Alberto Lutman (February 9th 2011)

Soft X-Rays beam pulse length measurement

Description of topic and motivation:

The goal is to measure the ultra-short soft x-rays pulse length through the analysis of the statistical properties of the SASE FEL spectra. The information on the pulse length is contained in the correlation function of the intensity spectra taken after a spectrometer. The method allows measuring both the beam pulse length and the spectrometer resolution, as long as the latter is much smaller compared to the FEL bandwidth, so the value of the spectrometer resolution is not needed for the measure. The idea proposed by Jacek Krzywinski has been developed including arbitrary time profiles and addressing non stationary issues like spectra jitter, statistical gain, and impact of the background noise. Further, since theory is developed for the exponential growth regime, numerical simulations have been run to show that the method is reliably applicable also at saturation and deep saturation. Finally the method has been applied to a first set of experimental data, providing good bunch length estimates.

Time tables of milestones:

- Theory
  Include arbitrary time profiles (done)
  Impact of the spectra jitter (done)
  Impact of statistical gain (done)
  Impact of spectrometer background noise (done)
  Possible extensions:
    Include energy chirp effects (for a linear energy chirp, 2 weeks, 0% done, for two Gaussians with different energies, few days, 80% done)
    Extensions are not strictly needed for any deliverable.

- Simulations
  Use the method on simulated data in exponential growth, at saturation, in deep saturation to show that pulse length measure is reliable and that spectrometer resolution is not needed (done)

- Experimental Results
  Analyze data collected November 2nd 2010 (done)
  Improving the code that make spectra projections from 2D images (1 week, with help of Juhao Wu and Marc Messerschmidt)
  Analyze data collected January 26th 2011 (2 weeks needed, 0% done)

- Writing Paper
  A paper is currently under writing, it comprises theory, simulations ad first experimental results. Results of January 26th 2011 are not yet included. After results are obtained
another week will be needed to include them and finalize the paper. (1 week after results)

- Implement a control room tool
  To analyze the data a Matlab GUI has been developed. The GUI allows selecting a subset of the collected spectra, to visualize the data and to perform the measure. The GUI if improved, removing bugs, and making it simpler to use, could become a control room tool to evaluate the bunch length (If it is decided to do so, I’m not sure about how long could it take, nor who could help to do this)

**Deliverables:**

1) **Journal paper “Soft X-Rays beam pulse length measurement”:**
   
is in good status of advancement (~80%), and will need about one month to be fully completed.

2) **Control Room tool to perform the measure:**
   
The current Matlab GUI that analyzes the data can be improved to be more stable, reliable, better looking and easier to use and deployed as control room tool to perform the measure. The eventual requirements for a working control room tool should be discussed.