Continued investigation of variable β_{IP} optical configurations

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Motivation:

- 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, CARE/ELAN Document-2007-005

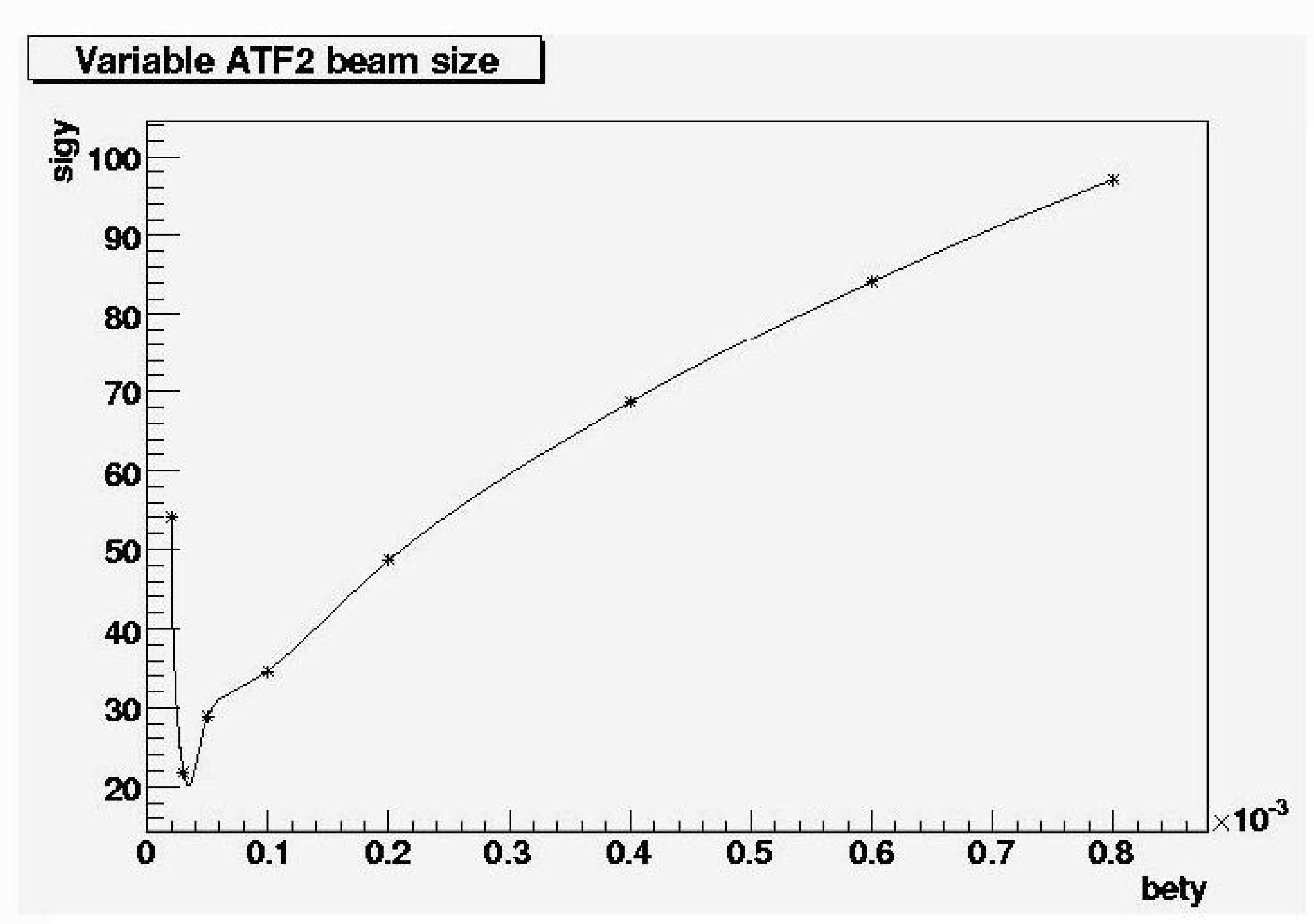
Matching method

• Use MAD8 matching module
• Fit quadrupoles QM12, QM13, QM14, QM15, QM16 to get :
-wanted beta functions
-$\alpha_x,\alpha_y=0$
-$D_x=0$
• 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

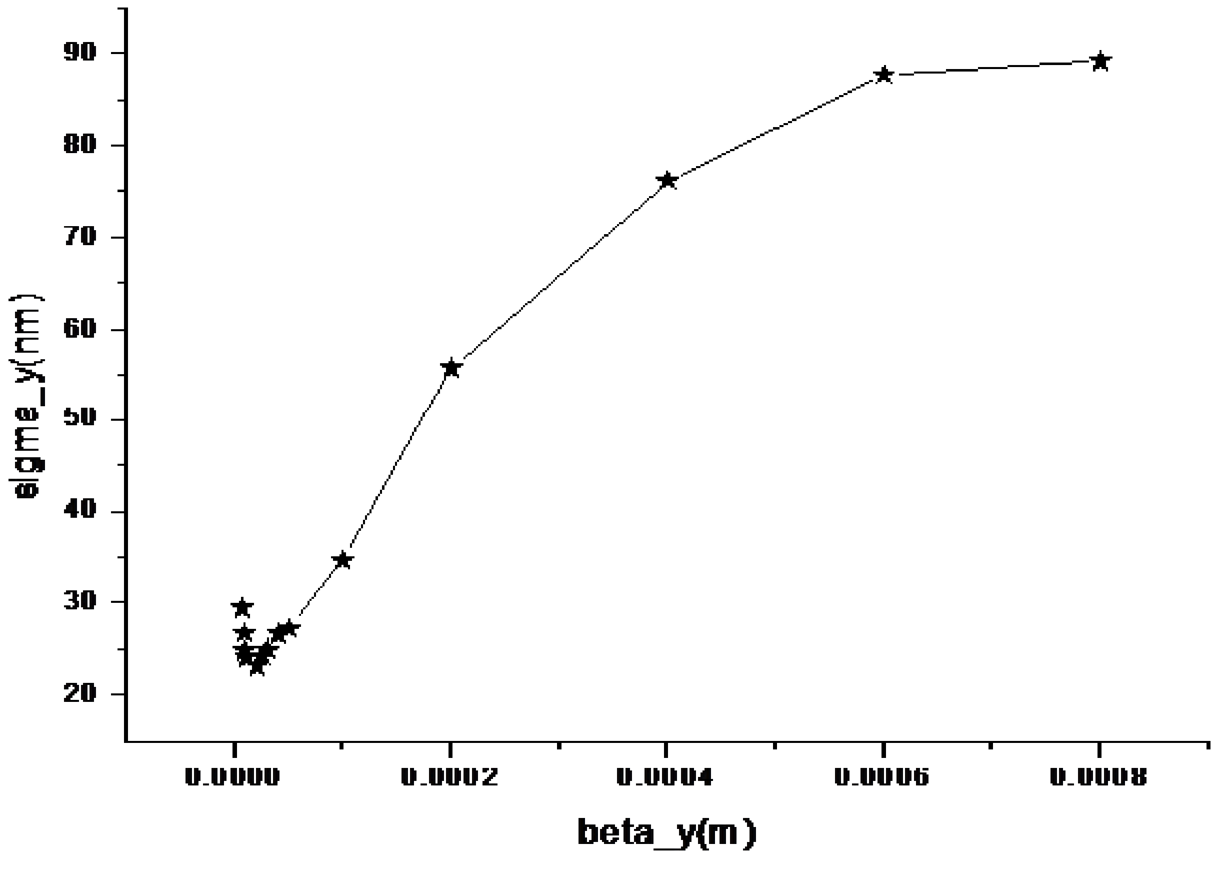
Variable beam size at the interaction point



Intermediate parameters

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

Variable beam size at the interaction point



Minimum $\beta_y = 2.0 \times 10^{-5}$ m

- Matching method : only the first quadrupoles, not the entire line
- 2nd and 3rd order contributions to the beam size at IP
- Transport code is chosen, for MAD8 can only compute to second order

Input beam :

$$\sigma_x = \sqrt{\varepsilon_x \beta_x} = 1.21E-4m$$

$$\sigma_{x'} = \sqrt{\varepsilon_x (\frac{1+\alpha_x^{\ 2}}{\beta_x})} = 2.56E-2mr$$

$$\sigma_y = \sqrt{\varepsilon_y \beta_y} = 6.09E-6m$$

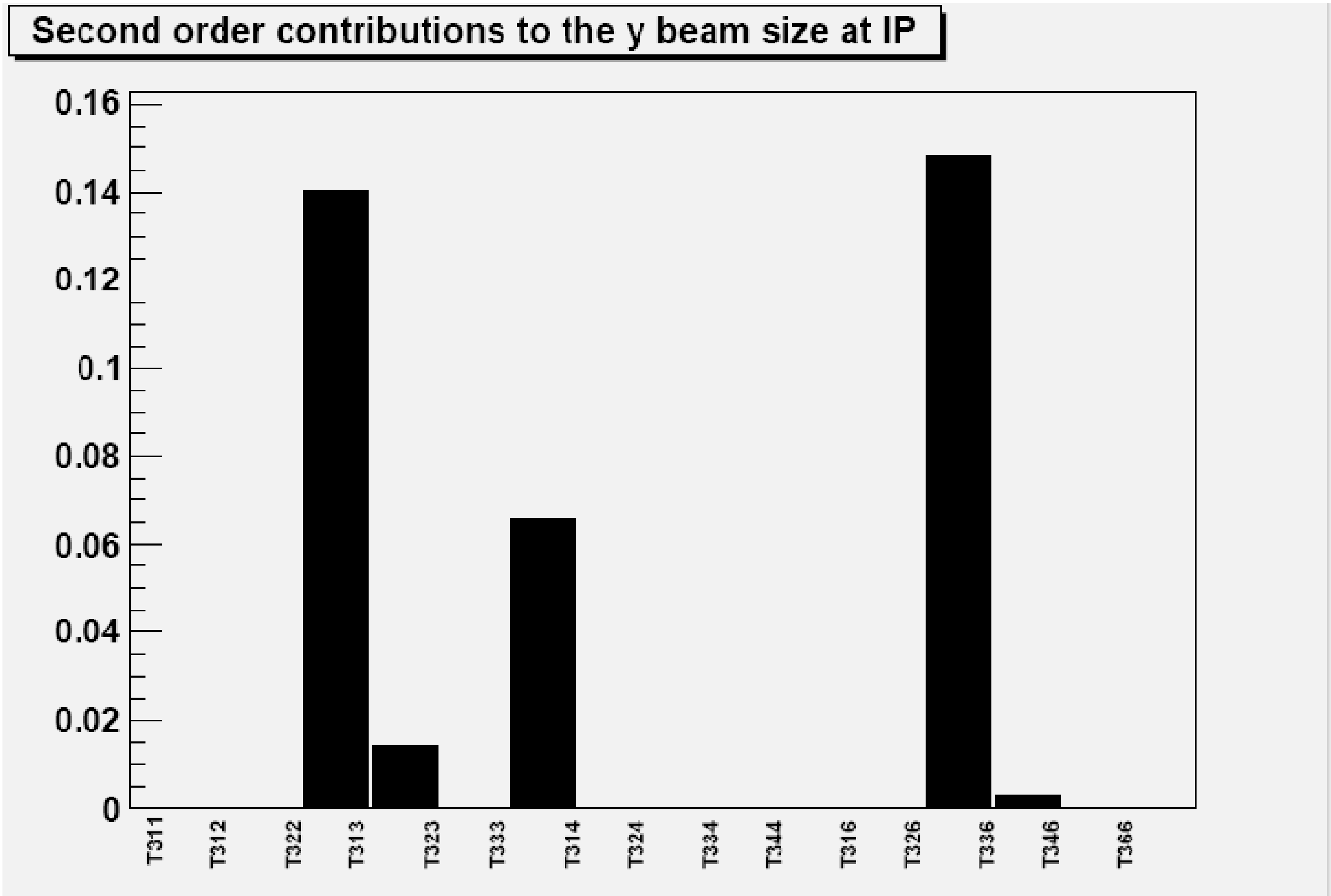
$$\sigma_{y'} = \sqrt{\varepsilon_y (\frac{1+\alpha_y^{\ 2}}{\beta_y})} = 3.94E-3mr$$

$$\delta = 0.0008\ fraction$$

Transformation equation:

$$X_i(1) = \sum_j R_{ij}\ X_j(0) + \sum_{jk} T_{ijk}\ X_j(0)\ X_k(0) + \sum_{jk\ell} U_{ijk\ell}\ X_j(0)\ X_k(0)\ X_\ell(0)$$

Nominal $\beta_y = 1.0 \times 10^{-4}$ m :



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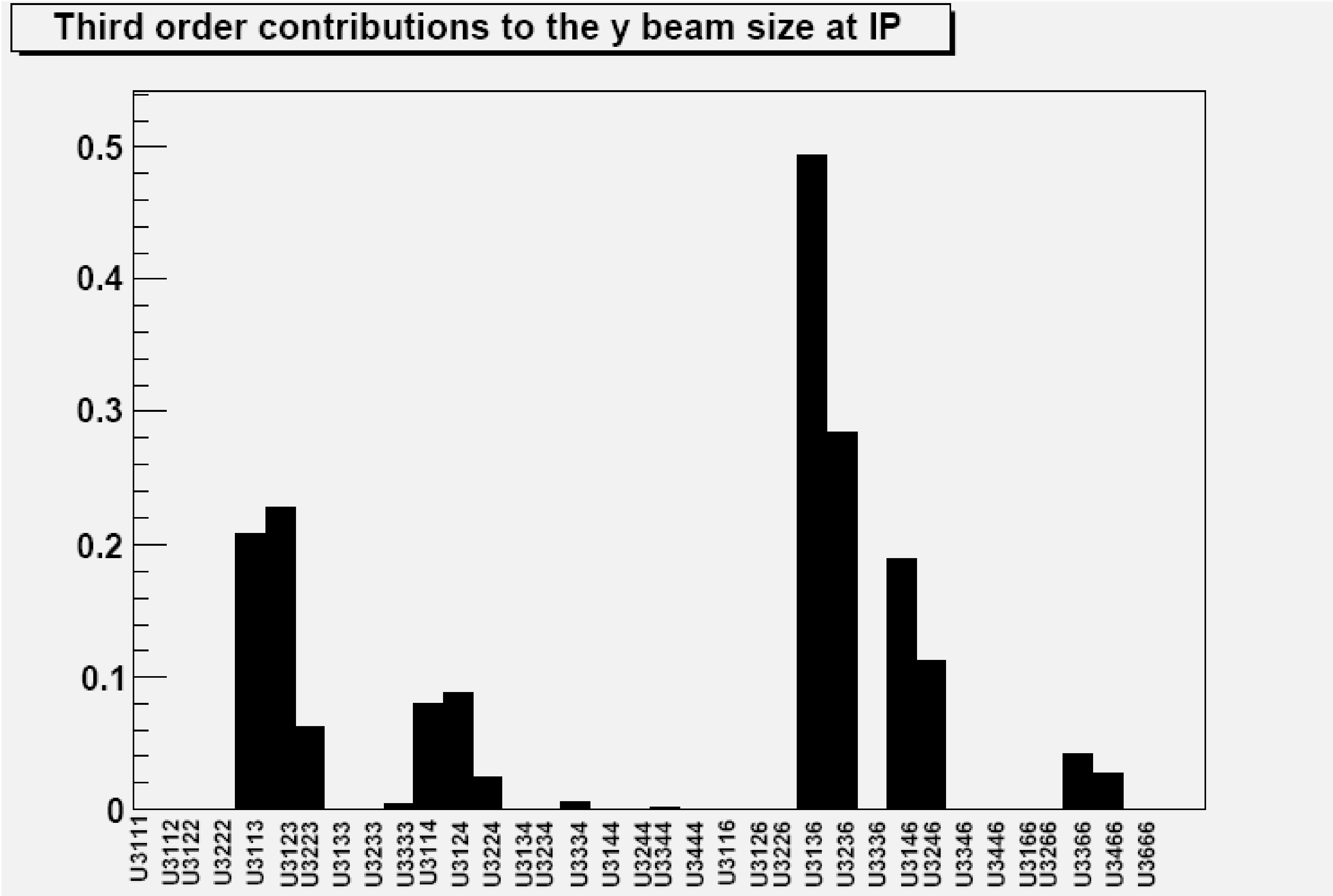
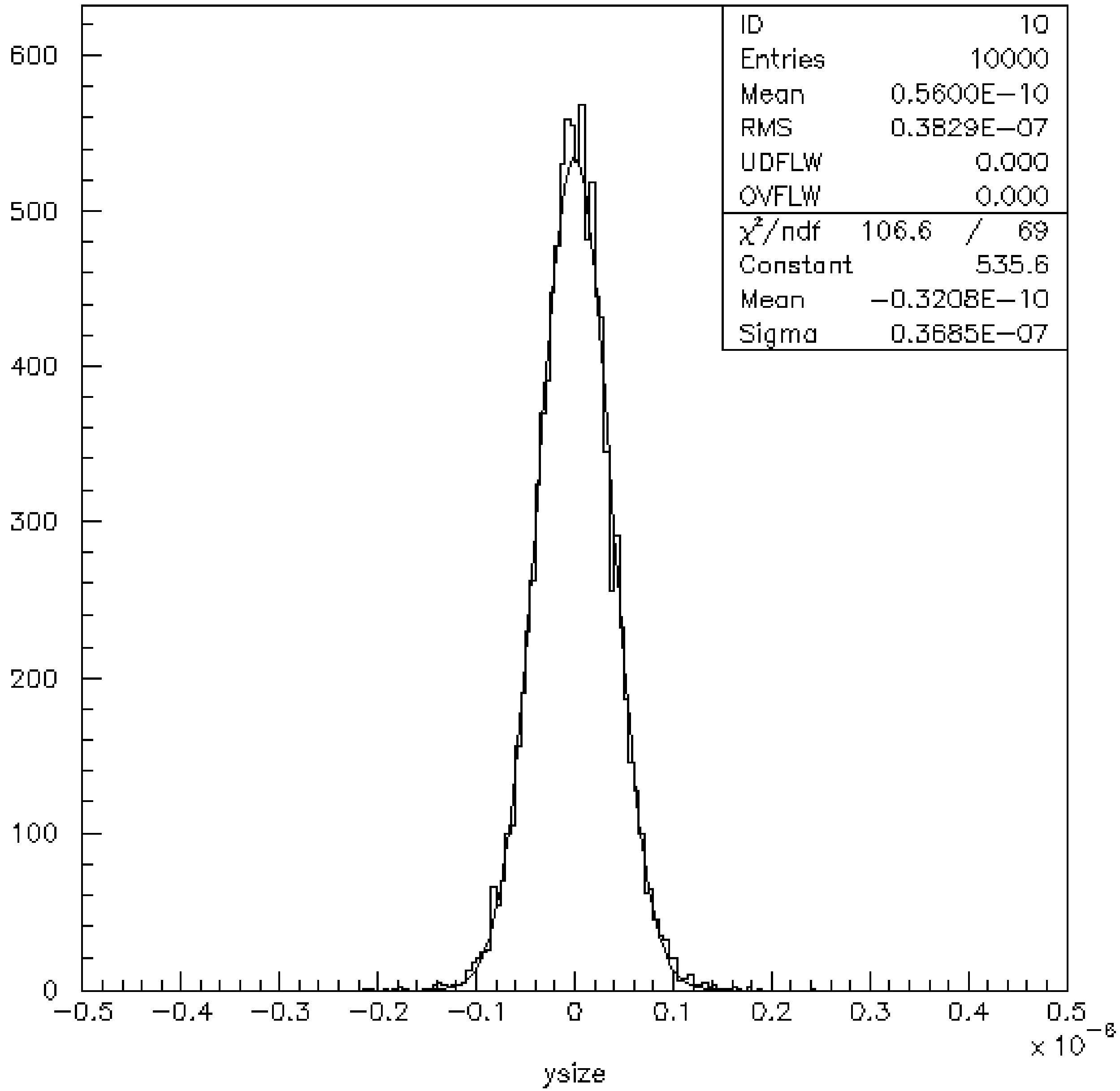
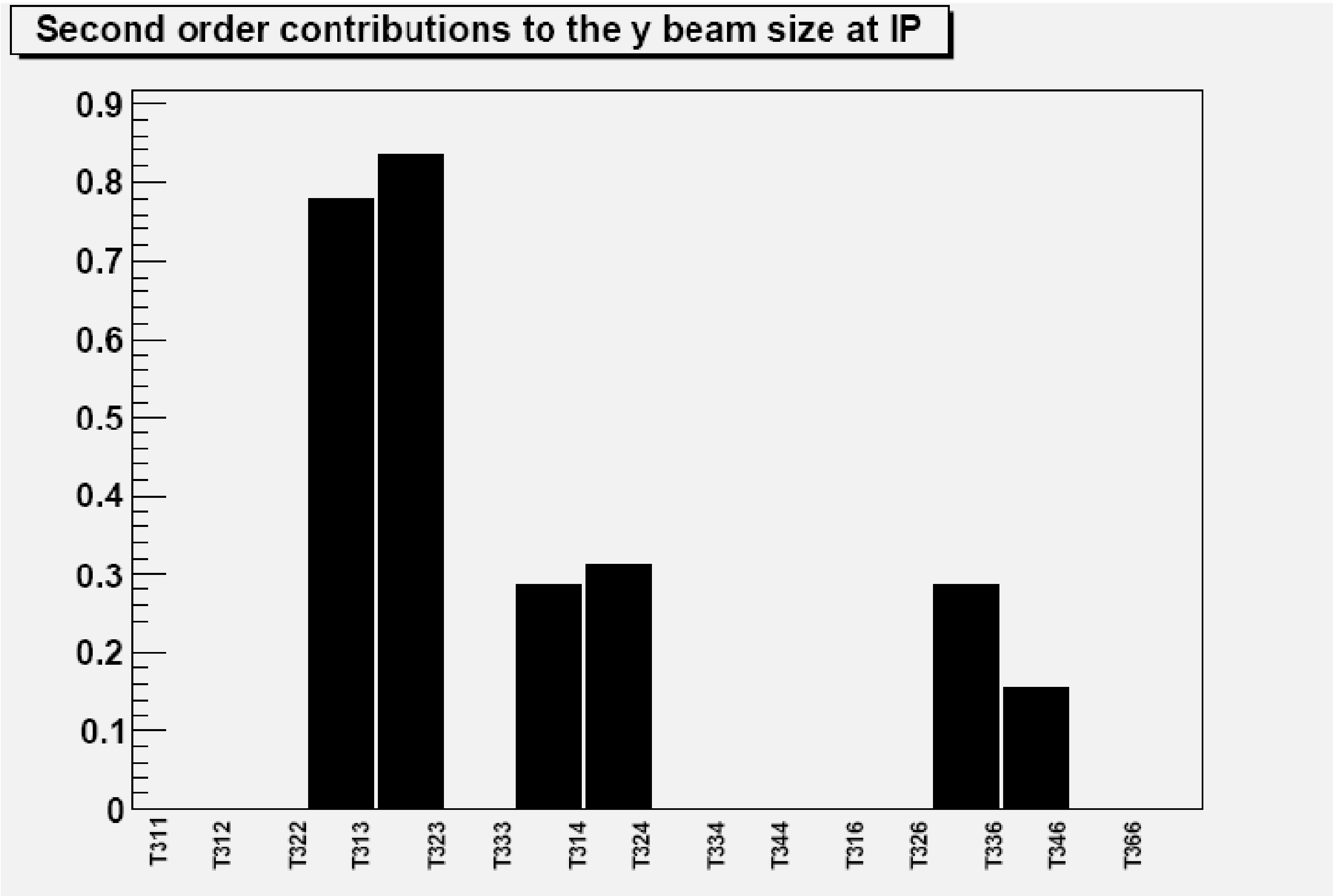


vertical particle distributions for $\beta_y = 1.0 \times 10^{-4}$ m:



Reduced $\beta_y = 2.0 \times 10^{-5}$ m :



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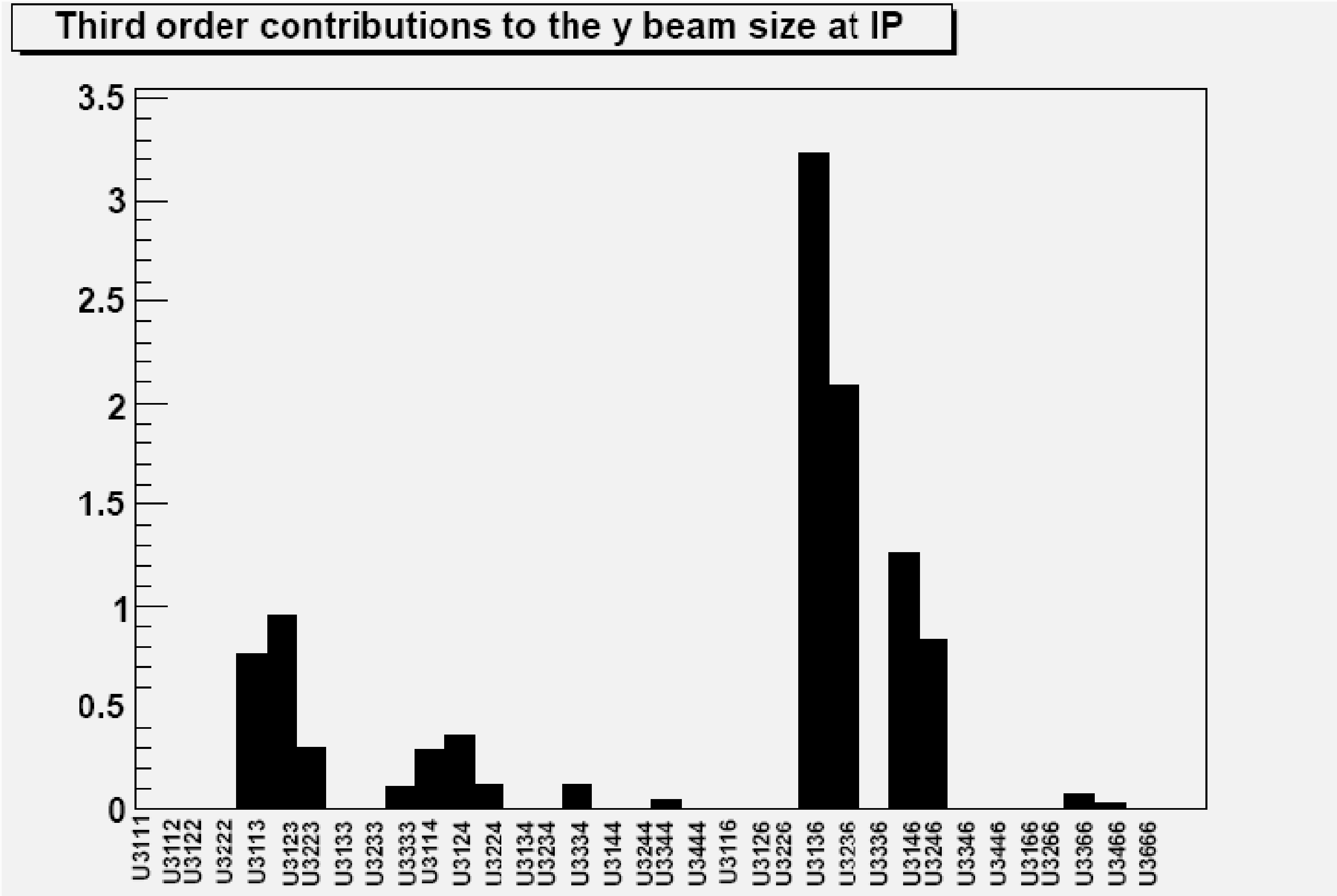

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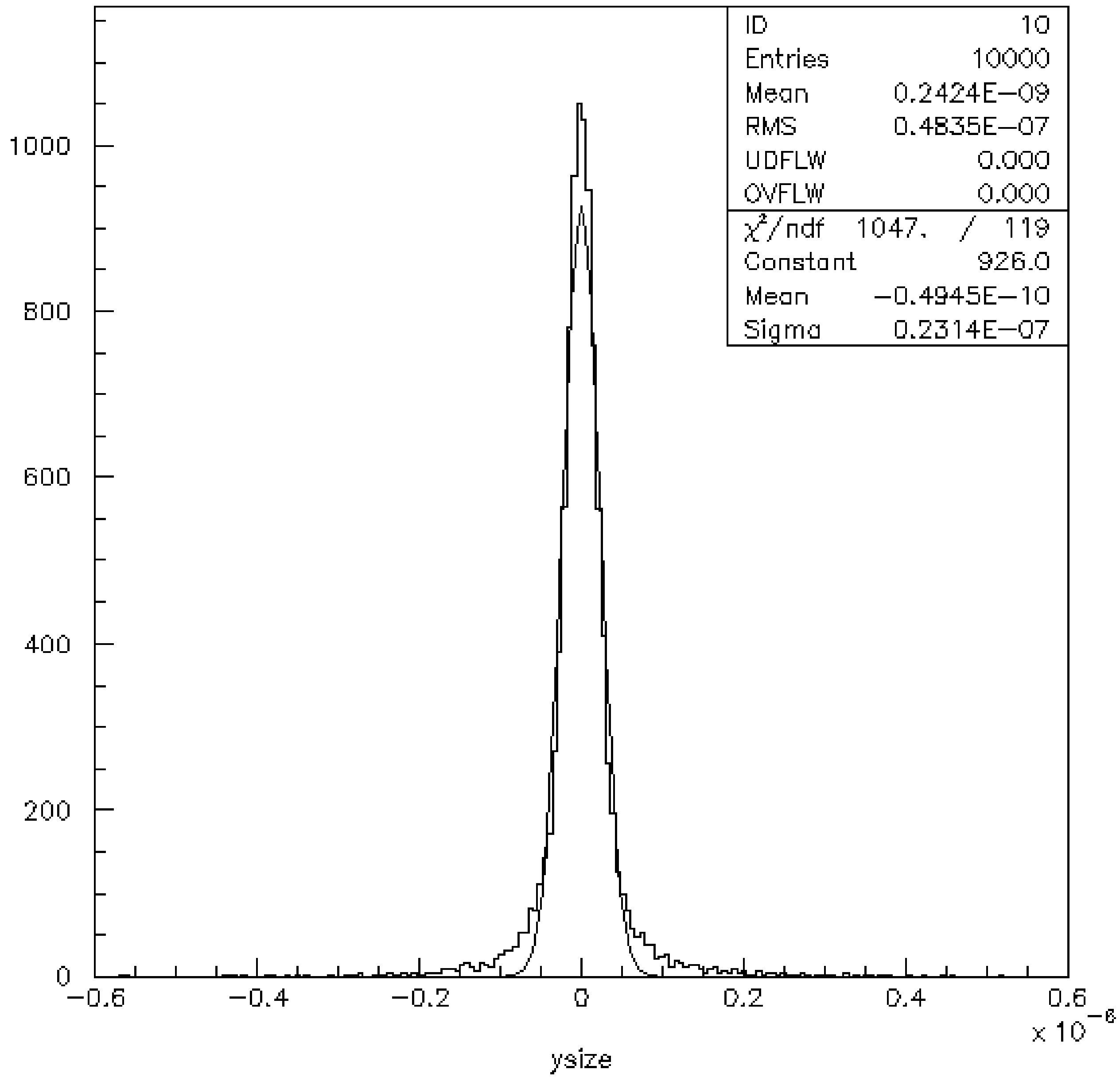

Conclusions and prospects

- Quadrupoles and sextupoles can be fitted to get intermediate parameters for the ATF2 line commissioning
- The minimum vertical beam size occurs for $\beta_y = 2.0 \times 10^{-5}$ m. Third order aberrations dominate in this case but a core size of 24nm can still be obtained
- Further optimisation of higher order properties would require more complete re-fitting of the final focus optics