PETRA III
A High Brilliant Synchrotron Radiation Source in the Hard X-ray Regime

K. Balewski et al.

DESY

Overview

- Introduction
- Basic Parameters for PETRA III
- How to achieve the design parameters?
- Technical aspects

Introduction

Present situation @ DESY:

DORIS III: 9 wiggler beam lines and 30 bending magnet stations

high flux at hard x-rays (E=4.5 GeV, I=150 mA, C˜ 300 m)

large ε_x=400nmrad

PETRA II: 1 undulator with two experimental stations

hard x-rays (E=11-12 GeV, I=50 mA, c=2304 m)

emittance (ε_x=25nmrad)

but only parasitically available

Introduction

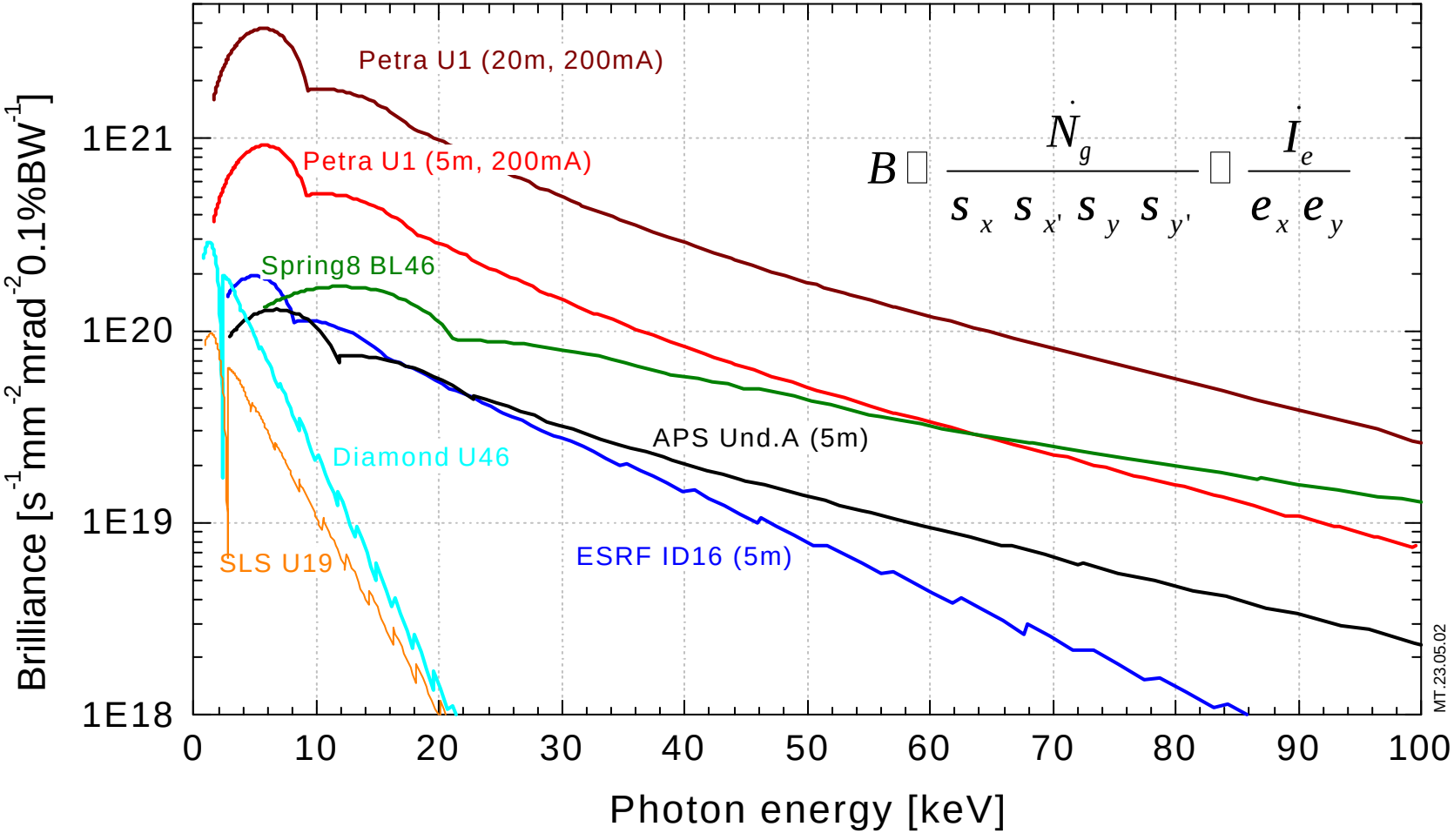
Near and far future @ DESY: Linac based light sources

- VUV FEL (TTF phase II)
- X-FEL (supported by German science ministry)

and

Strong user demand: (Komitee für Forschung mit Syn.)
international competitive ring based light source

Comparison of brilliance



Parameters of PETRA III

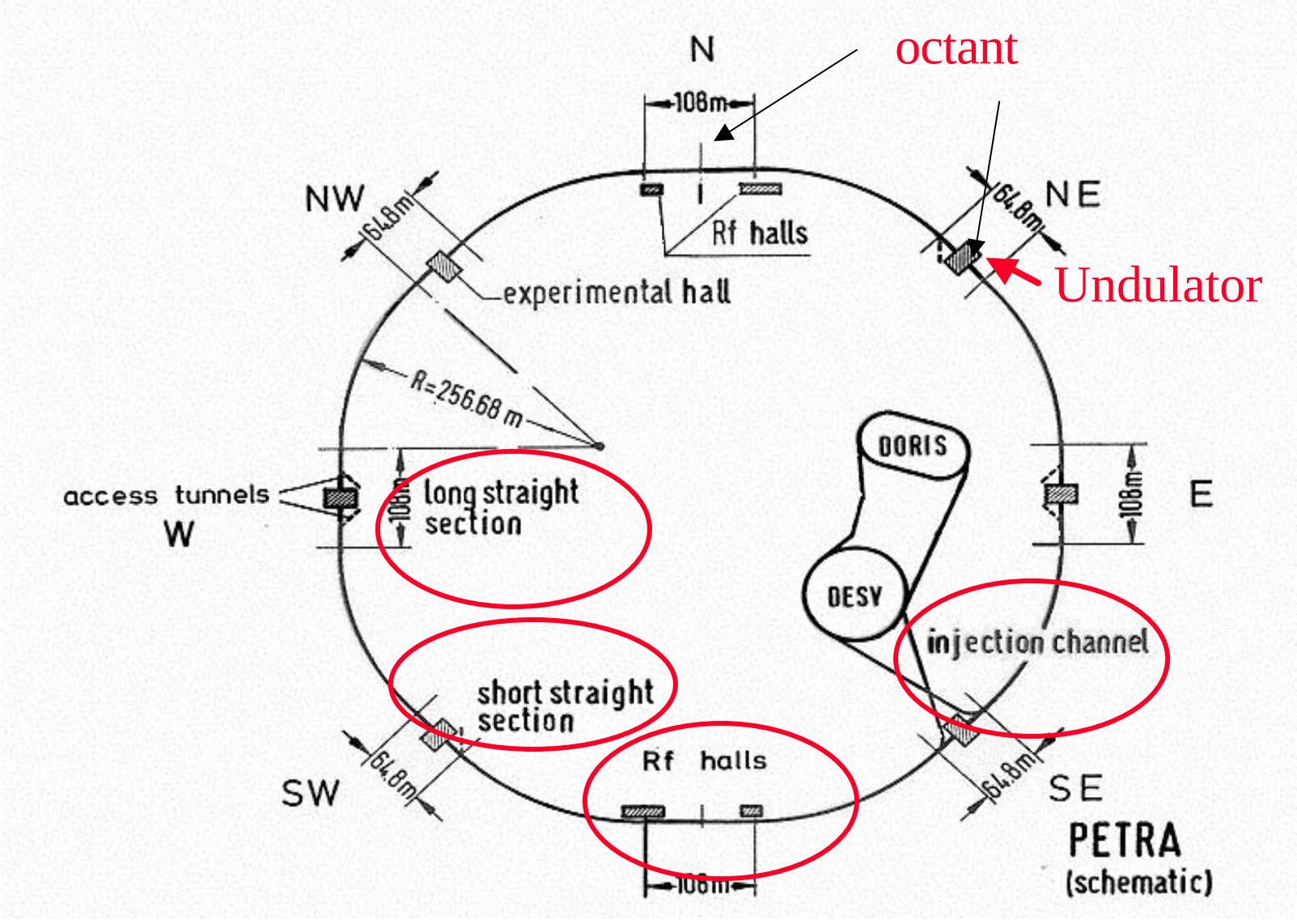
Parameter	
# insertion devices	13
energy (GeV)	6
max. current (mA)	>100
ε_x (nmrad)	1
ε_z (nmrad)	0.01

Parameters of PETRA III

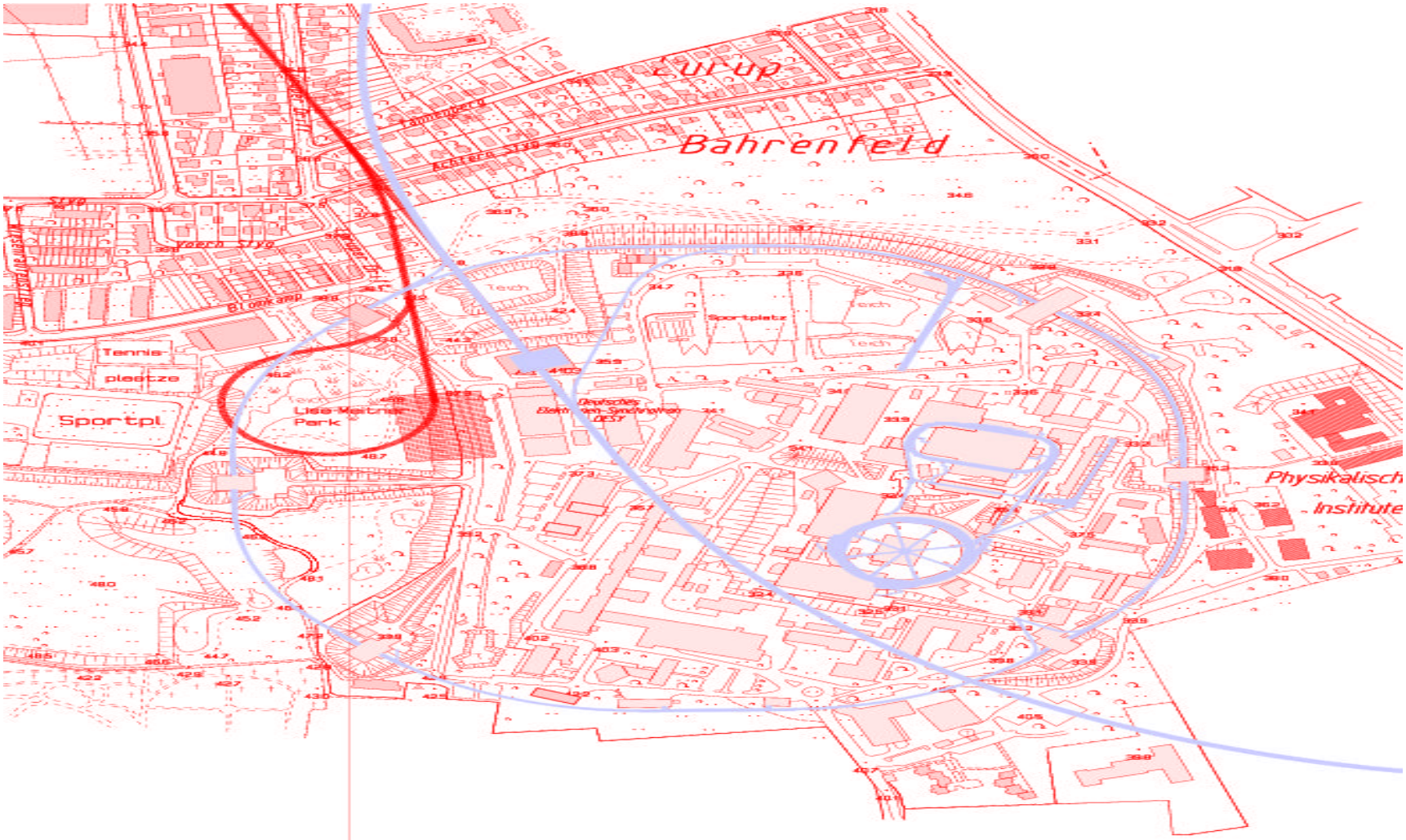
Task list:

- How to make room for 13 insertion devices?
  - Optical function at the ID
- How to get such a small emittance?
  - dynamic aperture
  - orbit stability
  - Touschek lifetime
- How to achieve 100 mA?

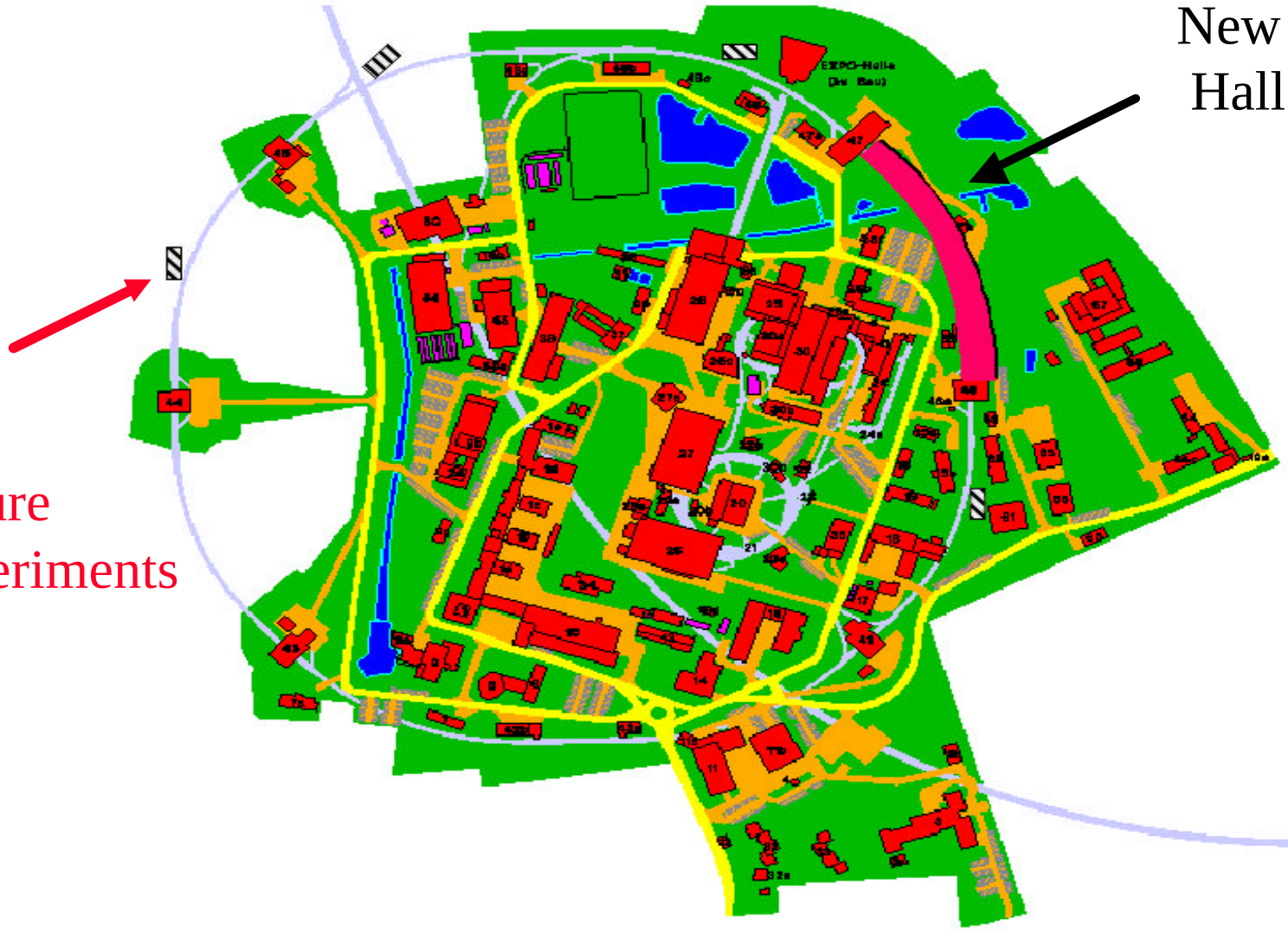
PETRA II


N
octant
108m
NW
64.8m
Rf halls
NE
64.8m
experimental hall
Undulator
R=256.68 m
DORIS
access tunnels
W
108m
long straight section
108m
E
DESY
injection channel
short straight section
Rf halls
64.8m
SW
64.8m
SE
108m
PETRA
(schematic)

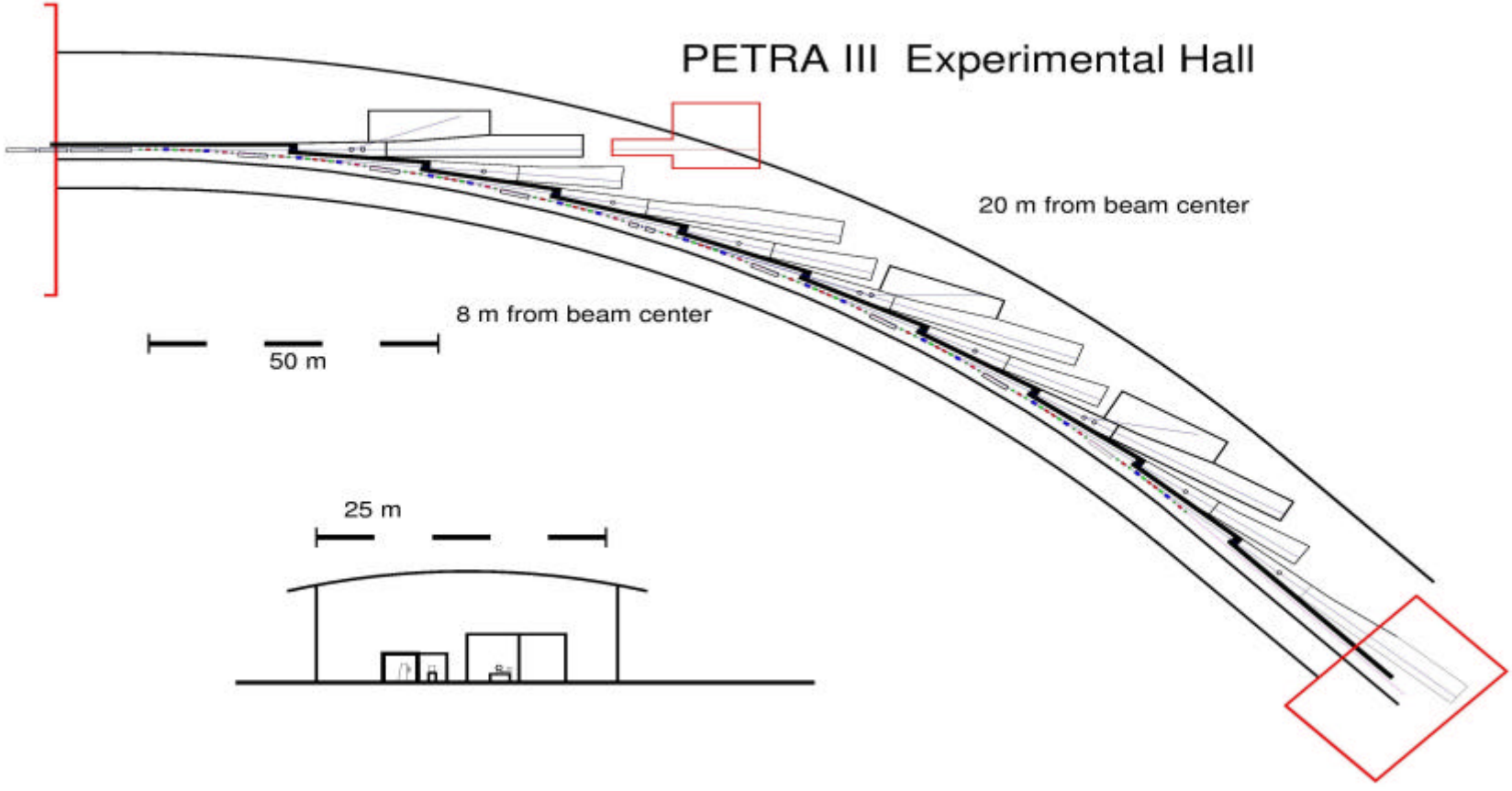
DESY Side


Curup
Bahrenfeld
Tennis-
plaetze
Sportpl
Sportplatz
Physikalisch
Institute

PETRA III



PETRA III
New Experimental Hall

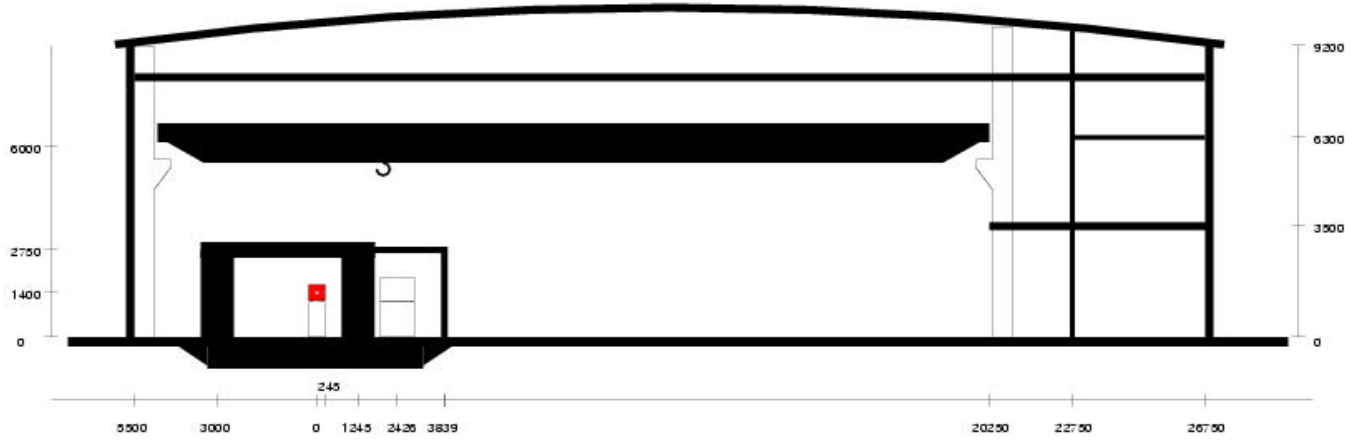


PETRA III
neue Experimentierhalle

PETRA III Experimental Hall

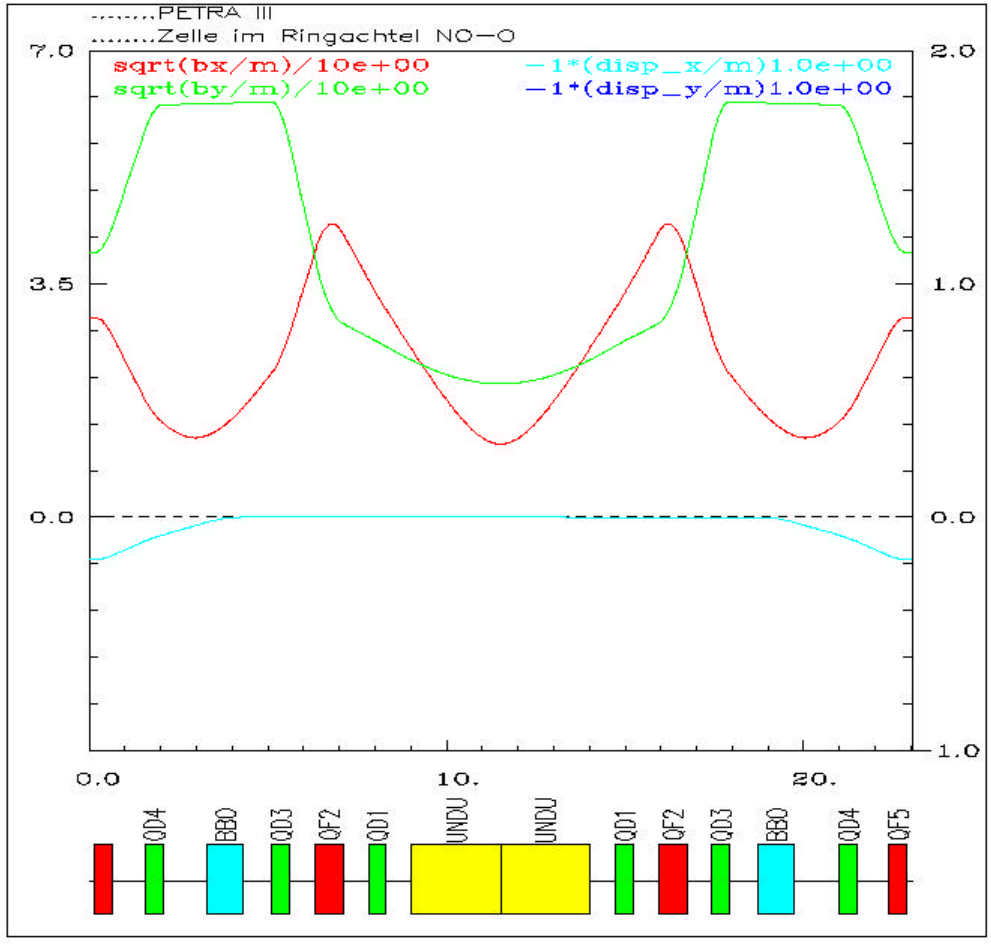
Cut 8 through QA4 in cell 2

beam separation is 244.7 and 2426.5 mm



HF, Version 20.2.2003

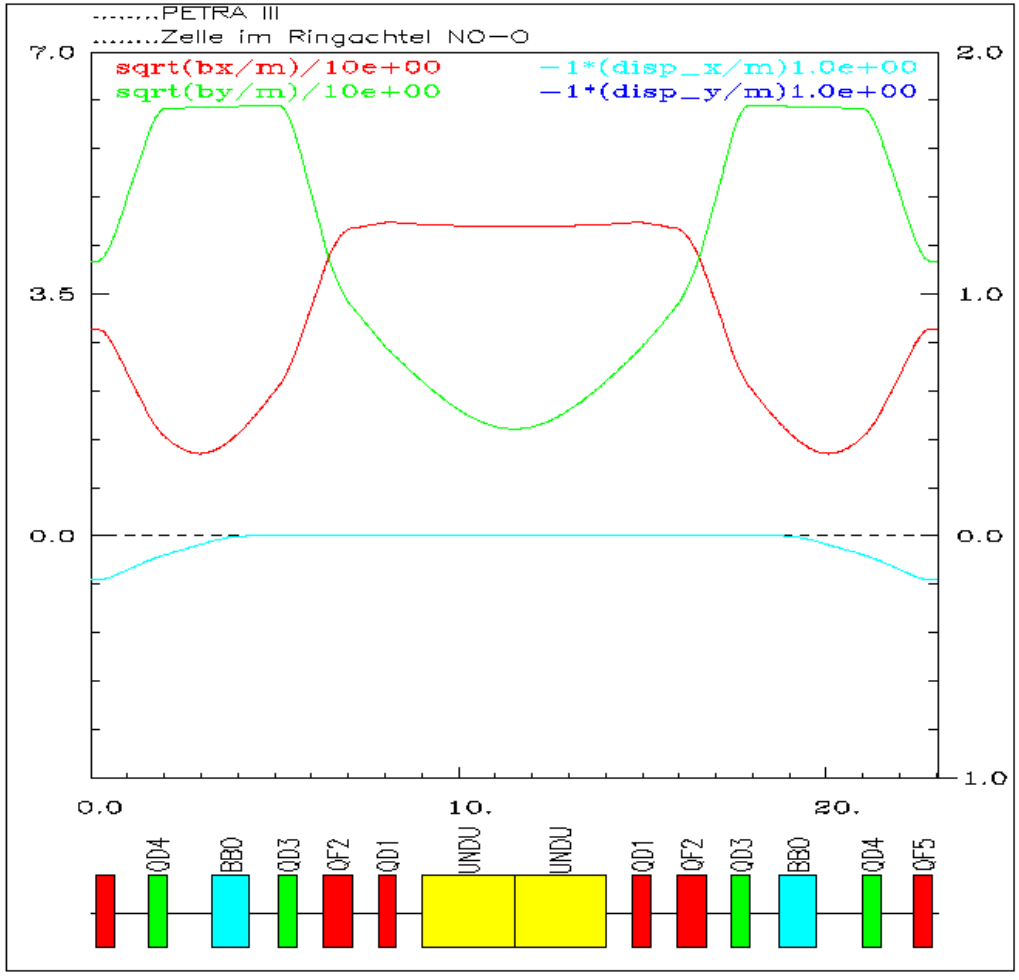
PETRA III
Low b_x Cell (b_x=1.2m & b_z=4m)



L_{DBA}	(m)	23
L_D	(m)	1
ρ_D	(m)	23
l_{DD}	(m)	6.6
l_{UNDS}	(m)	14.4
l_{UND}	(m)	5

4

PETRA III
High b_x Cell (b_x=20m & b_z=2.4m)



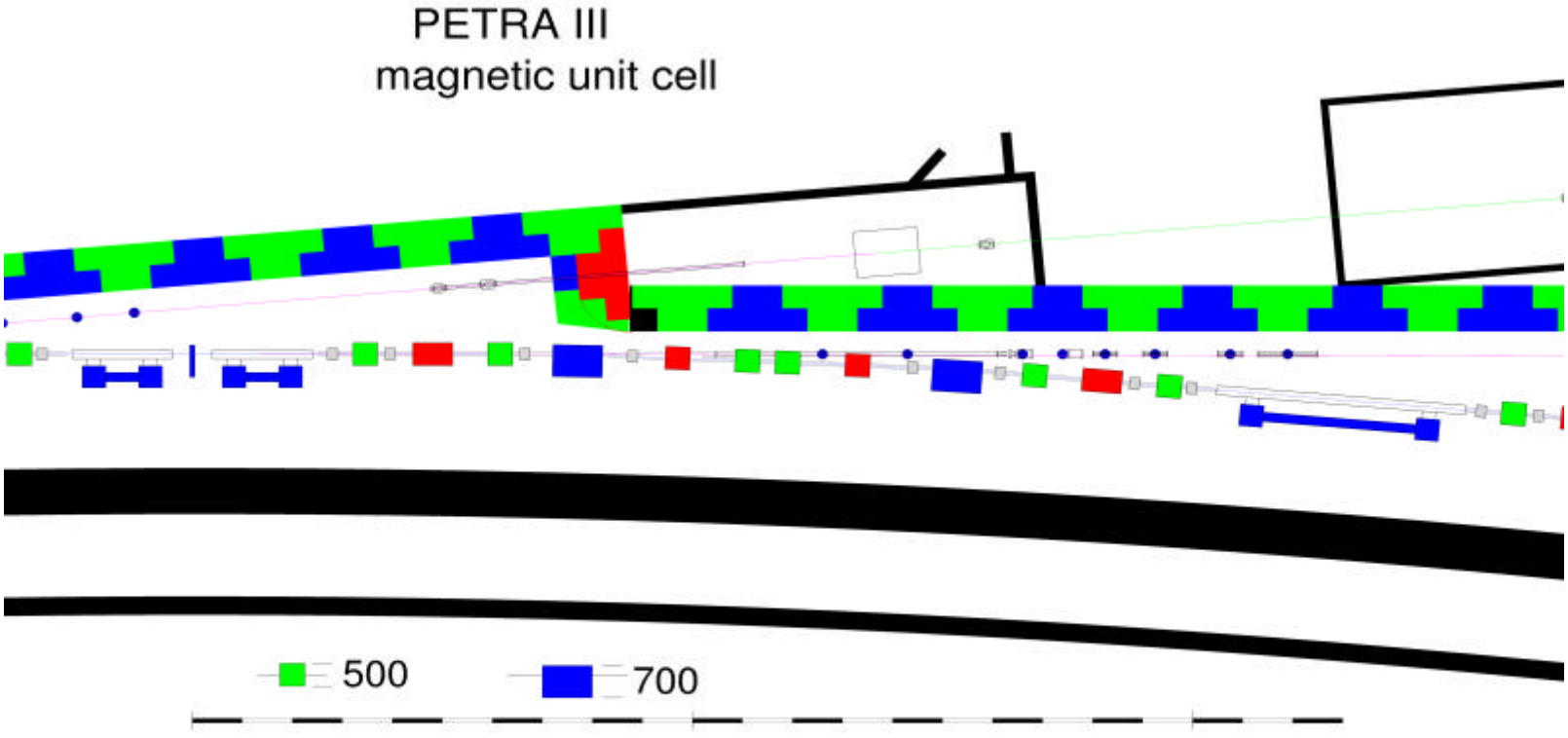
ID properties		unit
λ	2.1	cm
B	1	T
cham. Height	7	mm
cham. Mat.	Al	

Design constrains
- low ?
- low e

D_x small ? no sextupols here

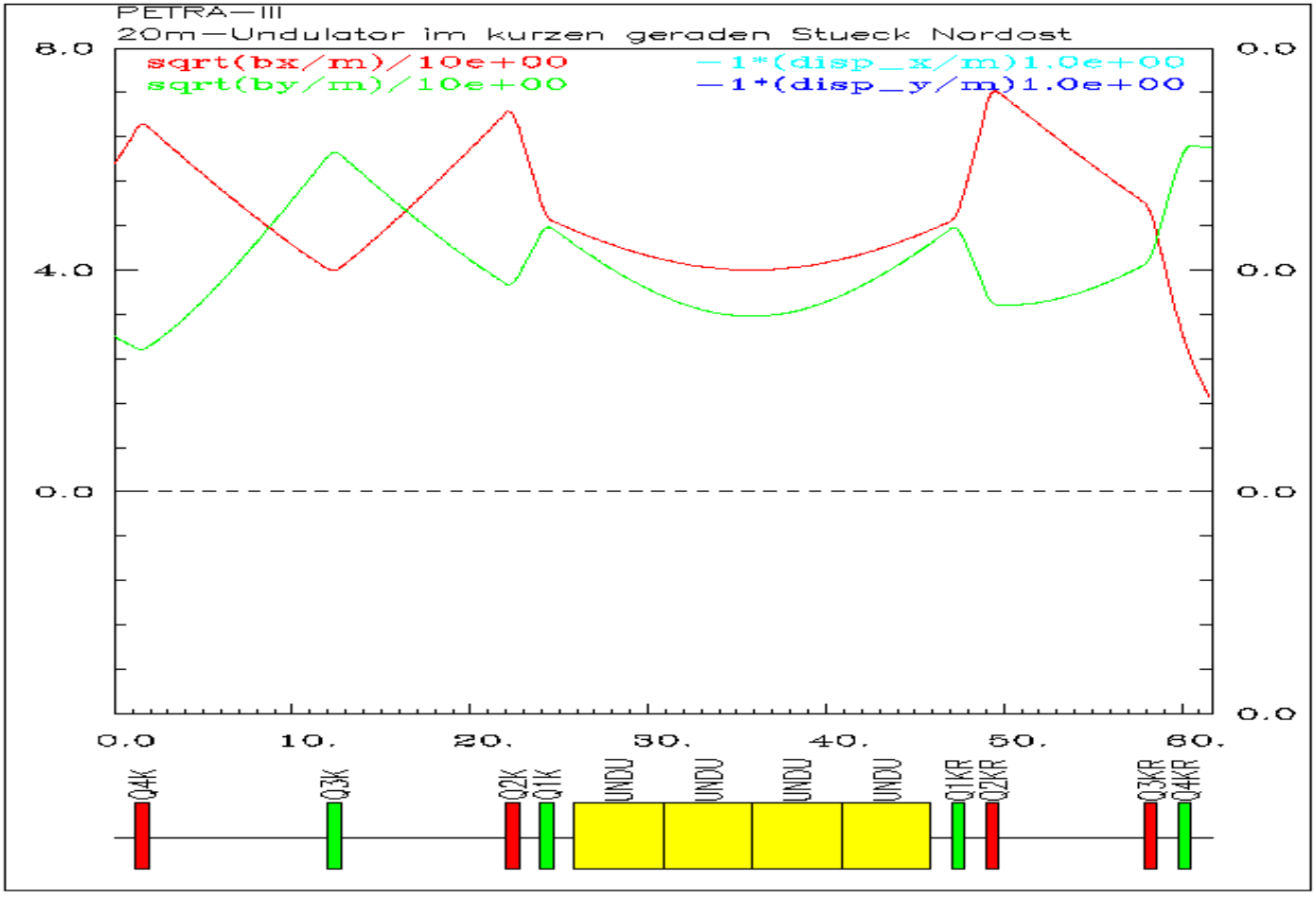
4

PETRA III
section of experimental HALL



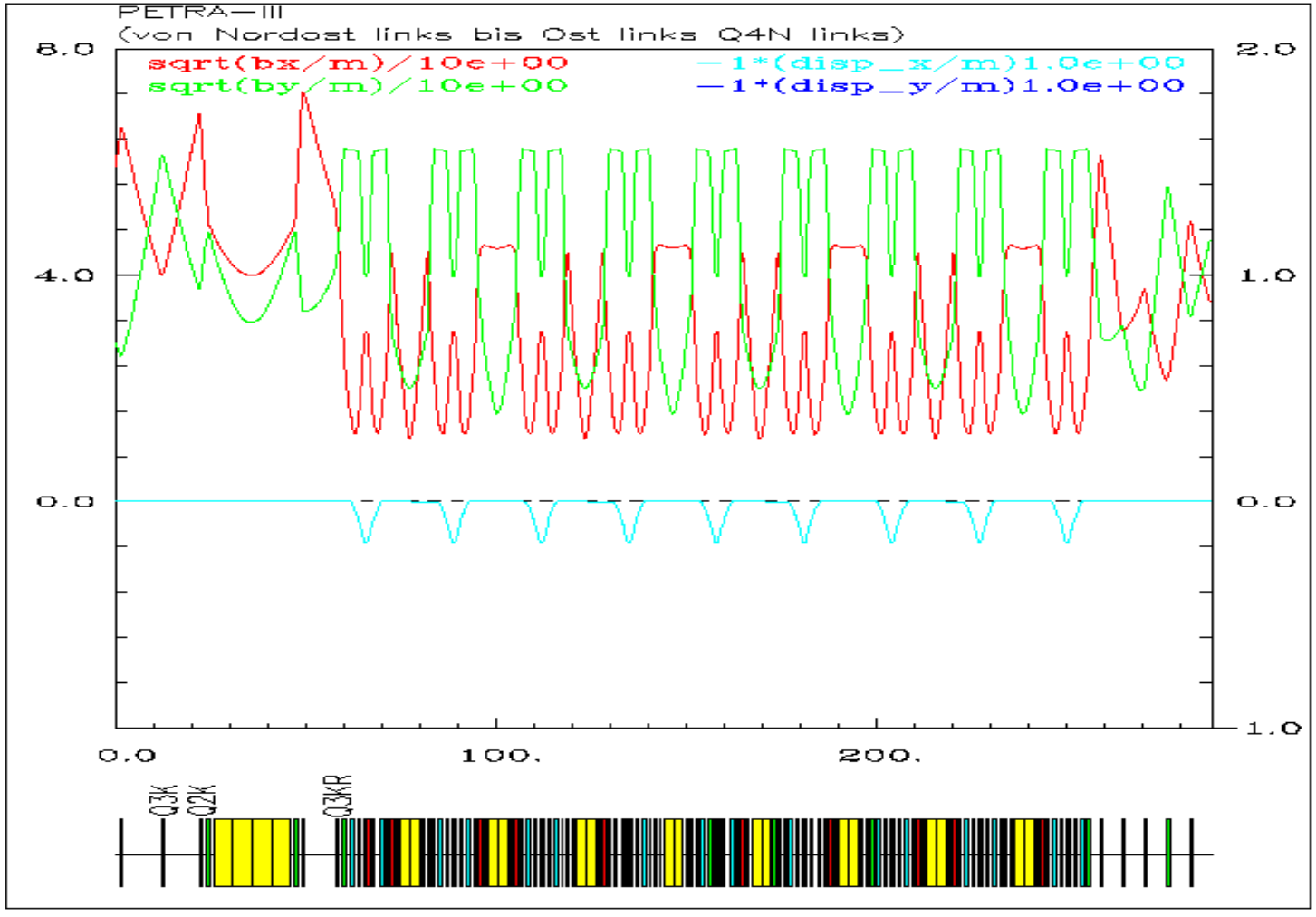
HF, Version 13.2.2003

PETRA III
long (20m) undulator in short straight



1

PETRA III
Optics of New Octant



PETRA III
e_x: 1 nmrad

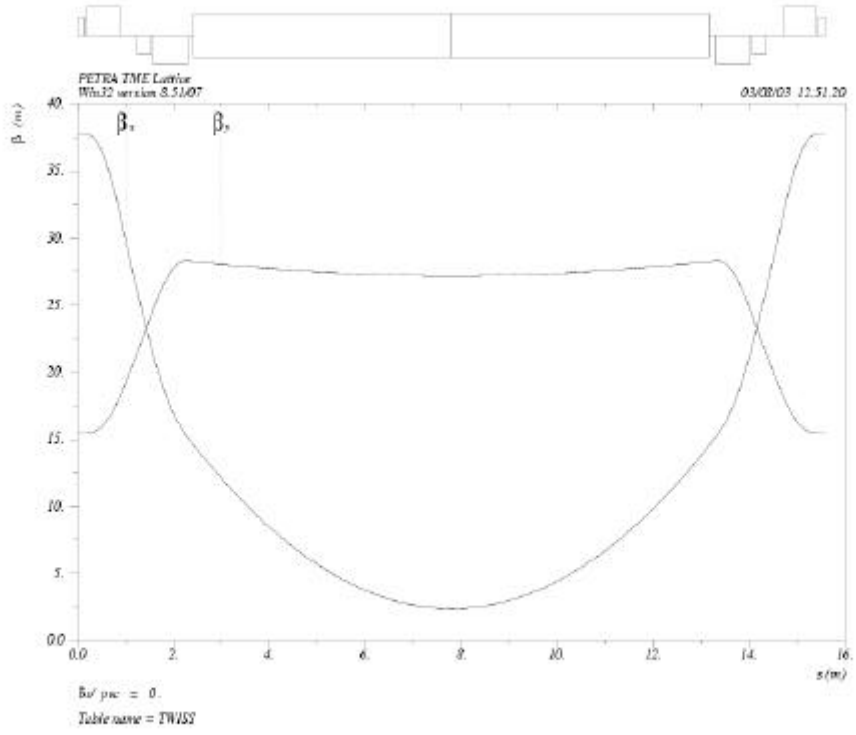
e_x = 6 nmrad @ 6 GeV (present situation)

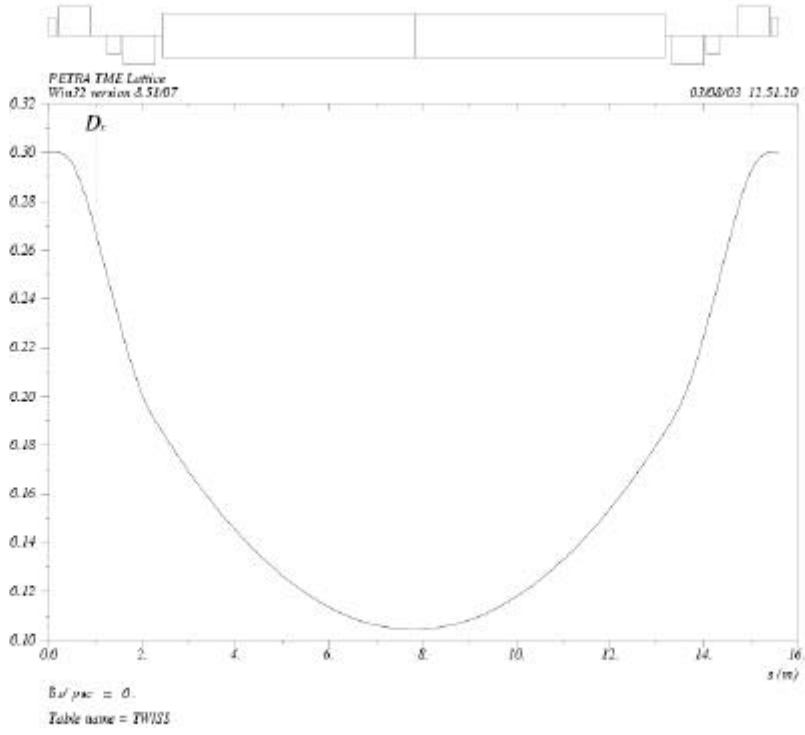
$$e_x \propto f(f_x) q^3$$

Possibilities:

- designing new optics with *existing magnet hardware (TME)*
- designing new optics with *new magnet hardware (FODO 90° shorter dipols)*
- designing new optics with *existing magnet hardware* and use of damping wigglers

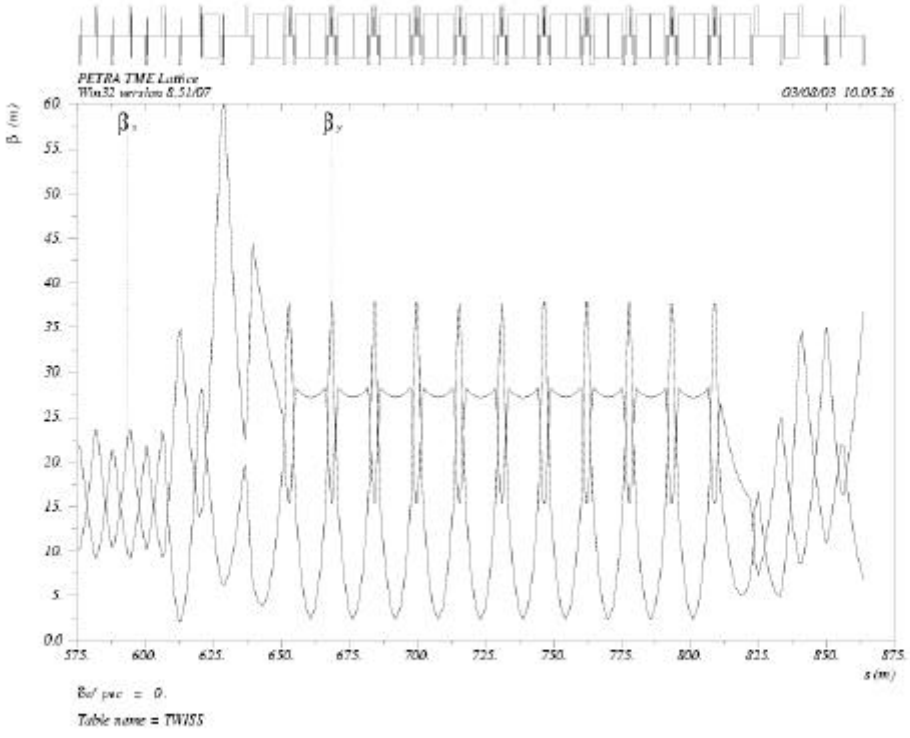
PETRA III
TME Cell

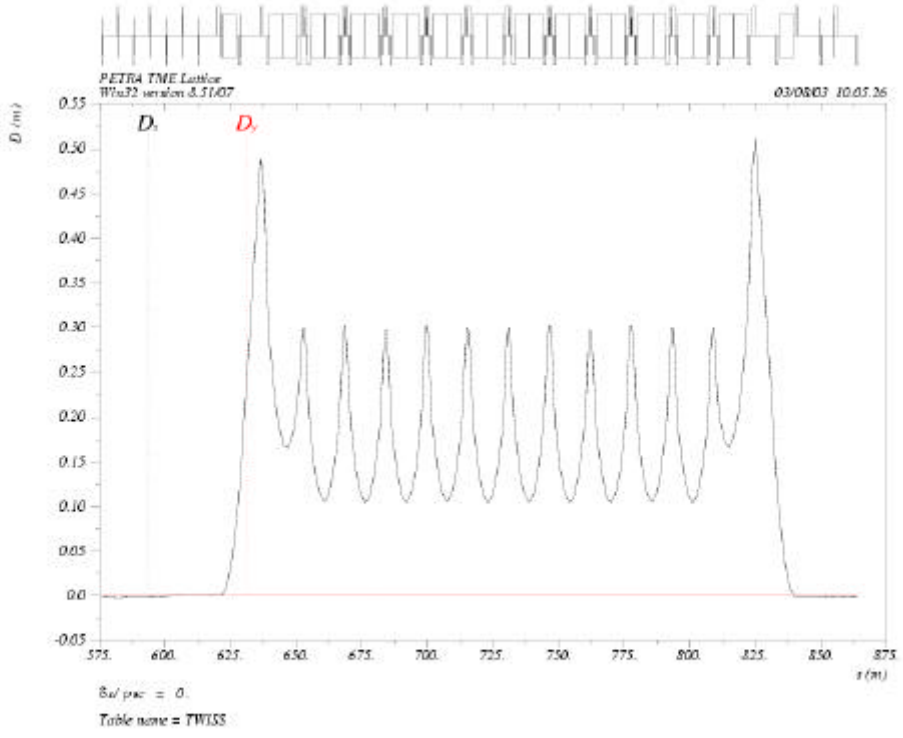




Phase advance of true TME cell 285°
actual phase advance 144°!
Min. of 1-st order sextupol effects

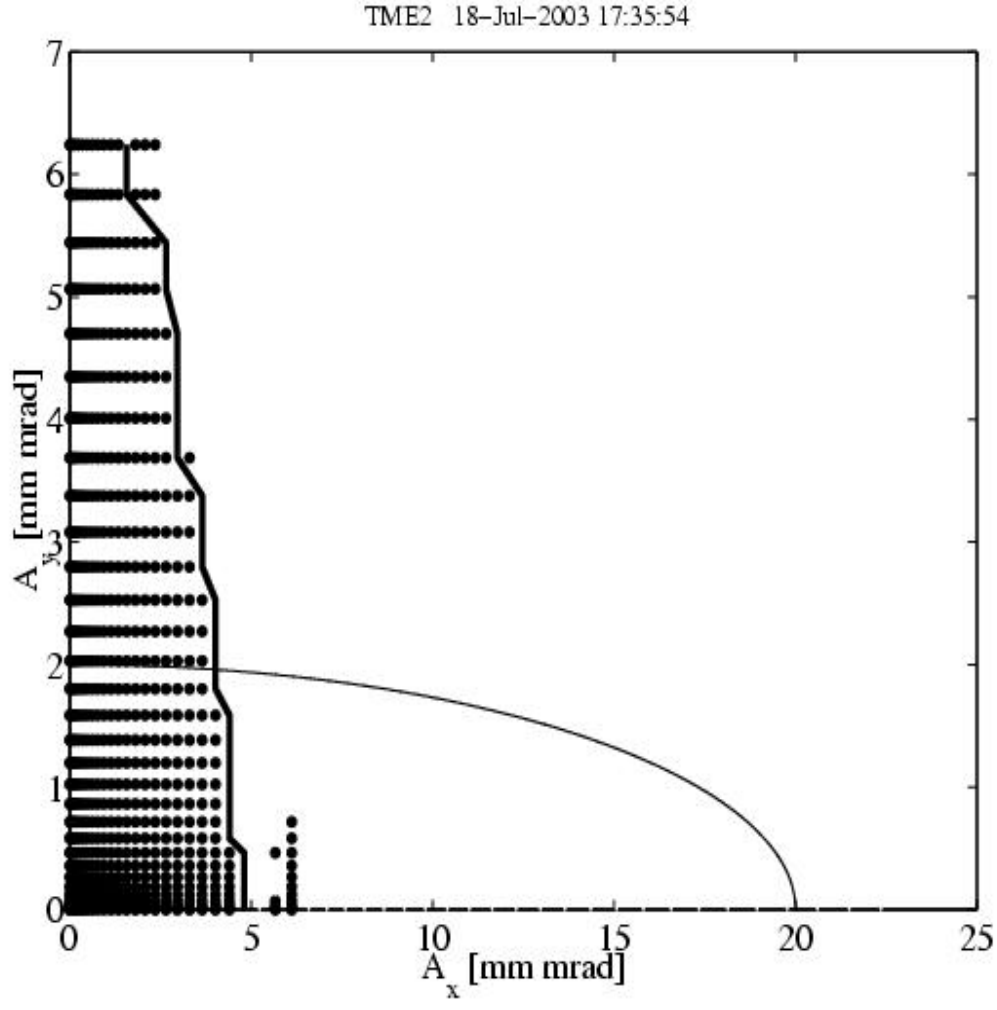
PETRA III
TME Lattice



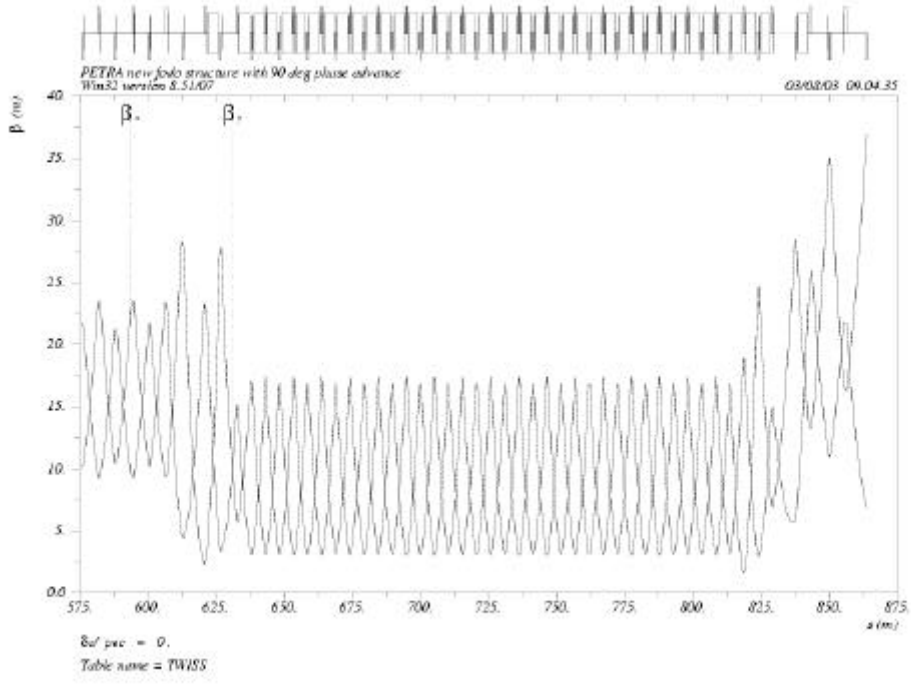


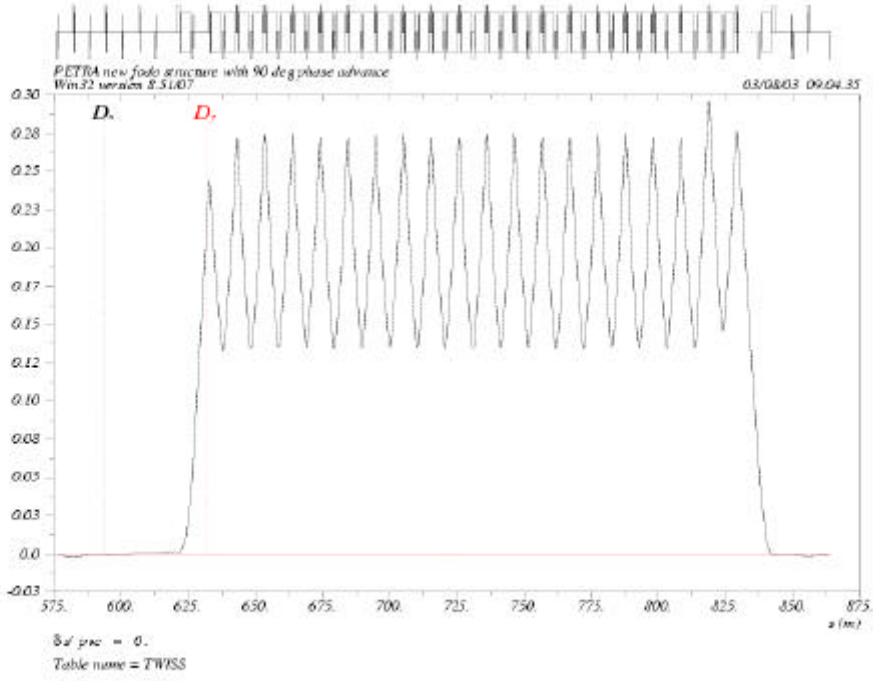
1) Phase advance TME cell 144˚/36°
2) Chromaticity correction in old octants
3) Min. of 1-st order sextupol effects (Sx=15m-3, Sy=9m-3)

PETRA III
TME



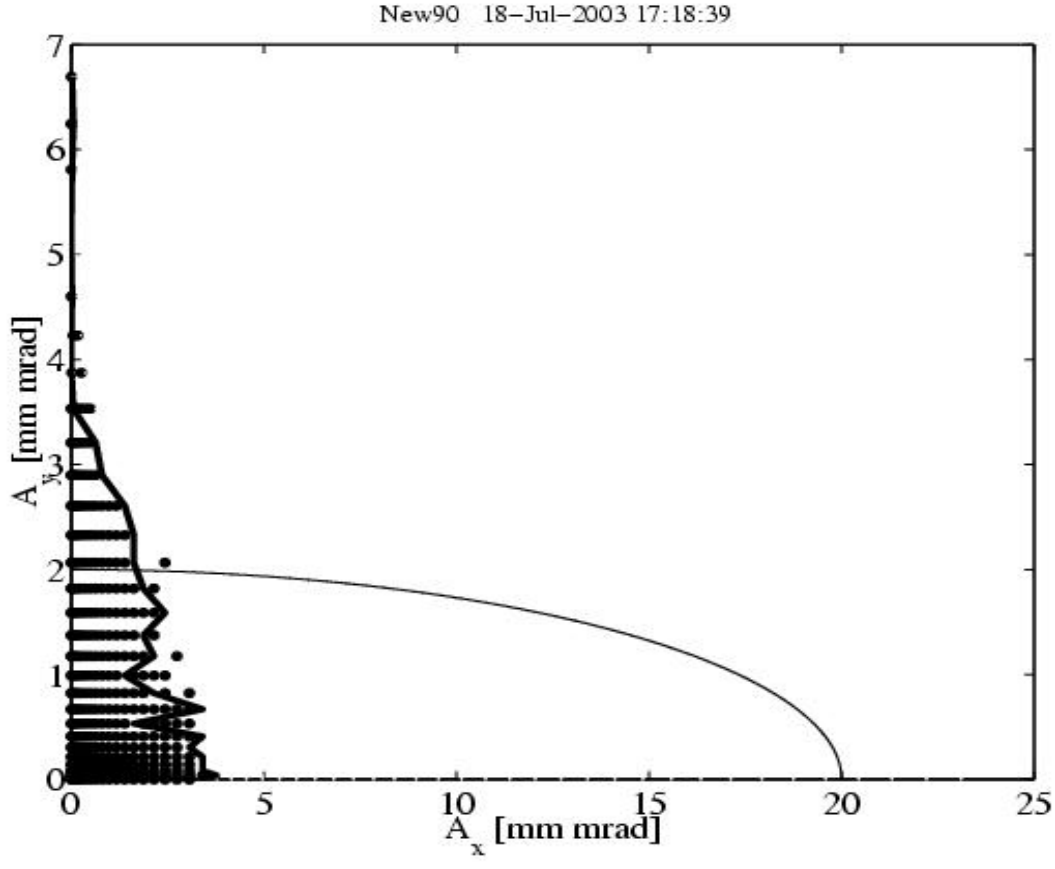
PETRA III
90° / 90° FODO Lattice



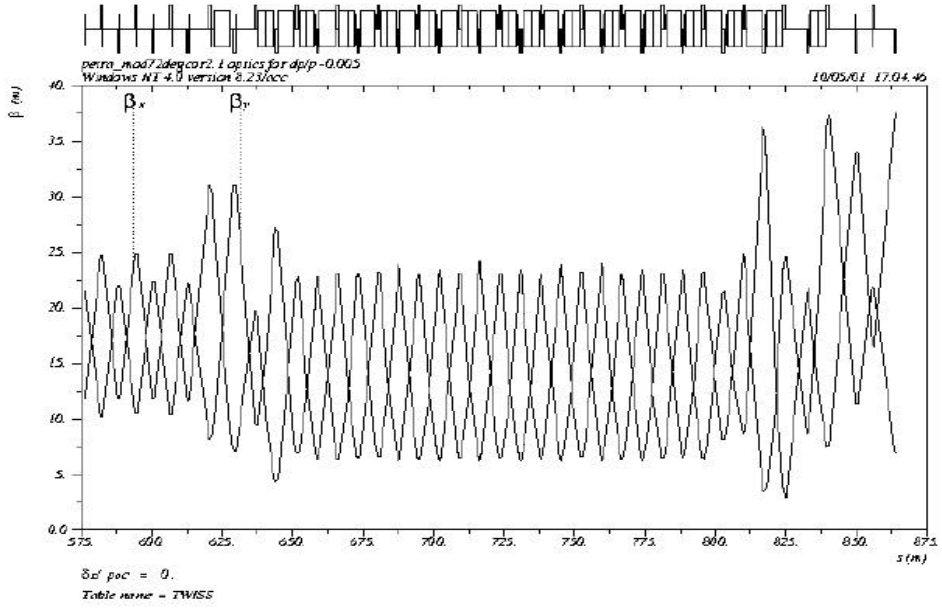


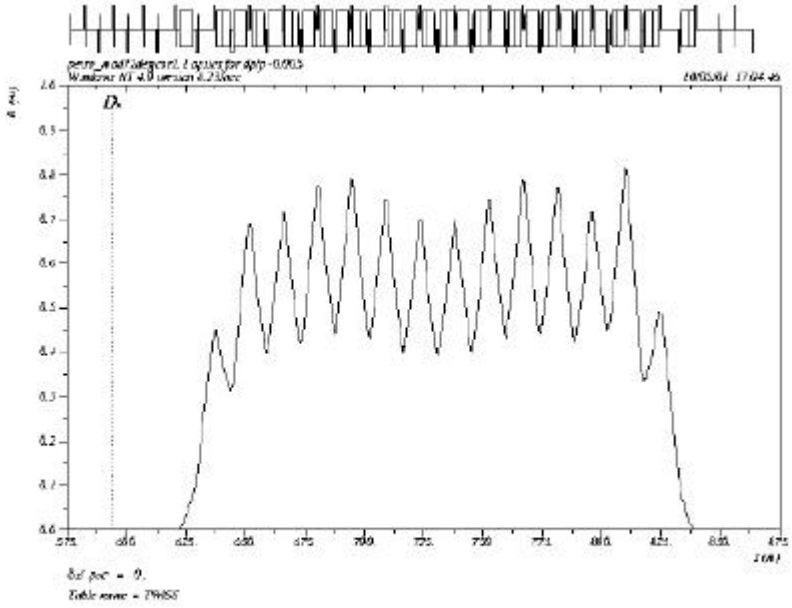
1) Phase advance per FODO cell **90^0**
2) Chromaticity correction in old octants
3) Min. of 1-st order sextupol effects (Sx=19 m-3, Sx=12 m-3)

PETRA III
FODO 90° shorter dipols



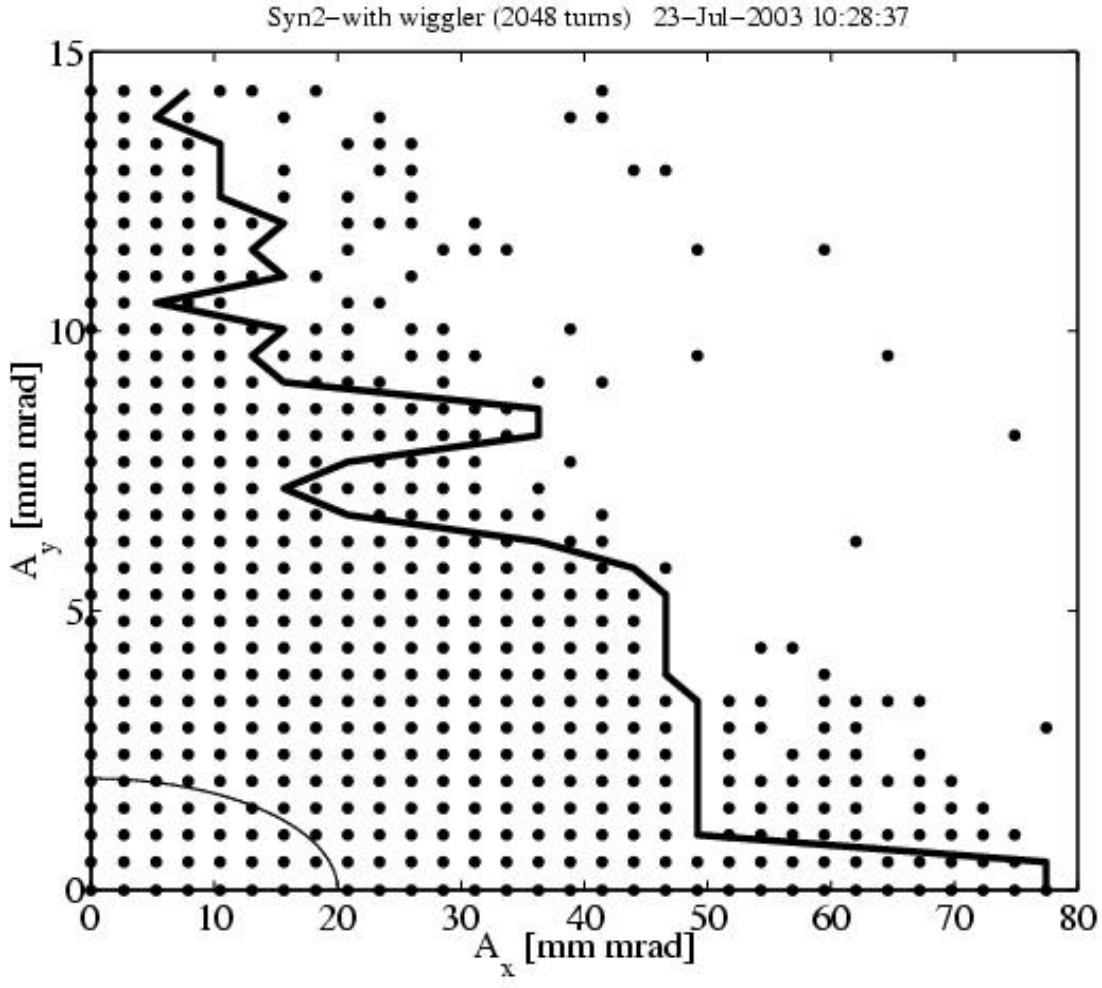
PETRA III
optics of old octant





1) Phase advance per FODO cell **72^0** : compromise between small emittance and sufficiently large dynamic aperture
2) Chromaticity correction in old octants
3) Minimization of 1-st order sextupol effects
4) Alignment tolerances comparable to present status (1/4 mm)

PETRA III
“damping wigglers“



PETRA III
damping wiggler

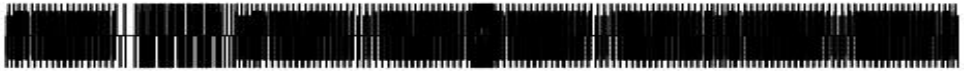
Damping wigglers

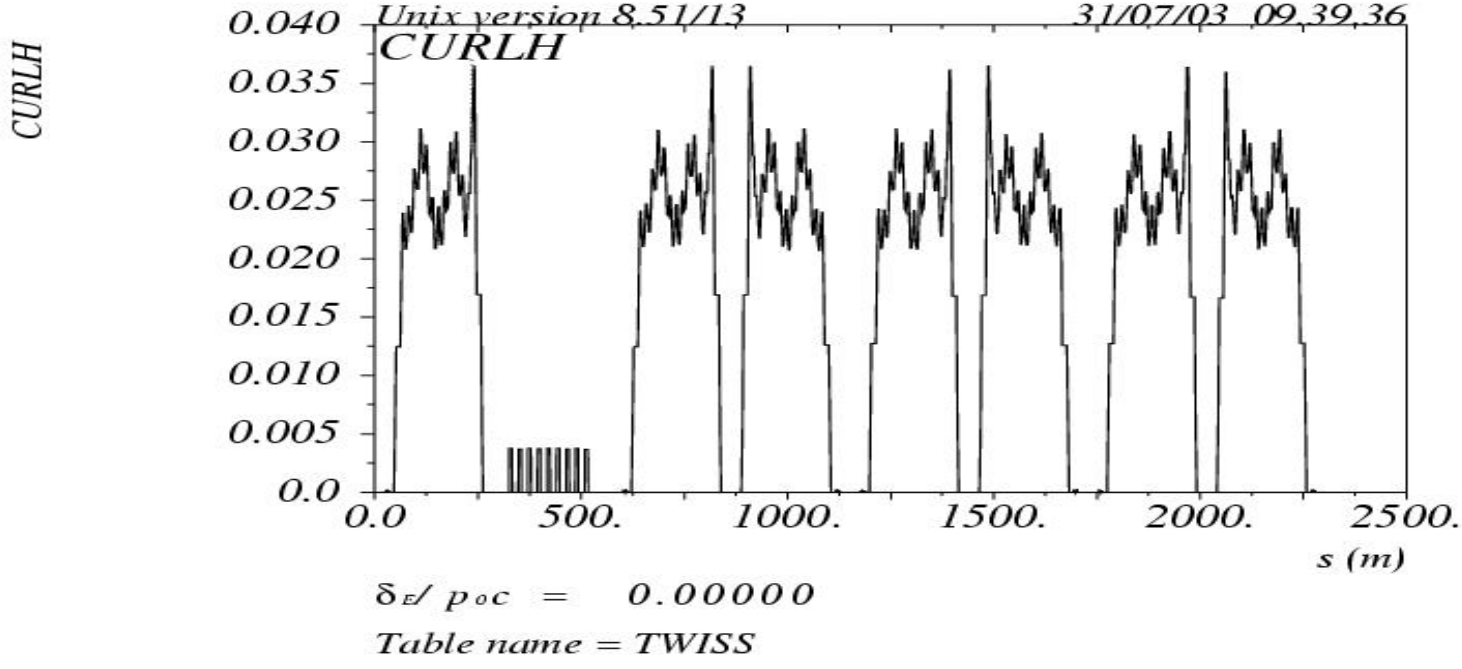
- **B = 1.5 T**
- **l = 0.25 m**
- **h = 0.025 m**
- **L_{tot} = 80 m (4 x 20m)**

e_x: 4 ® 1 nmrad

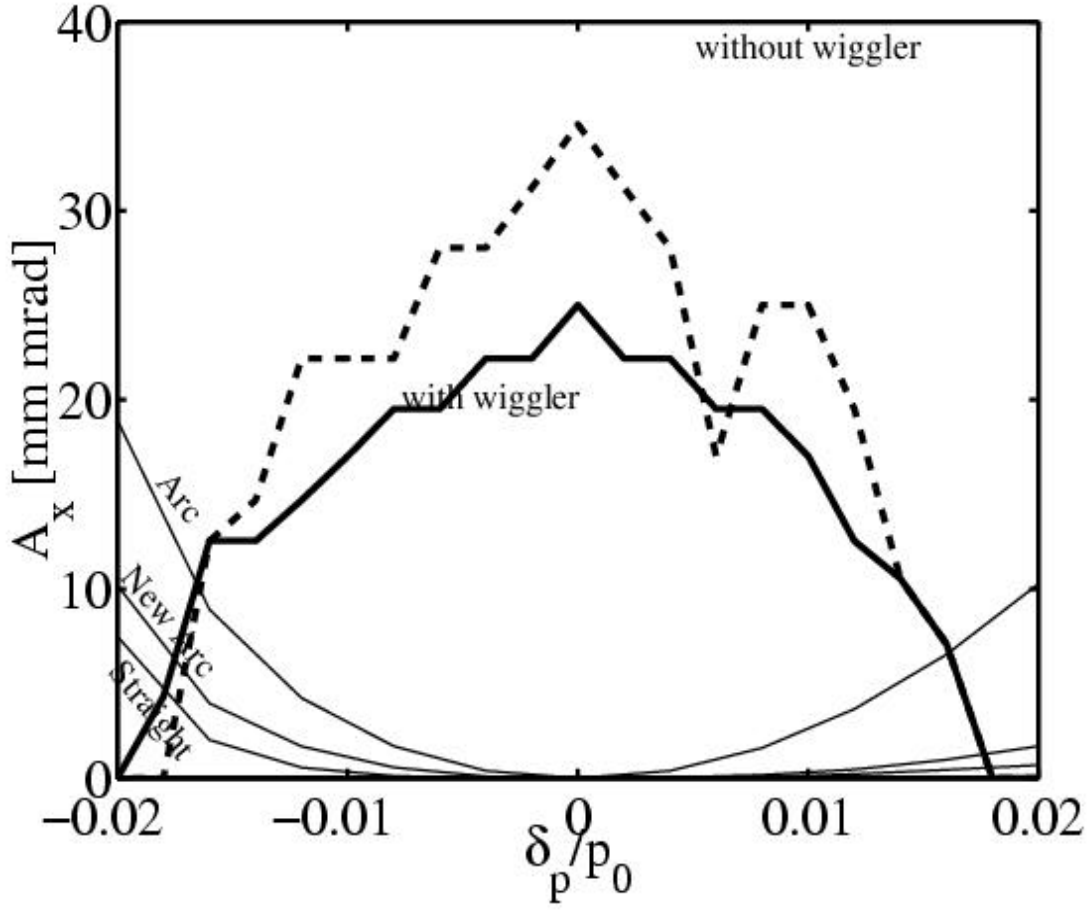
PETRA III
Toushek Lifetime

$$\frac{1}{t} \propto \frac{N_B}{\sigma_x \sigma_y \sigma_s} \left(\Delta p / p\right)_{acc}^3$$





PETRA III
Toushek Lifetime



PETRA III
Toushek Lifetime

Parameter	
total current (mA)	100
# bunches	40
current / bunch (mA)	2.5
momentum acc. (%)	1.5
Touschek lifetime (h)	2

PETRA III
Lifetime – Topping up

User demand 12 h run time ? total lifetime ˜ 24 h
? Touschek lifetime ˜ 50 h

Way out

- increase the number of bunches (1000) ? new feedback system
- Top up (time resolved measurements with a small number of bunches)

➢ More precise: injection at a Hertz rate (constants of I_{tot} ˜ **1 ‰)**

Also attractive in case of many bunches

1. Fill appr. every minute (constants of Itot ˜ **1 ‰)**
2. **?** thermal equillibrium **?** relaxes burden of orbit stabilisation (SLS)

PETRA III
Orbit Stabilization

	low β_x	**high** β_x
σ_x (µm)	34.6	141.4
σ_z (µm)	6.3	4.9
$\sigma_{x'}$ (µrad)	28.9	7.1
$\sigma_{z'}$ (µrad)	1.6	2.0

ε_x = 1nmrad

coupling 1%

Stab. Requirement 0.1 * s
? Sub micron orbit stability !!

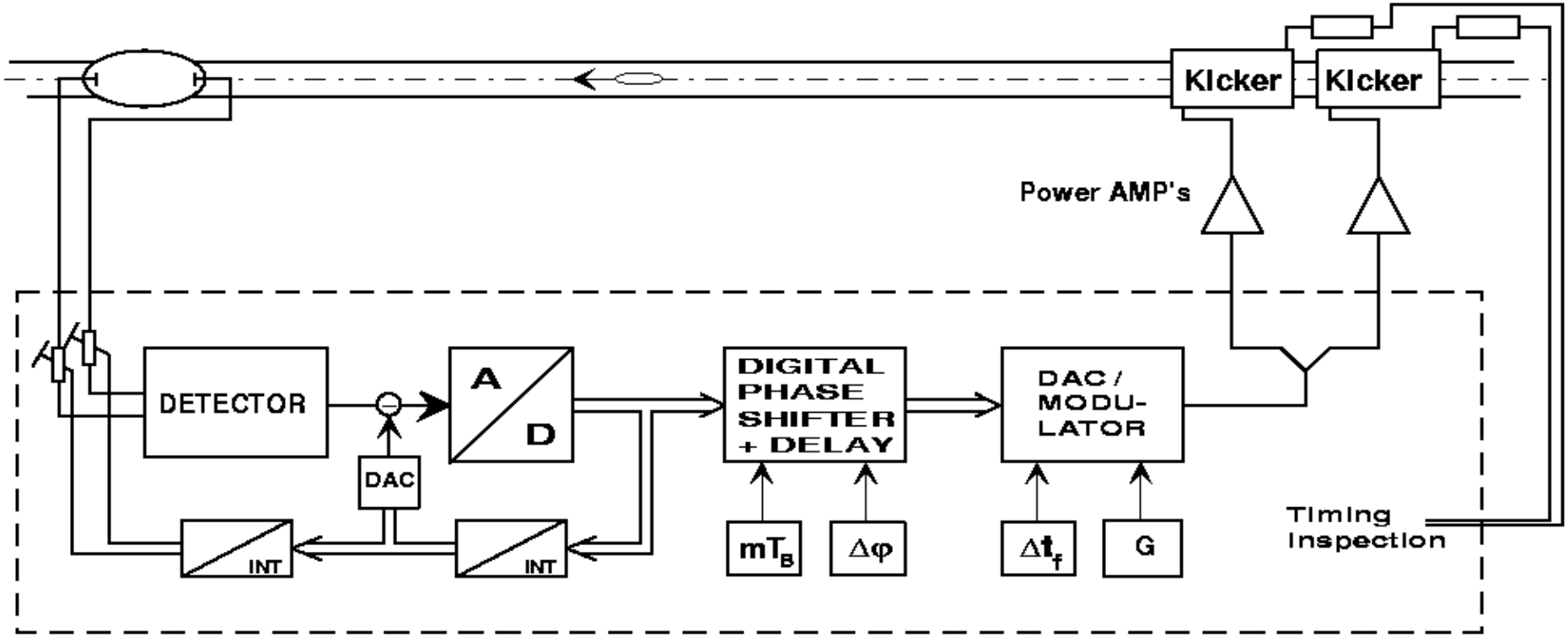
PETRA III
current limitations

- Single bunch instabilities: should not be an issue
- Multibunch instabilities is a problem:
  - Number of required rf-cavities between 12 and 16 seven cell cavities (P_{syn}=700 kW, P_U=700 kW)
  - Current limit: 5 – 10 mA

? powerful broadband (BW = 60MHz) feedback neccessary

PETRA III
multibunch feedback

Detector **DPU** **Amplifier & Deflector**

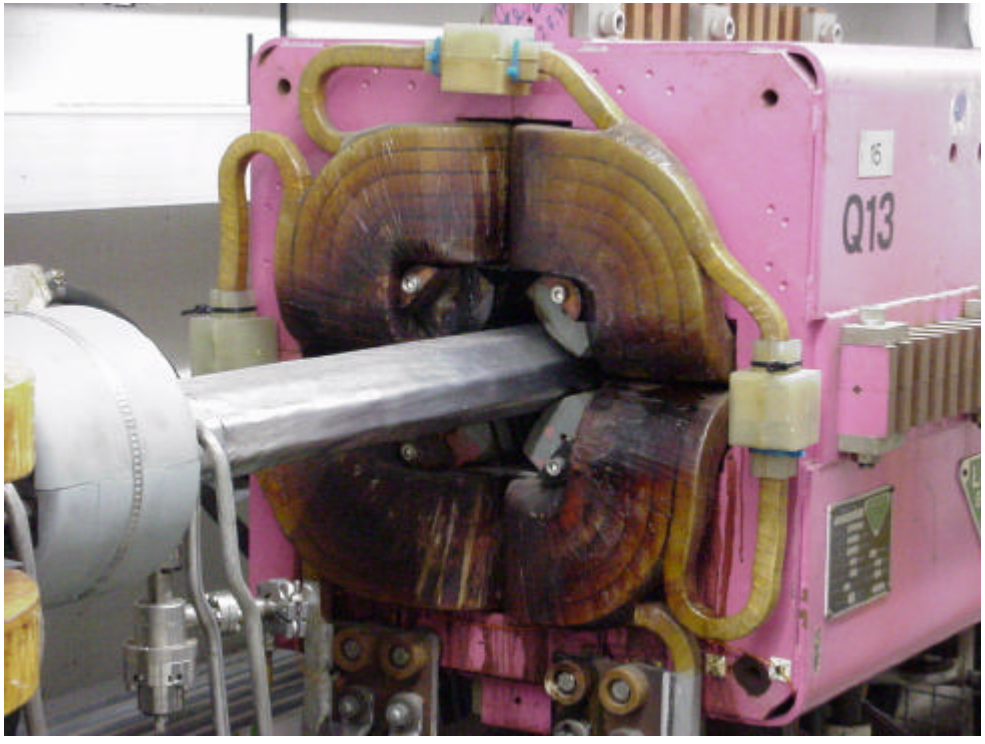


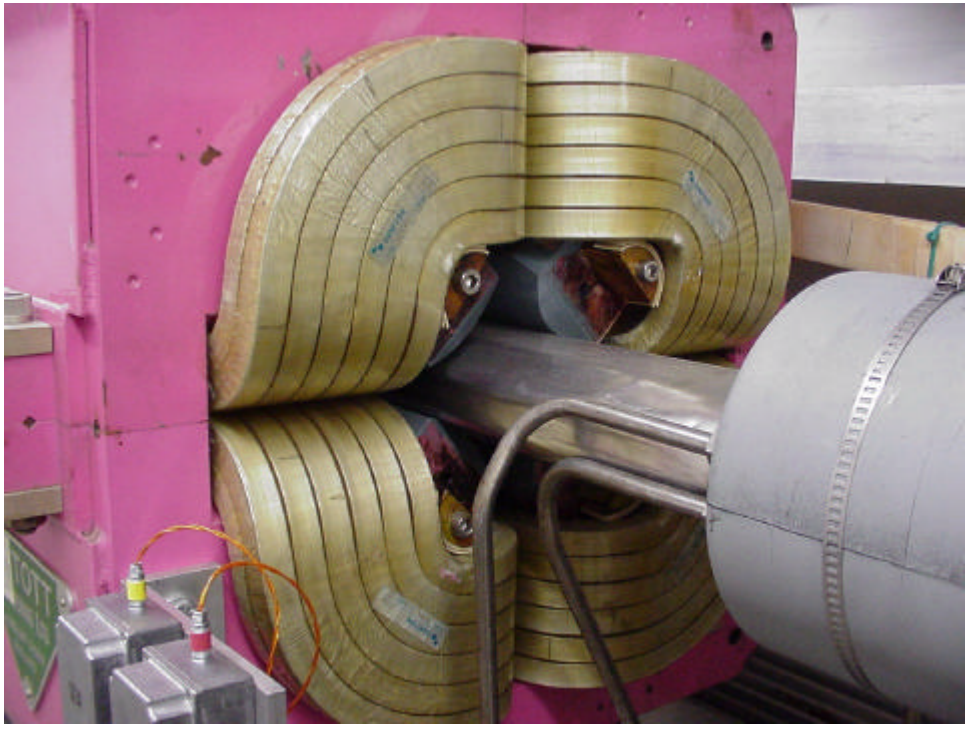
PETRA III
hardware changes

- new octant completely new hardware
- layout of damping wiggler sections

- Old octant:
  - make use of existing hardware whenever possible
  - **To ensure reliable machine operation**
    - **New vacuum system (decoupling of chamber and quads)**
    - Installation of more correctors and beam position monitors
    - Replace radiation damaged coils of magnets
    - Modernize rf system
    - New coupled bunch feedback system
    - Etc.

PETRA III
hardware changes





PETRA III
Schedule

Schedule:

- preliminary design study May 2001
- permission to hire add. staff to complete CDR June 2002
- completion of CDR beginning 2004
- approval of project in 2004
- final design of comp. and ordering of hardware in 2005/2006
- rebuilding of PETRA in 2007
- start of operation in 2008