1954-2004 CERN

Globe of Innovation

Európai Nukleáris Kutatási Szervezet
Európai Részecskefizikai Laboratórium

50 év a részecskefizika kutatásban

Már a görögök......... **Archimedes** died in battle of Syracus

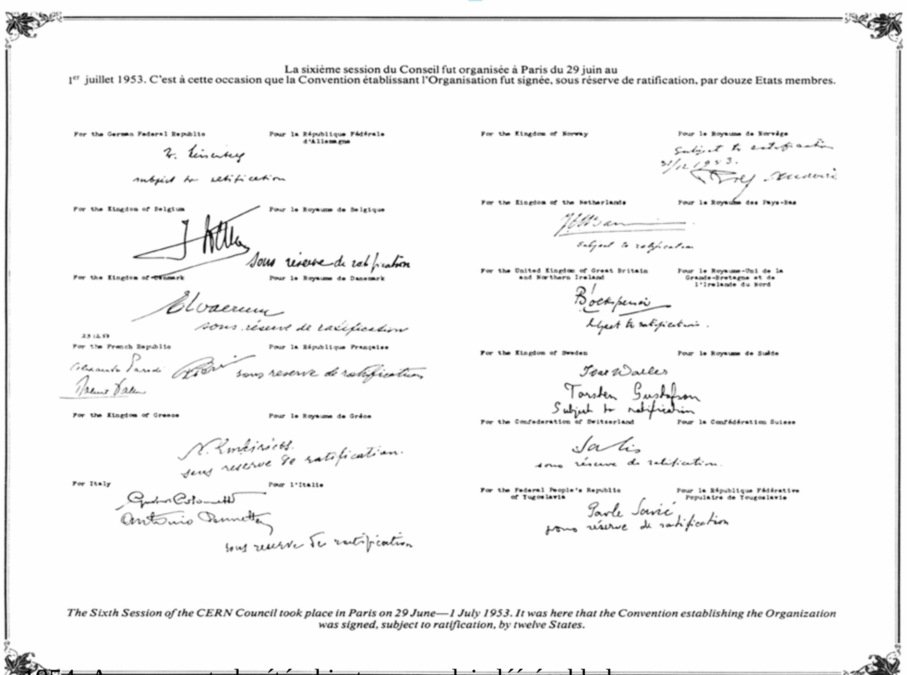
Galilei..."On 8 August 16O9, he *invited the Venetian Senate* to examine his spy-glass from the *tower of St. Marco*, with spectacular success: three days later, he made a present of it to the Senate, accompanied by a letter in which he explained that the instrument, which magnified objects **nine** times would prove of utmost importance in war. It made it possible to see *'sails and shipping that were so far of that it was two hours before they were seen with the naked eye, steering full-sail into the harbour'* thus being invaluable against invasion by sea. ... The grateful Senate of Venice promptly doubled Galilelo's salary ... and made his professorship at Padua a lifelong one.

It was not the first and not the last time that pure research, that starved cur, snapped up a bone from the warlord's banquet." A. Koestler: The SLEEPWALKERS p.369.

L. Szilárd, A. Einstein, Oppenheimer, E. Teller....

- 1954-ben 12 ország alapította, ma már 20 ország tagja
- Nukleáris = Atommagot kutató (nucleus)
- Évente több mint 7000 felhasználó
- Éves költségvetése 1000 MCHF (600M€)32O-13OFt/fő

European MANHATTAN project for PEACE


La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

For the German Federal Republic — Pour la République Fédérale d'Allemagne

For the Kingdom of Norway — Pour le Royaume de Norvège

For the Kingdom of Belgium — Pour le Royaume de Belgique

For the Kingdom of the Netherlands — Pour le Royaume des Pays-Bas

For the Kingdom of Denmark — Pour le Royaume de Danemark

For the United Kingdom of Great Britain and Northern Ireland — Pour le Royaume-Uni de la Grande-Bretagne et de l'Irelande du Nord

For the French Republic — Pour la République Française

For the Kingdom of Sweden — Pour le Royaume de Suède

For the Kingdom of Greece — Pour le Royaume de Grèce

For the Confederation of Switzerland — Pour la Confédération Suisse

For Italy — Pour l'Italie

For the Federal People's Republic of Yugoslavia — Pour la République Fédérative Populaire de Yougoslavie

The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

1954: A szervezet alapító okirata az eredei aláírásokkal

C.Rubbia initiative

MTA interest

J. Zimányi enthusiasm

J. Antal and E.Pungor political engagement

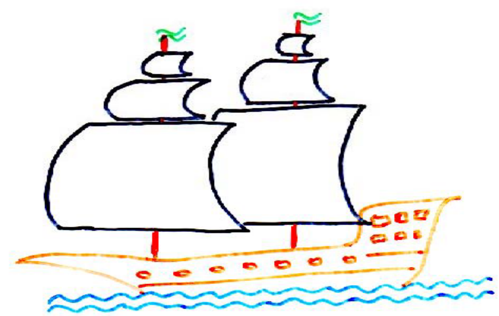
1492

A kutatás FRONTVONALA:

Az Atlanti Óceán partja

A kutatás ESZKÖZE:

Kolumbusz hajói



A kutatás CÉLJA: INDIA

A kutatás EREDMÉNYE: AMERIKA

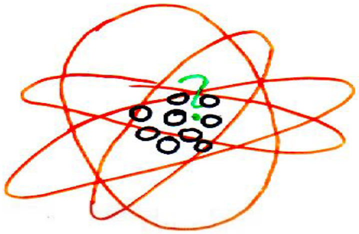
Fizikusok 12 évvel hamarabb léphettek be fizikus EU-ba!!!

Still TRUE now

1992...

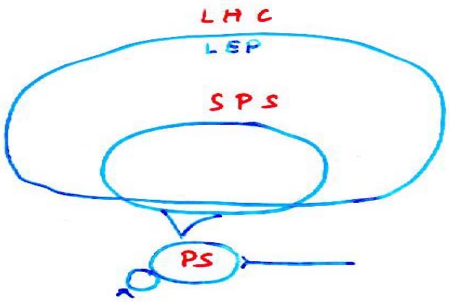
A kutatás FRONTVONALA:

Az atommag belseje



A kutatás ESZKÖZE:

Részecske gyorsítók



A kutatás CÉLJA:

HIGGS-BOZON (LEP) } LHC
Quark-Gluon-Plasma (SPS)

A kutatás EREDMÉNYE:

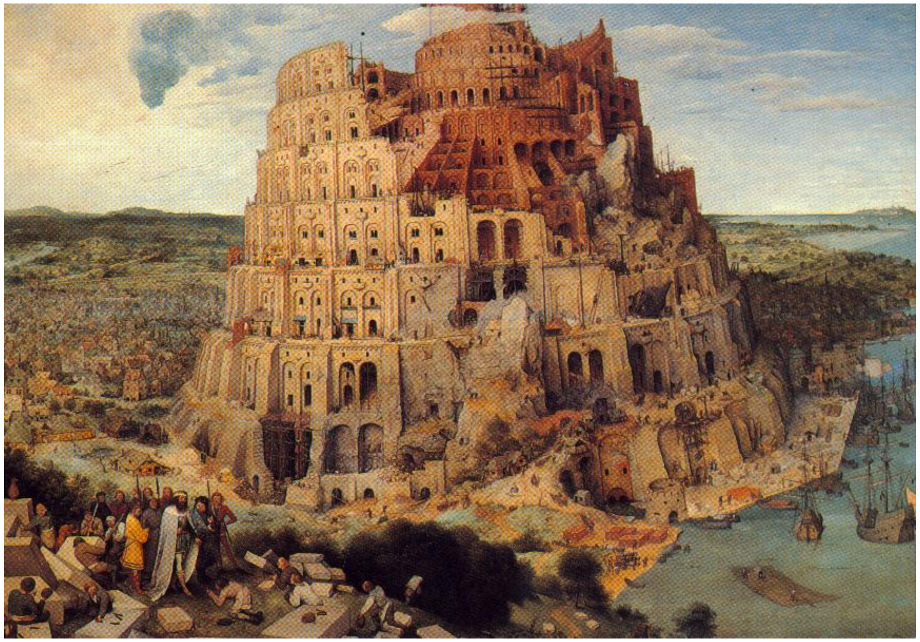
?

Bábel torony, amely működik

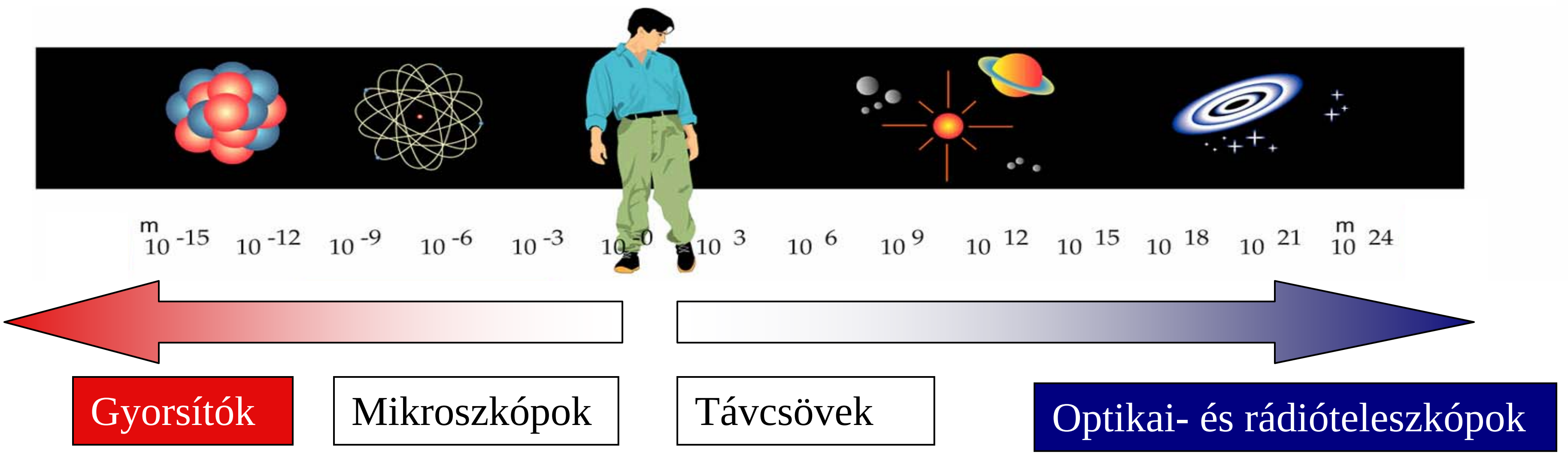
- A CERN 20 tagországa 18 különböző hivatalos nyelvet használ (A+D, CH=F+D)

- A 80 országból érkező kutatók közel 100 nyelven beszélnek

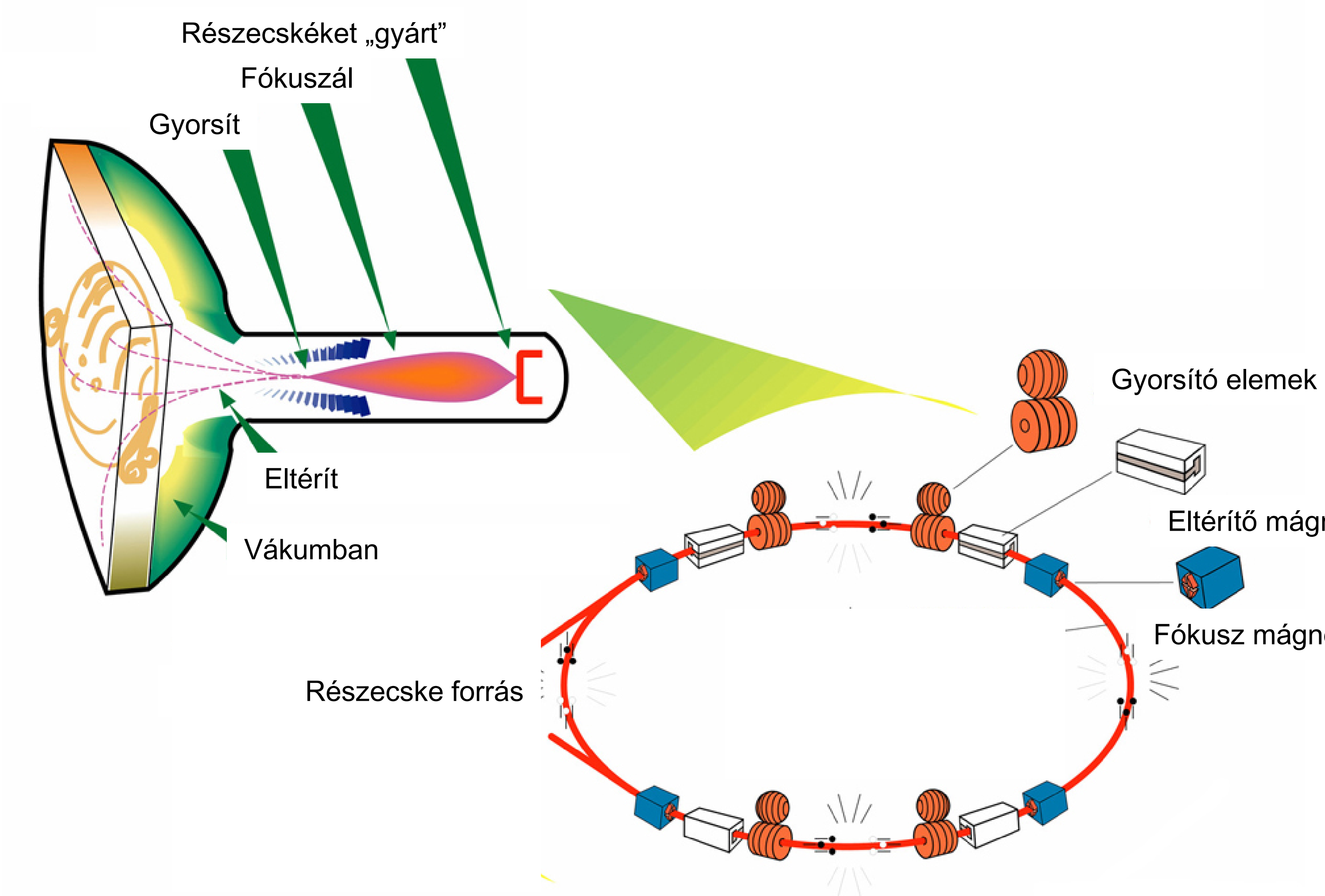
- A CERN hivatalos munkanyelvei
az angol és a francia



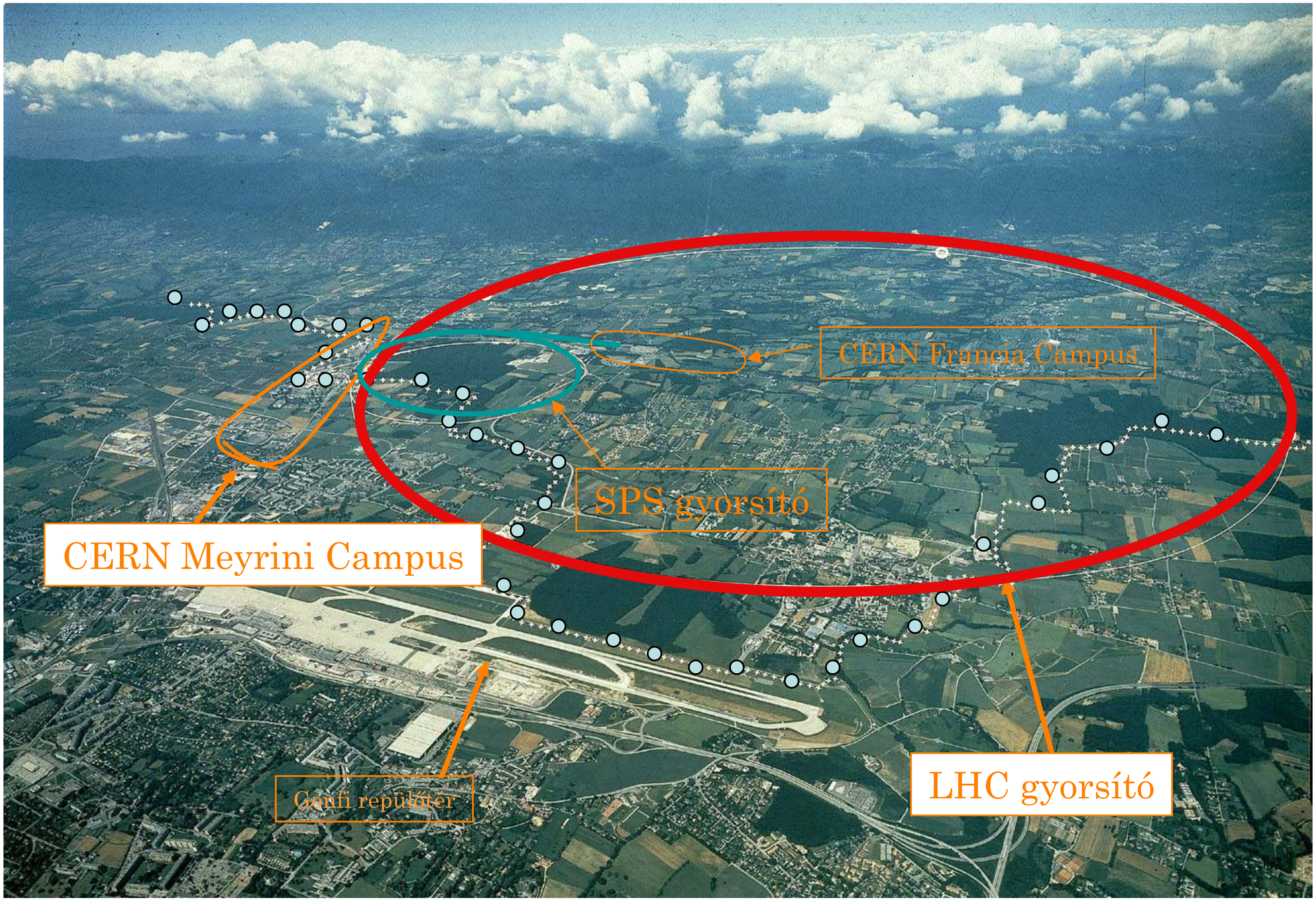
A részcskefizika az anyag legparányibb építőköveit vizsgálja módszeres alapossággal



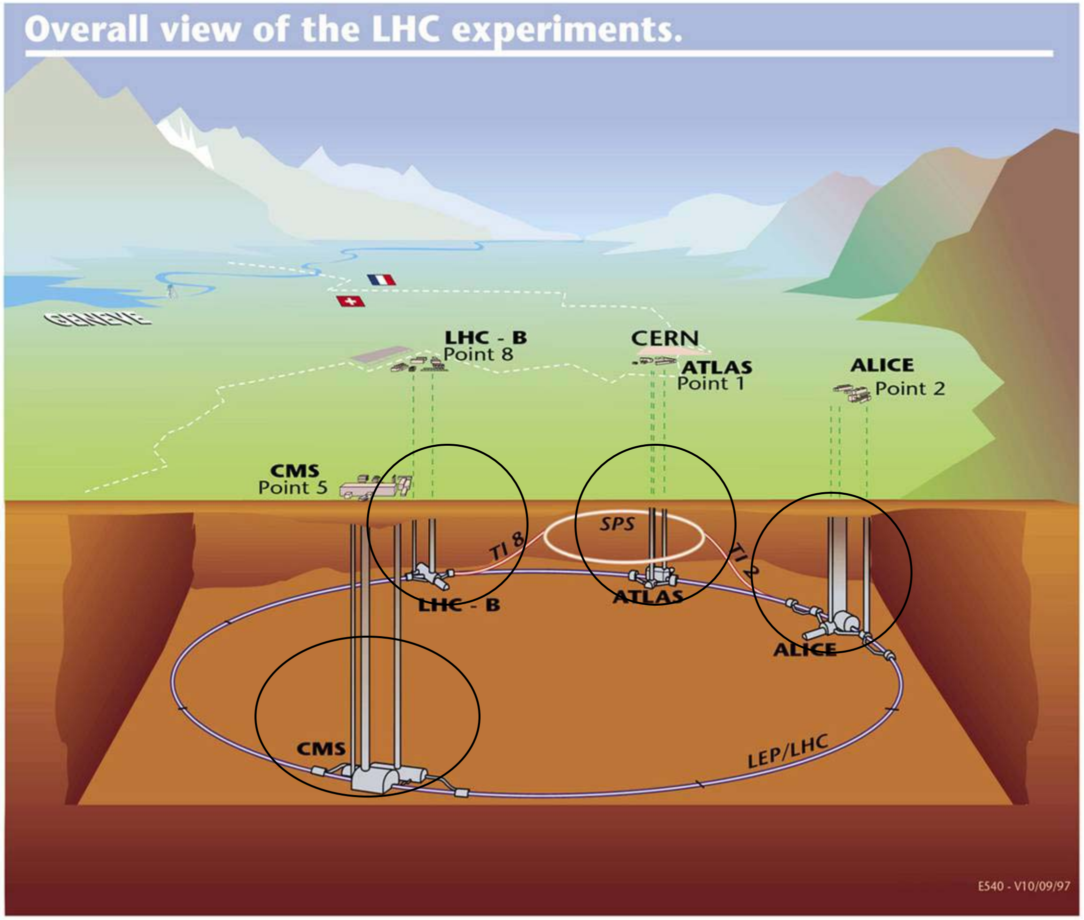
A televízió készülék!



CERN elhelyezkedése



A Nagy Hadron Ütköztető (LHC) lesz a valaha épített legnagyobb, az elemi részecskék vizsgálatára szolgáló tudományos műszer.



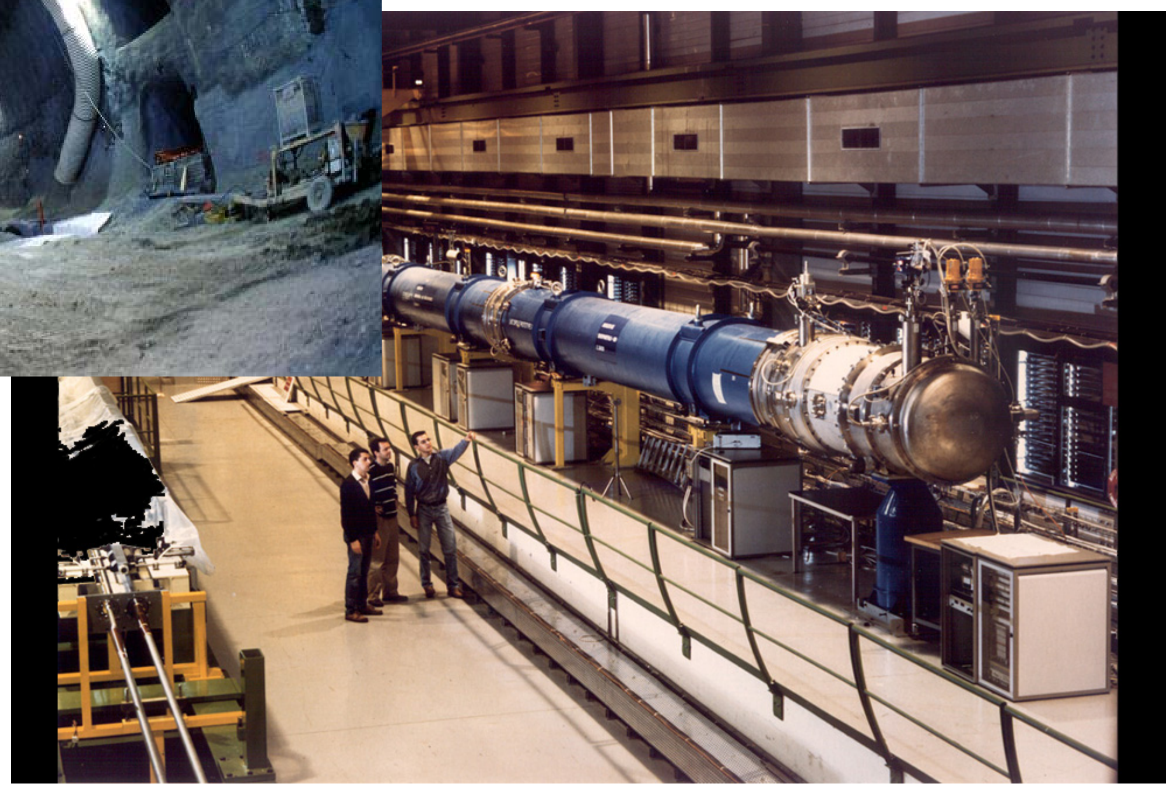
- Négy hatalmas földalatti csarnok készül az óriási detektorok számra

- A világ legnagyobb teljesítményű tudományos részecskegyorsítója
a legmelegebb pont az Uni -verzumban a BigBang óta

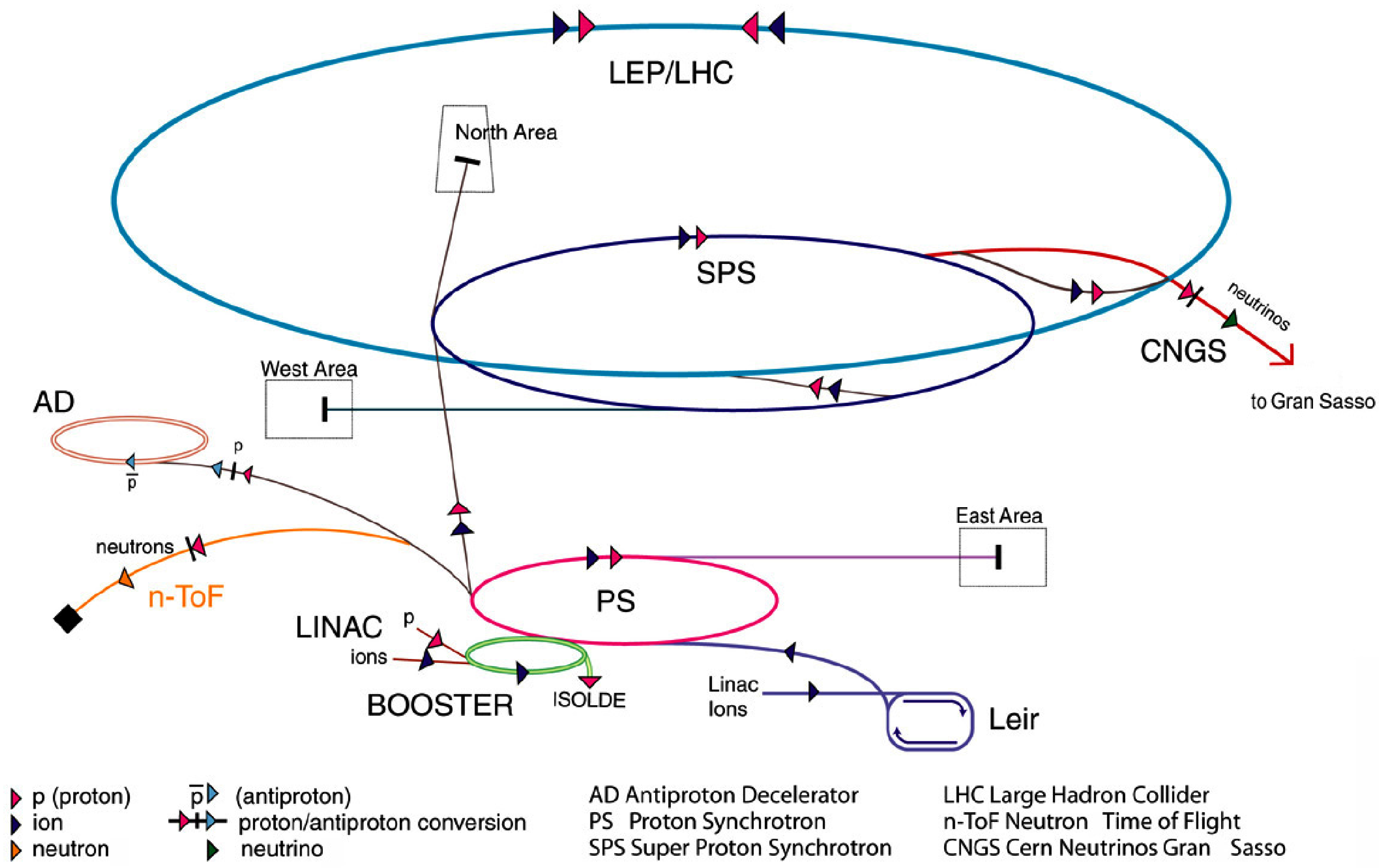
- Alacsonyabb hőmérsékleten mint a világűr dermesztő hidege
2.7 K > 1.8 K

Az LHC építése

27 km kerületű
100 méterre a föld alatt



CERN gyorsító komplexuma



Some units which we will use and some relationships that might be useful.

$$E^2 = \vec{p}^2 c^2 + m_0^2 c^4$$

$\beta = \frac{v}{c}$ $(0 \leq \beta < 1)$ $\gamma = \frac{1}{\sqrt{1-\beta^2}}$ $(1 \leq \gamma < \infty)$

$E = m_0 \gamma c^2$ $p = m_0 \gamma \beta c$ $\beta = \frac{pc}{E}$

energy E:	measured in eV
momentum p:	measured in eV/c
mass m_0 :	measured in eV/c^2

1 eV is a small energy.

1 eV = $1.6 \cdot 10^{-19}$ J

m_{bee} = 1g = $5.8 \cdot 10^{32}$ eV/c^2

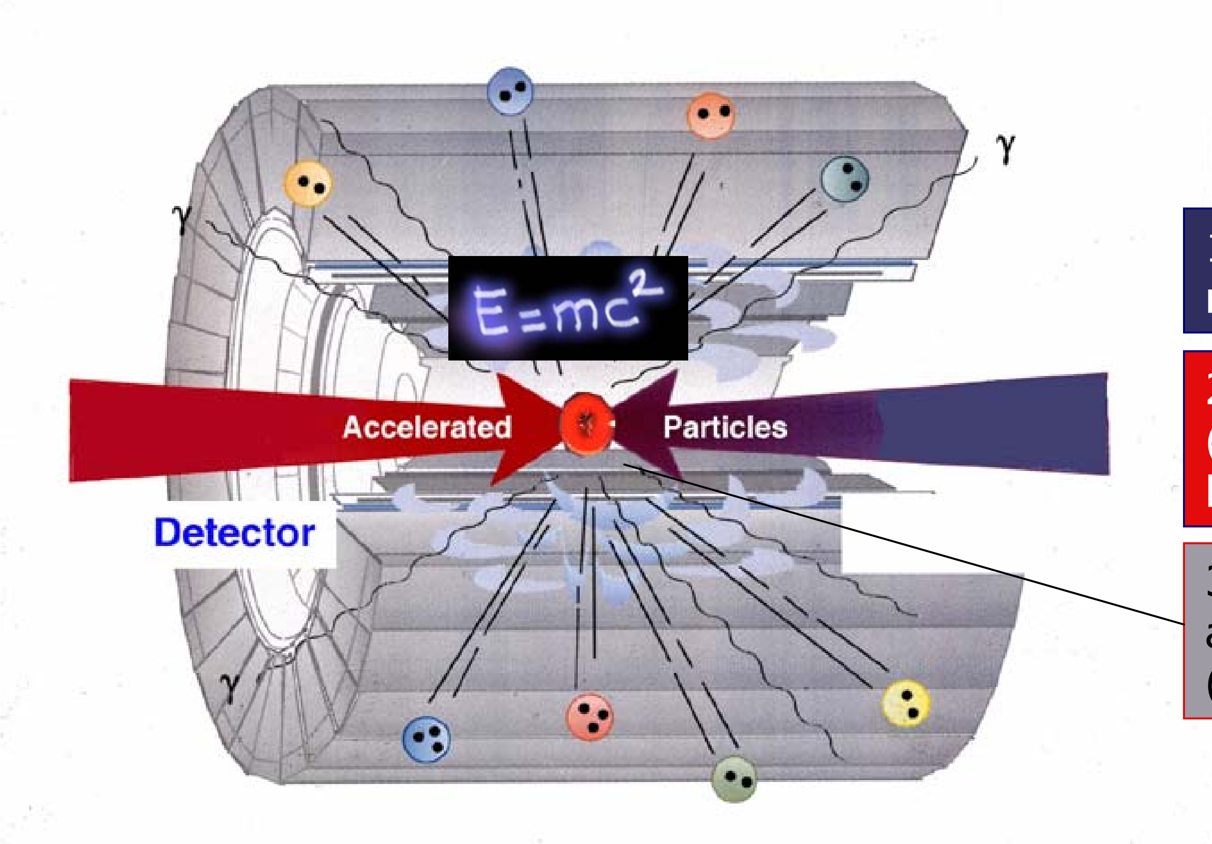
v_{bee} = 1 m/s $\rightarrow E_{\text{bee}} = 10^{-3}$ J = $6.25 \cdot 10^{15}$ eV

$E_{\text{LHC}} = 14 \cdot 10^{12}$ eV

However,
LHC has a total stored beam energy
10^{14} protons $\times$ $14 \cdot 10^{12}$ eV $\cong 10^8$ J
or, if you like

One 100 T truck at 100 km/h

http://www.nature.com/news/2004/040105/images/bee_180.jpg



1) Energiakoncentráció a részecskéken (**gyorsító**)

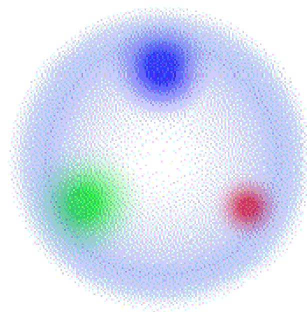
2) Részecskék **ütköztetése** (ősrobbanás –Big Bang-közeli állapot előidézése)

3) Létrehozott részecskék azonosítása a **detektorban** (tovább mutató jelek keresése)

A CMS kísérlet építése az LHC számára

Az anyag alkotói

Quarks (Gell-Mann) 1964



Proton

Napjaink periódusos rendszere

	Quarks		Leptons	
Generation 3	t Top	b Bottom	τ Tau	ν_τ Tau-neutrino
Generation 2	c Charm	s Strange	μ Muon	ν_μ Muon-neutrino
Generation 1	u Up	d Down	e Electron	ν_e Electron-neutrino

Még nem tudunk mindent!

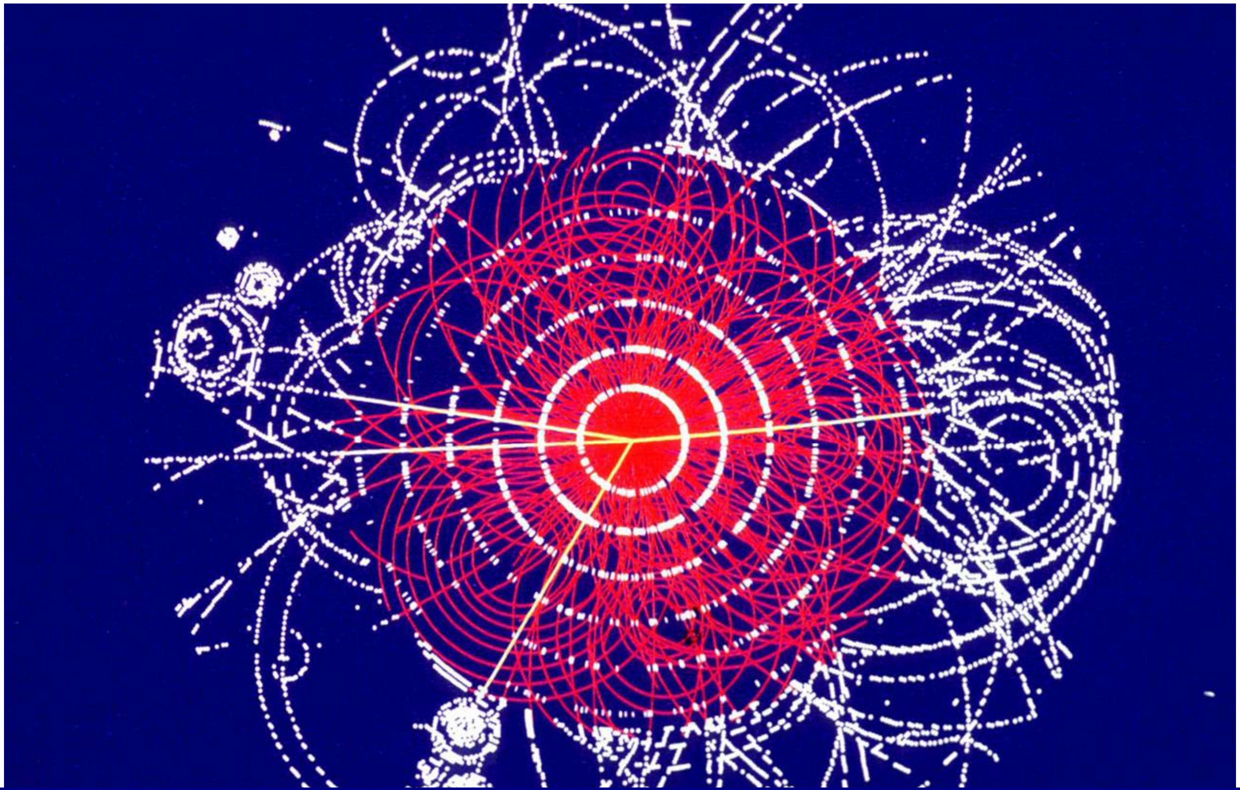
Miért van pont három generáció?

Szuperszimetria?

Hol van a Higgs bozon?

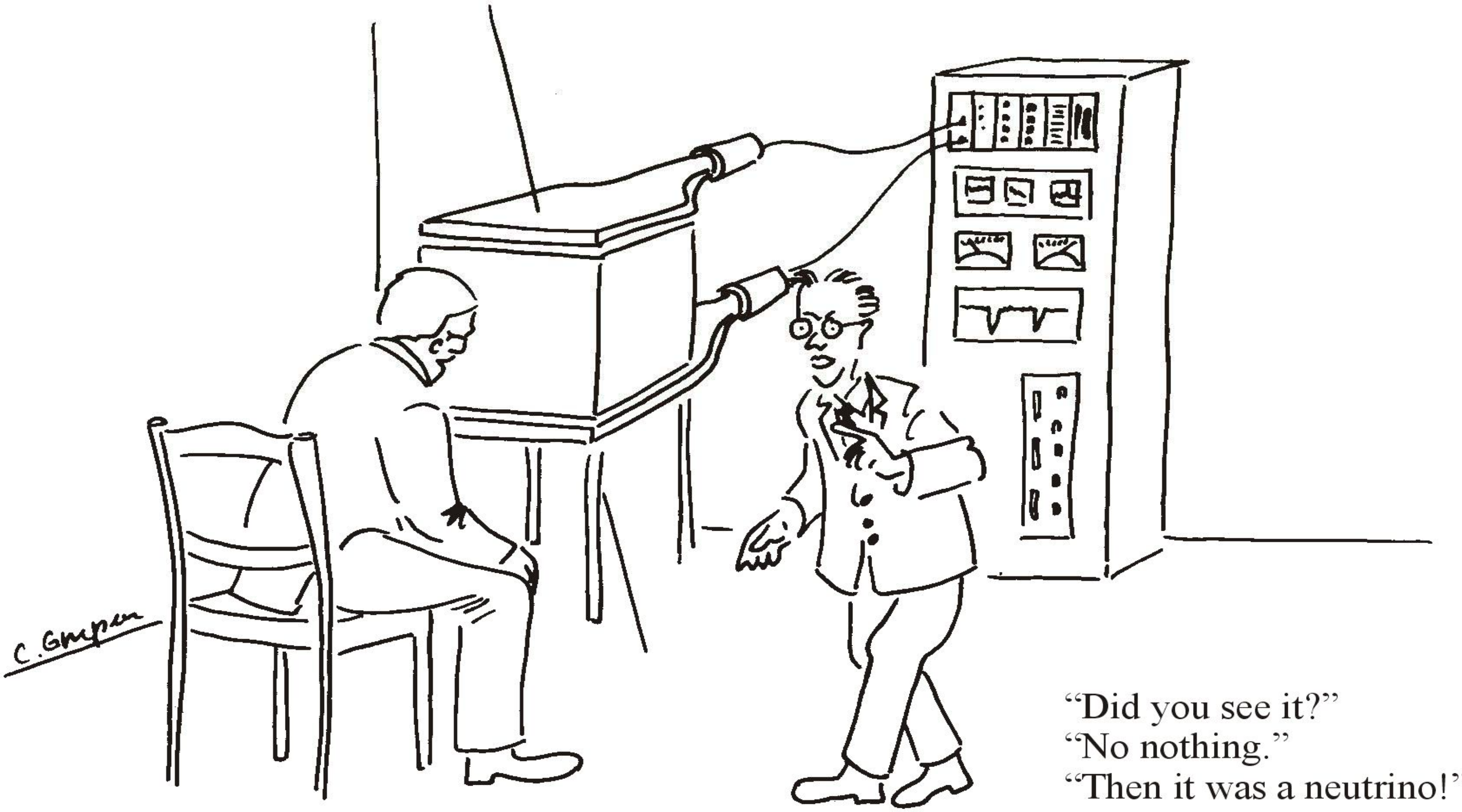
Az LHC segít megoldani ezeket a kihívó rejtélyeket

Az LHC két protonnyalábja másodpercenként 800 millió alkalommal fog ütközni



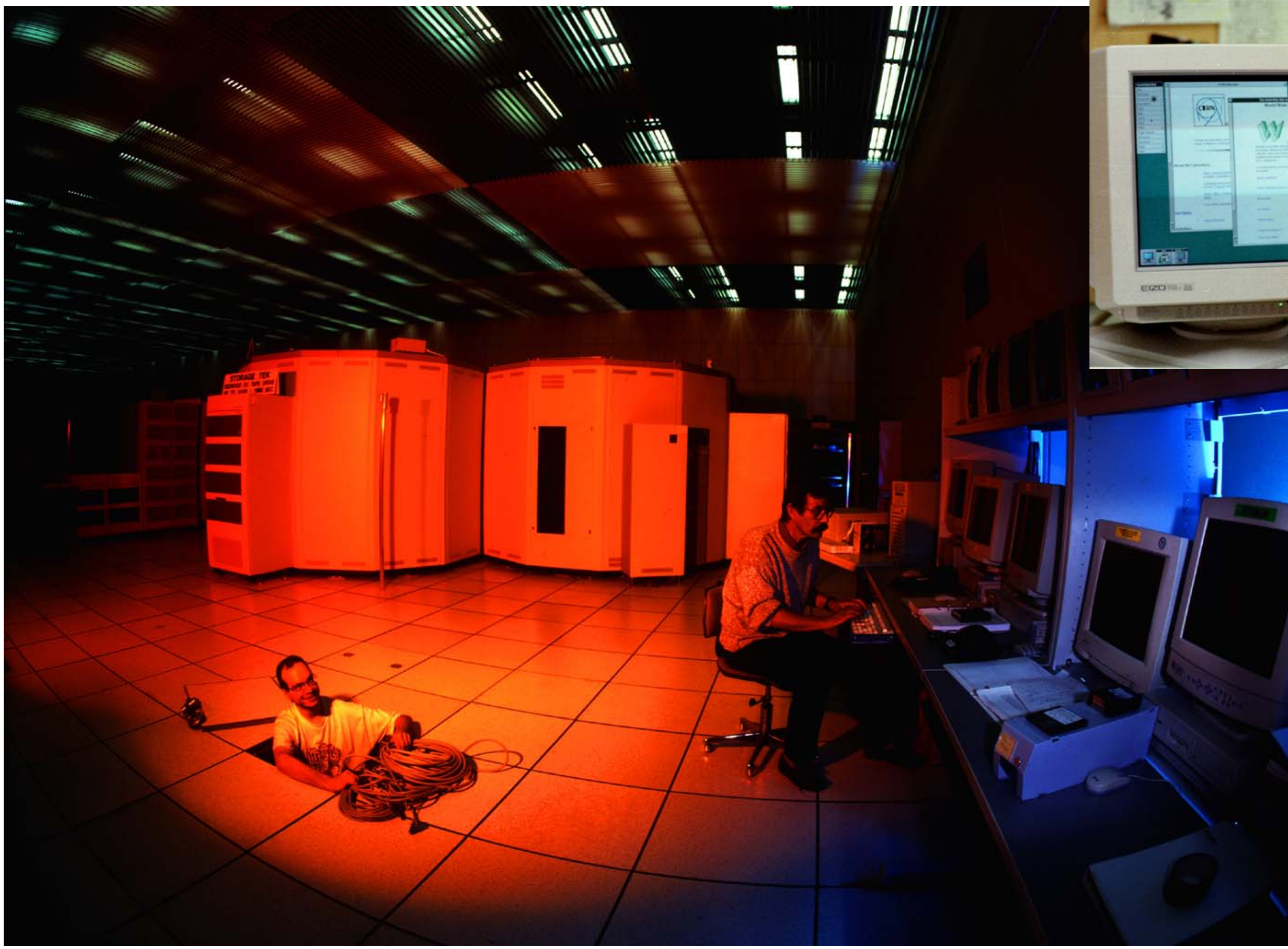
10,000,000,000,000 ütközésenként várunk 1 Higgs eseményt!

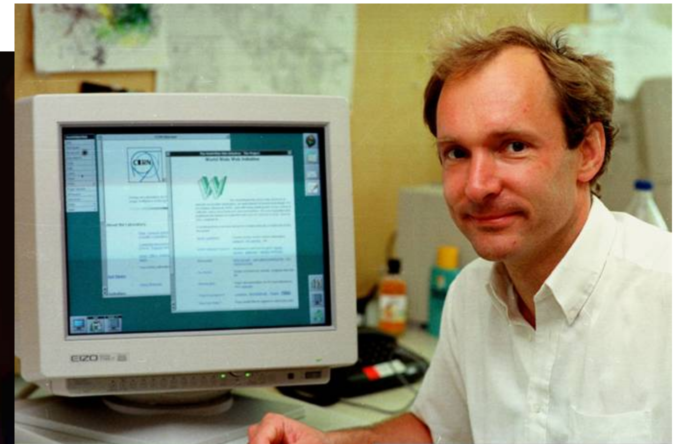
We can then start off

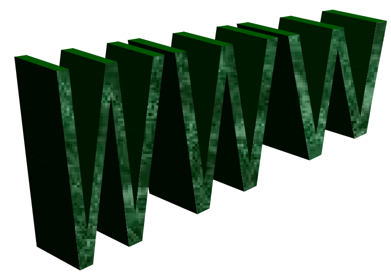


Claus Grupen, Particle Detectors, Cambridge University Press, Cambridge 1996 (455 pp. ISBN 0-521-55216-8)

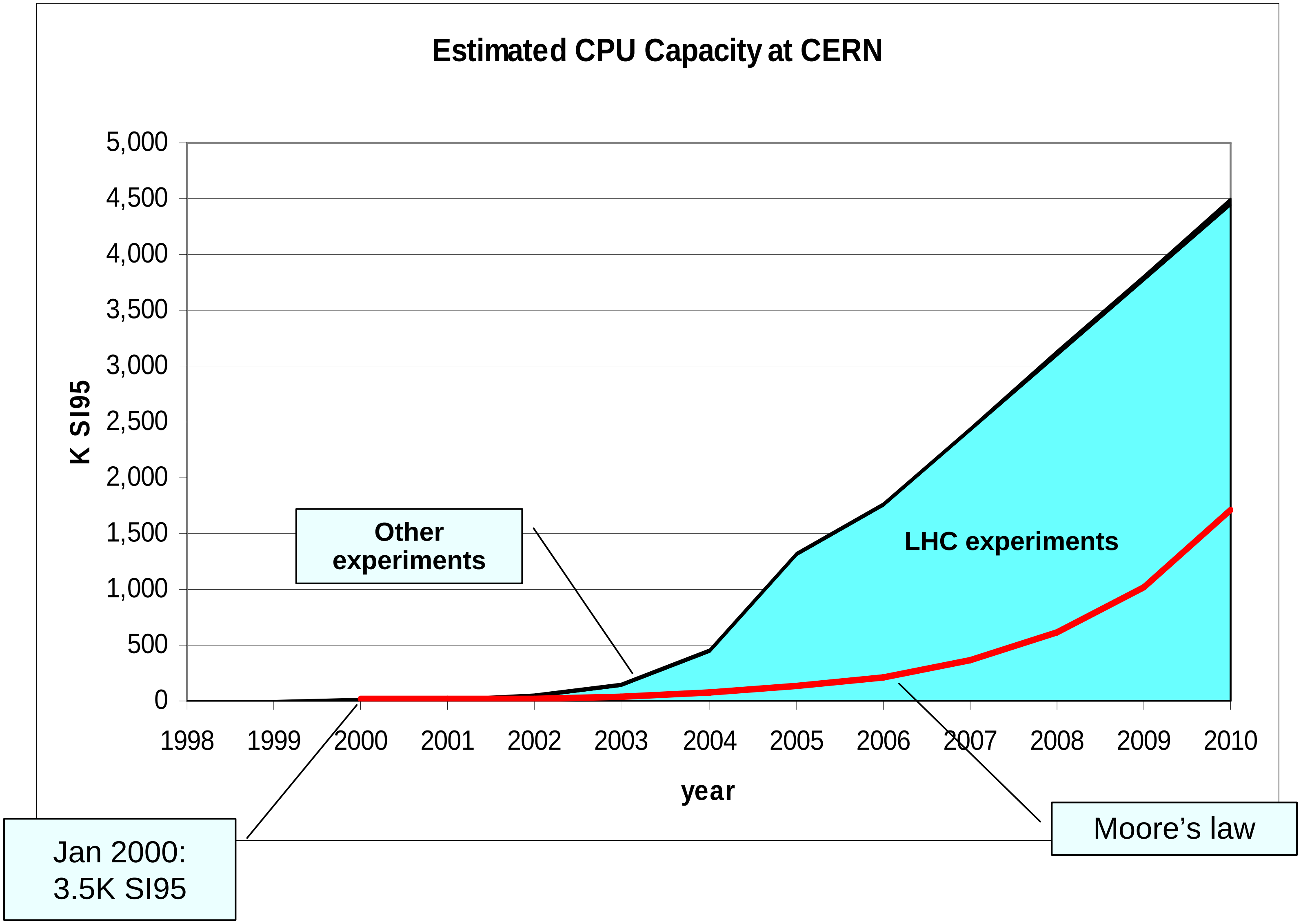
CERN, Internet és a WWW







CERN számítási igénye
Processzor kapacitás 1998-2010



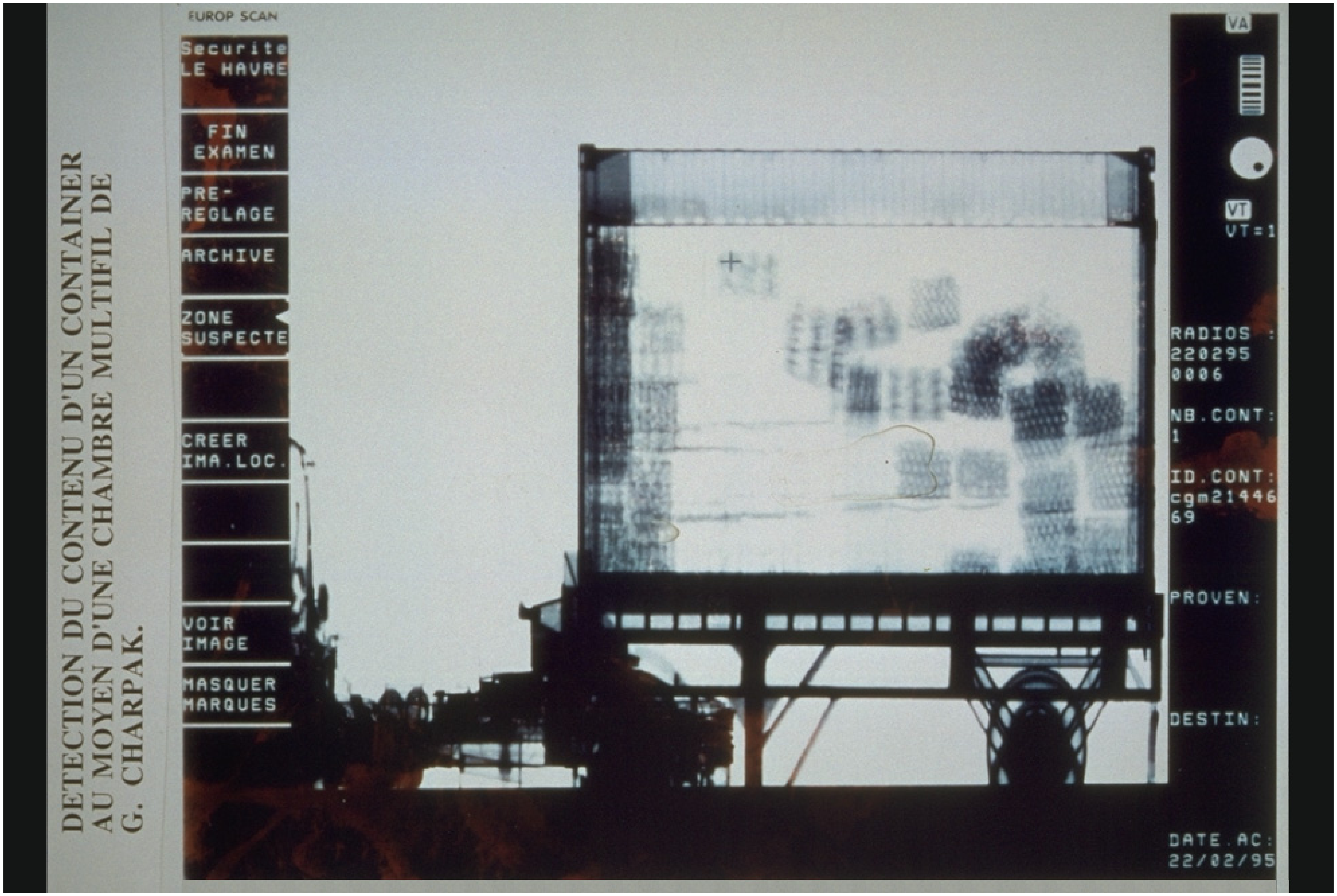
A GRID: egy lehetséges megoldás a számítási igény kielégítésére

Az LHC computing GRID az Európai Unió által támogatott projekt, melynek célja a jövő bonyolult számítási és elemzési feladatainak megoldásához szükséges számítástechnikai infrastruktúra kialakítása

Orvosi alkalmazások

Technológiai alkalmazások

Kormányzati alkalmazások



Évente közel 500 diák, akik hazaviszik az itt szerzett tudásukat

CERN as Model of OPEN Society

Minden kutatási eredmény PUBLIKUS

Mindent lehet fényképezni

Mindenhová be lehet menni, ha az az ott folyó munkát nem zavarja és nem káros az egészségre

Az LHC építés minden fázisa a web-en kamerával on-line és grafikonokon követhető

Nem a fejek MEGTÖMÉSE,

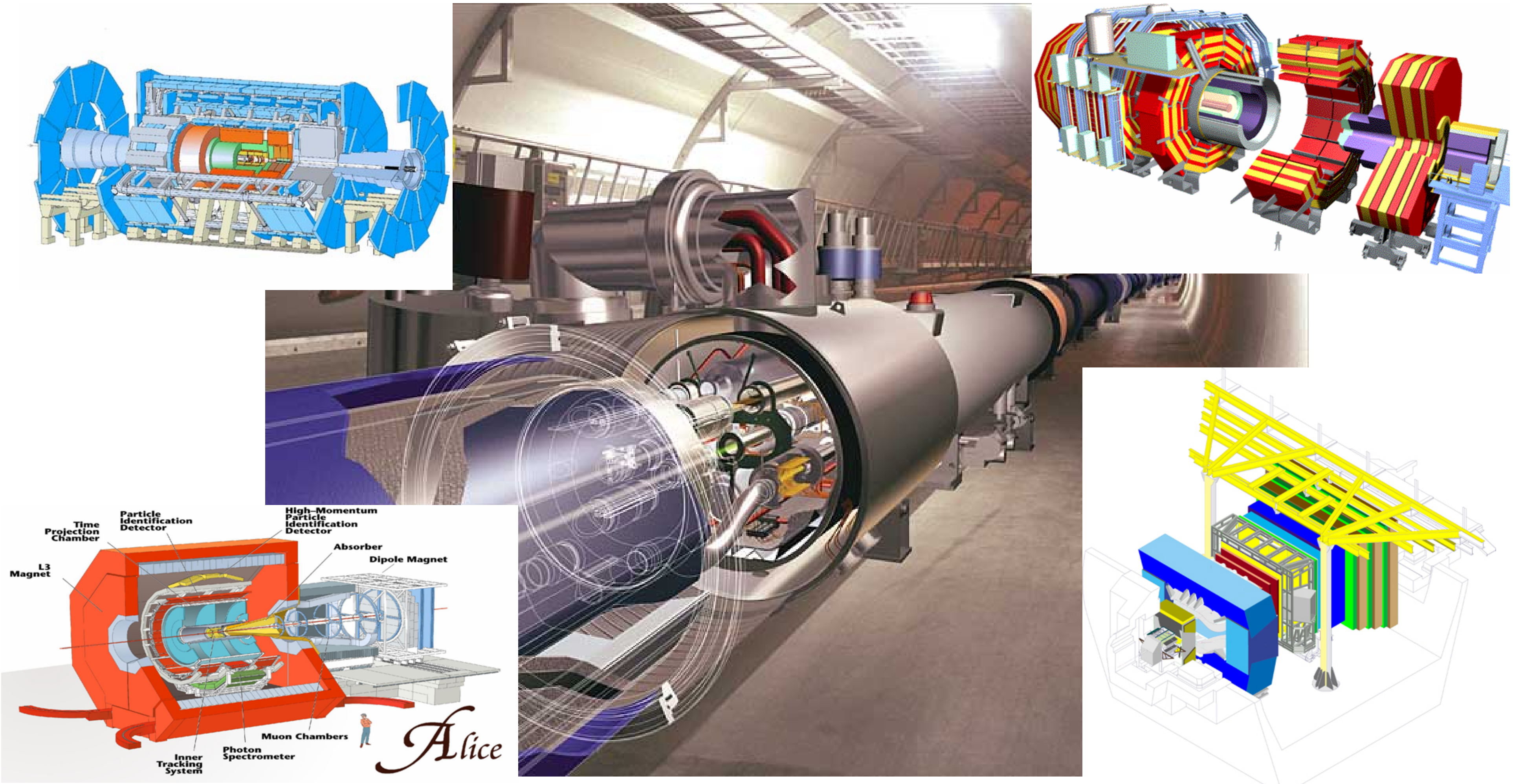
hanem

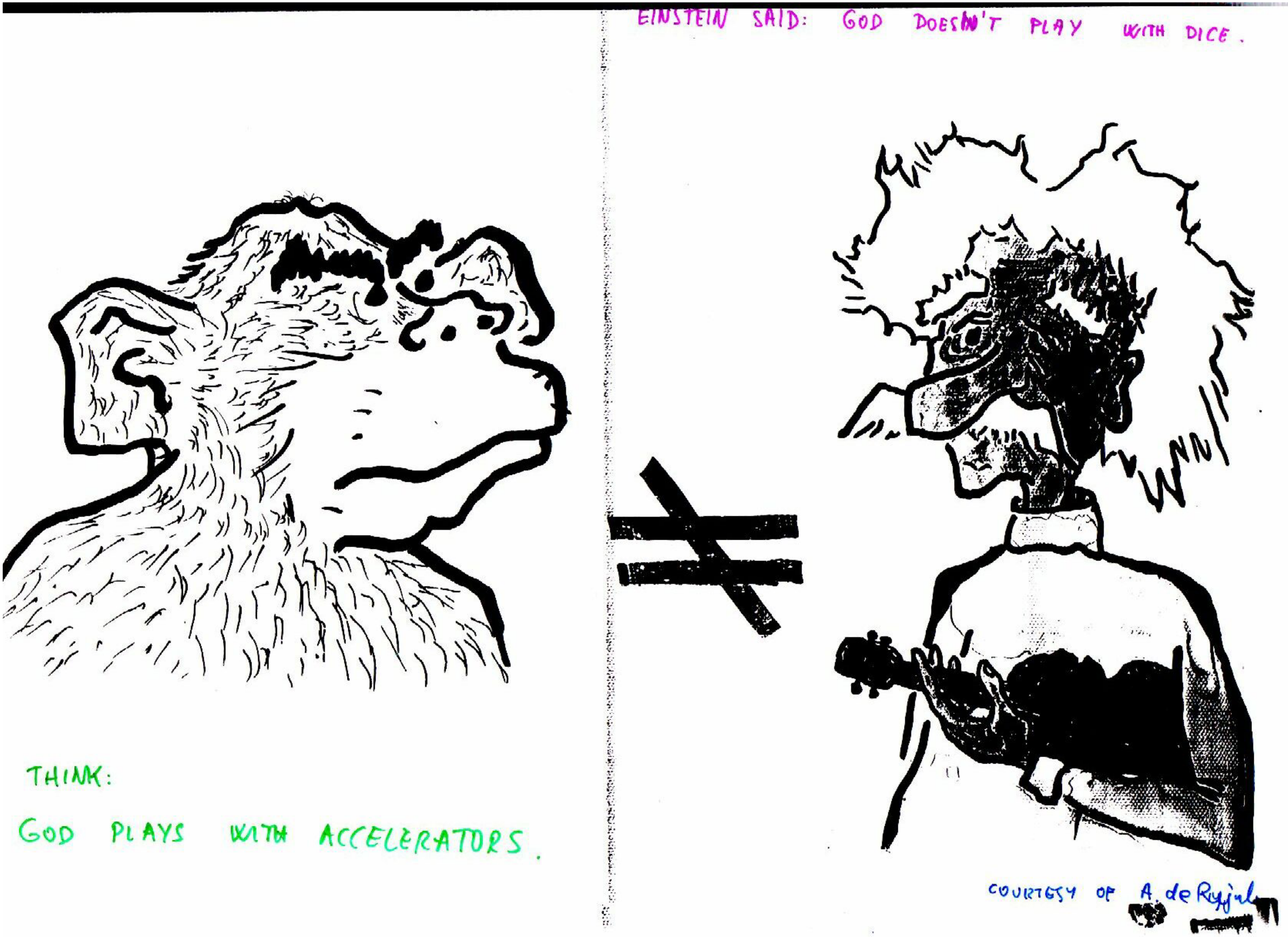
az ÜRES fejek lecserélése NYITOTT fejekre!!!!!!

(Diák - Tanársegéd - Professzor reláció)

Az LHC: így fog kinézni

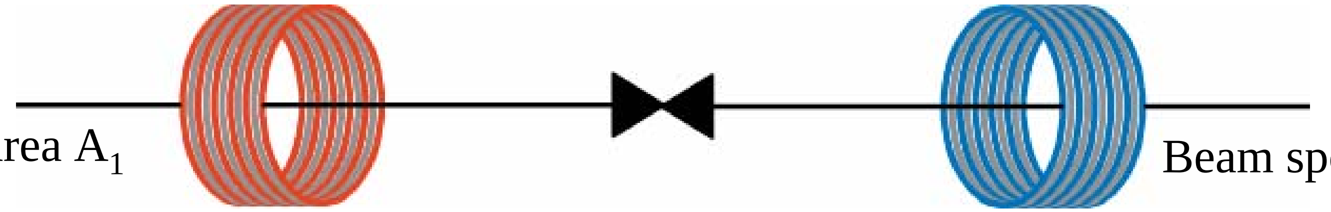
Az LHC 2007-ben kezdi meg működését és megváltoztathatja a világegyetemről alkotott képünket.




EINSTEIN SAID: GOD DOESN'T PLAY WITH DICE.
THINK:
GOD PLAYS WITH ACCELERATORS.
COURTESY OF A. de Rujula

END of welcome

Beam spot area A_1



Beam spot area A_2

$\Phi_1 = N_1/t$

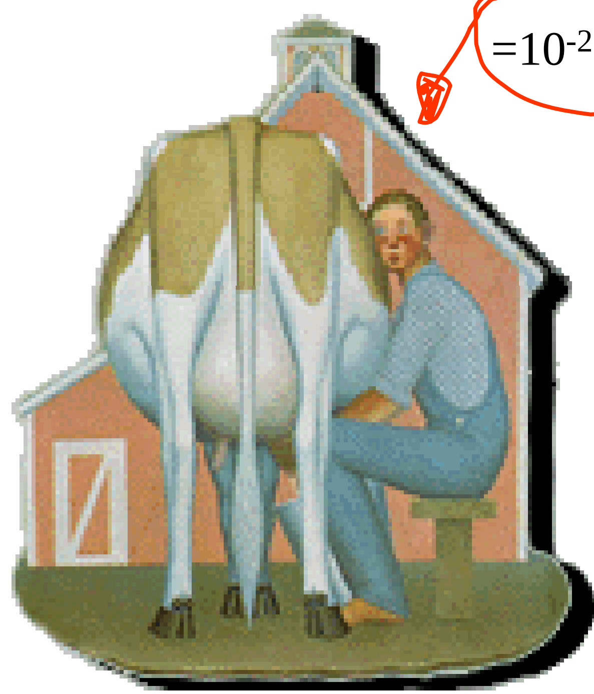
$\Phi_2 = N_2/t$

The interaction rate, R_{int}, is then given as:

$$R_{int} \propto \frac{N_1 N_2}{A \cdot t} = \sigma \mathcal{L}$$

σ has the dimension area.
1 barn = 10^{-24} cm^2

$= 10^{-28}$ m^2



Grant Wood, Fruits of Iowa: Boy Milking Cow, 1932

The luminosity, $\mathcal{L}$, is given in cm^{-2}s^{-1}

THE FIRST HUNGARIAN EXPERIMENT IN PARTICLE PHYSICS

R.v. Eötvös, D. Pekár, E. Fekete ANN. PHYS. 68 (1922) 11 !

BARION number dependence of the "fifth-force"

TABLE I. Summary of EPF results for $\Delta\kappa$, and page quoted from Ref. 6, along with the computed values of $\Delta(B/\mu)$. Ag-Fe-SO_4 refers to the reactants before and after the chemical reaction described by Eq. (7).

Materials compared	Page quoted	$10^8\Delta\kappa$	$10^3\Delta(B/\mu)$
Cu-Pt	37	$+0.4 \pm 0.2$	+0.94
Magnalium-Pt	34	-0.4 ± 0.1	+0.50
Ag-Fe-SO_4	39	0.0 ± 0.2	0.00
Asbestos-Cu	47	-0.3 ± 0.2	−0.74
$CuSo_4 \cdot 5H_2O$-Cu	44	-0.5 ± 0.2	−0.86
$CuSO_4$(solution)-Cu	45	-0.7 ± 0.2	−1.42
Water-Cu	42	-1.0 ± 0.2	−1.71
Snakewood-Pt	35	-0.1 ± 0.2	?
Tallow-Cu	48	-0.6 ± 0.2	?

Measured relative deviation: $\Delta a/g = \kappa_1 - \kappa_2 = \Delta\kappa$

Barion number and mass ratio difference: $\Delta(B/\mu) = \frac{B_1}{\mu_1} - \frac{B_2}{\mu_2}$

PHYSICAL REVIEW LETTERS

6 JANUARY 1986 !!

Reanalysis of the Eötvös Experiment

Ephraim Fischbach[a]

$$V(r) = -G_\infty \frac{m_1 m_2}{r}(1 + \alpha e^{-r/\lambda}) \quad (1)$$

$$= V_N(r) + \Delta V(r).$$

Here $V_N(r)$ is the usual Newtonian potential energy for two masses $m_{1,2}$ separated by a distance r, and G_∞ is the Newtonian constant of gravitation for $r \to \infty$. The geophysical data can then be accounted for quantitatively if α and λ have the values[2]

$$\alpha = -(7.2 \pm 3.6) \times 10^{-3}, \quad \lambda = 200 \pm 50 \text{ m}. \quad (2)$$

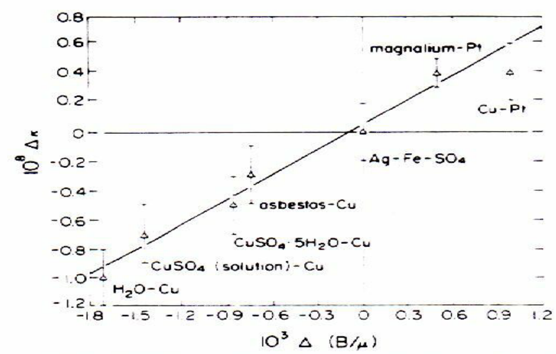


FIG. 1. Plot of $\Delta\kappa$ vs $\Delta(B/\mu)$ using the data in Table I. Ag-Fe-SO_4 refers to the reactants before and after the chemical reaction described by Eq. (7). The solid line represents the results of a least-squares fit to the data.

Other theoretical considerations also suggest that new effects may show up at short distances; string theories predict scalar particles (dilatons and moduli) that generate Yukawa interactions which could be seen in tests of the $1/r^2$ law. If supersymmetry is broken at low energies these scalar particles would produce mm-scale effects [11,14]. Finally, there may be some significance to the observation [12] that the gravitational cosmological constant, $\Lambda \approx 3\ \mathrm{keV/cm^3}$, deduced from distant Type 1A supernovae [15,16] corresponds to a length scale $\sqrt[4]{\hbar c/\Lambda} \approx 0.1$ mm. These, and other, considerations suggest that the Newtonian gravitational potential should be replaced by a more general expression [17]

$$V(r) = -G\frac{m_1 m_2}{r}(1 + \alpha e^{-r/\lambda}) \ . \qquad (2)$$

The simplest scenario with 2 large extra dimensions predicts $\lambda = R^*$ and $\alpha = 3$ or $\alpha = 4$ for compactification on an 2-sphere or 2-torus, respectively [17], while dilaton and moduli exchange could produce forces with α as large as 10^5 for Yukawa ranges $\lambda \sim 0.1$ mm [11].

This letter reports results of a test of gravitational inverse-square law at length scales well below 1 mm. Our instrument is shown in Fig. 1.

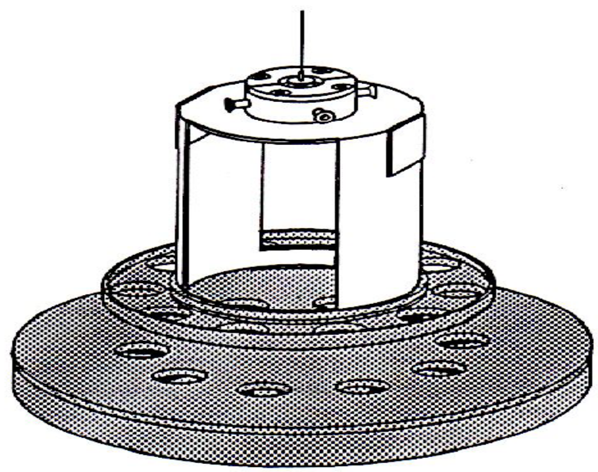


FIG. 1. Scale drawing of the torsion pendulum and rotating attractor. The active components are shaded. For clarity, we show an unrealistically large 1.5 cm vertical separation between pendulum and attractor, and omit the BeCu membrane and the attractor drive mechanism. The 4 horizontal screws were adjusted to make the pendulum precisely level.

Sci. Am. 1964 dec

Non-Cantorian Set Theory

In 1963 it was proved that a celebrated mathematical hypothesis put forward by Georg Cantor could not be proved. This profound development is explained by analogy with non-Euclidean geometry

by Paul J. Cohen and Reuben Hersh

The abstract theory of sets is currently in a state of change that in several ways is analogous to the 19th-century revolution in geometry. As in any revolution, political or scientific, it is difficult for those participating in the revolution or witnessing it to foretell its ultimate consequences, except perhaps that they will be profound. One thing that can be done is to try to use the past as a guide to the future. It is an unreliable guide, to be sure, but better than none.

We propose in this article to use the oft-told tale of non-Euclidean geometry to illuminate the now unfolding story of nonstandard set theory.

A set, of course, is one of the simplest and most primitive ideas in mathematics, so simple that today it is part of the kindergarten curriculum. No doubt for this very reason its role as the most fundamental concept of mathematics was not made explicit until the 1880's. Only then did Georg Cantor make the first nontrivial discovery in the theory of sets.

To describe his discovery we must first explain what we mean by an infinite set. An infinite set is merely a set with an infinite number of distinct elements; for example, the set of all "natural" numbers (1, 2, 3 and so on) is infinite. So too is the set of all the points on a given line segment.

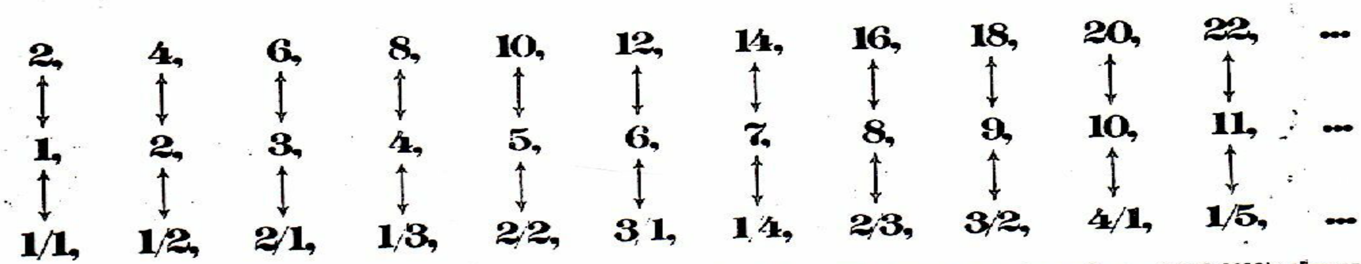
Cantor pointed out that even for infinite sets it makes sense to talk about the number of elements in the set, or at least to state that two different sets have the same number of elements. Just as with finite sets, we can say that two sets have the same number of elements—the same "cardinality"—if we can match up the elements in the two sets one for one. If this can be done, we call the two sets equivalent.

The set of all natural numbers can be matched up with the set of all even numbers, and also with the set of all fractions [*see illustration below*]. These two examples illustrate a paradoxical property of infinite sets: an infinite set can be equivalent to one of its subsets. In fact, it is easily proved that a set is infinite if, and only if, it is equivalent to some proper subset of itself.

All of this is engaging, but it was not new with Cantor. The notion of the cardinality of infinite sets would be interesting only if it could be shown that not all infinite sets have the same cardinality. It was this that was Cantor's first great discovery in set theory. By his famous diagonal proof he showed that the set of natural numbers is *not* equivalent to the set of points on a line segment [*see illustration on opposite page*].

Thus there are at least two different kinds of infinity. The first, the infinity of the natural numbers (and of any equivalent infinite sets), is called aleph nought ($\aleph_0$). Sets with cardinality $\aleph_0$ are called countable. The second kind of infinity is the one represented by a line segment. Its cardinality is designated by a lowercase German *c* ($\mathfrak{c}$), for "continuum." Any line segment, of arbitrary length, has cardinality $\mathfrak{c}$ [*see illustration on page 106*]. So does any rectangle in the plane, any cube in space, or for that matter all of unbounded *n*-dimensional space, whether *n* is 1, 2, 3 or 1,000!

Once a single step up the chain of infinities has been taken, the next follows naturally. We encounter the notion of the set of all subsets of a given set [*see illustration on page 111*]. If the



SET IS TERMED COUNTABLE if it can be matched one for one with the natural numbers (*middle row*). Thus the set of all even numbers (*top row*) is countable. The set of all fractions (*bottom row*) is also countable. The fractions shown here are the ones used by the German mathematician Georg Cantor (1845–1918); they are not in their natural order but in order according to the sum of the numerator and the denominator. Both examples show that an infinite set, unlike a finite set, can be equivalent to one of its subsets.