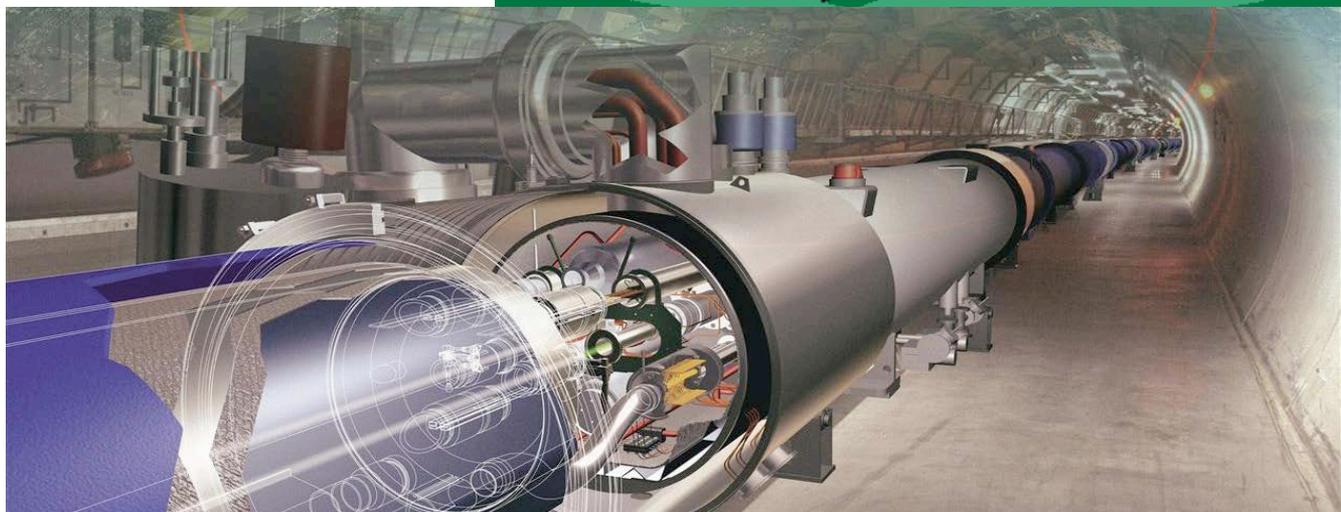
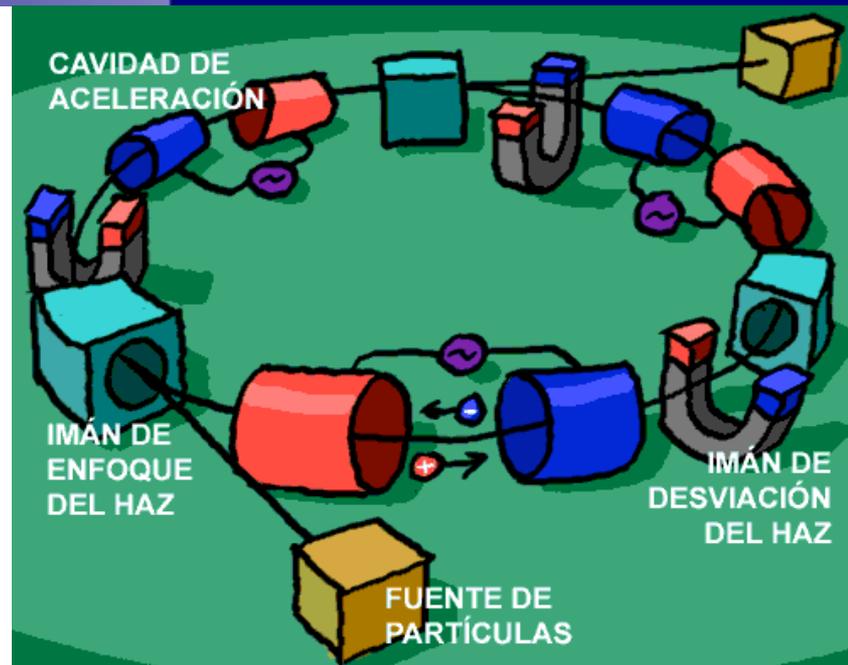


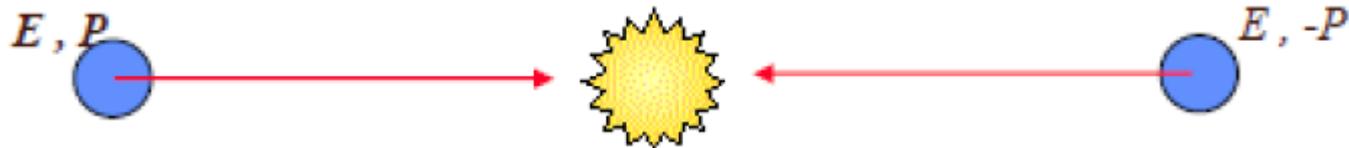
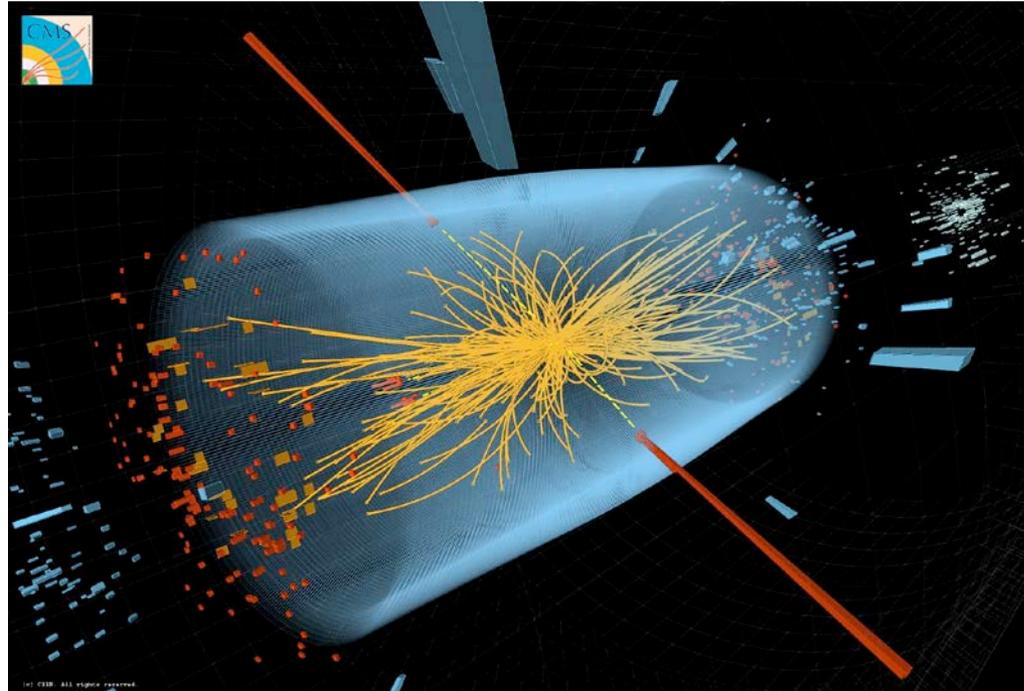
Principios de aceleradores de partículas

Stefano Mattei
CERN BE/ABP



- Que es un acelerador?
 - Los componentes
 - Cómo funciona?
- Los aceleradores del CERN
- Futuro



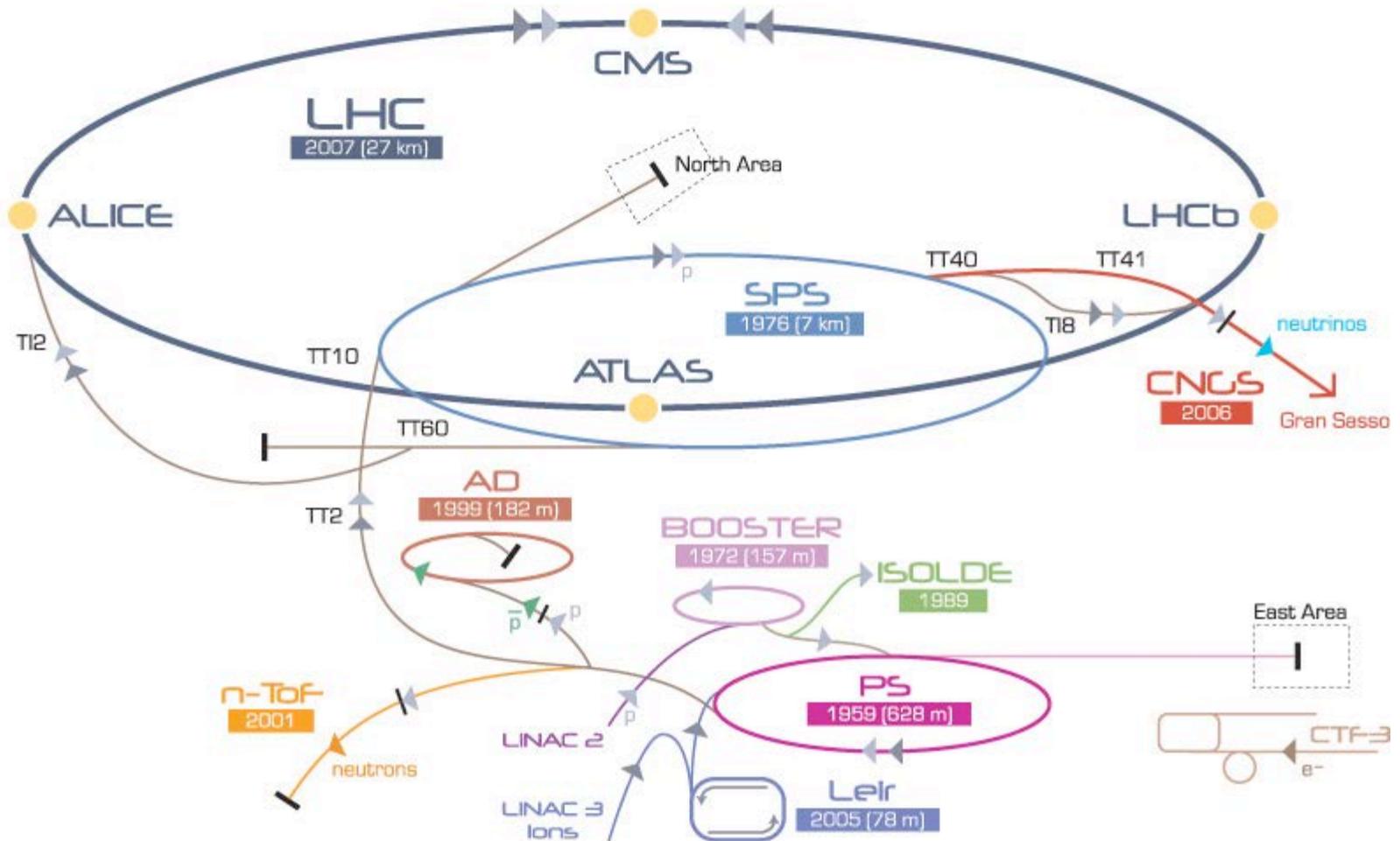


$$E=mc^2$$

Albert Einstein, 1905.

c = velocidad de la luz
300 000 000 m/s

CERN Accelerator Complex





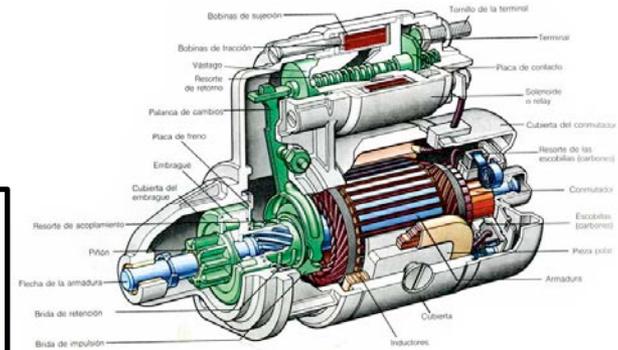
Qué acelerar?



Volante



Motor



Carretera



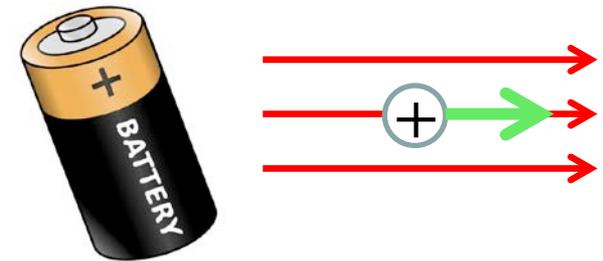
Qué acelerar?

Partículas cargadas electricamente



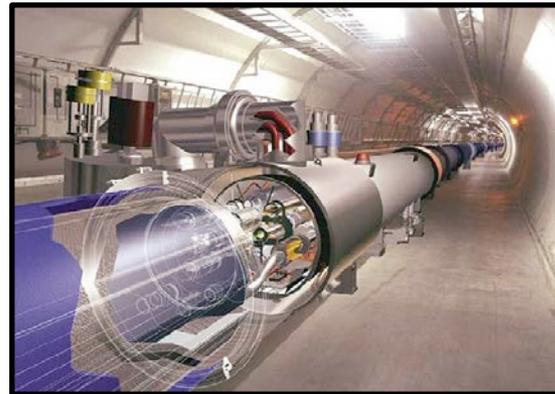
Motor

Campos eléctricos

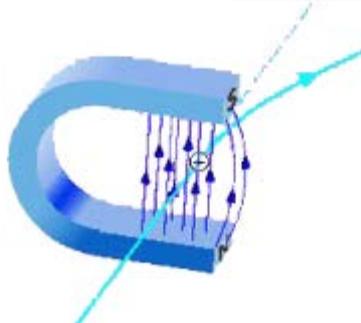
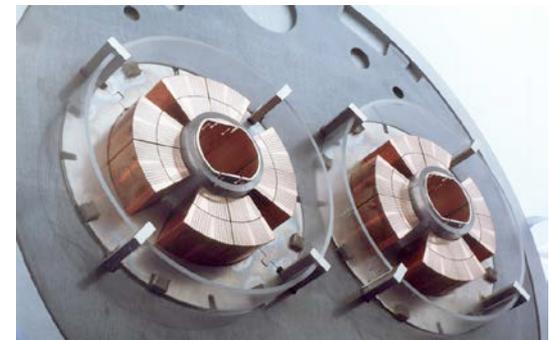


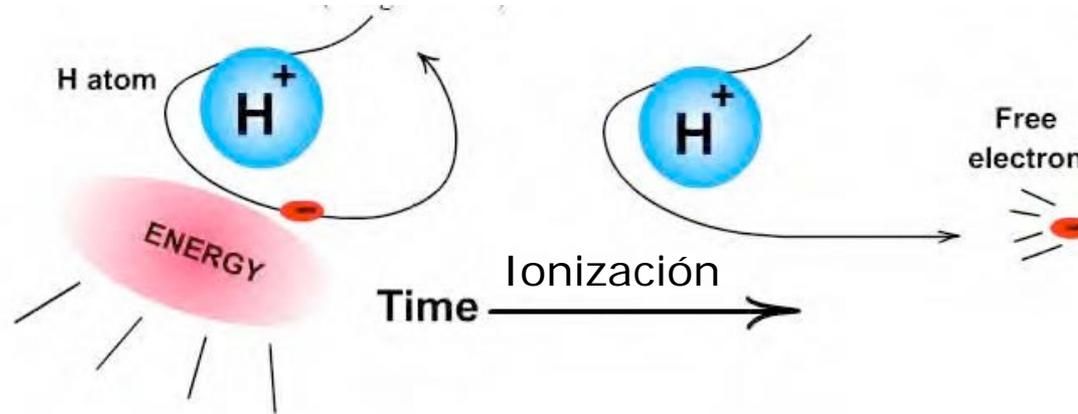
Volante

Campos magnéticos

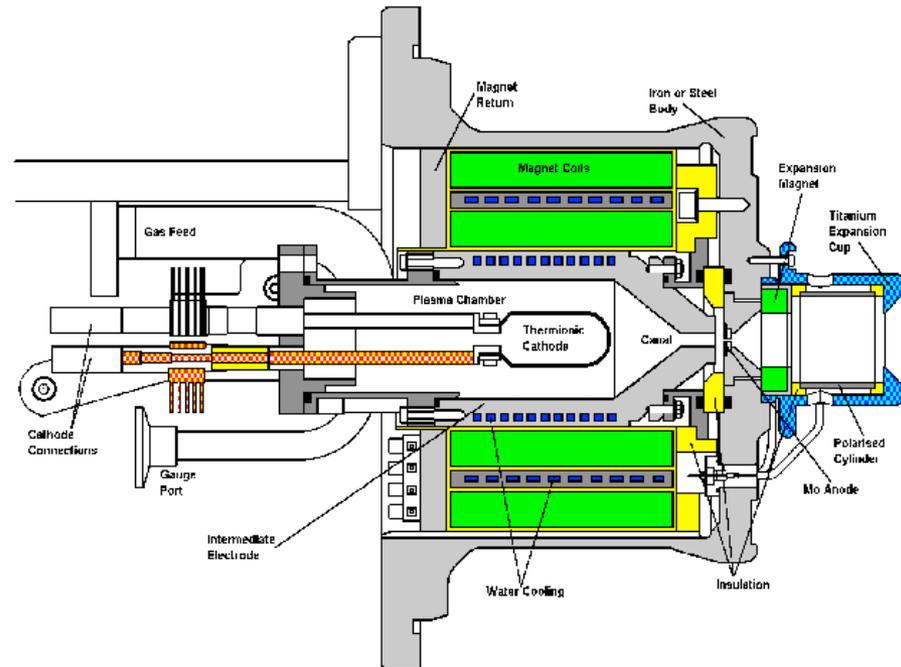


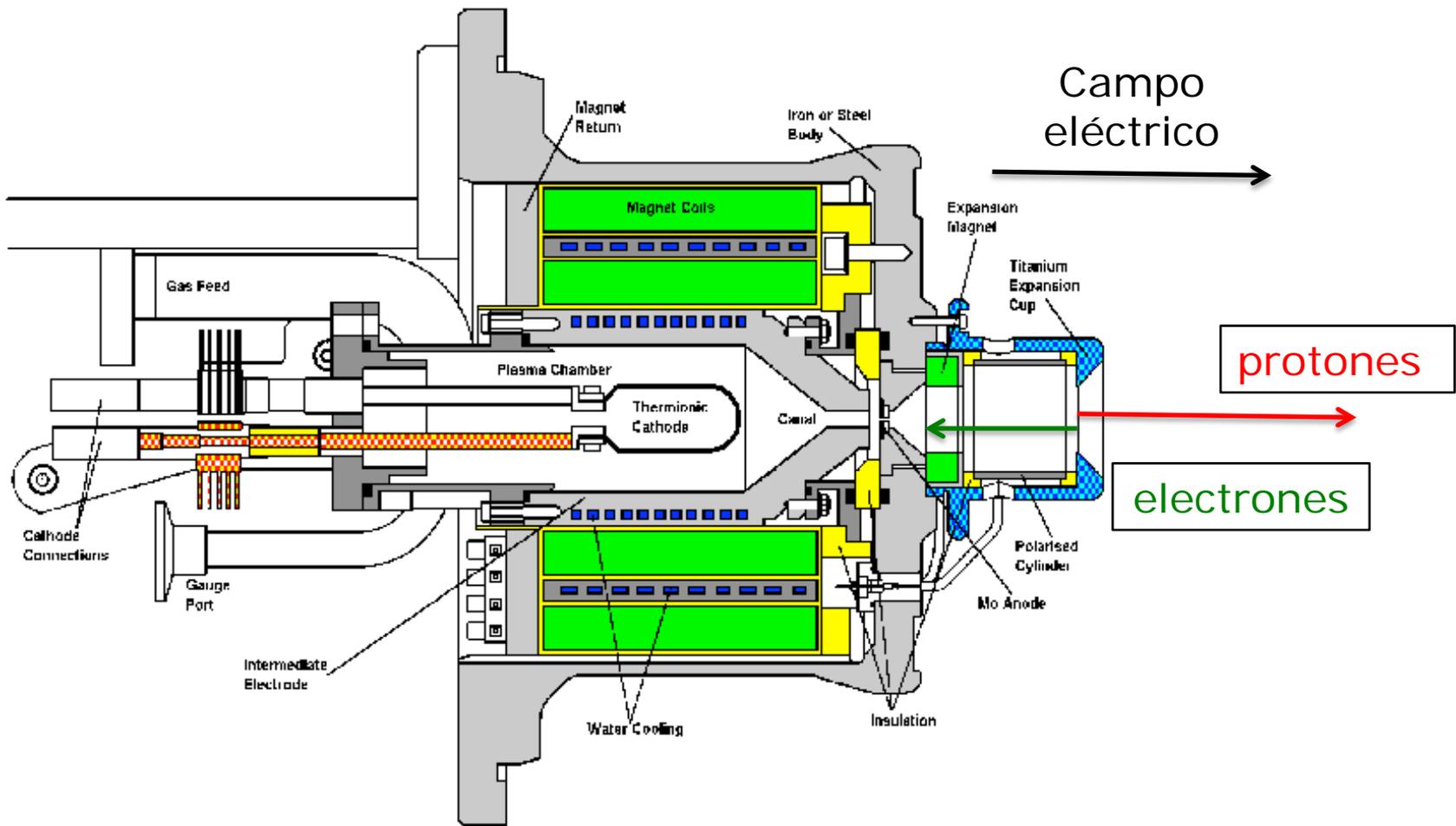
Carretera





Plasma de hidrógeno
gas muy caliente en el cual los electrones se separan de los protones





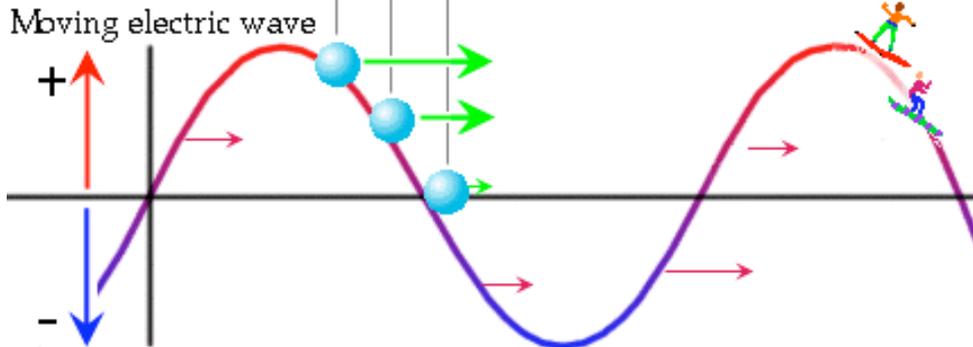
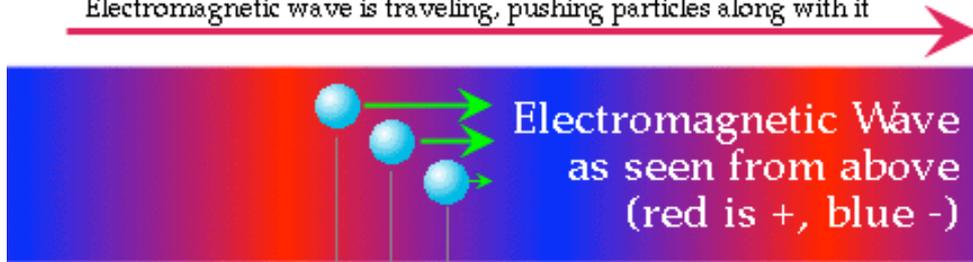


Tensiones muy altas son difíciles de aislar

Video:

<http://www.youtube.com/watch?v=vqgNrj6oEdc>

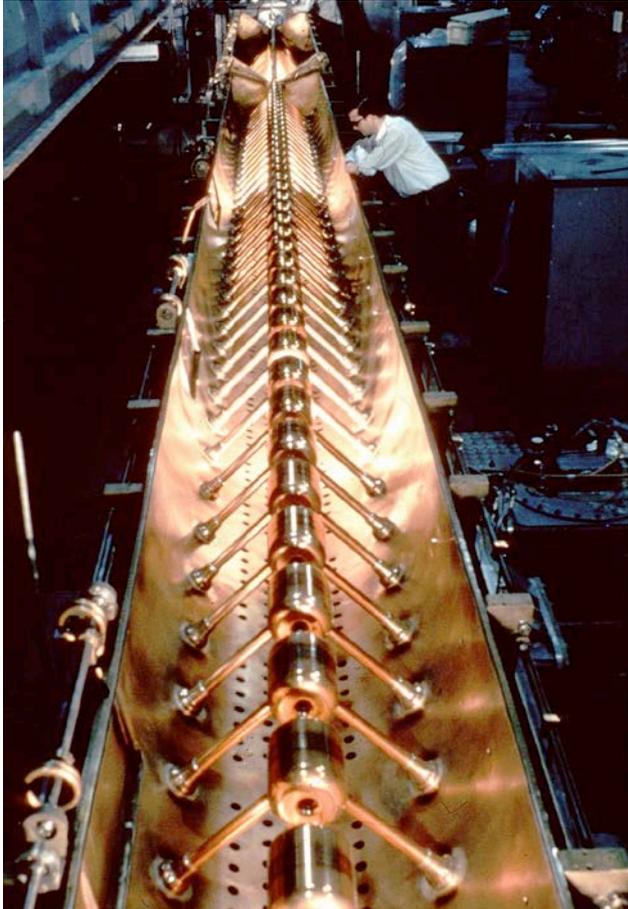
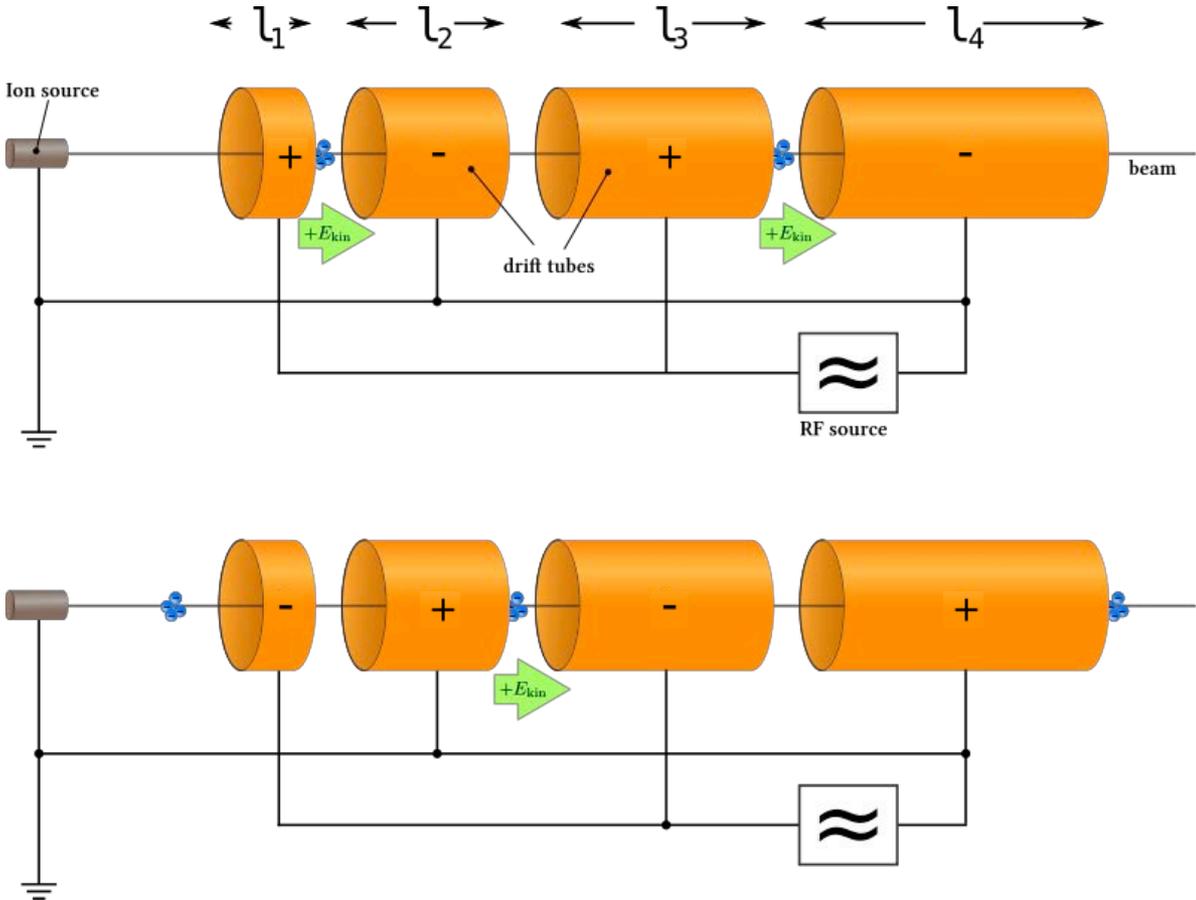
Electromagnetic wave is traveling, pushing particles along with it

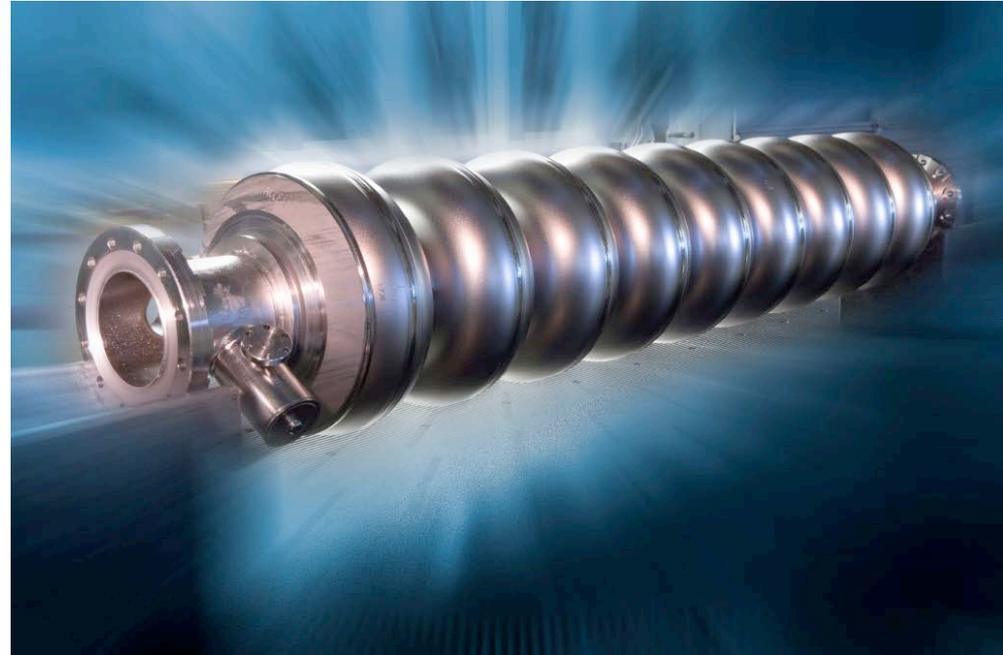
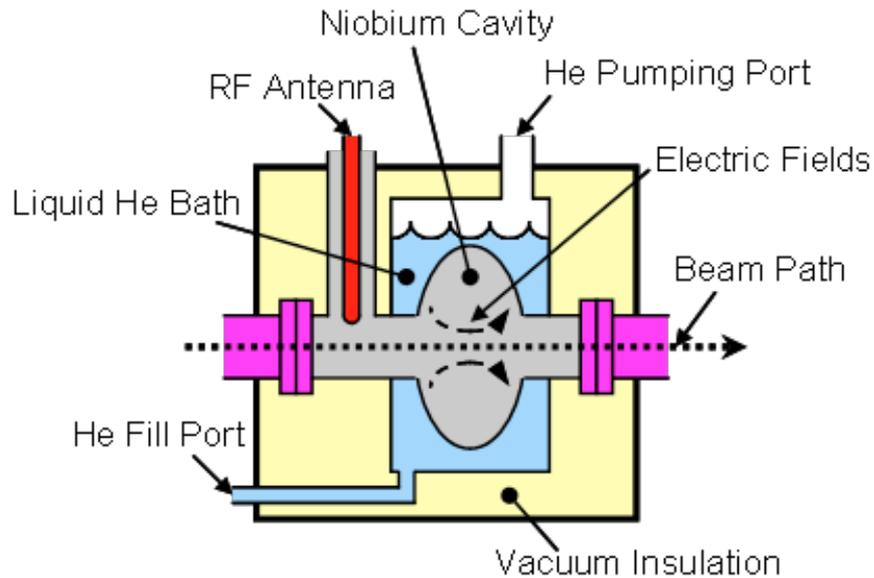


Positively charged particles (●) close to the crest of the E-M wave experience the most force forward; those closer to the center experience less of a force. The result is that the particles tend to move together with the wave.

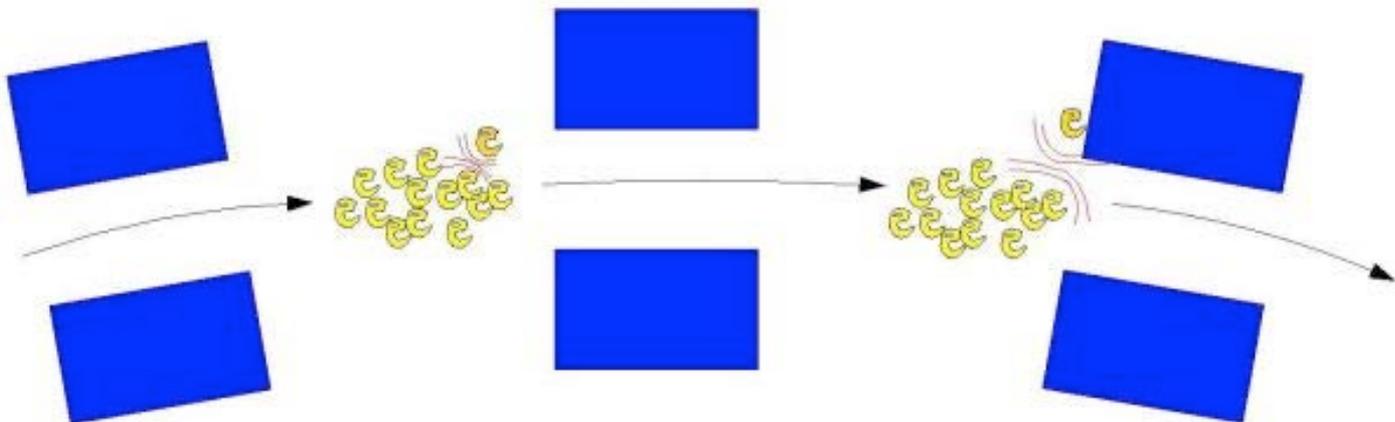
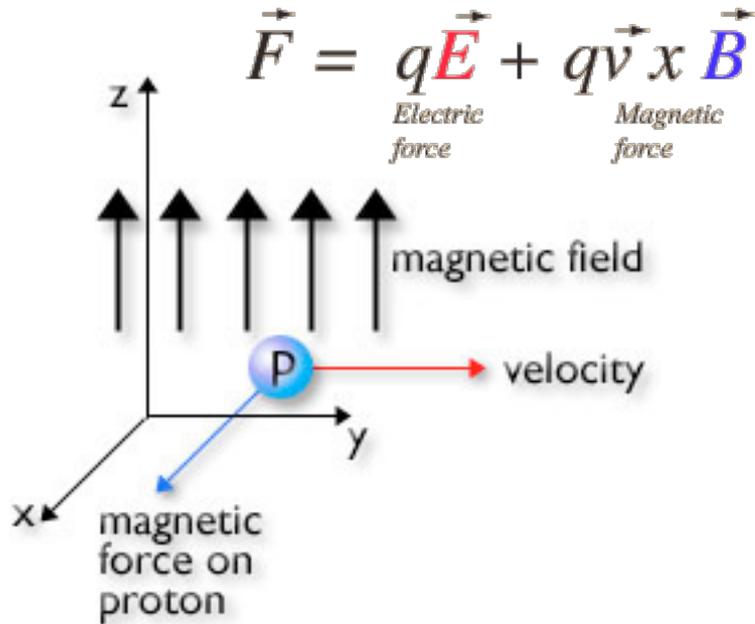


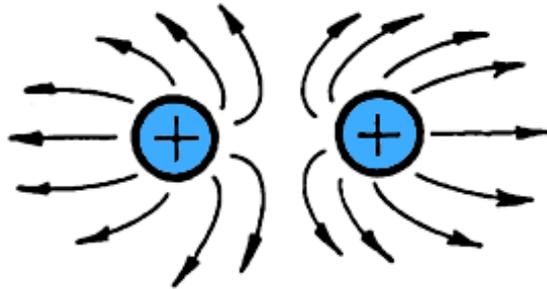
Paquetes de protones:
"BUNCH"



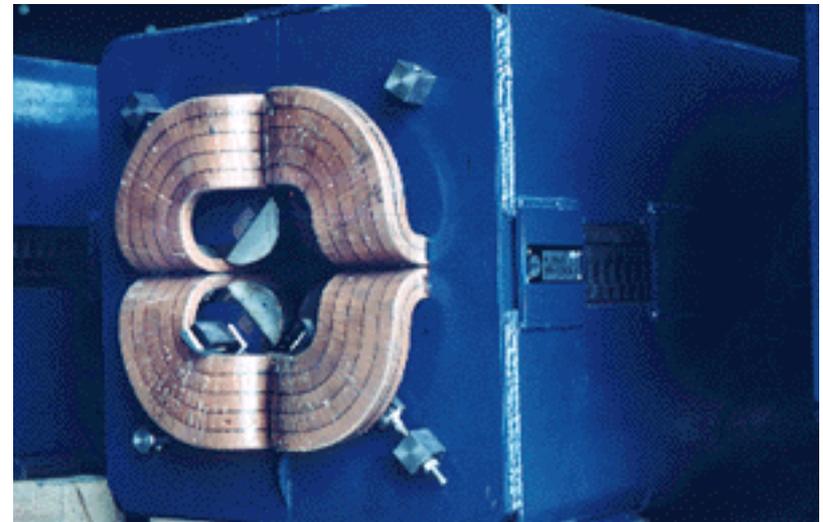
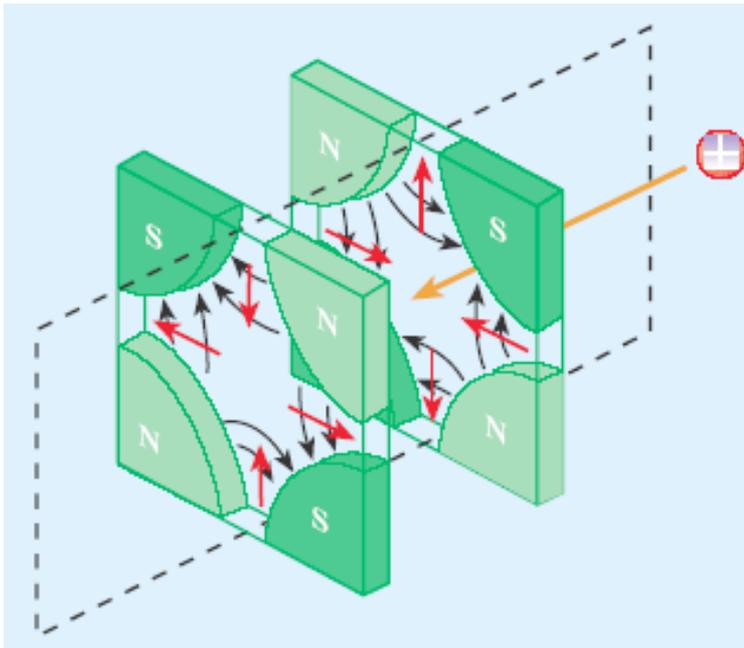


Superconductividad – algunos materiales a temperaturas cerca de 0 K tienen una resistencia eléctrica nula

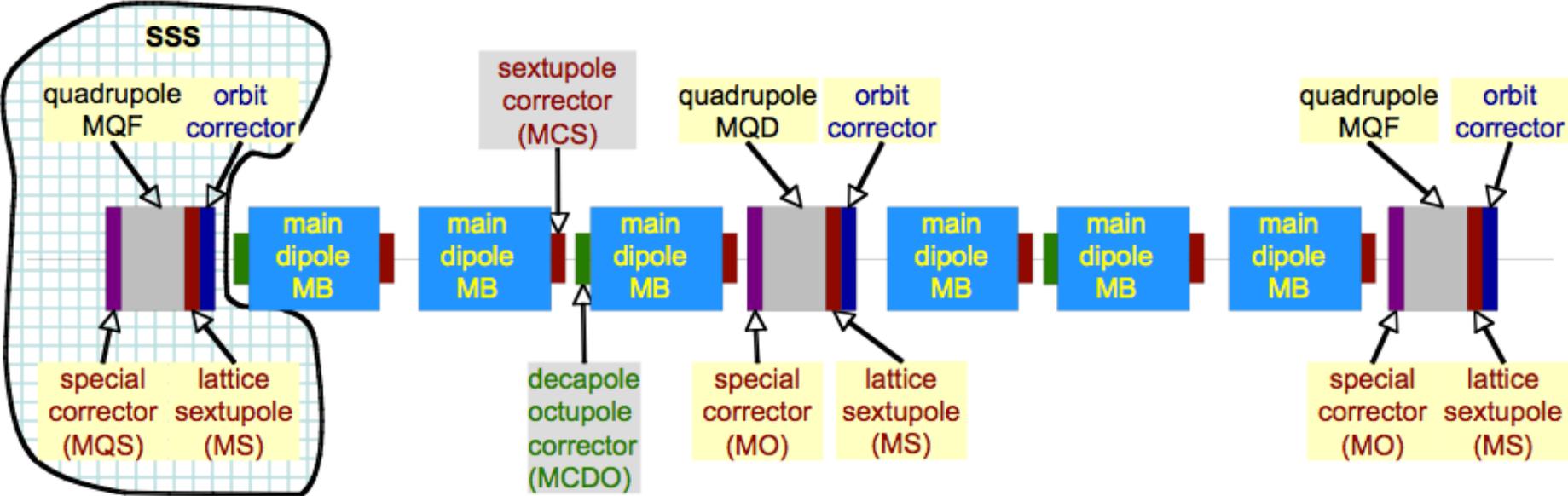




En un "bunch" tenemos muchos protones los cuales tienden a separarse debido a la fuerza eléctrica de repulsión entre ellos

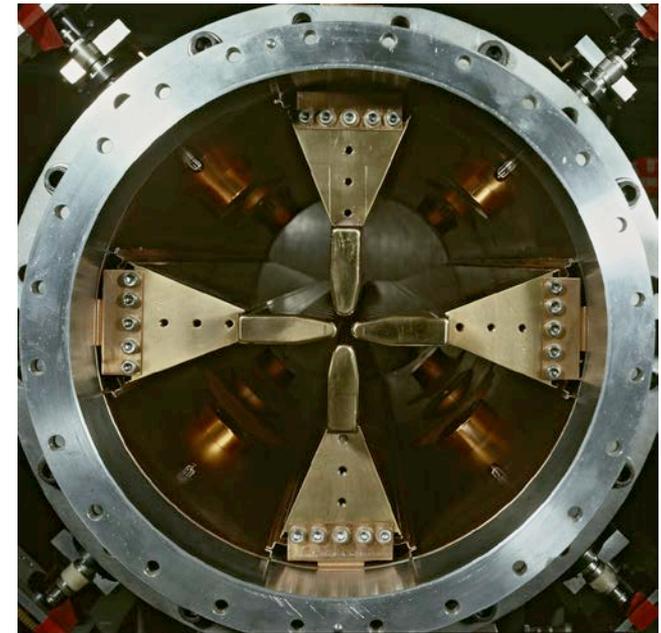
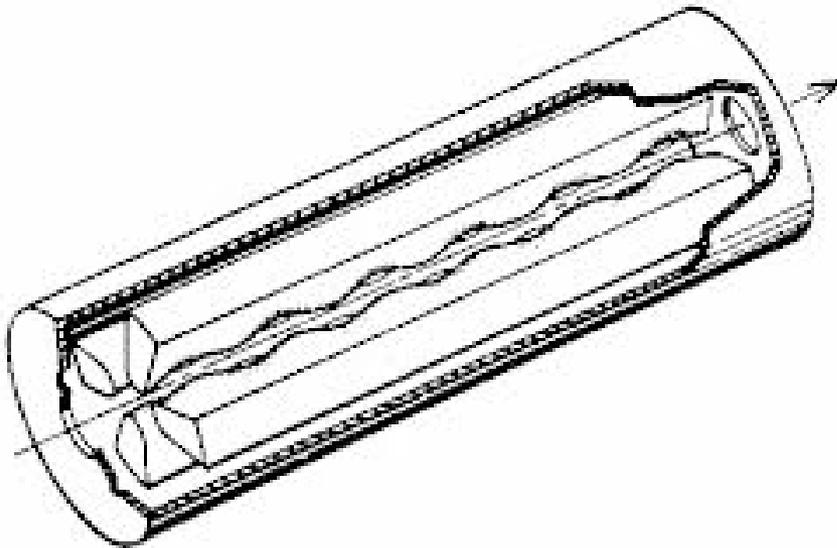


Muchos otros imanes para corregir el movimiento de los protones dependiendo de su posición y/o energía



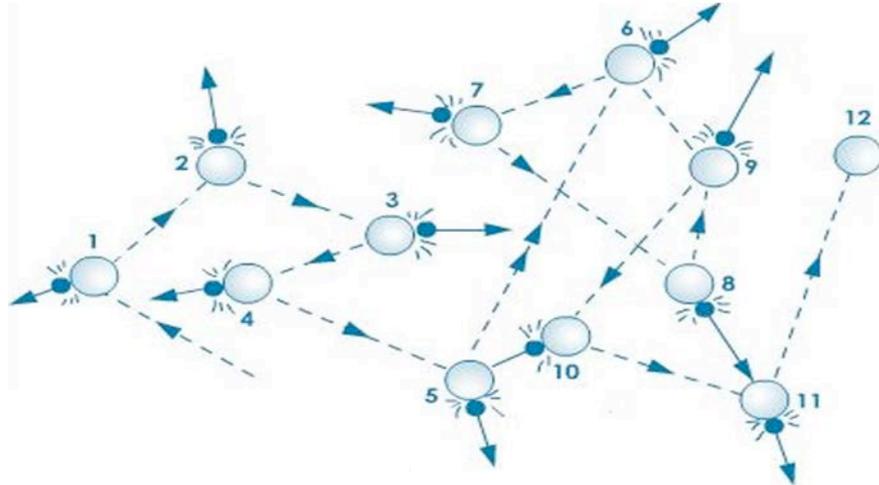
El quadripolo a radio frecuencias (RFQ)

Acelera – define los paquetes – enfoca





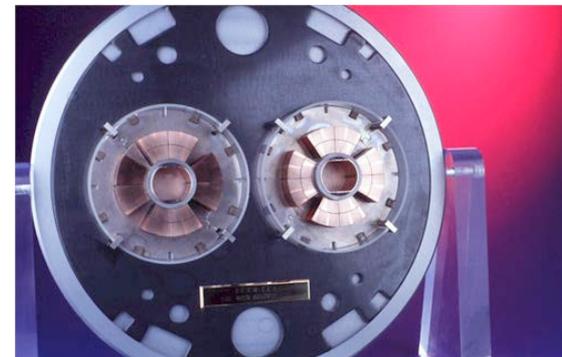
Proton



Creamos vacío para limitar las interacciones entre los protones y los átomos/moléculas del gas (ej. aire) residual

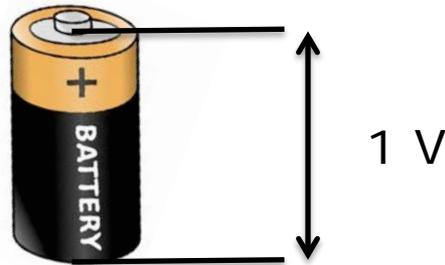
En el LHC hablamos de
ULTRA-ALTO-VACÍO

**Es el lugar más vacío del
Sistema Solar**



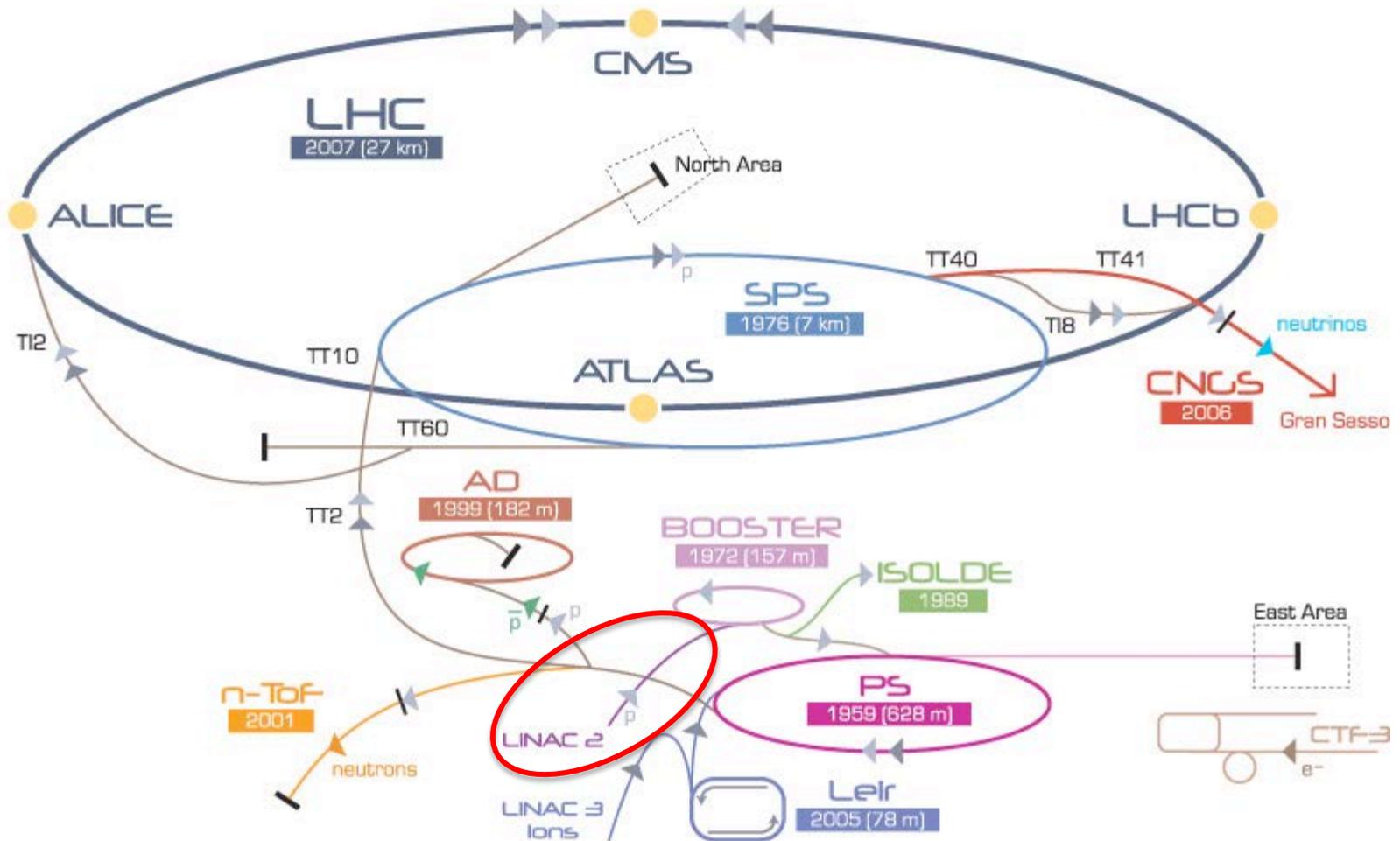
Le energía de las partículas se mide en electronvoltios (eV)

1 eV es la energía cinética que adquiere una partícula con carga eléctrica unitaria cuando se le aplica una diferencia de potencial de 1 V

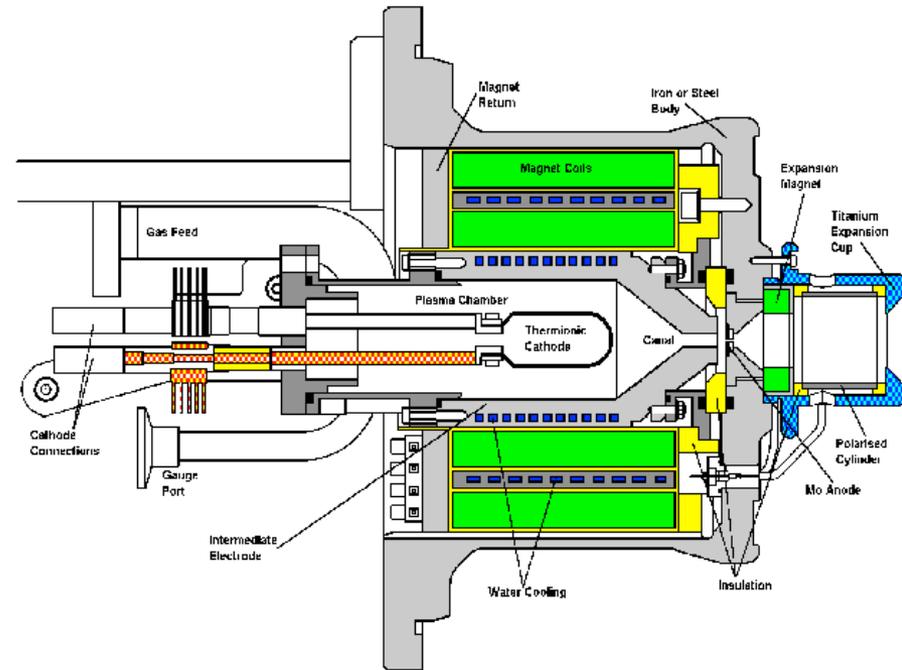


$\beta = v/c$ velocidad dividido por la velocidad de la luz

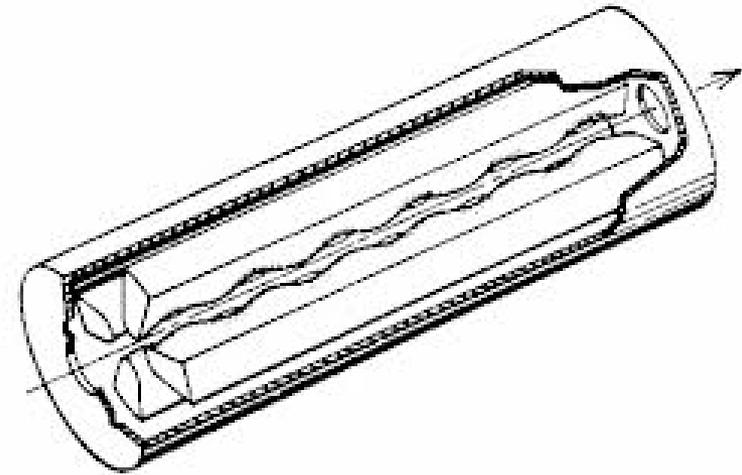
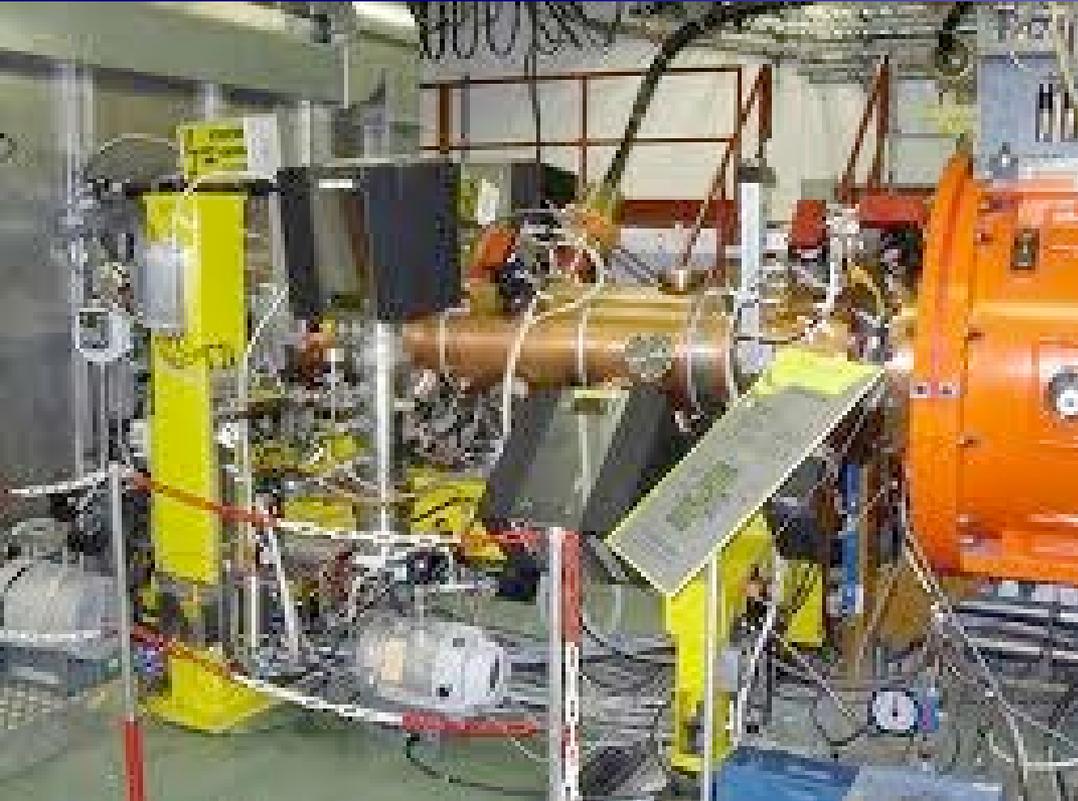
CERN Accelerator Complex



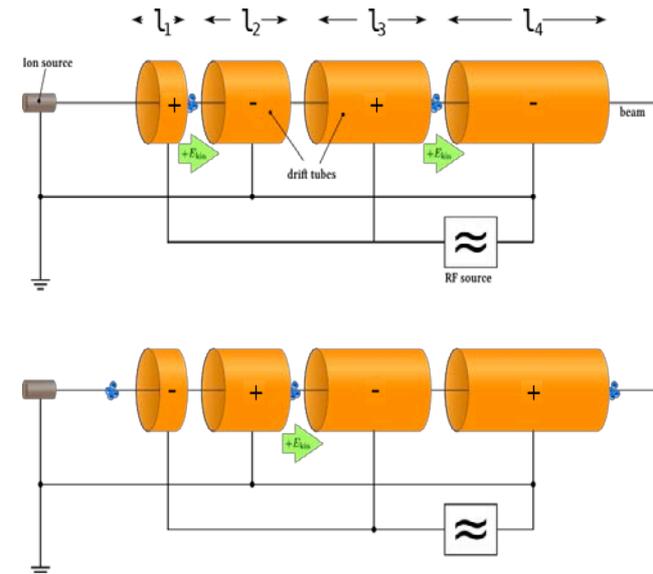
Duoplasmatron



$E = 90 \text{ keV}$
 $\beta = 0.0138$
 $v = 4140 \text{ km/s}$



$E = 750 \text{ keV}$
 $\beta = 0.040$
 $v = 12000 \text{ km/s}$

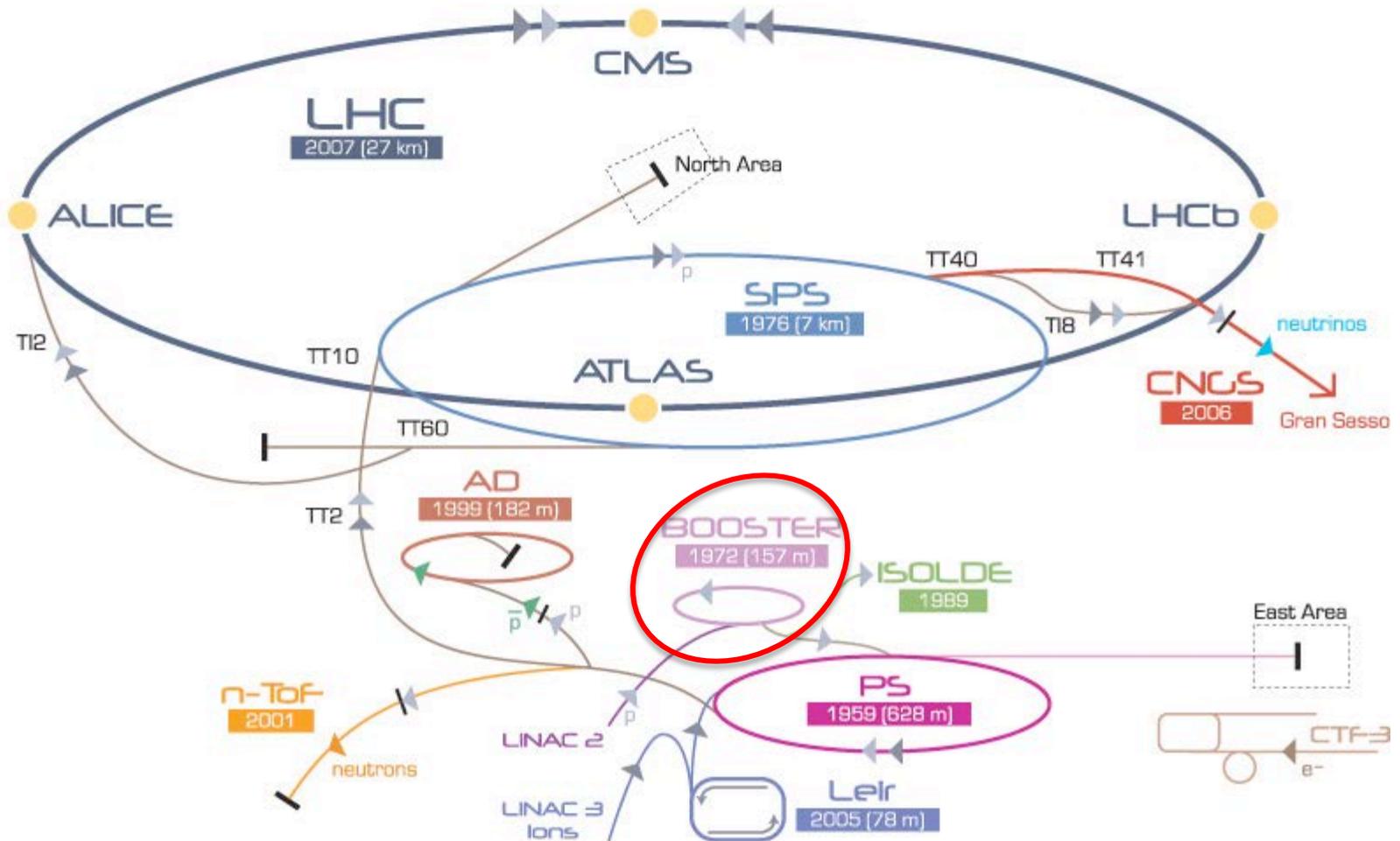


Tank 1
 $E = 10 \text{ MeV}$
 $\beta = 0.145$
 $v = 43500 \text{ km/s}$

Tank 2
 $E = 30 \text{ MeV}$
 $\beta = 0.247$
 $v = 74100 \text{ km/s}$

Tank 3
 $E = 50 \text{ MeV}$
 $\beta = 0.314$
 $v = 94200 \text{ km/s}$

CERN Accelerator Complex





4 anillos que aumentan la energía de 50 MeV a 1.4 GeV

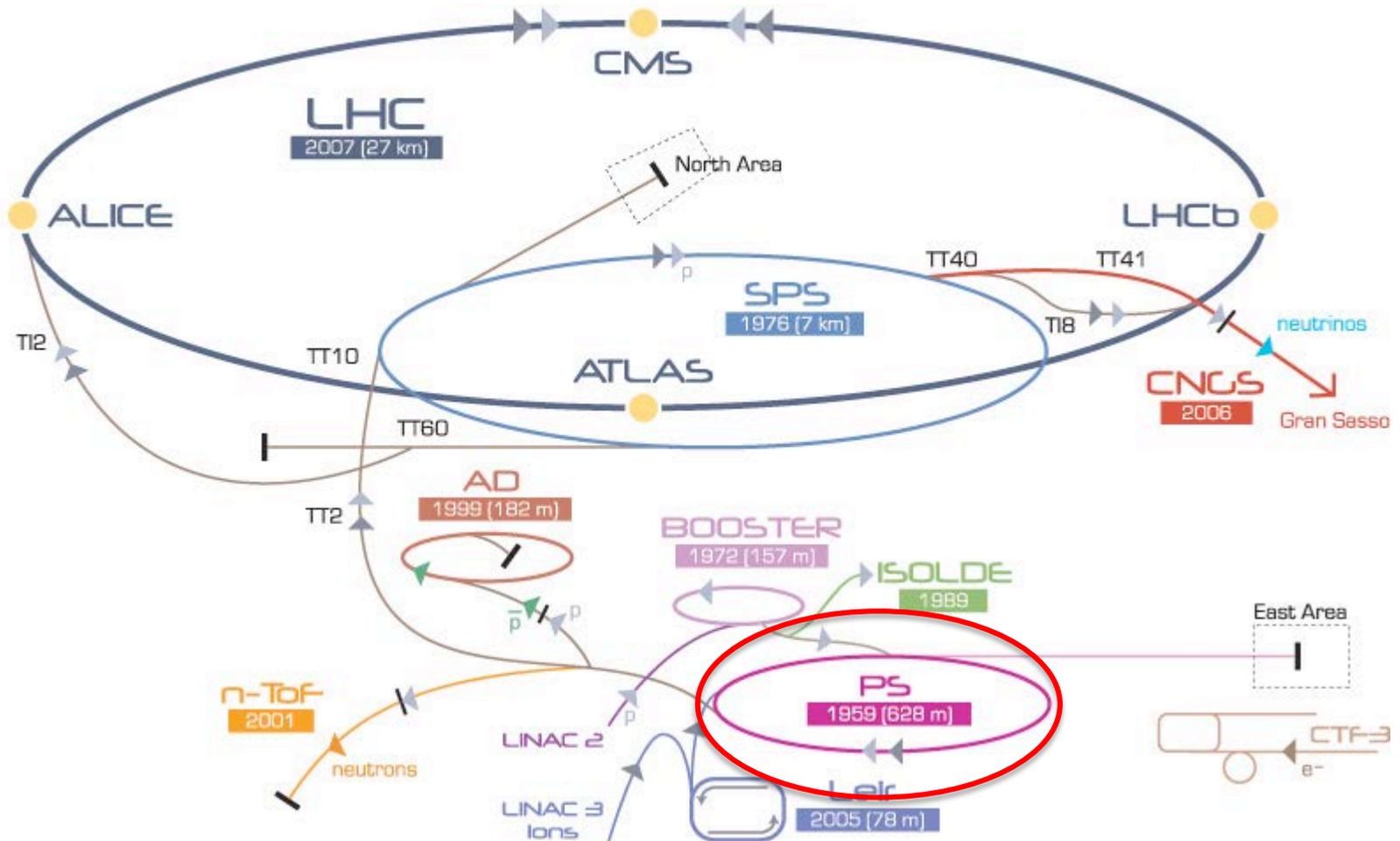
264 electroimanes

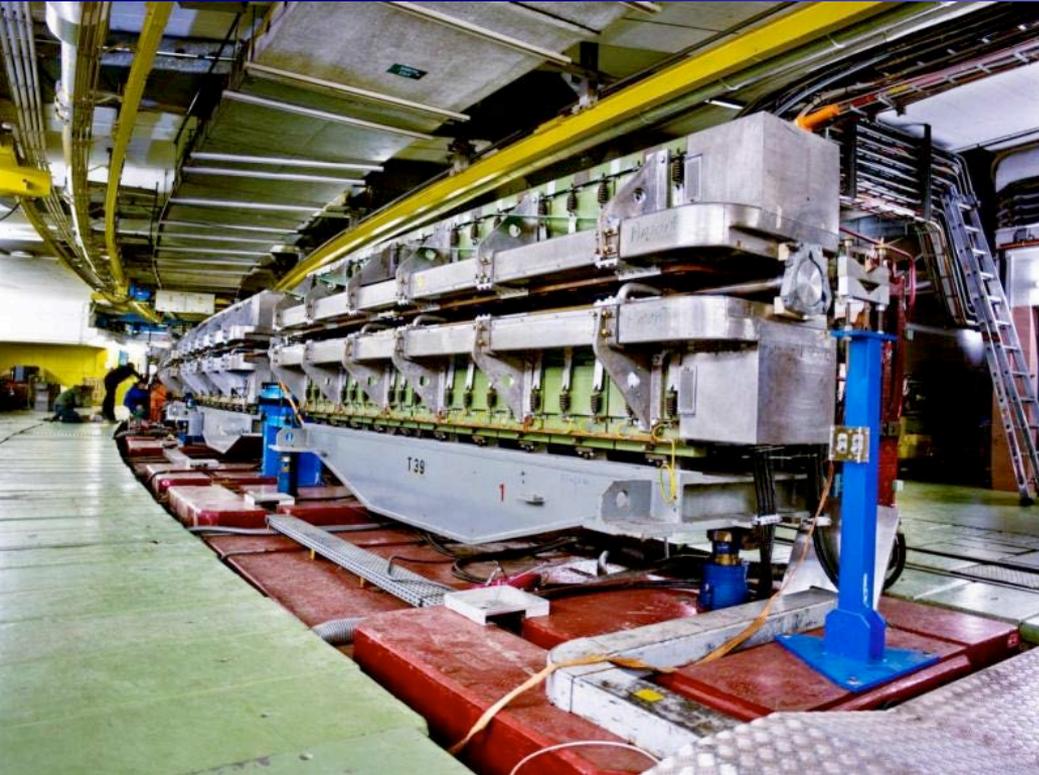
32 Dipolos

48 Quadripolos



CERN Accelerator Complex





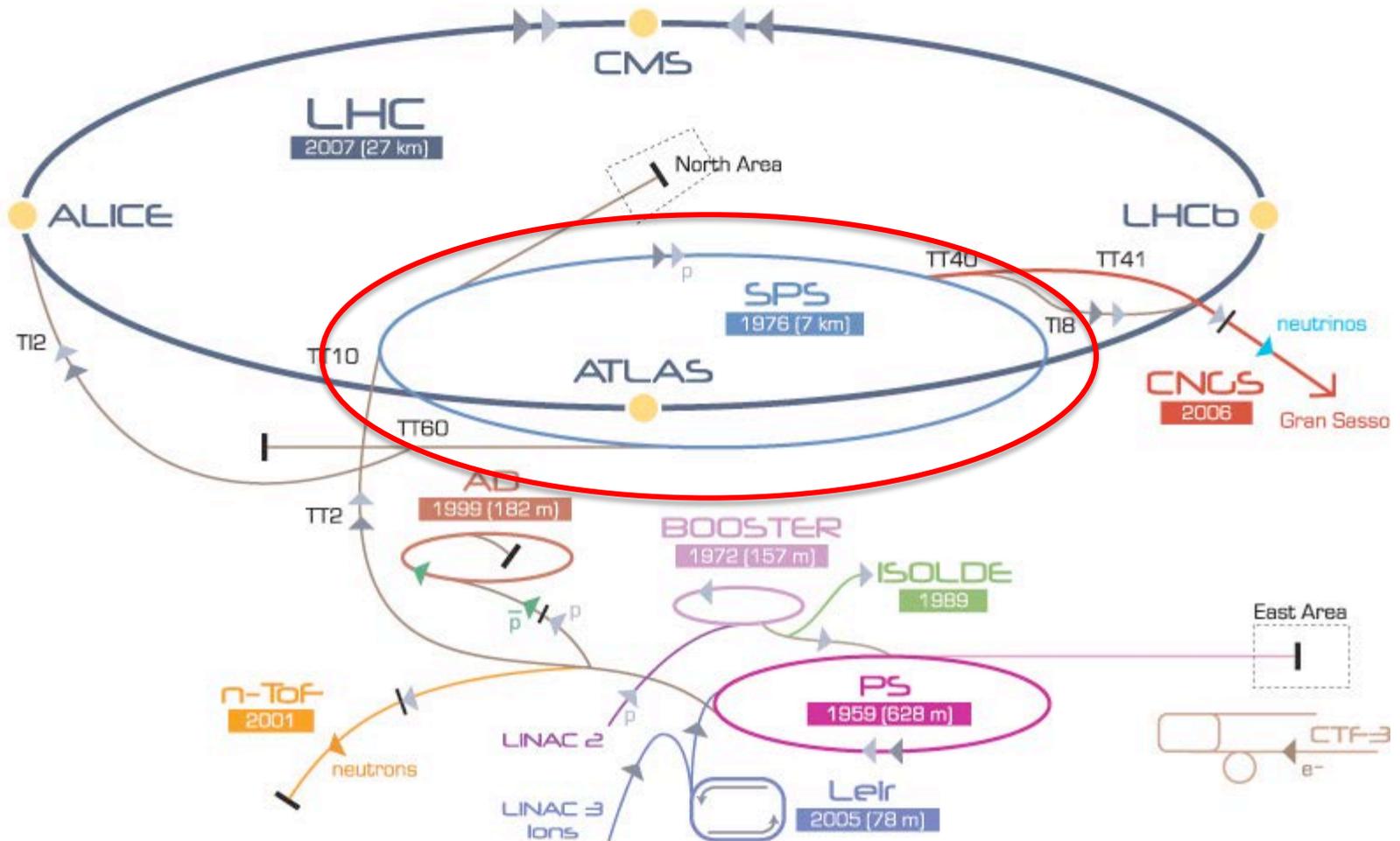
628 metros de circunferencia

277 electroimanes, que
incluyen 100 dipolos

Aumenta la energía de 1.4 a
25 GeV

El primer haz de protones circuló en el PS el 24 Noviembre 1959
Fue el primer sincrotrón del CERN

CERN Accelerator Complex





El SPS es el segundo acelerador más grande del CERN

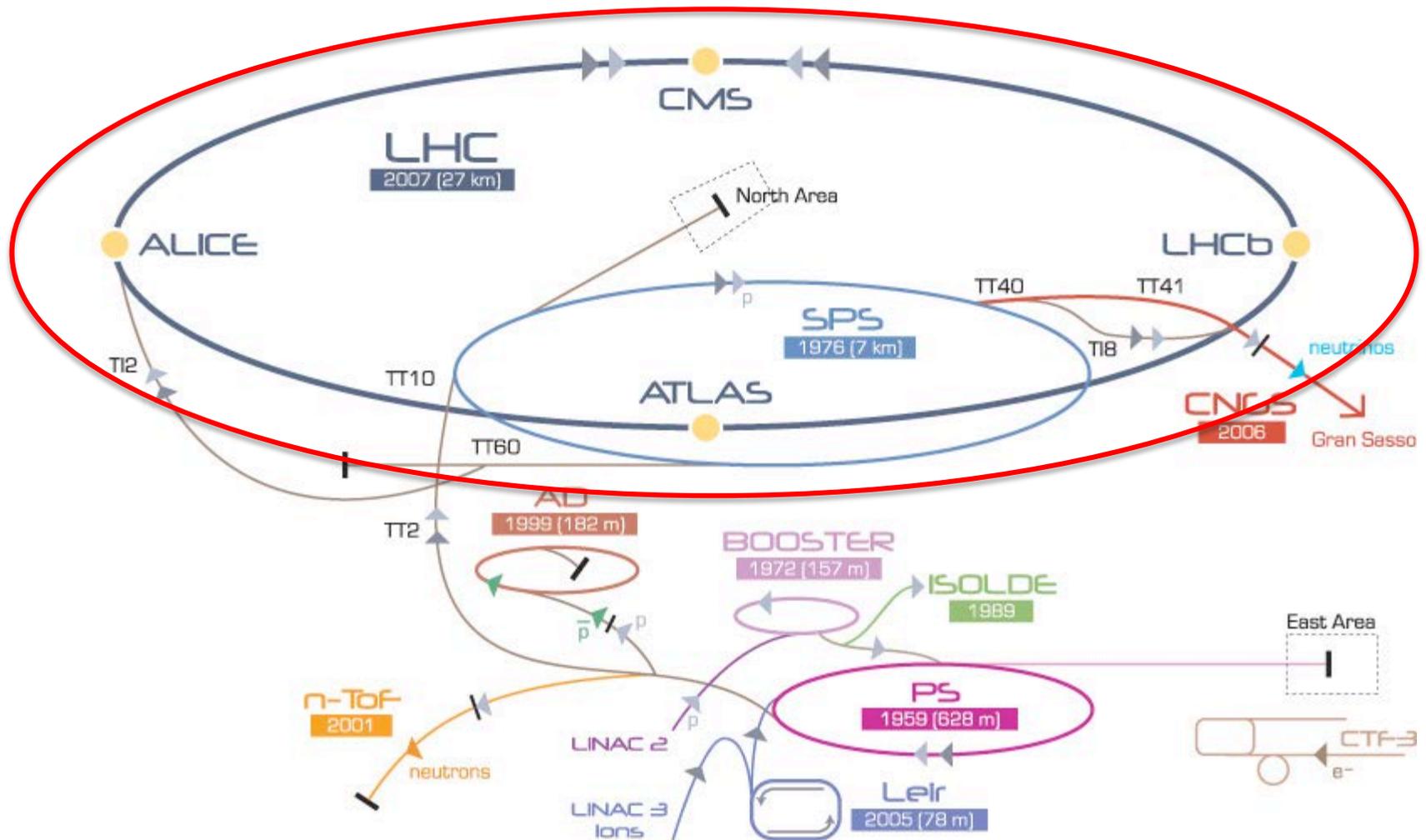
Circunferencia de 7 km

1317 electroimanes, que incluyen 744 dipolos

Aumenta la energía de 25 a 450 GeV

En el 1983, con el SPS funcionando como colisionador de protones y antiprotones, fueron descubiertas las partículas W y Z. Este descubrimiento fue merecedor del premio Nobel

CERN Accelerator Complex

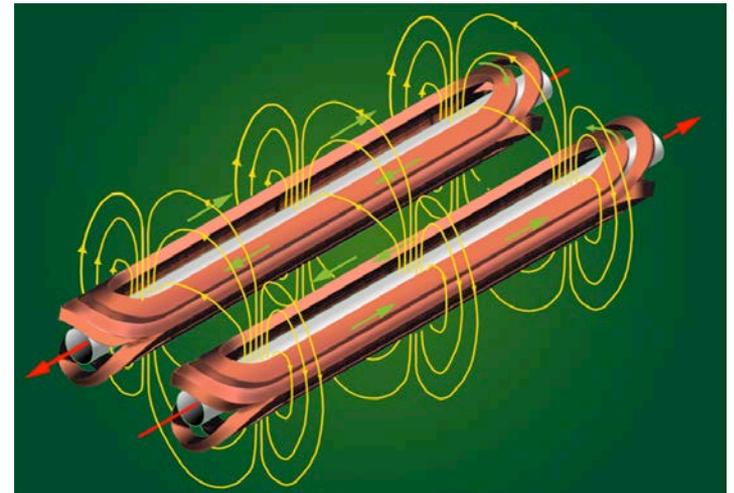


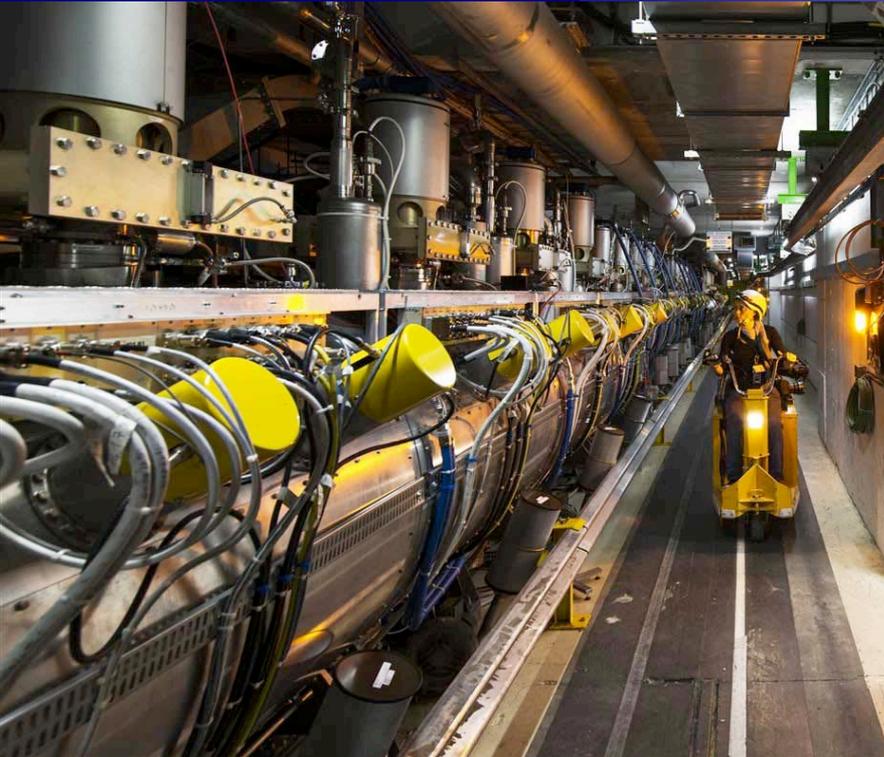


El acelerador más grande y más potente en el mundo

Circunferencia de 27 km

1232 dipolos, 392 quadripolos
a una temperatura de -
271.1°C (1.9 K)



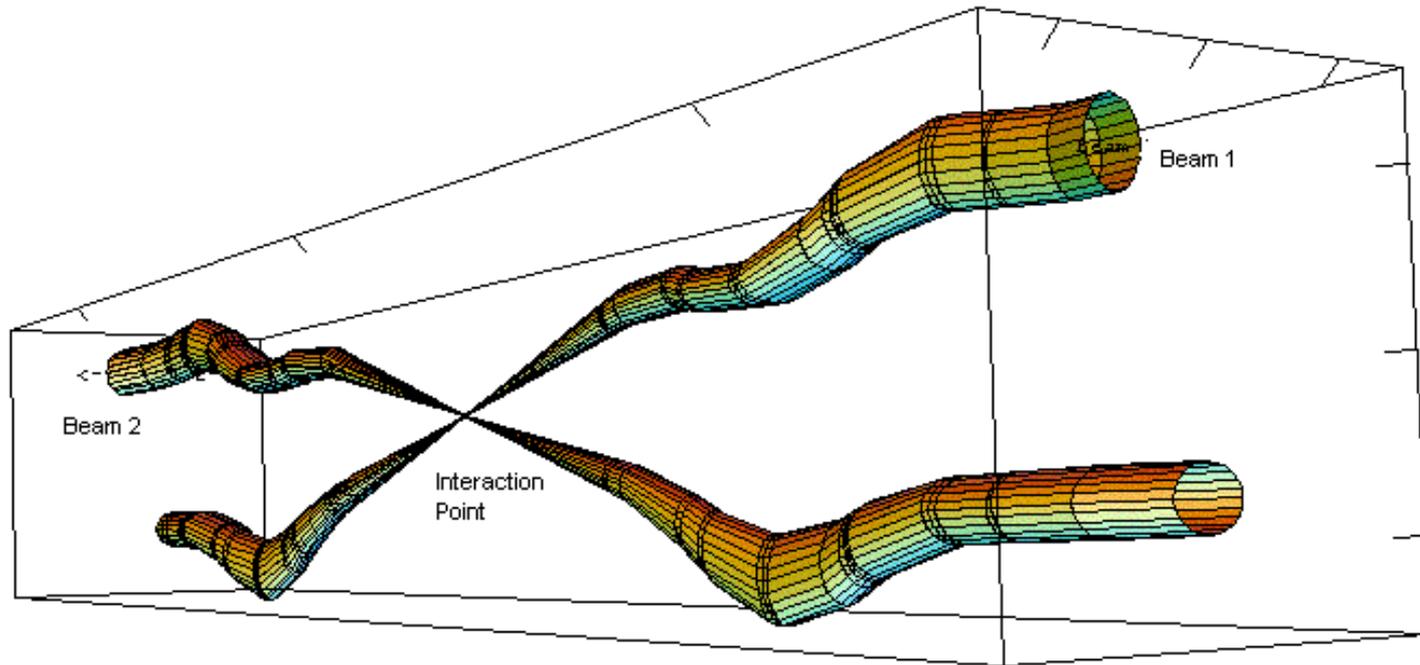


8 cavidades superconductoras en cada direccion aumentan la energia a 7 TeV

El haz llega a la energia maxima en aproximadamente 15 minutos: en este tiempo los paquetes de protones pasan 1 millon de veces las cavidades

A la maxima intensidad hay 2808 paquetes por haz

Cada paquete contiene 1.15×10^{11} protones



Dimensión del orden de 1 mm – los paquetes son comprimidos a 16 microns en el punto de colisión

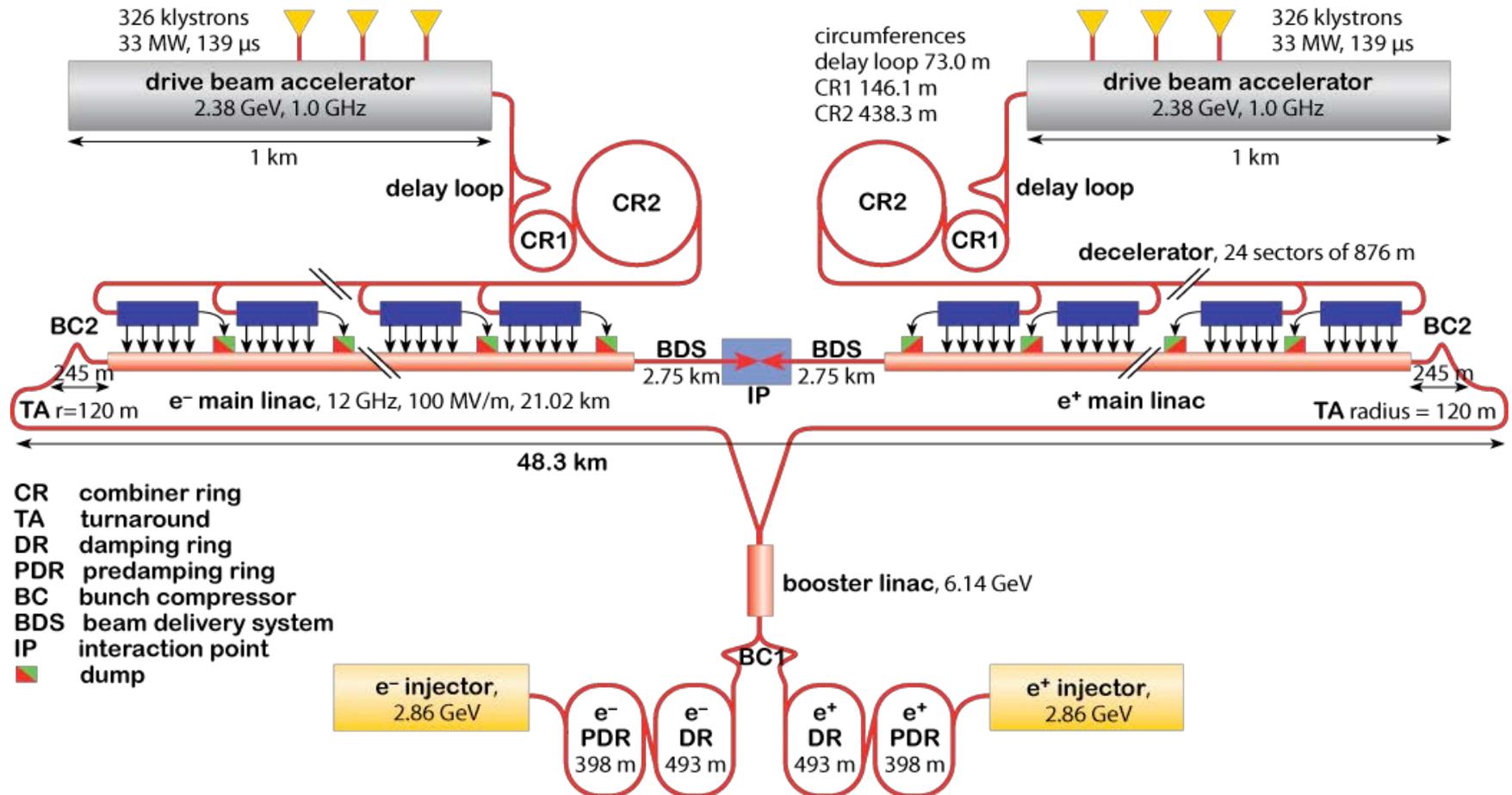
Un paquete es enviado cada 25 ns

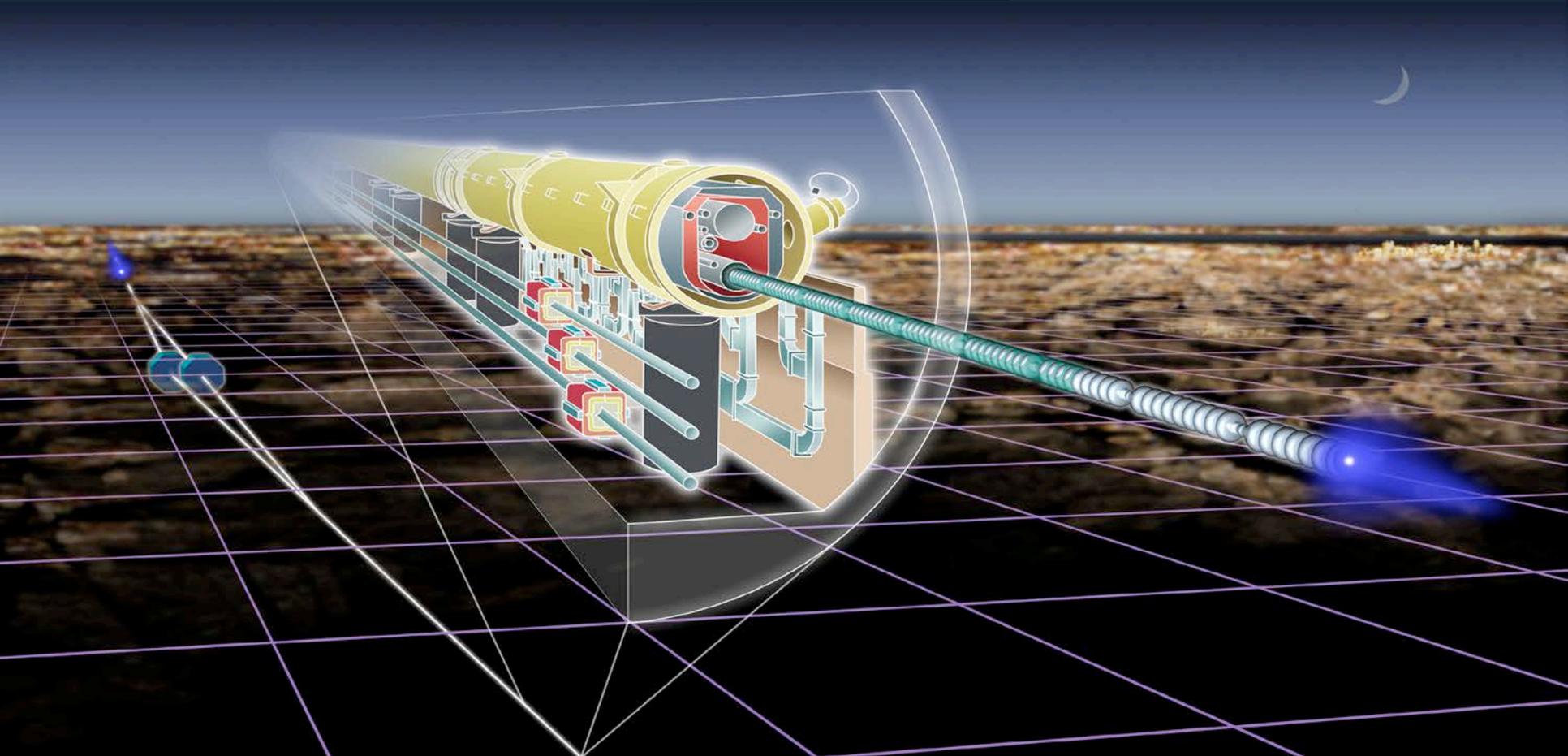


El complejo de aceleradores del CERN, video:

<https://cds.cern.ch/record/1610170>

Compact Linear Collider (Clic)

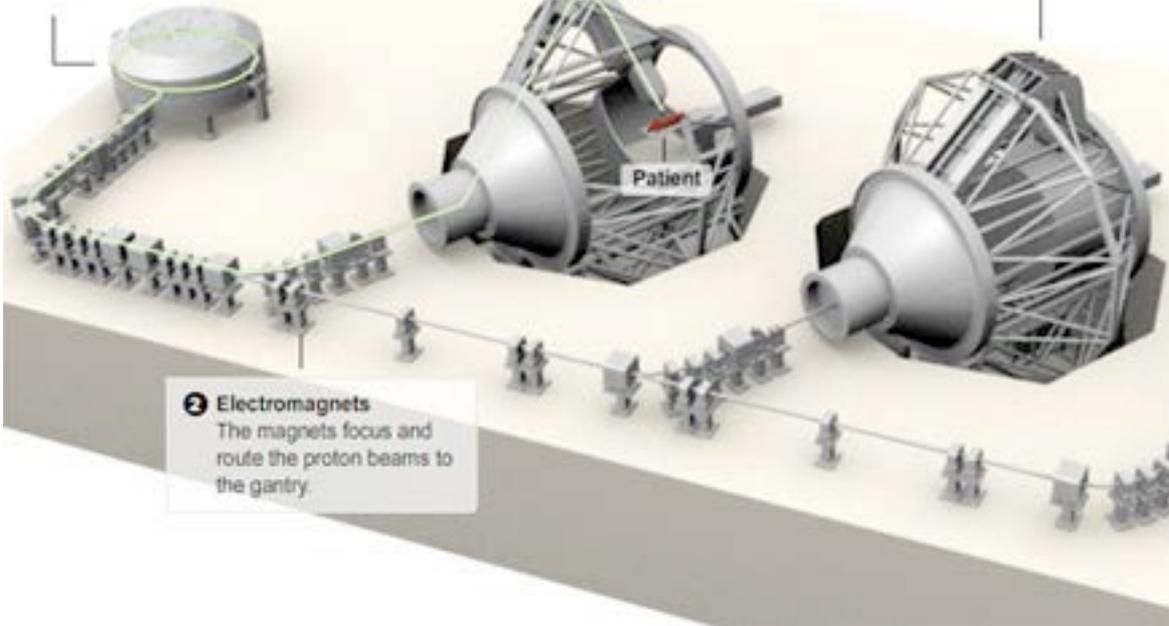




International Linear Collider

1 Cyclotron

Using electric fields, the cyclotron can accelerate the hydrogen protons to two-thirds the speed of light.

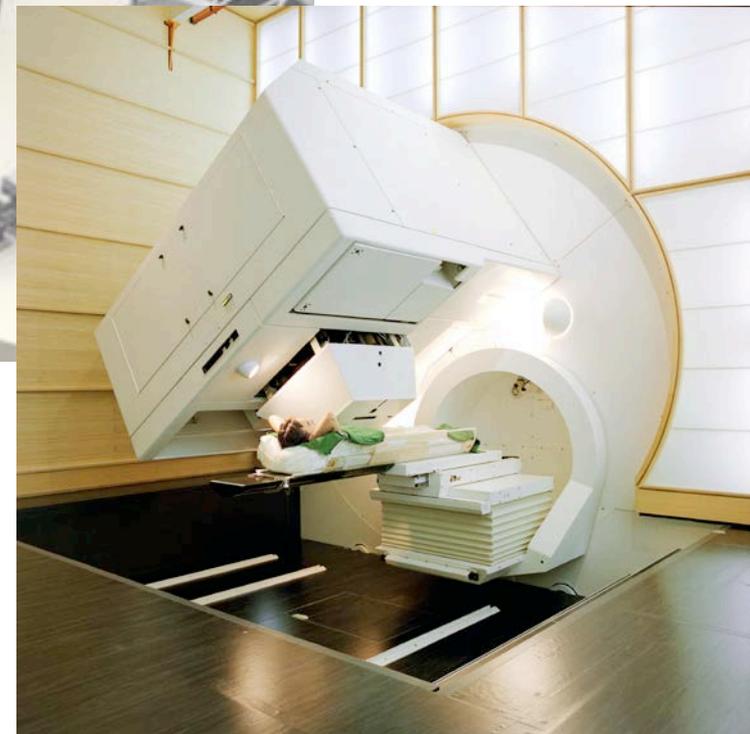


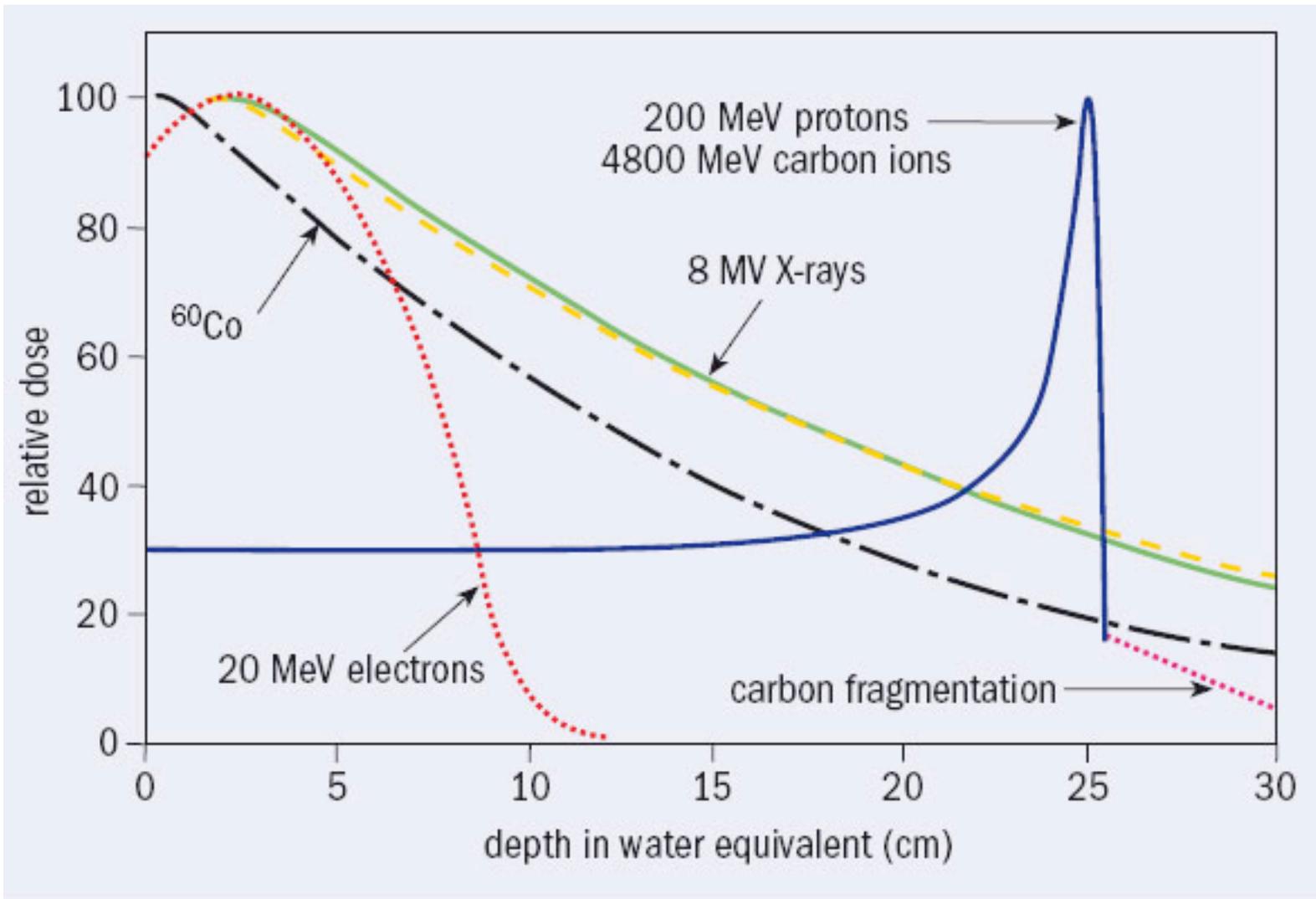
2 Electromagnets

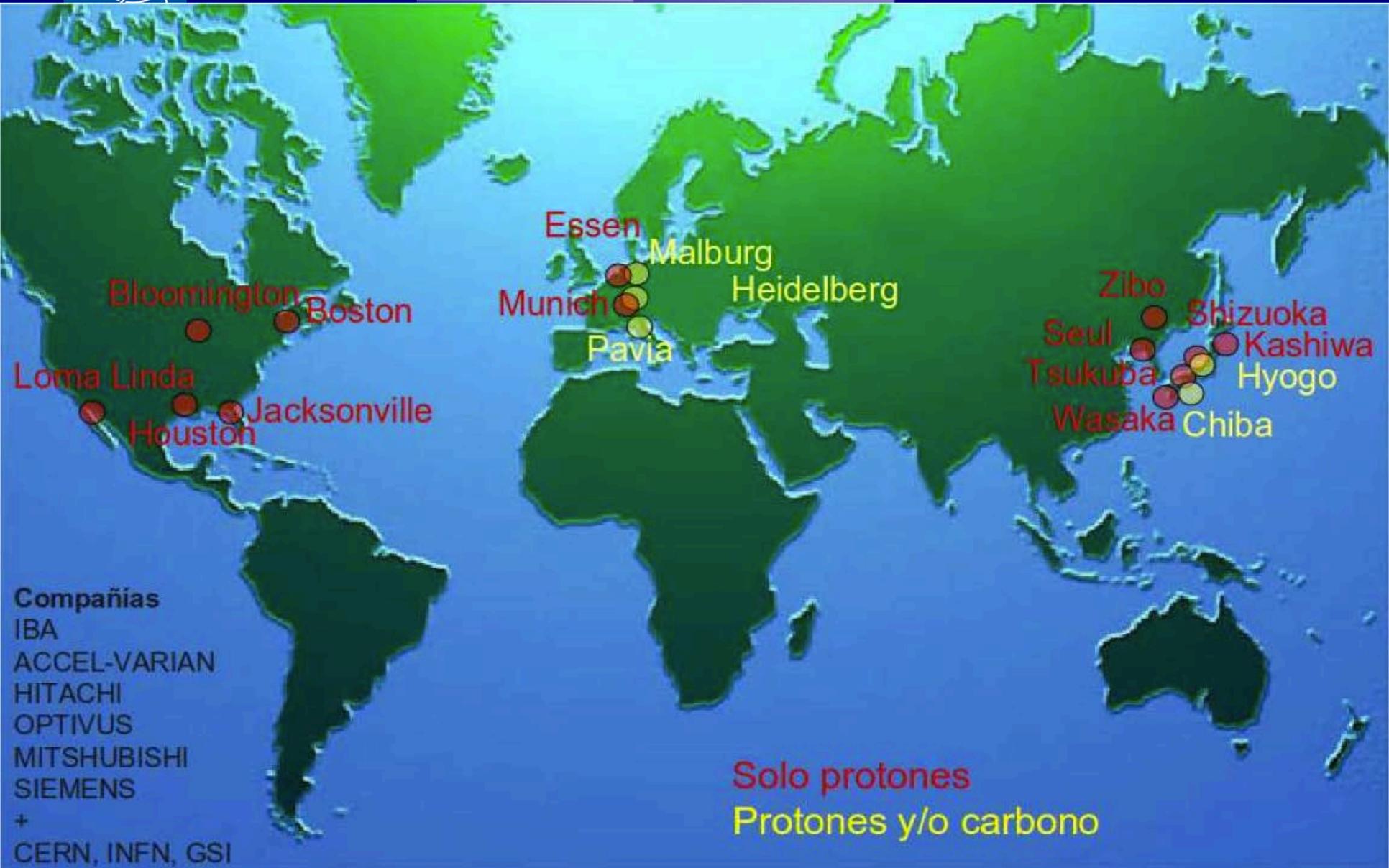
The magnets focus and route the proton beams to the gantry.

3 Gantry

Each of the three gantries is three-stories tall and weighs 200,000 lbs.







Gracias por su atención

Preguntas?

**En caso de dudas
stefano.mattei@cern.ch**