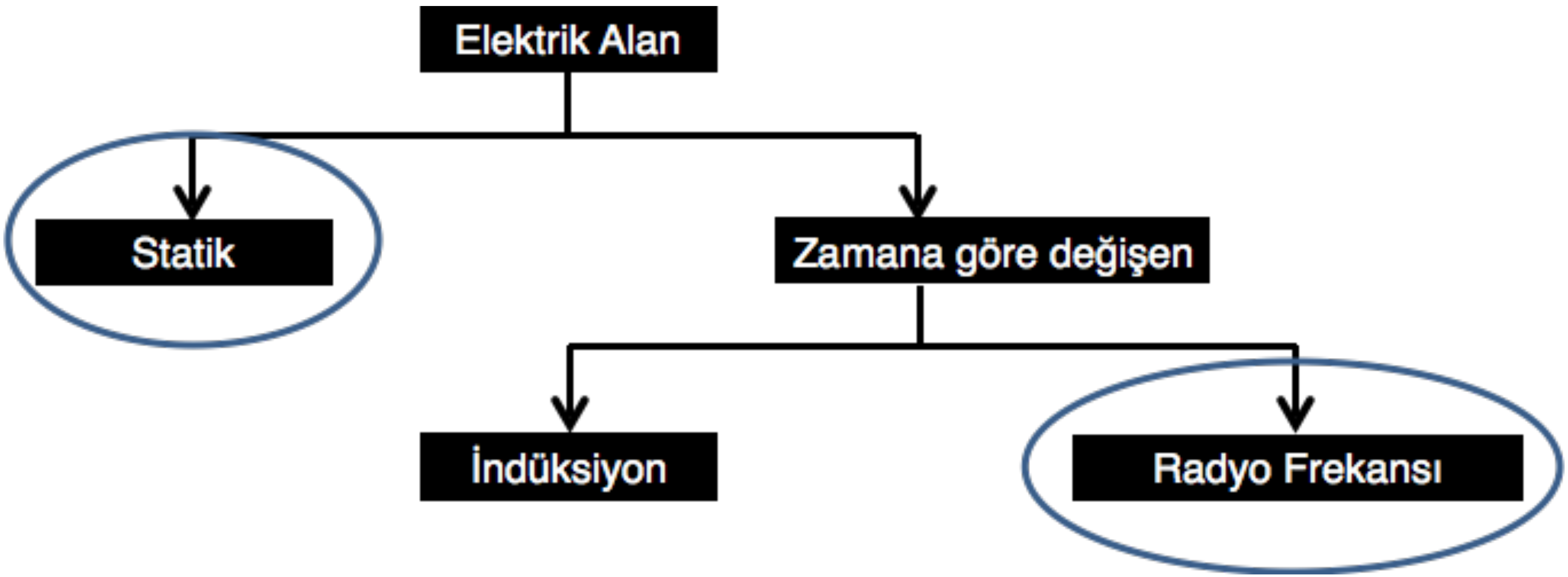
MODERN HIZLANDIRMA TEKNİKLERİ

VELİ YILDIZ

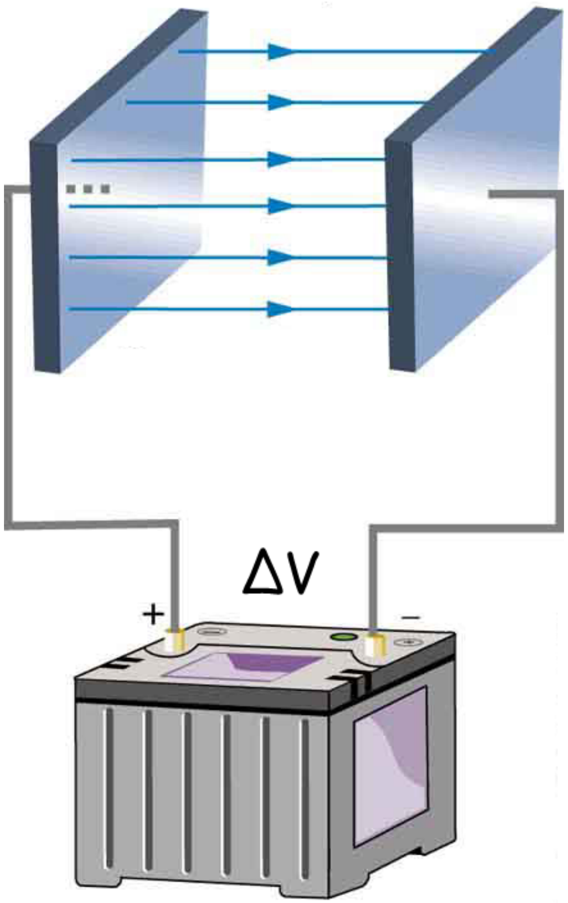
31.05.2016

ELEKTRİK ALANA GÖRE HIZLANDIRICILAR

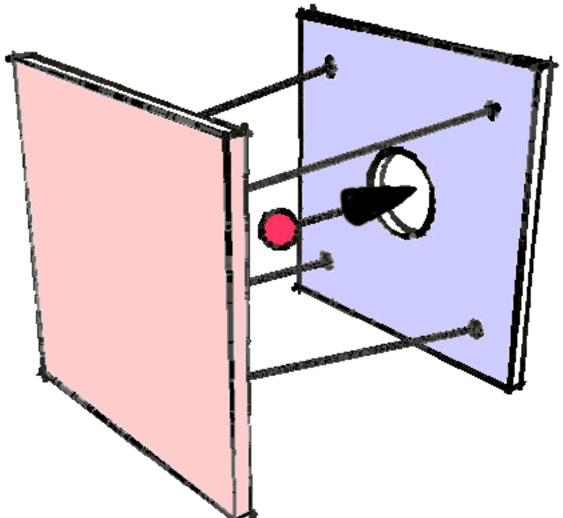


Do rusal
Dairesel

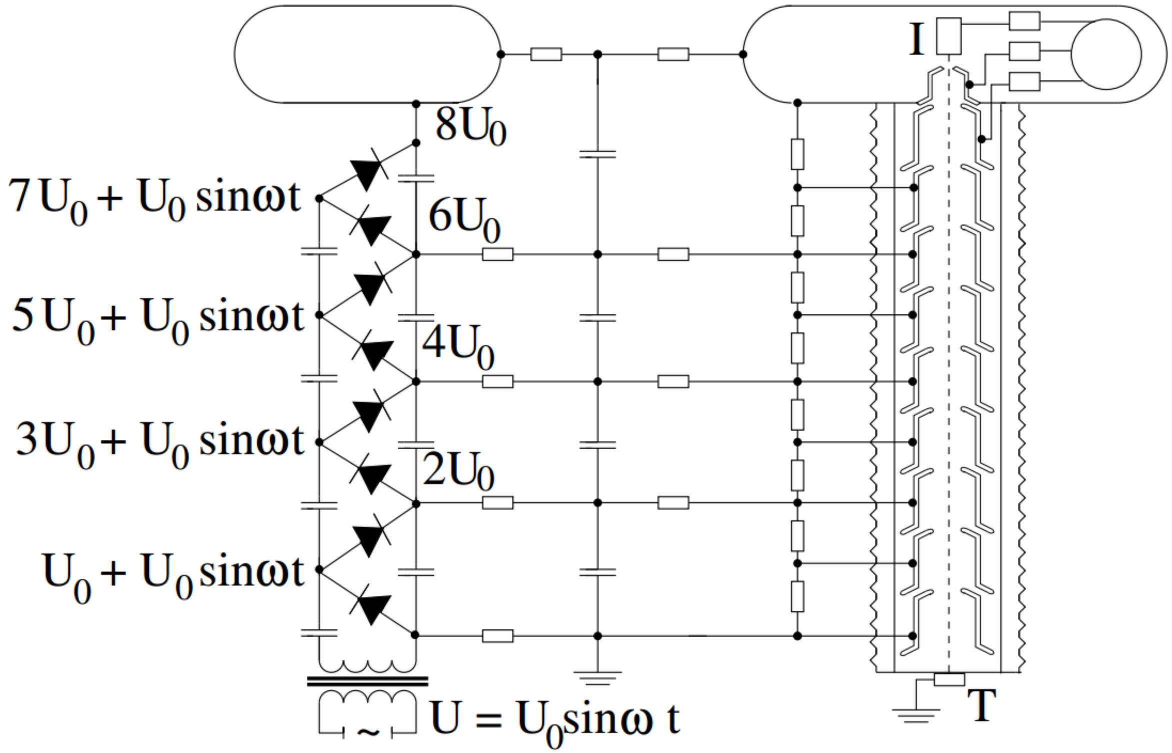
ELEKTROSTATIK HIZLANDIRICILAR

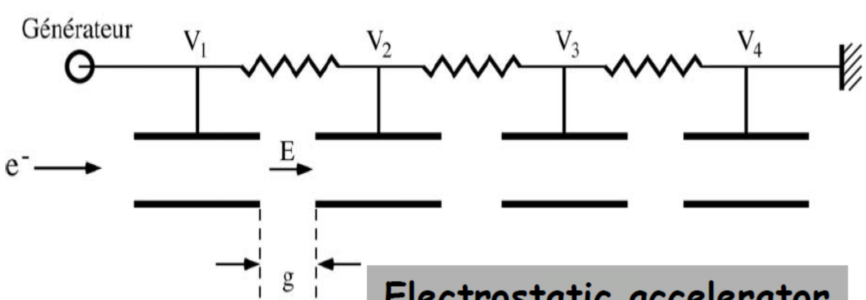


- En basit hızlandırma yöntemi: Paralel Levha
- **ΔE=q. ΔV**
- ***e*V**: bir elektronun yüküne sahip bir parçacığın 1V luk gerilimde hızlandığında kazandığı kinetik enerji.



COCKROFT-WALTON JENERATÖRÜ VE HIZLANDIRICI

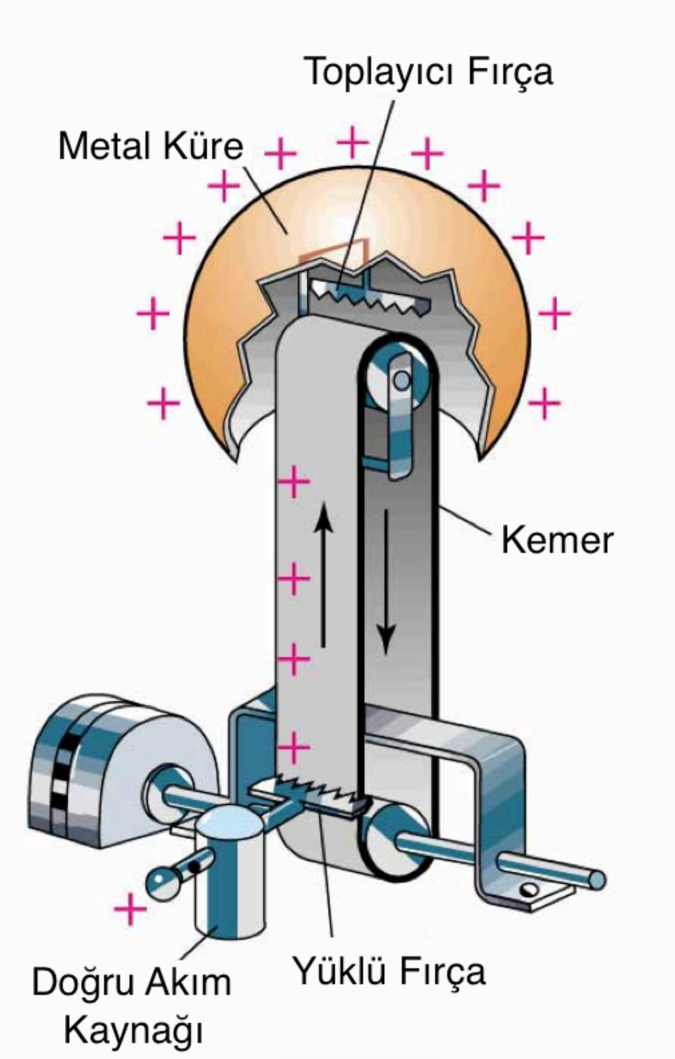




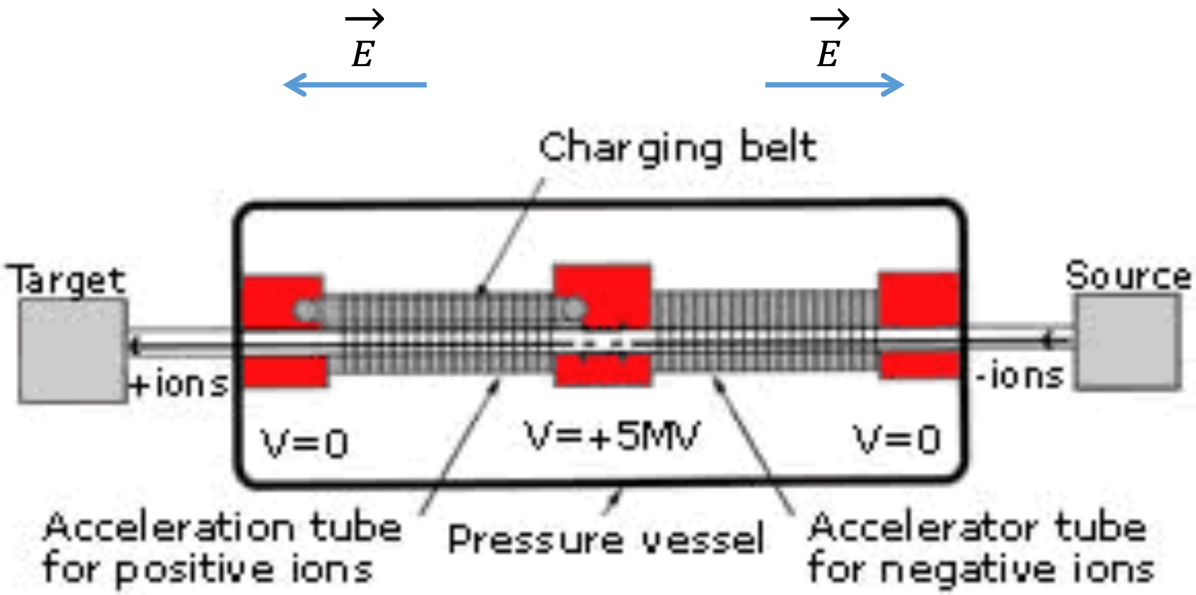
Electrostatic accelerator

VAN DE GRAAFF JENERATÖRÜ

- 1931 yılında Amerikalı fizikçi Robert J. Van de Graaff tarafından geliştirildi.
- Van de Graaff jeneratörü ile 20MV'tan daha yüksek potansiyel değerlerine çıkılmıştır.

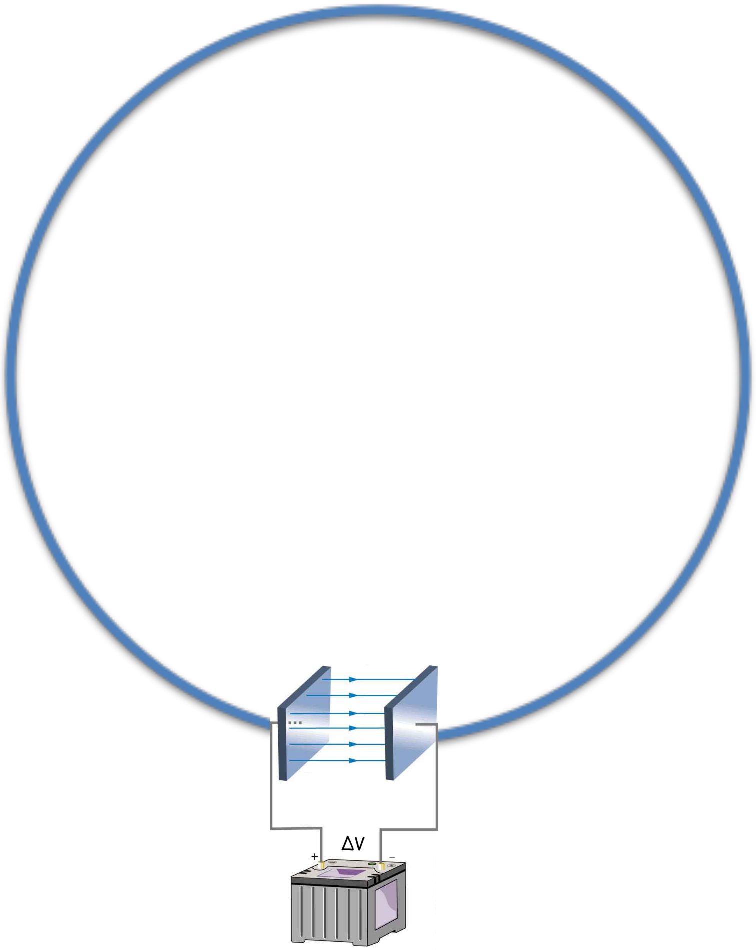


TANDEM HIZLANDIRICISI

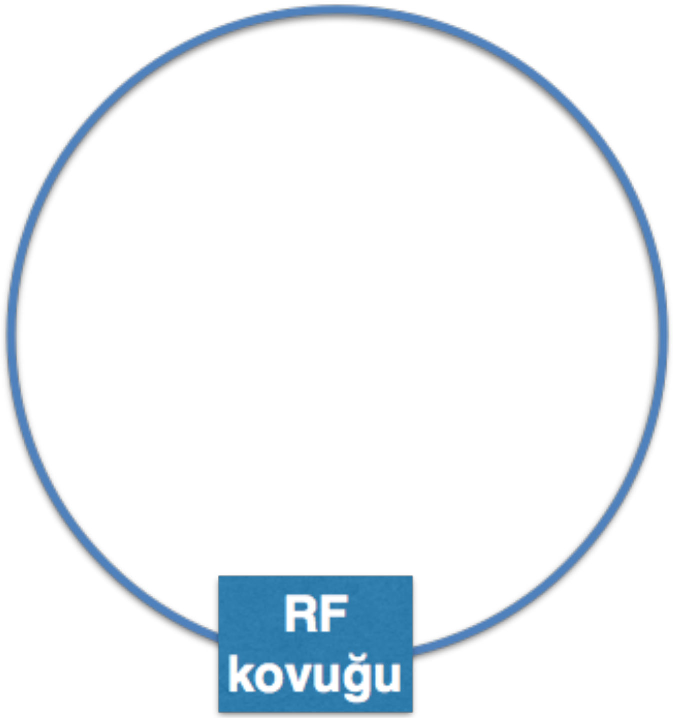


$\Delta E=2.q.\ \Delta V$

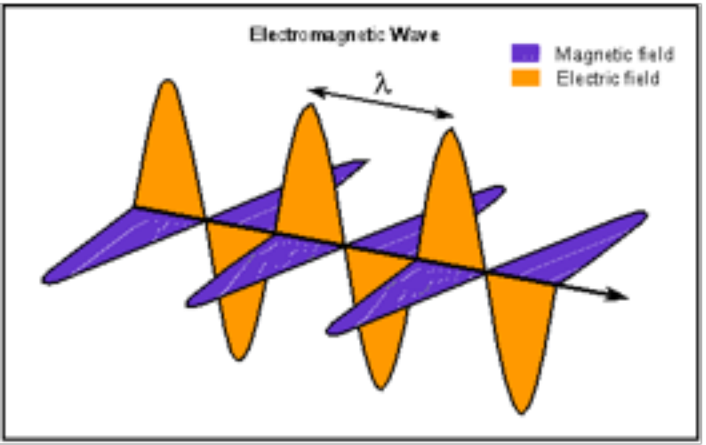
HIZLANMA MÜMKÜN MÜ?



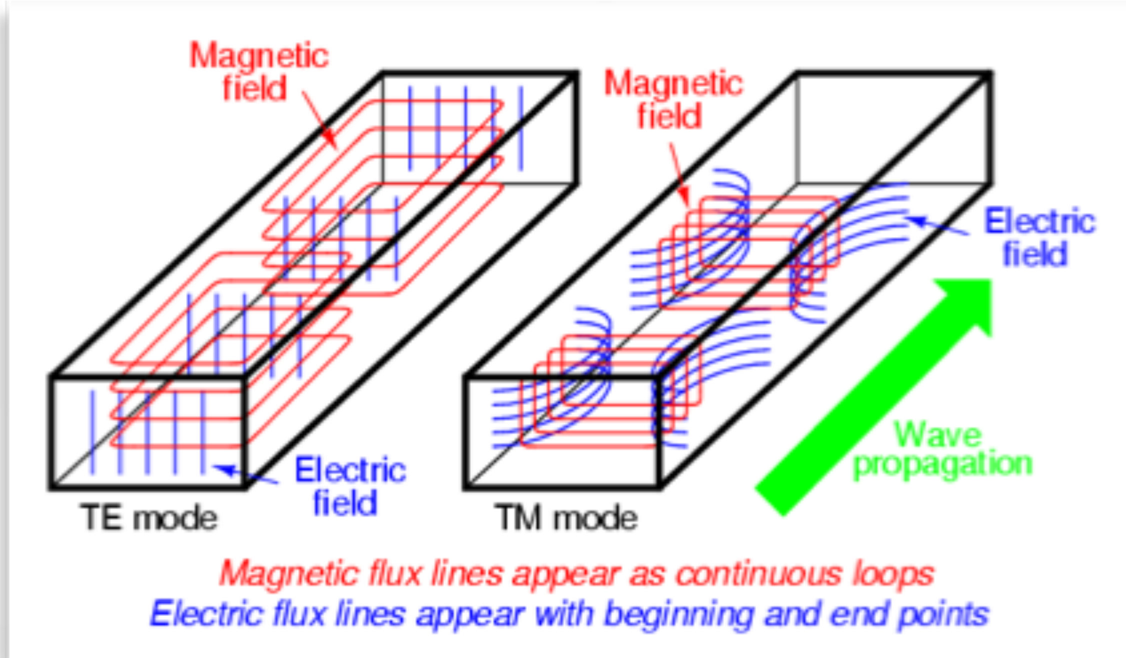
RF HIZLANDIRICILAR



EM DALGA



Boşlukta EM dalga



İletken bir yapının içerisinde EM dalga

$$\nabla \cdot \mathbf{E} = \rho/\varepsilon_0$$

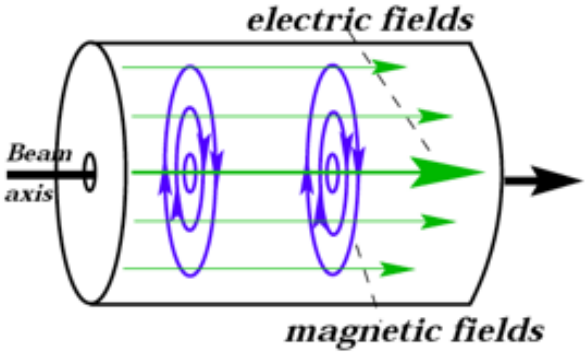
$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

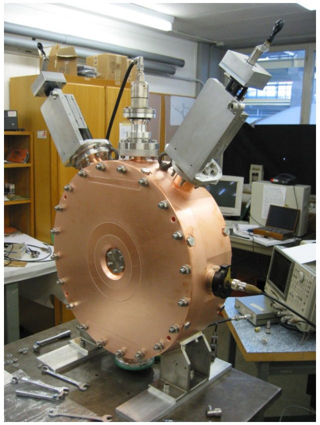
$$\nabla \times \mathbf{B} = \mu_0 \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} + \mu_0 \boldsymbol{j}_c$$

İletken bir yapı içerisinde ilerleyen elektromanyetik dalganın elektrik ve manyetik alan yönleri geometri ve frekans tarafından belirlenir.

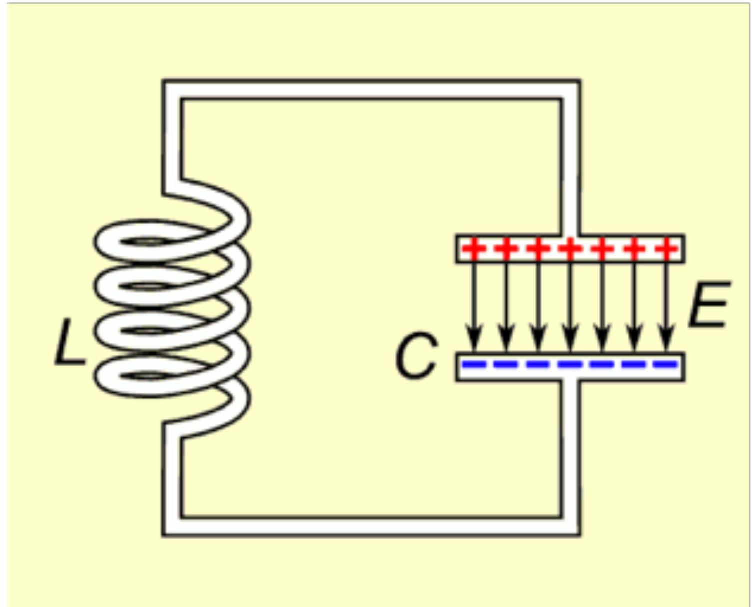
RF Kovuğu (Davul Kovuk-Pill Box Cavity)

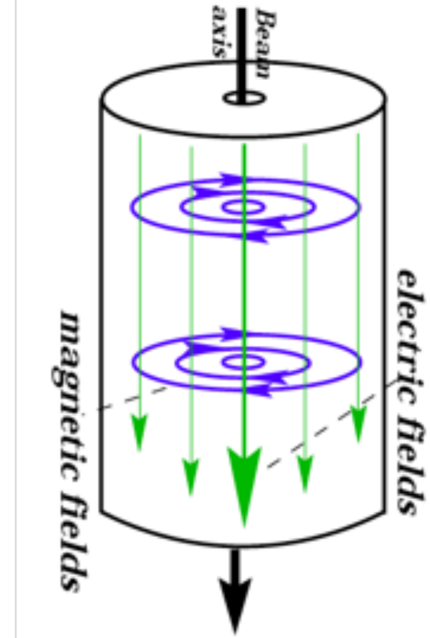


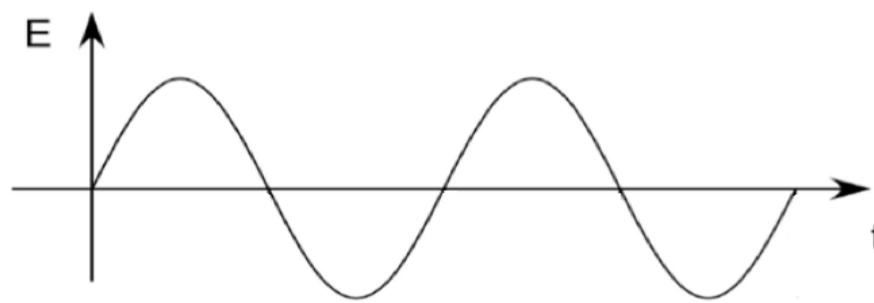
$$f_{RF} = \frac{1}{r}$$



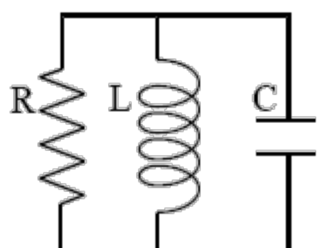
DAVUL KOVUK







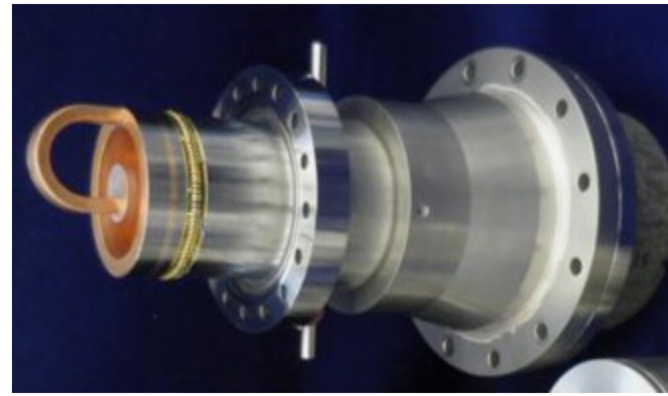
gerçek
durum

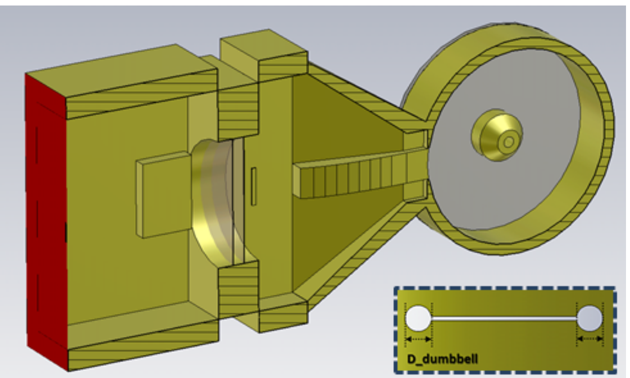


C: başta ve sondaki kapaklar
L:kovuk içerisindeki boşluk
kablo: iletken kovuk duvarı
R:kovuk duvarındaki direnç

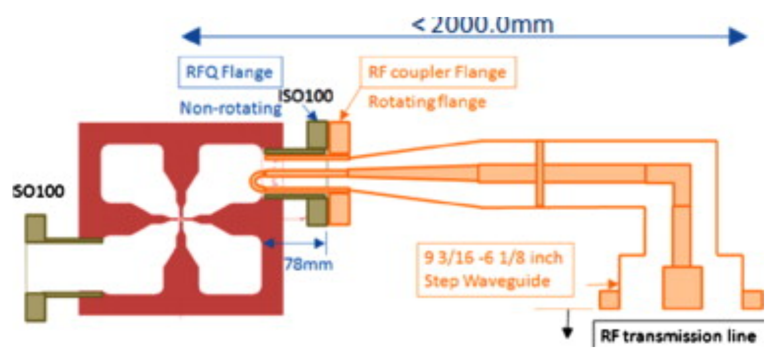
KOVUĞU RF İLE DOLDURMAK

- Antenlerle manyetik indükleme
- Veya RF penceresi ile (iris)

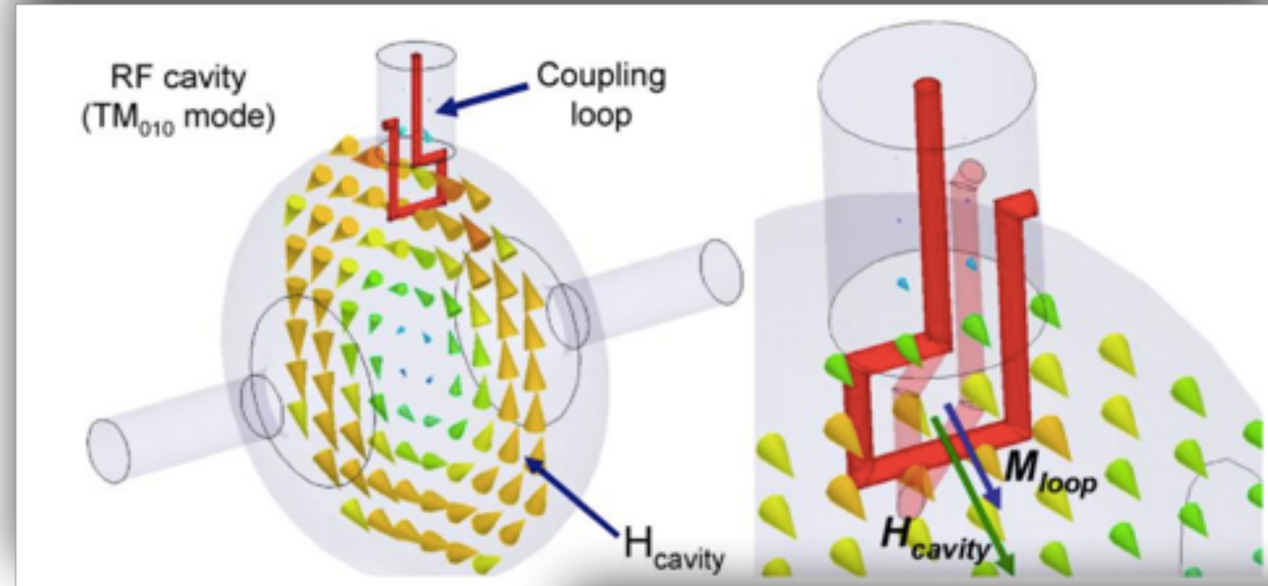


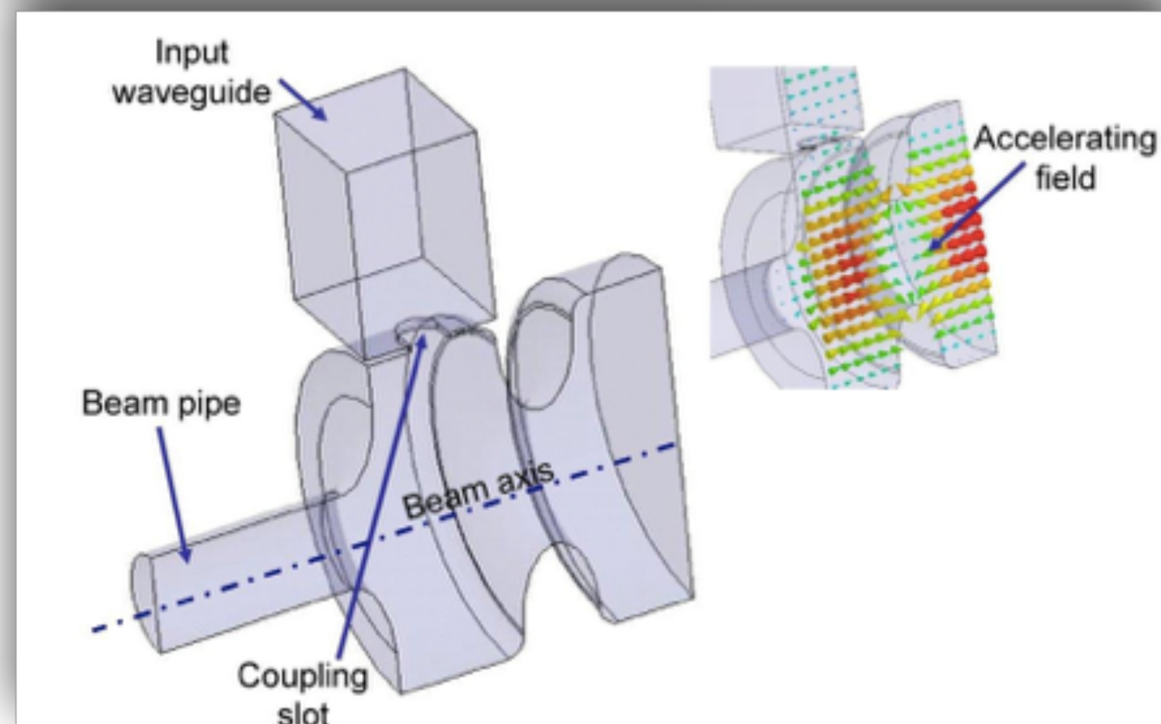


dalga klavuzu

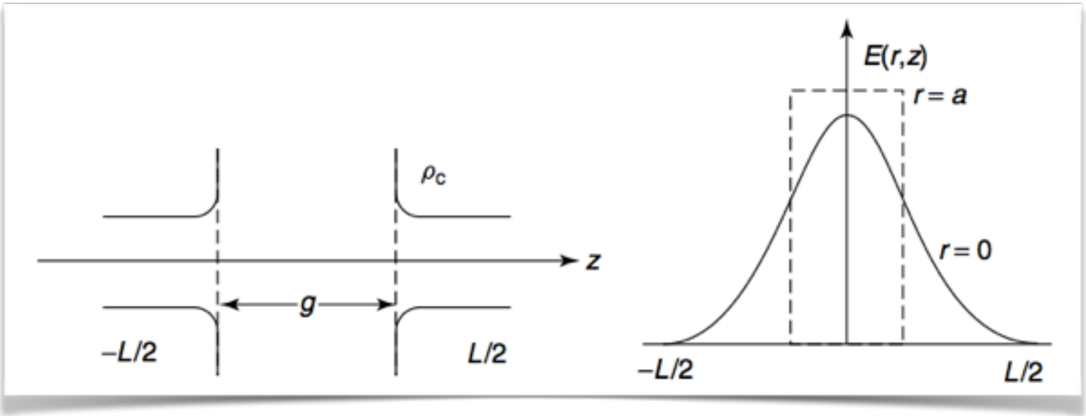


eşeksenli kablo


RF cavity
(TM_{010} mode)
Coupling
loop
H_{cavity}
M_{loop}
H_{cavity}


Input
waveguide
Accelerating
field
Beam pipe
Beam axis
Coupling
slot

HIZLANMA HÜCRESİNDE KAZANILAN ENERJİ



$$\vec{F} = q\vec{E}$$

$$F_z = qE_z$$

$$\Delta W = \int F_z dz$$

$$\Delta W = q \int_{-L/2}^{L/2} E(0,z)\cos(\omega t(z) + \phi)\, dz$$

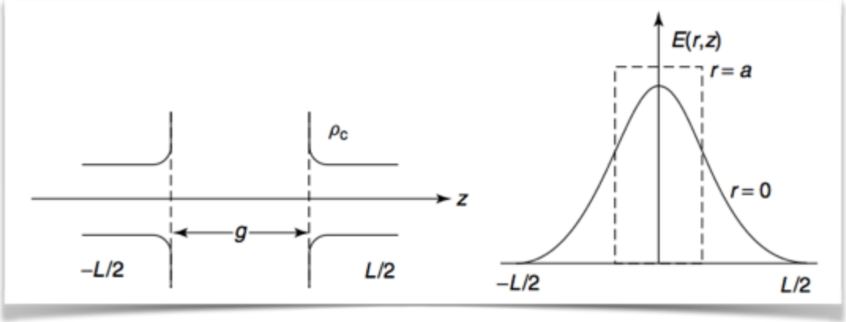
$$\Delta W = q \int_{-L/2}^{L/2} E(0,z)\,[\cos\omega t \cos\phi - \sin\omega t \sin\phi]\, dz$$

$$\Delta W = qV_0 T\cos\phi$$

$$V_0 \equiv \int_{-L/2}^{L/2} E(0,z)\, dz$$

$$T \equiv \frac{\int_{-L/2}^{L/2} E(0,z)\cos\omega t(z)\, dz}{\int_{-L/2}^{L/2} E(0,z)\, dz} - \tan\phi \frac{\int_{-L/2}^{L/2} E(0,z)\sin\omega t(z)\, dz}{\int_{-L/2}^{L/2} E(0,z)\, dz}$$

RF ELEKTRİK ALANDA ENERJİ KAZANIMI



$$V_0 \equiv \int_{-L/2}^{L/2} E(0,z)\,dz$$

$$E_0 = V_0/L$$

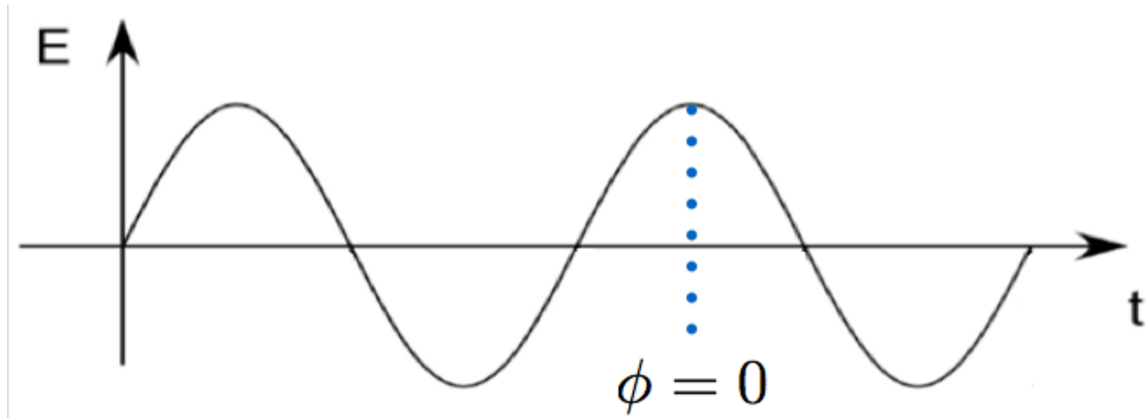
Bir hücre boyunca eksende oluşan ortalama elektrik alan

Bir hücrede kazanılan kinetik enerji

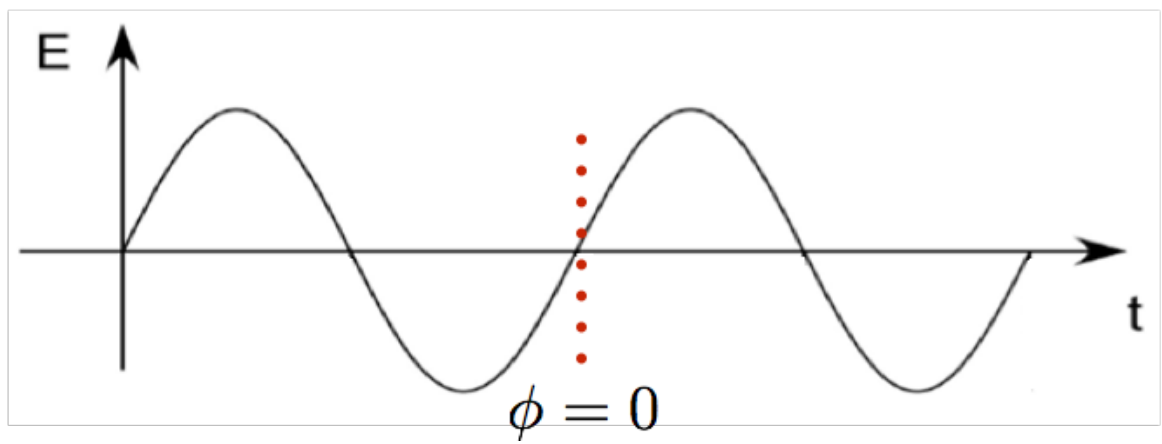
$$\Delta W = qE_0 T \cos\phi L$$

REFERANS FAZ

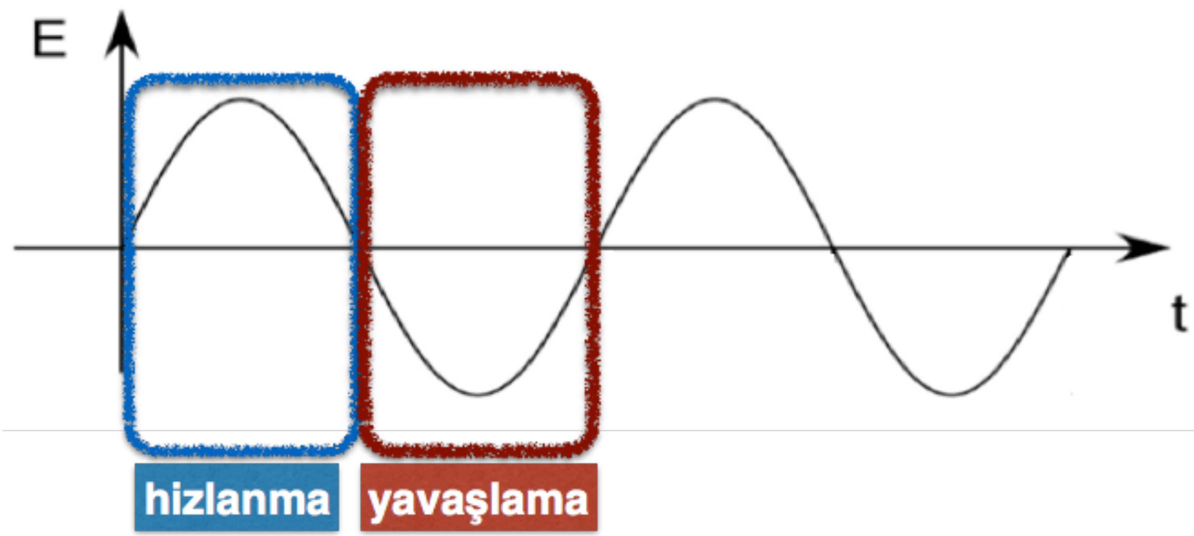
Doğrusal Hızlandırıcı

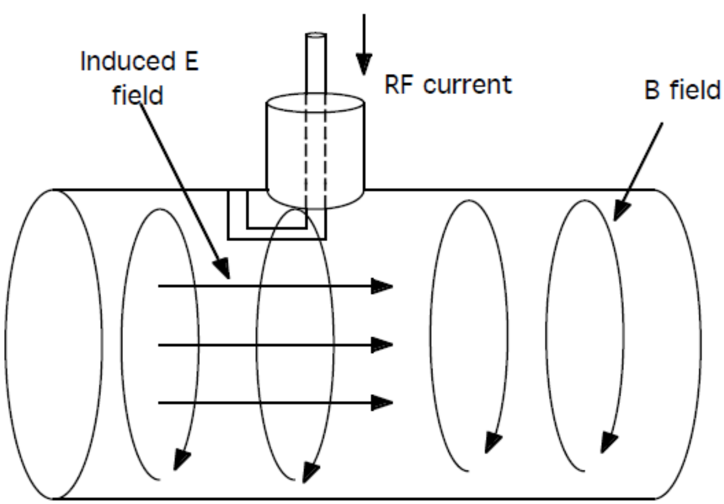


Dairesel Hızlandırıcı



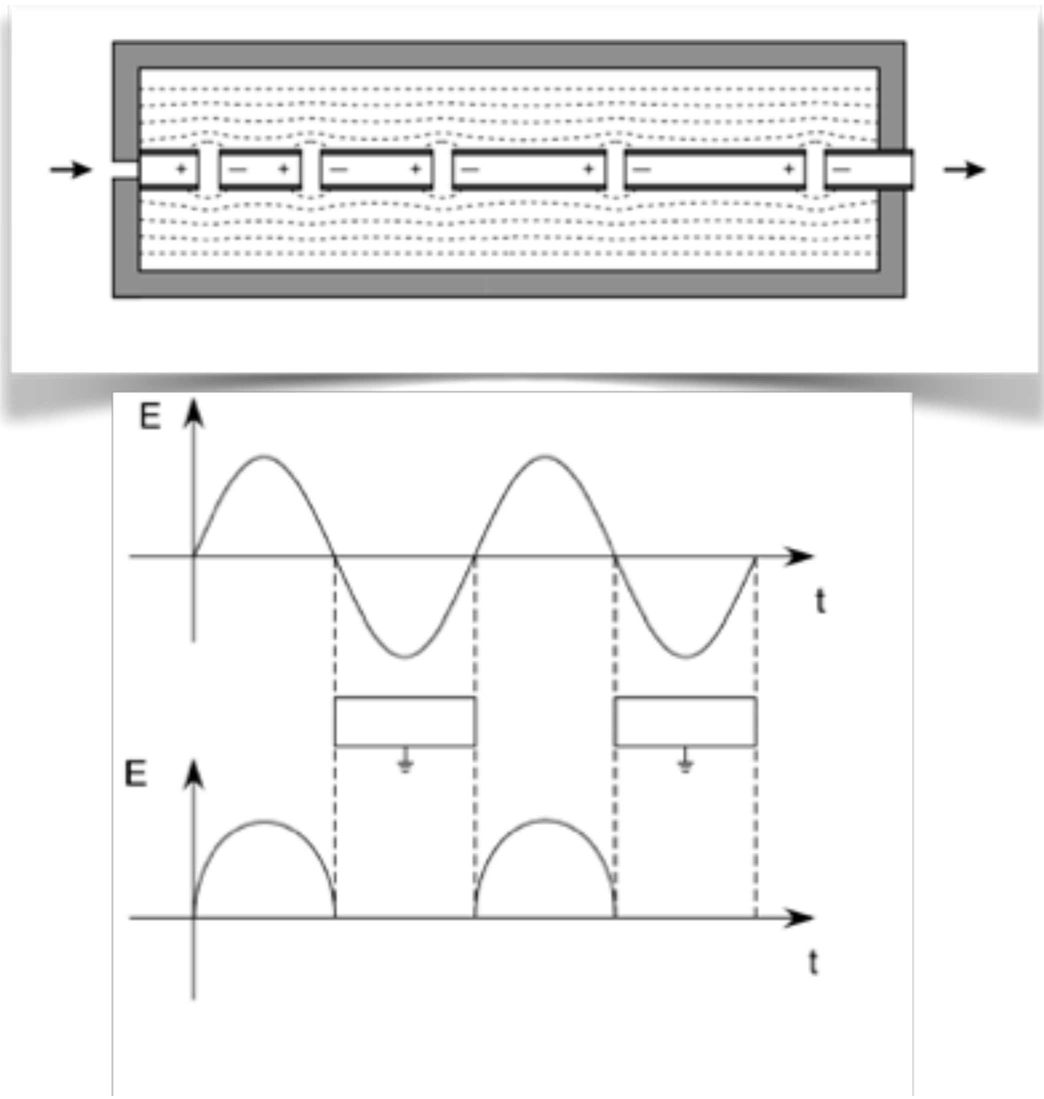
RF İLE NELER YAPABİLİRİZ





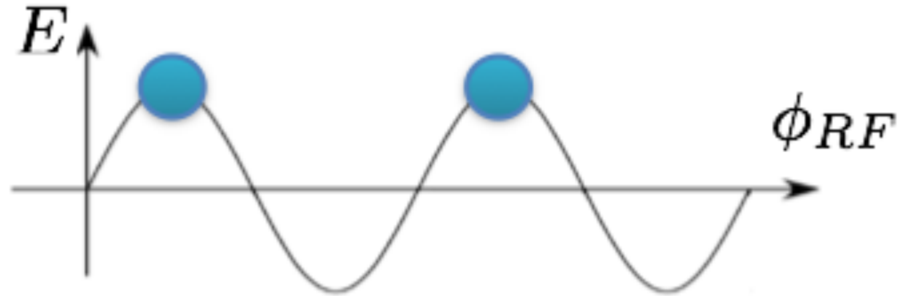
Uzun bir davul kovukta parçacıkları hızlandırabilir miyiz?

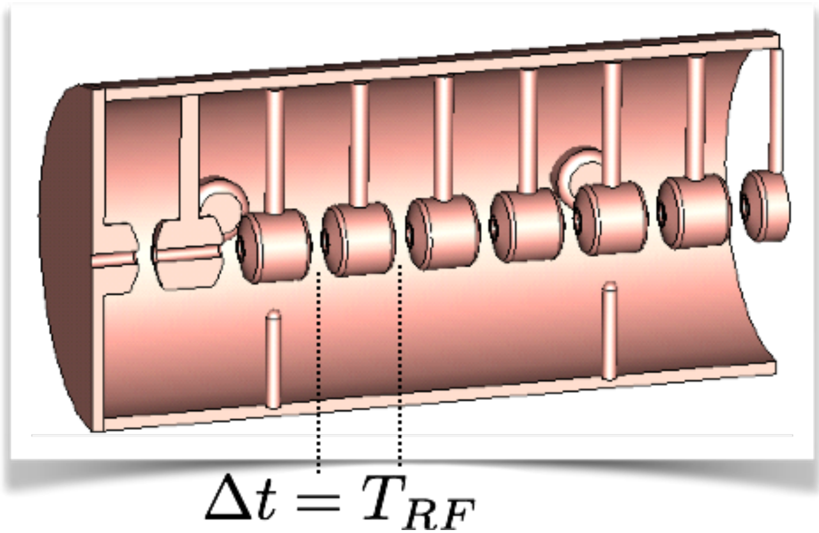
DAVUL KOVUKTAN DTL E GEÇİŞ



Sürüklenme tüpleri parçacıkları
Yavaşlatıcı yöndeki elektrik alandan
Koruyor.

DTL DE EŞZAMANLILIK





$$L_{hucre} = \beta\lambda$$

Hız arttıkça, eşzamanlılı ın sa lanması için hücre boyu da artmalı

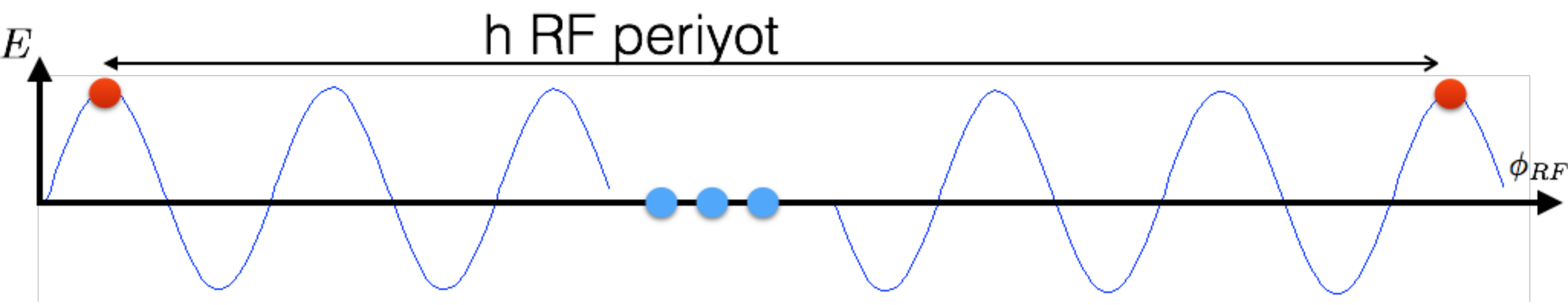
DTL (0-kip)

EŞZAMANLAYICIDA EŞZAMANLILIK

$$T_{donme} = hT_{RF}$$
$$f_{RF} = hf_{donme}$$

RF frekansi dönme frekansının tam katı olmalı.

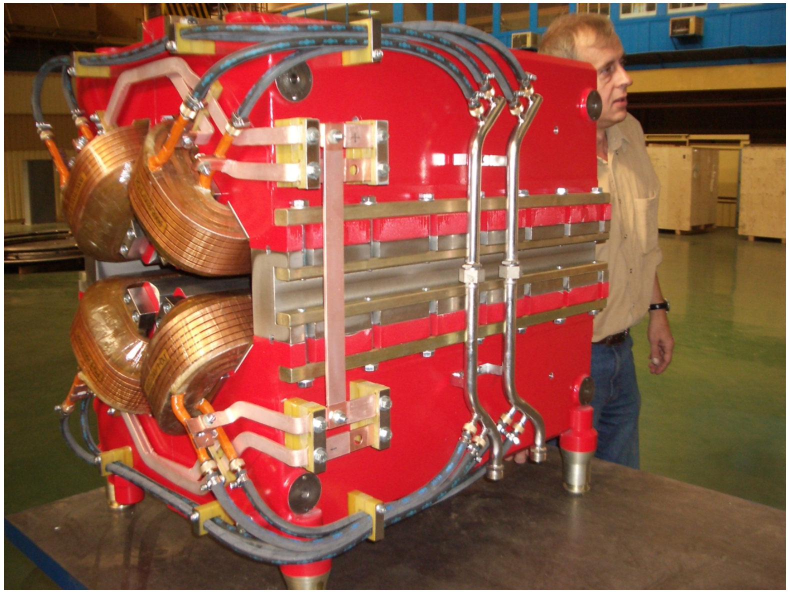
h:harmonik sayı (haronic number)

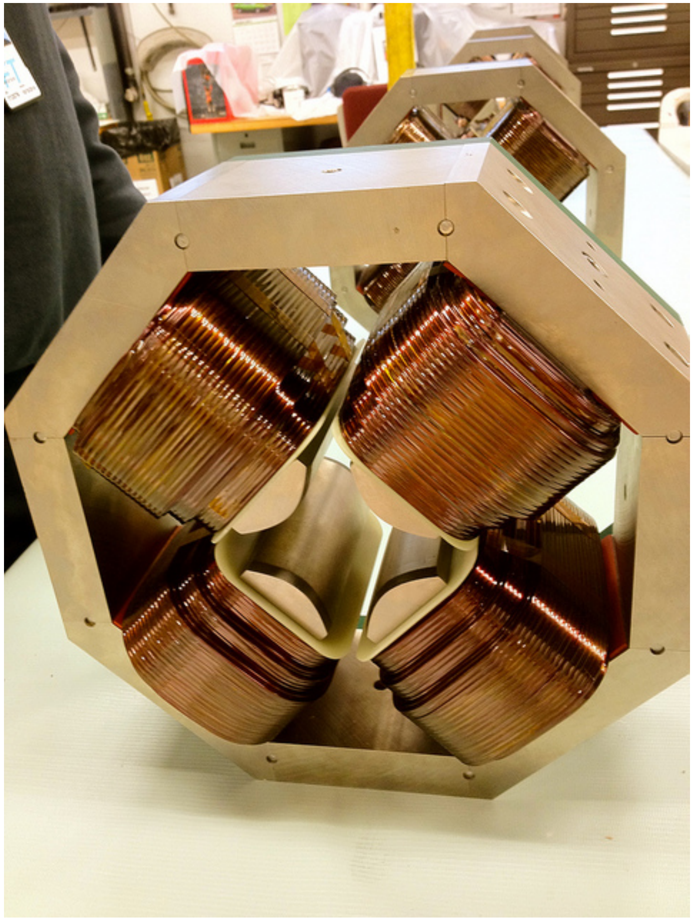


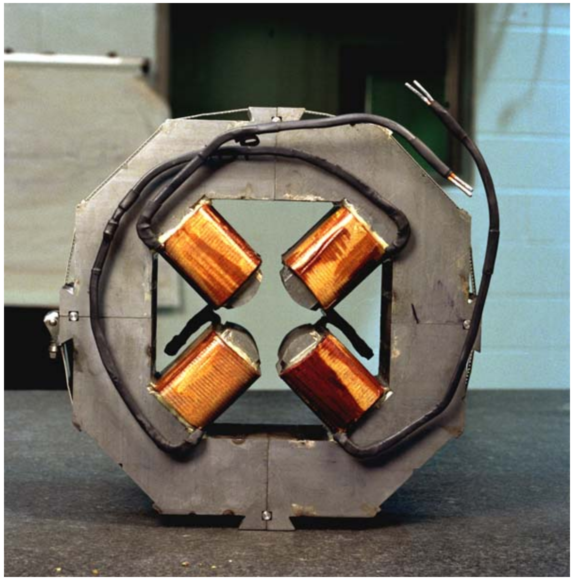
BOHÇA (BUNCH)

- Hızlanma esnasında bohçanın enine ve boyuna eksendeki büyüklüğünü korumalıyız.
- 4-kutuplu mıknatıs→ enine odaklama
- RF ile boyuna odaklama

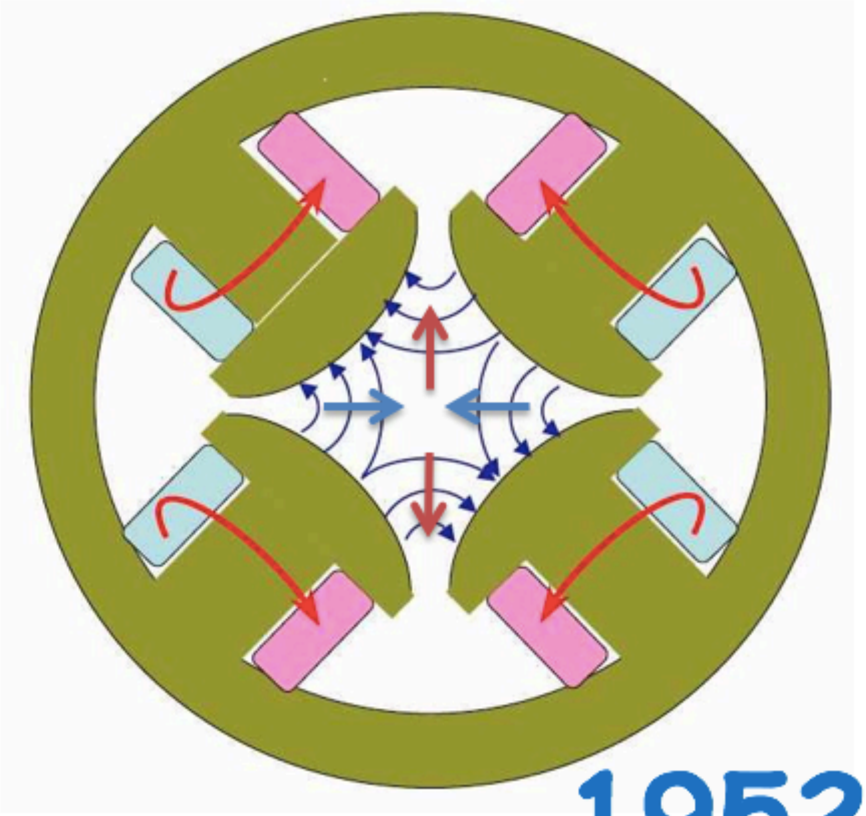
DÖRT KUTUPLULARLA ODAKLAMA



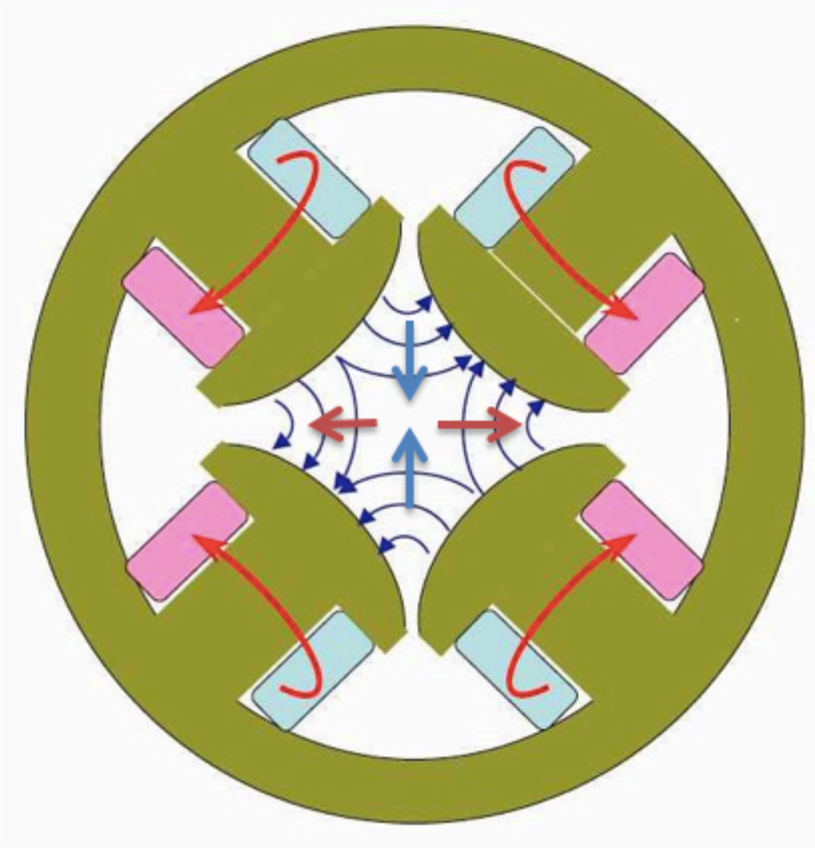




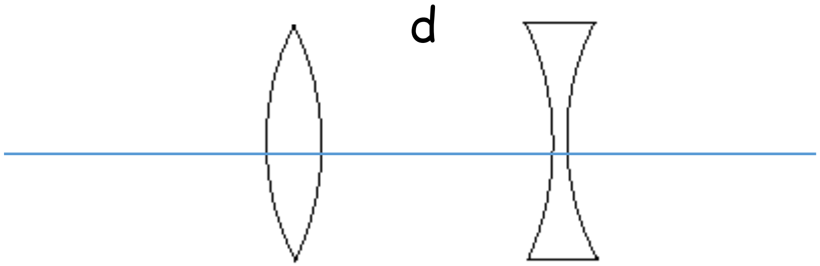
Dört Kutuplularla Odaklama

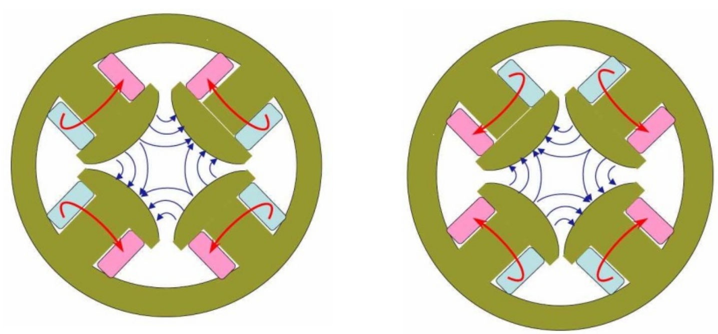


1952



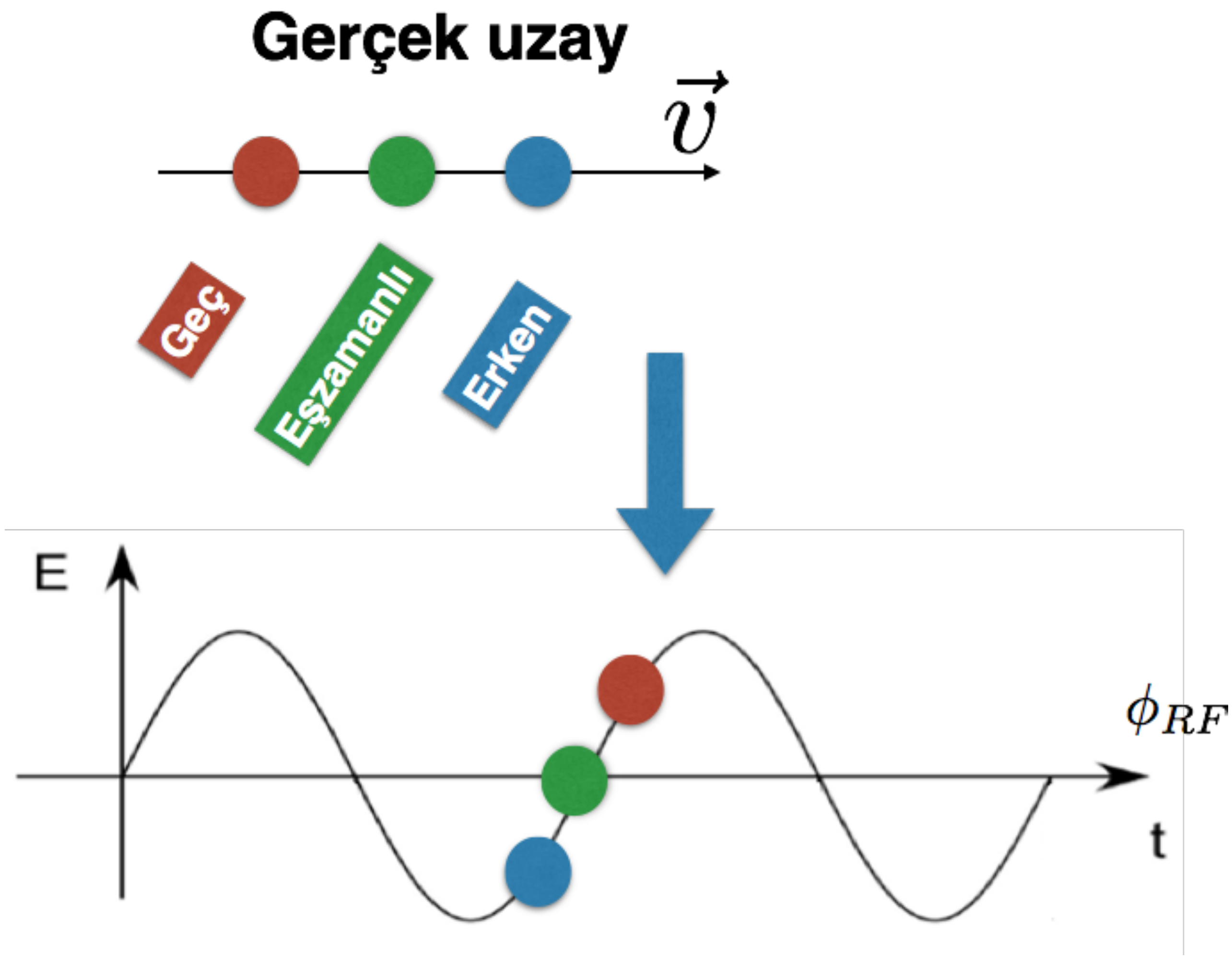
DÖRT KUTUPLULARLA ODAKLAMA



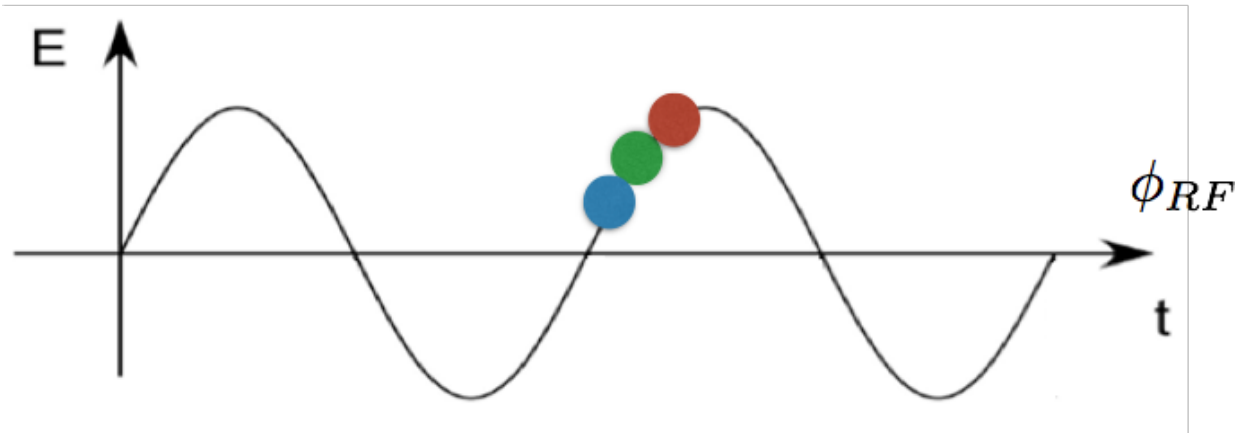


- Odak uzaklıkları aynı (f) olan bir ince kenarlı ve bir kalın kenarlı merceği arka arkaya koyarsak aradaki uzaklık d < f şartını sağladığı sürece bu iki merceğin yaptığı toplam etki odaklayıcıdır!!!
- Hızlandırıcılarda birbiri ardına gelen 4-kutuplu mıknatıslar birbirine göre 90 derece döndürülmüştür.

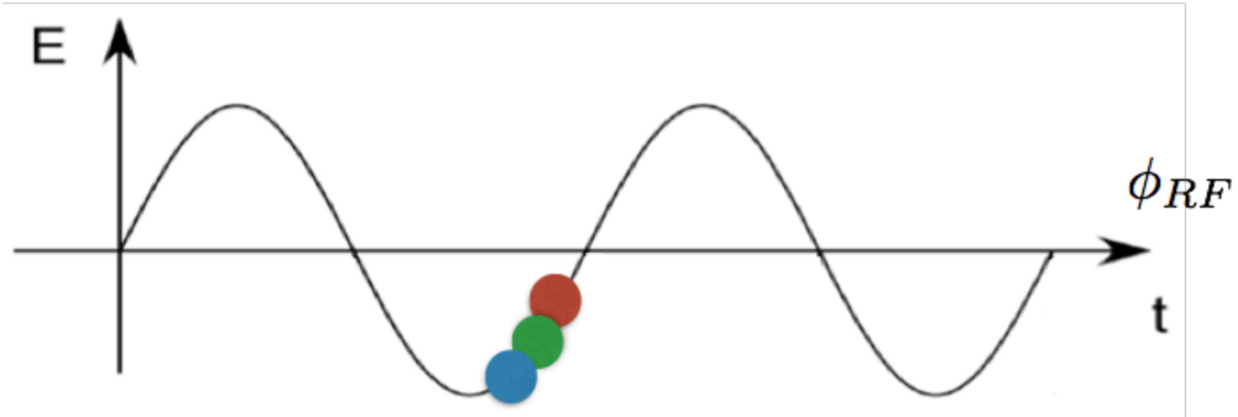
BOHÇALAMA (BUNCHING)



HIZLANMA VE BOHÇALAMA



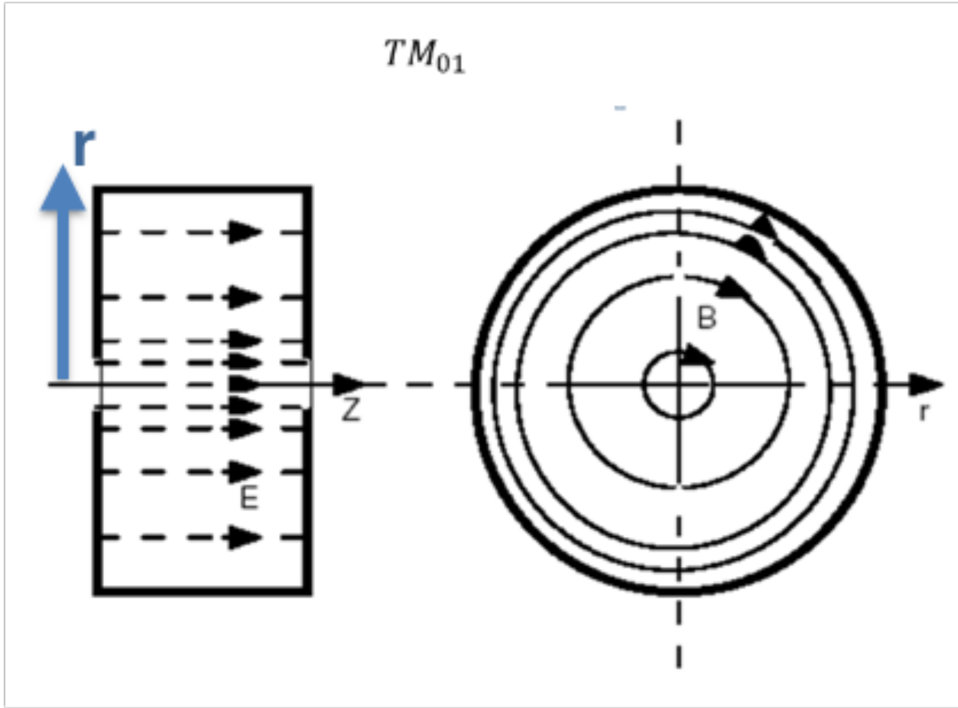
YAVAŞLATMA VE BOHÇALAMA



EM ALAN DESENİ

- Kovuk kipleri bize kovuk içerisinde elektrik ve manyetik alan desenlerinin nasıl olduğunu gösterir.
- Dikine- manyetik (transverse magnetic) (TM) kip yada dikine-elektrik (transverse electric) (TE) kipler olarak iki sınıfa ayrılır. TMmnp ve TEmnp deki alt indisler n, m, ve p kovuktaki alan desenini belirtir.
- m—> azimutal yön
- n—>radyal yön
- p—>boyuna yön
- Genelde p=0 (boyuna bir bağımlılık istemiyoruz). (iki sayı varsa, TM01 gibi, p= sıfırdır)

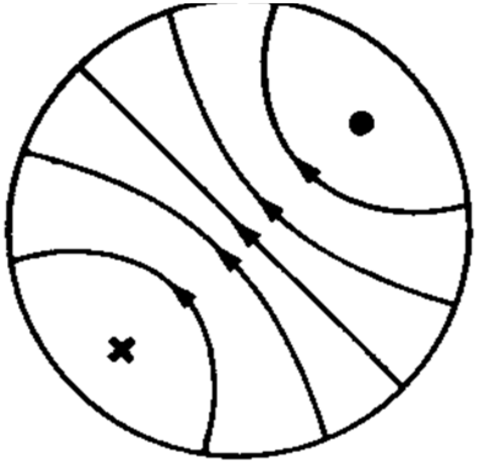
TM kipler



- Manyetik alan çizgileri parçacıkların hareket yönüne diktir. Elektrik alan parçacıkların hareket yönünde!!! Hızlandırma için uygun.
- **TE hızlandırıcılarda kullanılabilir mi?**

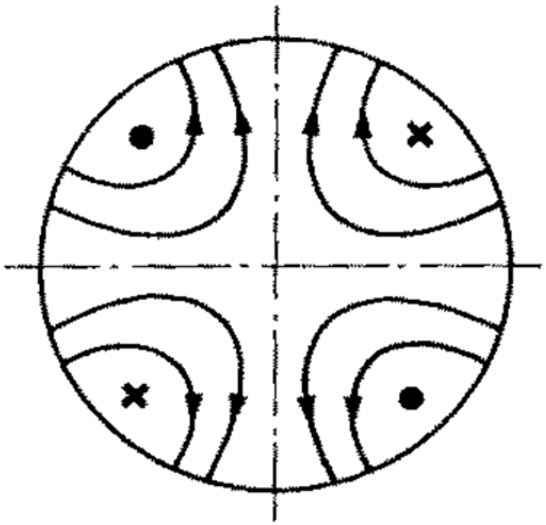
TE KİPLERİ

TE_{11}: **Dipole mode**



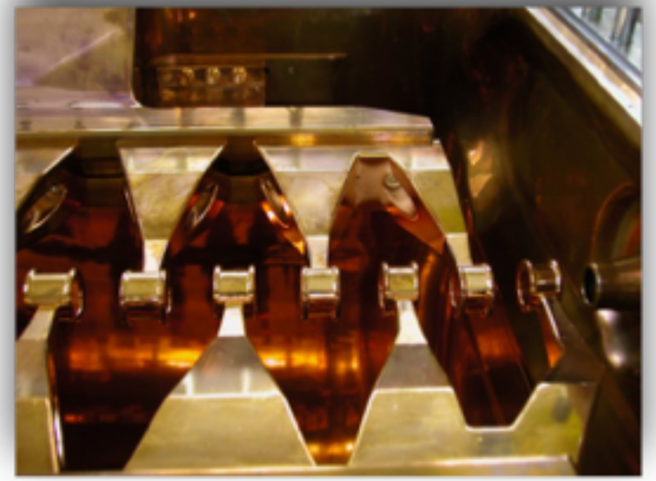
Empty cavity; mode TE_{11}

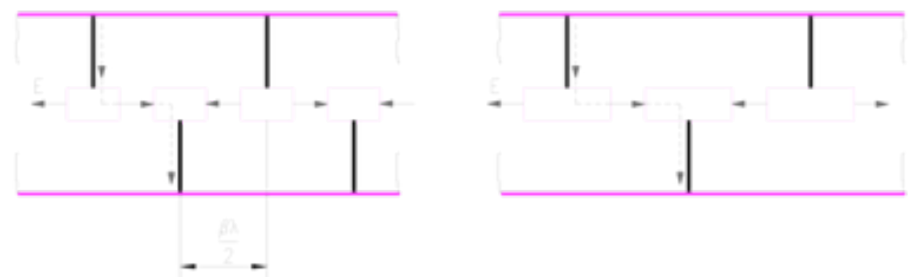
TE_{21}: **Quadrupole mode**

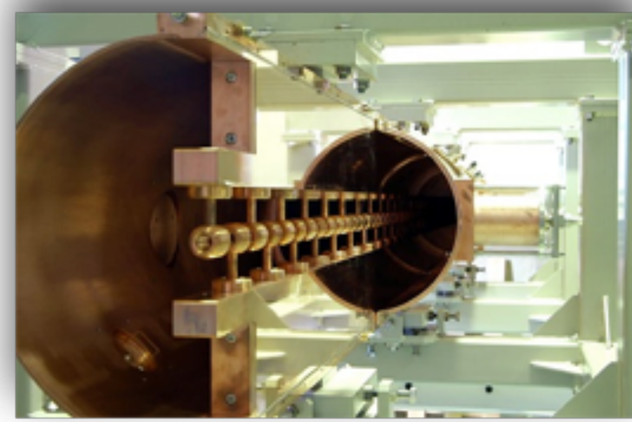


Empty cavity; mode TE_{21}

INTERDIGITAL H-TYPE (IH) (TE_{110})



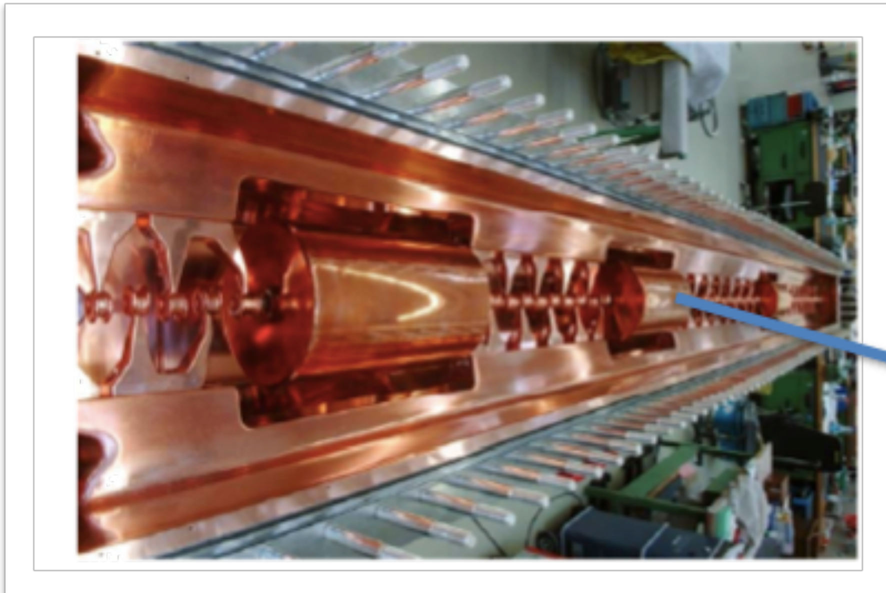


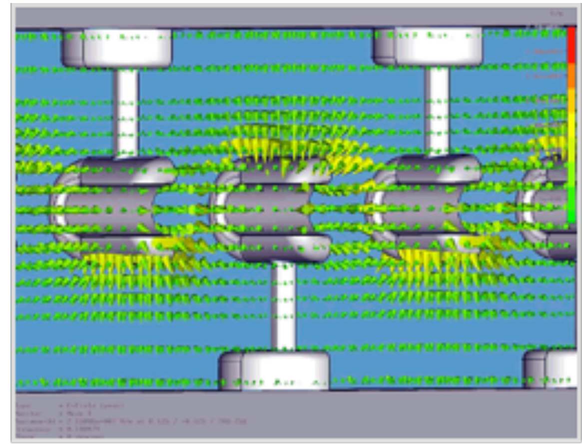


- **Sürüklenme tüpleri sayesinde dikine olan elektrik alanı saptırıp boyuna yönde elektrik alan elde edebiliyoruz? Hızlandırma için boyuna elektrik alana ihtiyacım var!!!**

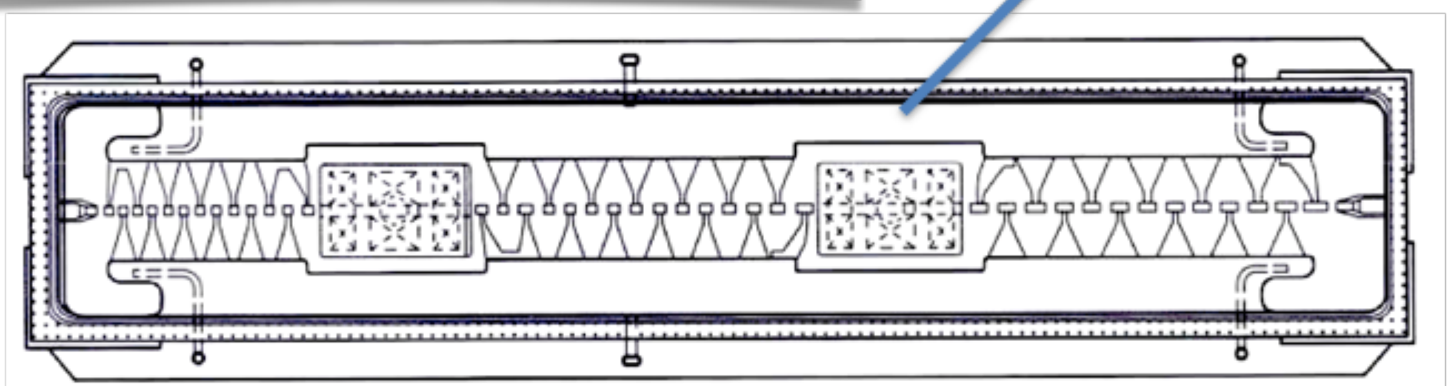
Düşük enerjilerde ağır iyonlar için kullanılır.
$0.02 < \beta < 0.08$

IH

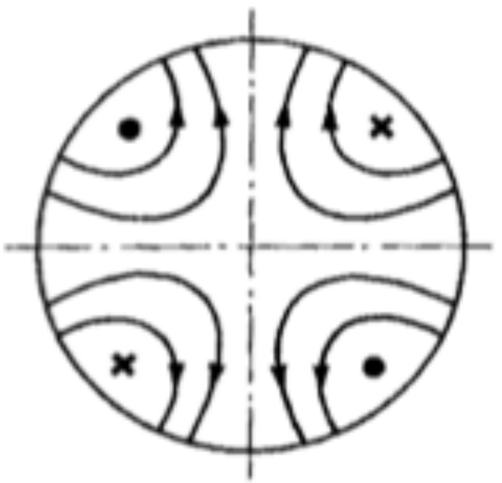




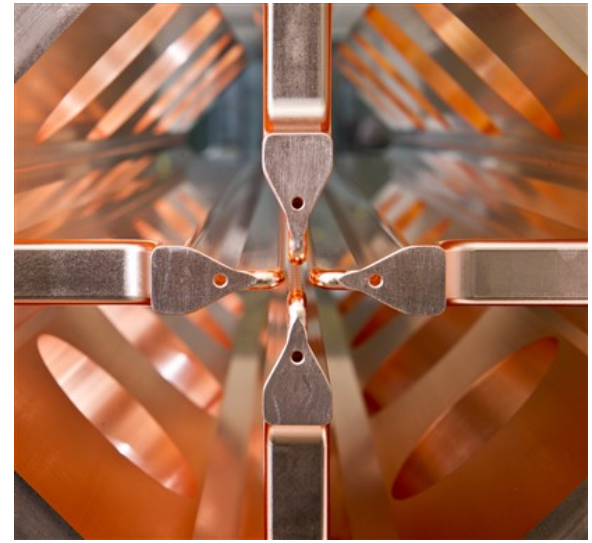
3 tane 4 kutuplu (triplet)
KONUS demet dinamiği

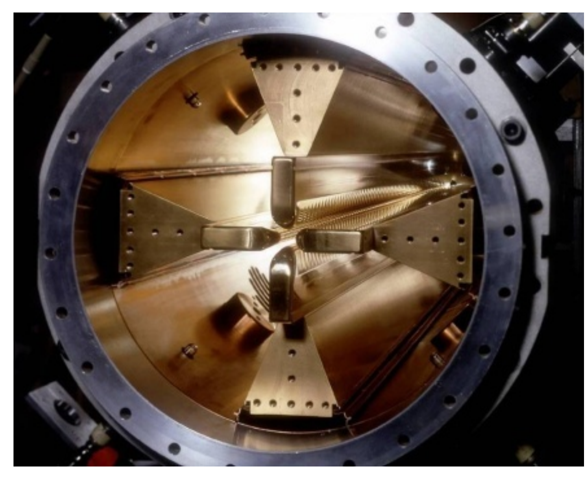


TE21 KİPİ



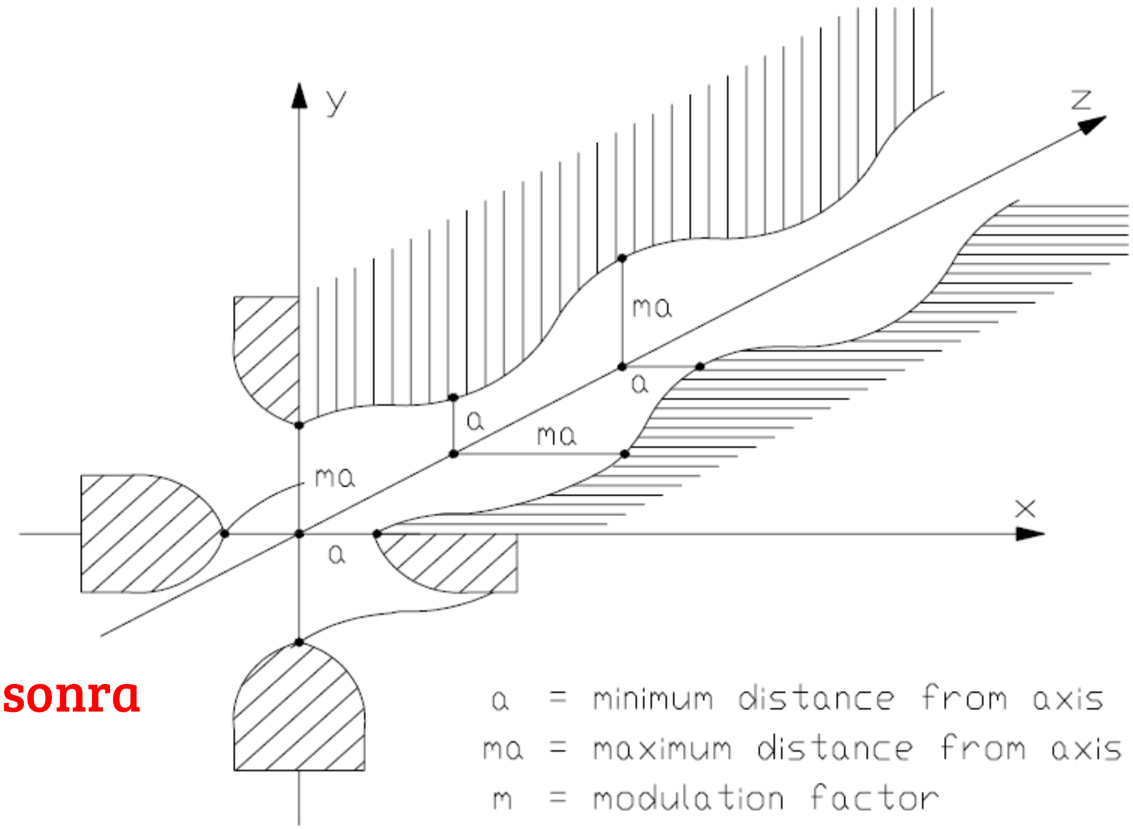
Empty cavity; mode TE_{21}





RADYO FREKANSI DÖRT KUTUPLUSU

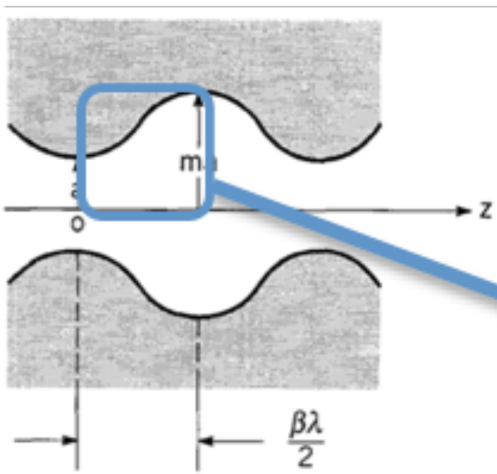
Bohçalama
Dikine odaklama
Hızlandırma

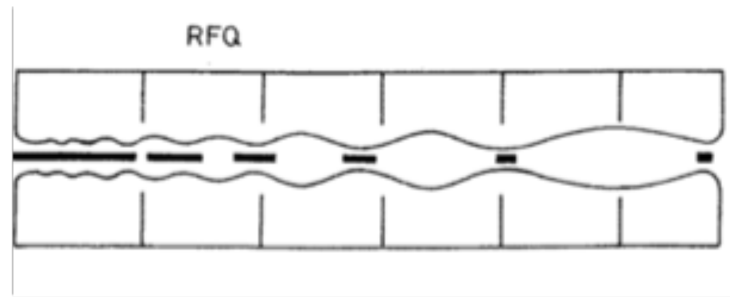


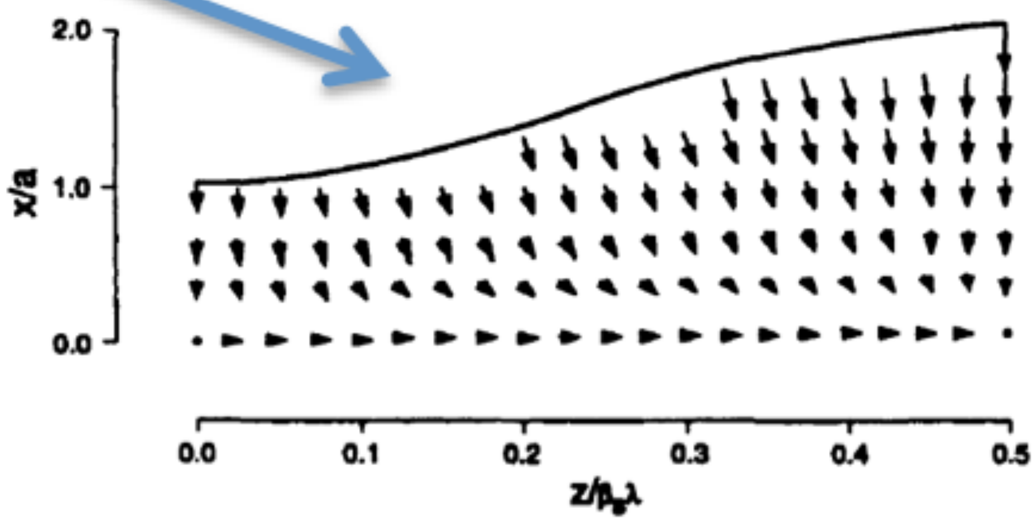
Iyon kayna ından sonra
Ilk hızlandırma.

Proton ve iyonlar için

RFQ İÇERİSİNDE ALANLAR







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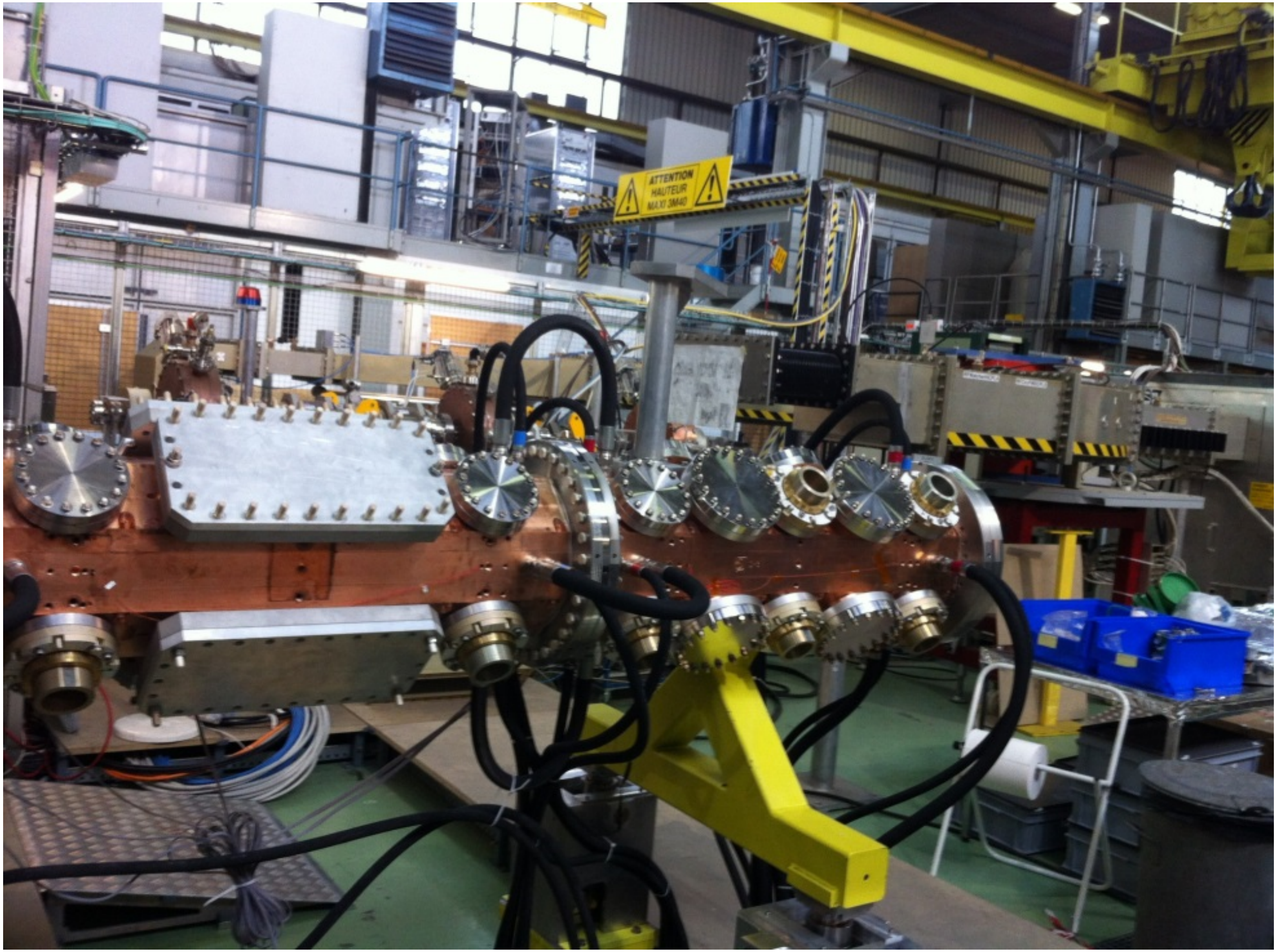
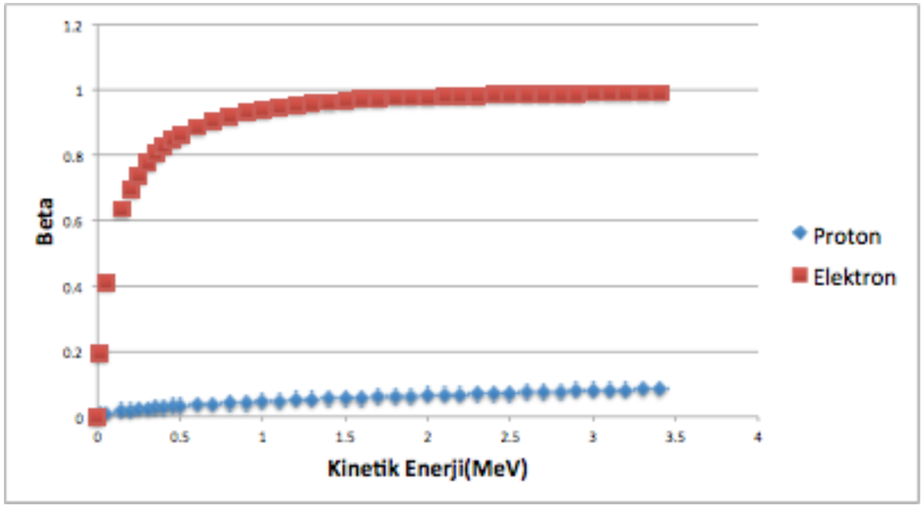
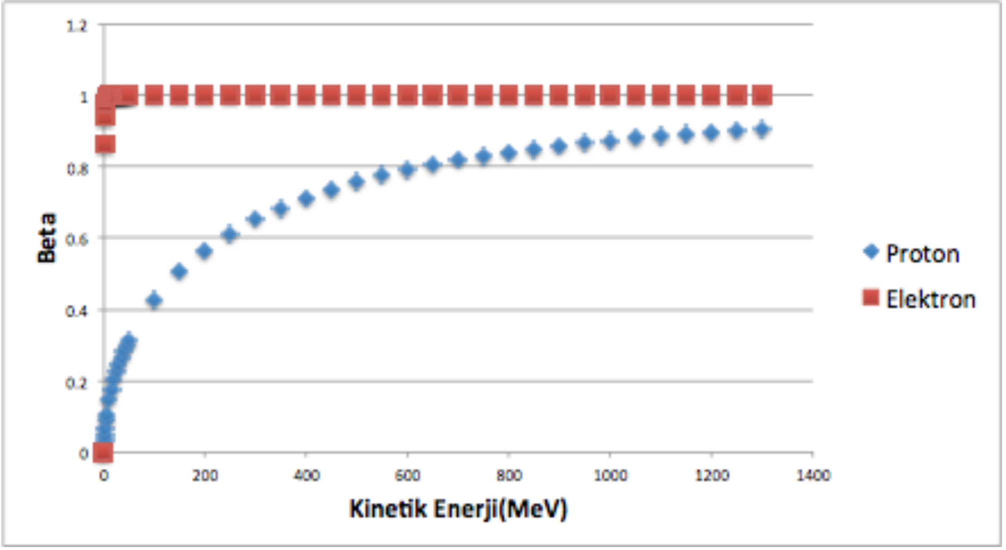


ELEKTRON VS. PROTON





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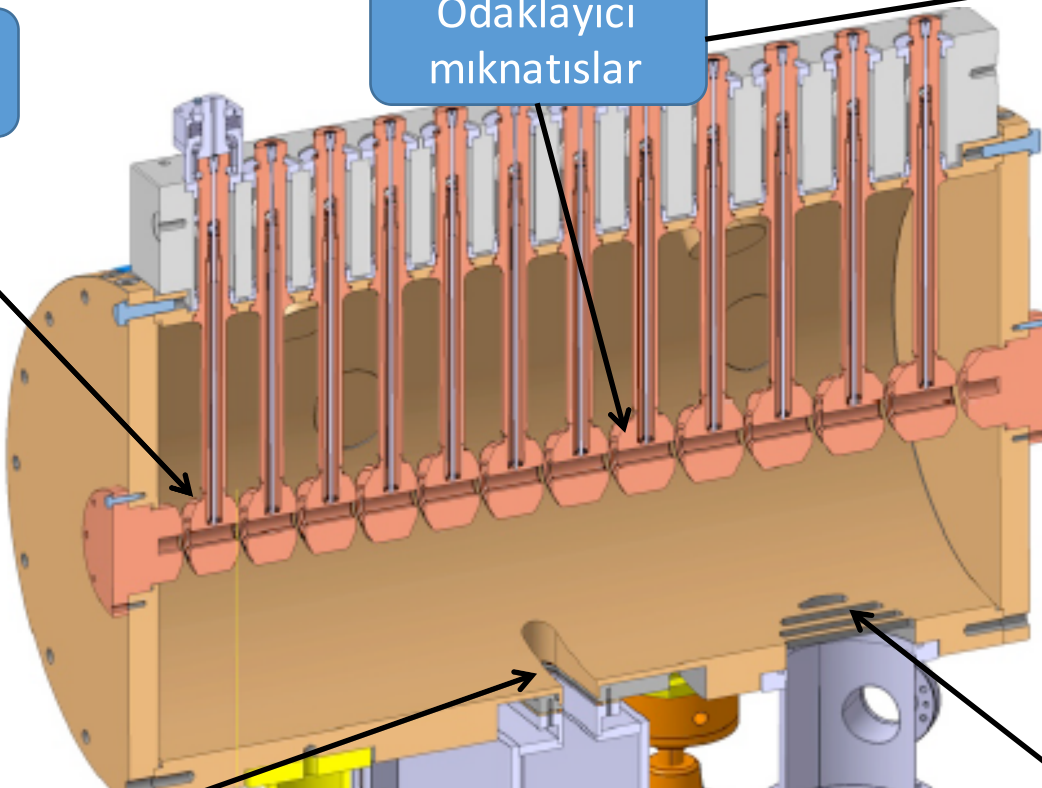


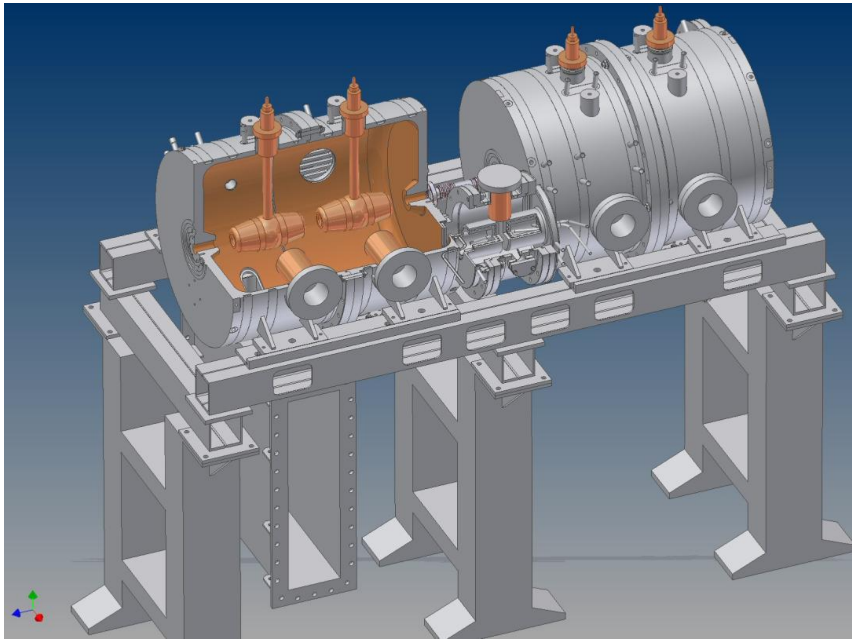
Sürüklenme tüpleri

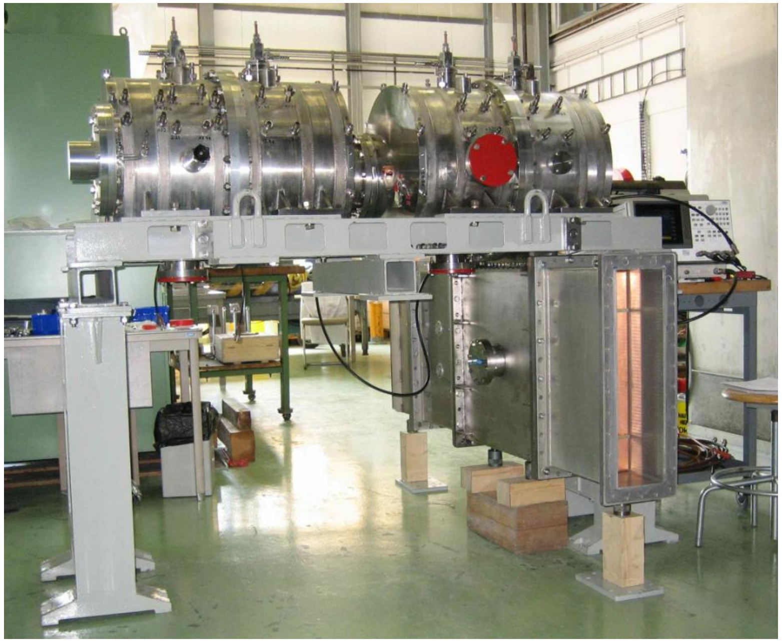
Odaklayıcı mıknatıslar

RF girişi

Vakum açıklığı

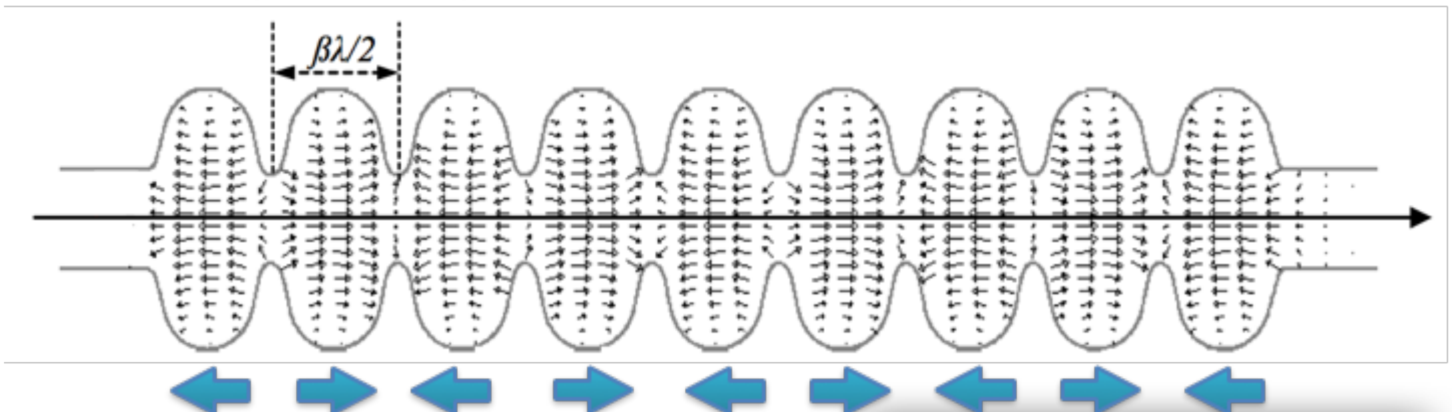
CCDTL

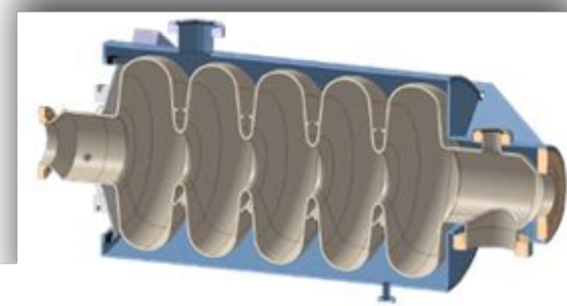




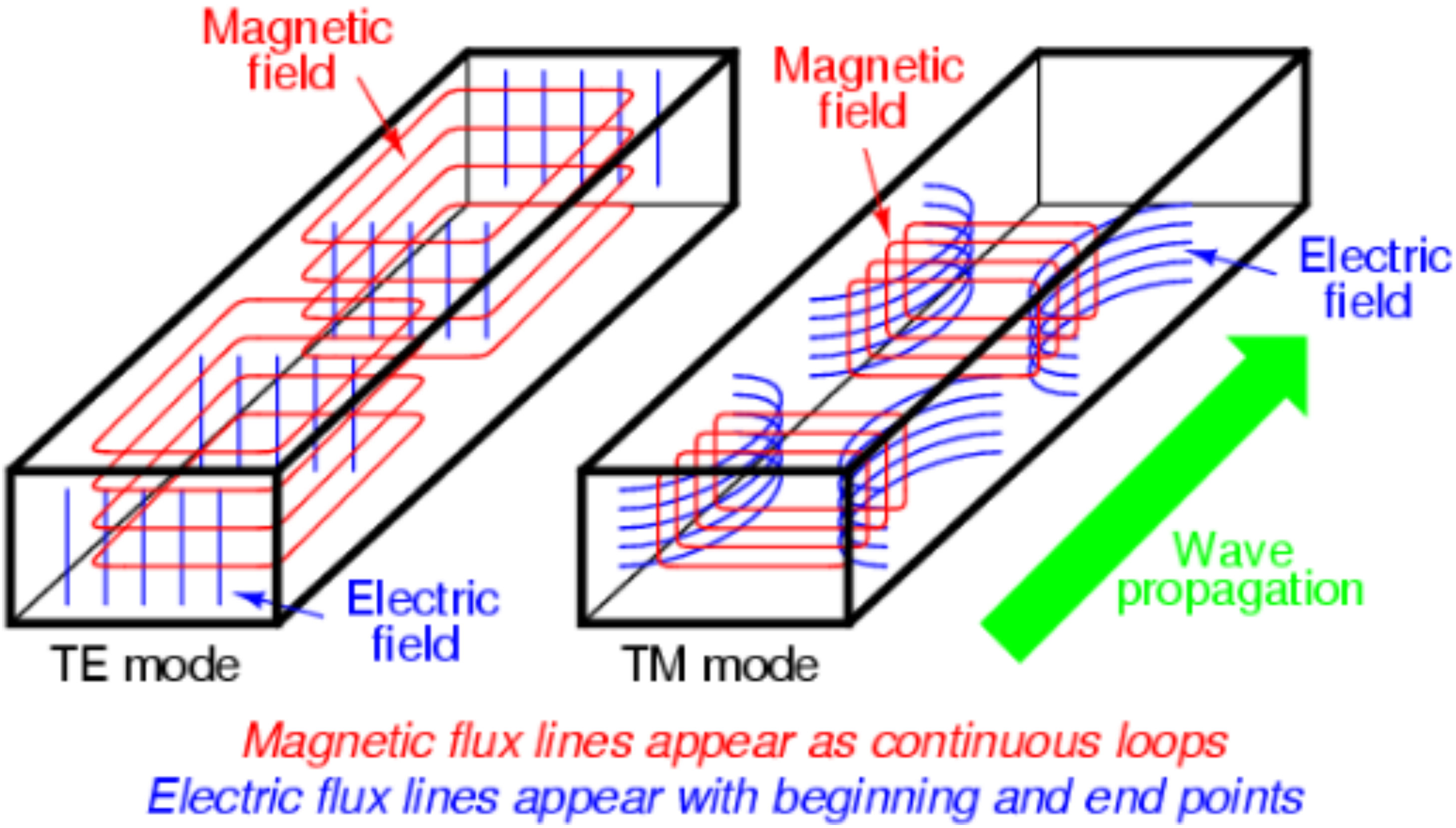
SUPERİLETKEN ELİPTİK KOVUK

π-kip: Superiletken eliptik kovuk





DALGA KLAVUZUNDAN ILERLEYEN DALGA KOVUGUNA



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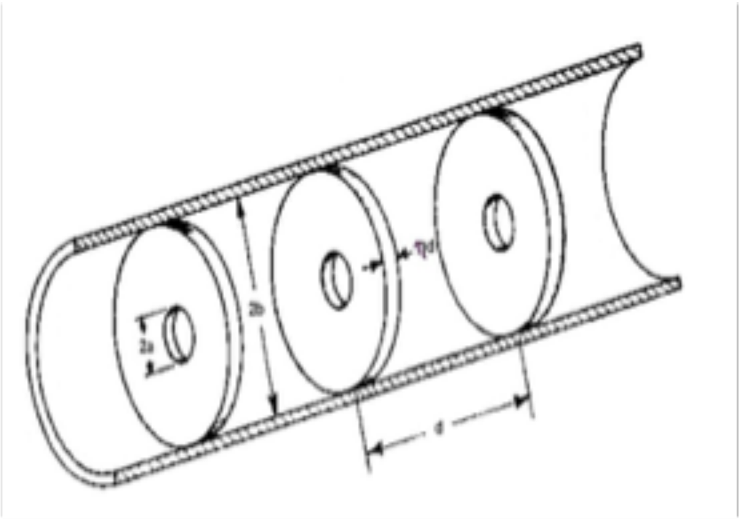

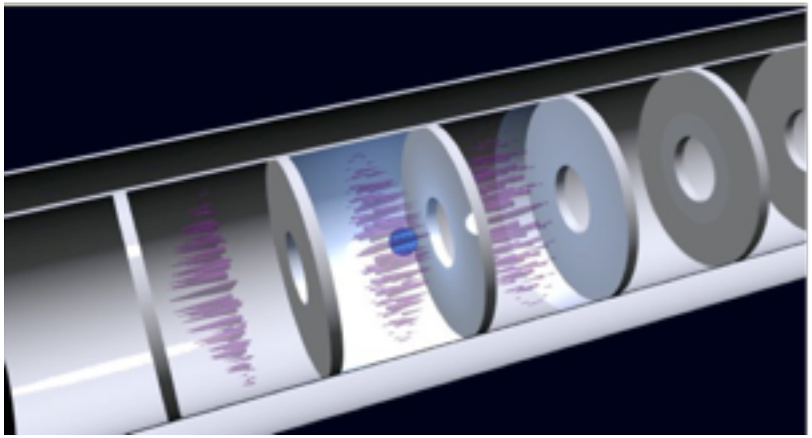

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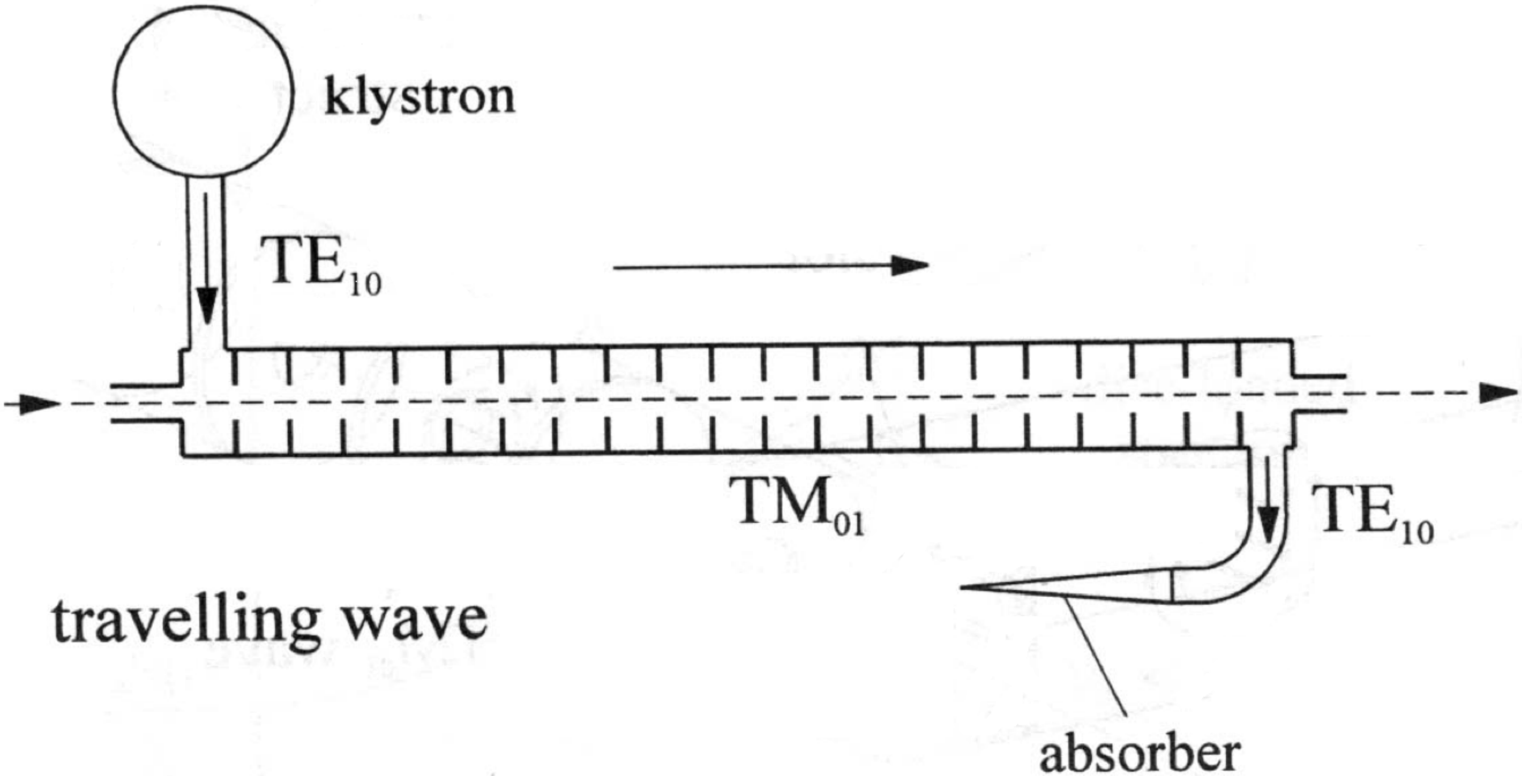
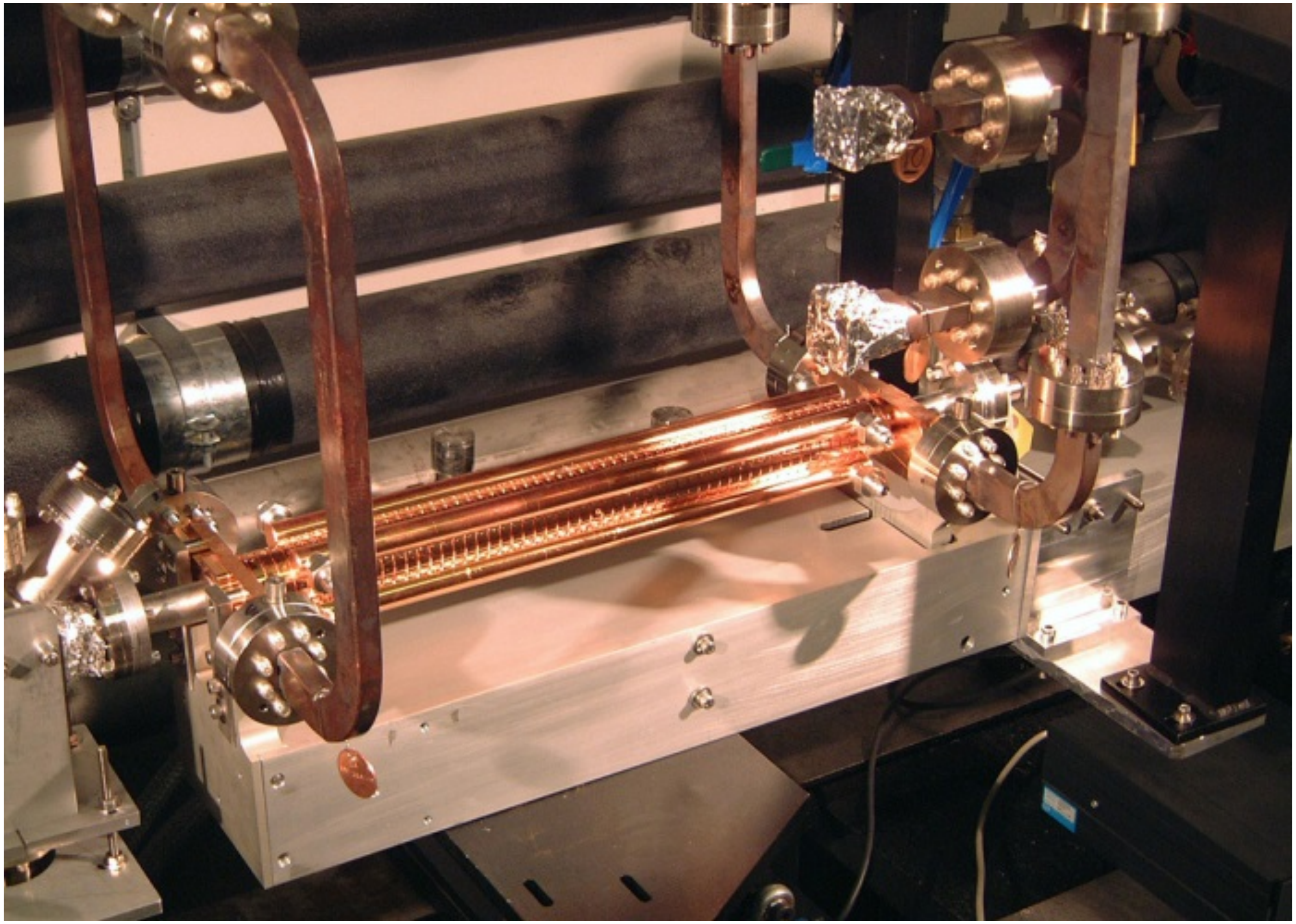


CLIC KOVUGU



TEŞEKKÜRLER!