



Karsit Madde

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Turkish Teacher Programme 6, 26
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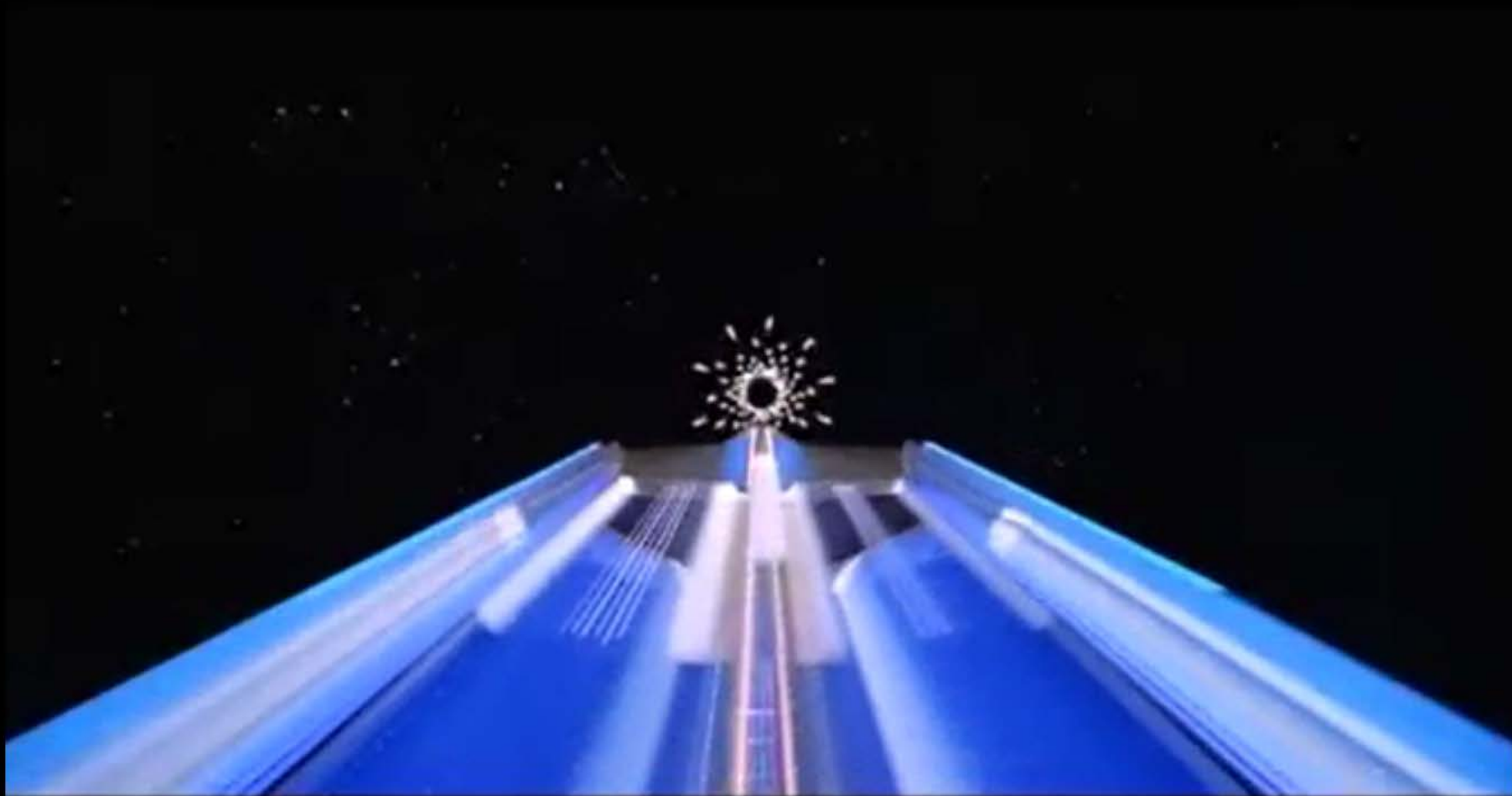
Karsit madde fikri ilk defa karsimizi Arthur Schuster tarafinda 1898 Nature dergisinde kaleme aldinan bir makalede cikmaktadir :

“Surely something is wanting in our conception of the universe. We know positive and negative electricity, north and south magnetism, and why not some extra terrestrial matter related to terrestrial matter, as the source is to the sink. ... Worlds may have formed of this stuff, with element and compounds possessing identical properties with our own, indistinguishable from them until they are brought into each other's vicinity. If there is negative electricity, then why not negative gold as yellow as our own?... Astronomy, the oldest and most juvenile of the sciences, may still have some surprises in store. Many anti-matter be commended to its care! ... Do dreams ever come true?”

Lost in Space

**THE
ANTI-MATTER
MAN**





Star Trek

ENTERPRISE 1701-D



SIRIUS, aka The Dog Star



Enterprise Uzay gemisinin madde-karsit madde reaksiyonlarini kullanan bir roket sistemi bulunmaktadir.

Yaklasik 190.000 tons agirliginda olan uzay gemisinin 0.5c hizıyla 8.6 isik yili uzaklikta bulunan Sirius yildizina seyahat ettigini dusunelim. **Uzay gemisini hizlandirmek icin ne kadar enerji ihtiyac var?**

Ne kadar antimaddeye ihtiyac var?



Angels and Demons

1928 Paul Dirac, Arthur Schuster'in karsit madde hayalinin matematiksel temellerini insa ediyor.

Dirac denklemi:

$$-i\hbar c \alpha \cdot \nabla \psi + \beta m c^2 \psi = E \psi$$



$$E = \pm \sqrt{c^2 p^2 + m^2 c^4}$$

“This would be a new kind of particle, unknown to experimental physics, having the same mass and opposite charge as the electron. We may call such a particle an anti-electron”

Carl Anderson, 1932, ilk karsit maddenin gozlemlenmesi: POSITRON (Karsit electron)

Manyetik alan uygulanmis bulut odasinda kozmik yagmur calismalari sirasinda kefediliyor. Elektronun kutlesiyle ayni ama manyetik alanda ters yonde hareket eden bir parcacik gozlemleniyor. Boylece Dirac'in karsit madde kuramini ispatlamis oluyor.

1936 Nobel, Anderson ve Dirac.

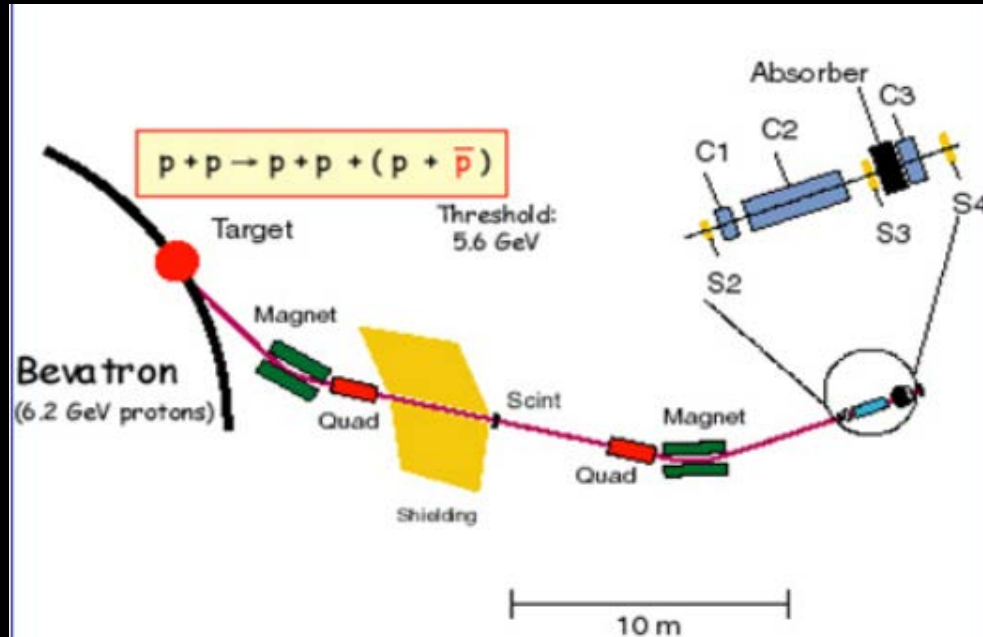
Dirac :

"Why did the experimentalists not see them? Because they were prejudiced against them.

The experimentalists ... sometimes saw the opposite curvature, and interpreted the tracks as electrons which happened to be moving into the source, instead of the positively charged particles coming out.

Dirac nobel sunumunda karsit maddeden olusan baska bir evrenin varligina iliskin fikrini dile getirmis

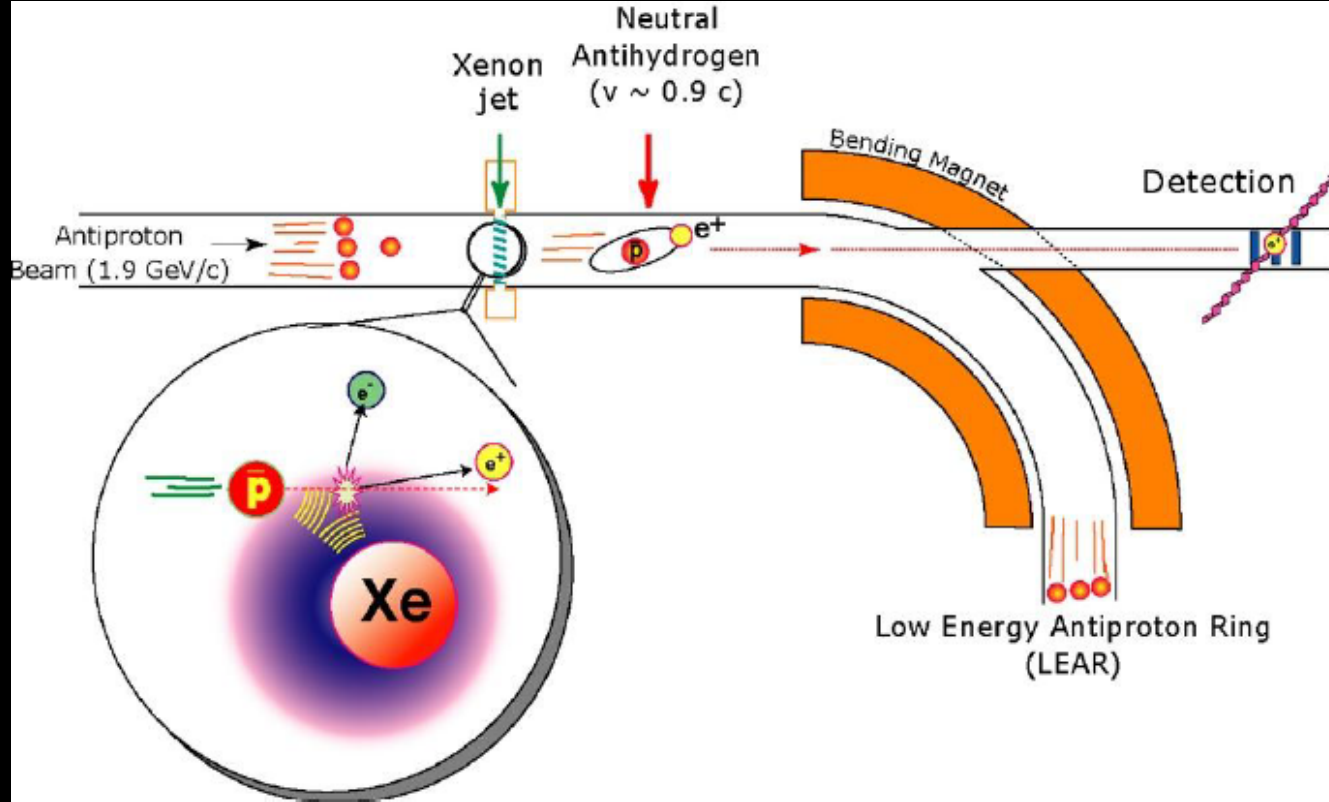
1955 Karsti proton, Lawrence Berkeley National Laboratory



1956 Karsit neutron: karsit_proton + karsit_proton \rightarrow notron + karsit notron

1965 Karsit doteryum, CERN

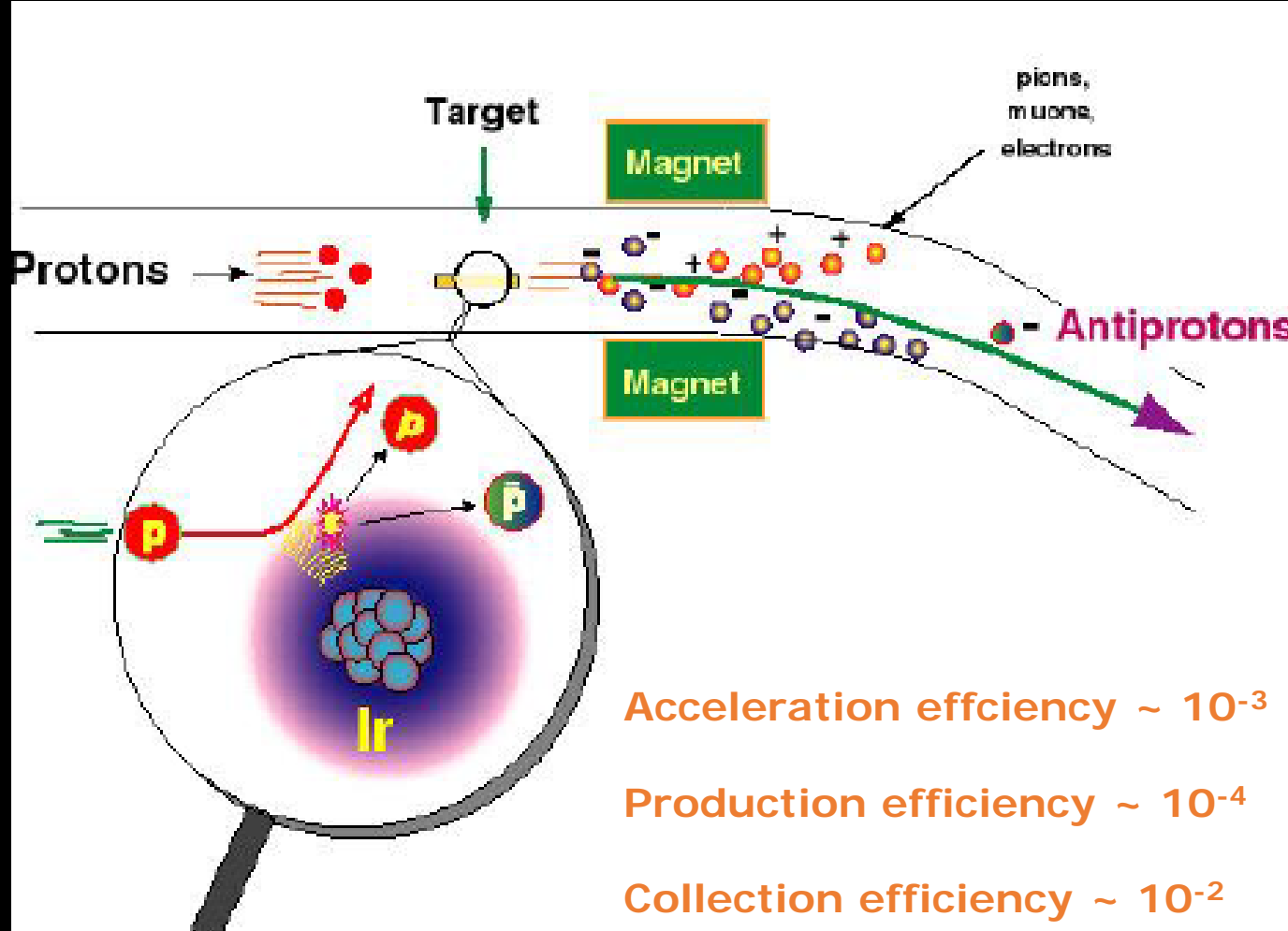
- 1995: First 9 anti-hydrogen atoms made:



Dusuk enerjili Antiprotonlar Xe gazina bombardiman edildiginde, Xe cekirdeginin yakinindan gecerken elektromanyetik etkilesim sonucunda photon sonra da electron-positron olusur. Oluan positron antiproton tarafindan yakalanarak antihidrojeni olusturur. Detectore yondeldirilen Antihidrojenler detektorun ceperine carparak yok olur. Burada olusan antihidrojenler enerjetik olduklari icin bunlari uzerinde ayrintili islem yapmam mumkun degil.

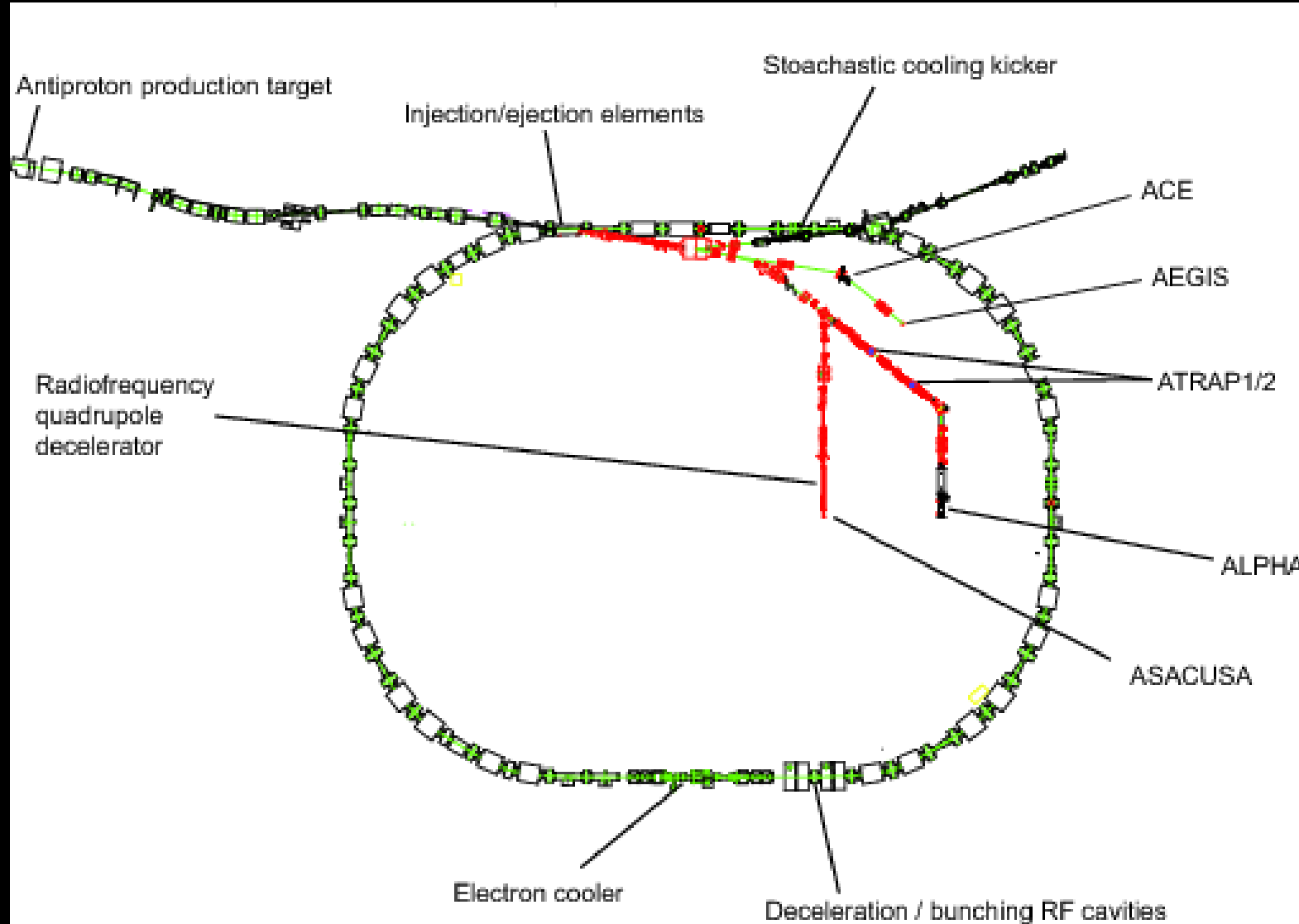
- 1997: anti-proton decelerator → hizlandiricilarin aksine ueriten antiproton 100 MeV'e kadar yavaslatan bir sistem

AD antiproton uretimi



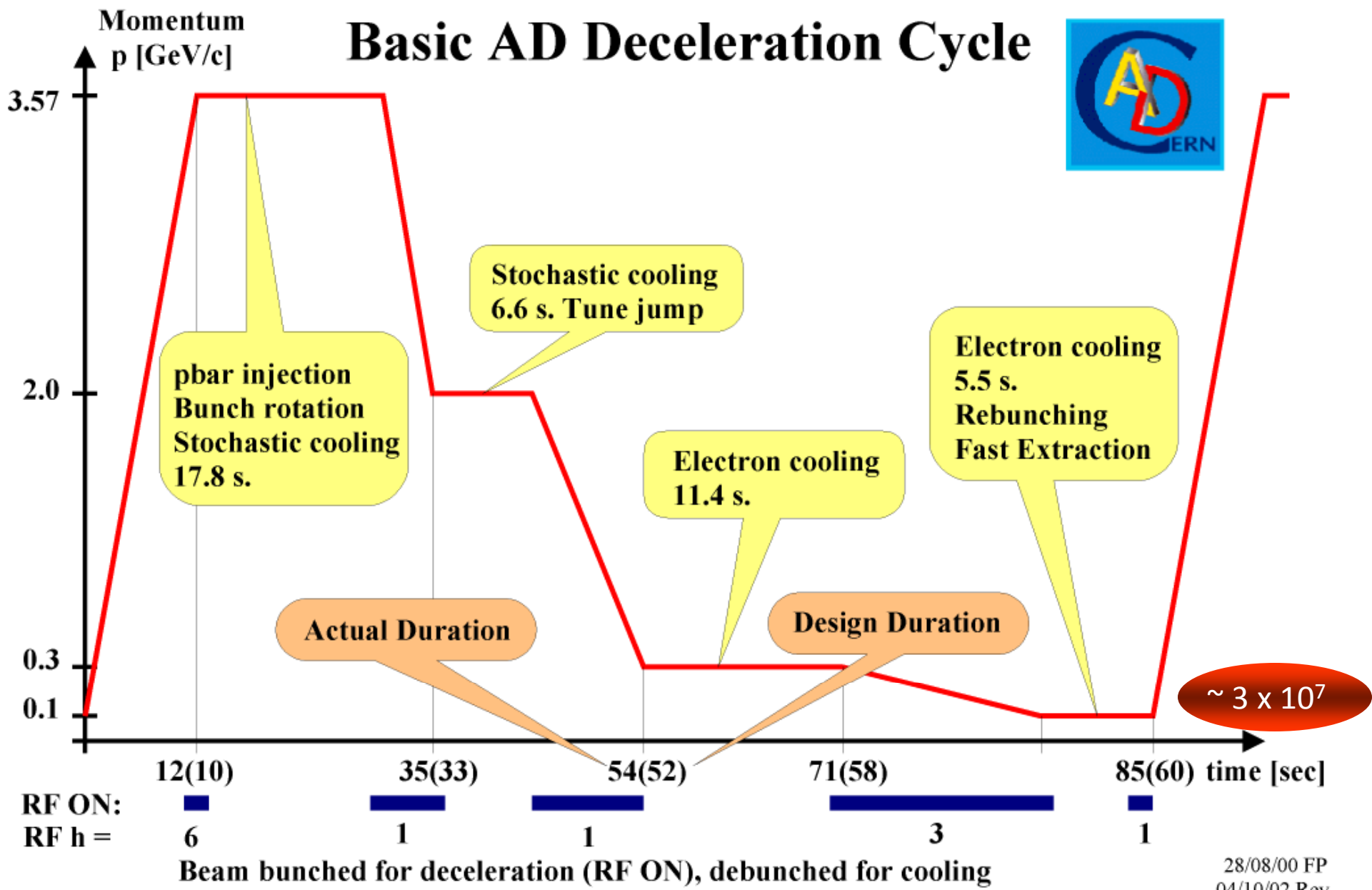
PS'te 28 GeV ye kadar hizlandirilan protonlar Iridyum hedefine carpilir. Yaklasik olarak her 100.000 proton etkilesimine karsilik 3.5 GeV enerjili bir antiproton olur. Olusan antiprotonlar miknatislar araciligiyla Antiproton Deceleration unitesine tasinir.

Antiproton deceleration:



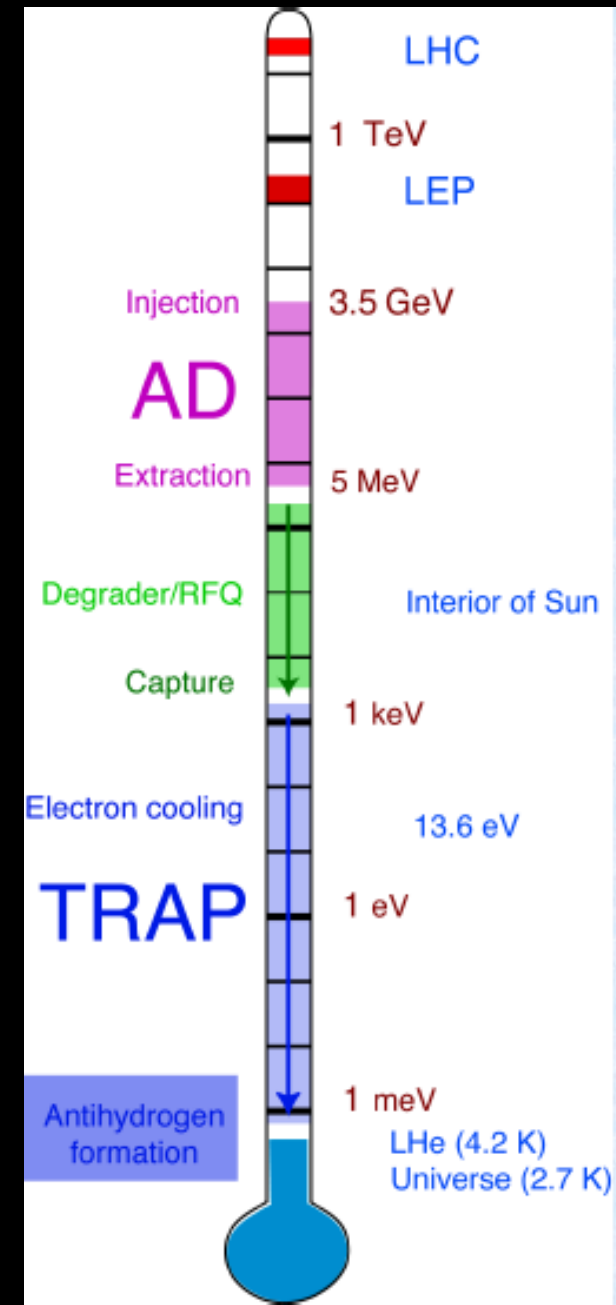
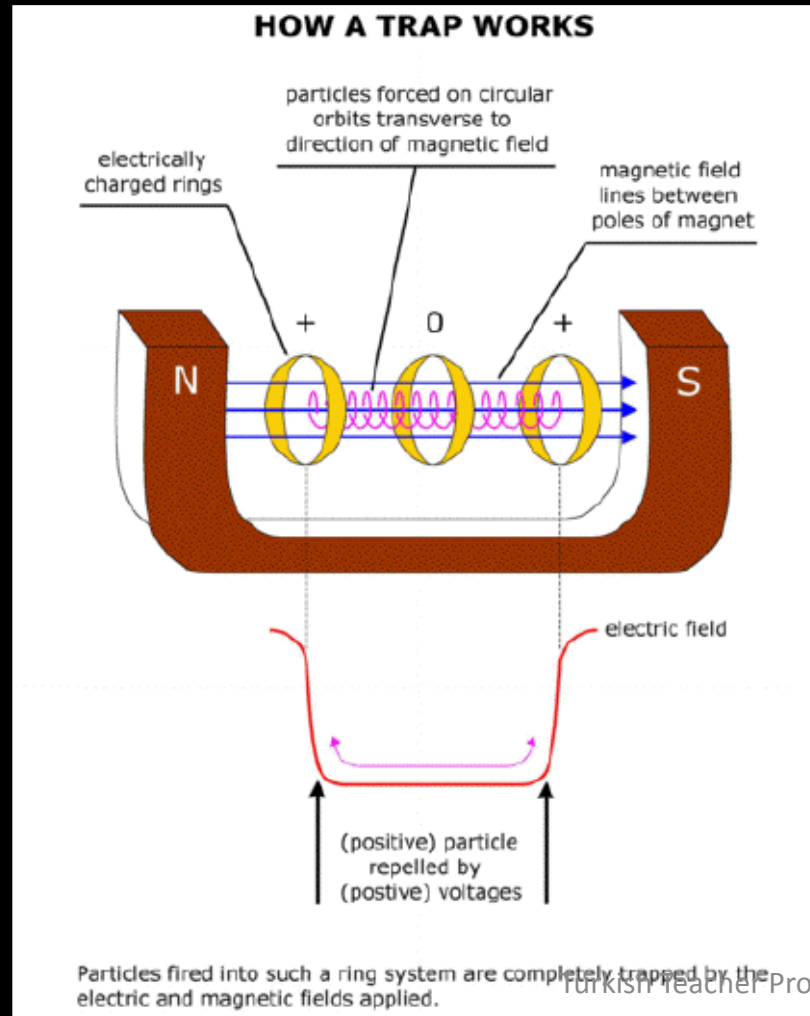
AD'ye tasinan 3.5 GeV enerjili antiprotonlar, stochastic cooling ve electron cooling yontemiyle 100 MeV kadar enerjileri dusurulur (sogutulur). Daha sonra AD'de bulunan 5 detektore yonlendirilir. Detektorlerde tuzaklanan antiprotonlar, pozitronlar eklenererek antihidrojen elde edilir.

Basic AD Deceleration Cycle



28/08/00 FP
04/10/02 Rev.

- Beam energy: \sim GeV
- Atomic energy scale: \sim eV
- Trap charged particles:



p^- and e^+ in mixing trap (cooling)

Antihydrogen formation

AD

p^- Production (GeV)

Deceleration (MeV)

Trapping (keV)

Cooling (meV)

$10^4 p^-$

$10^8 e^+$

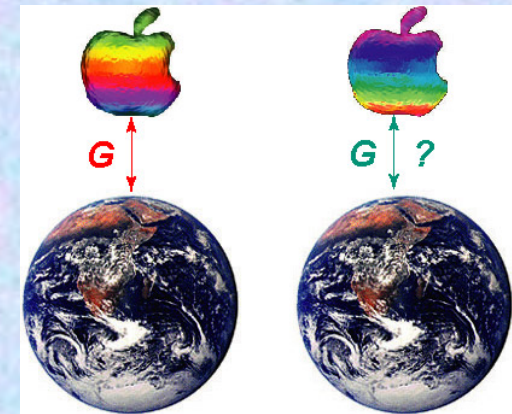
Na-22

e^+ Production (MeV)

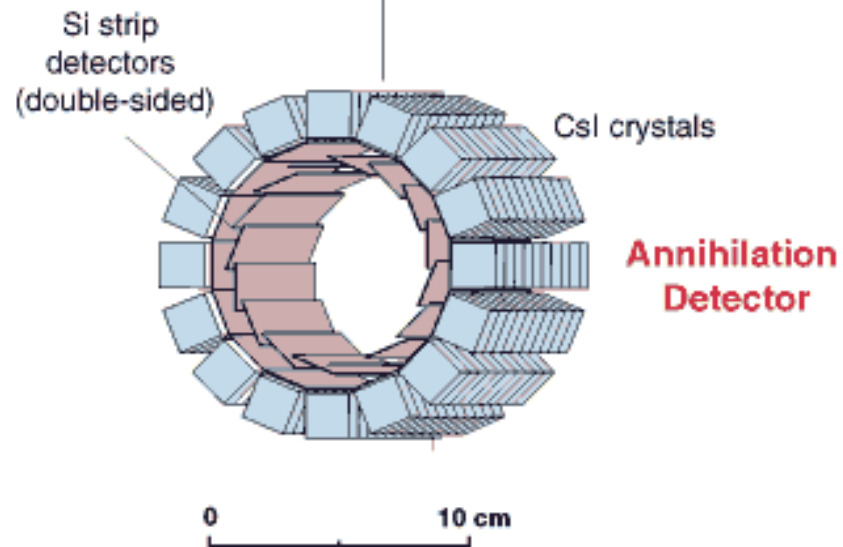
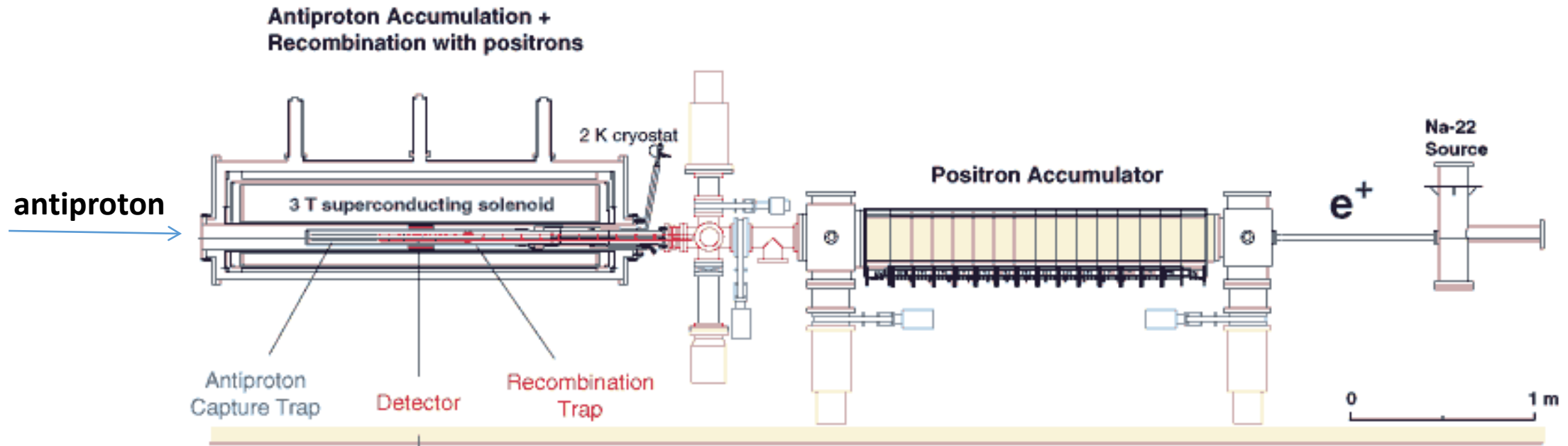
Moderation

Accumulation (eV)

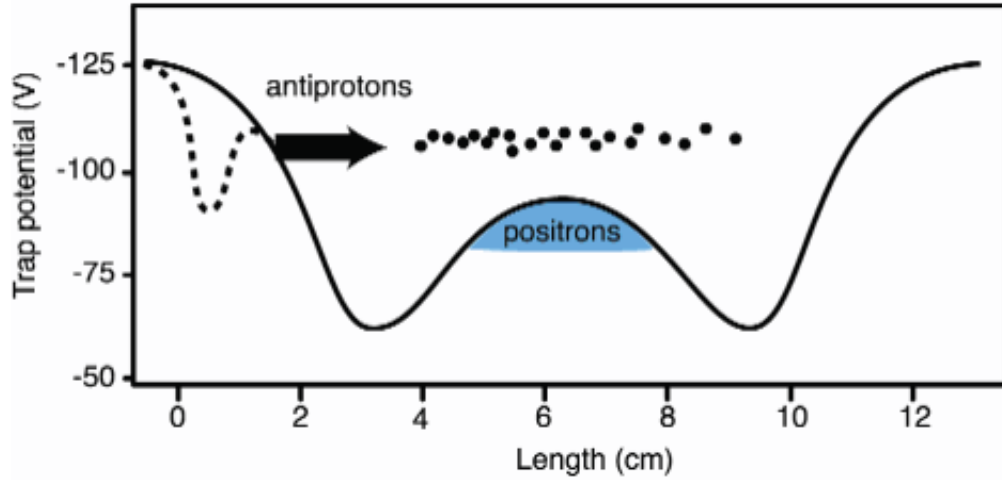
Detection of annihilation



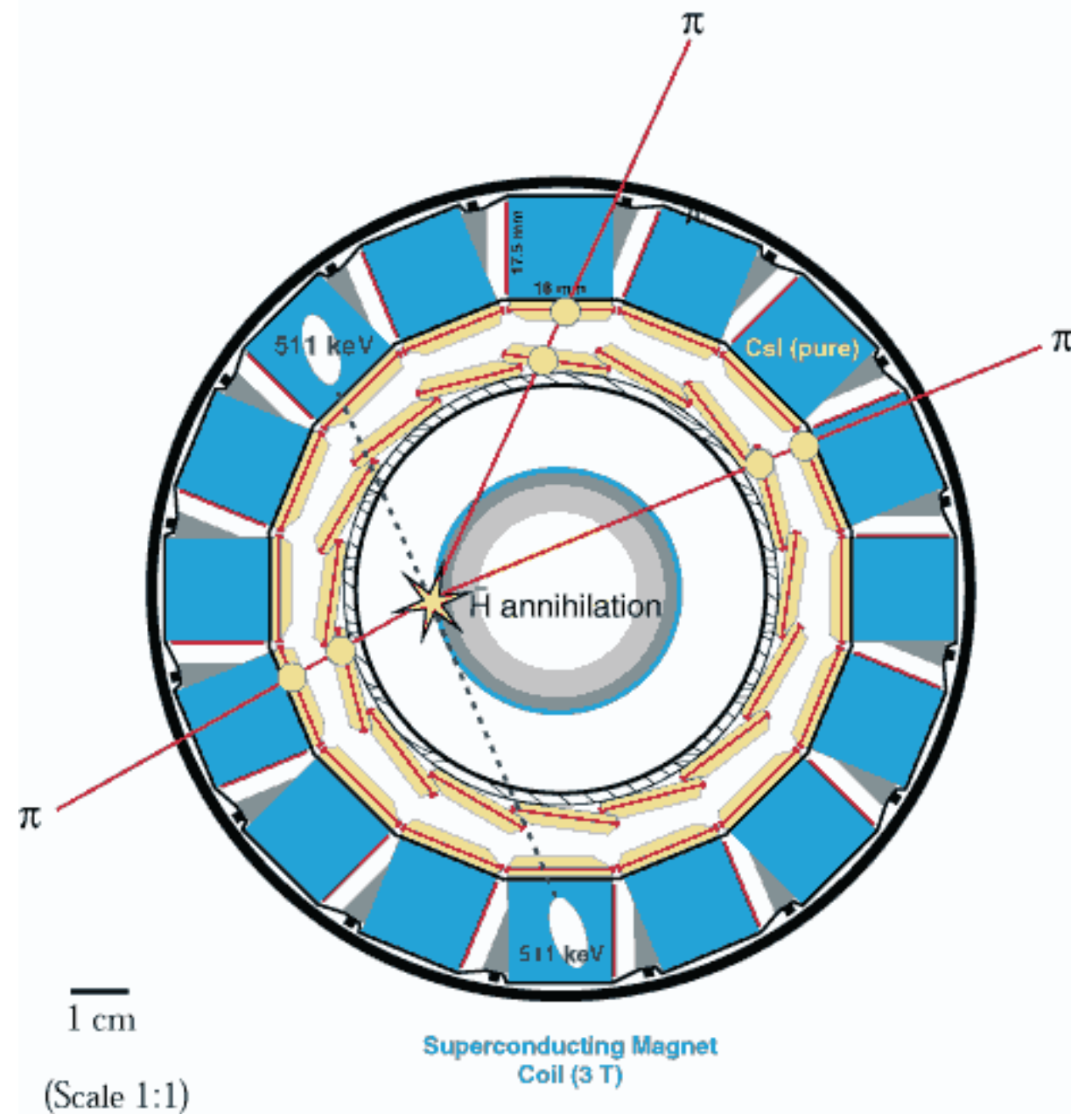
Needs trapping of antiprotons and positrons



Antihydrogen annihilation:



Detektorlerde genelde 8-kutuplu miknatislar kullanılmaktadır. Elde edilen manyetik alan sayesinde positronlar ve antiprotonlar detektörün içerisinde tutulur sonra da karıştırılır. Genelde 1 antiprotona karşılık 2 positron bulunmaktadır.



- Yilda sadece 1 ile 10 nano gram civarında antiproton üretilmektedir.
- Dünyada ki en pahalı ürünlerden biri.
1 gram yaklaşık \$62.5 trilyon.

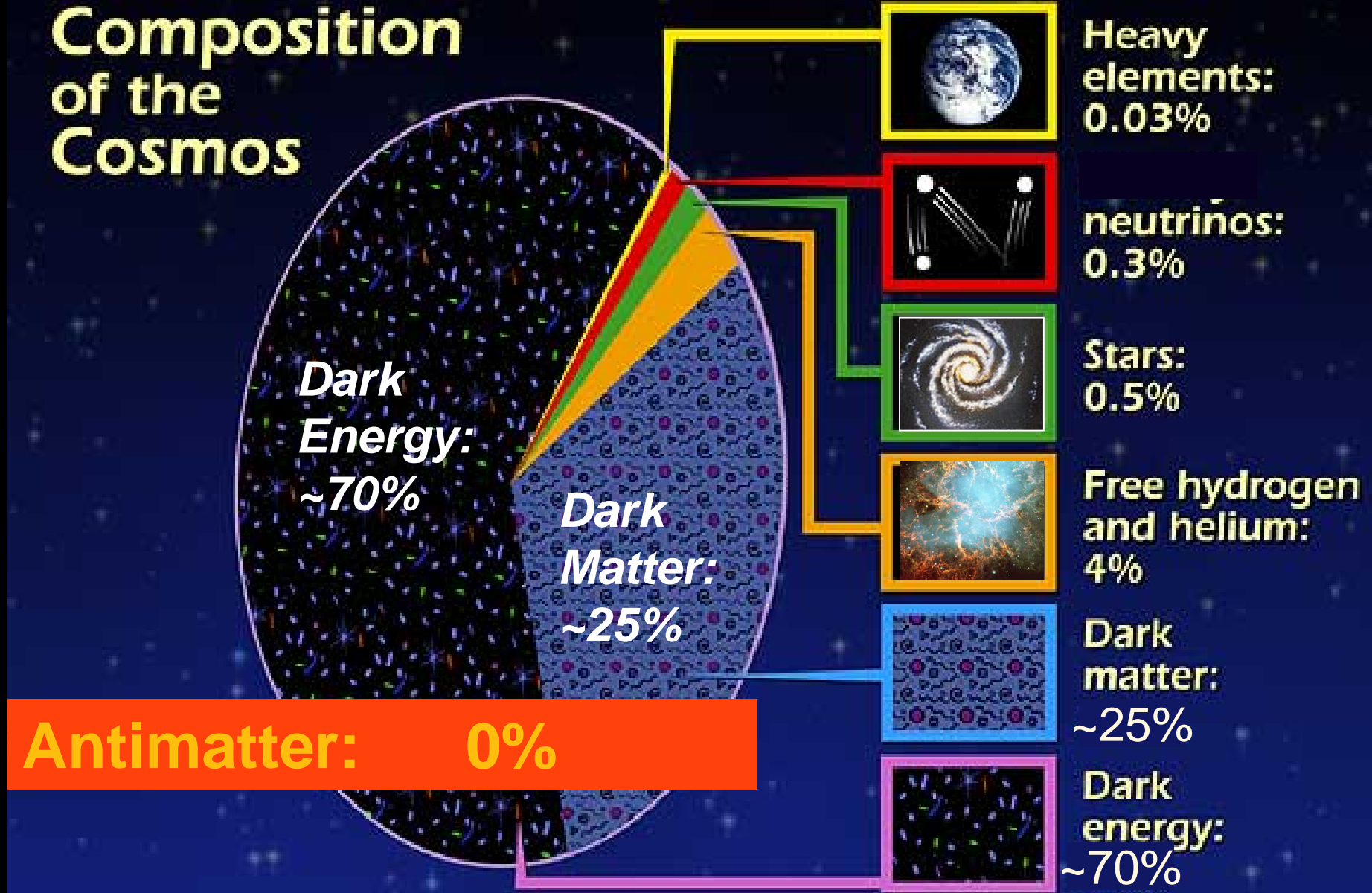
Soru:

Enterprise uzay aracında kullanılacak antimateriyi ne kadar sürede üretebiliriz?

Maddesel bir evrende yasiyoruz.



Composition of the Cosmos



Buyuk patlamadan sonra esit sayida olusan madde ve karsit madde simetrisi nasil kirildi?

Sakharov's idea (1967)

(Baryon Asymmetry of the Universe)

Particles decay (a little) faster than antiparticles
→ Charge-Parity violation

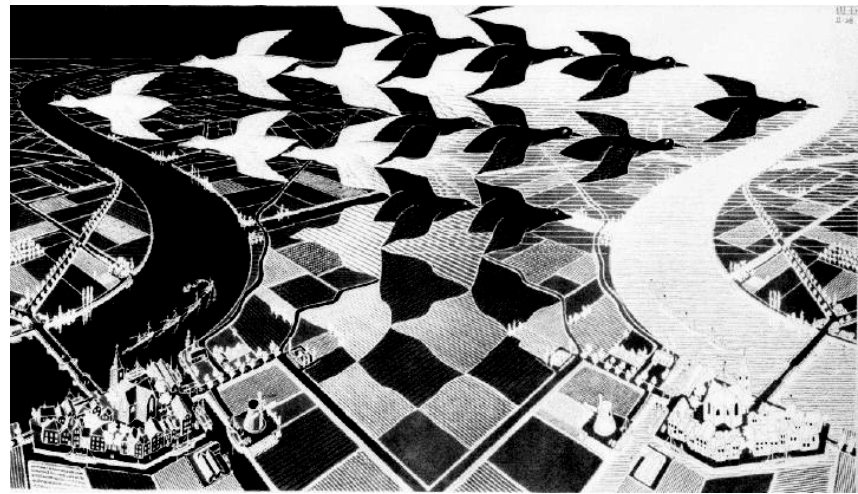
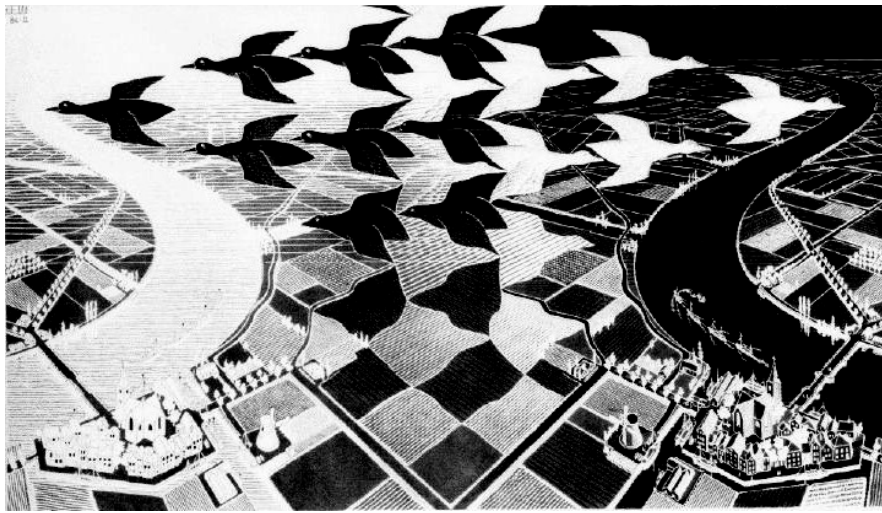
Small imbalance (1,000,000,001:1,000,000,000)
Occurs during cool-down of Universe

Most particle-antiparticle pairs annihilate to radiation

Galaxies, stars, planets, us = 'left-over'



1975 Nobel Peace Prize



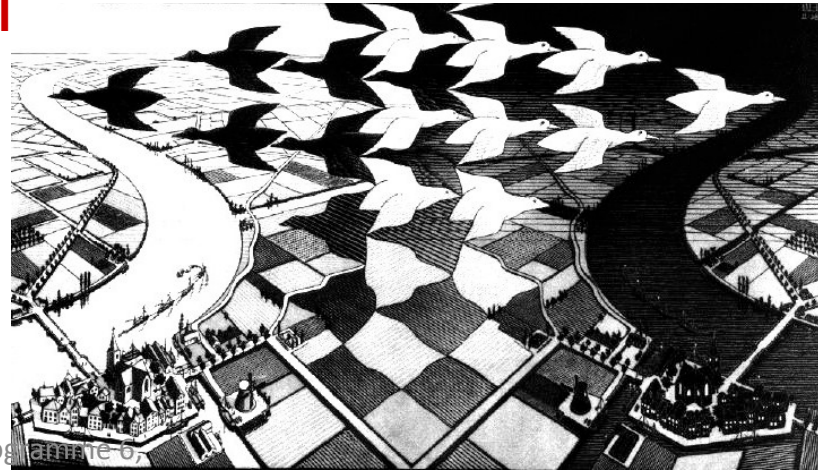
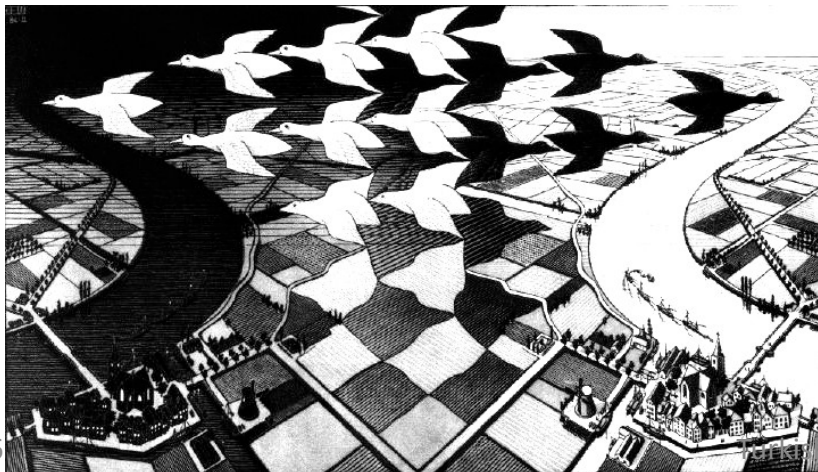
Charge Inversion
 Particle-antiparticle
 mirror

C

P

Parity
 Inversion
 Spatial
 mirror

CP



Evrende baryon asimetrisi soz konusu ve bunun kaynagi CP simetri ihlalinden kaynaklandigi dusunuyoruz.

CP bozunumu kuark ve leptonik sektorde calisilmaktadir.

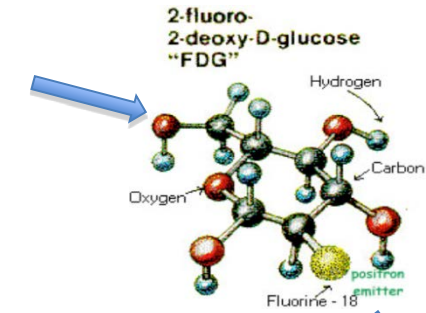
CP bozunumu ilk defa notral Kaon mezonunda gozlemlenmistir.

Belle, Babar ve LHCb gibi deneylerde kuark sektorunde CP bozunumu calisilmaktadir. Yakin gelecekte Amerikanin Fermilab merkezinde gerceklestirilecek notrino deneylerinde de CP bozunumu leptonik sektorde calisilacak ve evrende maddenin antimaddeye ustunlugunu aciklamaya daha cok yaklasacagiz.

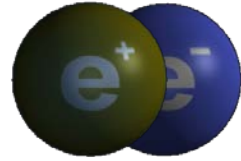
Saglikta antimadde kullanimi: Positron Emission Tomografi

RADIOACTIVE NUCLEI

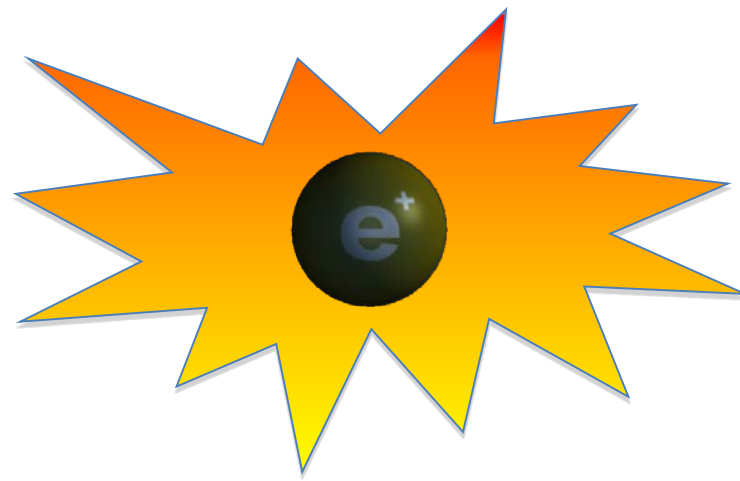
CARBON-11 (C-11)
OXYGEN-15 (O-15)
FLUORINE-18 (F-18)
SODIUM-22 (Na-22)





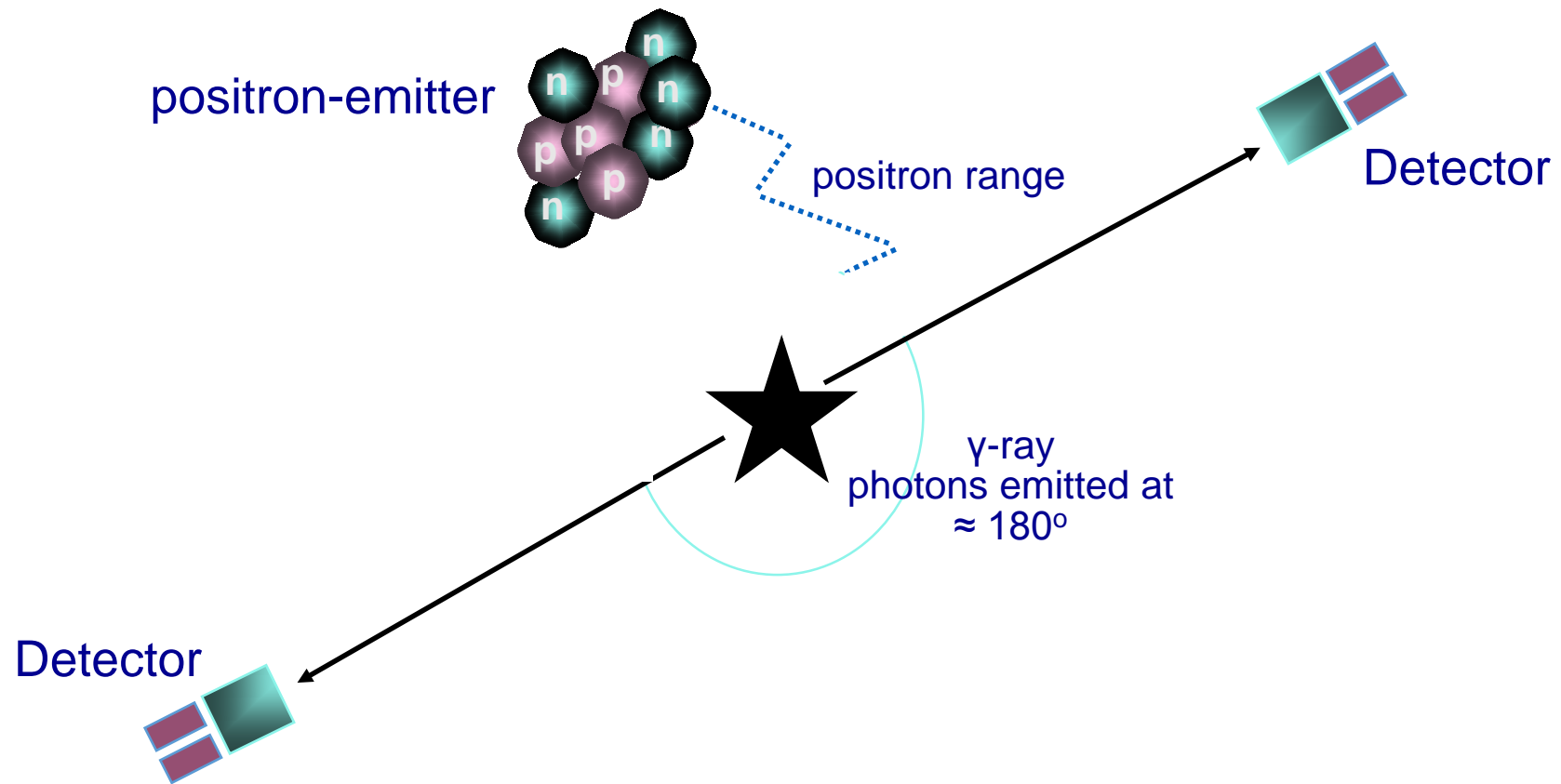


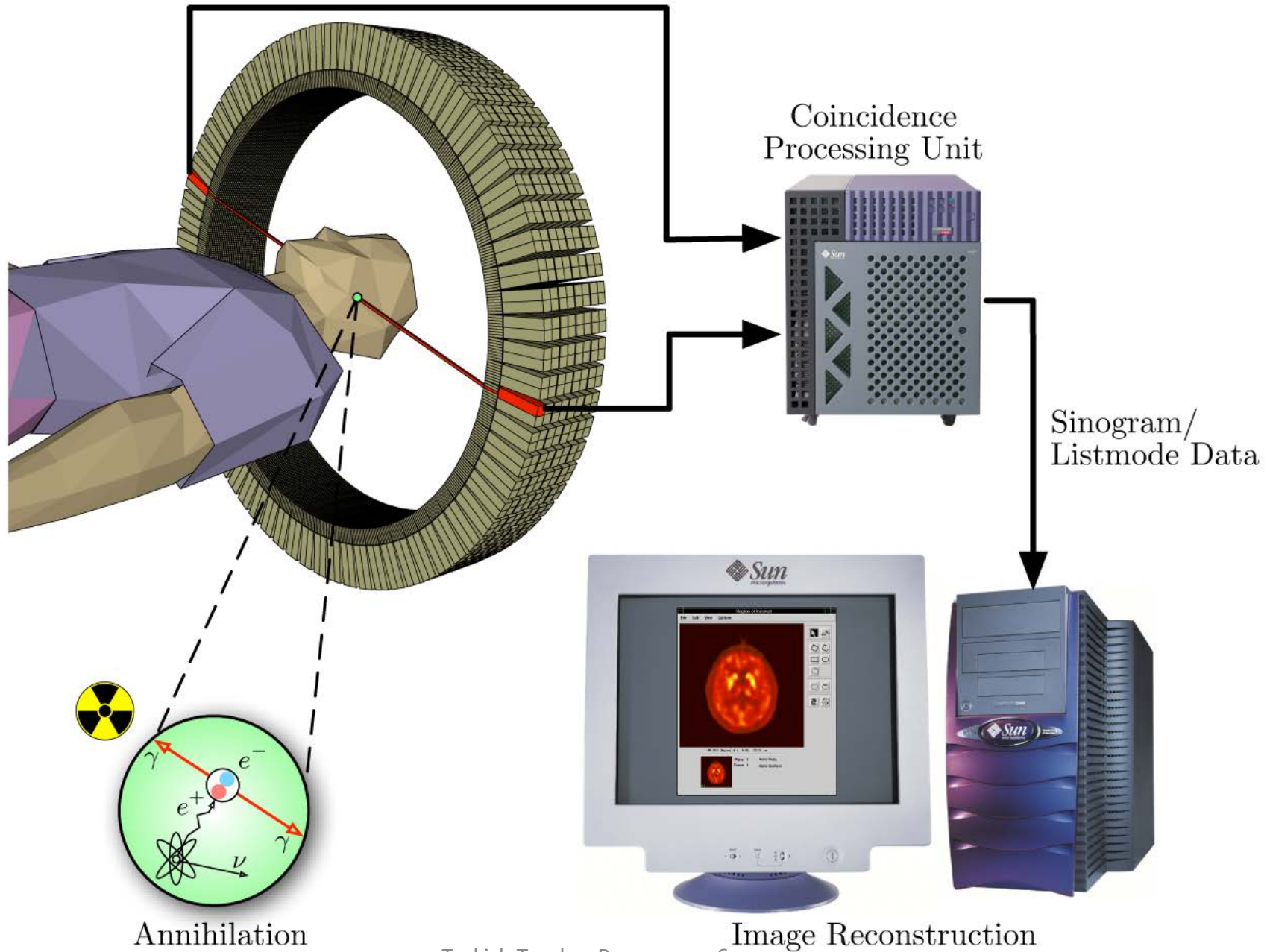














Kaynakca:

- www.cern.ch
- <http://ippog.web.cern.ch/resources/2010/cern-anti-matter-teaching-module>
- www.youtube.com