A plan of ATF Final Focus Test Beam Line (A-FFTB)

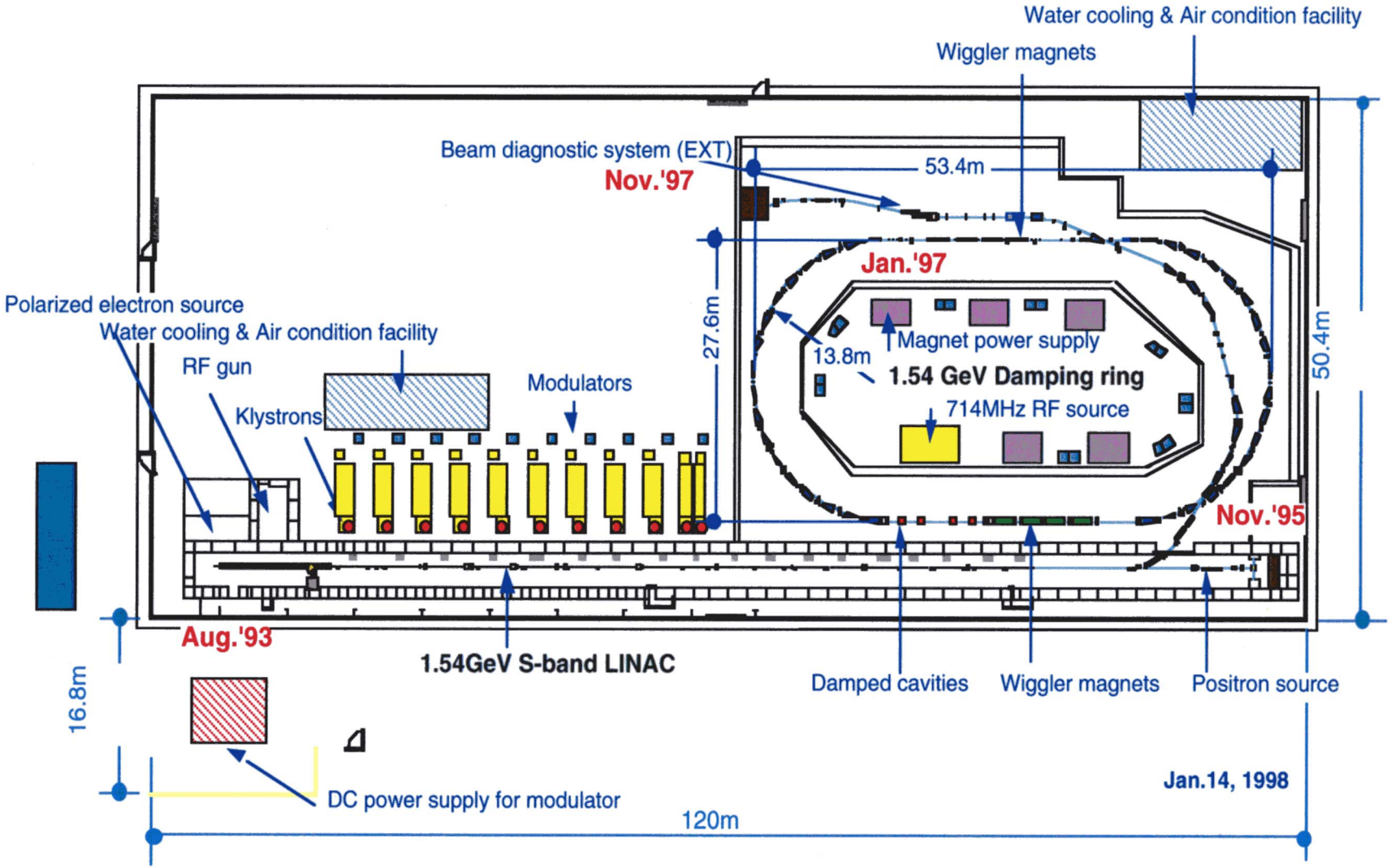
2002.9.5 Junji Urakawa

1. Introduction

2. Optics

3. Summary

ACCELERATOR TEST FACILITY FOR LC

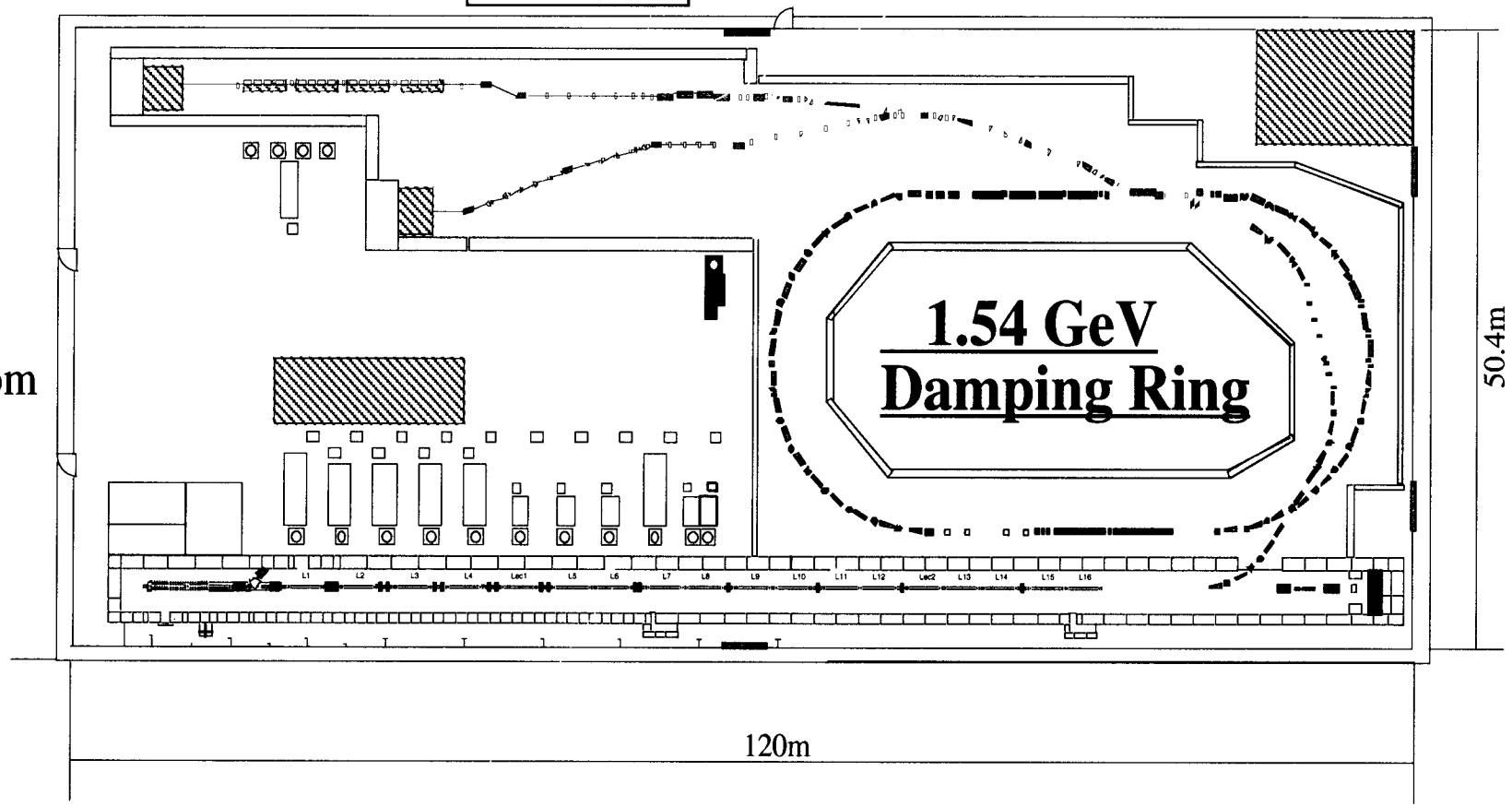


ATF-II

Bunch Compressor (30psec to 3psec)

X-band Section (ATF1)

Final Focus (ATF2)



Control Room

1.54 GeV S-band Linac

KEK is discussing ATF-II as next R&D for LC's.
Proposal of ATF-II will be obtained within two months.

*High Gradient beam acceleration with compact X-band System. (ATF1)

*Test of F.F. Optics (Proof of Principle Experiment). (ATF2)
Stabilization, FD to realize 50nm even if 1.3GeV.

Shigeru Kuroda, K.Kubo, T.Okugi, T.Tauchi and me (J.Urakawa)

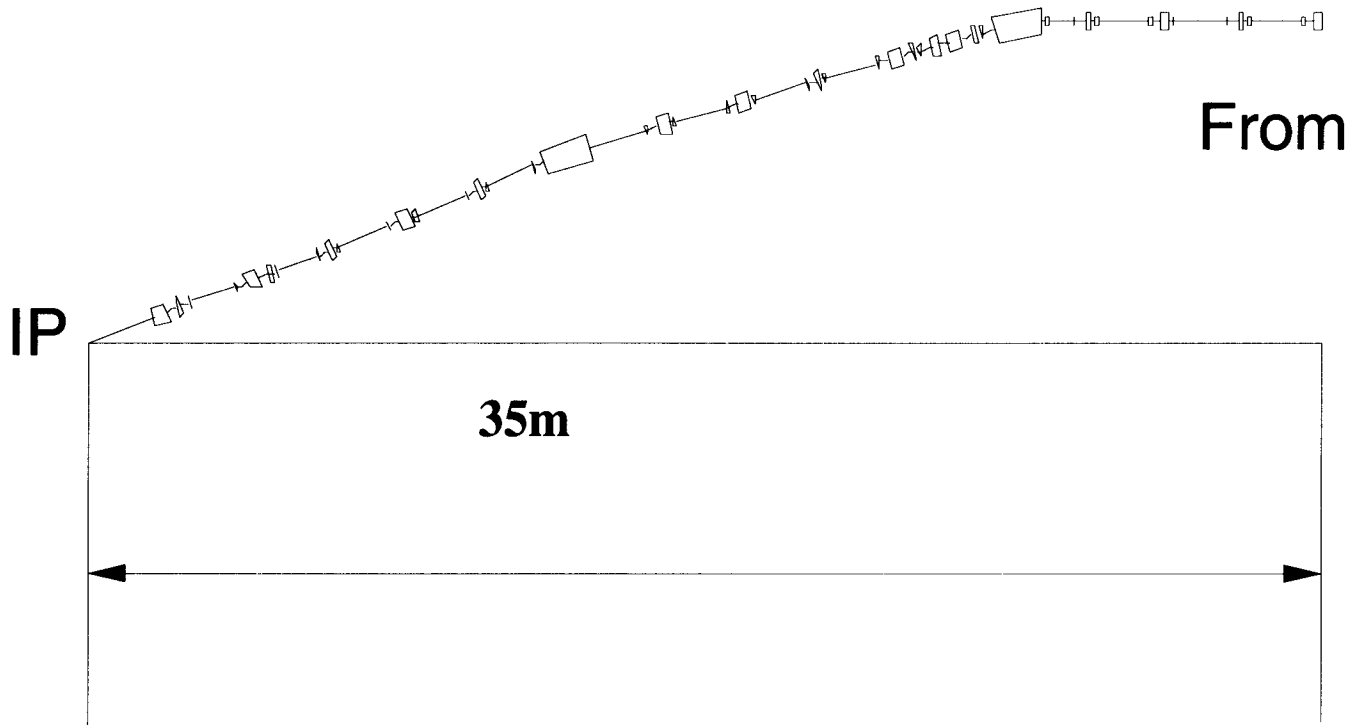
T.Tauchi : Leader of ATF2

ATF1:Simplest 2 single-mode DLDS and high gradient acceleration with 1.3GeV low emittance beam

- DLDS Experiment with Two 75MW Klystrons
- High Gradient Acceleration with 1.3GeV beam

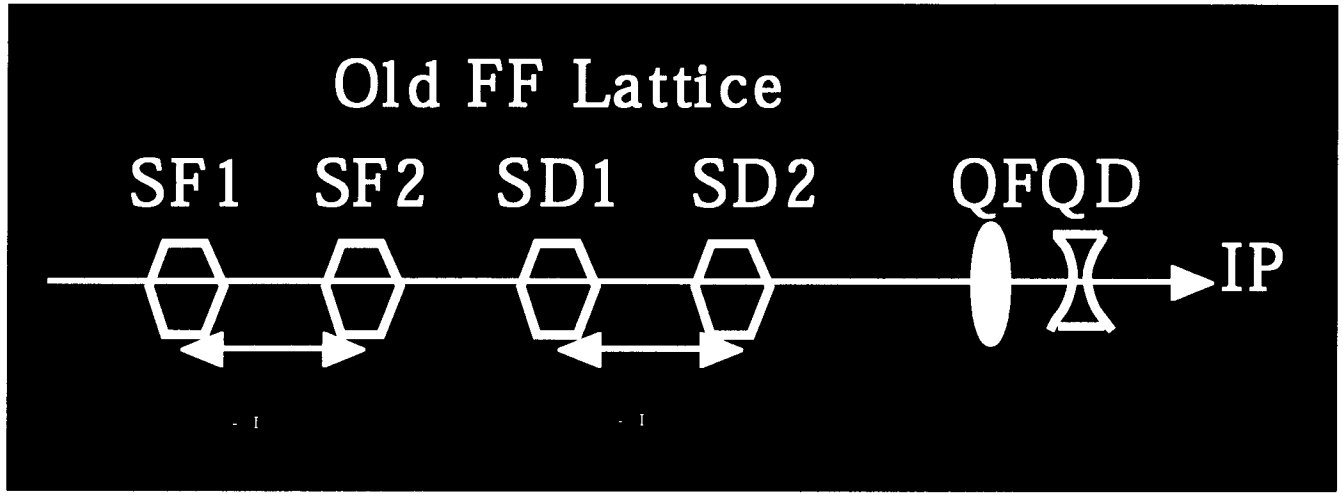
ATF1 has higher priolity. This is not related to my talk.
So, I will explain ATF2 for this workshop.

P.Raimondi and A.Seryi Lattice: Test of New Optics



Scaling (FFTB and ATF2) by only Physical Emittance

$$60nm \bullet \sqrt{\frac{46}{1.54}\frac{3\times10^{-6}}{3\times10^{-8}}} = 33nm!$$



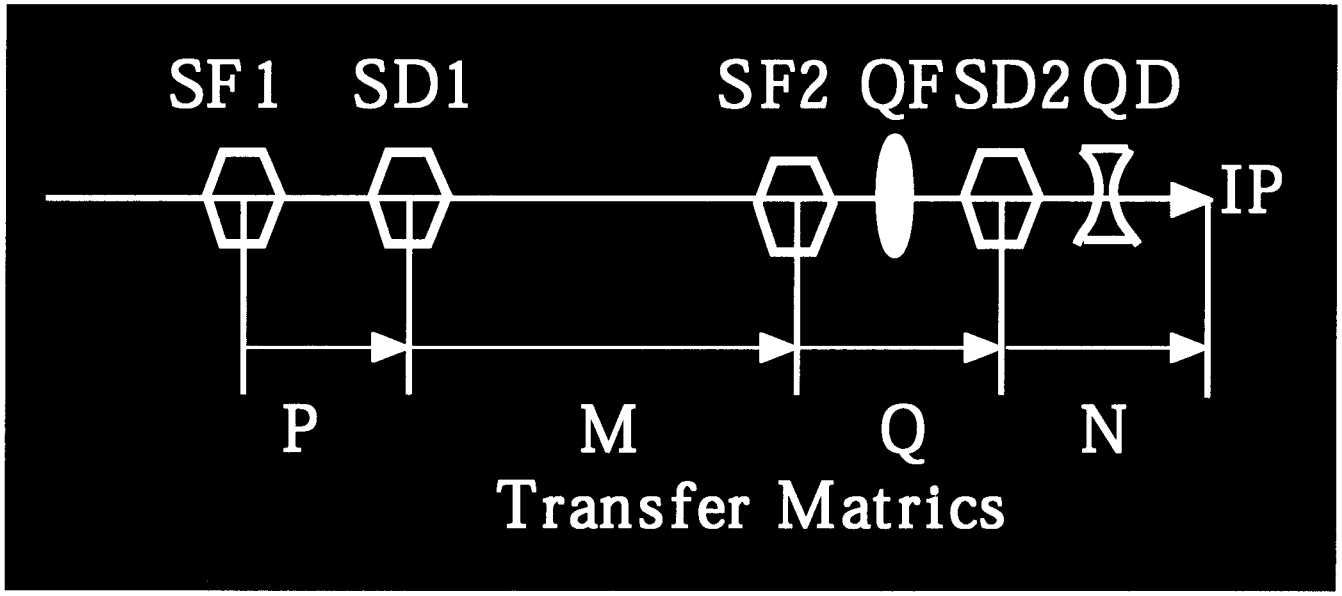
$$\Delta\sigma^* = \xi\delta\sigma_0^*$$

$$\delta = \frac{\Delta p}{p}$$

σ_0^* :linear optics beam size

Sexta in Dispersion region for chromaticity correction.
-I: Nonlinear Effect is cancelled.

P.Raimondi and A.Seryi (New FF Lattice)
~1600m is reduced ~500m.



2nd order geometric aberration is cancelled by SF1 and SD1.

$$MP = \begin{pmatrix} F & 0 & 0 & 0 \\ F_{21} & 1/F & 0 & 0 \\ 0 & 0 & F & 0 \\ 0 & 0 & F_{43} & 1/F \end{pmatrix}$$

$$QM = \begin{pmatrix} D & 0 & 0 & 0 \\ D_{21} & 1/D & 0 & 0 \\ 0 & 0 & D & 0 \\ 0 & 0 & D_{43} & 1/D \end{pmatrix}$$

$$K2_{SF1} = -F^3 K2_{SF2}$$

$$K2_{SD1} = -D^3 K2_{SD2}$$

Remain 3rd order geometric aberration.

Thin lens approximation:

$$K2_{SF1} = -F^3 K2_{SF2}$$

$$K2_{SD1} = -D^3 K2_{SD2}$$

$$U_{3444} \propto N_{34}^2 Q_{12} \left(N_{23} Q_{34} + N_{34} Q_{44} \right)^2$$

$$U_{1244} = U_{3224} \propto Q_{12} N_{34}^2 (NQ)_{12}^2 + Q_{12} N_{12}^2 (NQ)_{34}^2 - 4 Q_{34} N_{12} N_{34} (NQ)_{12} (NQ)_{34}$$

1,2,3 and 4 correspond to x, p_x, y and p_y

$U_{1244} = U_{3224} = 0$

U_{3444} : make small.

By final quads

Computer Program SAD:(http://acc-physics.kek.jp/SAD/sad.html
1.54GeV, 3×10^{-6}, 3×10^{-8}, $\Delta p/p=0.1\%$(Gaussian Distribution)
*Large Geometric Aberration due to large physical emittance
*Smaller nonlinear effect due to 0.1% energy spread
Comparing LC's design.
Required Condition:

$$L^* = 2m(IP - QD),(QF - SD2) = 2m$$
$$(SF2 - QF) = (SD2 - QD) = 0.3m$$

$$K_{QD} = -0.67m^{-1}, K_{QF} = 0.31m^{-1}$$

$U_{3444} = 9.57$ (not minimum but optimum choice considering ξ)

P-Lattice and Q-Lattice are identical. F=-1.12 and D=-0.893

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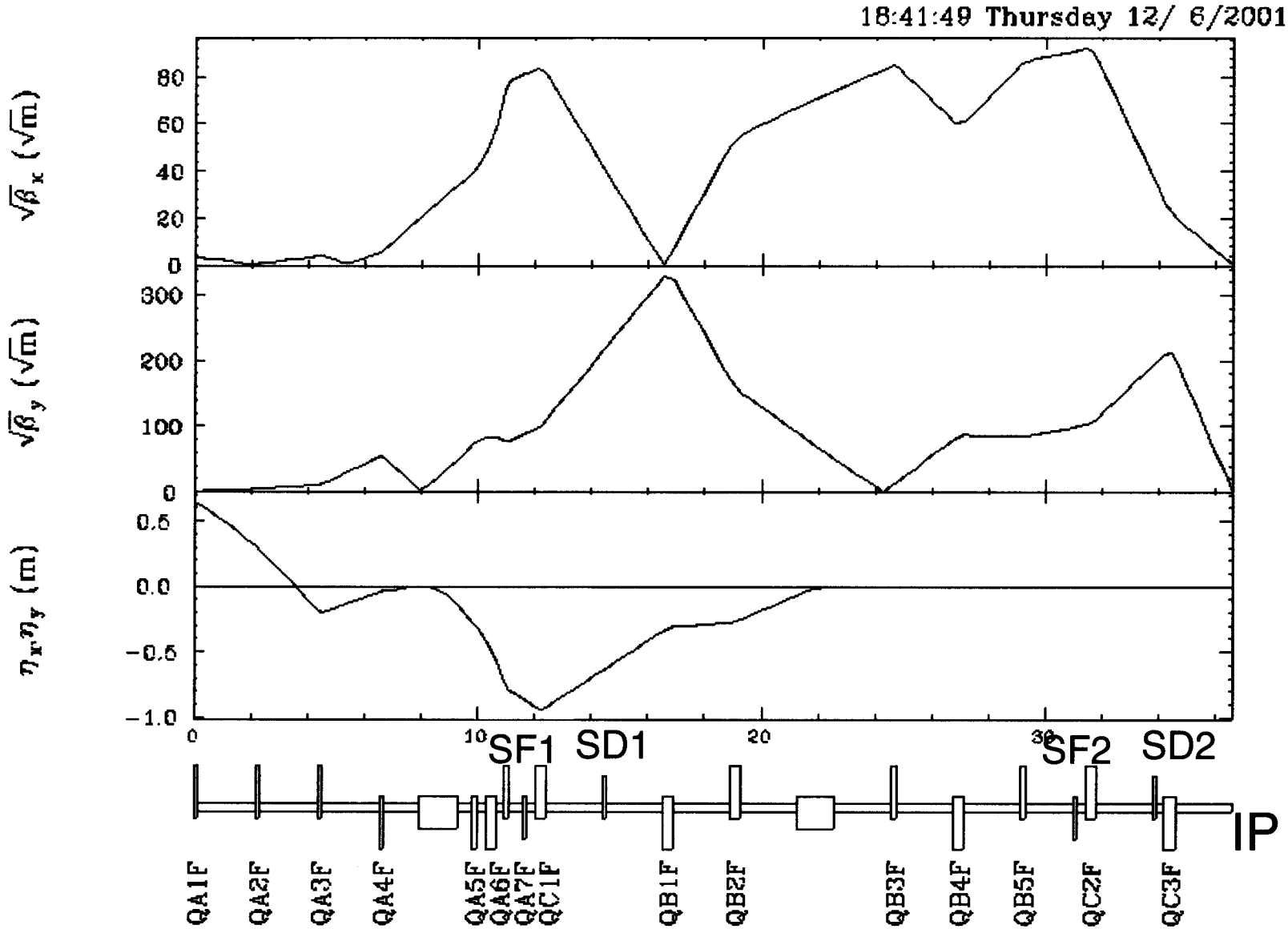
$$\left|K_{Quad}\right| \leq 0.2m^{-1}$$


18:41:49 Thursday 12/ 6/2001
$\sqrt{\beta}_x$ ($\sqrt{m}$)
$\sqrt{\beta}_y$ ($\sqrt{m}$)
η_x, η_y (m)
SF1
SD1
SF2
SD2
IP
QA1F
QA2F
QA3F
QA4F
QA5F
QA6F
QA7F
QC1F
QB1F
QB2F
QB3F
QB4F
QB5F
QC2F
QC3F

Matching at
IP:$\alpha_x=\alpha_y=0,\beta_x=0.01m,\beta_y=100\mu m,\eta_x=0$ for
δ=-0.2%,-0.1%,0%,0.1% and 0.2%

ΔP	-0.2%	-0.1%	0%	0.1%	0.2%
α_x	-0.089	-0.019	0.008	-0.010	-0.074
β_x[cm]	1.01	1.01	1.01	1.02	1.03
α_y	-0.063	0.003	0.007	-0.024	-0.058
β_y[μm]	102	102	101	101	101
η_y[μm]	-110	-20	12	-28	-153

$$K2_{SF2} = -1.2m^{-2}, K2_{SD2} = 3.5m^{-2}$$

Accidentally, the dispersion at the final sextupole magnets is Almost zero. This means the chromatic correction is done by The sextupole pair upstream and downstream sexta play the Role of the geometric aberration cancellation.--->$\eta=\eta'=0$

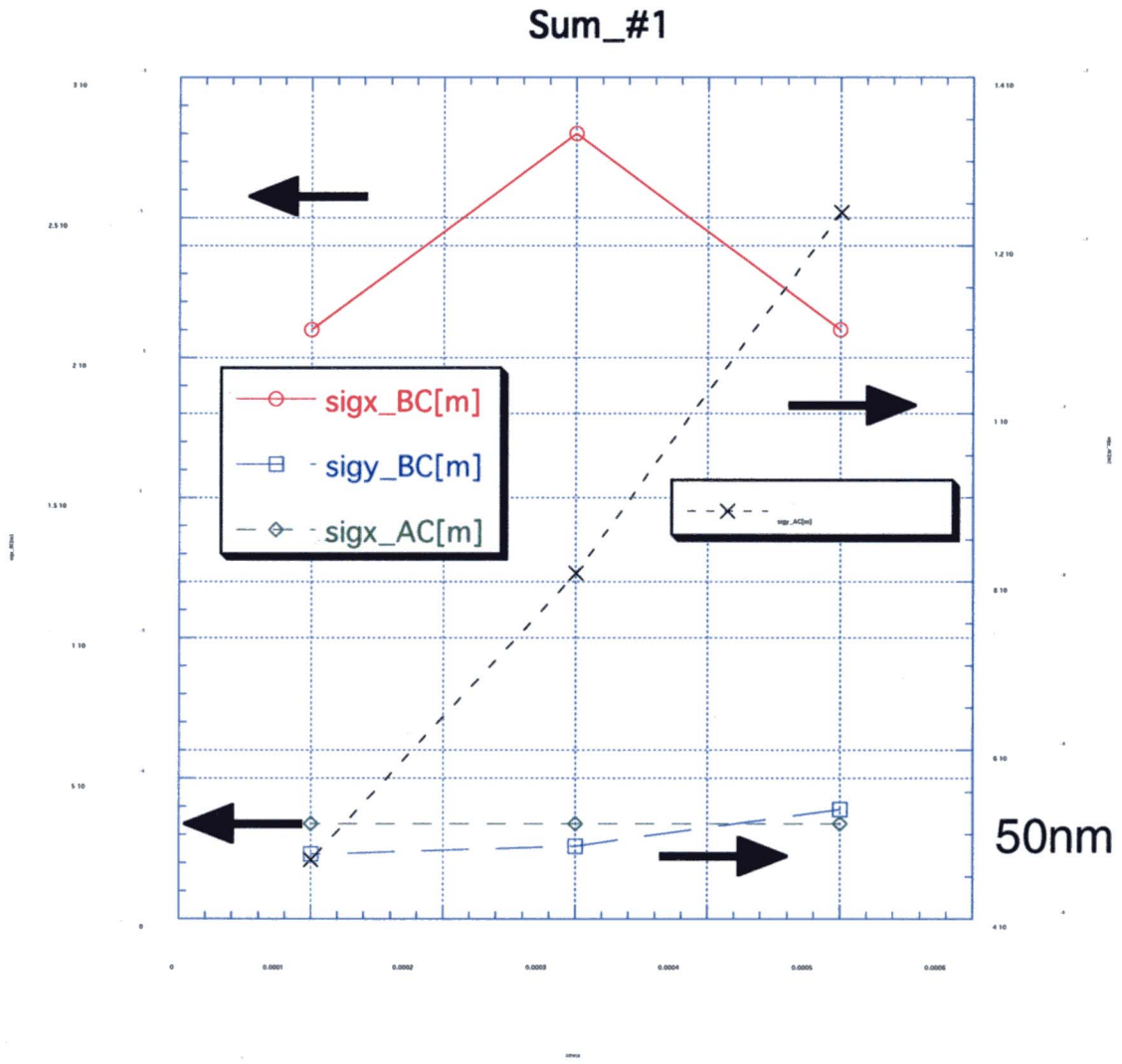
Tracking Simulation: 1000 particles, No Error
$\sigma_x^*=3.42\mu m$, $\sigma_y^*=36.8nm$
Error : 100 seeds
$\Delta\sigma_{rot}=0.1mrad$, $\Delta\sigma_z=500\mu m$, $\Delta\sigma_x=100\mu m$, $\Delta\sigma_y=50\mu m$,
$\Delta\sigma_{\Delta B/B}=0.01\%$ one σ cut distribution
After correction with ideal BPM and spot size monitor, Orbit Correction, Skew Correction, Position Correction of Sexta and FD.
$\sigma_y^*=47nm$ (90% C.L.)
If $\Delta\sigma_{rot}=0.02mrad$, $\Delta\sigma_z=50\mu m$, $\Delta\sigma_x=30\mu m$, $\Delta\sigma_y=30\mu m$,
$\sigma_y^*=37nm$??

Tuning Method

1. Orbit Correction with ideal BPM's (15 Quads), Longitudinal Movement of 2 Final Quads and 4 Sexta on Movable girders with ideal beam size monitor at IP.
2. (Orbit + Dispersion at 2 sexta near IP and IP): Minimize FQ, Sexta on Movable girder: tuning
3. 1-2 tuning : 4 times

First dispersion correction requires strong steerings.
So, we donot correct the dispersion due to error of quad-roll By steering magnets at first.

From ATF Alignment experience, Initial alignment of roll and pitch are +/-0.02mrad is possible by peak-to-peak. However, the diffusion of the alignment is fast and 0.15mrad peak-to-peak is diffused after about half year.



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Shigeru Kuroda asked me to say following “Words”;
“これは、とっても難しい！” It’s so challenging because of low energy 1.5GeV.
This is preliminary results. However, proposal for ATF-II will be completed by Tauchi (Group leader of ATF-FFTB).

Summary

It is very important to test experimentally the principle of the new final system. The beam size is expected as σ_x=3.4mm and σ_y=37nm.
R&D for some hardware is required.