Gli esperimenti LHC verso HiLumi

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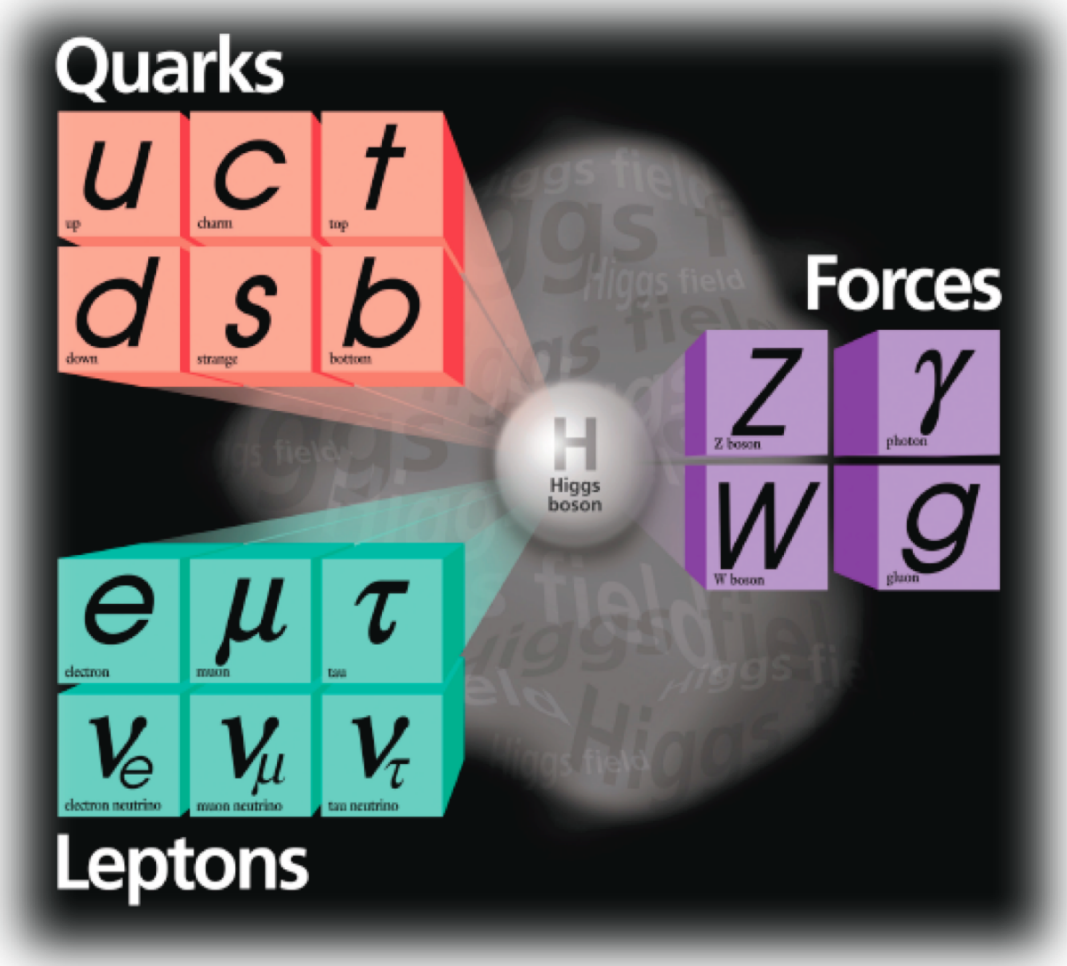
INFN TORINO

Bologna – 13 Ottobre 2018

LHC: indispensabile!



Modello Standard funziona…

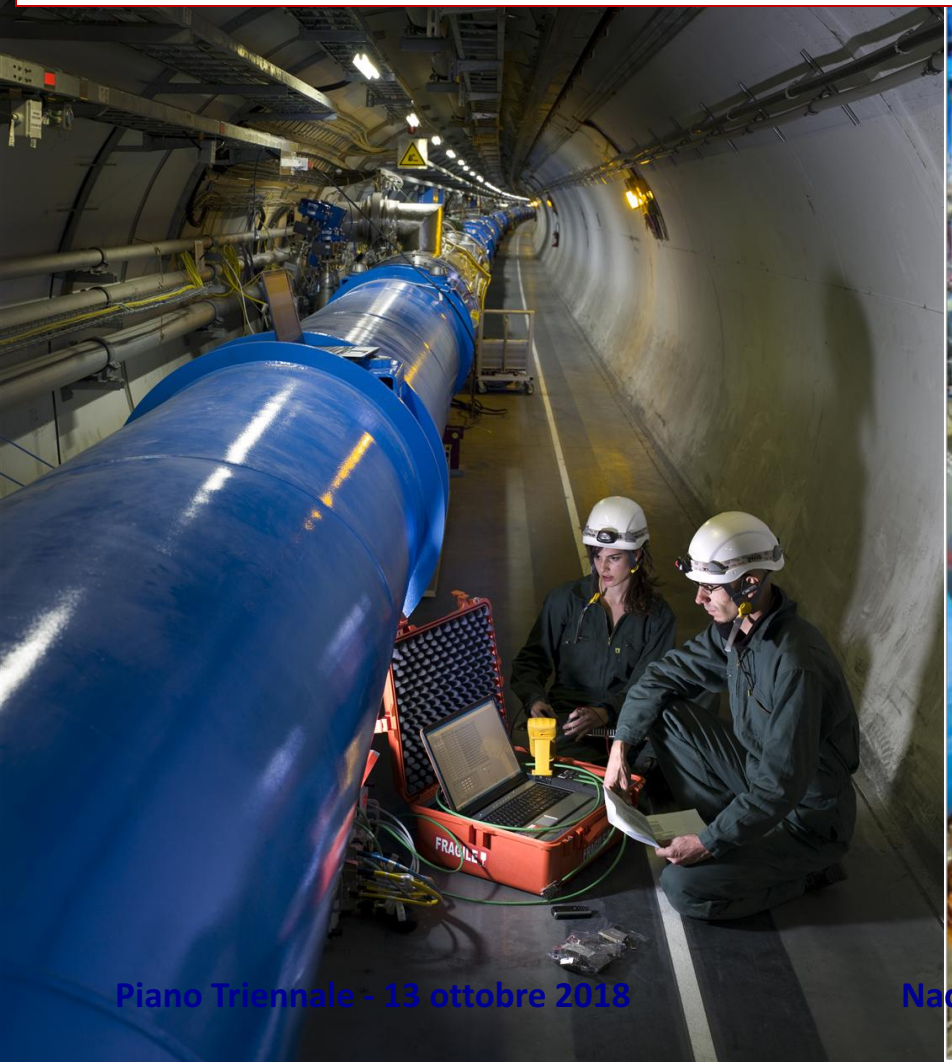
ma

domande fondamentali ancora oggi senza risposta

LHC: avventura scientifica globale

acceleratore, esperimenti, rete mondiale (GRID) di computer

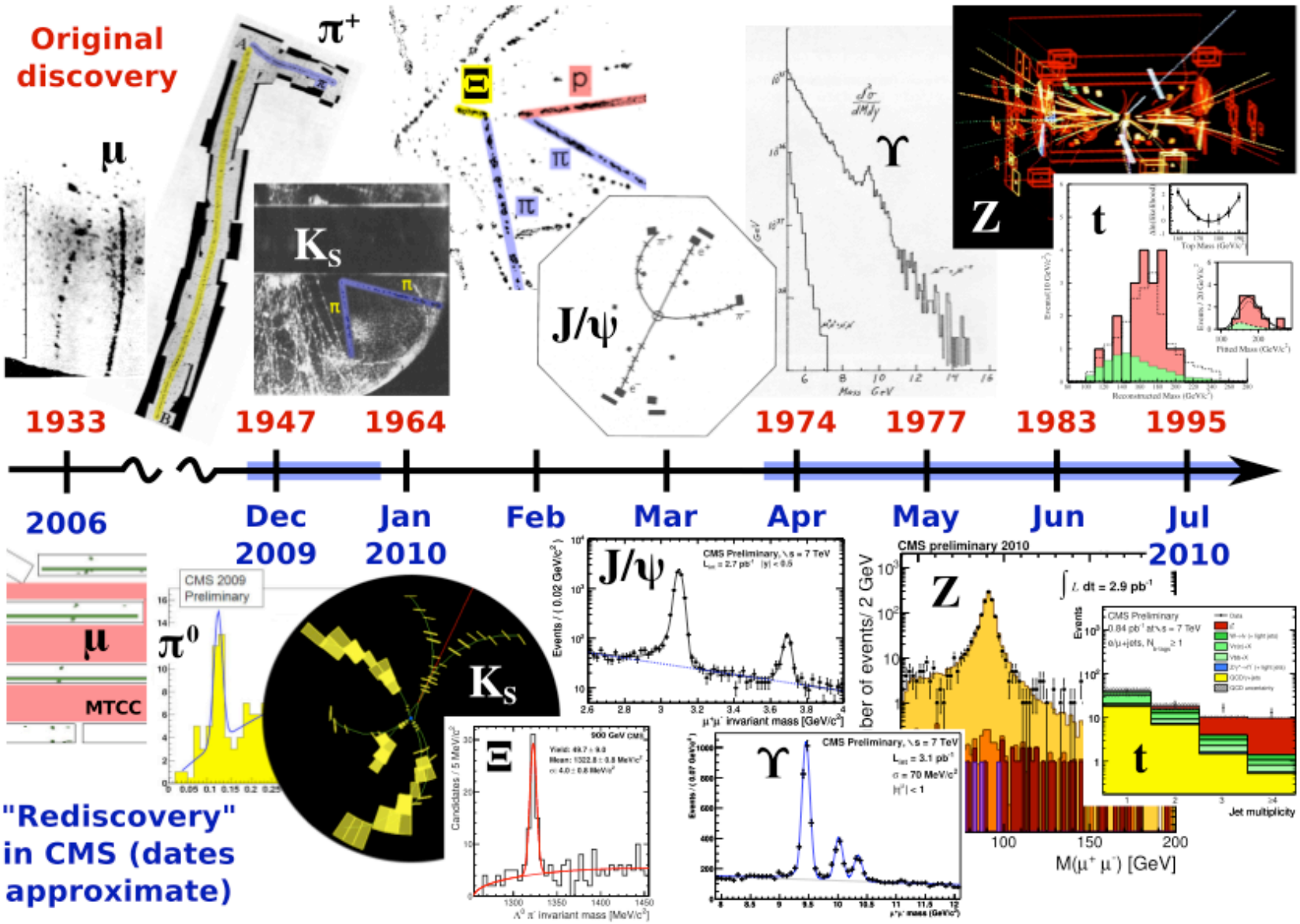
TUTTO HA AVUTO INIZIO 25 ANNI FA



INFN e Italia @ LHC

- Fortissimo contributo tecnologico su acceleratori, rivelatori, trigger e calcolo ➔ **gli sviluppi sono continui …**
- Essenziale il coinvolgimento di tutte le competenze dell'Ente
- Grande impegno a livello internazionale ➔ **responsabilità**
- Moltissimi giovani in Italia e all'estero con ruoli rilevanti
- Notevoli competenze acquisite, distribuite e a disposizione di tutti

LHC: riscoperta Modello Standard @ 2010



LHC: cosa si produce e misura

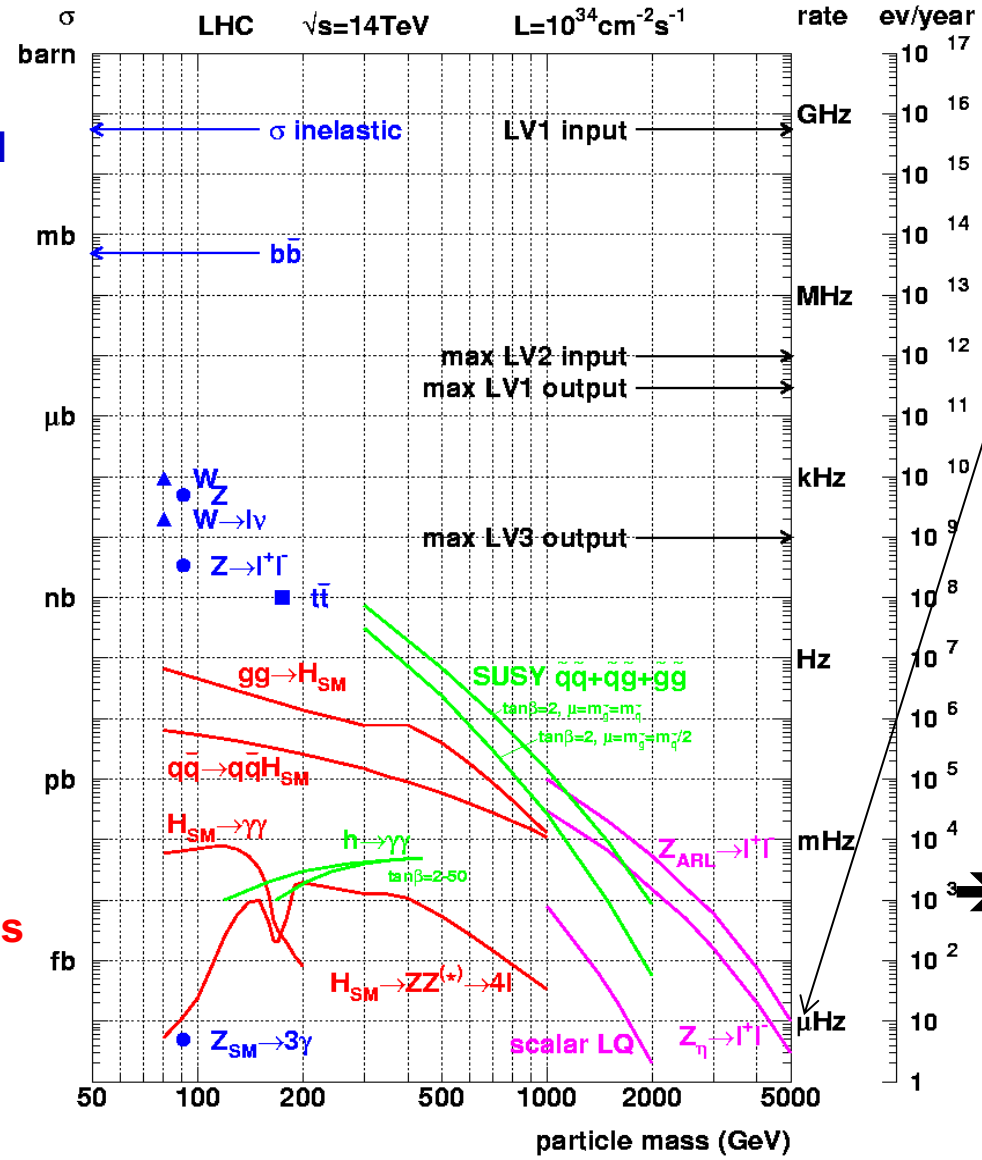
12 order of magnitude

Total

HF

SM

Higgs



RARE PROCESSES

$$R = \mathcal{L}\sigma$$

$$\mathcal{L} = f\frac{n_1 n_2}{A}$$

Number of p per beam

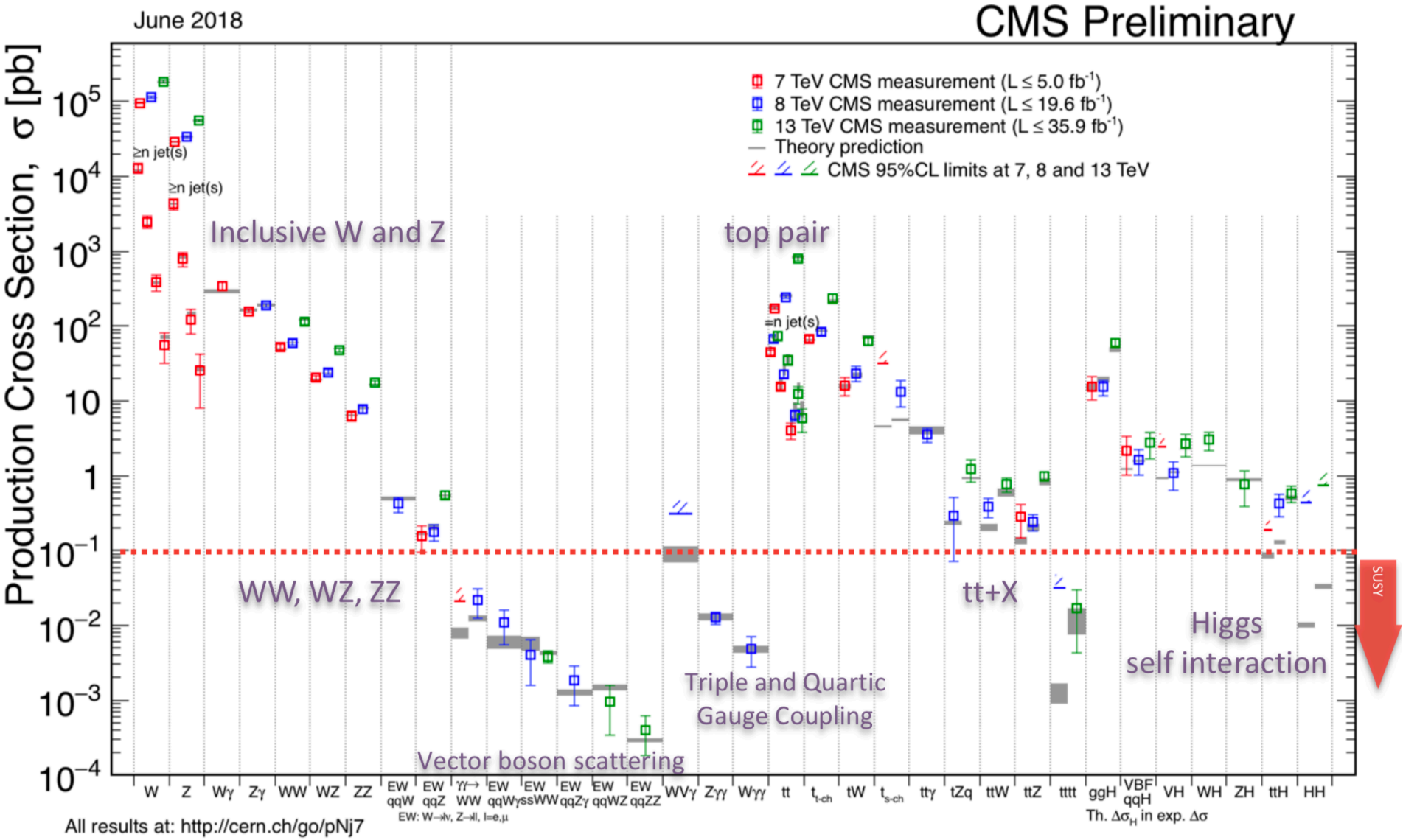
Collision frequency

Area of collision

➔ **The maximum achievable luminosity (L) is needed**

$1H/10^{12}$ events

LHC: eccellente strumento di misura



Bosone di Higgs

sfida durata mezzo secolo… ancora in corso!

- **1964:** articoli scientifici sul **campo di Higgs**
  (Brout & Englert; Higgs; Guralnik, Kibble & Hagen)

- **1967:** Weinberg, Glashow, Salam: **unificazione elettrodebole**
  con il campo di Higgs responsabile della massa delle particelle

- **1970:** ‘t Hooft and Veltman: il Modello Standard è rinormalizzabile

- **1970s:** si inizia a pensare a come può essere prodotto ed osservato l’Higgs

- **1980s–90s:** proposti SSC (USA, mai completato) e il Large Hadron Collider **(LHC)**

- **1990s–2000s:** ricerche dirette e indirette a **LEP** e **Tevatron**
  Costruzione di LHC e dei relativi esperimenti

- **2012:** LHC osserva un nuovo bosone consistente con l’Higgs a circa **125 GeV**

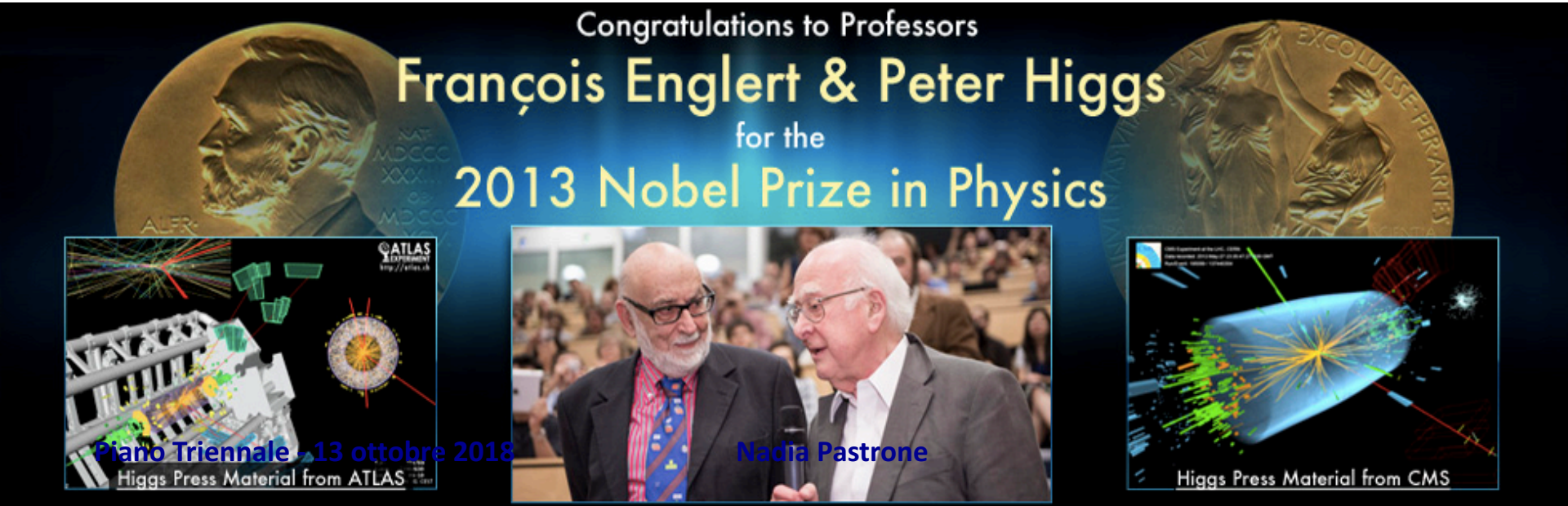
Premio Nobel 2013

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics for 2013 to

François Englert
Université Libre de Bruxelles, Brussels, Belgium

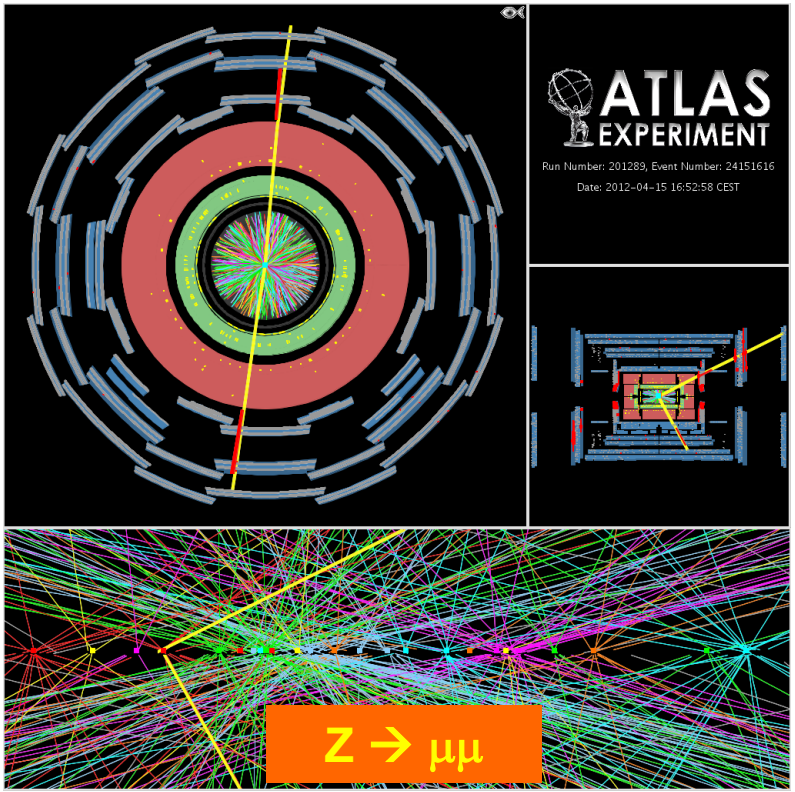
Peter W. Higgs
University of Edinburgh, UK

"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"

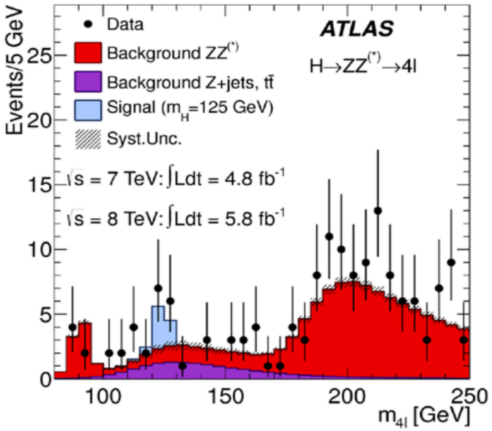


LHC: bosone di Higgs oltre la scoperta

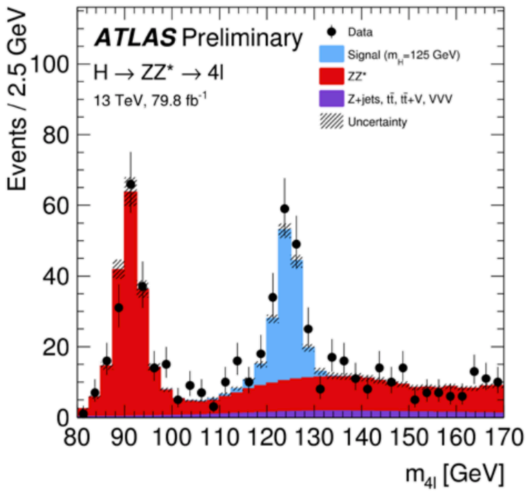
- Determinati numeri quantici
- Osservati quasi tutti i canali attesi
  - Recentemente ttH, $\tau^+\tau^-$, $b\,\bar{b}$
  - Pattern consistente con SM



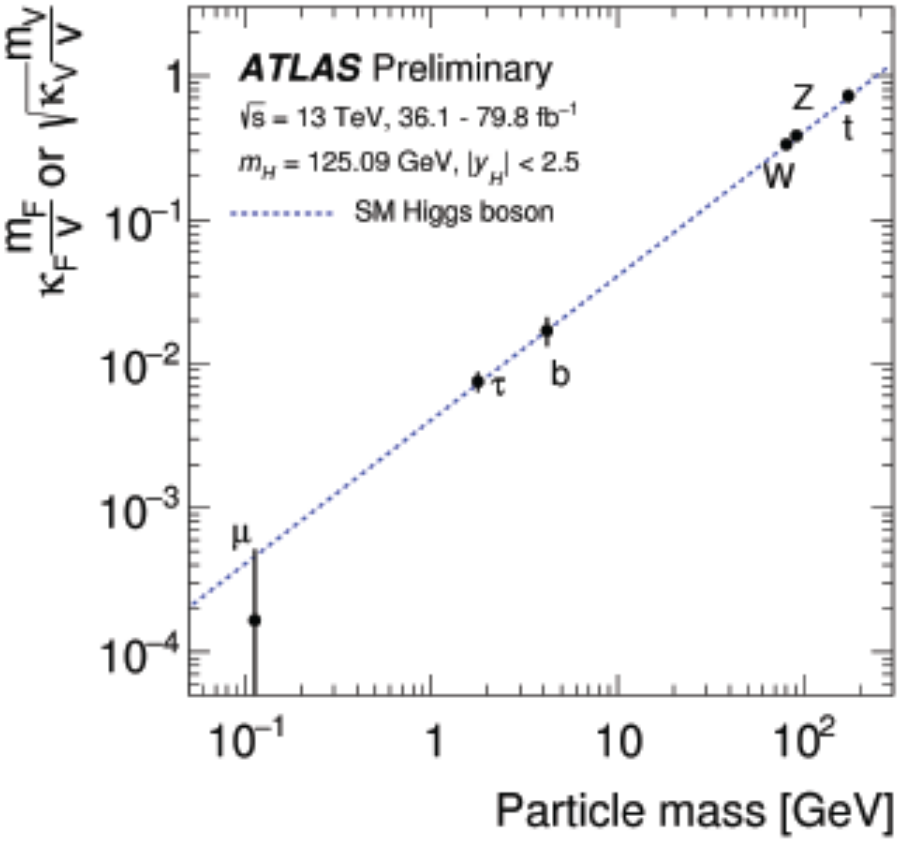
Phys. Lett. B 716 (2012) 1-29

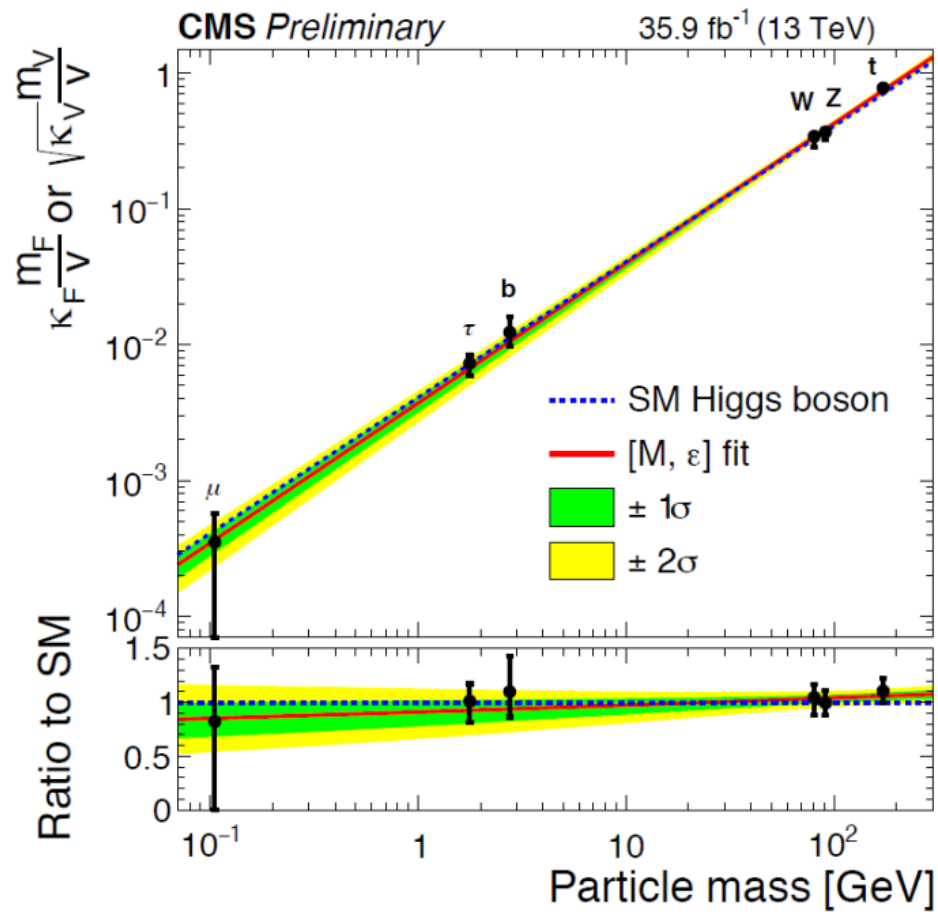


ATLAS-CONF-2018-018



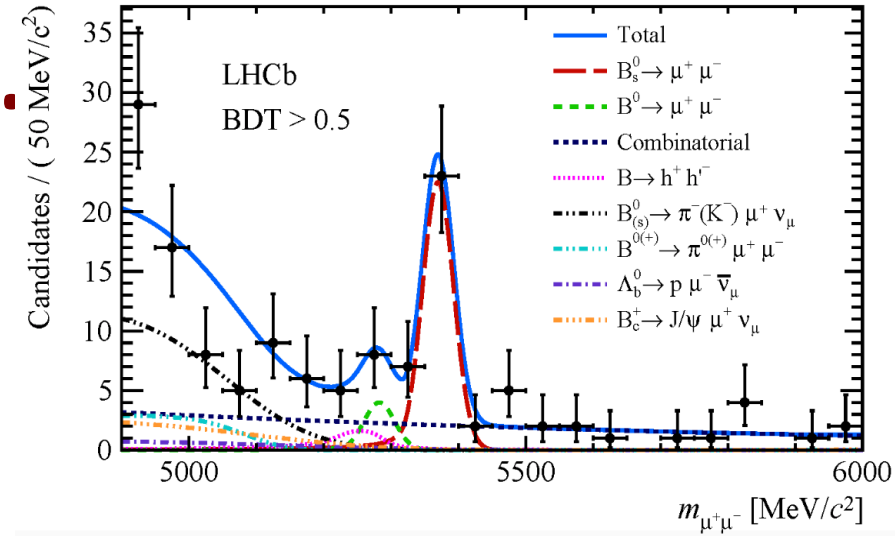
LHC: bosone di Higgs – dove siamo

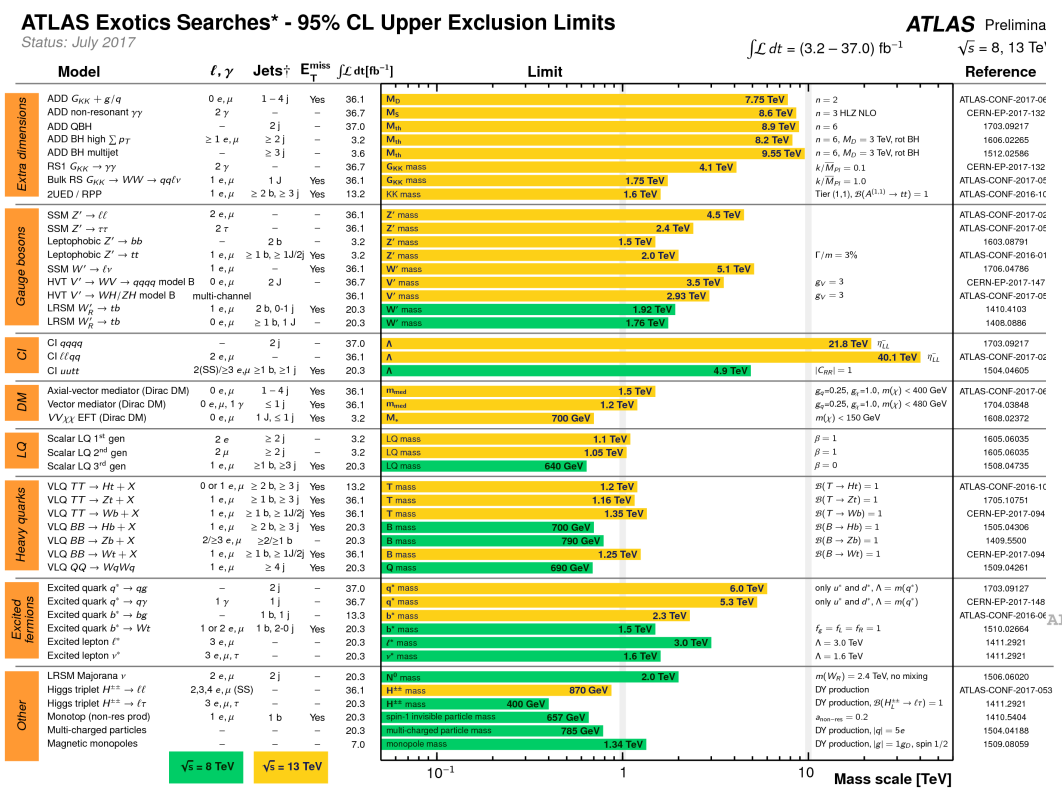


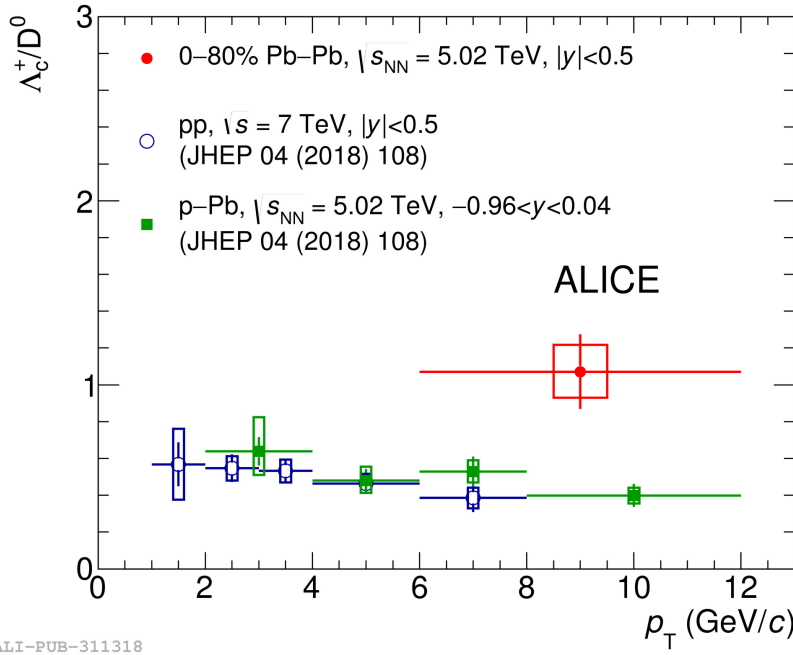


LHC: non solo Higgs…

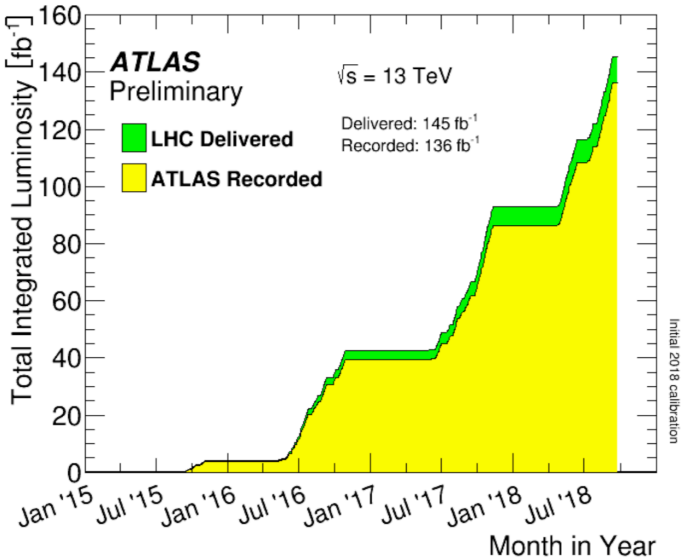
- Studiare collisioni pp, Pb-Pb, p-Pb, Pb-p

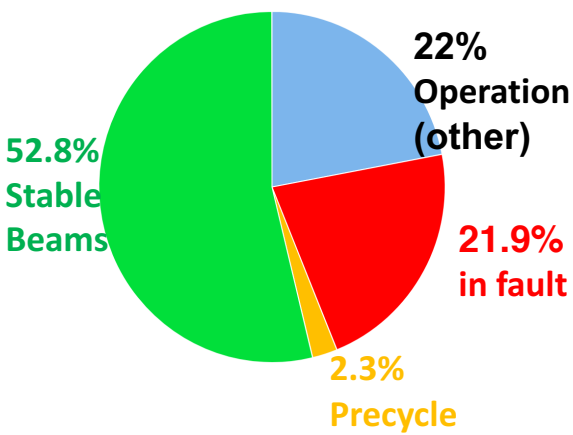


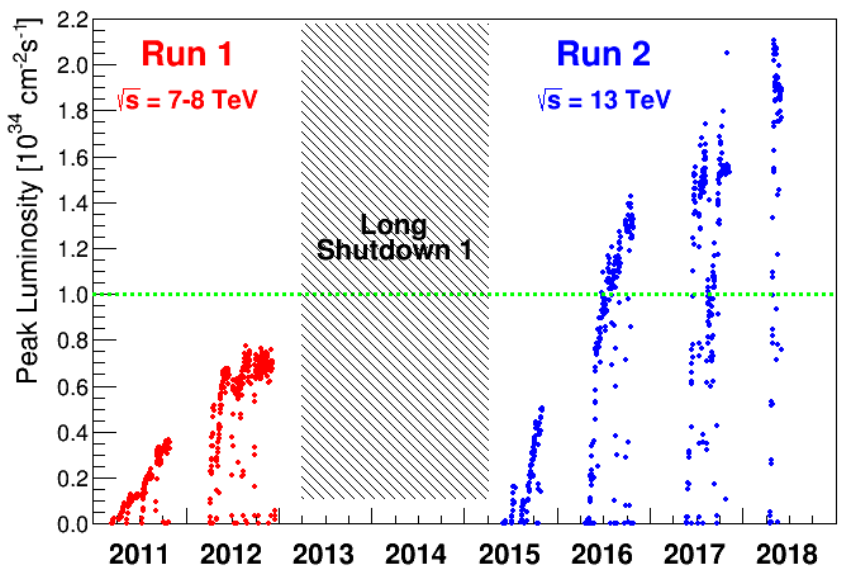




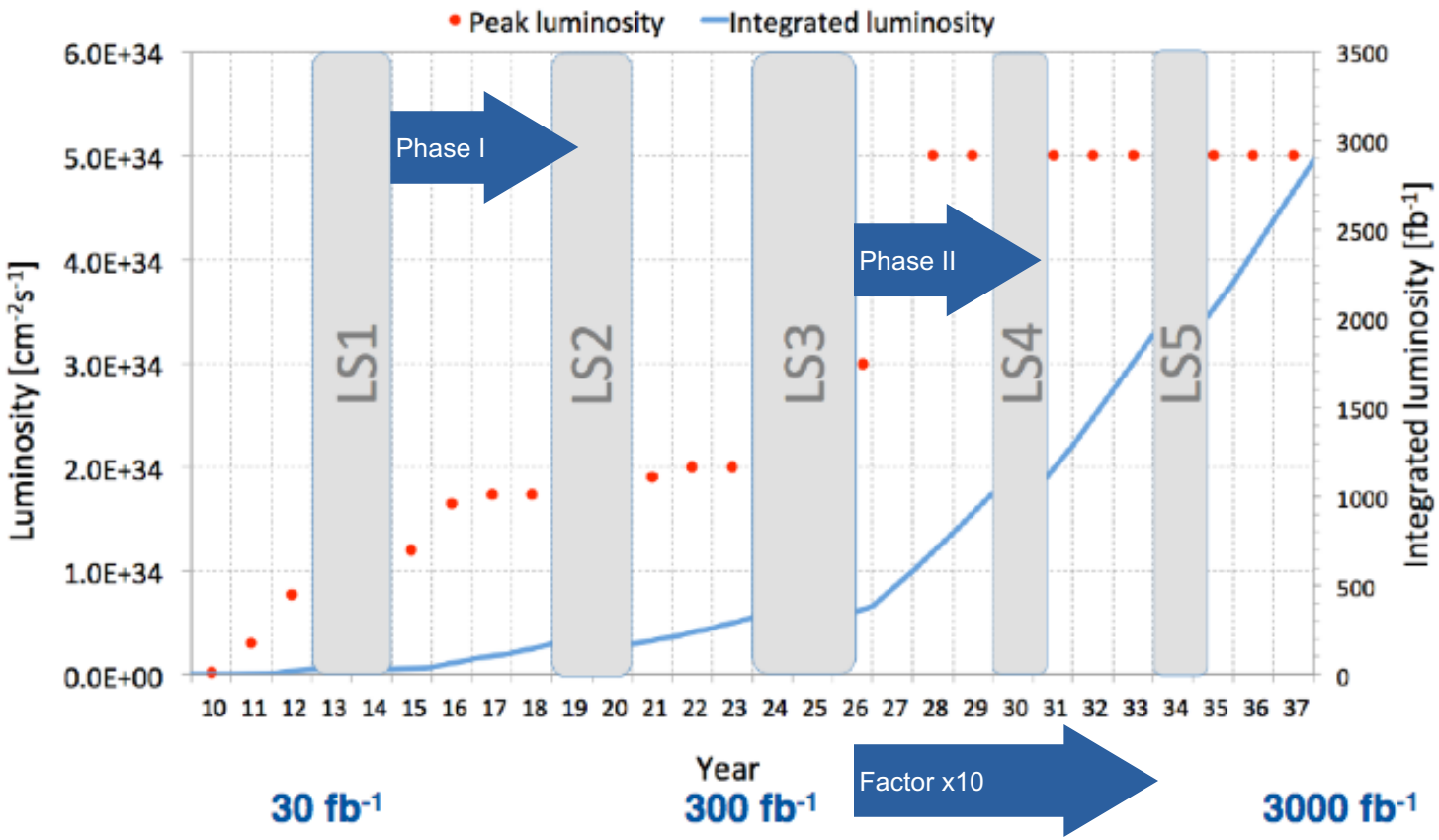
LHC: la storia







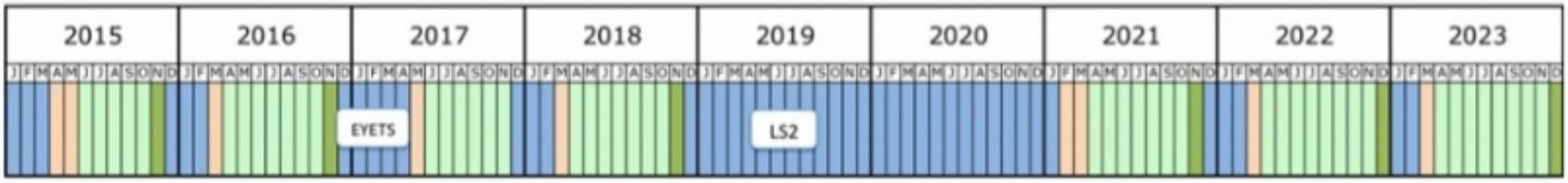
LHC: pianificazione



- **Periodo di presa dati**

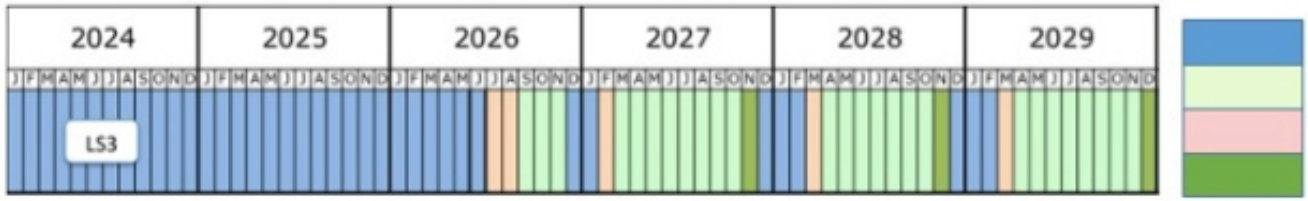
LS = Long Shutdown

Ioni pesanti @LHC



Run2 : $\mathcal{L}_{integrated}^{Pb-Pb} = 1.0\ nb^{-1}$

Run3: $\mathcal{L}_{integrated}^{Pb-Pb} = 6.0\ nb^{-1}$



Shutdown/Technical stop
Proton physics
Commissioning
Ions

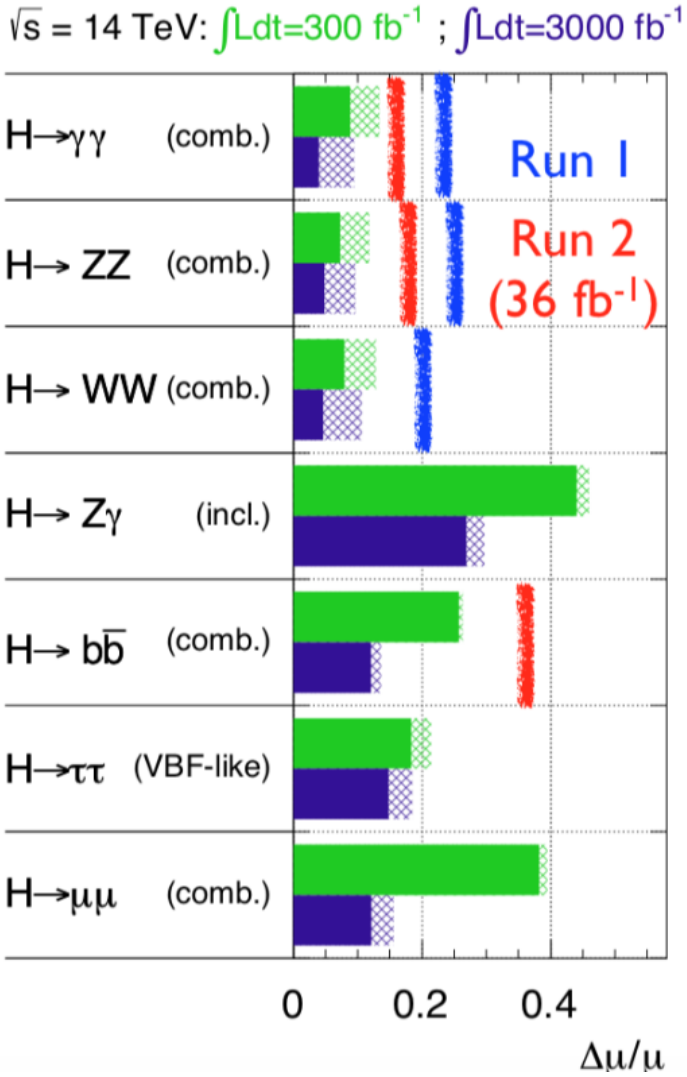
Run4 : $\mathcal{L}_{integrated}^{Pb-Pb} = 7.0\ nb^{-1}$

Higgs: misure di accoppiamento

PRECISIONE:

~ 10% Run 3
~ 5% con HL-LHC

Notare il sistematico



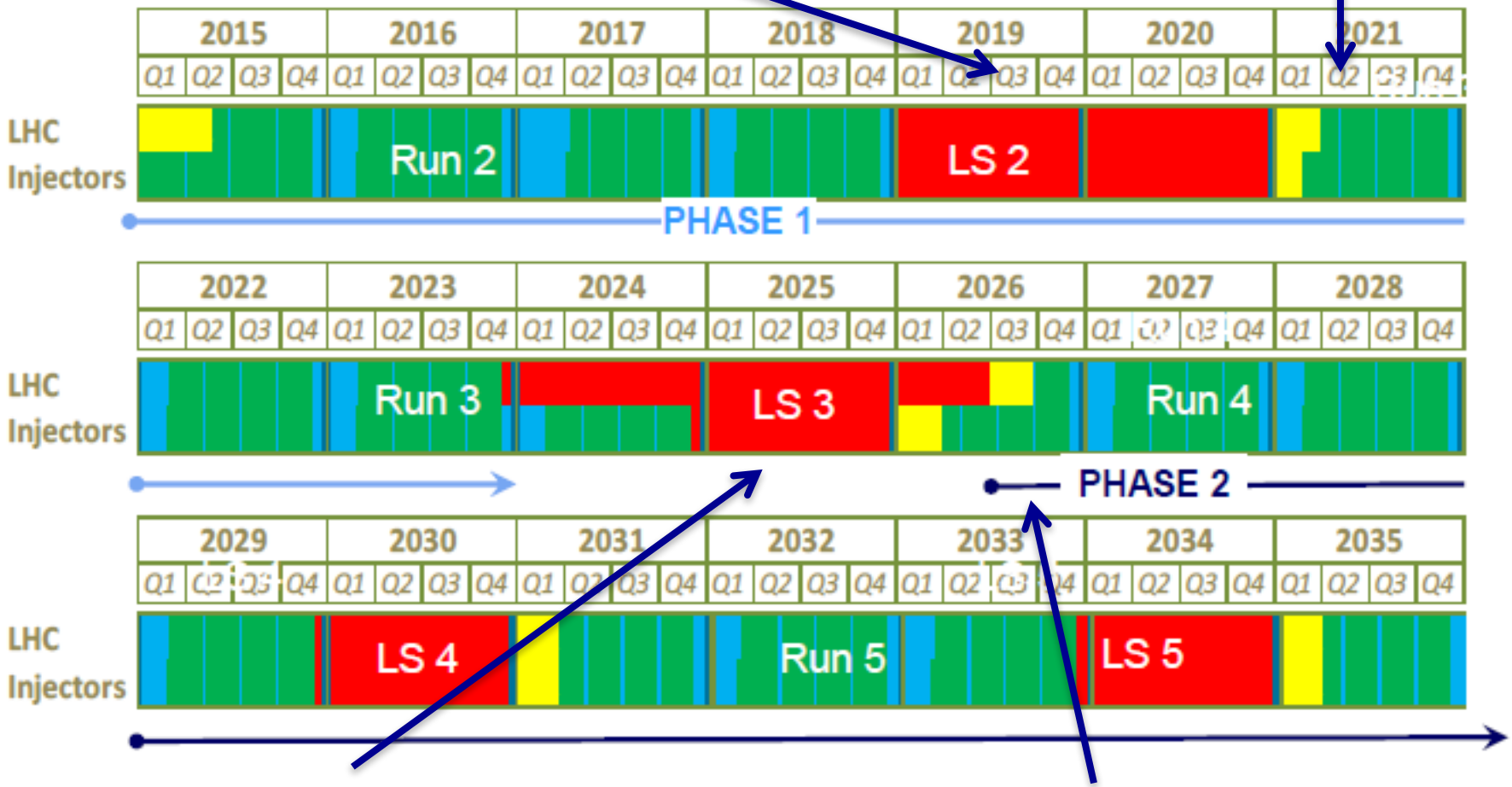
Piano temporale LHC

Upgrade FASE1

ALICE, LHCb major upgrade

ATLAS, CMS minor upgrade

Heavy Ion Luminosity from 10^{27} to 7 x10^{27}



PHASE II Upgrade

ATLAS, CMS major upgrade

HL-LHC, pp luminosity from 10^{34} (peak) to 5 x10^{34} (levelled)

HL-LHC: 2025-2035

CRUCIALE R&D congiuto

- ✓ Luminosità istantanea 5x ➔ 5x pile-up
  ➔ aumento tempo CPU (non-lineare)
- ✓ Dose radiazione integrata 6x

Importanti richieste sugli apparati sperimentali ➔ in definizione

- Nuovi tracciatori al silicio rad-hard con trigger di traccia a L1 (1 MHz➔10 kHz)

  10 × rate eventi "registrati" / 3-4 × event size

  (fluenze 2×10^{16} cm^{-2} e copertura estesa a $|\eta|\sim4$) **
- Nuovi calorimetri in avanti rad-hard e ad alta granularità (particle flow vs dual read-out ➔ critici fotosensori)
- Timing in fase di studio sui tracciatori e i calorimetri
- Nuovi trigger, nuova elettronica, nuovi rivelatori a muoni (MPGD)
- Nuovo modello di calcolo

** @ Flavour: notevole incremento della statistica
colliders(10^{14} *b*-decays, 10^{15} *c*-decays)
high-intensity beams (10^{19} pot/year)

Importante ricordare che

- **Senza** nuovi sviluppi di tracciatori

➔

- **Senza** trigger di traccia

➔

- **Senza** rivelatori di timing

➔

- **Senza** nuova concezione di presa dati

➔

- **Senza** nuova concezione di calcolo

➔

Conclusioni

- ✓ Stiamo preparando l'input all'Update alla EU Strategy per il 2020
- ✓ Abbiamo imparato quanto il lavoro di R&D e la pianificazione sono cruciali…
- ✓ ma ancora di più essere aperti a nuove idee e a sperimentarle

Vorrei che fosse di buon auspicio

Collisioni di particelle a LHC sulla banconota 200 CHF

Grazie per l'attenzione e a tutti i colleghi per il lavoro e la passione!