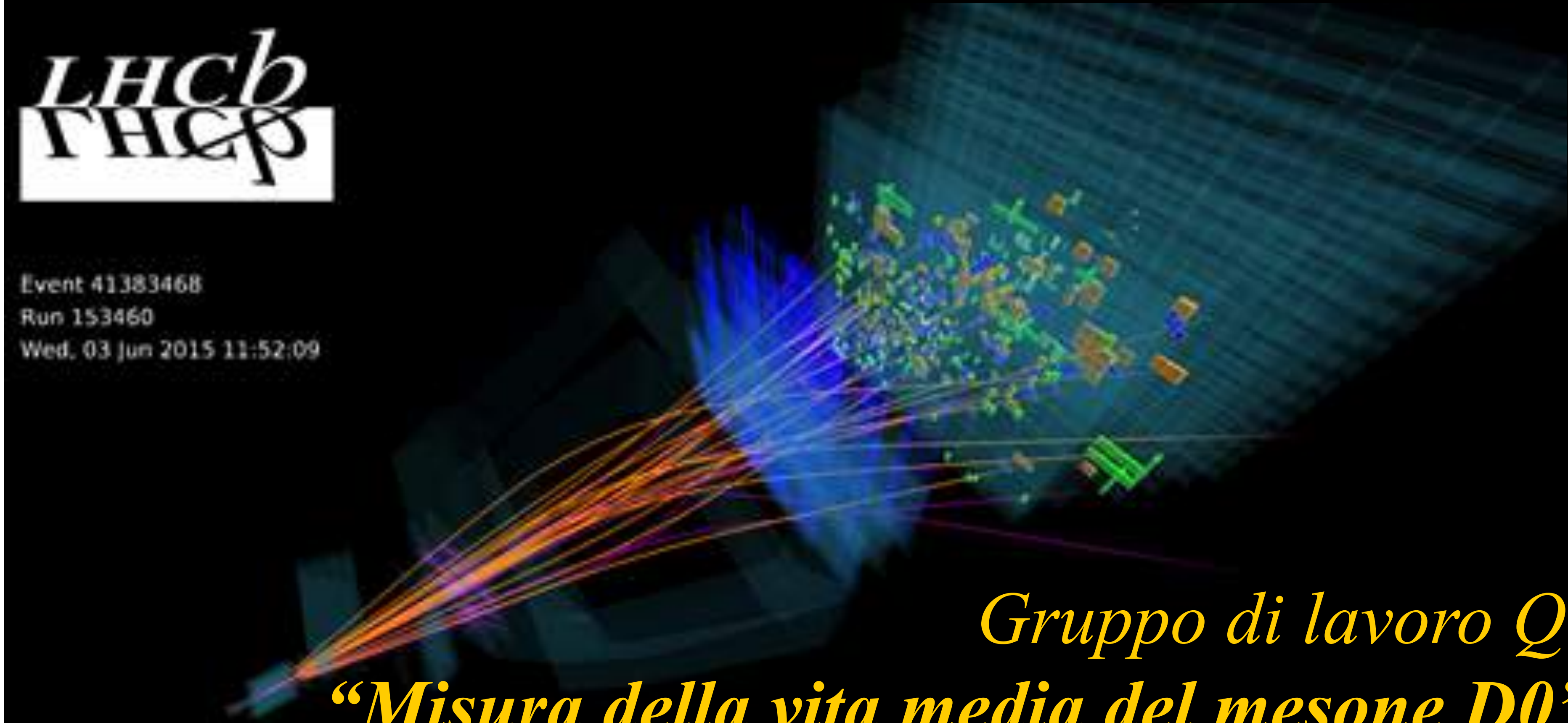


Gruppo di lavoro Q:
"Misura della vita media del mesone D0"

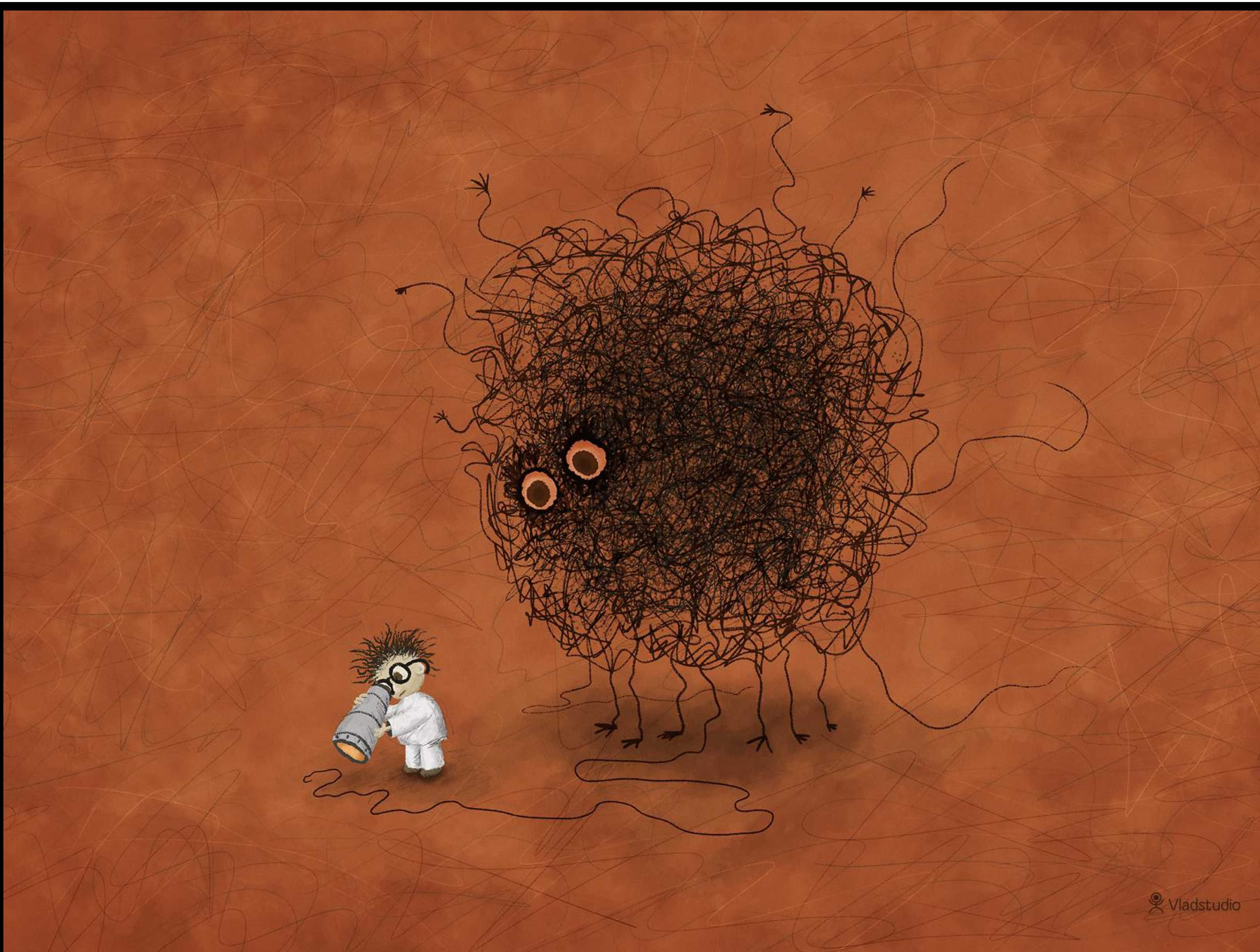
Introduzione

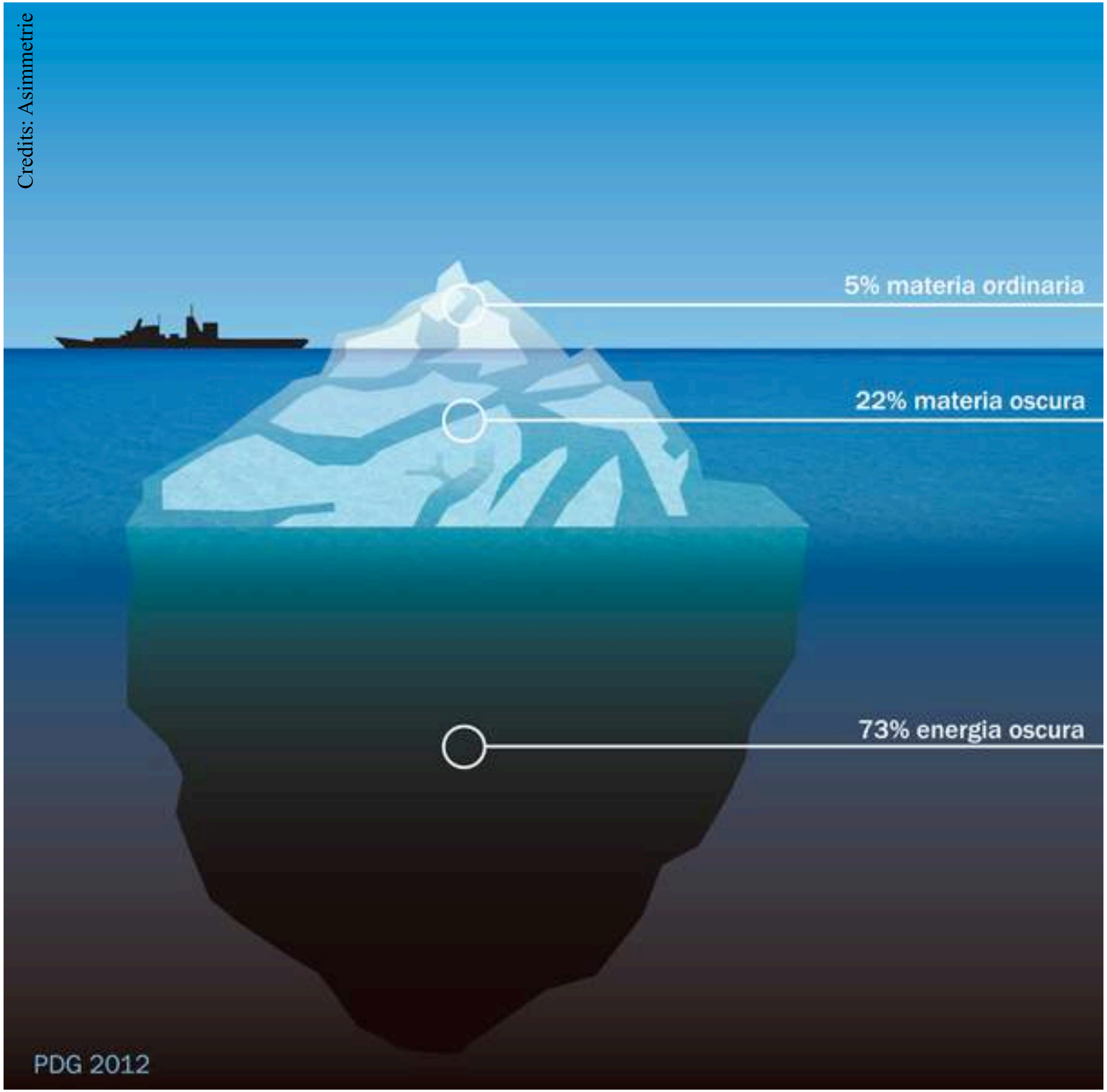
L'esperimento LHCb

La misura

B. Sciascia R. Vazquez Gomez
LNF-INFN

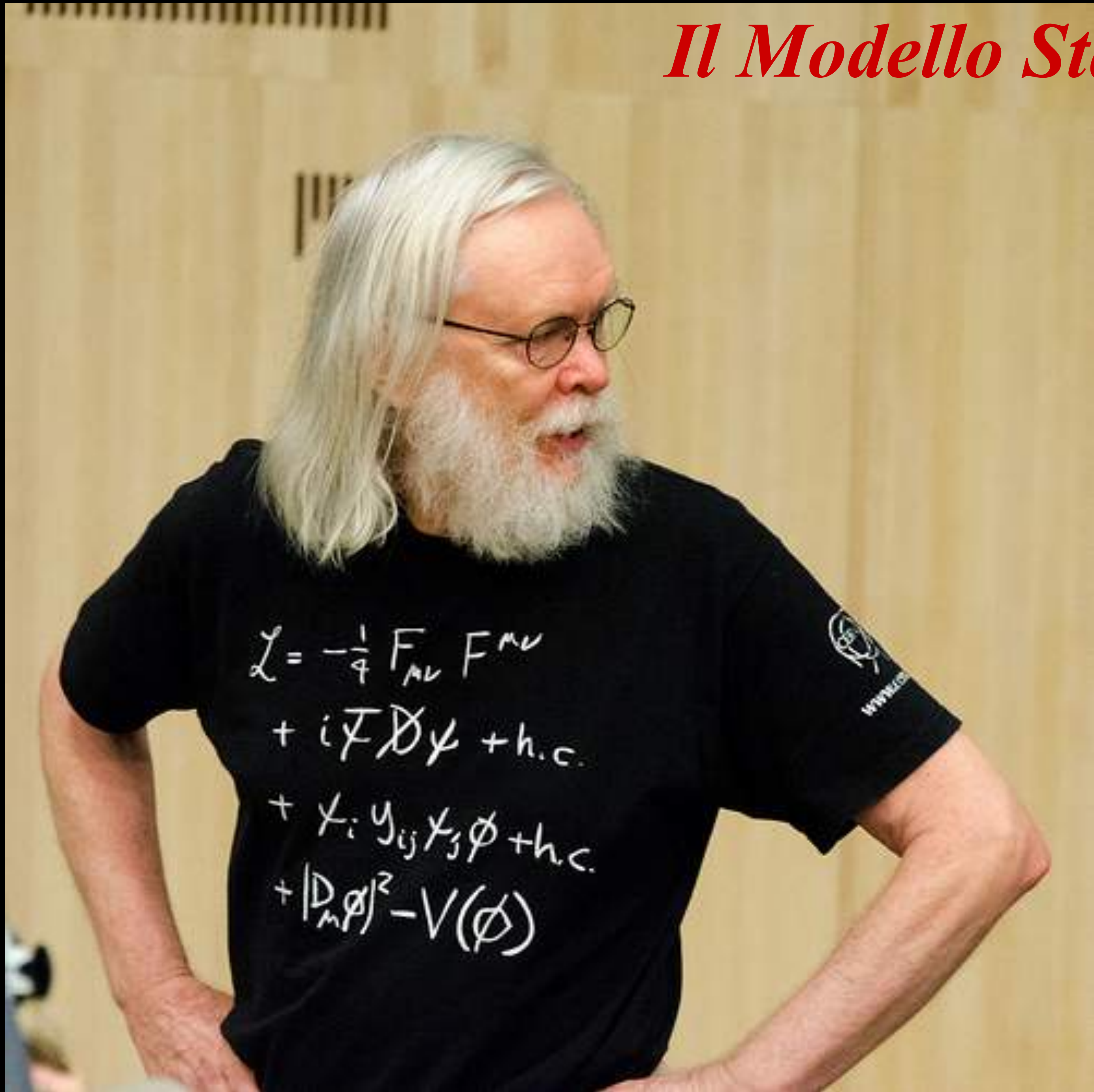
[Thanks to F. Alessio, A. Carbone, R. Forty, J. Rademacker for some material]


Vladstudio

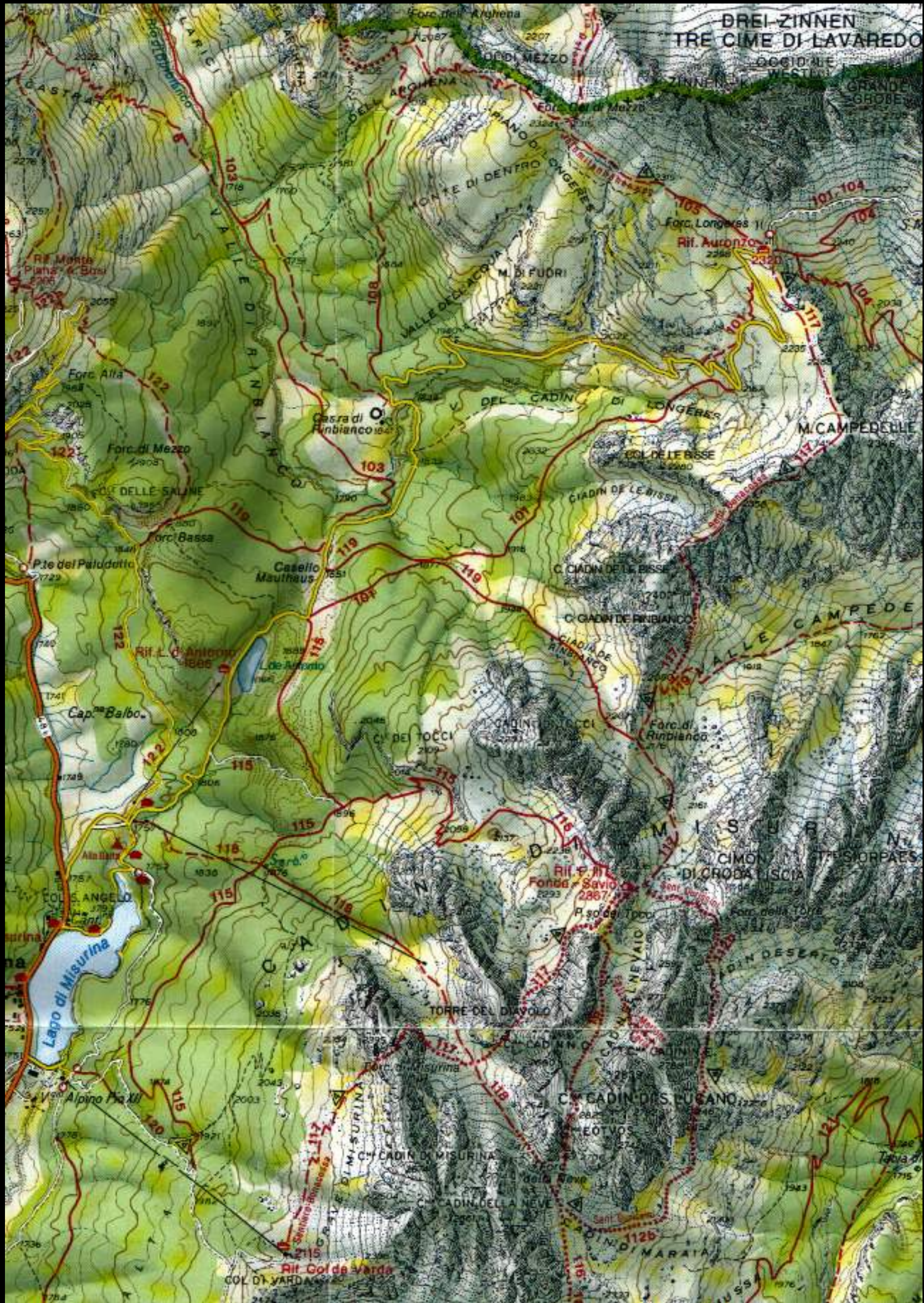


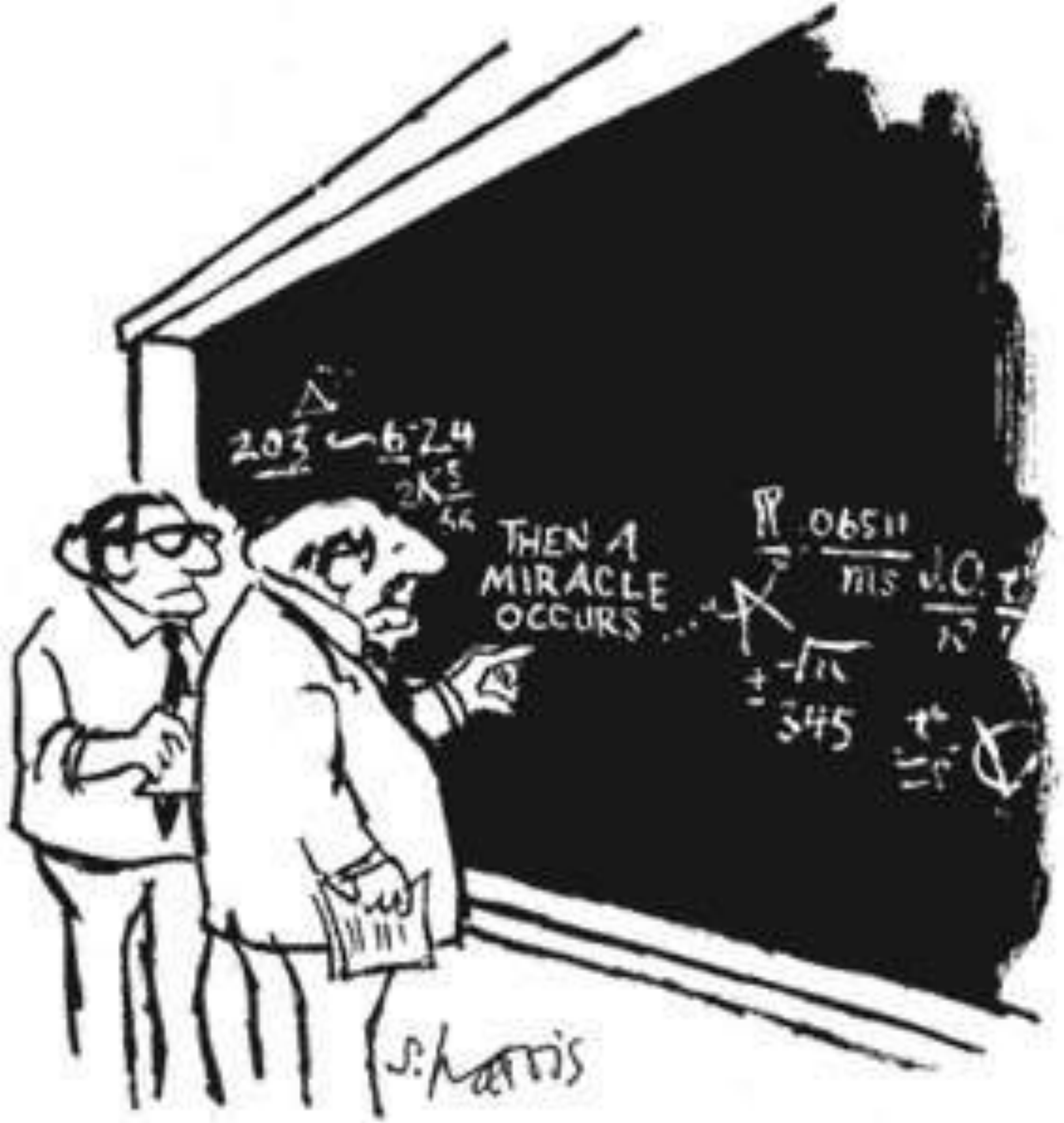
PDG 2014:
Materia ordinaria 5%
Materia oscura 27%
Energia oscura 68%

Il Modello Standard



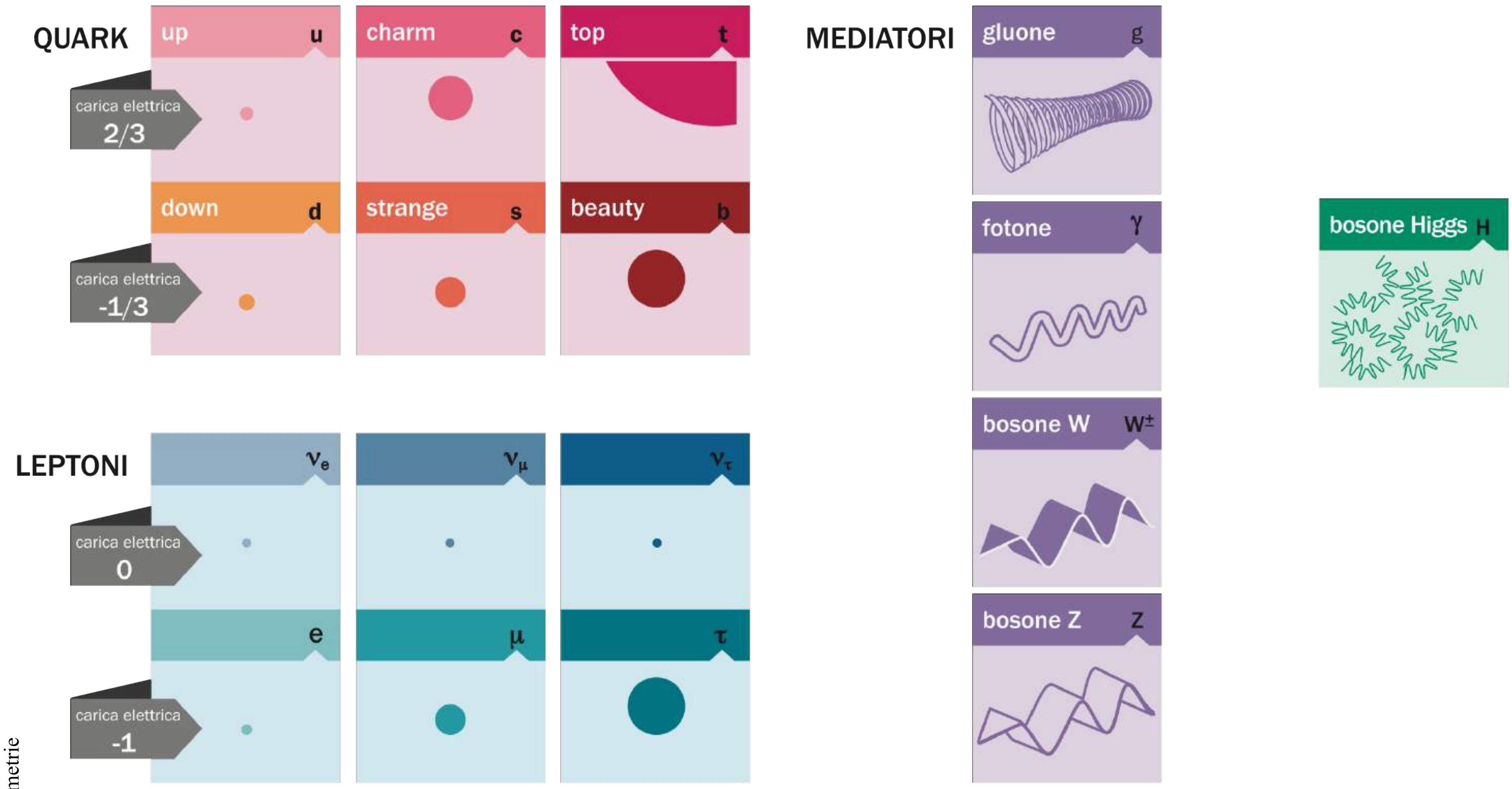
Il Modello Standard


DREI ZINNEN
TRE CIME DI LAVAREDO
Rif. Auronzo
Forc. Longeres
M. CAMPEDELLE
Forc. Alta
Forc. di Mezzo
Forc. Bassa
P.te del Paludetto
Rif. L. d'Antorno
Cap.na Balbo
C. CADIN DE LE BISSE
C. CADIN DE RINBIANCO
Lago di Misurina
TORRE DEL DIAVOLO
Rif. Col de Varda
COL DI VARDA



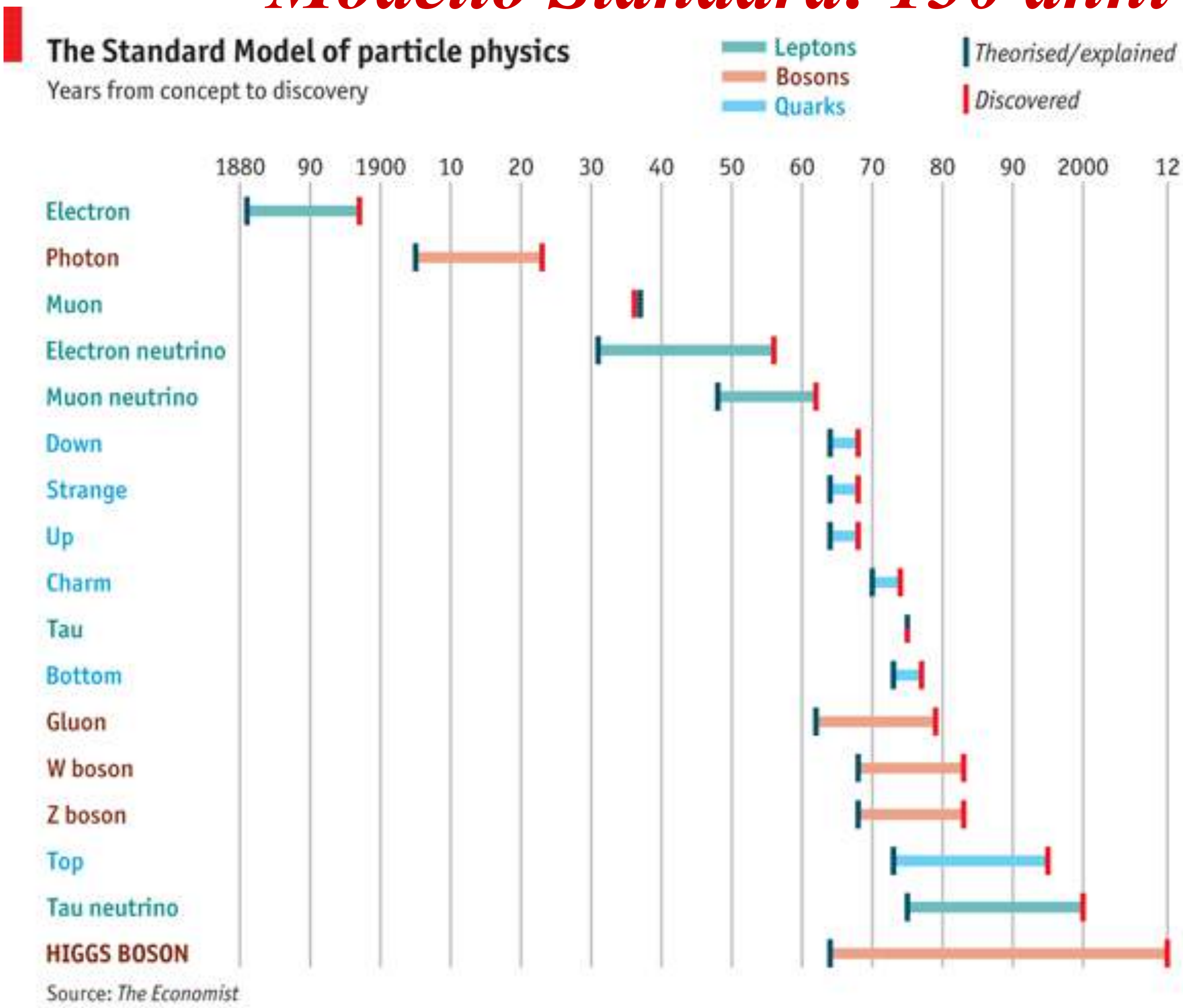
"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Modello Standard



Credits: Asimmetrie

Modello Standard: 130 anni di scoperte

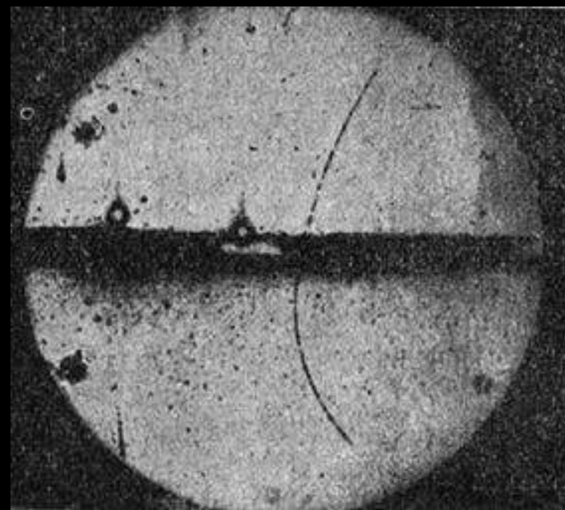


Antimateria

Dirac

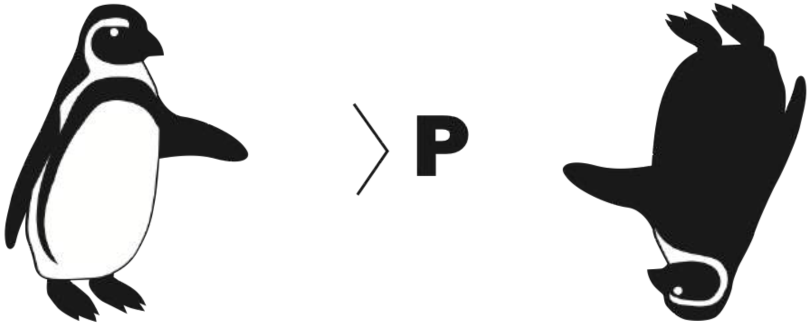
$$(i\gamma^\mu \partial_\mu - m)\psi = 0$$

Anderson



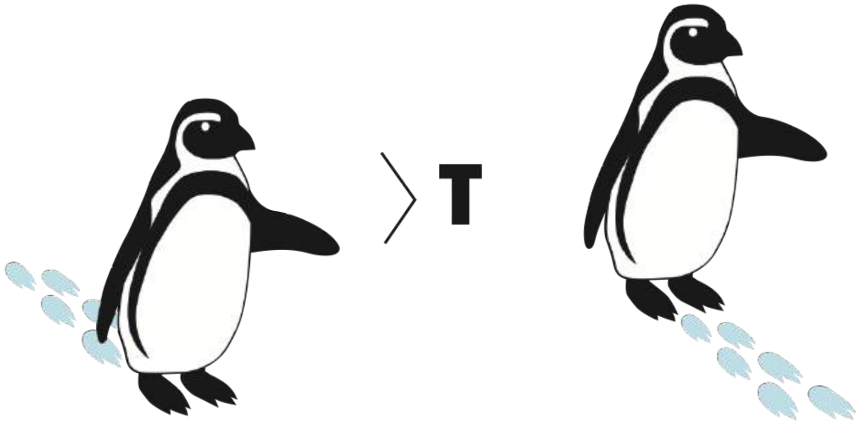
Credits: Asimmetrie

Simmetrie discrete



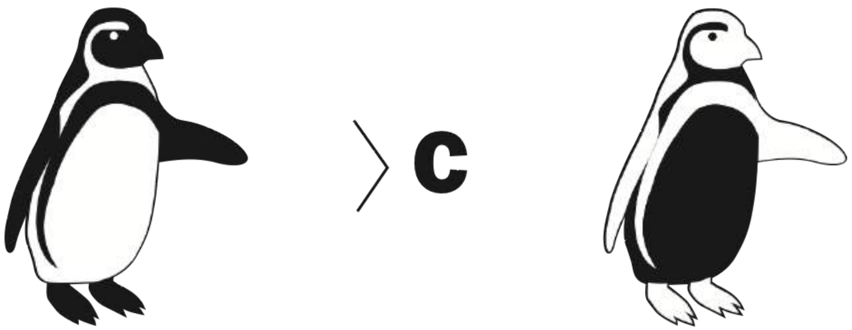
Trasformazione P

Le tre direzioni spaziali sono tutte invertite contemporaneamente.



Trasformazione T

La direzione del tempo (e quindi del moto) è invertita.



Trasformazione C

Tutte le particelle sono trasformate in antiparticelle e viceversa.

PROPOSAL FOR K^o_2 DECAY AND INTERACTION EXPERIMENT

J. W. Cronin, V. L. Fitch, R. Turlay

(April 10, 1963)

I. INTRODUCTION

The present proposal was largely stimulated by the recent anomalous results of Adair et al., on the coherent regeneration of K^o_1 mesons. It is the purpose of this experiment to check these results with a precision far transcending that attained in the previous experiment. Other results to be obtained will be a new and much better limit for the partial rate of $K^o_2 \to \pi^+ + \pi^-$, a new limit for the presence (or absence) of neutral currents as observed through $K_2 \to \mu^+ + \mu^-$. In addition, if time permits, the coherent regeneration of K_1's in dense materials can be observed with good accuracy.

II. EXPERIMENTAL APPARATUS

Fortuitously the equipment of this experiment already exists in operating condition. We propose to use the present 30° neutral beam at the A.G.S. along with the di-pion detector and hydrogen target currently being used by Cronin, et al. at the Cosmotron. We further propose that this experiment be done during the forthcoming μ-p scattering experiment on a parasitic basis.

The di-pion apparatus appears ideal for the experiment. The energy resolution is better than 4 Mev in the m^* or the Q value measurement. The origin of the decay can be located to better than 0.1 inches. The 4 Mev resolution is to be compared with the 20 Mev in the Adair bubble chamber. Indeed it is through the greatly improved resolution (coupled with better statistics) that one can expect to get improved limits on the partial decay rates mentioned above.

Simmetria CP

III. COUNTING RATES

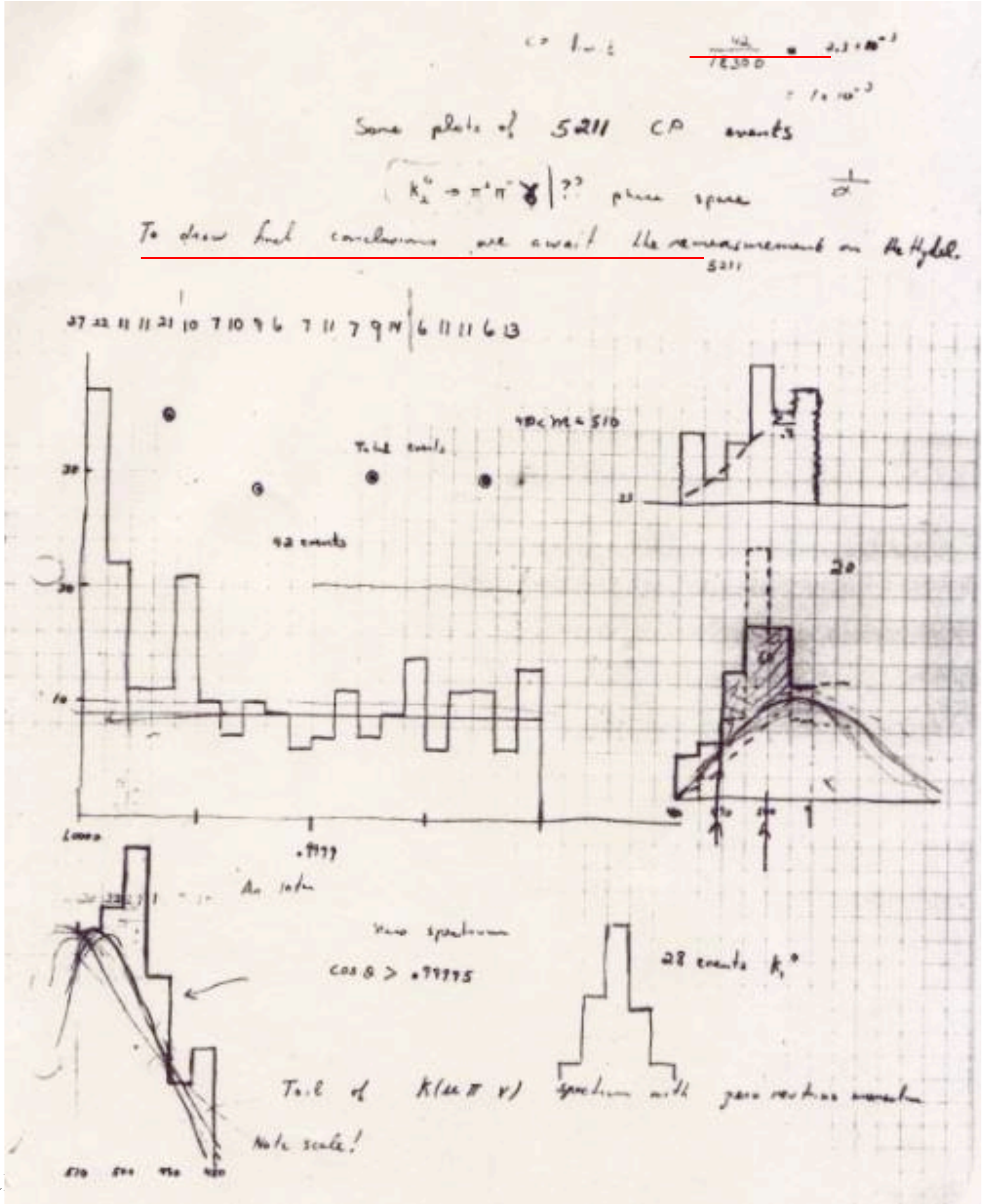
We have made careful Monte Carlo calculations of the counting rates expected. $\boxed{\text{For example, using the 30° beam with the detector 60-ft. from the A.G.S. target we could expect 0.6 decay events per } 10^{11} \text{ circulating protons if the } K_2 \text{ went entirely to two pions.}}$ This means that one can set a limit of about one in a thousand for the partial rate of $K_2 \to 2\pi$ in one hour of operation. The actual limit is set, of course, by the number of three-body K_2 decays that look like two-body decays. We have not as yet made detailed calculations of this. However, it is certain that the excellent resolution of the apparatus will greatly assist in arriving at a much better limit.

If the experiment of Adair, et al. is correct the rate of coherently regenerated K_1's in hydrogen will be approximately 80/hour. This is to be compared with a total of 20 events in the original experiment. The apparatus has enough angular acceptance to detect incoherently produced K_1's with uniform efficiency to beyond 15°. We emphasize the advantage of being able to remove the regenerating material (e.g., hydrogen) from the neutral beam.

IV. POWER REQUIREMENTS

The power requirements for the experiment are extraordinarily modest. We must power one 18-in. x 36-in. magnet for sweeping the beam of charged particles. The two magnets in the di-pion spectrometer are operated in series and use a total of 20 kw.

Simmetria CP



Simmetria CP

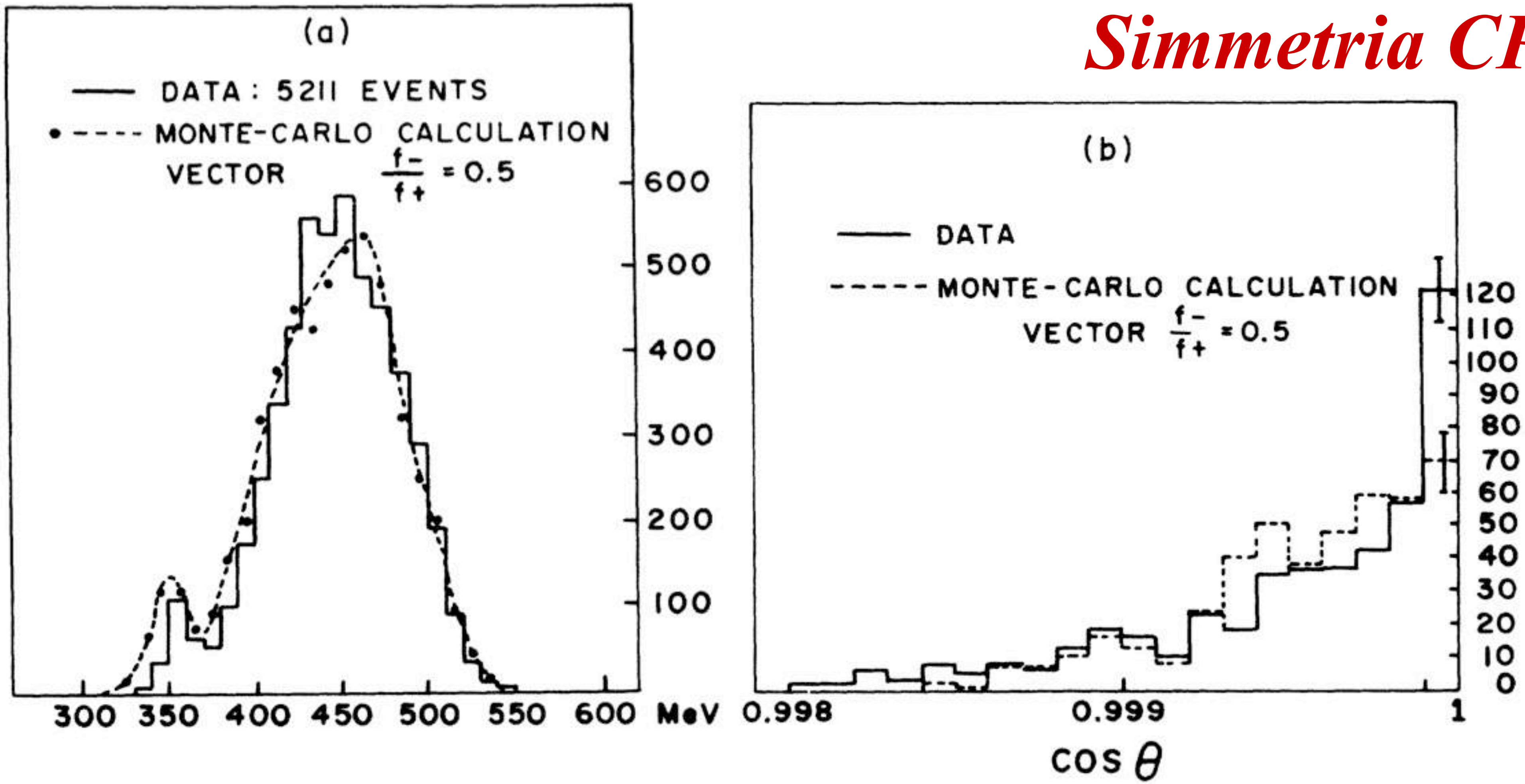
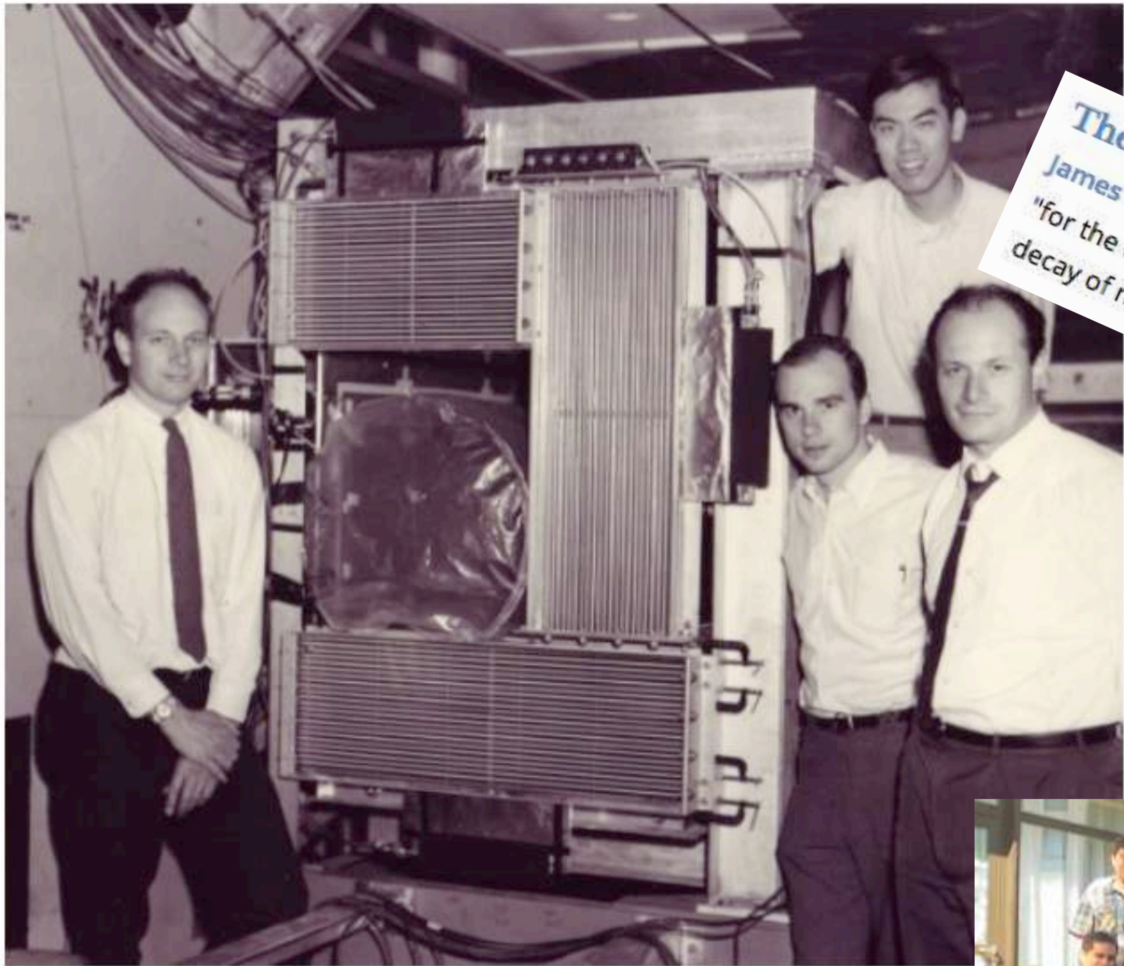
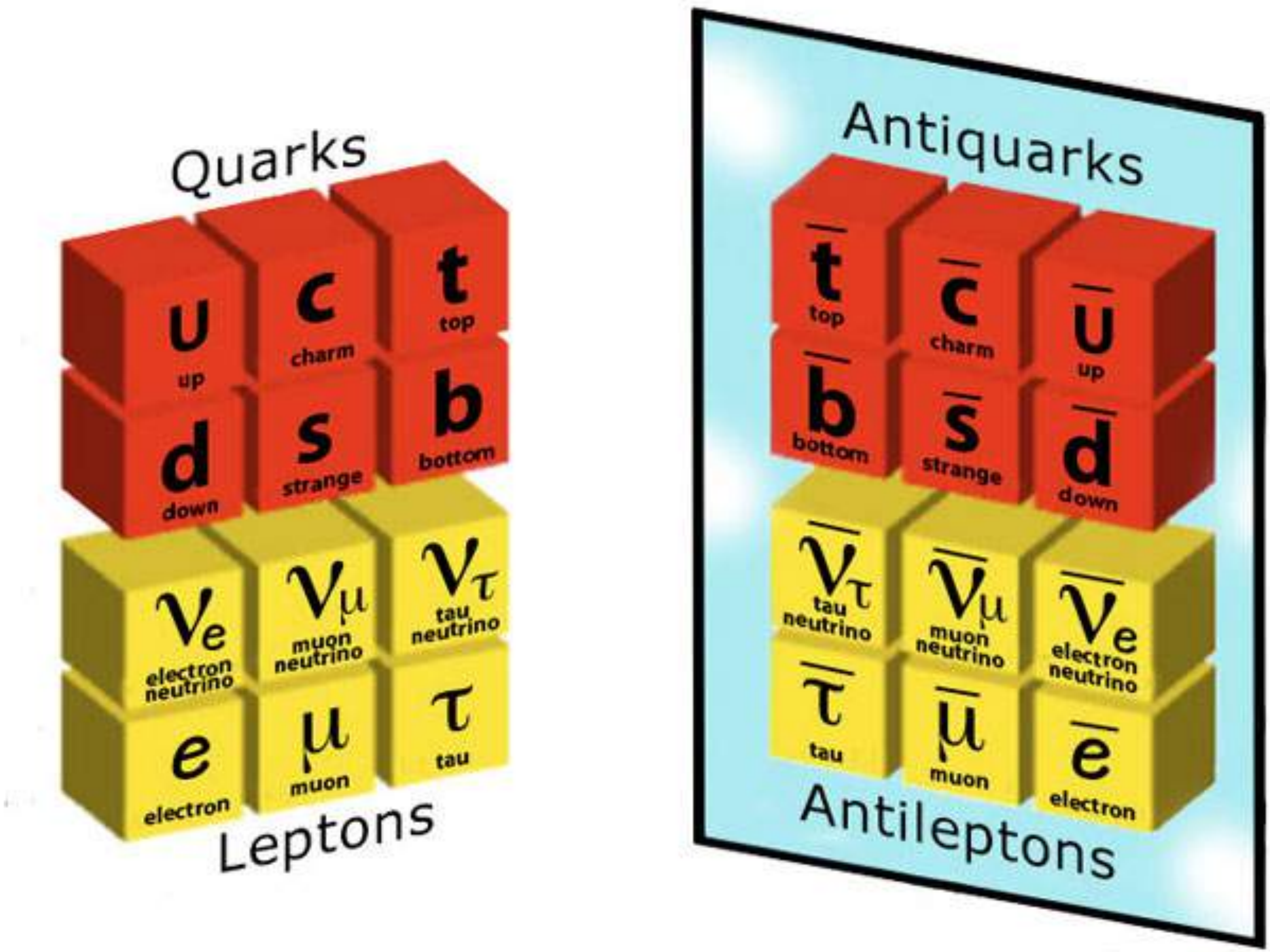


FIG. 2. (a) Experimental distribution in m^* compared with Monte Carlo calculation. The calculated distribution is normalized to the total number of observed events. (b) Angular distribution of those events in the range $490 < m^* < 510$ MeV. The calculated curve is normalized to the number of events in the complete sample.

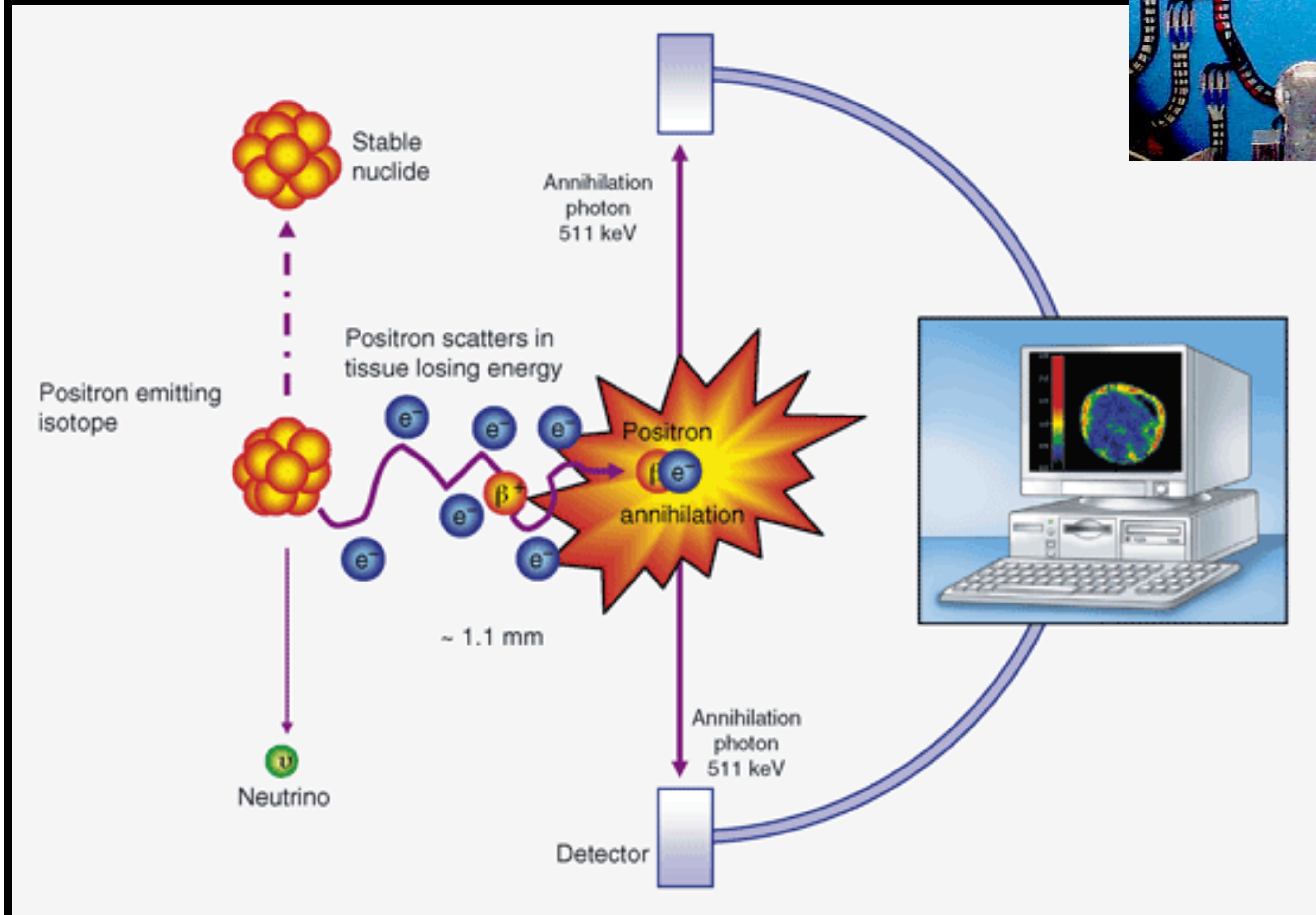
Simmetria CP

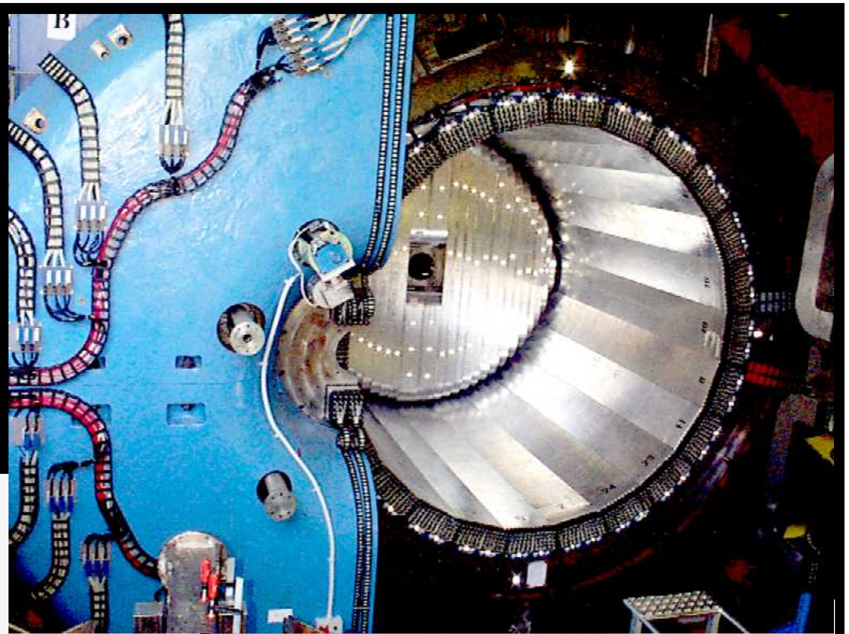


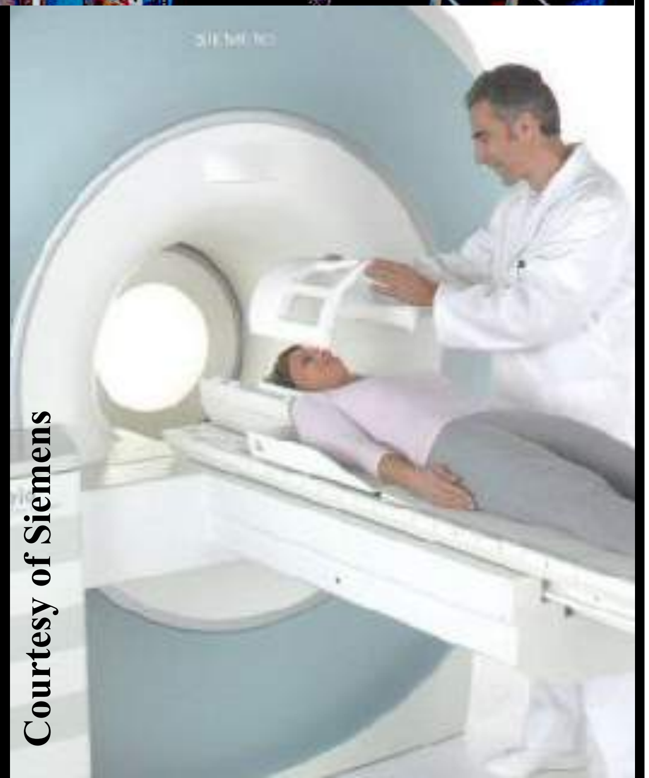
The Nobel Prize in Physics 1980
James Watson Cronin and Val Logsdon Fitch
"for the discovery of violations of fundamental symmetry principles in the decay of neutral K-mesons"


Quarks
u
up
c
charm
t
top
d
down
s
strange
b
bottom
ν_e
electron neutrino
ν_μ
muon neutrino
ν_τ
tau neutrino
e
electron
μ
muon
τ
tau
Leptons
Antiquarks
$\bar{t}$
top
$\bar{c}$
charm
$\bar{u}$
up
$\bar{b}$
bottom
$\bar{s}$
strange
$\bar{d}$
down
$\bar{\nu}_\tau$
tau neutrino
$\bar{\nu}_\mu$
muon neutrino
$\bar{\nu}_e$
electron neutrino
$\bar{\tau}$
tau
$\bar{\mu}$
muon
$\bar{e}$
electron
Antileptons

Positron Emission Tomography (PET)

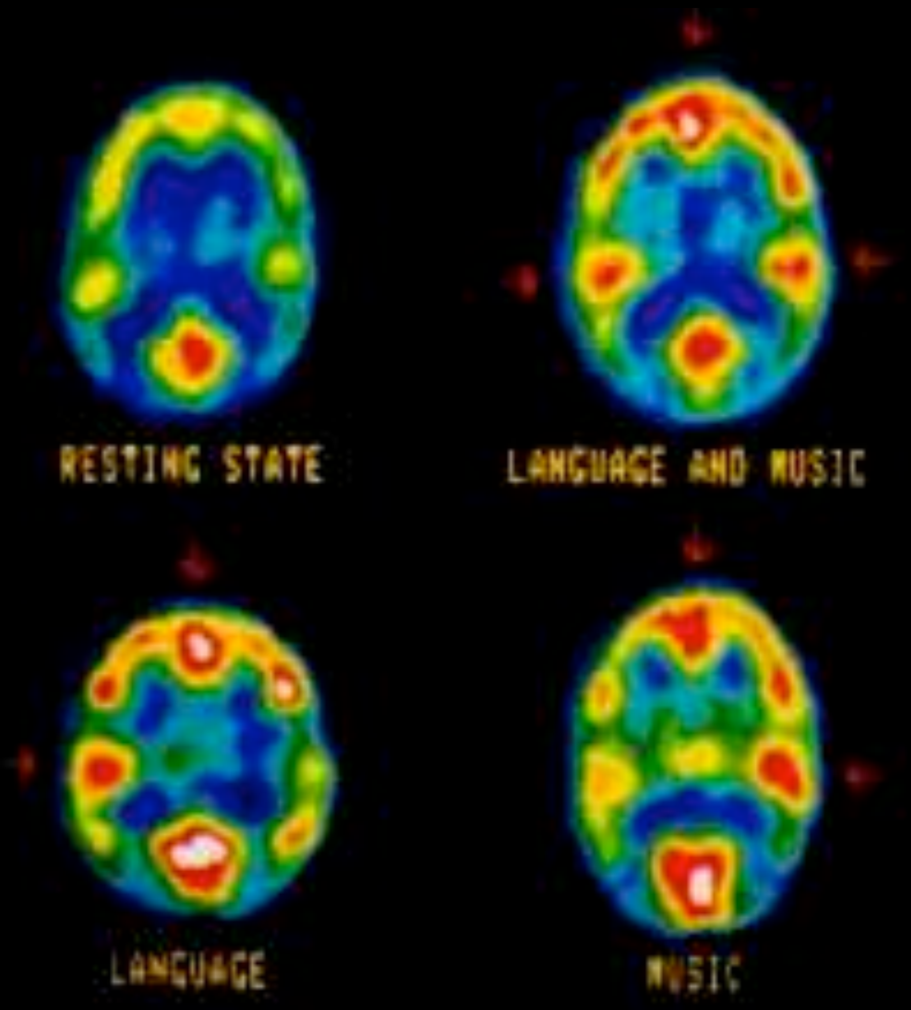


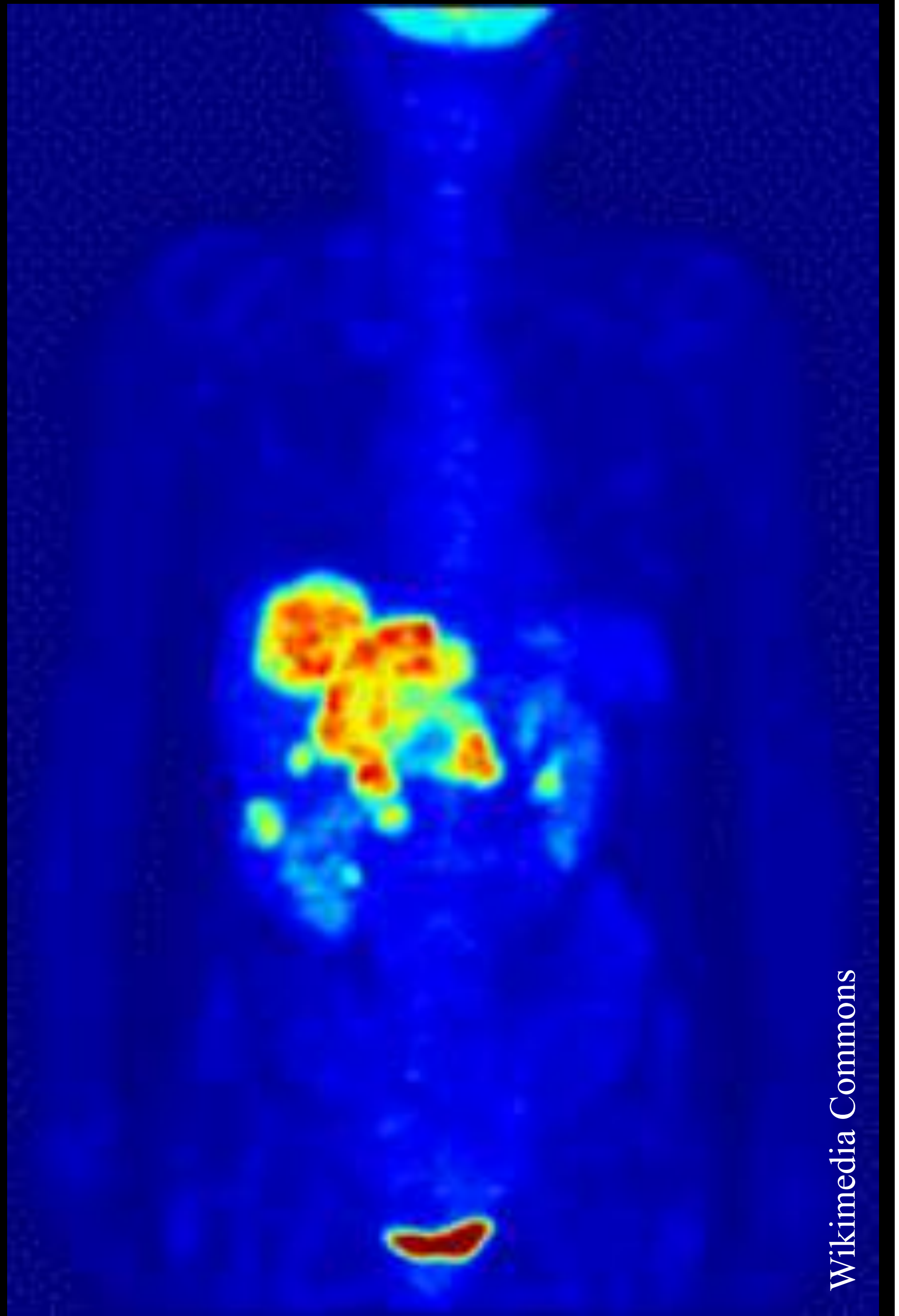




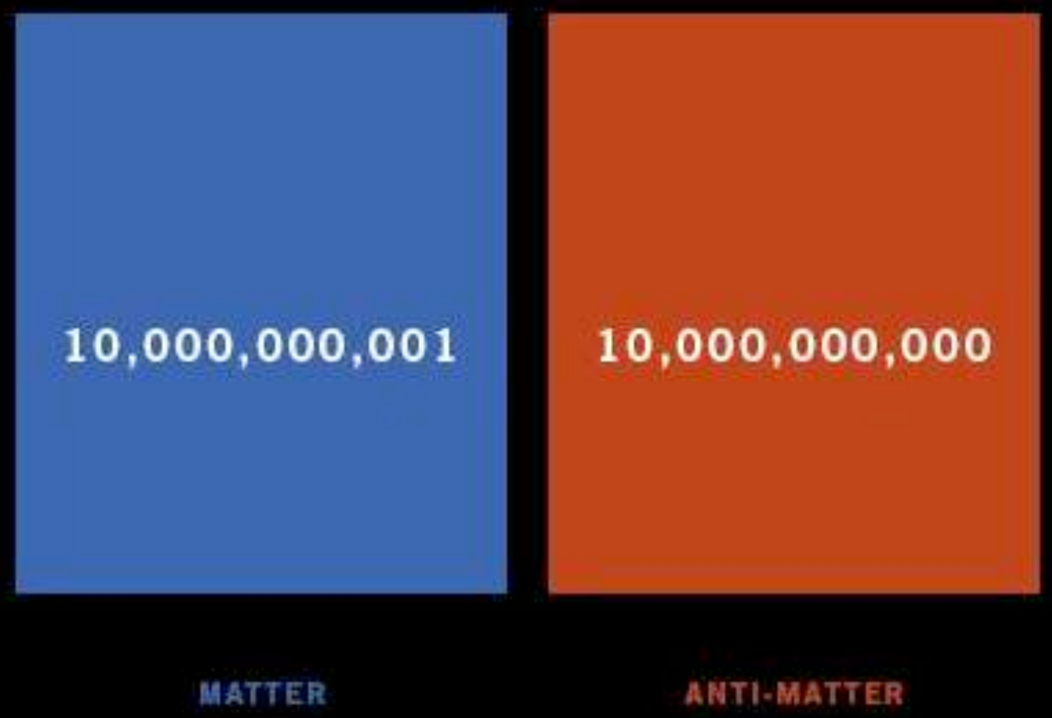
Courtesy of Siemens

PET


RESTING STATE
LANGUAGE AND MUSIC
LANGUAGE
MUSIC


Wikimedia Commons

Materia e Antimateria

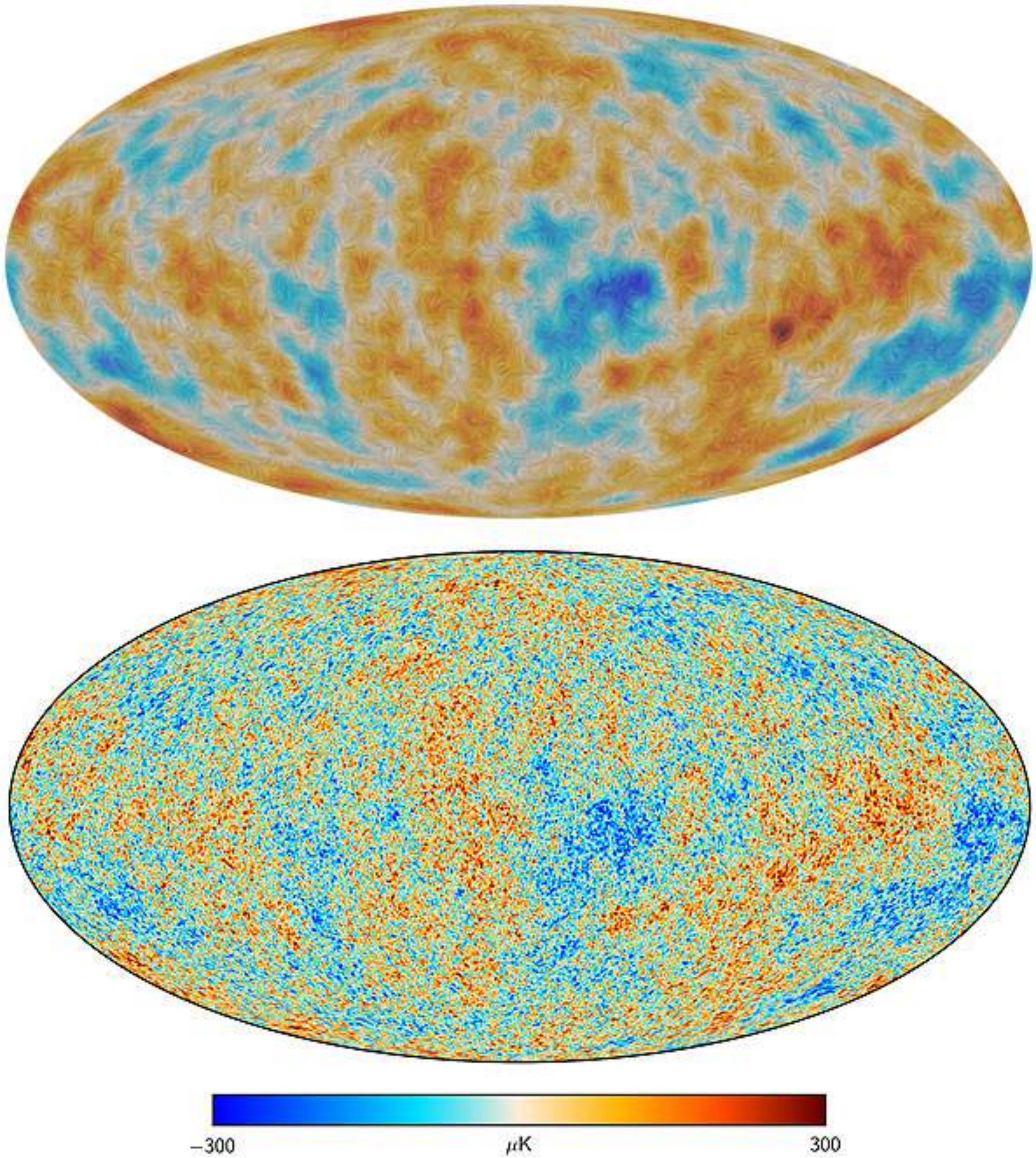


Credits: Hitoshi Murayama

Materia e Antimateria

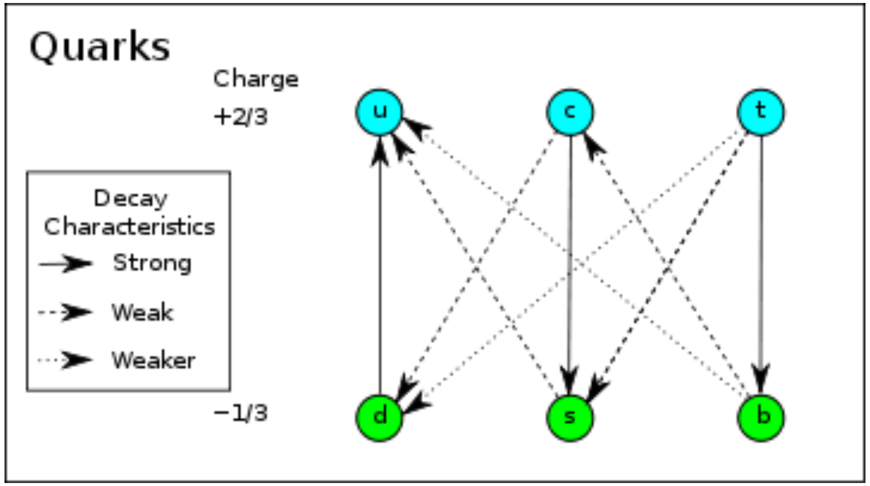
Credits: Hitoshi Murayama

CBR

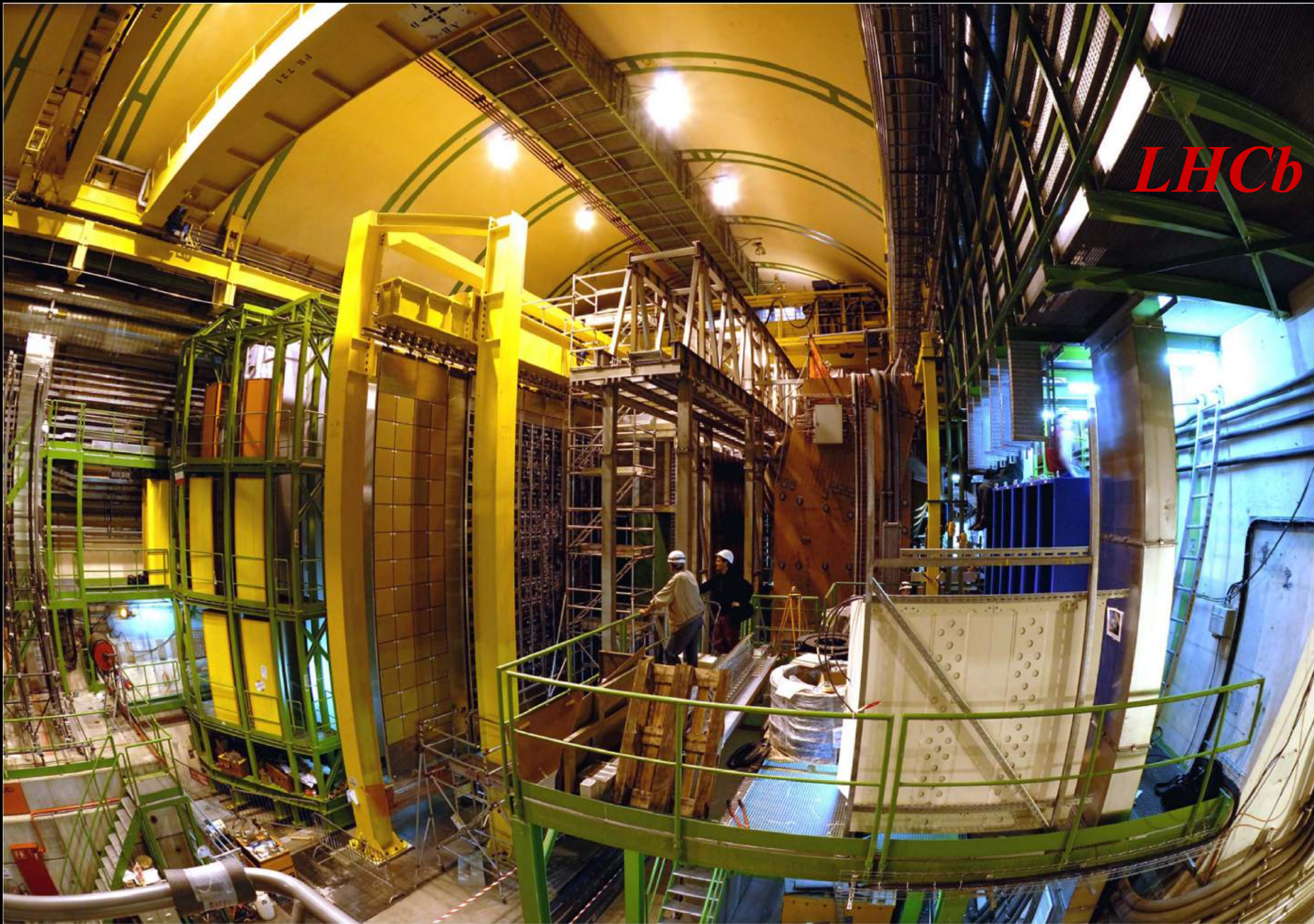


Matrice CKM

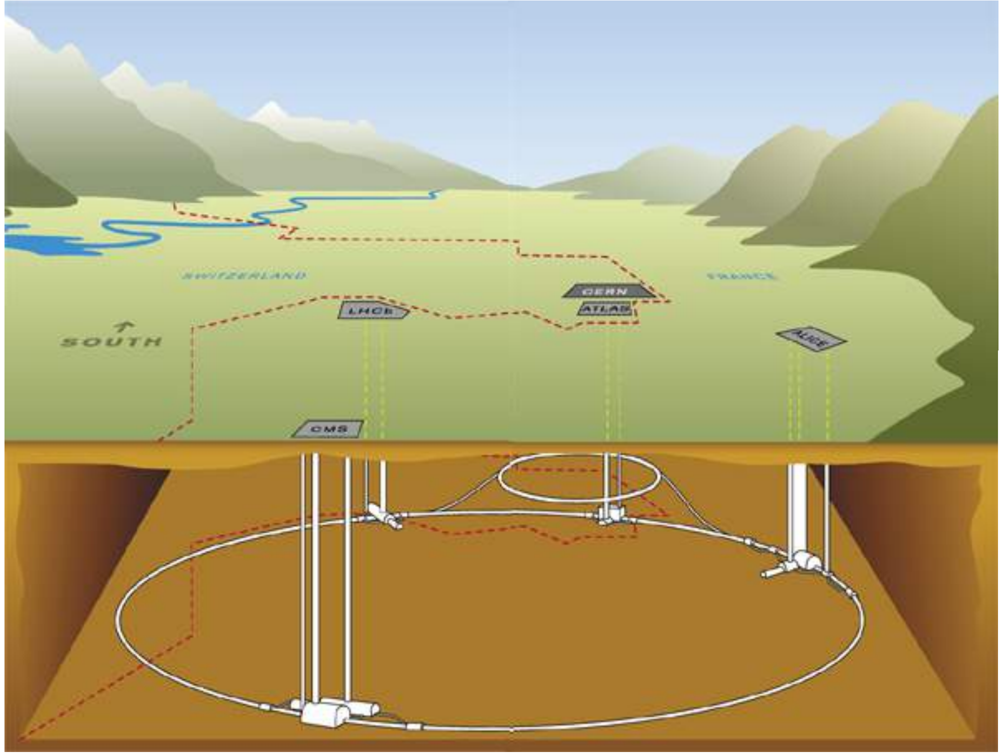
$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} \equiv \hat{V}_{\mathrm{CKM}} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

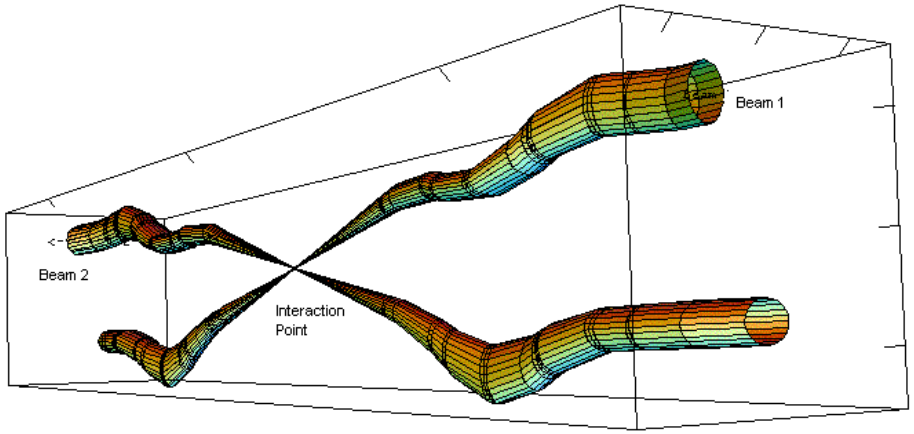


$$V = \begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

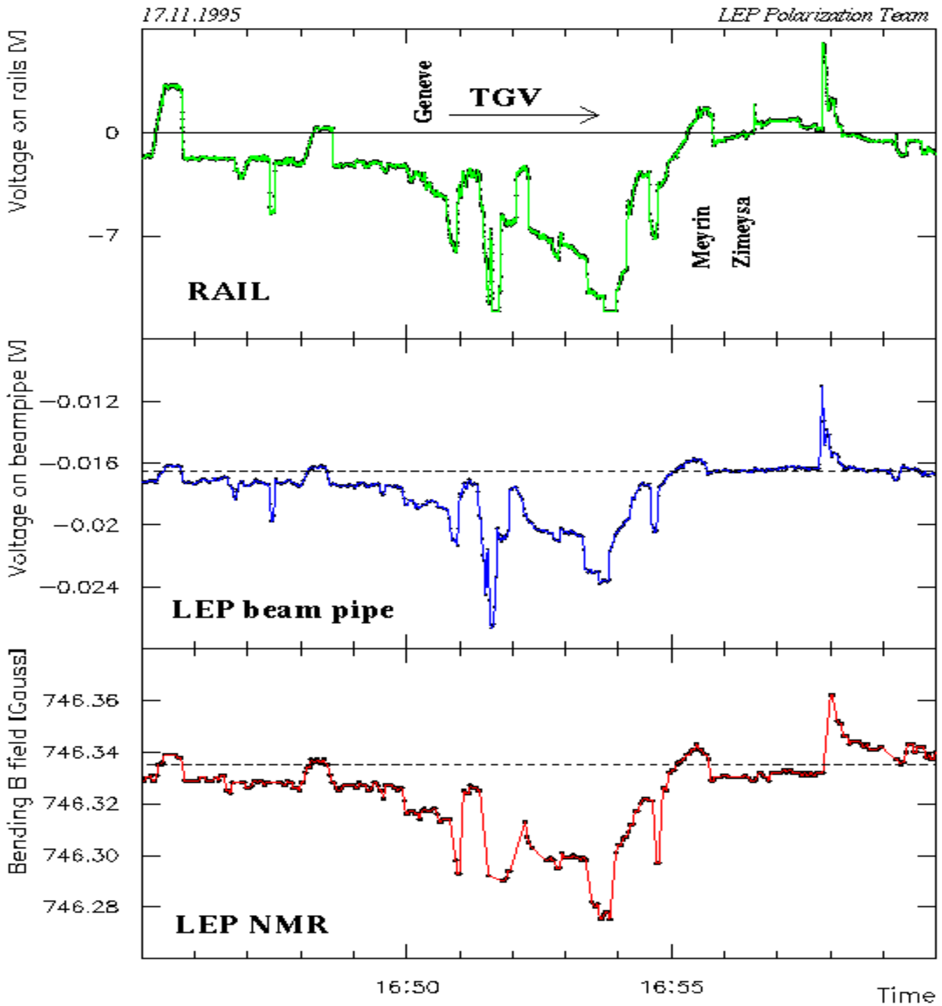

LHCb

LEP e LHC @ CERN



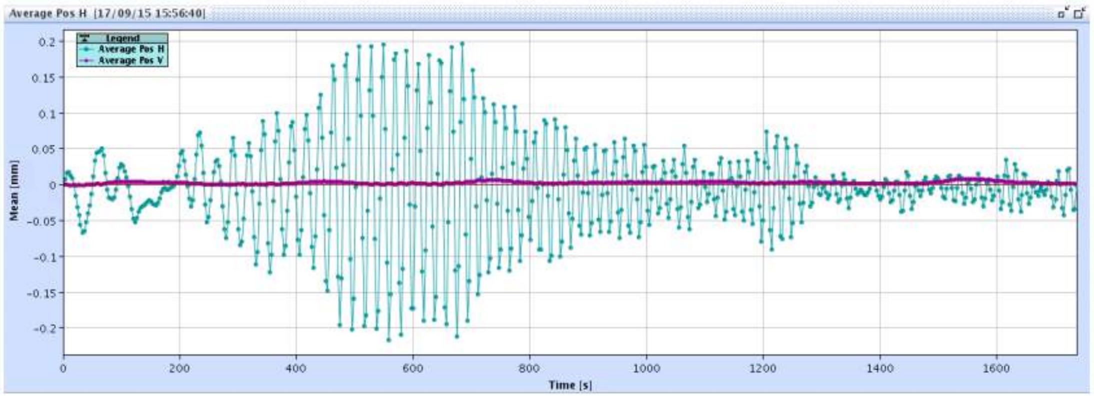


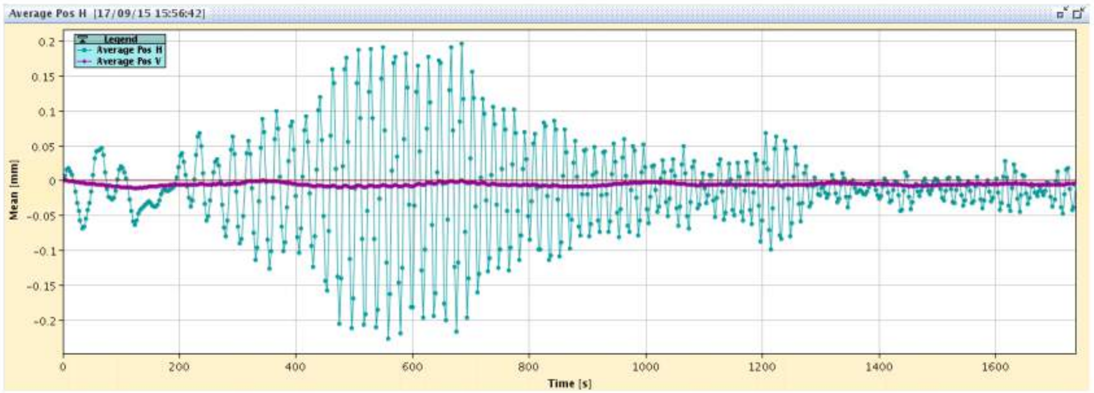
Relative beam sizes around IP1 (Atlas) in collision



Earthquakes in Chile

- LHC radial orbit change between **01:45** and **02:15 (23:45-24:15 UTC)**. LHC at injection energy. Radial amplitude is large (3 times larger than Costa Rica event, 200 microns).
- Roughly 1 hour after the 8.3M quake, which roughly fits a simple estimate based on a distance of 12'000 km at a speed of 4 km/s.





Period is ~ 25 seconds.

8.3 magnitude earthquake 46 km from Illapel, Coquimbo, Chile

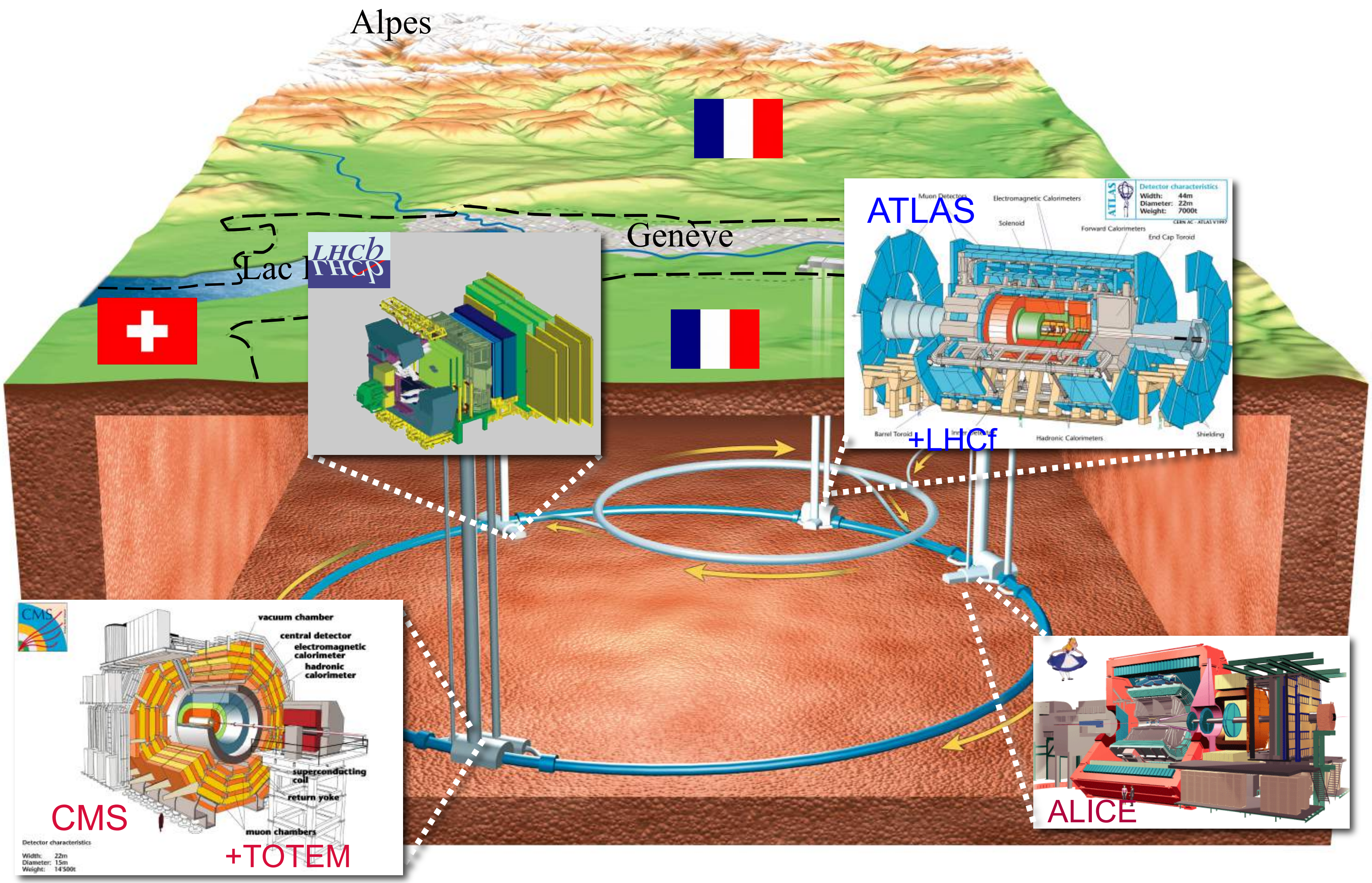
about 14 hours ago

UTC time: Wednesday, September 16, 2015 22:54 PM
Your time: Thursday, September 17 2015 12:54 AM
Magnitude Type: mww
USGS page: M 8.3 - 46km W of Illapel, Chile
USGS status: Reviewed by a seismologist
Reports from the public: 994 people

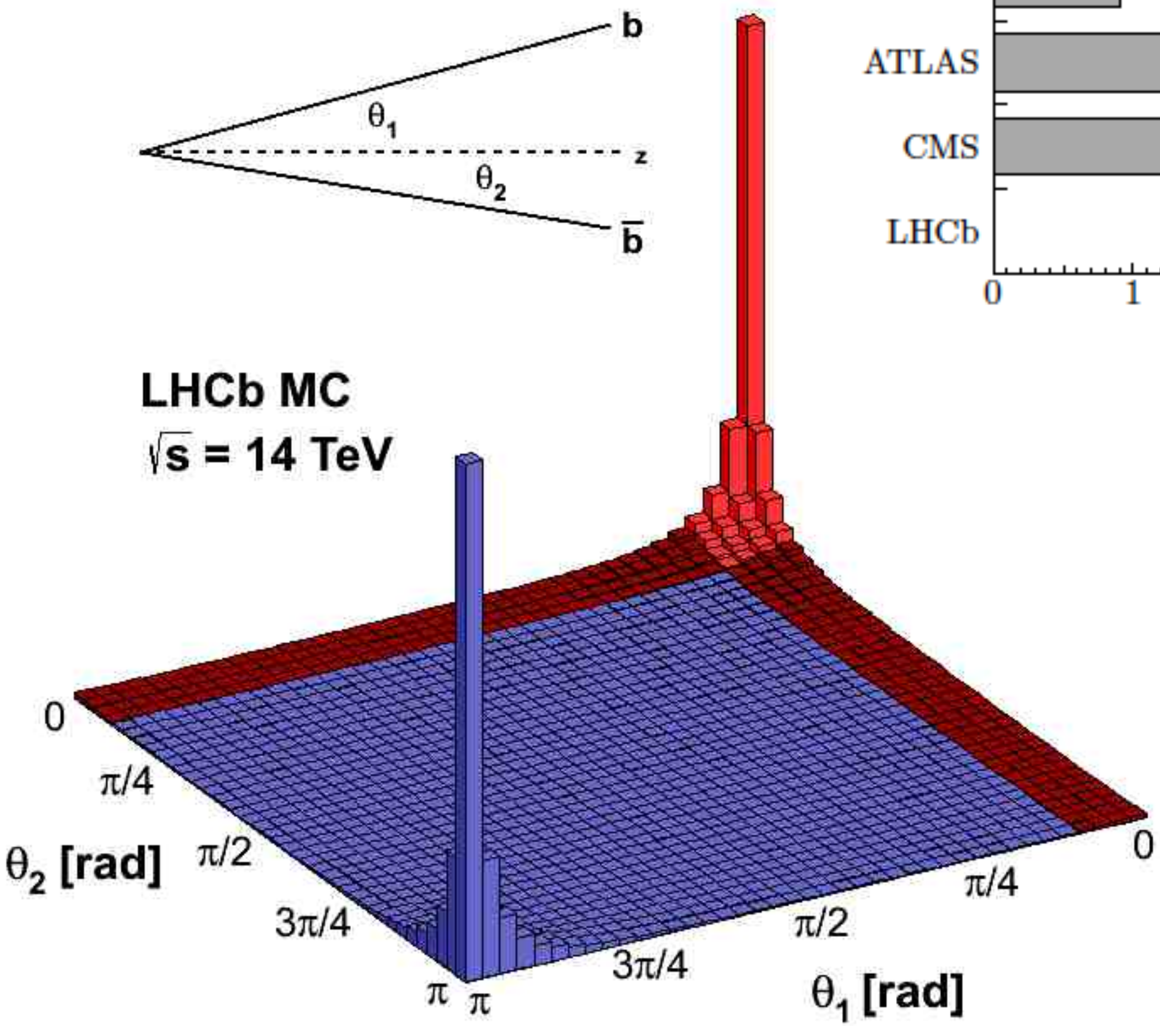
J.Wenninger

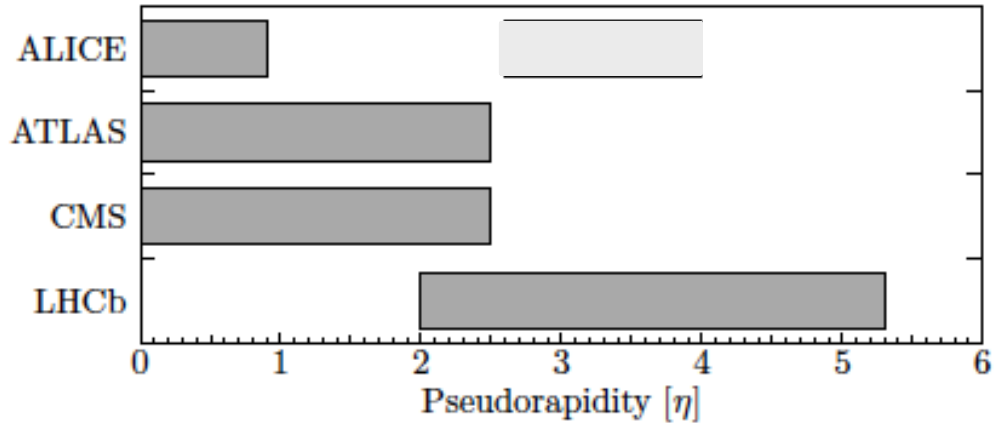
S. Redaelli, LMC meeting, 23-09-2015 21

LHC @ CERN

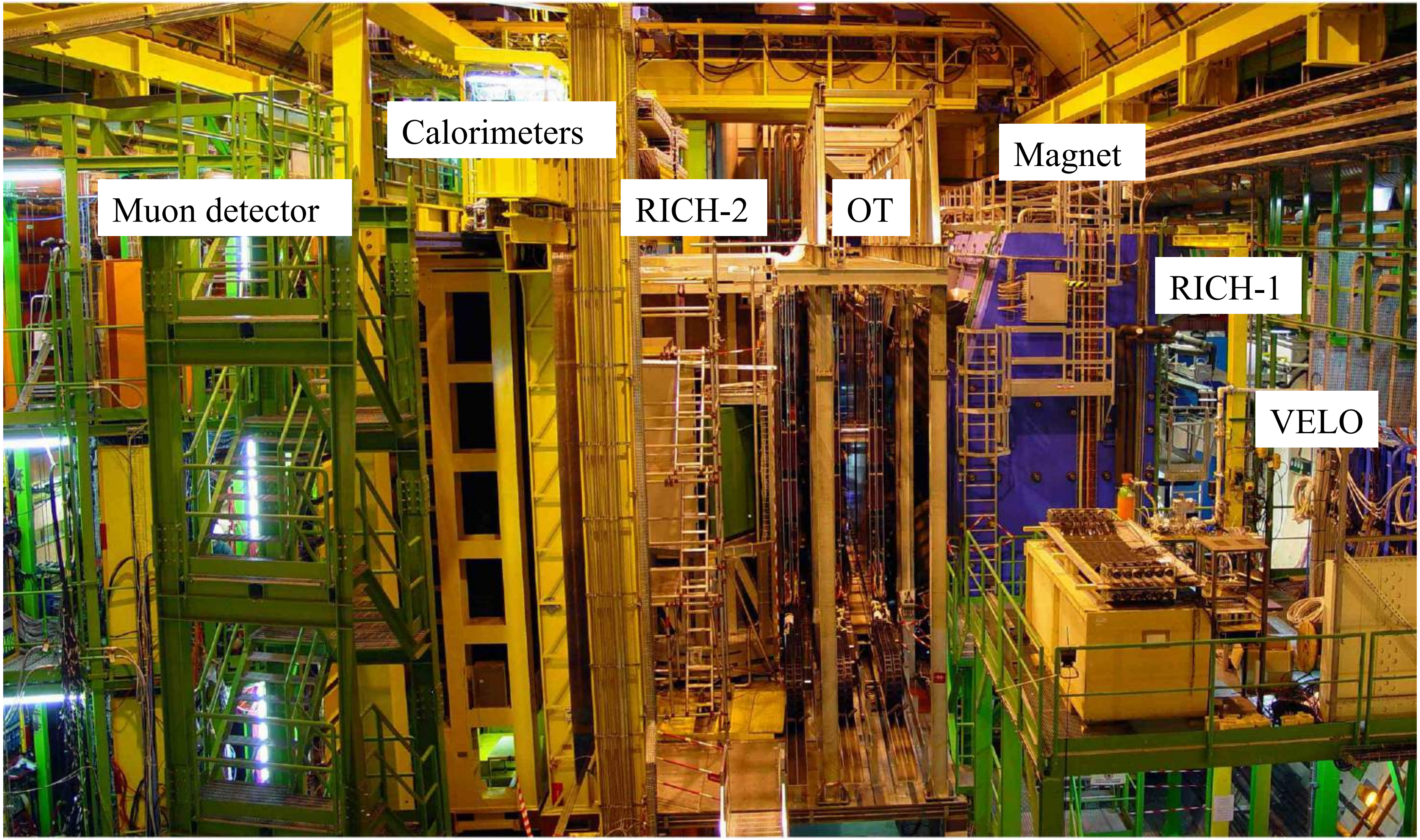


Alpes
Genève
Lac
LHCb
ATLAS
+LHCf
CMS
+TOTEM
ALICE
vacuum chamber
central detector
electromagnetic calorimeter
hadronic calorimeter
superconducting coil
return yoke
muon chambers

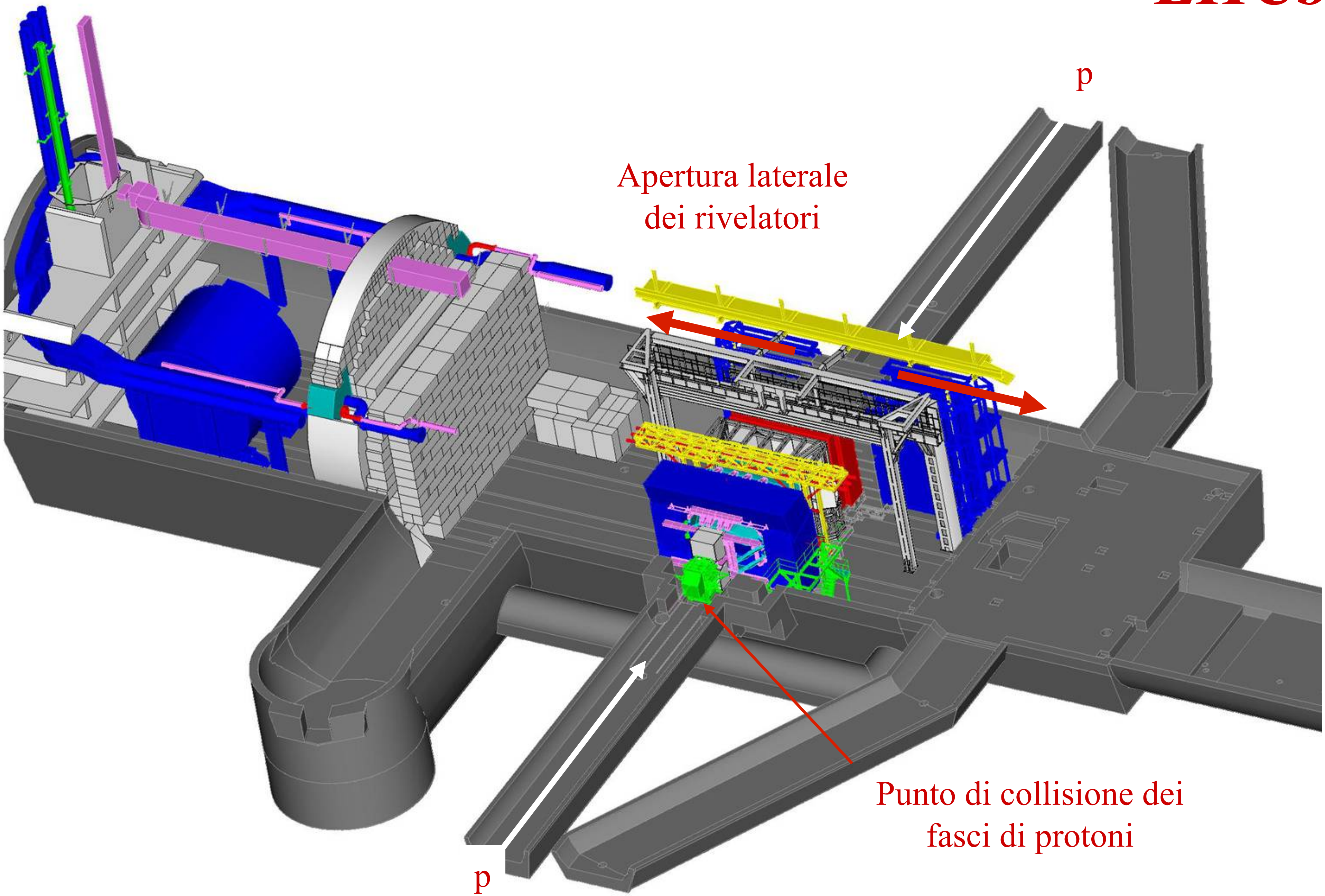

b
θ1
z
θ2
b̄
LHCb MC
√s = 14 TeV
0
π/4
θ2 [rad]
π/2
3π/4
π
π
3π/4
π/2
π/4
0
θ1 [rad]


ALICE
ATLAS
CMS
LHCb
0
1
2
3
4
5
6
Pseudorapidity [η]

LHCb

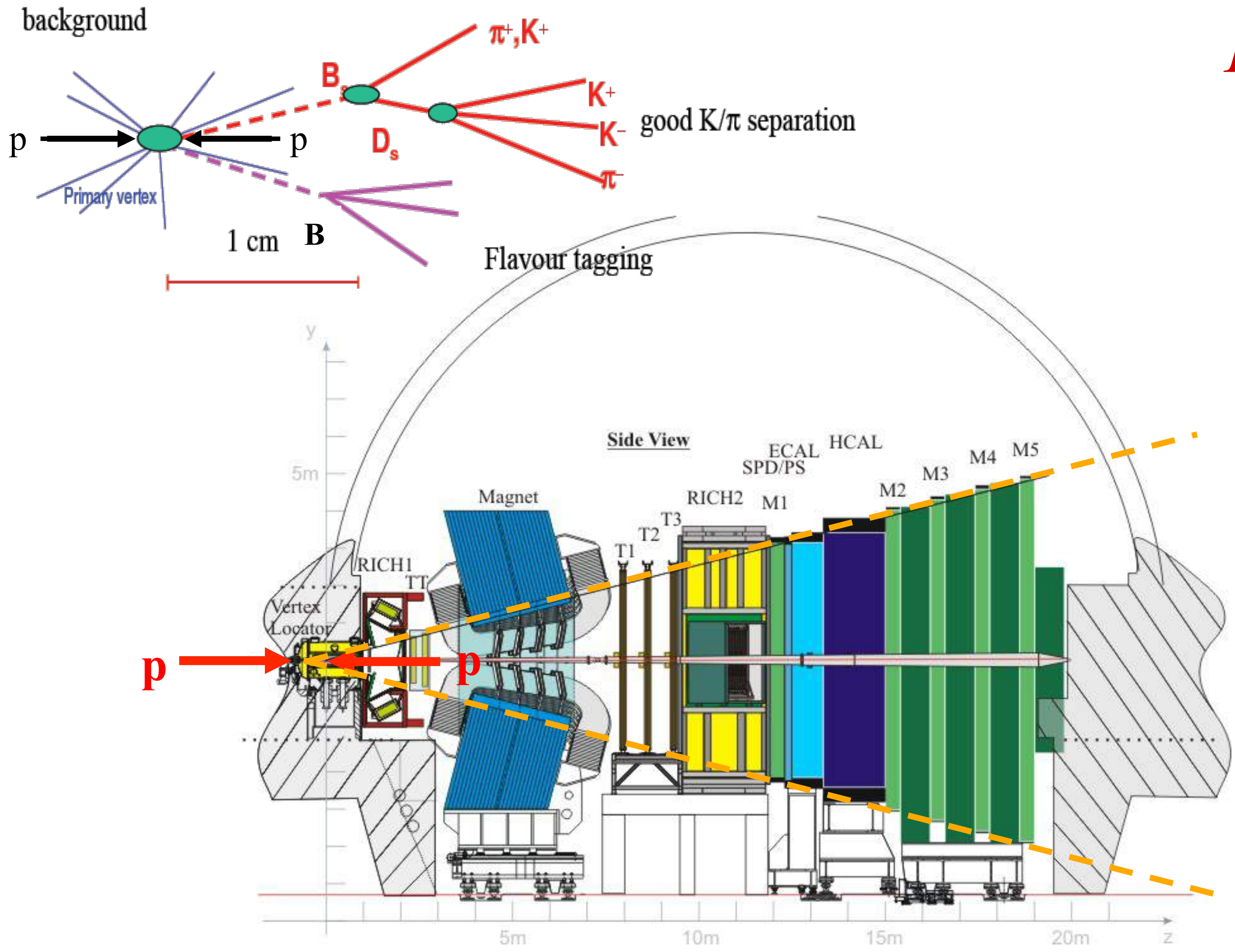


LHCb


p
Apertura laterale
dei rivelatori
Punto di collisione dei
fasci di protoni
p

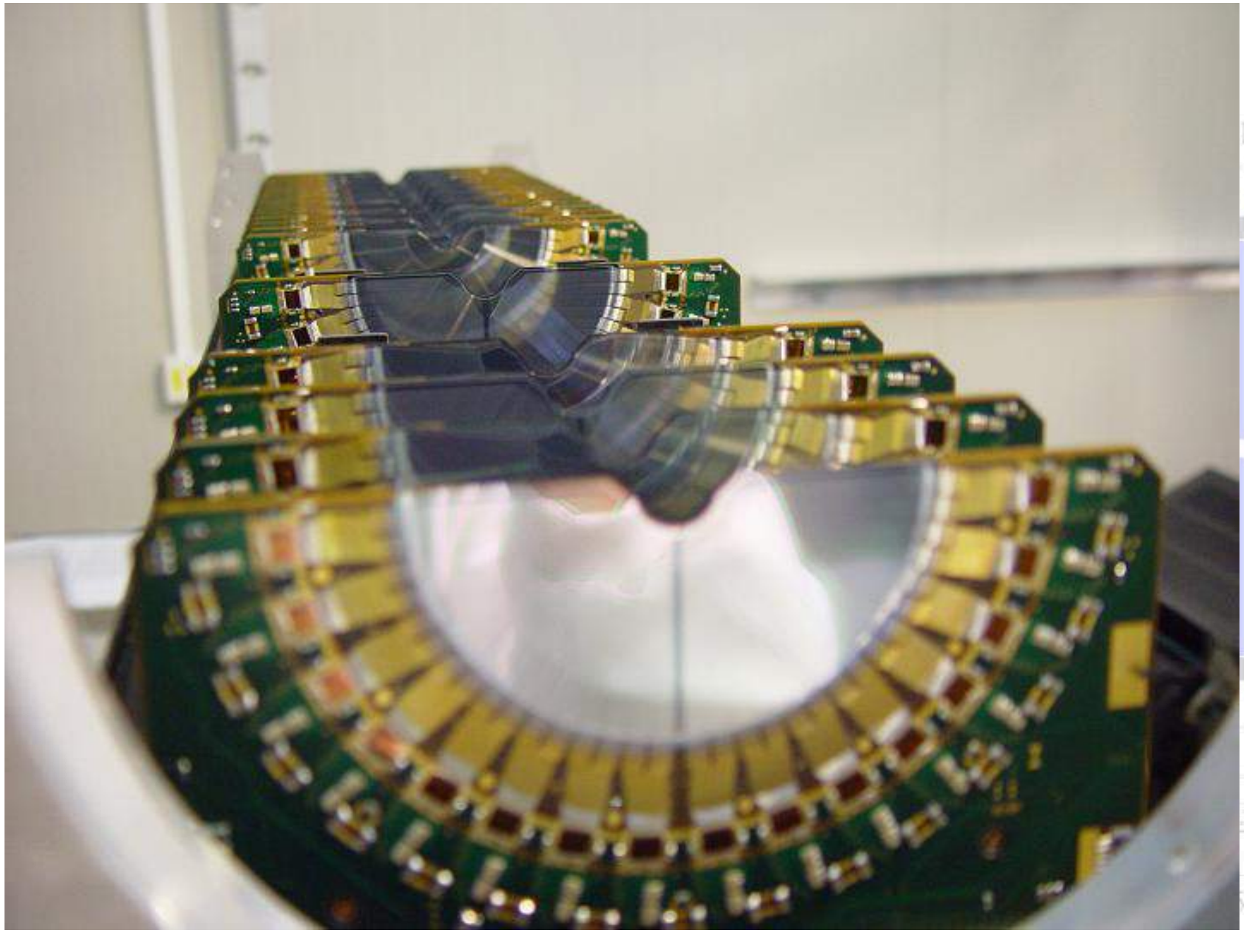
LHC per la prima volta a 13 TeV

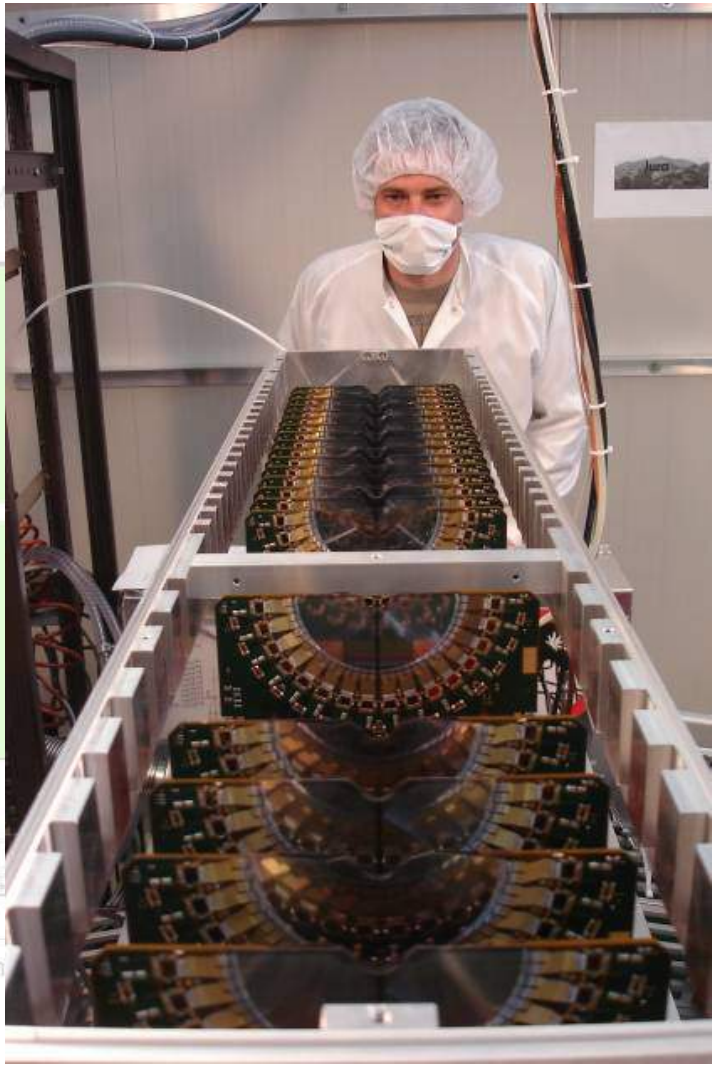
LHCb


background
p
p
Primary vertex
B_s
D_s
π^+, K^+
K^+
K^-
π^-
good K/π separation
1 cm
B
Flavour tagging
Side View
Magnet
RICH1
TT
Vertex Locator
T1
T2
T3
RICH2
M1
SPD/PS
ECAL
HCAL
M2
M3
M4
M5
5m
10m
15m
20m
y
z

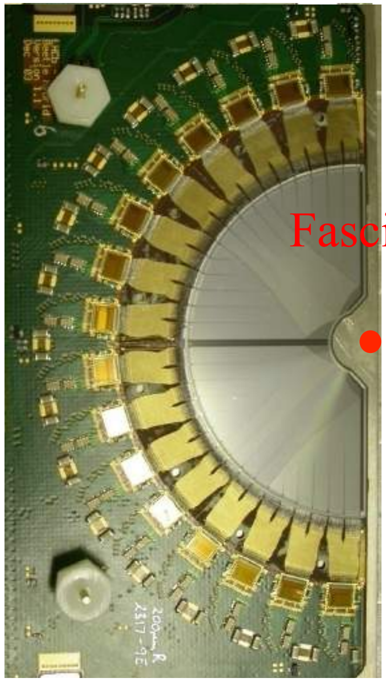
Punto di collisione e beam pipe

VELO



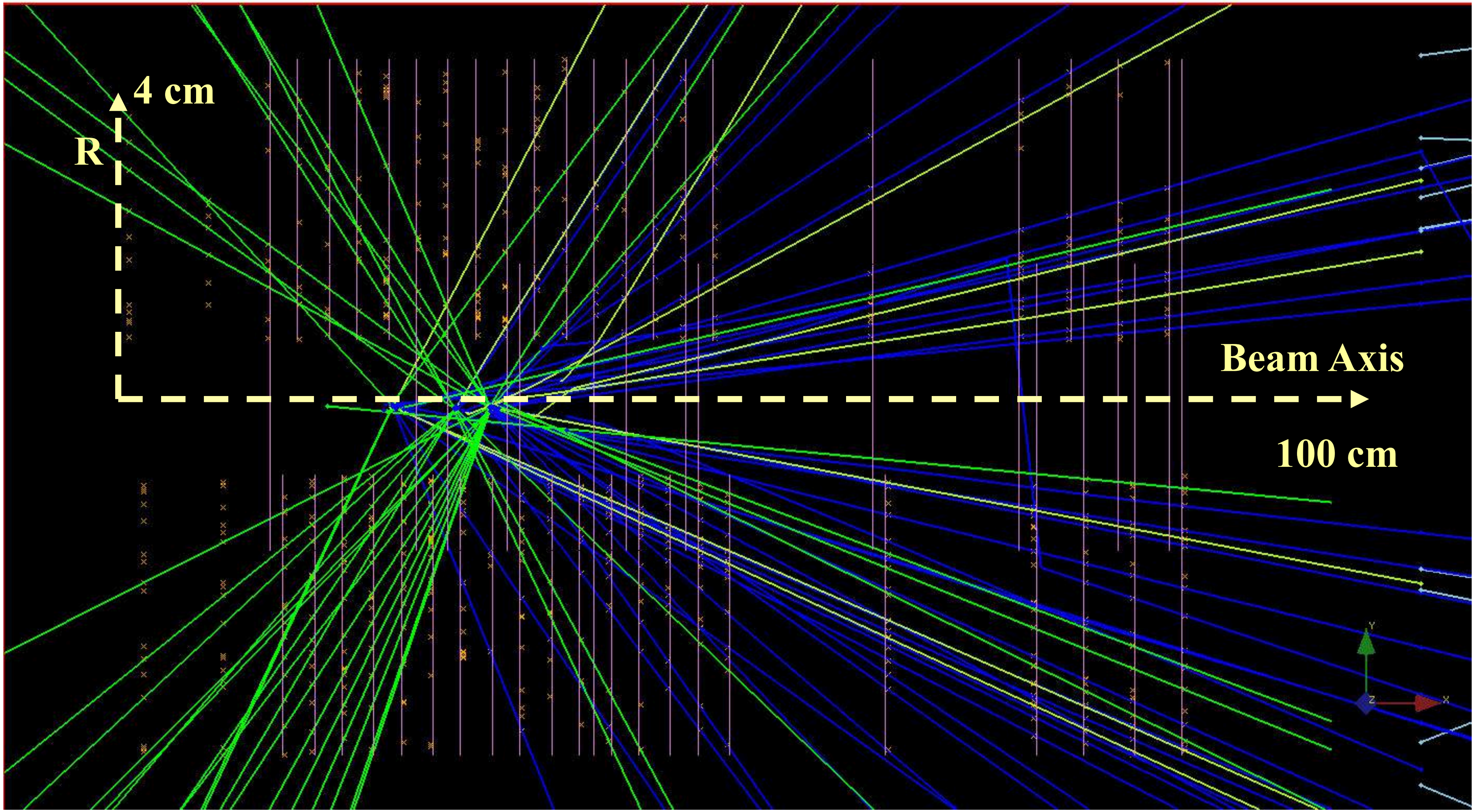


VELO

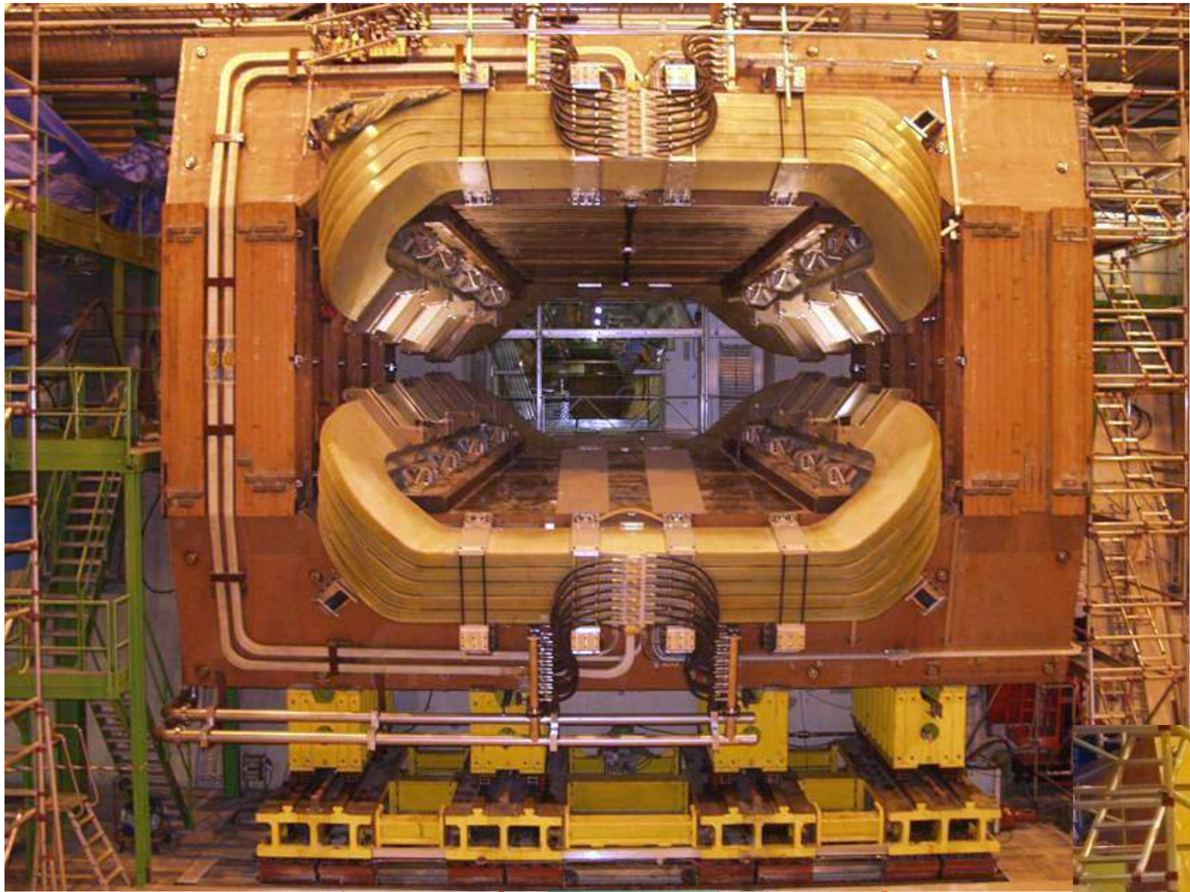


Fascio di protoni

VELO rz view

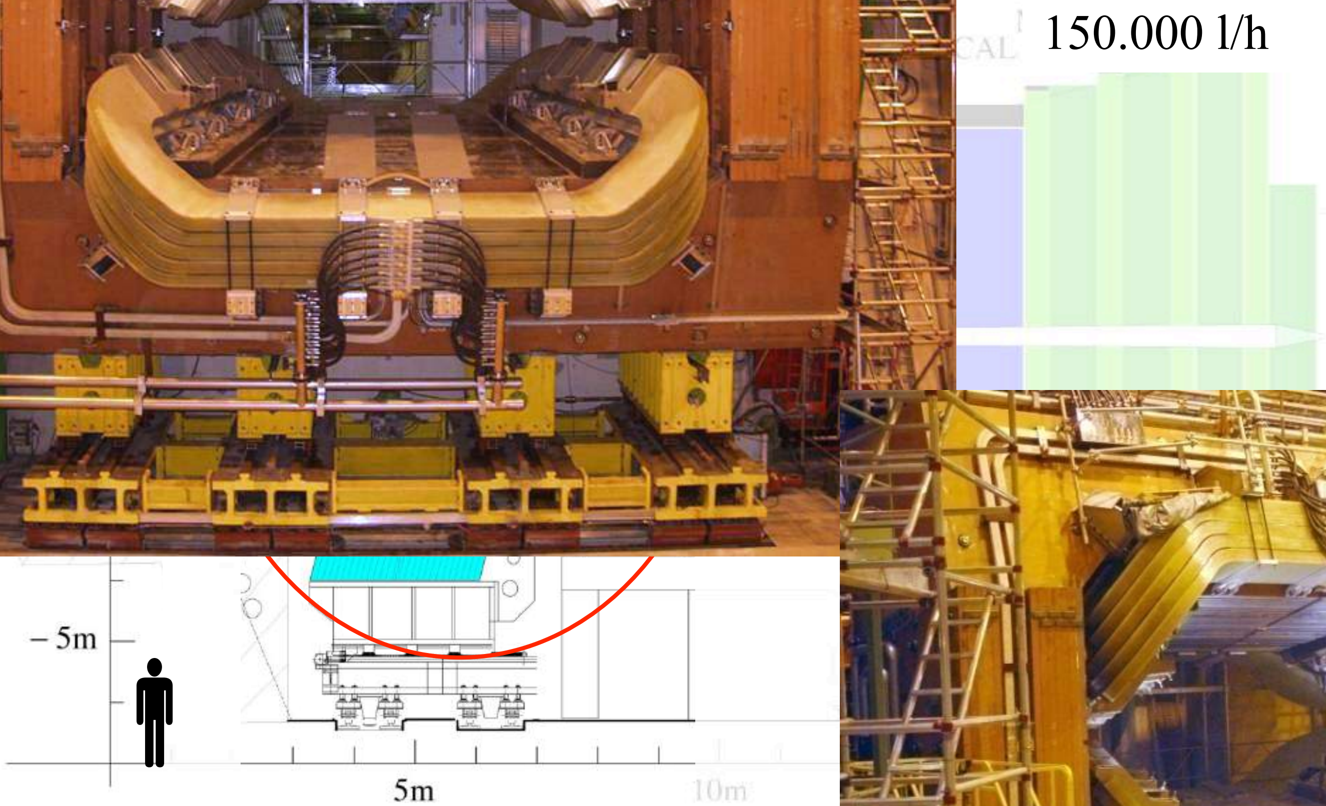


Magnete

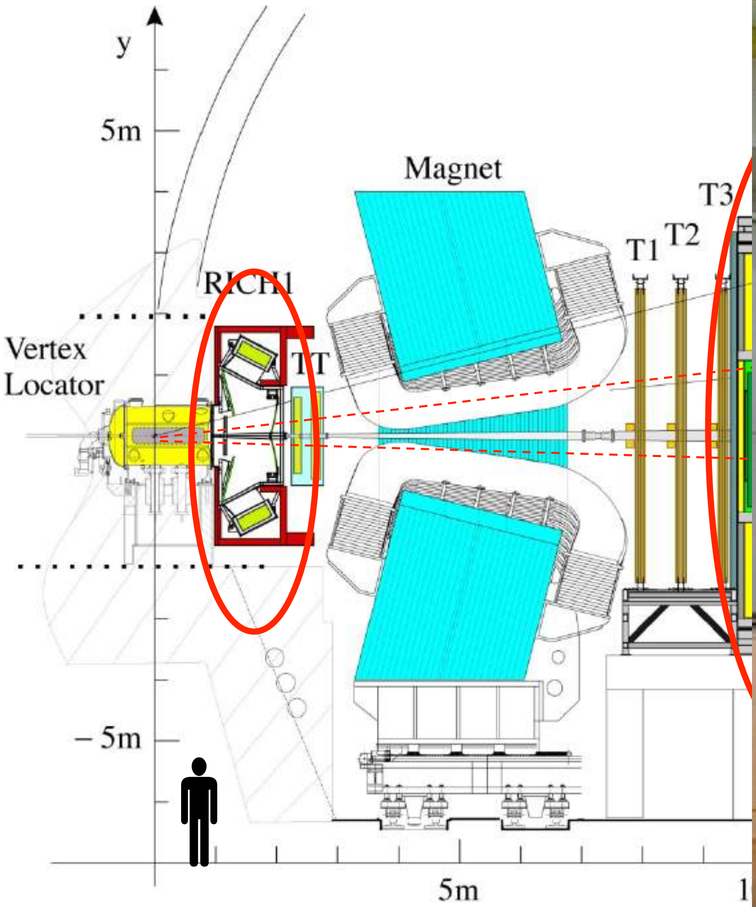


Peso = 1600 t
Potenza = 4200 kW

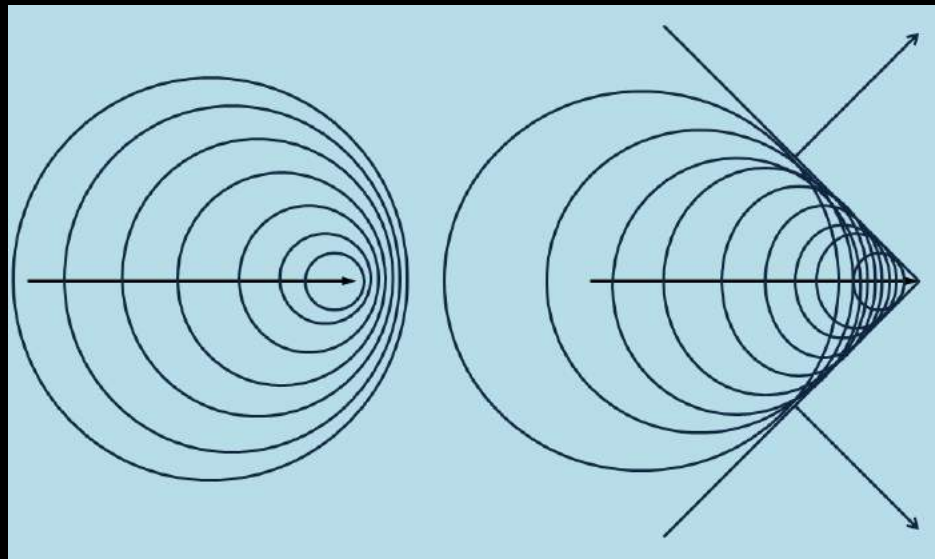
Acqua di raffreddamento = 150.000 l/h



RICH: Ring Imaging CHerenkov

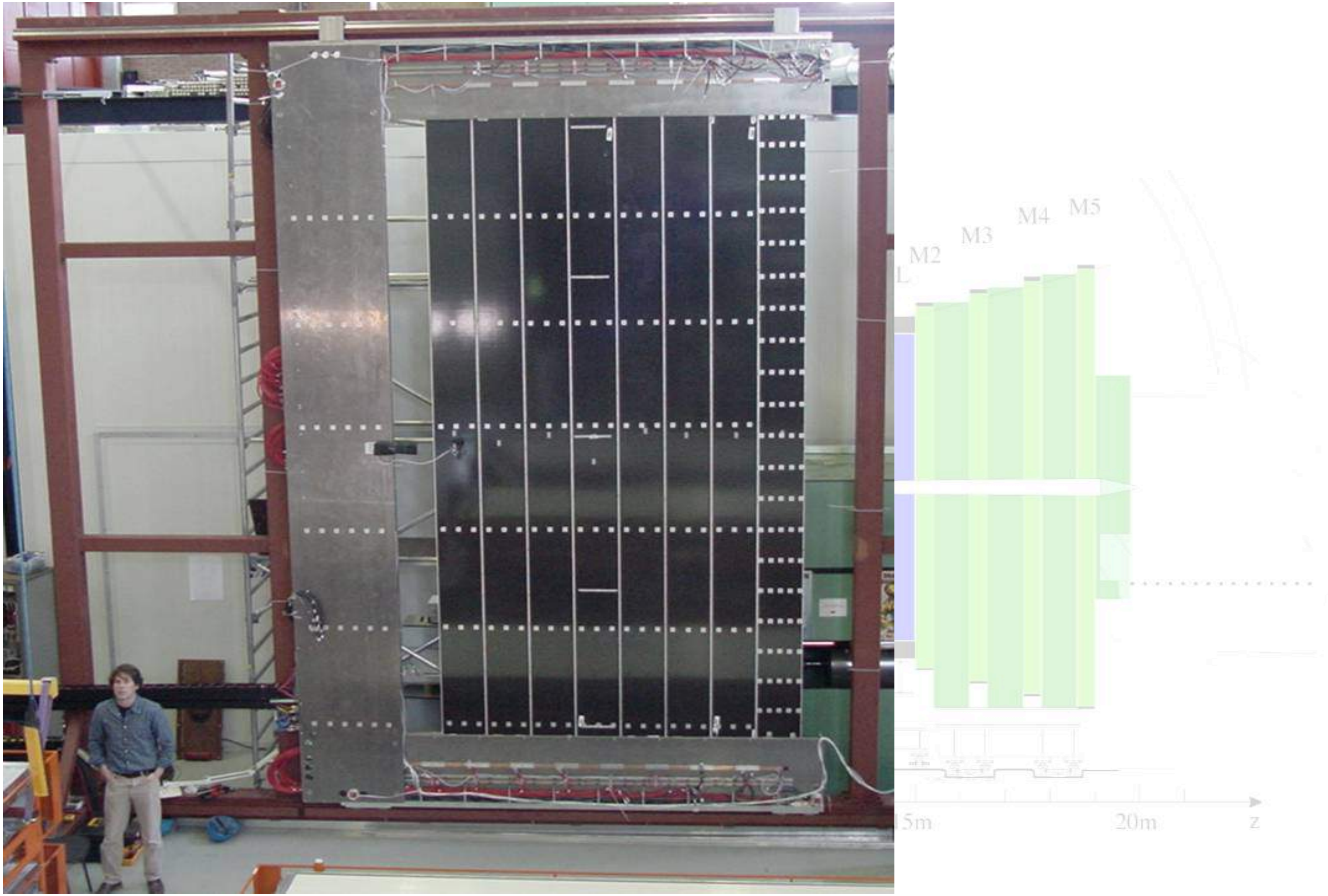


Effetto Cherenkov

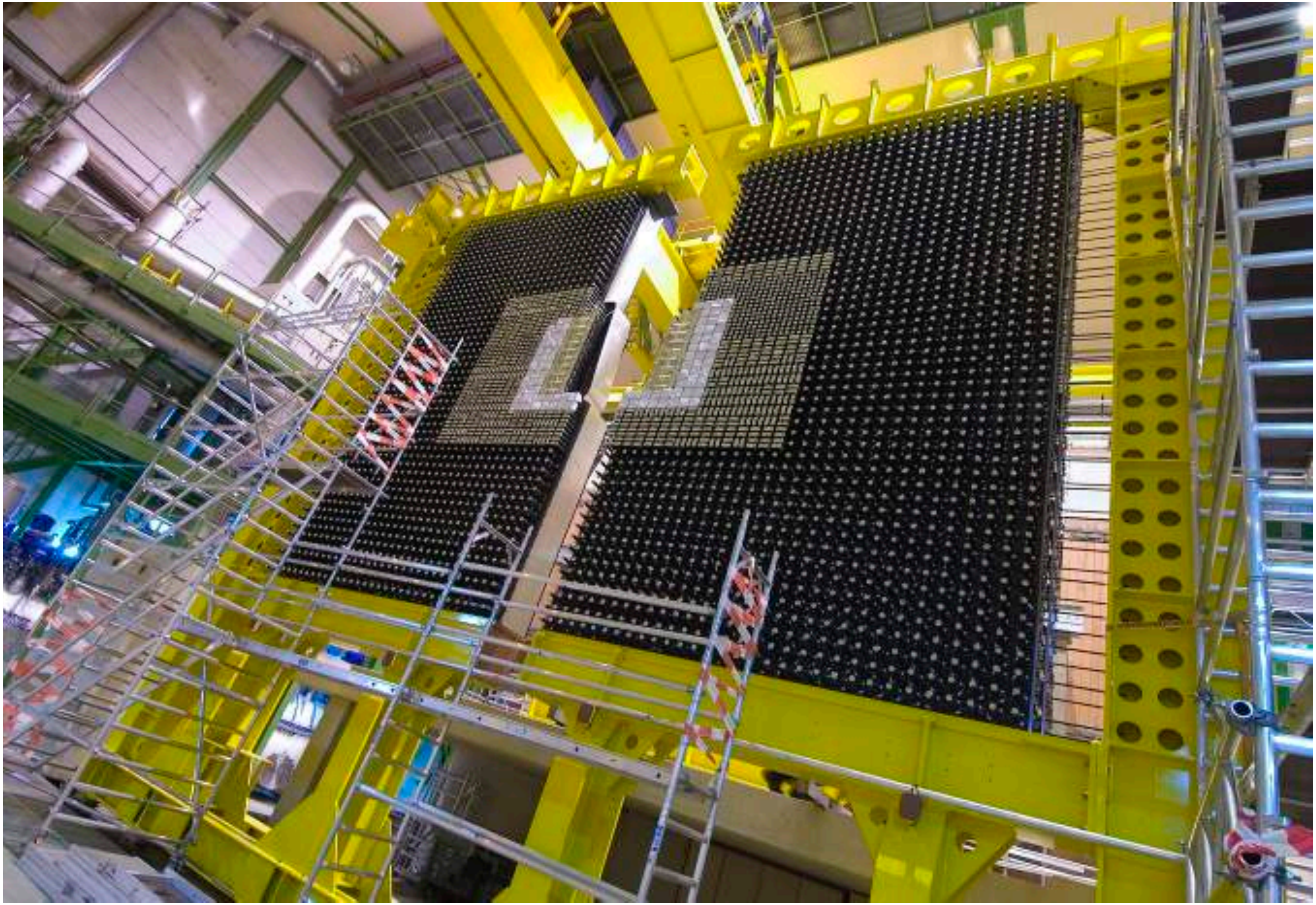


Effetto Cherenkov

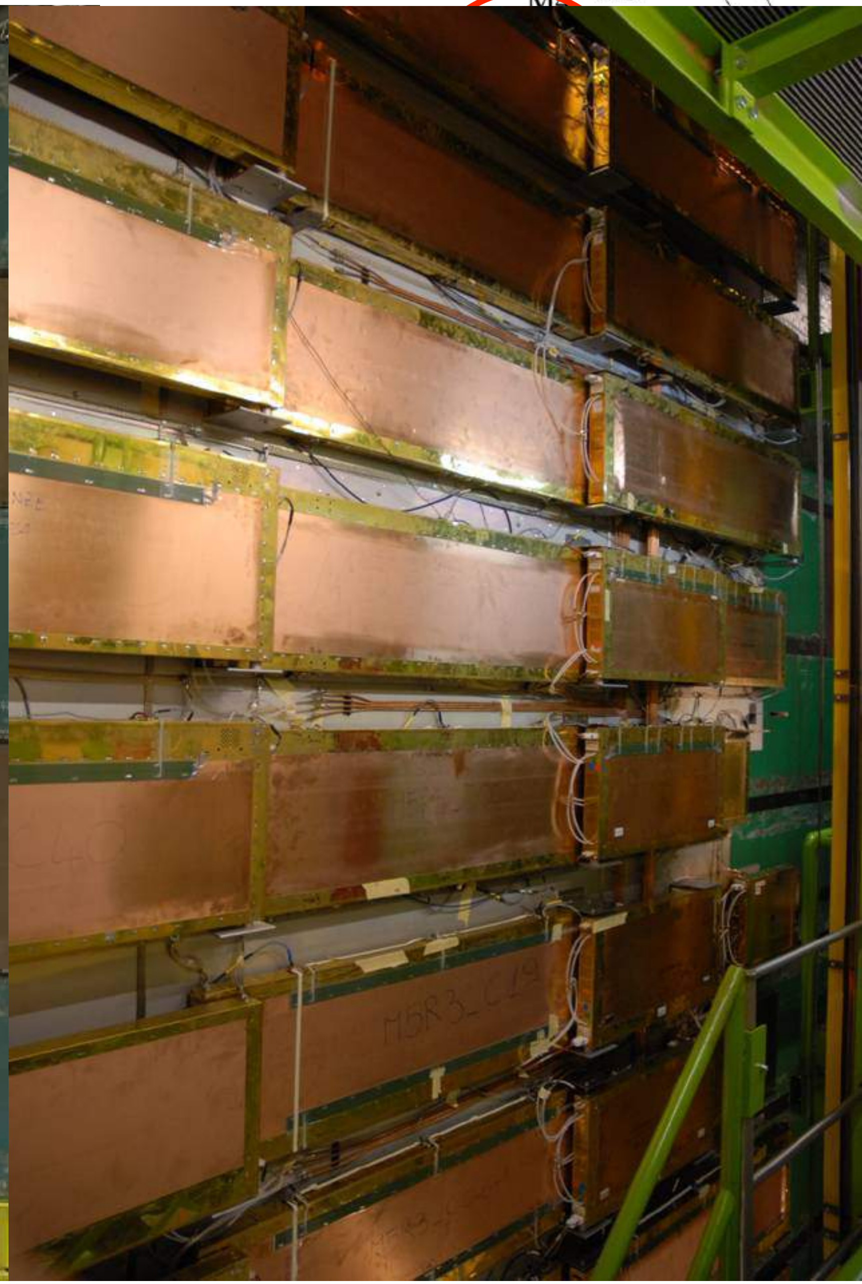
OT: Outer Tracker



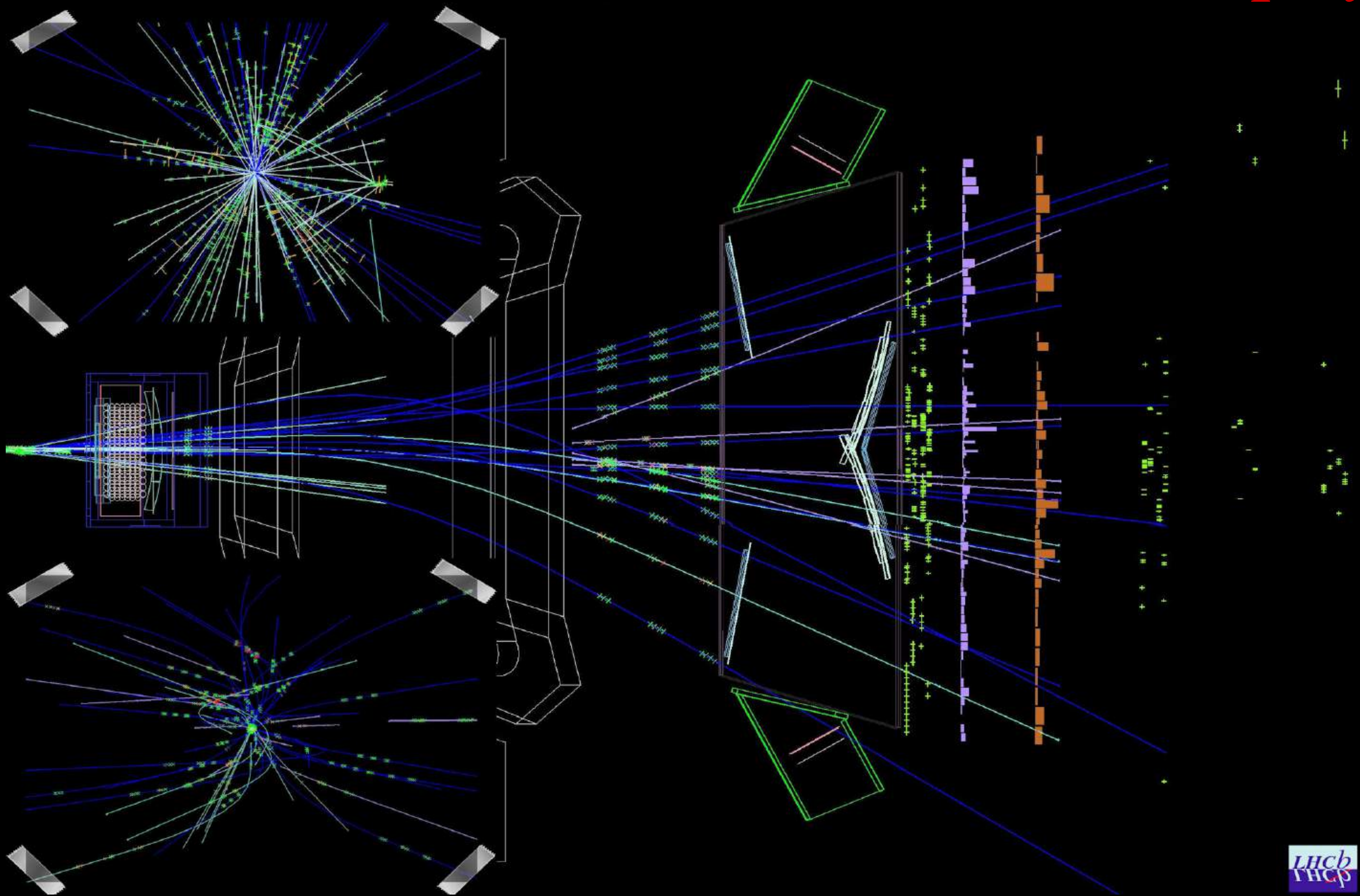
Calorimetro



Muon System



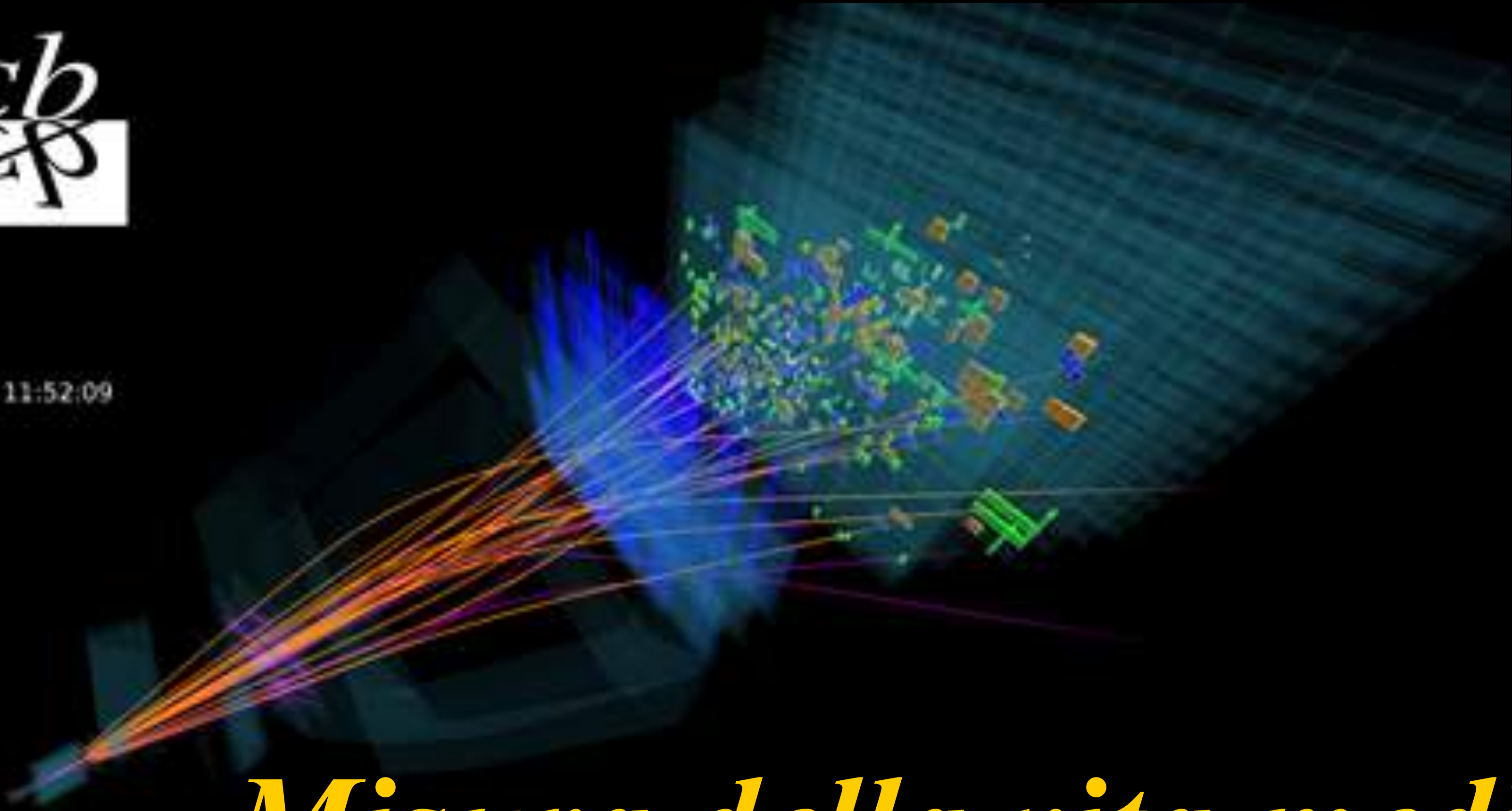
Event display



Incontri di Fisica

6 ottobre 2016

Event 41383468
Run 153460
Wed, 03 Jun 2015 11:52:09

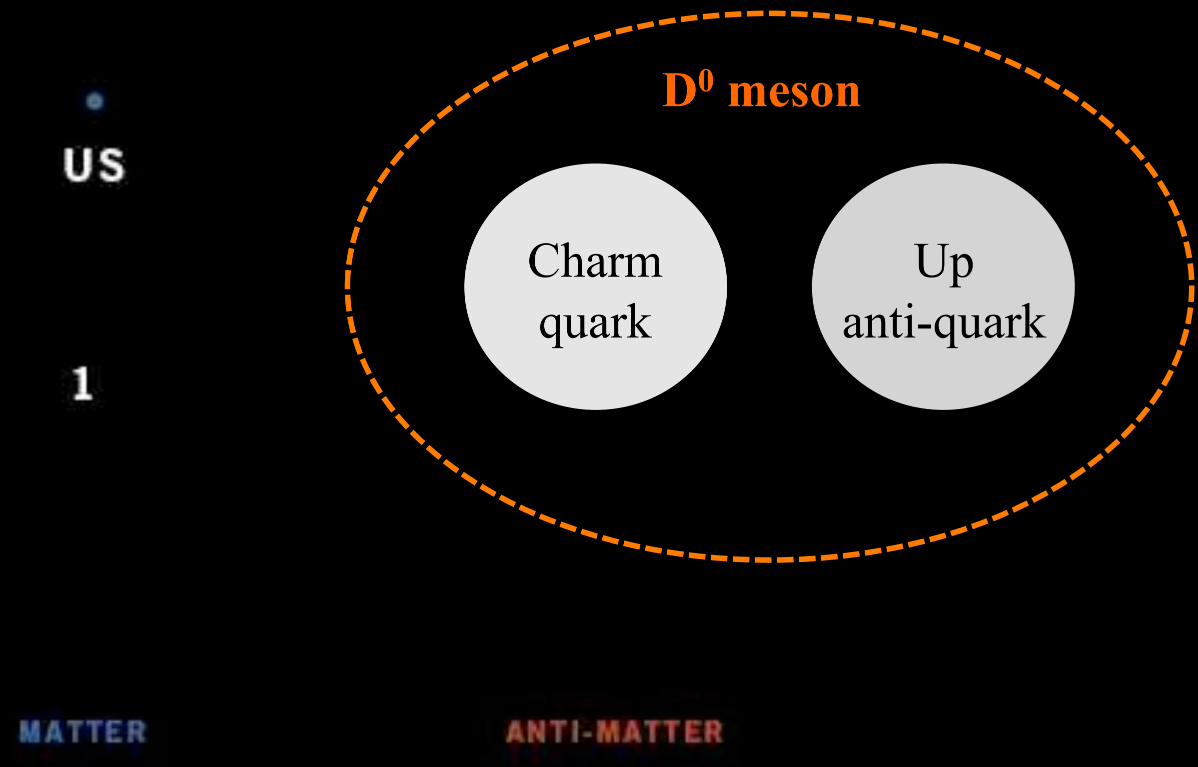


Misura della vita media del mesone D^0 a LHCb

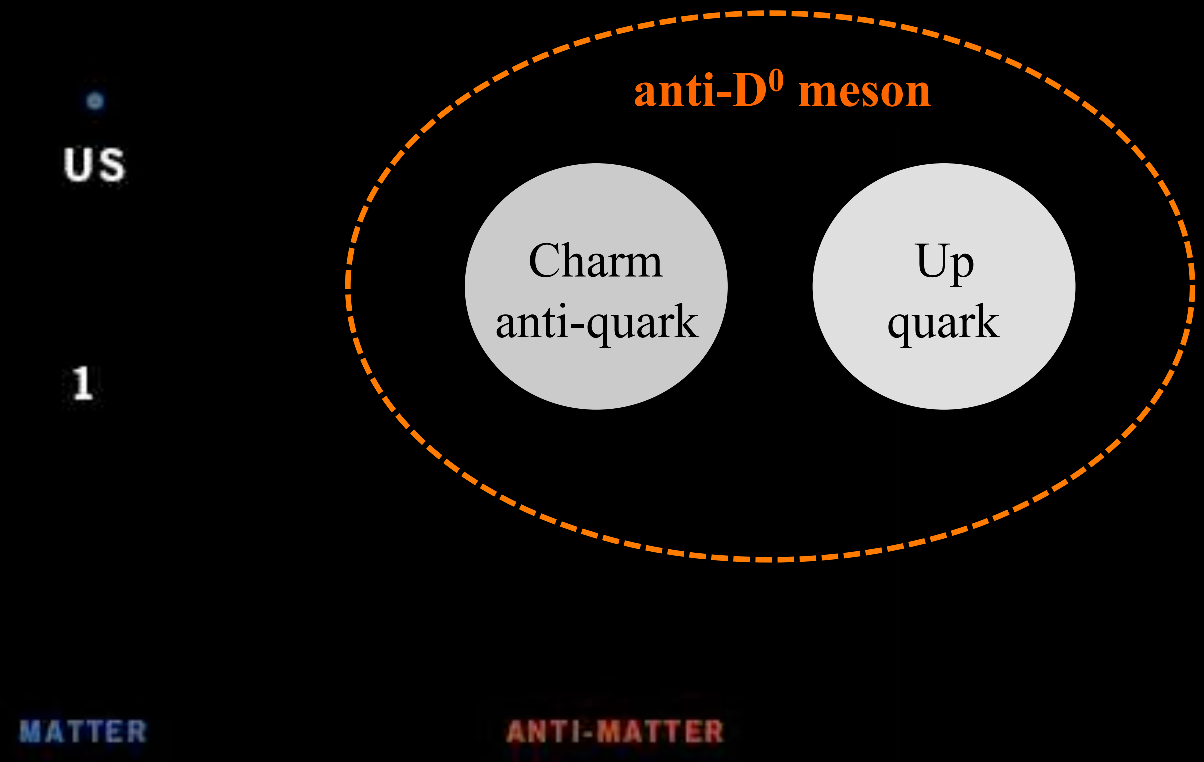
B. Sciascia R. Vazquez Gomez
LNF-INFN

[Thanks to A. Carbone, J. Rademacker for most of the material]

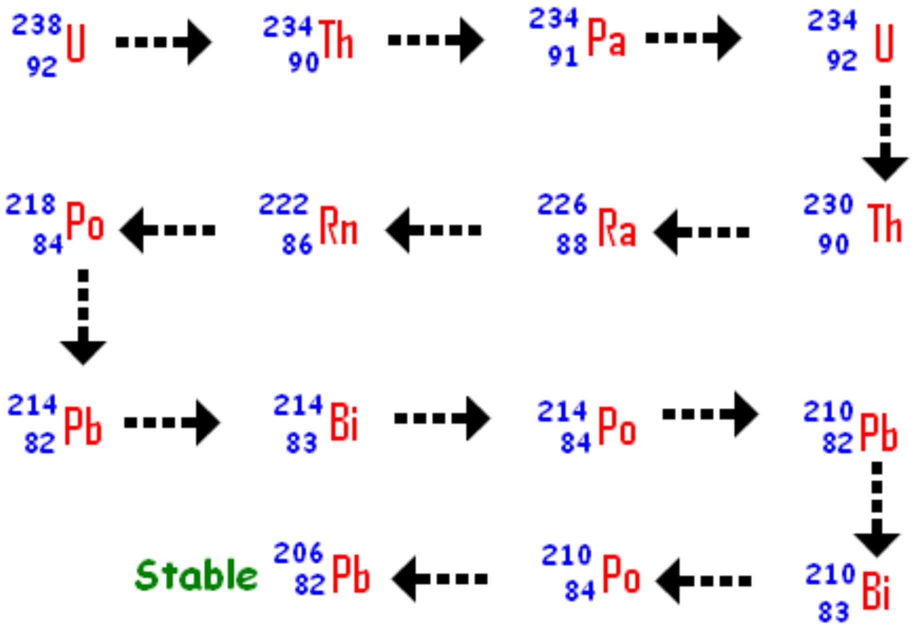
Materia e Antimateria

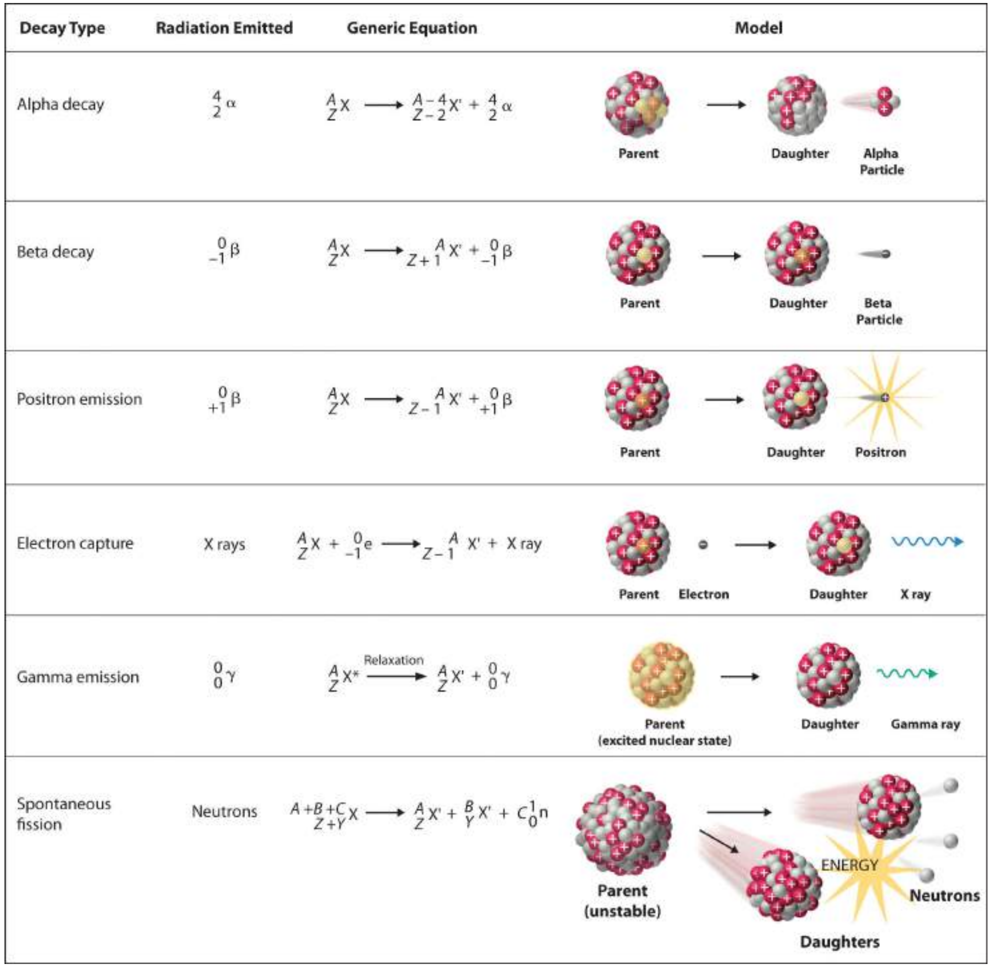


Materia e Antimateria



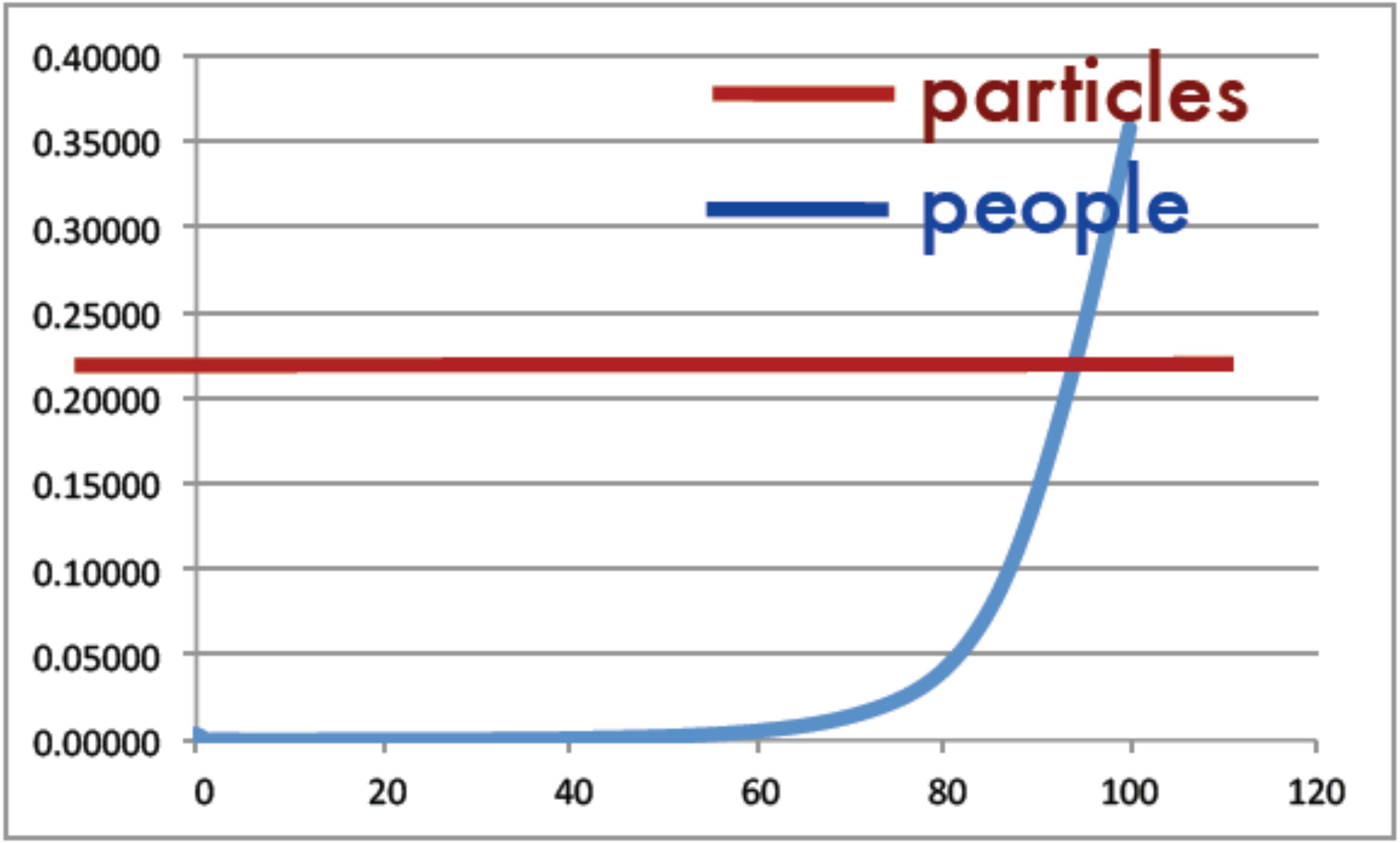
Decadimenti radioattivi





Decay Type	Radiation Emitted	Generic Equation	Model
Alpha decay	$^{4}_{2}\alpha$	$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}X' + {}^{4}_{2}\alpha$	Parent → Daughter Alpha Particle
Beta decay	$^{0}_{-1}\beta$	$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}X' + {}^{0}_{-1}\beta$	Parent → Daughter Beta Particle
Positron emission	$^{0}_{+1}\beta$	$^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}X' + {}^{0}_{+1}\beta$	Parent → Daughter Positron
Electron capture	X rays	$^{A}_{Z}X + {}^{0}_{-1}e \longrightarrow {}^{A}_{Z-1}X' + \text{X ray}$	Parent Electron → Daughter X ray
Gamma emission	$^{0}_{0}\gamma$	$^{A}_{Z}X^{*} \xrightarrow{\text{Relaxation}} {}^{A}_{Z}X' + {}^{0}_{0}\gamma$	Parent (excited nuclear state) → Daughter Gamma ray
Spontaneous fission	Neutrons	$^{A+B+C}_{Z+Y}X \longrightarrow {}^{A}_{Z}X' + {}^{B}_{Y}X' + C^{1}_{0}n$	Parent (unstable) → ENERGY Daughters Neutrons

Probabilità di "decadimento"



Tempi di dimezzamento e vita media

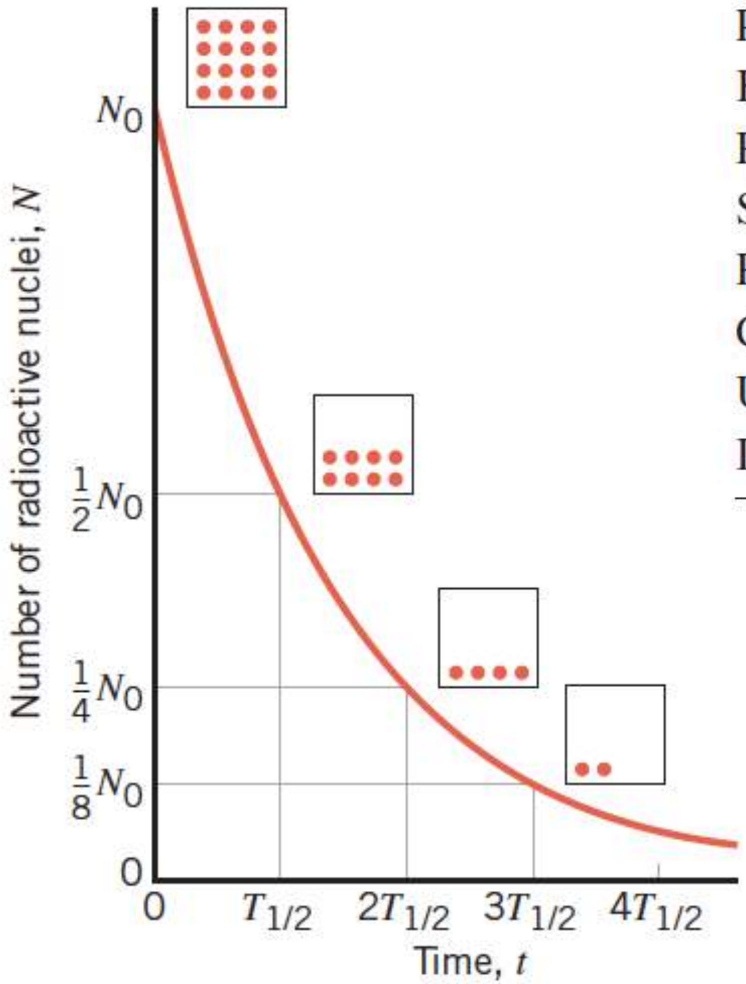
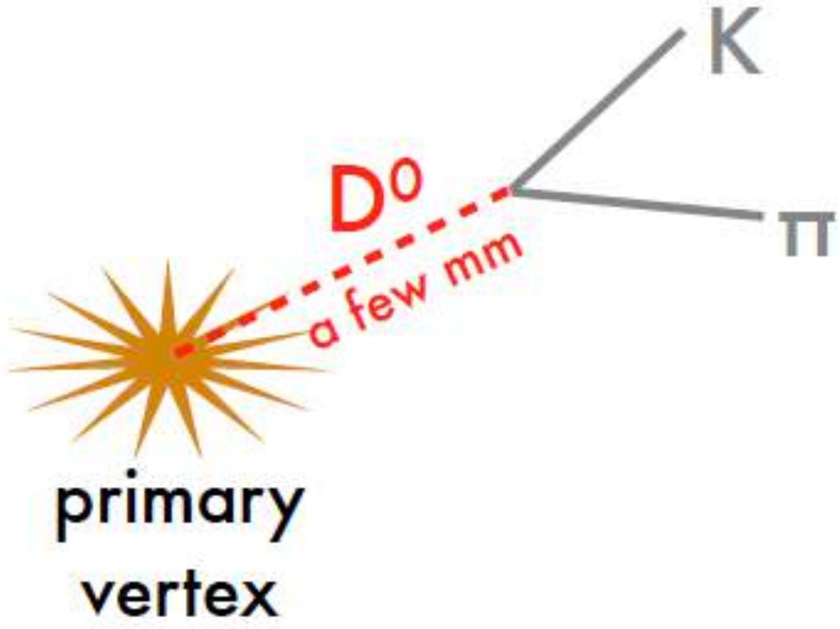


Table 31.2 Some Half-Lives for Radioactive Decay

Isotope		Half-Life
Polonium	$^{214}_{84}Po$	1.64×10^{-4} s
Krypton	$^{89}_{36}Kr$	3.16 min
Radon	$^{222}_{86}Rn$	3.83 d
Strontium	$^{90}_{38}Sr$	29.1 yr
Radium	$^{226}_{88}Ra$	1.6×10^{3} yr
Carbon	$^{14}_{6}C$	5.73×10^{3} yr
Uranium	$^{238}_{92}U$	4.47×10^{9} yr
Indium	$^{115}_{49}In$	4.41×10^{14} yr

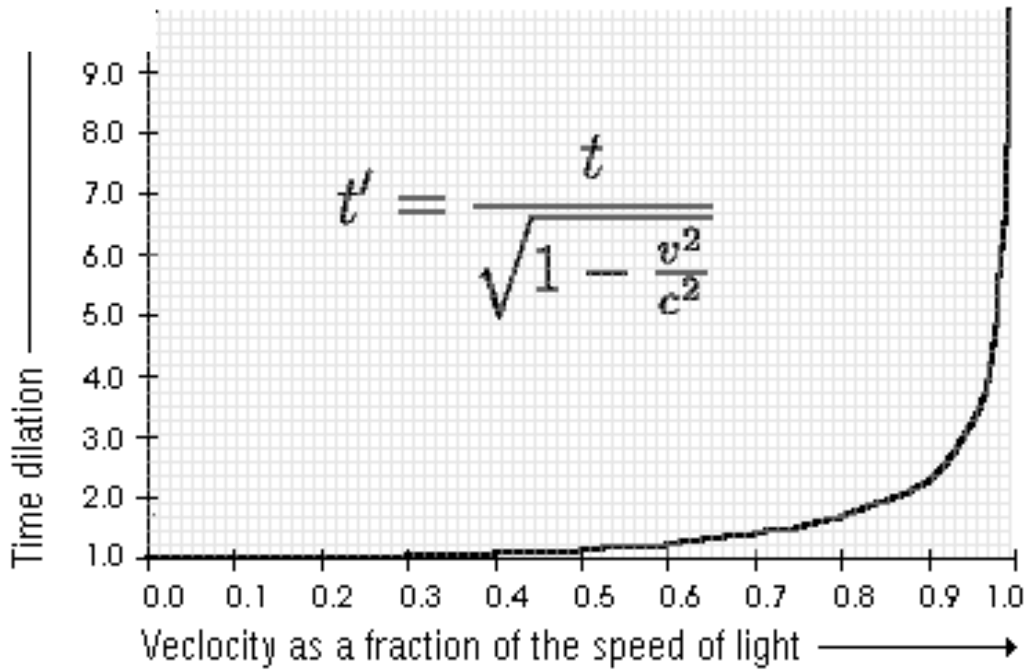
$$N = N_0 \cdot e^{-\frac{t}{\tau}} \Rightarrow \tau = \frac{T_{1/2}}{\ln 2} = \frac{T_{1/2}}{0.693}$$

Cinematica

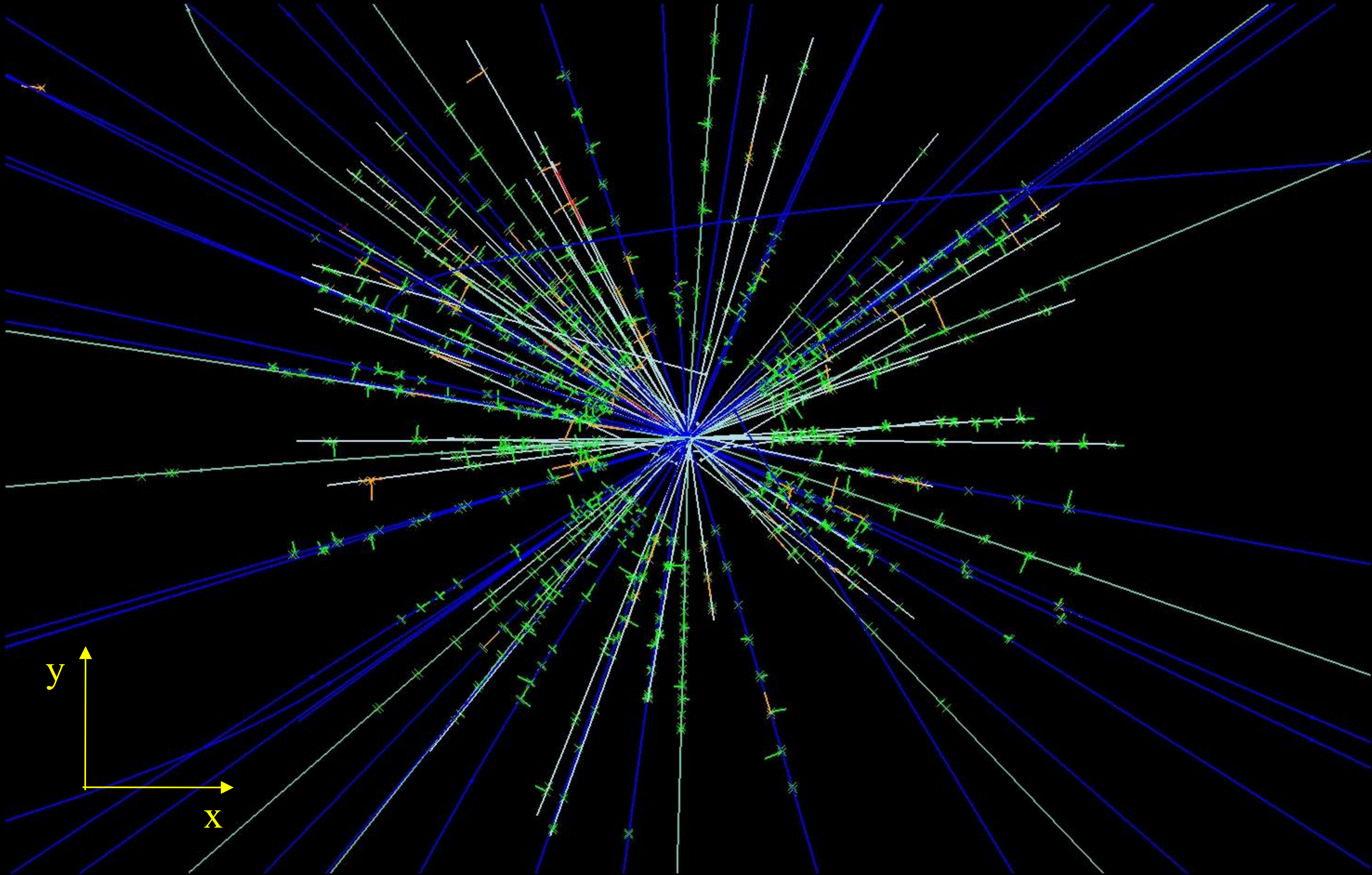


Vita media: t ~ 0.4 ps
Velocità: v ~ c (0.9992)

Lunghezza:
classica: v × t ~ 0.12 mm
relativistica: ~ 3 mm



Evento a LHCb



Particle Data Group

$$m^2_{D^0} = m^2_K + m^2_\pi + 2\sqrt{m^2_K + p^2_K}\sqrt{m^2_\pi + p^2_\pi} - 2p_K p_\pi \cos\vartheta$$

D^0 $\qquad I(J^P) = \frac{1}{2}(0^-)$

Mass $m = 1864.84 \pm 0.05$ MeV
$m_{D^\pm} - m_{D^0} = 4.77 \pm 0.08$ MeV
Mean life $\tau = (410.1 \pm 1.5) \times 10^{-15}$ s
$c\tau = 122.9\ \mu$m
$\left|m_{D^0_1} - m_{D^0_2}\right| = (0.95^{+0.41}_{-0.44}) \times 10^{10}\ \hbar\ s^{-1}$
$(\Gamma_{D^0_1} - \Gamma_{D^0_2})/\Gamma = 2y = (1.29^{+0.14}_{-0.18}) \times 10^{-2}$
$\left|q/p\right| = 0.92^{+0.12}_{-0.09}$
$A_\Gamma = (-0.125 \pm 0.526) \times 10^{-3}$
$K^+\pi^-$ relative strong phase: $\cos\delta = 0.97 \pm 0.11$
$K^-\pi^+\pi^0$ coherence factor R ... $= 0.82 \pm 0.07$

D^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
		Topological modes		
0-prongs	[aaa]	(15 ± 6) %		–
2-prongs		(70 ± 6) %		–
4-prongs	[bbb]	(14.5 ± 0.5) %		–
6-prongs	[ccc]	$(6.4 \pm 1.3) \times 10^{-4}$		–

http://pdg.lbl.gov

Misura dell'impulso

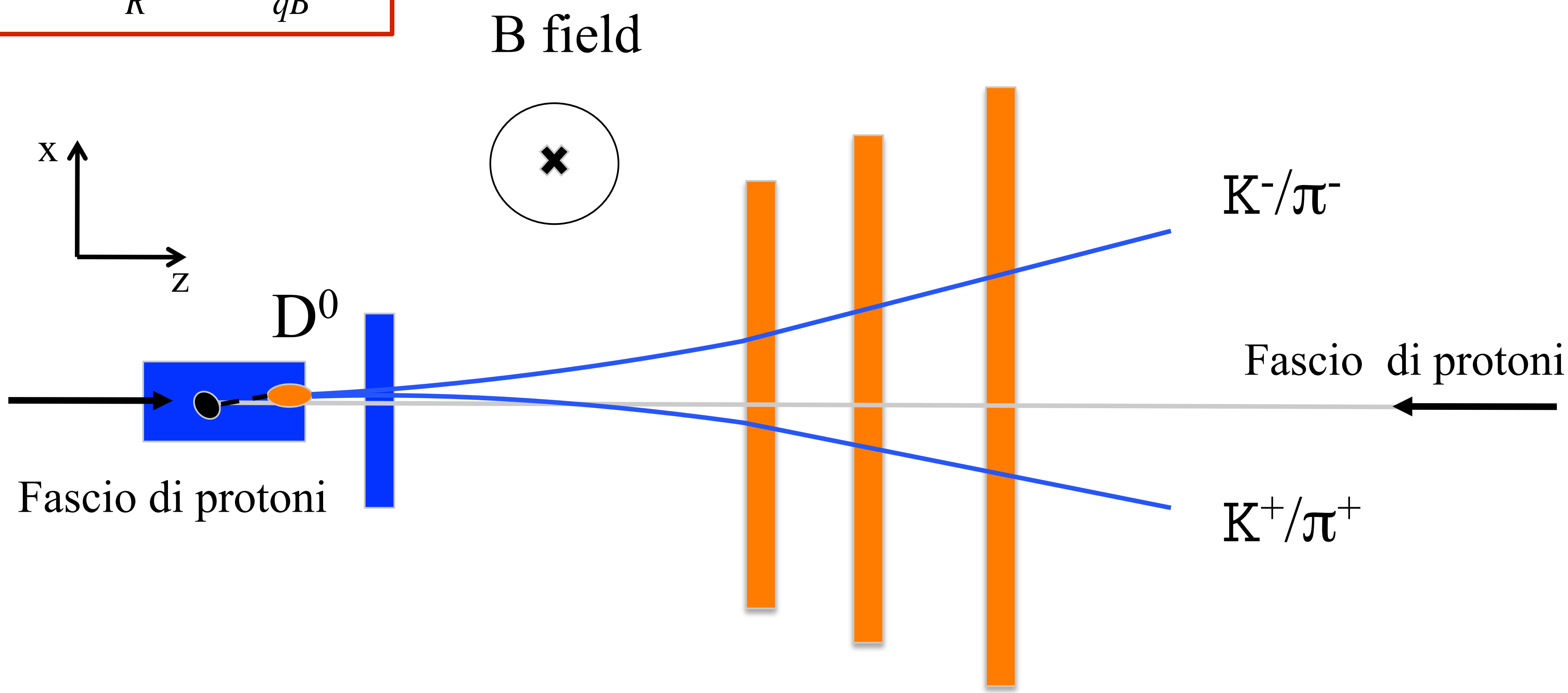
$$\vec{F} = q\vec{v} \times \vec{B}$$

[se v e B perpendicolari]

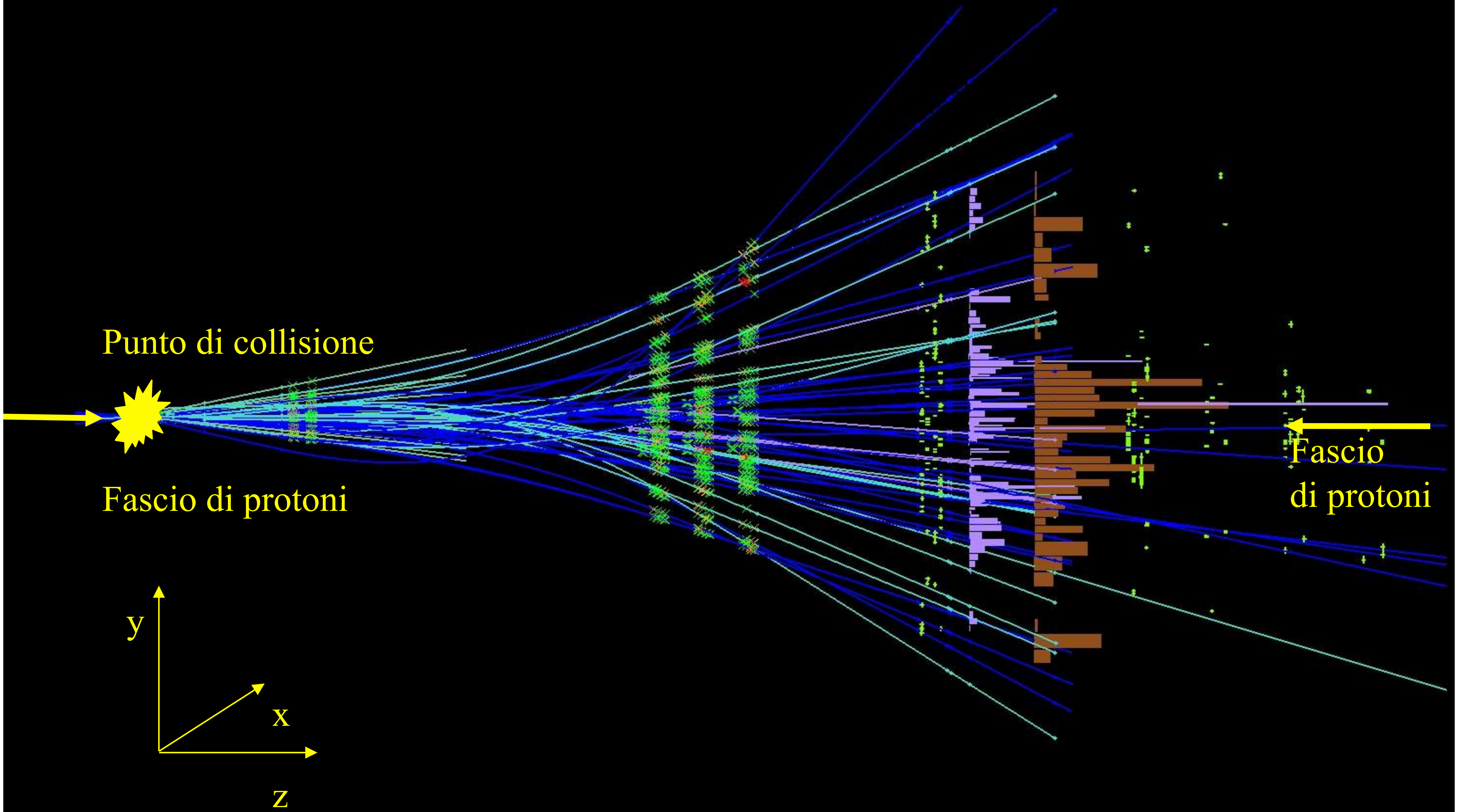
$$F = qvB$$

$$F = ma \quad \Rightarrow \quad a = \frac{v^2}{R}$$

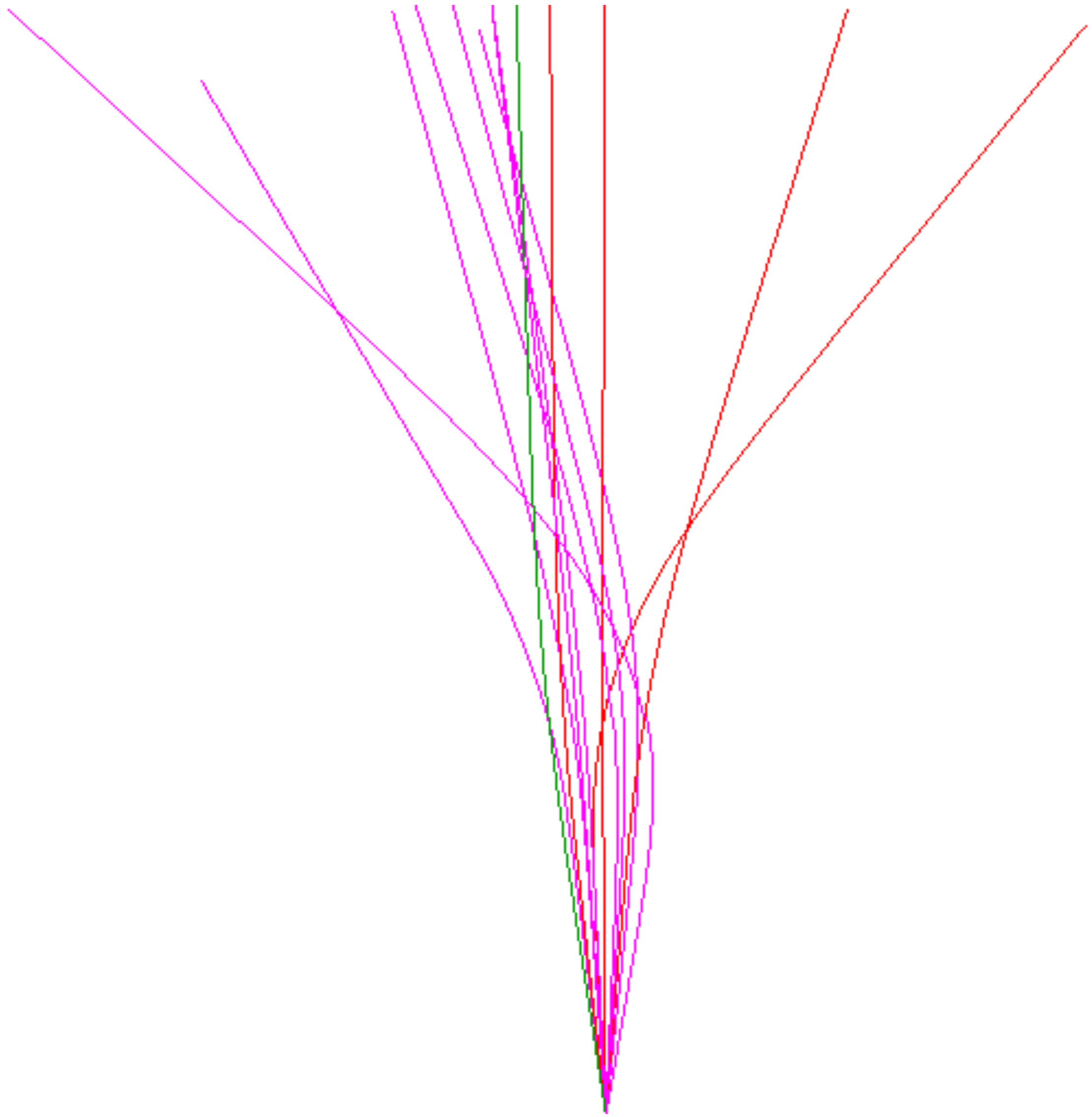
$$qvB = m\frac{v^2}{R} \quad \Rightarrow R = \frac{p}{qB}$$



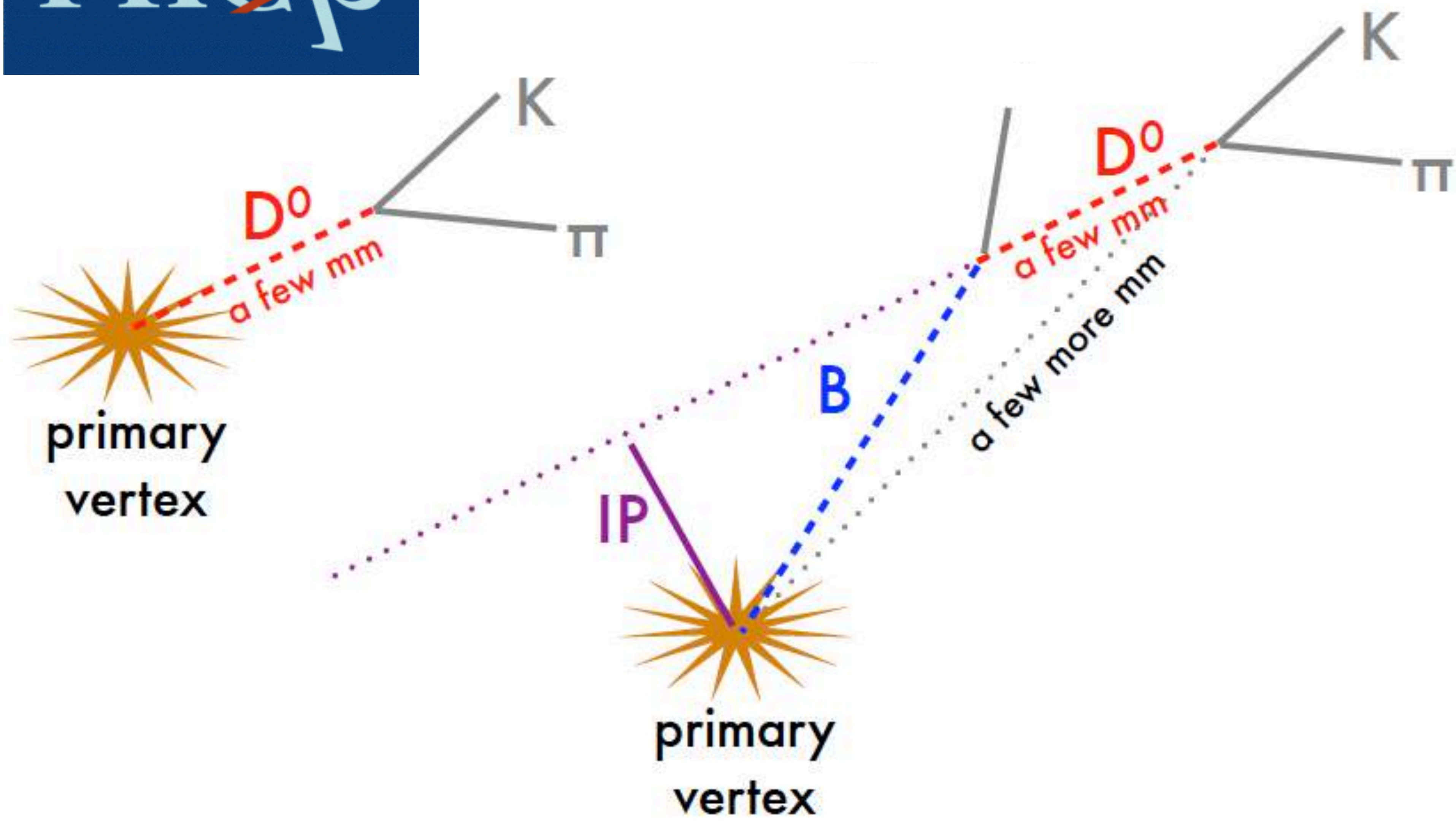
Evento a LHCb

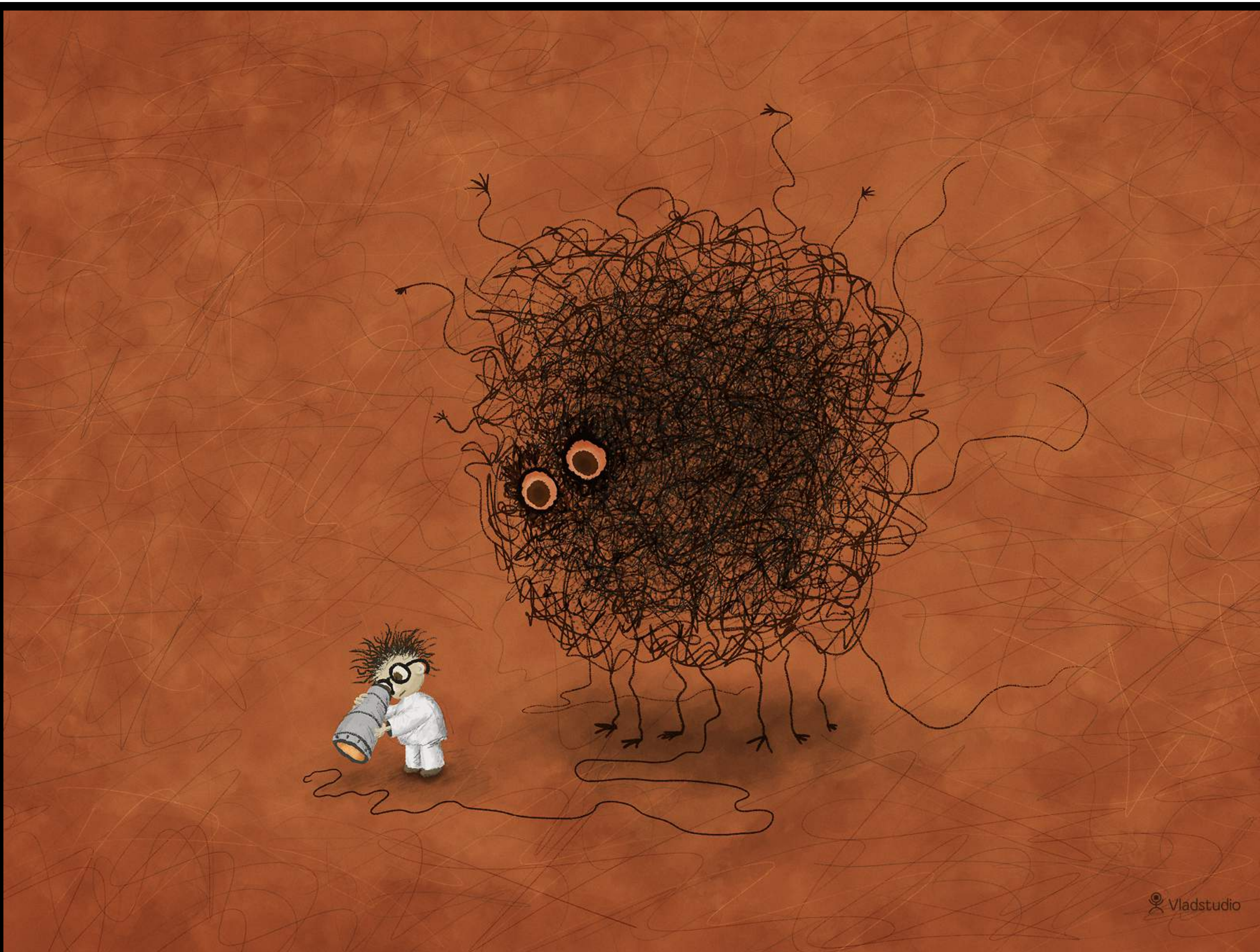


Identificazione delle particelle

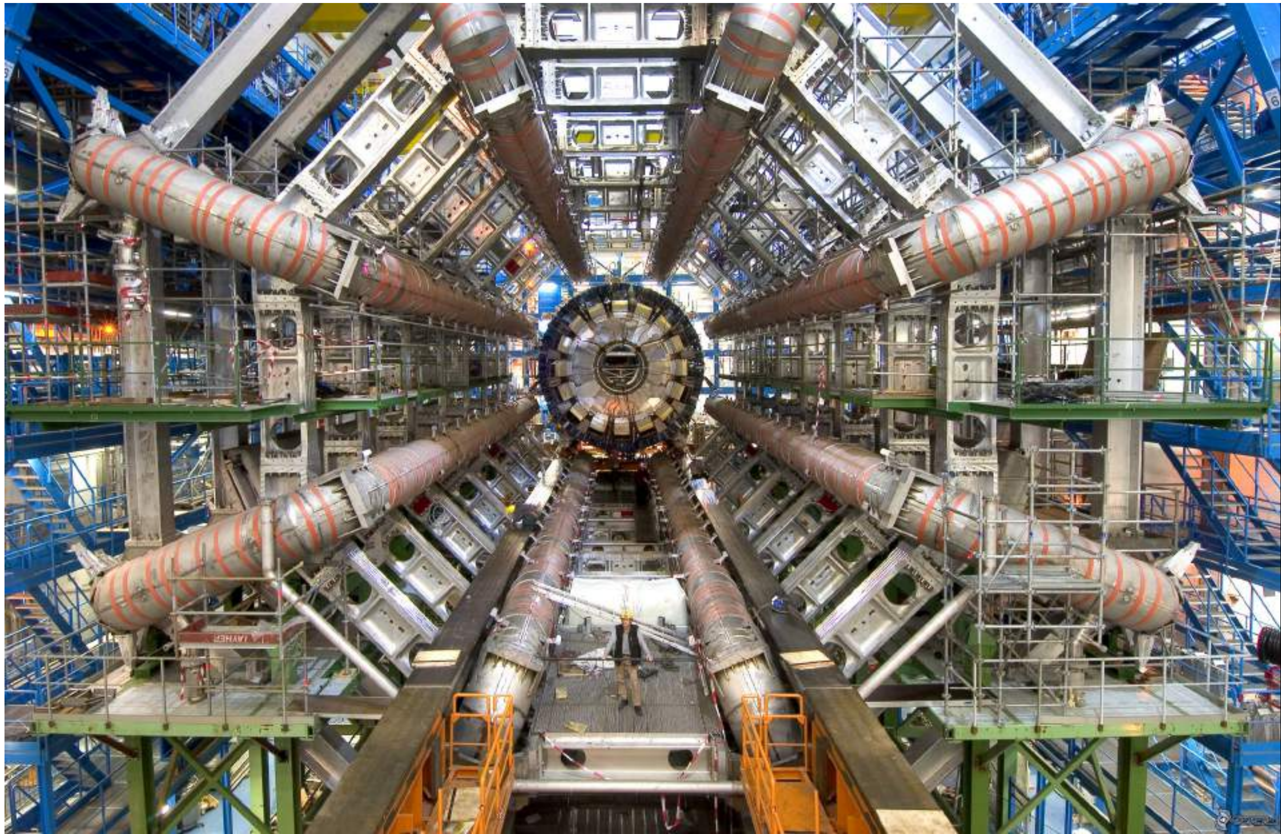


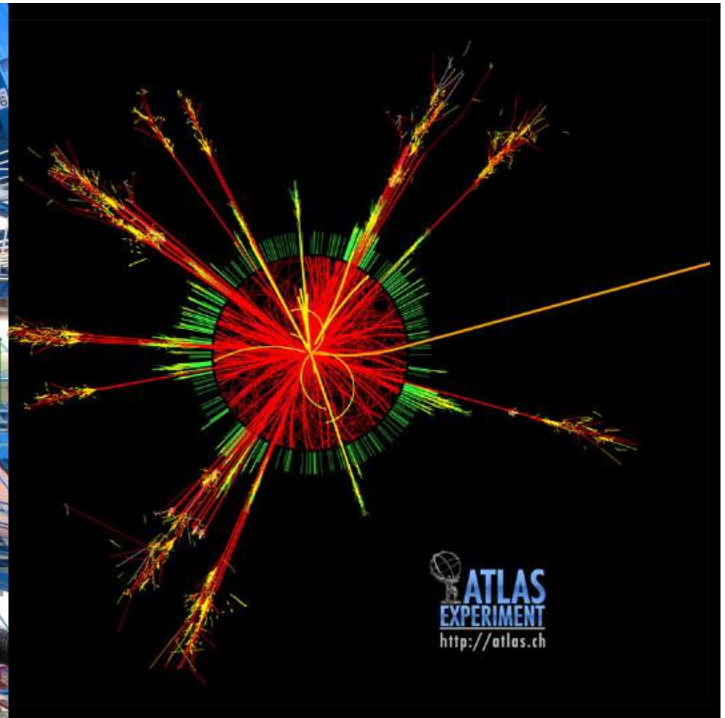
Charm and Beauty

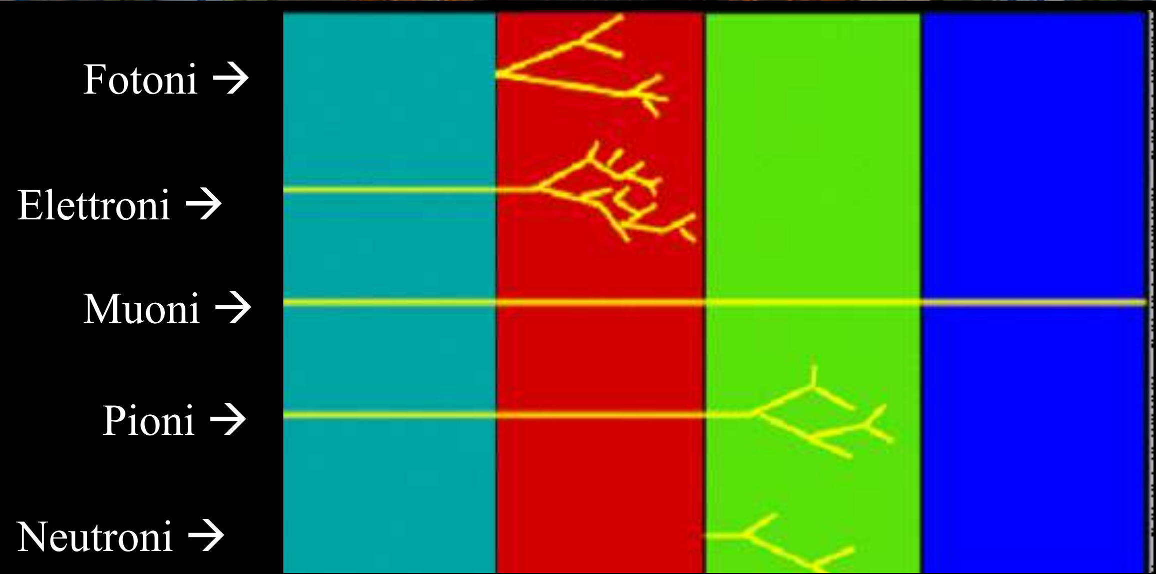


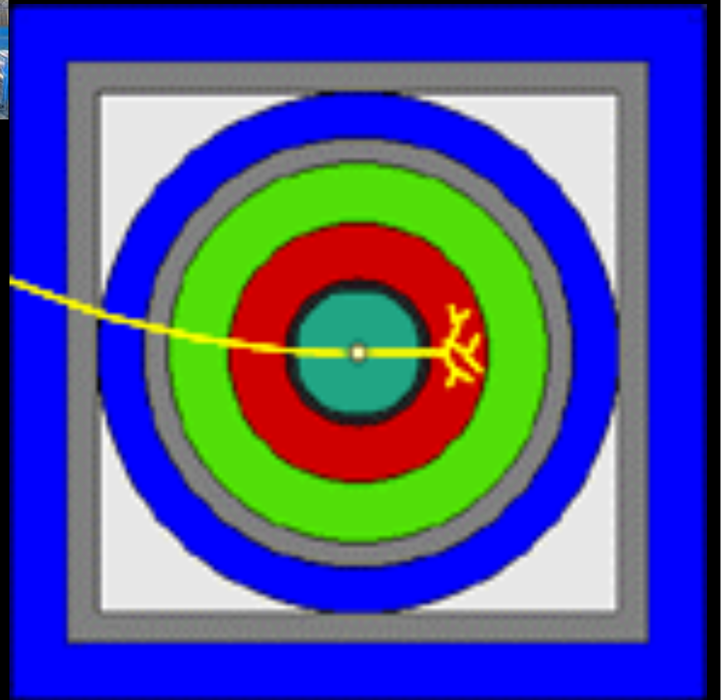

Vladstudio

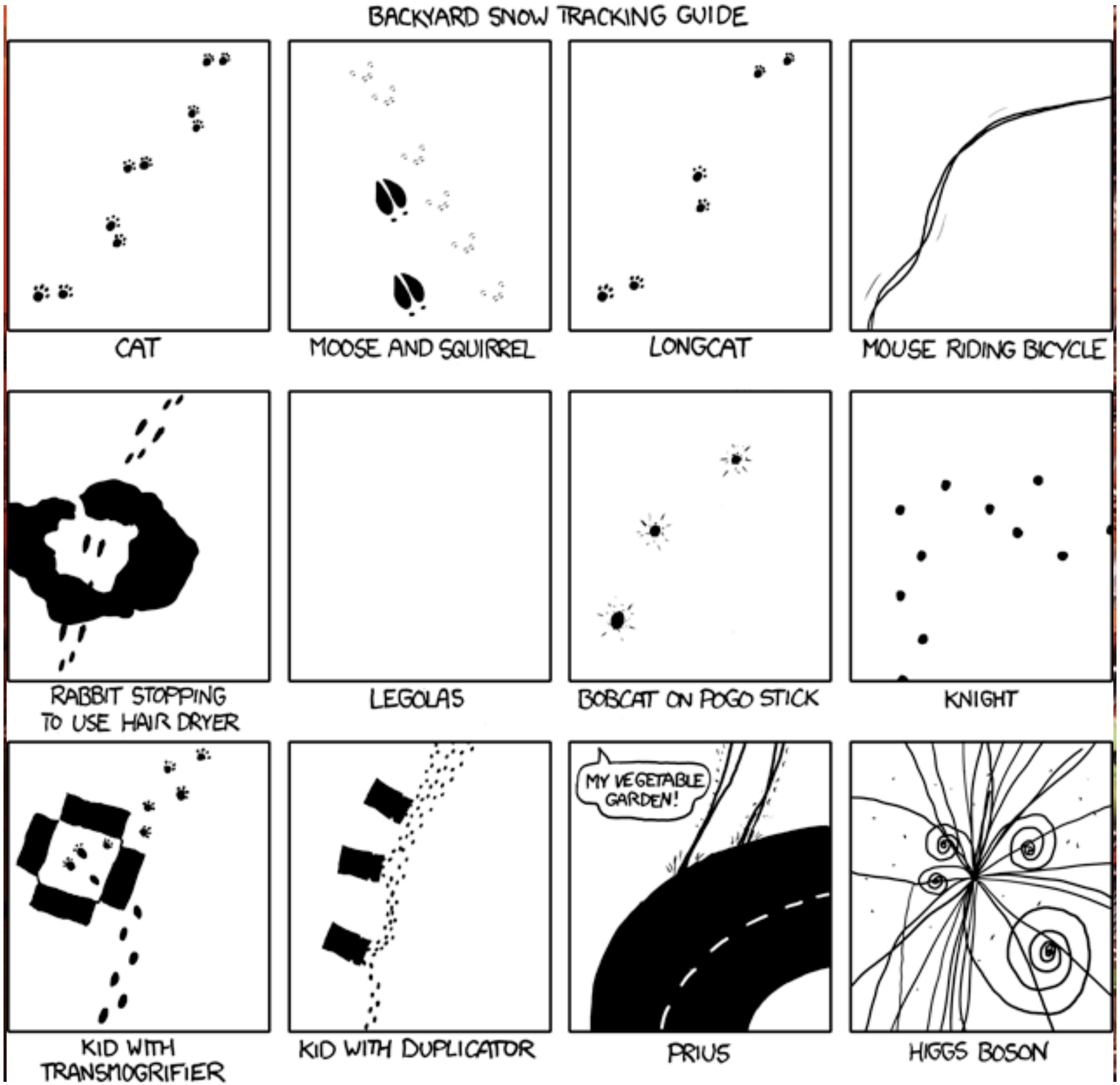
Back up




ATLAS
EXPERIMENT
http://atlas.ch


Fotoni →
Elettroni →
Muoni →
Pioni →
Neutroni →



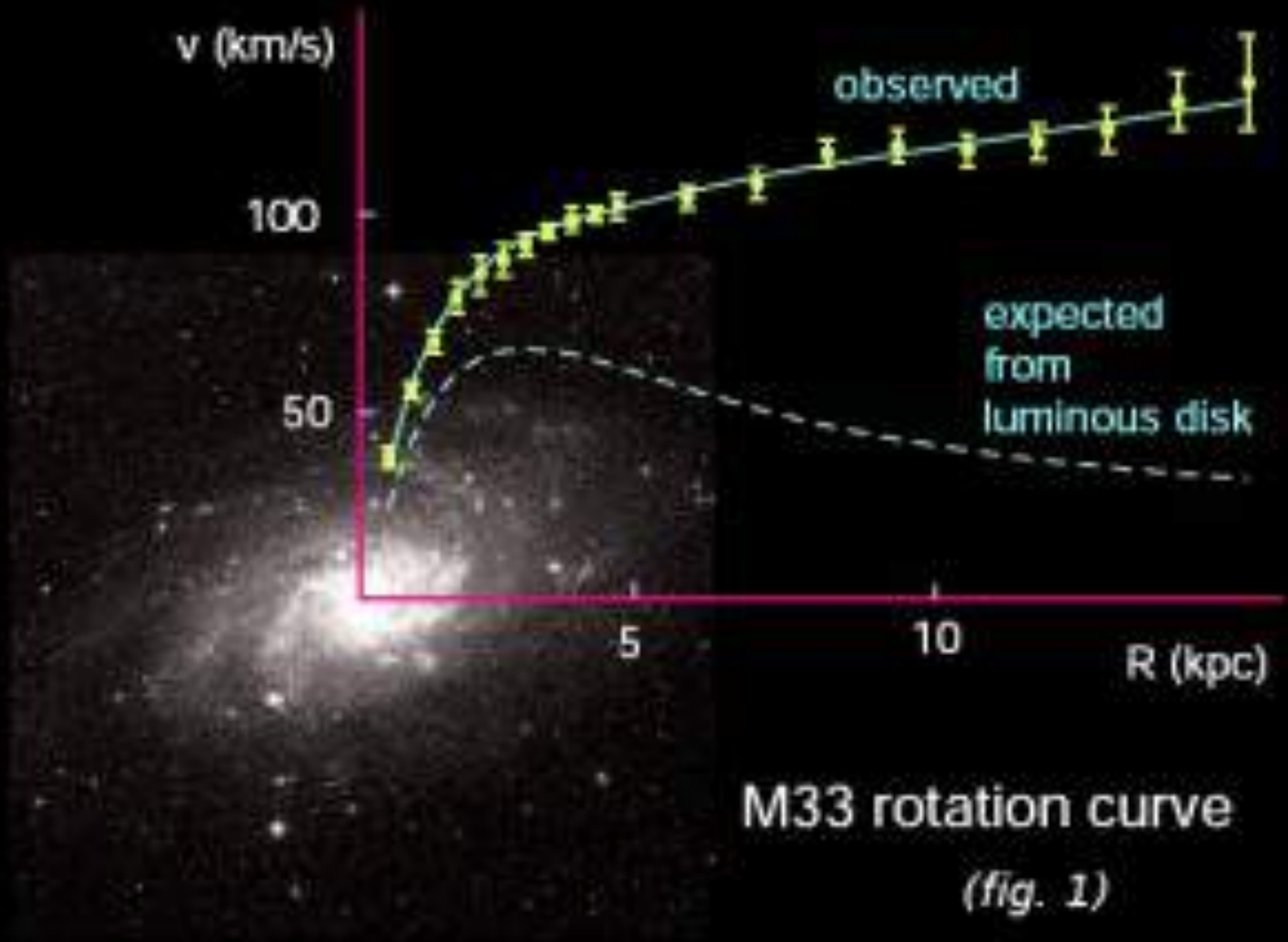


Giganti a caccia di tracce

[https://xkcd.com/702/]

Materia e materia oscura

Materia e Materia Oscura



Materia e Materia Oscura