FFIR Test Facility

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KEK
ATF2 Collaboration

LCWS2004, Paris

Goals

(1) Final focus test beam at ATF

- experimental verification of Pantaleo's optics
- demonstration of 30nm focus with $\sigma_x/\sigma_y=100/1$
- establishment of tuning methods
- nano technology of BPM, Shintake monitor
- final focus quadrupole magnet in the support tube
- beam halo studies by "octupole optics" etc.

Goal continued

(2) Nanometer stabilization of final doublet

- one final doublet and nano-BPM at IP for the demonstration
- support tube structure; role of a central CFRP tube
- nanometer position measurements based on laser interferometer (QPD, Optical anchor)
- nanometer stabilization with active movers
- inertial sensors
- fast feedback system at nanometer level

Option

(1) Test facility for photon collider

- Laser facility for LC specifications

  laser: 1.3J/pulse with a spot size of 3um,

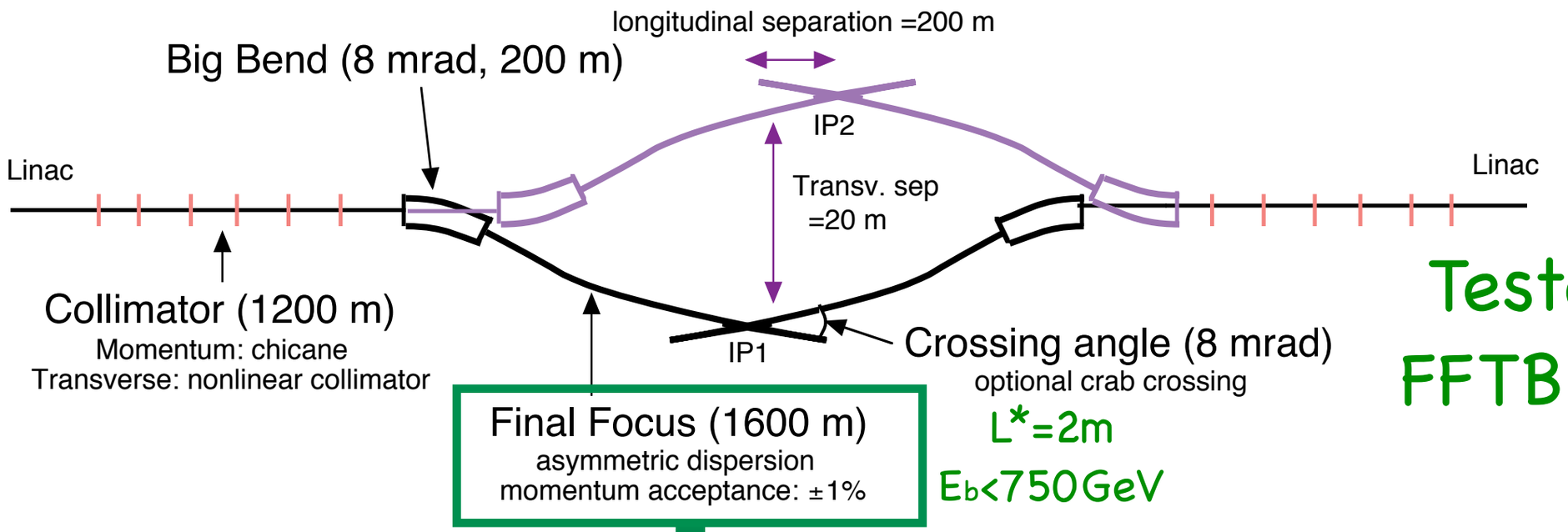
  192 pulses/1.4ns at 150Hz

  optics at IP

- Study of "strong" QED

Two Final Focus Systems

(1) Non-local chromaticity correction : JLC Design Study

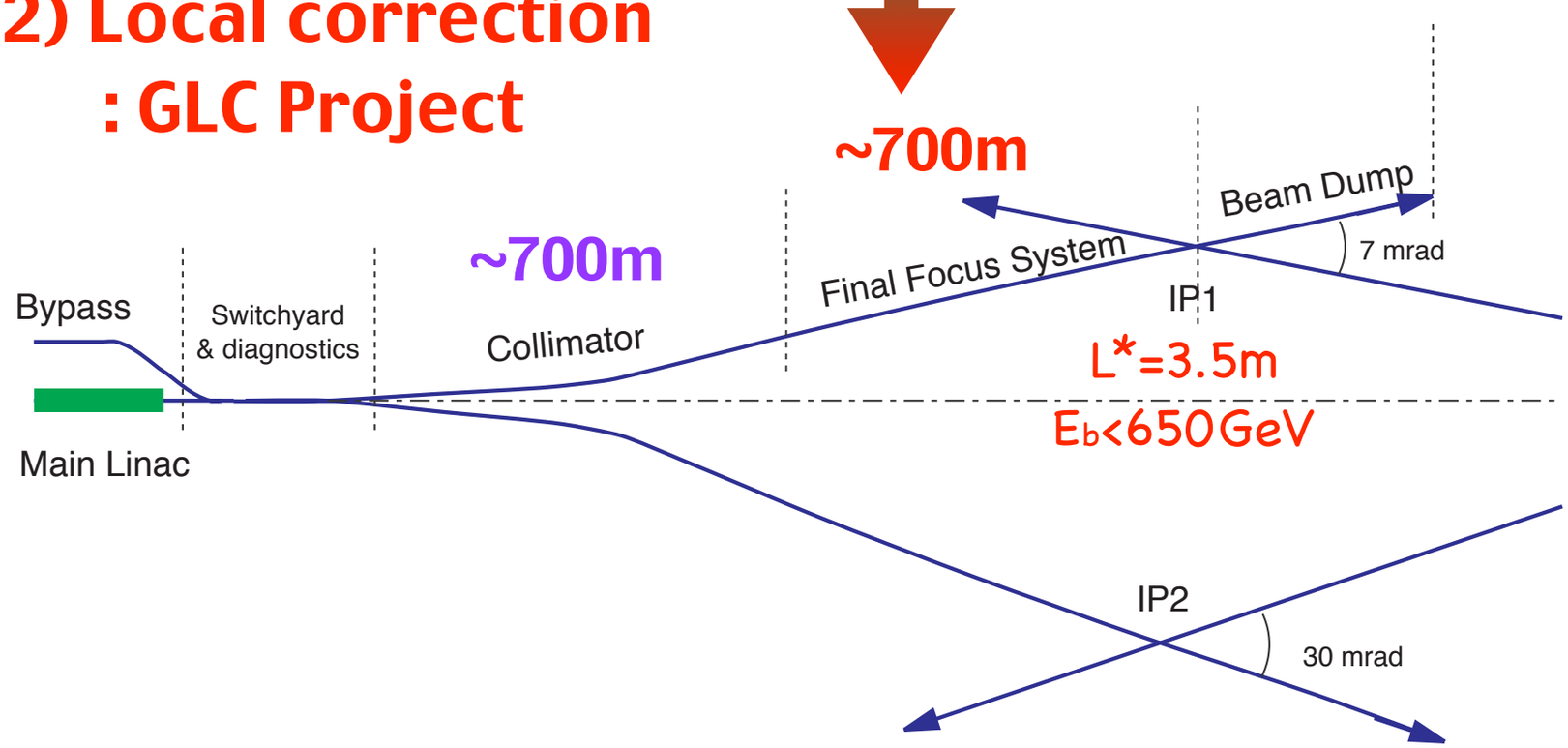


L^*=2m

E_b<750GeV

Tested at FFTB/SLAC

(2) Local correction : GLC Project



L^*=3.5m

E_b<650GeV

Not tested

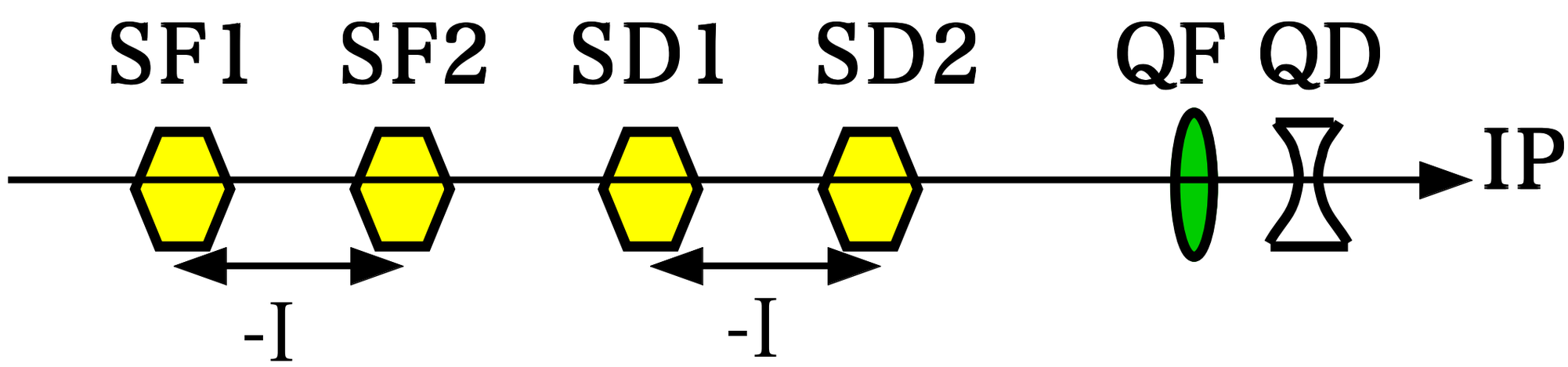
Optics Designs

Chromaticity : $\Delta\sigma^* = \xi\delta\sigma^*$, $\delta=(E-E_0)/E_0$

ξ correction by Sextupole (SX)

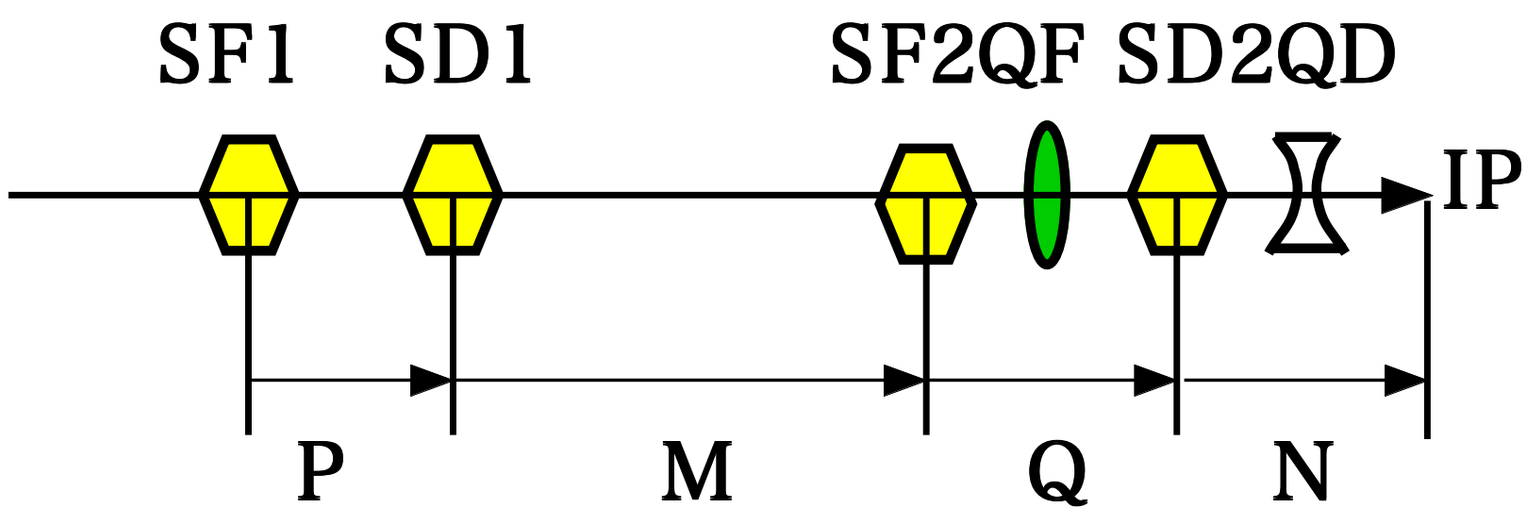
SX geometric aberration cancellation

(1) Non-local correction



FFTB/SLAC to ATF : $60\ \mathrm{nm} \bullet \sqrt{\frac{46}{1.28}\frac{3\times10^{-8}}{3\times10^{-6}}} = 36\ \mathrm{nm}!$

(2) Local correction



Transfer Matrics

geometric aberration cancellation

$$MP = \begin{pmatrix} F & 0 & 0 & 0 \\ F_{21} & \frac{1}{F} & 0 & 0 \\ 0 & 0 & F & 0 \\ 0 & 0 & F_{43} & \frac{1}{F} \end{pmatrix} \qquad QM = \begin{pmatrix} D & 0 & 0 & 0 \\ D_{21} & \frac{1}{D} & 0 & 0 \\ 0 & 0 & D & 0 \\ 0 & 0 & D_{43} & \frac{1}{D} \end{pmatrix} \qquad \begin{pmatrix} x \\ x' \\ y \\ y' \end{pmatrix}$$

$$k2_{SF1} = -F^3 k2_{SF2} \qquad k2_{SD1} = -D^3 k2_{SD2}$$

3rd order geometric aberration cancellation

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

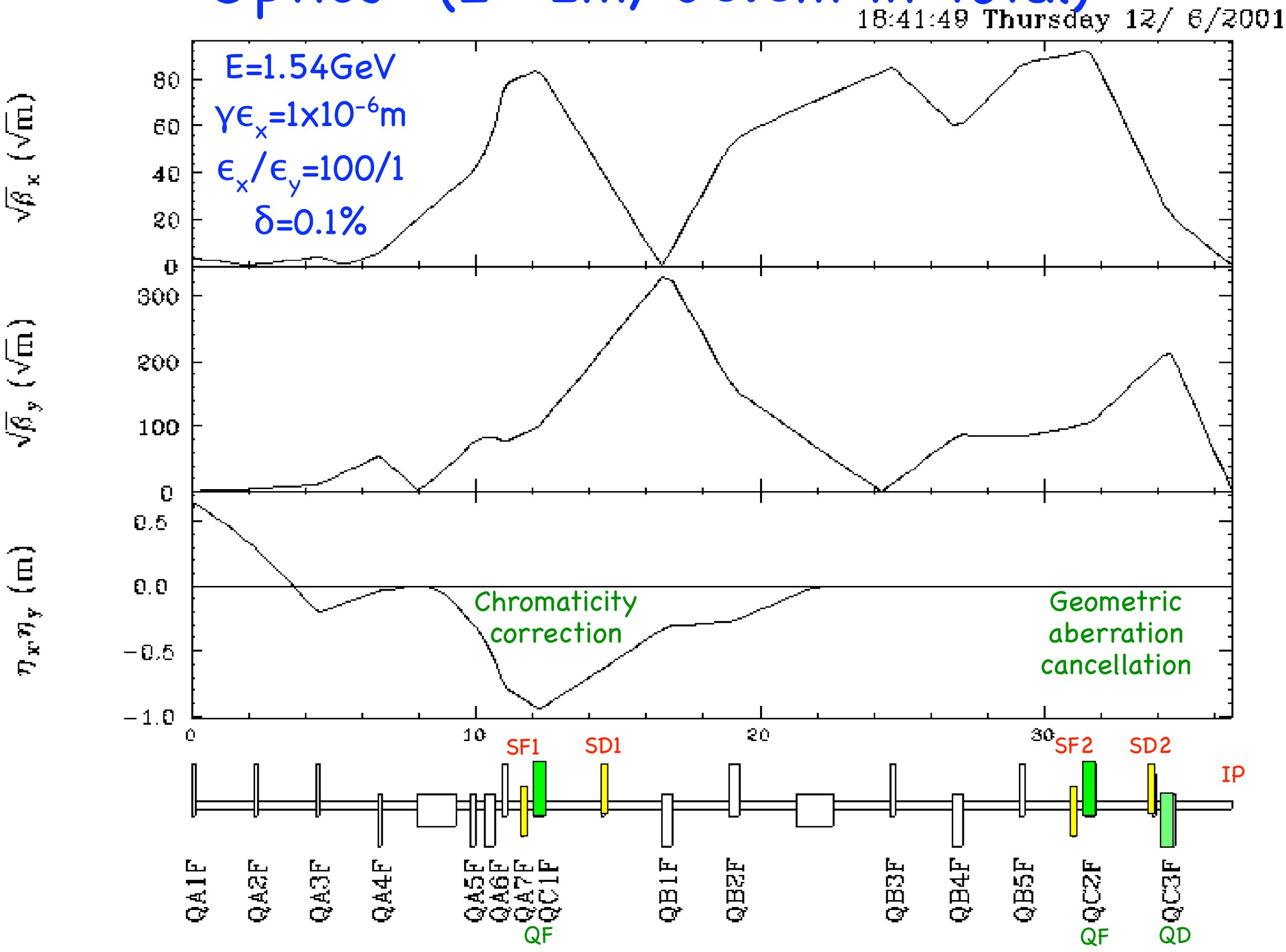
L* given =0, then $k_{QD}=f(k_{QF})$

$$U_{3444} \propto N_{34}^2 Q_{12} (N_{33} Q_{34} + N_{34} Q_{44})$$

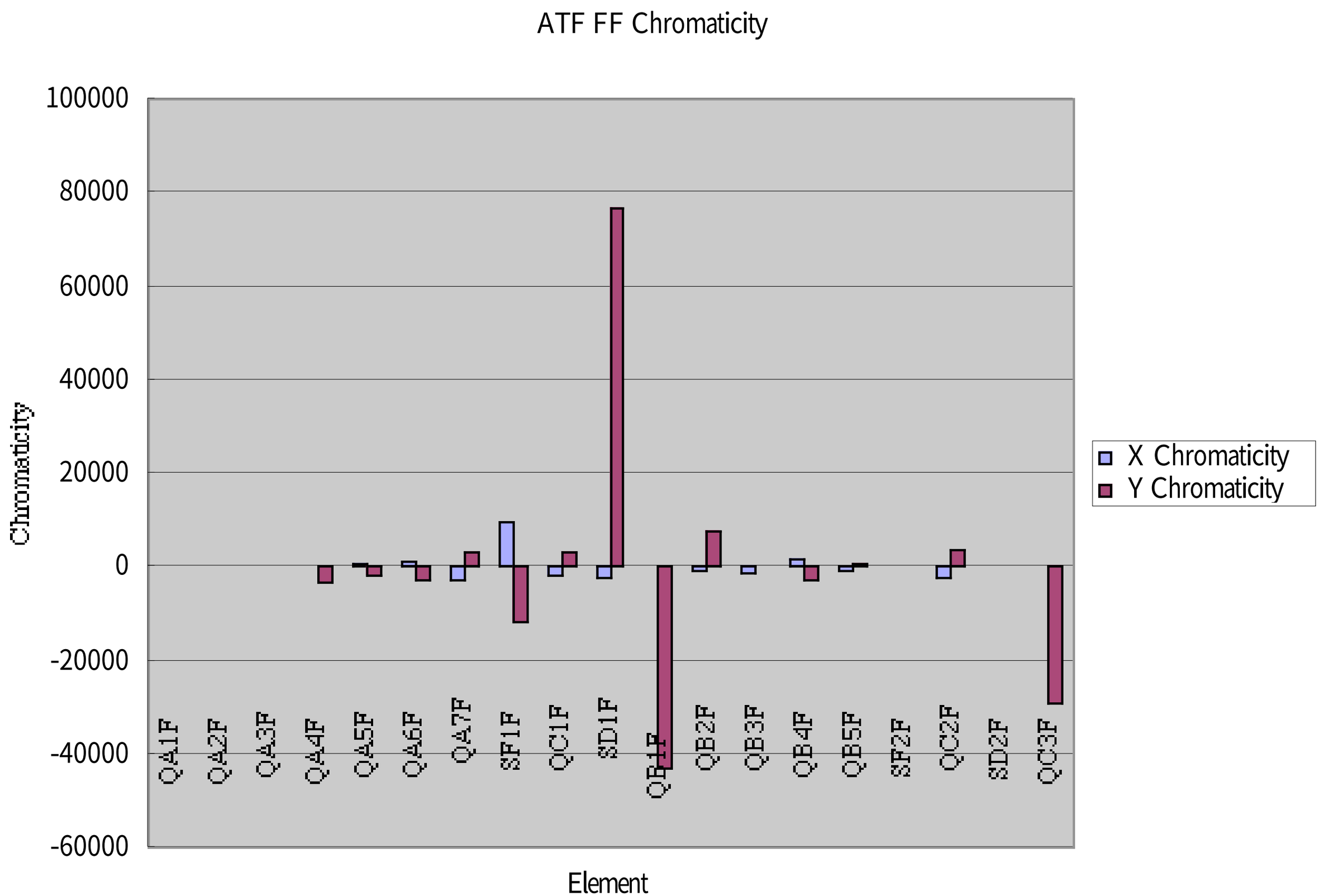
k_{QD}, k_{QF} by U_{3444} minimization

Optics (L*=2m, 36.6m in total)

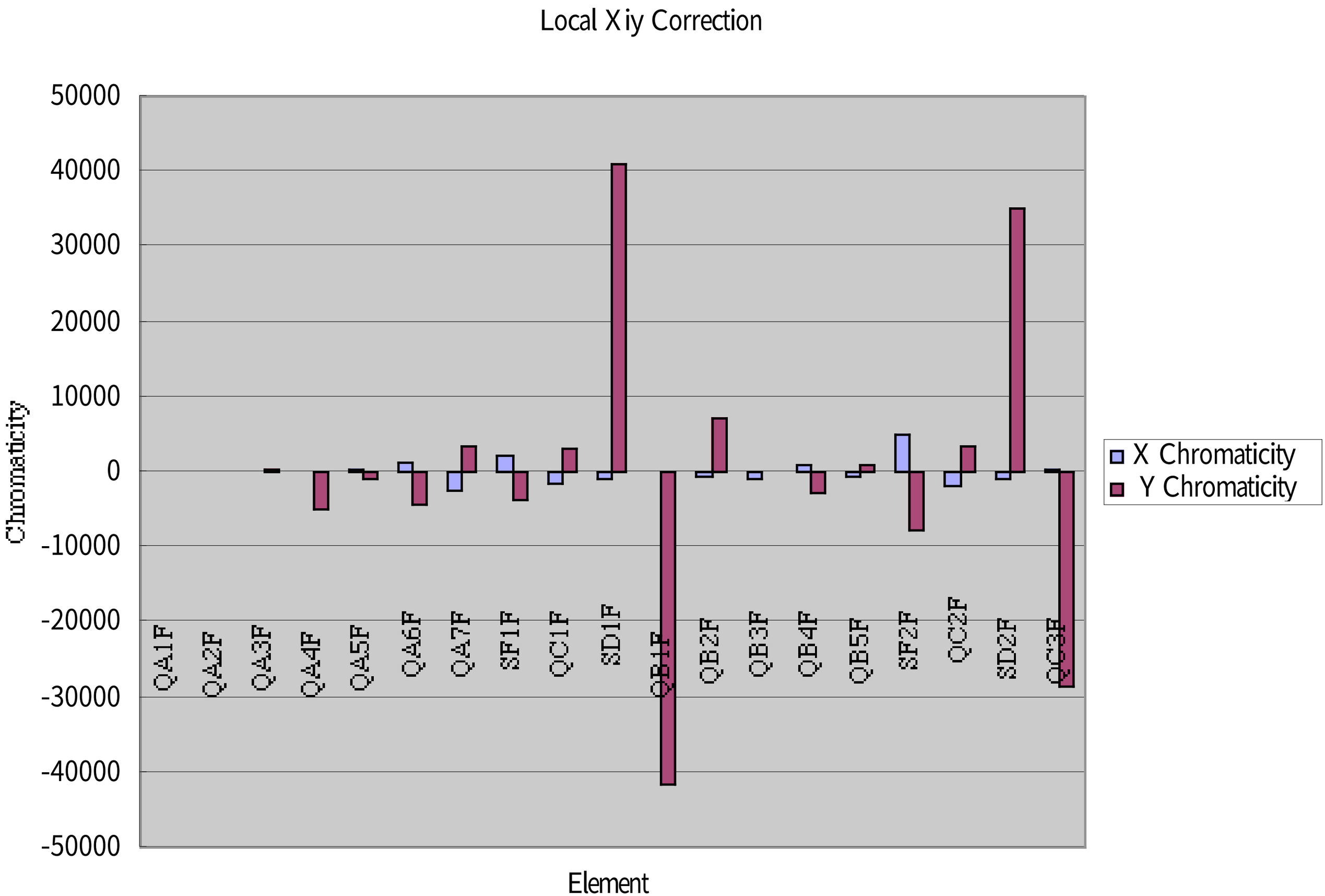
S. Kuroda



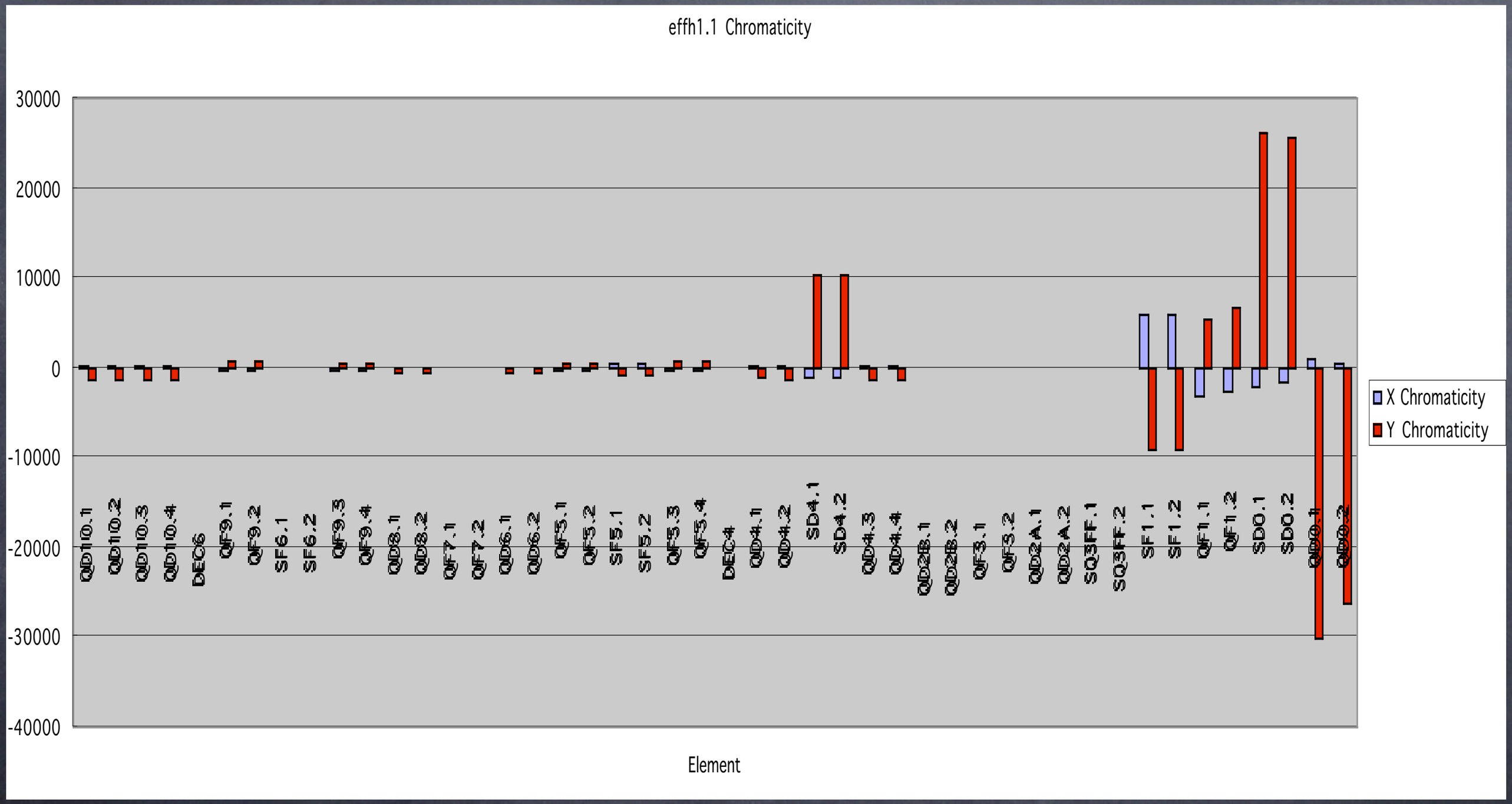
Chromaticity Correction at the nominal optics



Chromaticity Correction at optics (a)



Chromaticity Correction at the GLC; L*=3.5m



Summary of Chromaticity Corrections

LC	L*=3.5m;Roadmap		L*=4.3m;NLC2001	
magnet	ξ_x	ξ_y	ξ_x	ξ_y
SF1(SF1B)	11,704.8	-18,419.3	9,328,2	-11,503.7
QF1	-5,965.4	12,167.1	-6,009.2	9,880.8
SF1A	-	-	2,890.8	-10,209.2
SD0	-3,886.1	51,772.3	-3,039.3	69,872.7
QD0	1,320.7	-56,556.2	943.1	-64,457.0
Total	-31.1	-2.8	-39.6	-42.1
Local;from QF3.2	3,190.5	-11,016.0	4,149.9	-6,429.1

ATF2	(a) ; L*=2m		(b) ; L*=2m	
magnet	ξ_x	ξ_y	ξ_x	ξ_y
SF2F	4,884.1	-7,637.6	3,853.1	-4,076.5
QC2F	-1868.5	3367.6	-2,505.8	3,055.1
-	-	-	-	-
SD2F	-891.9	35,193.7	-691.0	18,446.4
QC3F	261.7	-28,500.1	350.9	-25,858.2
Total	-151.1	168.5	-43.3	142.6
Local;from QB3F	-1718.0	-258.0	-115.7	-10854.0

Proposed at the Nanobeam2002 by J. Urakawa

(compress from 30ps to 3ps)

Bunch Compressor

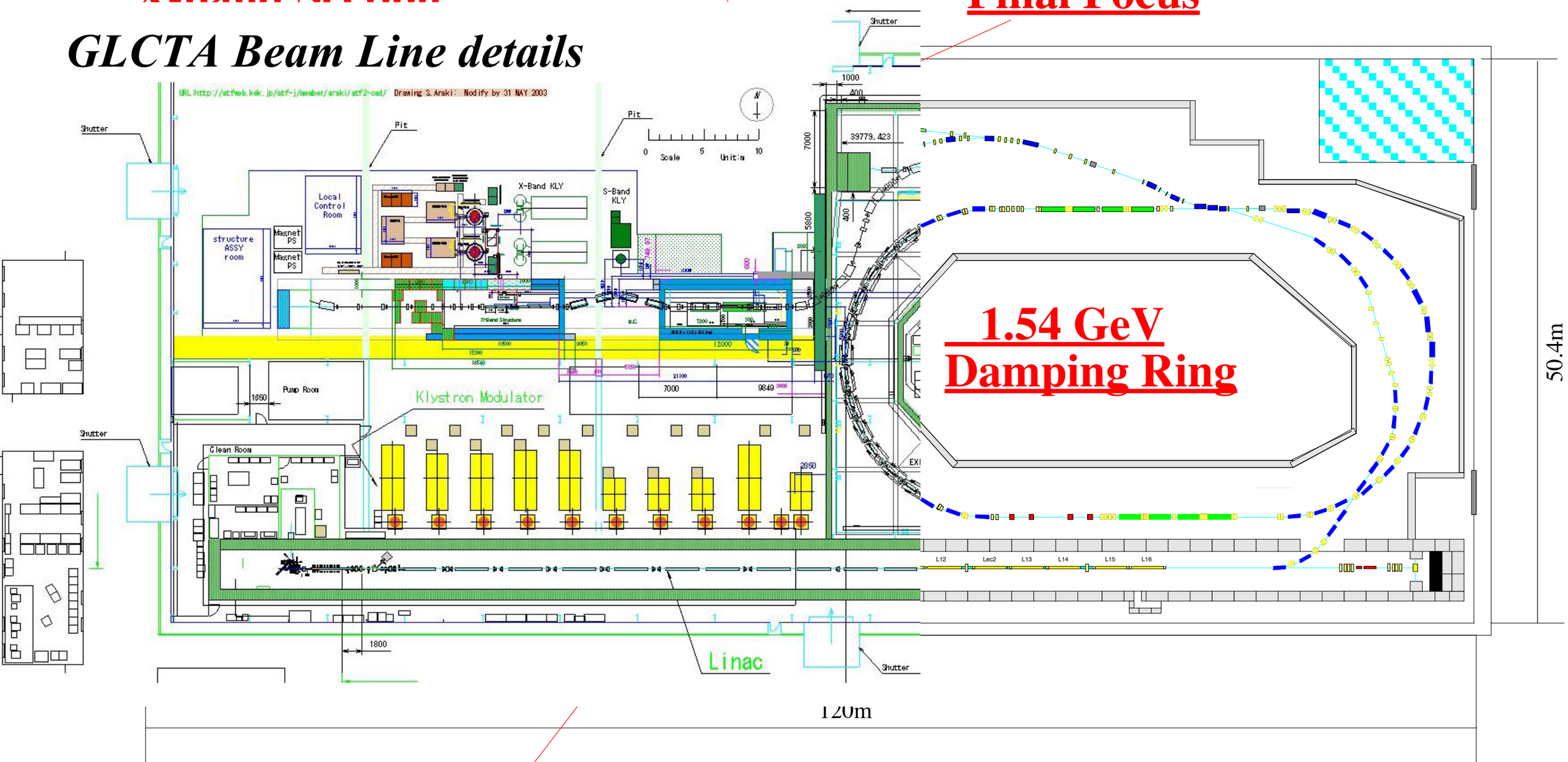
ATF1

ATF2

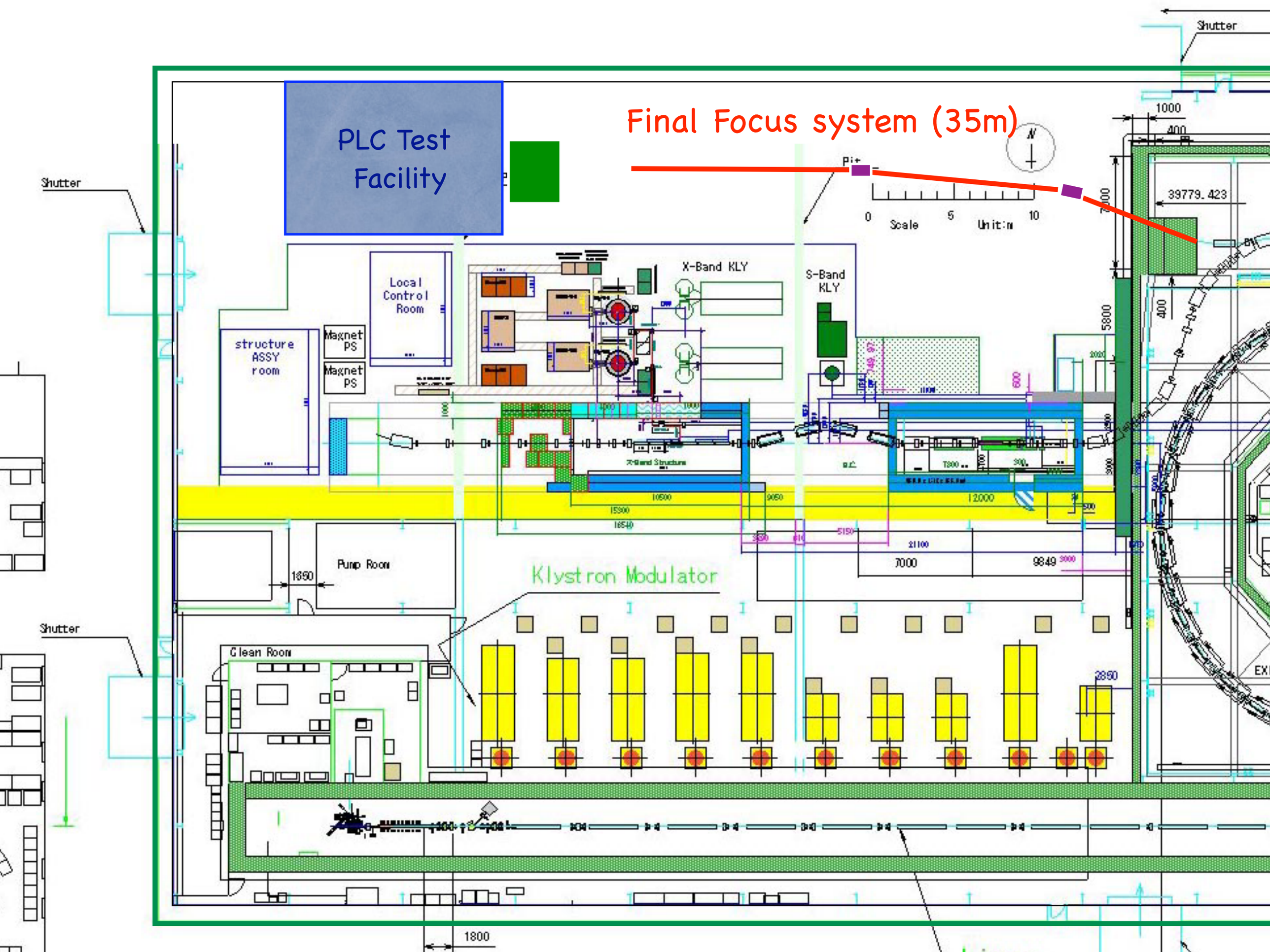
X-band Section

Final Focus

GLCTA Beam Line details



1.54 GeV S-band Linac


PLC Test Facility
Final Focus system (35m)
Shutter
Shutter
Shutter
Local Control Room
structure ASSY room
Magnet PS
Magnet PS
X-Band KLY
S-Band KLY
Pump Room
Klystron Modulator
Clean Room
Scale
Unit:m
39779.423
1000
400
5800
1800

Cost Estimation : FF facility

FFTB/ATF	thick	width	length	area	cost/area	cost
unit	m	m	m	m^2	yen/m^2	yen
floor	1	7.2	56	403.2	126,960	51,190,078

shield	thick x 2	height	length	volume	cost/volume	cost
unit	m	m	m	m^3	yen/m^3	yen
concrete	2	3	56	336	20,000	6,720,000
concrete	2	3	5.2	31.2	20,000	624,000
total	-	-	-	367.2	20,000	7,344,000

Cost Estimation : FF components

magnet	number	cost/unit	cost (yen)
QA	8	1,200,000	9,600,000
QB	8	1,200,000	9,600,000
QC1	2	2,500,000	5,000,000
QC2	2	2,500,000	5,000,000
BH	2	2,500,000	5,000,000
SEXT	4	1,200,000	4,800,000
Power supply	26	1,500,000	39,000,000
Support	26	1,000,000	26,000,000
Cable	0	0	0
cavity-BPM	20	2,300,000	46,000,000
streak camera	0	0	0
laser wire	5	7,000,000	35,000,000
wire scanner	0	0	0
laser interferometer	1	10,000,000	10,000,000
vacuum chamber,pump	36.6	300,000	10,980,000
labor for setup	36.6	70,000	2,562,000
Total	-	-	208,542,000

Schedule

2002 optics design (Local correction, S.Kuroda)
2004 proposal
2005 construction starts
2008 Summer, completion
2009 achievement of $\sigma_y^* = 36$nm
nanometer stabilization of final quadrupole
2010-α PLC test facility
strong QED experiments

SLAC-FFTB schedule
1989 optics design (Oide)
1990 proposal (CDR)
1993 summer completed
1994 spring 70nm
1995 RF-BPM
1997 E144:collision with laser (non-linear QED)

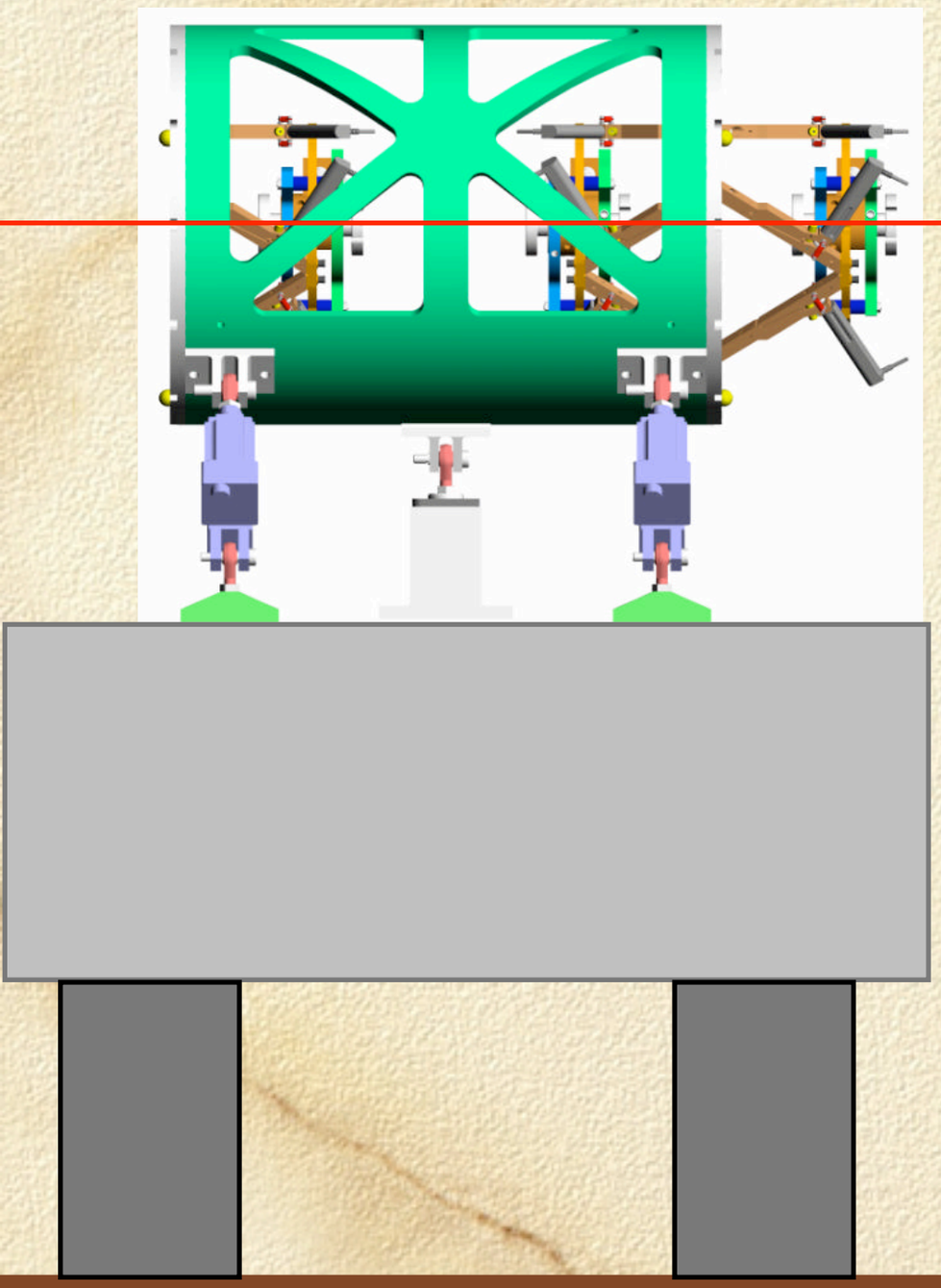
NanoBPM

LLNL/SLAC system

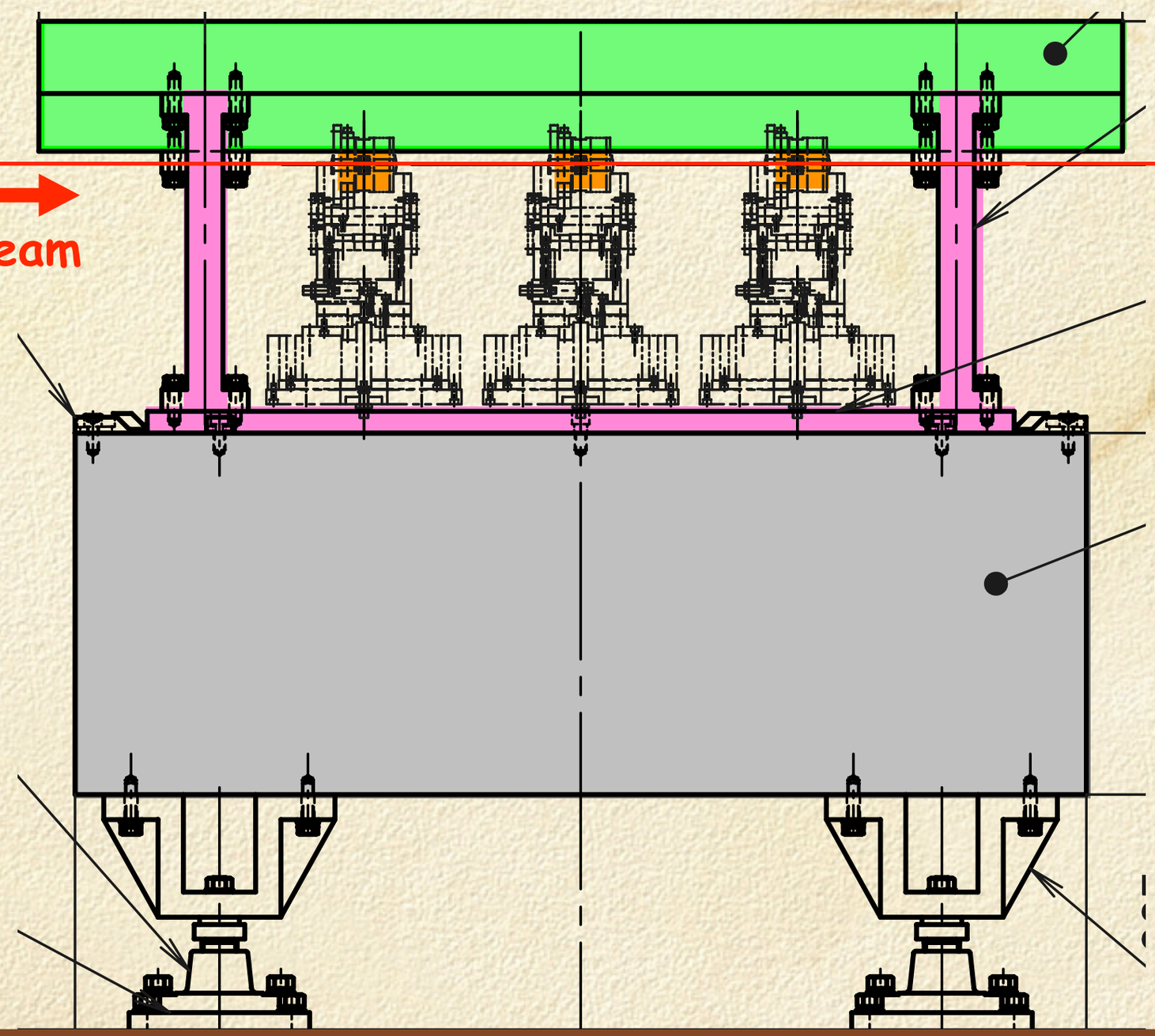
45cm dia., 62cm long tube supported by 4 linear actuators on a girder; No active mover

KEK system

10cm thick, 150cm long reference bar; each BPM is set on active movers, which are controlled by laser interferometers



beam



Stabilization between two systems by Optical Anchor as well as Inertial Sensors; FEATHER/FONT at the 2nd phase.