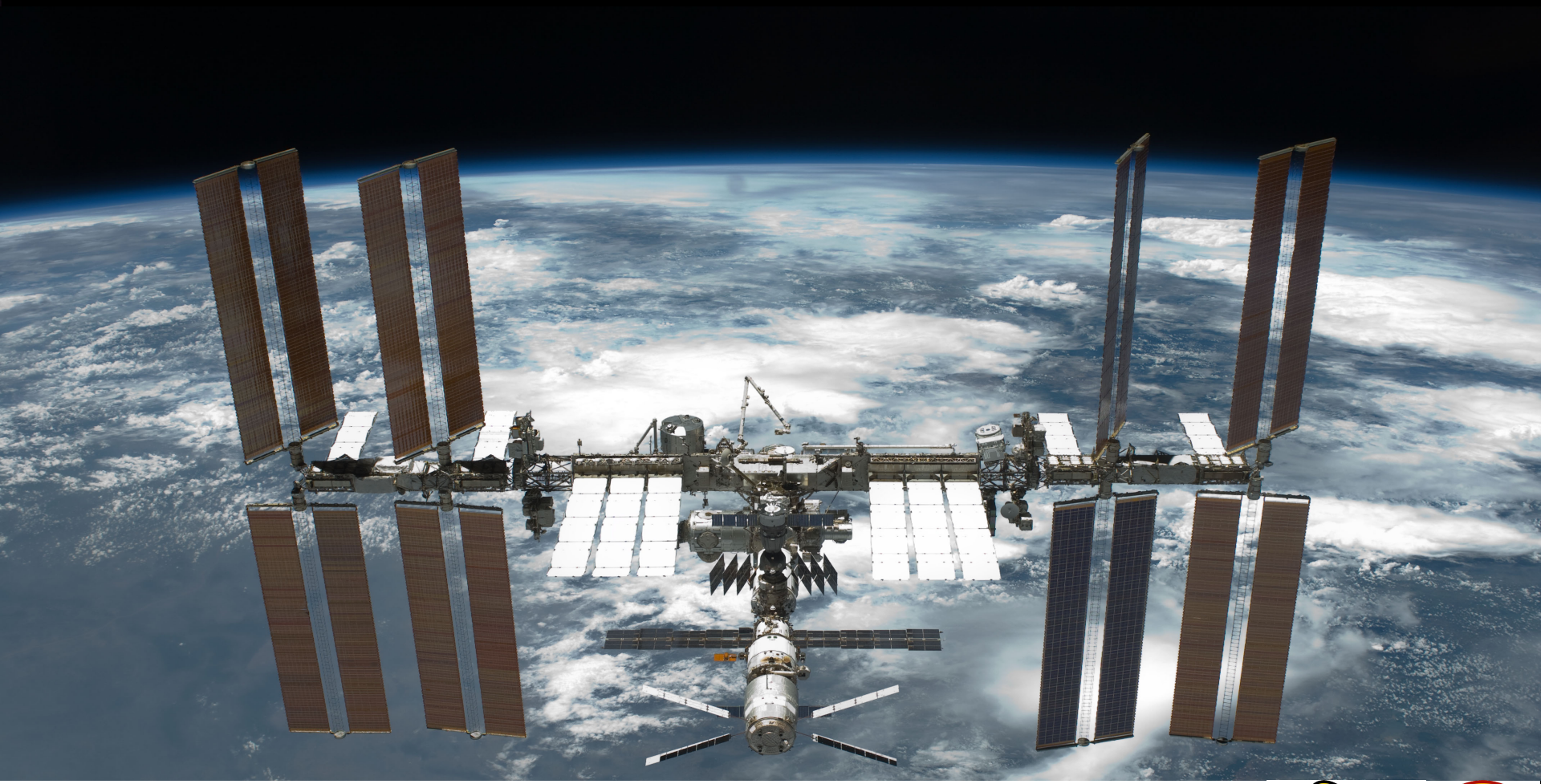
# LA FISICA DELLE PARTICELLE ELEMENTARI NELLO SPAZIO: AMS-02

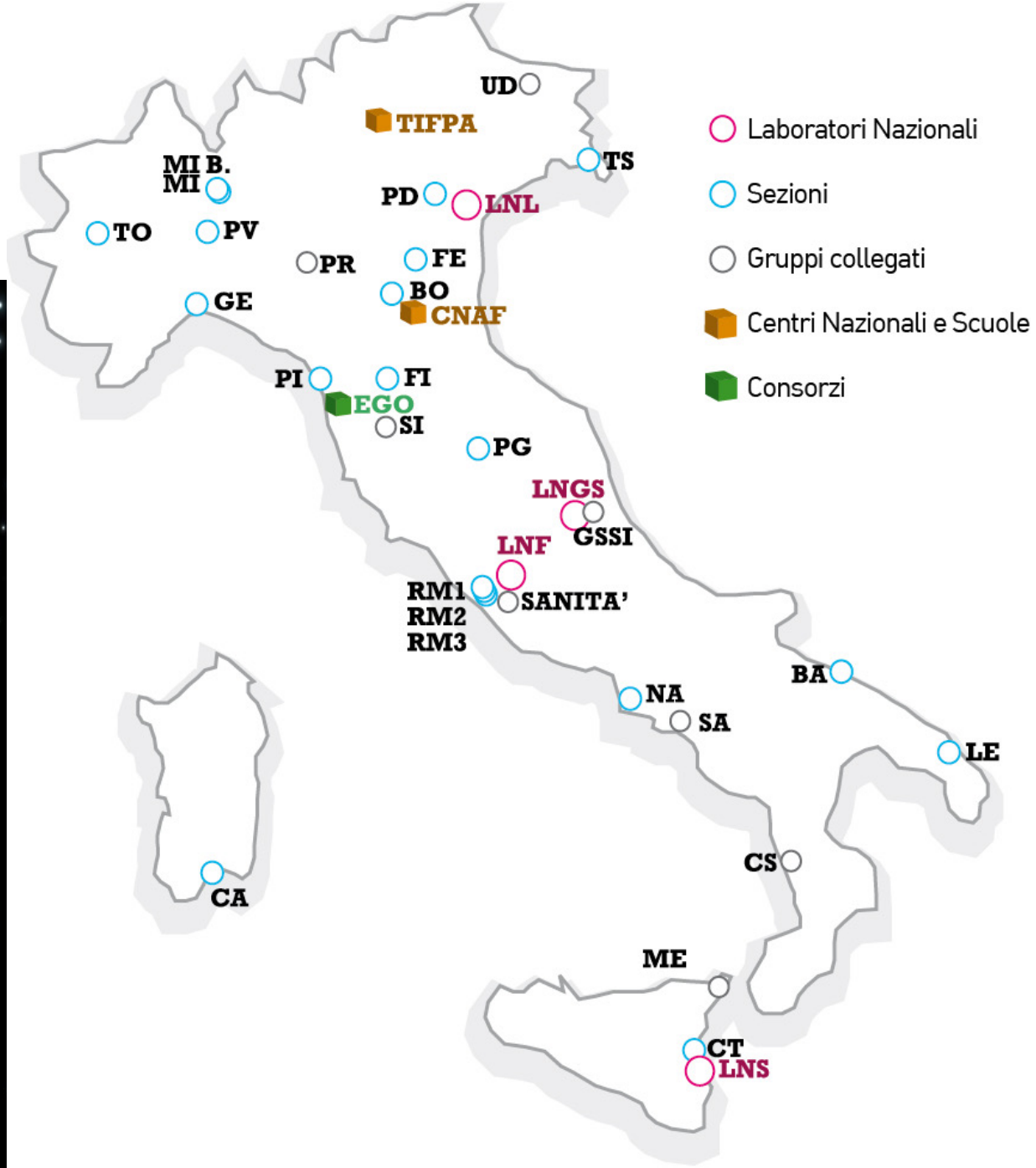



INFN PERUGIA

**Matteo Duranti**
**Valerio Vagelli**

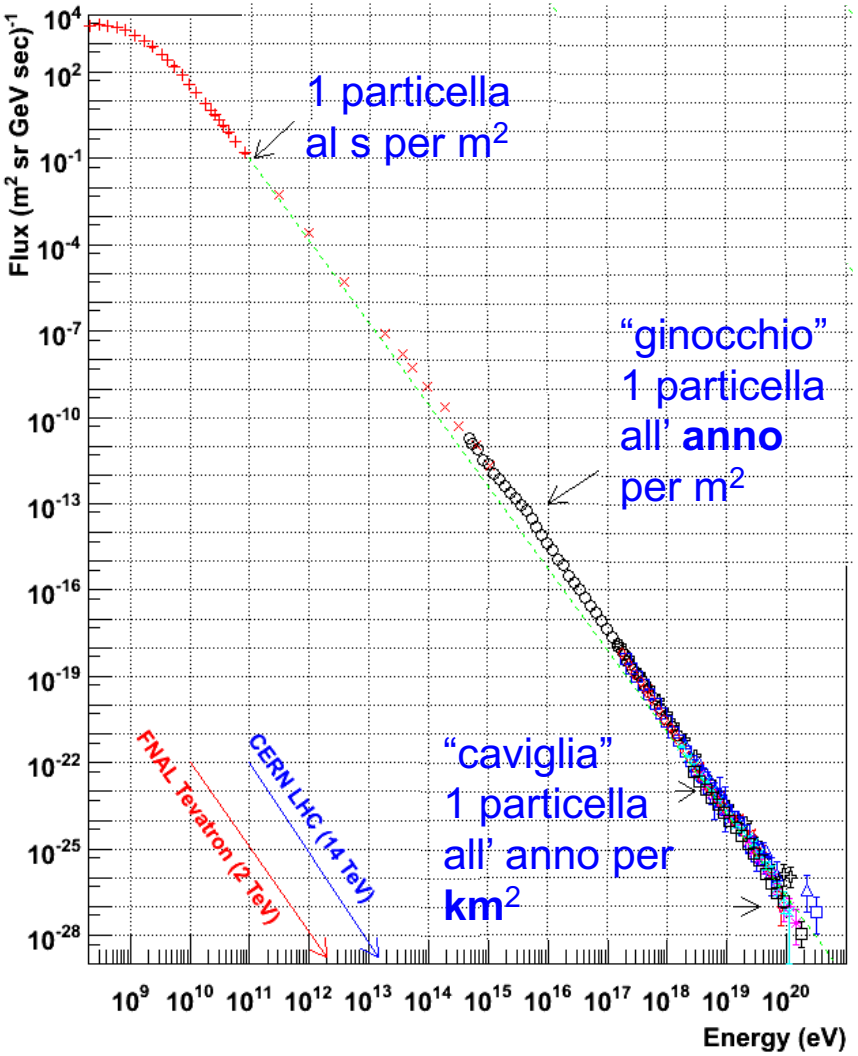
INFN
PERUGIA

Uno degli obbiettivi scientifici dell'INFN è lo studio della fisica fondamentale tramite la misura sperimentale dei raggi cosmici



# I RAGGI COSMICI

# Spettro dei CR



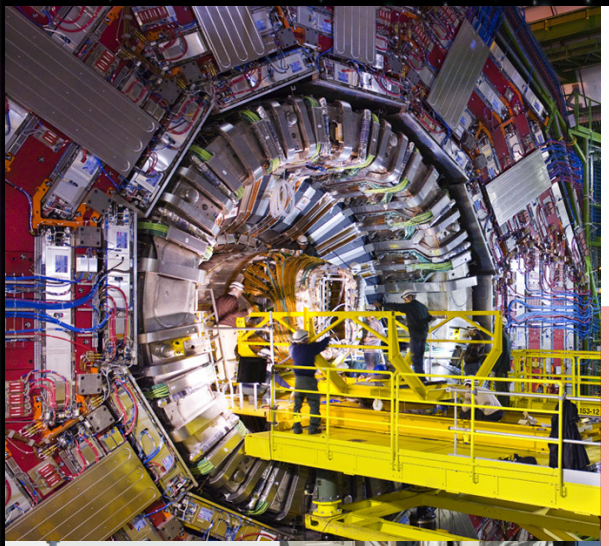

- Andamento in funzione dell'energia (i.e. "spettro") approssimabile con una legge di potenza:

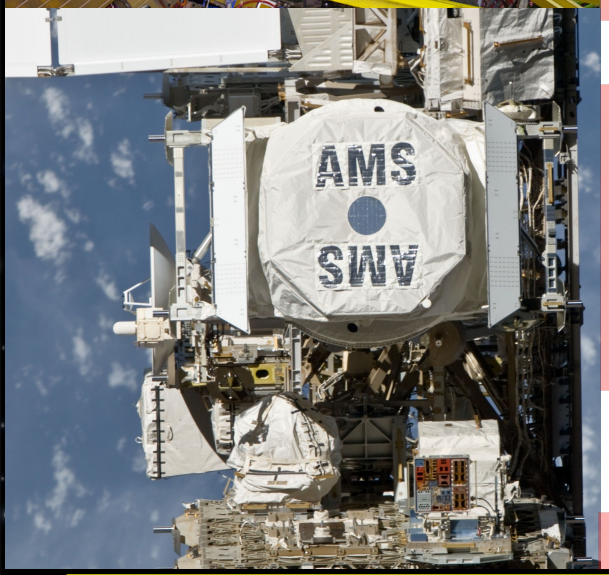
$$\Phi(E) \sim E^{-\gamma}$$

con $\gamma \sim 2.7\text{-}3$

- Composizione e abbondanze relative delle varie specie funzione dell'energia
- Energia massima (finora rivelata!) molto maggiore di quella attualmente producibile dall'uomo con acceleratori di particelle

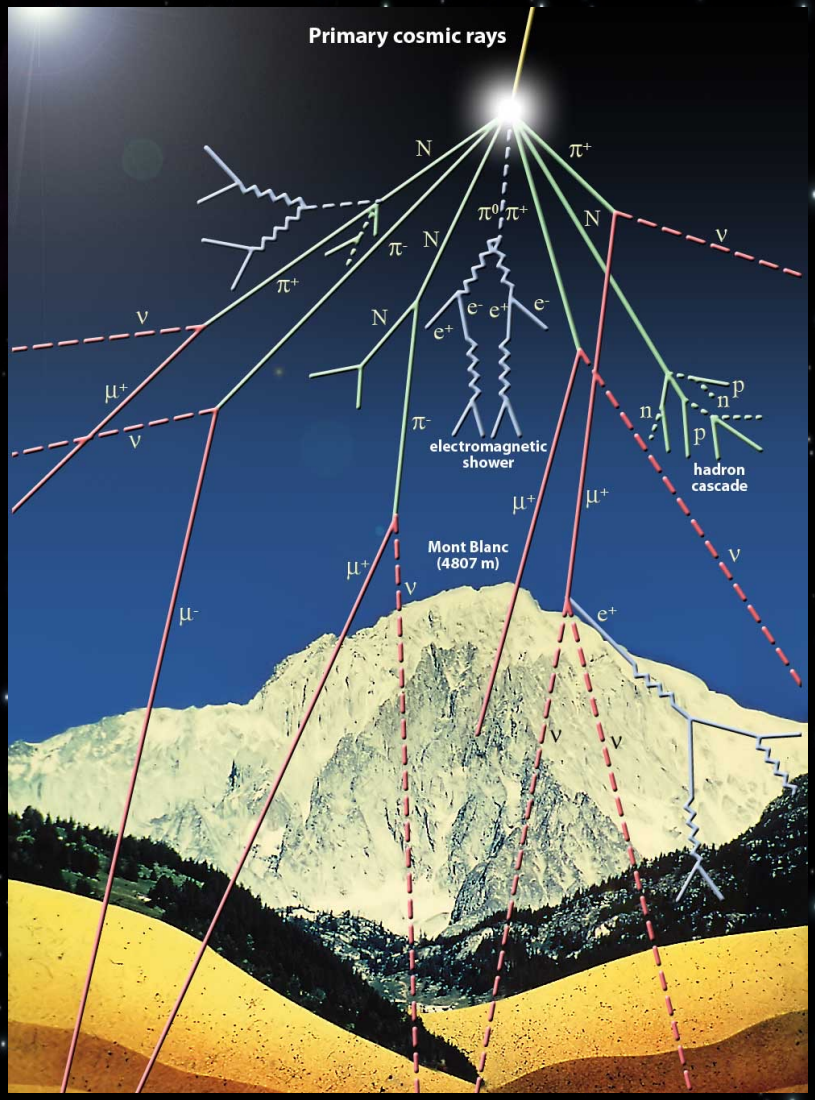
# RAGGI COSMICI E FISICA DELLE PARTICELLE






| Particle | Year | Discoverer (Nobel Prize) | Method |
|---|---|---|---|
| $e^-$ | 1897 | Thomson (1906) | Discharges in gases |
| $p$ | 1919 | Rutherford | Natural radioactivity |
| $n$ | 1932 | Chadwik (1935) | Natural radioactivity |
| $e^+$ | 1933 | Anderson (1936) | Cosmic Rays |
| $\mu^\pm$ | 1937 | Neddermeyer, Anderson | Cosmic Rays |
| $\pi^\pm$ | 1947 | Powell (1950) , Occhialini | Cosmic Rays |
| $K^\pm$ | 1949 | Powell (1950) | Cosmic Rays |
| $\pi^0$ | 1949 | Bjorklund | Accelerator |
| $K^0$ | 1951 | Armenteros | Cosmic Rays |
| $\Lambda^0$ | 1951 | Armenteros | Cosmic Rays |
| $\Delta$ | 1932 | Anderson | Cosmic Rays |
| $\Xi^-$ | 1932 | Armenteros | Cosmic Rays |
| $\Sigma^\pm$ | 1953 | Bonetti | Cosmic Rays |
| $p^-$ | 1955 | Chamberlain, Segre' (1959) | Accelerators |
| anything else | 1955 $\Longrightarrow$ today | various groups | Accelerators |
| $m_\nu \neq 0$ | 2000 | KAMIOKANDE | Cosmic rays |

# Allacciate le cinture!

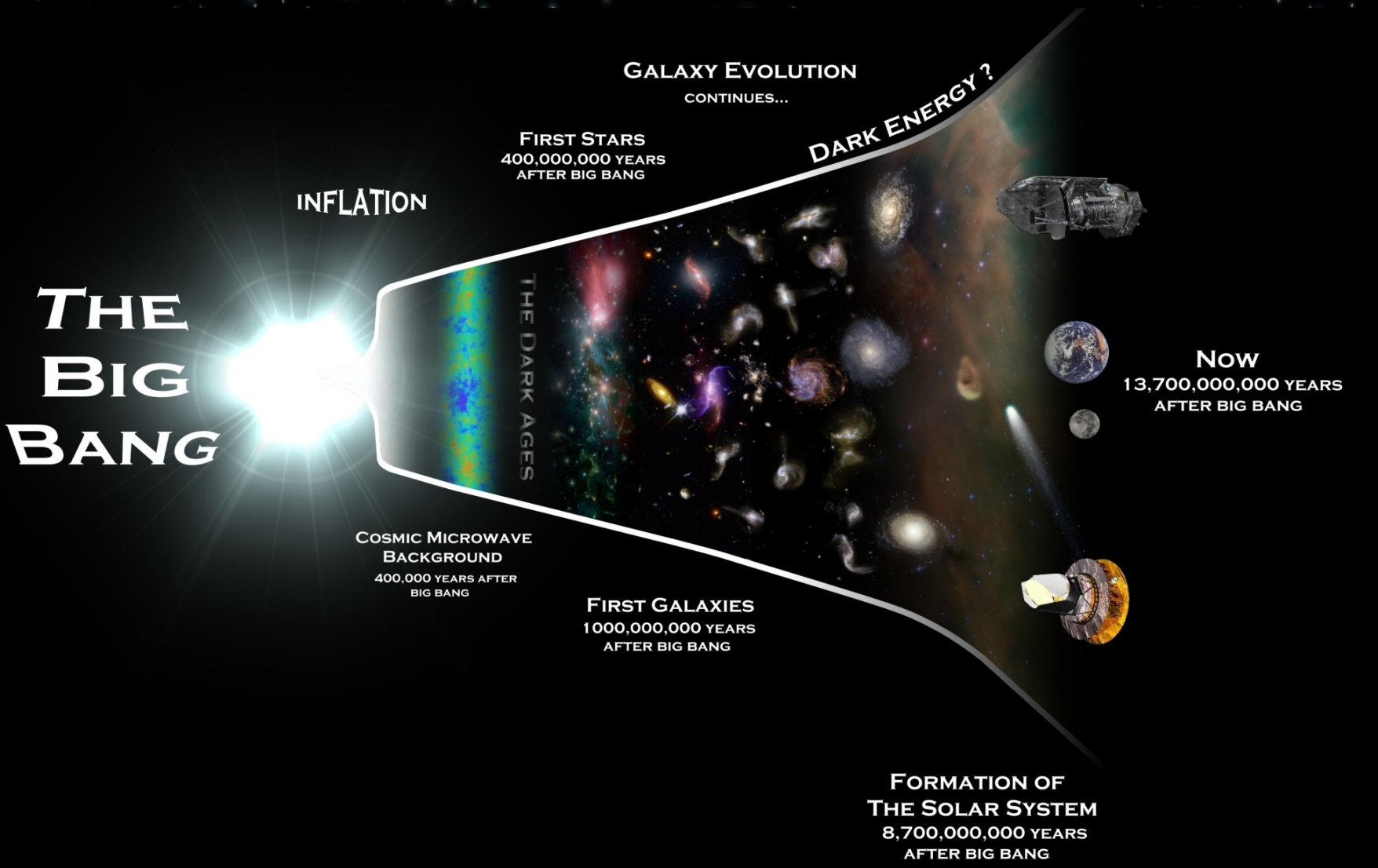



La maggior parte dei CR non raggiunge terra per via dell'interazione con l'atmosfera

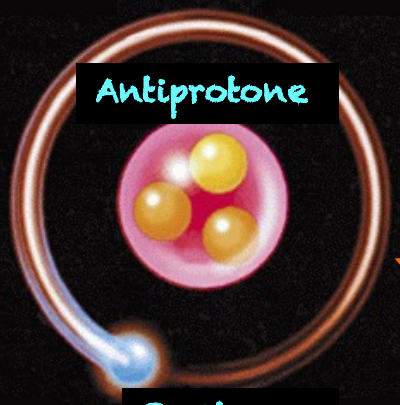
Andiamo sopra l'atmosfera (almeno sopra la troposfera, nella stratosfera, raggiungibile anche via pallone)!

**Fisica delle Particelle nello spazio!**

# Antimateria



# Materia & Antimateria




Positrone

Atomo di Anti-Idrogeno

BIG BANG!

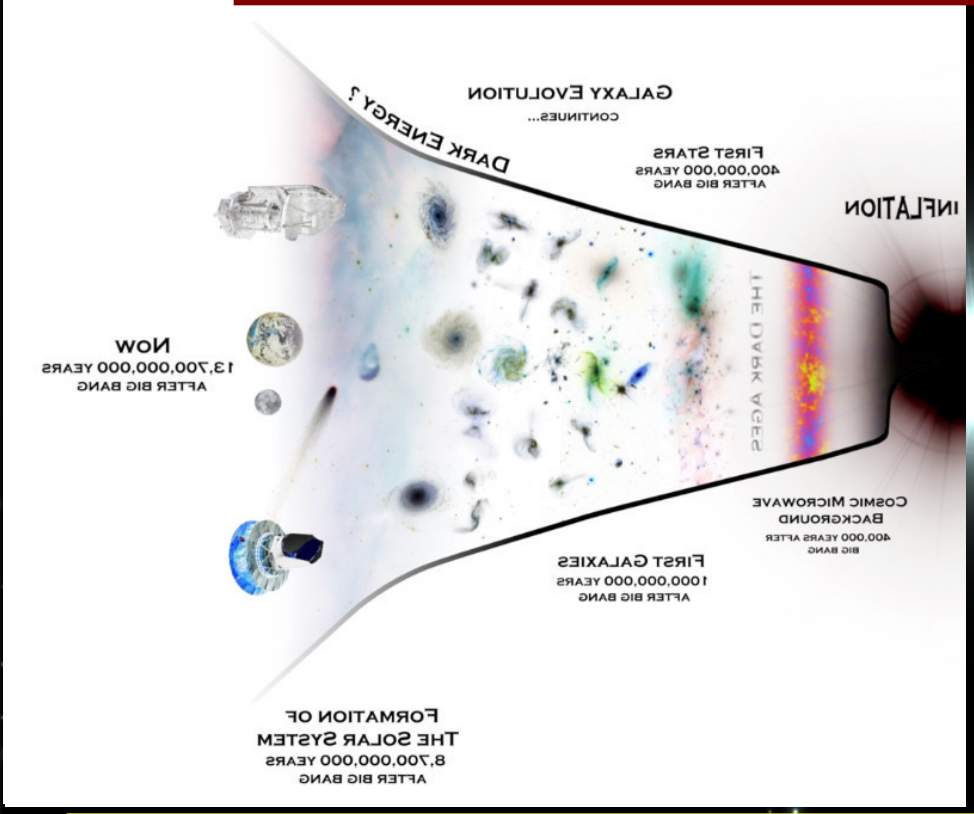

Elettrone

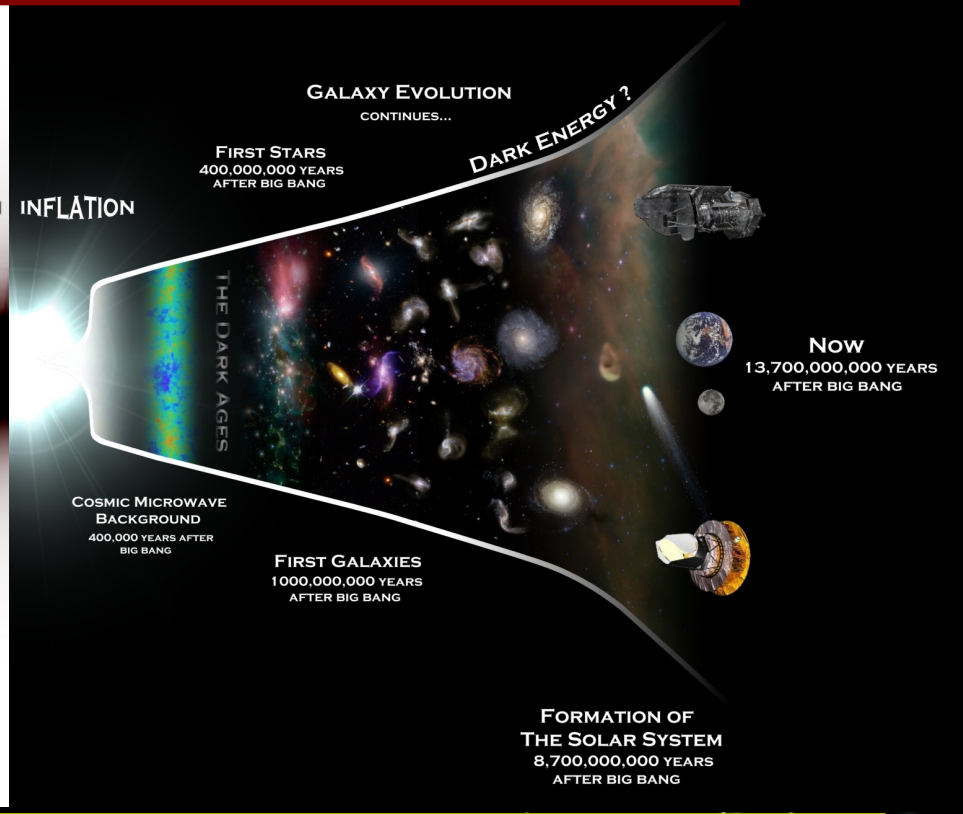
Atomo di Idrogeno

# Materia & Antimateria Primordiale

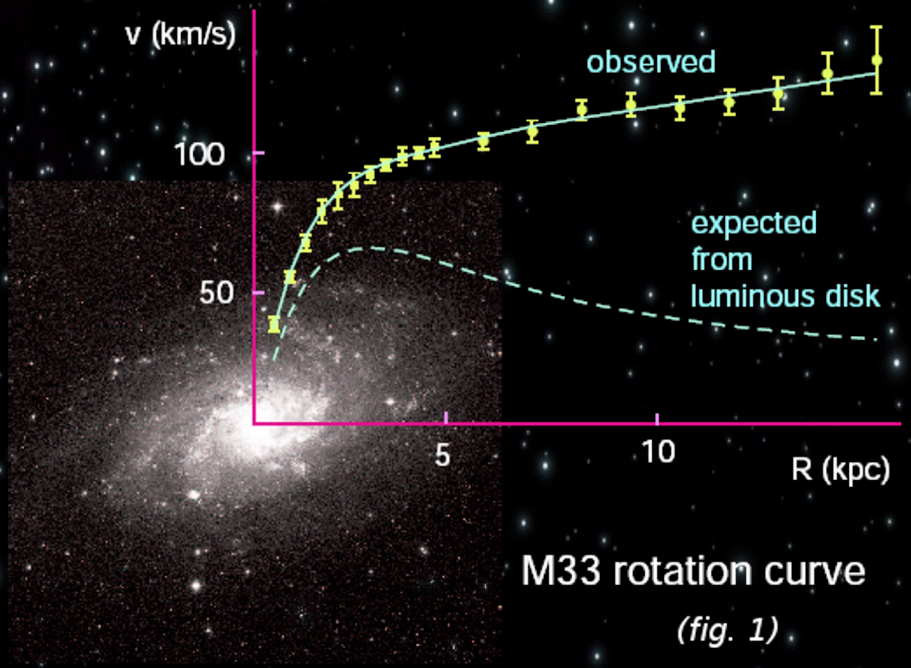
## Dirac's Nobel speech

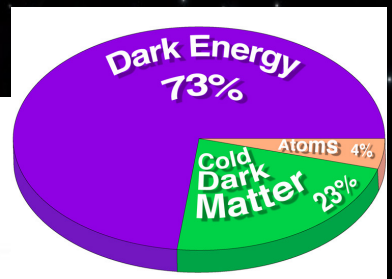
*"We must regard it rather as an accident that the Earth [...] contains a preponderance of negative electrons and positive protons. It is quite possible that for some stars it is the other way about."*





# Materia Oscura (Dark Matter, DM)



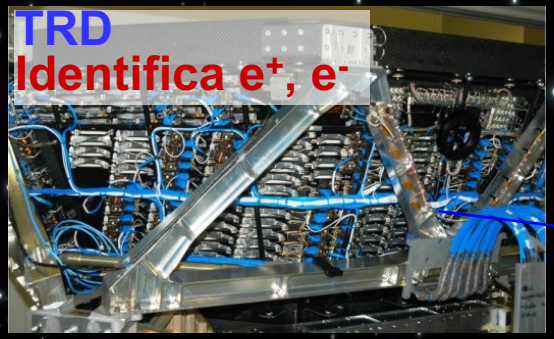




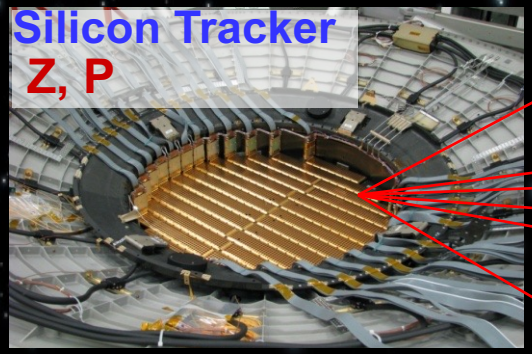
La velocità di rotazione degli "oggetti" nelle galassie è in contraddizione con quella prevista assumendo come massa della galassia solo quella visibile

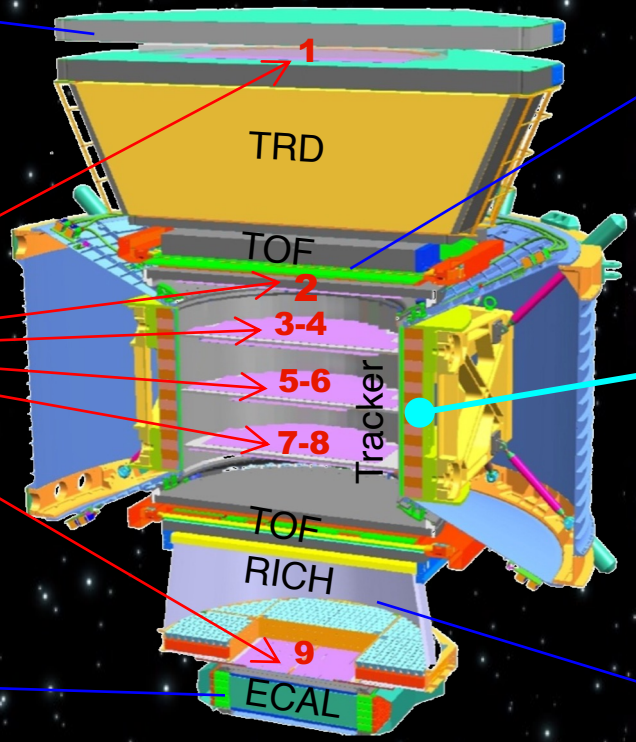
Un "agglomerato", invisibile, di materia oscura può agire come "lente gravitazionale" e deformare l'immagine "apparente" di una sorgente luminosa

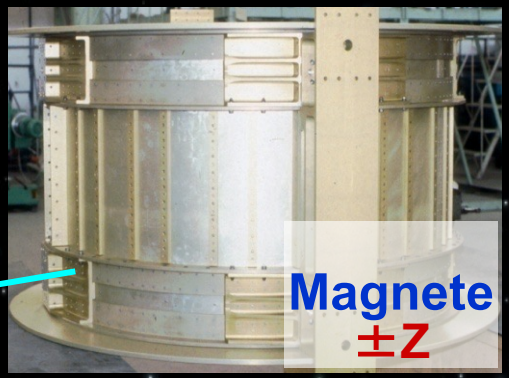
# Il rivelatore AMS-02

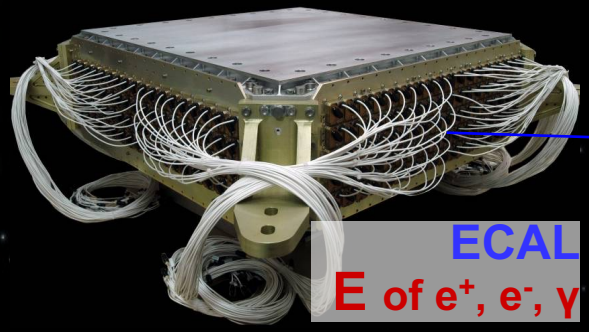


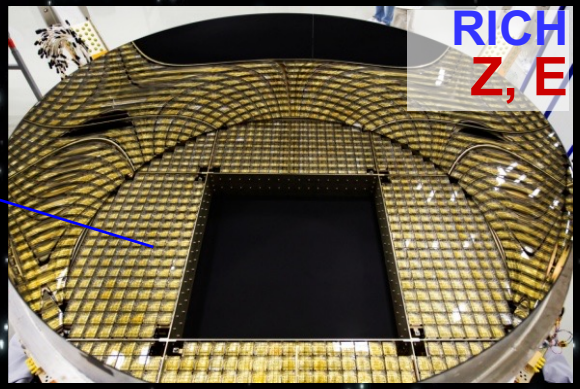

*Z, P sono misurate indipendentemente da Tracker, RICH, TOF e ECAL*

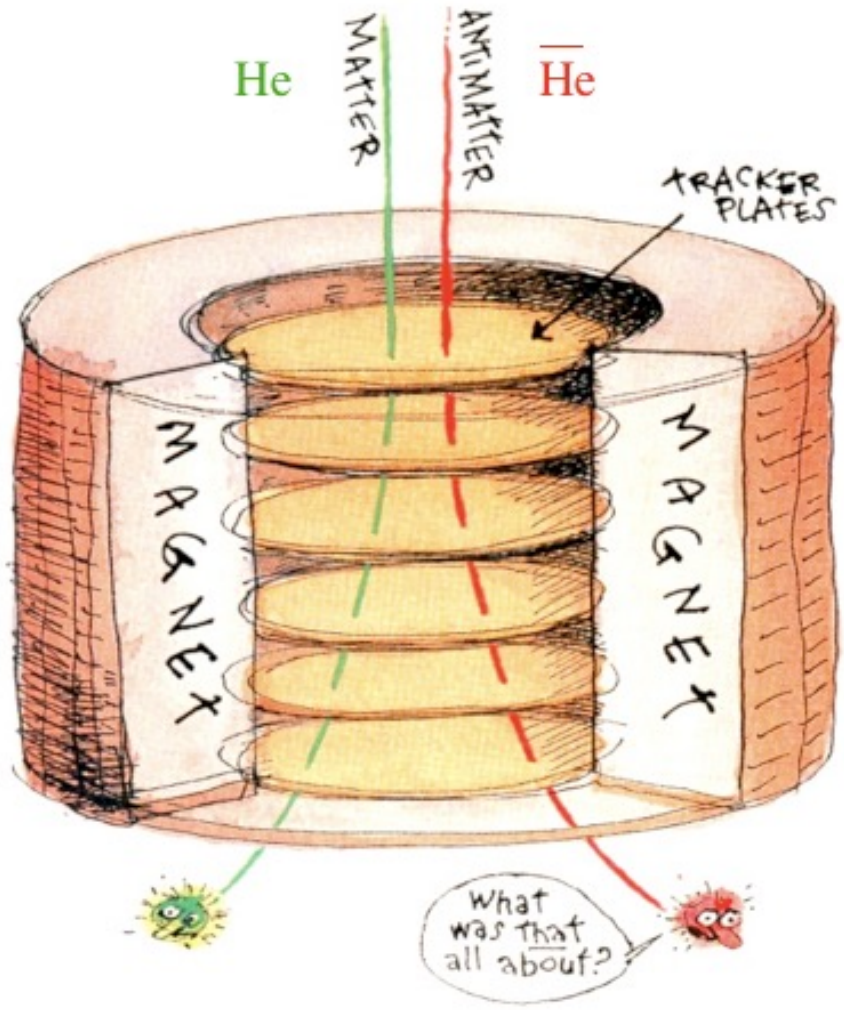



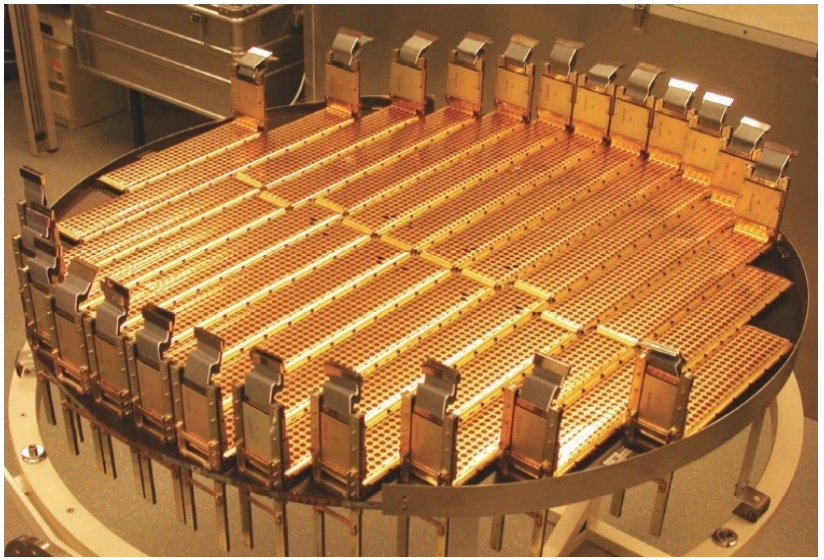



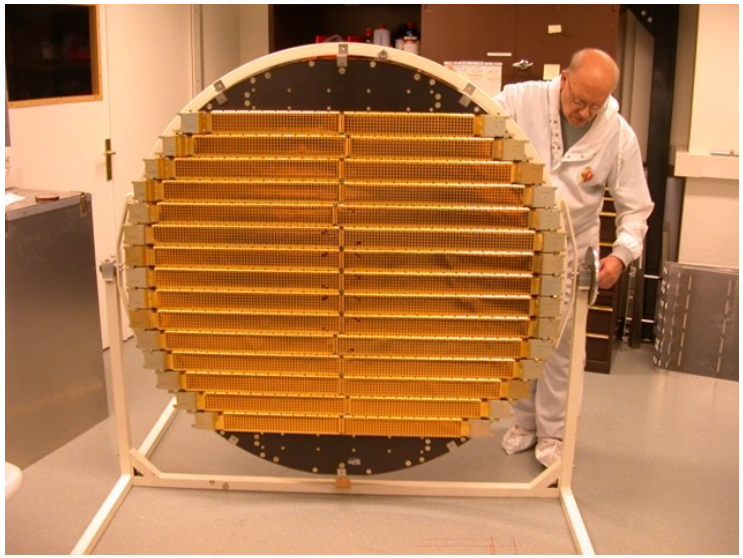



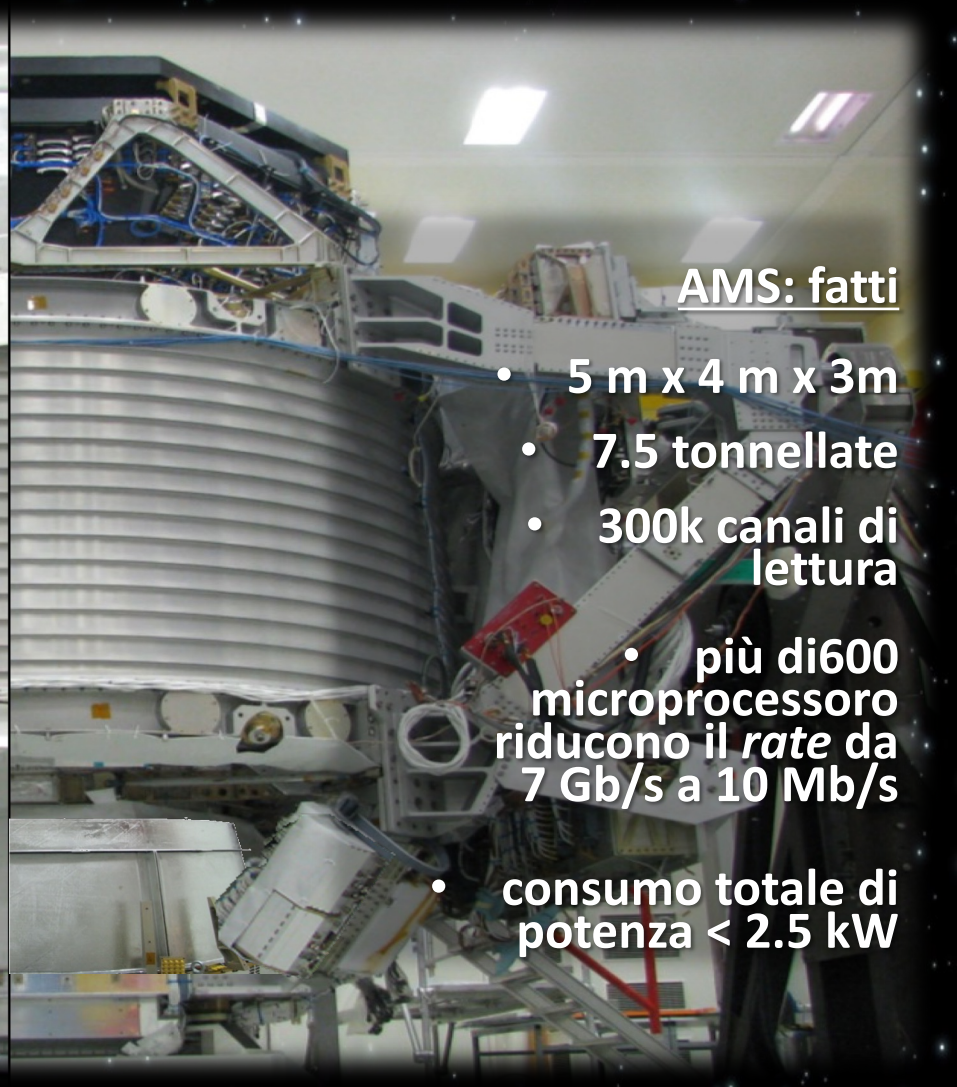
# Spettrometria magnetica





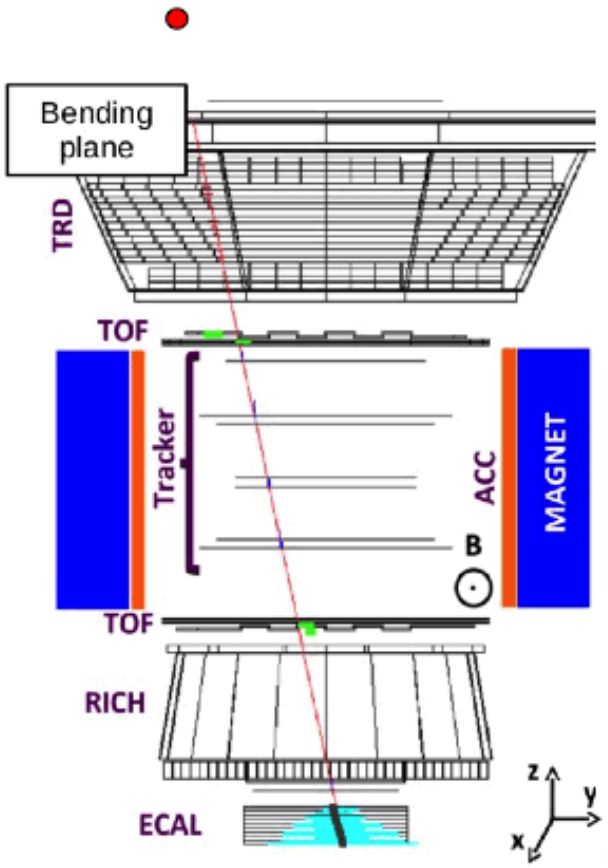
# AMS-02 assemblato



**AMS: fatti**

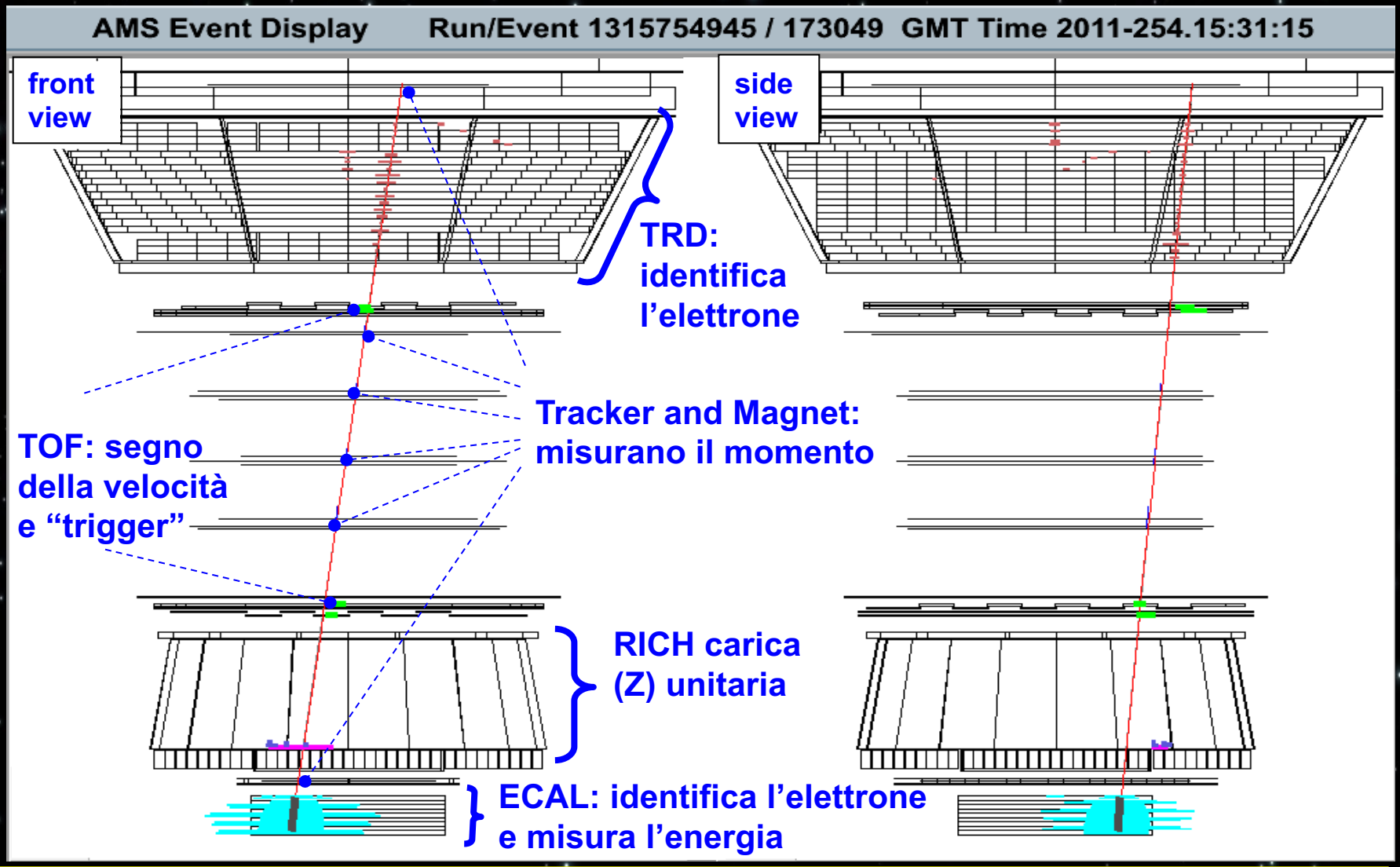
- 5 m x 4 m x 3m
- 7.5 tonnellate
- 300k canali di lettura
- più di600 microprocessoro riducono il *rate* da 7 Gb/s a 10 Mb/s
- consumo totale di potenza < 2.5 kW

# Le "foto" scattate da AMS




| | $e^-$ | p | He |
|---|---|---|---|
| **TRD** 20 layers | | | |
| **TOF** 4 layers | | | |
| **TRK** 9 layers | | | |
| **RICH** | | | |
| **ECAL** 20 layers | | | |

# Dati di AMS sulla ISS – Elettrone di 1.03 TeV

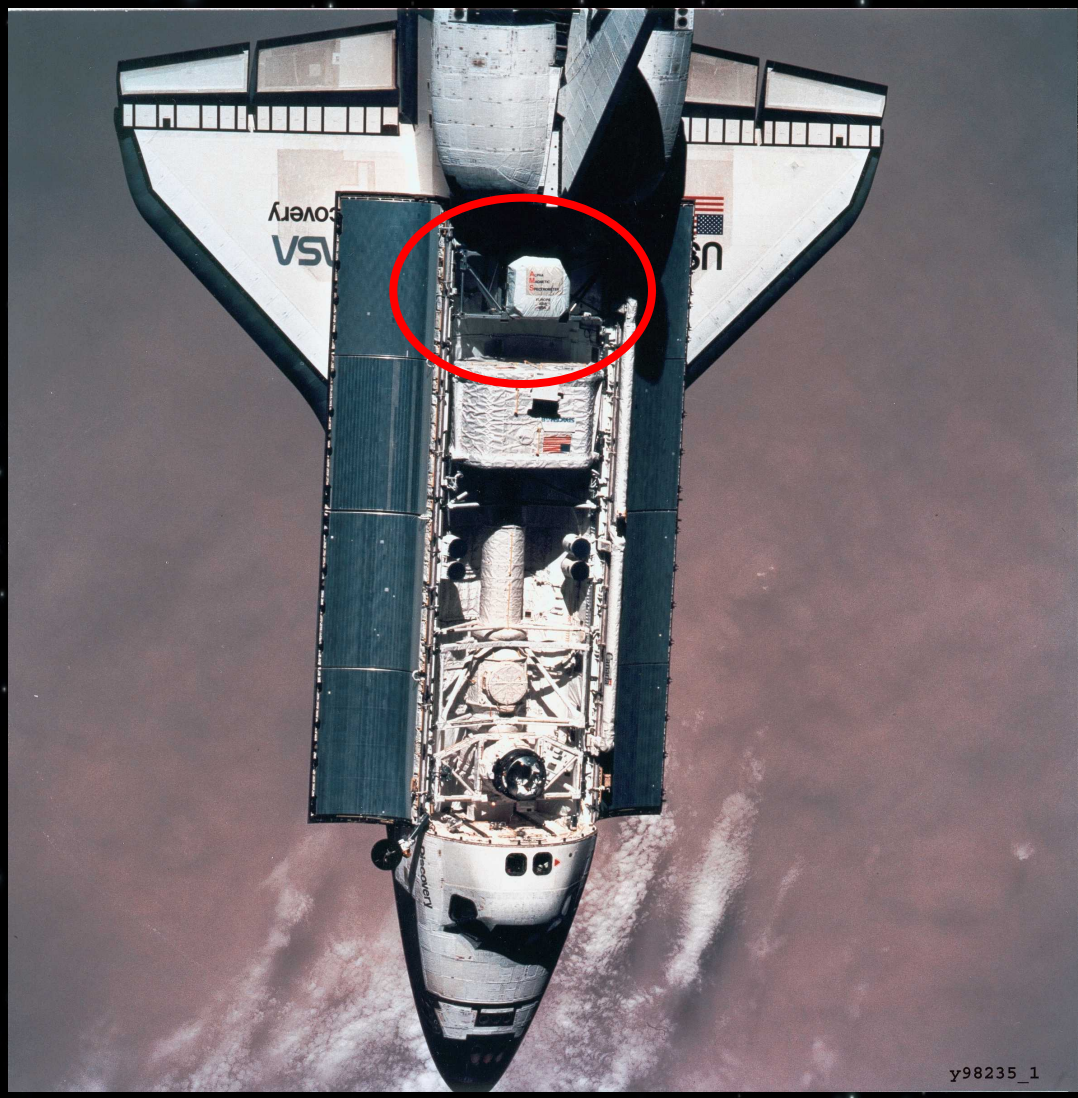


# 2 – 12 Giugno 1998: AMS-01 sul Discovery STS91

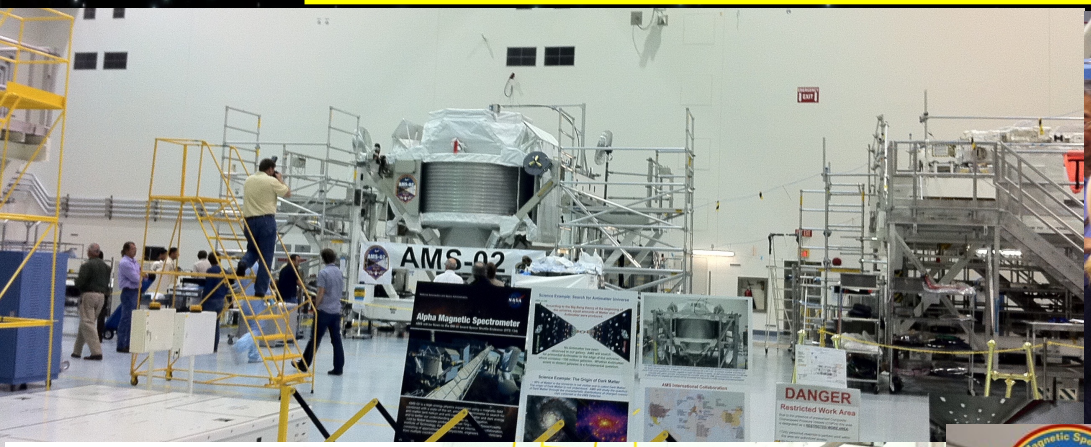
- 10 giorni di presa dati in orbita:
  - 400 Km di altitudine
  - latitudini <51.7°
  - tutte le longitudini
- $10^8$ eventi acquisiti
- risultati di fisica

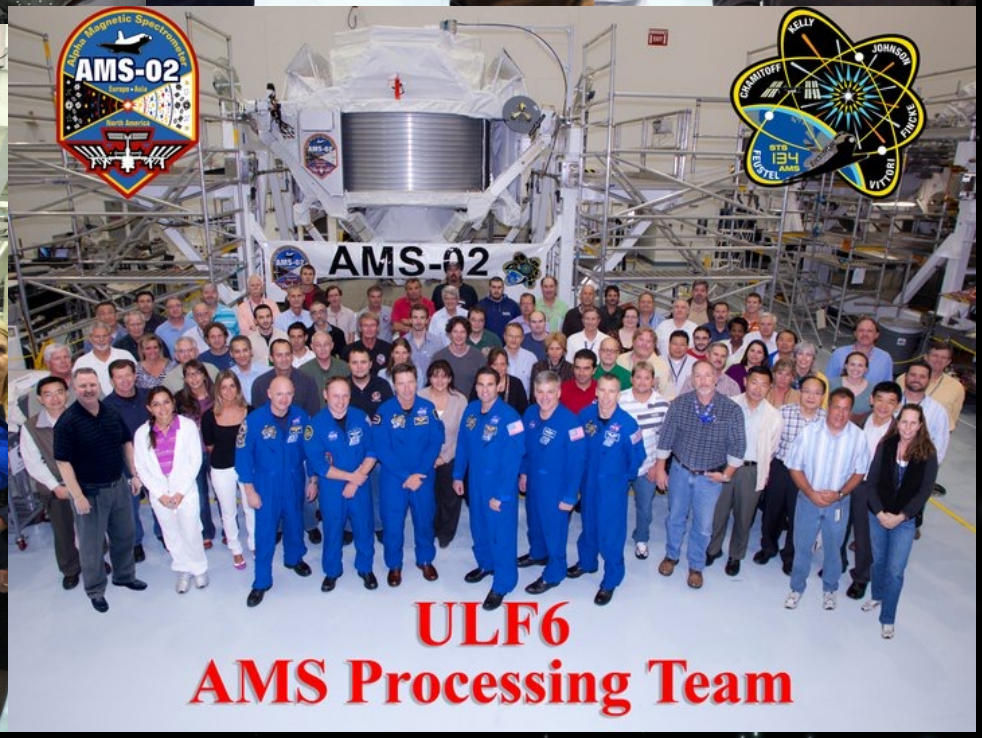
(Phys. Rep. 366 (2002) 331)

  - misure di precisione dei flussi primari
  - rivelazione di particelle secondarie (quasi-trapped)
  - limite sull'antimateria a $10^{-6}$



# Settembre 2010: AMS-02 al KSC!




STOP
ACUATION INSTRUCTIONS

# AMS nello Shuttle (Endeavour, STS134)


© Michele Famiglietti / AMS Collaboration

# Il lancio di AMS - @ KSC, Florida


**Peso totale: 2008 t**

**Peso di AMS: 7.5 t**

# Il lancio di AMS - @ JSC, Texas

**Houston, JSC – 16 Maggio, 2011@ 07:56 AM**

# AMS sulla International Space Station


May 19, 2011: AMS installazione completa

# Una bella esperienza

Il gruppo del Tracker aspetta l'installazione

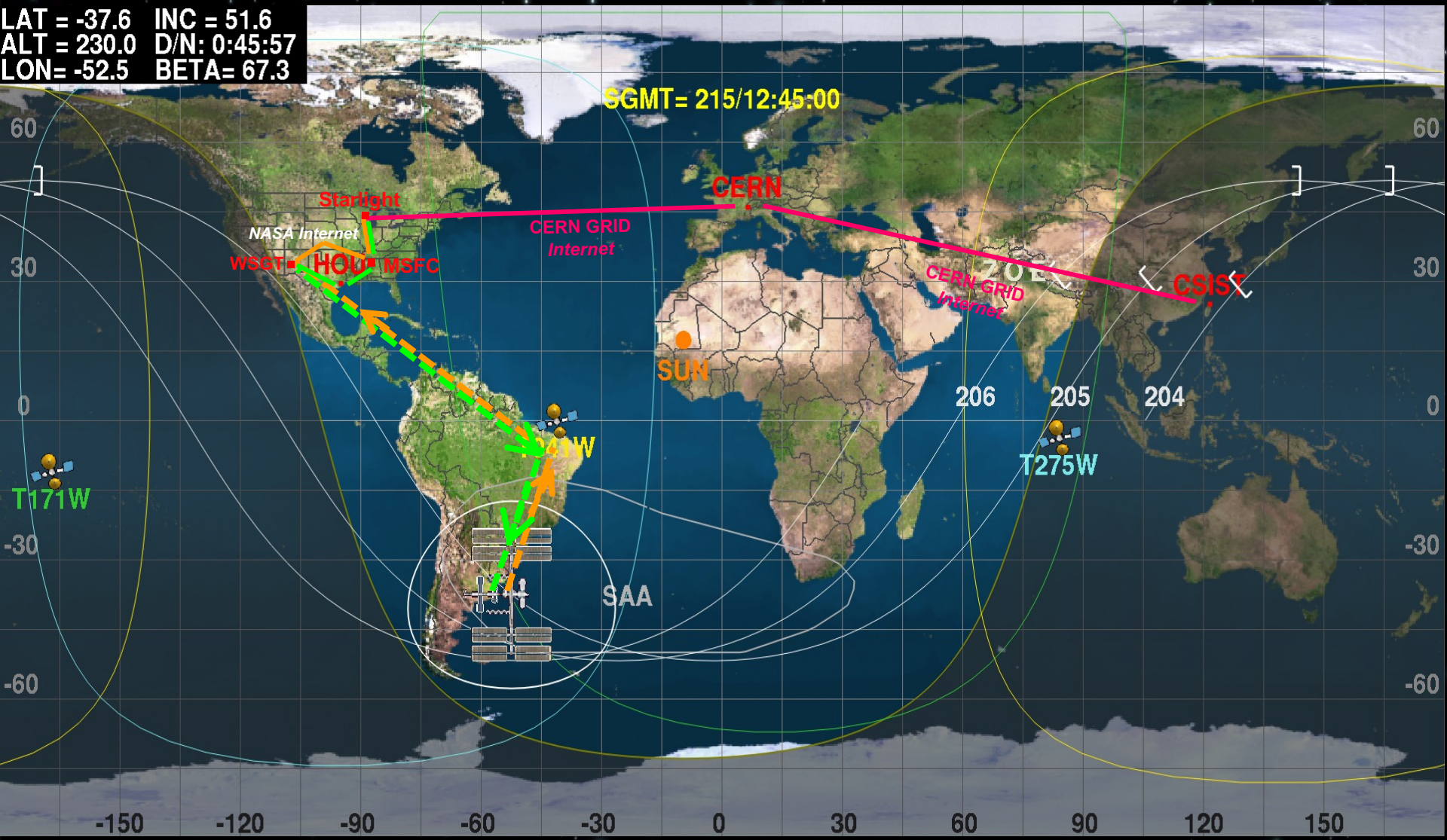

Il gruppo del Tracker aspetta il lancio


AMS-Italy con il "nostro" shuttle


Dopo 3 turni di notte aspettando l'installazione


AMS-02
STS-134
AMS Tracker
Chips Ahoy!

# In orbita @ 400 km da terra



# Payload Operation Control Center (POCC) @ CERN

# Payload Operation Control Center (POCC) @ CERN

# Payload Operation Control Center (POCC) @ Taiwan

# State connessi per nuova fisica!


## STS-134/ULF6

## Alpha Magnetic Spectrometer Team

28 February 2011

## Kennedy Space Center