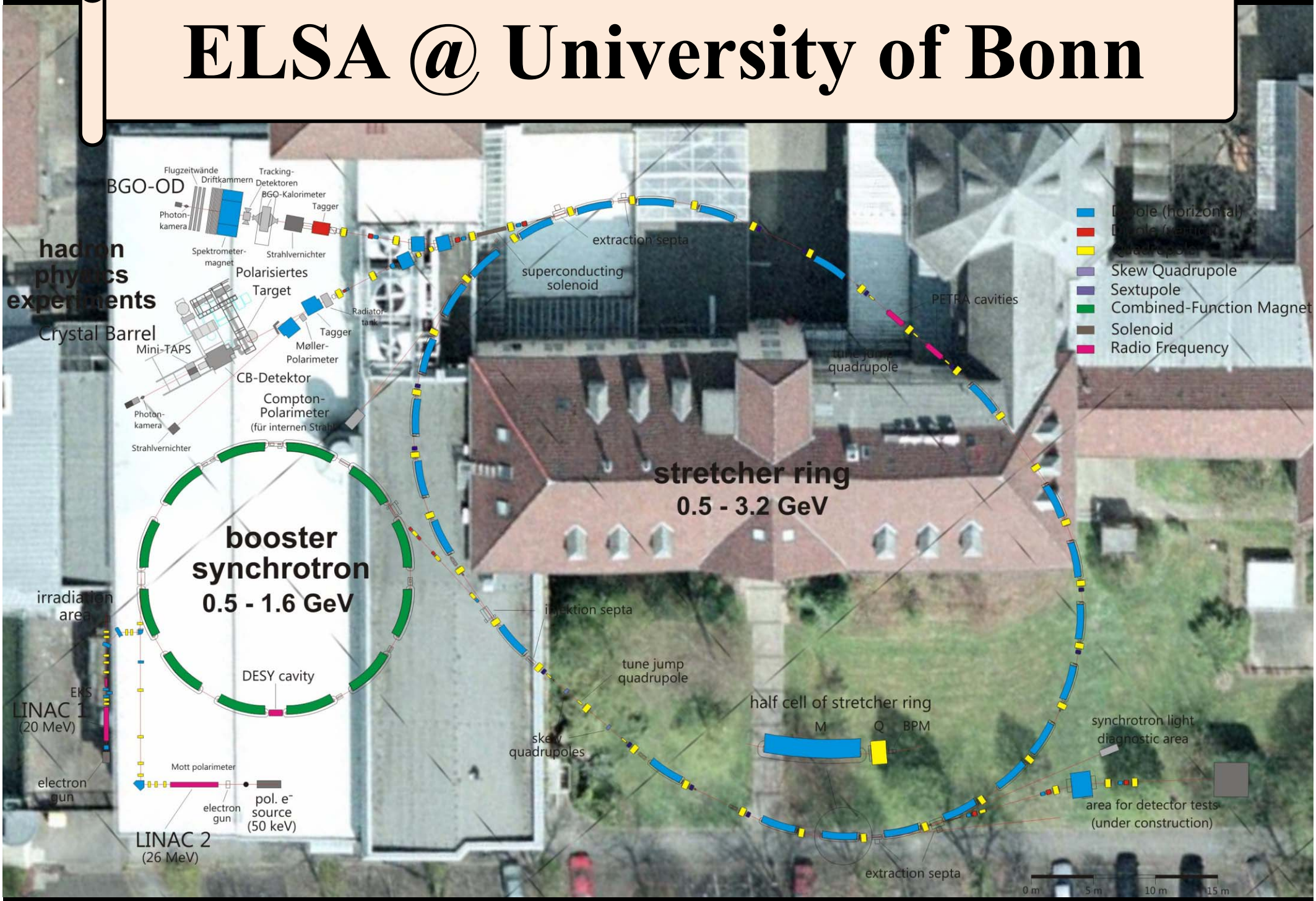
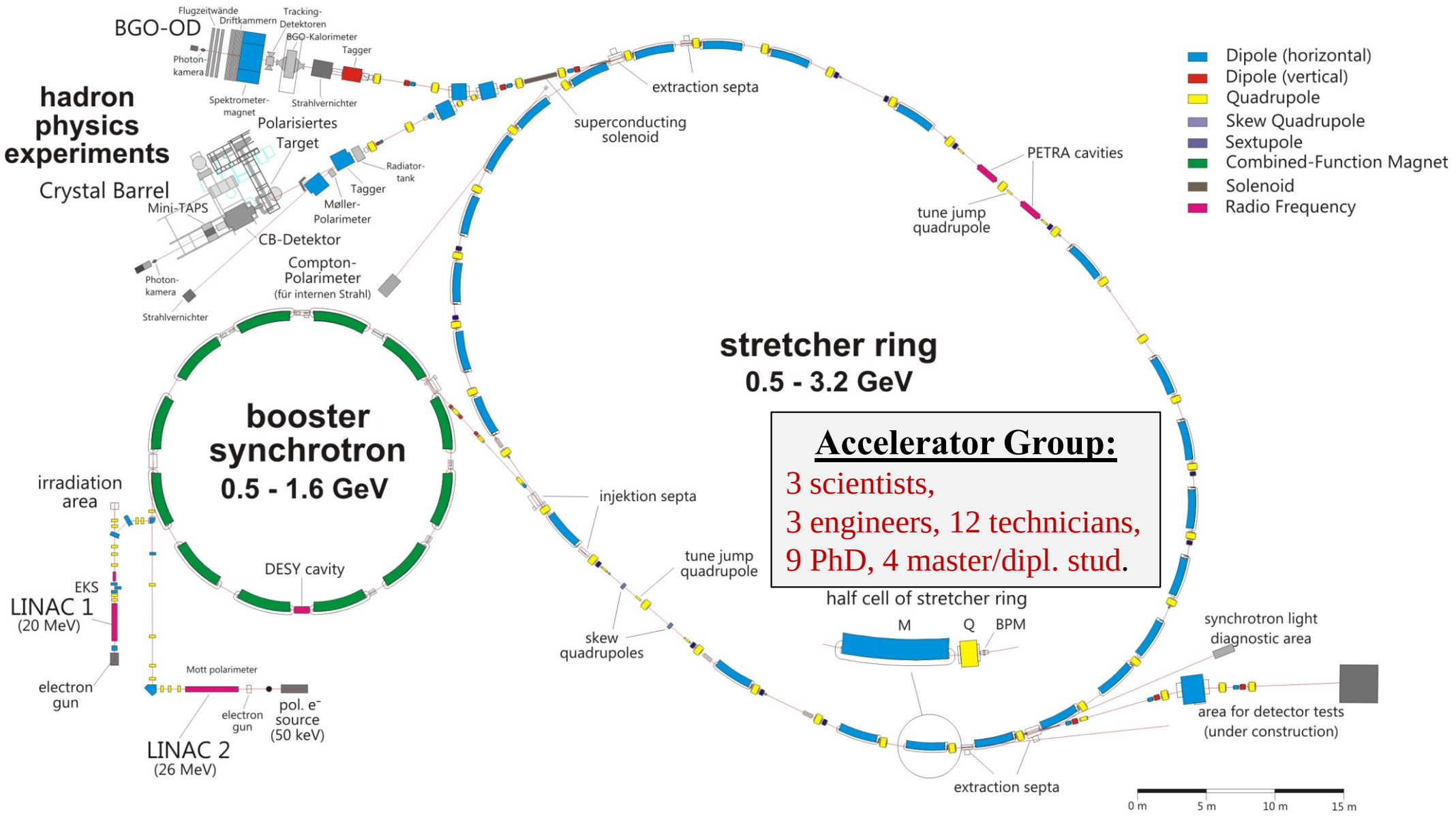
ELSA @ University of Bonn



Electron Stretcher Accelerator (ELSA)



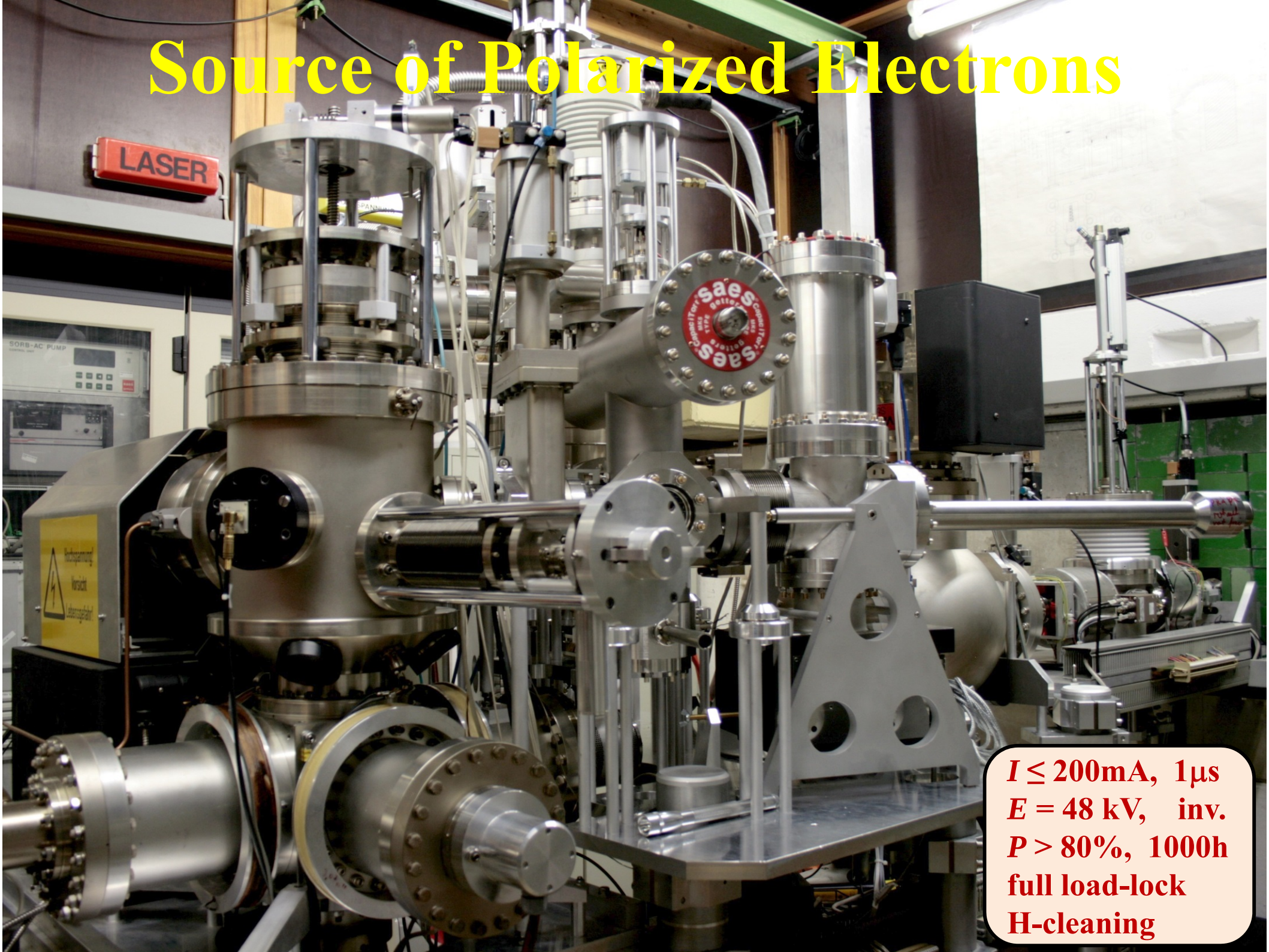
Accelerator Group:

3 scientists,
3 engineers, 12 technicians,
9 PhD, 4 master/dipl. stud.

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

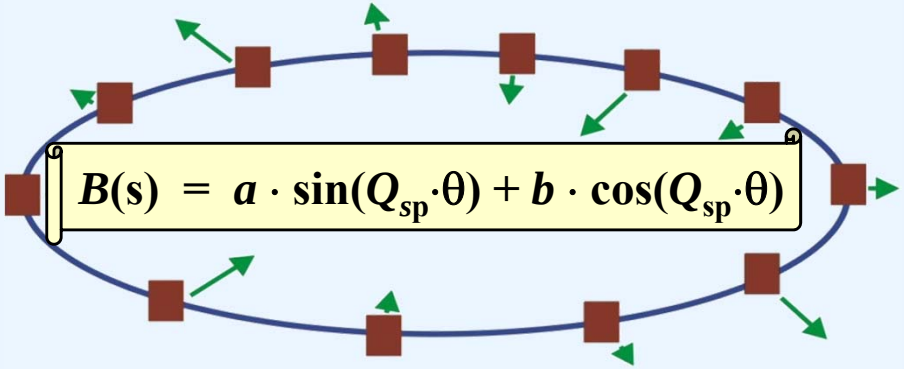


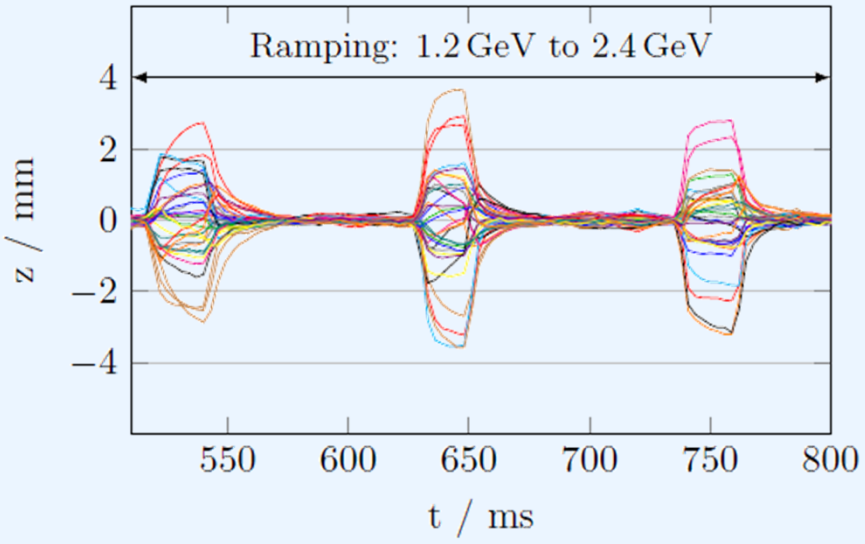
$I \leq 200$mA, 1μs
$E = 48$ kV, inv.
$P > 80\%$, 1000h
full load-lock
H-cleaning

Acc. of Polarized Electrons

Integer Resonances: $\gamma a = n$

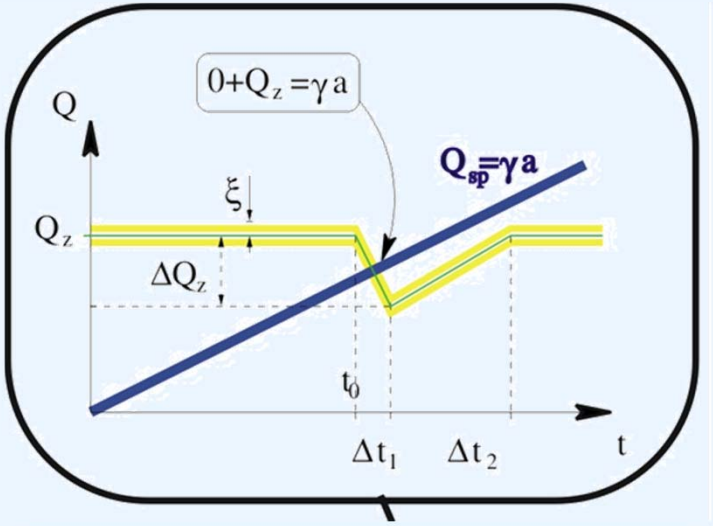
- precise CO correction
- harmonic correction





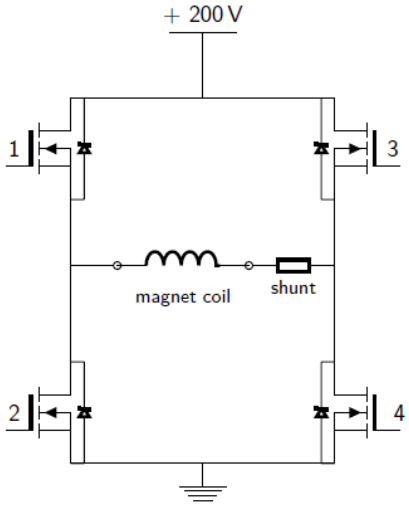
Intr. Resonances: $\gamma a = nP \pm Q_z$

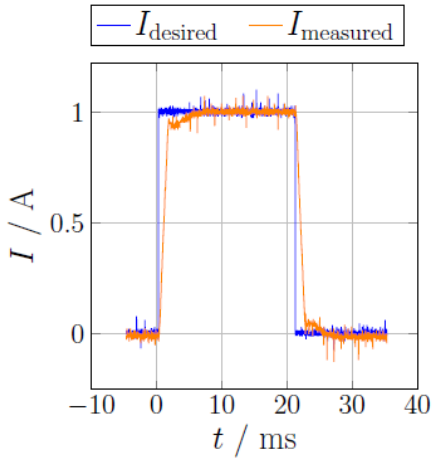
- small vertical beam size
- tune jumping with pulsed quads



Fast Steerer System

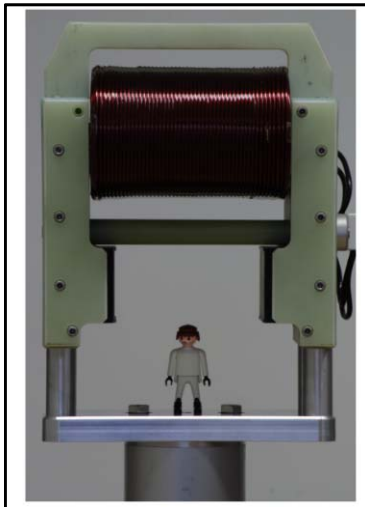
Programmable 4-Quadrant PS:





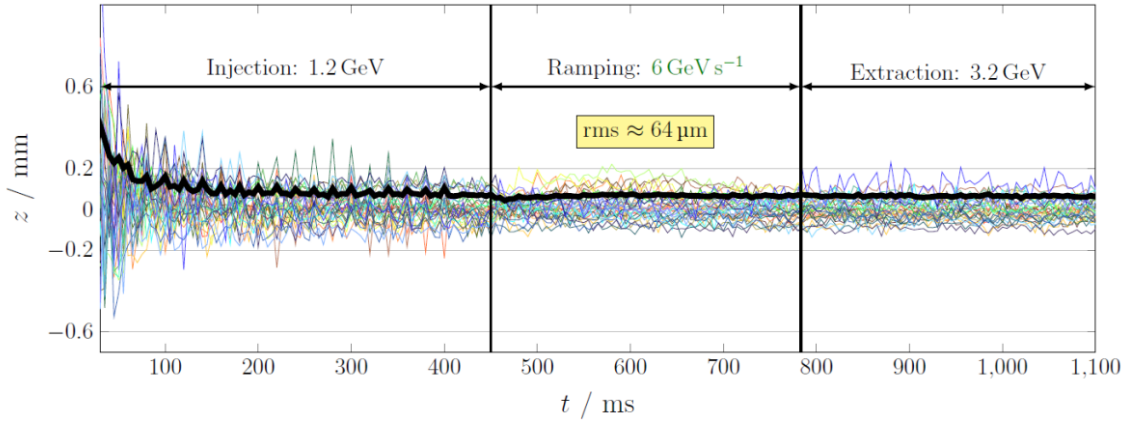
- 20 kHz pulsed H-bridge
- PI-controller
- current precision ≈ 1 ‰
- CAN-Bus module
- stored current ramps
- external trigger
- in total 54 power supplies distributed in 14 cabinets along the ELSA tunnel

Correction Coils:

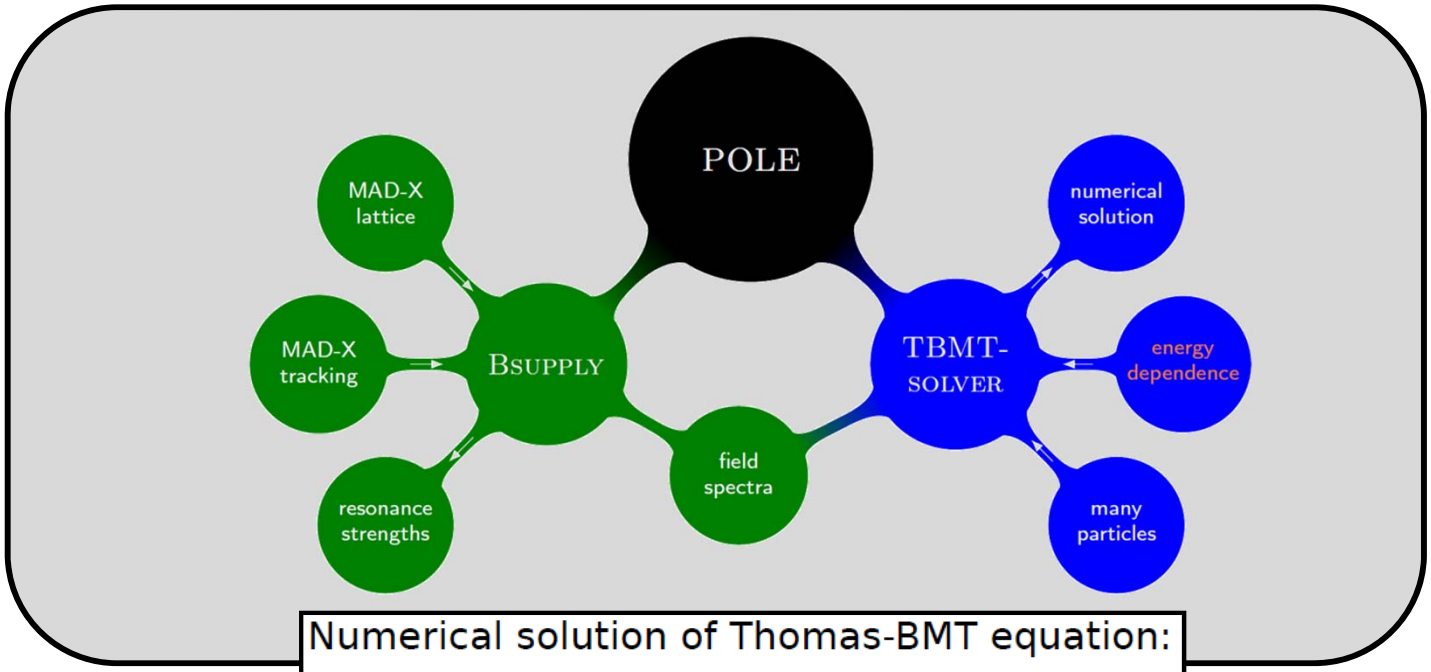


	new
voltage	200 V
max. current	8.0 A
inductance	260 mH
max. field	40 mT
weight	30 kg
field integral	9.8 mT m

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



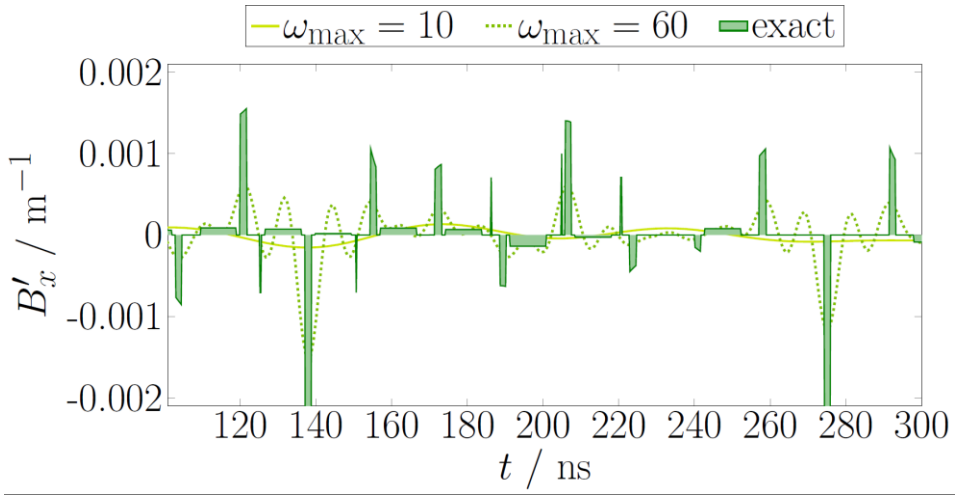
Simulation of Spin Dynamics



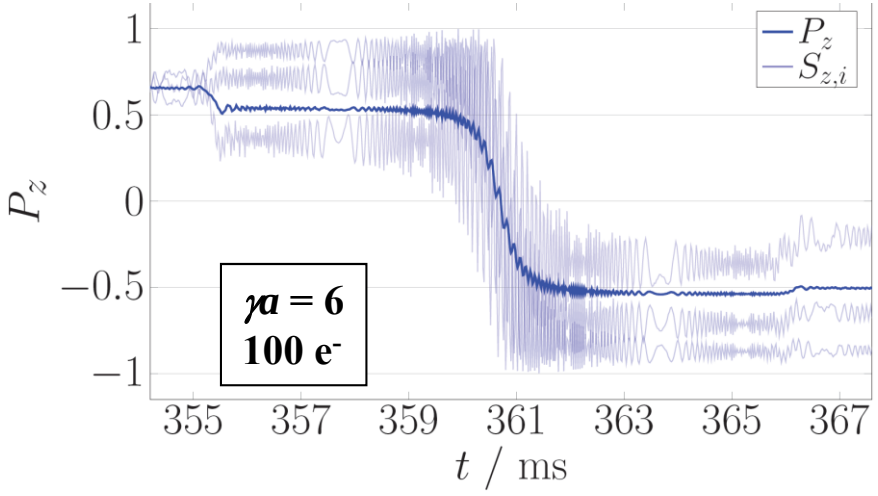
Numerical solution of Thomas-BMT equation:

$$\frac{\mathrm{d}}{\mathrm{d}t}\vec{S}(t) \approx c \cdot \vec{S}(t) \times \left[a\gamma(t)\vec{B}'_{\perp}(t) + a\vec{B}'_{\parallel}(t)\right]$$

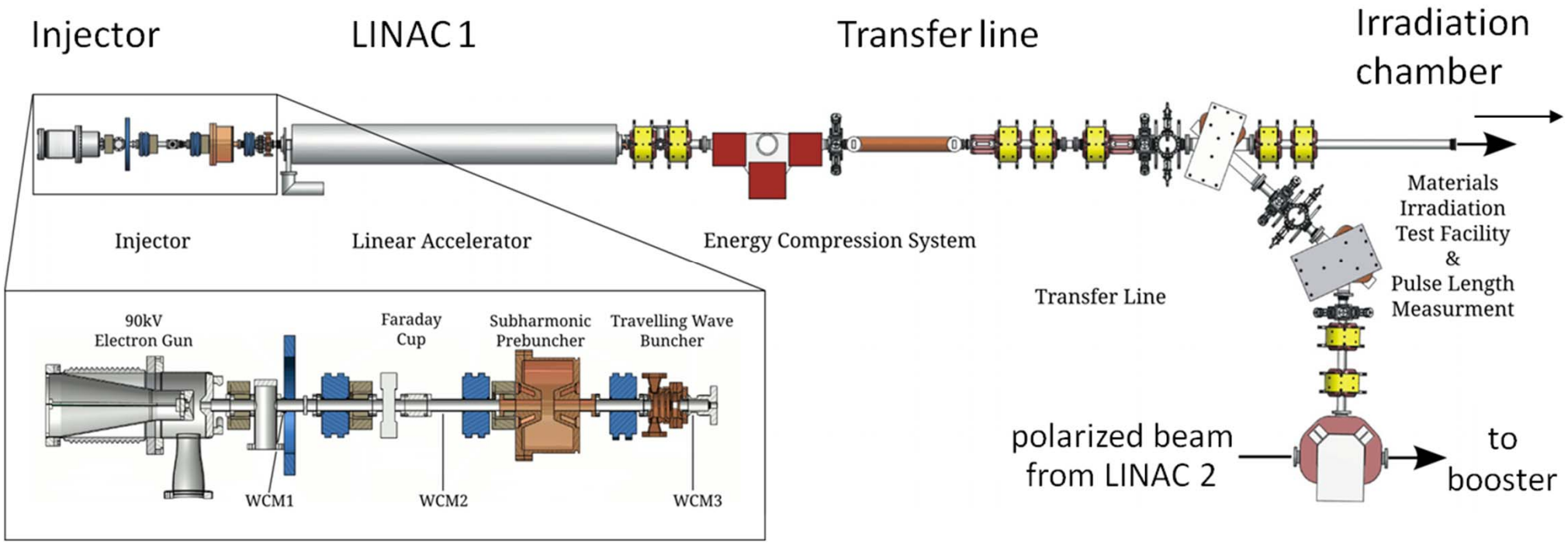
B-field as (filtered) Fourier series:



Resonance crossing:



High Current Single Bunch Injector



Thermionic Gun:

- U = 90 kV
- I = 800 mA (1-2μs) / 2 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

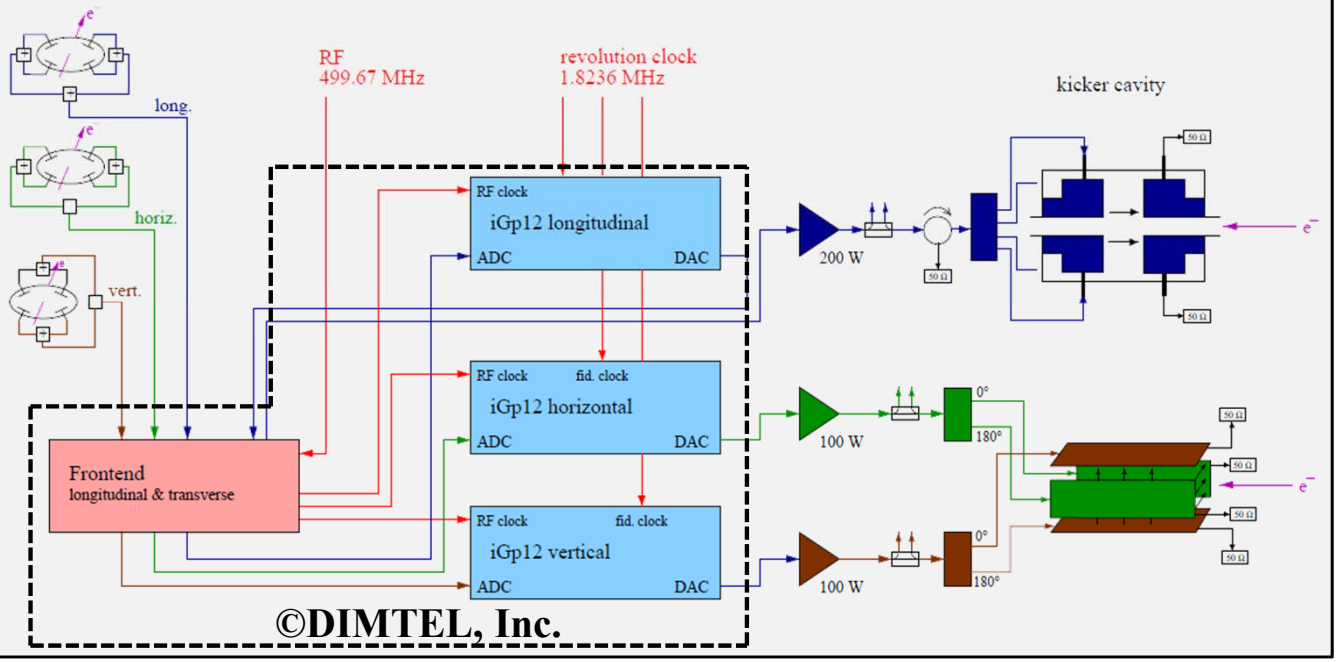
Energy Compression System:

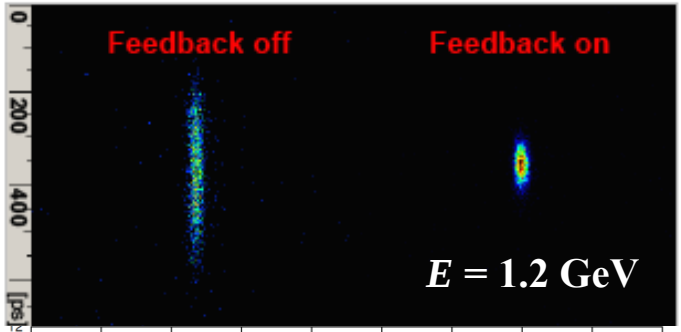
- 3-bend magnetic chicane
- 3GHz TW structure

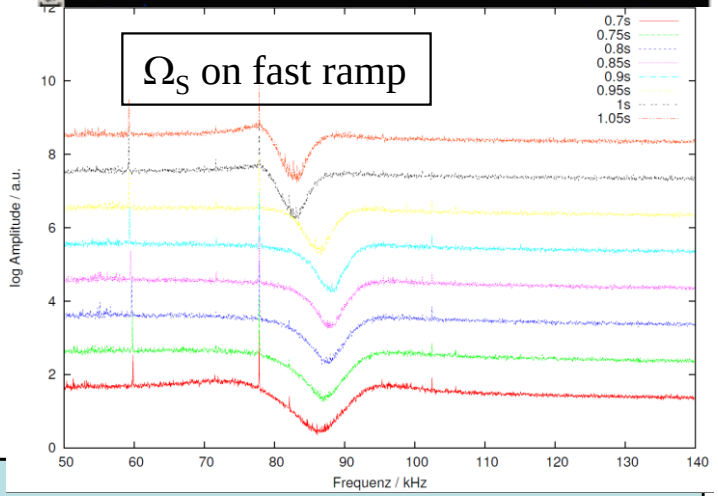
Coming 2014

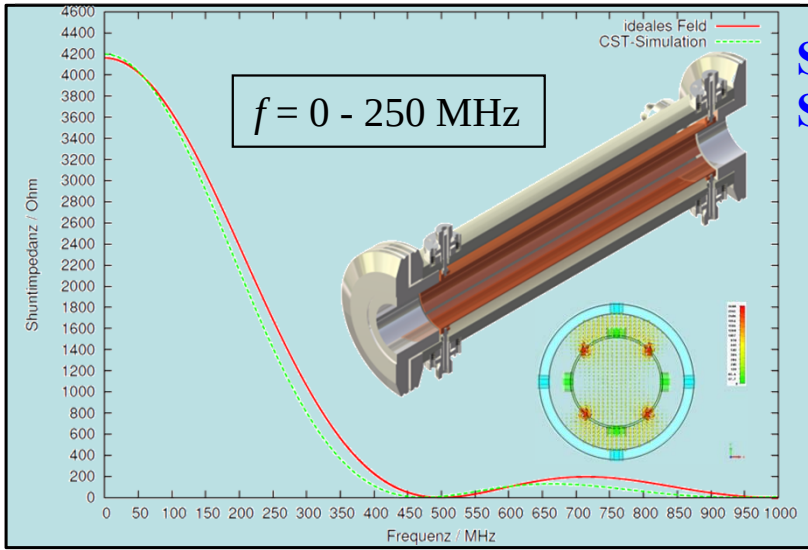
3D Bunch by Bunch Feed-Back in a fast ramping machine

System Layout:

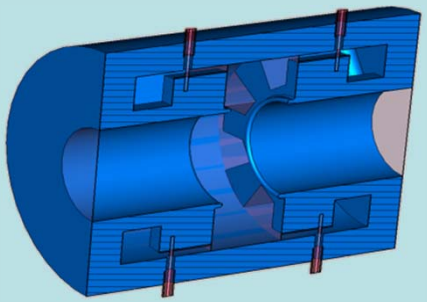




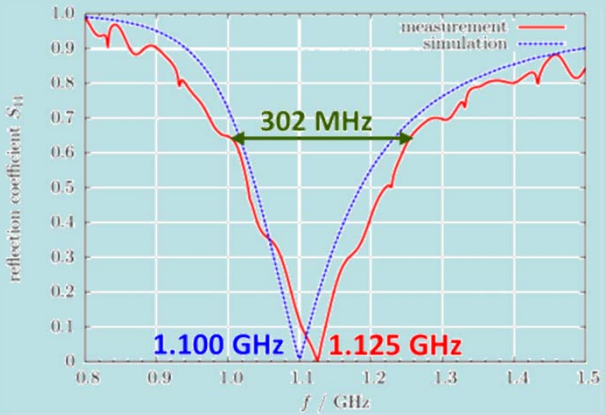




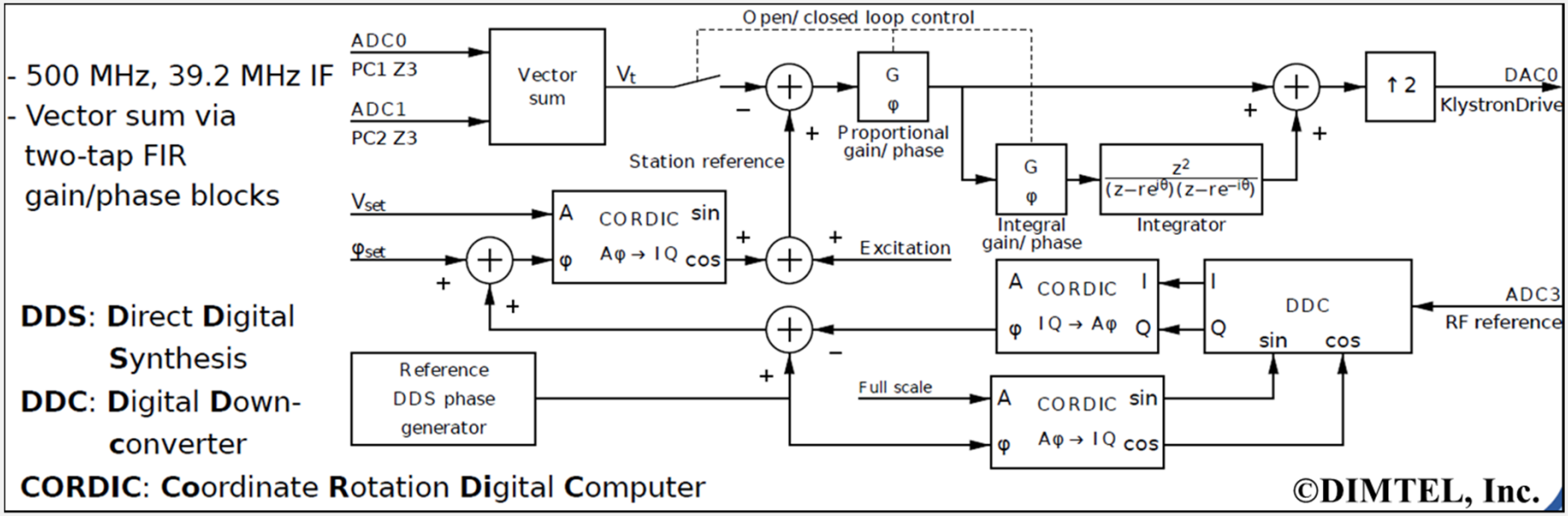
Simulation with CST Microwave Studio & In-house fabrication

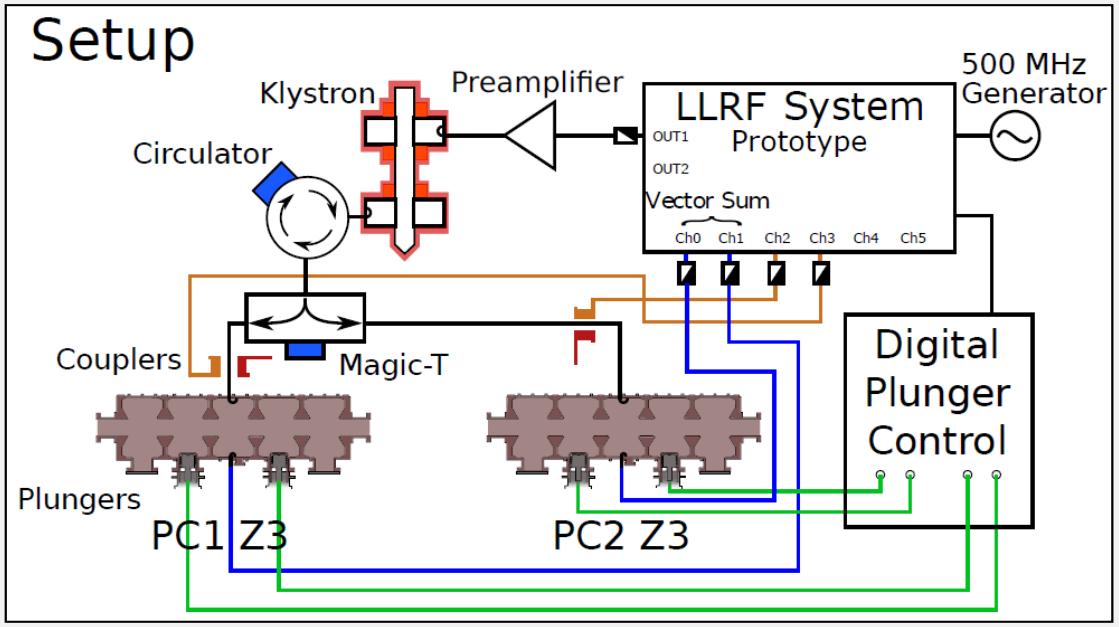


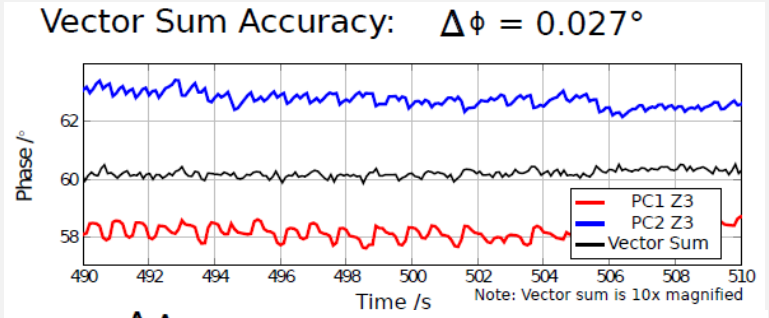
f = 1125 ± 150 MHz

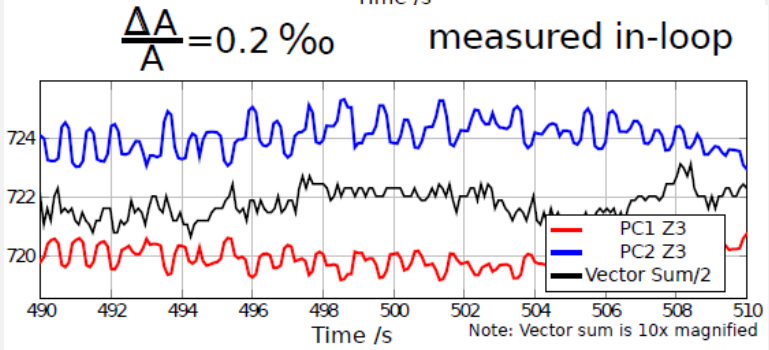


RF Control & Stabilization

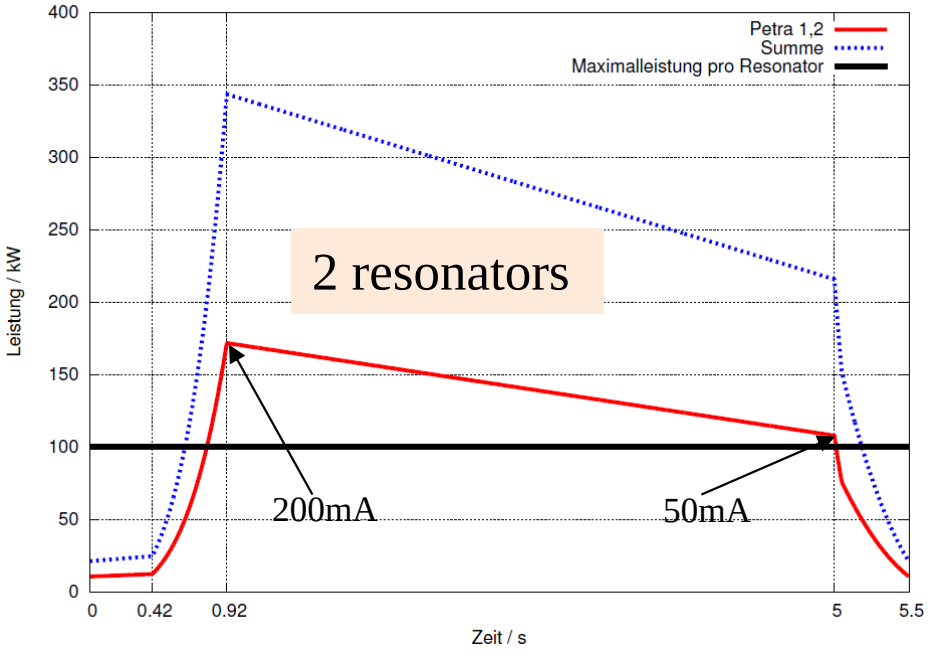


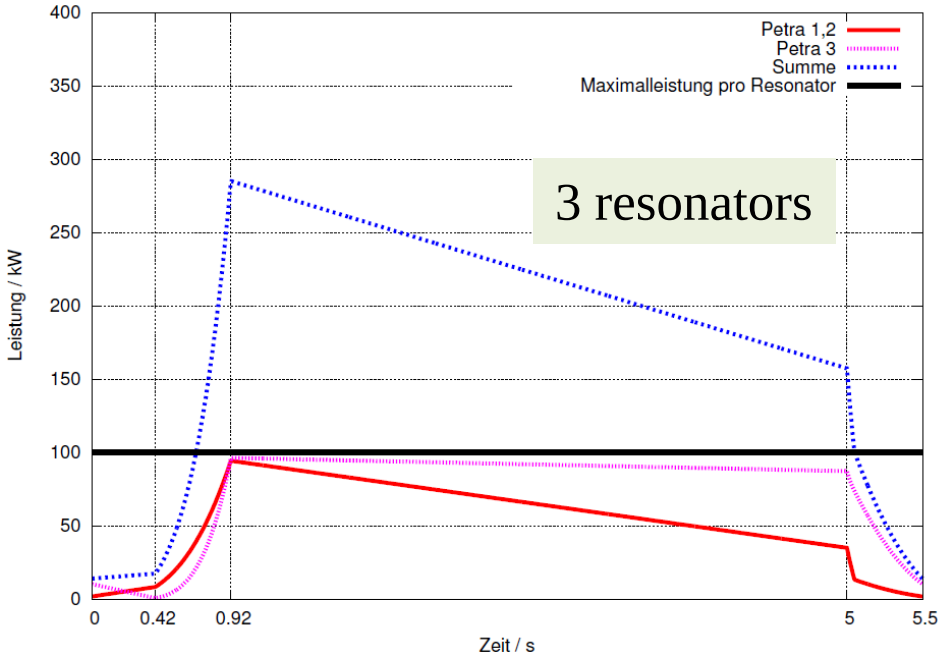




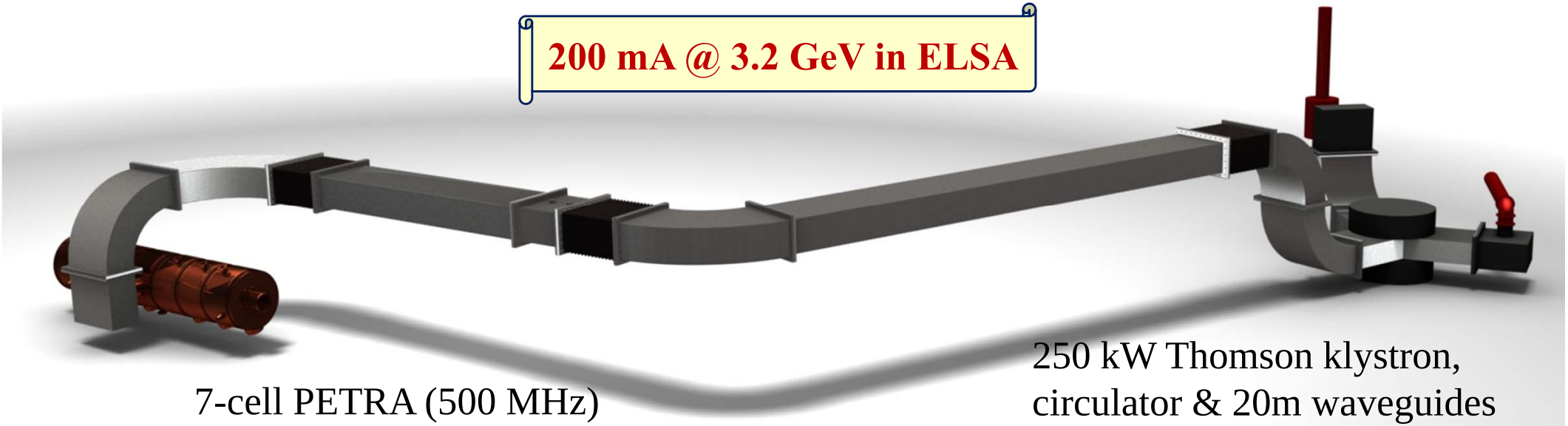


New RF System





200 mA @ 3.2 GeV in ELSA



7-cell PETRA (500 MHz)

250 kW Thomson klystron,
circulator & 20m waveguides

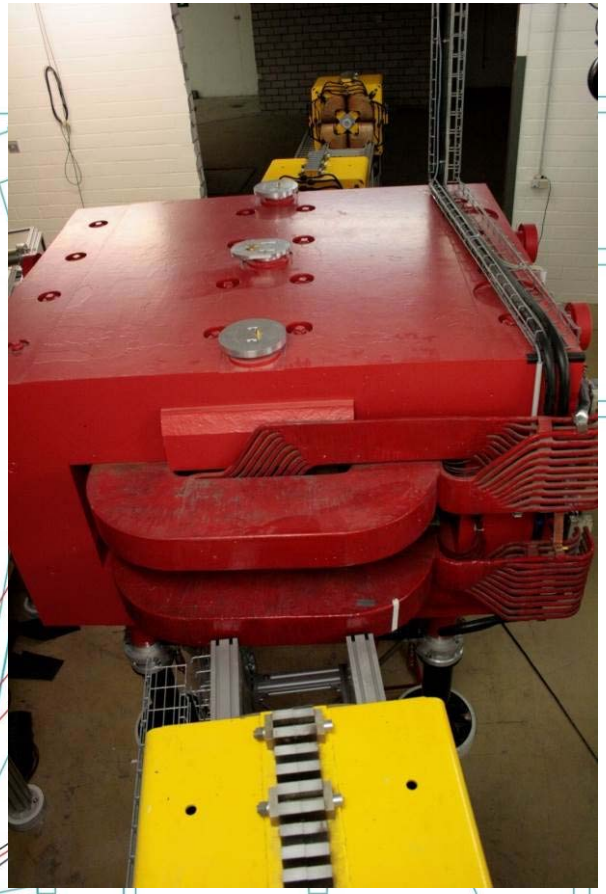
New Area for Detector Testing

External Electron Beam:

- Beam Energy: **1.0 GeV < *E* < 3.5 GeV**
- Beam Current: **1 fA < *I* < 100 pA**
- Beam Radius: **0.5 mm < σ < 7 mm**

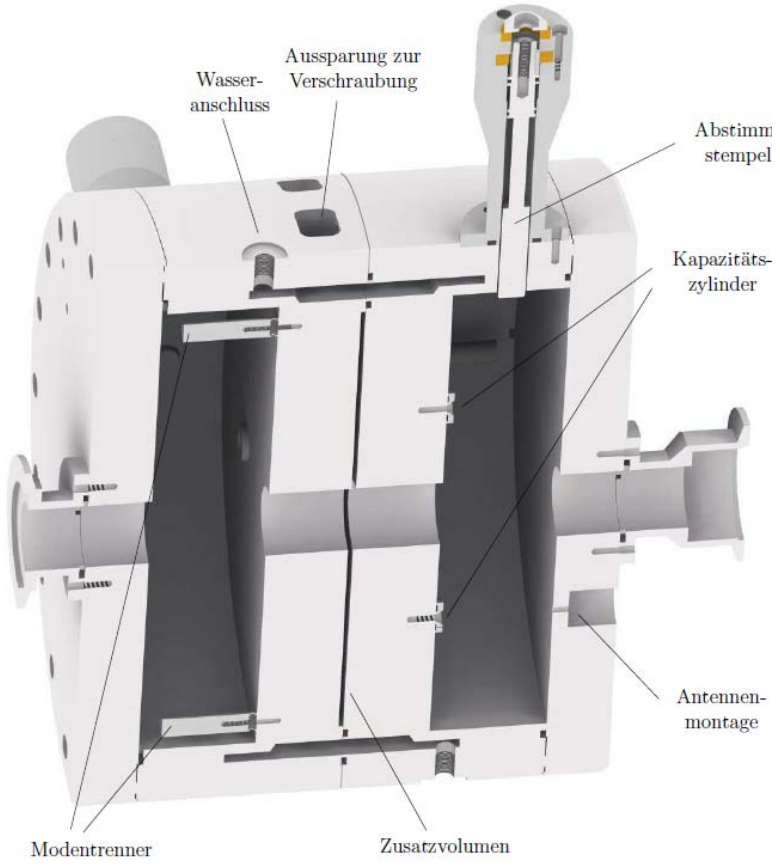
Single-Bunch Operation!

extraction of a single electron every 300 revolutions!

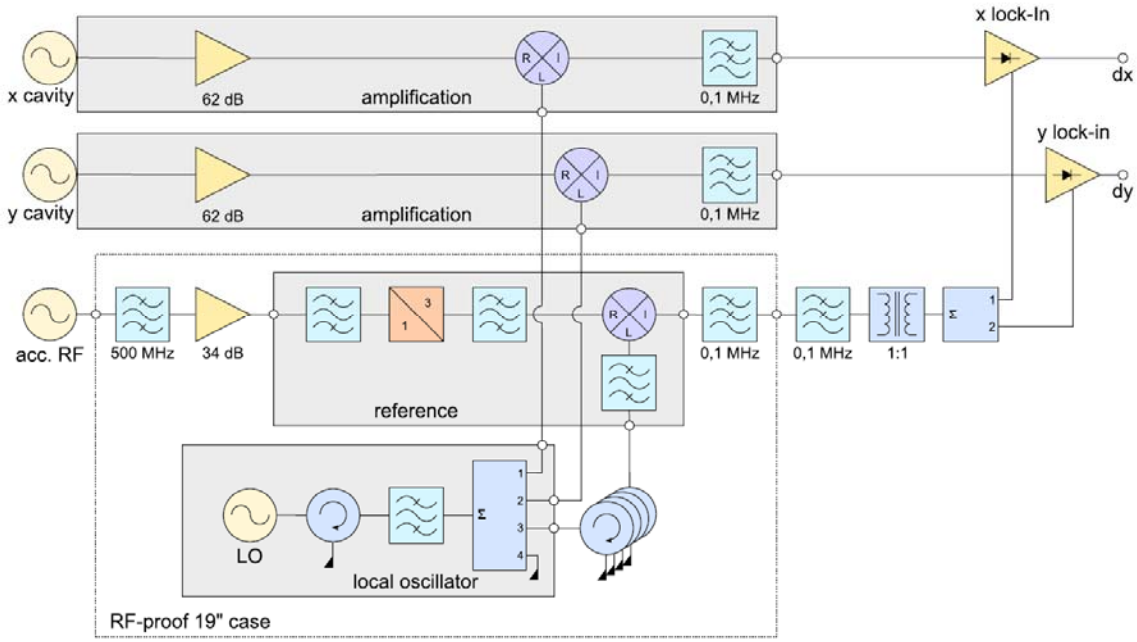


Coming 2014

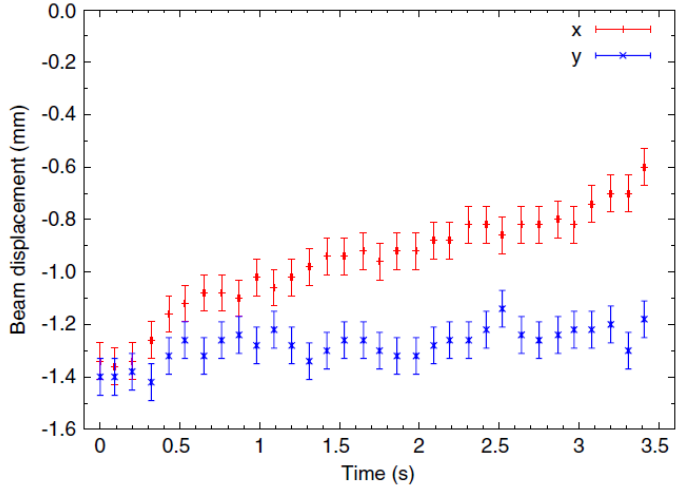
RF-based position measurement @ low beam currents



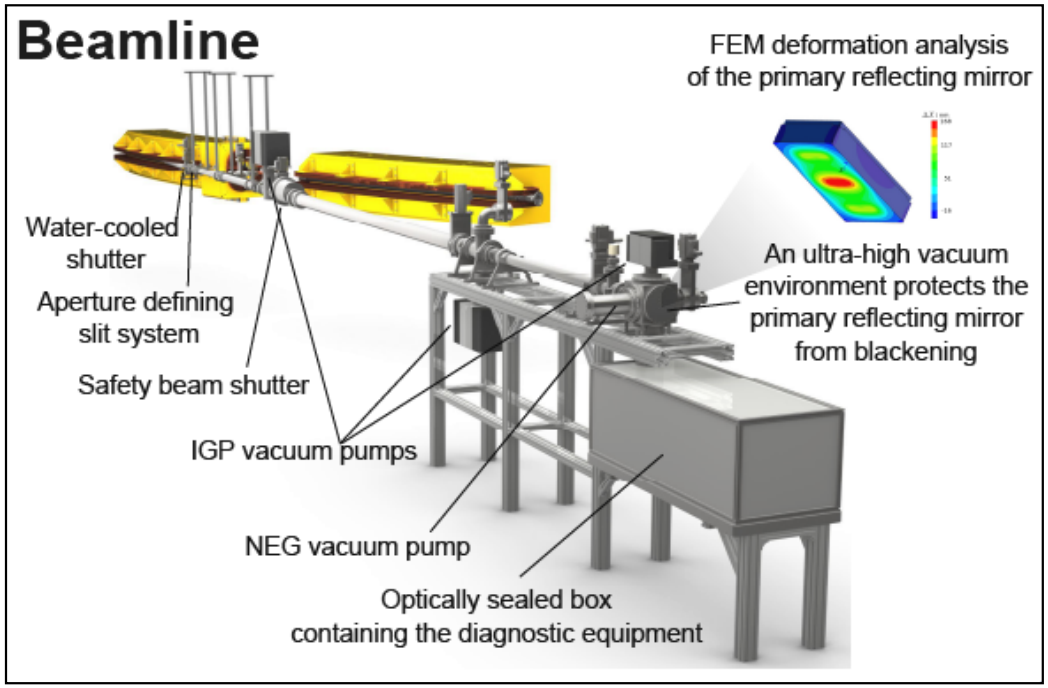
Parameter	Value
Mode	TM_{110}
Inner diameter	242 mm
Inner length	52 mm
Opening diameter	34 mm
Resonant frequency ν_0	1.499010 GHz
Shunt impedance $R_s/\Delta x^2$ (CST)	411 Ω/mm^2
Unloaded quality factor Q_0	11090
Coupling factor κ	0.89

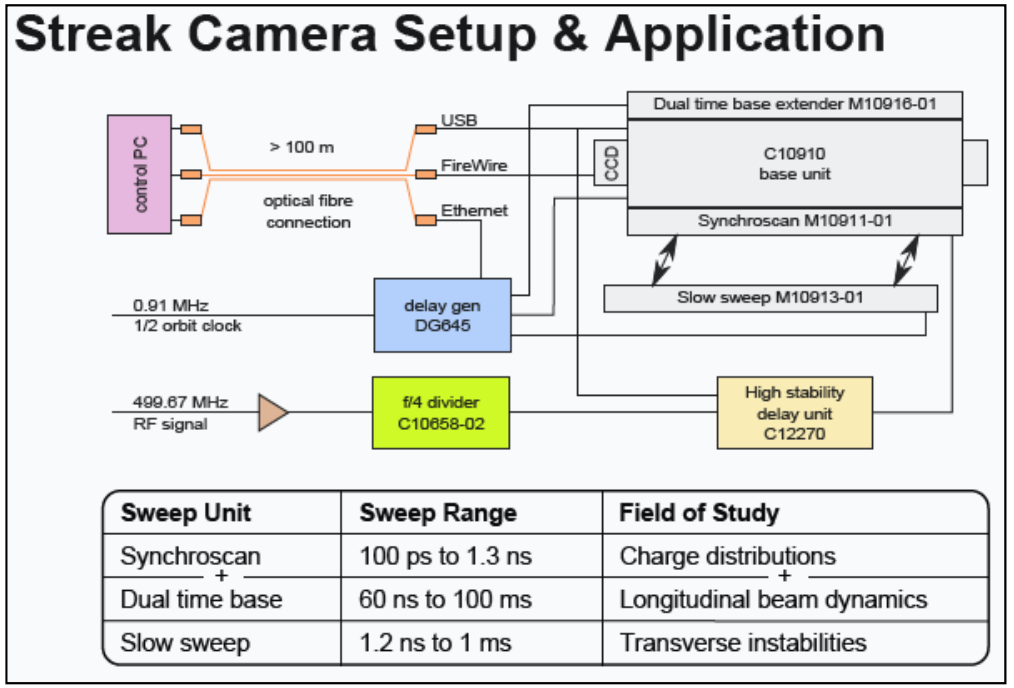


$\Delta x < 50\mu m$ @ $I = 100$ pA, $dx = 1$mm

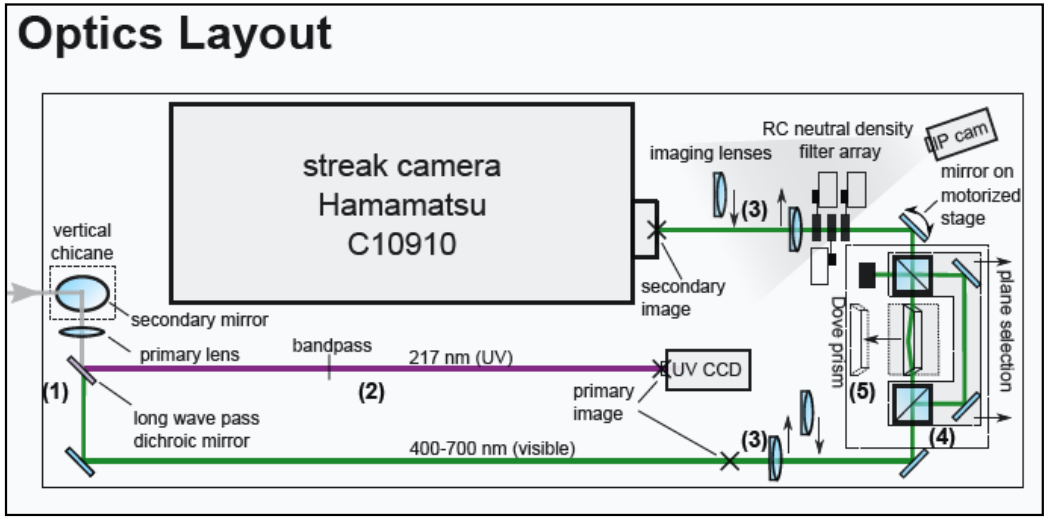


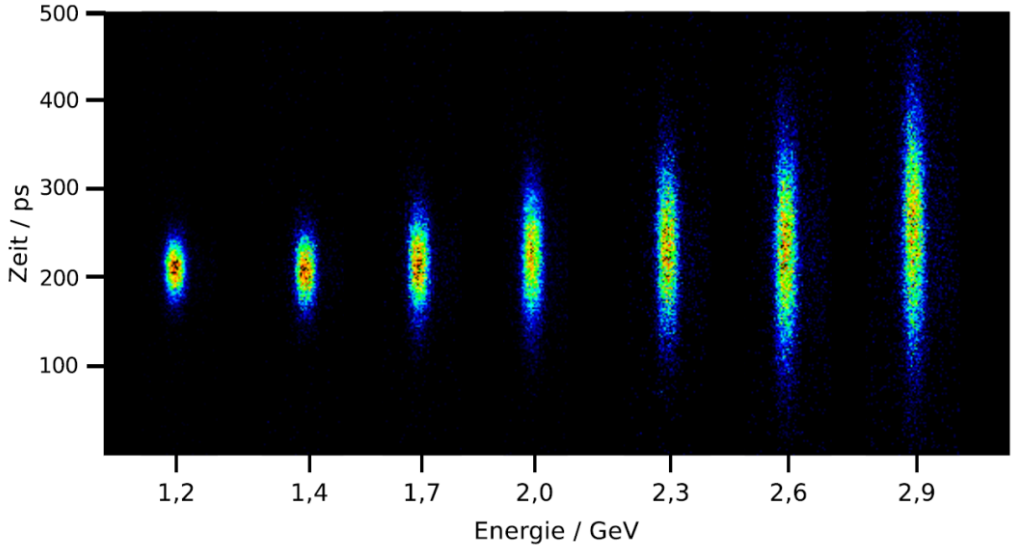
ps Diagnosis: Streak Camera





Sweep Unit	Sweep Range	Field of Study
Synchroscan	100 ps to 1.3 ns	Charge distributions
+		+
Dual time base	60 ns to 100 ms	Longitudinal beam dynamics
Slow sweep	1.2 ns to 1 ms	Transverse instabilities

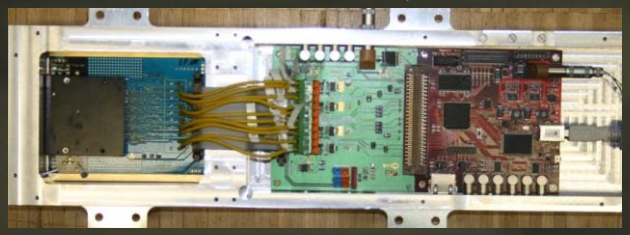


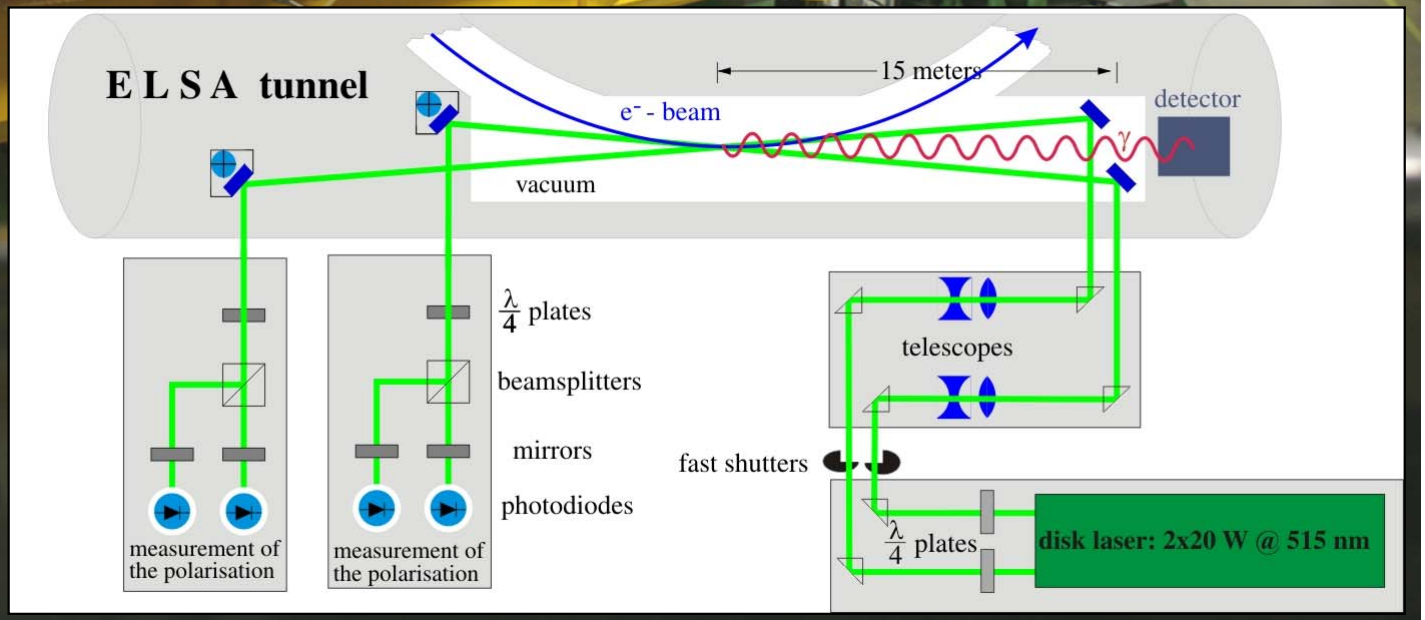


Compton Polarimeter

Coming 2014

Si microstrip detector
768 channels, 50 µm 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,…)
- …