10 agosto 2011

Proposta di laboratorio per il III SNRI:
ESPERIENZE CON RIVELATORI DIMOSTRATIVI

Parte 1 – CAMERA A SCINTILLA

La camera a scintilla è costituita da una serie di lastre metalliche parallele inserite in un volume riempito di gas nobile (miscela elio-neon). Le lastre sono alternativamente connesse a terra ed a un generatore che fornisce un rapido impulso di circa 5kV in corrispondenza di un trigger di particella fornito tramite un sistema esterno basato su una coppia di scintillatori in coincidenza. Grazie al campo elettrico che si viene a creare tra le lastre, la ionizzazione primaria prodotta dalla particella genera un scarica a valanga che dà luogo ad una spettacolare scintillazione ben visibile ad occhio nudo lungo tutta la traccia.

In collaborazione con Openlab:
http://www.poloscitec.unifi.it/openlabweb/

Nelle pagine successive:

- Manuale di istruzione della camera a scintilla (in inglese);
- Schema a blocchi del sistema di trigger (implementato con moduli NIM);
- Schema elettrico della camera a scintilla.

Attività Proposte

1) Messa in opera della camera;
2) messa in opera del sistema di trigger;
3) realizzazione di semplici misure di flusso di raggi cosmici: per esempio, flusso in funzione dell'angolo con opportuna scelta del tipo e della posizione degli scintillatori di trigger.

Materiale disponibile per le differenti misure

1) Camera a scintilla, alimentatore HV, alimentatore LV
2) Sistema di trigger con scintillatori plastici di varia foggia e dimensione

Stazioni di lavoro

Personale
G.Sguazzoni, S.Straulino (OpenLab)

Instruction Manual for the CERN Optical Spark Chamber

1. The Gas

The gas to be used is a mixture of HeNe, premixed by Carba Gas (http://www.carbagas.ch/). The mixing ratio is 30% He and 70% Ne, its quality is He50 and Ne40. The gas mixture is standardized at CERN and the SCEM is 61.03.31.001.0.

The gas pressure of the HeNe mixture must be regulated to 1.1 bar, i.e. 100 mbar over atmospheric pressure. A higher pressure may damage the front Plexiglas plate.

The flow rate of the gas is typically regulated to 1 l/h, giving 7500 h of operation with one bottle of gas.

In order to flush the chamber, open the needle valve on the flow meter fully (turn counter-clockwise until end). Flush chamber for two hours and then regulate the flow to $\leq$ 1 l/h.

Fill the fixed mounted bubbler with paraffin oil using the syringe (delivered with chamber) by carefully removing either the patch panel by a few cm (do not damage the 2 cables HV and ground) or the small front plate fixed to the patch panel. The bubbler oil should be ~ 2 – 3 mm above the interior pipe. Note that the second (loose) bubbler serves as oil separator.

2. Electronics

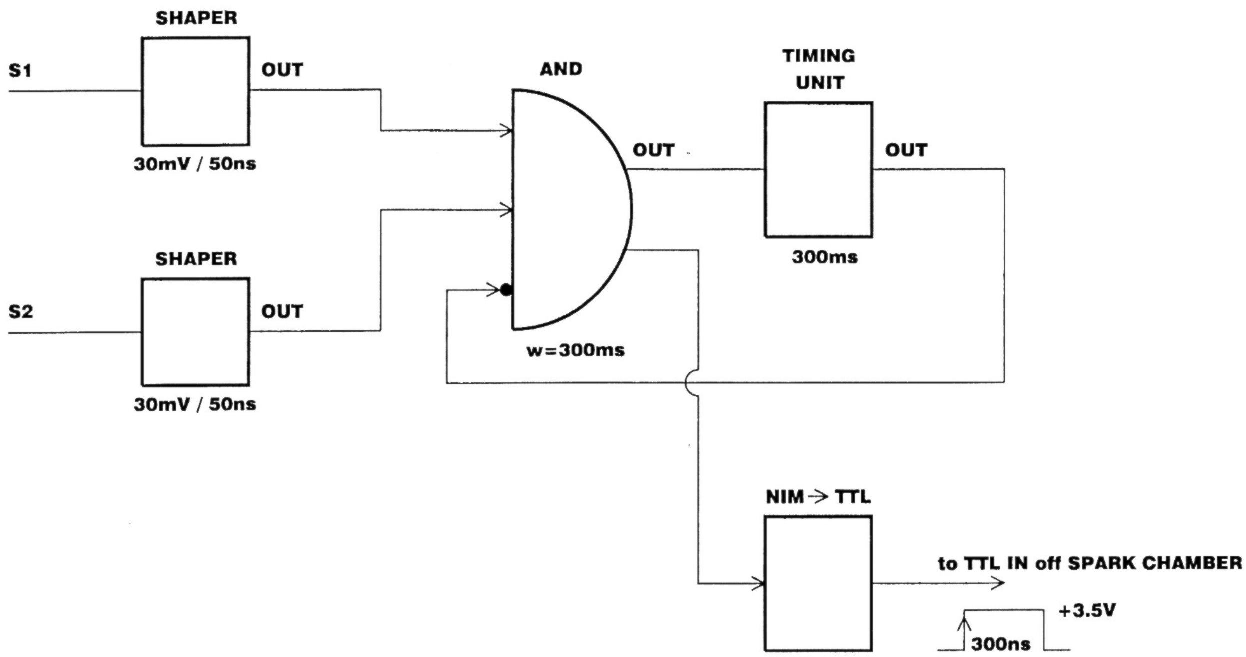
Cable the electronics as indicated in the electronics plan. Minimize the accidental rate by carefully setting the HV of the scintillators. Note that the level of the trigger pulse should be $\geq$ 3.5 V

3. Low Voltage

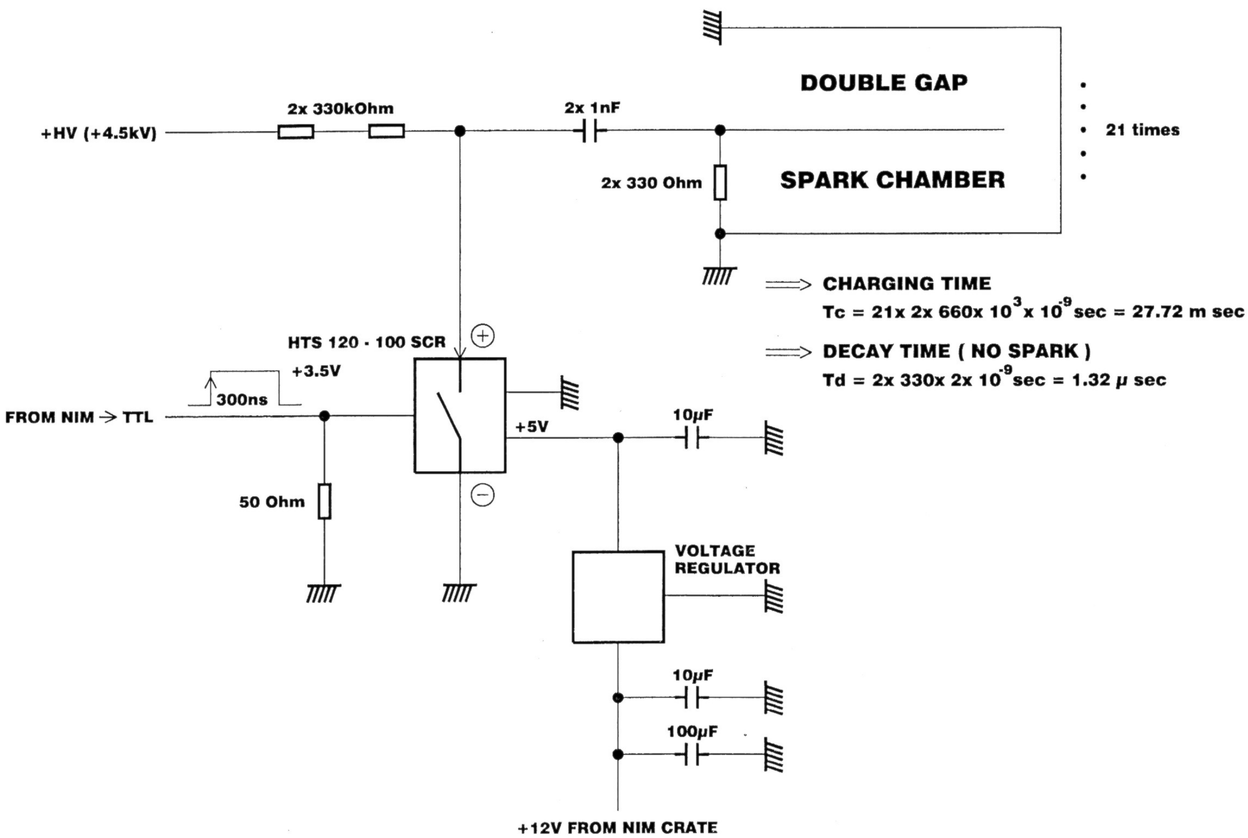
Connect the LV cable (delivered with chamber) from the NIM crate to the 4-pole Lemo connector. The light diode should go from red to green after stabilization of the voltage (< 1 sec). Presence of cosmic ray trigger is indicated by the flashing of the yellow light diode.

4. High Voltage

After having seen the yellow light diode flashing, turn on the HV to + 4.5 kV. You should now see cosmic ray tracks in the chamber. Polarity errors will destroy the HV switch.
Turning off the chamber goes in reverse order. Before turning off the LV, wait for several trigger to discharge the capacitors.



Schema semplificato del sistema di trigger della camera a scintilla.



Schema elettrico della camera a scintilla

Parte 2 – CAMERA A NEBBIA

Si propone la realizzazione di una camera a nebbia partendo da semplici componenti facilmente reperibili. La camera a nebbia funziona sul principio che un gas soprassaturo in appropriate condizioni chimico-fisiche condensa localmente in corrispondenza del deposito di carica lasciato da una particella ionizzante. La traccia della particella è dunque visibile ad occhio nudo grazie alle goccioline che vengono a crearsi lungo la sua traiettoria.
La camera a nebbia proposta consiste in un scatola con le pareti di vetro o plastiche, purché trasparenti, salvo la parete inferiore che deve essere metallica, per esempio d'alluminio. Nella parte alta della scatola c'è il sitema di distribuzione dell'alcool isopropilico, realizzabile anche con semplici spugne. Il fondo metallico viene messo in contatto con ghiaccio secco. In questo modo, in prossimità del piano metallico stesso, si viene a creare un volume di circa un centimetro di spessore in cui sussistono le condizioni per osservare la condensazione indotta dal passaggio di particelle cariche.

In collaborazione con Openlab:
http://www.poloscitec.unifi.it/openlabweb/

Nelle pagine successive:

– Scheda sulla camera a nebbia (in inglese, fonte CERN);

Attività Proposte

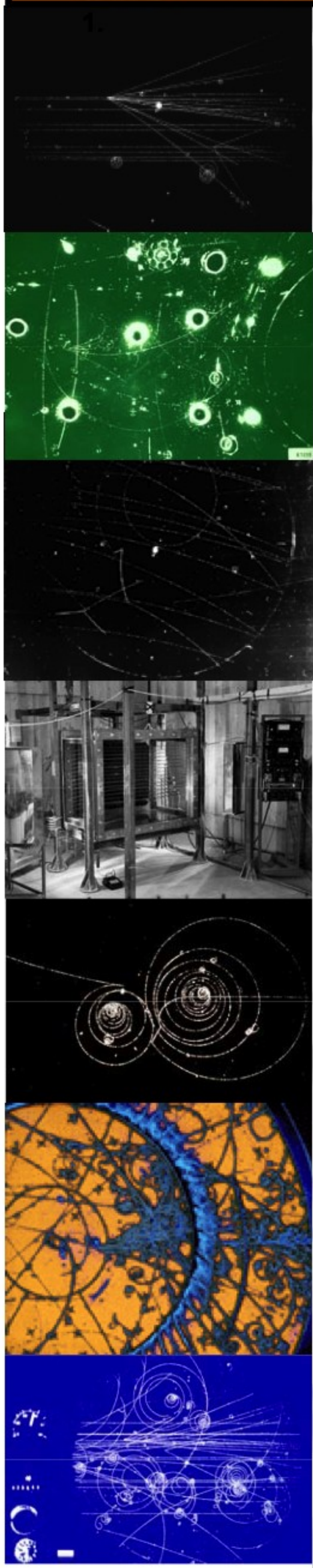
1) Messa in opera della camera;
2) osservazione del suo funzionamento, anche con l'utilizzo di sorgenti.

Materiale disponibile

1) Componenti base per la realizzazione della camera: scatola trasparente, piano di alluminio, alcool isopropilico, ghiaccio secco;
2) accessori per l'illuminazione;
3) sorgente radioattiva.

Stazioni di lavoro

Personale
G.Sguazzoni, S.Straulino (OpenLab)



Cloud Chamber Workshop

BUILD YOUR OWN CLOUD CHAMBER AT HOME

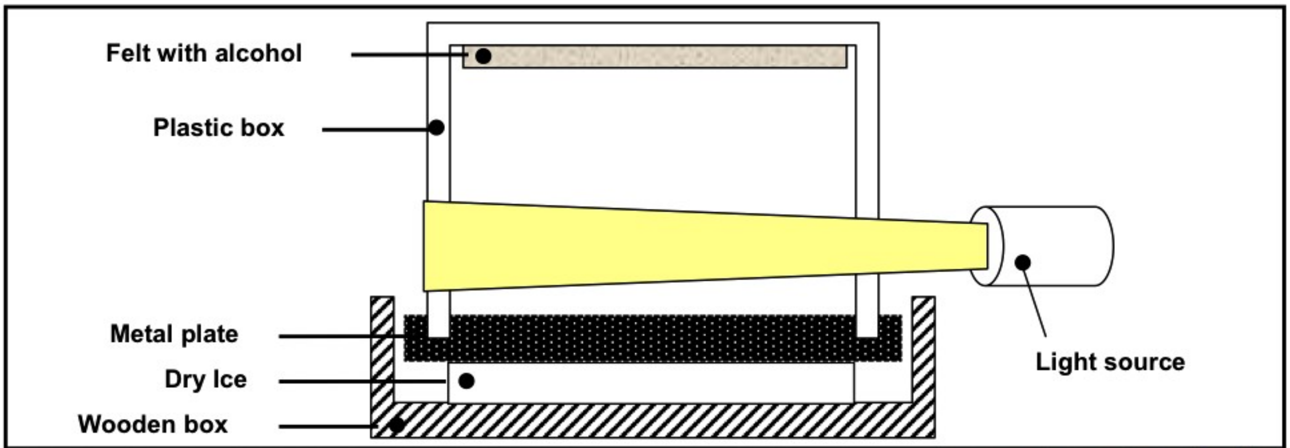
Particles coming from the universe (cosmic rays) are crossing the earth all the time – they are harmless but invisible to us, also called natural radiation. Cloud chambers are detectors to make the tracks of the particles visible. Some decades ago – these detectors were used at CERN in the first experiments to detect particles. Wouldn't it be nice to build such a detector at home in your kitchen? We show you how to build a small one at home in your kitchen for your own research ....

Shopping list

- A clear, see-through box-like plastic container, with flat sides and an open top, roughly 20 x 30cm (open side) x 15cm (height)
- A metal plate (at least 5mm thick) to cover the open size of the container completely (plate must be a little bit larger than the box). The plate should be preferably black and should have a little grooves matching the side walls of the plastic box. As this is probably hard to find, you can also use a flat metal plate and use black electrical tape to make the metal plate surface black.
- A thick felt (few mm), a bit smaller than the bottom of the box.
- 4 clips (self-adhesive cable-tie holders + cable ties) to attach the felt to the inside of the bottom of the box
- A small wooden box that is just a little bit larger in area than the metal plate and approx. 5cm in height. The box later on has to take the ice plates and the metal plate but the sides should not be much higher so that it doesn't cover the plastic box.
- A very intense, bundled light source, e.g. a slide projector, strong flashlight ...
- Pure (not 70%) isopropyl alcohol – make sure you get the right one – it will only work well with this one it and keep it out of reach of children).
- Dry Ice (Careful with your hands – always use thick gloves and never touch the ice directly! The ice is at -78°C; touching it directly will give you a burn.)
- Security goggles to handle the ice
- Gloves to handle the ice and the alcohol

A word of warning:

Isopropyl alcohol is not intended for drinking and harms your health if you drink it. So never ever drink it and keep it out of range of children. Handle it only with plastic gloves. Dry ice is at -78°C so never touch it directly – it will burn your skin – always use thick gloves and security goggles to handle it and watch children carefully. Also dry ice ($C0_2$) evaporates as it heats up which can harm your health in large quantities. So make sure you ventilate your room very well while doing the experiment.



Step by step instructions:

1. Preparing the base plate

If you were not able to get a black metal plate, you have to wrap one side of the metal plate completely with the black electrical tape. This will make it much easier for you to see the "white particle tracks" later on in front of a black background. The bottom will be in contact with alcohol when you run the chamber, so do not use alcohol-soluble tape or glue to attach it. If you have already a black metal plate you can skip to point 2.

2. Prepare the Alcohol dispenser

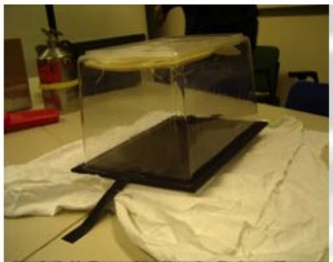
Attach the cable tie holders to the bottom of the box and clamp the felt with the cable ties to the bottom of the box. Later on these felts will be soaked with alcohol and will produce a rain-like mist of alcohol. Also, you can drill very small holes in the bottom of the box, just above the felt. Like this you will be able to easily add later on alcohol to keep the chamber running for a longer time.

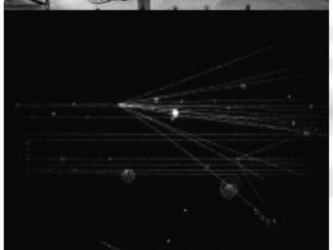
3. Add the alcohol to the chamber

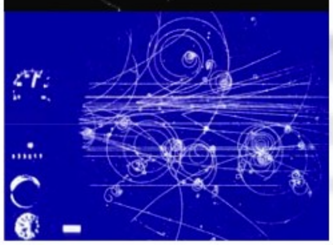
Next you have to add the alcohol to the chamber. Make sure you have plastic gloves on so that the alcohol does not touch your skin excessively. Again – never ever drink the alcohol and keep it away from children! It is very crucial that you use the right alcohol – the chamber will not work with another one! You have to add the alcohol to the felt – add so much alcohol that the felt is thoroughly soaked with alcohol. This alcohol will later form the mist in which you see the tracks appearing. Also put alcohol into the little deepening of your metal plate if you have it. This will help sealing the box.

4. Put the chamber together

Now you can close the chamber: Put the metal plate with the black surface pointing to the inside of the box and turn it around. Your chamber should how have the plastic box inverted, metal plate on the bottom. Fit the box so that the box walls fit the grooves in the metal plate. Make sure there is some alcohol in the grooves - that will seal the box better. If you metal plate has no deepening you must seal the box in addition by putting black electrical tape around the connection of the box with the plate. Make sure that you seal the box carefully and completely.







5. Prepare the ice

Now take the dry ice and put it into the wooden box. Make sure to use thick gloves (the ones for handling heavy things or heavy winter gloves) and safety goggles when handling the ice. The temperature of the ice is -78°C! Finally put the box with the metal plate on the bottom on the ice.

Now your chamber is ready to detect particles tracks !!!

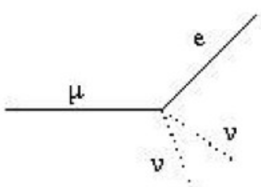
6. Running the chamber

The chamber will take a few minutes to get to an equilibrium state before you can see the first track appearing. Turn off the room lights and turn on your light source (flash light or slide projector) and point it through the chamber along the bottom of your chamber. At first, you will only see a rain-like mist of alcohol. The sensitive place of the chamber where you will see tracks is near the bottom of your chamber. Make sure that the chamber stays sealed and that you have no air leaks.

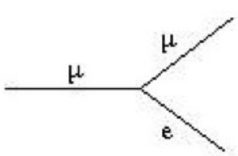
After about 10 minutes, you should start to see the tracks of particles passing through. The tracks look a little like spider's threads going along the chamber floor. You should be able to see a couple of tracks per minute. If needed, you can add extra alcohol through the holes in the top of the box without reopening the box.

What can you see ?

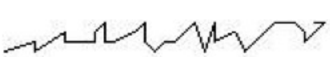
You will see different kinds of tracks coming from different cosmic particles. You might notice that some tracks are very "bright" and thick, and others are very faint. Besides straight lines of tracks from one particle you might see:



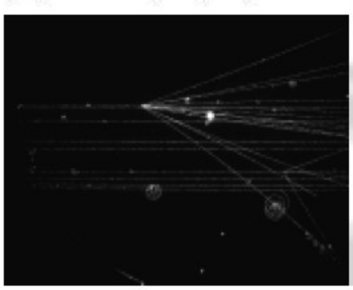
- *A straight track that sharply "kinks" off to the left or right. This is a decay of a muon particle. The two dashed lines are particle called neutrinos (the dashed lines) that your chamber is not able to detect.*



- Three tracks that meet at a single point. In these events, one track is an incoming cosmic ray, a particle called muon. This particle hits an atomic electron. The electron and the outgoing cosmic track are the two other tracks.



- *A very windy, chaotic track. This is "multiple scattering", as a low-energy cosmic ray bounces off of one atom in the air to the next.*



How does this work?

As the top of the box is at room temperature, the alcohol evaporates from the felt (i.e. exists in gaseous form) and slowly sinks down in the direction of the bottom of the chamber. Because there is so much alcohol, the chamber will be saturated with alcohol vapour.

The dry ice keeps the bottom very cold – so that the vapor, once it has fallen, is in a so called supercooled state. This means, the alcohol is in vapor form, but at a temperature at which vapor normally can't exist. It is, as if you had made steam at 95°C. Since the vapor is at a temperature where it normally can't exist, it will very easily condense into liquid form if anything disturbs its equilibrium.

Now what happens if a charged cosmic particle crosses the chamber? The particle will *ionize* the vapor: it tears away the electrons in some of the gas atoms along its path. This leaves these atoms positively charged (since the electrons that have negative charge have been removed).

This is enough to start the condensation process: Small droplets of alcohol form along the path of the initial particle through the chamber. These droplets are the tracks you see appearing.

TROUBLESHOOTING

Like in any real experiment, things might not work from the beginning and you may find yourself with difficulties. Here are a few common problems and their solutions:

- *"I don't see any tracks!".*

  Solution: Be sure the light is well placed. The sensitive part of the chamber is near the bottom where the alcohol is in its supercooled state. Make sure the dry ice is neatly packed and in good contact with the metal plate. Try adding some alcohol so that the chamber is well saturated. Check that the chamber is airtight.

- *"I only see mist, and no tracks."*

  Solution: Wait. It takes about 10-15 minutes for the chamber to get to the right temperature. Make sure that you use the right alcohol – other alcohol have different "activation energies" that so that cosmic rays will not be able to start the condensation process.

- *"I see big clouds at the edges of the chamber."*

  Solution: This probably means you have an air leak. Be sure that the chamber is tightly sealed.

TO LEARN MORE ABOUT IT …

If you want to learn more about cosmic particles and cloud chamber have a look at the following sites:
A. Foland cloud chamber page (this is who **we** learned it from!)
http://w4.lns.cornell.edu/~adf4/cloud.html
Cambridgephysics
www-outreach.phy.cam.ac.uk/camphy/cloudchamber/cloudchamber_index.htm
Cloudchambers
http://www.cloudchambers.com/
Science Learning Network
http://www.jsf.or.jp/sln/fog_e/indexpre.html

CERN Cloud chamber workshop developed by:
D. BERTOLA, M. CIRILLI, J. FLAMMER, G. SCHLAGER, S. SCHUH, P. SCHUNE