Intermediate β configurations at the IP for commissioning and optimization

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- Increased β_{IP} parameters may be useful to reduce the beam sensitivity to the energy spread and magnet displacement during early commissioning and approach an optimal value gradually
- Decreasing them can also be considered for the final optimisation

Based on :
Marie Thorey, LAL/RT- 07-05

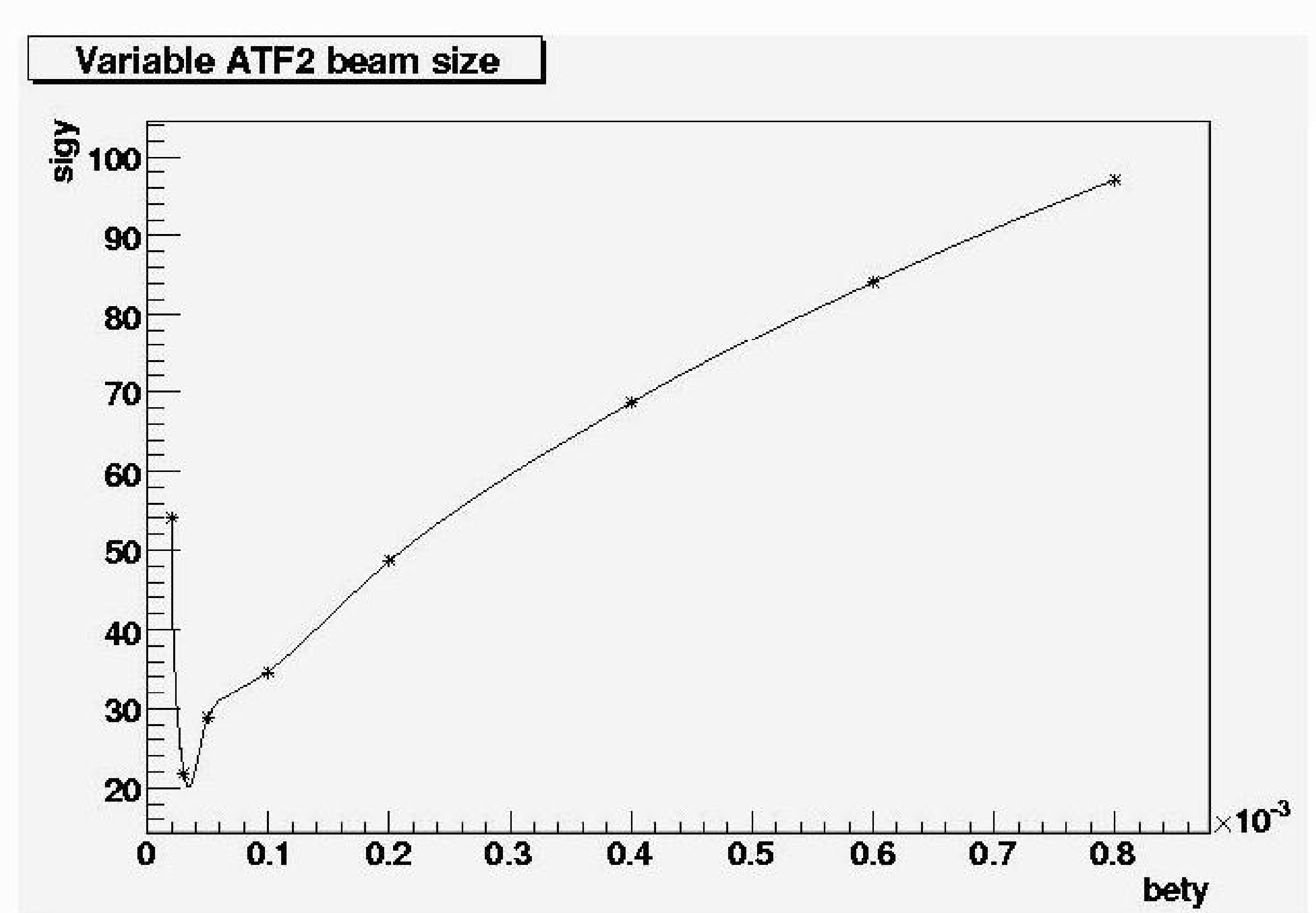
Matching method

• Use MAD8 matching module
• Fit quadrupoles QM12, QM13, QM14, QM15, QM16 to get :
-wanted β functions
-α_x,α_y=0
-D_x=0
• Fit sextupoles SD0, SF1, SD4, SF5, SF6 to cancel T122, T126, T166, T342, T346

Intermediate parameters

Beta y (m)	0.00002	0.00003	0.0001	0.0002	0.0004	0.0008
Sigy (nm)	54	21.76	34.6	48.62	68.67	97.1
KLQM12 (m^{-2})	0.391	0.392	0.386	0.382	0.380	0.383
KLQM13 (m^{-2})	1.03	1.02	0.989	0.971	0.954	0.934
KLQM14 (m^{-2})	-2.12	-2.08	-1.64	-1.45	-1.32	-1.16
KLQM15 (m^{-2})	-0.157	-0.186	-0.108	-0.0299	0.0681	0.105
KLQM16 (m^{-2})	0.276	0.138	-0.0560	-0.168	-0.288	-0.374
KLSD0 (m^{-3})	4.30	4.46	4.47	4.48	4.49	4.51
KLSF1 (m^{-3})	-2.45	-2.63	-2.64	-2.65	-2.-65	-2.65
KLSD4 (m^{-3})	14.2	14.5	14.6	14.6	14.6	14.7
KLSF5 (m^{-3})	0.890	-0.804	-0.899	-0.917	-0.930	-0.939
KLSF6 (m^{-3})	9.40	7.89	7.84	7.82	7.82	7.81

Variable beam size at the interaction point



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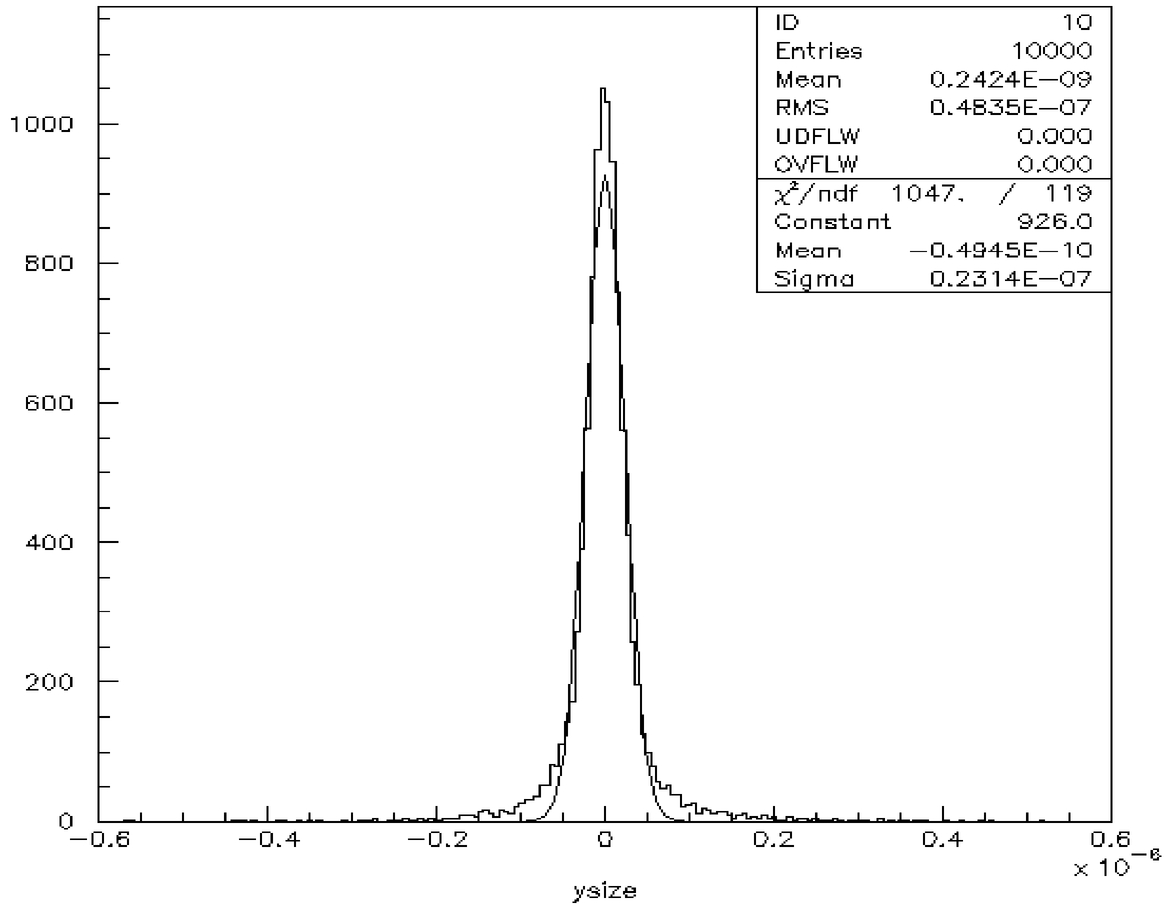
Intermediate parameters (cross-check)

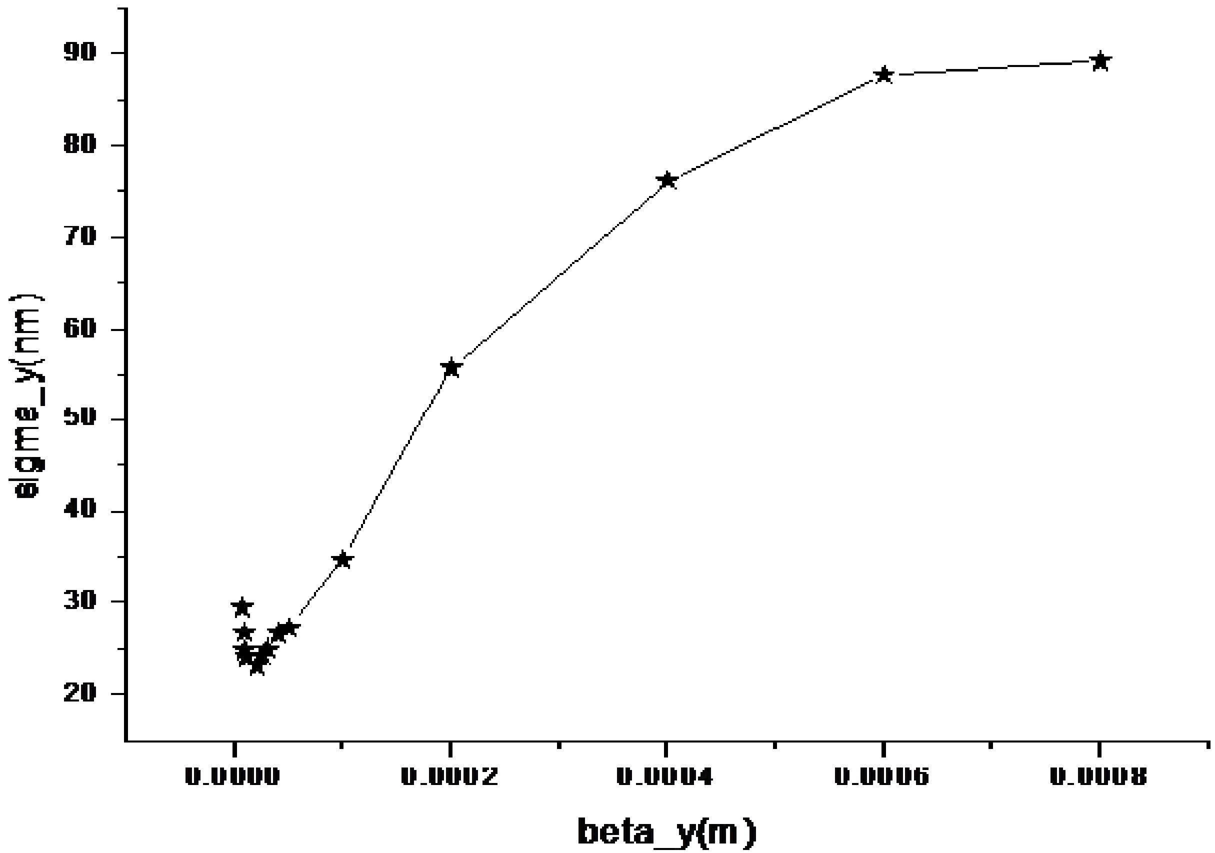
Beta y (m)	1.00E-05	2.00E-05	3.00E-05	1.00E-04	2.00E-04	4.00E-04
Sigy (nm)	24.08	23.14	24.91	34.6	55.71	76.12
KLQM12(/m^2)	3.66E-01	3.59E-01	3.54E-01	0.386	0.3739	3.75E-01
KLQM13(/m^2)	9.59E-01	9.43E-01	9.34E-01	0.989	0.9521	9.54E-01
KLQM14(/m^2)	-1.98	-1.67	-1.52E+00	-1.64	-2.035	-2.05E+00
KLQM15(/m^2)	-3.79E-02	-1.07E-01	-1.51E-01	-0.108	-0.138	-1.38E-01
KLQM16(/m^2)	6.82E-01	6.40E-01	6.20E-01	-0.056	-1.00E-10	-1.00E-10
KLSD0(/m^3)	4.3	4.31	4.31	4.47	4.301	4.30E+00
KLSF1(/m^3)	-2.58	-2.58	-2.58	-2.64	-2.576	-2.58E+00
KLSD4(/m^3)	1.49E+01	1.49E+01	1.49E+01	14.6	14.86	1.49E+01
KLSF5(/m^3)	-7.96E-01	-7.94E-01	-7.93E-01	-0.899	-0.7936	-7.94E-01
KLSF6(/m^3)	8.55E+00	8.55E+00	8.56E+00	7.84	8.539	8.54E+00

Tracking for reduced beam sizes : e.g. $\beta_y = 2.0 \times 10^{-5}$ m

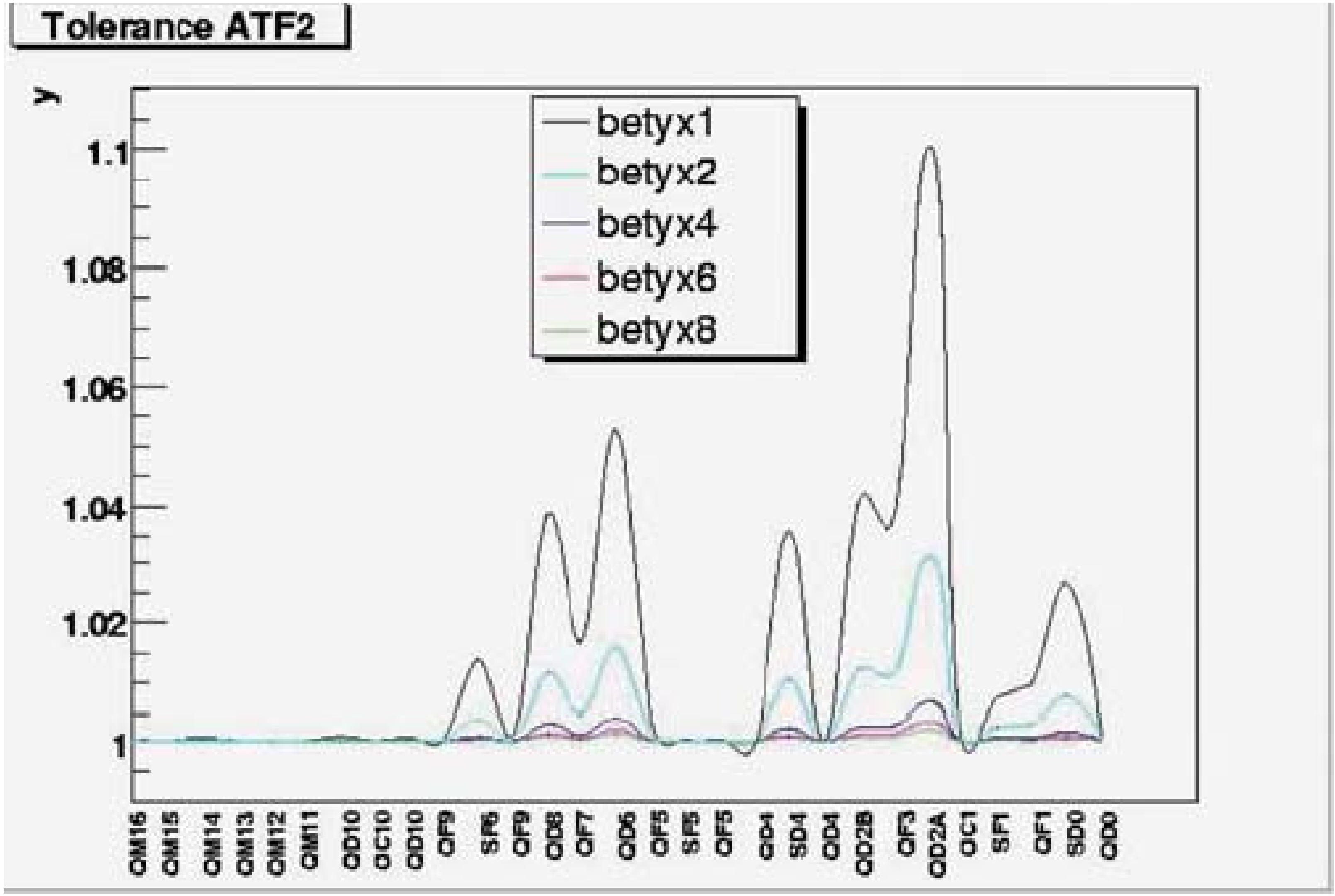
- Only first quadrupoles used, not the entire line



Variable beam size at the interaction point (Gaussian fit to core)



Relative IP beam size increase for 1 micron displacements of the magnets moved one at a time → reduced tolerances with increased β_y



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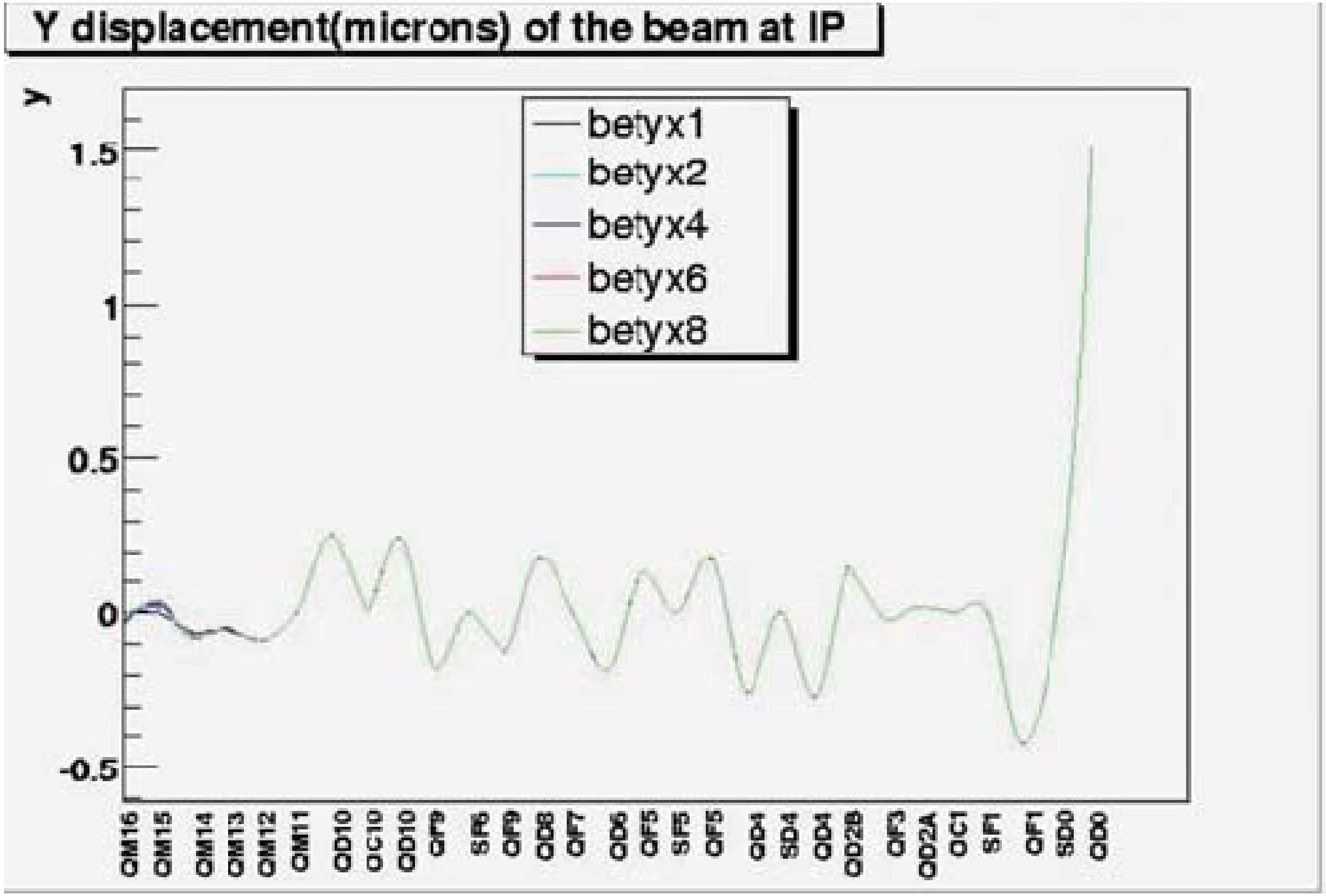
IP position change for 1 micron displacements of the magnets moved one at a time → transfer matrix unchanged with increased β_y

(but effects relative to size are reduced)



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Variable $\beta_{x,y}$ at longitudinally displaced IP

Beam size at focal point is a function of choice of FD effective focal length (L*) and injected beam matching

→ L* adjusted by FD strength (orthogonal combinations for x and y waist positions in z)
→ injected beam adjusted by QM12,13,14,15,16

During commissioning, Honda monitor and wire scanner at displaced IP, respectively at -54cm and +39cm, with resolutions of 300-1000 nm.

Procedure to control β_y at displaced IP

1) For close to nominal values at IP+39cm, use QM12~16 to obtain:

$\beta_x = 2 \times \beta_x^{nominal} = 0.008$m

$\beta_y = 4 \times \beta_y^{nominal} = 0.0004$m

at the nominal IP

2) use QD,QF to fit $\alpha_x = \alpha_y = 0$ at IP+39cm, step by step...

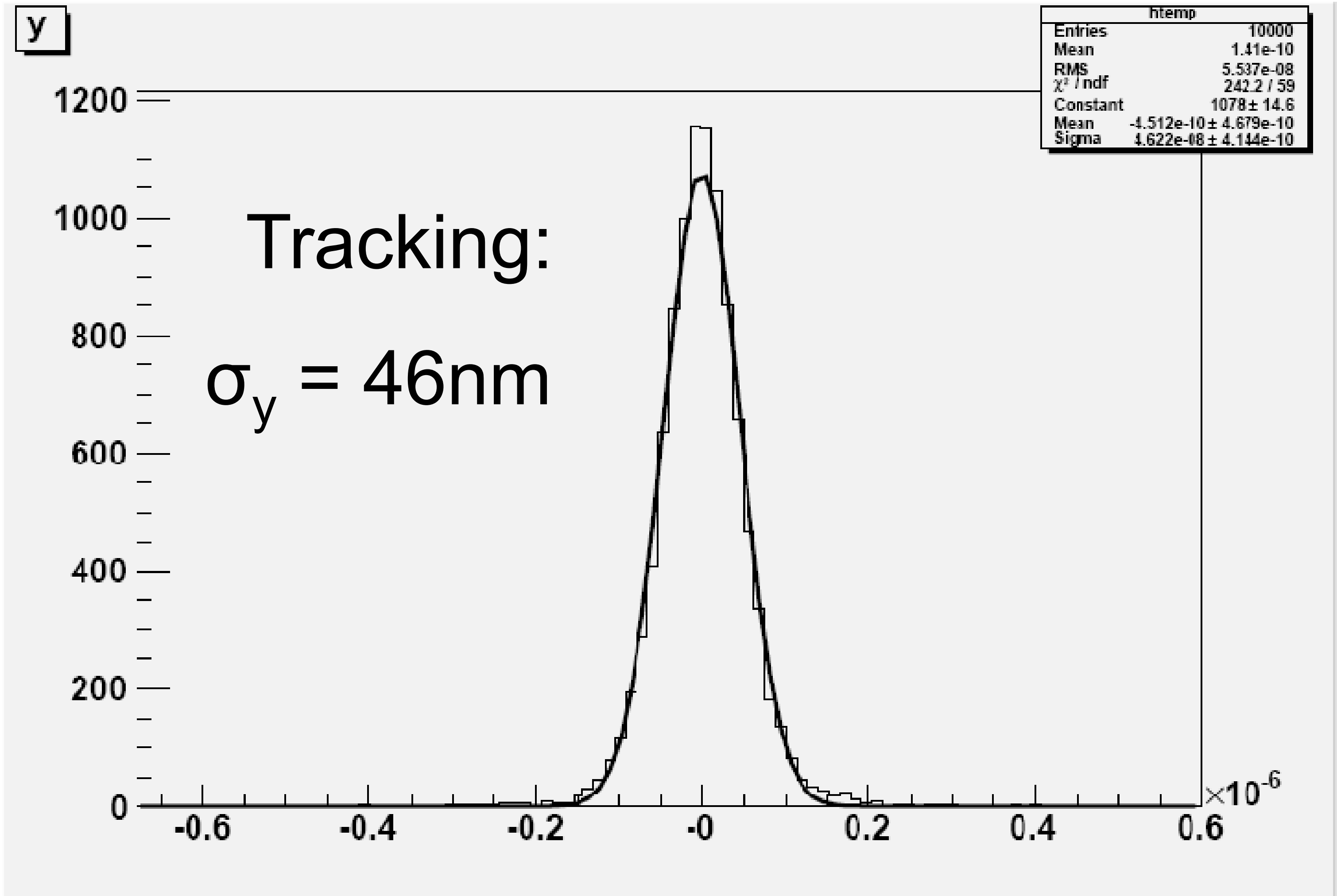
3) use SD0,4 & SF1,5,6 to zero $T_{122}, T_{126}, T_{166}, T_{342}, T_{346}$

Configuration [m^{-2}]

KLQM12FF = 3.347954E-01
KLQM13FF = 9.109371E-01
KLQM14FF =-1.126109E+00
KLQM15FF =-3.172467E-01
KLQM16FF = 6.492773E-01
KLQD0FF = -1.117399E+00
KLQF1FF = 7.030127E-01

Close to nominal beam size at IP+39cm

Linear optics β_x =0.004m, β_y=0.00016m → σ_y = 43nm



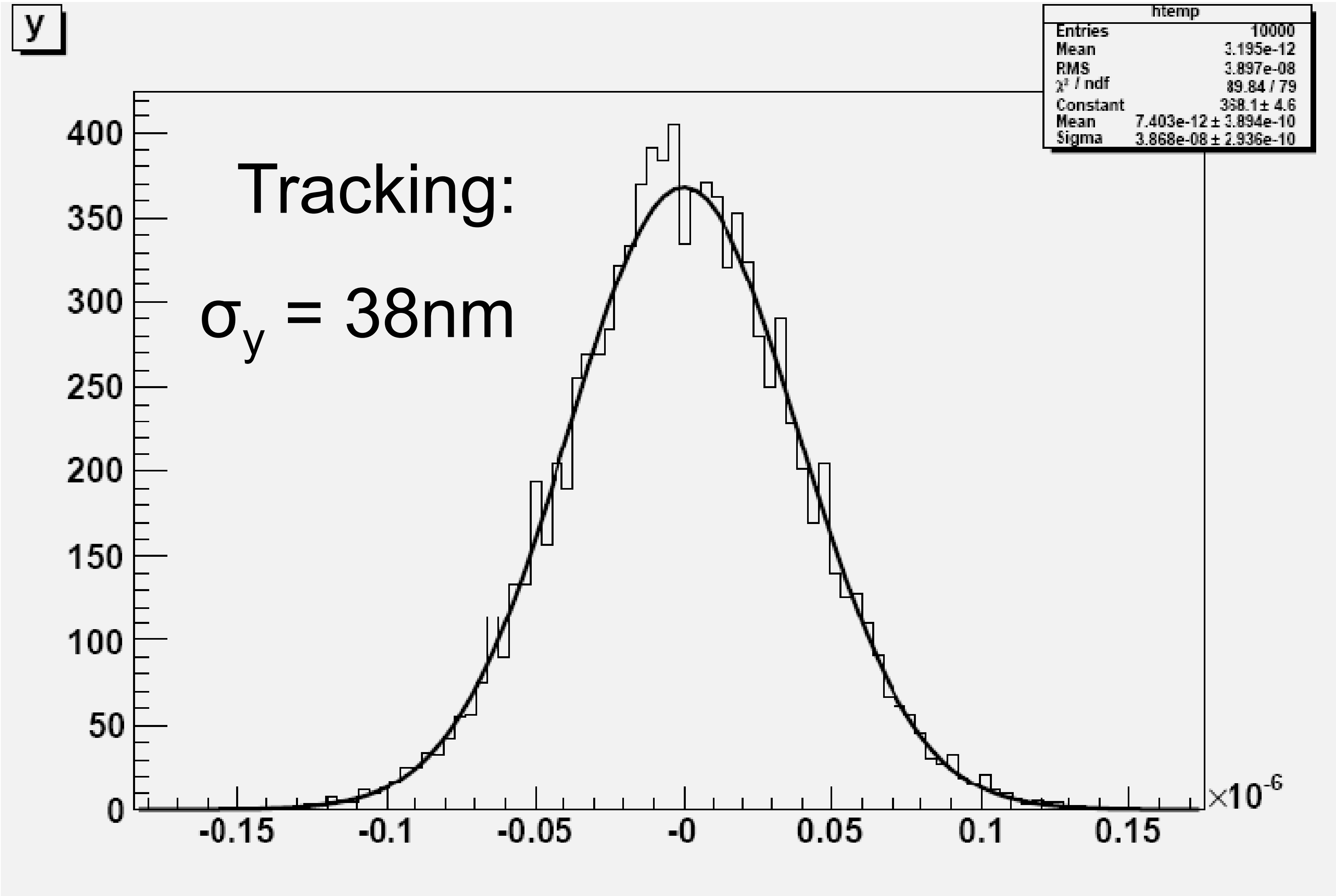
- Use similar procedure for close to nominal values at IP-54cm

Configuration [m^{-2}]

KLQM12 = 3.438185E-01
KLQM13 = 8.779989E-01
KLQM14 = -1.182823E+00
KLQM15 =4.439885E-02
KLQM16 =-1.750061E-01
KLQD0FF=-2.204962E+00
KLQF1FF = 8.173861E-01

Close to nominal beam size at IP-54cm

Linear optics β_x =0.005m, β_y=0.00011m → σ_y = 37nm



Increase β_y at IP-54cm

1) a. Use QM12~16 to obtain:

β_x=0.004m

$\beta_y=10\times\beta_y^{nominal}$ =0.001m

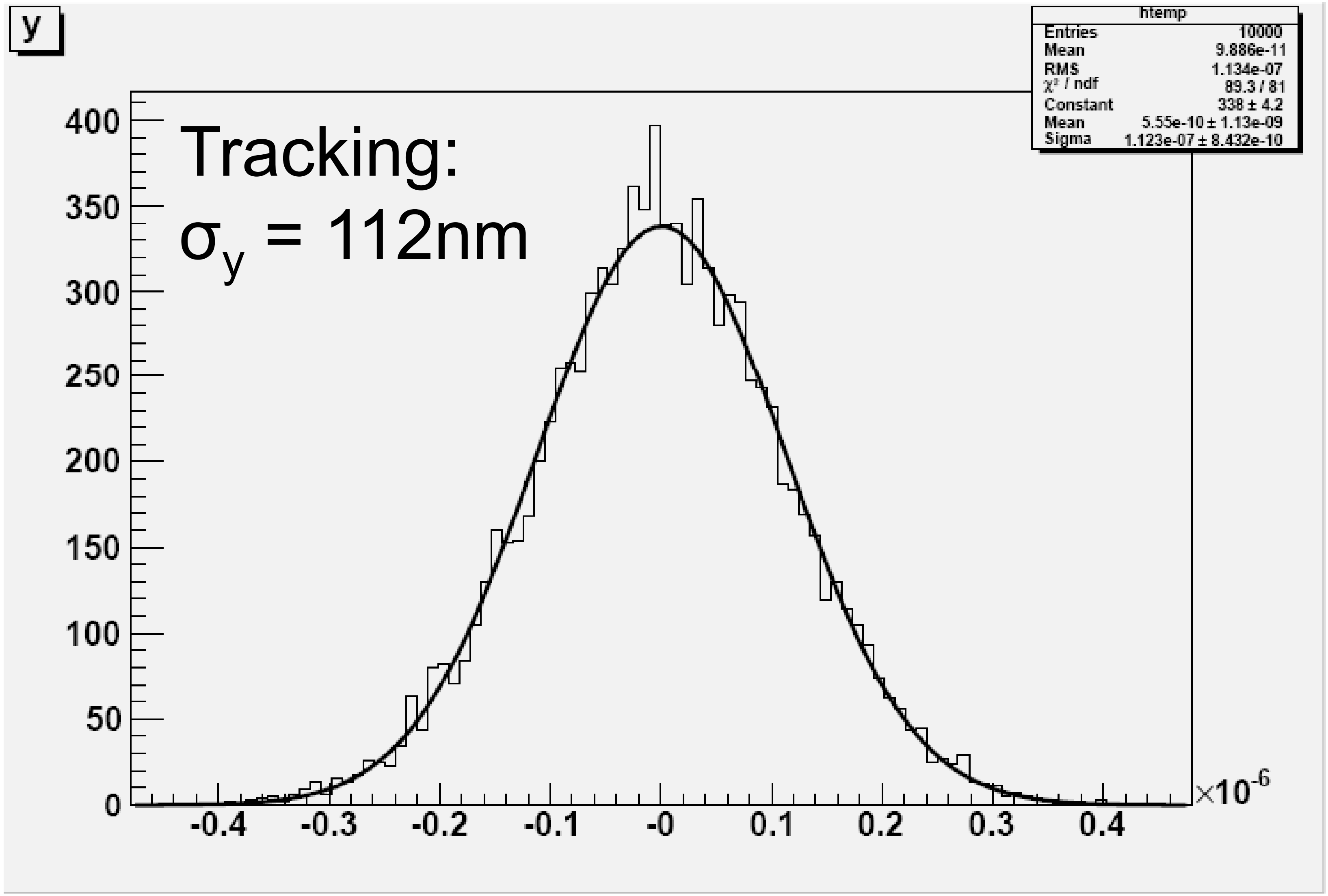
b. Use SD0,4 & SF1,5,6 to zero T122,T126, T166, T342,T346

Configuration [m^{-2}]

KLQM12 = 4.374117E-01
KLQM13 = 8.278653E-01
KLQM14 =-1.06454E+00
KLQM15 = 3.285206E-01
KLQM16 =-6.317261E-01

Close to $10\times\beta_y^{nominal}$ at IP-54cm

Linear optics β_x =0.004m, β_y=0.001m → σ_y = 108nm



2) a. Use QM12~16 to obtain:

β_x=0.004m

$\beta_y=20\times\beta_y^{nominal}$=0.002m

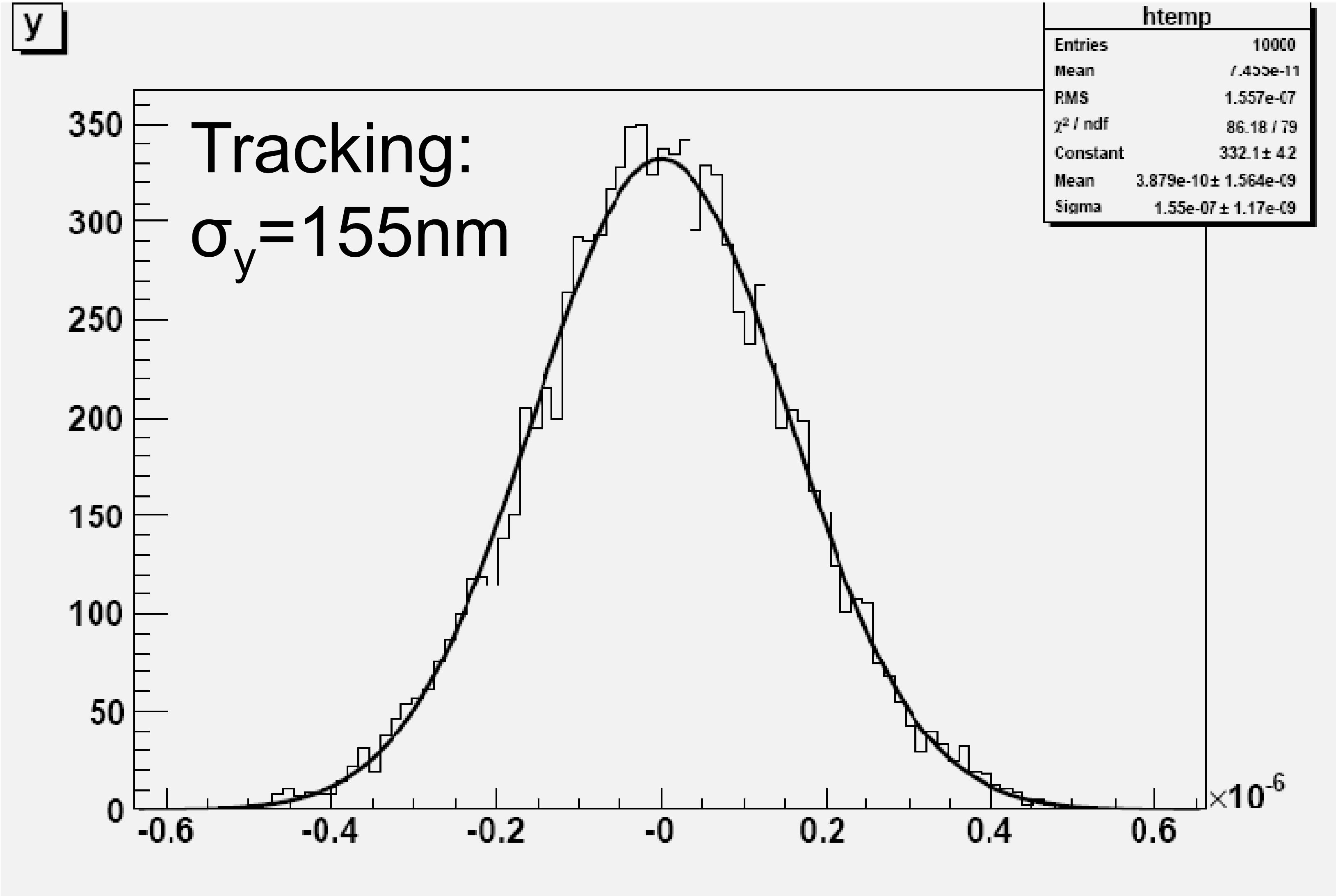
b. Use SD0,4 & SF1,5,6 to zero T122,T126, T166, T342,T346

Configuration [m^{-2}]

KLQM12FF = 4.658464E-01
KLQM13FF = 8.260043E-01
KLQM14FF =-1.139217E+00
KLQM15FF = 4.000200E-01
KLQM16FF =-6.980810E-01

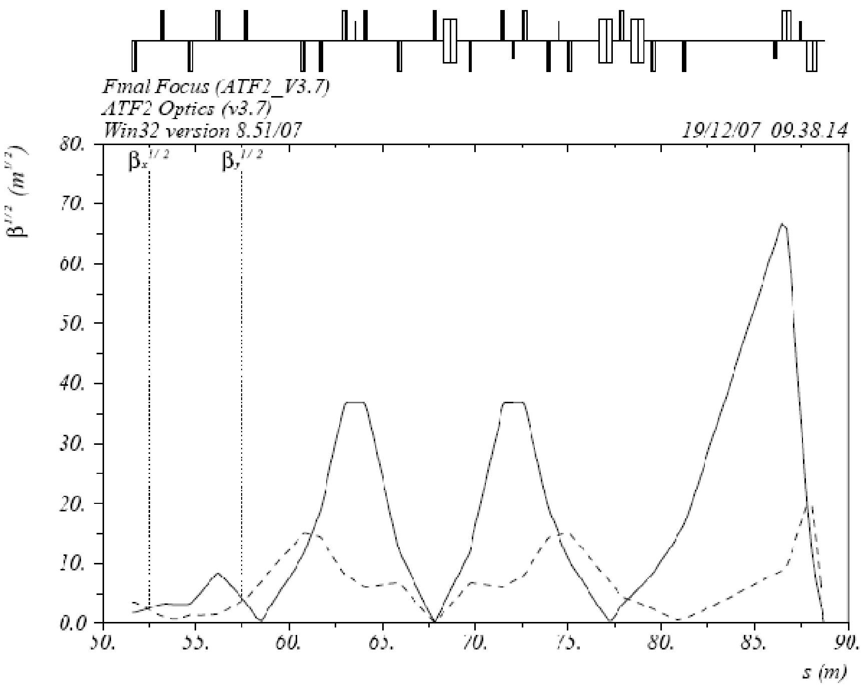
Close to 20 $\times \beta_y^{nominal}$ at IP-54cm

Linear optics β_x =0.004m, β_y=0.002m → σ_y = 153nm

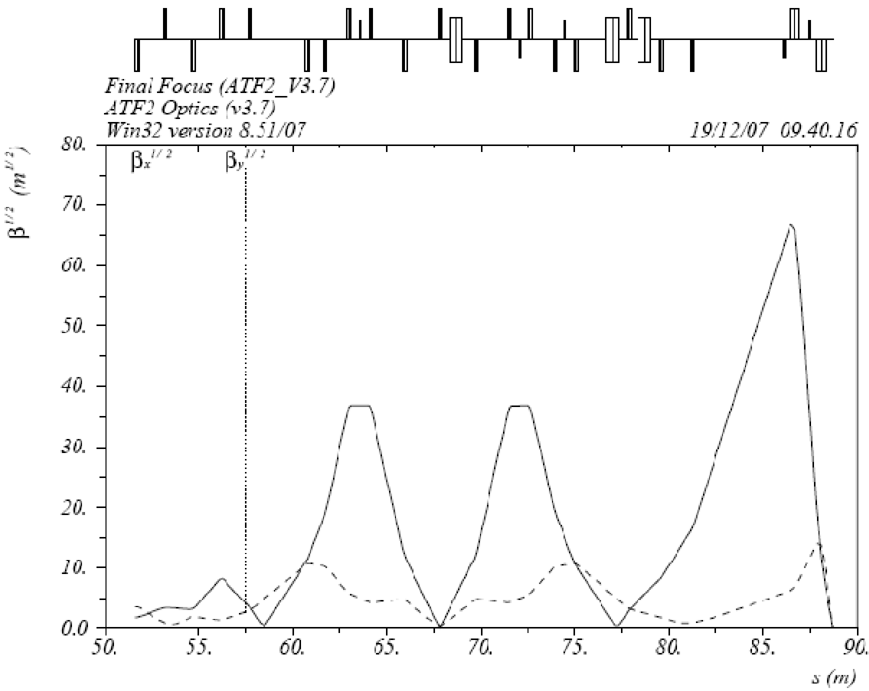


β functions

$\beta_y = 10 \times \beta_y^{nominal} = 0.001m$



$\beta_y = 20 \times \beta_y^{nominal} = 0.002m$



Conclusions and prospects

- With increased β_y, tolerance reduced; while decreasing β_y, get the minimum 23nm beam size at nominal IP.
- β_y can also be adjusted at the displaced IP, where additional instruments will be used with larger resolutions for commissioning. This will be explored further including tolerances.
- Linear combinations of QD,QF will be prepared for orthogonal waist scanning at the different focal point locations.