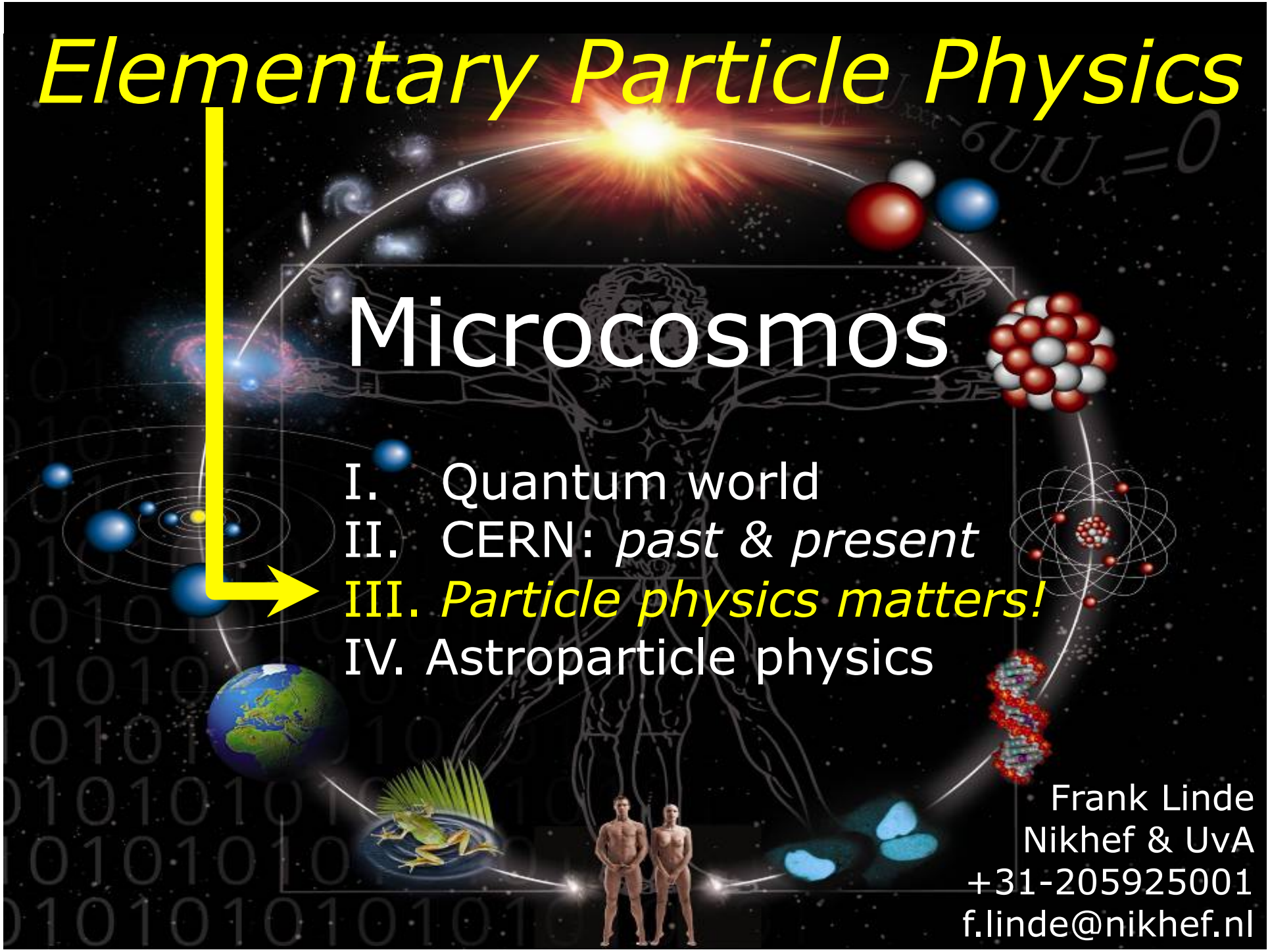
Elementary Particle Physics



Microcosmos

I. Quantum world
II. CERN: *past & present*
III. *Particle physics matters!*
IV. Astroparticle physics

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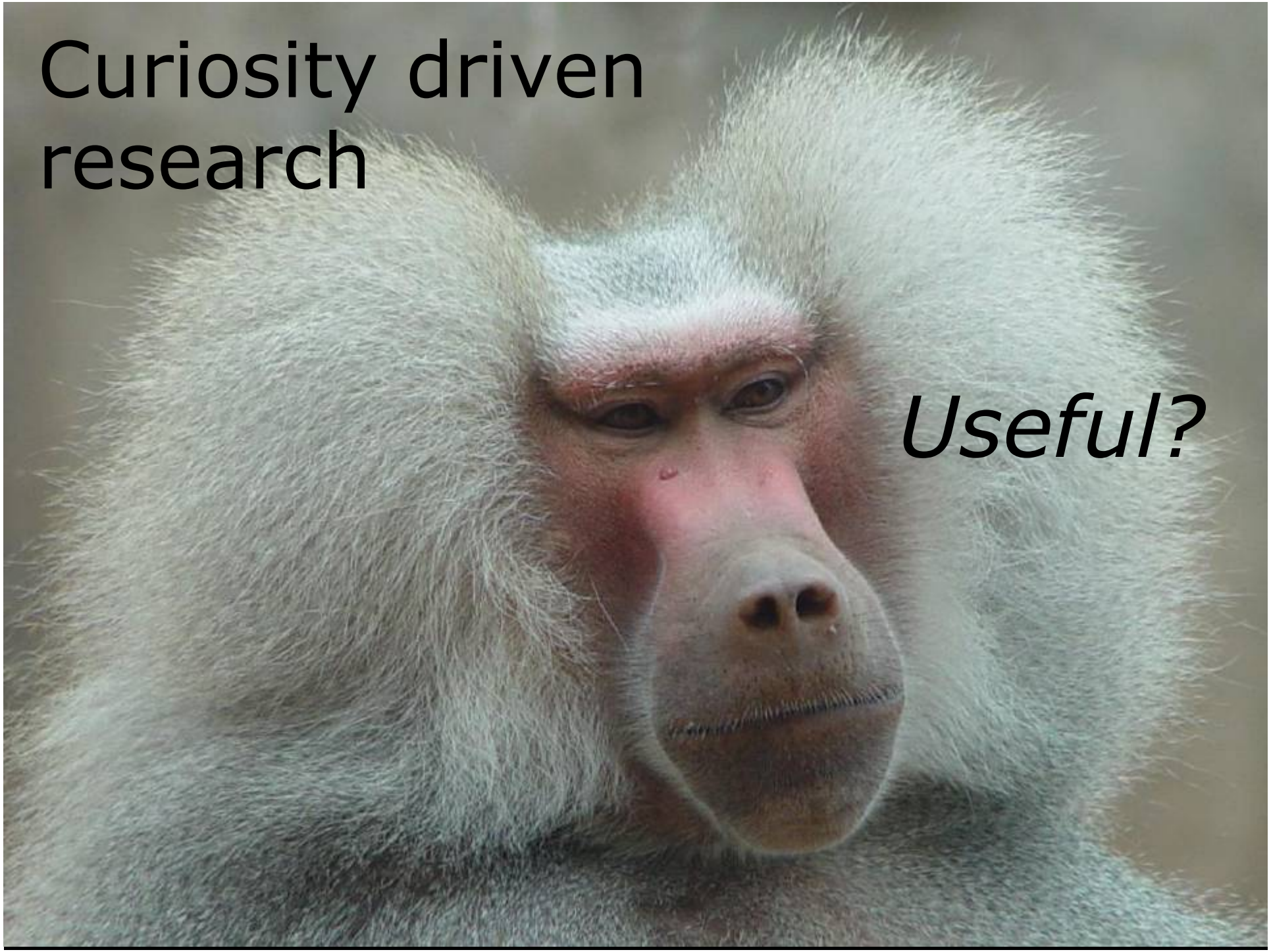
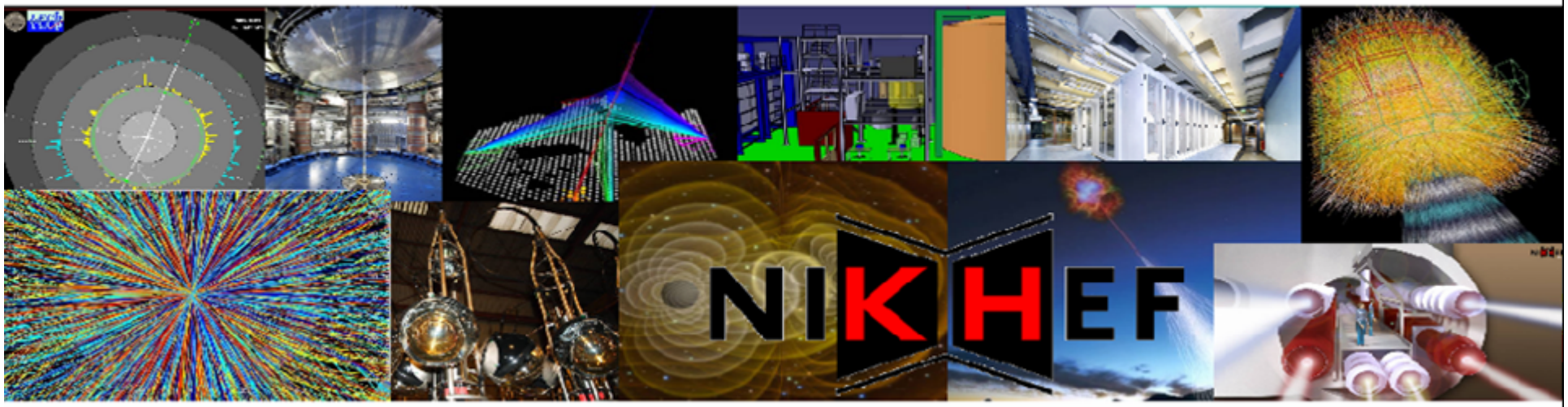

Curiosity driven research
Useful?

Nikhef Blog

Blogging at lightspeed

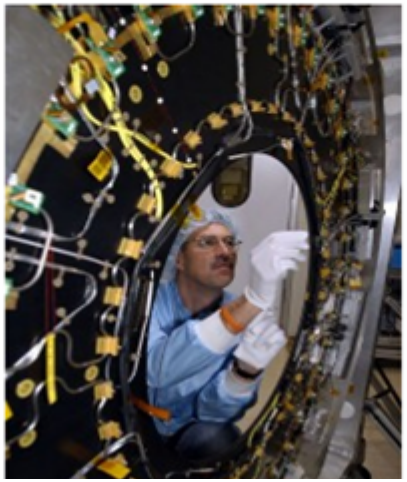


Home About Nikhef

The most frequently asked question

Posted on 15 December 2011 by melissa

By: Frank Linde, director Nikhef



A guaranteed question after all (ok, almost all) of my public lectures is: "What is the societal impact of …?" In Tuesday night's Dutch talkshow "Pauw & Witteman" Jolande Sap (member of Dutch parliament) asked Robbert Dijkgraaf (chairman of the KNAW, the Royal Netherlands Academy of Arts and Sciences) exactly this question. I already saw it on Jolande's face while Robbert was giving his excellent explanation

ARCHIVES

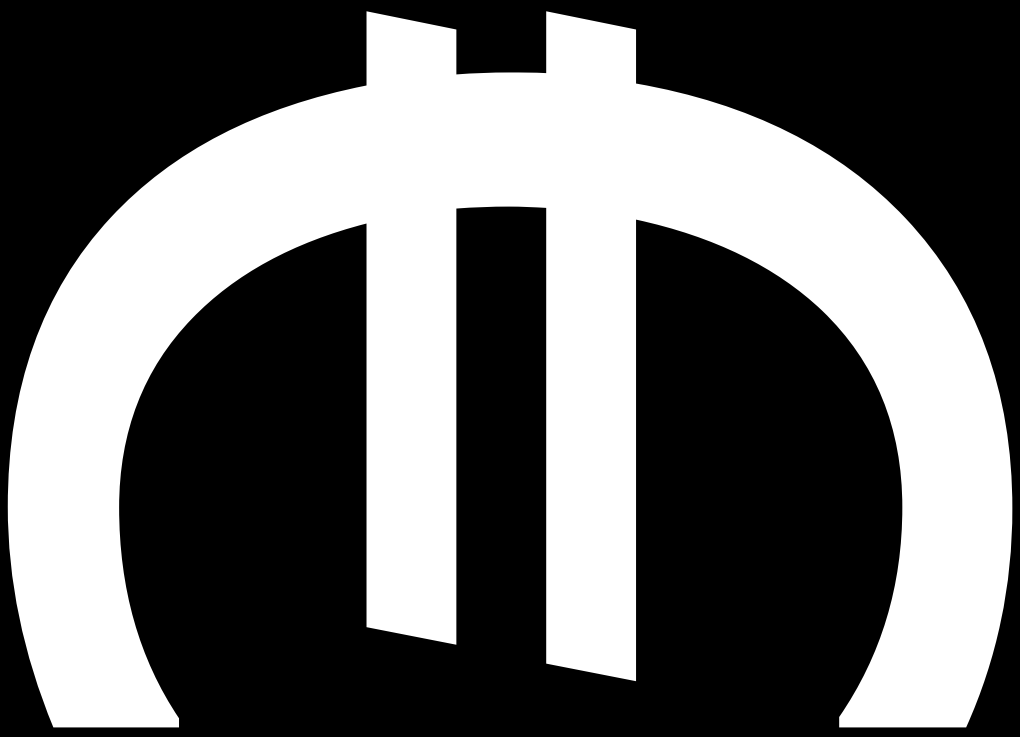
December 2011
November 2011
October 2011

META

Log in

Particle physics

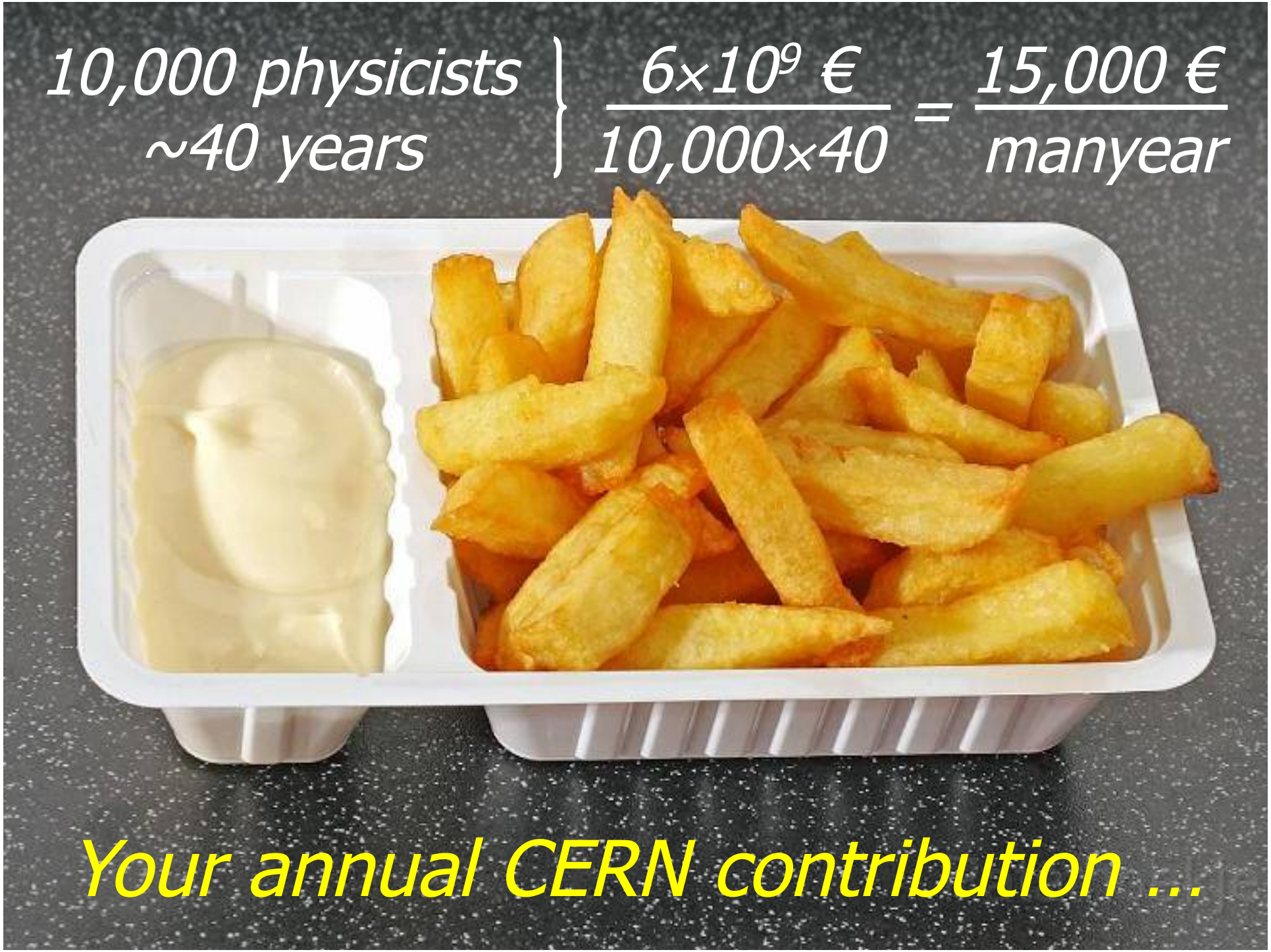
expensive?

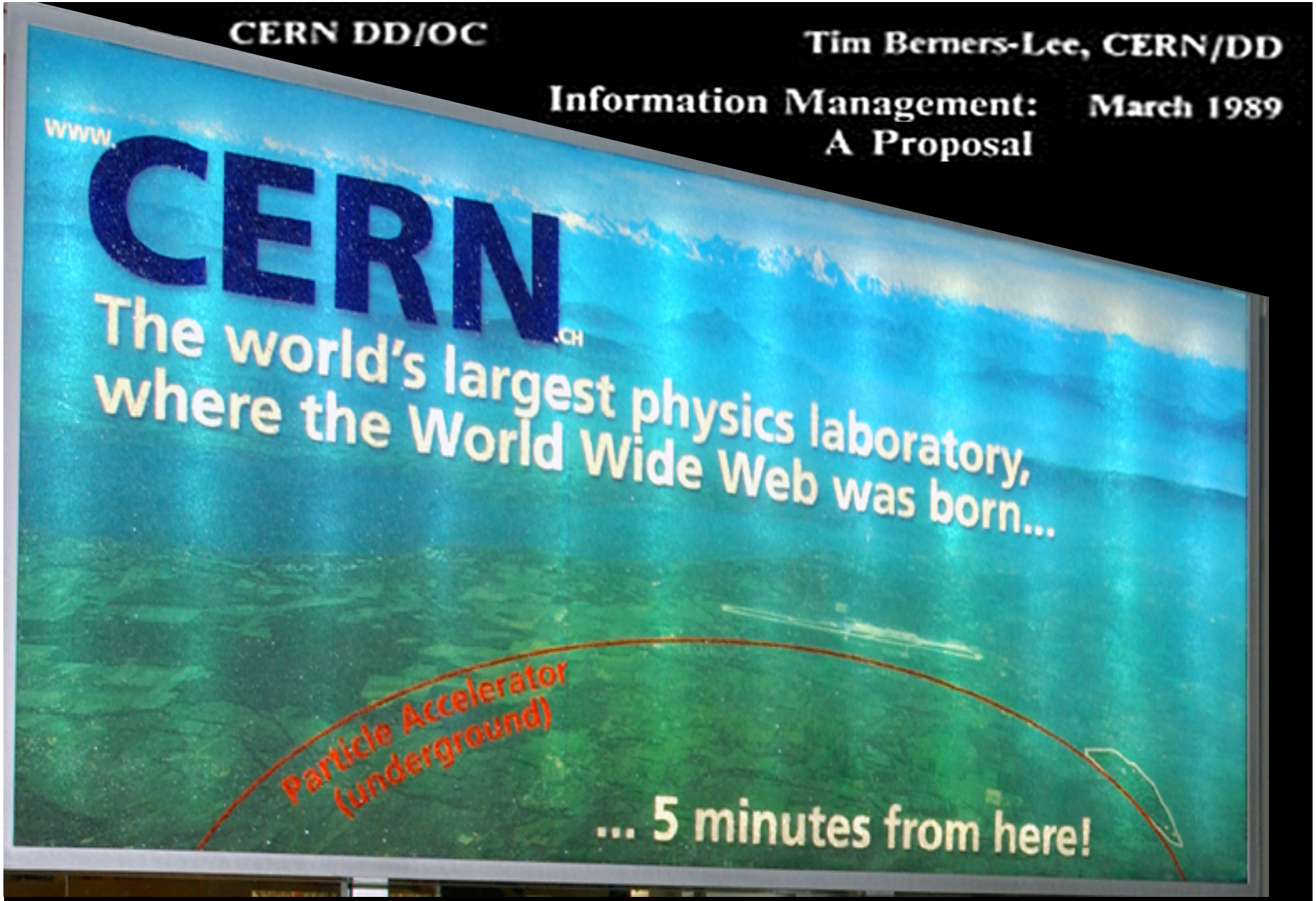


How much does it cost?

The cost for the machine alone is about 5 billion CHF (about 3 billion Euro). The total project cost breaks down roughly as follows:

Construction costs (MCHF)	Personnel	Materials	Total
LHC machine and areas*)	1224	3756	**4980**
CERN share to detectors	869	493	**1362**
LHC computing (CERN share)	85	83	**168**
Total	**2178**	**4332**	**6510**


10,000 physicists
~40 years
6×10^9 €
10,000×40
=
15,000 €
manyear
Your annual CERN contribution …



Few % of your internet subscription

Particle physics *matters*

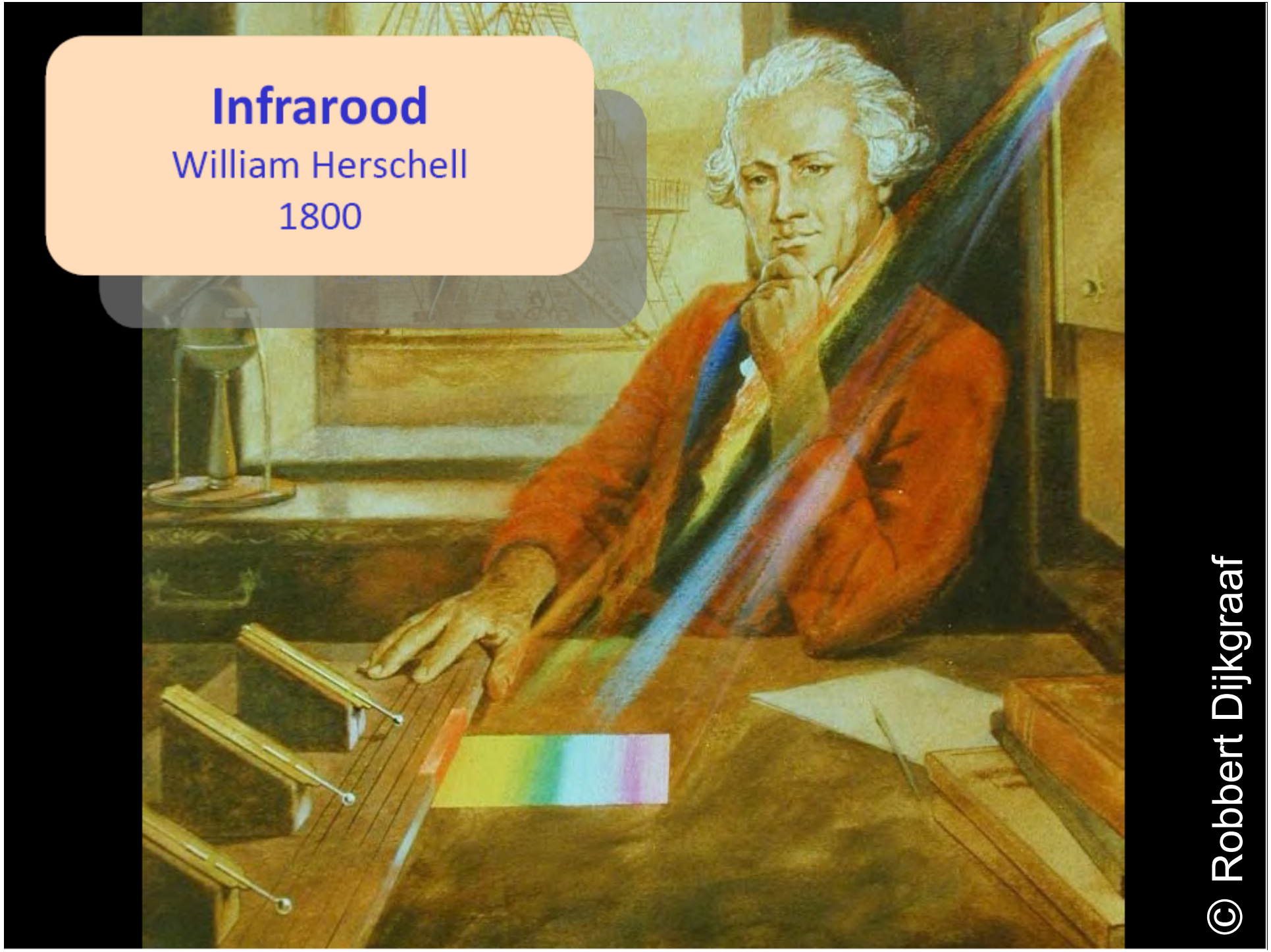
THE USEFULNESS OF USELESS KNOWLEDGE

BY ABRAHAM FLEXNER

Is it not a curious fact that in a world steeped in irrational hatreds which threaten civilization itself, men and women—old and young—detach themselves wholly or partly from the angry current of daily life to devote themselves to the cultivation of beauty, to the extension of knowledge, to the cure of disease, to the amelioration of suffering, just as though fanatics were not simultaneously engaged in spreading pain, ugliness, and suffering? The world has always been a sorry and confused sort of place—yet poets and artists and scientists have ignored the factors that would, if attended to, paralyze them. From a practical point of view, intellectual and spiritual life is, on the surface, a useless form of activity, in which men indulge because they procure for themselves greater satisfactions than are otherwise obtainable. In this paper I shall concern myself with the question of the extent to which the pursuit of these useless satisfactions proves unexpectedly the source from which undreamed-of utility is derived.

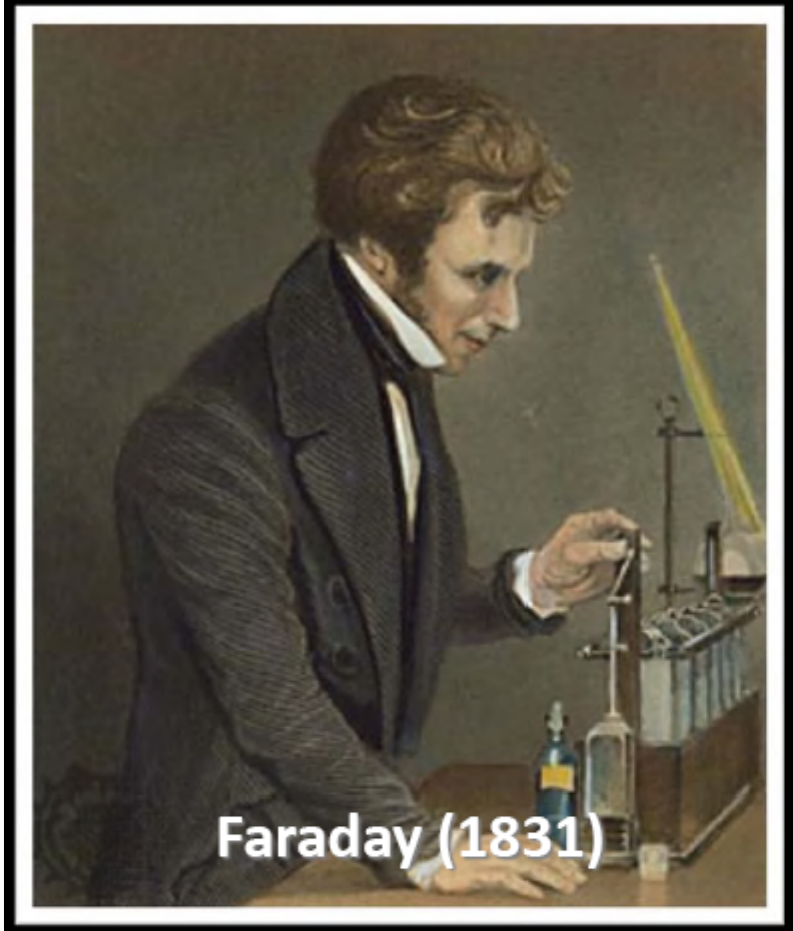
mental problems. I have no quarrel with this tendency. The world in which we live is the only world about which our senses can testify. Unless it is made a better world, a fairer world, millions will continue to go to their graves silent, saddened, and embittered. I have myself spent many years pleading that our schools should become more acutely aware of the world in which their pupils and students are destined to pass their lives. Now I sometimes wonder whether that current has not become too strong and whether there would be sufficient opportunity for a full life if the world were emptied of some of the useless things that give it spiritual significance; in other words, whether our conception of what is useful may not have become too narrow to be adequate to the roaming and capricious possibilities of the human spirit.

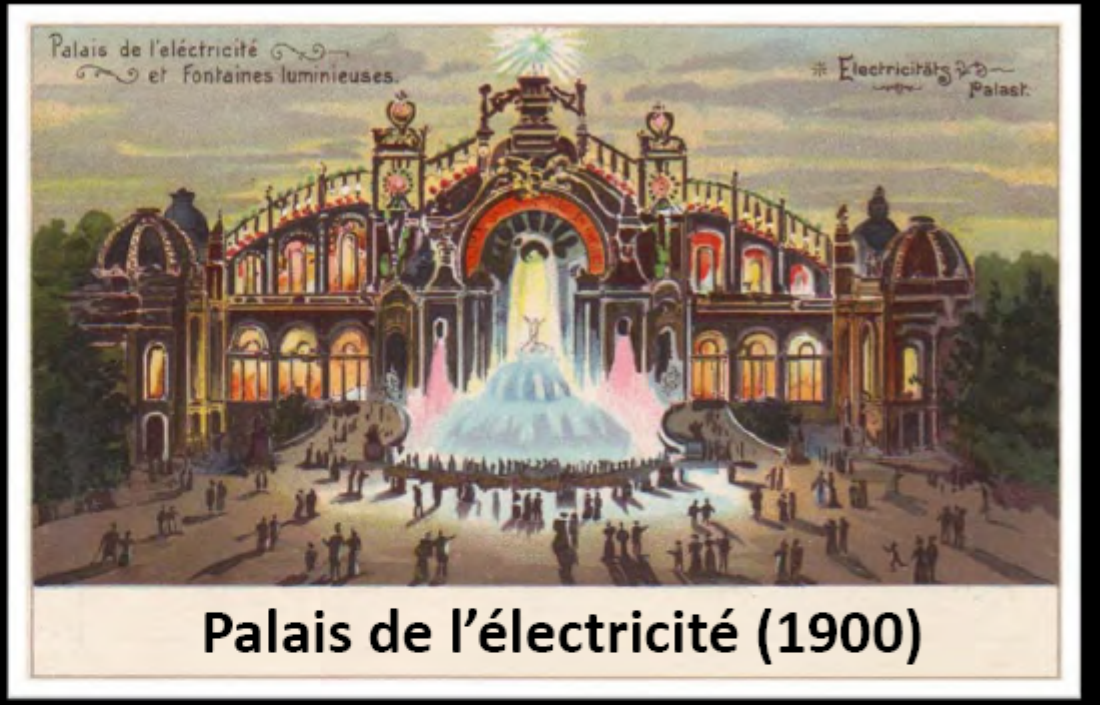
We may look at this question from two points of view: the scientific and the humanistic or spiritual. Let us take the scientific first. I recall a conversation


Infrarood
William Herschell
1800
© Robbert Dijkgraaf

Infrared
100% of our life

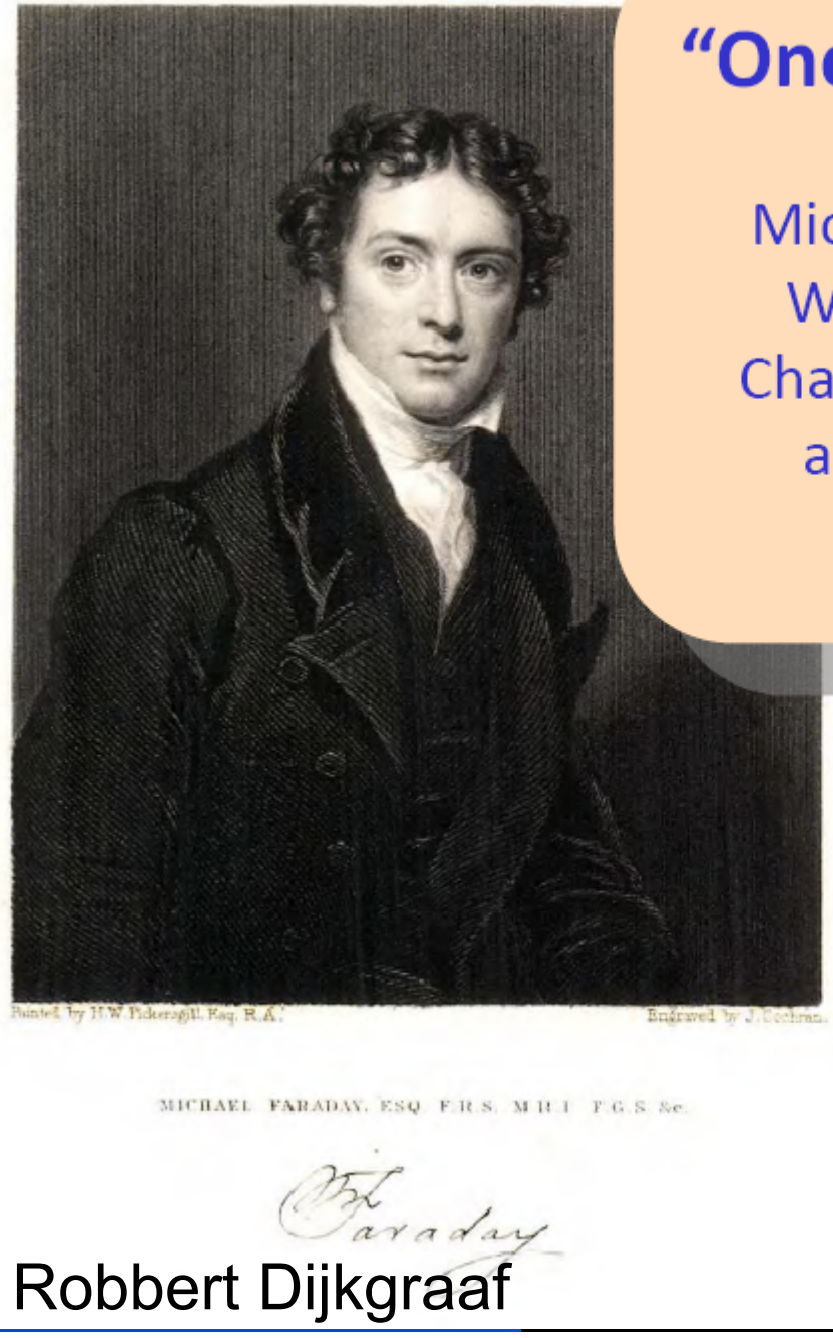
© Robbert Dijkgraaf





Electricity
100% of industry

© Robbert Dijkgraaf



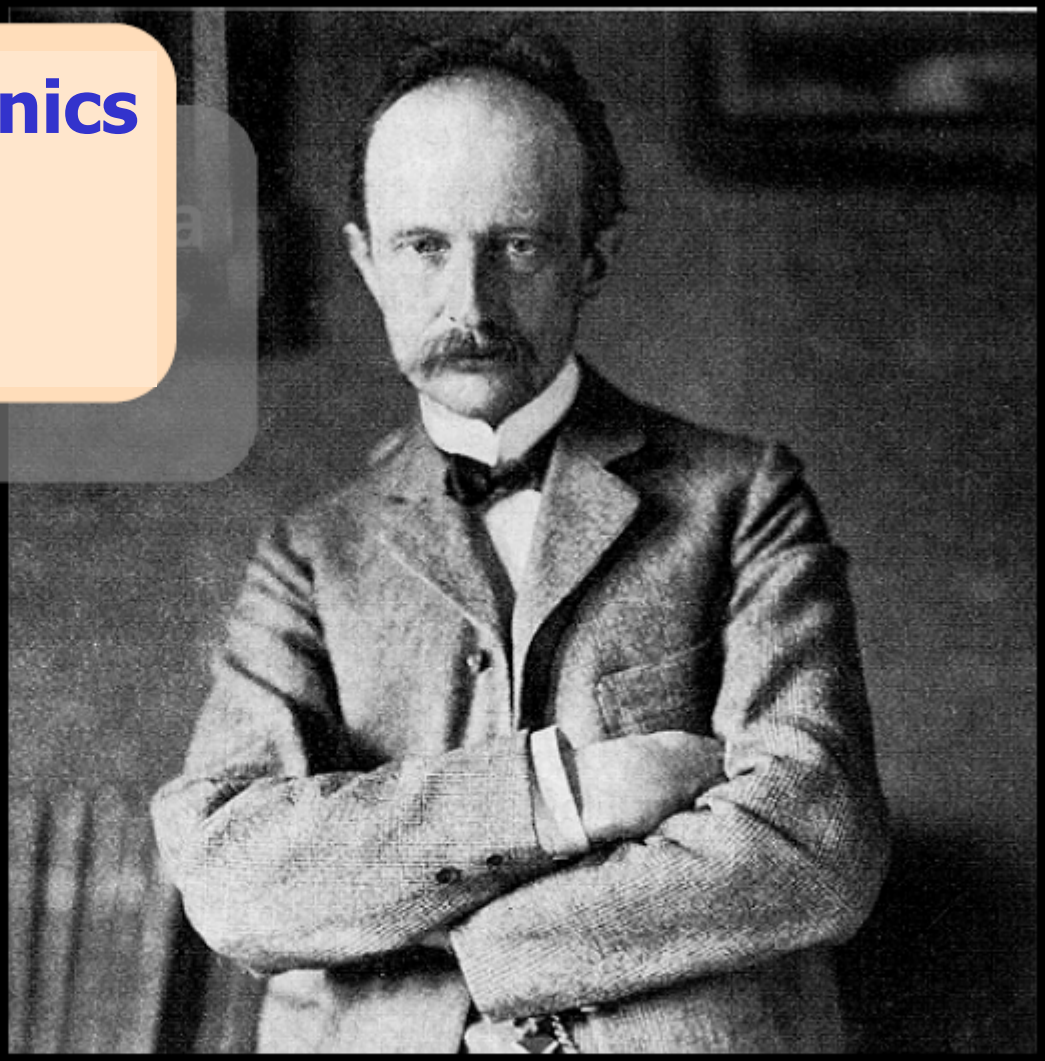
"One day sir, you may tax it."

Michael Faraday's alleged reply to William Gladstone, then British Chancellor of the Exchequer, when asked of the practical value of electricity (1850).

© Robbert Dijkgraaf

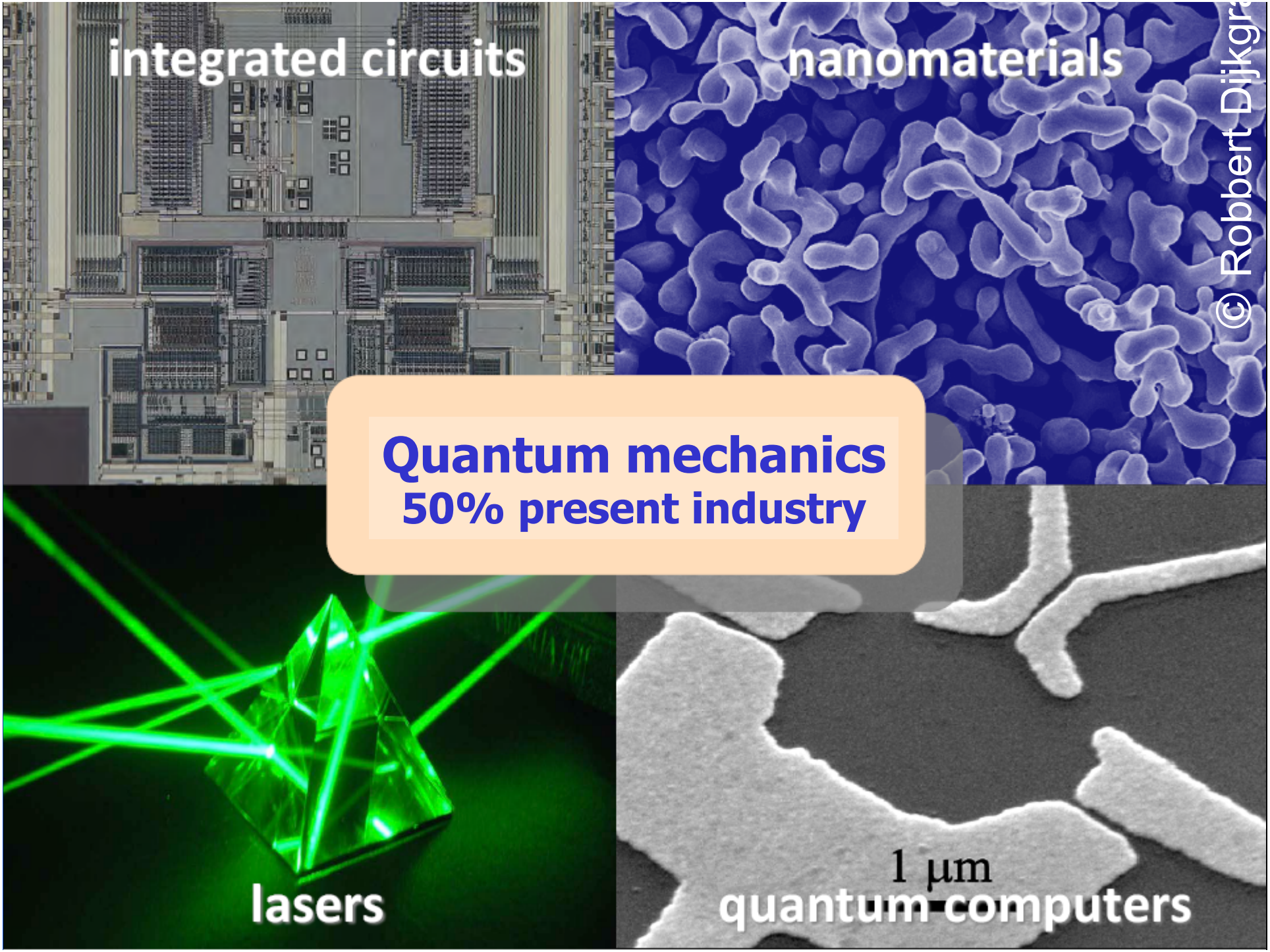
Quantum mechanics

Max Planck
1900



"ein Akt der Verzweiflung … ich war zu jedem Opfer an meinen bisherigen physikalischen Überzeugungen bereit"

© Robbert Dijkgraaf


integrated circuits
nanomaterials
© Robbert Dijkgra
Quantum mechanics
50% present industry
lasers
1 µm
quantum computers

Superconductivity

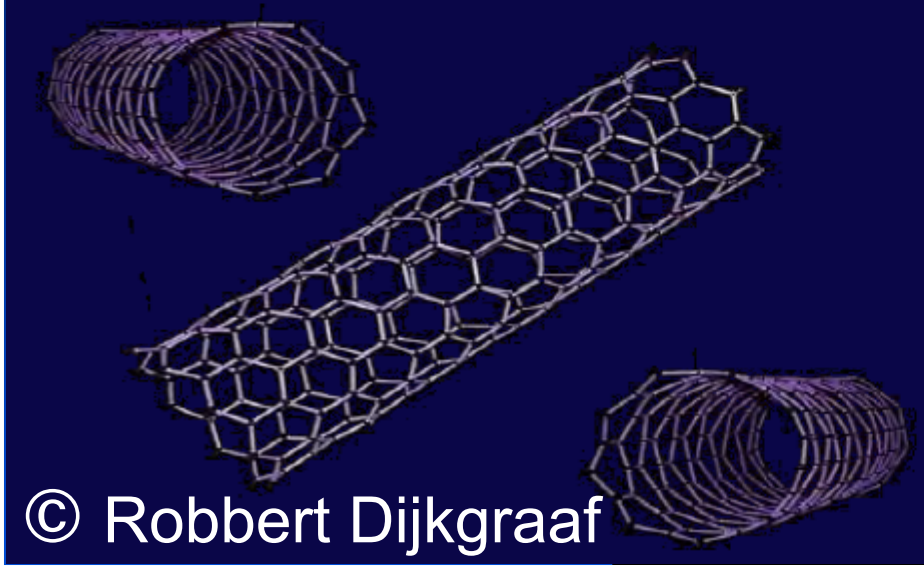
Heike Kamerlingh Onnes
1911

© Robbert Dijkgra

maglev

fmri scanners

nanotubes



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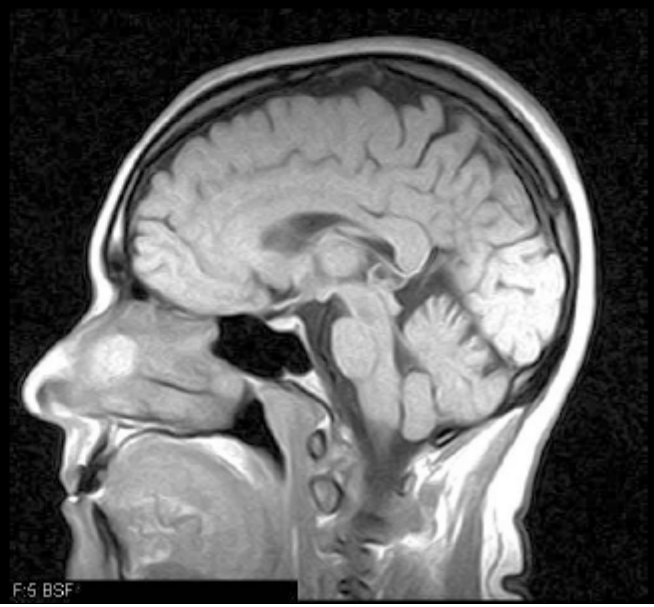
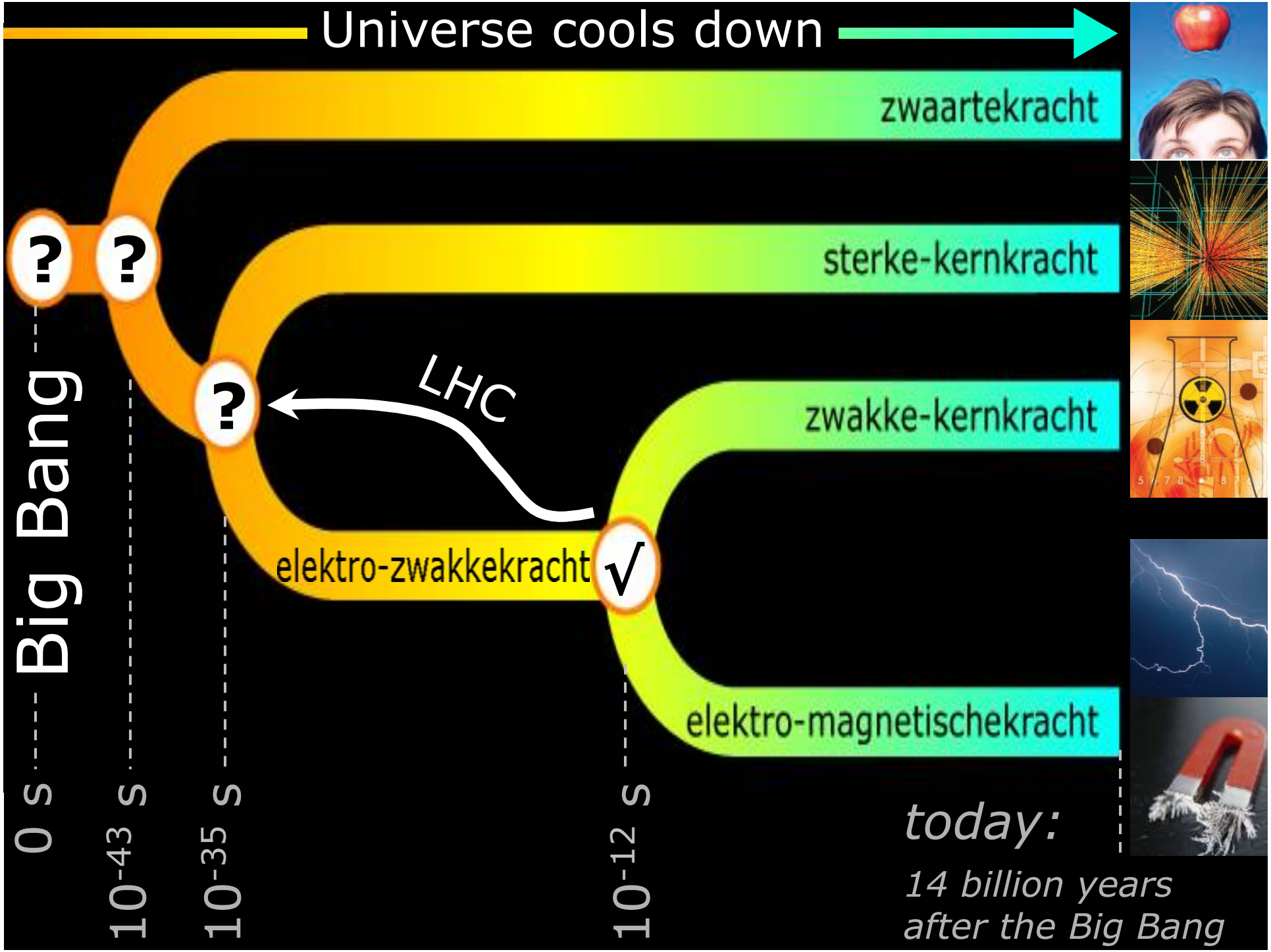
brain science



electronics

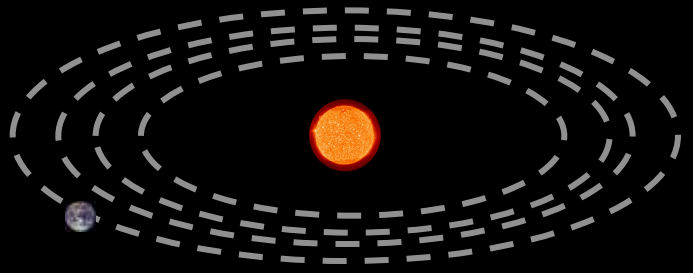
ELECTRON
e–
The ELECTRON is a fundamental subatomic particle carrying a negative charge. Its mass is 1/1000 that of the smallest atom. It participates in electromagnetic interactions, and is typically found orbiting the nucleus of an atom.
Fleece with poly fill for minimum mass.
$9.75 PLUS SHIPPING
MADE IN CHINA.
AGE 3 AND UP.
BACK
LIGHT
HEAVY
electron
e–
GLUON PHOTON NEUTRINO TACHYON ELECTRON UP QUARK DOWN QUARK TAU NEUTRINO MUON UP QUARK PROTON NEUTRON DOWN QUARK TAU GLUON ELECTRON NEUTRINO TACHYON ELECTRON UP QUARK DOWN QUARK TAU NEUTRINO MUON UP QUARK PROTON NEUTRON DOWN QUARK TAU GLUON PHOT


Universe cools down
zwaartekracht
sterke-kernkracht
zwakke-kernkracht
elektro-magnetischekracht
elektro-zwakkekracht
?
?
?
LHC
√
Big Bang
0 s
10-43 s
10-35 s
10-12 s
today:
14 billion years
after the Big Bang

Fundamental forces

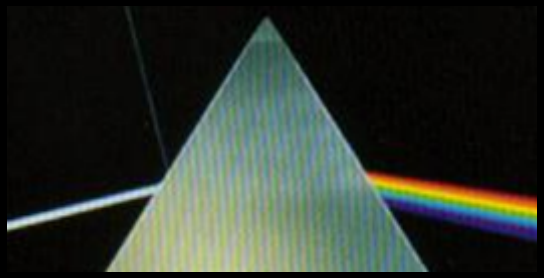
Gravity:

Newton *(1666)*



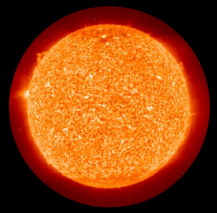
Electro-Magnetic:

Maxwell e.a. *(1873)*



Weak nuclear:

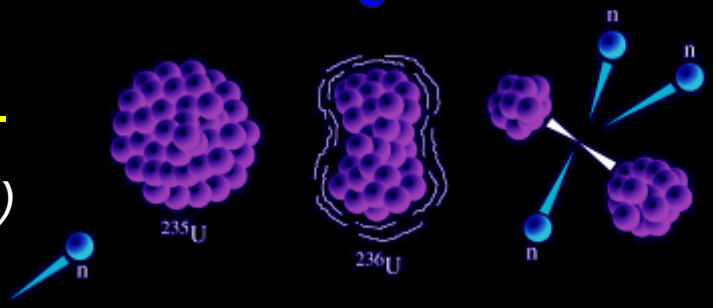
Fermi e.a. *(1934)*



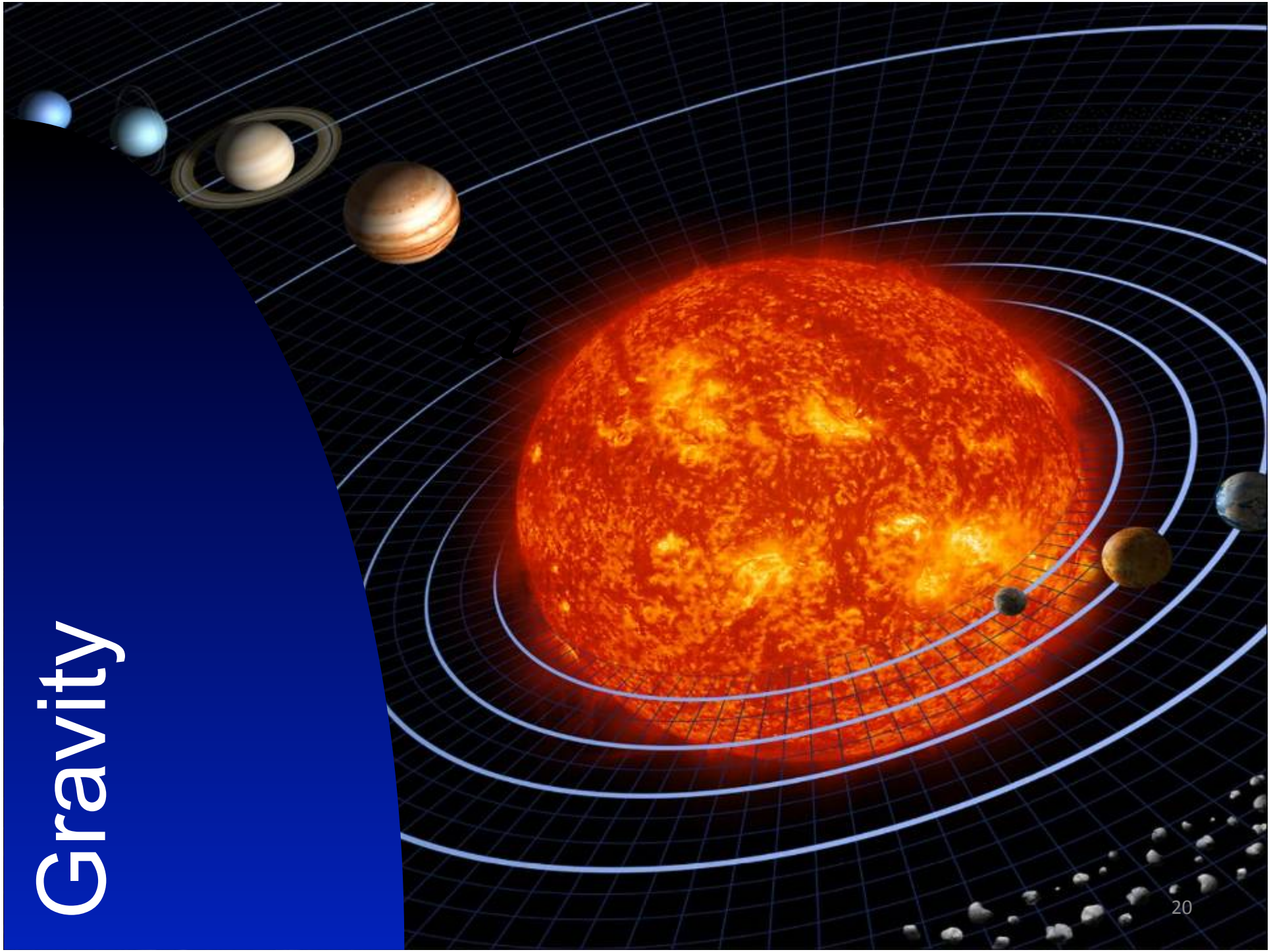
$$4p \rightarrow {}^{4}He + 2e^{+} + 2\nu_e + energie$$

Strong nuclear:

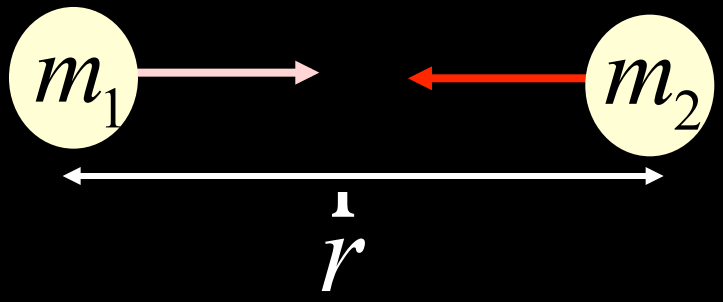
Yukawa e.a. *(1935)*



Gravity



Gravity

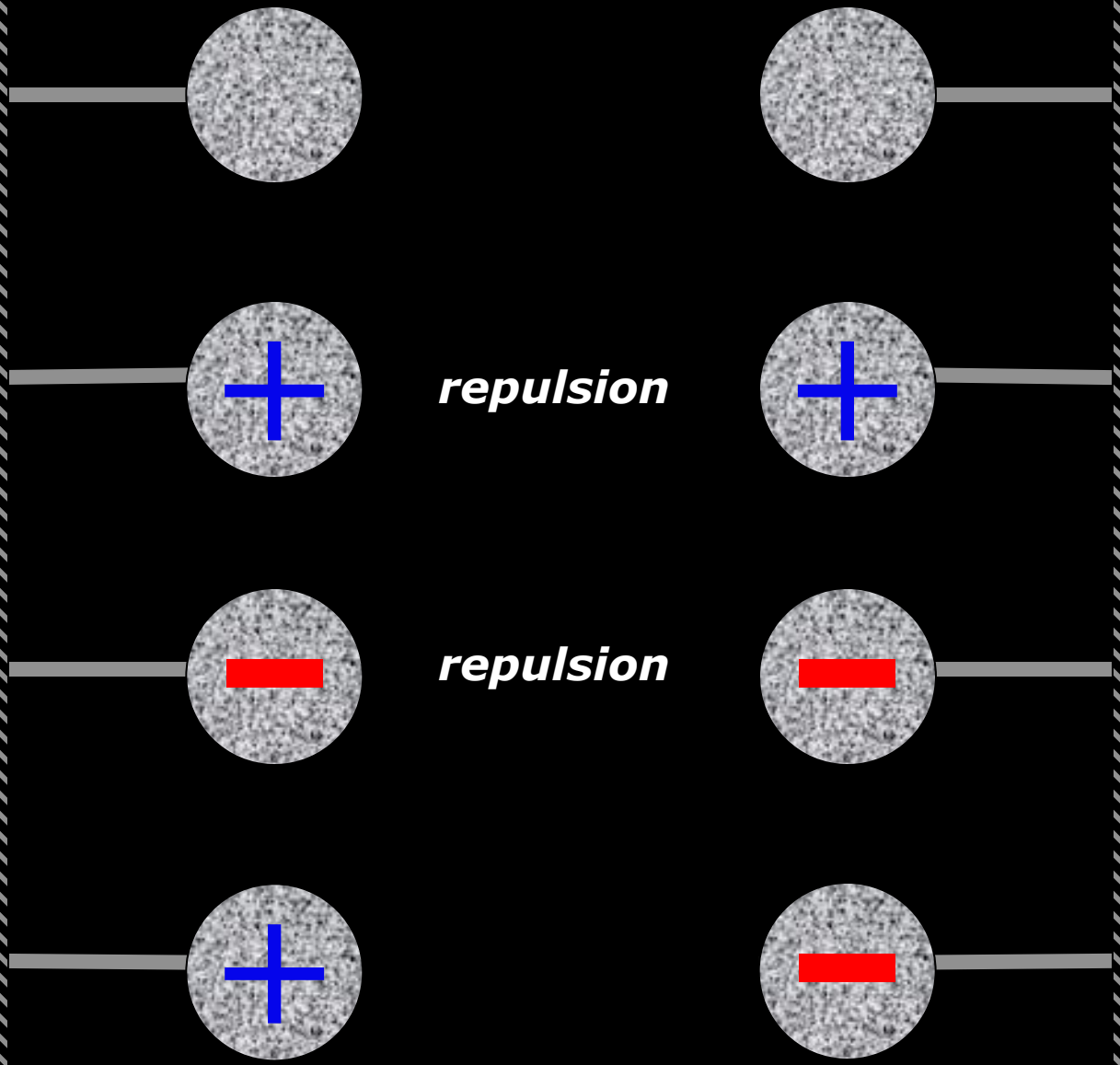


$$\vec{F}_g = \frac{G_N m_1 m_2}{r^2}\hat{r}$$

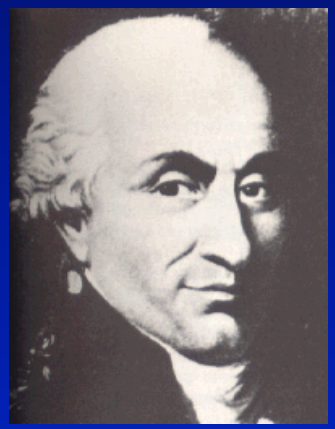
$G_N = 6.7\times10^{-11}\ Nm^2kg^{-2}$

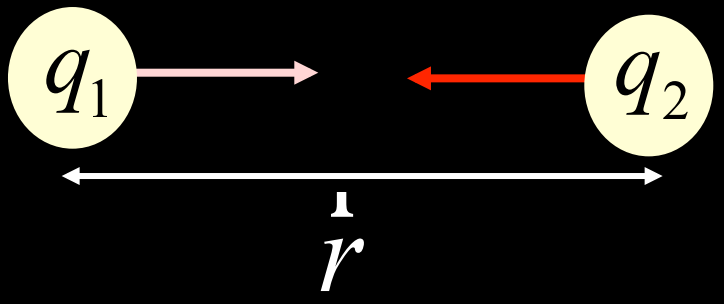
Electricity

Electricity



Electricity





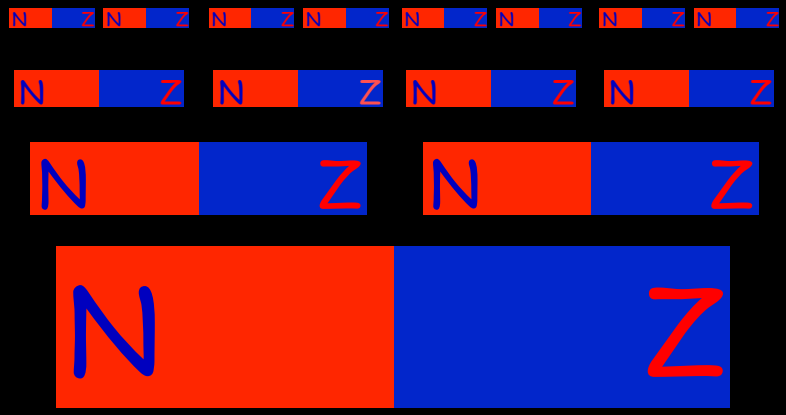
$$\vec{F}_q = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$$

$$\frac{1}{4\pi\varepsilon_0} = 9\cdot 10^9\ Nm^2C^{-2}$$

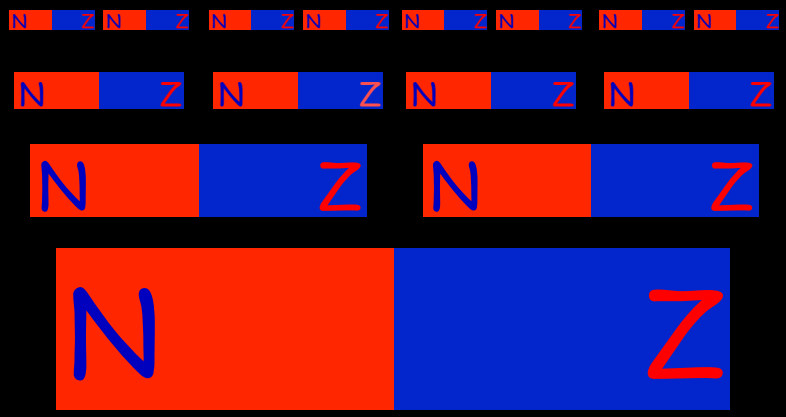
(G_N=6.7×10^{-11} Nm^2kg^{-2})

Magnetism

Magnetism



Magnetism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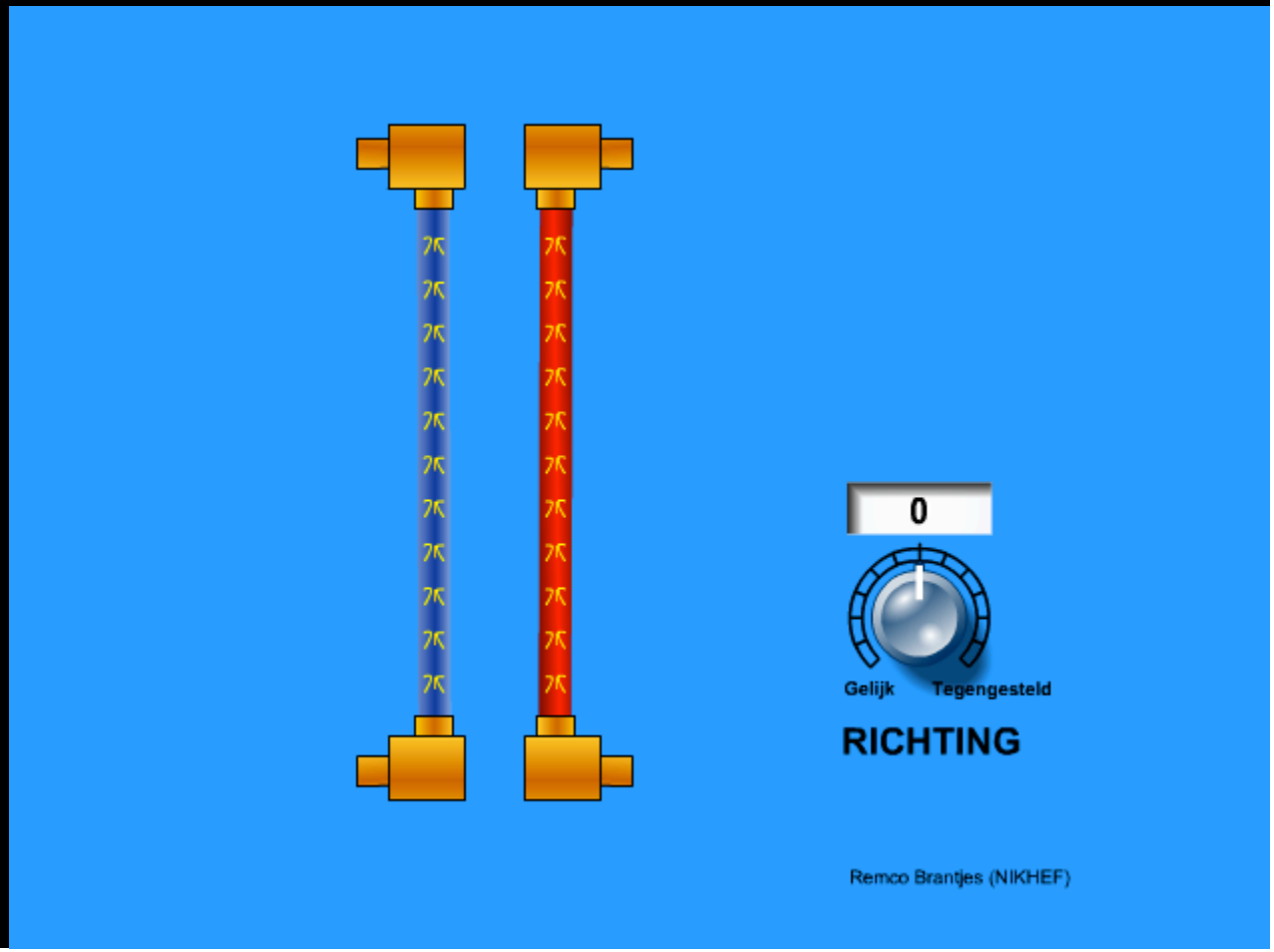
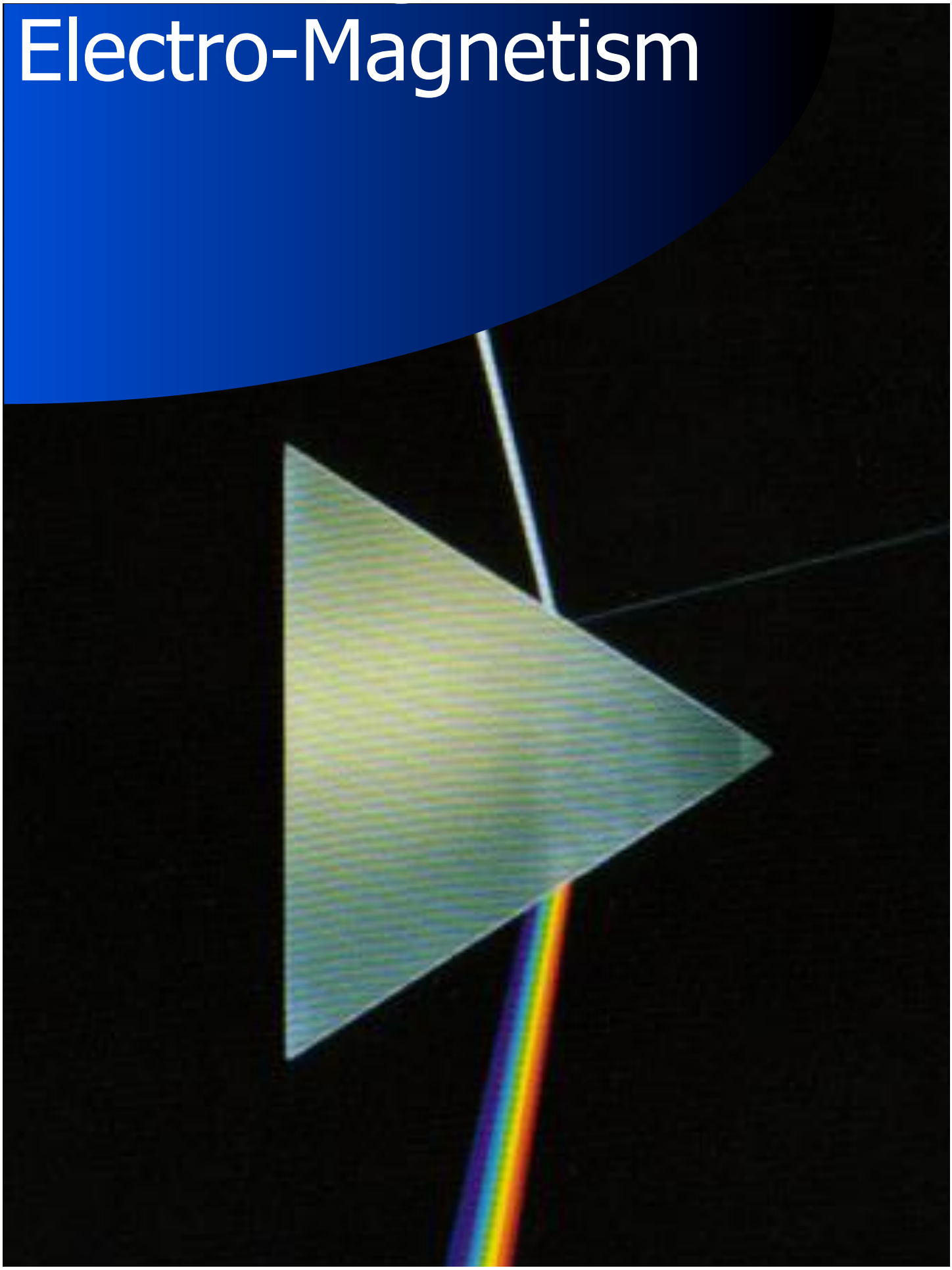
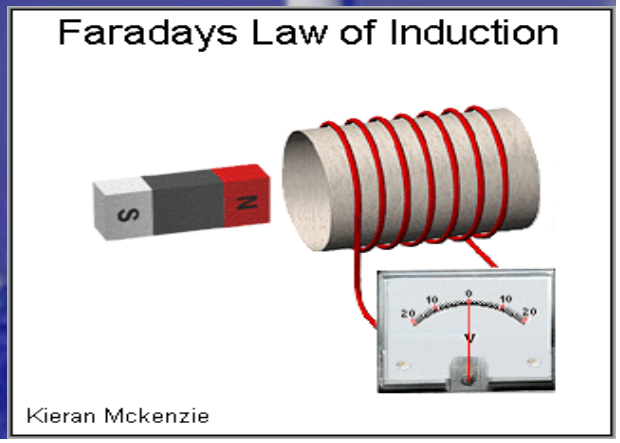
N Z N Z N Z N Z
N Z N Z
N Z


0
Gelijk
Tegengesteld
RICHTING
Remco Brantjes (NIKHEF)

Electro-Magnetism



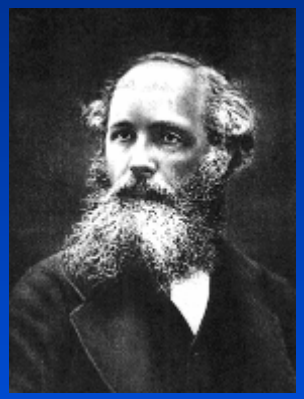
Magnetic induction



Genesis I:3

En God zeide: "Er zij licht; en er was licht."

Electro-Magnetism



Maxwell (1873)

$$\vec{\nabla}\cdot\vec{B}=0 \qquad \vec{\nabla}\times\vec{B}=\varepsilon_0\mu_0\frac{\partial\vec{E}}{\partial t}$$

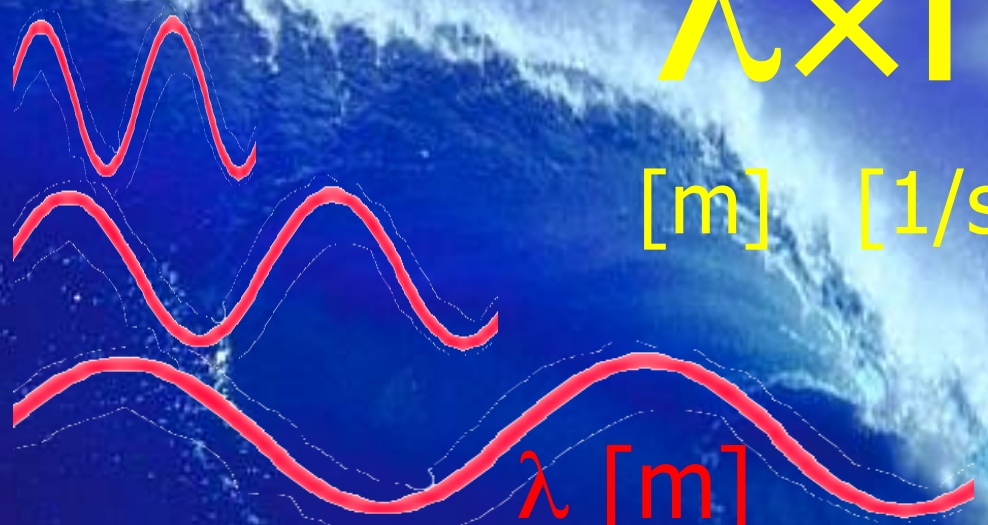
$$\vec{\nabla}\cdot\vec{E}=0 \qquad \vec{\nabla}\times\vec{E}=-\frac{\partial\vec{B}}{\partial t}$$

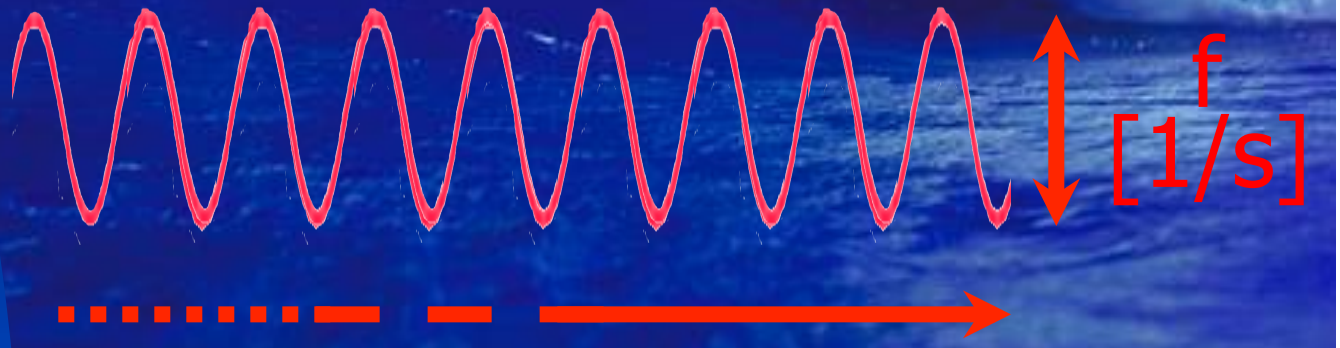
$$\varepsilon_0\mu_0=1/c^2$$

Waves

$$\lambda \times f = v$$

[m] [1/s] [m/s]





λ
wavelength

f
frequency

v
velocity

V=299792458 m/s = c
(exact; definition meter!)

Spin-off

1793
battery

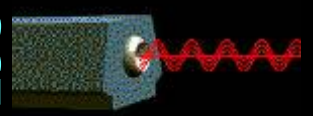
1879
light bulb

1947
transistor

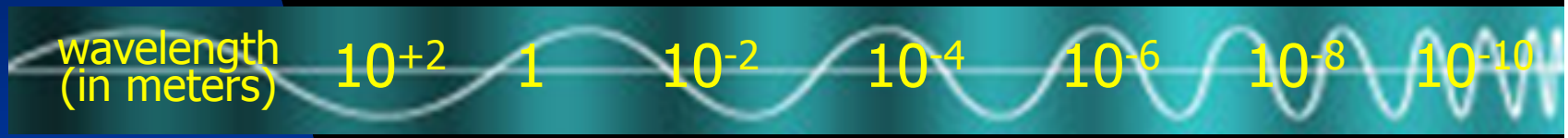
Microsoft
Windows xp
intel
pentium 4
1975
personnel computer

1901
radio

1946
microwave


1954
laser

1896
γ-radiation


wavelength
(in meters)
10+2
1
10-2
10-4
10-6
10-8
10-10

phone
1947-1975

radar
1935

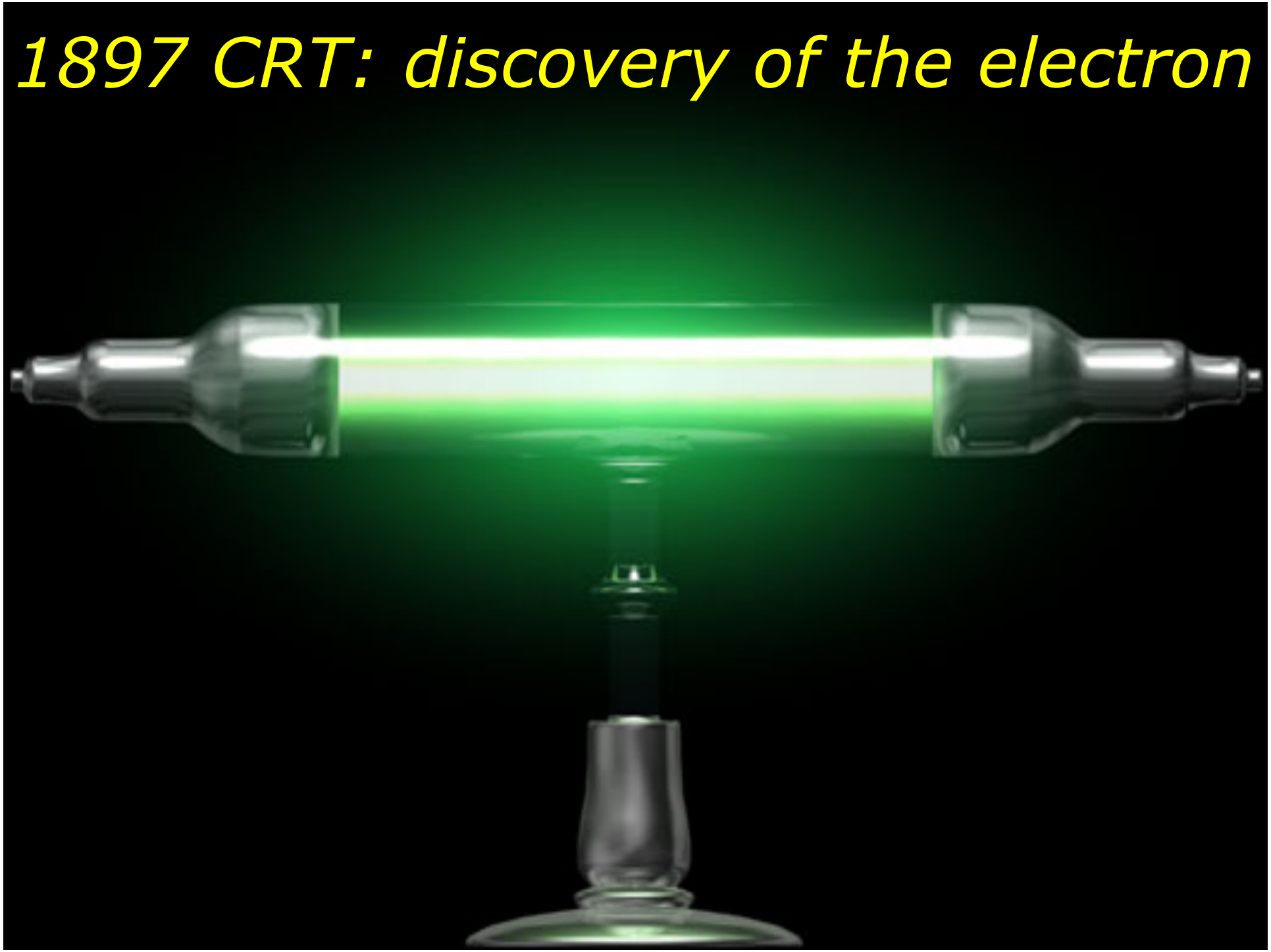
visible
light

Röntgen
1895

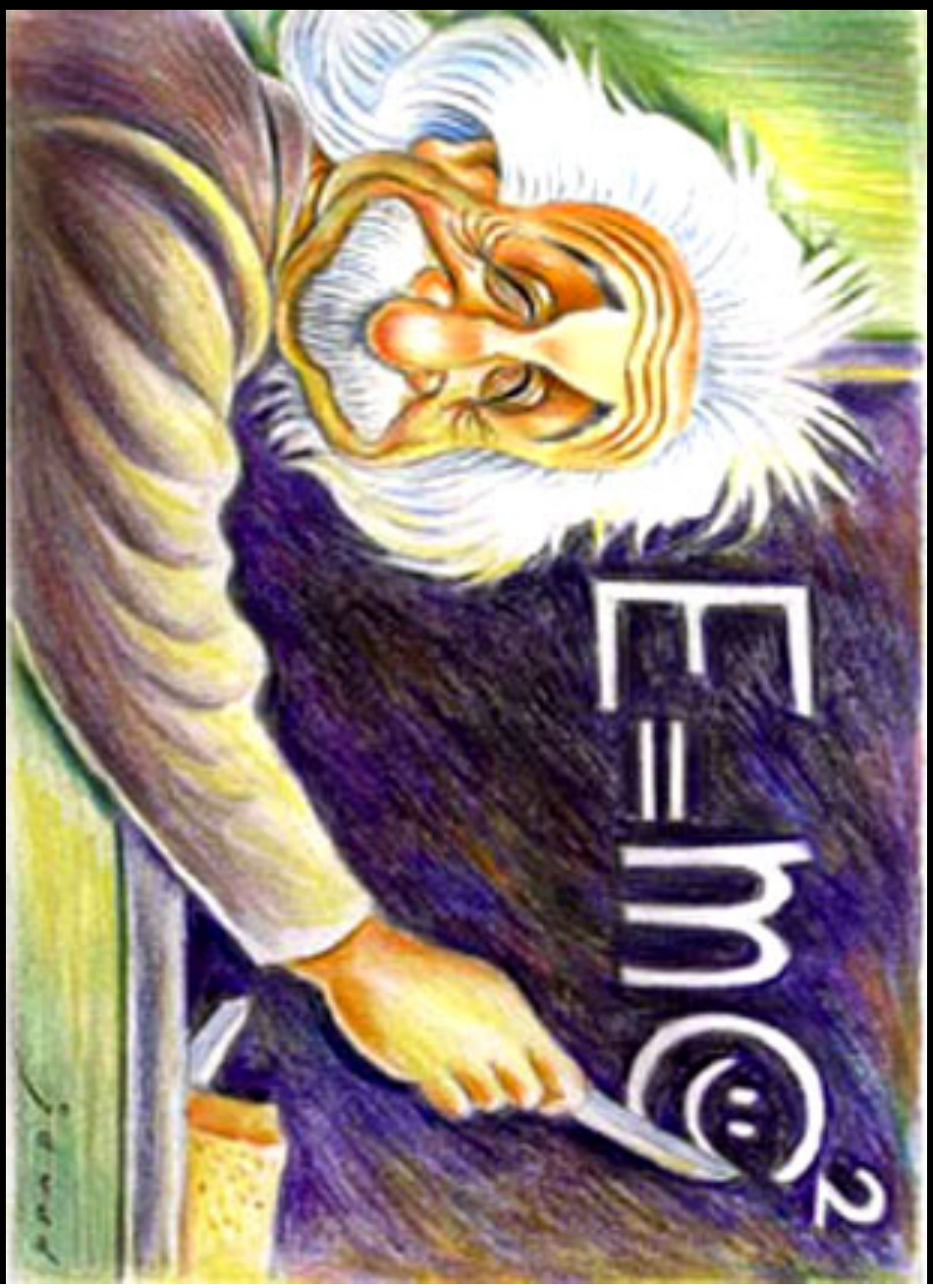
Microwave

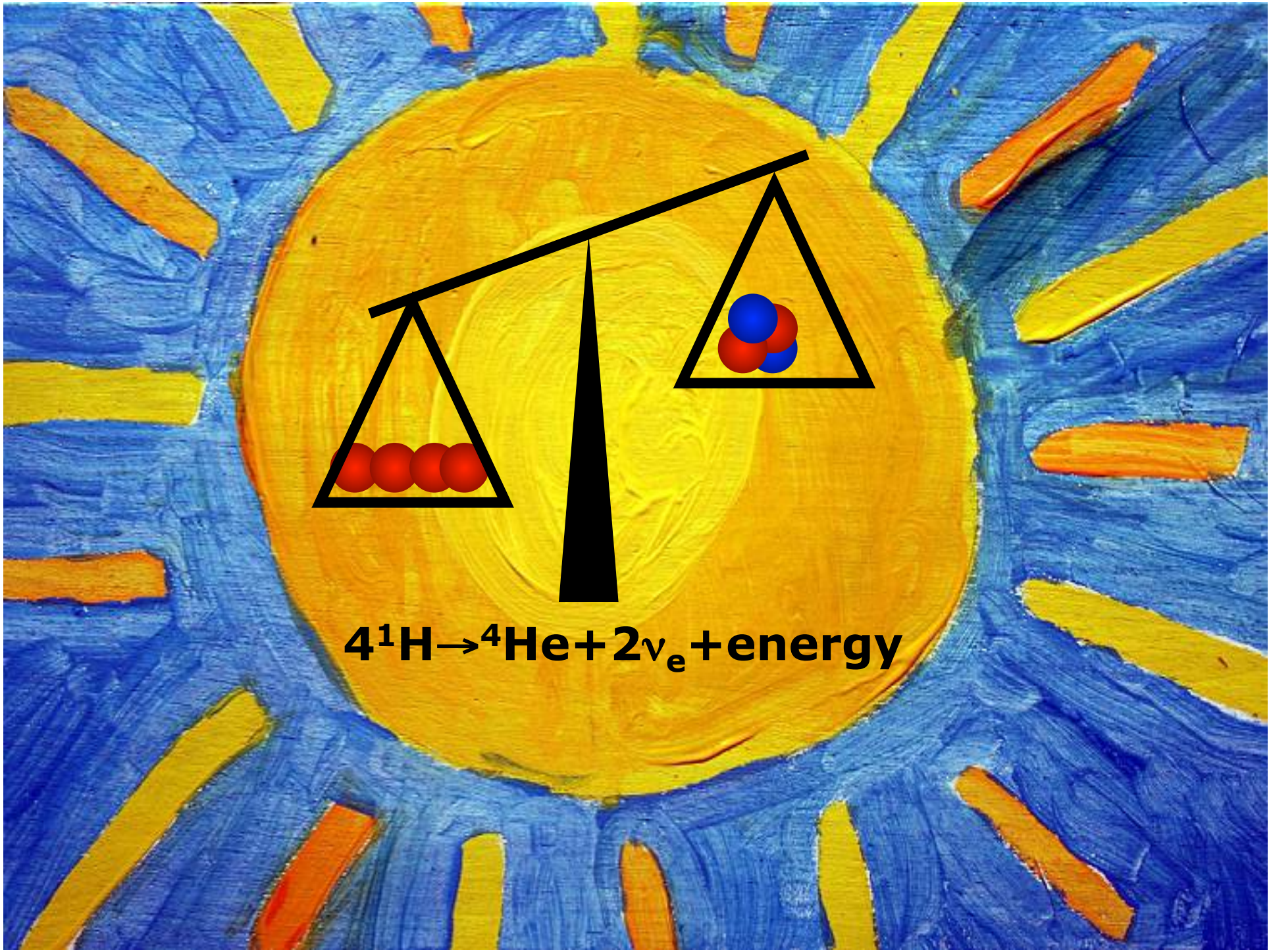
Wave length

1897 CRT: discovery of the electron

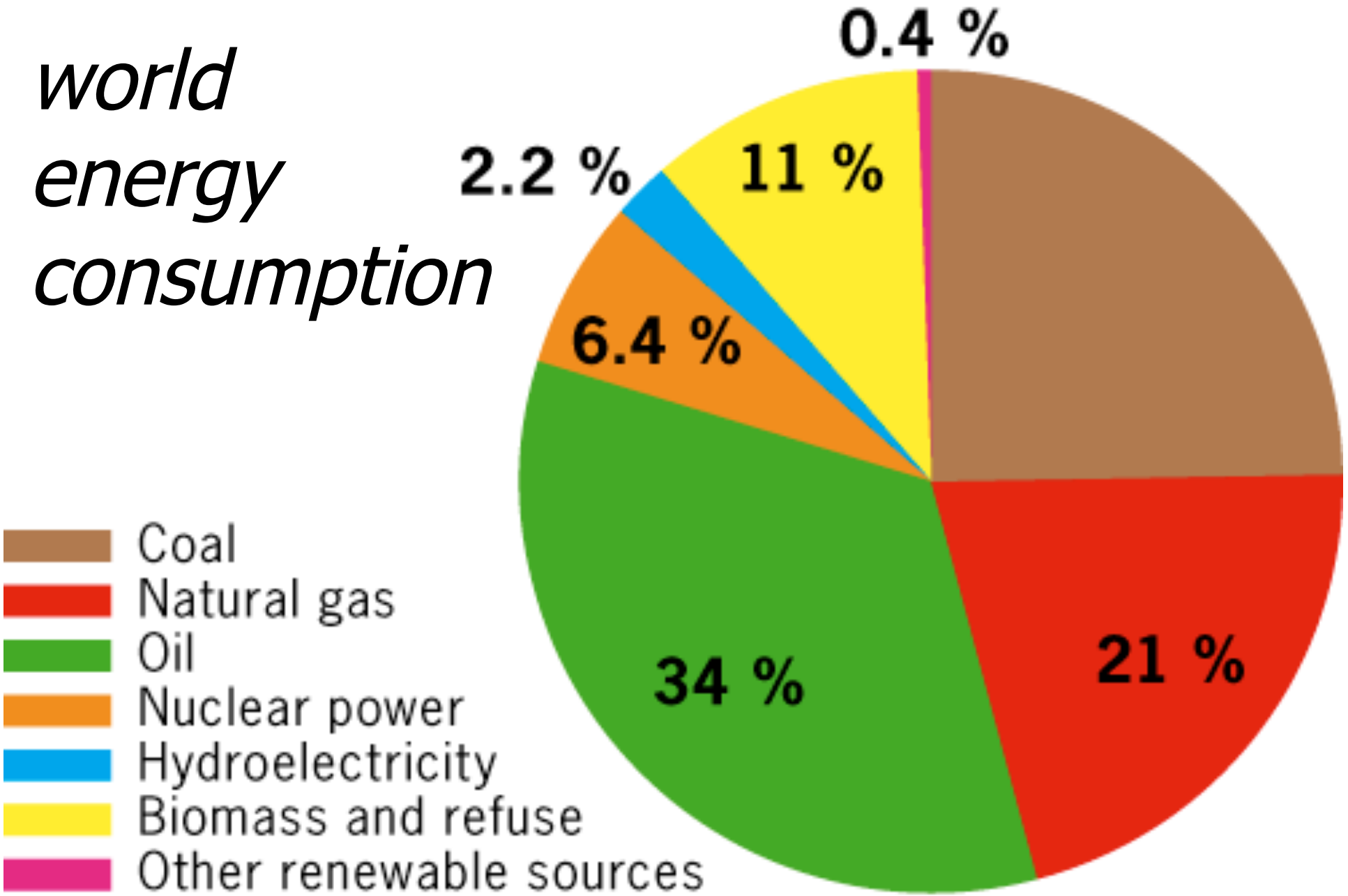


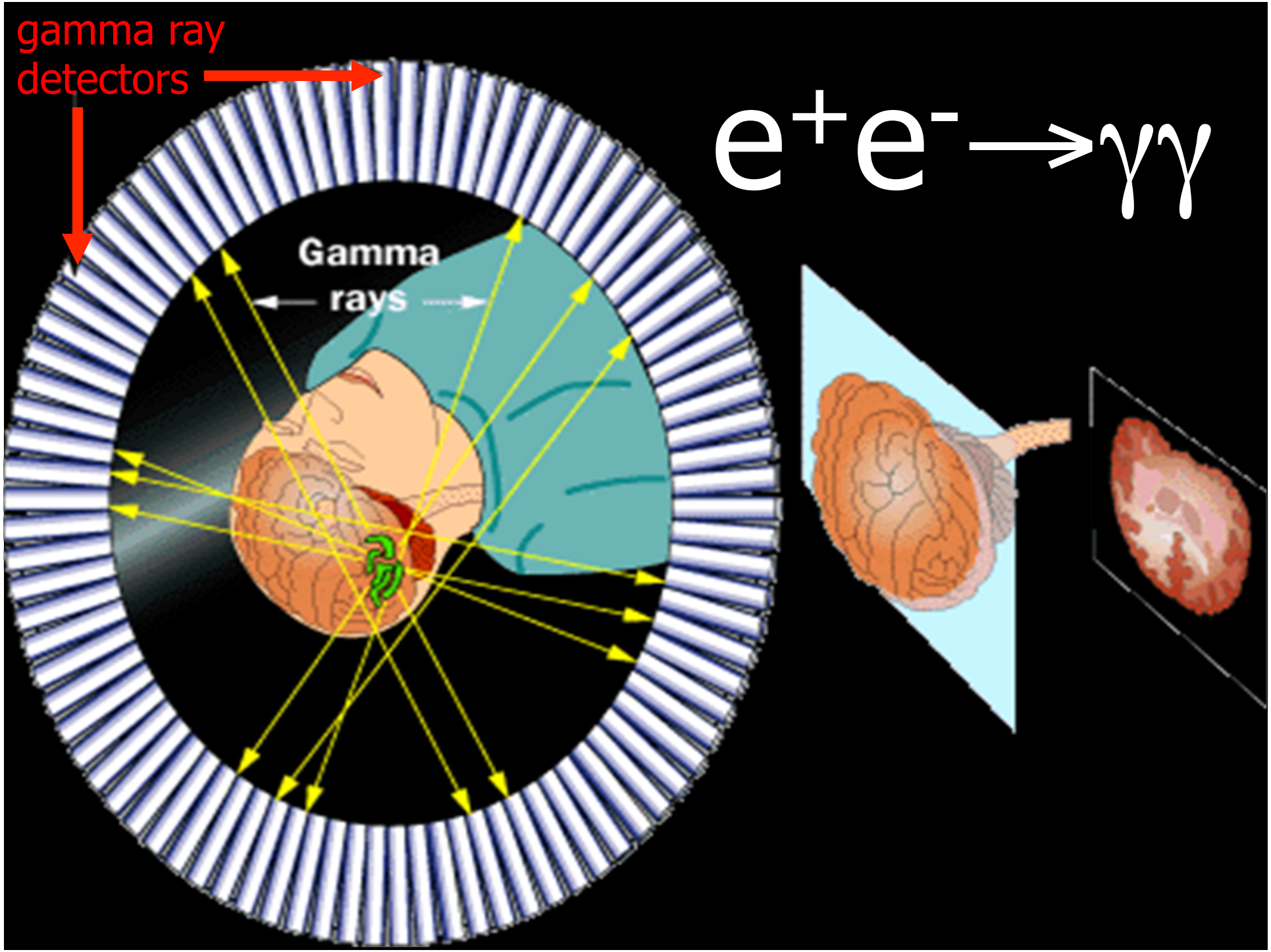
Relativity theory




$4\,^{1}H \rightarrow {}^{4}He + 2\nu_e + energy$

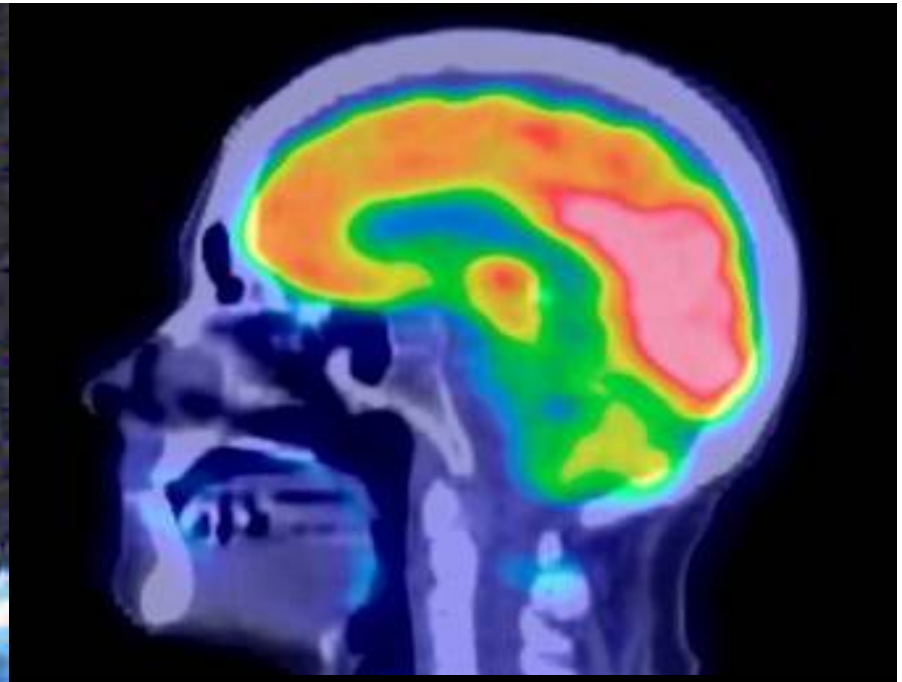
world energy consumption

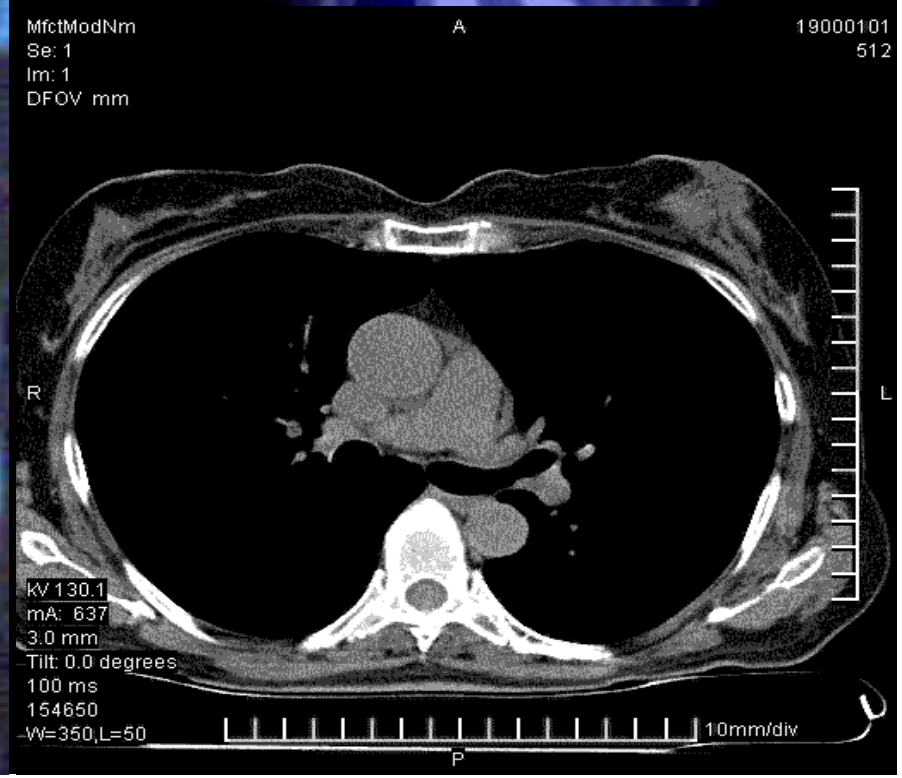



gamma ray
detectors
Gamma
rays
$e^+e^- \rightarrow \gamma\gamma$

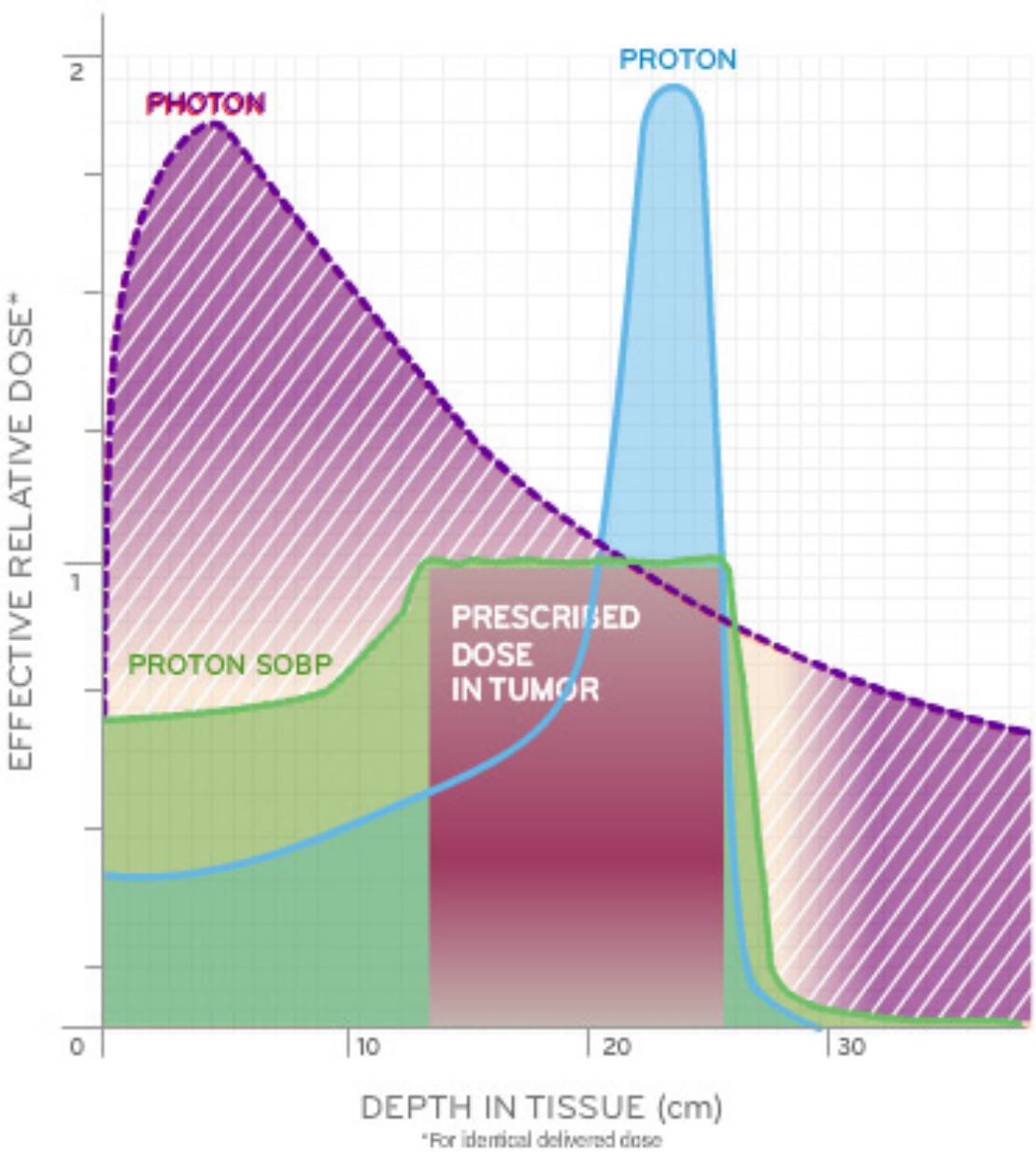
NATIONAL
M5
South Western Motorway
130
metres
11:02
11:26
100 km/h
TOMTOM

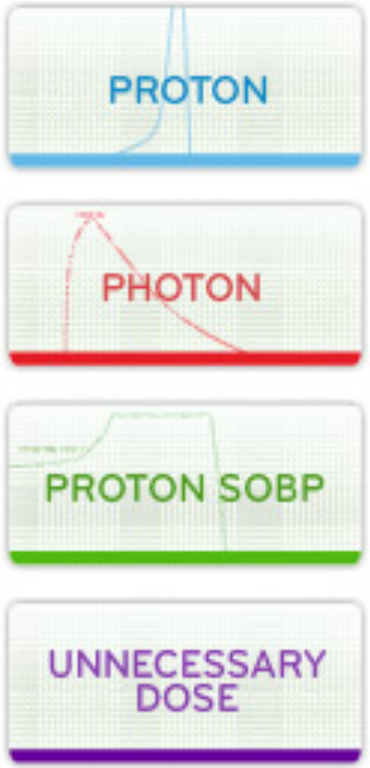
health




MfctModNm
Se: 1
Im: 1
DFOV mm
A
19000101
512
R
L
kV 130.1
mA: 637
3.0 mm
Tilt: 0.0 degrees
100 ms
154650
W=350,L=50
10mm/div
P

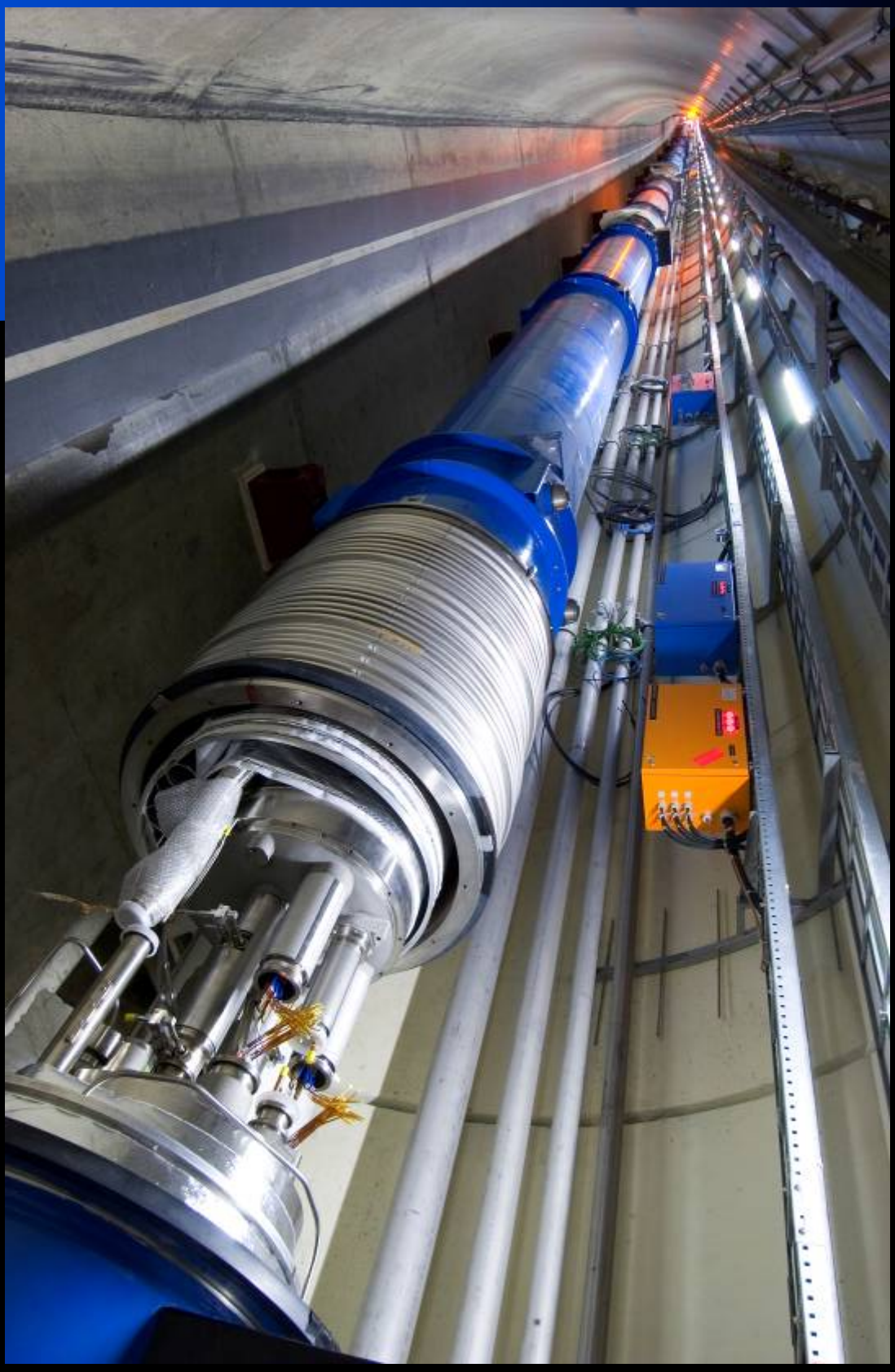
THE BRAGG PEAK



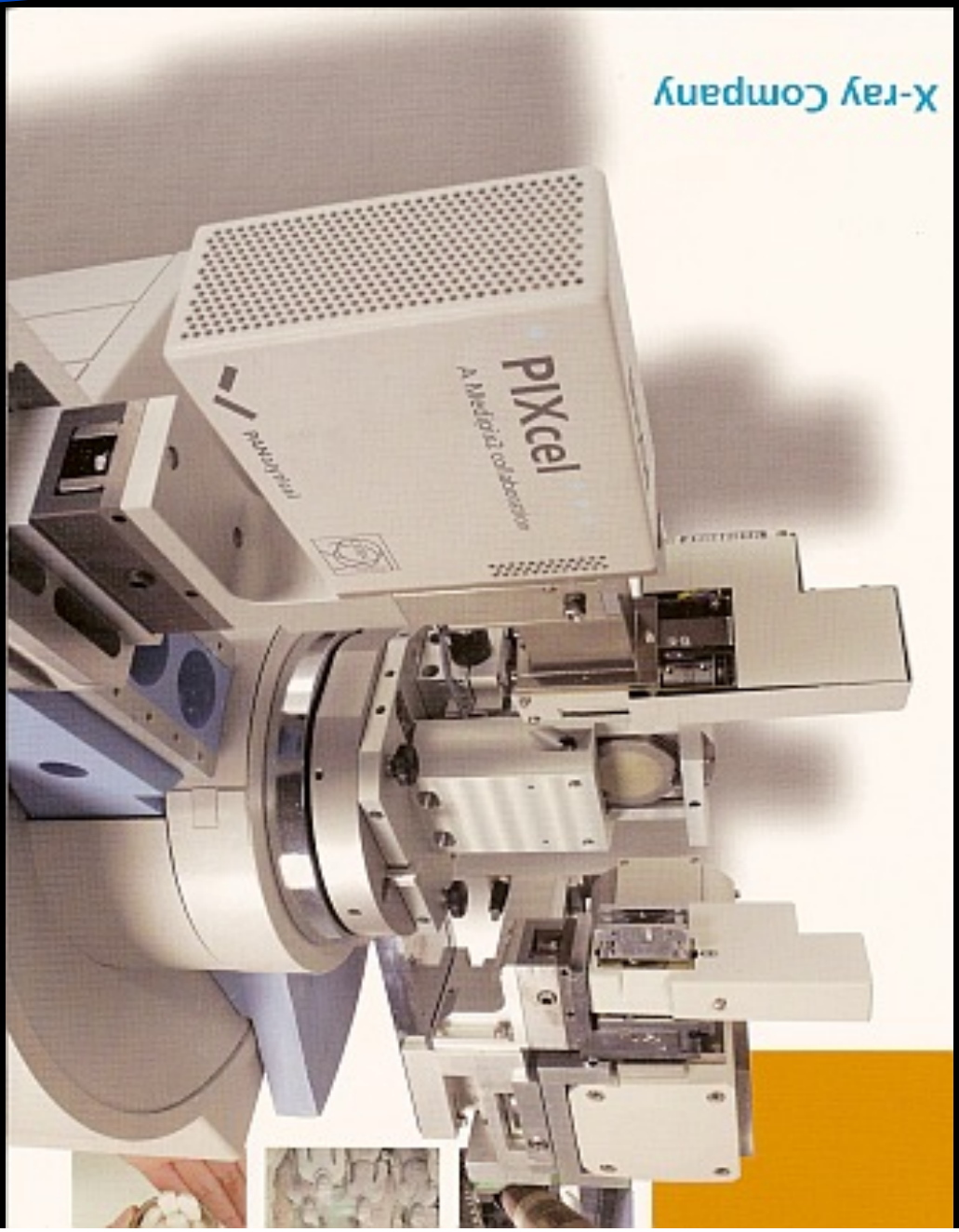


Proton therapy

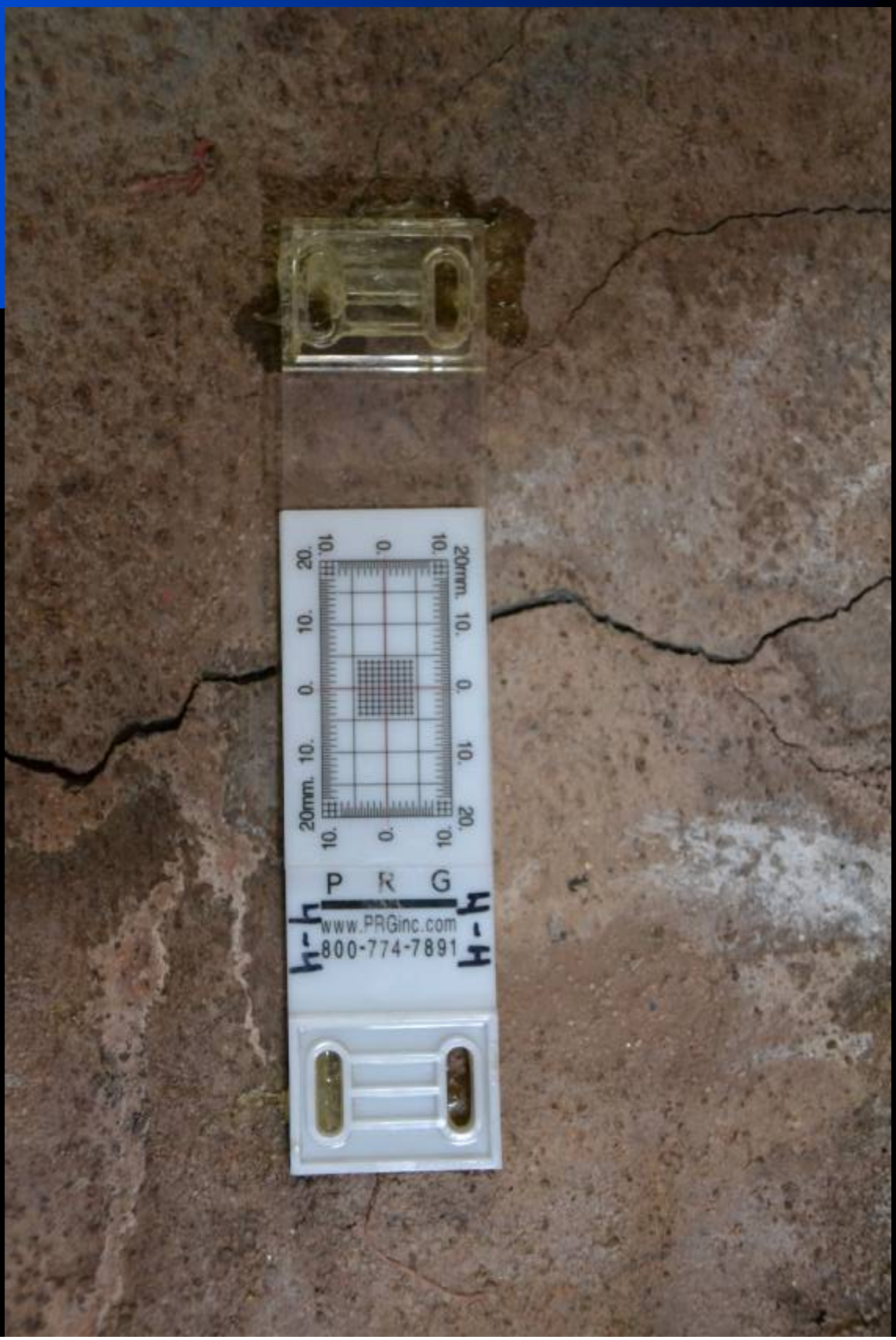
superconductivity



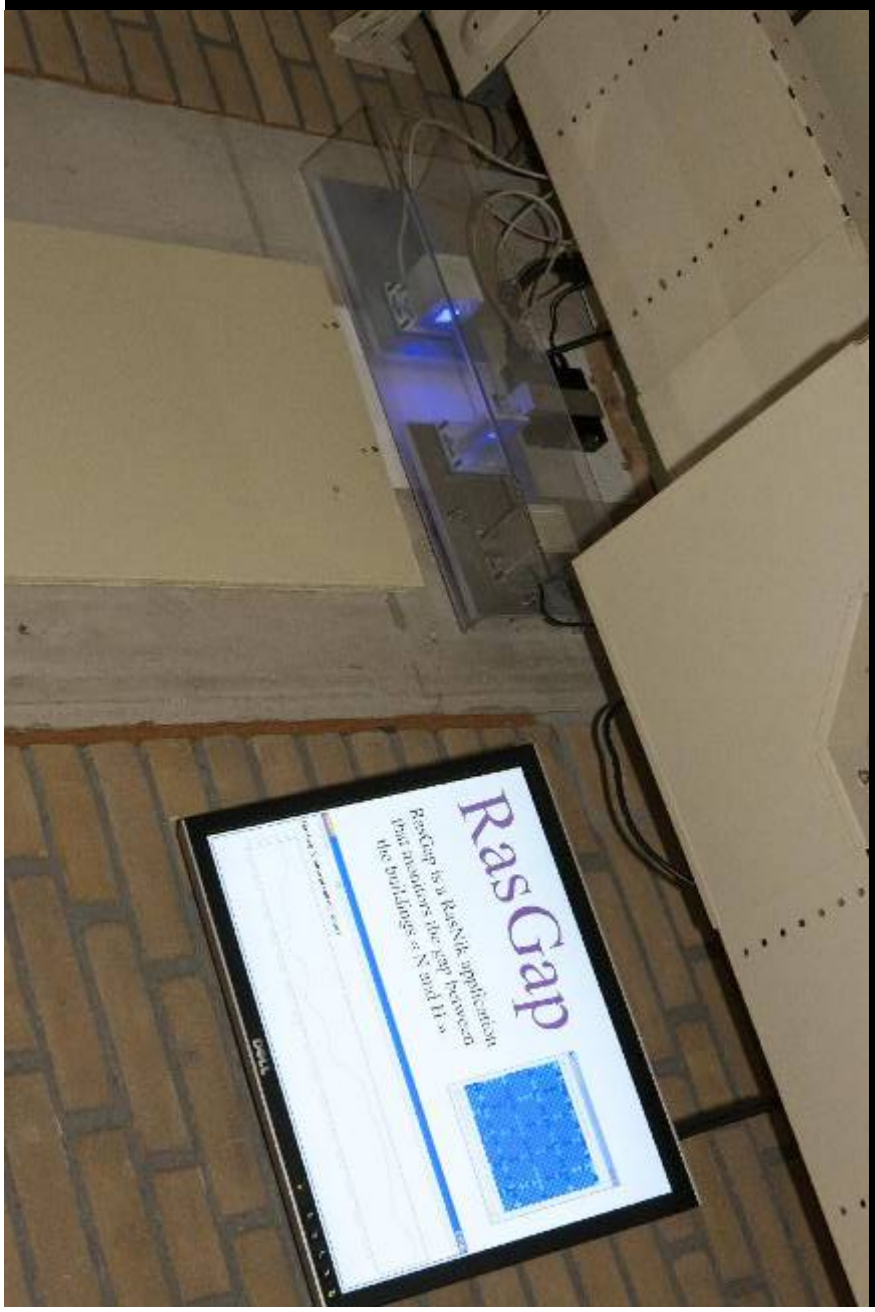
particle detectors

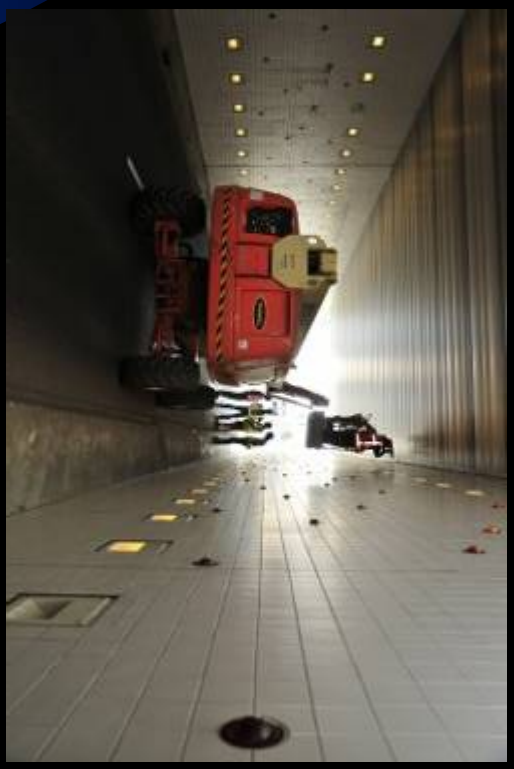


alignment

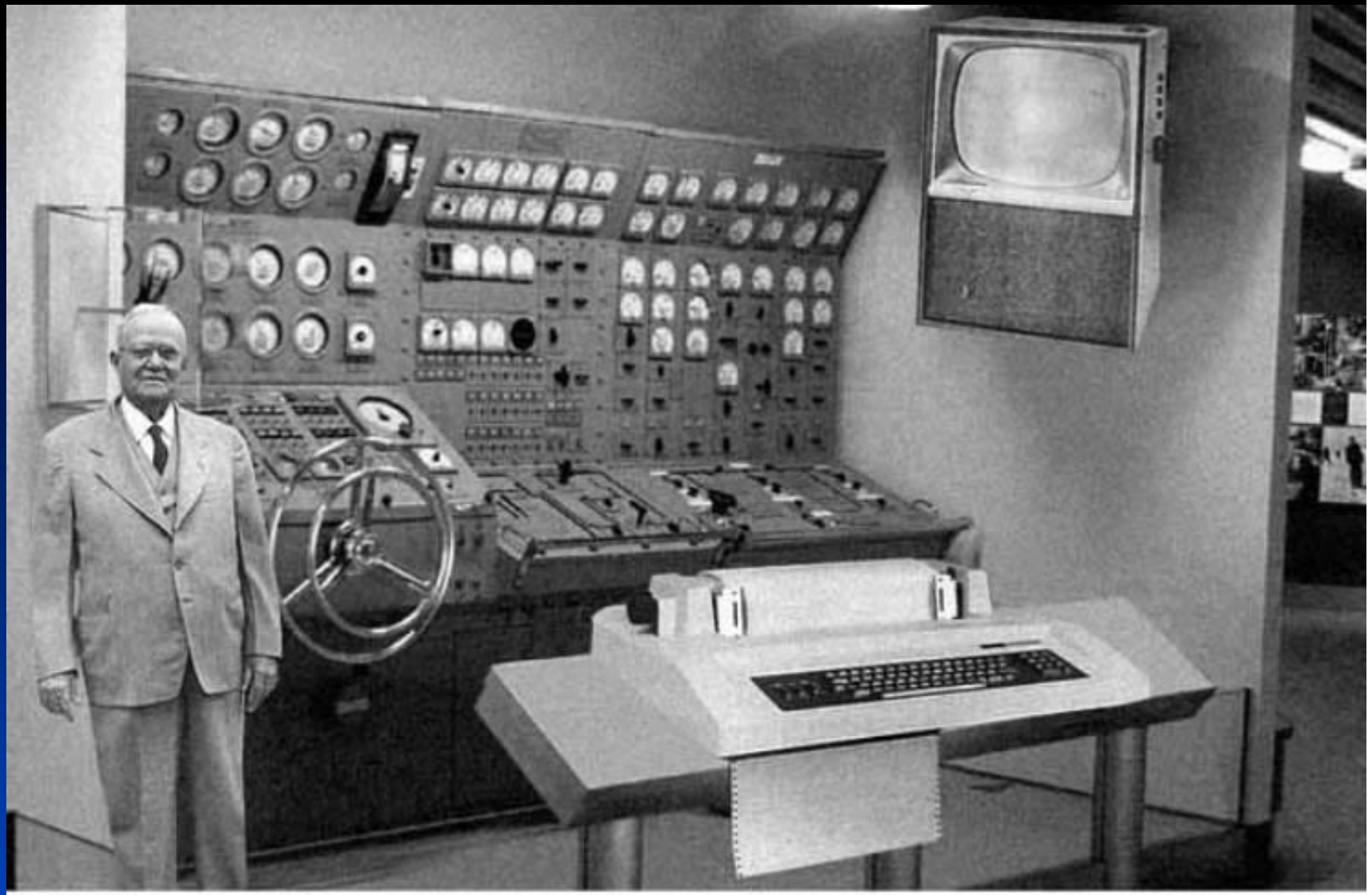


alignment





ICT

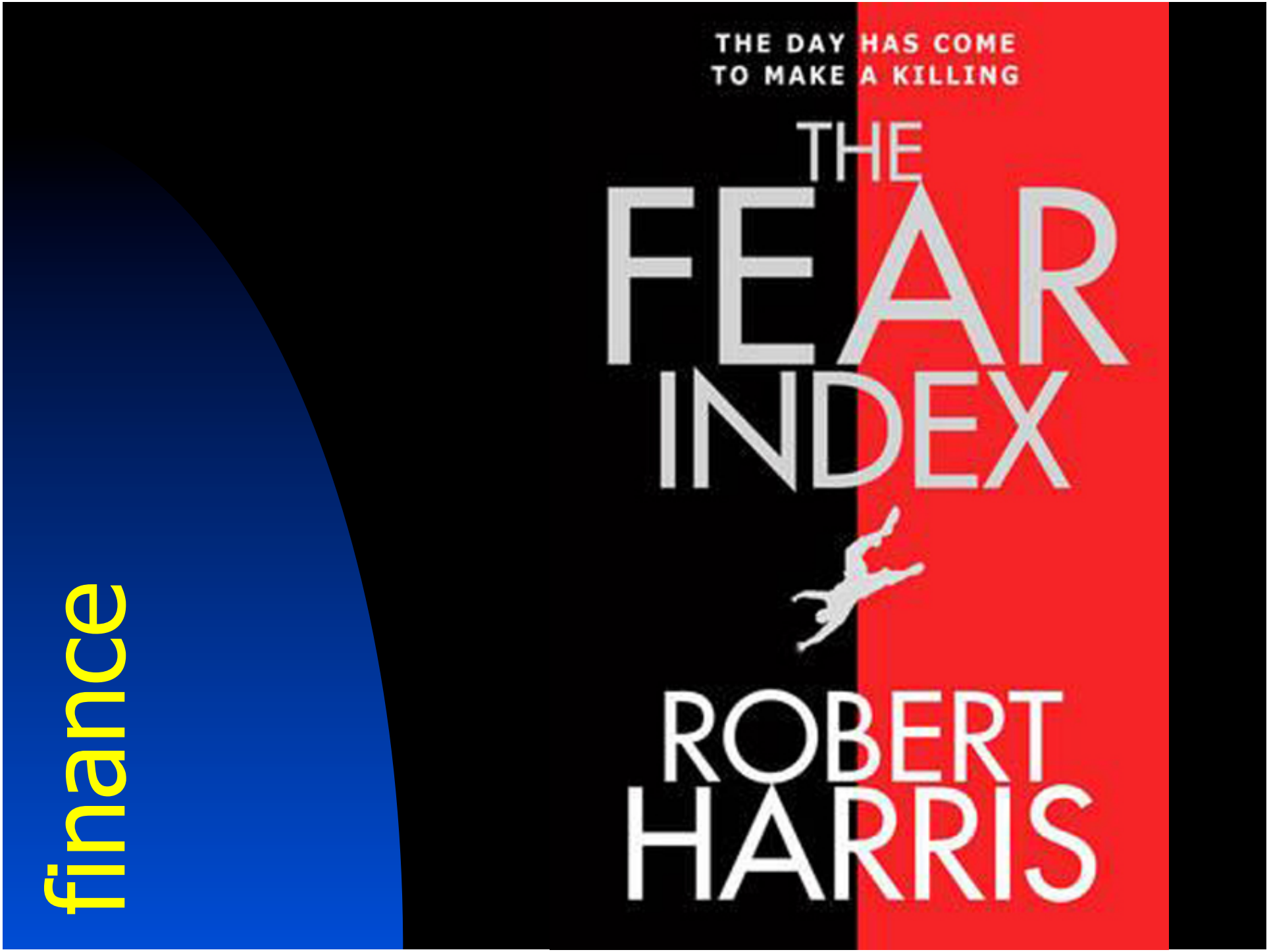


Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use.

ICT

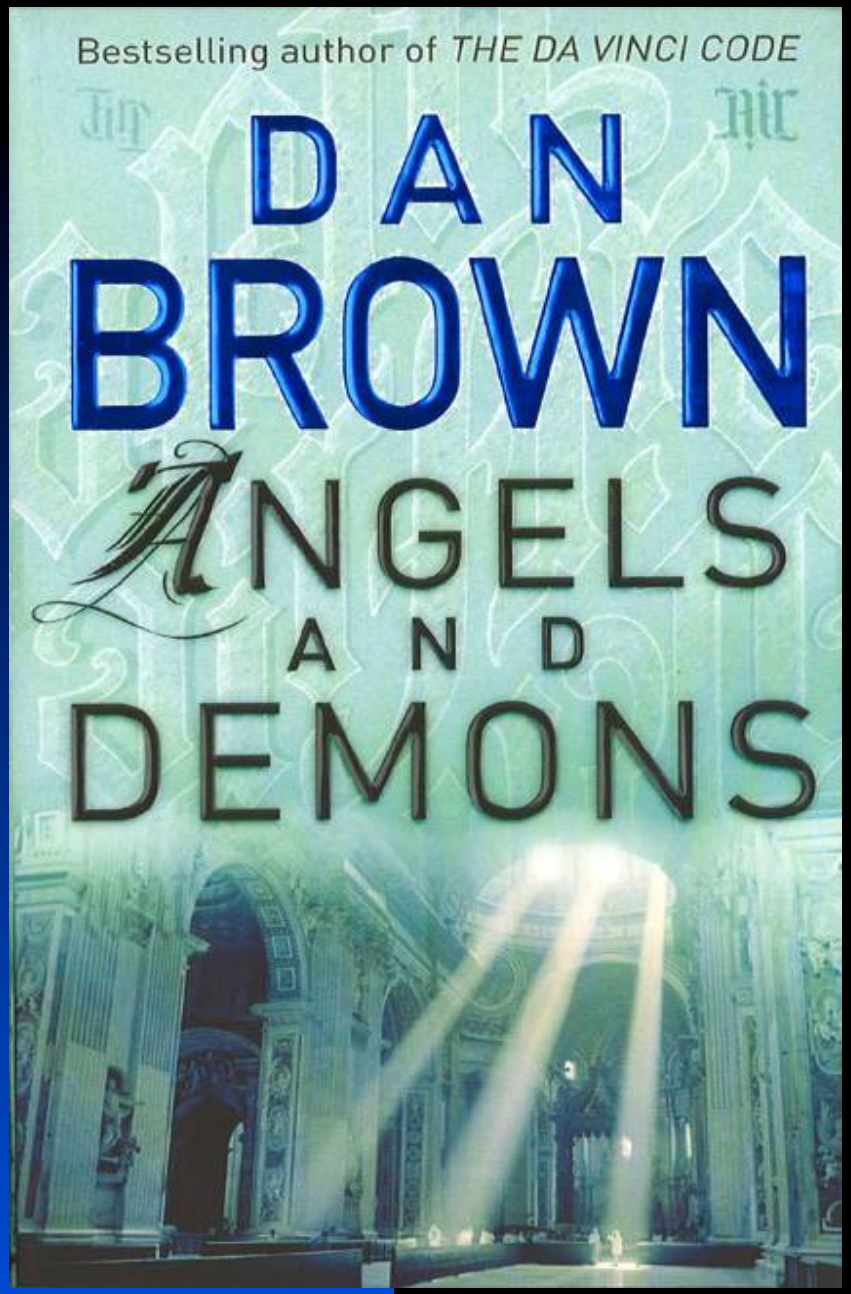
CERN's 1st computer: *Wim Klein*

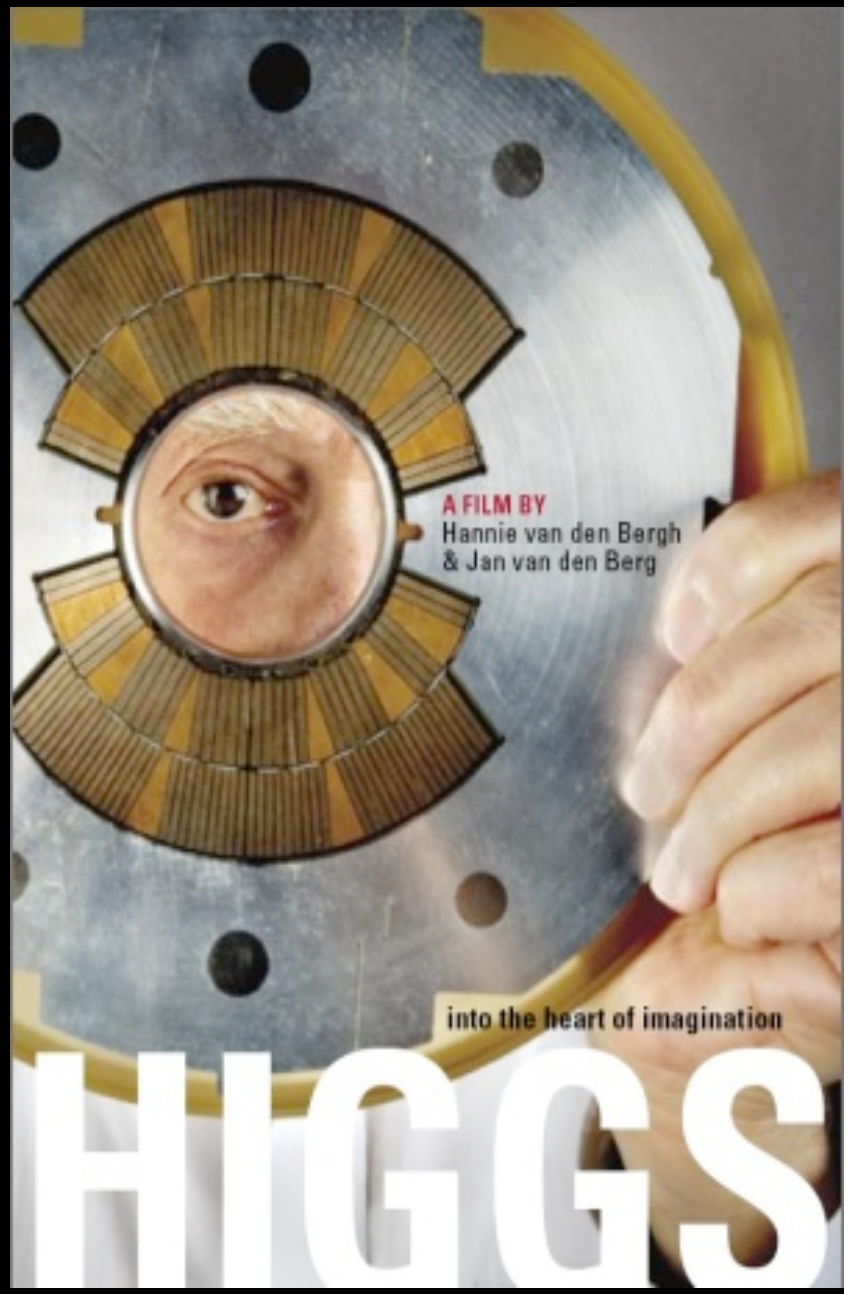
finance


THE DAY HAS COME
TO MAKE A KILLING
THE FEAR INDEX
ROBERT HARRIS

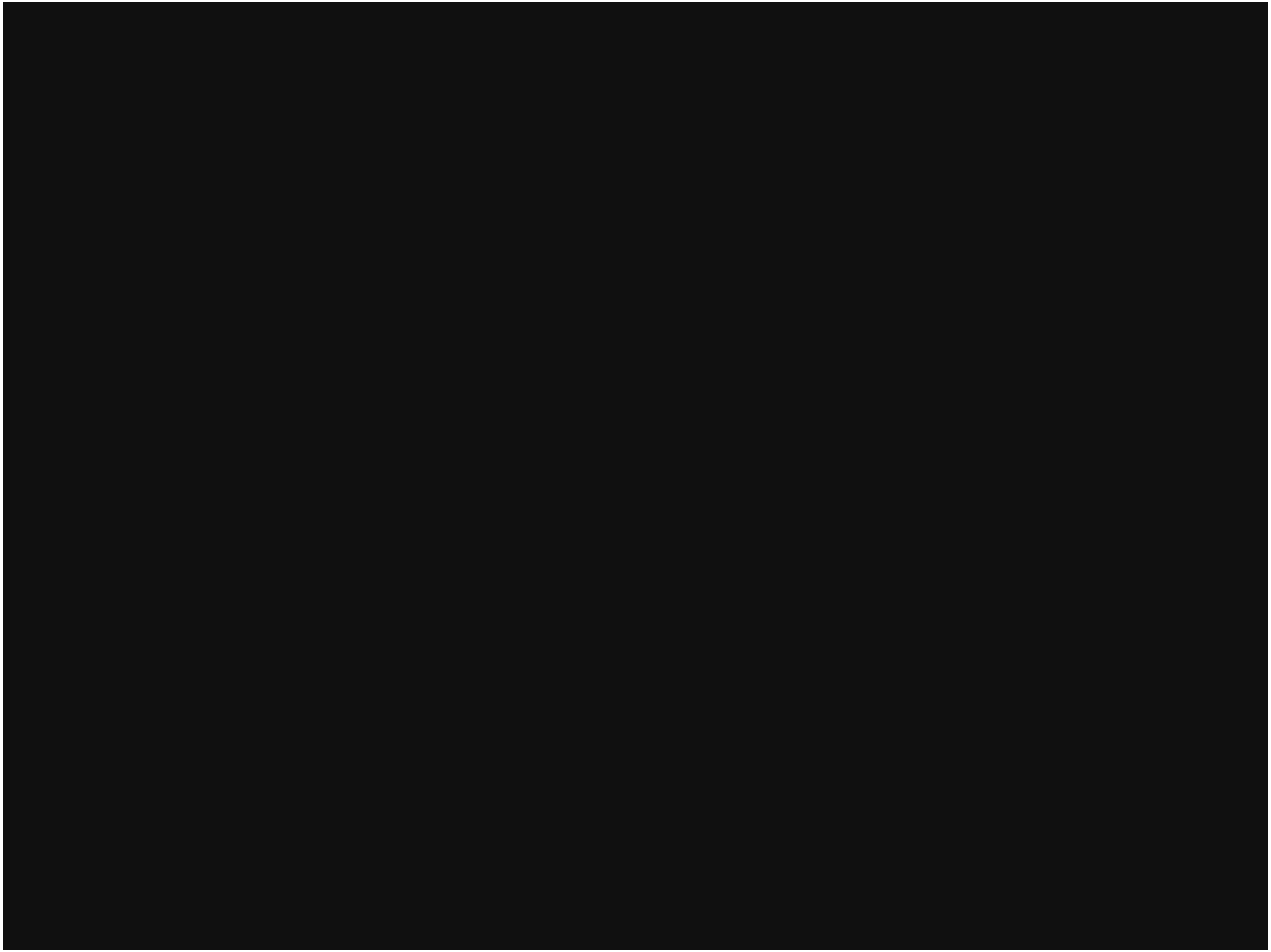
Young talent

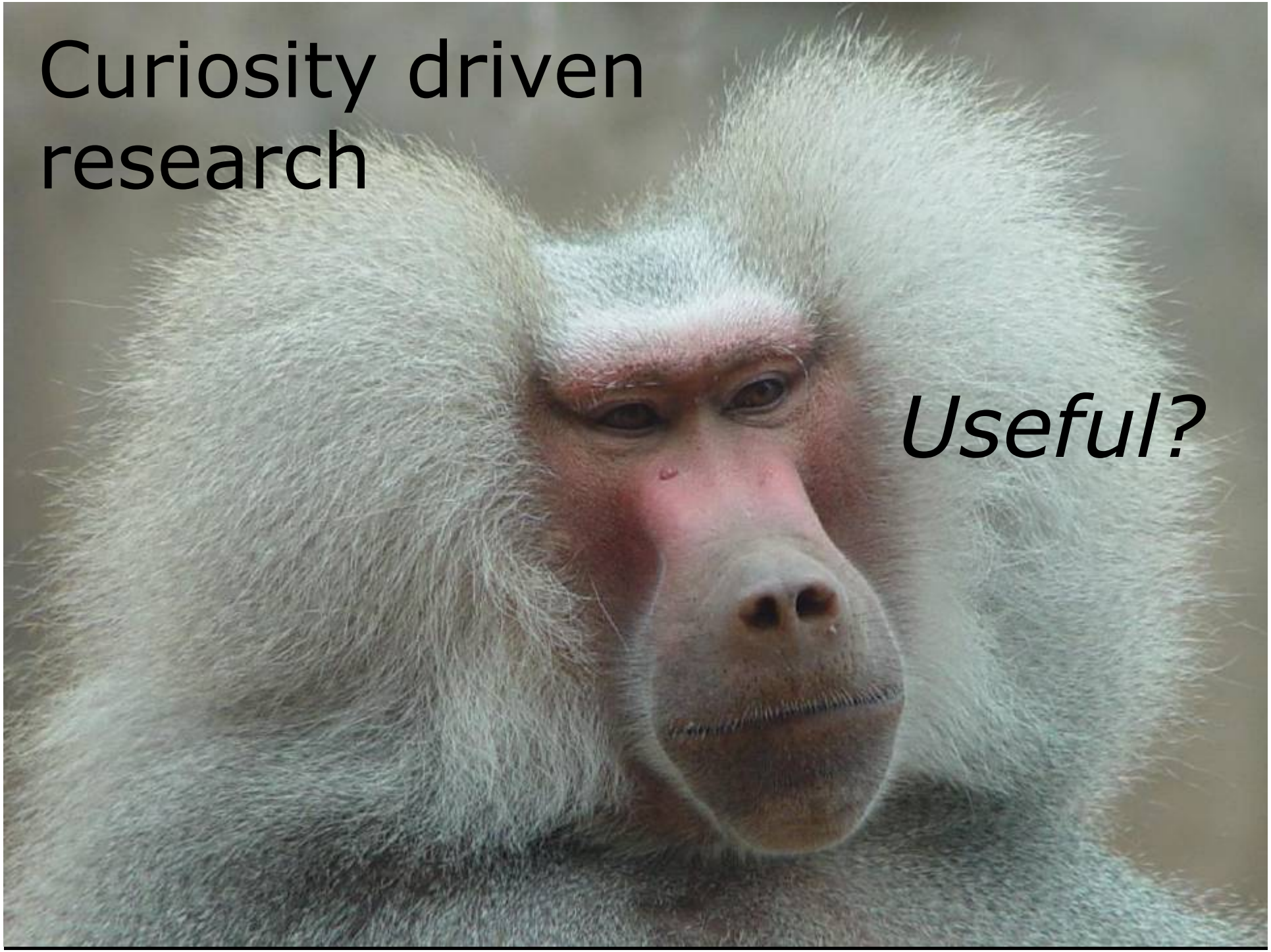
culture


Bestselling author of THE DA VINCI CODE
DAN
BROWN
ANGELS
AND
DEMONS


A FILM BY
Hannie van den Bergh
& Jan van den Berg
into the heart of imagination
HIGGS

fun




Curiosity driven research
Useful?

Who achieved this? *Politicians, economists, lawyers or …?*

Candle

?

Light bulb

Edison
1880

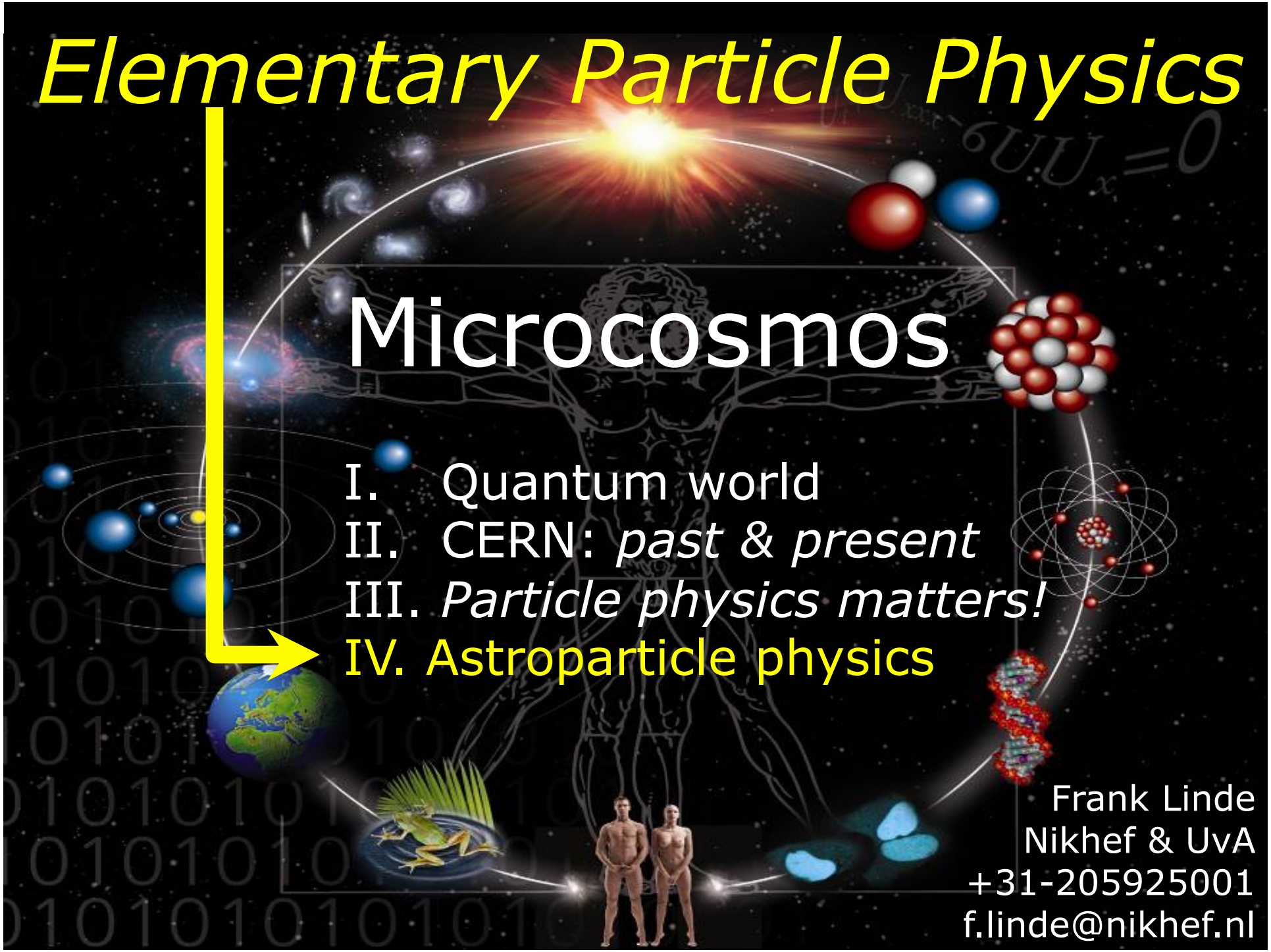
Fluorescent light

Hewitt
1901

LED

Losev
1927

Elementary Particle Physics



Microcosmos

I. Quantum world
II. CERN: *past & present*
III. *Particle physics matters!*
IV. Astroparticle physics

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