parameter for each element, so that the beam would not get lost on the insides and would get to the destination focused.

Table 1. Triplets and doublet position (from the beginning) and gradient and dipole magnetic field and position (from the beginning).

Element	**Magnet**	**Gradient** (T/m) or **B** (T)	**z** (m)
E2.3Q.01	Q1, Q3	-5.94	3.89
	Q2	5.95	
E2.3Q.02	Q1, Q3	-5.94	6.39
	Q2	5.95	
E2.D.01		1.12	11.16
E22.2Q.01	Q1	2.57	14.54
	Q2	-2.70	
E22.3Q.01	Q1, Q3	-10.30	21.13
	Q2	10.50	

The magnetic field B is calculated by dividing the rigidity Bρ, given by TraceWin, and the dipole radius of curvature ρ.

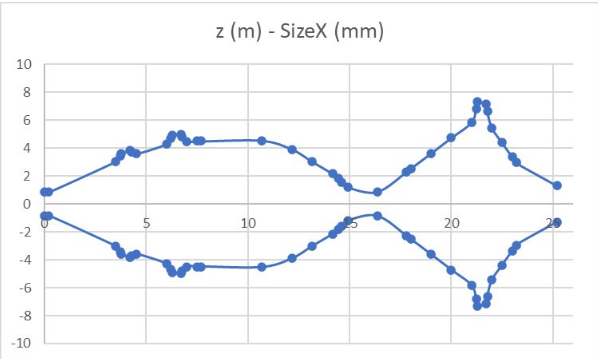

Fig. 5. Beam envelope on the horizontal plane.

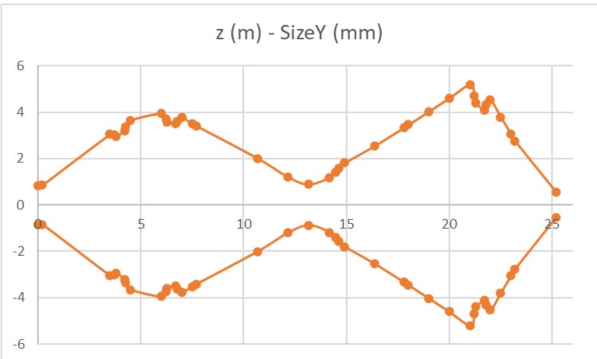

Fig. 6. Beam envelope on the vertical plane.

CONCLUSIONS

From Fig. 5 and Fig. 6, made using Excel with data from TraceWin, we can compare both initial and final apertures of the beam and observe that at the destination they appear decreasing, thus the beam ends focused, ready and suitable for the experiment. This result was possible adjusting the gradient parameter values. In particular, we calculated other two parameters: "force" F and "displacement" S, where g_1 and g_2 are the gradient absolute values of two consecutive quadrupoles in a triplet.

$$F = \frac{g_1 + g_2}{2}$$

$$S = \frac{g_1 - g_2}{2F}$$

So, as to achieve a proper result, the displacement S had to be less than 0.1. In the E22.3Q.01 triplet S is about 0.01 and in E2.3Q.01 and E2.3Q.02 it is even lower.

ACKNOWLEDGEMENTS

We would like to thank our tutor Carlo Roncolato for the support, the inspiration and the willingness.

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Discovering the Atomic Nucleus: Rutherford Experiment

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INTRODUCTION

Ernest Rutherford was a New Zealand chemist and physicist, considered the father of nuclear physics.
He won a Nobel Prize in chemistry in 1908.

How did Rutherford change the conception of the atomic model?

Through his experiment Rutherford made the model proposed by Thomson obsolete.
Thomson in fact supported the thesis of the "plum pudding" model, a positively charged "bubble" with negatively charged electrons inside, which was denied by Rutherford.
The physicist collided a bundle of alpha particles (with Polonium radioactive source) against a gold foil of 0.01 mm. He proved the presence of a positive nucleus in the centre of the atom capable of deflecting the beam of alpha particles that were detected by a screen of Zinc sulphide, a fluorescent material that emits flashes of light when hit by particles.

THEORICAL BACKGROUND

Scattering processes are usually described by their differential cross section, $d\sigma/d\Omega$. This expression relates the differential size of a cross section and the differential range of the scattered particle. This function is proportional to the probability of such a scattering event to occur. Intrinsically, translation from differential cross section to observed scattering rates depends on other parameters, such as the incoming flux of particles and the density of our scattering material. However, these factors contribute multiplicative constants to the differential cross section. Therefore, our differential cross section will be assumed to be proportional to our counting rate. In the case of Rutherford's model of the atom, scattering processes are given by Coulomb interactions between the nucleus of incoming atom and the nuclei of the atoms in the scattering material. The electrons are too light to produce scattering effects. Furthermore, the atoms in the scattering material are assumed to be fixed, reducing the calculation to our incoming charged particles scattering off stationary charges. The differential cross section is given by

$$\frac{d\sigma}{d\Omega} = \left(\frac{ZZ'e^2}{16\pi\epsilon_0 E}\right)^2 \frac{1}{\sin^4(\theta/2)}$$

here Z and Z' are the atomic numbers of the incoming particle and scattering material, respectively, e is the elementary charge, E is the incoming energy of the particle, and θ is the angle at which our particle scatters. This equation indicates that our scattering rate at an angle θ will be proportional to $1/\sin^4(\theta/2)$.

EXPERIMENTAL SETUP

In this experiment, we measured the scattering of α particles, that consist of two protons and two neutrons bound together into a particle identical to a helium-4 nucleus, emitted from 3 sources: number 83, a Am-241 and Cm-244 double source, number 1, a triple component source (Am-241, Cm-244, Pu-239) and number 86, a single component source.

The best-known source of alpha particles is alpha decay of heavier (> 106 u atomic weight) atoms. When an atom emits an alpha particle in alpha decay, the atom's mass number decreases by four due to the loss of the four nucleons in the alpha particle. The atomic number of the atom goes down by exactly two, as a result of the loss of two protons – the atom becomes a new element.
Our apparatus consisted of an accelerator, AN2000, which is a Van der Graaff electrostatic-type and the voltage terminal is 2 MeV, a target room, where the beam-target interaction took place, a target, to which were attached the following elements: Au/Si, Au/Ni, SiO_2 /Si, Au, and a Si semiconductor solid detector, whose main features are sensitivity, high-speed response, high energy resolution, detection efficiency and dead time.

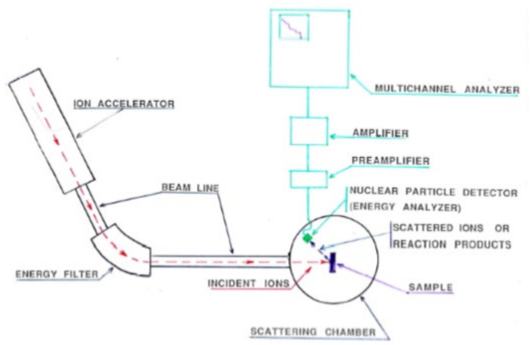

Figure 1. Experimental setup

The AN2000 emitted a beam of α particles, accelerated by Coulomb force and at discrete energies, the most common of which being 1800 keV ,1700 keV, 1600 keV, 1500 keV, 1400 keV, 1300 keV, 1200 keV and 1100 keV.
This beam was directed at the target room throughout the intervention of magnetic fields. The particles, directed at a mylar film of polyester $(C_{10}H_8O_4)_n$ with a thickness of 12 μm, were scattered off at some angle θ. These particles could then be detected by our Si semiconductor solid detector, which collected the particle's energy as an electrical signal and sent it to a preamplifier to be analysed.
We were able to assign to every channel the corresponding value of energy thanks to the construction of a calibration line indicating channel on the x axis and energy on the y axis.

DATA ANALYSIS

At the time Rutherford used alpha particle sources, we use three different types of sources (americium, curium and plutonium) for the calibration and the AN2000 accelerator to obtain a collimated, monoenergetic and high intensity beam of 4 He + nuclei. The main effect of the interaction of these radiations with matter is the transfer of all or part of the energy to matter, up to the reduction of the particles to a state of quiet. The alpha energy is absorbed by the material mainly thanks to the Coulombian interaction with electrons. In order for radiation to lose all energy, many impacts are needed with the electrons of the medium

Table 1: Alpha sources in use during the experiment at INFN LNL.

ELEMENTS	**$T_{1/2}$**
AMERICIO (Am - 241)	433 years
CURIO (Cm - 244)	17,8 years
PLUTONIO (Pu - 239)	24100 years

After the alpha particle has collided with our target it arrives on the silicon detector and creates an electrical signal. The more energetic the alpha particle are, the more intense the electrical signals are and the more electrons will be produced and collected. To be able to extract this information, an electronic module called ADC (Analog to Digital Converter) is used; it takes the analogic electrical signal (proportional to how many electrons have been collected) and transforms it into a digital signal which will have the following characteristic: the more intense the electrical signal, the more it will be translated into something found on high channels. In order to do this, it is necessary, before the experiment, to make the calibration with which we "translate" the values of the channels of the ADC into units of measurement of energy, the MeV
(1 eV = 1.6 x 10^{-19} J, 1 MeV = 10^6 eV)

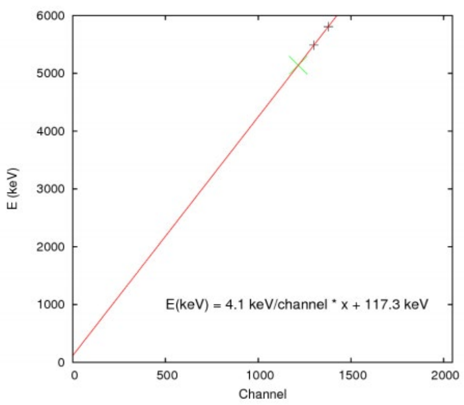

Figure 2: Calibration line with Am-241 and Cm-244. Resolution at the impulse peak: 1 channel equal to 4 KeV.

Let's talk now about Rutherford Backscattering spectrometry, a technique that allows to reveal the particles that are deflected after colliding with the target's nucleus. It consists in sending a beam of ions ($^4He^+$) accelerated to an energy on the order of MeV on a target sample. Then the energy of the beam particles is measured after the collision with the target.
In the RBS technique the kinematic factor is studied: the relationship between initial and final energy (specific for each element).

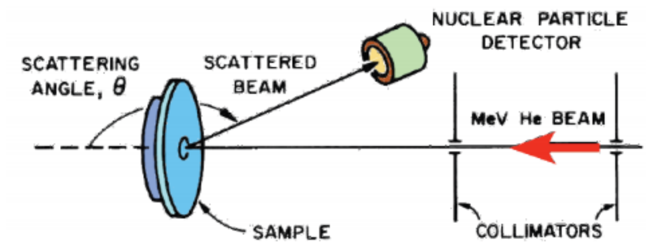

Figure 3: Sketch of Rutherford's experiment with accelerator.

$$k_t = \frac{M_1^2}{(M_1+M_2)^2} \times \left[cos\theta + \sqrt{\left(\frac{M_1}{M_2}\right)^2 - sin^2\theta} \right]^2$$

With this method we can measure target thickness and composition in order to verify that it is actually uncontaminated pure gold.

Let's now proceed with the actual experiment by counting the number of particles that hit the detector located at an angle θ with a certain energy.
By calculating the integral of the curve using XRump (an analysing program), the number of events that the detector has recorded is therefore found.

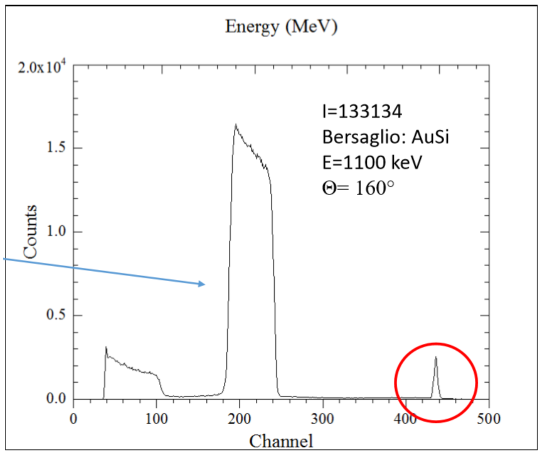

Figure 4: Spectrum of run 12953 and its respective integral.

To obtain a wide range of results, we take care to observe what happens (in terms of trends and peaks) both by varying the angle (with fixed energy) and, conversely, by varying the energy at a fixed angle.

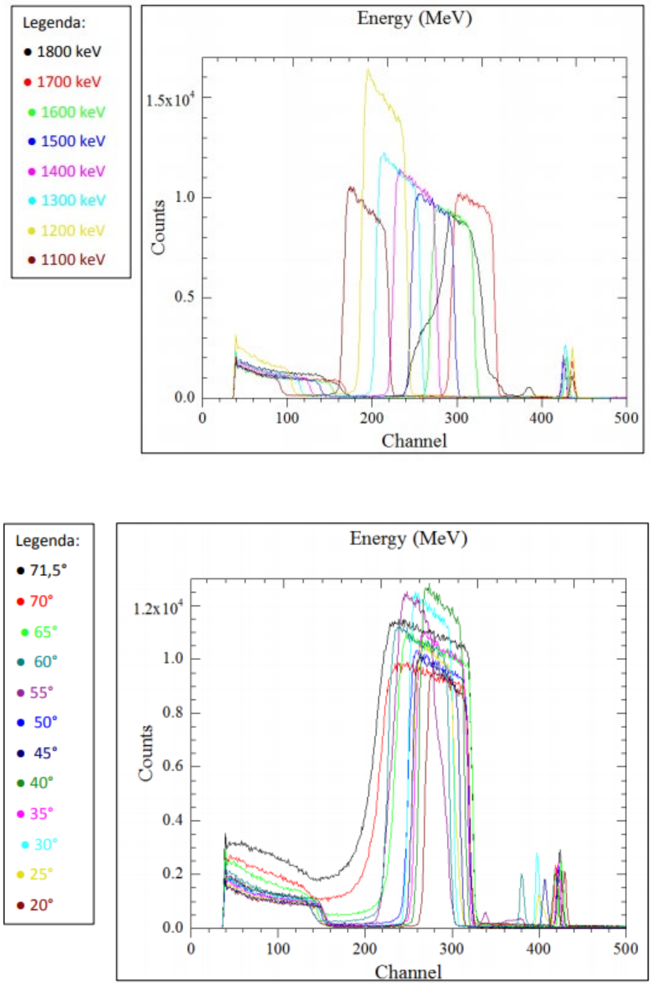

Figure 5: Spectrum of runs changing beam energies (top). Spectrum of runs changing Si detector angle (bottom).

Now we are ready to analyse the collected data; it was necessary to calculate a normalization factor ($F = Qr/q$) by making the ratio between the charge collected in the Run and the smallest charge of all.
F is necessary because all the Runs have different time length and charge, therefore counts that, if not normalized, do not match with the other Runs.

With the normalization factor we can calculate the normalized counts ($Cn = Ci/F$) by making the ratio between the integral counts and F.

Table 1: Data taken during the experiment in 2019 and the analysis after the data taking day.

Y(E) θ=20° Au/Si						
RUN	E±10 (keV)	Conteggi int.	Cariche (μC)	F	Conteggi N.	Errore (±)
12960	1800	556447	9,3	2,91	191466	438
12958	1700	501391	7,6	2,38	211112	459
12934	1600	468493	6,1	1,91	245767	496
12947	1500	497394	5,8	1,81	274424	524
12948	1400	555959	5,6	1,75	317691	564
12949	1300	595789	5,1	1,59	373828	611
12953	1200	799749	6,0	1,88	426533	653
12954	1100	511049	3,2	1,00	511049	715
Y(θ) E=1600 KeV Au/Si						
RUN	180,0° - θ±0,5 (°)	Conteggi int.	Cariche (μC)	F	Conteggi n.	Errore (±)
12934	160,0	468493	6,1	1,91	245767	496
12946	155,0	507232	6,3	1,97	257642	508
12936	150,0	637620	7,7	2,41	264985	515
12945	145,0	620271	7,2	2,25	275676	525
12937	140,0	536802	5,8	1,81	296167	544
12944	135,0	633486	6,5	2,03	311870	558
12938	130,0	701833	6,6	2,06	340283	583
12943	125,0	690236	6,0	1,88	368126	607
12939	120,0	772994	6,1	1,91	405505	637
12942	115,0	953473	6,8	2,13	448693	670
12940	110,0	1032491	6,5	2,03	508303	713
12941	108,5	1333416	8,0	2,50	533366	730

At the end, we observe the dependencies of the counts normalized by energy and by scattering angle (Figure 6).

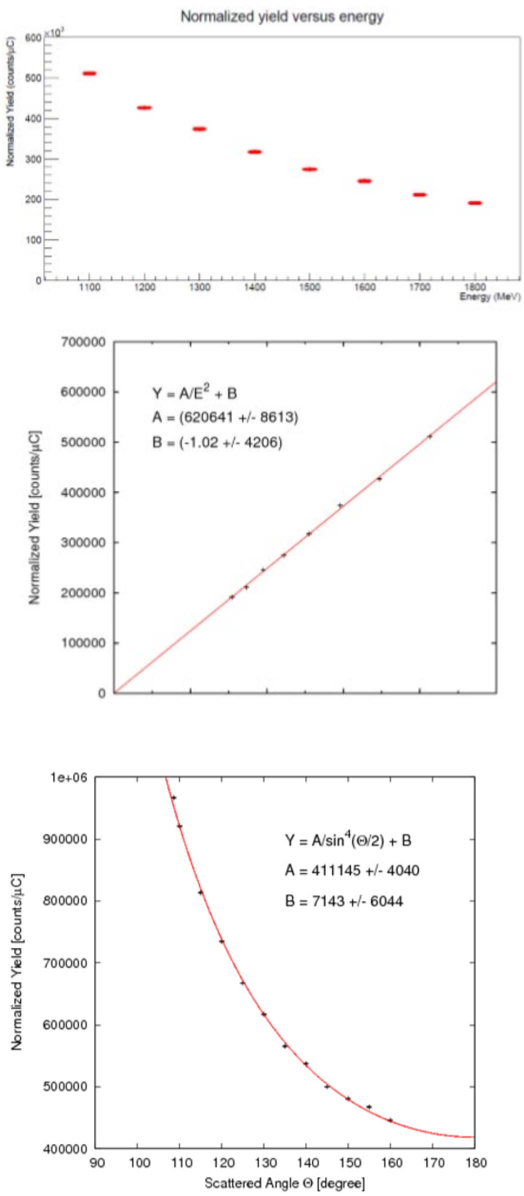

Figure 6: Results about integral counts versus beam energy (top and middle) and about integral counts versus scattering angle (bottom).

CONCLUSIONS

By measuring the scattering rates of α particles through gold foil, we are able to determine that Rutherford's scattering formula describes our data more accurately than Thomson's predictions from his "plum pudding" model. As such, we can conclude that the atomic structure is more closely described by Rutherford's model than Thomson's. Through calibration techniques, we are able to account for a systematic effect of our apparatus through a convolution, which is verified to improve the goodness of fit of the Rutherford prediction.

AKNOWLEDGEMENTS

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Information Technology and Physics Through a Screen

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INTRODUCTION

What is needed to carry out an experiment and fully understand it?

Firstly, you certainly need a knowledge of what you are going to see. And secondly, you need to have an idea of what resources you can use for the test.

During an experiment in the laboratory you must be aware that you will probably need to use all the different knowledges that comes from different subjects, such as mathematics, physics, chemistry and informatic technology. Only if you can put together all of these you will you be able to fully understand the purpose of what you are doing.

Nowadays it is certainly useful to know how to use the resources that new technological discoveries are offering us. These include well-known websites also used for school or work (Microsoft Excel, Geogebra), but also others more specific for certain fields of investigation (LabView, XRump). But we should not forget that the best way to learn is to do things in presence, asking questions and discussing with others.

PRESS RELEASE

A press release is a text where someone shortly describes their experience. To make it understandable to everyone it is usually written in a easy way and in English. Furthermore, to facilitate the understanding, you can also add images or graphics taken from websites, scientific magazines or books.
While writing a press release you should pay attention to some characteristic:

- divide into paragraphs;
- introduce the subject briefly;
- present the contents but do not waste too many words describing;
- use connectors (besides, however, in conclusion);
- do not write long sentences;
- respect words orders using the 5W rule (who, what, where, when, why).

ELECTRONIC CHAIN

The signal obtained by the detector is analogic and it can be described by a continuous function of continuous variable x (t). However, calculation and control systems operate on a digital basis. To process the results obtained, it is therefore necessary to convert the analogic signal into a digital (discrete) signal.
In order to do this there are several steps that together form the electronic chain [1].

Preamplifier:

- It receives the current signal from the detector, calculates its integral, where the integral of the electric current represents the electric charge produced by ionization radiation entering the detector, and outputs a voltage signal with amplitude proportional to the charge itself. If necessary, it can also amplify the signal;
- It is positioned near the detector so that the signal travels a short distance and it is influenced as little as possible by noise.

Amplifier:

- It increases the signal amplitude, which is proportional to the energy deposited by the radiation;
- Its rise time must be compatible with that of the detector;
- It filters the signal in frequency minimizing the noise, but keeping the characteristics of interest of the signal (in particular rise time and amplitude);
- It forms the signal for the ADC, producing approximately a Gaussian curve;

- The shaping time must be much greater than the detector rise time;
- RC and CR electronic filtration (band-pass), thus eliminating high and low frequencies from those that make up the signal useful for the purpose of improving the signal-to-noise ratio.

Analog to Digital Converter (ADC): discretizes the signal, transforms the analogic signal from the amplifier into a digital signal that can be represented with numerical values.
The three main operations of ADC are:

1. Sampling: time discretization;
2. Quantization: discretization of amplitudes;
3. Encoding: representation of the quantized sample with a number of N digits.

The sampling operation selects suitable values from the input signal which will be converted into digital values. These values are spaced by a constant time interval, called sampling time, and its inverse is called sampling frequency (fc).
The fundamental rule in order to correctly reconstruct a signal, according to Shannon's theorem, is that $fc \geq 2 f_{max}$, where f_{max} is the maximum harmonic content of the signal. If this rule is not respected, the aliasing phenomenon occurs.
If a sampled signal is affected by aliasing, it is no longer possible to correctly reconstruct the original signal (Figure 1).

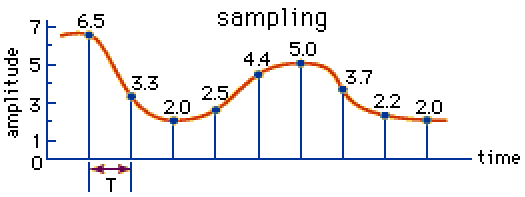

Fig. 1. Sampling operation

The quantization and encoding operation consist in matching each analogic sample with a numerical value.
The range of variation of the signal is divided into a certain number of intervals associated with a number, coded in binary code (sequence of 0 and 1). Each amplitude value obtained from sampling is associated with the number of the corresponding interval. The sequence of numbers thus obtained is the digital representation of the signal. The process of quantization, unlike sampling, inevitably introduces an uncertainty, called quantization error.

The digital output signal from an A/D converter is, in fact, defined by a finite number of bits (N) which identify 2^{N-1} quantization intervals, each of amplitude $\Delta/(2^{N-1})$, where Δ denotes the maximum signal amplitude.
For example, if the converter is a 10 bits one and the input signal is 10 V, the amplitude corresponding to each quantization interval is equal to $10/(2^{10-1}) = 9.77mV$.
The maximum error that can occur in quantizing a signal is half quantum (i.e. when the continuous value is exactly in the middle of the quantization interval).
The value of the quantization error is lower the higher the resolution of the A/D converter, defined by the number N of output bits (Figure 2).

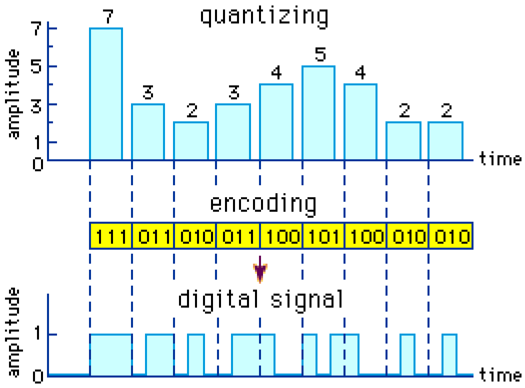

Fig. 2. Quantization and encoding operation

DATA ACQUISITION AND STORAGE

Data Acquisition (DAQ) is a method that allows to process a physical or electrical phenomenon such as voltage, temperature, current, using a computer. A DAQ system is made of three parts: a sensor, a measurement hardware and a computer. First of all, the sensor is capable of turning a physical phenomenon like temperature or vibration into a measurable electrical signal like voltage or resistance. There are a lot of different sensors that works in different ways to collect different data. For example, to measure temperatures variations are often used Thermocouples or Resistance Temperature Detector (RTD), tools that change their voltage and their resistance respectively with temperature. To measure sound instead we use microphones, tools capable of recording the pressure variations in the air and then turning them first into capacitive variations and then into electrical voltage. Other types of sensors are accelerometers that measure vibrations, or strain gages that measure the deformation of materials.

DAQ devices act as an interface between the computer and the sensor, meaning that these devices convert the signals coming from the real world into digital signals and they make them computer readable. Similarly, to the sensors we have also a variety of DAQ devices, each one with different functions. This is why it is important to understand the different types of signals. For example, an analogic inputs/outputs measure and generate analogic signals, while digital inputs/outputs measure and generate analogic signals. Now it is proper to explain the difference between an analogic signal and a digital signal. Analog and digital are just two different ways to represent a physical dimension, like sound or temperature. An analogic signal is a continuous signal in which one quantity represents another variable. More simply one variable is an analogic of the other. On the other side digital signals express variation in the system's variable through a set of discrete values. The signals are not continuous anymore but we can say it "jumps".

At the end of the whole process the data can be seen and analysed on the computer where using apposite programs they can be manipulated and they can be used to forms charts.

The data, later on, can be stored in the computer or in a pen drive, otherwise, if the data are to heavy they might need to be analysed in data centres.

SOFTWARE

The programs listed below (Figure 3) can be used in the processing of data related to the Rutherford experiment through the creation of graphs and spectra allowing their analysis:

1. LabView: graphic simulation environment that allows the virtual reproduction of electronic signals by varying their characteristics (waveform, frequency, amplitude, etc.).

2. Microsoft Excel: program able to produce spreadsheets containing ordered tables and graphs through the use of mathematical functions. It allows data storage in a dynamic way and a possible analysis of the obtained graphs.

3. Gnuplot: it is written in the computer language C++ and is used for the production of bi- or tri-dimensional graphs (2D, 3D) with trend lines and error intervals. An application is about counts as a function of angle and/or energy variation.

4. Root: Also based on the C++ language, it is developed by CERN as line software and with the aim of analysing files of various sizes (up to terabytes of data).

5. XRump: allows the display of experimental values in the form of variable graphs of the relative spectrum and with various functions (e.g. Raw plot, Reg, Replot, Overlay, Int, Cur).

6. Joomla: allows the creation of websites (such as the National Institute of Nuclear Physics, https://www.lnl.infn.it/index.php/it/); among the main implementations there are drop-down menus and cataloguing of articles.

7. GeoGebra: It can be used to create many different mathematical functions and to show them as graphics in a dynamic cartesian plane. Graphs through the use of mathematical functions. It allows data storage in a dynamic way and a possible analysis of the obtained graphs.

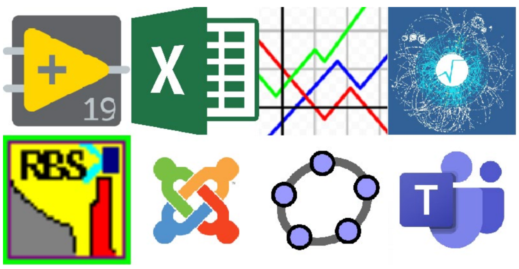

Fig. 3. Icons of the software that we used.

SCIENTIFIC COMPUTING INFRASTRUCTURE AND WEBSITE

The scientific computing infrastructure is made up of HTC and HPC. HTC means "high throughput calculation" and HPC means "high performance calculation". HPC is used to perform calculations that require enormous computing power and uses the simulation of a more powerful processor by putting many together.

The scientific computing infrastructure is managed by CloudVeneto which is an institution made up of the servers of the INFN Laboratories of Legnaro.

This union was created to solve the need for greater computing power required by both the University and the INFN laboratories. CloudVeneto is used for: running interactive applications, deploying services, configuring clusters for running multiple instances of computing applications (including containers) in batch mode and running parallel computing applications that require the simultaneous use of multiple virtual machines. The INFN Cloud of the Paduan Area and the Cloud of the University of Padua have integrated to form a single computing infrastructure which nowadays forms an aggregation of about 2500 logical cores (organized in 60 compute nodes), 12 GPUs and about 400 TB of storage

The site is made up of a "home page" and the "front end" where there is all the information visible to the public. It is managed by Joomla: a content management system for creating websites, written in php. The site administrator area is called "back-end" and allows other users to be authorized to modify the site.

Microsoft teams is an application that promotes the sharing of material and the organization of video lessons. It is one of many Microsoft programs and, to use this service, you need a Microsoft account.

CONCLUSIONS

To sum up we learned:

- how to write a press release;
- what an electronic chain is;
- what a DAQ is and how it works;
- how to use new software;
- what the scientific computing infrastructure is and how it is used.

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[1] F. Zheng, P. Pero, A. Peraro, A. Cavion, powerpoint (2019)

Surface Treatments for Research and Industry

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INTRODUCTION

Our team was assigned to the theme D of the INFN Legnaro stage program; with the collaboration of our tutors: V. Garcia, A. Tsymbaliuk, E. Chyhyrynets, we studied one of the techniques to produce superconductive Nb on Cu accelerating cavities for particles accelerators.

The purpose of our research is to find the best way to deposit a superconductive film on different types of materials. There are two main techniques for achieving our goal: chemical deposition or physical deposition. Between them, we studied in particular one type of physical vapor deposition technique: sputtering technique.

The sputtering process permits to deposit any type of film over any type of material with minimum quantity of impurities, for this reason this procedure is one of the best ways to create a superconductive film.

For particle accelerators applications, a clean and smooth surface is fundamental for the cavities production, along with a high purity and quality of the superconducting coating. The preparation of the surface prior the deposition, represents a crucial and needed process in order to obtain efficient accelerating cavities.

MATERIALS AND MACHINES

In our studies we used copper pieces as our substrate. Copper is commonly used in research and production of superconductive radiofrequency cavities for particle accelerators due to its mechanical, thermal and electrical properties. The material for the film studied was niobium titanium which is a superconductive material.

The main equipment that is used to deposit NbTi in copper samples is the magnetron sputtering machine, together with chemical and mechanical cleaning instruments. Different techniques are frequently used to characterize the samples after each process: balance for the mass measurement, profilometer for the surface profile measurement, scanning electron microscope (SEM) for the imagine of the surface and energy dispersive spectroscopy (EDS) for the chemical composition.

CHEMICAL CLEANING PROCESS

Before the actual cleaning process, it is necessary to grind the samples with fine sandpaper (granulometry: 30µm - 3µm); Then the first washing is made with a chemical reagent: caustic soda surfactant and ethanol, followed by the drying with nitrogen. Usually, are cleaned with special soaps like RODACLEAN, in an ultrasound bath.

The next step is the pickling of the plates, done with ammonium persulfate. This treatment is used to remove the oxides from the surface. At this point, test is done to check the results of the chemical treatments (with the machines aforementioned [1]).

After these pretreatments, the procedure that follows is the electropolishing, which is a type of electrochemical cleaning; the copper sample (anode) are immersed in an acid solution with another copper plate (cathode), between this plate is generated a potential difference that starts a dissolution of the surface (peaks and impurities) of the anode plate and a deposition on the cathode plate. The last step is the chemical polishing done by a solution of ammonium citrate and butanol, followed by a bath in a passivating solution to avoid oxidation.

Table 1. Before and after cleaning data of copper samples treated prior this study.

Plates	Mass before treatment (g)	Mass after treatment (g)	Removed surface (µm)
1	24,88	24,38	13
2	19,97	19,43	30
3	38,30	37,92	24
4	24,32	23,91	17
5	19,36	18,91	18

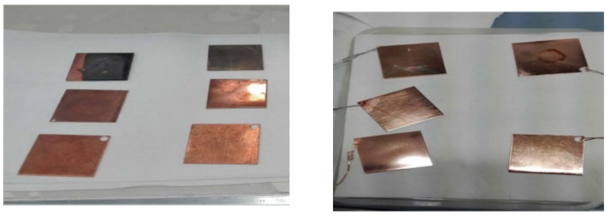

Fig. 1. Before and after the cleaning process of the samples

SPUTTERING PROCESS

As we said before, the sputtering process is used to modify the mechanical and physical properties of the substrate material. In this case the superconductive niobium titanium film is added to the copper plates, this way we can produce a suitable superconductive material for particles accelerators.

The process begins with fixing of the plates inside the holder using silvered screws (and also some quartz samples in the holder for the following tests that will be effectuate). Then, the machine is closed and the vacuum system is activated, so the pressure inside the chamber goes down to 10^{-6} mbar. At the same time, the heating bands are turned on for the degassing of the chamber and the infrared lamp are set up to heat up the substrate to 250 °C.

All these processes take two days and at the end the pressure arrives approximately to $8 \cdot 10^{-8}$ mbar.

This process is done to eliminate all the impurities in the chamber that could ruin or contaminate the final film.

At this point, the Argon is introduced into the chamber using a leak valve, rising the pressure to $8 \cdot 10^{-3}$ mbar (that is the pressure we need during the deposition process). Then the magnetron system is turned on with a magnetic field which allows the ionization of the argon gas, transforming it into plasma.

The positive ions in the plasma are accelerated and collide to the target surface (titanium niobium), The particles of the target are then detached from the surface (in this case NbTi) with enough energy to move towards the copper plates creating the superconductive film. The whole process lasts 40 minutes.

Fig. 2. The figure shows a well-done sputtering process (1) and a poorly done sputtering process (2), the difference depends on the previous polish process.

CHARACTERIZATION PROCESSES

After the sputtering process, different tests are made on the quartz samples to inspect the quality of the film.

Using the profilometer, the thickness of the film is analyzed, with the EDS we examined the chemical composition and also, we used the diffractometer to analyze the crystalline structure.

The two final tests are the Residual Resistivity Ratio (RRR) test and the RF test.

The first one is used to check that the resistivity at low temperatures is zero; if not, the film was not deposited correctly and the material is not superconductive as it should be.

The test consists in putting the samples in a container (dewar) with liquid helium (10K), then a software measures the resistivity and, by comparing these data with the value of the resistivity at room temperature (300 K), we have the RRR factor.

Lastly, the RF test is done to ensure that the material that was deposited in cavities is suitable for the particle accelerators.

The cavity that will be characterized, is immerse in liquid helium to cool down the temperature and reach the superconducting state typically for niobium. The cavity is them subjected to a radiofrequency field in which power is given to the cavity and an antenna receive the power transmitted in the cavity walls.

This test gives the Q factor that represents the quantity of power lost in the cavity; if the Q factor is high, the power loss is low and vice versa, which means that the higher is the Q factor, the better the cavities work.

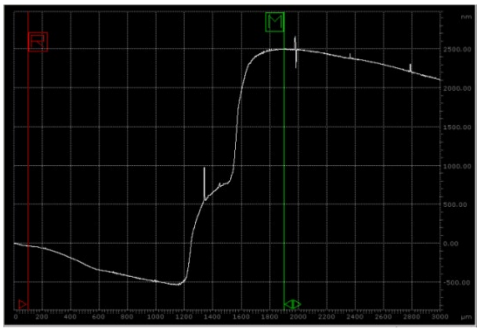

Fig. 3. Graphic of profile of the quartz sample.

CONCLUSIONS

To sum up this experience taught us how the surface treatments are made and how relevant they are for the construction of particles accelerators and for the research of superconductive materials. We learned that, the better is the surface of the substrate before the sputtering, the better results we will obtain in the deposition of the film, and also the properties of the material will be the best possible.

ACKNOWLEDGEMENTS

All information was taken from the website of the Legnaro National Laboratories of INFN in collaboration with our tutors V. Garcia, A. Tsymbaliuk, E. Chyhyrynets. For the presentation with pictures and data we thank Massimo Fumiani, Nicola Girotto, and. the students that took part in the stage before us and gave us the opportunity to see their presentations to develop our work.
We thank INFN for the opportunity to attend this stage especially Andrea Gozzelino, Luisa Pegoraro, Marco Cinausero, Antonio Palmieri, Liliana Mou and Valentino Rigato for the welcome and the lessons during the first week.

Negative Sources of Ions for Accelerators

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A negative ion source in the Legnaro laboratories is located in the Tandem accelerator (Figure 1).

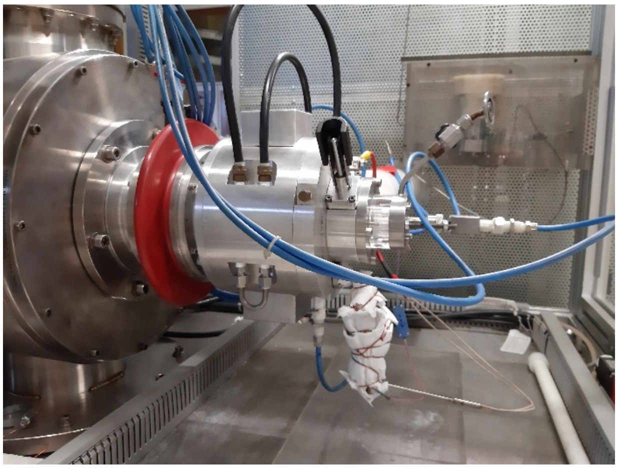

Fig.1 Negative source attached to the Tandem

The negative ion source produces beams by the sputtering of Cesium (Cs) against a target (Figure 4) filled of the metal required for the experiment. The sputtering technique could be direct or reverse: here the reverse is applied instead of the direct one, in which the beam and the cesium gases runs in the same direction.

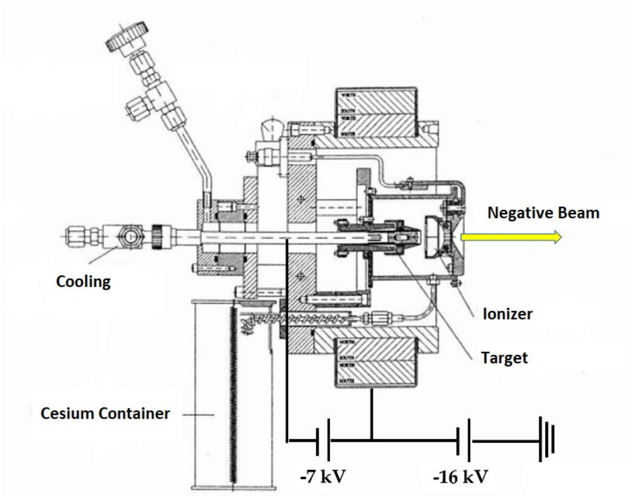

Fig.2 Sketch of the negative ion source.

The process starts in the cesium container where the temperature of the liquid is kept around 100°C by a heating serpentine. The cesium vapors go up till the sputtering chamber through a thermally insulated pipe.

At INFN of Legnaro cesium is employed because it is very easy to ionize (it lost electrons easily): it makes all the process simpler.

Now the gases arrive in the ionizer (Figure 3), made by tungsten (W), which increases the temperature of cesium until 2000°C. Under and over the negative source there are fixed magnets that attract the electrons generated by the ionizer. The supports of the ionizer prevent the fusion and the damage of the other parts in the source.

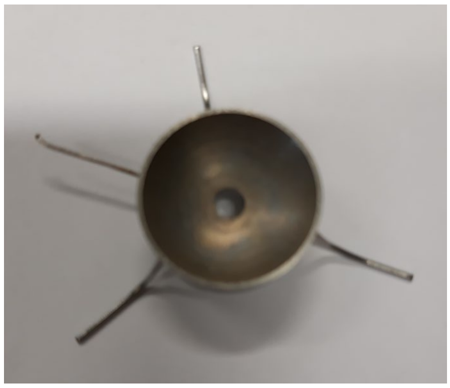

Fig.3 Photography of an ionizer.

By interacting with the ionizer, the cesium loses an electron becoming Cs^+ (with a positive charge). The positive cesium is attracted by the target that is a cathode. The beam is stabilized and concentrated in the target region by the -7kV electric field (Figure 4) that also gives the first acceleration. The field is necessary to maintain all the negative charge in order so it can reach the hole of the ionizer and to be useful in the accelerator.

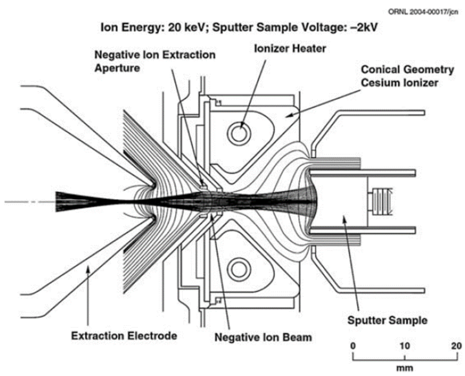

Fig.4 Scheme of the electric field.

The target is a cylindrical container filled with the material required for the experiment, the target is made by copper (Cu) and its particular shape is necessary to have a good sputtering yield: specifically, the front face has an inclination angle of 60°. This inclination allows the best angle of impact for the gases into the target.
The target can be made of many types of materials but when they have got low electronic affinity is better to use their molecules or their compound to have a successful result.

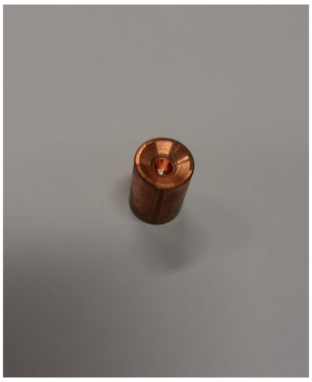

Fig.5 Photography of a target.

The cesium makes a layer on the target. The target (Figure 5) expels neutral particles by the sputtering process, they cross the cesium layer and take an electron from the cesium becoming negatively charged. They are accelerated from the target (that is a cathode) towards the ionizer, thanks to the existing electric field between the target and the ionizer. Then the negative ion beam exits through a hole in the ionizer.
The last acceleration to the beam is given by the potential difference between the ionizer (-16 kV) and ground.

The operation of the source foresees other ancillary systems:

- The vacuum system;
- The cooling system;
- High and low electric power;
- Thermometer for the cesium;
- Gas management system.

When the ion beam exits from the source it come into the Tandem accelerator, which is designed for beams of heavy ions (from the carbon to the gold). In the Tandem the ion beam is accelerated at almost the speed of light thanks to magnets fields with a tension of 15 MV.
At the end the beam goes on a fixed target in the experimental chamber, and through special detectors the interactions between the materials can be analyzed.

Protection and Prevention for the Respiratory Tract in the Workplace

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INTRODUCTION

Safety in the workplace is the necessary condition for a worker to be able to perform his duty without or with a limited risk of accidents; the risk is therefore the probability of someone being harmed by a hazard, which turns out to be the set of circumstances capable of causing damage, i.e. physical injury or an alteration of the organism or part or function of the organism. The probability and the damage therefore, affect the risk and to decrease it we can reduce the probability that an event will occur, for example, by changing the way an action is carried out or we can work on the damage by protecting ourselves with collective or individual protection devices that we will see more often. In the workplace there is a set of bodies working together to keep workers healthy. The first among them is the employer who has to guarantee the health of his employees and he is criminally responsible, so this figure has to enforce the rules on hygiene, safety and the environment.

It is also important to specify which tools are being used in this period marked by the COVID-19 epidemic and what the main respiratory protection tools are. The employer appoints an RSPP (Responsible of Security for the Protection and Prevention service) who must identify the safety measures to be implemented in the event of accidents. Another figure is the competent doctor, who verifies the suitability of the workers by subjecting them to health checks; if a worker already has health problems he cannot work at his best. The RLS (Rappresentante dei Lavoratori per la Sicurezza) is there to protect the employees and is the spokesperson for the workers on health and safety needs. These staffs work in order to maintain a state of health among the workers, not only for an absence of illness or infirmity but also a state of physical, mental and social well-being. It is important to specify that these bodies are present in all areas of work by assessing many risks which are disparate. For instance, in hospitals, these staffs have urged and imposed to the use of new equipment to make safe the doctors who work at risk of infection.

AIR-RELATED DANGER

COVID19 isn't the only problem which we can transmit by the air. However, the virus isn't the only example of "aerial threat": the air we breathe must meet certain standards for not resulting harmful or insufficiently useful to our body. Air toxicity consists of a set of factors that negatively modify the correct proportion of gas.

Our body is formed by numerous protective barriers that block many pathogens and harmful substances, in the case of the respiratory system it is equipped with hairs, eyelashes, mucous membranes in the trachea and nose that can block substances up to 3.3-4.7µm.

But what if this is not enough? Once harmful compounds are inserted into our body, they can cause various effects.

On one hand, we speak of a chronic effect when the subject is exposed to low doses of a substance for long periods of time. A fairly current example is that of asbestos fibres that penetrate the respiratory system and deposit themselves in the lining of the thoracic cavity and carry out a carcinogenic action on cells; today the most dangerous categories are workers in steel and metallurgical industries.

An acute effect, on the other hand, manifests itself after short-term exposure to high doses of a carcinogenic substance. The severity of the effect depends above all on the size of the gas. The more water-soluble it is, the better it dissolves in the walls of the respiratory system, irritating them, sometimes causing permanent damage or instantaneous death. An example of lethal substance is hydrogen sulphide, a gas produced by the fermentation of slurry: at low concentrations it induces irritation or pulmonary oedema and at medium-high concentrations inhibits mitochondrial cell respiration and inactivates sensory olfactory perception, causing the death of the individual who is unable to react.

OXYGEN DETECTORS

Oxygen detectors are tools considered necessary in places that represent a potential risk of asphyxiation, given the presence of inert or toxic gases. Their function is to measure oxygen content in the air: the ideal percentage tends to be about 20,9%. If the level is up to 18%, it represents no danger. However, once the quantity falls below this level, detectors send either an acoustic or visual signal to warn about the decrease of oxygen, ensuring that those within the concerned areas will have enough time to escape. Detectors' functionality can be based on different technologies, for instance electrochemical and optical systems.

Electrochemical detectors feature a zirconium oxyde membrane. Firstly, the sample gas is brought to high temperature. It is separated from the reference gas by the membrane. At this point, depending on the partial pressure of oxygen, the oxygen ions pass through the zirconium oxyde layer, causing a measurable potential difference. This device's operating principle is based on Nerst's equation.

$$E = \frac{RT}{4F}\log\frac{O_2\ reference\ gas}{O_2\ sample\ gas} \qquad \frac{\rightarrow partial\ oxygen\ pressure\ of\ the\ reference\ gas}{\rightarrow partial\ oxygen\ pressure\ of\ the\ sample\ gas}$$

R= perfect gases constant
F=Faradaway constant
T= zirconium oxyde membrane temperature

E=potential difference (mV)

Optical detectors, meanwhile, operate according to the fluorescence of a certain material. These particular devices are in fact equipped with an excited material (fluorescent), whose luminosity decreases as the quantity of oxygen dissolved in the air increases. The light is then captured by a photodiode, converted in an electric signal and finally converted into the amount of oxygen contained in the air.

PROBLEMS CONCERNING LACK OF OXYGEN

Lack of oxygen is a very frequent problem in structures like LNL, since certain accelerators and experiments require cryogenic gases, such as nitrogen (77 K) and helium (4K), which are stored within the tanks, even in large amounts. The problem comes if there is a leak in the pipes and especially in the valves, namely critical point of the system. These two gases, deployed as coolants in cryostats, turn out to be really dangerous when released from the appropriate structures, since they saturate air causing a deficiency of oxygen that could prove to be fatal for the operators. Furthermore, nitrogen and helium fall into the category of "inert gases": they are odourless, colourless and tasteless; hence they can't be perceived by humans.

The risk of lack of oxygen is present in environments such as the ALPI building (nitrogen and helium, both in gaseous and liquid state), the compressor room (nitrogen and helium, both in gaseous and liquid state), and the laboratory of superconductivity 1 (gaseous helium and nitrogen), as well as 2 and 3 (gaseous nitrogen). Detectors help monitoring of the oxygen percentage in the air through various systems. They need to be positioned at different heights, depending on which gas needs to be surveyed. Nitrogen tends to deposit at the bottom, so detectors will be placed lower. On the contrary, in order to monitor helium, they will be placed higher. When the detector raises the alarm, it is of extreme importance to escape the area as fast as possible: the drop-in oxygen percentage can be a matter of seconds, and it causes fainting. Once everyone evacuated the area, rescuers are required to wear a rebreather and check the actual state of the concerned establishment, whether the alarm was false, or also rescue eventual people in need of help. A portable detector is also a required tool. Only after the area is declared safe, general duties concerning that establishment can be resumed.

RPE

(RESPIRTORY PROTECTIVE EQUIPMENT)

Respiratory protective equipment is required as PPE when coming into contact with substances and situations that could reveal themselves to be dangerous and even lethal for the respiratory system.

Respiratory protection devices are divided in two main categories: insulators and non-insulators. The difference lies in the fact that insulating equipment provides a total isolation, meanwhile non-insulating devices act more as filters.

The first group further divides into two subcategories:

- "autonomous": they are available both as open circuits (compressed air) and closed circuits (oxygen);
- "non-autonomous": they are classified based on the method used to achieve air. Non-autonomous insulators can be provided with external air intake (assisted or unassisted) or with air supply (compressed or "from the line";

The second group presents three typologies. Non-insulators' effectiveness is dependent on the atmosphere and don't provide new oxygen: the air purified by the filter needs to present a percentage equal or superior to 20,3 %. At the same time, the concentration of the pollutant must not exceed 2%.

- "dustproof": devices consisting of a fibre barrier (cellulose) capable of retaining particles in the form of powders of microscopic size. They are classified based on their filtering efficiency: FFP1, FFP2, FFP3. Half-masks could serve as an example;
- "anti-gas": capable of intercepting or neutralising individual gaseous compounds;
- "combined": both dustproof and anti-gas.

COVID-19 AND SAFETY INTO THE WORKPLACE

The acronym SARS-cov-2 (Severe Acute Respiratory Syndrome coronavirus 2) refers to a virus belonging to the group Coronaviridae. This RNA viruses are equipped with an envelope, which is characterized by glycoprotein spikes. They are known as the cause of various upper respiratory tract infection.

The most recent strain was first isolated in Wuhan, China, during December 2019. Its formation was the result of the various recombination that occur during the replication stage. Moreover, it represents one of many cases of animal-human transmission of new pathogens.

The viral entry is made possible by the interaction between the Spike protein present on the surface of the virus and the ACE receptors of the host cell. Once inside, the SARS-cov-2 performs RNA replication of its genome. Subsequently, the ribosomes of the cell itself initiate the creation of the proteins needed for the creation of ulterior. pathogens, part of which are ejected outside of the organism. It is important to note that viruses lose their infectious capacity once their envelope is disintegrated.

Respiratory droplets represent a crucial role in the spreading of the virus: a subject can come into contact with Coronavirus trough saliva or contaminated surfaces, and by bringing the pathogens to the airways and eyes allows the transmission into the organism. The illness caused by SARS-cov-2 is known as COVID-19, which has resulted in a global pandemic that counted approximately 9 million cases and 467k deaths as of June 2020.

Prevention plays a key role in decreasing a virus spread: given that vaccines capable of fighting SARS-cov-2 are yet to be found, it is fundamental to adopt various safety measures, both individually and collectively. The most obvious precaution to be taken is limiting direct contact with others and possibly maintain a distance between one and two meters when in public places. Moreover, it is fundamental to frequently wash and sanitize hands in order to kill bacteria formed on the skin. Sanitizers are recommended for sanitizing surfaces: it is more efficient to use a diluted alcohol-based formula (to 70%), since the presence of water allows a more effective disaggregation of the virus membrane.

The clearest example of personal protection in this situation is brought by face masks. There are specific types indicated to ensure a certain level of safety, such as surgical masks, FFP2 masks and FFP3 masks. This form of protection is important, but it must be accompanied by the precautions previously cited. Moreover, none of these protection items are capable of filtering viruses, but rather block the droplets. Surgical masks initially hinder their trajectory, but the design allows leakage. This problem can be solved by using a FFP2 or a FFP3 mask, which can also be provided with exhalation valves, but are usually recommended for rescuers and health workers.

The Coronavirus pandemic had a remarkable impact on the economy of many countries. The issue regarding this emergency lies in its novelty. Therefore, every working field has had to make necessary changes and adapt every working procedure to the indications given by organizations such as WHO and by the local government. Different work-environments require different measures. Right now, the employment in the healthcare sector represents the major exposure to the risk of contracting COVID-19.

The employer represents the authority responsible of putting into action the various safety measures. The competent doctor contributes and follows this process in order to guarantee professional insight. Different companies will take different measures. Meanwhile many professions can be practised trough smart working, other fields had to rely on numerous changes in the actual workplace. Introducing an obligatory check-up prior to the entrance in the structure may be one of them, being fever one of the first symptoms. It is important to allow frequent air changes and periodical sanitization. In this respect, it is important to form both those in charge of cleaning and the other employees on the current situations, in order to clarify the correct method when managing PPE (Personal Protective Equipment). It is always the employer’s duty to provide the necessary regulations and information in order to reduce the risk at minimum.

Appendix

Covers proposed by the students

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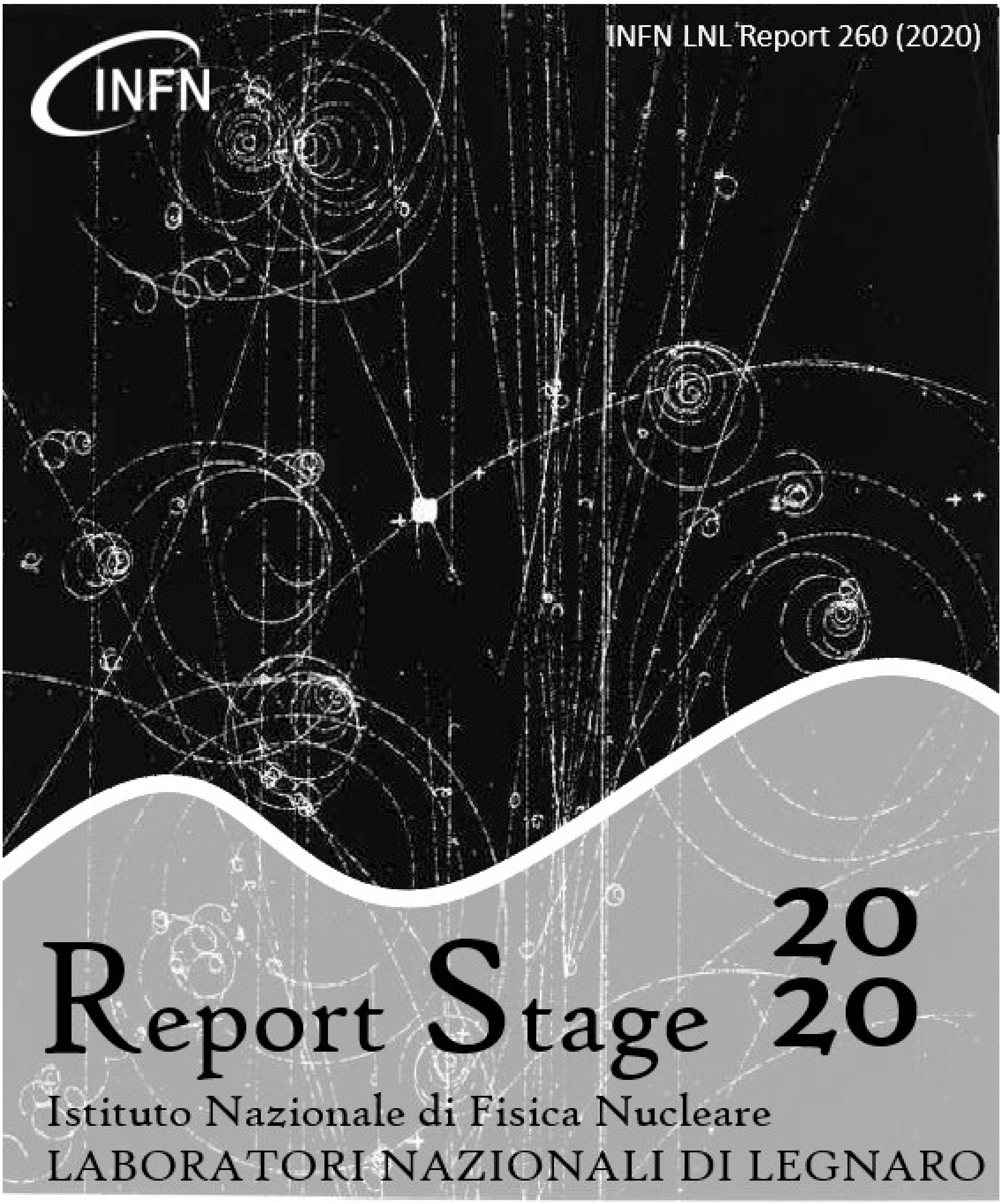

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