

ILC Injector ***-ATF in SCLC era-***

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for ATF collaboration

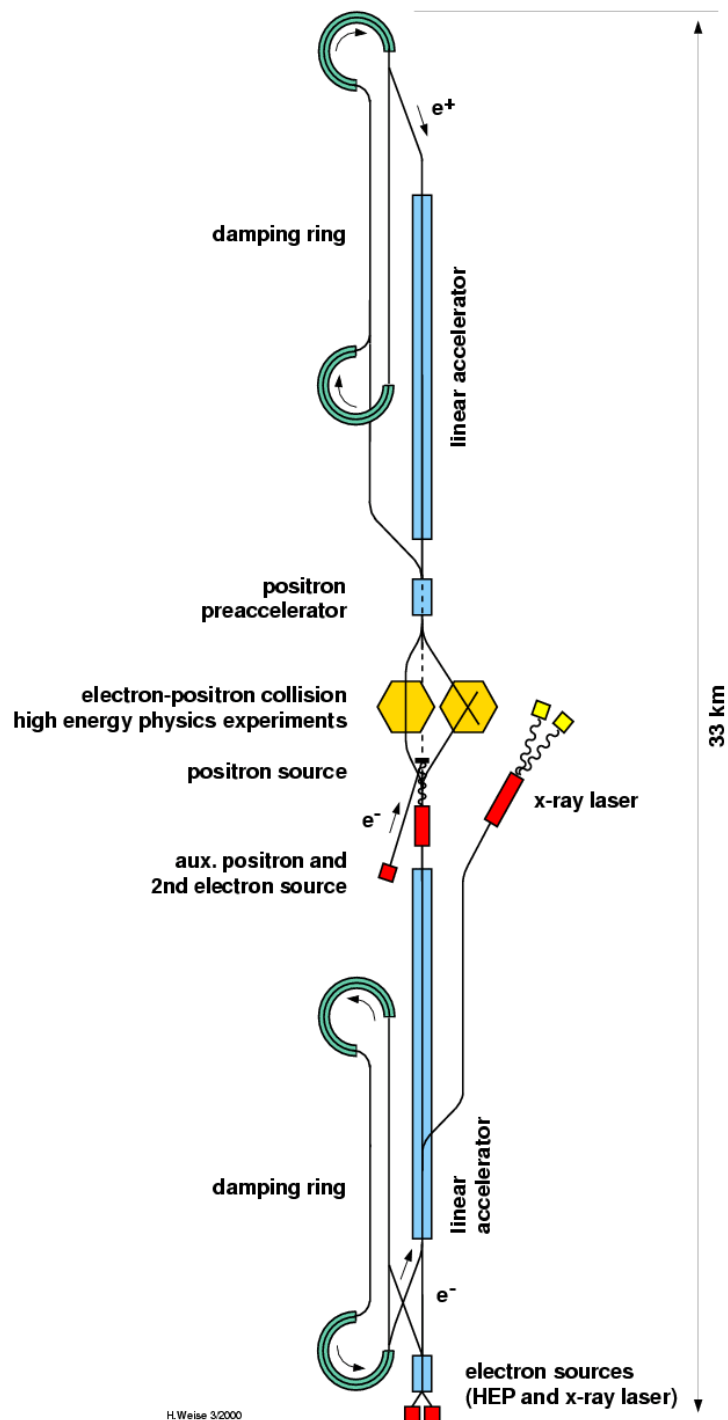
- ▲ ***SCLC injector overview***
- ▲ ***RF gun in SCLC***
- ▲ ***ATF in SCLC***
- ▲ ***Summary***

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ILC project

- ▲ According to the technical choice of ITRP (International Technology Recommendation Panel) under ICFA(International Committee for Future Accelerator), linear collider projects around the world is unified as ILC based on the SC technology.
- ▲ The choice is only for the technology, not for the desing. There is no design of ILC yet.
- ▲ Design (CDR) of ILC will be written until the end of 2005.

TESLA design



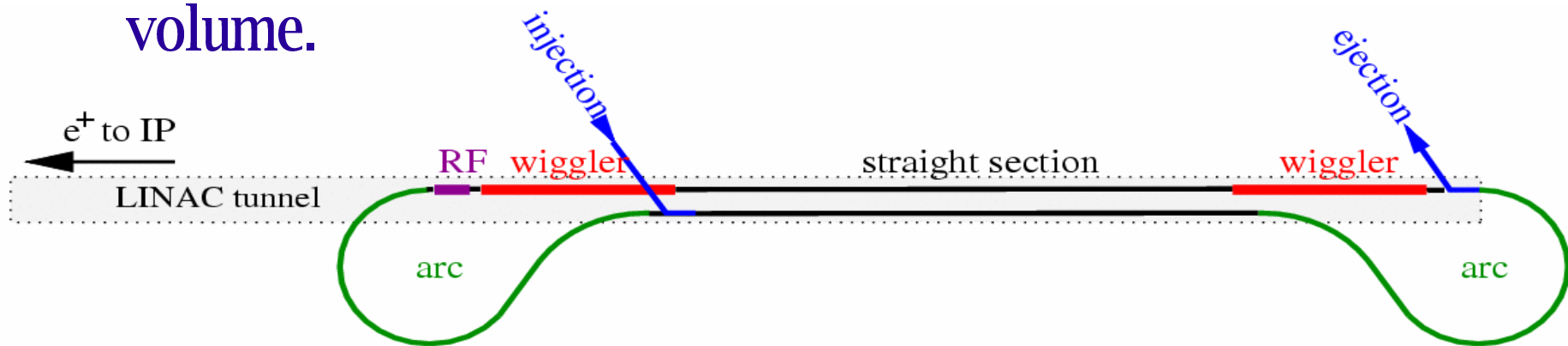
- ▲ A long bunch train (2820 bunches, 3nC/bunch, 337ns spacing) is repeated with 5Hz.
- ▲ Polarized electron beam is generated with PC DC gun.
- ▲ Positron is generated from photon conversion emitted from an undulator placed in the electron main linac.
- ▲ A whole bunch train is stored in DR with a compressed mode of 20ns bunch spacing instead of 337 ns. DR circumference is 17km.

TESLA Electron Source

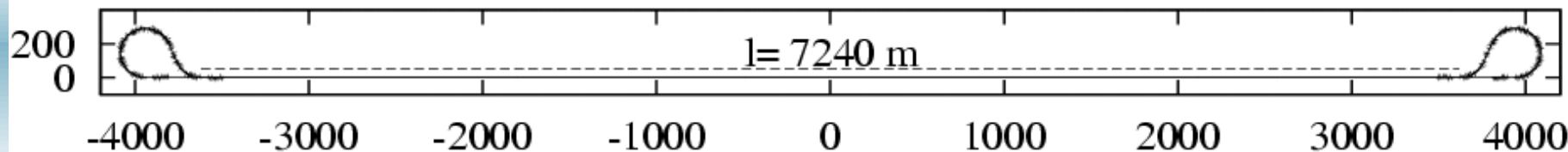
- ▲ Three types are planned:
 - Primary polarized electron source (NEA GaAs PC DC gun with NC bunching section)
 - Secondary unpolarized electron source (CsTe PC L-band RF gun)
 - Electron source for XFEL (CsTe PC RF gun with bunch compressor)
- ▲ These three sources share a SC injector linac accelerating up to 5 GeV.
- ▲ The train structure is common to that in the main linac.

Damping Ring

- ▲ If the whole bunches were stored in a DR, circumference became $2820 \times 337 \times c = 300 \text{ km}$.
- ▲ Beam is stored in a compressed mode with 20ns bunch spacing that makes the circumference $2820 \times 20 \times c = 17 \text{ km}$.
- ▲ The tunnel is shared with the main linac to save the volume.



Real scale



Issues on Dogbone

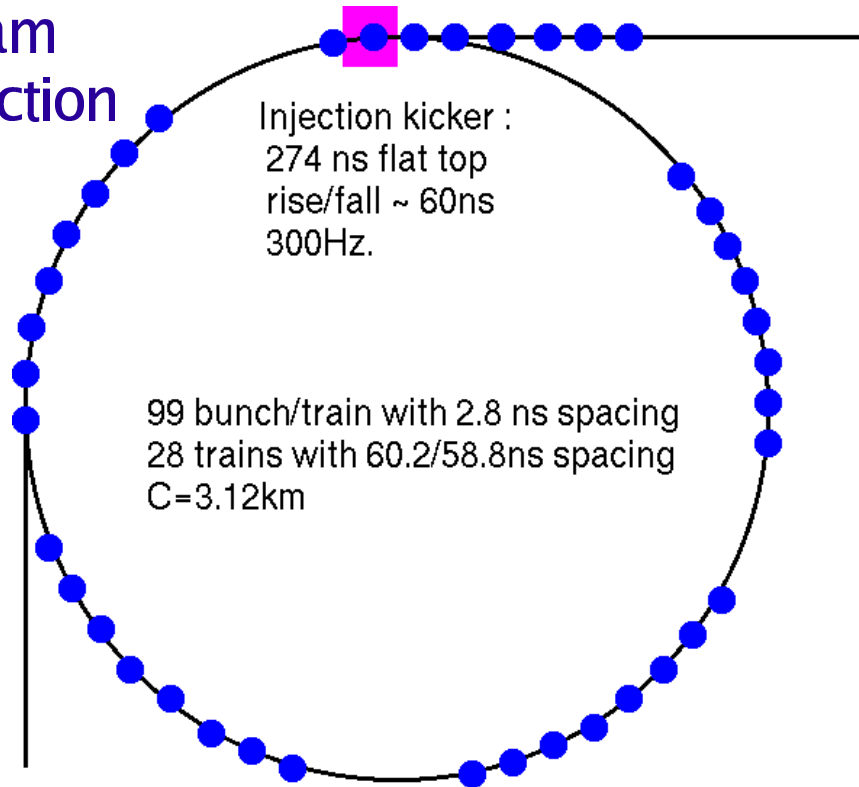
- ▲ Space charge tune shift -> coupling bumps -> emittance growth
- ▲ Large C -> Large damping time -> Long wiggler sections -> dynamic aperture
- ▲ Large C -> Tunnel sharing with the main linac -> Conflict between the DR commissioning and the main linac construction
- ▲ Some people are trying to decrease the DR size.

NC accelerator scheme

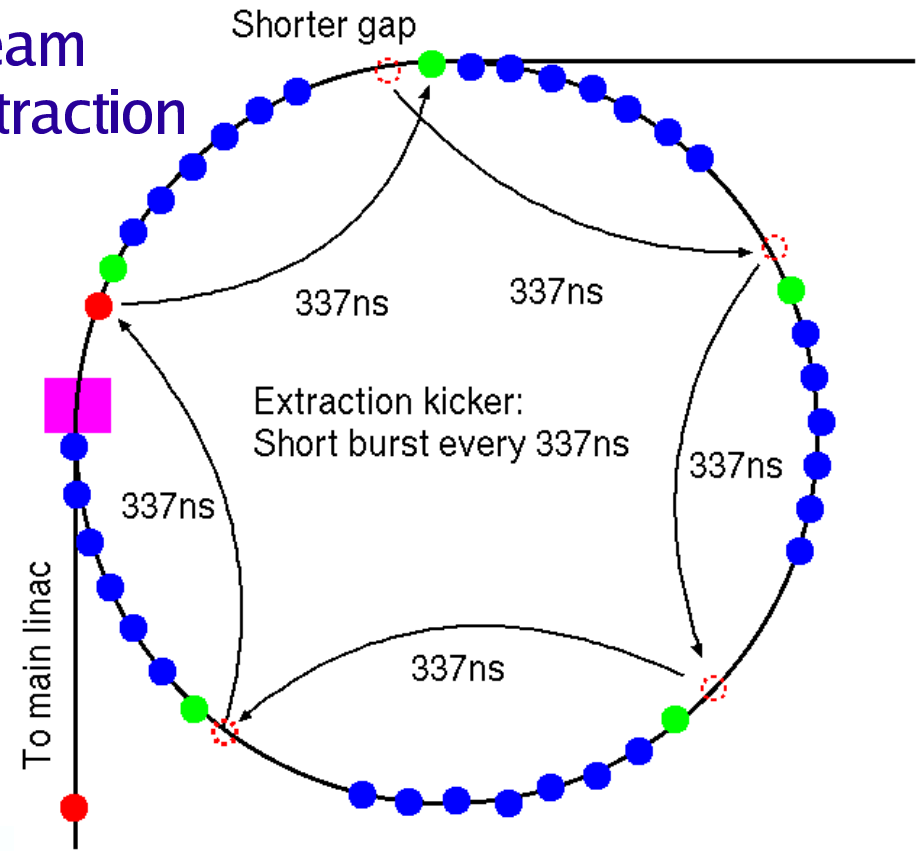
- ▲ S-band (NC) accelerator based injector linac.
- ▲ Multi trains with 1.4 or 2.8 ns bunch spacing is stored in DR.
- ▲ Shorter DR circumference (1.5, 3, or 6 km)
- ▲ DR expands this dense bunch train to fit the SCRF main linac (337ns spacing) by extracting an RF/fast kicker.

Beam Handling

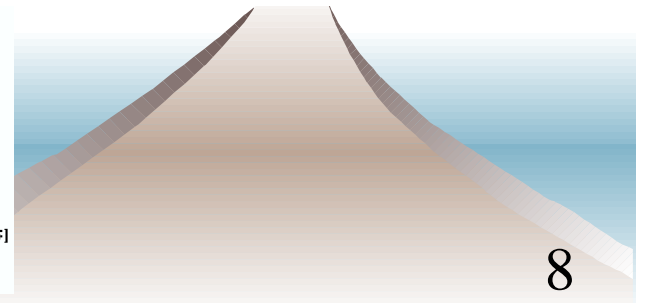
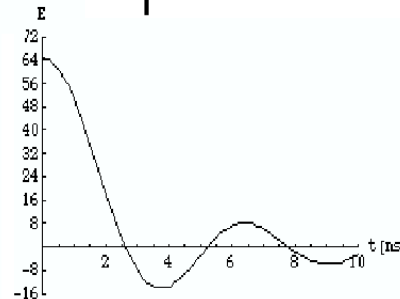
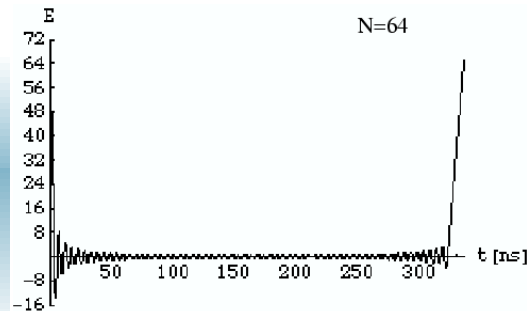
Beam injection



Beam extraction



Fourier
Kicker

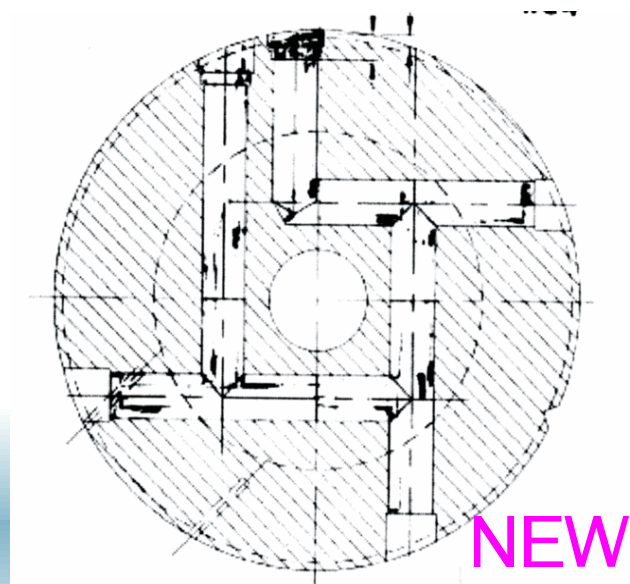
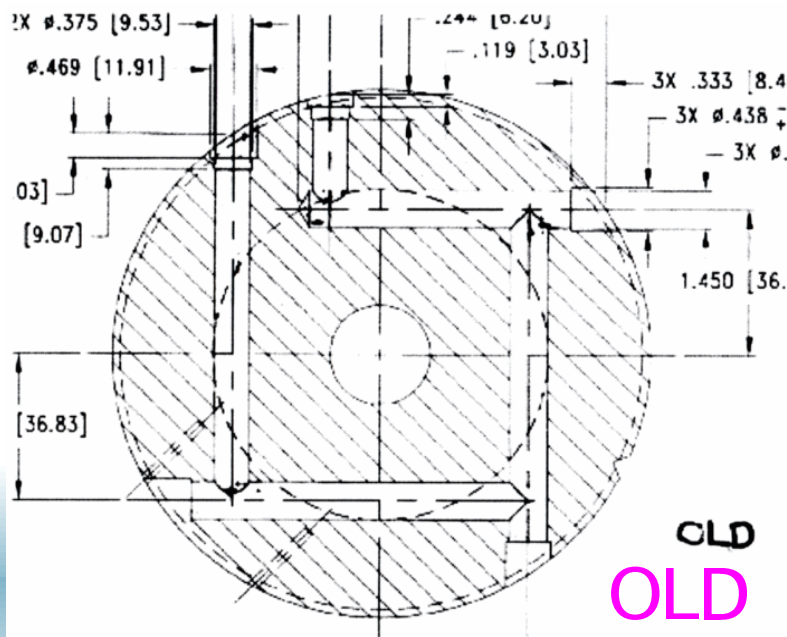


RF gun in 300Hz

- ▲ The train structure fits to an ordinal RF gun, but 300 Hz operation is unusual.
- ▲ For example, BNL gun IV was designed to operate in 100 Hz, but it was demonstrated only up to 50 Hz.

BNL gun IV in 300Hz

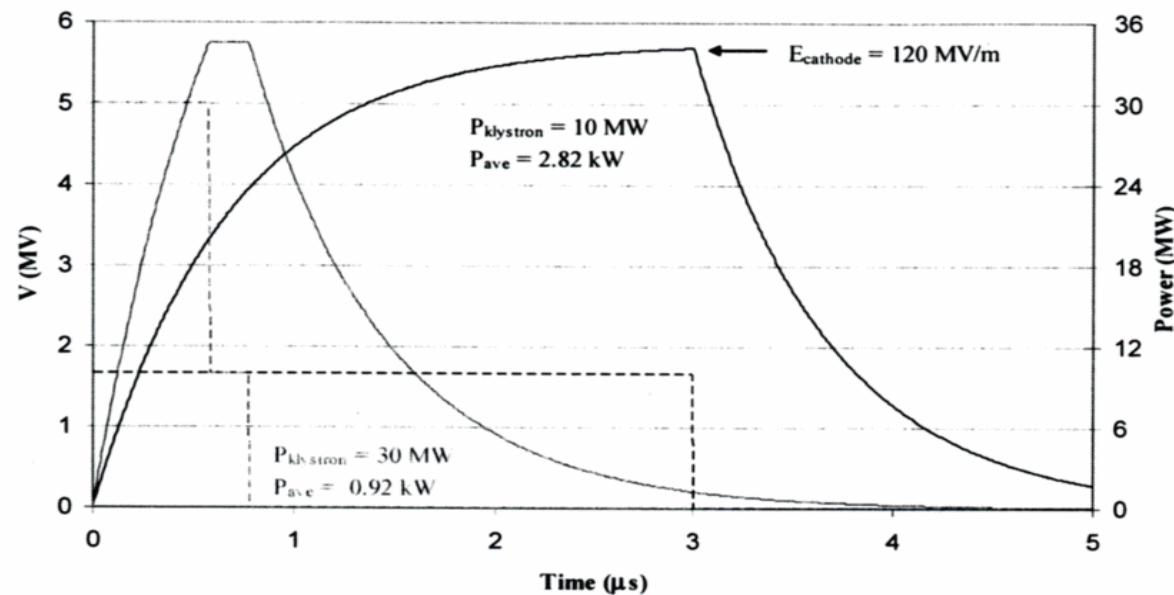
- ▲ X. J. Wang estimated that the repetition can be x3 (150Hz) with a minor modification on the cooling channel.



BNL-67922

BNL gun IV in 300Hz

- J. F. Schmerge proposed an amplitude modulation on input RF to reduce the heat load that gains the repetition more than three.



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- Employing bosc ideas, BNL gun IV can be operated up to 450 Hz.

Polarized electron from RF gun

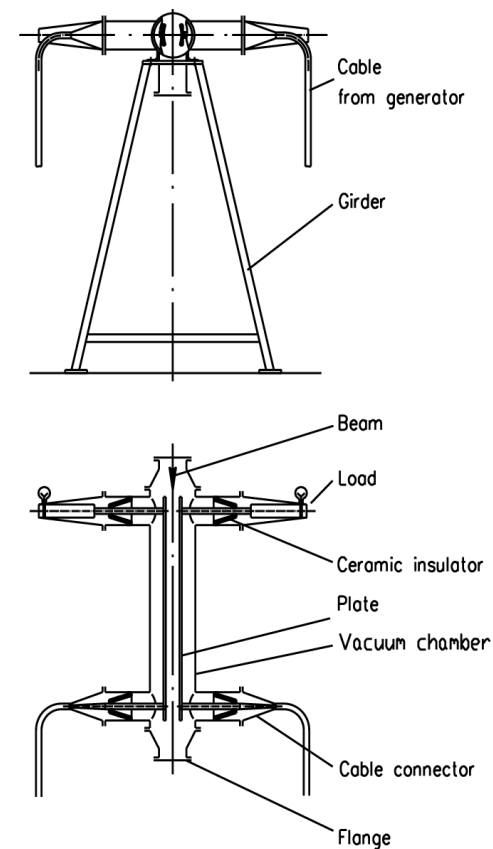
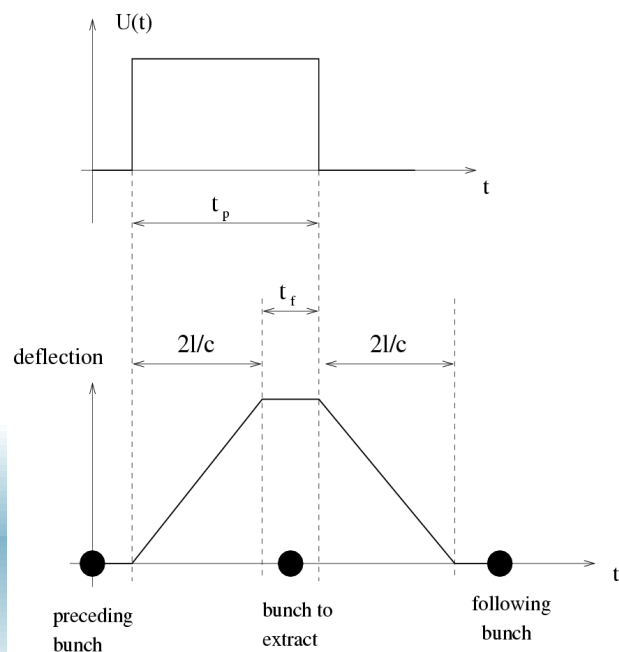
- ▲ From a strong request of the physics side, the polarized electron source must be implemented.
- ▲ According to the present technology, the polarized electron from a RF gun is very difficult.
- ▲ NEA surface need a super UHV($< 1\text{E-}10$ Pa).
- ▲ Two photon conversion from bulk GaAs (no NEA surface): need an extremely high-intensity laser light.
- ▲ NEA GaAs + SC RFgun may be a good combination due to the super UHV. Need R&D for SCRF gun and the demonstration.

ATF in SCLC era

- ▲ ATF is a only test facility for the LC DR in the world.
- ▲ We need many R&D works on injector of ILC (e-source, e⁺ source, DR, etc).
- ▲ A demonstration of DR of ILC, especially a critical beam injection/extraction, is possible only in ATF.

Kicker

- ▲ A strip line kicker is designed and tested.
- ▲ $\theta \sim 0.6\text{mrad}$, $\int B dl \sim 0.01\text{Tm}$ at 5GeV and $\beta_{\text{kicker}} = 50\text{m}$.
- ▲ $7\text{E-}6\text{ Tm}$ stability for $<0.1\sigma_x$.



Kicker prototyping

- ▲ HTS 50-12-UF by BEHLKE Electronic GmbH
 - 7ns pulse, 1.4 Mhz repetition(700ns)
 - FET switch, 5000V, 120A, 1.6ns rise time (10-90%).
- ▲ Results
 - HV:2.4kV, 3.2 G.m, reflection<8%, stability<5%.
 - Decreasing pulse amplitude with increasing pulse number.
- ▲ In a real DR, we need 12kV, $2a=40\text{mm}$, $l=10\text{m}$ make $S=400\text{G.m}$.

Fourier series kicker

- ▲ Kickers driven by variety of the frequencies make beats with an interval determined by the base frequency.
- ▲ If the beat is even sharp to inject/extract only one bunch in a train, the bunch is stored in DR with a condensed mode and extracted with a wider bunch spacing.
- ▲ The beam can be injected with a small bunch spacing also which allows to use NC injector linac.

Demonstration in ATF

- ▲ Any kicker has to be demonstrated prior to make a technological choice for ILC injector.
- ▲ ATF bunch spacing, 2.8 ns is even small to examine one bunch injection/extraction.
- ▲ ATF is an only test facility to examine kickers.
- ▲ DR scheme can not be decided without any qualification for kickers.
- ▲ ILC is therefore impossible without ATF.

Additional ATF contribution to ILC

- ▲ Collective effects and instabilities in DR are also important to make ILC design.
- ▲ A basic experiment for positron production, e.g., the production target heat character in nano second scale can be investigated.

Summary

- A RF gun is considered as a backup option of SCLC as same as in GLC.
- The gun property strongly depends on the injector scheme.
- In the case of S-band NC injector, an ordinal NC RF gun can be used as the electron source with a high reputation.
- BNL gun IV can be operated up to 450 Hz with a minor modification and AM on RF input.
- ATF is a unique facility to demonstrate the DR for LC still in SCLC era.