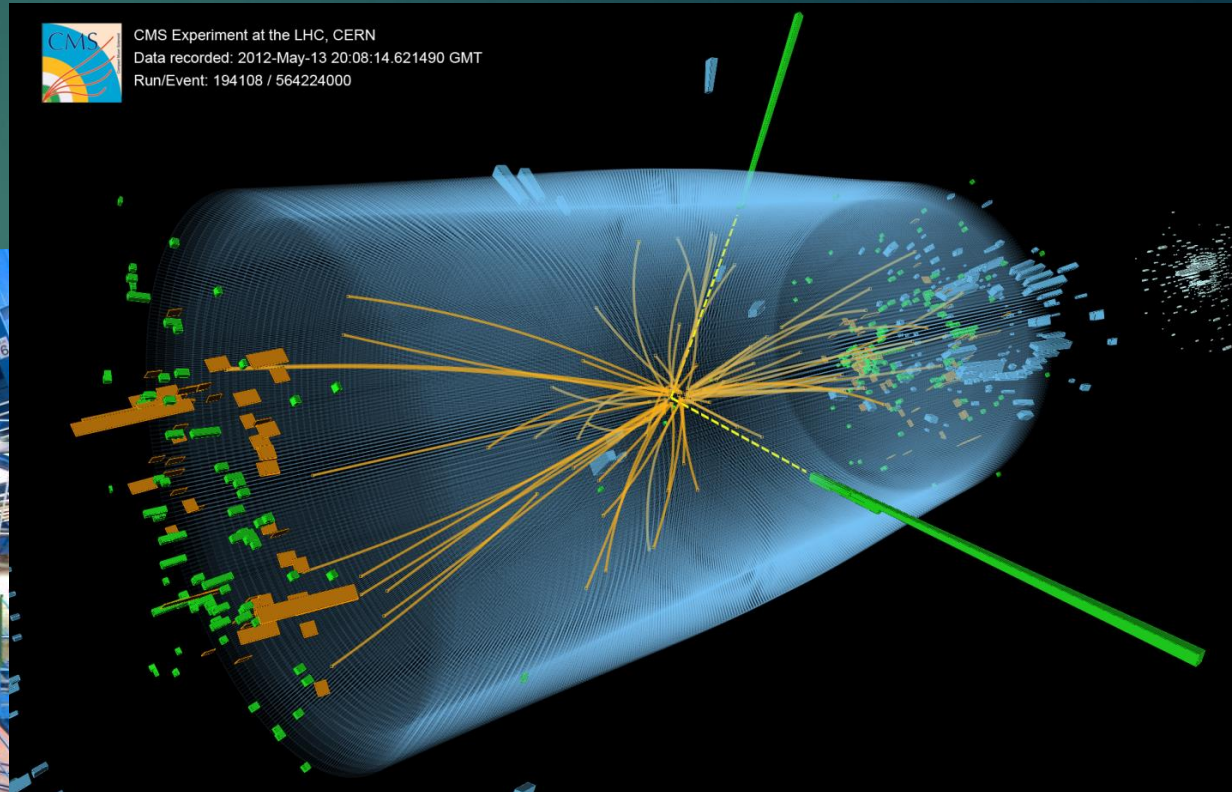
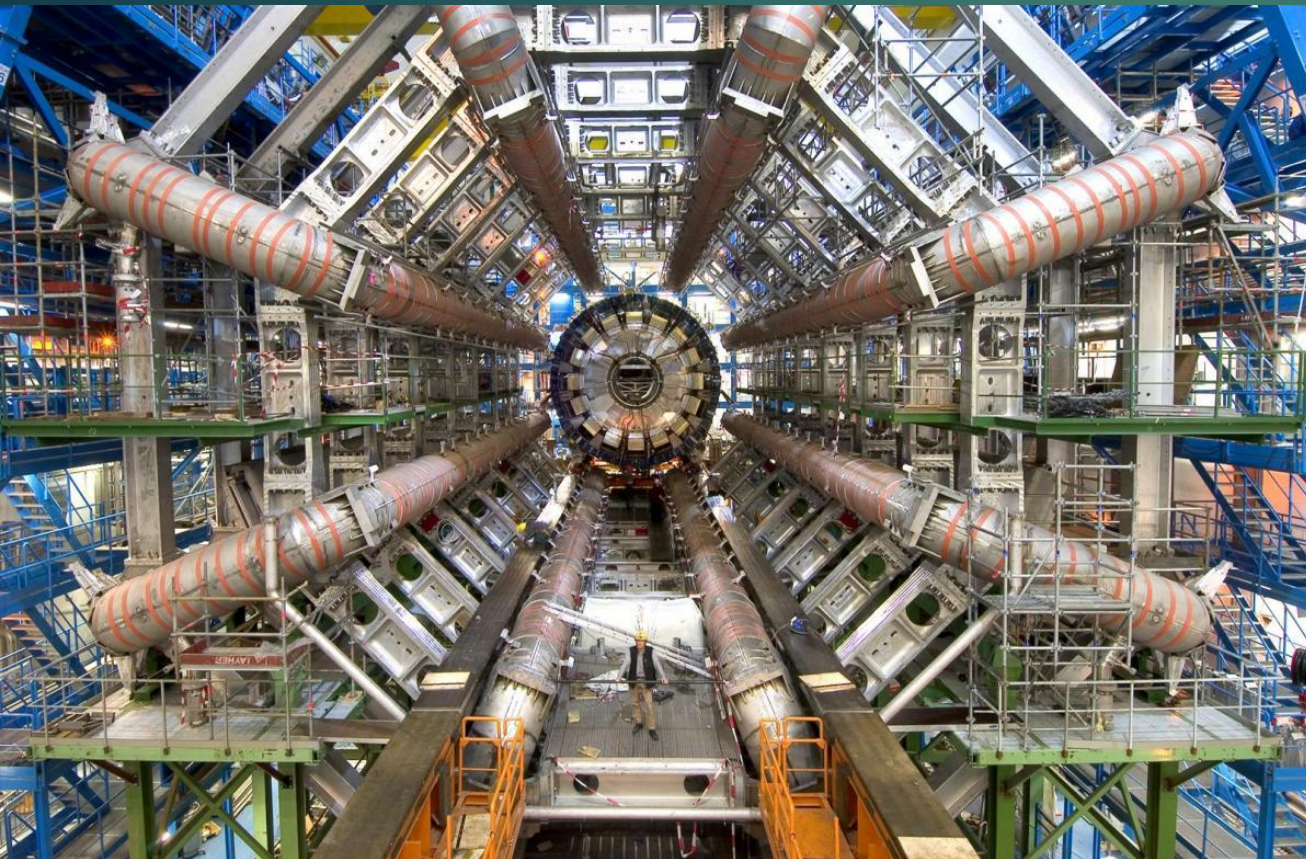
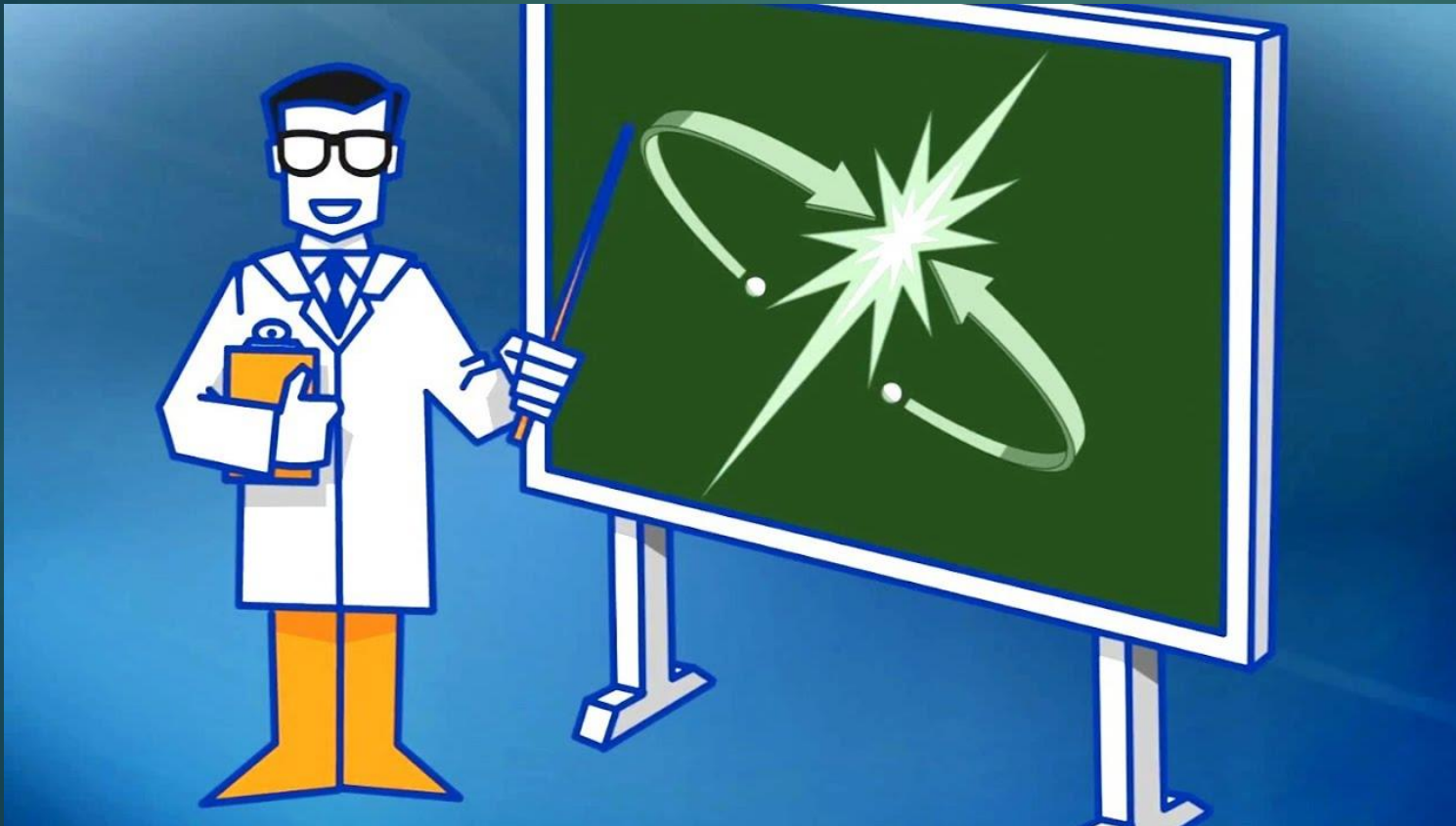


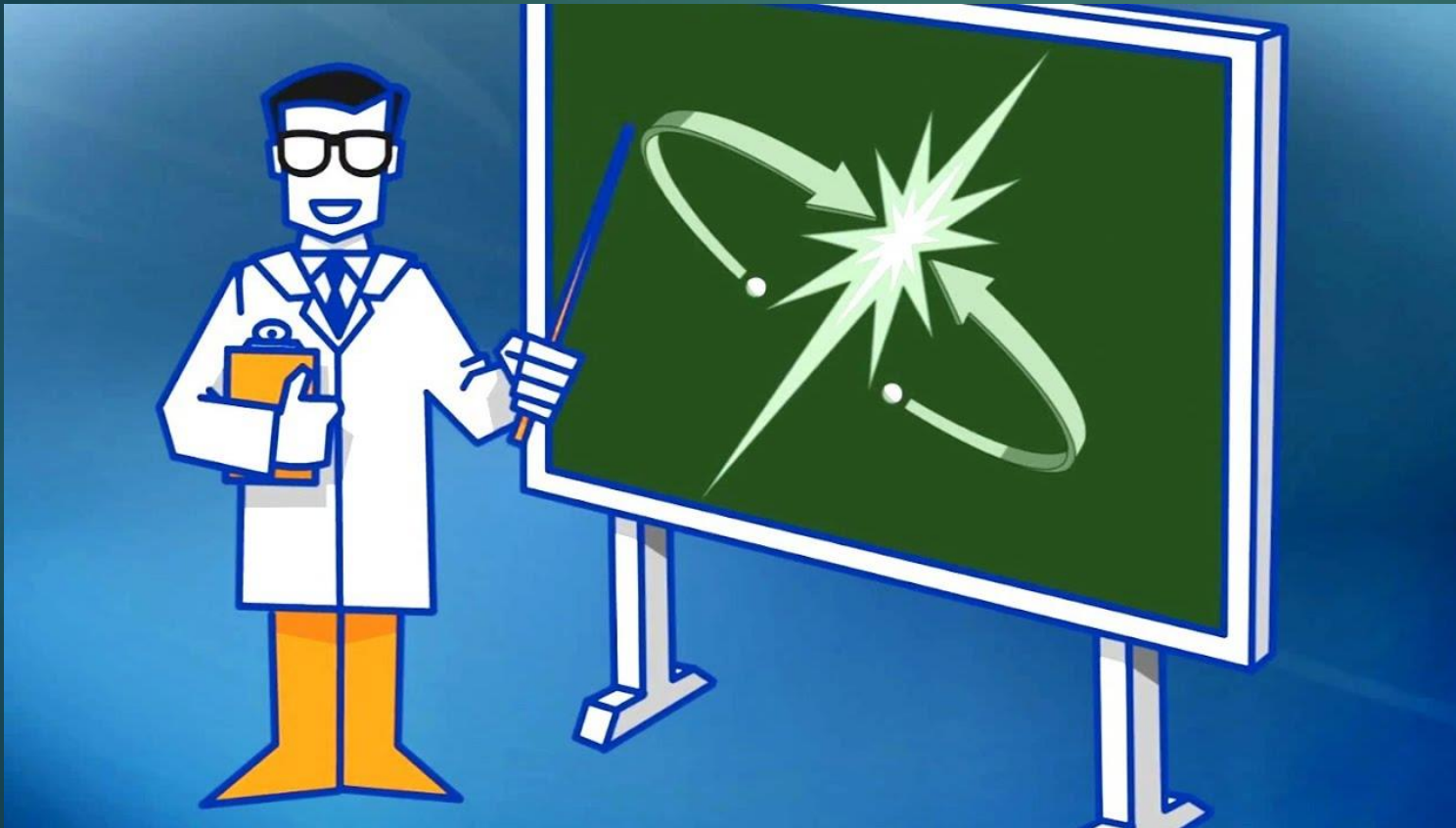
Rivelare le particelle – International Masterclasses 2022

Stefano Marcellini – INFN Sezione di Bologna



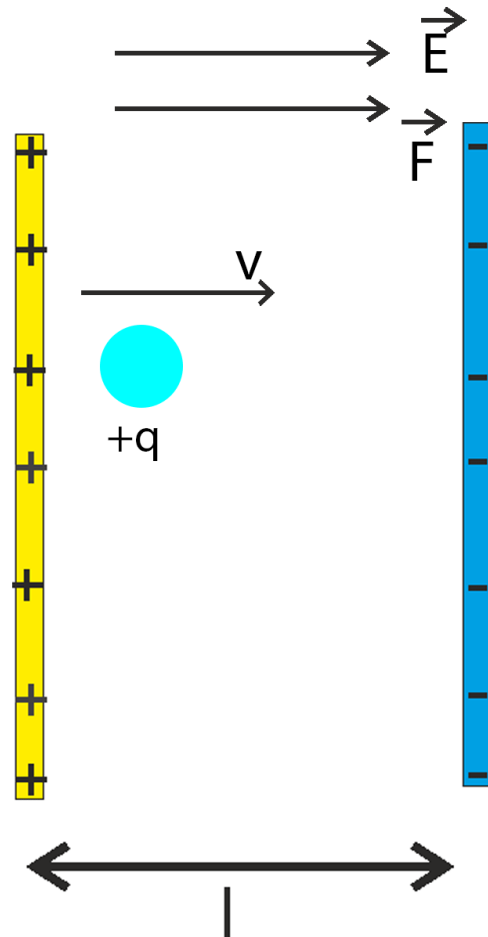


Come funziona un
esperimento di
fisica delle
particelle agli
acceleratori?

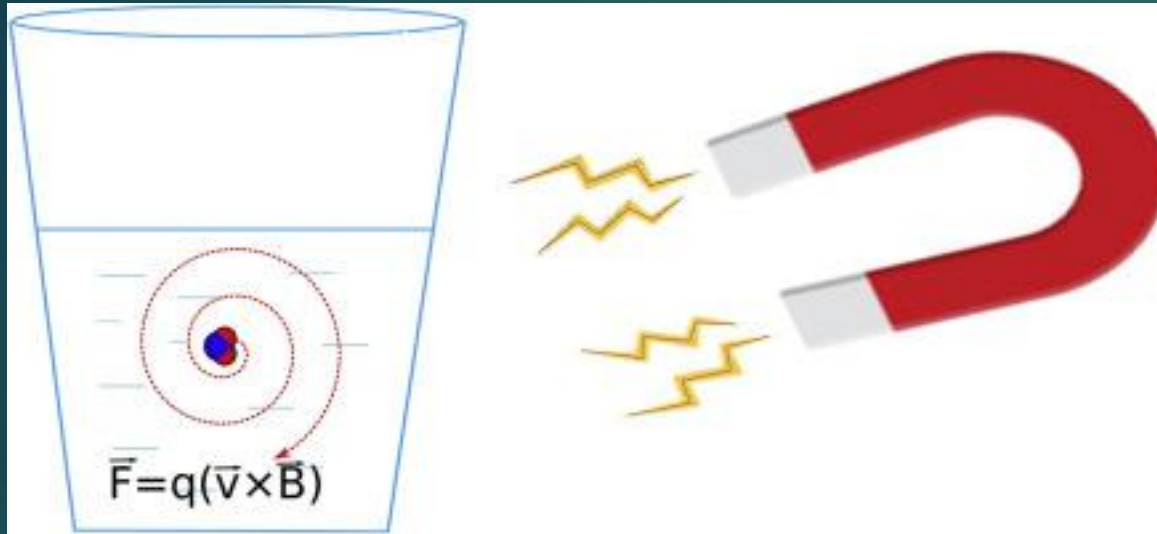


Le particelle vanno:

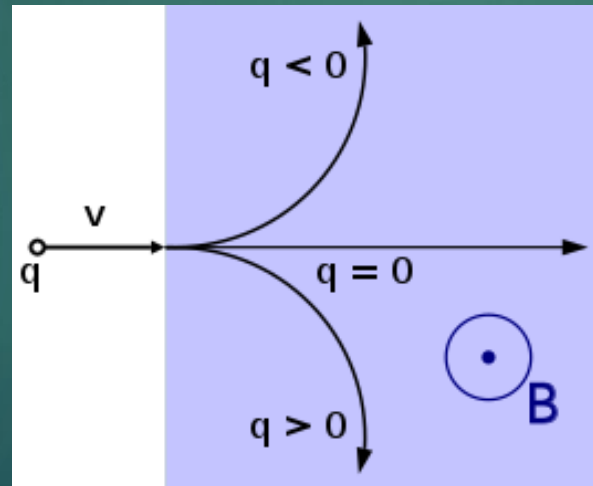
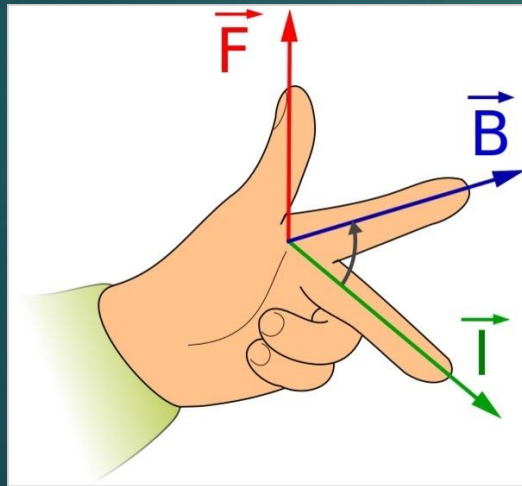
- ACCELERATE
- FATTE SCONTRARE FRA LORO
- SI OSSERVA COSA SUCCEDDE DOPO L'URTO

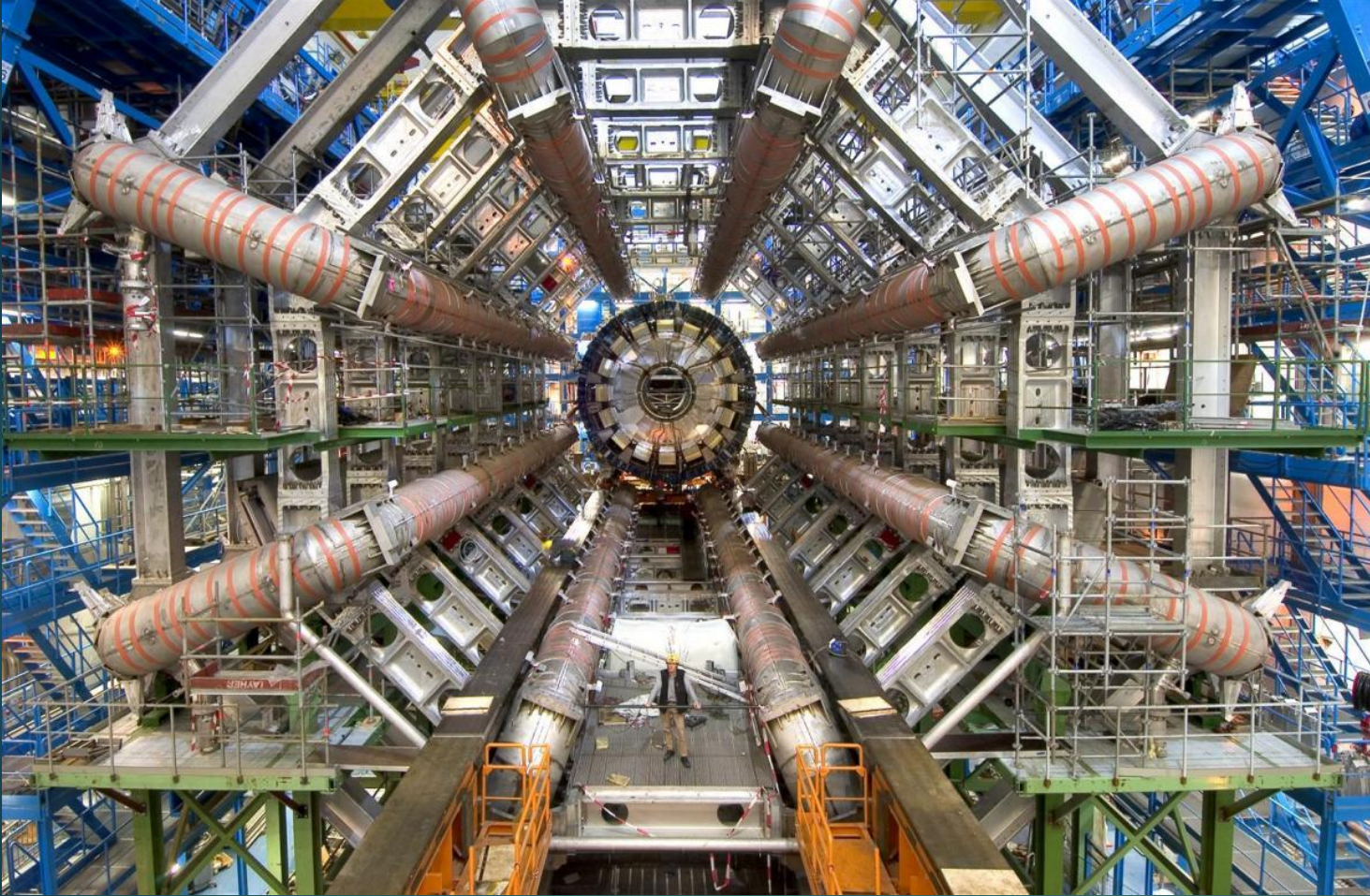


Un campo elettrico accelera una particella carica

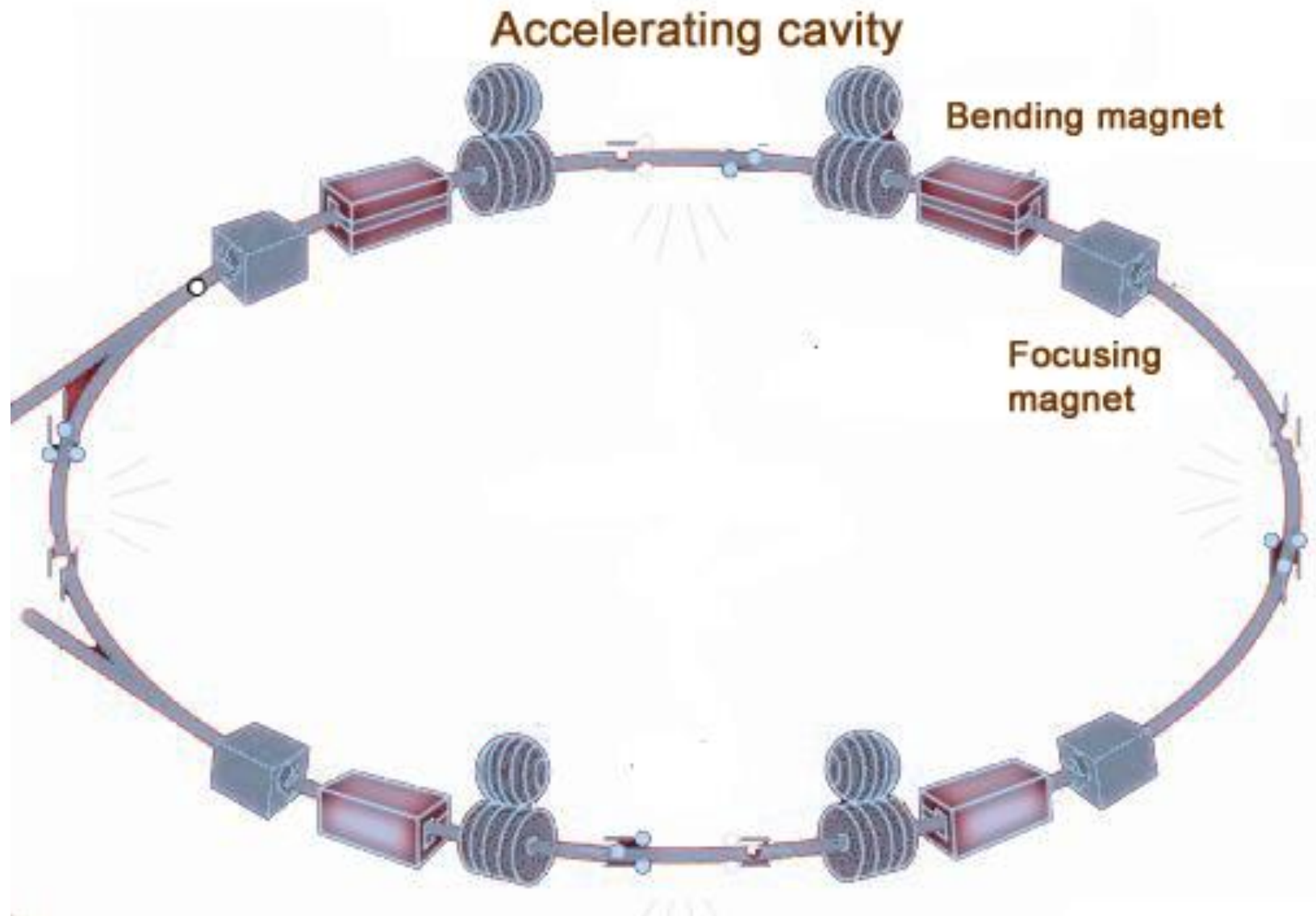


Un campo magnetico curva la traiettoria di una particella carica.

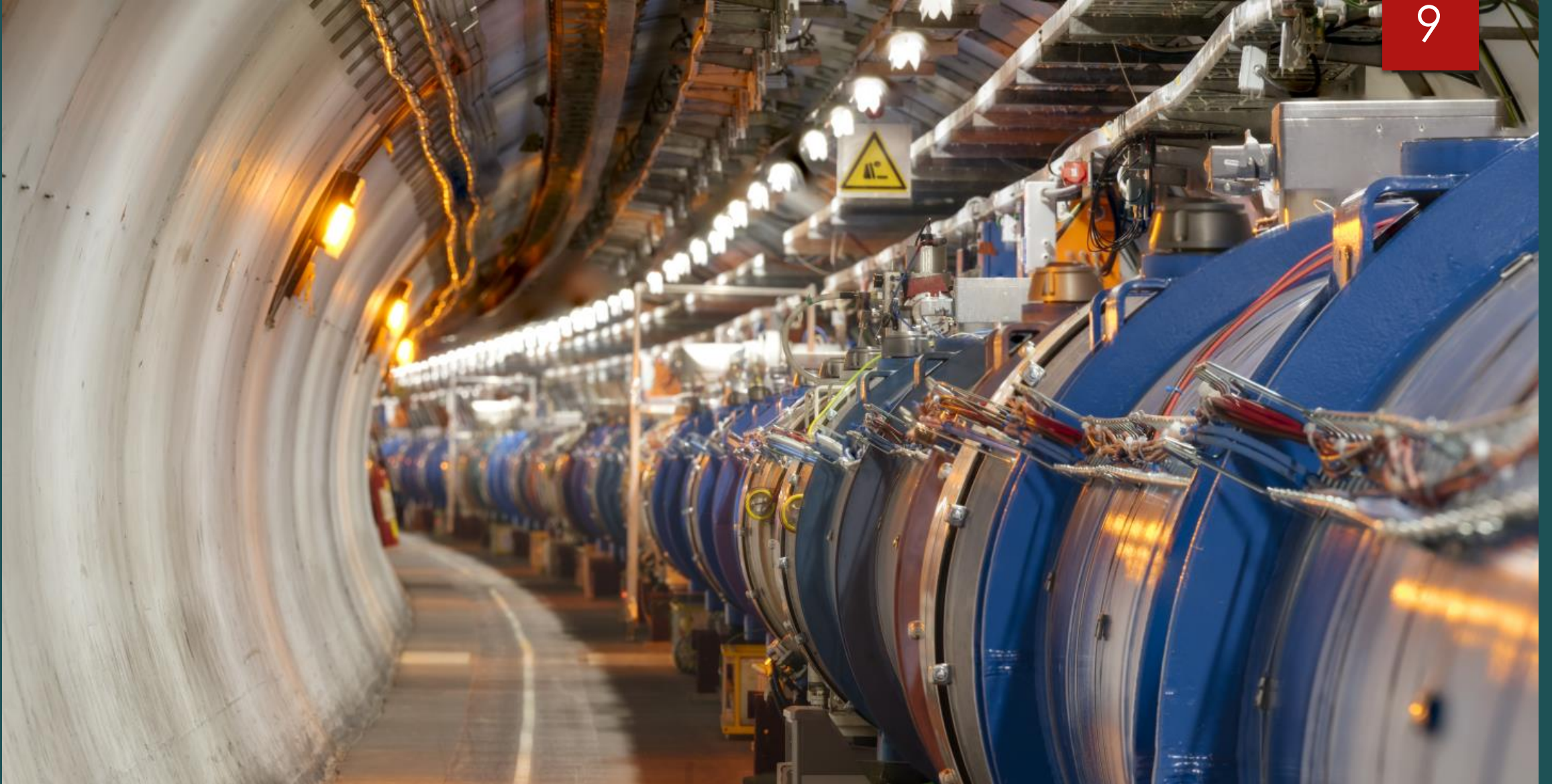


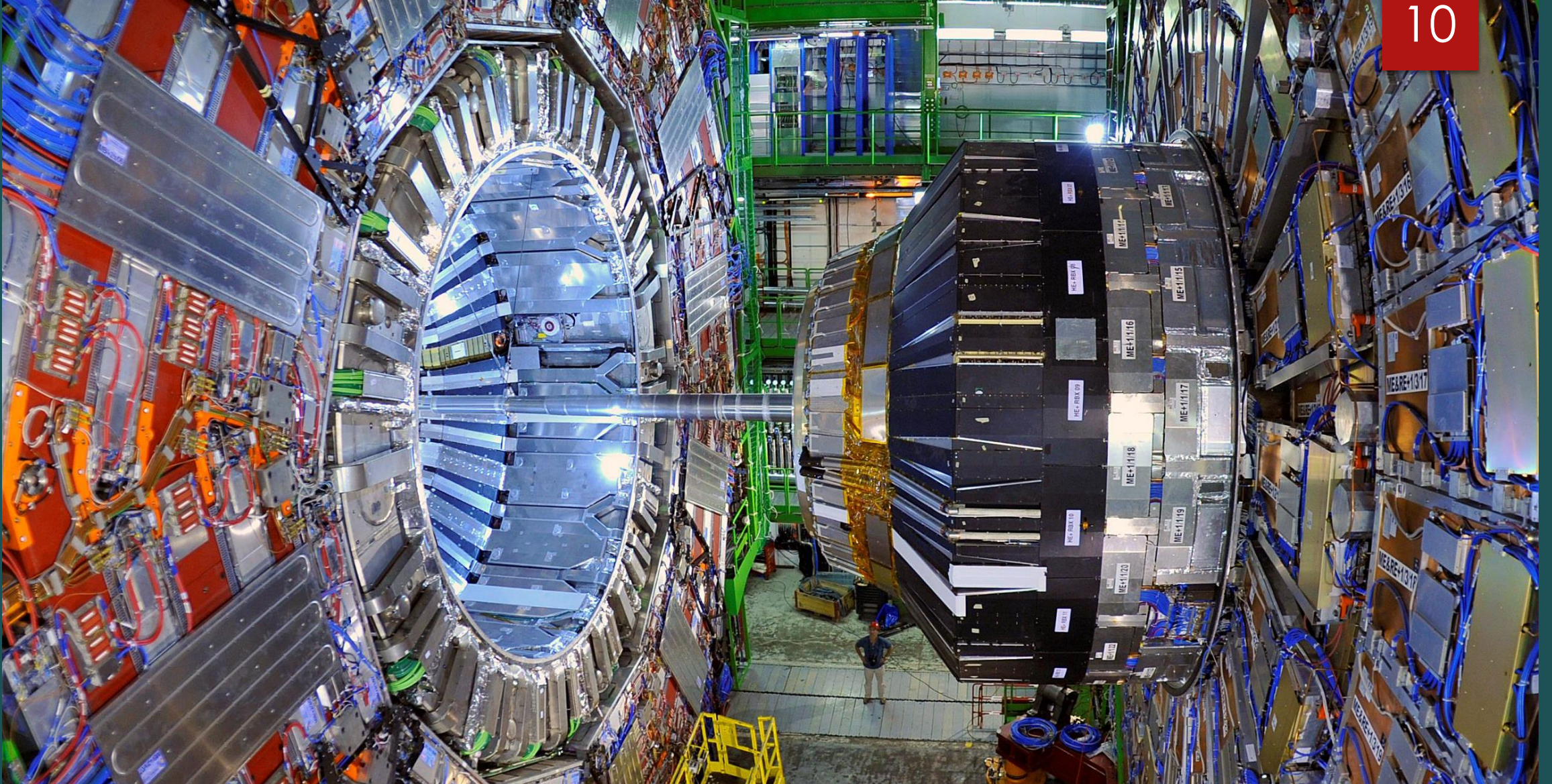


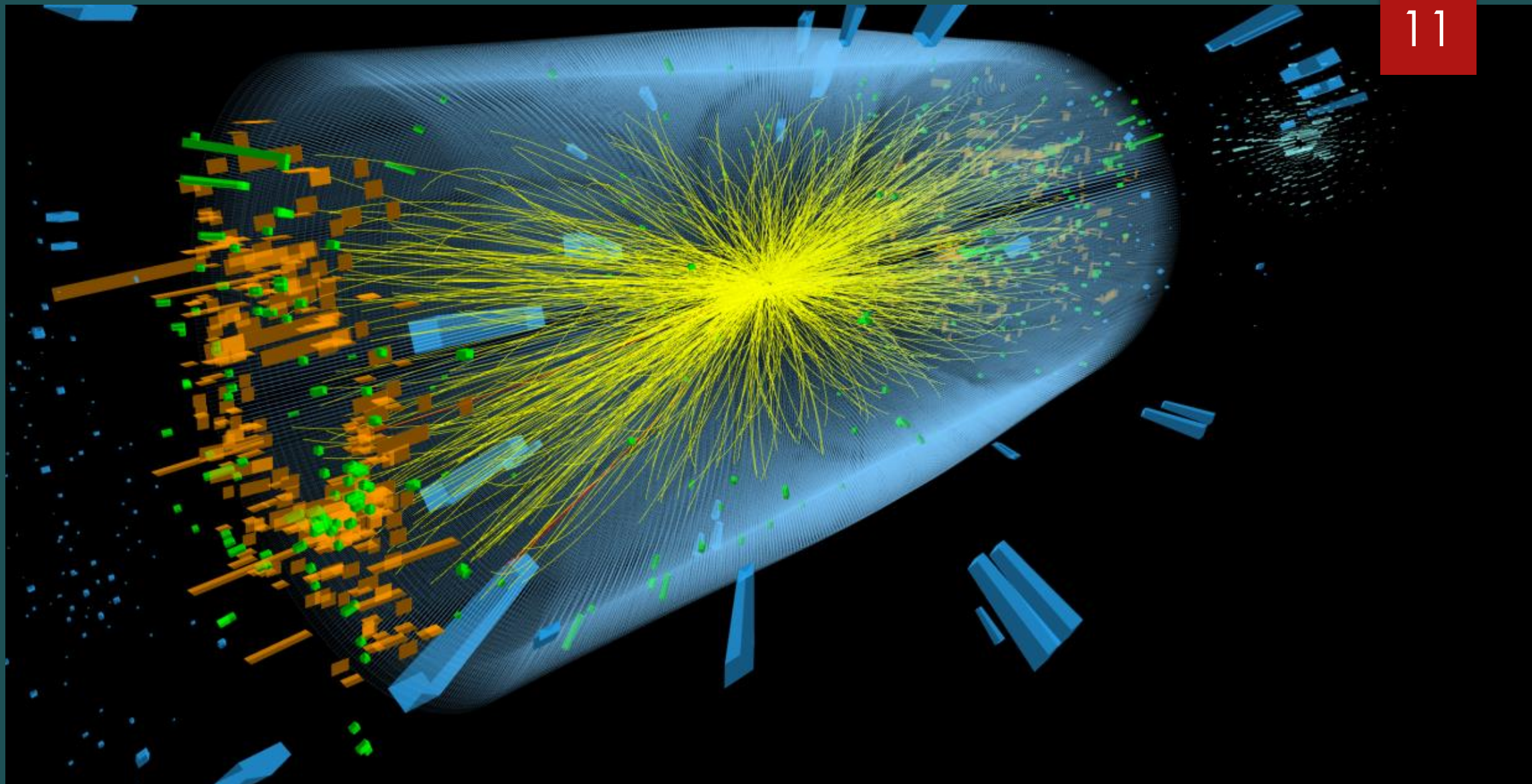
Un rivelatore di particelle, che «vede» cosa succede negli urti fra le particelle









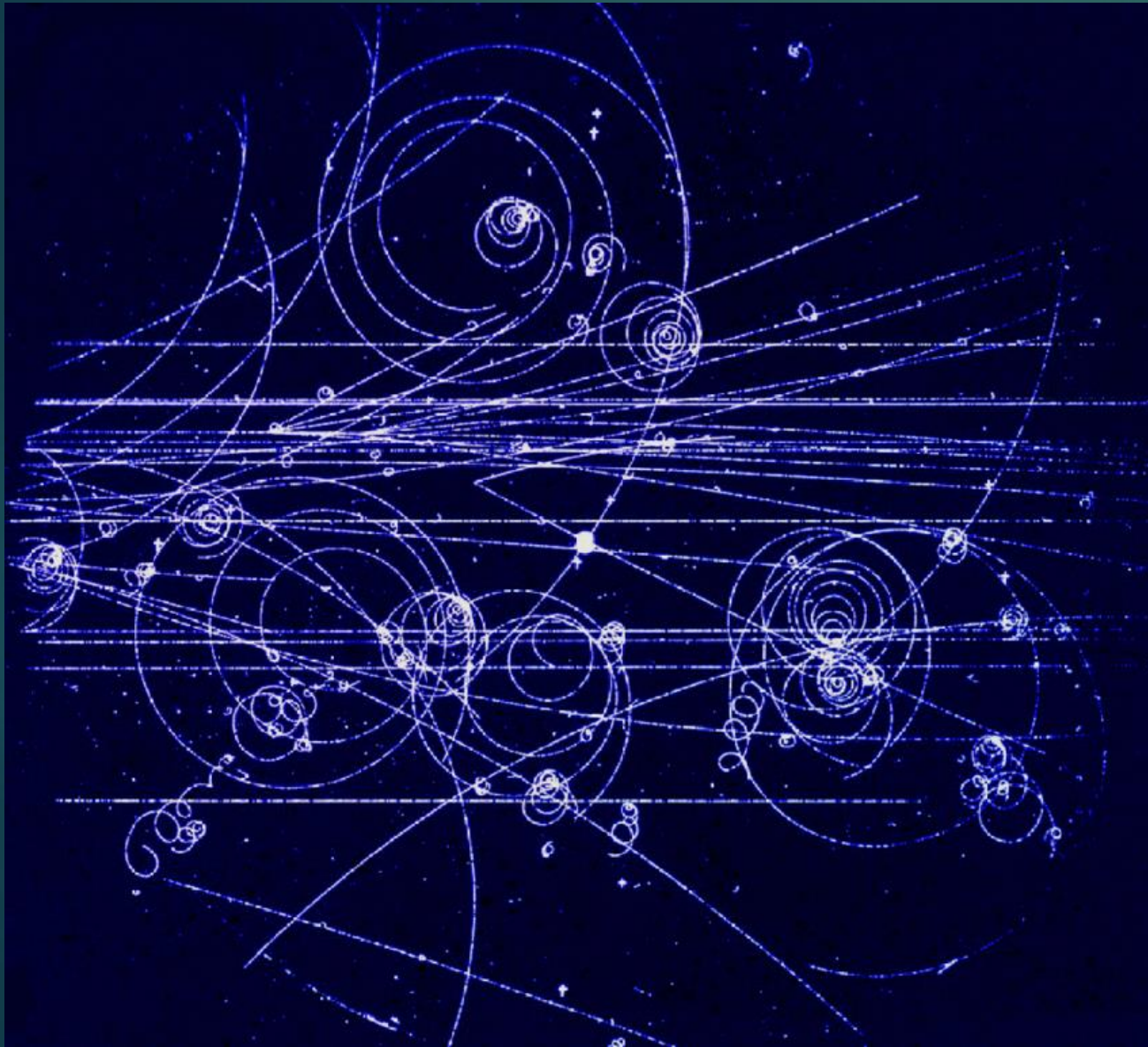




Come
possiamo
«vedere» le
particelle?

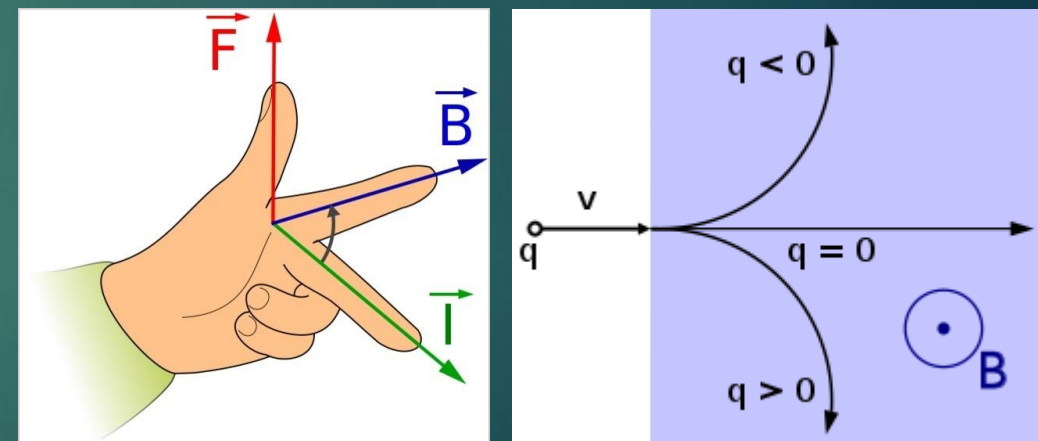
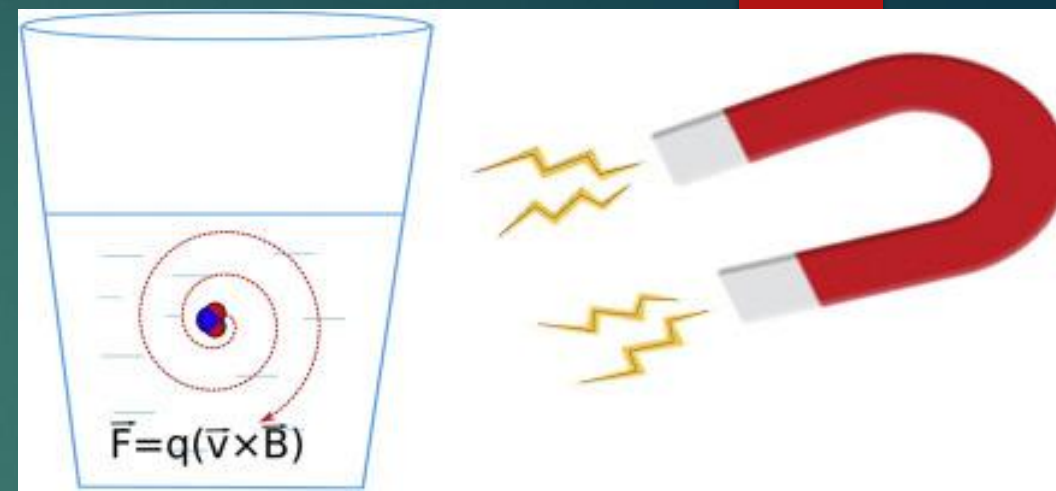
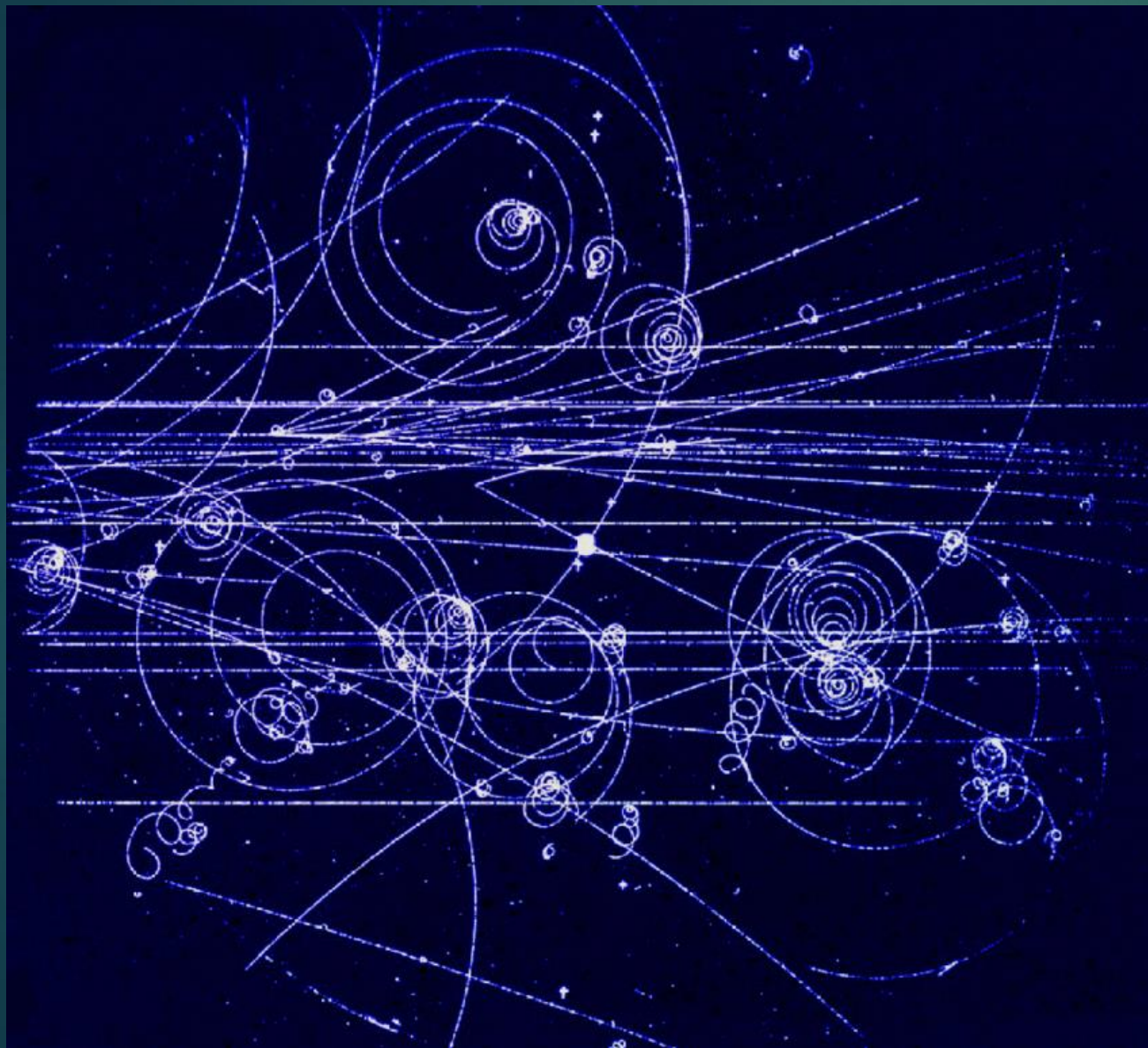


Vedere
qualcosa
tramite
l'interazione
con il mezzo
circostante

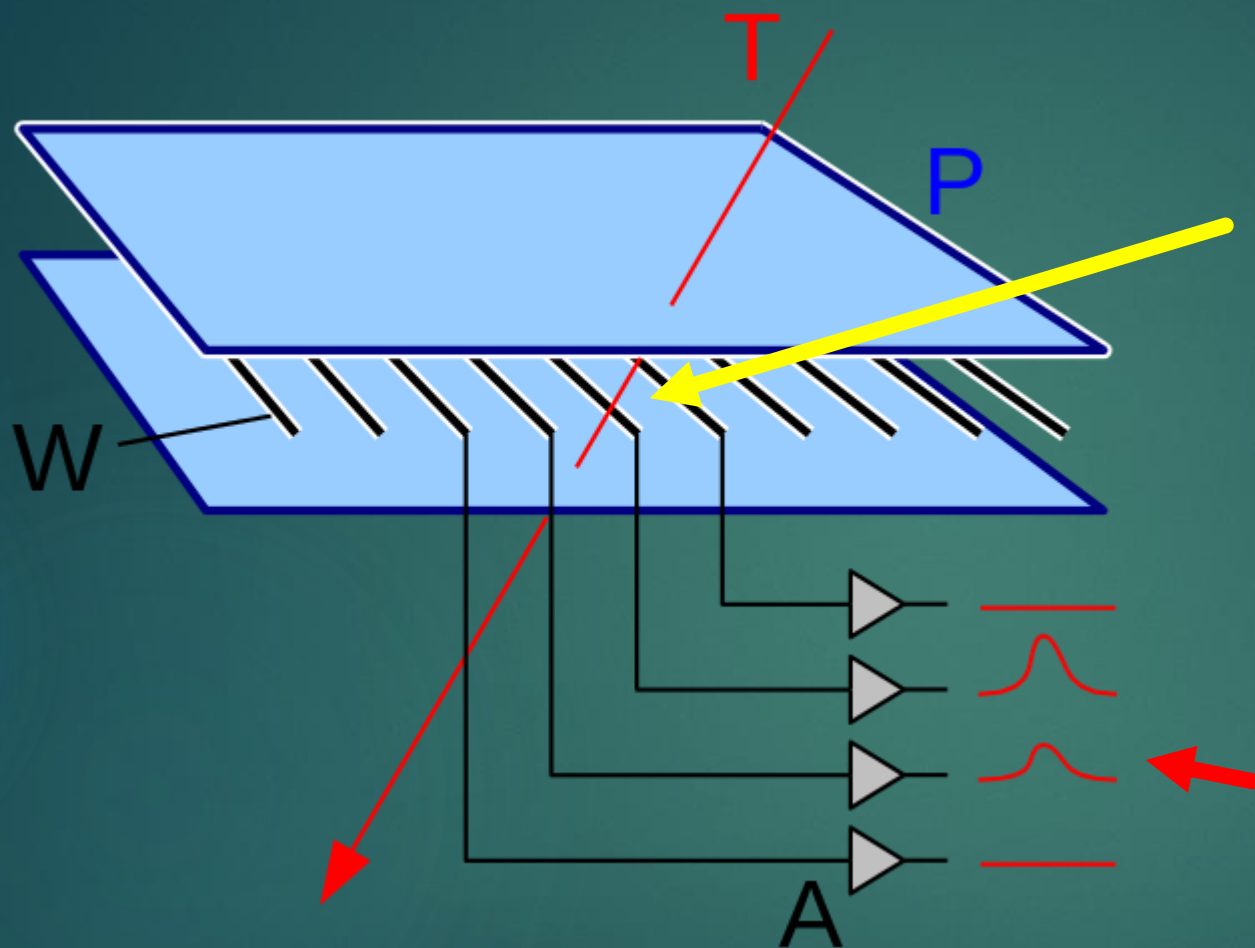


Le particelle cariche
ionizzano il mezzo in cui
passano

Dalla ricostruzione
della ionizzazione
prodotta è possibile
ricostruire le loro tracce



$$p = 0.3 R \cdot B$$

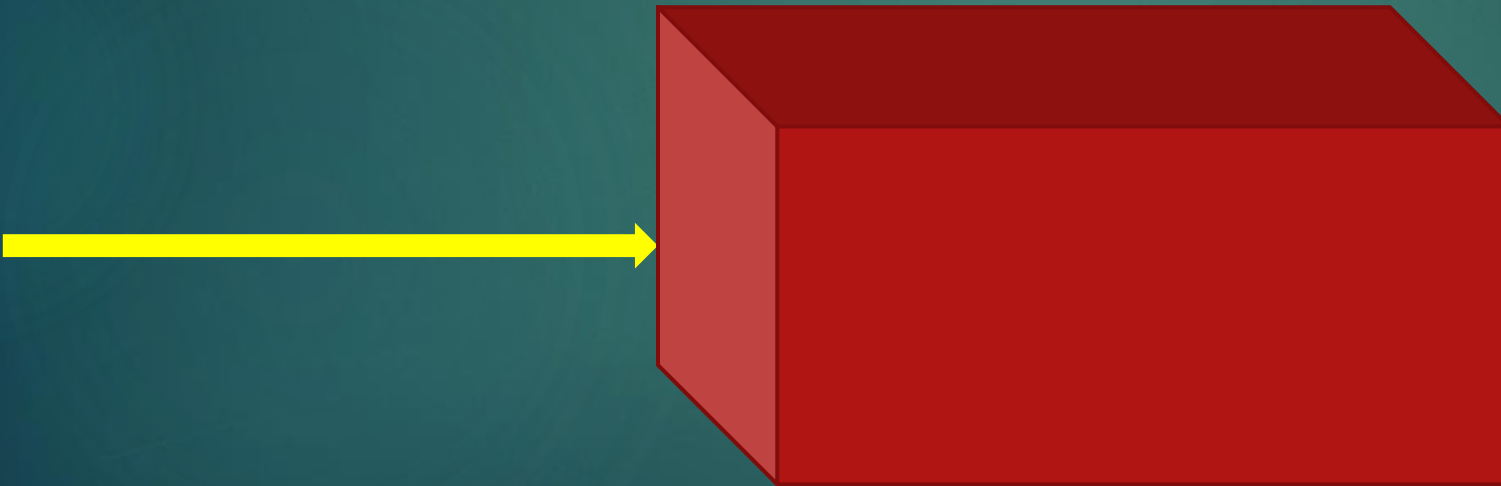


Una particella carica ionizza il mezzo che attraversa producendo cariche elettriche libere di muoversi

Cariche positive e negative viaggiano verso il catodo e i fili anodici.

Dall'altezza della carica raccolta si ricava la posizione in cui è passata la particella

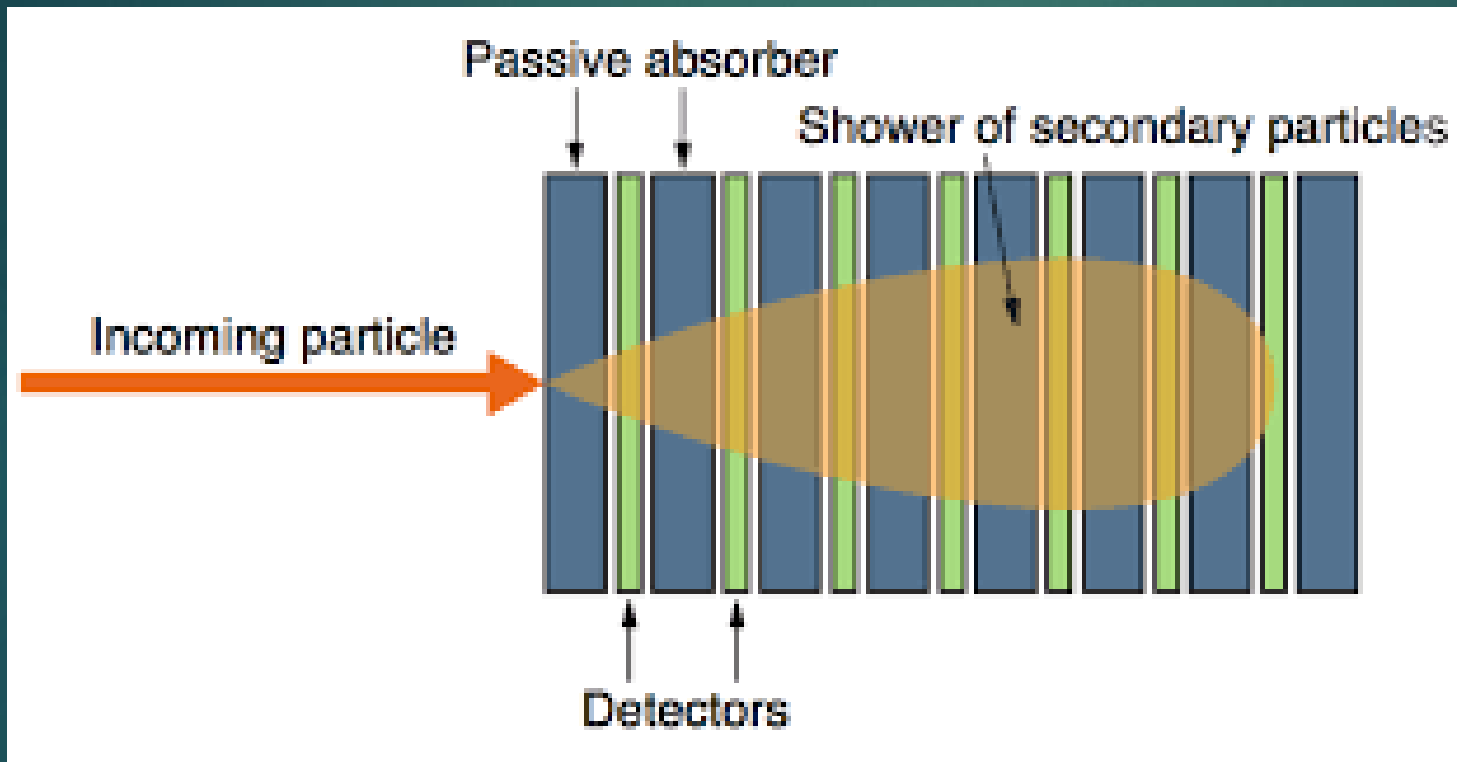
Calorimetri:
misurare l'energia
delle particelle



Calorimetri:
misurare l'energia
delle particelle

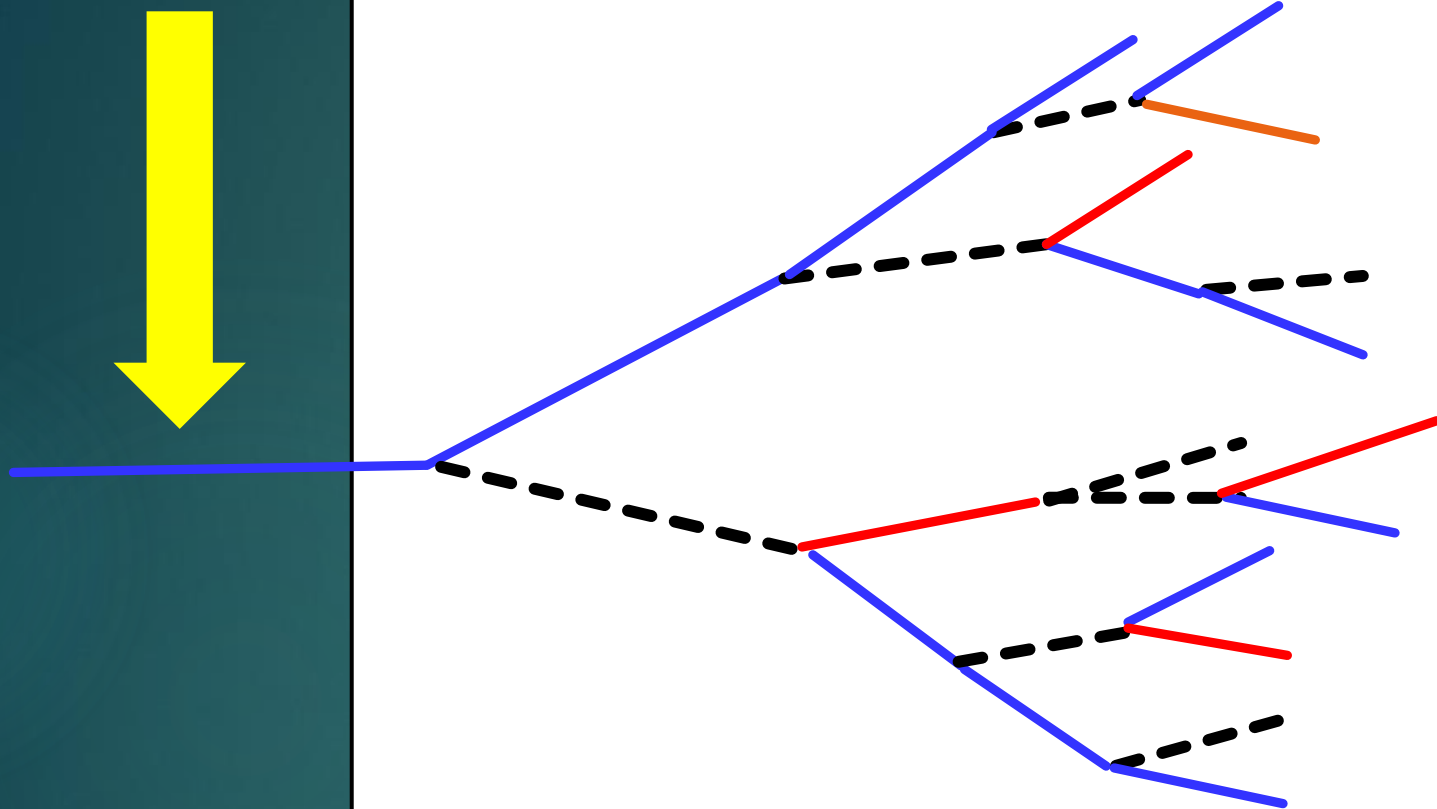
«Distrugge» la
particella originaria



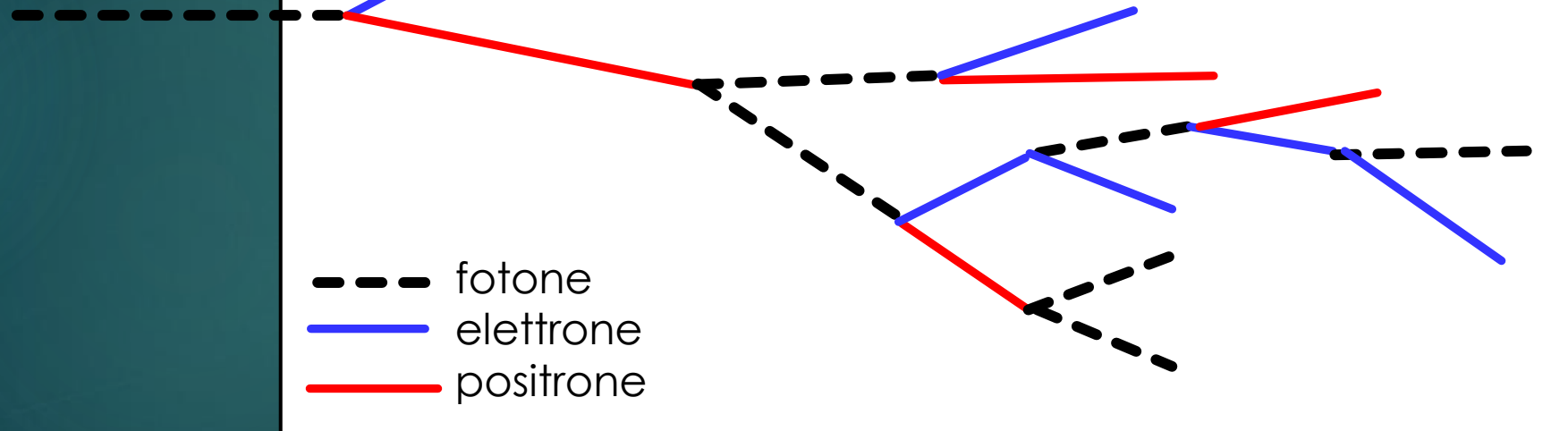


Oltre il calorimetro
assorbitore, in linea
di principio non
esce fuori niente

ELETRONE

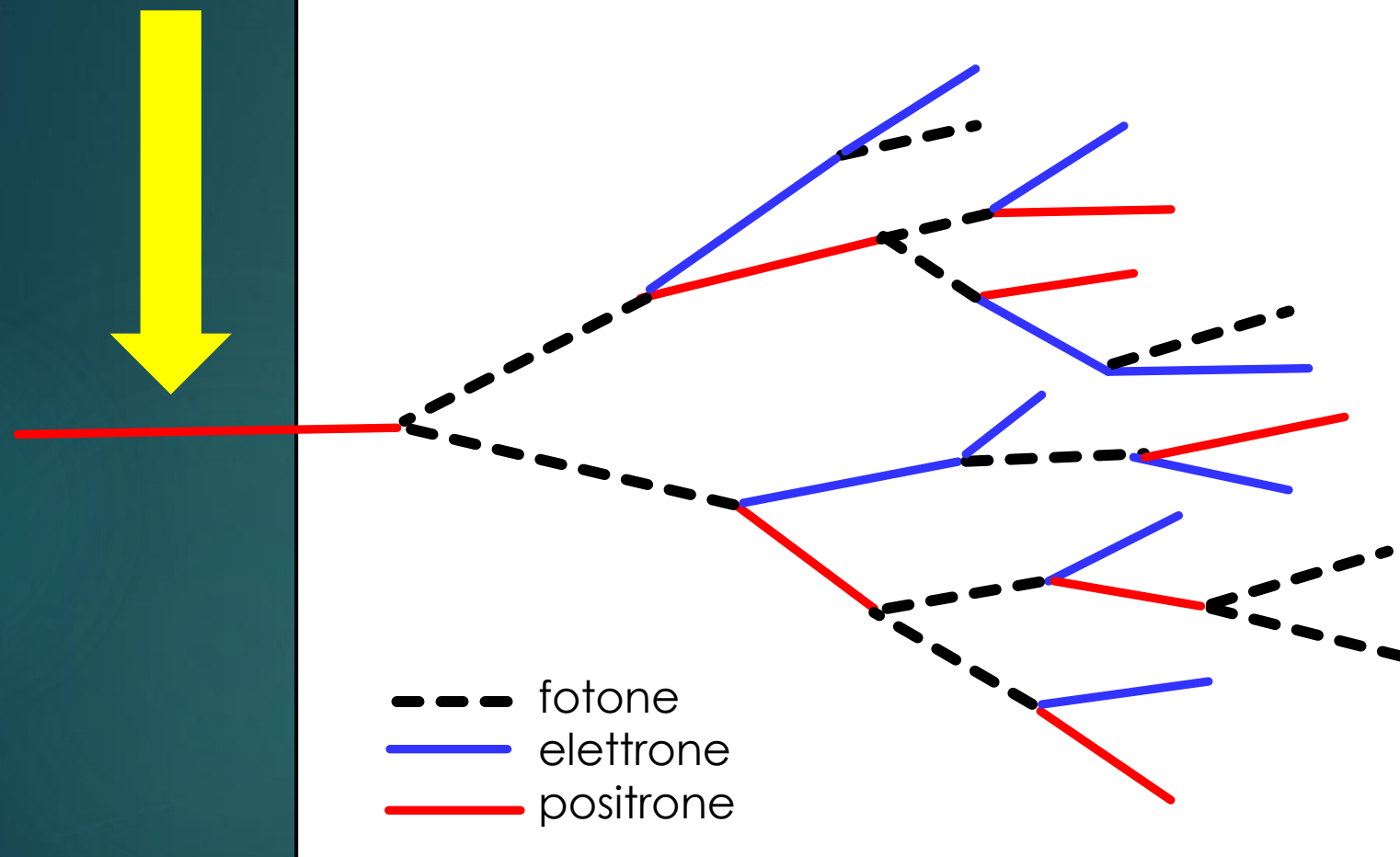


elettrone
positrone
fotone

FOTONE

elettrone
positrone
fotone

POSITRONE



elettrone
positrone
fotone

MUONE?

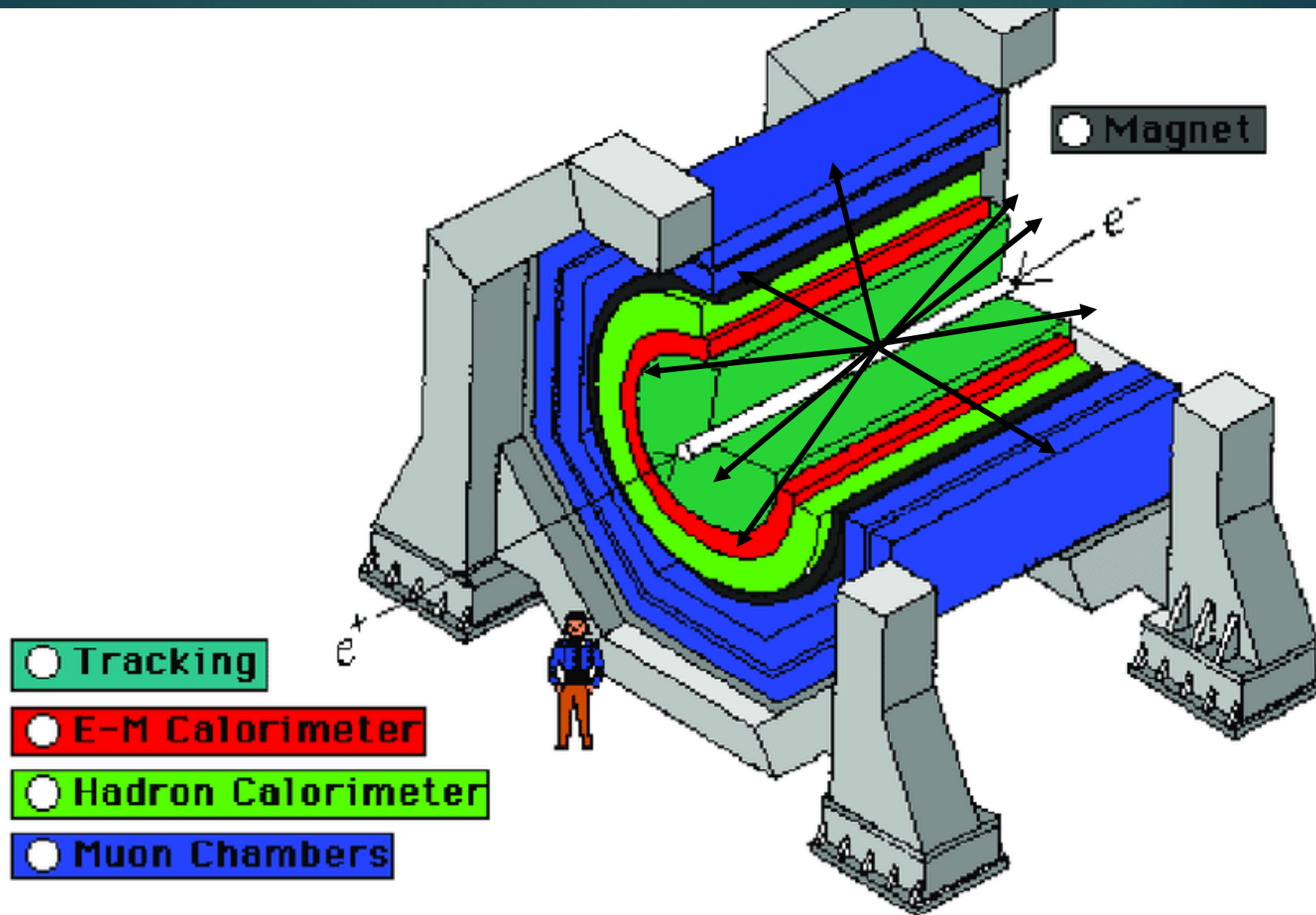


P_{sciamiEM} proporzionale m^{-4} : $m_{\mu} \approx 200 m_e$

MUONE?

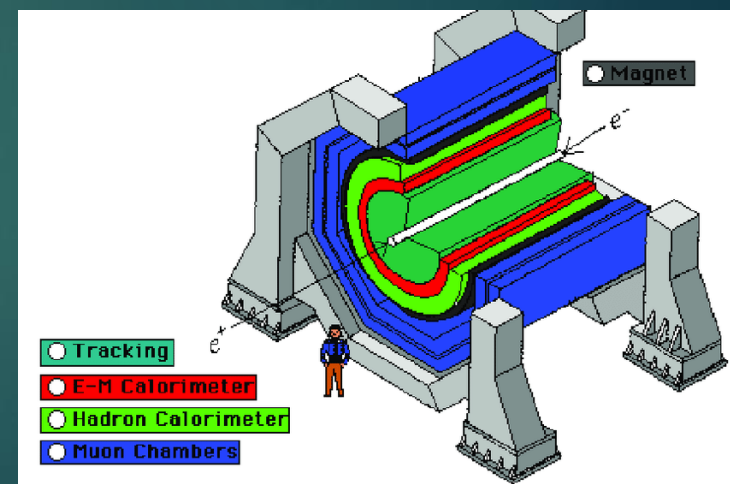
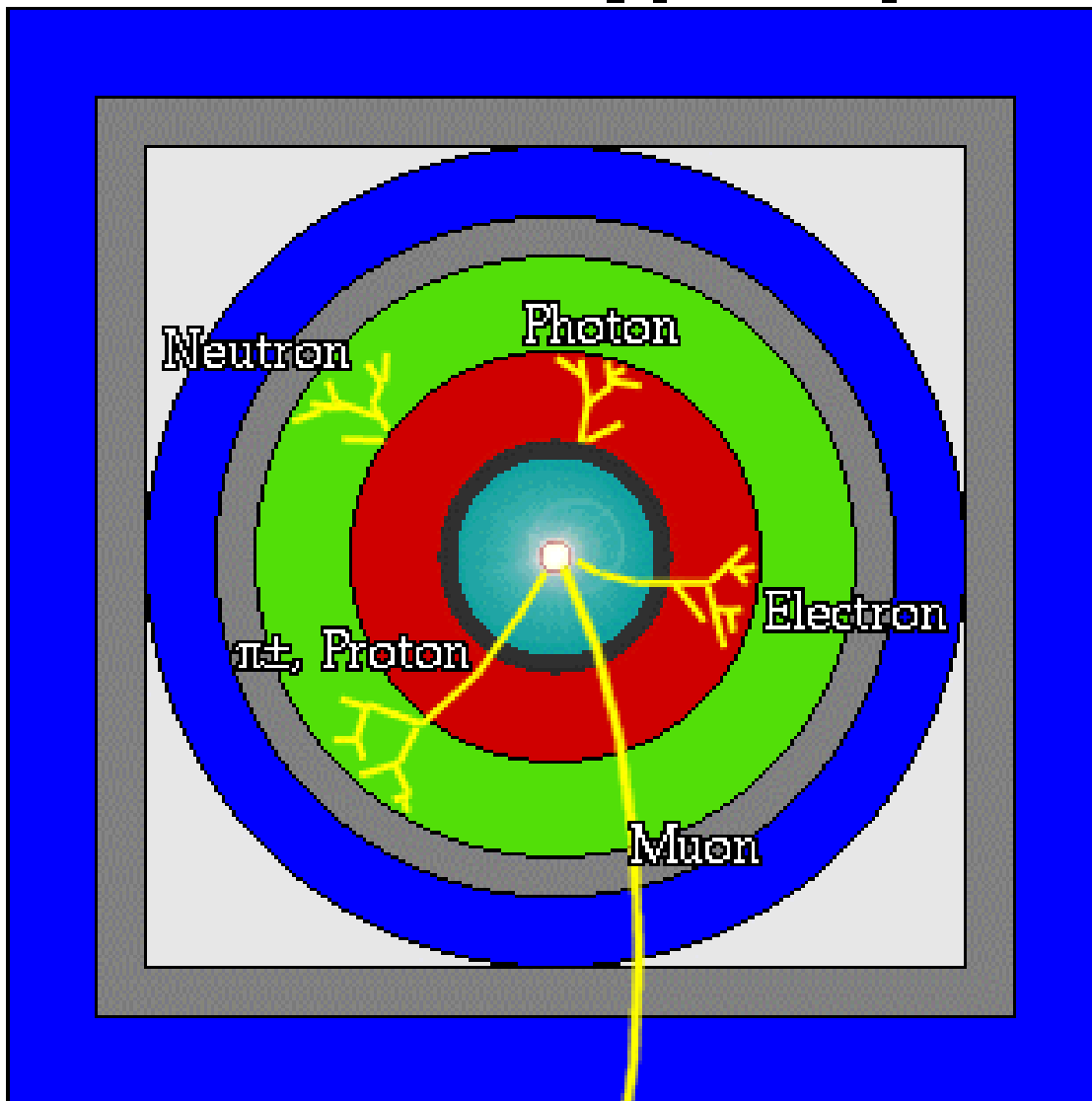


P_{sciamiEM} proporzionale m^{-4} : $m_{\mu} \approx 200 m_e$



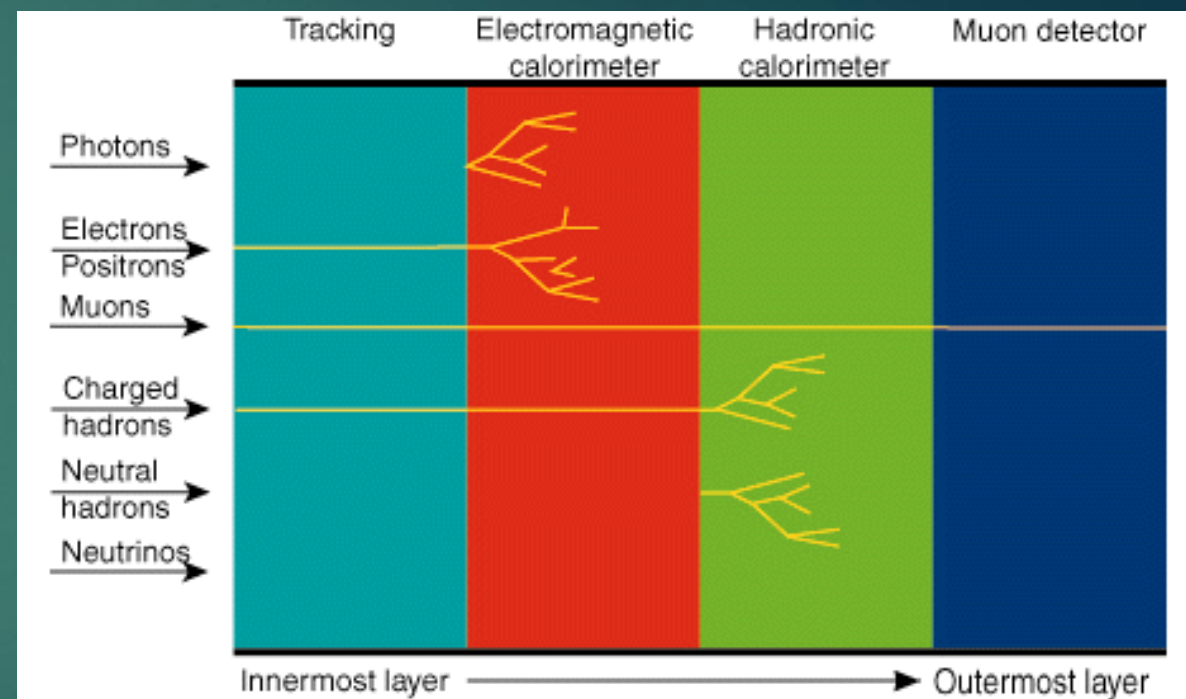
A detector cross-section, showing particle paths

-  Beam Pipe (center)
-  Tracking Chamber
-  Magnet Coil
-  E-M Calorimeter
-  Hadron Calorimeter
-  Magnetized Iron
-  Muon Chambers



Traccia sciame EM Segnale Muoni

Elettrone	SI	SI	NO
Positrone	SI	SI	NO
Fotone	NO	SI	NO
Muone	SI	NO	SI
Altre particelle cariche	SI	NO	NO
Neutrino	NO	NO	NO

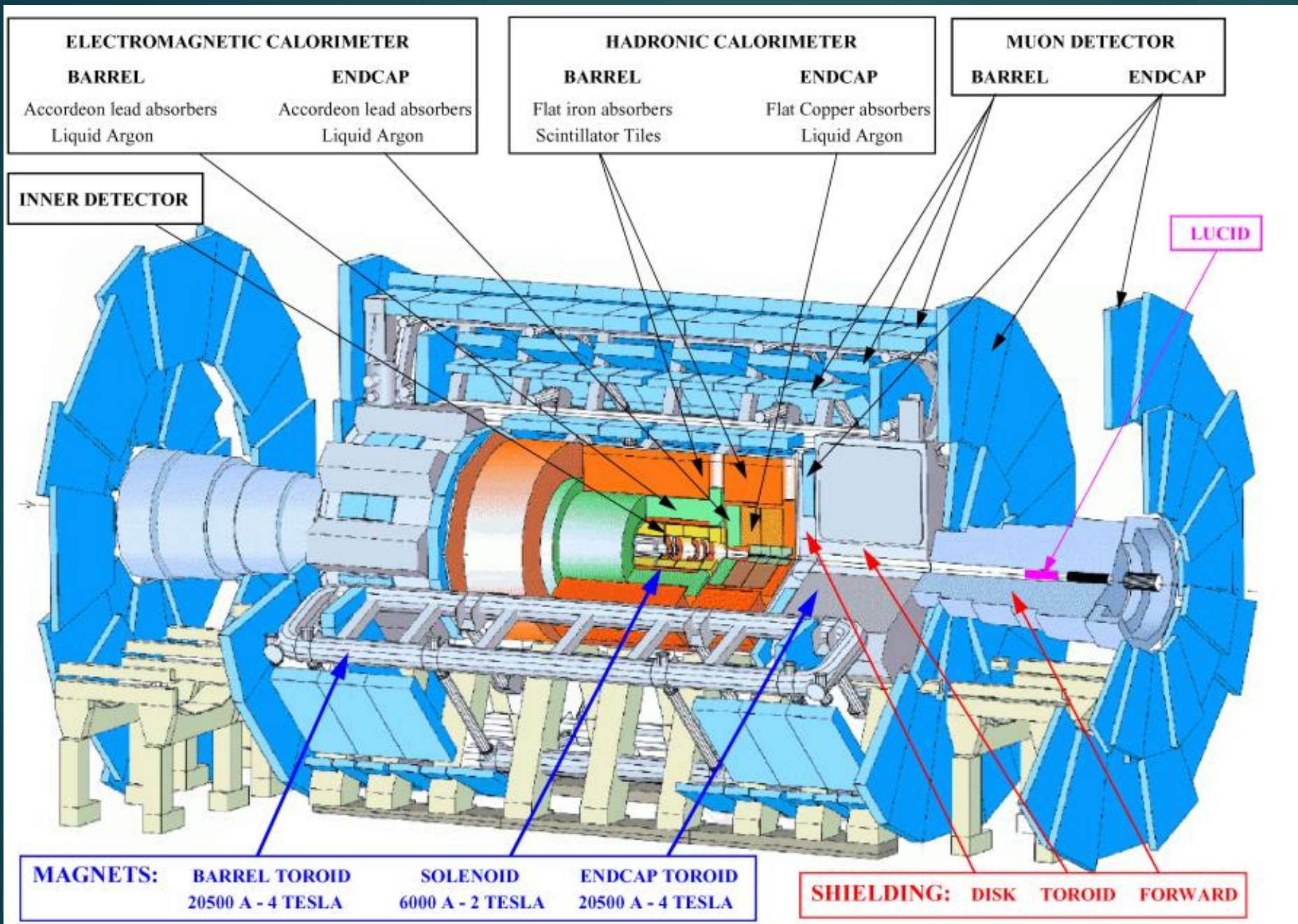




CMS Experiment at the LHC, CERN

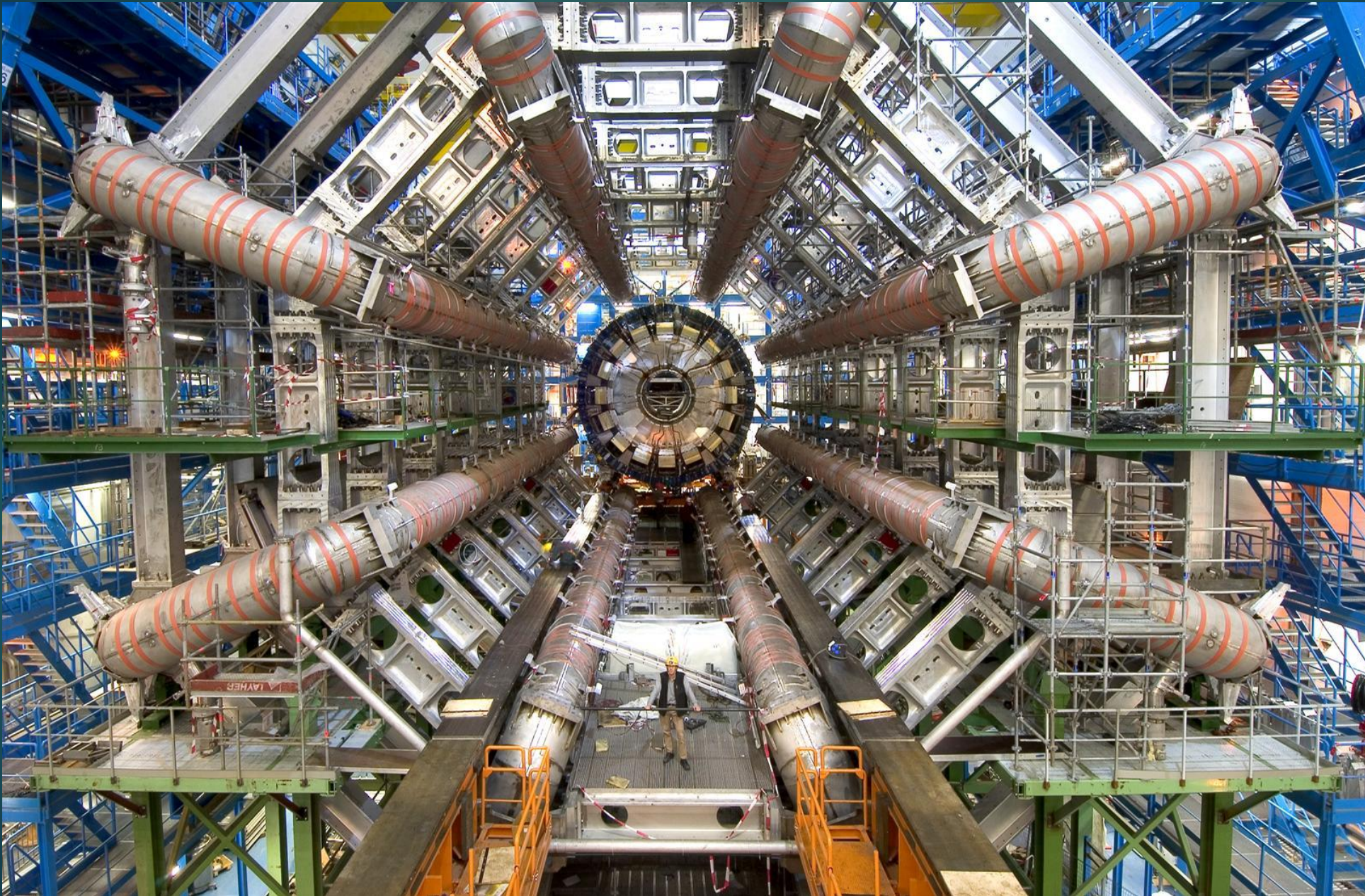
Data recorded: 2010-Jul-09 02:25:58.839811 GMT(04:25:58 CEST)

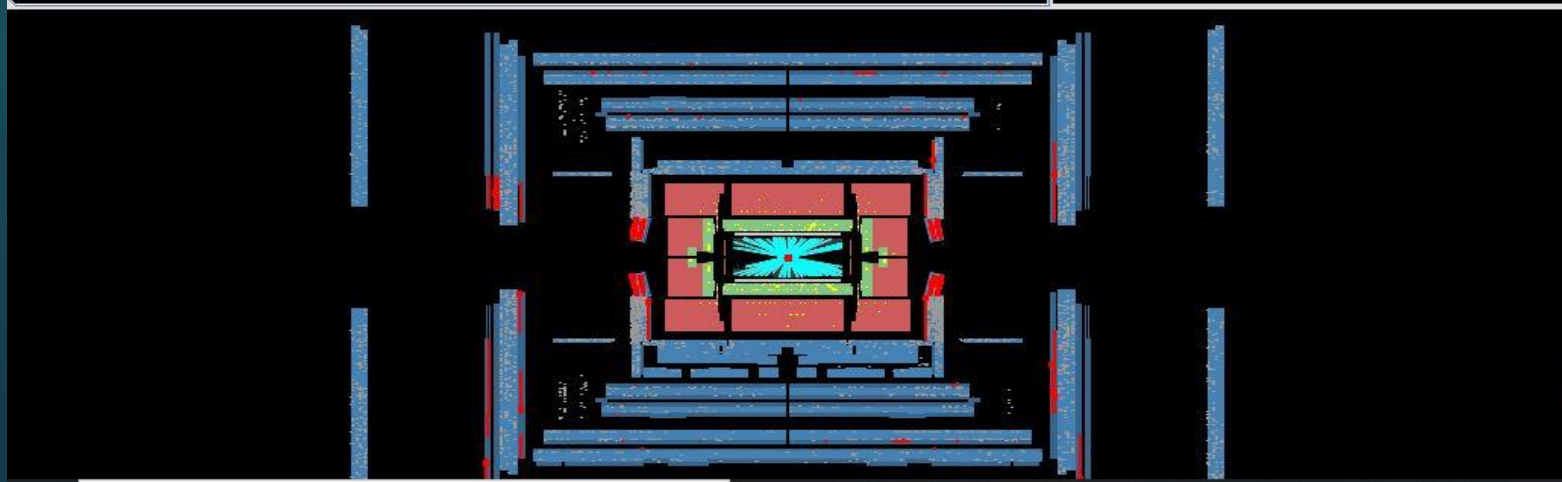
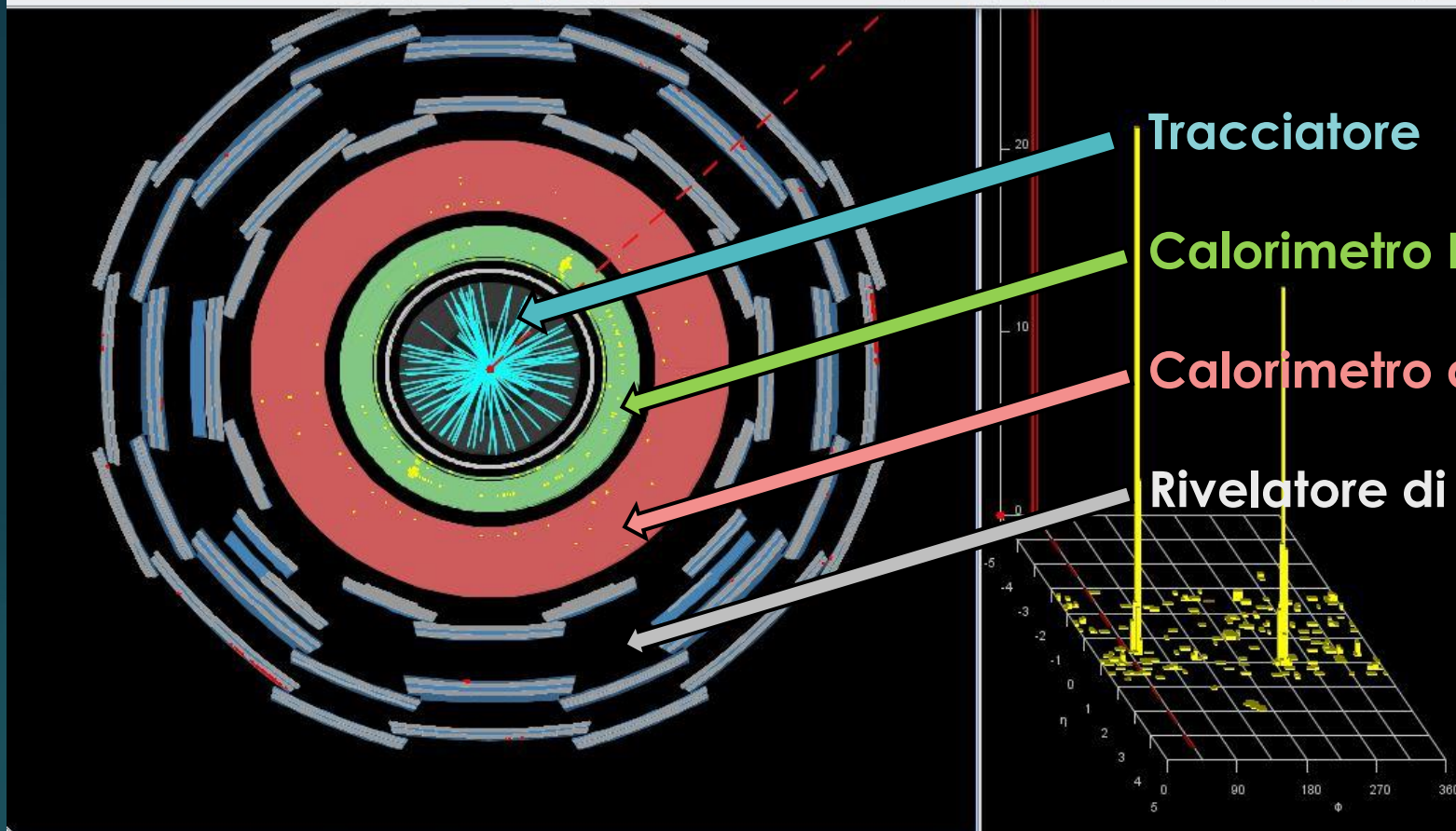
Run / Event: 139779 / 4994190



ESPERIMENTO ATLAS

A Toroidal LHC Apparatus





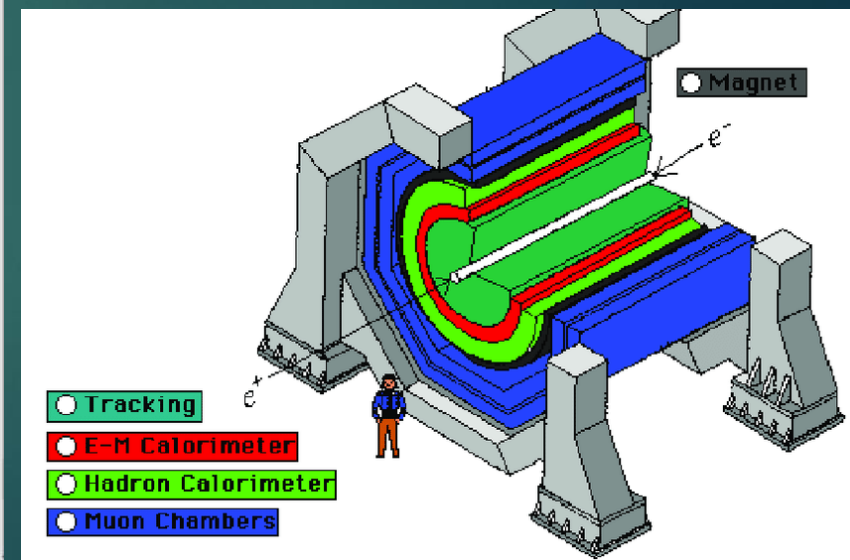
31

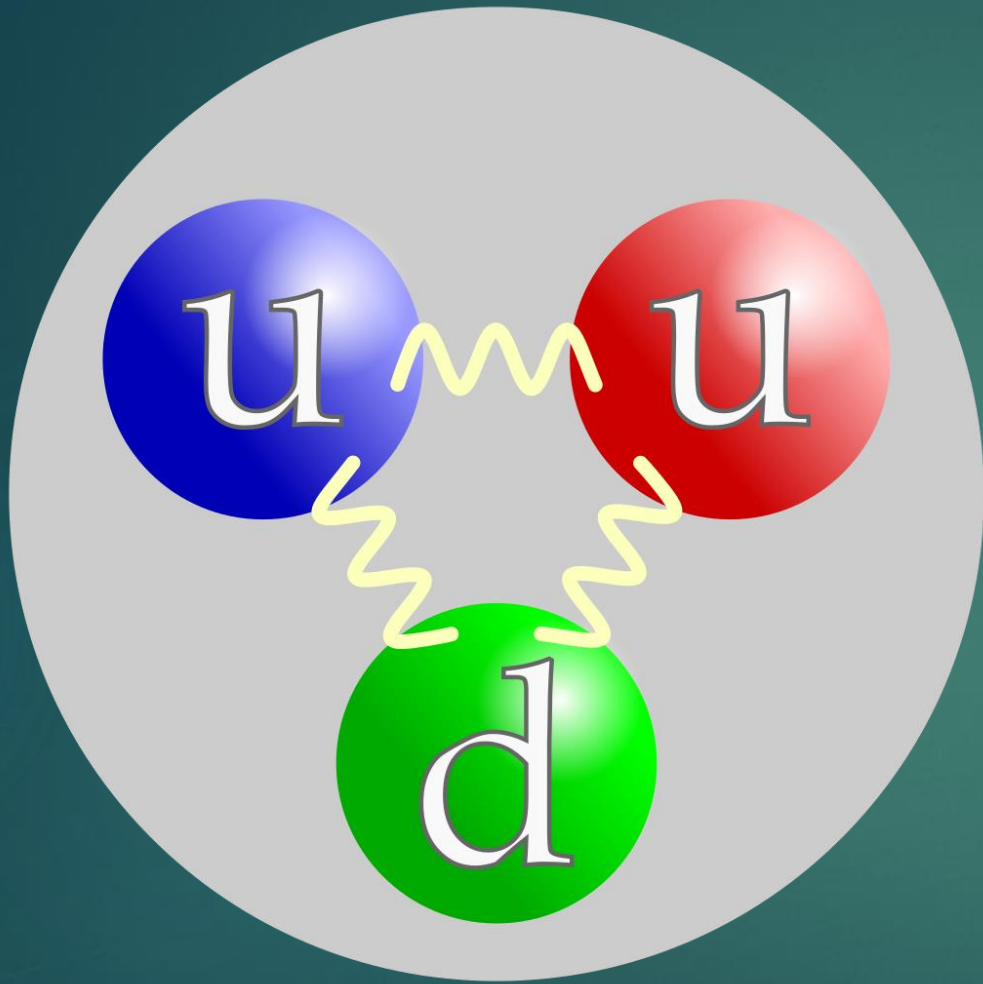
Tracciatore

Calorimetro EM.

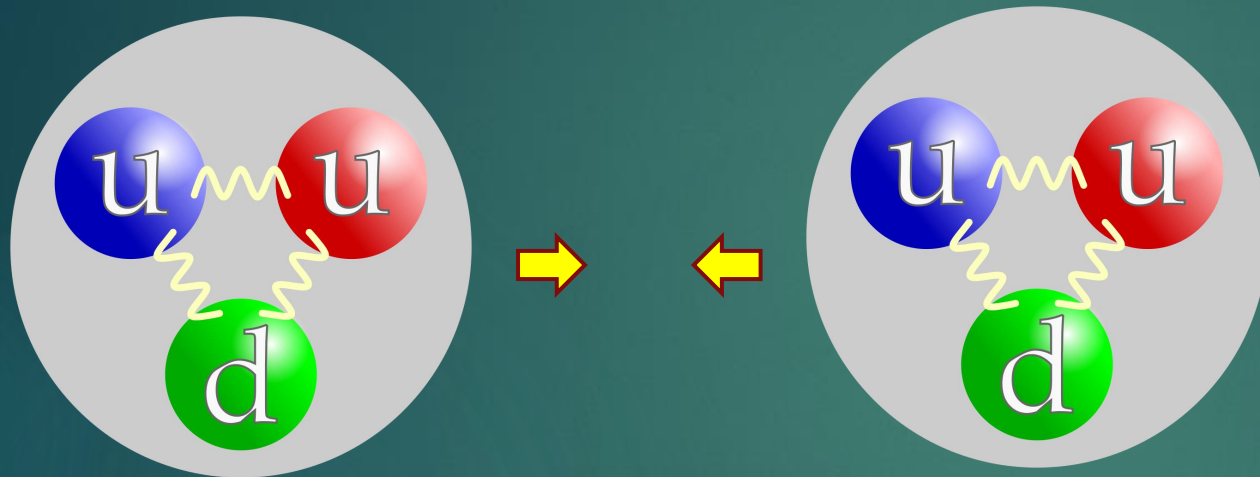
Calorimetro adronico

Rivelatore di Muoni

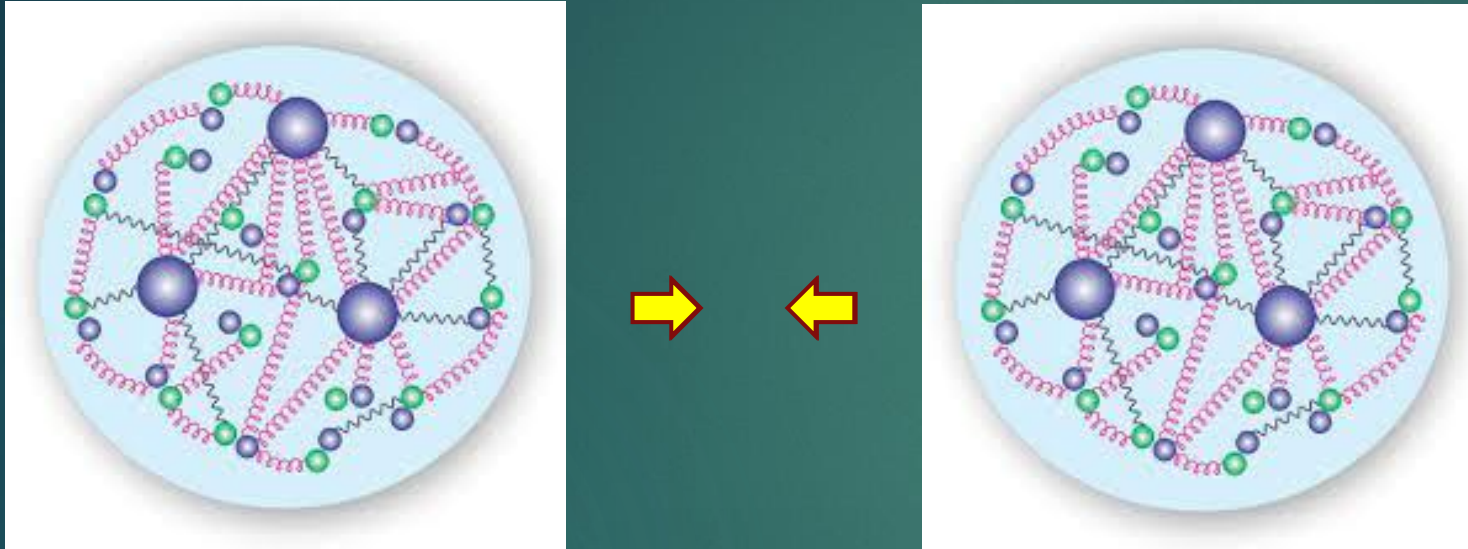




Un protone, a livello «basico», è relativamente semplice



Quando però due protoni si urtano ad alta energia, si «scrutano» reciprocamente in grande dettaglio



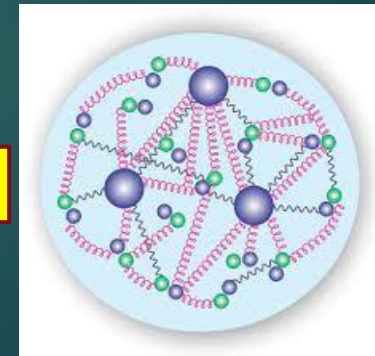
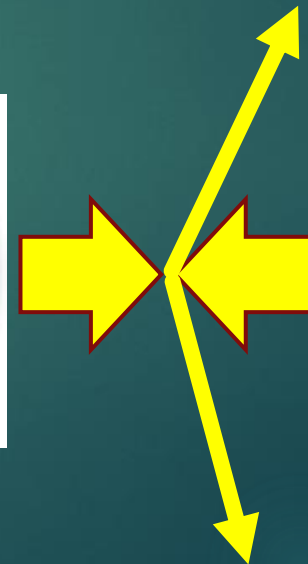
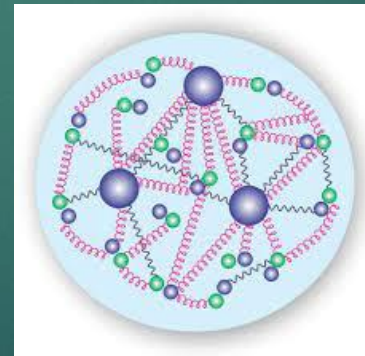
E scoprono di
essere molto
complessi al loro
interno

Momento (o impulso) trasverso

Impulso p della particella

Impulso trasverso p_T della particella

Direzione del fascio di
protoni incidente





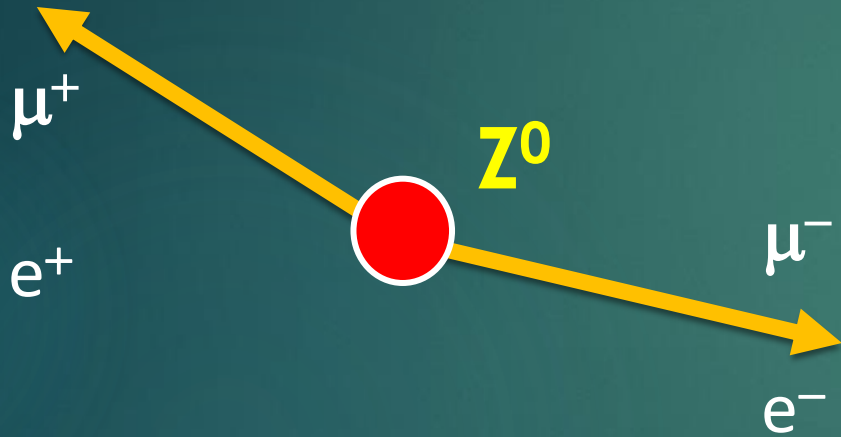
CMS Experiment at the LHC, CERN

Data recorded: 2010-Jul-09 02:25:58.839811 GMT(04:25:58 CEST)

Run / Event: 139779 / 4994190

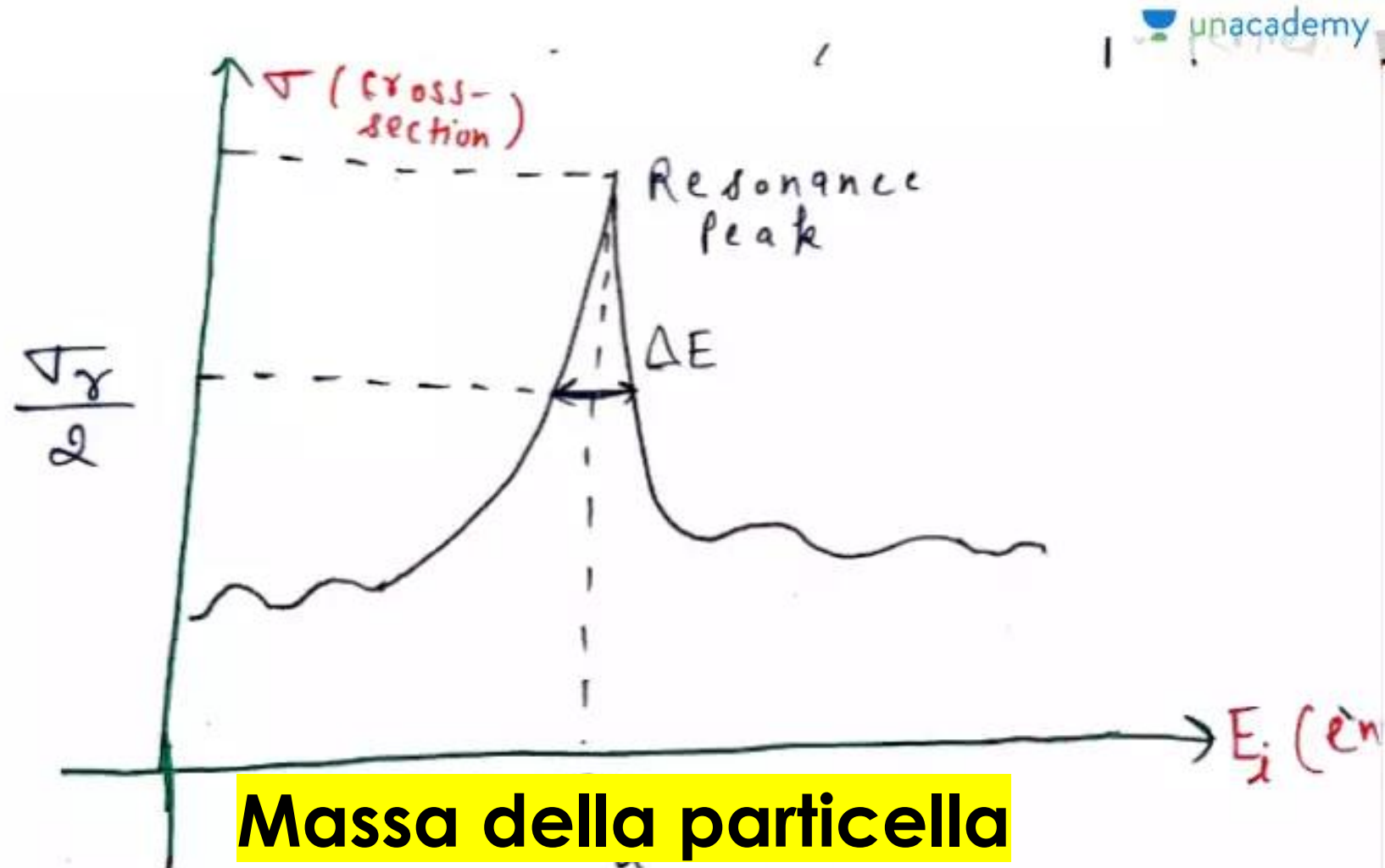
In pochissimi casi
all'interno di questa
moltitudine di tracce ce ne
sono alcune di alto impulso
trasverso **SONO I CASI CHE
PIU' INTERESSANO!**

Massa invariante: Ricostruzione della massa di una particella a partire dai suoi prodotti di decadimento

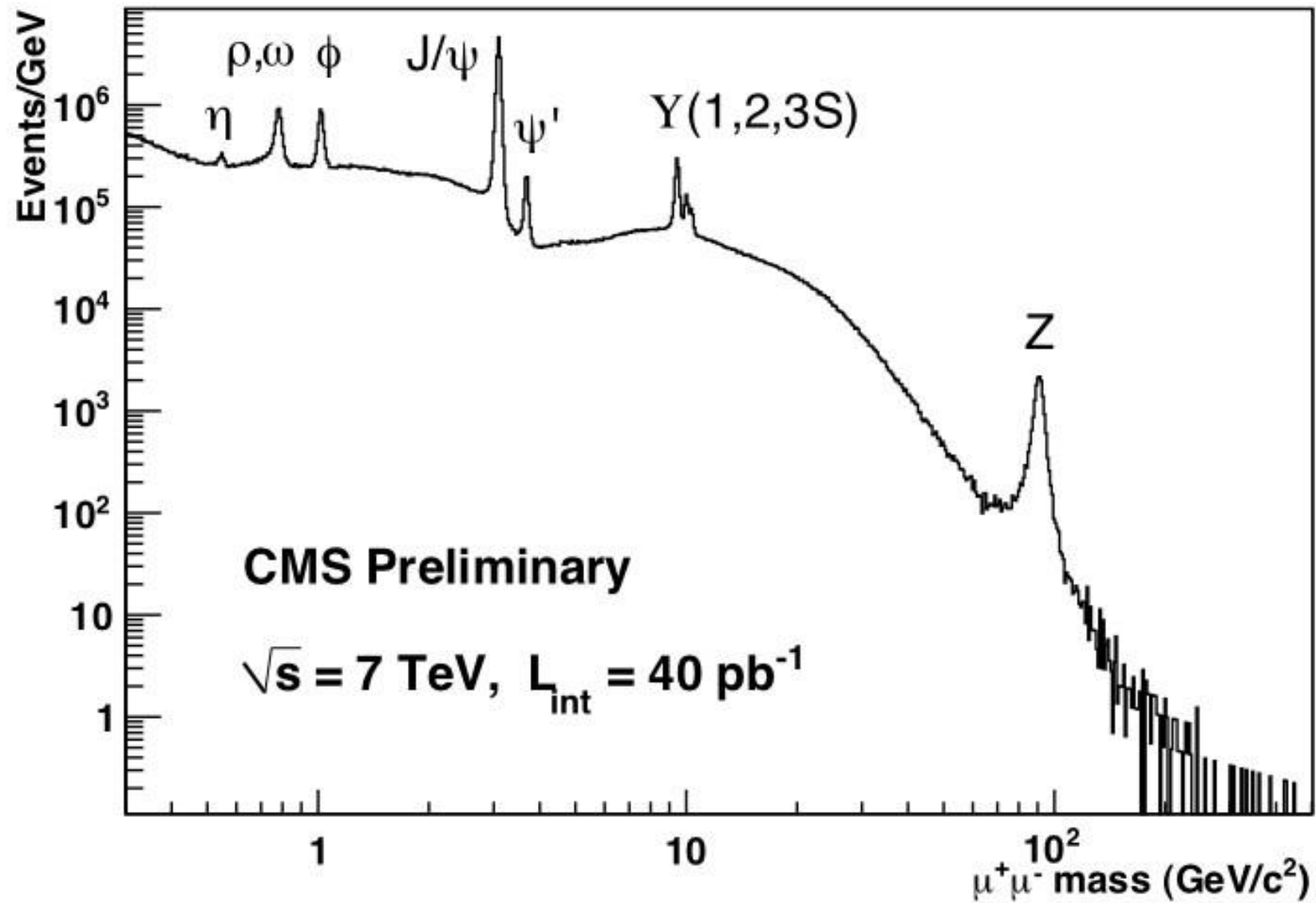


2 muoni segno opposto, oppure
2 elettroni segno opposto

$$M_{Z^0} = \sqrt{\left(\frac{E_{\mu^+}}{c^2} + \frac{E_{\mu^-}}{c^2}\right)^2 - \left(\frac{\vec{p}_{\mu^+}}{c} + \frac{\vec{p}_{\mu^-}}{c}\right)^2}$$



Massa della particella



Eventi da ricercare nei dati a vostra disposizione:

Coppie e^+e^-
Coppie $\mu^+\mu^-$ } Possibile decadimento della Z

Coppie fotone-fotone
Coppie $e^+e^- e^+e^-$
Coppie $\mu^+\mu^- \mu^+\mu^-$
Coppie $e^+e^- \mu^+\mu^-$ } Possibile decadimento di Higgs in ZZ

File Name

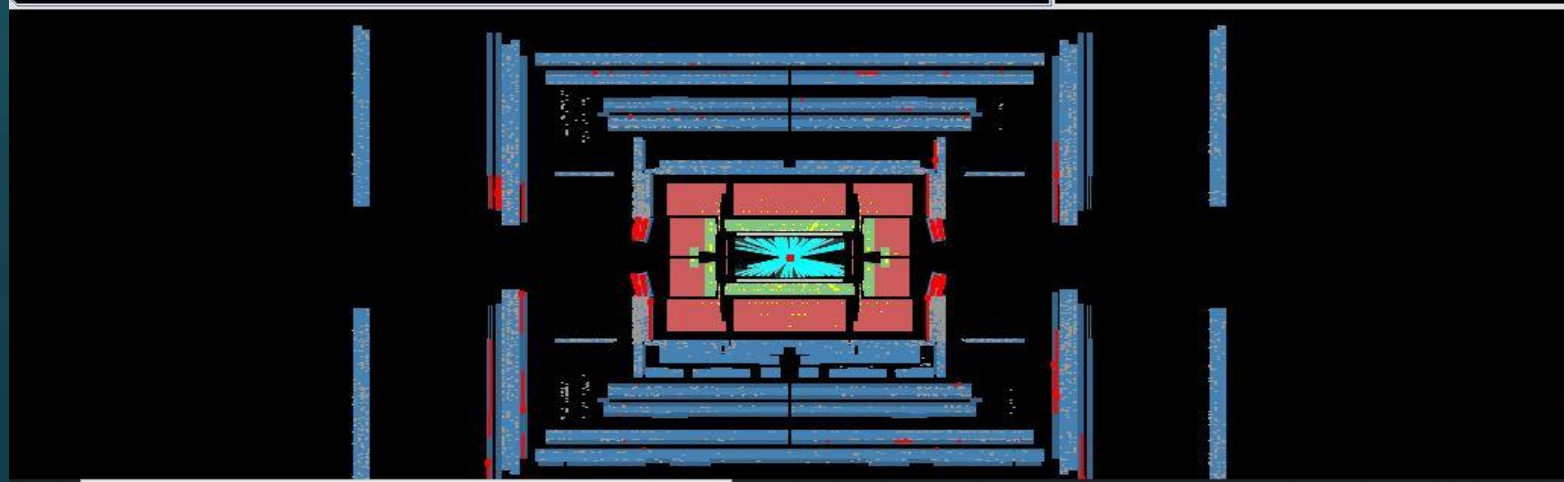
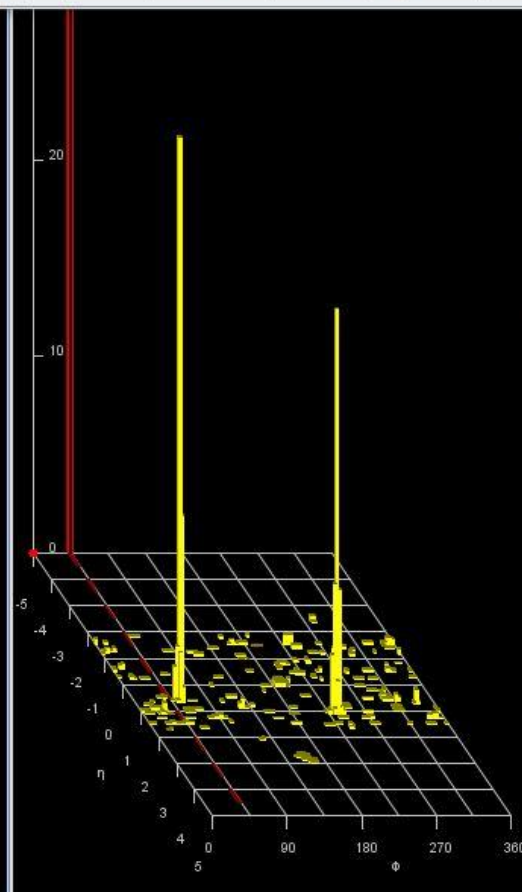
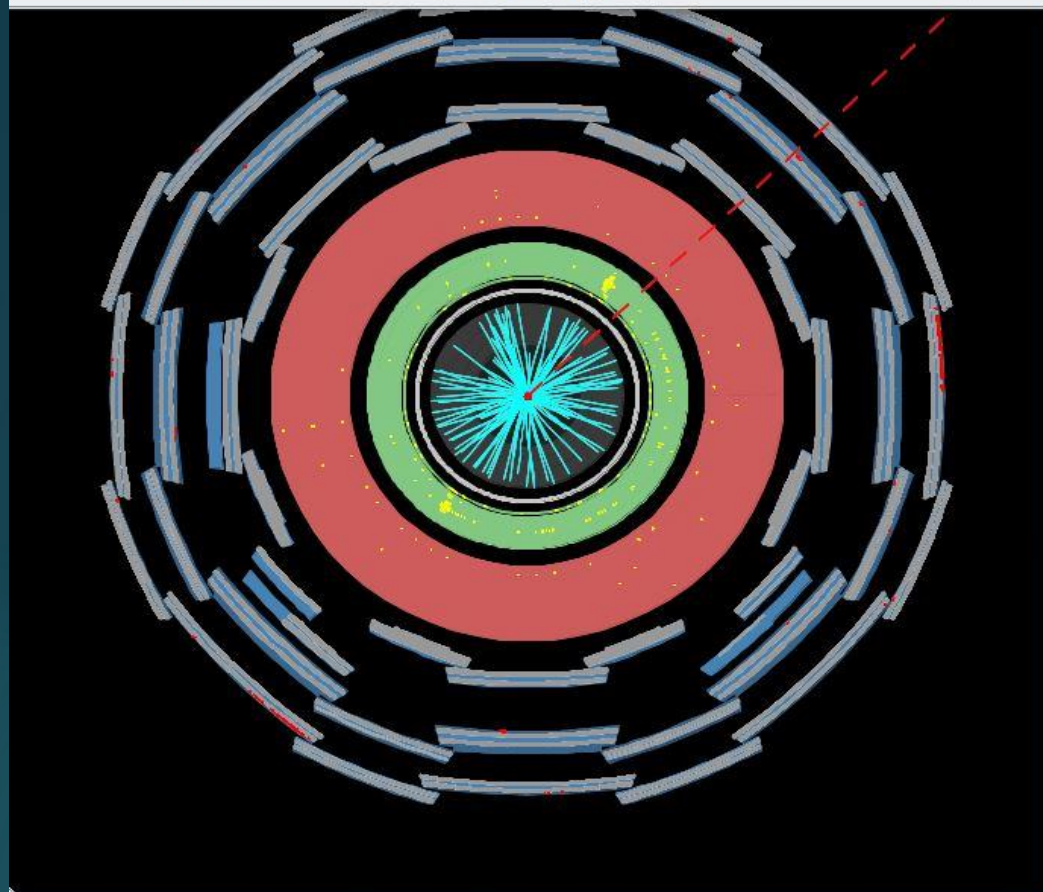
ETMis [GeV]

Track

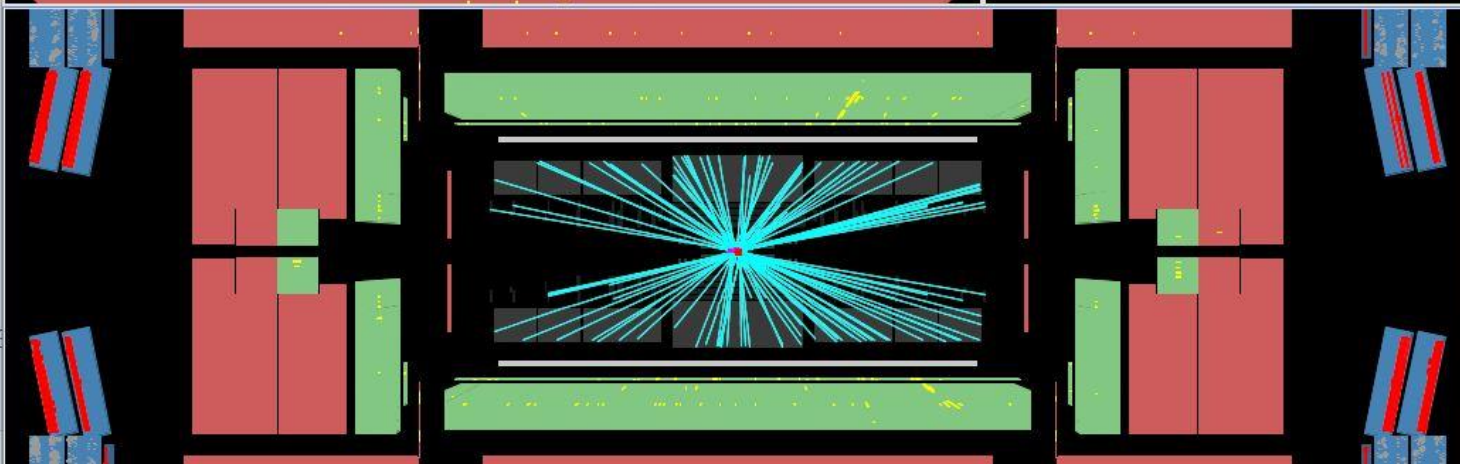
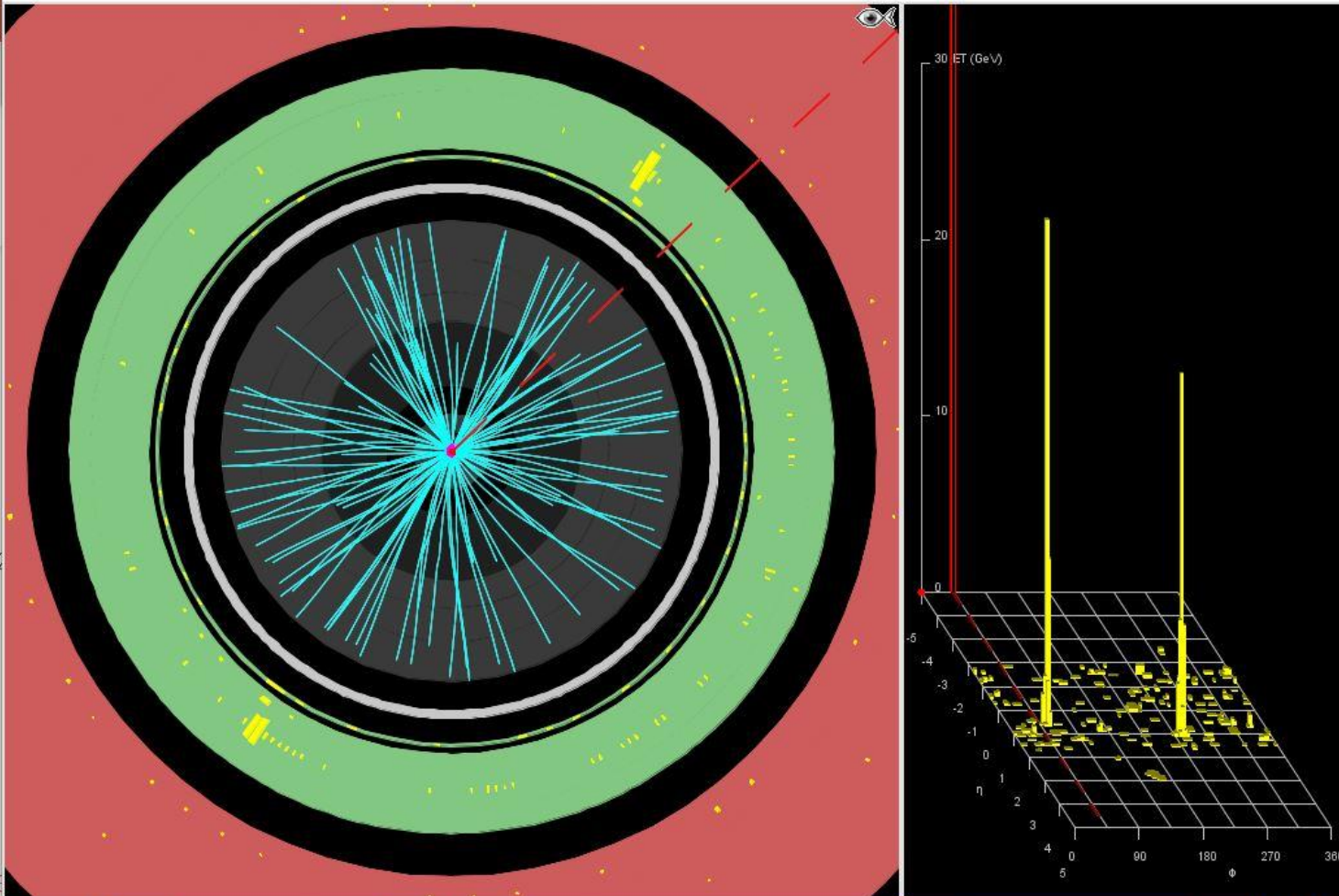
P [GeV]

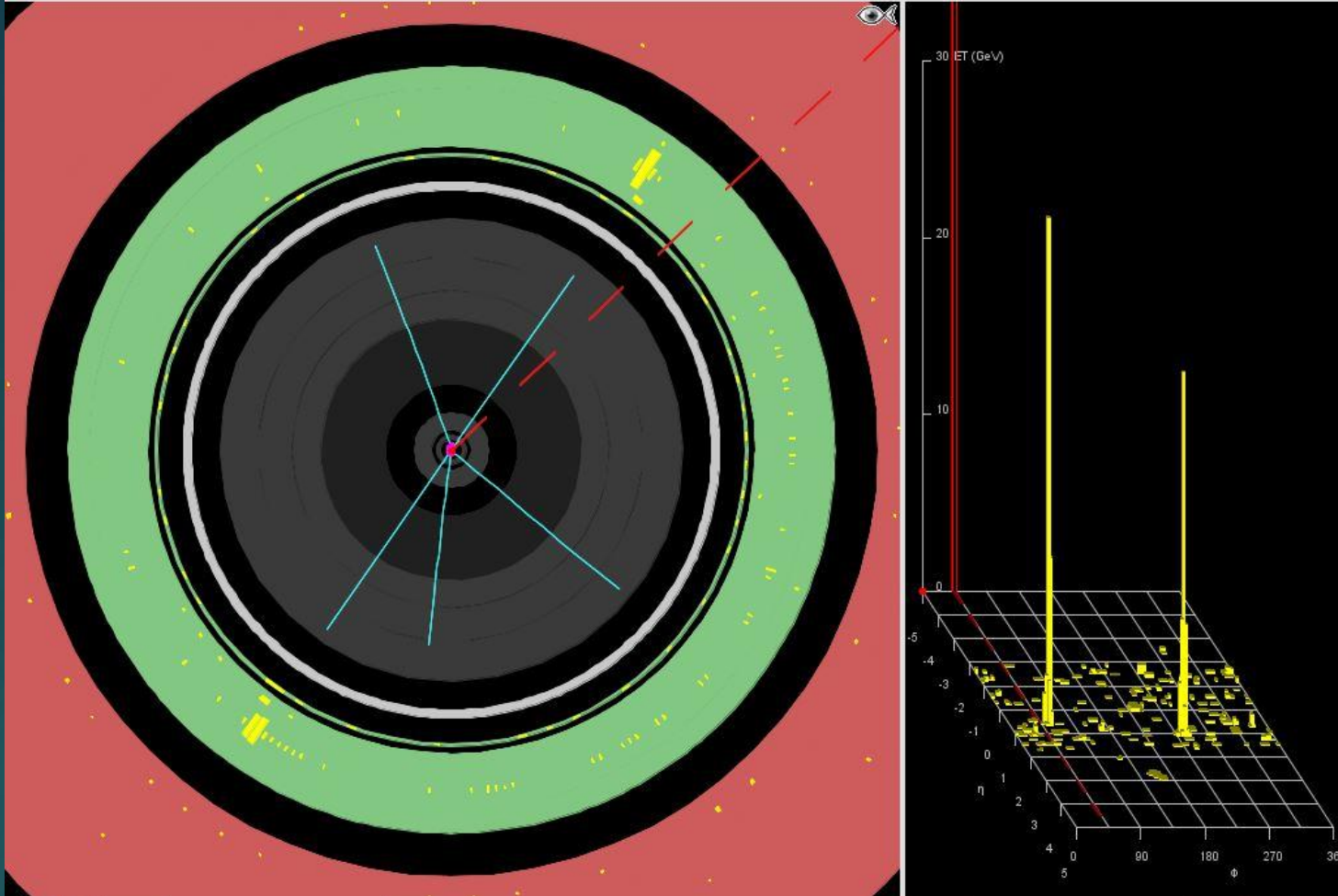
+/-

Pt [GeV]



p_T delle tracce > 1 GeV





p_T delle tracce > 10 GeV

