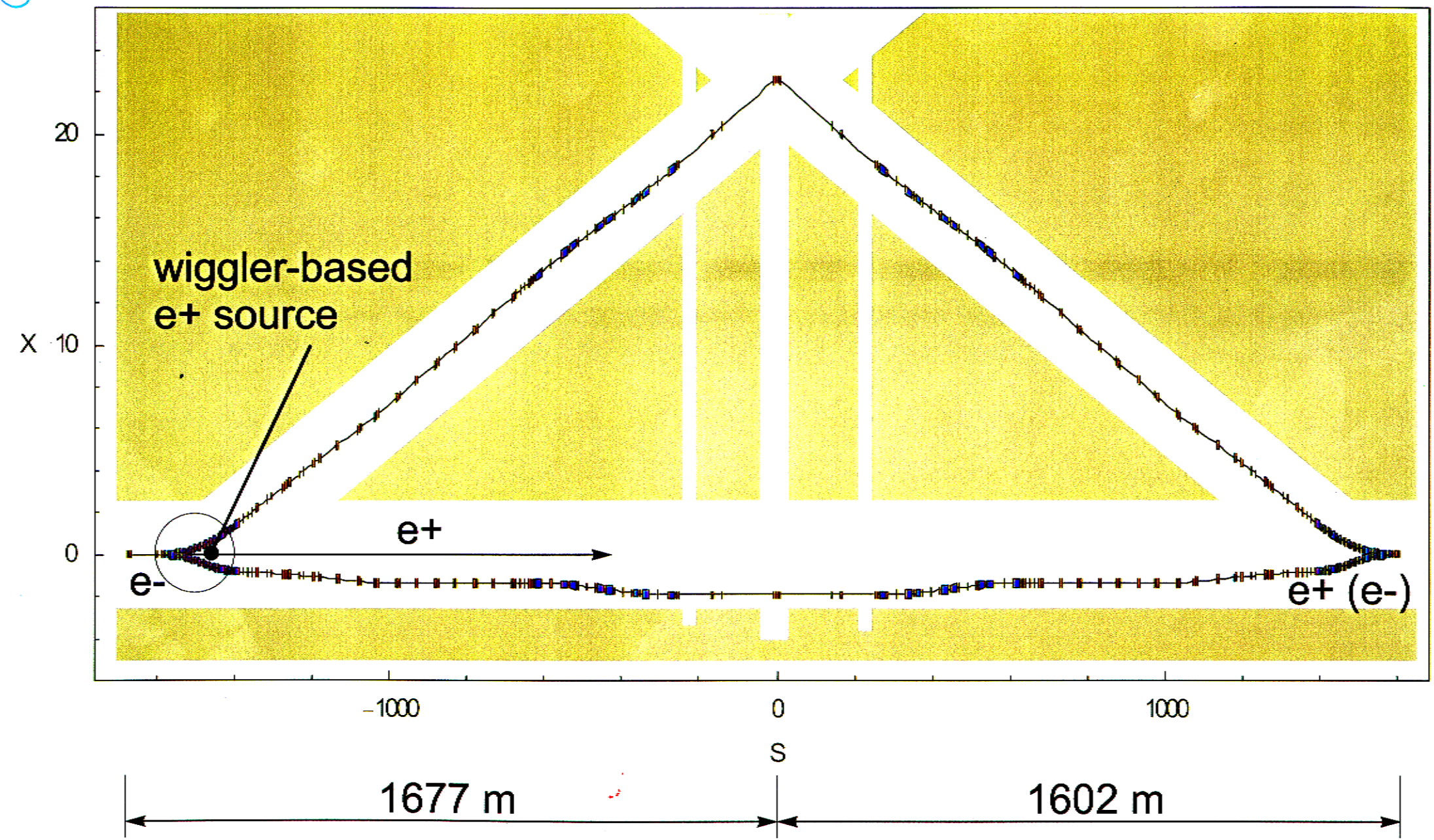
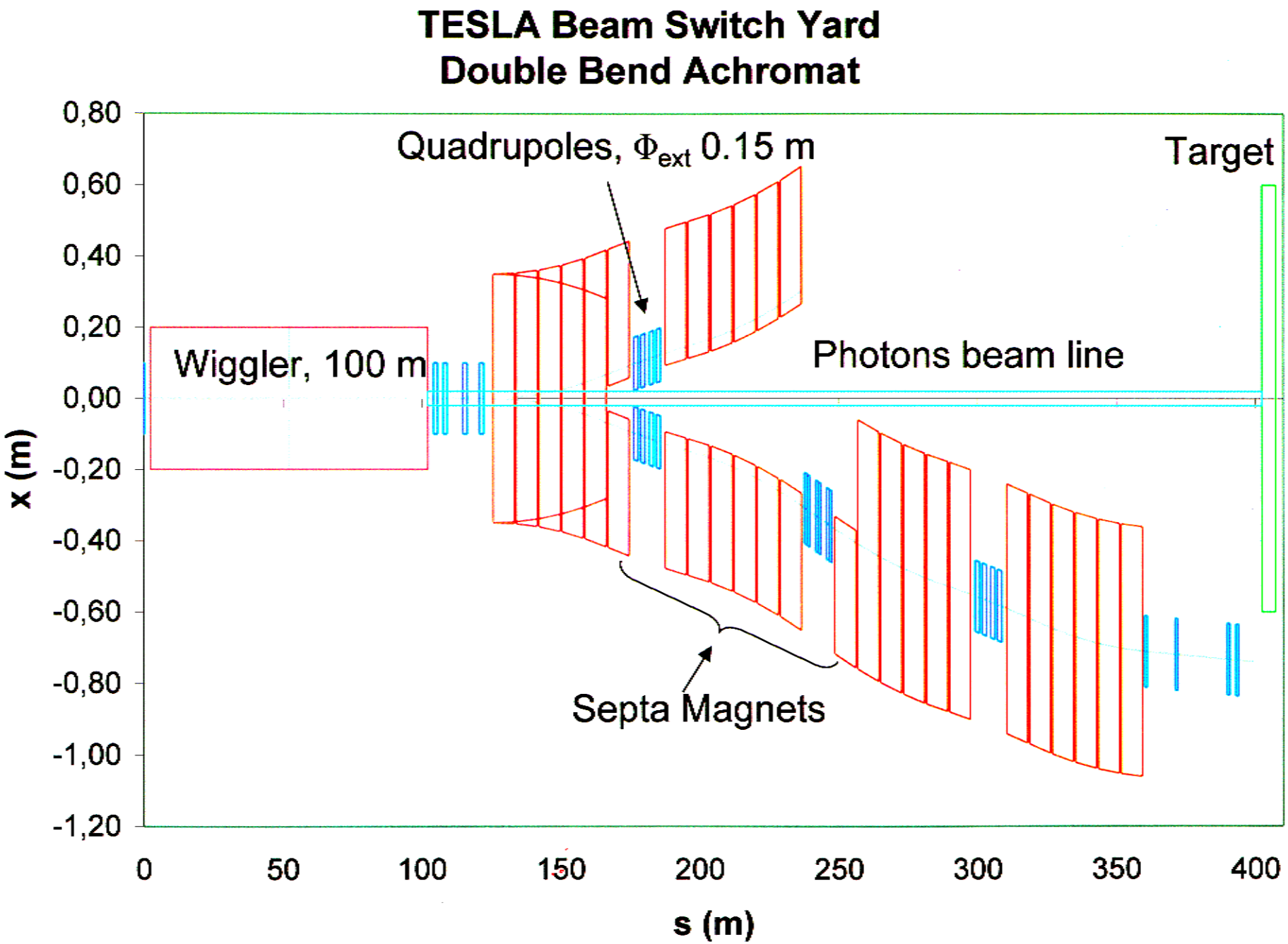
TESLA IR Layout, Collimation and Extraction

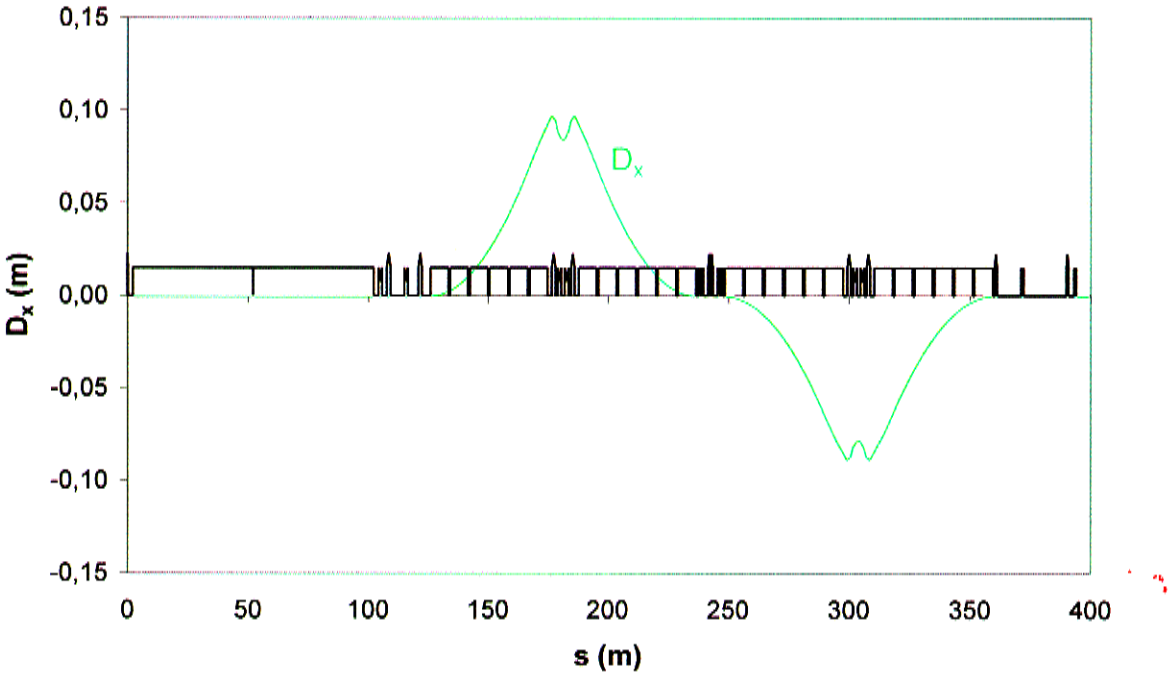
- Beam Switch Yard
- Collimation Section
- Beam and Background Extraction

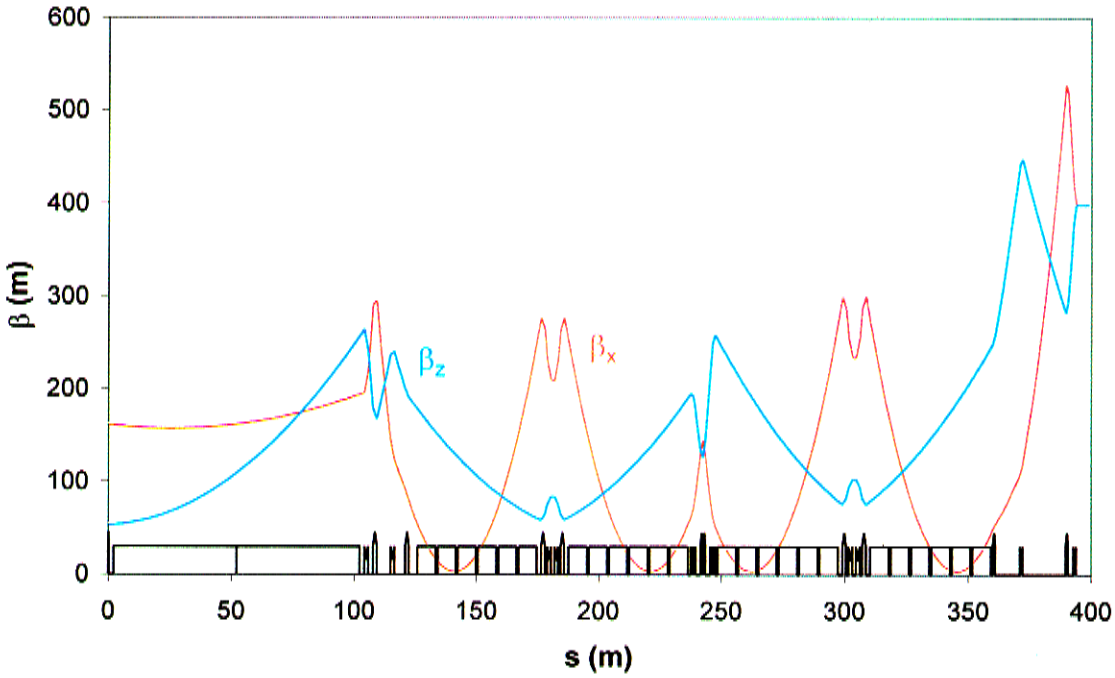

wiggler-based
e+ source
e+
e-
e+ (e-)
X
20
10
0
-1000
0
1000
S
1677 m
1602 m


TESLA Beam Switch Yard
Double Bend Achromat
Quadrupoles, Φ_{ext} 0.15 m
Target
Wiggler, 100 m
Photons beam line
Septa Magnets
x (m)
s (m)
0,80
0,60
0,40
0,20
0,00
-0,20
-0,40
-0,60
-0,80
-1,00
-1,20
0
50
100
150
200
250
300
350
400

TESLA Beam Switch Yard Emittance Growth Reduction

- Double Bend Achromat
- Minimum of β_x at L/3 in bend



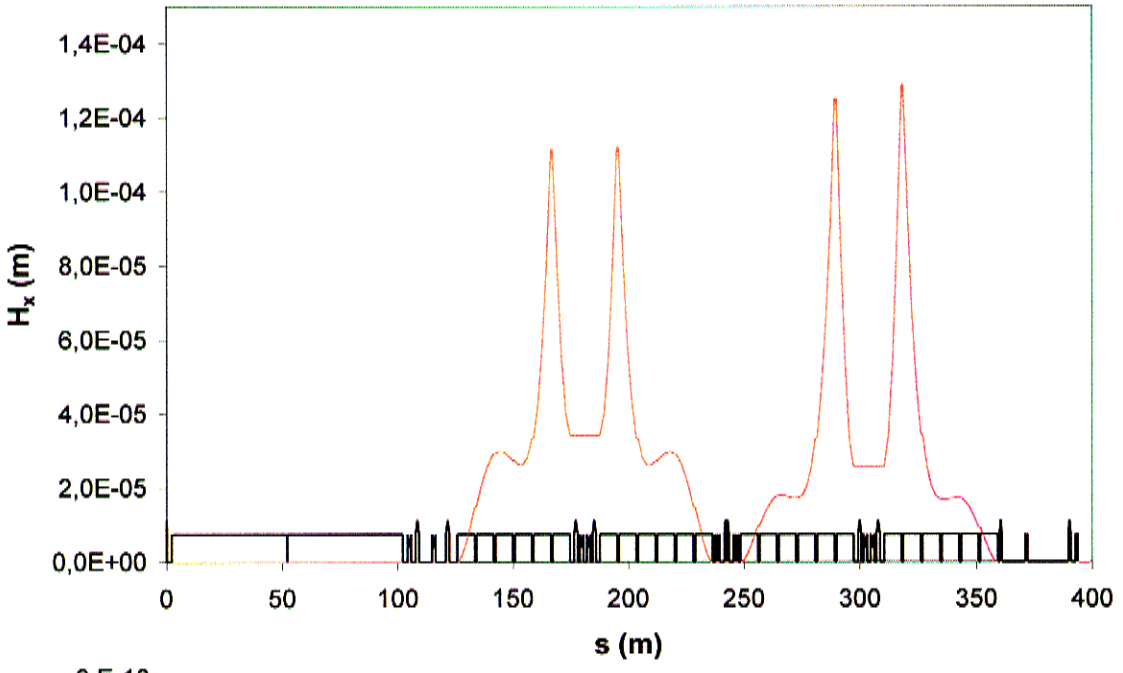


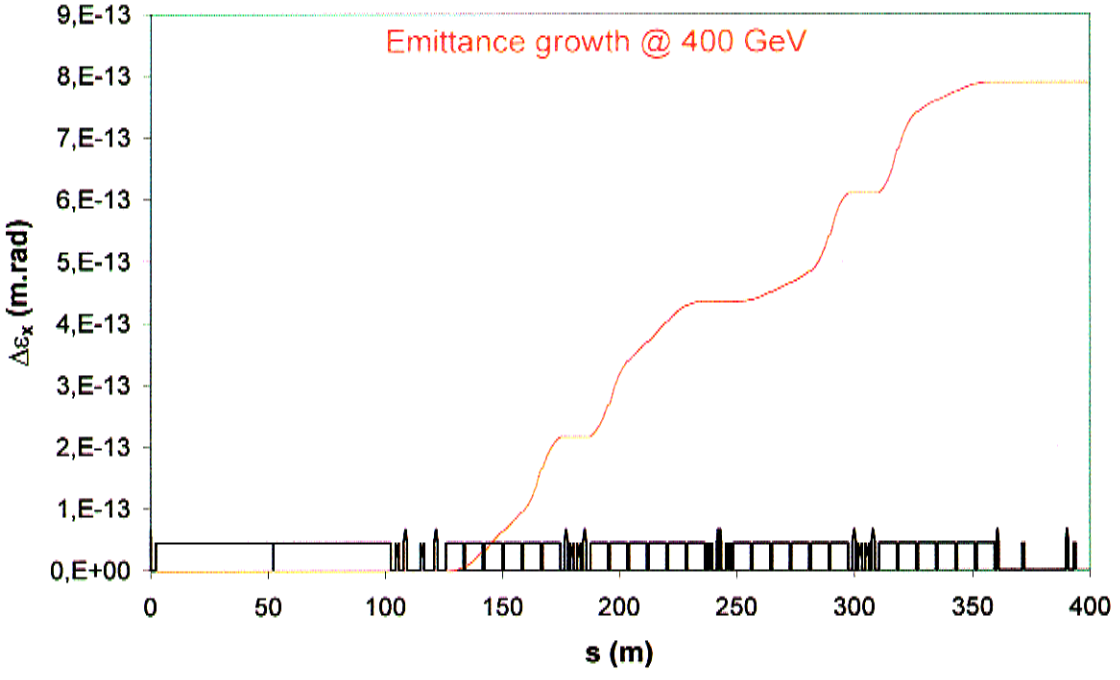
TESLA Beam Switch Yard Emittance Growth Reduction

- Minimum of β_x at L/3 in bend

$\Longrightarrow$ Minimization of $\int_{Bend} H_x ds$

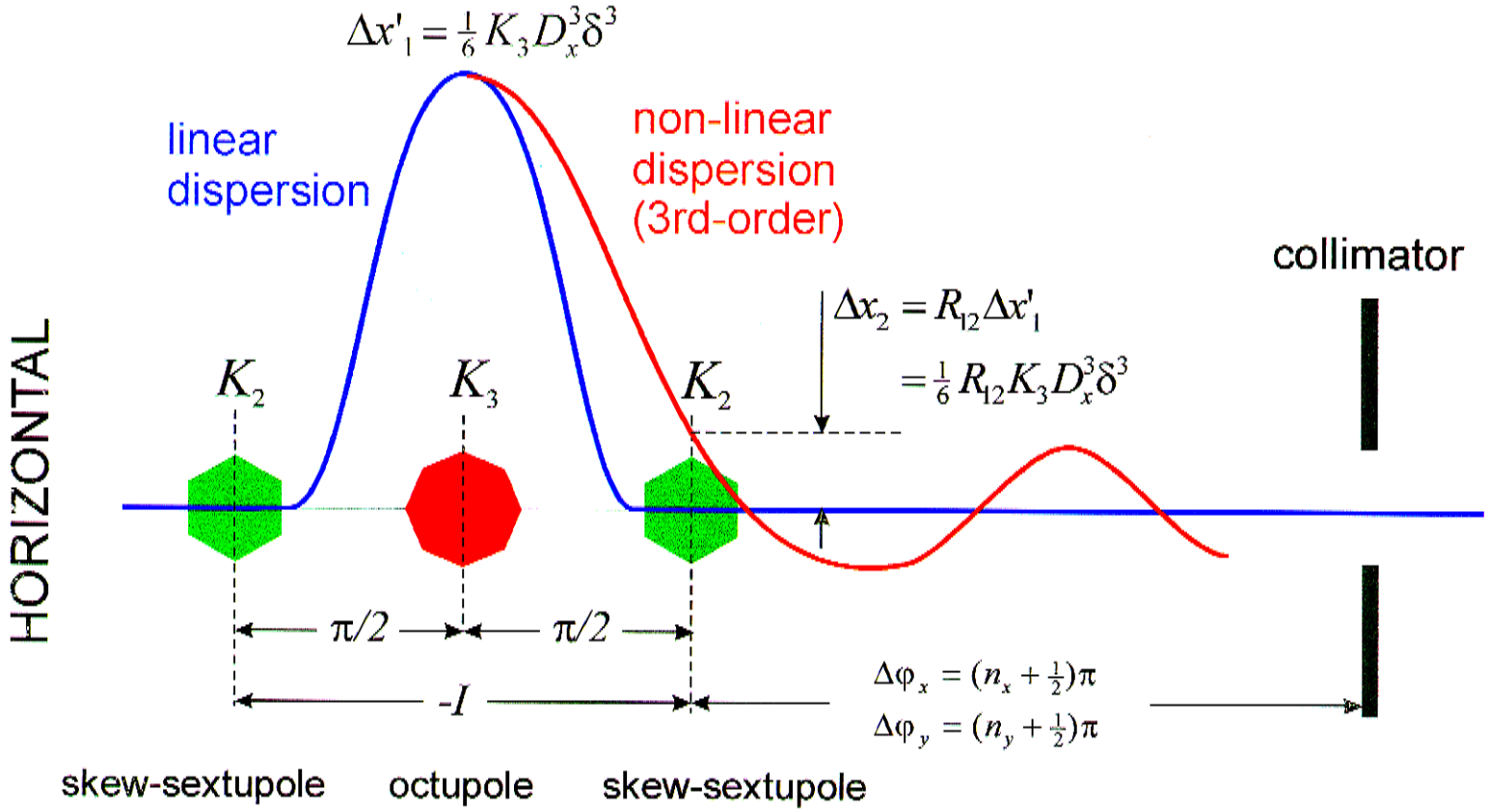
$\Longrightarrow$ Minimization of $\Delta\varepsilon_x$

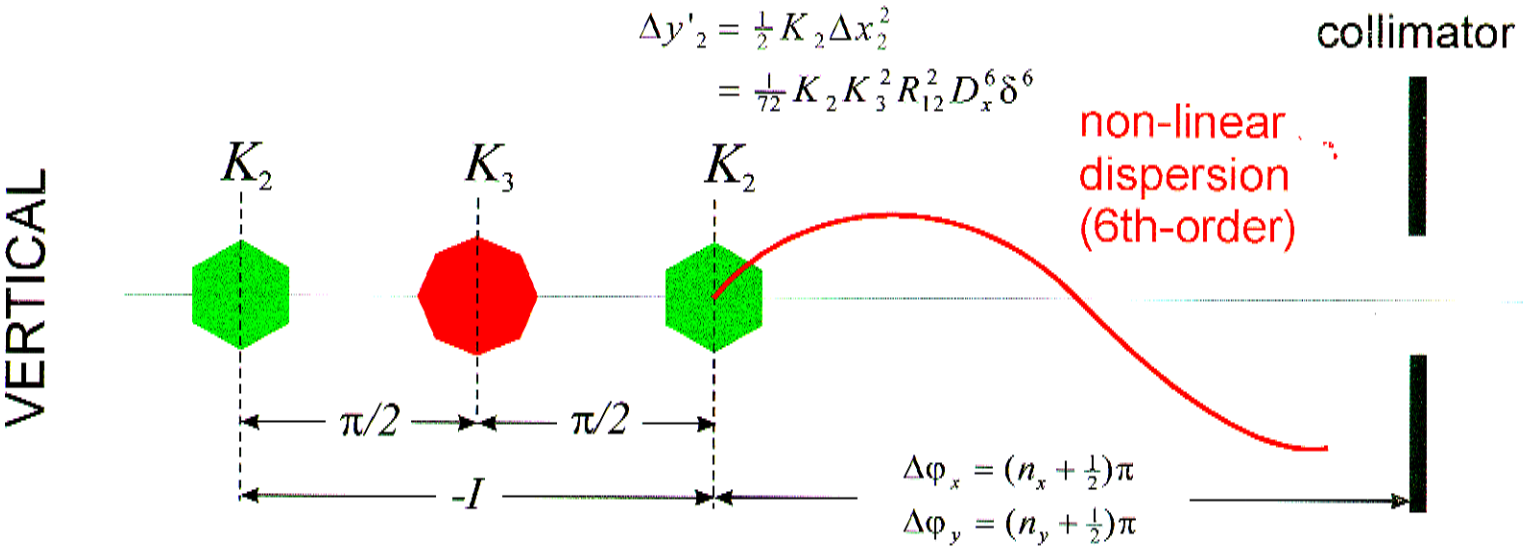




Collimator Protection System

- collimators (spoilers) need to withstand a direct hit from a few (design) bunches
- assume "most likely" failure mode is fast energy error
- construct non-linear magnetic lattice such that beam area (power density) on spoiler is a strong function of $\Delta P/P$



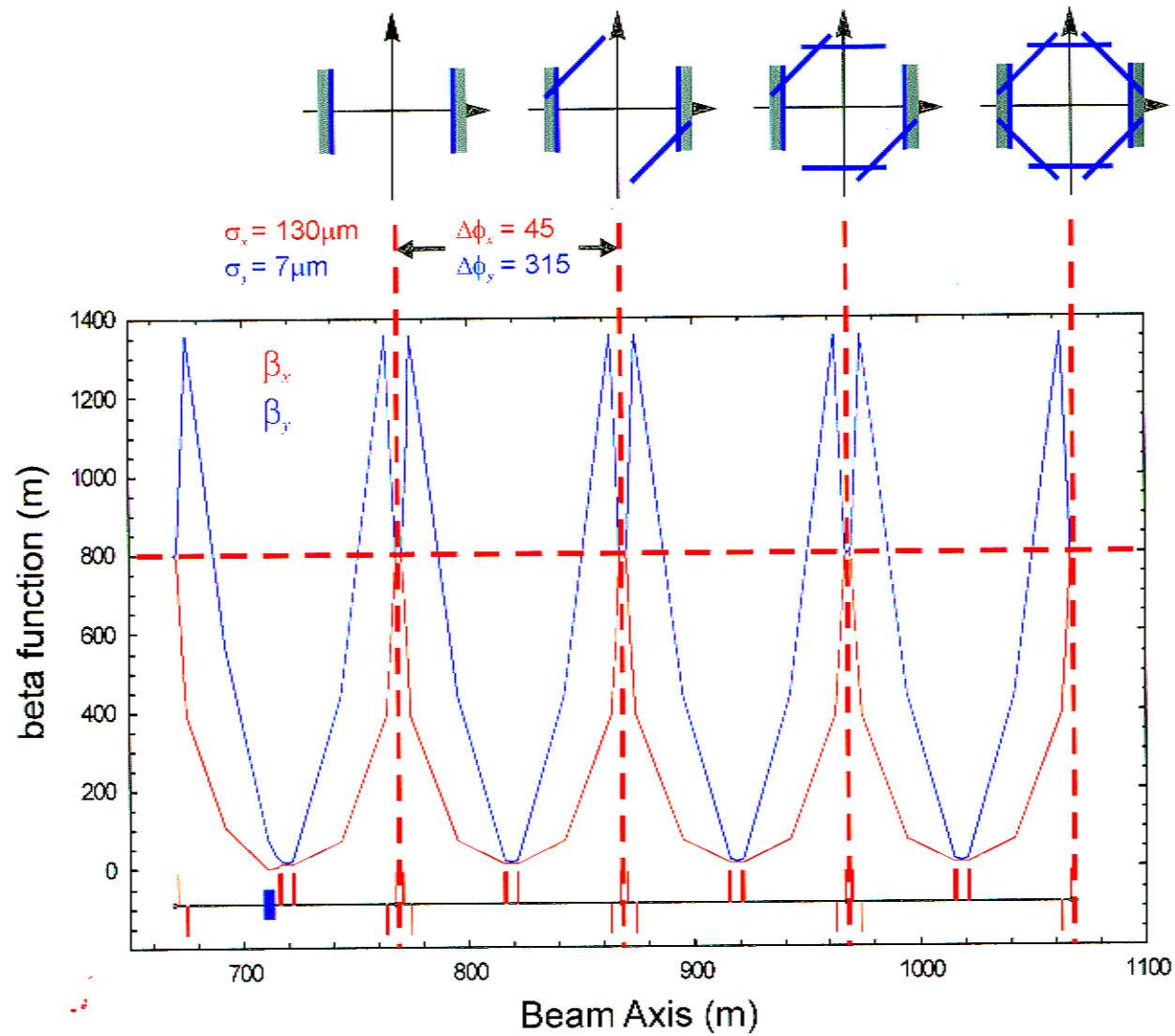


Second skew-sextupole generates energy dependent skew-quadrupole

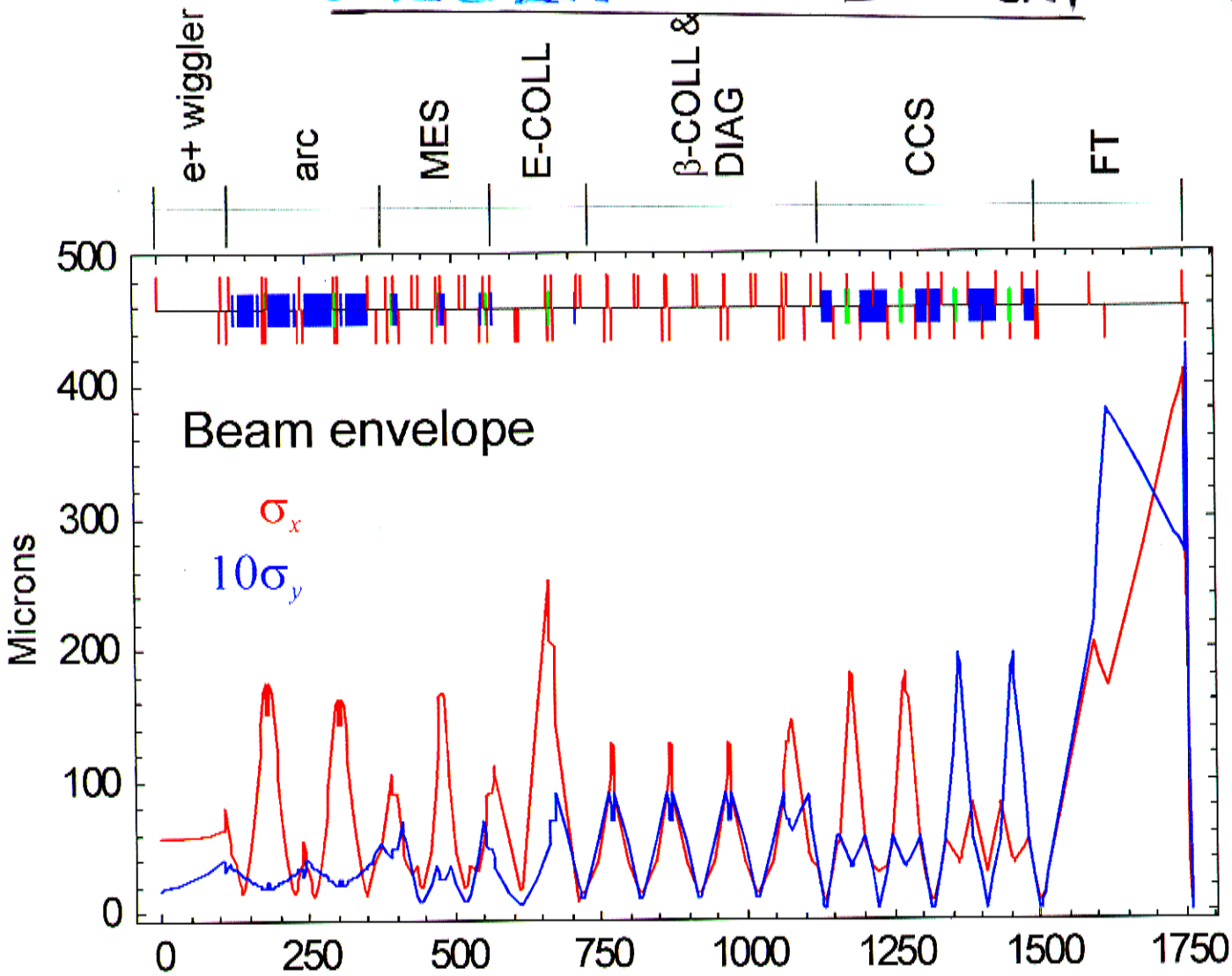
$$K_{skew} = K_2 \Delta x_2$$
$$= \frac{1}{6} K_2 K_3 R_{12} D_x^3 \delta^3$$

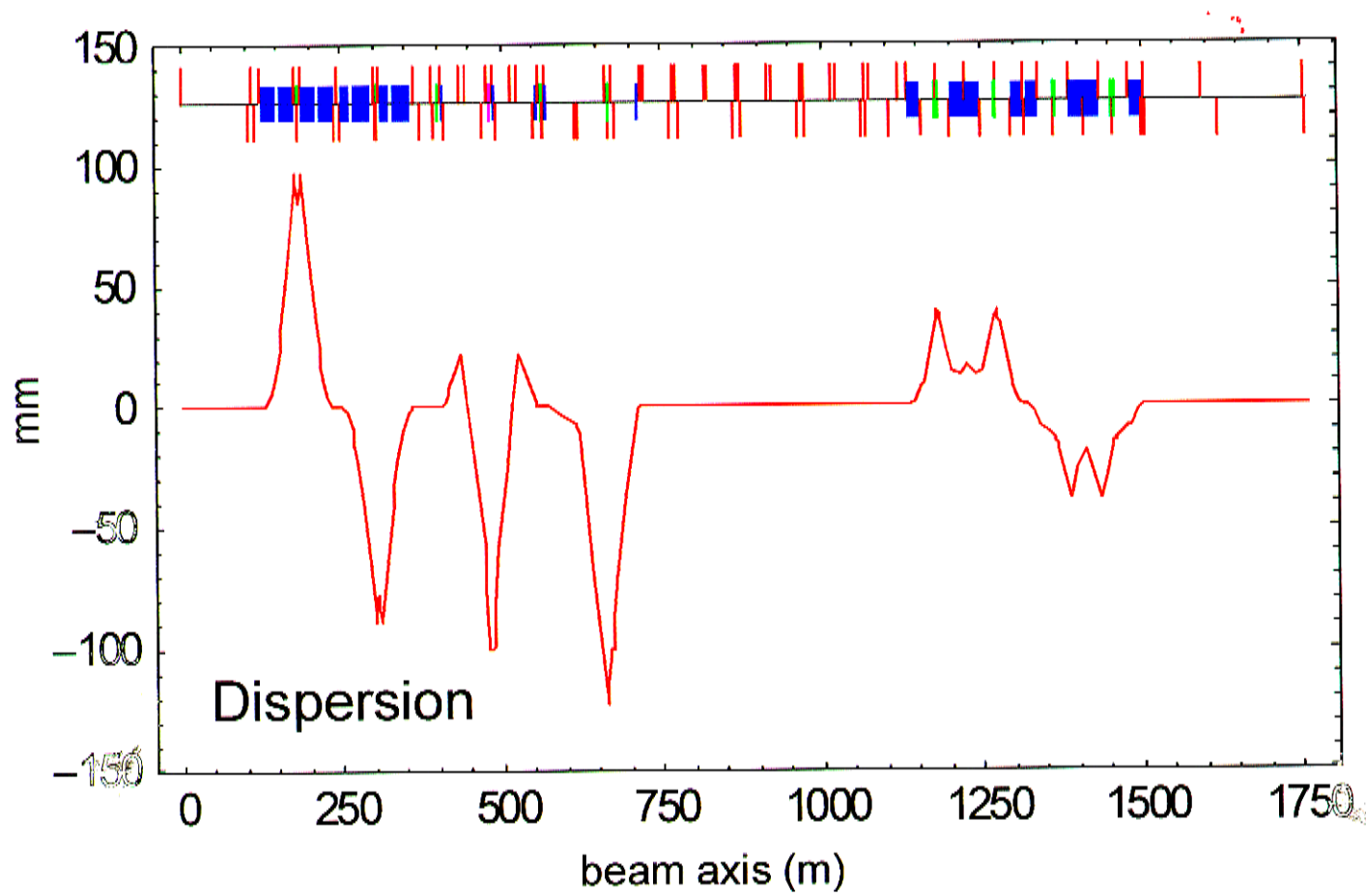
β-Collimation & Diagnostics

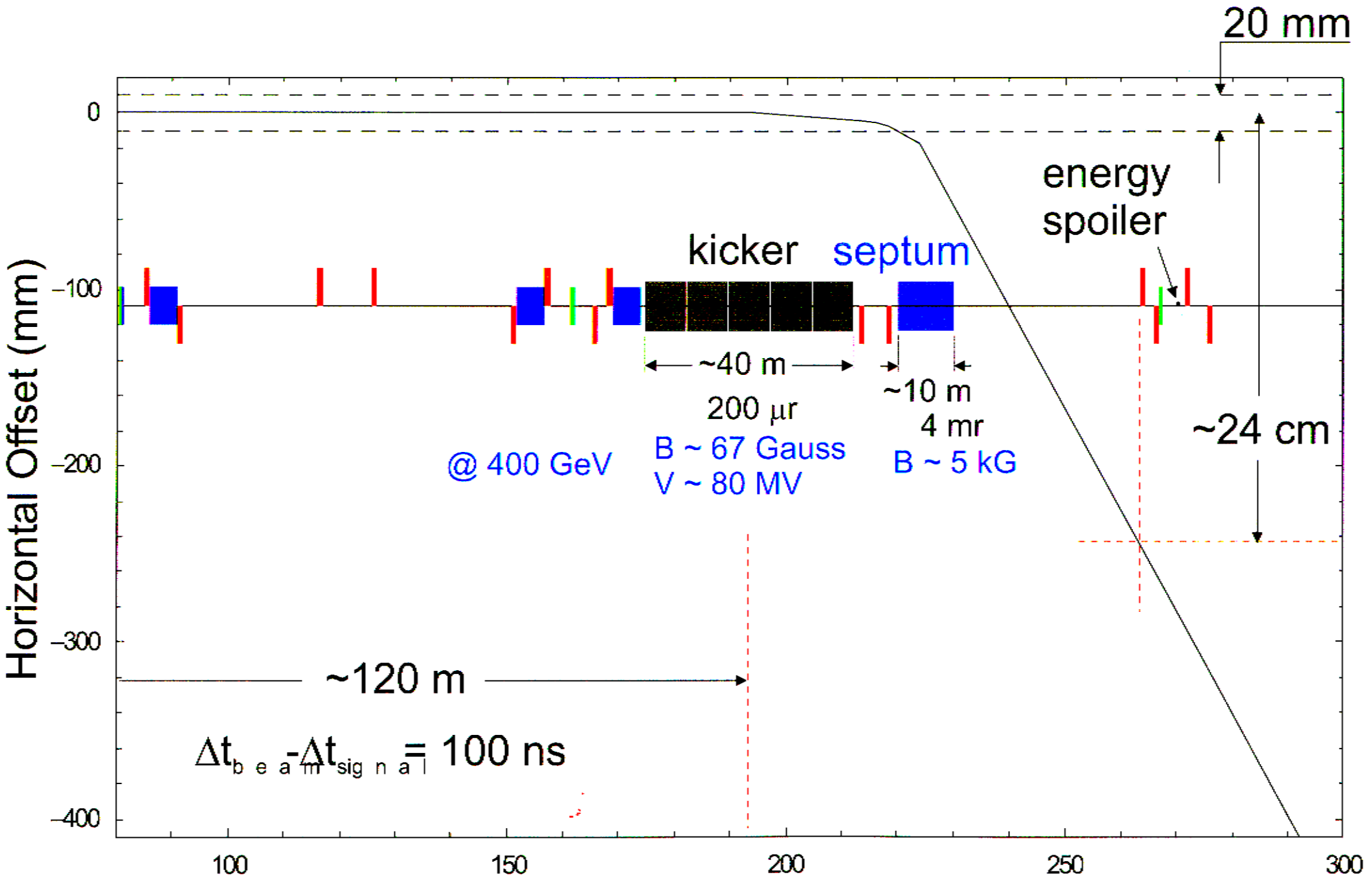
- Betatron collimation now consists of four collimators separated by 45° in phase space.
- $\beta_x = \beta_y = 800$m gives $\sigma_x \times \sigma_y = 130 \times 7\ \mu m^2$ [250GeV].
- Beam size is large enough for C [graphite] spoilers to survive direct hit from ~3 design bunches.



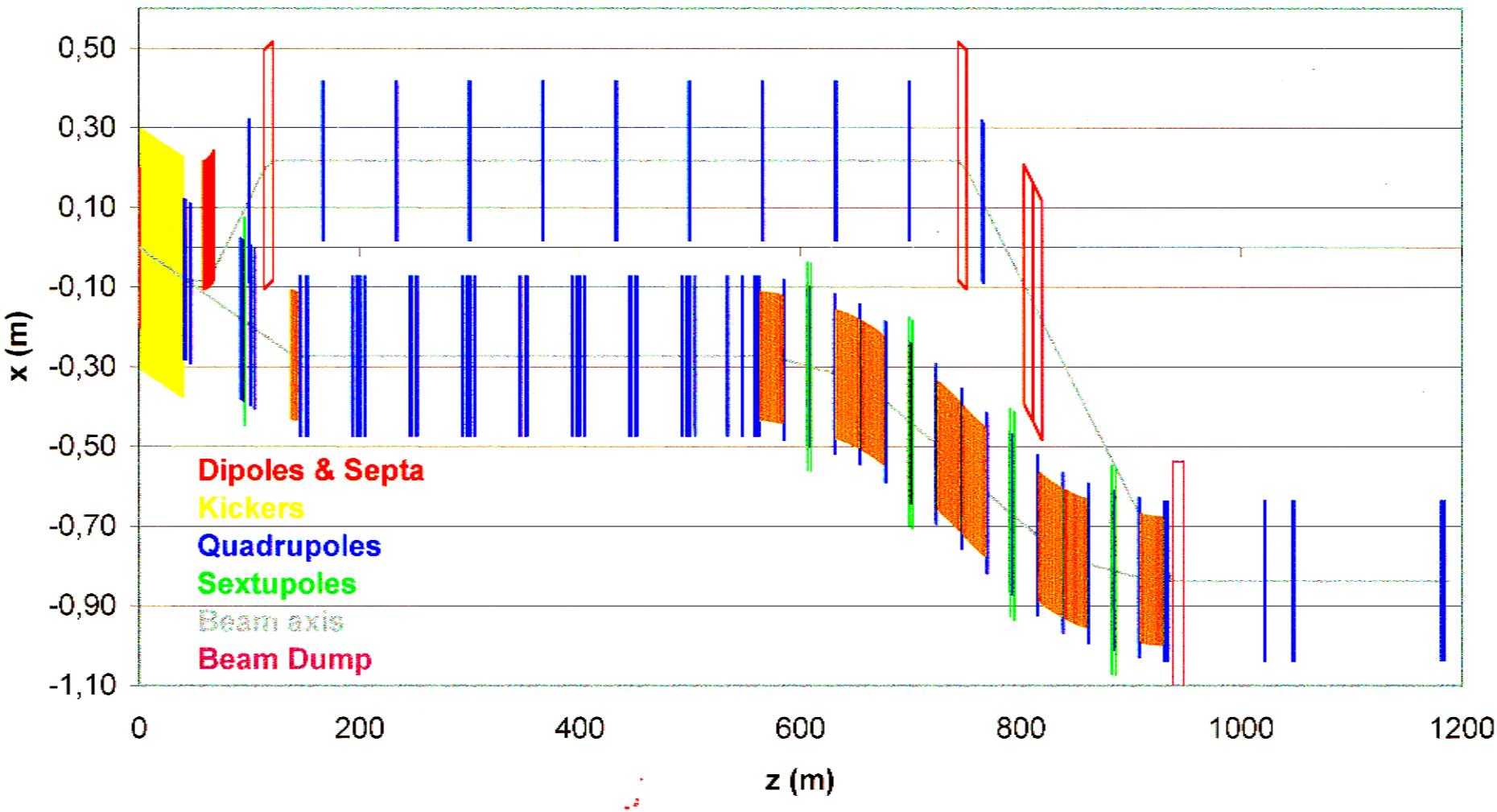
TESLA BEAM DELIVERY



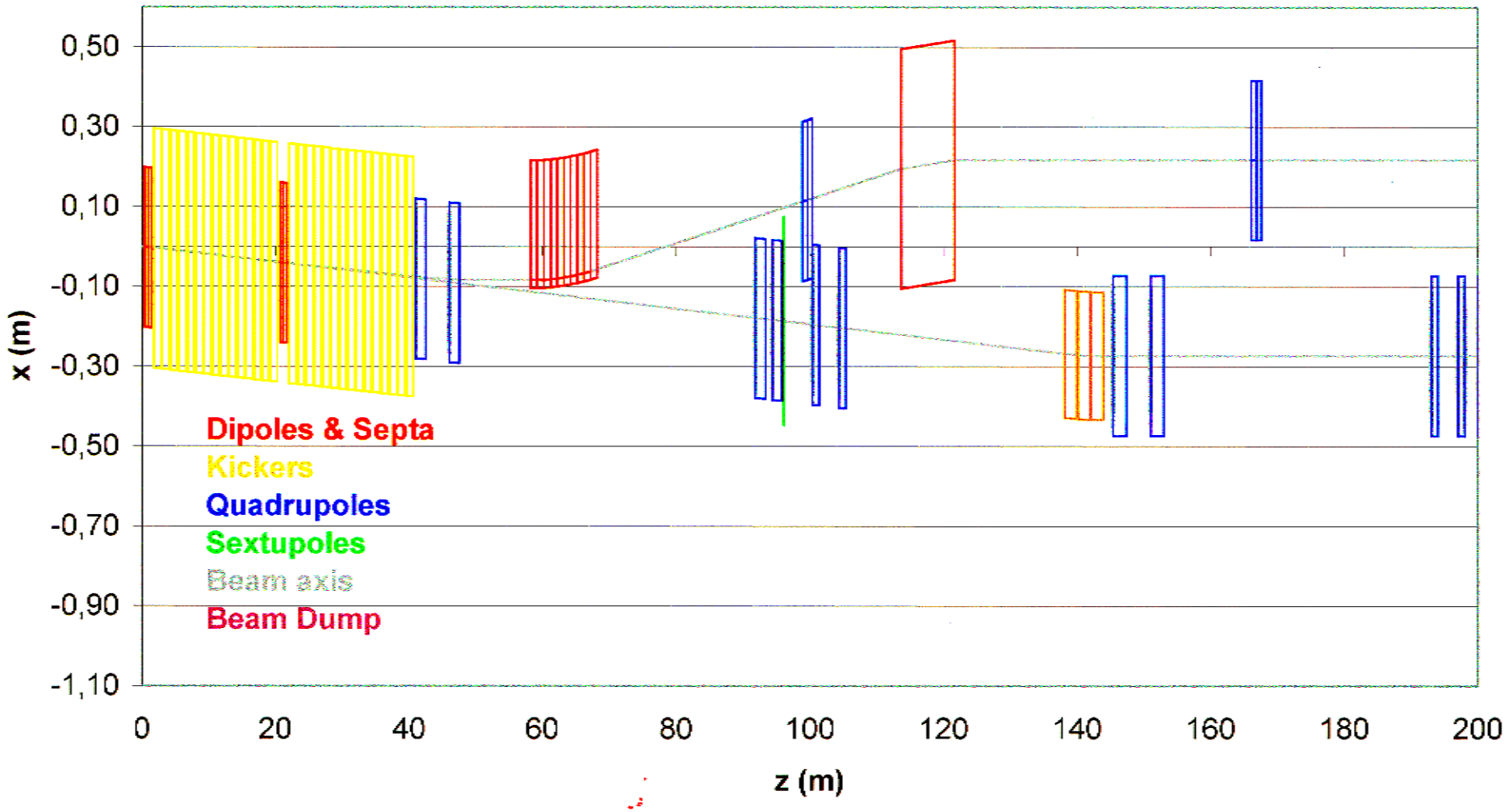



20 mm
energy
spoiler
kicker
septum
~40 m
200 μr
~10 m
4 mr
@ 400 GeV
B ~ 67 Gauss
V ~ 80 MV
B ~ 5 kG
~24 cm
~120 m
Δt_beam - Δt_signal = 100 ns
Horizontal Offset (mm)
0
-100
-200
-300
-400
100
150
200
250
300

Emergency beam line layout



Emergency beam line layout



BEAM EXTRACTION

Main Challenges:

- low emittance beam area $> 0.4\ mm^2$

  $\Rightarrow \Delta T < 80K$ in water dump

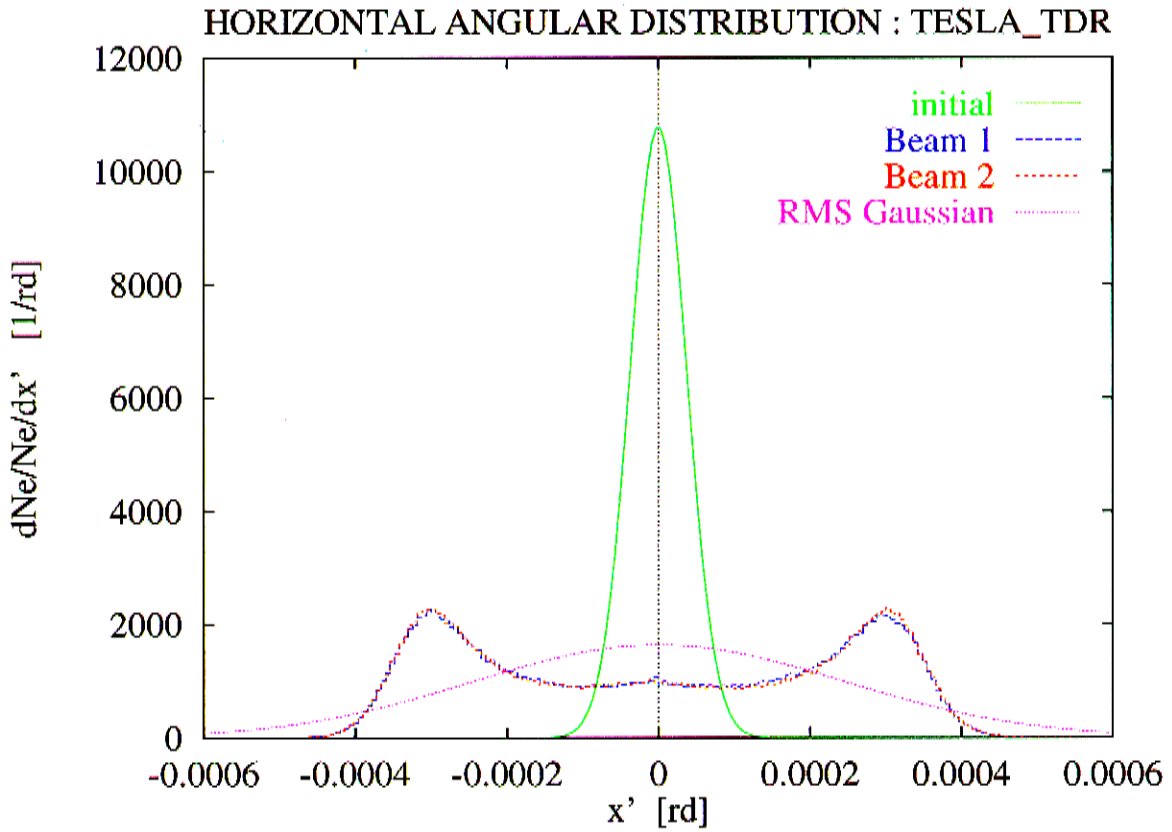
- disrupted beam radius $<$ 50 cm $\hat{=}$ dump window

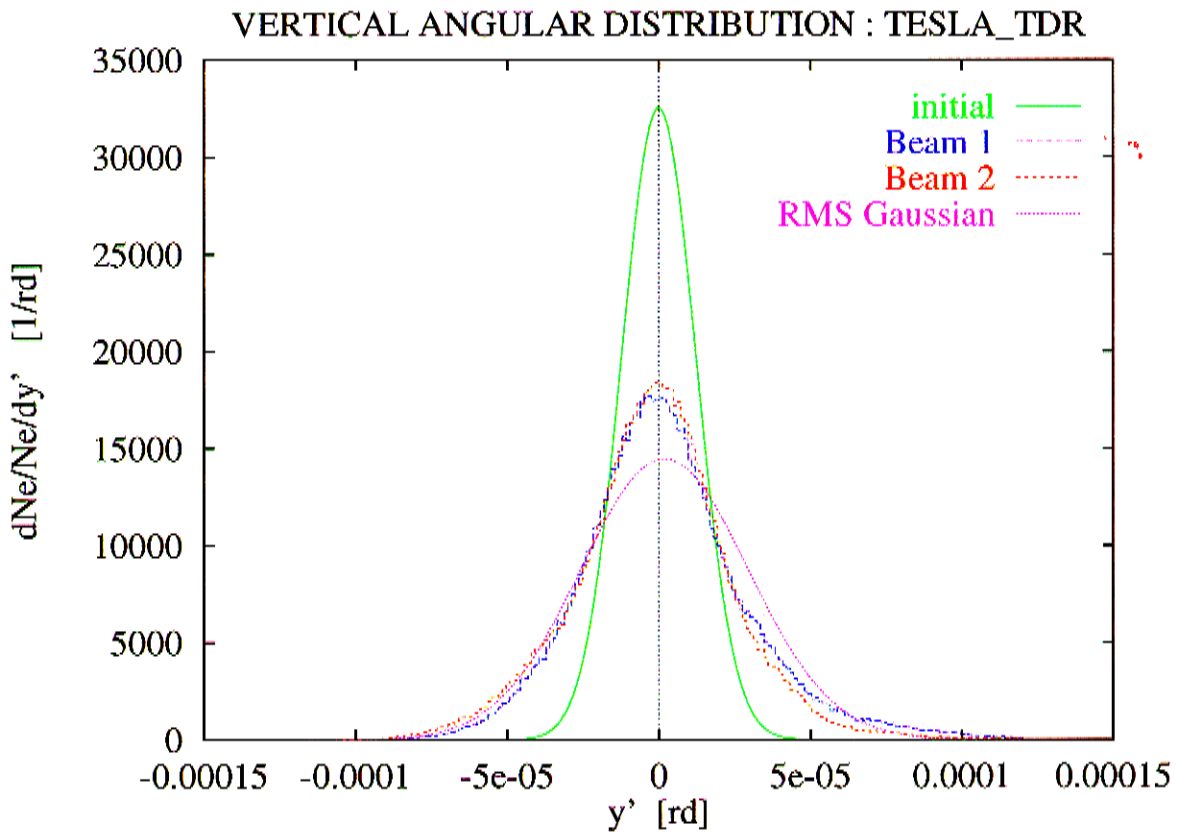
- 15 mrad bend down to earth

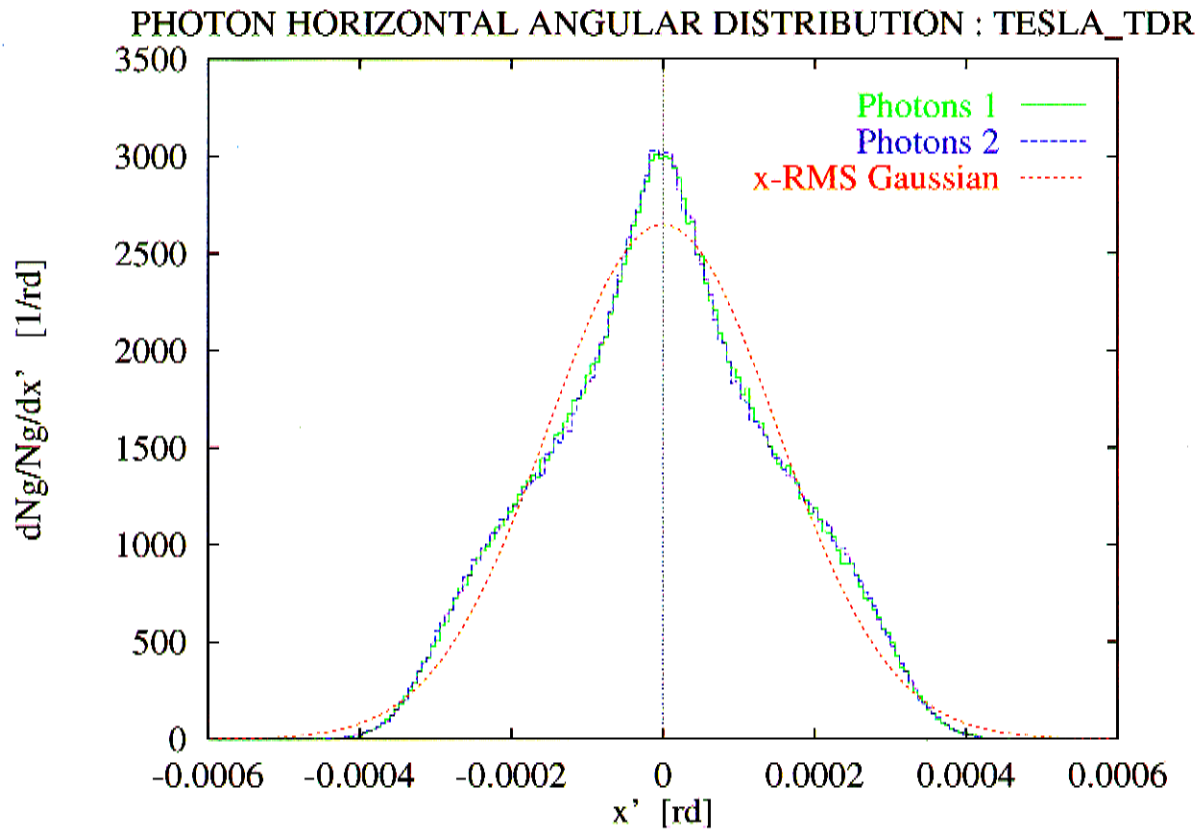
  required for atmosphere μ - activation

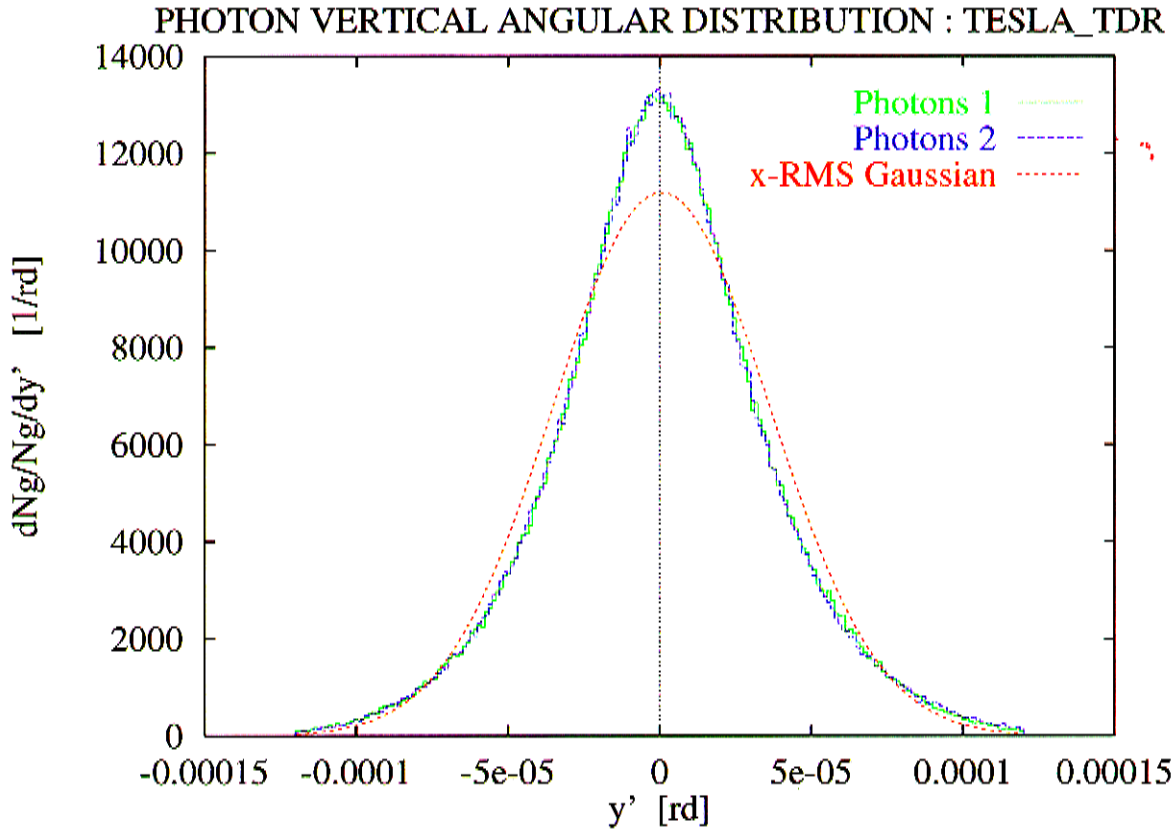
- Beam loss $<$ ~ 10 kW in beam line

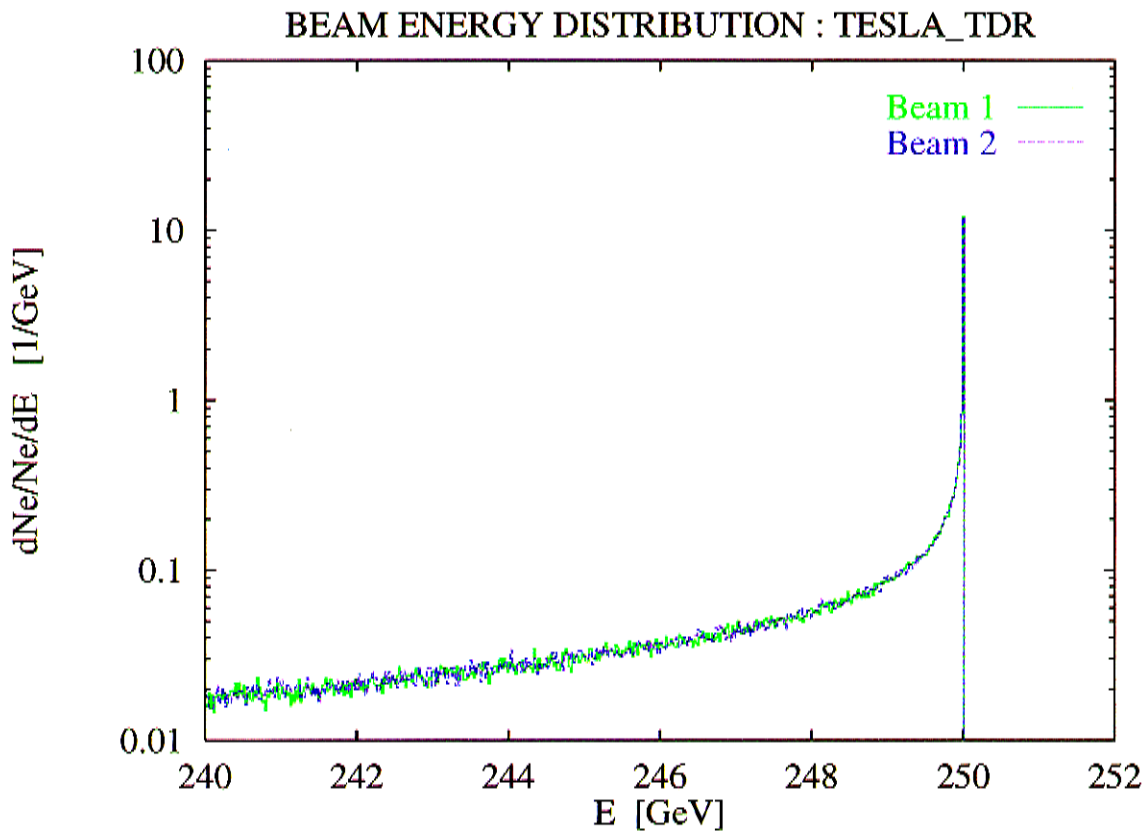
- (Diagnostics ($\vec{P}$, E) in beam line)

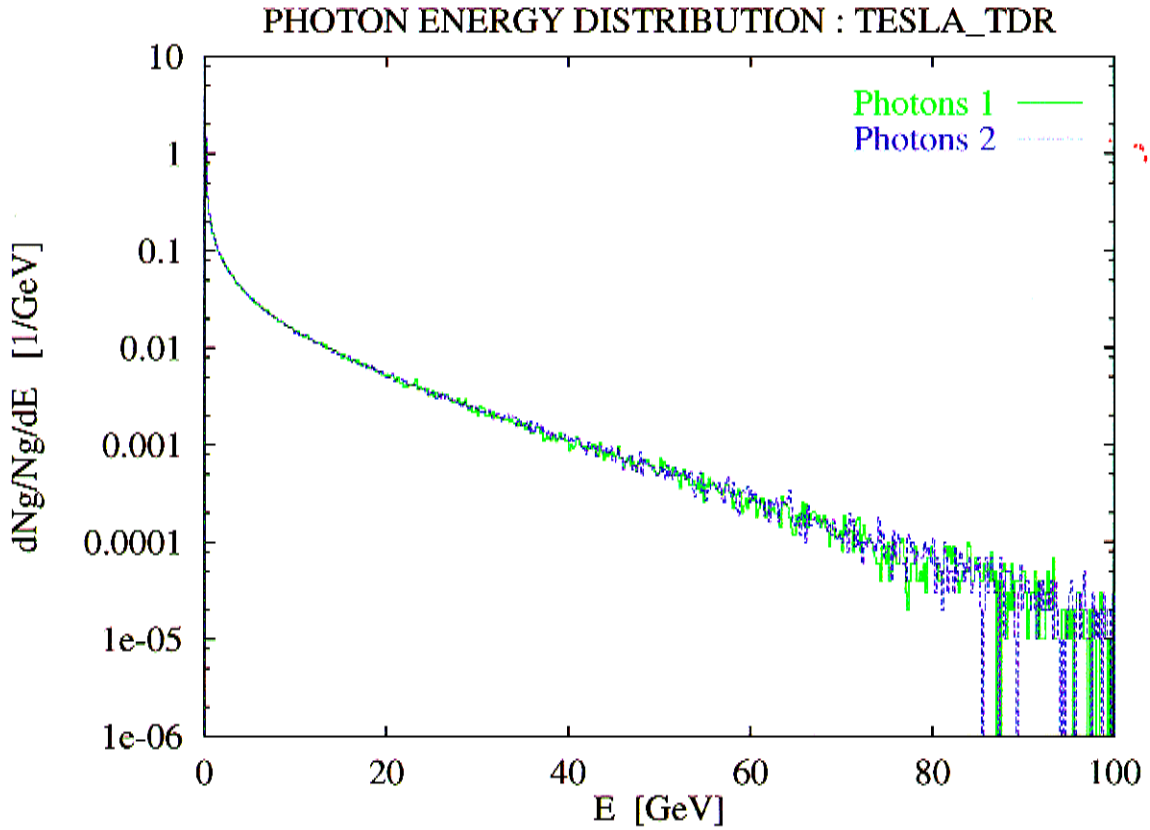

HORIZONTAL ANGULAR DISTRIBUTION : TESLA_TDR
initial
Beam 1
Beam 2
RMS Gaussian
dNe/Ne/dx' [1/rd]
x' [rd]
12000
10000
8000
6000
4000
2000
0
-0.0006
-0.0004
-0.0002
0
0.0002
0.0004
0.0006

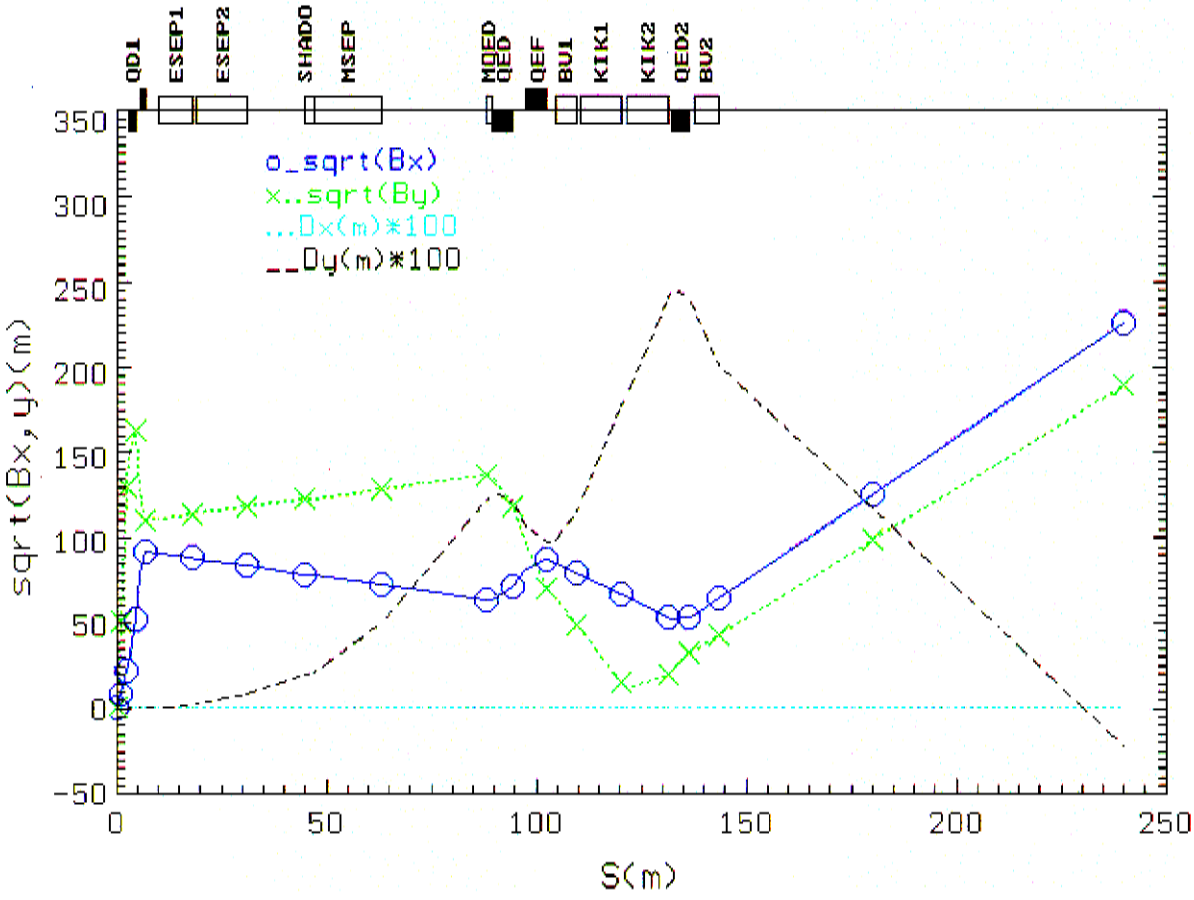

VERTICAL ANGULAR DISTRIBUTION : TESLA_TDR
initial
Beam 1
Beam 2
RMS Gaussian
dNe/Ne/dy' [1/rd]
y' [rd]
35000
30000
25000
20000
15000
10000
5000
0
-0.00015
-0.0001
-5e-05
0
5e-05
0.0001
0.00015

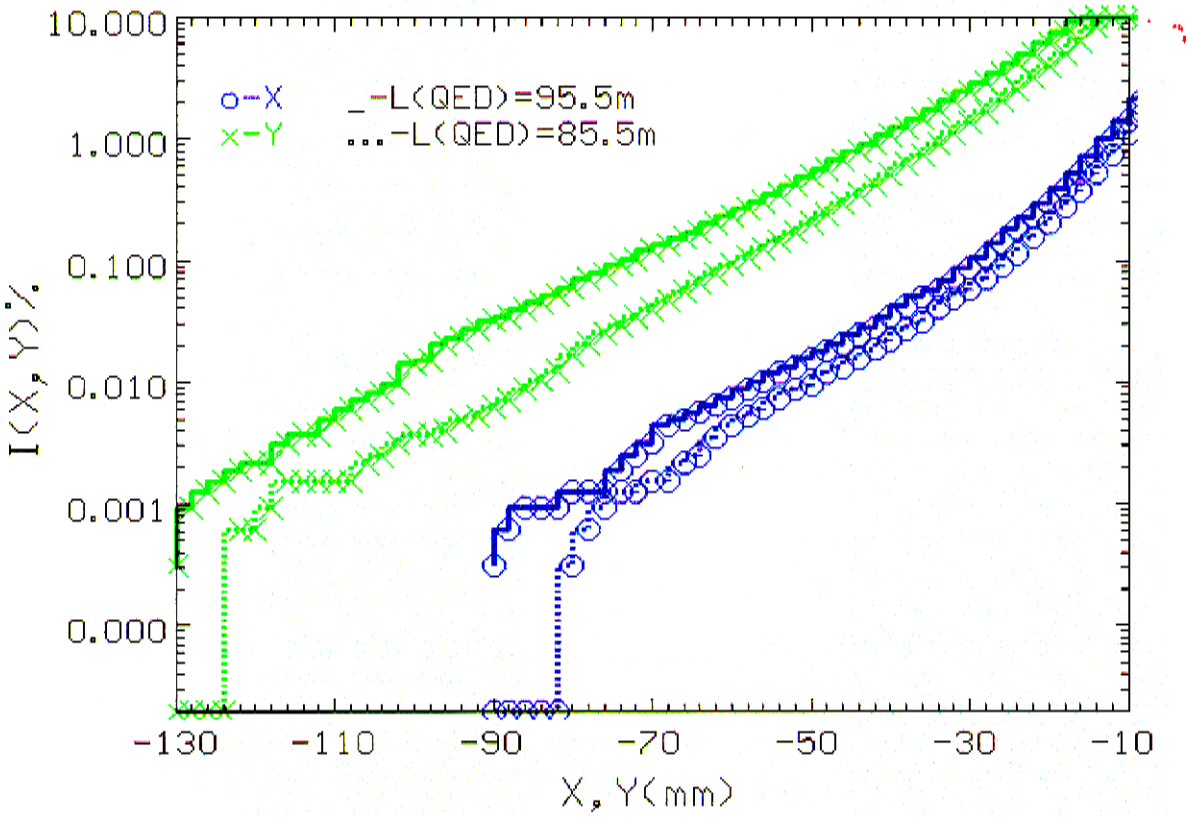

PHOTON HORIZONTAL ANGULAR DISTRIBUTION : TESLA_TDR
Photons 1
Photons 2
x-RMS Gaussian
dNg/Ng/dx' [1/rd]
x' [rd]
3500
3000
2500
2000
1500
1000
500
0
-0.0006
-0.0004
-0.0002
0
0.0002
0.0004
0.0006


PHOTON VERTICAL ANGULAR DISTRIBUTION : TESLA_TDR
Photons 1
Photons 2
x-RMS Gaussian
dNg/Ng/dy' [1/rd]
y' [rd]
14000
12000
10000
8000
6000
4000
2000
0
-0.00015
-0.0001
-5e-05
0
5e-05
0.0001
0.00015

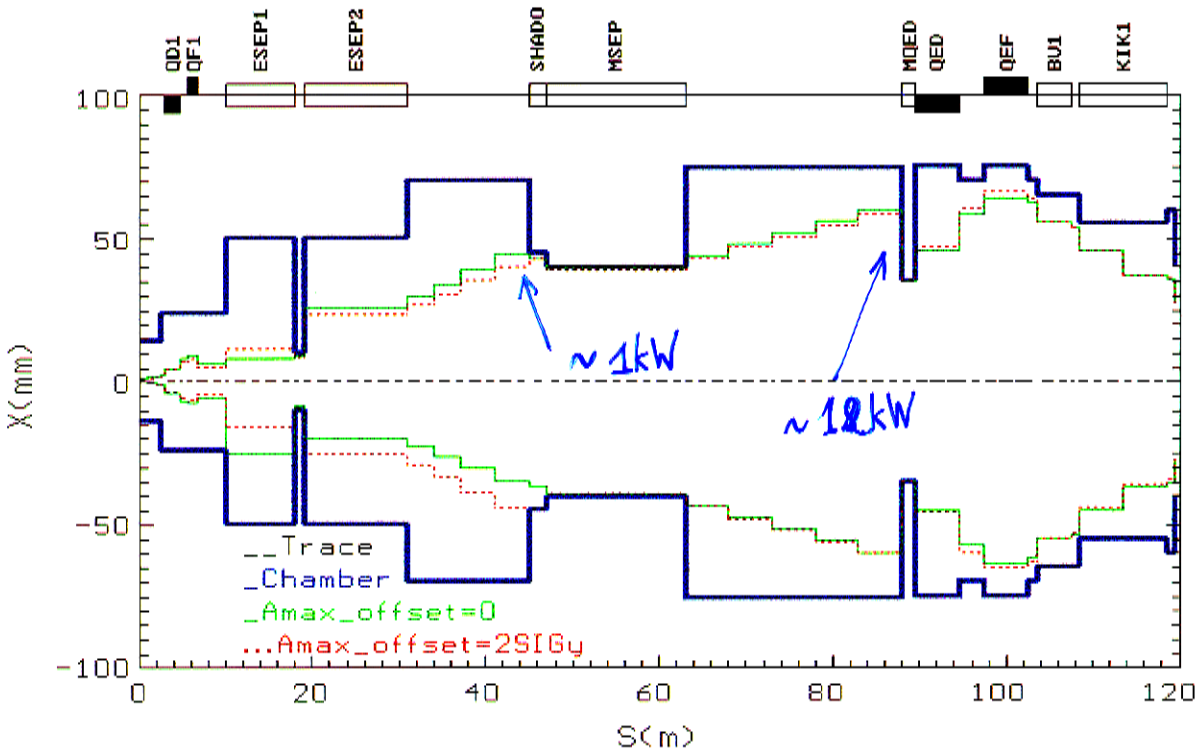

BEAM ENERGY DISTRIBUTION : TESLA_TDR
Beam 1
Beam 2
dNe/Ne/dE [1/GeV]
100
10
1
0.1
0.01
240
242
244
246
248
250
252
E [GeV]

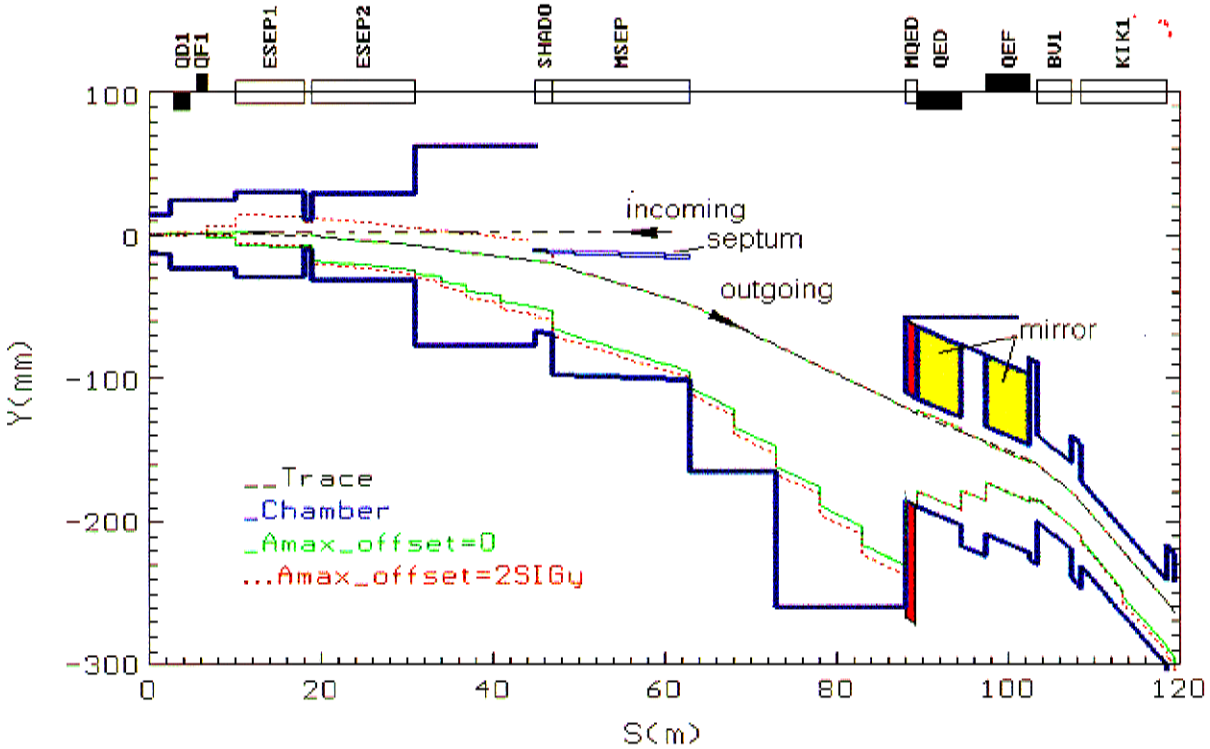

PHOTON ENERGY DISTRIBUTION : TESLA_TDR
Photons 1
Photons 2
dNg/Ng/dE [1/GeV]
10
1
0.1
0.01
0.001
0.0001
1e-05
1e-06
0
20
40
60
80
100
E [GeV]

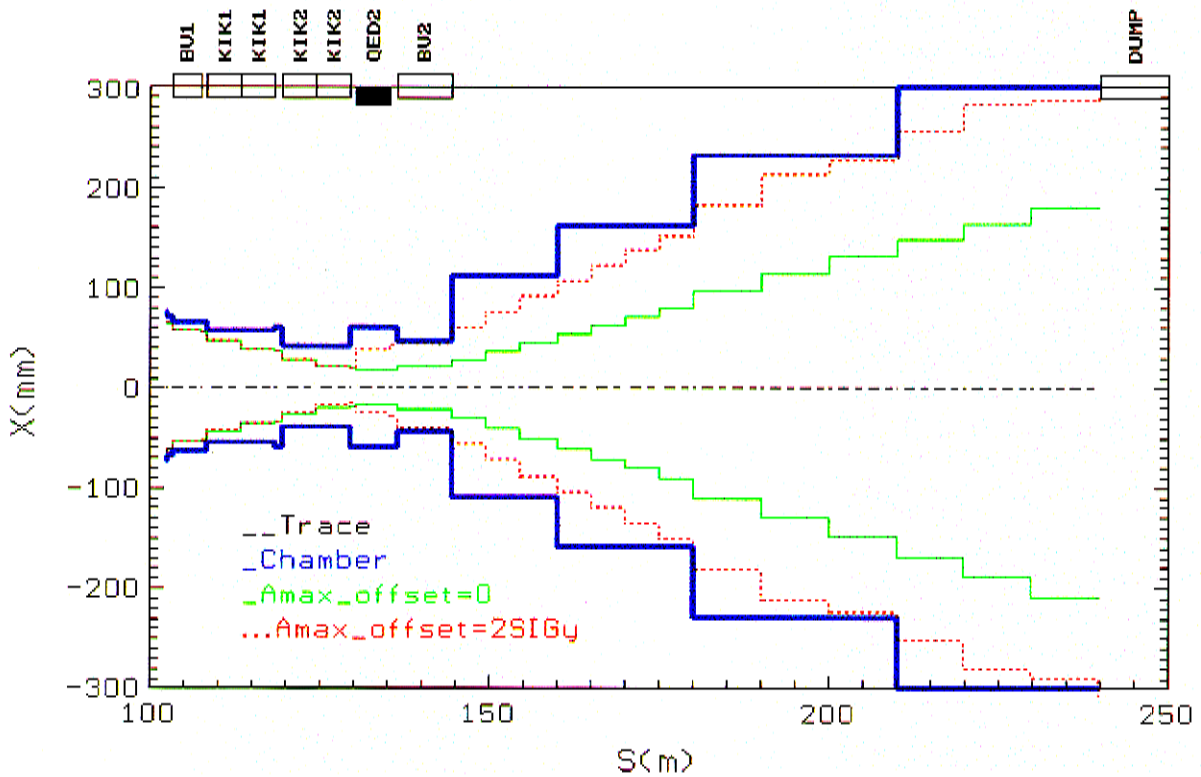

QD1
ESEP1
ESEP2
SHADO
MSEP
MQED
QED
QEF
BU1
KIK1
KIK2
QED2
BU2
o_sqrt(Bx)
x..sqrt(By)
...Dx(m)*100
__Dy(m)*100
sqrt(Bx,y)(m)
S(m)

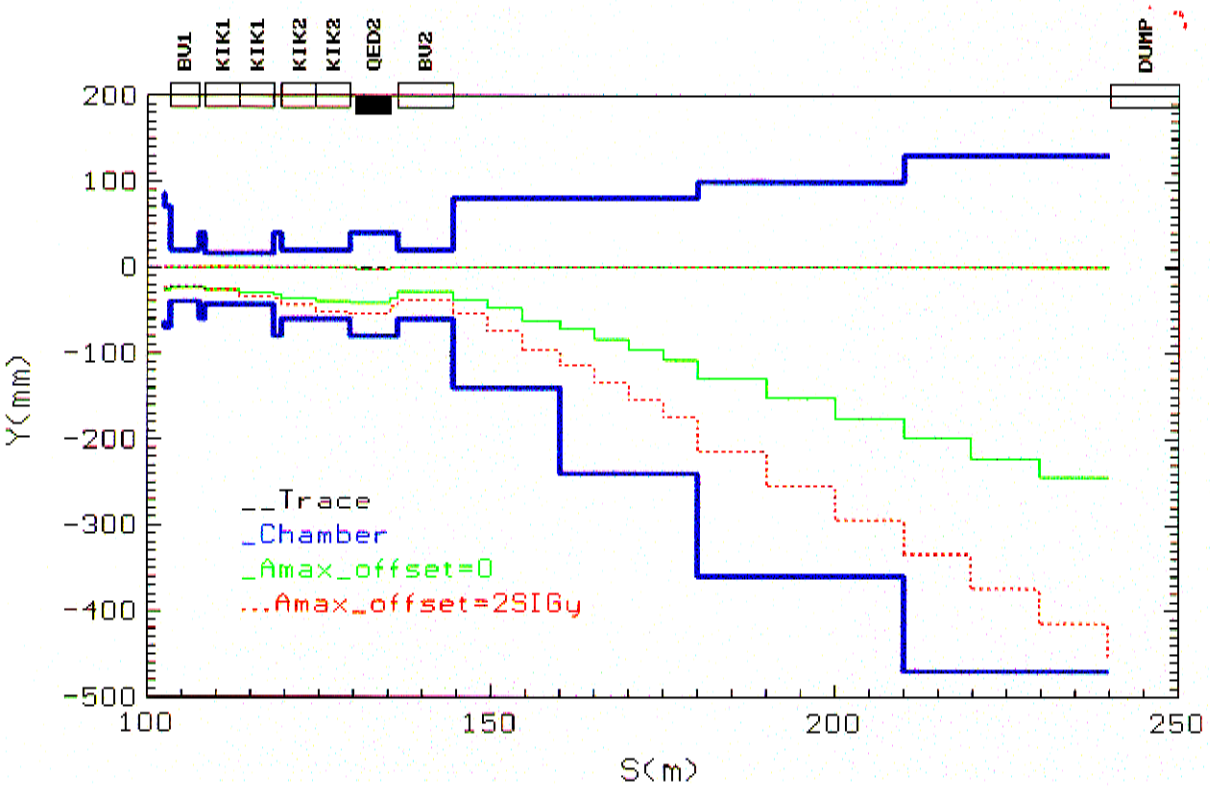

o-X
x-Y
_-L(QED)=95.5m
...-L(QED)=85.5m
I(X,Y)%
X,Y(mm)

BEAM ENVELOPES



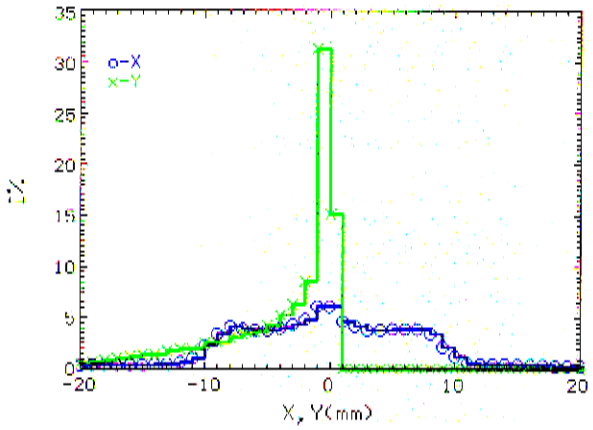



BU1
KIK1
KIK1
KIK2
KIK2
QED2
BU2
DUMP
300
200
100
0
-100
-200
-300
X(mm)
100
150
200
250
S(m)
__Trace
_Chamber
_Amax_offset=0
...Amax_offset=2SIGy

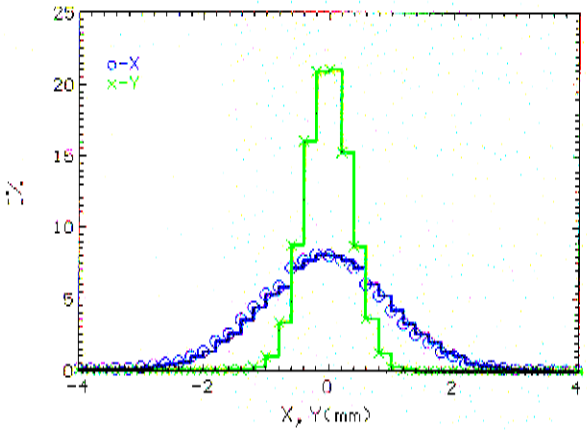

BU1
KIK1
KIK1
KIK2
KIK2
QED2
BU2
DUMP
200
100
0
-100
-200
-300
-400
-500
Y(mm)
100
150
200
250
S(m)
__Trace
_Chamber
_Amax_offset=0
...Amax_offset=2SIGy

BEAM PROFILES @ DUMP

disrupted beam

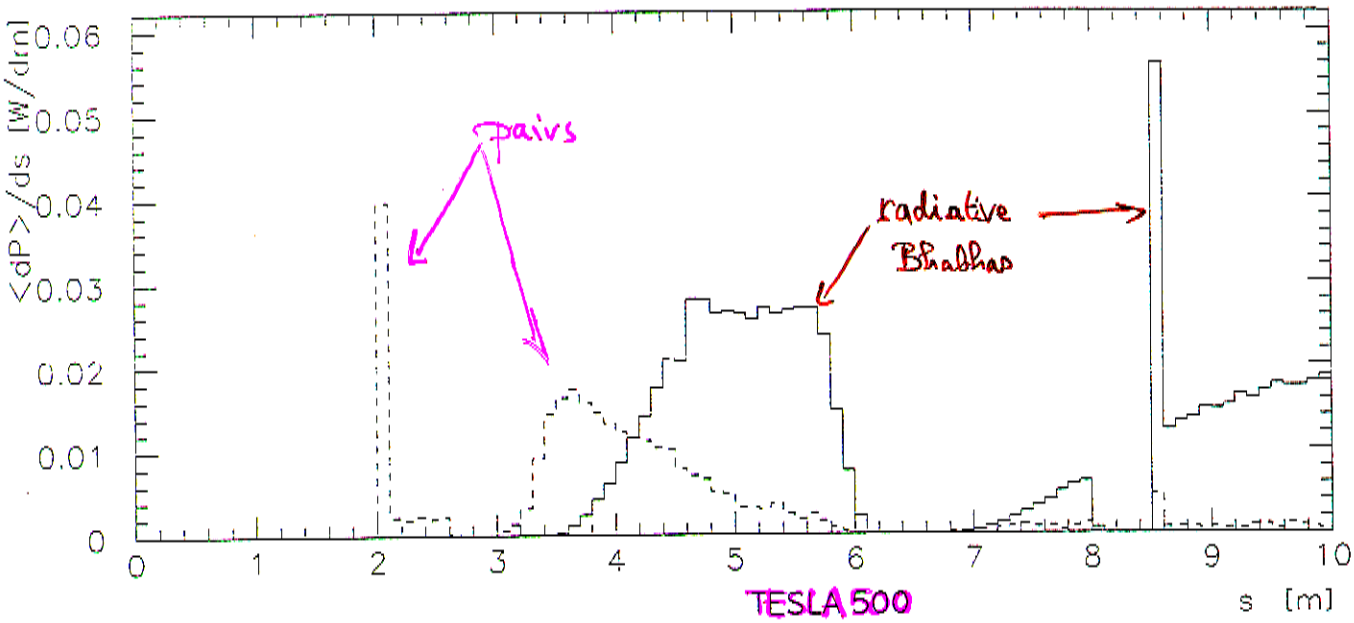


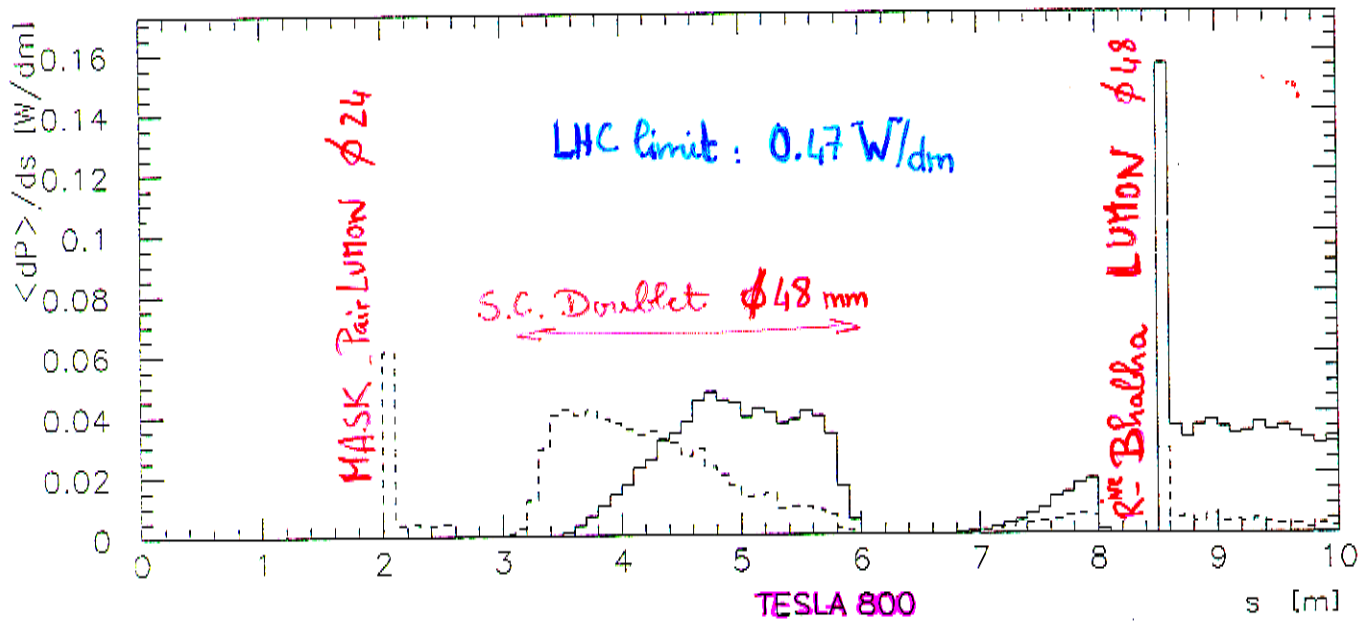
low-emittance



AVERAGE POWER LOSS

PAIRS AND RADIATIVE BHABHAS PARTICLE LOSS





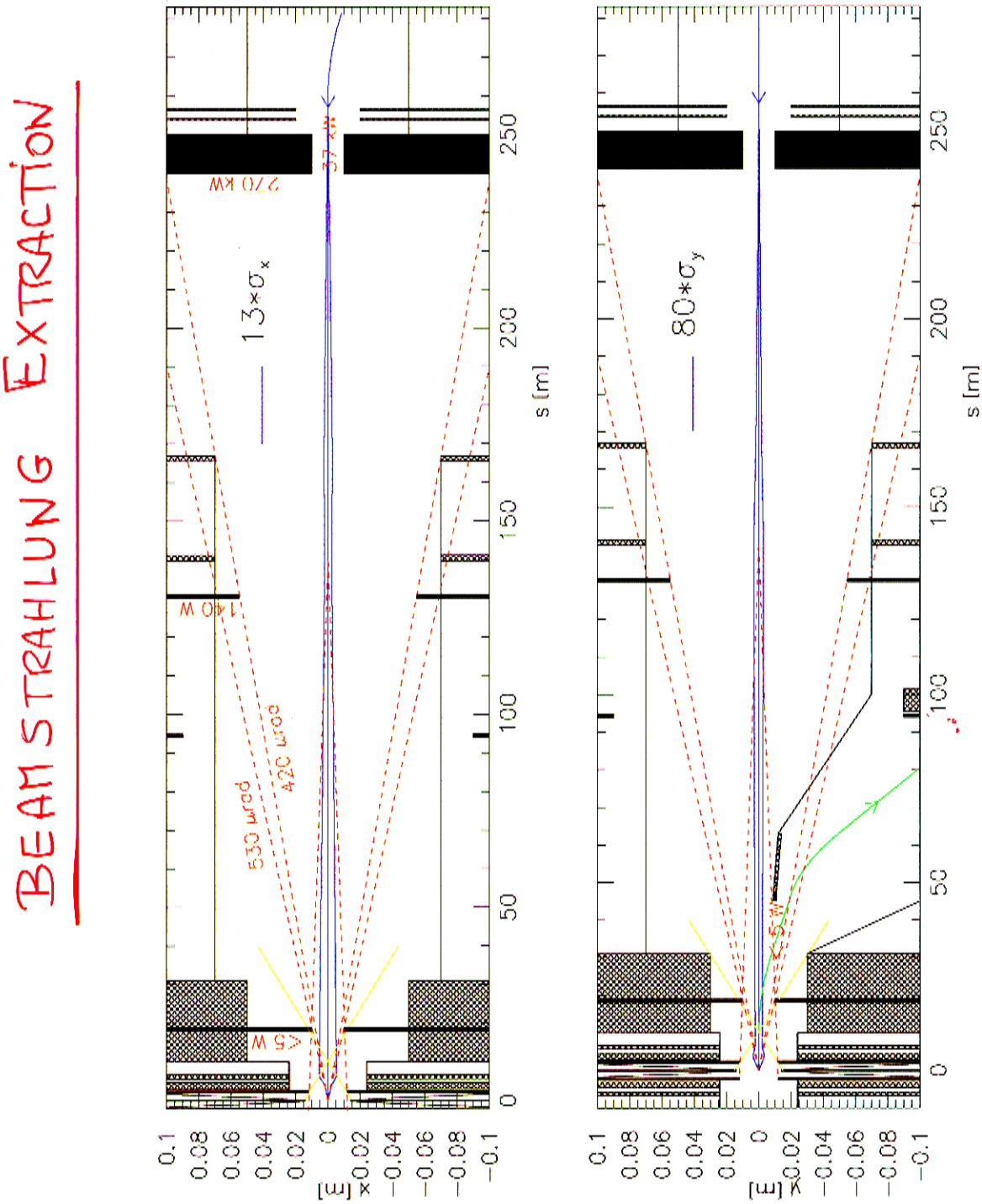
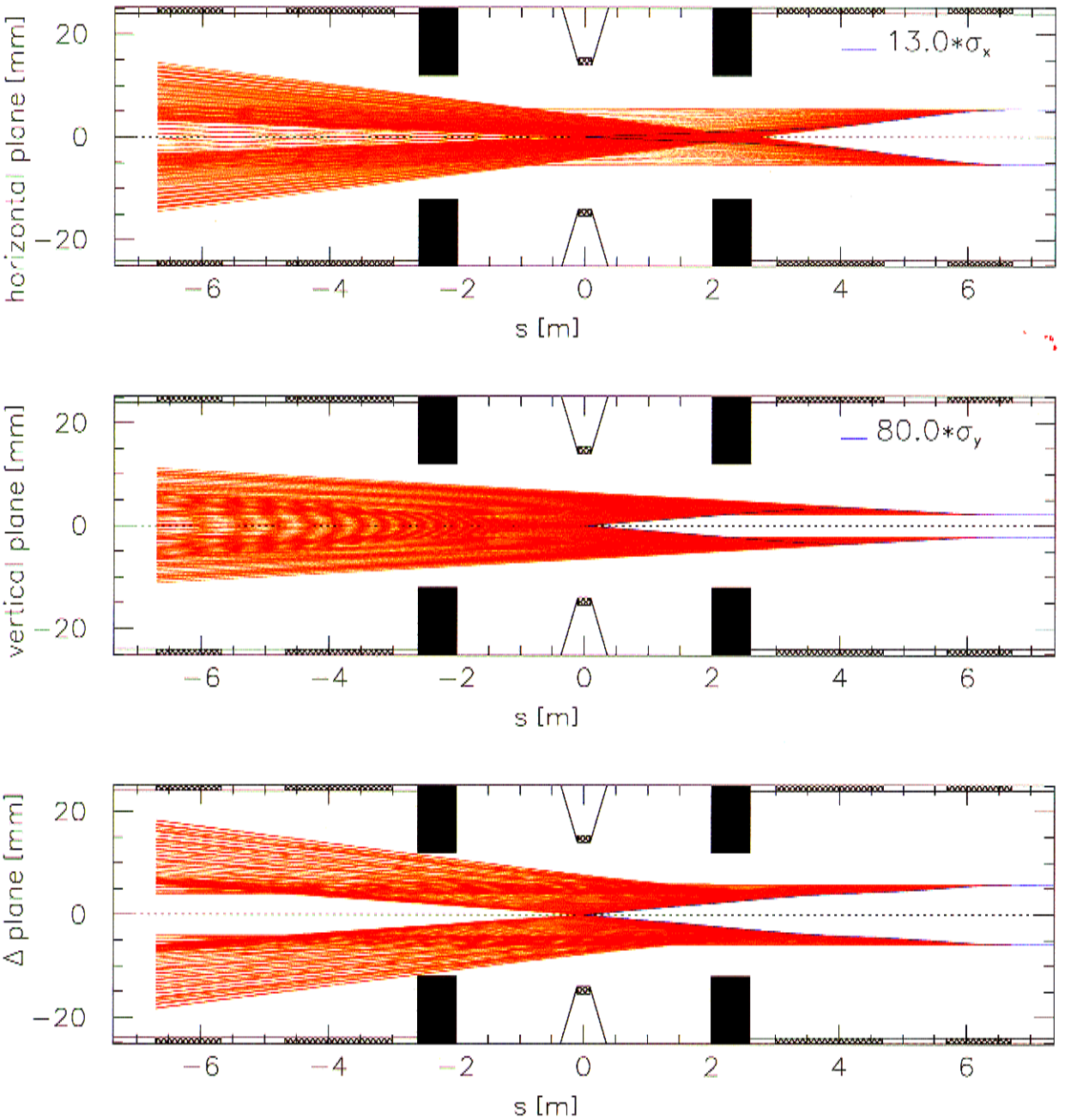

BEAMSTRAHLUNG EXTRACTION
13×σx
80*σy
270 kW
37 kW
140 W
530 μrad
420 μrad
<5 W
5 kW
x [m]
s [m]

Figure 1:

SYNCHROTRON RADIATION from FINAL DOUBLET QUADRUPOLES

TESLA_iL 500 GeV (3 doublets)