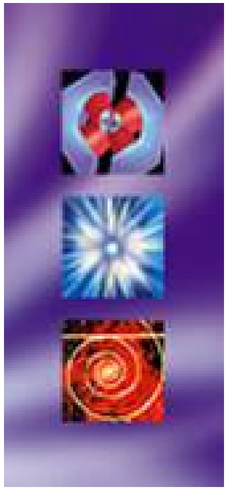
The 2mrad horizontal crossing angle IR layout for a TeV ILC



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LCWS'05 - 20/03/05
(at Stanford, CA, USA)

SLAC-BNL-UK-France task group

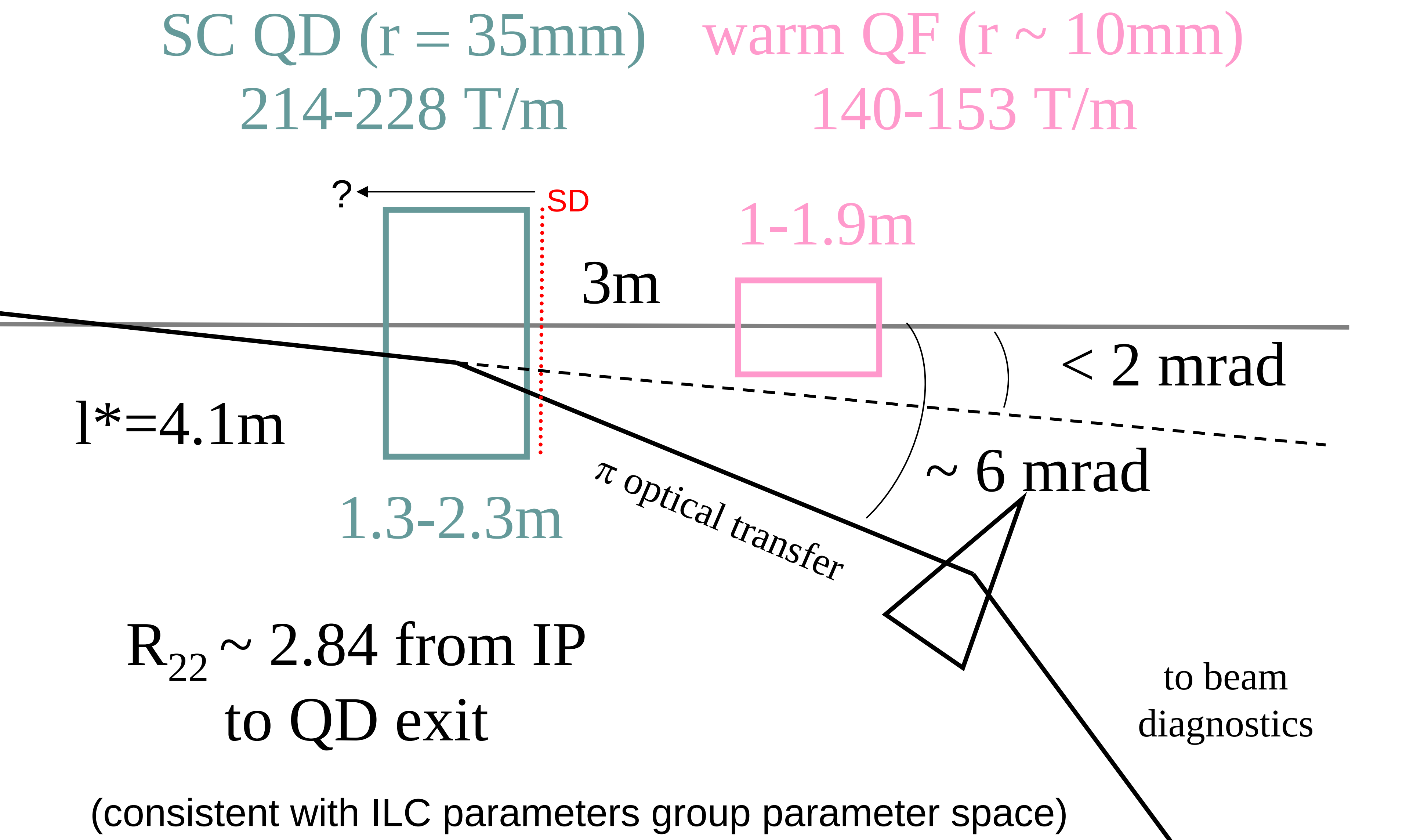
Rational and overview

- Benefits of using a small horizontal crossing angle are well documented:
  - Small Luminosity loss **without crab cavity**, and partially correctable if exploit finite η' in the local chromatic correction scheme
  - No separators or kickers needed
  - Some improved conditions for physics (better very forward hermeticity, no need for local solenoid compensation) **but** harder post-IP diagnostics
- I intend to be transatlantic:
  - The scheme developed at Daresbury/Orsay
  - SLAC/BNL recently developed scheme

    (schemes will merge - choose best features for offspring!)

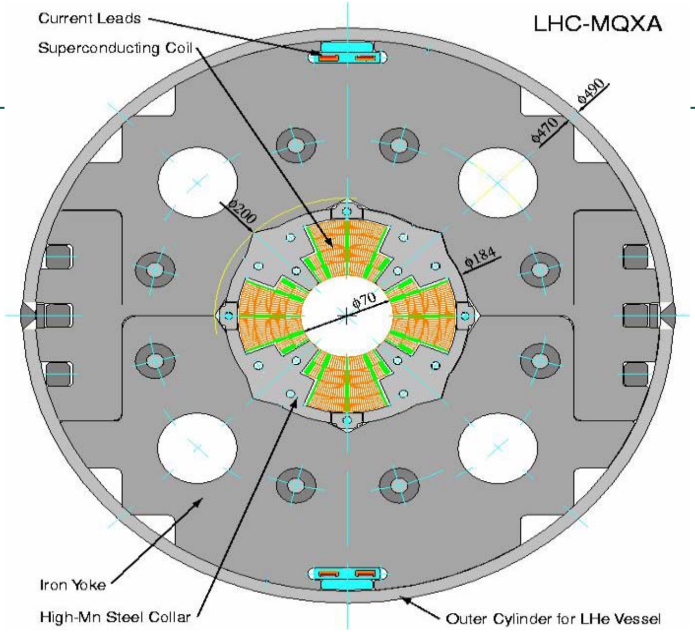
Focus on the parallel designs at **1 TeV**

Possible doublet parameters for 0.5-1 TeV



(consistent with ILC parameters group parameter space)

LHC NbTi IR quads



- gradient for 0.5 TeV : 215 T/m,
- radius = 35mm (effective = 31mm)
- higher gradients are studied for LHC upgrades using NbTi(Ta), Nb_3Sn

Tolerable beam power losses in SC QD

local & integral LHC spec: 0.4 mW/g & 5 W/m

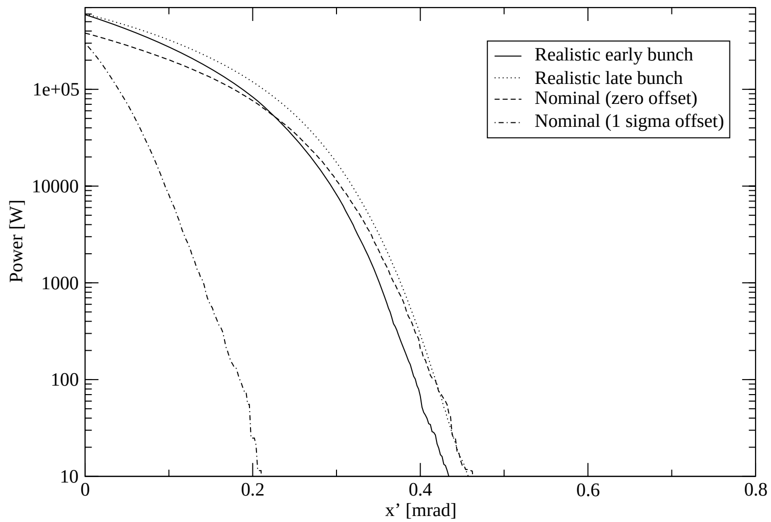
Assumed ILC WG parameters at IP

(assuming worst case for extraction where possible)

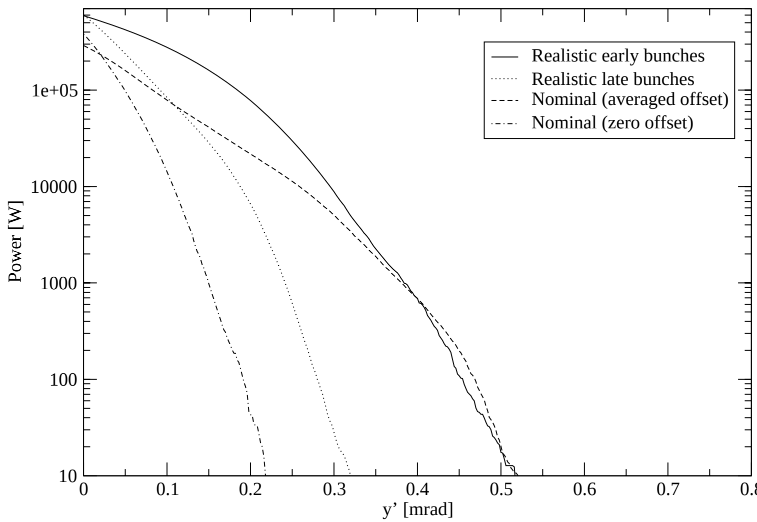
Beamstrahlung clearance at QF

Calculated need of ± 0.5mrad around beam direction at IP in realistic beam conditions & beam pipe with r = 10mm in QF

Horizontal cone half-opening angle



Vertical cone half-opening angle

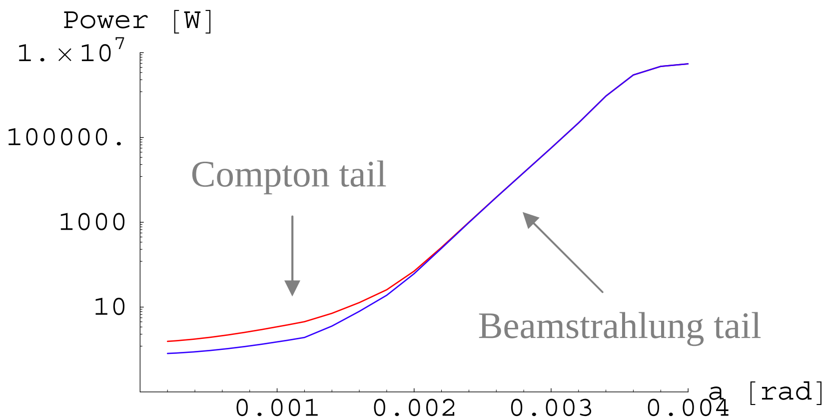


CARE/ELAN document 2004-21 (A+B)

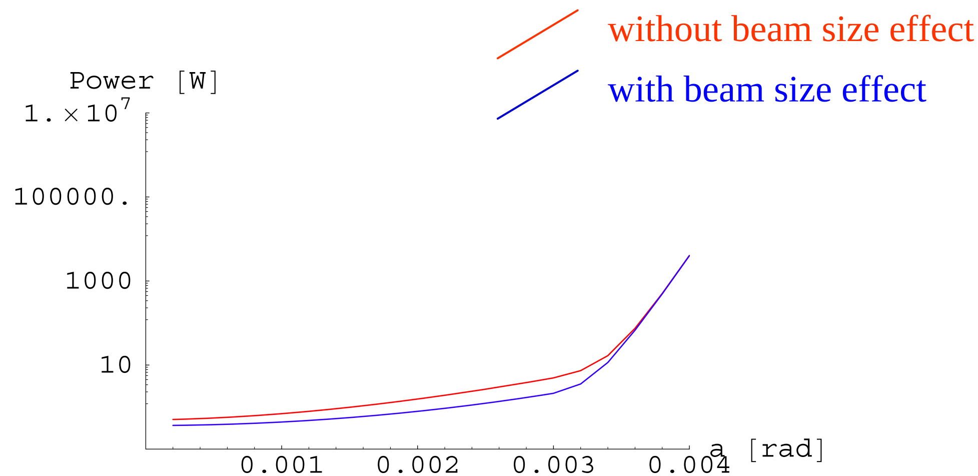
0.5 TeV doublet $\rightarrow$ θ_c > 1.7mrad

1 TeV doublet $\rightarrow$ θ_c > 1.6mrad

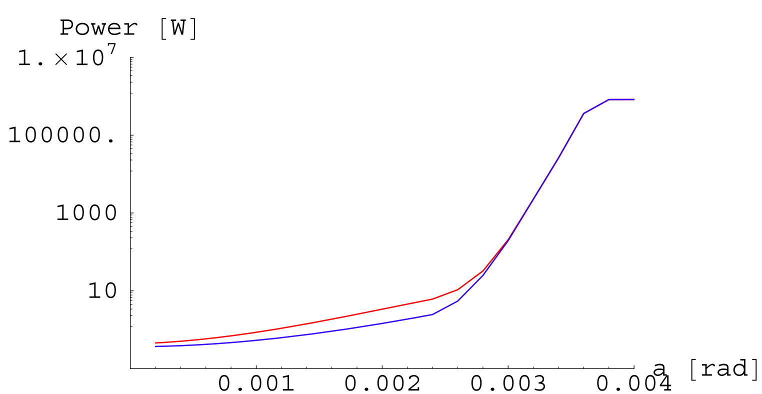
Beam power losses in QD sets crossing angle



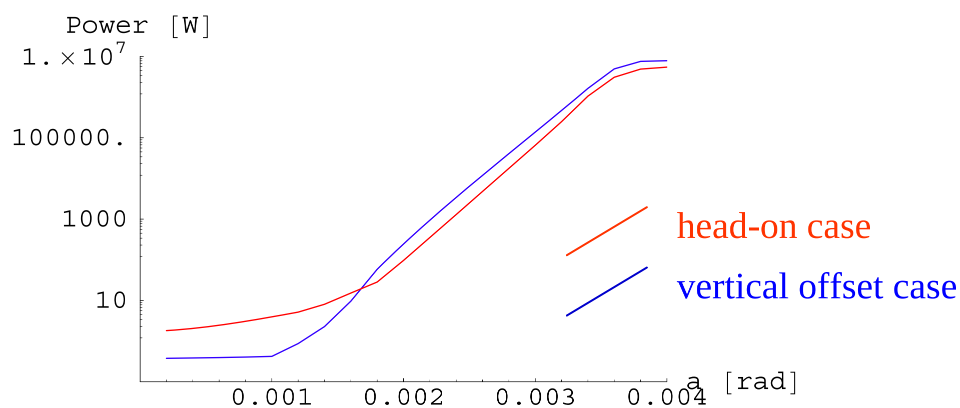
1 TeV doublet for $N_e = 2\ 10^{10}$ per bunch



0.5 TeV doublet



1 TeV doublet for $N_e = 10^{10}$ per bunch



150nm vertical offset (1 TeV)

(assume US-cold parameters at IP - key parameters are close to WG parameters)

Extraction line for disrupted beam

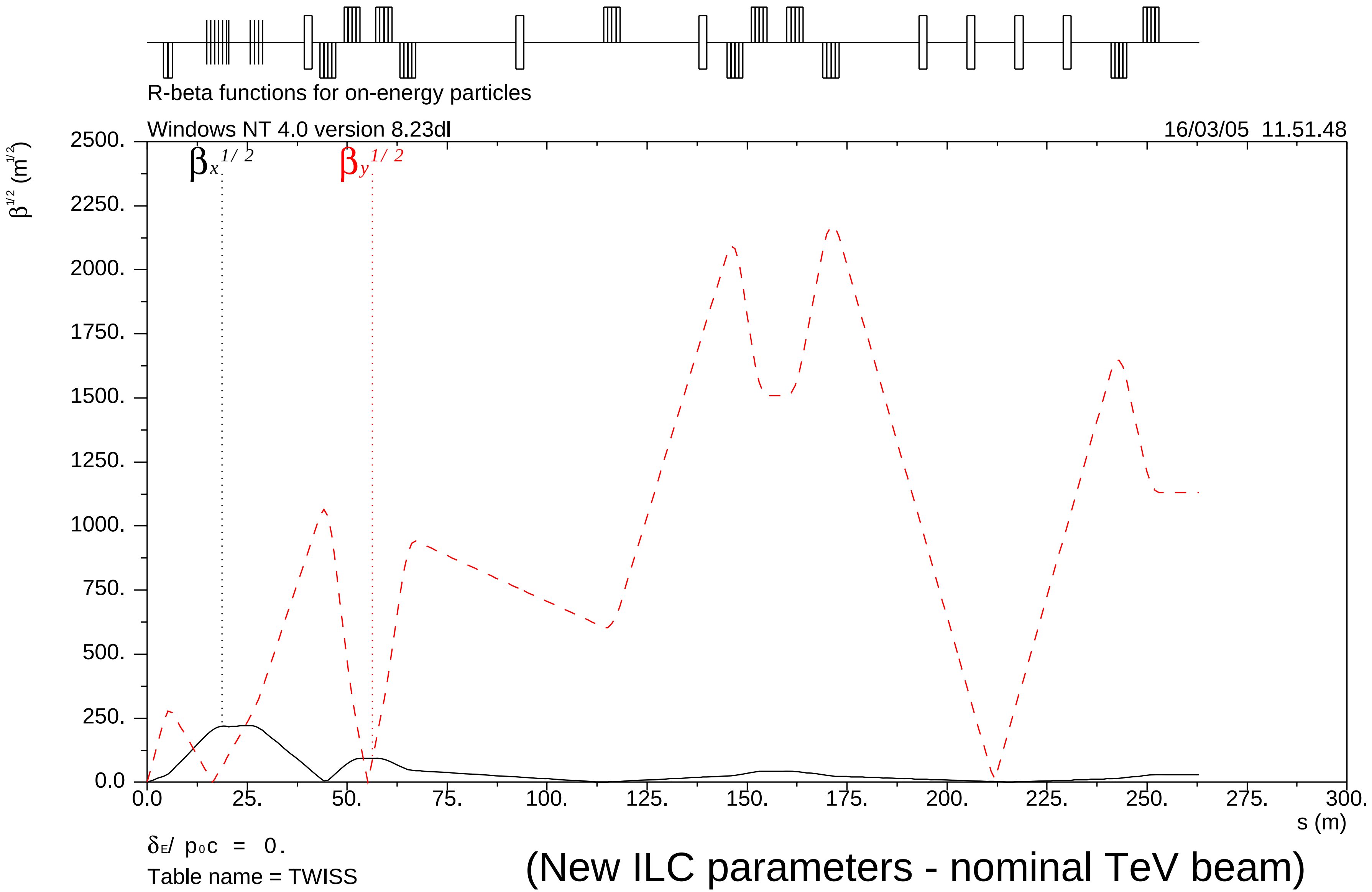
- Transport spent beam with controlled losses, both under disrupted and undisrupted conditions.
- Constant geometry up to 1 TeV, so use 1 TeV doublet design
- Diagnostics on disrupted beam
  - Compton polarimeter (need chicane and zero net bend)
  - Energy measurement (energy chicane)
  - WISRD-style spectrometer
  - image beam

Choose 10W in QD, requiring crossing angle of 1.6mrad

Study for 1 TeV machine for max beam-beam (hardest case!)

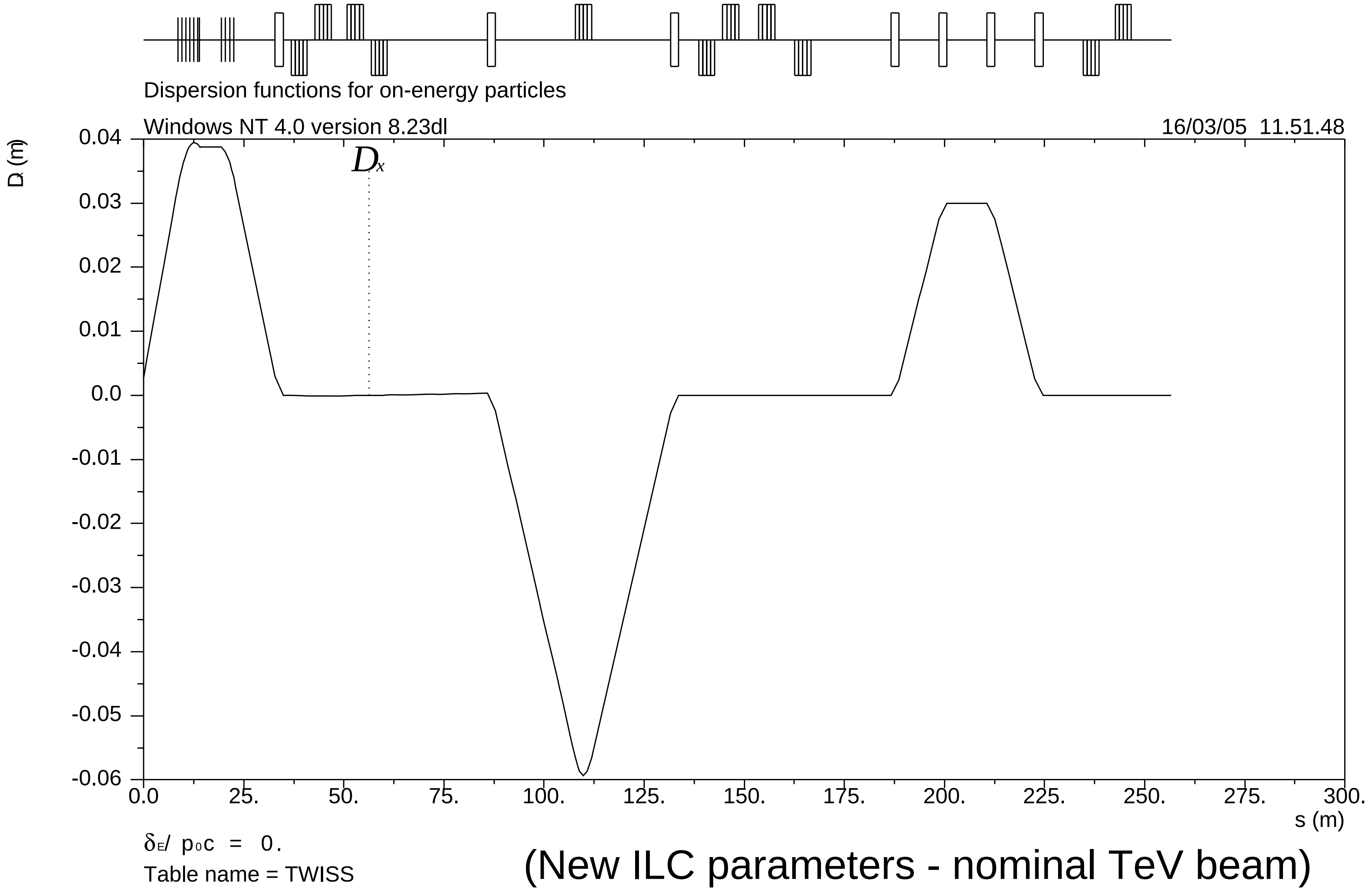
Extraction line geometry fixed: angle of 4.544mrad (+f.f.)

Beta-functions for the 1 TeV lattice



(New ILC parameters - nominal TeV beam)

Linear dispersion for the 1 TeV lattice

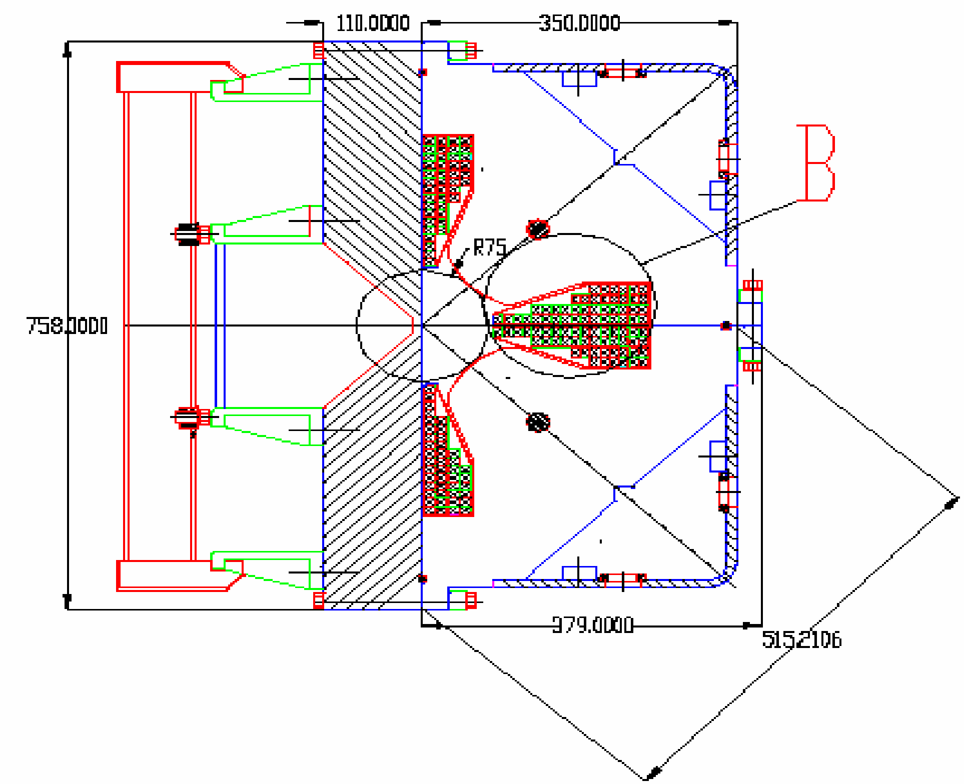


(New ILC parameters - nominal TeV beam)

First magnets of the extraction line

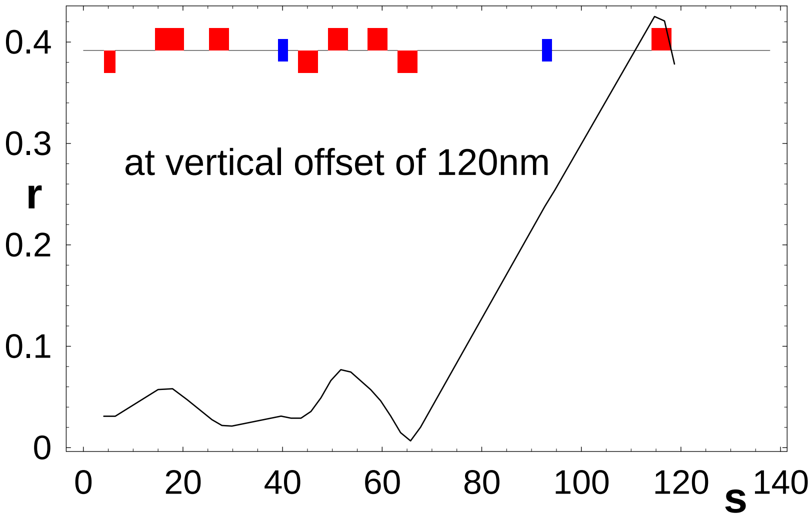
- Off-axis beam in QD produces horizontally dispersed beam
- Initial extraction line achromat designed to cancel this
- Horizontally focussing quad QFX produces □ phase advance

QFX very close to incoming beamline (50mm)⇒ use current-sheet quadrupole and 8m drift QD->QFX

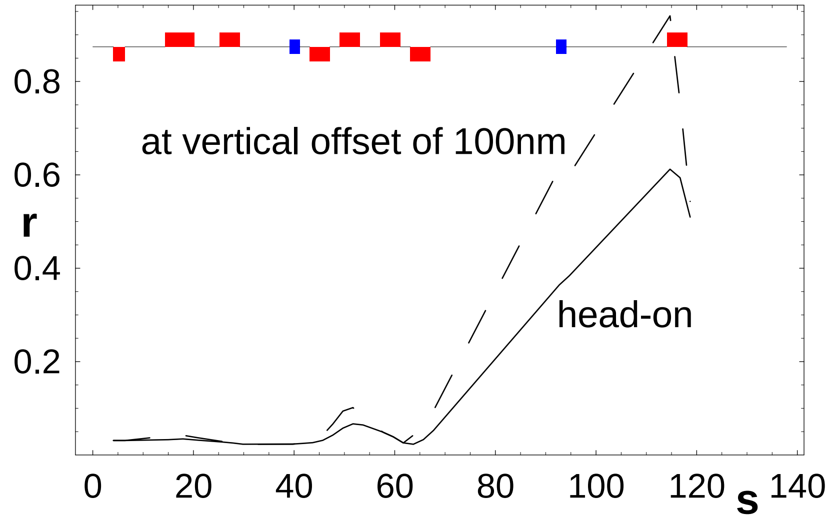


- B^{PT}=1.3T (g=26 T/m)
- aperture radius 5cm
- l=5.8m (1 TeV)
- Designed and costed for TESLA TDR (2001-21)
- QFX becomes weaker doublet; reduce over focussing

Apertures of magnets fixed by power losses



500 GeV "high L" parameters



TeV "nominal" parameters

- Optimise apertures for fixed power loss at each element
- ILC parameters group suggested parameter space
- Ray-trace disrupted beam from IP to main dump
- TeV lattice downstream magnets need further optimisation
- @ collimators: 0.5 ppm of power loss

Some on-going studies

- Final focus fringe fields shown to be important - need to be included, and the assessment on extraction reliability needs to be determined. Multipole expansions?
- Sextupoles will help beam tail transport in extraction line, and inclusion of detail QFX magnetic field map
- Beam dumps? incoming beam to ♑-dump separation 0.62m, ♑-dump to disrupted beam separation 0.54m
- Background generation from photon and charged beam backsplash - DL/Orsay/RHUL collaboration
- Merging of transatlantic 2mrad IR layouts and formulation of unified design for the CDR. Snowmass plans?
- Good IR working collaboration - ("SLAC-BNL-UK-France task group")

Upgrade of SLAC 2 mrad scheme to 1 TeV

- 1 TeV, nominal Luminosity
- Disrupted beam for vertical offset : 100 nm, low energy tail (energy down to 18%)
- Lengths of sextupoles increased to keep the pole tip field < 3.5 T
- Over focussing of low energy tail particles
  - L* increased to 4.1m
  - Length of QD0 reduced from the optimised 500 GeV 2mrad extraction line design.
  - Re-optimisation of optics and additional collimators in the vertical plane
- High Luminosity case – will need more modifications and optimisations

Tracking including the low energy tail particles and fringing fields of QF1