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# 0 mrad Interaction Region -Final Focus design status-

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*0 mrad meeting*  
*ORSAY, 17<sup>th</sup> May 2006*

# Outline

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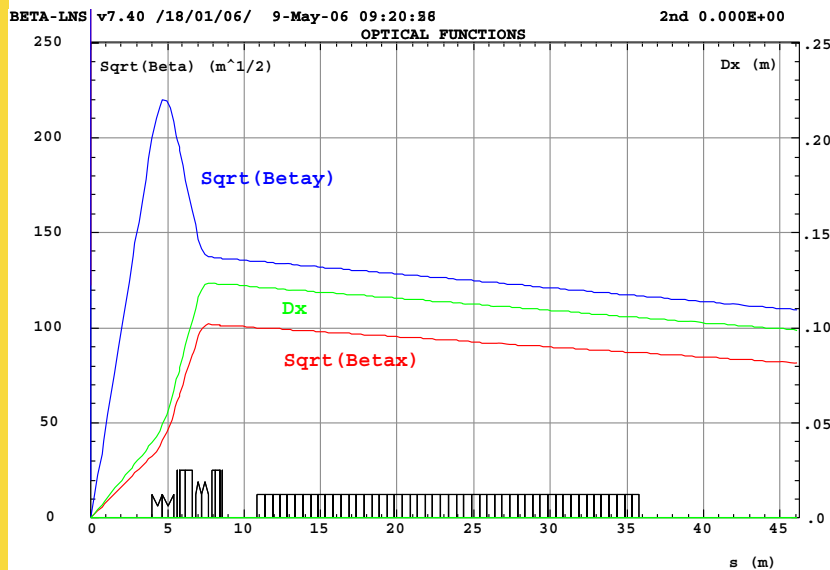
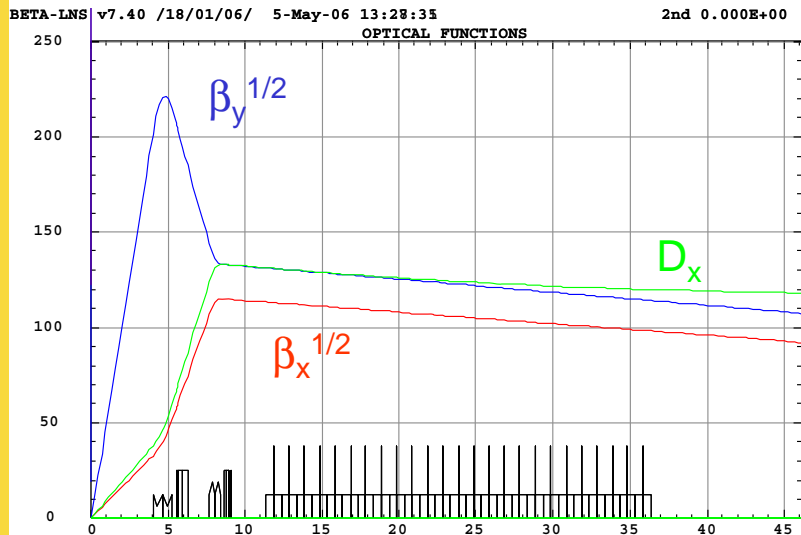
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- Why we need to change the Final Focus
- The new lattices
- Luminosities
- Multi Kink instability
- Conclusions

# 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  $1.81 \cdot 10^{-5}$  rad.
  - The distance IP → B1 is the same.
  - FD quadrupôles with maximum gradient (249.34 T/m).
  - FD sextupoles with maximum strength ( $\phi$  56 mm,  $\sim 3$  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

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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 23 %

↑  
Relative change 34 %

↑  
Relative change 54 %

# New Final Focus Chromaticities

## Chromaticities

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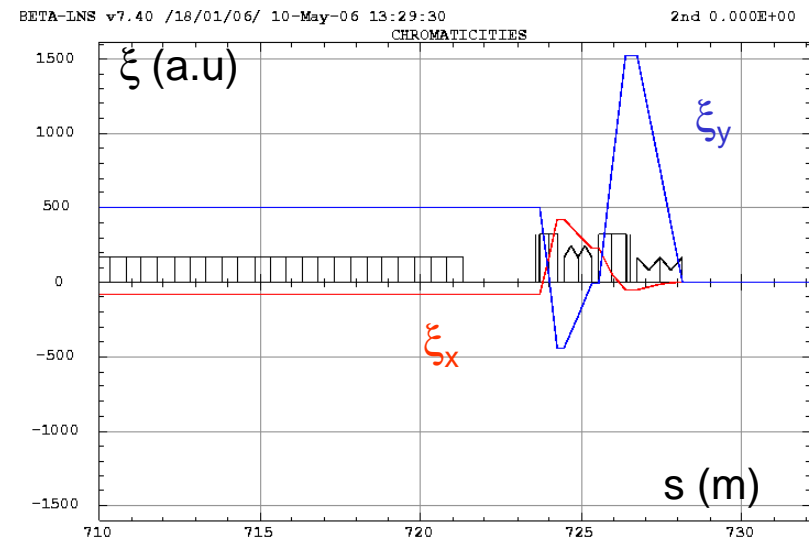
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When the distance decrease :

- 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 $E=250 \text{ GeV}$ $L=2 \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

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		Nominal	Large Y	Low P	High L	TESLA	Med Q P
N	$\times 10^{10}$	2	2	2	2	2	1.3
$n_b$		2820	2820	1330	2820	2820	2820
$\epsilon_{x,y}$	$\mu\text{m}, \text{nm}$	9.6, 40	12, 80	10, 35	10, 30	10, 30	9.6, 30
$\beta_{x,y}$	$\text{cm}, \text{mm}$	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
$\sigma_z$	$\mu\text{m}$	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
$\delta_{BS}$	%	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

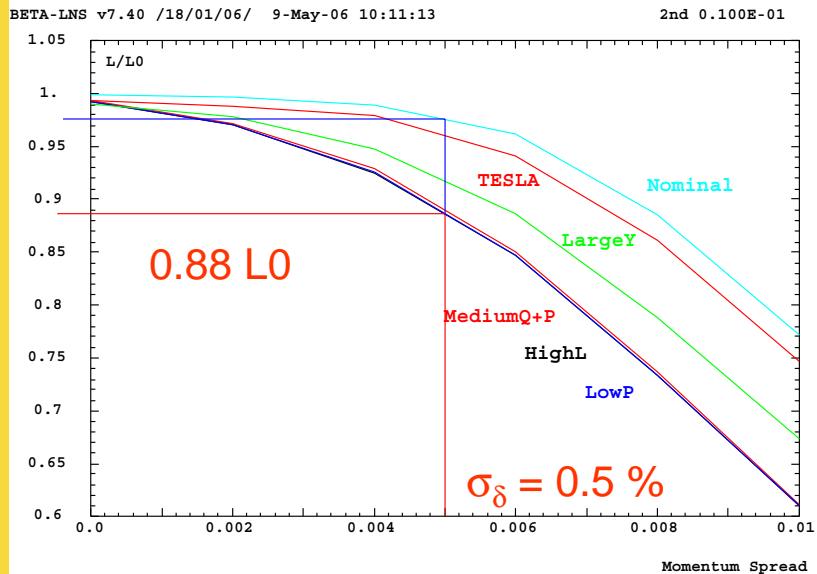
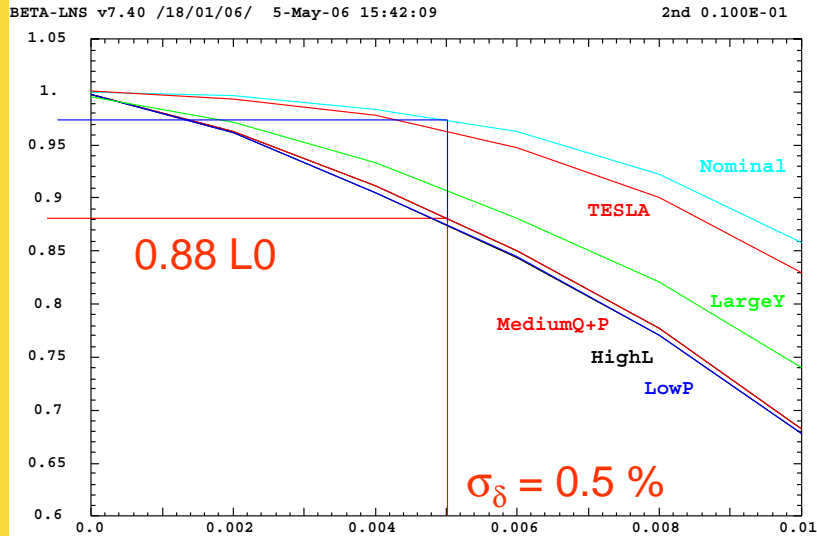
# New Final Focus : Luminosity

## Luminosity

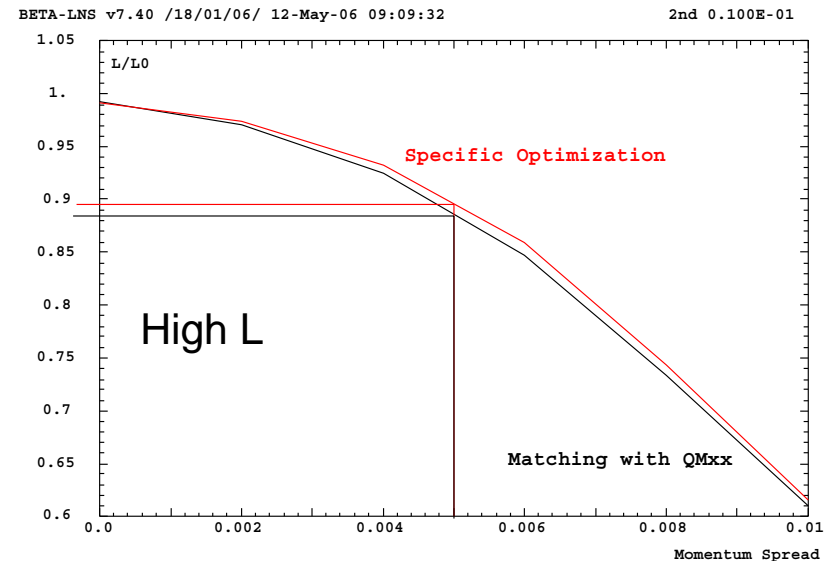
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- Optimization for the TESLA case.
- Matching with QM16-QM13 for the other cases.
- Specific optimization gives an identical result.
- The best luminosity curves are obtained for the largest free drift.
- The luminosity curves are similar to the previous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





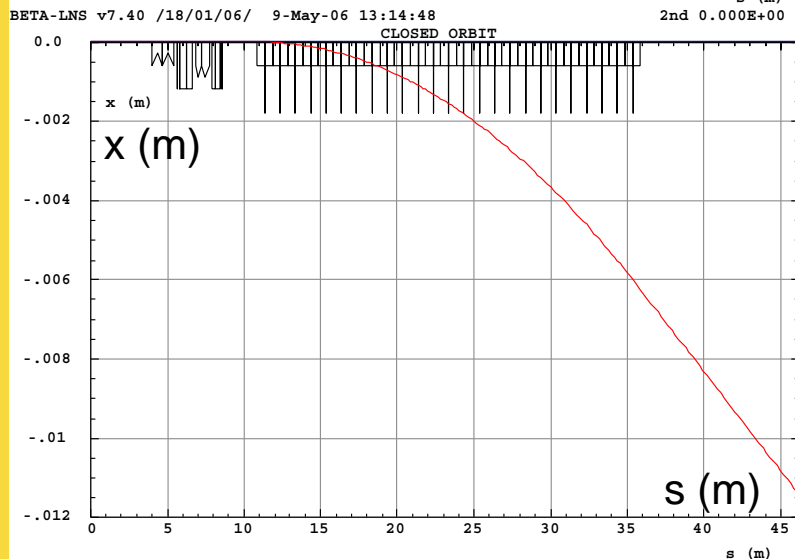
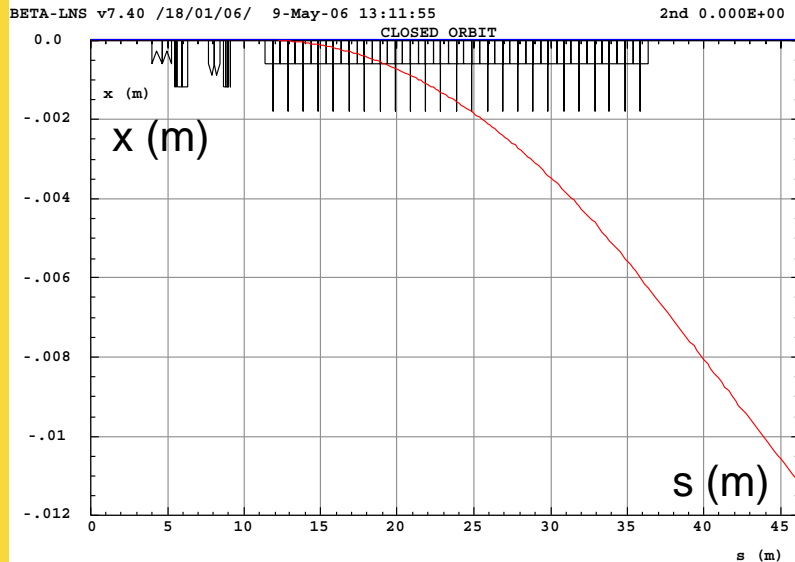
# New Final Focus : Beam Separation

## Central Trajectory

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0.5 mrad deviation for 25 m long electrostatic separator.

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

- With 1.21 m free  $\Rightarrow$  11.17 mm
- With 0.64 m free  $\Rightarrow$  11.32 mm
- With 0.00 m free  $\Rightarrow$  11.42 mm

The separations are comparable with the previous lattice.

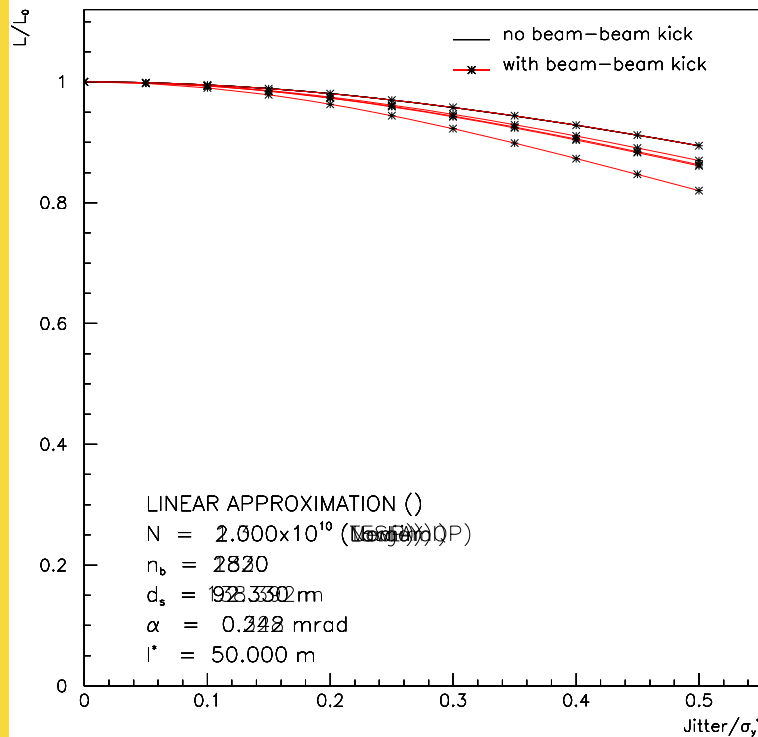
In the Low P case the parasitic collision occurs at 69.196 m from the IP.

The separation is then  $\sim$  22.68 mm.

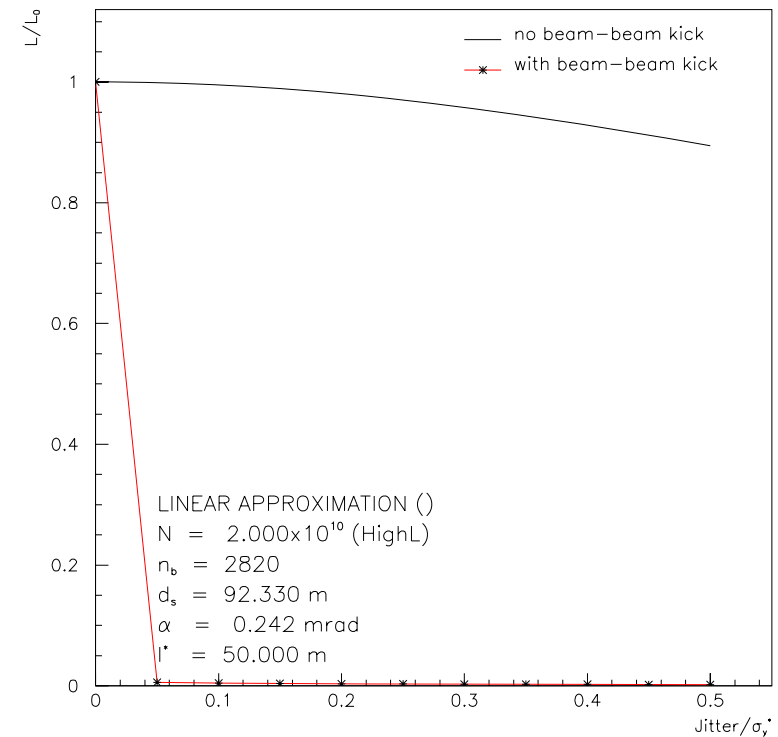
# New Final Focus : Multi Kink Instability

## Luminosity vs. jitter

LUMINOSITY REDUCTION FACTOR vs. BEAM JITTER AMPLITUDE



LUMINOSITY REDUCTION FACTOR vs. BEAM JITTER AMPLITUDE



The multi kink instabilities are evaluated for the largest free drift  $\Rightarrow$  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

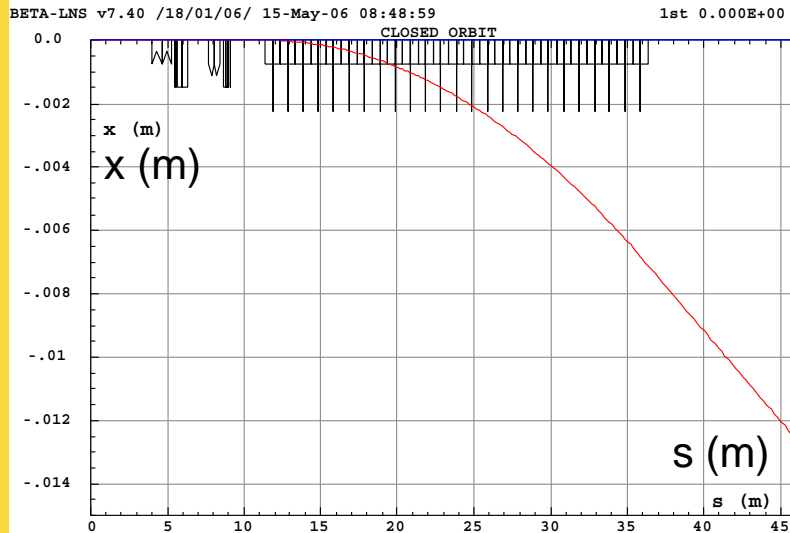
⇒ We have to **enlarge the separation** at the parasitic collision

# New Final Focus : Multi Kink stability for High L Central Trajectory

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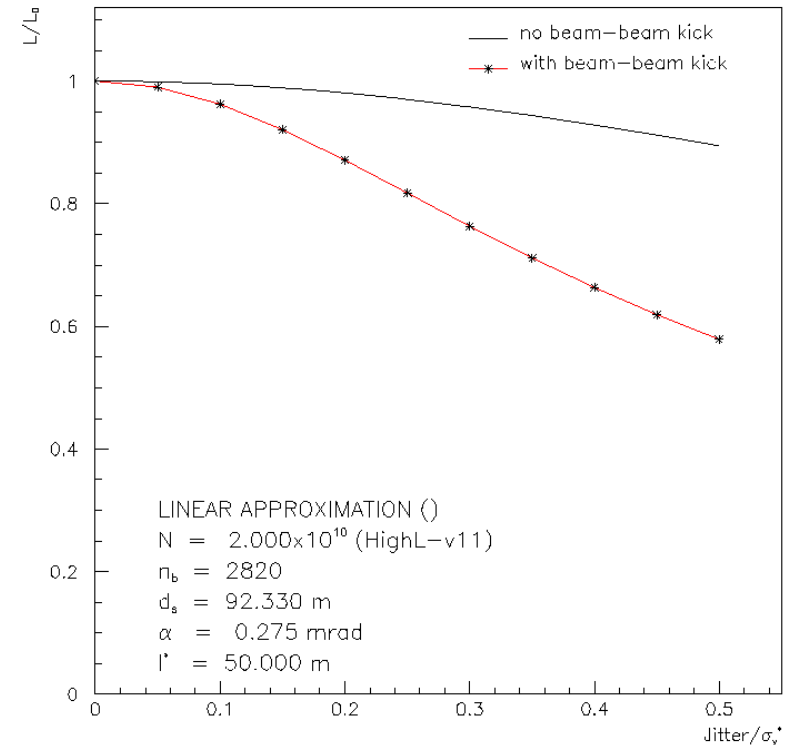


The multi kink instabilities are evaluated for the largest free drift  $\Rightarrow$  lowest separation.

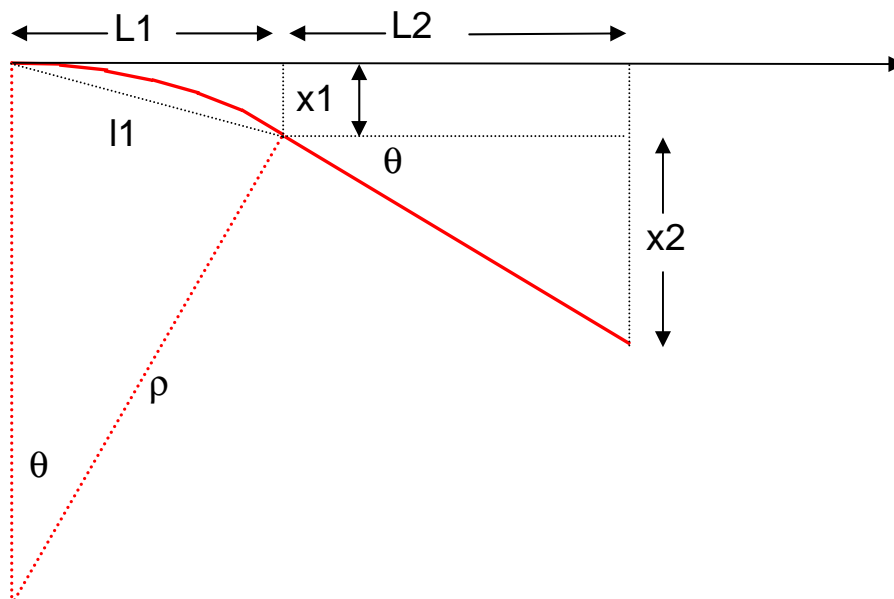
To reach the stability, the separation needed is then 12.7 mm

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

LUMINOSITY REDUCTION FACTOR vs. BEAM JITTER AMPLITUDE



# Separator study for lowest field increase



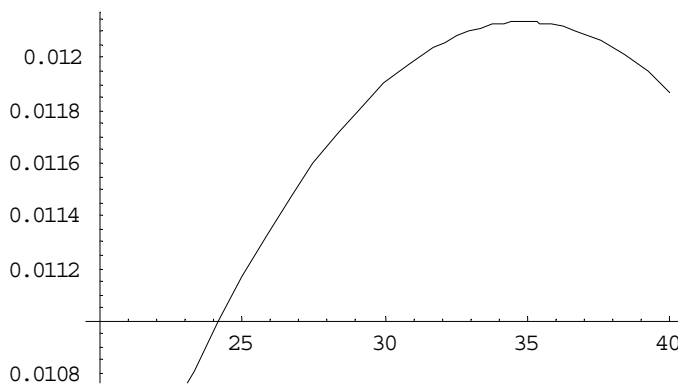
$$x1 = L1 \sqrt{\frac{1}{\left(\frac{2 \sin(\theta/2)}{1 - \cos(\theta)}\right)^2 - 1}}$$

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

$$x1 \approx \frac{L1\theta}{2} \quad x = L1\theta_L \left( L - \frac{L1}{2} \right), \quad \theta_L = \frac{\theta}{L1}$$

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

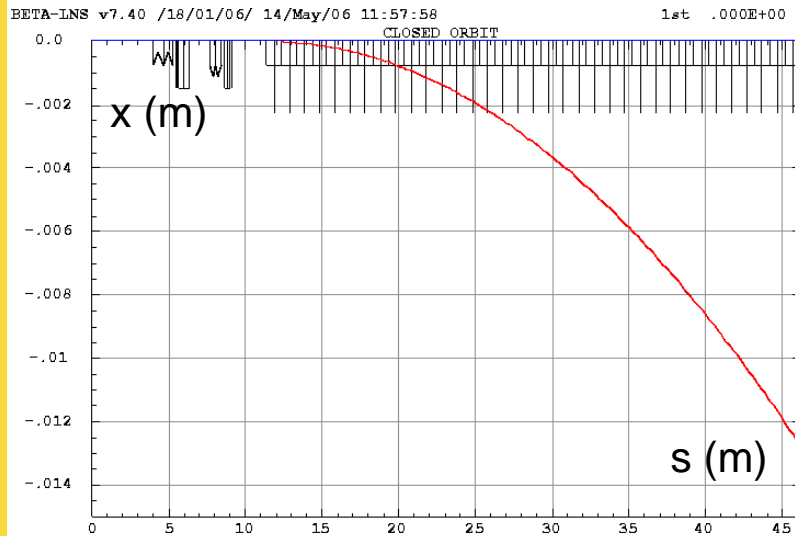
For a given  $\theta_L$ , the separation  $x$ , is a parabolic function of  $L1$ .  
The maximum is obtained when  $L1=L$



separation  $x$  as function of  $L1$  ( $\theta_L=0.02$  mrad/m)

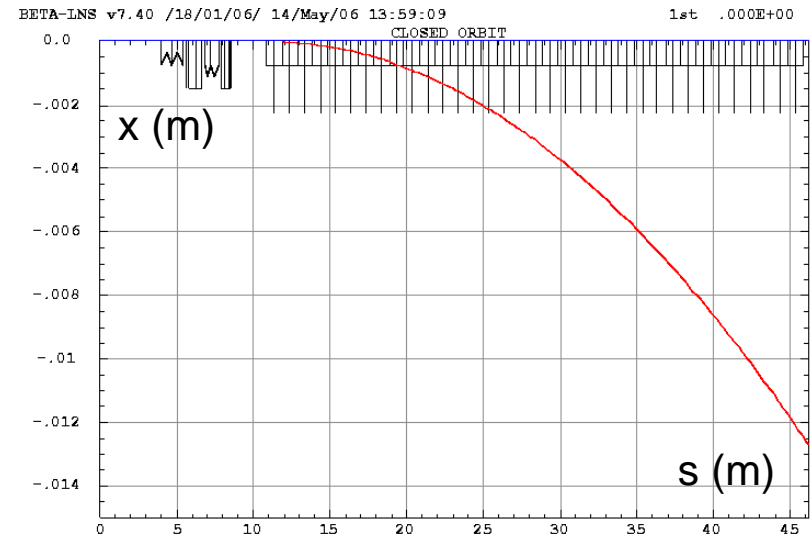
In the High  $L$  case, we reach the stability with 0.0127 m separation. To obtain this with the lowest separator field, **we need 34.8386 m long separator with  $\theta_L=0.020927$  mrad/m deviation.**

# New Final Focus : Multi Kink stability for High L Central Trajectory



The multi kink instabilities are evaluated for the largest free drift  $\Rightarrow$  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  $\Rightarrow$  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  $1.8 \cdot 10^{-5}$  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.