



La stessa domanda ammette risposte diverse a seconda di chi risponde.

→ Q: DI CHE COSA E' FATTO CIO' CHE CI CIRCONDA?

→ **Risposta 1 (biologo): organismi viventi**

→ **Risposta 2 (chimico): molecole fatte di atomi**

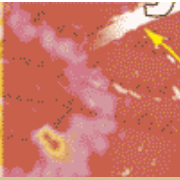
→ **Risposta 3 (fisico): atomi, protoni, neutroni,..**



Fisica delle Particelle Elementari

Punta a rispondere alle due domande:

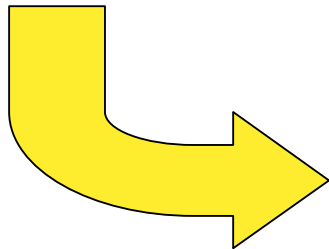
- Quali sono i costituenti fondamentali della materia?
- Quali sono le forze che controllano il loro comportamento?



Einstein in the 21st Century



Dopo
2000 anni
di ricerche



The Periodic Table

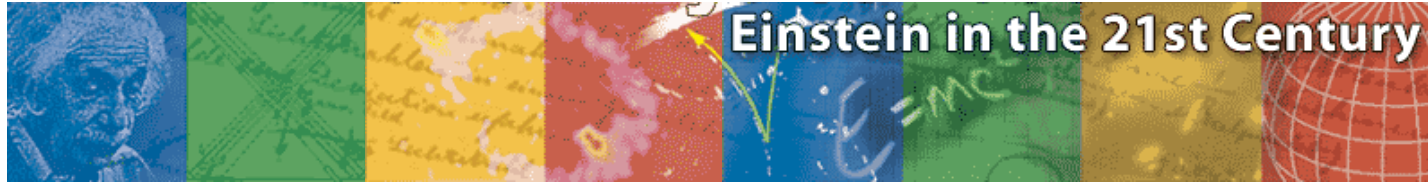
1 H	Group																18 He														
2 Li	3 Be	Atomic number										4 B	5 C	6 N	7 O	8 F	9 Ne														
Period																	10 Na	11 Mg	12 Al	13 Si	14 P	15 S	16 Cl	17 Ar							
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr														
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe														
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	104 Uuq	105 Uup	106 Uuh	107 Uus	108 Uuo	109 Uue									

KEY OF ELEMENT TYPES

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Lanthanides (Rare Earths)
- Actinides
- Poor Metals
- Semimetals
- Nonmetals
- Noble Gases

Atomic Number	Chemical Name	Relative Atomic Mass
1.0	Hydrogen	1
4.0	Helium	2
6.9	Lithium	3
9.0	Beryllium	4
10.8	Boron	5
12.0	Carbon	6
14.0	Nitrogen	7
16.0	Oxygen	8
19.0	Fluorine	9
20.2	Neon	10
23.0	Sodium	11
24.0	Magnesium	12
27.0	Aluminium	13
28.1	Silicon	14
31.0	Phosphorus	15
32.1	Sulphur	16
35.5	Chlorine	17
40.0	Argon	18
39.1	Potassium	19
40.1	Calcium	20
48.0	Scandium	21
47.9	Titanium	22
50.9	Vanadium	23
52.0	Chromium	24
54.9	Manganese	25
55.9	Iron	26
58.9	Cobalt	27
58.7	Nickel	28
63.5	Copper	29
65.4	Zinc	30
69.7	Gallium	31
72.6	Germanium	32
74.9	Arsenic	33
79.0	Selenium	34
79.9	Bromine	35
83.8	Krypton	36
85.5	Rubidium	37
87.6	Strontium	38
88.9	Yttrium	39
91.2	Zirconium	40
92.9	Niobium	41
95.9	Molybdenum	42
99.0	Technetium	43
101.0	Ruthenium	44
102.9	Rhodium	45
106.4	Palladium	46
107.8	Silver	47
112.4	Cadmium	48
114.8	Indium	49
118.7	Tin	50
121.8	Antimony	51
127.8	Tellurium	52
126.9	Iodine	53
131.3	Xenon	54
132.9	Cesium	55
137.4	Barium	56
138.9	Lanthanum	57
140.9	Cerium	58
144.3	Praseodymium	59
147.1	Neodymium	60
150.4	Promethium	61
150.4	Samarium	62
152.0	Europium	63
157.2	Gadolinium	64
158.9	Terbium	65
162.5	Dysprosium	66
164.9	Holmium	67
167.3	Erbium	68
168.9	Thulium	69
173.0	Ytterbium	70
175.0	Lutetium	71
178.0	Hafnium	72
181.0	Tantalum	73
183.8	Tungsten	74
186.2	Rhenium	75
186.2	Osmium	76
192.2	Iridium	77
195.1	Platinum	78
197.0	Gold	79
200.6	Mercury	80
204.4	Thallium	81
207.2	Lead	82
209.0	Bismuth	83
210.0	Polonium	84
210.0	Astatine	85
222.0	Radon	86
223.0	Francium	87
226.0	Radium	88
227.0	Actinium	89
232.0	Thorium	90
231.0	Protactinium	91
238.0	Uranium	92
237.0	Neptunium	93
242.0	Plutonium	94
244.0	Americium	95
247.0	Curium	96
247.0	Berkelium	97
251.0	Californium	98
254.0	Einsteinium	99
253.0	Fermium	100
254.0	Mendelevium	101
254.0	Nobelium	102
257.0	Lawrencium	103
261.0	Ununquadium	104
262.0	Ununpentium	105
263.0	Ununhexium	106
263.0	Ununseptium	107
265.0	Ununoctium	108
264.0	Ununennium	109

Padova 15 Mar



元素周期表

族 周期	I A																	0	电子层	电子数						
1	1 H 氢 $1s^1$ 1.008																	2 He 氦 $1s^2$ 4.003	K	2						
2	3 Li 锂 $2s^1$ 6.941	4 Be 铍 $2s^2$ 9.012																	5 B 硼 $2s^2 2p^1$ 10.81	6 C 碳 $2s^2 2p^2$ 12.01	7 N 氮 $2s^2 2p^3$ 14.01	8 O 氧 $2s^2 2p^4$ 16.00	9 F 氟 $2s^2 2p^5$ 19.00	10 Ne 氖 $2s^2 2p^6$ 20.18	L K	8 2
3	11 Na 钠 $3s^1$ 22.99	12 Mg 镁 $3s^2$ 24.31																	13 Al 铝 $3s^2 3p^1$ 26.98	14 Si 硅 $3s^2 3p^2$ 28.09	15 P 磷 $3s^2 3p^3$ 30.97	16 S 硫 $3s^2 3p^4$ 32.07	17 Cl 氯 $3s^2 3p^5$ 35.45	18 Ar 氩 $3s^2 3p^6$ 39.95	M L K	8 8 2
4	19 K 钾 $4s^1$ 39.10	20 Ca 钙 $4s^2$ 40.08	21 Sc 钪 $3d^1 4s^2$ 44.96	22 Ti 钛 $3d^2 4s^2$ 47.87	23 V 钒 $3d^3 4s^2$ 50.94	24 Cr 铬 $3d^5 4s^1$ 52.00	25 Mn 锰 $3d^5 4s^2$ 54.94	26 Fe 铁 $3d^6 4s^2$ 55.85	27 Co 钴 $3d^7 4s^2$ 58.93	28 Ni 镍 $3d^8 4s^2$ 58.69	29 Cu 铜 $3d^{10} 4s^1$ 63.55	30 Zn 锌 $3d^{10} 4s^2$ 65.39	31 Ga 镓 $4s^2 4p^1$ 69.72	32 Ge 锗 $4s^2 4p^2$ 72.61	33 As 砷 $4s^2 4p^3$ 74.92	34 Se 硒 $4s^2 4p^4$ 78.96	35 Br 溴 $4s^2 4p^5$ 79.90	36 Kr 氪 $4s^2 4p^6$ 83.80	N M L K	8 18 8 2						
5	37 Rb 铷 $5s^1$ 85.47	38 Sr 锶 $5s^2$ 87.62	39 Y 钇 $4d^1 5s^2$ 88.91	40 Zr 锆 $4d^2 5s^2$ 91.22	41 Nb 铌 $4d^4 5s^1$ 92.91	42 Mo 钼 $4d^5 5s^1$ 95.94	43 Tc 锝 $4d^5 5s^2$ [99]	44 Ru 钌 $4d^7 5s^1$ 101.1	45 Rh 铑 $4d^8 5s^1$ 102.9	46 Pd 钯 $4d^{10}$ 106.4	47 Ag 银 $4d^{10} 5s^1$ 107.9	48 Cd 镉 $4d^{10} 5s^2$ 112.4	49 In 铟 $5s^2 5p^1$ 114.8	50 Sn 锡 $5s^2 5p^2$ 118.7	51 Sb 锑 $5s^2 5p^3$ 121.8	52 Te 碲 $5s^2 5p^4$ 127.6	53 I 碘 $5s^2 5p^5$ 126.9	54 Xe 氙 $5s^2 5p^6$ 131.3	O N M L K	8 18 18 8 2						
6	55 Cs 铯 $6s^1$ 132.9	56 Ba 钡 $6s^2$ 137.3	57-71 La-Lu 镧系	72 Hf 铪 $5d^2 6s^2$ 178.5	73 Ta 钽 $5d^3 6s^2$ 180.9	74 W 钨 $5d^4 6s^2$ 183.8	75 Re 铼 $5d^5 6s^2$ 186.2	76 Os 锇 $5d^6 6s^2$ 190.2	77 Ir 铱 $5d^7 6s^2$ 192.2	78 Pt 铂 $5d^9 6s^1$ 195.1	79 Au 金 $5d^{10} 6s^1$ 197.0	80 Hg 汞 $5d^{10} 6s^2$ 200.6	81 Tl 铊 $6s^2 6p^1$ 204.4	82 Pb 铅 $6s^2 6p^2$ 207.2	83 Bi 铋 $6s^2 6p^3$ 209.0	84 Po 钋 $6s^2 6p^4$ [209]	85 At 砹 $6s^2 6p^5$ [210]	86 Rn 氡 $6s^2 6p^6$ [222]	P O N M L K	8 18 32 18 8 2						
7	87 Fr 钫 $7s^1$ [223]	88 Ra 镭 $7s^2$ 226.0	89-103 Ac-Lr 锕系	104 Rf 𨭎* $(6d^2 7s^2)$ [261]	105 Ha 𨭏* $(6d^3 7s^2)$ [262]	106 * $(6d^4 7s^2)$ [263]	107 * $(6d^5 7s^2)$ [262]	108 * $(6d^6 7s^2)$ [265]	109 * $(6d^7 7s^2)$ [266]																	
镧系	57 La 镧 $5d^1 6s^2$ 138.9	58 Ce 铈 $4f^1 5d^1 6s^2$ 140.1	59 Pr 镨 $4f^3 6s^2$ 140.9	60 Nd 钕 $4f^4 6s^2$ 144.2	61 Pm 钷 $4f^5 6s^2$ [147]	62 Sm 钐 $4f^6 6s^2$ 150.4	63 Eu 铕 $4f^7 6s^2$ 152.0	64 Gd 钆 $4f^7 5d^1 6s^2$ 157.3	65 Tb 铽 $4f^9 6s^2$ 158.9	66 Dy 镝 $4f^{10} 6s^2$ 162.5	67 Ho 铥 $4f^{11} 6s^2$ 164.9	68 Er 铒 $4f^{12} 6s^2$ 167.3	69 Tm 铥 $4f^{13} 6s^2$ 168.9	70 Yb 镱 $4f^{14} 6s^2$ 173.0	71 Lu 镥 $4f^{14} 5d^1 6s^2$ 175.0											
锕系	89 Ac 锕 $6d^1 7s^2$ 227.0	90 Th 钍 $6d^2 7s^2$ 232.0	91 Pa 镤 $5f^2 6d^1 7s^2$ 231.0	92 U 铀 $5f^3 6d^1 7s^2$ 238.0	93 Np 镎 $5f^4 6d^1 7s^2$ 237.0	94 Pu 钚 $5f^6 7s^2$ [244]	95 Am 镅 $5f^7 7s^2$ [243]	96 Cm 锔* $5f^7 6d^1 7s^2$ [247]	97 Bk 锫* $5f^9 7s^2$ [247]	98 Cf 锿* $5f^{10} 7s^2$ [251]	99 Es 镄* $5f^{11} 7s^2$ [252]	100 Fm 镆* $5f^{12} 7s^2$ [257]	101 Md 镎* $(5f^{13} 7s^2)$ [258]	102 No 铈* $(5f^{14} 7s^2)$ [259]	103 Lr 铈* $(5f^{14} 6d^1 7s^2)$ [260]											

注：1. 相对原子质量录自1995年国际原子量表，并全部取4位有效数字。
 2. 相对原子质量加括号的为放射性元素的半衰期最长的同位素的质量数。

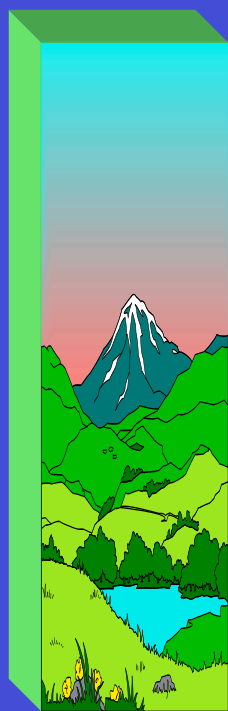


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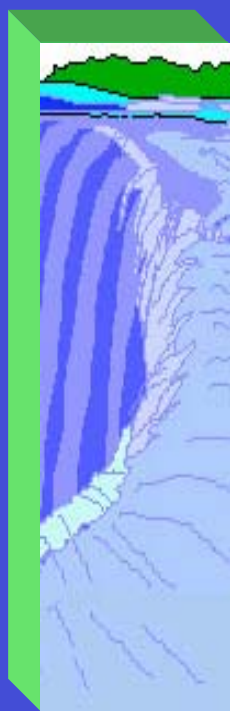
Il Modello Antico

Costituenti materiali

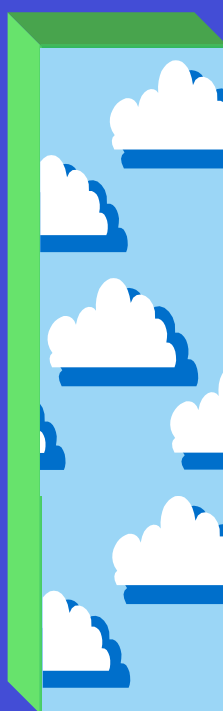
Forze



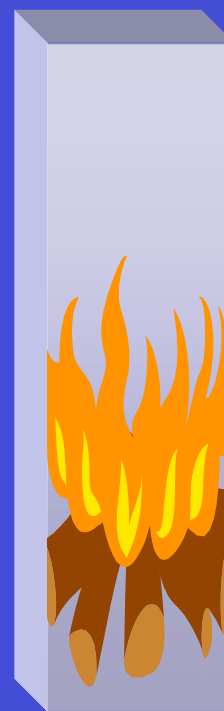
Terra



Acqua



Aria



Fuoco

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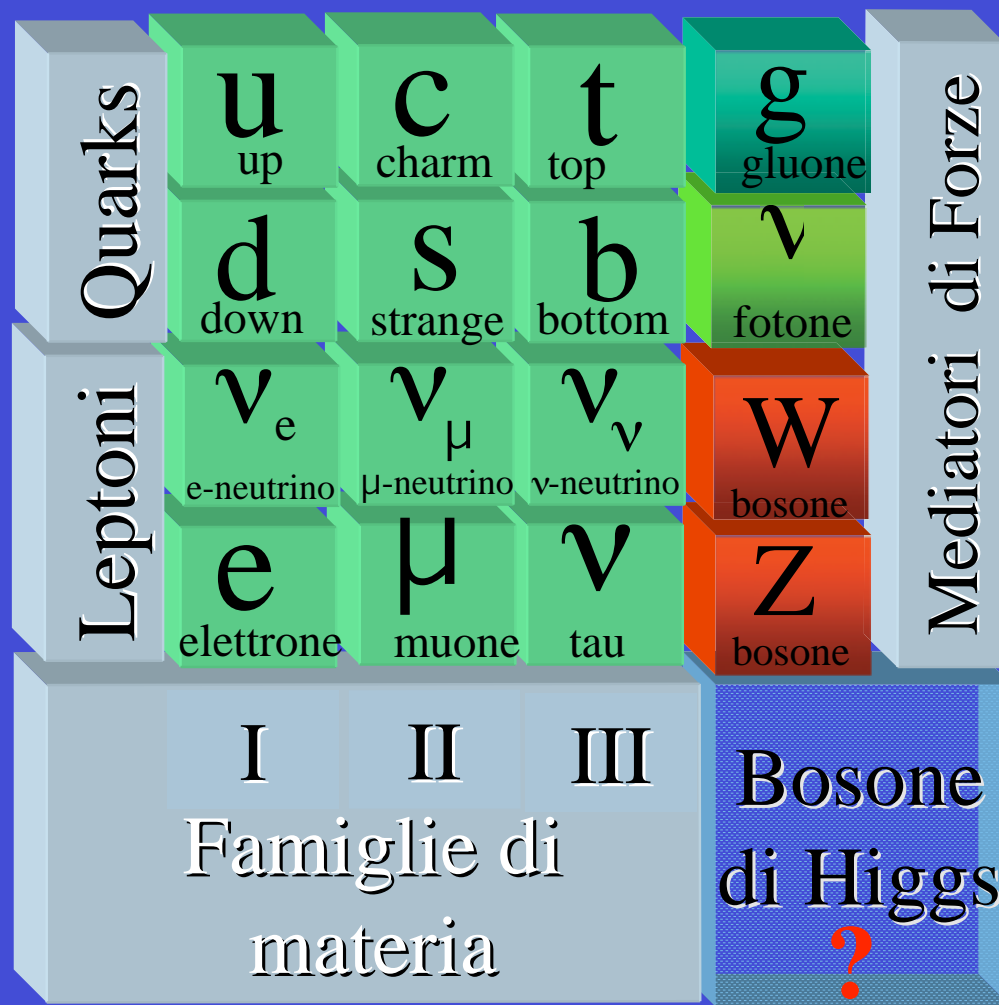
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Il Modello Standard



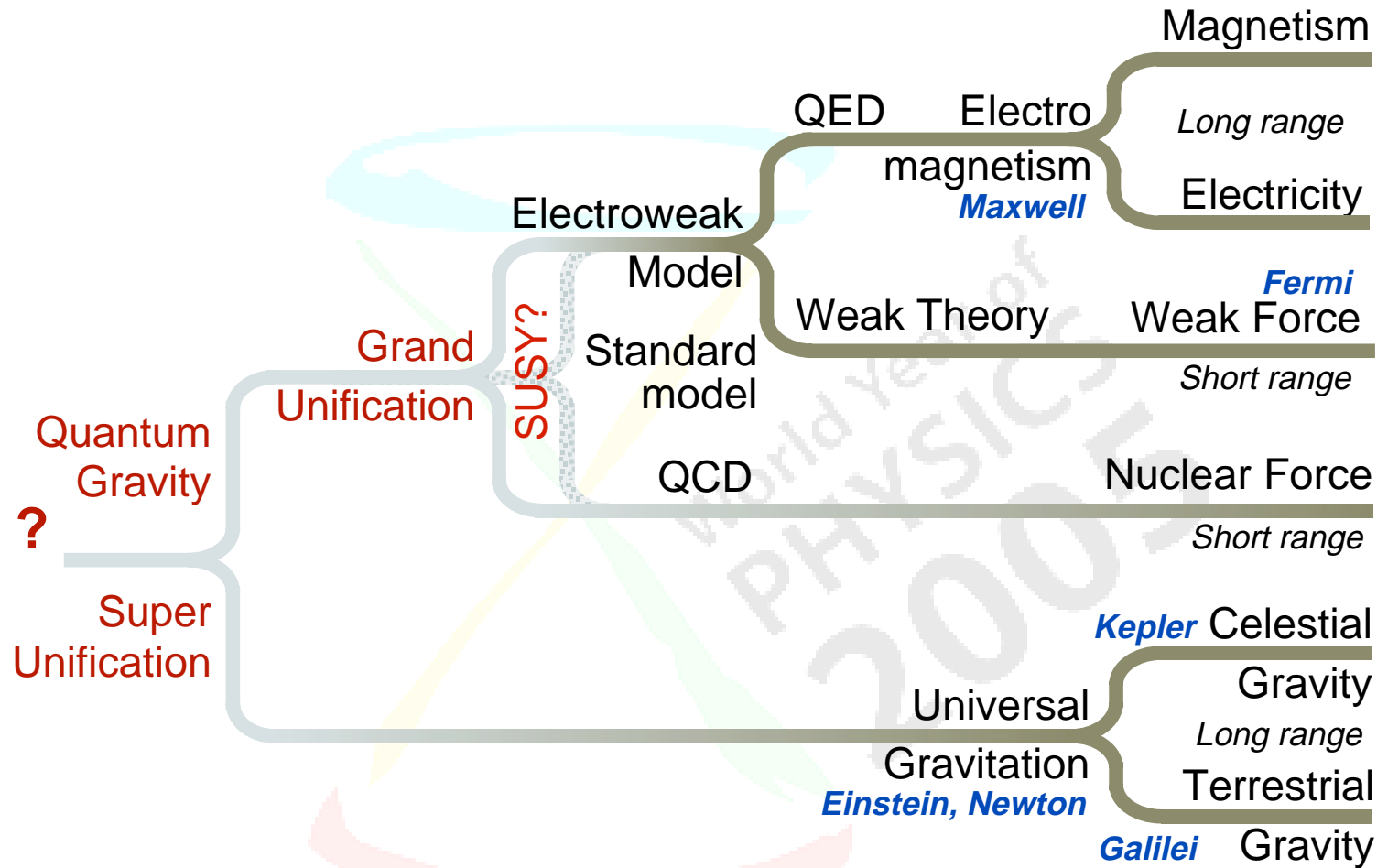
Costituenti materiali Forze





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Sommario delle forze



Pad

Theories:		
STRINGS?	RELATIVISTIC/QUANTUM	CLASSICAL



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The size of the things



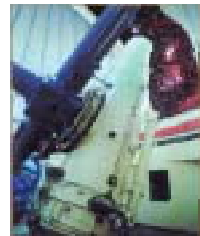
Instruments



Accelerators
LHC, LEP



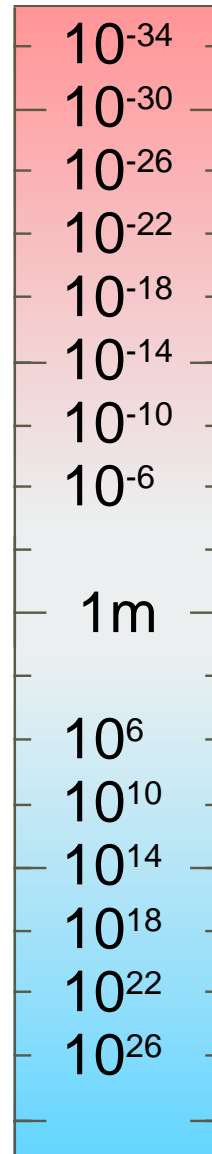
(Particle beams)
Electron
Microscope



Telescope

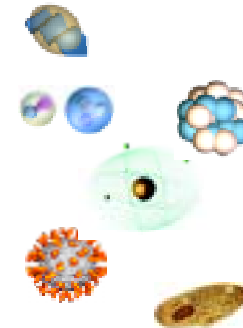


Radio
Telescope

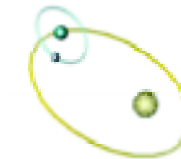


Observables

SUSY particle?
Higgs?
Z/W (range of nuclear force)
Proton Nuclei (range of weak force)
Atom
Virus
Cell



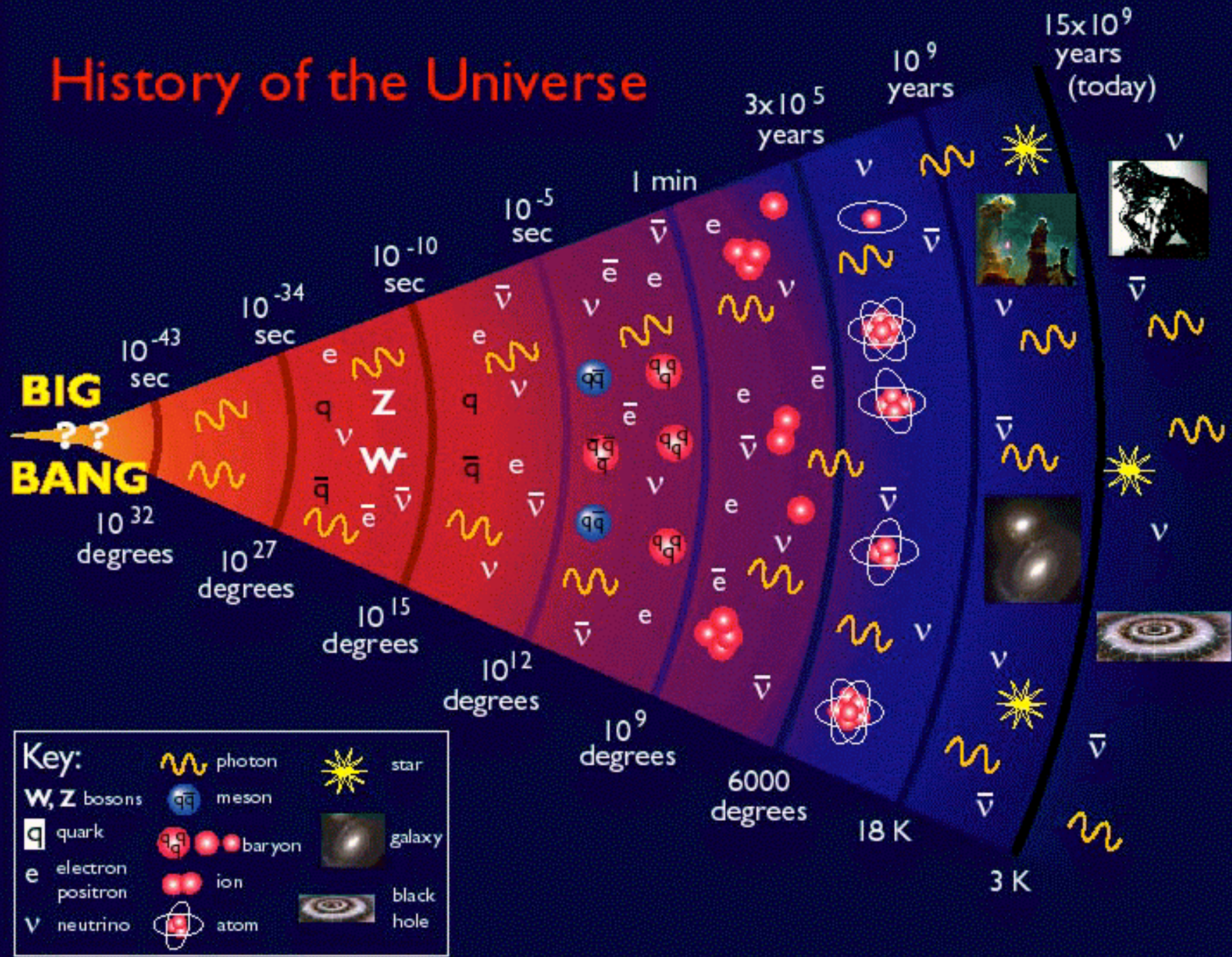
Earth radius
Earth to Sun



Galaxies
Radius of observable Universe



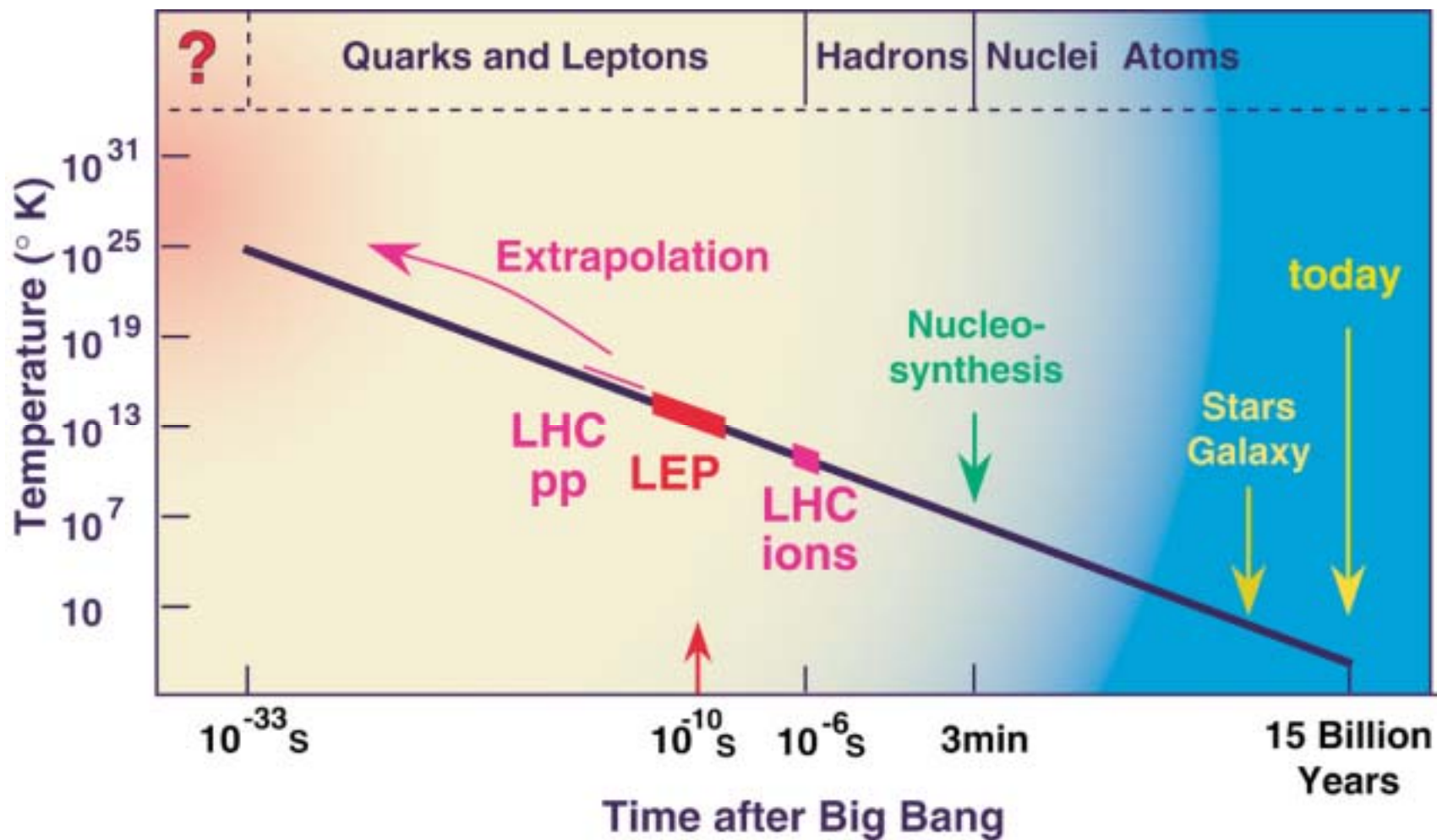
History of the Universe





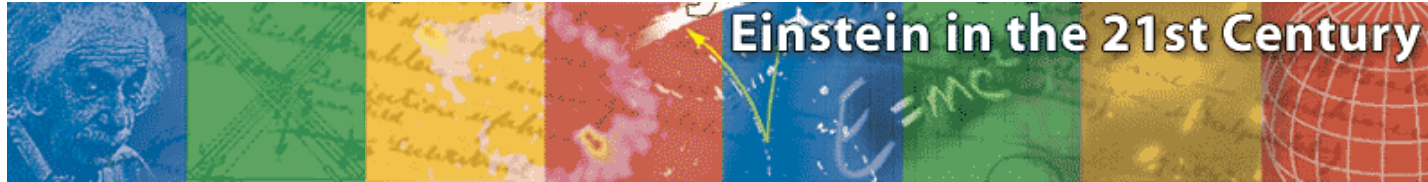
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Verso l'origine



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Per riassumere l'attività odierna di ricerca in Fisica delle Particelle comprende:

- 1. Verifica, tramite esperimenti agli acceleratori, del Modello Standard ricercando deviazioni dallo stesso**
- 2. Per compiere il pto 1. si studiano eventi ad alta energia per produrre e studiare nuove particelle (per es. Higgs, dettagli del top, etc) o eventi rarissimi per studi dedicati (per es. simmetria materia-antimateria tramite decadimenti mesoni B o K)**
- 3. Studi sulle proprietà dei neutrini (per es. loro massa)**
- 4. Studi con raggi cosmici e ricerca delle onde gravitazionali**



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dafne @ Lab. Naz. Frascati



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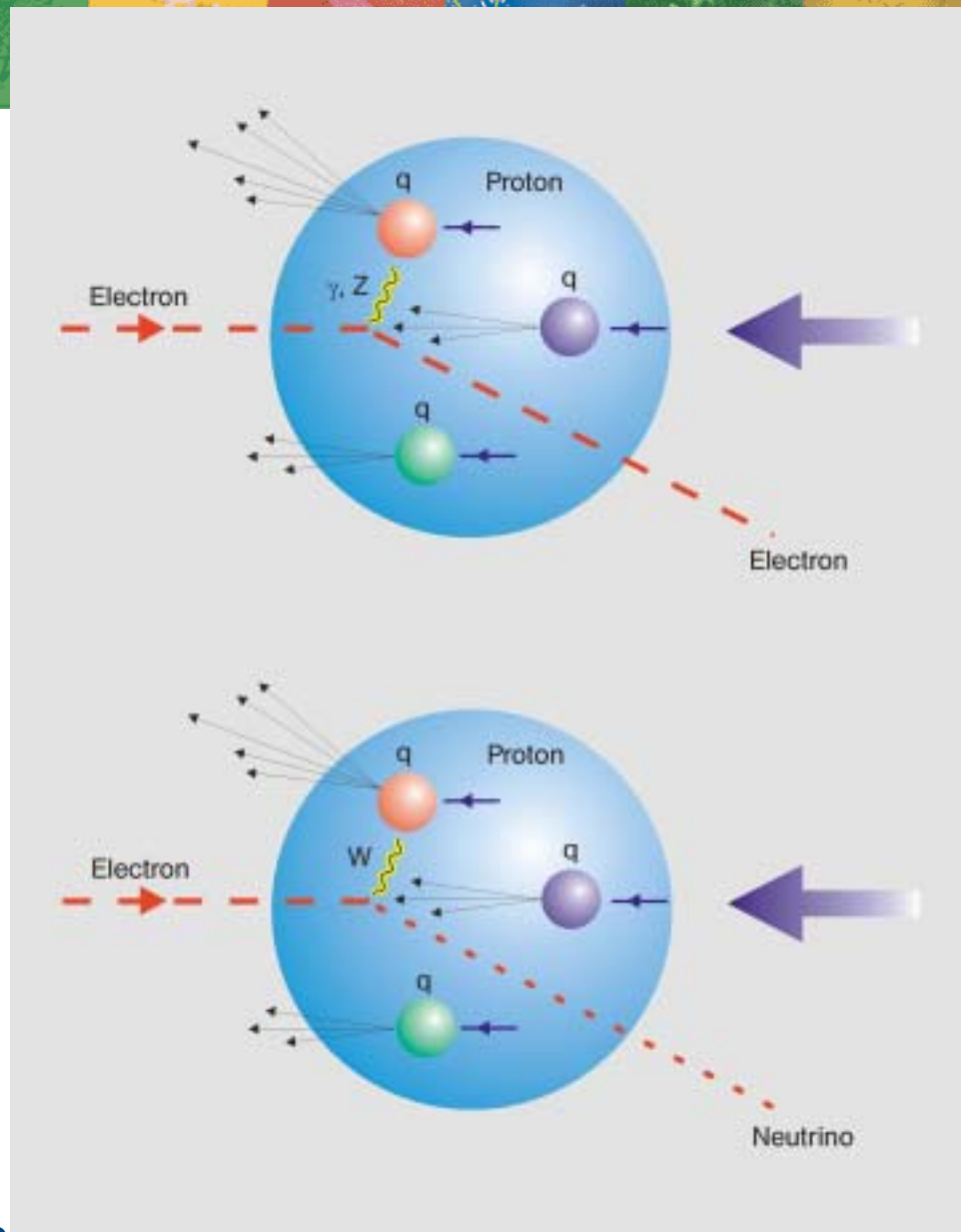


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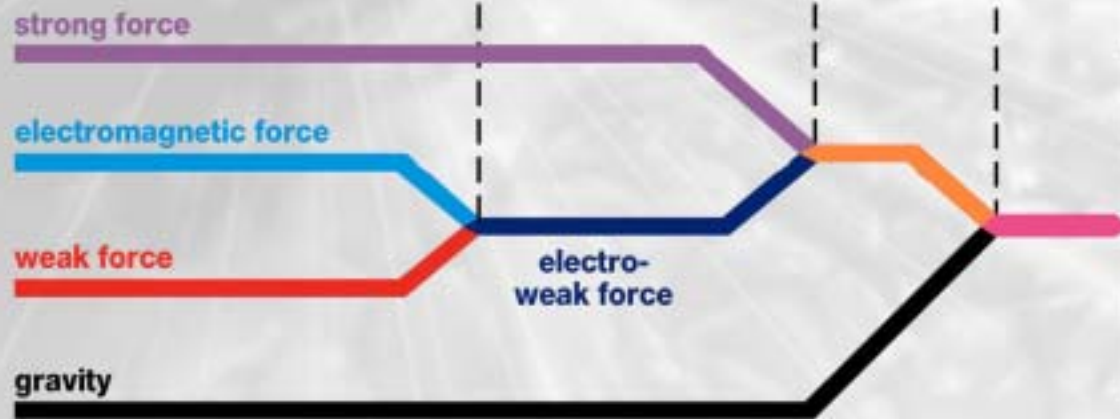
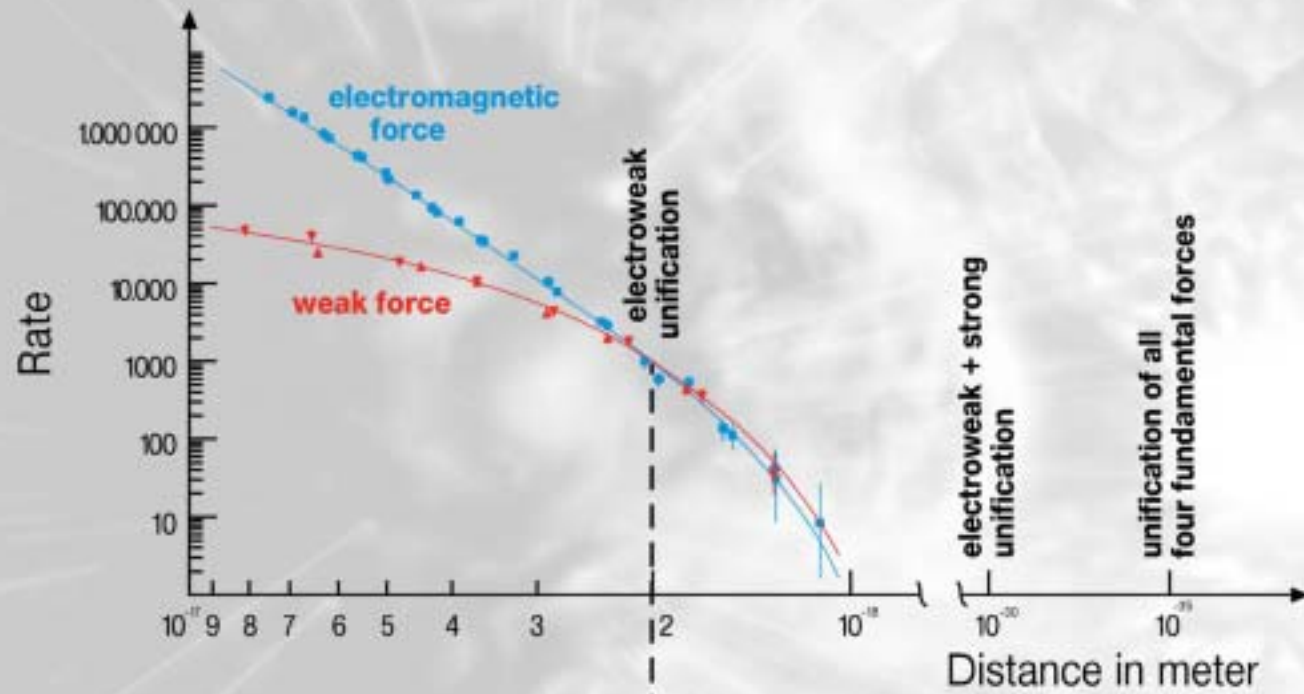
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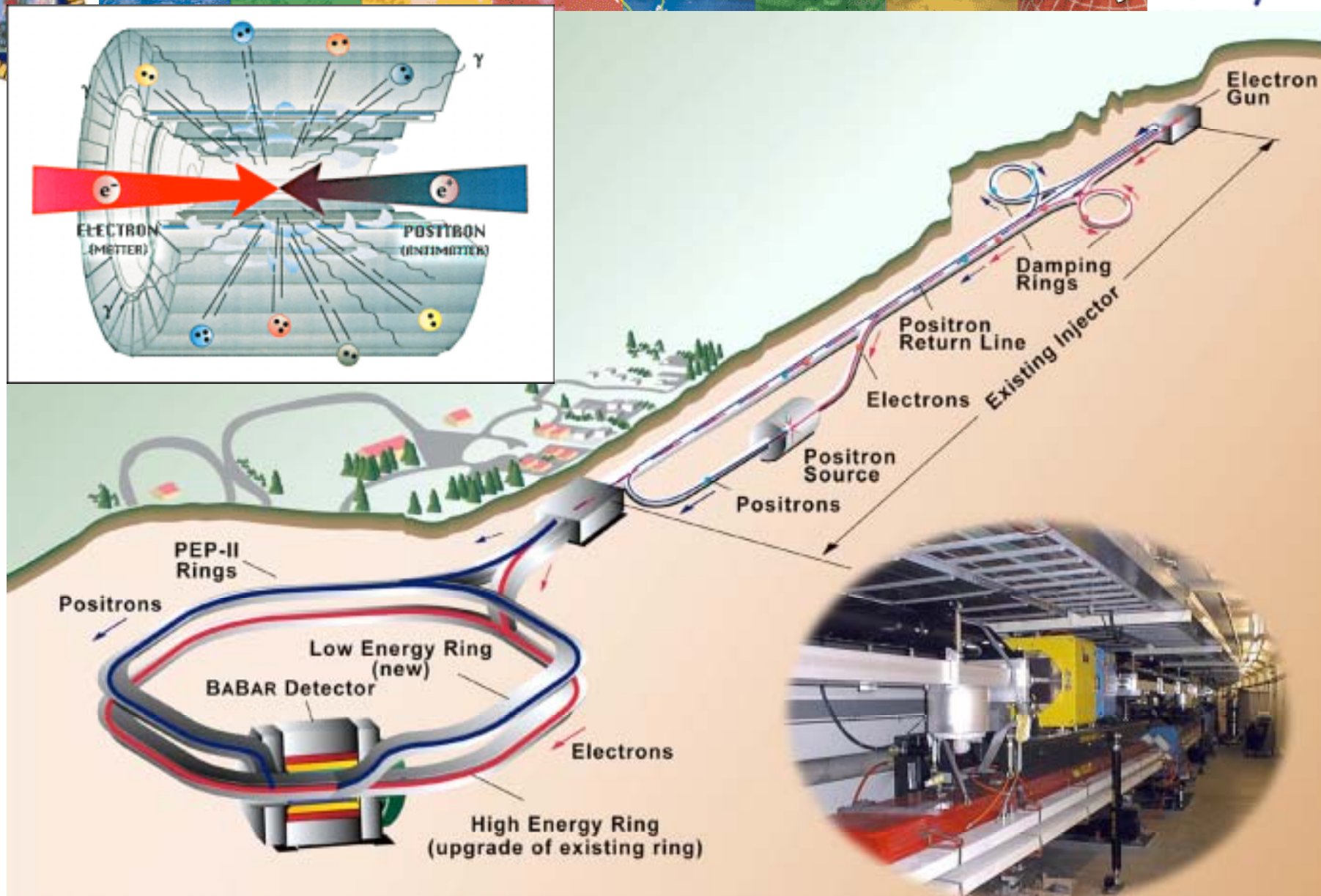
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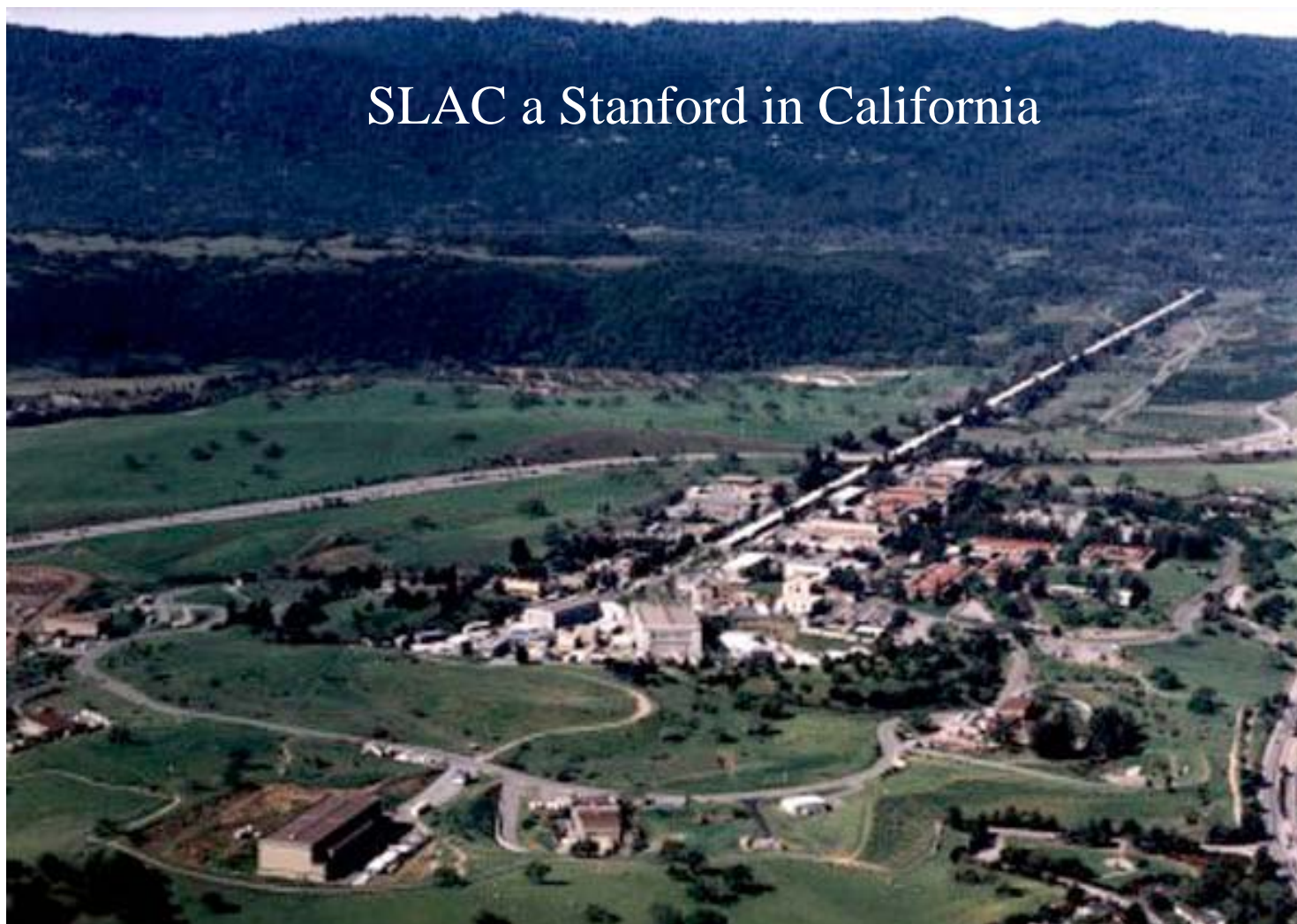
Padova 1



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Both Rings Housed in Current PEP Tunnel



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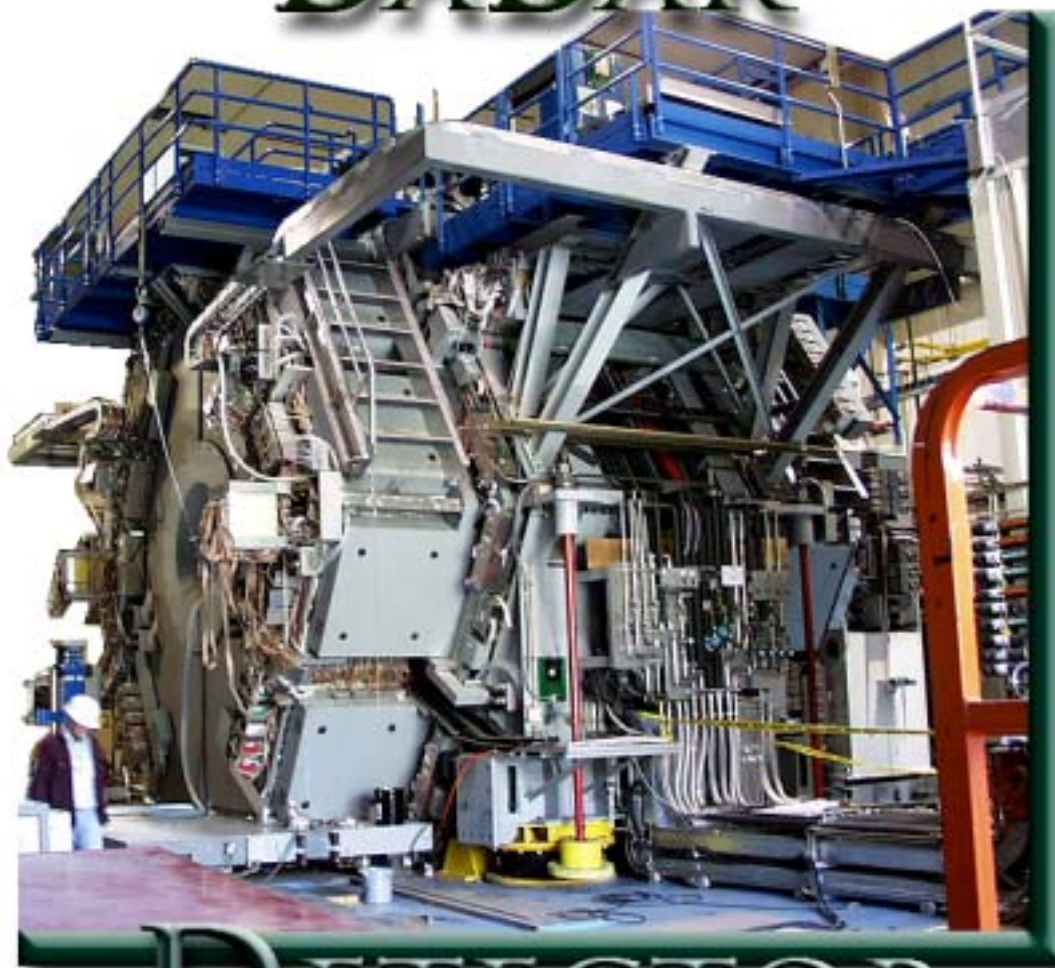
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BABAR

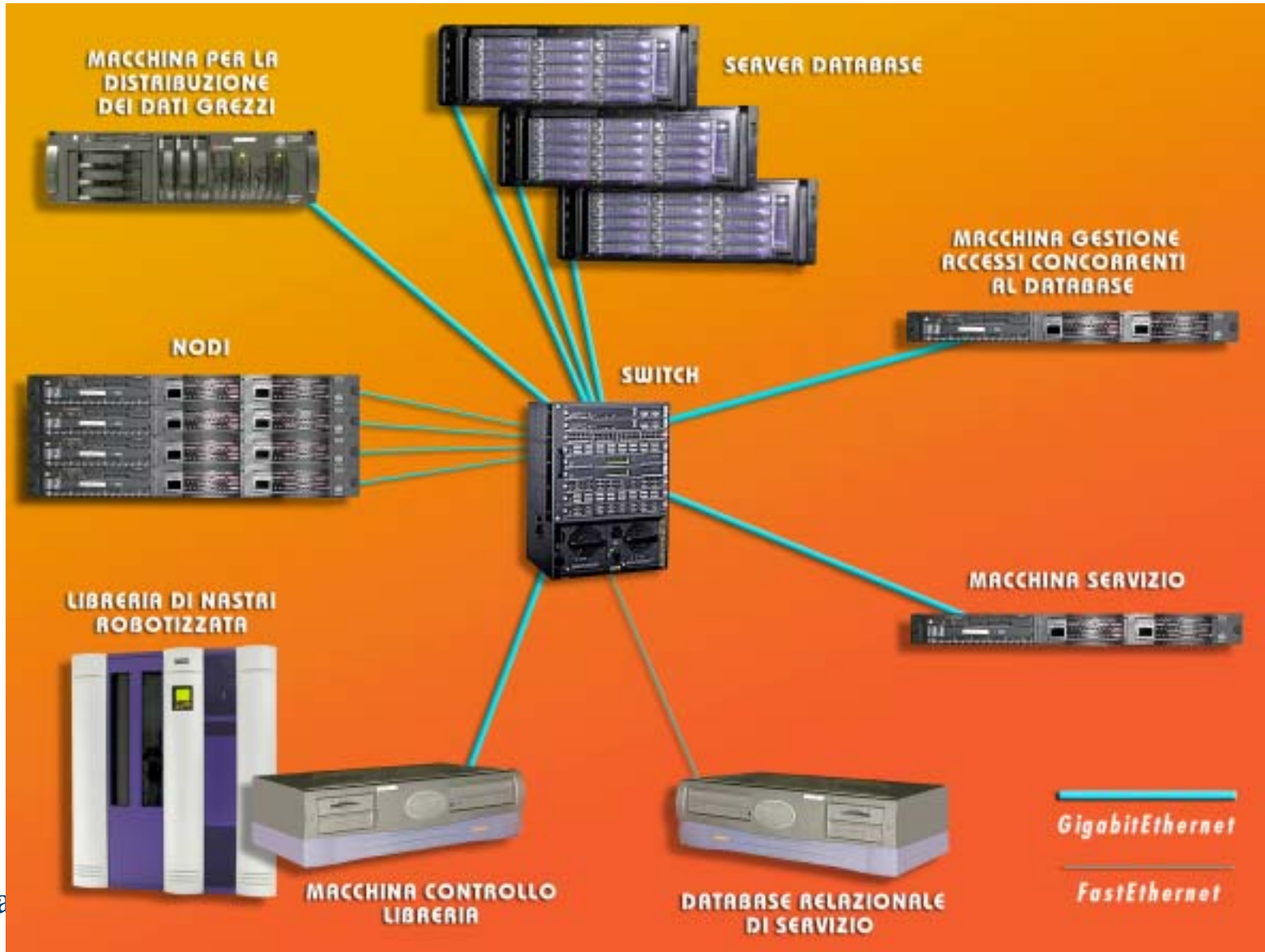


DETECTOR

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Layout of the Babar reprocessing farm in Padova: ~ 300 dual CPU's , ~ 20 TB disk space and ~ 300 TB tape storage





IL TEVATRON AL FERMILAB- Chicago

Il collisore protone-antiprotone a piu' alta energia:
2000 GeV



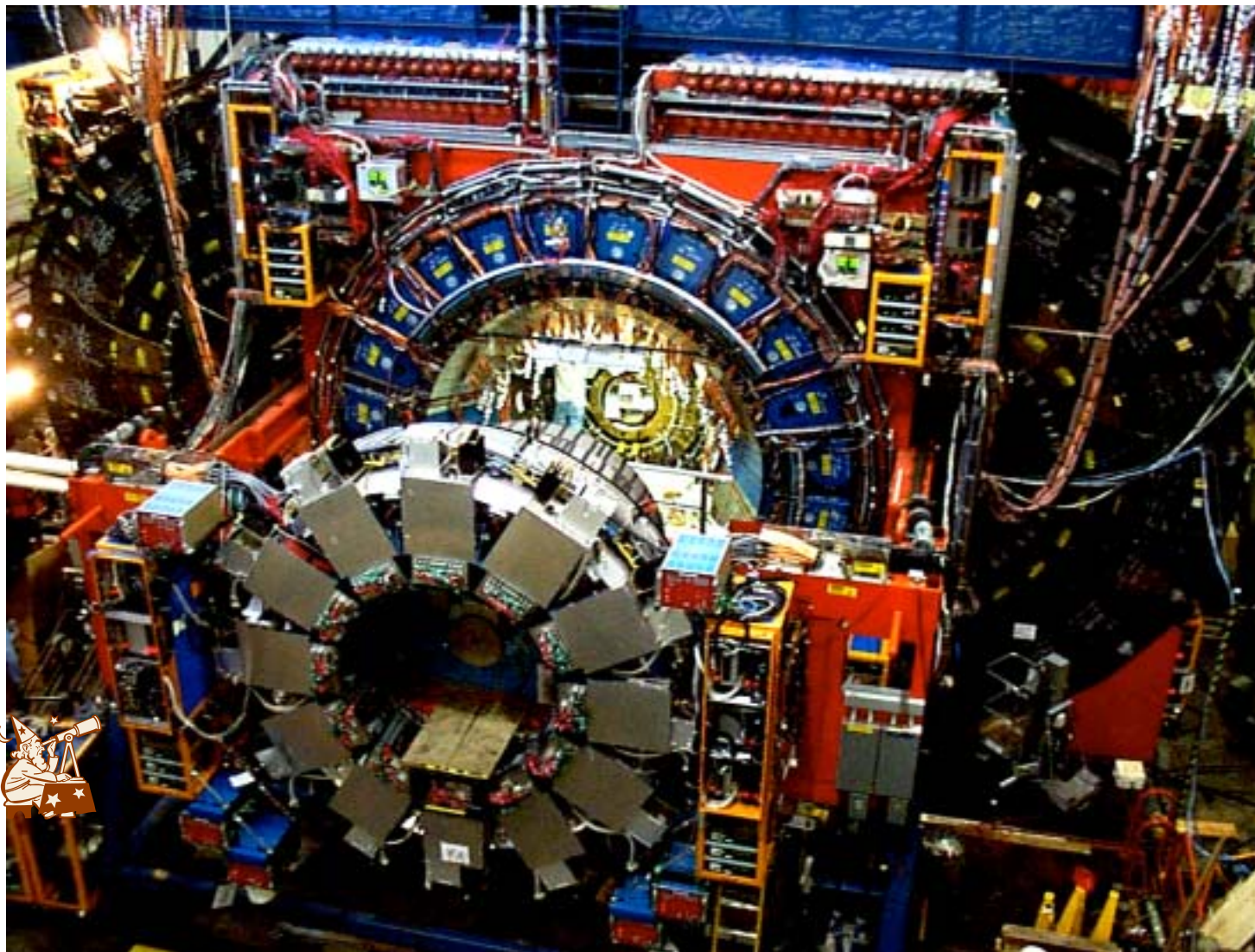
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Collider Detector at Fermilab



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COLLABORAZIONI INTERNAZIONALI esperimenti di fisica subnucleare



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CERN site

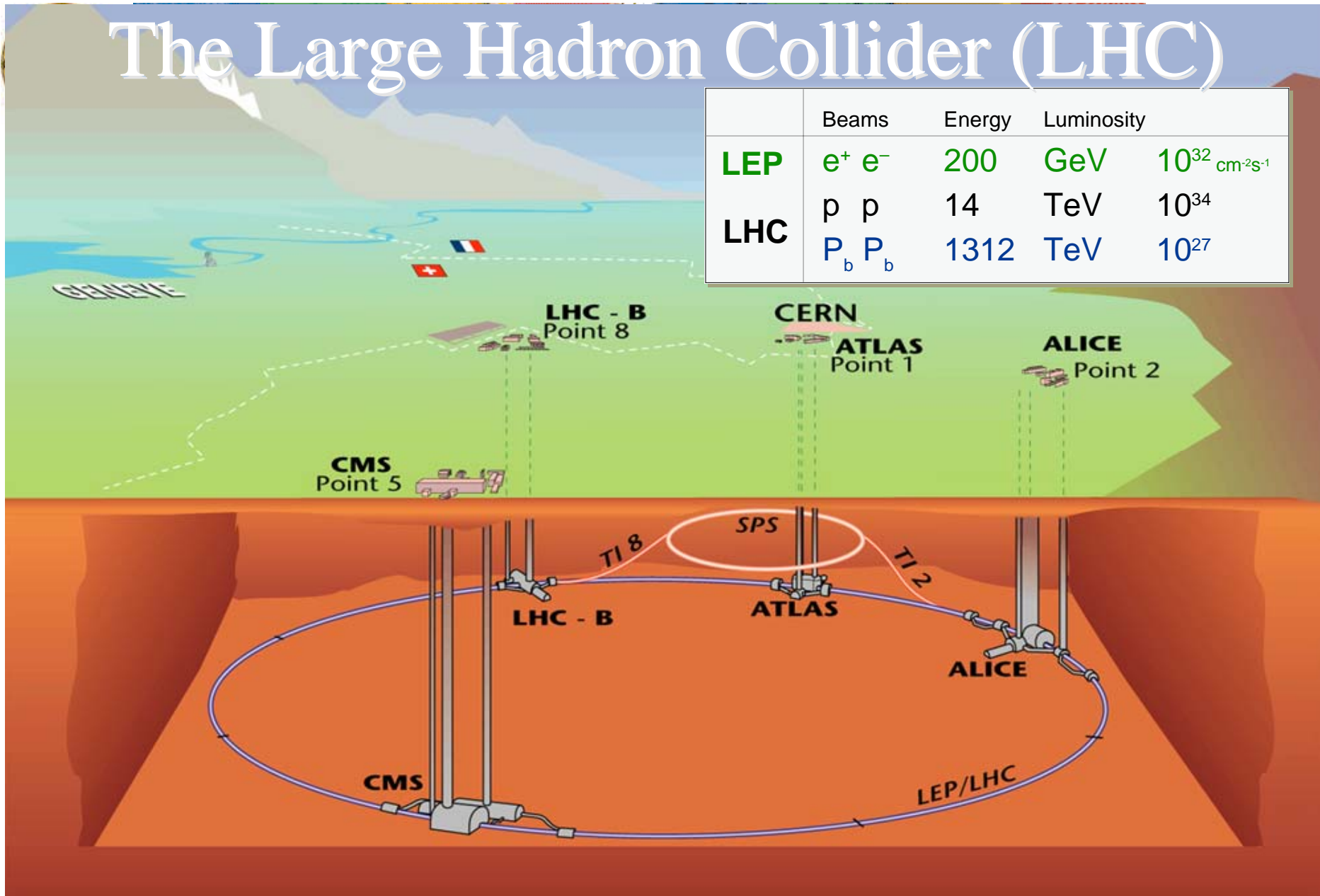


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The Large Hadron Collider (LHC)

	Beams	Energy	Luminosity
LEP	$e^+ e^-$	200 GeV	$10^{32} \text{ cm}^{-2}\text{s}^{-1}$
LHC	$p p$	14 TeV	10^{34}
	$P_b P_b$	1312 TeV	10^{27}

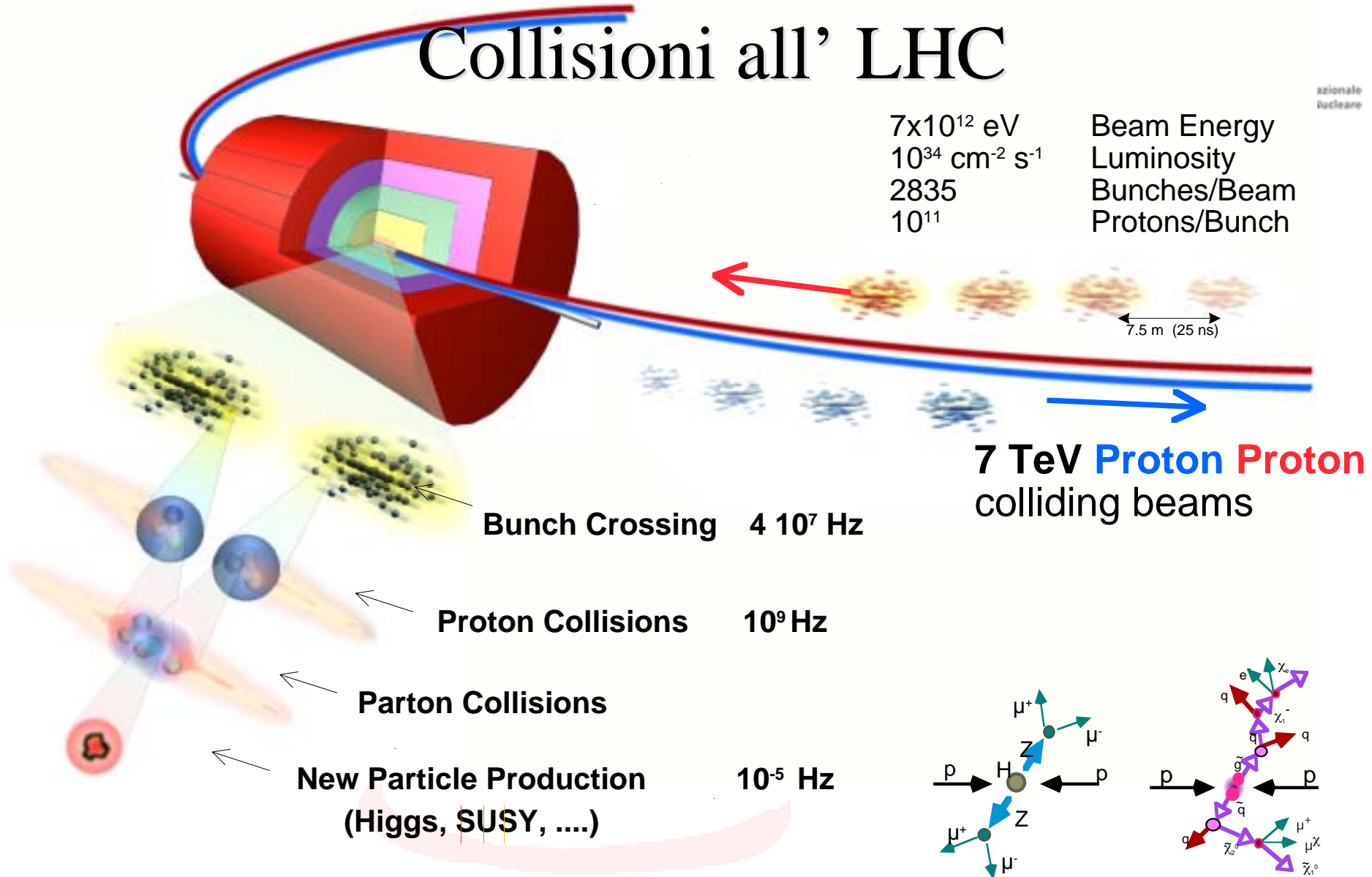


Collisioni all' LHC

azionale
nucleare

7×10^{12} eV
 10^{34} cm⁻² s⁻¹
 2835
 10^{11}

Beam Energy
 Luminosity
 Bunches/Beam
 Protons/Bunch



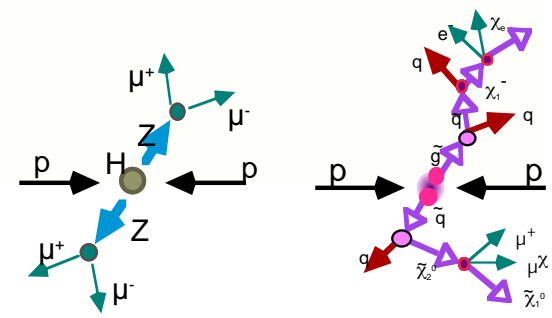
Bunch Crossing $4 \cdot 10^7$ Hz

Proton Collisions 10^9 Hz

Parton Collisions

New Particle Production (Higgs, SUSY,) 10^{-5} Hz

7 TeV **Proton Proton** colliding beams

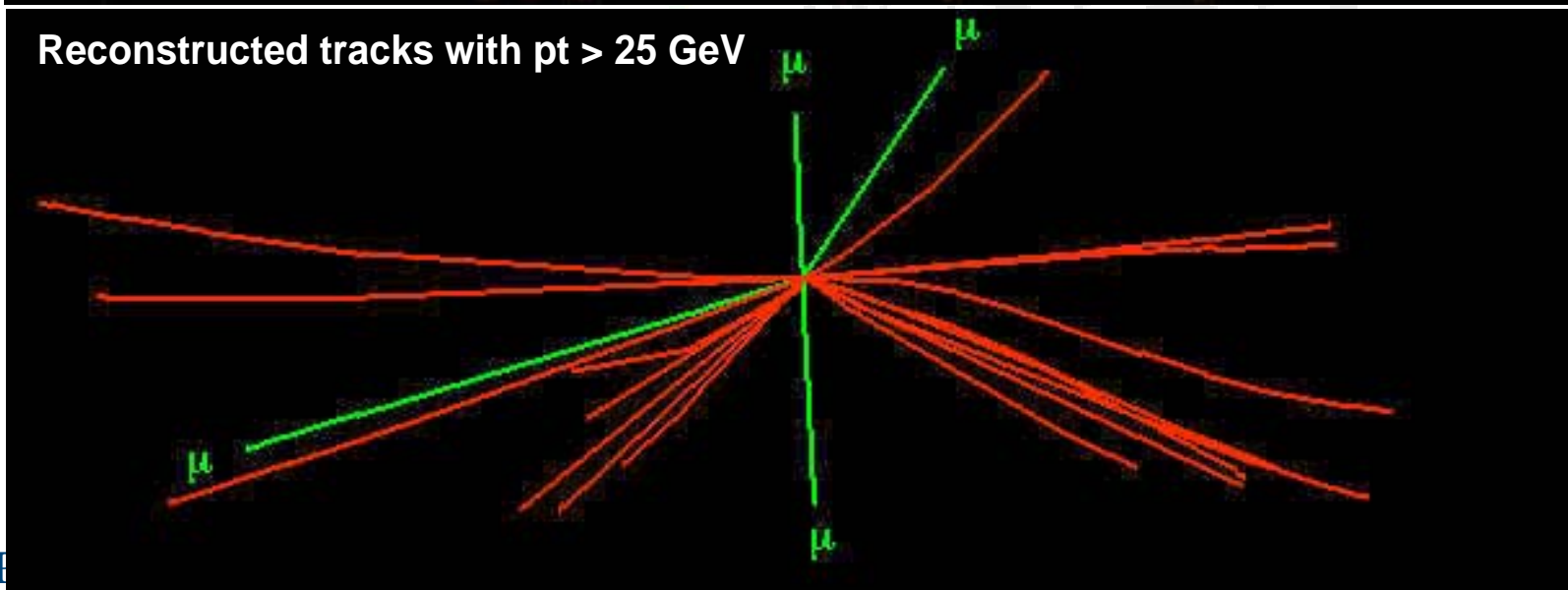
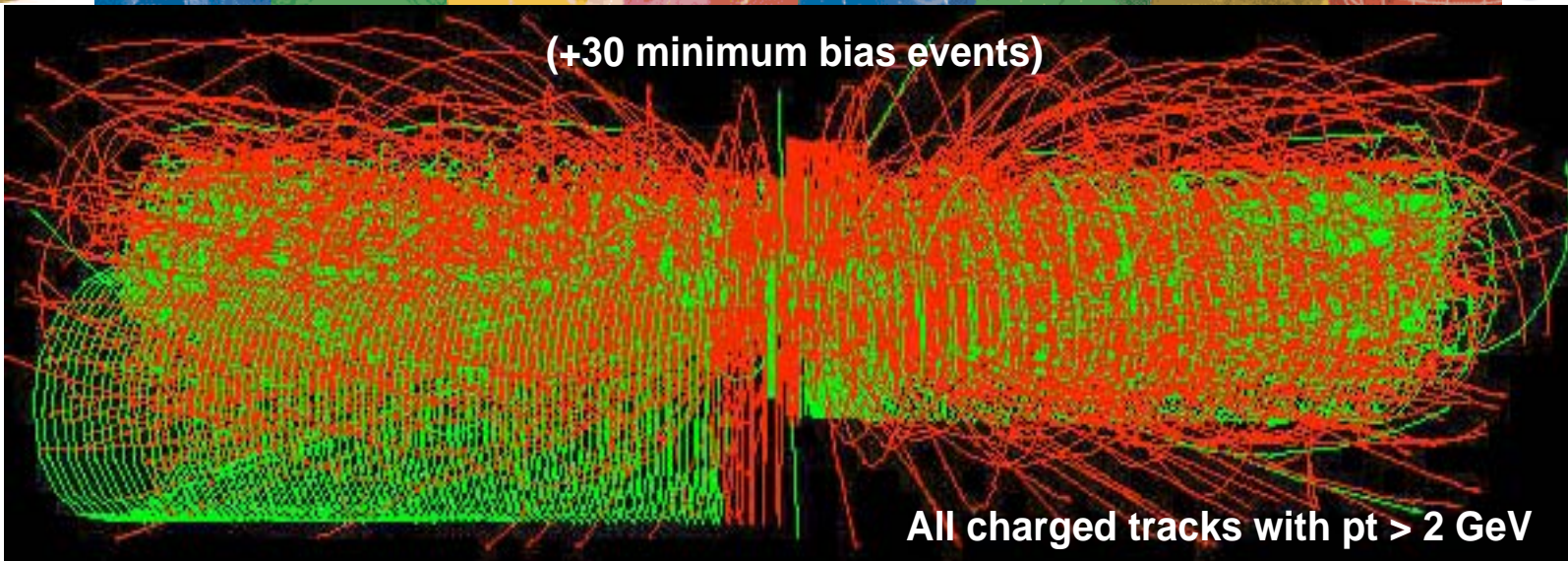


Selection of 1 event in 10,000,000,000,000



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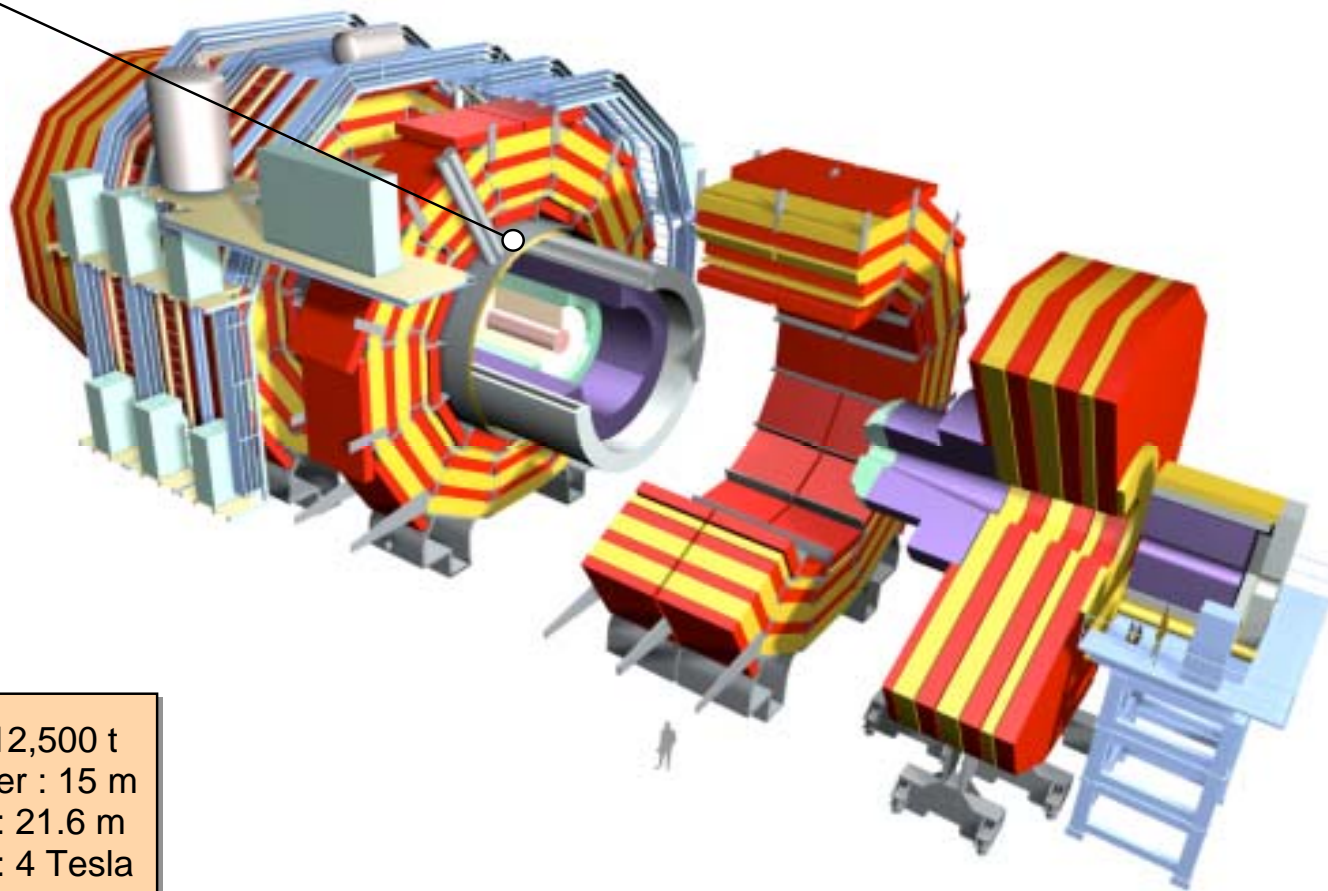
Higgs decay in 4 muons





The Compact Muon Solenoid (CMS)

**SUPERCONDUCTING
COIL**



Total weight : 12,500 t
Overall diameter : 15 m
Overall length : 21.6 m
Magnetic field : 4 Tesla

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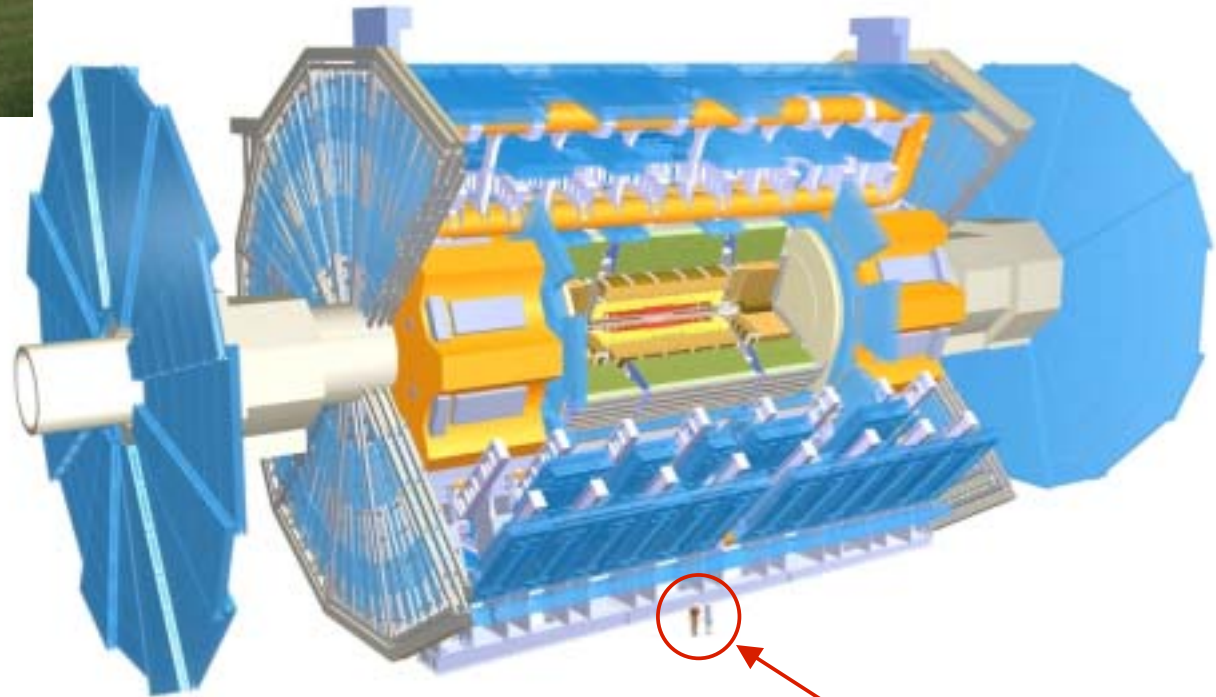
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ATLAS superimposed to the 5 floors of building 40



The ATLAS Detector



- Diameter**
- Barrel toroid length**
- End-cap end-wall chamber span**
- Overall weight**

- 25 m**
- 26 m**
- 46 m**
- 7000 Tons**

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ATLAS Collaboration

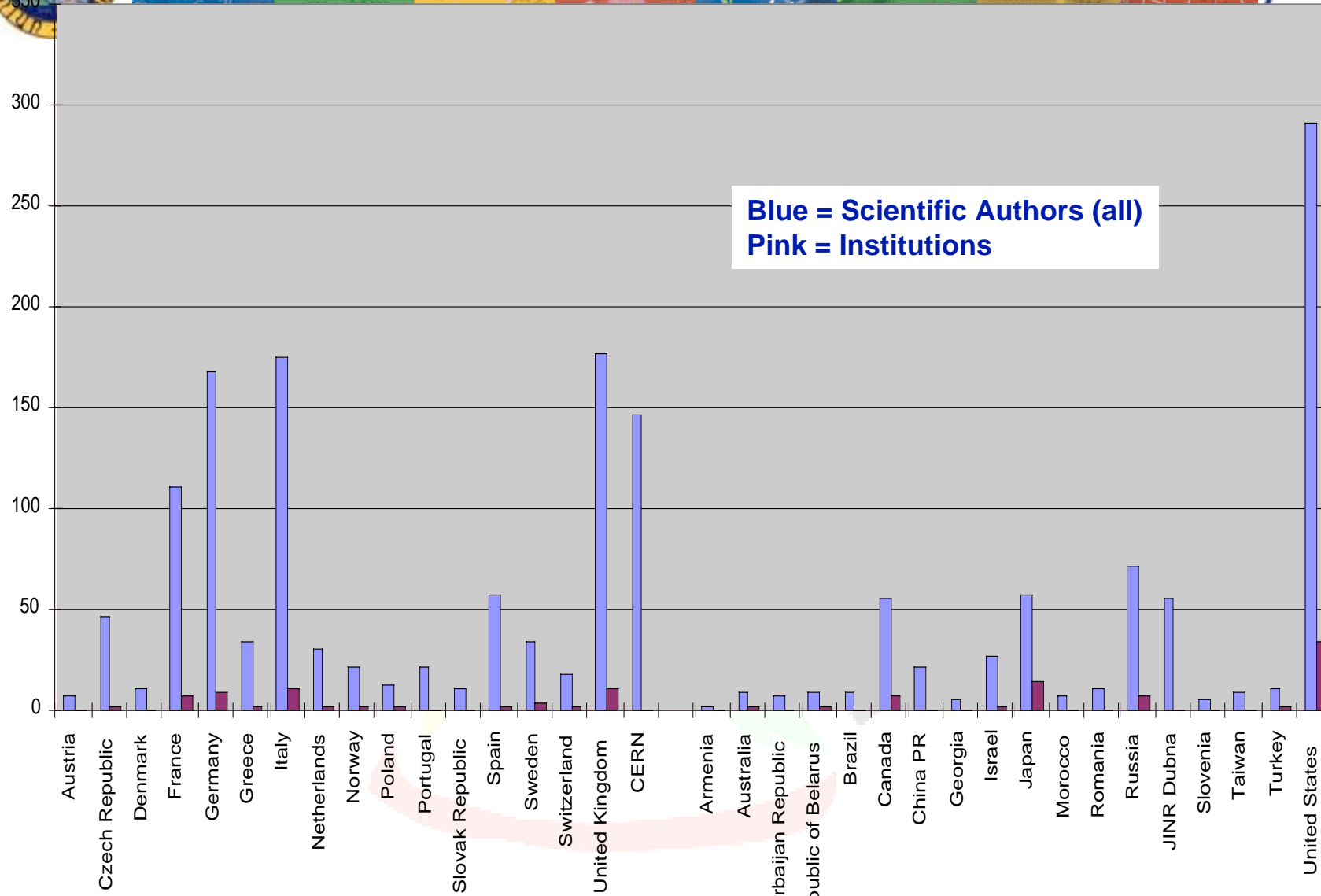
34 Countries
151 Institutions
1770 Scientific Authors



Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Ancecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, Bern, Birmingham, Bonn, Boston, Brandeis, Bratislava/SAS Kosice, Brookhaven NL, Bucharest, Cambridge, Carleton/CRPP, Casablanca/Rabat, CERN, Chinese Cluster, Chicago, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, INP Cracow, FPNT Cracow, Dortmund, JINR Dubna, Duke, Frascati, Freiburg, Geneva, Genoa, Glasgow, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Irvine UC, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, Mannheim, CPPM Marseille, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, FIAN Moscow, ITEP Moscow, MPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Naples, Naruto UE, New Mexico, Nijmegen, Northern Illinois, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, LAL Orsay, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Ritsumeikan, UFRJ Rio de Janeiro, Rochester, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, Southern Methodist Dallas, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Tokyo UAT, Toronto, TRIUMF, Tsukuba, Tufts, Udine, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, Wisconsin, Wuppertal, Yale, Yerevan



Einstein in the 21st Century

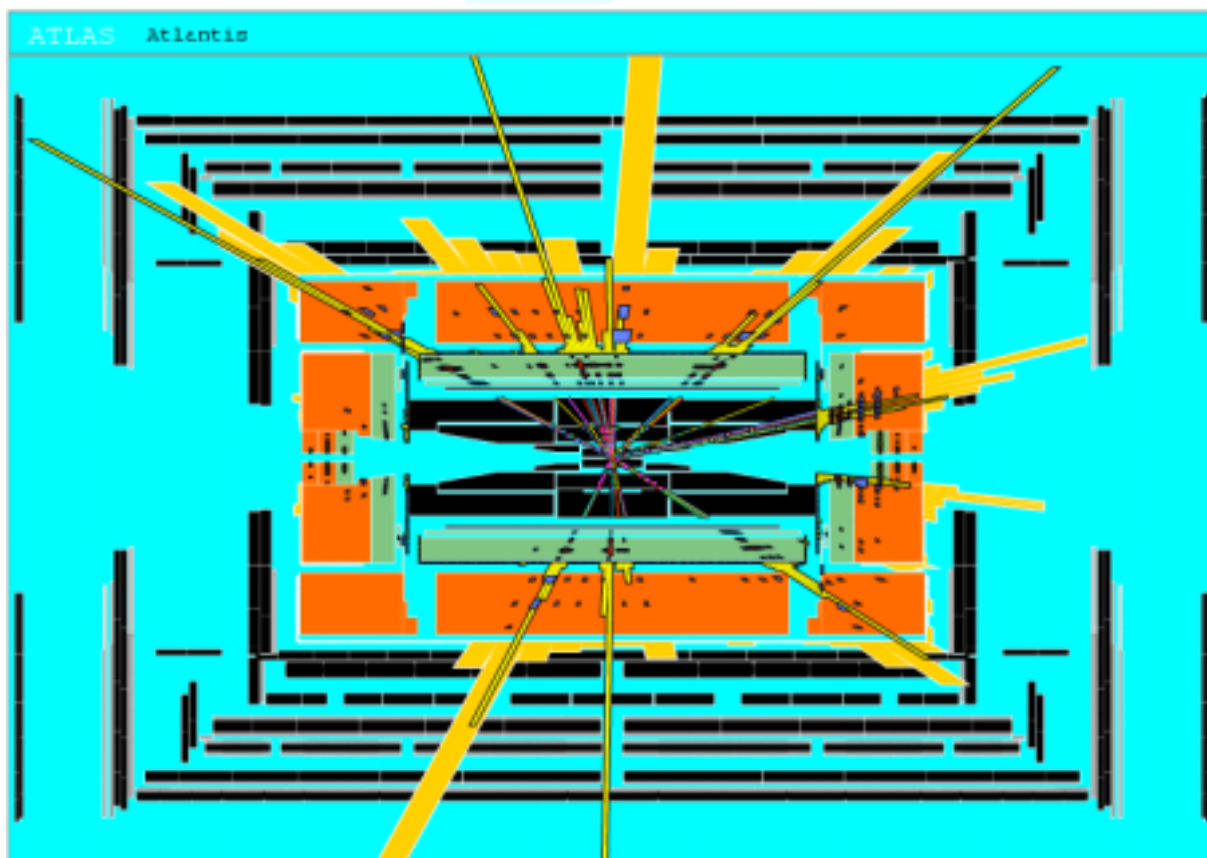


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If theories with **Extra-dimensions** are true, **mini black holes** should be abundantly produced and observed at the LHC.



Simulation of a black hole event with $M_{BH} \sim 8 \text{ TeV}$ in ATLAS

They decay immediately
→ harmless

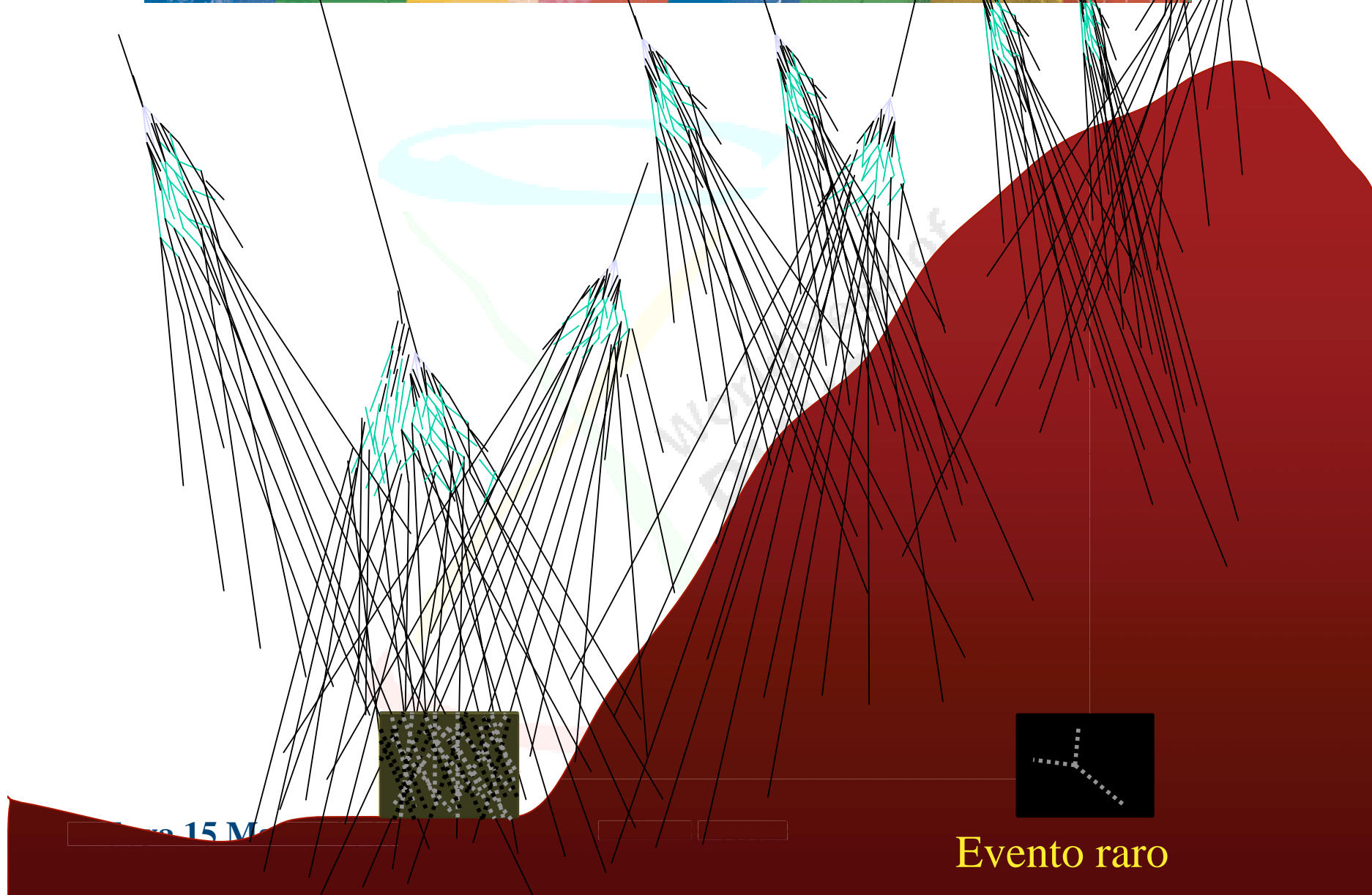
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Einstein in the 21st Century

Laboratori sotterranei



Evento raro



Einstein in the 21st Century

Garage 17 nel tunnel del Monte Bianco



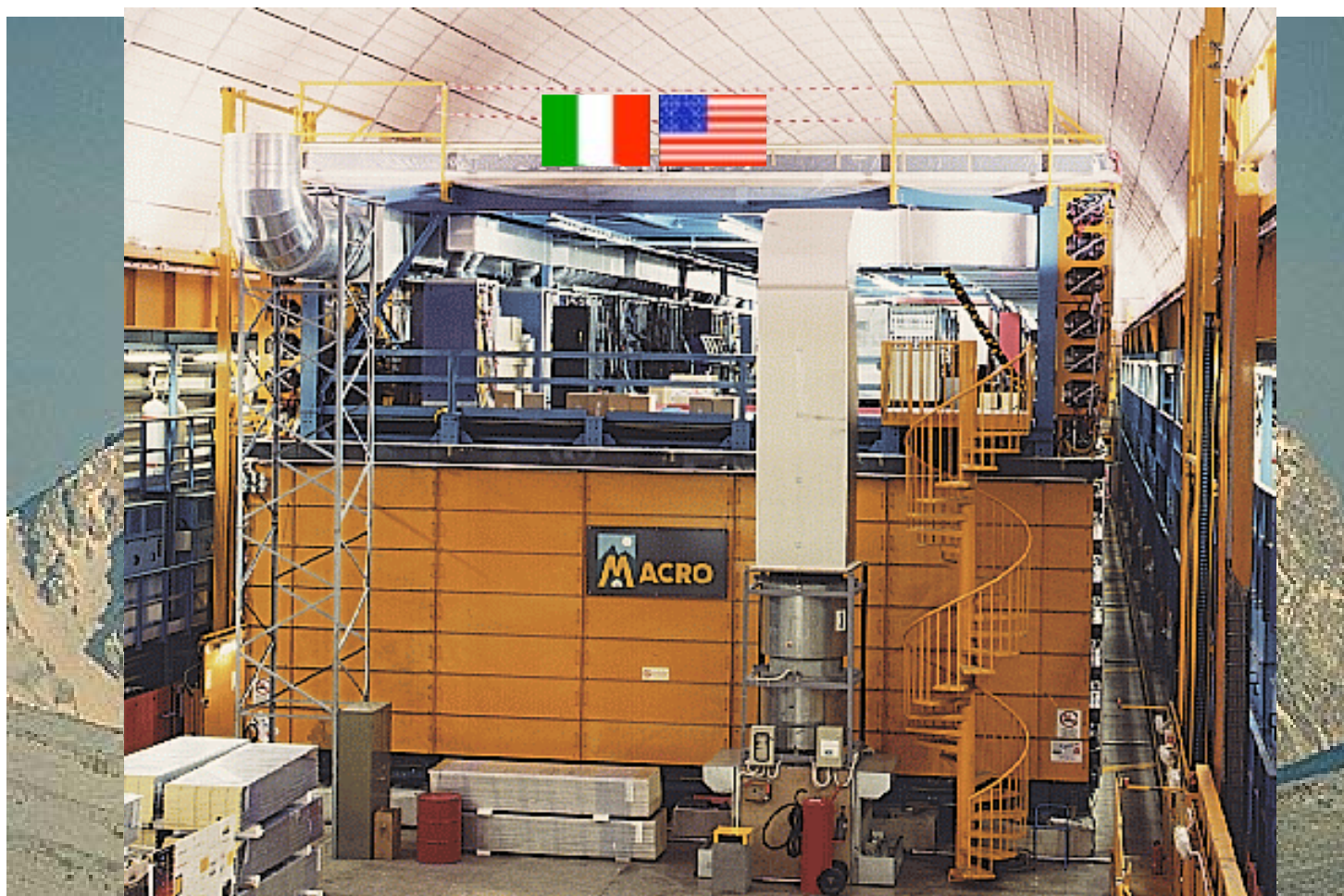
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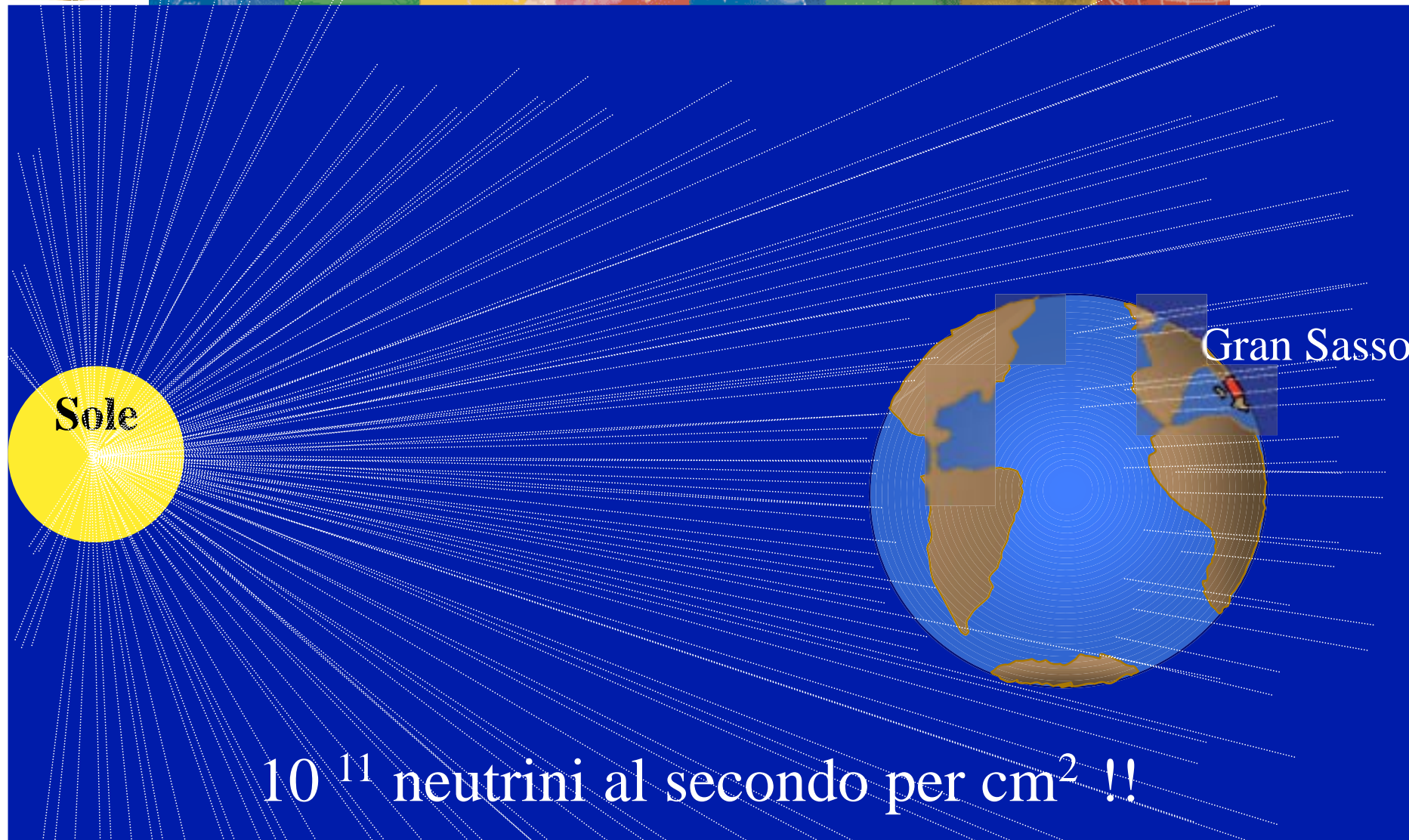
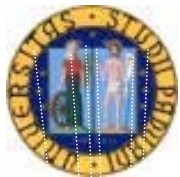
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Laboratori sotterranei del Gran Sasso



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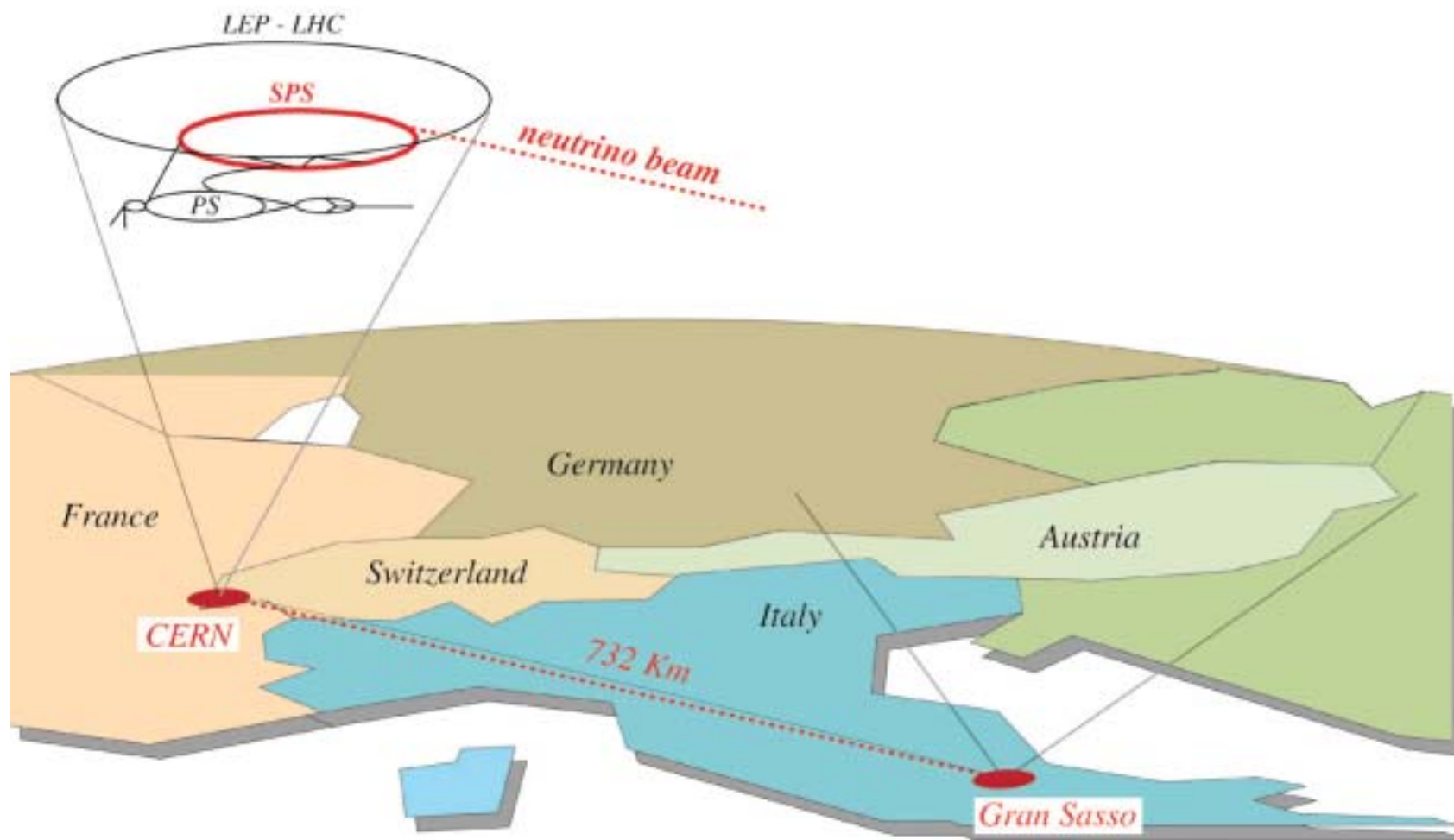
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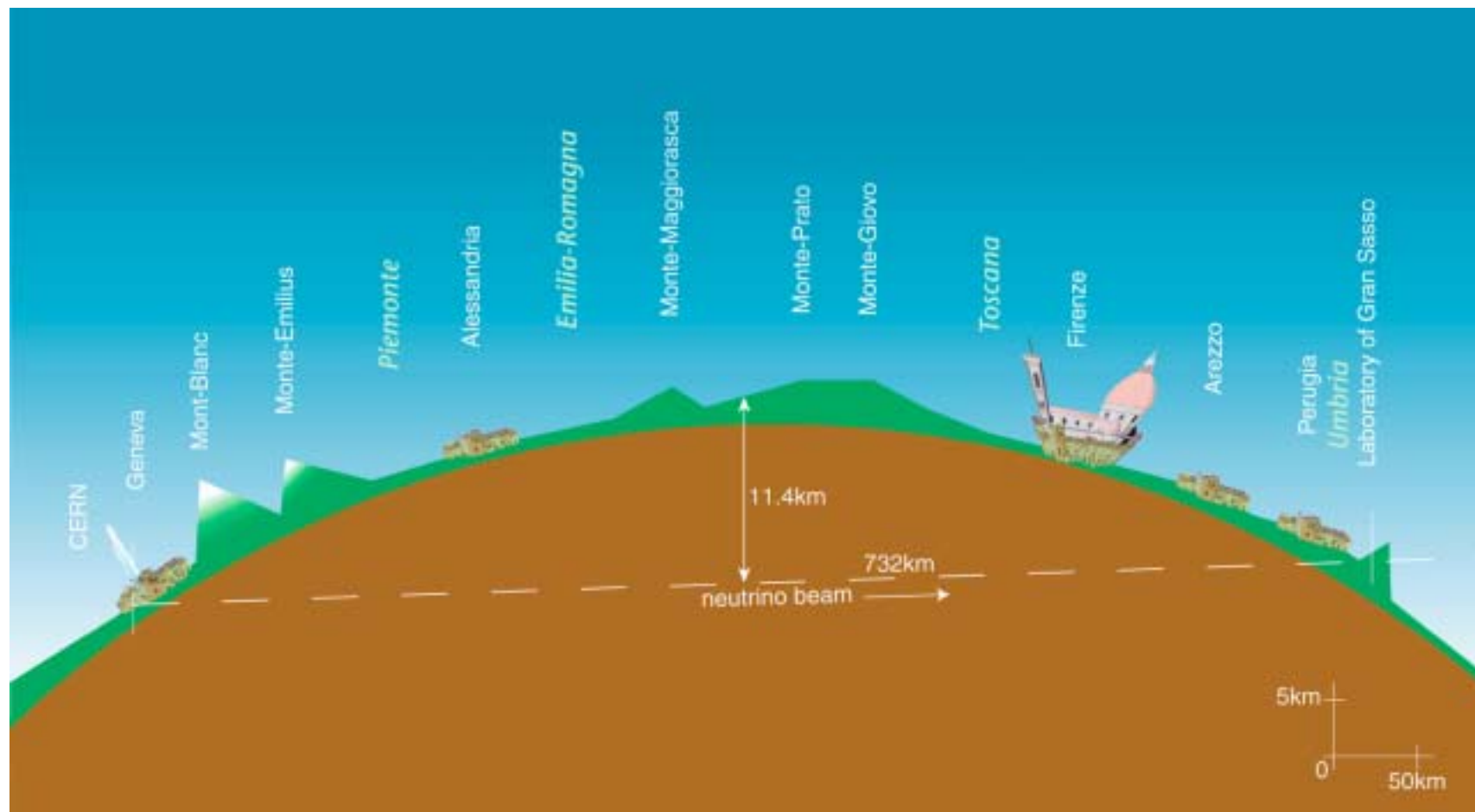


CERN to Gran Sasso Neutrino Beam



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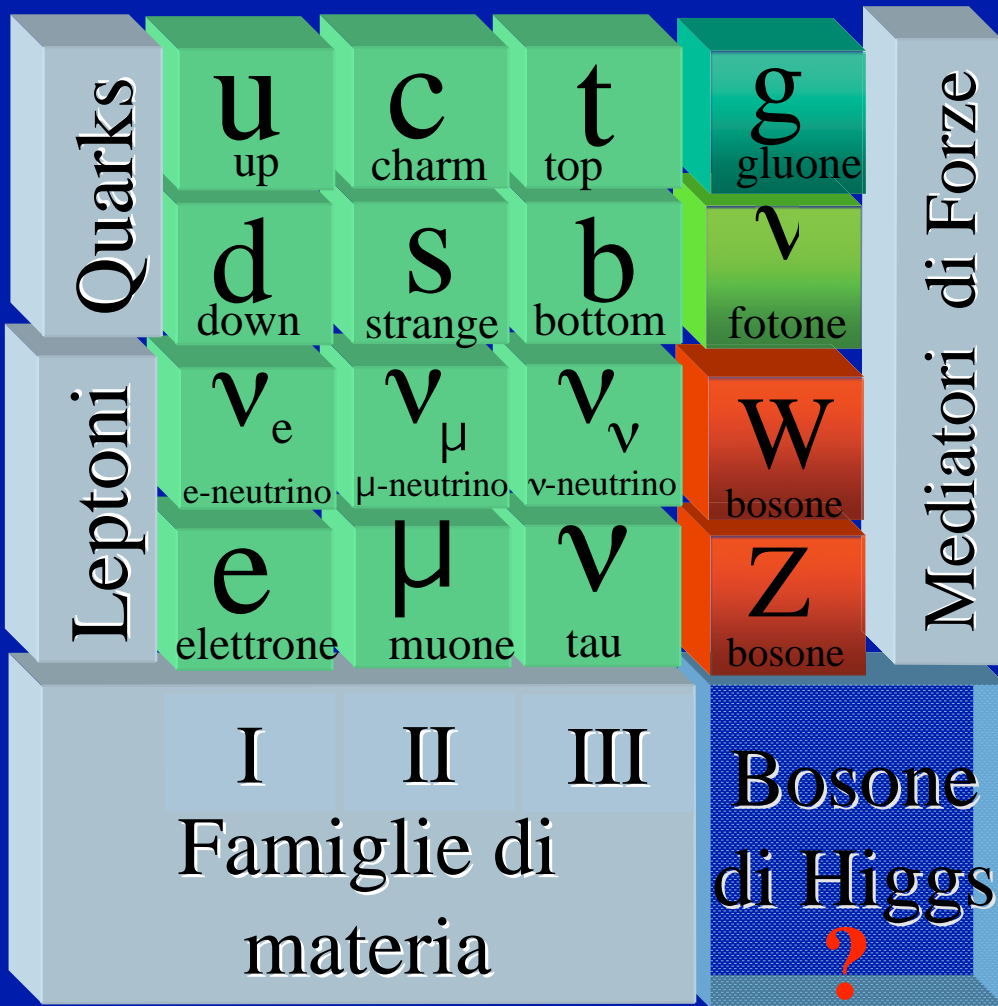
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La gravità

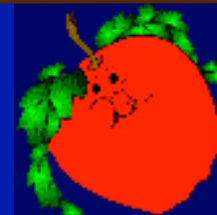
Costituenti materiali Forze



Gravità



il fantasma
dell'opera





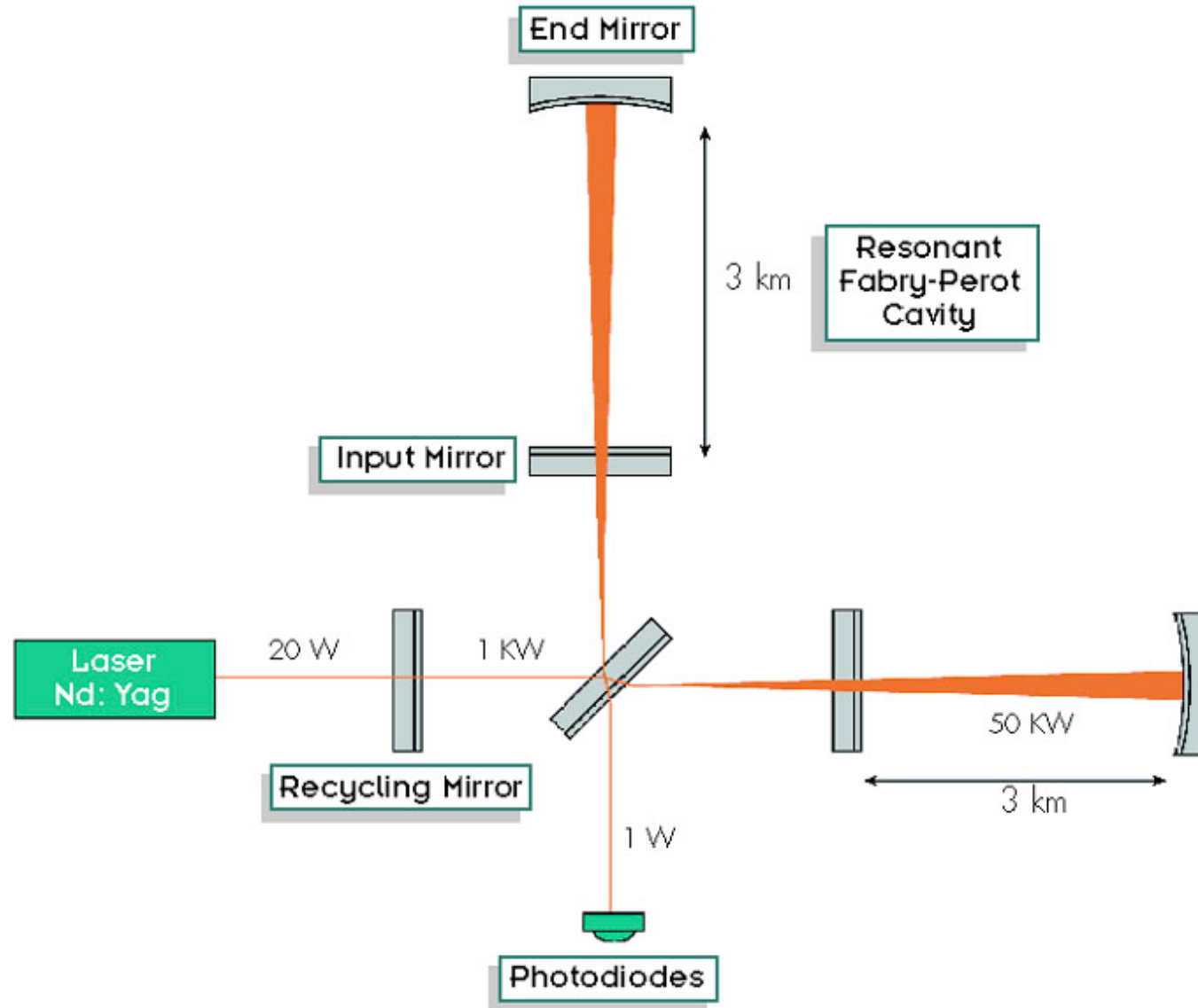
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Interferometro gravitazionale Virgo

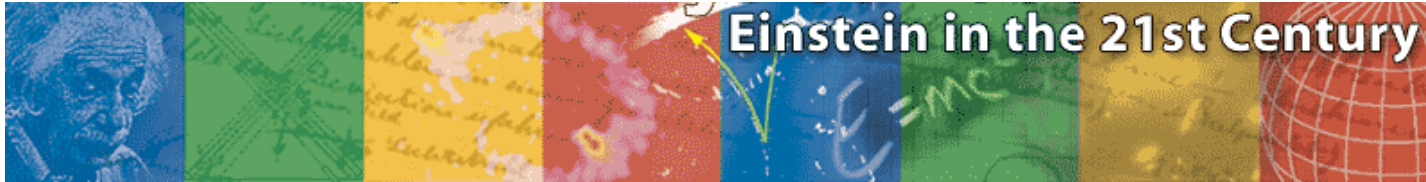


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Padova 1



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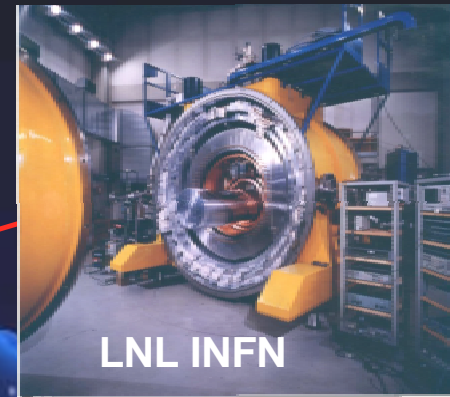
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Gravitational Wave Detectors



Gravitational Wave Detectors

● Interferometric

● Resonant-Mass





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From E. Fermi, preparatory notes for a talk on "What can we learn with High Energy Accelerators ?" given to the American Physical Society, NY, Jan. 29th 1954



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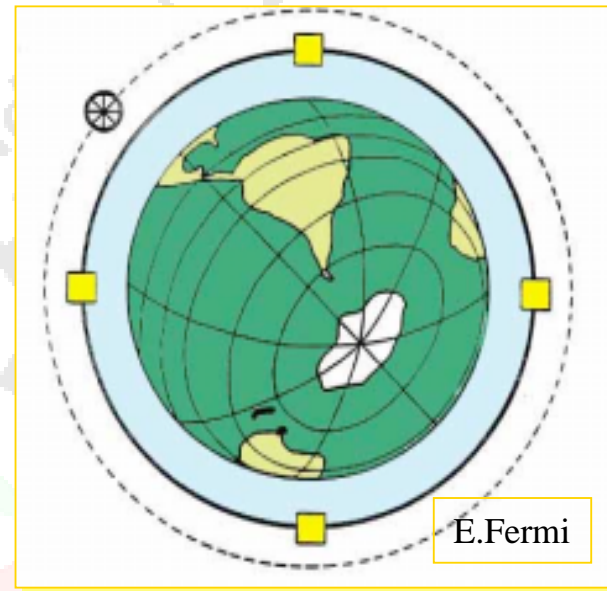
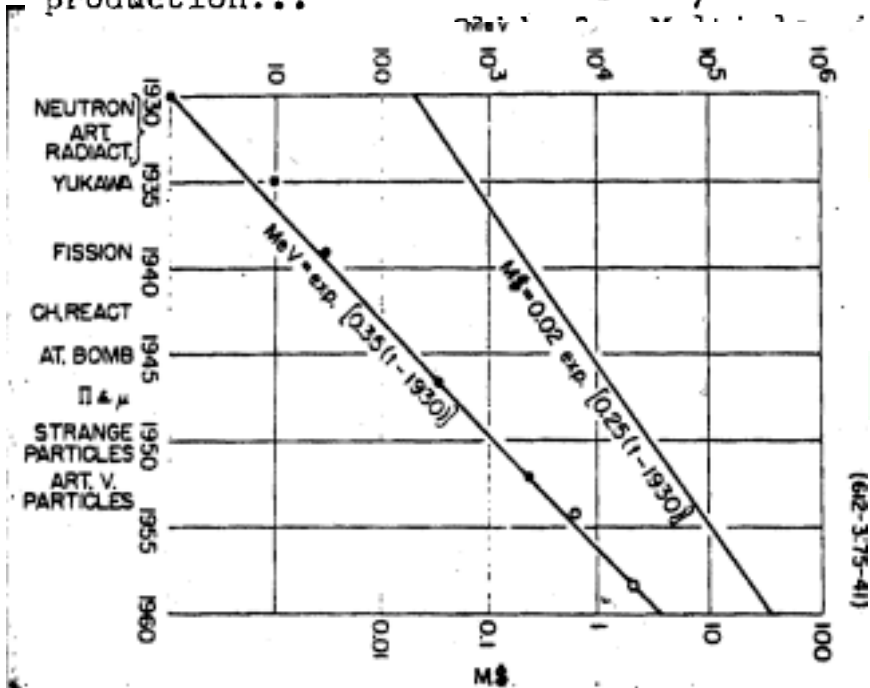
For these reasons....clamoring for higher and higher....

Slide 1 - MeV - M\$ versus time.

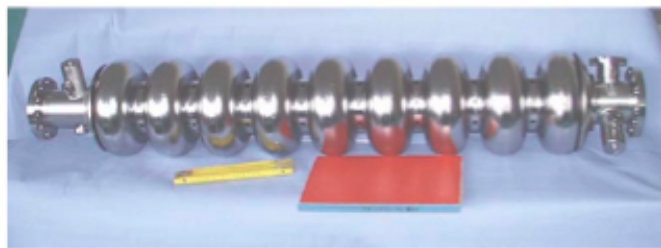
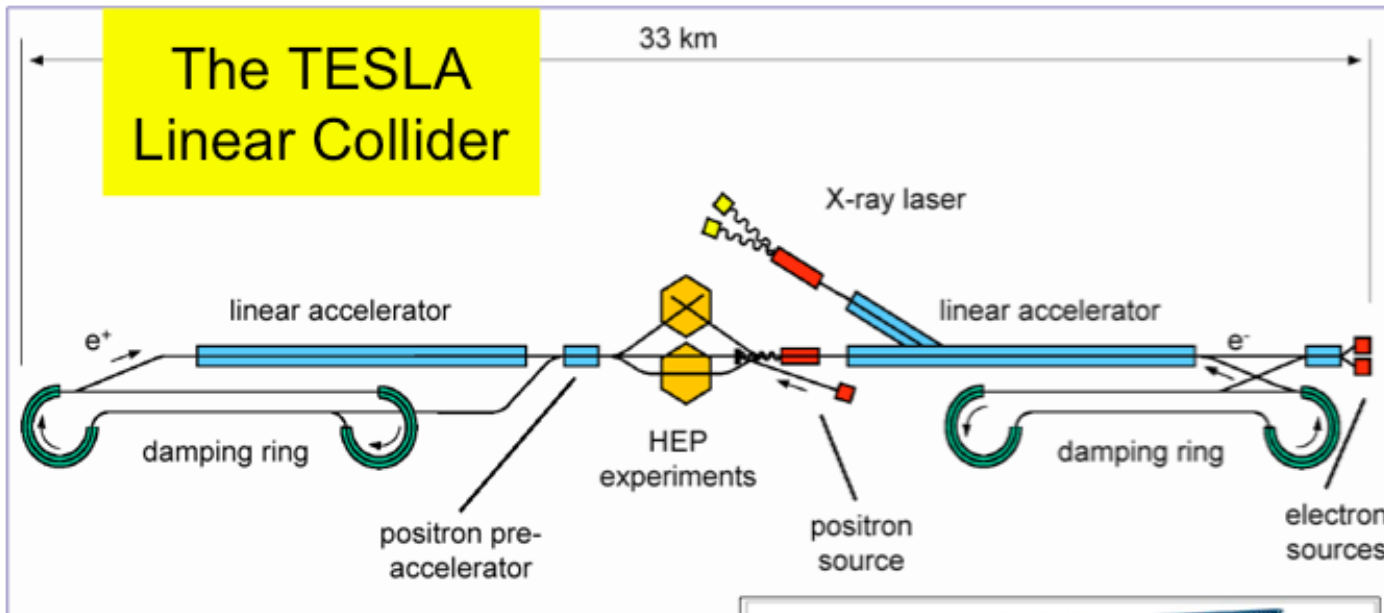
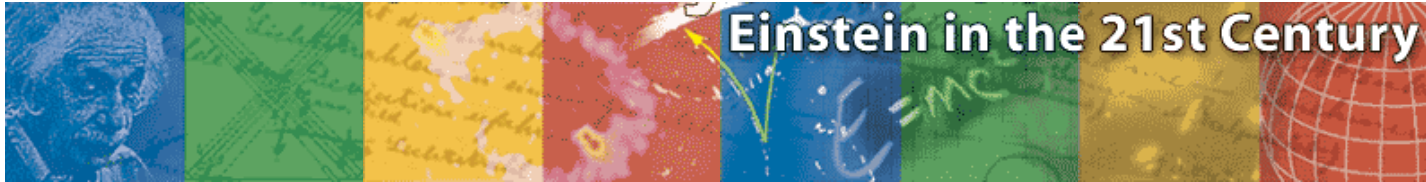
Extrapolating to 1994...5 hi 9 Mev or hiest cosmic...170 B\$....preliminary design....8000 km, 20000 gauss

Slide 2 - 5 hi 15 eV machine.

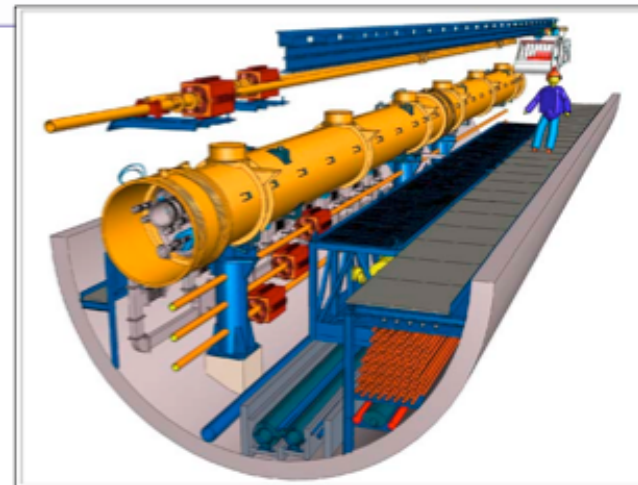
Whay we can learn impossible to guess....main element surprise....some things look for but see others....Experiments on pions....sharpening knowledge...~~spin zero and odd symmetry~~...certainly look for multiple production...



Fermi's extrapolation to year 1994:
 2T magnets, R=8000 Km machine
 $E_{beam} \sim 5 \times 10^3$ TeV , cost 170 B\$



superconducting Nb cavities



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- **L' LHC** : - **inizio tecnico 2007**
 - **inizio sperimentazione 2008**
 - **periodo di sfruttamento ~ 10 anni**

→ **Linear Collider**: **inizio presa dati ~ 2015**

→ **2005 Anno Mondiale della Fisica** per festeggiare
“**annus mirabilis**” : **1905 Einstein (26 anni...)**
pubblica Teoria della Relativita' ristretta



→ Il futuro della Fisica delle Particelle SIETE VOI!