



Praktische Ergänzung zum Higgs-Modul

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26.April

Gunther Roland/MIT

G. Roland - Introduction to 8.13 Junior Lab

Praktischer Ergänzungsteil

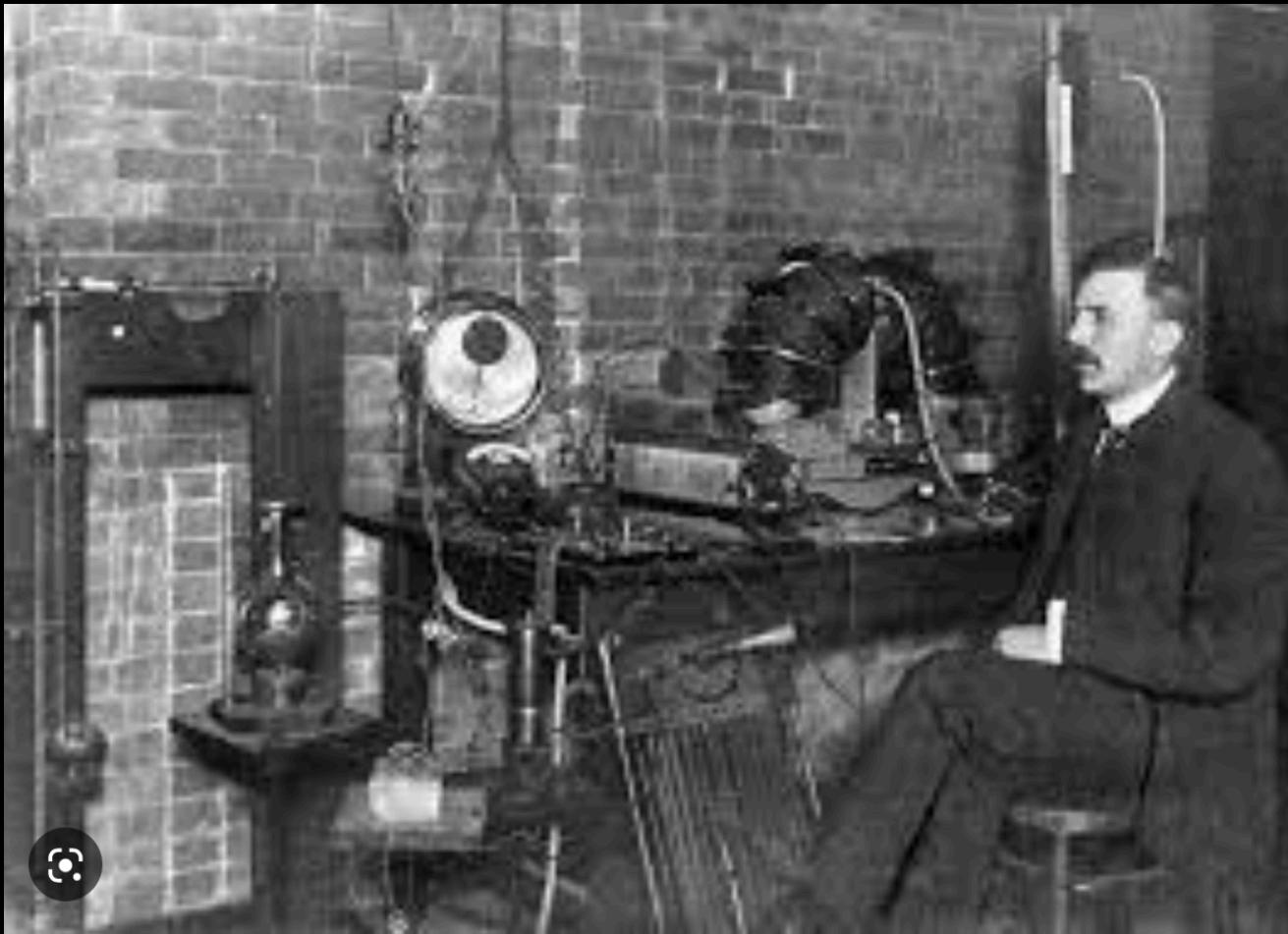
- Ziel: Analyse des “Golden channel”: $H \rightarrow 4l$ Higgs Signals
- **“Cosmicwatch” desktop muon detectors (2.5 sessions)**
 - **Grundlagen der muon Wechselwirkungen in Materie**
 - **Uebungen zu Datenanalyse (Python/ROOT), Statistik, wissenschaftlicher Kommunikation → 10+5min Vorträge**
- Higgs Hunter quick-start Guide (1.5 sessions)
 - Kanäle, Raten, LHC p+p facts
 - Detecting the Higgs in CMS
- (Re-) Discovering the Higgs in the 4 lepton channel (2.5 sessions)
 - Gruppenarbeiten mit CMS *open data* (und Simulationen)
 - Methoden zur Optimierung der Higgs Signal Signifikanz → *letter-style* Papiere

Zum Kennenlernen, bevor's losgeht

- Welcher Abschluss (momentan/angestrebт?)
- Programmierkenntnisse
 - Bevorzugt Python oder ROOT/C++?
 - Erfahrung?
- Detektor/Analyse Erfahrung?

Vermischtes zur kosmischen Höhenstrahlung

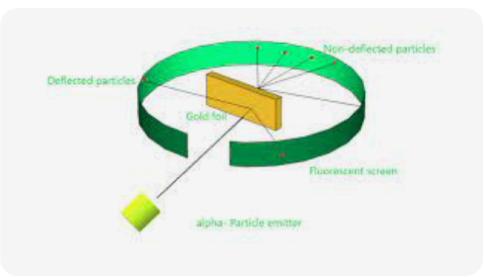
Am Anfang war...



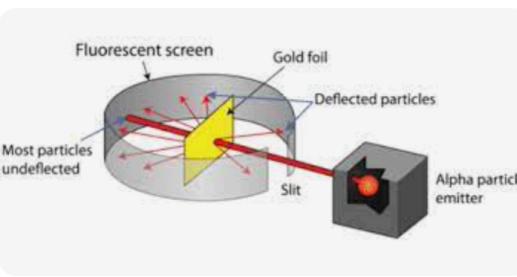
Ernest Rutherford Discovers the Nucleus | SciHi Blog

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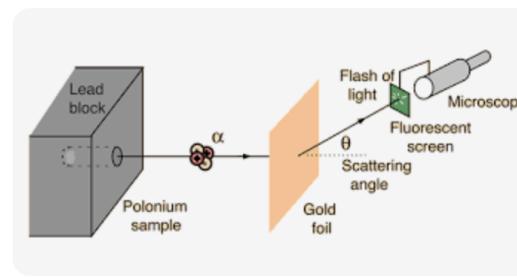
“Rutherford scattering experiment”



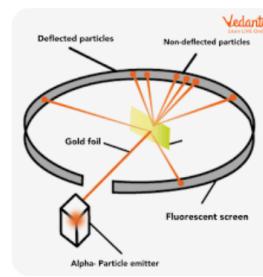
GeeksforGeeks
Alpha Scattering Experiment ...



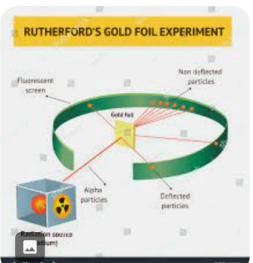
CK-12
Alpha Particle Scattering Experiment ...



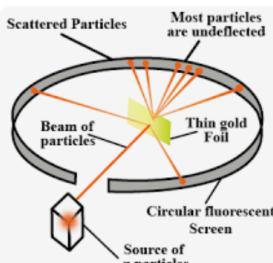
HyperPhysics Concepts
Rutherford Scattering



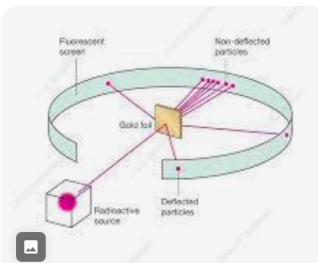
Vedantu
JEE - Rutherford Scatteri...



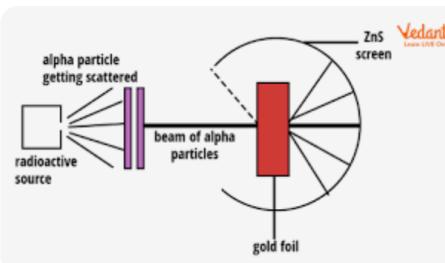
Shutterstock
33 Rutherford Scatterin...



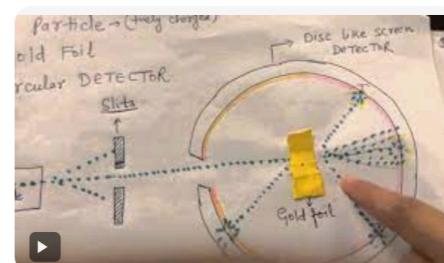
Toppr
ray scattering experiment w...



Science Photo Library
Rutherford scattering experime...

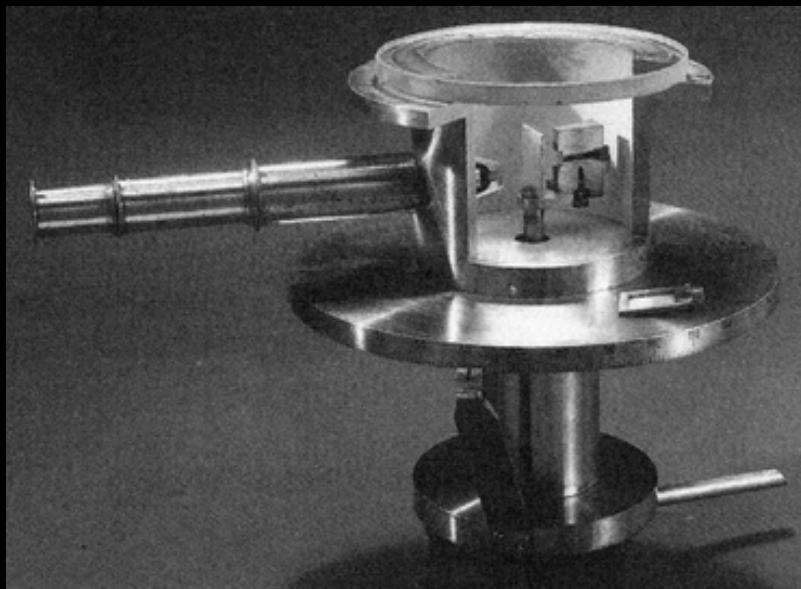


Vedantu
Alpha Scattering Experiment ...



YouTube
Rutherford scattering experiment - YouTube

“Rutherford scattering experiment”



1913

492

The Scattering of the α -Particles by Matter.

By H. GEIGER, Ph.D.

(Communicated by Prof. E. Rutherford, F.R.S. Received February 1,—
Read February 17, 1910.)

In a preliminary note ('Roy. Soc. Proc.,' A, vol. 81, p. 174, 1908) on the above subject, experiments were described which gave direct evidence of the scattering of the α -particles.* In those experiments a strong source of α -radiation was placed at one end of a long exhausted tube, and the α -particles, after passing through a narrow slit, fell upon a zinc sulphide screen sealed to the other end of the tube. When the pressure inside the tube was very low, the narrow line of scintillations which marked the place of incidence of the α -particles on the screen was well defined, but when the rays on their way to the screen passed through gas or through thin metal foils the edges of this line of scintillations became indistinct. The amount of scattering could be estimated for different foils by placing them in the path of the rays and noting the distribution of the scintillations on the screen.

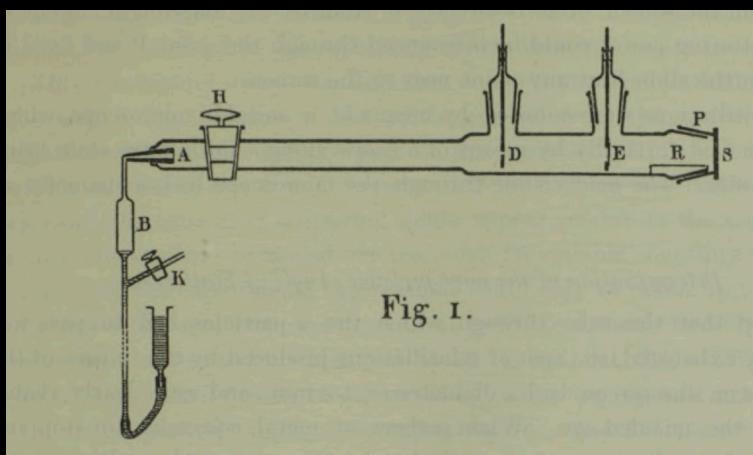


Fig. I.

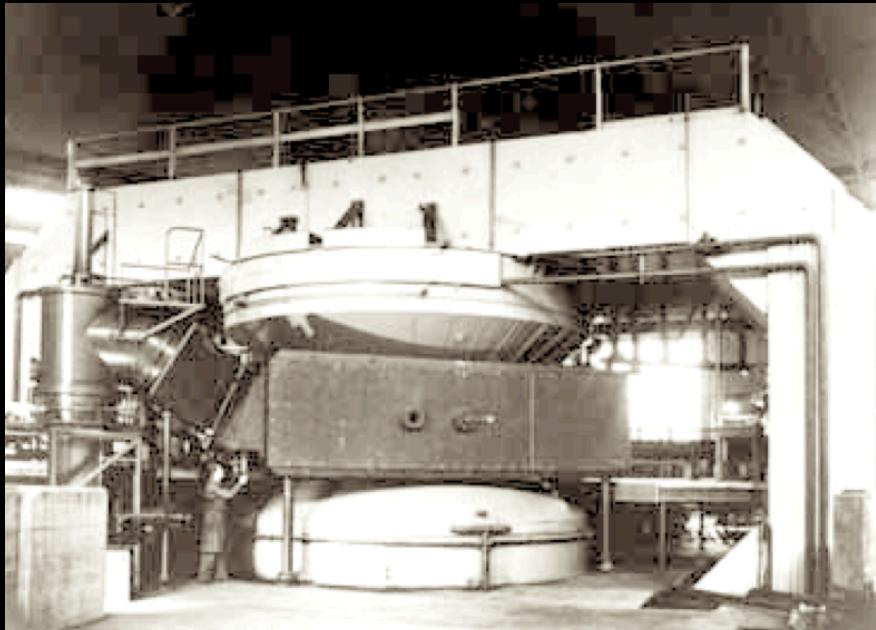
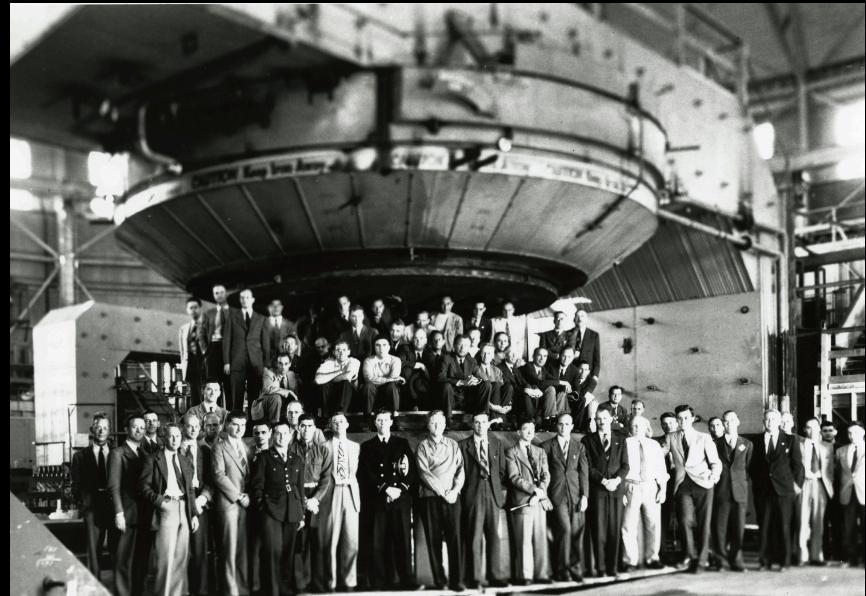
- Charakteristische Energien von α Teilchen in radioaktiven Zerfällen?
 - keV, MeV, GeV?
- Warum?
- Wie kann man höhere Energien erreichen?

184" Cyclotron @ Berkeley

Led by Ernest Lawrence
Nobel prize in '39 for invention of
cyclotron

First machine to exceed
100MeV energy

Accelerated deuterons to
190MeV in 1946 (!)



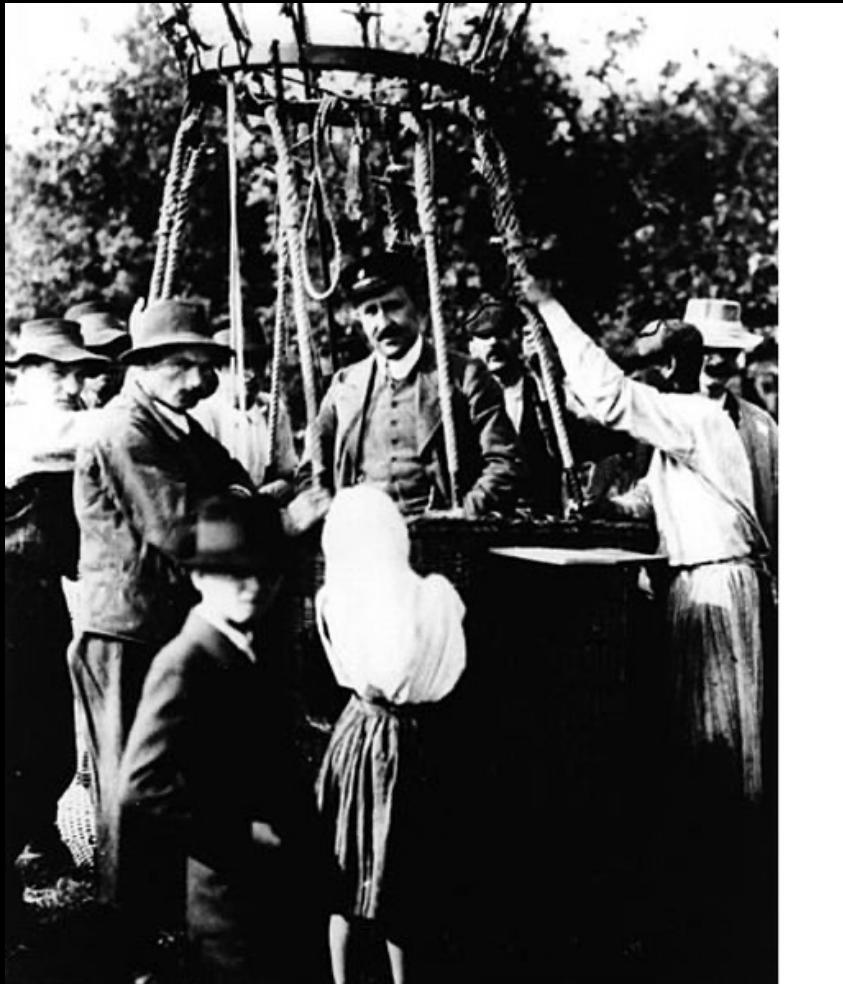
From the Division of Geophysics, Meteorology and Geomagnetism:

Viktor F. Hess (Wien),

MEASUREMENTS OF THE PENETRATING RADIATION
DURING SEVEN BALLOON FLIGHTS

(Translated and commented by A. De Angelis and C. Arcaro b. Schultz)

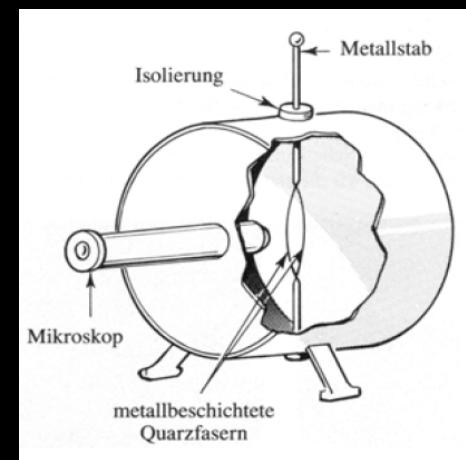
Viktor Hess (1912)



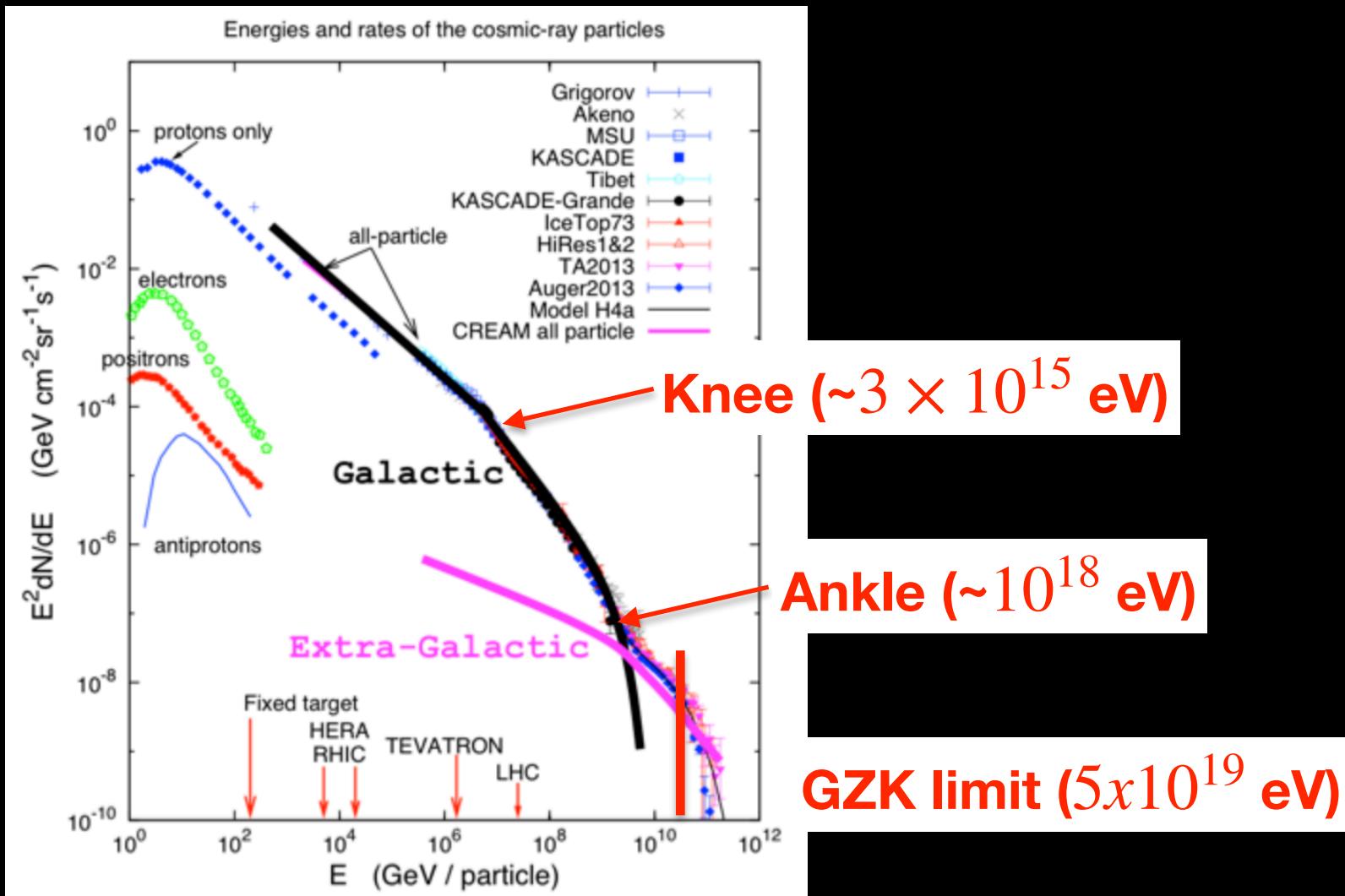
<https://arxiv.org/pdf/1808.02927.pdf>



Original Elektroscope (Smithsonian)

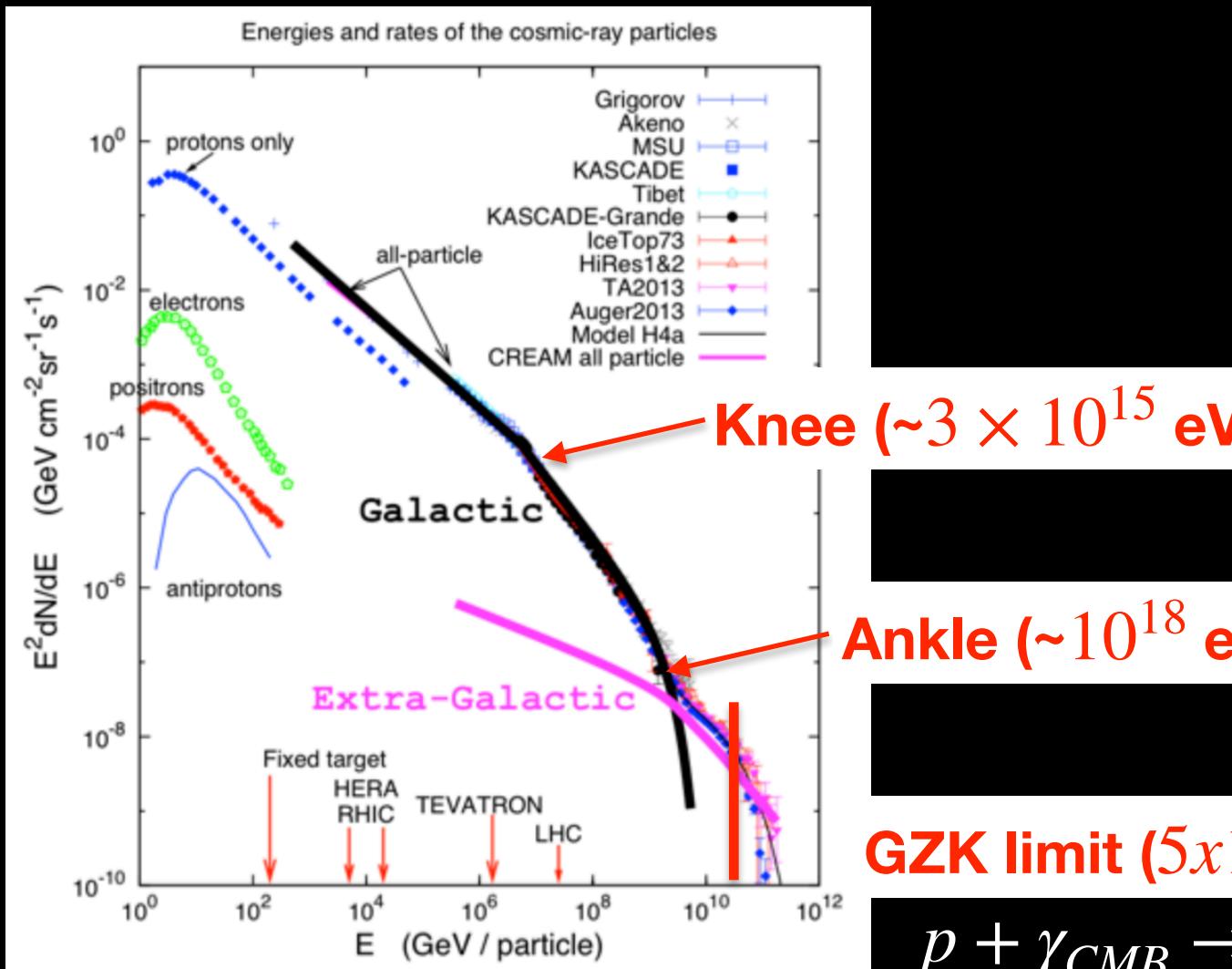


Primary cosmic rays



<https://masterclass.icecube.wisc.edu/en/analyses/cosmic-ray-energy-spectrum>

Primary cosmic rays



<https://masterclass.icecube.wisc.edu/en/analyses/cosmic-ray-energy-spectrum>

PHYSICAL REVIEW

A Journal of Experimental and Theoretical Physics Established by E. L. Nichols in 1893

VOL. 50, No. 4

AUGUST 15, 1936

SECOND SERIES

Cloud Chamber Observations of Cosmic Rays at 4300 Meters Elevation and Near Sea-Level

CARL D. ANDERSON AND SETH H. NEDDERMEYER, *Norman Bridge Laboratory of Physics, California Institute of Technology*
(Received June 9, 1936)

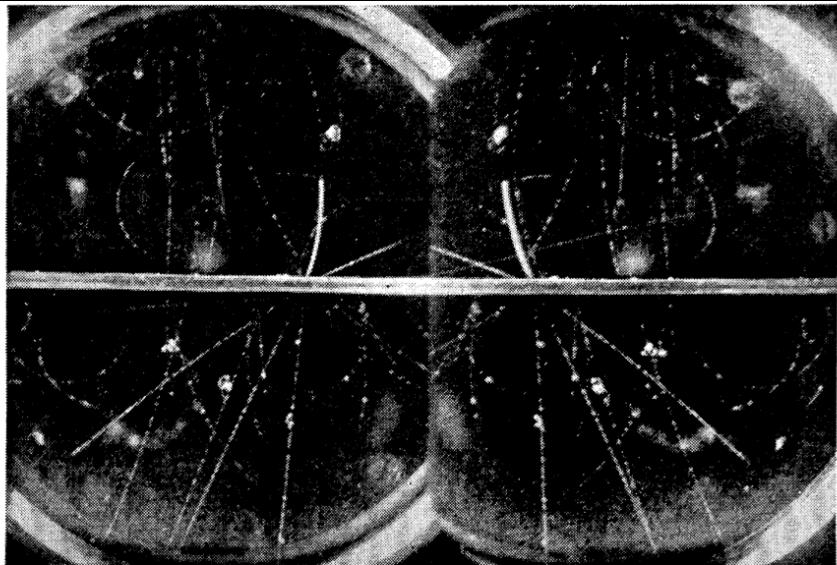


FIG. 12. Pike's Peak, 7900 gauss. A disintegration produced by a nonionizing ray occurs at a point in the 0.35 cm lead plate, from which six particles are ejected. One of the particles (strongly ionizing) ejected nearly vertically upward has the range of a 1.5 MEV proton. Its energy (given by its range) corresponds to an $H\rho = 1.7 \times 10^5$, or a radius of 20 cm, which is three times the observed value. If the observed curvature were produced entirely by magnetic deflection it would be necessary to conclude that this track represents a massive particle with an e/m much greater than that of a proton or any other known nucleus.

Mesotron (Intermediate Particle) as a Name for the New Particles of Intermediate Mass

THE existence of particles intermediate in mass between protons and electrons has been shown in experiments on the cosmic radiation¹. Since at present so little is known concerning the properties of these particles, for example, the exact value of the mass, the laws governing their production, their stability against disintegration, etc., it may yet be too early to assign to them a name. But inasmuch as several names have already been suggested, namely, dynatron, penetron, barytron, heavy electron, yukon and α -particle, it may be wise to consider the matter at this time.

The property which so far serves to distinguish the new particles from the other two types of particles which carry the same magnitude of electric charge, namely, the proton and the electron, seems to be the magnitude of their mass. Although from the experiments so far performed, it is not possible to say definitely whether the new particles exist with a unique mass only, or whether they occur with a range of masses, it does appear quite certain that the mass, whether unique or not, is greater than that of an electron and less than that of a proton. One must consider then three types of particles all carrying electric charges of equal magnitude: electrons, the new particles and protons. We should like to suggest therefore the word 'mesotron' (intermediate particle) as a name for the new particles. It appears quite likely that the appropriateness of this name will not be lost, whatever new facts concerning these particles may be learned in the future.

CARL D. ANDERSON.
SETH H. NEDDERMEYER.

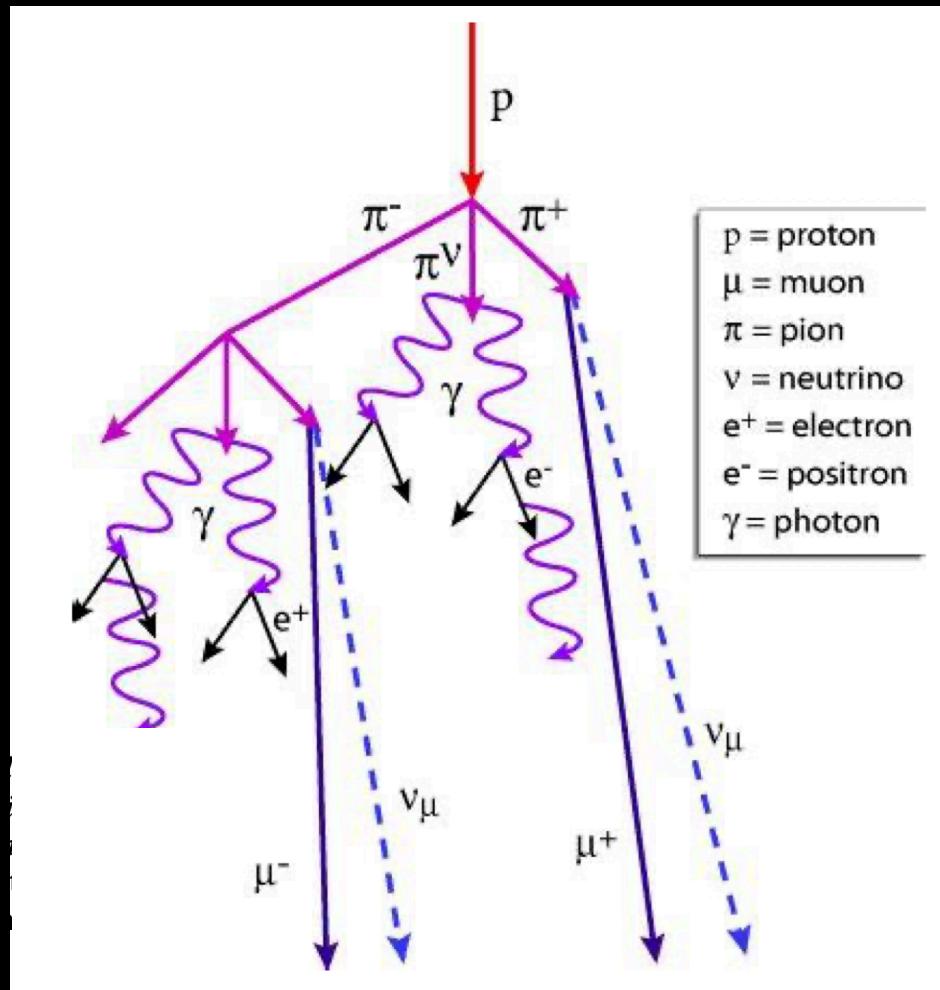
California Institute of Technology,
Pasadena. Sept. 30.

¹ For historical summary see Wentzel, G., *Naturwiss.*, **26**, 273 (1938); and Bowen, Millikan and Neher, footnote, *Phys. Rev.*, **53**, 219 (1938).

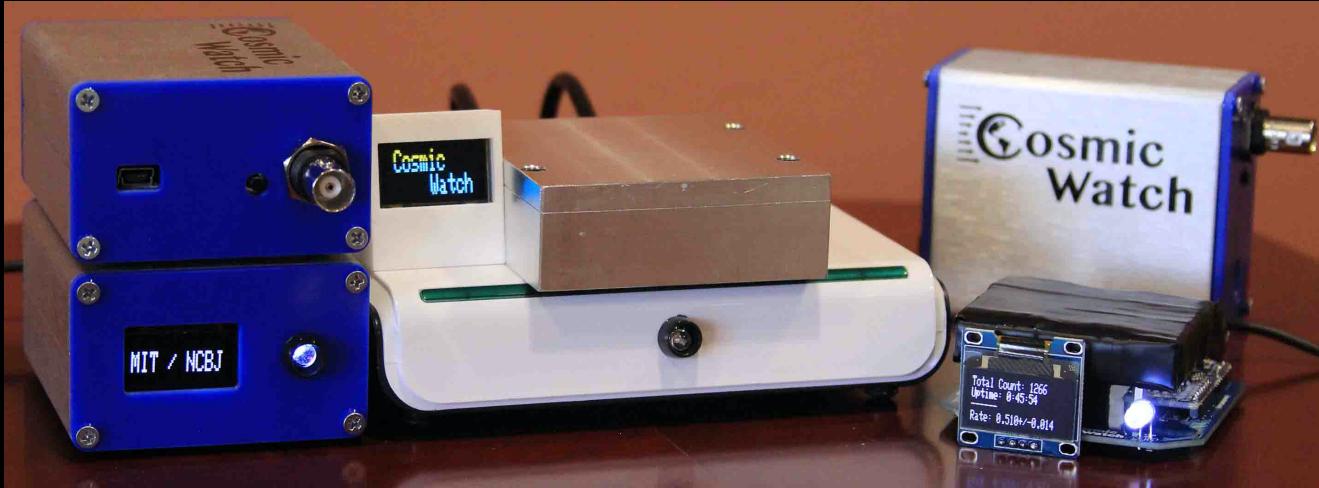
Wie wurde aus dem Mesotron das Muon?

- Meson, ein Teilchen mit der ~mesotron Masse war von Yukawa vorhergesagt als Kraftteilchen der starken Kernkraft
 - Masse $\sim \hbar/(Reichweite\ der\ starken\ Kernkraft\sim 1\text{fm})$
- Aber: Mesotronen werden nicht von Kernen absorbiert - nicht das Yukawa meson
 - pi-meson wurde 1947 entdeckt
 - Zwei Teilchen mit “zwischen” (meso) Masse -> Mesotron in mu-meson umbenannt, zur Unterscheidung vom pi-meson
- Dann folgte Entdeckung vieler anderer Meson ($q\bar{q}$ Zustände) - mu-meson ist anders (naemlich Fermion und Lepton), also neuer Name: Muon...

Warum Muonen?



Cosmicwatch



<https://arxiv.org/pdf/1801.03029.pdf>

<https://arxiv.org/pdf/1908.00146.pdf>

Cosmicwatch

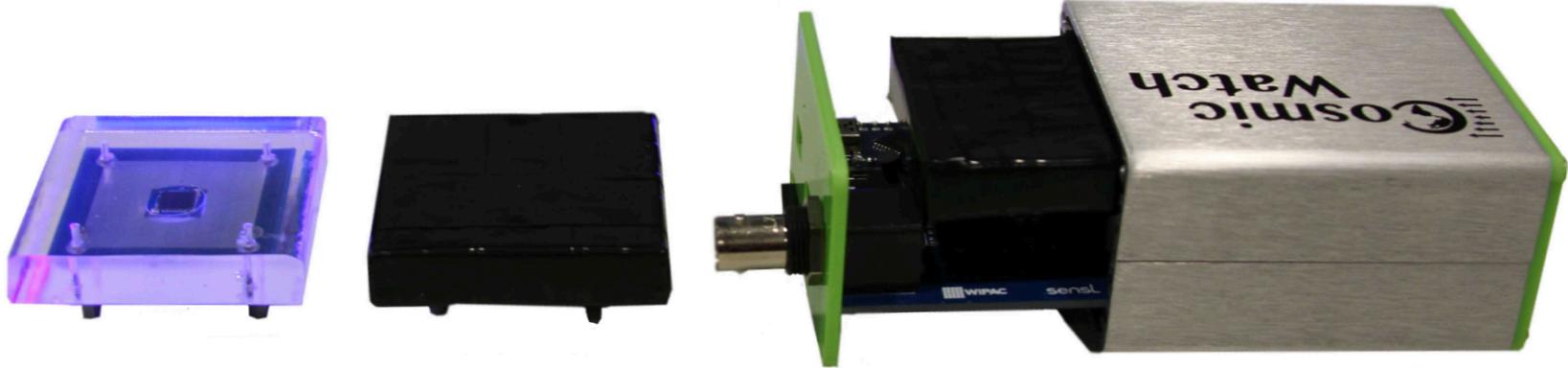
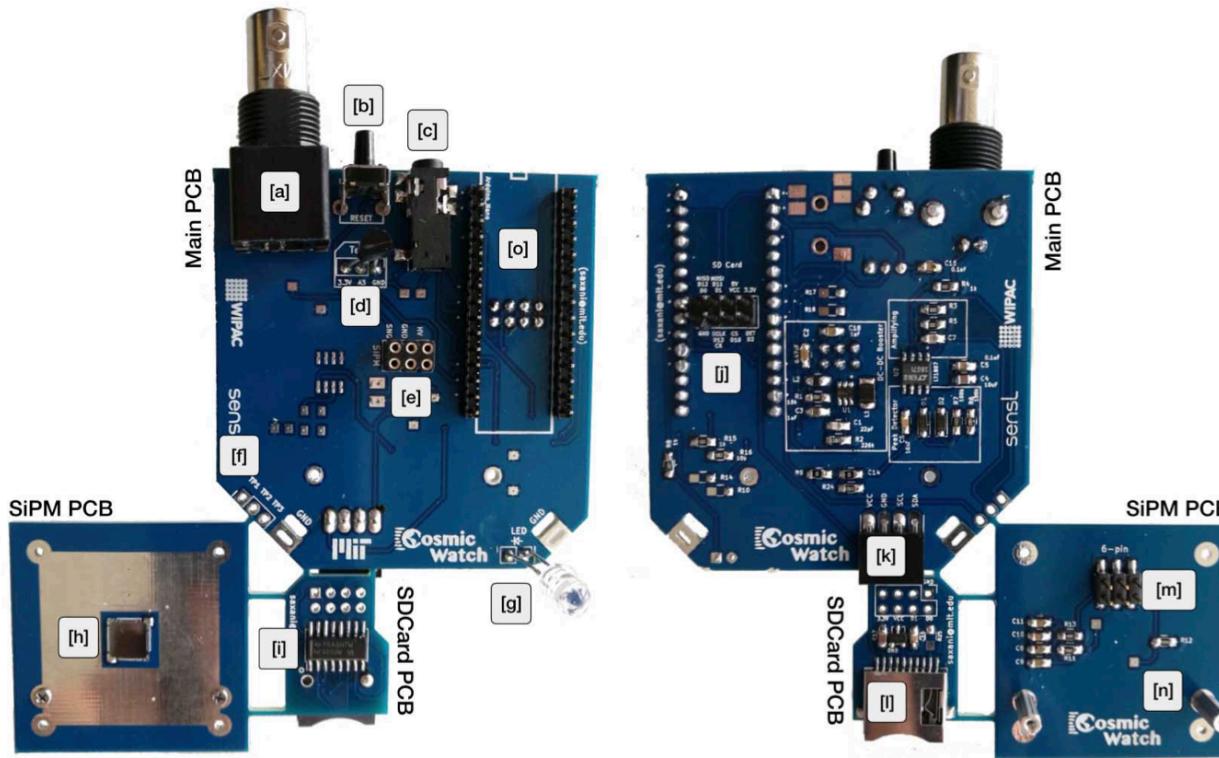


Figure 3. Left: the scintillator mounted on the SiPM PCB with the reflective foil and optically isolating black electrical tape removed. Middle: a fully constructed SiPM + scintillator assembly. Right: The SiPM PCB connected to the main PCB resting on the rails of the aluminum enclosure.

Cosmicwatch

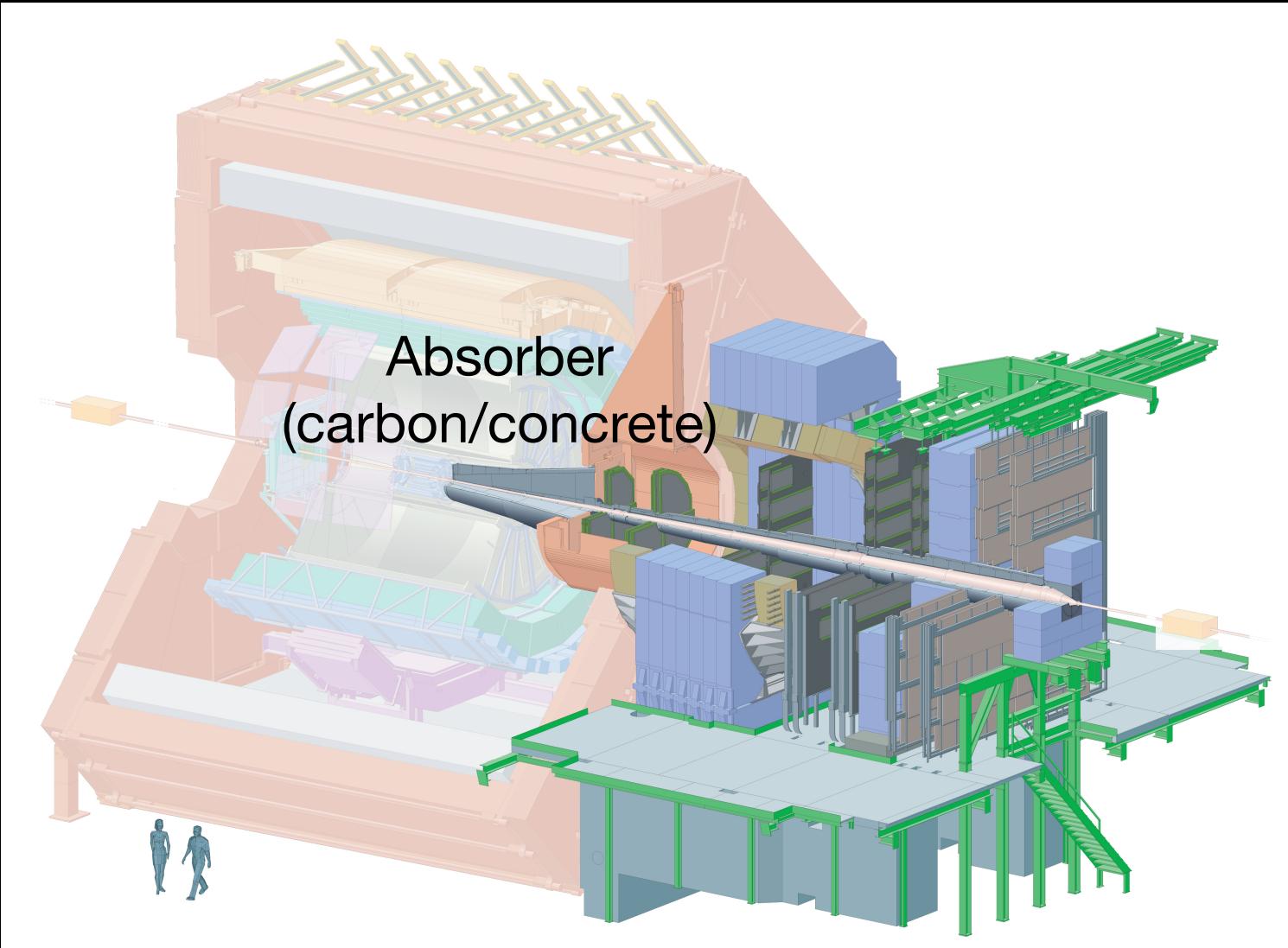


Element	Component
a	BNC receptacle
b	Reset button
c	Coincidence connection
d	Temperature sensor
e	6-pin connector
f	Test point connections
g	LED
h	SiPM
i	Logic converter
j	8-pin header
k	4-pin OLED connector
l	microSD card socket
m	6-pin header
n	Hex standoffs
o	Arduino header

Figure 2. The top (left) and bottom (right) of the PCBs. They are two-layer boards and printed together to fit inside a $10 \times 10 \text{ cm}^2$ square. All components in this figure have been populated except for the Arduino Nano, which mounts on the rails, element [o].

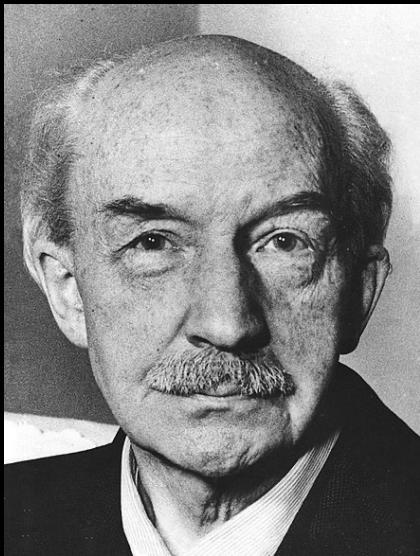
Zaehlen wir wirklich Muonen?

ALICE muon arm



Why is the absorber made out of carbon/concrete and not e.g. Pb?

Coincidence method



Walter Bothe

Nobel prize 1954 “for the coincidence method and his discoveries made therewith”

Ein Weg zur experimentellen Nachprüfung der Theorie von Bohr, Kramers und Slater.

Von W. Bothe und H. Geiger in Charlottenburg.

Mit einer Abbildung. (Eingegangen am 7. Juni 1924.)

Nach den bisherigen Vorstellungen über den Vorgang der Streuung (Compton, Debye) ließe sich eine Versuchsanordnung denken, durch welche das gleichzeitige Auftreten je eines gestreuten Strahlungsquants und des zugehörigen Rückstoßelektrons nachgewiesen werden könnte. Es bedeute $h\nu$ das primäre, $h\nu'$ das gestreute Strahlungsquant und e das Rückstoßelektron. Bringt man in den

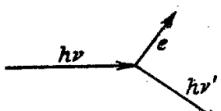


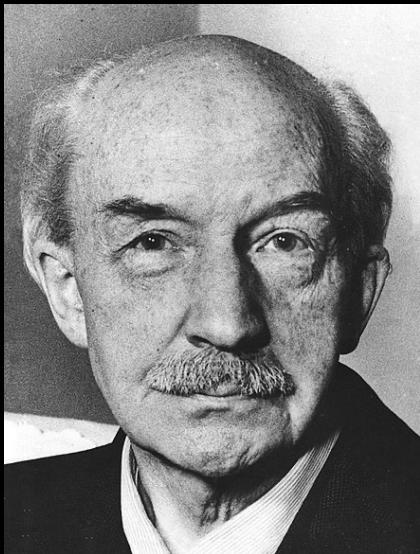
Fig. 1.

Weg von $h\nu'$ und e je eine quantitativ arbeitende Zählvorrichtung, so müssen beide stets gleichzeitig ansprechen. Nach den neuesten Anschauungen von Bohr, Kramers und Slater¹⁾ könnte ein solcher zeitlicher Zusammenhang nicht bestehen.

Ein derartiger Versuch erscheint uns durchaus durchführbar, z. B. mit Hilfe zweier Spitzenzähler, von welchen der eine auf die Rückstoßelektronen, der andere auf die Streustrahlung anspricht. Zwar wird der Energieumsatz im zweiten Zähler gering sein, da dieser nur die Photoelektronen anzeigt, die unter dem Einfluß der Strahlung in das Innere des Zählers emittiert werden. Aus diesen und aus anderen Gründen ist daher in keinem Falle eine lückenlose Folge von Koinzidenzen zu erwarten. Dies ist jedoch belanglos, wenn es nur gelingt, zu entscheiden, ob überhaupt eine statistische Abhängigkeit zwischen den beiden Zählreihen besteht oder nicht. Für die Schärfe dieses Nachweises ist entscheidend das Verhältnis des mittleren zeitlichen Abstandes der Ausschläge zu dem kritischen Zeitintervall, innerhalb dessen zwei aufeinanderfolgende Ausschläge nicht mehr unterscheidbar sind. Dieses Verhältnis läßt sich durch passende Versuchsanordnung (photographische Registrierung beider Zählreihen auf demselben Streifen) leicht genügend groß machen. Ergibt sich mit Sicherheit eine Abhängigkeit zwischen den beiden Zählreihen, so dürfte sich eine statistische Auffassung des Energie- und Impulssatzes kaum aufrecht erhalten lassen.

Versuche in dieser Richtung sind in Angriff genommen.

Coincidence method



Walter Bothe

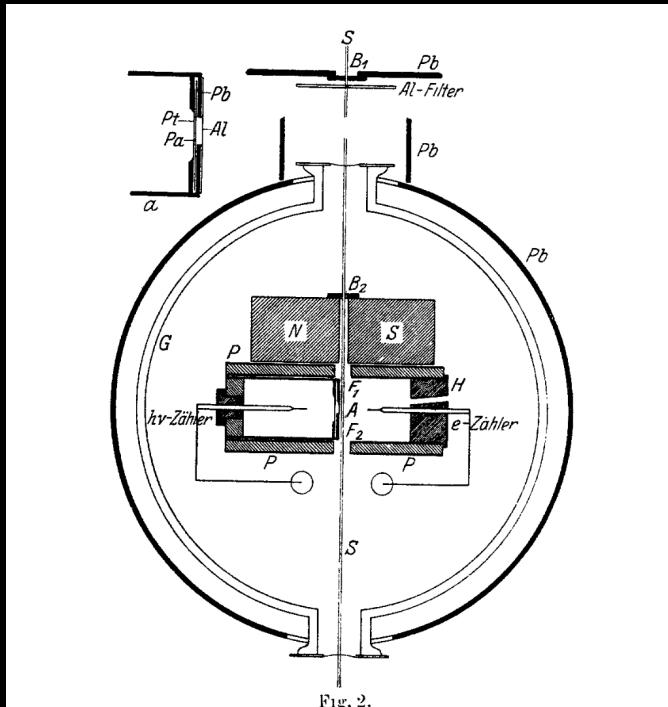


Fig. 2.

Die Fäden der beiden Elektrometer E_1 und E_2 wurden dicht nebeneinander auf den Spalt F eines mit Motorantrieb versehenen Registrieraufgerätes projiziert (Fig. 4). Die benutzten Bromsilberfilme hatten eine Breite von 1,5 cm und eine Länge von 75 m und liefen in 6 bis 10 Minuten ab. Diese hohe Geschwindigkeit war erforderlich, um den Zeitpunkt eines Ausschlags möglichst scharf erfassen zu können. Andererseits war aber die Entscheidung, ob tatsächlich Koinzidenzen auftraten, erst möglich, wenn für mehrere Stunden mit dieser Schnelligkeit registriert worden war. Der dadurch bedingte große Filmverbrauch setzte der Ausdehnung der Versuche eine natürliche Grenze¹⁾.

Coincidence method

Method of Registering Multiple Simultaneous Impulses of Several Geiger's Counters.

PROF. W. BOTHE in the *Zeitschrift für Physik* (vol. 59, p. 1) describes a method for registering simultaneous impulses of two Geiger's counters, which depends principally on the working of a two-grid thermionic valve. Lately, I have had the opportunity of experimenting with a circuit which perhaps is simpler and at the same time has the advantage that it can be extended also to the registering of triple

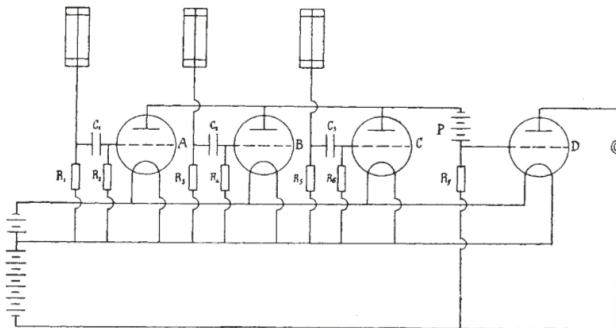


FIG. 1.

simultaneous impulses or even more. The circuit adopted (for triple coinciding impulses) is shown in the accompanying diagram (Fig. 1).

$$\begin{aligned} R_1, R_3, R_5 &= 5 \times 10^9 \text{ ohms.} \\ R_2, R_4, R_6 &= 8 \times 10^6 \text{ ohms.} \\ C_1, C_2, C_3 &= 10^{-4} \mu\text{F.} \end{aligned}$$

The positive electrodes of the three counters (in my experiments I have used Geiger's wire counters) are electrostatically coupled to the grids of the three valves *A*, *B*, *C*. In normal conditions these grids have a zero potential; whenever a discharge occurs they become negative, thus interrupting the current flow.

As the resistance R_s is very great compared with the internal resistances of the valves *A*, *B*, *C*, their anodes are at a potential near to zero. The grid of the valve *D* (for the introduction of the auxiliary battery *P*) is at a slight negative potential. This potential varies very little when only one or two counter tubes are working, while it undergoes a sudden rise when, for the simultaneous working of the three counter tubes, the current is interrupted in all the three valves.

The consequent variation of the anode current (eventually amplified by a fifth valve) is acoustically detected by a telephone.

The circuit arrangement, in regard to the counter tubes, is perfectly symmetrical, a condition which is not fulfilled in the circuit of Prof. Bothe, because the grids of the two-grid valve have rather different characteristics.

No. 3156, VOL. 125]

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The Conversion of α Benzilmonoxime into the β Oxime by Animal Charcoal.

DURING the course of an investigation into the properties of the isomeric monoximes of benzil, we have made the following somewhat startling observation.

We have been able to devise a method for estimating mixtures of the α and β oximes and have shown that the α oxime shows no appreciable change into its isomer (which is the more stable of the two) in solution in alcohol or benzene at 50° in a period of thirty-six hours, and that the change is not accelerated by acids or alkalis when present in small concentration. On the other hand, if a benzene solution of the α oxime is boiled with animal charcoal for a few seconds, the change is complete and no α oxime can be detected in the solution.

Finely powdered soft-wood charcoal and powdered silica gel showed no such effect, the α oxime being recovered unchanged. Finely divided calcium phosphate is also without action. That the conversion does not arise from the action of catalysts dissolved from the charcoal by the benzene is shown by boiling some benzene with animal charcoal, filtering off the charcoal, and using the filtrate as a solvent for the α oxime; there is no conversion into the isomer.

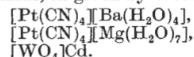
This observation suggests that care should be exercised in the use of animal charcoal as a decolorising agent in the purification of isomers of the type of this α oxime. A full account of our work on this subject will be published later elsewhere.

T. W. J. TAYLOR.
SALLY MARKS.

The Dyson Perrins Laboratory,
Oxford, Mar. 17.

Fluorescent and Phosphorescent Substances.

SUBSTANCES which fluoresce strongly under the influence of X-rays are barium and magnesium platinocyanides and cadmium tungstate. The formulae of these compounds, as given by Werner, are as follows:



An atom of high stopping power with four light atoms or radicals arranged about it, perhaps tetrahedrally, and a bivalent positive ion, are present in all.

With the first part of the formulae may be compared the structure of zinc sulphide and diamond, which phosphoresce in X-rays; phosphorus and yellow arsenic exhibit phosphorescence on oxidation, and arsenious oxide is luminous on crystallisation from acid solution.

J. R. PARTINGTON.

East London College,
University of London, E.1.



Bruno Rossi
Invented an electronic coincidence circuit (at age 24)

Koinzidenz und Höhenstrahlung

(Mitteilung aus der Physikalisch-Technischen Reichsanstalt.)

Das Wesen der Höhenstrahlung.

Von W. Bothe und W. Kolhörster.

Mit 8 Abbildungen. (Eingegangen am 18. Juni 1929.)

Stellt man zwei Geiger-Müllersche Zählrohre aneinander, so findet man in den Ausschlägen, welche durch die Höhenstrahlung hervorgerufen werden, einen erheblichen Bruchteil solcher, welche gleichzeitig in beiden Zählrohren erfolgen. Aus der Abhängigkeit von der gegenseitigen Lage der Zählrohre sowie aus der großen Häufigkeit dieser Koinzidenzen ist zu schließen, daß sie den Durchgang einzelner Korpuskularstrahlen durch beide Zählrohre anzeigen. Die Absorbierbarkeit dieser Korpuskularstrahlen wurde dadurch bestimmt, daß absorbierende Schichten zwischen die beiden Zählrohre gebracht und die Abnahme der Koinzidenzen gemessen wurde. Es ergab sich, daß die Korpuskularstrahlung ebenso stark absorbiert wird wie die Höhenstrahlung selbst. Hieraus ist zu schließen, daß die Höhenstrahlung, soweit sie sich in den bisher beobachteten Erscheinungen äußert, korpuskularer Natur ist. Ihre voraussichtlichen Eigenschaften werden aus diesem Gesichtspunkt diskutiert.

Viele interessant Referenzen in
<https://arxiv.org/pdf/1106.1365.pdf>

II. Hauptversuche.

3. Anordnung und Auswertungsverfahren. In Fig. 1 ist die Anordnung dargestellt, welche mit geringen Änderungen für alle Höhenstrahlungsversuche benutzt wurde. Die beiden Zählrohre Z_1 , Z_2 hatten

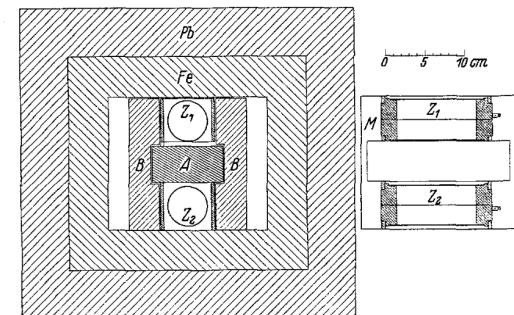


Fig. 1.

innen 5 cm Durchmesser und 10 cm Länge; sie waren anfangs aus 1 mm starkem Messing, später aus 1 mm starkem Zink hergestellt und an den Enden mit Ebonitstopfen verschlossen, welche die zentralen Drähte trugen.

Uebungen/Hausaufgaben

- 1. Schritt: Einlesen der CW Text Datei
- Wie hoch ist die durchschnittliche Koinzidenzrate über den gesamten Versuch?
- Wie hoch ist diese Rate in Zeitfenstern von 1s und 1min und 10min?
 - Plot the distributions and fit them with the appropriate functions

rolandg@mit.edu