Stelle e particelle

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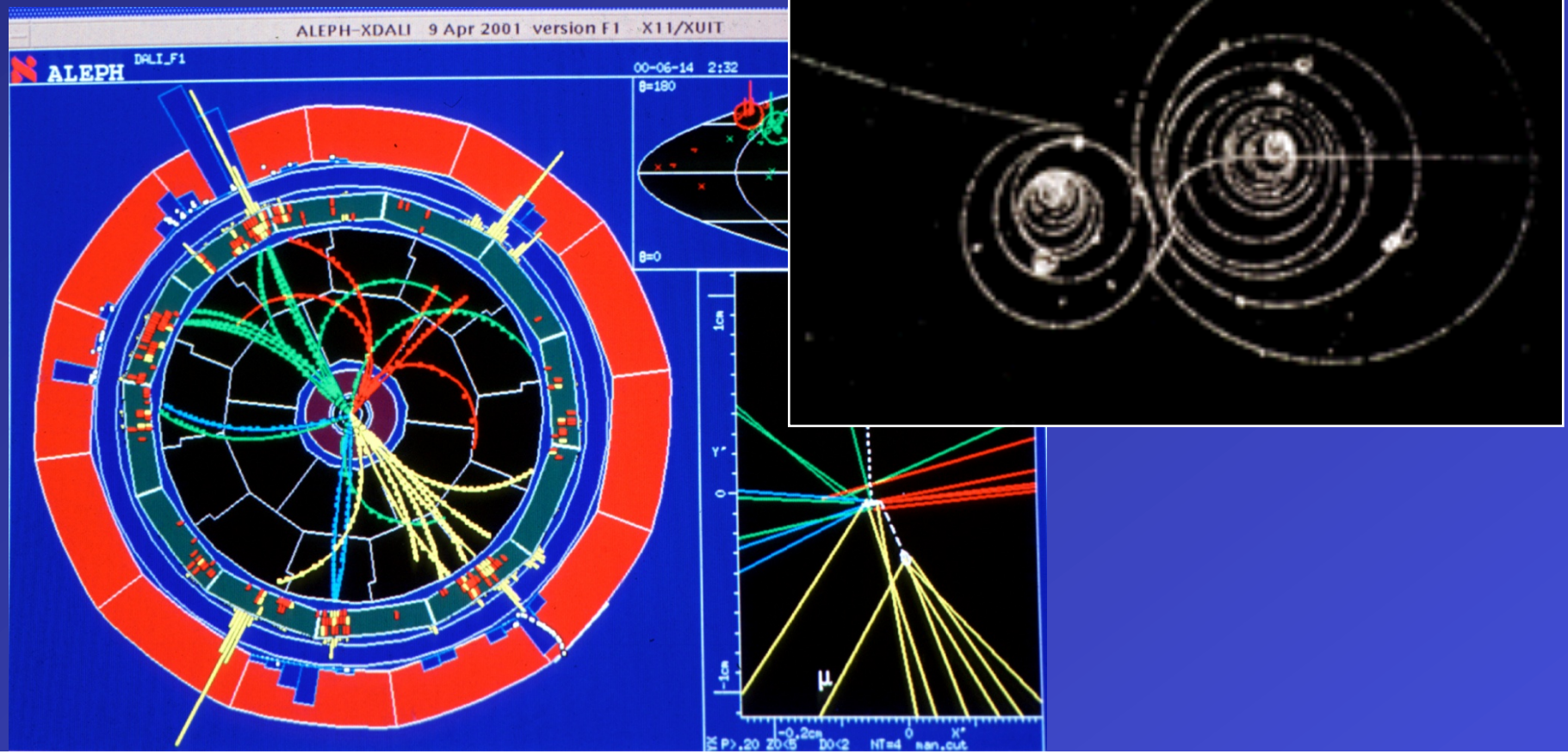
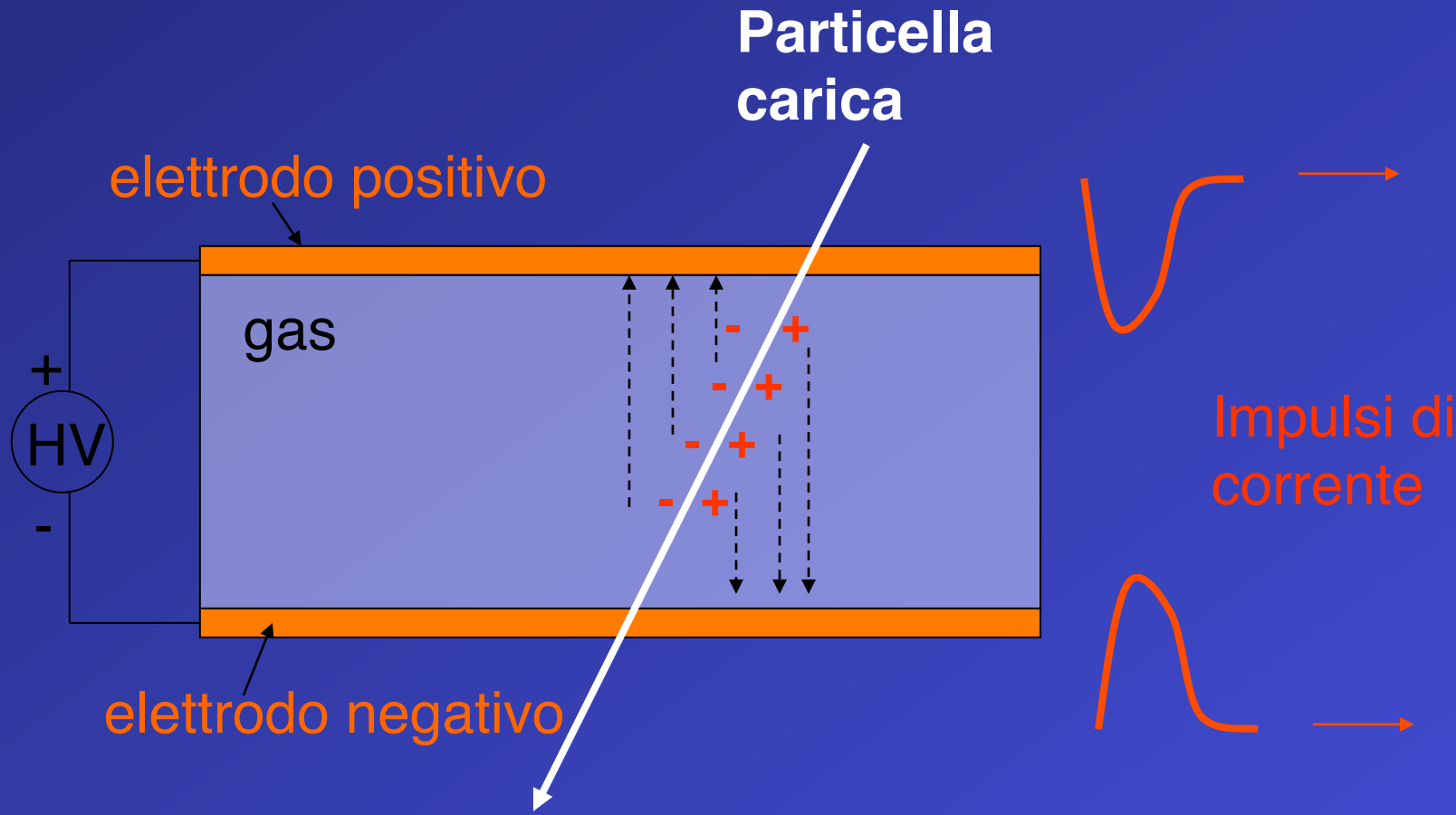
I rivelatori di particelle

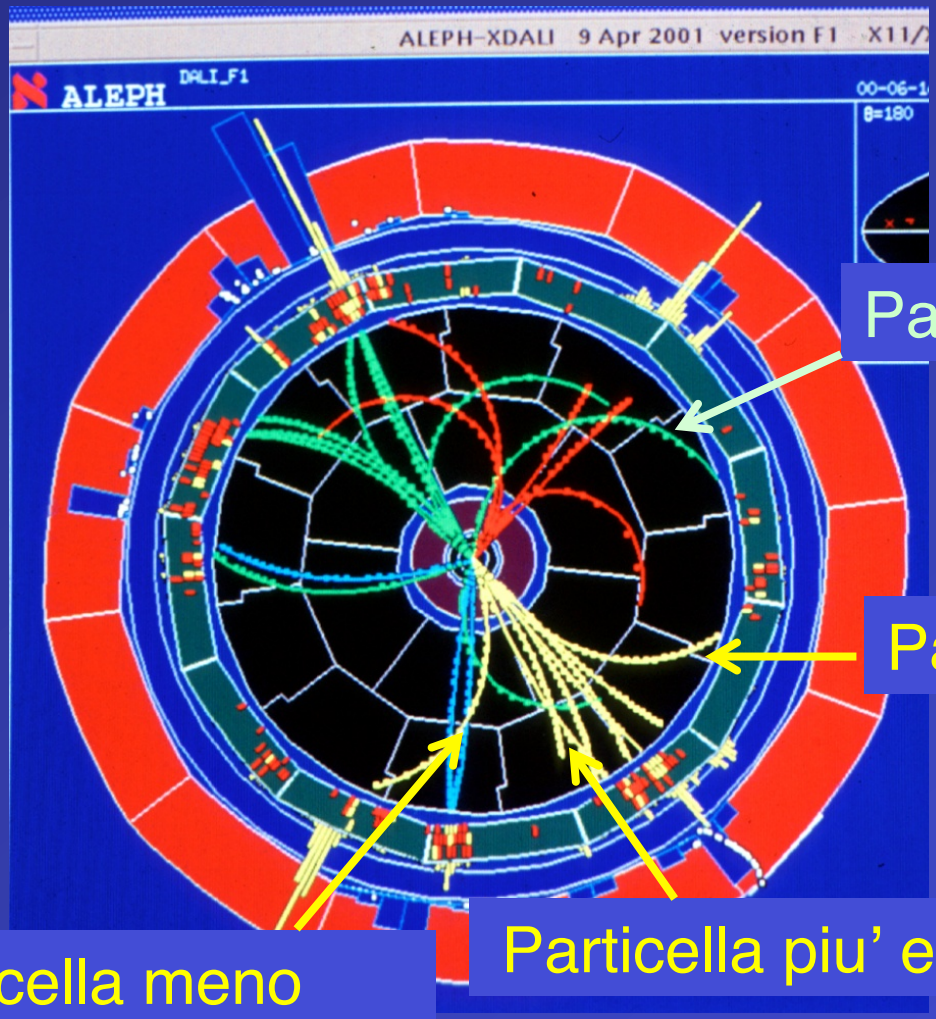
La rivelazione delle particelle si basa sugli effetti prodotti dal loro passaggio nella materia.



Rivelatori di particelle : principio di funzionamento
IONIZZAZIONE



Misura impulso con campo magnetico



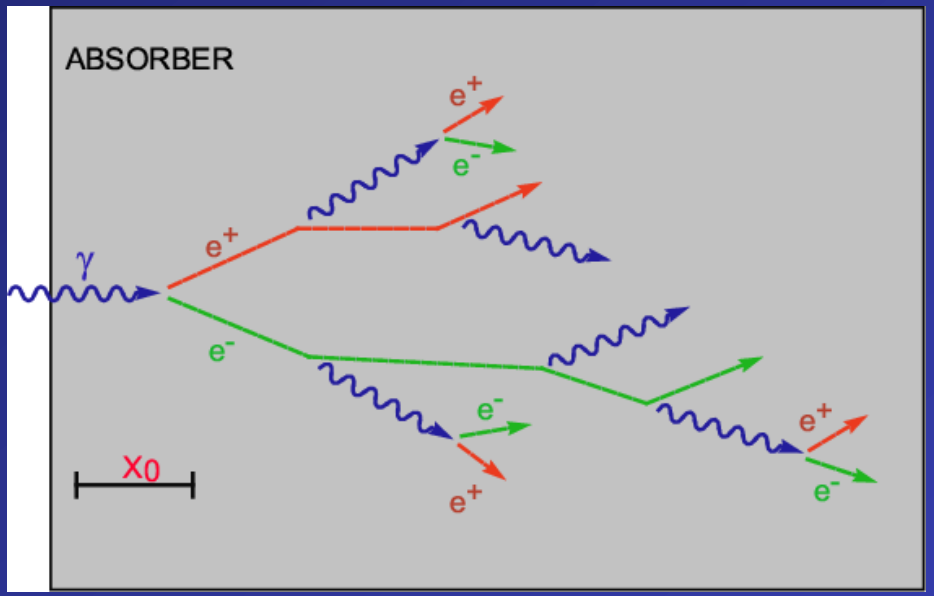
Particella carica +

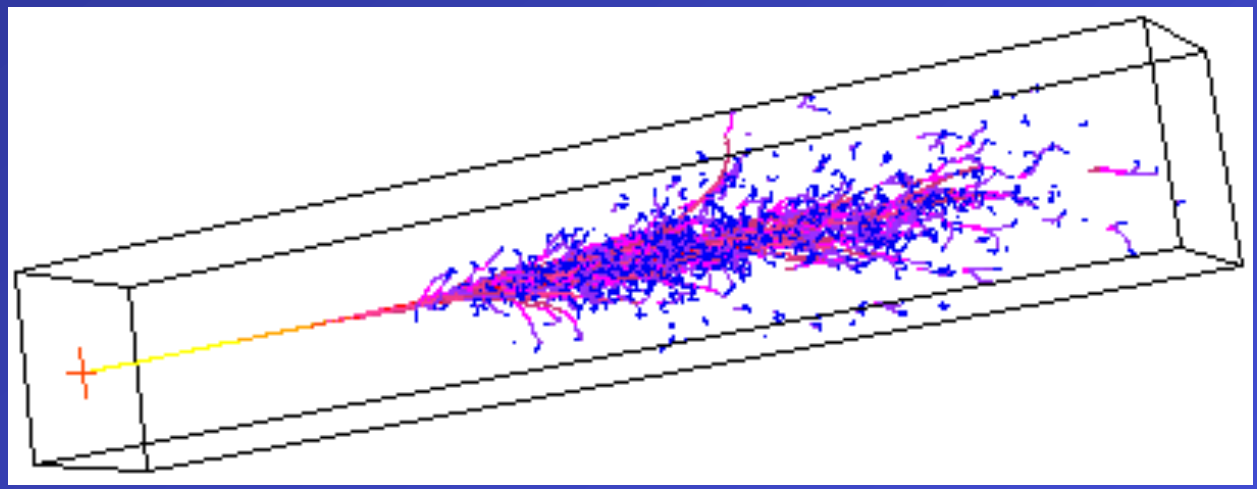
Particella carica -

Particella piu' energetica

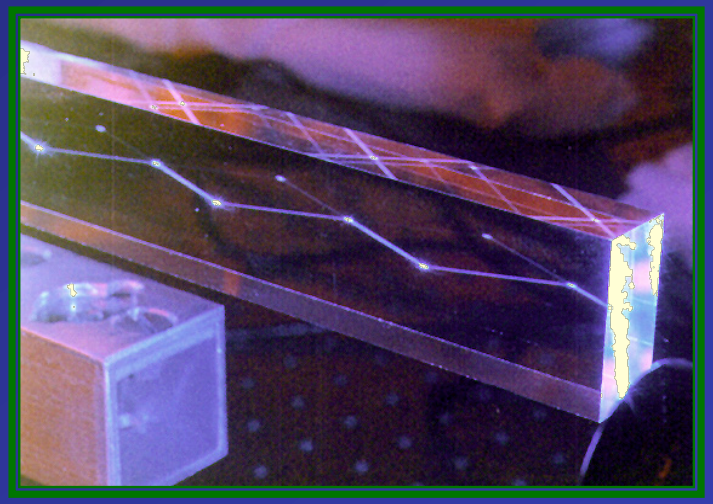
Particella meno energetica

Calorimetri elettromagnetici

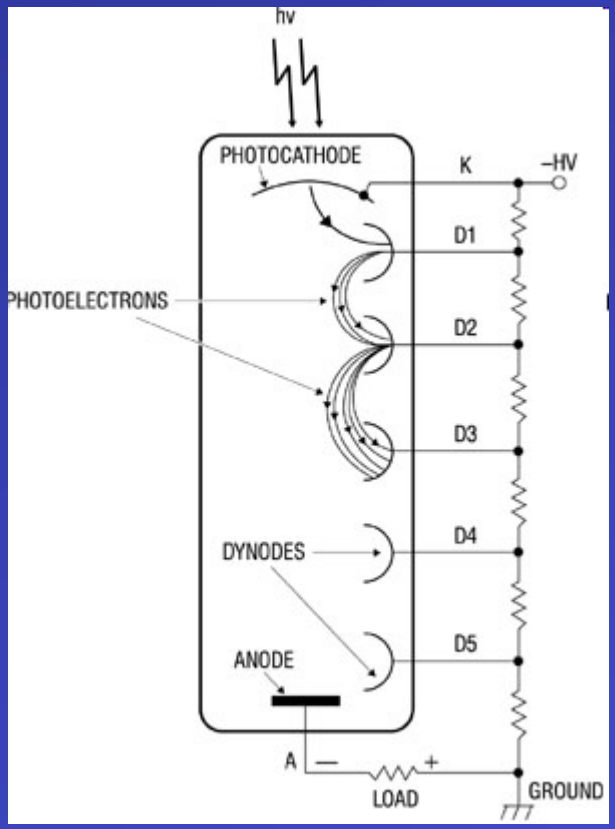




Due altri ingredienti

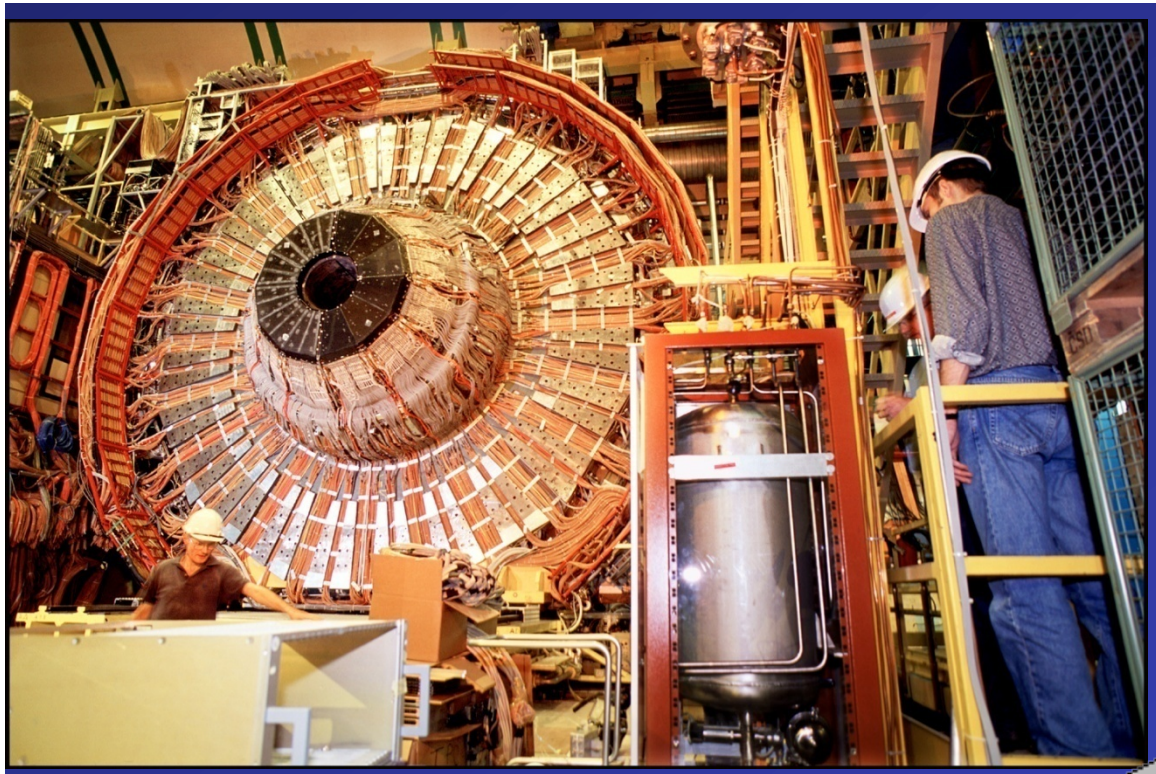


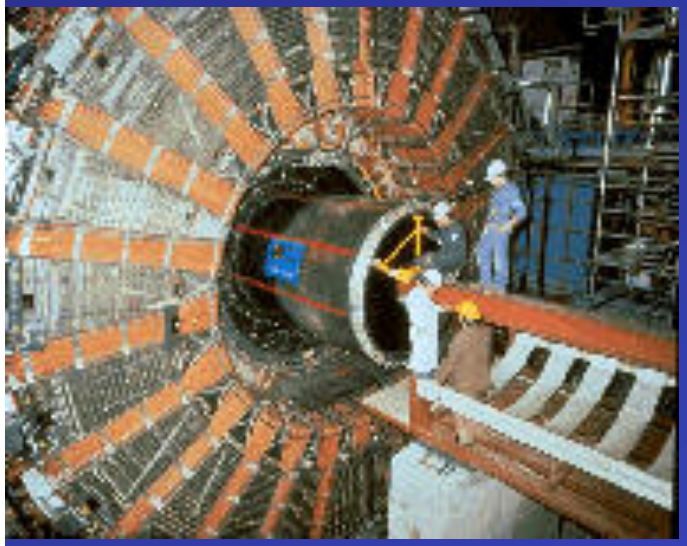
Guida di Luce

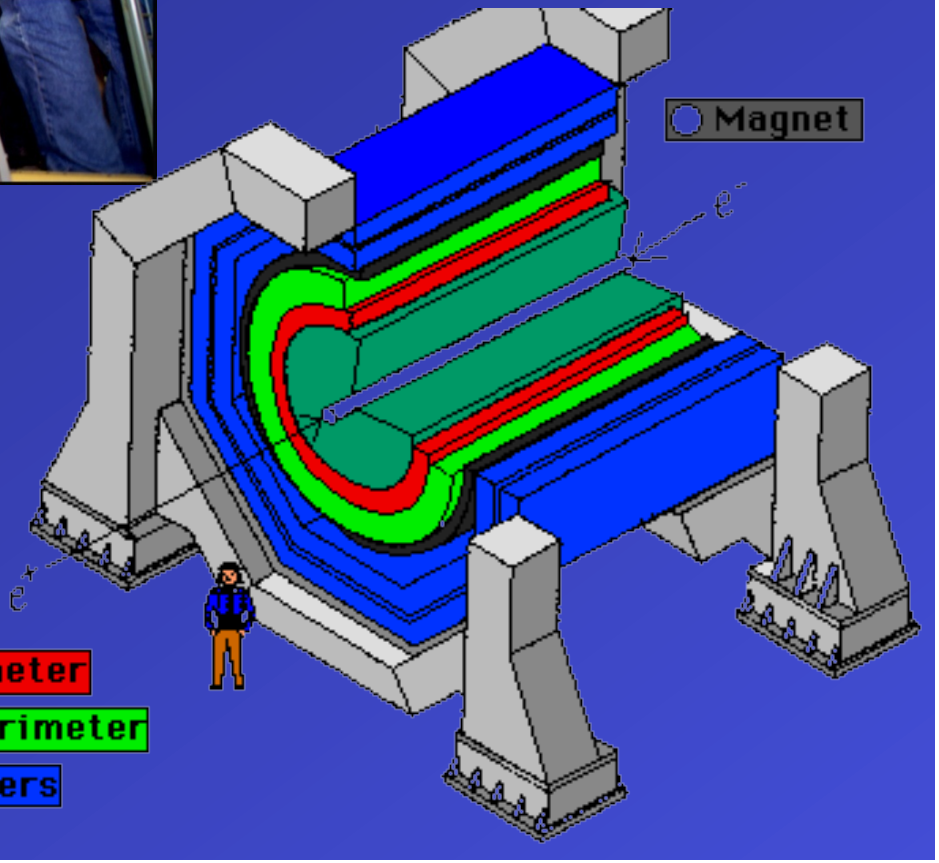


Fototubi per convertire luce → corrente

Rivelatori ai collisori



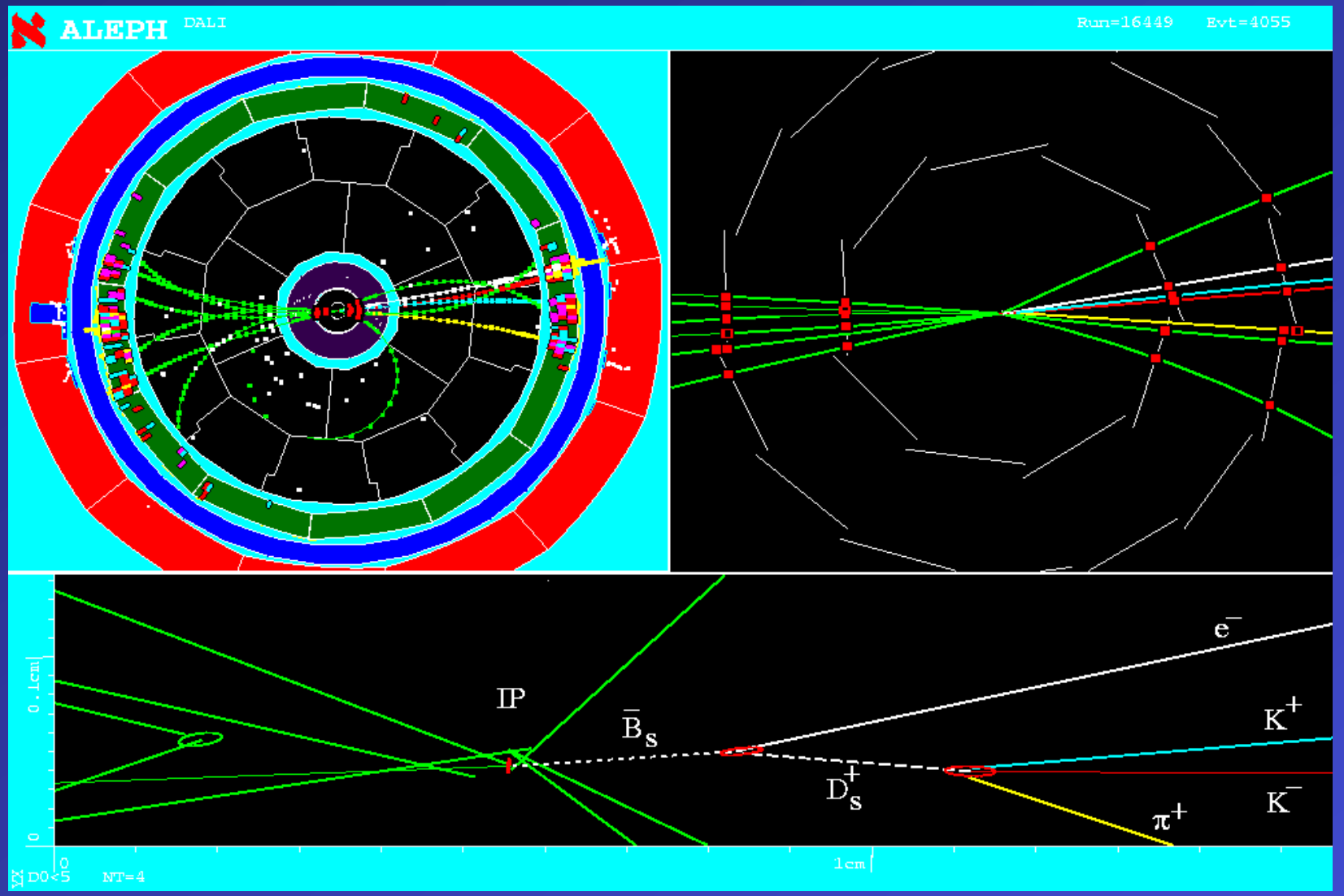




Particelle instabili

- Fin qui le particelle che vivono abbastanza da arrivare ai rivelatori (almeno qualche cm)
- E quelle instabili?
  - Mesoni B,D vivono 10^{-12} s → tipicamente 0.1mm di cammino prima di decadere
  - Mesoni W,Z,H vivono decine di migliaia di volte meno → decadono appena create

Decadimenti B e D



Bosone di Higgs: analogia

← Tanti fisici in una stanza

Inerzia ≅ massa
Fisici≅ bosoni di Higgs
Eistein≅ particella massiva

Bosone di Higgs: analogia

← Tanti fisici in una stanza

Entra Einstein e tutti vogliono parlargli →

Inerzia ≅ massa
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Bosone di Higgs: analogia

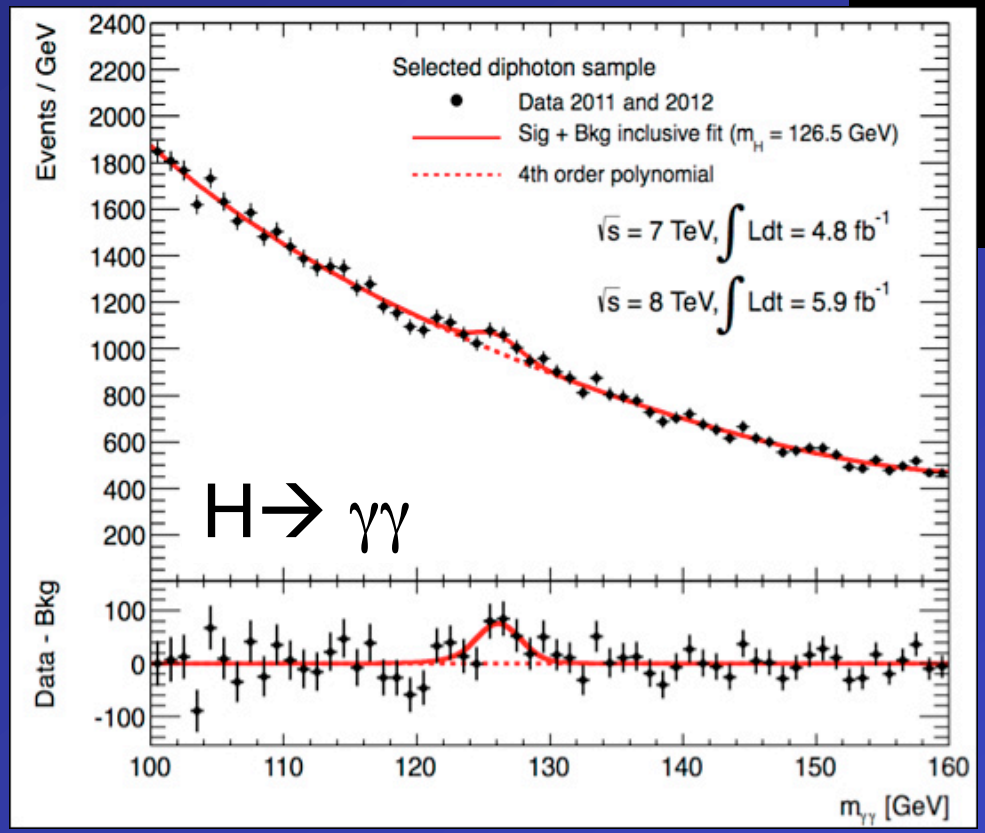
← Tanti fisici in una stanza

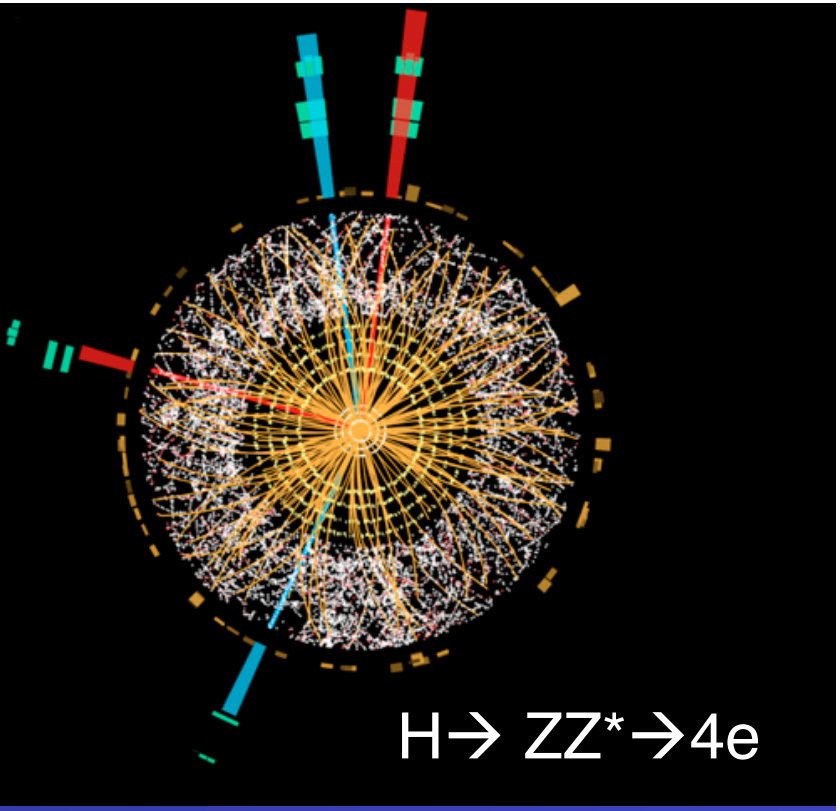
Entra Einstein e tutti vogliono parlargli →

← Einstein fa fatica a muoversi (maggiore inerzia)

Inerzia ≅ massa
Fisici≅ bosoni di Higgs
Eistein≅ particella massiva

Higgs: come si vede?



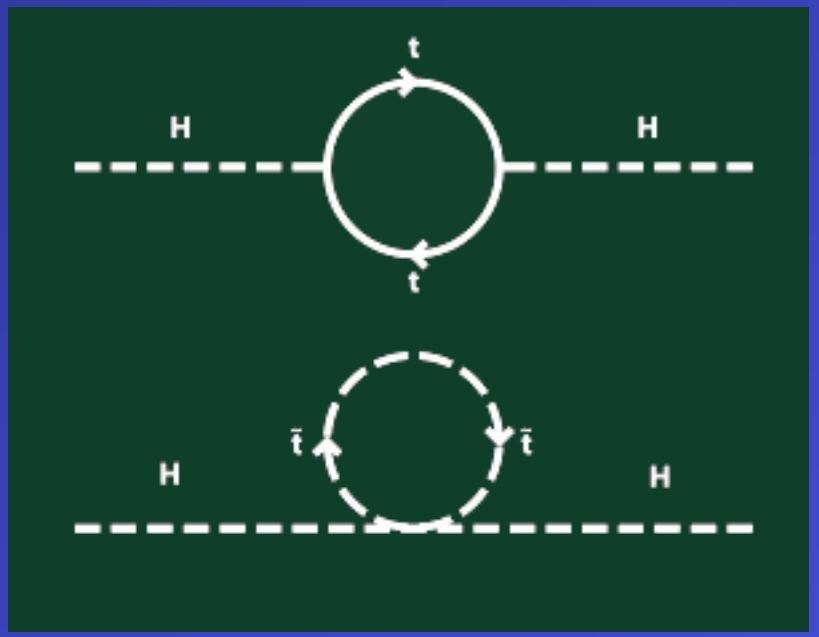


Ma l'Higgs non basta

Interagendo da' massa alle particelle, ma esse ne danno troppa a lui

" The Higgs boson is as likely as a snowball in heaven "

Soluzione possibile: introdurre particelle che diano contributi opposti alla massa dell'Higgs → SuperSimmetria

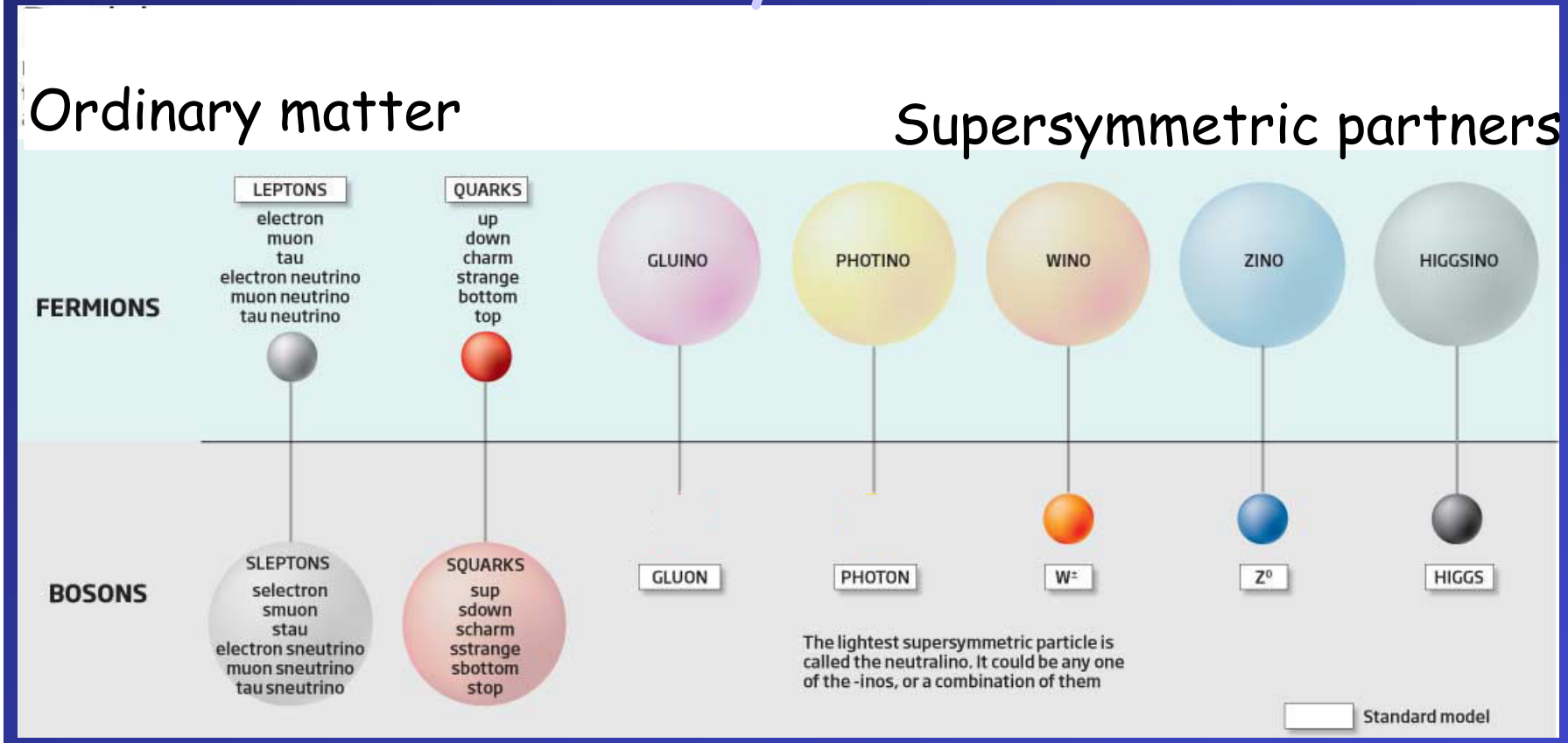


Backup

Players

Ordinary matter

Supersymmetric partners



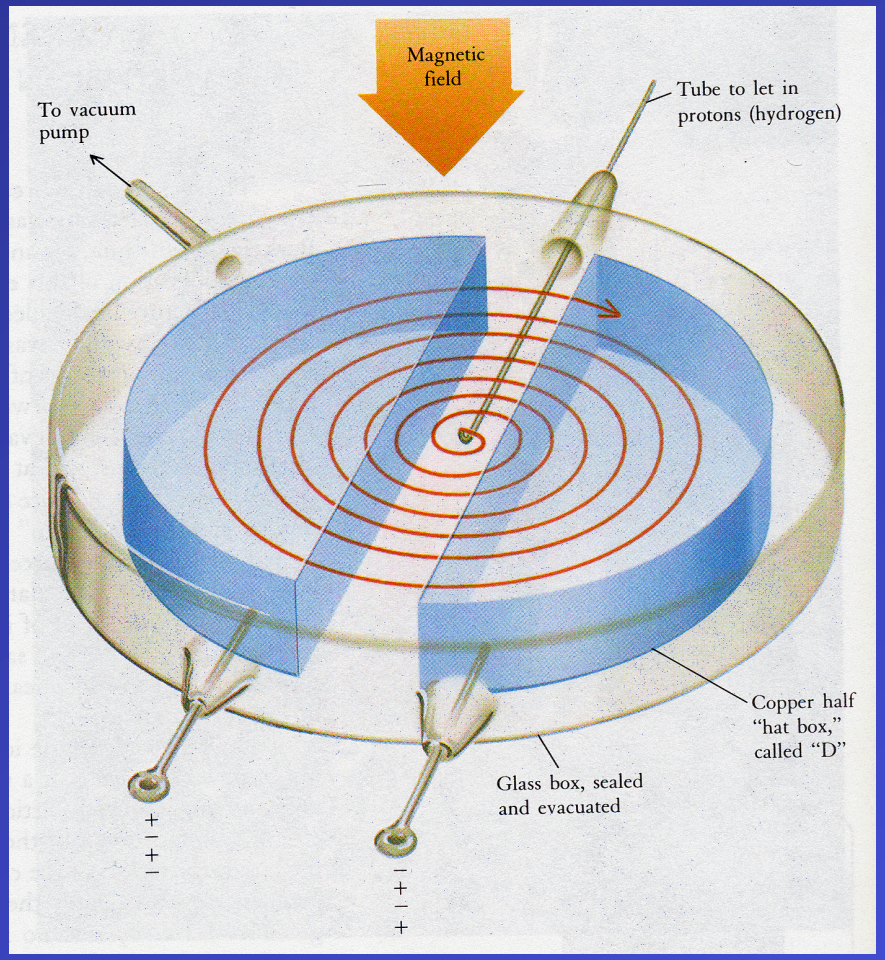
Supersymmetric partners

Interaction mediators

Cockroft Walton

CERN, protoni da 800 keV

Ciclotrone



1930, Lawrence, protoni da 100 MeV

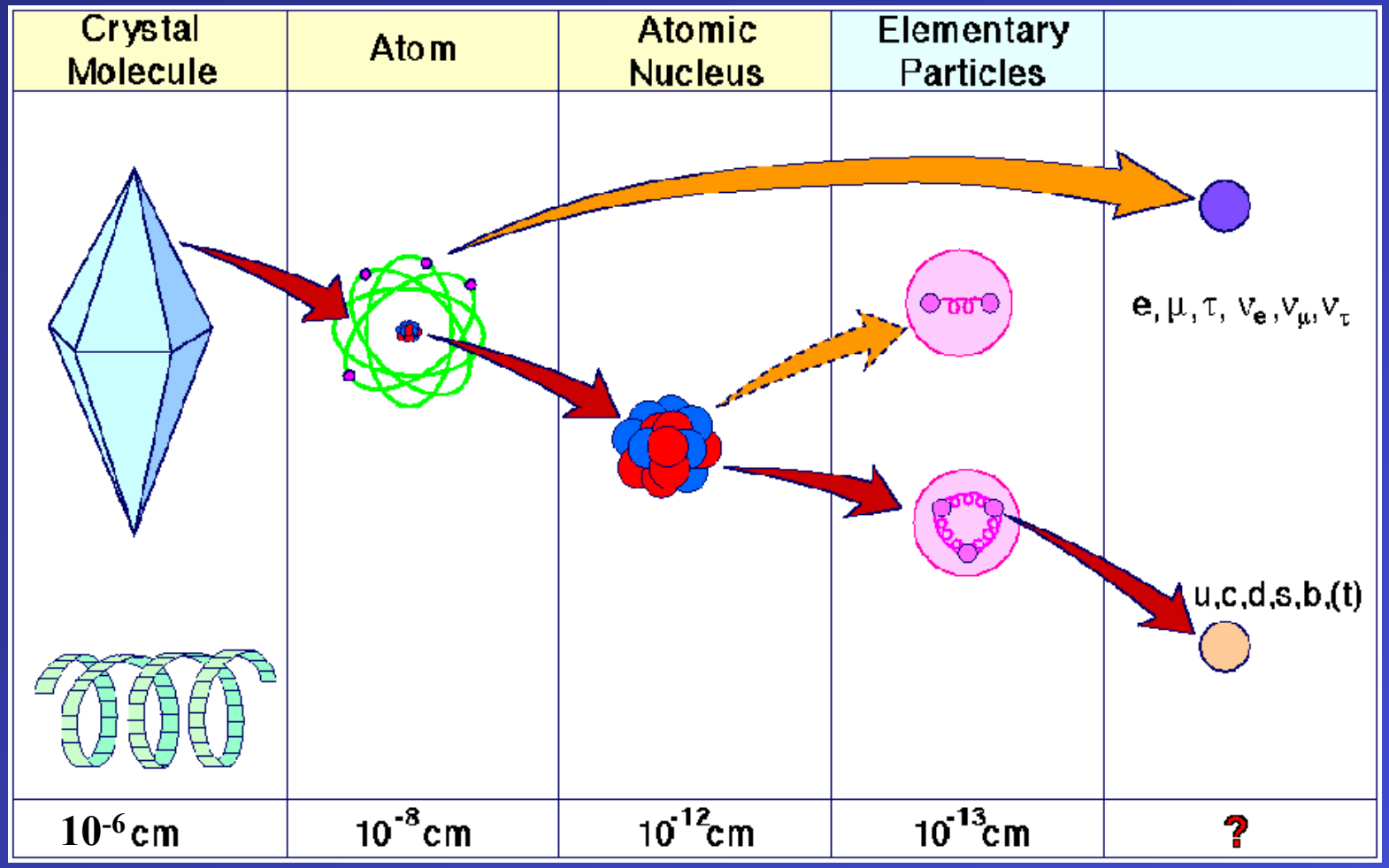
Acceleratori lineari e circolari

Stanford Linear Accelerator Center (California)

Fermilab (Chicago, IL) Tevatron

Perche' accelerare?

Rompere sistemi sempre piu' legati



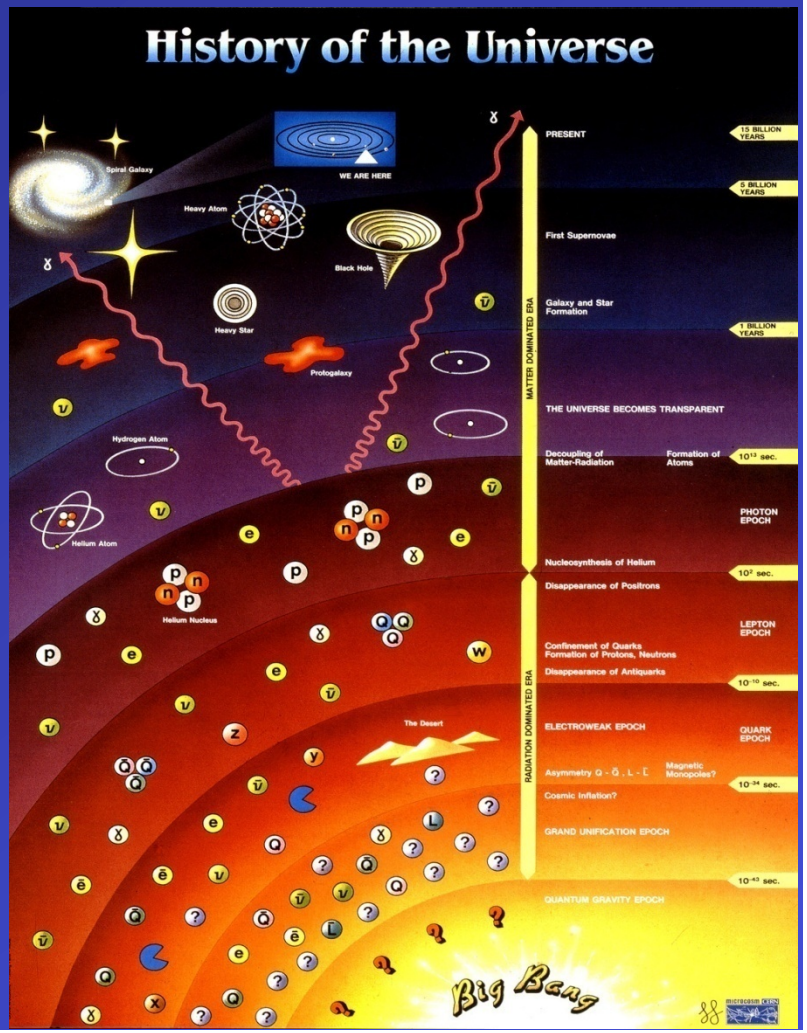
Perche' accelerare?

Cercare particelle di massa sempre maggiore

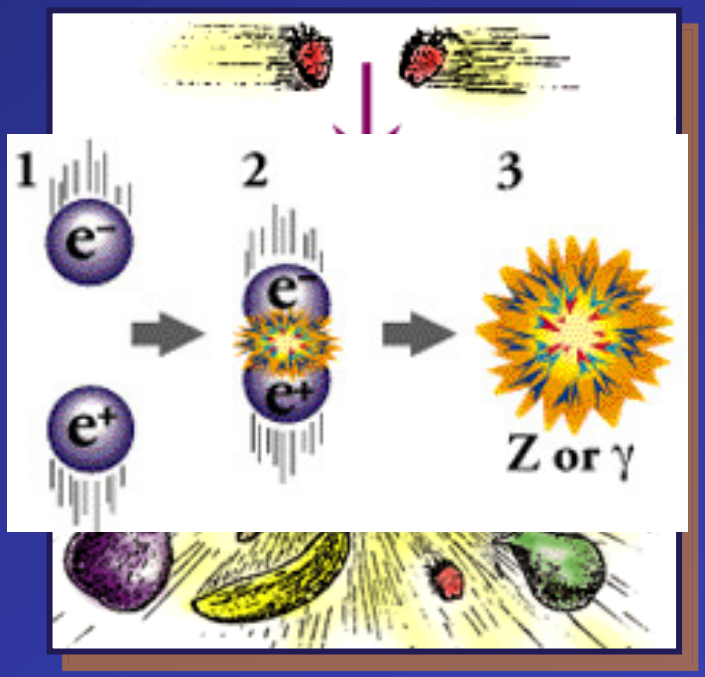
➔ "risalire il big-bang"

$$E=mc^2$$

Serve accumulare abbastanza energia per generare oggetti di massa m



Reazioni di interesse



Una particella Z può decadere in:

- due elettroni ($Z^0 \rightarrow e^+ + e^-$) ~3,3 %
- due muoni ($Z^0 \rightarrow \mu^+ + \mu^-$) ~3,3 %
- due particelle tau ($Z^0 \rightarrow \tau^+ + \tau^-$) ~3,3 %

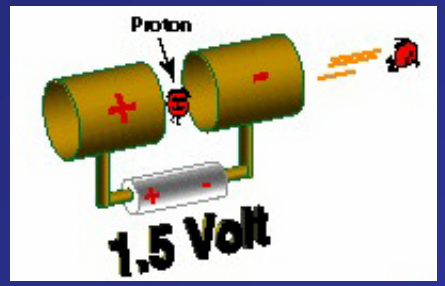
} ~10 %

- due neutrini ($Z^0 \rightarrow \nu + \nu$) ($\nu = \nu_e, \nu_\mu, \nu_\tau$) ~20 % INVISIBILE!
- due quark ($Z^0 \rightarrow q + q$) (q=u,d,c,s,b ma non t che è troppo pesante) ~70 %

Ordini di grandezza

Particella	Massa (kg)	E (cal)
Elettrone	$\sim 10^{-30}$	$2\ 10^{-14}$
Pione/ Muone	$\sim 2\ 10^{-28}$	$4\ 10^{-12}$
Protone/ neutrone	$\sim 2\ 10^{-27}$	$4\ 10^{-11}$
W/Z/top	$\sim 2\ 10^{-25}$	$4\ 10^{-9}$
E_{LHC}(H?)	$\sim 2\ 10^{-23}$	$4\ 10^{-7}$

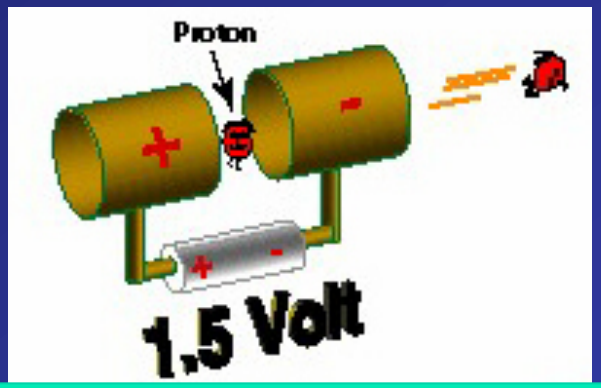
Ordini di grandezza



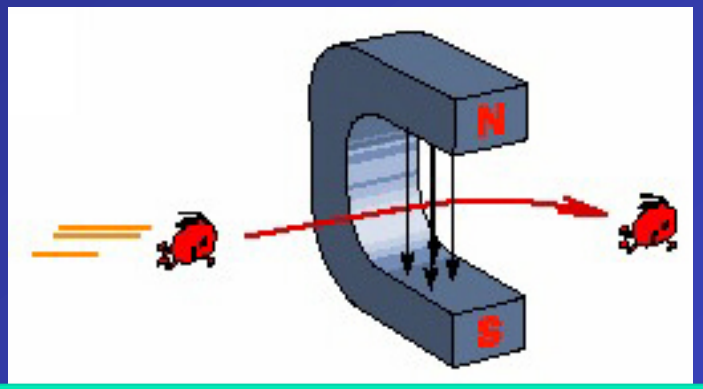
Particle accelerated to 1.5 eV
(in ~5cm)

Particella	Massa (MeV)	Lunghezza in "pile"(km)
Elettrone	~0.5	15
Pione/ Muone	~100	3.000
Protone/ neutrone	~1.000	30.000
W/Z/top	~100.000	3.000.000
E_{LHC}	~10.000.000	300.000.000

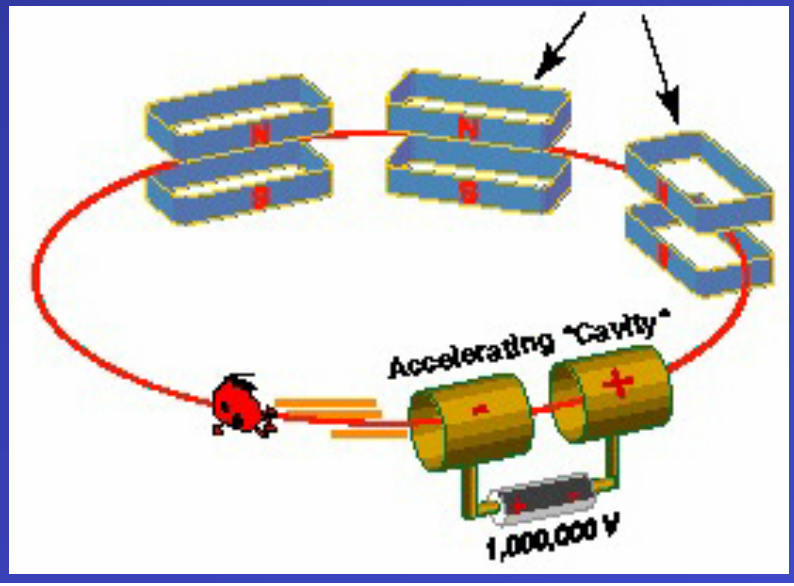
Acceleratori: principio di funzionamento

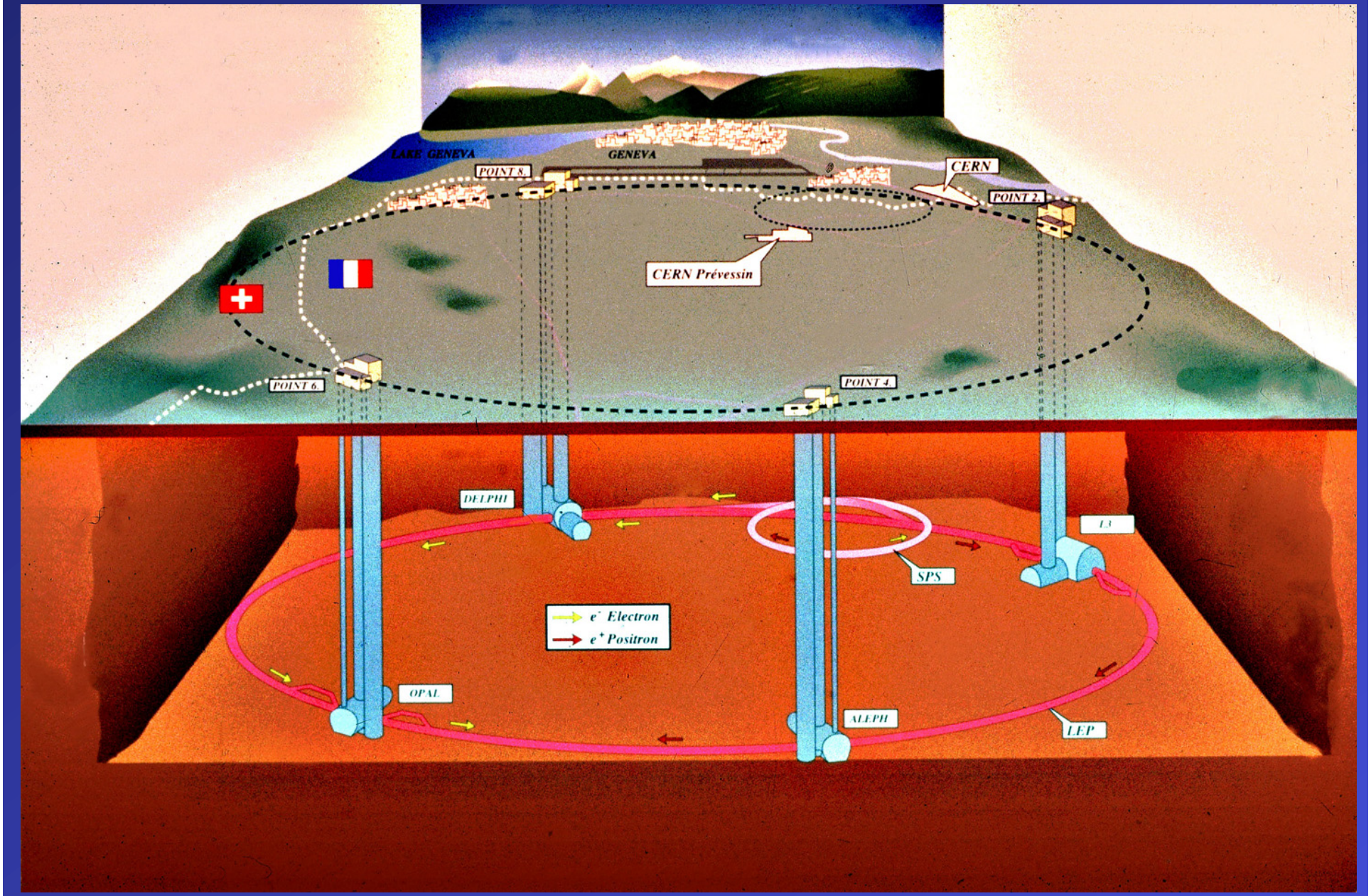


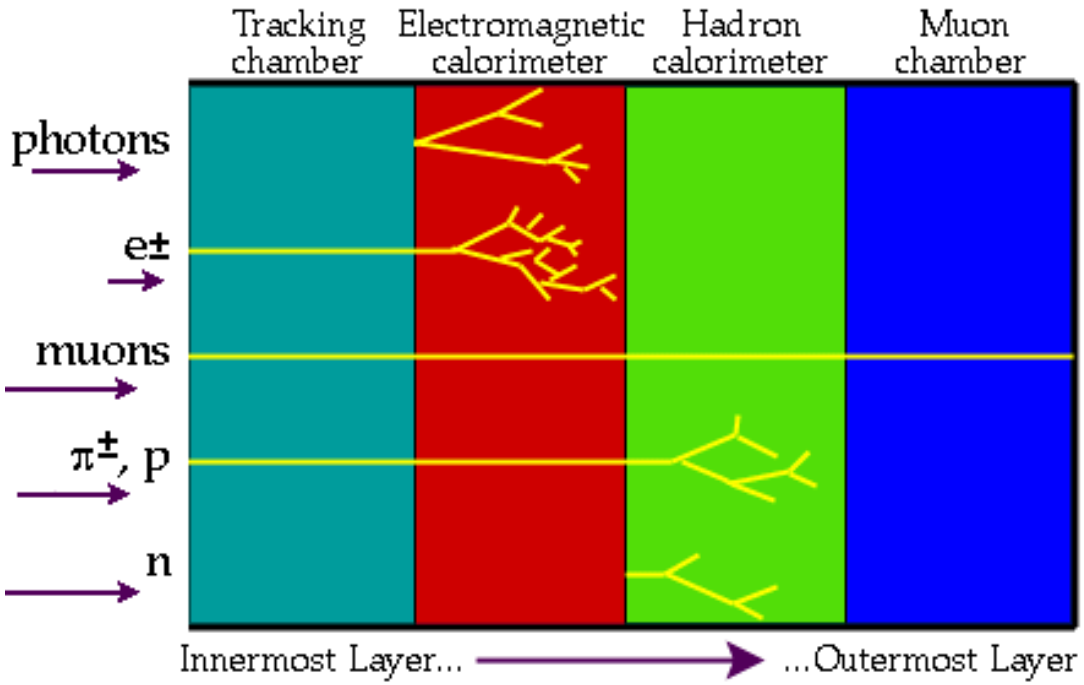
Campo elettrico: accelera.



Campo magnetico: curva

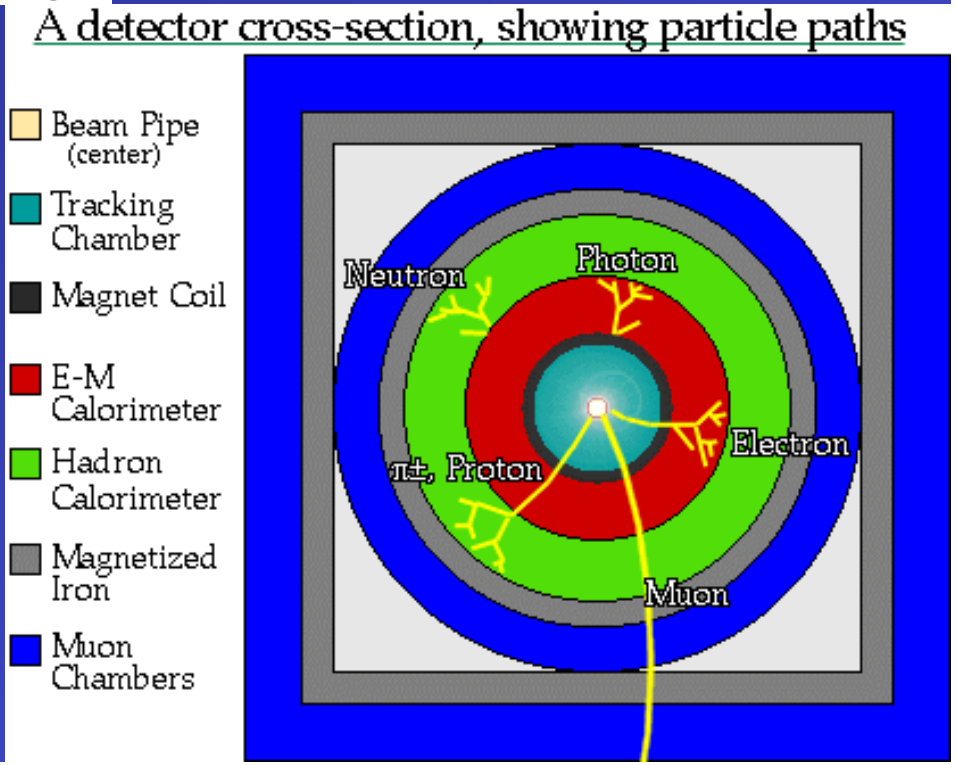



LAKE GENEVA
GENEVA
POINT 8
CERN
POINT 2
CERN Prévessin
POINT 6
POINT 4
DELPHI
L3
SPS
e⁻ Electron
e⁺ Positron
OPAL
ALEPH
LEP



Interazioni di vari tipi di particelle nella materia.

Struttura modulare dei rivelatori



Identificazione di particelle