Some HG RF Issues in a HOM Polarized RF Gun for the ILC

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Outline

- **Motivation and Technical Challenges**
- **Preliminary RF Structure Design**
- **Planned Work**

Motivation and Technical Challenge

- Advantages of RF gun:
- High charge density at significantly higher extraction fields;
- Short bunch profile defined by source laser without post-extraction RF bunchers;
- Low emittance beam with higher capture efficiency .
- A pressure of 10^{-11} Torr or better for GaAs photocathode is required.
- In order to obtain extended QE lifetime of activated GaAs photocathode. the effect of back bombardment of field emitted electrons has to be carefully studied and suppressed.
- Reduction of field emission from RF coupler, RF seal for the cathode plug and irises.
- Choice of materials,
- Machining and assembly techniques, and cleaning procedures.

Basic parameters for a polarized RF gun

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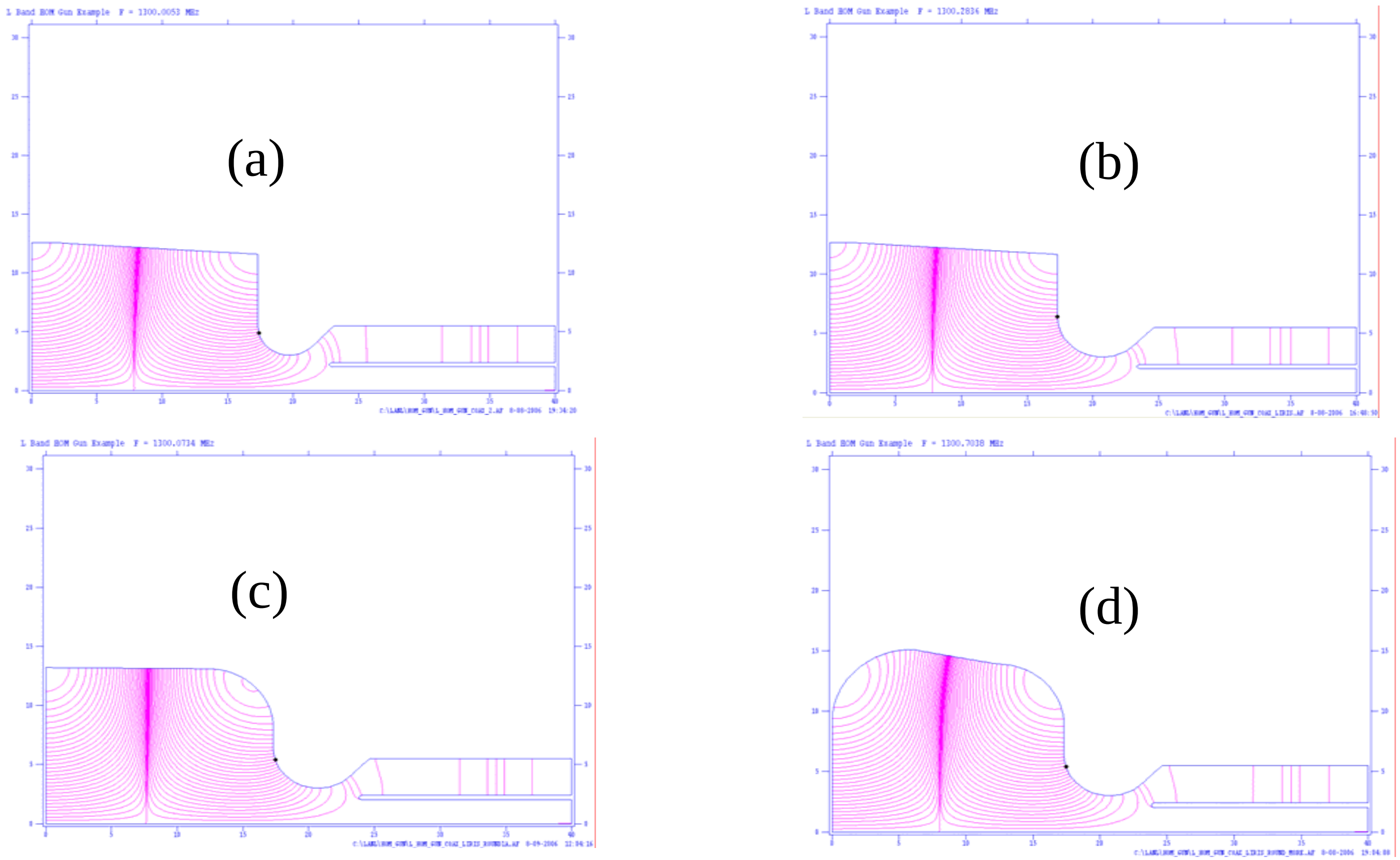
RF Cavity	f	1300 MHz
	Q_0	31230
	T_f	1.9 μs
	E_c	40 MV/m
Bunch Structure	Charge/Bunch	5 nC
	Bunch Train	2820 Bunches
	Bunch Spacing	0.337 μs
	Train Length	1 ms
	Repetition Rate	5 Hz
Laser	Transverse	1 cm dia., round, flat top.
	Longitudinal	42.7 ps (20ºRF) Gaussian 4 σ
Cathode	Material	GaAs
	Size	1 cm

Design Examples

- To minimize the RF power requirement;
- To minimize the maximum surface electrical field for lowest possible field emitted current;
- To minimize the maximum surface magnetic field for reduction of pulse heating and ease of cooling.

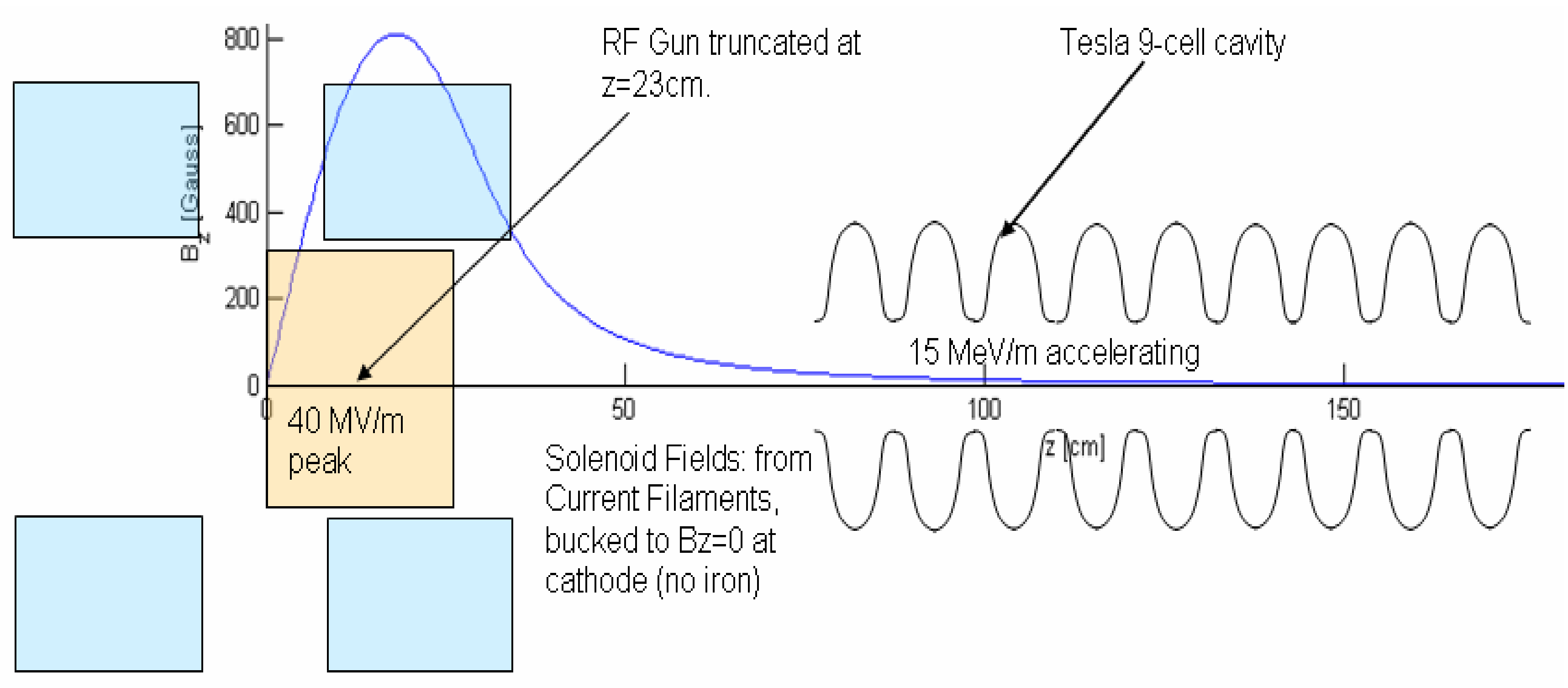


Design examples for an HOM RF gun: (a) with an output iris radius of 2.4 mm; (b) with an output iris radius of 3.4 mm; (c) with a rounding radius of 5 cm on the outer cell wall at the output end; and (d) with an additional rounding radius of 6 cm.

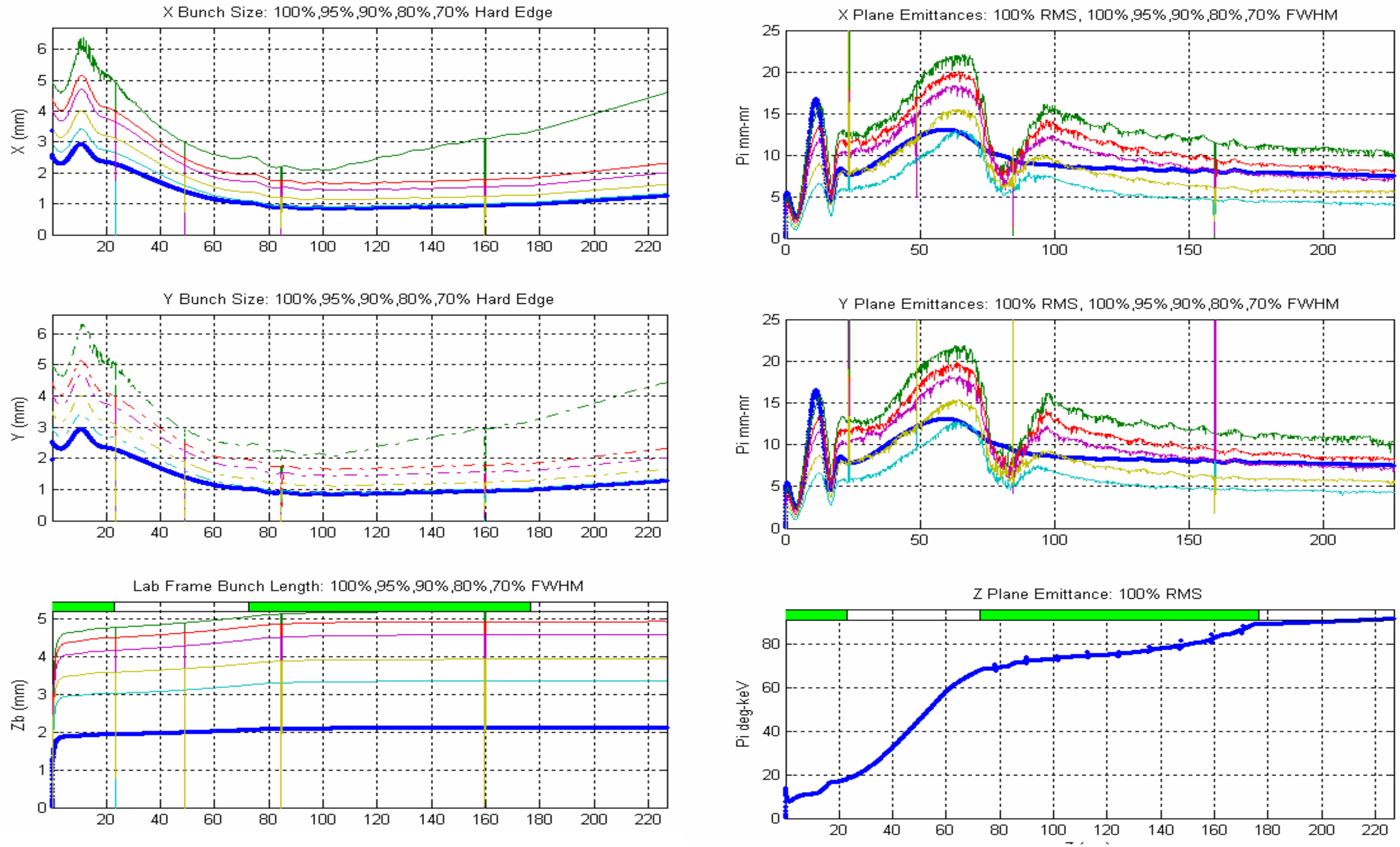
Parameters for 40 MV/m of E field on cathode surface

	Power (MW)	E_{max}/E_c	Amax (MV/m)	r (M Ω /m)	Max P_d (kW/cm^2)
(a)	5.52	1.26	50.5	7.40	5.24
(b)	5.66	1.16	46.4	6.97	5.36
(c)	5.49	1.11	46.4	7.36	4.54
(d)	4.90	1.085	43.4	7.40	4.78

Layout for the beam dynamics simulation



Beam Dynamics Calculation

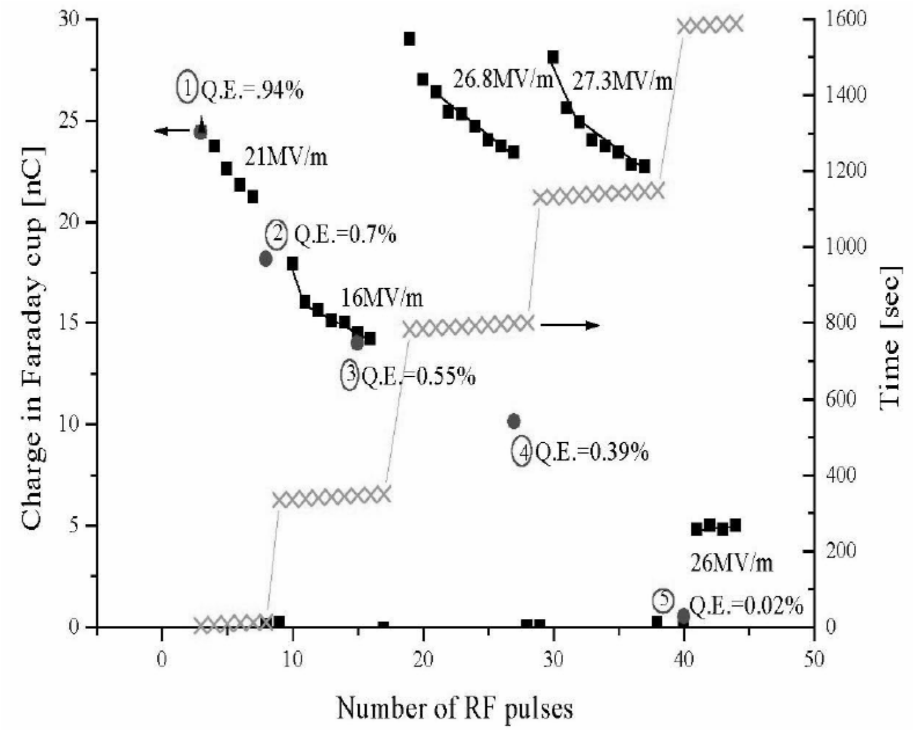


Plots for the transverse (top and middle) and longitudinal (bottom) envelopes (left) and RMS emittances (right).

Experimental Studies

A GaAs cathode activated to negative electron affinity (NEA) was tested in a ½-cell ~30 MV/m S-band RF gun at BINP, the QE lifetime of the cathode was measured (A. Aleksandrove, et, al. EPAC98).

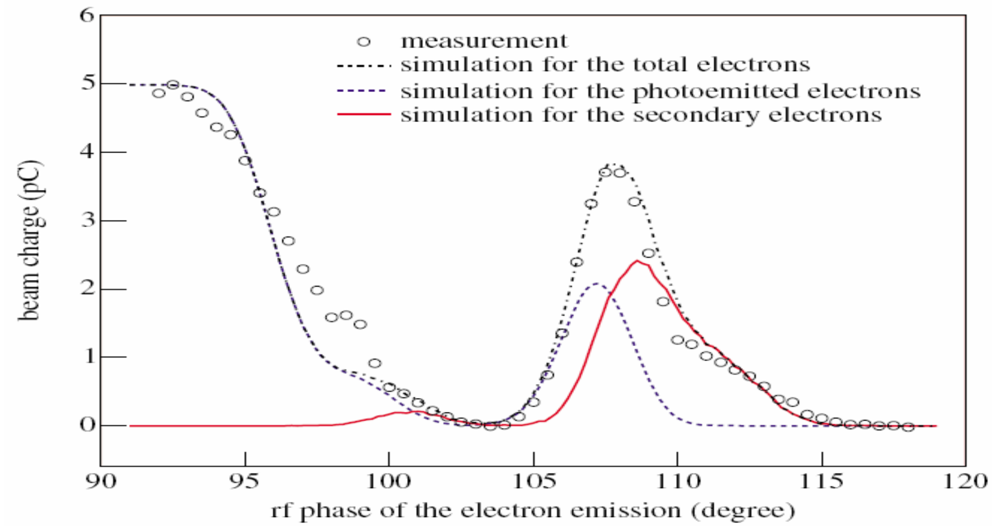
This rapid deterioration was attributed to back bombardment of the cathode by field emitted electrons. Field emission is most likely to originate at the cathode plug, the iris, and the rf input coupler.



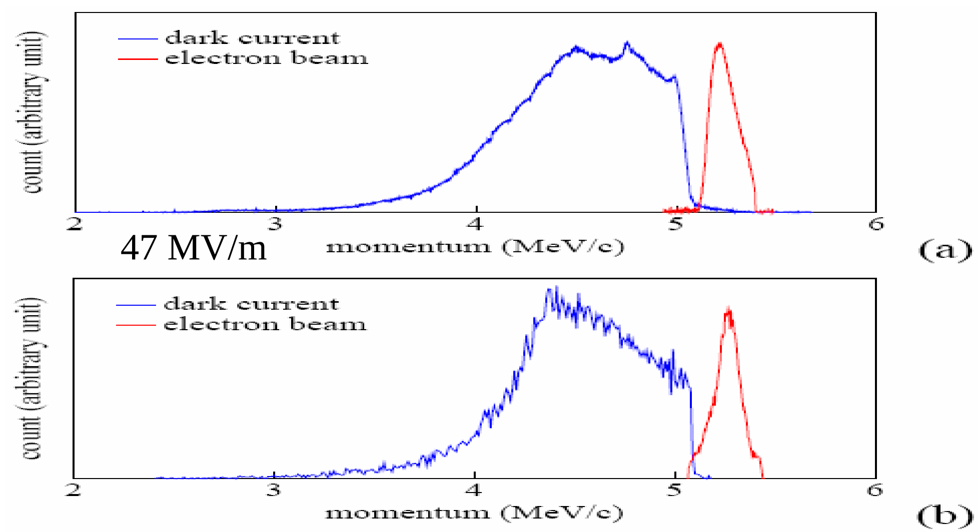
Simulation Studies

Secondary electron emission and dark current in a DESY photocathode RF gun was simulated and measured. (J. Han, et al.):

- Because of the space charge field, some part of the electrons emitted from the cathode might move backward to the cathode produce secondary electrons.
- A high electric field in the gun cavity generates a large amount of dark current. If the field-emitted electrons from the cathode or any other surface inside the cavity hit the cathode, secondary electrons can be produced as well.



Simulation of the primary and secondary electrons



Spectrum of dark current (a) Measurement, (b) Simulation

Plan

- Design optimization of RF structures
  - Minimize the RF power requirement.
  - Minimize the maximum surface electrical field for lowest possible field emitted current.
  - Minimize the maximum surface magnetic field for reduction of pulse heating and ease of cooling.
  - Increase the conductance for pumping on the cathode by using holes or z-slots in the cavity cylinder.
- Simulation studies on back bombardment and field emission electrons.
- Other design issues
  - Choice of materials.
  - Machining and assembly techniques.
  - Cleaning procedures.