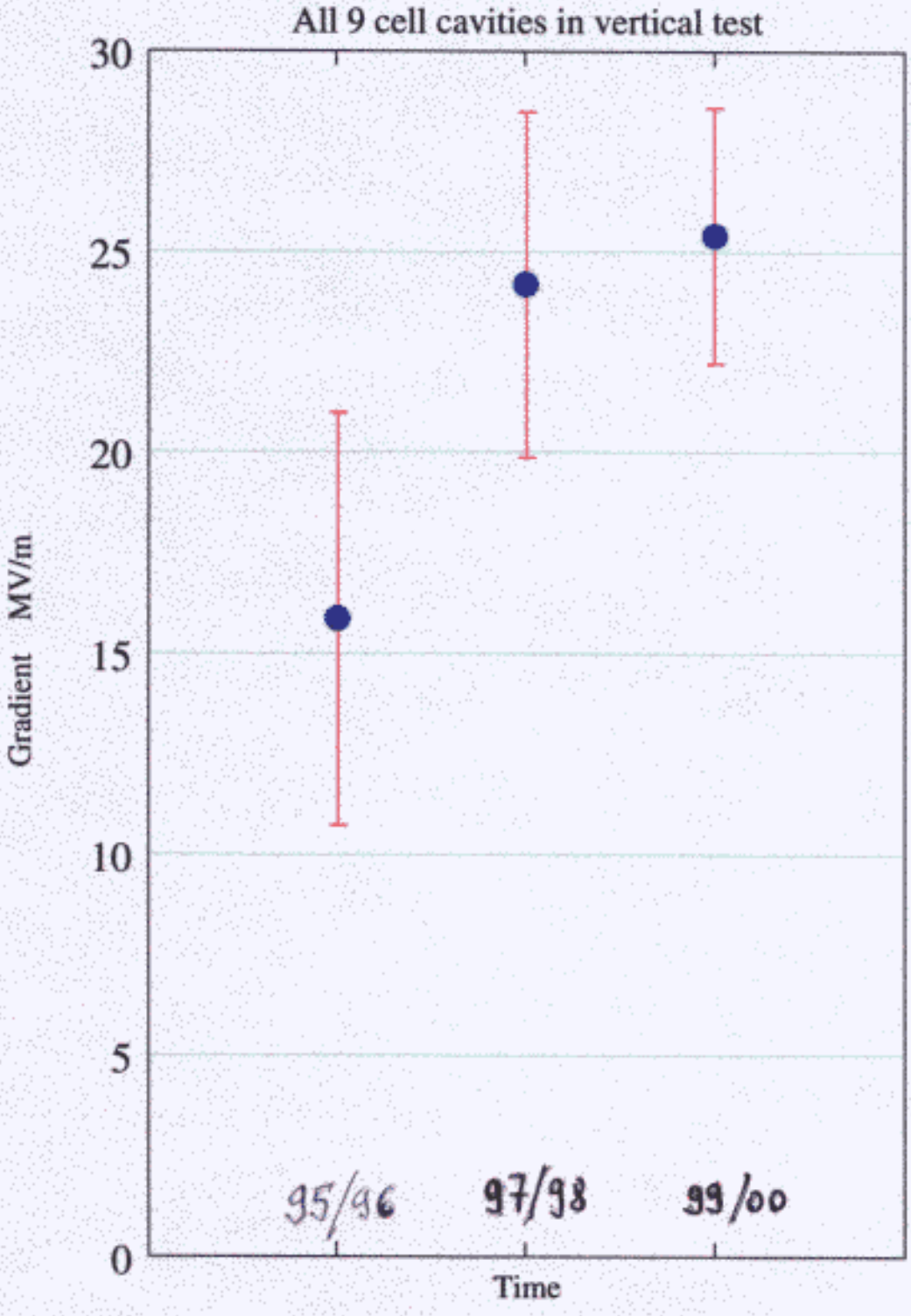
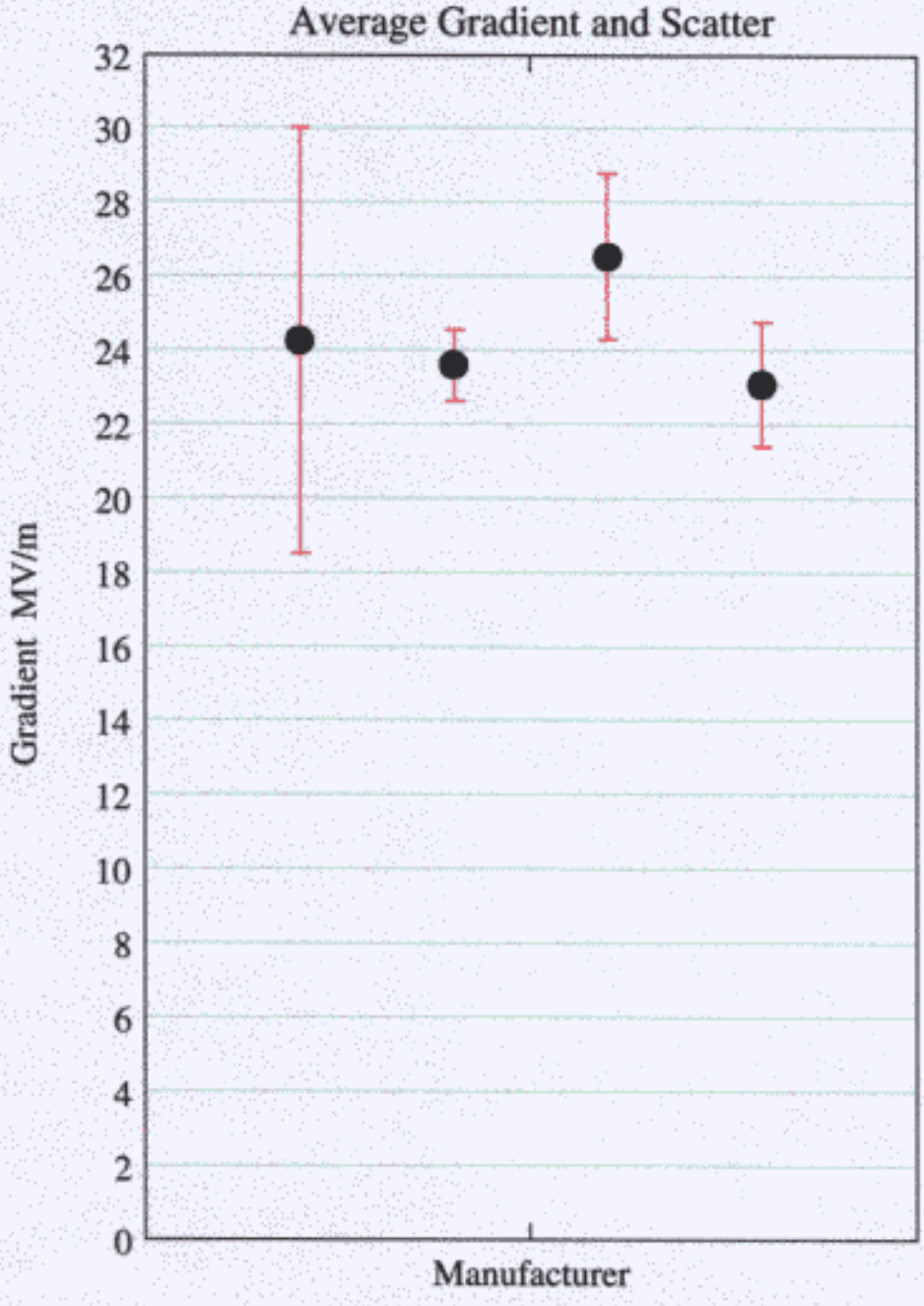
TESLA Machine Update

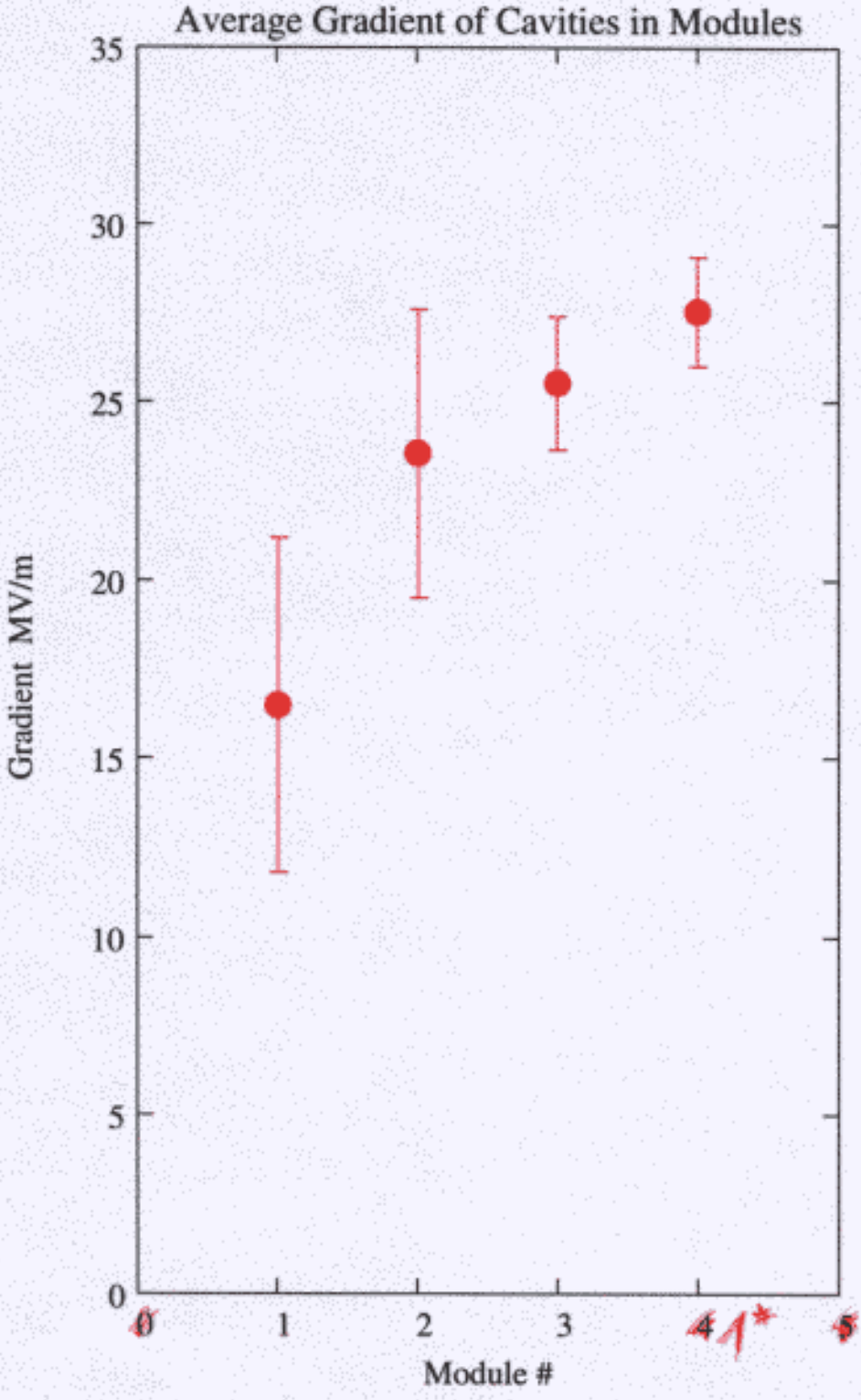
- Hardware R&D
  - Cavity status
  - LFD stabilisation using Fast Piezo Tuner
  - MB Klystron Results
- Beam Dynamics Update
  - Linac wakefield "stability"
  - Damping ring space-charge tune-shift compensation
- e^+ source and polarisation
- Some comments on $\gamma\gamma$ for the TDR
- TDR and Cost status

TESLA
High Luminosity Parameters

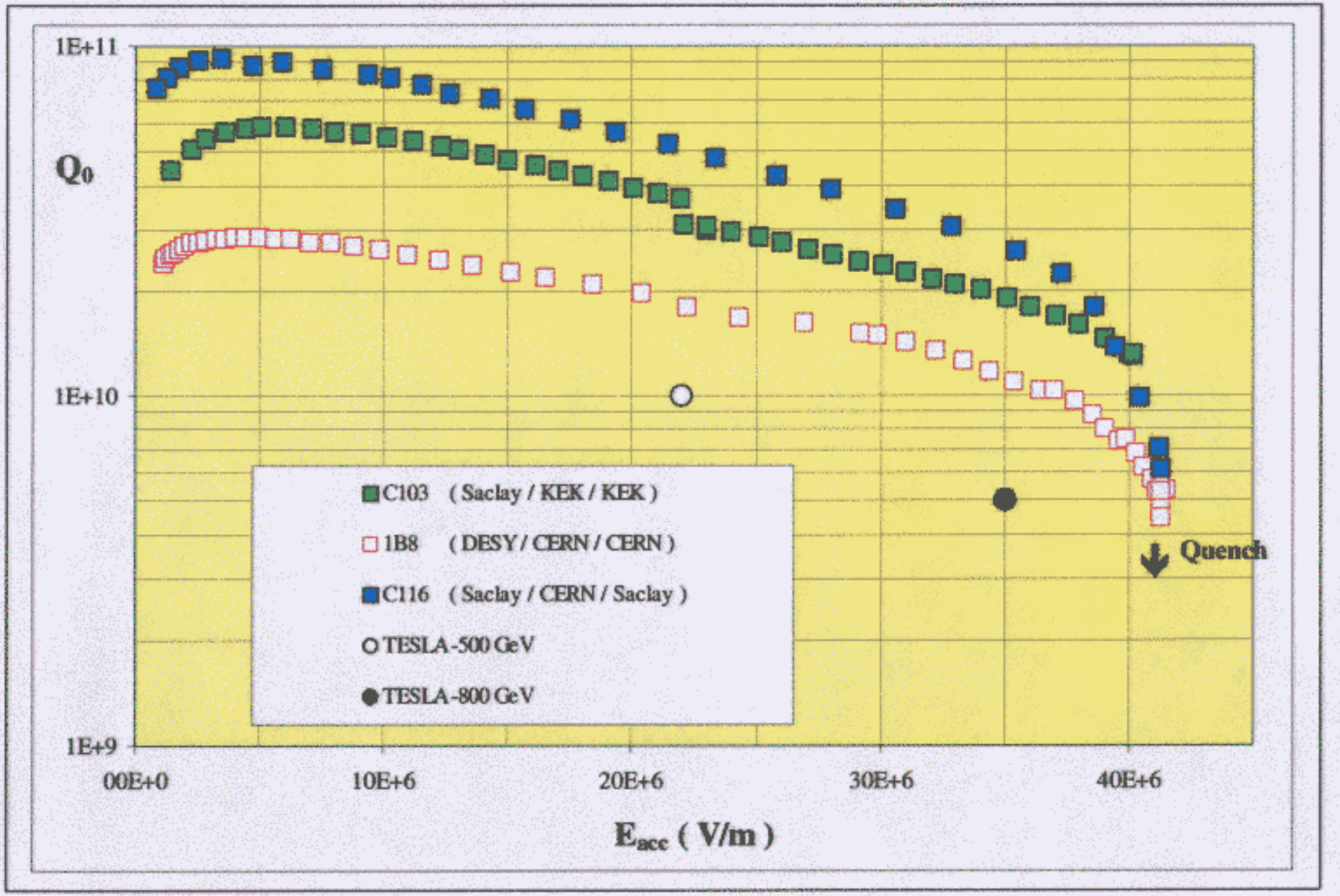
$\sqrt{s}$	GeV	**500**	**800**
Luminosity	$10^{34}\text{cm}^{-2}\text{s}^{-1}$	3.2	4.3
RF-frequency	GHz	1.3	-
Accelerating gradient	MV/m	~~21.7~~ 23.4	35
Quality factor Q_0	-	10^{10}	$5 \cdot 10^9$
Fill factor	%	76	-
Total site length	km	33	-
Repetition rate	Hz	5	4
Pulse length	μs	950	860
# bunches/pulse n_b	-	2 820	4 530
Bunch spacing τ_b	ns	337	190
Bunch charge N_e	-	$2 \cdot 10^{10}$	$1.4 \cdot 10^{10}$
Spot sizes at IP $\sigma^*_{x,y}$	nm	553 , 5	391 , 2.8
Emittances at IP $\gamma\varepsilon_{x,y}$	μm	10 , 0.03	8 , 0.015
Betas at IP $\beta^*_{x,y}$	mm	15 , 0.4	15 , 0.4
Bunch length σ_z	μm	300	300
Beamstrahlung parameter δ_B	-	2.8	4.7
Average current	μA	45	30
Beam power ×2	MW	22.6	32.5
AC power	MW	95	160
Efficiency	%	24	20


All 9 cell cavities in vertical test
30
25
20
15
10
5
0
Gradient MV/m
95/96
97/98
99/00
Time

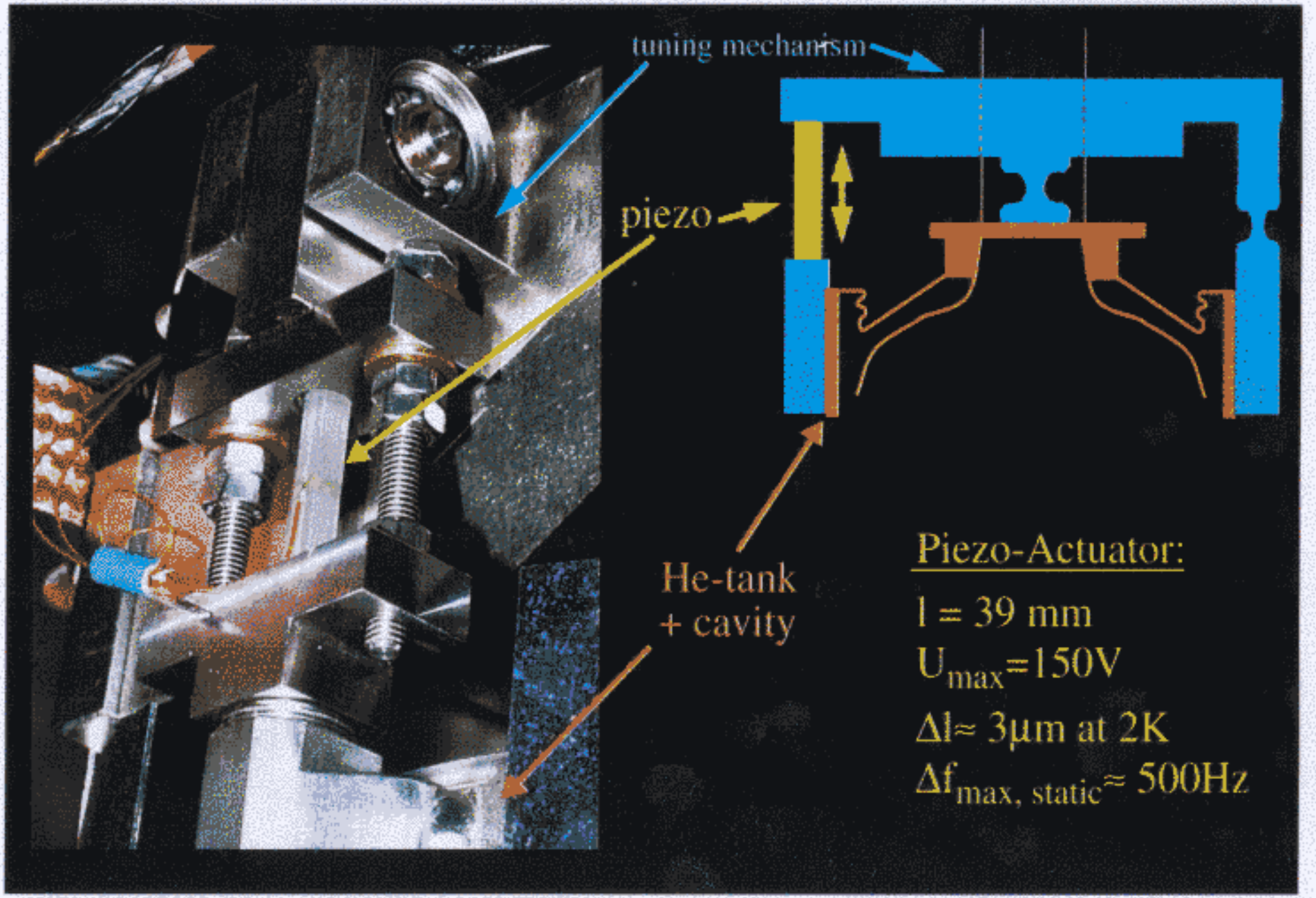

Average Gradient and Scatter
Gradient MV/m
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Manufacturer


Average Gradient of Cavities in Modules
Gradient MV/m
35
30
25
20
15
10
5
0
0
1
2
3
4
1*
5
Module #

Single Cell Cavities : Electropolishing + Baking (120°

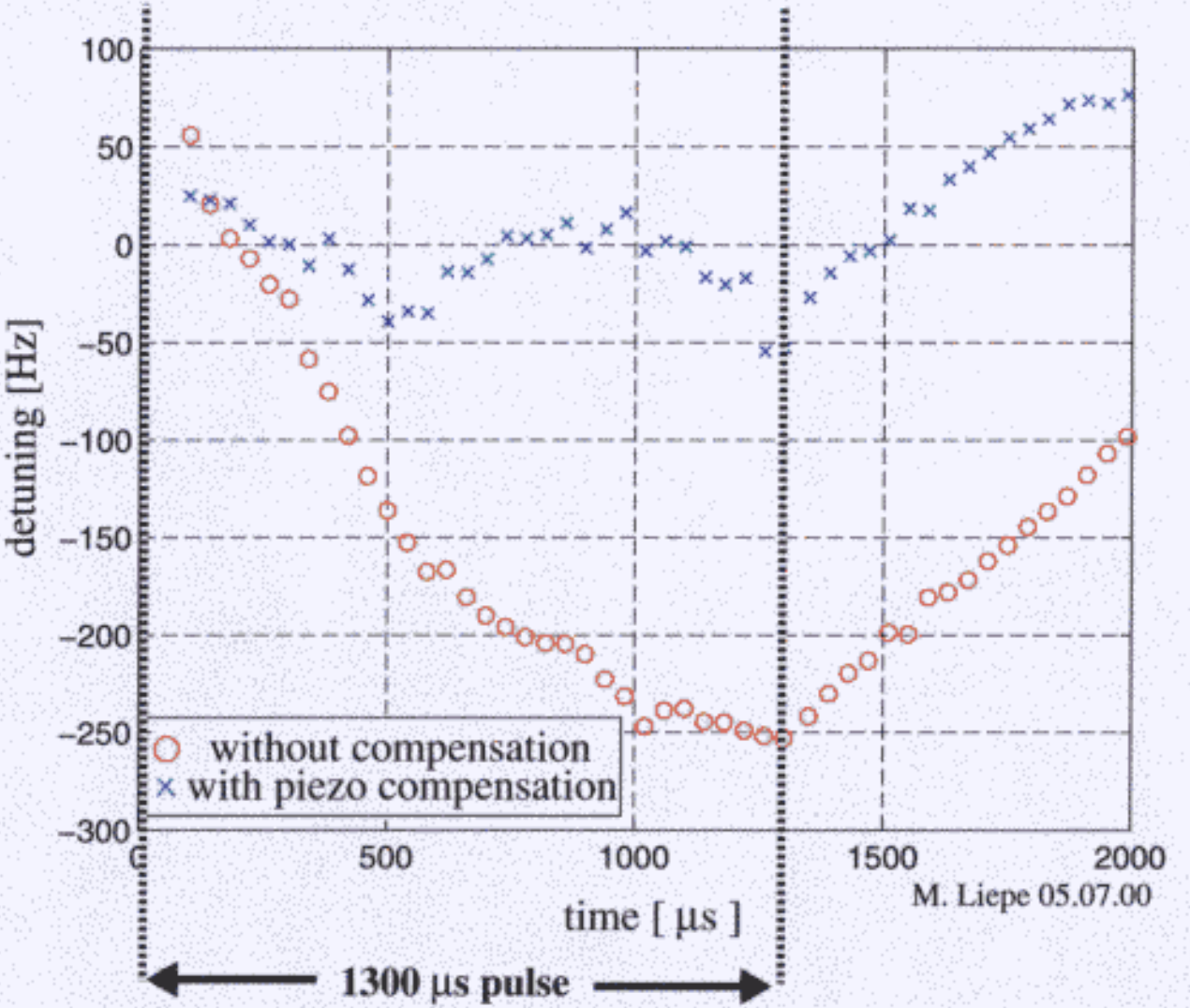


Fast Piezo-Tuner for active Lorentz-force compensation



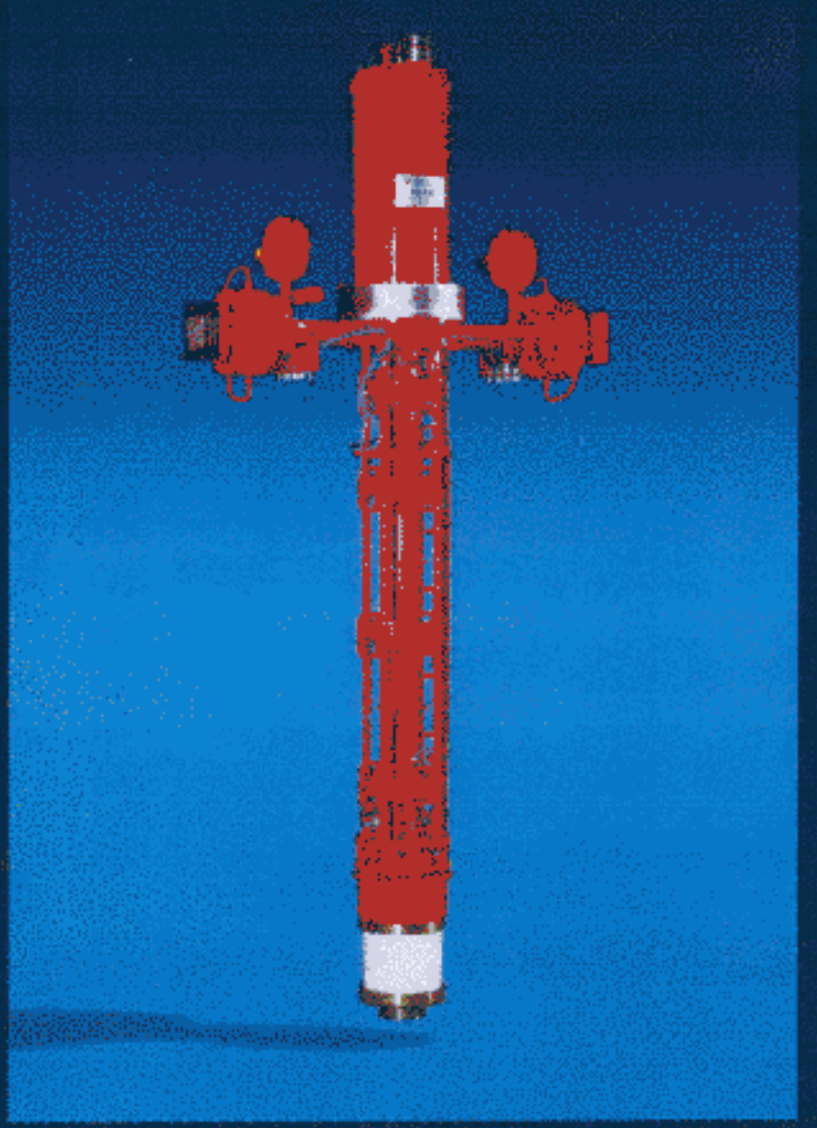
Active Lorentz-Force Compensation during the RF pulse

First *Successful Test on* Cavity C45 at 20 MV/m



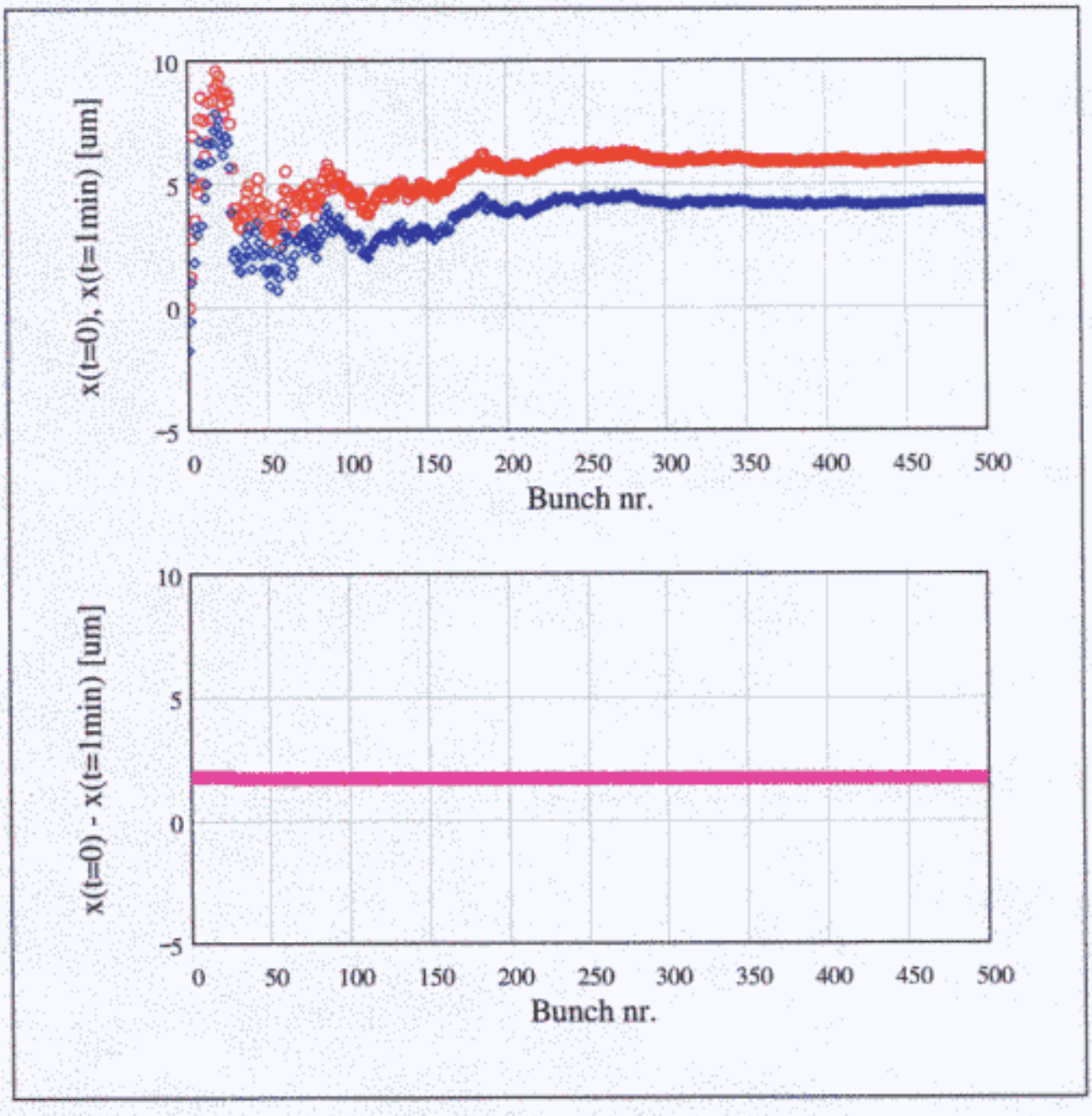
⇒ 200 to 250 Hz detuning compensated!

TH 1801 multi beam klystron



High power	10 MW peak at 1300 MHz
Low voltage	117 kV
High efficiency	65 %
Long pulse	1.5 ms

Bunch train at end of linac at initial time and after 1 minute



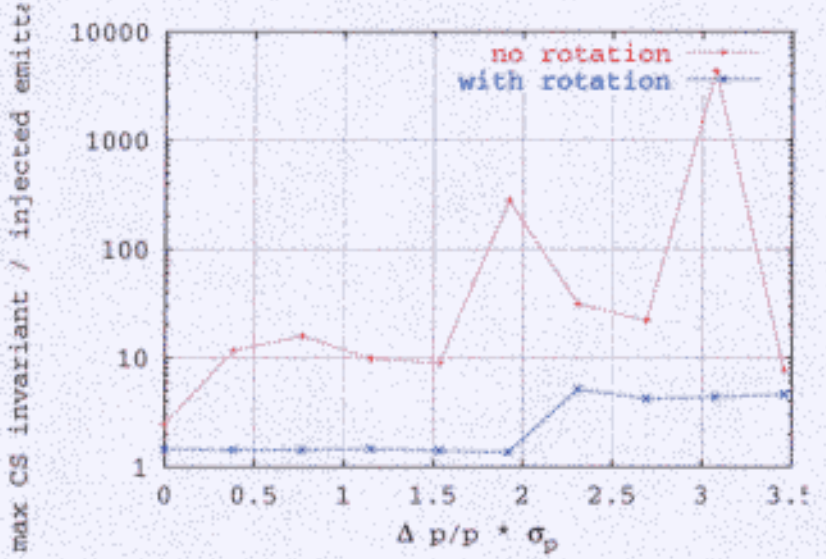
Effects of Emittance Blow Up

- Include misalignment and orbit distortion (0.2 % coupling)
- Tunes at $Q_x = 72.32, Q_y = 39.30$

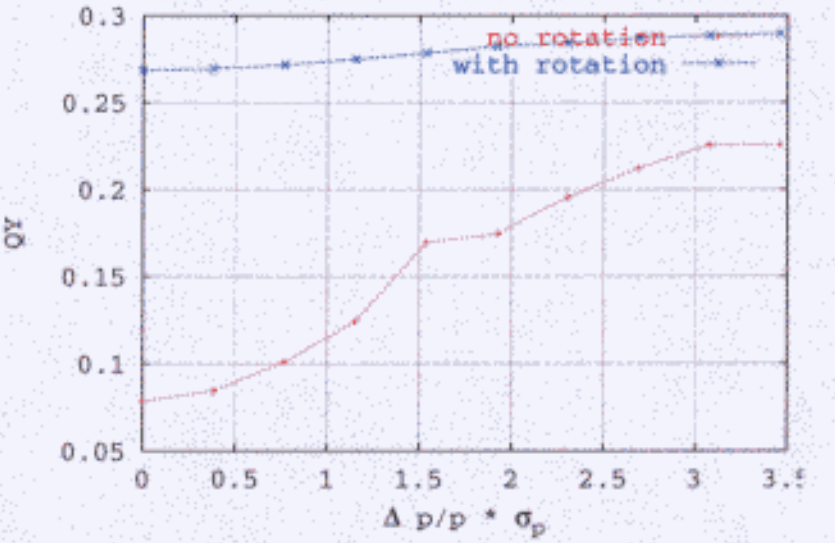
red: no vertical emittance increase in straight sections

blue: vertical emittance increased in straight sections with local coupling bump

Maximum CS Invariant versus initial $\Delta p/p$



Vertical Tune versus initial $\Delta p/p$



TESLA e^+ - SOURCE CONCEPT

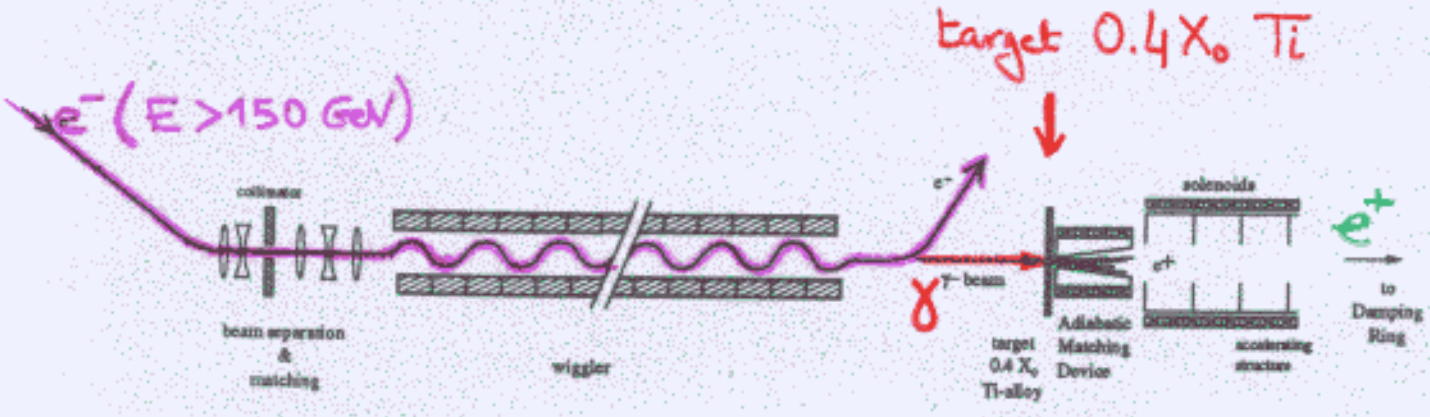
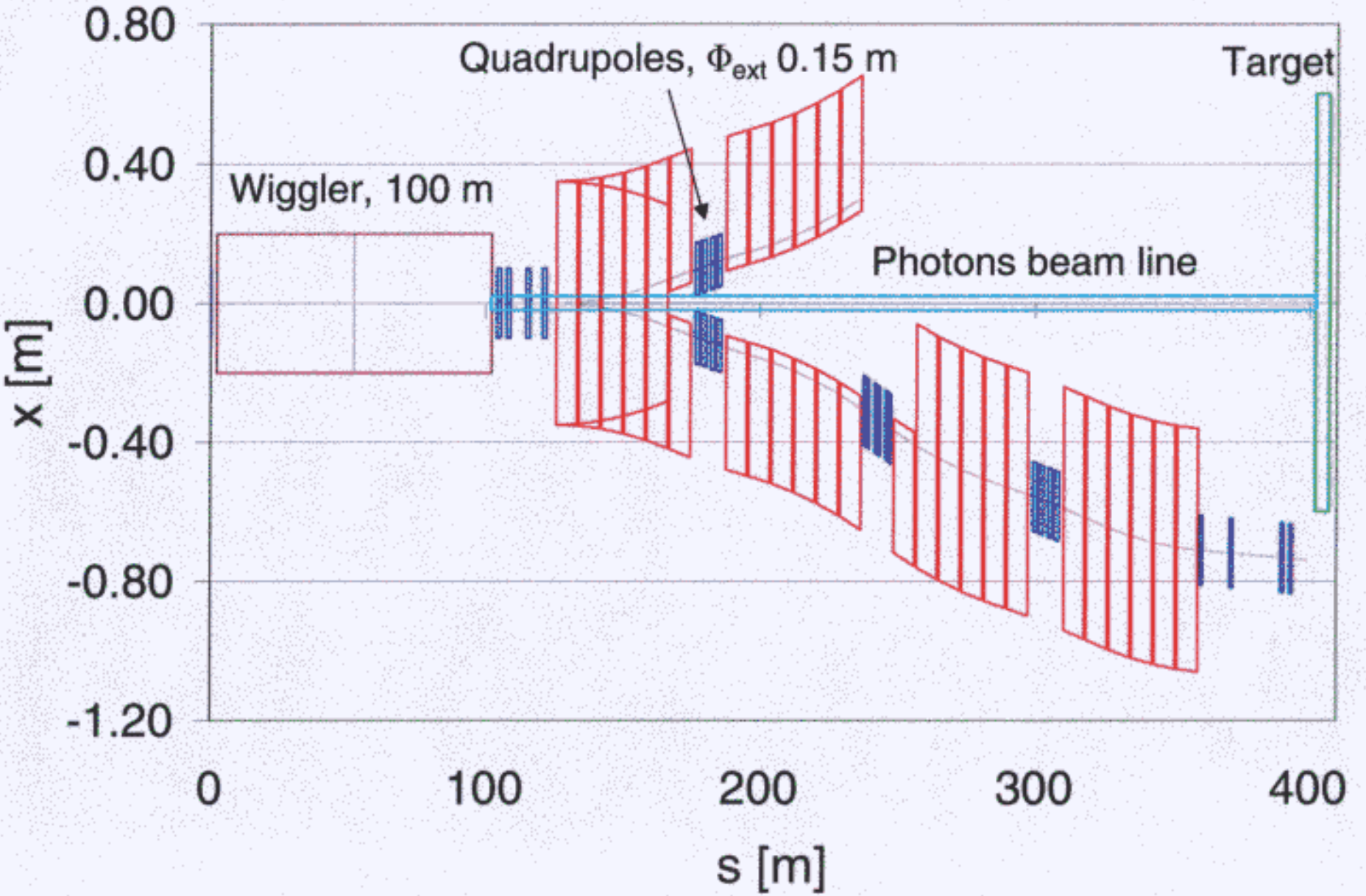


Figure 3.4.4: *Sketch of the positron source layout.*

- Wiggler (60 m, 0.9T) produces
  ~ 340 × N_e photons (E_{e^-} = 250 GeV)
  with $E_c \simeq 37$ MeV (~175 kW)
- Electrons lose ~ 3.9 GeV
  with $\left(\Delta E/E\right)_{RMS} \simeq 1.8 \times 10^{-3}$


0.80
0.40
0.00
-0.40
-0.80
-1.20
x [m]
Quadrupoles, Φext 0.15 m
Target
Wiggler, 100 m
Photons beam line
0
100
200
300
400
s [m]

e^+ source and polarisation

- Source now upstream of IP (exit of linac)
- IP e^- $\Delta P/P \sim 1.8\times10^{-3}$ [e+ ~4×10^{-4}]
- Polarisation from helical undulator [250GeV]:

  ~40% at full e^+ intensity

  ~55% at 60% intensity

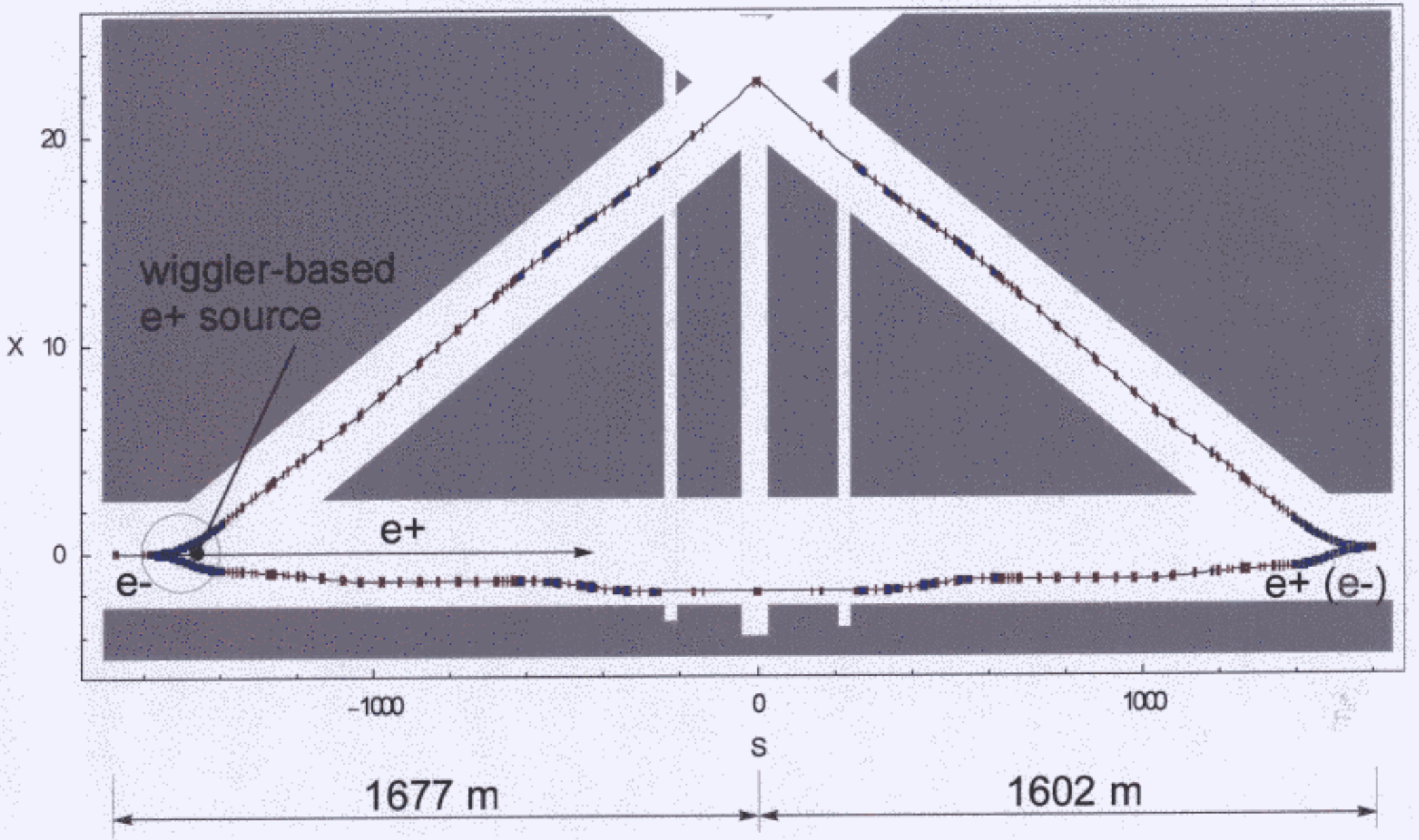
Problem: photon beam must be collimated

[77% of power for 55% case (480 kW, r = 0.42mm) !!!!]

NOTE: **NO** polarised e^+ at turn-on
[upgrade only]

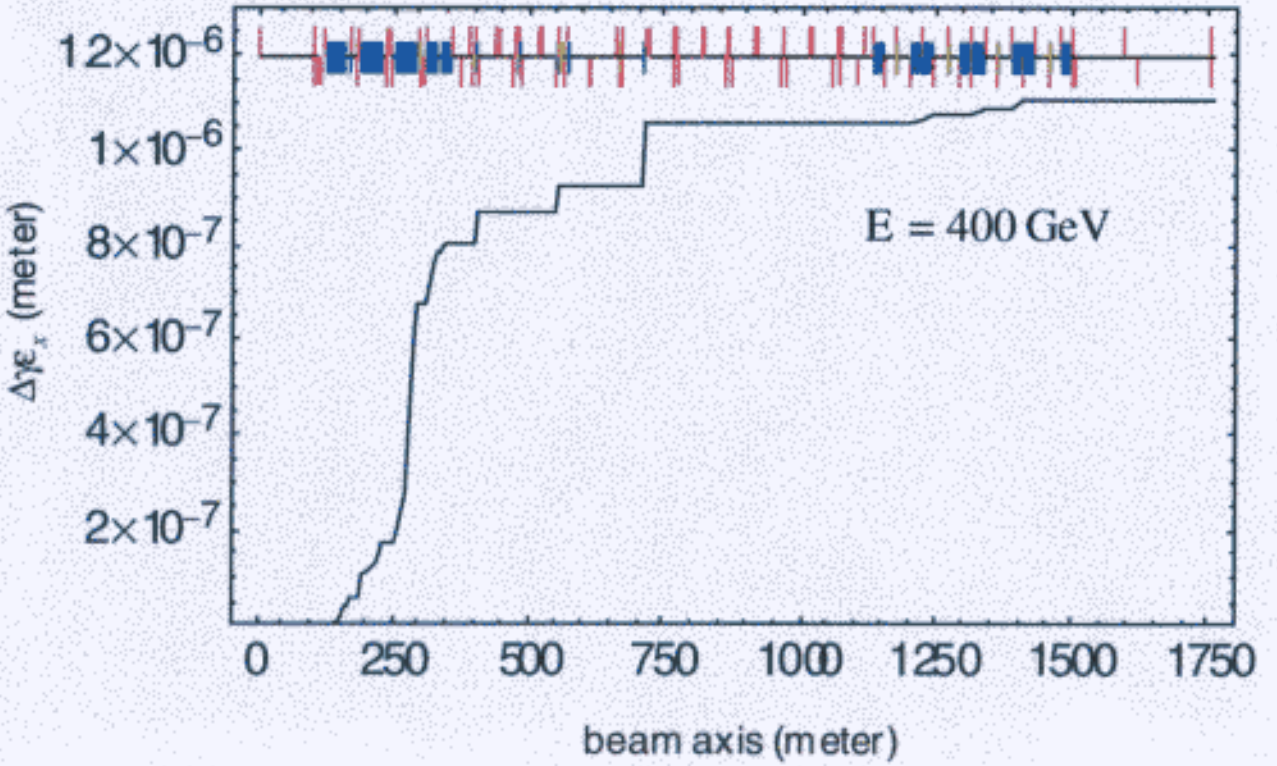
$\gamma\gamma$ collider at TESLA

- No beamstrahlung constraint on σ_x
  - Reduce $\sigma_x = \sqrt{(\varepsilon_x / \gamma)\beta_x^*}$
- Limits from current machine:
  - factor of 4 in $\gamma\varepsilon_x$ from damping ring [space charge limit]
  - With current BDS system: β_x^* can be reduced from 14 mm to 2-4 mm [Note fundamental limit: new FFS design may do better]
- Factor of 4 in geometric luminosity over e^+e^-


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

$\gamma\gamma$ collider at TESLA

- Synchrotron Radiation Loss in ARCS



$$\Delta\varepsilon \propto \frac{E^6}{L^4}$$

Need to increase
L ~100m

Current geometry
OK!

Machine TDR & Costs

- Currently consolidating design and costing components
- LINAC cost will be based in modified TTF structure NOT super-structure
  [conservative approach]
- Engineering designs for DR and BDS (inc. costs) approaching completion

TDR

• Overview	15 pages
• Status of R&D	25 pages
• Main Linac	40 pages
• Injection Systems	30 pages
• Damping Ring	20 pages
• Bunch Compression	15 pages
• Beam Delivery System	25 pages
• Infrastructure	40 pages
• FEL	60 pages
• Cost Estimate	10 pages
• Project Management	10 pages

290 pages

Last Comments

- Still lots of work to do
- writing panic due to start about ... NOW!