Analysis on statistical properties of FLASH radiation in spectral domain

Svitozar Serkez,

Natalia Gerasimova

DESY

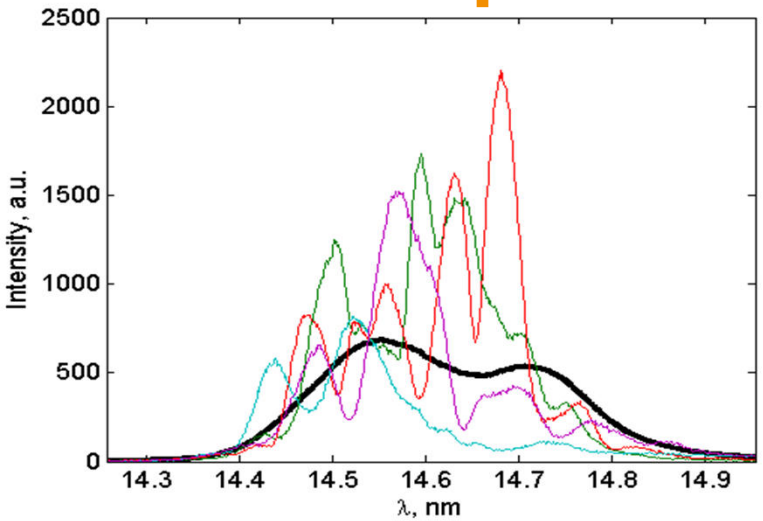
Hamburg, January 17, 2012

HELMHOLTZ ASSOCIATION

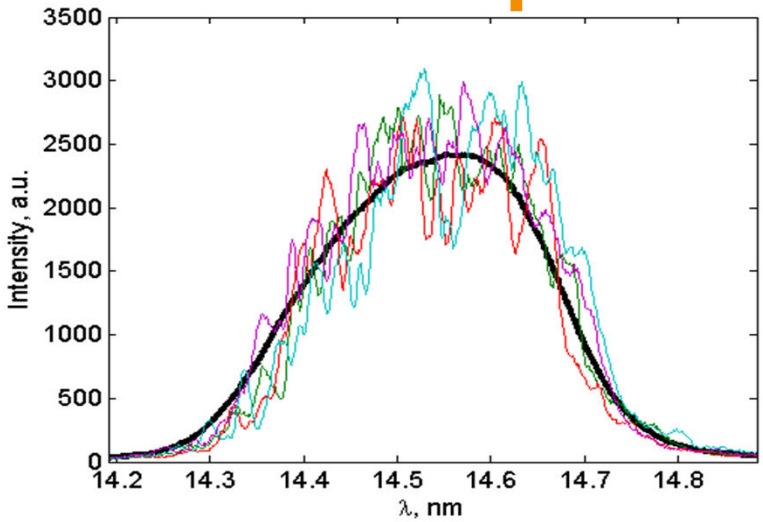
DESY

Analysis of statistical properties of FLASH radiation in spectral domain to characterize pulse duration

150 pC



500 pC



January 20-21, 2011

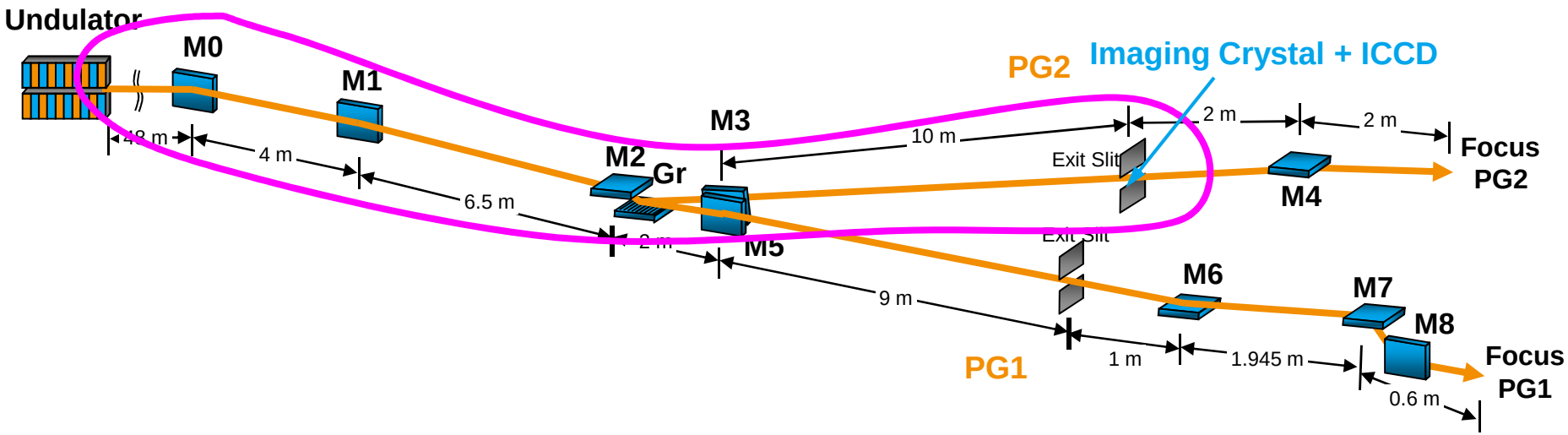
High resolution spectrometer at the PG2 beamline

(Resolving Power > 10.000)

High Resolution Spectrometer in the PG2 beamline

Spectrometer mode of operation

M. Martins et al., Rev. Sci. Instrum. 77 (2006) 115108
N. Gerasimova et al. , J. Mod. Opt. 58 (2011) 1480



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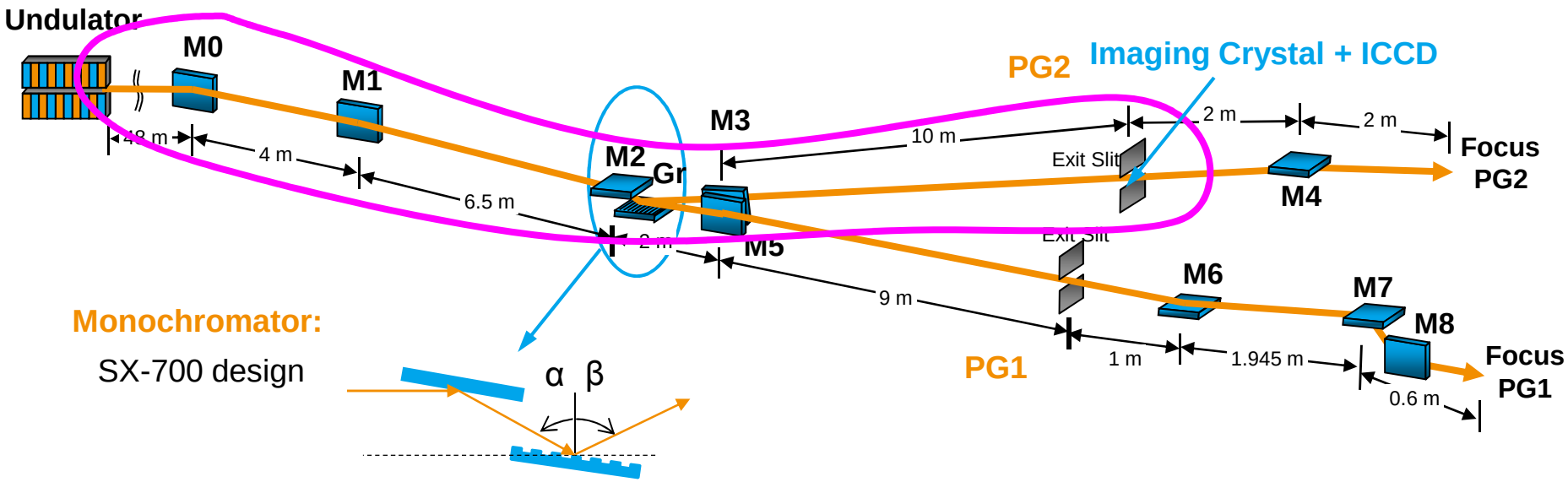

> **Free choice** of best **compromise between flux and resolution** on the **same grating** by varying cff → **High flexibility**

> **Slitless** → **Accept whole beam**

> **Precise calibration**

precise measurements:
- average bandwidth
- central wavelength

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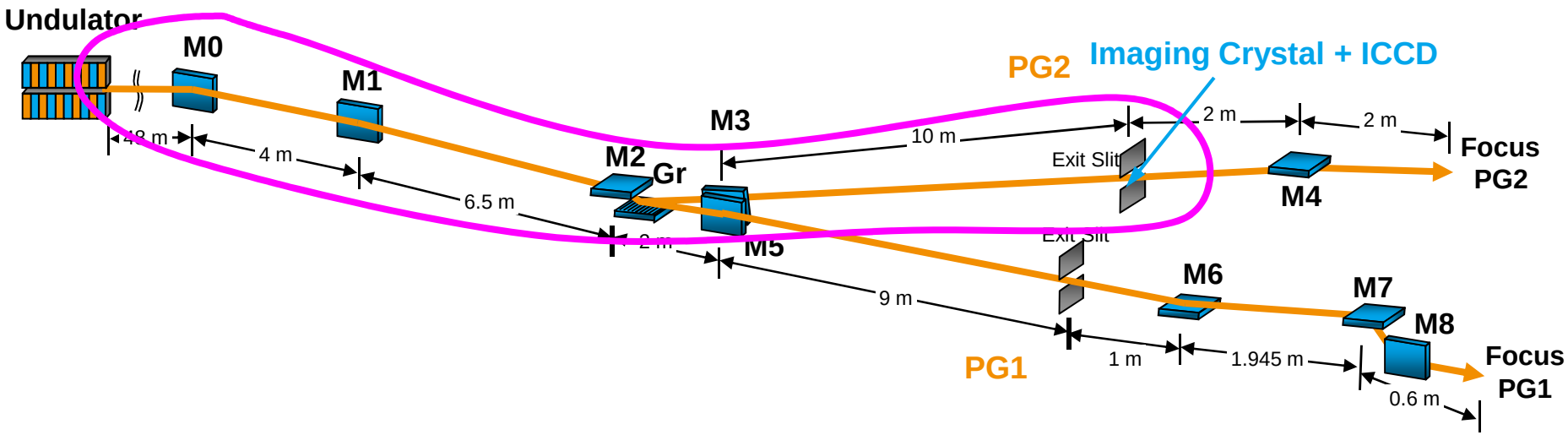
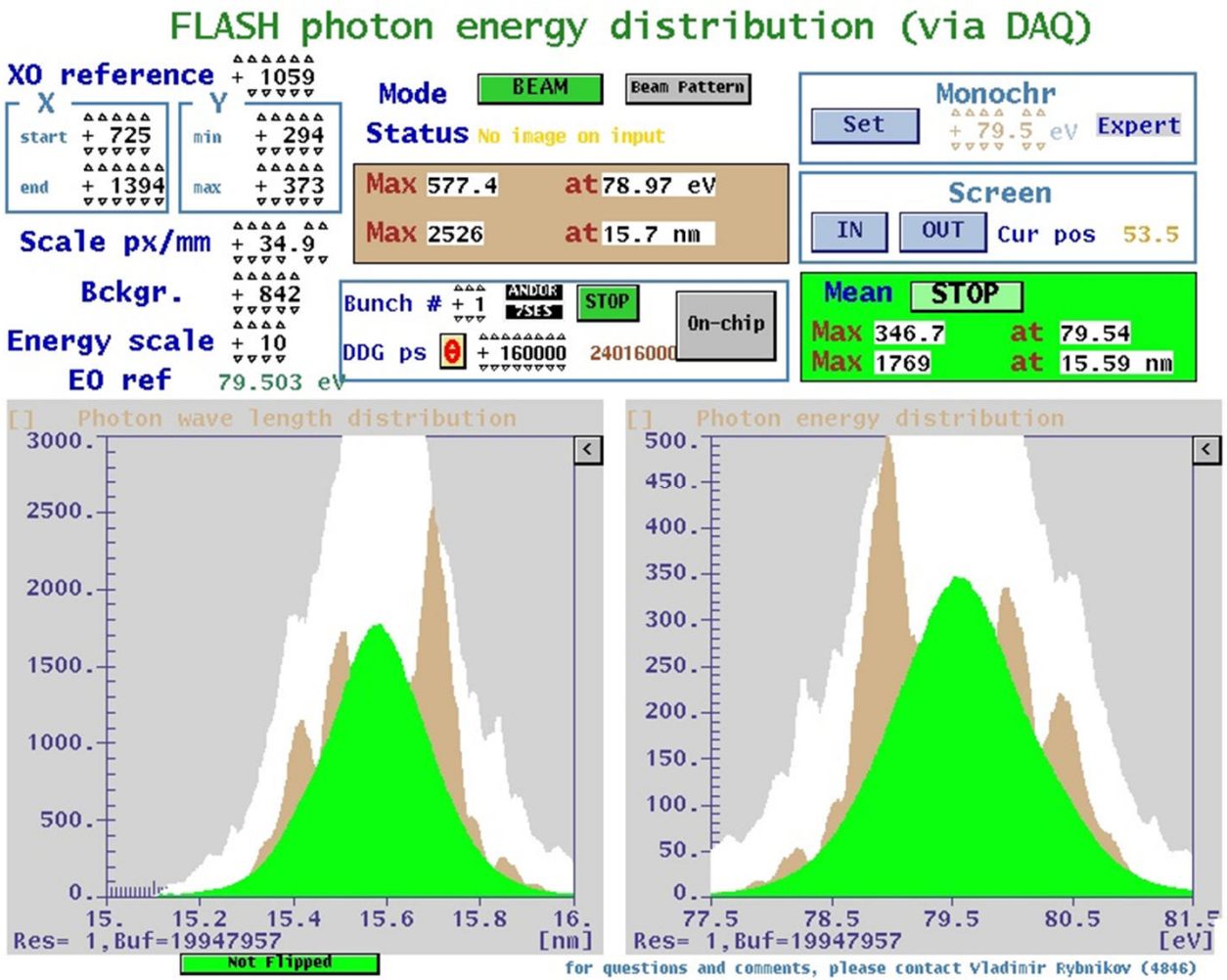


> **Resolution > 10.000**
measured in 1st diffraction order,
low-resolution grating

> **High sensitivity**

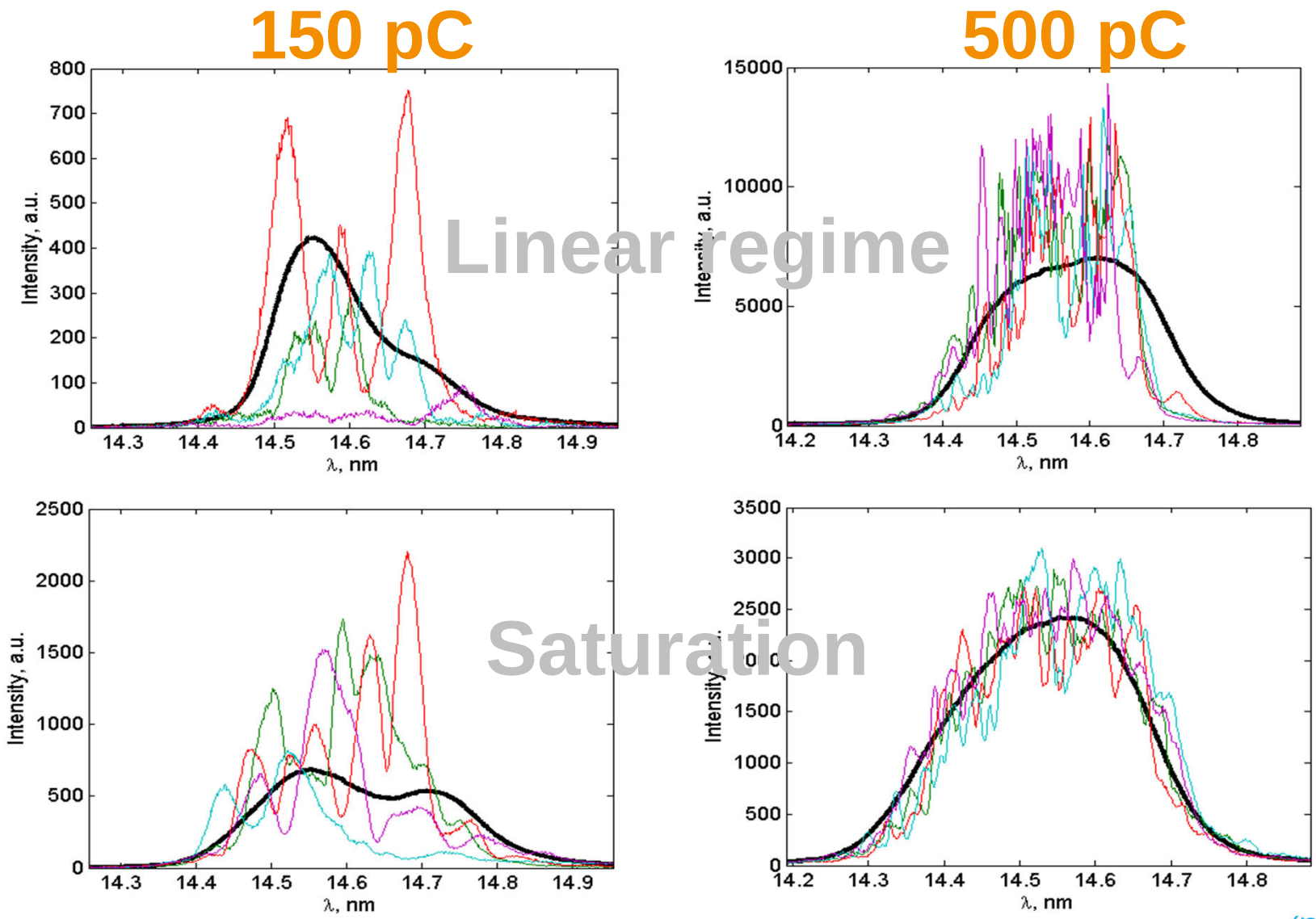
- **high harmonics**
- **linear regime of operation**
- **work in high diffraction orders**

High Resolution Spectrometer in the PG2 beamline



Spectrometer software and Data Aquisition: ***Vladimir Rybnikov***

Analysis of statistical properties of FLASH radiation in spectral domain to characterize pulse duration

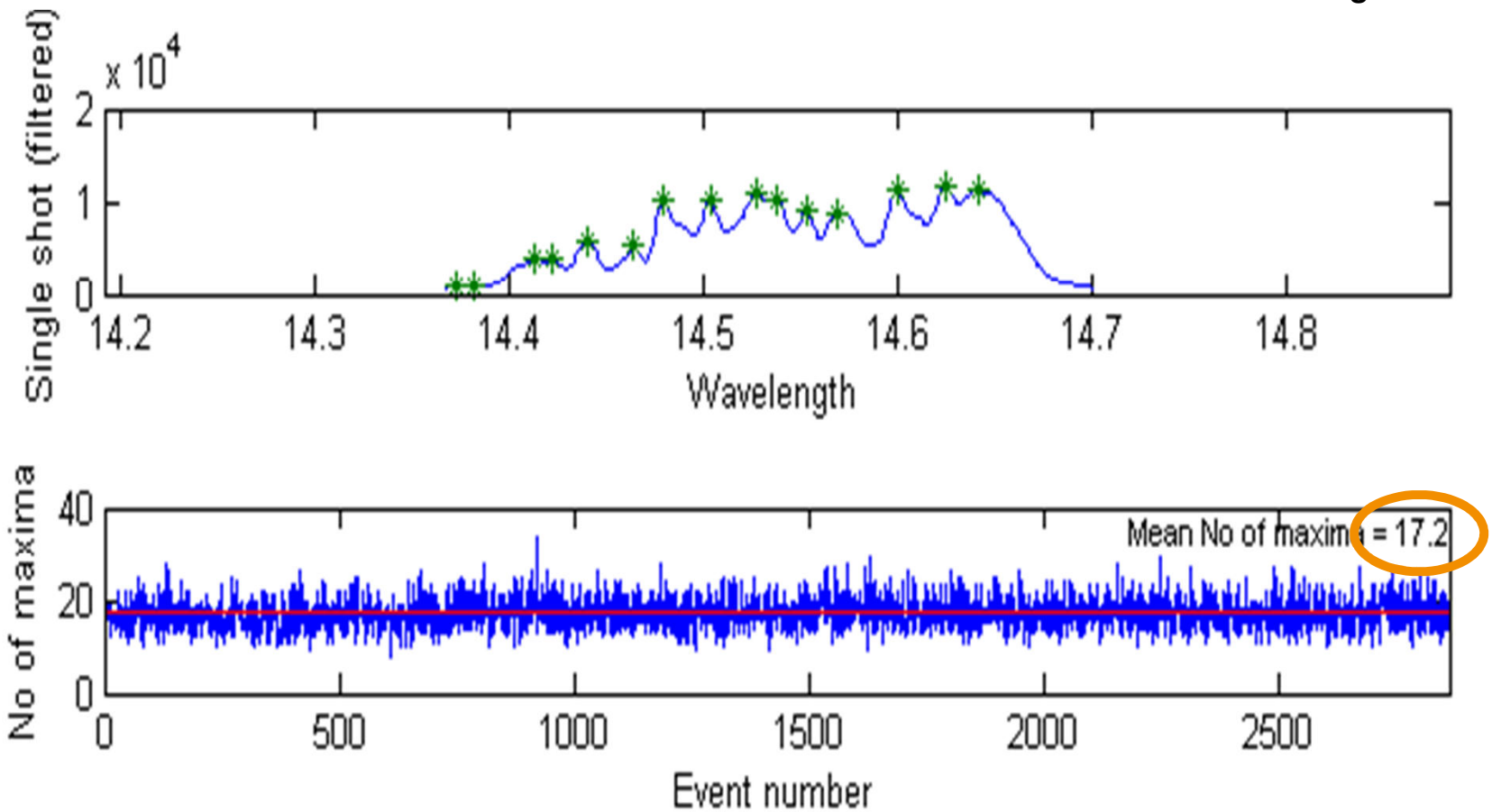


Number of spikes / number of modes

Linear regime

Number of spikes per frequency unit (no energy chirp)**: N ~ 0.64*Tb / (2*π)**

Tb – bunch length



Statistical Analysis code: ***Svitozar Serkez***

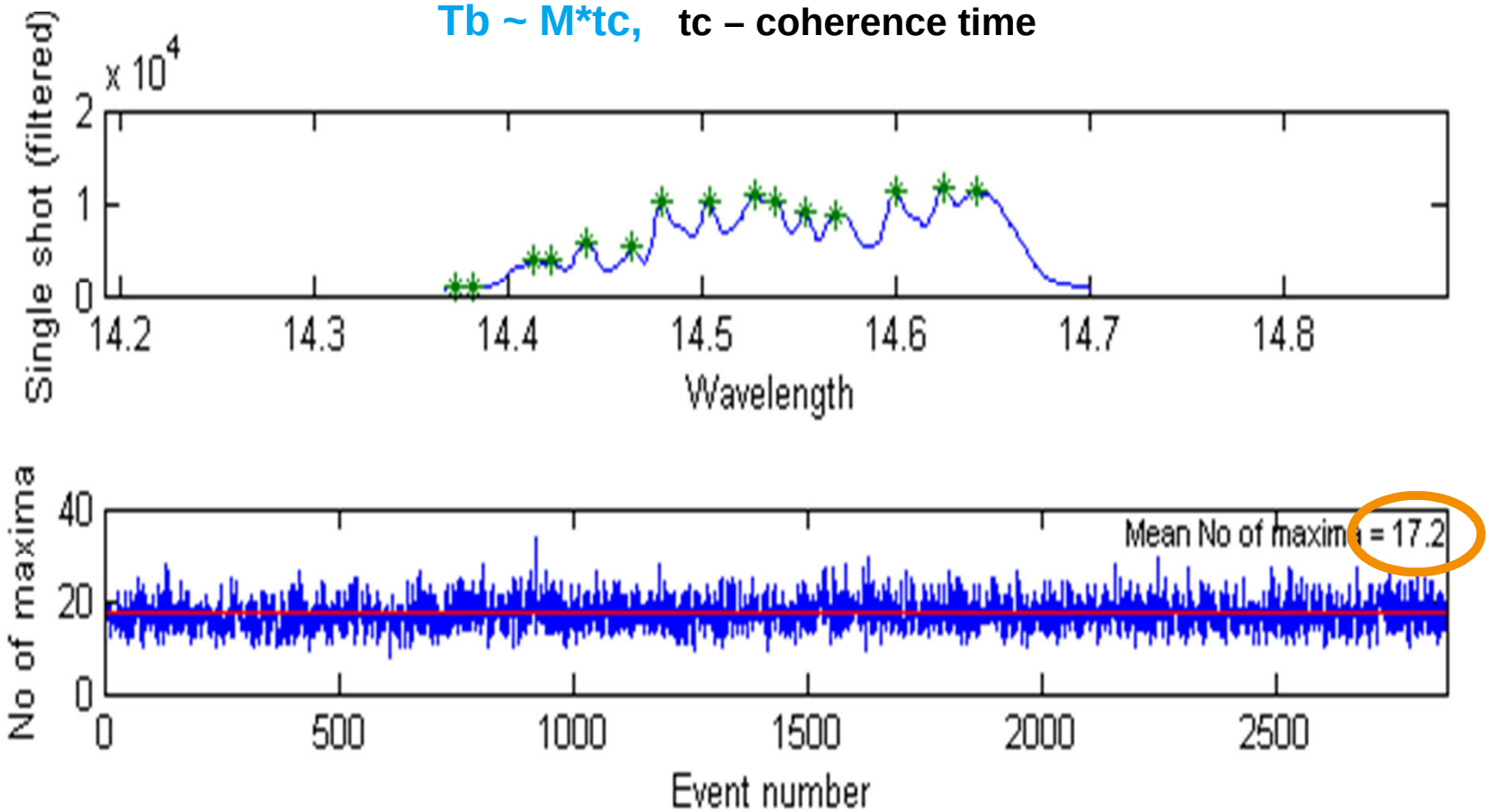
Number of spikes / number of modes

Linear regime

Number of spikes: **Ns ~ 0.7*M,**

M = 1/σ^2, **number of modes**

Tb ~ M*tc, **tc – coherence time**



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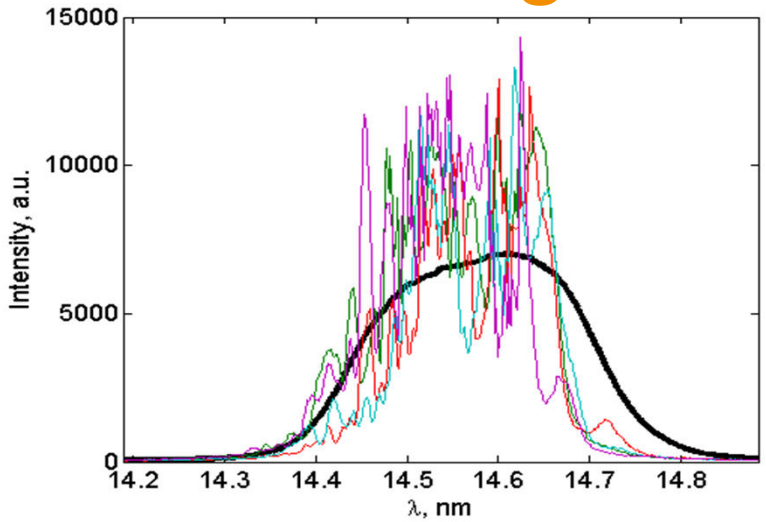
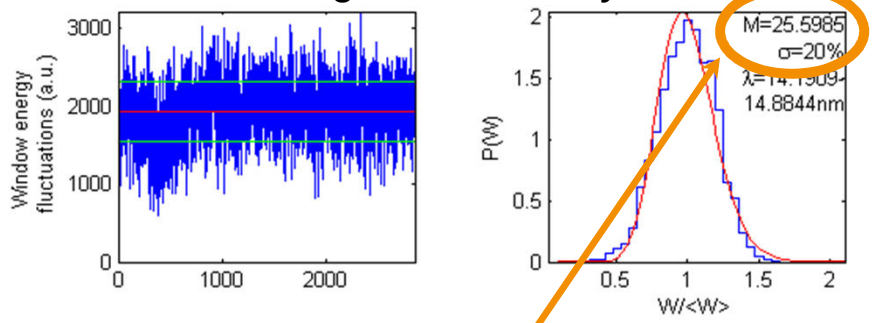
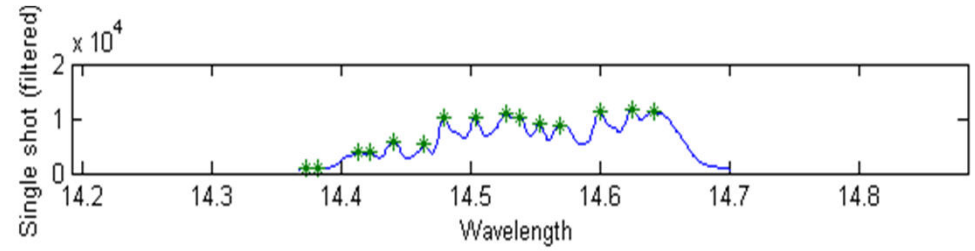
Number of spikes / number of modes

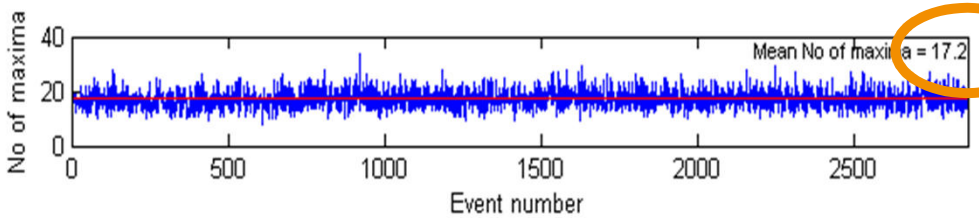
Linear regime



Integrated intensity







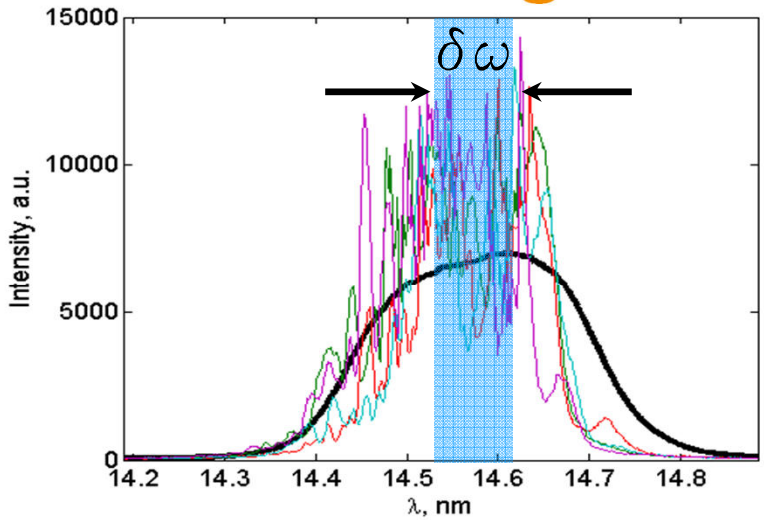
$M = 1/\sigma^2$, number of modes

$Tb \sim M*tc$, tc – coherence time

Statistical Analysis code: ***Svitozar Serkez***

Number of spikes / number of modes

Linear regime



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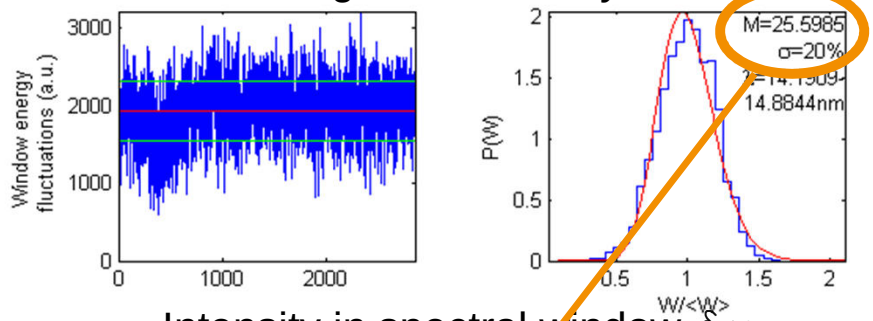
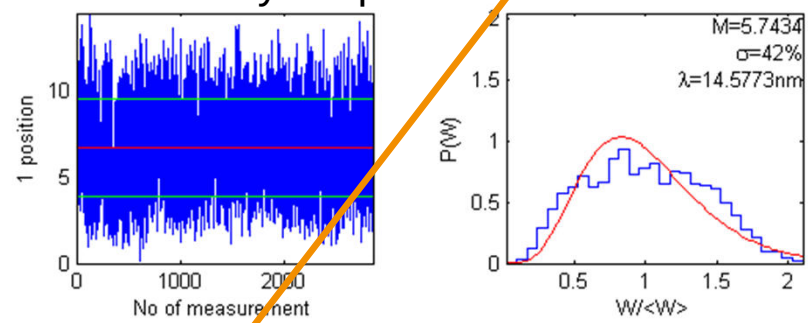
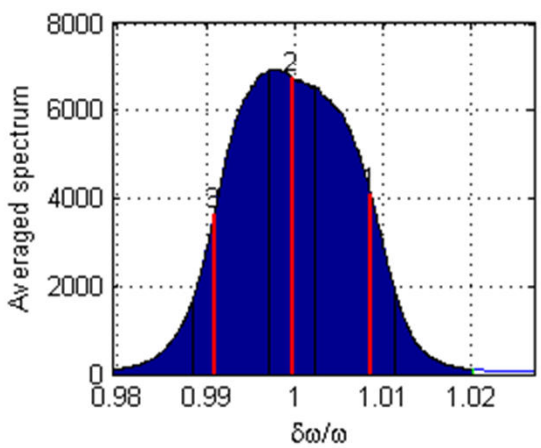
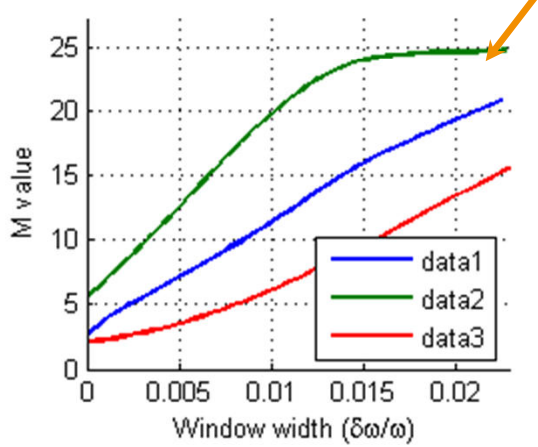


Intensity in spectral window $\delta\omega$







$M = 1/\sigma^2$, number of modes

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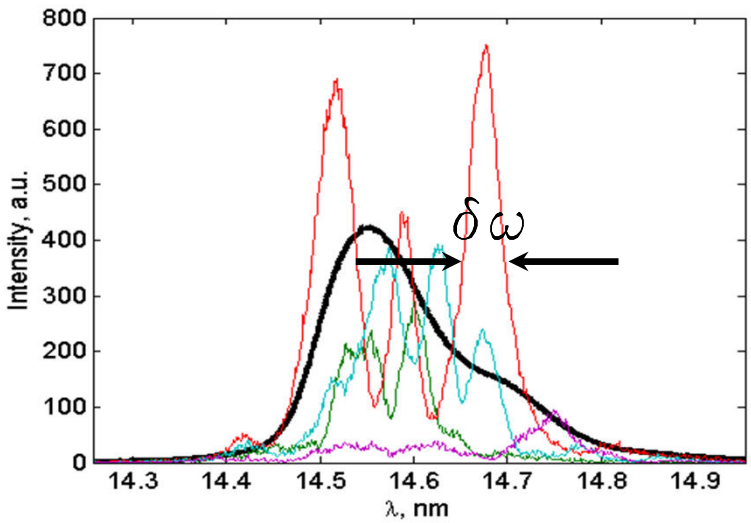
Statistical Analysis code: ***Svitozar Serkez***

Spectral coherence / second order correlation function



Spectral coherence

$$\omega c = \int_0^{+\infty} \left| G_1(\omega - \omega') \right|^2 d(\omega - \omega')$$

Second order correlation function

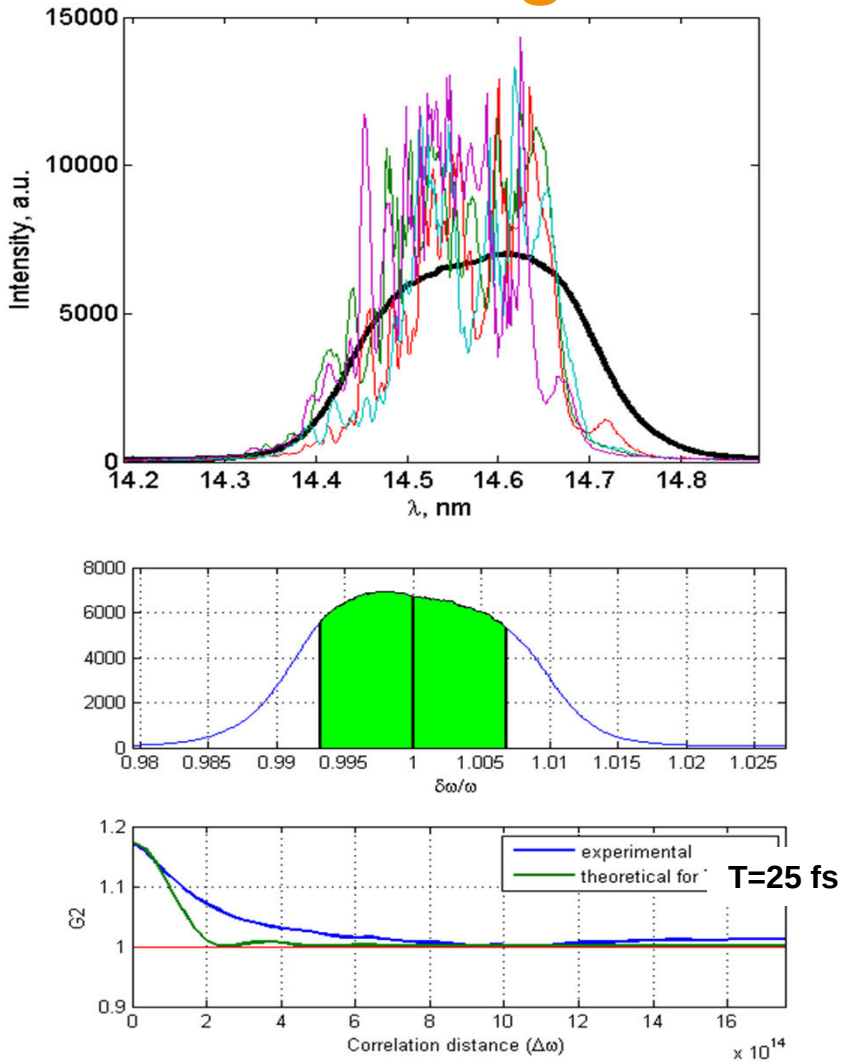
$$G_2(\omega, \omega') = \frac{\left\langle \left| \bar{E}(\omega) \right|^2 \left| \bar{E}(\omega') \right|^2 \right\rangle}{\left\langle \left| \bar{E}(\omega) \right|^2 \right\rangle \left\langle \left| \bar{E}(\omega') \right|^2 \right\rangle}$$

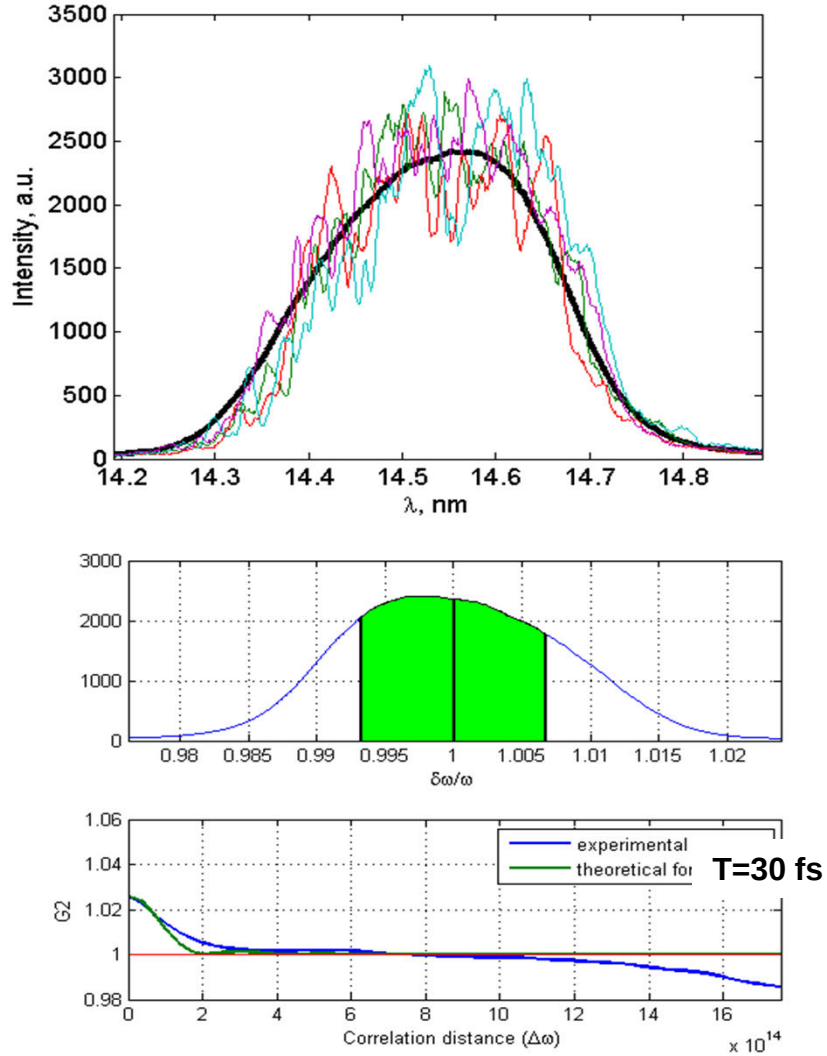
$$G_2(\omega, \omega') = 1 + \left| G_1(\omega, \omega') \right|^2$$

Spectral coherence / second order correlation function

Linear regime

Saturation 500pC





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Spectral coherence / second order correlation function

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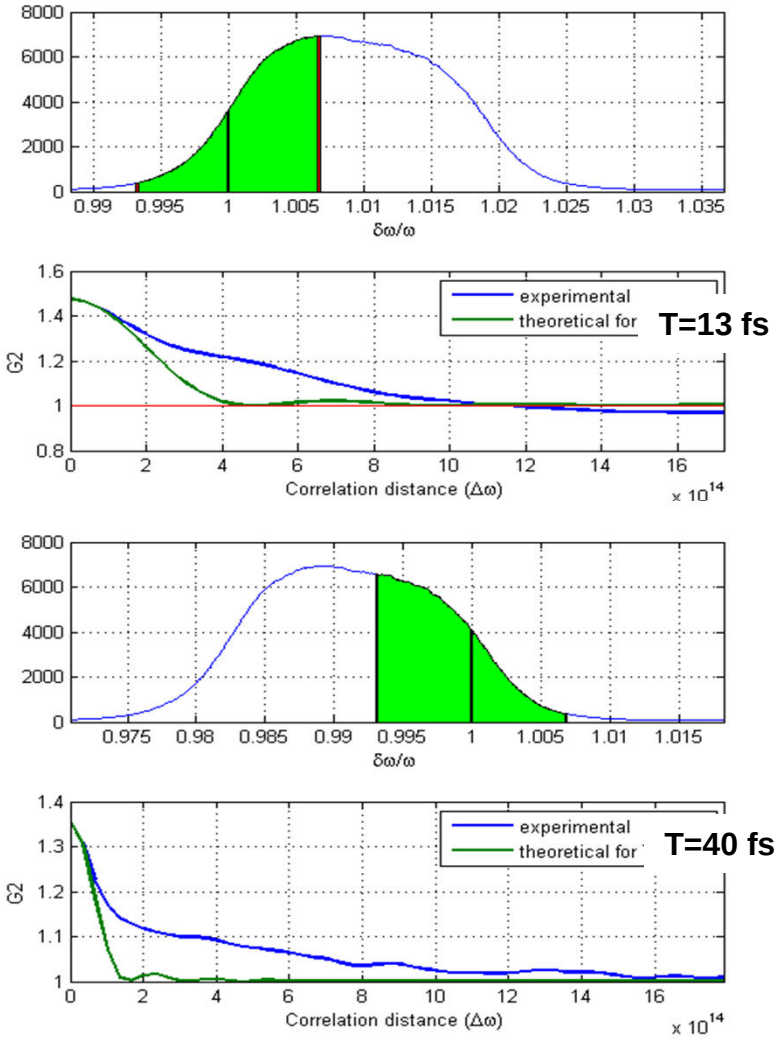
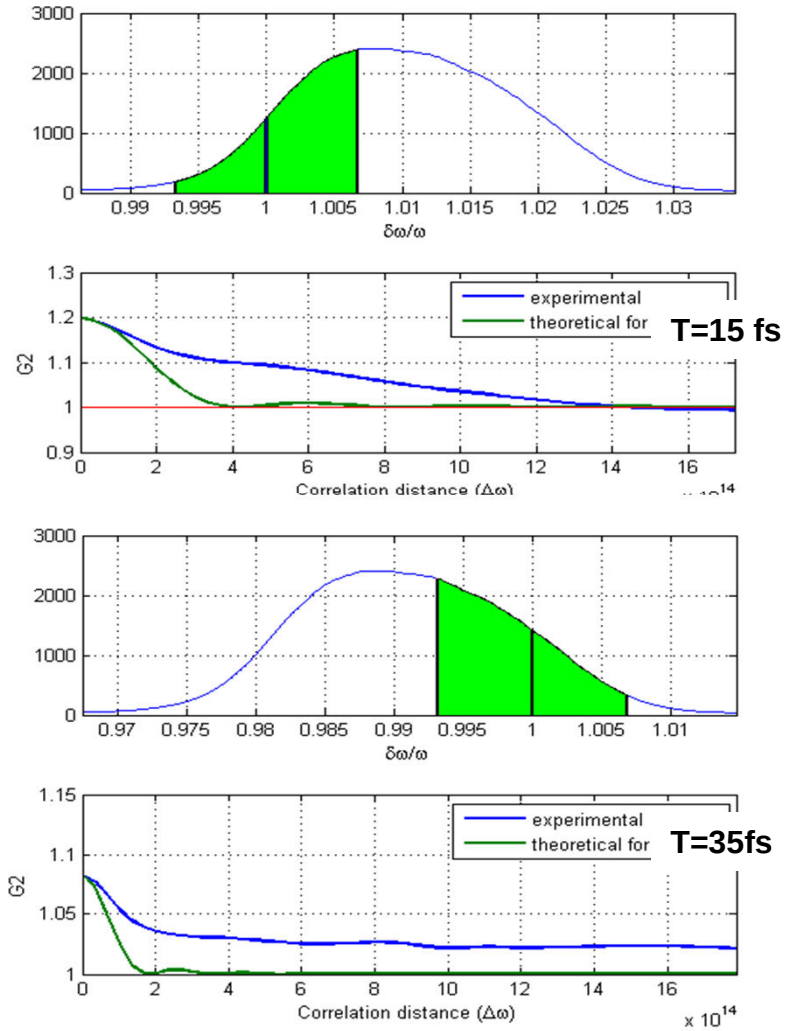


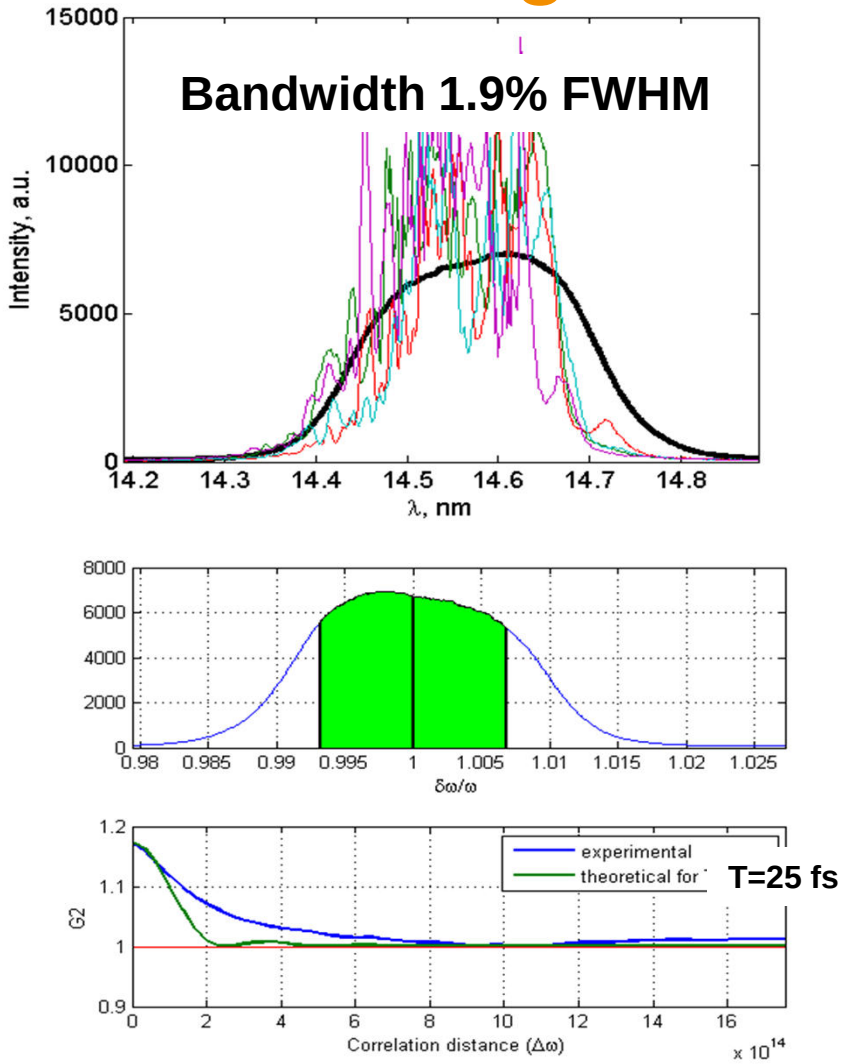


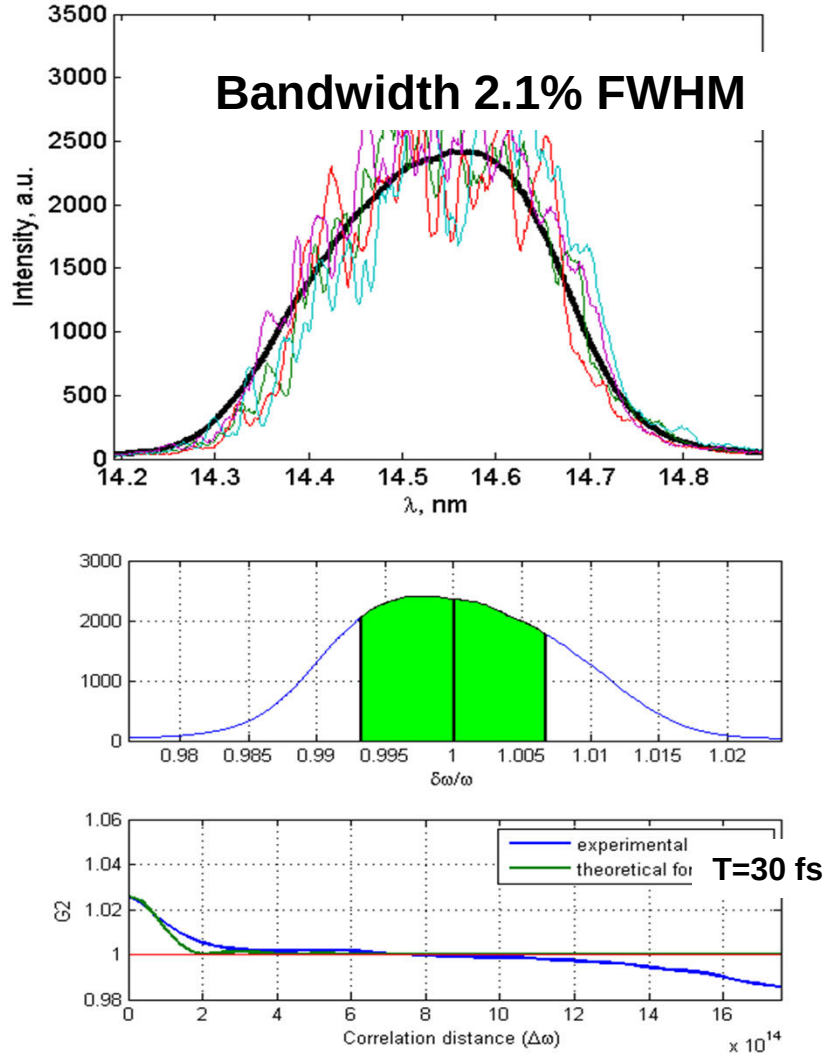
Statistical Analysis code: ***Svitozar Serkez***

Spectral coherence / second order correlation function

Linear regime

Saturation 500pC



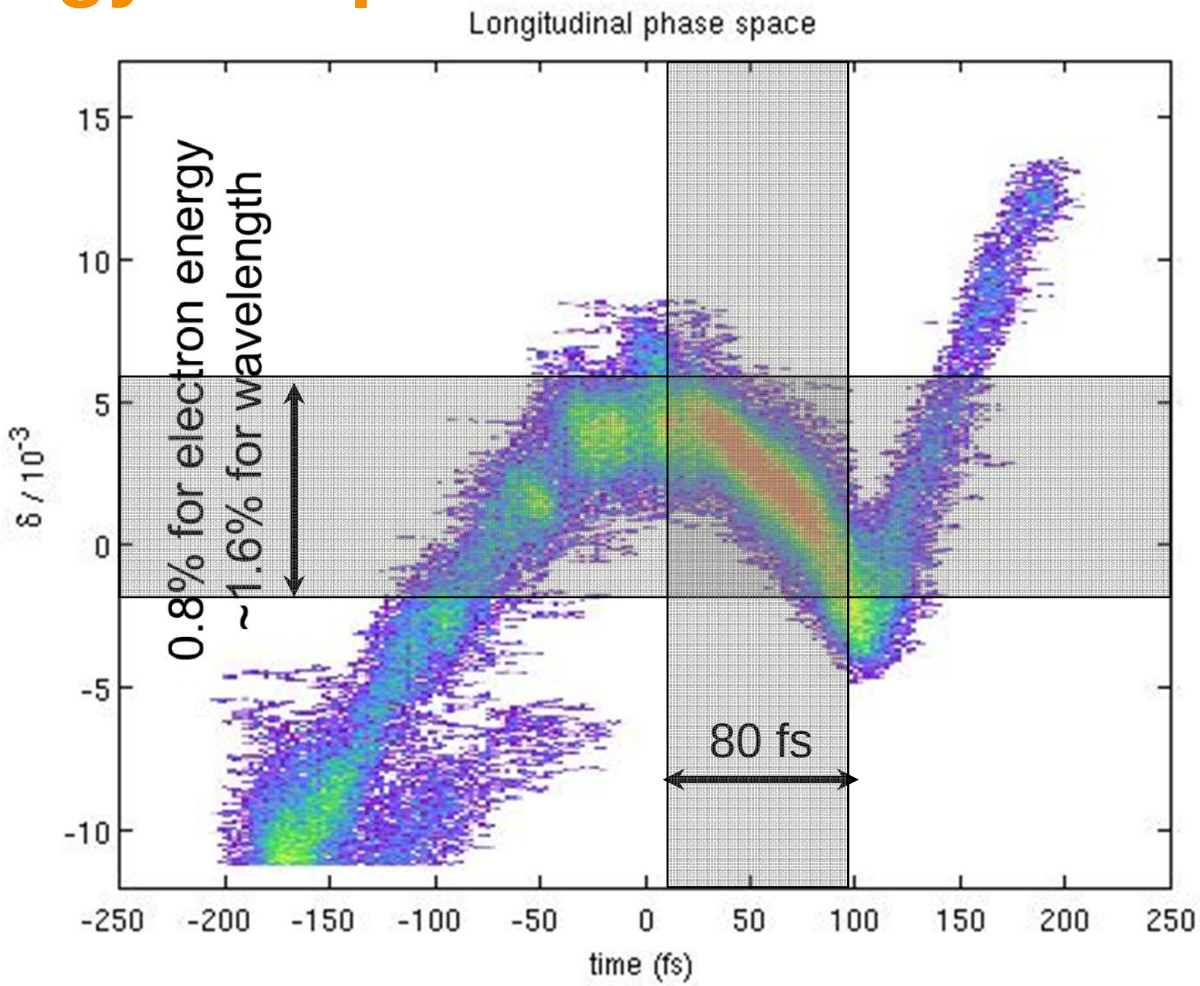


Statistical Analysis code: ***Svitozar Serkez***

Analysis of statistical properties of FLASH radiation in spectral domain to characterize pulse duration

Energy Chirp

500pC

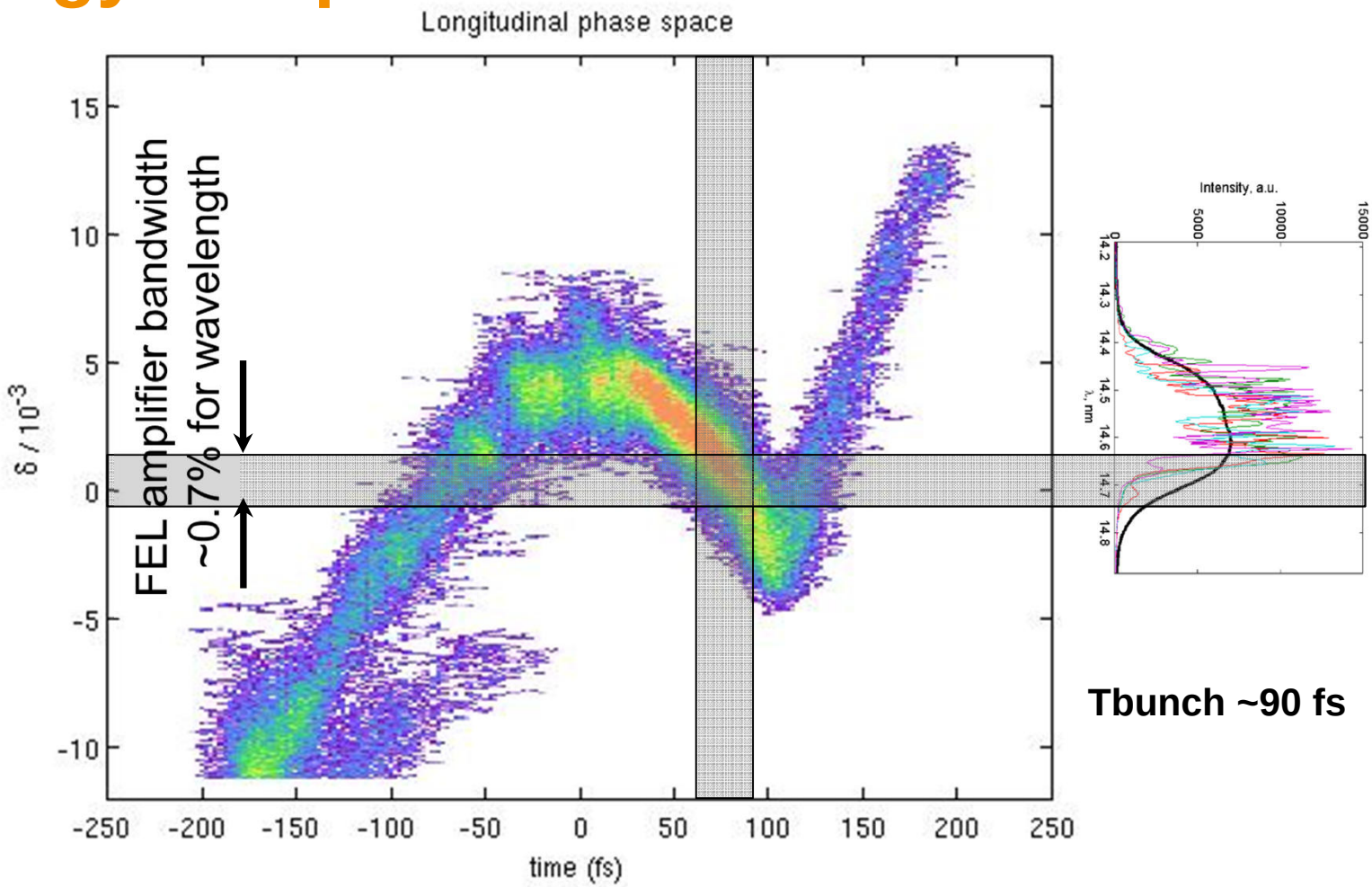


LOLA measurements: ***Christopher Behrens***

Analysis of statistical properties of FLASH radiation in spectral domain to characterize pulse duration

Energy Chirp

500pC

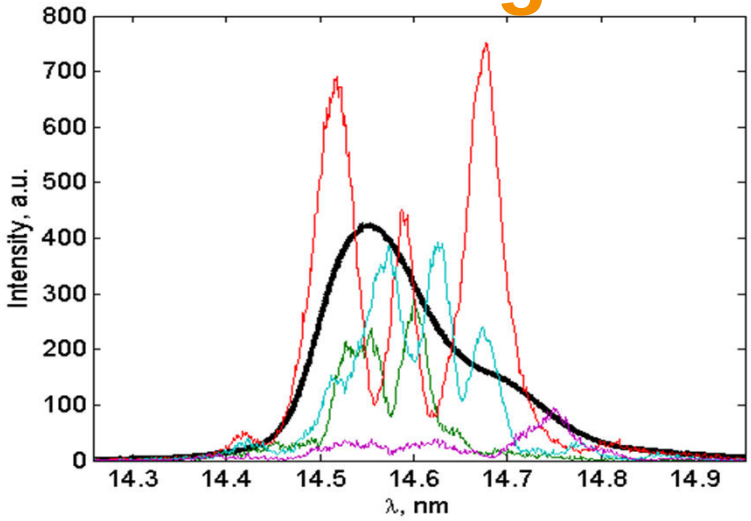


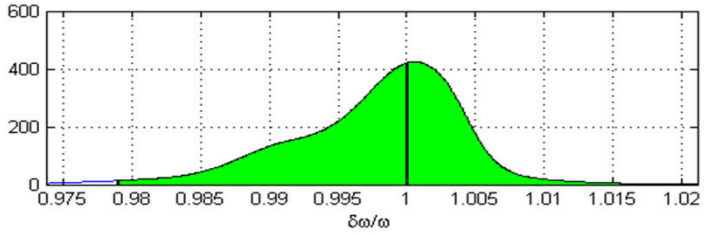
Tbunch ~90 fs

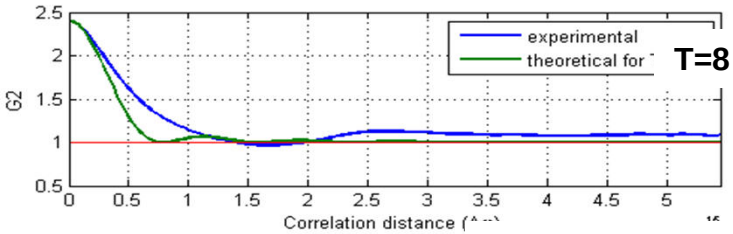
LOLA measurements: ***Christopher Behrens***

Spectral coherence / second order correlation function

Linear regime

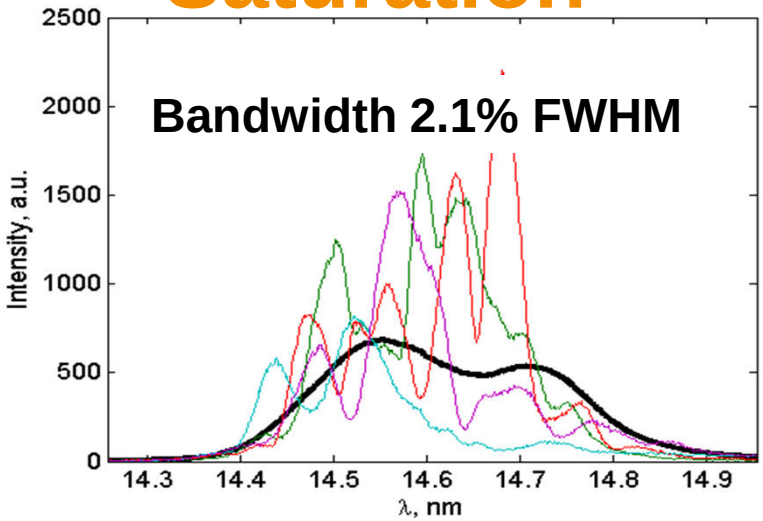


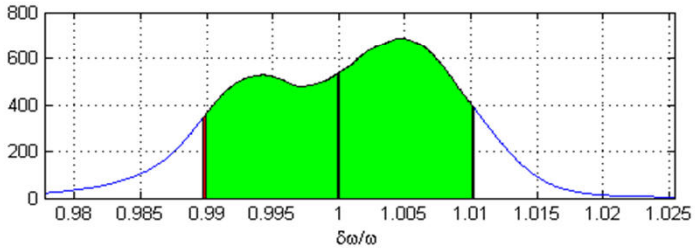


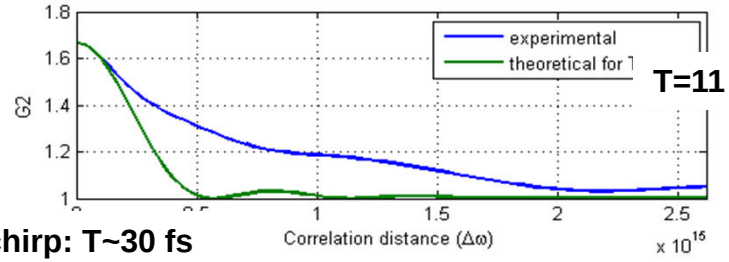


T=8 fs

Saturation 150pC







T=11 fs

Taking into account energychirp: T~30 fs

Statistical Analysis code: ***Svitozar Serkez***

Acknowledgments

- E. Saldin, E. Schneydmiller, M. Yurkov (DESY)
- C. Behrens (DESY)
- V. Rybnikov (DESY)
- FLASH team

Acknowledgments

Thank you