ERRORS AND TUNING PROCESS

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A. Objectives

- Estimate the error tolerances of arc elements.
- Clarify the importance of the beam-based tuning process and its role in the tuning procedure.
  --> Guidelines for the development of beam-based measurement.

B Simulations of tuning procedure

1. Effects considered
   - Emittance ratio
     criterion : $\varepsilon_y/\varepsilon_x < 2$ %
   - Dynamic aperture
     criterion :
     $2J_x/\varepsilon_x/1000 + 2J_z/\varepsilon_z/600 > 1$
     ($dp/p > 1.7\%$ with $n_x=0$ and $n_x > 32$ with $dp/p = 0$)
     --> τ (Touchek) > 35000 sec
     Also $2J_x > 1.2\times10^{-5}$ $dp/p > 0.3\%$ for injected beam
   - Miss-crossing at IP for field ripples.

2. Errors and assumptions
   - The magnitude of errors are given in Table -1.0 (static errors)

Table -1.0: Errors used in simulation[1)]

element	Δx(mm)	Δy(mm)	$\Delta\theta$(mrad)	Δk/k
quads	0.15	0.15	0.2	1×10^{-3}
quads(QC)[2)]	0.01	0.01	0.1	1×10^{-4}
sexts	0.15	0.15	0.2	2×10^{-3}
bends		0.1	0.1	2×10^{-3}
correctors		0.1	0.2	
BPM[3)]	0.075	0.075		

[1)] The figures are for one standard deviation (σ).

[2)] Two quads near IP(QCS and QC1).

[3)] Assume Beam-based measurement of BPM offset.

Table -1.1: Tolerance of field jitter

element	relative jitter (σ)	what limits
Bends	1×10^{-5}	$\Delta x^* = 3.4\mu$m ($\sigma_x^* = 80\mu$m)
Quads	1×10^{-4}	$\epsilon_y/\epsilon_{y0} = 5 \pm 19\%$ $A/A_0 = 3 \pm 14\%$
Quads(QCS)	1×10^{-5}	$\epsilon_y/\epsilon_{y0} = 10\%$ $A/A_0 = 10\%$
Sexts		
Correctors	1×10^{-5}	$\Delta y^* = 0.1\mu$m ($\sigma_y^* = 2\mu$m)

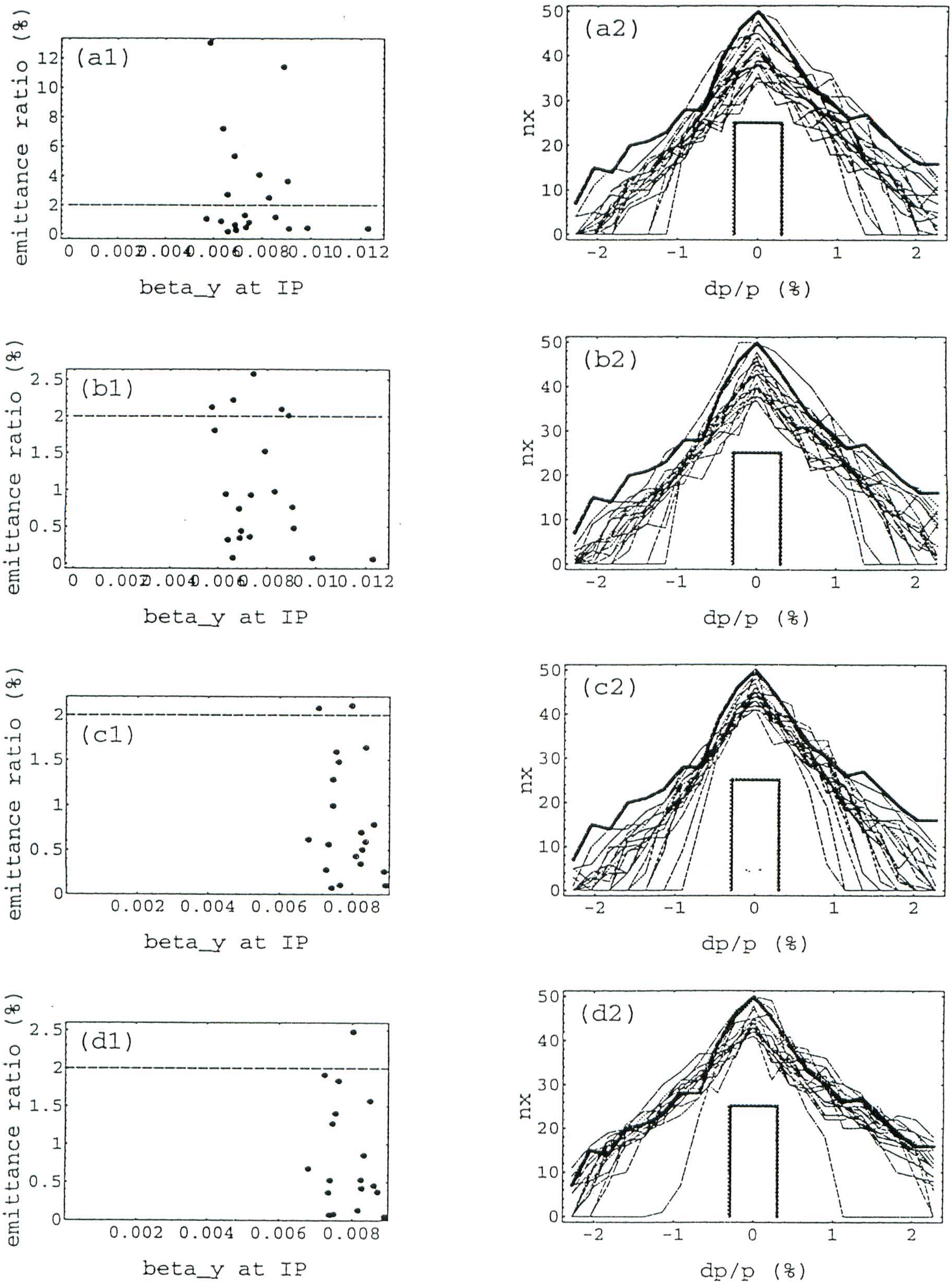
* TRISTAN
$(2\sim3)\times10^{-5}$
50 Hz.

- Consider only LER. The situation of the HER is expected to be similar since its arc lattice is basically identical to that of LER.
- Errors of quads near the IP (QCS and QC1) are very small. This is to magnify the effects of errors in the arc section.
- Every sextupoles have a mover with a maximum stroke of 3 mm in both horizontal and vertical directions.
- Offset of BPMs relative to the magnetic center of quads are measurable with an accuracy of 75 μm using beam-based method.
- Magnetic center of the sextupole is measurable with an accuracy of 75 μm using beam-based method.
- Strength errors of quads are measurable with an accuracy of 0.1% using direct or beam-based measurement.
- The errors obey Gaussian distribution with cut-off at 3 standard deviations (3σ).

3. Simulation results

3.1 Static errors

- Simulations with 20 different random seeds.
  $(\nu_x,\nu_y)=(46.52,46.08)$
  initial conditions: $2J_x=n_x^2\varepsilon_{x0}$
  $2J_y=0.11*\ 2J_x$
  $dp/p=-2 \sim +2\%$


(a1)
emittance ratio (%)
beta_y at IP
(a2)
nx
dp/p (%)
(b1)
emittance ratio (%)
beta_y at IP
(b2)
nx
dp/p (%)
(c1)
emittance ratio (%)
beta_y at IP
(c2)
nx
dp/p (%)
(d1)
emittance ratio (%)
beta_y at IP
(d2)
nx
dp/p (%)

! Sextupole re-alignment is very effective to improve the vertical emittance.

! The ordinary orbit correction and the sextupole re-alignment are sufficient in almost all the cases to fulfill the requirements.

! Measurement of the field error of quads with an accuracy of 0.1% is important for precise optics tuning.

3.2 Field ripples

Field ripples with a frequency for which the orbit feedback does not work may degrades the performance..

- Criteria:
  - Emittance growth and deterioration of dynamic aperture are less than 10%
  - Deviation of beam position at IP does not exceed $0.1\sigma^{*}_{x,y}$

D Summary

static errors

- Required emittance ratio and the dynamic aperture is achievable under the errors given in Table -1.0 if the sextupole has a mover and assumed beam-based measurement technique is available.
- Sextupole re-alignment is very effective to improve the vertical emittance.
- Measurement of the field error of quads with an accuracy of 0.1% is important for precise optics tuning.

Field ripples

- Tolerance of field ripples was estimated.

Beam-based measurement

- beam-based measurement should be developed.