Laser Wire Scanner test on CTF2

- Motivation
- Experimental set-up
- Time and space overlap
- X-ray detection
- Result of the scan
- Future improvements and perspectives

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CLIC Project : Main beam

For measuring for very small beam size at high energy

Beam size : 40-0.4 μm
Beam energy : 9 - 1500 GeV

➡ Using the spatial performances of a laser
(very small spot size : a few λ)

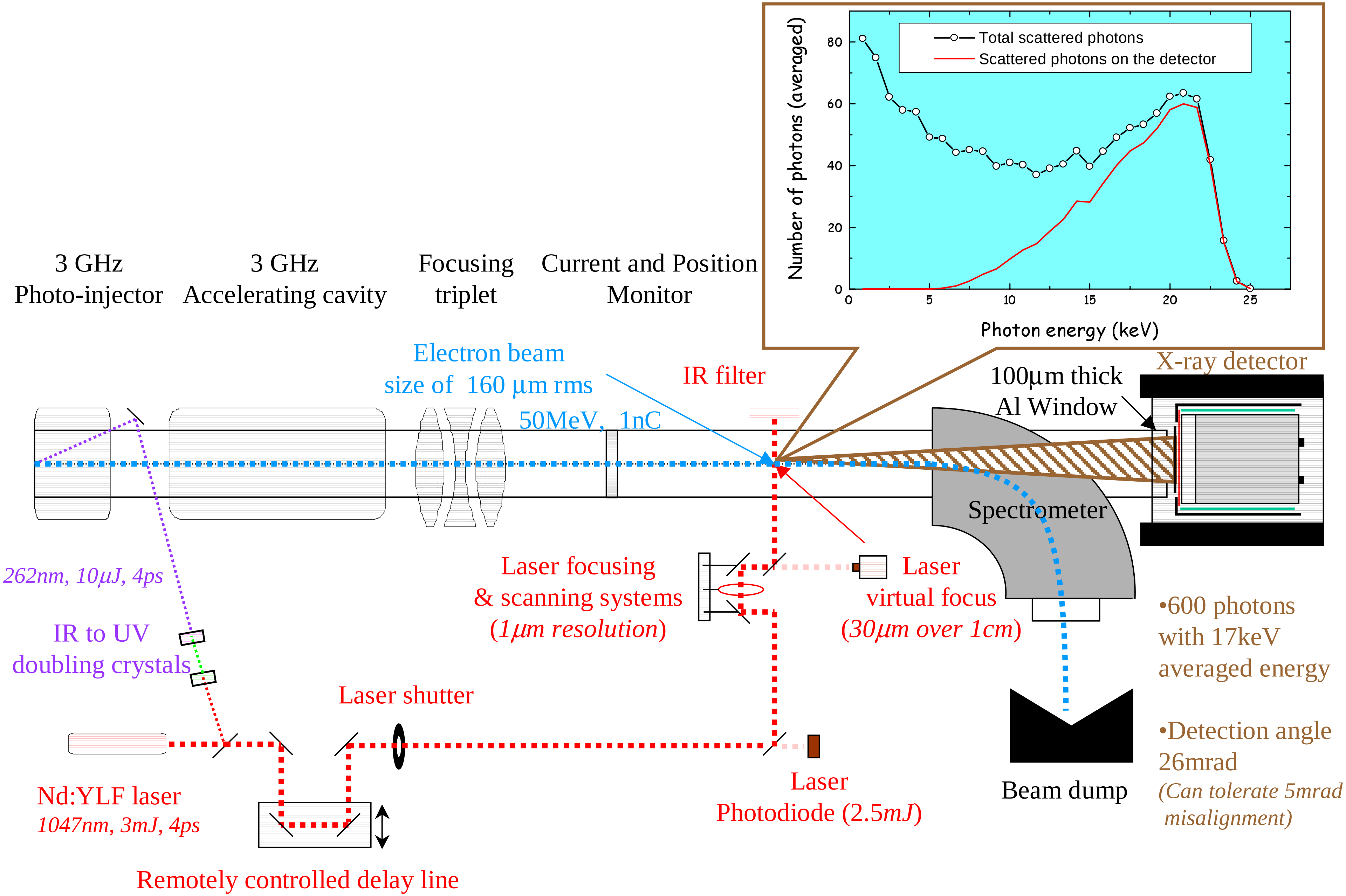
CTF 3 and CLIC Drive beams

For measuring beam profile on a high average current beam

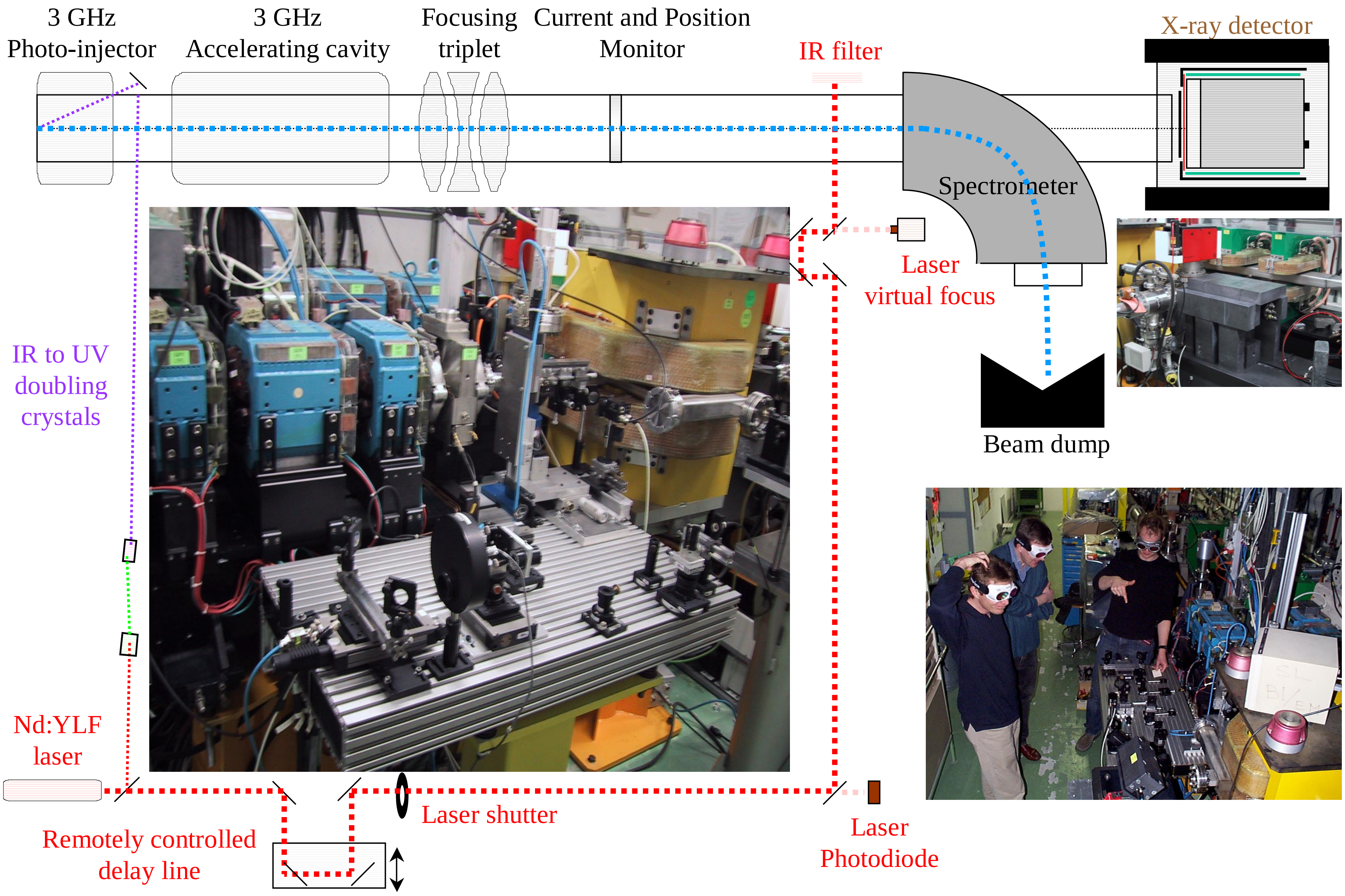
Beam size : 50-500 μm
Beam current : 3.5- 35 A
Beam energy : 50 MeV- 2 GeV

➡ Non - degradable detector compared
to classic wire scanners or optical diagnostic
(OTR and Cherenkov)

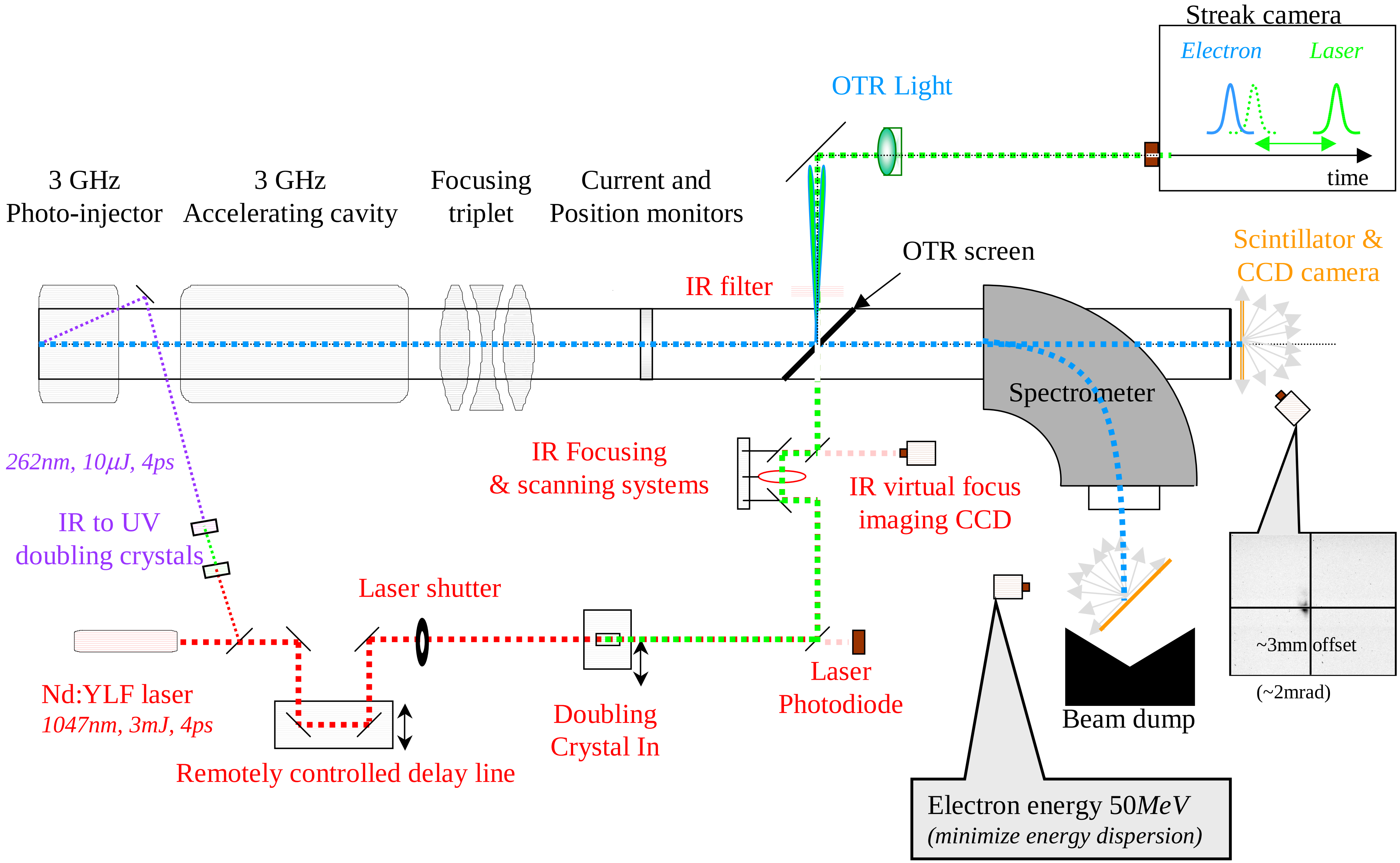
LWS : Experimental Set-up



LWS : Experimental Set-up



LWS : Overlap technique

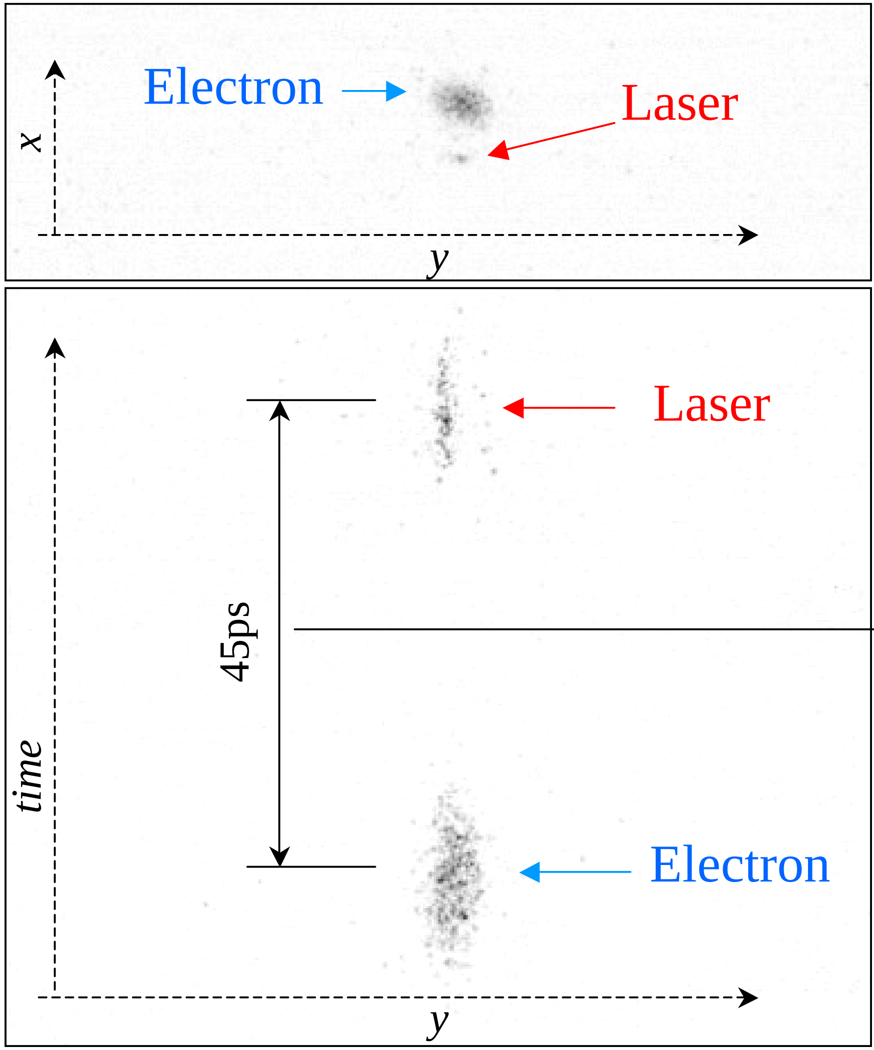


LWS : Overlap performances

Streak camera images

Focus mode (2D)

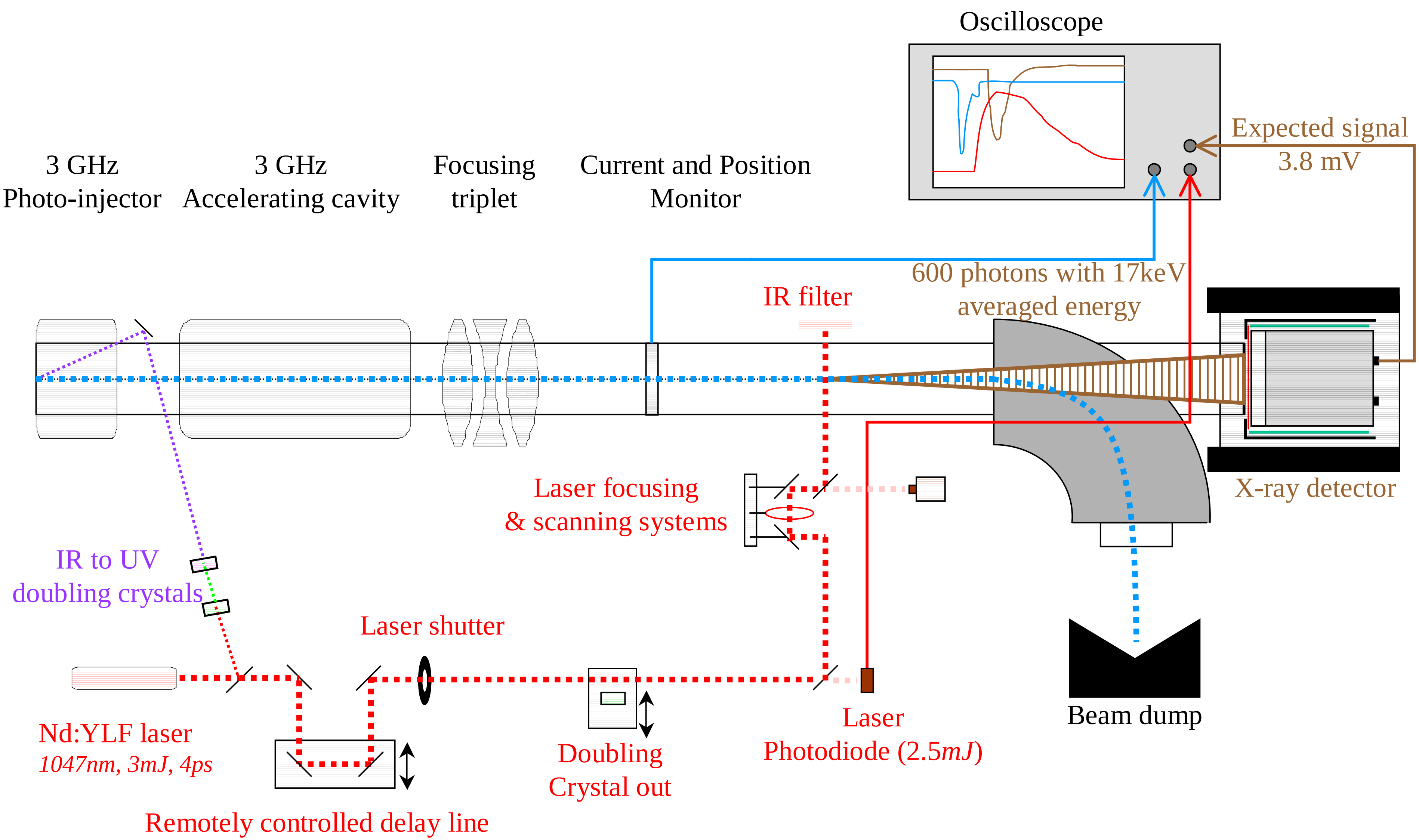
Streak mode
Sweep speed 10ps/mm



Delay introduced by the presence of the doubling crystal

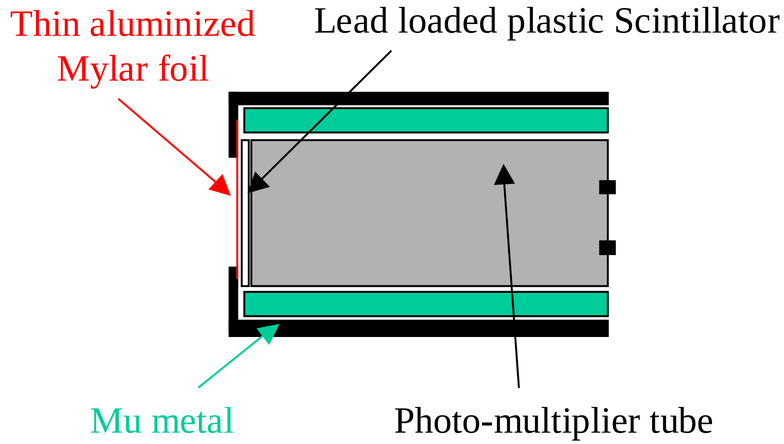
Estimated accuracy: ±3ps and ±300µm

LWS : X-ray detection



LWS : X-ray detector

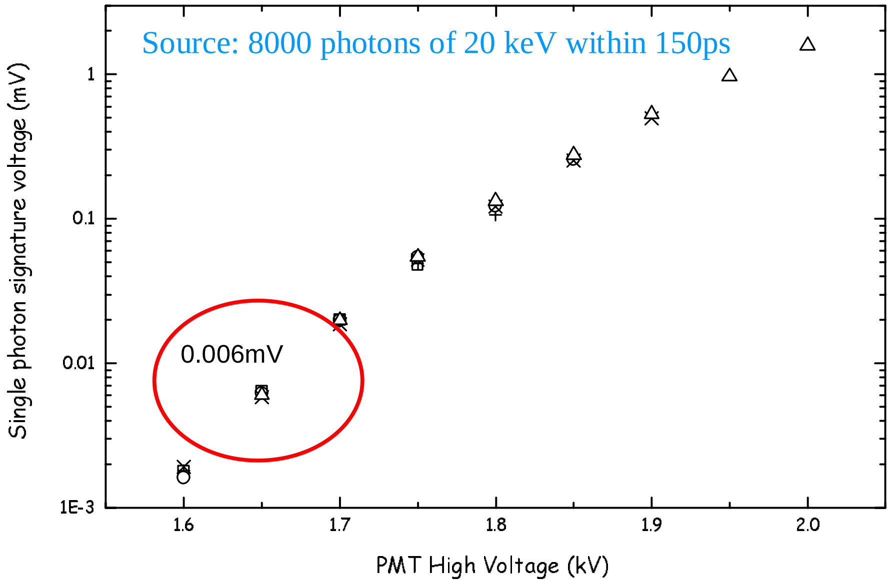
Detector assembly



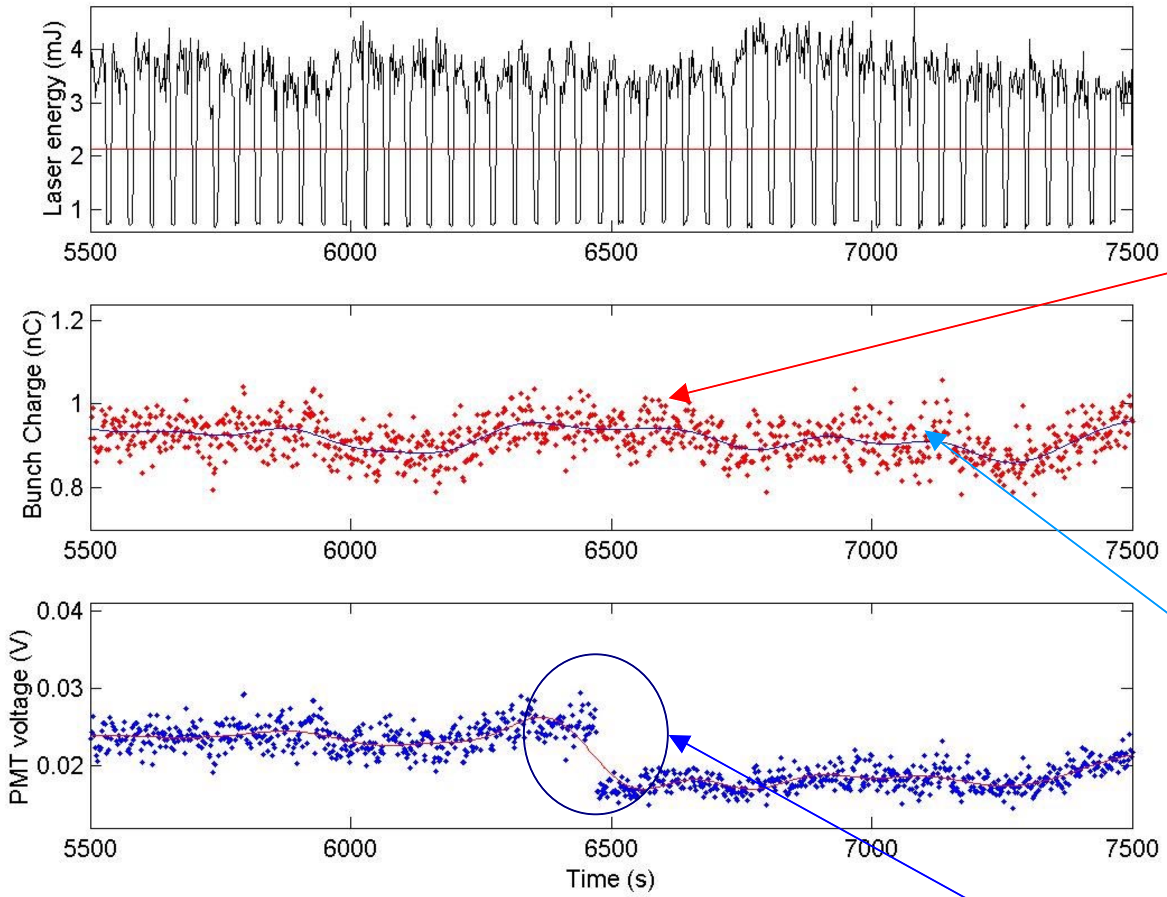
Calibration curve done at ESRF on the Swiss Norwegian beam line

600 photons with 17keV averaged energy

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



LWS : Raw signals



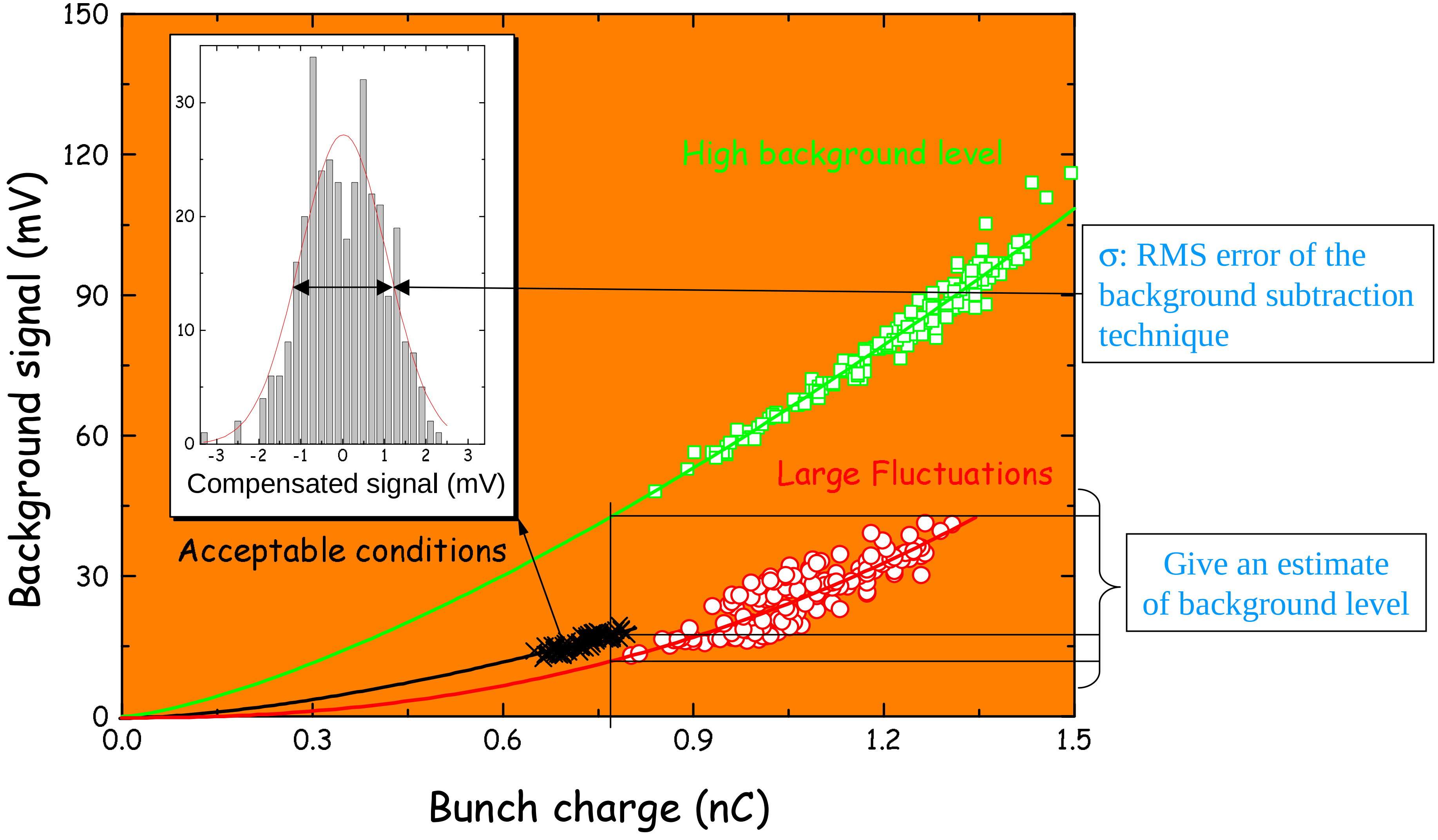
- Fast variations (20%) due to the shot to shot reproducibility in the UV laser pulse energy

- 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

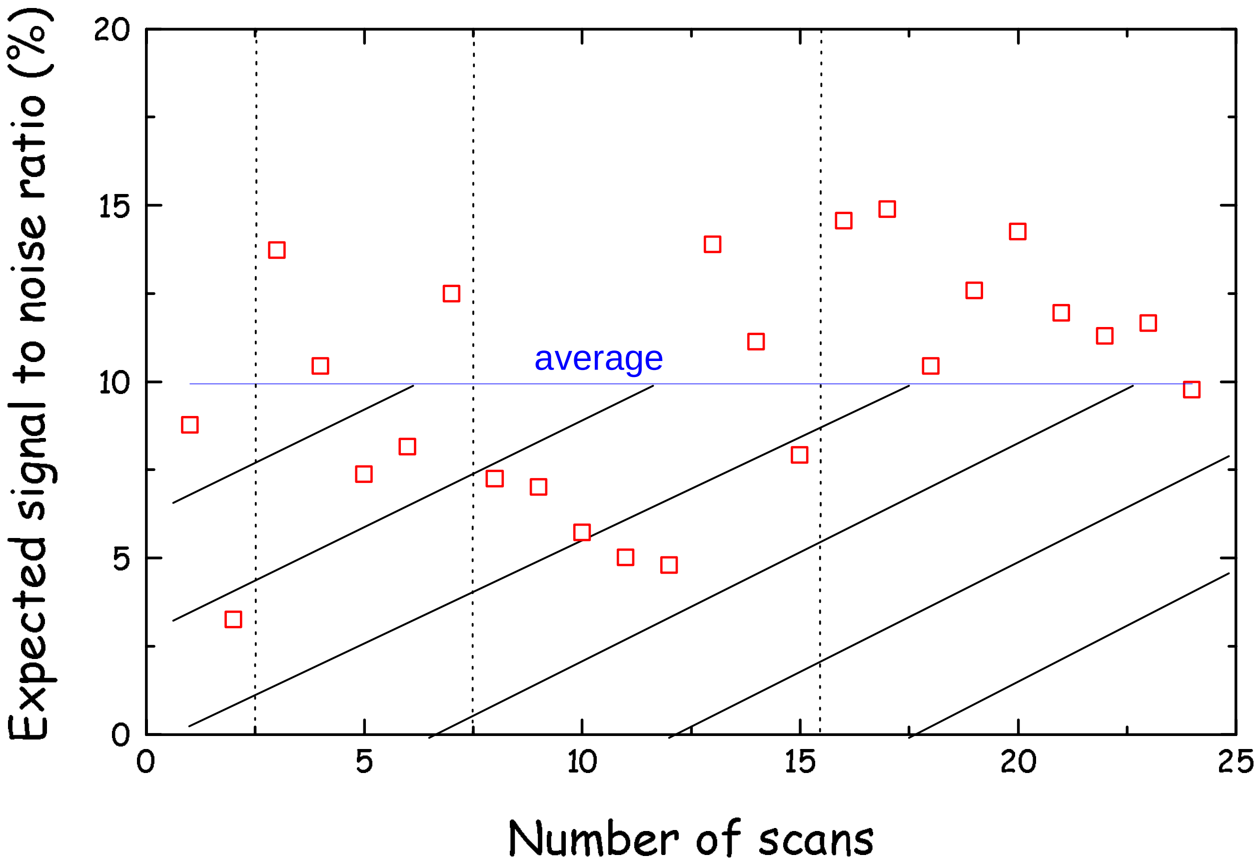
LWS : Background subtraction

Laser off values are used to evaluate the background signal



LWS : Statistics on the scans

Expected signal to noise ratio



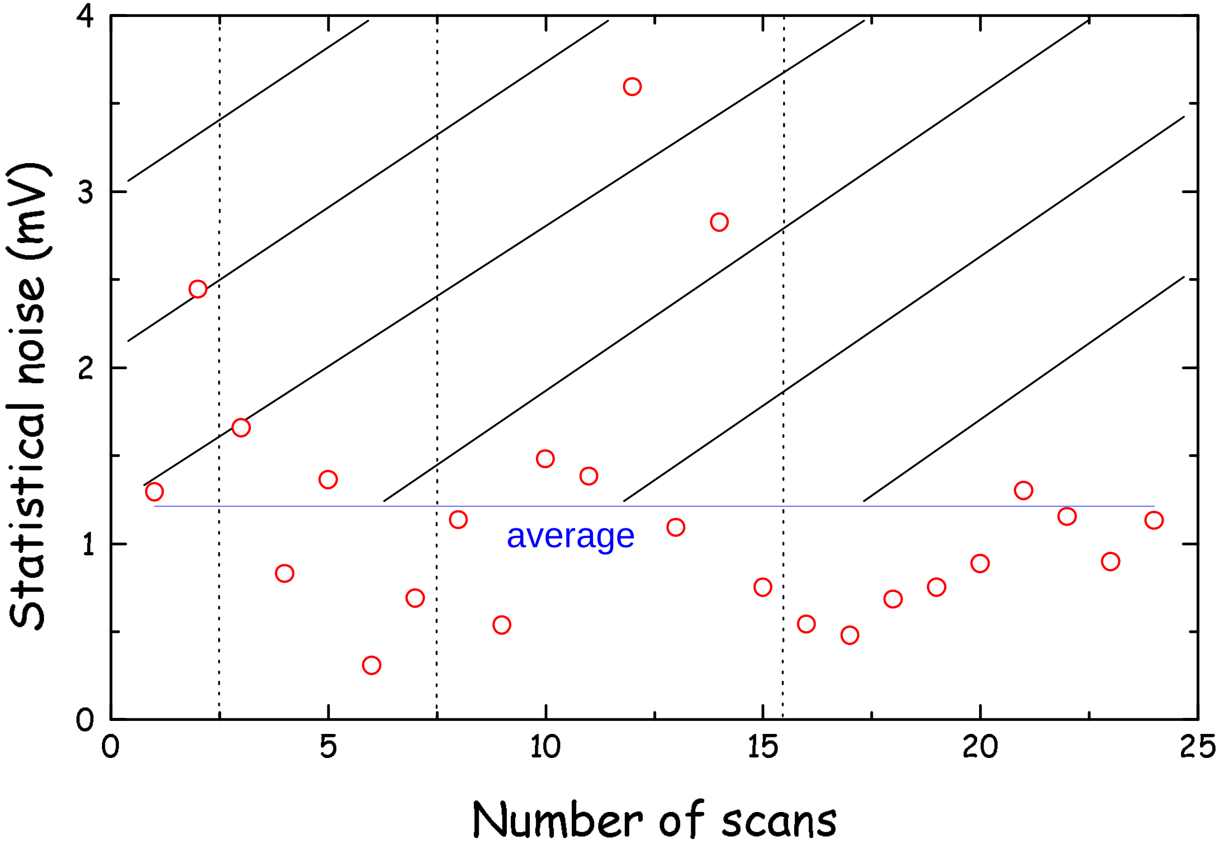
Background level ~

- 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

LWS : Statistics on the scans

Statistical noise : r.m.s value of the histograms of the compensated data

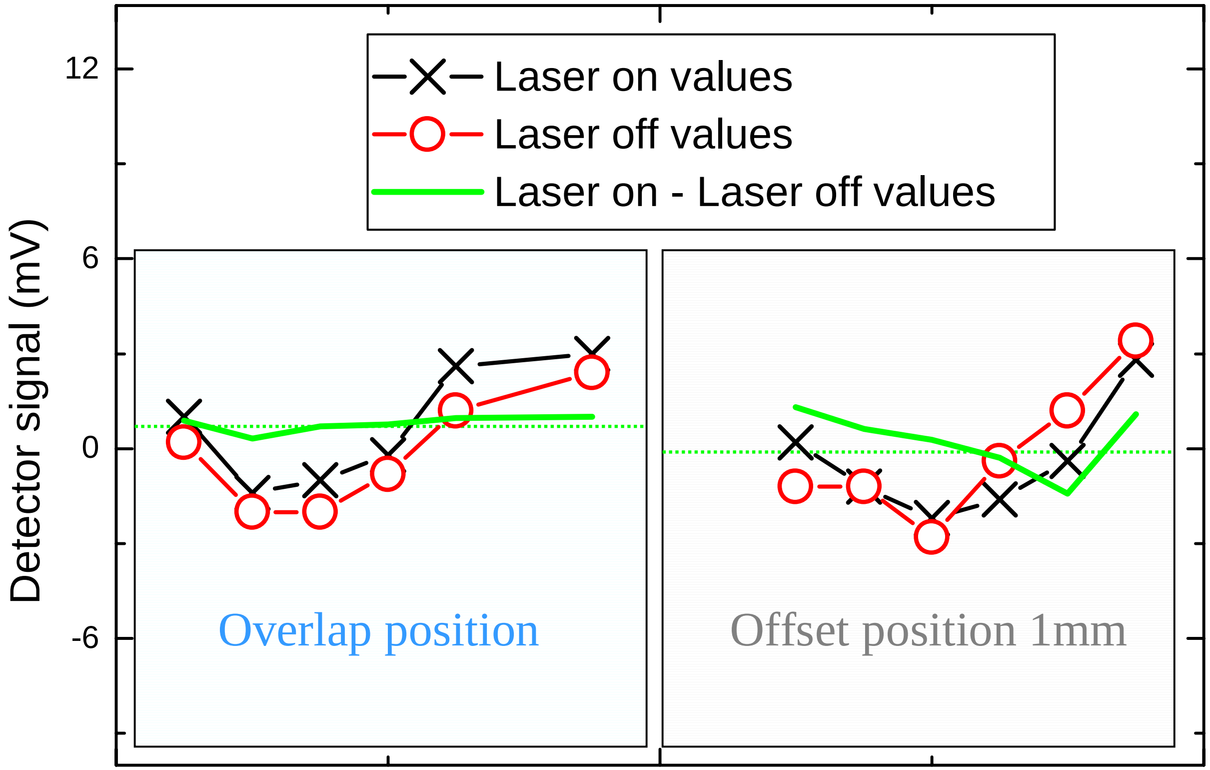


- Statistical noise changes from 0.3 to 3.5 mV
- 9 scans are above the average value

LWS : Scattered photons measurements

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

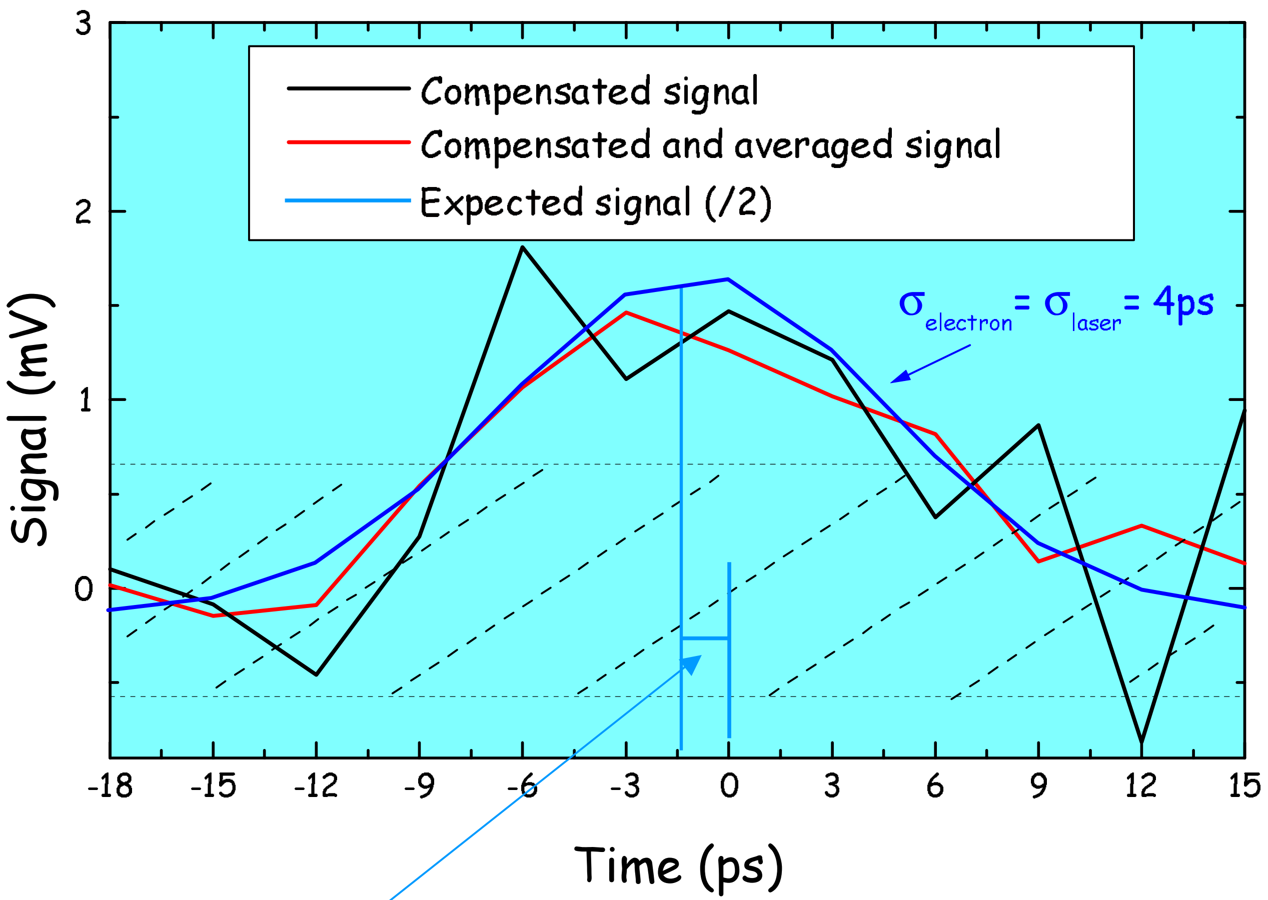


Averaged value
1.04mV

Averaged value
-0.06mV

LWS : Profile measurements

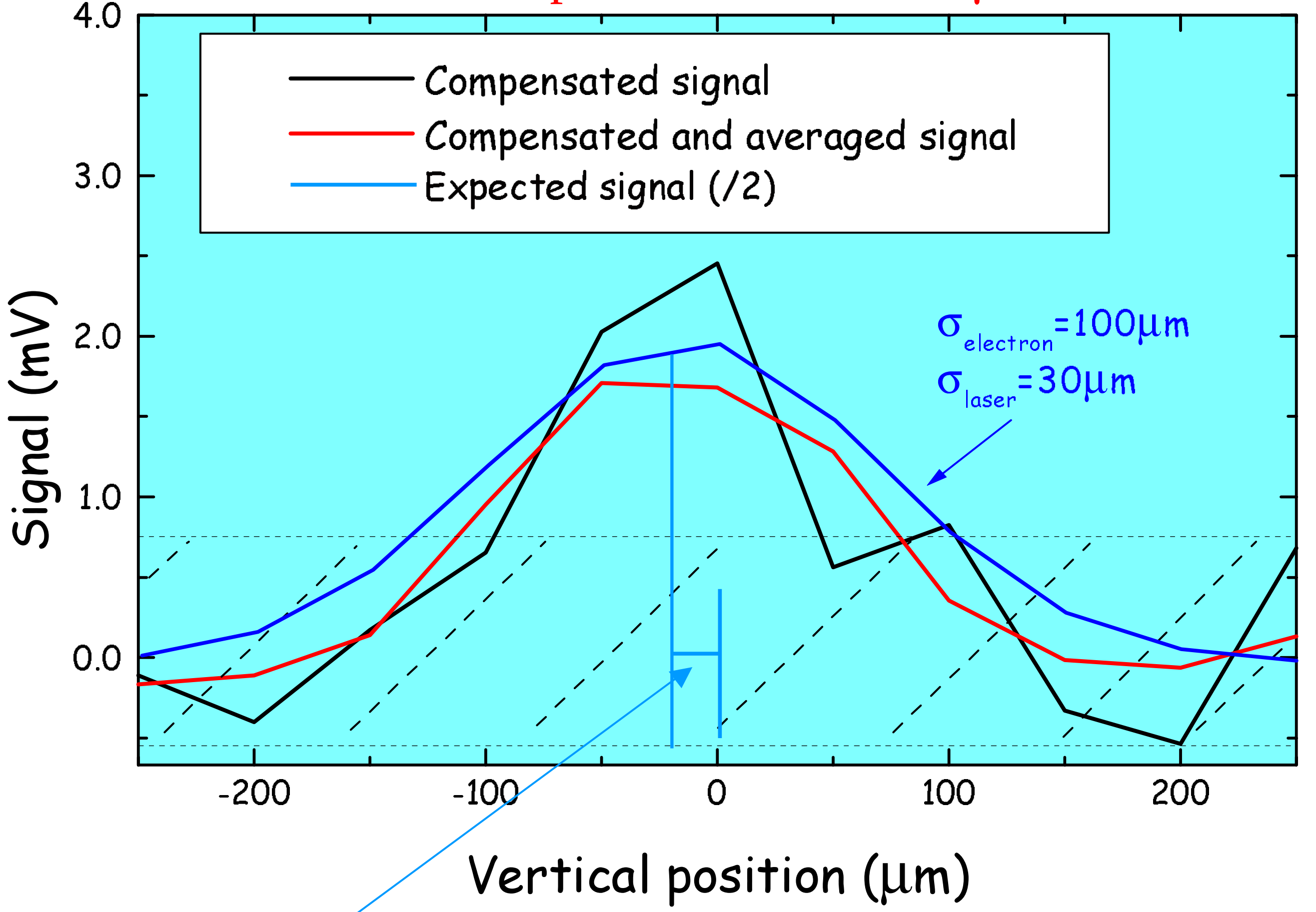
Longitudinal profile : Scan ±18ps



1.5ps offset compared to the overlap values *(2ps offset maximum)*

LWS : Profile measurements

Vertical profile : Scan ± 250µm



25 µm offset compared to the overlap values (150 µm offset maximum)

LWS : Conclusion and Perspectives

• 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)