Alternative IR geometries for TESLA with a small crossing angle

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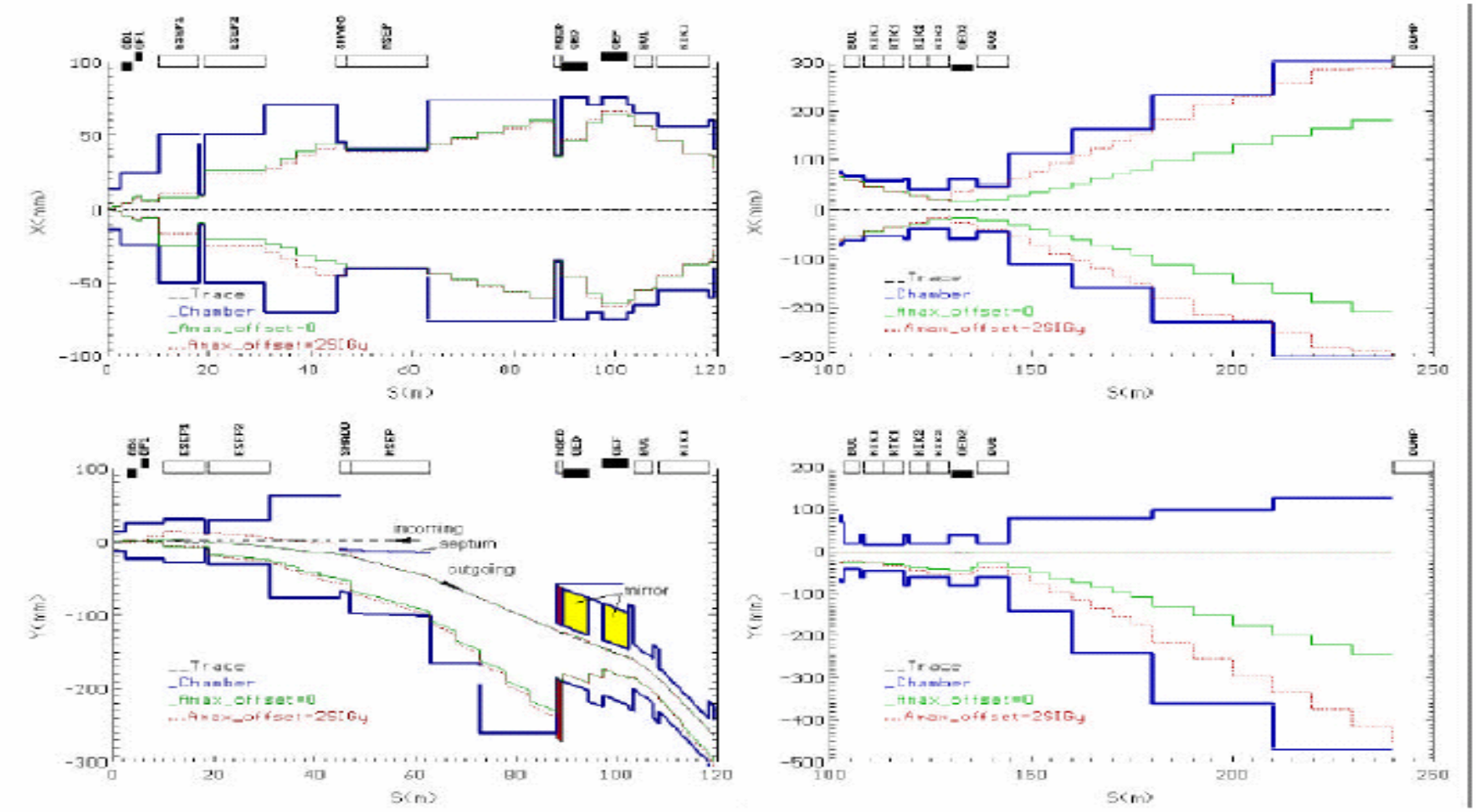
Deepa Angal-Kalinin
Bambade, Mouton, Napoly and Payet

Overview of talk

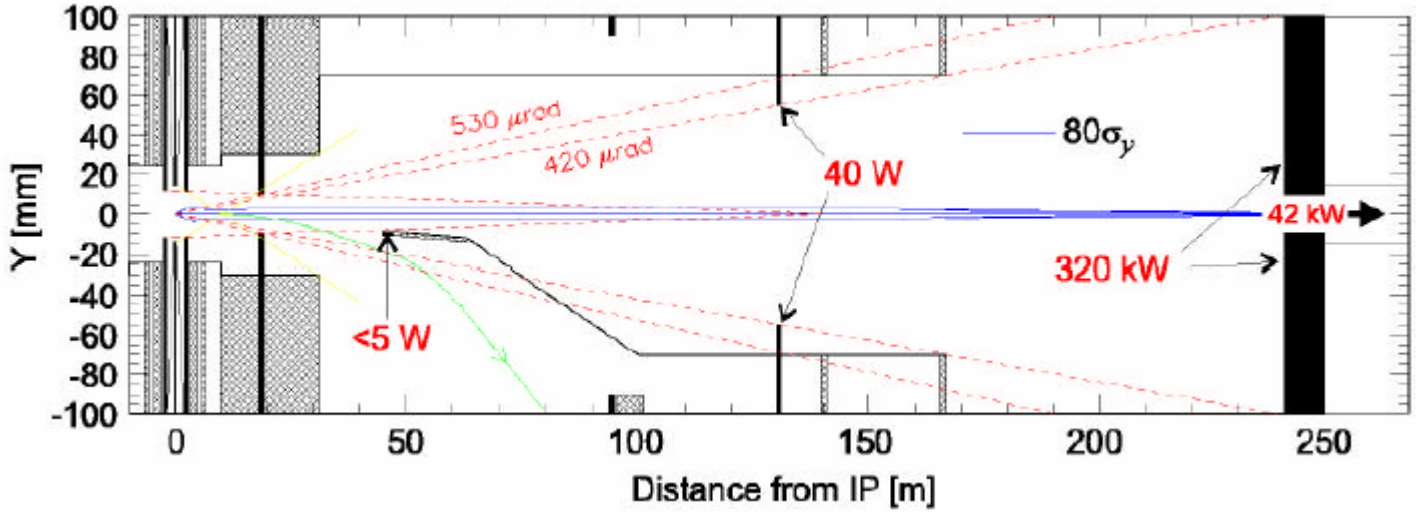
- Vertical crossing angle scheme
  - Concept (Brinkmann)
  - Final focus properties
  - Charged particle extraction properties
- Horizontal crossing angle
  - Was asked to talk about this, and slides contributed by, Bambade, Mouton, Napoly and Payet.
  - Uses small (2 mrad) crossing angle

Will focus on L*=5m results for the vertical crossing angle scheme, but good designs exist for L*=4m

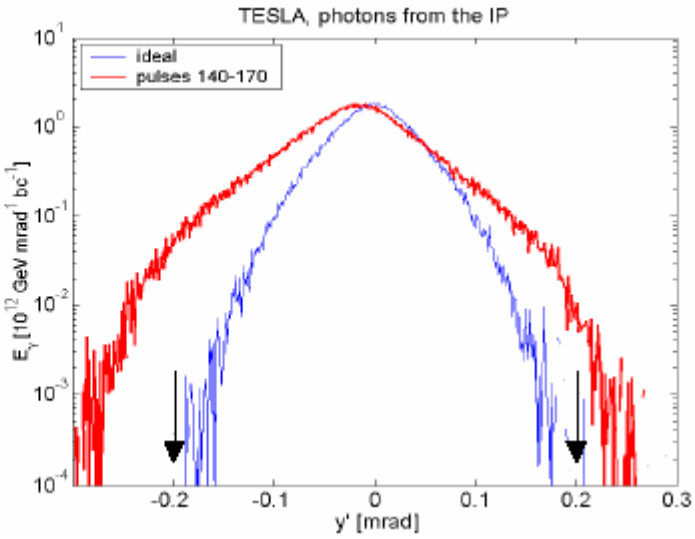
The TDR horizontal and vertical physical layout



R. Brinkmann – Spent beam extraction seminar – 3.12.02



Free opening angle for beamstrahlung is only ~0.2mrad at septum → too small under ***realistic*** beam collision conditions



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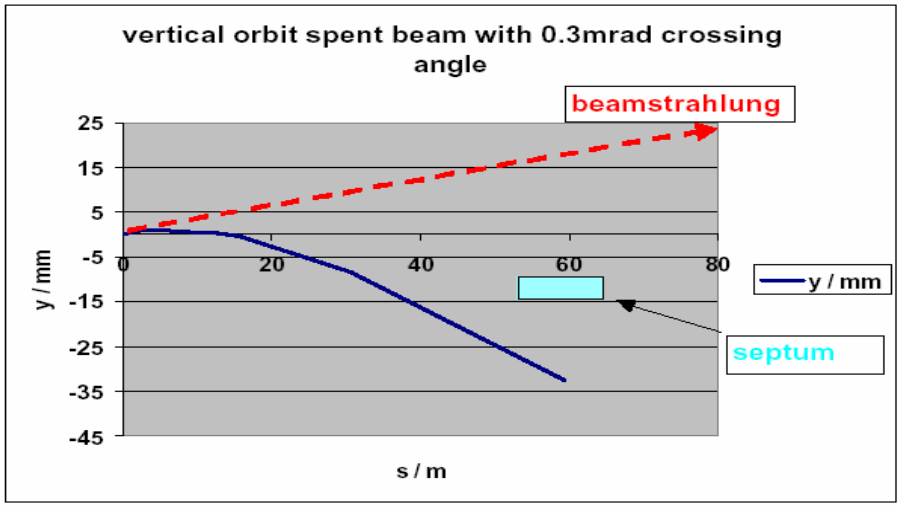
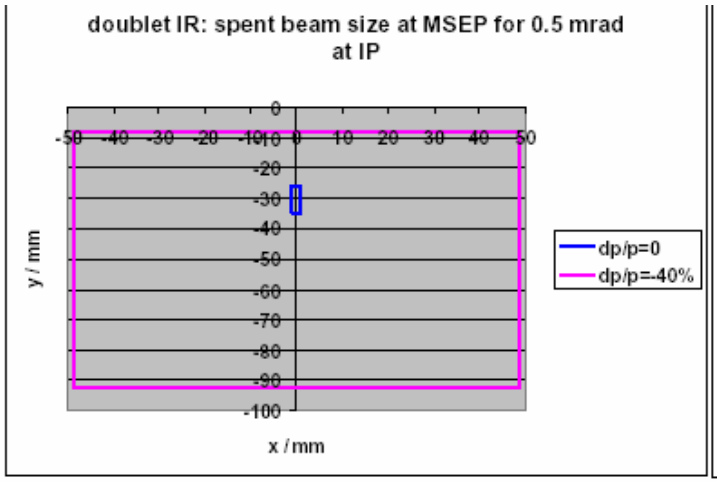
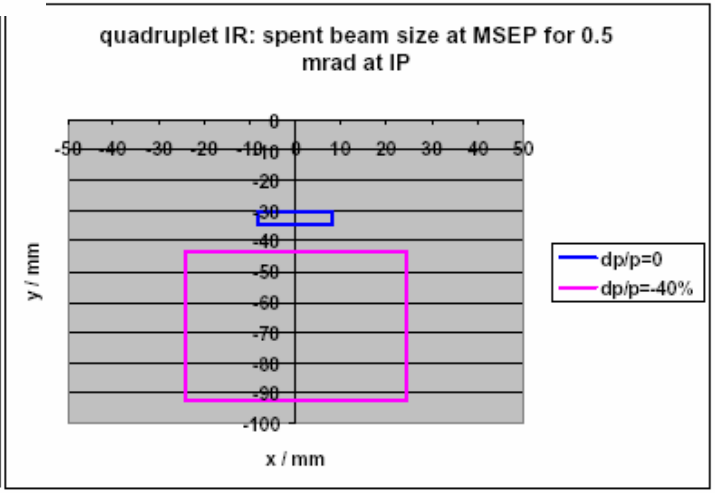
Suggestion: vertical crossing angle ~0.3mrad at IP



Reduction of photon loss
→less photons at septum blade

Strong final doublet over focuses low energy tail particles (For TDR as well!). Doublet split into quadruplet →reduces this effect!





Solution to the two problems

1. Reduction of photon loss by vertical crossing.
2. Reduction of e-particle loss by reduction of over-focusing of low energy beam tail.

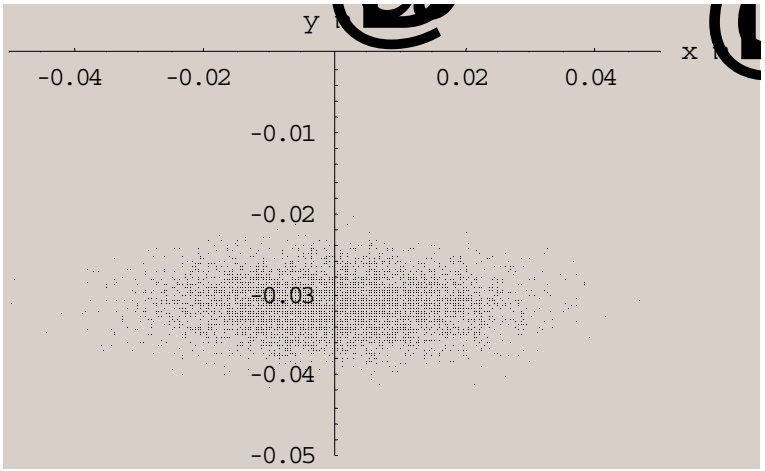
Tried to look at the feasibility of the optics solution which will satisfy the conditions for the incoming beam and outgoing beam simultaneously.

Tracking of –40% energy tail particles using NLC version of DIMAD → includes chromatic precision option which NLC group uses for correctly transporting the low energy tail particles in the extraction line. (Tracking through a lattice which is correct to all orders in δ)

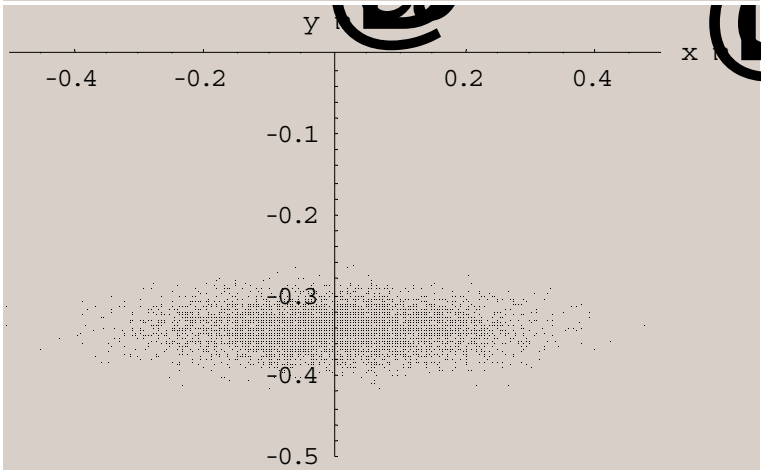
The importance of higher order terms in δ

Beam Sizes for –40% energy tail particles at the dump of the TDR extraction line:

Without higher order chromatic terms



With higher order chromatic terms



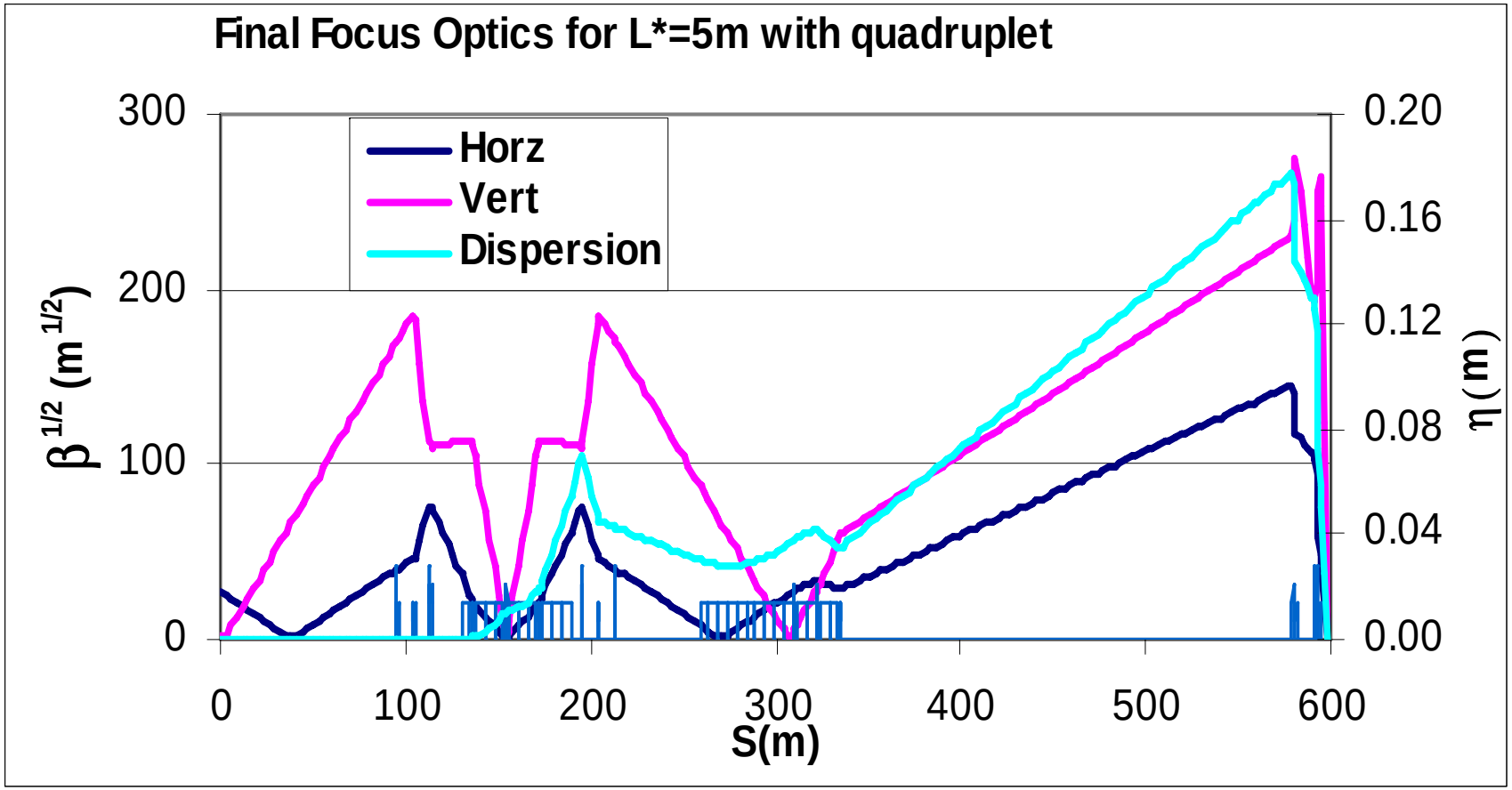
(Note the difference in scale)

Solutions for L*=4,5 m lattices

As the TDR solution will be changed to new final focus with local chromaticity correction, looked at the feasibility of the solution with L*=4,5 m final focus lattice. (O.Napoly,J.Payet)

Optical solution has been found for both L*=4m and L*=5m decks with a final quadruplet instead of doublet with good chromatic properties for the incoming beam. The quadruplet also reduces the beam size of tail energy particles of the spent beam.

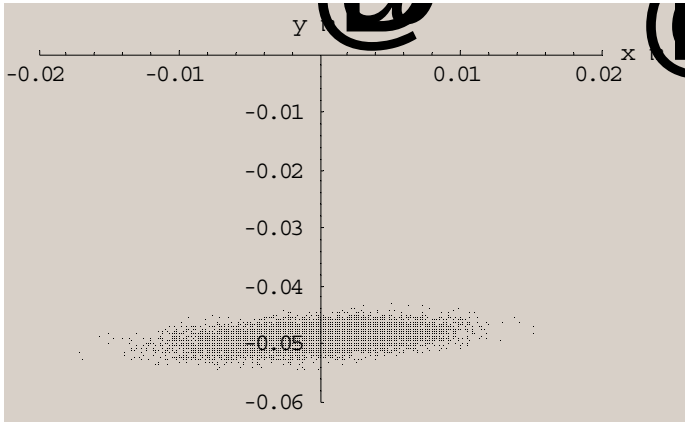
L*=5m with final quadruplet



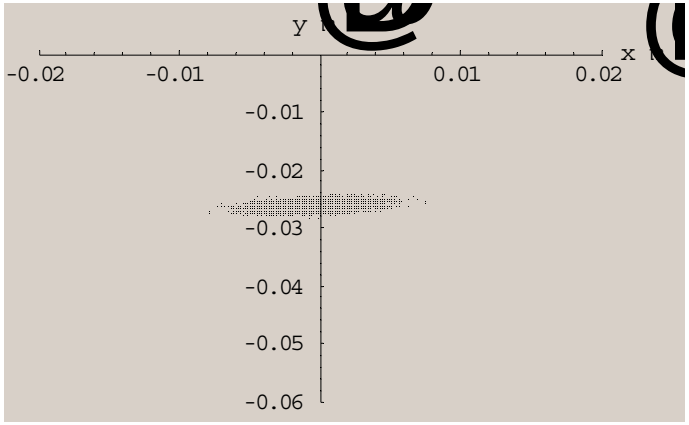
L*=5m with final quadruplet

Beam Sizes for –40% energy tail particles at MSEP (~50 m from IP) in the extraction line:

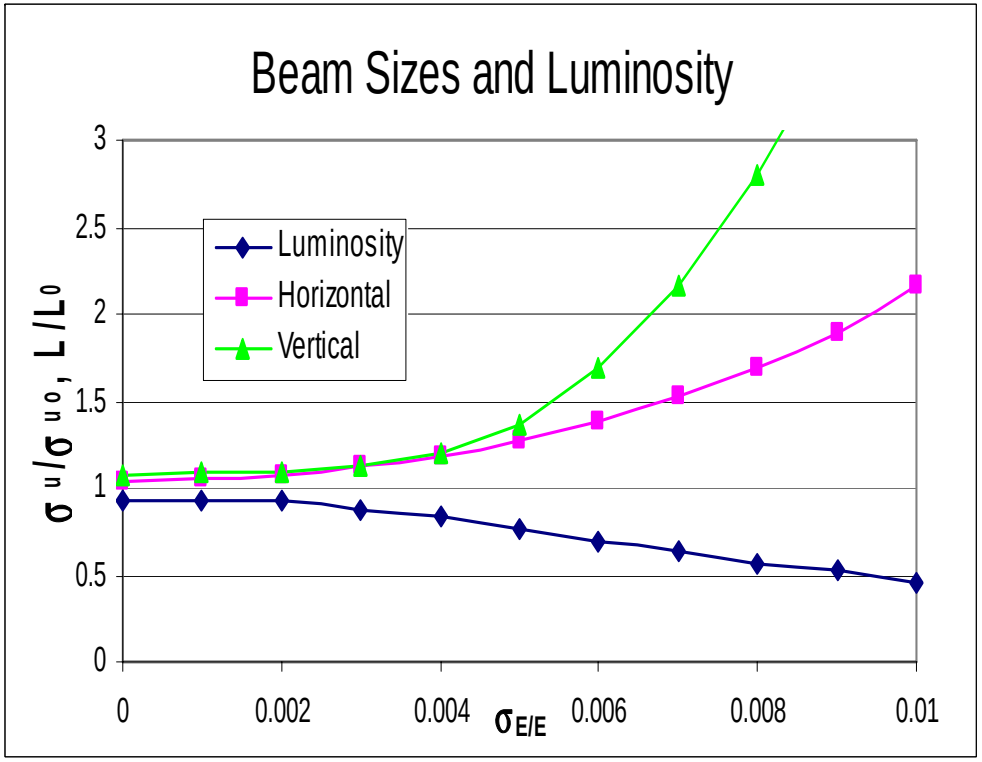
With doublet

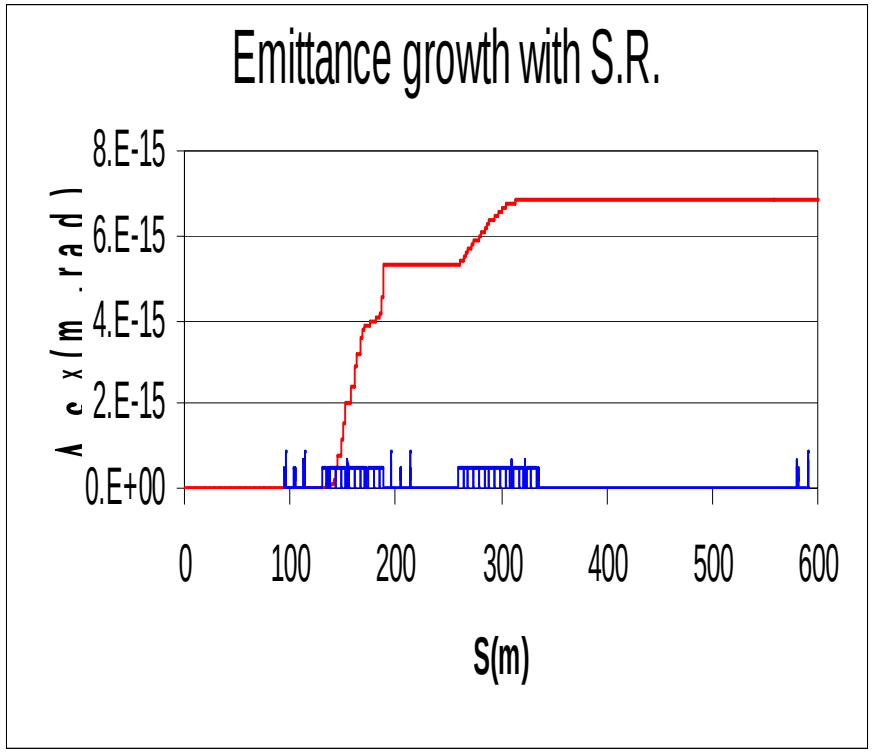


With quadruplet

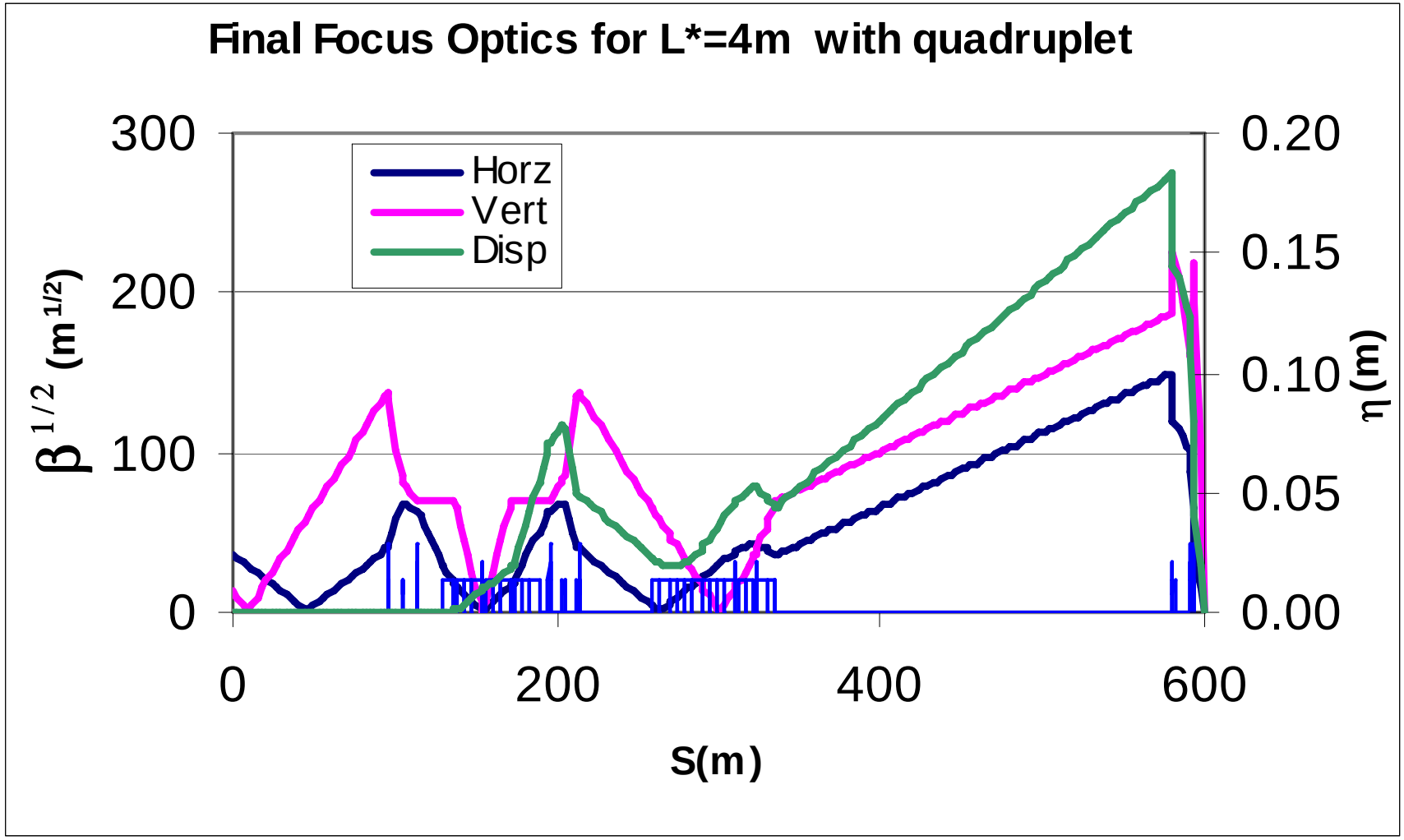


L*=5m with final quadruplet





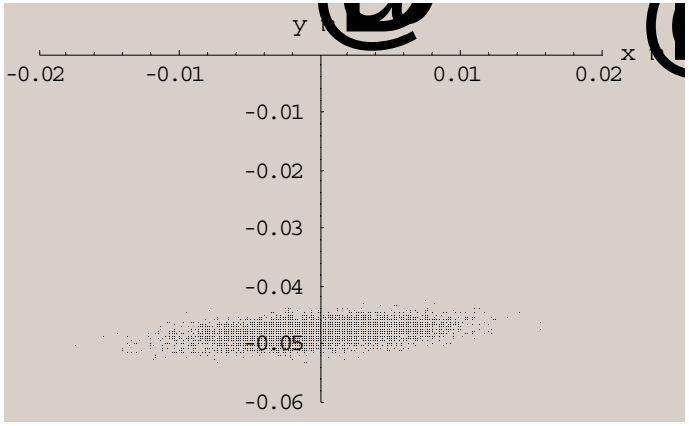
L*=4m with final quadruplet



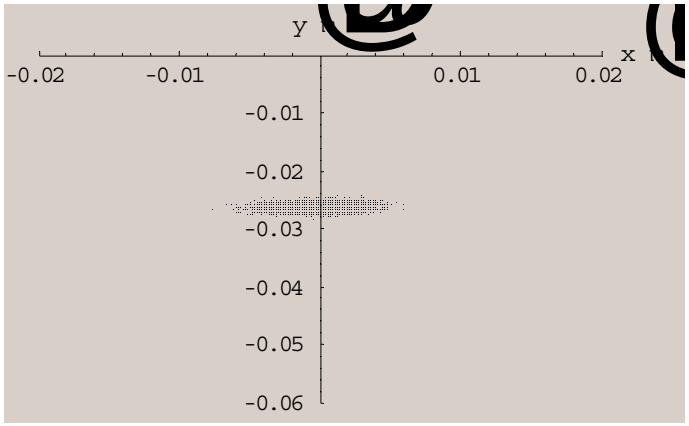
L*=4m with final quadruplet

Beam Sizes for –40% energy tail particles at MSEP (~50 m from IP) in the extraction line:

With doublet



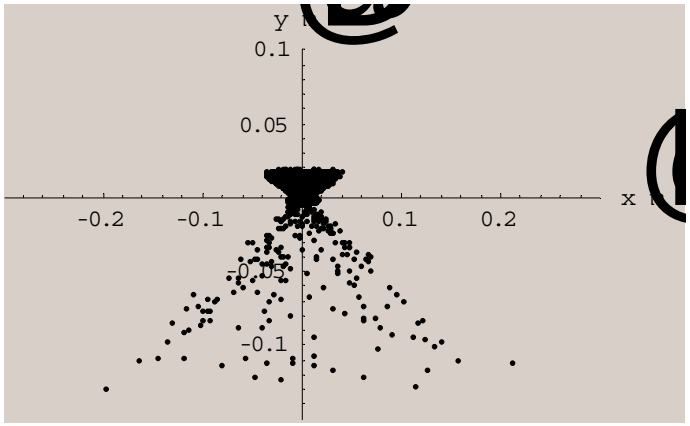
With quadruplet



Tracking of disrupted beam through extraction line

Phase space generated using GUINEA-PIG and tracked using NLC-DIMAD

beam sizes for TDR quadruplet lattice on the dump:



includes:
SR effects
collimation
All δ terms

- Higher order chromatic terms increase beam size and hence collimation energy loss. (TDR: MQED, 250GeV beam losses go from 0.1% to ~0.26%).
- Working on a new layout with L*=4,5m.

Small horizontal crossing-angle ($\cong 2 \times 1$ mrad) for TESLA ?

ideas & some on-going work by :

P. Bambade, B. Mouton (Orsay)

O. Napoly J. Payet (Saclay)

- not a finished study -

Could this be used for TESLA ?

Design of a final focus system for CLIC in the multi-bunch regime

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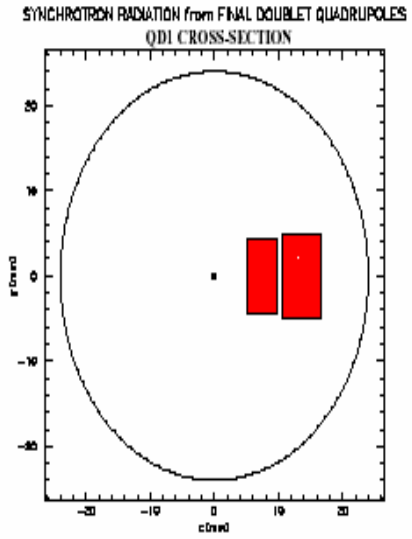
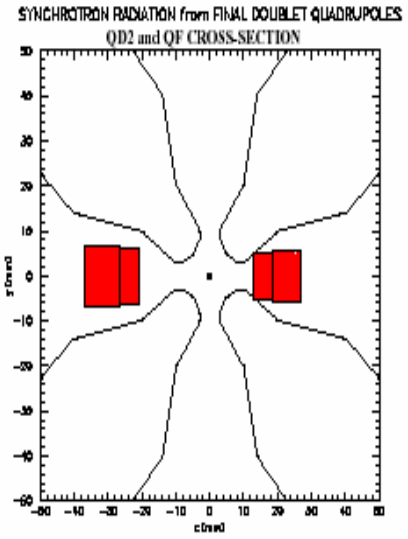
CEA, DSM/DAPNIA/SEA
CE-Saclay, F-91191 Gif-sur-Yvette Cedex, France

December 10, 1997





Quadrupoles	Length [m]	Aperture diameter [mm]	Gradient [T/m]
QD1	1.2	48	250
QD2	1.378	13.7	219
QF	1.330	13.7	219
last drift	1.5		
between quads	0.50		

Table 2: Doublet parameters

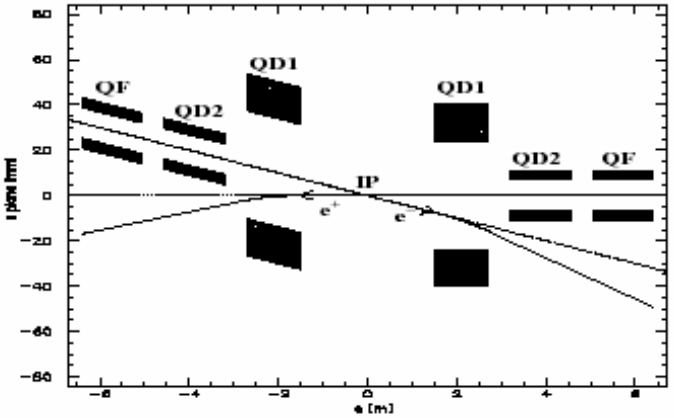


Figure 3: Magnet layout with a 5 mrad crossing-angle. The e^+ and e^- orbits (solid lines) correspond to the nominal energy of 250 GeV.

Rationale

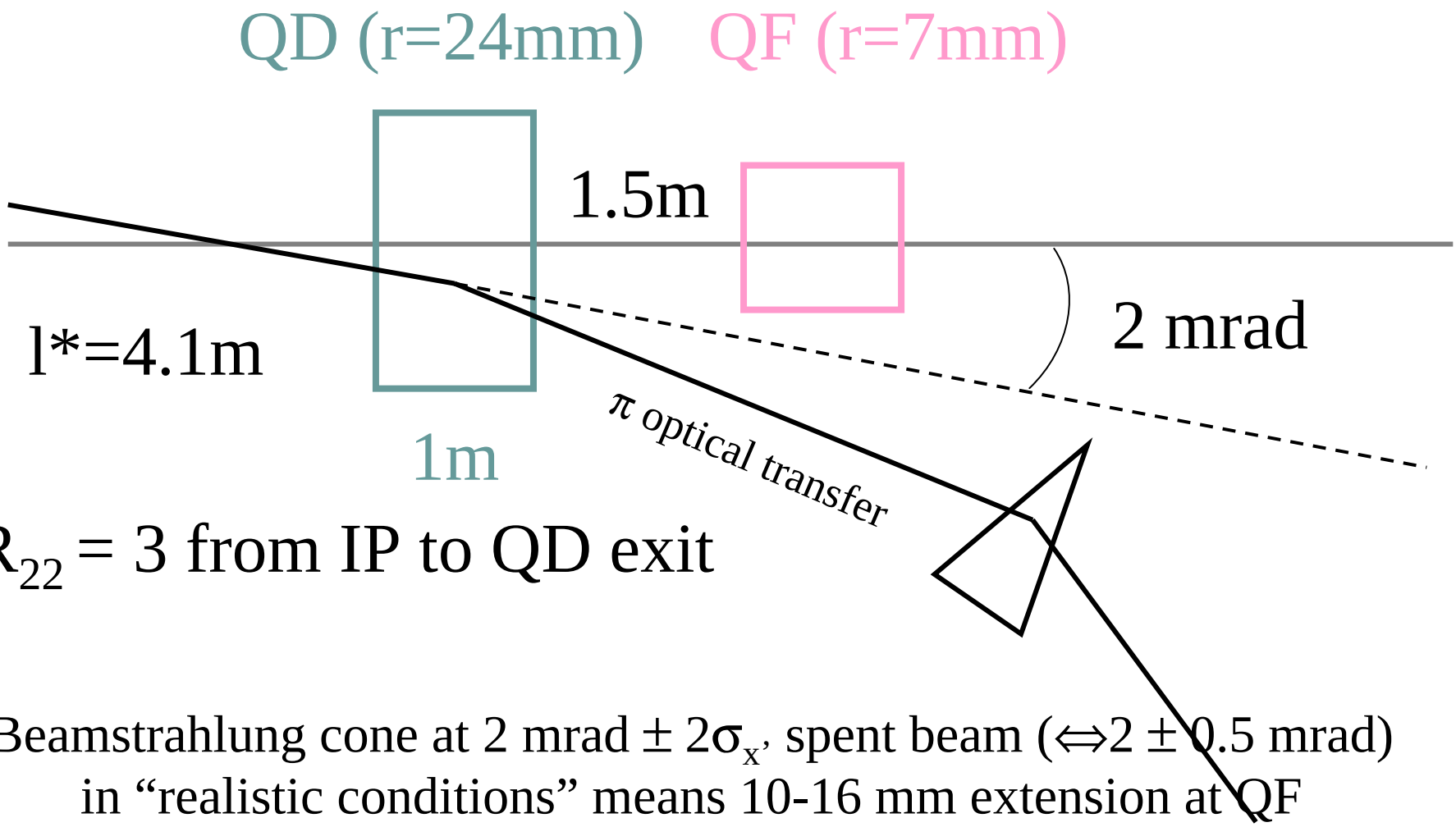
(TESLA bunch-spacing → no multi-bunch kink instability)

- only ~15% luminosity loss without crab-crossing (2 mrad)
- correction possible without cavities exploiting the natural η' in the local chromatic correction scheme used

- no miniature SC final doublet needed
- no strong electrostatic separators needed
- both beams only in last QD → more freedom in optics

- negligible effects on physics
- diagnostics of spent beam should be easier

Set-up for TESLA at E_{cms} = 500 GeV



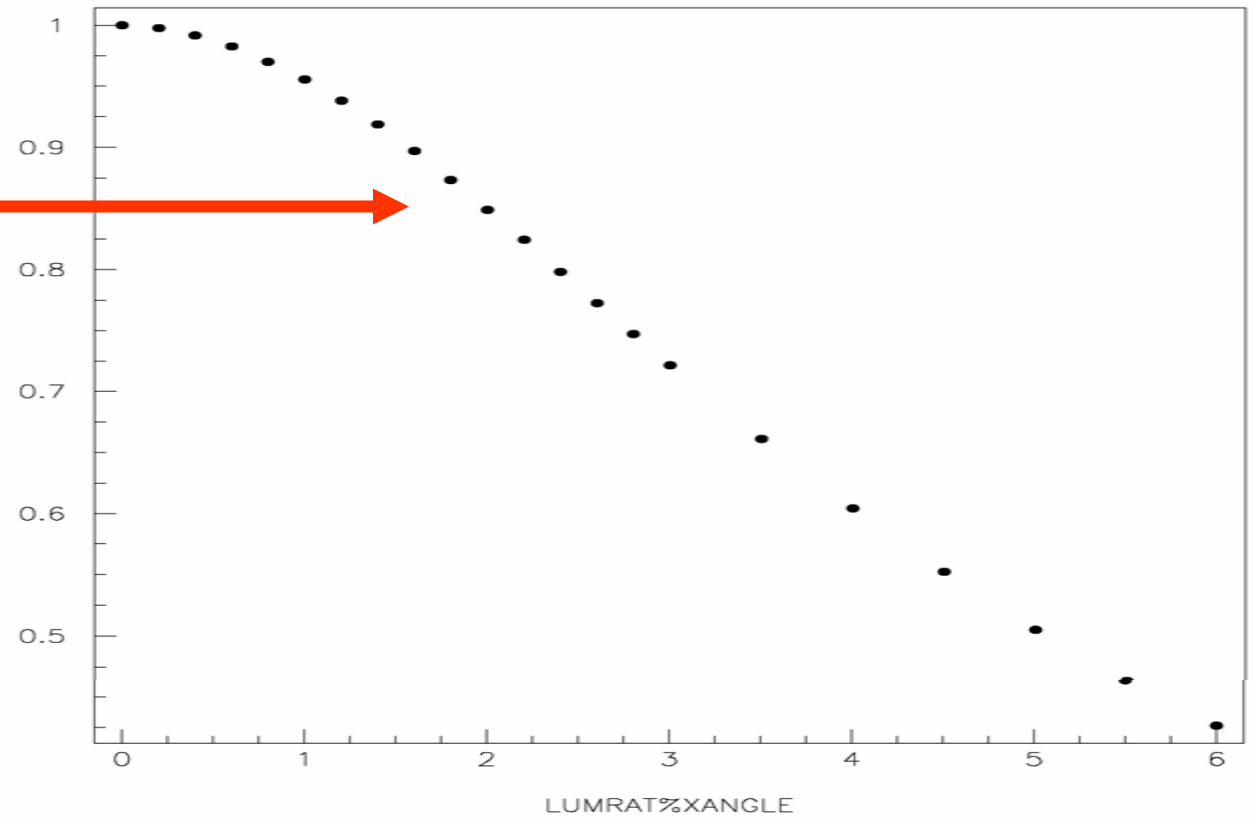
R_{22} = 3 from IP to QD exit

Beamstrahlung cone at 2 mrad ± $2\sigma_x$, spent beam (⇔2 ± 0.5 mrad)
in "realistic conditions" means 10-16 mm extension at QF

Luminosity loss without crab-crossing

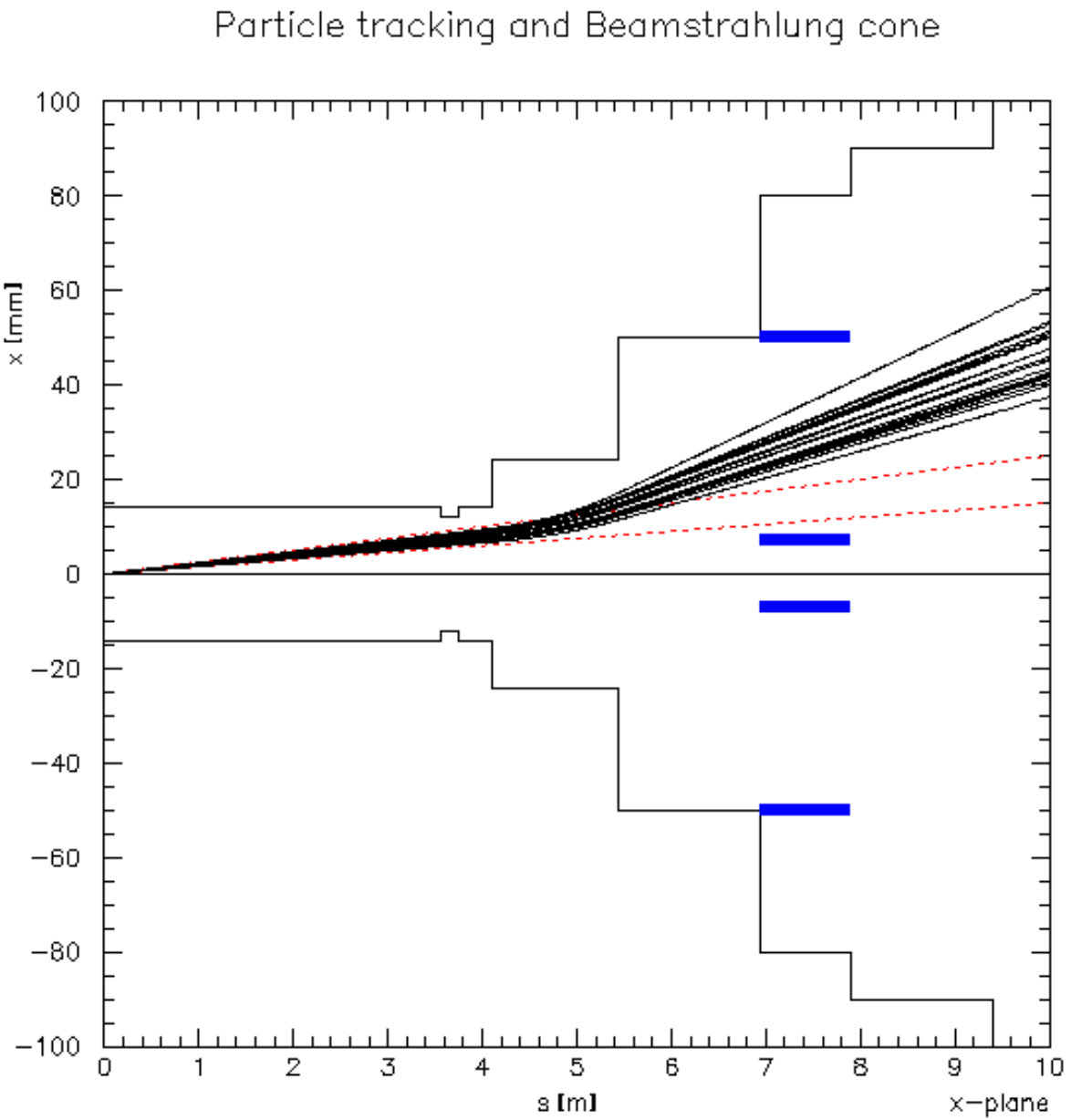
L/L_0

~ 0.85

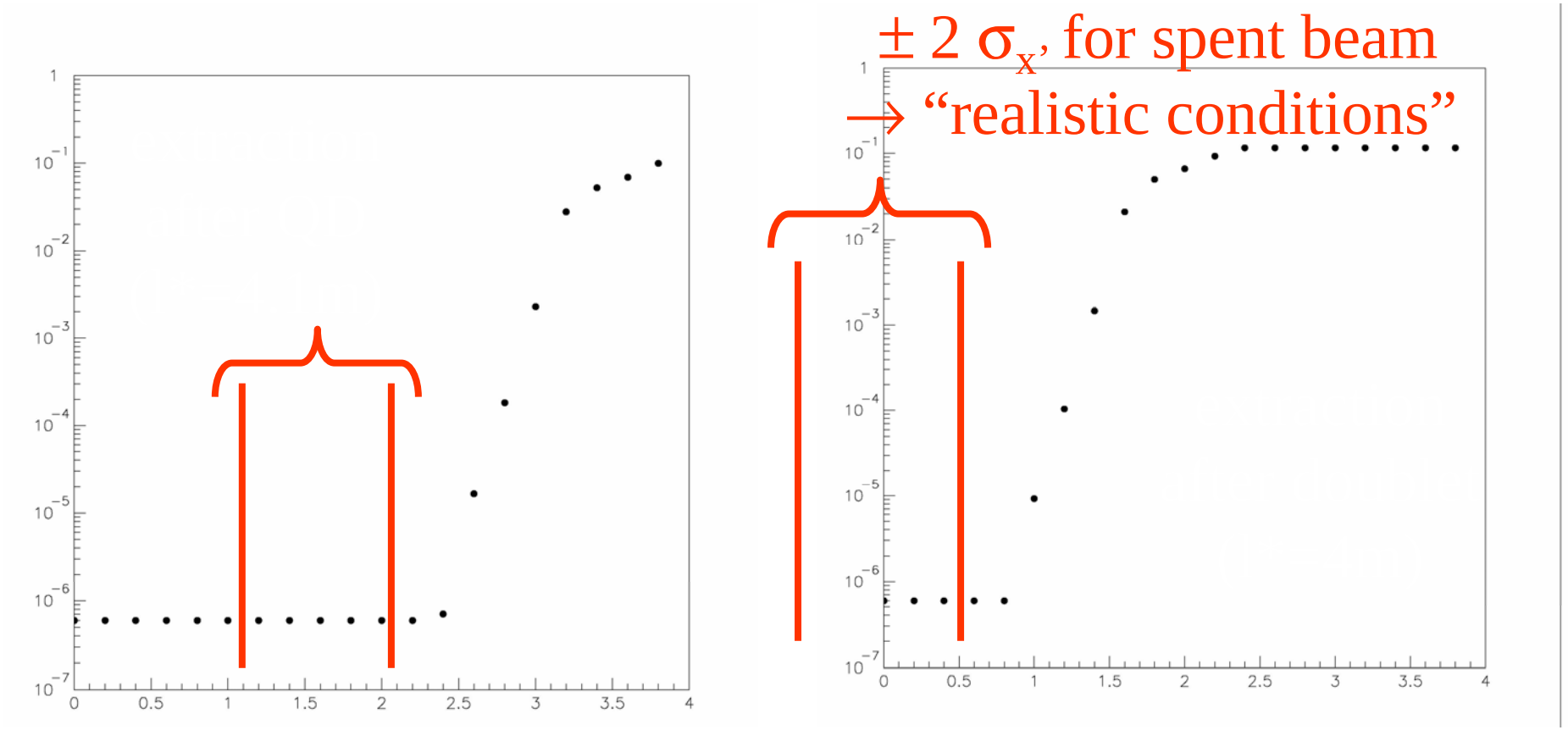


geometric formula → 0.88

2θ[mrad]


Particle tracking and Beamstrahlung cone
x [mm]
100
80
60
40
20
0
−20
−40
−60
−80
−100
0
1
2
3
4
5
6
7
8
9
10
s [m]
x−plane

First look at primary beam extraction



Beam energy fraction lost as function of total angle [mrad]

Equivalent clearance after QD as in head-on if $2 \times \theta \sim 1.6$ mrad

Conclusions

- Design of small vertical crossing angle solution, with final quadruplet, for TESLA with L*=3,4,5m.
- Overcomes problems of septum irradiation and over focusing of disrupted beam tail.
- Solutions work for the final focus, and also have good transmission of charged particles to dump.

- Horizontal crossing angle scheme by Bambade, Mouton and Napoly uses a 2 mrad crossing angle.
- This scheme has many benefits e.g. avoids the use of electrostatic separators and possible upgrade to 1 TeV.

- Both schemes need more work and further studies.