(RF DEFLECTORS)
and
FAST KICKERS
for
Dafne and
ILC DAMPING RING

F. Marcellini, D. Alesini
(P.Raimondi speaker)

RF DEFLECTORS

- **INJECTION/EXTRACTION SCHEME.**
- **USE OF MULTI-FREQUENCY.**
- **ARE THEIR TESTS POSSIBLE IN ATF?**

REFERENCES

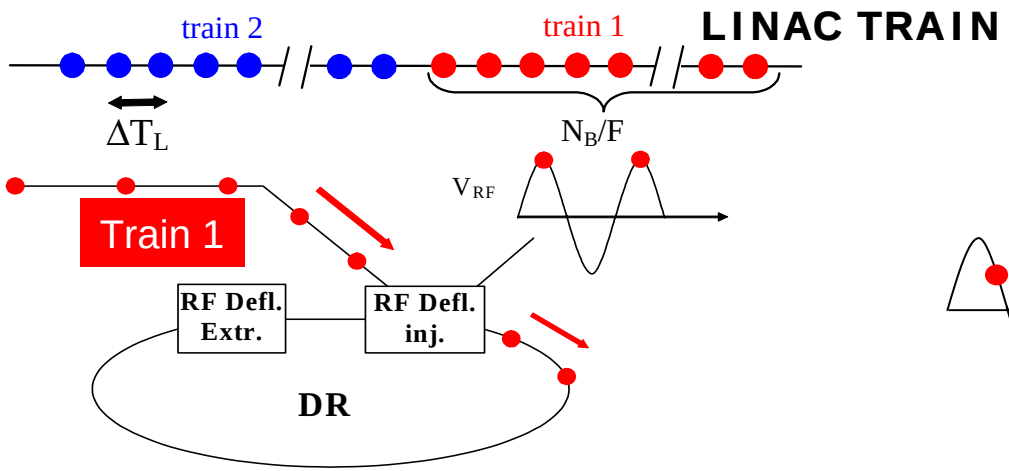
First evaluations made by J.P. Delahaye, TESLA 93-02

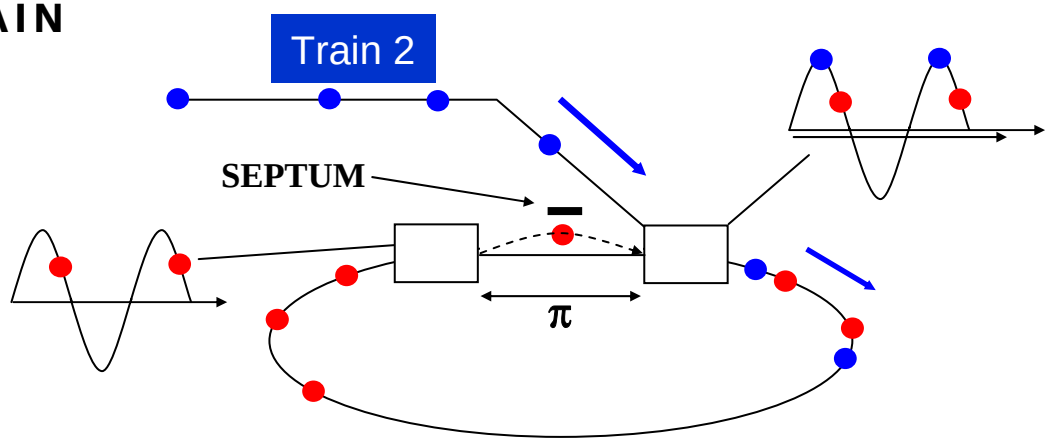
D. Alesini, S. Guiducci, F. Marcellini and P. Raimondi, TESLA 2003-26

D. Alesini, F. Marcellini and P. Raimondi, TESLA 2003-27

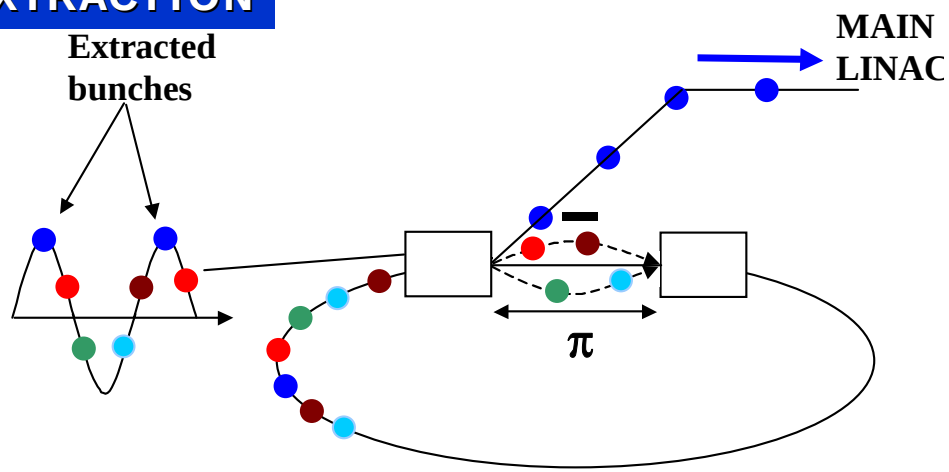
CTF3-LIKE INJECTION/EXTRACTION SCHEME

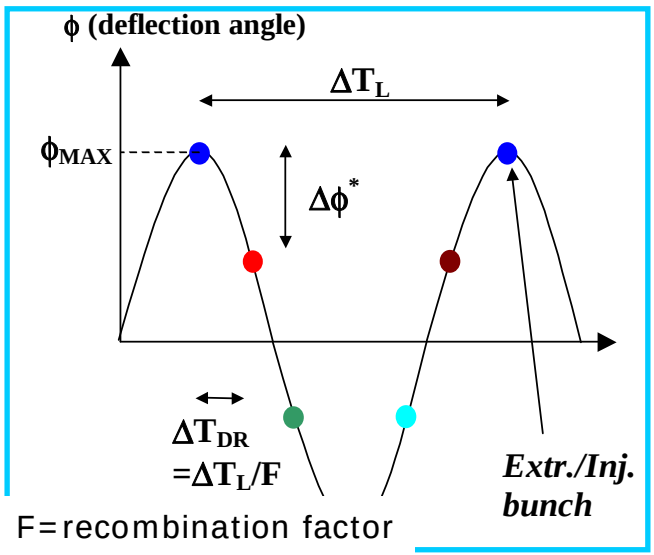
INJECTION





EXTRACTION



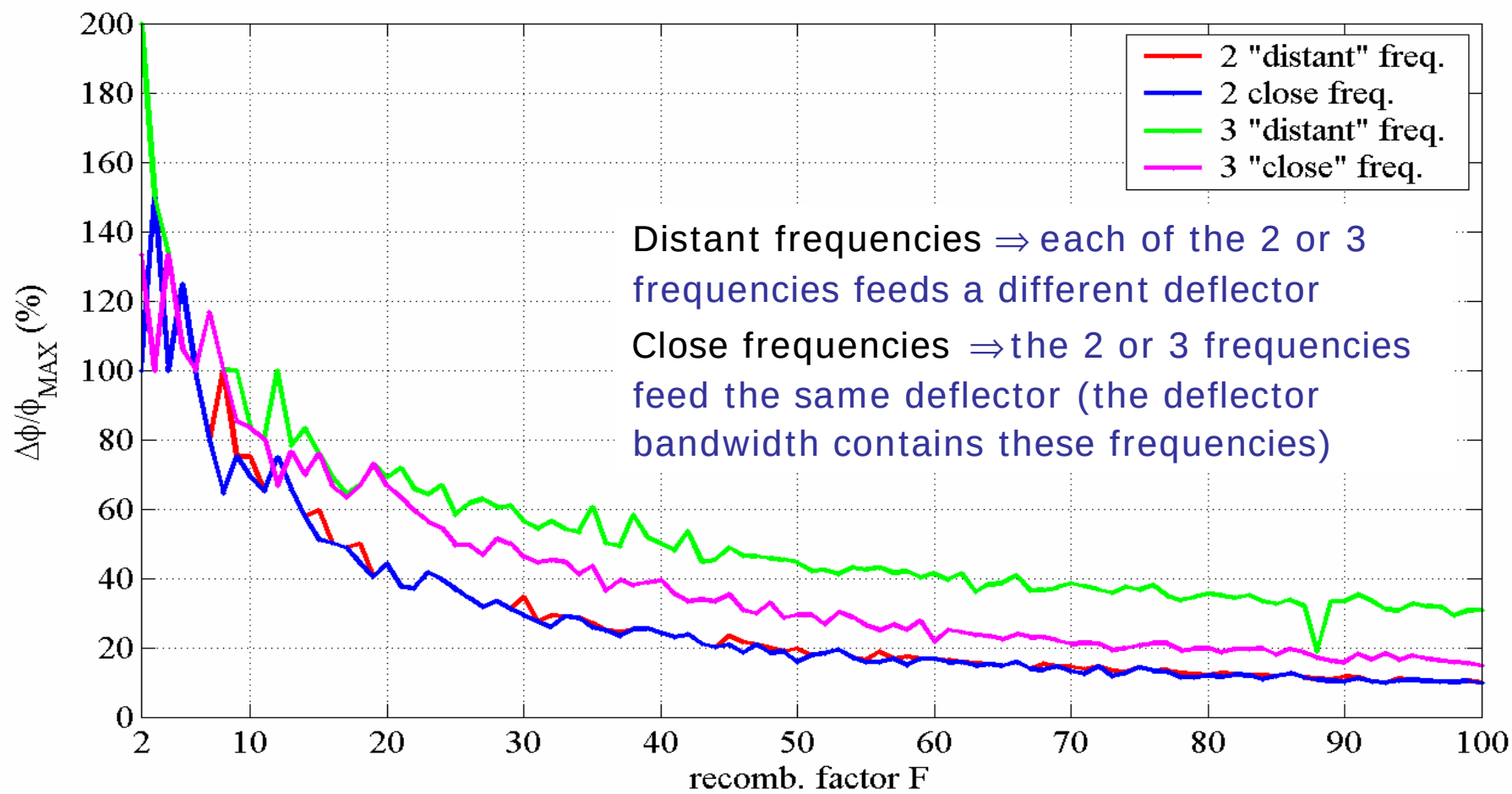


- If the ***filling time*** **(τ_F)** of the deflectors is less than ΔT_{DR} it is possible to inject or extract the bunches without any gap in the DR filling pattern.
- $\Delta\phi$ ***should be*** $\geq \Delta\phi^*$ depending on the ring optics and septum position. Considering a *single* RF frequency $\Rightarrow \Delta\phi/\phi_{MAX} = 1-\cos(2\pi/F)$

⇒ **choice of a set of 2 or 3 frequencies for the maximization of $\Delta\phi / \phi_{MAX}$**
frequency range scanned: [430*1/ ΔTL× 450*1/ ΔTL] =1.276 × 1.335 GHz

⇒ **zero length bunch considered**

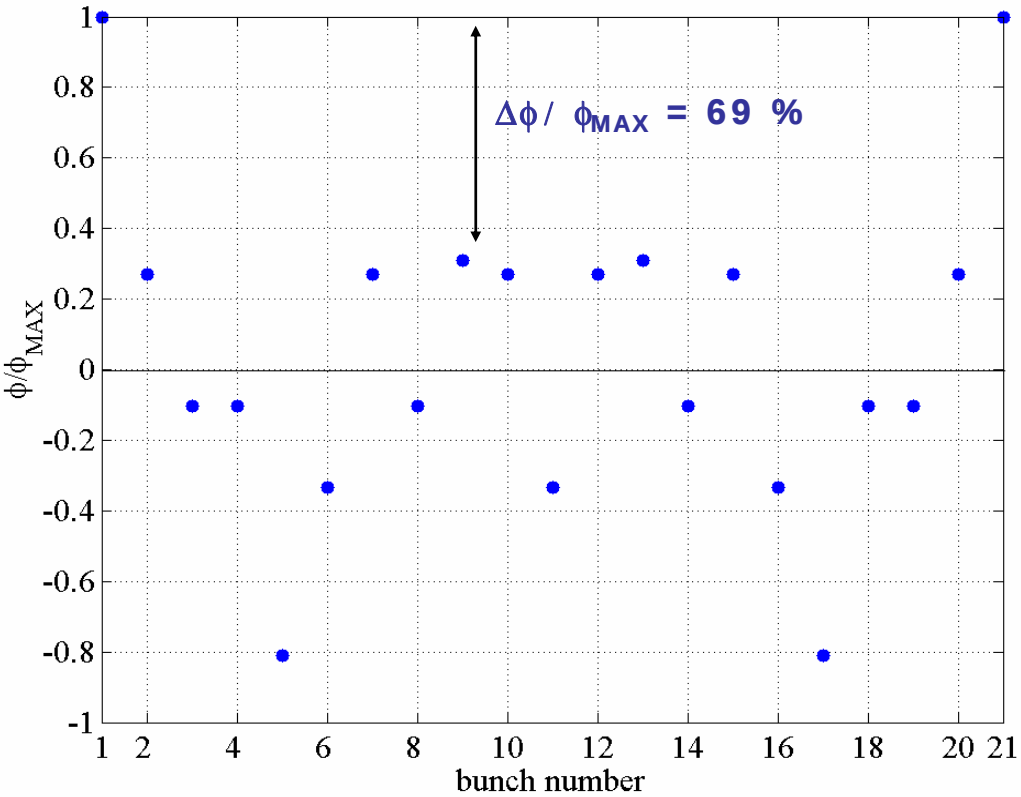
⇒ **different recombination factors F**



Example 1:
INJECTION/EXTRACTION WITH 3 RF FREQUENCIES NEAR 1.3 GHz (recombination factor F=20)

⇒ **choice of a set of 3 frequencies for the maximization of $\Delta\phi / \phi_{MAX}$**

frequency range scanned: $[430*1/\Delta T_L \times 450*1/\Delta T_L] = 1.276 \times 1.335$ GHz



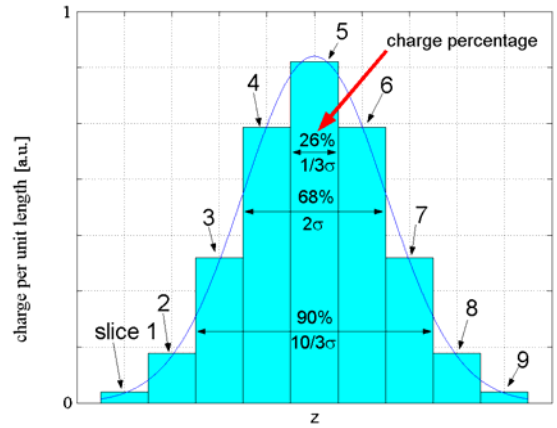
DEFLECTOR PARAMETERS ($\pi/2$ mode)
6 Deflectors (3 injecton + 3 extraction)

Defl 1 $\Rightarrow f_{RF1} = 433*1/\Delta T_L =$ **1284.87** [MHz]
Defl 2 $\Rightarrow f_{RF2} = 438*1/\Delta T_L =$ **1299.70** [MHz]
Defl 3 $\Rightarrow f_{RF3} = 443*1/\Delta T_L =$ **1314.54** [MHz]

Total beam deflection = 0.87 [mrad]
Deflection given by deflector#1 = 0.29 [mrad]
Deflection given by deflector#2 = 0.29 [mrad]
Deflection given by deflector#3 = 0.29 [mrad]

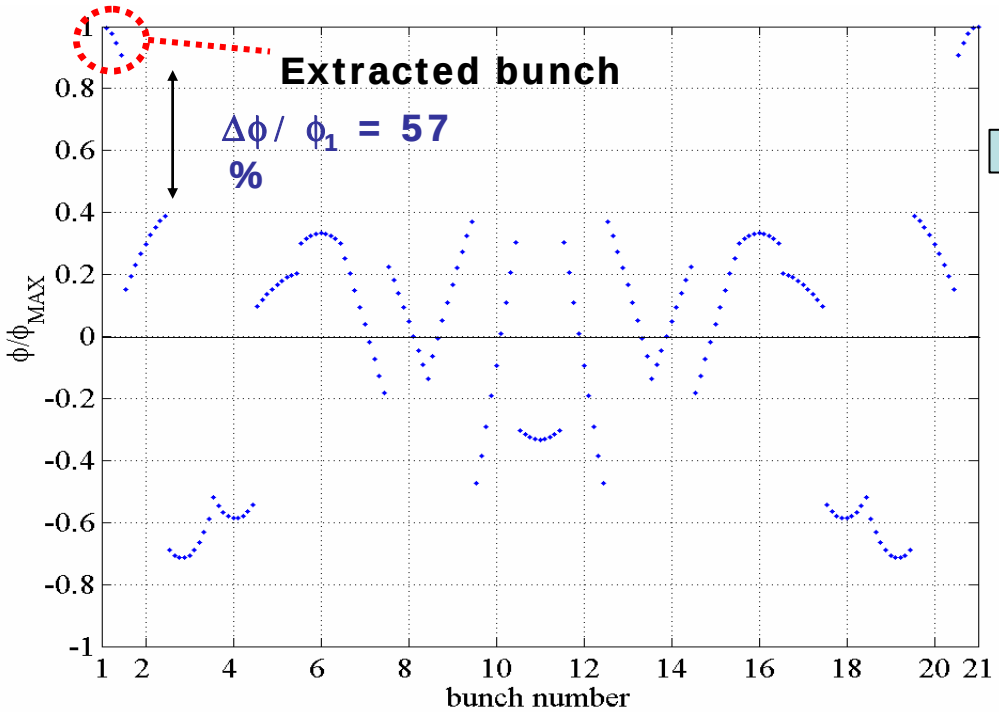
Klystron power	Deflector length	Filling time	# of cell
5 [MW]	0.86 [m]	64 [ns]	15
9 [MW]	0.64 [m]	48 [ns]	11

Example 2:
INJECTION/EXTRACTION WITH 3 RF FREQUENCIES NEAR 1.3 GHz CONSIDERING THAT BUNCH HAS FINITE LENGTH.



choice of a set of 3 frequencies for the maximization of $\Delta\phi / \phi_{MAX}$ and the reduction the RF slope over the bunch length

frequency range scanned: $[430*1/\Delta T_L \times 450*1/\Delta T_L] = 1.276 \times 1.335$ GHz



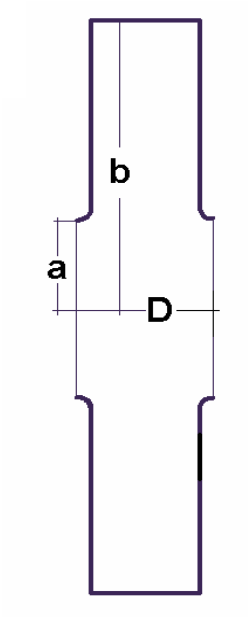
DEFLECTOR PARAMETERS (π/2mode)
6 Deflectors (3 injection+ 3 extraction)

Defl 1 $\Rightarrow f_{RF1} = 444*1/\Delta T_L =$ **1317.51** [MHz]
Defl 2 $\Rightarrow f_{RF2} = 437*1/\Delta T_L =$ **1296.74** [MHz]
Defl 3 $\Rightarrow f_{RF3} = 435*1/\Delta T_L =$ **1290.80** [MHz]

Total beam deflection = 1.05 [mrad]
Deflection given by deflector#1 = 0.35 [mrad]
Deflection given by deflector#2 = 0.35 [mrad]
Deflection given by deflector#3 = 0.35 [mrad]

Klystron power	Deflector length	Filling time	# of cell
5 [MW]	1.04 [m]	77 [ns]	18
9 [MW]	0.78 [m]	58 [ns]	13

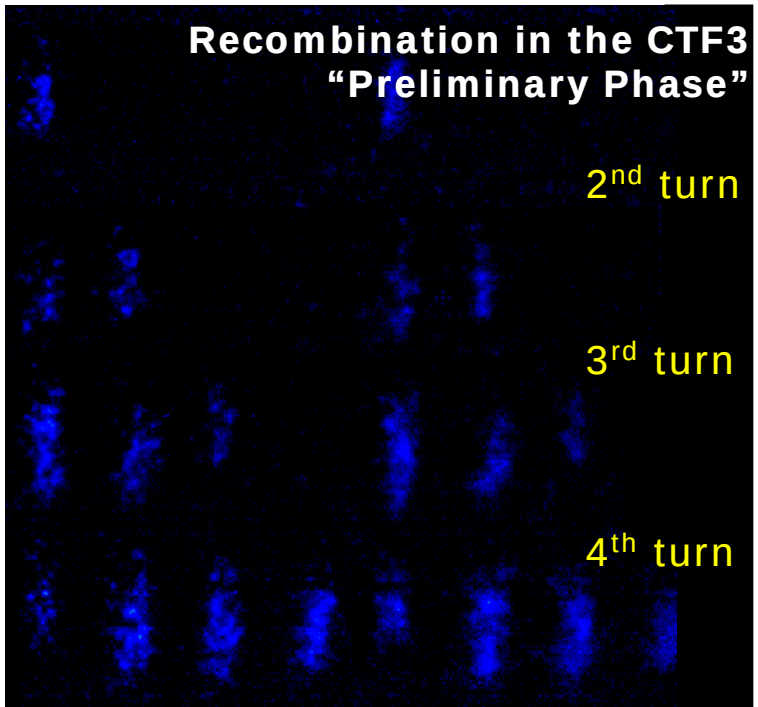
RF DEFLECTORS DESIGN



	p/2	p/3
a [mm]	**41.8**	41.8
b [mm]	**133**	133.5
D [mm]	58.06	38.70

Single cell dimensional parameters (f≈1.3GHz)

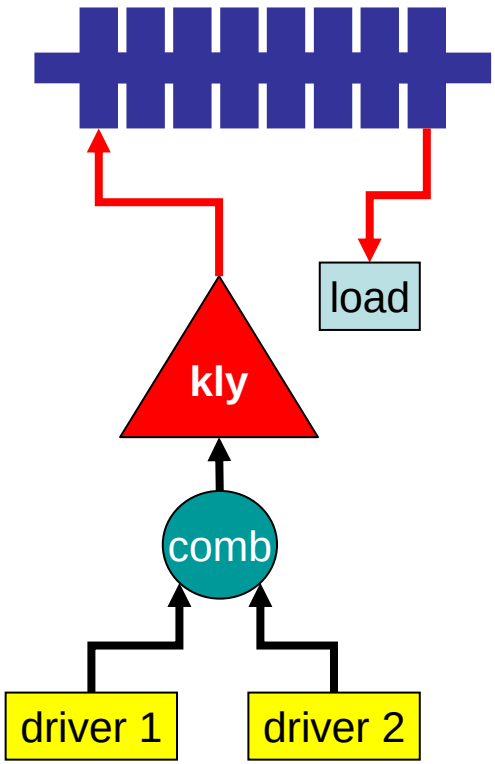
Quantity (π/2 mode)		HFSS	MAFIA
Series impedance	$Z = \frac{E_\perp^2}{P} \quad \left[\frac{\mathrm{M\Omega}}{\mathrm{m}^2}\right]$	0.578	0.552
Quality factor	$Q = \omega \frac{w}{p_d}$	17000	17300
shunt impedance	$R = \frac{E_\perp^2}{p_d} \quad \left[\frac{\mathrm{M\Omega}}{\mathrm{m}}\right]$	16.07	15.95
Attenuation	$\alpha \quad [1/\mathrm{m}]$	0.0180	0.0174
Group velocity	v_g	0.045*c	0.045*c

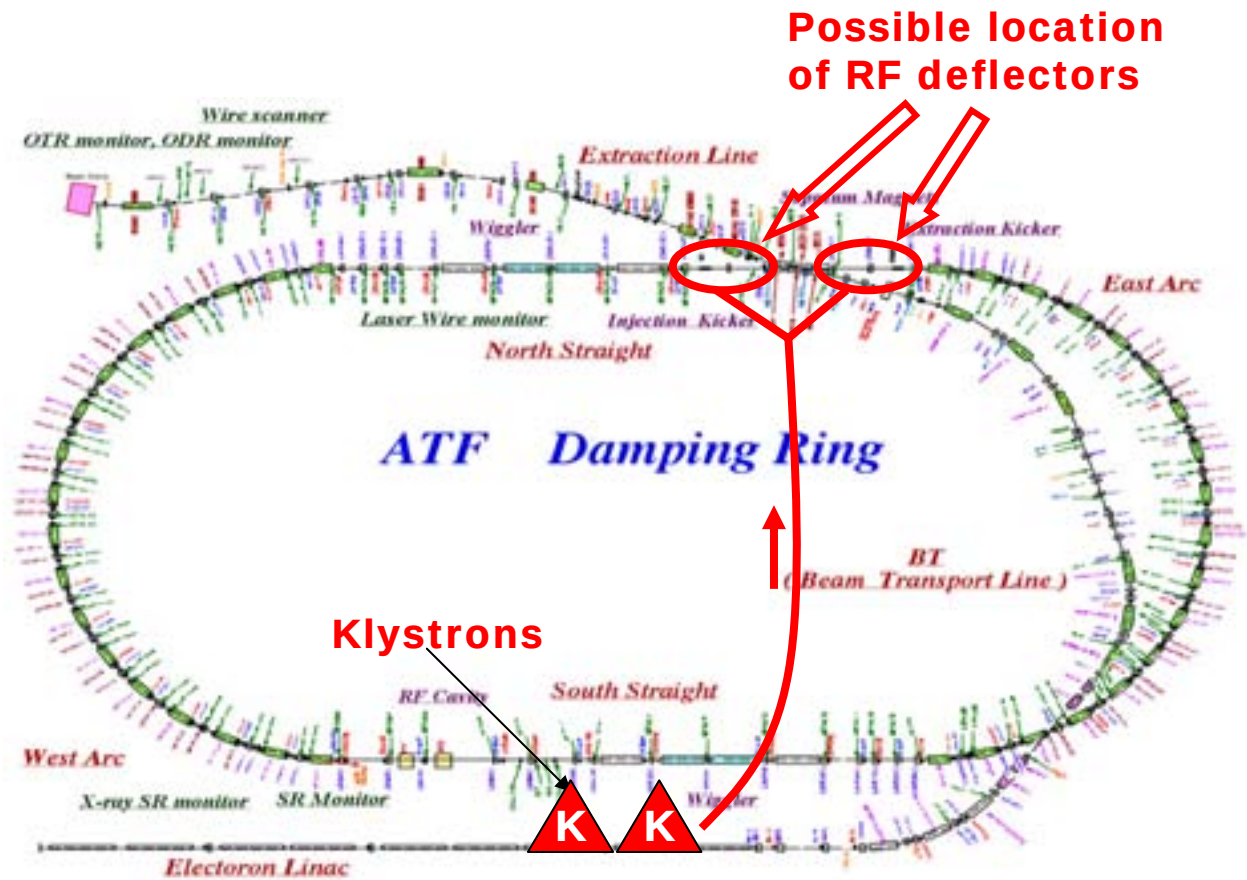


CAN BE RF DEFLECTOR TESTED IN ATF?

2 KLYSTRONS AVAILABLE @ 2.856GHz

- Multifrequency driver for single klystron?
- Required waveguides length ~100 m (costs, attenuation,...)
- cost estimate for both the deflector realization and the purchasing of the whole system components (mainly wgs)



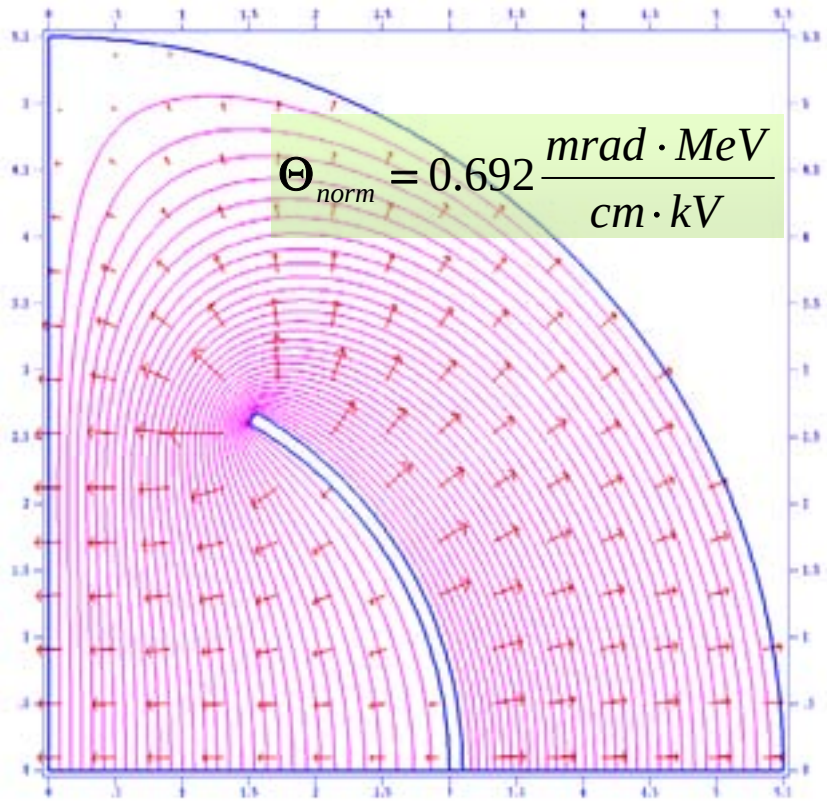


STUDY OF A STRIPLINE KICKER FOR Dafne and ILC DAMPING RING.

- EVALUATION OF THE KICKER PERFORMANCES (EFFICIENCY, FIELD UNIFORMITY) FOR DIFFERENT STRIPLINE GEOMETRIES.
- DETERMINATION OF PULSER REQUIREMENTS IN TERMS OF NEEDED OUTPUT VOLTAGE.

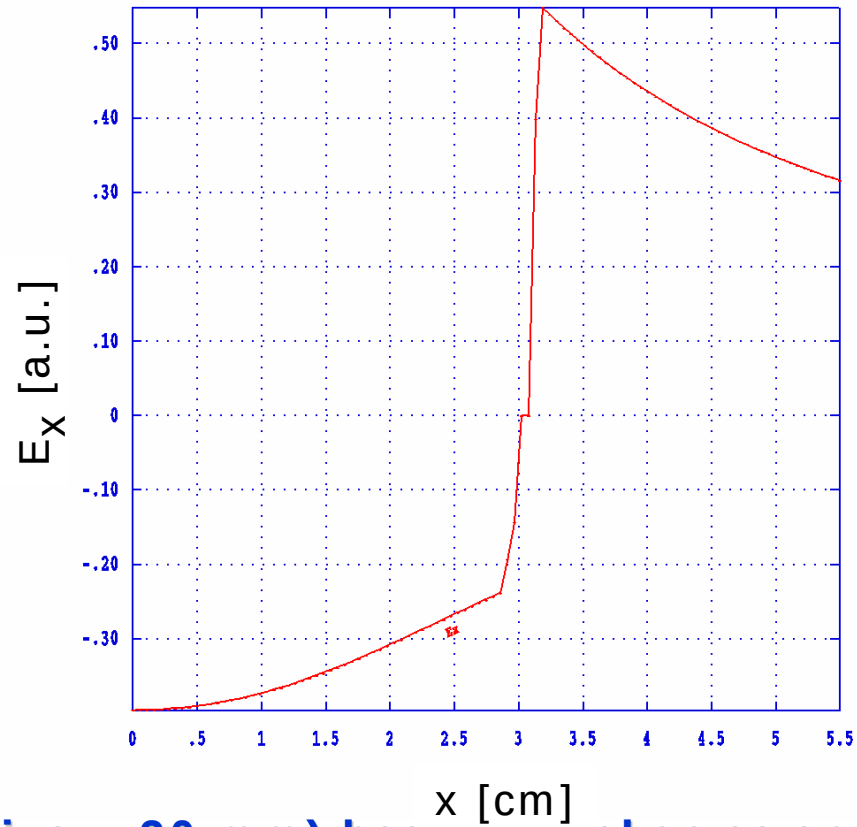
OPTIMIZE THE INTENSITY AND UNIFORMITY OF THE DEFLECTING FIELDS FOR DIFFERENT STRIPLINE GEOMETRIES.

2-D static fields for a 50 Ω, 120 deg covering strip



$$\Theta_{norm} = 0.692 \frac{mrad \cdot MeV}{cm \cdot kV}$$

deflecting field along the kicker horizontal axis

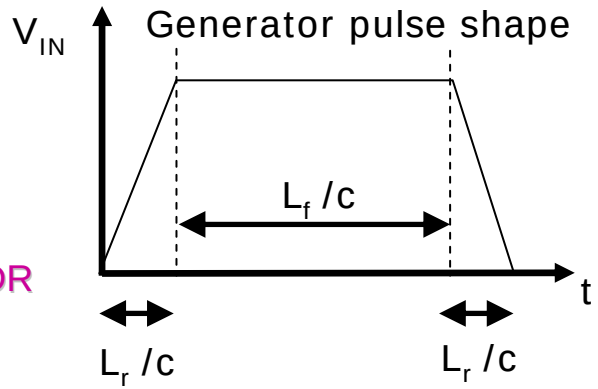


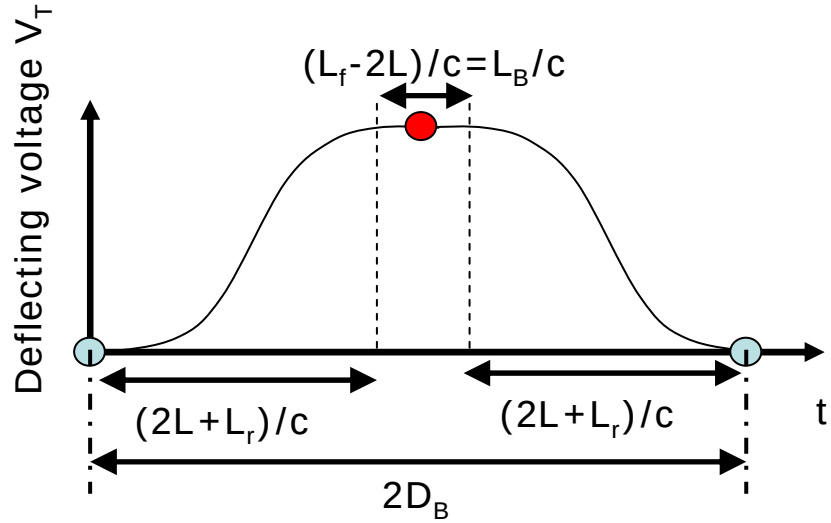
Example: This geometry (electrode radius = 30 mm) has been taken as an example and gives about 0.69 mrad of deflection per cm of electrode length, per kV of electrode voltage per 1/MeV of beam energy.

Final design completed, full 3d optimization done (not shown here)

DEFINITION OF THE KICKER STRIPLINE LENGTH AND PULSE CHARACTERISTICS

$L \equiv$ electrode length
$L_r \equiv$ rise time length
$L_f \equiv$ flat top length
$L_B \equiv$ bunch length
$D_B \equiv$ bunch spacing in DR





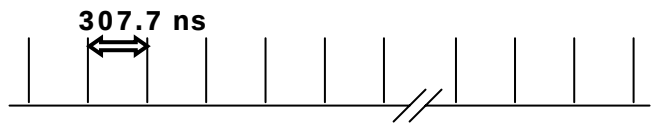
$L_f - 2L = L_B = 4\sigma_{z\ inj} \cong 24mm$
$2L + 2L_r + L_f = 2D_B$

Let's assume:
$L_r/c = 300ps$

number of bunches 2820

DR length [km]	D_B [ns]	L_f/c [ns]	L [cm]
17	20	19.74	295
6	7	6.74	100
3	3.5	3.24	47

3 hypothesis considered



Bunch spacing in linac 307.7ns

Kicker repetition rate 3.25 MHz

EXAMPLE

with the geometry previously considered
($\Theta_{norm} = 0.69\,mrad \cdot MeV/cm/kV$)

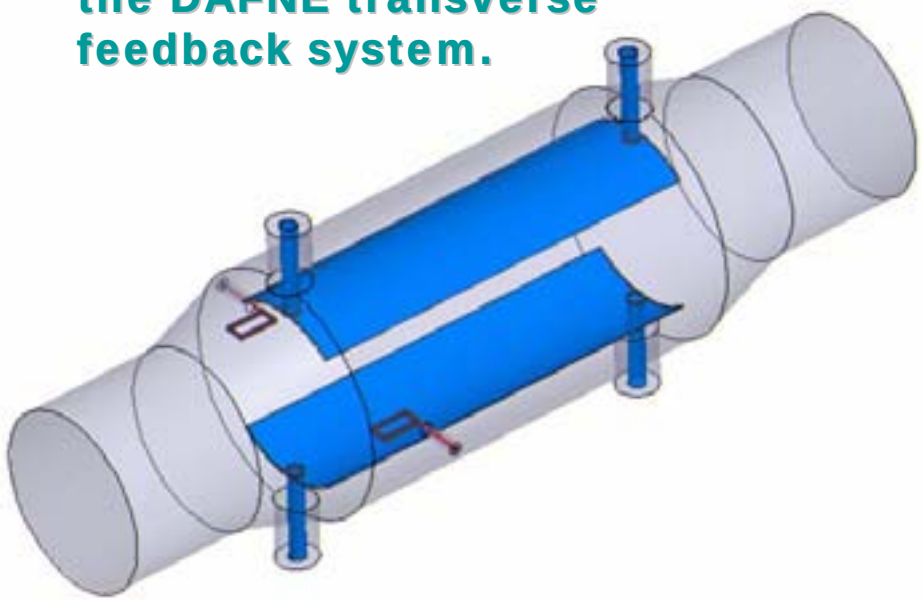
DR length [km]	Pulser voltage [kV]	Average power [MW]
17	15	0.29
6	44	0.85
3	94	1.86

$Z_0 \equiv 50\ \Omega$,
rep. rate = 3.25 MHz

The required deflection can be shared out among more than a single kicker:
for the considered geometry, in the case of a DR 3 km long, using N kickers, each half a meter long electrode has to be fed at 94/N kV. The average power scales by a factor N^2.

DEFINITION OF KICKER MAIN PARAMETERS.
KICKER DESIGN.

Stripline kicker used in the DAFNE transverse feedback system.



To maximize the shunt impedance:

- Length of electrodes.
- Electrode coverage angle.
- Electrode and outer pipe shape.

To minimize the kicker contribution to the DR impedance:

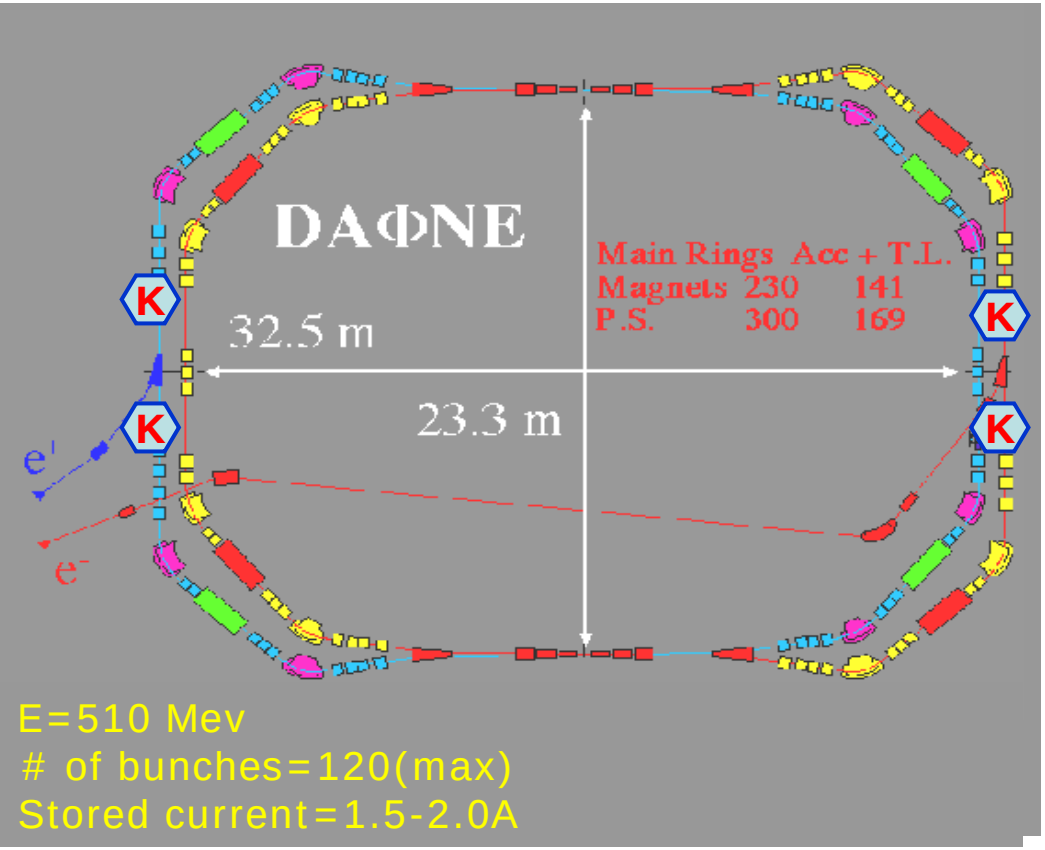
- Avoid sharp discontinuity in the beam pipe (tapers?) and/or use the electrodes to shield the pipe enlargement.
- Look after damping of possible HOMs.
- Minimize the VSWR of the coax/stripline transition.

NEW FAST INJECTION KICKER FOR DAFNE

- DEFINITION OF PULSER SPECS.
- PULSER PURCHASING.
- HIGH POWER AND RELIABILITY TESTS ON PULSER AND HV FEEDTHROUGH.

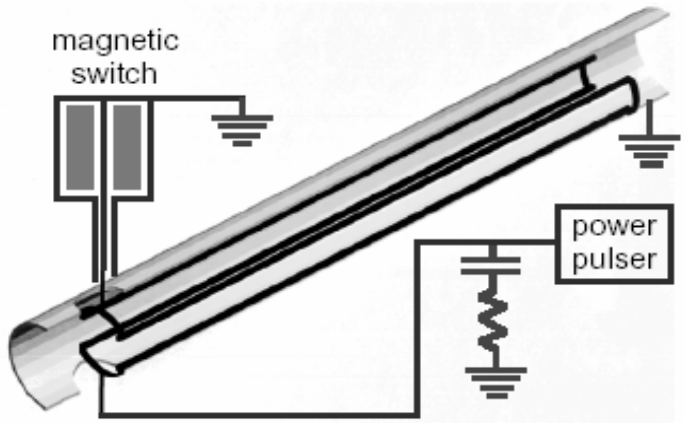
- DEFINITION OF KICKER MAIN PARAMETERS.
- KICKER DESIGN.
- KICKER REALIZATION.
- MEASUREMENTS AND TESTS OF THE WHOLE SYSTEM.

STUDIES FOR NEW DAFNE INJECTION KICKERS

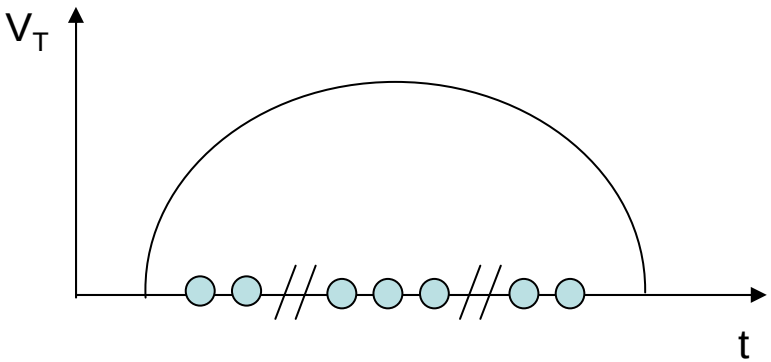


E=510 Mev
# of bunches=120(max)
Stored current=1.5-2.0A

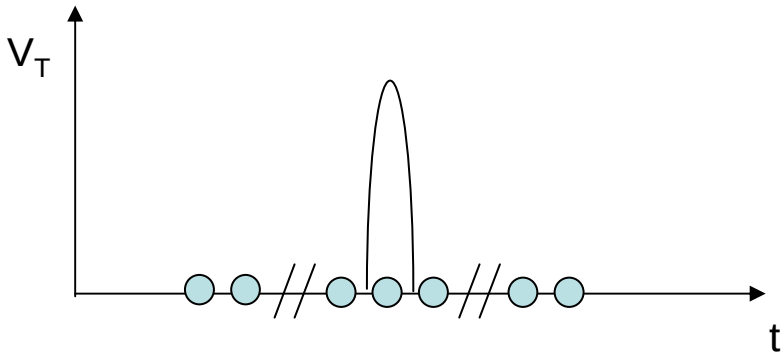
Schematic of the present inection kicker system and kicker structure



2 kickers for each ring
φ ~ 10mrad
Beam pipe radius = 44 mm
Kicker length = 1m

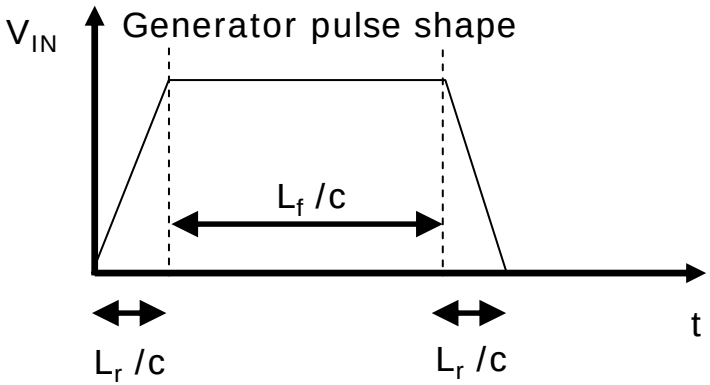


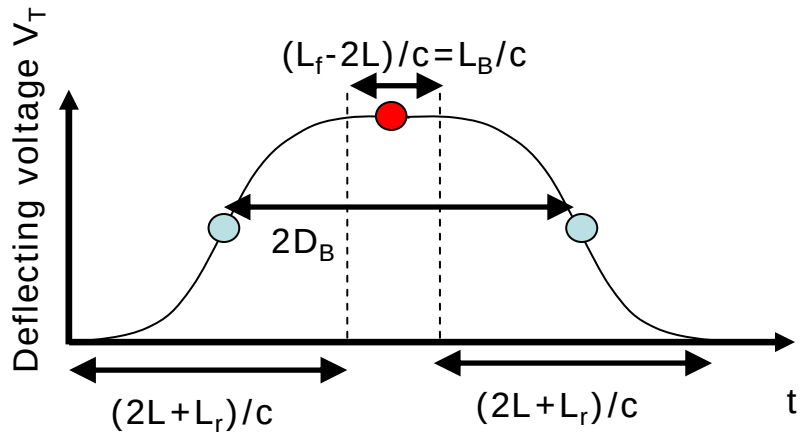
present pulse length ~150ns



aimed FWHM pulse length ~5.4 ns

EVALUATION OF THE KICKER LENGTH (L) AND THE PULSE SHAPE (Lf , Lr)





$L_f - 2L = L_B = 4\sigma_{z\ inj} \cong 140mm$

$L_r + L_f = 2D_B \cong 1.6m$

Let's assume: **$L_r/c = 300ps$**

$L \cong 680mm$
$L_f/c = 5ns$

GENERATOR REQUIREMENTS ($\Theta_{norm} = 0.69mrad.MeV/cm/kV$)

Beam energy	510 MeV
Angle of deflection	6 mrad
Stripline length	68 cm
Stripline radius (optimized covarage angle)	30 mm
Required voltage from pulse generator	**~65 kV**
Average power (max rep. rate 50Hz)	24.5 W
Pulser output current	1400A

Neglecting the bunch length...

$L_f - 2L = L_B = 0$

$L \cong 750mm$
$L_f/c = 5ns$

Stripline length	75 cm
Required voltage from pulse generator	**~59 kV**

SUITABLE PULSER AND HV FEEDTHROUGH CHOICE. HIGH POWER AND RELIABILITY TESTS ARE NECESSARY.

The following table of sample generators will help you to estimate FID GmbH possibilities.

Pulser	Output voltage	Rise time	Pulse width	Pulse repetition frequency	Size (mm)	Delivery (months)
FPG1	1 kV	<0.7 ns	1 - 2 ns	500 kHz	260x110x260	3
FPG5	5 kV	<0.7 ns	1 - 2 ns	200 kHz	260x110x260	3
FPG10	10 kV	<0.7 ns	1 - 2 ns	100 kHz	260x110x260	3
FPG20	20 kV	<1 ns	1 - 10 ns	10 kHz	260x110x320	4
FPG50	50 kV	<1 ns	1 - 10 ns	2 kHz	340x140x310	4
FPG100	100 kV	<1 ns	1 - 3 ns	1 kHz	340x140x310	4
FPG2P	2 kV	<0.1 ns	0.2 - 3 ns	300 kHz	260x110x260	3
FPG5P	5 kV	<0.1 ns	0.2 - 3 ns	200 kHz	260x110x260	3
FPG10P	10 kV	<0.1 ns	0.2 - 3 ns	100 kHz	260x110x260	3
FPG20P	20 kV	<0.15 ns	1 - 2 ns	10 kHz	260x110x320	4
FPG50P	50 kV	<0.2 ns	1 - 2 ns	2 kHz	340x140x310	4
FPG100P	100 kV	<0.2 ns	1 - 2 ns	1 kHz	400x400x200	4
FPG200P	200 kV	<0.3 ns	1 - 2 ns	1 kHz	500x500x300	5

Examples of FID GmbH pulser specs

50Ω High Voltage Vacuum Feedthroughs

CONCLUSIONS 1

OUR ACTIVITY ABOUT THE KICKERS FOR DR FOLLOWS TWO MAIN LINES

THE FIRST ONE IS BASED ON RF DEFLECTORS, USING A SCHEME ALREADY TESTED IN CTF3, BUT IMPROVED WITH THE USE OF MORE THAN A SINGLE FREQUENCY TO GET HIGHER FACTORS OF RECOMBINATION. THE POSSIBILITY TO TEST THESE KIND OF DEFLECTORS ON THE ATF BEAM HAS TO BE INVESTIGATED.

THE SECOND LINE CONCERN KICKERS WITH STRIPLINES, WHERE THE CURRENT GENERATED BY VERY FAST HV PULSER FLOWS. PULSER SPECIFICATIONS AND KICKER PARAMETERS HAVE BEEN DETERMINED. MANY ISSUES CONCERNING THE KICKER DESIGN ARE COMMON TO THE ILC DR AND TO THE NEW INJECTION KICKERS THAT WE ARE GOING TO STUDY AND REALIZE FOR DAFNE.
FOR THIS REASON THE DESIGN AND TEST OF THE NEW DAFNE KICKER WILL BE USEFUL TO GET EXPERIENCE FOR THE DR KICKER.

Conclusion 2

- Design of the Stripline kicker for Dafne completed
- Design completely compatible with a 6Km DR kicker
- Field flatness about 5% up to 3cm (stripline radius)
- Kick duration about 6ns
- Kicker voltage needed 50 KV (5mrad at 0.5 GeV)
- (100KV for 0.5mrad at 5GeV and 3ns pulse duration)
- Prototipe should be build by end of October
- Pulser avalaible from industry (about 30Keuro)
- Project founded by CARE
- Installation in Dafne in coincidence with the end of Kloe-run and installation of the Finuda-detector (April 2005)