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2004/08/02
IUC

Report on Linac Study 2004/06/28-07/01

1. Multi-energy linac
2. Secondary e^- from e^+ target

Multi-energy linac

- Motivation: beam injection to KEKB/PF/AR "simultaneously".
  - KEKB: 8GeV e^- / 3.5 GeV e^+
  - PF: 2.5 GeV e^-
  - AR: 3 GeV e^- (upgrade to 3.5 - 4 GeV in future plan)
- Energy adjustment can or will be done by klystron or sub-booster phase quickly.
  - Beam is accelerated up to ~5.3 GeV then decelerated to 2.5 GeV using deceleration phase.
  - PF/AR should accept beam from A1 Gun (common source).
- It is difficult to change magnetic field fast by using current system.
- Is there beam optics to satisfy different energy beams ?
- If answer is "yes", beams can be injected to KEKB/PF/AR simultaneously in at least KEKB e^- mode w/o bypass line.
- Need modification/construction of SY3 and AR beam-transport line.

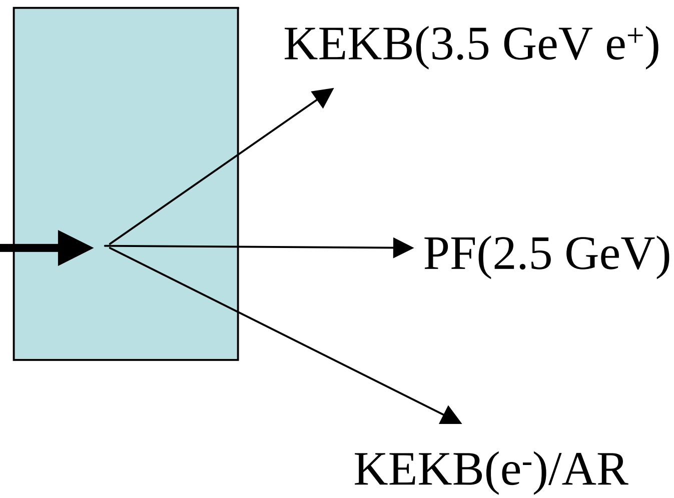
Beam separation

Linac end

Now

BM611(ECS 1st bend)

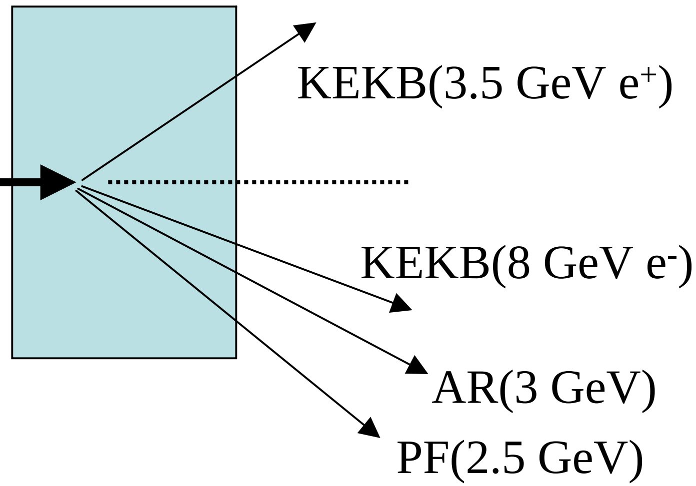
- Optics changes
- Magnet standardization
- Energy adjustment by switching ACC/STB



LINAC

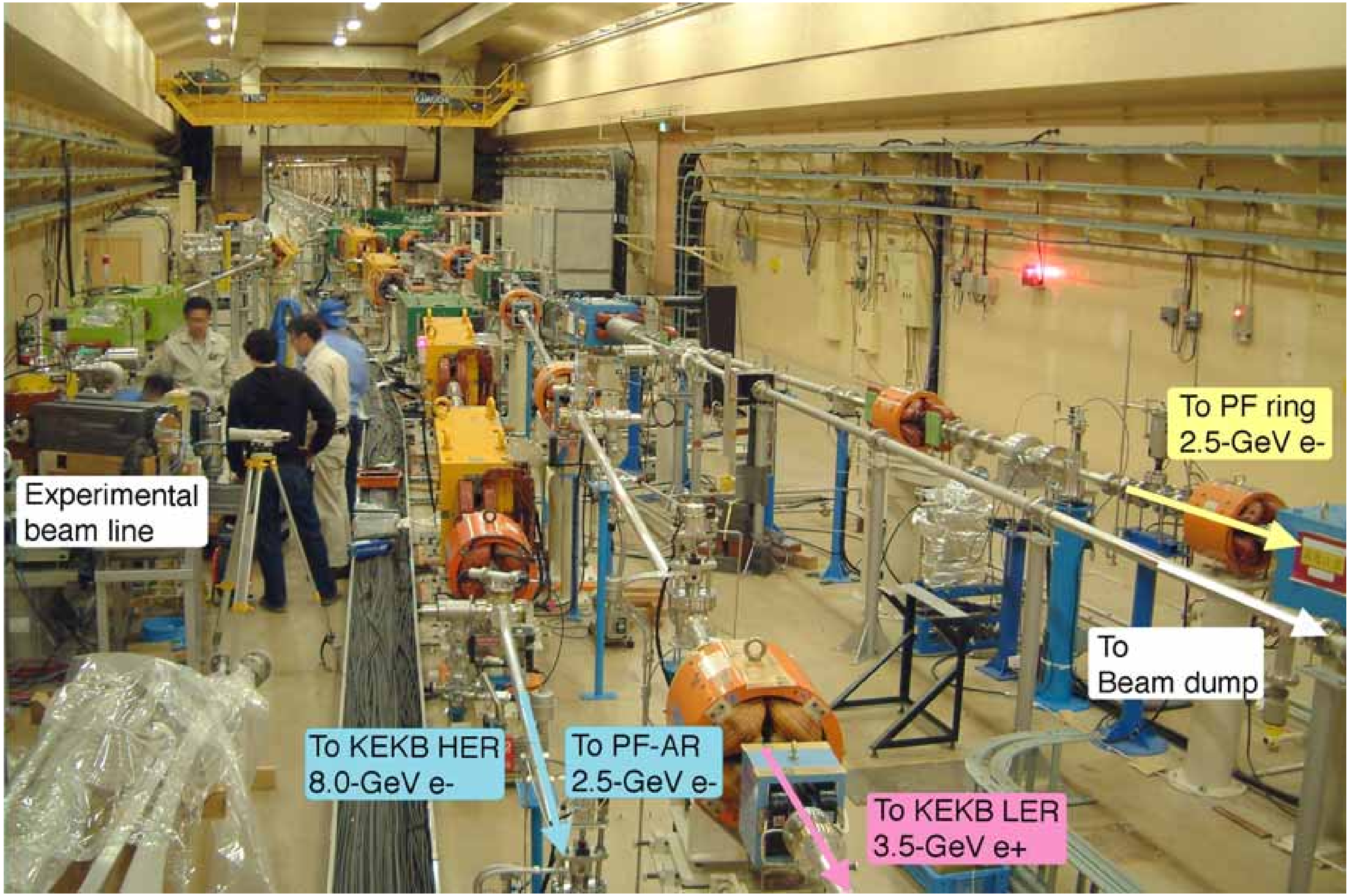
New

- No magnet standardization or changes
- Energy adjustment by fast phase shifter

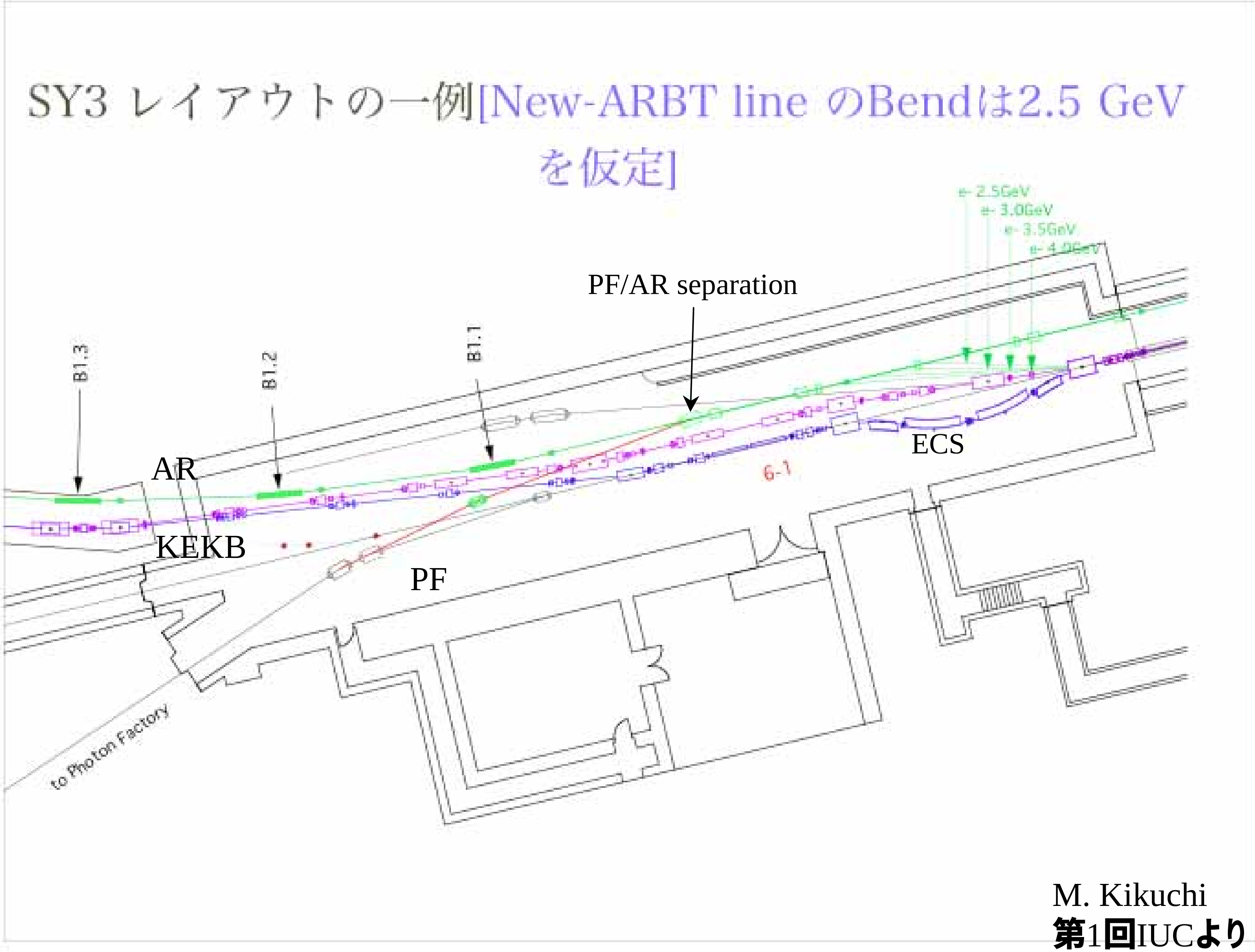


multi-energy
8 GeV e-/3 GeV e- /2.5 GeV e-

SY3 configuration (present)



Modification of SY3 for multi-energy linac



M. Kikuchi
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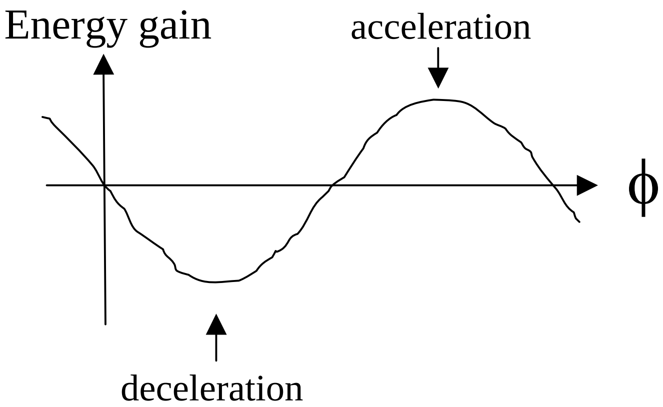
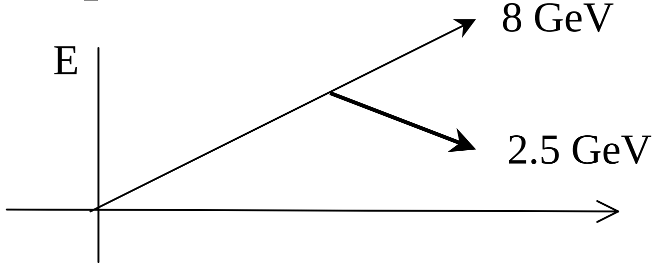
"2.5 GeV" e^- optics
&
8 GeV e- optics (based on 2.5 GeV)

- Energy adjustment
  - C1~34: full acceleration up to 5 GeV
  - 35~5-sector end: full deceleration to 2.5 GeV with 180 deg. phase shift of klystrons or sub-boosters.
- 90 deg. phase advance (4-sector & 5-sector) for 2.5 GeV optics ⇒ ~25 deg. phase advance for 8 GeV optics

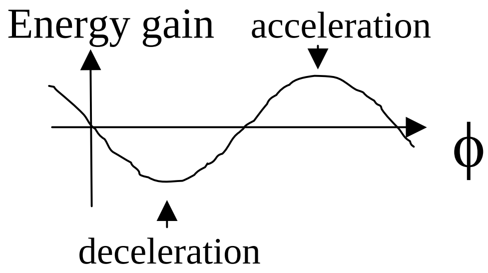
- Measurement
  - Energy (BM611 & SP61H/SC61H)
  - Emittance (5-sector wire scanner)

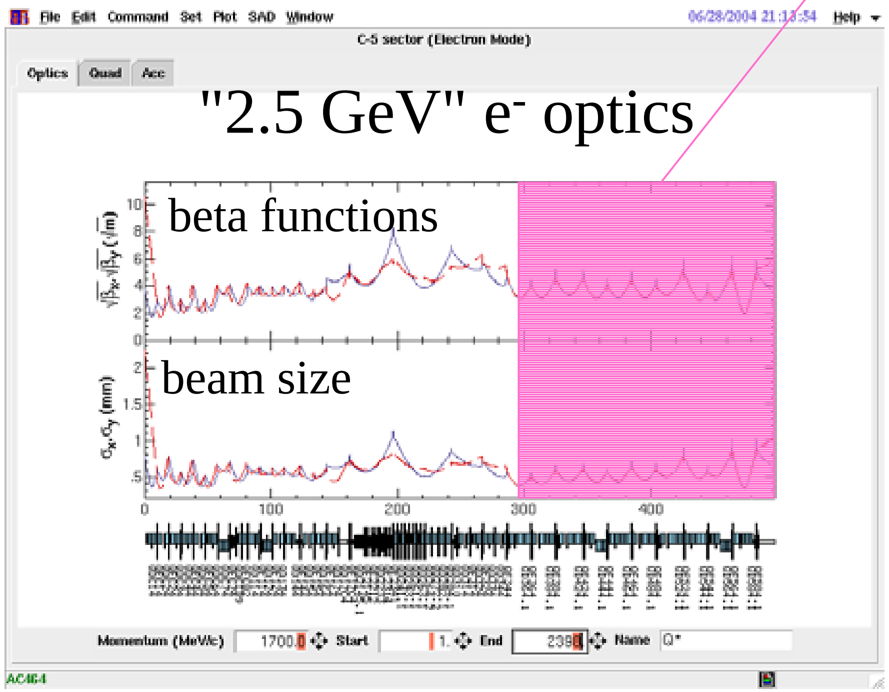


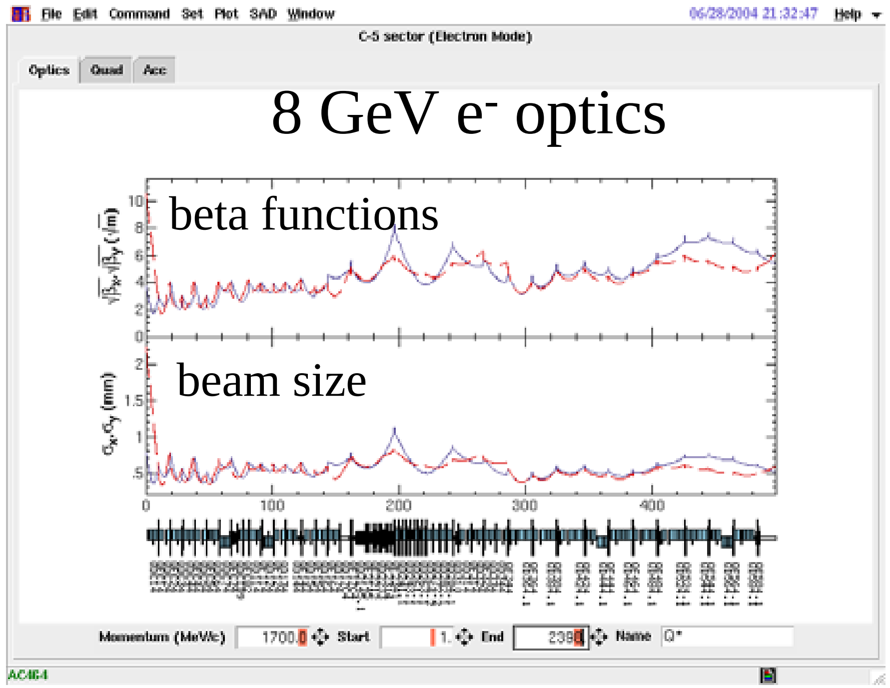
Experiment



deceleration phase



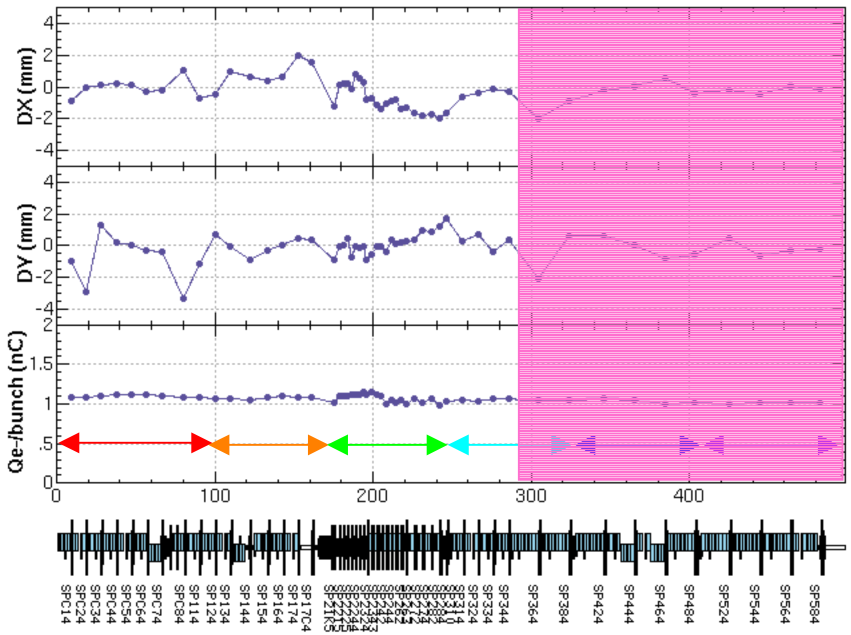




- Difference between 2.5 GeV and 8 GeV optics is phase of klystrons or sub-boosters.
- Magnetic field DO NOT change.

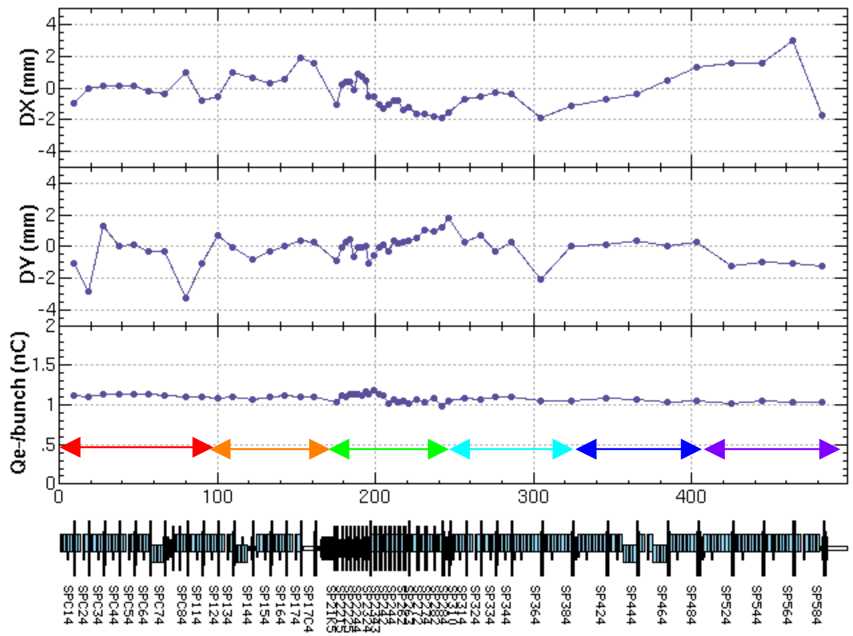
Beam orbit in "2.5 GeV" and 8 GeV e^- optics

"2.5 GeV" e^- optics



C-sector 1-sector 2-sector 3-sector 4-sector 5-sector

8 GeV e^- optics



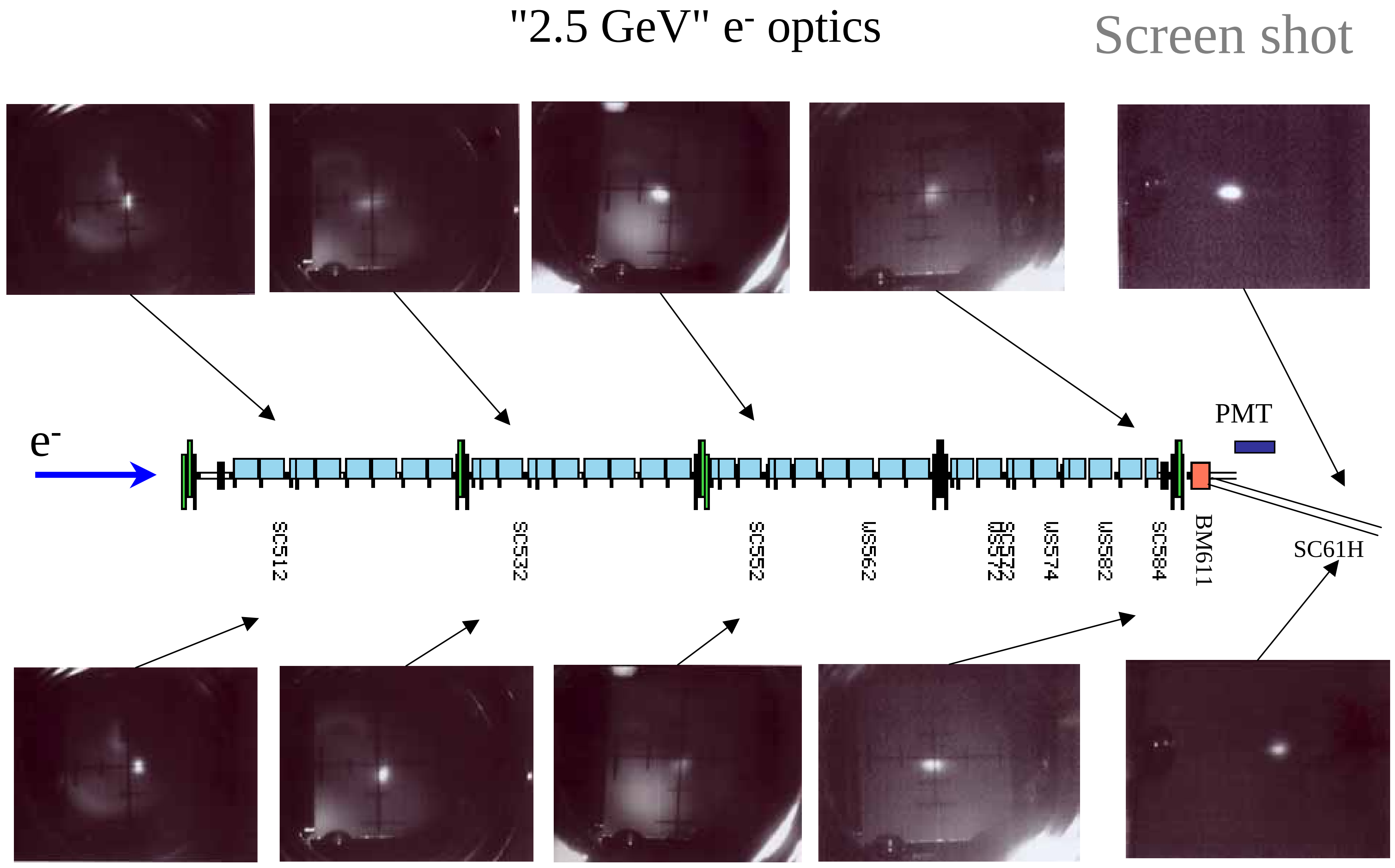
C-sector 1-sector 2-sector 3-sector 4-sector 5-sector

Measurement of energy and emittance

- Energy = 2.7 GeV (SC61H)
- $\gamma\varepsilon_x$ = 3.6x10^{-4} m
- $\gamma\varepsilon_y$ = 6x10^{-5} m

- Energy = 8 GeV (SC61H)
- $\gamma\varepsilon_x$ = 2.5x10^{-4} m
- $\gamma\varepsilon_y$ = 4x10^{-5} m

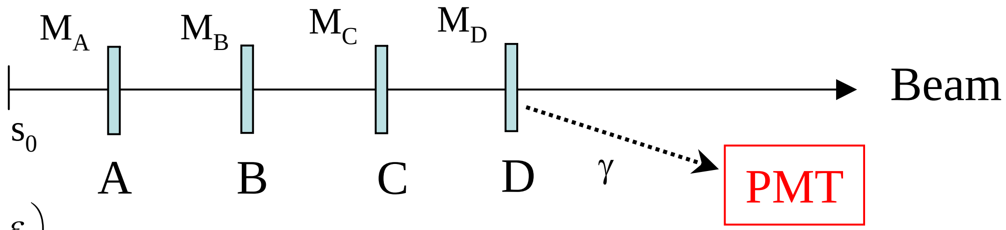
"2.5 GeV" e^- optics



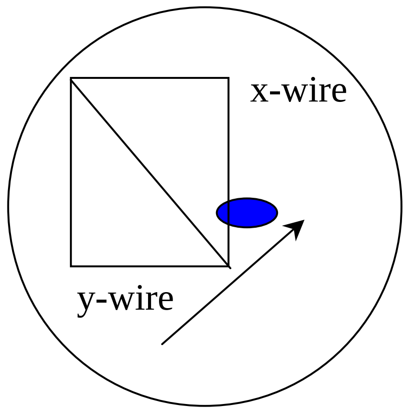
8 GeV e^- optics

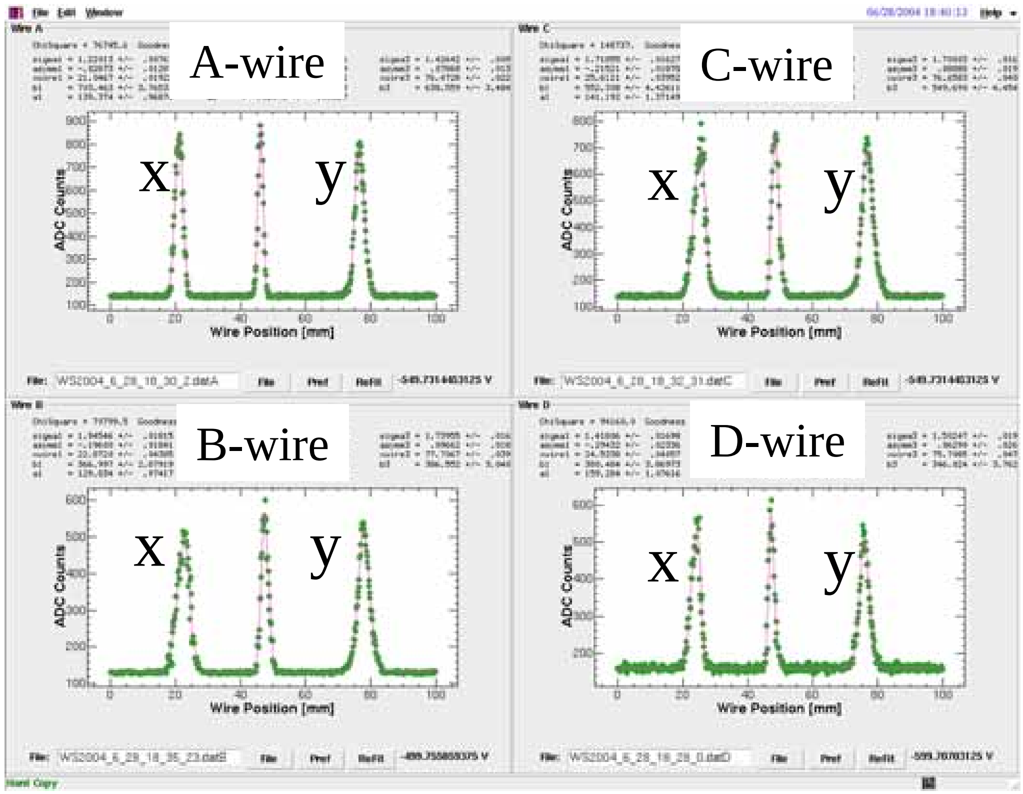
Emittance measurement using Wire Scanner

- Non-destructive
- $e^- X \rightarrow e^- X \gamma$



$$\begin{pmatrix} \sigma_{xA}^2 \\ \sigma_{xB}^2 \\ \sigma_{xC}^2 \\ \sigma_{xD}^2 \end{pmatrix} = \begin{pmatrix} m_{11A}^2 & -2m_{11A}m_{12A} & m_{12A}^2 \\ m_{11B}^2 & -2m_{11B}m_{12B} & m_{12B}^2 \\ m_{11C}^2 & -2m_{11C}m_{12C} & m_{12C}^2 \\ m_{11D}^2 & -2m_{11D}m_{12D} & m_{12D}^2 \end{pmatrix} \begin{pmatrix} \beta_0\varepsilon \\ -\alpha_0\varepsilon \\ \gamma_0\varepsilon \end{pmatrix}$$





Summary of multi-energy linac

- Common magnet setting has been tested for "2.5 GeV" and 8 GeV e^- beams.
- Orbit displacement is "mild" between "2.5 GeV" and 8 GeV e^- optics.
- Orbit correction satisfies both energies can be made.
- Normalized emittance of 8 GeV is similar to "2.5 GeV" e- optics.

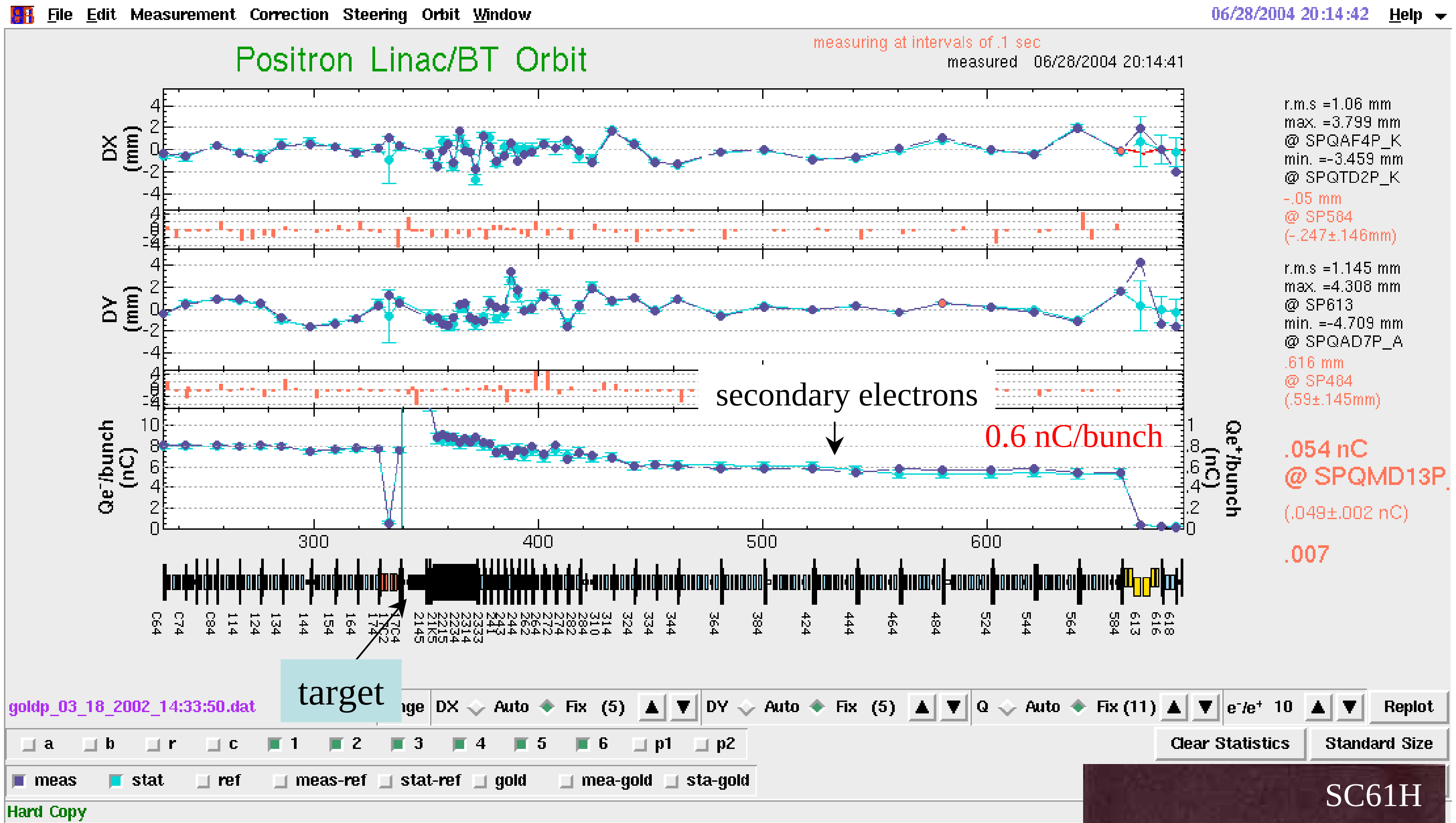
Secondary e^- from e^+ target

- Primary e^- (4 GeV) hits tungsten-copper target and e^-/e^+ are generated.

- e^- from target can be accelerated with phase shift of klystrons(opposite phase of e^+).
  - up to 3.5 GeV. C-Bands are needed to achieve 4 GeV e^- beam.
- Emittance of secondary electrons become larger than primary electrons. (similar emittance to e^+)

- Velocity bunching
  - idea of bunching beams with radio-frequency(RF) structures
  - to make energy-spread small (bunch compression)
  - phase slippage between e^- and rf wave during acceleration of non-relativistic e^-.

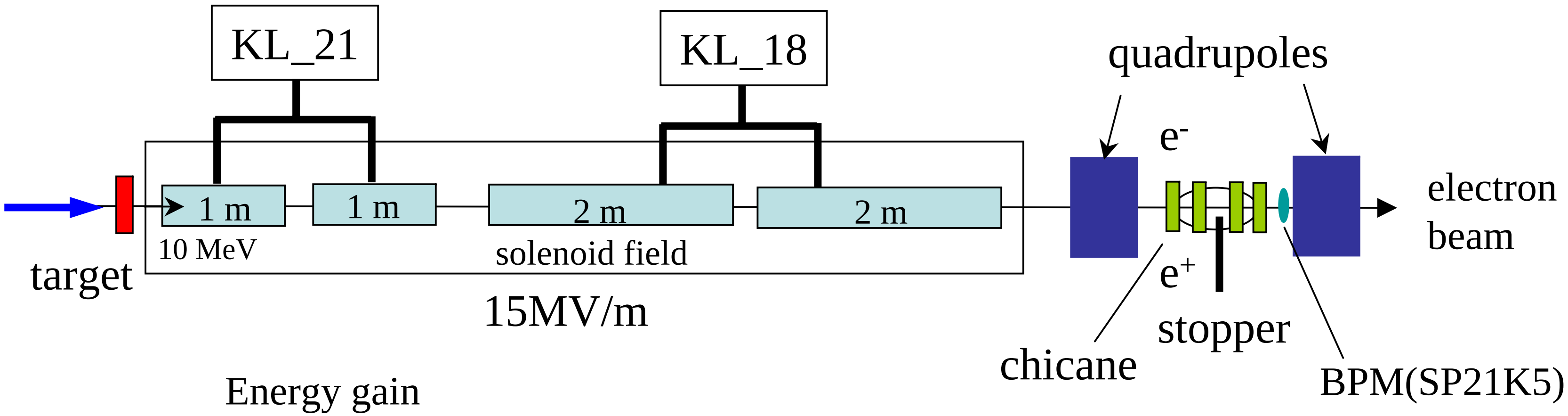
Secondary 3.5 GeV electrons (normal setting)

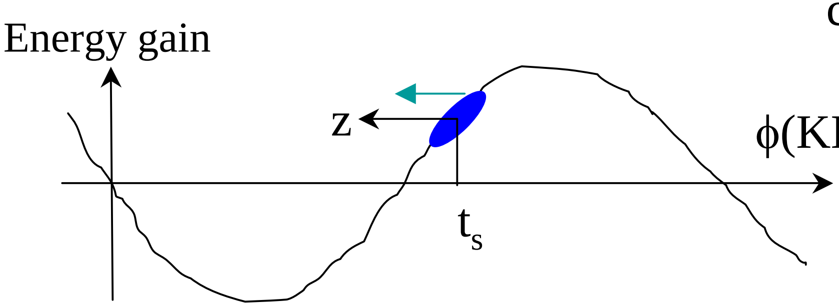


Emittance measurement with WS

- Energy = 3.5 GeV
- $\gamma\varepsilon_x = 1.8\text{x}10^{-3}$ m
- $\gamma\varepsilon_y = 1.5\text{x}10^{-3}$ m

Velocity bunching

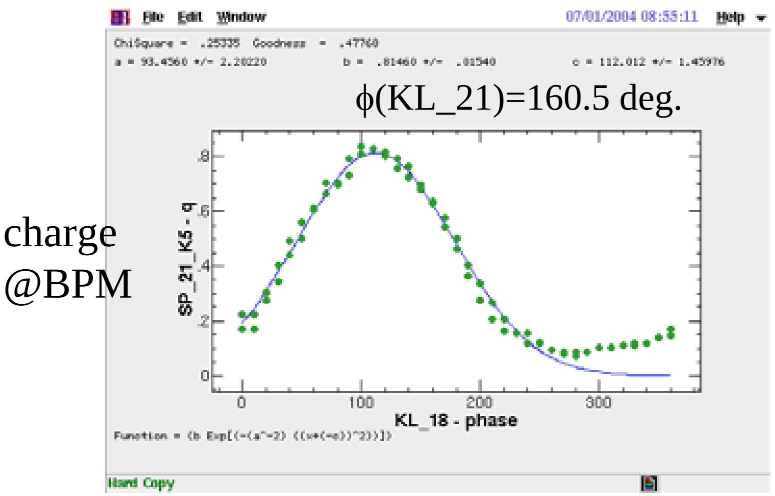


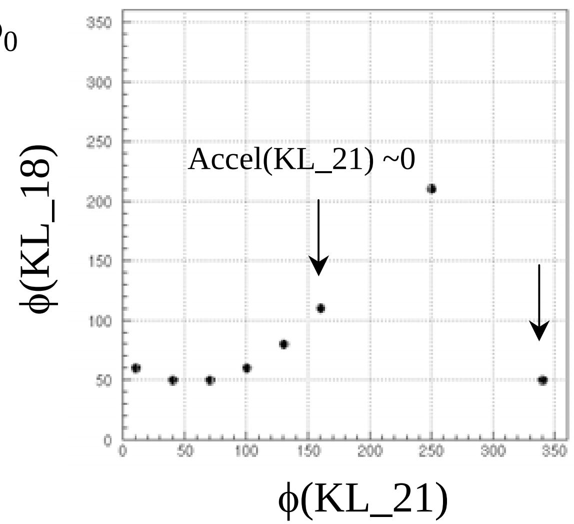


$z = -v(t-t_s)$

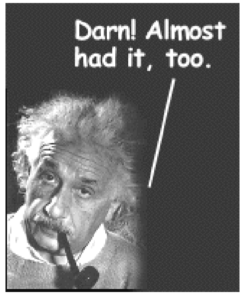
$\Delta E = -\,eV\sin(2\pi f_{RF}(t-t_s) + \phi_0)$

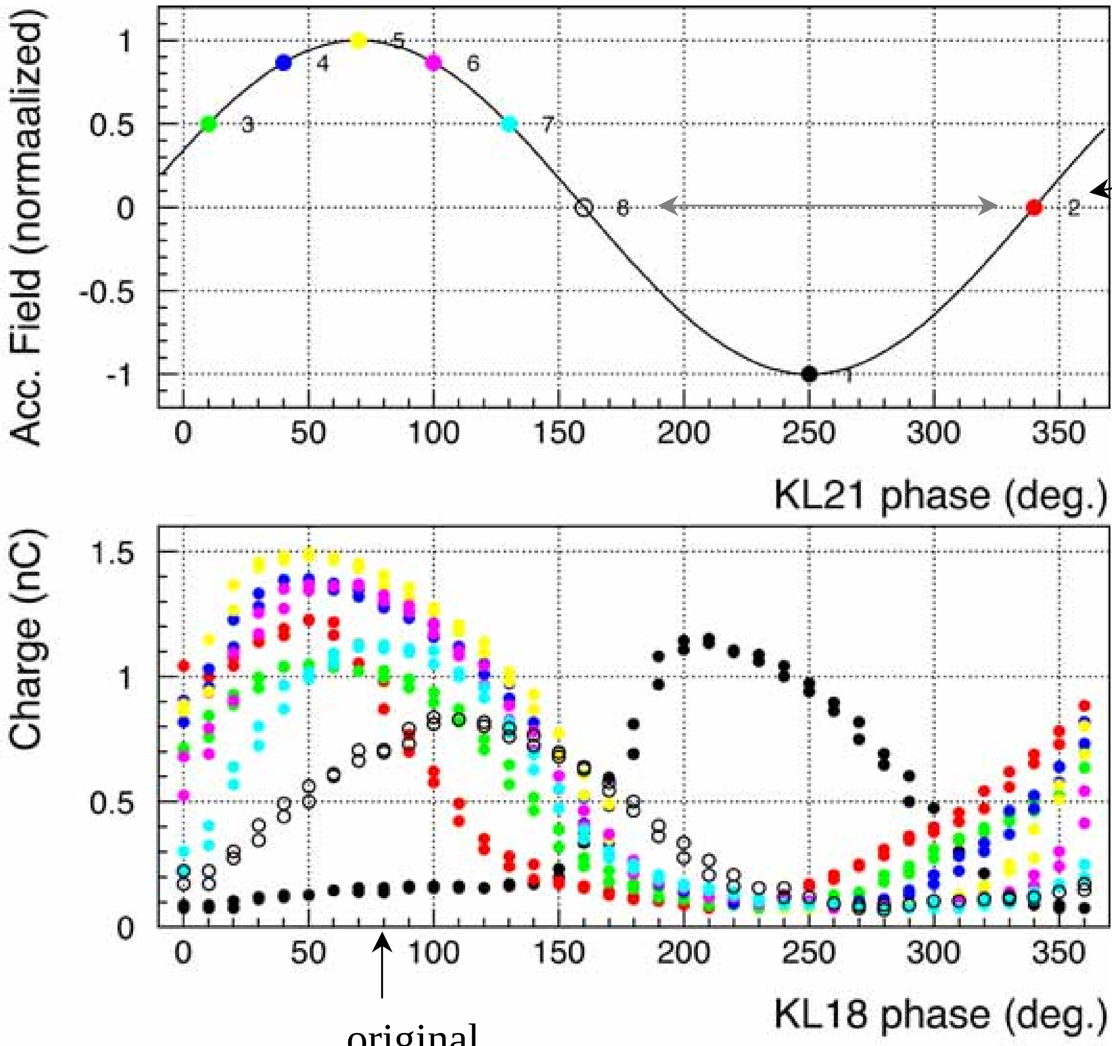
$\phi = 2\pi f_{RF}(t-t_s)+\phi_0 = -2\pi f_{RF}(z/v)+\phi_0$





Velocity bunching (cont'd)





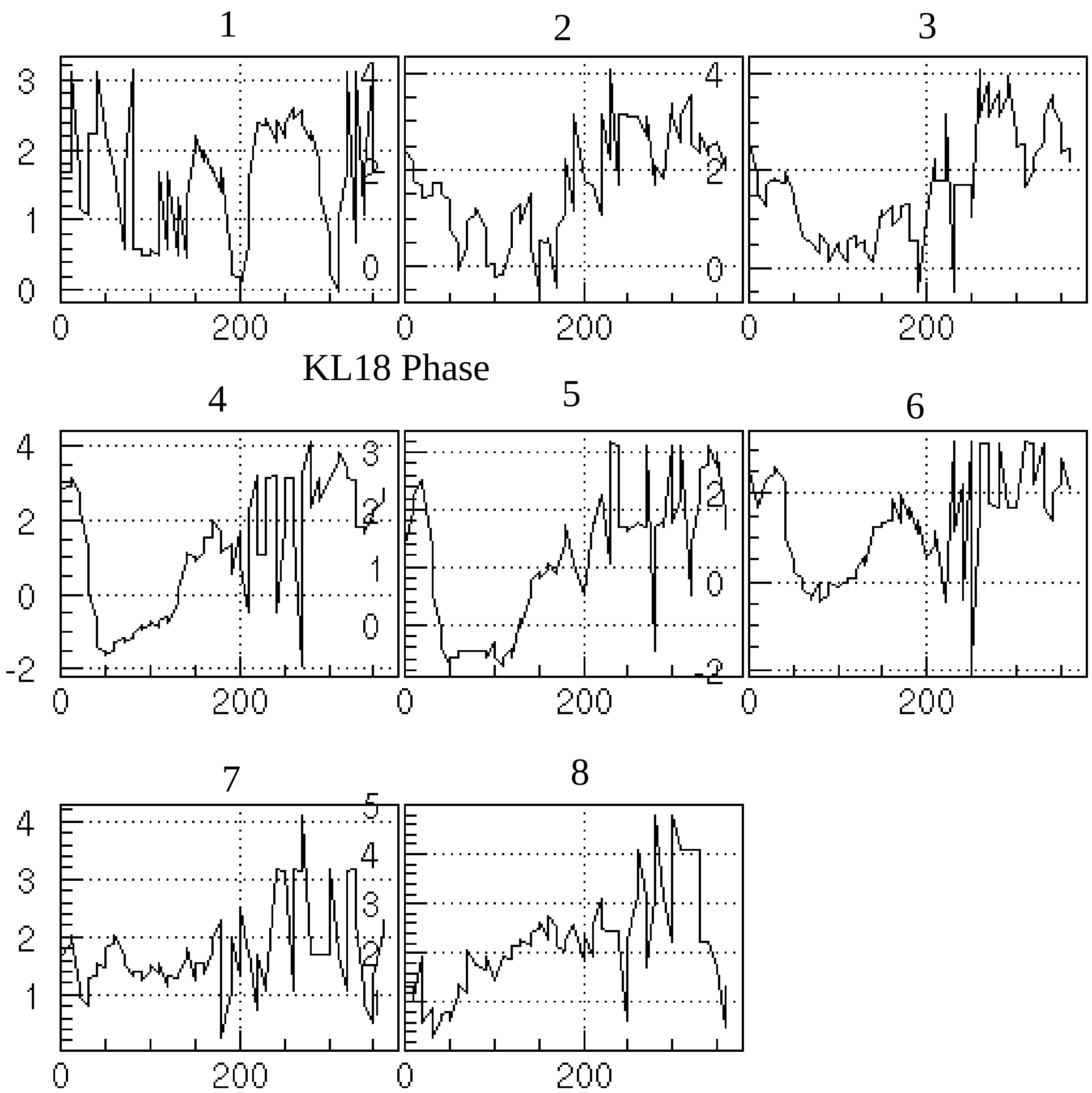
bunching
phase ?

phase shifter ?
θ or 2π-θ

original
phase

Summary of secondary e^-

- Secondary e^- can be accelerated to linac end.
- Emittance of e^- is similar to that of e^+ .
  - $\gamma\varepsilon_x = 1.8 \times 10^{-3}$ m / $\gamma\varepsilon_y = 1.5 \times 10^{-3}$ m
- Preliminary experiment for velocity bunching
  - Comparison of data with simulation.
  - Future plan:
    - Bunch length measurement using streak camera.
    - Preparation of optics for low initial energy e^- to transport to linac end.
    - Emittance measurements using 5-sector wire scanner.


KL18 Phase
1
2
3
4
5
6
7
8
0
200