

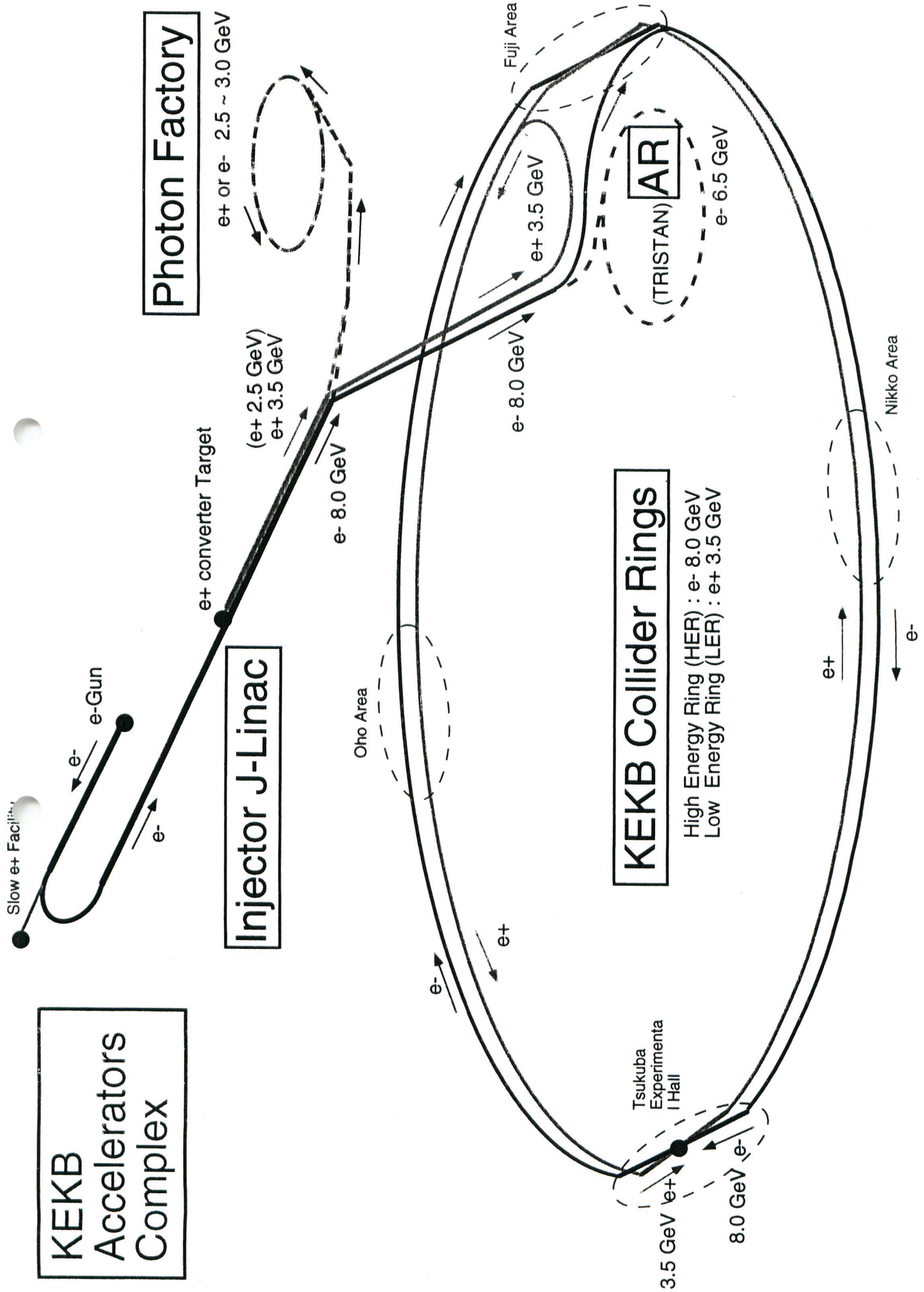
# LINAC UPGRADE

## Progress Report

KEK PF LINAC Y.OGAWA

- [1] Objectives
- [2] Energy Upgrade
- [3] Positron Production
- [4] Recent Progress & Tests
- [5] Schedule
- [6] Summary

# KEKB Accelerators Complex



## [1] Objectives

### *Linac Upgrade*

- (a) Energy Upgrade from 2.5 GeV to 8 GeV for  $e^-$   
3.5 GeV for  $e^+$   
(full energy injection)
- (b) Positron Production Upgrade from 0.032 nC to 0.64 nC  
( $I_{\text{ring}}=2.6$  A, full injection time : 13-14 min, re-fill time : 1-2 min)

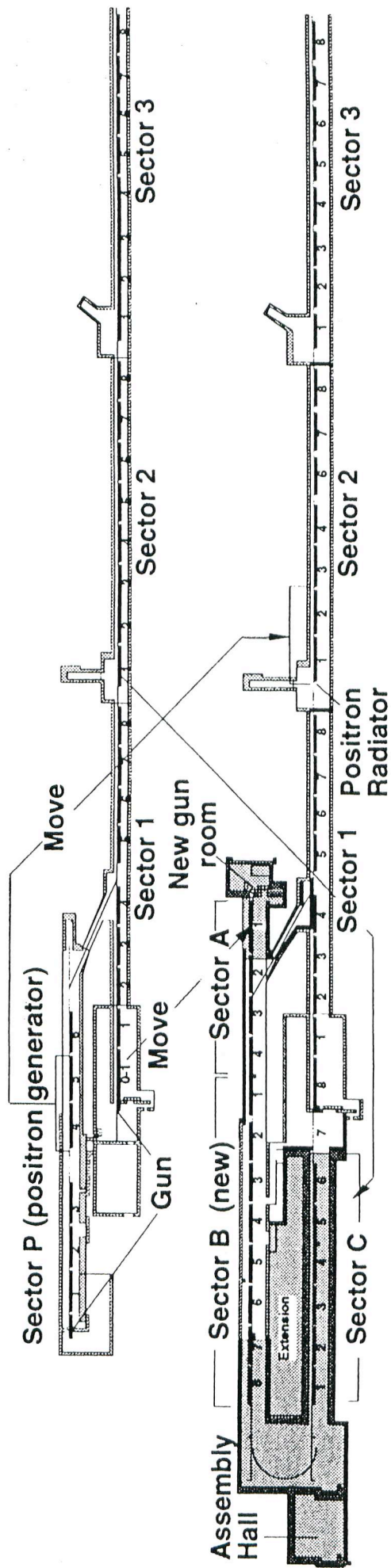


Fig. 2 Linac reconstruction from 2.5 GeV (upper) to 8 GeV (lower). The existing linac has 40 accelerator units which are divided into 5 sectors. The shadow areas are extension buildings to increase the number of accelerator units from 40 to 57.



## [2] Energy Upgrade

### (a) Extension of LINAC

40 klystron units  $\rightarrow$  57 units

(building construction completed at the end of 1996)

### (b) Modification of high-power klystrons & modulators

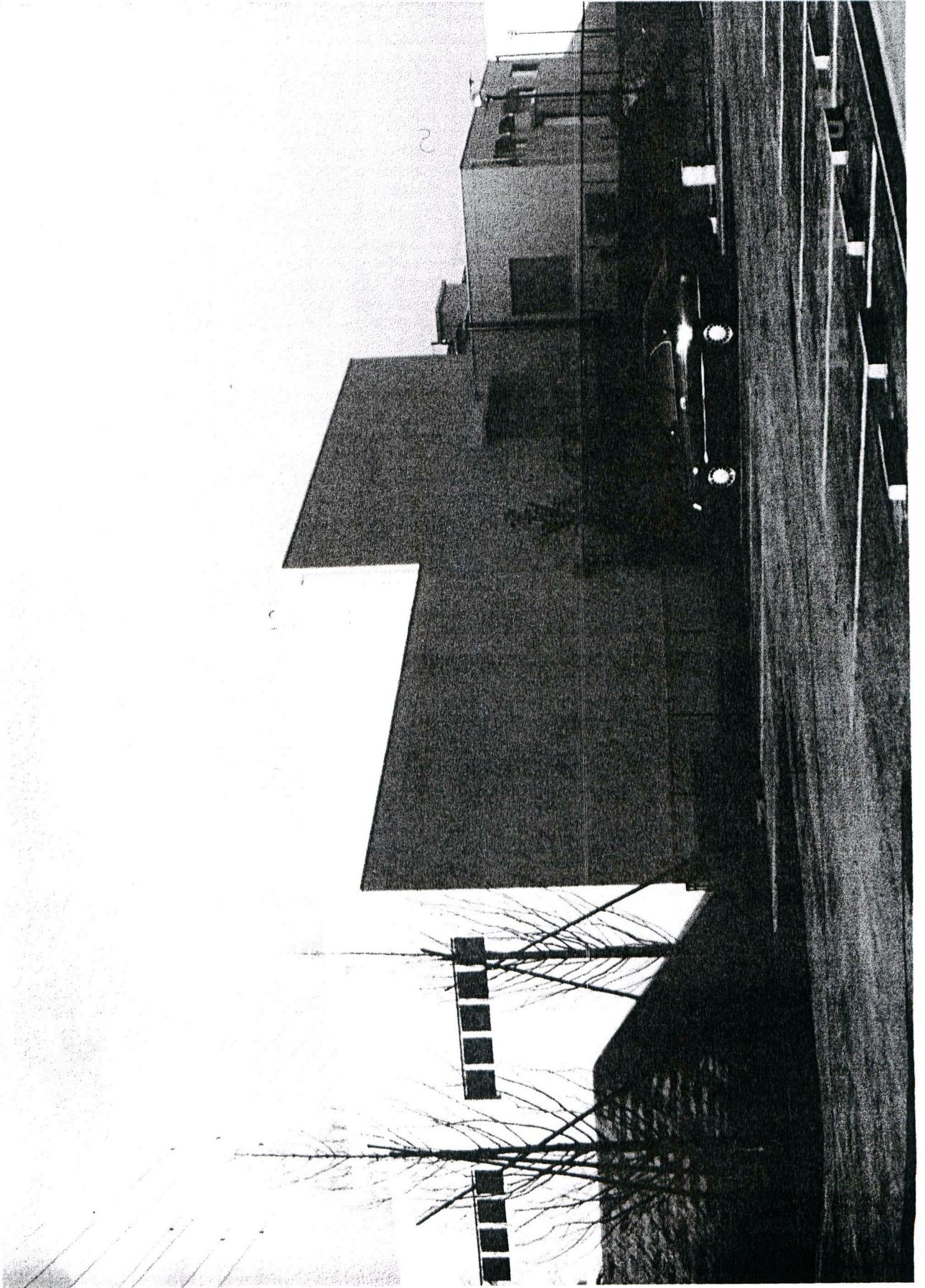
30 MW klystron (21 MW)  $\rightarrow$  50 MW klystron (41 MW)

modulator power  $\rightarrow$  twice

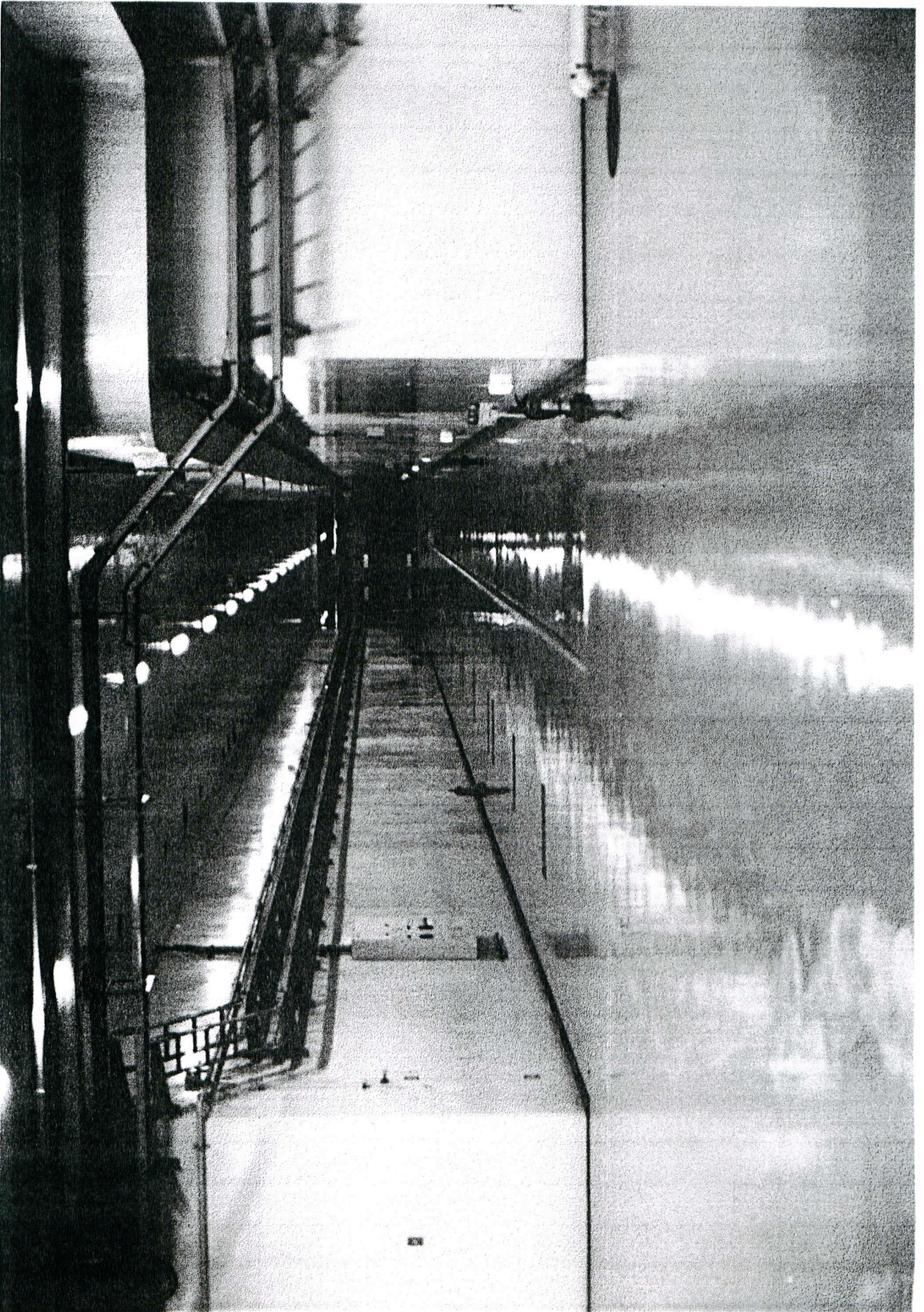
### (c) SLED energy doubler

(b) & (c)  $\Rightarrow$  acceleration gradient : 7.8 MV/m  $\rightarrow$  20 MV/m

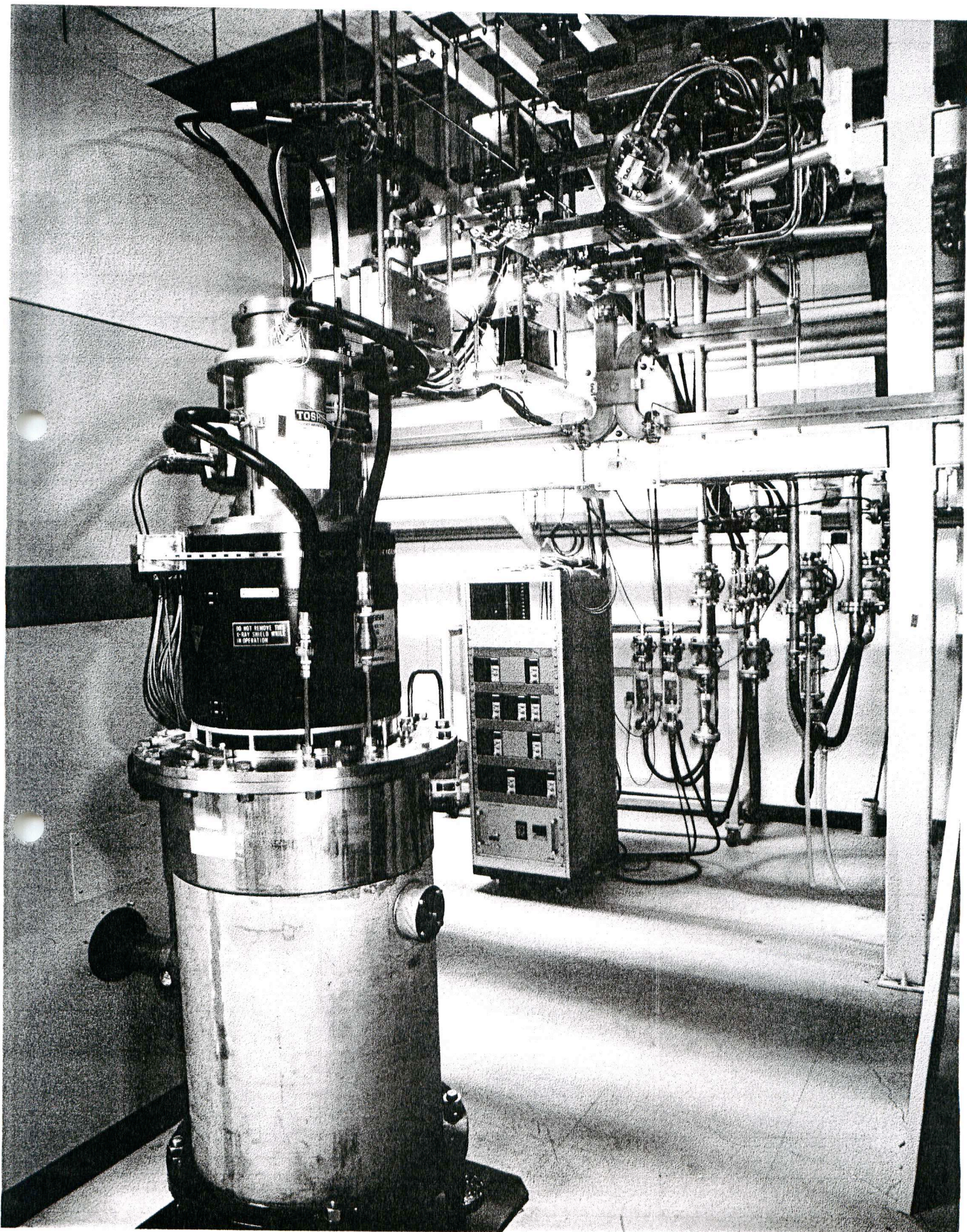
(a), (b), (c)  $\Rightarrow$  2.5 GeV  $\rightarrow$  8 GeV for  $e^-$  and 3.5 GeV for  $e^+$







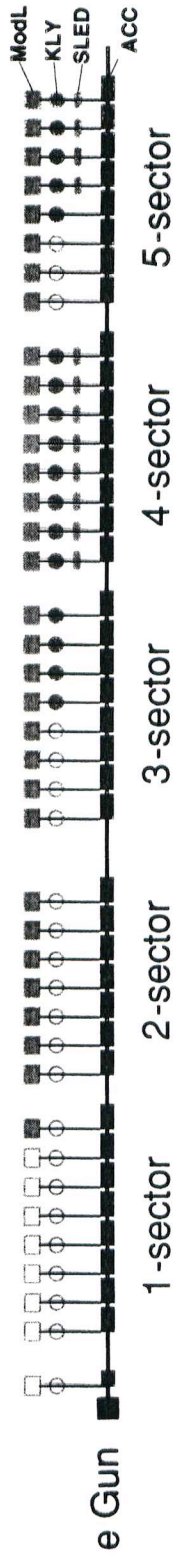




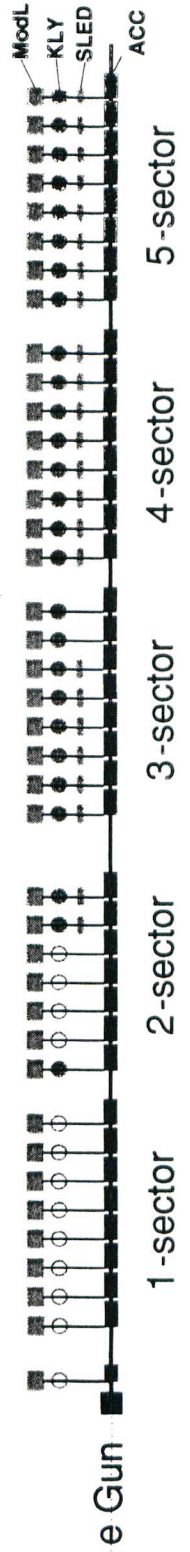


- High Power RF Modulator
- Ordinary RF Modulator
- High Power Klystron
- Ordinary Klystron
- Accelerating Unit
- SLED

## 1996 Jul.



## 1997 Jan.





### [3] Positron Production

#### (a) Target

position: moved from 0.25 GeV to 3.7 GeV

material: Ta --> W (thermal problem : efficient cooling)

#### (b) High-current primary $e^-$ beam acceleration

single bunch: 2 SHBs (114 MHz & 571 MHz)

stable acceleration: BPM, precise alignment ( $< 0.1$  mm)

==>>  $e^+$  : 0.032 nC --> 0.64 nC (1.8 % [ $e^+/e^-/\text{GeV}$ ])

## [4] Recent Progress & Tests

(a) Energy measurement of the accelerator units with SLED

average : 160 MeV / unit except for some units

(b) High-current beam test using the existing linac & new target

(1) electron beam acceleration: 4 nC @1.1 GeV

(2) positron production: 1.2 % [ $e^+/e^-/\text{GeV}$ ] @0.55 GeV

remarks:

# not high gradient : 7.8 MV/m (still without SLEDs) (1), (2)

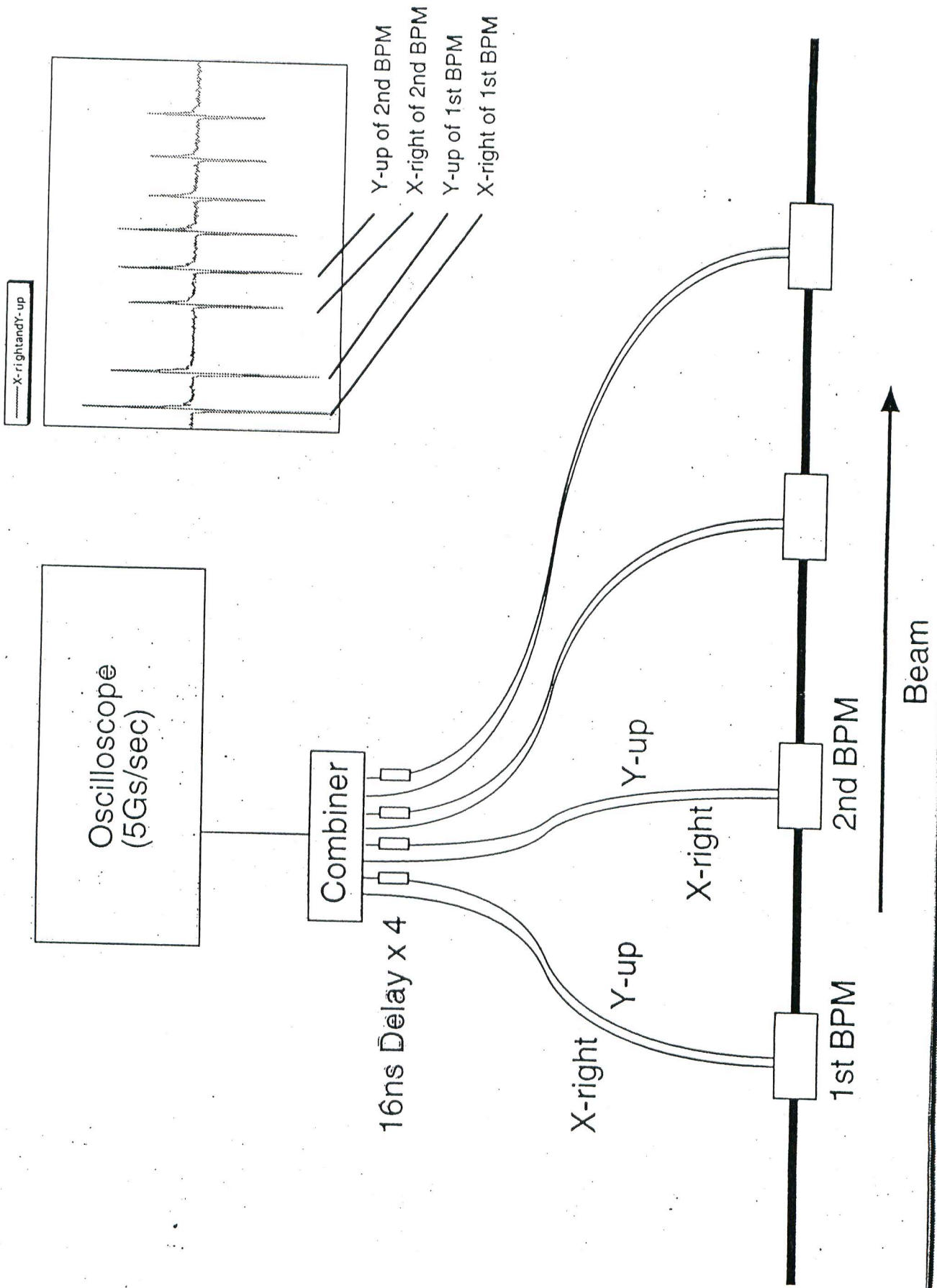
# BT : weak focusing (1) / not completed for  $e^+$  transport (2)

# efficient tools : BPM, Bunch monitor (1)

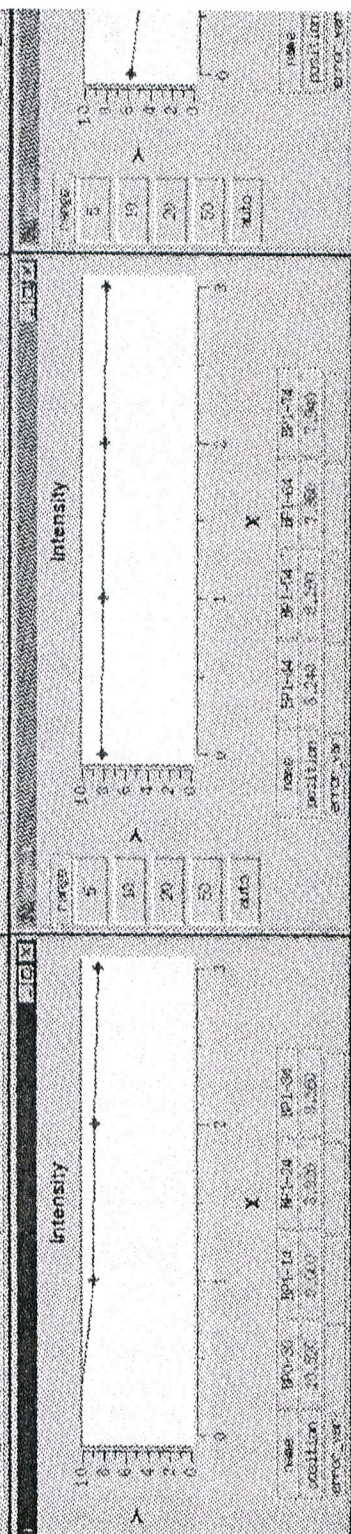
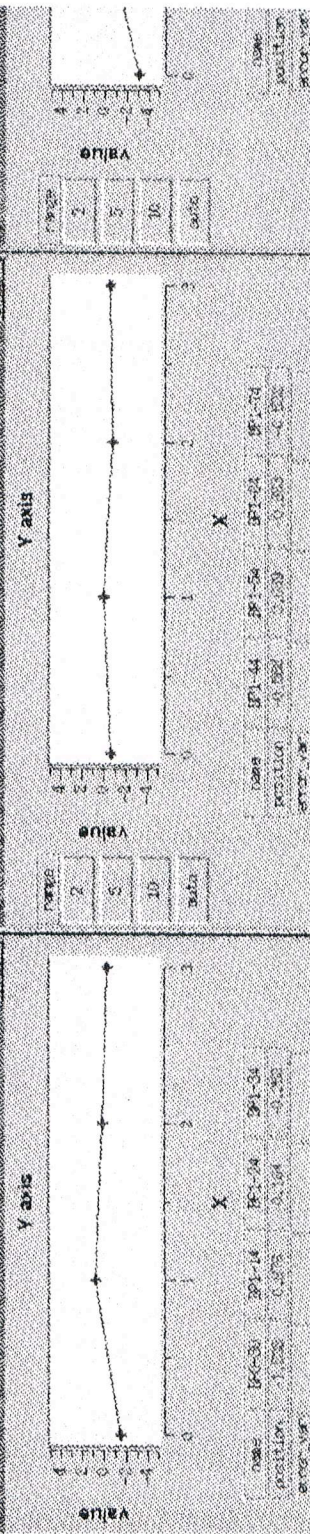
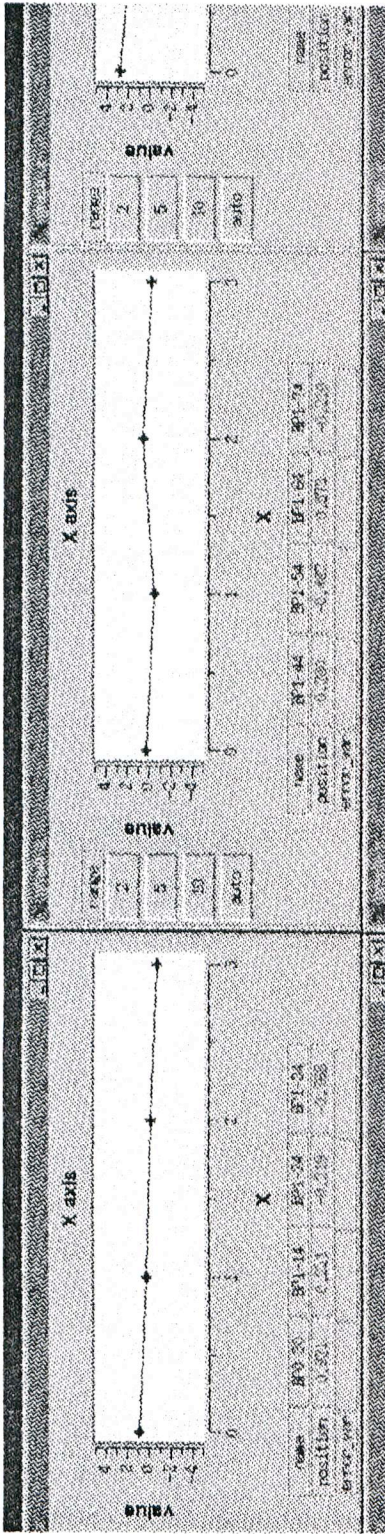
## Accelerating Unit Energy Gain Measurement

ACC Unit	$E_{PFN}$ (kV)	Energy Gain (MeV)	
3 - 1			Not Ready
3 - 2	42.0	166.3	
3 - 3			Not Ready
3 - 4	40.9	147.6	
3 - 5	42.0	107.1	
3 - 6	42.0	162.7	
3 - 7			No SLED
3 - 8			No SLED
4 - 1	44.0	152.5	
4 - 2	41.9	164.5	
4 - 3	44.0	164.0	
4 - 4	40.2	148.5	
4 - 5	42.2	165.0	
4 - 6			No SLED
4 - 7	43.0	170.0	
4 - 8	44.1	170.0	
5 - 1	42.0	132.1	
5 - 2	42.0	148.7	
5 - 3	42.0	50.1	IVR trouble
5 - 4	42.0	154.9	
5 - 5			Not Ready
5 - 6	41.2	140.0	
5 - 7	42.0	170.2	
5 - 8	42.0	152.5	

# Linac Beam Study with BPM







Start

Stop

Print

Zoom

Fit

Auto

Manual

Help

File

Edit

View

Tools

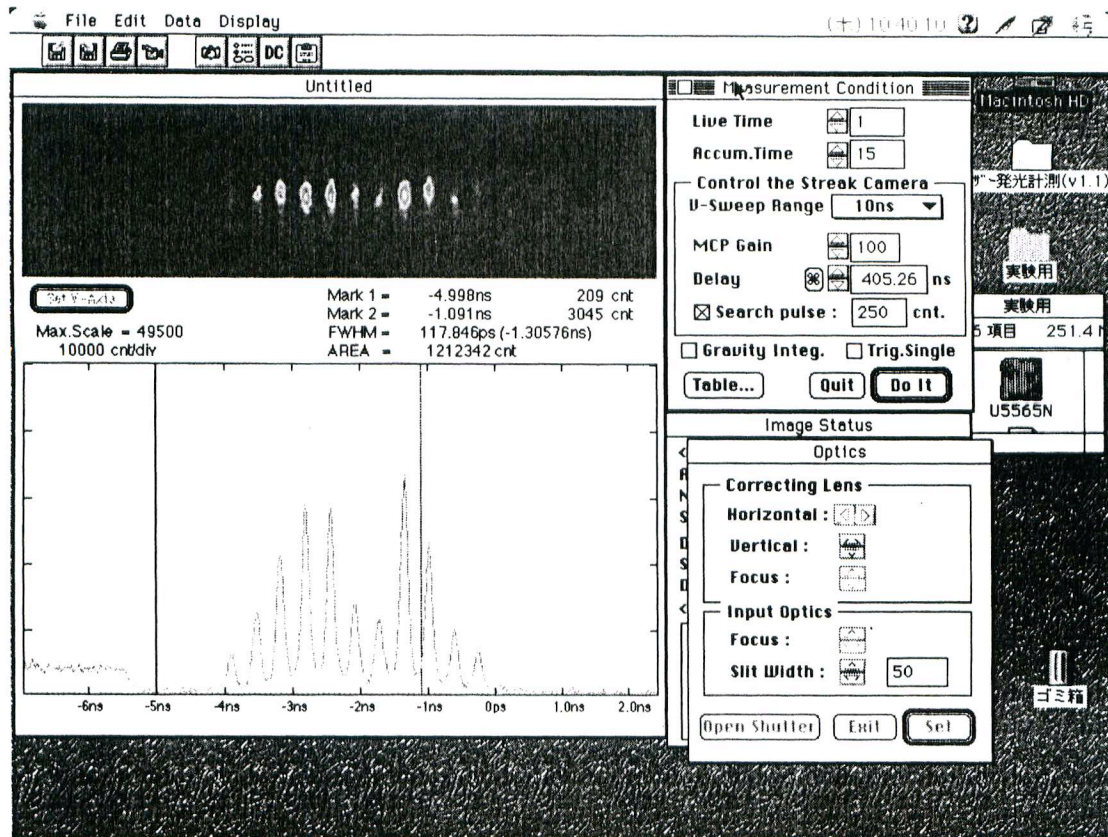
Window

Help

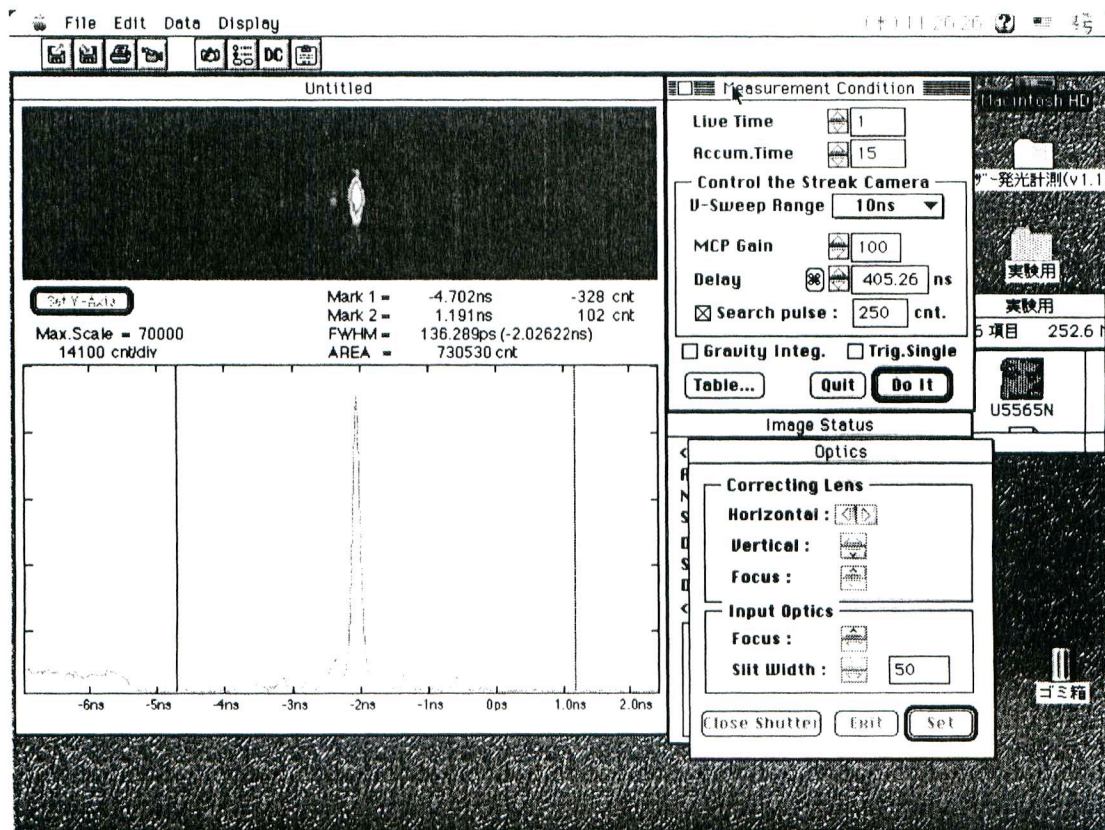


# Streak Camera Images

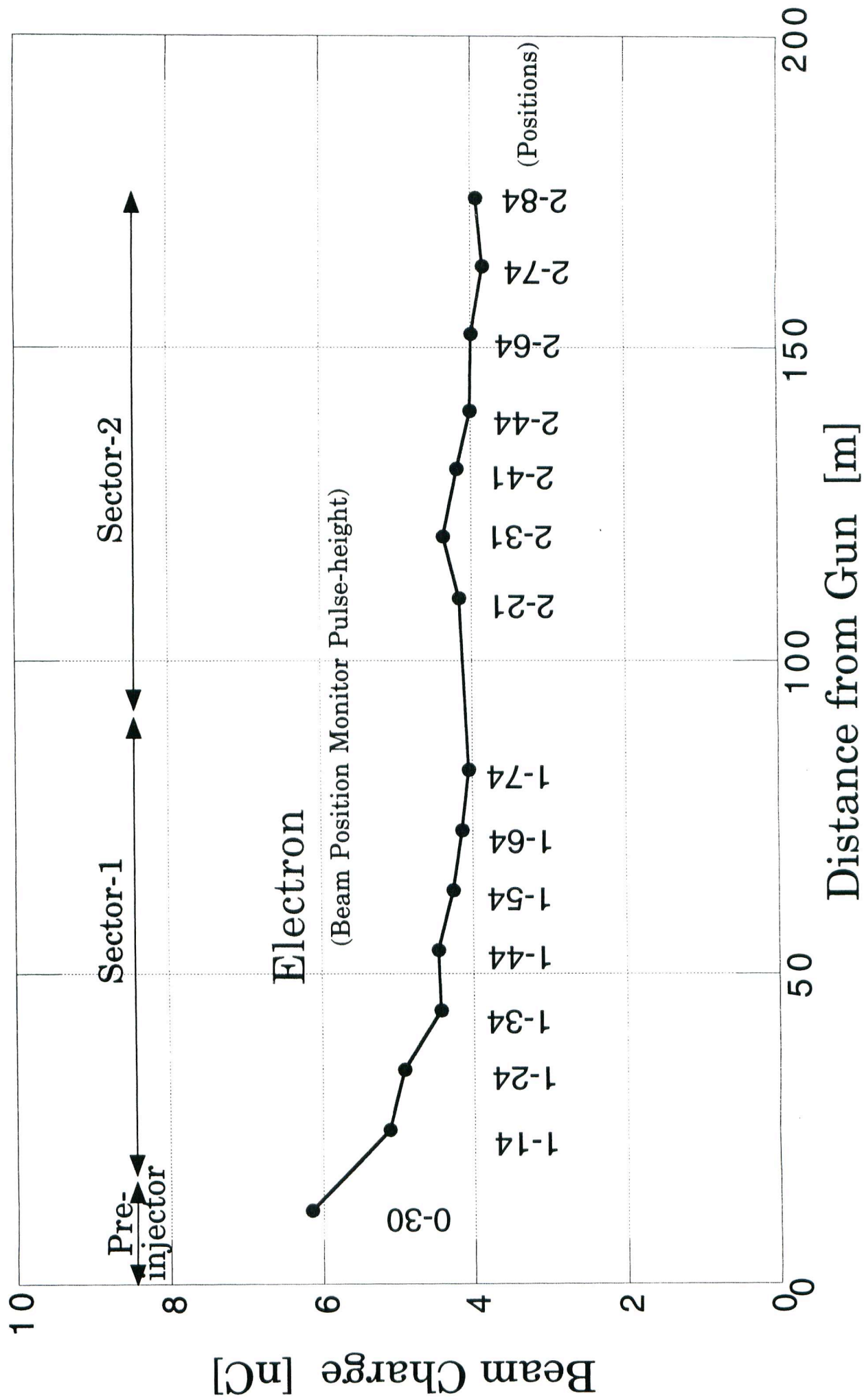
## Multi-Bunch Beam (SHB1, SHB2 OFF)



## Single-Bunch Beam (SHB1, SHB2 Tuned)

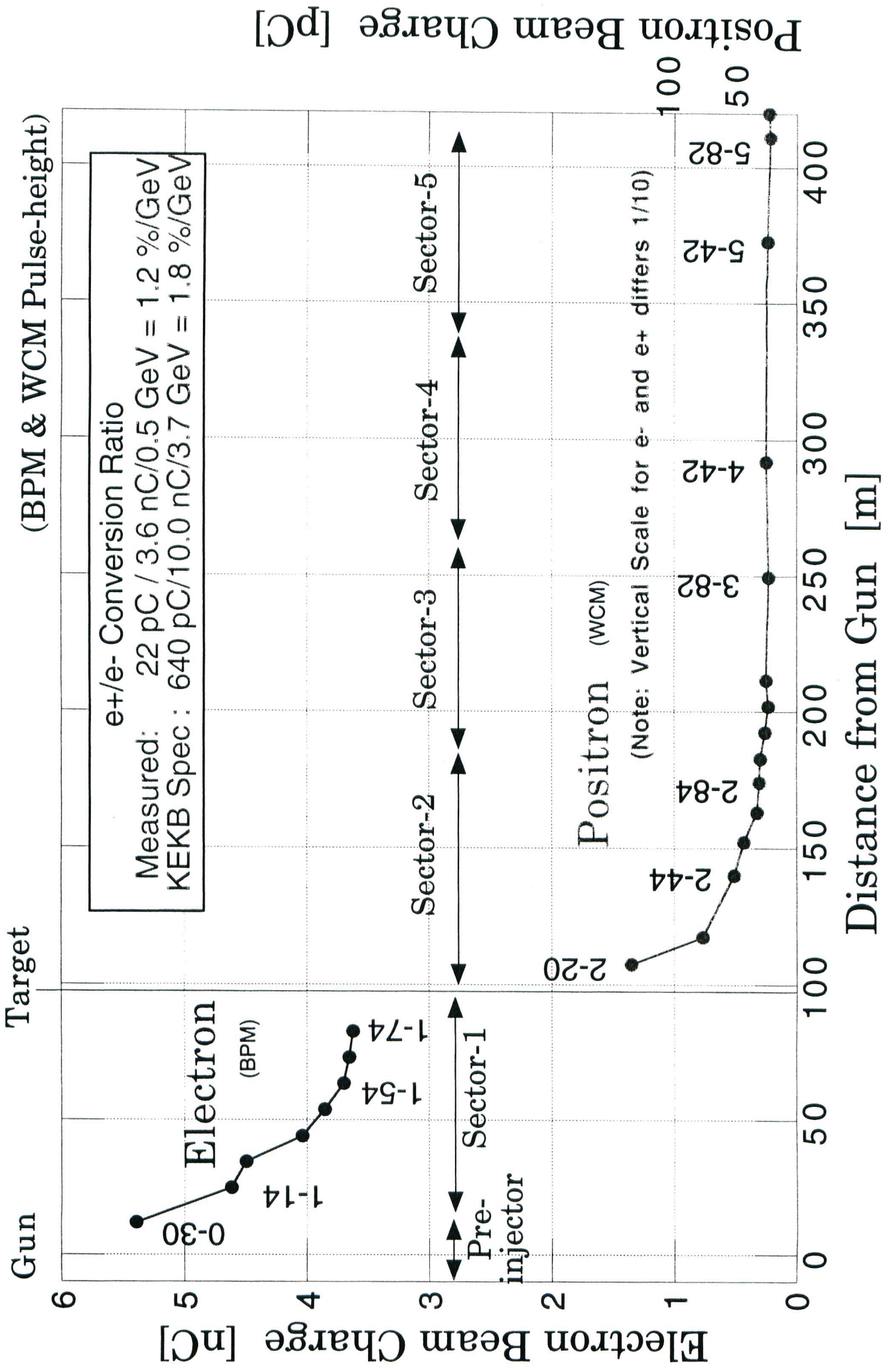


# Electron 5nC Transport





# Positron Charge (Generated & Transmitted)



## Beam characteristics of KEKB linac

	Intensity $q$ [nC]	Emittance [m]	Energy spread [ $\sigma_E / E$ ]
Electron	1.28	$6.4 \cdot 10^{-8}$ <sup>(1)</sup>	0.125 % @ 8 GeV
Positron	0.64 <sup>(2)</sup>	$8.8 \cdot 10^{-7}$ <sup>(1)</sup>	0.125 % <sup>(3)</sup> @ 3.7 GeV

(1) measured using the  $e^+$  linac for TRISTAN (3) BCS & ECS used

Injection time ( $t_{inj}$ ) <sup>(2)</sup> of the positron beam

	Full injection $I_{ring} = 2.6$ A	Re-fill $\Delta I_{ring} = 0.3$ A	Assumed efficiency
13 - 14 min	1 - 2 min	100 %	
27 min	3 - 4 min	50 %	

(2)  $q_{linac}$   $rep_{linac}$   $t_{inj} = I_{ring}$   $t_{ring, revolution}$   $rep_{linac}$  : linac repetition = 50 pps,  $t_{ring, revolution} = 10 \mu s$

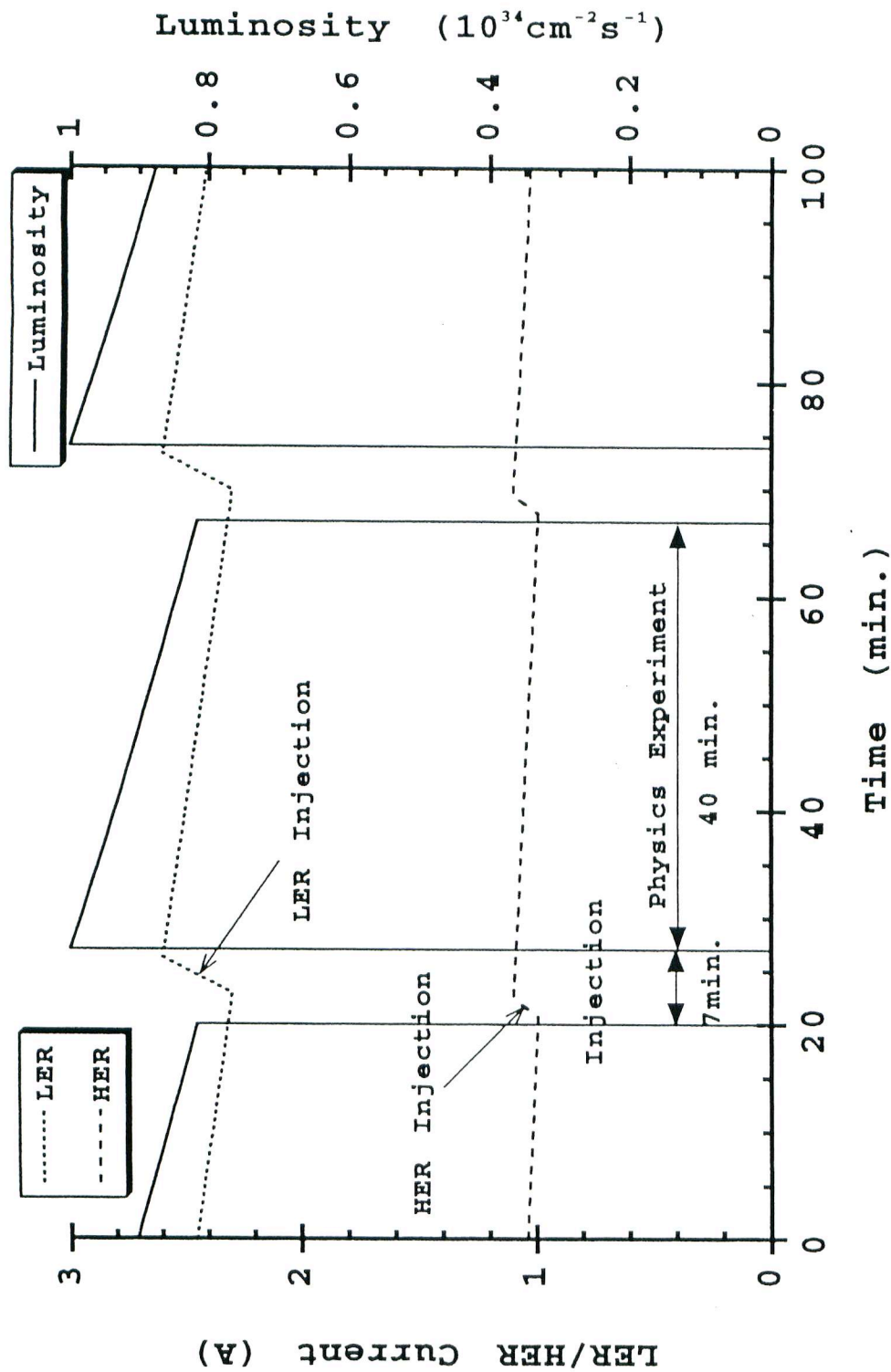


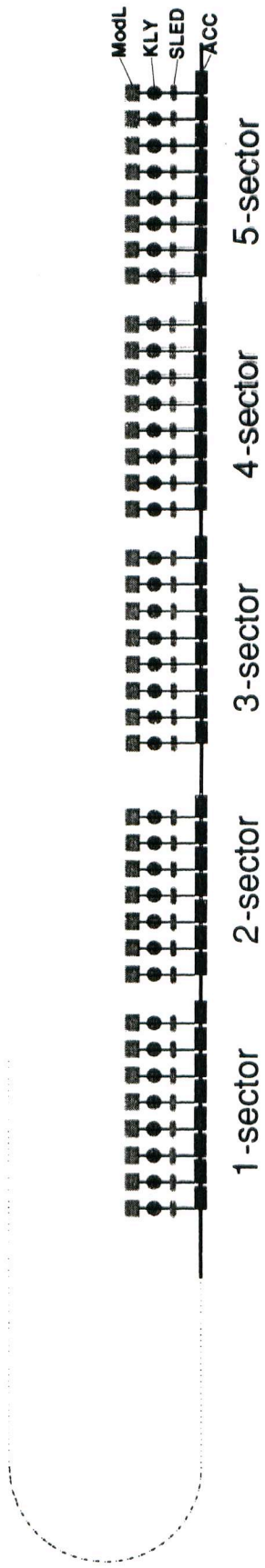
Figure 12.25: Luminosity and the LER/HER currents on the typical operation condition. The injection time includes the LER/HER topping times and the time period for changing the operation mode.



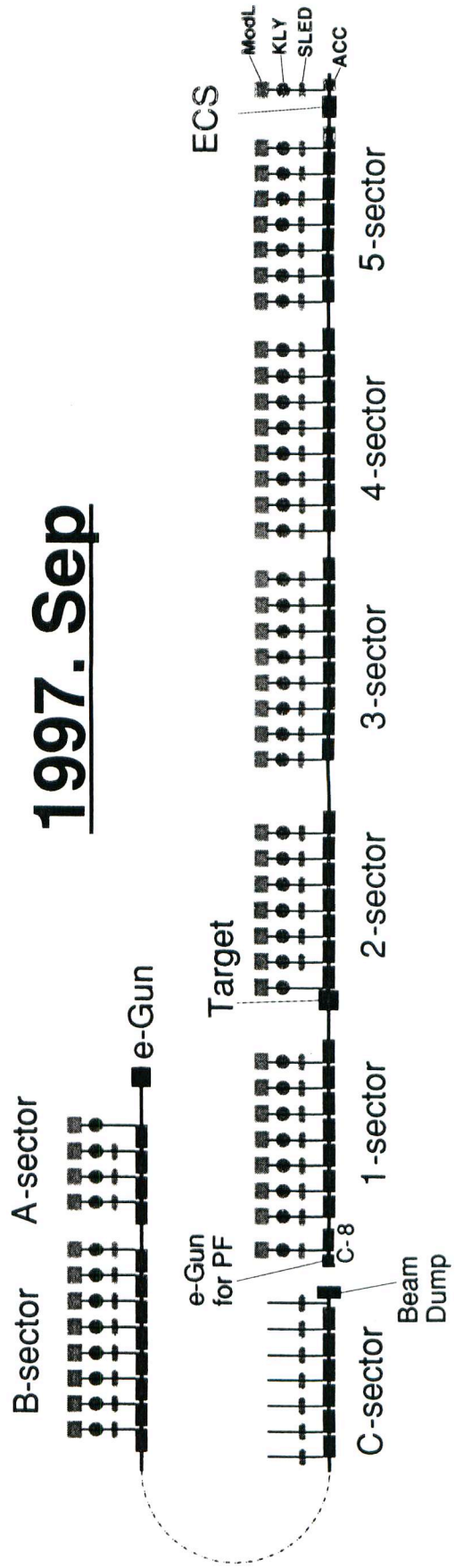
## [5] Schedule

1997. 3 Complete energy upgrade in the existing linac
1997. 9 Complete energy upgrade in A & B sectors
1997. 9 - Beam test in A & B sectors  
(also  $e^-$  injection into the Photon Factory)
1997. 12 Construct the arc section
1998. 2-3 Complete energy upgrade in C sector
- Beam test in A, B, C sectors & the arc section
1998. 5 Connect the existing linac with A, B, C & arc  
LINAC commissioning ( tentative schedule)

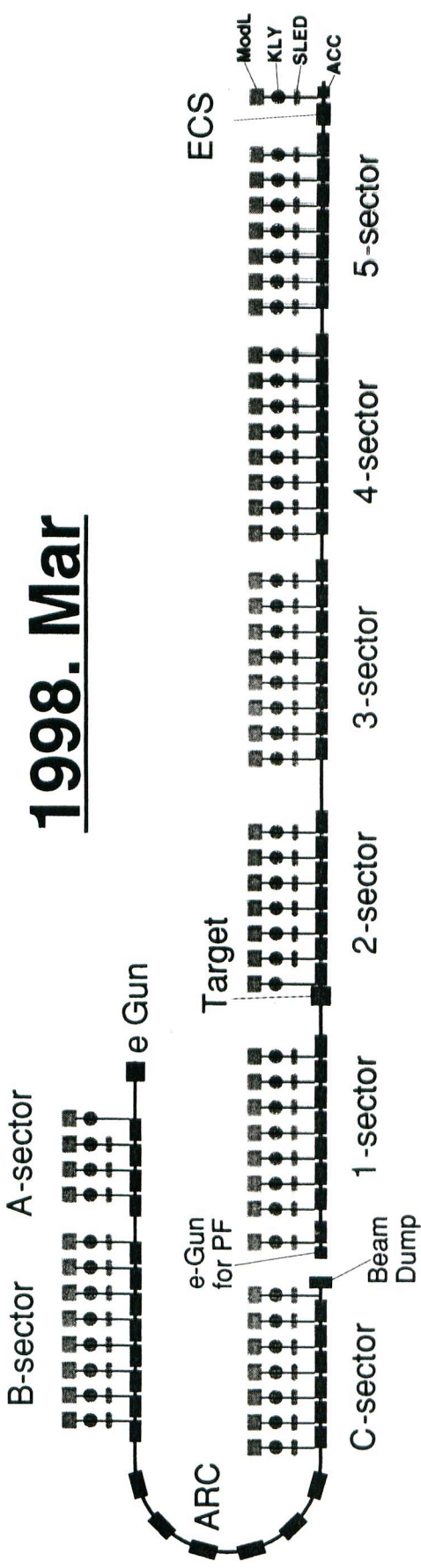
# 1997 Mar.



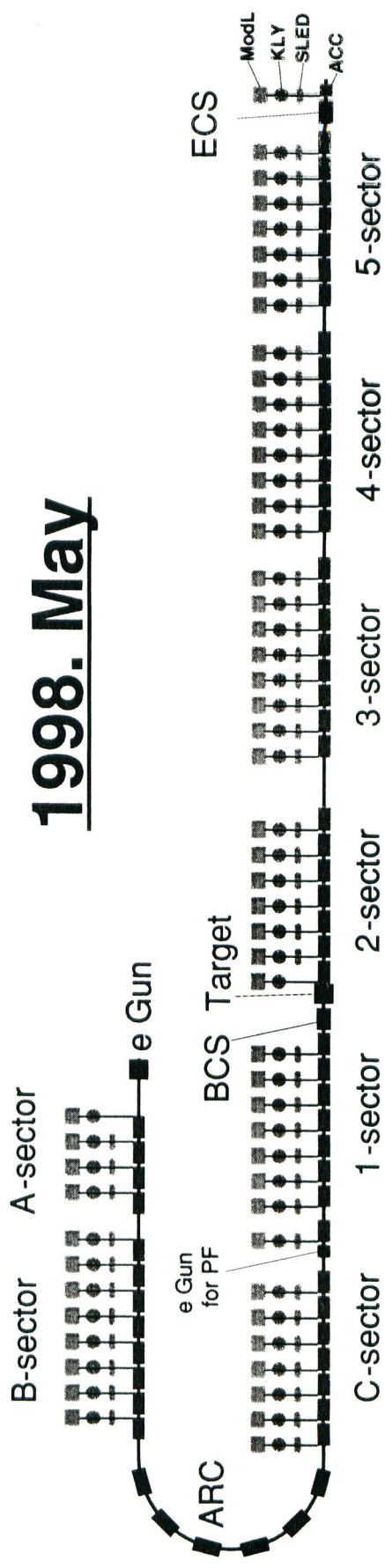
# 1997. Sep



# 1998. Mar



# 1998. May



## [6] Summary

(a) Energy Upgrade ---- OK

building completed

klystrons / modulators developed and modified

SLED works well

(b) Positron Production ---- in progress

target tested @ 0.5 GeV

high-current beam acceleration at the existing linac ( 4 nC)

beam test : 1997. 9-11 A & B 1998. 2-3 A, B, C & arc

1998. 5-6 A, B, C , arc & the existing linac