Further FEL schedule for TTF 1

and schedule for TTF Phase 2

The TESLA FEL concept

- towards 1Å coherent radiation

Test Facility Phase 1:	390 MeV
- under construction -	$\lambda_{ph} = 42$ nm
	1999
Test Facility Phase 2:	1000 MeV @15 MV/m
- approved -	$\lambda_{ph} = 6$ nm
	2002
X-ray FEL laboratory:	up to 50 GeV
- design in combination	$\lambda_{ph} = 0.1$ nm
with 500 GeV linear collider-	????

Objectives

PHASE 1:

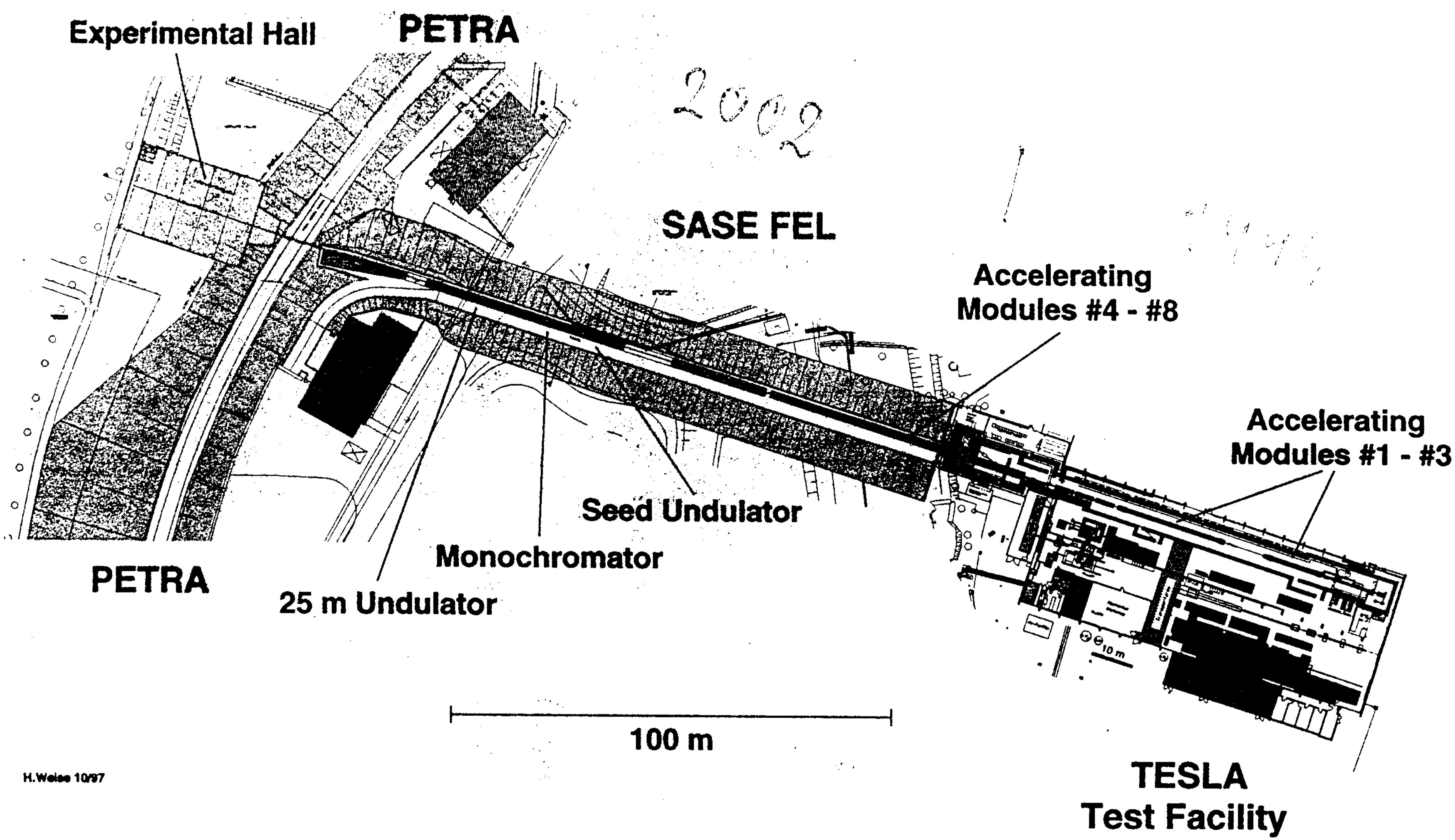
- Proof of the Self Amplified Spontaneous Emission (SASE) principle for single Pass FELs in the wavelength regime $\lambda < 100$ nm

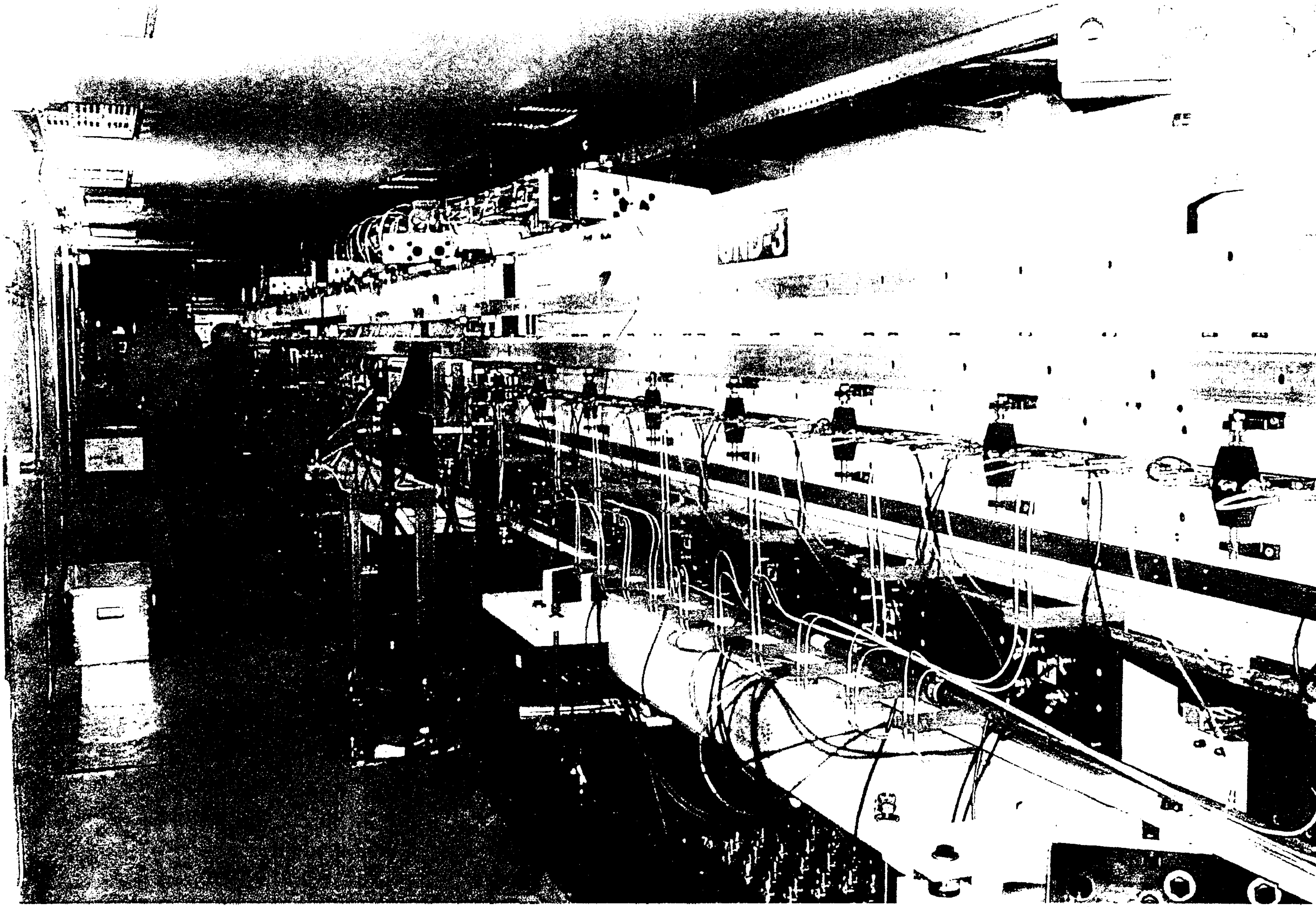
- Development of required accelerator technology

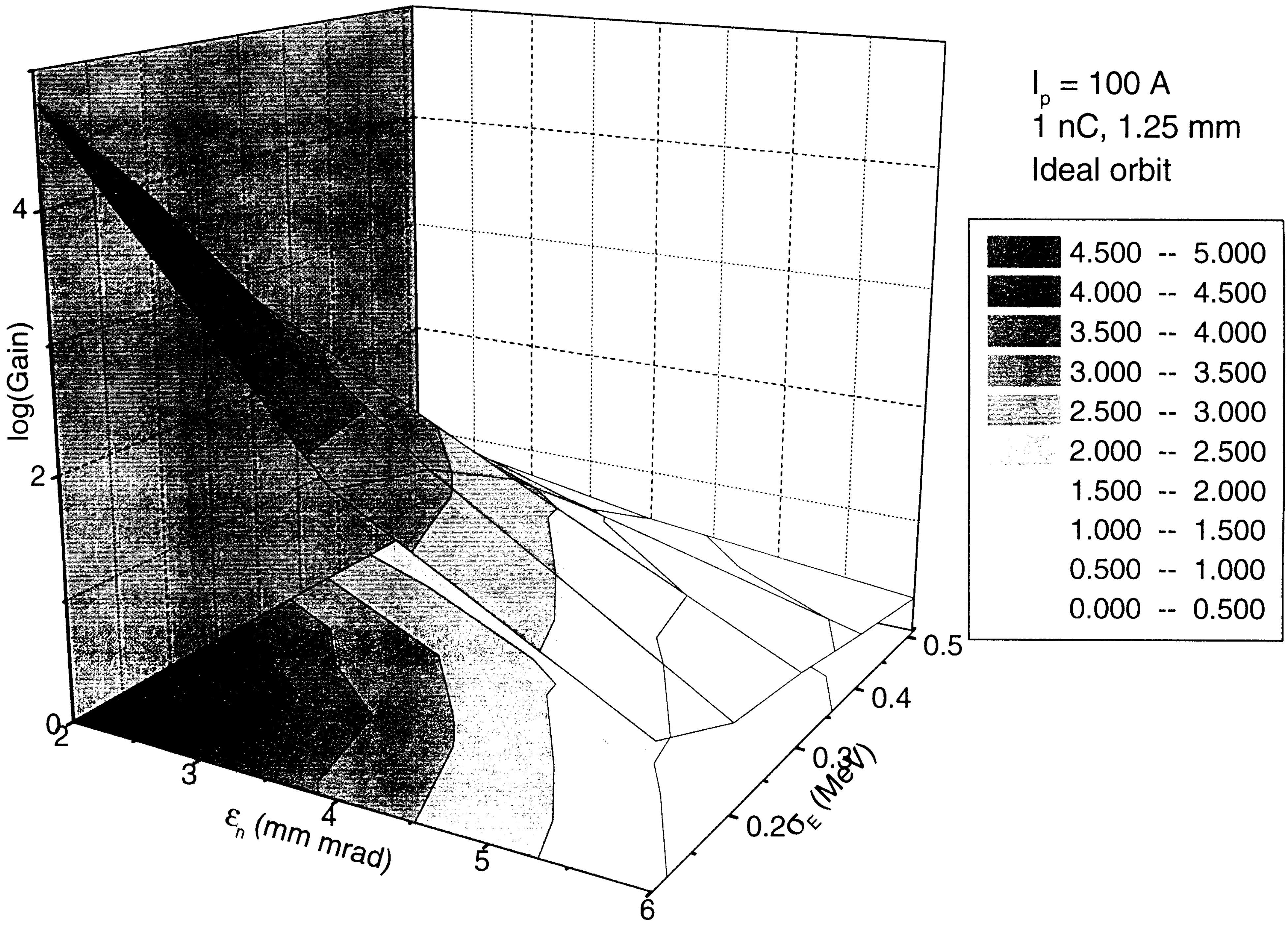
PHASE 2:

Installation of an FEL User Facility at $\lambda = 6$ nm

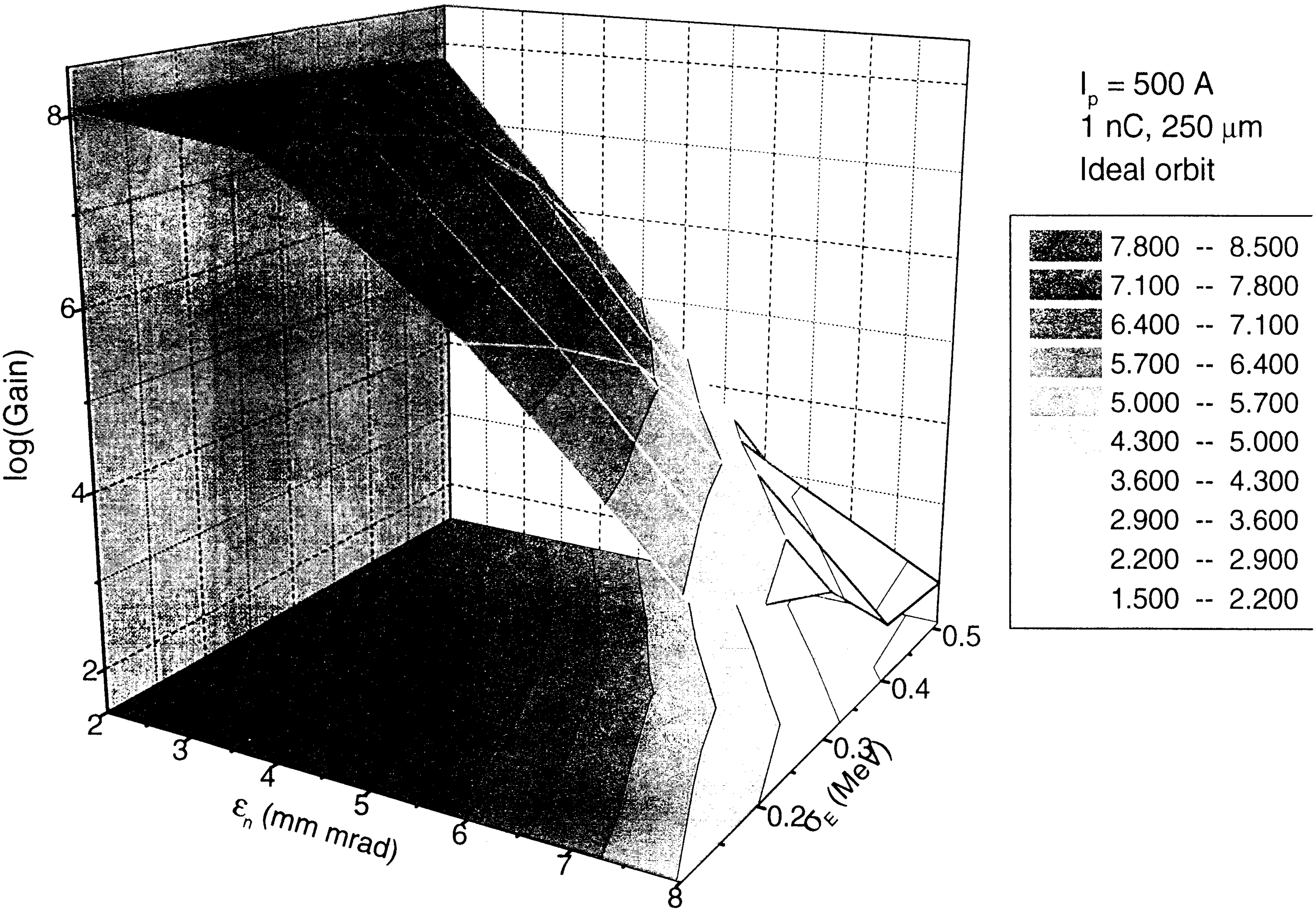
- Exciting science
- Learn to handle photon beam
- Learn reliable, stable machine operation for FELs

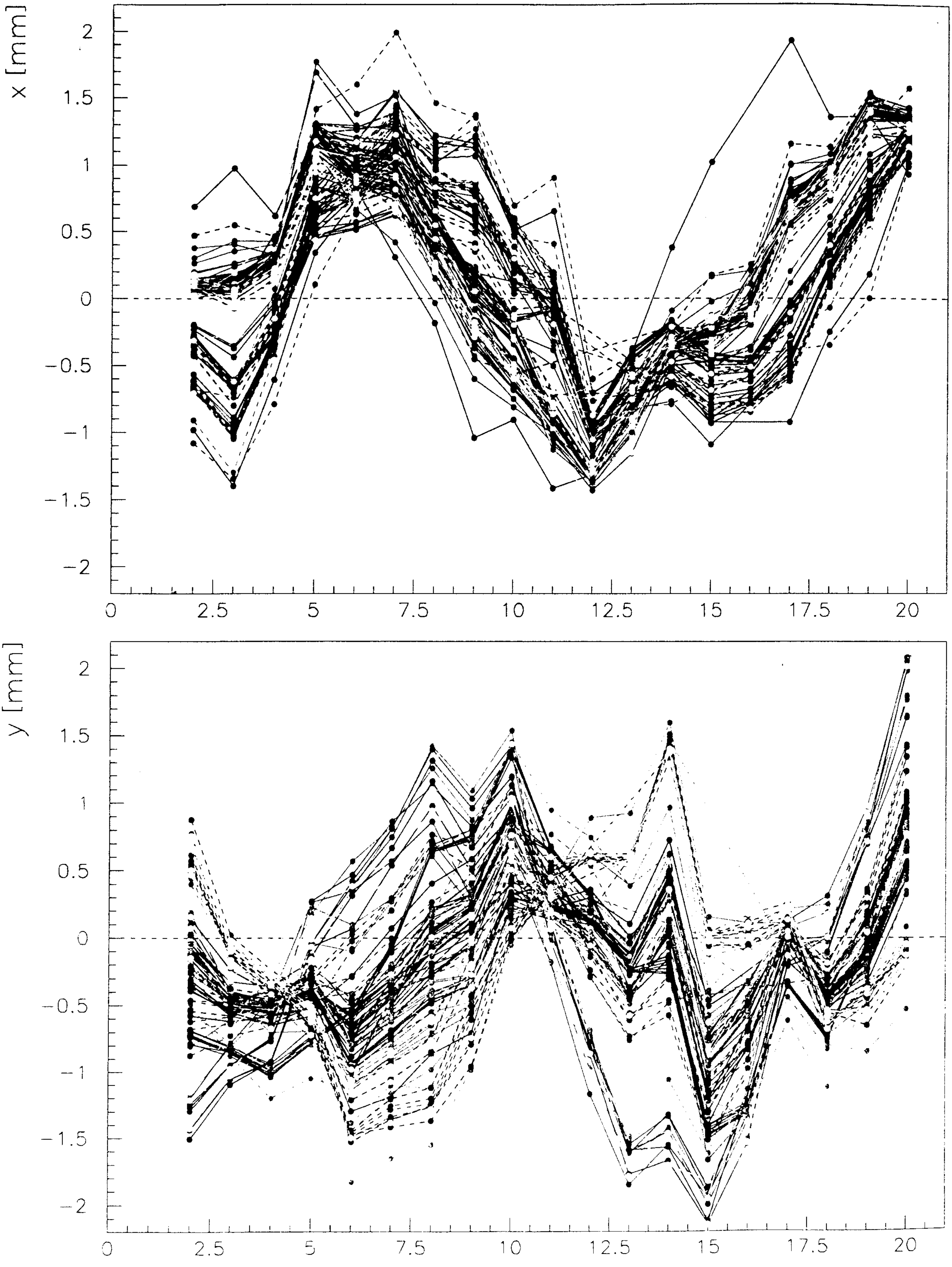

Experimental Hall
PETRA
2002
SASE FEL
Accelerating
Modules #4 - #8
Accelerating
Modules #1 - #3
Seed Undulator
Monochromator
PETRA
25 m Undulator
10 m
100 m
H.Weise 10/97
TESLA
Test Facility



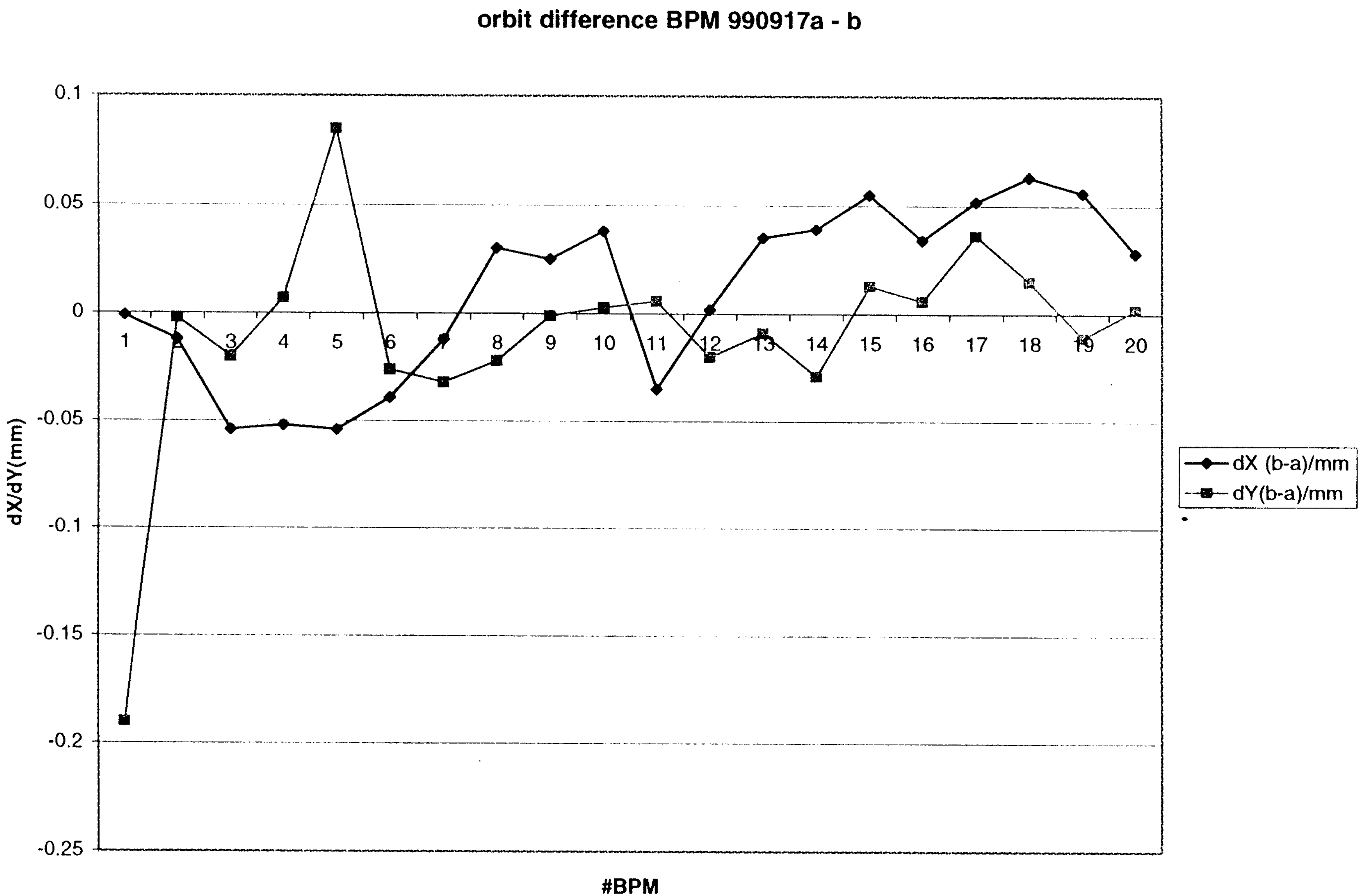


I_p = 100 A
1 nC, 1.25 mm
Ideal orbit
4.500 -- 5.000
4.000 -- 4.500
3.500 -- 4.000
3.000 -- 3.500
2.500 -- 3.000
2.000 -- 2.500
1.500 -- 2.000
1.000 -- 1.500
0.500 -- 1.000
0.000 -- 0.500
log(Gain)
0
2
4
ε_n (mm mrad)
2
3
4
5
6
σ_E (MeV)
0.2
0.3
0.4
0.5


I_p = 500 A
1 nC, 250 μm
Ideal orbit
7.800 -- 8.500
7.100 -- 7.800
6.400 -- 7.100
5.700 -- 6.400
5.000 -- 5.700
4.300 -- 5.000
3.600 -- 4.300
2.900 -- 3.600
2.200 -- 2.900
1.500 -- 2.200
log(Gain)
8
6
4
2
ε_n (mm mrad)
2
3
4
5
6
7
8
σ_E (MeV)
0.2
0.3
0.4
0.5



x [mm]
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
0
2.5
5
7.5
10
12.5
15
17.5
20
y [mm]
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
0
2.5
5
7.5
10
12.5
15
17.5
20



ROSSBACH@MPYNTROSSBACH, SEP22/13:12

Requests for TTF1 Beam Time

Coordinator	Subject	Installation time (weeks)	Run time (weeks)	Remark * = start in 1999
		Lin. Coll. issues		
	Integrated System Test: design current, 25 MeV/m	0	5	* (25 MV/m)
	Cryo load due to HOMs (at small gradient)	0	2	*
	Dark currents	0	1	*
	Simulation of vacuum accident	0	1	
	HPP on individual cavities (Re-conditioning)	2	0	
	2 modules operation with 1 klystron (stabil?)	1	2	
	2 modules different operation, 1 klystron	0	2	
	De-activate 1 cavity (with beam current)	0	2	
	microphonics	0	2	
	HOM-absorber	1	2	
	Radiation damage of electronics	0	2	Parasitic
	HOMs with 54 MHz RF-Modulation, frequency scan, 9/4 MHz oper.	1	2	*
	HOMs with kickers	0	1	*
	Fast protection system	0	1	
	Test Bunch Compressor 1	0	1	
	SUM	5	26	
		FEL issues		
	Parameter studies Inj. II	0	2	*
	Emittance measurements (phase, solenoid strength)	0	2	*
	Bunch length measmts.		2	*
	Test ceramics for kickers	1	1	
	Timing for Feedback	0	1	
	Install + test FB kicker	4	1	
	Feedback tests	0	3	
	Surface roughness tests „Wakefield Radiator“	1	2	
	RAFEL	4	6	
	BCII small gap chamber	3	1	
	BTM for trajectory in undul.	3	2	
	FEL-Gun	3	4	
	Commission optics and BPMs	0	6	*
	Orbit in undulator	0	2	*
	Beam based alignment	0	4	*
	BC2 with undulator	0	2	*
	Demonstrate SASE	0	6	*
	Photon diagnostics in time, spectrum, statistics	4	16	
	Cluster experiments	2	8	
	SUM (weeks)	25	71	

Topics marked with a * will be done (or started) in 1999

Proposal of a Regenerative FEL Amplifier at the TESLA Test Facility

J. Krzywinski

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I.N. Ivanov, M.V. Yurkov

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J. Feldhaus

Deutsches Electronen-Synchrotron, Notkestrasse 85, D-22607 Hamburg, Germany

E.L. Saldin, E.A. Schneidmiller

Automatic Systems Corporation, 443050 Samara, Russia

Abstract

We propose to construct a regenerative FEL amplifier (RAFEL) at the TESLA Test Facility (TTF). The concept has been developed in the framework of the JINR participation in the TESLA collaboration. The RAFEL project may be regarded as a milestone towards a short wavelength FEL user facility, since it aims at demonstrating the possibility of seeding an FEL, turning it from a mere amplifier of shot noise into a real VUV/soft X-ray laser. The proposed project requires the additional installation of a narrow-band feedback system and is fully compatible with the present design and the infrastructure developed for the TTF FEL project. It would allow to construct a tunable VUV laser with a minimum wavelength around 70 nm, a pulse duration of 1 ps, a peak power of about 300 MW and an average power of about 30 W. The output radiation of the regenerative FEL amplifier would possess all the features which are usually associated with laser radiation: full transverse and longitudinal coherence and shot-to-shot stability of the output power. The degeneracy parameter of the output radiation would be about 10^{14} and thus have the same order of magnitude as that of a quantum laser operating in the visible.

approved spring 1998

The Regenerative Amplifier FEL
= RAFEL

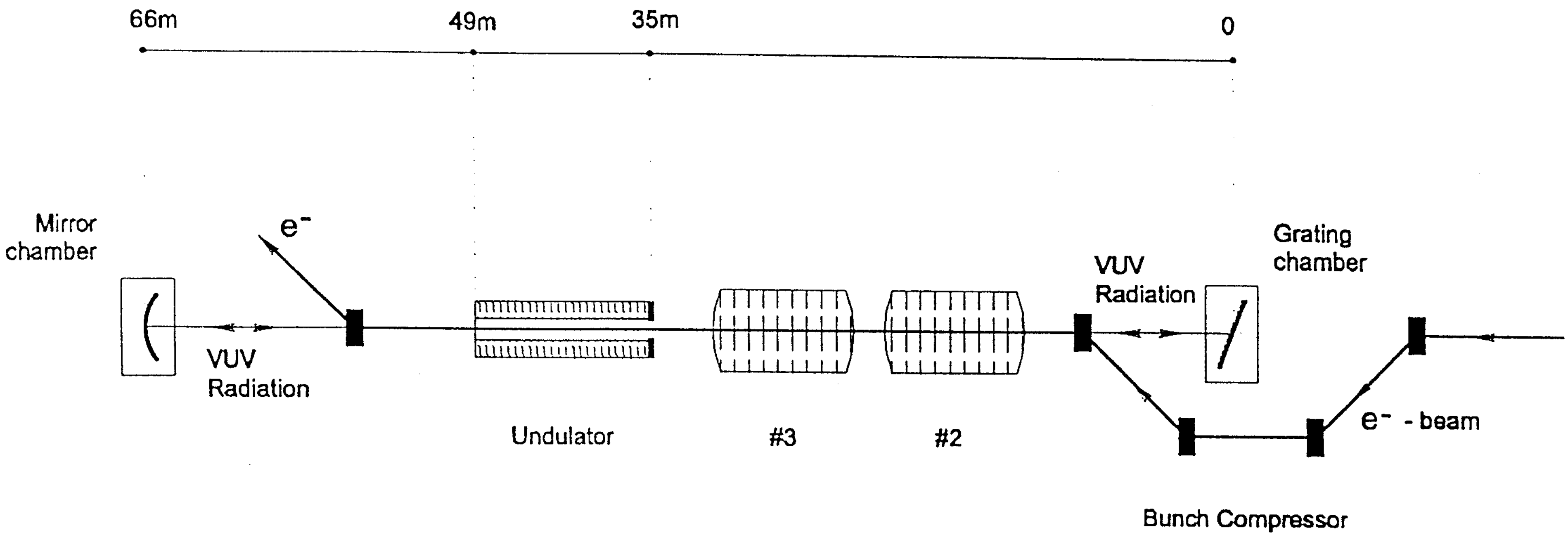
J. Roßbach
23.7.1999

Goal:

* reach saturation even with poor electron beam quality

* suppress statistical fluctuations (characteristic for SASE)

→ tunable VUV laser with full transv. + long. coherence
300 MW peak power $\lambda > 70$ nm

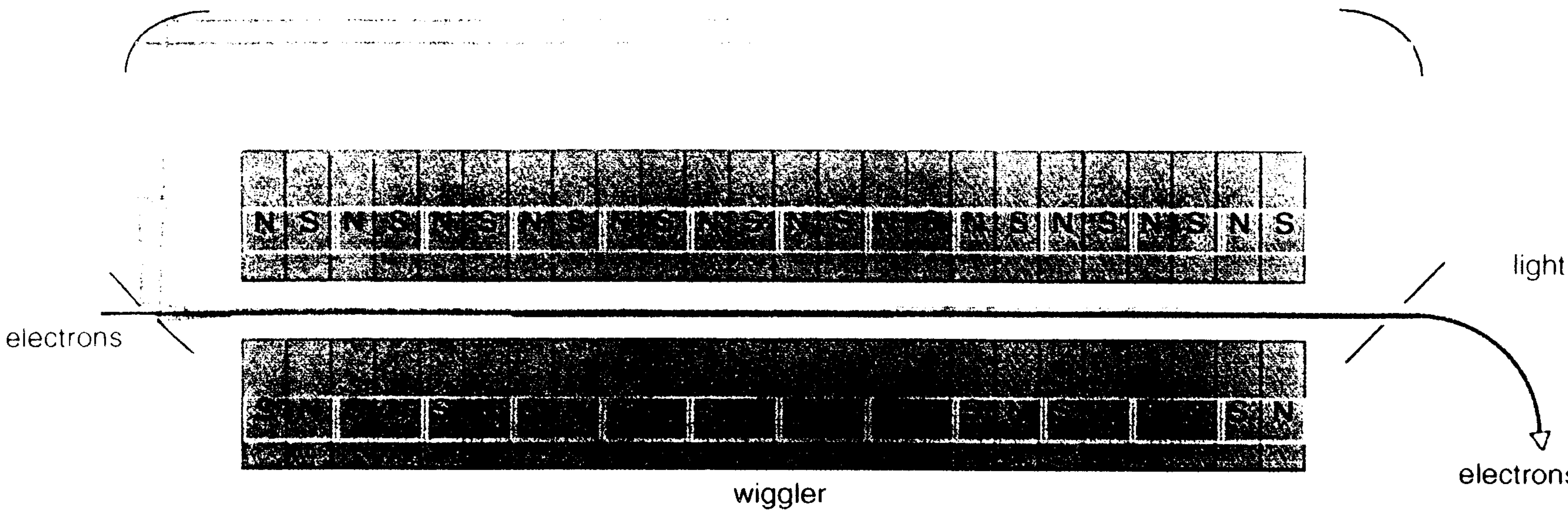


Layout of the regenerative FEL amplifier at the TESLA Test Fasility

Figure 1:

R. Sheffield 1997

Regenerative Amplifier FEL Uses Annular Mirrors to Provide Variable Optical Feedback



- High-Gain Single-Pass Amplifier
- Gain-Guided Optical Mode
- Small Optical Feedback

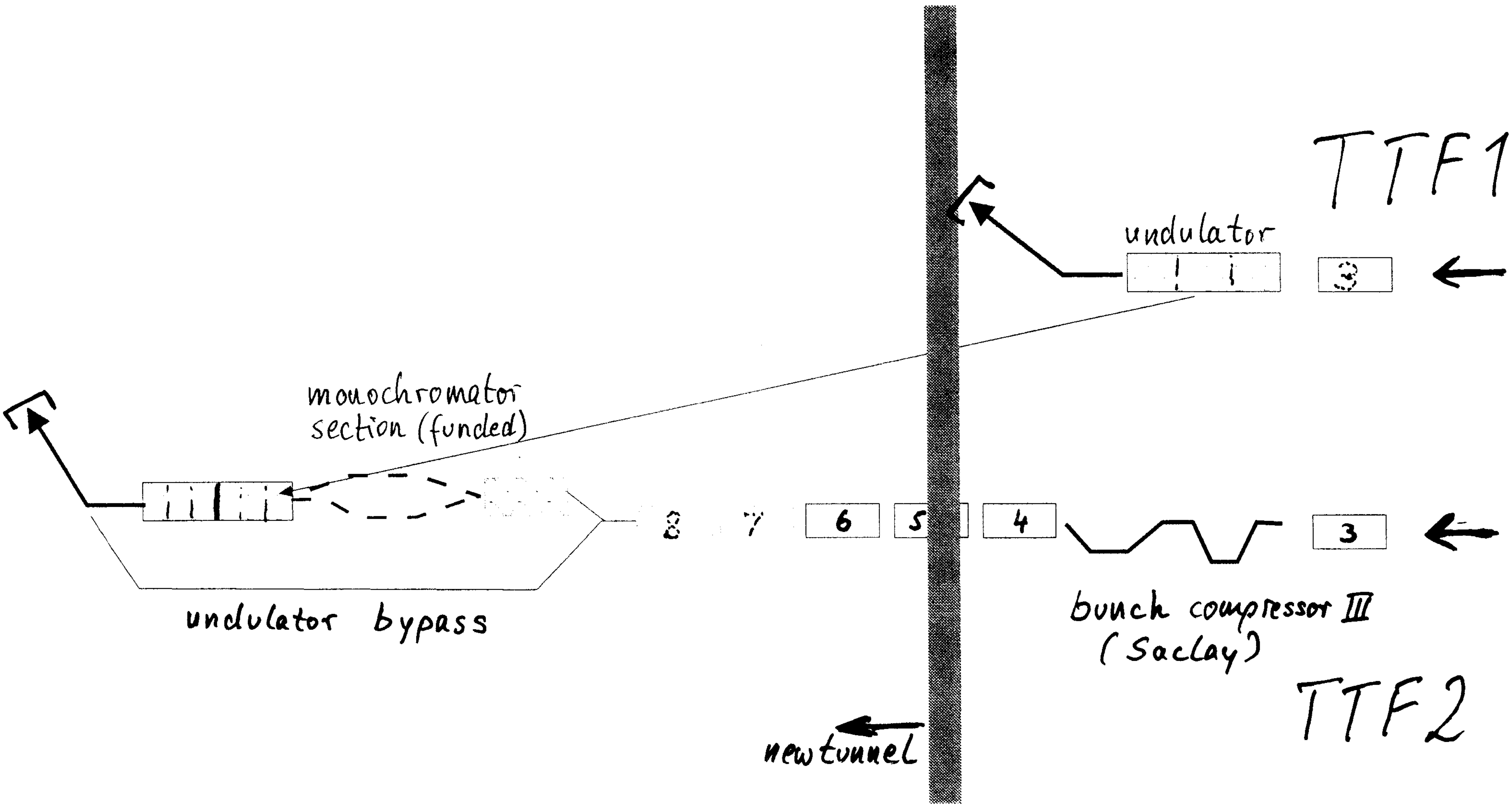
WE-1-01

First Lasing of the Regenerative Amplifier FEL

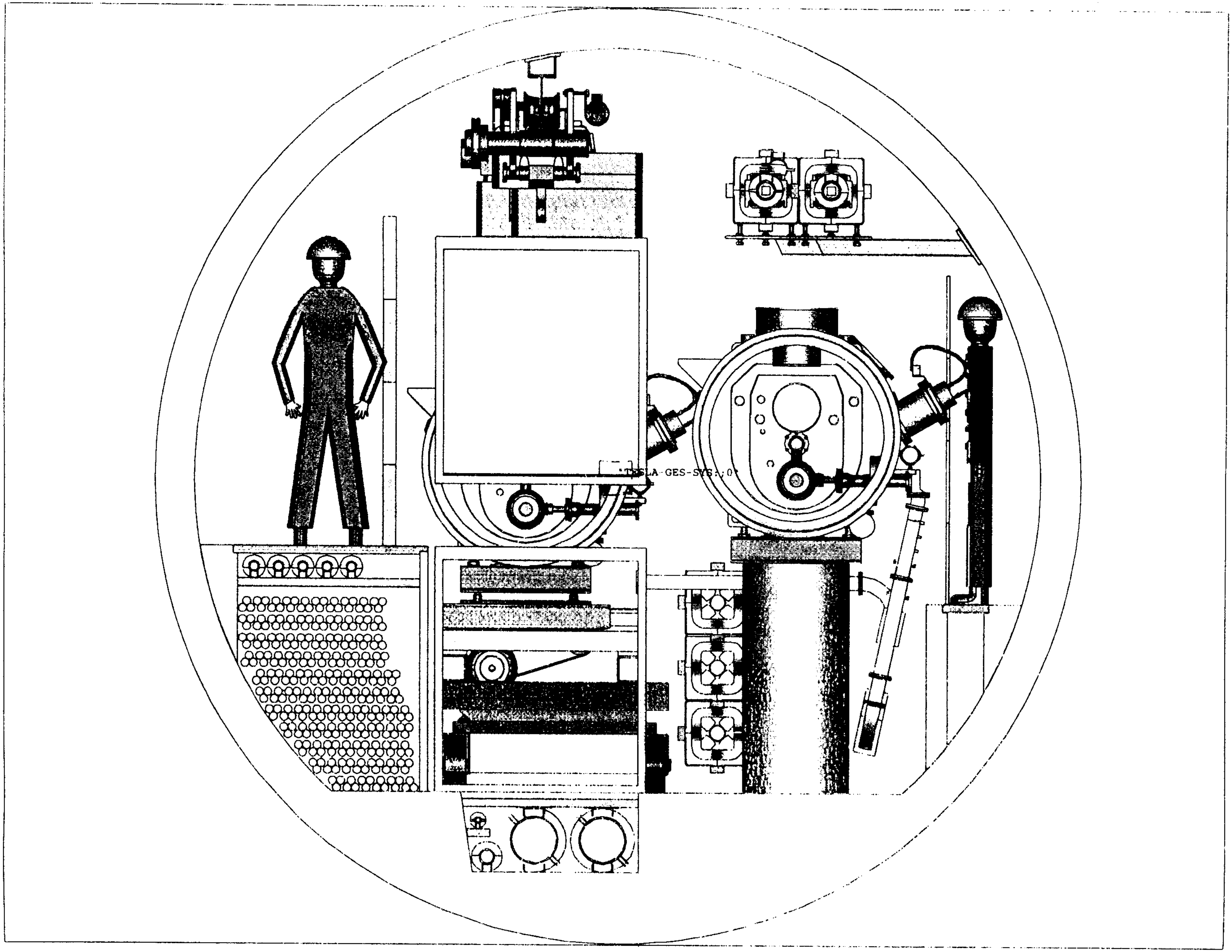
D.C. Nguyen, R.L. Sheffield, C.M. Fortgang, J.C. Goldstein, J.M. Kinross-Wright, N.A. Ebrahim
Los Alamos National Laboratory, Los Alamos, New Mexico

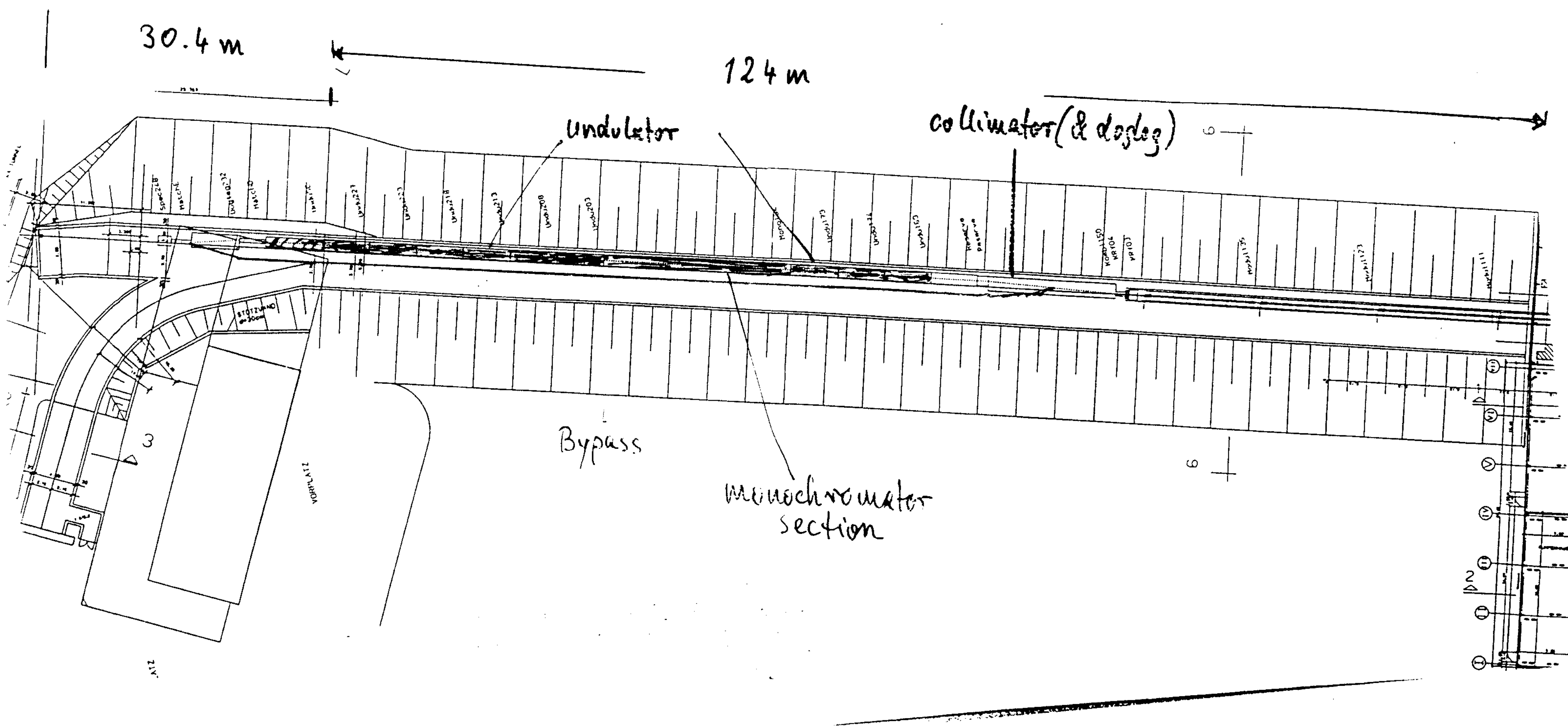
The Regenerative Amplifier Free-Electron Laser (RAFEL) is a new FEL approach aimed at achieving the highest optical power from a compact rf-linac FEL. The key idea is to re-inject a small fraction (<10%) of the optical power into a high-gain (10^3 in a single pass) wiggler to enable the FEL to reach saturation in a few passes. The use of large outcoupling increases the FEL output efficiency and reduces the risk of optical damage to the feedback mirrors. This paper summarizes the design of a high-power infrared regenerative amplifier FEL and describes the initial experimental results. The highest optical energy achieved thus far at 15.5 µm is 0.5 J over a train of 1000 micropulses. We infer a pulse energy of 0.5 mJ in each 10 ps micropulse, corresponding to a peak power of 50 MW.

Transition TTF 1 → TTF 2



7.11.99 J Rossbach
DESY


SLA-GES-SYS:;0

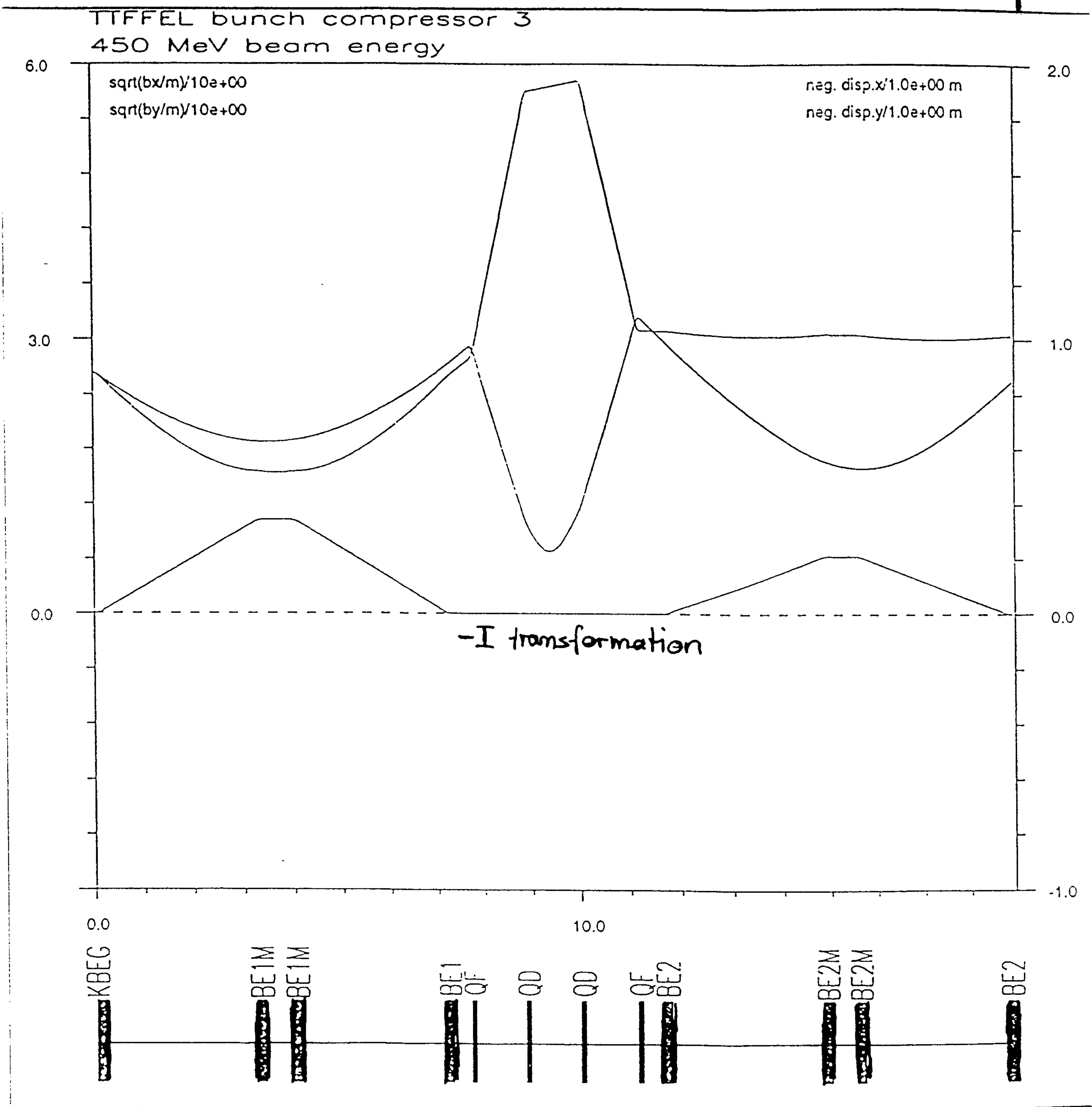

30.4 m
124 m
undulator
collimator (& dogleg)
Bypass
monochromator section
STÜTZWAND
VORPLATZ

Bunch Compressor BC III

Parameter	Double chicane	FODO cell chicane
Total available space	24.4 m	24.4 m
length	20.0 m	16.0 m
matching section incl. cold warm transition	2×2.2 m	2×4.2 m
beam deviation	≈ 0.4 m	1.17 m
slice emittance growth	≈ 1.7 mm mrad	< 0.5 mm mrad

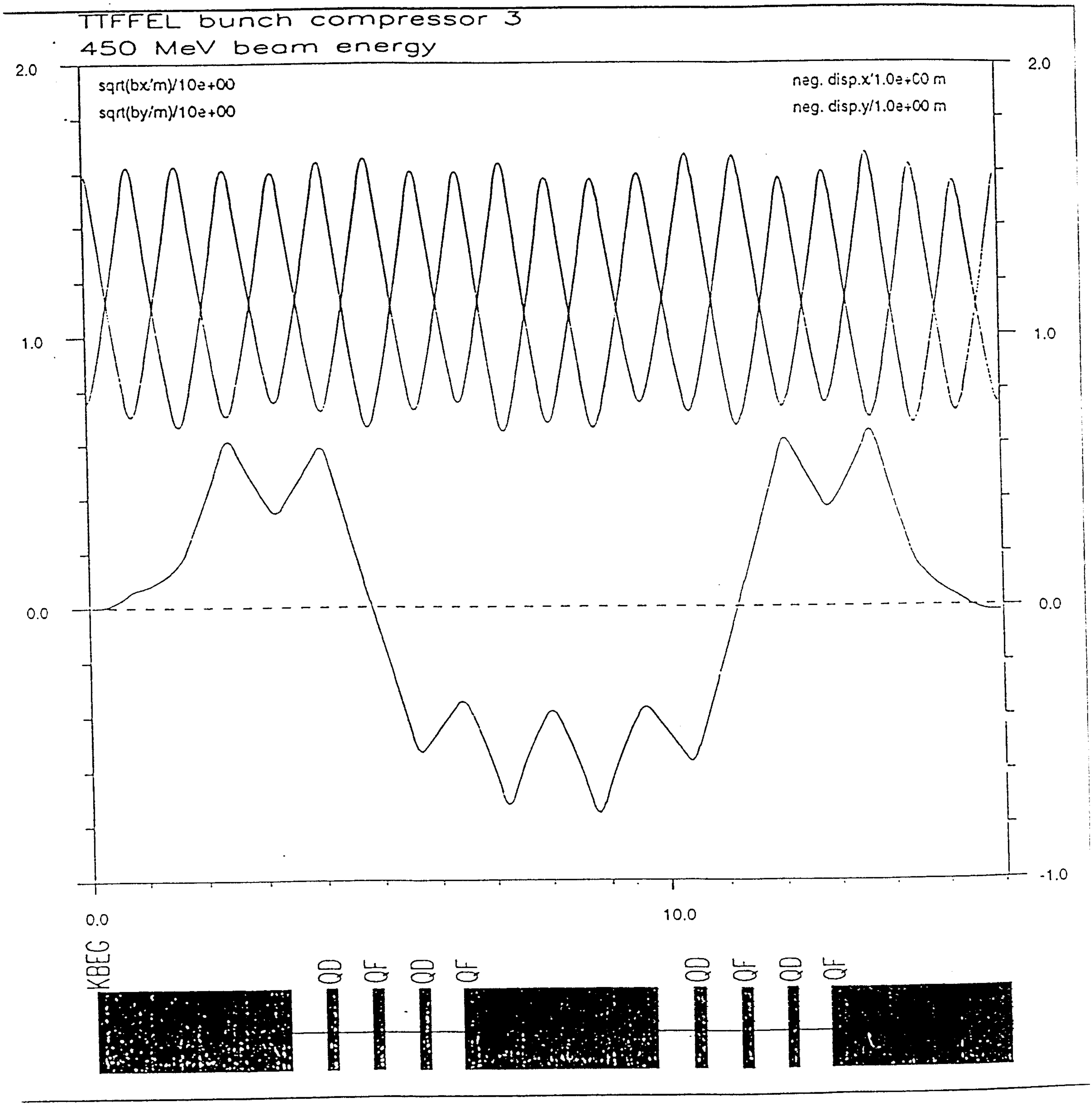
Open question whether to find a good double chicane or to focus the investigations on the FODO cell chicane ?

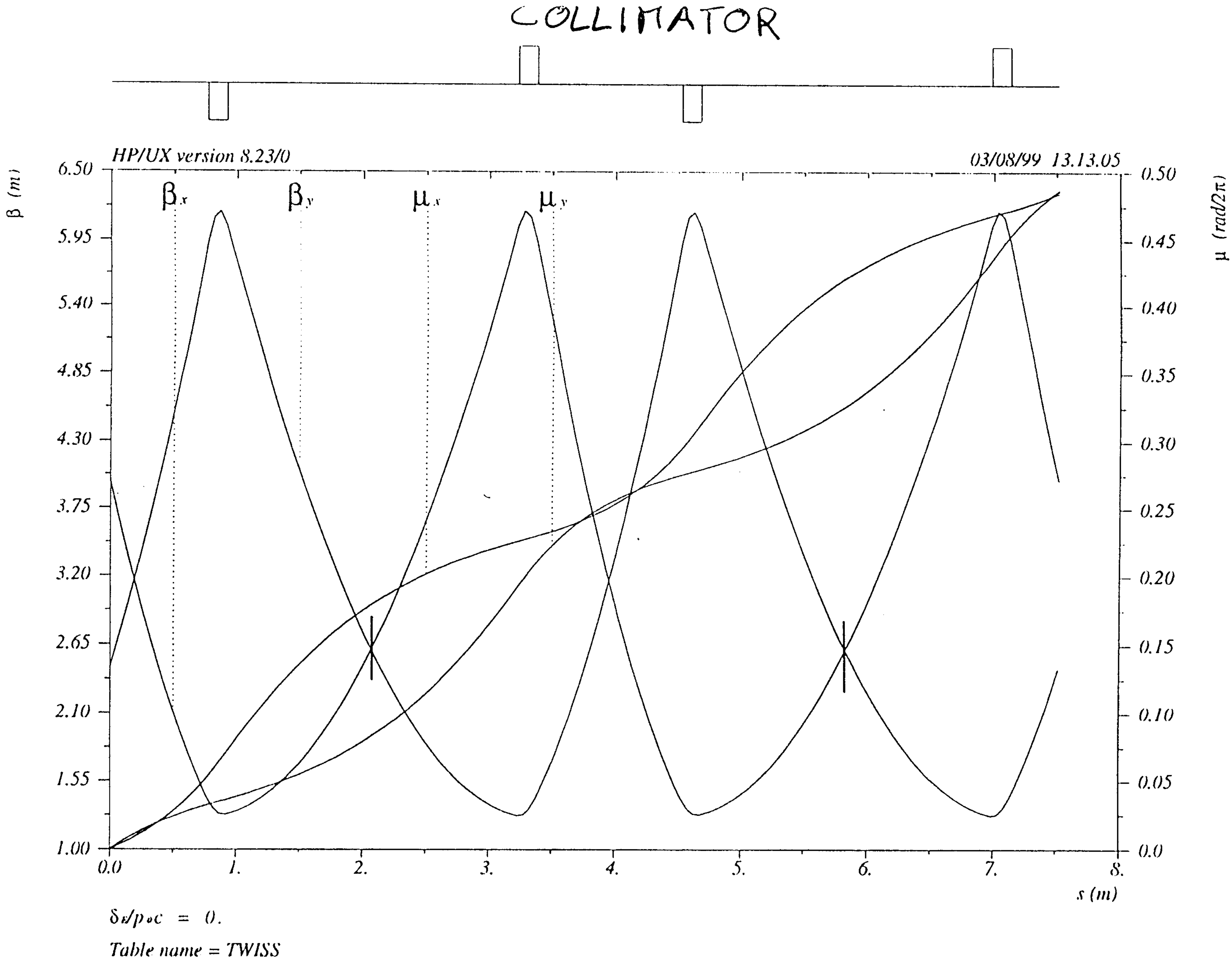
Double chicane   T. Limberg



FODO cell chicane

T. Limberg
R. Brinkmann

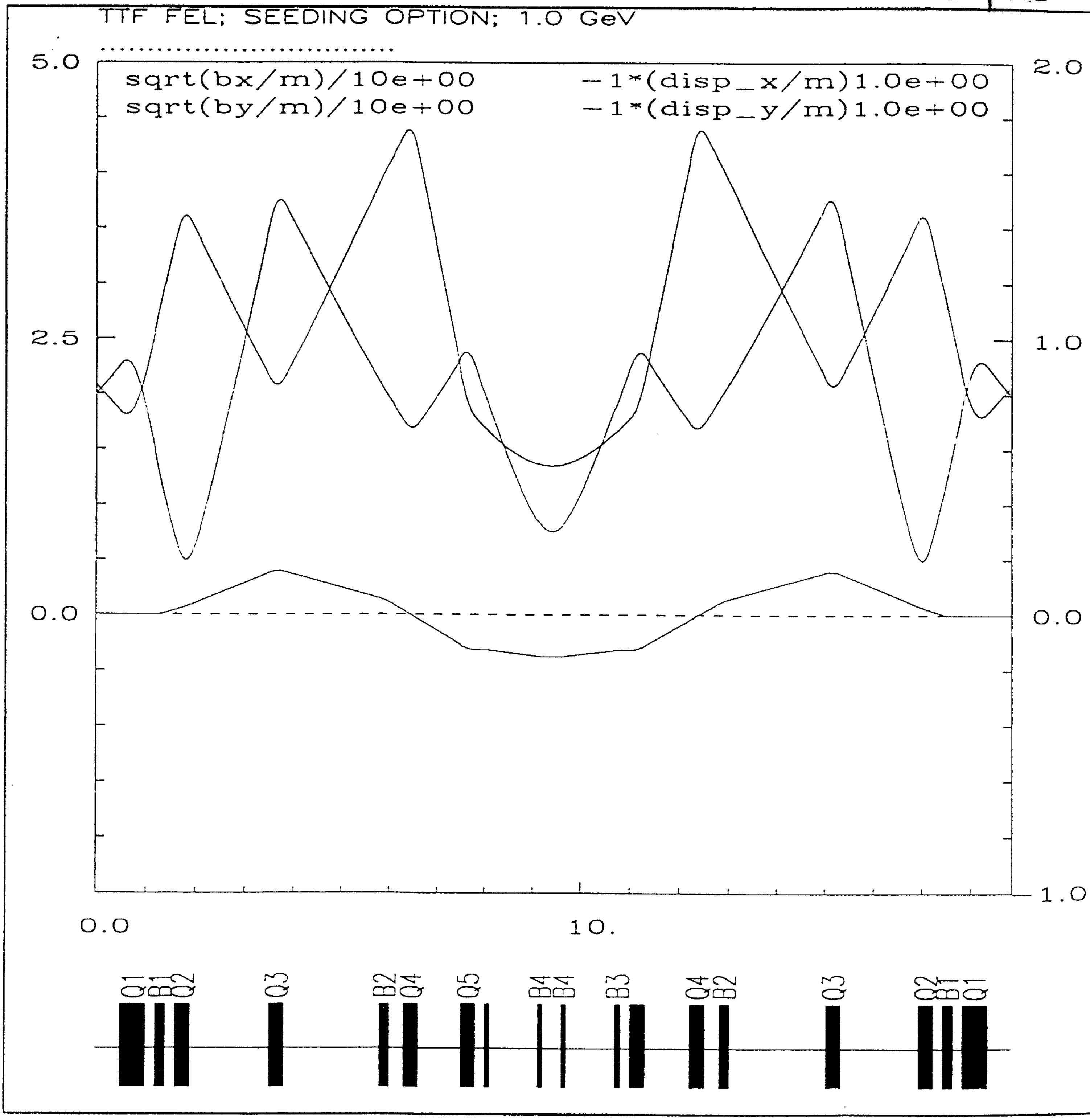




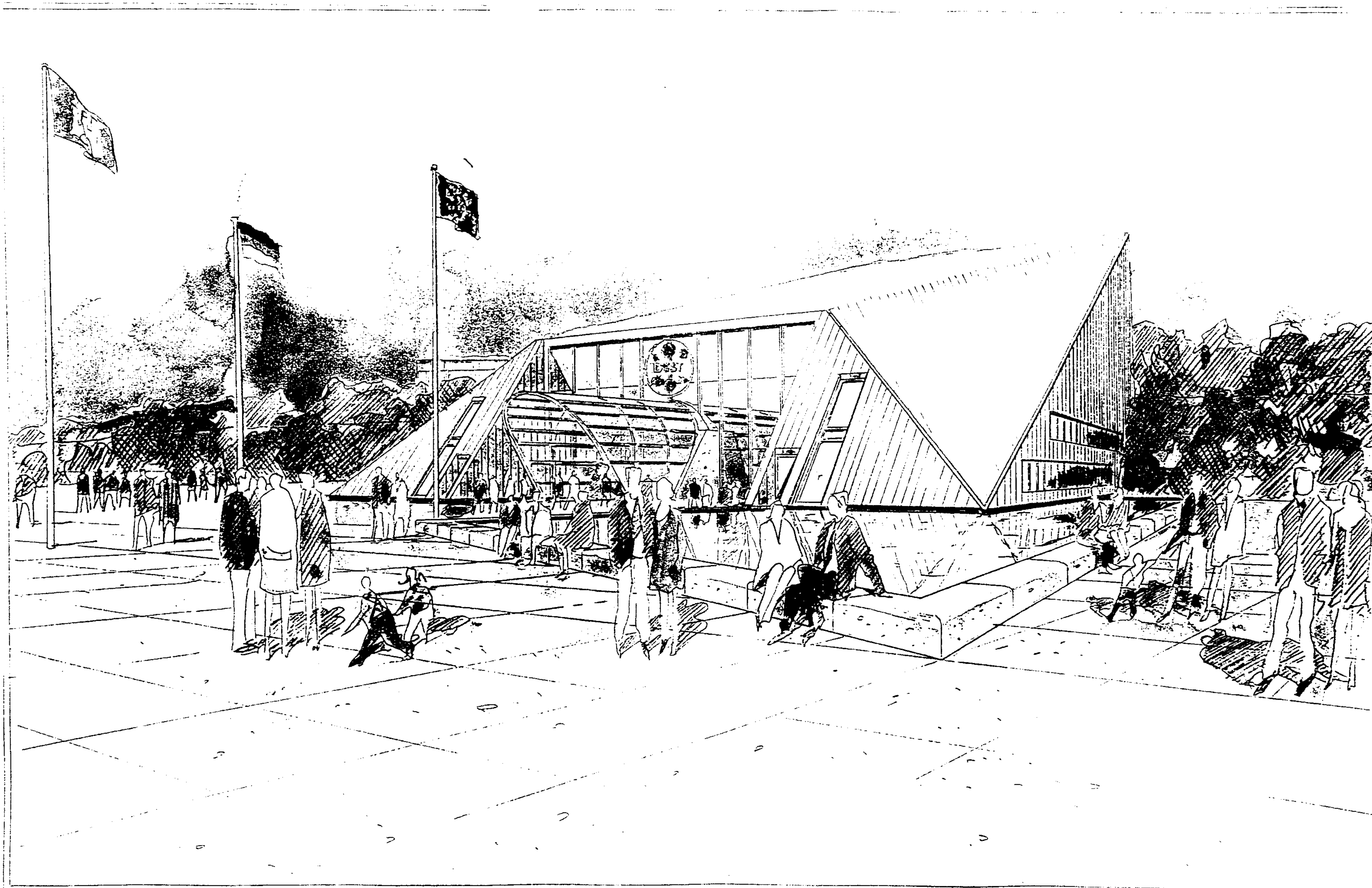
COLLIMATOR
HP/UX version 8.23/0
03/08/99 13.13.05
β (m)
μ (rad/2π)
βx
βy
μx
μy
6.50
5.95
5.40
4.85
4.30
3.75
3.20
2.65
2.10
1.55
1.00
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.0
0.0
1.
2.
3.
4.
5.
6.
7.
8.
s (m)
δE/p0c = 0.
Table name = TWISS

MONOCHROMATOR
- electron optic -

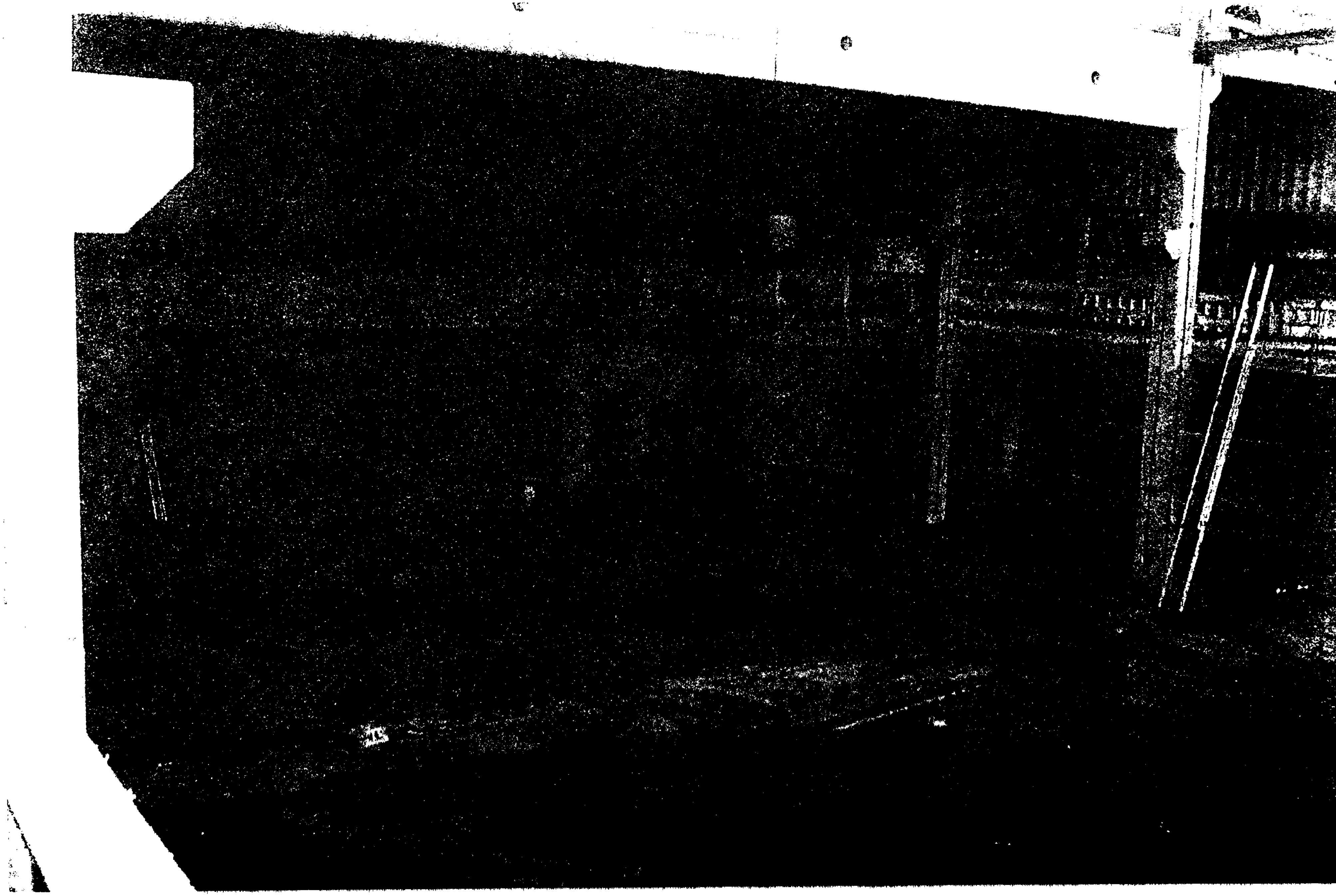
W. Brefeld

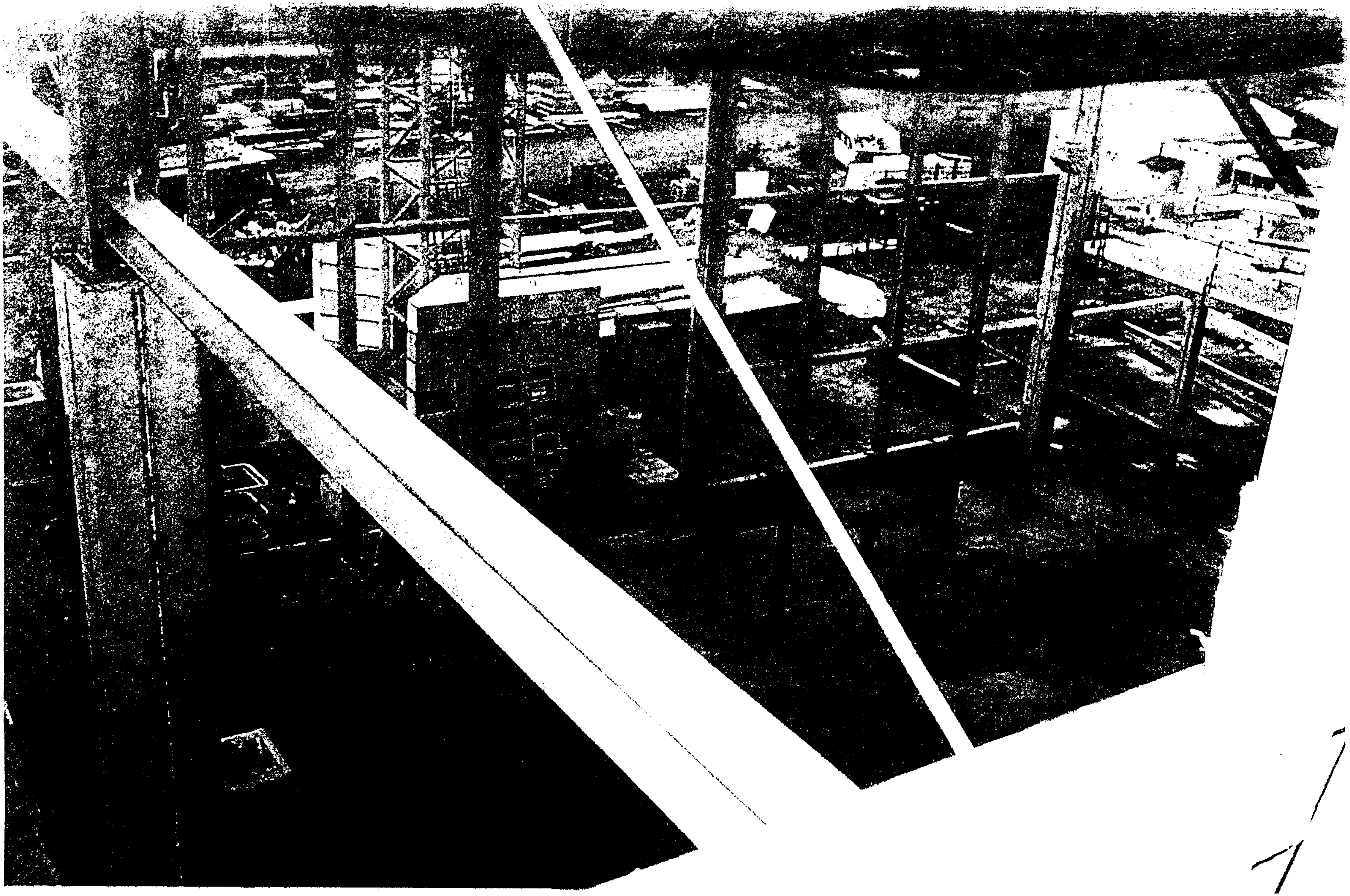



904
Litronic
LIEBHERR
MIETPARTNER



工三配图





G. Schmidt, -MPY-, 8.11.99

Tentantive time schedule for TTF Linac Run 3/99

Basis for discussion in the working group

1) Week 45

Prepare and measure maximum gradient of the complete module 1 (cryo loss)

Startup the injector with klystron 2. Maybe it is necessary to exchange the klystrons from module and gun due to timing reasons?
If not Module 1 should stay connected to klystron 3 because the rf calibration was done with klystron 3.
Module 2 be detuned?

Thursday: Tunnel open for Absorber 3 alignment of the collimator and installation for waveguide electronics.
All photo multipliers and scintillators should be checked and
if necessary be repaired (M. Werner/ H. Schultz).
Three waveguide monitor electronics will be installed under the undulator (2 hrs needed inside the tunnel on Thursday).
Friday: New optic for only one module (P. Castro).
Check if energy calibration could be done with the bunch compressor 2.

G. Schmidt, -MPY-, 8.11.99

2) Week 46

Calibrate the gradient of module 1 with beam

➔ optic needed for transport through undulator to spectrometer magnet. Three klystrons needed?

➔ Or measure energy in the BC

Demonstrate 25 MV/m with beam.
Test the rf electronics of the waveguide monitors from Zeuthen with beam.
In parallel work on toroid system (Jean Fusilier)
Get all BPM's working.

3) Week 47: Start with FEL program

Calibrate BPM's.
Especially the reentrant cavity BPM's in the collimator are important for the reproducibility of steering into the collimmator.
Switch on the bunch compressor 2.

4) Week 48

Demonstrate that the collimator is working:
Measure center of quads and compensate their offset with the collimator steerer.

5) Week 49

Waveguide BPM electronics should arrive and be installed.
First tests (calibration should be done).

G. Schmidt. -MPY-, 8.11.99

6) Week 50-51

Minimise orbit deviation with all BPM's inside undulator. Then fix it inside the Wire scanners.

Beam jitter due to energy variation or orbit offsets? Get 3 BPM's around dipole running and make analysis.

Measure beta mismatch with the wire scanners and try to adjust it.

If the orbit is below 200 micro meter a 4 dimensional scan should be done with steerers to see some amplification (B. Faatz, P. Castro)

Try closed orbit bumps ?

7) Week 1

restart the machine

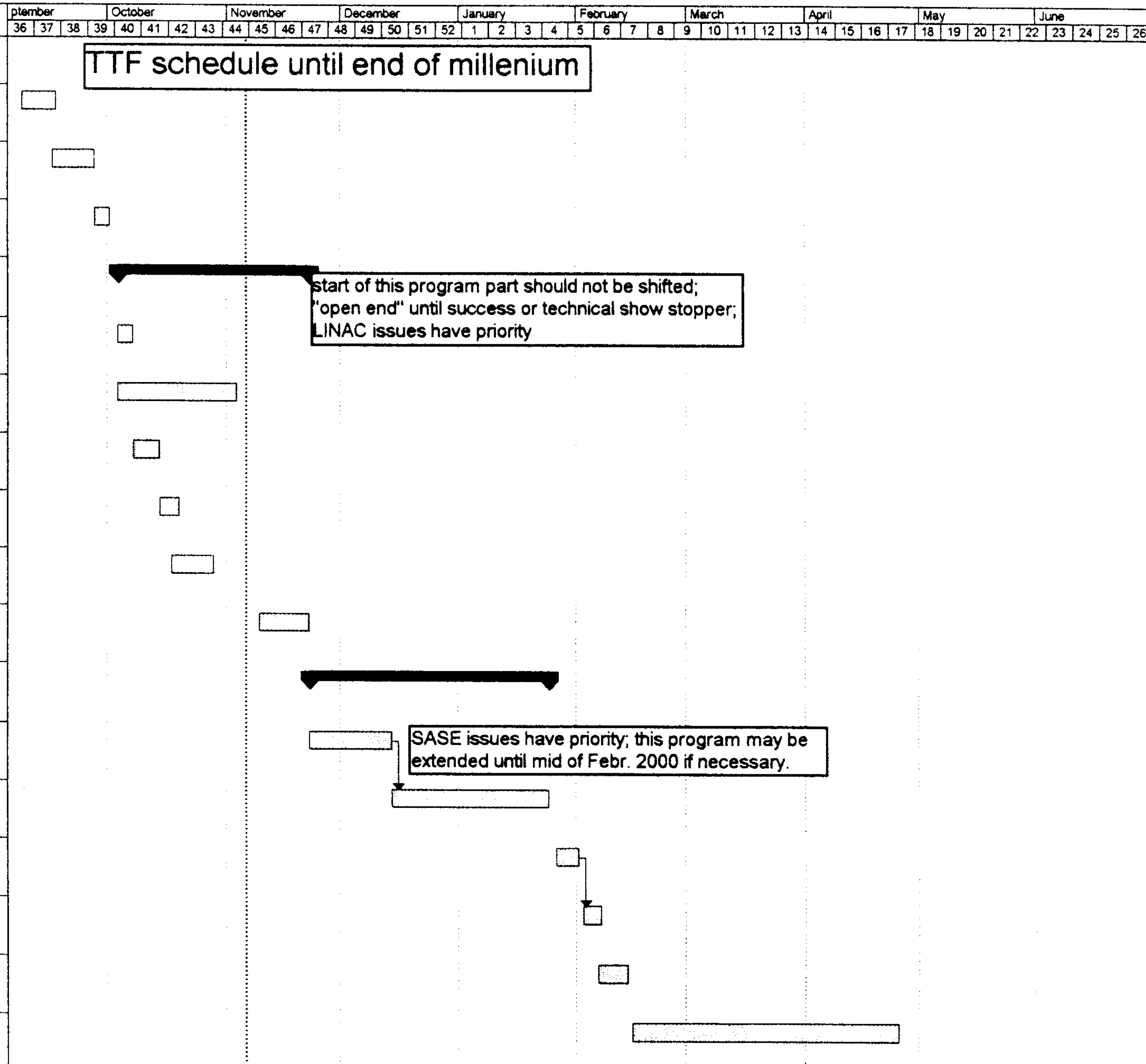
8) Week2

continue work on search for SASE

End of the run probably mid to end of February 2000

TTF schedule until end of millenium

ID	Task Name
1	
2	Orbit in the undulator: reproducibility, tools (BPMs, wire scanners),1st orbit correction in undulator, measure dispersion
3	Understand collimator; Switch on 2nd bunch compressor; measure bunch length at injector (streak camera?!), at BC2, in ACC3 (INFN Thesis)
4	measure emittance effect of bunch compressor 2 and downstream of undulator
5	**LINAC PROGRAM : 25 MV/m, 10 Hz, 800 microsec pulse length**
6	file operation of magnets and RF; "automatic" turn on and turn off; RF operation from main control room
7	conditioning module 1
8	optimize laser
9	measure emittance (vs. inj.phase and solenoid settings) at injector; online analysis
10	laser: 2.25 MHz operation; tests
11	linac start-up; measure beam energy, emittance, (bunch length?)
12	**FEL PROGRAM**
13	calibrate BPMs ; Switch on BC2 ; collimator test and beam based alignment; test RF amplifyer for waveguide BPMs
14	orbit corrcection in the undulator; (beam based alignment); SASE test
15	Measure HOMs with Balakin system
16	Prepare 54 MHz laser operation; Measure HOMs with 54 MHz system
17	Test of ceramics for FB kickers; Reserve
18	linac shut down



ID		Task Name
1		**FEL PHASE I:**
2	▦	Combined operation TTF with FEL phase 1
3		install superstructure module
4		TTF1 Test of superstructure
5		**FEL PHASE II:**
6	▦	fabrication modules 4 - 6
7	▦	construction linac tunnel incl. dump
8		tunnel installations
9		preliminary installation module 4 (or 3?)
10	▦	construction experimental/EXPO hall
11		infrastructure experimental/EXPO hall
12	▦	connect phase 1 and phase 2 tunnels
13	▦	Installation undulator bypass
14	▦	Installation spectrometer and beam dump
15		Installation BC3
16		installation modules 4+ 5 + 6
17		linac commissioning at 1 GeV
18		installation undulator
19		combined operation TTF with FEL phase 2