Ultra-Short Pulse Reconstruction Software in High Power Laser System

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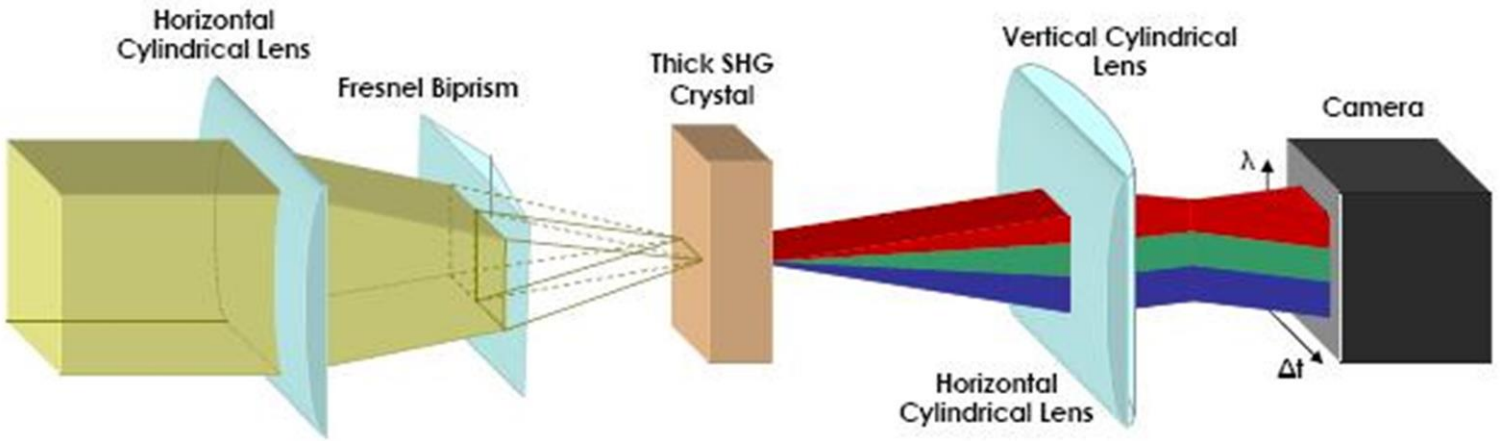
Summary

- Laser Diagnostic: ***Grenouille***
- Software
- Experimental Set-up and Data
- Data processing
- Conclusion

GRating-Eliminated No-nonsense Observation of Ultrafast Incident Laser Light E-fields



Like FROG, GRENOUILLE is a spectrally resolved autocorrelation.
GRENOUILLE set-up is simpler than FROG one.

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Ultra-Short Pulse Reconstruction Software 1/2

The algorithm, on which the software is based, consists of 2 main parts:

- ***Experimental image capture***, image that will be compared with (involves determining the χ^2 "distance") calculated one, the latter produced by a pulse similar to the experimental one;

- ***An iterative loop*** (includes a minimization algorithm) that proposes to vary the arbitrary initial pulse for the χ^2 decreases, succeeding so to obtain a reconstructed pulse as similar as possible to the real one.

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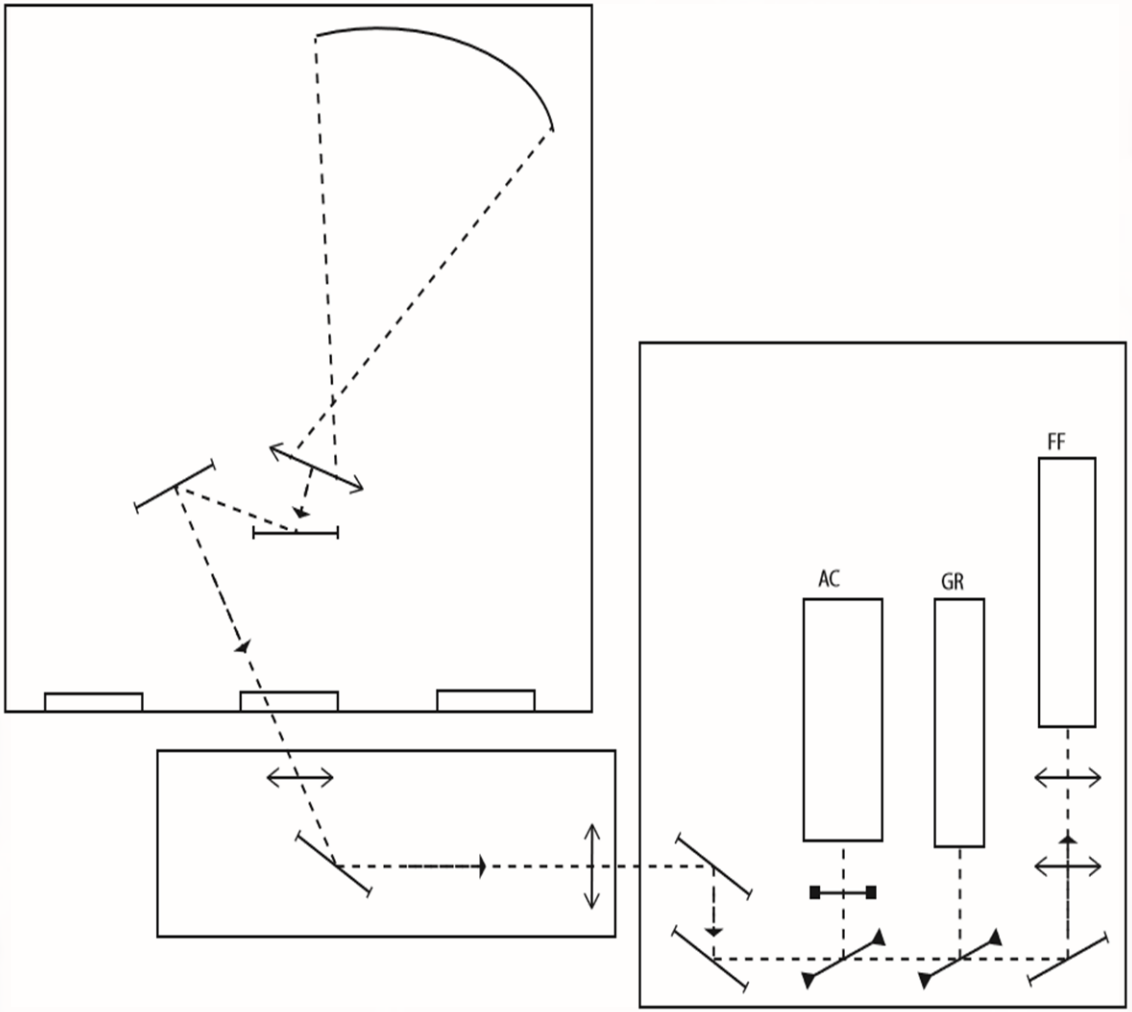
Ultra-Short Pulse Reconstruction Software 2/2

The iterative loop consists in:

- ***Choice of the field*** $E(t)$ similar to the experimental one;
- ***Sampling*** of the field, E_j;
- ***Calculation*** of the GRENOUILLE signal, of the 'distance' χ^2,of the χ^2 gradient with respect to E_j and of χ^2 minimum in the gradient direction;
- ***Updating*** of the new E_j with the minimum position.

The steps are repeated until reaching conditions for which the reconstructed pulse does not vary significantly.

Experimental Set-up



The laser beam (60 cm, mJ, 2 Hz, 1053 nm), leaving the Vulcan TAP compressor, is:

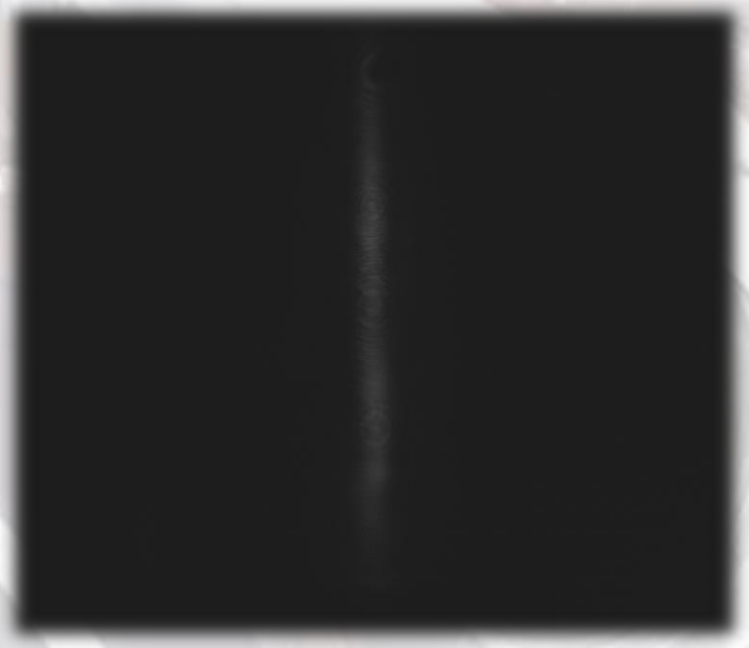
- ***Focused*** by an off-axis parabola (f=180 cm);
- ***Re-collimated*** by a lens (f=34 mm) an reduced to a D=1cm;
- ***Propagated*** outside the vacuum chamber thanks to a pair of lenses;
- ***Sent inside*** the diagnostics (AC,GR) thanks to reflective mirrors;

Experimental AC Data

In the CPA, adjusting the stretching factor, simply by moving the grating, can compensate the different dispersion in order to obtain shorter pulses.

AC_13

AC_14



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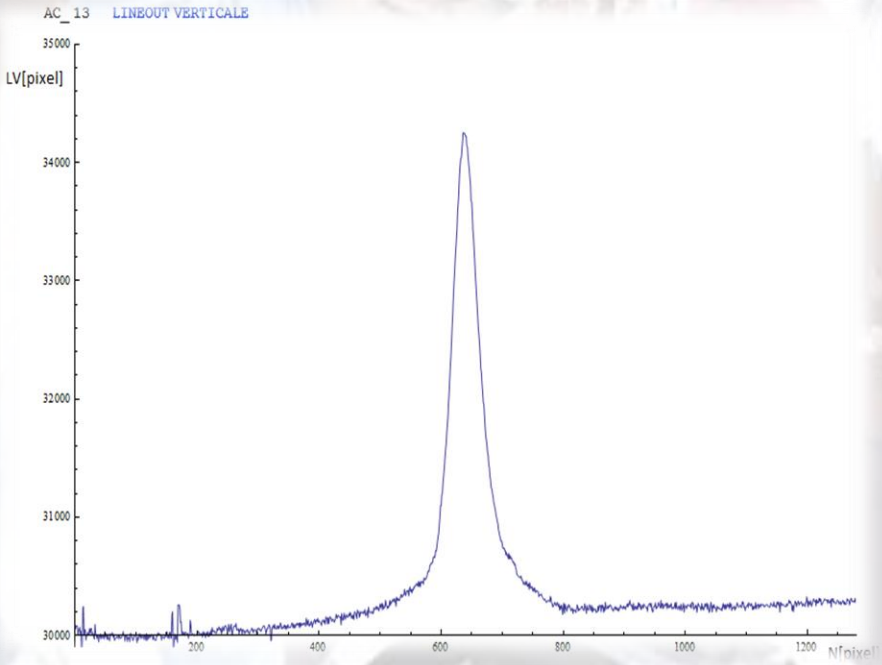
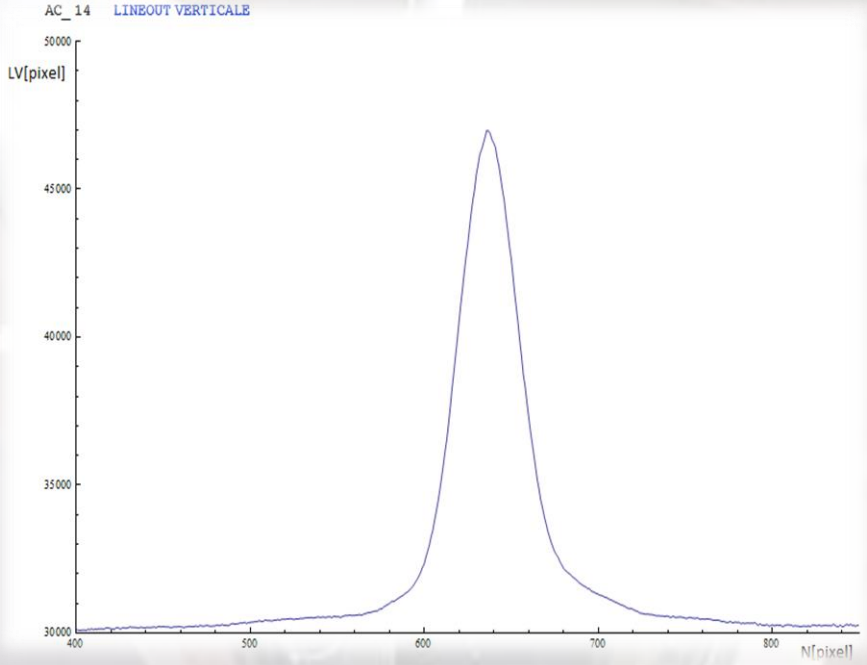
AC Data processing

Horizontal lineout of the experimental images:

AC_13



AC_14



Found FWHM of the pulse thanks to

$$1.54\,\Delta\tau_p^{FWHM} = \Delta\tau_A^{FWHM}$$

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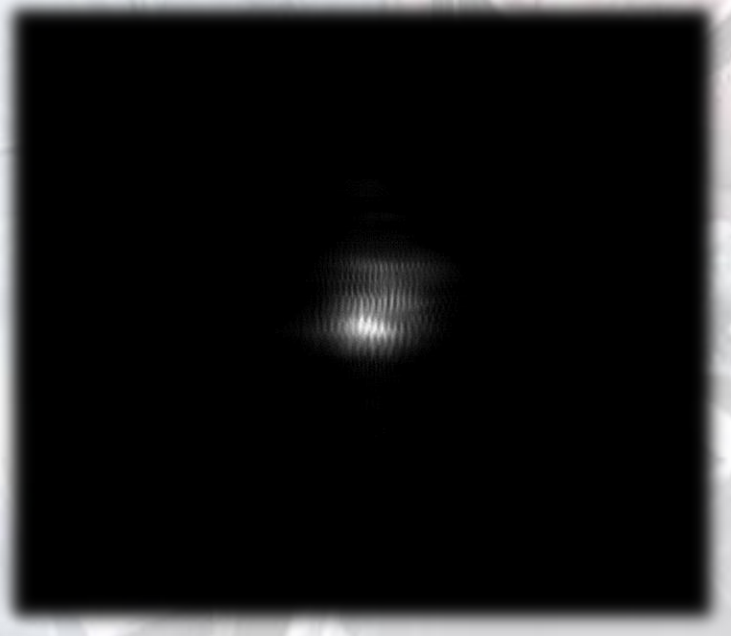
GRENOUILLE Data processing

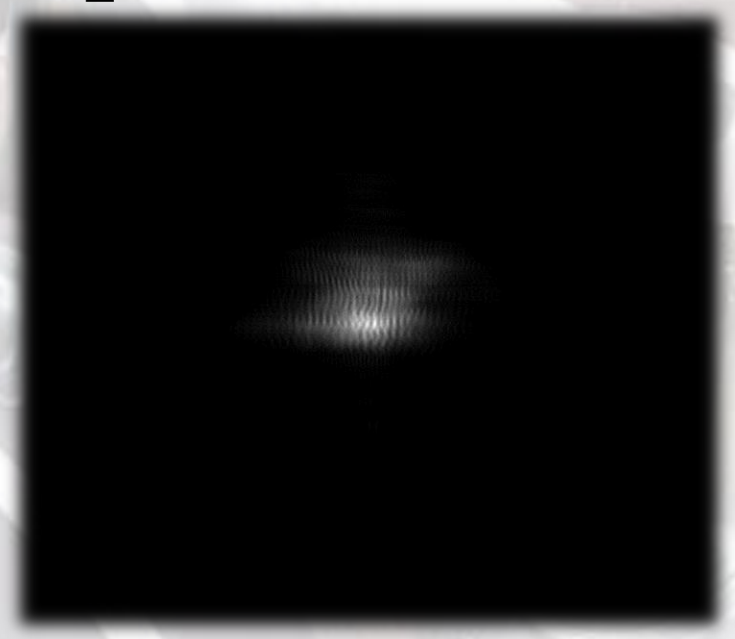
Before processing, the experimental images have been:

- Subtracted from the background;
- Re-scaled and Centered in the maximum of I(t).

GR_25



GR_26



GRENOUILLE Data processing

The reconstructed images are:

GR_25

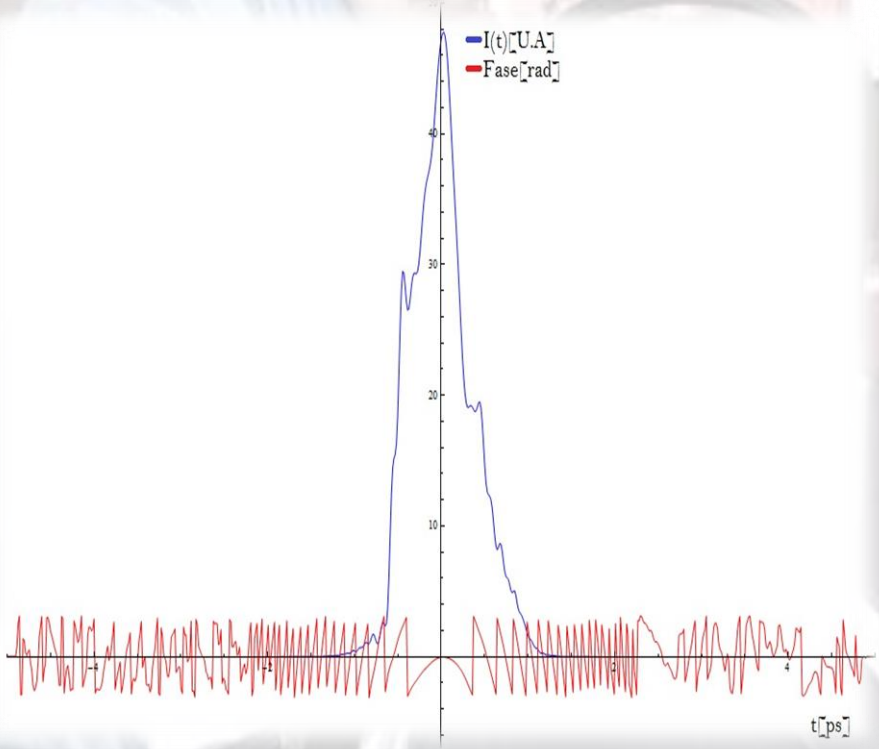
GR_26

- The reconstruction is not perfect (experimental images have more structures);
- Experimental image not symmetric (chromatic aberrations).

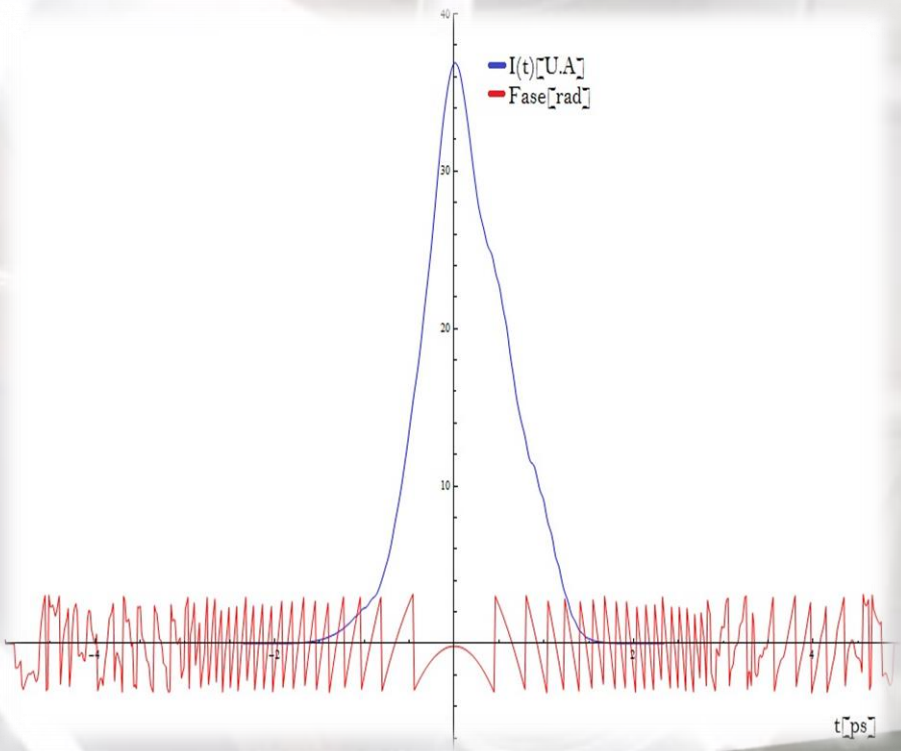
GRENOUILLE Data processing

The reconstruction software gave us:

GR_25



GR_26



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Data processing

The results of the measurement:

Images	Stretcher position (mm)	FWHM AC (ps)	FWHM AC pulse (ps)	FWHM GR pulse (ps)
GR_25	17.5			0.717
GR_26	17.5			1.0038
AC_14	17.5	1.0836	0.7662	
AC_13	17.5	1.3674	1.0071	

The last two columns show the excellent agreement between the Autocorrelation and GRENOUILLE measurement.

Conclusion

- In this experimental research was analyzed for the first time, in Target Area Petawatt of Vulcan, the laser pulse with a ***different technique*** from the AC.

- The results are compatible with the standard technique of measurement (AC) and give us a ***convincing pulse shape***.

- The analysis will be extended to data taken at ***full power*** to try to improve the characterization of laser pulses of such powers (1PW).