The Radiation Source ELBE

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Outline

1. Introduction – ELBE concept

2. The electron accelerator
   injector
   accelerating module
   beam lines/diagnostics

3. Results of the first operational period
   parameters/experiences

4. Conclusions and outlook

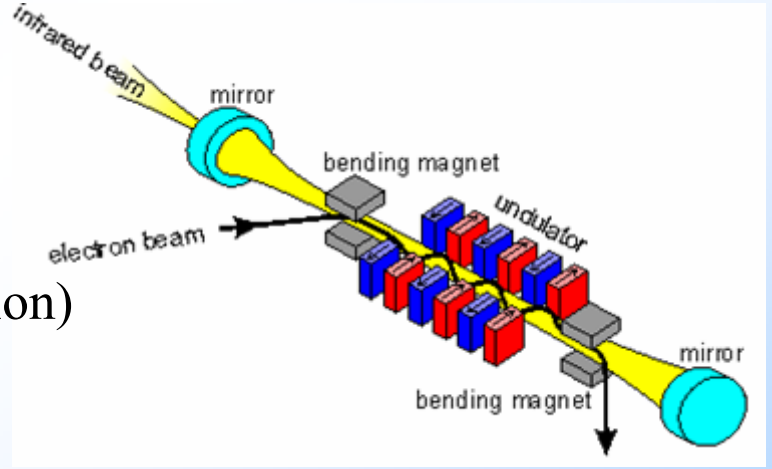
1. Introduction

Radiation Source ELBE

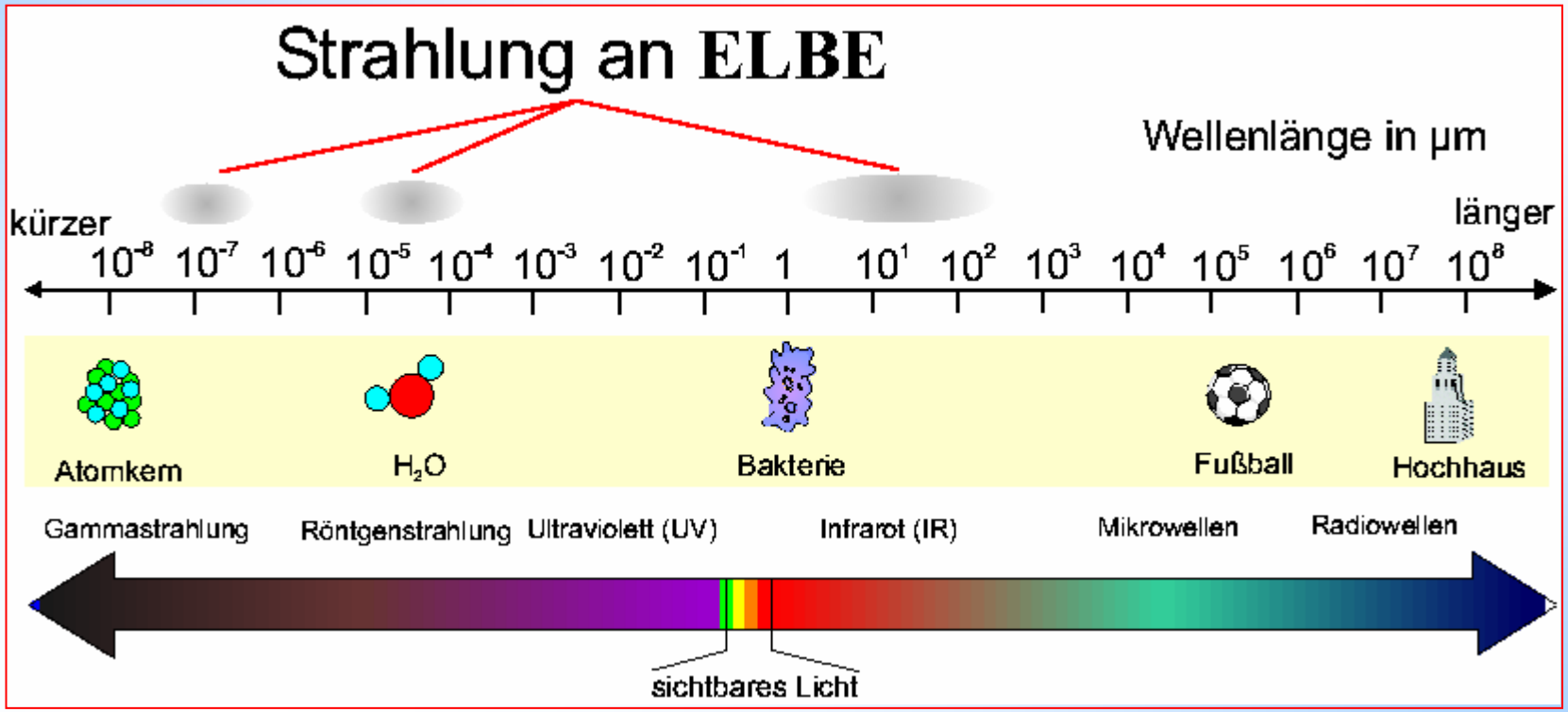
superconducting Electron Linac

quasi-continuous (cw) beams of high Brilliance and low Emittance

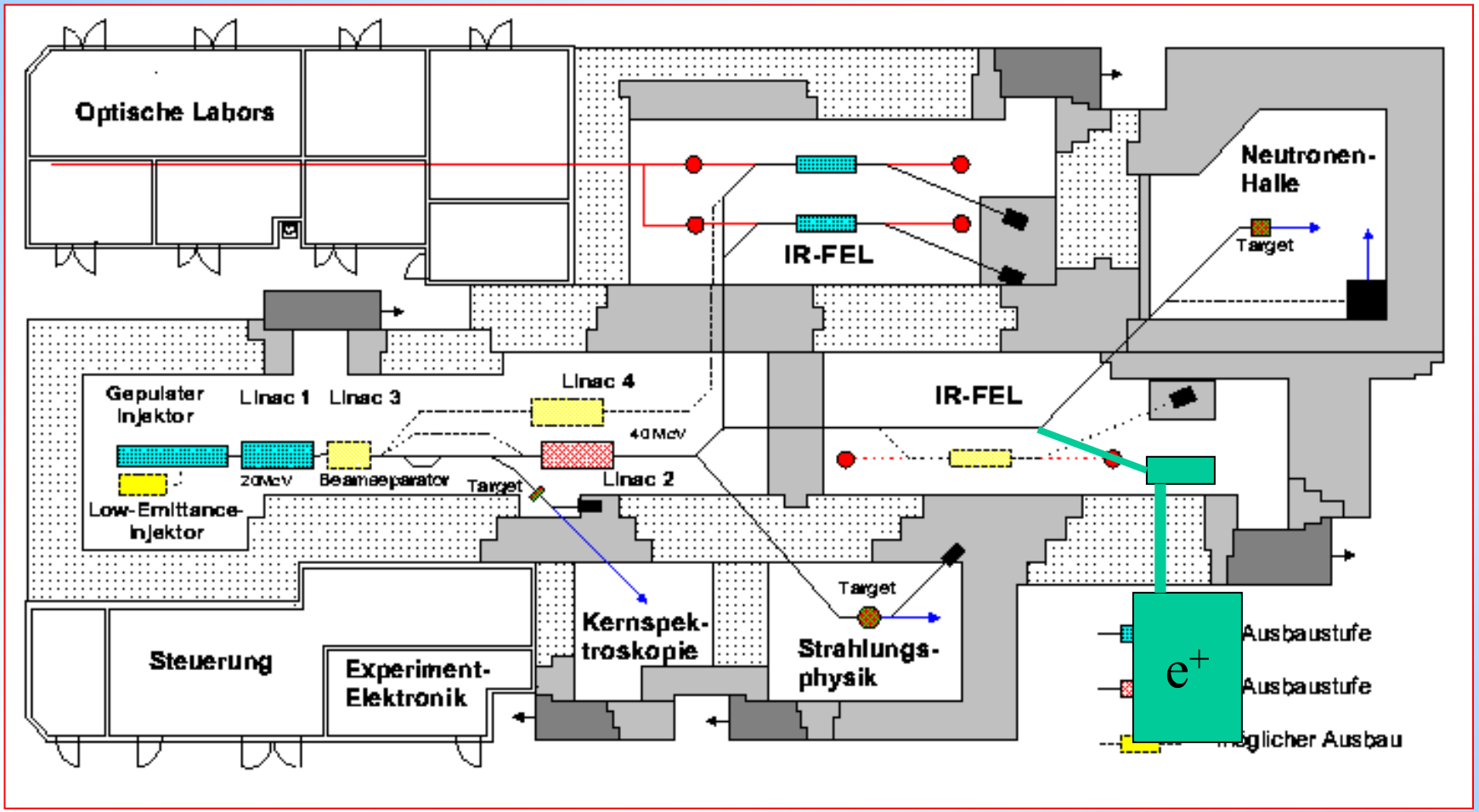
- Free-Electron Lasers (FEL)
  5 - 20 µm undulator U27
  15 - 150 µm undulator U50
  ~5 µJ p. pulse, 13 MHz
- Monoenergetic x-rays (Channeling radiation)
  10-100 keV,~ 10^{11} s^{-1}
- MeV Bremsstrahlung photons
  ~ 10^{7} MeV^{-1} s^{-1}
- Neutrons, white spectrum, (γ,n)
  ~ 10^{13} s^{-1}
- Positrons, materials research
  ~ 10^{8} s^{-1}, monoenergetic, keV



The Spectrum of Electromagnetic Radiation

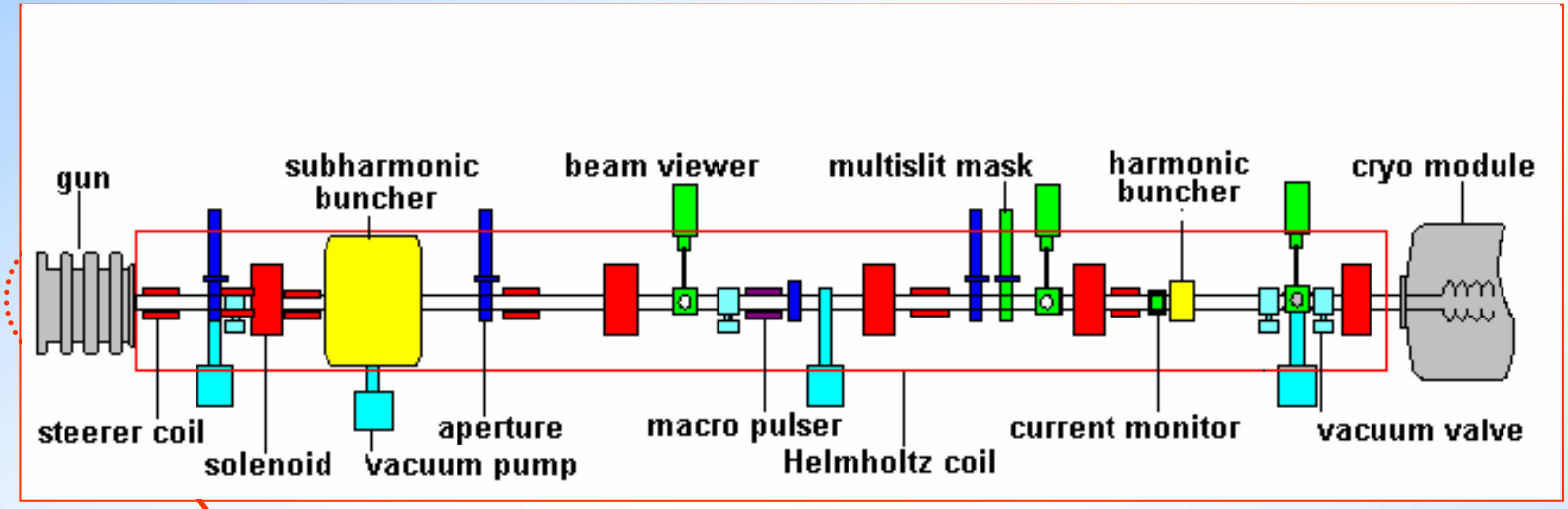


ELBE building

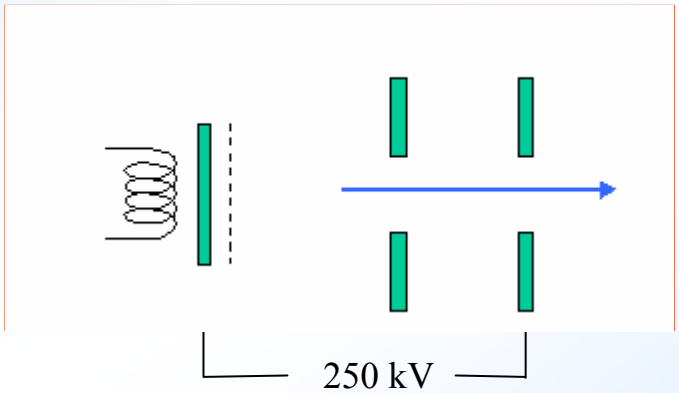


2. ELBE Accelerator

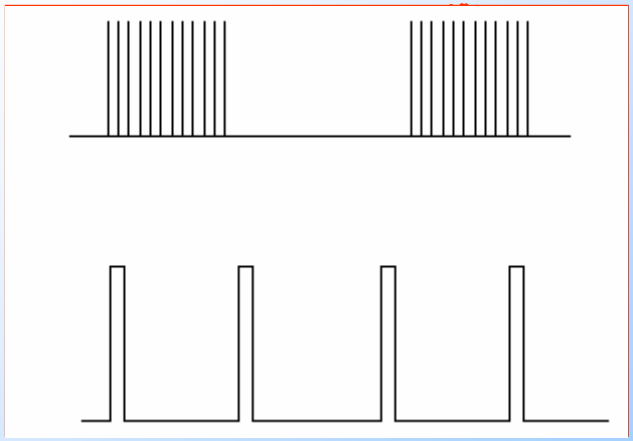
Electron source and injection



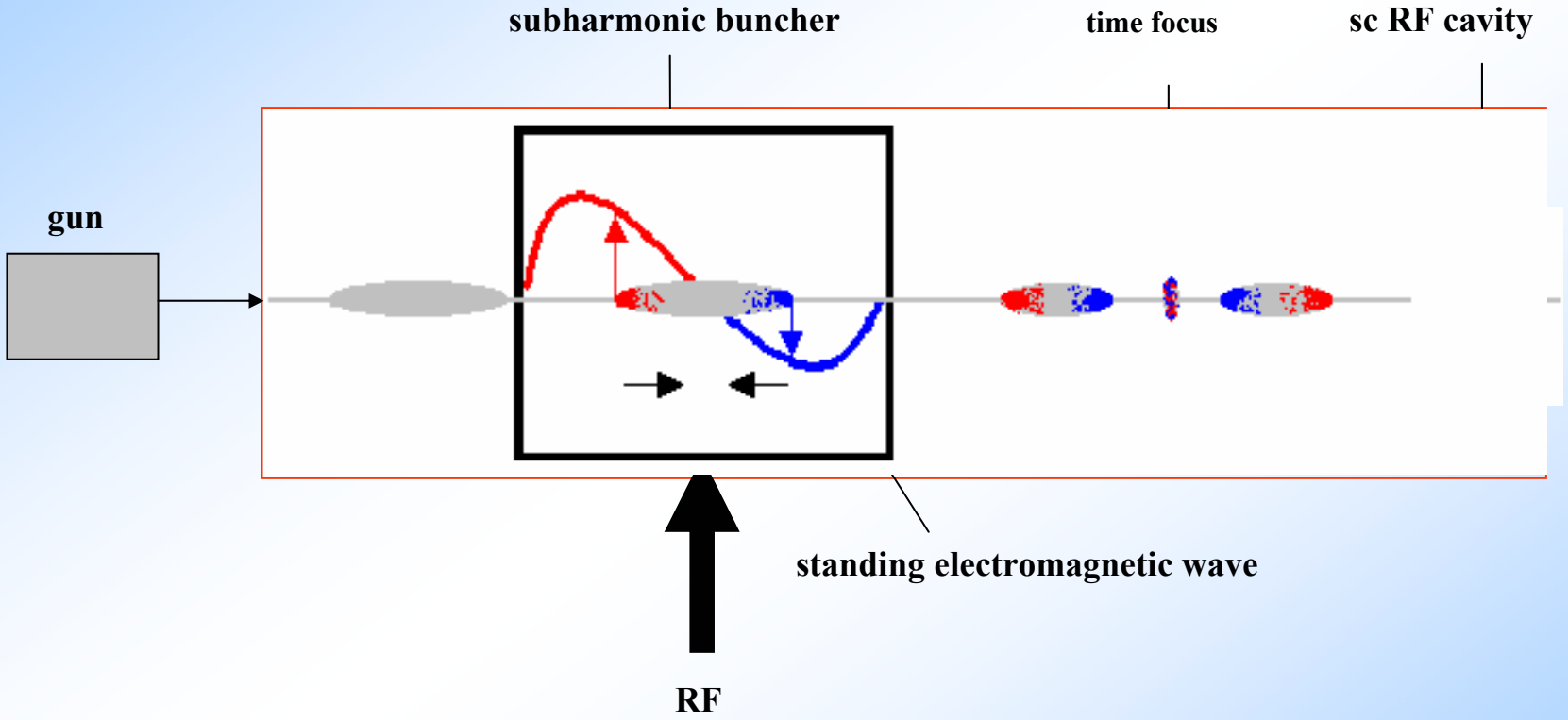
Thermionic gun



Puls structure of electron beam



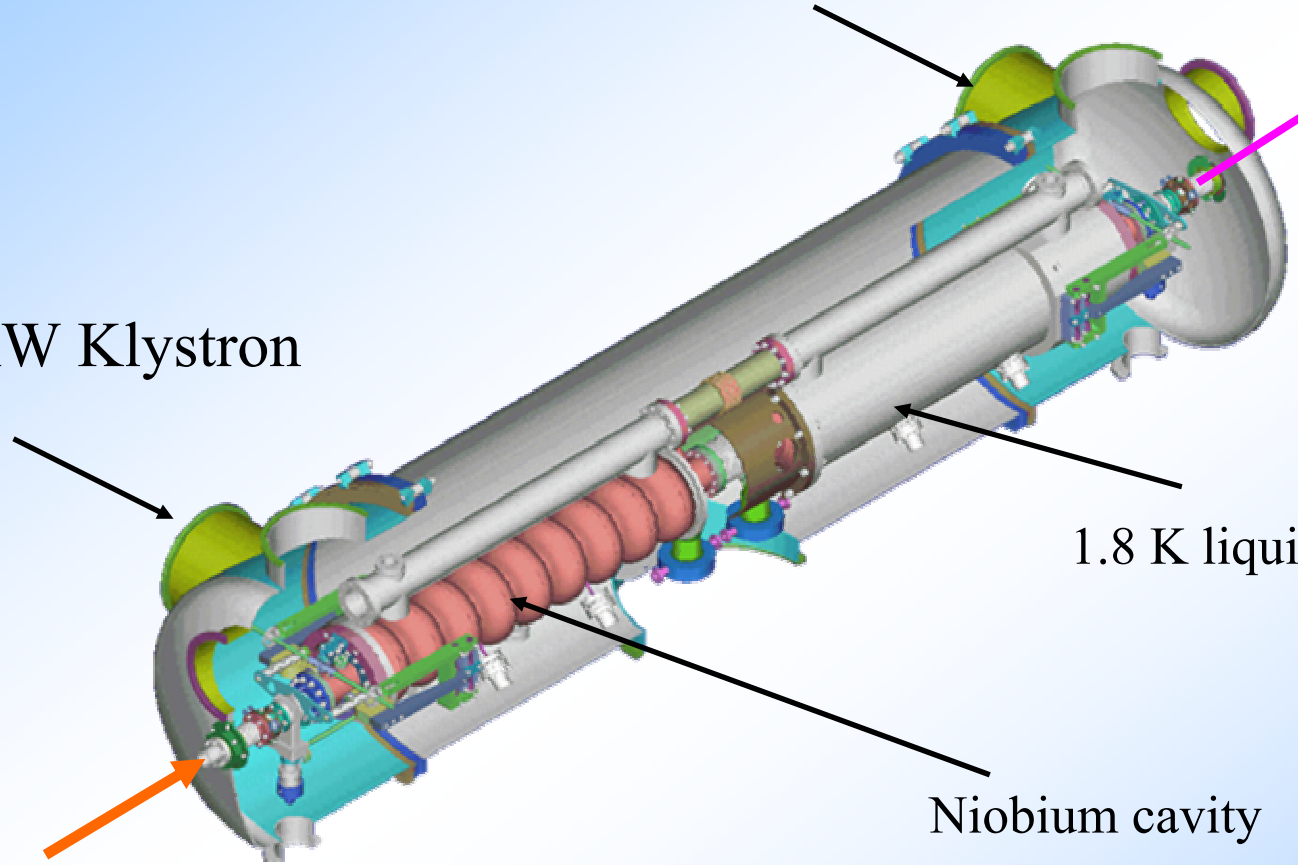
Puls compression



ELBE radio-frequency accelerator

20 MeV · 1mA = 20kW

$\beta = 0{,}999687$



10 kW Klystron

1.8 K liquid He vessel

Niobium cavity

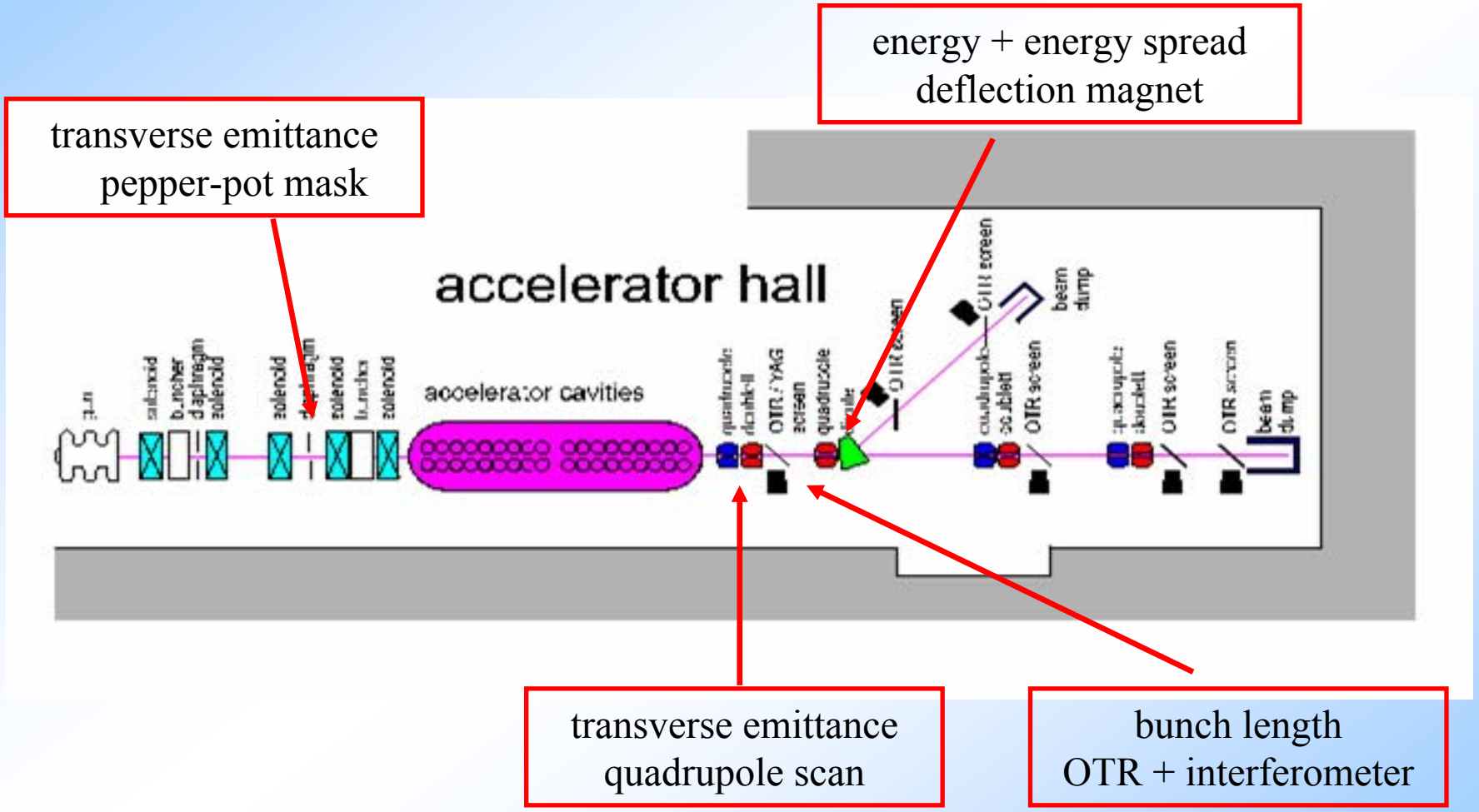
250 keV, 1 mA

$\beta = \frac{v}{c} = 0{,}74$

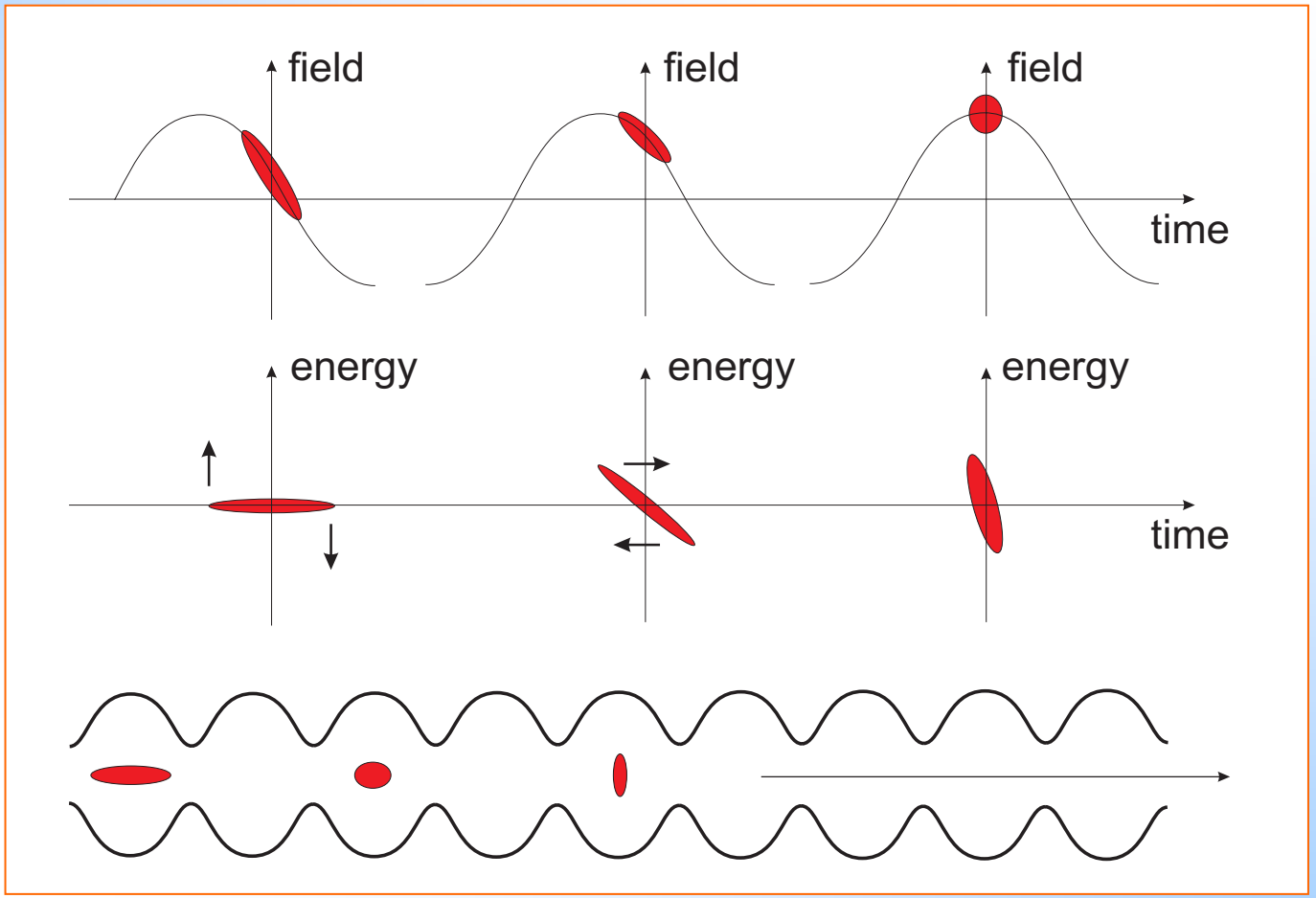
Beam lines & Diagnostics & Others

• vacuum system	DN 40 UHV + ion getter pumps (< 10^{-9}mbar)
• magnets	DANFYSIK dipole/quadrupol (< 80 MeV electrons)
• beam viewer	OTR→digital frame grabber→online imaging/evaluation
• emittance measurement	pepperpot mask / automated quadrupol scan
• online beam position	stripline detectors
• bunch length	MP interferometer
• online beam loss	long ionization chambers (machine protection)
• dumps	radiation cooled graphite (50 kW)
	+ steel/concrete/water shielding
•control system	PC based , Simatic-PLC/WINCC

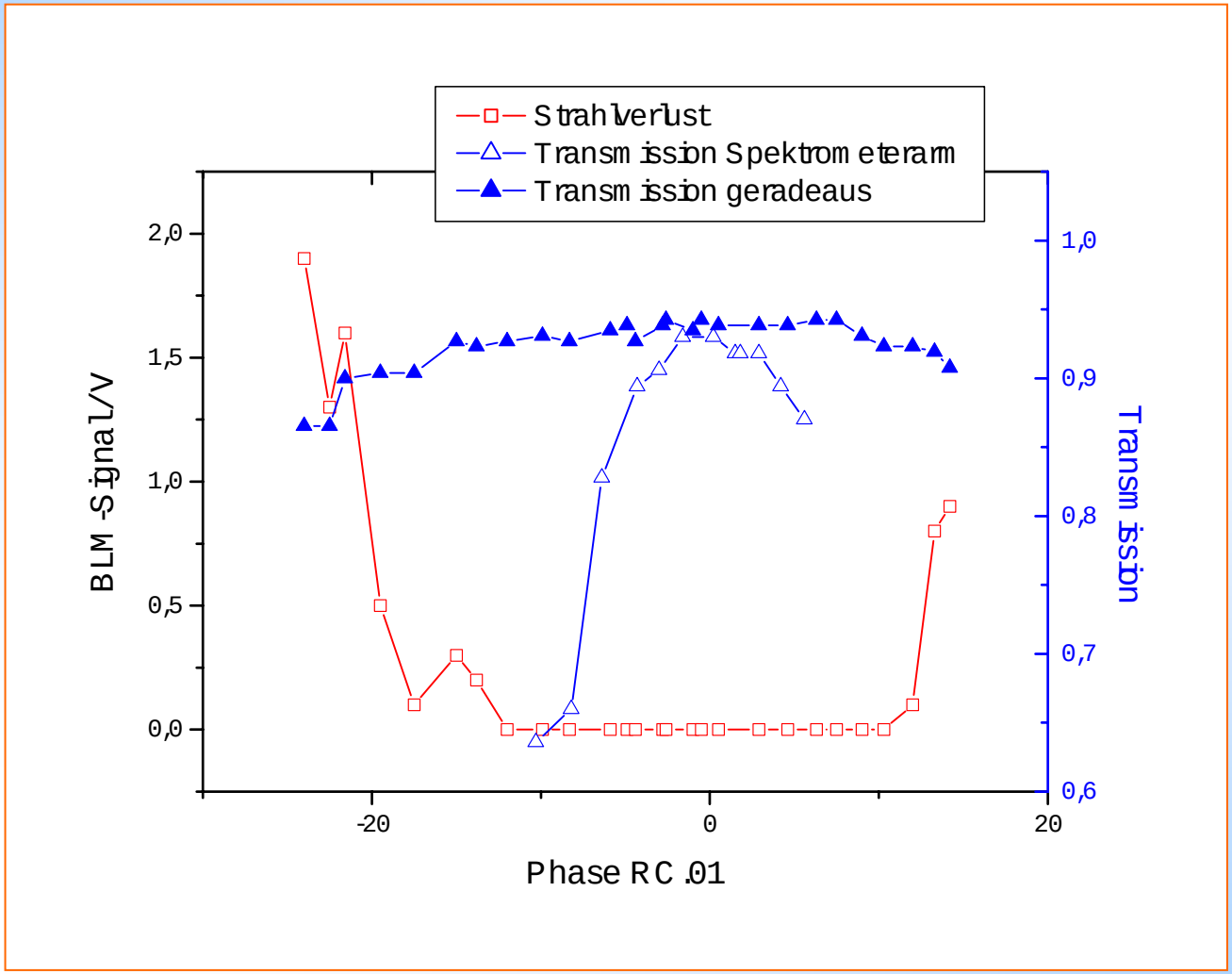
3. Results of the first operational period



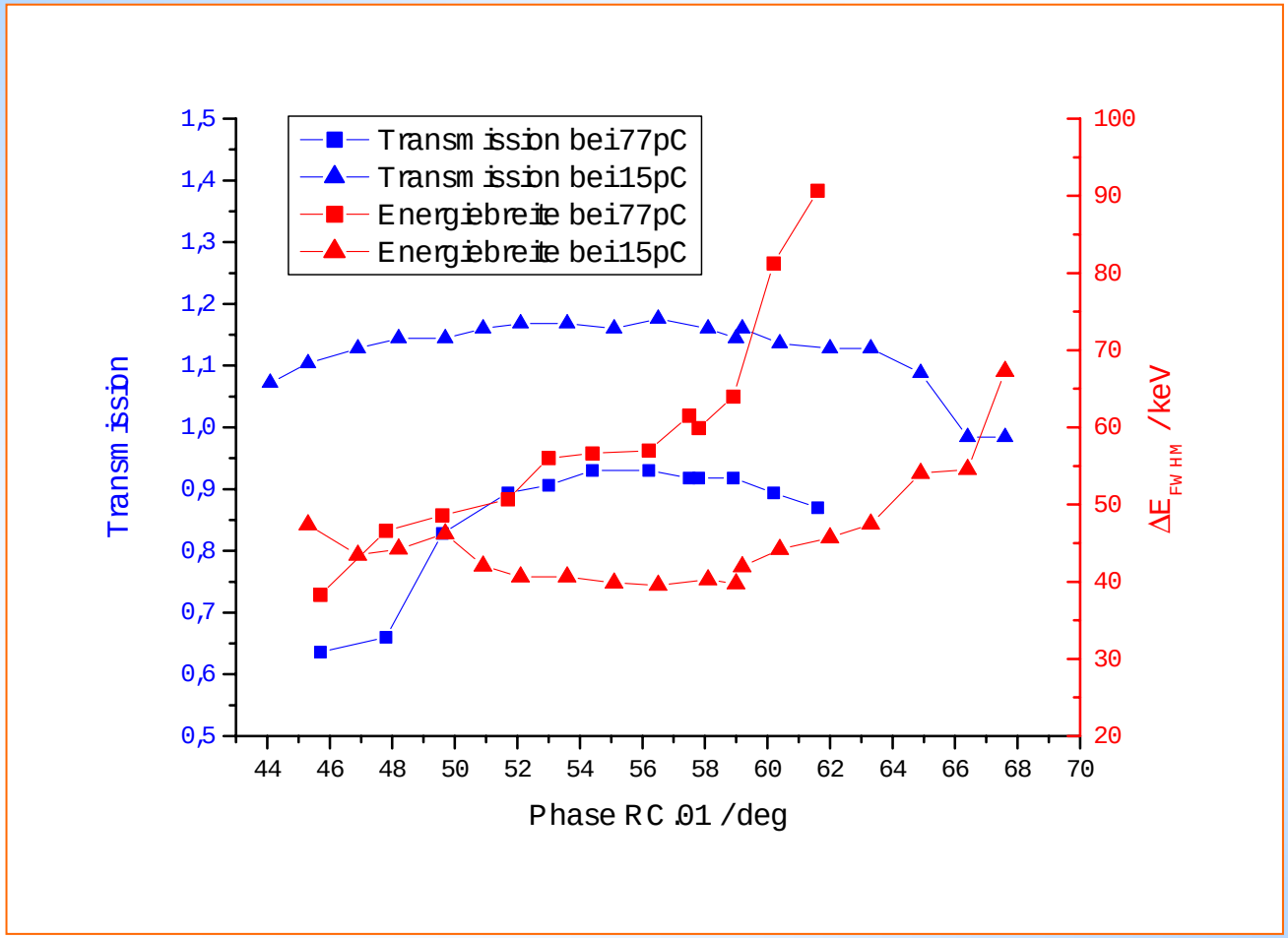
Electron beam capture into the field of the first accelerator cavity



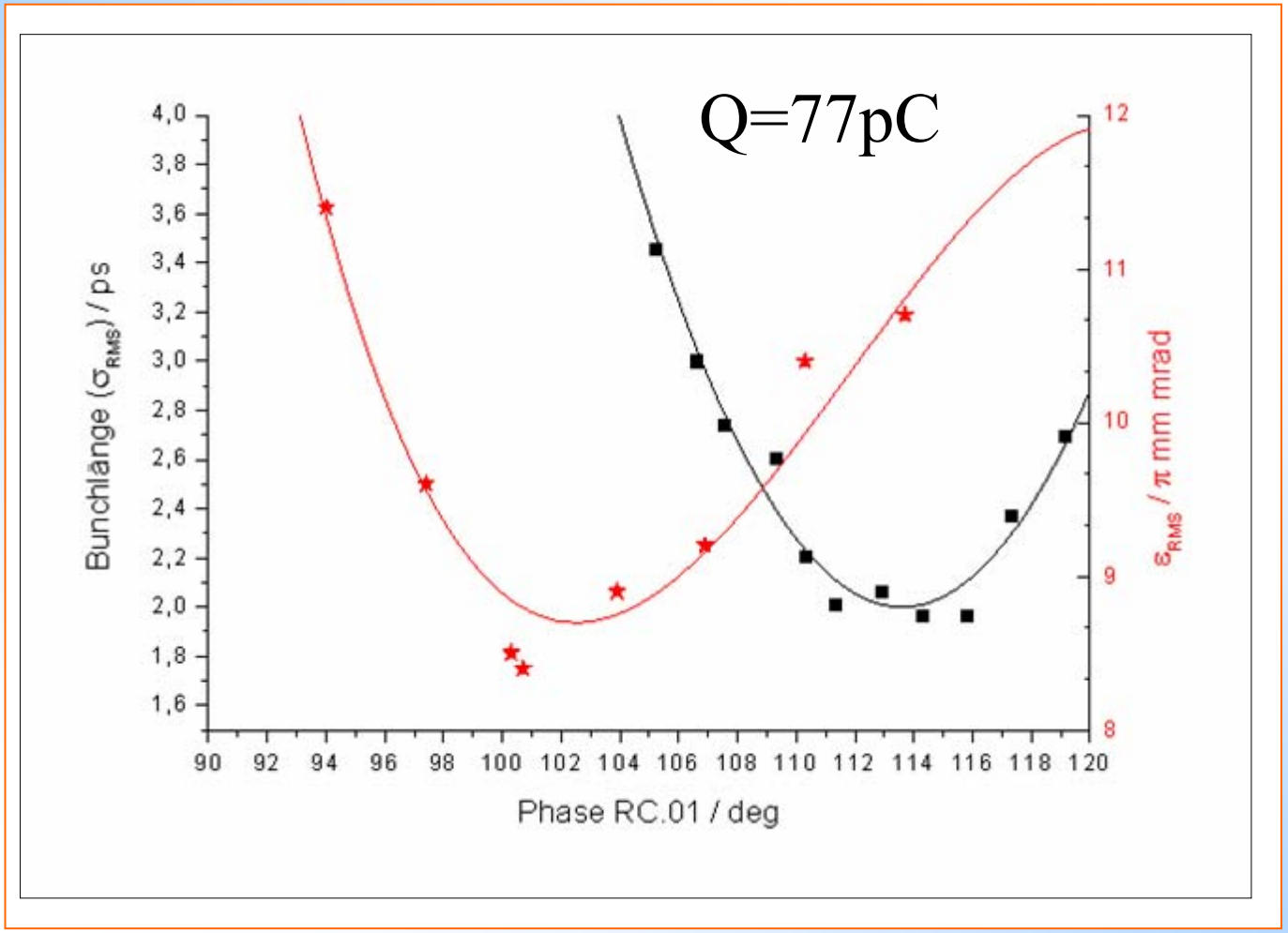
Transmission at 77 pC bunch charge



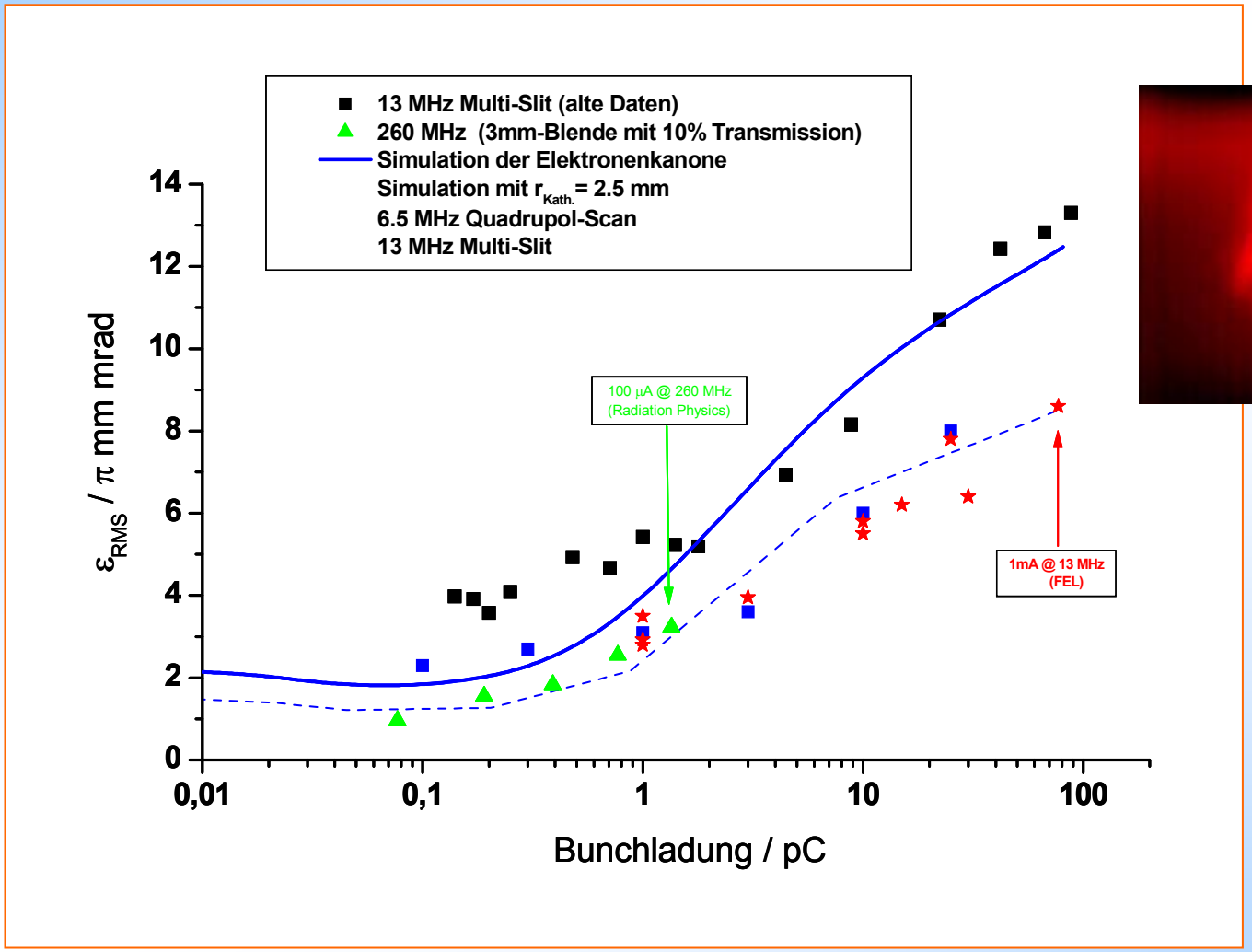
Transmission and energy spread

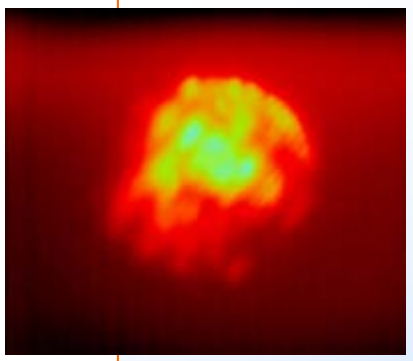


Bunch length and transverse emittance



Transverse emittance of the ELBE electron beam





Electron beam parameters of ELBE

maximum beam energy		20 MeV ⟶ 40 MeV	
maximum bunch charge		~ 77 pC	
maximum beam current		0.85 mA ⟶ 1 mA	
	at 1 pC bunch charge	at 77pC bunch charge	
		combined	separate
energy spread ΔE (FWHM)	35 keV	55 keV	40 keV
transverse emittance ε_{RMS}	3 π mm mrad >2 π mm mrad	10 π mm mrad	8 π mm mrad
bunch length σ_{RMS}		2.5 ps	2.0 ps

Test of the main accelerator components

LHe - cooling system
Cryostat
Cavities and rf system
beam line elements and diagnostics

Beam parameter measurement

2001,	April	cool down
	May	first beam (5 µA @ 6 MeV)
	July	full energy(20 MeV @ 10 µA)
	Aug.	full bunch charge (77 pC)
	Nov.	850 µA current

Construction periode (Jan – Aug 2002)

2002,	final setup	
	Sept.	start
	Oct.	first user run

4. Conclusions and Outlook

- Specified beam parameters has been achieved
- Autumn/Winter 2002

  nuclear physics (MeV bremsstrahlung)
- Winter 2002/Spring 2003

  radiation physics (channelling radiation)

  beam lines to FEL (undulator U 27)

  new improved cryo-module (20 MeV)
- 2003

  Neutron physics beam line

  two accelerator modules (40 MeV)

Thanks to all colleagues:
for the help with
hardware & software, useful discussions and
running the machine

Thank you for your attention.

Outline

INPUT: injector beam parameter

energy: 250 keV, β = 0.74

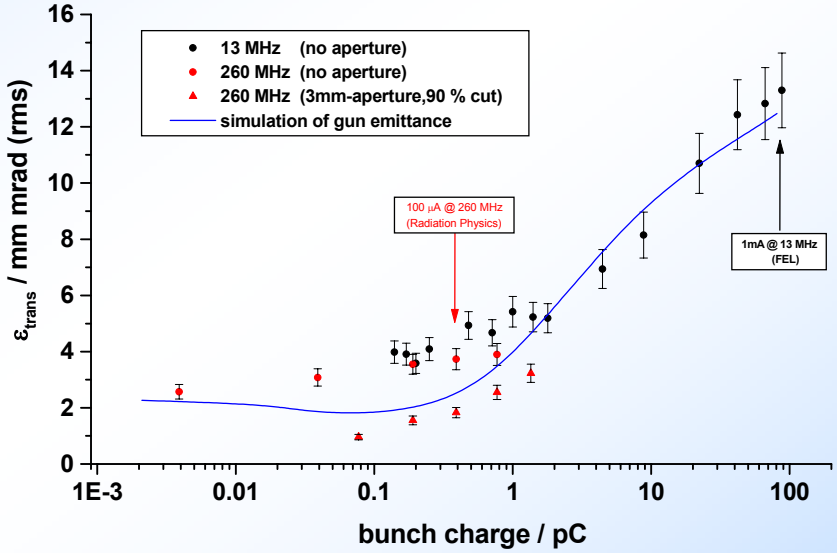
f = 1/n * 13 MHz, n = 1,2 ...,

variable macro-pulsing

I = 0 ... 1 mA, Q = 0 ... 77 pC

bunch length = < 12 ps

™$_{trans}$ = 2 ... 12 mm mrad



ACCELERATOR:

final energy: 12 MeV

Cavity I 11 MV, >> 6 MeV

Cavity II 6 MV, >> 12 MeV

dependence on bunch charge ?

phase of Cavity I ?

capture and transv.+longit. focussing