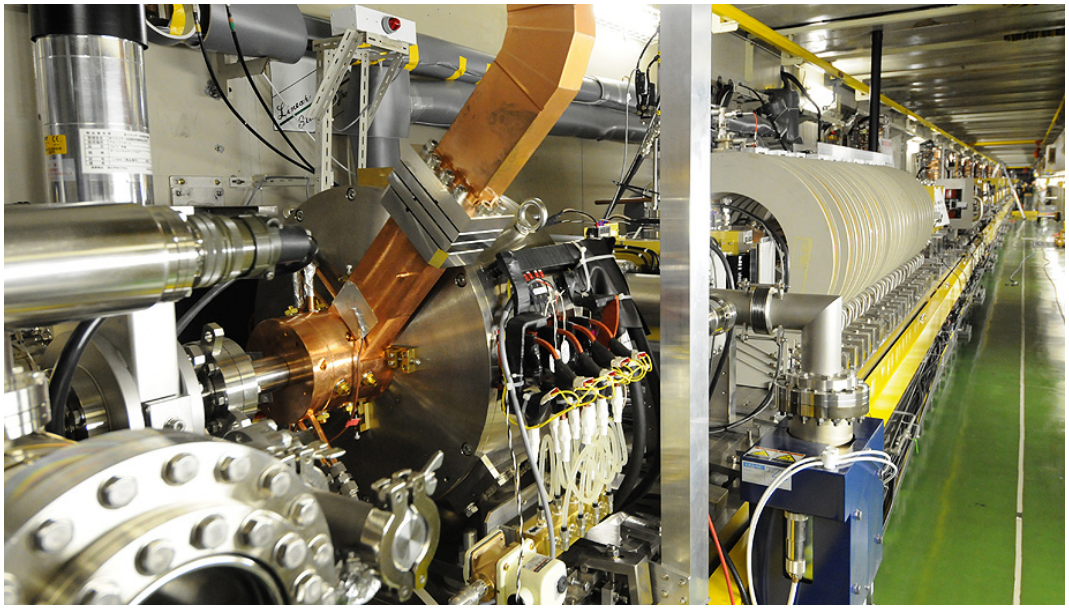
300Hz Linac scheme and the cost

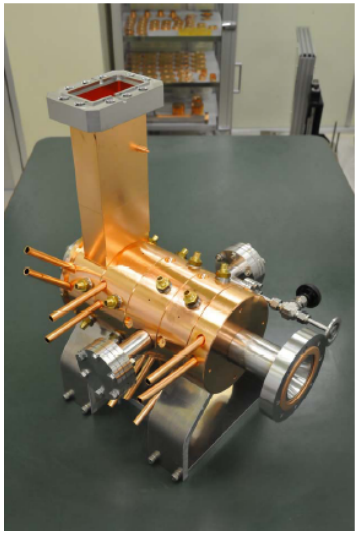
Junji Urakawa , KEK

Contents :

1. **Electron Beam Generation by Photo-cathode RF Gun**
2. **300Hz Linac**
3. **Cost**

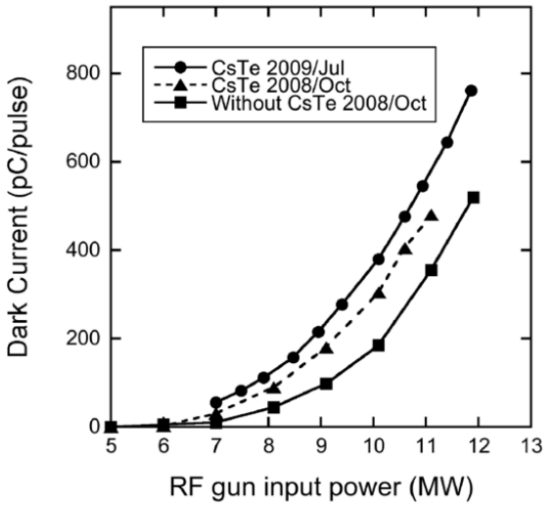
Photo-cathode RF Gun

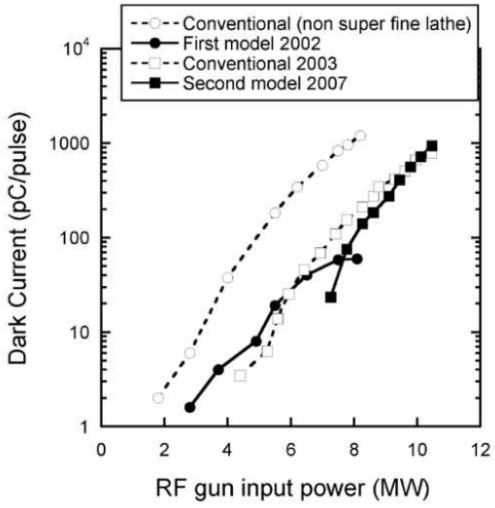


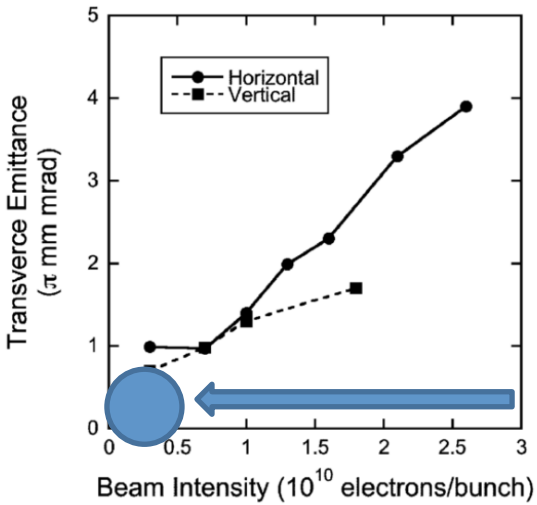


1.3GeV ATF Linac, results by 80MeV beam. **10MeV 3.6 cell gun** **6MeV 1.6 cell gun**

From 2002 onward, successive improvements have been incorporated into newer models of the RF gun. In 2008, a new gun incorporating all of the earlier modifications was produced for the ATF. A typical transverse emittance of **1.3 π mm·mrad** has been obtained under solenoid field of 0.18 T, beam intensity of **1.6nC/bunch**, and **RF power of 9 MW**.







Study to reduce normalized emittance.
0.3 πmm-mrad at 0.1nC/bunch

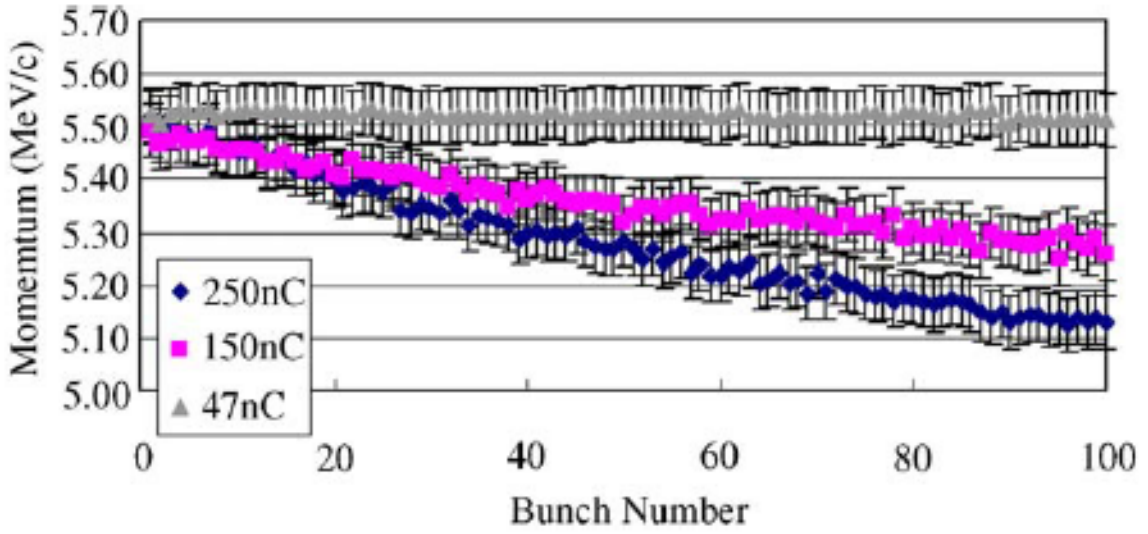


Fig. 11. Momentum of a multi-bunch beam at a laser injection timing of 1.703 μs.

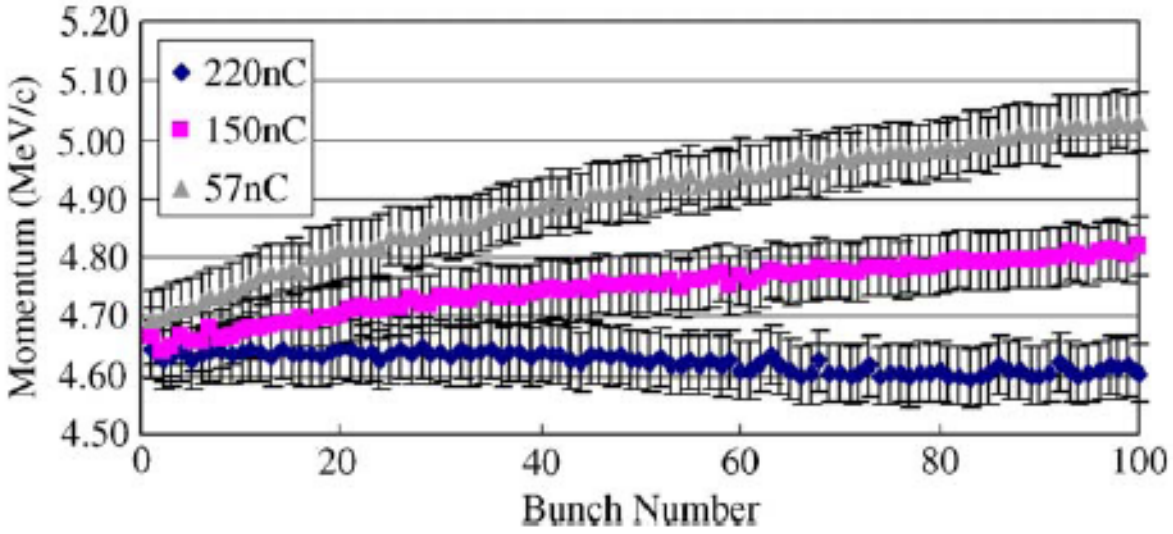
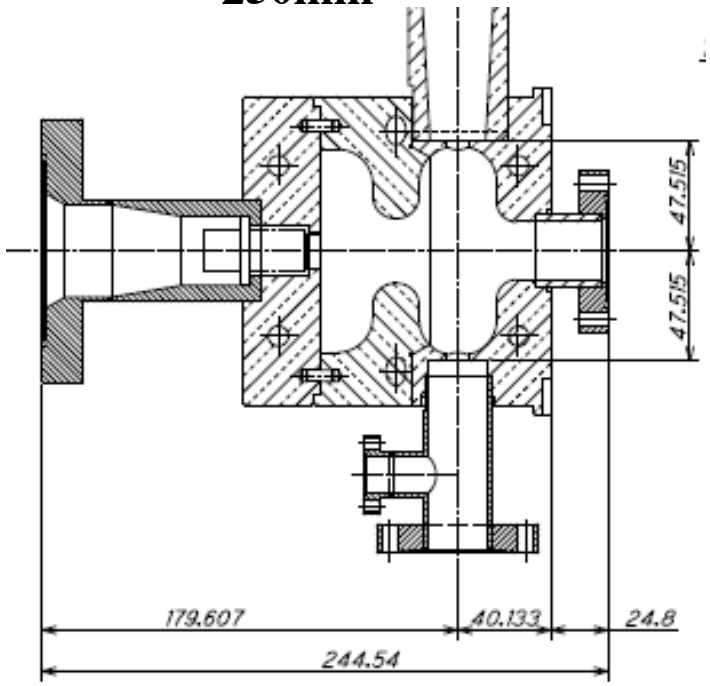


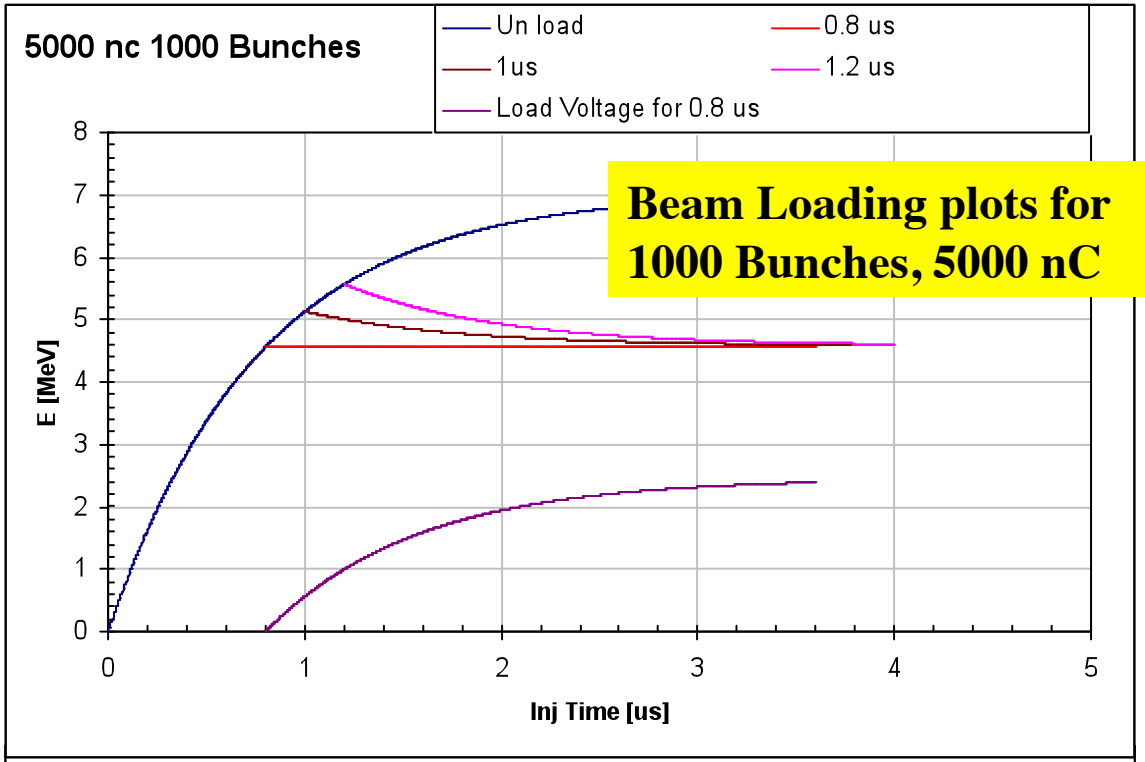
Fig. 12. Momentum of a multi-bunch beam at a laser injection timing of 0.906 μs.

JFY2004
300nC achieved
Schedule
JFY2012
1000nC-10000nC
JFY2012
Soft X-ray Gen.

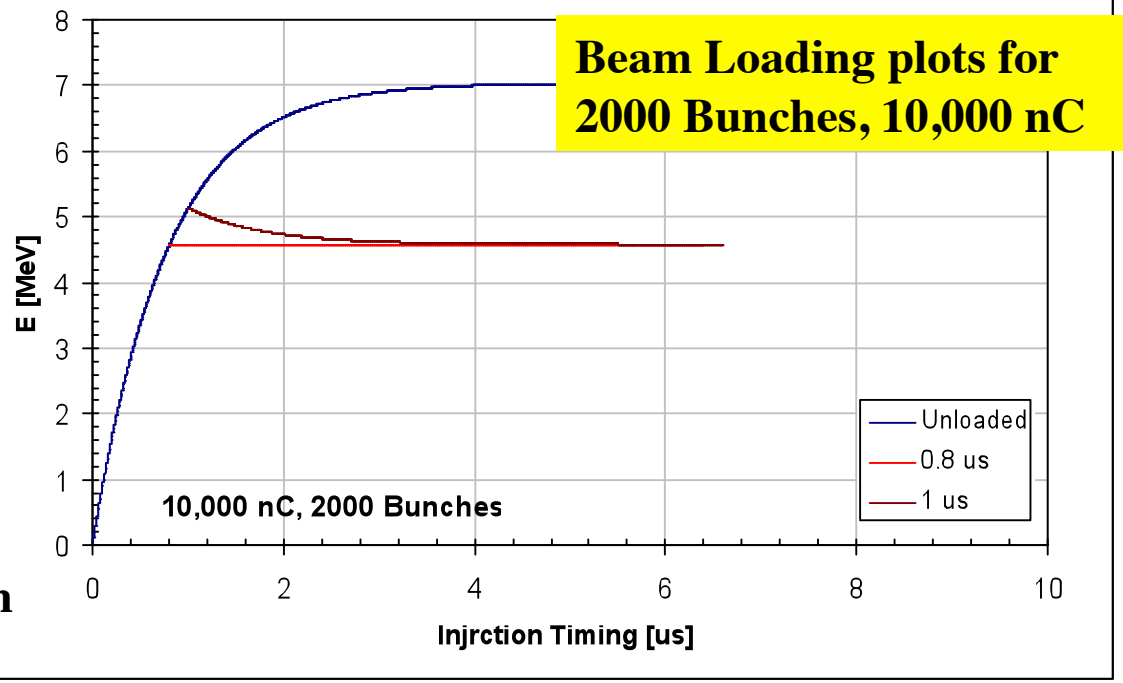
250mm



S-band RF Gun, more than 100MV/m
Operation:120MV/m,max.:140MV/m



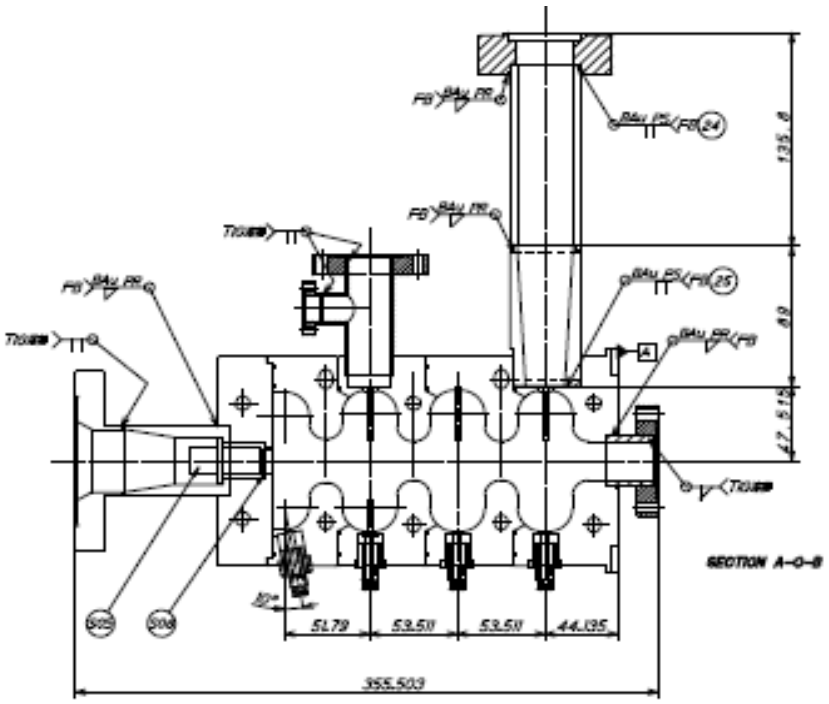
Beam Loading plots for 1000 Bunches, 5000 nC



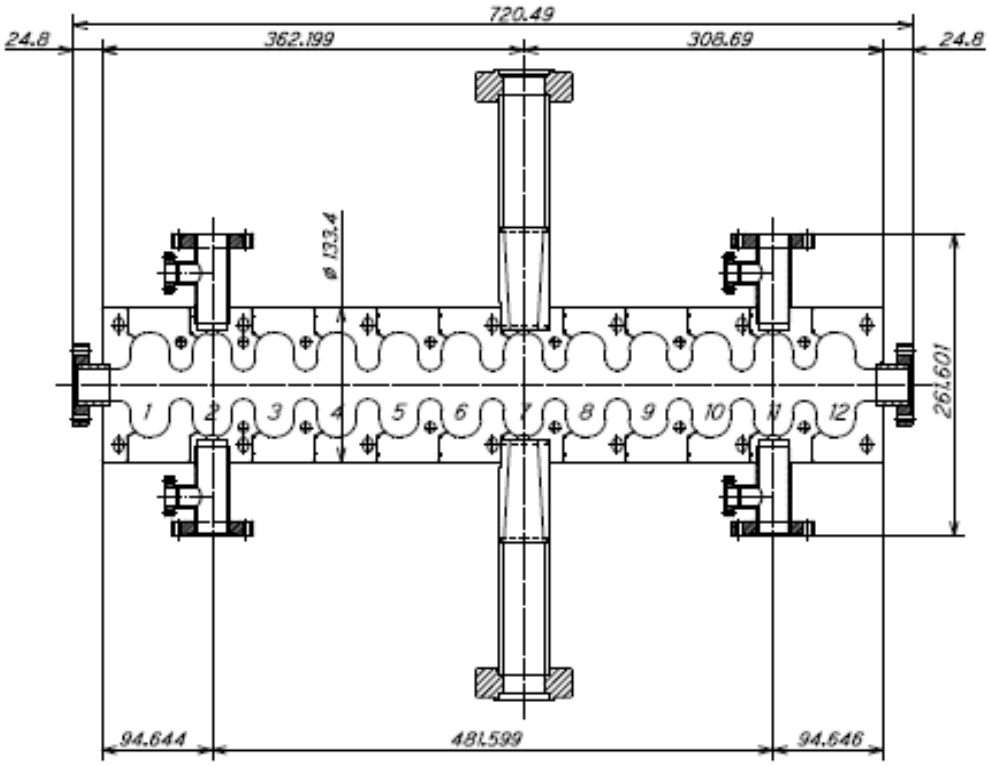
Beam Loading plots for 2000 Bunches, 10,000 nC

Advanced Photo-cathode RF Gun and accelerator R&D

360mm



720mm



S-band 3.6 cell RF Gun ~ 12MeV

S-band 12 cell booster linac to get 50MeV.

Comparison of various parameters of 1.6 cell RF Gun

	Simulated	Measured	
	New Gun	New Gun	Old Gun
Frequency MHz	2855.64	2855.61	2855.74
Mode Separation MHz	8.67	8.63	3.52
Field Balance	1.0	0.98	1.3
Quality Factor Q	18000	14,700	7900
Coupling β	1.0	1.0	0.6

RF Gun	Q
BNL (original)	7900
LUCX (original)	7900
ATF (modified)	12600
BNL (modified)	12780
LUCX New (Curved Profile)	14,700
LCLS (modified)	13,900

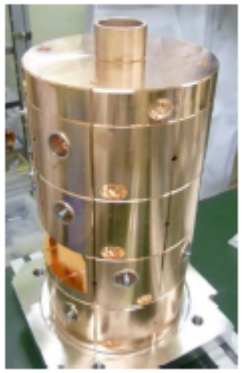
3.6 cell RF Gun perfect machining and tuning

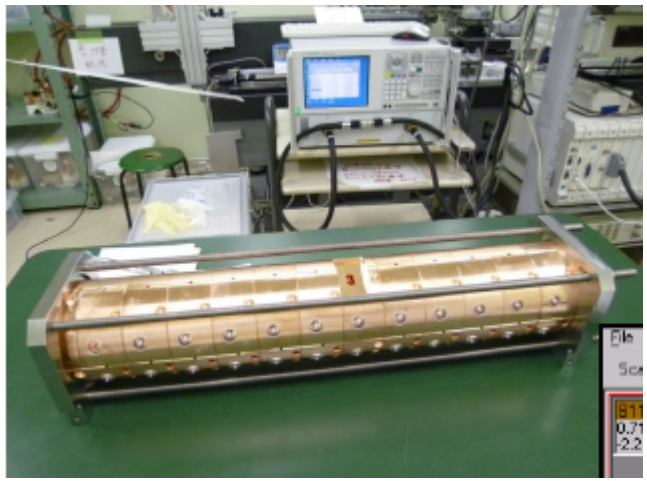
Resonance mode	3pi/3	2pi/3	1pi/3	0pi/3
Measurement [MHz]	2855.63	2852.82	2846.59	2841.55
Target [MHz]	2855.65	2852.82	2846.57	2841.65

Cell	Half cell	Full cell-1	Full cell-2	Full cell-3
Measurement [MHz]	2848.97	2848.06	2847.64	2851.82
Target [MHz]	2848.85	2848.10	2847.45	2851.70

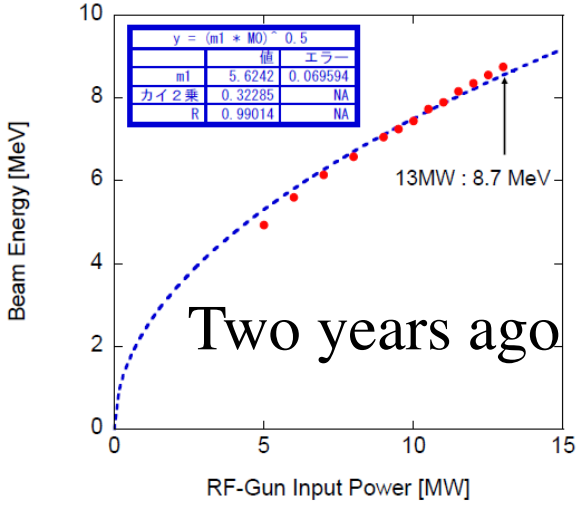
Machining on 12 cell booster structure is on going.
We will replace 3m TW structure to this booster soon.

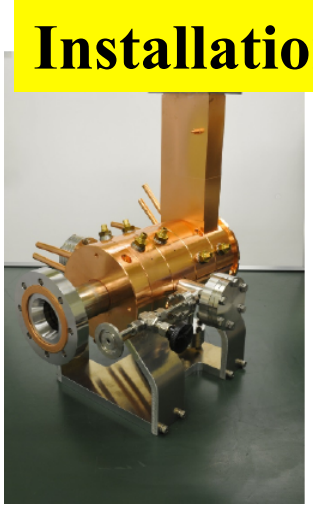
4 cell Test

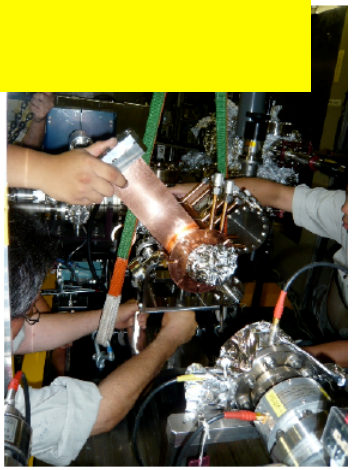




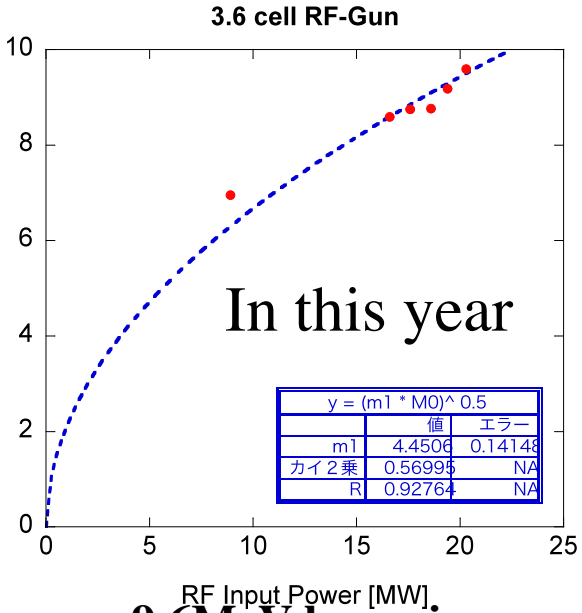
3.6 cell RF Gun Installation

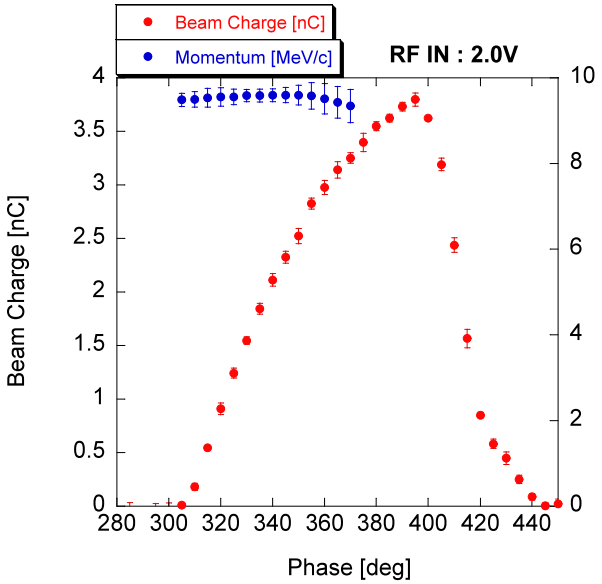


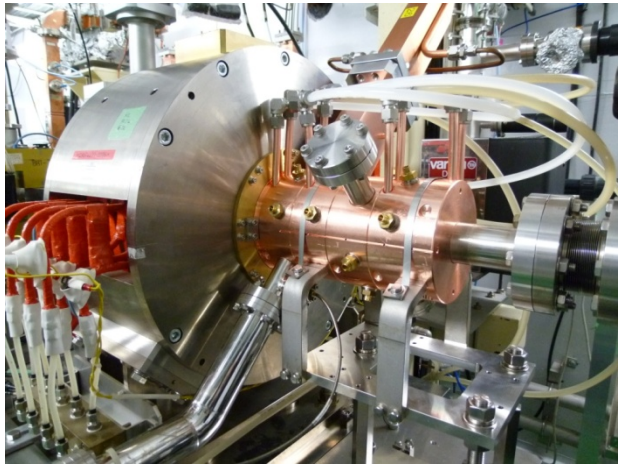




ATF インストールの様子

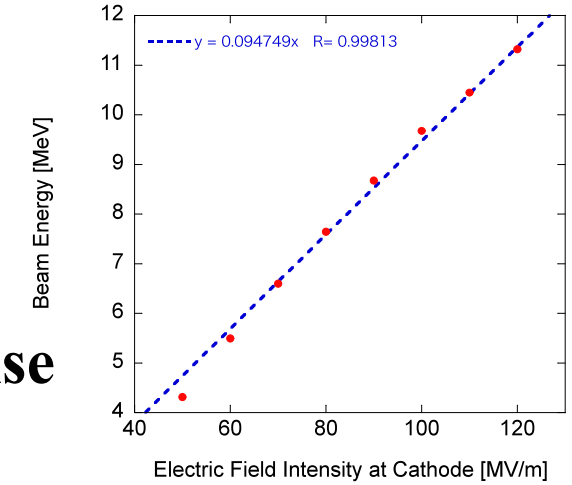






9.6MeV beam in a week RF aging with ~20.3MW RF input power

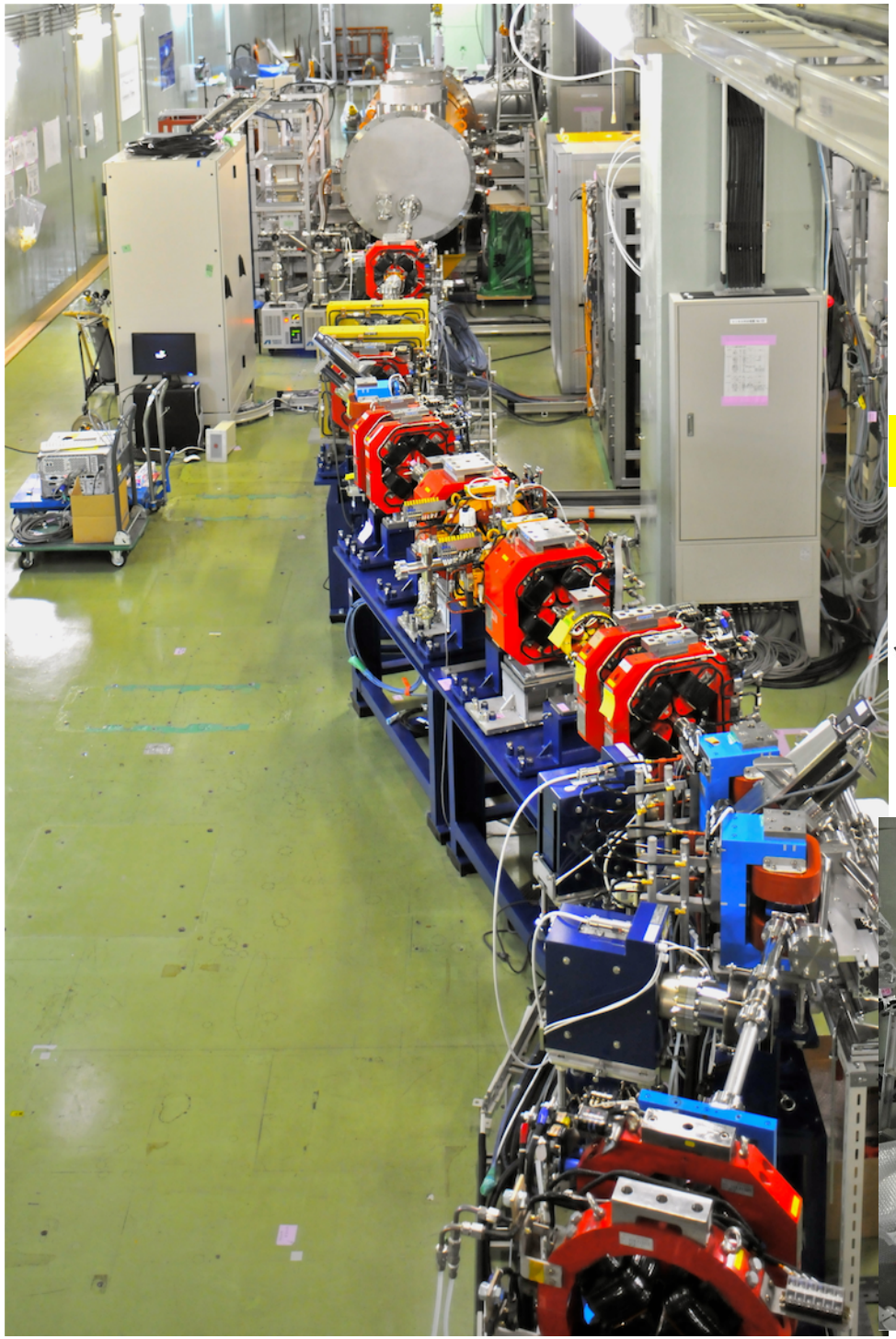
PARMELA SIMULATION

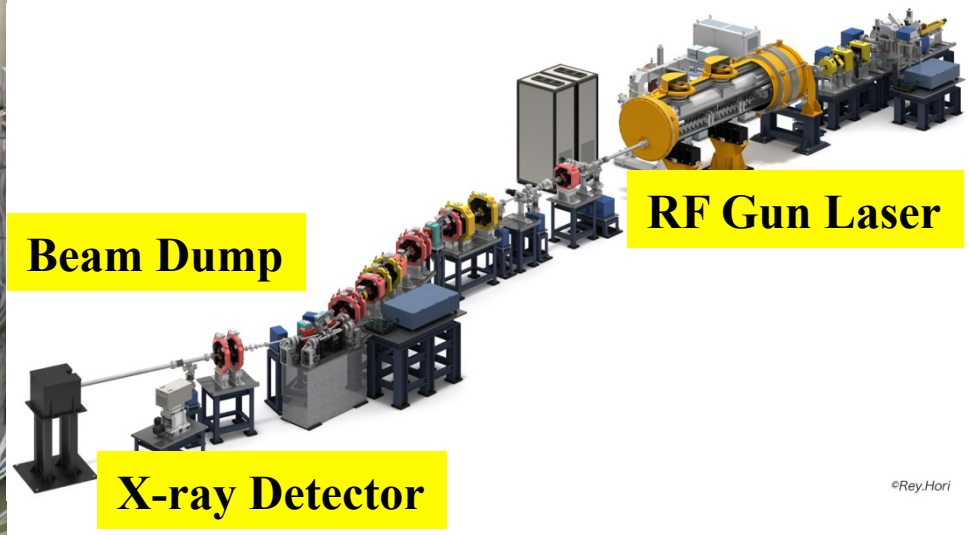


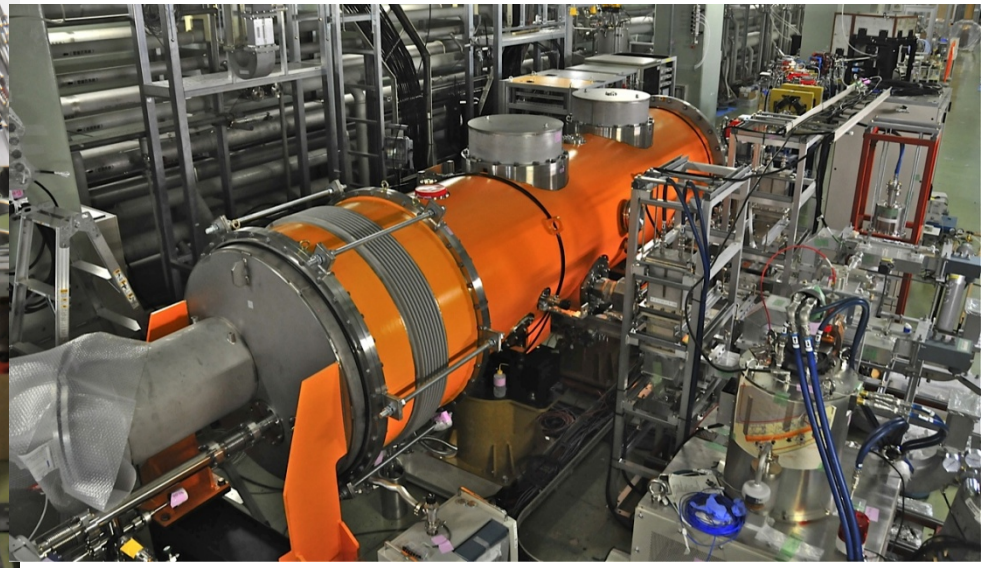
3.6 cell RF-Gun
Start of beam acceleration test from 1/11,2012.

11MeV beam at 120MV/m, from 100bunches/pulse to 1000bunches/pulse beam generation

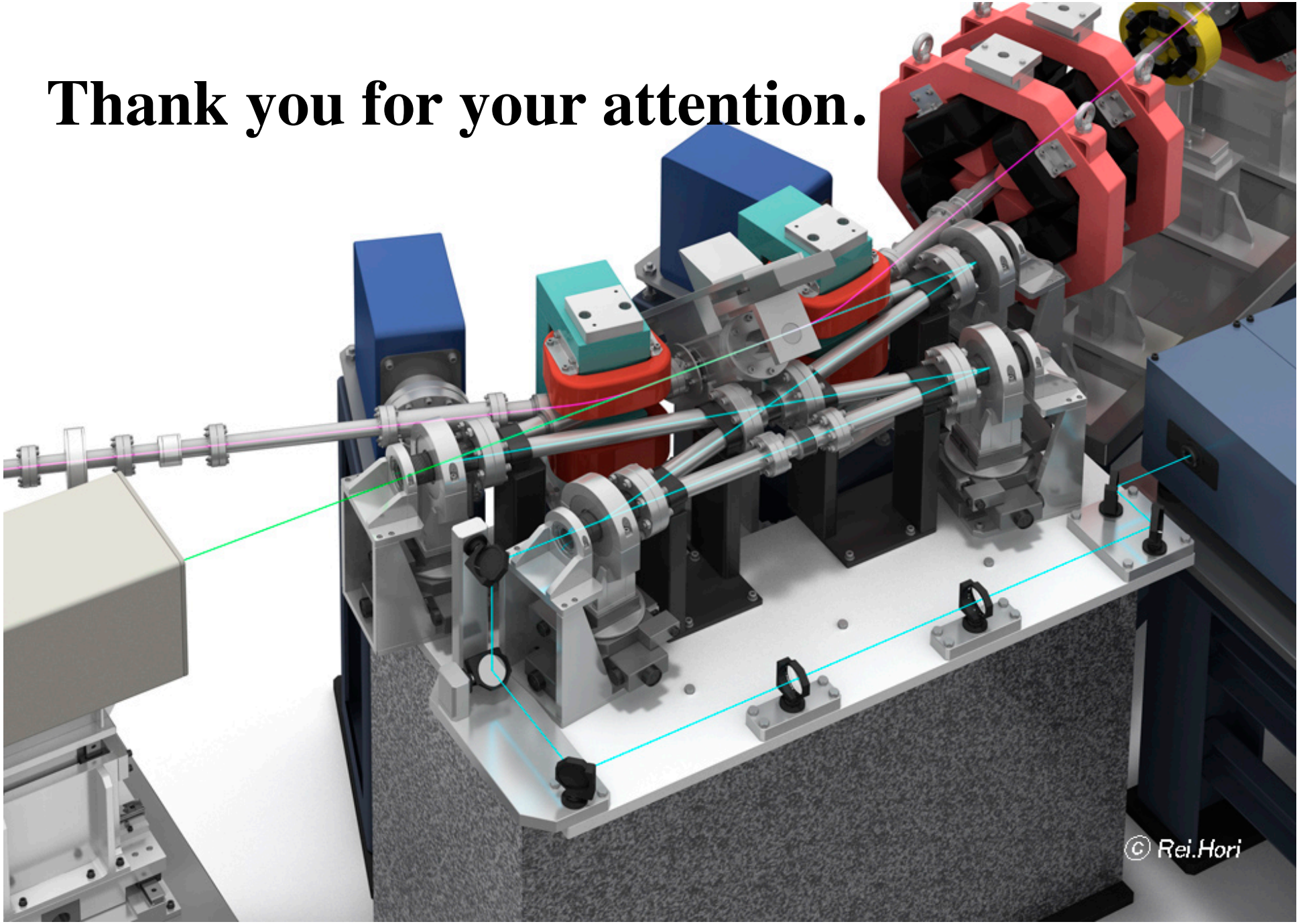
View of QBTP from Beam Dump



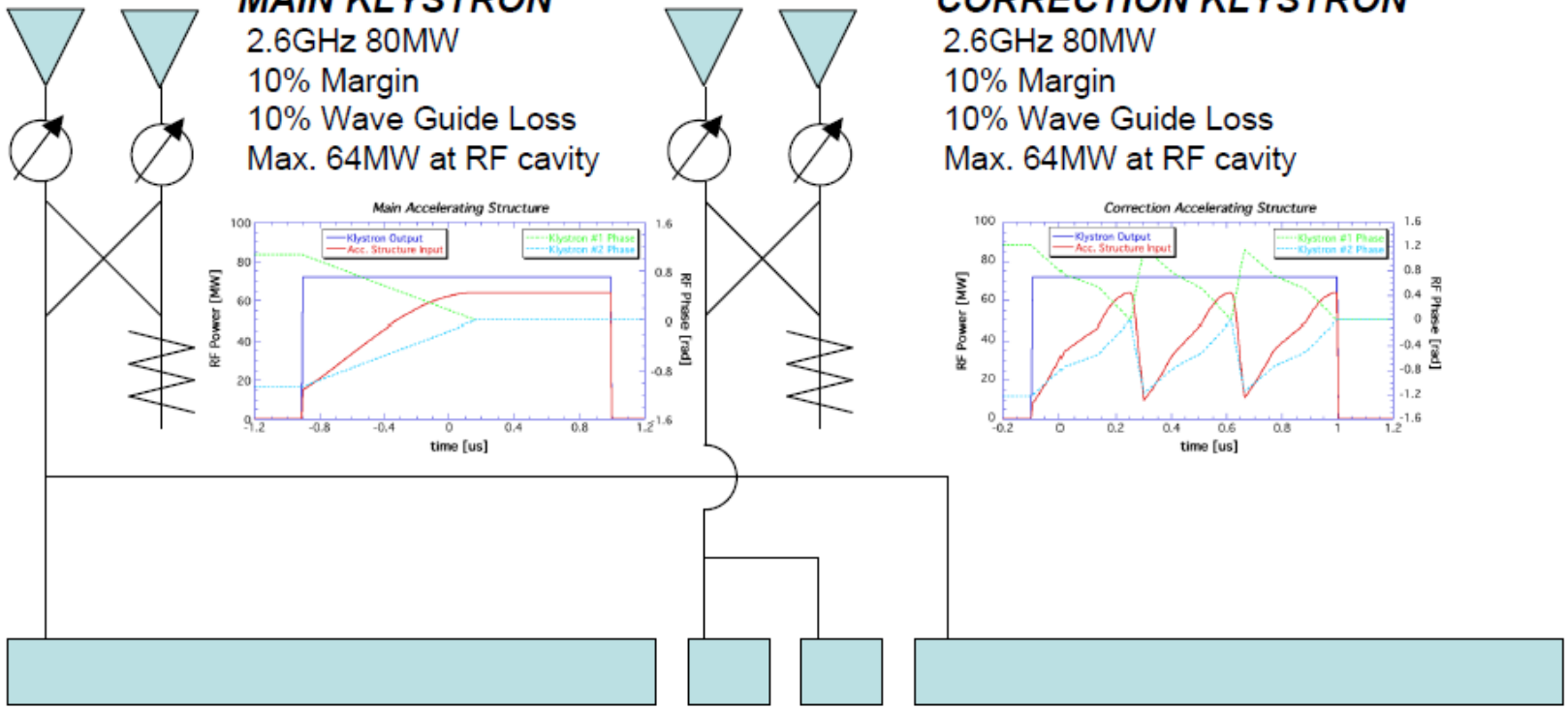




Thank you for your attention.



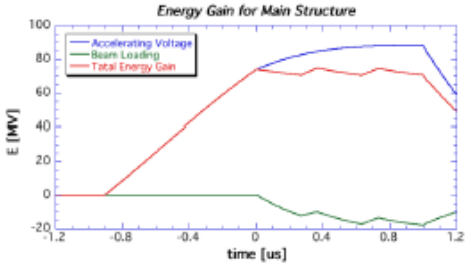
Concept Design of Single RF Unit (Nb=2e10)



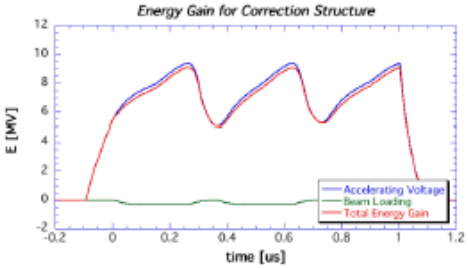
MAIN KLYSTRON
2.6GHz 80MW
10% Margin
10% Wave Guide Loss
Max. 64MW at RF cavity

CORRECTION KLYSTRON
2.6GHz 80MW
10% Margin
10% Wave Guide Loss
Max. 64MW at RF cavity

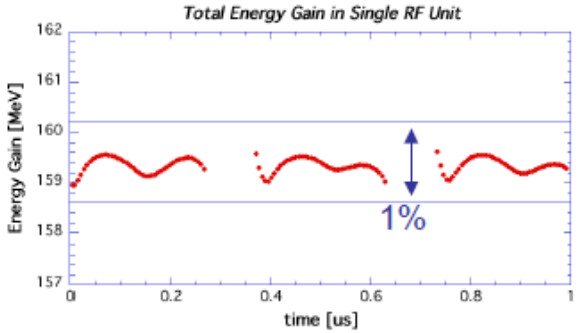
Main RF Cavity
L=3.00m (2.6GHz)
tf=906ns
Q0=13000
r0=60MOhm



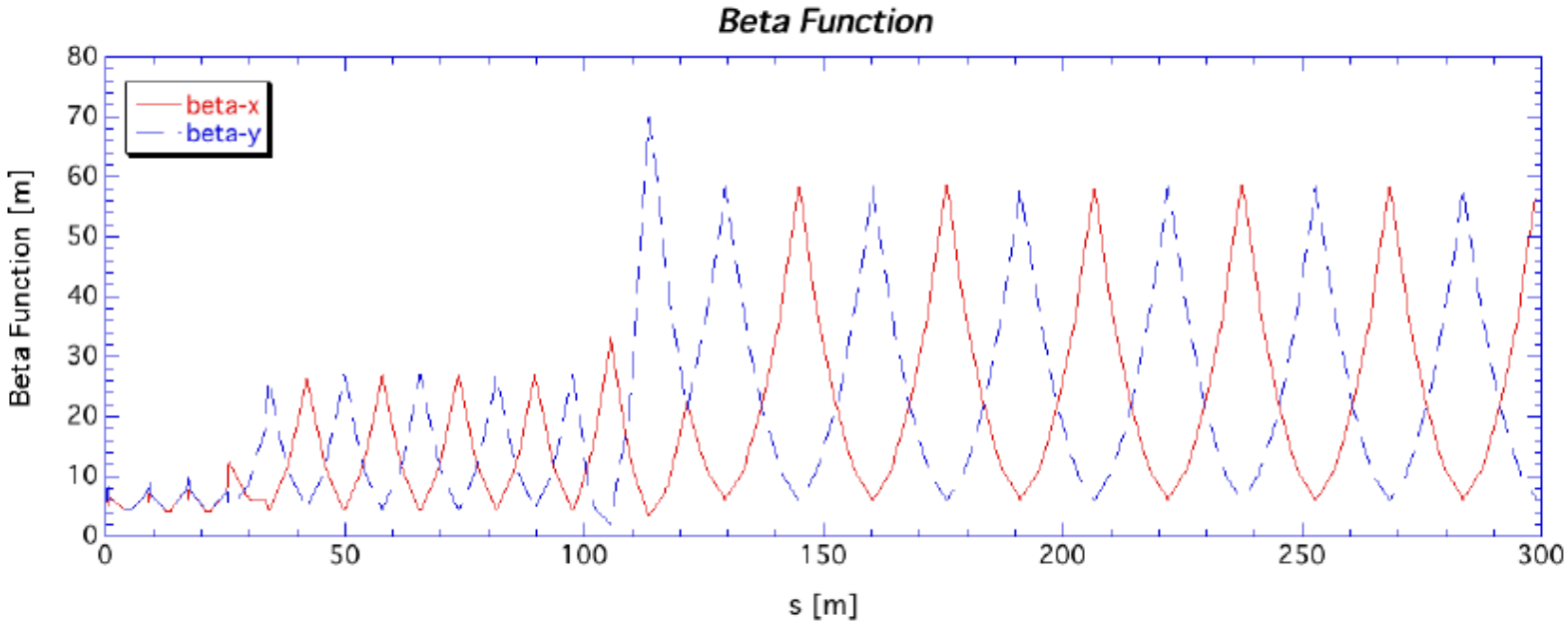
Correction RF Cavity
L=0.33m (2.6GHz)
tf=96ns
Q0=850
r0=5.3MOhm

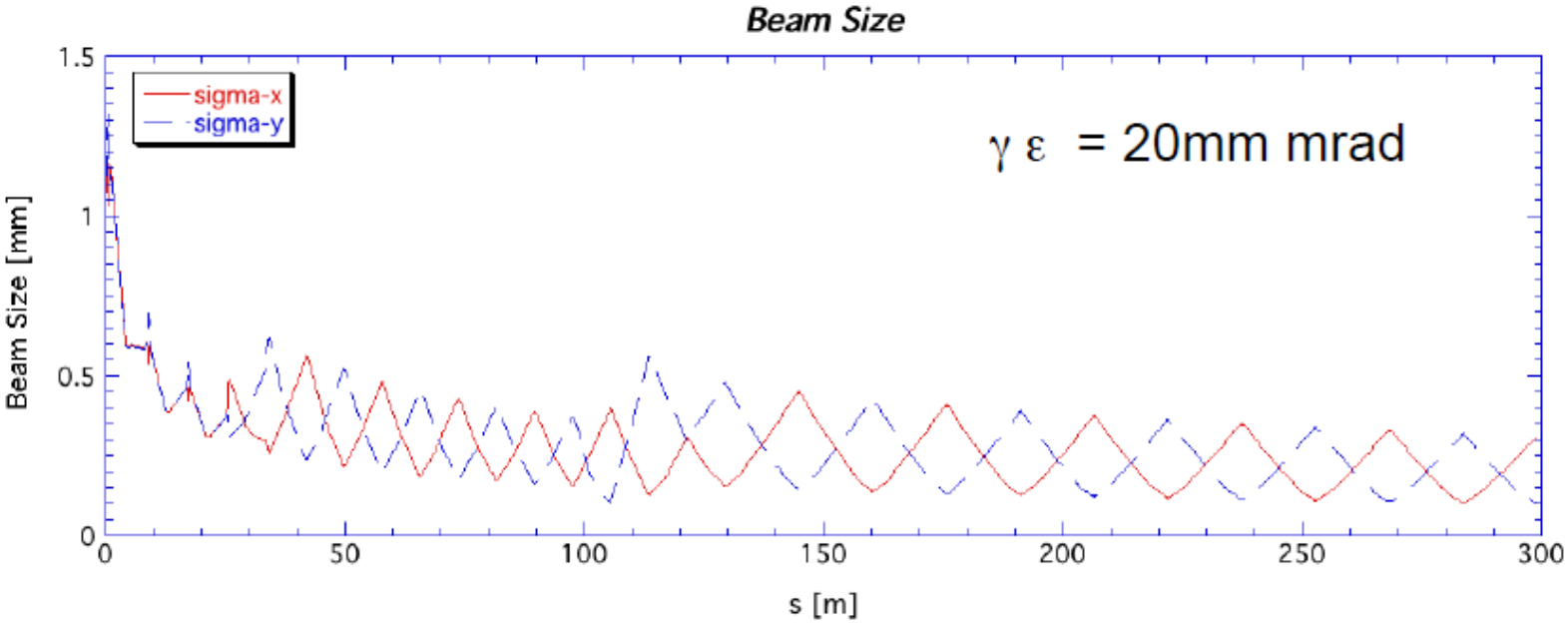


Total Energy Gain in 1 Unit
159.3MeV



Beam Optics Design for 6GeV Linac (Nb=2e10)





Device List for 6 GeV Linac (Nb=2e10)

Magnet List

35 quads
27 horizontal steerings
27 vertical steerings

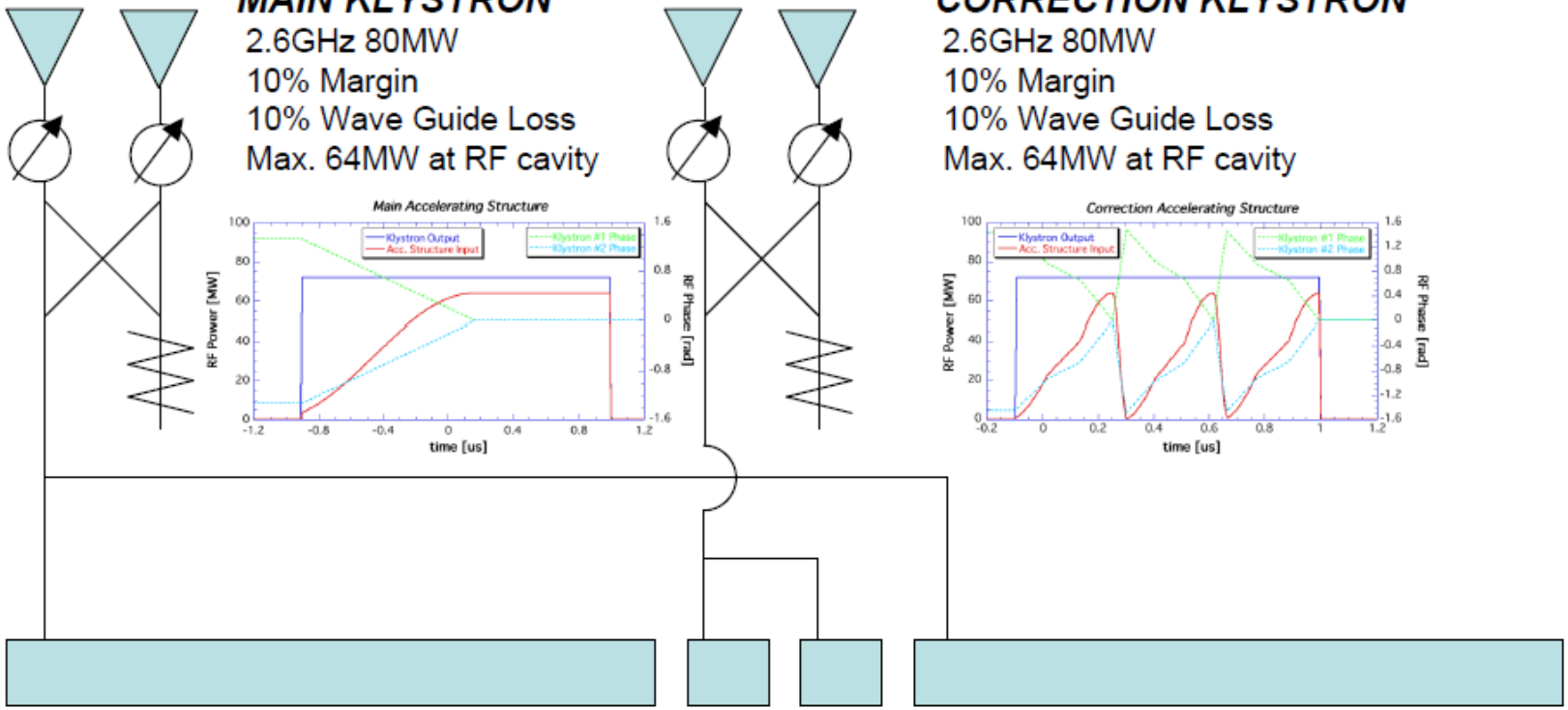
Magnet Name	Effective Length [m]	dB/dx [T/m]
Q01.1	0.1	1.3332
Q02	0.1	−2.6201
Q01.2	0.1	1.3332
Q03.1	0.1	6.0686
Q04	0.1	−11.9069
Q03.2	0.1	6.0686
Q05.1	0.1	11.1410
Q06	0.1	−21.8199
Q05.2	0.1	11.1410
Q07	0.1	−13.9861
Q08	0.1	14.5026
Q09	0.1	11.9981
Q10	0.1	−14.1085
Q11.1	0.1	5.0587
Q12.1	0.1	−6.0110
Q11.2	0.1	6.9631
Q12.2	0.1	−7.9155
Q11.3	0.1	8.8675
Q12.3	0.1	−9.8199
Q11.4	0.1	10.7720
Q13	0.1	−14.7304
Q14	0.1	13.3063
Q15	0.1	−12.6623
Q16	0.1	14.5968
Q17.1	0.1	−9.1552
Q18.1	0.1	10.2777
Q17.2	0.1	−11.4002
Q18.2	0.1	12.5226
Q17.3	0.1	−13.6451
Q18.3	0.1	14.7676
Q17.4	0.1	−15.8901
Q18.4	0.1	17.0125
Q17.5	0.1	−18.1350
Q18.5	0.1	19.2575
Q17.6	0.1	−20.3800

RF section

RF Unit

Maximum Accelerating Volatage (80MW Klystron Output)	170MV
Nominal Accelerating Voltage (72MW Klystron Output)	159.3MV
Number of Unit	38
Nominal Accelerating Voltage	6.05GeV

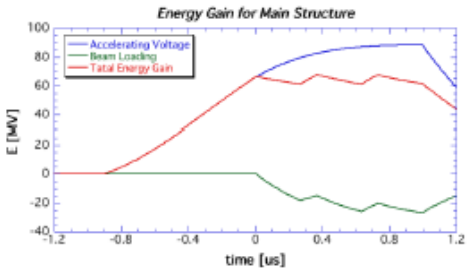
Concept Design of Single RF Unit (Nb=3e10)



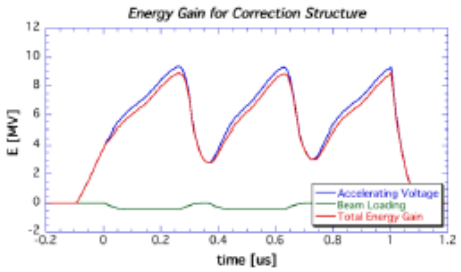
MAIN KLYSTRON
2.6GHz 80MW
10% Margin
10% Wave Guide Loss
Max. 64MW at RF cavity

CORRECTION KLYSTRON
2.6GHz 80MW
10% Margin
10% Wave Guide Loss
Max. 64MW at RF cavity

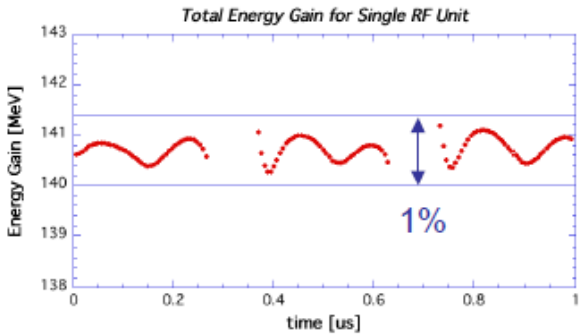
Main RF Cavity
L=3.00m (2.6GHz)
tf=906ns
Q0=13000
r0=60MOhm



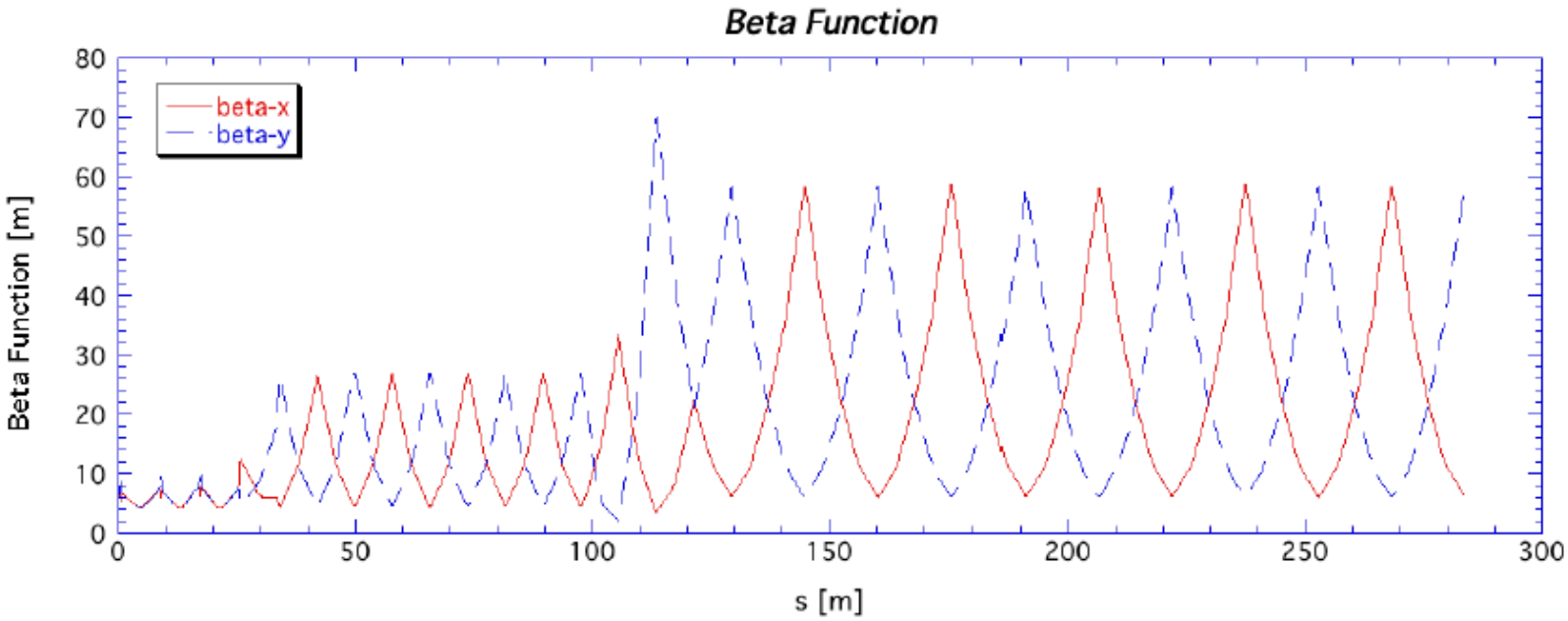
Correction RF Cavity
L=0.33m (2.6GHz)
tf=96ns
Q0=850
r0=5.3MOhm

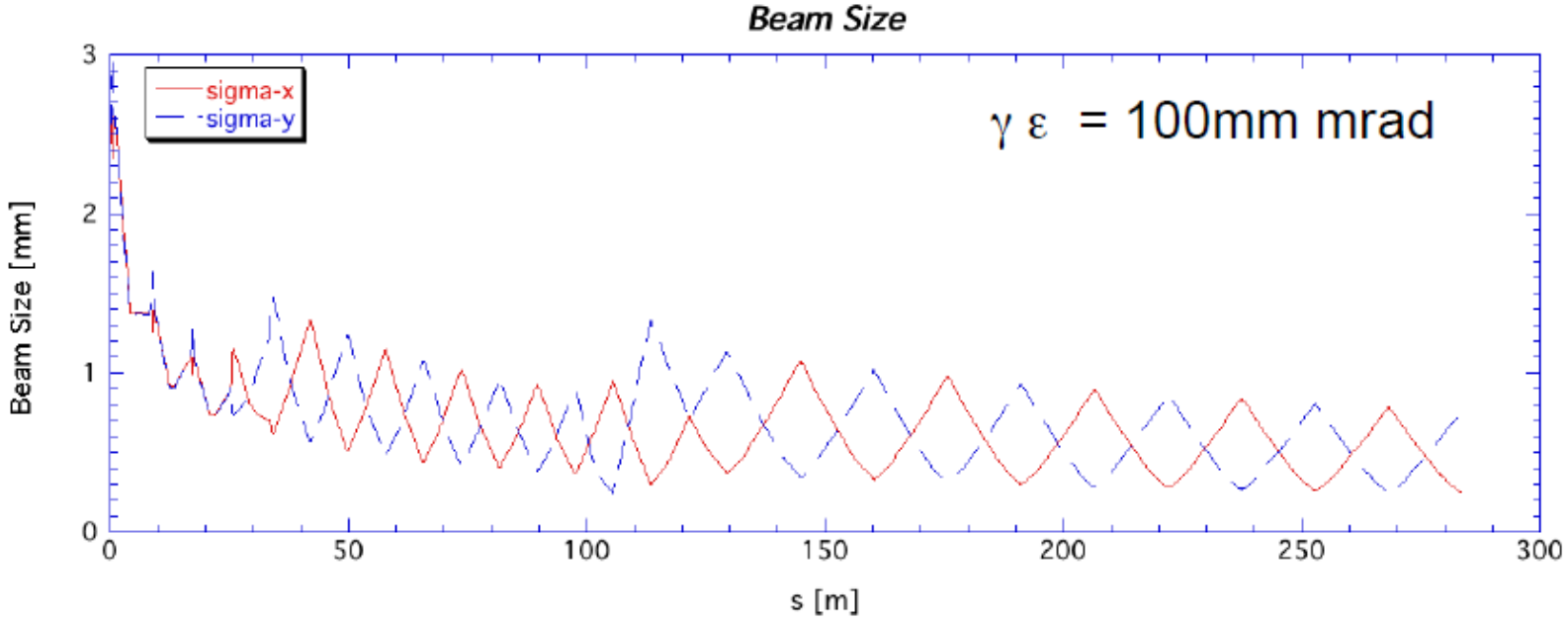


Total Energy Gain in 1 Unit
140.6MeV



Beam Optics Design for 5GeV Linac (Nb=3e10)





Device List for 5 GeV Linac (Nb=3e10)

Magnet List

34 quads
26 horizontal steerings
26 vertical steerings

Magnet Name	Effective Length [m]	dB/dx [T/m]
Q01.1	0.1	1.3391
Q02	0.1	−2.6322
Q01.2	0.1	1.3391
Q03.1	0.1	5.5491
Q04	0.1	−10.8851
Q03.2	0.1	5.5491
Q05.1	0.1	10.0016
Q06	0.1	−19.5879
Q05.2	0.1	10.0016
Q07	0.1	−12.4680
Q08	0.1	12.9311
Q09	0.1	10.6418
Q10	0.1	−12.5256
Q11.1	0.1	4.4933
Q12.1	0.1	−5.3325
Q11.2	0.1	6.1716
Q12.2	0.1	−7.0108
Q11.3	0.1	7.8498
Q12.3	0.1	−8.6892
Q11.4	0.1	9.5281
Q13	0.1	−13.0255
Q14	0.1	11.7631
Q15	0.1	−11.1916
Q16	0.1	12.8989
Q17.1	0.1	−8.0889
Q18.1	0.1	9.0780
Q17.2	0.1	−10.0672
Q18.2	0.1	11.0564
Q17.3	0.1	−12.0456
Q18.3	0.1	13.0348
Q17.4	0.1	−14.0239
Q18.4	0.1	15.0131
Q17.5	0.1	−16.0023
Q18.5	0.1	16.9915

RF section

RF Unit

Maximum Accelerating Volatage (80MW Klystron Output)	148MV
Nominal Accelerating Voltage (72MW Klystron Output)	140.6MV
Number of Unit	36
Nominal Accelerating Voltage	5.06GeV

6GeV Drive Linac with 2x10E10 e/bunch	unit :Myen	5GeV Positron Linac with 3x10E10 e/bunch	unit :Myen
38 RF units		36 RF units	
2 main klystrons x 38 with 10% margin and 10% loss		02 main klystrons x 36 with 10% margin and 10% loss	0
2.6GHz 64MW at RF cavity, total 76 Klystrons		17482.6GHz 64MW at RF cavity, total 72 Klystrons	1656
number of 3m long cavities, total 76 structures		1157number of 3m long cavities, total 72 structures	1096
2 phase shifters x 38, total 76 phase shifters		382 phase shifters x 36, total 72 phase shifters	36
HP combinor x 38		130HP combinor x 36	120
3dB divider x 38		703dB divider x 36	66
waveguide x 38		20waveguide x 36	20
2 modulators x 38, total 76 modulators		39522 modulators x 36, total 72 modulators	3744
Computor Control Unit x 38		30Computor Control Unit x 36	30
2 correction klystrons x 38 with 10% margin and 10% loss		02 correction klystrons x 36 with 10% margin and 10% loss	0
2.6GHz 64MW at RF cavity, total 76 Klystrons		17482.6GHz 64MW at RF cavity, total 72 Klystrons	1656
number of 0.33m long cavities, total 76 structures		468number of 0.33m long cavities, total 72 structures	443
2 phase shifters x 38, total 76 phase shifters		382 phase shifters x 36, total 72 phase shifters	36
HP combinor x 38		130HP combinor x 36	120
3dB divider x 38		703dB divider x 36	66
waveguide x 38		20waveguide x 36	20
2 modulators x 38, total 76 modulators		39522 modulators x 36, total 72 modulators	3744
Computor Control Unit x 38		30Computor Control Unit x 36	30
35 quads		3534 quads	34
27 horizontal steerings		1026 horizontal steerings	10
27 vertical steerings		1026 vertical steerings	10
power supplies for magnets		50power supplies for magnets	50
beam monitor devices		50beam monitor devices	50
	13756		13037

Total 26793MYen for 6GeV and 5GeV S-band 300Hz Linac