

# The Bonn Electron Stretcher Accelerator

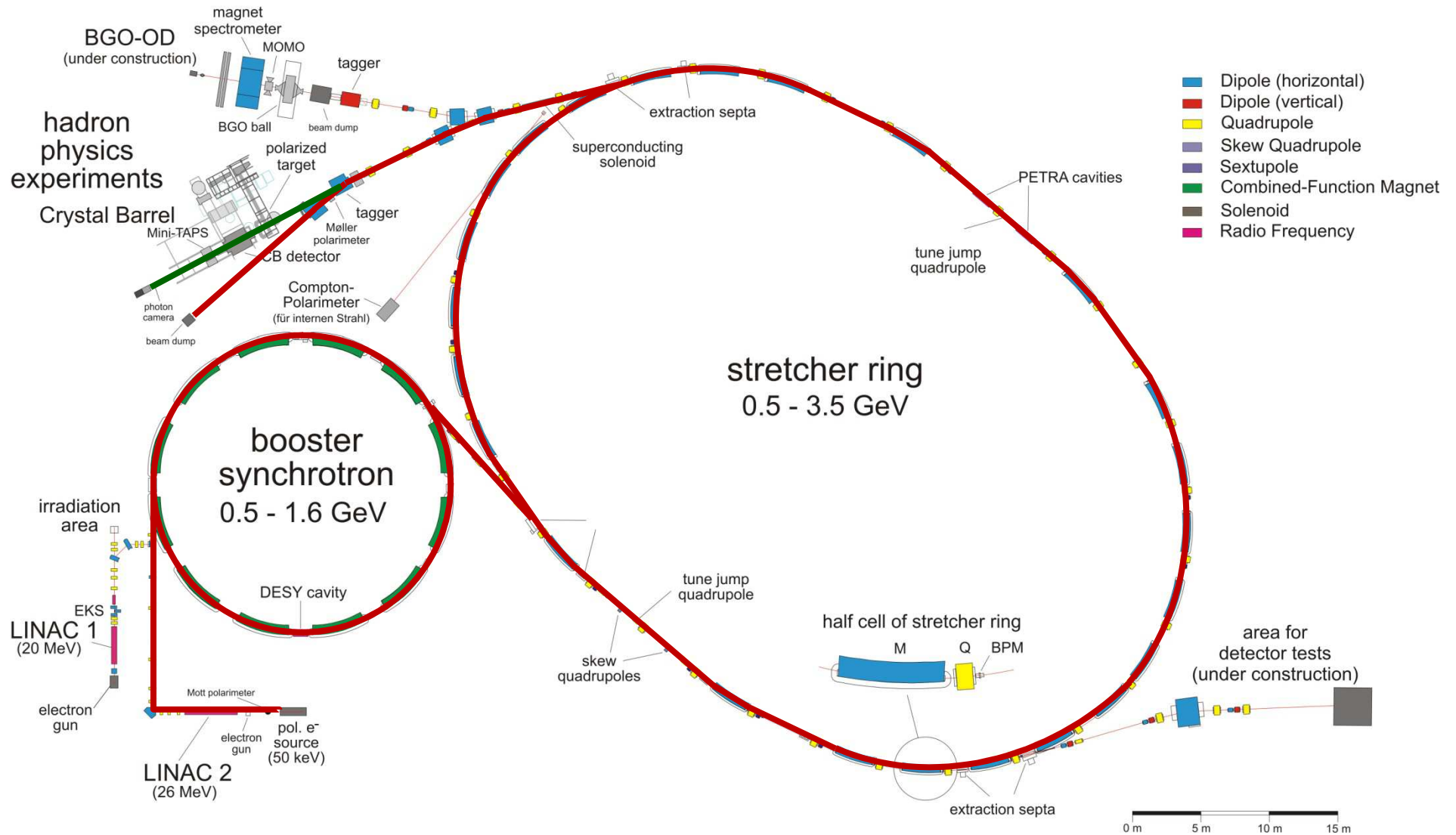


*... and the BGO-OD electron beamline*

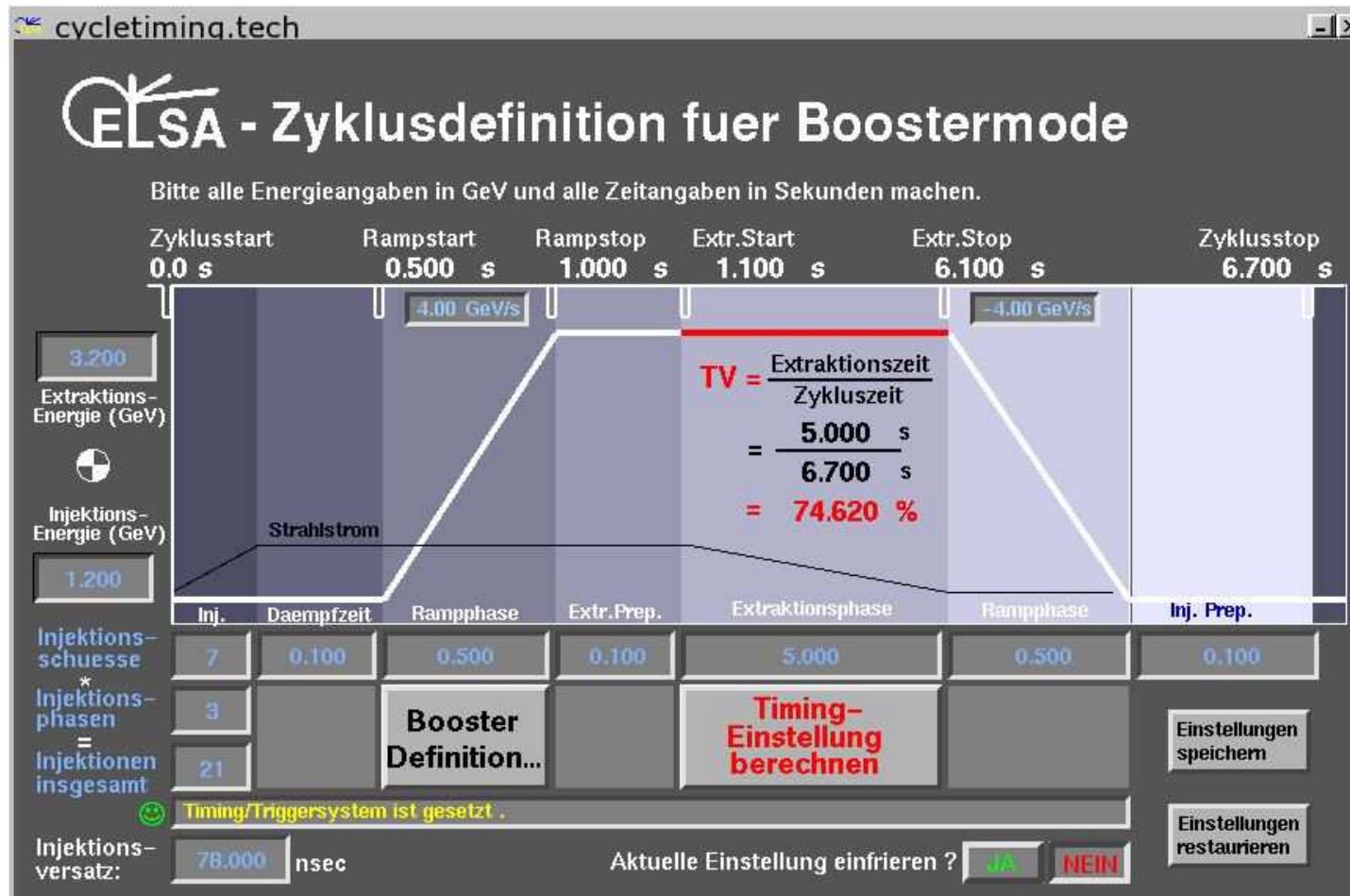
*Wolfgang Hillert*

*Physics Institute of Bonn University*

# Electron Stretcher Accelerator (ELSA)

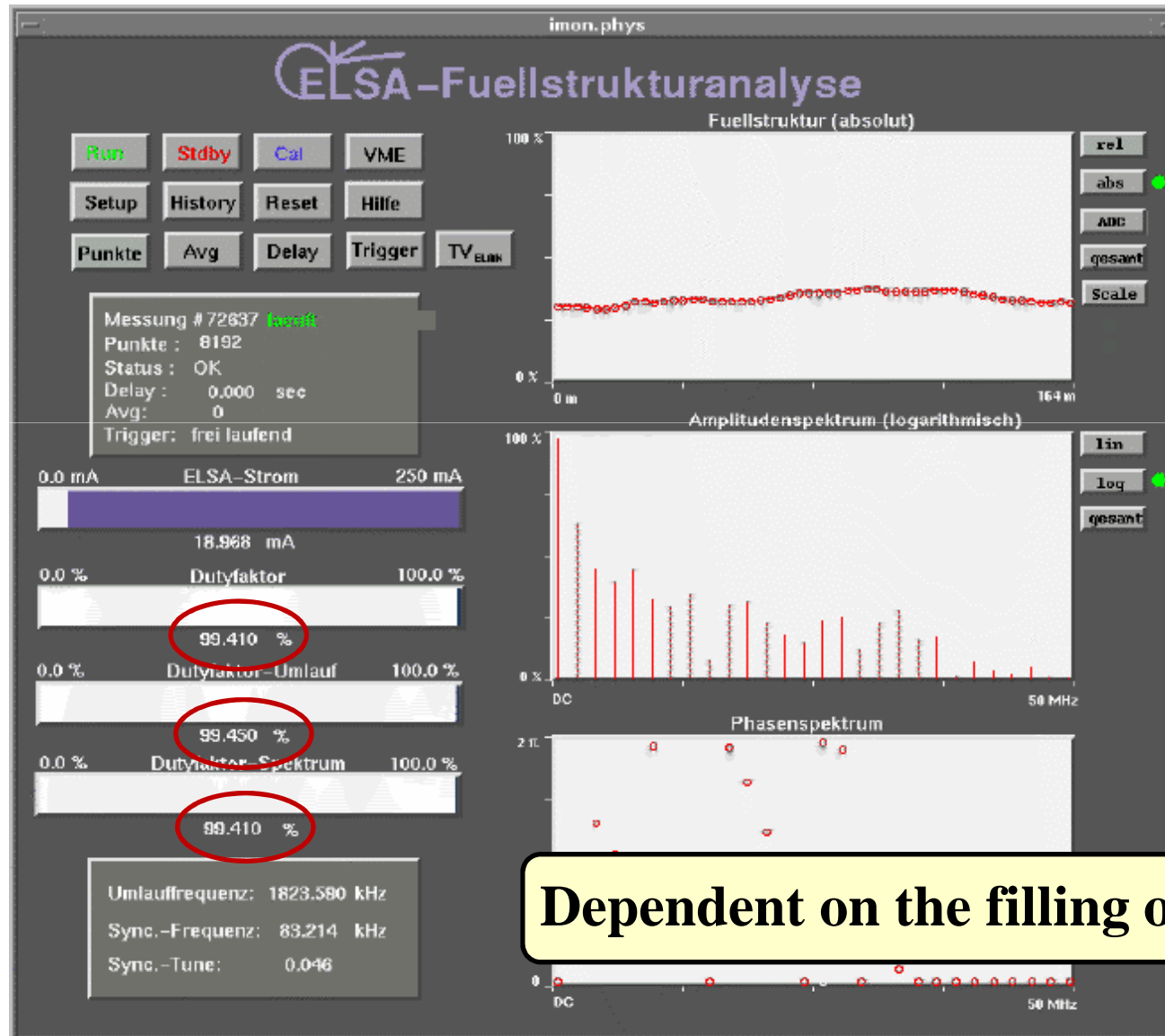


# Duty Cycle



Macroscopic duty cycle:  $DC_{mac} = \frac{\Delta T (\text{external beam})}{\Delta T (\text{complete cycle})}$

# Microscopic Duty Cycle



**Dependent on the filling of ELSA**

# Beam Characteristics:

## Internal Beam:

### Emittance (natural, stand. optics):

- horz.:  $\epsilon_x \geq 78 \cdot (E [\text{GeV}])^2 \text{ nm} \cdot \text{rad}$
- vert.:  $\epsilon_z \approx 0.1 \cdot \epsilon_x$  (typ.)

Quadratic scaling  
with energy!

### Energy spread (natural, $\sim 1/R$ ):

- $\sigma_E/E = 3.7 \cdot 10^{-4} \cdot E [\text{GeV}]$

Linear scaling with  
energy!

### Bunch length:

- $\approx \text{cm}$ , depends on RF acceleration voltage

## Typical values for $E = 3.2$ GeV:

### Beam Emittance:

$$\varepsilon_x = 768 \text{ nm}\cdot\text{rad}$$

$$\text{useful: } 4\pi\varepsilon = \lambda \leftrightarrow \lambda \approx 10 \mu\text{m}$$

### Beam Divergence:

Focus to  $\sigma_x = 1 \text{ mm} \rightarrow \sigma_{x'} = 77 \mu\text{rad} \approx 8/\gamma$

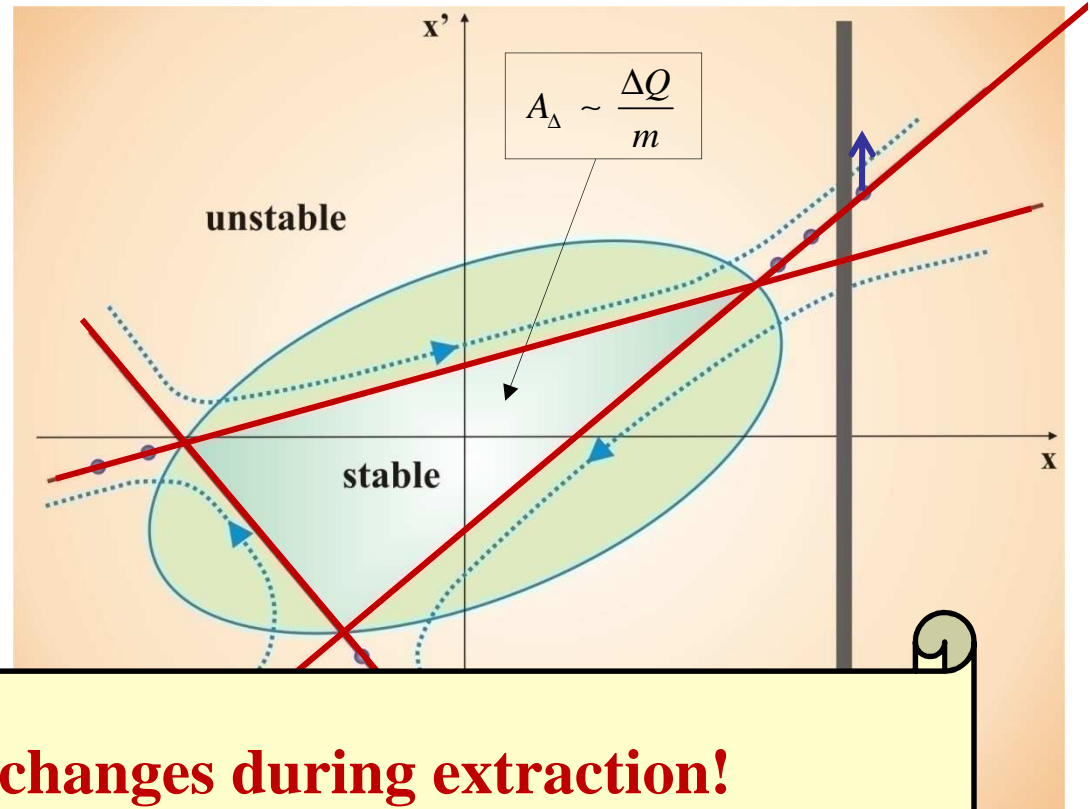
### Bunch length:

$$2\sigma_s \approx 5.76 \text{ cm}, \quad 2\sigma_t \geq 190 \text{ ps}$$

### Energy spread:

$$\sigma_E/E \approx 0.08\%, \quad \sigma_E \approx 2.6 \text{ MeV}$$

# Slow Beam Extraction



Sext  
Excit

**Beam direction changes during extraction!**  
**Compensated by ramping the current of the septum extraction magnet coil!**

# Strahlungsmessung ELAN-Beamline

	Betrag	Phase	Mittel	Position	Mittel
X	15.7 $\mu$ V	-89 °	-96 °	-0.38 mm	-0.42 mm
Y	54.6 $\mu$ V	-88 °	-89 °	-1.68 mm	-1.69 mm
I	Bunch-Faktor: 0.808			612 pA	604 pA

## Lock-In-Verstaerker

Zeitkonstante  
◀ 30 ms ▶

Status ● ● ●

## Datenerfassung

Messung

ON

AUS

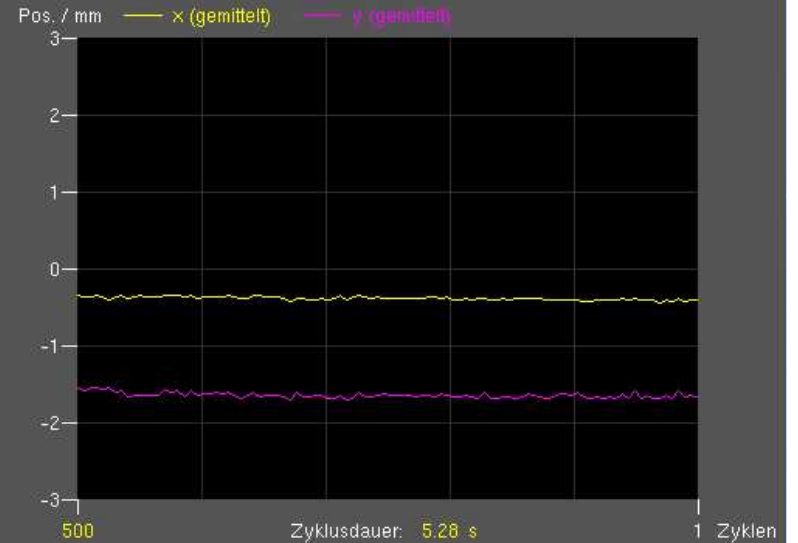
Logging

ON

AUS

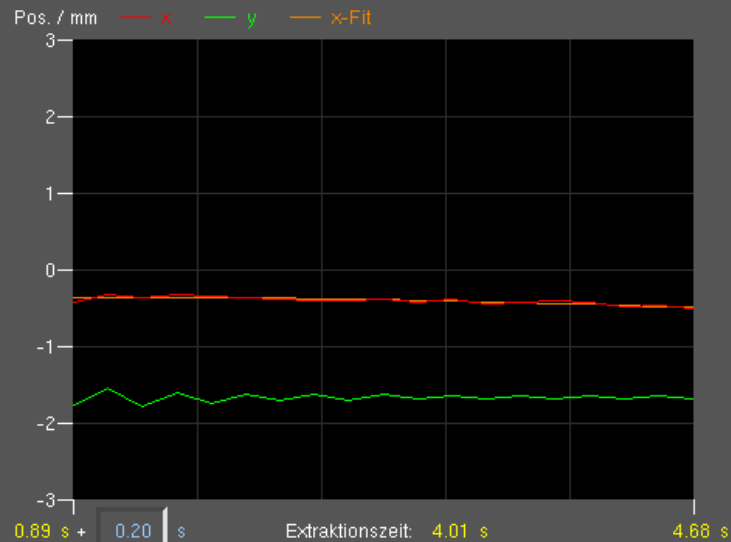
Meldungen: **Messung laeuft.**

Mittelwerte, alle **5** Zyklen erfasst

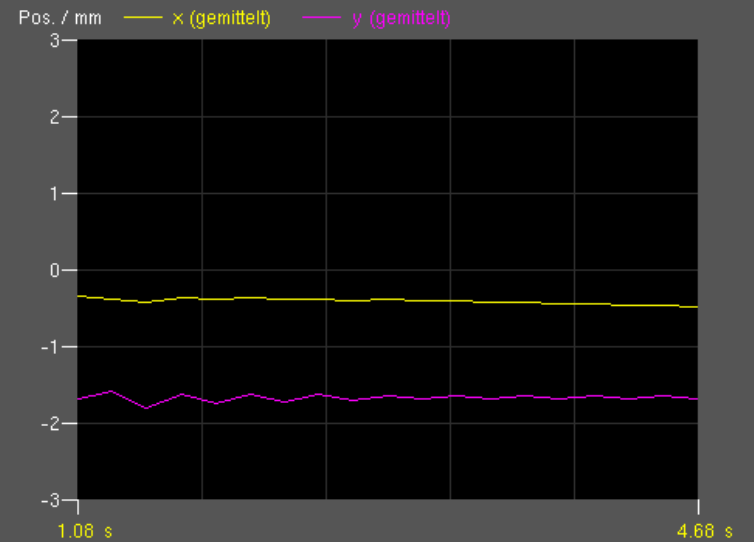


## Zeitliche Entwicklung waehrend der Extraktion

Letzte Extraktion, Ausleserate: ● **5.0** Hz



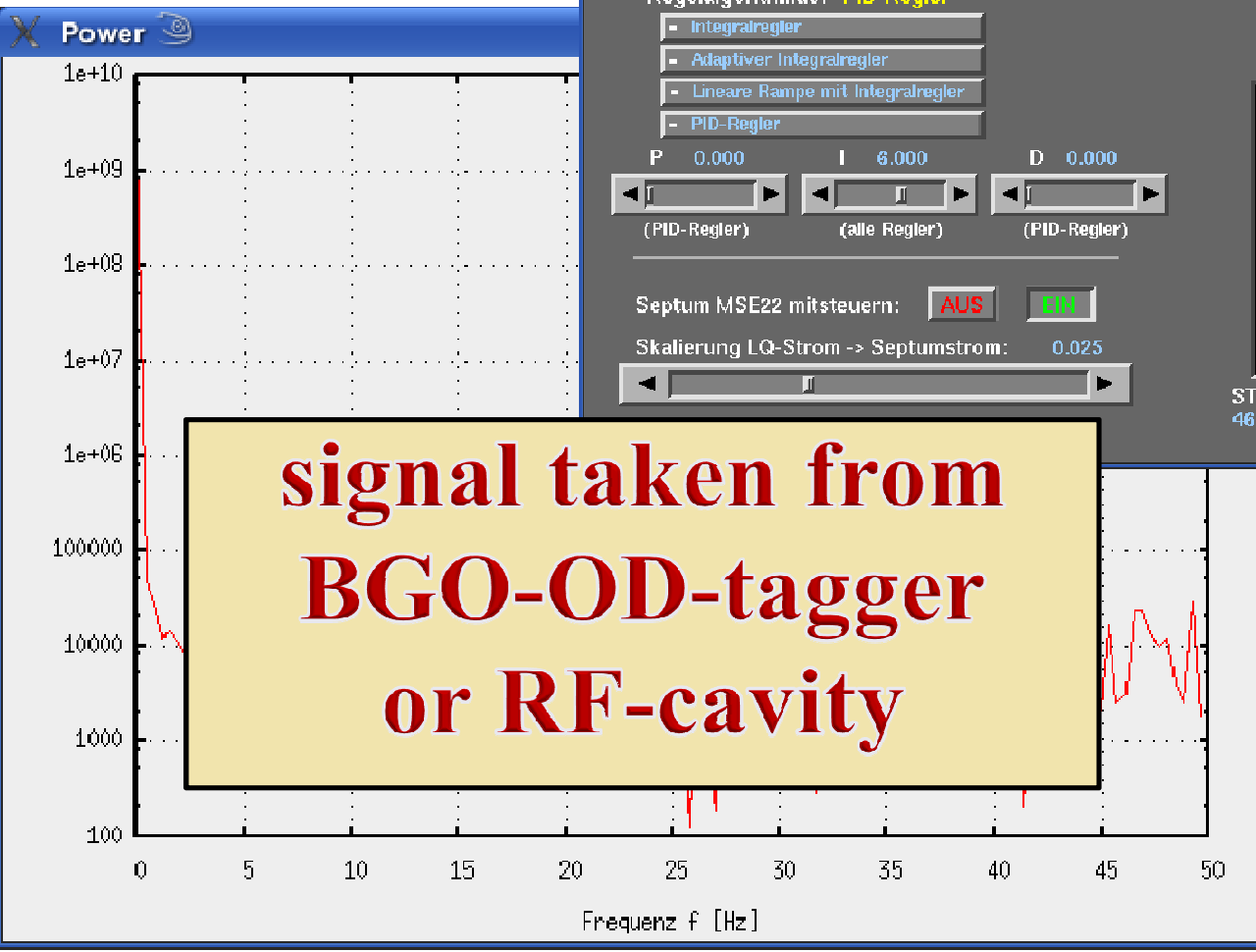
Gemittelt ueber **10** von **10** Extraktionen





# Intensity Stability

The screenshot shows the 'extmon.phys' control interface. At the top, there are buttons for 'EIN' and 'Hold'. Below that, a section for 'Feedback' includes 'AUS', 'EIN', and 'Hold' buttons, along with 'Tagger' and 'Kluxen' labels. The 'Regelalgorithmus' is set to 'PID-Regler', with sub-options for 'Integralregler', 'Adaptiver Integralregler', 'Lineare Rampe mit Integralregler', and 'PID-Regler'. The PID parameters are displayed as P: 0.000, I: 6.000, and D: 0.000. There are also buttons for 'Septum MSE22 mitsteuern' (AUS/EIN) and a slider for 'Skalierung LQ-Strom -> Septumstrom' (0.025). On the right, there are two monitoring graphs: 'Anzeige Kluxen' showing a fluctuating signal with a 'SOLL' value of 48439, and 'Luftquadrupolstrom letzter Zyklus' showing a rising curve with 'START' at 46.376 A and 'MAX' at 117.389 A. The total event count is 2398622.



signal taken from  
BGO-OD-tagger  
or RF-cavity

Stabilization of  
"overall"  
tagging rate  
(tagger-or)

# Beam Characteristics:

## External Beam:

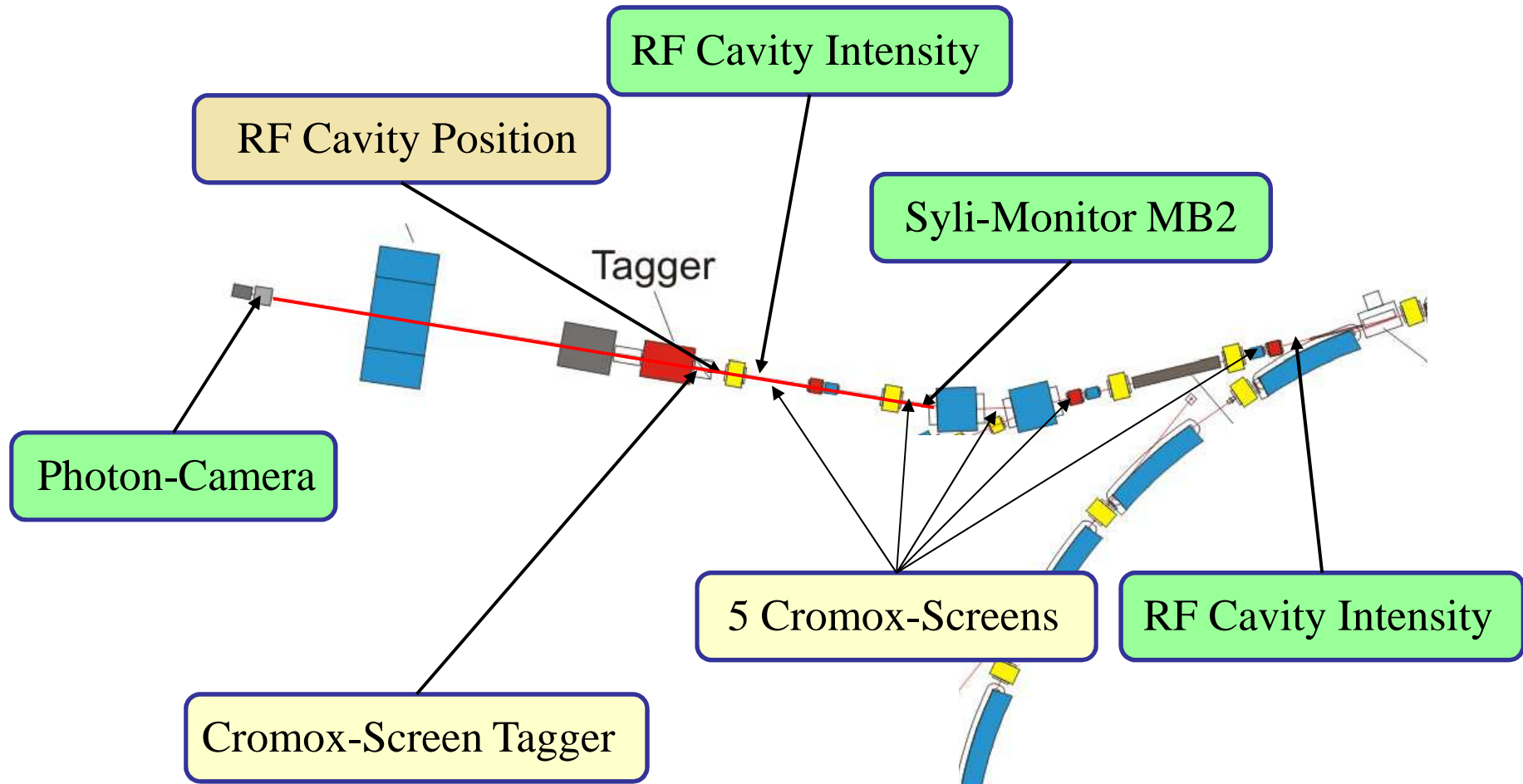
### Beam Parameters:

- **horz.:** affected by extraction, **have to be measured**
- **vert., long.:** about the same as the internal values

### Long-Term Stability (experience from CB):

- beam pointing stability  $\leq 20 \mu\text{rad}$   $\leftrightarrow$  **photon-camera**
- beam position stability  $\leq 0.2 \text{ mm}$   $\leftrightarrow$  **RF-cavity**

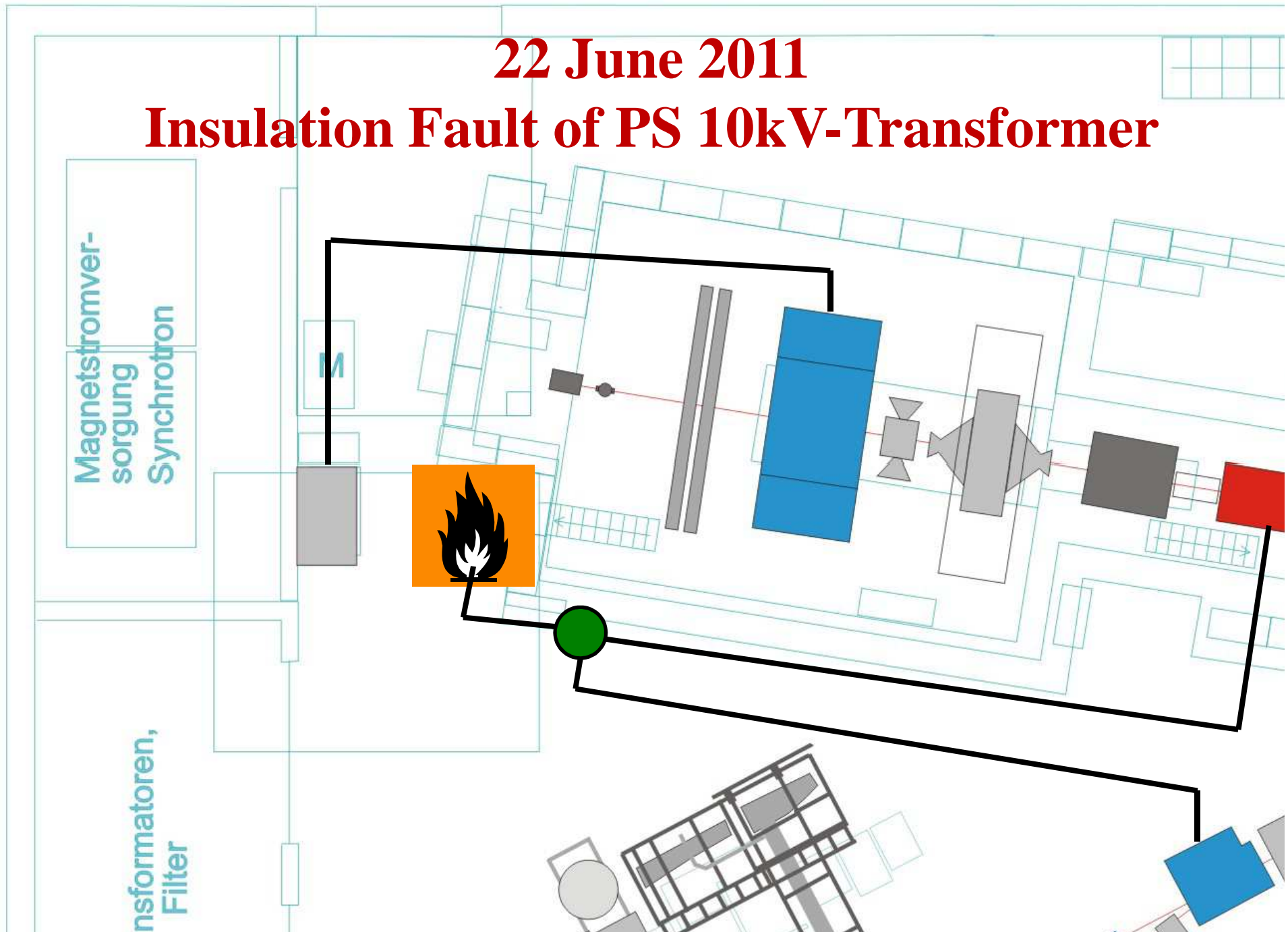
# BGO-OD Beamline



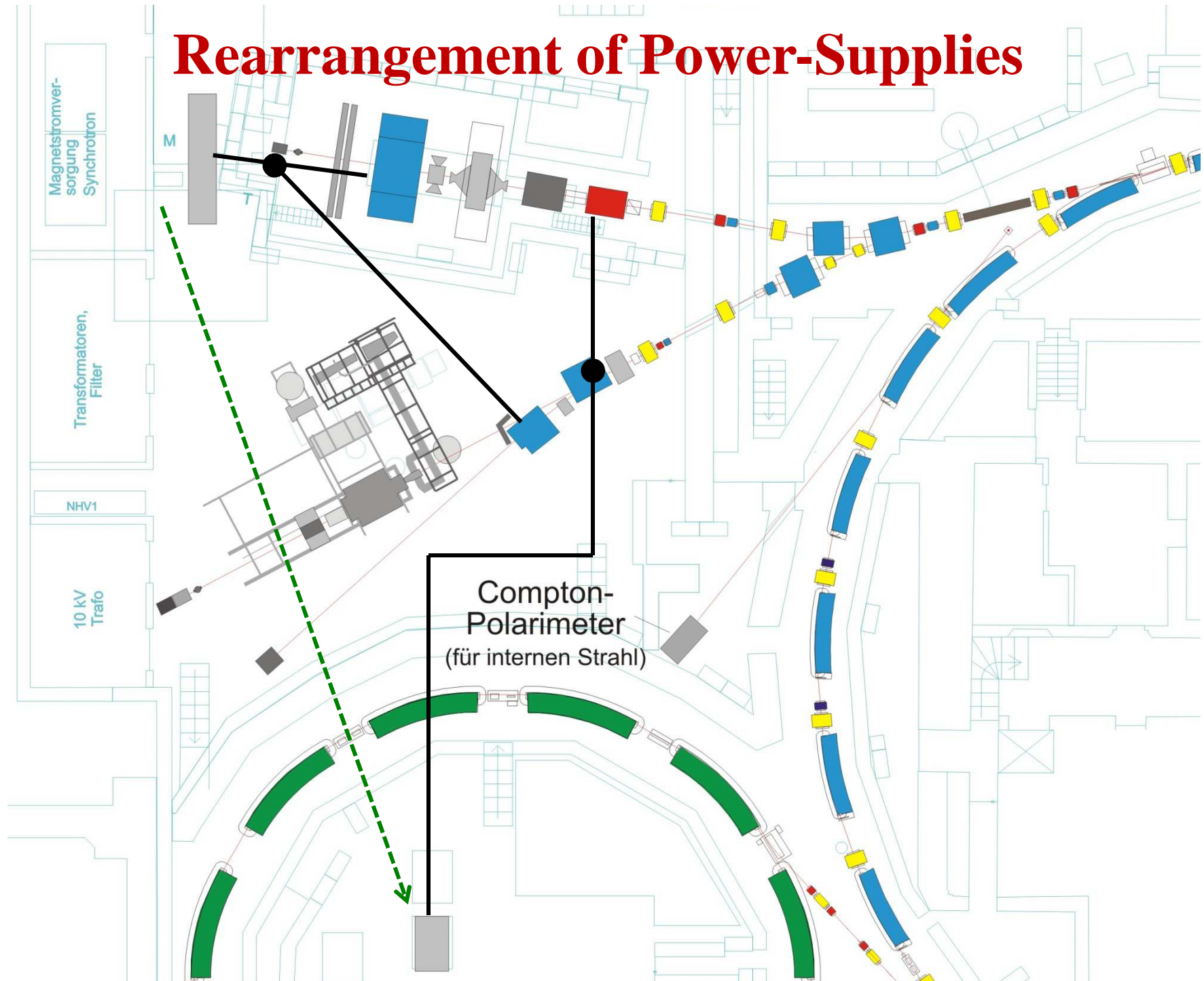
**Careful alignment of experimental components (collimators!!) required!**

22 June 2011

# Insulation Fault of PS 10kV-Transformer



# Rearrangement of Power-Supplies



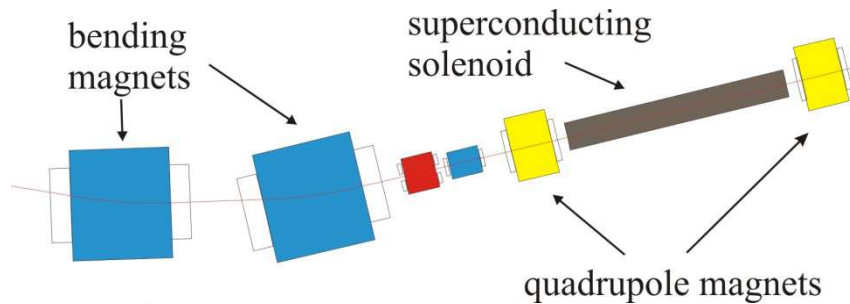
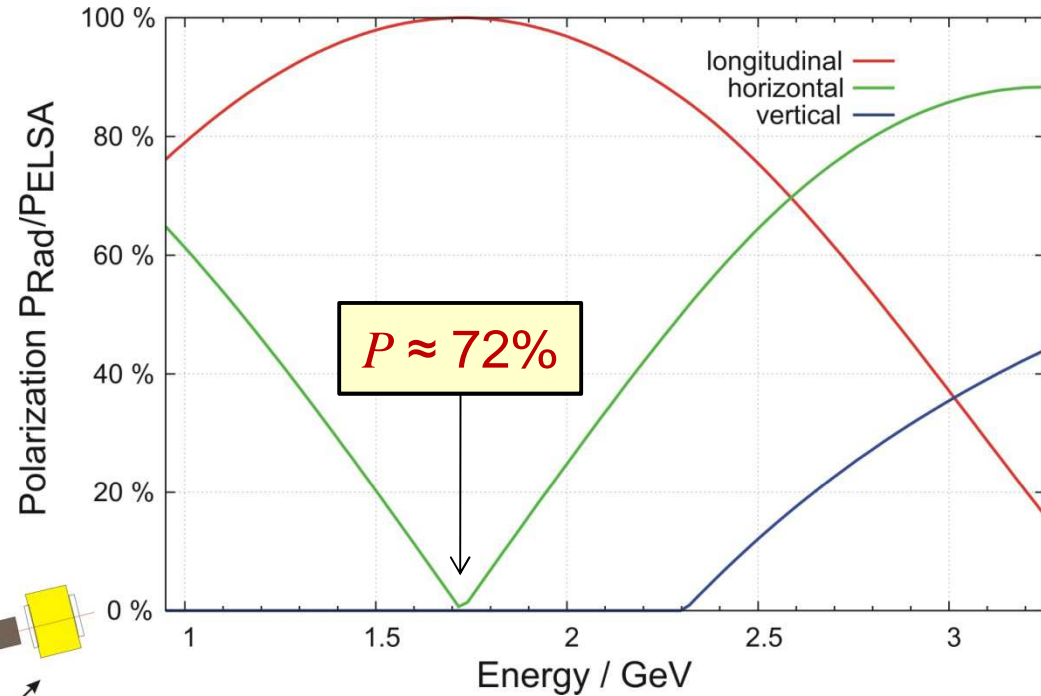
# Things still need to be done:

- **Power Supply Tagging Magnet:**
  - Installation of passive filter (in progress, nearly completed)
  - Balancing of current regulator (not before Oct)
- **Spectrometer Magnet:**
  - Connection to PS on ramp (serves M5/CB-beamline)
  - Balancing of current regulator (not before Oct)
- **Tagging Target:**
  - Installation of the target vessel, closing of beam-pipe
  - Later: Installation and commissioning of  $TM_{110}$ -cavities

# Time Schedule

- **September: Maintenance**
  - test of 10kV safety switches
  - installation of power supplies for ext. dipoles
  - cabling of tagger / spectrometer magnet
  - acc: feedback, correctors, cooling, LINAC I, loadlock, ...
- **October: Re-Commissioning of ELSA**
  - balancing regulators power supplies ext. dipoles
  - test of all subsystems, accelerator switch-on
  - conditioning of PETRA resonators
  - internal beam tests, commissioning of 3D-feedback-system
  - set up of standard operation
- **November / December: operation for CB / BGO-OD**

# Spin Transmission to BGO-OD



**Spin Transfer to the Tagger of the BGO-OD Beamline**

Lamor Precession 
$$\Delta\phi = -\frac{e}{m_0c} \cdot \frac{1+a}{\sqrt{\gamma^2-1}} \cdot \int B_s(s) \cdot ds$$

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

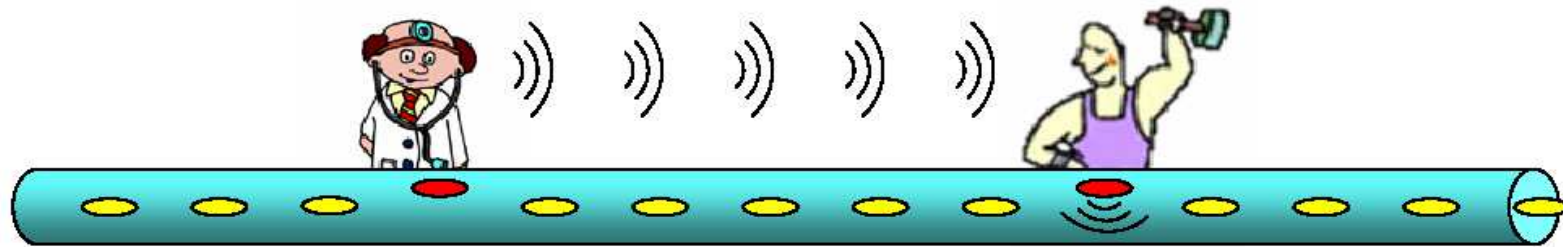


# Operation at Higher Currents

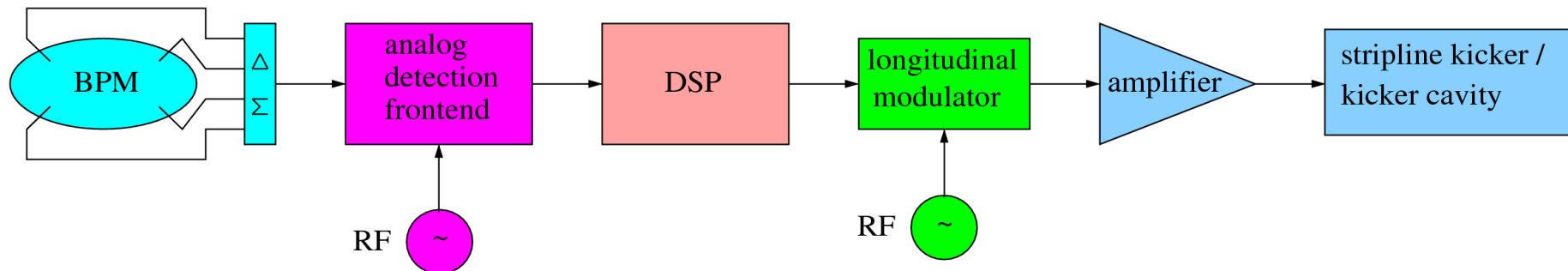
## Generation of wake-fields, beam neutralization

- excitation of coherent oscillations
- damping due to SR-emission
  - 1/e damping times:
    - Injection (1.2 GeV):**  $\tau_x = 100 \text{ ms}$  /  $\tau_s = 35 \text{ ms}$
    - Extraction (3.2 GeV):  $\tau_x = 5.2 \text{ ms}$  /  $\tau_s = 2 \text{ ms}$
- **first instabilities observed for  $I > 20 \text{ mA}$**
- **stronger damping required!**
  - aiming for  $\tau \approx 1 \text{ ms!}$

# Bunch by Bunch Feedback



$$\Delta t = 2 \text{ ns}, \text{ BW} = 250 \text{ MHz}$$



**Full 3D system installed at ELSA, very promising!**

# Actual Status & Outlook

BGO-OD – beamline “operational” with unpolarized beam:

➤ **Tagged photon** operation only (incl. lin. polarization)

➤ **Energy range:**  $1.0 \text{ GeV} < E < 3.5 \text{ GeV}$

➤ **Current range:**  $10 \text{ pA} < I < 1 \text{ nA}$

} electrons

**Intensity stabilization using RF cavity or tagger-or**

**Up to 10 nA envisaged with active bunch by bunch feedback!**

**Linearly polarized photons avail. from coh. bremsstrahlung**

**Circularly polarized photons require Møller-polarimeter!**