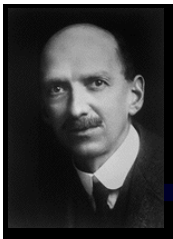
My outreach activity 2018

A Diffusion Cloud Chamber to observe natural radioactivity

- **What is a Wilson cloud chamber ?**
  principle of operation ⇒ 2 types
  - **Expansion Cloud Chambers**
  - Continuously sensitive **Diffusion Cloud Chambers**
- **How to build and operate a home made chamber ?**
- **What is observed ?**

⇨ **Demo**

UMONS Université de Mons
E. Daubie, F. Defontaines, S. Devouge
Service de Physique Nucléaire & Subnucléaire
PNSN



Wilson cloud chamber

Nobel Prize 1927

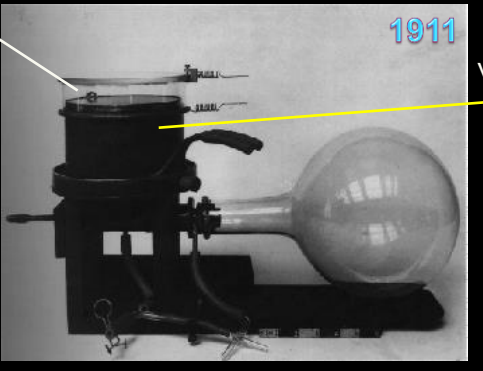
Charles Wilson Scottish meteorologist
interested in cloud formation initiated by electricity

Transparent cylindrical vessel

16.5 cm diameter
3.4 cm high

gas-vapor mixture ***at the vapour saturation***

Ex. Air – water vap.
Argon - alcohol vap.



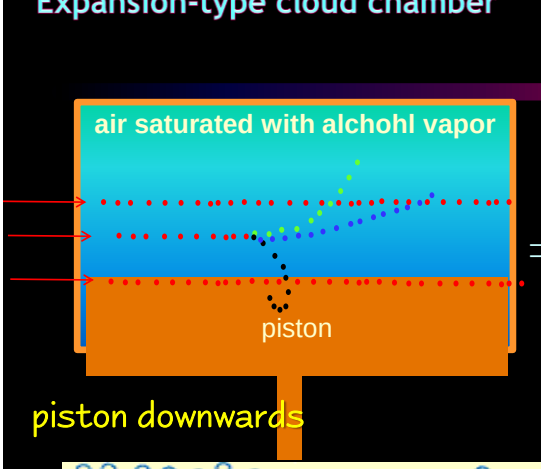
vessel floor
piston

Fast expansion
adiabtic expansion

[1] C.T.R. Wilson, Proc. R. Soc. London, **A85**, 285-288 (1911)

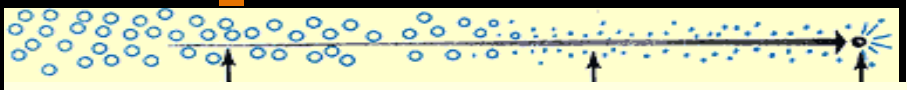
Principle of operation

Expansion-type cloud chamber



⇒ *supersaturated state*

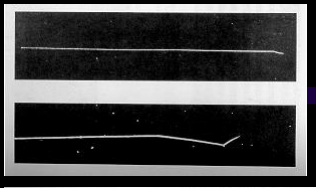
- Time-consuming : Recompression 1s + recovery phase (draining of ions) 1-10 min ☹
- Need Geiger counters to trigger the expansion



condensation droplets ions charged part.

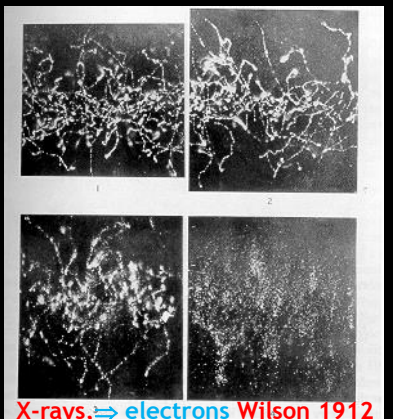
3

Cloud Chamber : first clichés



1st Alpha-Ray tracks Wilson 1912

scattering



X-rays, ⇒ electrons Wilson 1912

Fig. 13. K. Philipp, Naturwiss. 14, 1203 (1926).

Alphas, Philipp 1926

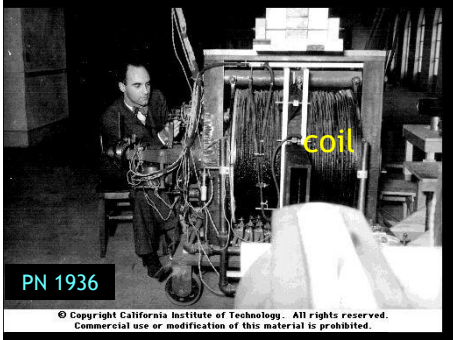
From W. Riegler's talk / CERN

4

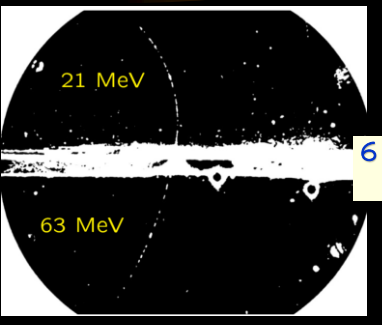
Cloud Chamber : famous pictures

cosmic ray studies

1932 Anti-electron or positron discovery



C.D. Anderson at CAL-Tech



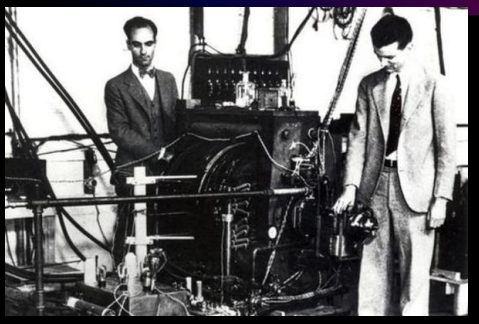
The ionization of the particle, its deflection and its behaviour in passing through Pb are the same as those of an electron

B = 1,5 T

5

Cloud Chamber : famous pictures

1936 Muon discovery « heavy electron »



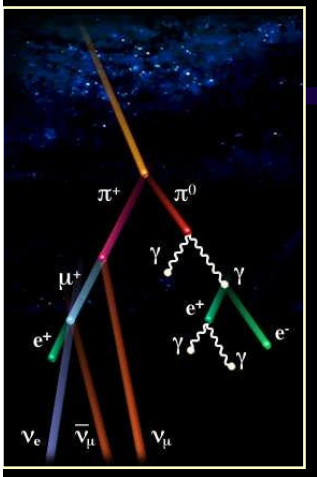
Carl Anderson & Seth Neddermeyer

at Caltech - same magnet cloud chamber as used to discover the positron in 1932

6

Cloud Chamber : pictures

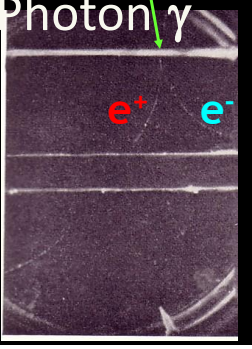
cosmic ray studies 20s - 50s



Neutral particles

V shape events

Photon γ

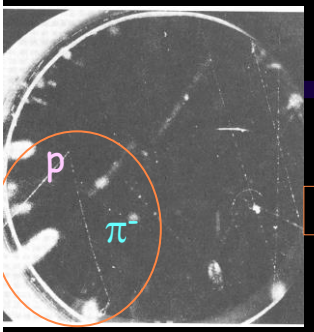


Production
e^+e^- pair
in Pb plate

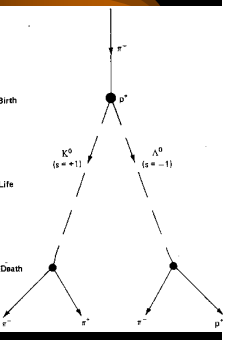
7

Cloud Chamber : pictures

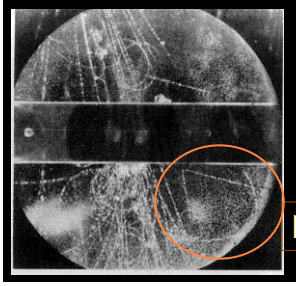
50s Strange particles discoveries



Neutral particle $\Lambda^0 \rightarrow \pi^-$ p



V shape events



Neutral partcile $K^0 \rightarrow \pi^+ \pi^-$

8

another type of operation

Continuously Sensitive Diffusion Cloud Chamber

1939 Dr A. Langsdorf [Univ. of California - Berkeley]

Supersaturation necessary for condensation of a vapor upon ions is maintained continuously by the diffusion of an initially warm saturated vapor through a noncondensing gas into a refrigerated region.

[2] Langsdorf A., Review of Scientific Intruments **10**, 91, (1939)

Expansion Piston movement

Temperature gradient

***Cloud** or **fog** = supersaturated state achieved near the bottom*

9

Our Home made chamber

Components & operation

1/ Airtight glass container (≈ 35 × 25 × 18 cm)

2/ Felt glued on the bottom floor

Spray pure isopropanol on the felt

3/Insulation box

Fill the box with dry ice

4/ metallic plate covered with black tape

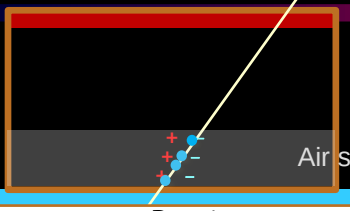
Put down onto the dry ice layer

container turned upside -down

10

Our Home made chamber
Components & operation

5/ intense light source
pointed onto the chamber bottom



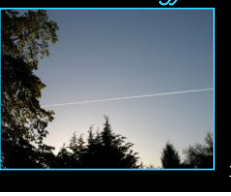
After a few minutes :
Air supersaturated with alcohol vapour
≈ cm high

Dry ice

Charged particle = ionizing radiation

vapor trails
curls

Analogy

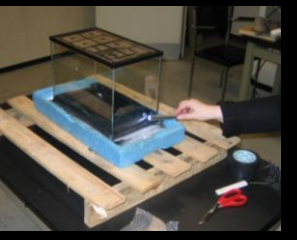


11

Our Home made chamber
Critical points

- Pure isopropanol (99 % purity)
- Rubber insulation strip for door *or window*
to ensure *airtightness* of the chamber

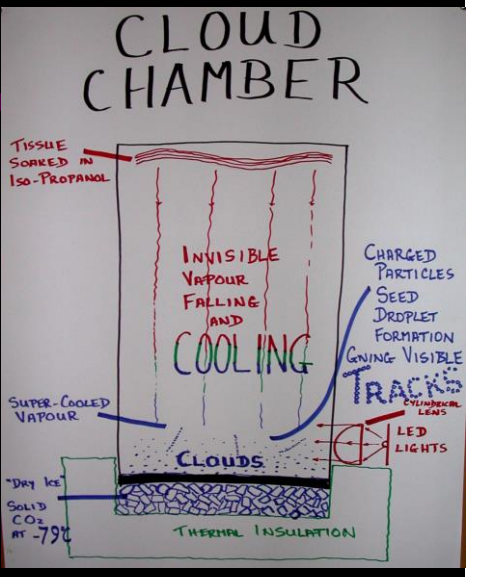
- Intense light source LEDs
- *Turtle tub more convenient than an aquarium*



12

Many home-made models

Diffusion-type recipes



http://www.hep.phy.cam.ac.uk/outreach/cloud.html

Commercial models as educational tool

$149.50

Petri dish 4$

2016

\+ ^{210}Pb sample

Air cooling system, Peltier based

More expensive

What can be observed ?

Continuously Sensitive **Diffusion Cloud Chamber**
enable to observe live particles

Natural radioactivity:
- Cosmic rays
- Telluric radiations

⇒ Idea of the flux

15

What can be observed ?

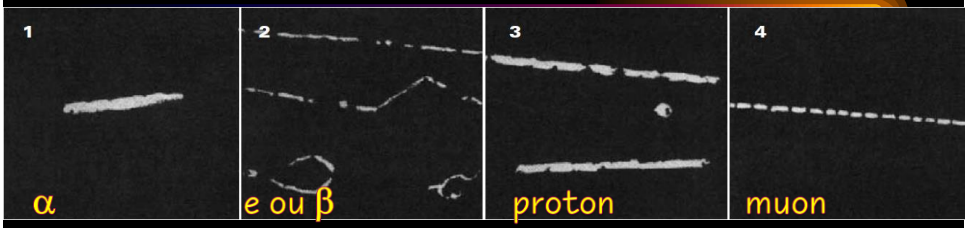
α
Radioactive source

^{241}Am α Tracks : short, thick, heavily ionized, straight

16

α β γ p μ ionizing rays **invisible !**

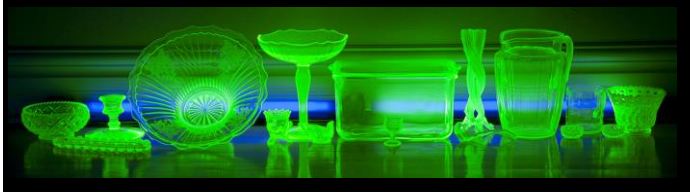
⇒ *Tracks observed*



Weak radioactive source

U fluorescence property

Uranium glass (U oxide) glowing under UV light



Henri Becquerel

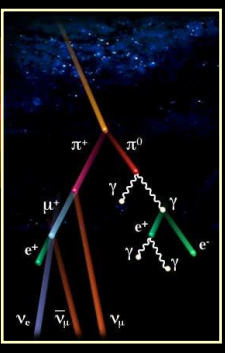
1895

17

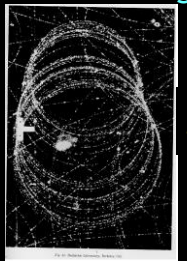
Cloud chamber in a classroom

- Thermodynamics
- Nuclear physics
- Particle physics
- Cosmic ray physics
- Special relativity $\mu \rightarrow e\ \nu\nu$ $\tau = 2\ \mu s$

Needed to understand : muons can reach Earth surface



- ElectroMagnetism



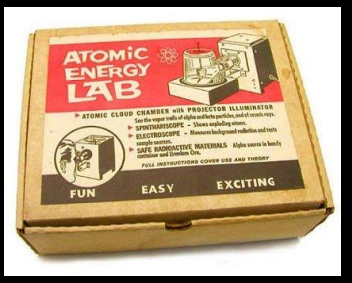
Fast electron in a magnetic field at the Bevatron, 1940

to understand how charged particles bend when affected by a magnetic bield 18

Thanks for your attention

⇨ Demo

Atomic cloud chamber kit for children !



In the 50s

19

References

[1] C.T.R. Wilson, Proc. R. Soc. London, **A85**, 285-288 (1911)
[2] Langsdorf A., Review of Scientific Intruments **10,** 91, (1939)
[3] http://www.scienceinschool.org/fr/2010/issue14/cloud
https://scool.web.cern.ch/sites/scool.web.cern.ch/files/documents/SCoolLAB_CloudChamber_DIYManual_2017_v3.pdf
https://icecube.wisc.edu/outreach/activity/cloud_chambers
http://astrobulletin.amnh.org/exhibitions/einstein/promos/for-educators/building-a-cloud-chamber-cosmic-ray-detector/ (Andy Foland's Cloud Chamber Page)
[4] E. Segré, Nuclei and Particules, W.A.Benjamin Inc., 1965, pp. 99-102
C. Grupen and B. Shwartz, Particle detectors, Cambridge University Press, 2008, pp. 160-162.
[5] Louis LEPRINCE-RINGUET, les rayons cosmiques, Ed. Albin Michel, 1945
R. Mermod, De l'électron aux quarks, Presses Polytechniques et Universitaires Romandes, 1999, pp. 9-23

More info

https://icecube.wisc.edu/outreach/activity/cloud_chambers

https://home.cern/students-educators/updates/2015/01/how-make-your-own-cloud-chamber

http://www.hep.phy.cam.ac.uk/outreach/cloud.html

http://www.cloudylabs.fr/wp/hadron_pictures/

More fun on

https://www.youtube.com/watch?v=noP7HT-Uins

https://www.youtube.com/watch?v=AMaDqaRzDm4

https://www.youtube.com/watch?v=pewTySxfTQk

20