Osaka Univ. Gun Problem

2007/1/10 by J. Yang

RF gun setup in Osaka University:

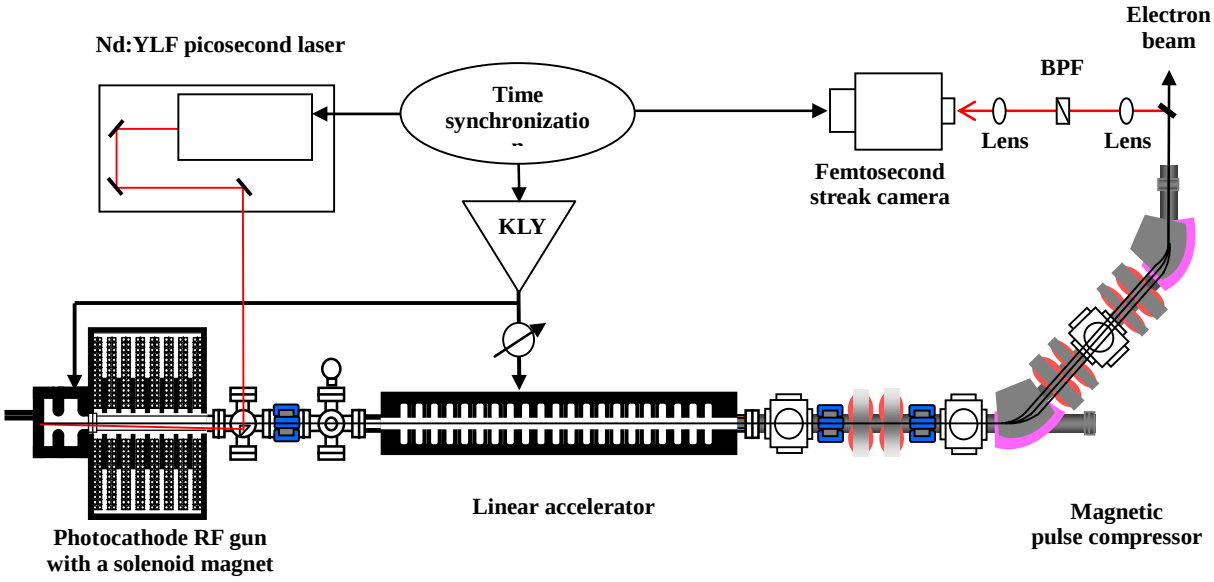


Fig. 1

Main parameters and conditions:

Gun cavity & field balance:

S-band (2.856GHz) 1.6-cell gun cavity is operated at power of ~10MW, corresponding to the peak electric field at cathode ~115MV/m. Gun cavity geometry is given as Fig.2.

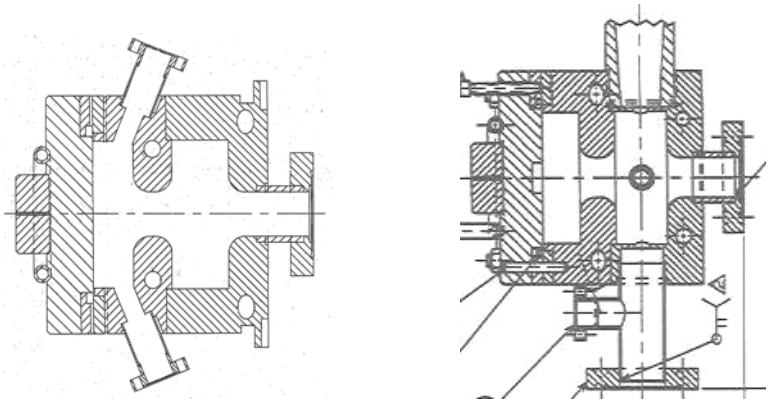


Fig. 2

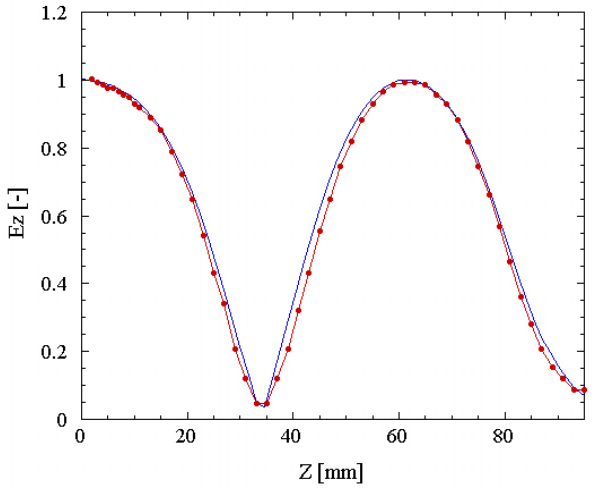
The Superfish input file is given as

```
Photocathode rf gun geometry for the Osaka femtosecond linac
Nominal geometry in cm.
Outer radius adjusted for resonant frequency = 2856 MHz, and
uniform electric field Ecathode/Efullcell =1.0

&reg kprob=1,                              ;Superfish problem
freq=2856,                                 ;Mode frequency
nbsup=1,nbslo=0,nbsrt=0,nbslf=1,     ;Boundary conditions
rmass=-1,
xdri=6.1415, ydri=4.20525,                 ;Drive point coordinates
xreg=0,2.311,3.238,3.4135,3.583,4.516,6.1415,7.767,8.694
kreg=1,    87,   127,    137,   147,   187,    237,   287,   327,
xmax=15.0,
kmax=367,
yreg=0,1.25,2.177,4.1536,
lreg=1,   46,    86,    126,
ymax=4.20525,
lmax=128 &

&PO X=0.0,Y=0.0 &
&PO X=0.000,Y=4.1536 &
&PO X=2.311,Y=4.1536 &
&PO X=2.311,Y=2.177 &
&PO NT=2,X0=3.238,Y0=2.177,R=0.927,THETA=270.0 &
&PO X=3.583,Y=1.250 &
&PO NT=2,X0=3.583,Y0=2.177,R=0.927,THETA=0.0 &
&PO X=4.516,Y=4.20525 &
&PO X=7.767,Y=4.20525 &
&PO X=7.767,Y=2.177 &
&PO NT=2,X0=8.694,Y0=2.177,R=0.927,THETA=270.0 &
&PO X=15.00,Y=1.250 &
&PO X=15.00,Y=0.00 &
&PO X=0.0,Y=0.0 &
```

Axial *Ez(z)* field distribution and e-field balance are shown in Fig. 3, where the red line (dot) represents the experimental data and the blue line is the simulation results. The data is the experimental results measured by technique of longitudinal bead pull.



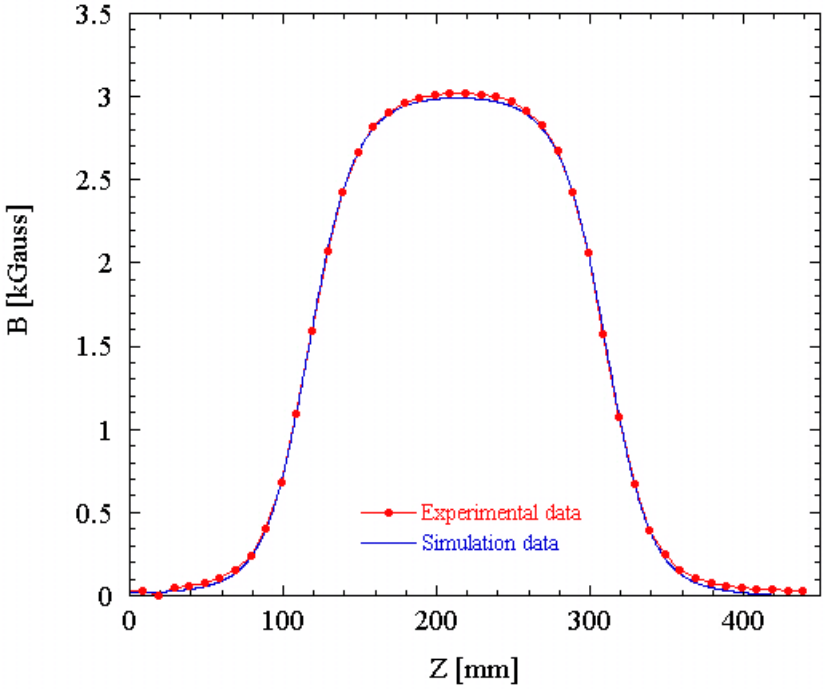
z[mm]	E [-]	z[mm]	E [-]	z[mm]	E [-]
2.0000	1.0028	31.000	0.12152	67.000	0.95746
3.0000	0.99384	33.000	0.047622	69.000	0.92942
4.0000	0.98485	35.000	0.047622	71.000	0.88106
5.0000	0.97579	37.000	0.12152	73.000	0.82004
6.0000	0.97579	39.000	0.20838	75.000	0.74390
7.0000	0.96666	41.000	0.32233	77.000	0.66111
8.0000	0.95746	43.000	0.43279	79.000	0.56953
9.0000	0.94819	45.000	0.55555	81.000	0.46558
10.000	0.92942	47.000	0.64863	83.000	0.36154
11.000	0.91991	49.000	0.74390	85.000	0.27996
13.000	0.89091	51.000	0.82004	87.000	0.20838
15.000	0.85099	53.000	0.88106	89.000	0.15282
17.000	0.78812	55.000	0.92942	91.000	0.12152
19.000	0.72100	57.000	0.96666	93.000	0.086910
21.000	0.64863	59.000	0.98485	95.000	0.086910
23.000	0.54131	61.000	0.99384	97.000	0.086910
25.000	0.43279	63.000	0.99384	99.000	0.086910
27.000	0.34228	65.000	0.98485	101.00	0.086910
29.000	0.20838				

Fig. 3

Gun solenoid magnet:

Solenoid magnet has a center position at z=213.78 mm from the cathode, calibration of the peak field Bz_peak[kG]=0.015017*I[A]+0.019686 was obtained from solenoid field measurements (interpolation for 0A<I<220A).

The measured axial Bz-field profile is given in Fig. 4 which was compared with the POISSION simulation results. The data is the measured axial Bz-field.



z[mm]	B [kG]	z[mm]	B [kG]	z[mm]	B [kG]
-41.220	0.021441	128.78	2.0677	298.78	2.0647
-31.220	0.022320	138.78	2.4244	308.78	1.5772
-21.220	0.024077	148.78	2.6671	318.78	1.0729
-11.220	0.026011	158.78	2.8178	328.78	0.67381
-1.2200	0.028647	168.78	2.9079	338.78	0.39631
8.7800	0.031810	178.78	2.9606	348.78	0.24517
18.780	0.0000	188.78	2.9916	358.78	0.15554
28.780	0.044112	198.78	3.0098	368.78	0.10580
38.780	0.055185	208.78	3.0176	378.78	0.076977
48.780	0.072759	218.78	3.0192	388.78	0.058699
58.780	0.10141	228.78	3.0141	398.78	0.048155
68.780	0.15132	238.78	2.9991	408.78	0.041125
78.780	0.24359	248.78	2.9705	418.78	0.036028
88.780	0.40650	258.78	2.9174	428.78	0.032513
98.780	0.68243	268.78	2.8271	438.78	0.030053
108.78	1.0944	278.78	2.6728		
118.78	1.5882	288.78	2.4251		

Fig. 4

The POISSION input file is given as

```
Solenoid coil magnet

&reg kprob=0, icylin=1,
dx=0.1,dy=0.09,
xmin=0.0,xmax=23.087,
ymin=0.0,ymax=42.756,
kmin=1, ktop=11, ltop=100(
xminf=0.0, xmaxf=2.0,
yminf=0.0, ymaxf=42.756 &

&po x=0.0,y=0.0 &
&po x=23.087,y=0.0 &
&po x=23.087,y=42.756 &
&po x=0.0,y=42.756 &
&po x=0.0,y=0.0 &

&reg mat=2 &
&po x=4.0,y=10.0 &
&po x=22.087,y=10.0 &
&po x=22.087,y=32.756 &
&po x=4.0,y=32.756 &
&po x=4.0,y=30.846 &
&po x=19.547,y=30.846 &
&po x=19.547,y=11.91 &
&po x=4.0,y=11.91 &
&po x=4.0,y=10.0 &

&reg mat=1,cur=5800. &
&po x=5.65,y=11.91 &
&po x=18.2765,y=11.91 &
&po x=18.2765,y=13.84 &
&po x=5.65,y=13.84 &
&po x=5.65,y=11.91 &

&reg mat=2 &
&po x=4.0,y=13.93 &
&po x=11.747,y=13.93 &
&po x=11.747,y=14.25 &
&po x=4.0,y=14.25 &
&po x=4.0,y=13.93 &

&reg mat=1,cur=5800. &
&po x=5.65,y=14.34 &
&po x=18.2765,y=14.34 &
&po x=18.2765,y=16.27 &
&po x=5.65,y=16.27 &
&po x=5.65,y=14.34 &

&reg mat=2 &
&po x=4.0,y=16.36 &
&po x=11.747,y=16.36 &
&po x=11.747,y=16.68 &
&po x=4.0,y=16.68 &
&po x=4.0,y=16.36 &

&reg mat=1,cur=5800. &
&po x=5.65,y=16.77 &
&po x=18.2765,y=16.77 &
&po x=18.2765,y=18.70 &
&po x=5.65,y=18.70 &
&po x=5.65,y=16.77 &

&reg mat=2. &
&po x=4.0,y=18.79 &
&po x=11.747,y=18.79 &
&po x=11.747,y=19.11 &
&po x=4.0,y=19.11 &
&po x=4.0,y=18.79 &

&reg mat=1,cur=5800. &
&po x=5.65,y=19.20 &
&po x=18.2765,y=19.20 &
&po x=18.2765,y=21.13 &
&po x=5.65,y=21.13 &
&po x=5.65,y=19.20 &

&reg mat=2 &
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&po x=18.2765,y=23.56 &
&po x=5.65,y=23.56 &
&po x=5.65,y=21.63 &

&reg mat=2 &
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&po x=11.747,y=23.65 &
&po x=11.747,y=23.97 &
&po x=4.0,y=23.97 &
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&po x=18.2765,y=25.99 &
&po x=5.65,y=25.99 &
&po x=5.65,y=24.06 &

&reg mat=2 &
&po x=4.0,y=26.08 &
&po x=11.747,y=26.08 &
&po x=11.747,y=26.40 &
&po x=4.0,y=26.40 &
&po x=4.0,y=26.08 &

&reg mat=1,cur=5800. &
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&po x=18.2765,y=26.49 &
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&reg mat=2 &
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&po x=11.747,y=28.51 &
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&po x=4.0,y=28.83 &
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&reg mat=1,cur=5800. &
&po x=5.65,y=28.916 &
&po x=18.2765,y=28.916 &
&po x=18.2765,y=30.846 &
&po x=5.65,y=30.846 &
&po x=5.65,y=28.916 &
```

Booster linac

Booster linac was installed at the solenoid downstream, about 1.3 m from the cathode. The linac was a type of traveled wave linear accelerator. The beam energy at the exit of the linac was 32 MeV at maximum. The normalized transverse emittance was measured downstream of the linac by Q-scan technique. The energy spread was measured by spectrometer which was constructed with a 45-degree bending magnet and a 30-um-thick beam screen, while the bunch length was obtained by streak camera.

The dimensions of the beam line downstream of the linac are given in the following PARMELA file:

```
run 1 2 2856. -.00113 .5e-6
title
   Photocathode RF gun + Solenoid + Transport line, 3-D p-to-p SC
poisson 0    0.92    0. 0. 0.
gun4.po7
drift 0.0 5. 1
input 9 1999      50 0.15    50 2.5    0.0
CELL 15.000 1.25 1 180.00 35. 1 0.5 -1 2856 0
cfield 1
gun4.t7
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5.225 5. 1
;laser injection
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 4.55 5. 1
;Screen
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 5. 5. 1
drift 6.71916666666667 5. 1
;Trwave linac
cell 3.499 1.2475 1 405.0 17.0 3 5 1 2856. 0 0
1.68683, 0.318342, -6.126892E-02, -1.363461E-02,
4.028170E-03, 4.920846E-04, -2.630831E-04, -2.631357E-06,
1.477689E-05, -1.670119E-06, -5.768230E-07, 1.807875E-07,
6.606186E-10, -1.040544E-08
trwave 1.7495 1.2475 1 315.0 17.0 1 5 2856. 2 -5 5 .666667 56 0 0 0 0 0 0
1.834060E-05 -2.053204E-04 2.415633E-03 -2.825164E-02
0.368203 0.928447 -4.001708E-02 2.598950E-03
-1.641184E-04 9.798464E-06 -5.371079E-07
trwave 3.499 1.24375 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.24000 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.23625 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.21375 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.21000 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.20250 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.19875 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.19500 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.18375 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.17625 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.16875 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.16500 1 315.0 17.0 1 5. 2856. 2
```

```
trwave 3.499 1.16125 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.15750 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.15375 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.15000 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.14625 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.14250 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.13500 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.12375 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.12000 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.11250 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.10875 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.10500 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.10125 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.09750 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.09375 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.09000 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.08625 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.08250 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.07875 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.07500 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.07125 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.06750 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.06000 1 315.0 17.0 1 5. 2856. 2
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trwave 3.499 1.05250 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.04875 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.04500 1 315.0 17.0 1 5. 2856. 2
trwave 3.499 1.04500 1 315.0 17.0 1 5. 2856. 2
drift 10. 5. 1
drift 10. 5. 1
drift    9. 5. 1
;screen
drift 10. 5. 1
drift 10. 5. 1
drift 10. 5. 1
drift    7.172 5. 1
;savepoint
zout
OUTPUT 5
scheff 2.856 0.5 1.0 20 120 0 0 5 1.5 0
start    2.3    .1 100 1 0
;scheff 2.856 0.5 1.0 20 120 0 0 5 1.5 0
;start    2.3    10 100 1 0
;continue 10 5000 1 0
scheff 2.856 1.2 1.2 20 120 0 0 5 1.5 0
continue .1 1800 1 0
scheff 2.856 1.2 1.2 20 120 0 0 5 1.5 0
continue .5 360 1 0
scheff 2.856 0.5 1.2 20 120 0 0 5 1.5 0
continue 2 5000 1 0
scheff 2.856 1.0 1.2 20 120 0 0 5 1.5 0
continue 10 5000 1 0
continue 10 5000 1 0
continue 10 5000 1 0
continue 10 5000 1 0
continue 10 5000 1 0
continue 10 5000 1 0
continue 10 5000 1 0
continue 10 5000 1 0
save 5
end
```

ベンチマークテスト問題

Gun	
加速電場	100MV/m
ガン位相	30°
ソレノイド磁場	スキャン
Laser	
パルス幅（FWHM）	5、10、20ps；Gaussian、Flat-top
ビーム直径（FWHM）	1、2、3mm；Gaussian、Flat-top
Linac	
長さ	2m
カソードからの距離	1.3m
加速電場	？MV/m（加速管出口のビームエネルギーは30MeV）
位相	スキャン
Measurement	
ビーム評価位置（カソードからの距離）	3.5m？