R&D at the Electron-Stretcher Accelerator

Status 09/2010

Wolfgang Hillert

Physics Institute of Bonn University

R&D at the Electron-Stretcher Accelerator

Main subjects (experimenters wish list):

- **high beam polarization**
- **high beam quality (emittance, halo)**
- **high beam pointing and intensity stability**
- **high intensity**

Sc. Accelerator Group 09/10

Scientific Members:

W. Hillert	F. Frommberger	A. Dieckmann

PhD Students:

A. Balling	J. Wittschen	M. Eberhardt	T. Pusch
F. Klarner	A. Roth	O. Preisner	S. Zander
D. Heiliger	O. Boldt	S. Patzelt	

Diploma / Master Students:

D. Krönung	R. Zimmermann	N. Hofmann	
J.P. Thiry	D. Proft	N. Heusch	M. Schedler

Bachelor Students:

M. Schedler	N. Thau	J. Oberem	C. Reinsch
J. Schmidt	D. Sauerland		

Polarized Electrons:

- **Intensity upgrade photoinjector** (100mA → 200mA, beam transport)
- **New loadlock system** (storage of up to 6 crystals, hydrogen cleaning)
- **Compensation of depolarizing resonances** (harmonic correction, tune jumping)
- Spin Dynamics: computer aided modeling (tracking, matrix and Hamilton codes)

Beam Diagnostics:

- **RF cavity based measurements** (intensity and position @ low currents)
- Synchrotron radiation monitors (beam profiles in ELSA and ext. beamline)
- Compton Polarimetry (internal polarimeter: laser, beamline and detector)

High Currents in ELSA:

- LINAC I overhaul and upgrade (short and long pulse operation, high intensity)
- **HOMs of PETRA resonators** (HOM calculation, T-stabilization, fc damping)
- **Active damping with feedbacks** (design, construction, commissioning)
- Beam loss monitoring system (installation and read-out)

Resonance Extraction:

- Computer aided modeling (simulation of external beam properties)
- Emittance measurements (measurement of external beam properties)
- **Beam position stabilization**

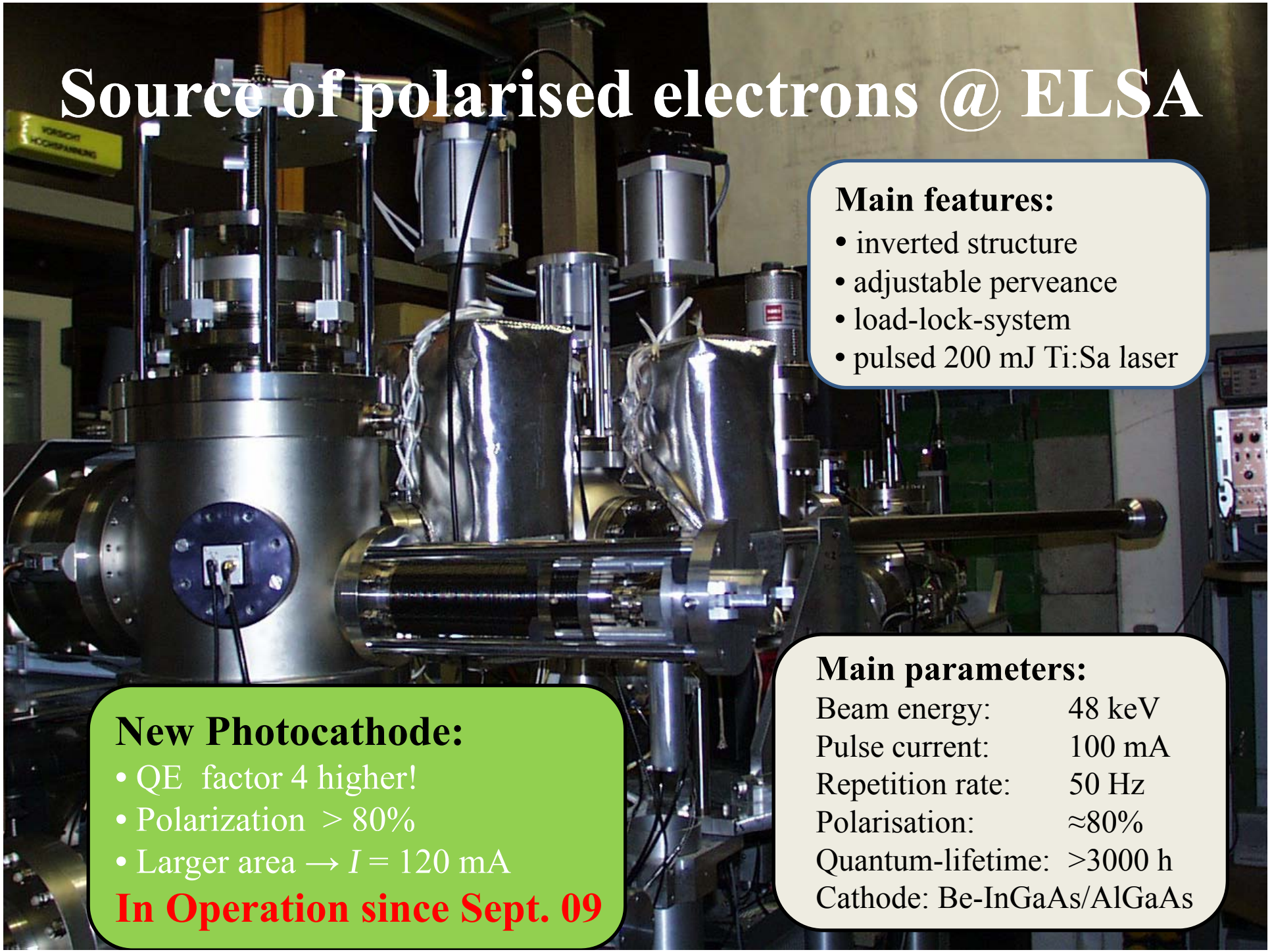
Beamline for Detector Testing:

- Design, construction and commissioning of the beamline

R&D@ELSA

Polarized Electrons: Source & Resonances

Source of polarised electrons @ ELSA



Main features:

- inverted structure
- adjustable perveance
- load-lock-system
- pulsed 200 mJ Ti:Sa laser

New Photocathode:

- QE factor 4 higher!
- Polarization > 80%
- Larger area → I = 120 mA

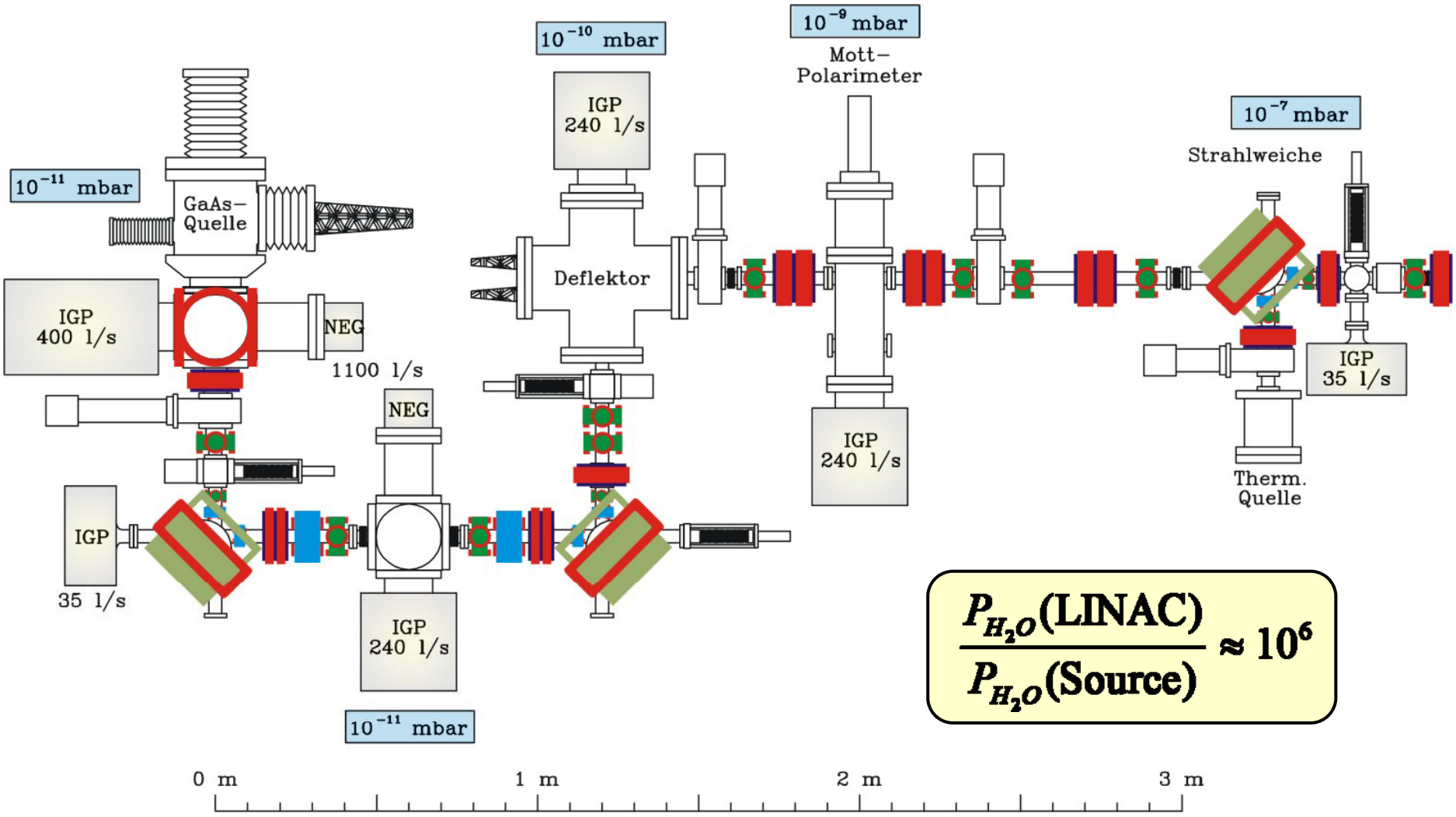
In Operation since Sept. 09

Main parameters:

Beam energy:	48 keV
Pulse current:	100 mA
Repetition rate:	50 Hz
Polarisation:	≈80%
Quantum-lifetime:	>3000 h

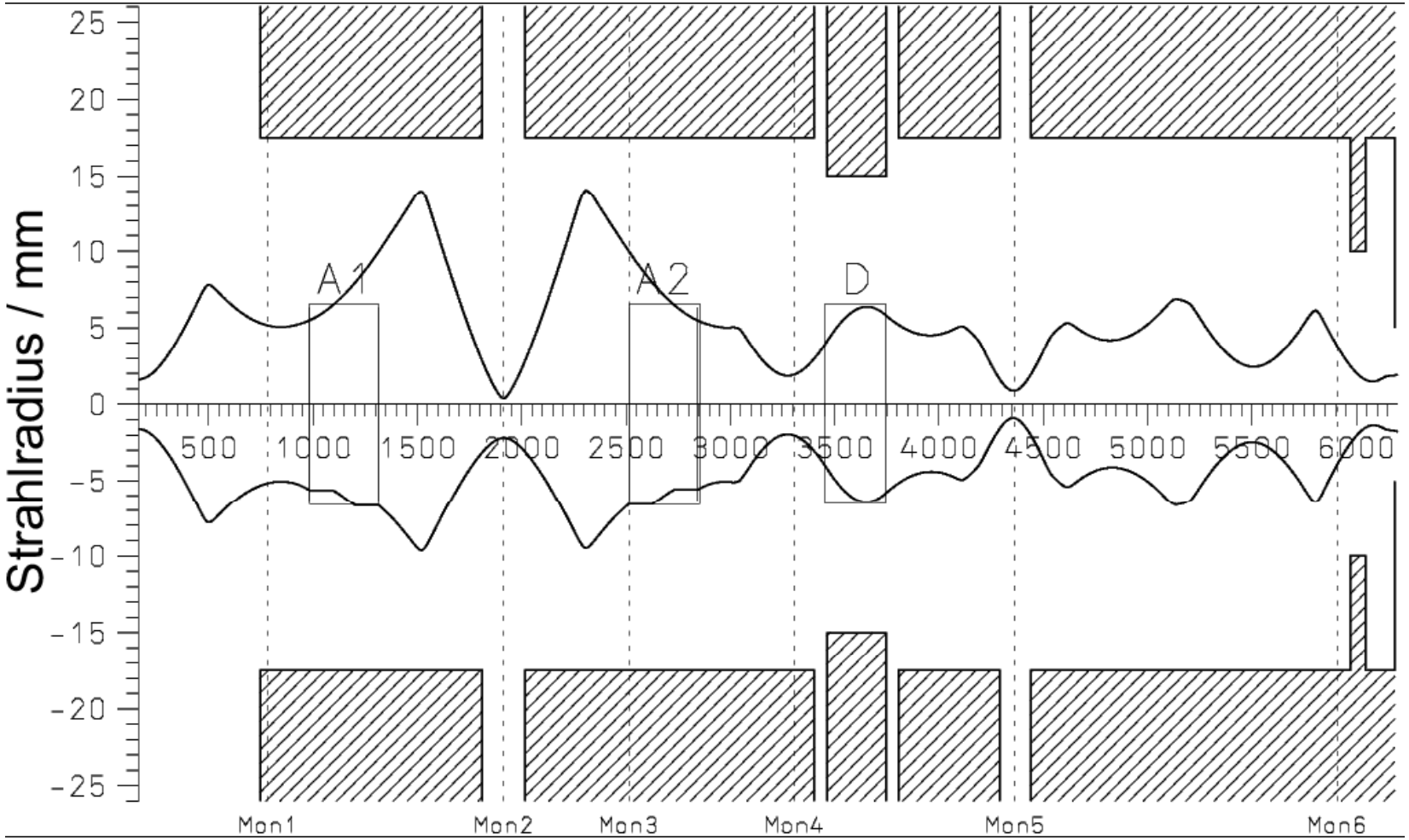
Cathode: Be-InGaAs/AlGaAs

50 keV Beamline to LINAC II



$$\frac{P_{H_2O}(\text{LINAC})}{P_{H_2O}(\text{Source})} \approx 10^6$$

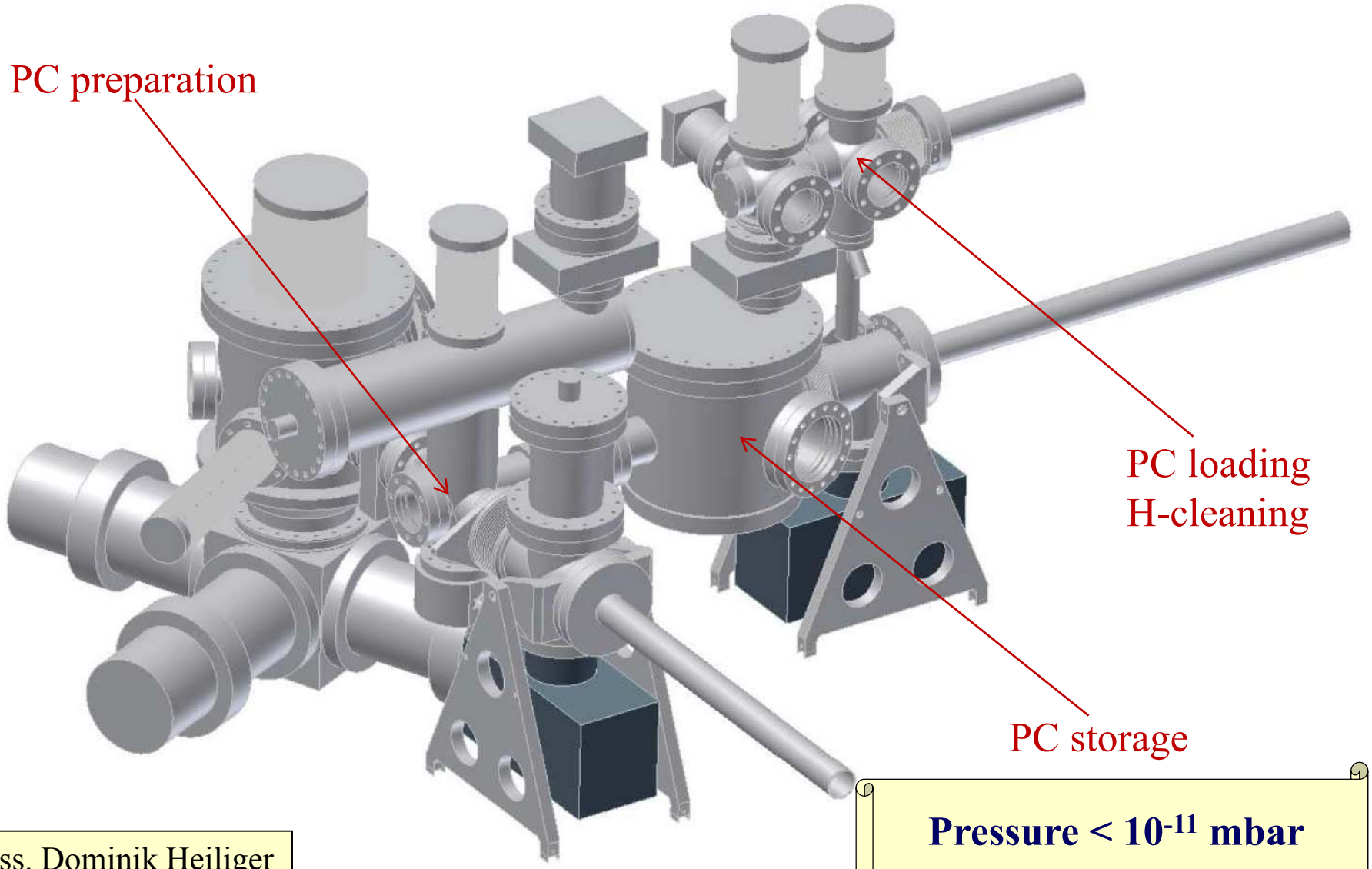
Intensity Upgrade to 200 mA



Diss. Dominik Heiliger

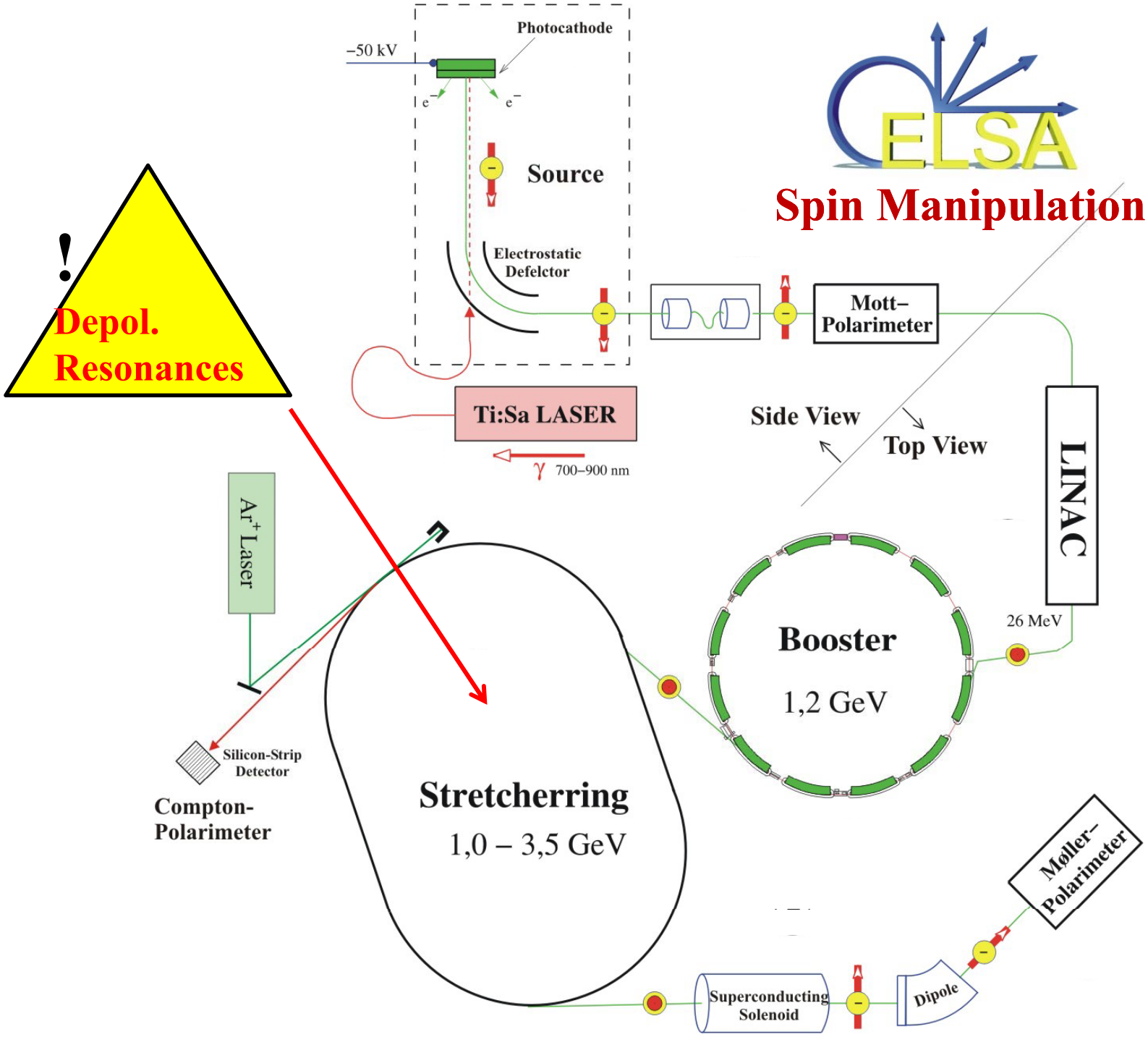
space charge dominated beam transport: opt. focusing

New Load-Lock: coming 2011

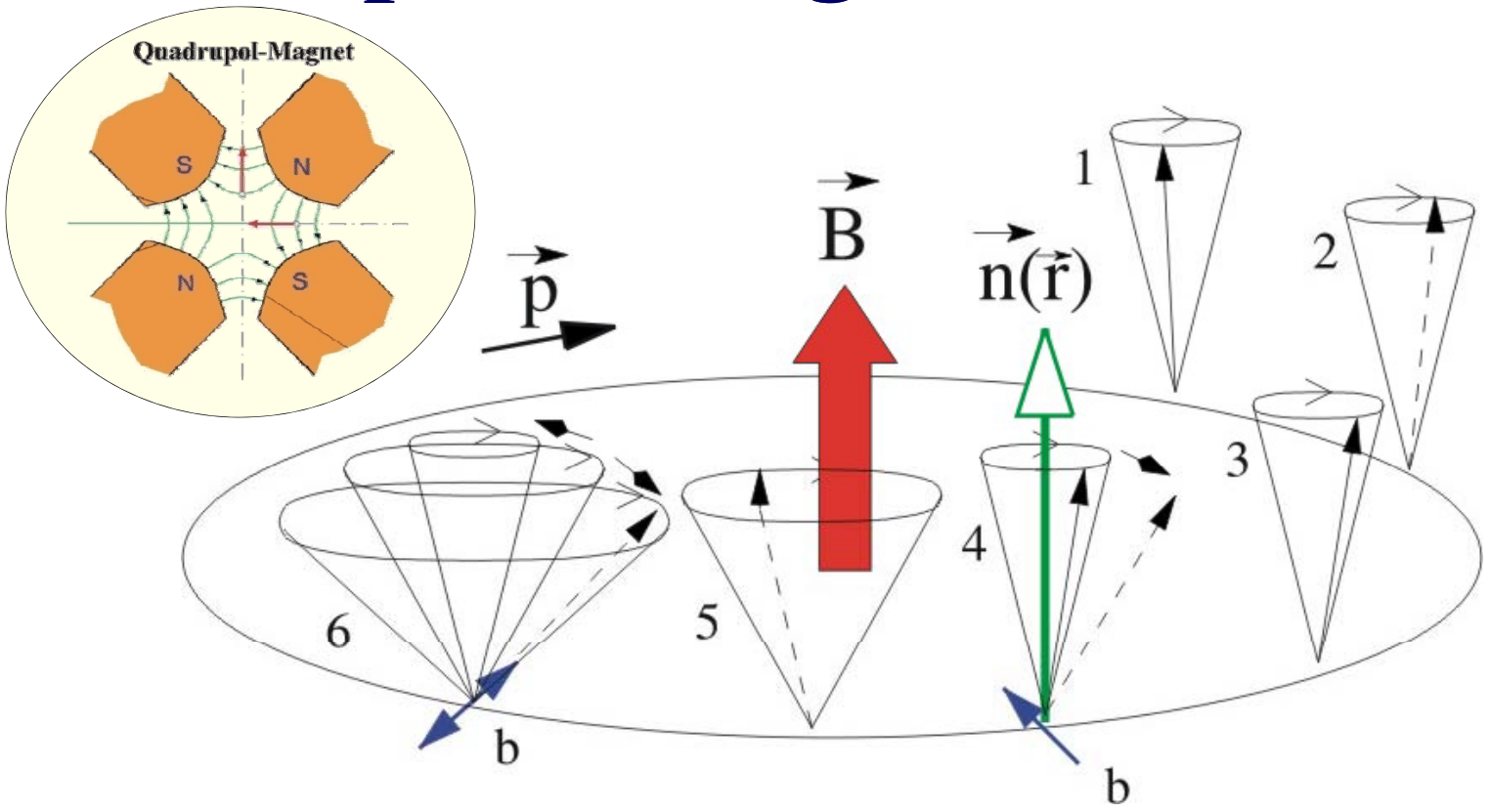


Diss. Dominik Heiliger

Pressure < 10^{-11} mbar


Photocathode
−50 kV
e⁻
e⁻
Source
Electrostatic
Defelctor
Mott–
Polarimeter
Ti:Sa LASER
γ 700–900 nm
Side View
Top View
LINAC
26 MeV
Booster
1,2 GeV
Ar⁺ Laser
Silicon-Strip
Detector
Compton-
Polarimeter
Stretcherring
1,0 – 3,5 GeV
Superconducting
Solenoid
Dipole
Møller–
Polarimeter
ELSA
Spin Manipulation
!
Depol.
Resonances

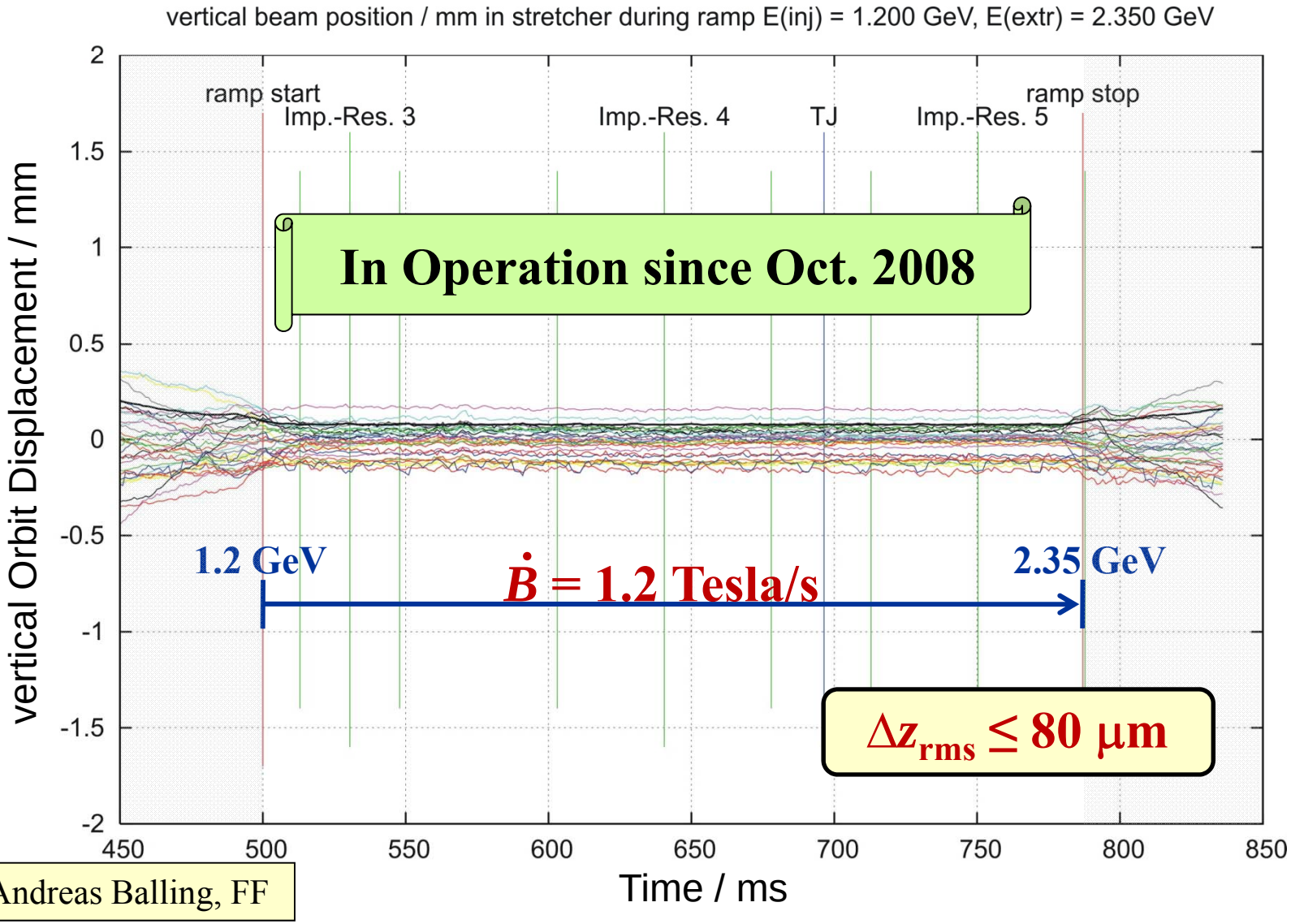
Depolarizing Resonances



Imperfektions-Resonanz: $\gamma \cdot a = n, \qquad n \in Z$

Intrinsische Resonanz: $\gamma \cdot a = n \cdot P \pm Q_z, \quad n \in Z$

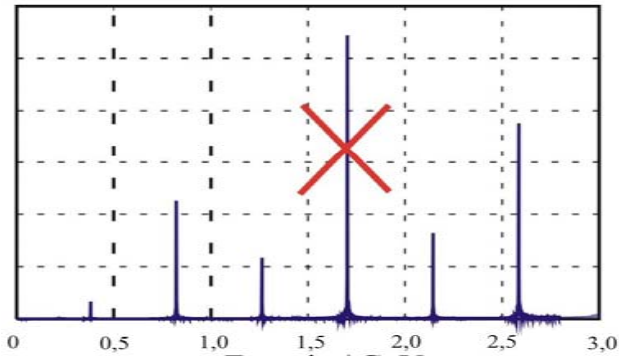
Orbit Correction on the Ramp

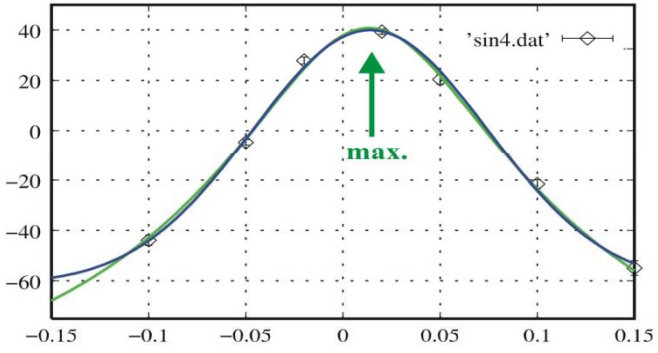


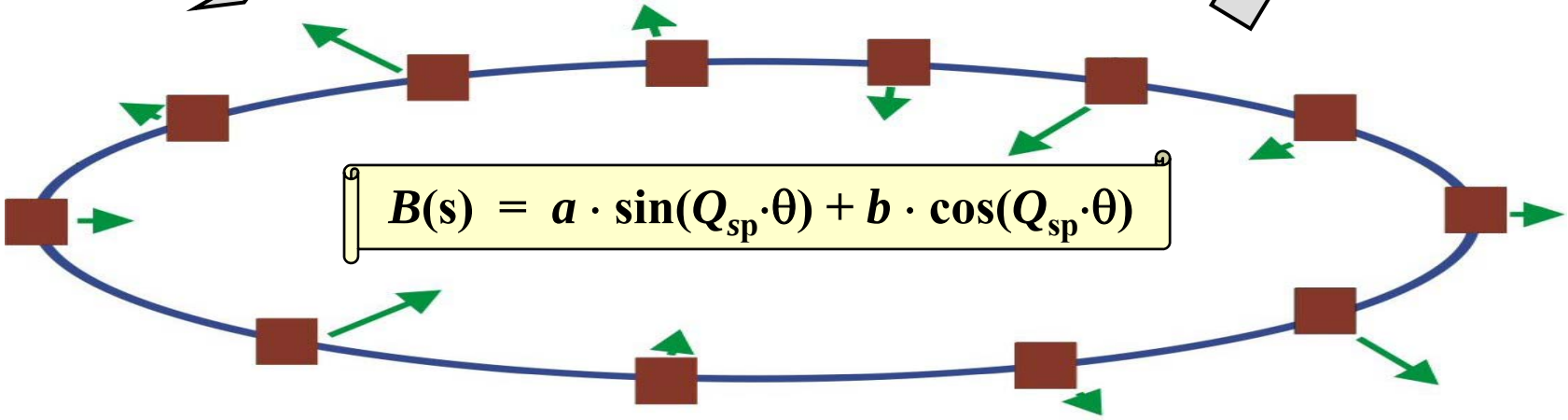
Diss. Andreas Balling, FF

Harmonic Correction

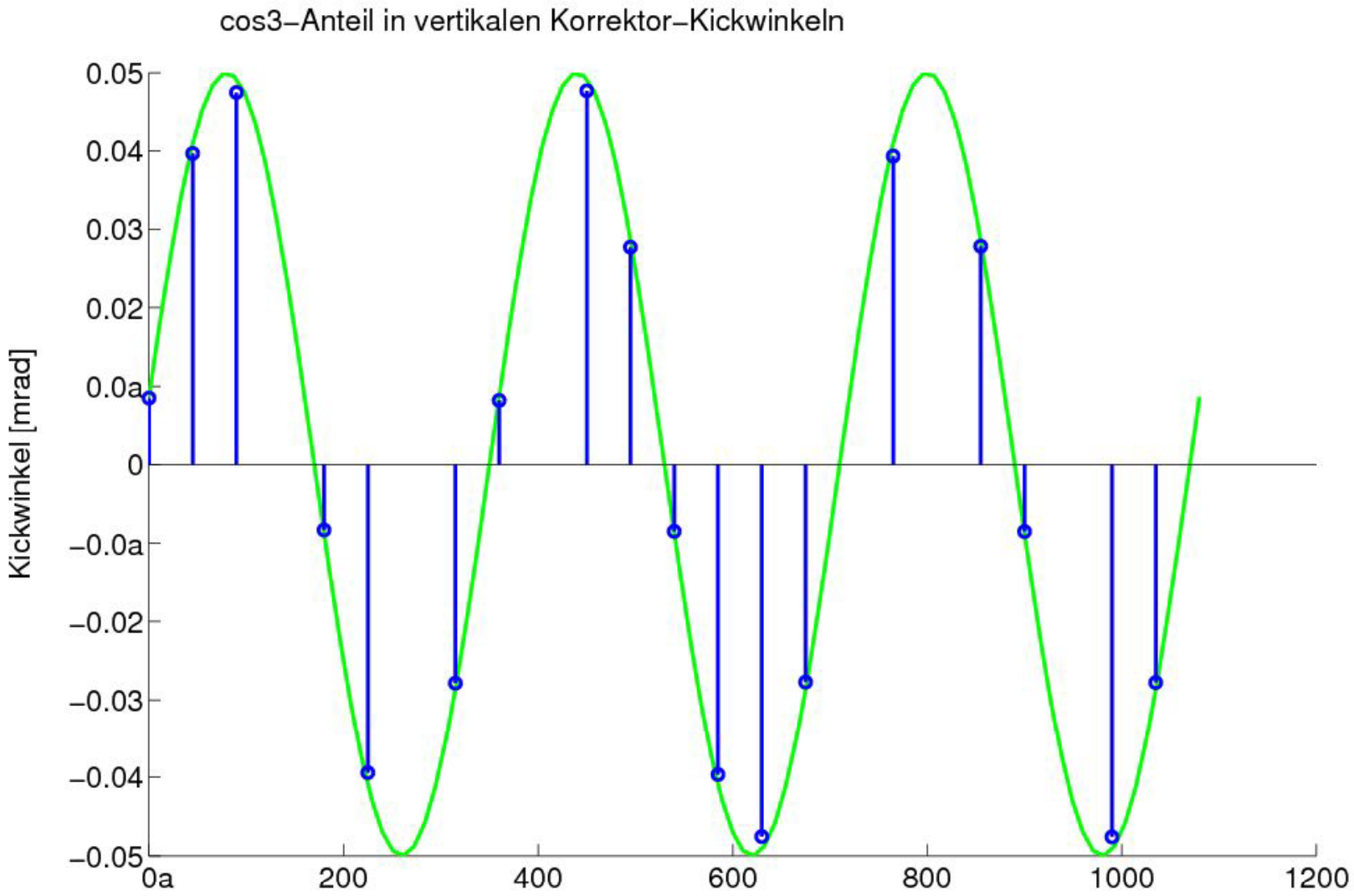
(Imperfection Resonances)





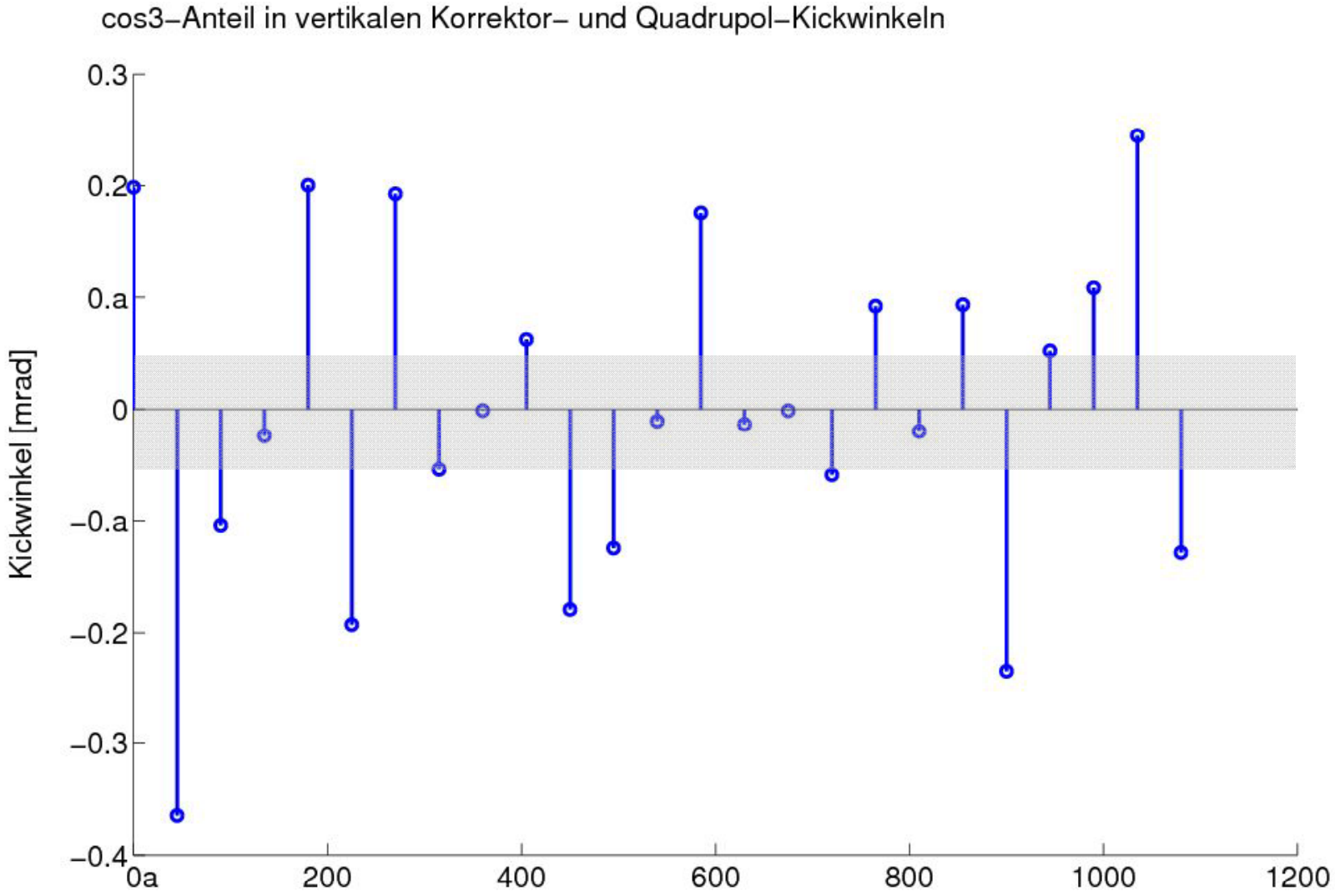


Effect of CO Displacements



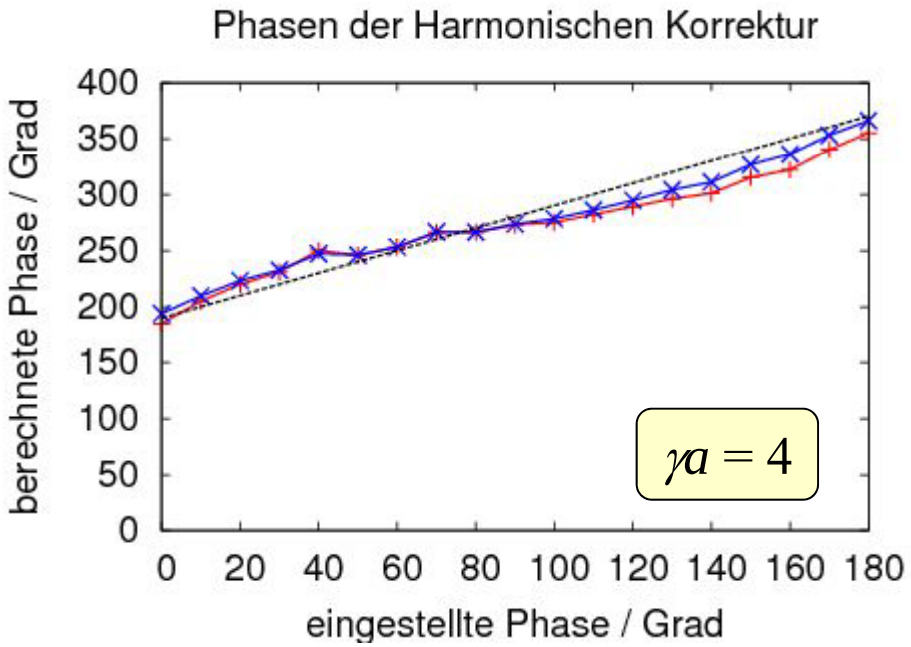
Diss. Oliver Boldt, WH

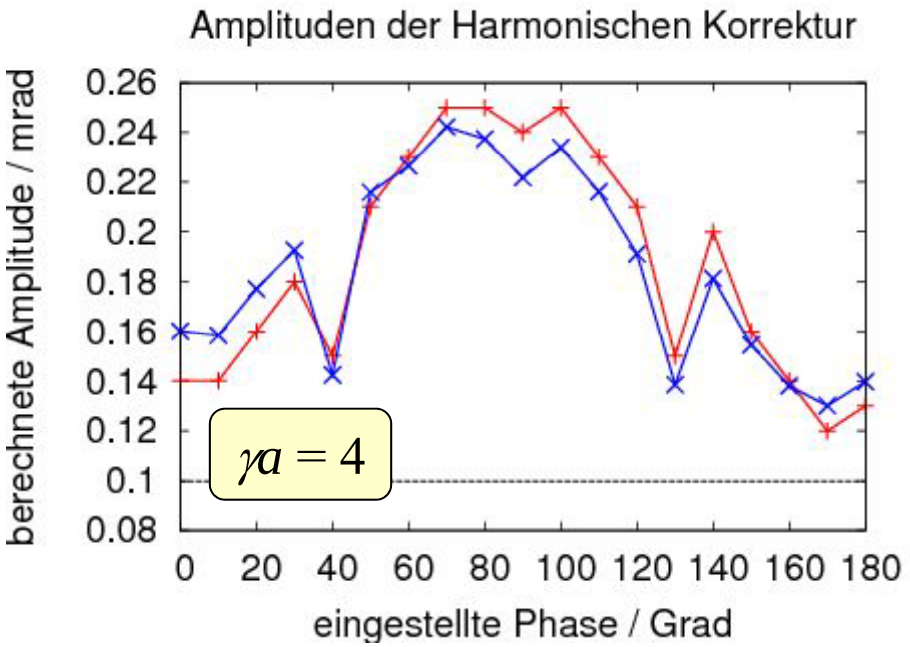
Effect of CO Displacements

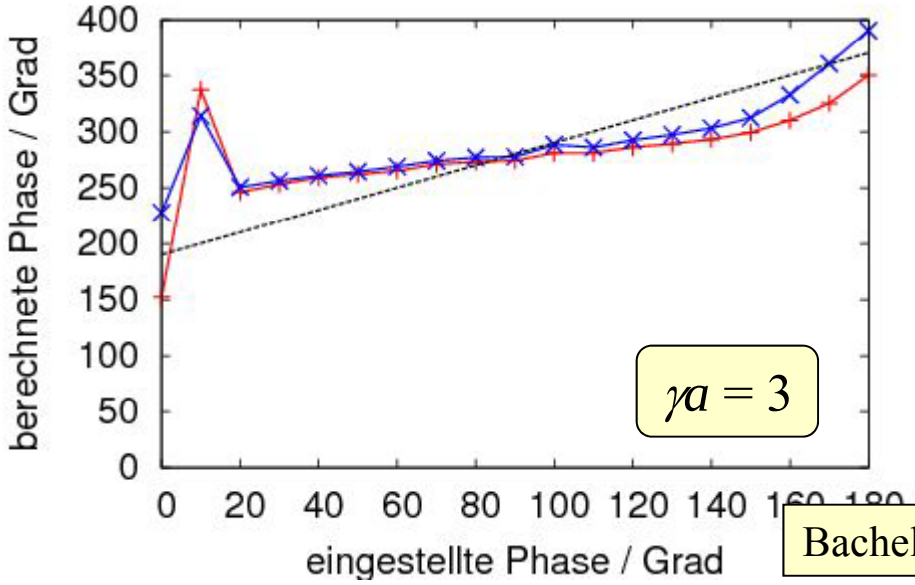


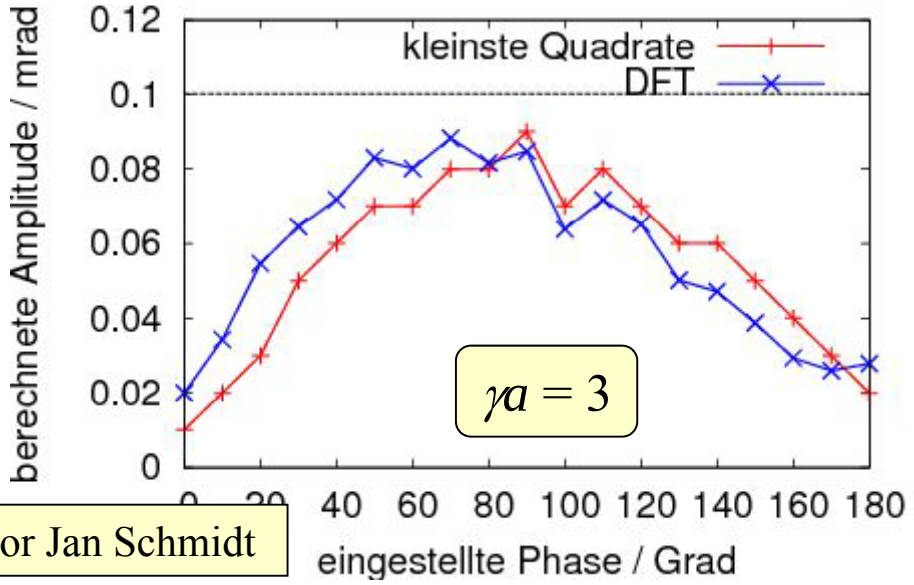
Diss. Oliver Boldt, WH

Phase and Amplitude Response









Bachelor Jan Schmidt

Improved Correction

New Correction-System:

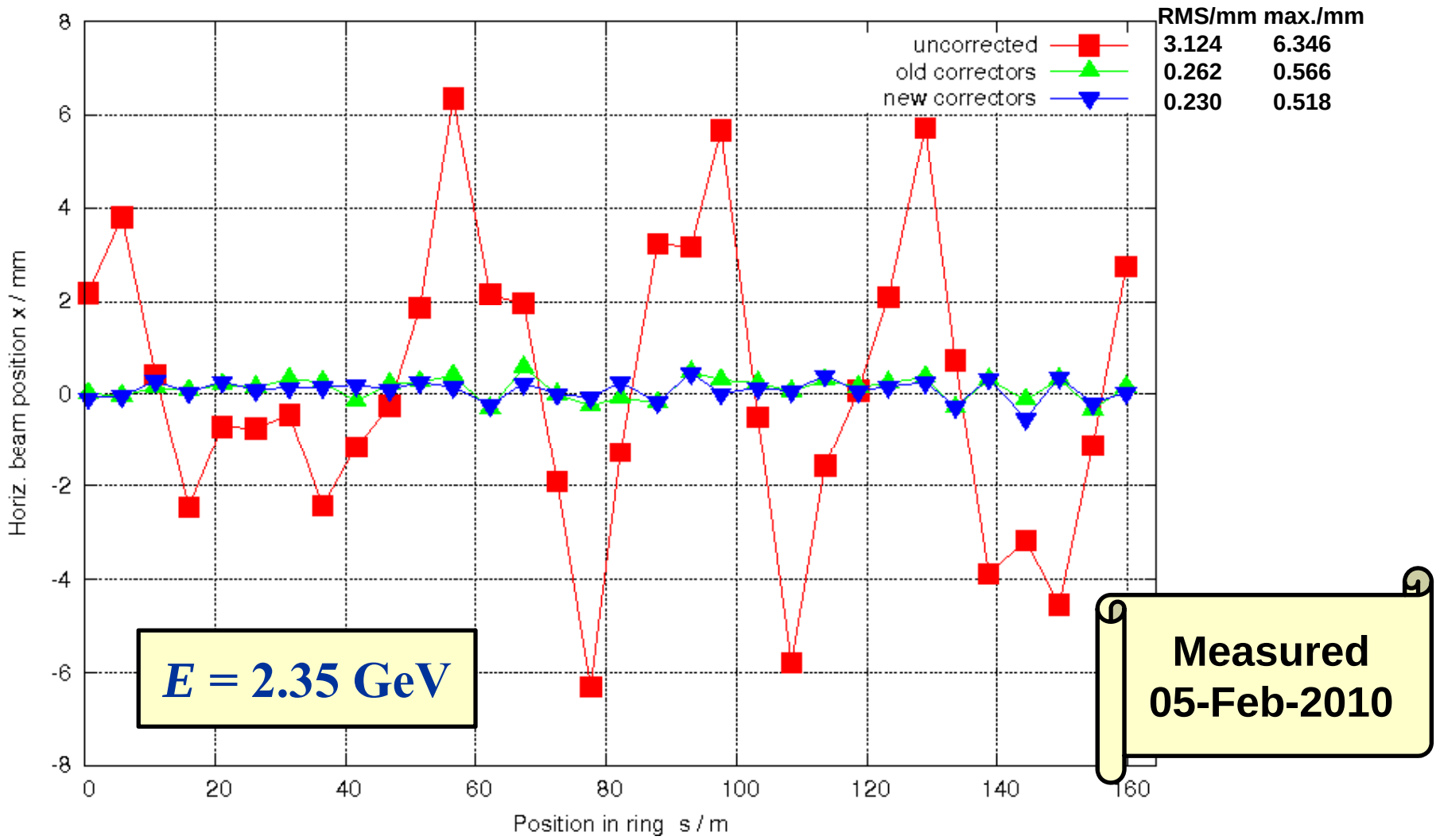
24 correction coils (main dipoles)

30 new vert. dipole correctors

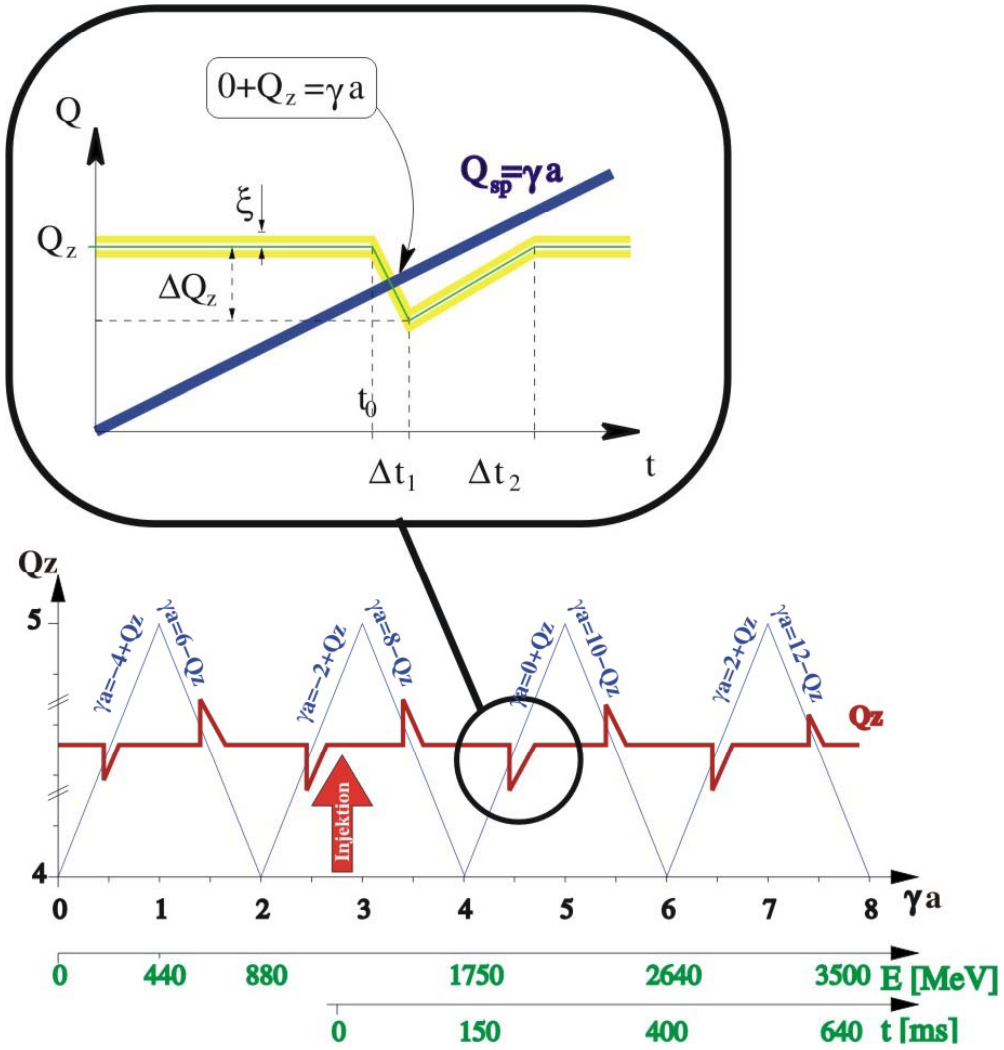
54 new "pulsed" power supplies

Diss. Andreas Balling

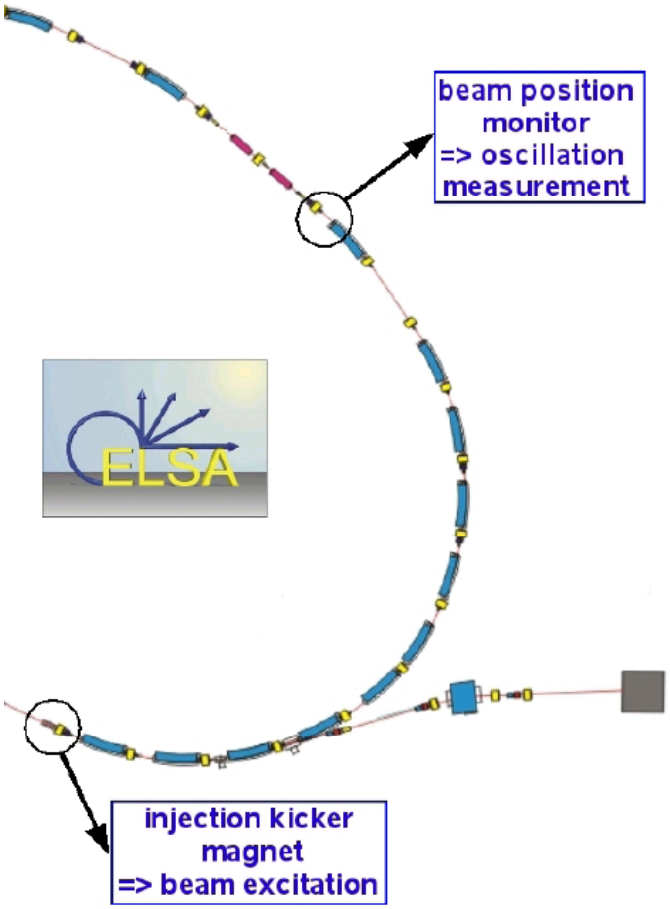
CO with Dipole Windings

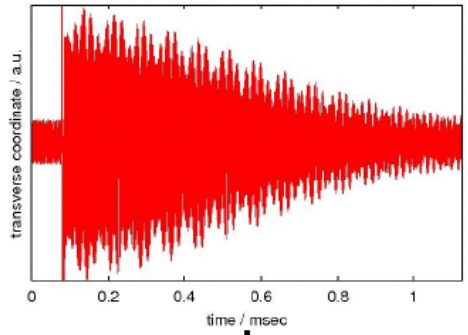


“Tune Jumping”



Tune Measurements

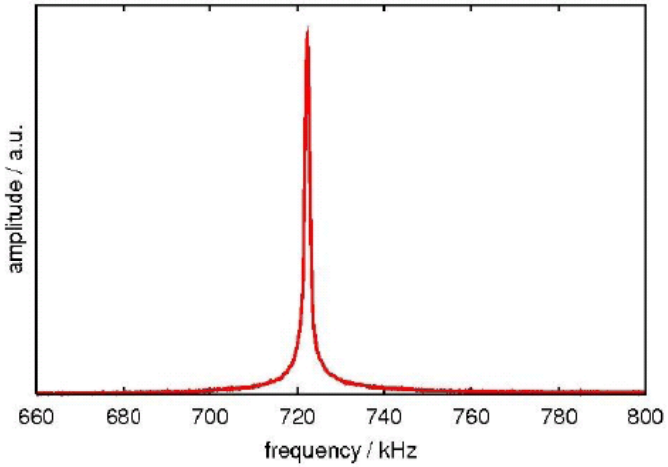




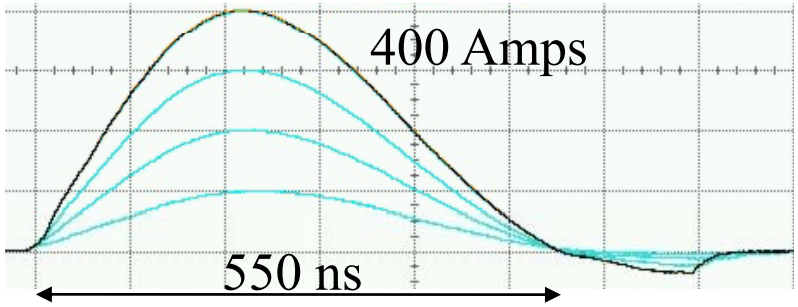
Damping effects:

- decreasing coherence
- synchrotron light radiation

Fourier analysis

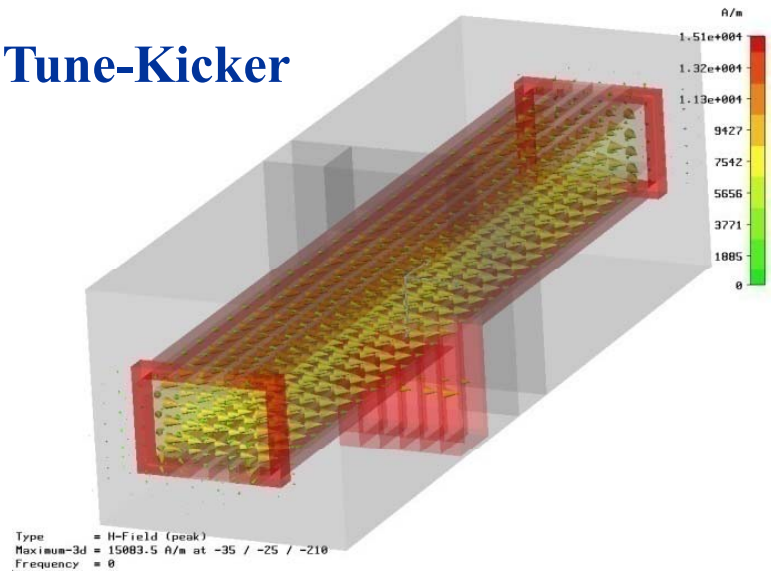


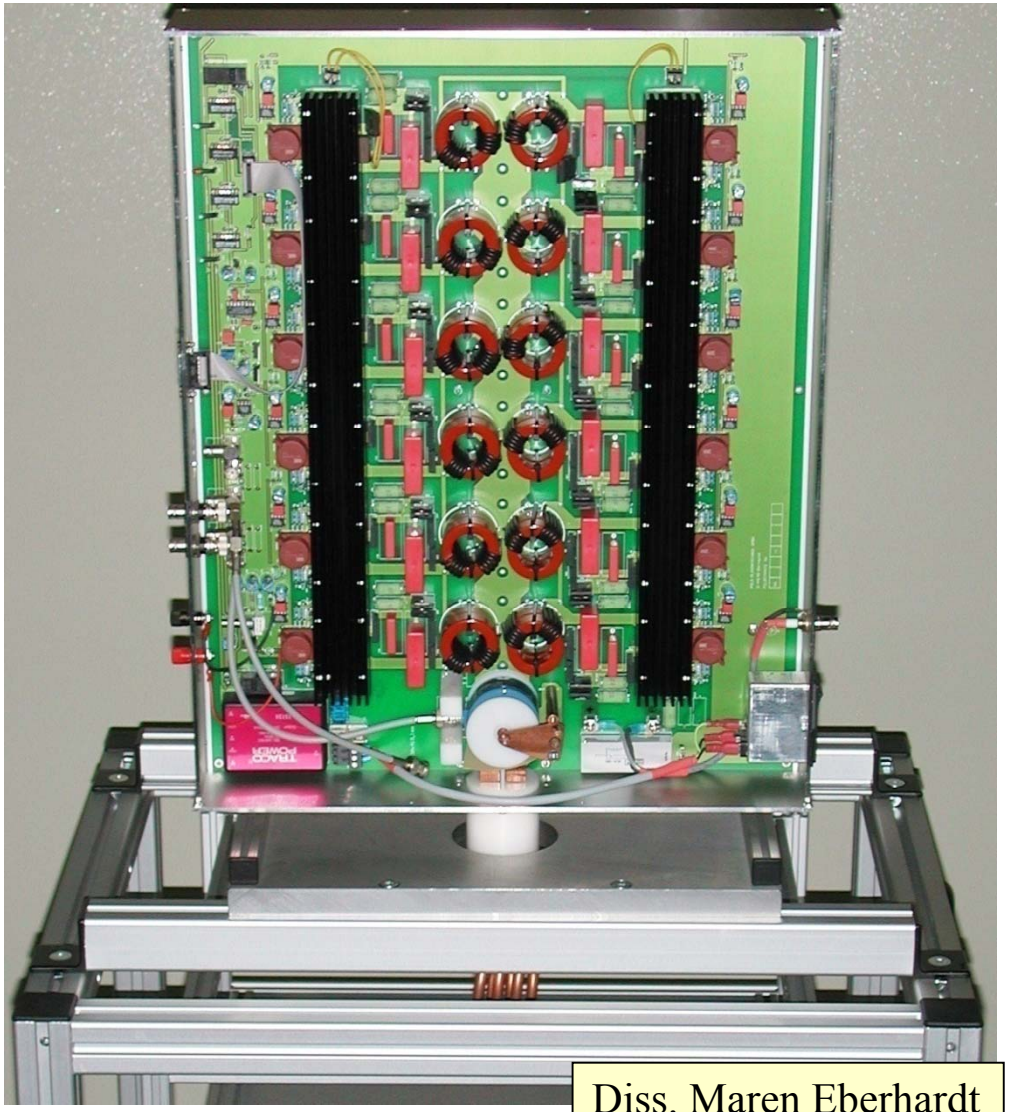
Vertical Tune-Kicker



One-Turn Excitation

Tune-Kicker

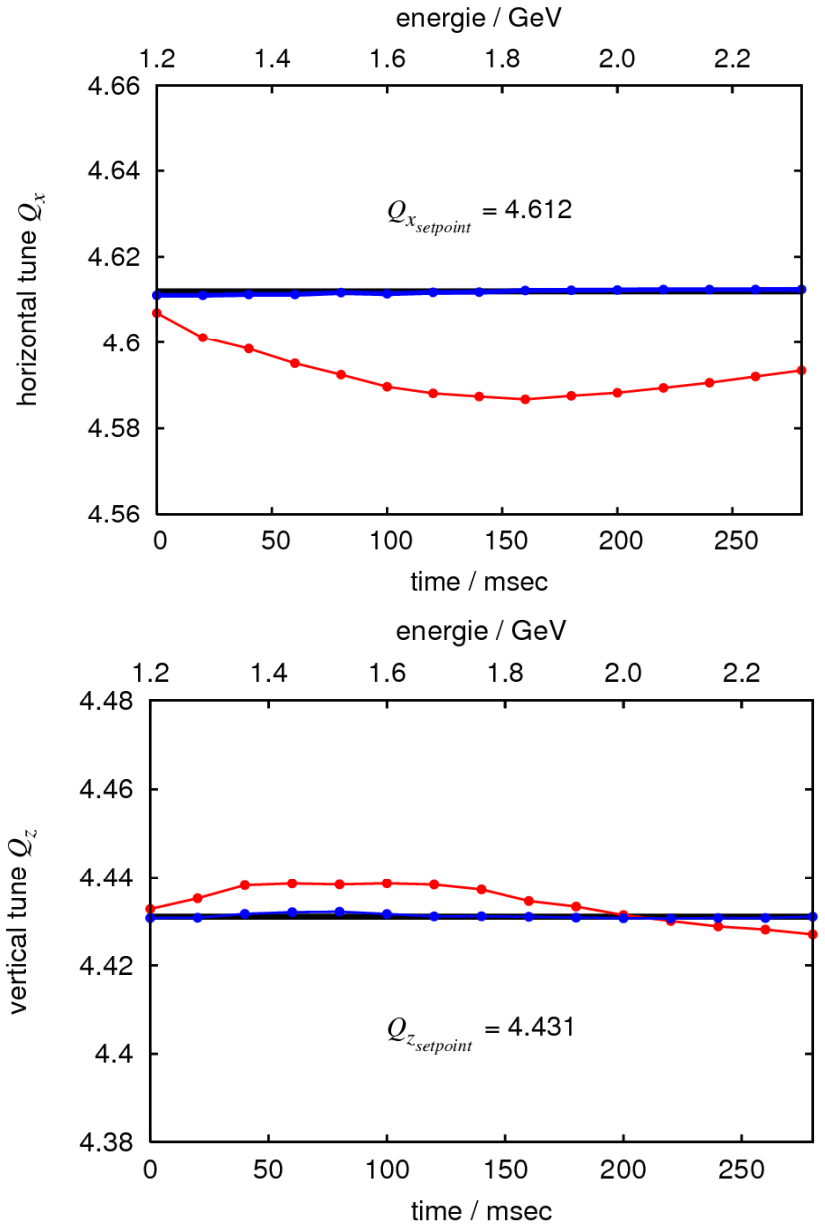




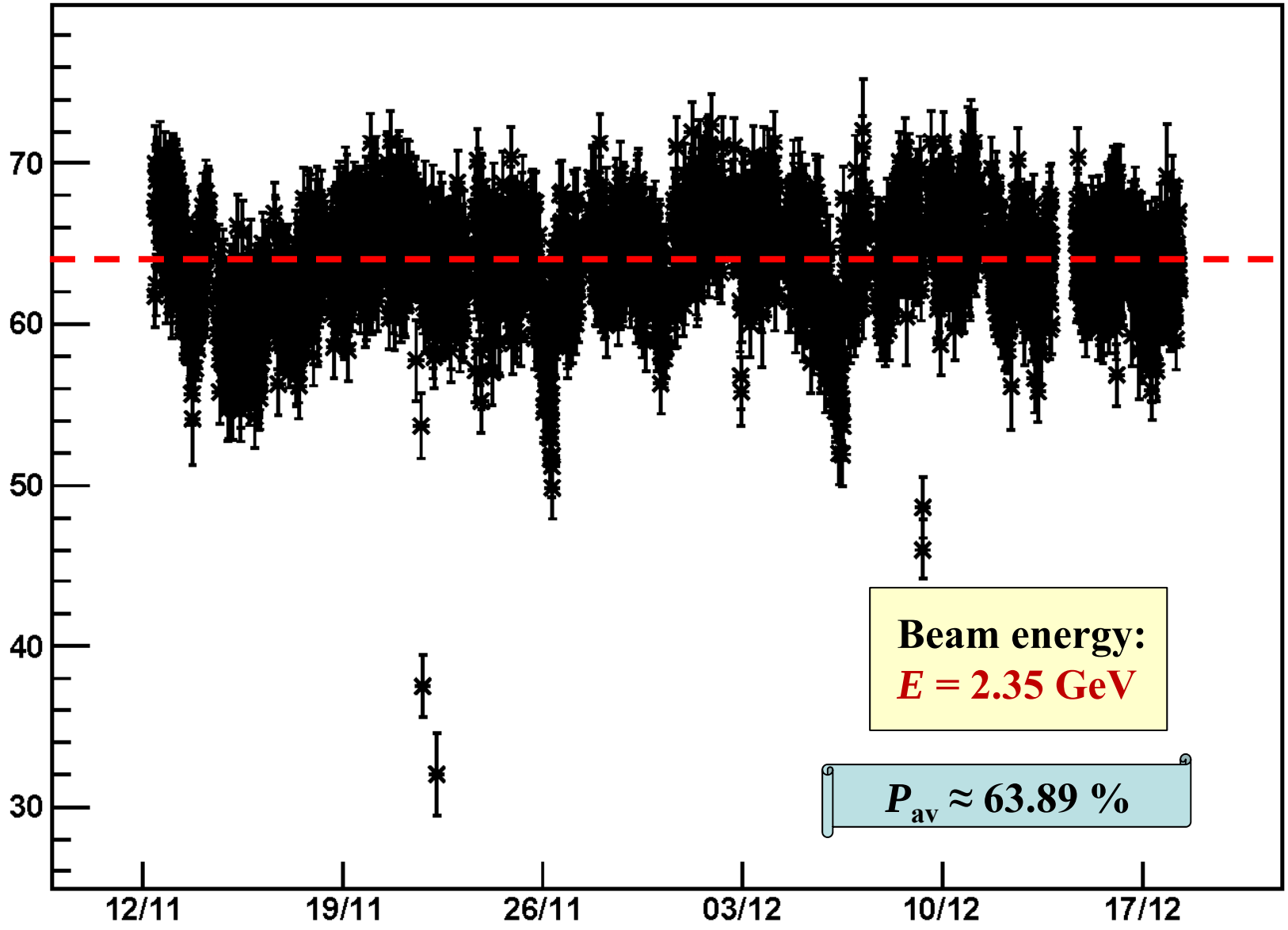
Diss. Maren Eberhardt

Tune Measurements

Diss. Maren Eberhardt

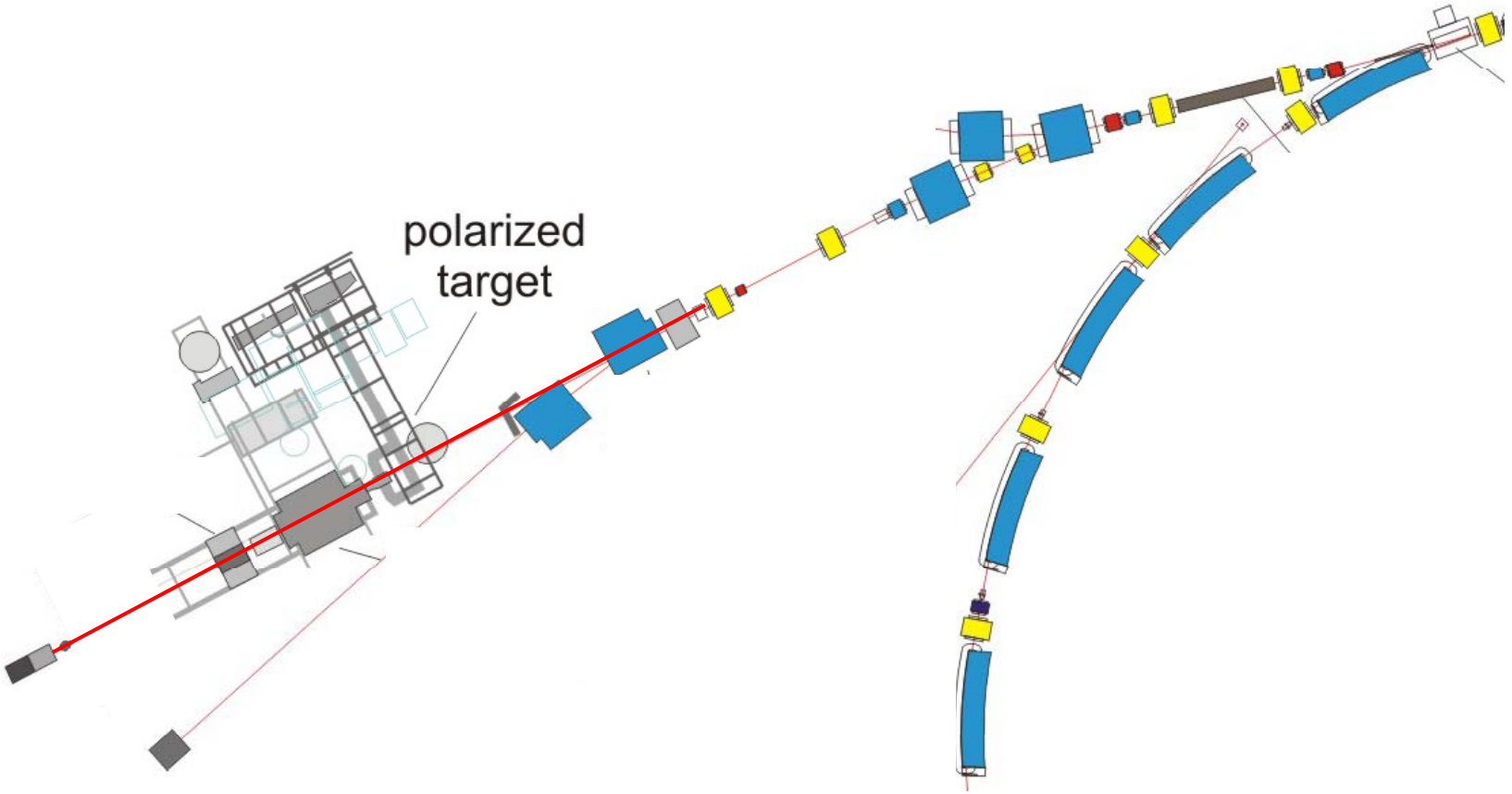


Polarisation @ 2350MeV, 12.11.2009, 10:54 - 18.12.2009, 8:49

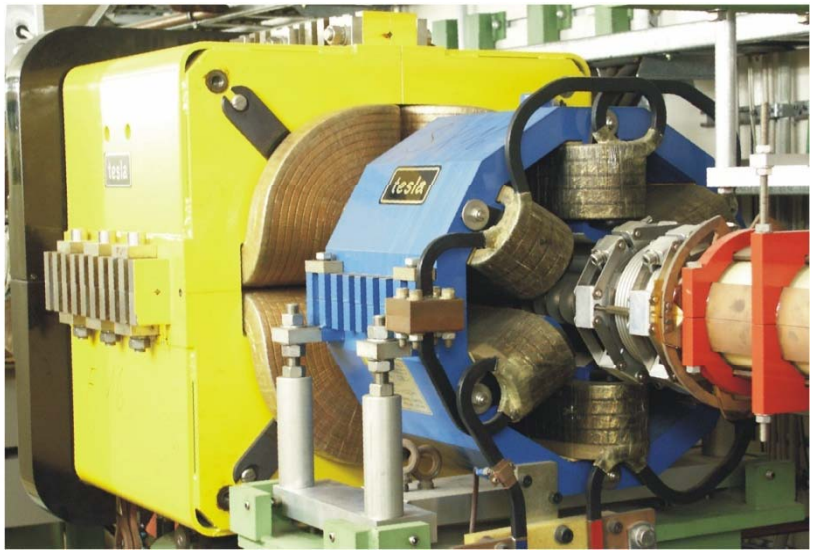


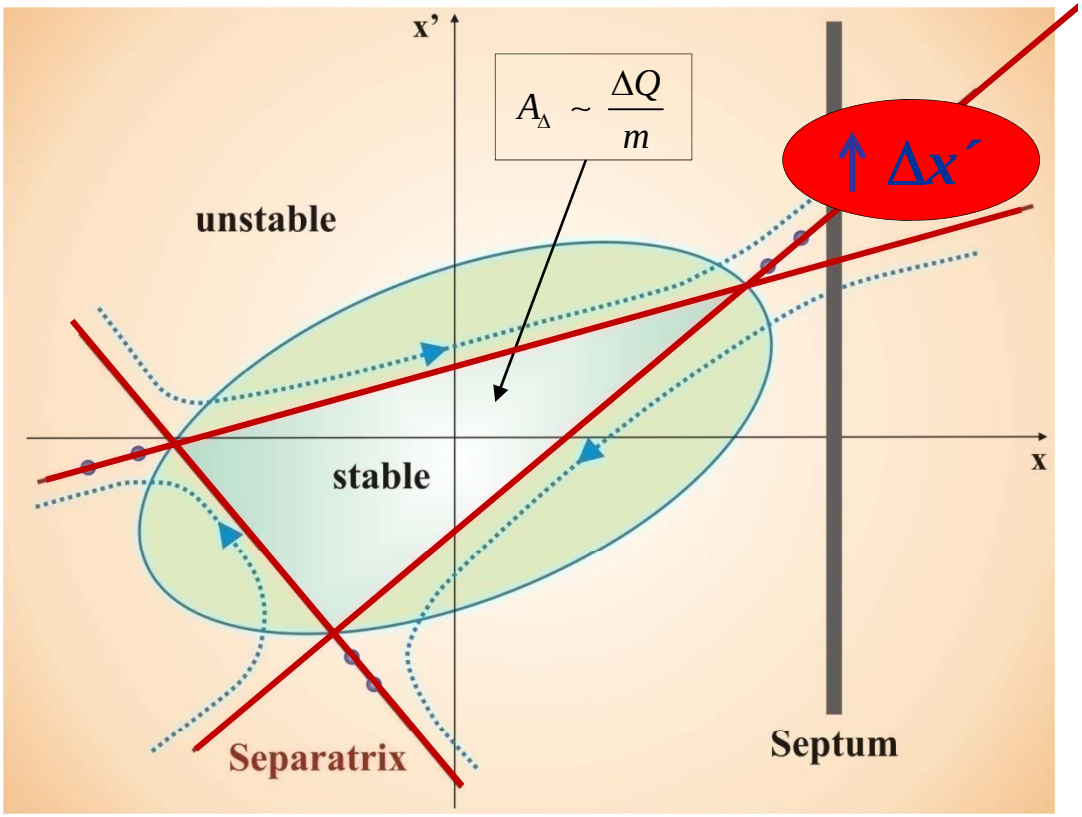
Beam Position Stab.
RF-based Diagnostics

Slow Beam Extraction: Beam Pointing Stability



Slow Beam Extraction

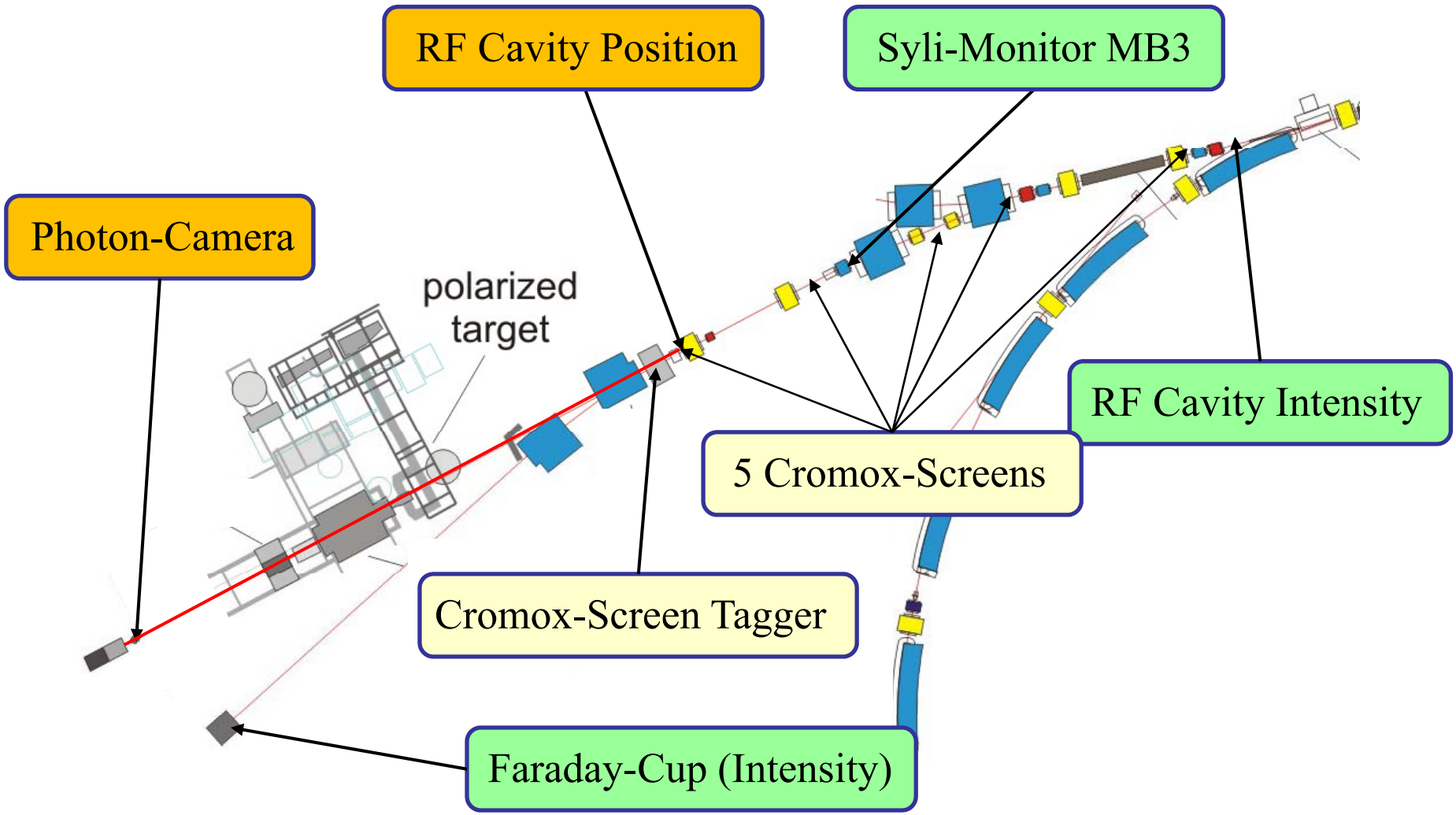


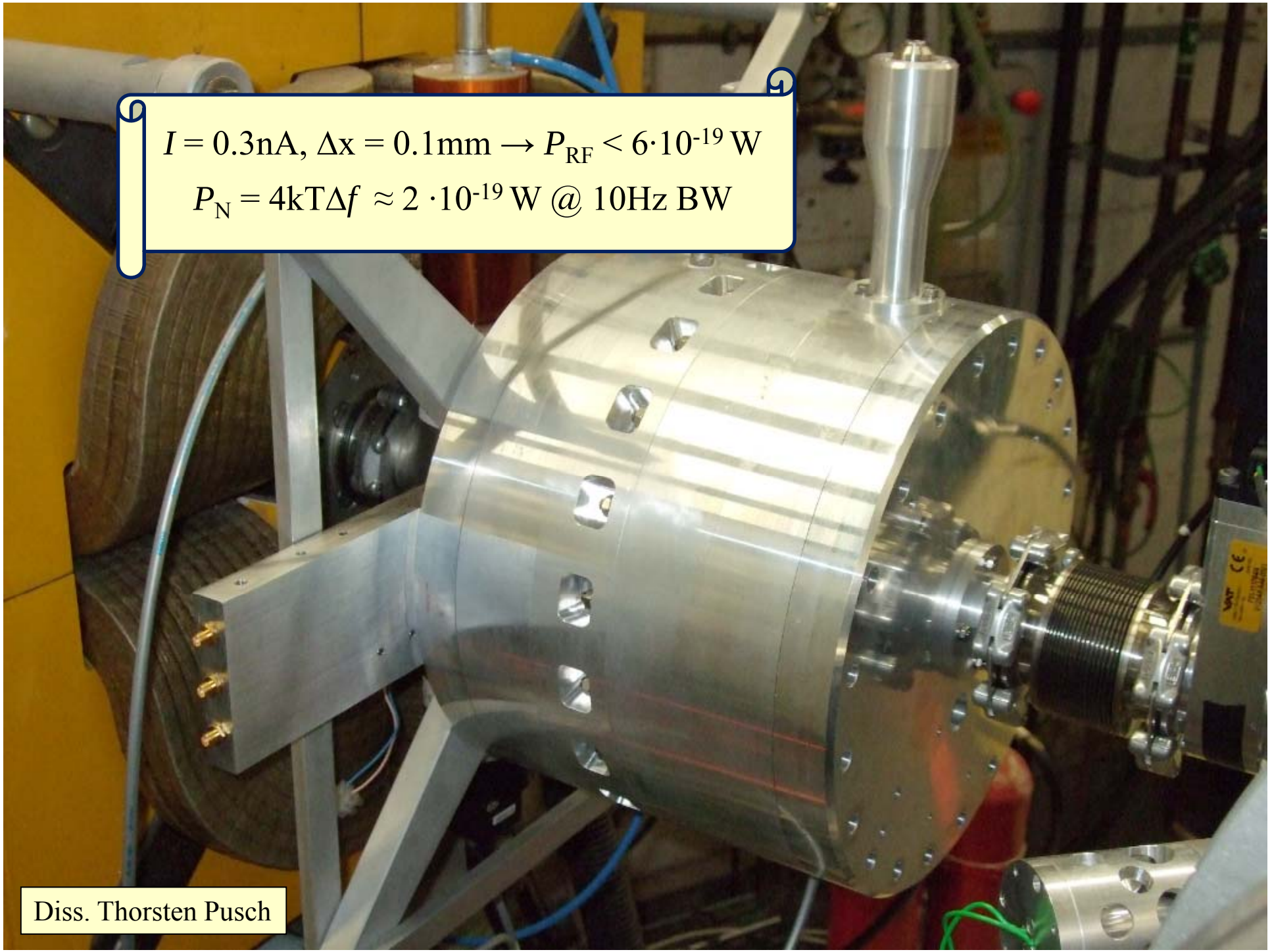


Sextupole Magnets (Extraction):
Excitation of a third integer resonance

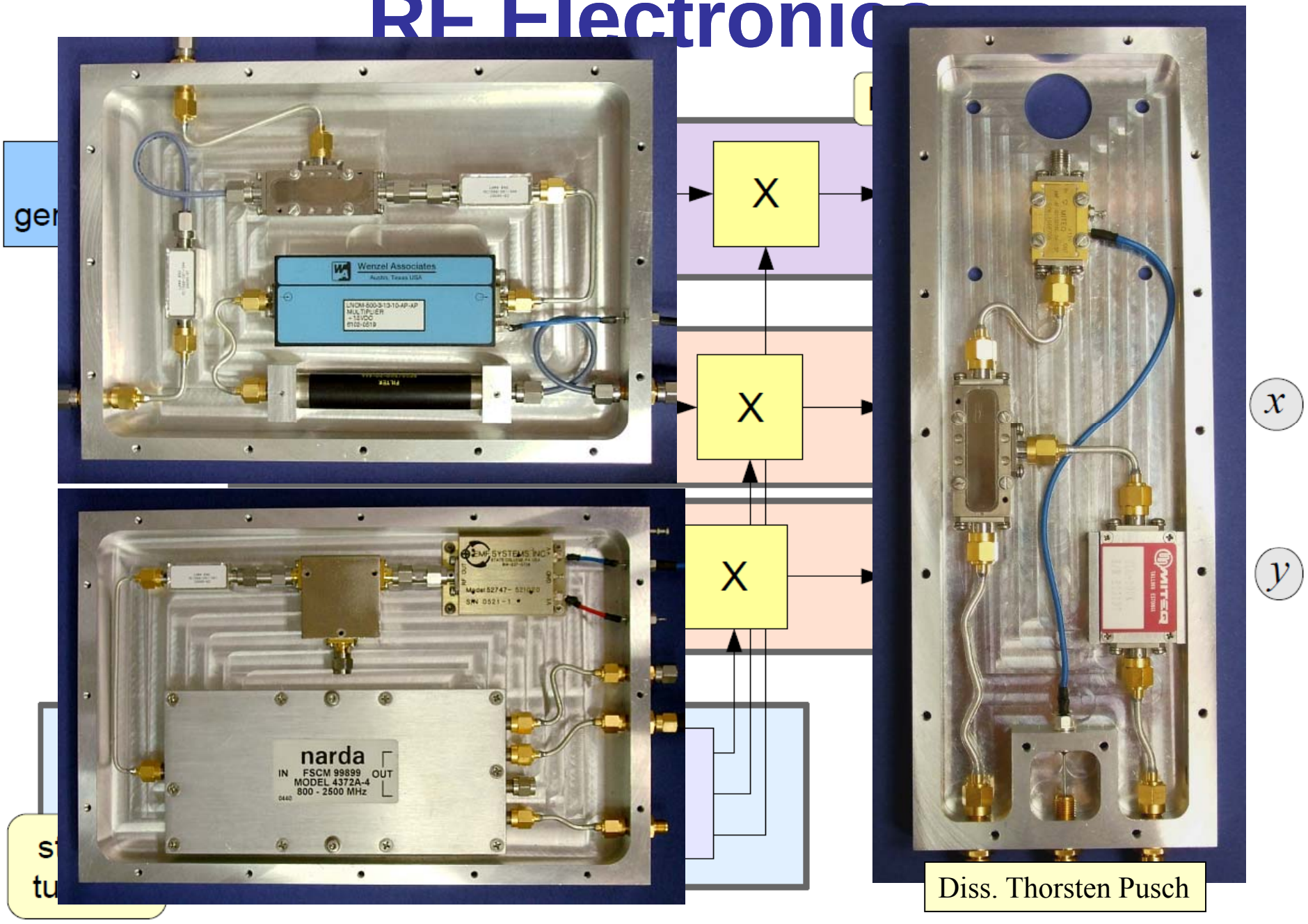
Ironless Quadrupole Magnets (Extraction):
Shift of the horizontal betatron tune close to a third integer value, "current feedback-loop"

Beam Position Monitoring



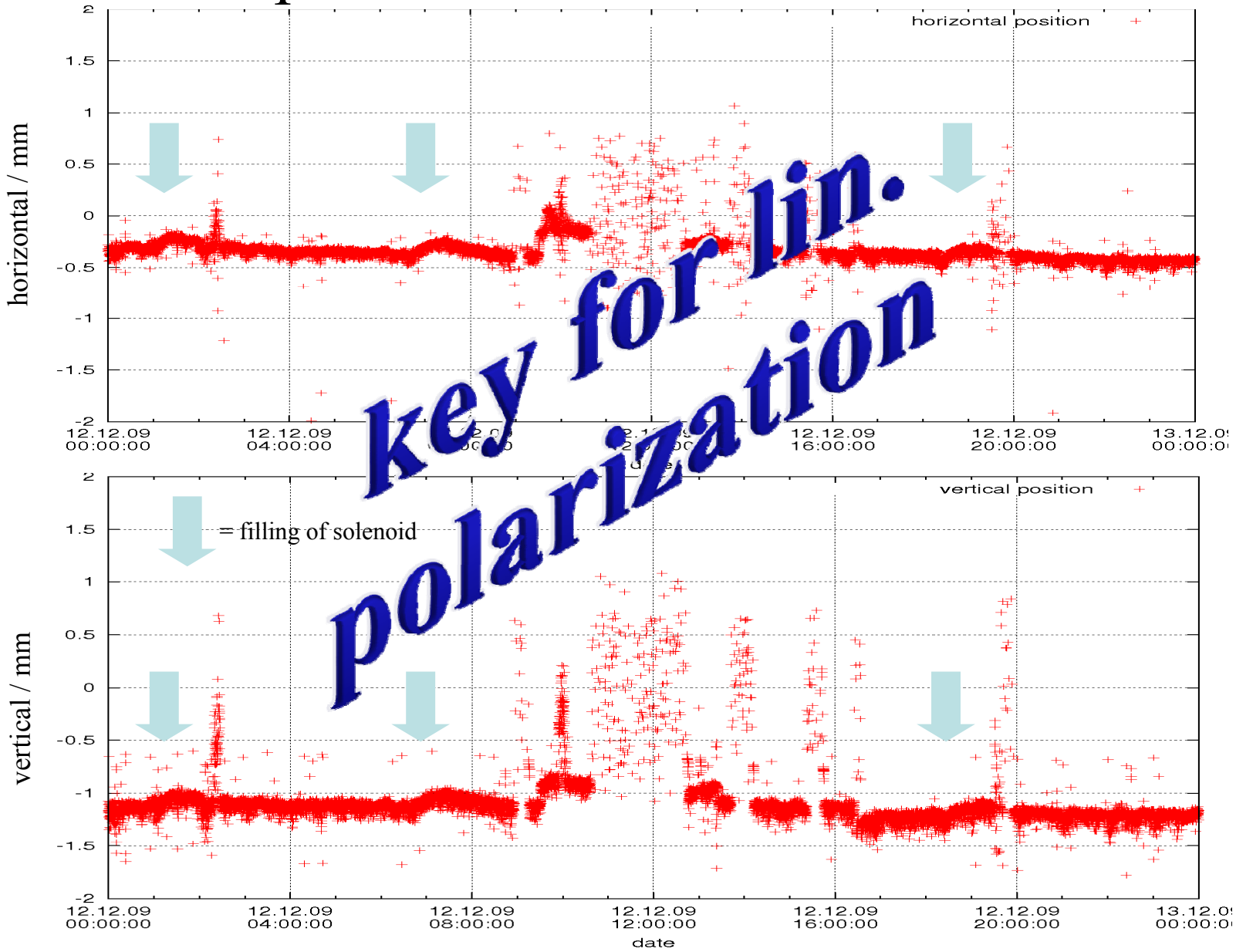

$I = 0.3\text{nA}, \Delta x = 0.1\text{mm} \rightarrow P_{RF} < 6 \cdot 10^{-19}\,\text{W}$
$P_N = 4kT\Delta f \approx 2 \cdot 10^{-19}\,\text{W}$ @ 10Hz BW
Diss. Thorsten Pusch

RF Electronics



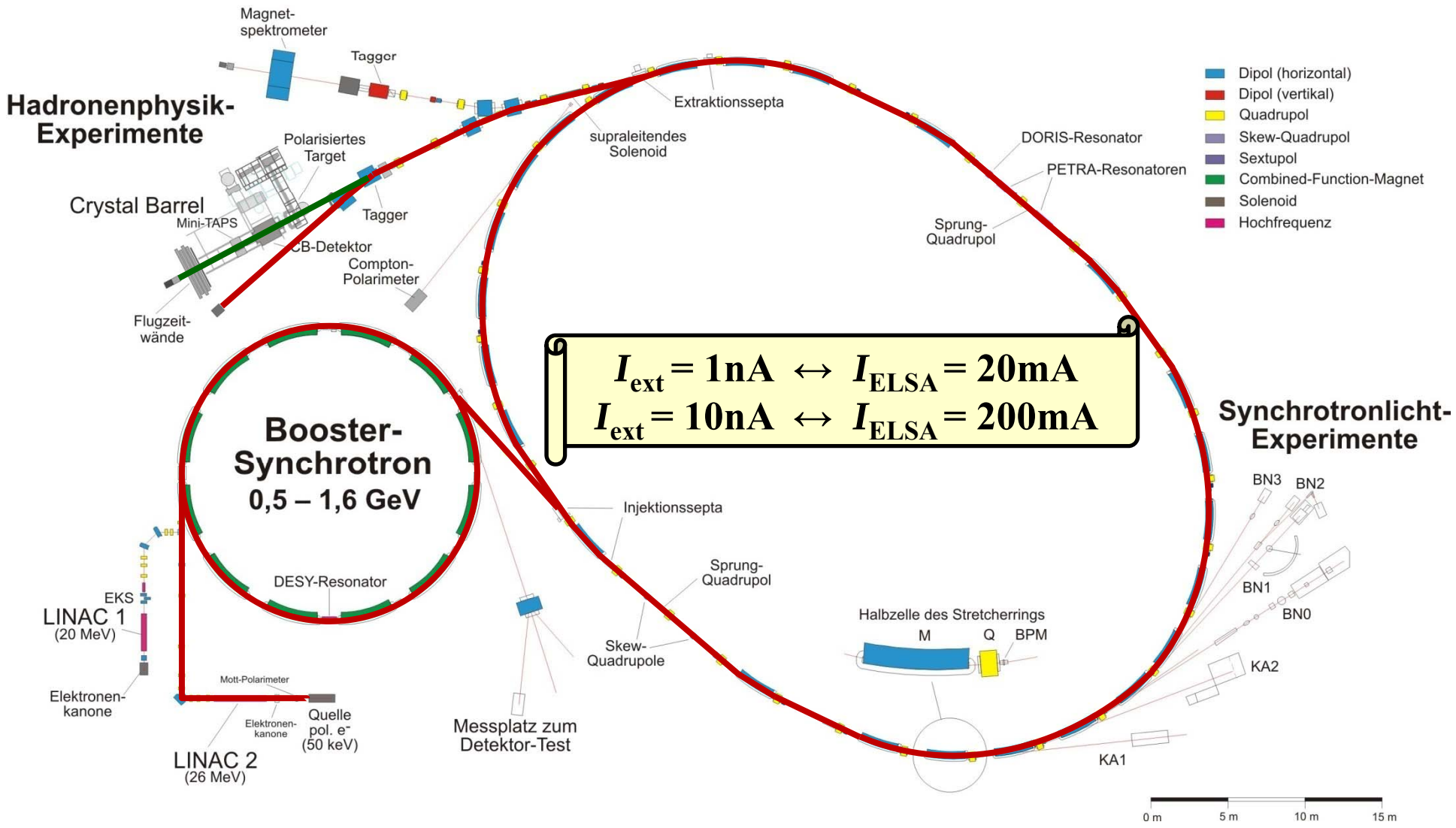
Diss. Thorsten Pusch

Beam position measured with rf cavities

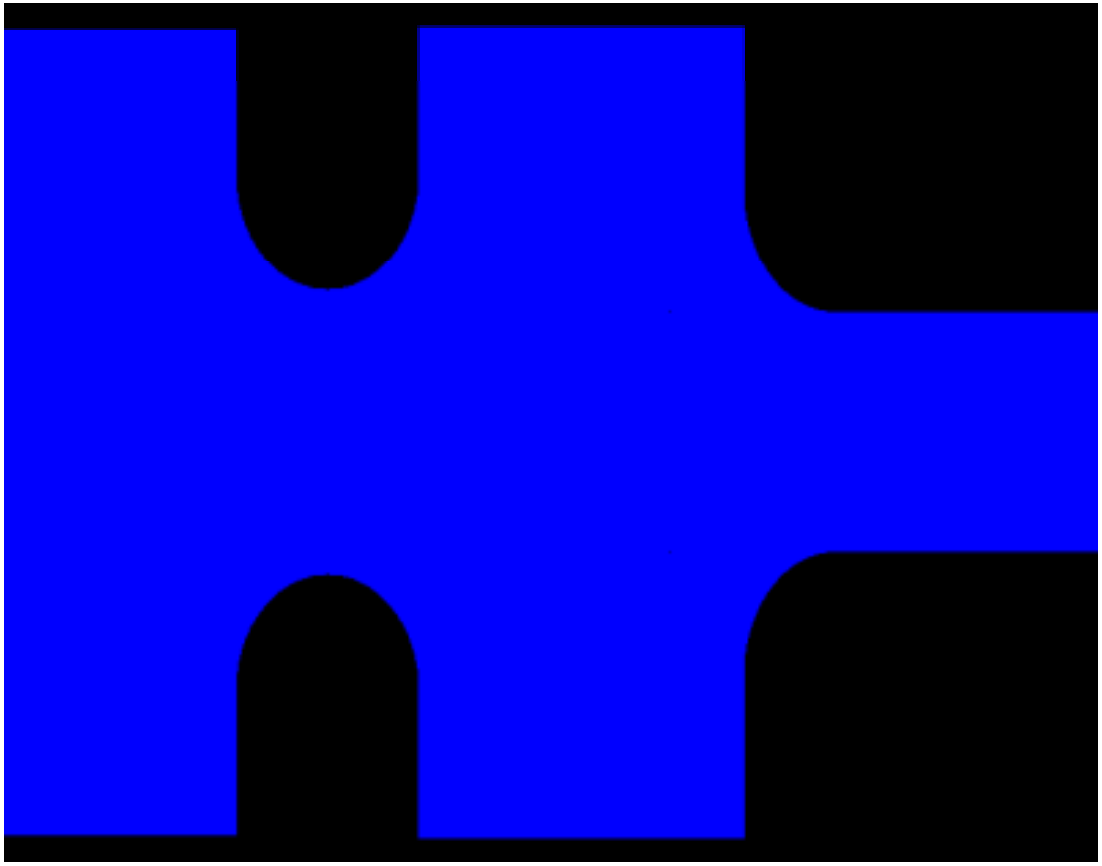


Intensity Upgrade
Coherent Instabilities

Elektronen-Stretcher-Anlage (ELSA)



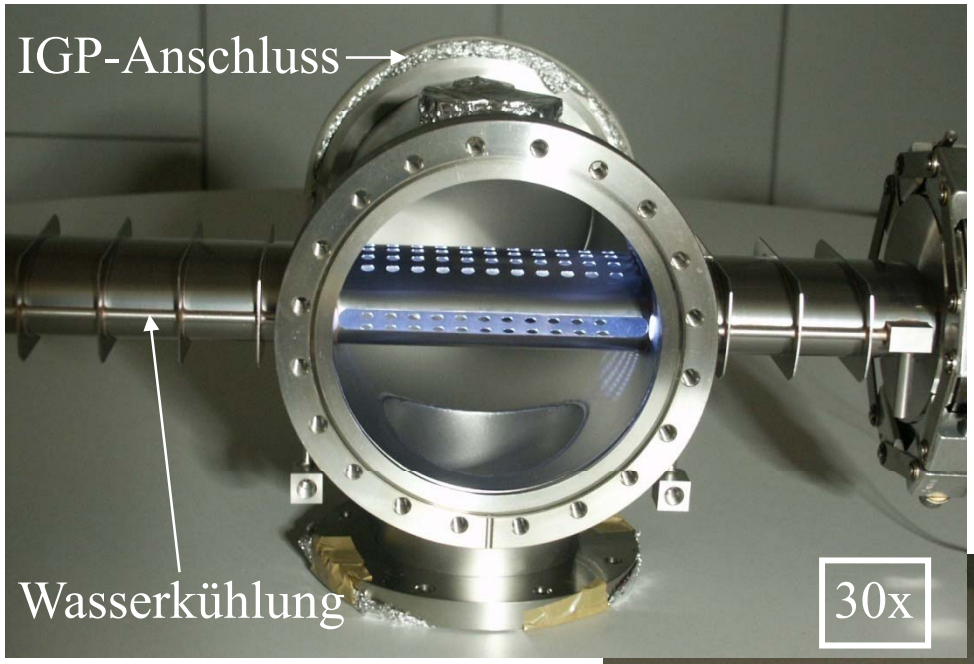
High Currents in ELSA



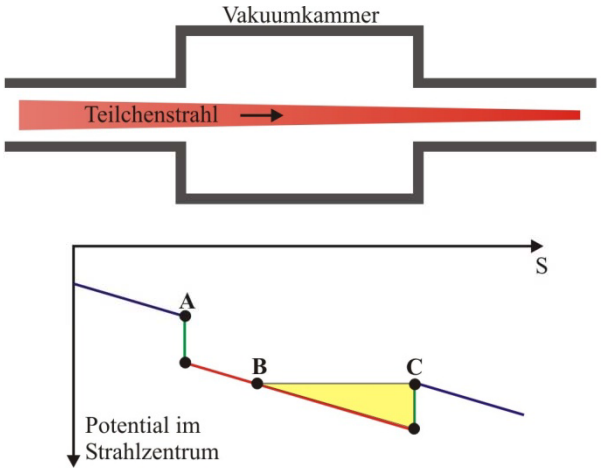
Geometry Changes → High Coupl. Impedance → Wake Fields

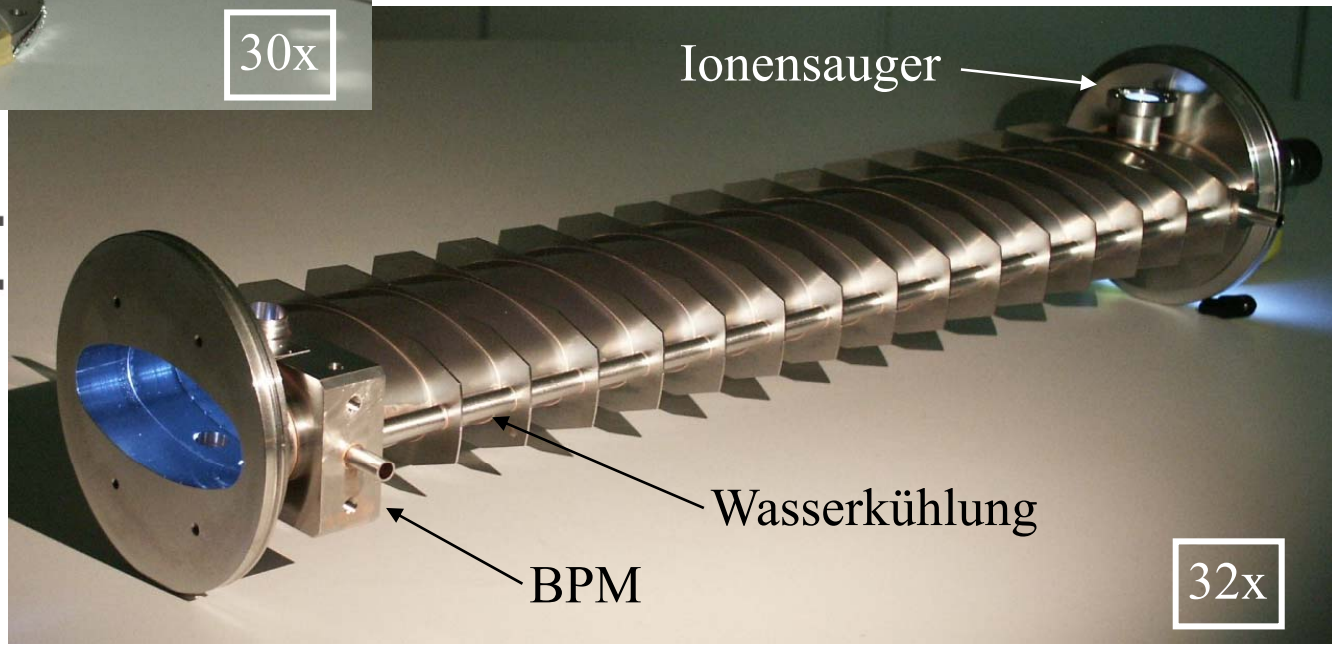
Courtesy of Arno Candel, 2008

Operation with $I = 200$ mA



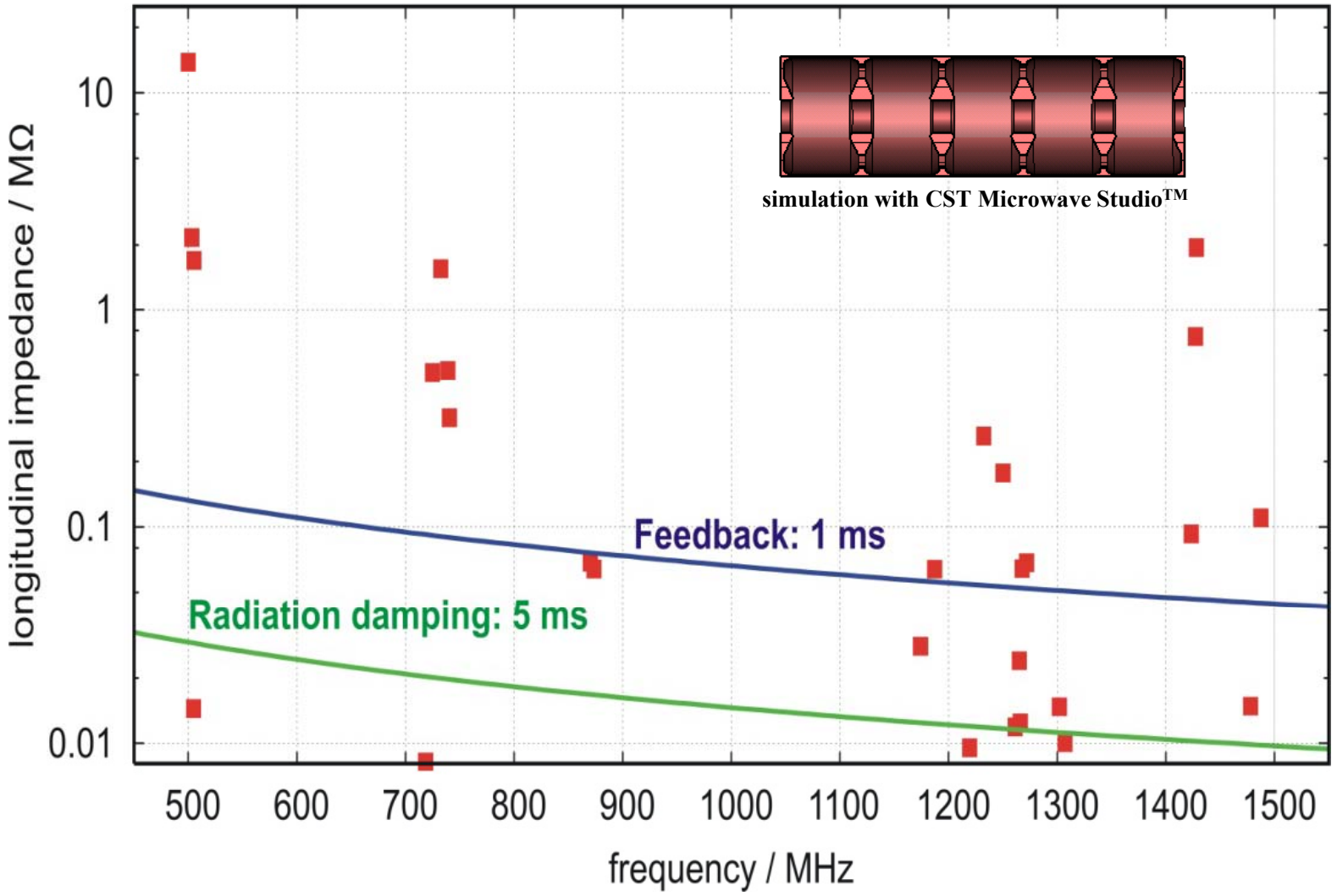
- Messung der Strahllage im Quadrupol
- direkte **BPM-Befestigung am Quadrupol**
- einheitliche Geometrie → **kleine Impedanzen**
- **Ionensauger** unmittelbar an den Quadrupolen
- vollständige **Wasserkühlung**
- optimiert für neue **Korrektur-Magnete**



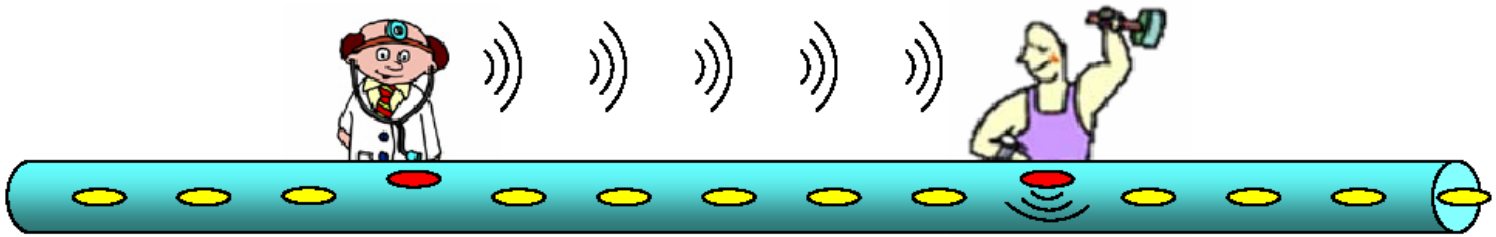


High Current Operation

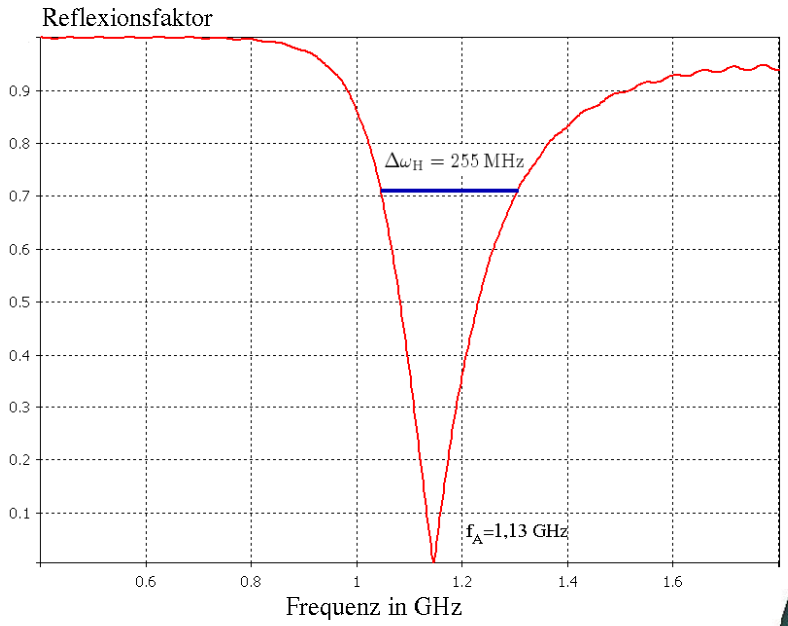
Impedances of undamped monopol HOMs of Petra cavity at ELSA
and typical thresholds for beam instabilities at 30 mA and 2.4 GeV

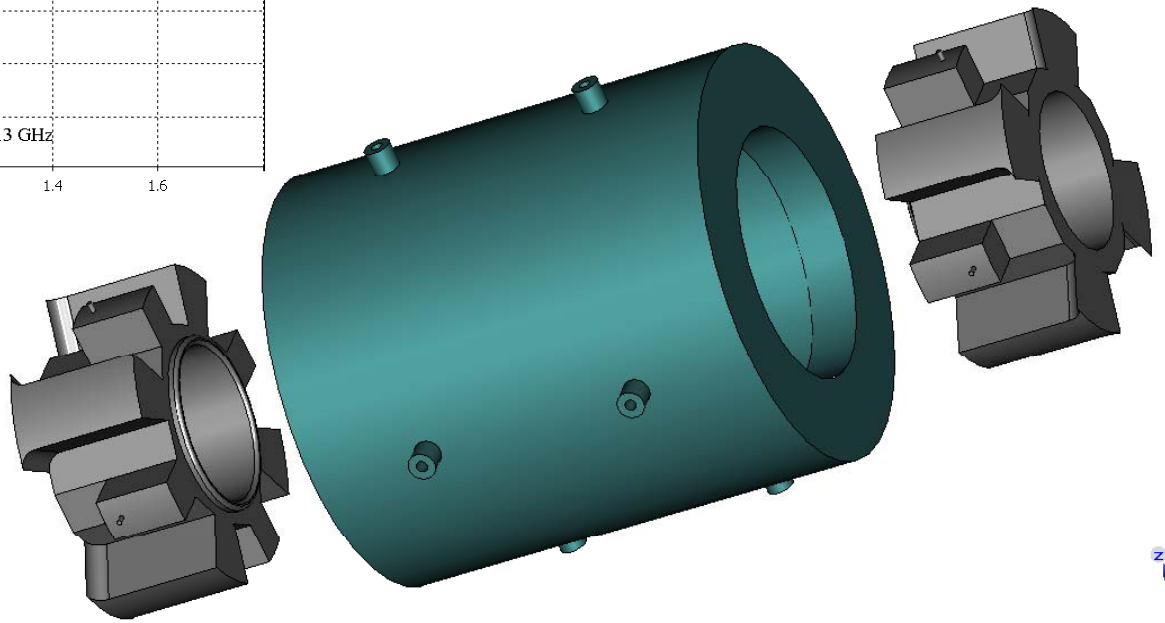


Bunch by Bunch Feedback

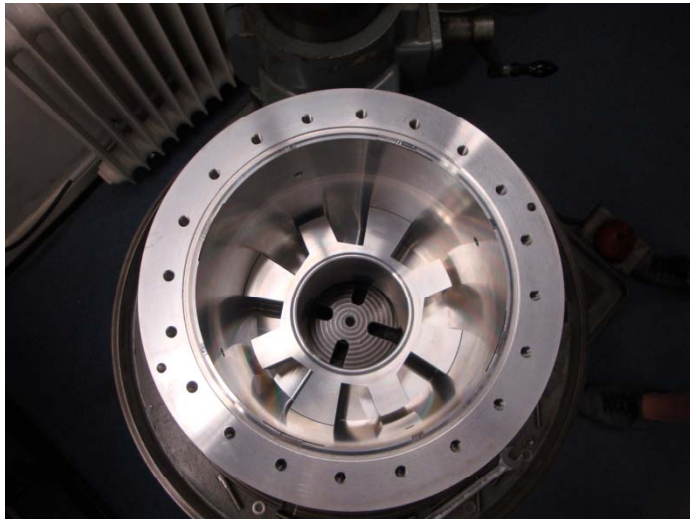


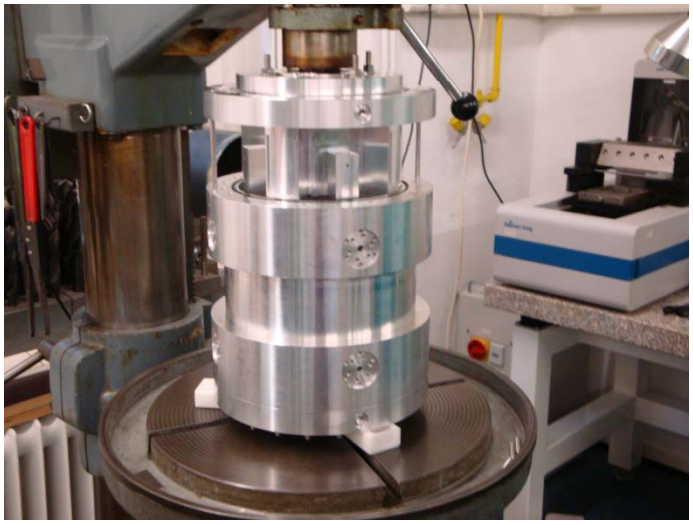
Development of broadband kicker cavity

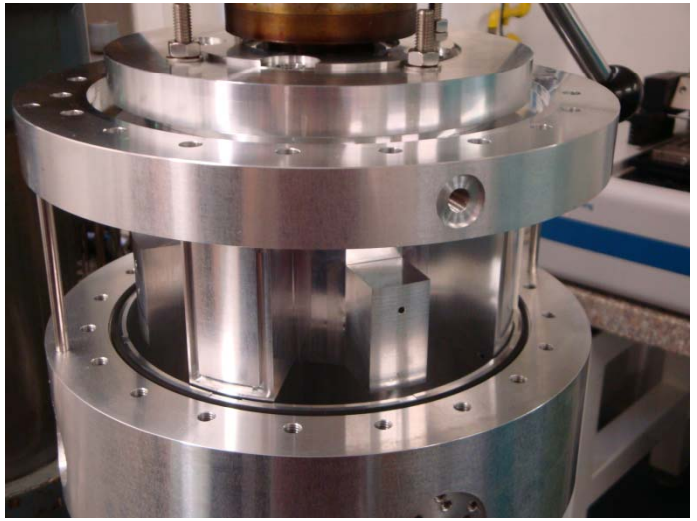




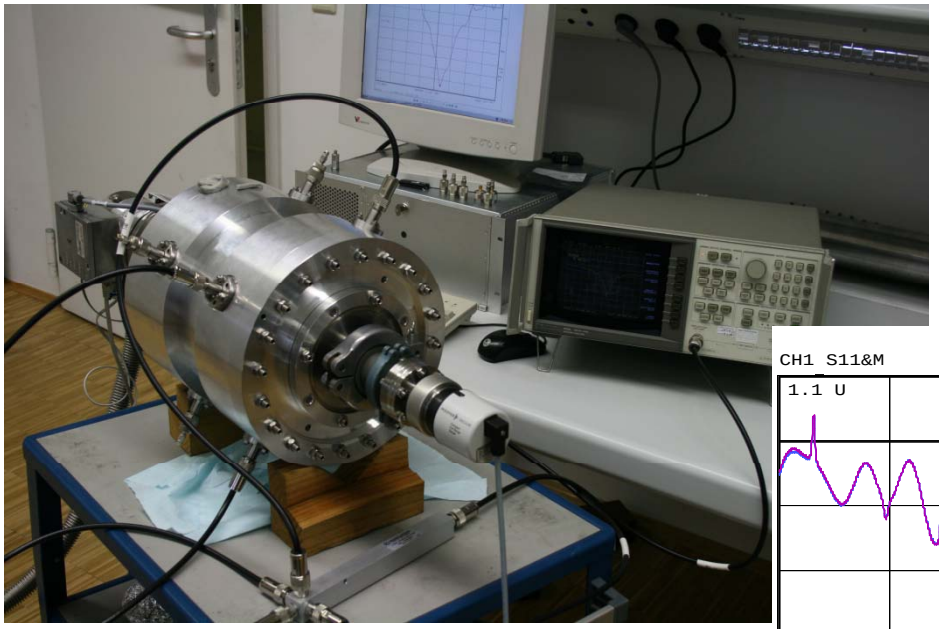
Construction of a prototype







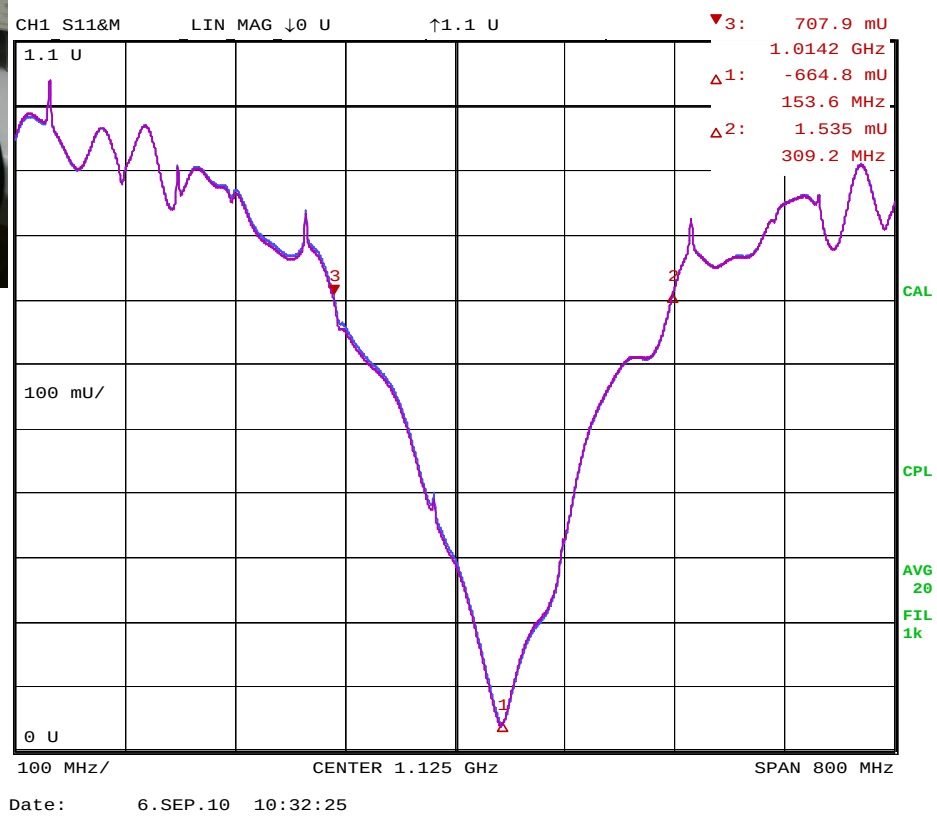
Measurement results



Pressure: 5,4 10^{-7} mbar

$Q_L = 1.168 / 0.309 = 3.78$

expected $R_S = 387\ \Omega$



Prototype ready for installation in ELSA!

Spares

Operating Statistics 2009

ELSA Operation 2008

4 CB/TAPS Runs with extended Data-Taking

28.04. – 26.06.	**1420 hours @ 3.2 GeV**	(lin. Pol.)
04.08. – 31.08.	**650 hours @ 3.2 GeV**	(lin. Pol.)
29.10. – 27.11.	**630 hours @ 2.35 GeV**	(cir. Pol.)
28.11. – 15.12.	**400 hours @ 2.35 GeV**	(cir. Pol.)

Σ = 3100 hours

Tests in CB-Area:	**290 hours**	(incl. H2-target testing)
Tests in B1-Area:	**160 hours**	
Students Experiment:	**60 hours**	
ELSA Tests:	**100 hours**	(incl. horz. Polarization)

approx. 3700 operating hours in 2008

ELSA Operation 2009

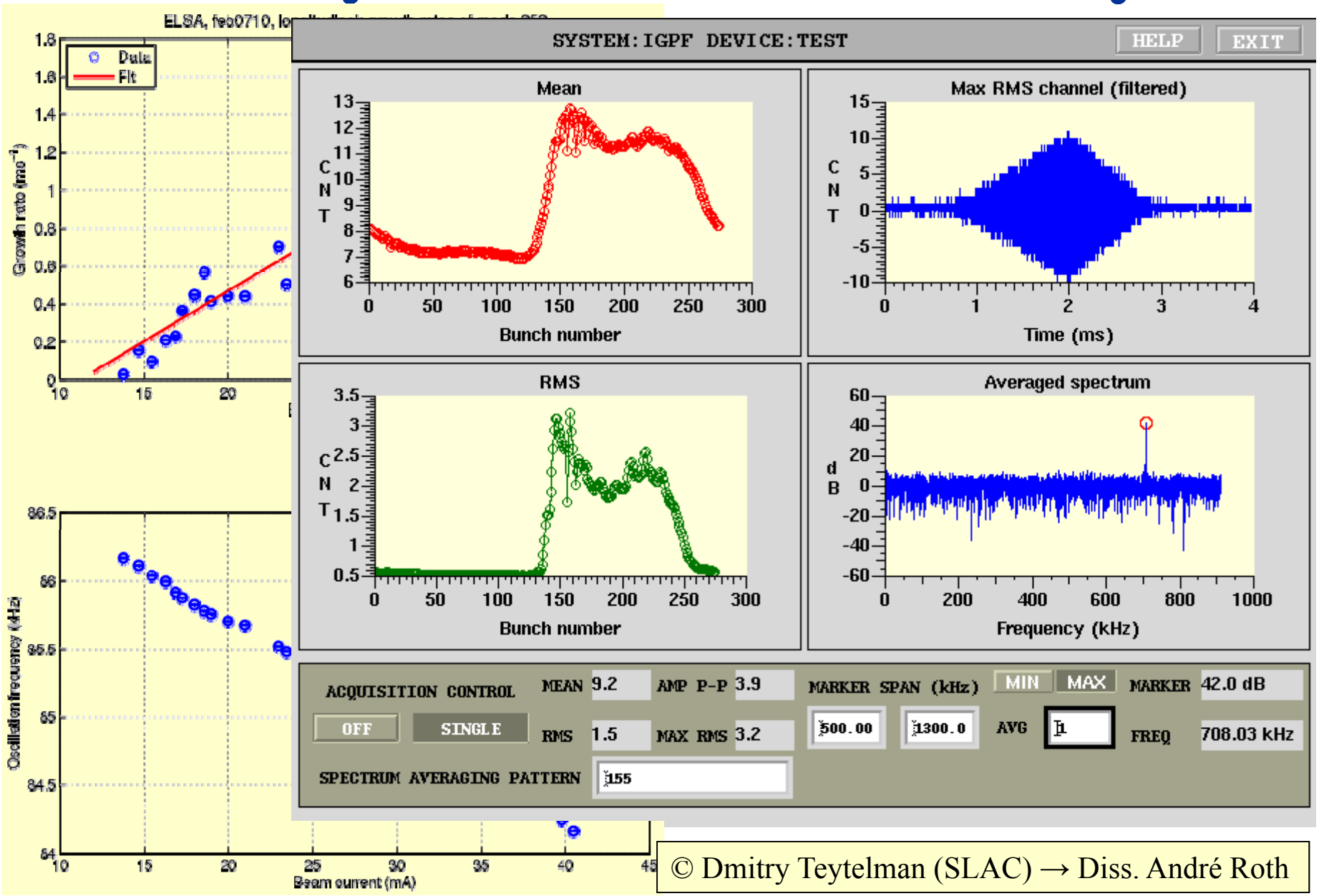
3 CB/TAPS Runs with extended Data-Taking

26.01. – 04.03.	**888 hours @ 3.2 GeV**	(no Pol.)
17.08. – 09.10.	**1012 hours @ 2.35 GeV**	(cir. Pol.)
10.11. – 20.12.	**976 hours @ 2.35 GeV**	(cir. Pol.)
	Σ = 2876 hours	

Tests in CB-Area:	**160 hours**
Ilcpol in B1-Area:	**200 hours**
Students Experiment:	**70 hours**
ELSA Tests:	**75 hours**

approx. 3380 operating hours in 2009

Bunch by Bunch Feed-Back System



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