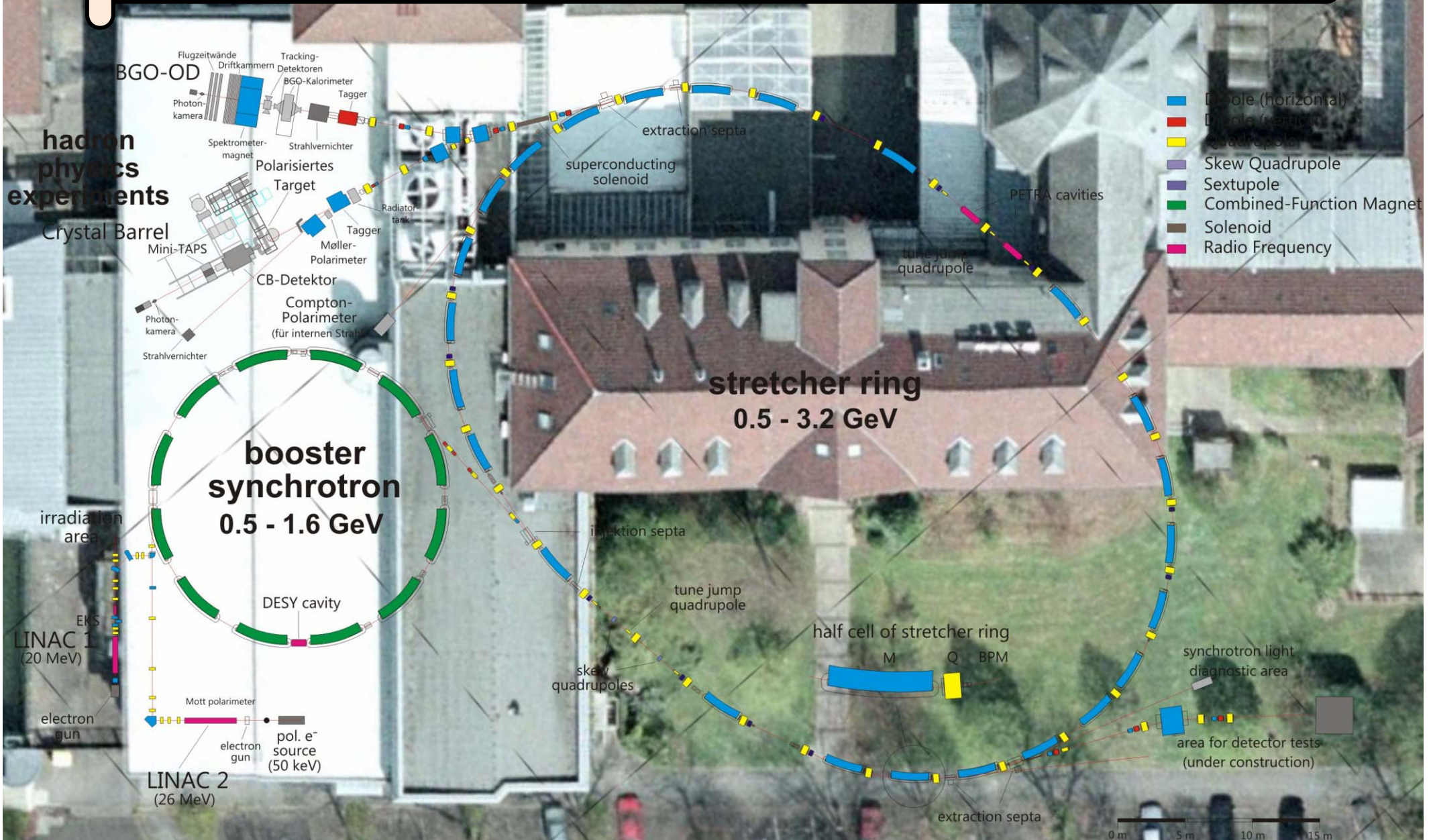
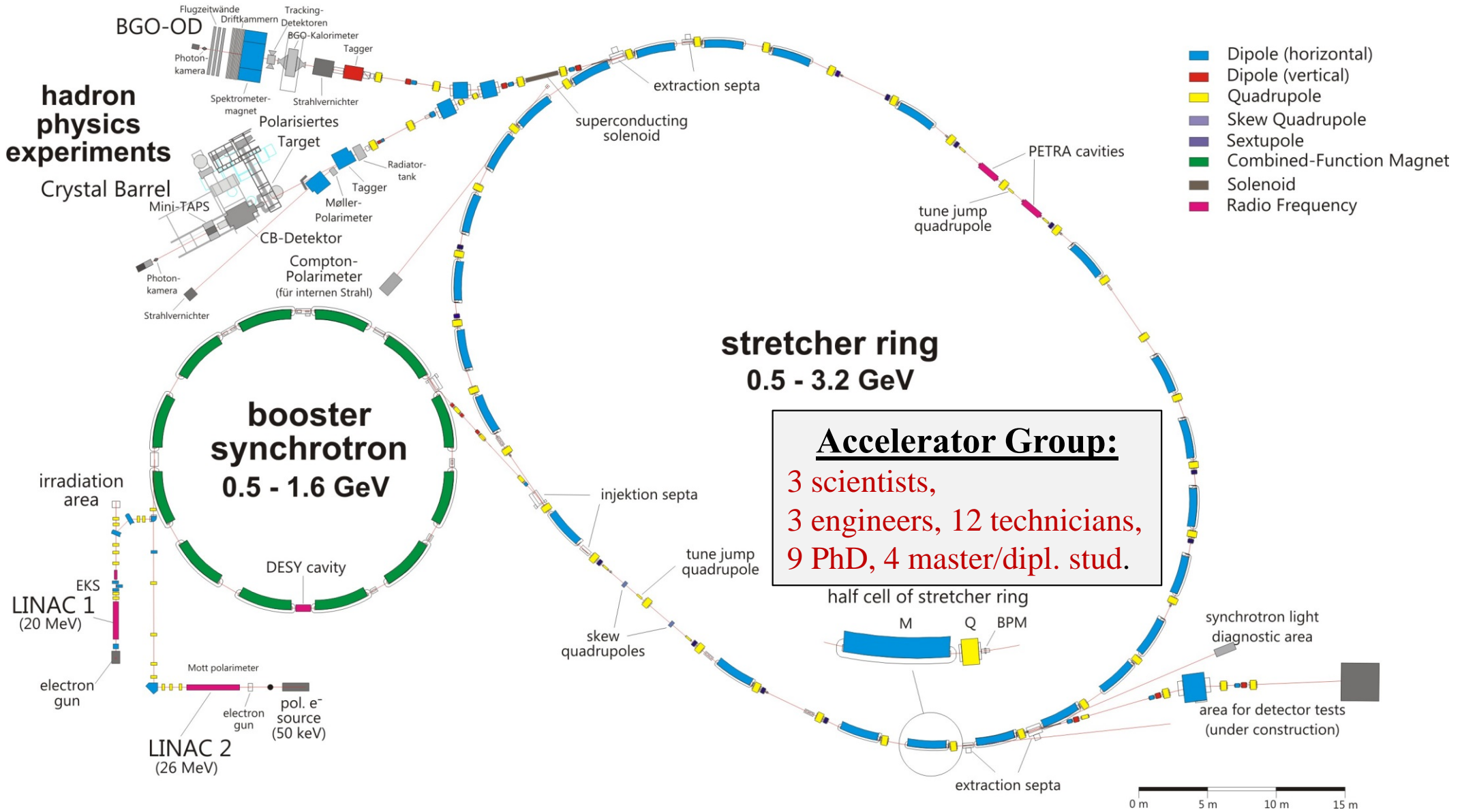


# ELSA @ University of Bonn



# Electron Stretcher Accelerator (ELSA)



**hadron physics experiments**  
Crystal Barrel

**booster synchrotron**  
0.5 - 1.6 GeV

**stretcher ring**  
0.5 - 3.2 GeV

**Accelerator Group:**  
3 scientists,  
3 engineers, 12 technicians,  
9 PhD, 4 master/dipl. stud.

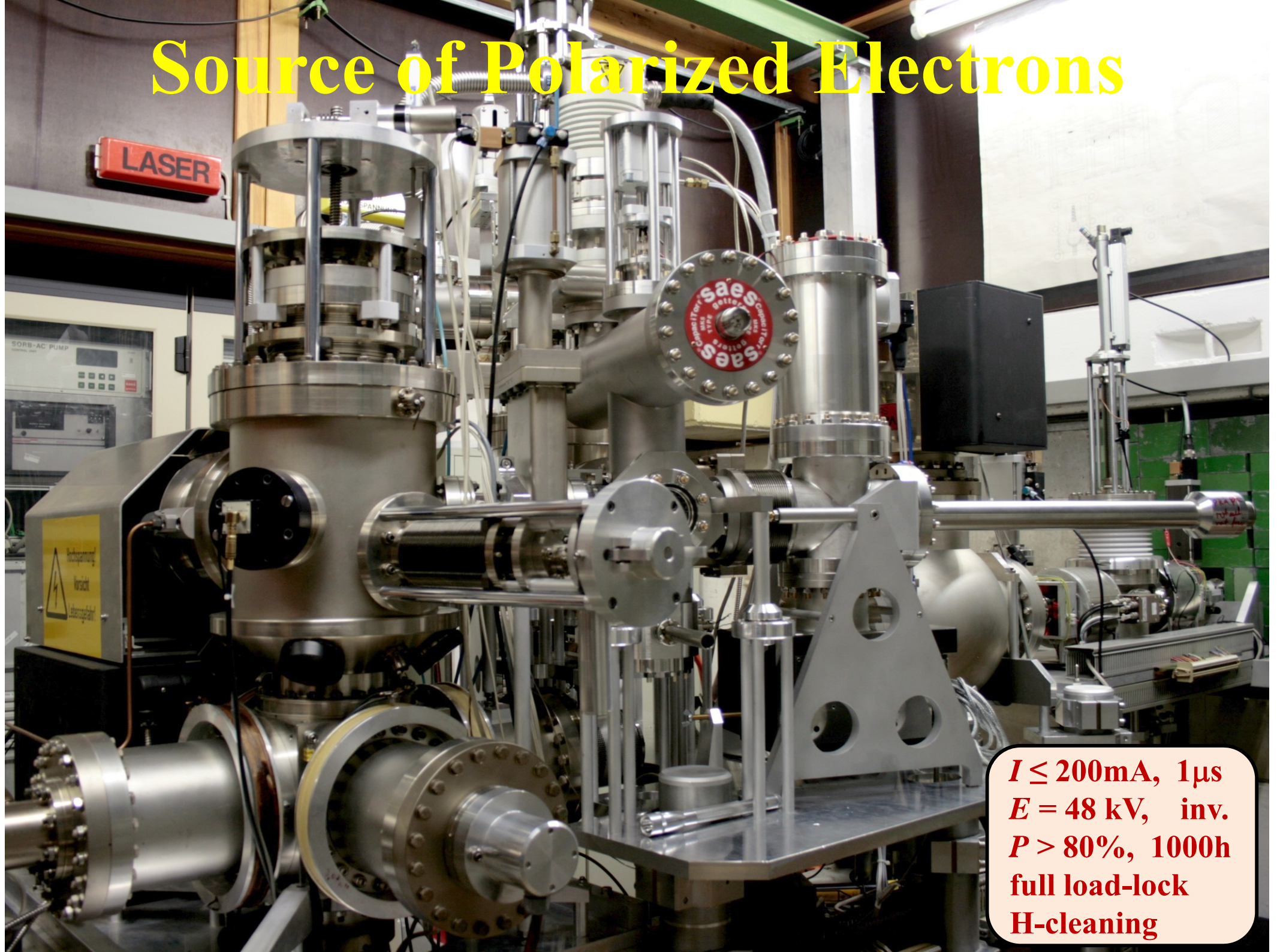
- Dipole (horizontal)
- Dipole (vertical)
- Quadrupole
- Skew Quadrupole
- Sextupole
- Combined-Function Magnet
- Solenoid
- Radio Frequency

0 m 5 m 10 m 15 m

# F&E @ ELSA

- **Polarisierte Elektronen**
  - Quelle und Schleusensystem, Photokathodenpräparation
  - Spindynamik: Exp. und Sim., Resonanzkreuzung: Korrekturverfahren
- **Intensitätserhöhung auf 200mA intern**
  - Injektor-upgrade, neue HF-Anlage, FPG-basierte LLRF-Ansteuerung
  - Instabilitäten: 3D feed-back, Impedanzreduktion, HOM-Dämpfung
- **Einzelpulsbetrieb und –akkumulation**
  - Studium von Instabilitätsmechanismen, geringe Ströme für Teststrahl
- **Teststrahl mit hoher Variabilität**
  - Materialbestrahlung am LINAC mit 20MeV Elektronen
  - Neue Strahlextraktion und Experimentierfläche für Detektor-Tests
- **Strahldiagnose**
  - Lage- und Intensitätsmessungen im pA-Strombereich
  - Strahlprofilmessungen mit ps-Zeitauflösung
  - Polarimetrie

# Source of Polarized Electrons

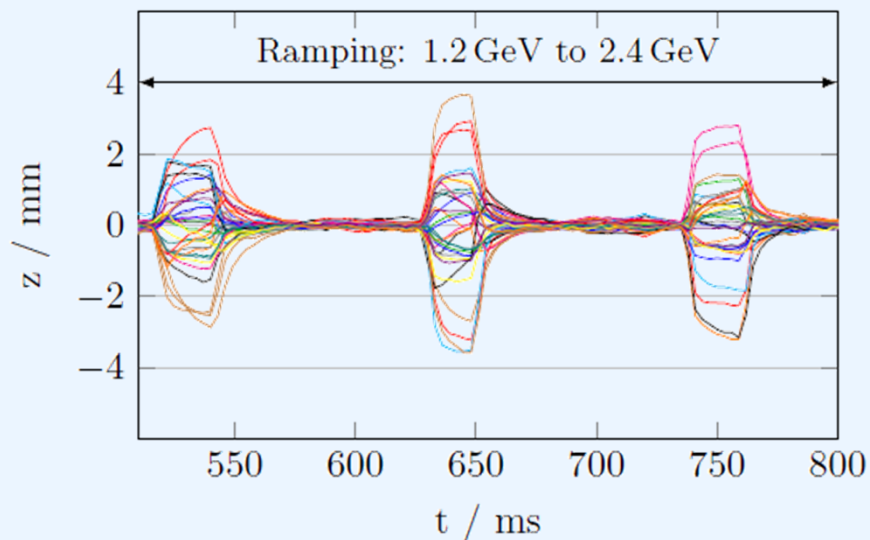
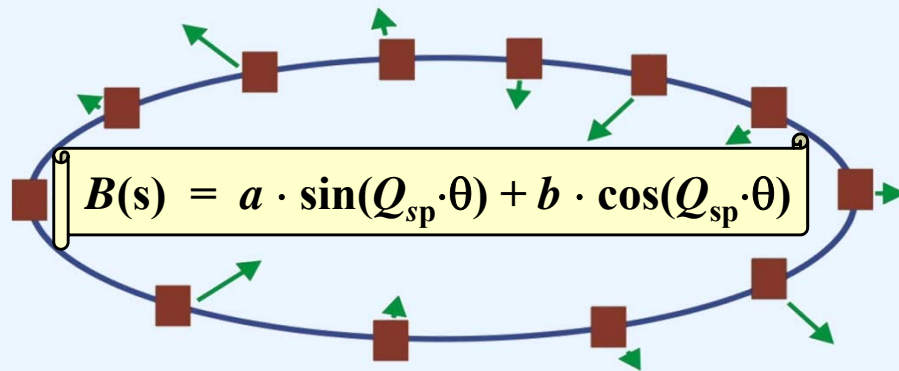


$I \leq 200\text{mA}$ ,  $1\mu\text{s}$   
 $E = 48\text{ kV}$ , inv.  
 $P > 80\%$ , 1000h  
full load-lock  
H-cleaning

# Acc. of Polarized Electrons

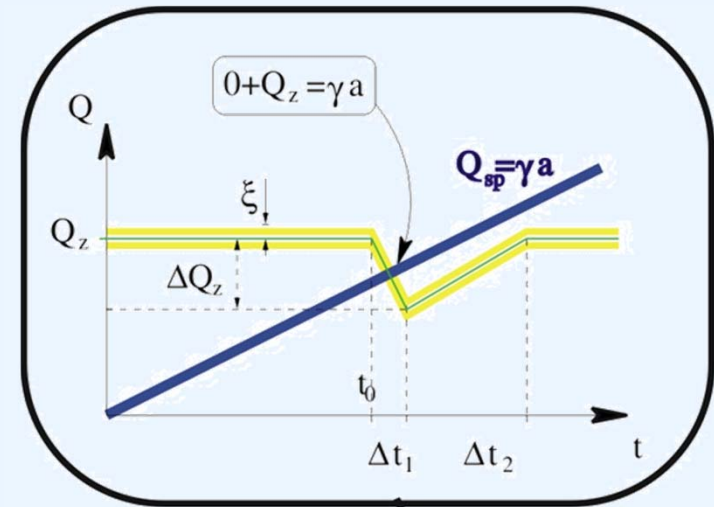
## Integer Resonances: $\gamma a = n$

- precise CO correction
- harmonic correction



## Intr. Resonances: $\gamma a = nP \pm Q_z$

- small vertical beam size
- tune jumping with pulsed quads

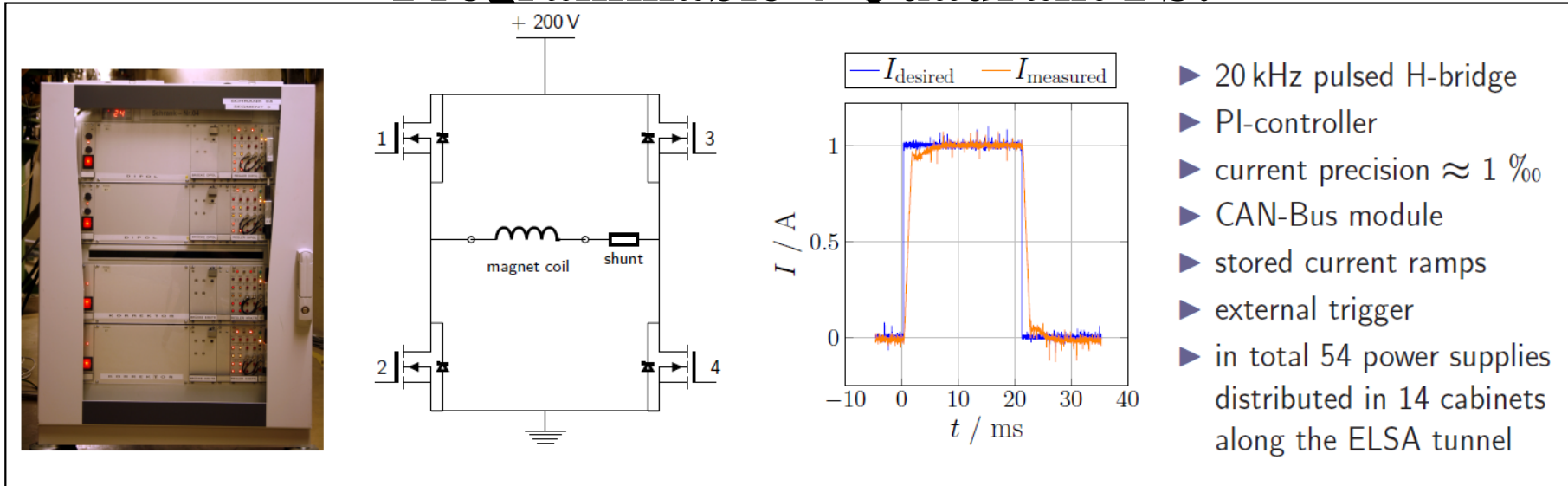


Tune Jump Quadrupole

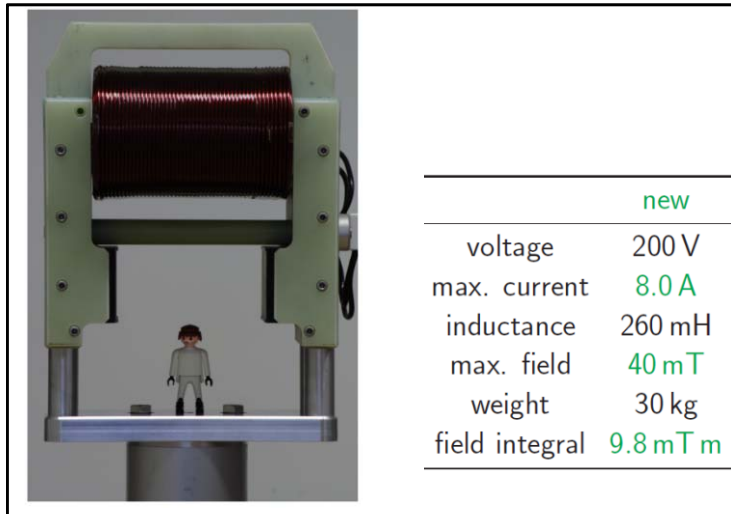


# Fast Steerer System

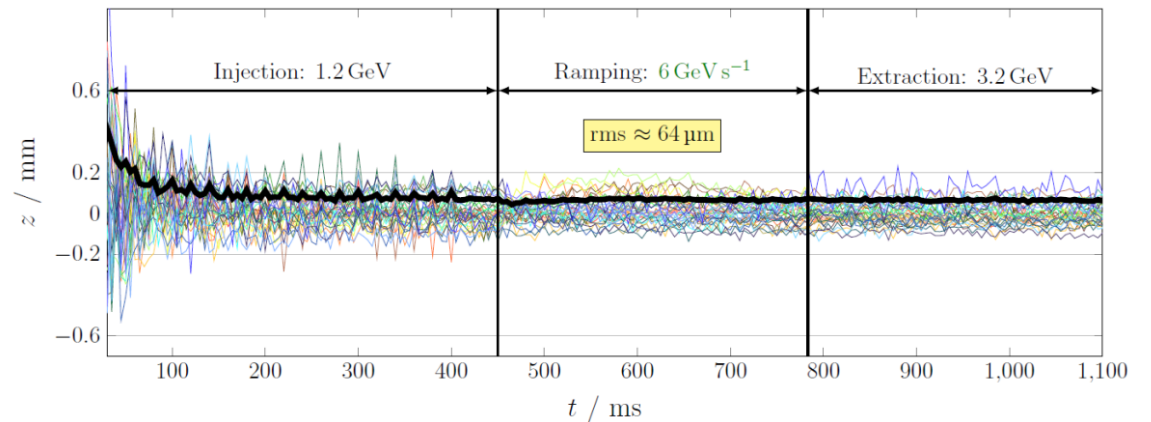
## Programmable 4-Quadrant PS:



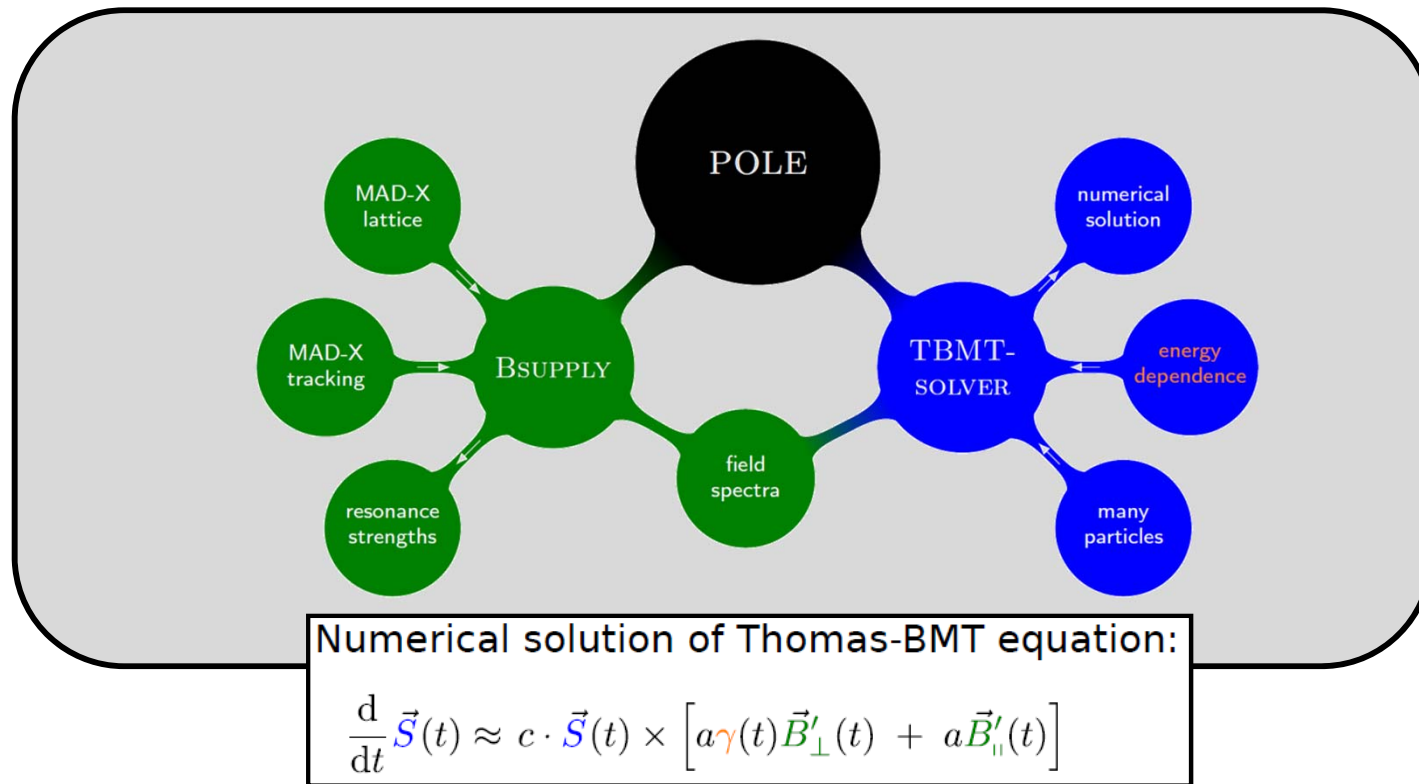
## Correction Coils:



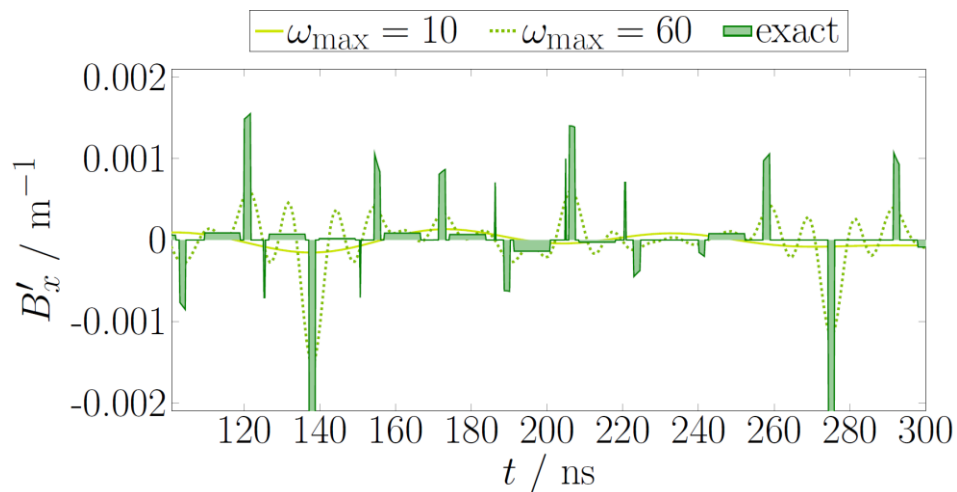
$$\dot{I} = 400 \text{ A/sec} \leftrightarrow \dot{B} = 2 \text{ Tesla/sec}$$



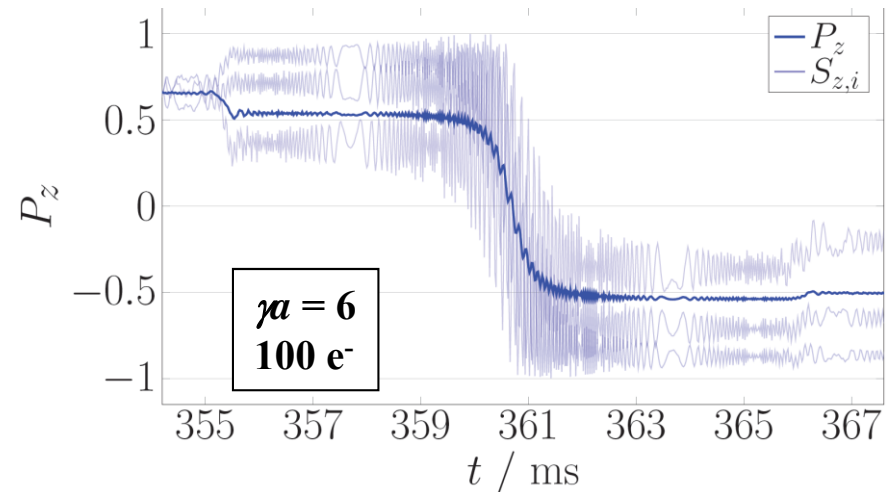
# Simulation of Spin Dynamics



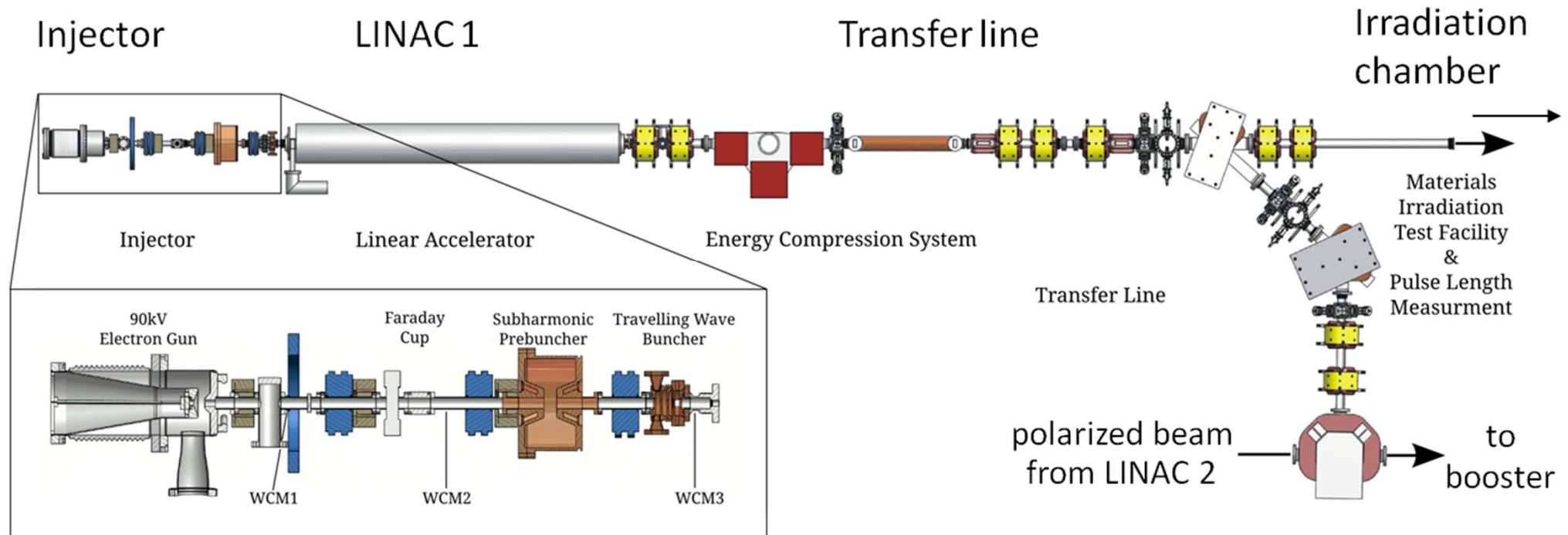
**B-field as (filtered) Fourier series:**



**Resonance crossing:**



# High Current Single Bunch Injector



## Thermionic Gun:

- $U = 90 \text{ kV}$
- $I = 800 \text{ mA (1-2}\mu\text{s)} / 2 \text{ A (1ns)}$

## Bunching:

- 500 MHz prebuncher
- 3 GHz TW buncher (4 cells)

## LINAC:

- 20 MV 3GHz TW structure (constant gradient)
- ongoing overhaul of modulator and waveguides

## Energy Compression System:

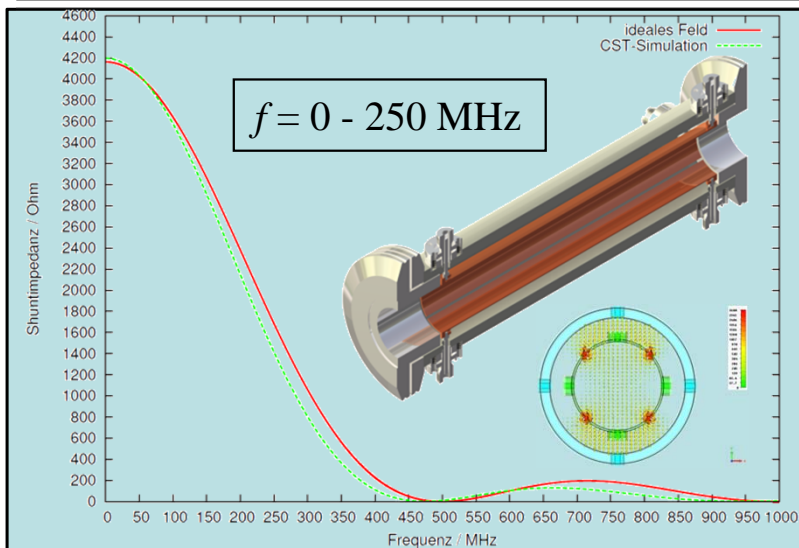
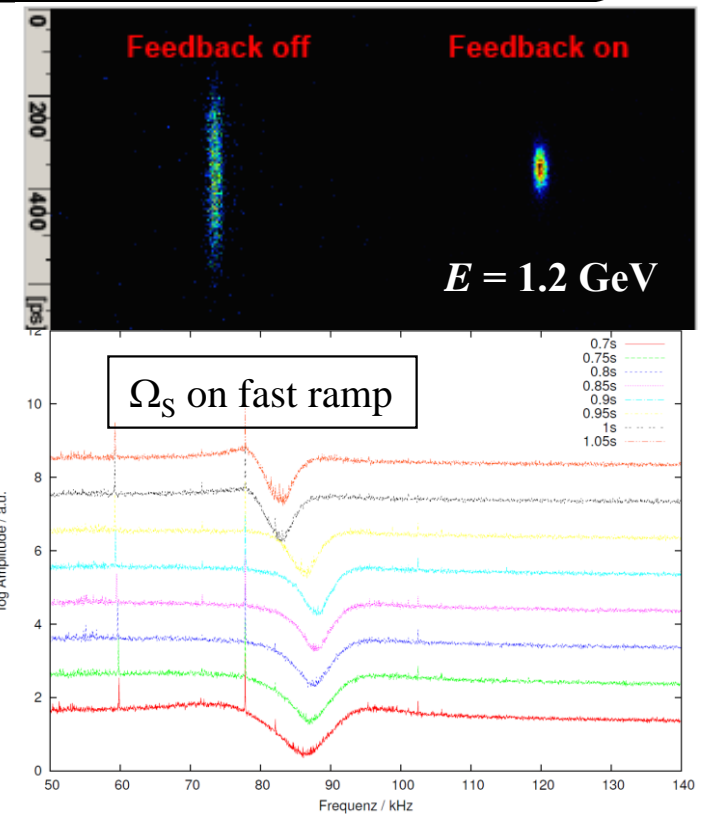
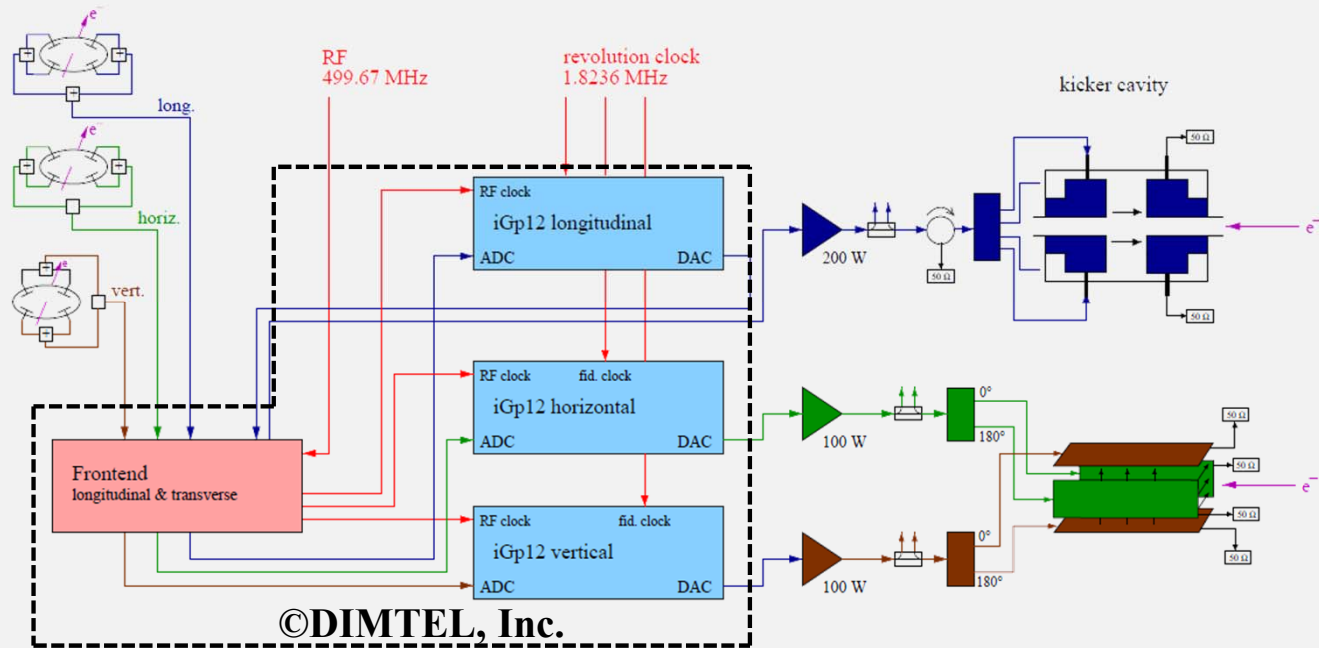
- 3-bend magnetic chicane
- 3GHz TW structure

Coming 2014

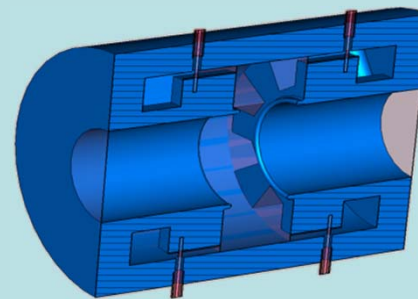


# 3D Bunch by Bunch Feed-Back in a fast ramping machine

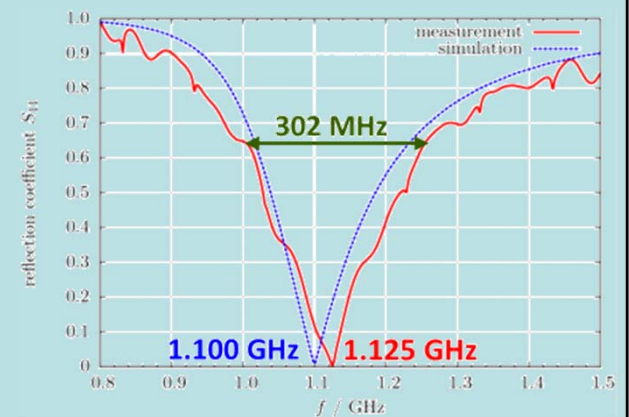
## System Layout:



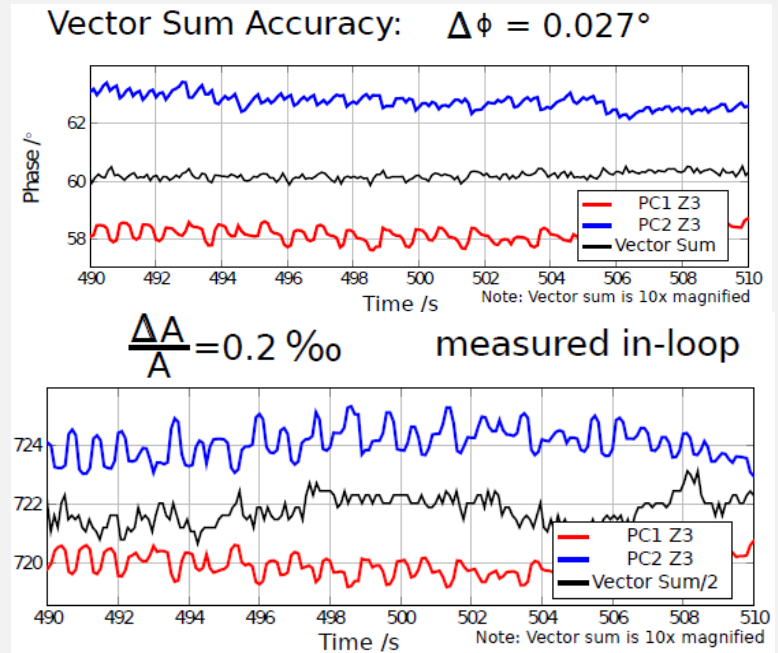
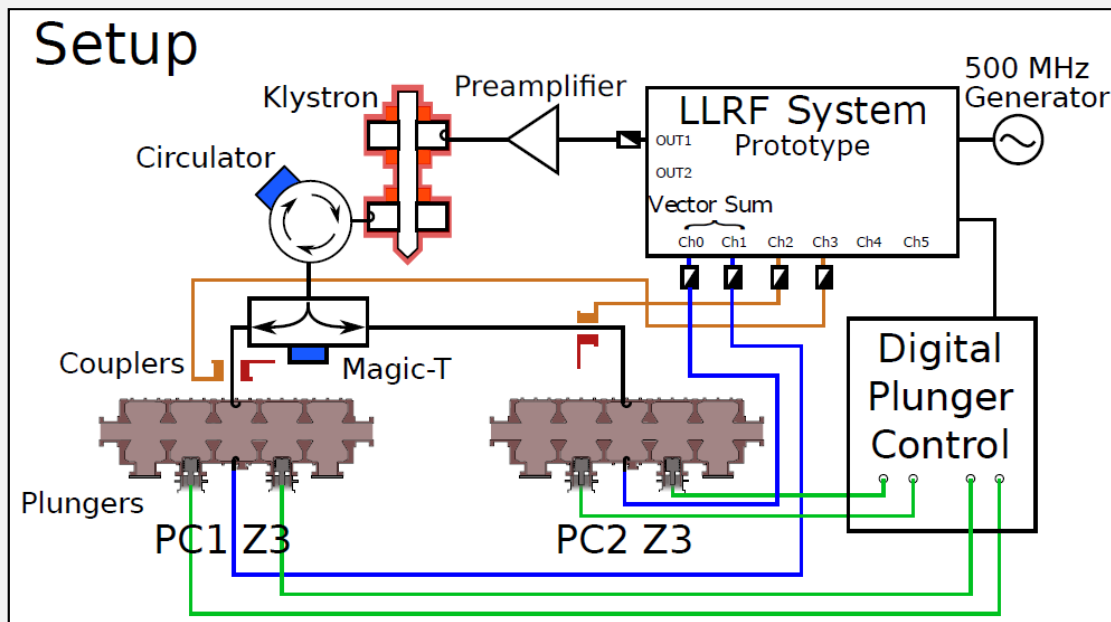
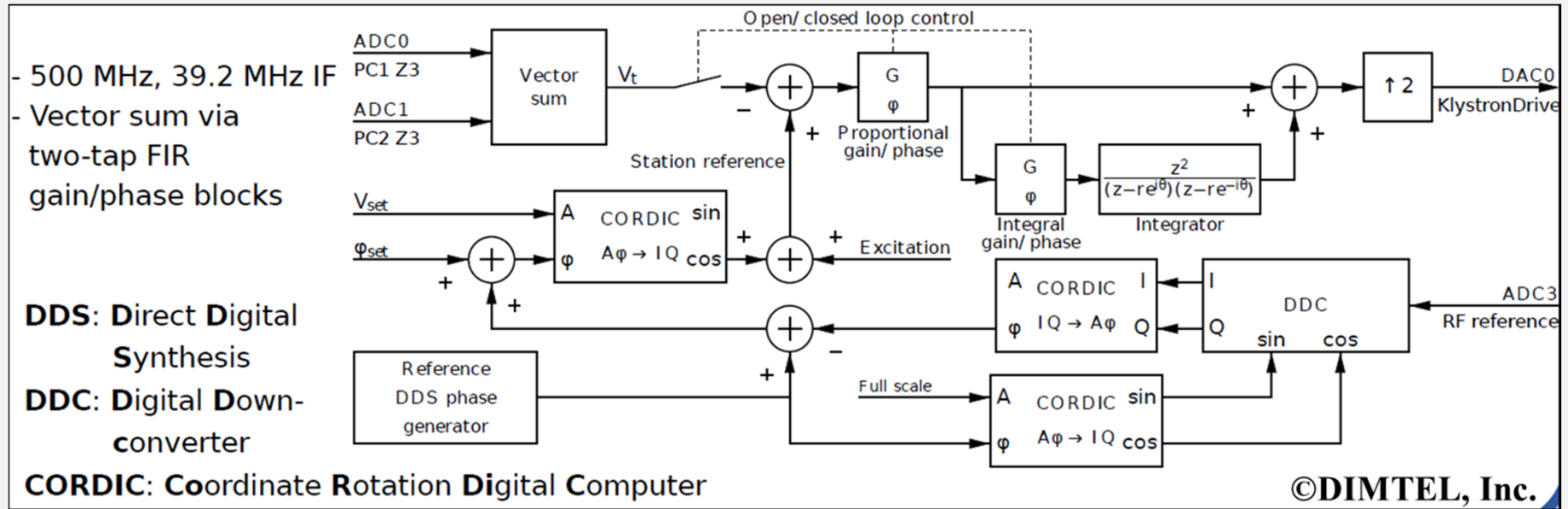
## Simulation with CST Microwave Studio & In-house fabrication



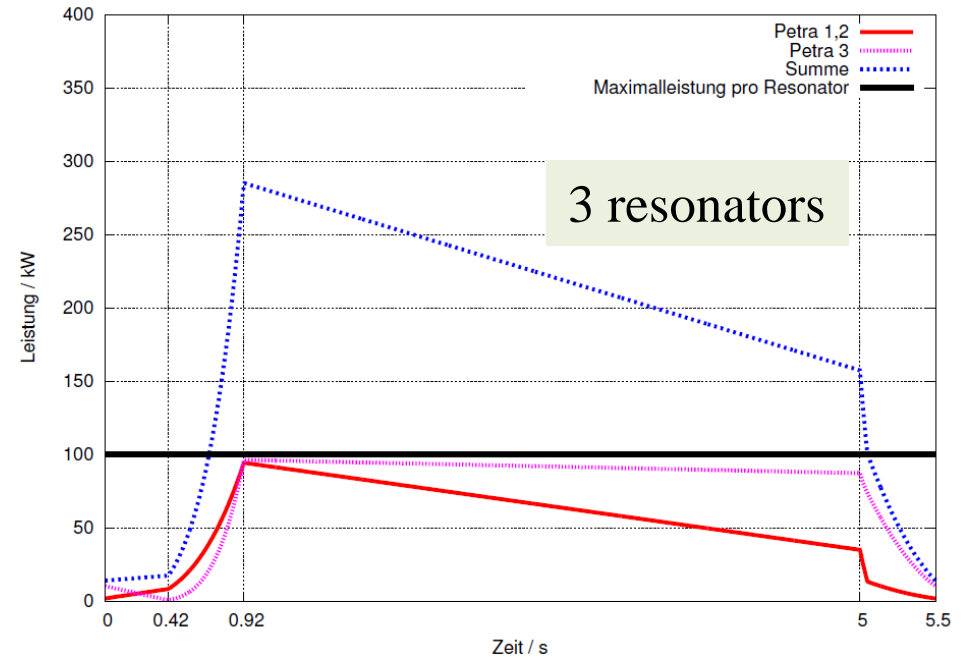
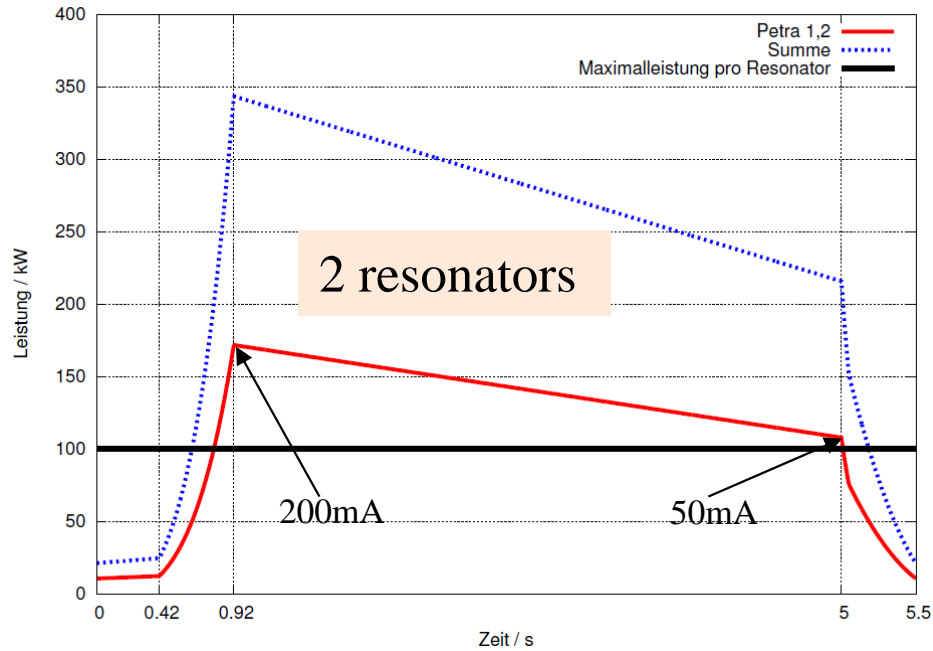
$$f = 1125 \pm 150 \text{ MHz}$$



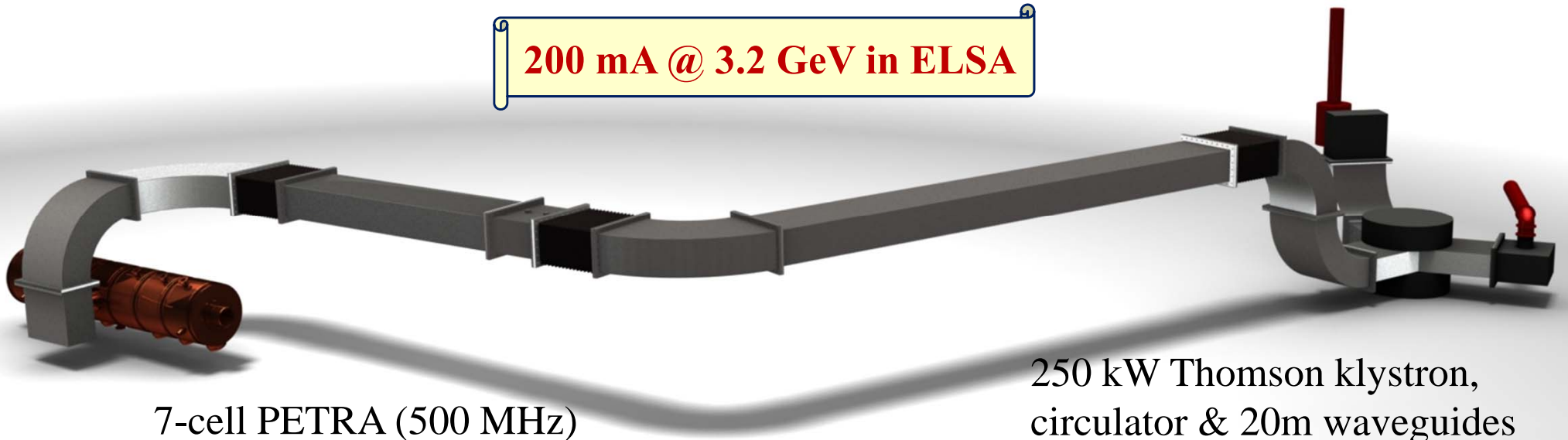
# RF Control & Stabilization



# New RF System



**200 mA @ 3.2 GeV in ELSA**



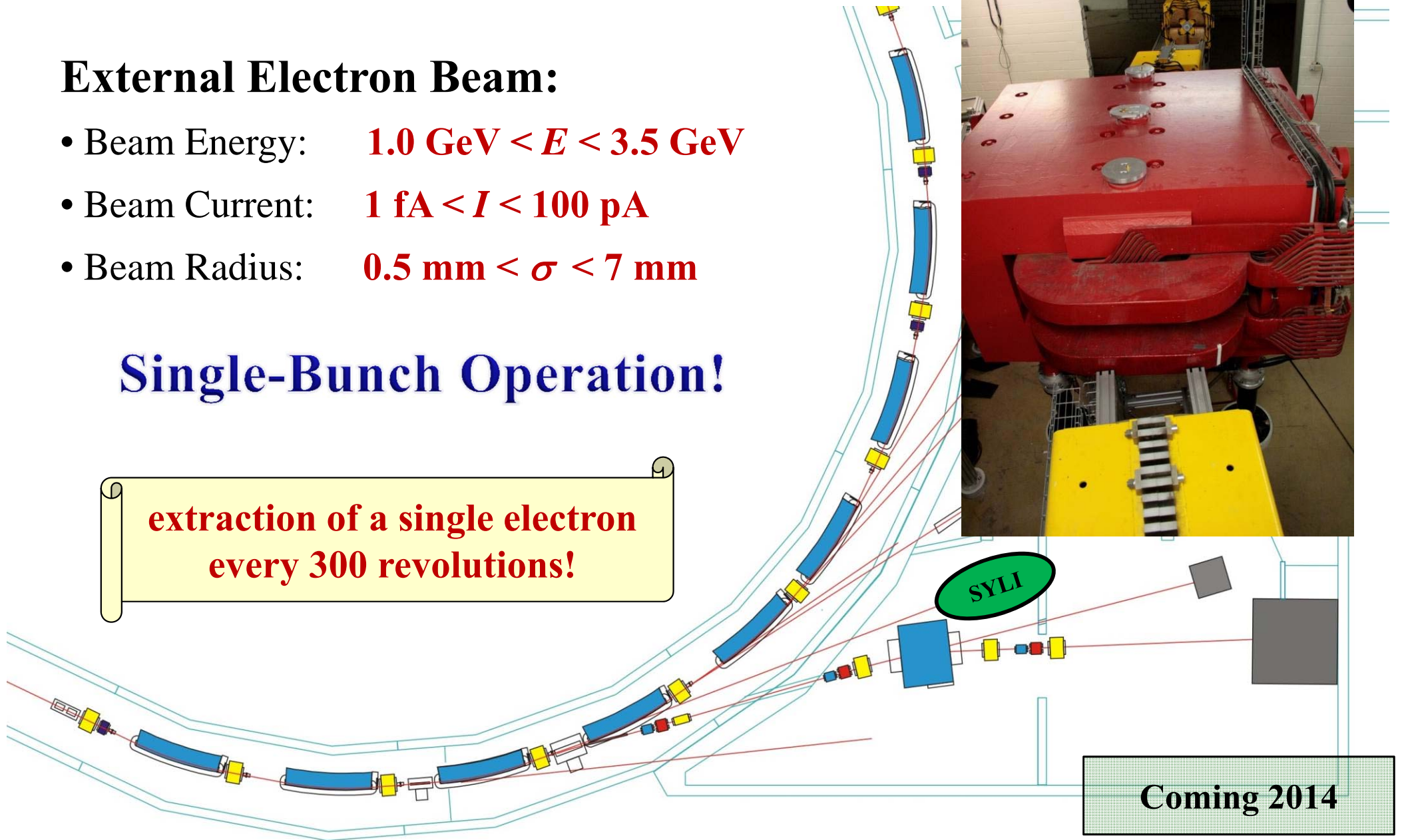
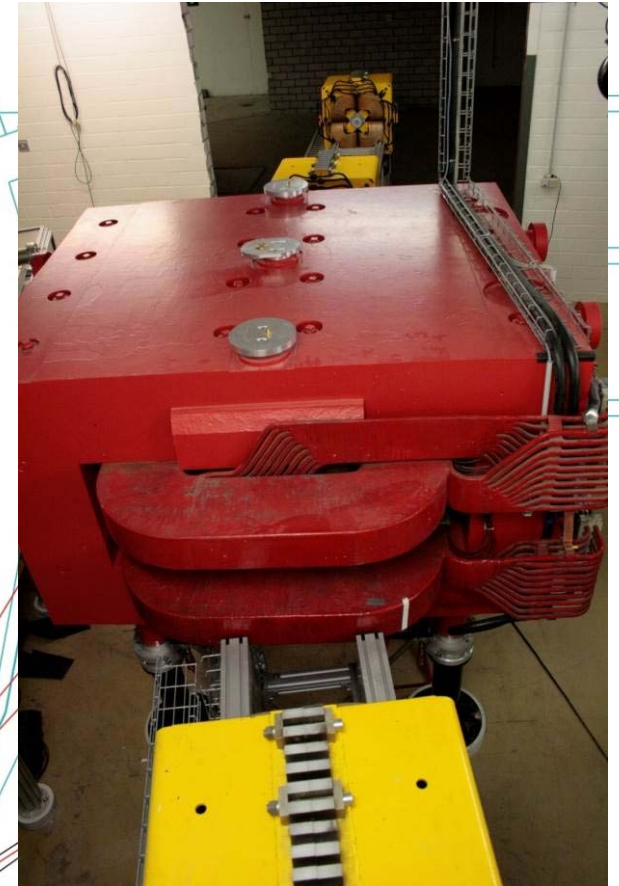
# New Area for Detector Testing

## External Electron Beam:

- Beam Energy:  $1.0 \text{ GeV} < E < 3.5 \text{ GeV}$
- Beam Current:  $1 \text{ fA} < I < 100 \text{ pA}$
- Beam Radius:  $0.5 \text{ mm} < \sigma < 7 \text{ mm}$

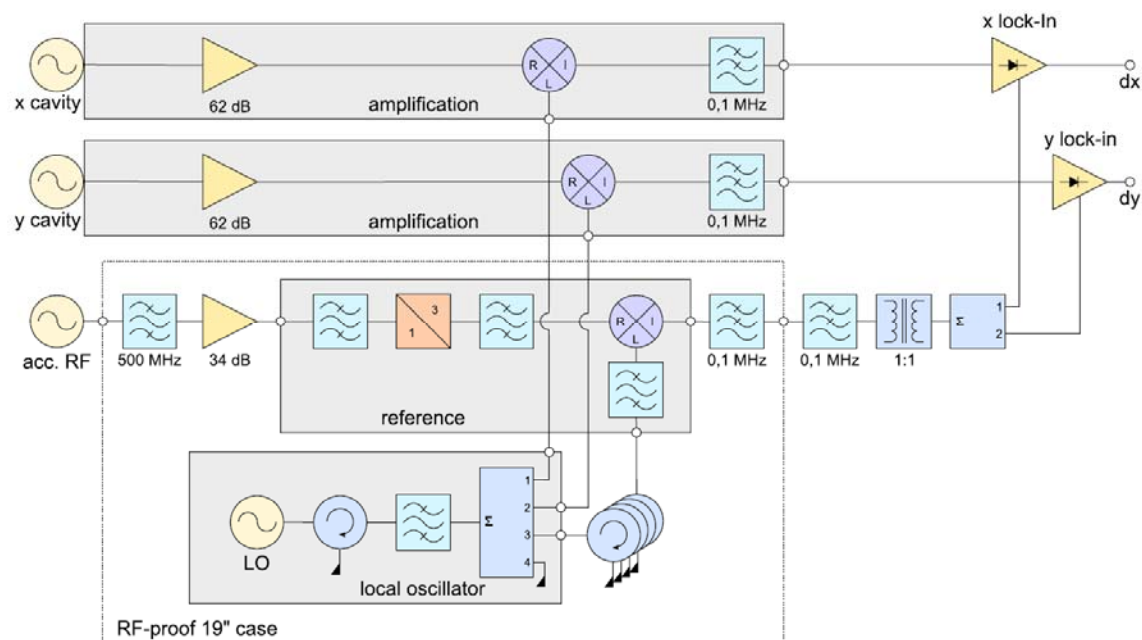
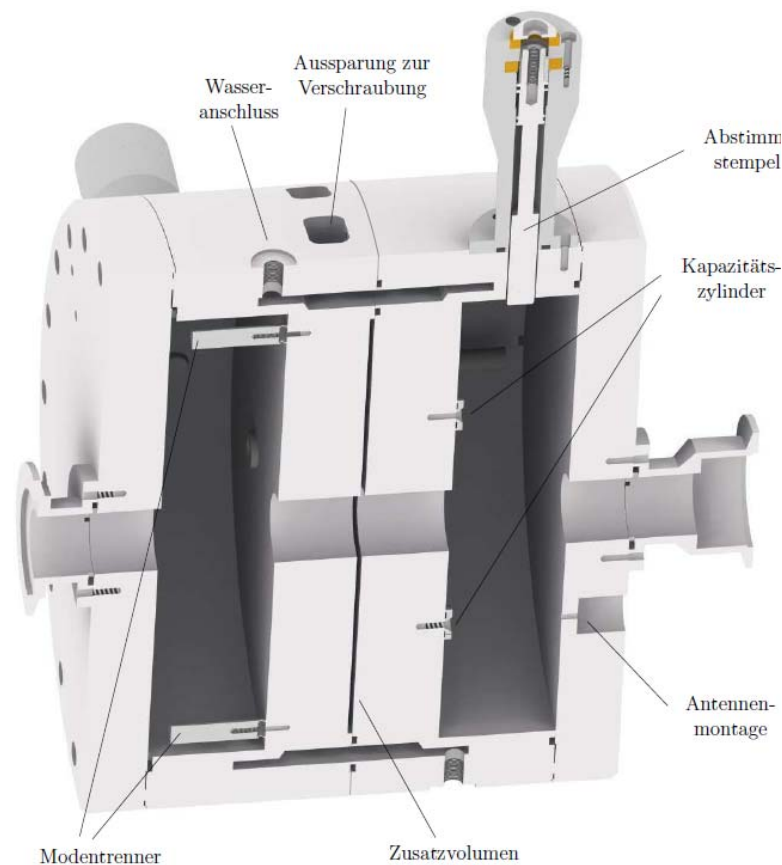
## Single-Bunch Operation!

extraction of a single electron  
every 300 revolutions!

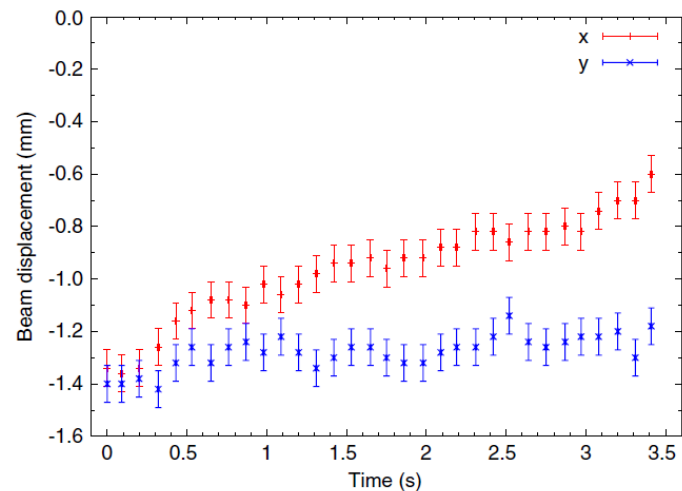


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# RF-based position measurement @ low beam currents

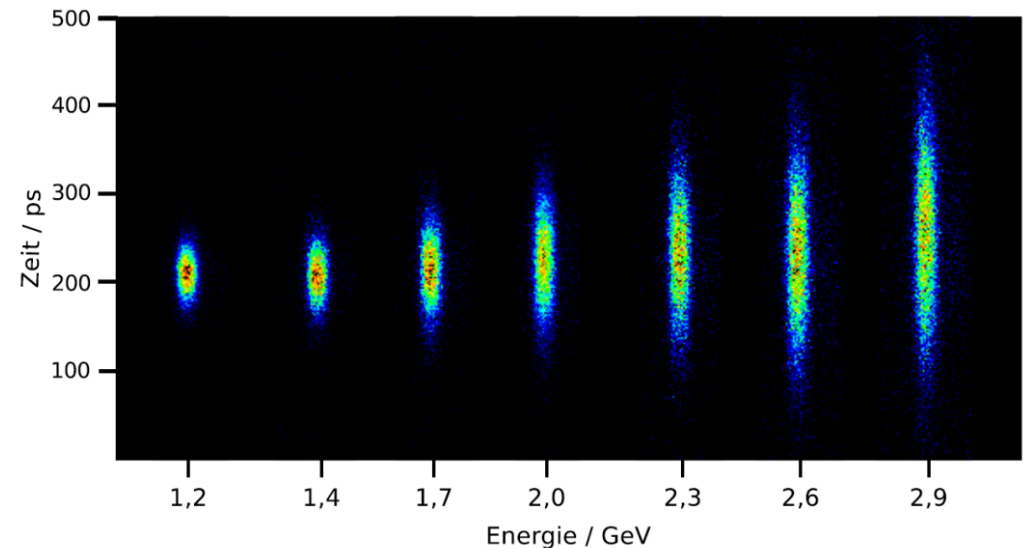
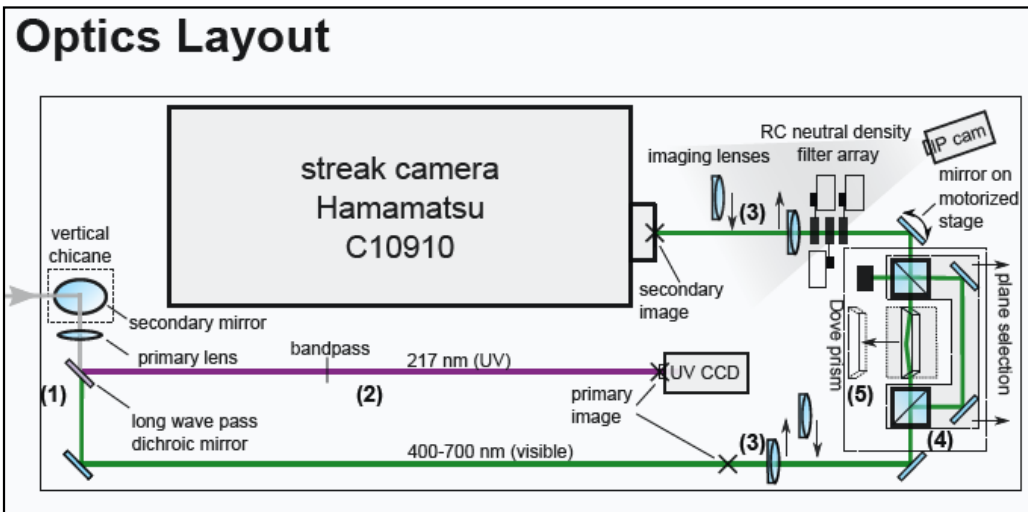
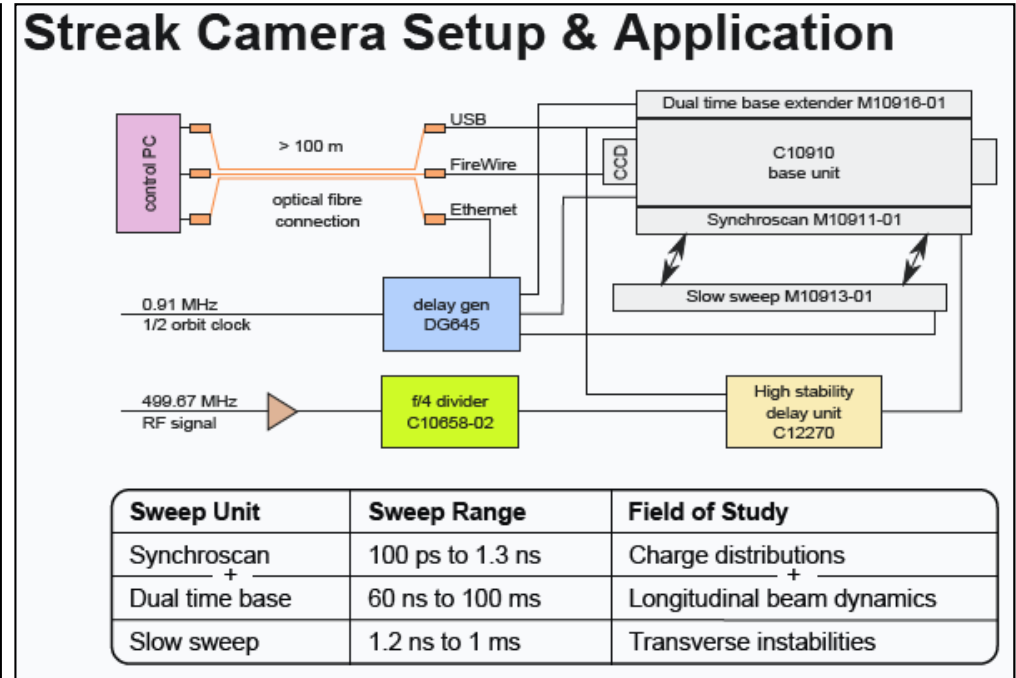
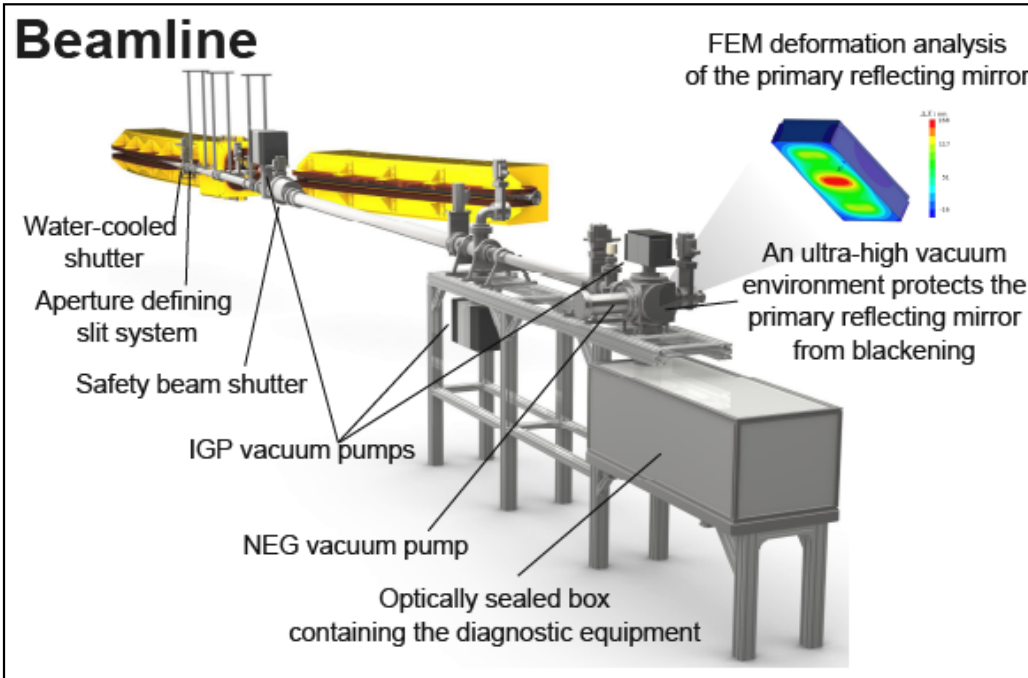


$\Delta x < 50\mu\text{m} @ I = 100 \text{ pA}, dx = 1\text{mm}$



Parameter	Value
Mode	TM <sub>110</sub>
Inner diameter	242 mm
Inner length	52 mm
Opening diameter	34 mm
Resonant frequency $\nu_0$	1.499010 GHz
Shunt impedance $R_s/\Delta x^2$ (CST)	411 $\Omega/\text{mm}^2$
Unloaded quality factor $Q_0$	11090
Coupling factor $\kappa$	0.89

# ps Diagnosis: Streak Camera

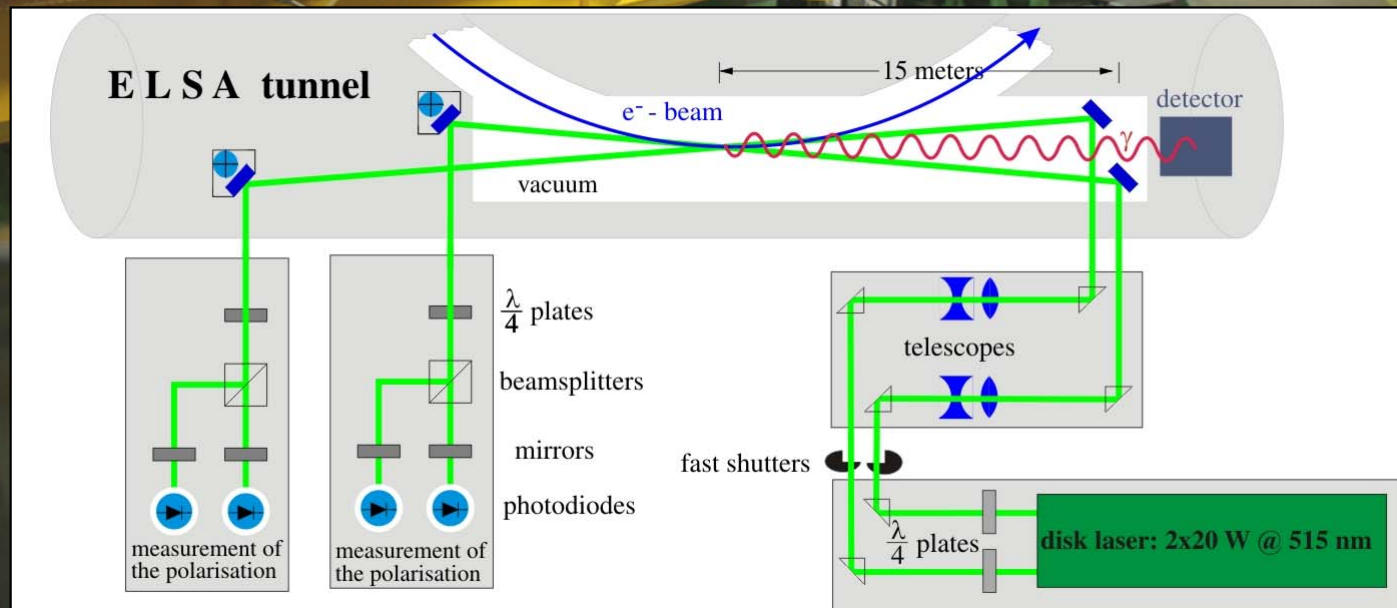


# Compton Polarimeter

Coming 2014

M24

Si microstrip detector  
768 channels, 50  $\mu\text{m}$  pitch



# Expertise at ELSA/Uni Bonn

## **Operation of electron linacs and circular accelerators**

*(incl. repair and construction of PS's, RF, cabinets, protection, ...)*

## **Special knowledge in the fields:**

- polarized electrons (photo-injector, spin dynamics)
- beam dynamics (instabilities, slow extraction)
- beam control (CO correction, tune jumping, slow extraction, feed-back)
- beam diagnosis (optical, RF-based, etc.)
- accelerator control systems

## **Development and construction of accelerator components:**

- XHV systems, thin SS beam pipes, monitors, steerers, PS, ...
- RF resonators ( $TM_{01}$ ,  $TM_{11}$ , kicker cavity)
- ferrite based magnets (tune kicker, tune jump quadrupoles,...)
- ...