Gli esperimenti
ATLAS e CMS @ LHC

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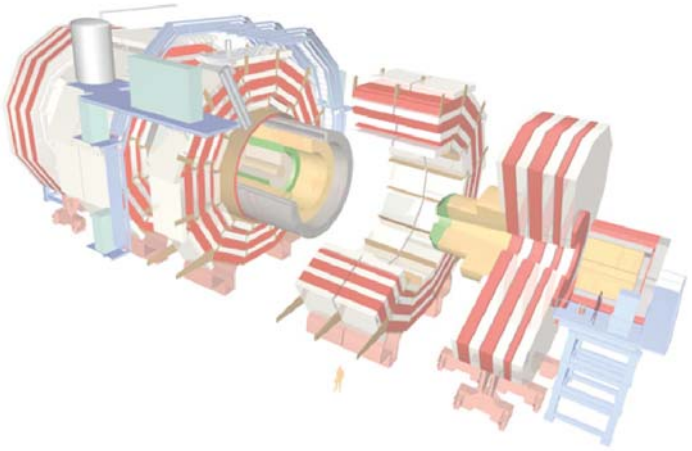
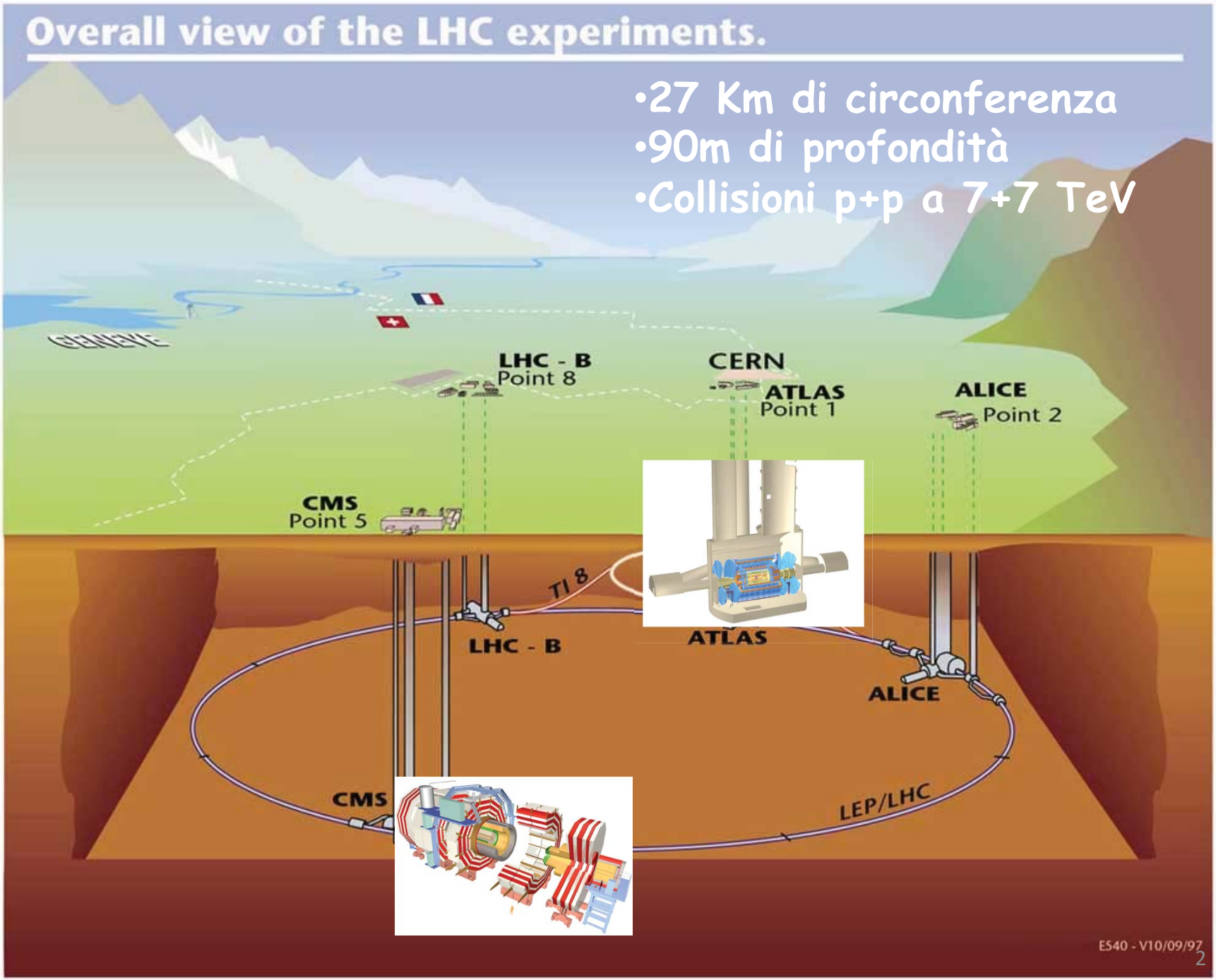
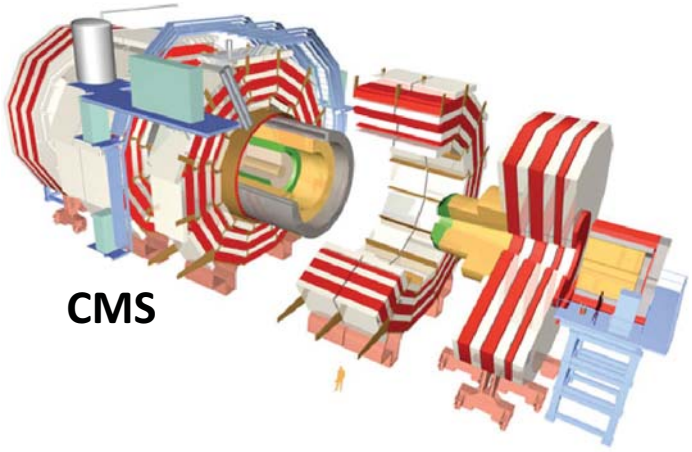


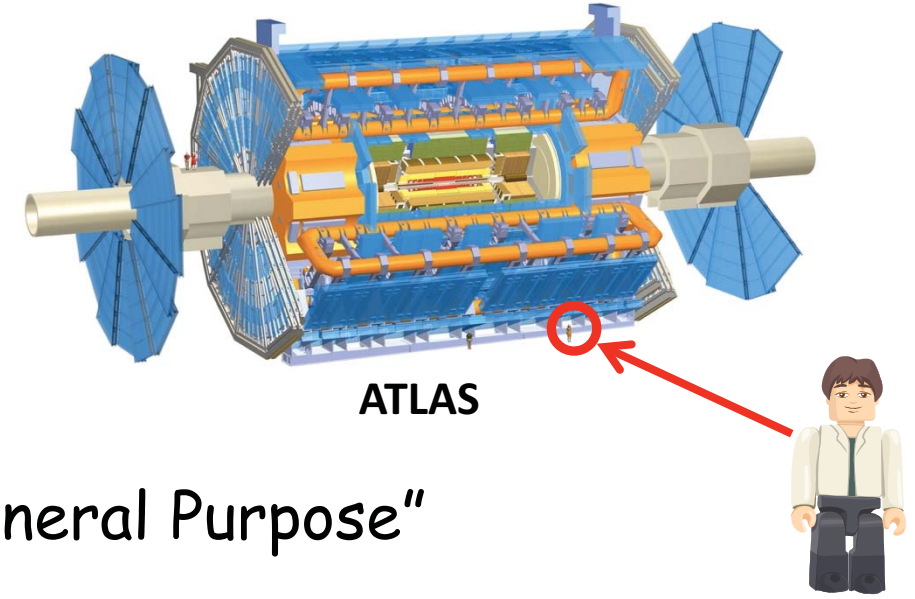
Overall view of the LHC experiments.

- 27 Km di circonferenza
- 90m di profondità
- Collisioni p+p a 7+7 TeV



ATLAS e CMS



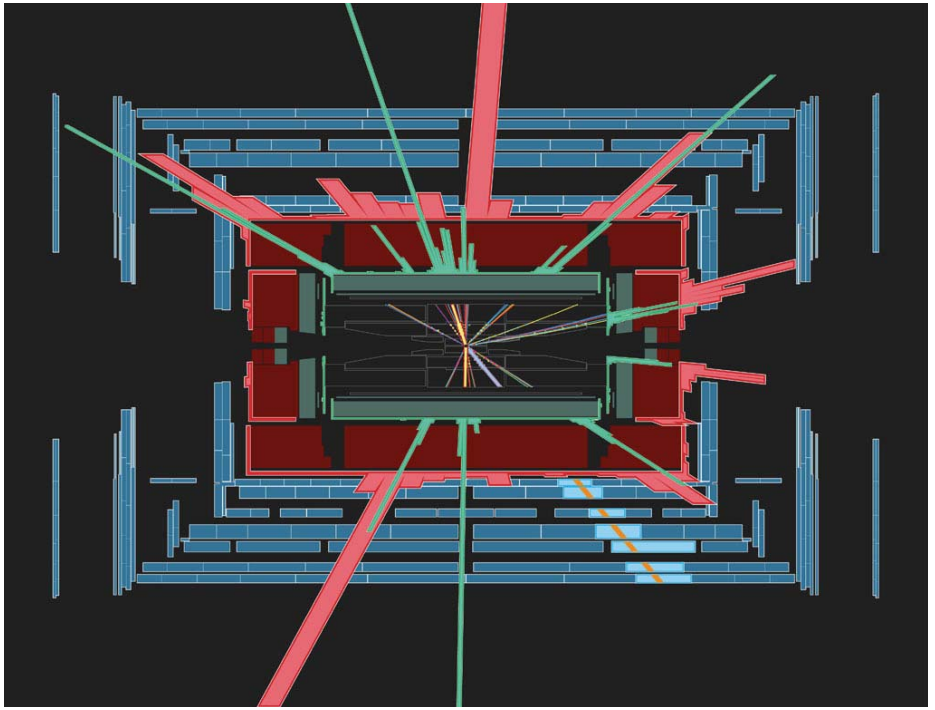


esperimenti "General Purpose"

- perché due?: conferma indipendente di eventuali nuovi fenomeni tramite due apparati differenti e spesso complementari
- diversi strati di rivelatori per differenti particelle
- urto frontale nel CM → simmetria cilindrica

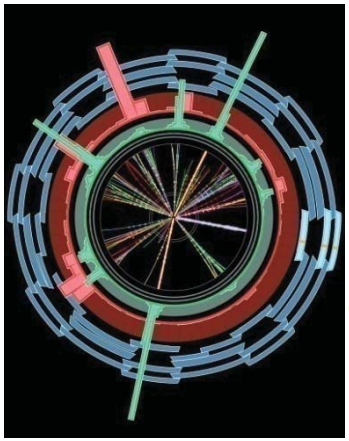
	ATLAS	CMS
diametro	22 m	15 m
lunghezza	46 m	21 m
massa	7000 tonnellate =	14000 tonnellate = 2500 x
canali di lettura	100 milioni	75 milioni

….a cosa serve….

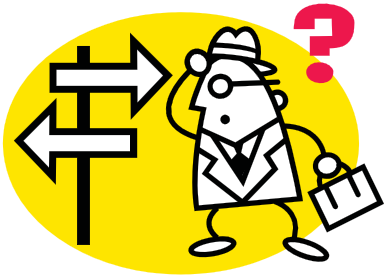


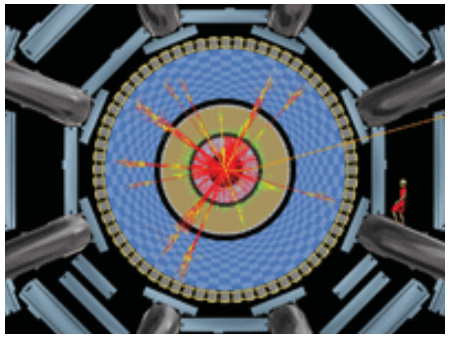
- 'vedere' le particelle prodotte dalle interazioni@LHC

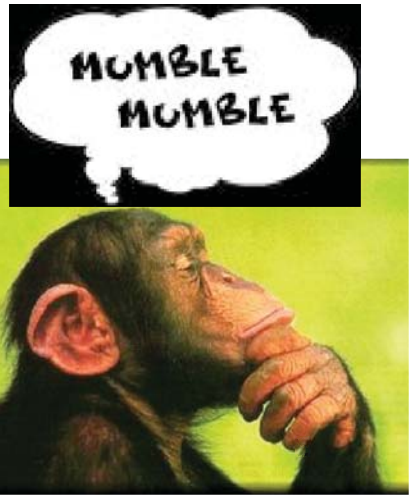
3D-100Mpx-
~100.000 foto/s



- scegliere gli eventi interessanti….







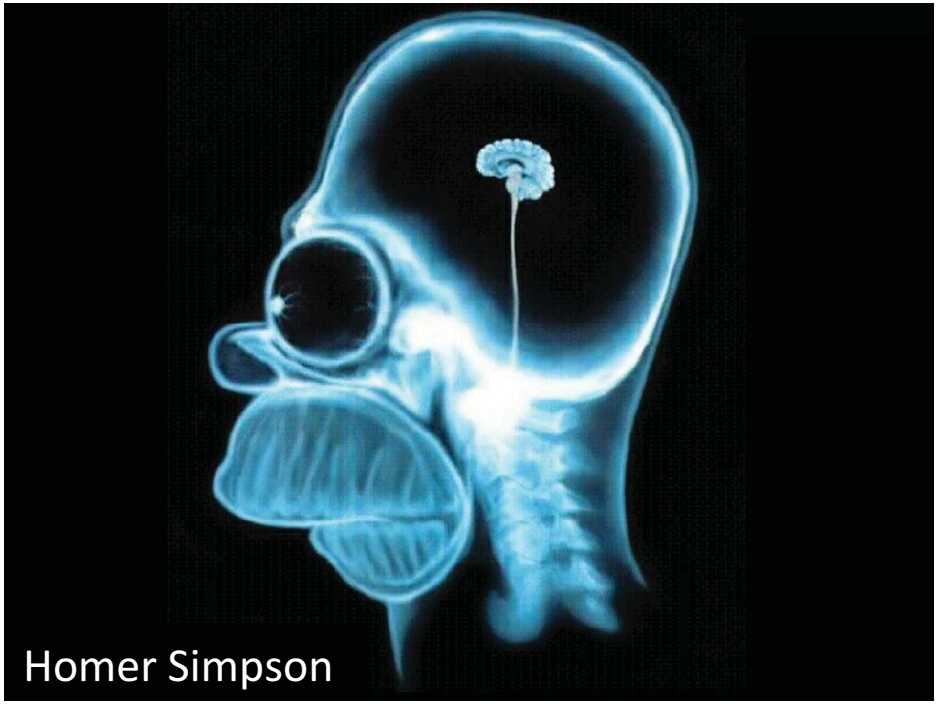
- conservarli  per l'analisi fisica successiva

come si rivelano le particelle?

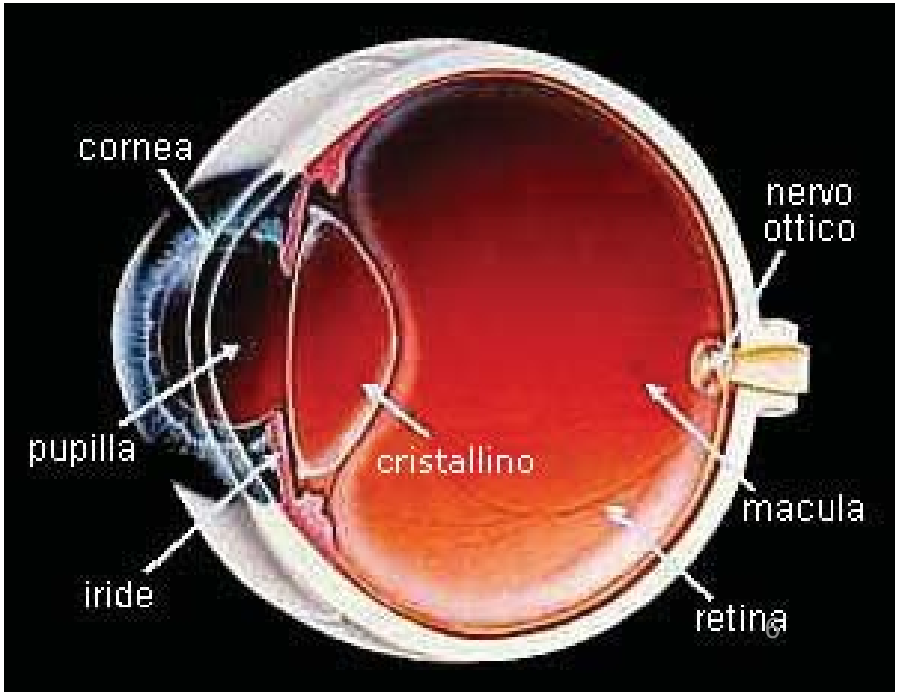
- tramite la loro interazione con la materia che attraversano

…esempi nella vita quotidiana…

Lastre fotografiche…..

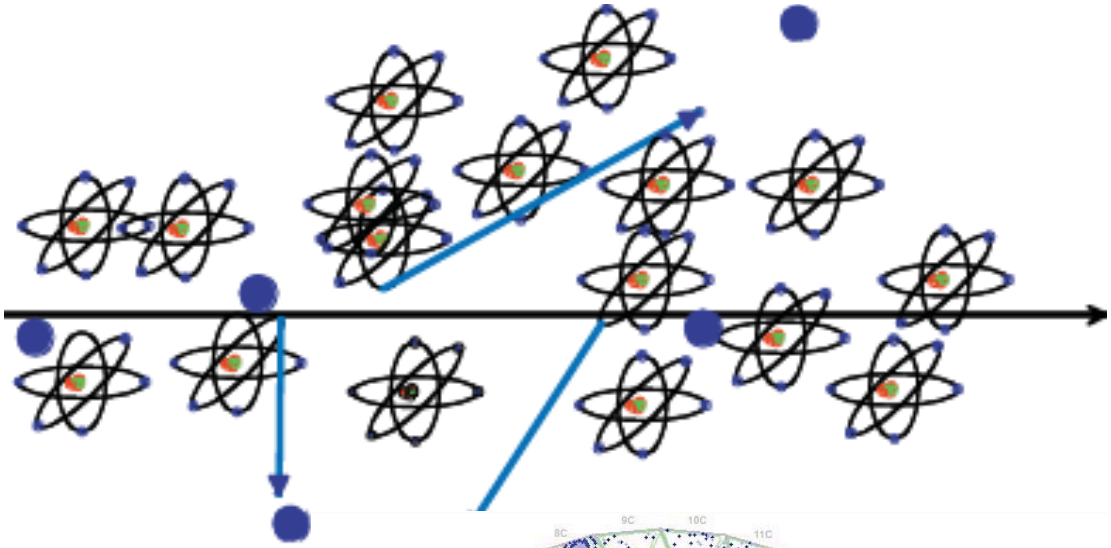


Occhio umano…..



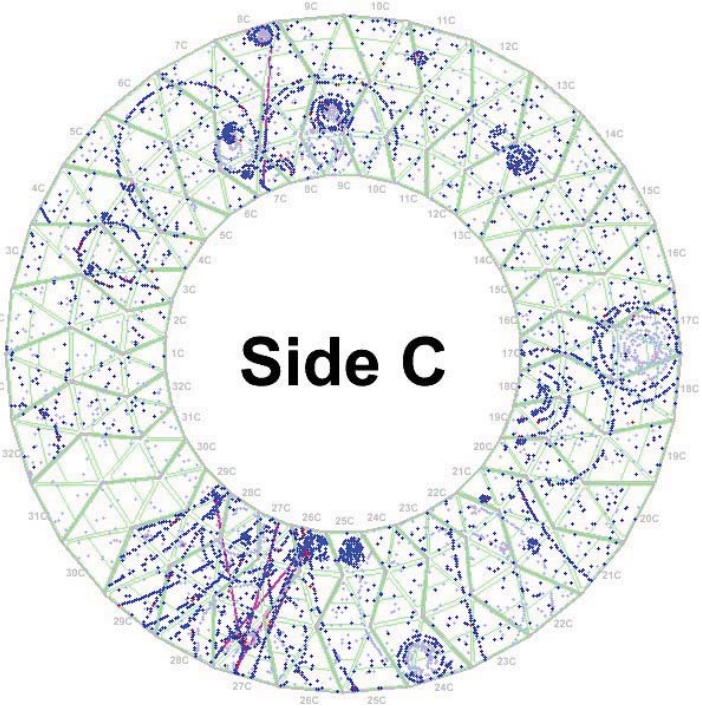
…esempi alle energie di LHC…

Particelle cariche
interagiscono in genere em con gli elettroni atomici producendo



IONIZZAZIONI e/o ECCITAZIONI

…esempio di tracce nel rivelatore a radiazione di transizione + ionizzazione (TRT) di Atlas



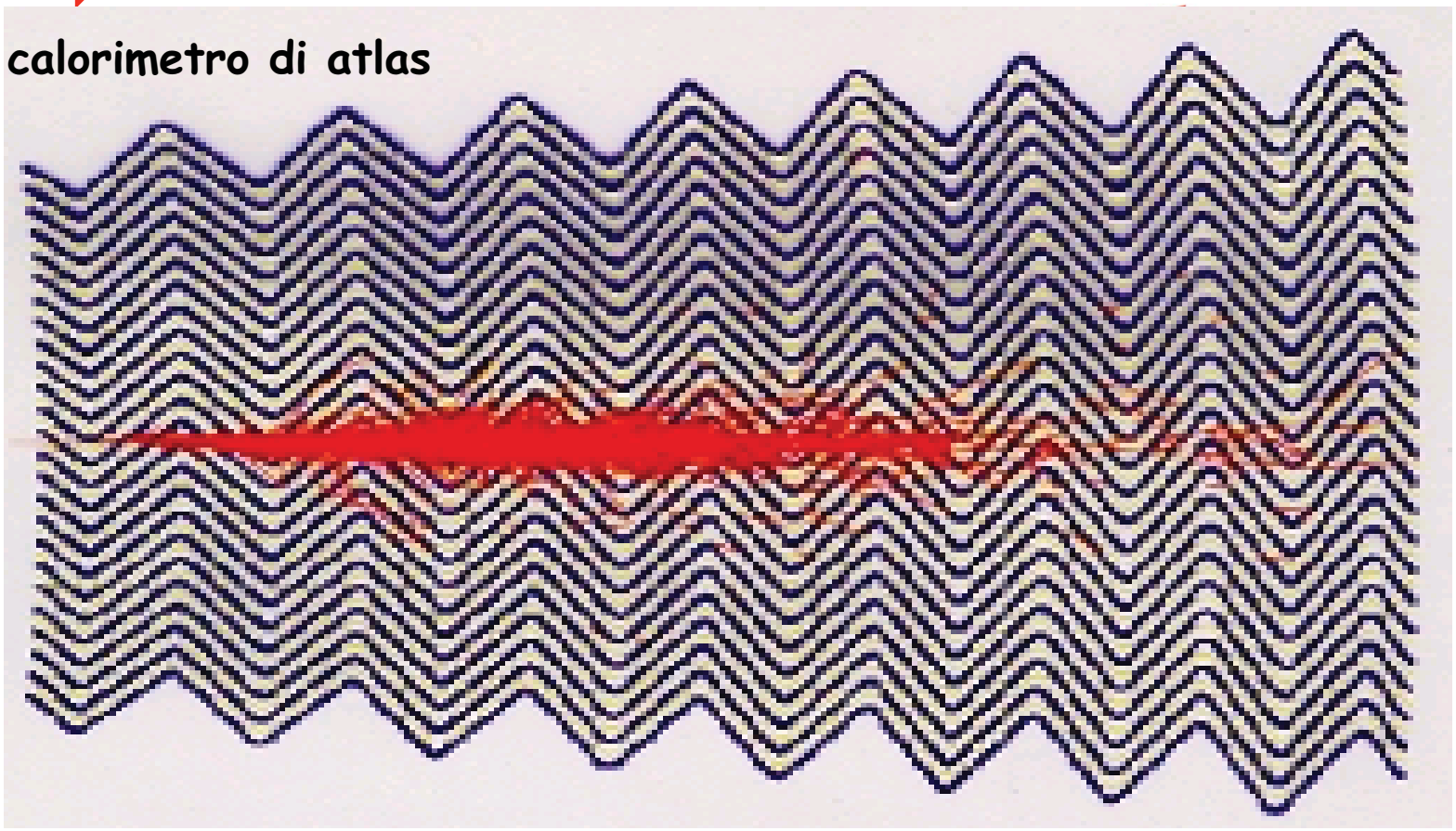
RADIAZIONE di TRANSIZIONE

…esempi alle energie di LHC…

-Elettroni e fotoni di alta energia:

-elettroni frenati dalla materia irraggiano fotoni i quali 'convertono' in coppie elettrone-positrone

SCIAME ELETTROMAGNETICO



…esempi alle energie di LHC…

- **Adroni** interagiscono 'forte' producendo 'getti' di particelle simili agli sciami em (oltre che ionizzare se carichi…)

- **Muon**i ionizzano ma poco….

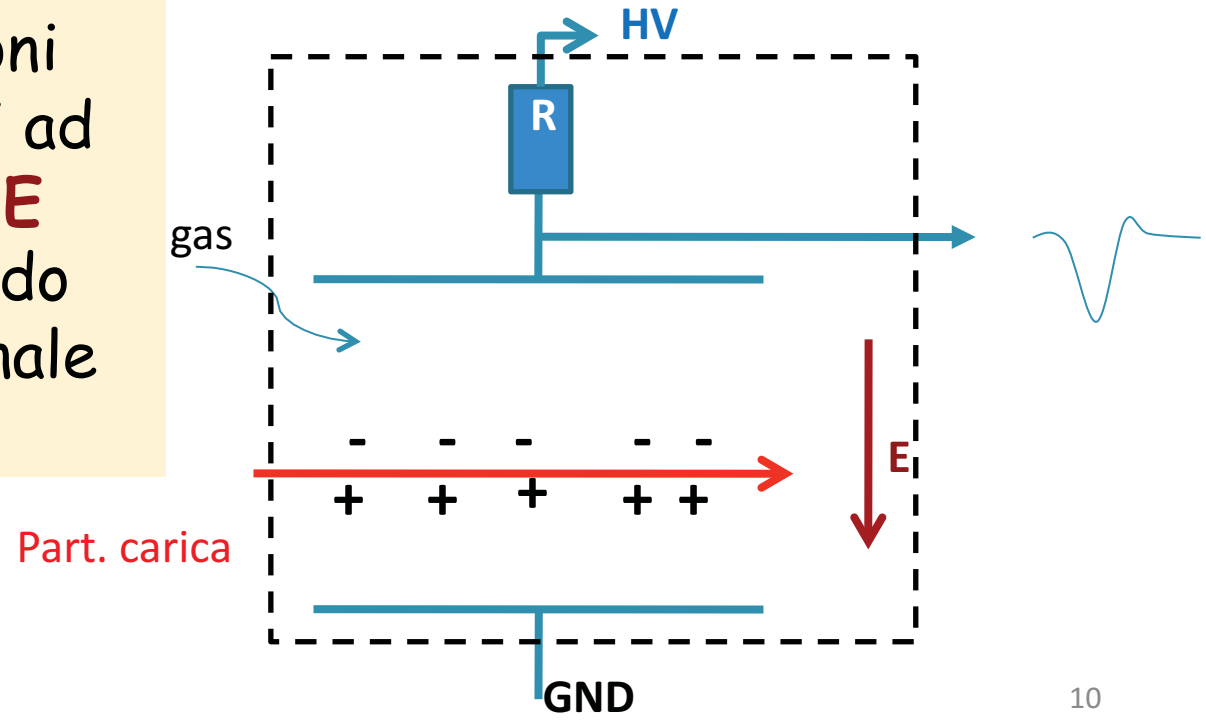
- **Neutrini** interagiscono debolmente …possono attraversare la Terra senza interagire……

I rivelatori

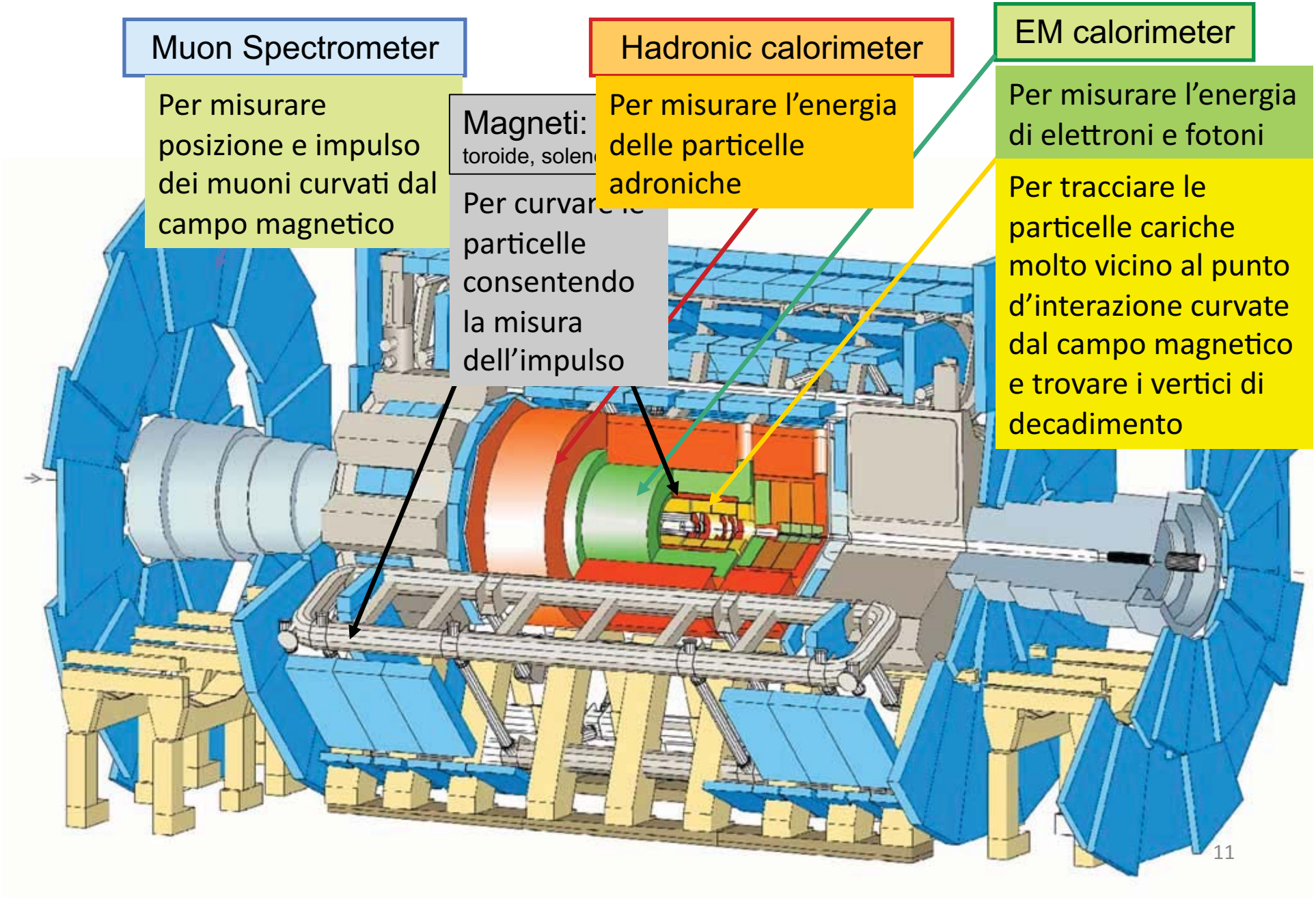
- Sfruttano i diversi tipi di interazione per produrre un segnale visibile, in genere elettrico, dal quale risalire al punto/istante di passaggio delle particelle, tracciarle e ricostruire gli eventi

Es. di rivelatore che sfrutta la ionizzazione nel gas:

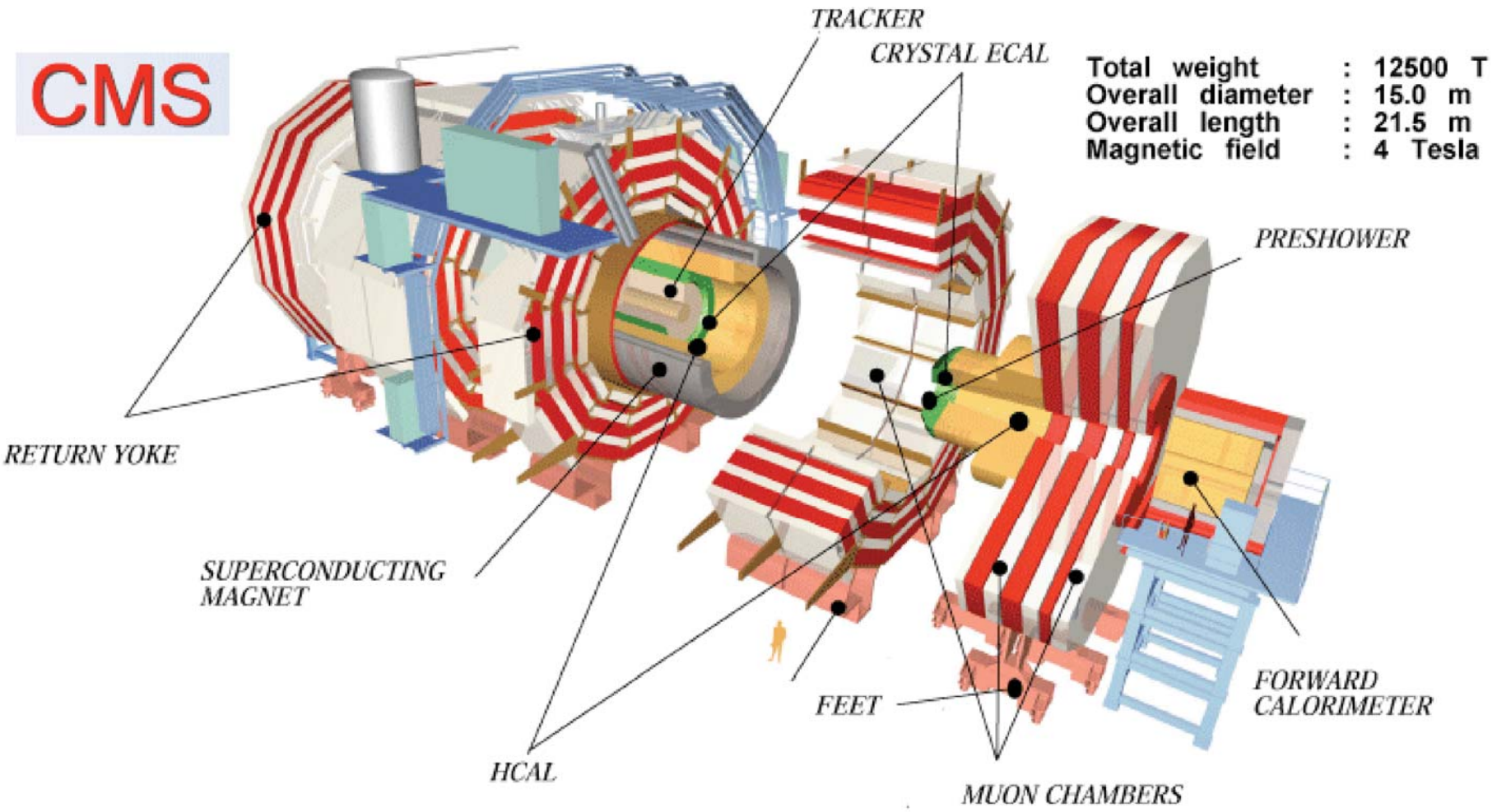
- Gli elettroni e gli ioni prodotti sottoposti ad un campo elettrico **E** migrano verdo l'anodo producendo un segnale elettrico



Rivediamo adesso la struttura di ATLAS….

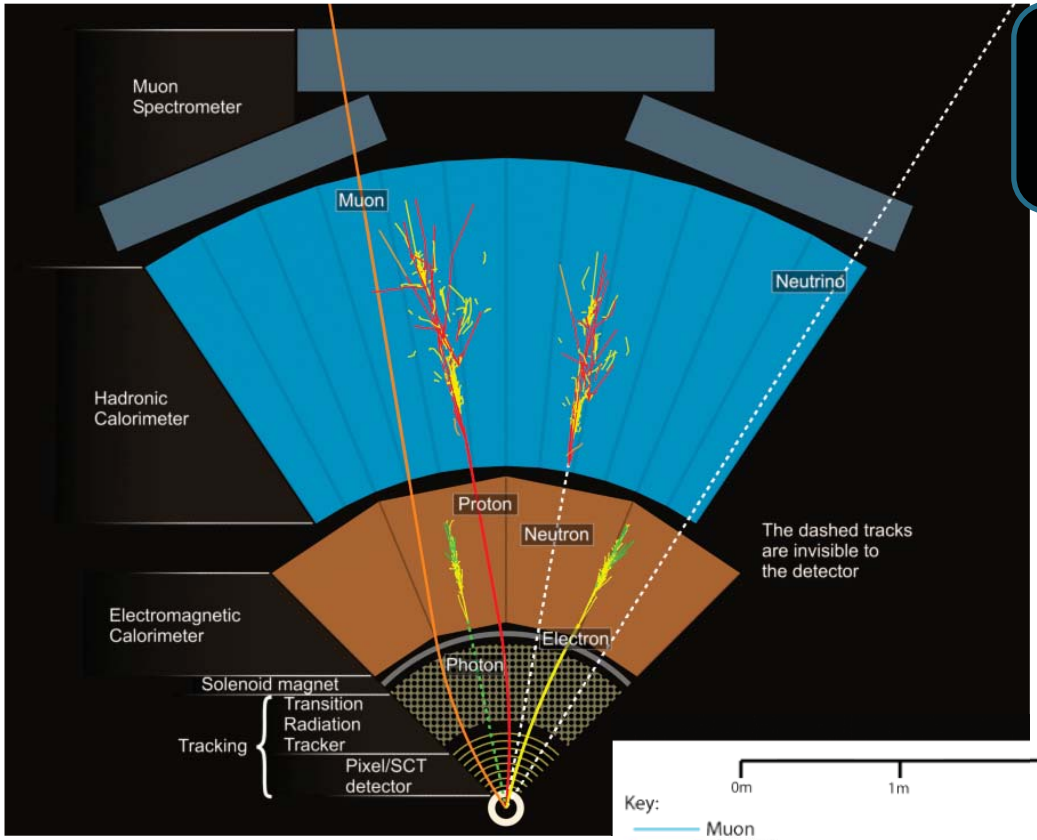


….e di CMS



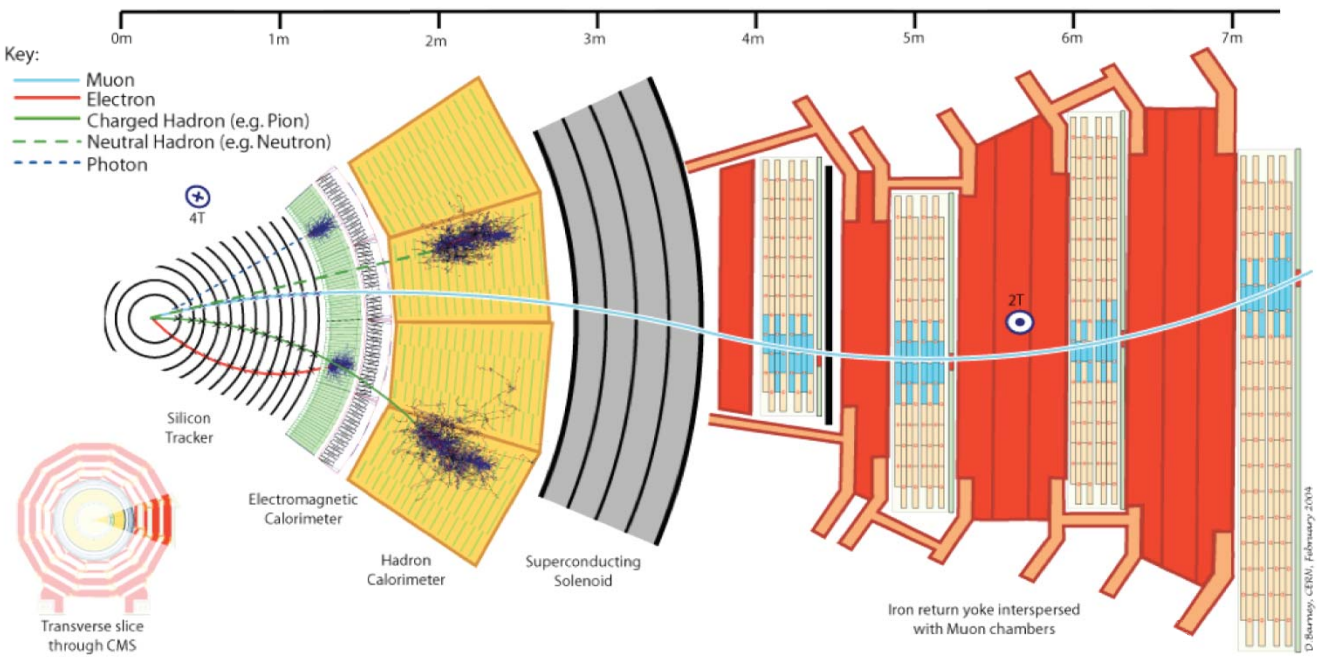
Differenze: Magnete, Calorimetri
Similitudini: Tracciatore, Rivelatori di muoni

← slice di ATLAS

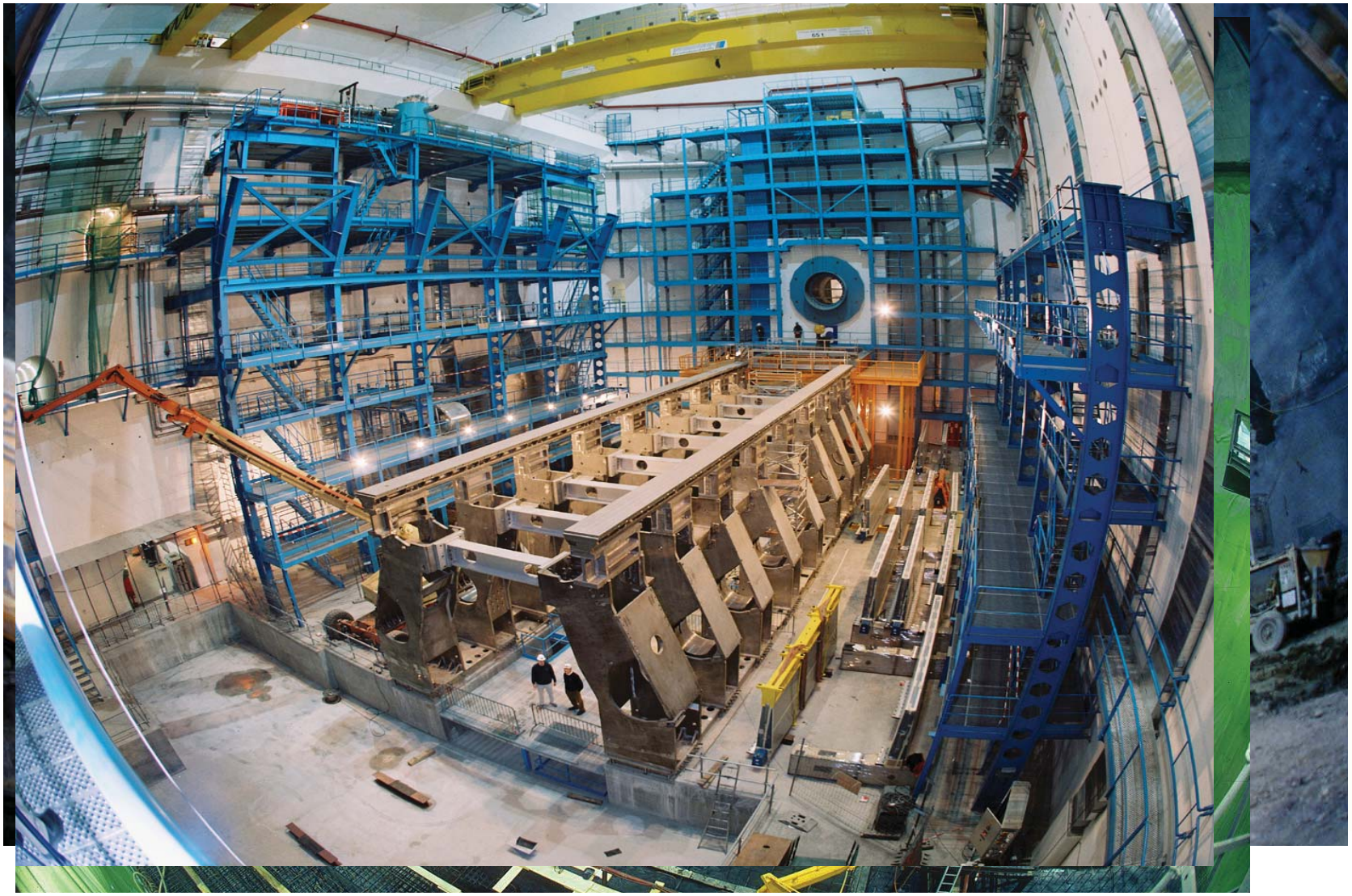


Deflection ~ BL^2/p →
need high B and large magnets;
need high resolution position measurements (10 -100μ) at large p; also energy and position measurement through total absorption (photon, electron, hadron)

slice di CMS →



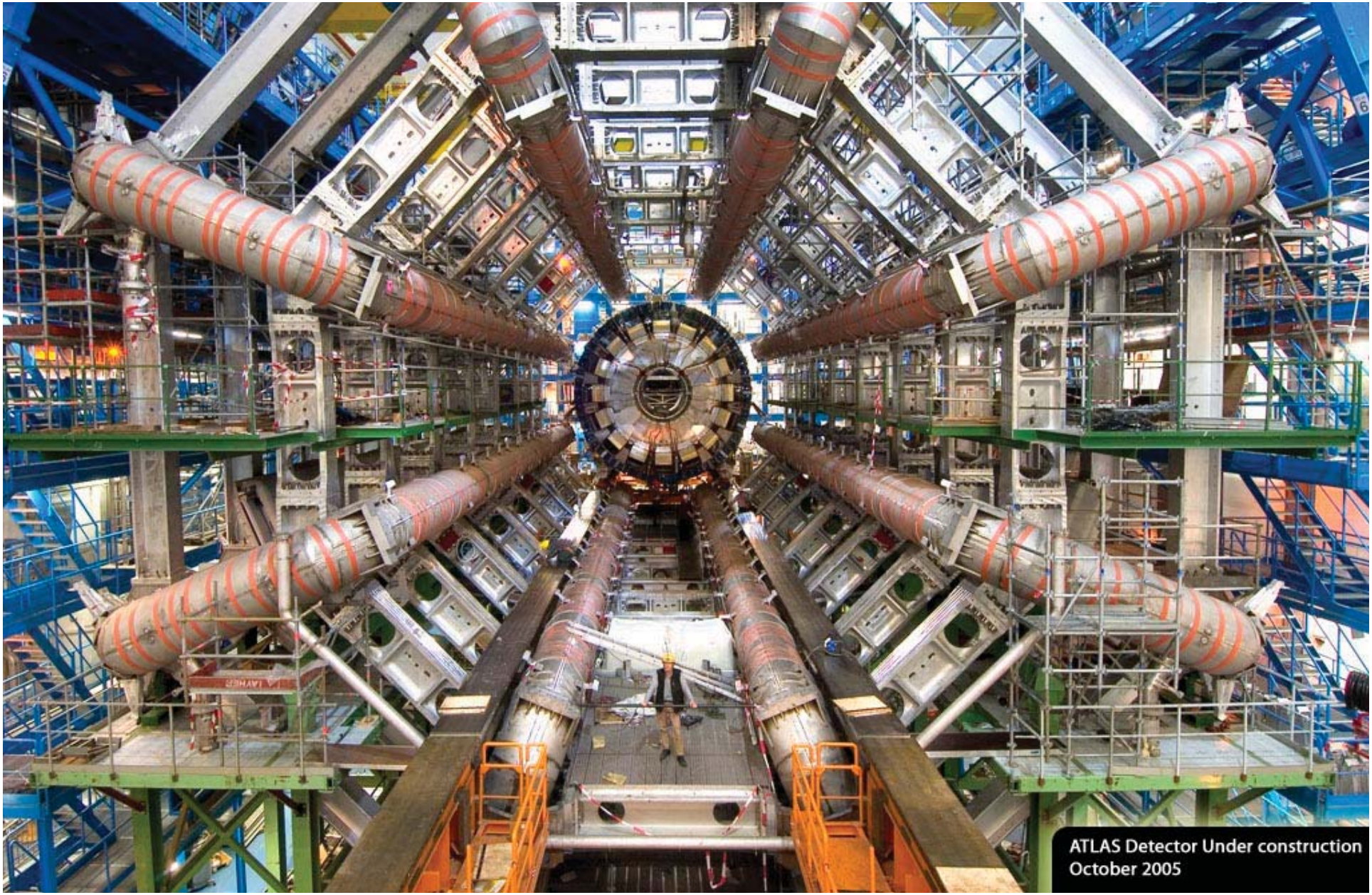
Atlas non è 'fotogenico' perché occupa praticamente tutta la caverna…….



2000

2002

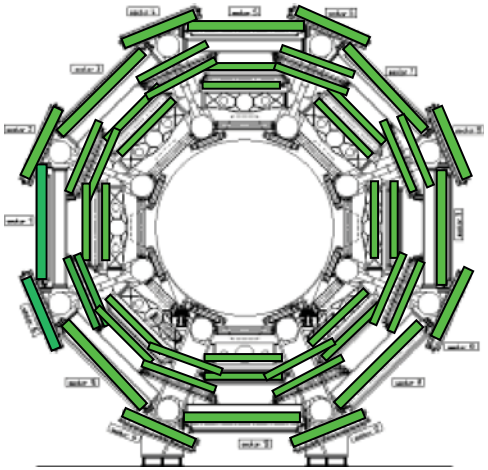
2004

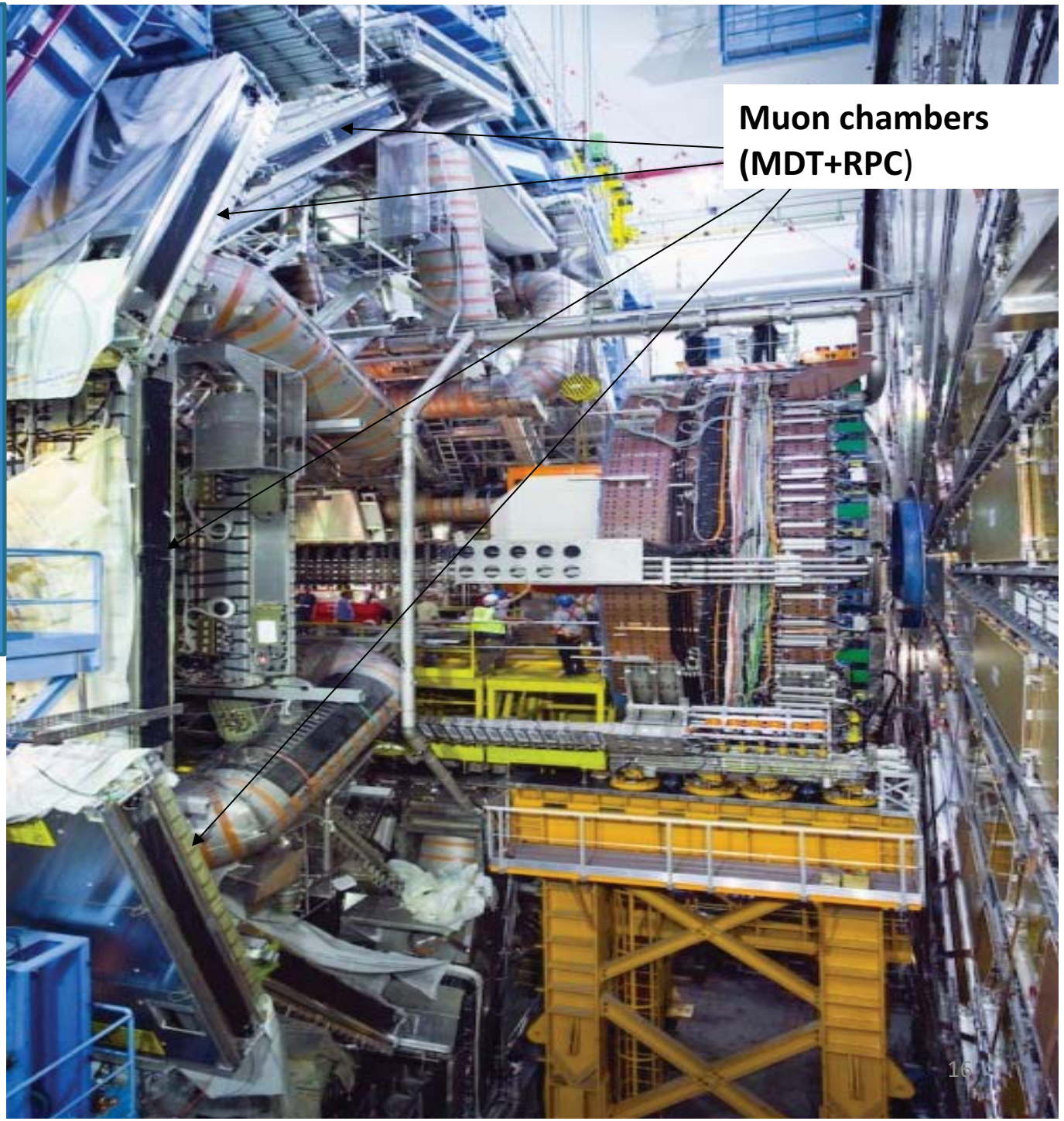

ATLAS Detector Under construction
October 2005

Lo Spettrometro di Muoni

di Atlas è una variante più complessa del semplice rivelatore a ionizzazione di cui abbiamo parlato

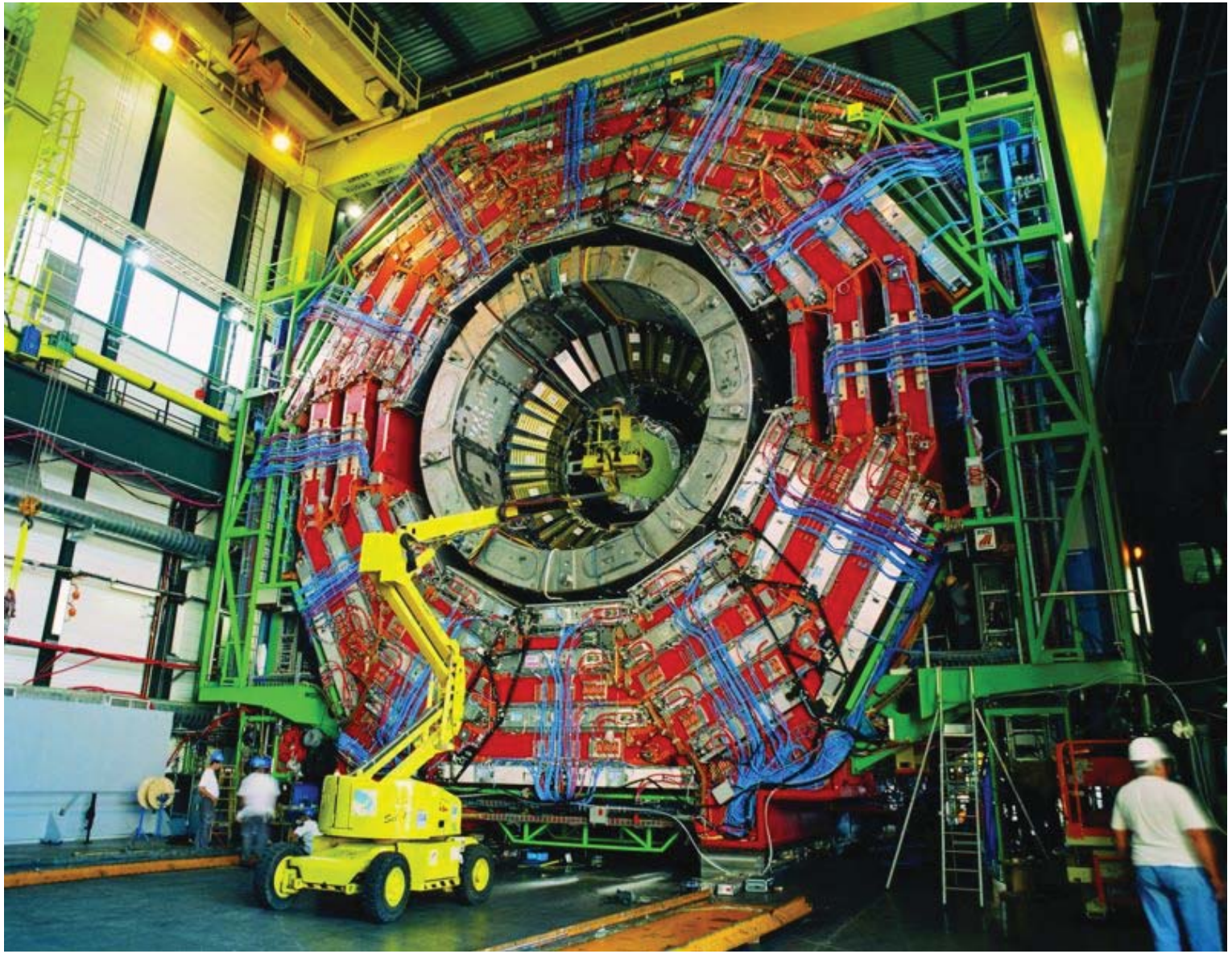
Napoli si è occupata degli RPC insieme a Bologna, Lecce e Roma





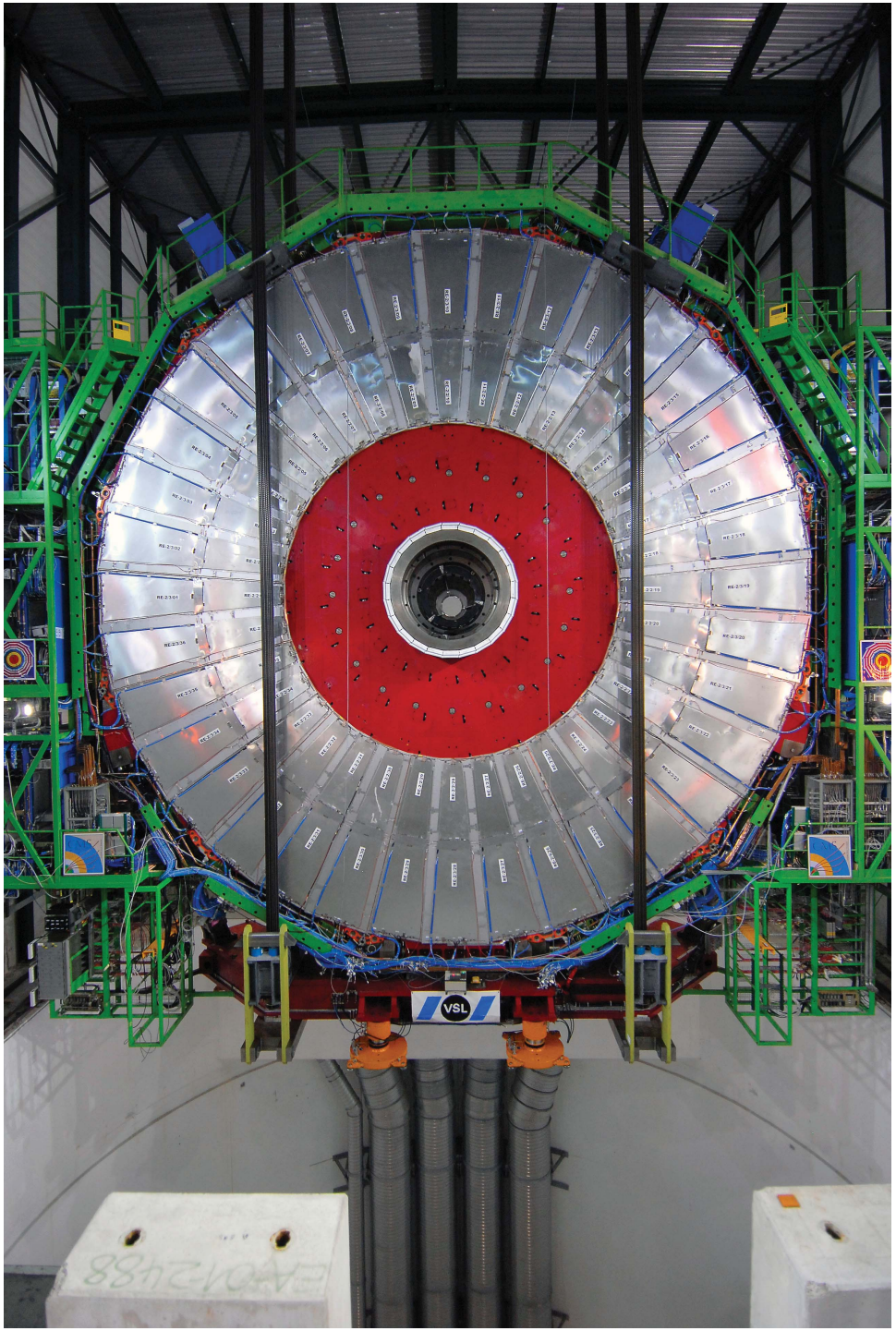
Installazione dell' ultimo elemento di ATLAS

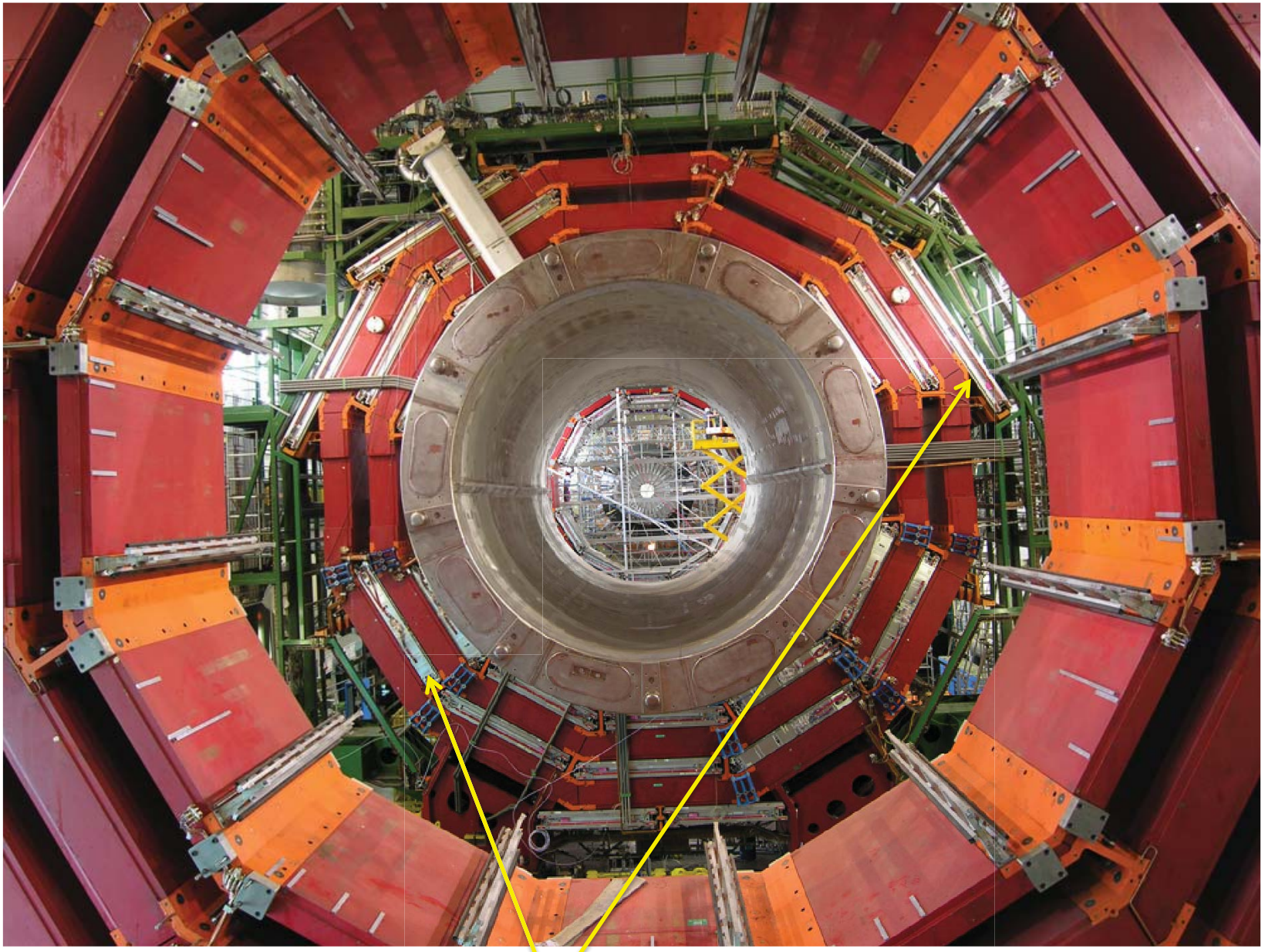
CMS invece è stato montato in superficie….



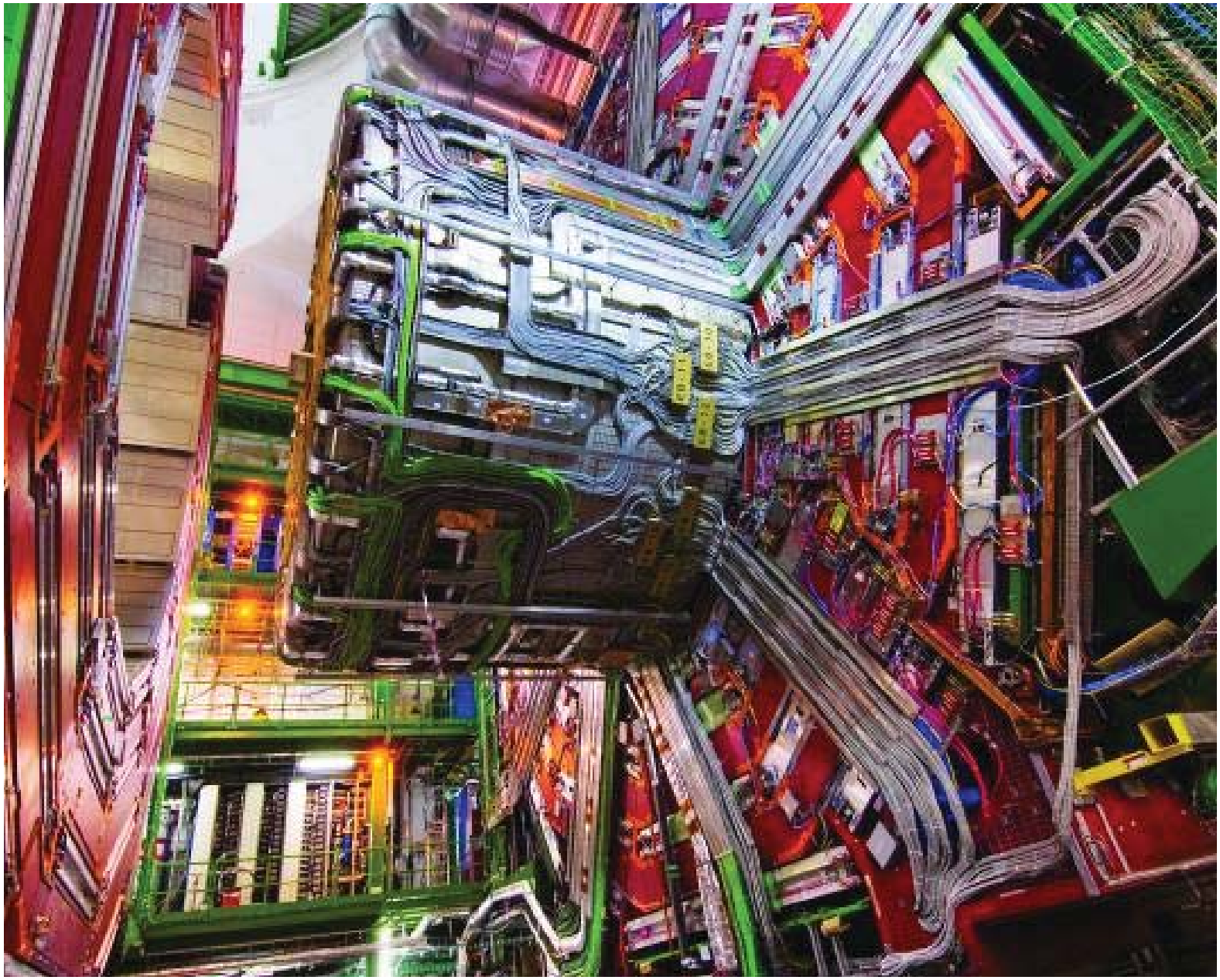
… e poi calato 100m sottoterra!

Foto della discesa di uno dei dischi nel pit



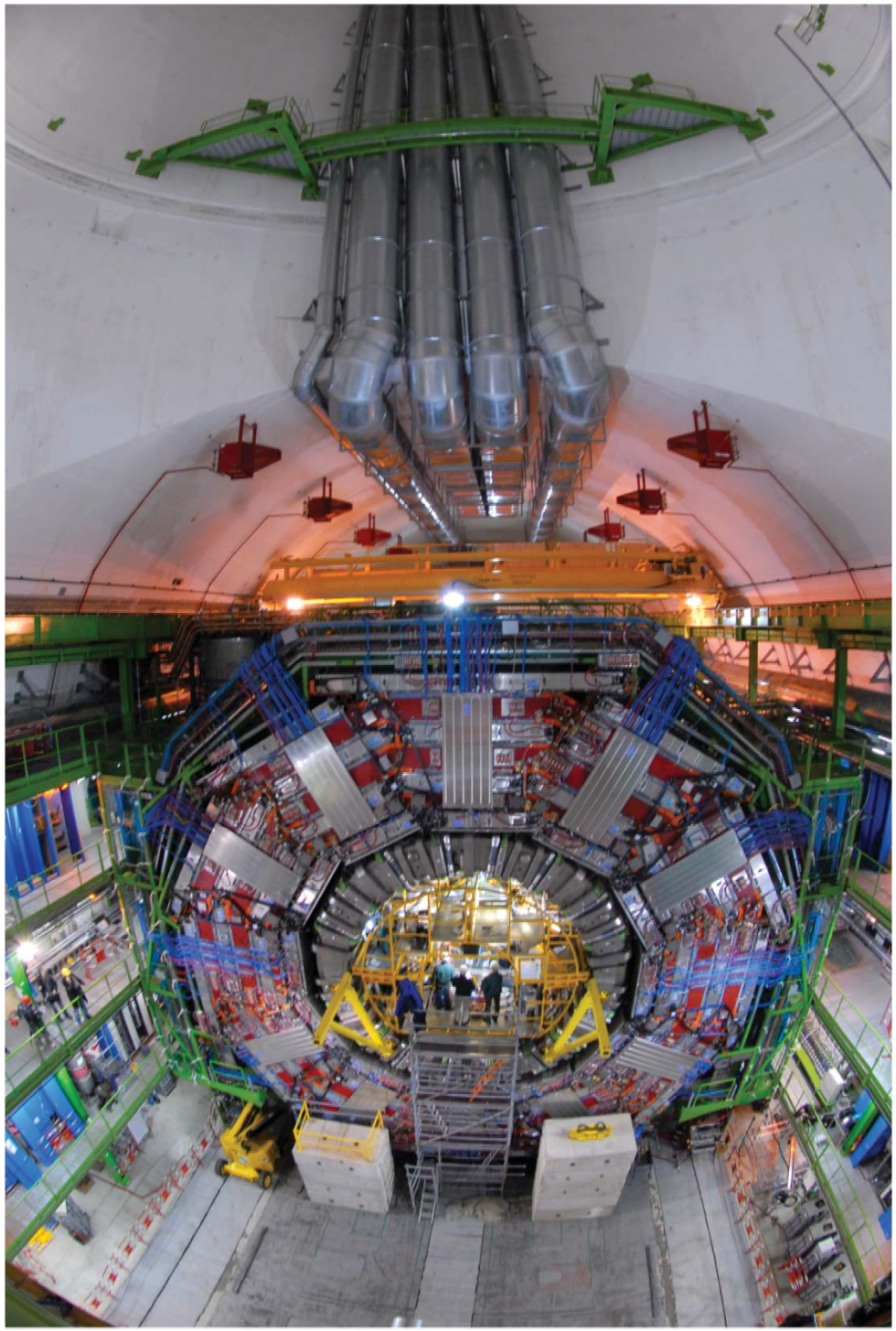


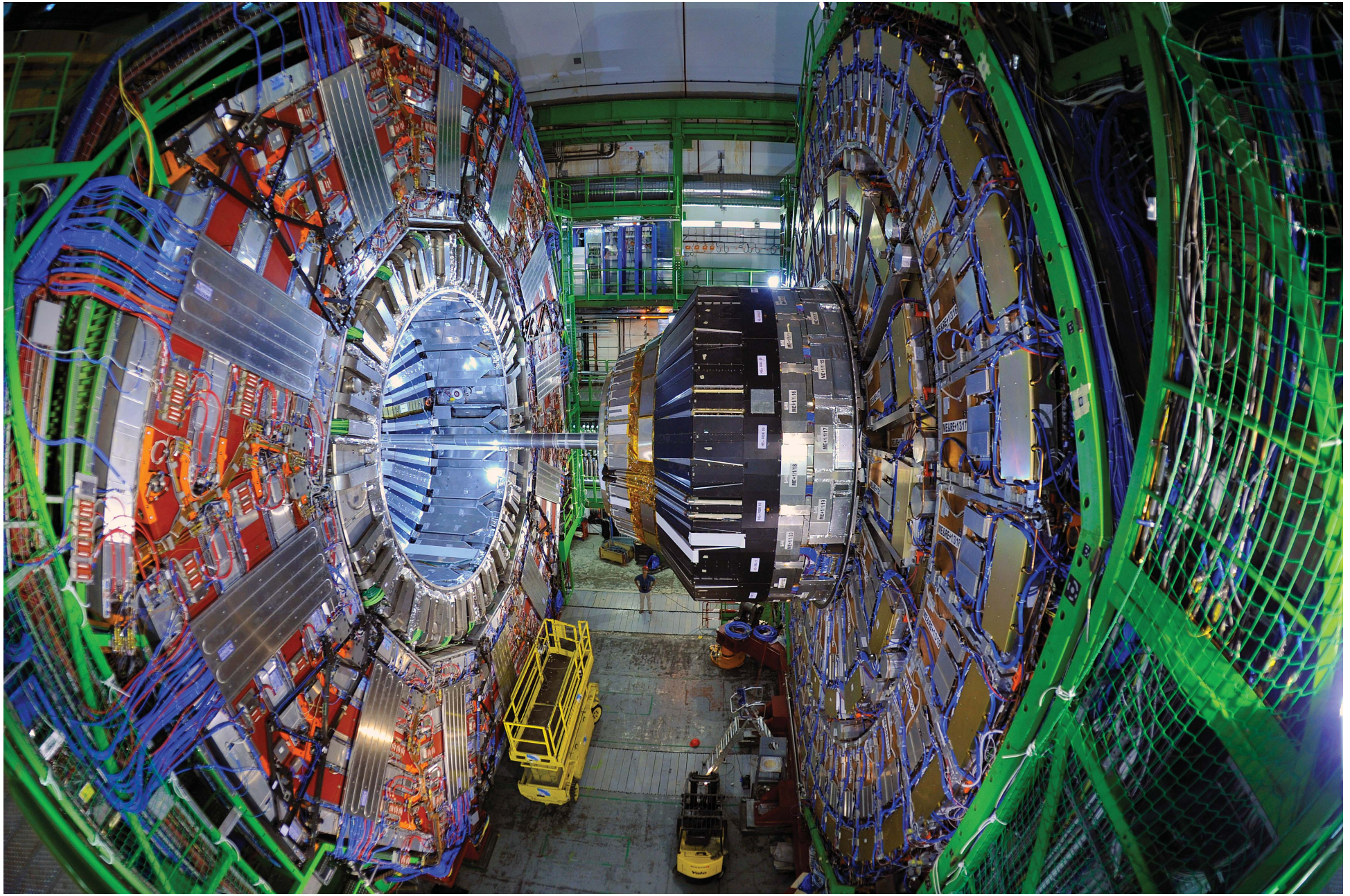
Napoli ha contribuito al sistema di camere per la rivelazione dei muoni (RPC)



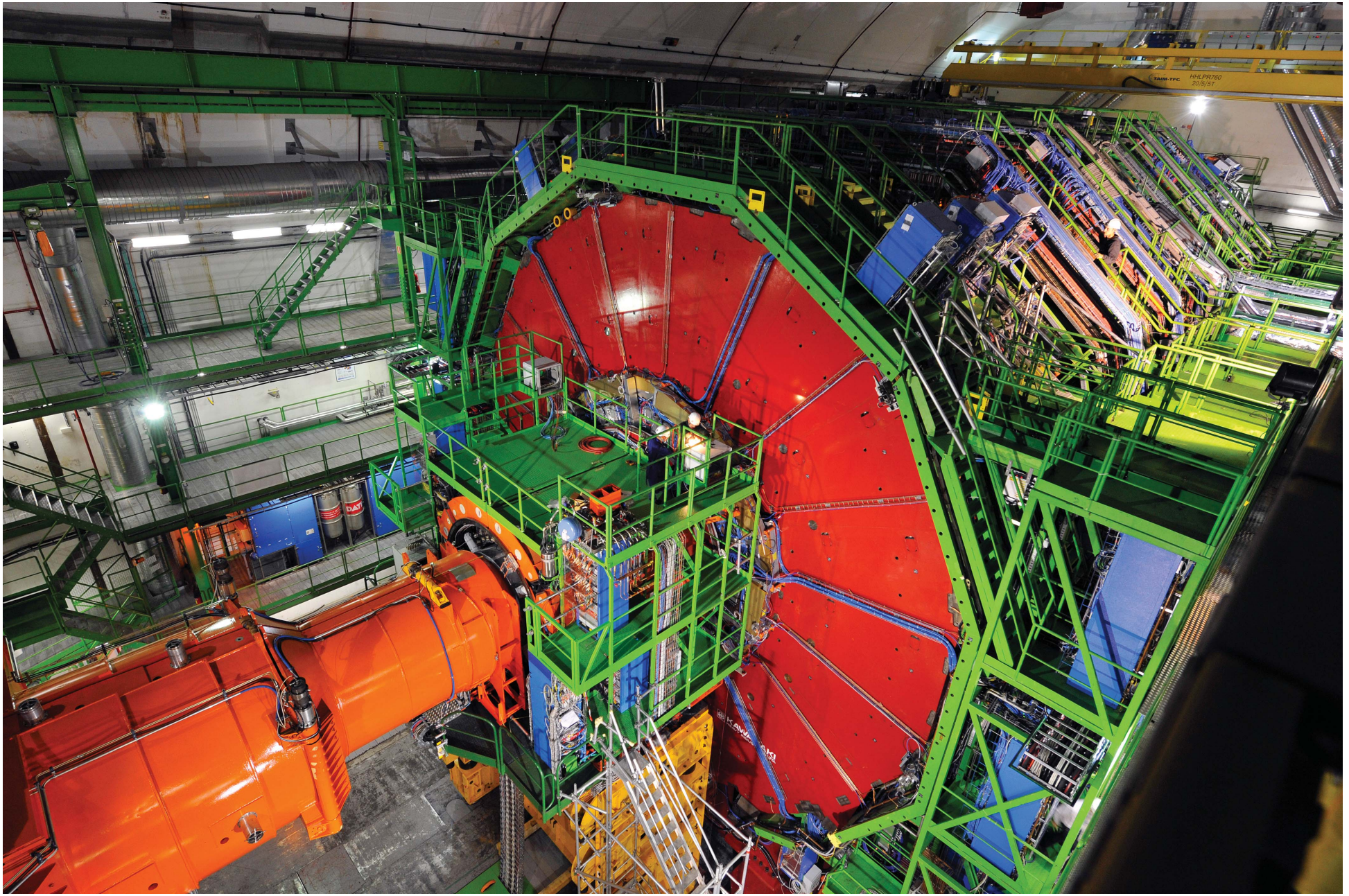
Particolare di CMS che mostra la complessità del cablaggio

Vista frontale di CMS nel pit durante la costruzione



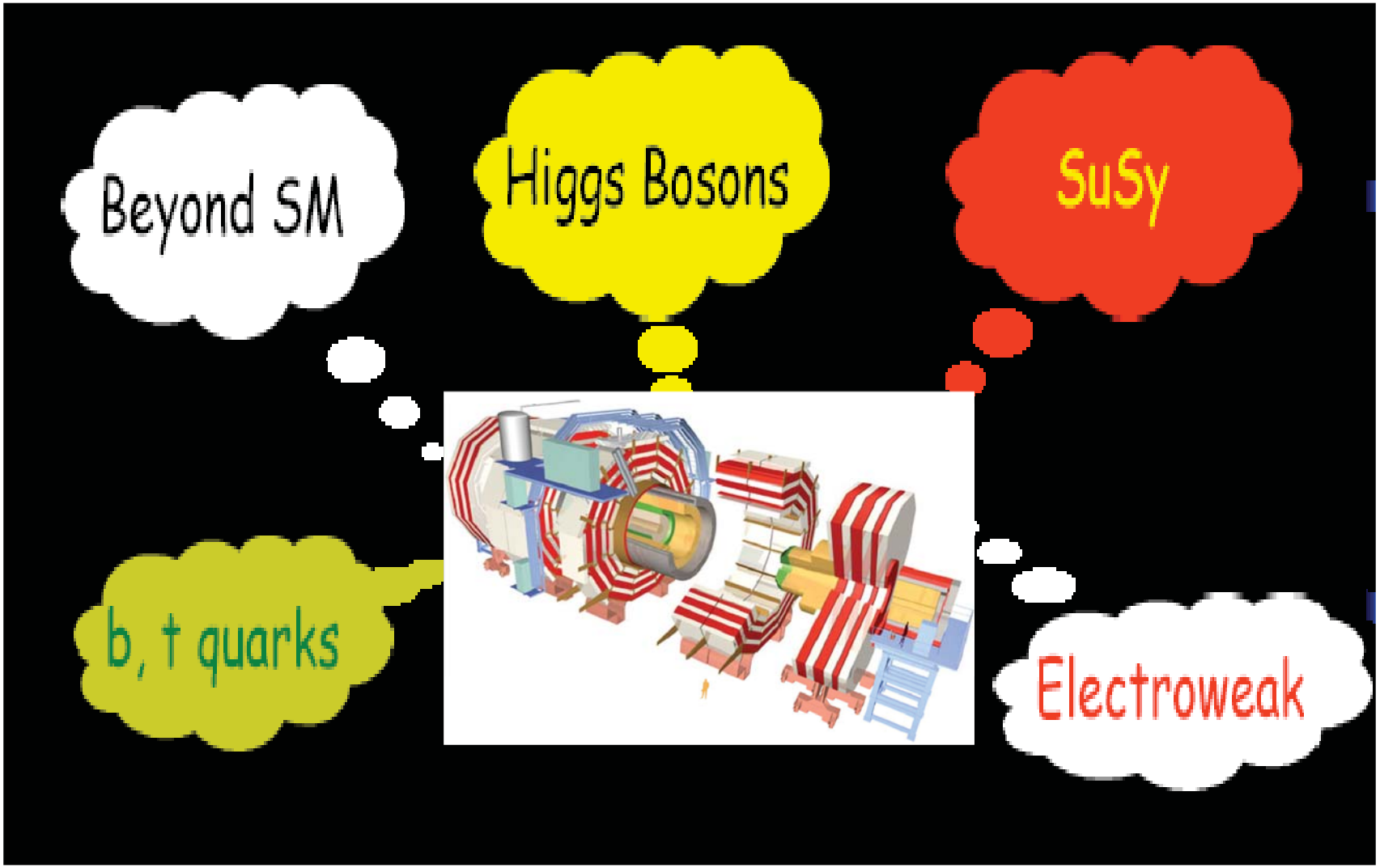


Vista laterale di CMS nel pit prima della chiusura

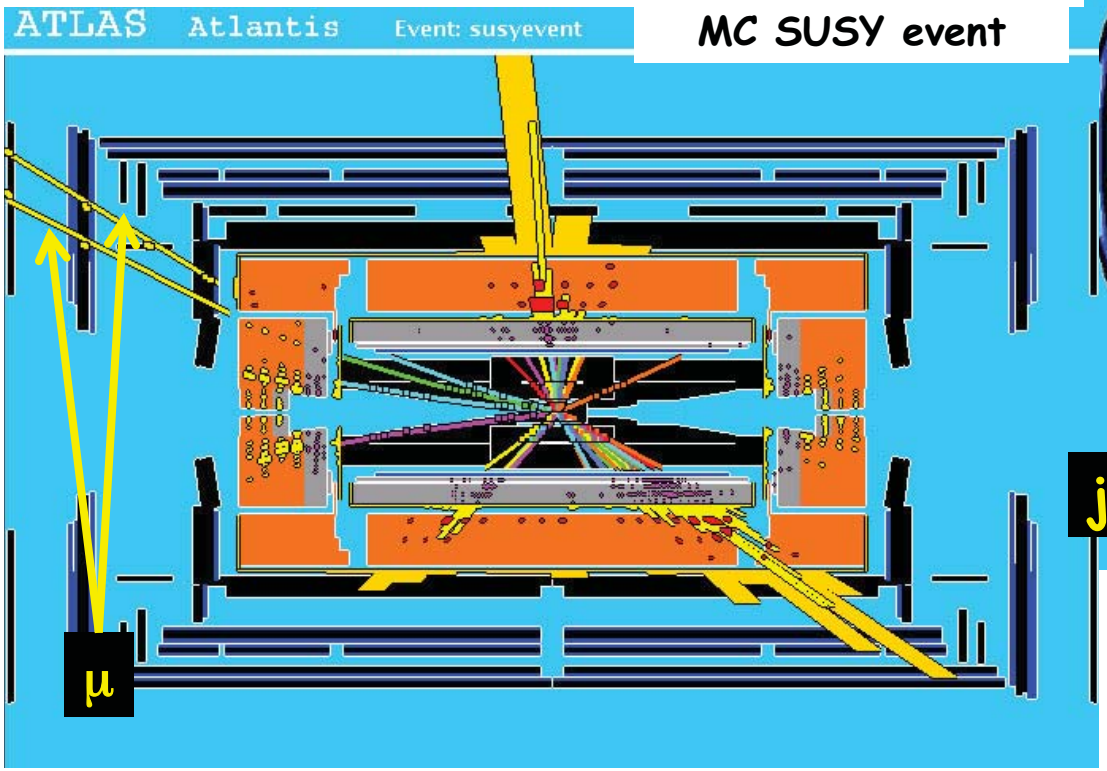


Vista dall'alto di CMS nel pit

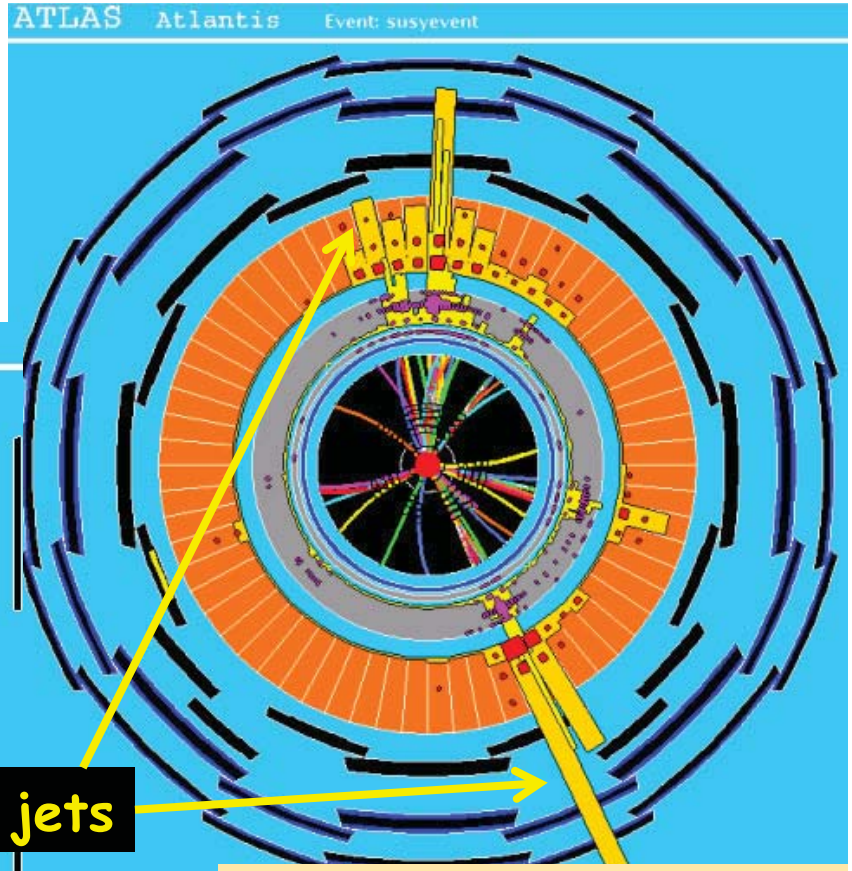
Obiettivi di 'fisica' ...



… come vediamo gli eventi?



MC SUSY event

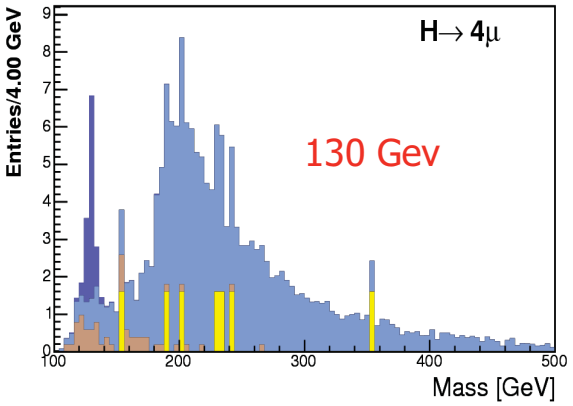


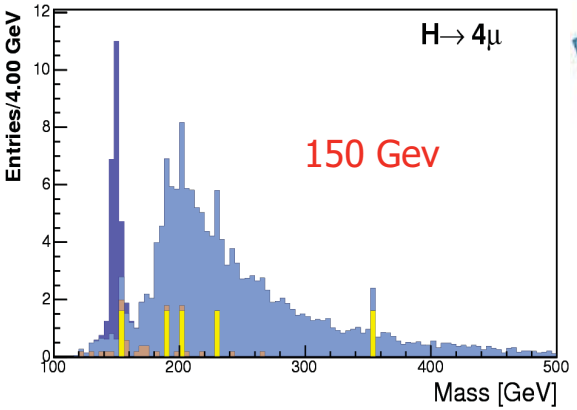
… ricostruendoli tramite misure di:

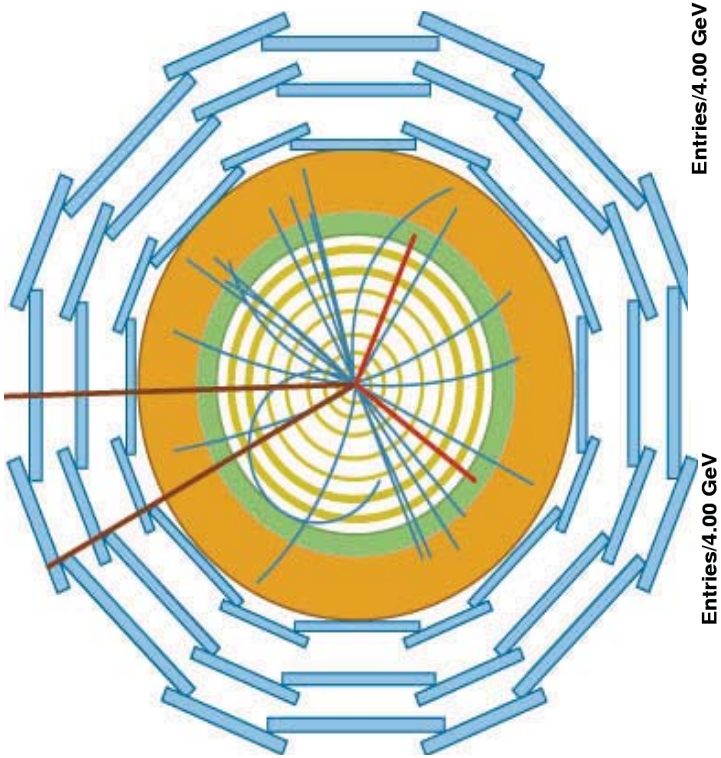
- traiettoria
- carica elettrica
- energia
- impulso
- massa
- vita media

… e producendo distribuzioni …

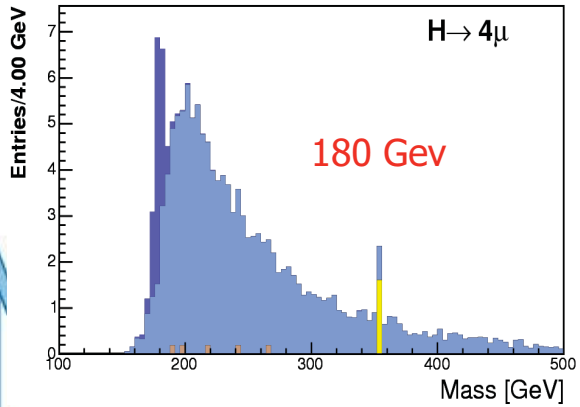
… esempio: ricerca dell'Higgs …

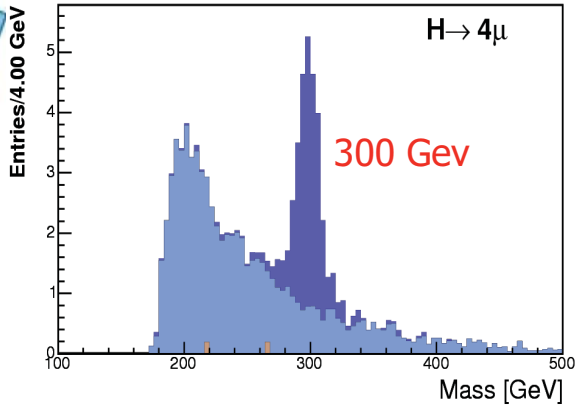






$H \rightarrow Z Z^* \rightarrow 4 l$





Massa invariante:

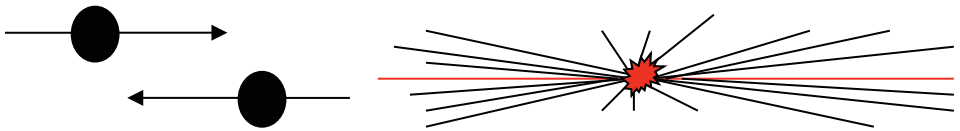
$$m = \frac{1}{c}\sqrt{\left(\sum_{i=1}^{N} p_i\right)^2} = \frac{1}{c}\sqrt{\left(\sum_{i=1}^{N} \frac{E_i}{c}\right)^2 - \left(\sum_{i=1}^{N} \overrightarrow{p_i}\right)^2}$$

fino ad ora l'unico Higgs visto in Atlas e CMS è stato… il Prof. Higgs….

… quanti eventi ?

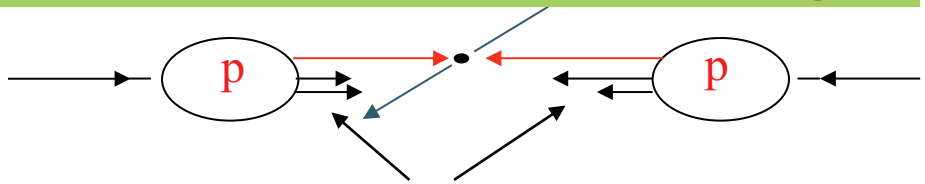
frequenza di eventi =
7×10^8 interazioni/s

Minimum bias events: collisioni tra protoni 'a grande distanza':

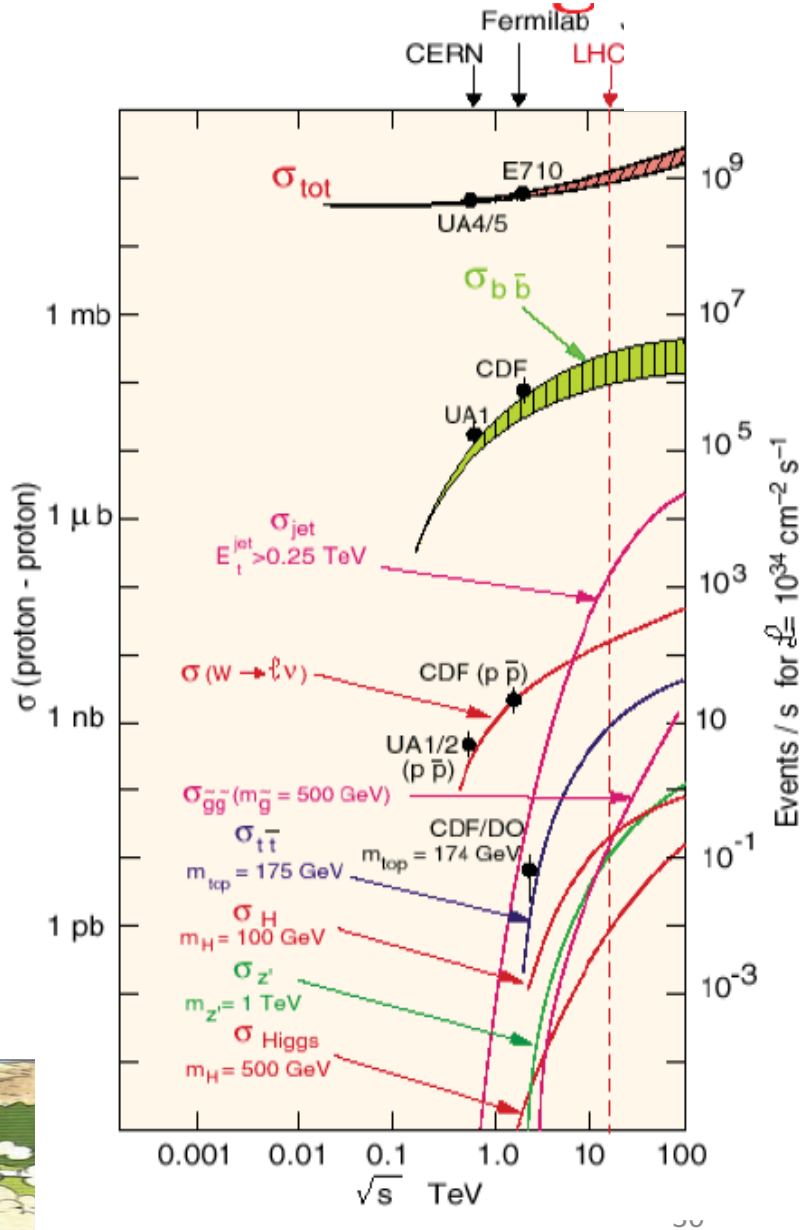


frequenza di collisione dei fasci = **40MHz**
→ circa 20 eventi di questo tipo si sovrappongono ad ogni bunch crossing.

Occasionamente: 'hard scattering'



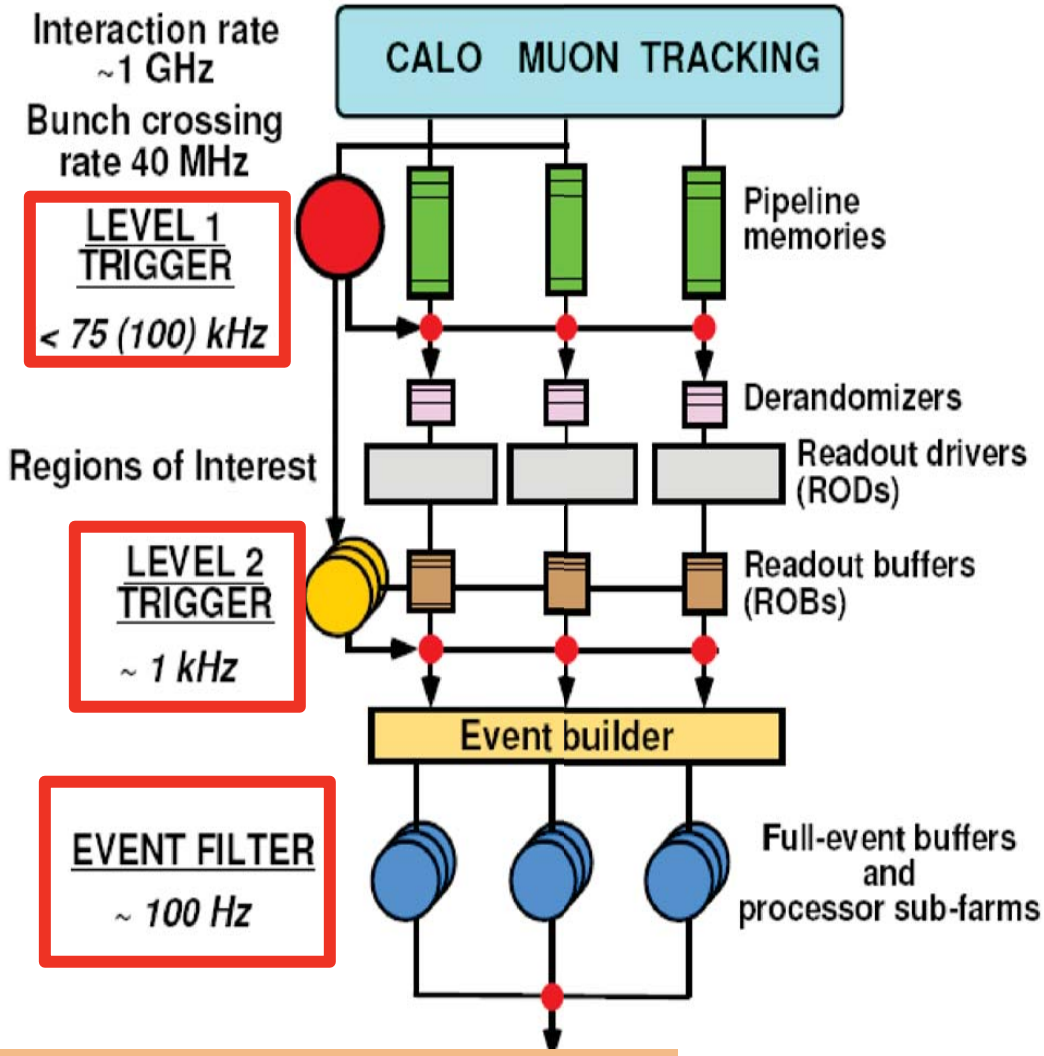
Spectator quarks



Trigger & DAQ

- collisioni:10^9/s
- collisioni che producono processi interessanti: ordine 100 al s
- collisioni che producono eventi rari di enorme interesse: 1 al giorno!

Sistema di Trigger e di DataAcQuisition per selezionare gli eventi interessanti e scriverli su disco

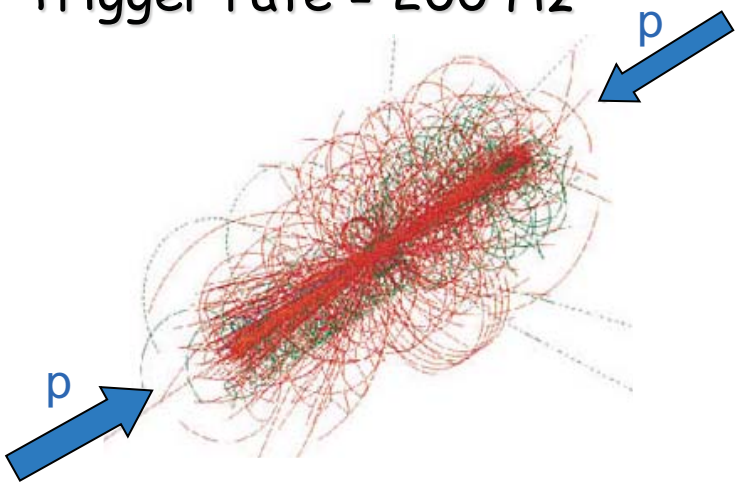


Napoli ha dato contributo sia hardware che software ad entrambi

gli eventi in Atlas & CMS…

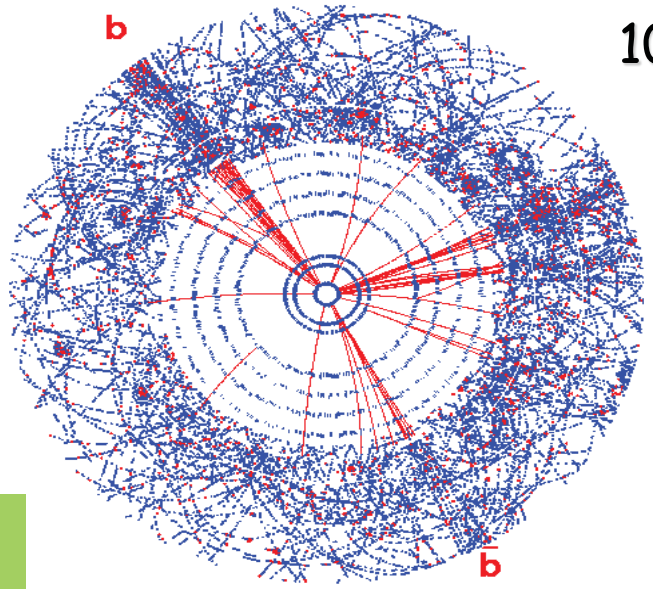
…sono molti….

Trigger rate = 200 Hz



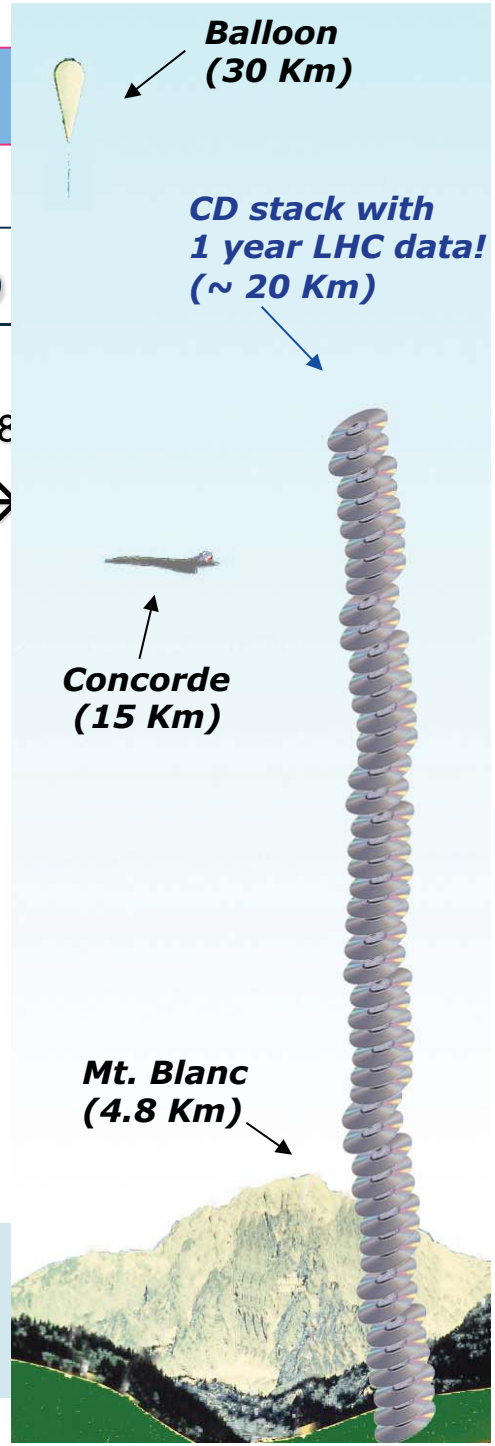
400MB al secondo!
1 CD ogni 2 secondi

H → bb event



…e sono

10^8 →

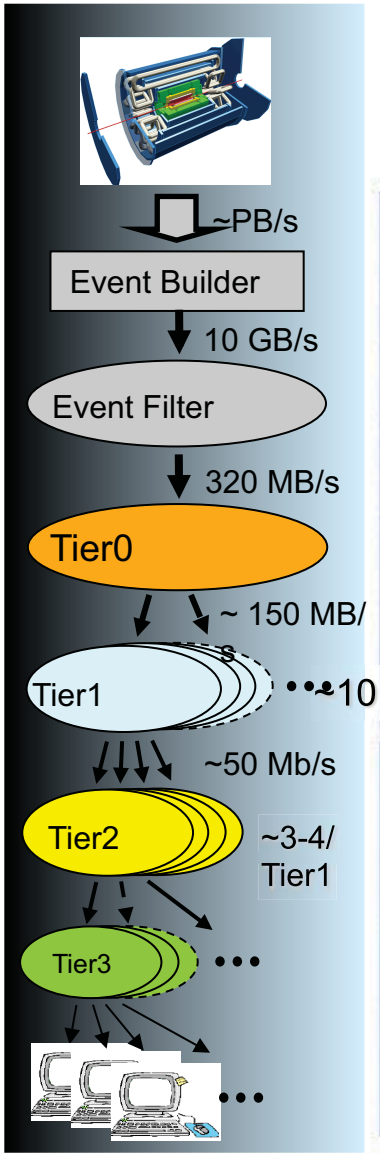


~4 PetaBytes/anno

necessaria un enorme potenza di calcolo e capacità di storage……

GRID Computing

Struttura di calcolo distribuita organizzata in livelli (tier):



Tier-0 at CERN ⇒ 10 Tier-1 ⇒ 35 Tier-2

Tier2 in Italia: 4 Atlas (Napoli), 3 CMS

Fasci @ LHC !

Novembre 2009:

→ prime collisioni a 450+450 GeV

Dicembre 2009:

→ **Collisioni @ 1,18+1,18 Tev!**

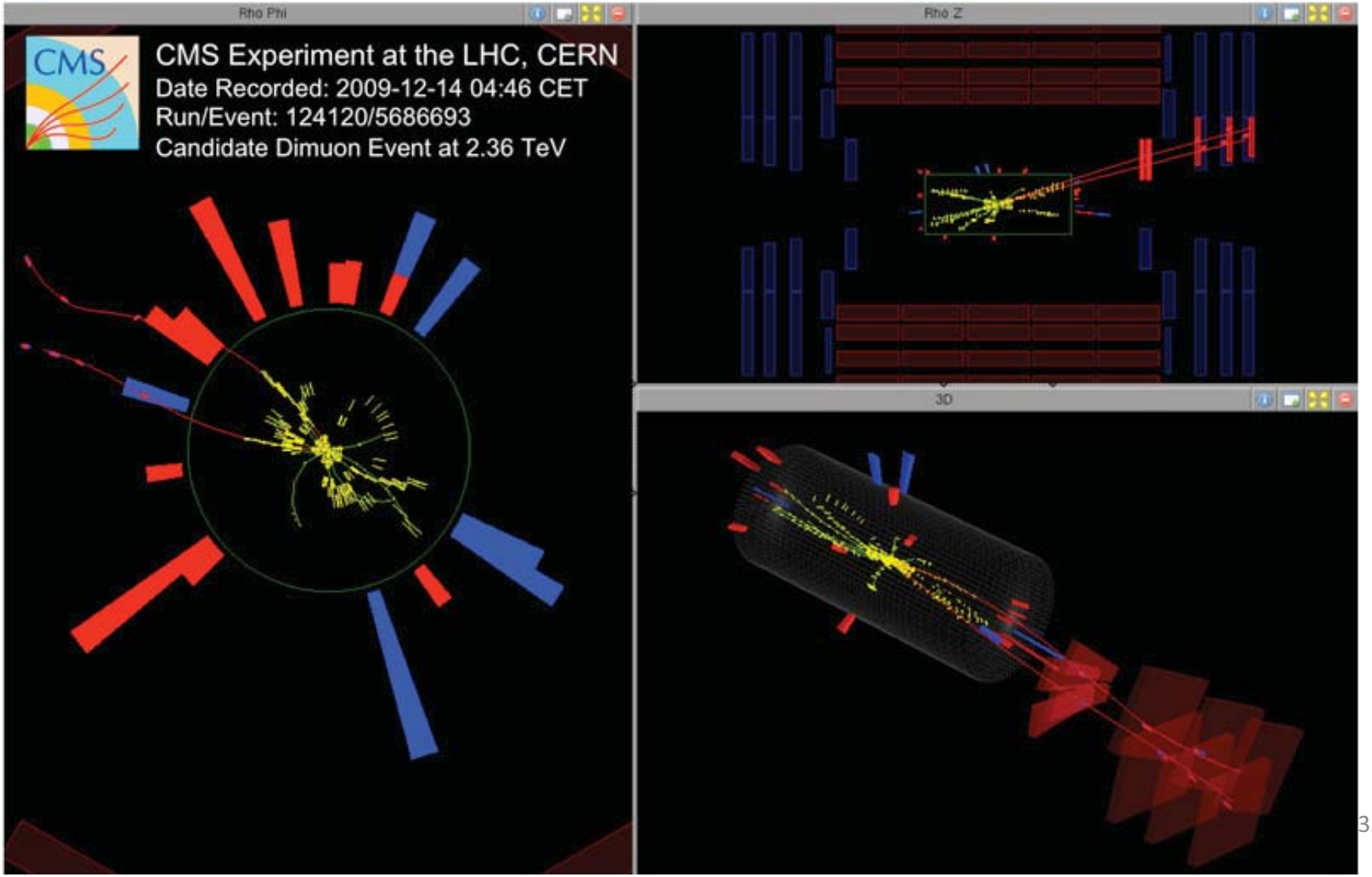
World record !!!

Febbraio 2010:

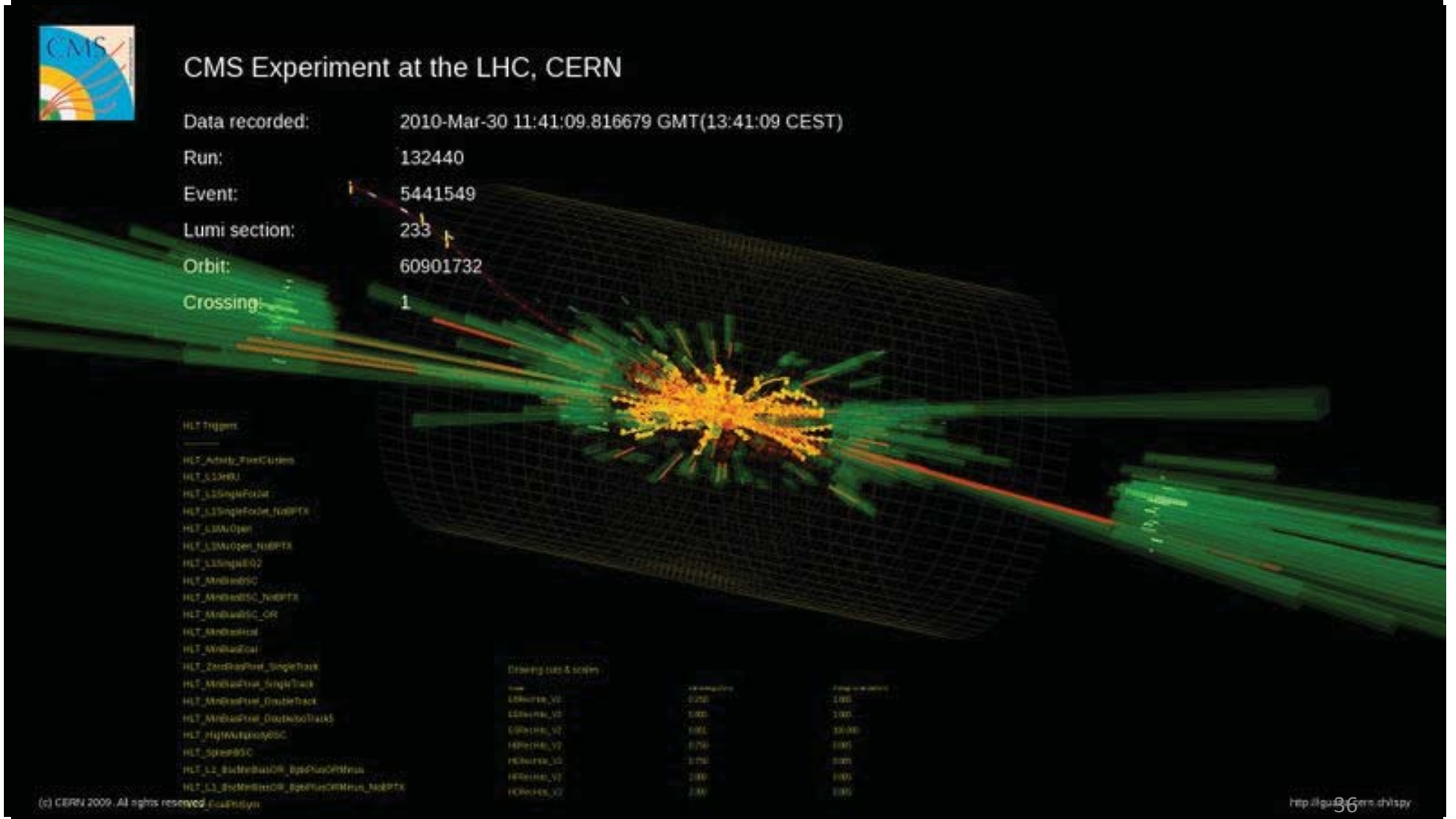
→ Collisioni a 3,5+3,5 TeV

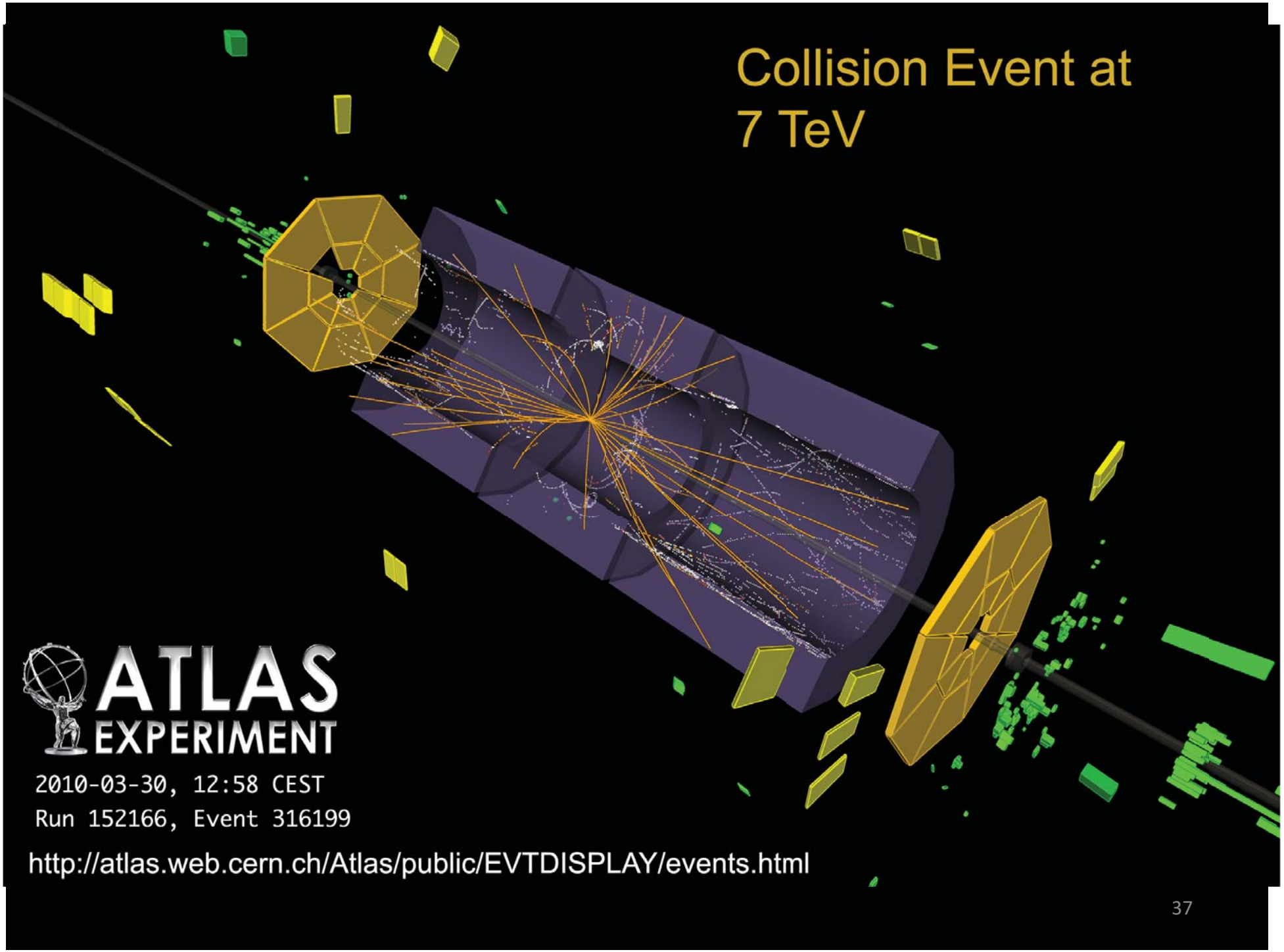
...qualcuno dei primi eventi...

CMS di-muon event @ 2,36 TeV



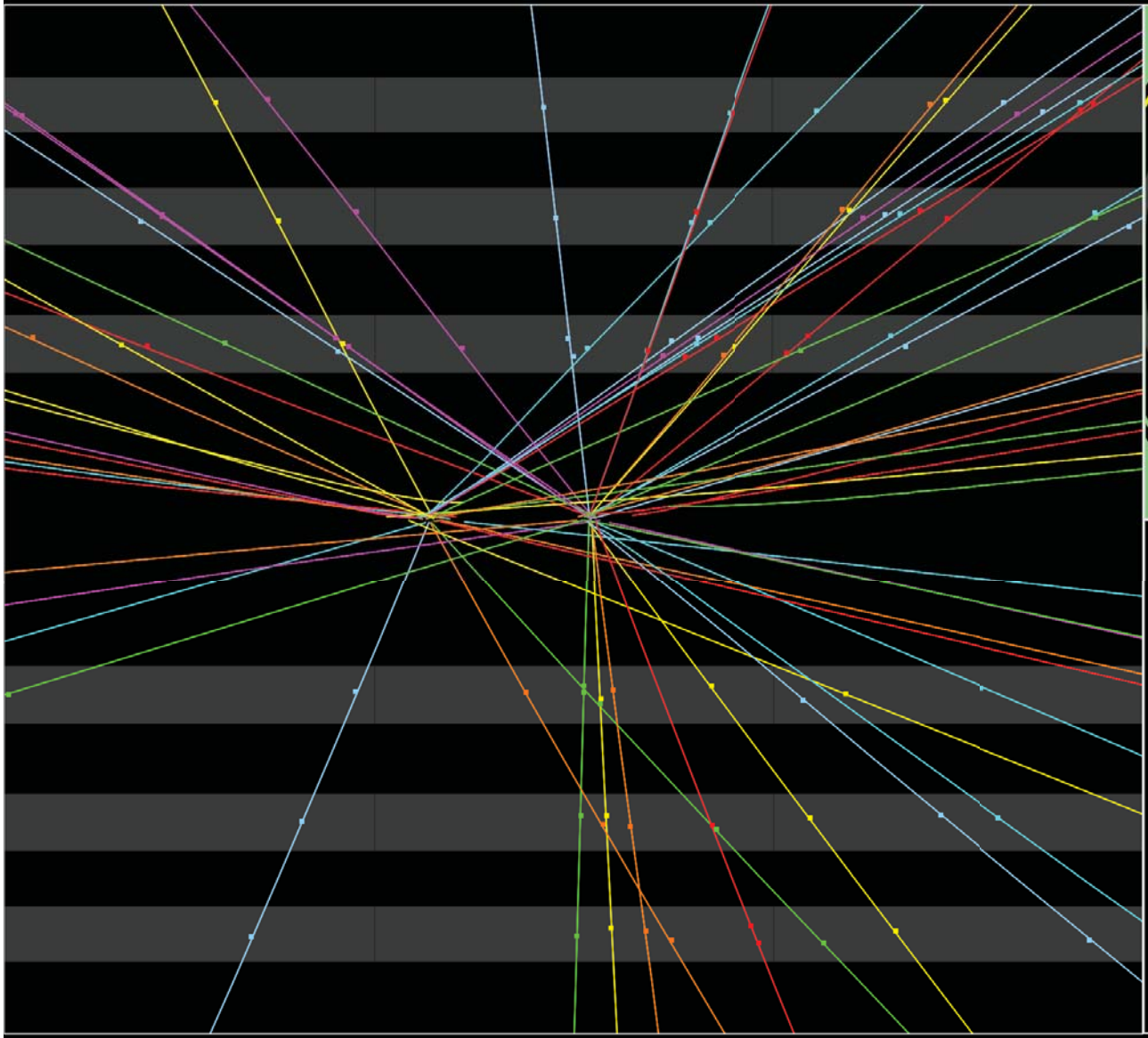
CMS event @ 7 TeV

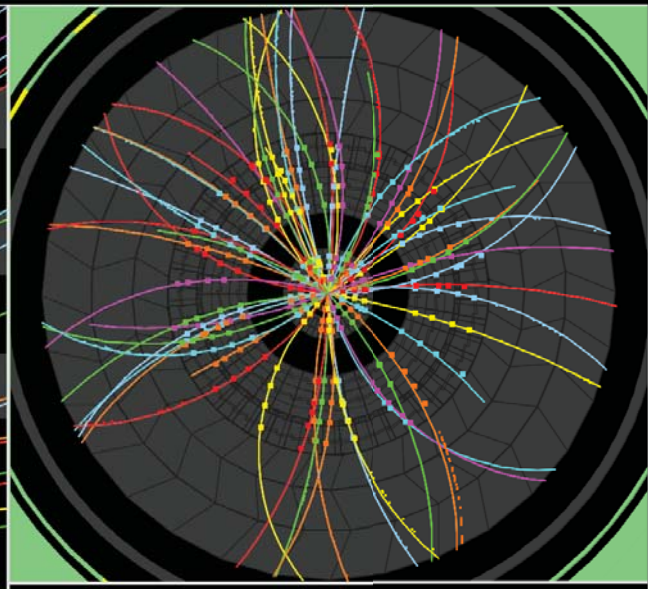



Collision Event at
7 TeV
ATLAS
EXPERIMENT
2010-03-30, 12:58 CEST
Run 152166, Event 316199
http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

Sovrapposizione di due collisioni !

Collision Event at 7 TeV with 2 Pile Up Vertices





ATLAS EXPERIMENT

Run Number: 152166, Event Number: 467774

Date: 2010-03-30 13:31:46 CEST

http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

…con questi dati…

LHC raggiungerà l'energia (14TeV) e la luminosità di progetto (10^{34} $cm^{-2}s^{-1}$) per passi (2012)
Fino ad ora:

- bunches 2x2, carica/bunch= 10^{10} p/bch, → $L \sim 10^{28} cm^{-2}s^{-1}$
- energia nel CM= 7TeV
- $L_{int} \sim 10\ nb^{-1}$

1) calibrare il rivelatore ed il trigger con canali di fisica ben noti

2) 'riscoprire' e misurare i parametri del Modello Standard a 7TeV

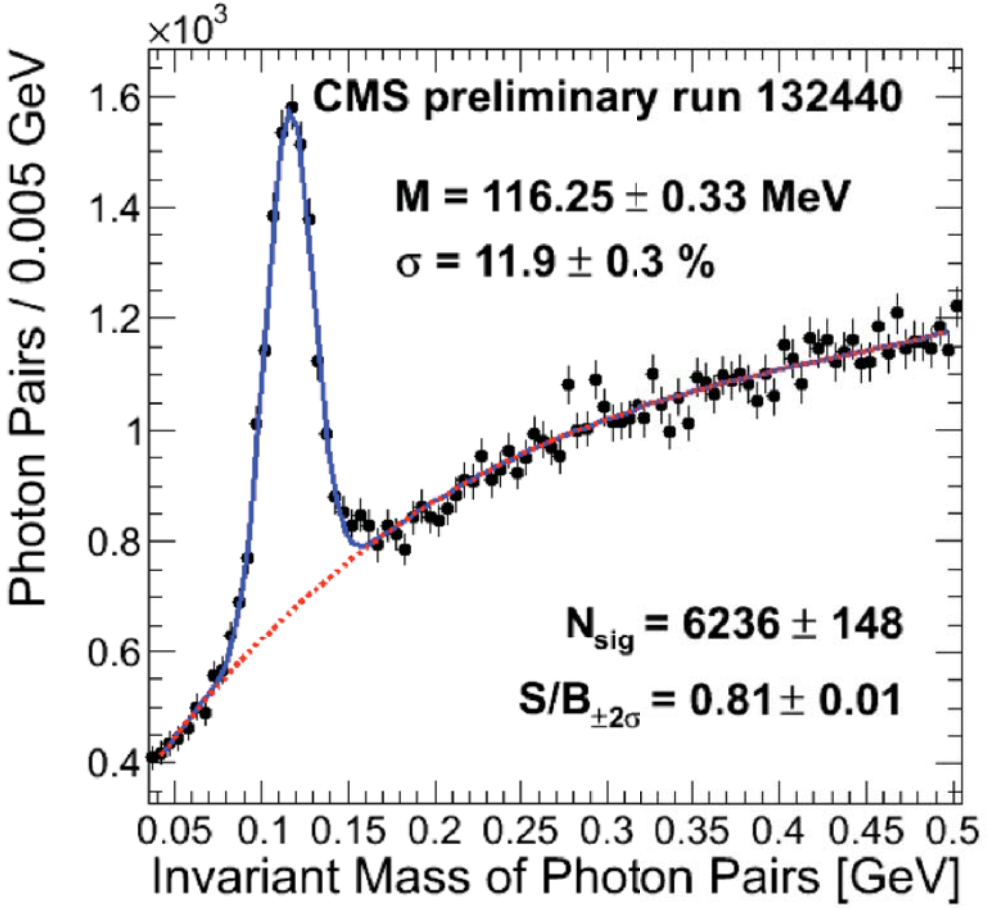
3) sempre 'aperti' ad eventuali scoperte…

Prime distribuzioni: π^0

- mesone (quarks u,d)
- m=135,0 MeV/c^2
- τ=8,4×10^{-17} s

- Decade nel 98,8% in:

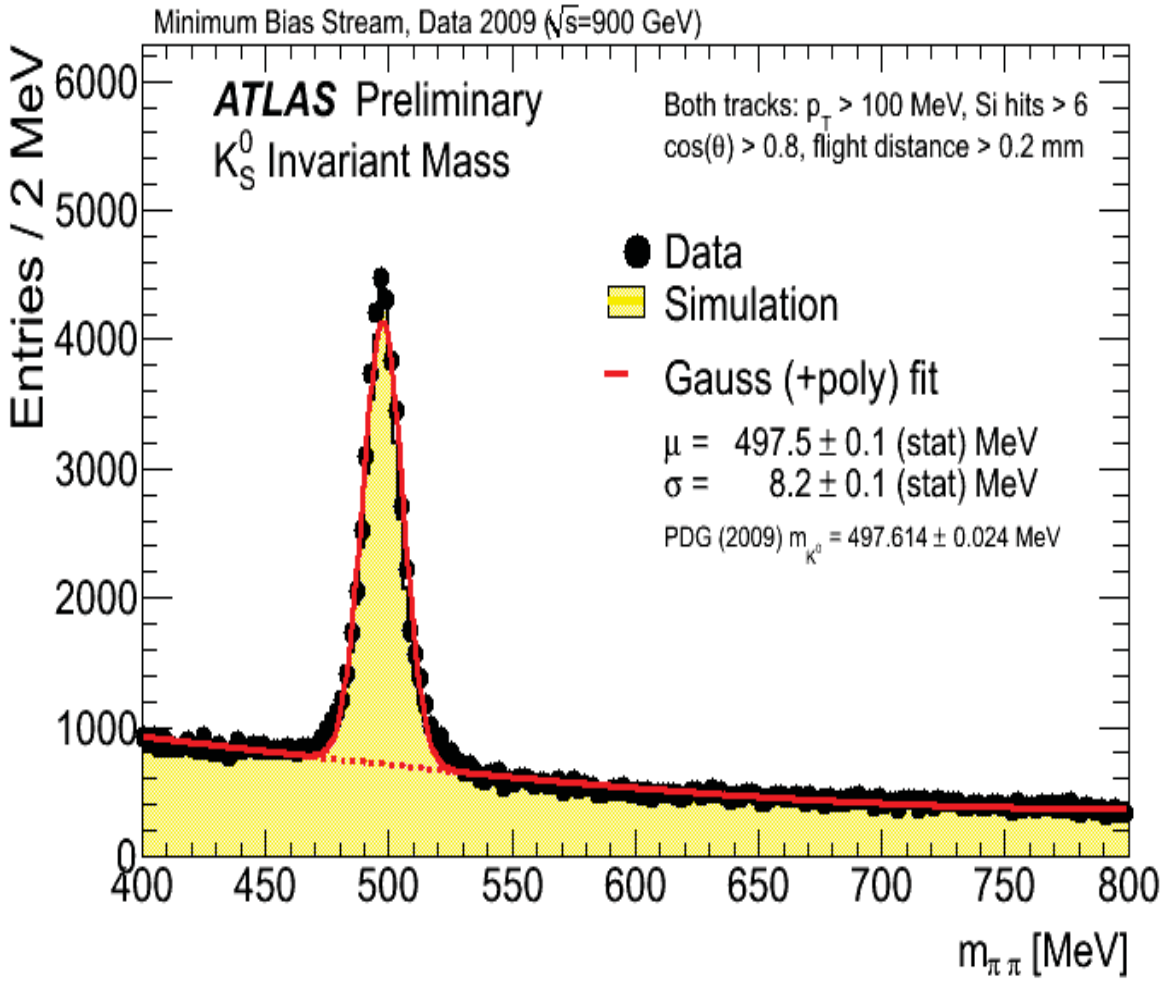
  $\pi^0 \rightarrow \gamma\gamma$



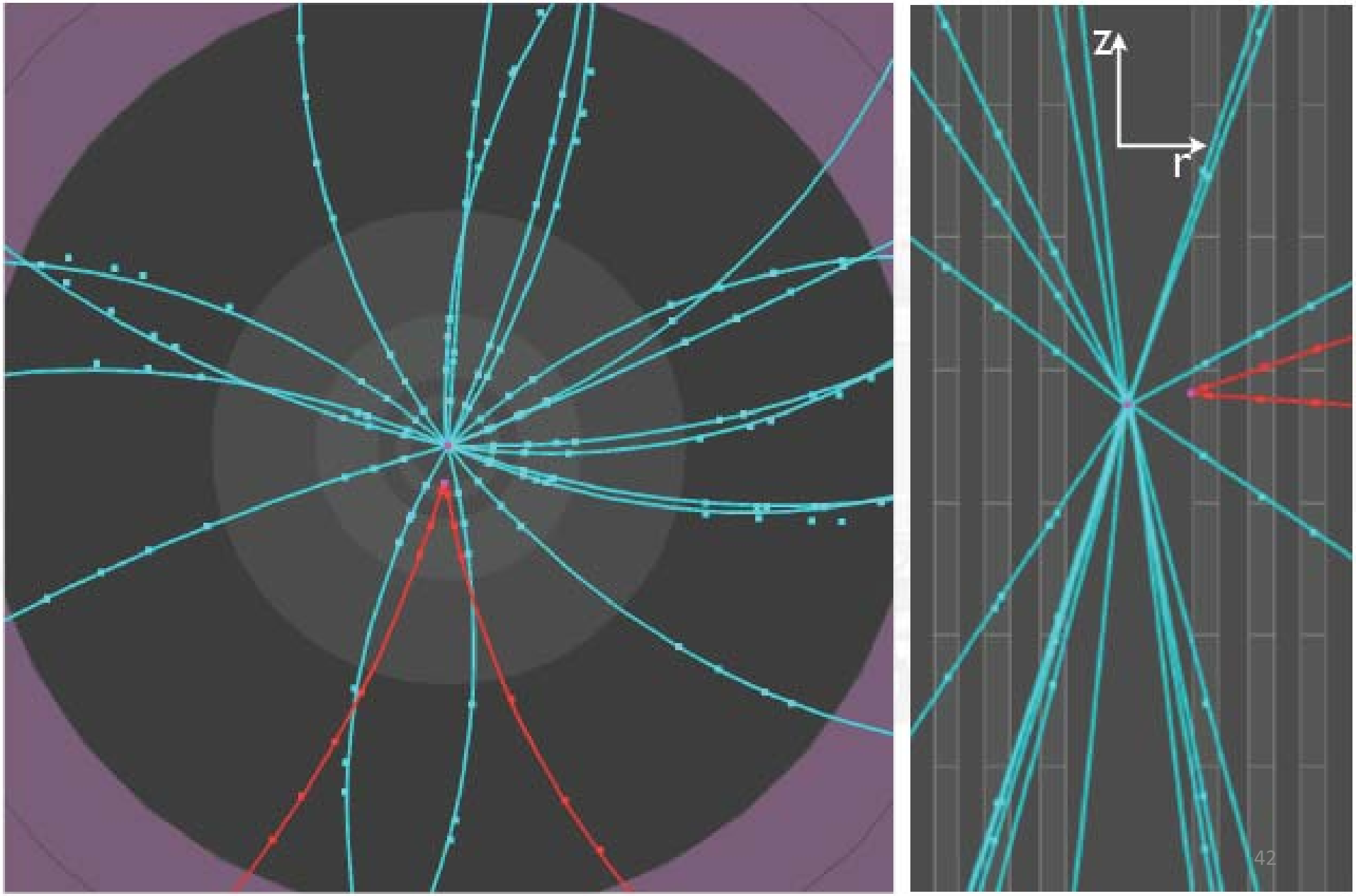
Prime distribuzioni: K^0_s

- mesone (quarks d,s)
- m=497.6MeV
- $\tau = 8.953 \times 10^{-11}$ s

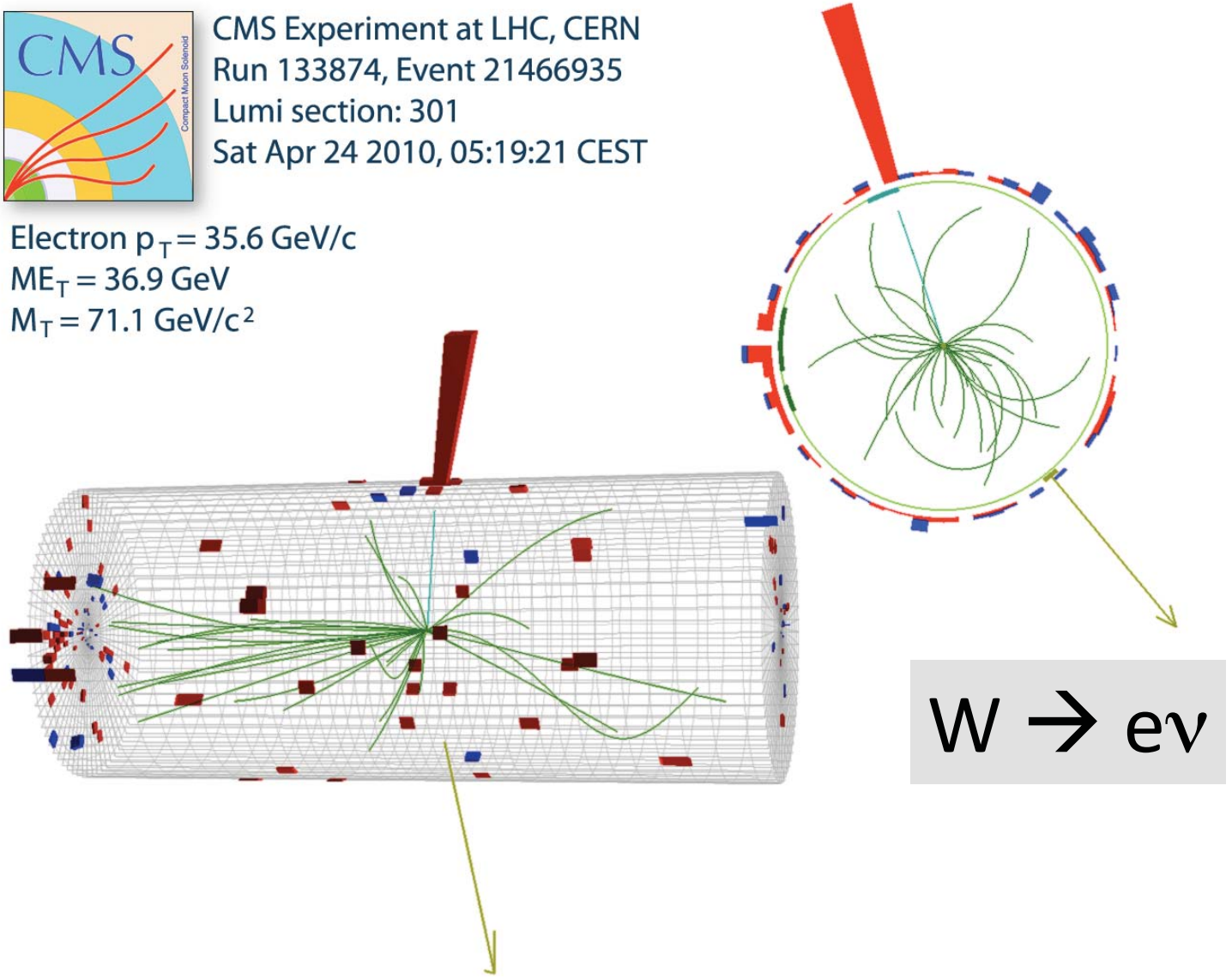
- Decade nel 31% in $K^0_s \rightarrow \pi^+\pi^-$



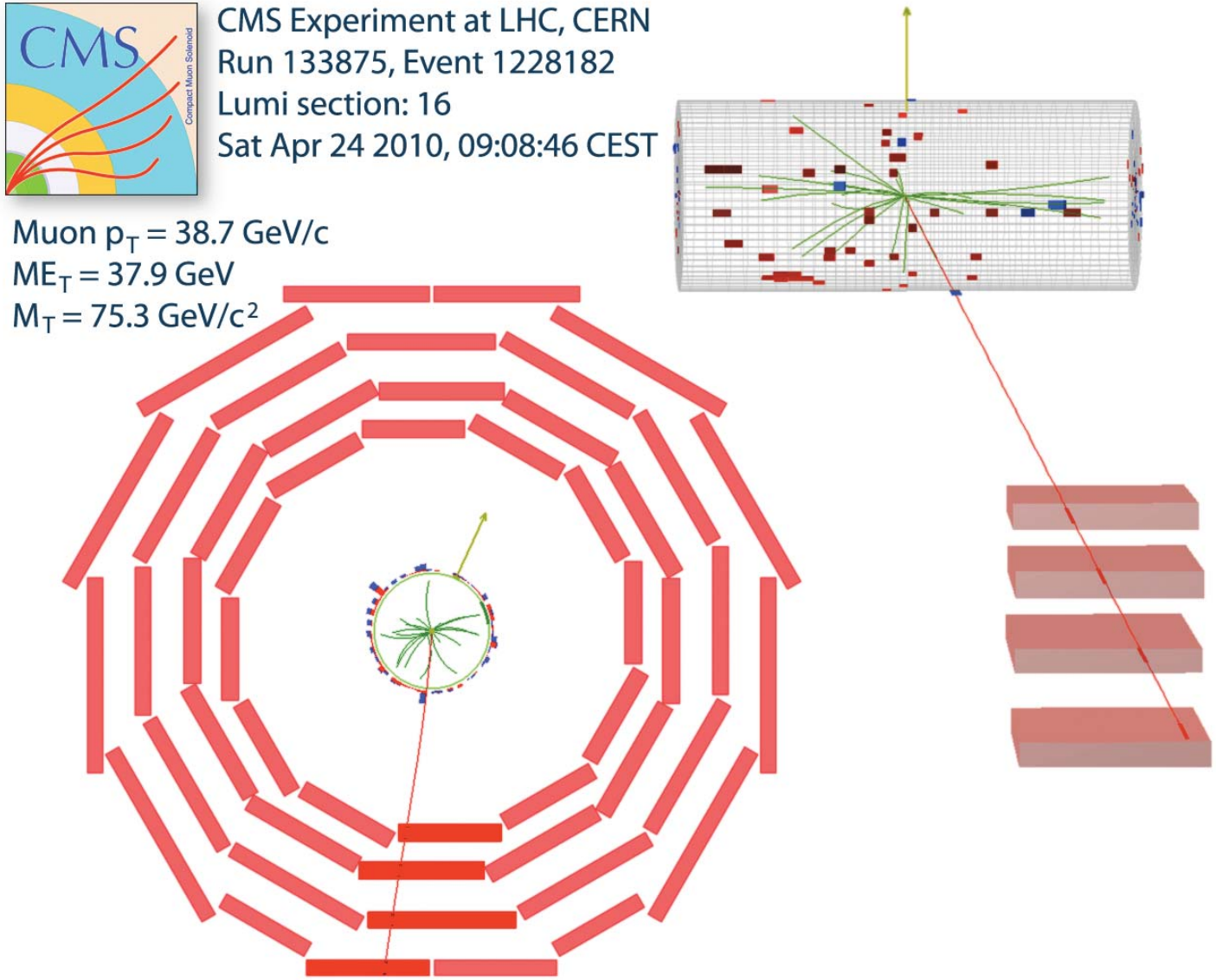
$K^0_s \rightarrow \pi^+\pi^-$ event display



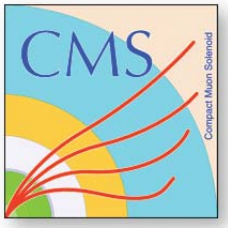
…primi eventi ‘rari’ interessanti…



evento W → μν

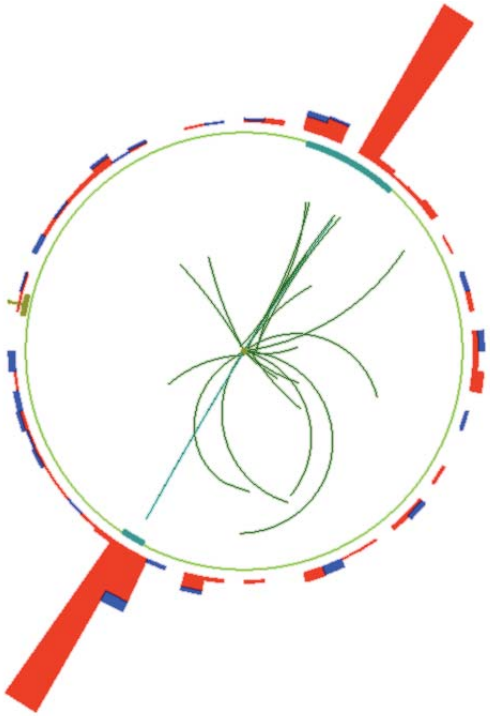

CMS
Compact Muon Solenoid
CMS Experiment at LHC, CERN
Run 133875, Event 1228182
Lumi section: 16
Sat Apr 24 2010, 09:08:46 CEST
Muon p_T = 38.7 GeV/c
ME_T = 37.9 GeV
M_T = 75.3 GeV/c^2

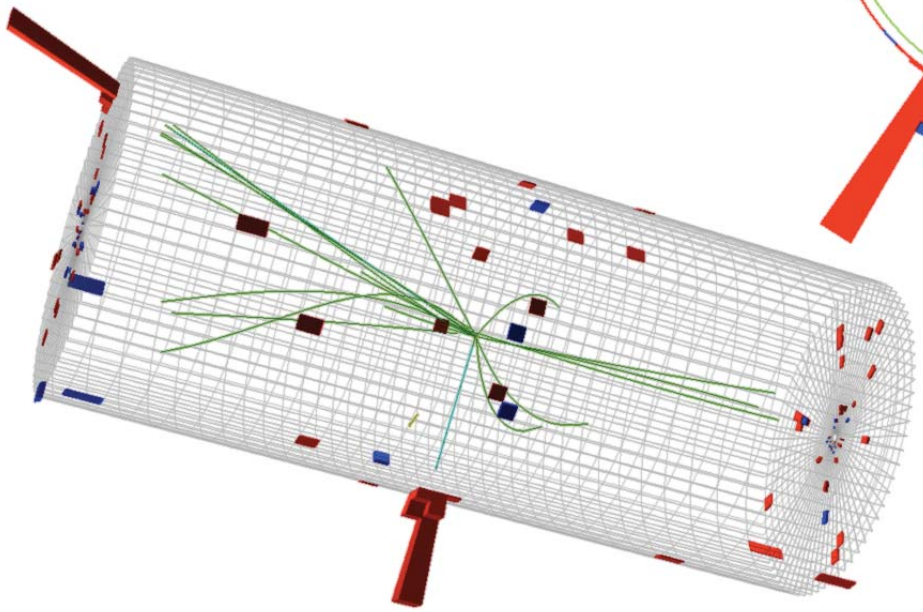
evento Z → e^+ e^-



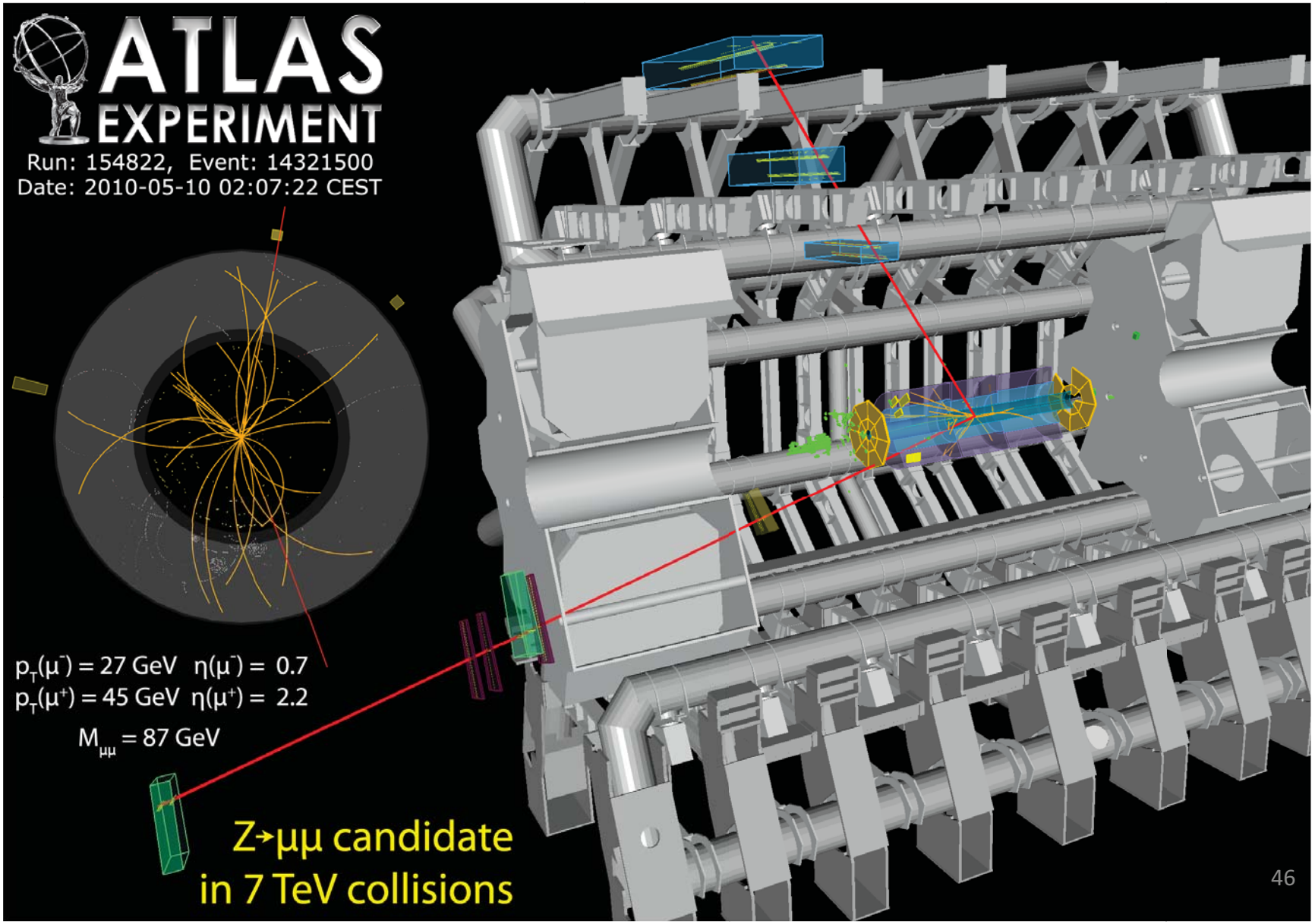
CMS Experiment at LHC, CERN
Run 133877, Event 28405693
Lumi section: 387
Sat Apr 24 2010, 14:00:54 CEST

Electrons p_T = 34.0, 31.9 GeV/c
Inv. mass = 91.2 GeV/c^2

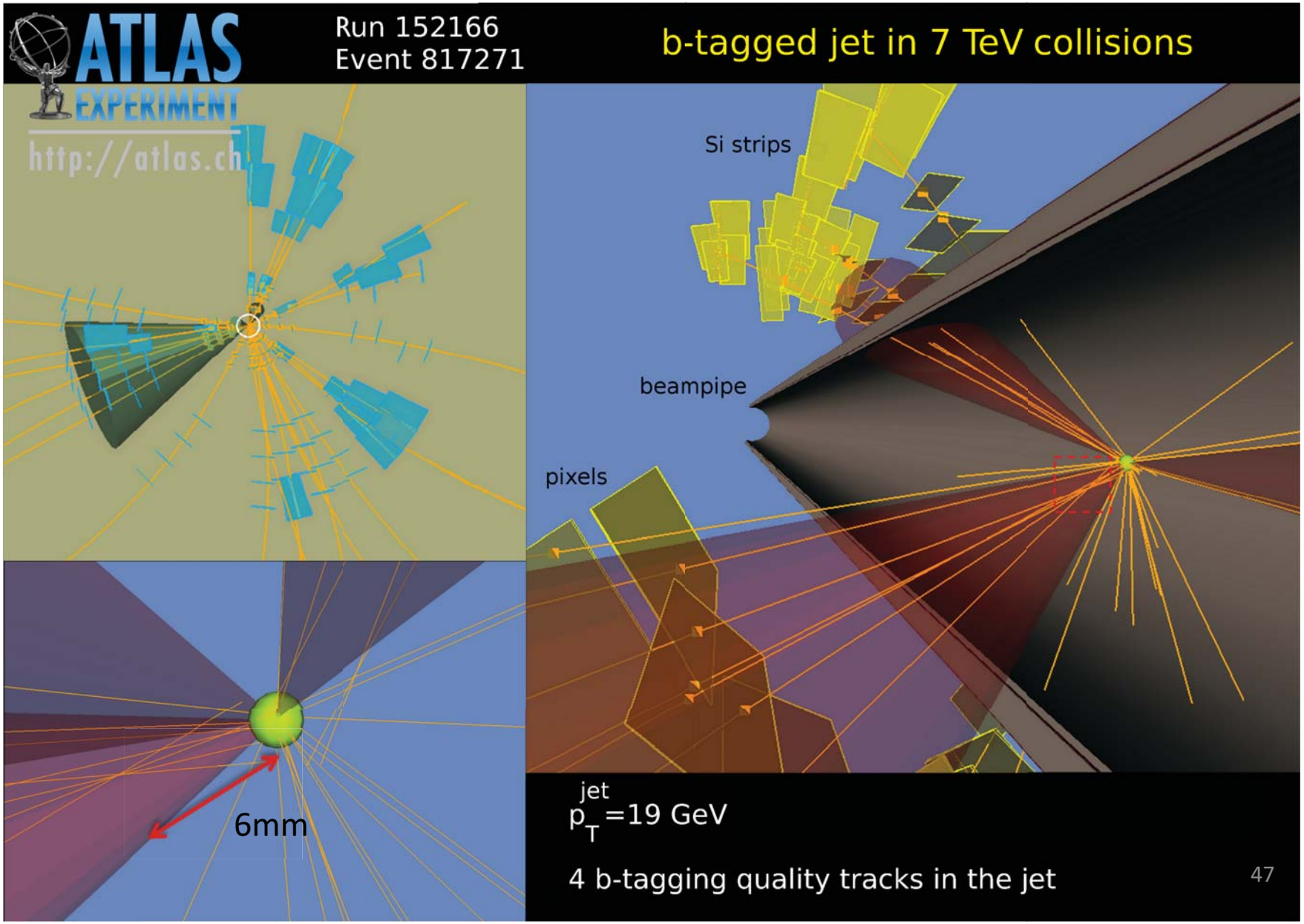




evento Z → $\mu^+ \mu^-$



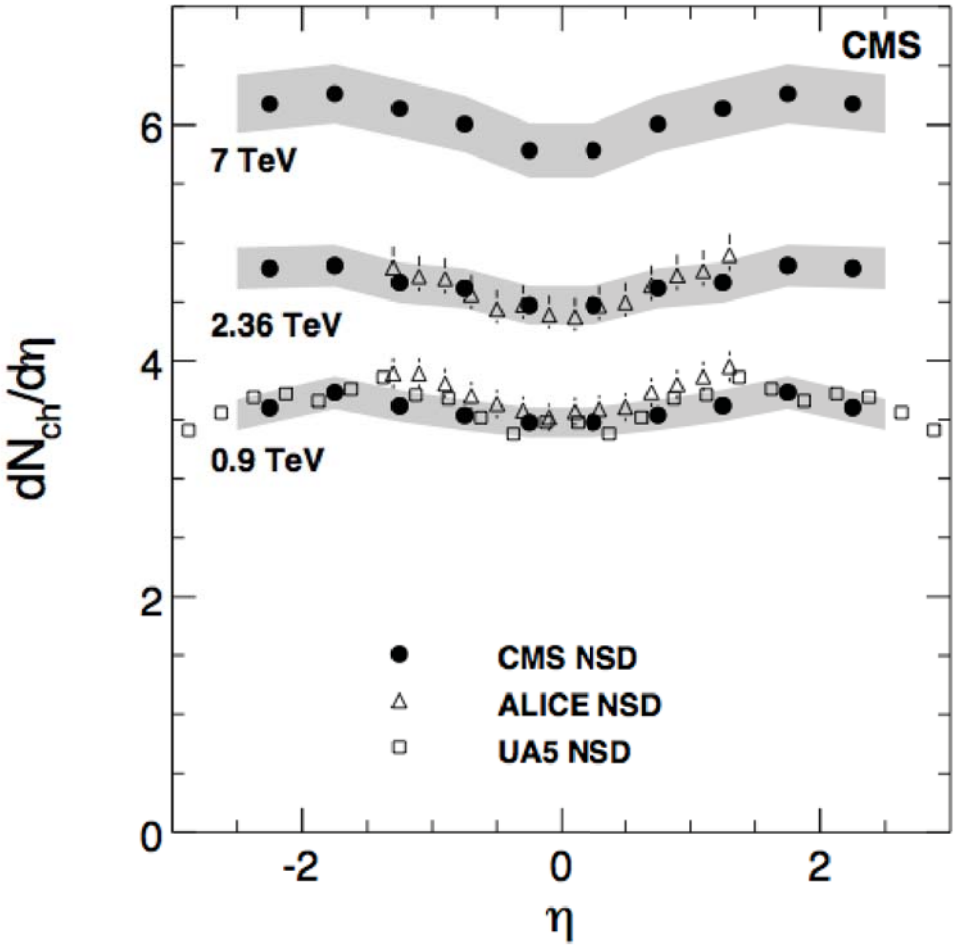
evento con b-tagged jet



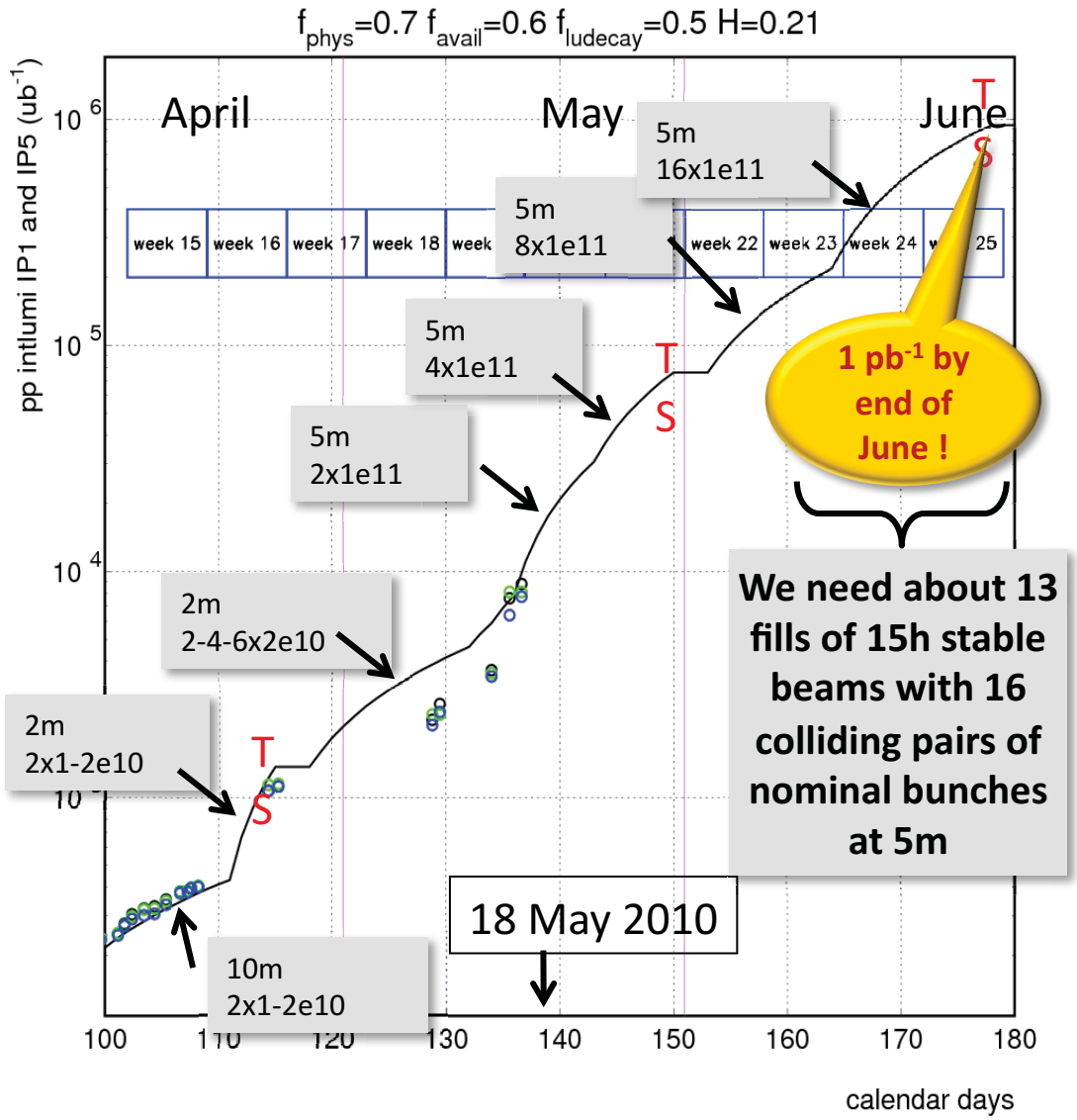
Pubblicazioni dai dati acquisiti

Sia ATLAS che CMS hanno pubblicato:

- articolo sulla 'molteplicità di tracce cariche'
- vari articoli sulle 'performance' dei sottorivelatori



…LHC schedule…



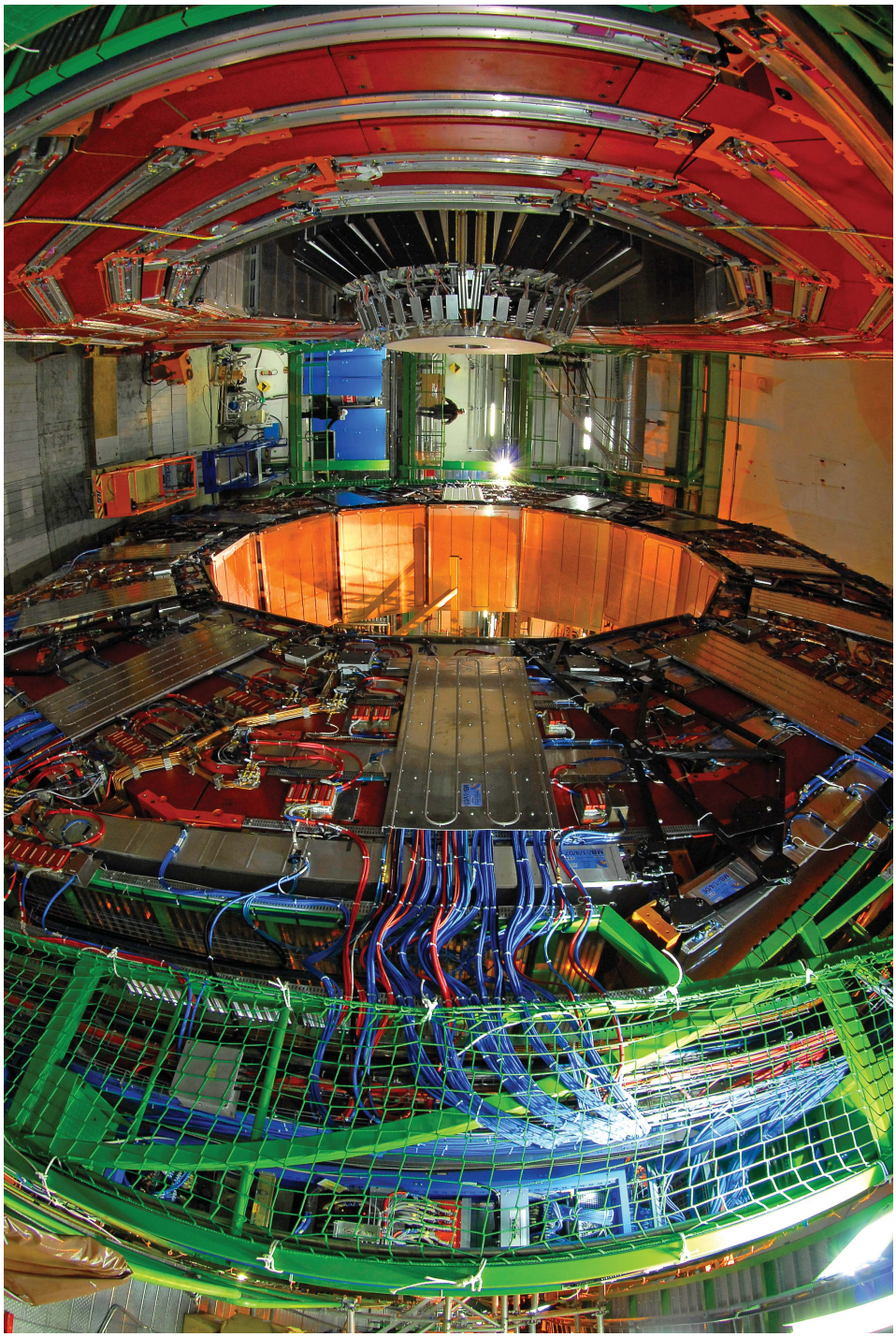
fino a giugno:

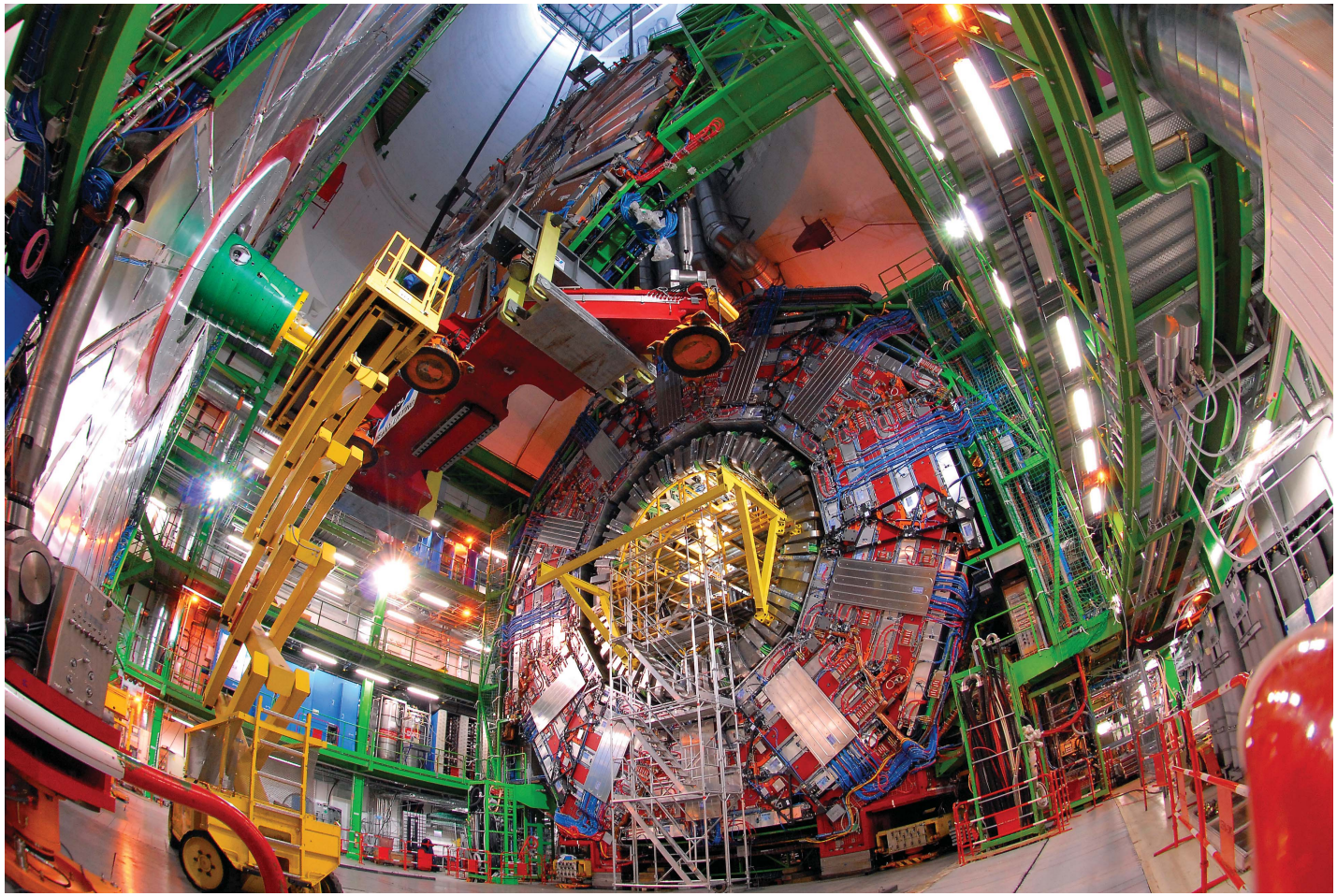
- aumentare il numero di protoni per bunch a 10^{11}
- raddoppiare # bunch ogni 2 settimane fino a 16+16
- raggiungere 1pb^{-1}

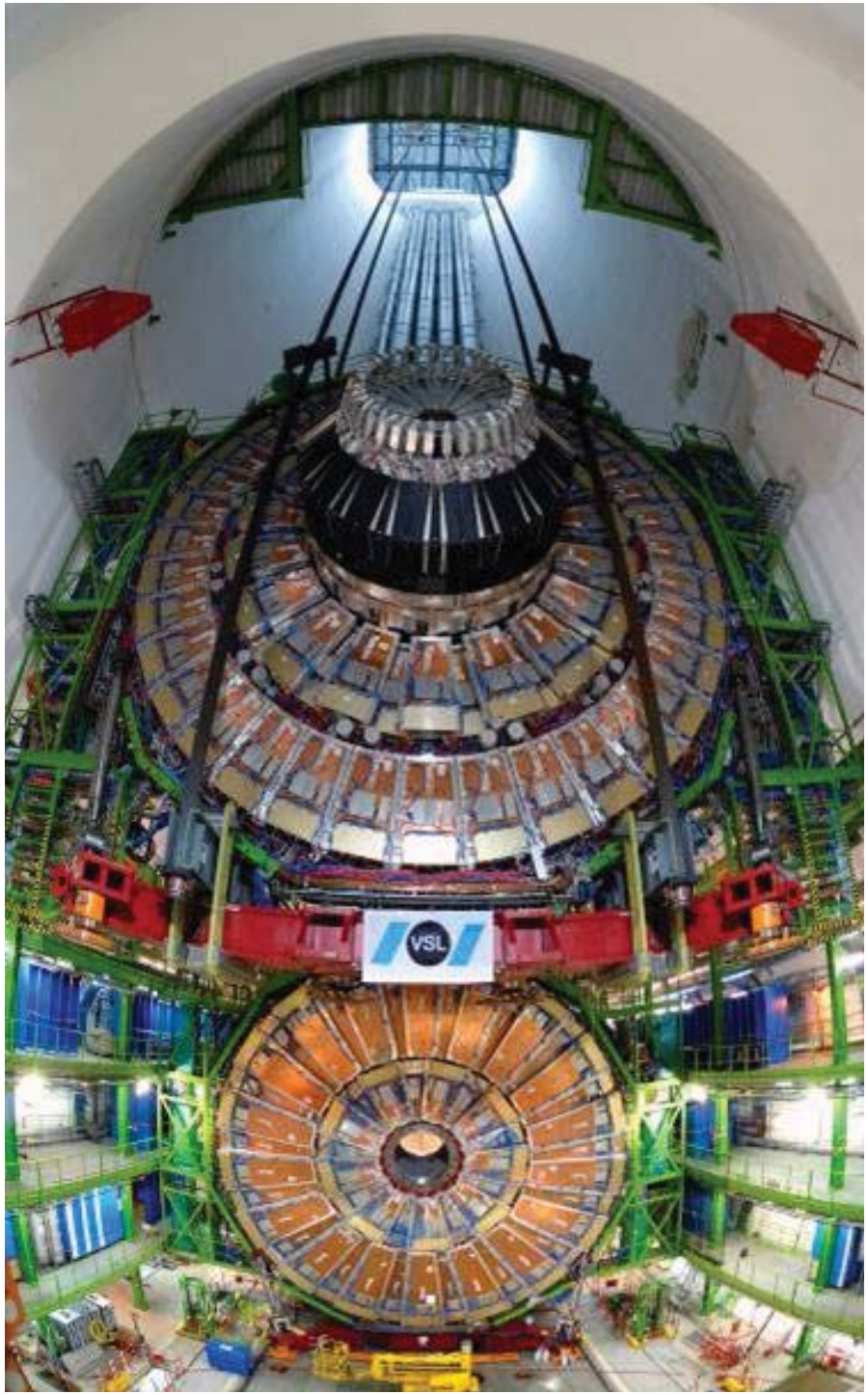
- 2010-11, run fino ad accumulare 1000 pb^{-1}

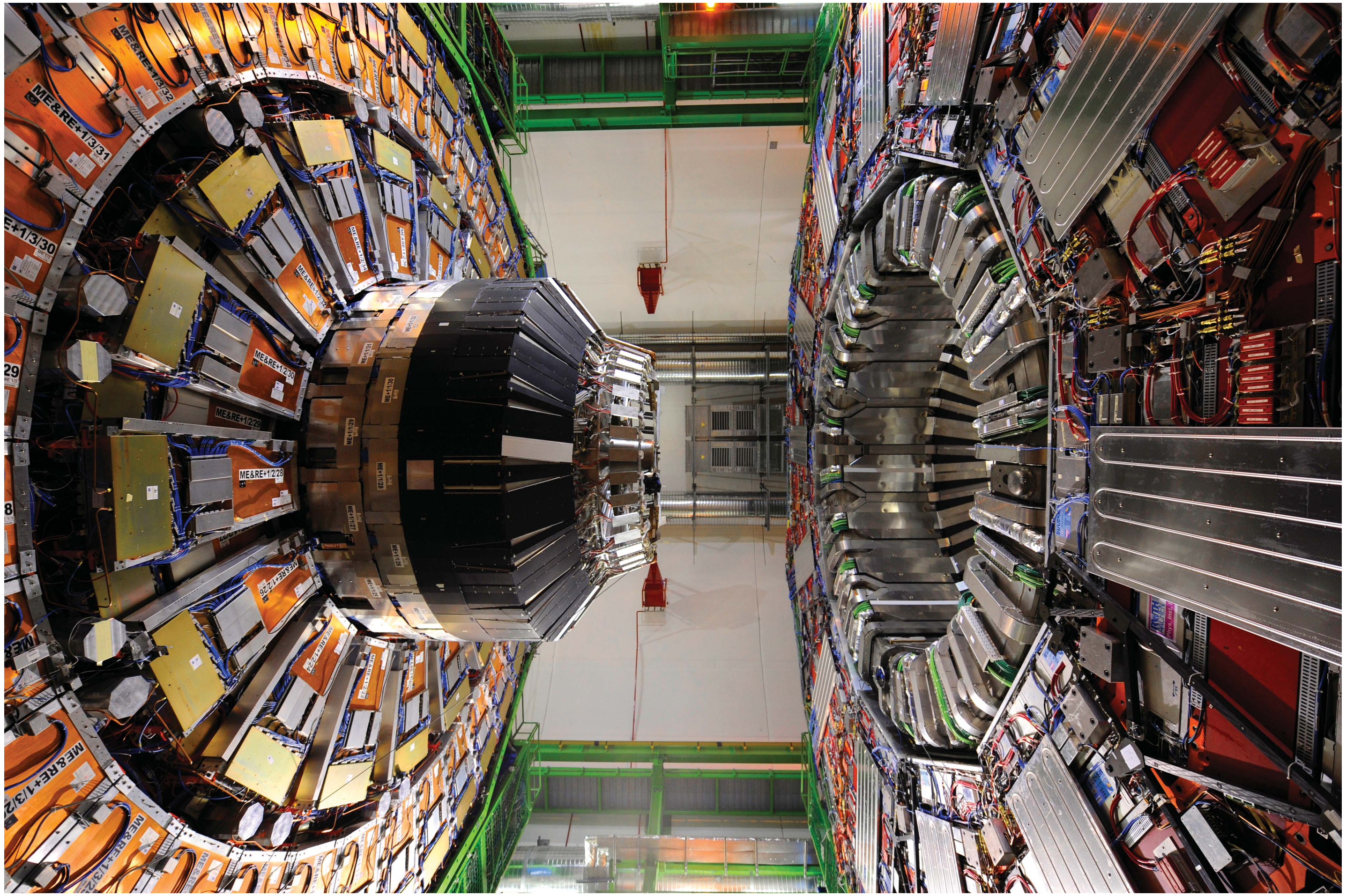
- 2011-12, shut down per lavori ad LHC → $L=10^{34}cm^{-2}s^{-1}$ e E=14TeV

THE END






VSL


ME&RE+1/3/32
ME&RE+1/3/31
E+1/3/30
ME&RE+1/2/30
ME&RE+1/2/29
ME&RE+1/2/28