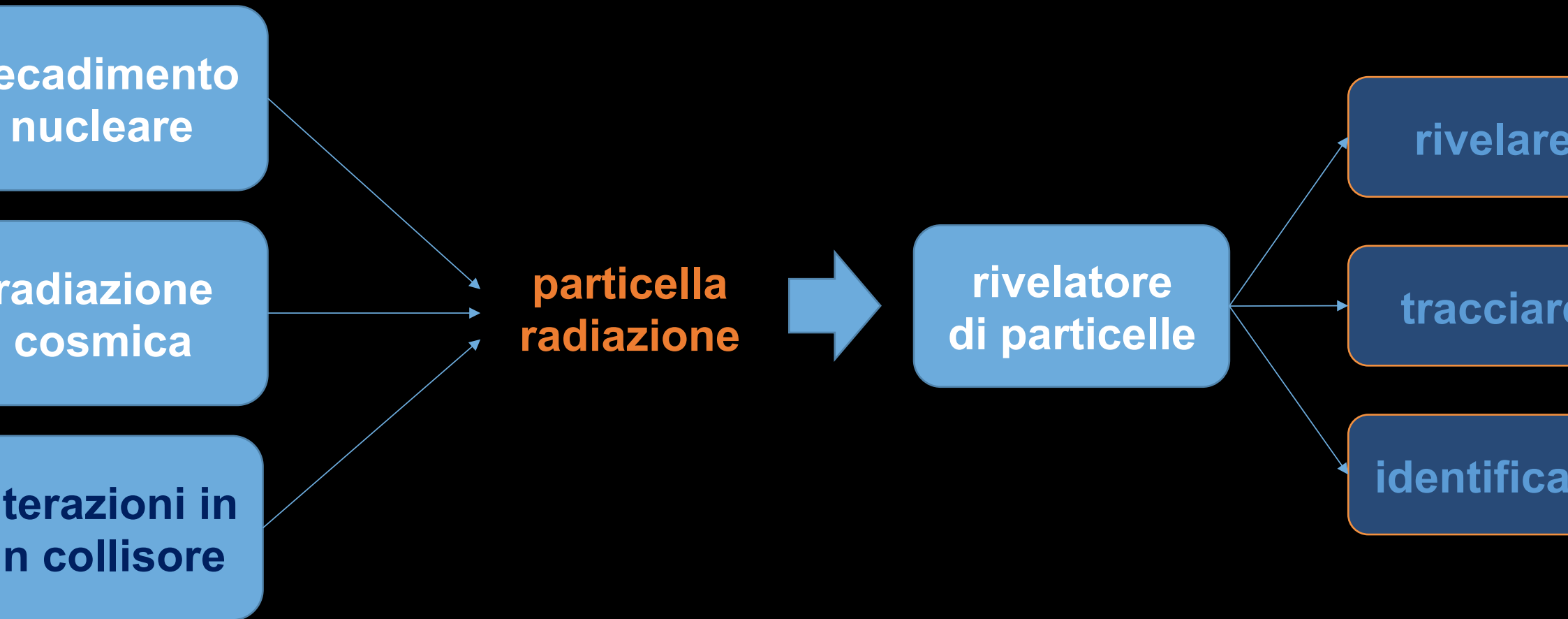


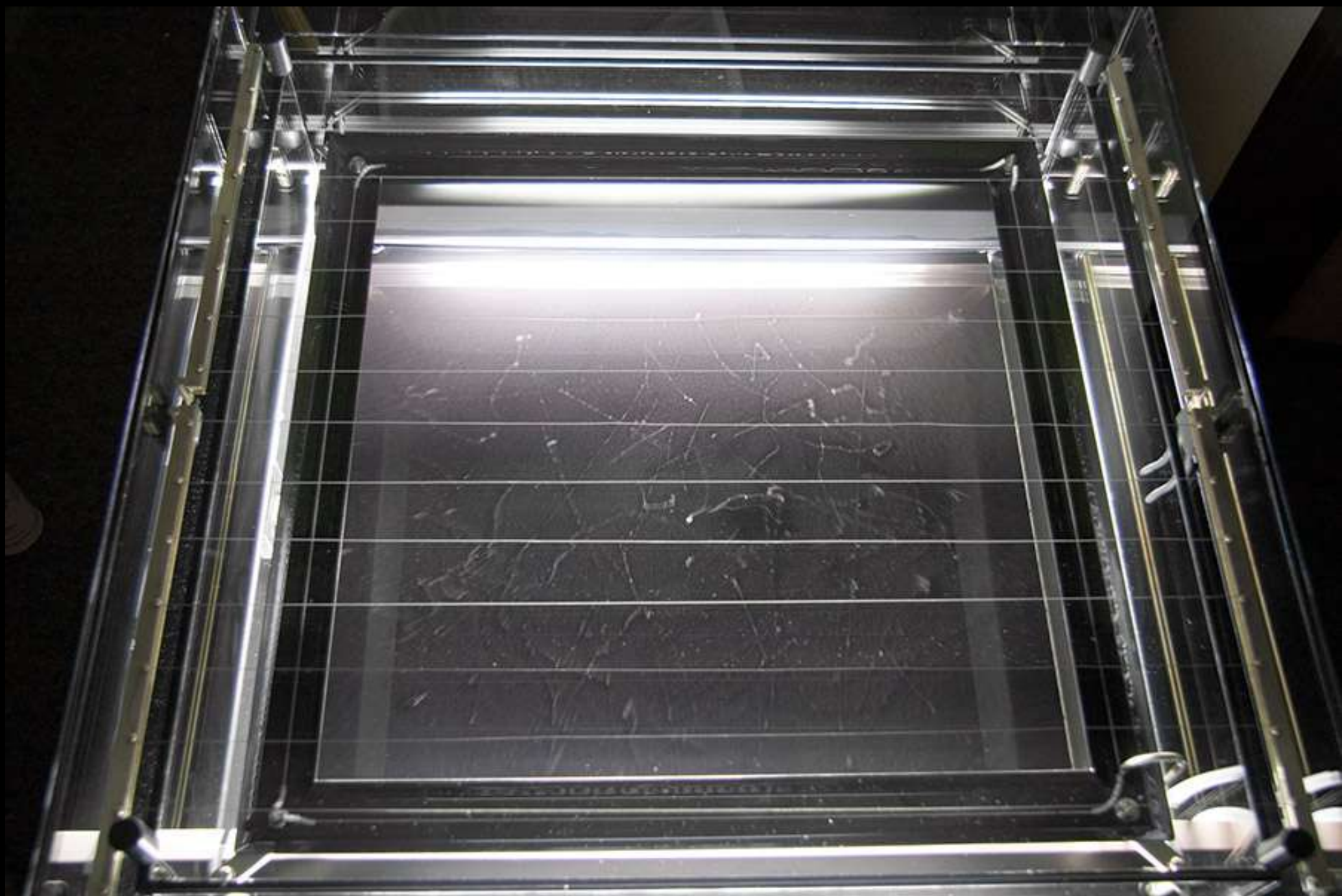
Rivelatori di Particelle

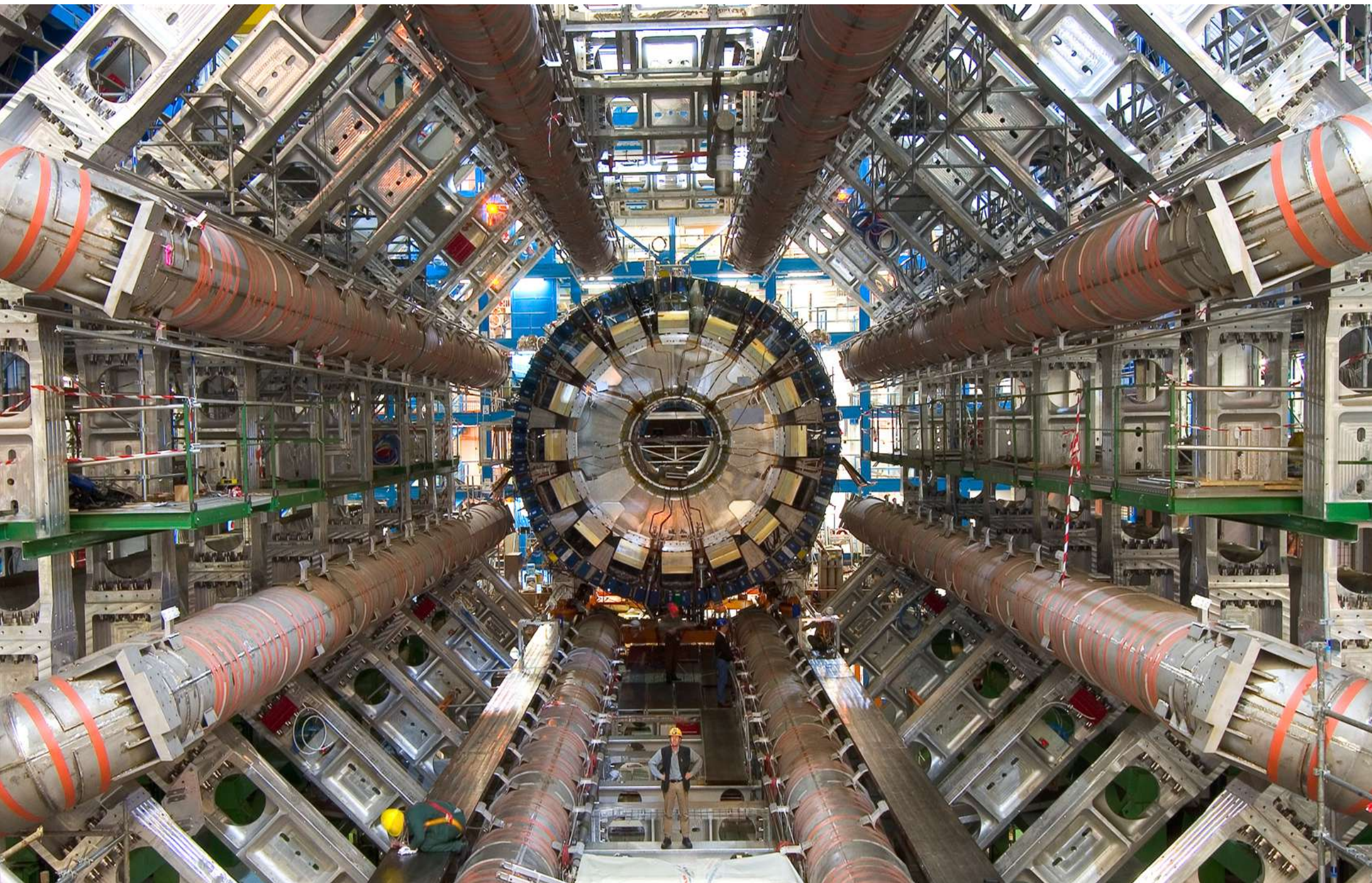
Danilo Domenici

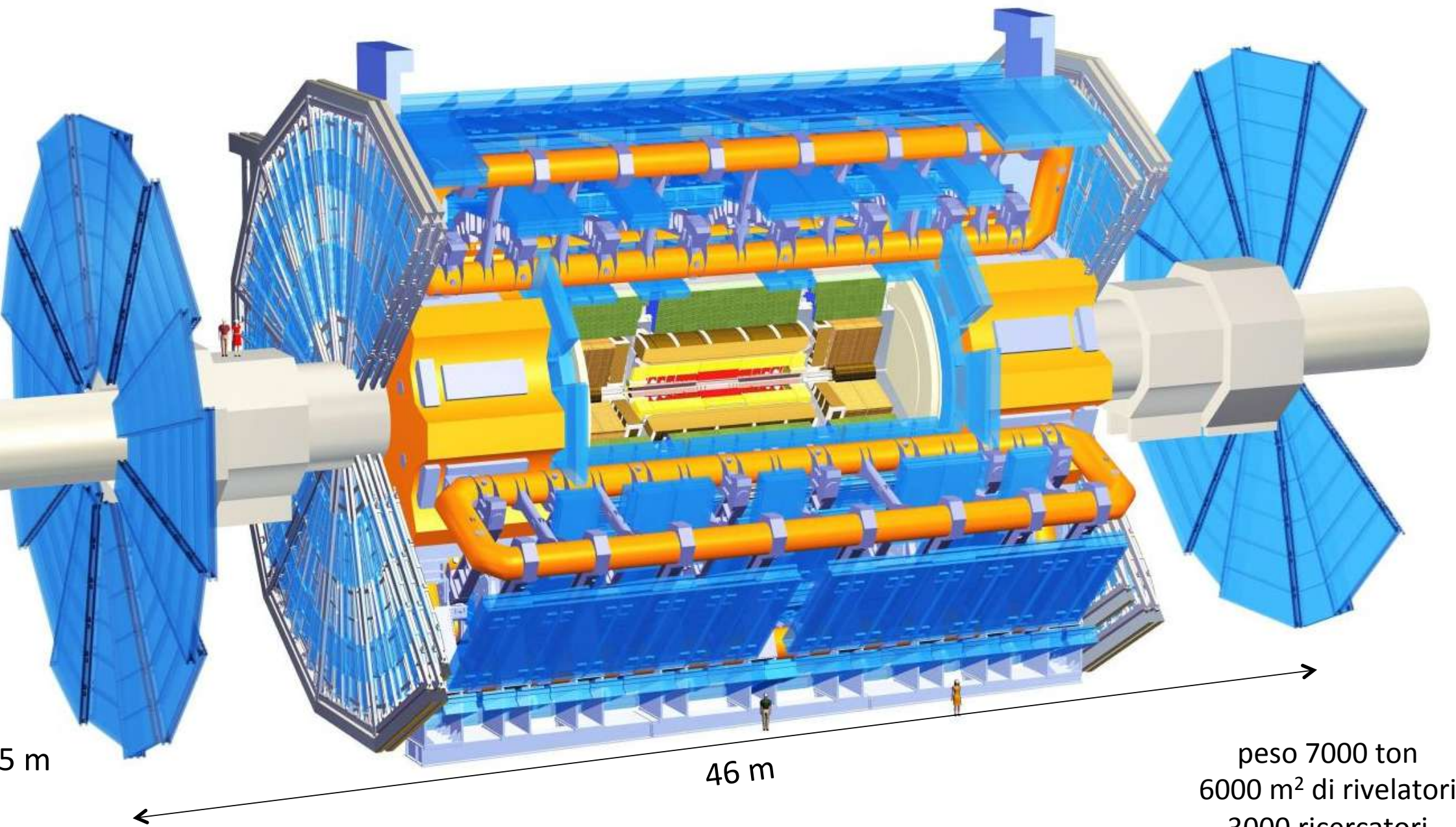
mappa concettuale









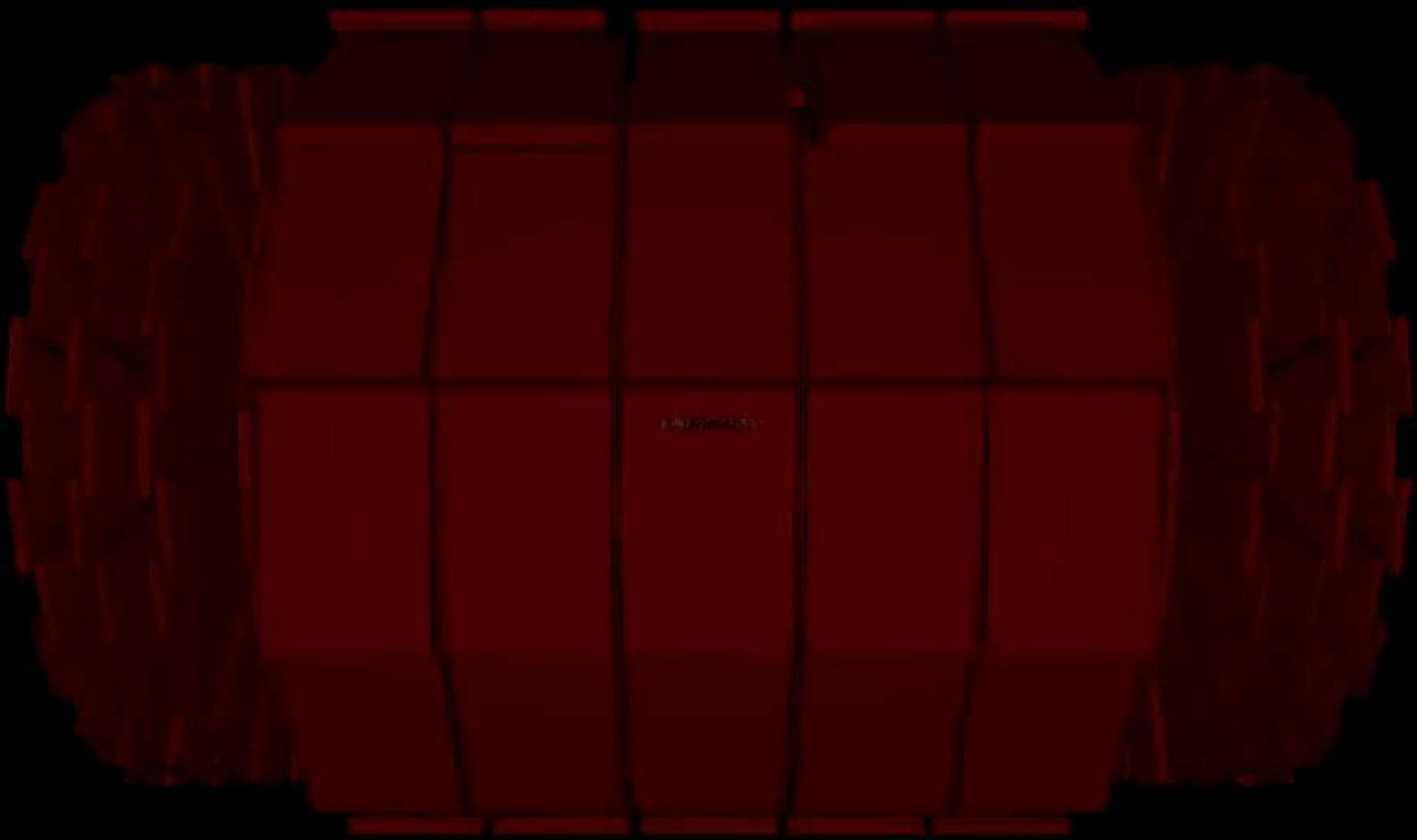


5 m

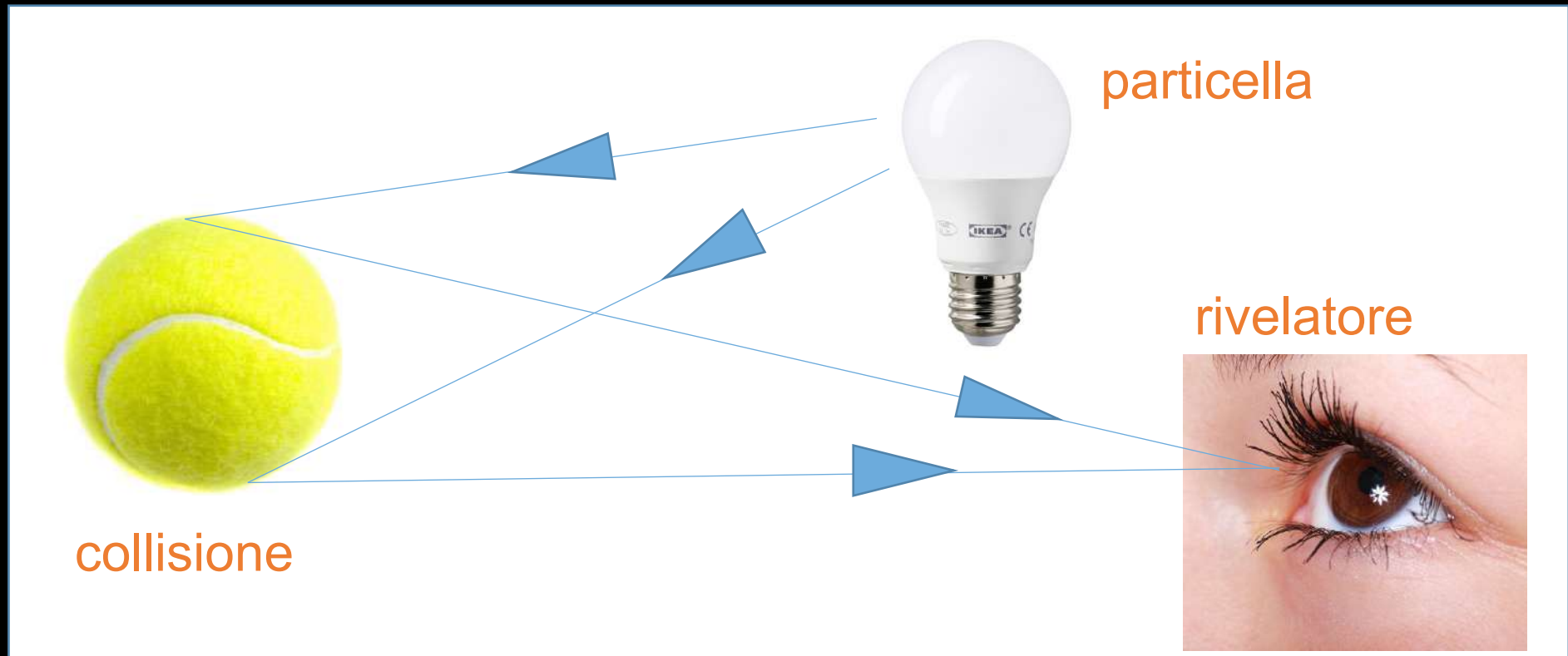
46 m

peso 7000 ton
6000 m² di rivelatori
3000 ricercatori
38 paesi del mondo

CMS Experiment at the LHC, CERN
Tue 2010-Mar-30 13:23:00 CET
Run 132440 Event 4285681
COM Energy 7.00TeV

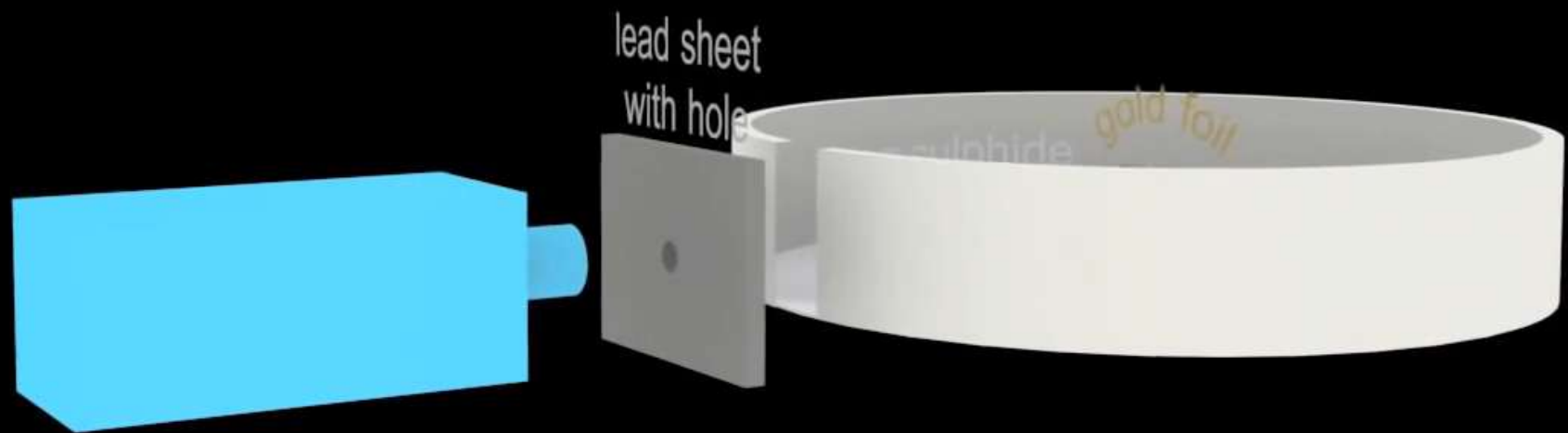


perché facciamo collidere le particelle?

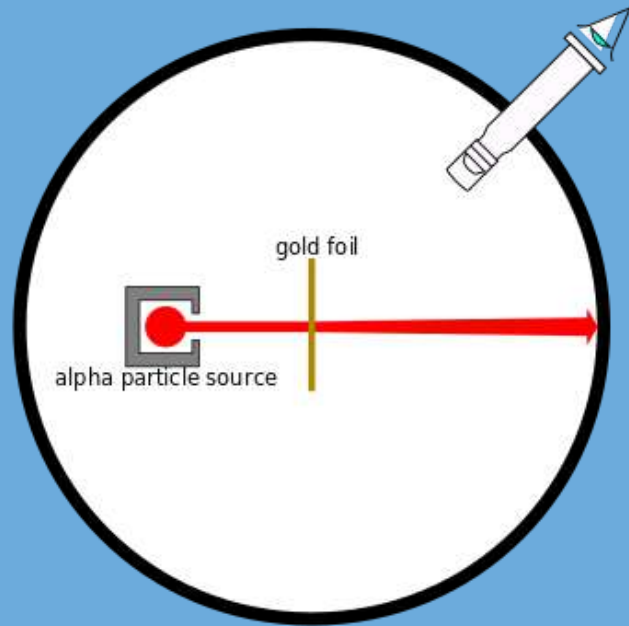
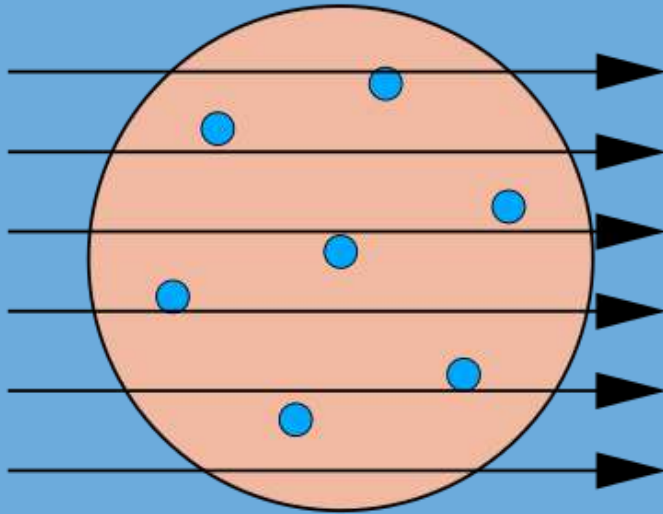


per capire come è fatta la materia

esperimento di rutherford



THOMSON MODEL



perché le facciamo collidere
a energia sempre più alta?

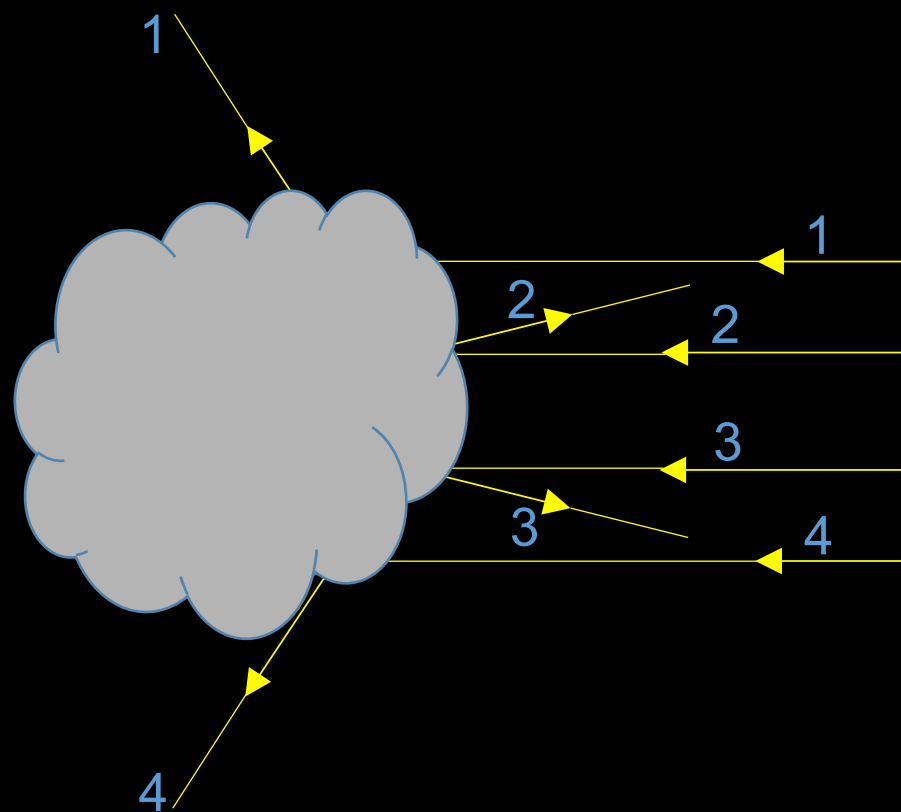
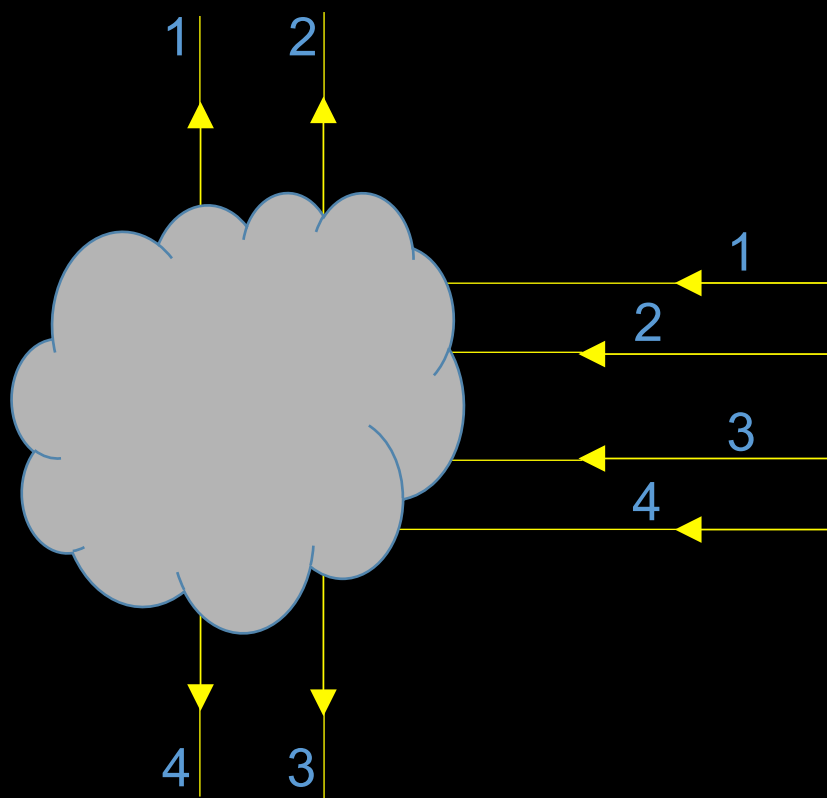


diminuisce la lunghezza
che posso studiare



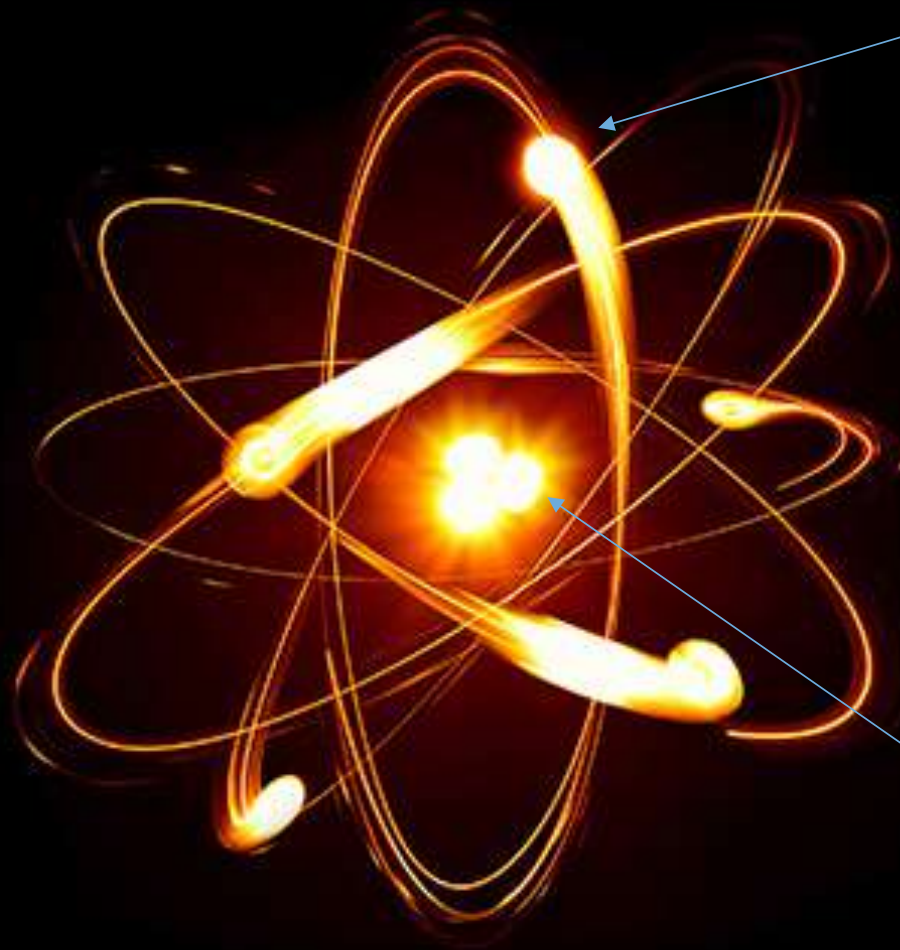
aumenta la nuova materia
che posso creare

come vediamo l'invisibile



interazione radiazione-materia

tipi diversi
di particelle
possono interagire
con gli elettroni
o con il nucleo



elettroni
carica elettrica negativa

nucleo
carica elettrica positiva
carica forte

interazione radiazione-materia

particelle direttamente rivelabili

e

elettrone

p

protone

n

neutrone

γ

fotone

particelle stabili

μ

muone

π

pione

K

kaone

particelle con vita media $> 10^{-10}$ s

tutte le particelle con vita media $< 10^{-10}$ s
si identificano attraverso i loro prodotti di decadimento



interazione radiazione-materia

urti con gli elettroni – forza elettromagnetica



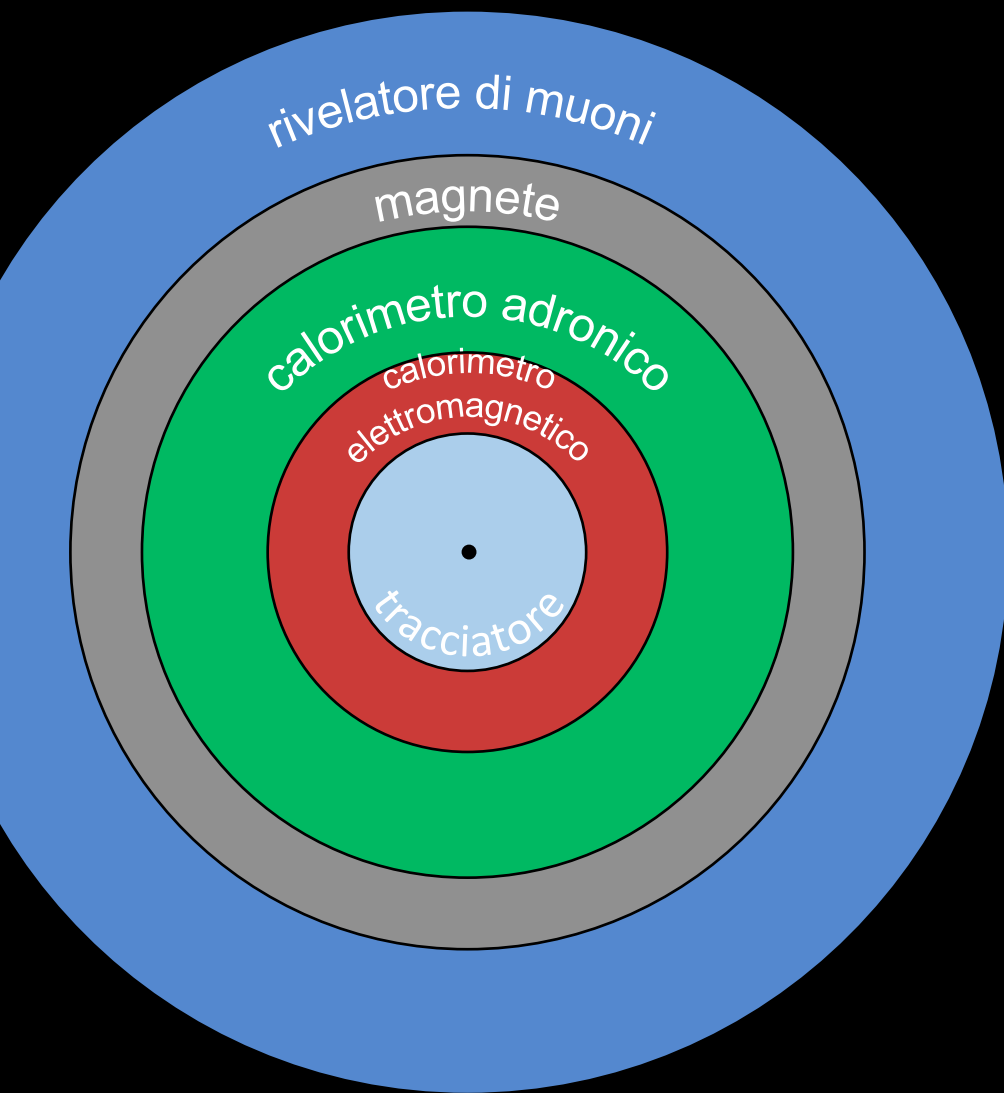
urti con il nucleo – forza forte



produzione di coppie e^+e^-



apparato di rivelazione ermetico



Rivelatore di Vertice o Tracciatore Interno
rivela le particelle cariche
e ne misura la quantità di moto

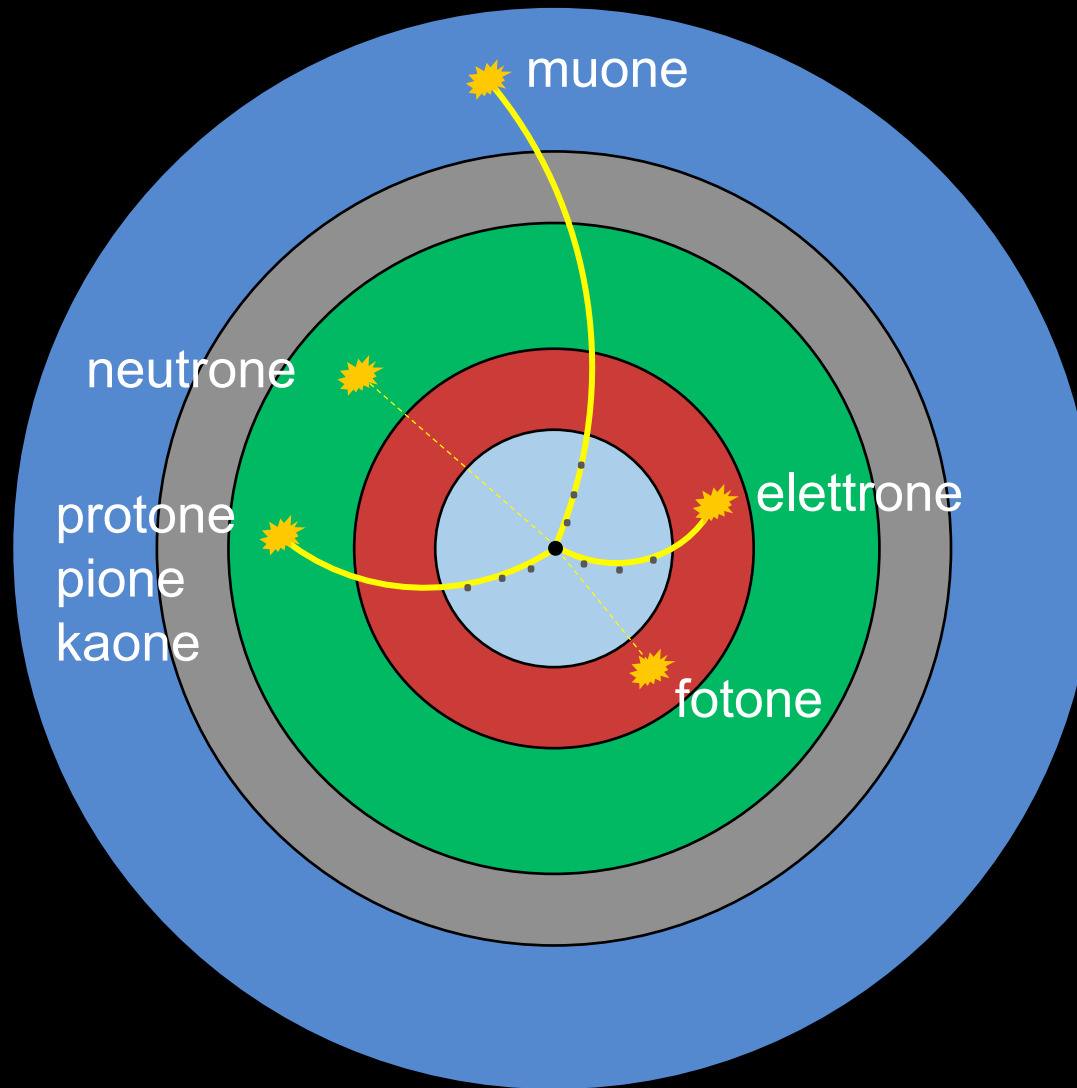
Calorimetro Elettromagnetico
rivela elettroni e fotoni
e ne misura l'energia

Calorimetro Adronico
rivela protoni, neutroni, pioni, kaoni
e ne misura l'energia

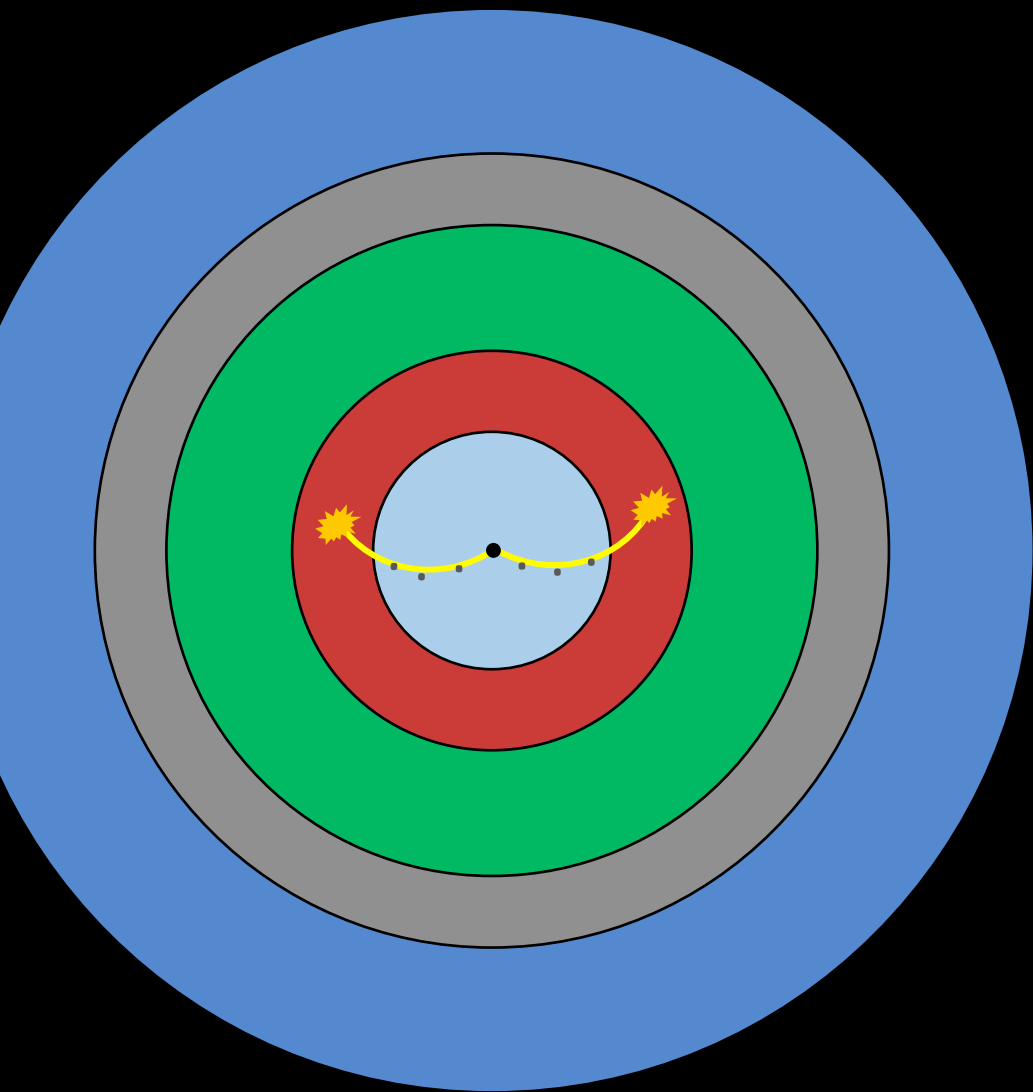
Magnete
curva le particelle cariche
e ne permette la misura della quantità di moto

Rivelatore di Muoni
rivela i muoni

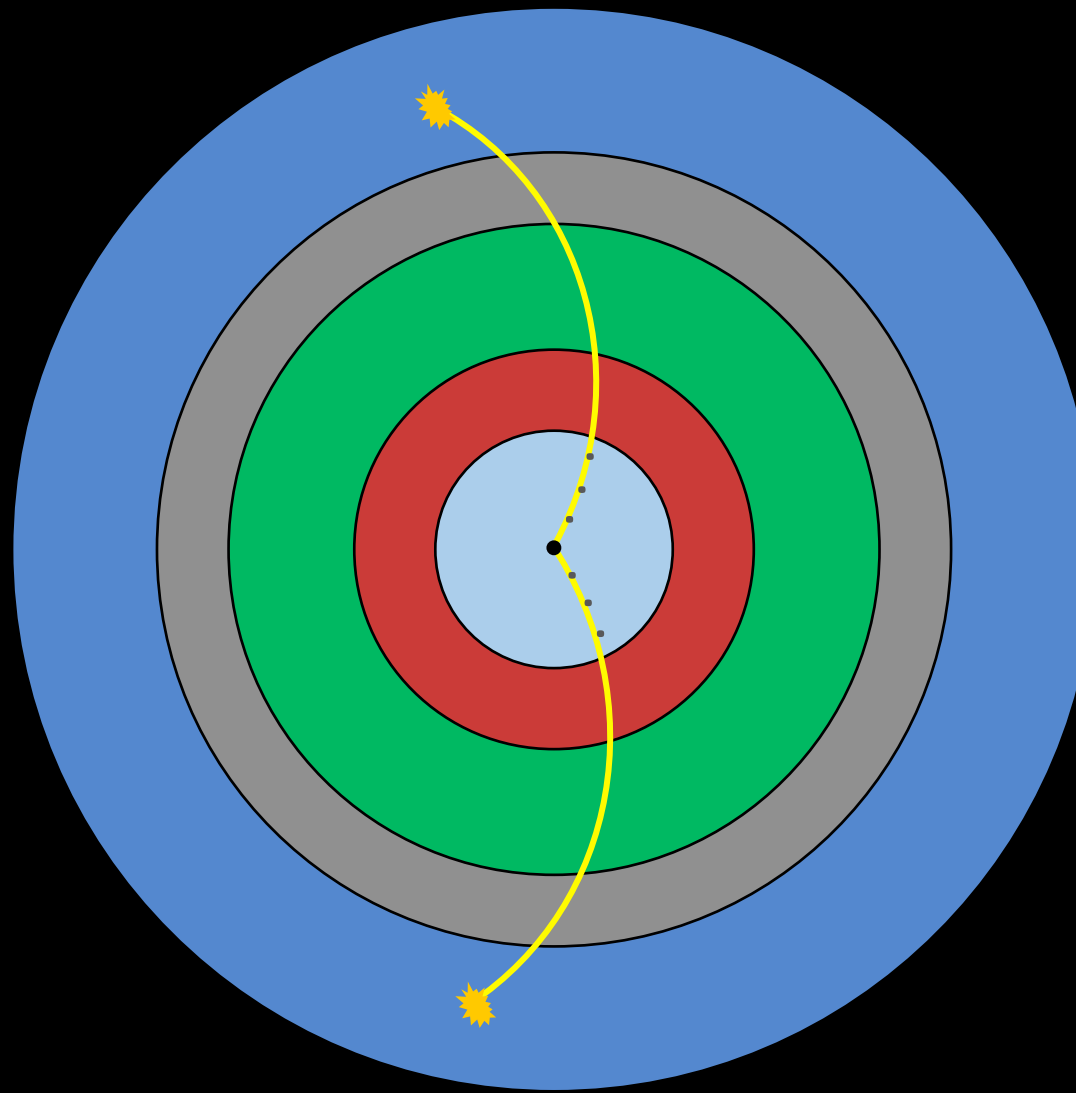
identificazione delle particelle



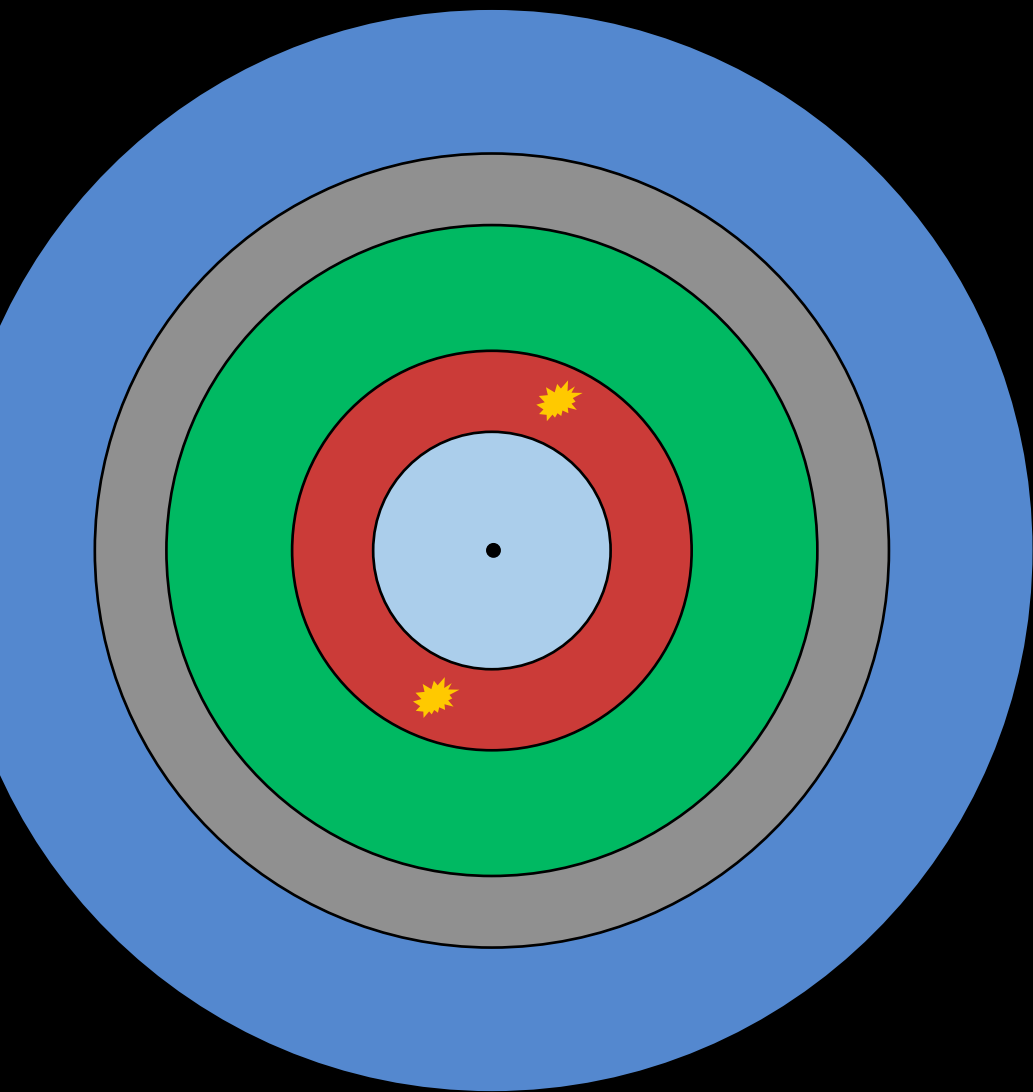
$$e^+ e^- \rightarrow e^+ e^-$$



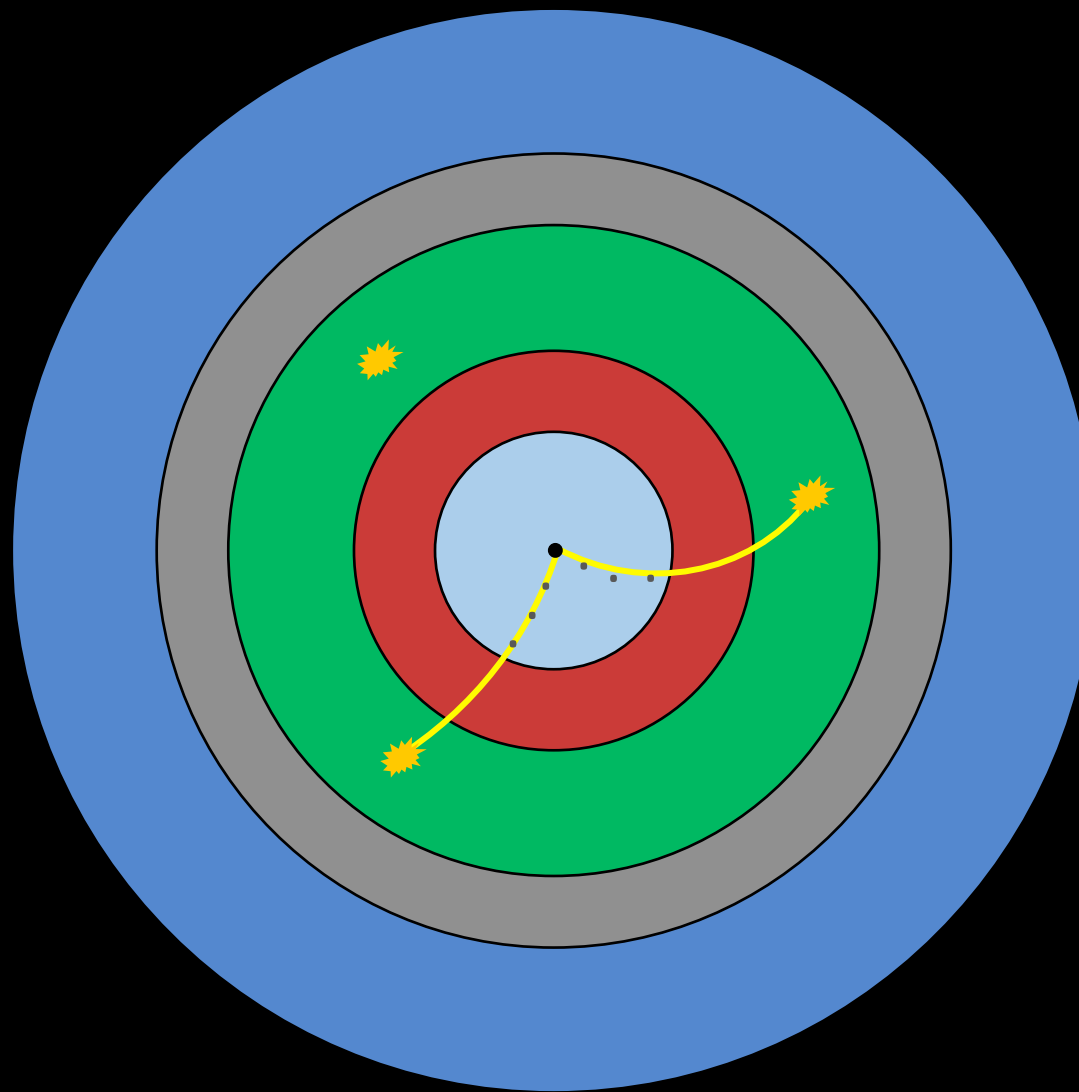
$$e^+ e^- \rightarrow \mu^+ \mu^-$$



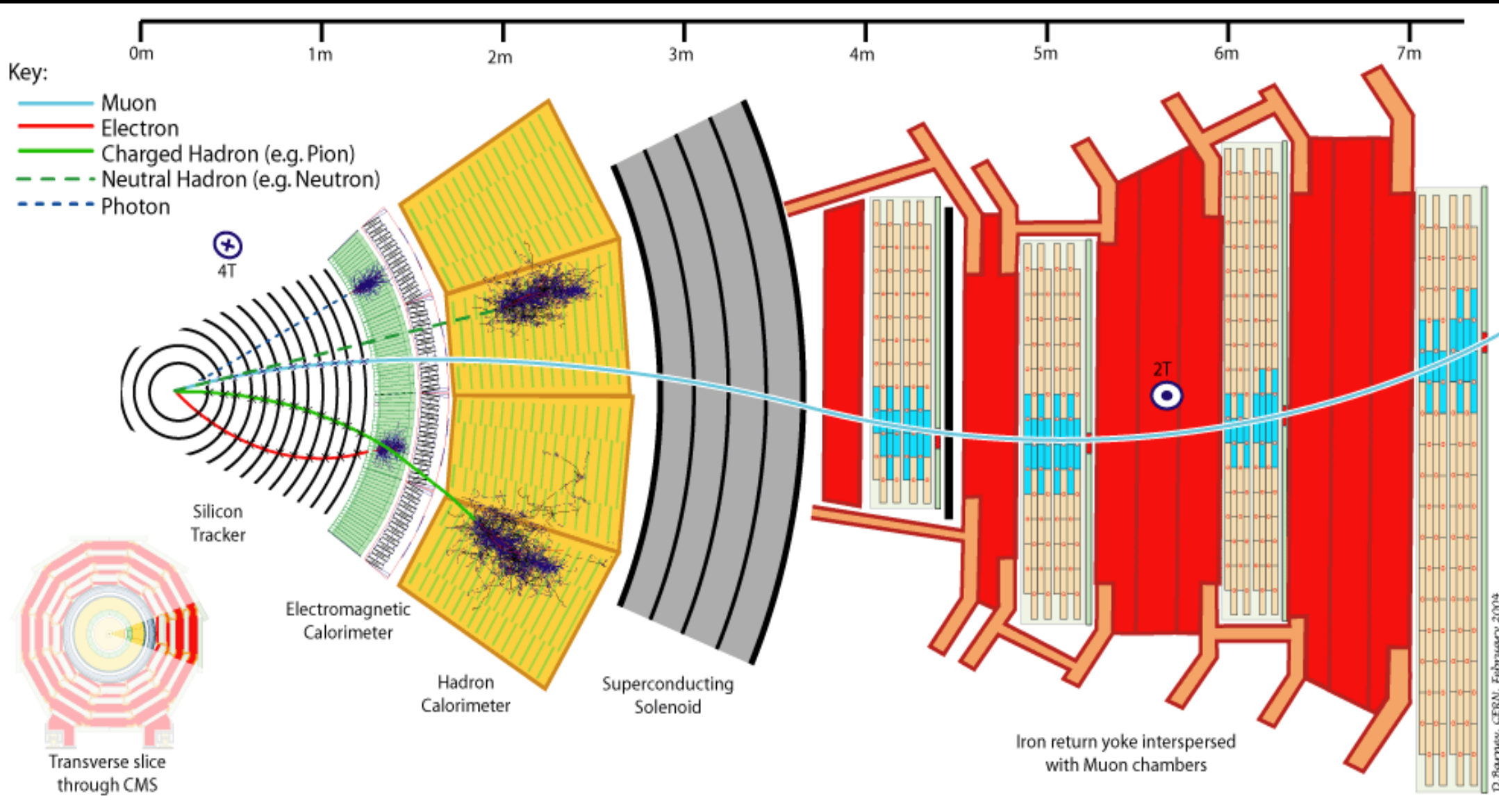
$$e^+ e^- \rightarrow \gamma \gamma$$



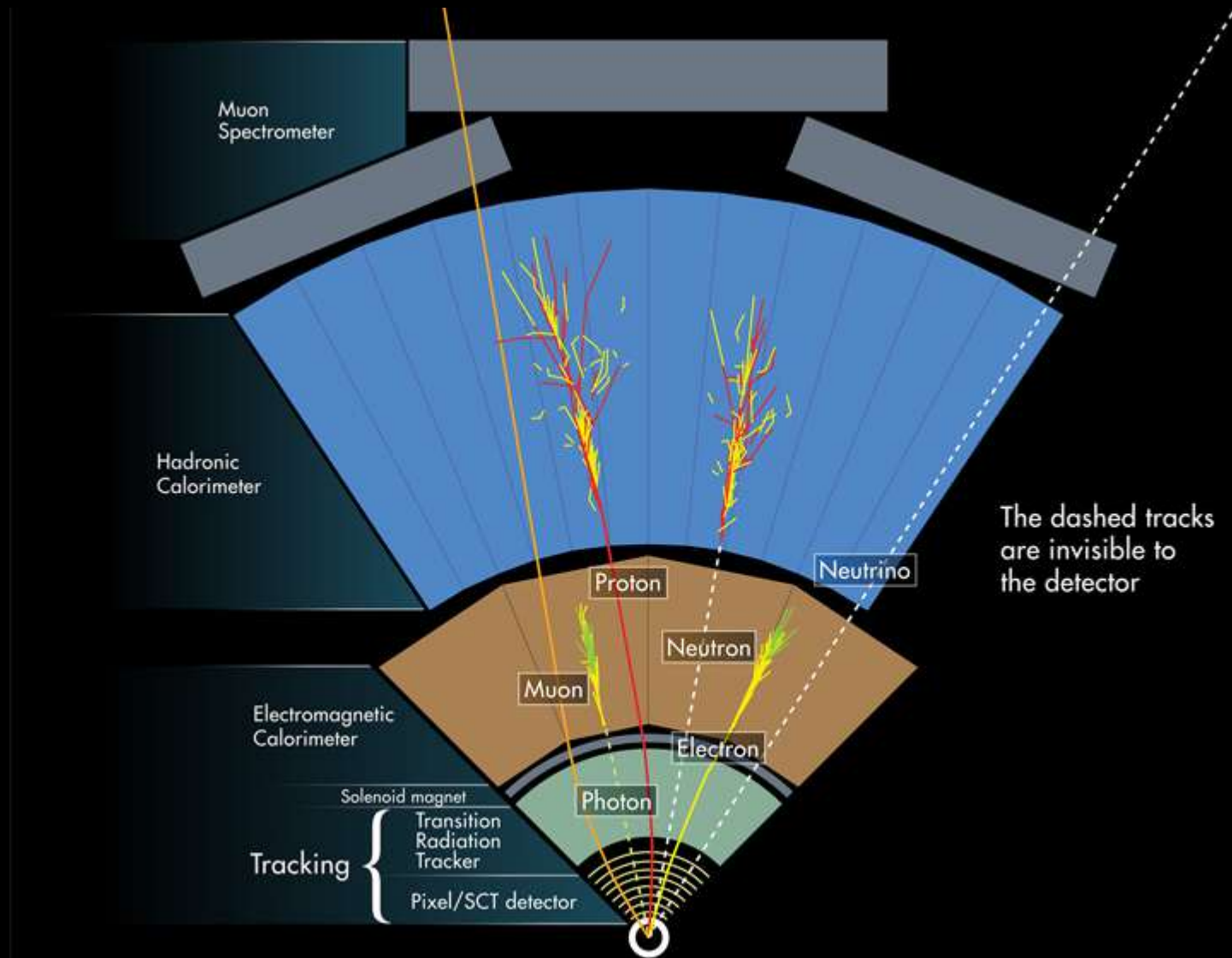
$$e^+ e^- \rightarrow \pi^+ \bar{p} n$$



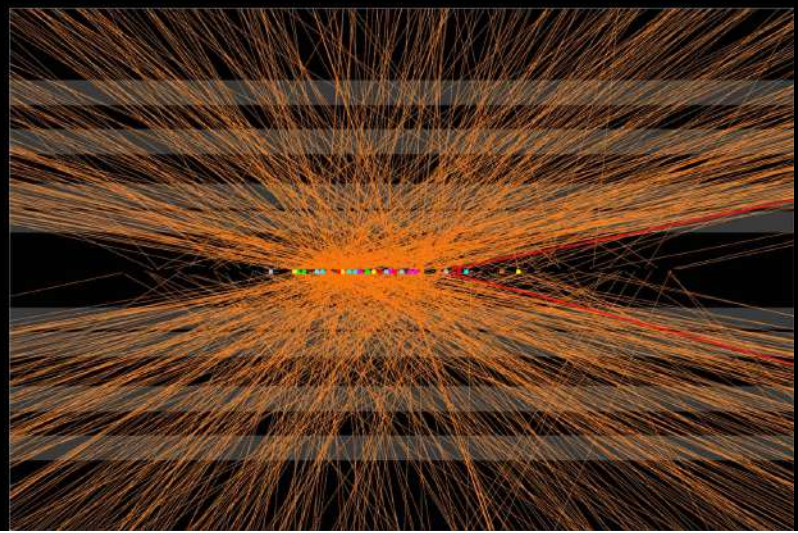
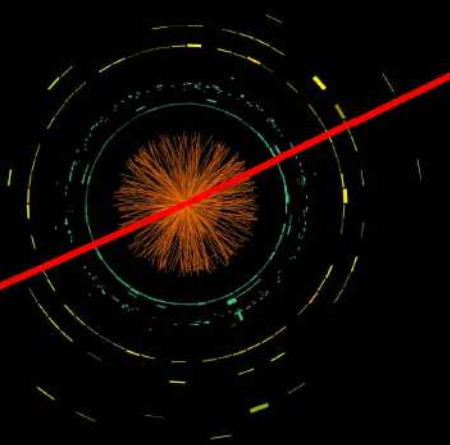
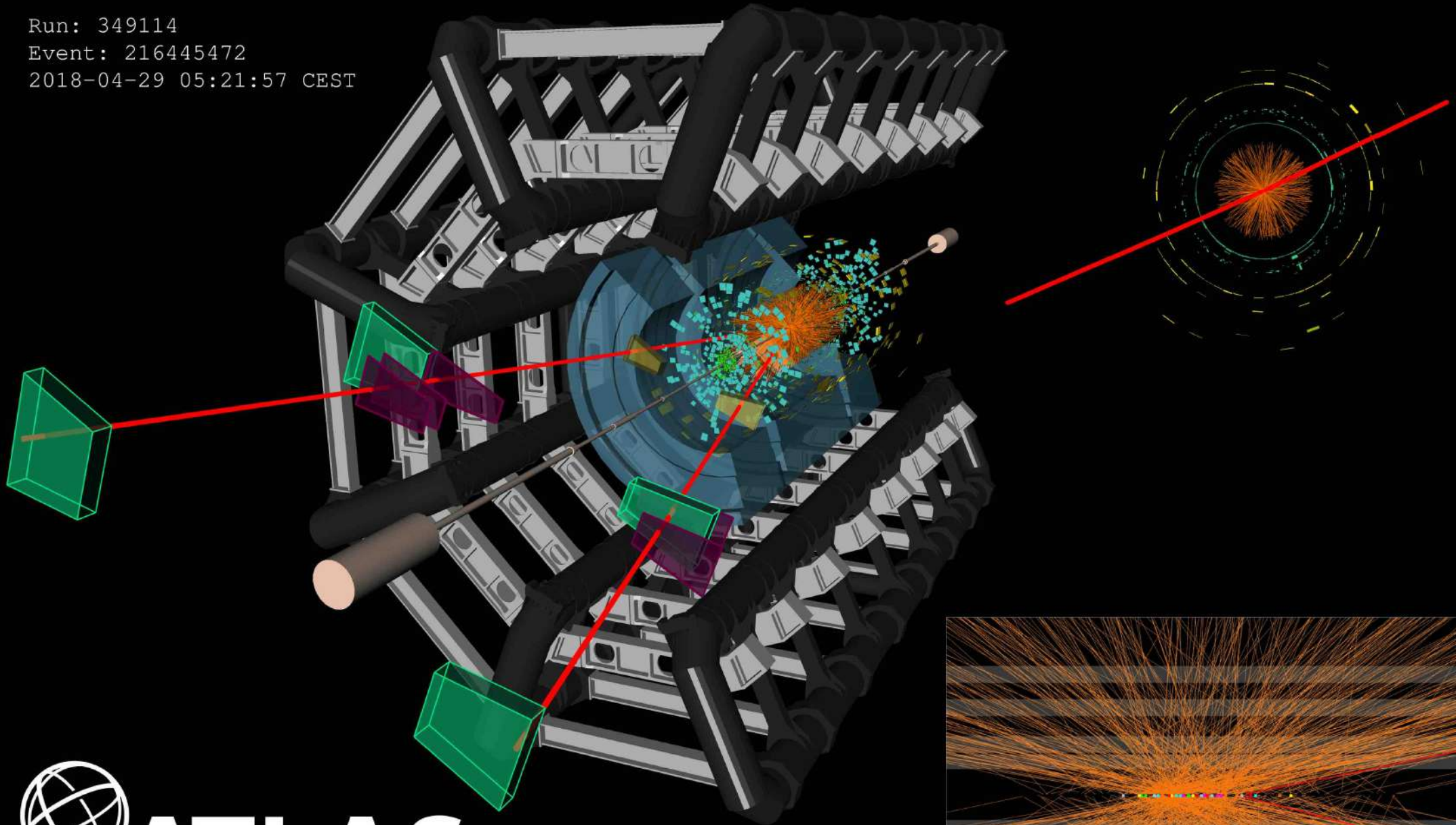
il rivelatore cms a lhc



il rivelatore atlas a lhc

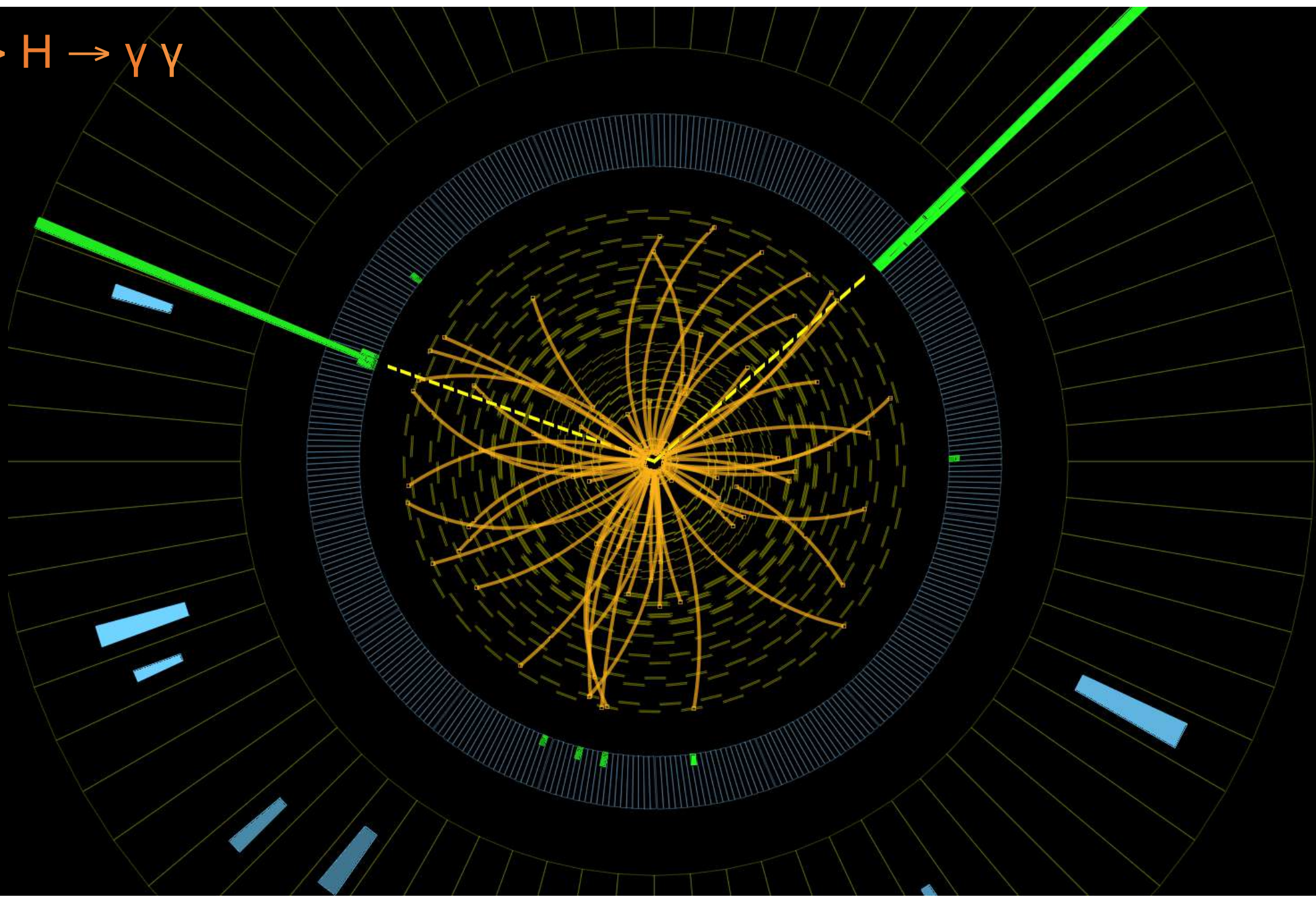


Run: 349114
Event: 216445472
2018-04-29 05:21:57 CEST



 **ATLAS**
EXPERIMENT

→ H → γ γ



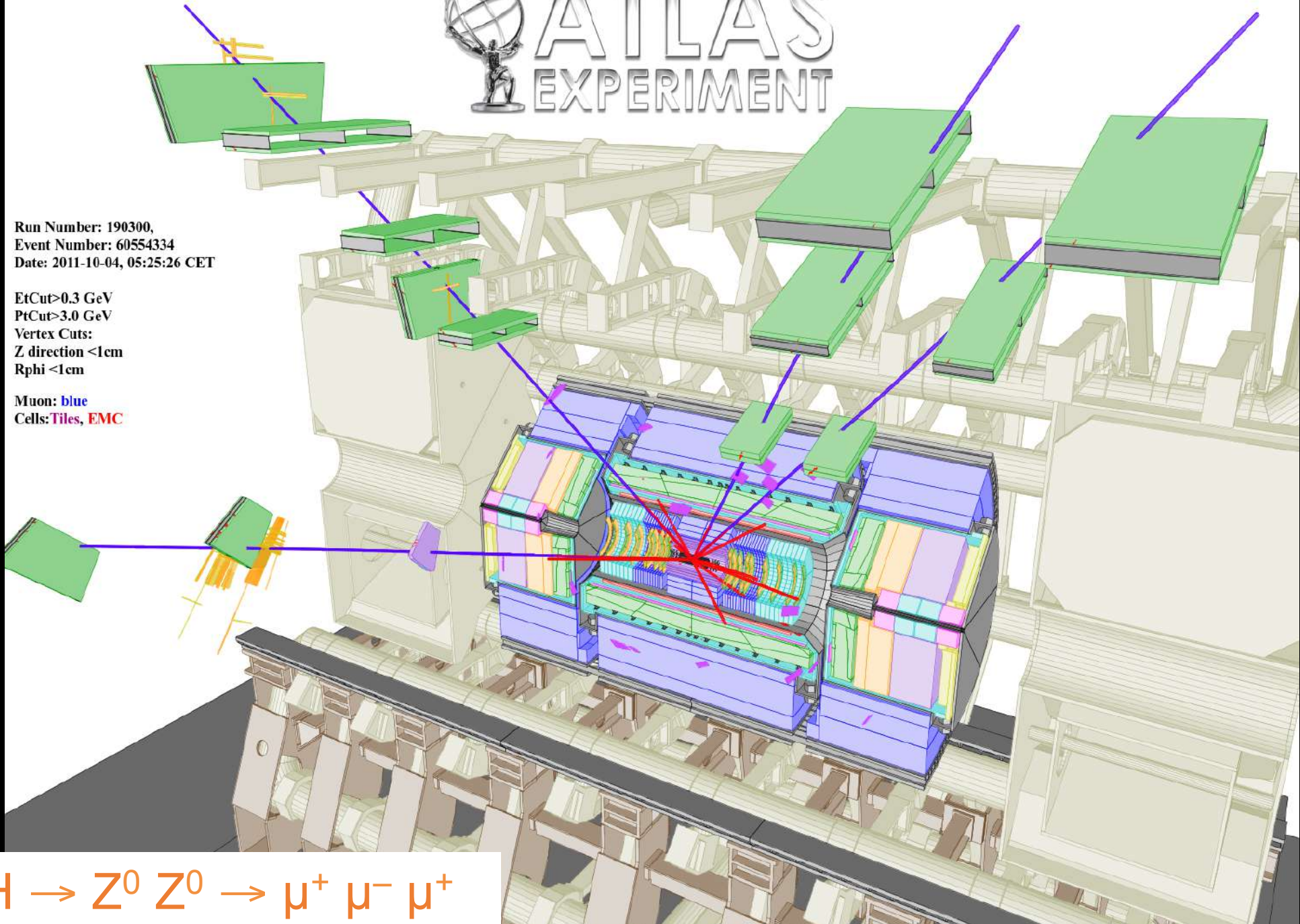


ATLAS EXPERIMENT

Run Number: 190300,
Event Number: 60554334
Date: 2011-10-04, 05:25:26 CET

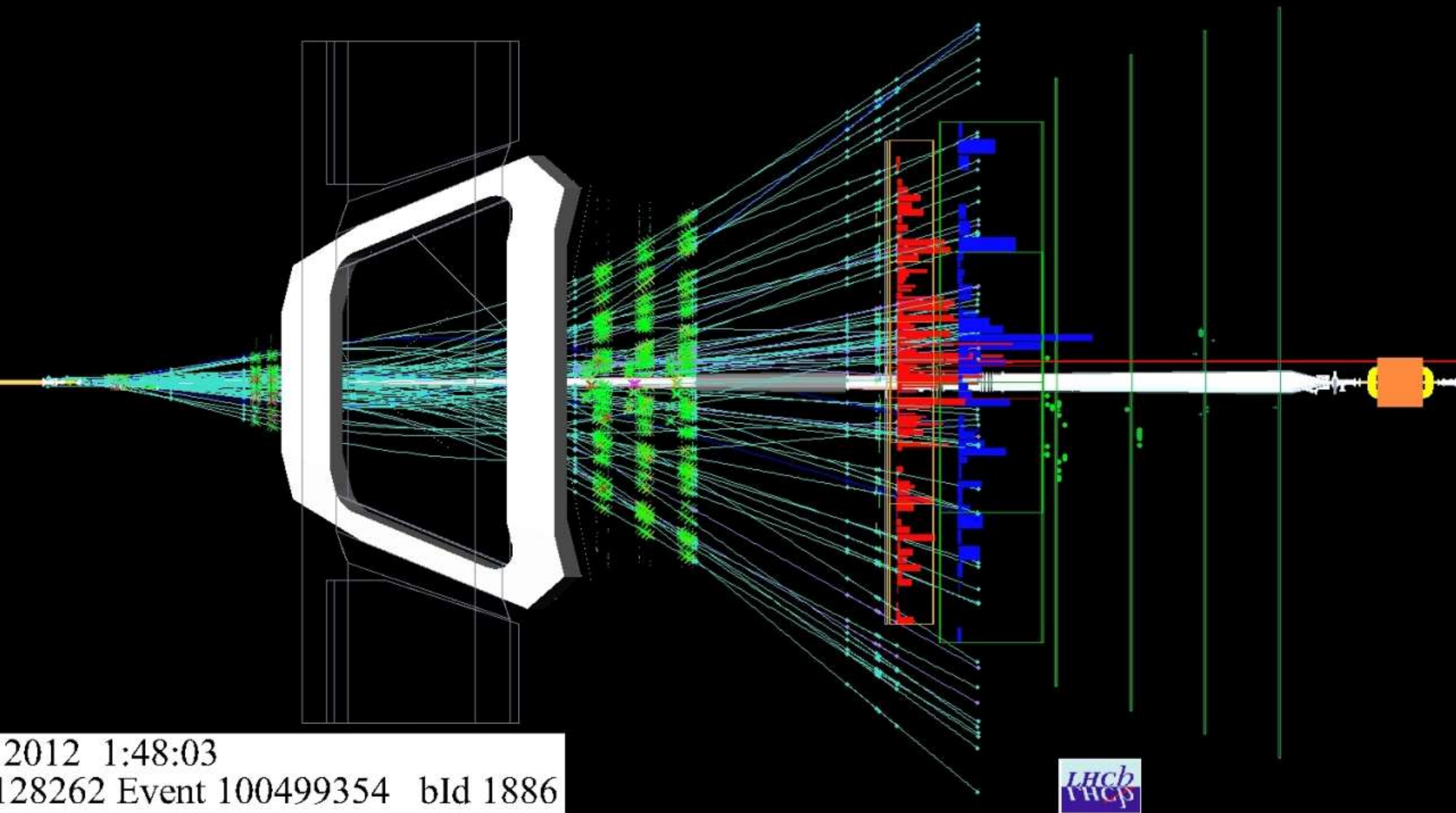
EtCut>0.3 GeV
PtCut>3.0 GeV
Vertex Cuts:
Z direction <1cm
Rphi <1cm

Muon: blue
Cells: Tiles, EMC



→ $H \rightarrow Z^0 Z^0 \rightarrow \mu^+ \mu^- \mu^+$

LHCb Event Display

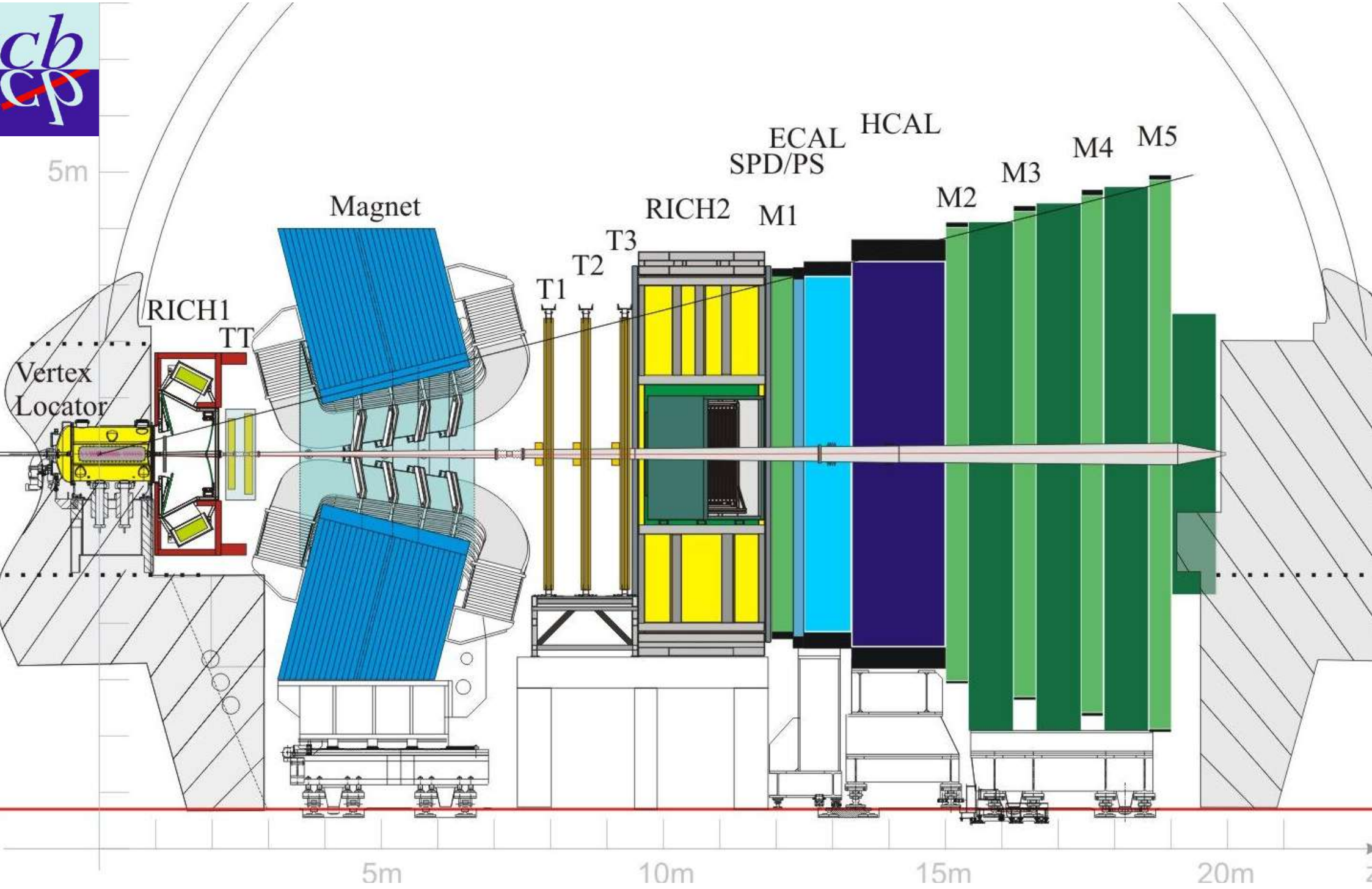


2012 1:48:03
128262 Event 100499354 bld 1886





5m



5m

10m

15m

20m

LHC computing



LHC big data



40 M/s x 100 MB
4 PB/s

Trigger
Livello1

100 k/s x 1 MB
100 GB/s

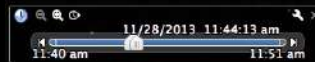
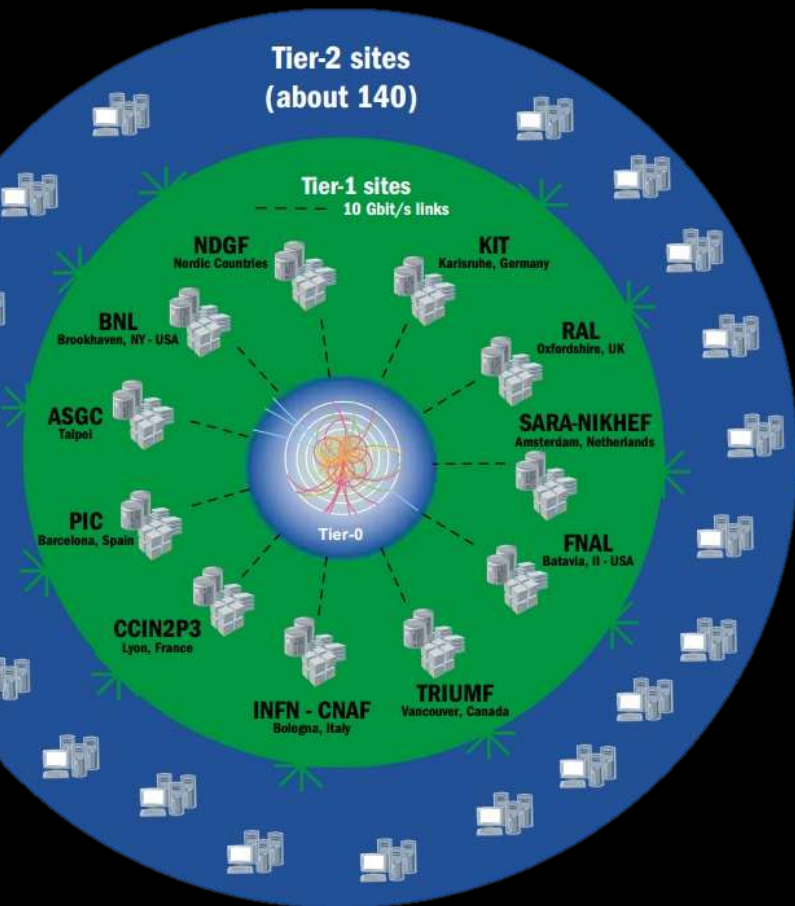
Trigger
Livello2

300/s x 1 MB
100 PB/y

Lhc computing grid



170 centri di calcolo
in 42 paesi del mondo
collegati a 10Gb/s



Running jobs: 214268
Transfer rate: 42.74 GB/s

US Dept of State Geographer
© 2013 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google

caratteristiche dei rivelatori

Sensibilità

capacità di produrre un segnale per un certo tipo di radiazione e di energia

Risoluzione

capacità di distinguere tra due misure vicine di una grandezza fisica misurata (es. posizione o tempo)

Efficienza

frazione di particelle rivelate rispetto a quelle incidenti

Tempo morto

tempo necessario per essere di nuovo attivo dopo la rivelazione di una particella

tipi di rivelatori

tipo di funzione

Tracciatori

Calorimetri

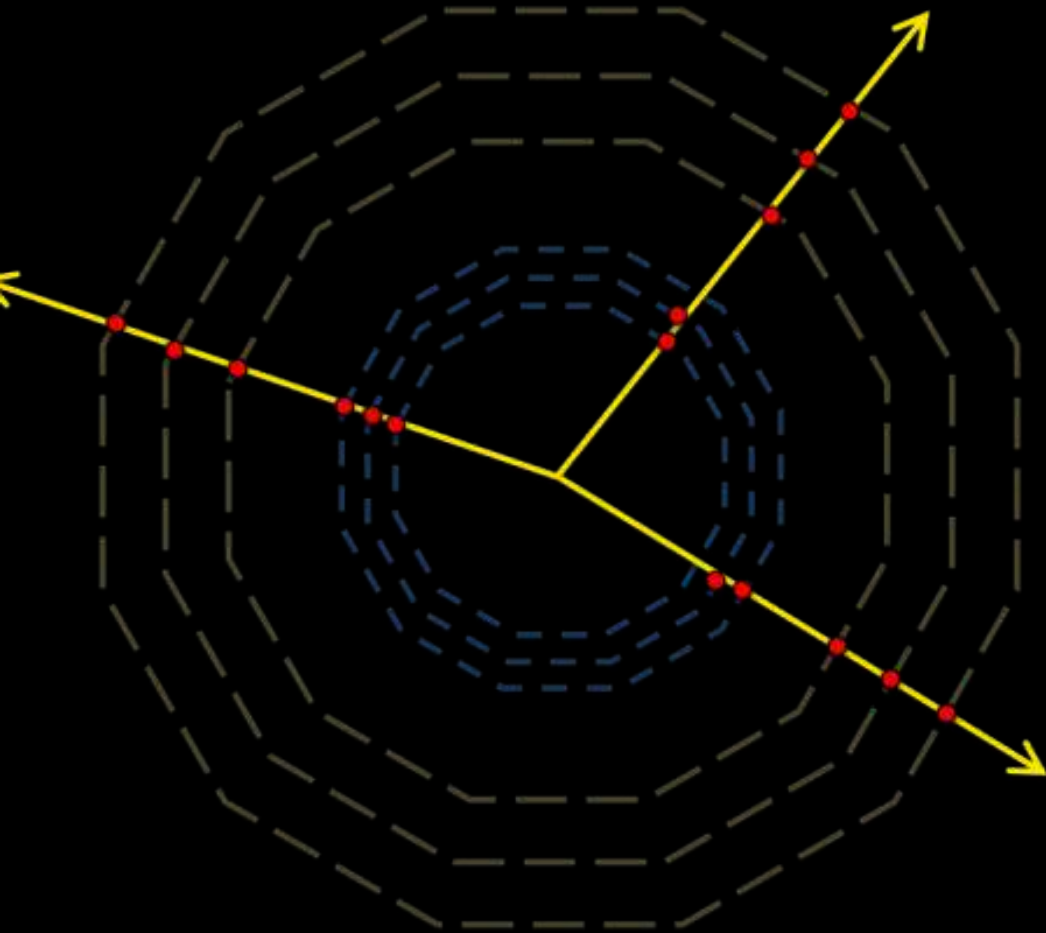
Rivelatori
Cherenkov

Materiale

Rivelatori
a gas

Rivelatori
a stato solido

tracciatori



Sensibilità

tutte le particelle cariche

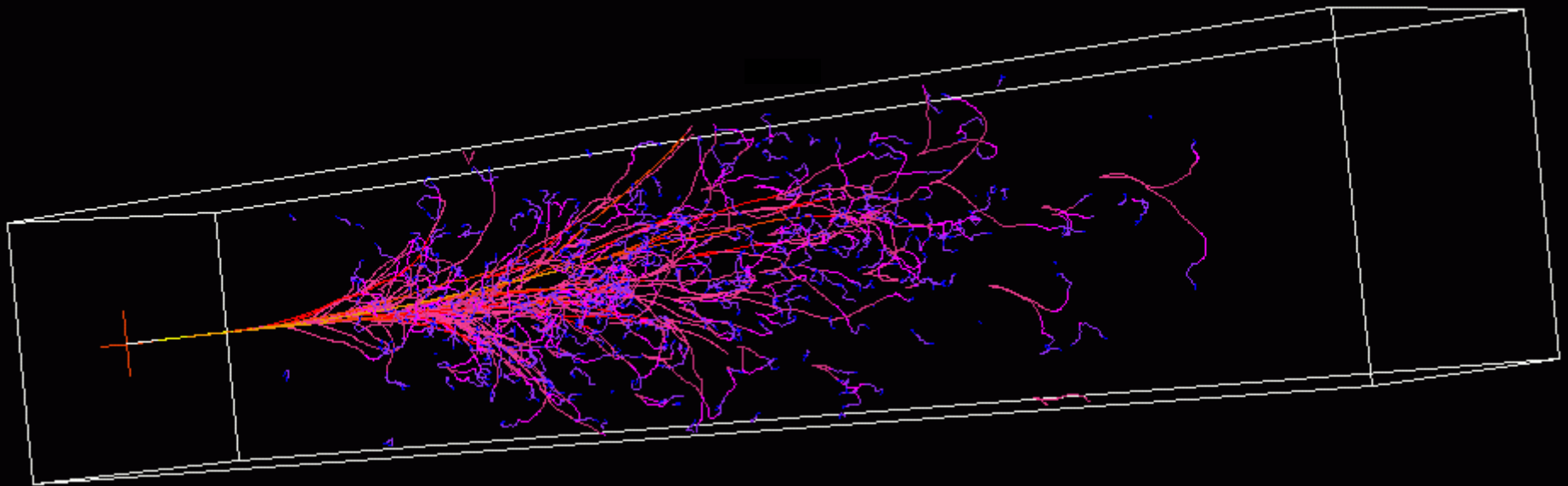
$$F = p \times B$$

immersi in campo magnetico
misurano la quantità di moto

Materiali leggeri

la particella deve perdere
poca energia

calorimetri



Sensibilità

Ecal: elettroni e fotoni

Hcal: protoni, neutroni, pioni, kaoni

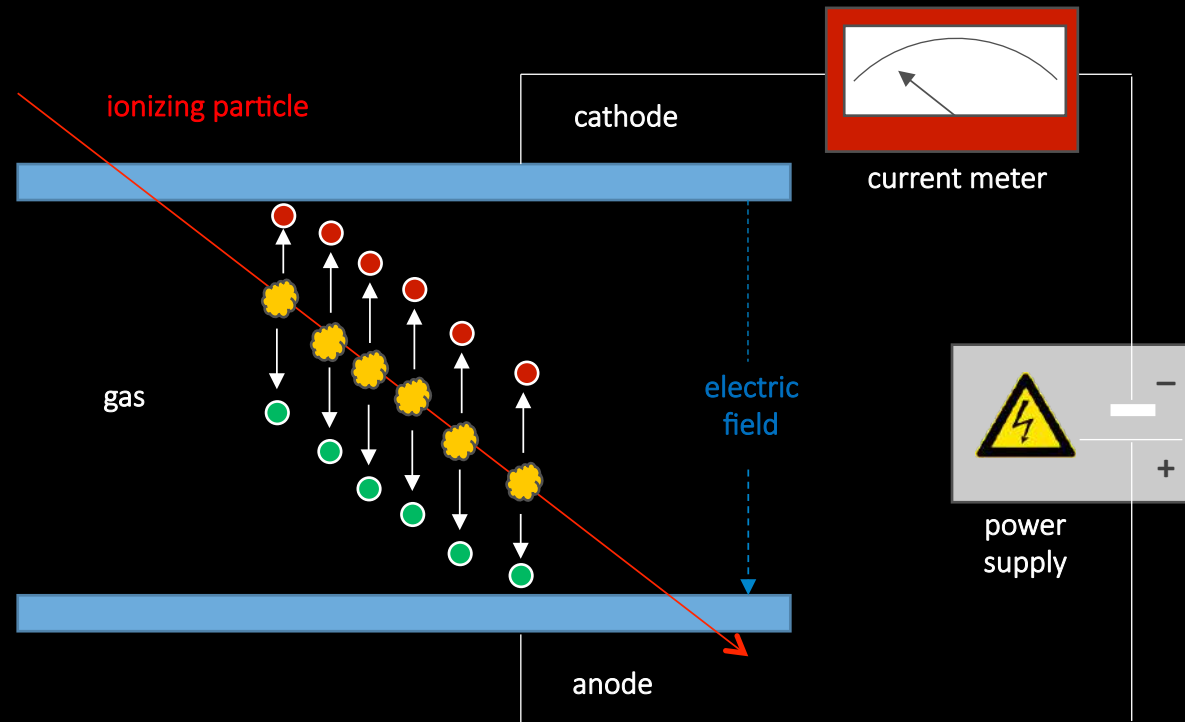
Energia

misurano l'energia
(senza campo magnetico)

Materiali pesanti

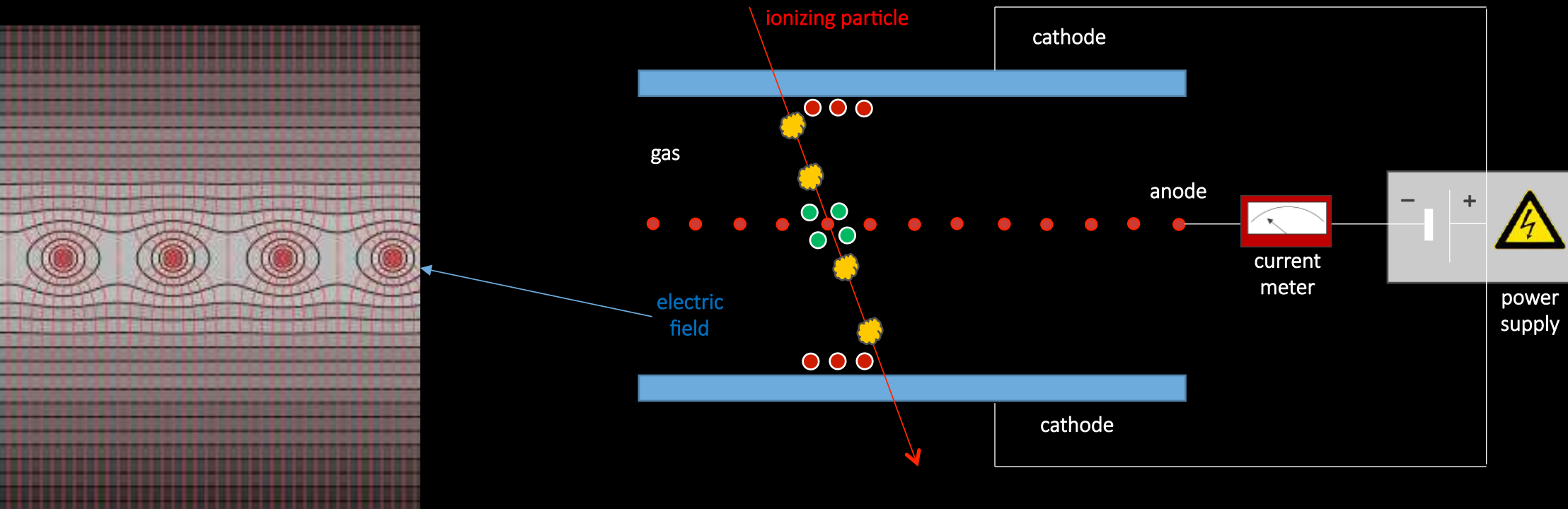
la particella deve perdere
tutta la sua energia

rivelatori a gas

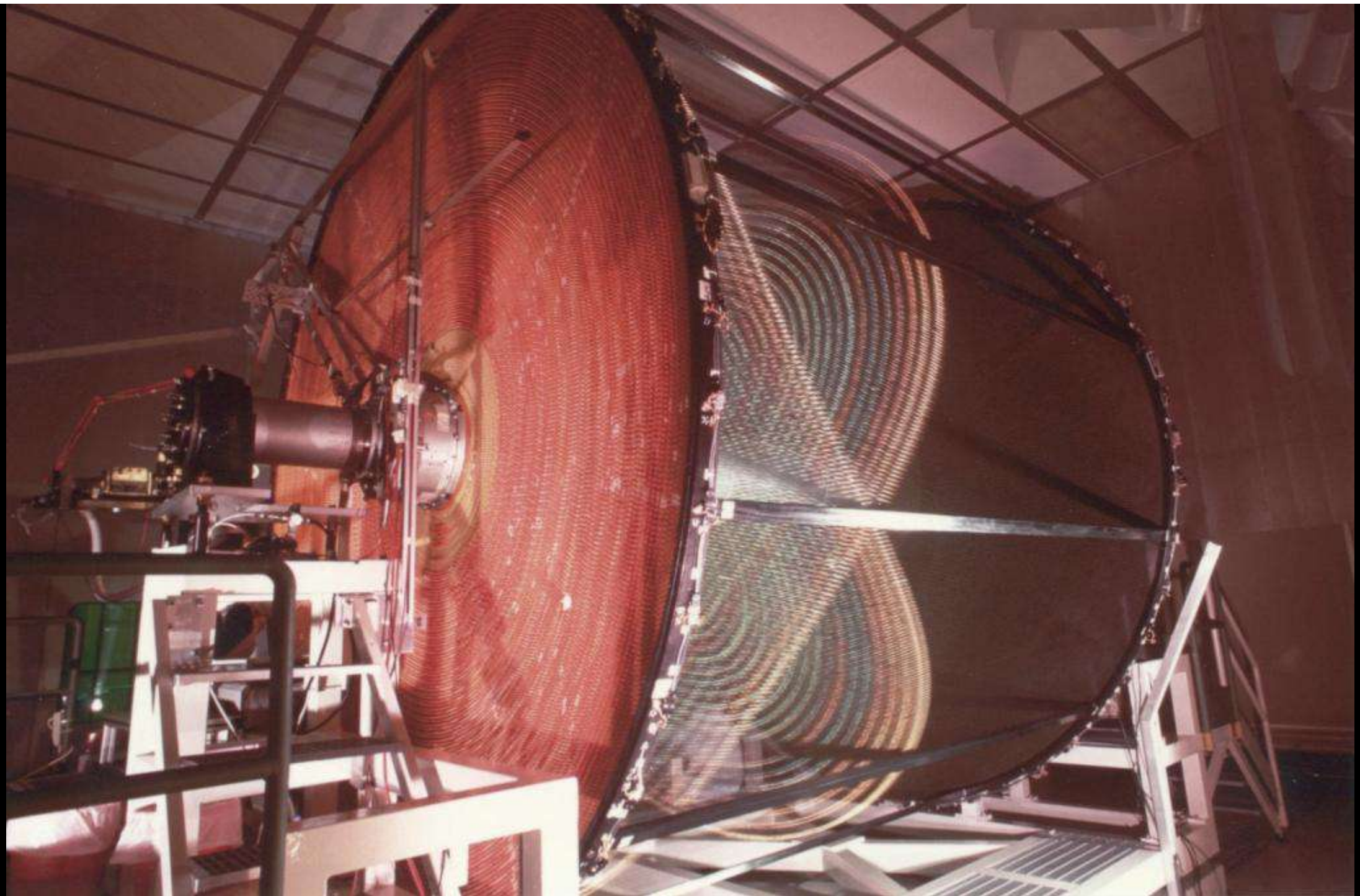


Punti di Forza
grandi volumi con poca spesa
segnale grande

Multiwire proportional chamber



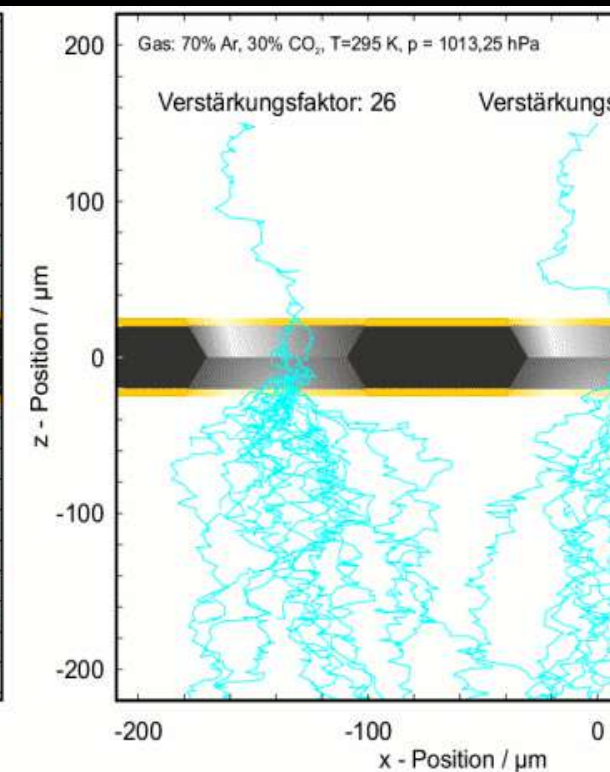
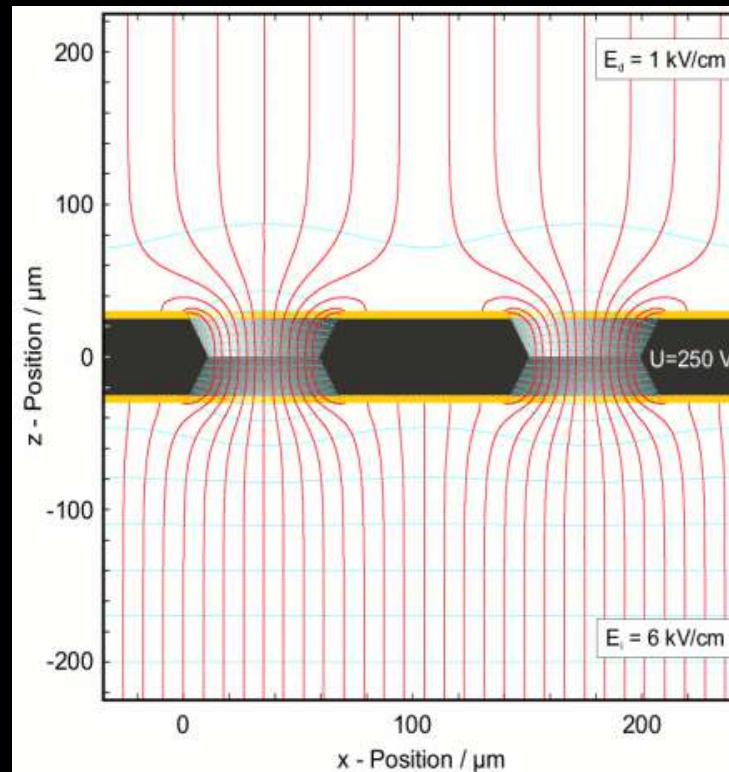
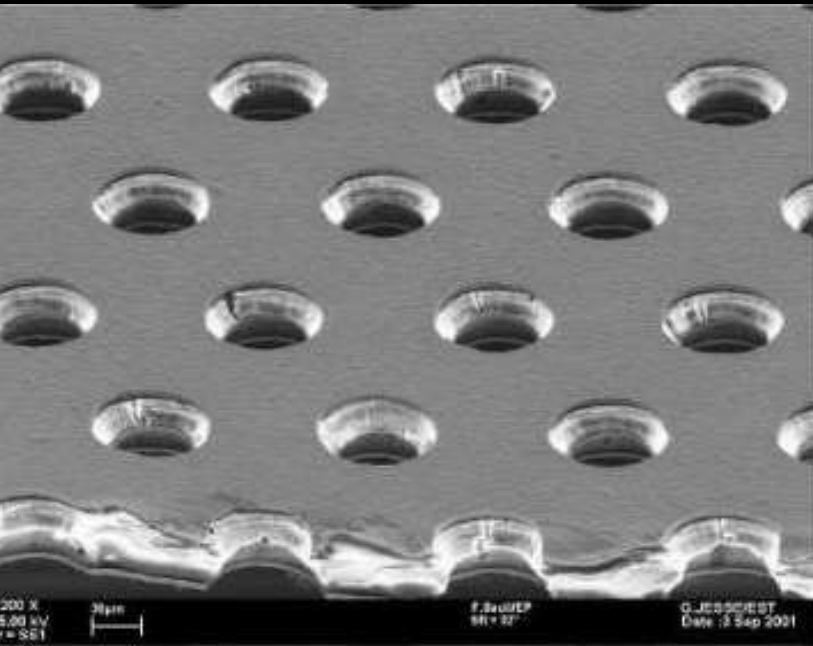
il segnale del filo fornisce la **posizione** della particella
il campo elettrico vicino al filo ($1/r$) **moltiplica** gli elettroni



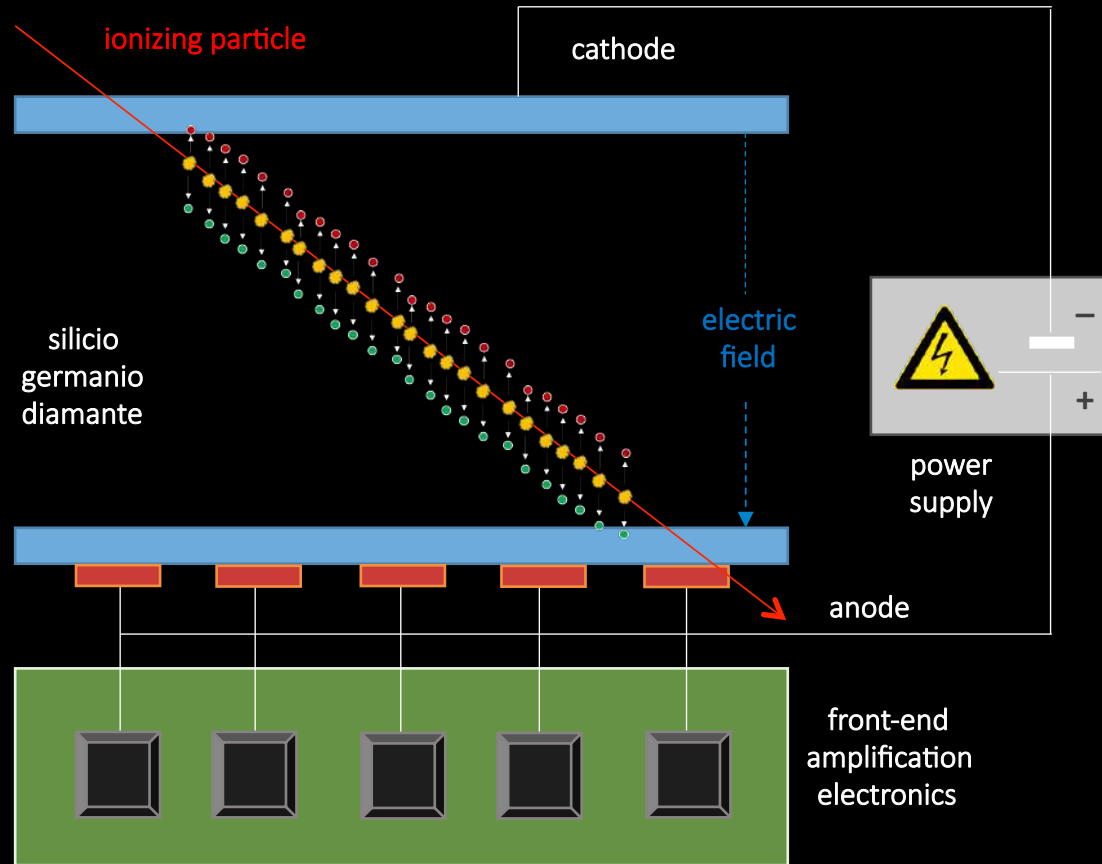
gas electron multiplier

un foglio di kapton metallizzato e micro-forato
moltiplica gli elettroni

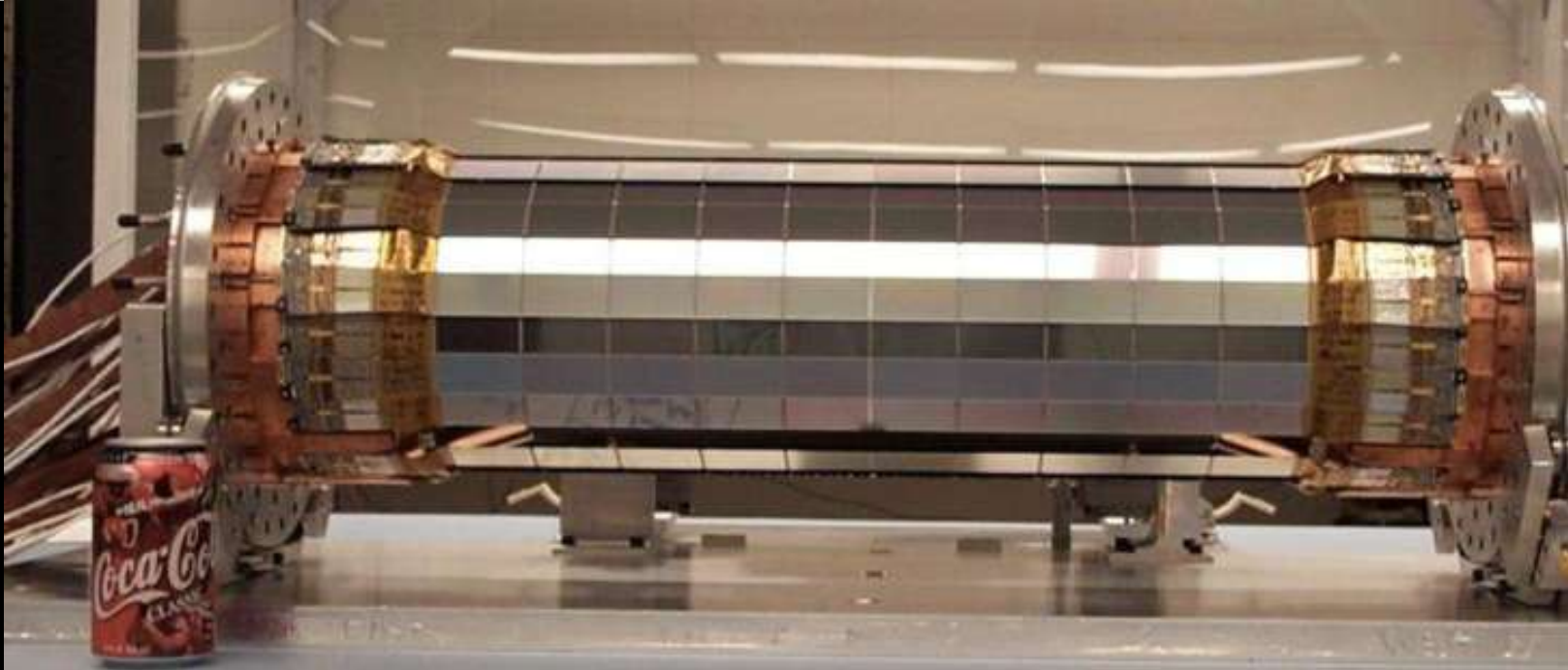
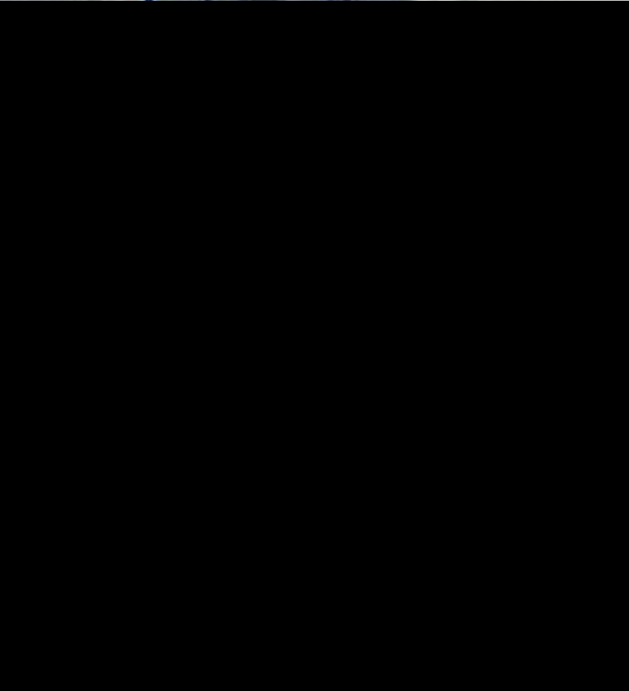
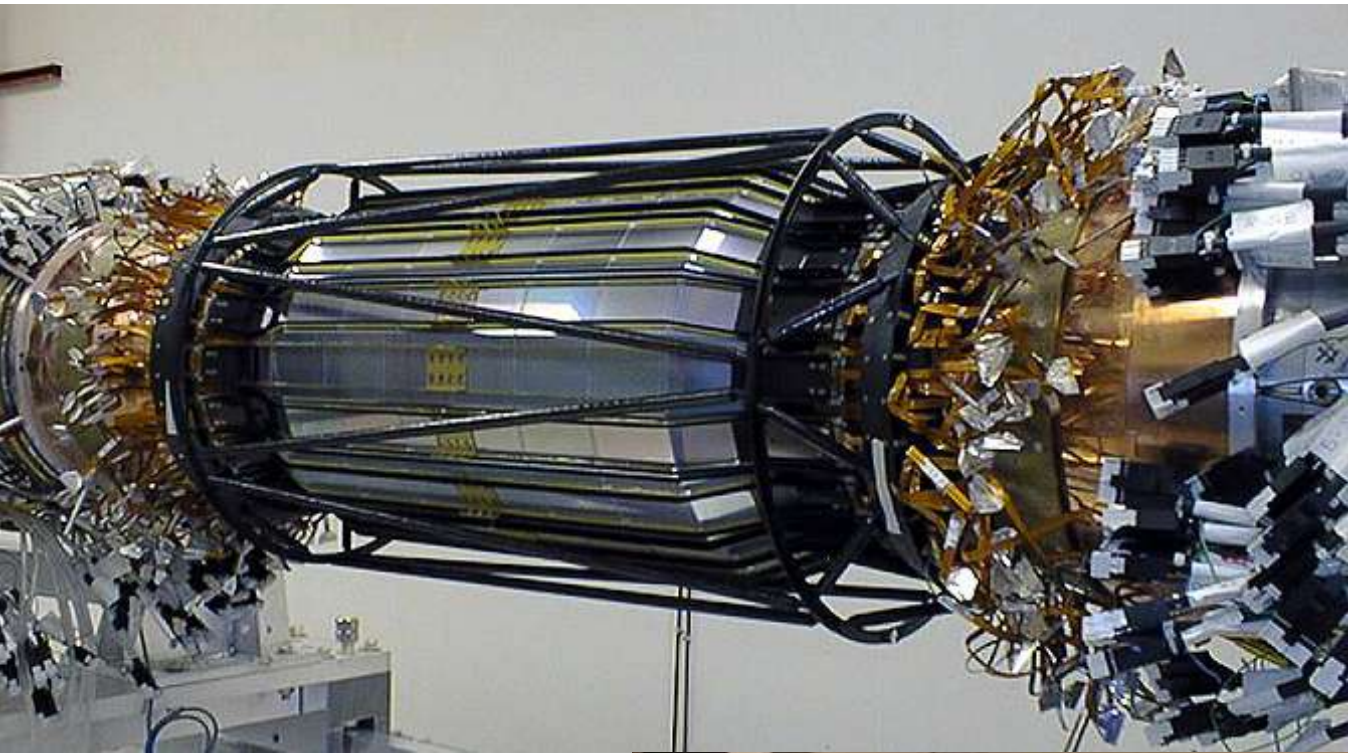
Punti di forza
piccolo tempo morto

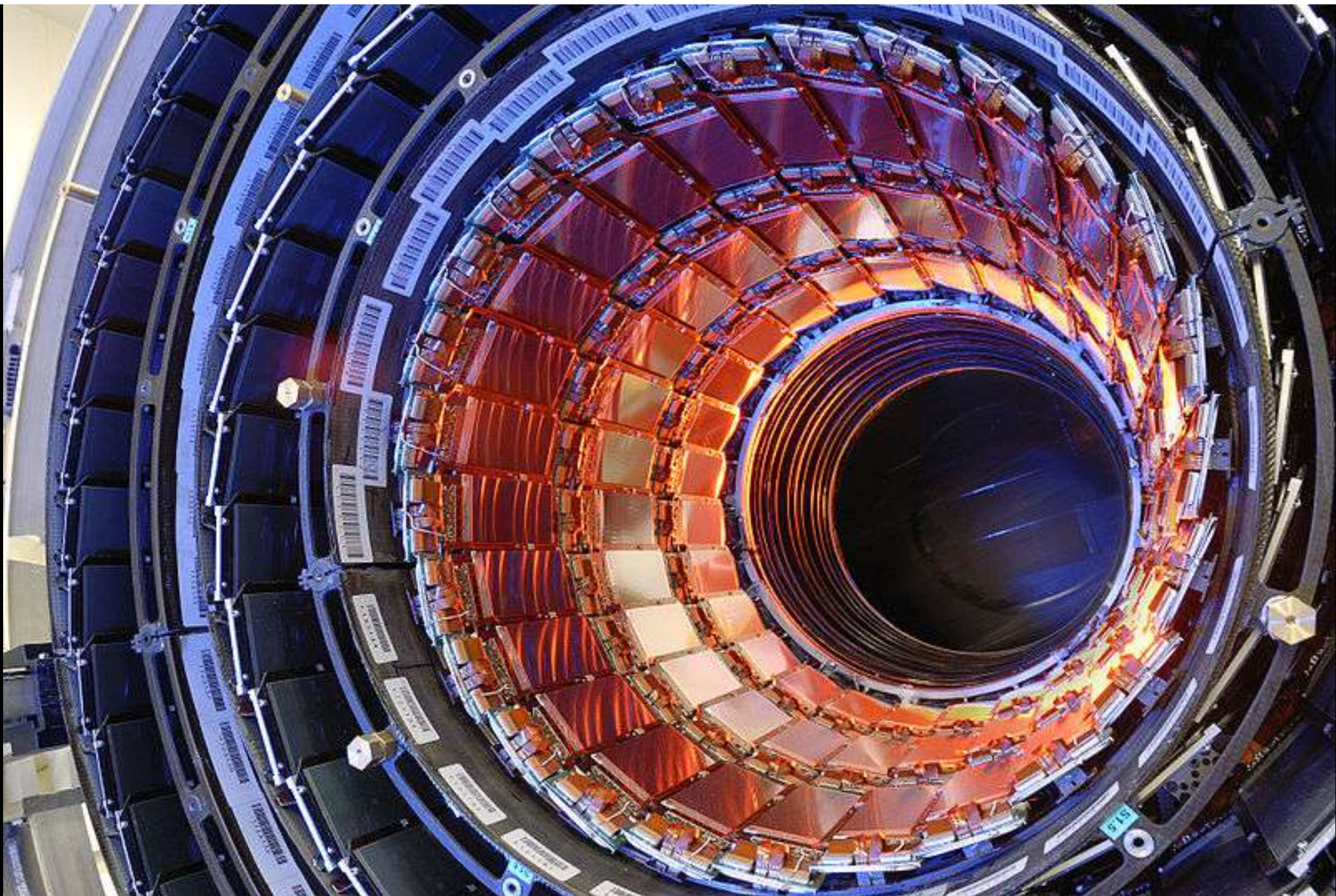


rivelatori a stato solido



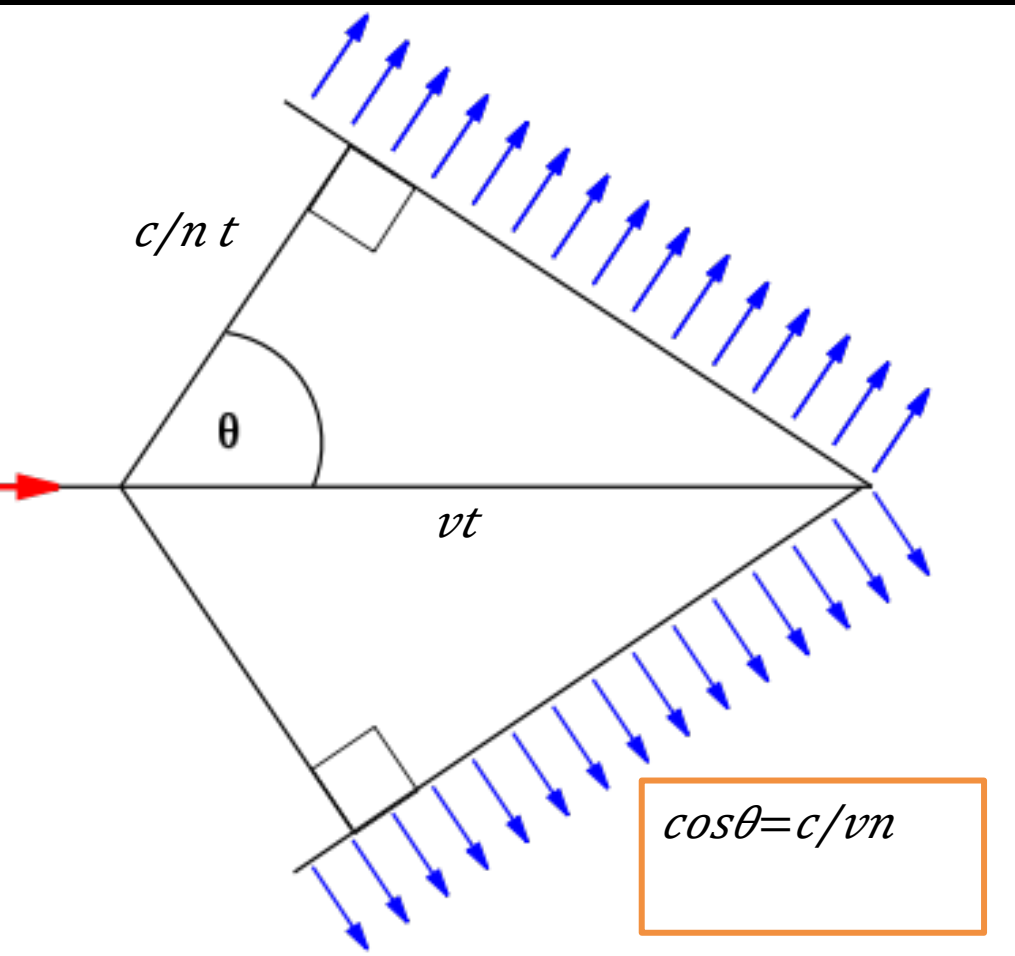
Punti di Forza
risoluzione spaziale e temporale



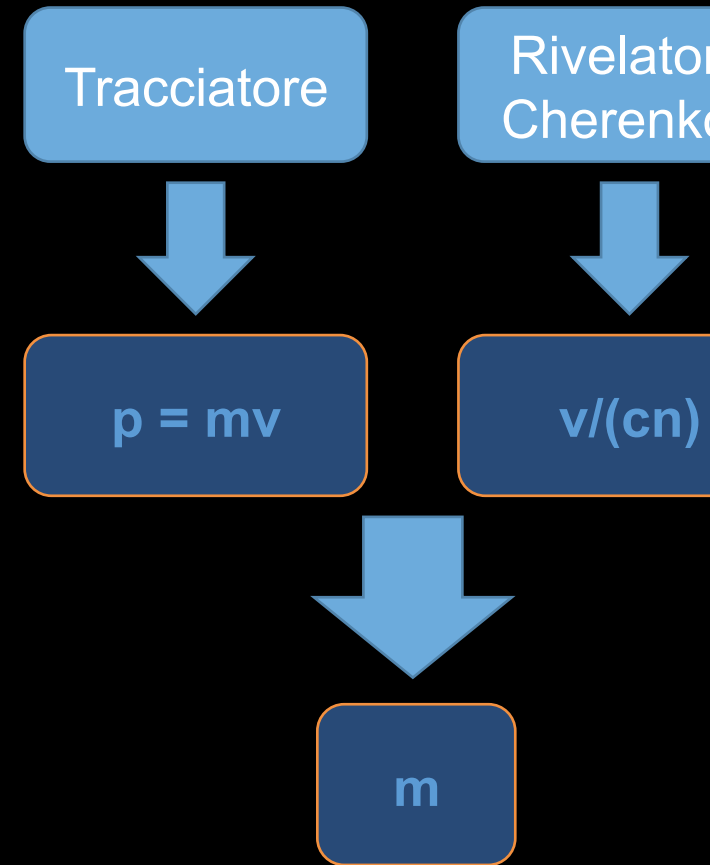
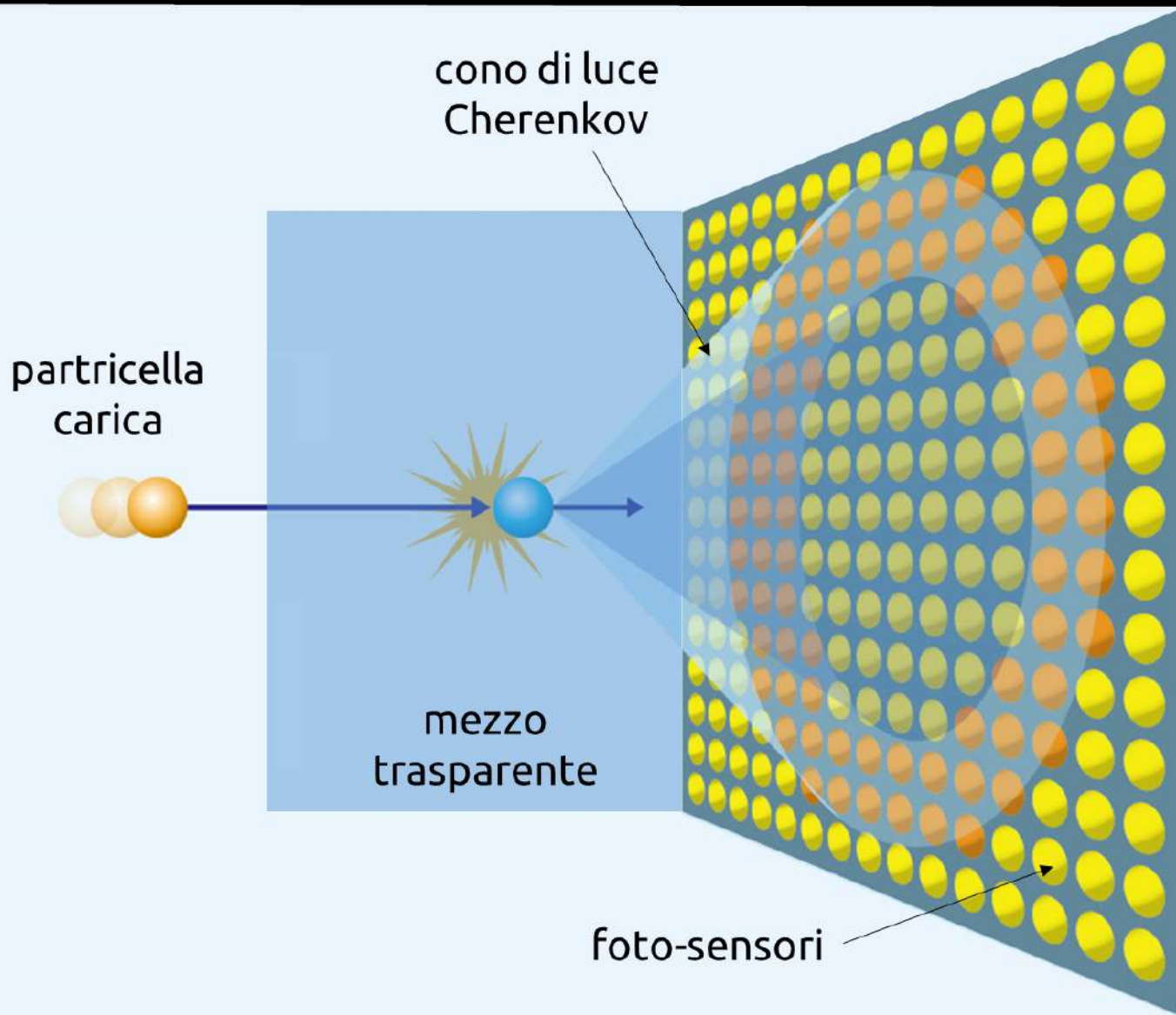




effetto cherenkov

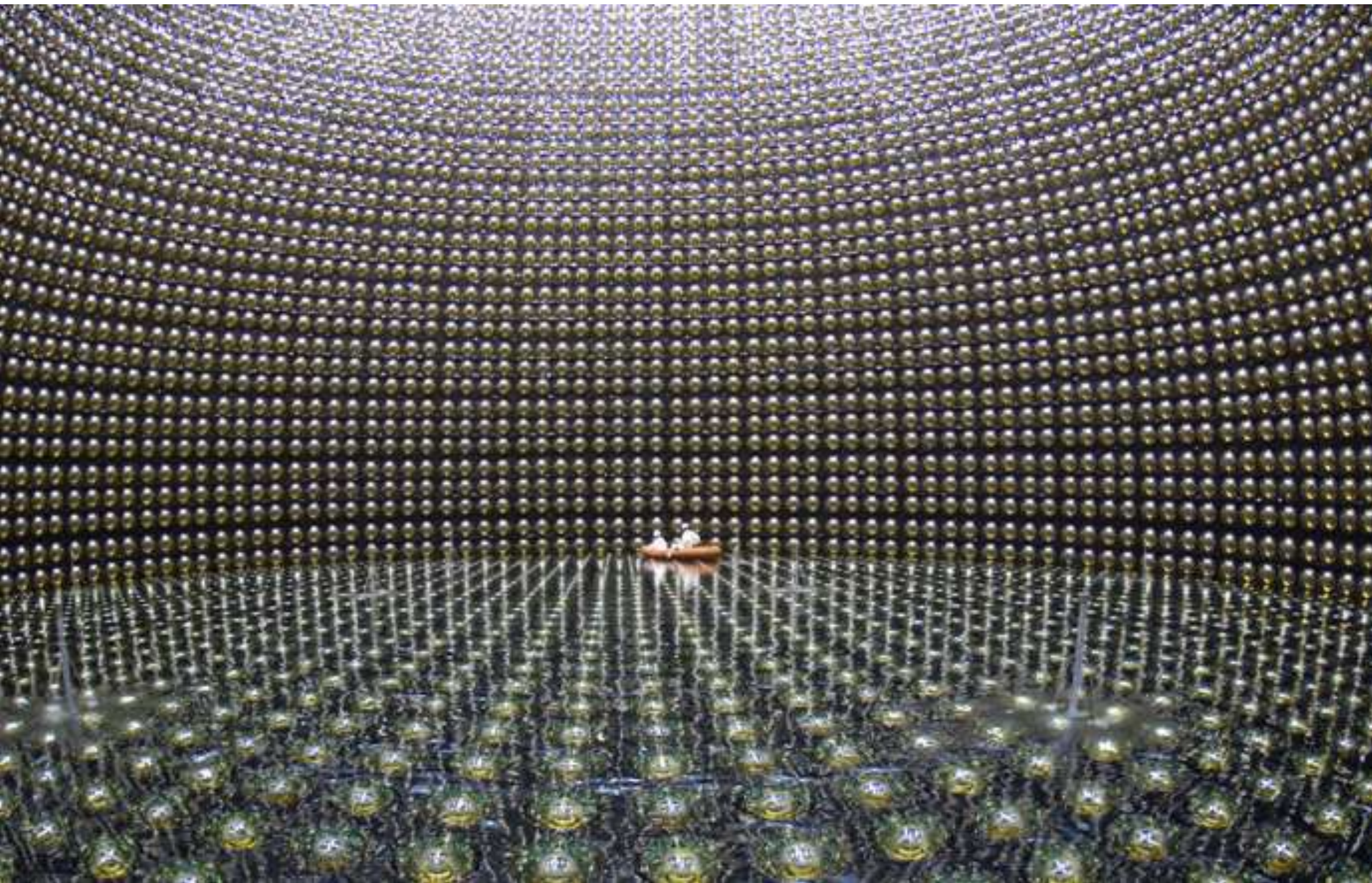


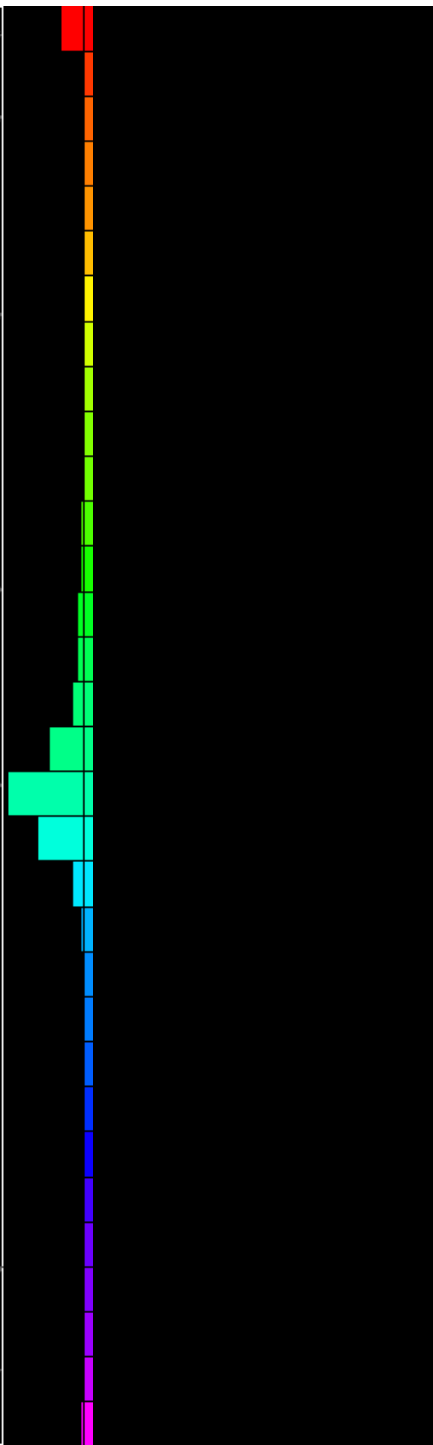
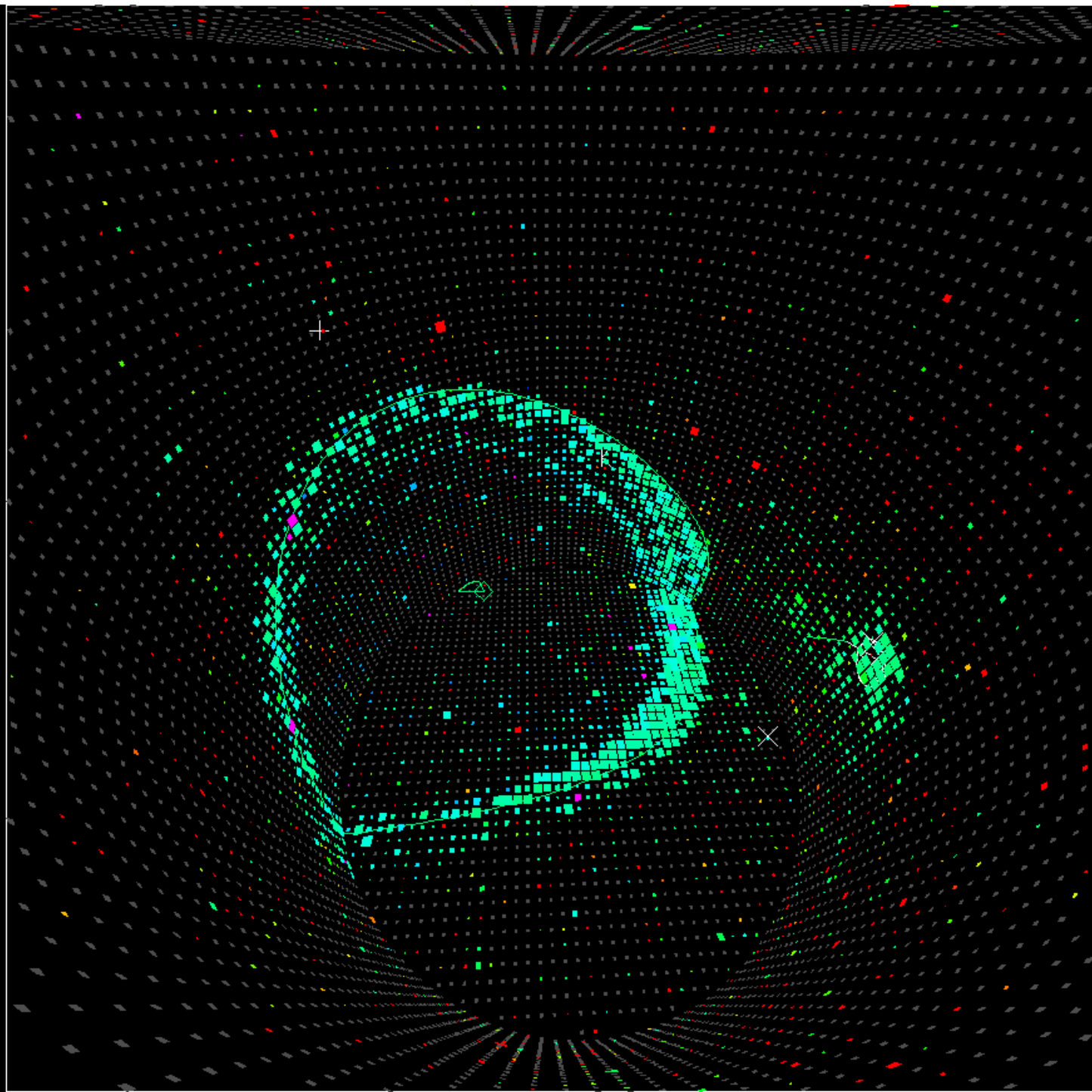
rivelatori cherenkov



identificazione della particella

pione	140 MeV
kaone	500 MeV
protone	940 MeV





positron emission tomography

