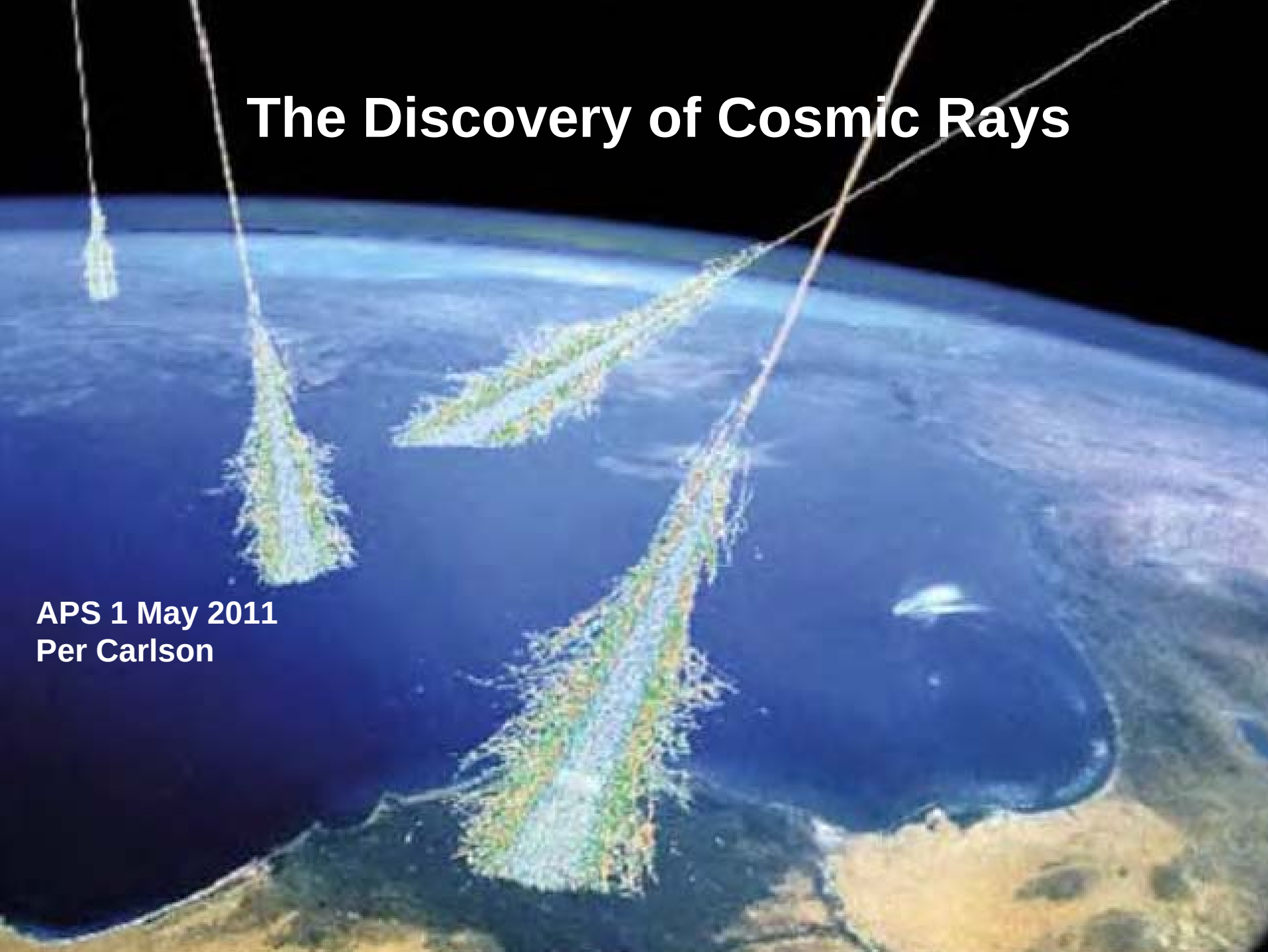
The Discovery of Cosmic Rays



APS 1 May 2011
Per Carlson

Based on

P. Carlson and **A. De Angelis**,
'Nationalism and internationalism in science: the case of the discovery of cosmic rays', *Eur. Phys. J. H* **36**, 309 (2010)

Highlights from European journals

Vol 42/2 2011

PARTICLE PHYSICS

Cosmic rays:
A (partly) untold story

The work behind the discovery of cosmic rays, a milestone in science, involved many scientists in Europe and the New World fascinated by the puzzling penetrating radiation, and took place during a period characterized by lack of communication and by nationalism caused primarily by World War I. It took eventually from the turn of the century until 1926 before the extraterrestrial nature of the penetrating radiation was generally accepted.

Important milestones

1785 Coulomb: *Spontaneous discharge*

1835 Faraday: *Confirms discharge*

1879 Crookes: *Discharge rate reduced with pressure*

1896 Bequerel, Curie's: *Radioactivity*

1900-1910: *A decade of intensive research*

1910 Wulf: *Climbes the Eiffel tower*

1910-11 Pacini: *Ionization under water*

1912 Hess: *Ionization at high altitudes with balloon*

1914-18: *World War I*

1920s Compton, Millikan: *Cosmic rays*

1926: *General agreement on cosmic rays*

1936: *Nobel Prize to Anderson and Hess*

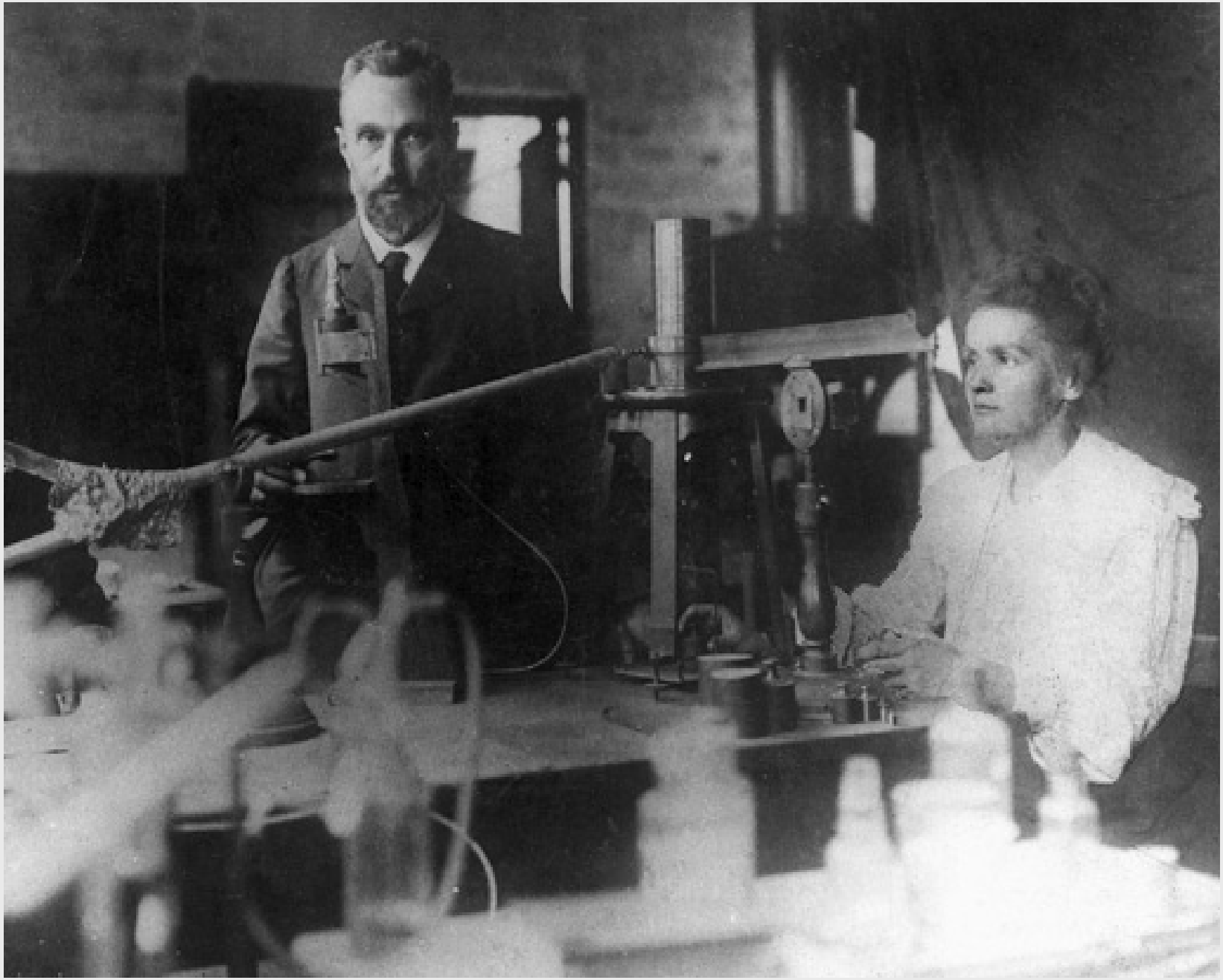
1900-1908

Important background discovery
Discovery of radioctivity, Nobel Prize to Becquerel, Marie and Pierre Curie

In action on penetrating radiation:
Elster and Geitel, Wilson, Rutherford, Cooke, McLennan, Burton, Mache, Strong, Eve

Improvements and experiments*:*
Electroscope improvements
Metal shields
In tunnels, on sea

General view 1908:
The earth and radioactivity is the source of the radiation



Wilson 1901

After experimenting with a gold leaf electroscope, Wilson concludes

”*It is unlikely, therefore, that the ionization is due to radiation which has traversed our atmosphere; it seems, as Geitel concludes, a property of air itself*”

1909-1914

In action on penetrating radiation:

Pacini, Wulf, Hess, Kohlhörster

Improvements and experiments:

Electroscope improvements
On sea, in sea, on Eiffel tower, balloons

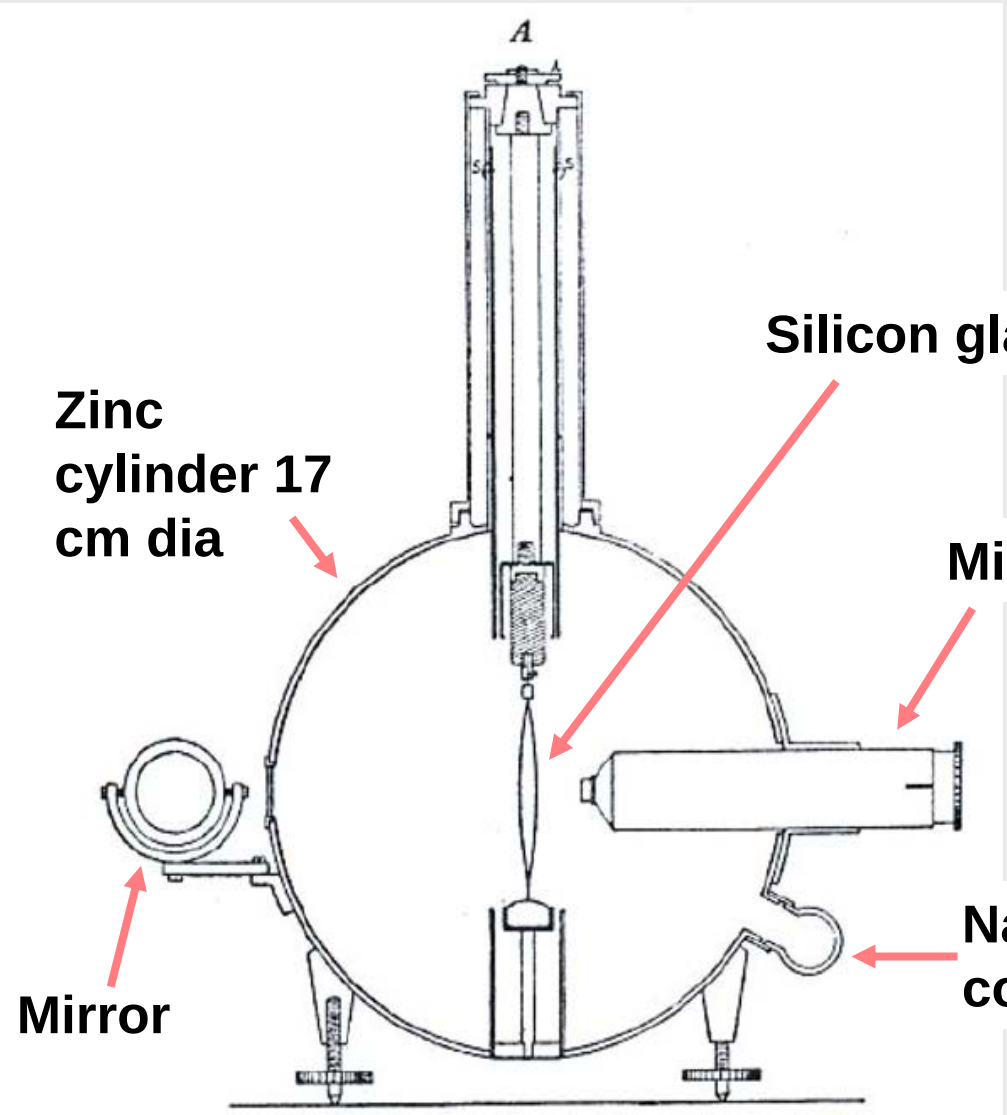
Common view 1912-14:

There is a radiation coming from outside the earth

But:

Not everybody believed an external source for the radiation

Wulf electroscope



Theodore Wulf, German scientist and a Jesuit priest, visits friends in Paris easter 1910. He brings his electroscope and climbs the Eiffel tower.....

Th. Wulf Phys. Zeitschr. 11, 811 1910
(Phys. Inst. Des Ignat.-Koll., Valkenburg,, Holland)

Datum	Ort	Ionen ccm sec
28. März	Valkenburg	22,5
29. „	Paris, Boden	17,5
30. „	„ Eiffelturm	16,2
31. „	„ „	14,4
1. April	„ „	15,0
2. „	„ „	17,2
3. „	„ Boden	18,3
4. „	Valkenburg	22,0

Expected with an 80 m absorption length was a few percent of the radiation at ground. Results requires another source for the gamma-radiation or a significantly weaker absortion of gamma..OR?

OR

Is the radiation coming from the tower structure?

Domenico Pacini 1878-1934

June 1911

With an electroscope 3 m deep in the sea at Livorno and Bracciano Pacini finds a significant 20% decrease in the radiation.

He concludes in the Nuovo Cimento article (translated from italian):

”..*a sizable cause of ionization exists in the atmosphere, originating from penetrating radiation, independent of the direct action of radioactive substances in the soil”*

Pacini made important contributions that were not fully appreciated. Pacini’s work is not mentioned in most reviews on the history of cosmic rays.


Pacini observing 1910

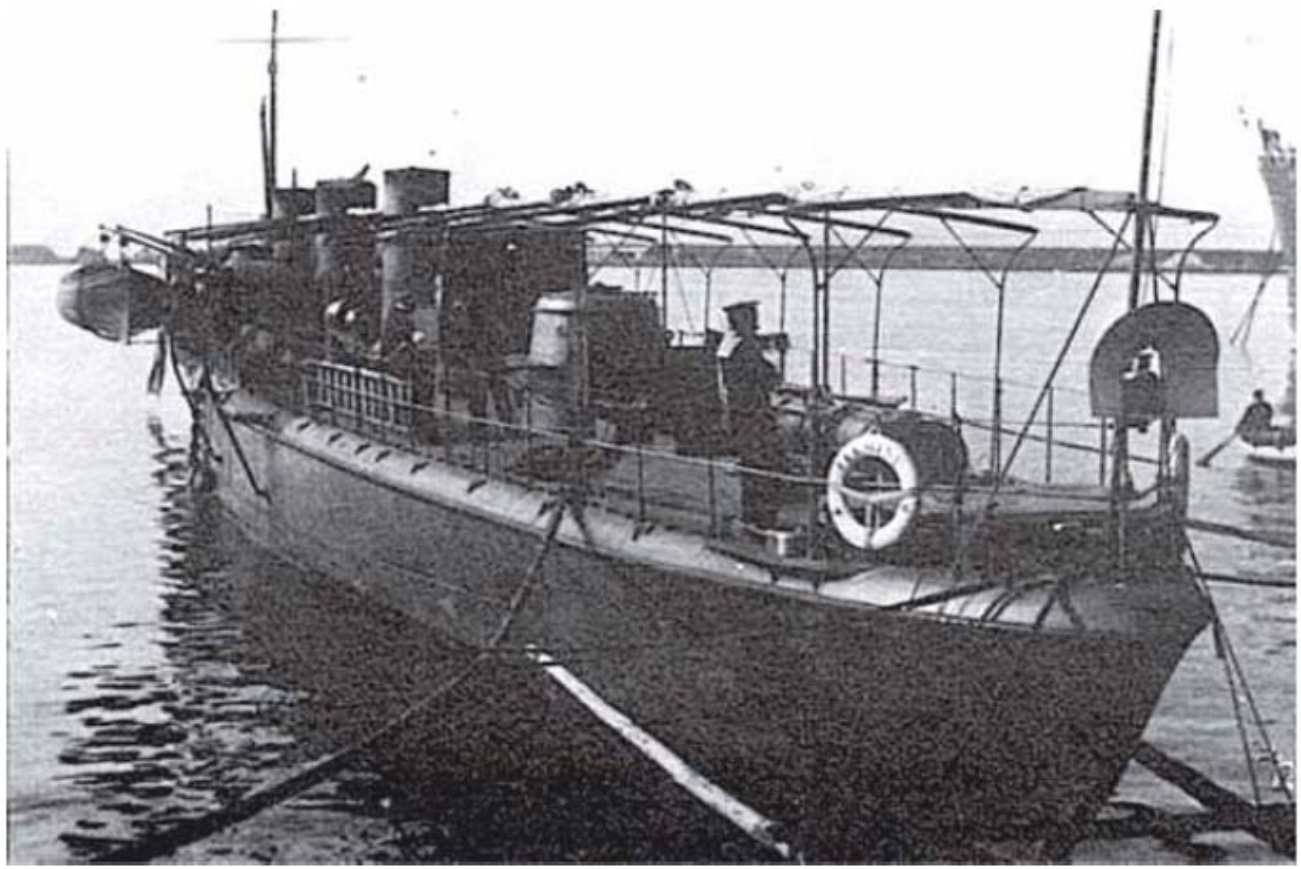
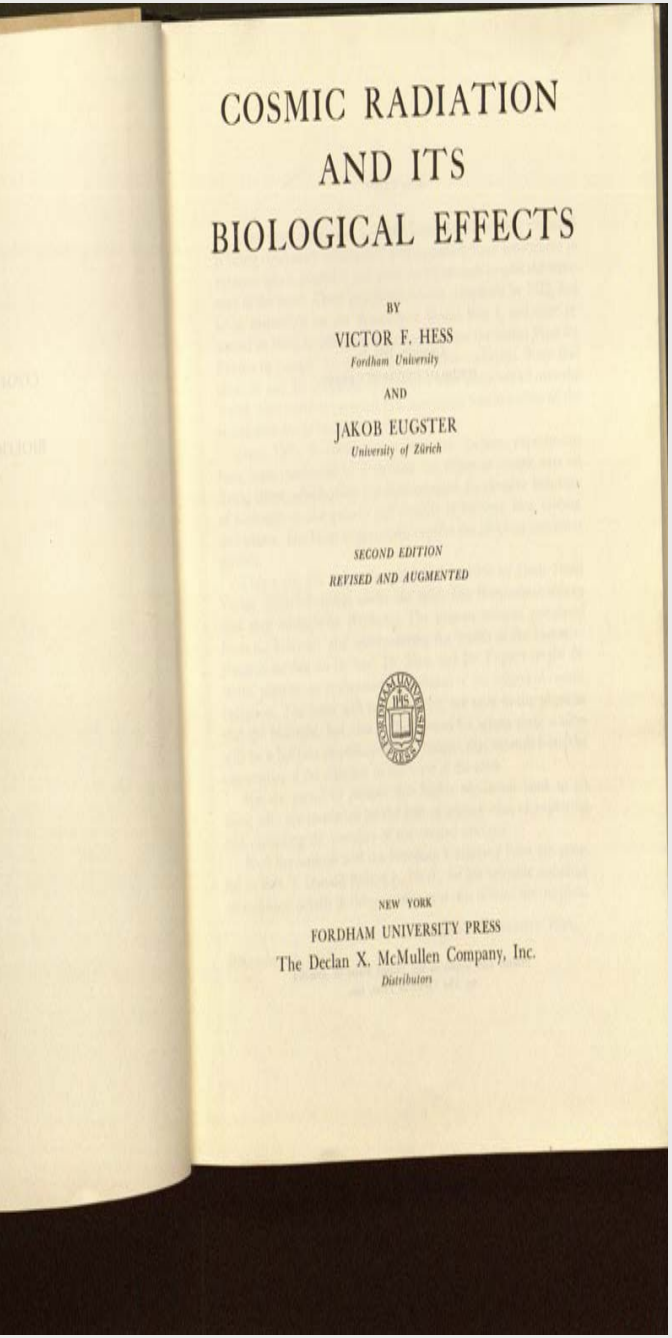


Fig. 4. The cacciatorpediniere "Fulmine", used by Pacini for his measurements on the sea (courtesy of the Marina Militare Italiana).



Hess and Eugster published ***Weltraumstrahlung und ihre biologische Wirkung*** in 1940. The translated edition shown here was published by Fordham University Press in 1949 and incorporated research carried out in the interim.

In a very complete 1909 review Kurz concludes that the known amounts of radioactive substances in the soil, in water and in air could fully account for the observed ionizations.

Hess and Eugster writes about the contribution of Pacini:

"*The first who expressed some doubts as to the correctness of this view was D. Pacini, who, in 1910, from measurements over sea and on shores at Livorno concluded that part of the observed ionization might be due to sources other than the known radioactive substances."*

Pacini, who died in 1934, was never nominated for the Nobel Prize. Hess was first nominated in 1931 and received the prize in 1936.

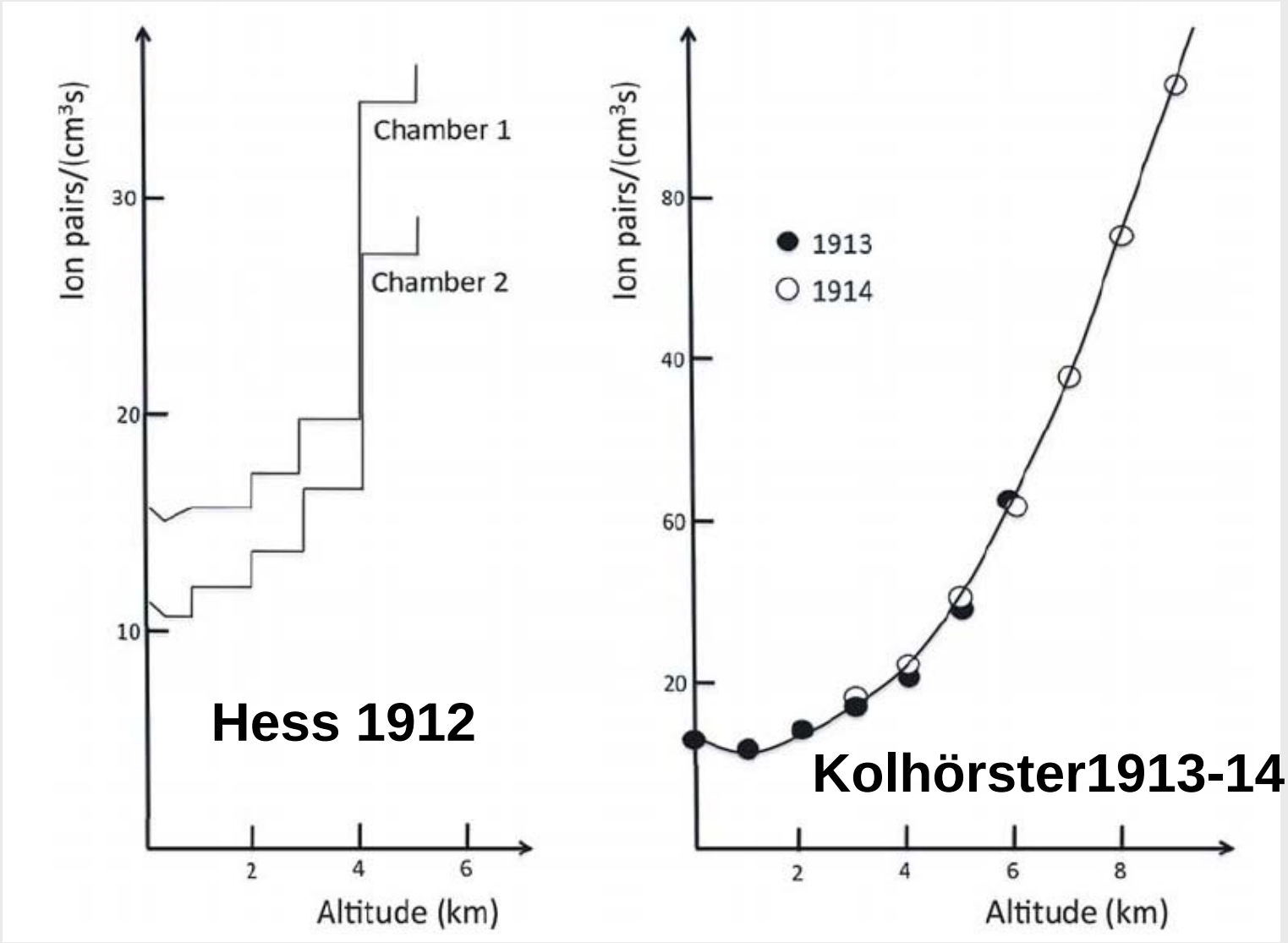
Diplomarbeit Georg Federmann
Institut für Radiumforschung und Kernphysik
Wien, 2003

Data 7th flight

Beob. Nr.	Zeit	Mittlere Höhe		Beobachtete Strahlung [J]				Temperatur [° C]	Relative Feuchtigkeit [%]	Anmerkungen
		absolut [m]	relativ [m]	App. I q^{I} [J]	App. II q^{II} [J]	App. III q^{III} [J]	App. III $q^{III}_{red.}$ [J]			
1	15:15-16:15	156	0	17.3	12.9	---	---	---	---	Zwei Tage vor dem Aufstieg am Klubplatz in Wien
2	16:15-17:15			15.9	11.9	18.4	18.4	---	---	
3	17:15-18:15			15.8	11.2	17.5	17.5	---	---	
4	06:45-07:45	1700	1400	15.8	14.4	21.1	25.3	+ 6.4	60	
5	07:45-08:45	2750	2500	17.3	13.3	22.5	31.2	+ 1.4	41	
6	08:45-09:45	3850	3600	19.8	16.5	21.8	35.2	- 6.8	64	
7	09:45-10:45	4400-5350 (4800)	4700	40.7	31.8	---	---	- 9.8	40	
8	10:45-11:15	4400	4200	28.1	22.7	---	---	---	---	
9	11:15-11:45	1300	1200	(9.7)	(11.5)	---	---	---	---	
10	11:45-12:10	250	150	11.9	10.7	---	---	+ 16.0	68	
11	12:25-13:12	140	0	15.0	11.6	---	---	+ 18.0	76	

Abbildung 4-16 Ballonfahrt Viktor Hess, 7. August 1912

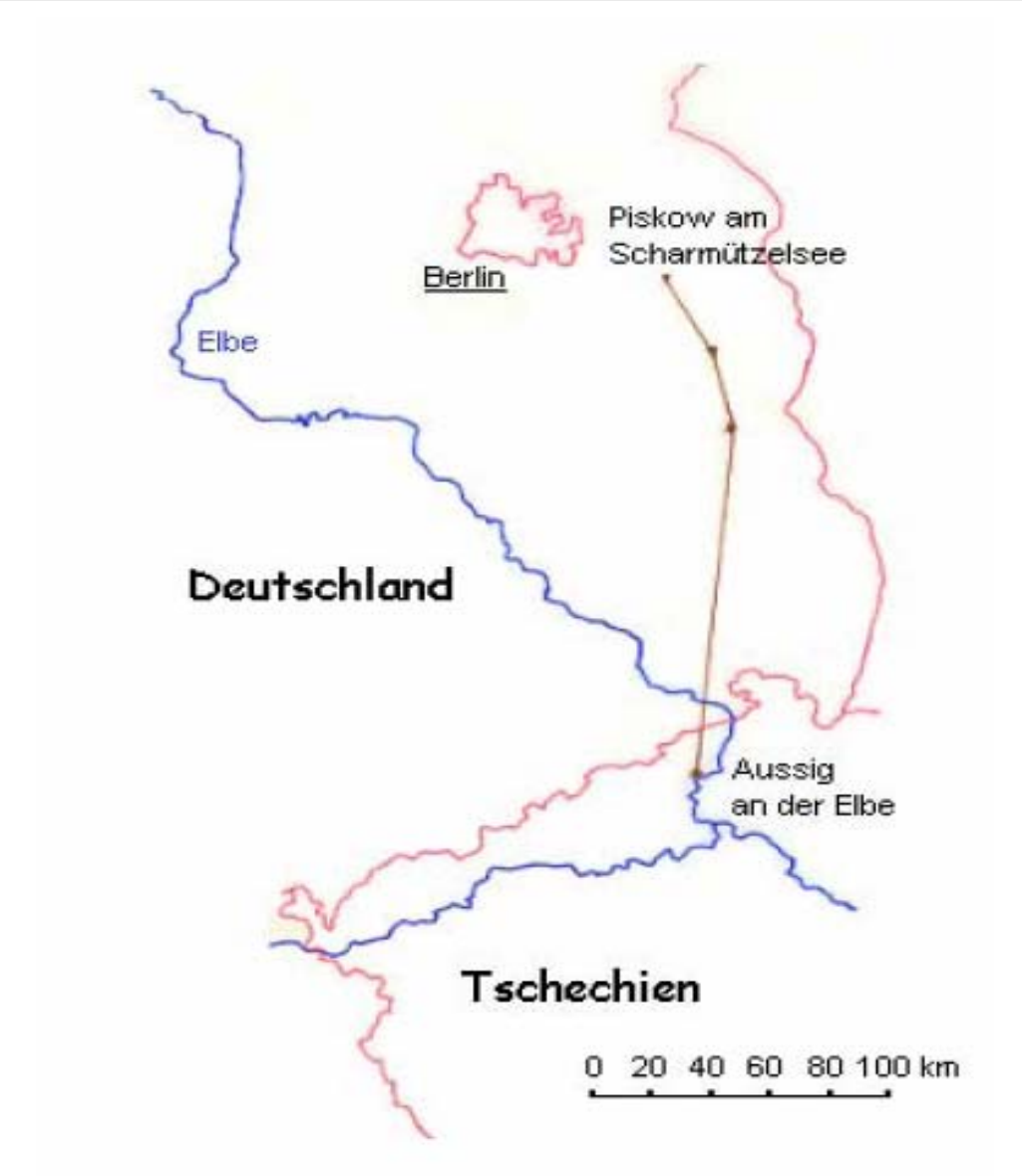
Ionization as function of altitude



Hess 7th flight

7 August 1912

Following Elbe in the Bohemian (Böhmen) countryside.



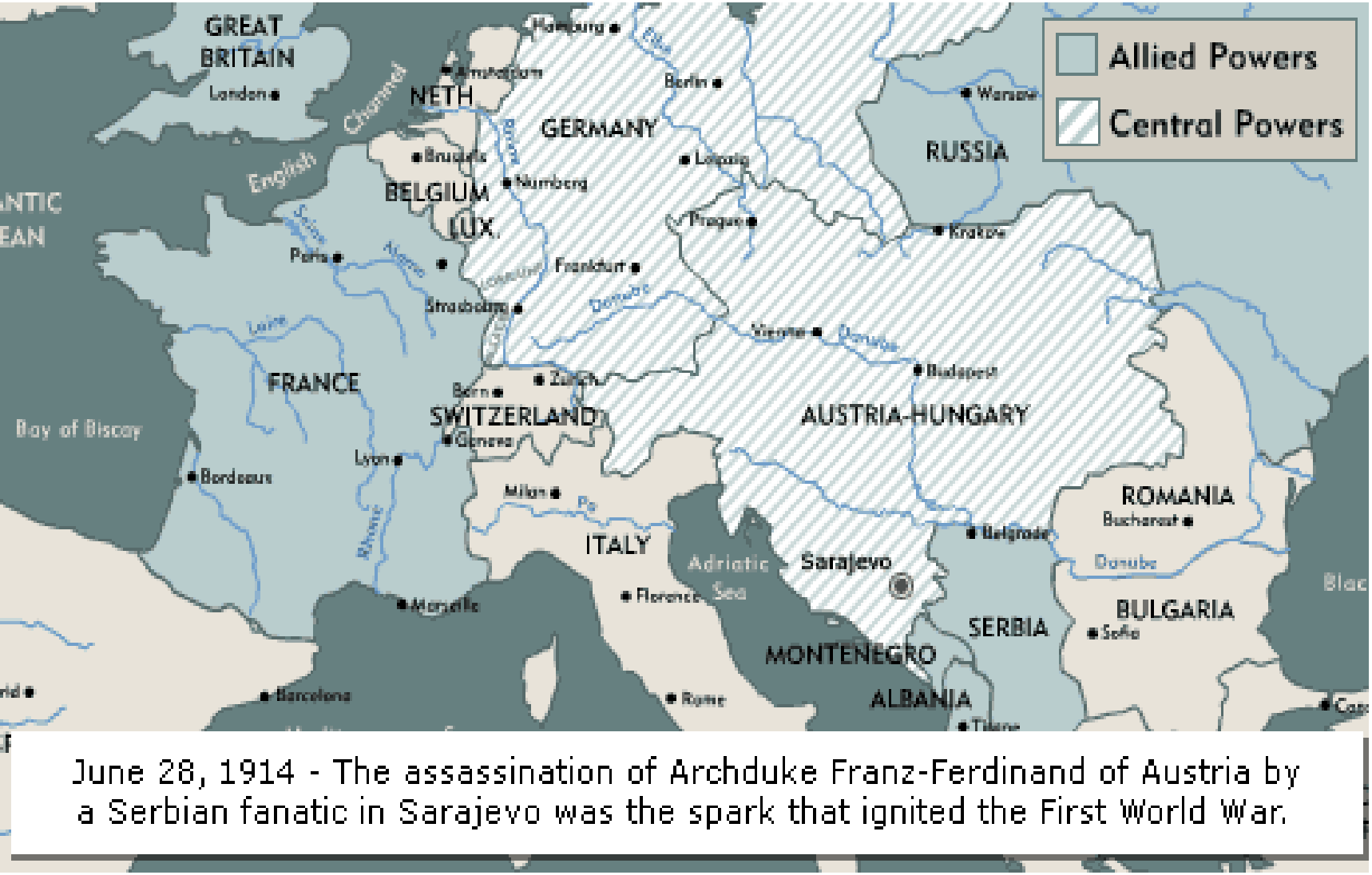
Diplomarbeit Georg Federmann
Institut für Radiumforschung und Kernphysik
Wien, 2003

1914-1918

World War I

Nationalism!

A difficult time for Europe and for Science: World War I 1914-1918



June 28, 1914 - The assassination of Archduke Franz-Ferdinand of Austria by a Serbian fanatic in Sarajevo was the spark that ignited the First World War.

Also on 28th June 1914: Kolhörster measured the ionization at 9300 m!

The Era of Nationalism starts
The German Appeal

In October 1914 ninety-three German professors, among them Wilhelm Röntgen, Max Planck, and thirteen other scientists of comparably high repute, issued an *Appeal to the Cultured World (Der Amruf an die Kulturwelt)*, a manifesto denying that Germany was responsible for the war, protesting the "lies and defamations" leveled against its conduct in the conflict, and claiming that its soldiers had not committed atrocities in Belgium.

Daniel J. Kevles Albert Einstein: Relativity,War, and Fame.

Nationalism in the nominations for the Nobel Prize: Proportions of nominations from different countries

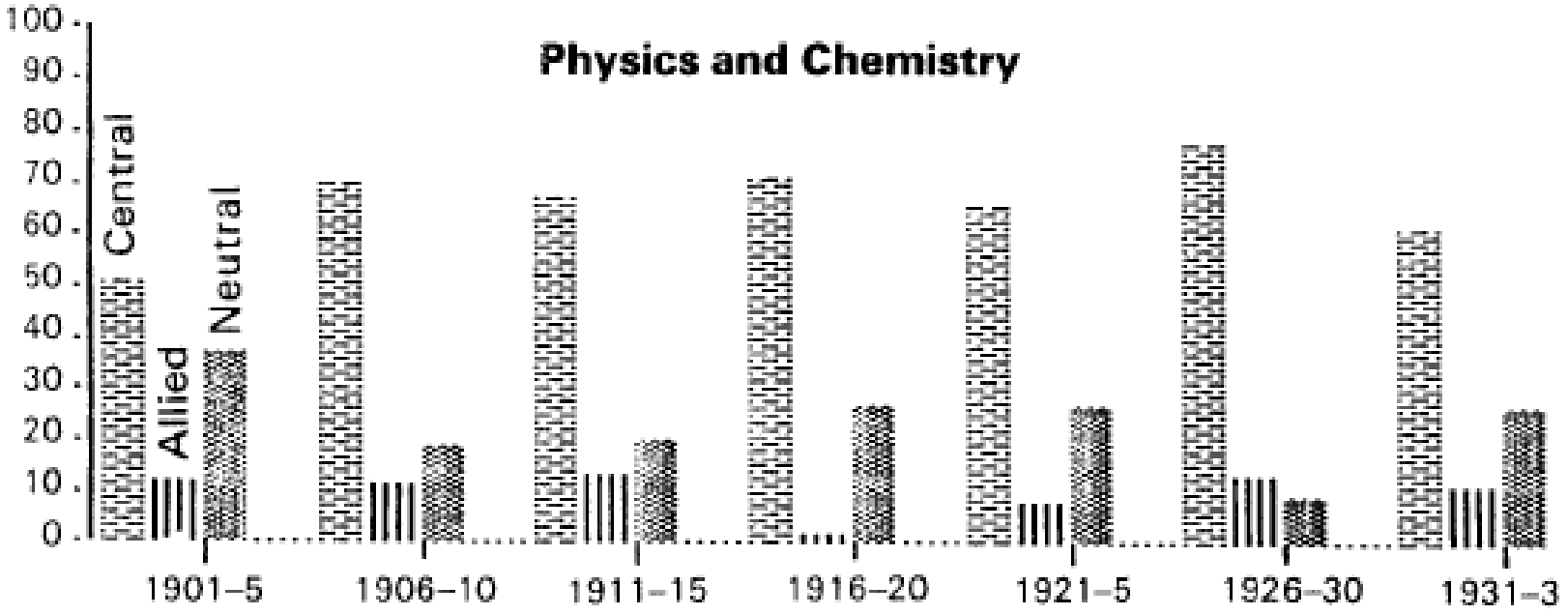


Figure 3: Proportion of nominations received by Central Power candidates from nominators in Central Power, Allied, and neutral countries, 1901–1933 (in percentages). "Allied Nations" = Belgium, Canada, England, France, Italy, Russia, and the United States. "Central Powers" = Austria, Czechoslovakia, Germany, Yugoslavia, Hungary, and Poland. "Neutral" countries = Denmark, Sweden, Switzerland, Norway, Finland, Spain, and the Netherlands.

Source: E Crawford

Central power scientists no longer welcome

Lashing back, angry fellows of the Royal Society of London demanded the removal of all Germans and Austrians from the list of foreign members, and the French Academy dropped the signers of the manifesto.

In mid-1917, the eminent French mathematician Emile Picard, a former president of the French Academy of Sciences, told an influential member of the National Academy of Sciences in the United States that “personal” relations of any kind would be “impossible” with German scientists even after the war. They had to be ostracized from the structure and activities of international science indefinitely.

Daniel J. Kevles Albert Einstein: Relativity,War, and Fame.

REPORT OF THE MEETINGS OF THE INTERNATIONAL RESEARCH COUNCIL AND OF THE AFFILIATED UNIONS HELD AT BRUSSELS, JULY 18–28, 1919

Presented to the Division of Foreign Relations, National Research Council

By W. W. CAMPBELL, *Chairman*, American Delegation to the International Research Council

III—CONDITIONS OF ADMISSION

3. The countries in the following list may participate in the foundation of the International Research Council, and of any scientific Union connected with it, or join such Union at a subsequent period:

Belgium, Brazil, United States, France, the United Kingdom of Great Britain and Ireland, Australia, Canada, New Zealand, South Africa, Greece, Italy, Japan, Poland, Portugal, Roumania, Serbia.

[1] "That it is desirable that the nations at war with the Central Powers withdraw from the existing conventions relating to International Scientific Associations in accordance with the Statutes or Regulations of such Conventions, respectively, as soon as circumstances permit; and

"That new associations, deemed to be useful to the progress of science and its applications, be established without delay by the nations at war with the Central Powers with the eventual coöperation of neutral nations."

The 1920s

Few measurements in Europe, focus moved to the US.

An extra-terrestrial nature of the radiation still questioned.

Millikan (Nobel Prize 1923) 1925 APS: ”*The whole of the penetrating radiation is of local origin”.* Compton was of another opinion.

Millikan changed mind in 1926 and coined the name ”cosmic rays”. He suggested that the penetrating gamma-rays were ”birth cries of atoms” in our galaxy.

1927-1930: Millikan vs. Austria/Germany

History of Research in Cosmic Rays.*

By Dr. ROBERT A. MILLIKAN,
Norman Bridge Laboratory of Physics, California Institute of Technology, Pasadena.

In spite of these precautions, misunderstandings seem to have arisen and a spirit of unfriendliness and suspicion of motives to have been engendered which I can account for only upon the assumption that it is another unfortunate aftermath of the War. This spirit, illustrated by the title "Zu Abwehr . . ." of an article found on p. 705 of *Physikalische Zeitschrift*, **19**, has led the authors to make altogether unjustified charges, to which my German friends have urged me to make some reply

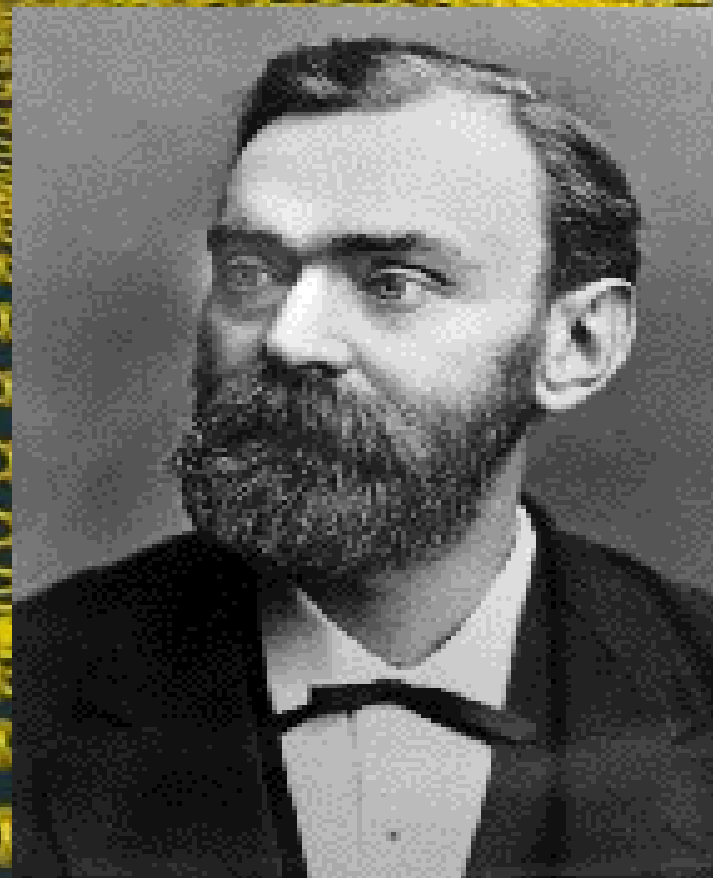
Feststellungen zur Geschichte der Entdeckung und Erforschung der kosmischen Höhenstrahlung (Ultragammastrahlung).

Von K. Bergwitz, V. F. Hess, W. Kolhörster und E. Schweidler.

Zur Abwehr sehen wir uns veranlaßt folgendes aus dem vorläufigen Bericht von R. A. Millikan und G. H. Cameron (Nature **121**, S. 19—26, Supplement, 7. Januar 1928) richtig zu stellen. Die beanstandeten Punkte dürften sich im wesentlichen auf die „additions" beziehen, welche die beiden Autoren in die von R. A. Millikan in Leeds am 2. September 1927 gehaltene „Public Lecture" eingefügt haben.

Phys. Zeit. 29(1928)705

1936: The Nobel Prize to Hess



Nominations for the 1936 Nobel Prize in Physics

The Royal Swedish Academy of Sciences had received a total of 22 Prize proposals from 31 nominators for 18 different Prize Candidates in Physics.

Hess was nominated by J. Clay, Amsterdam, for a non-shared prize and by A.H. Compton, Chicago, for a prize shared with J. Clay, Amsterdam. Compton also nominated C.D. Anderson for the discovery of the positron.

Hess had been nominated the first time in 1931 by Pohl, from Göttingen, and then in 1933 by Plotnikov, from Zagreb and in 1934 by Willstätter, from Munich.

We note that Pacini was never nominated.

Compton’s (Nobel Prize 1927) nomination 1936

“The time has now arrived, it seems to me, when we can say that the so-called cosmic rays definitely have their origin at such remote distances from the Earth that they may properly be called cosmic, and that the use of the rays has by now led to results of such importance that they may be considered a discovery of the first magnitude. ...

It is, I believe, correct to say that Hess was the first to establish the increase of the ionisation observed in electroscopes with increasing altitude; and he was certainly the first to ascribe with confidence this increased ionisation to radiation coming from outside the Earth”.

Compton cont’d

“Before it was appropriate to award the Nobel Prize for the discovery of these rays, it was necessary to await more positive evidence regarding their unique characteristics and importance in various fields of physics.This has now been accomplished. Studies of the magnetic latitude effect on cosmic rays have shown that they include electrical particles of much higher energy than are available from artificial sources, further that these rays come from a source which may be properly called cosmic. The usefulness of the rays has been demonstrated by the experiment which has revealed the existence of the positron”.

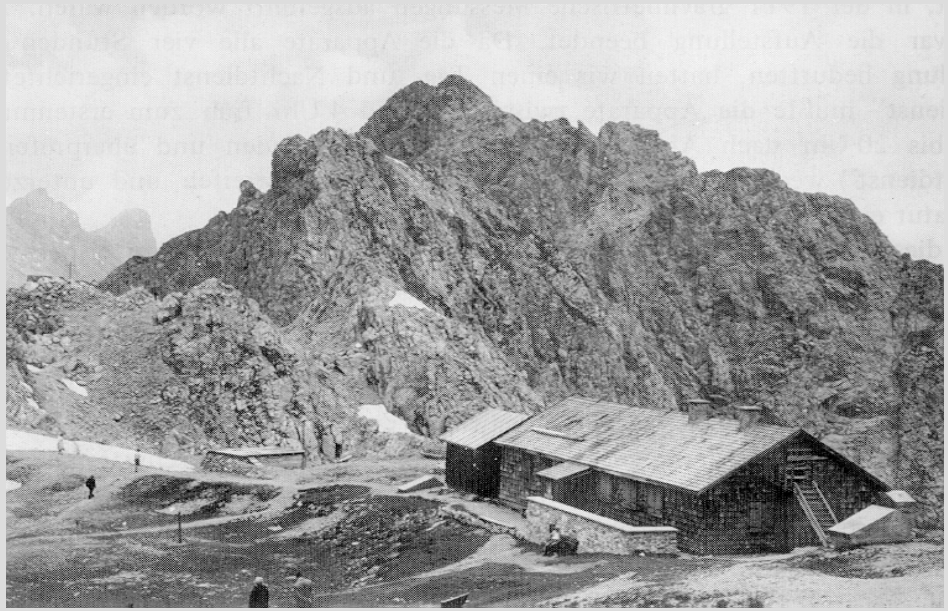
The recommendation to the Academy

In its recommendation to the Academy, the Nobel Committee for Physics points out that the discovery of cosmic rays has opened new areas for experimental and theoretical physics of greatest significance to our understanding of the structure and origin of matter. It is clear, the Committee says, that

”Hess with his skillful experiments has proven the existence of an extraterrestrial penetrating radiation, a discovery more fundamental than that of the radiation’s corpuscular nature and that of the latitude variation of its intensity.”

10 December 1936, Stockholm

Victor Hess
Nobel Prize 1936



Austrian alps cosmic ray station

Particles or e-m rays??

Conclusions

The discovery of cosmic rays came after detailed studies using electroscopes on land at sea level, on sea, in sea and at high altitudes

Scientists in Europe and North America participated in the work characterized by lack of communication and by nationalism caused primarily by Worl War I.

The important contribution by Pacini, made a few years before the crucial balloon flight by Hess, was not fully recognized.