• Motivation
• Experimental set-up
• Time and space overlap
• X-ray detection
• Result of the scan
• Future improvements and perspectives
CLIC Project: Main beam

For measuring for very small beam size at high energy

- Beam size: 40-0.4 \( \mu m \)
- Beam energy: 9 - 1500 GeV

Using the spatial performances of a laser (very small spot size: a few \( \lambda \))

CTF 3 and CLIC Drive beams

For measuring beam profile on a high average current beam

- Beam size: 50-500 \( \mu m \)
- Beam current: 3.5 - 35 A
- Beam energy: 50 MeV - 2 GeV

Non-degradable detector compared to classic wire scanners or optical diagnostic (OTR and Cherenkov)
LWS : Experimental Set-up

3 GHz Photo-injector
3 GHz Accelerating cavity
Focusing triplet
Current and Position Monitor

3 GHz

Electron beam size of 160 µm rms
50MeV, 1nC

Laser focusing & scanning systems (1µm resolution)

IR filter

Laser virtual focus (30µm over 1cm)

Laser shutter

Nd:YLF laser 1047nm, 3mJ, 4ps

IR to UV doubling crystals

Remote controlled delay line

262nm, 10µJ, 4ps

100µm thick Al Window

Spectrometer

600 photons with 17keV averaged energy

Detection angle 26mrad (Can tolerate 5mrad misalignment)

X-ray detector

Beam dump

Total scattered photons
Scattered photons on the detector

Number of photons (average)

Photon energy (keV)

0 5 10 15 20 25

0 20 40 60 80
LWS : Experimental Set-up

- **3 GHz Photo-injector**
- **3 GHz Accelerating cavity**
- **Focusing triplet**
- **Current and Position Monitor**
- **IR filter**
- **Spectrometer**
- **Laser shutter**
- **IR to UV doubling crystals**
- **Nd:YLF laser**
- **Remotely controlled delay line**
- **Laser Photodiode**
- **X-ray detector**

**Beam dump**

**Laser virtual focus**
LWS: Overlap technique

- 3 GHz Photo-injector
- 3 GHz Accelerating cavity
- Focusing triplet
- Current and Position monitors
- Nd:YLF laser 1047nm, 3mJ, 4ps
- 262nm, 10µJ, 4ps
- IR to UV doubling crystals
- IR Focusing & scanning systems
- Laser shutter
- Doubling Crystal In
- Remotely controlled delay line
- IR filter
- OTR screen
- IR virtual focus imaging CCD
- Laser Photodiode
- OTR Light
- Spectrometer
- Streak camera
- Electron energy 50MeV (minimize energy dispersion)
- Electron Laser
- Scintillator & CCD camera
- Beam dump (~3mm offset, ~2mrad)
- ~3mm offset
LWS: Overlap Performances

Focus mode (2D)

Streak camera images

Streak mode
Sweep speed 10ps/mm

Delay introduced by the presence of the doubling crystal

Estimated accuracy: ±3ps and ±300µm
3 GHz Photo-injector
3 GHz Accelerating cavity
Focusing triplet
Current and Position Monitor

Nd:YLF laser
1047nm, 3mJ, 4ps

IR to UV doubling crystals

Laser focusing & scanning systems

Remote controlled delay line

Doubling Crystal out

Laser shutter

IR filter

Laser photodiode (2.5mJ)

600 photons with 17keV averaged energy

Expected signal 3.8 mV

Oscilloscope

X-ray detector

Beam dump
LWS : X-ray detector

Detector assembly

Thin aluminized Mylar foil

Lead loaded plastic Scintillator

Mu metal

Photo-multiplier tube

Calibration curve done at ESRF on the Swiss Norwegian beam line

600 photons with 17keV averaged energy

Expected signal of 3.8mV
(PMT high voltage : 1.65kV)

Source: 8000 photons of 20 keV within 150ps
LWS : Raw signals

- Fast variations (20%) due to the shot to shot reproducibility in the UV laser pulse energy
- Slow variation (30%) due to temperature changes in the laser room
- Not correlated with a significant change in the bunch charge
- Very sensitive to a steerer located along the accelerating cavity
- Change in the position of the laser on the photo-cathode or Drift in the RF phase or in a power supply
Laser off values are used to evaluate the background signal.

σ: RMS error of the background subtraction technique

Give an estimate of background level.
LWS : Statistics on the scans

Expected signal to noise ratio

- Background level ~
  - 8000 photons of 20keV
  - 2000 photons of 1MeV
  - 1000 photons of 20MeV

- Signal to noise ratio changes between 1/8 and 1/30
- 11 scans are under the average value
Statistical noise: r.m.s value of the histograms of the compensated data

- Statistical noise changes from 0.3 to 3.5 mV
- 9 scans are above the average value
Total of 9 scans with a S/N ratio better than 1/10 and a RMS error smaller than 1mV.

No scan: Acquiring data at fixed position

![Graph showing detector signal (mV) for Laser on and Laser off values, with overlapped and offset positions. Averaged values: Laser on - 1.04mV, Laser off - -0.06mV.](image)
LWS : Profile measurements

Longitudinal profile : Scan ±18ps

- Black: Compensated signal
- Red: Compensated and averaged signal
- Blue: Expected signal (/2)

σ_{electron} = σ_{laser} = 4ps

1.5ps offset compared to the overlap values (2ps offset maximum)
LWS : Profile measurements

Vertical profile : Scan ± 250μm

- Compensated signal
- Compensated and averaged signal
- Expected signal (/2)

σ_{electron} = 100μm
σ_{laser} = 30μm

25 μm offset compared to the overlap values (150 μm offset maximum)
• Thomson photons have been detected
  • LWS profiles are in accordance with the beam dimension measured by optical means

  • Small offsets of maximum 2ps and 150µm have been observed which corresponds to the accuracy of the overlap technique.

  • The signal to noise ratio is still too low to allow an accurate measurement

• Background consideration is a key issue in the use of LWS. The main source of background comes from the accelerating cavity (beam halo losses)

• With our background subtraction technique we can tolerate a signal to noise ratio of 1/10.

  Possible improvements using a second detector in parallel for direct background measurement (gain a factor 2)

• Concerning the CTF3 machine, a much higher laser power would be required to the obtain an adequate signal to noise ratio.

  Q-switched lasers do not deliver enough power
  Ti:Sapphire lasers must be foreseen (but very expensive)