Low Frequency RF System for Neutorino Factory.

KEK

Kiyomi Koba

Measurement results of the characteristic of new ferrite, SY20

Calculation of the RF parameter for muon acceleration.

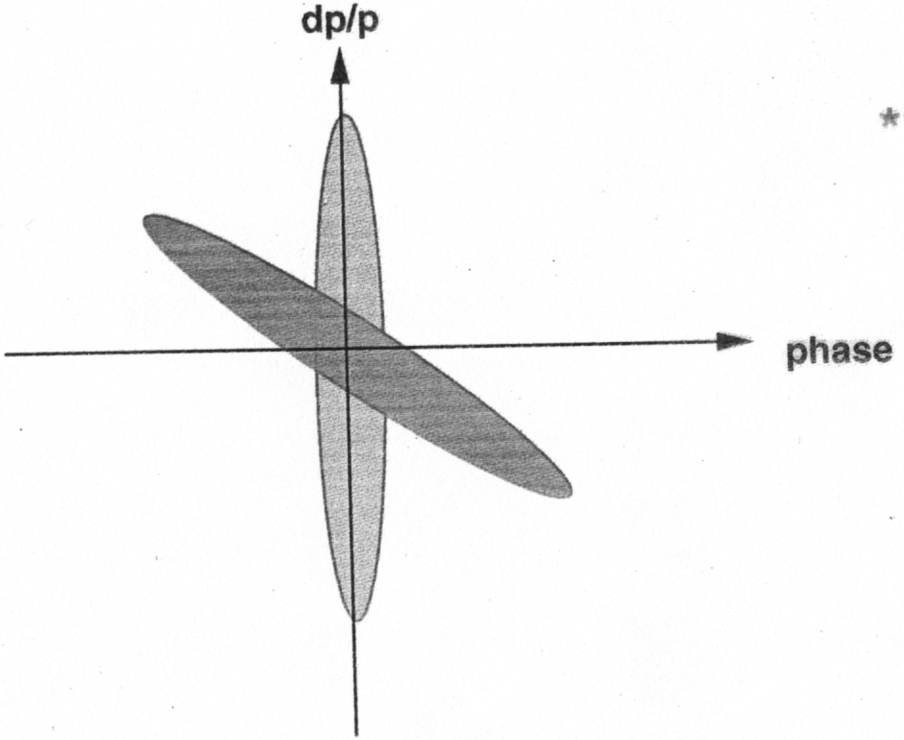
Principle of the phase rotation

Calculation of the RF parameter for PRISM.

Summary

To obtain a monochromatic muon beam

Phase Rotation



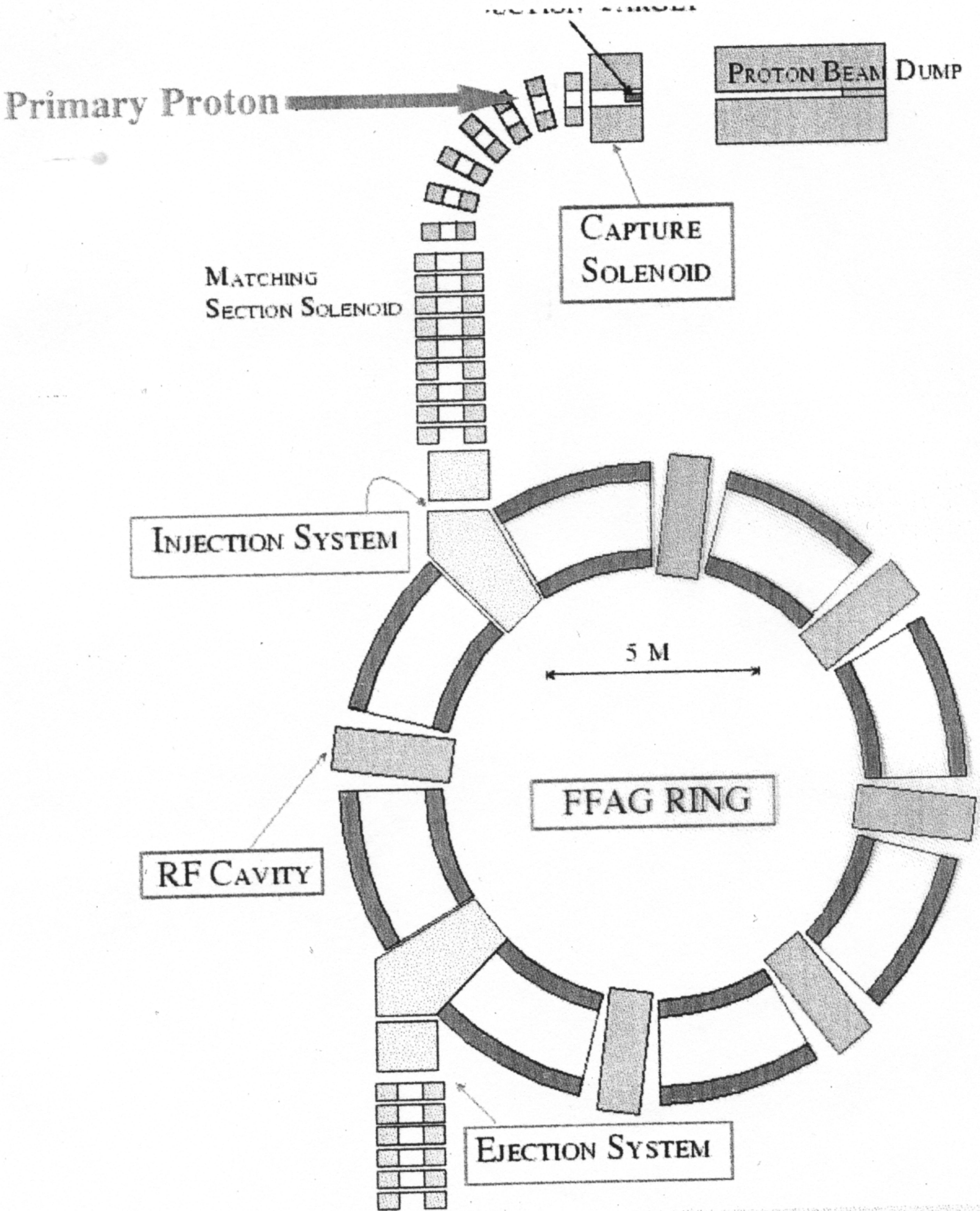
*** synchrotrons oscillation ***

$$f_{s0} = f_{rev}\sqrt{\frac{-\eta eVrf}{2\pi\beta^2 E_s}\cos\phi_s}$$

↓

muon life ~2.2μsec ⟶ **High Gradient RF Cavi**

PRISM
(Phase Rotation Intense Slow Muon Beams)

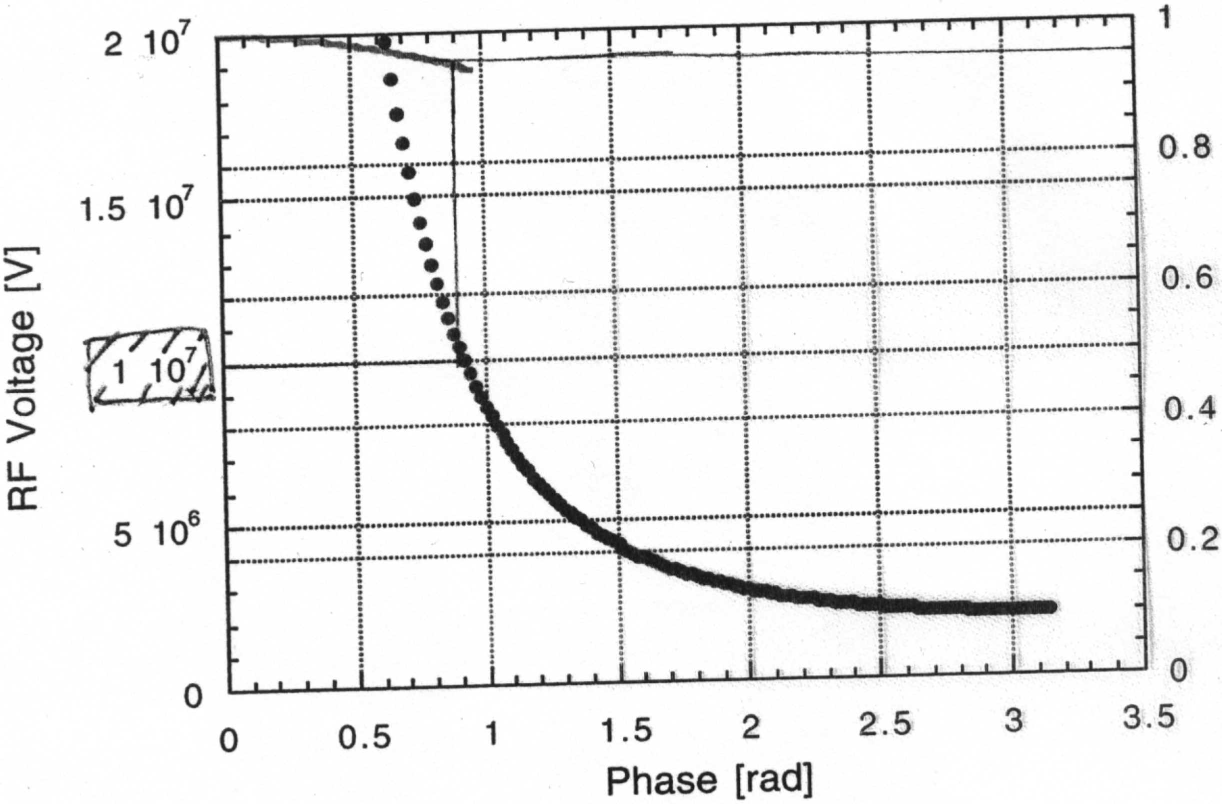


Particle	μ^-
Injection Energy	20MeV
intensity	10^{19} particles/year
dp/p	< +/- 5%
repetition rate	1 kHz

beam @injection : E_k= 20MeV

bunch length= 10nsec

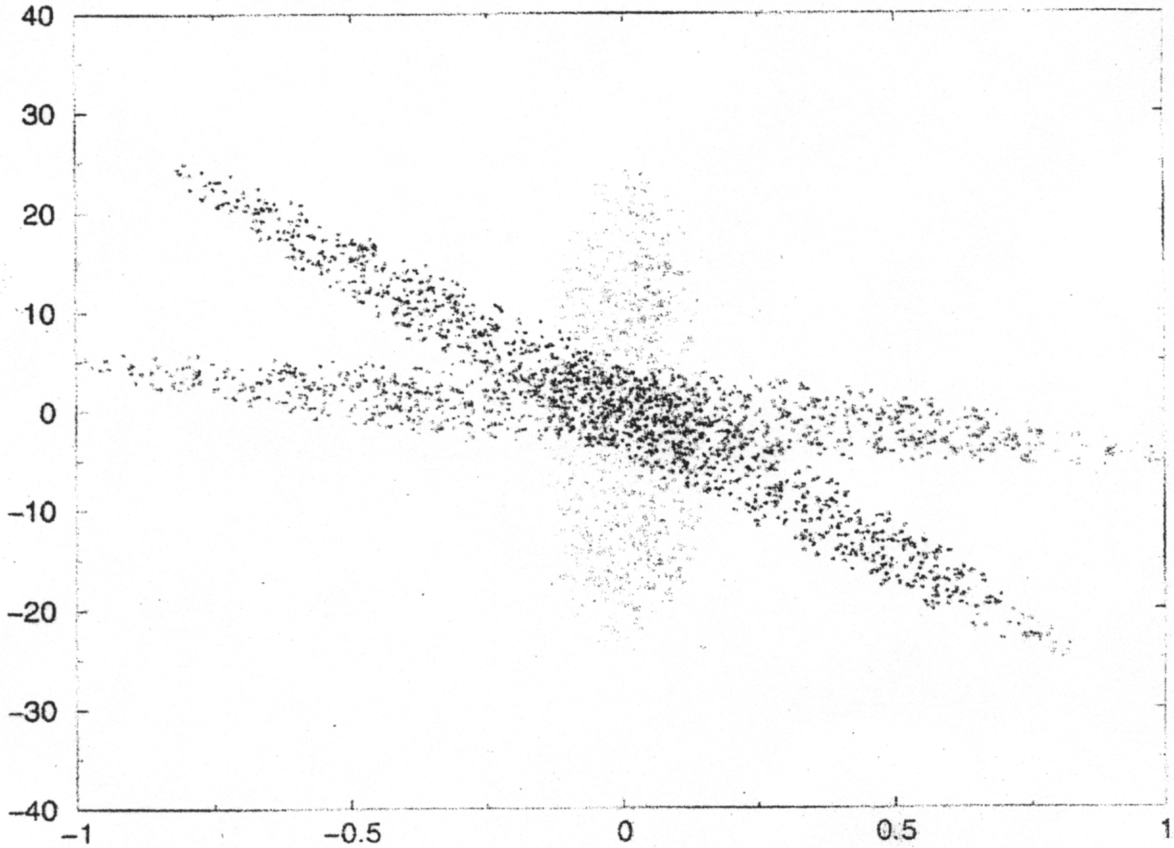
dp/p= ±25% → dp/p < ±5%



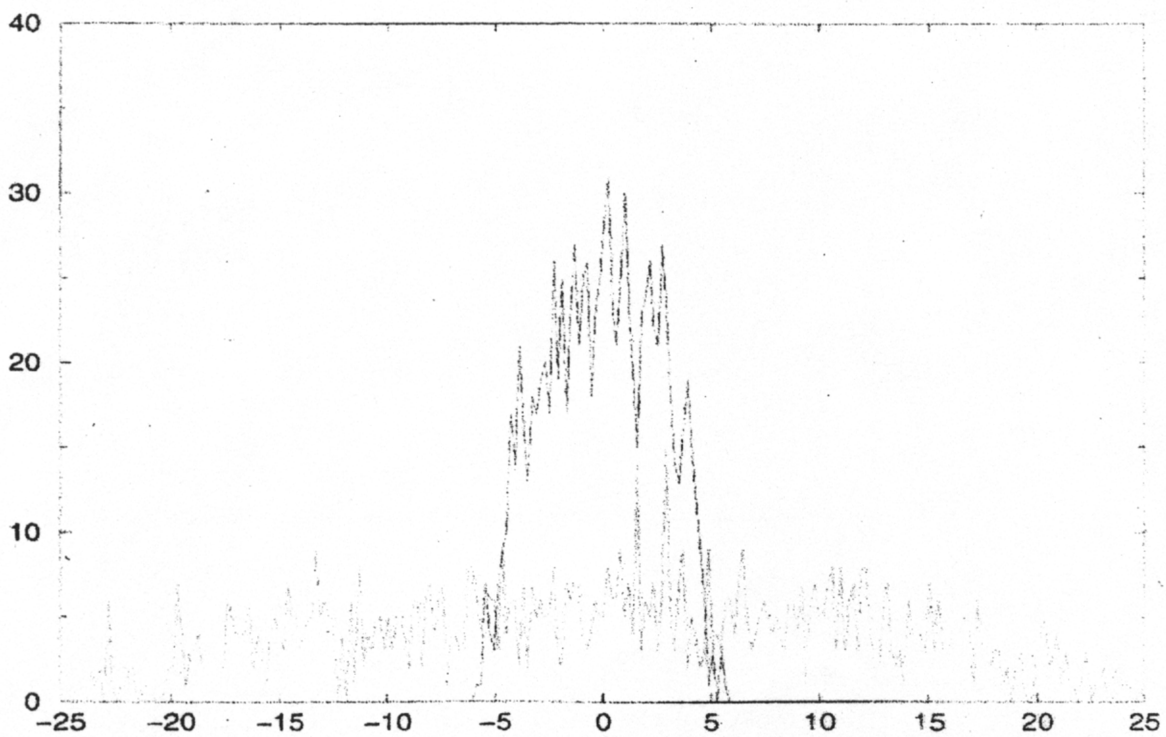
to avoid the rf non-linear effects

Vrf= 10MV @5.2MHz

dp/p [%]



phase [rad]



Muon Beam Acceleration for the Neutorino Factory

dp/p: +/-50%

momentum: 300MeV/c ---> 1GeV/c

bucket height

$$\frac{\Delta p}{p} = \sqrt{\frac{eV_{rf}}{\eta \pi h \beta^2 E_s}(-2\cos\phi_s + \pi \sin\phi_s - 2\phi_s \sin\phi_s)}$$

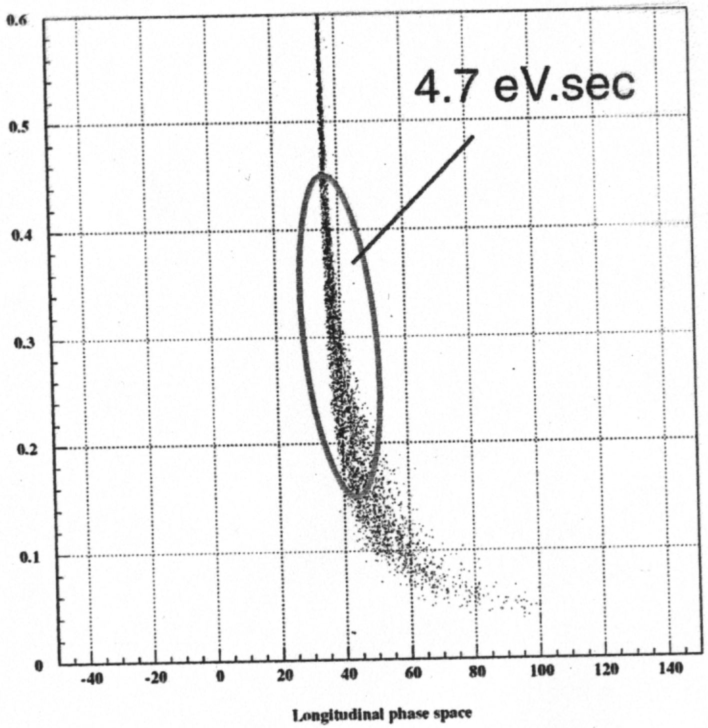
energy gain

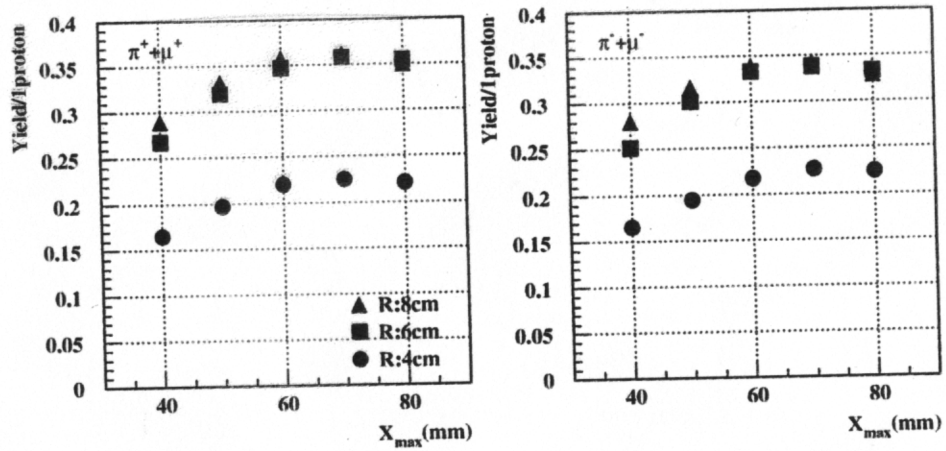
$$\Delta E_s = eV_{rf} \sin\phi_s$$

Accelerator Scenario - FFAG Option

Direct Acceleration by Low Frequency RF

No Phase Rotation, No Cooling

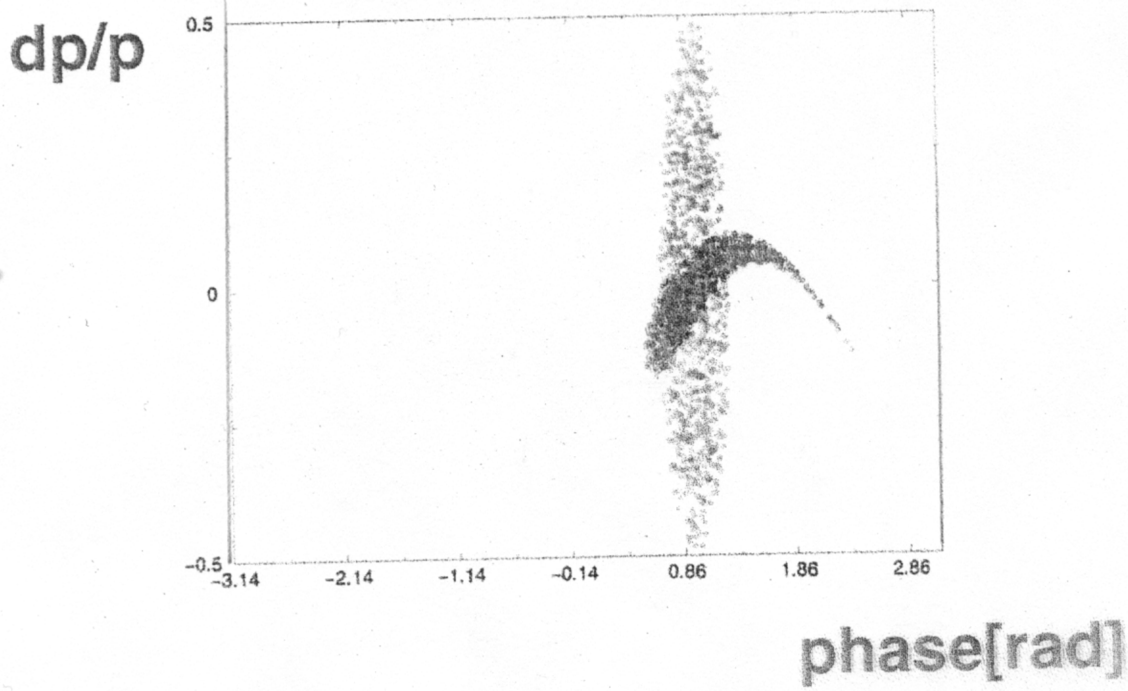




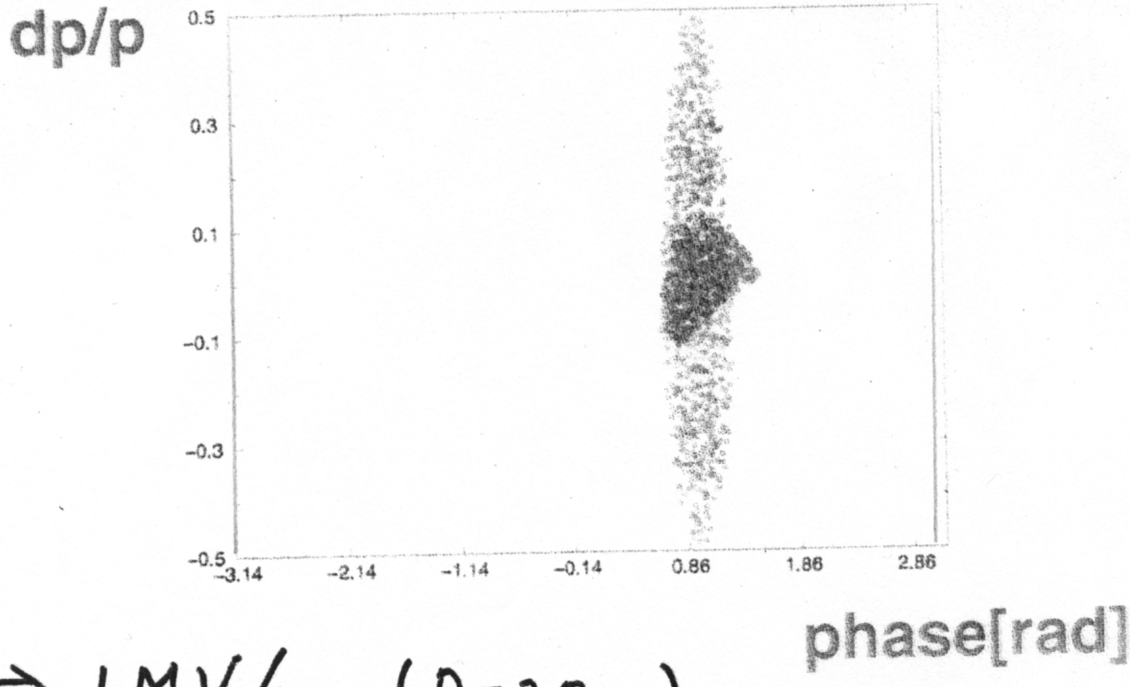
$\Delta p/p$=+-50%@300MeV/c, A=0.01-0.02πm.rad

~ 0.3muons / proton @ 50-GeV PS

ϕ_s=55[deg] Vrf=50M[V]



ϕ_s=55[deg] Vrf=100M[V]



⇒ 1 MV/m (R=20m)

Longitudinal simulation scheme for FFAG

synchrotron

$$\frac{\Delta T}{T} = \frac{\Delta L}{L} - \frac{\Delta v}{v} \longrightarrow \Delta\phi \approx 2\pi h \eta \left(\frac{\Delta p}{p}\right)$$

$$\frac{\Delta L}{L} \approx \frac{1}{\gamma_t^2}\left(\frac{\Delta p}{p}\right)$$

$$\frac{\Delta v}{v} \approx \frac{1}{\gamma^2}\left(\frac{\Delta p}{p}\right)$$

FFAG

$$\Delta T = \frac{2\pi r}{v} - \frac{2\pi r_s}{v_s} \longrightarrow \Delta\phi = 2\pi h\left\{\left(\frac{p}{p_s}\right)^{\frac{1}{1+k}} \frac{\beta_s}{\beta} - 1\right\}$$

@ k=2

0.3 GeV → 1 Ge

$$\frac{r}{r_s} = \left(\frac{p_s}{p_s}\right)^{\frac{1}{K+1}} \qquad \frac{B}{B_s} = \left(\frac{r}{r_s}\right)^{K}$$

η: $-0.062 \rightarrow +0.03$

(R=20m)

$f \approx 5$ MHz , $Q \approx 50$

$$\frac{\Delta f}{f_0} \approx 2\%$$

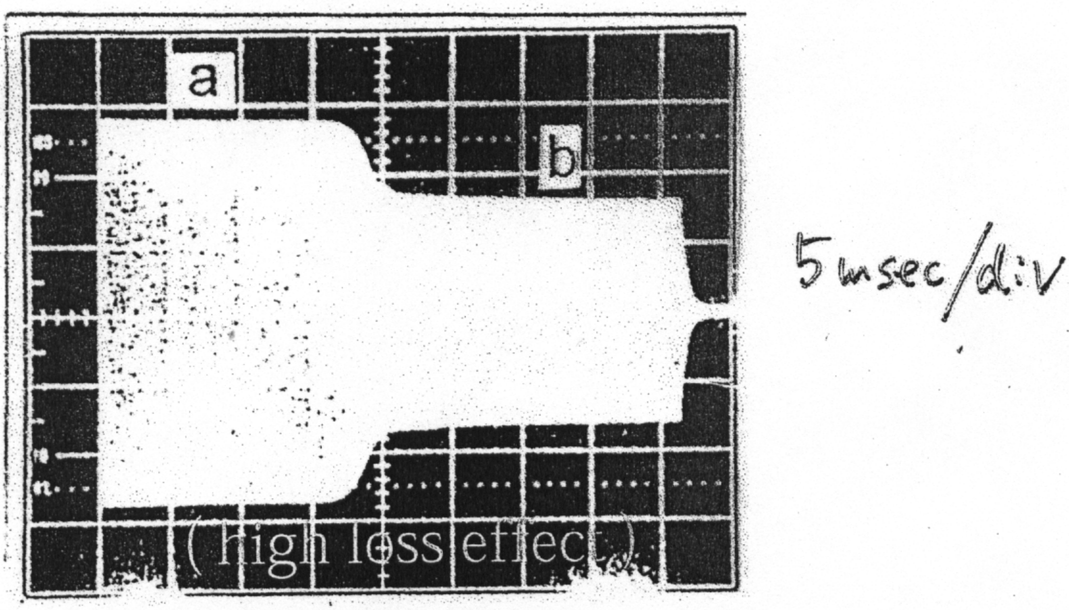
'FINEMET'

The μQf-product is constant
when the magnetic field strength(Brf) is increased.

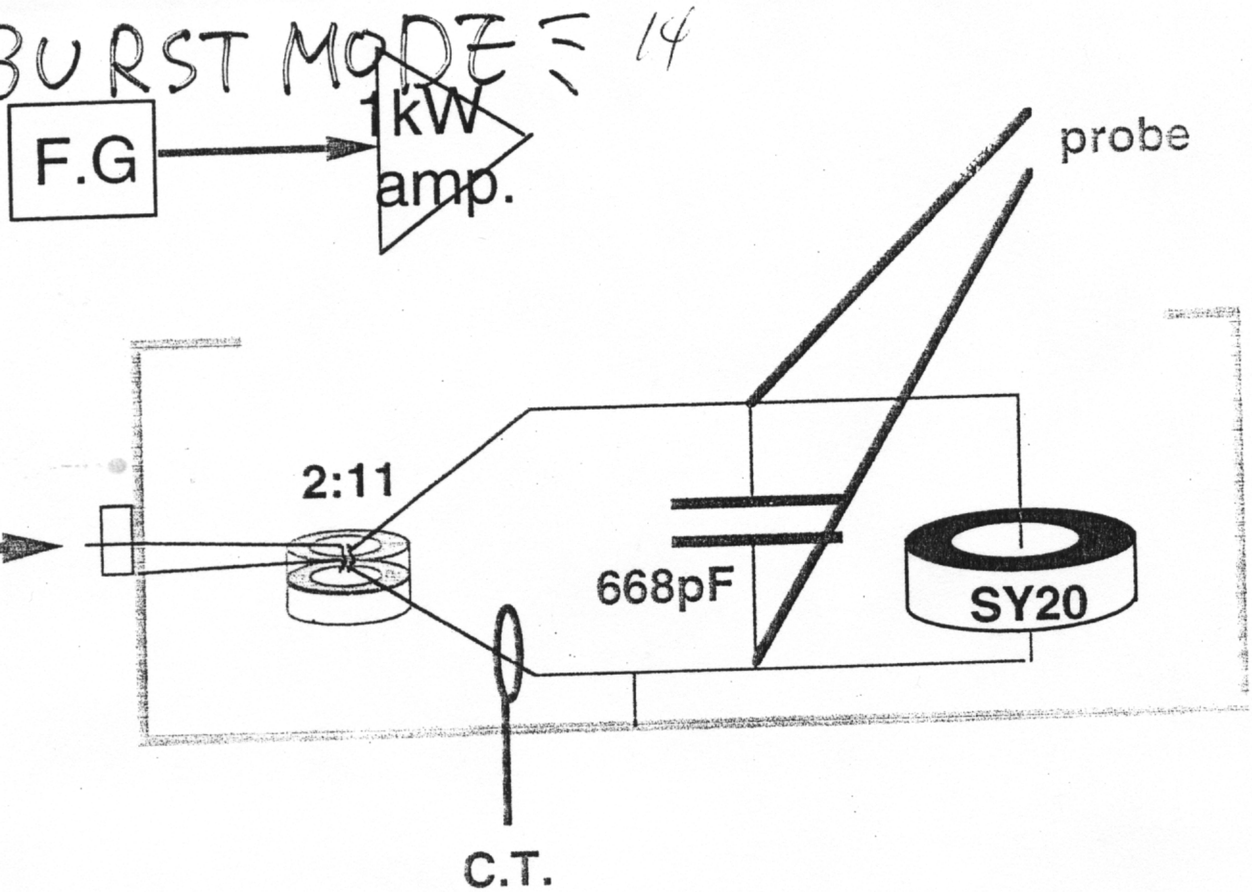
Q value is low.

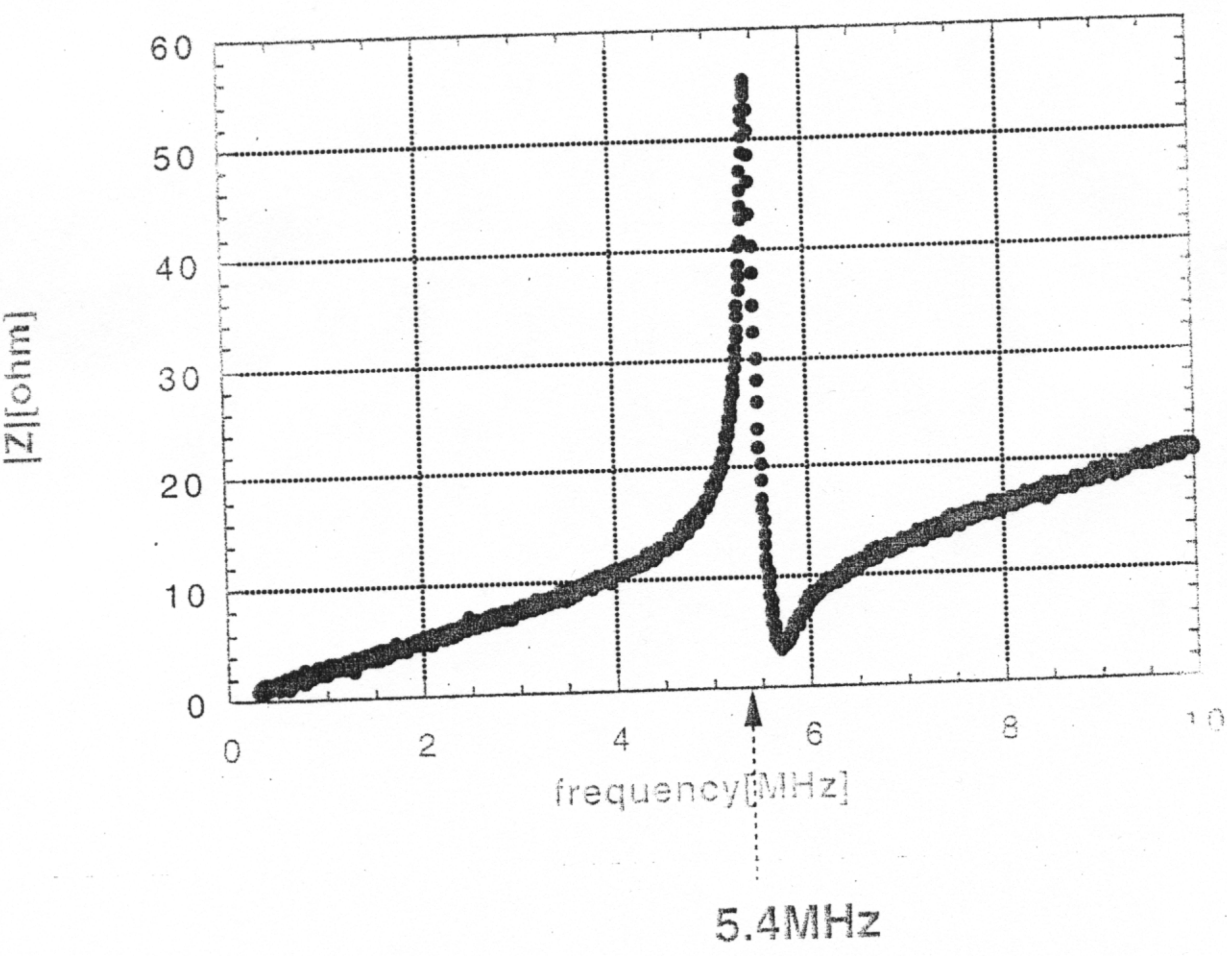
Ferrite

The μQf-product decreases
when the magnetic field strength(Brf) is increased.

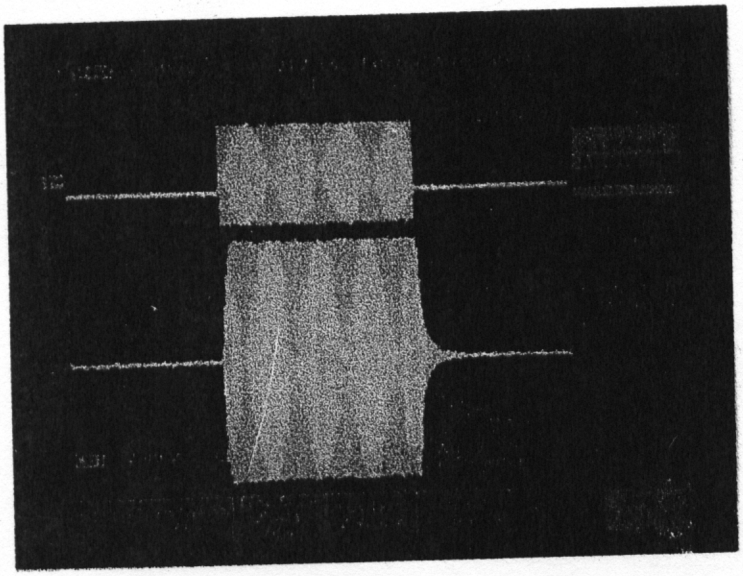


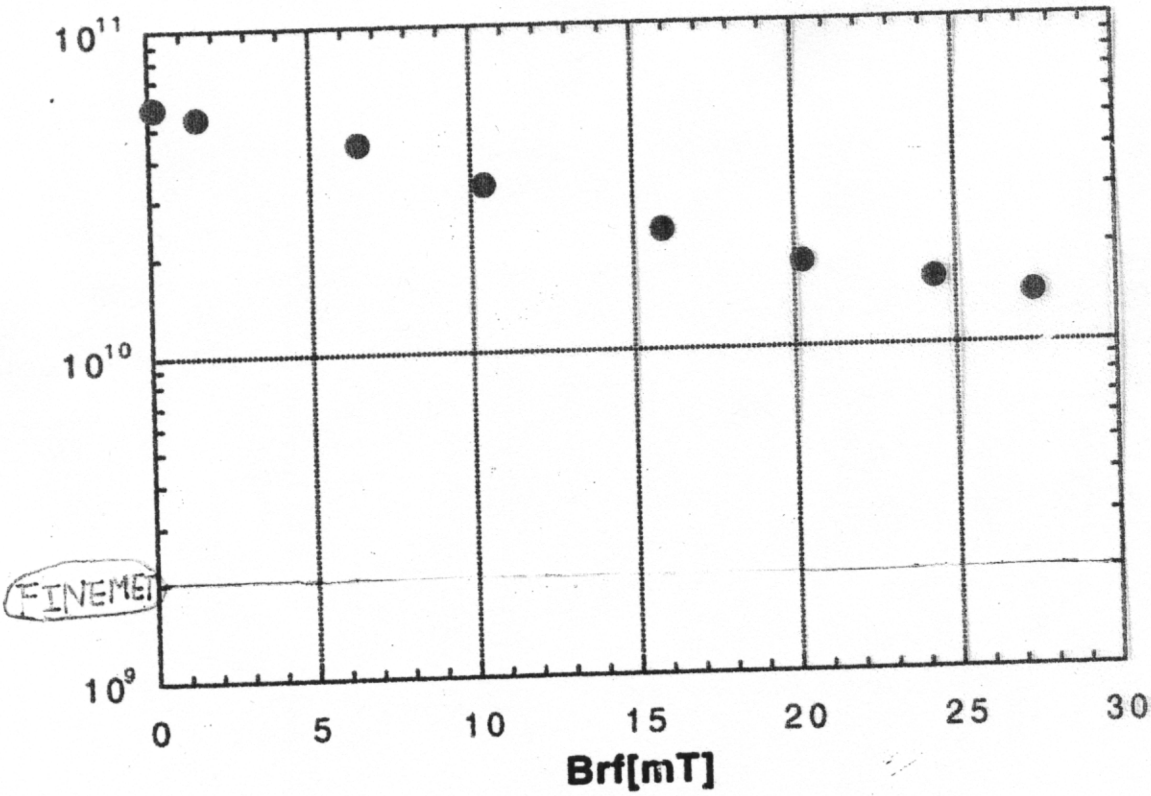
Q value is high.


BURST MODE = 14
F.G
1kW
amp.
probe
2:11
668pF
SY20
C.T.


60
50
40
30
20
10
0
|Z|[ohm]
0
2
4
6
8
10
frequency[MHz]
5.4MHz

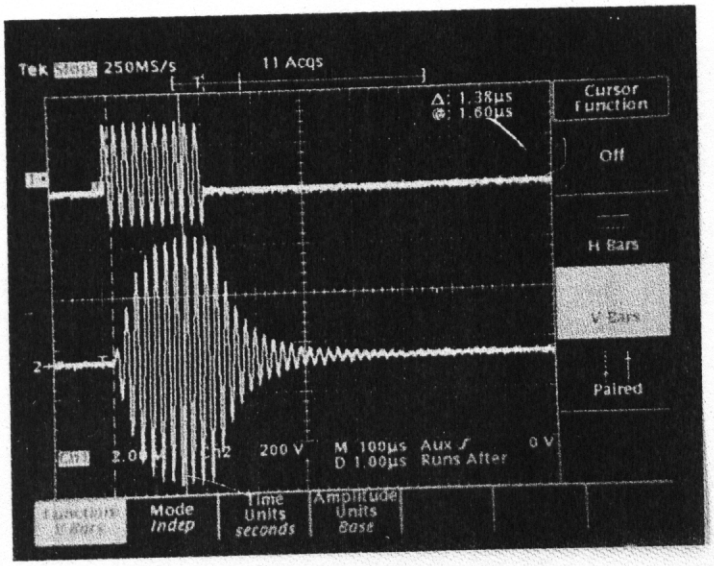
BURST MODE





@ Brf = 30mT

Q value



1µsec/div

filling time = 0.5µsec

SY20: Q~10

Summary

The low frequency high gradient rf cavity can be realized with SY20 ferrite.

We are going to develop this type of model cavity.