- Linac upgrade situation and goals
  - annual operation and construction
  - energy
  - positron
- Energy upgrade
  - modulator power increase
  - developments of high-power klystrons
  - rf compression device
  - high-power operation of acceleretor
  - acceleration test with SLED
- Positron increase
  - location of the positron production target
  - producing high-current single-bunch beams
  - injector
  - wake-field issues
  - alignment
  - beam position monitors
  - acceleration tests
  - expected positron intensity and injection time
- Operation of e+/e- beams
- Schedule

Two main goals for KEKB

1) Energy upgrade

electron: 2.5 GeV ---(×3.2)---> 8.0 GeV

positron: 2.5 GeV -----> 3.5 GeV

2) Positron increase

2×10^8 (/ 2-ns pulse)

---(×20)---> 4×10^9 (/ single bunch)

Users of Linac

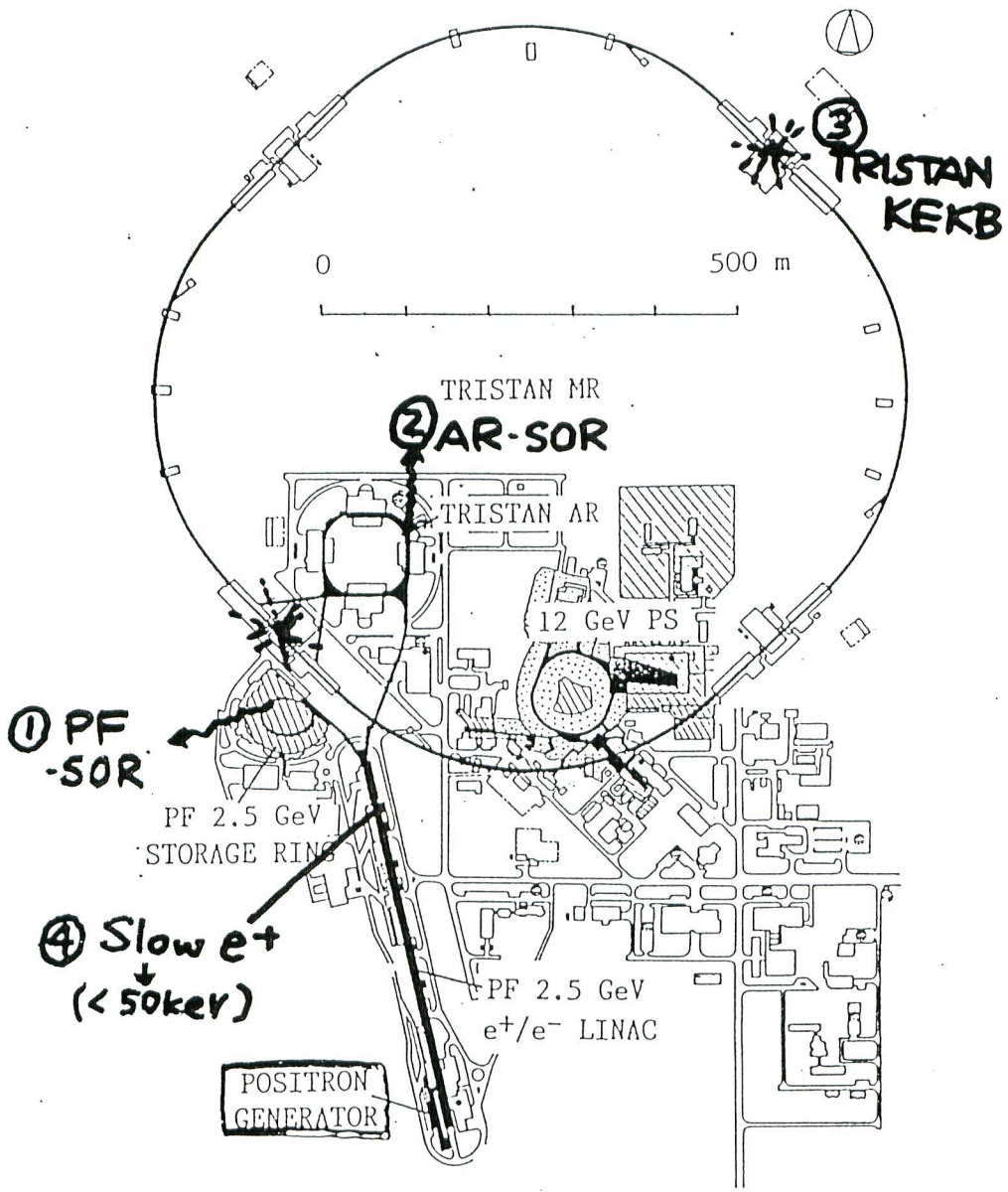
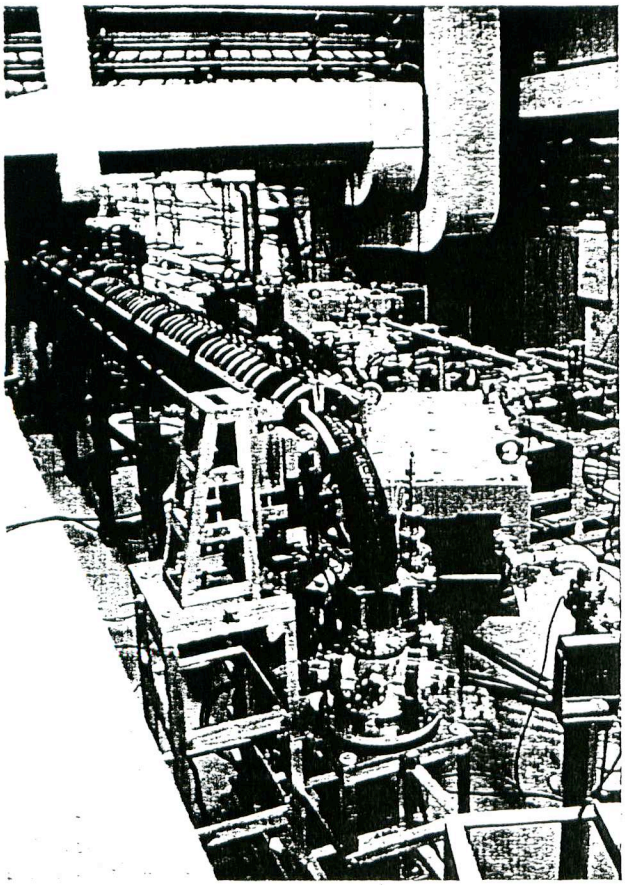


Fig.1



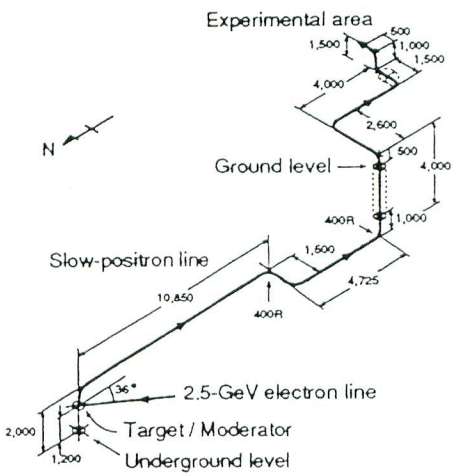


Fig. 10 Schematic layout of the slow-positron beam line.

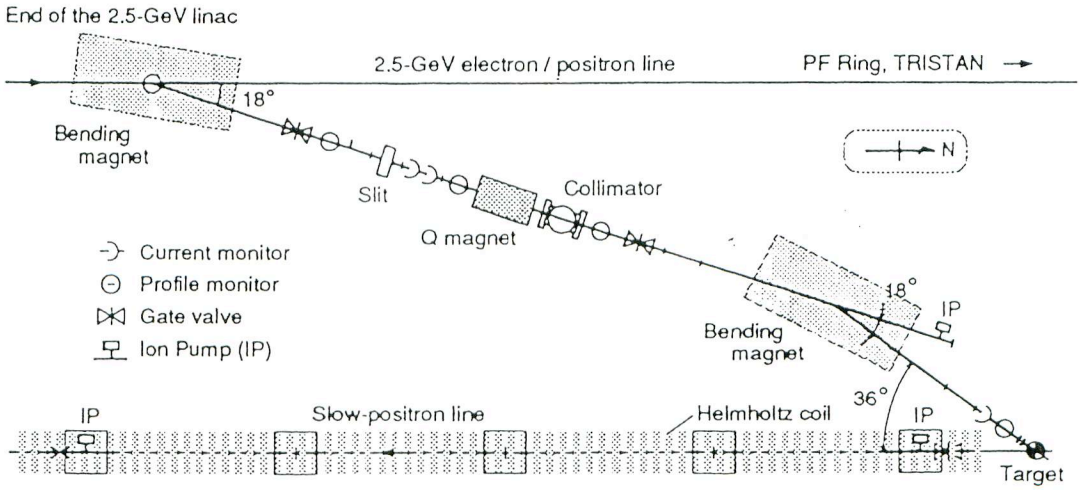


Fig. 9 Layout of the reconstructed beam lines in the switchyard at the end of the 2.5-GeV Linac.

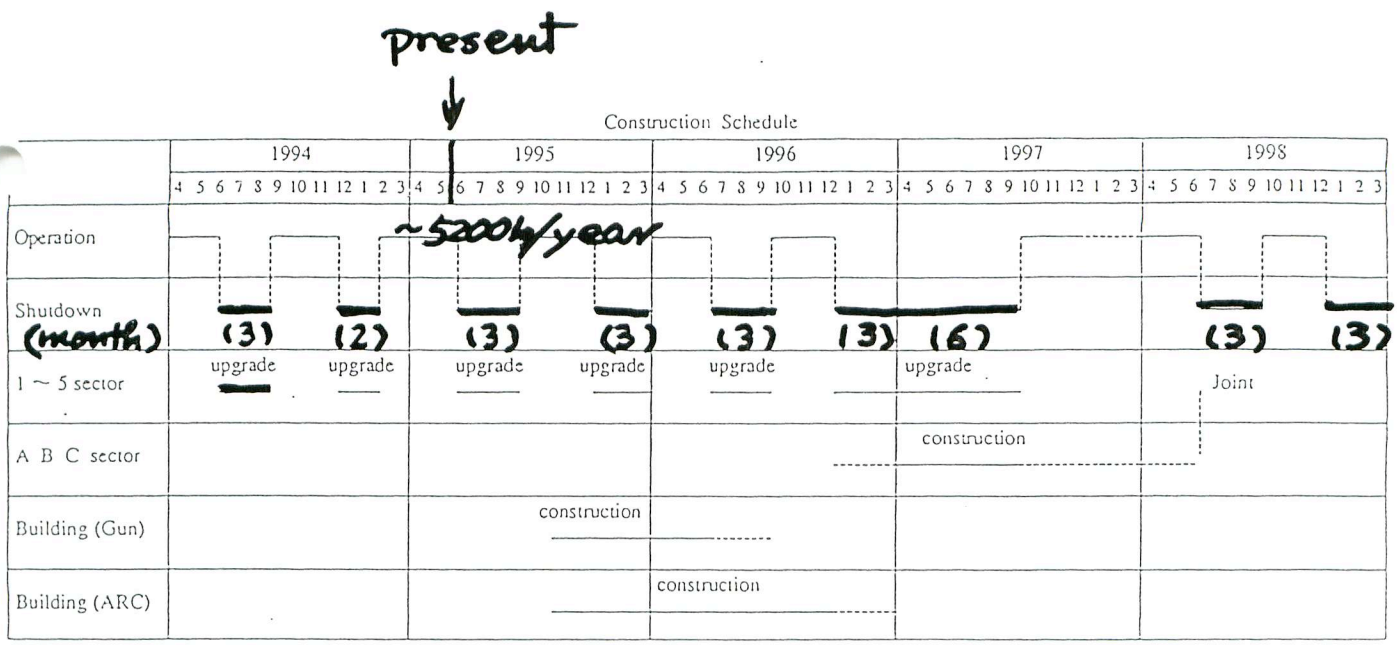


Table 9.4: The schedule of the injector upgrade program.

For energy upgrading...

did not choose complete replace -
ment by higher-power rf sources

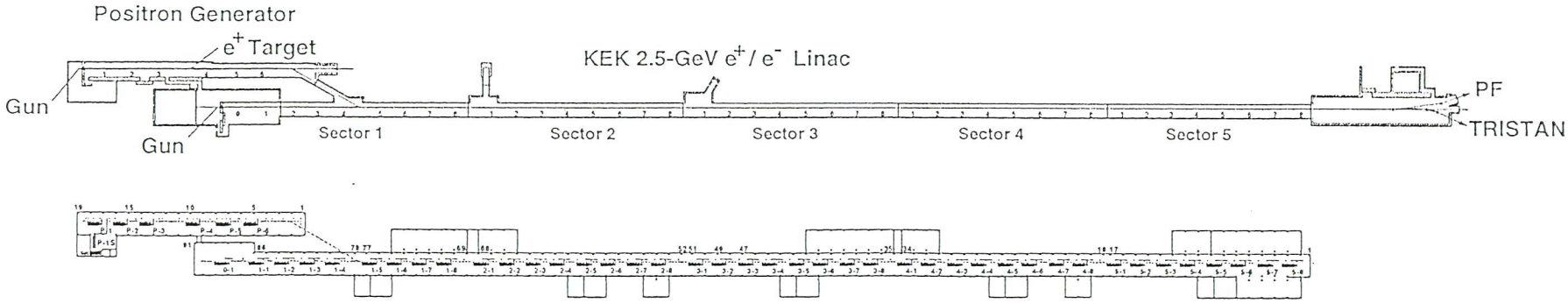
instead

chose succesive improvement
from 30-MW to 50-MW system
using existing rf sources

+

small extension of the linac
2 pre-injectors + 46 regular units
------> 1 pre-injector + 57 units

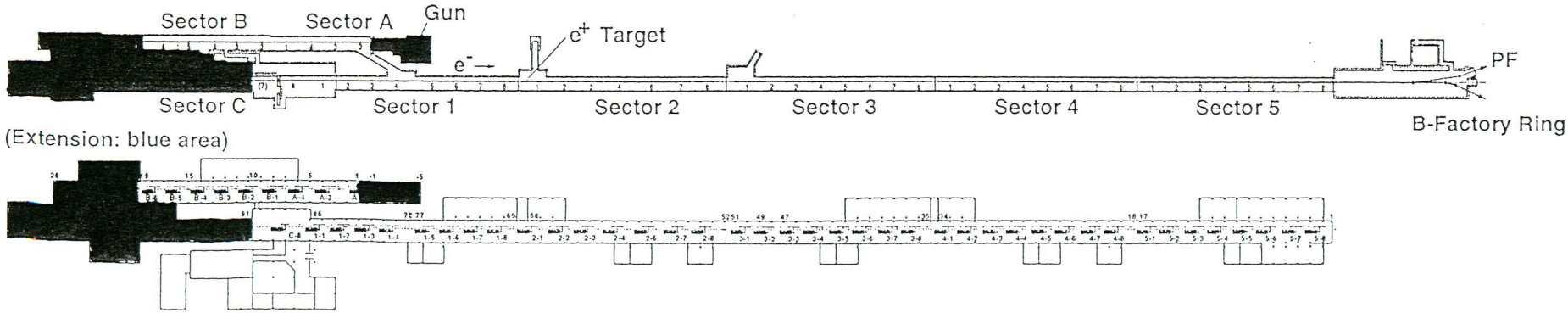
LAYOUT OF THE KEK INJECTOR LINAC



PRESENT

Energy up grade by linac extension

UPGRADED



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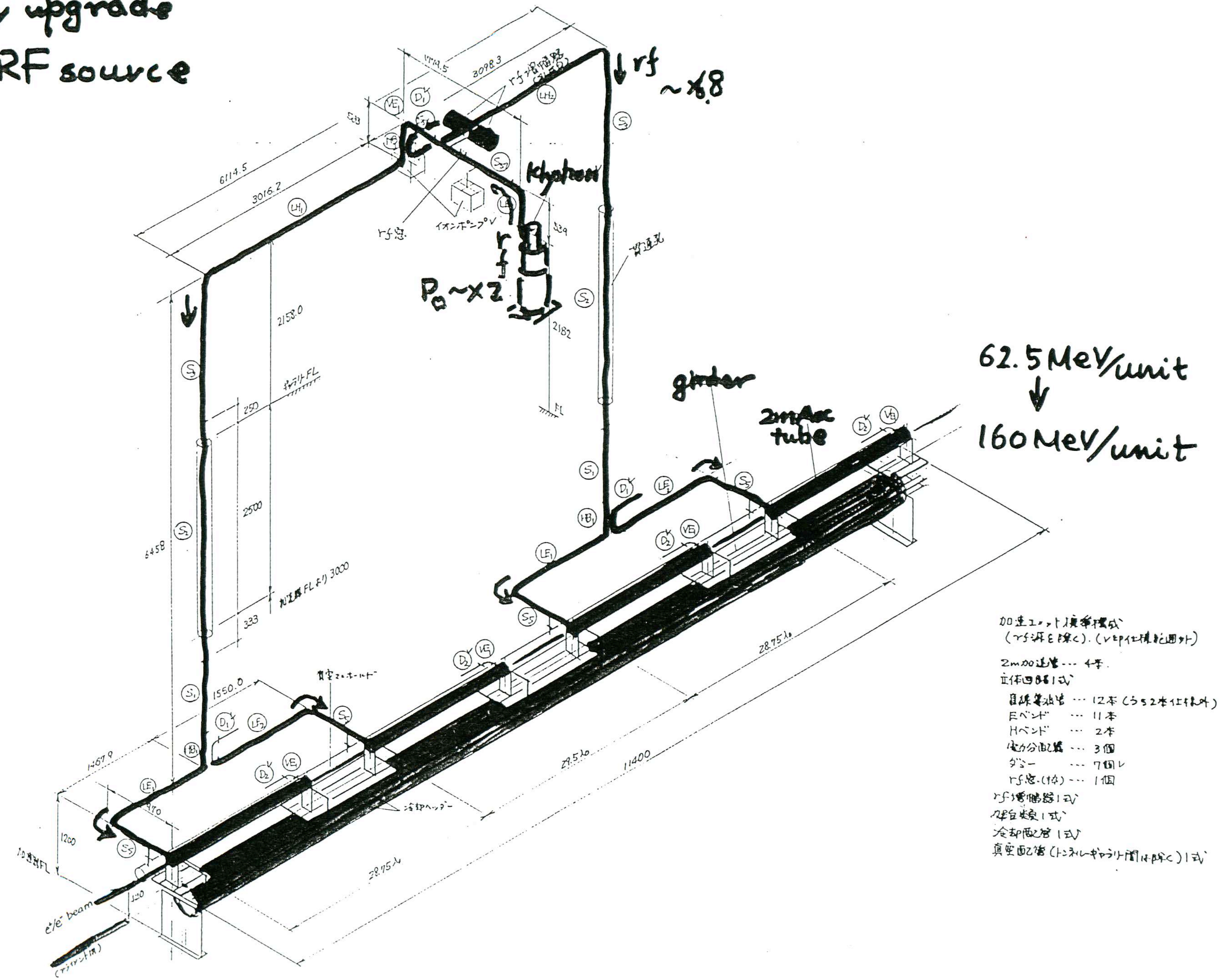
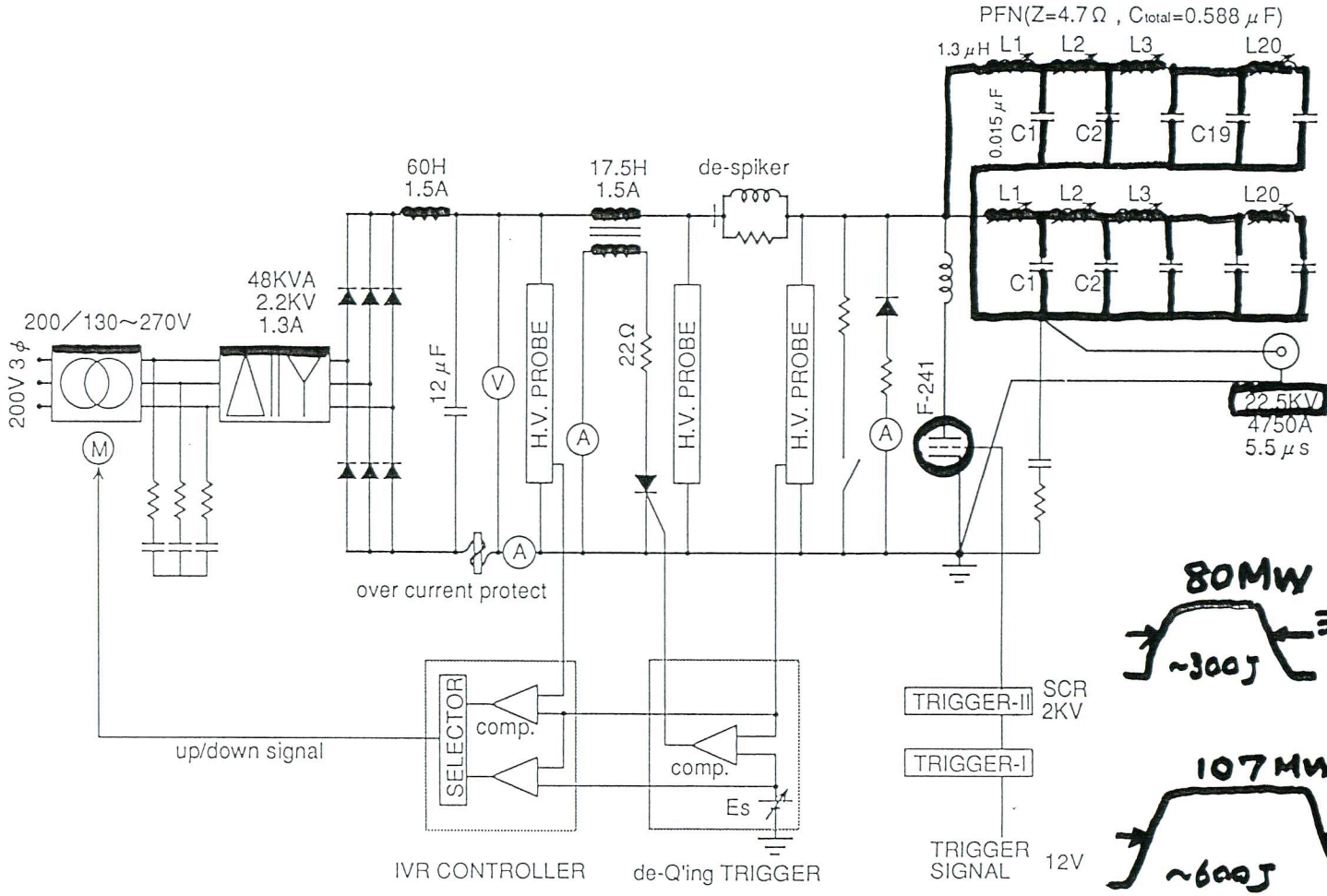
Energy upgrade in RF source



Modulator Upgrade



Step-up

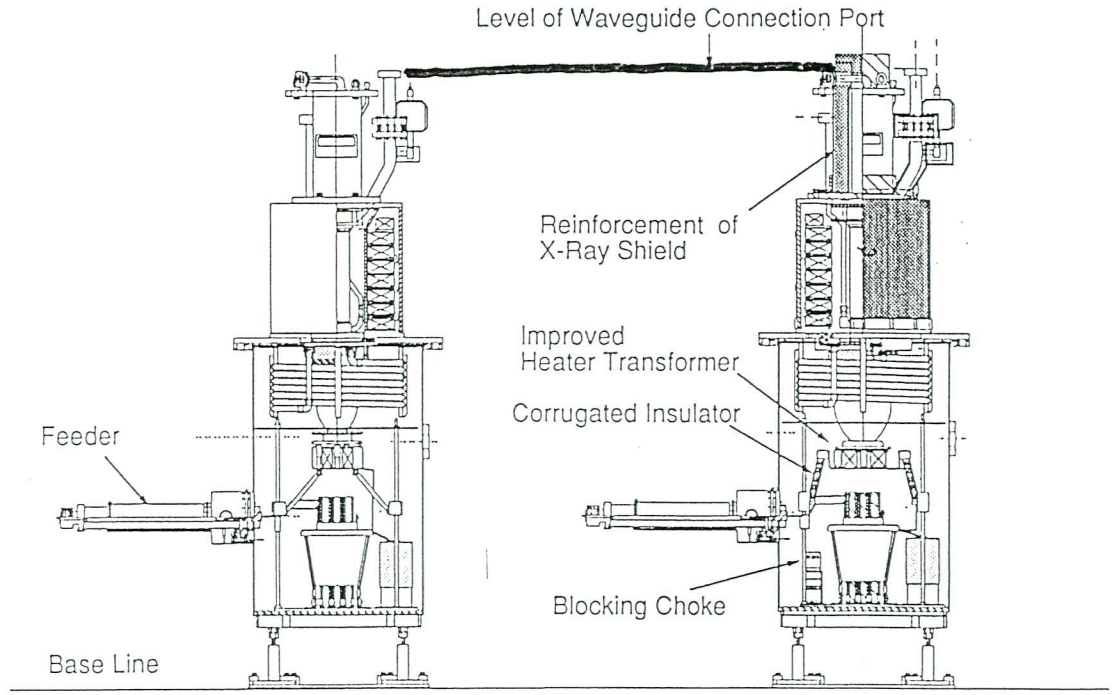
80MW
3.5μs
~300J
270V
295A
1:12

⇓ upgrade

107MW
5.6μs
~600J
304V
352A
1:13.5

22.5kV
4.75kA

High-power Klystron Developements



Old system
Klystron PV3030A2, 30 MW
260 kV, 2 microsec(rf), 50 pps
Permanent Magnet Focusing
(partly electromagnet)
Pulse Transformer 1:12
Without core bias

Final design
system
Under test

Klystron 50 MW Tube
310 KV(max), 4 microsec (rf)
50 pps, SLED system
Electromagnet Focusing
Pulse Transformer 1:13.5
With core bias

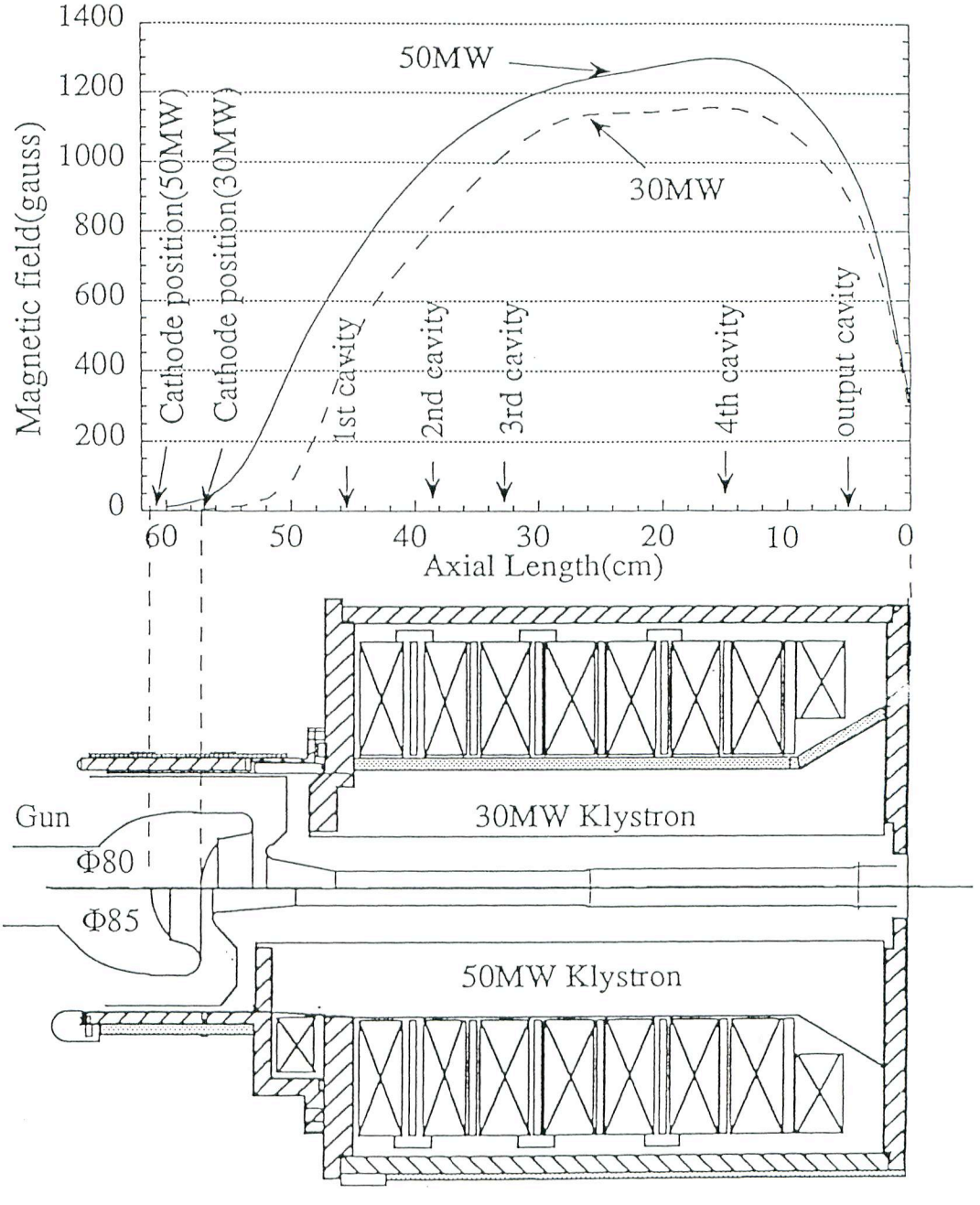
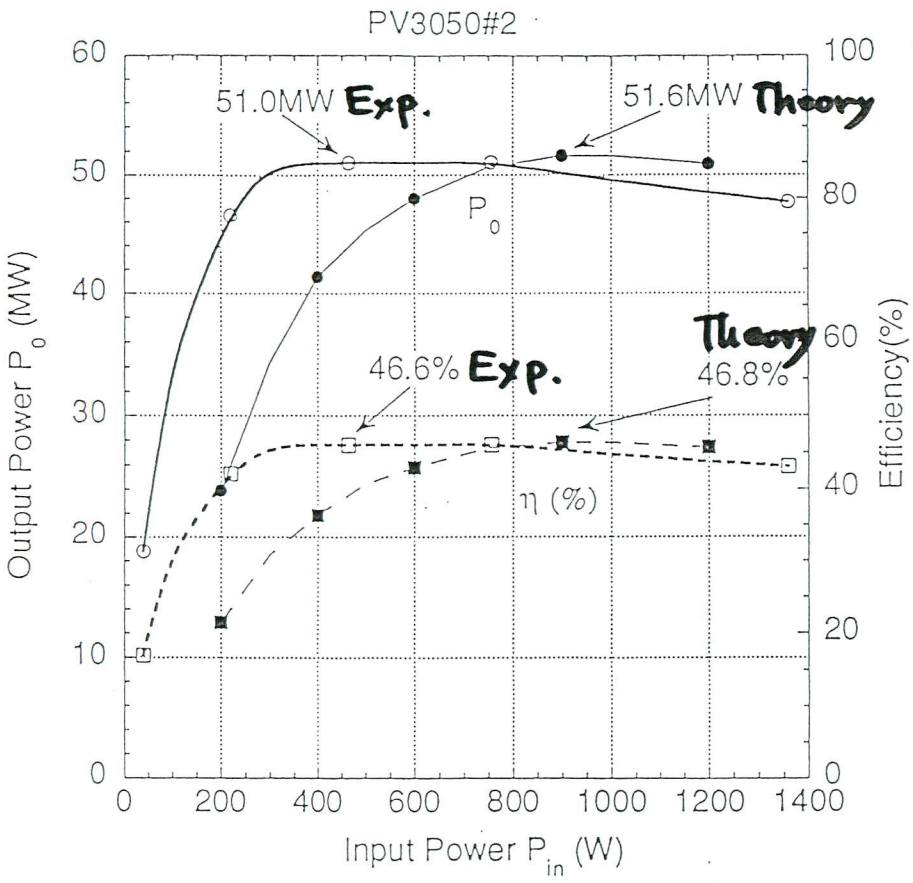

1400
1200
1000
800
600
400
200
0
Magnetic field(gauss)
50MW
30MW
Cathode position(50MW)
Cathode position(30MW)
1st cavity
2nd cavity
3rd cavity
4th cavity
output cavity
60
50
40
30
20
10
0
Axial Length(cm)
Gun
Φ80
Φ85
30MW Klystron
50MW Klystron

Figure 3


PV3050#2
51.0MW Exp.
51.6MW Theory
P0
Theory
46.6% Exp.
46.8%
η (%)
Output Power P0 (MW)
Efficiency(%)
Input Power Pin (W)
0
10
20
30
40
50
60
0
20
40
60
80
100
0
200
400
600
800
1000
1200
1400

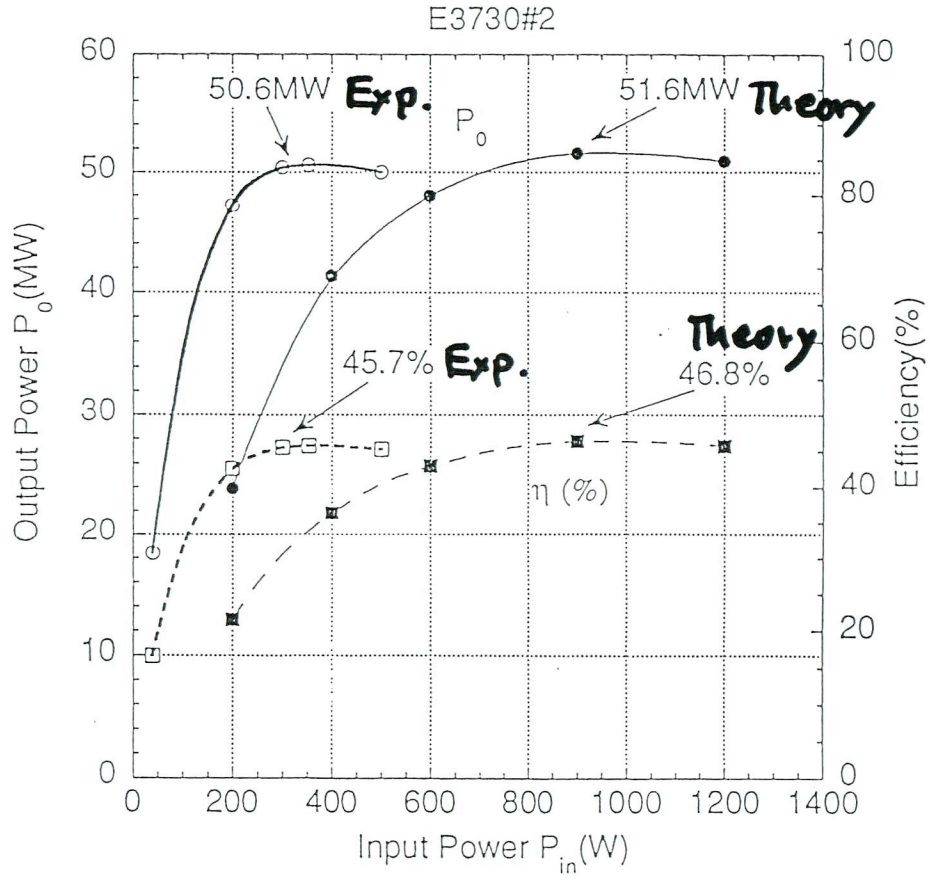
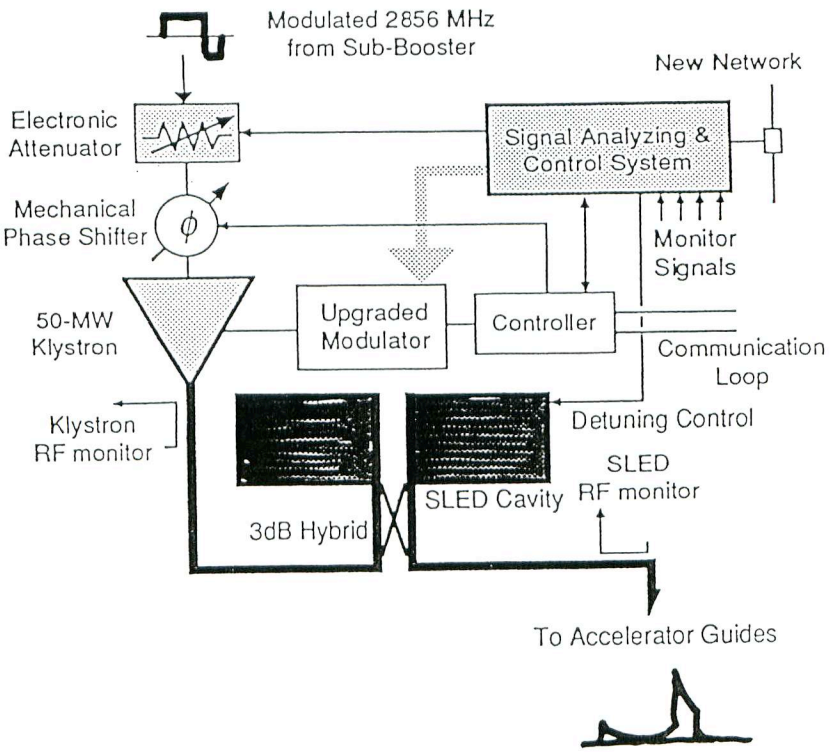

E3730#2
50.6MW Exp.
51.6MW Theory
P0
Theory
45.7% Exp.
46.8%
η (%)
Output Power P0(MW)
Efficiency(%)
Input Power Pin(W)
0
10
20
30
40
50
60
0
20
40
60
80
100
0
200
400
600
800
1000
1200
1400

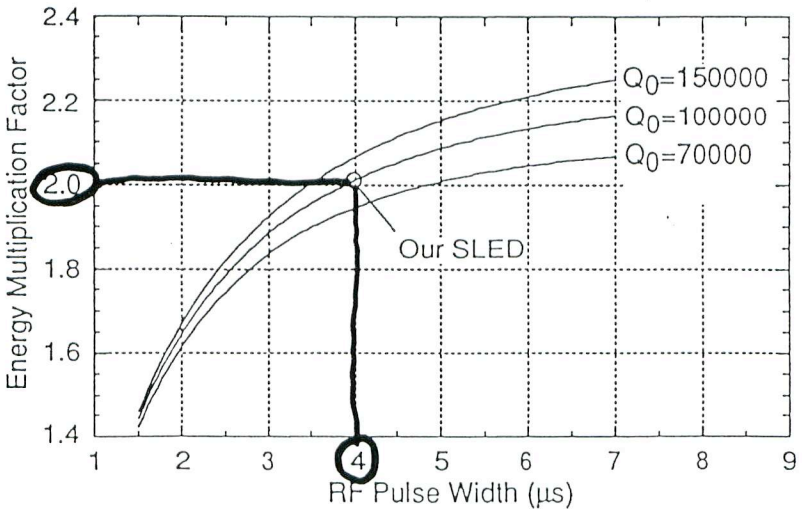
Table 4-2-5-1 Parameters of the high power klystrons

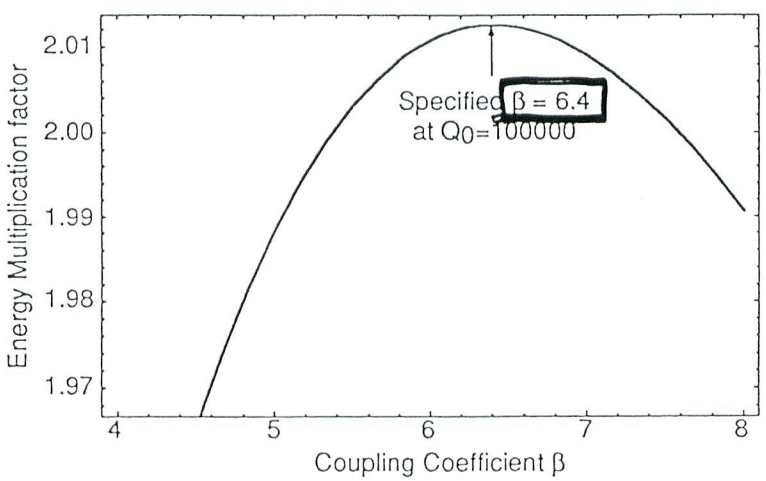
	Unit	existing(PV3030)	PV3030A3	50MW
beam voltage	kV	270	285(310)	315
beam current	A	295	319(362)	370
beam power	MW	80	91(112)	117
beam pulse width	kV	3.5	5.5	5.5
repetition rate	Ω	50	50	50
rf output power peak	MW	33	40(50)	50
rf output power av.	kW	3.3	8.0	10
rf pulse width	μs	2	4	4
efficiency	%	42	44	44
perveance	$\mu A/V^{3/2}$	2.1	2.1	2.1
overall length	mm	1317	1317	<1400
number of cavity.		5	5	5
rf window		single	single	single

RF Pulse Compression System (SLED)

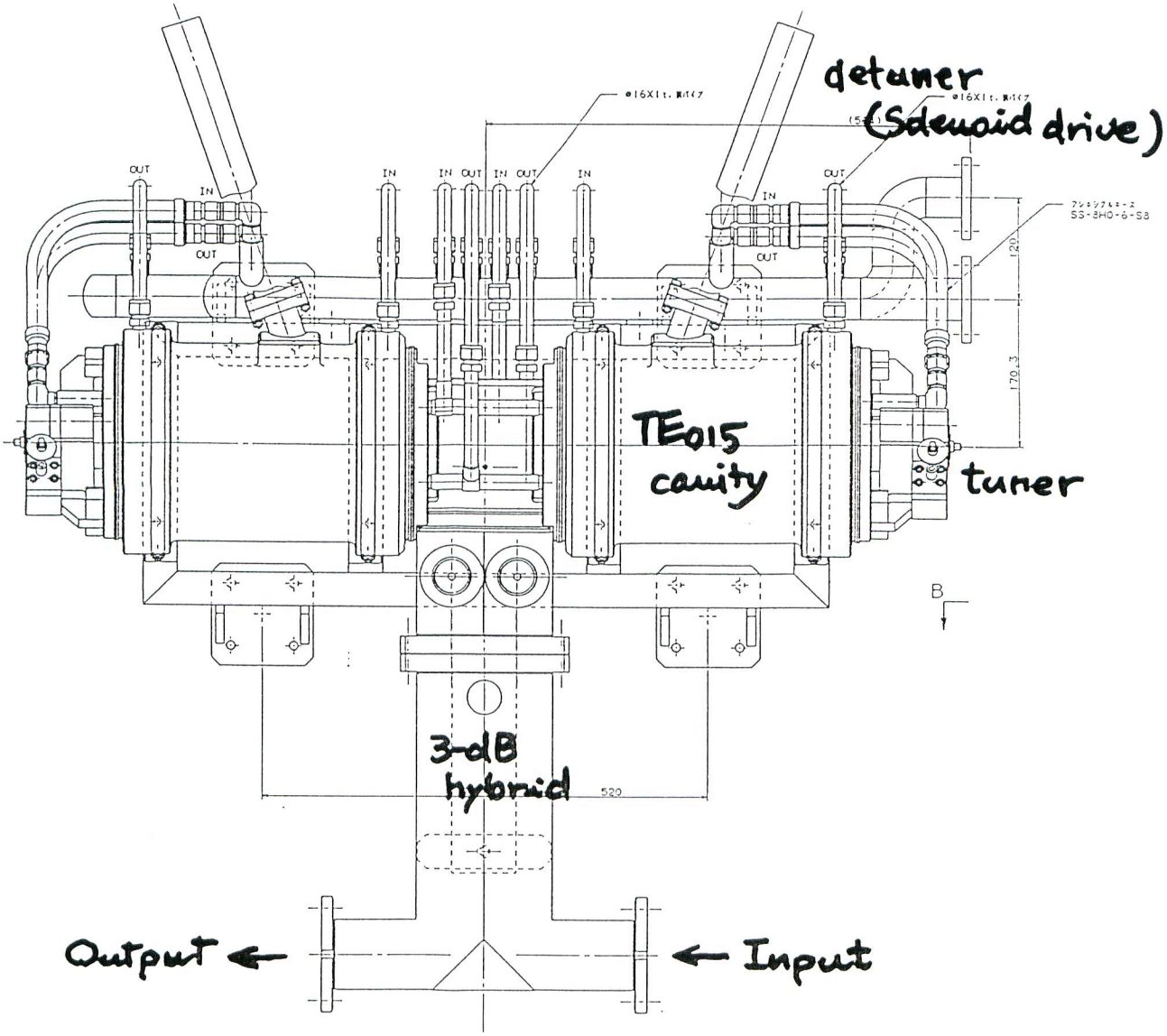


Parameter choice for SLED





SLED (final design)



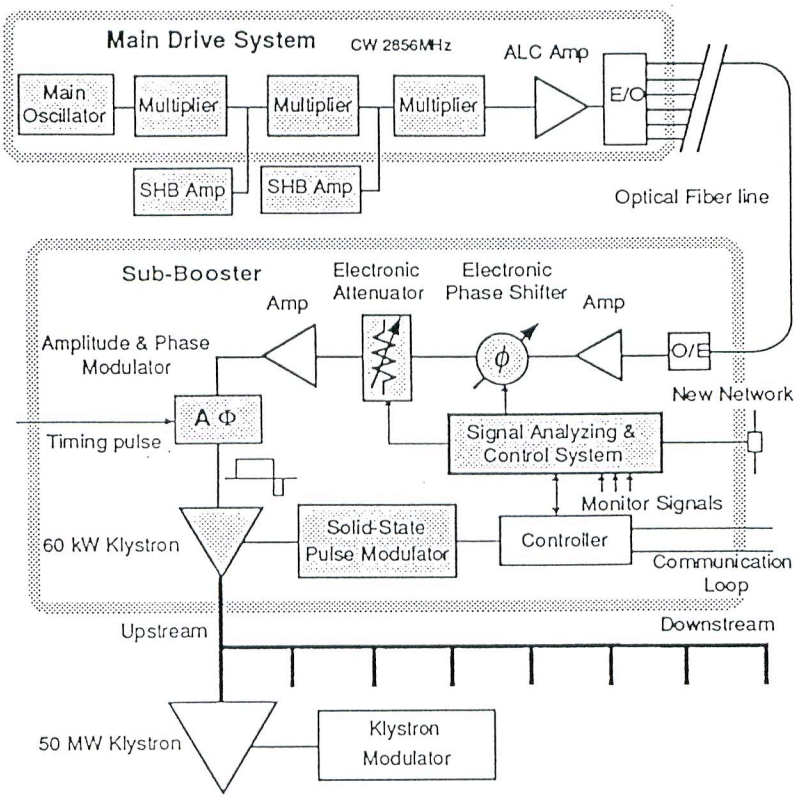
VIEW B-B

Table 4-2-1-2 SLED specification for KEKB linac

Resonant morde	TE015
Q (theoretical)	105000
Q (measured)	100000
Coupling (type)	two-hole, side-wall
(β)	6.4
tuner	< 2kHz／step (manual)
detuner (type)	solenoid-drive, needle (ϕ 2mm, stroke 168mm)
(separation)	>20MHz
gain-shift	0.1%／5kHz(0.1° C)

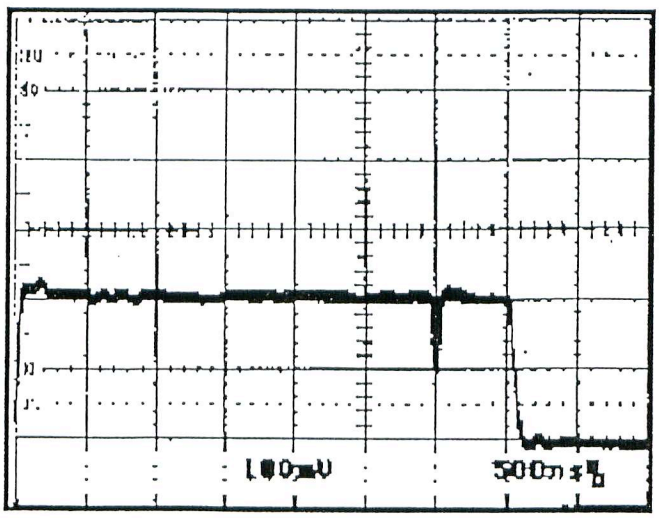
Installation of SRED

Improvements for RF-drive system

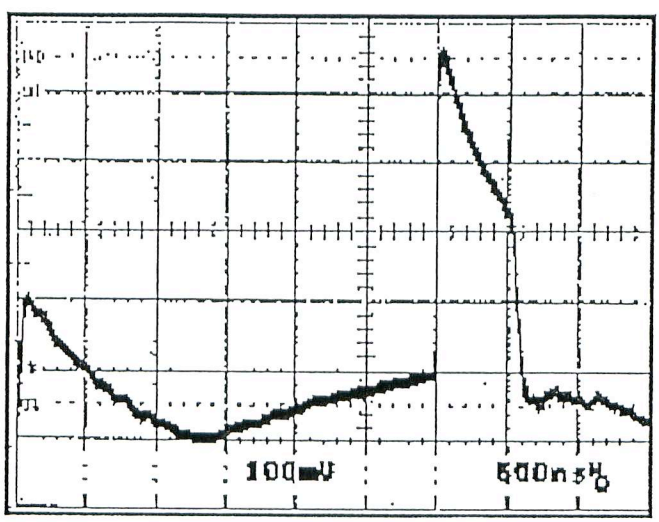


Output Waveform from SLED

(high-power operation)



SLED off (SLED cavities detuned)



SLED on (tuned)

Acceleration Test

requirement for KEKB

>160MeV/unit

Table 1
Results of beam-acceleration tests with the SLED

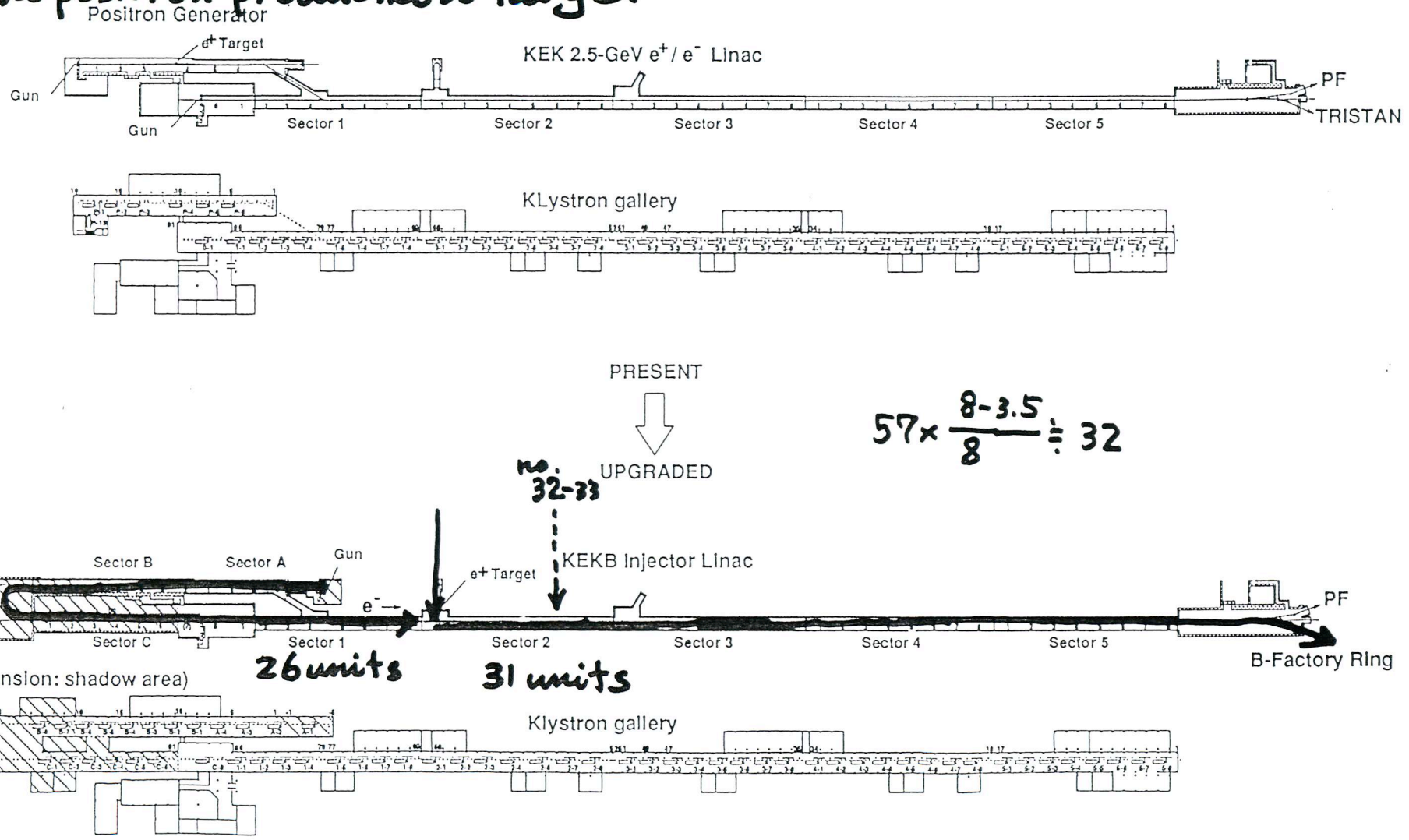
RF power (MW)	SLED	Energy gain (MeV)	Field (MV/m)	Multiplication
38±3	OFF	87±4	11.5±0.5	
	ON	164±4	21.7±0.5	1.88±0.1
48±4	OFF	97±4	12.8±0.5	
	ON	179±4	23.7±0.5	1.85±0.1

RF pulse width = 3.5 μs.
RF power was calculated from the measured energy gain.
Field is an averaged value.
Theoretical multiplication factor is 1.96.

Positron Production

Determination of the position for the positron production target

LINAC UPGRADE FOR KEKB



$57 \times \frac{8-3.5}{8} \fallingdotseq 32$

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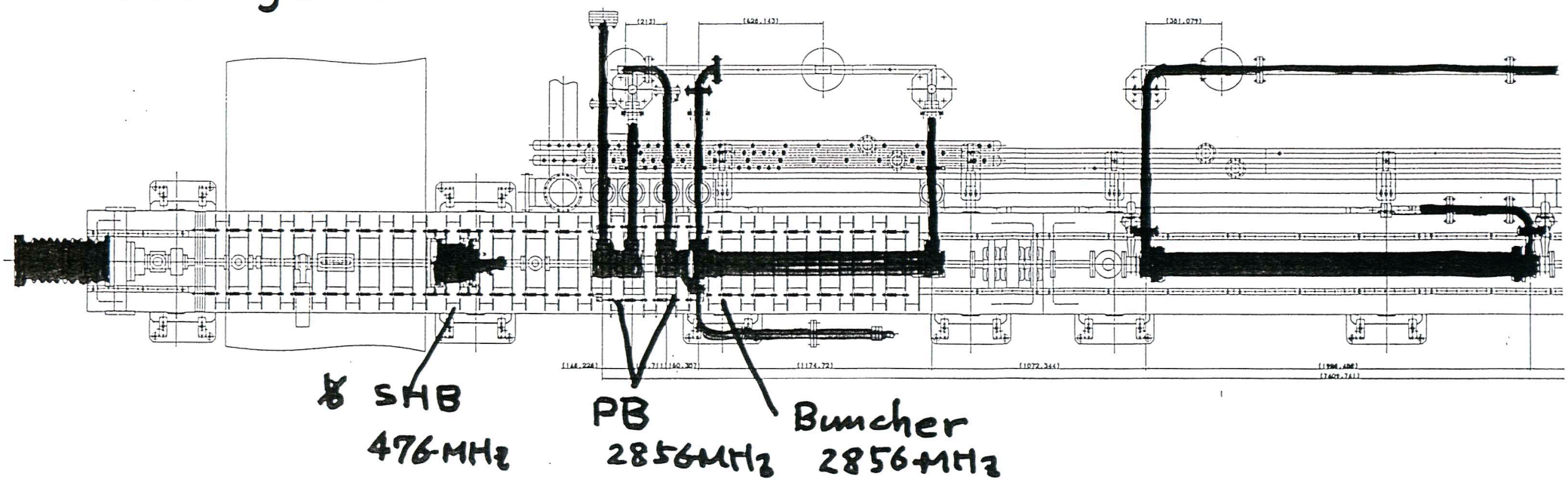
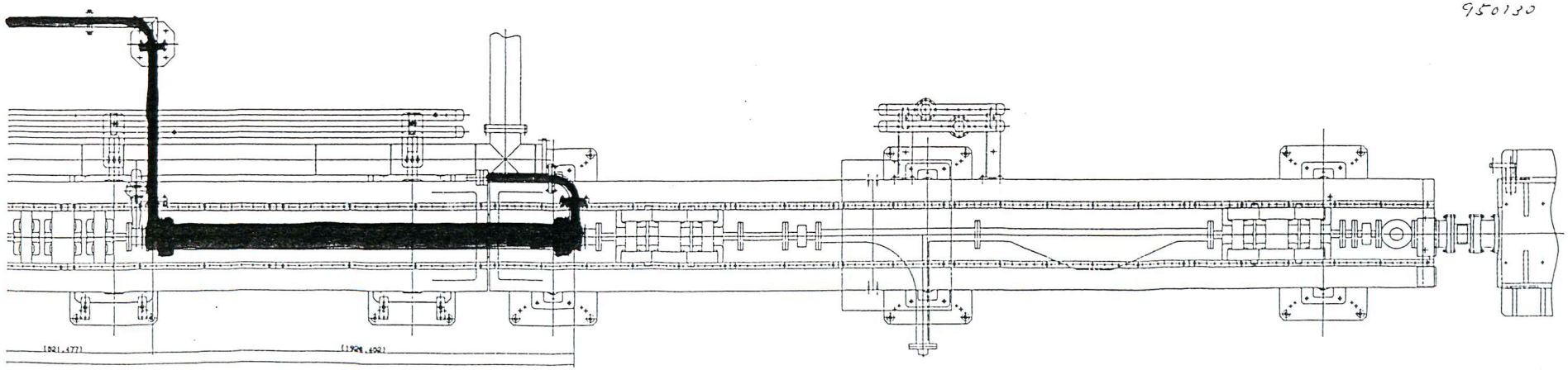
Single-bunch Beam Test

Pre-injector

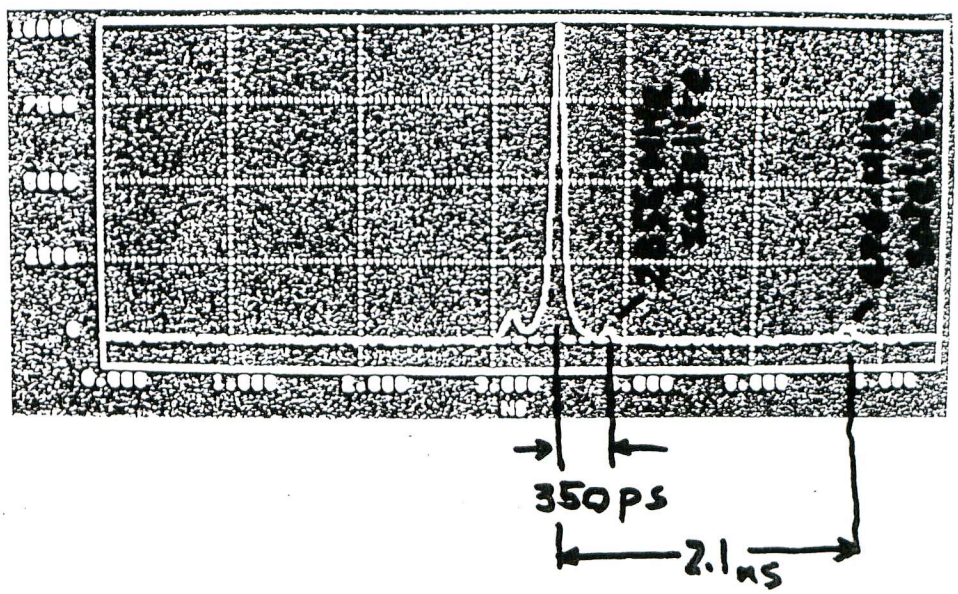


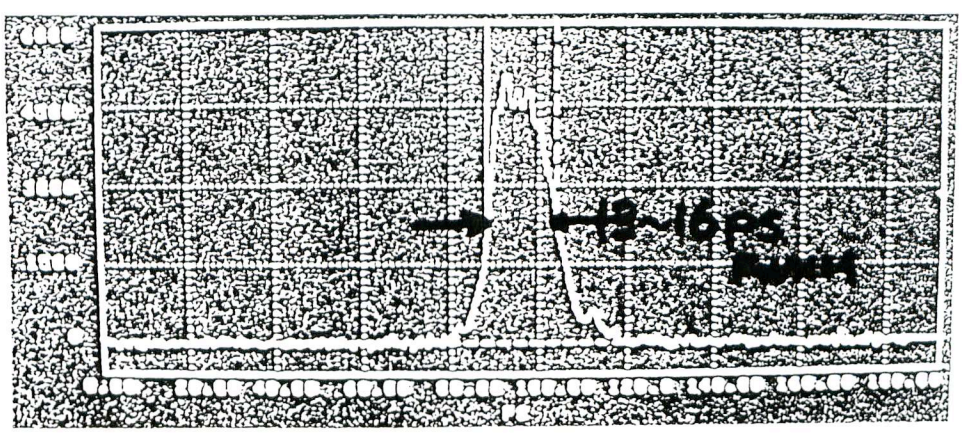
950130



~11nC ($7 \times 10^{10} e^-$)

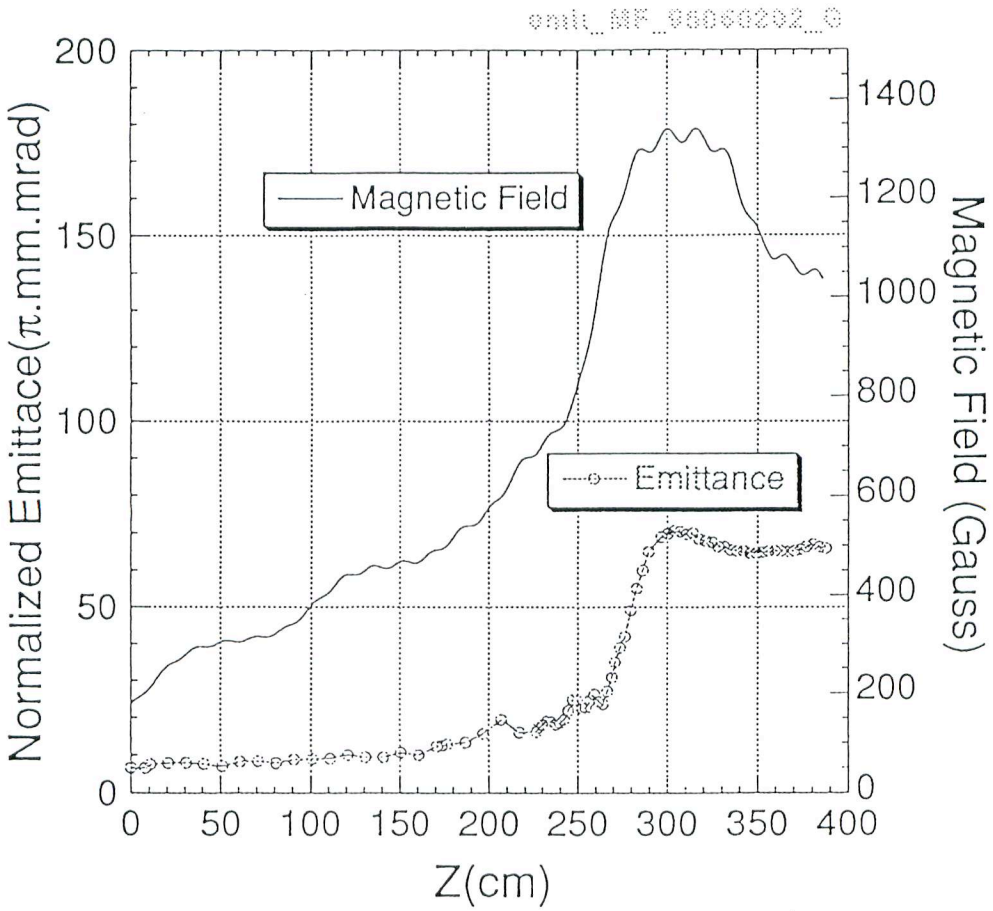
~Single-bunch beam

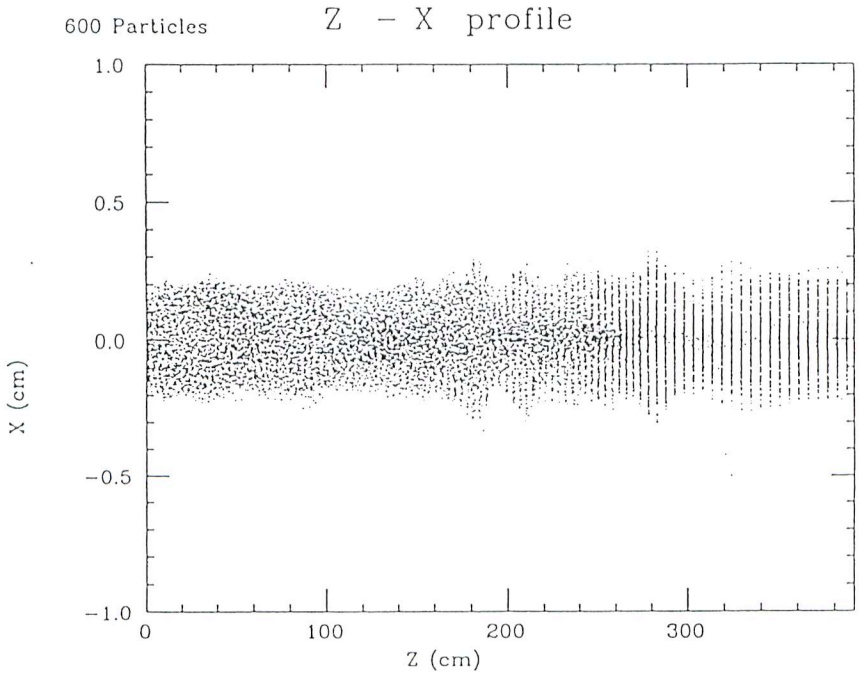




preliminary results obtained
with single SHB
at the end of the pre-injector

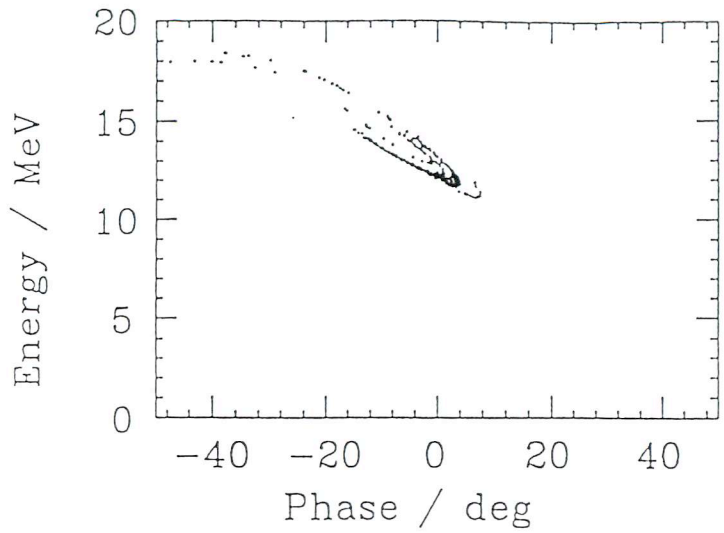
Simulation

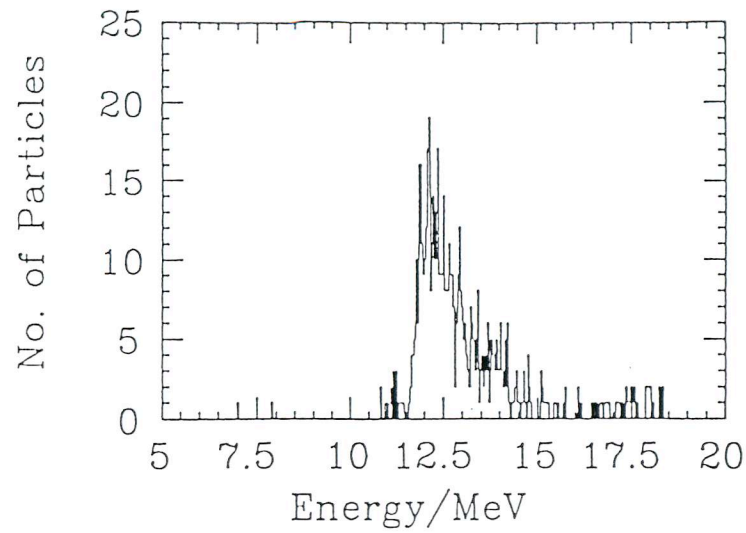


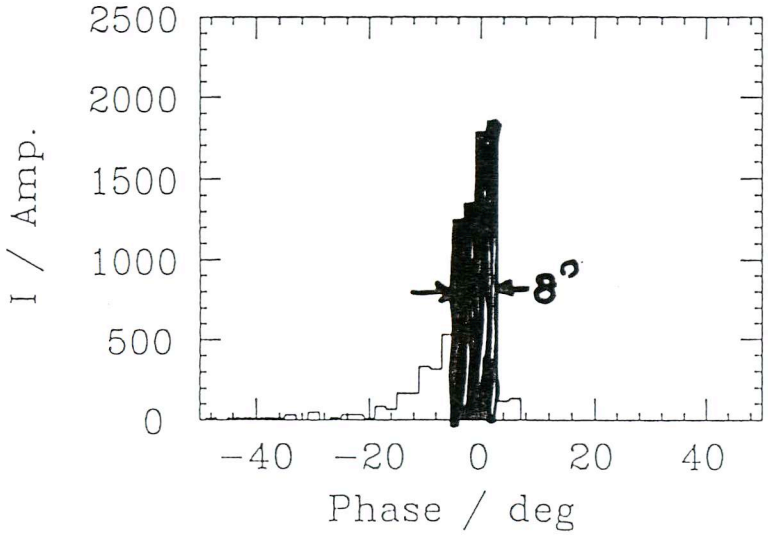


DOUBLE SHB, 2 nS

Fig 3.1.6





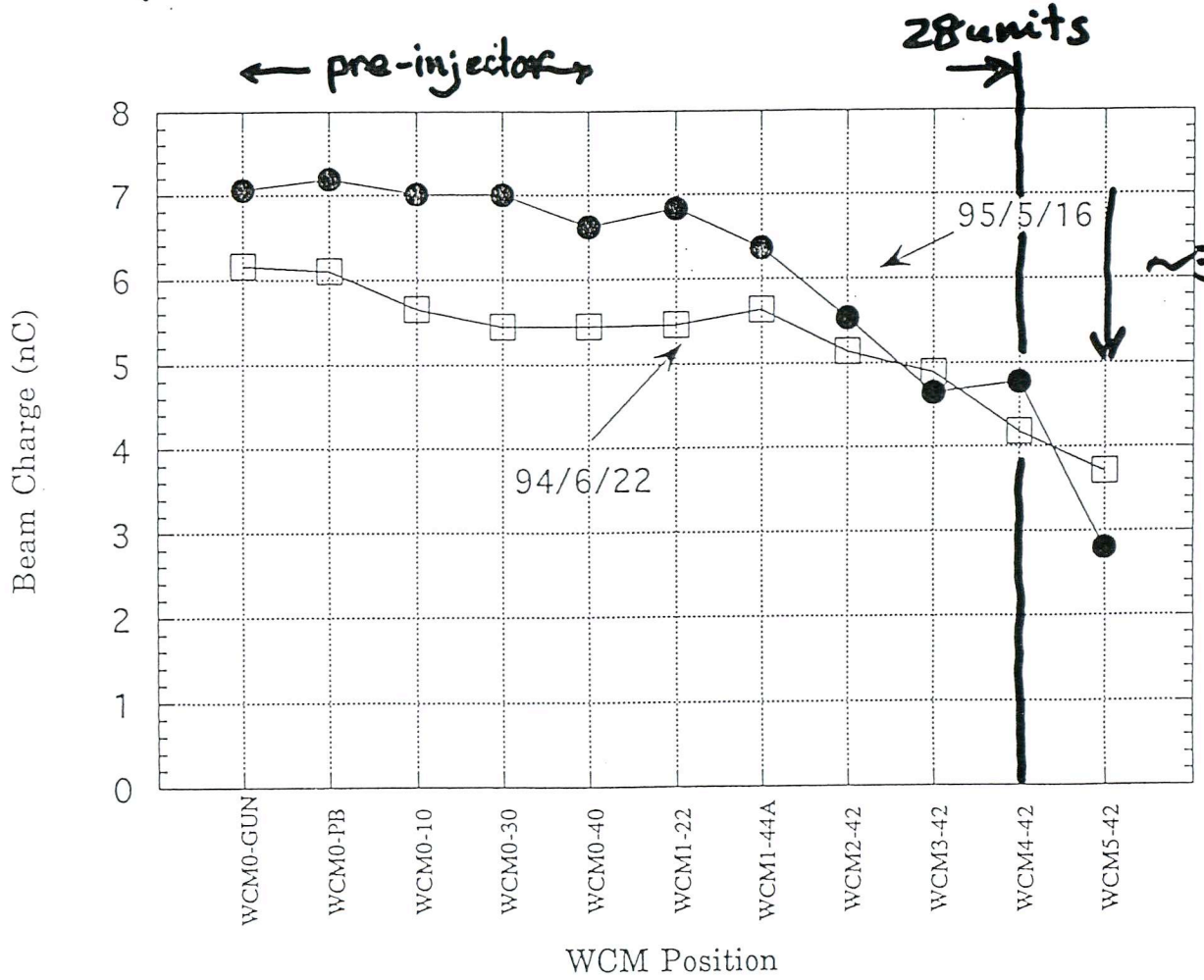


DOUBLE SHB, 2 nS 10.0 AMP
Element : No. 79/ 79(TRWAVE)
: Zexit 391.22 cm
Particles / init : 592/ 600

Phase mode : RF OF TRWAVE

Fig 3.1.5 にみる

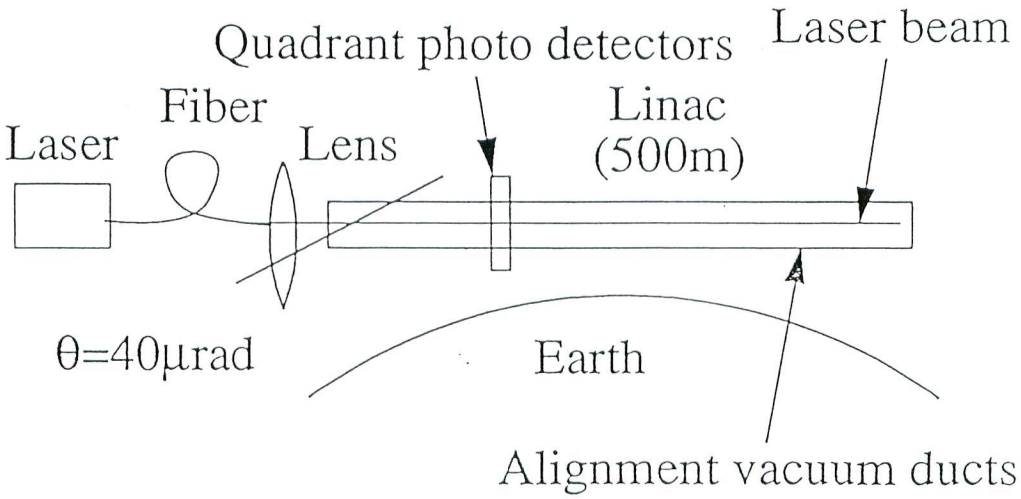
Beam Transport Test using the present linac

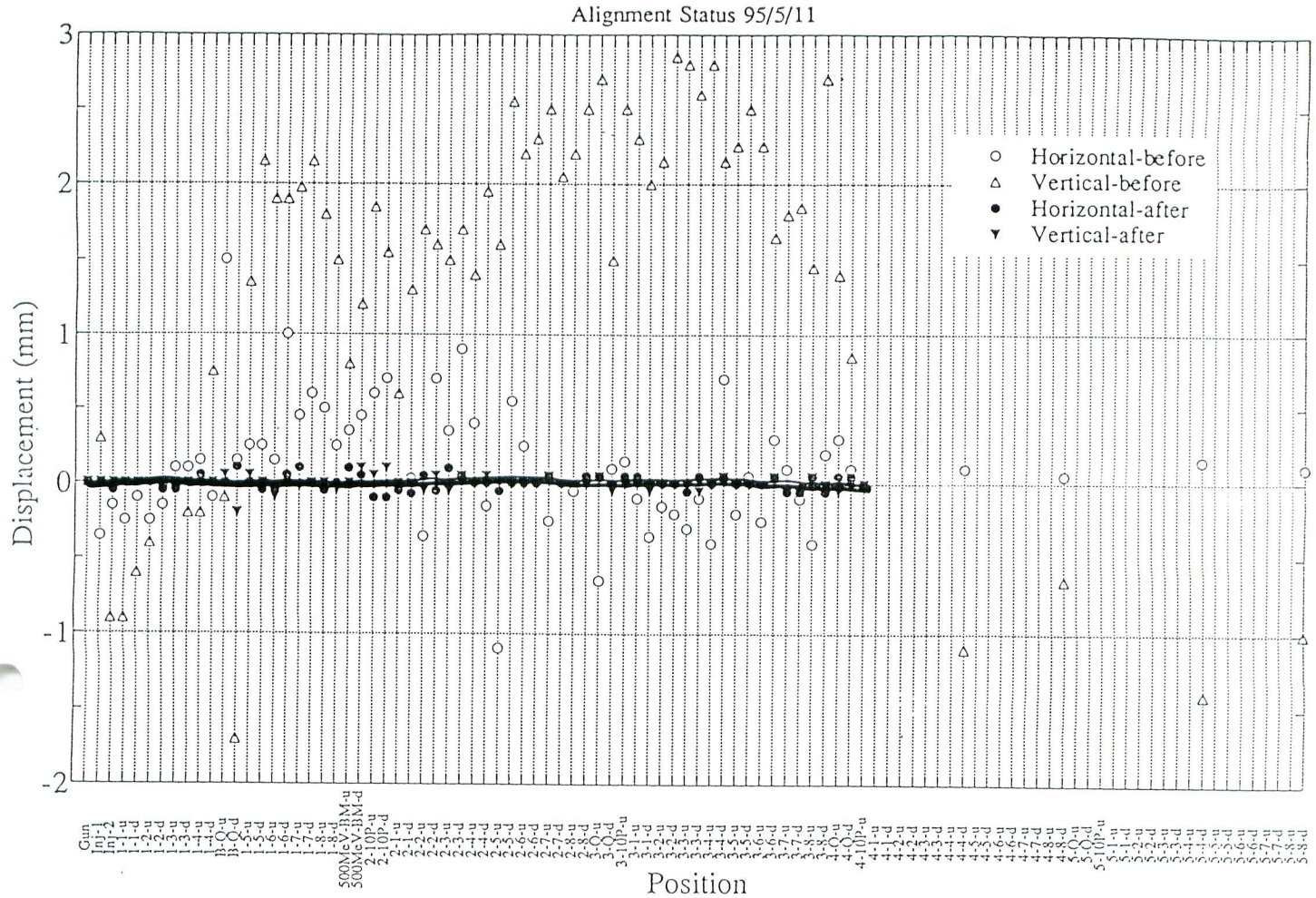


~30% loss

inadequate Qs

- alignments
- monitors


Quadrant photo detectors
Laser beam
Fiber
Linac
(500m)
Laser
Lens
θ=40μrad
Earth
Alignment vacuum ducts



Requirement for Q-magnet Alignment

< 0.12 mm

for $r_{\text{at target}} = 0.6$ mm

10nC bunch

Positron Intensity

primary e^- → $10\,nC$

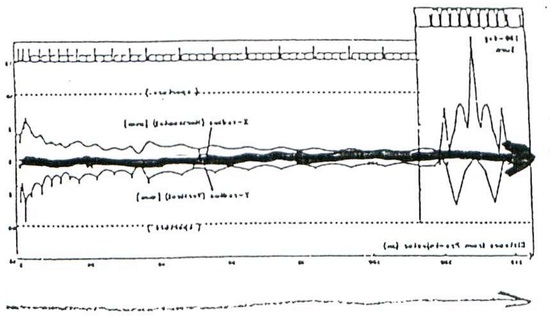
expected conversion rate → $0.018 \times 3.7\,GeV$

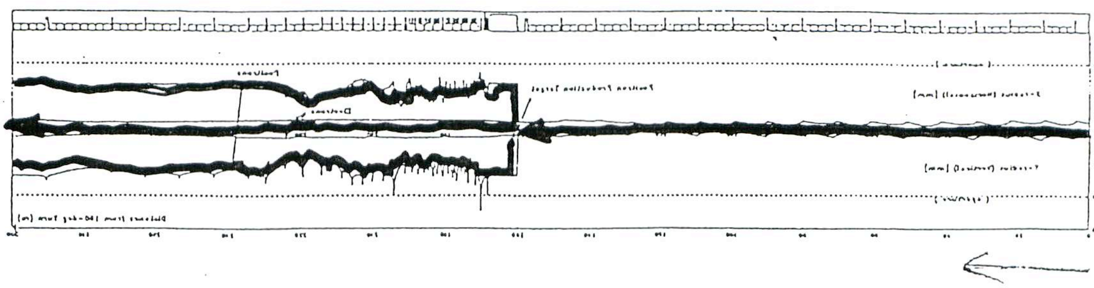
$= 0.67\,nC$

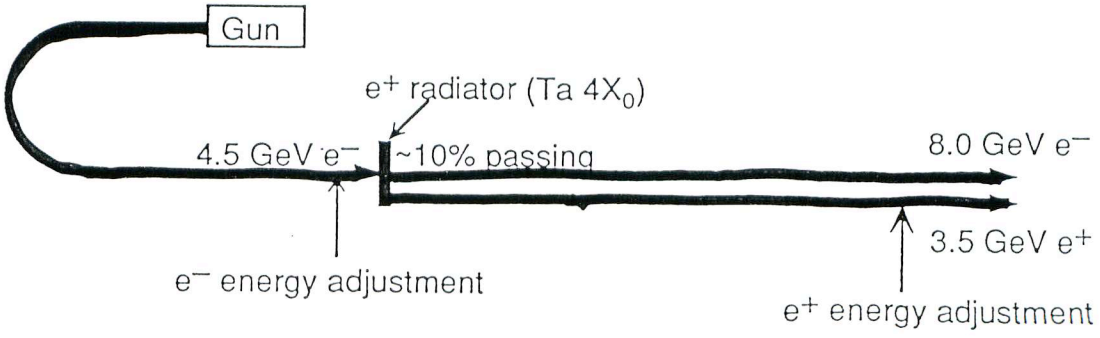
$\gtrsim$ requirement

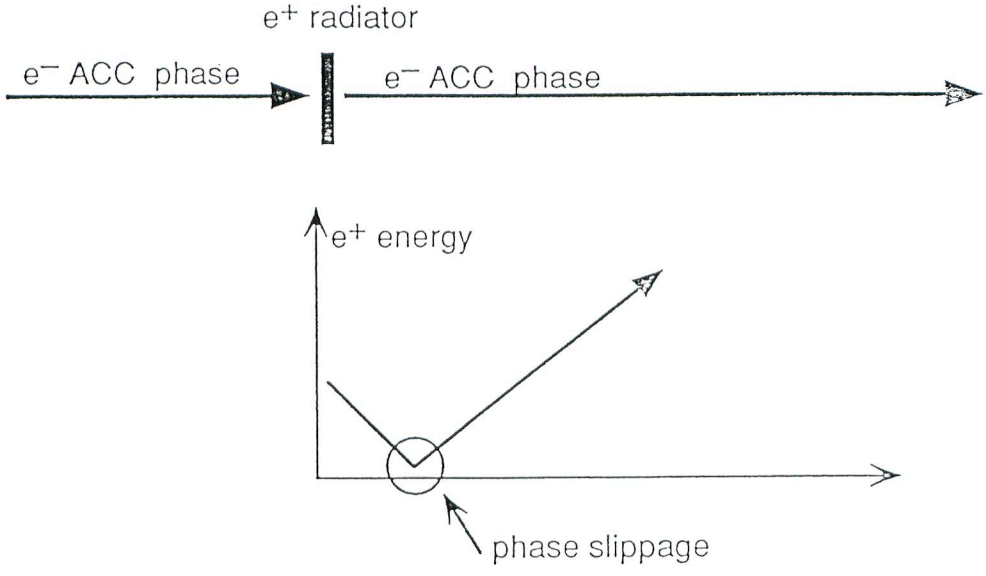
$$\frac{2.6\,A \times 10.06\,\mu s}{0.67 \times 10^{-9}\,C \times 50\,pps} \cong 780\,sec$$

$$\cong 13\,min$$



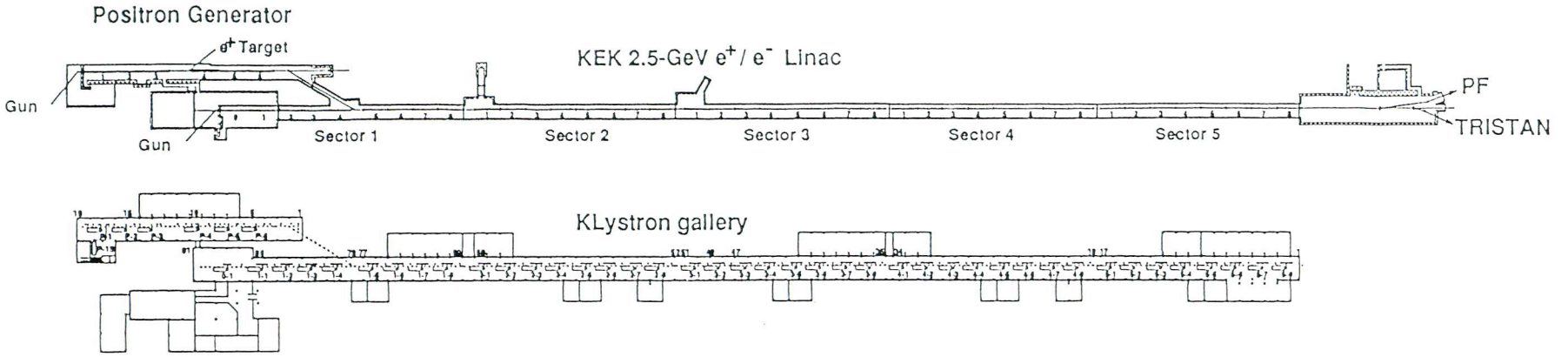



Gun
e+ radiator (Ta 4X0)
4.5 GeV e−
~10% passing
8.0 GeV e−
3.5 GeV e+
e− energy adjustment
e+ energy adjustment


e+ radiator
e− ACC phase
e− ACC phase
e+ energy
phase slippage


e+ radiator
e− ACC phase
e+ ACC phase
e− ACC phase
chicane
e+ s (~100 MeV) delay 180° (52.5 mm)

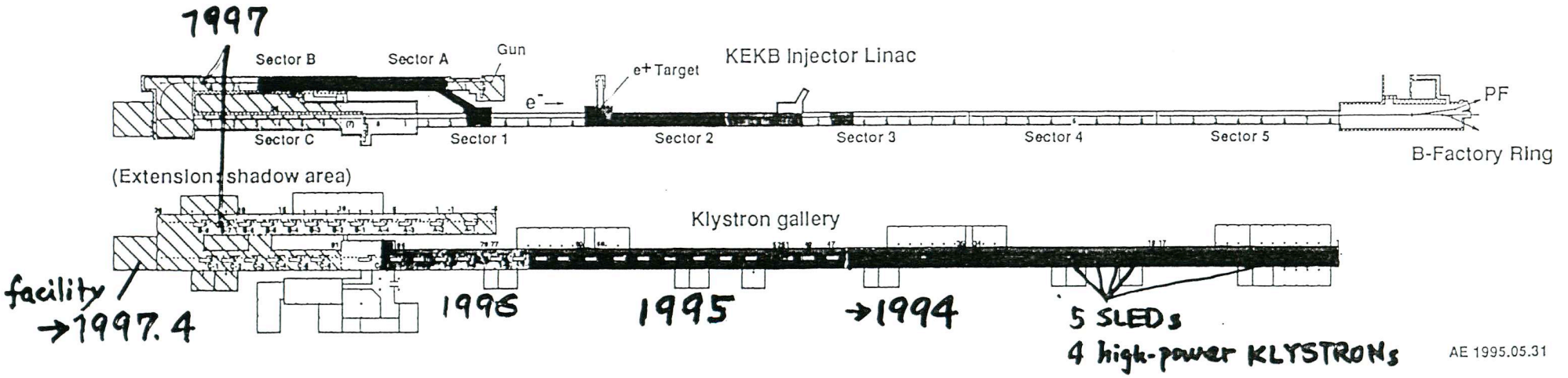
LINAC UPGRADE FOR KEKB



PRESENT

UPGRADED

Schedule



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