Laser Synchronization at REGAE Using Phase Detection at an Intermediate Frequency.

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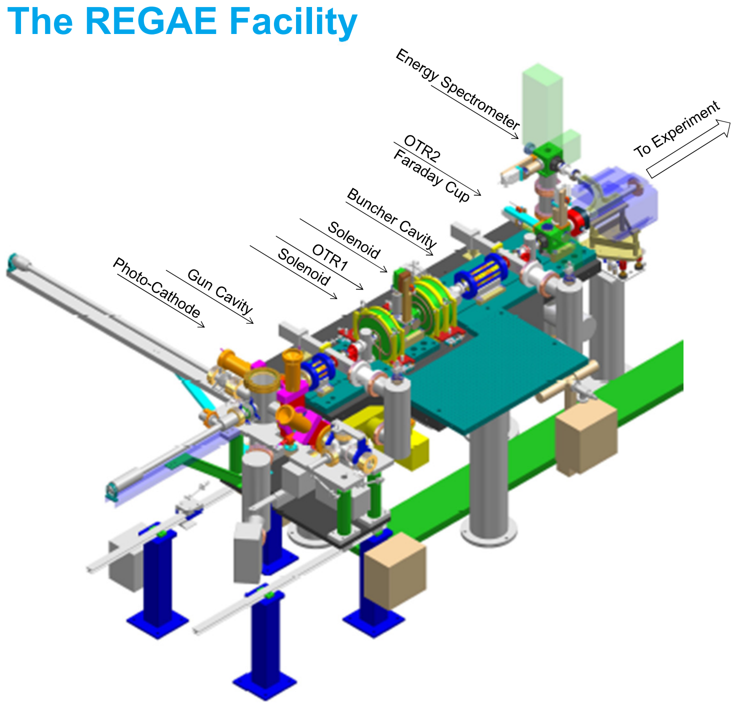
Abstract

At DESY in Hamburg a **new linear accelerator** is being set up for electron diffraction experiments. This machine, called **REGAE (Relativistic Electron Gun for Atomic Exploration)**, is composed of a photo-cathode gun and a buncher cavity. It uses one laser system for both the generation of the electron bunches and for pump-probe experiments. At the experiment the **required timing jitter between the electron bunches and the laser pulses is in the order of 10 fs**. The conventional method for laser synchronization using RF technique to measure phase(jitter) in the baseband is susceptible to distortions caused by ground-loops and electro-magnetic interference. At REGAE **a new scheme for an RF-based laser synchronization is deployed**. It uses a down-converter which mixes a higher harmonic of the laser repetition rate down to an intermediate frequency (IF). The IF is digitized and its phase is calculated. This information is used for the feedback controller to keep the laser synchronized to the RF reference.

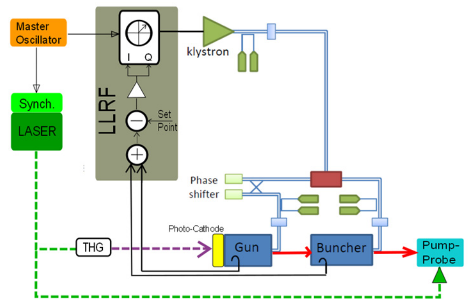
The REGAE Facility



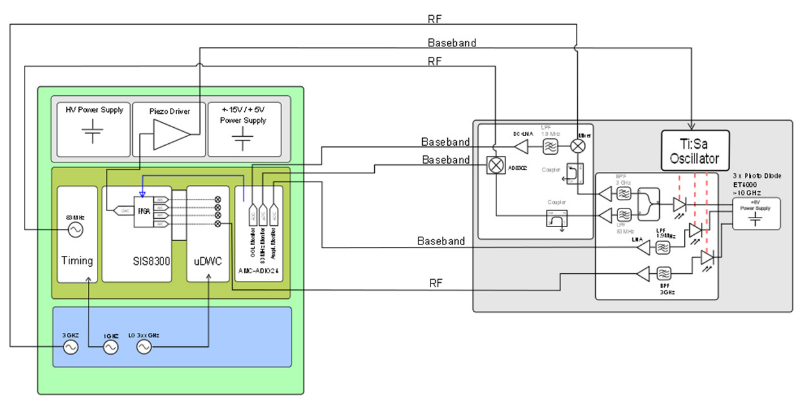
- Joint project of **CFEL** partners (Max Planck Society, University of Hamburg, DESY)
- Femtosecond electron diffraction in pump-probe experiments
- **First beam in November 2011**

- Normal conducting **S-band** (3 GHz) linac. ~ 10 m length
- 1½-cell gun and 4-cell buncher cavities
- **One laser system** (Ti:sapphire) **for photo-cathode and pump-probe**
- 50 Hz repetition rate

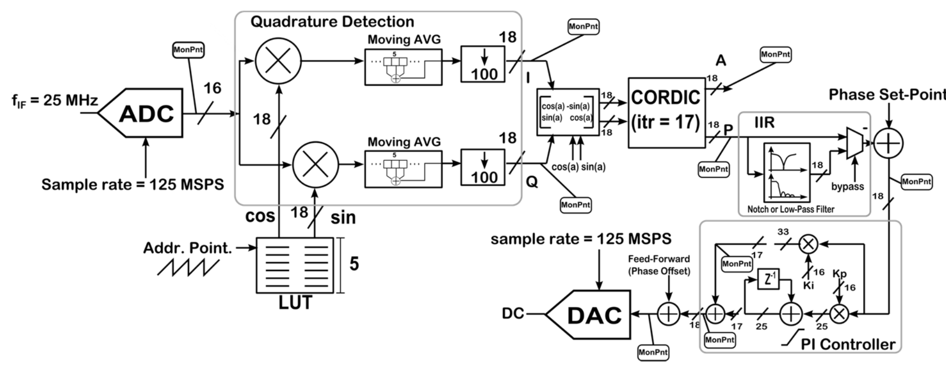
- Energy: 2-5 MeV
- **Charge 100 fC – 1 pC**
- **Bunch length 7-30 fs**
- Transverse emittance: $6x10^{-3}$ mm mrad
- Transverse coherence 30 nm



Synchronization Setup

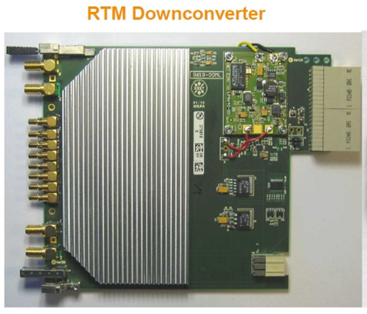


FPGA Firmware for Digital Phase Detection and Control



µTCA Hardware

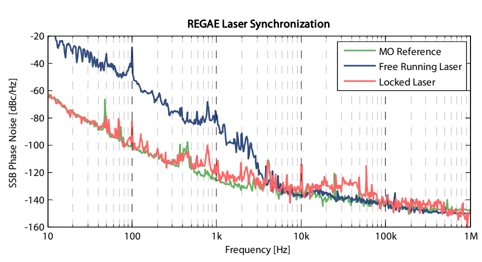
RTM Downconverter

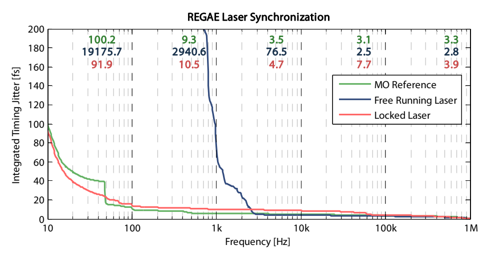


AMC ADC Board (SIS8300)

- MTCA.4 standard
- RTM with **down-converters** (3 GHz → 25 MHz)
- AMC with **125 MSP/s ADCs** and **Virtex 5 FPGA**

First Results





Summary and Outlook

- New locking scheme shows **excellent results** compared to the conventional setup
- **Synchronization in the order of 10-20 fs**
- µTCA platform offers better computing power and high flexibility
- No need for vector modulator, phase shift can be set in software
- Server **development in progress for automation** / implementation to the control system

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