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0 mrad Interaction Region -Final Focus design status-

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0 mrad meeting
ORSAY, 17th May 2006

Outline

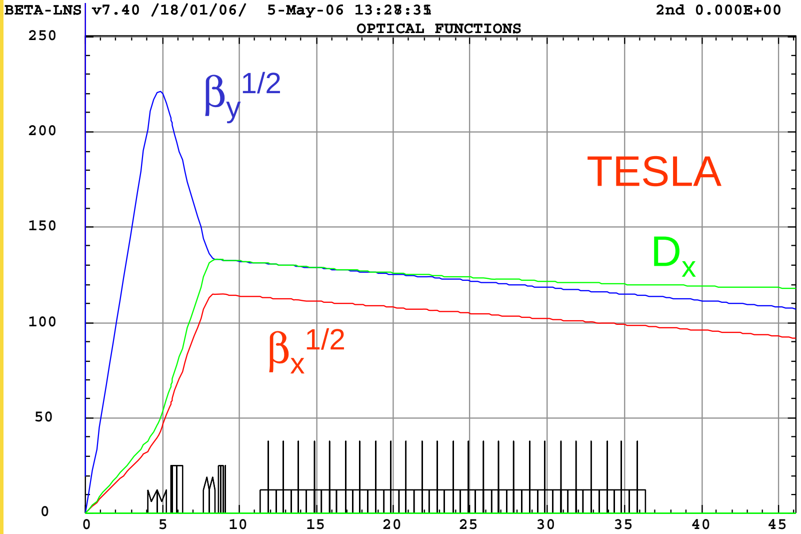
- Why we need to change the Final Focus
- The new lattices
- Luminosities
- Multi Kink instability
- Conclusions

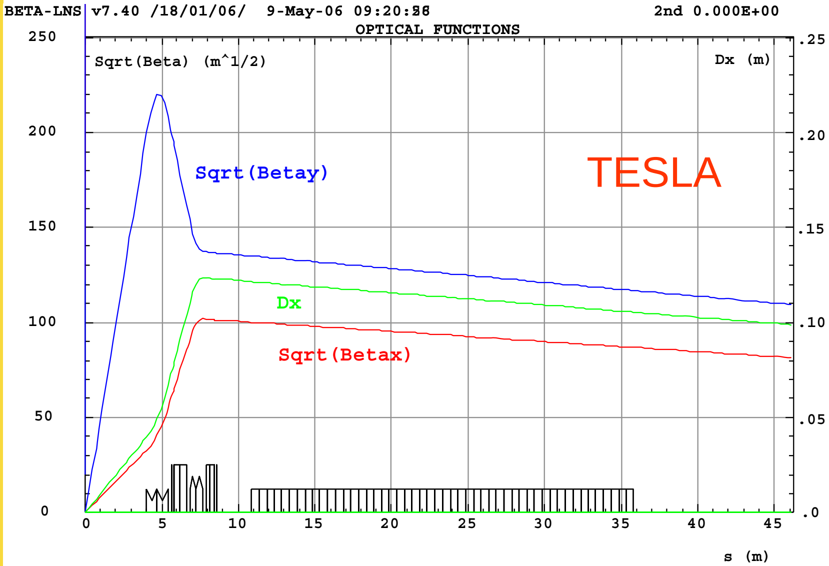
Why to change

- The goal was to keep a 10.5 m distance between the IP and the separator
- With the previous lattice we take into account many remarks
  - SD0 sign
  - B1 field
  - DMSQ length
- We have checked the optimization procedures
  - Lattice matching
  - Luminosity optimization
  - Losses computation
  - ...
- But I don't take care to the sextupole field :
  - with 7 T on coil, the sextupoles are too much strong
- I have to correct this !!!

New Final Focus Lattice

Optical Functions





- 4 m long drift to IP.
- B1 deviation is 1.81$10^{-5}$ rad.
- The distance IP→B1 is the same.
- FD quadripôles with maximum gradient (249.34 T/m).
- FD sextupoles with maximum strength (ϕ 56 mm, ~ 3 T on coil).
- 2 m long drift between the last sextupole and the separator.

⇒The element lengths are minimum

⇒The distance IP → Separator varies with the distance between QP:

- With 1.21 m free ⇒ 11.33 m
- With 0.64 m free ⇒ 11.03 m
- With 0.00 m free ⇒ 10.82 m

Length of Elements

Free Drift (m)	QD0 (m)	SD0 (m)	QF1 (m)	SF1 (m)	IP To ES (m)
1.2104	1.242	0.602	0.718	0.354	11.3264
0.6424	1.298	0.670	0.786	0.432	11.0284
0.0	1.380	0.806	0.886	0.546	10.8180

Relative change 11 %

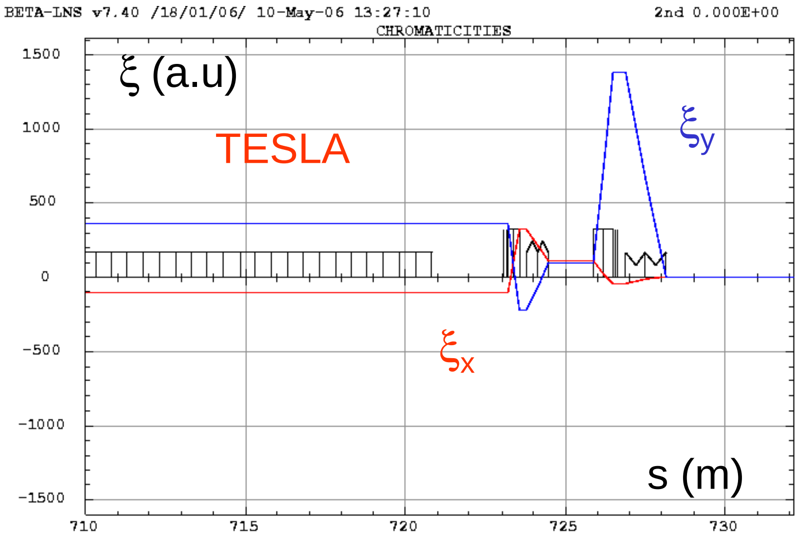
Relative change 34 %

Relative change 23 %

Relative change 54 %

New Final Focus Chromaticities

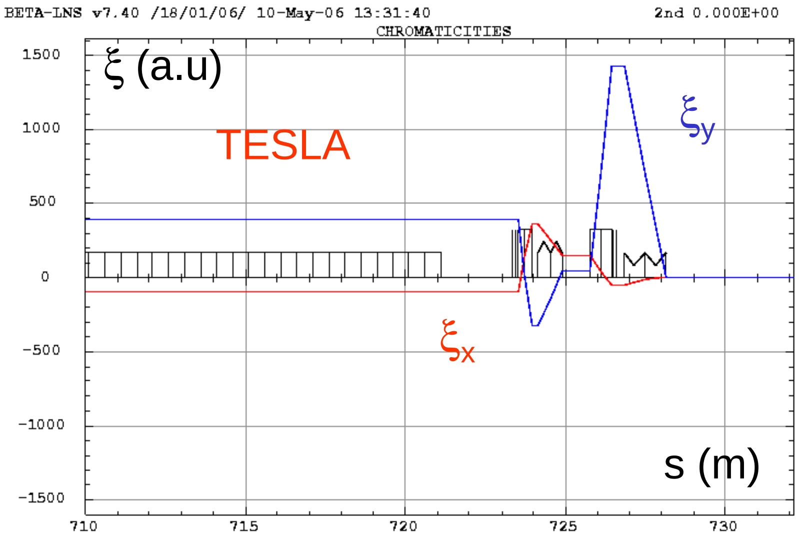
Chromaticities

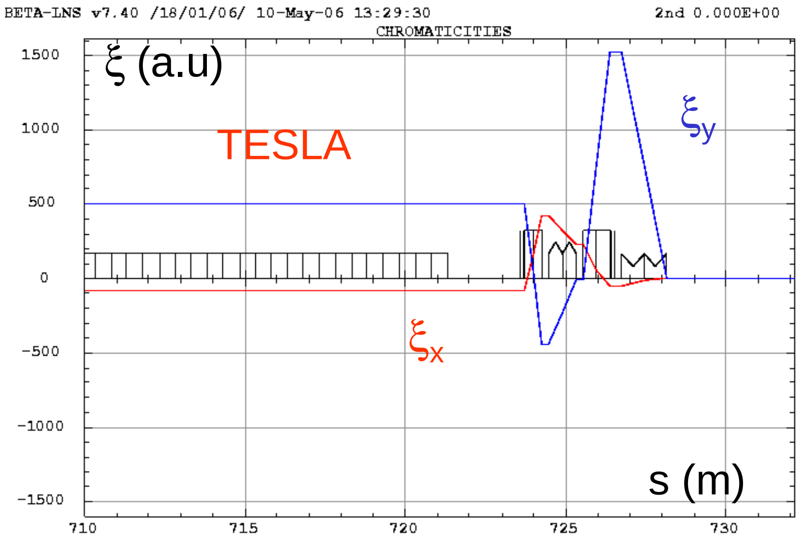


When the distance decrease :

- The QP chromaticities increase
- The SX correction increase
- The SF1 coupling increase and it counteracts the SD0 contribution

⇒The QP/SX lengths change are not similar.





Parameter Space for E=250 GeV L=2 10^{34} $cm^{-2}s^{-1}$

		Nominal	Large Y	Low P	High L	TESLA	Med Q P
N	x 10^{10}	2	2	2	2	2	1.3
n_b		2820	2820	1330	2820	2820	2820
$\varepsilon_{x,y}$	µm,nm	9.6, 40	12, 80	10, 35	10, 30	10, 30	9.6, 30
$\beta_{x,y}$	cm,mm	2, 0.4	1, 0.4	1, 0.2	1, 0.2	1.5, 0.4	1, 0.2
$\sigma_{x,y}$	nm	626.5, 5.7	495.3, 8.1	452.1, 3.8	452.1, 3.5	553.7, 5	443, 3.5
σ_z	µm	300	500	200	150	300	200
Bunch space	ns	308.5	308.5	462.4	308.5	308.5	308.5
D_y		19.12	28.30	26.72	21.66	24.98	19.16
δ_{BS}	%	2.2	2.2	5.1	6.2	2.7	2.5
P	MW	11.3	11.3	5.3	11.3	11.3	7.3

New Final Focus : Luminosity

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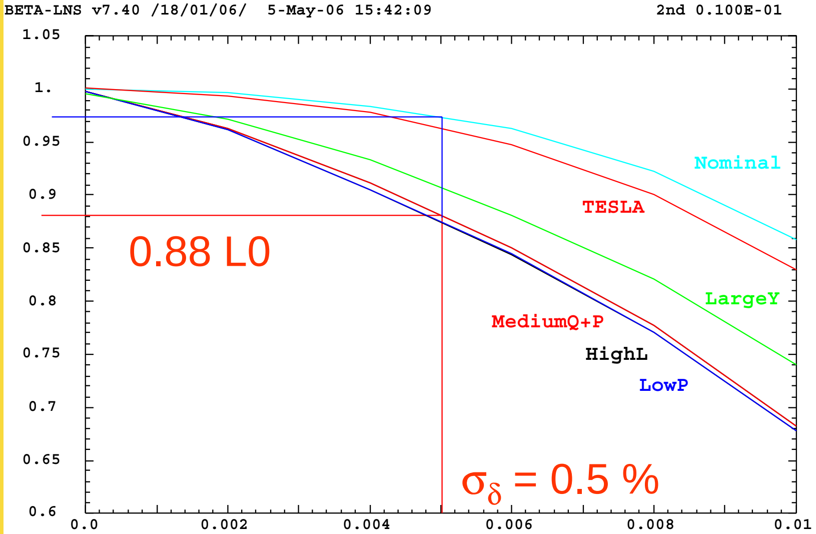
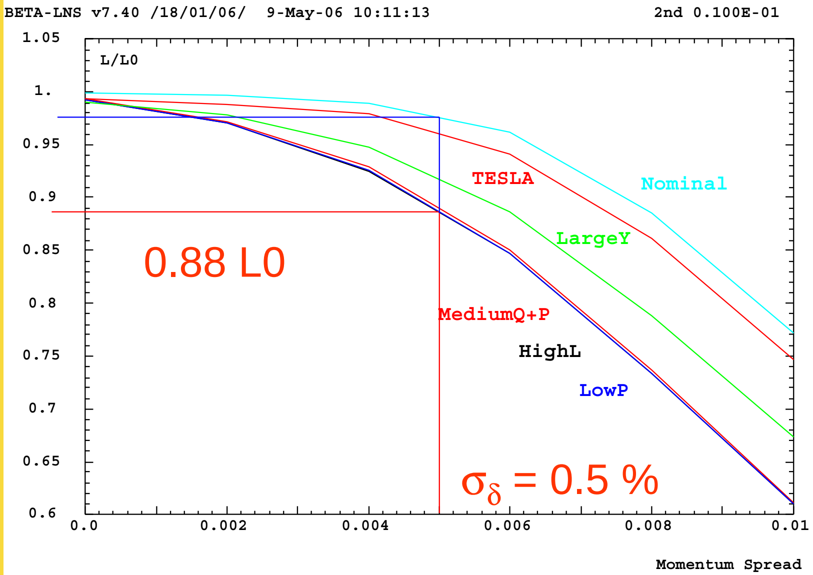
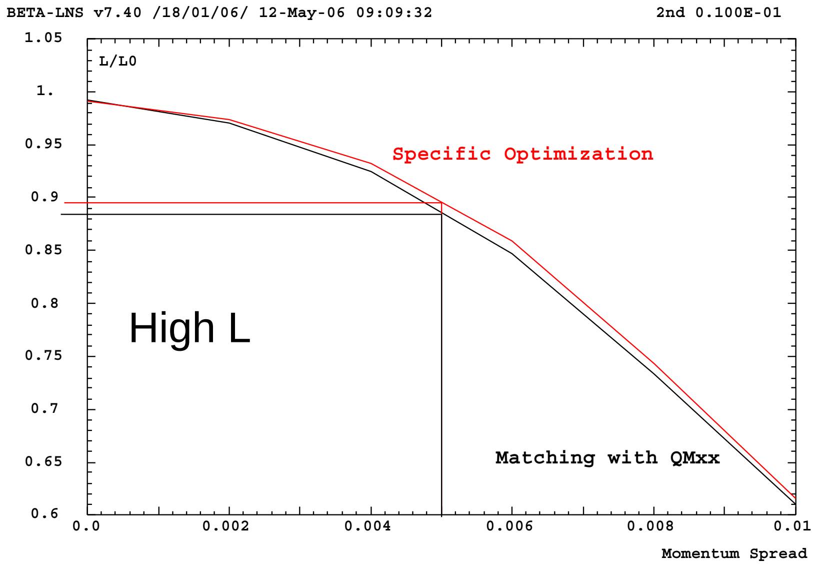
Luminosity



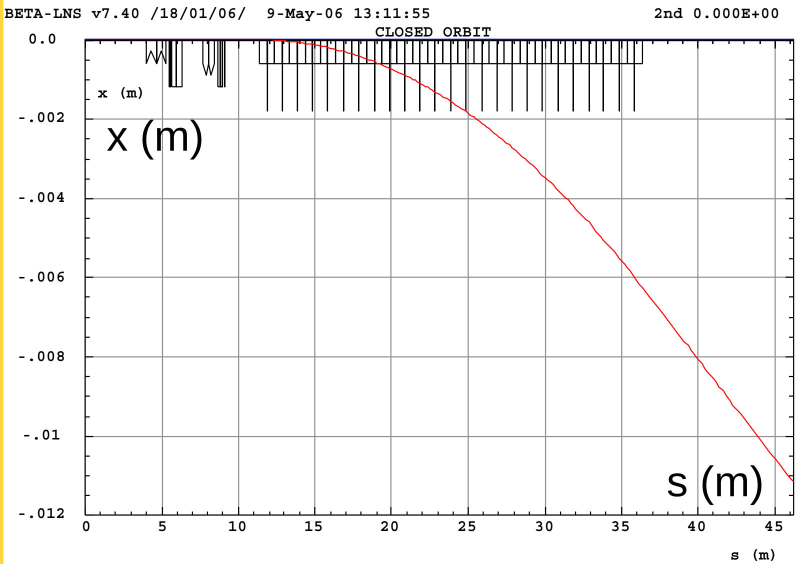
- Optimization for the TESLA case.
- Matching with QM16-QM13 for the other cases.
- Specific optimization gives an identical result.
- The best luminosity curves are obtained for the largest free drift.
- The luminosity curves are similar to the previous one.

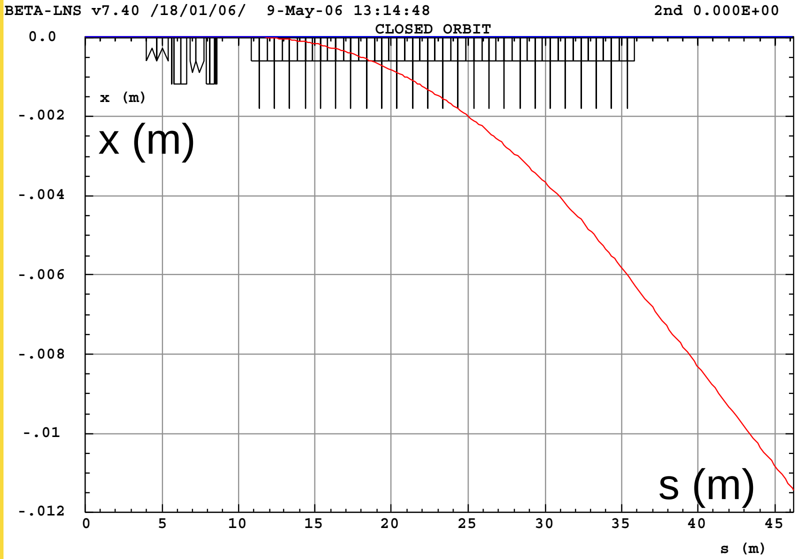




New Final Focus : Beam Separation

Central Trajectory





0. 5 mrad deviation for 25 m long electrostatic separator.

The parasitic collision is at 46.165m and the horizontal separation is :

- With 1.21 m free ⇒ 11.17 mm
- With 0.64 m free ⇒ 11.32 mm
- With 0.00 m free ⇒ 11.42 mm

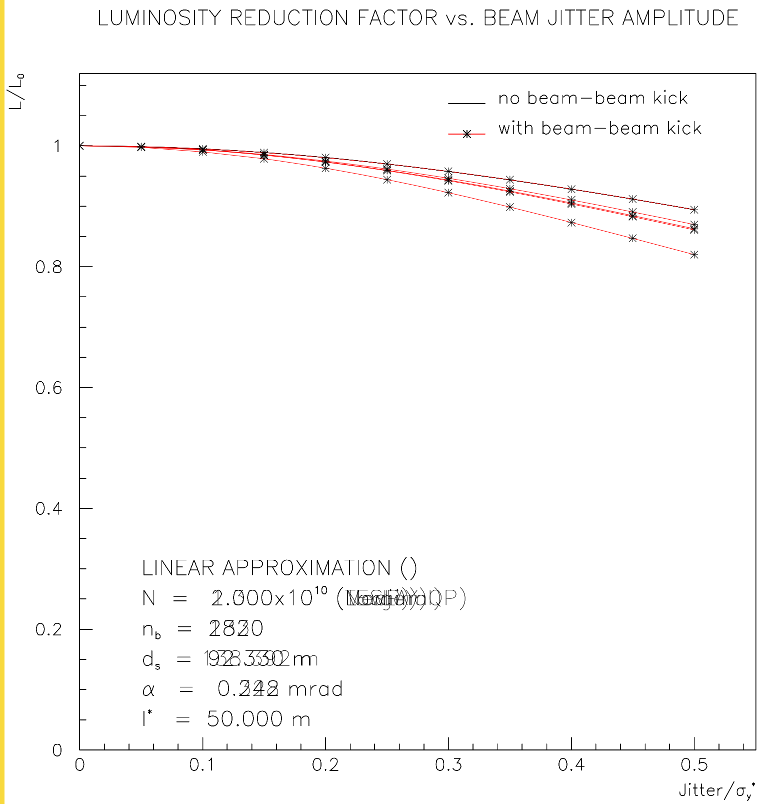
The separations are comparable with the previous lattice.

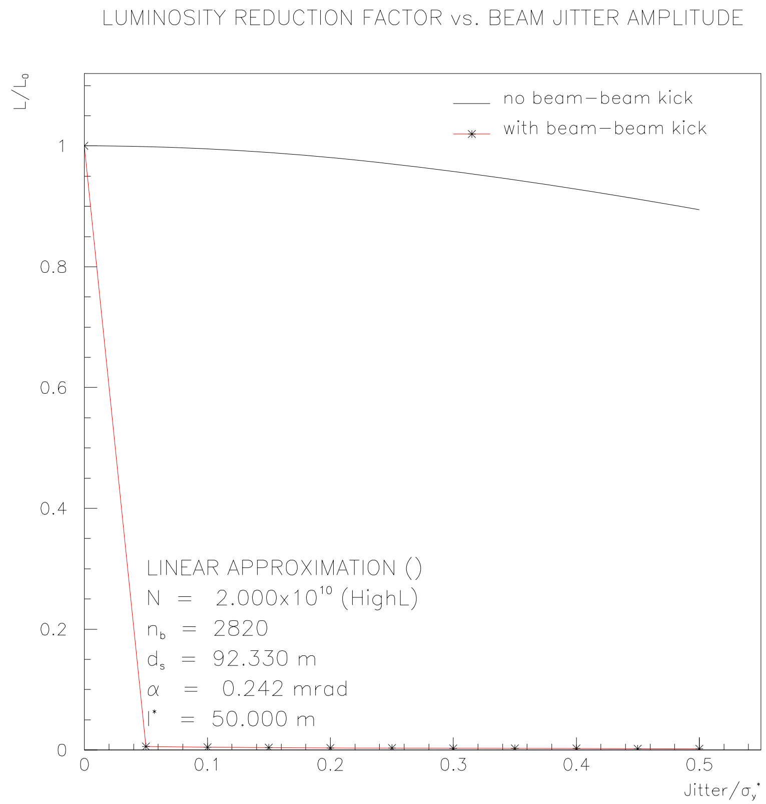
In the Low P case the parasitic collision occurs at 69.196 m from the IP.

The separation is then ~ 22.68 mm.

New Final Focus : Multi Kink Instability

Luminosity vs. jitter





The multi kink instabilities are evaluated for the largest free drift ⇒ lowest separation.

With 0.5 mrad deviation for 25 m long electrostatic separator the separation is sufficient for all cases except for the High L case.

Kick at IP

The IP Kick is given by $D_y/\sigma_z/2$
(the reduction by 2 is for coherent beam-beam)

Nominal	Large Y	Low P	High L	TESLA	Med QP
31864	28298	66803	72200	41635	47890

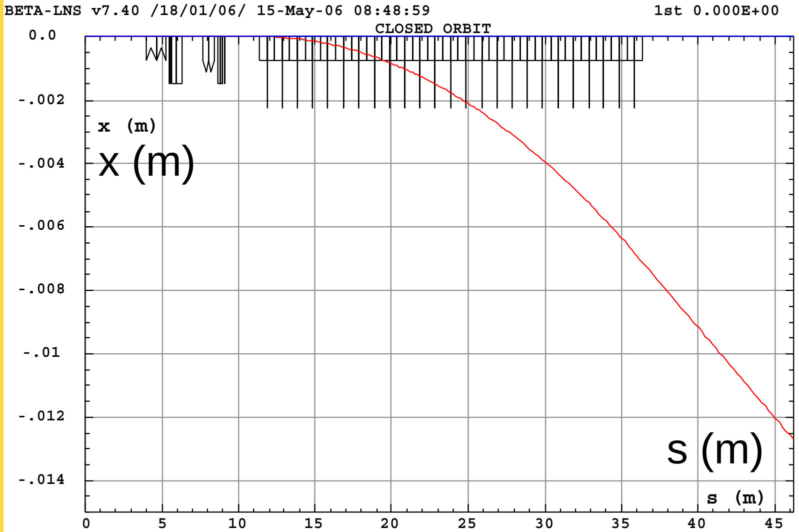
2.5 to 1.5 larger

Comparable, but larger separation

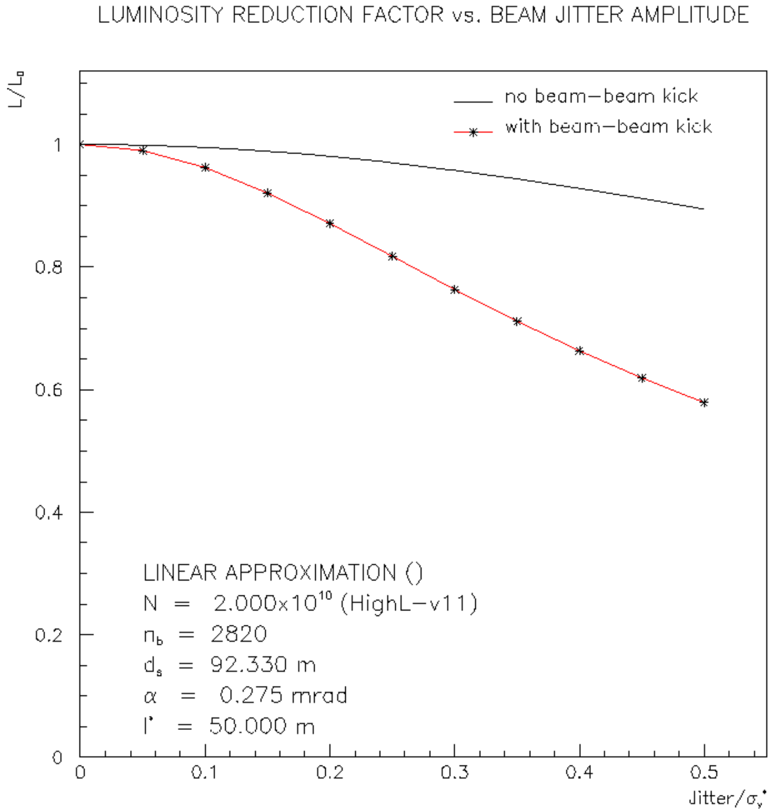
⇒We have to enlarge the separation at the parasitic collision

New Final Focus : Multi Kink stability for High L

Central Trajectory



Luminosity vs. jitter

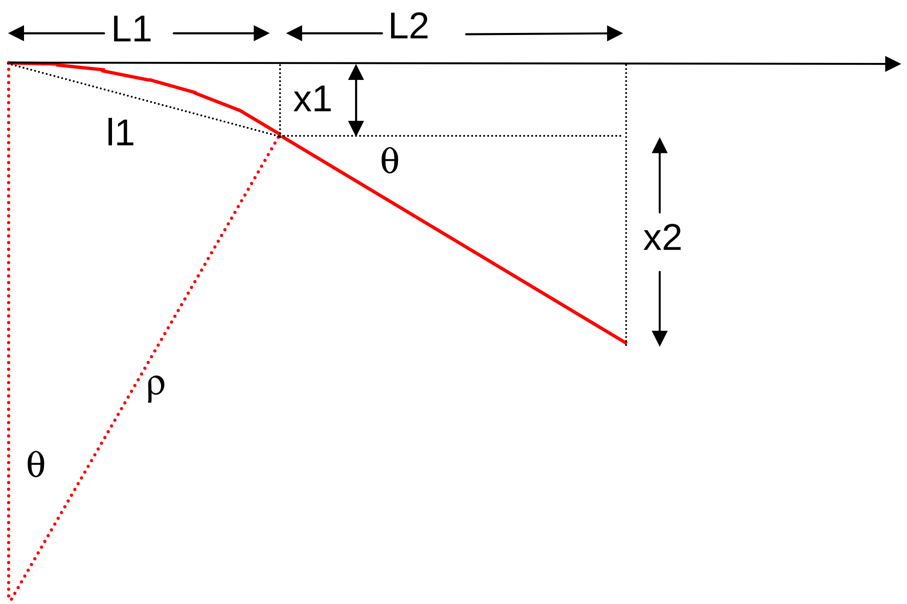


The multi kink instabilities are evaluated for the largest free drift ⇒ lowest separation.

To reach the stability, the separation needed is then 12.7 mm

With 0.685 mrad deviation for 25 m long electrostatic separator (13.7% field increase) the separation is sufficient for the High L case.

Separator study for lowest field increase



$$x1 = L1\sqrt{\frac{1}{\left(\frac{2\sin(\theta/2)}{1-\cos(\theta)}\right)^2 - 1}}$$

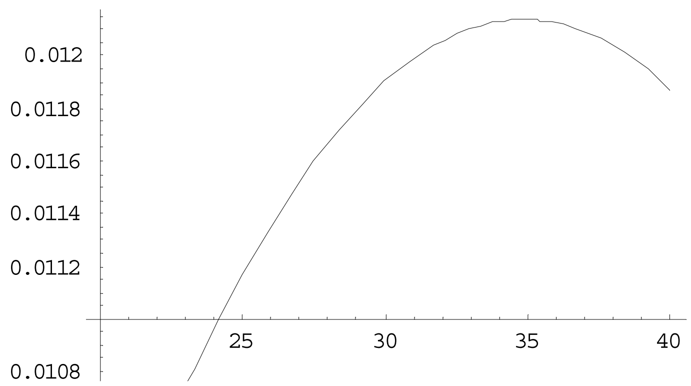
$$x2 = (L - L1)\tan(\theta)$$

$$x1 \approx \frac{L1\theta}{2}$$

$$x2 \approx (L - L1)\theta$$

$$x = L1\theta_L\left(L - \frac{L1}{2}\right), \quad \theta_L = \frac{\theta}{L1}$$

For a given θ_L, the separation x, is a parabolic function of L1.
The maximum is obtained when L1=L

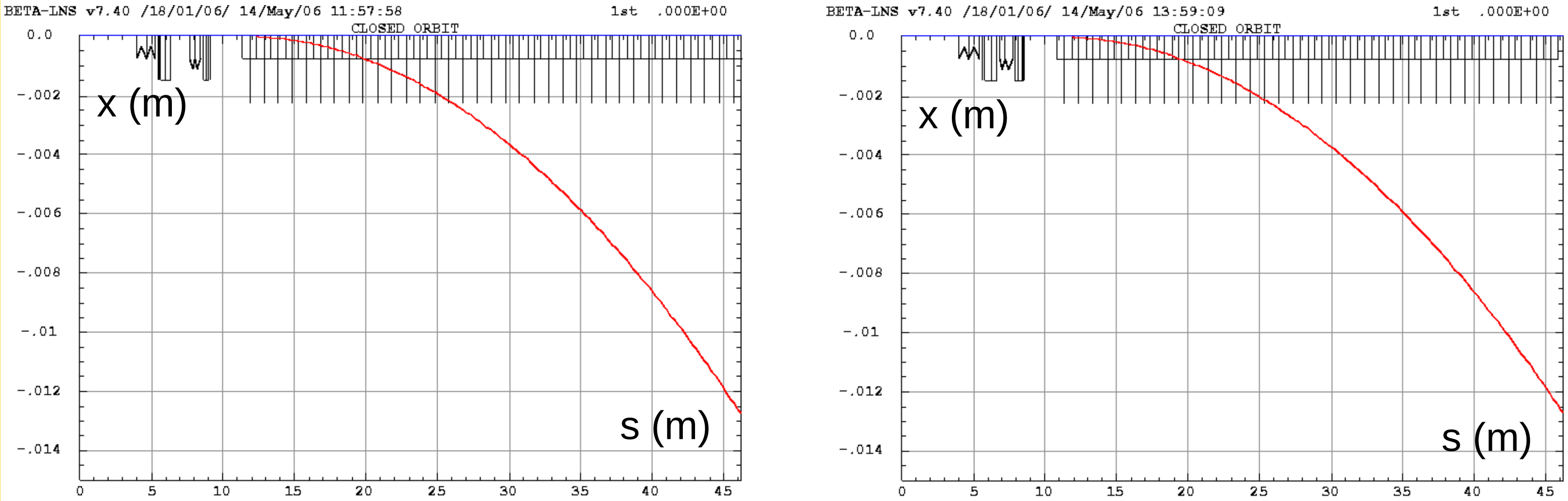


separation x as function of L1 (θ_L=0. 02 mrad/m)

In the High L case, we reach the stability with 0.0127 m separation. To obtain this with the lowest separator field, we need 34.8386 m long separator with θ_L=0. 020927 mrad/m deviation.

New Final Focus : Multi Kink stability for High L

Central Trajectory



The multi kink instabilities are evaluated for the largest free drift ⇒ lowest separation.

With 0.79 mrad deviation for 34.8386 m long electrostatic separator (4.6% field increase) the separation is sufficient for the High L case.

The multi kink instabilities are evaluated for the 0 m free drift ⇒ largest separation.

With 0.712 mrad deviation for 35 m long electrostatic separator (1.7% field increase) the separation is sufficient for the High L case.

Conclusions

- We have new final focus designs which reach the requirements
  - The B1 deviation angle is 1.8 10^{-5} rad.
  - The sextupole field is limited to 3T at 0.028 m.
  - The SD0 is a negative sextupole.
  - For all tunings, the luminosity is larger than 0.88 L0 for momentum below 0.5%.
- The electrostatic separator allows sufficient separation to avoid multi kink instability, except for the High L tuning.
  - In this later case, we can enlarge or/and strengthen the separator to obtain the stability.
  - In the worse case (1.21 m free drift inside the FD) we need :
    - 13.7% field increase for a 25m long separator.
    - 4.6% field increase for a 34.84 m long separator.
  - In the best case (0 m free drift inside the FD) we need :
    - 11.2% field increase for a 25 m long separator.
    - 1.7% field increase for a 35 m long separator.
- We have to select the appropriate final focus lattice in comparison with the extraction easiness.