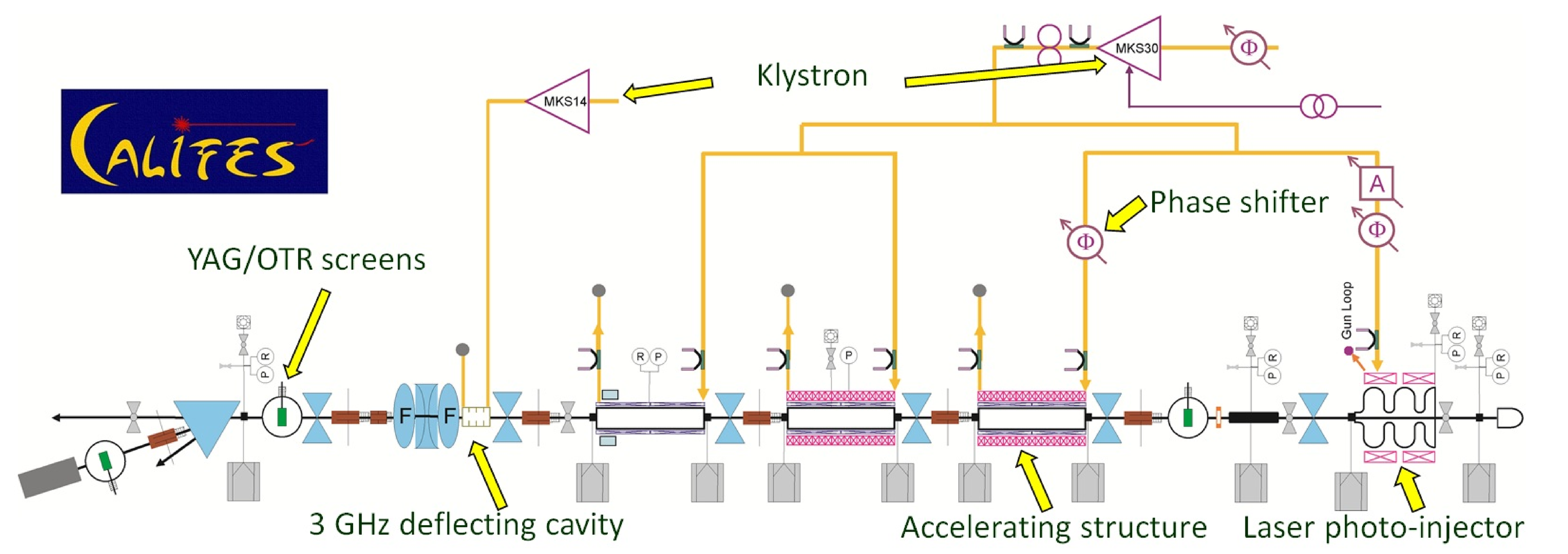
Abstract

A bunch profile monitor based on electro-optical spectral decoding (EOSD) is being designed for the probe beam of the CLIC Test Facility 3 at CERN and is expected to be installed and tested in the summer of 2012. Using this technique the profile information of an electron bunch is encoded into a chirped laser pulse and decoded using a spectrometer. Accurate synchronisation between the laser and electron bunch is mandatory. The poster describes the different aspects of the synchronization between the laser and the electron beams.

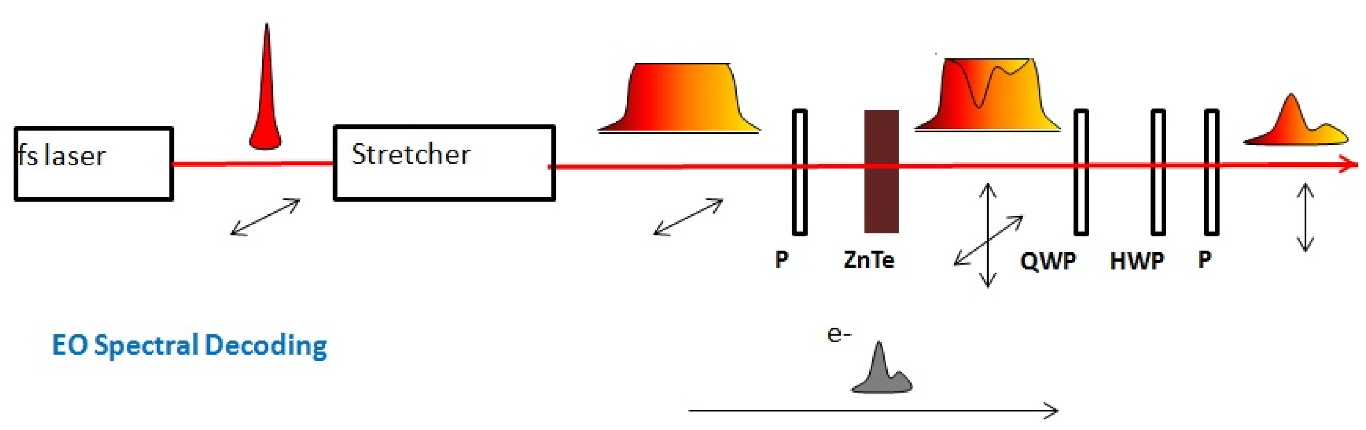
CALIFES, the probe beam of CLIC Test Facility 3 (CTF3)



The layout of CALIFES

CTF3 is used to study the key feasibility issues of a 3 TeV e+ e- Compact Linear Collider (CLIC) at CERN [1, 2, 3]. CALIFES is the probe beam of CTF3, and it is composed of a laser photo-injector followed by three travelling-wave structures and beam diagnostic line. Typical bunches of CALIFES can have a charge up to 0.6 nC and a bunch length of 1.4 ps r.m.s [4, 5]. At the end of the linac, the beam energy can reach up to 200 MeV .

Electro-Optical Spectral Decoding



Spectral Decoding (EOSD): The profile of the e-bunch Coulomb field is encoded onto a time-wavelength correlated optical probe. The temporal profile is read-out through the spectrum of the probe [6].

$$E_{\mathrm{Out}}(\omega) = \begin{bmatrix} 0 & 1 \end{bmatrix} R(\varphi)\, M_{\mathrm{H}} R(-\varphi)\, R(\alpha)\, M_{\mathrm{Q}} R(-\alpha)\, R(\theta)\, M_{\mathrm{EO}} R(-\theta) \begin{bmatrix} E^{\mathrm{Chirp}}_{\mathrm{Laser}}(\omega) \\ 0 \end{bmatrix}$$

$$M_{\mathrm{EO}} = \begin{bmatrix} \left(1 + \frac{i\omega}{2nc} \cdot \tilde{E}^{Eff}_{\mathrm{Coul}}{}^{*}\right) & 0 \\ 0 & \left(1 - \frac{i\omega}{2nc} \cdot \tilde{E}^{Eff}_{\mathrm{Coul}}{}^{*}\right) \end{bmatrix}$$

$$\tilde{E}^{Eff}_{\mathrm{Coul}}(0,\Omega) = \chi^{(2)}_{Eff} \left[\frac{e^{i\Delta k(\omega,\Omega) z} - 1}{i\Delta k(\omega,\Omega)} \right] \cdot \tilde{E}_{\mathrm{Coul}}(0,\Omega)$$

The limitation of EOSD: For short bunches (eg. 100fs), the measured signal is strongly distorted. It leads to a large broadening of the measured profile. The limitation depends on the pulse duration of original and chirped laser and can be calculated by [7] :

$$\tau_{lim} \approx \sqrt{\tau_0^{FWHM} \tau_c^{FWHM}}$$

The limitation for a 100 fs laser pulse chirped to 3 ps is around 550 fs.

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References

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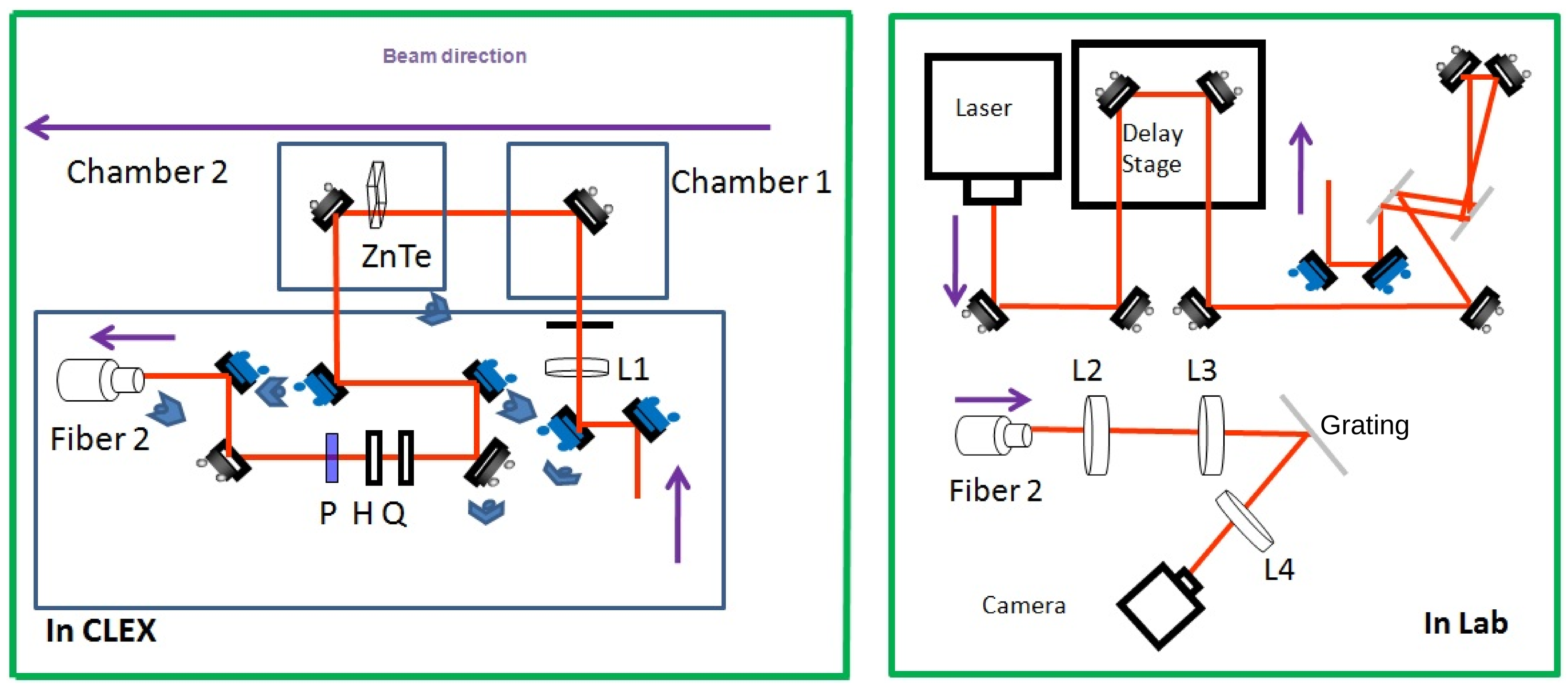
Bunch Profile Monitor

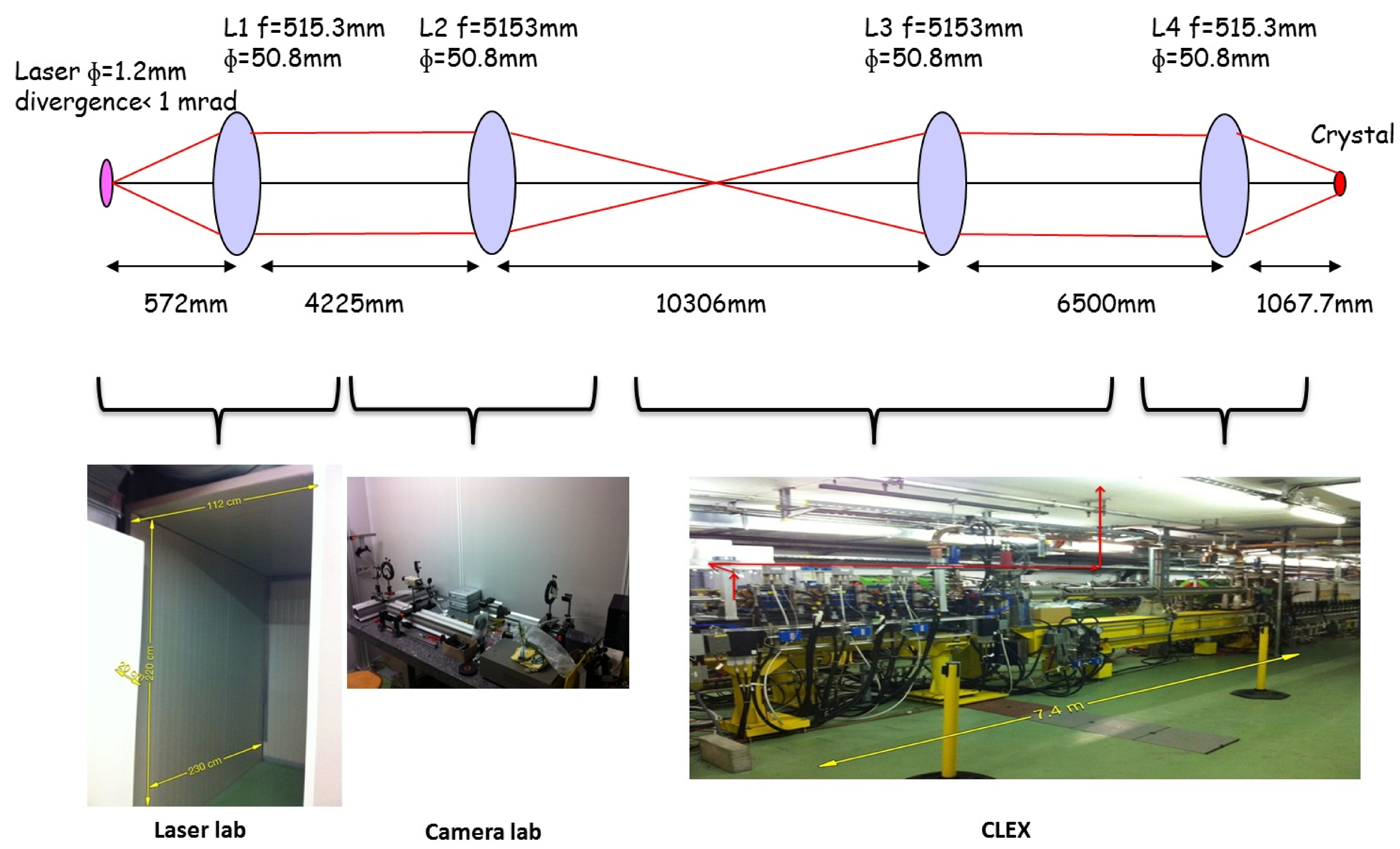


P: Polarizer **H**: Half wave plate
Q: Quarter wave plate
: Mirror with actuators
: Finger camera

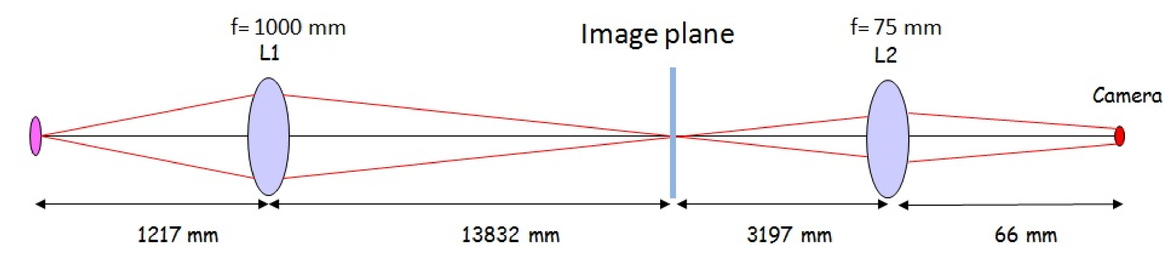
Laser:
Wavelength: 780 nm Duration: 100 fs
Repetition: 37.4815 MHz Pulse energy: 2.7 nJ
Crystal: Thickness: 1mm Distance: 5-10 mm

Transfer Line

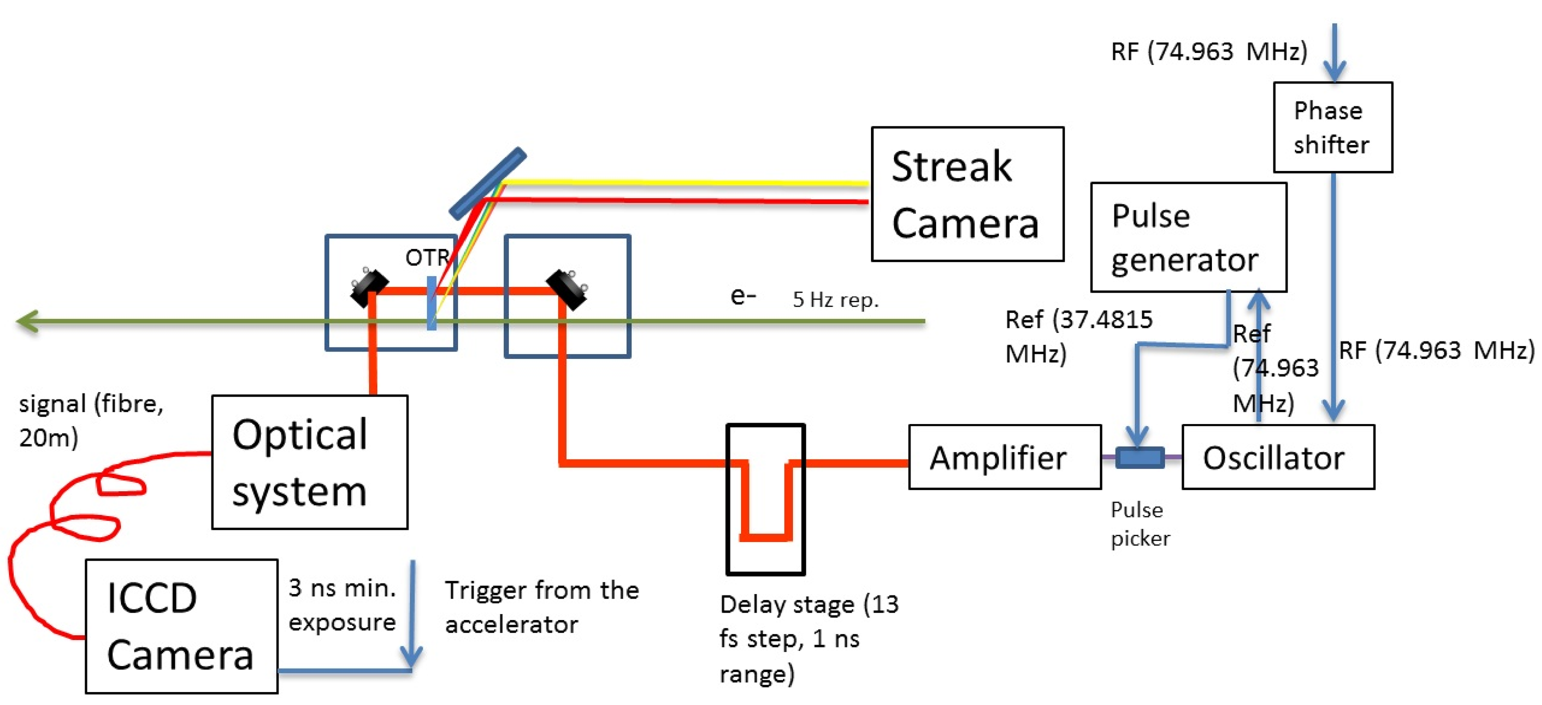
(1) Laser transfer line: from the laser lab to CLEX



(2) OTR photons transfer line: from CLEX to the camera lab



Timing Synchronization



(1) Synchronization between laser pulse and e-bunch
OTR photons induced by the e-bunch and laser photons reflected by the OTR screen will be sent to an optical laboratory and their arriving times will be monitored within few ps accuracy using a streak camera. The laser oscillator is synchronised to the beam using an RF signal derived from the low level RF system driving the accelerating cavities. The rough (100ps) timing adjustment is provided by adjusting the phase of this signal. The precise timing overlap between laser and electrons is performed using an optical delay line with an ability of 13 fs step increment and 1 ns scanning range.

(2) Imaging the laser pulse
A low jitter (<1ns) signal will trigger the ICCD camera, which can be gated with a 3 ns minimum exposure.