Polarized Electrons in

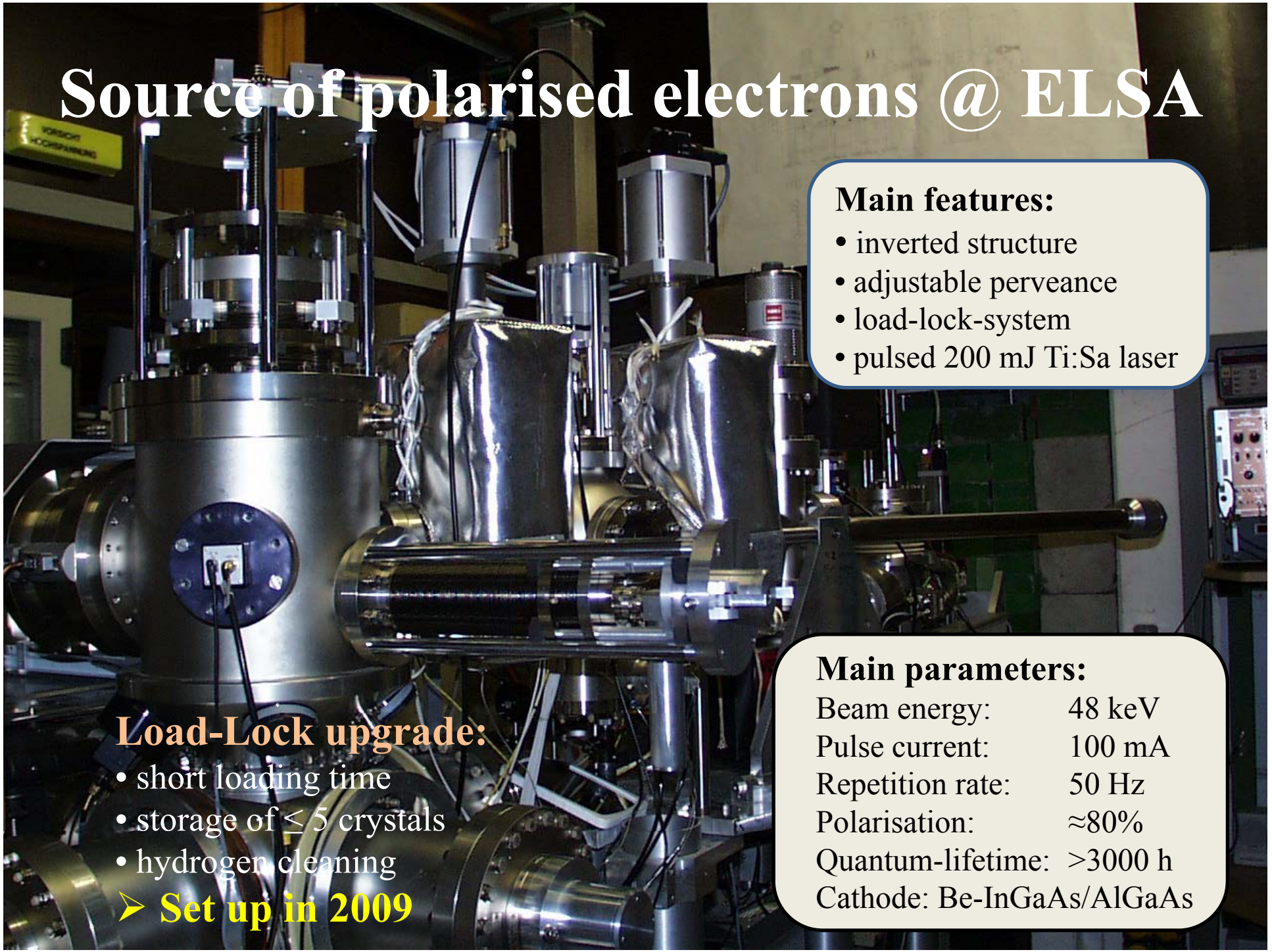
Physics / Problems & Status

Contents:

- Generation (Source of polarized electrons)
- BMT equation and depolarizing resonances
- Resonance crossing
- Correction schemes
- Improvements since the GDH experiment
- **Beam time statistics ´08 and perspectives ´09**

universitätbonn

Source of polarised electrons @ ELSA



Main features:

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

Load-Lock upgrade:

- short loading time
- storage of ≤ 5 crystals
- hydrogen cleaning

➢ **Set up in 2009**

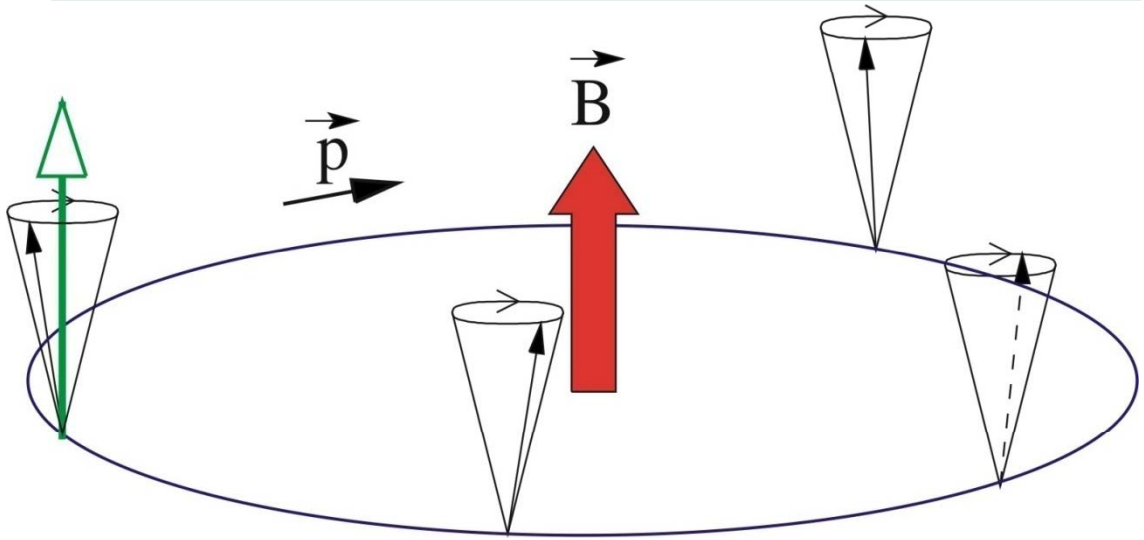
Main parameters:

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

Cathode: Be-InGaAs/AlGaAs

Spin-Precession

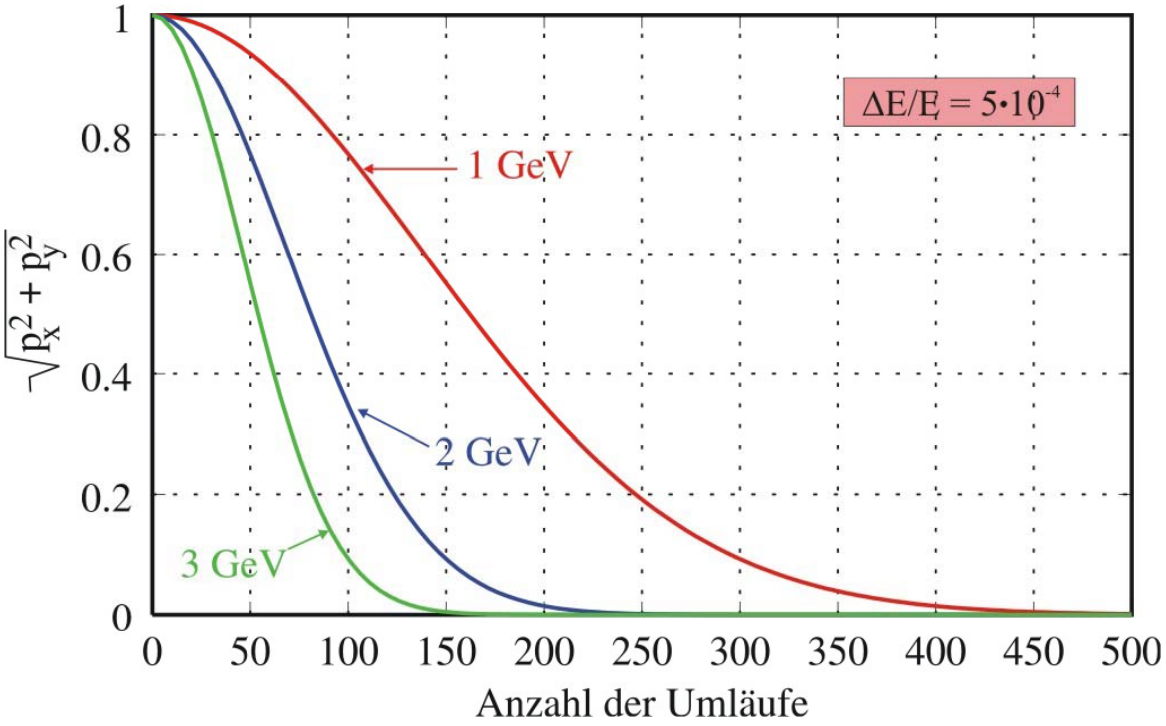
Spin-Tune: $Q_{Sp} = \gamma a, \quad a = \dfrac{g-2}{2}$



$$\frac{d\vec{S}}{dt} = \vec{\Omega} \times \vec{S} \qquad \vec{\Omega}^{*} = -\frac{e}{m_0}(1+a)\cdot\vec{B}$$

$$\vec{\Omega}_{BMT} = -\frac{e}{m_0\gamma}\left\{(1+a\gamma)\cdot\vec{B}_{\perp} + (1+a)\cdot\vec{B}_{\parallel}\right\}$$

Spin-Precession



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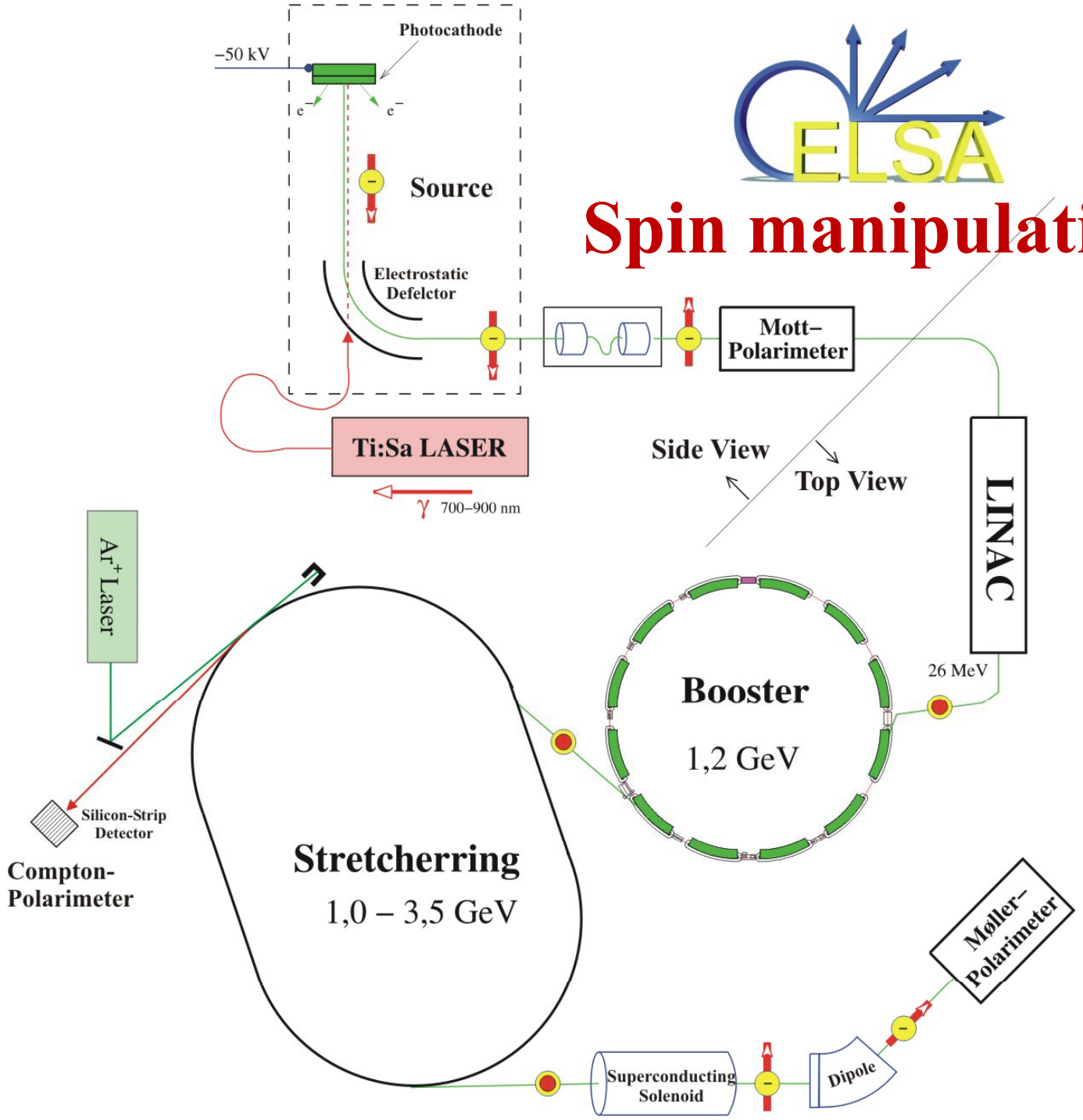
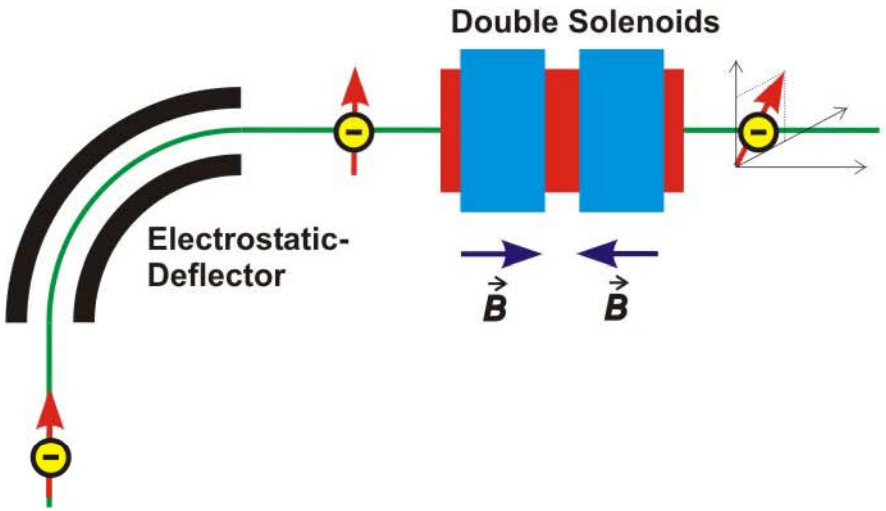
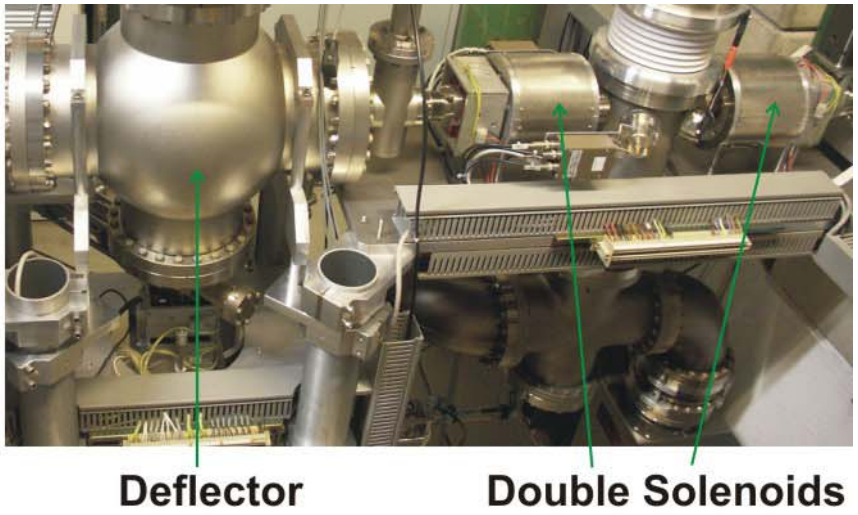
Spin manipulation



Spin Rotation I

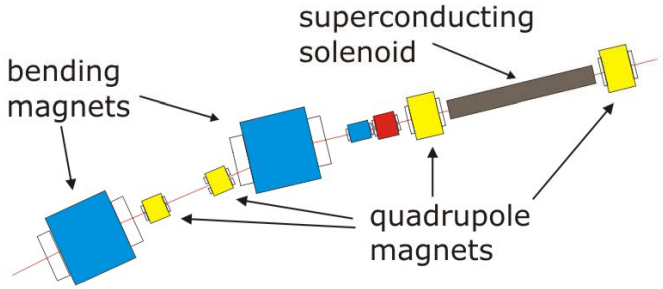


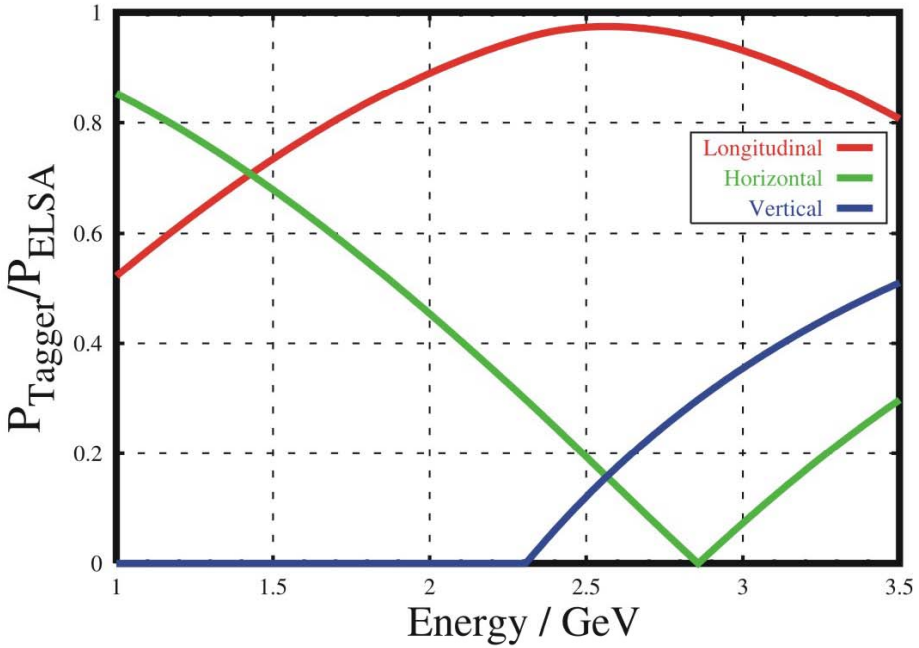


Focusing: $$\frac{1}{f} = \int \left(\frac{e}{p} \cdot \frac{B_s(s)}{2} \right)^2 ds$$

Spin Rotation: $$\Delta\phi = \int \frac{e}{p} \cdot \frac{B_s(s)}{2} \cdot ds$$

Spin Rotation II



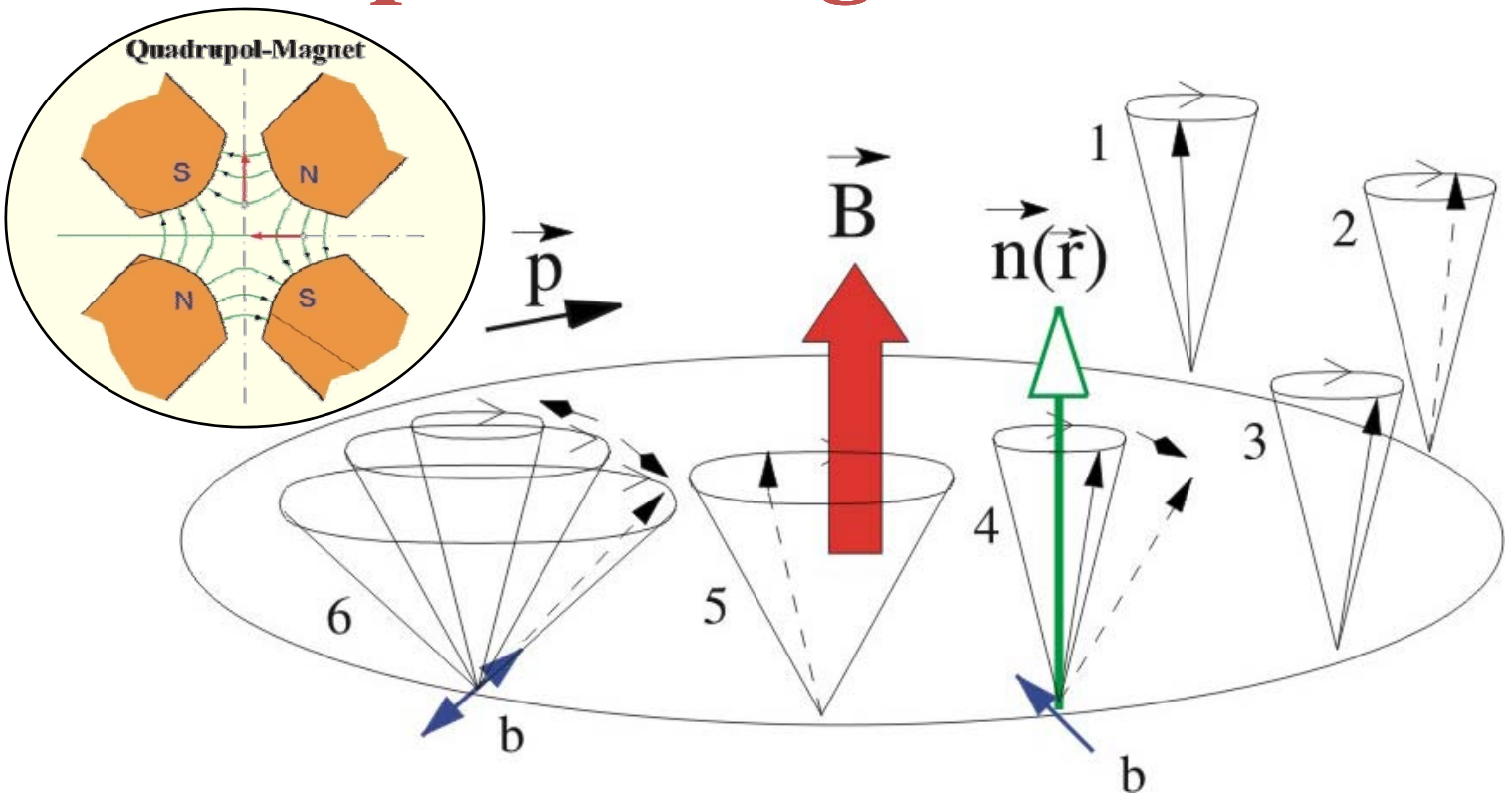


Spin Transfer to the Tagger of the GDH Experiment

Lamor Precession $\Delta\phi = -\frac{e}{m_0 c} \cdot \frac{1+a}{\sqrt{\gamma^2 - 1}} \cdot \int B_s(s) \cdot ds$

Thomas Precession $\Delta\phi = \gamma \cdot a \cdot \vartheta$

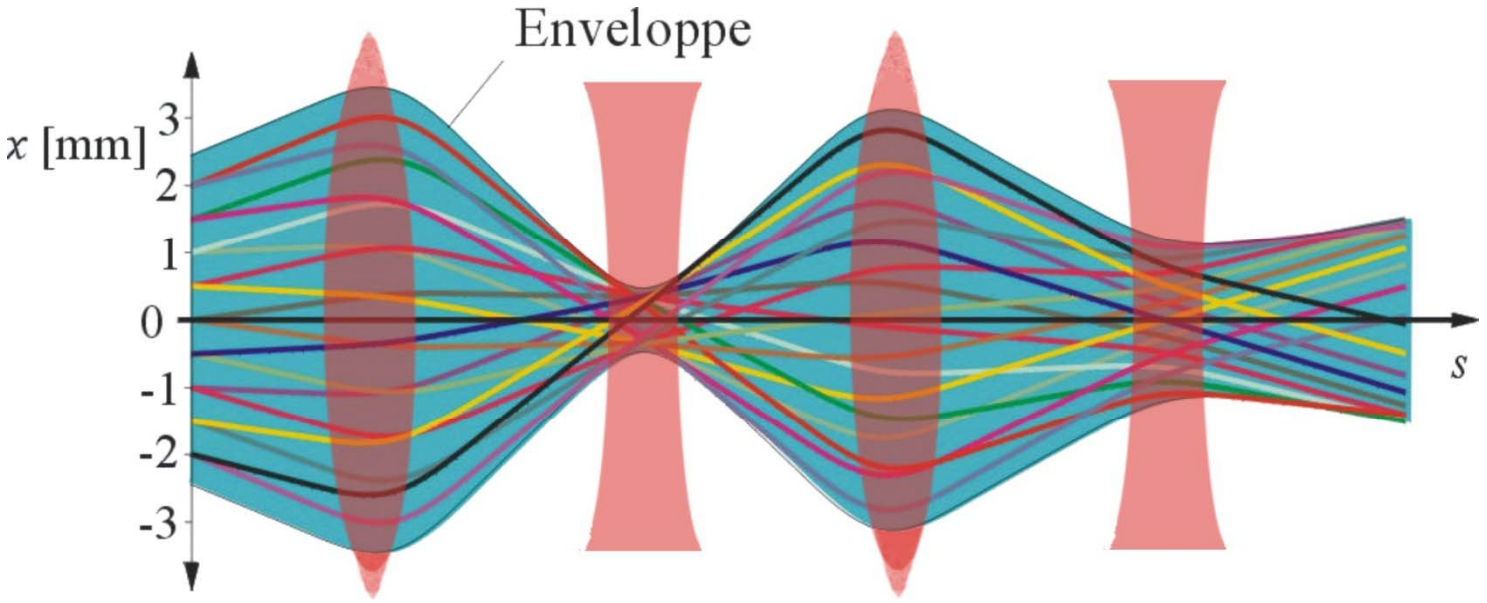
Depolarizing Resonances



imperfection resonances: $\gamma \cdot a = n, \quad n \in Z$

intrinsic resonances: $\gamma \cdot a = n \cdot P \pm Q_z, \quad n \in Z$

Depolarizing Resonances

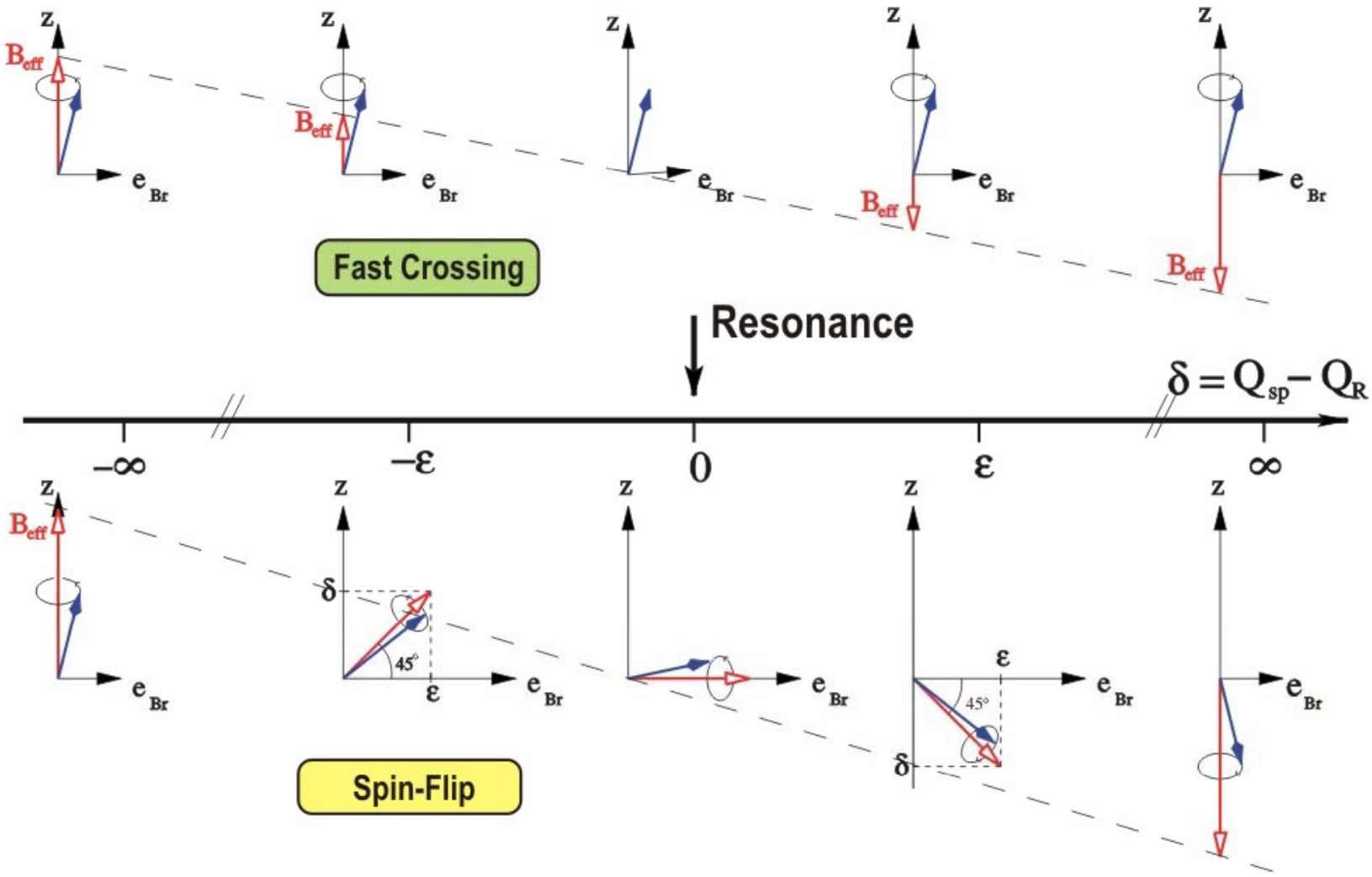


Strong Focussing: Betatron Oscillations!

imperfection resonances: $\gamma \cdot a = n, \quad n \in Z$

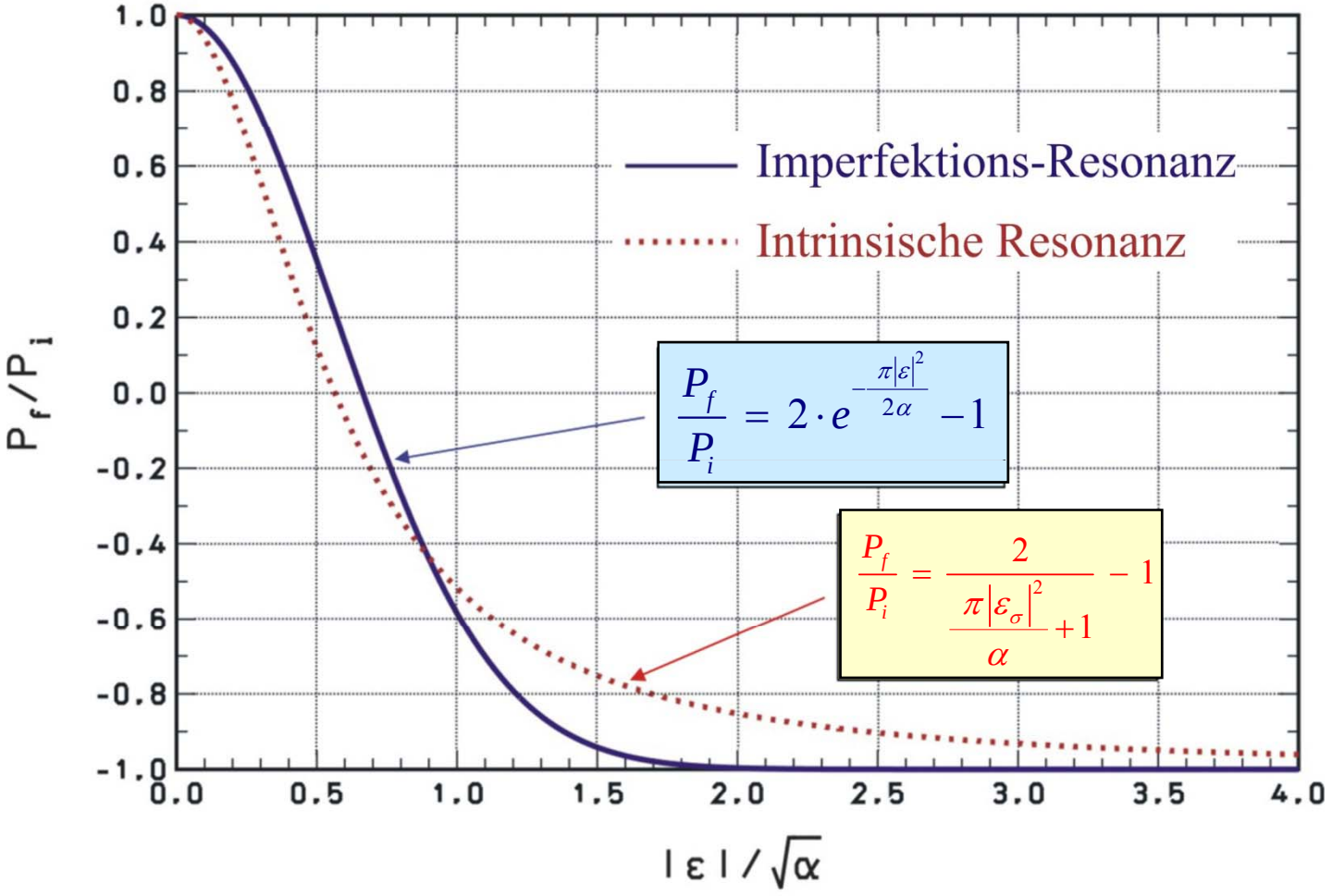
intrinsic resonances: $\gamma \cdot a = n \cdot P \pm Q_z, \quad n \in Z$

Resonance Crossing

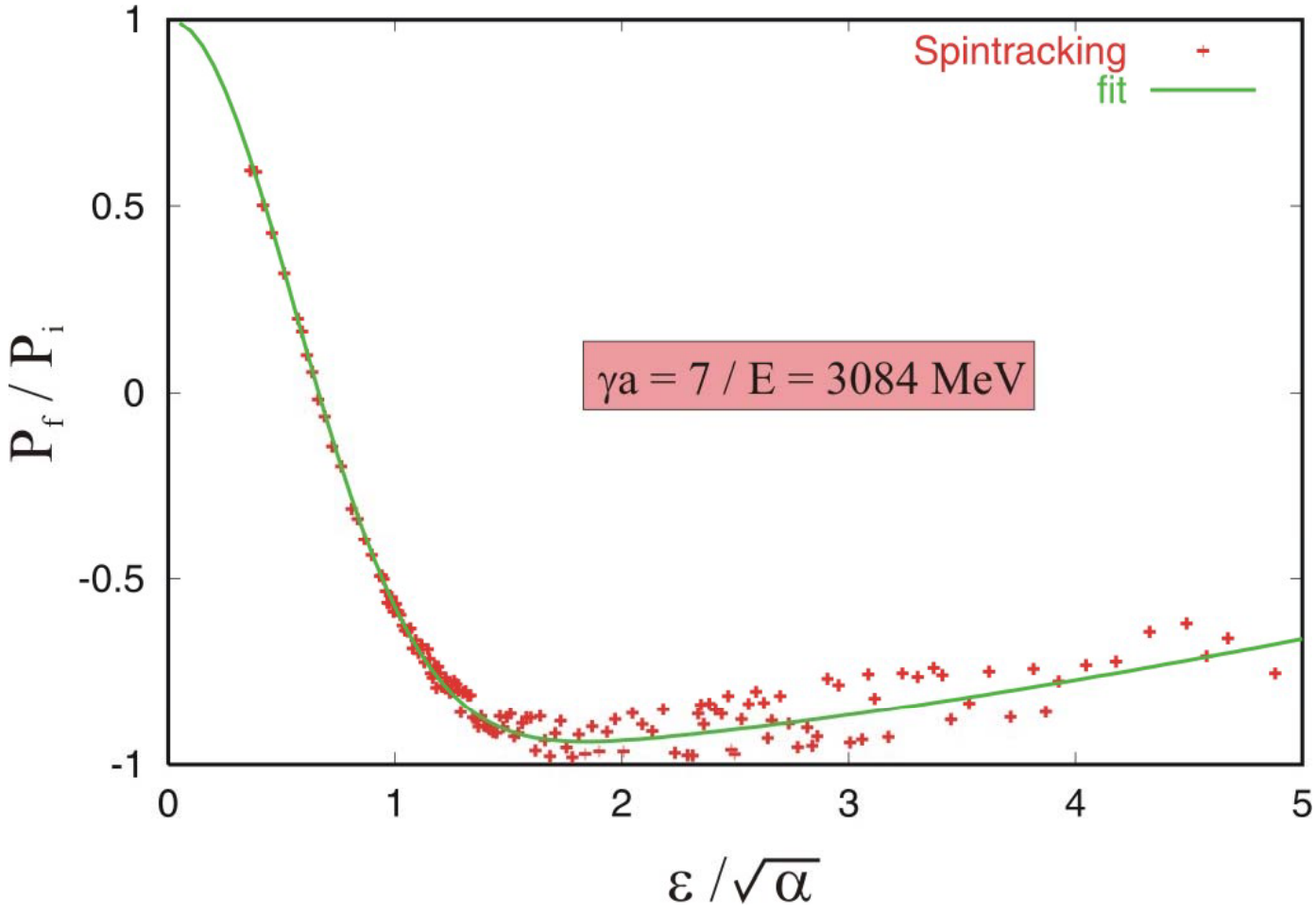


Resonance Crossing

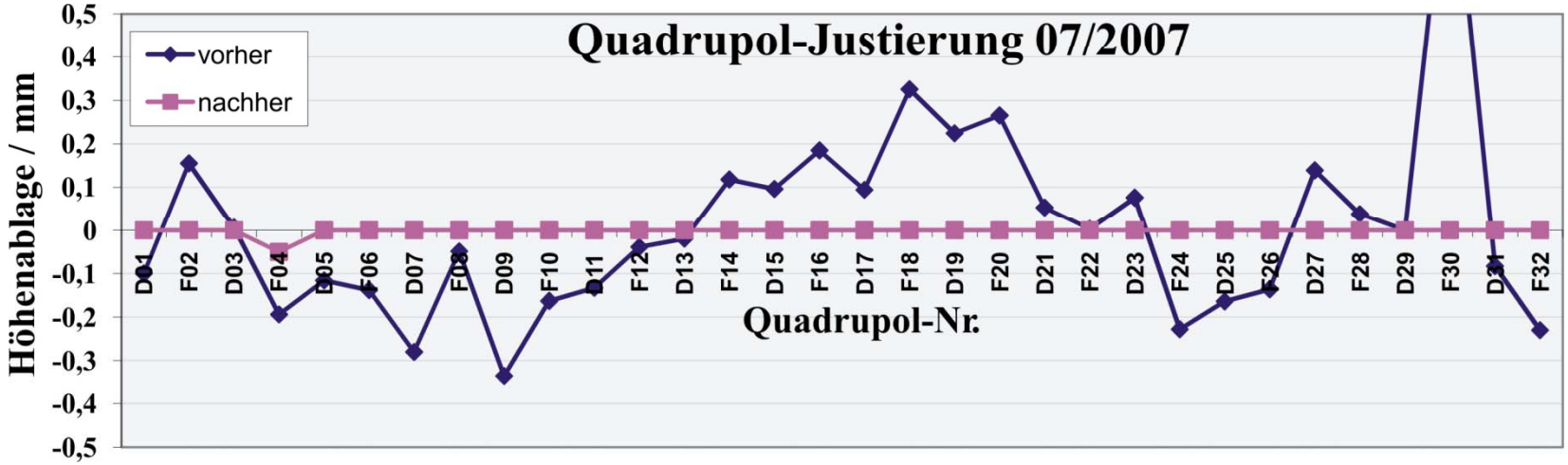
Froissart-Stora-Formula

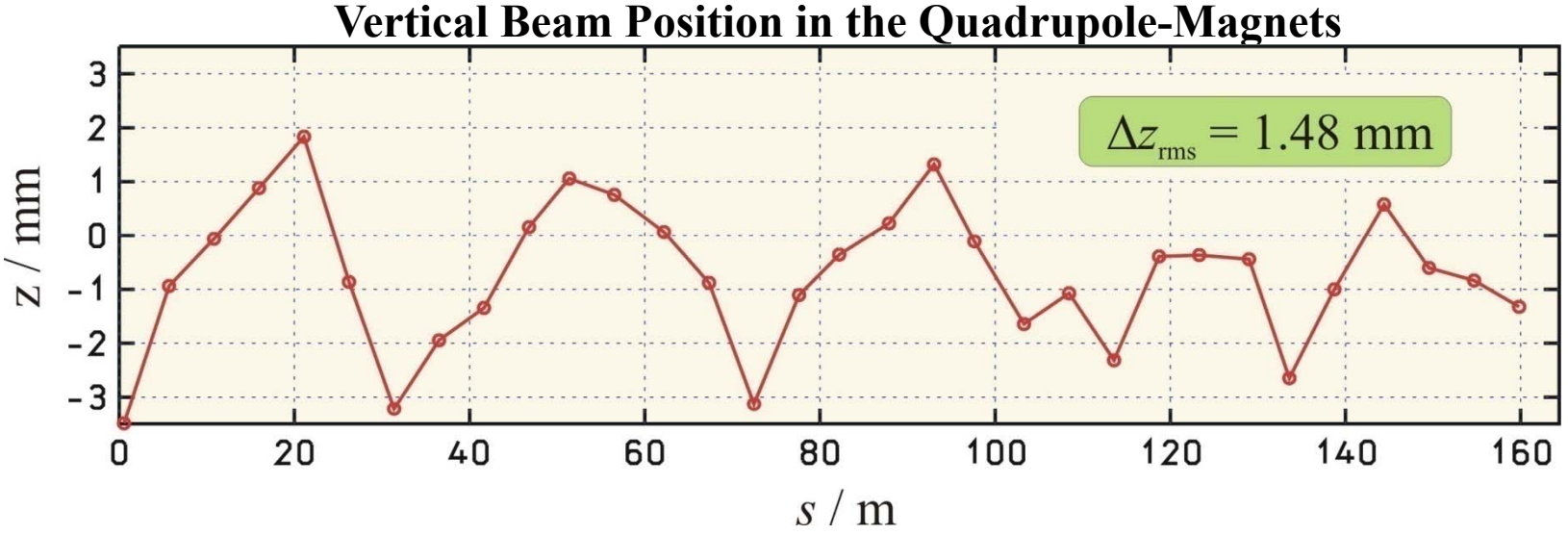


Spin Diffusion

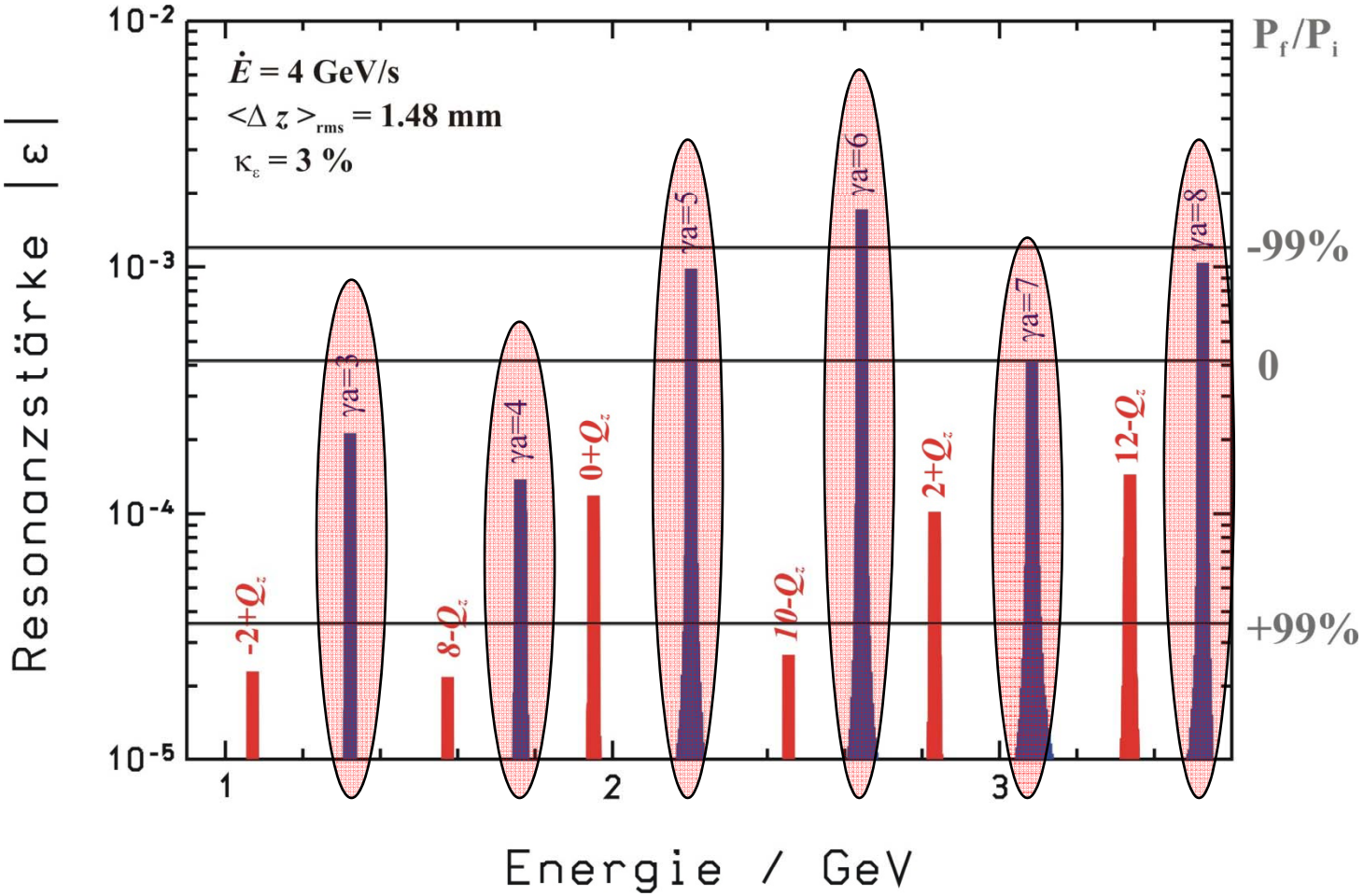


Quadrupole Alignment



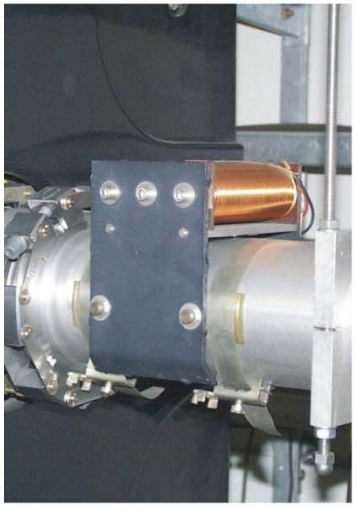


Resonance Strengths



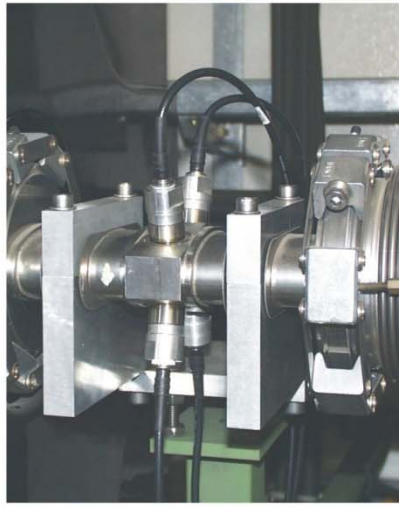
Closed Orbit Correction

Korrektur



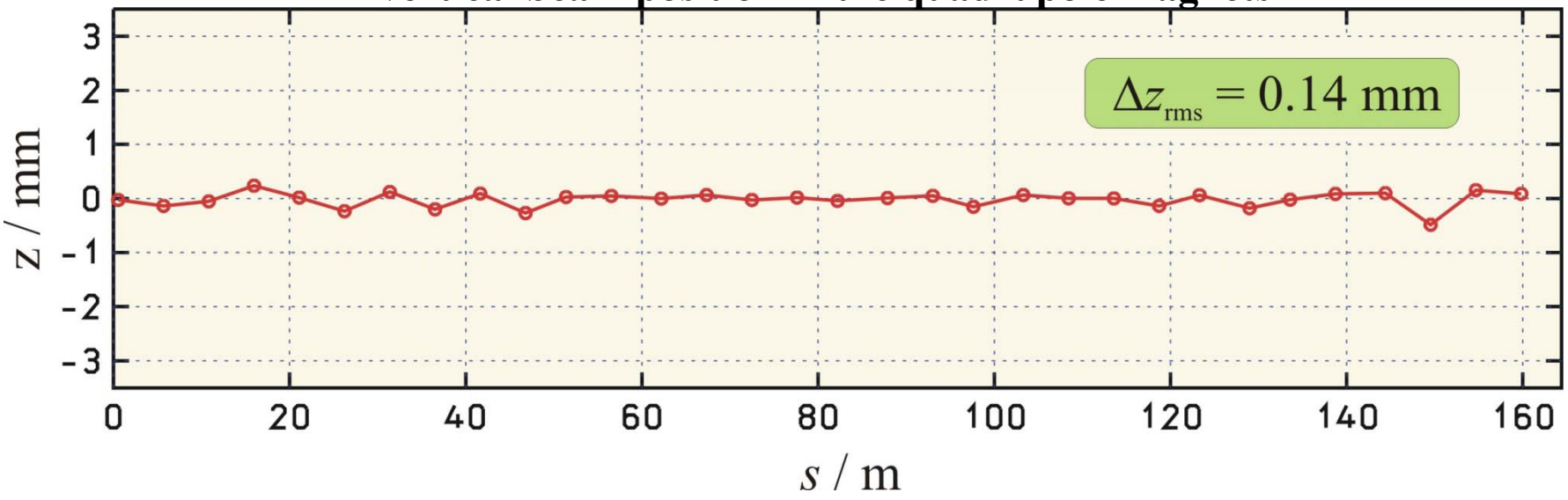
Signalverarbeitung

Messung

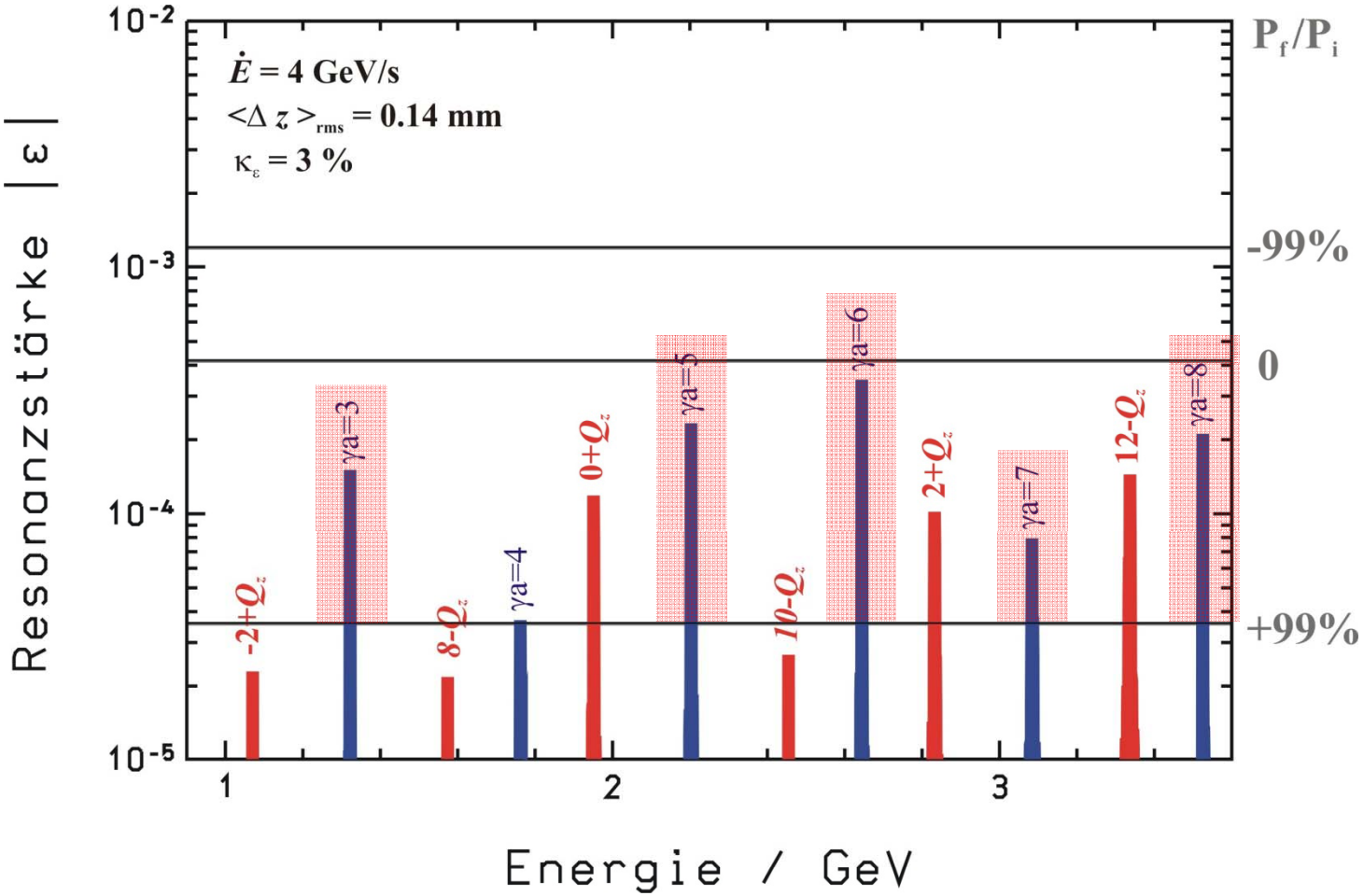


Closed Orbit Correction

vertical beam position in the quadrupole magnets

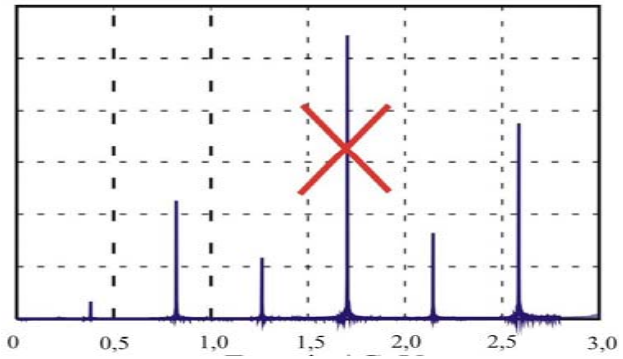


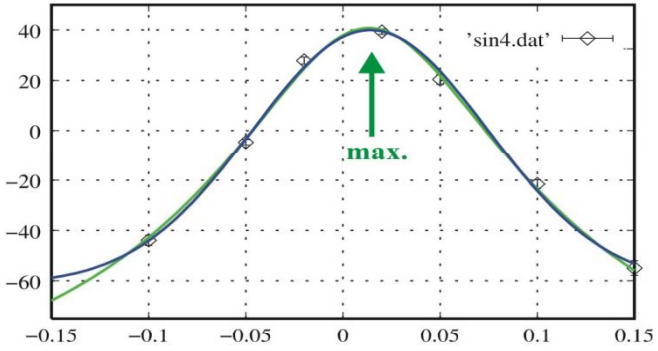
Resonance Strengths

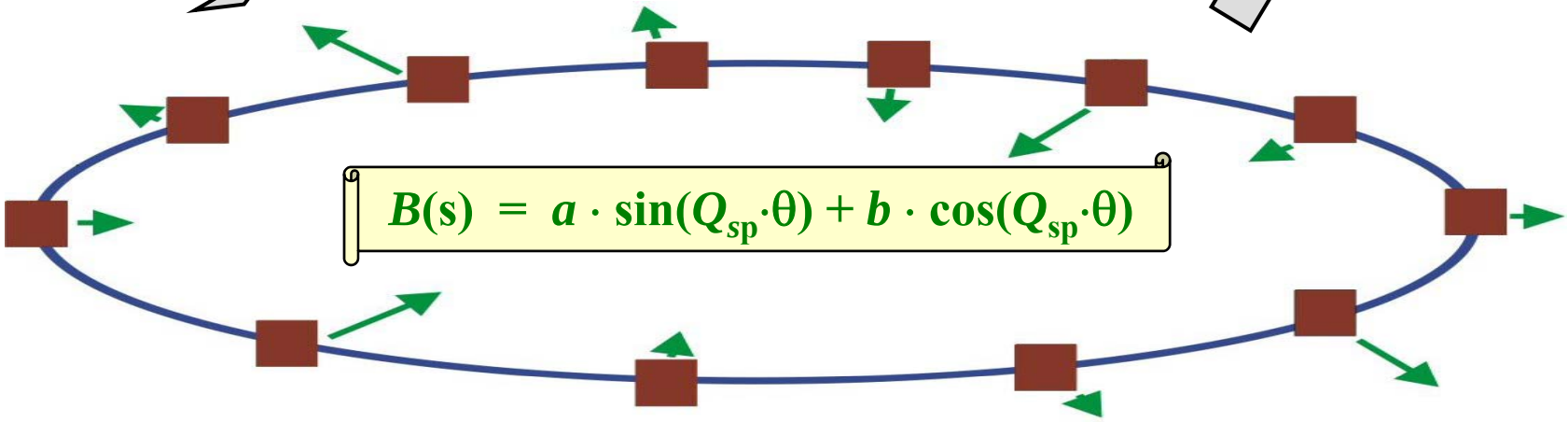


Harmonic Correction

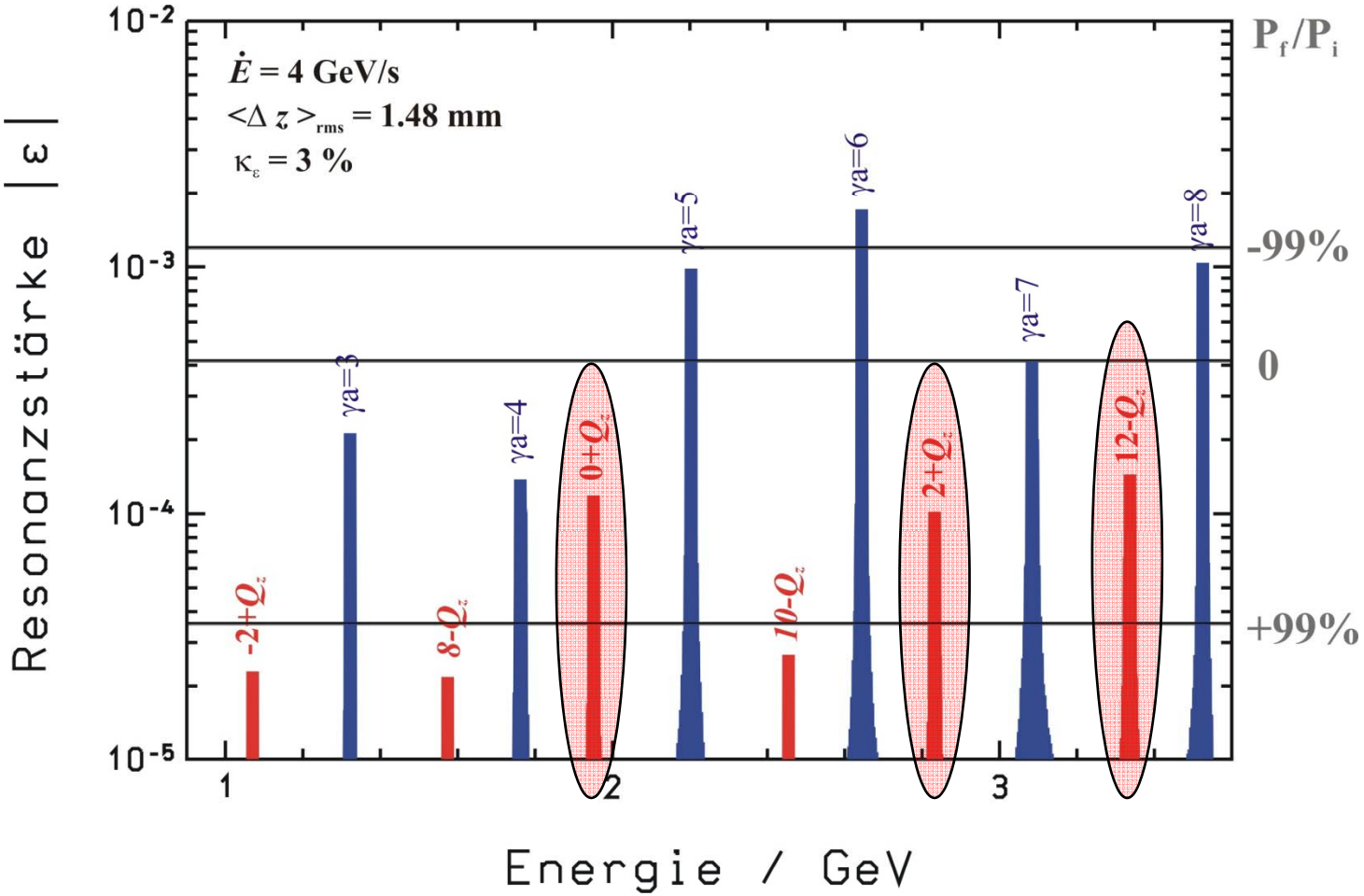
(Imperfection Resonances)



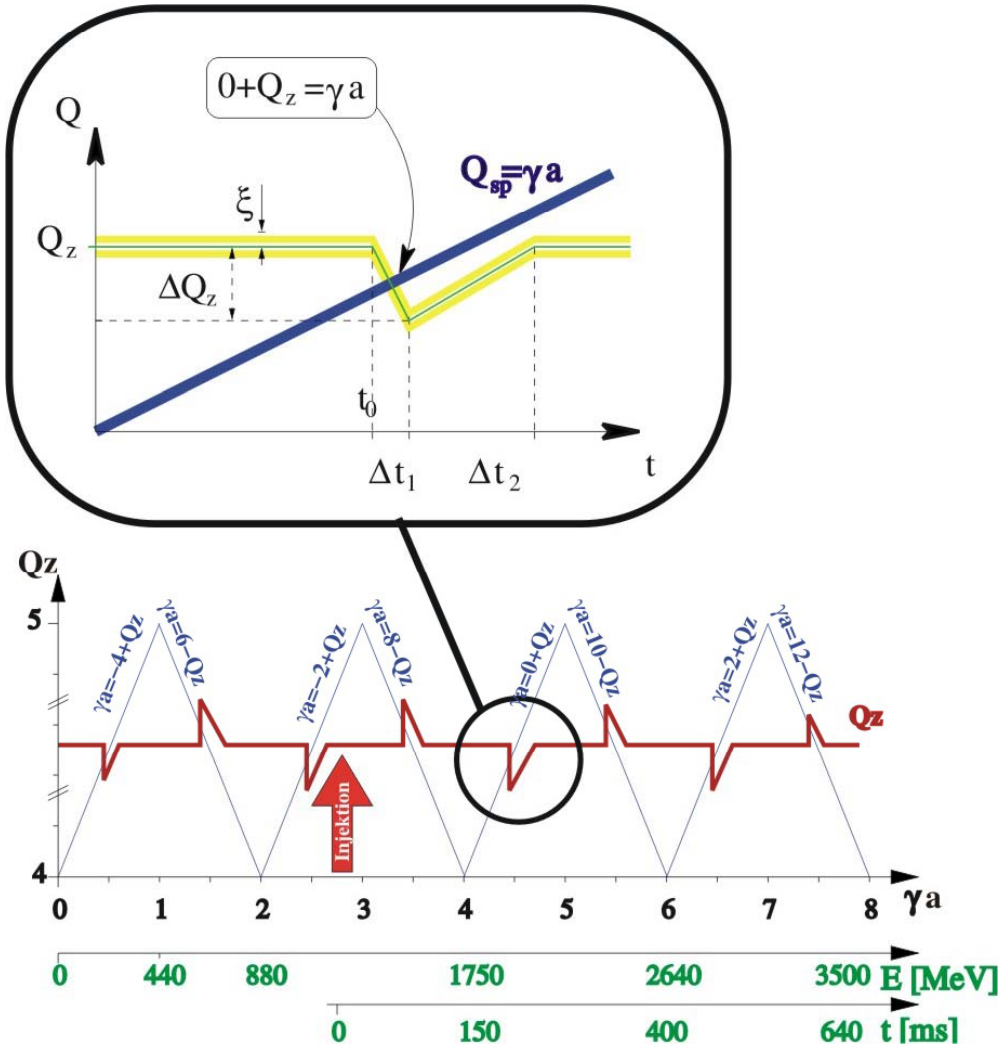




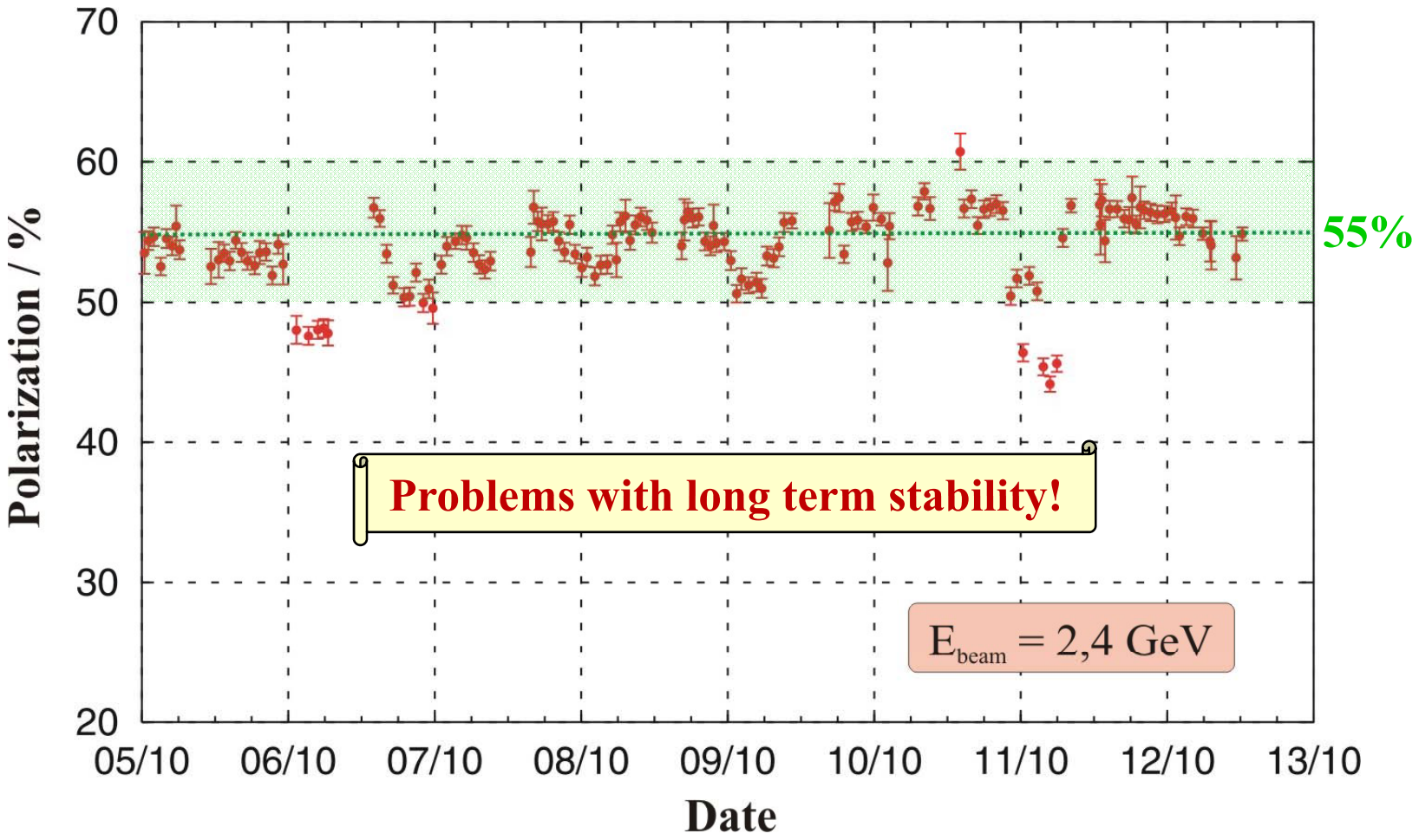
Resonance Strengths



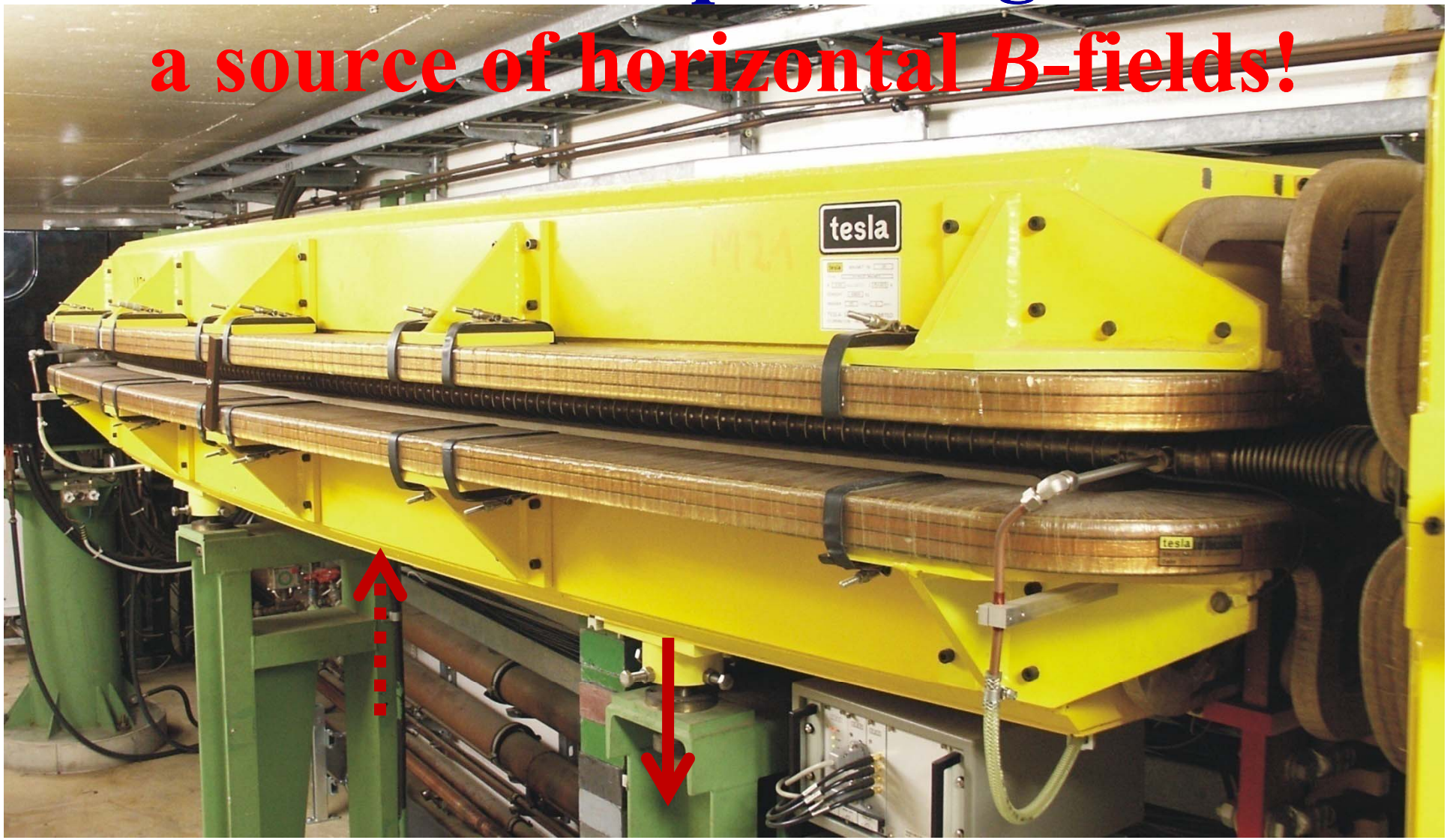
“Tune Jumping”



GDH: Achieved Polarization

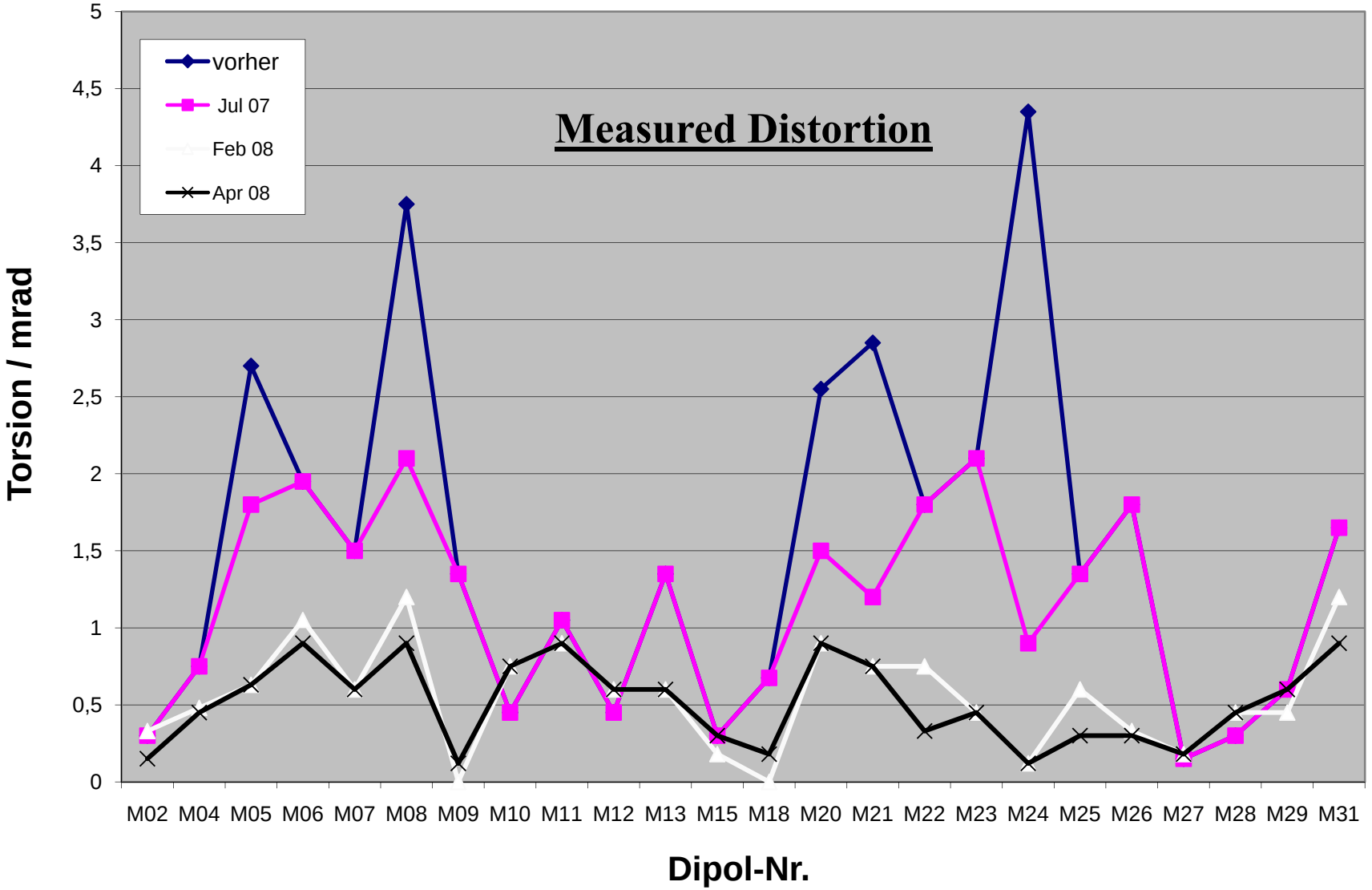


Distorted Dipole Magnets:



a “simple” but very useful idea?!!

Dipole ”Flattening” 2007/2008



“Static” CO Correction

Set up:

- 32 BPM stations
- 40 Correcting magnets

Method:

- **Meas. of CO at certain energies (32 data points each)**
- **Corr. of CO at these energies (40 corrector values)**
- Generation of corrector ramps (lin. Interpolation, **#5sp**)
- Superimposition of harmonic corrections

“Dynamic” CO Correction

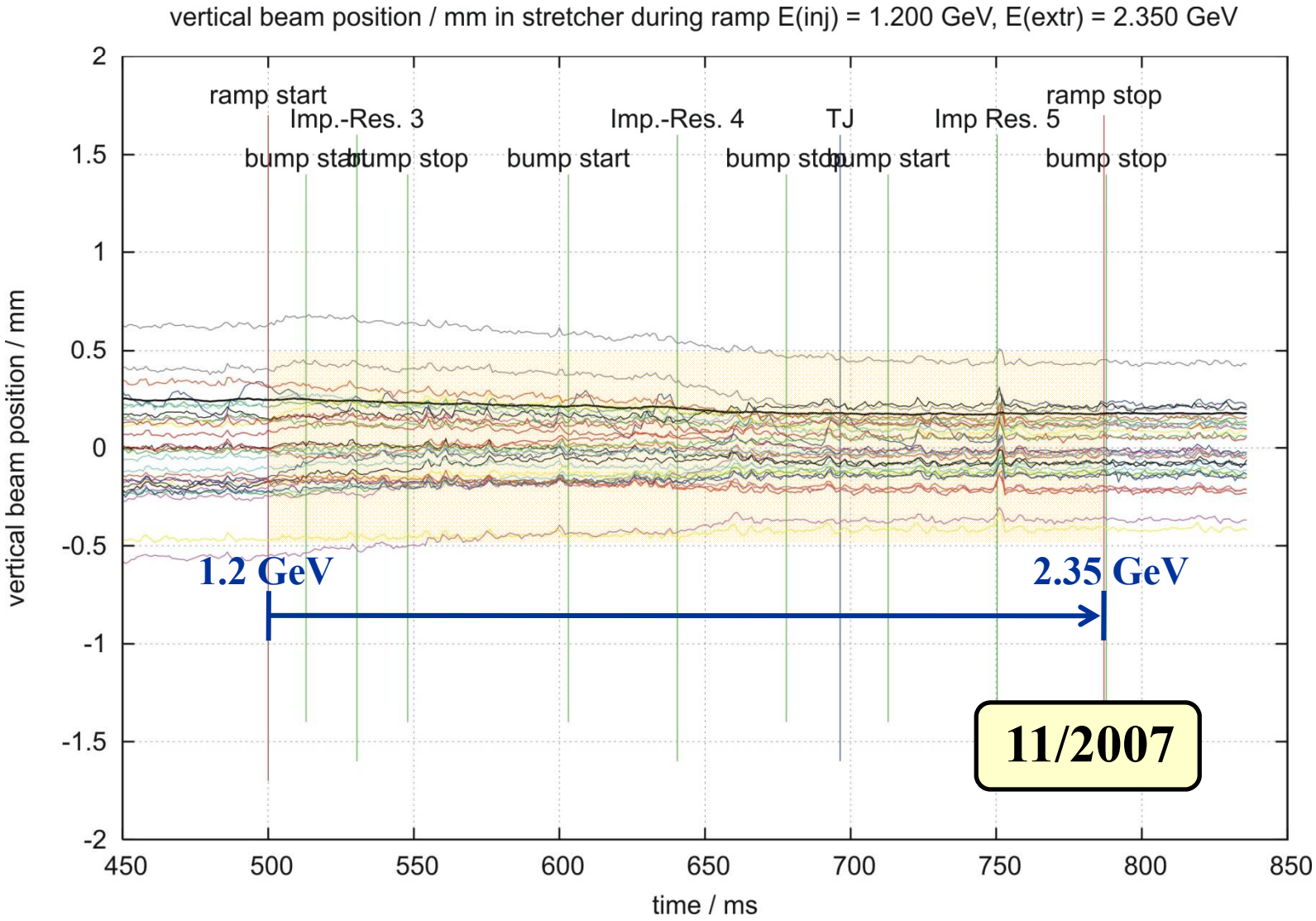
Set up:

- 32 BPM stations
- 40 Correcting magnets

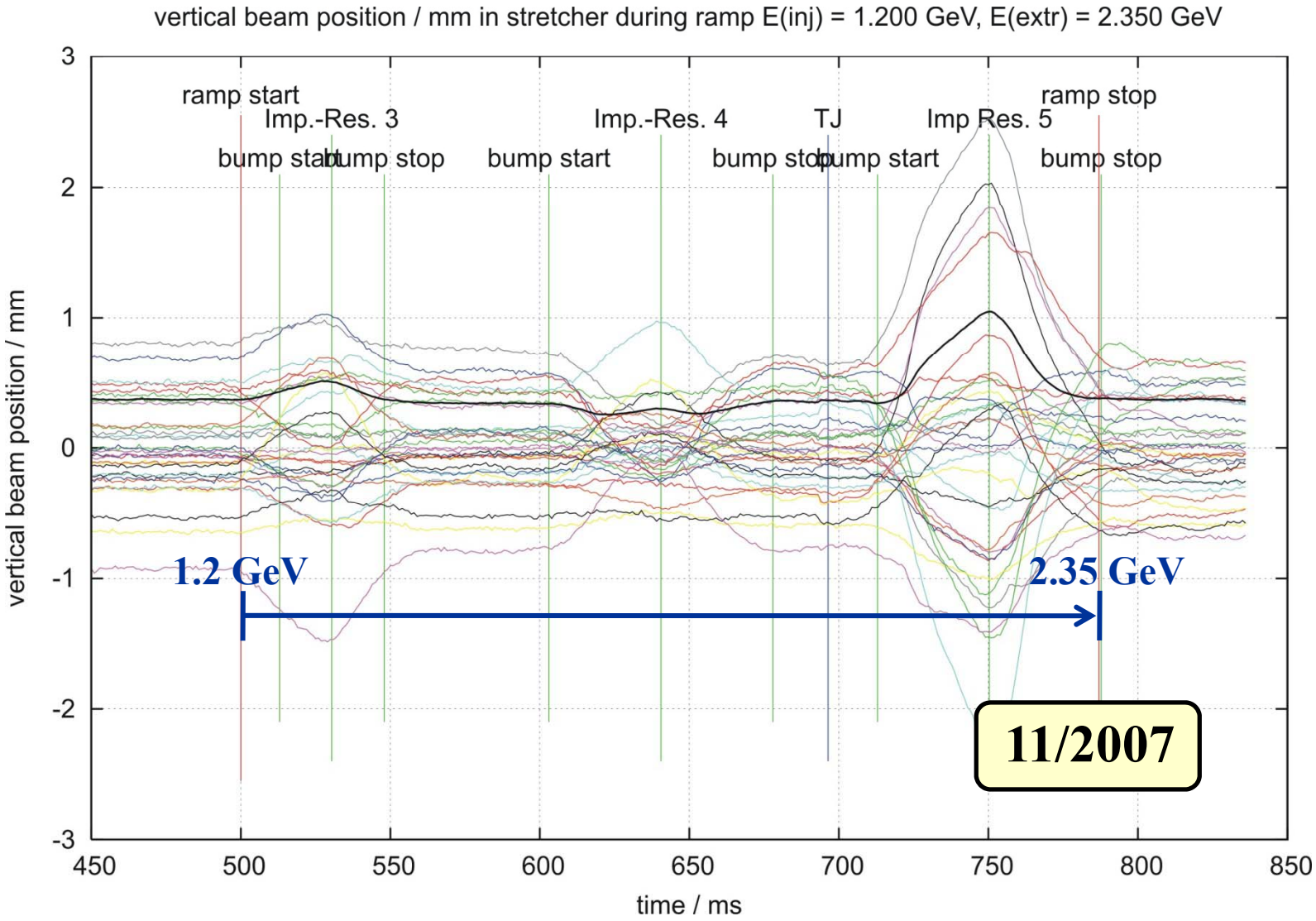
Method:

- **Meas. of CO on energy ramp (32 x 4095 data points)**
- **Calc. of current values for magnets (40 x 25 values)**
- Generation of corrector ramps (lin. Interpolation, **#12sp**)
- Superimposition of harmonic corrections

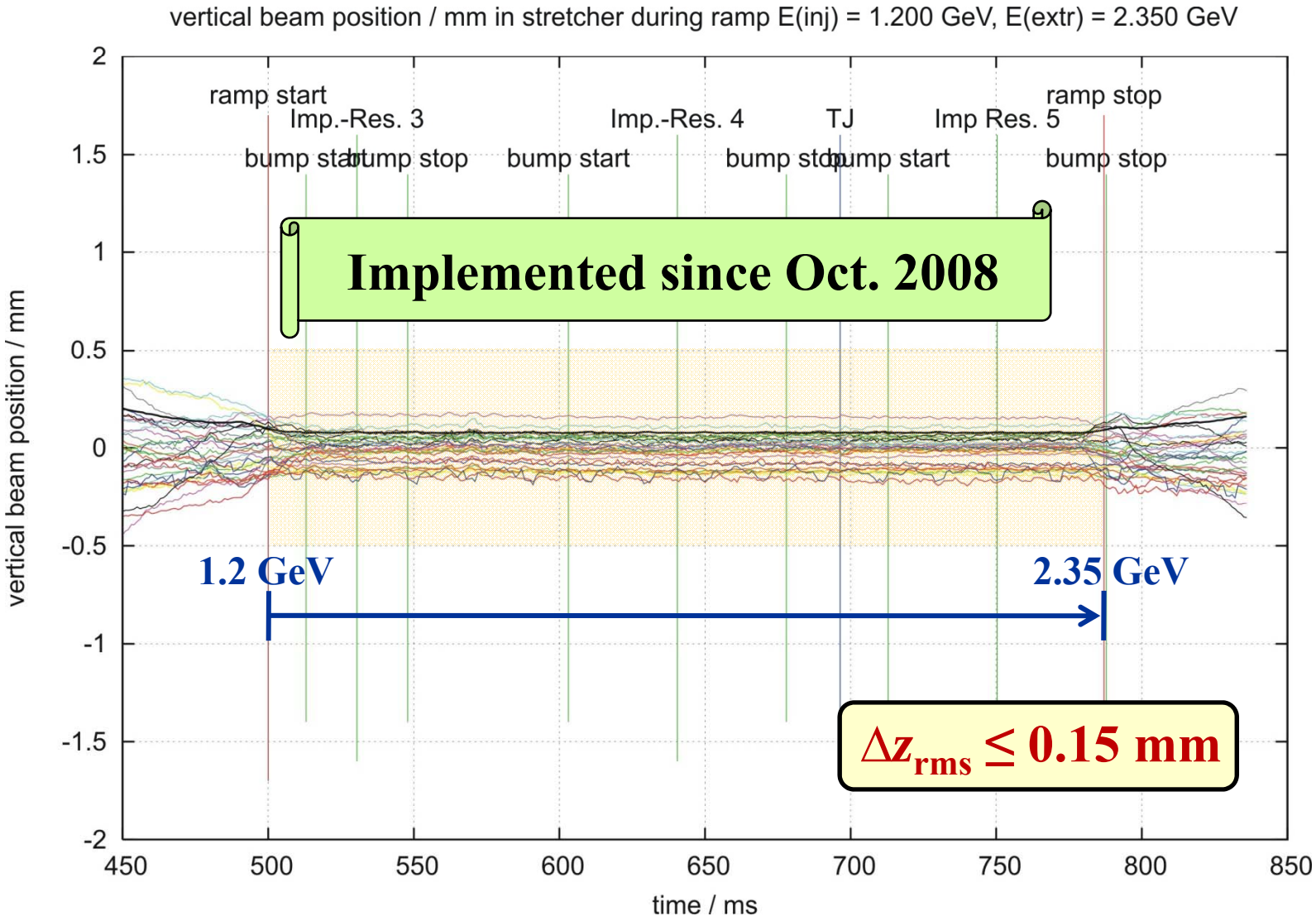
Vertical Orbit Displacements



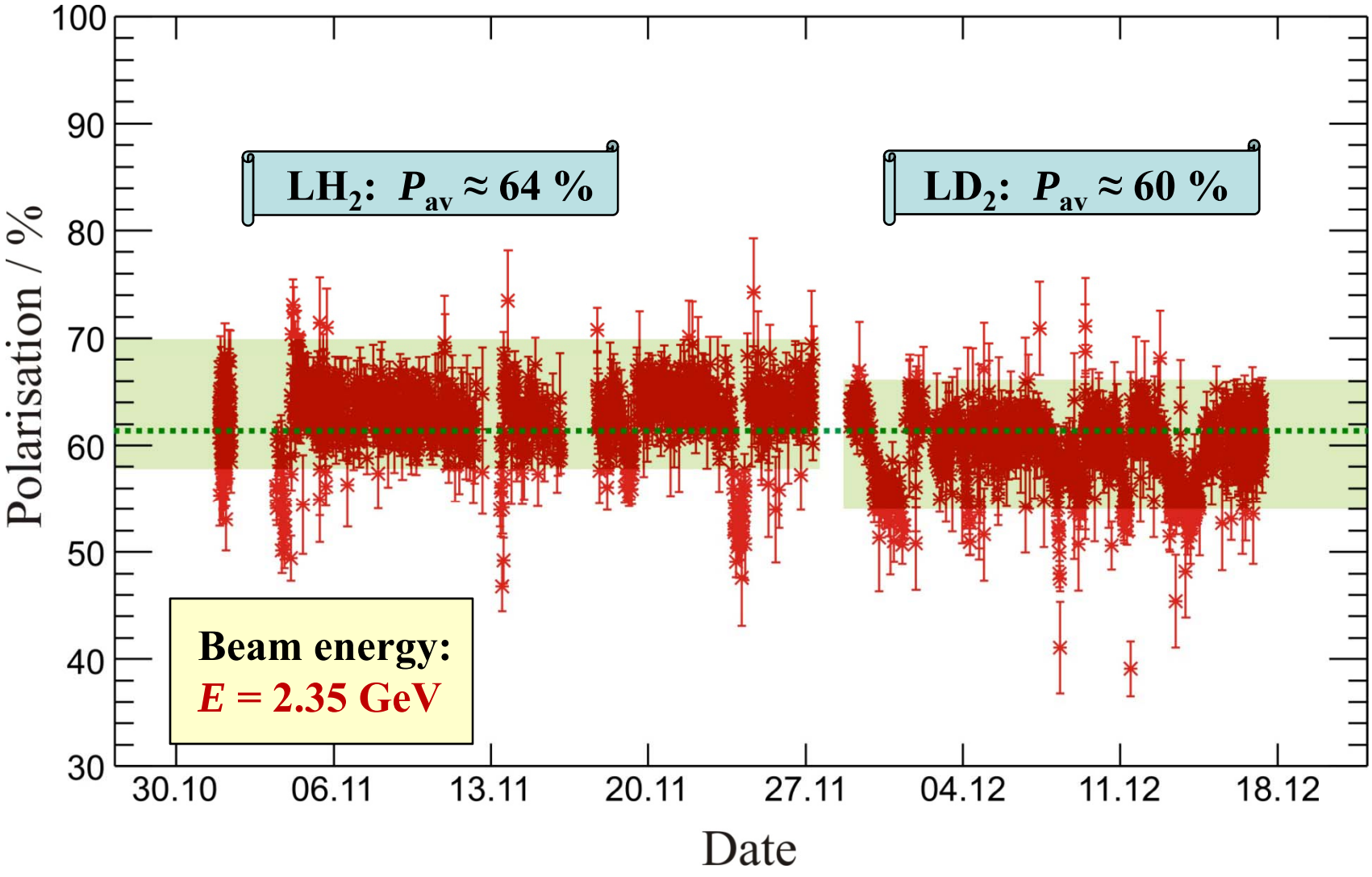
Vertical Orbit Displacements



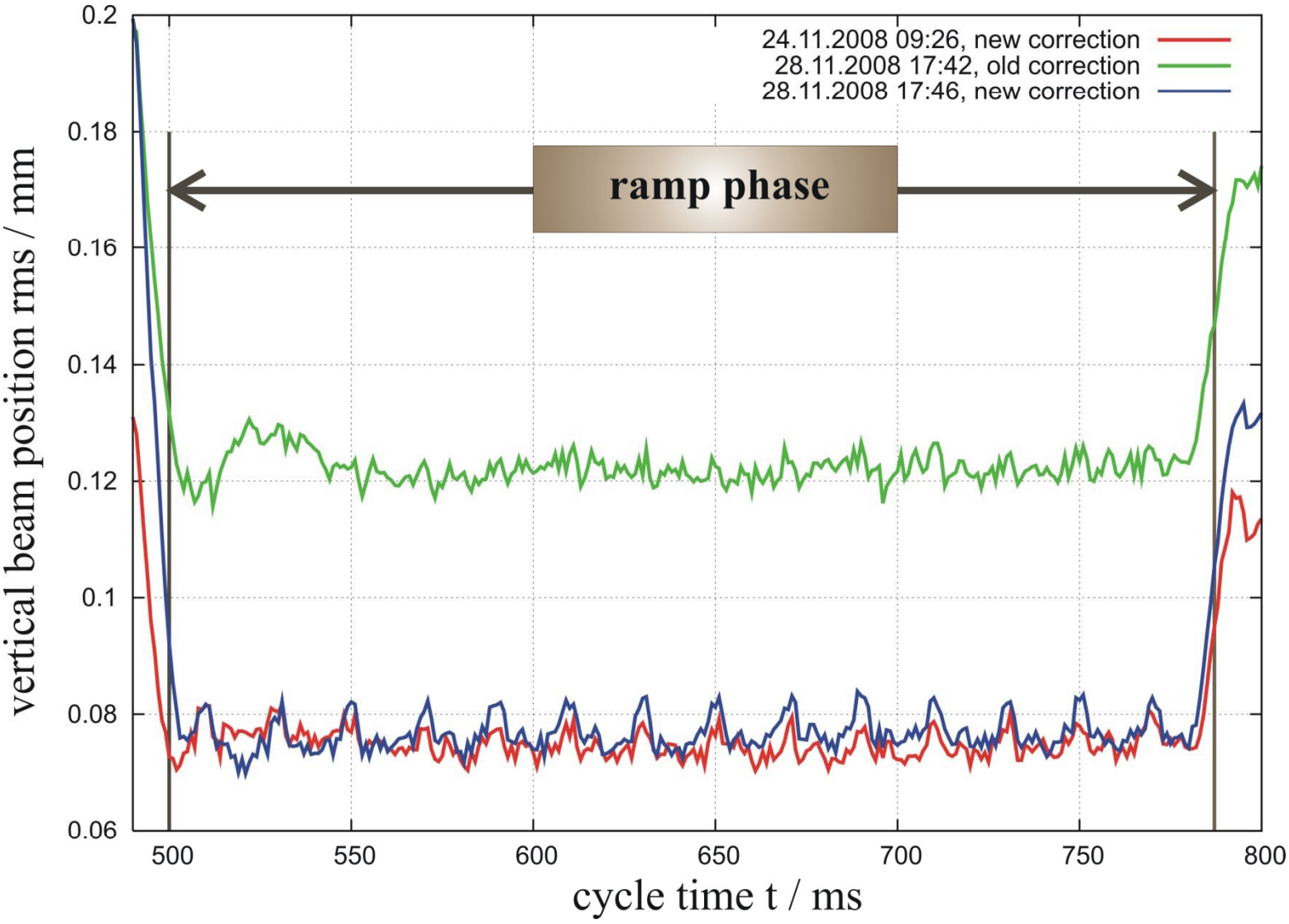
Orbit Correction on the Ramp



Polarization Nov. / Dec. 2008



Requirements on CO



Conclusions

Meanwhile 2 standard operation modes @ ELSA:

- **linearly polarized photons up to E_e- = 3.2 GeV**

  photon polarization dependent on coherent edge

  polarization orientation ±45° routinely achievable

- **circularly polarized photons up to E_e- = 2.35 GeV**

  electron beam polarization higher than 60 %

  photon polarization dependent on photon energy

High long term stability of beam position and polarization!

Outlook: Planned Improvements

- **Source**: new **load-lock** with storage and H-cleaning
- **Polarimetry**: **Compton polarimeter** at ELSA
- **Polarization**: new **correctors** and **power supplies**
- **Stability**: **RF-based BPM** @ CB-Tagger
- **Optics**: full accelerator **tune stabilization**
- **Intensity**: high intensity operation (**D2: 2008-2012)**
- **Test-Area**: **new beam-line** for detector testing
- **Single-Bunch** operation: **ultra low intensity** (fA!)

...

Statistics

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

Operation 2009 ???

Date	Beam	Experimental Area, Target
12.01. – 13.01.	3.2 GeV	CB, **High intensity test, ripple investigations!**
19.01. – 20.01.	3.2 GeV	CB, **preparation for high intensity operation**
21.01. – 19.02.	3.2 GeV	CB, **unpolarized beam**, **solid state targets**
19.02. – 14.04.		Break and maintenance: **Set up polarized target**
15.04. – 18.05.	2.35 GeV $\vec{e}$	CB, **polarized beam**, **double polarization**
01.06. – 07.06.	Pentecost	Break for **surveying** (Geodäsie, Schauerte)
08.06. – 06.07.	2.35 GeV $\vec{e}$	CB, **polarized beam**, **double polarization**
07.07 – 31.10.		**Break**, **lack of working funds!!!**
01.11. – 21.12.	t.b.d.	**Operation on working funds of 2010!?!**

$\Sigma = 2.250$ hours

Not realizable without additional funds!

Unsolved problem up to now!!!

$\lesssim$ 1500 hours covered by working funds 01-10/2009!