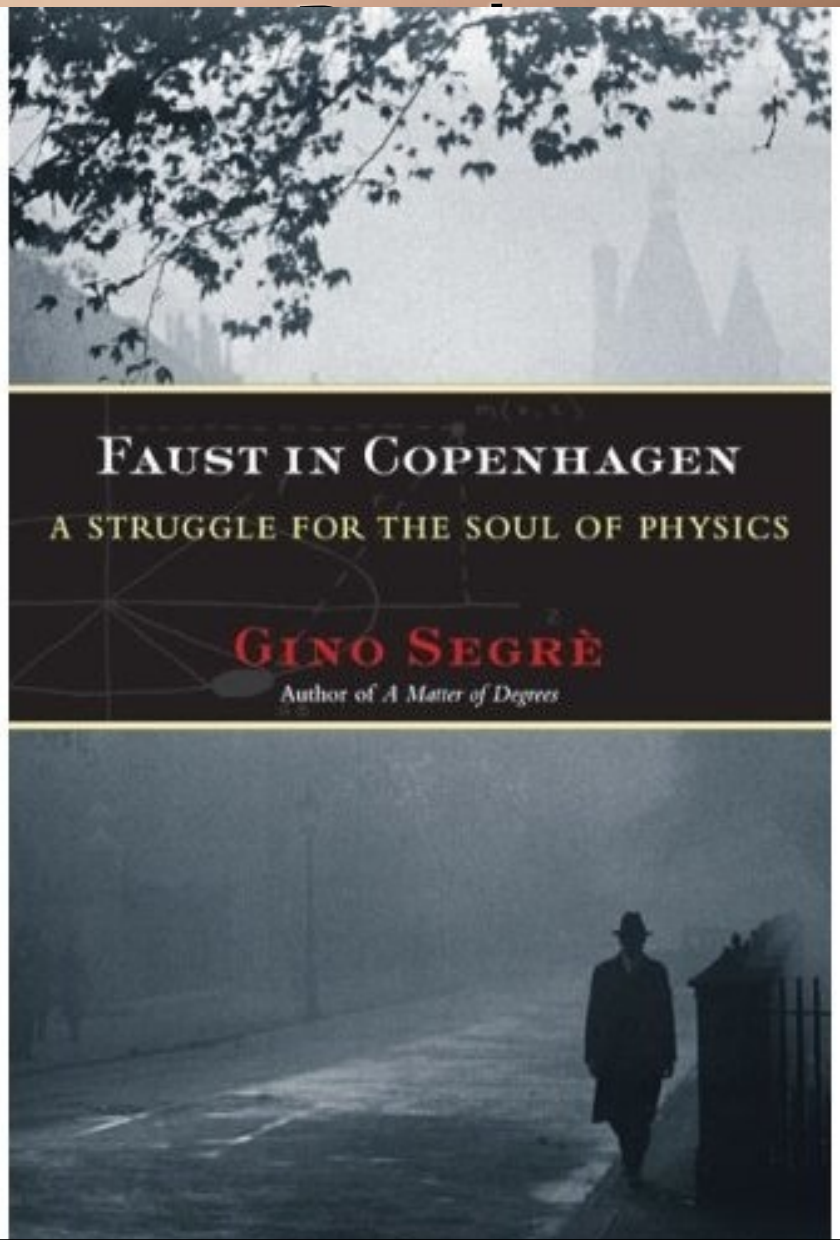
ROMA---Marzo 2013

FAUST A COPENHAGEN

Lotta per l'anima della fisica

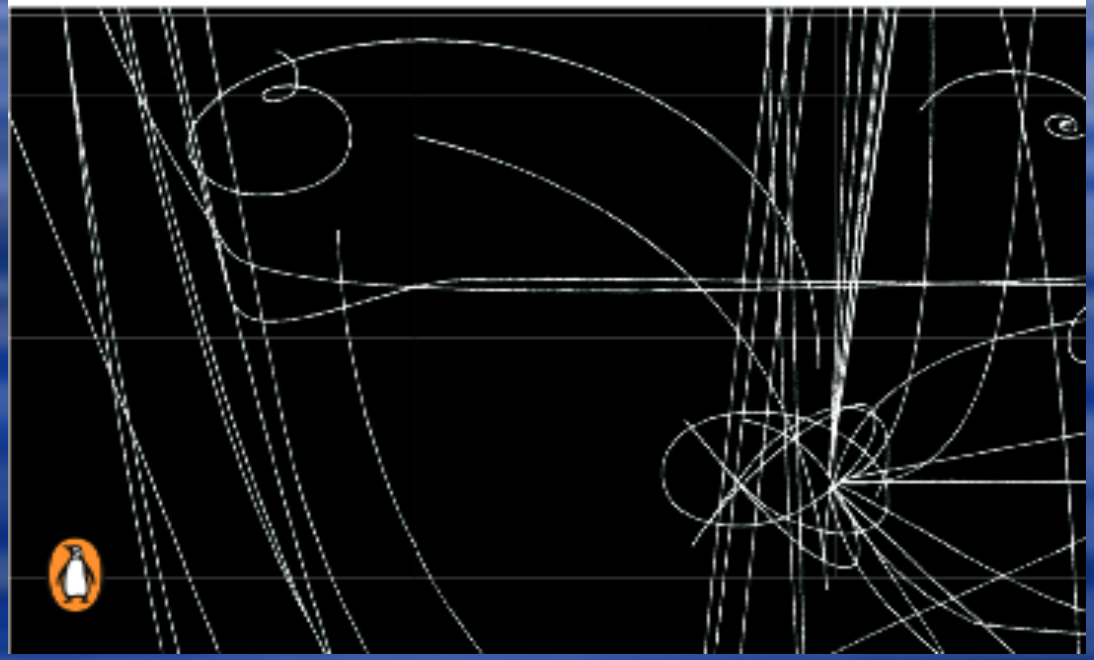

FAUST IN COPENHAGEN
A STRUGGLE FOR THE SOUL OF PHYSICS
GINO SEGRÈ
Author of A Matter of Degrees

"In 1932, the year the neutron was discovered, the greatest names of what was arguably the greatest age in physics met in Copenhagen to talk shop, among them Niels Bohr, Werner Heisenberg, Paul Dirac, and Wolfgang Pauli. . . . . This is the stuff of which cracking good narrative history is made." —*Time*

FAUST IN COPENHAGEN

A STRUGGLE FOR THE SOUL OF PHYSICS

GINO SEGRÉ



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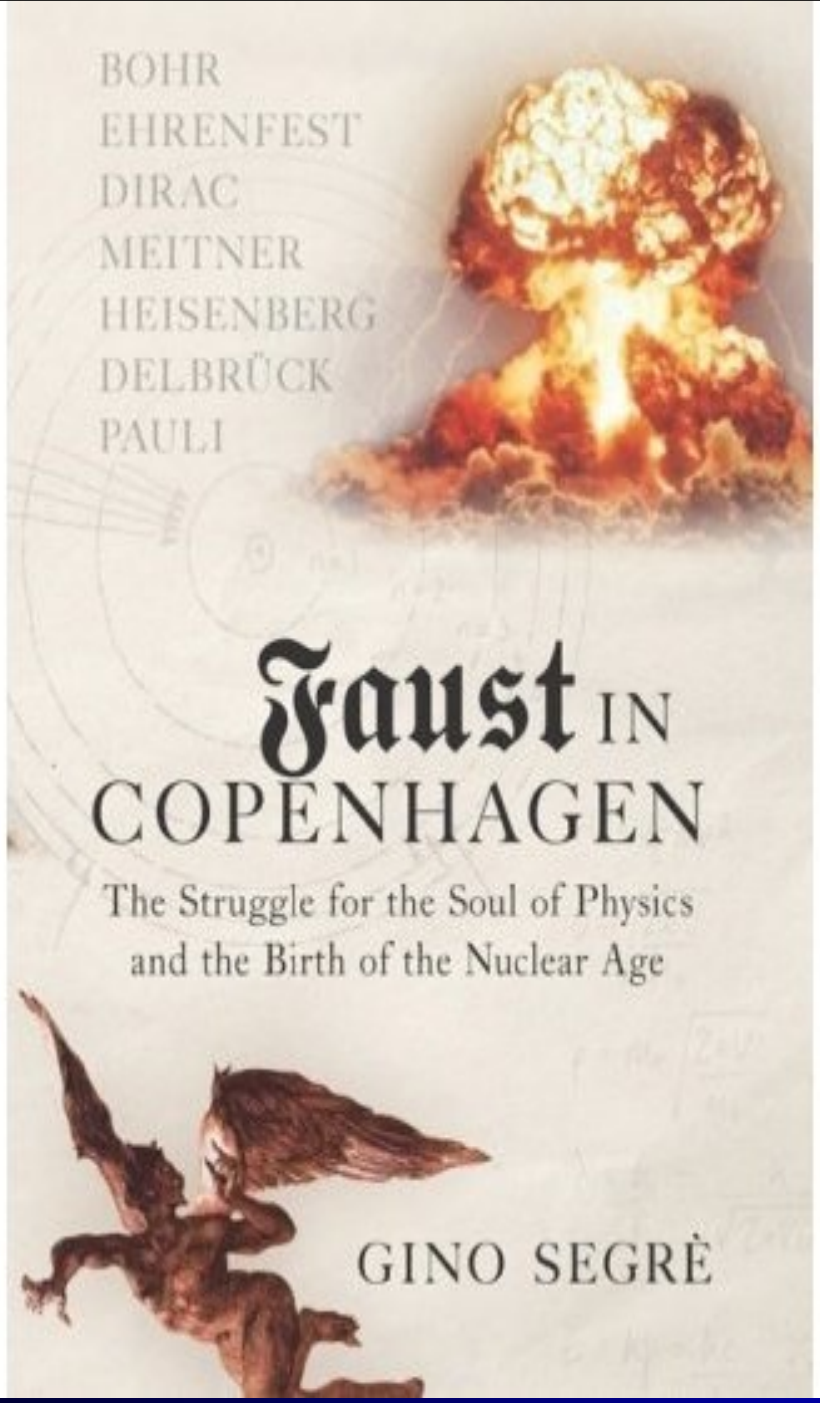
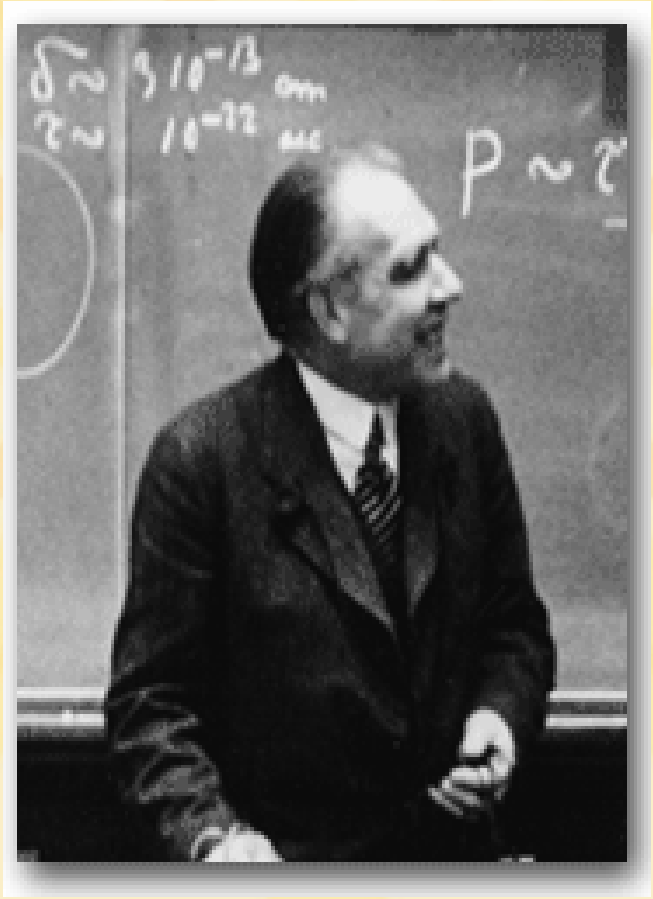

BOHR
EHRENFEST
DIRAC
MEITNER
HEISENBERG
DELBRÜCK
PAULI
Faust IN COPENHAGEN
The Struggle for the Soul of Physics and the Birth of the Nuclear Age
GINO SEGRÈ

Niels Bohr



Goethe

Contributi di Bohr alla fisica

- Atomo di Bohr
- Fisica Atomica- 1913-24-- Correspondence Principle
- Interpretazione della Meccanica Quantistica
- Istituto di Bohr
- Fisica Nucleare

Come Altri Vedevano Bohr

- *“Bohr’s Influence on science is only partially expressed in his published work. ……But quite apart from their unbounded admiration for his achievements, the scientists of all nations felt for him an affection which has perhaps never been equaled.”*
- Sir George Thomson

Bohr--Fisica Atomica

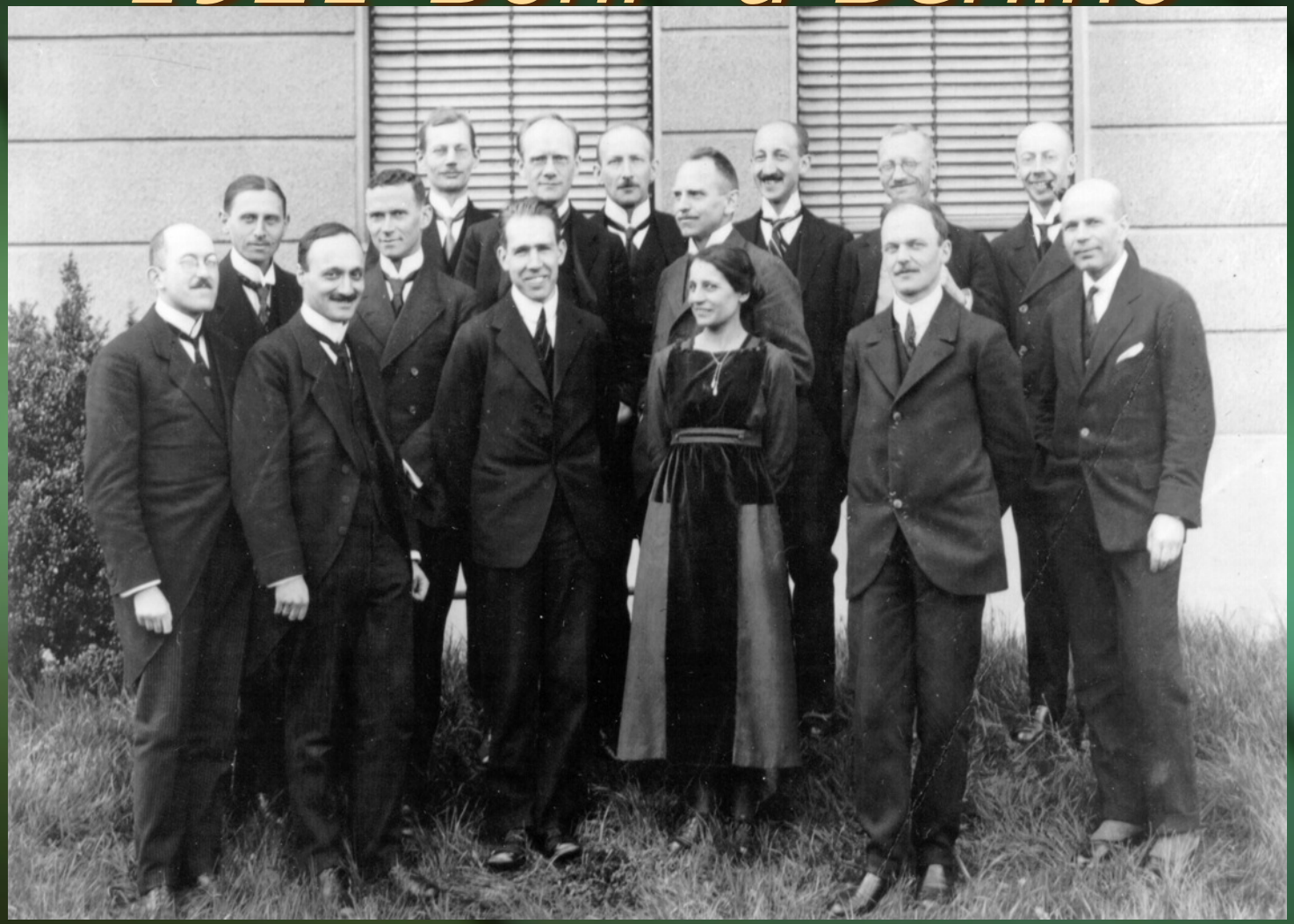
- *"This walk (Gottingen June 1922) was to have profound repercussions on my scientific career, or perhaps it is more correct to say that my real scientific career only began that afternoon".*
- *"Bohr's influence on the physics and physicists of our century was greater than that of anyone else, even than that of Albert Einstein."*
- Werner Heisenberg

Bohr-Fisica Nucleare

- Nothing has done more to convince me that there once existed friends of mankind with the human wisdom of Confucius and Buddha, Jesus and Pericles, Erasmus and Lincoln than walks and talks under the beech trees of Klampenborg Forest with Niels Bohr.

- John Wheeler

1921-Bohr a Berlino



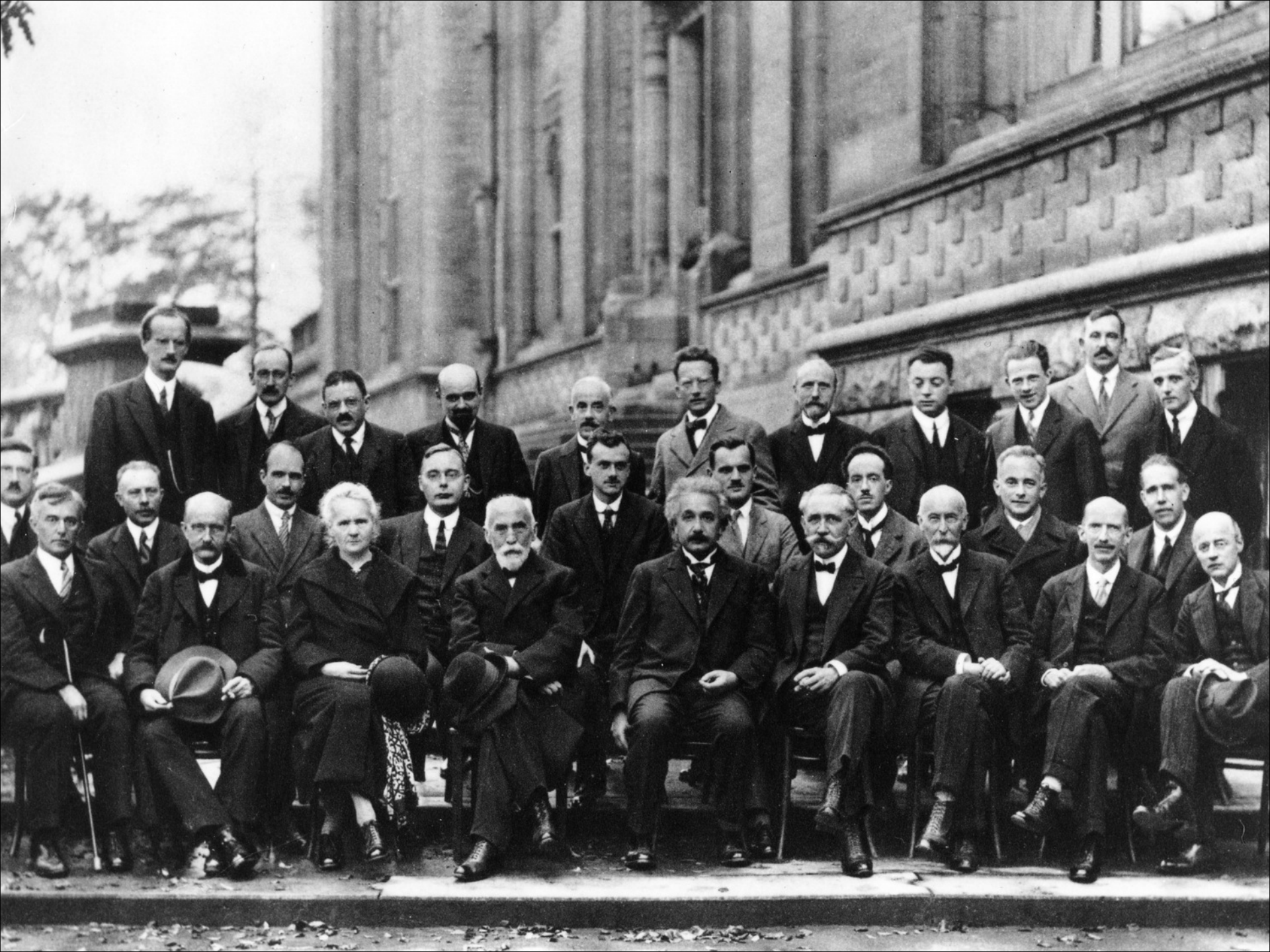
Istituto di Fisica nel 1921

La Nascita della Meccanica Quantistica

- 1924-Pauli Exclusion Principle
- Summer 1925---Heisenberg's Matrix Mechanics
- January- June 1926---Schrodinger's Wave Mechanics
- 1927 -Copenhagen Interpretation with Uncertainty Principle--Complementarity

I problemi della Meccanica Quantistica

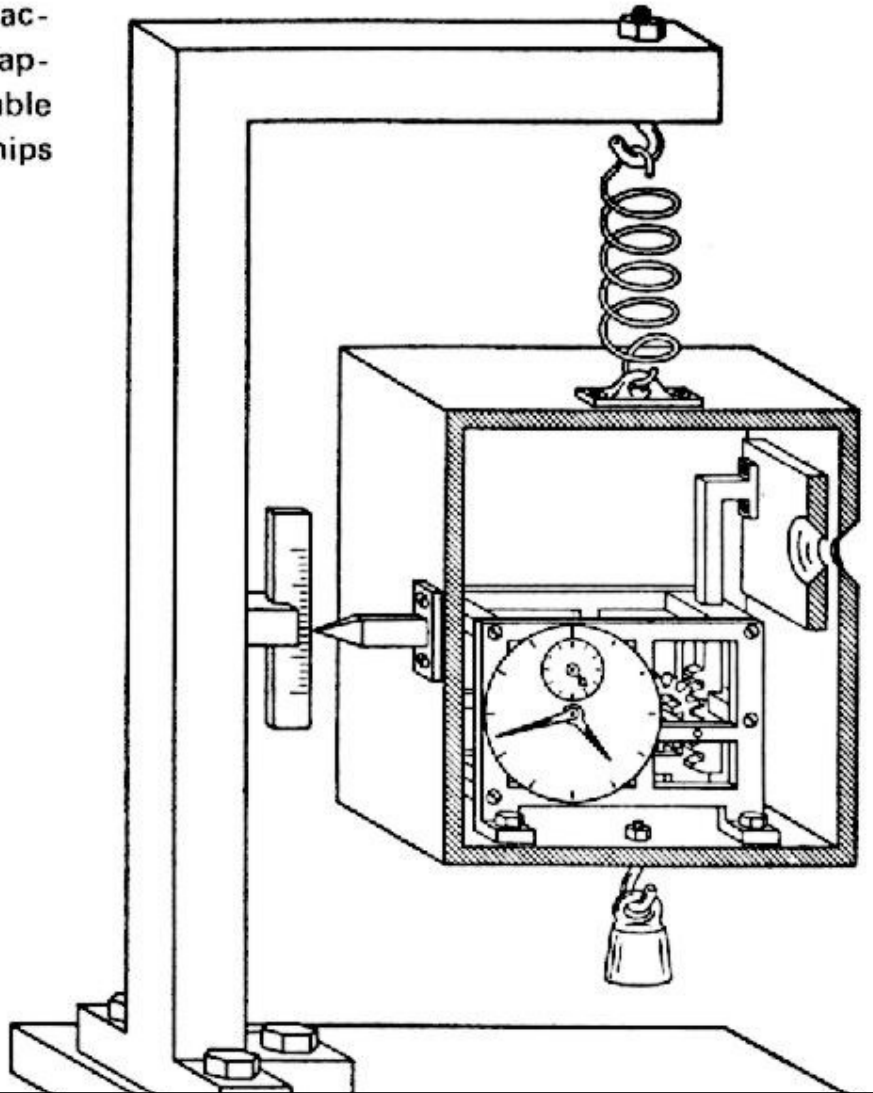
- 1) Probabilistic Interpretation (what does the psi function represent?)
- 2) Particle-Wave Duality
- 3) Uncertainty Principle
- 4) Relativity



1930 Solvay-Bohr e Einstein

- I shall never forget the sight of the two antagonists leaving the conference, Einstein, a tall majestic figure walking quietly with a somewhat ironic smile and Bohr trotting near him, very excited. The next morning came Bohr's triumph." Bohr had refuted Einstein's paradox.

Illustration of a thought experiment which played an important part in the discussions between Bohr and Einstein on the interpretation of quantum mechanics (1930). With the many "technical" details in the drawing Niels Bohr wanted to stress that, in measurements of atomic quantities, the whole experimental arrangement must be taken into account. Thus, it is indicated that an accurate time measurement requires a solid sytem of gears and that a determination of position assumes the existence of a properly fixed measuring rod. The apparatus has become so elaborate because, during the discussions, Einstein proposed new measurements to control the interaction of the atomic object with the original apparatus now enclosed in a box. Bohr was able to show how the complementary relationships appear also in the new experiment.



1930---ΔEΔT

- Measuring scale with accuracy Δq implies uncertainty Δp such that
  - ΔpΔq >h
- During time T of balancing procedure, there is an uncertainty Δm of box's mass and hence an uncertainty in its momentum of Δm v = Δm gT where g= gravitational constant. We want Δp, intrinsic uncertainty due to the act of measuring, to be smaller than this. In other words we should have
- ΔmgT > h/Δq----the more precise the position, the longer the time needed to measure it for a given uncertainty in mass

Bohr's refutation II

- Because of the gravitational redshift, an uncertainty Δq in the clock's position implies an uncertainty ΔT in its measurement of time
- ΔT/T= Δf/f= v/c =g Δq/c^2
- Using ΔmgT > h/Δq, (previous page)
- And 1/Δq =gT/ ΔT we find

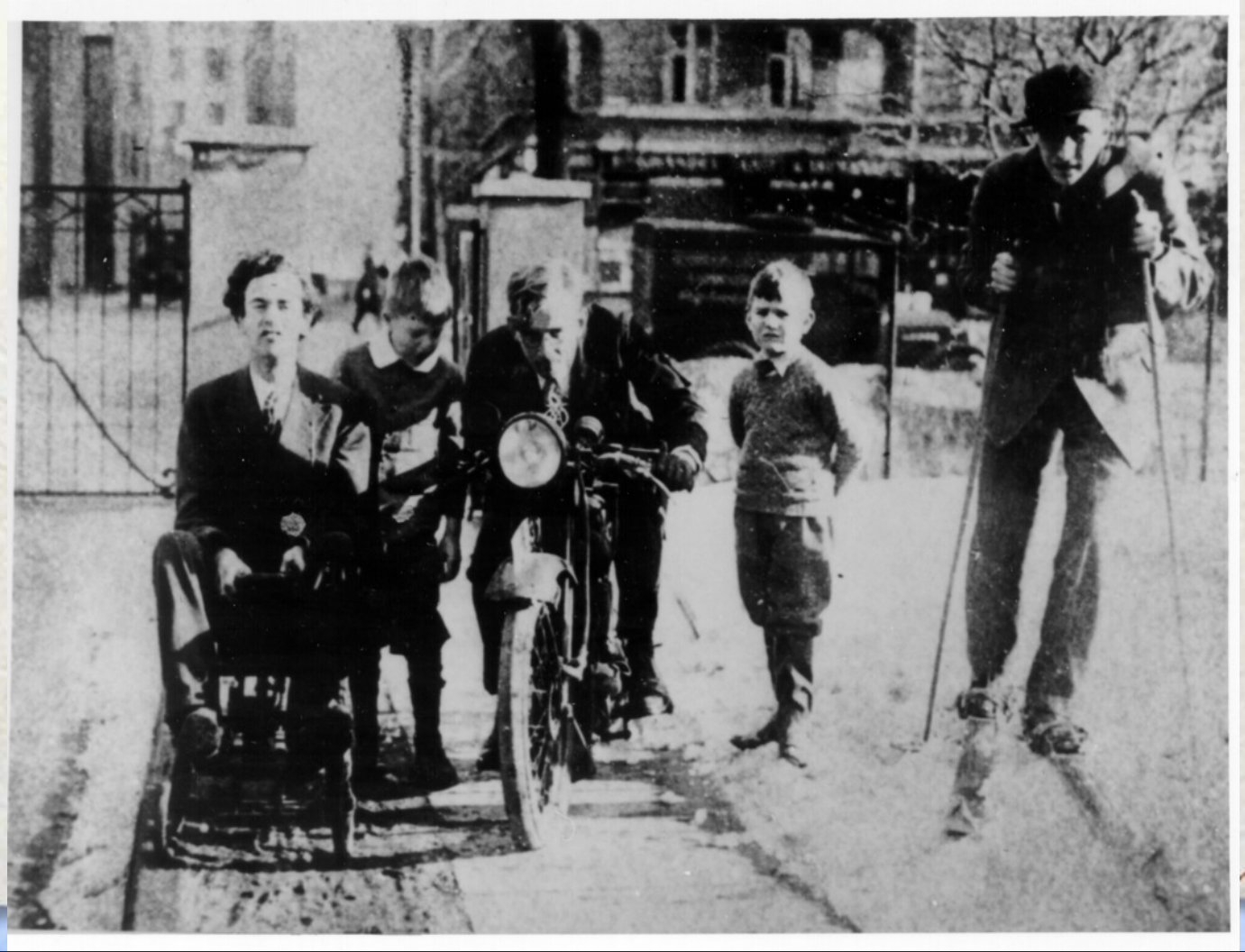
ΔmgT >h gT/ ΔT or ΔT> h/Δm c^2
implying ΔEΔT > h QED

Pellegrinaggi Famosi

- Santiago de Compostela

- Sulla via per Lhasa

Sulla via per Copenhagen



Incontri--1930 Prima Fila

1932 Discussioni

- Quantum Mechanics did not explain the behavior of the atomic nucleus
- There was also an apparent violation of energy conservation

Bohr propone che l'energia non e`conservata nelle interazioni nucleari

- Dirac:*I should prefer to keep rigorous conservation at all costs*
- Pauli (letter to Bohr):*Do you intend to mistreat the poor energy further*?
- Rutherford:*I have heard you are on the warpath and wanting to upset the Conservation of Energy. I will wait and see before expressing an opinion but I always feel " there are more things in Heaven and Earth than are dreamt of in our philosophy*"

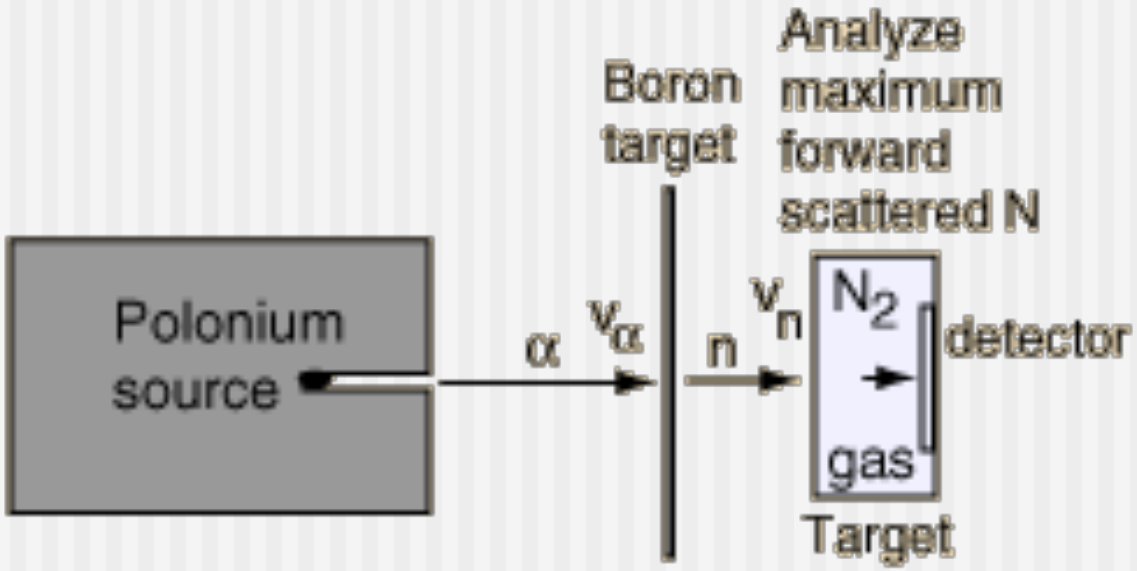
Ragioni per la proposta e le quattro Soluzioni

- 1) Paradosso di Klein --apparent violation of unitarity (solution:positron existence- pair production possible)
- 2) Statistica dei Nuclei--N-14 nucleus appeared to be bosonic--(solution: neutron not a proton-electron bound state)
- 3) Raggi Beta-- Energy non conservation (solution:neutrino)
- 4) Energia nelle stelle--(solution: nuclear forces, pep chain, carbon cycle etc.----pion)

1932-- Sperimenti arrivano

- 1) Discovery of Neutron (beginning of nuclear physics
- 2) First Nuclear Disintegration
- 3) First Cyclotron--the move to BIG physics
- 4) Discovery of anti- matter (positive electron or positron)
- 5) Discovery of deuterium
- 6) Proton Magnetic Moment Measurement

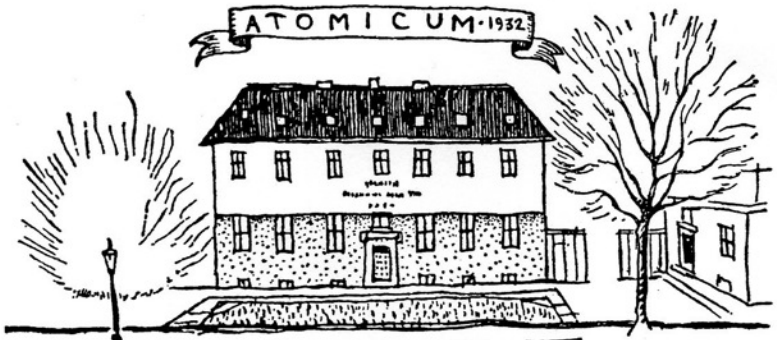
Chadwick (February 1932) scoperta del neutrone



La Parodia del Faust di Goethe

- 1932 was 100th anniversary of Goethe's Death
- 1932 was 10th anniversary of Institute's Founding
- Skit was part of meeting (young make fun of their elders--very much unlike Solvay)
- 1932 skit was parody of Faust adapted to world of physics---Gretchen was the neutrino

B



FAUST

EINE HISTORIE

MANUSCRIPT AFTER: J. W. von Goethe

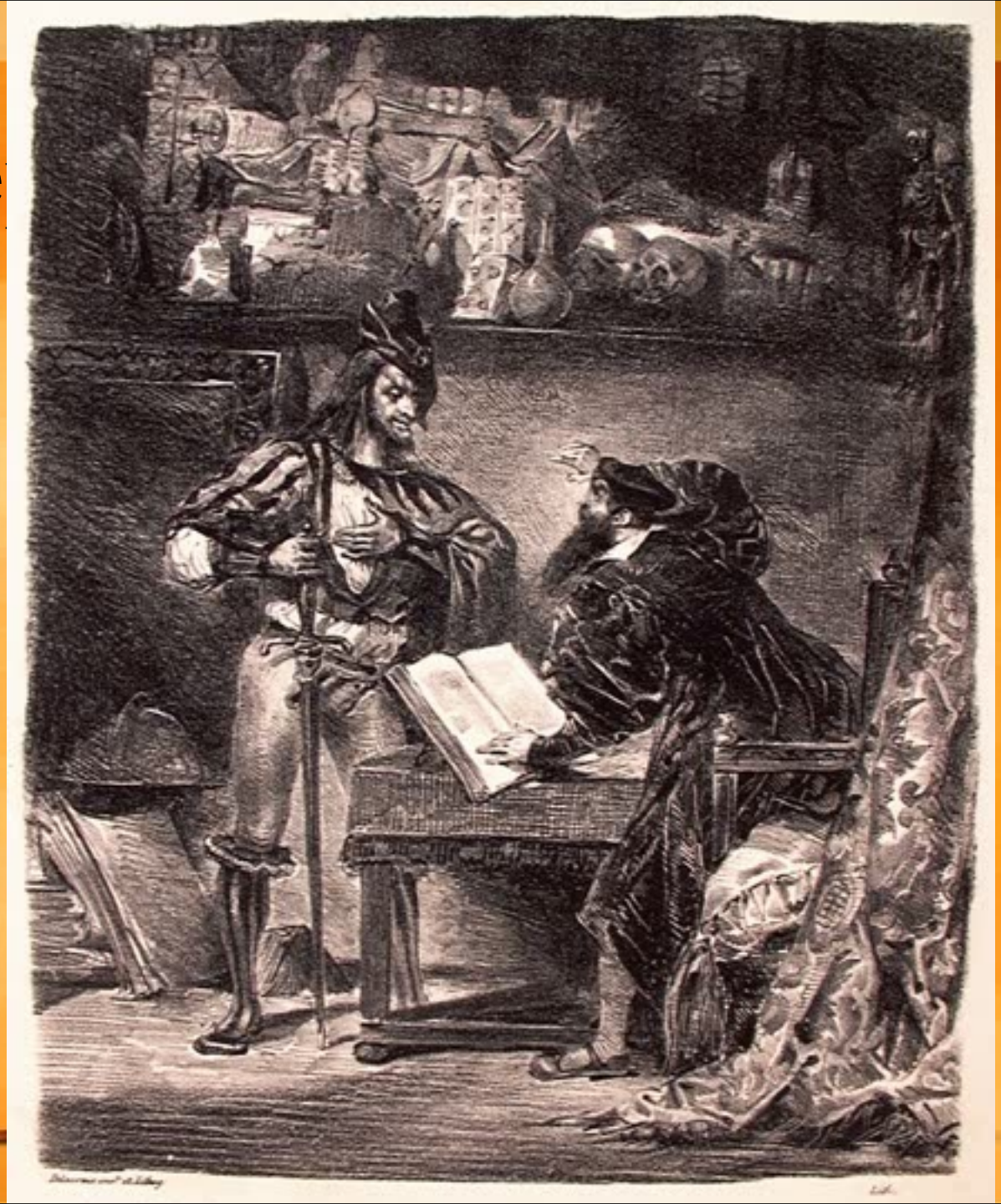
PRODUCED BY: The Task Force of the
"Institute for Theoretical Physics,"
Copenhagen

Motto:

Not to criticize . . .

N. Bohr

Me



FIRST PART

Faust's Study

fest)

THE THREE

This vision fills us with elation
(Though none of us can understand).
As on the Day of Publication
The brilliant Works are strange and grand.

MEPHISTO

(*springing forward*)

Since you, O *Lord,* yourself have now seen fit
To visit us and learn how each behaves,

WAGNER[41]

(*appears, as the personification of the ideal experimentalist, balancing a black ball on his finger, and says, with pride*)

The *Neutron* has come to be.
Loaded with Mass is he.
Of Charge, forever free.
Pauli, do you agree?

Mefistofele Conclude

- That which experiment has found
- Though theory had no part in
- Is always reckoned more than sound
- To put your mind and heart in

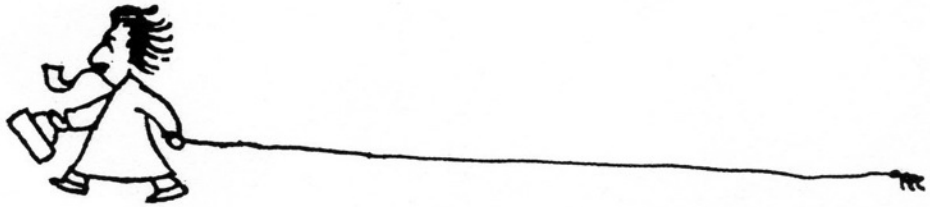
La Vecchiaia

- *Old age is a cold fever, it's an ague that freezes, fancies that torment and plague . Once over thirty you're as good as dead.*
  - Faust, Act II
- *Certainly old age is a cold fever that every physicist suffers with! When one is past thirty, he is as good as dead!*
  - Skit

Einstein

A *Monarch* cherished dearly
A *Flea,* just as a son,[19]
And quite as much—or nearly—
As Gra-vee-táy-shee-un.

The Monarch summoned *Mayer,*[20]
Said Mayer: "To be sure!
I'll make him tensors, Sire,[21]
With junker curvature."



Attired as a dandy,
The Flea was then displayed.
Folks ate him up like candy
So sweetly was he made.

Auerbachs Keller in Leipzig

- Es war eimal ein Konig
- Der hat einen grossen Floh
- Der liebt er gar nicht wenig
- Als wie seinen eignen sohn

- Es war eimal ein Konig
- Der hat einen grossen Floh
- Der liebt er gar nicht wenig

- Als wie Gravitation

La Canzone di Gretchen

- Meine Ruh ist hin
- Mein Herz ist schwer
- Ich finde sie nimmer
- Und nimmermehr

- Meine Ladung ist hin
- Statistik ist schwer

- Ich finde sie nimmer
- Und nimmermehr

THE LORD

Don't interrupt this colloquy!
I'll do the talking. Dau, you see,
The only proper rule of thumb
Is

LANDAU

Um! Um-um! Um-um! Um-um!

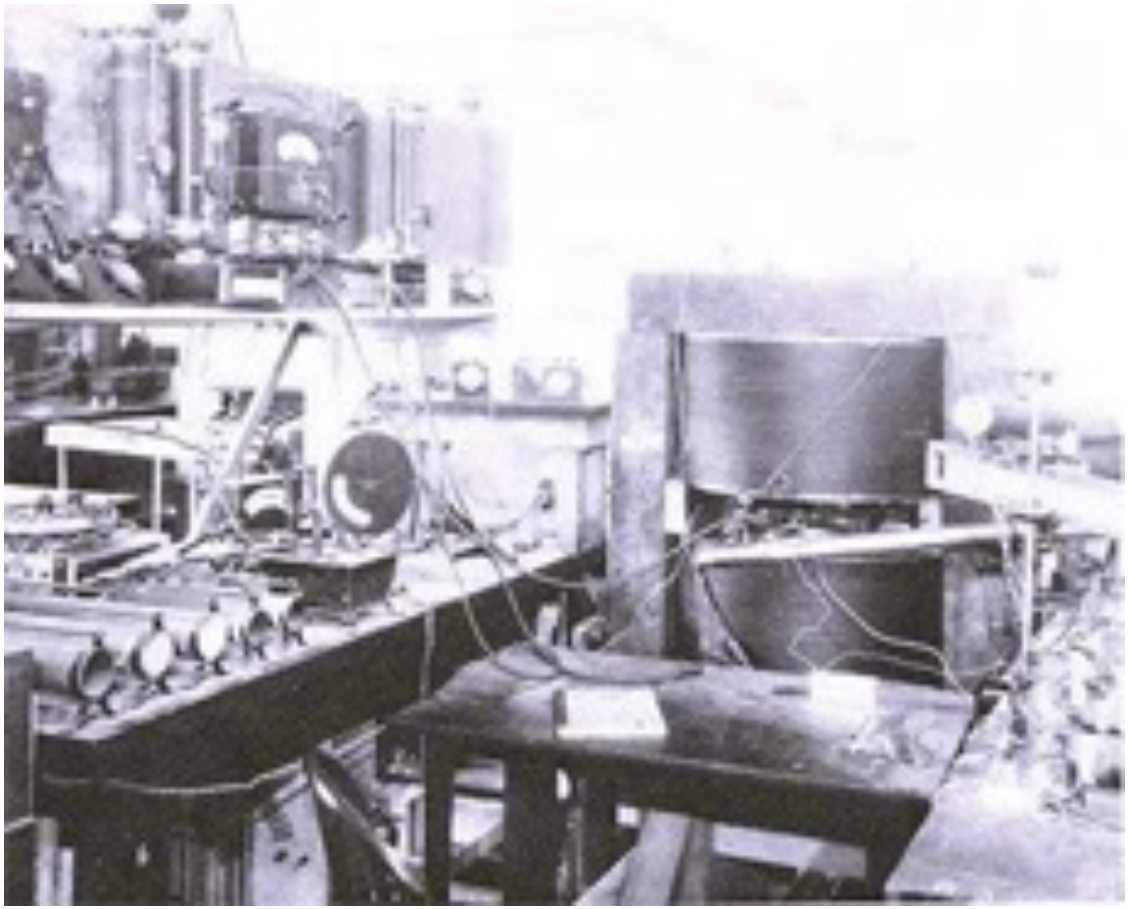
(*At the other side of the stage, to the back, appears the face of* GAMOW, *through bars*)

Altre Scoperte del 1932

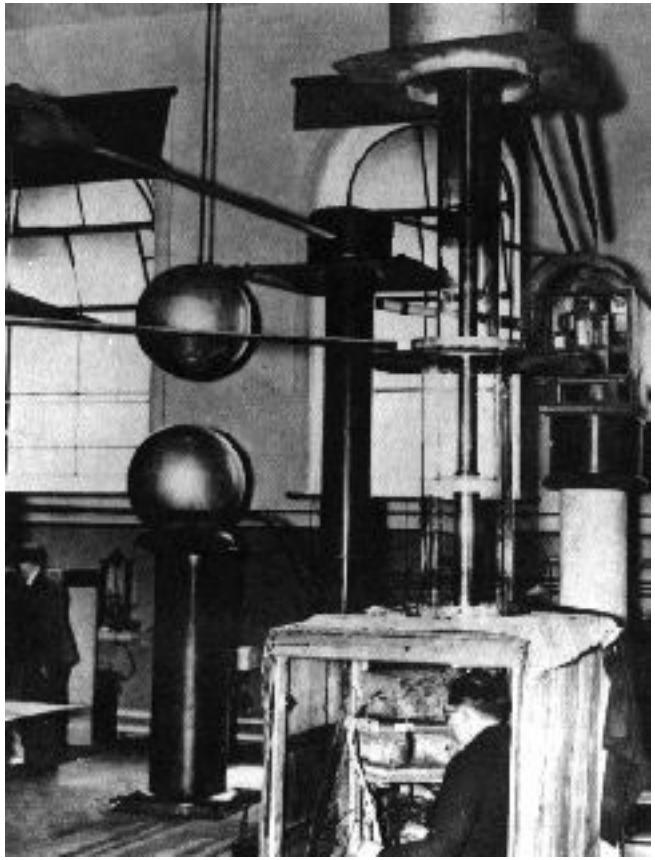
- 2) First Nuclear Disintegration
- 3) First Cyclotron--the move to BIG physics
- 4) Discovery of anti- matter (positive electron or positron)
- 5) Discovery of deuterium
- 6) Proton Magnetic Moment Measurement

Anderson e la scoperta del positrone

Il Ciclotrone di Lawrence



Cockroft Walton (1932)



Josef Stalin -Iosif Dzughashvlii

Adolf (Schickelgruber) Hitler

L'Incendio al Reichstag (Febraio 1933)

Copenhagen 1933