Opportunities for Two-color Experiments at the SASE3 undulator line of the European XFEL

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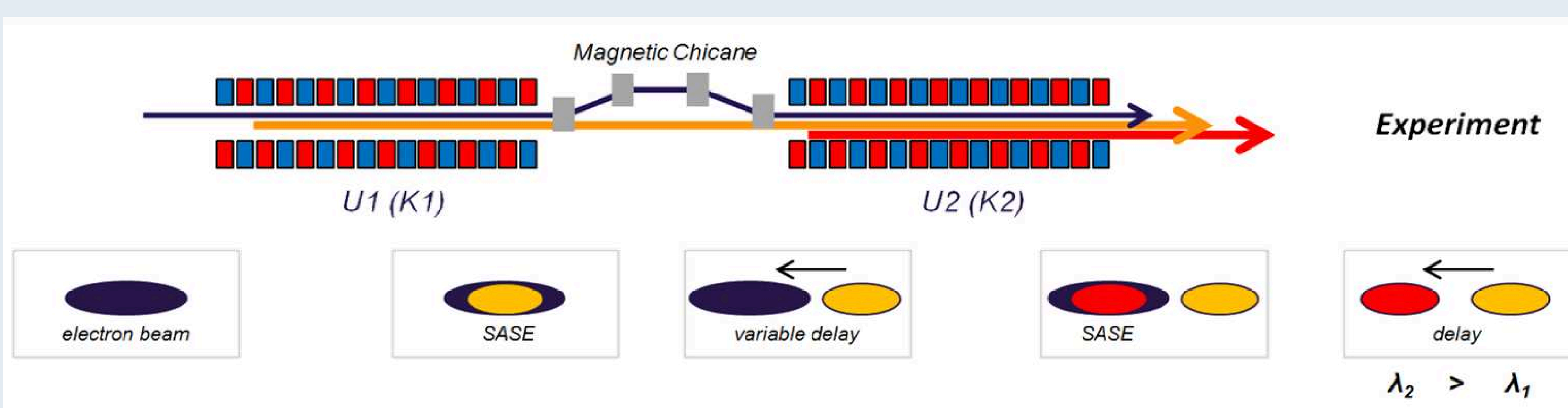
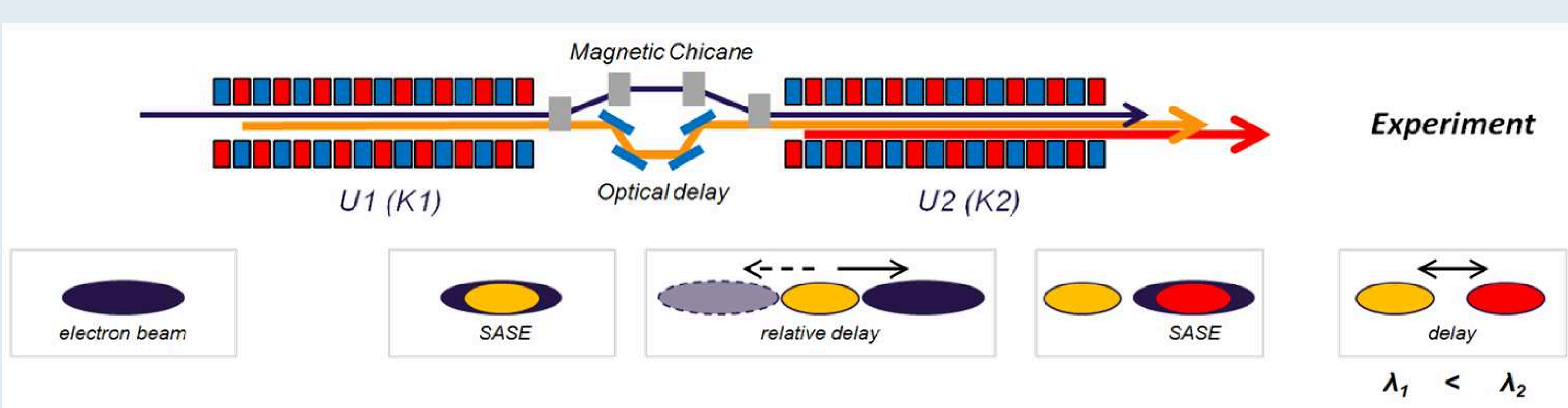
Method

- Aiming at X-ray-pump/X-ray-probe in the Soft X-ray region
- Simplest, cost-effective way for generating two-colors

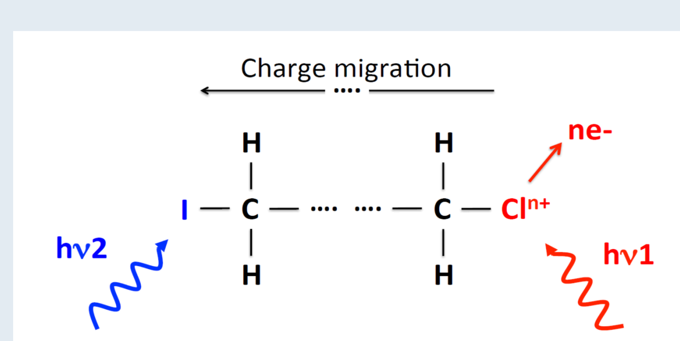


- Inserting an optical delay allows for scanning through zero delay



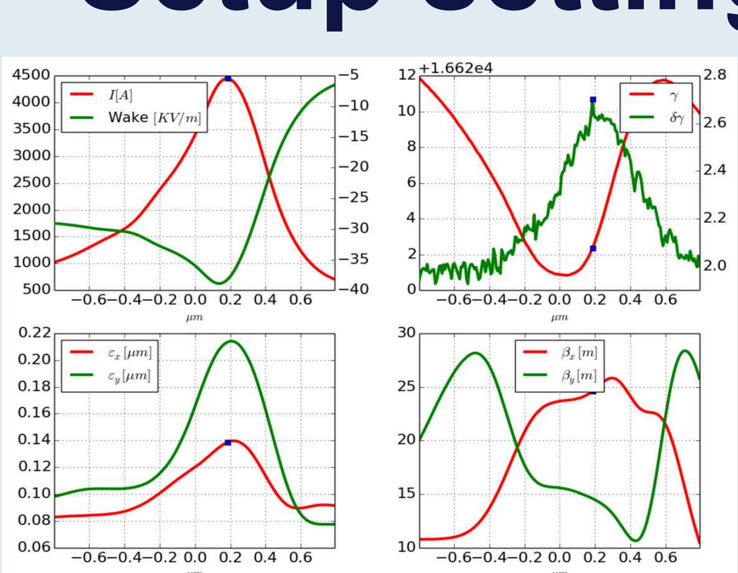
- Funded and to be installed at SASE3
- Expected tuneability between 250eV and 3000eV
- Expected max delay: several hundreds of femtoseconds

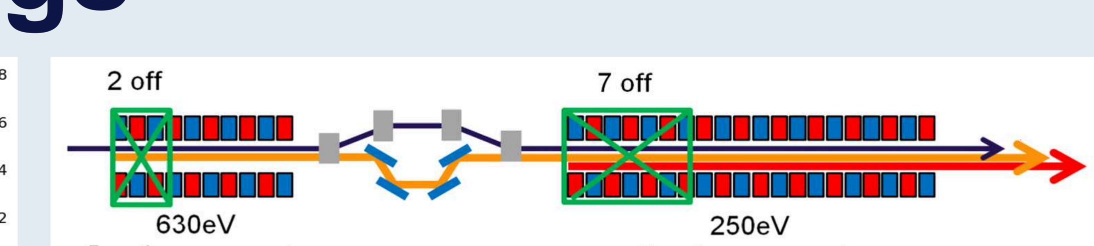
SQS science case



- Site-specific pump and probe
- Example: charge transfer in a linear molecule ($I\text{-}C_n\text{-}H_{2n}\text{-}Cl$)
- Cl 2p electron threshold at 210eV
- I 3d electron threshold at 630eV
- Intramolecular process investigation via:
  - High-resolution Auger spectroscopy
  - Ion spectroscopy
  - Electron-ion coincidence
- Coincidence arrangement feasible due to the high-rep rate of the European XFEL
- Possible experiment:
  - Individual Auger spectra at 250eV and 630eV; coincidence provides charge and fragment resolved spectra
  - Delay scan of 250eV-pulse vs. the 630eV-pulse
- Short pulses are needed → low electron beam charge

Setup settings



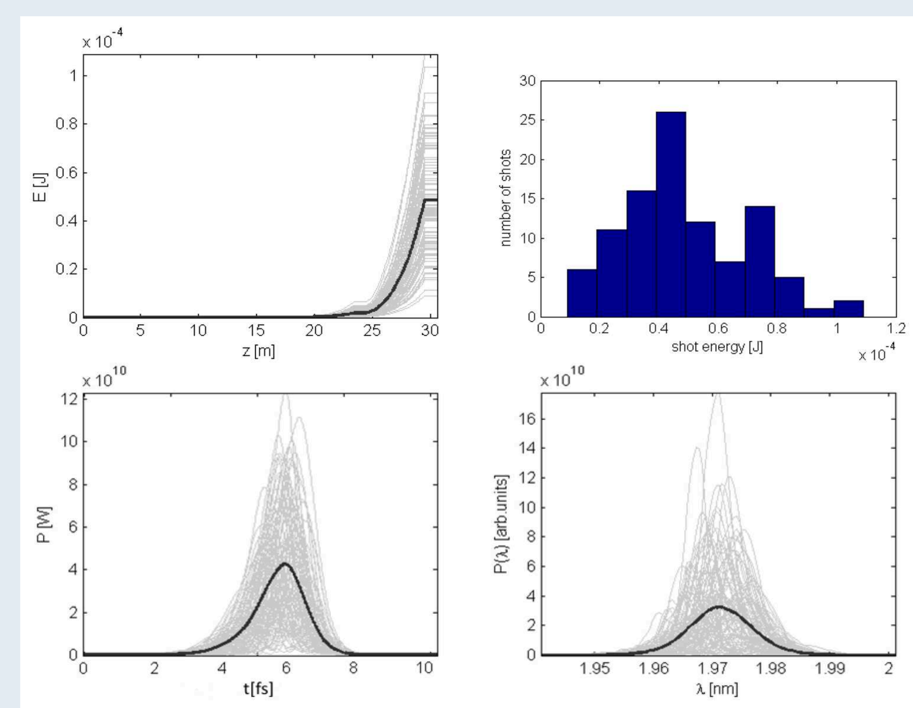


- The nominal 20pC beam propagated through closed SASE1 undulator with betatron oscillations and accounting for wakefields and quantum fluctuations

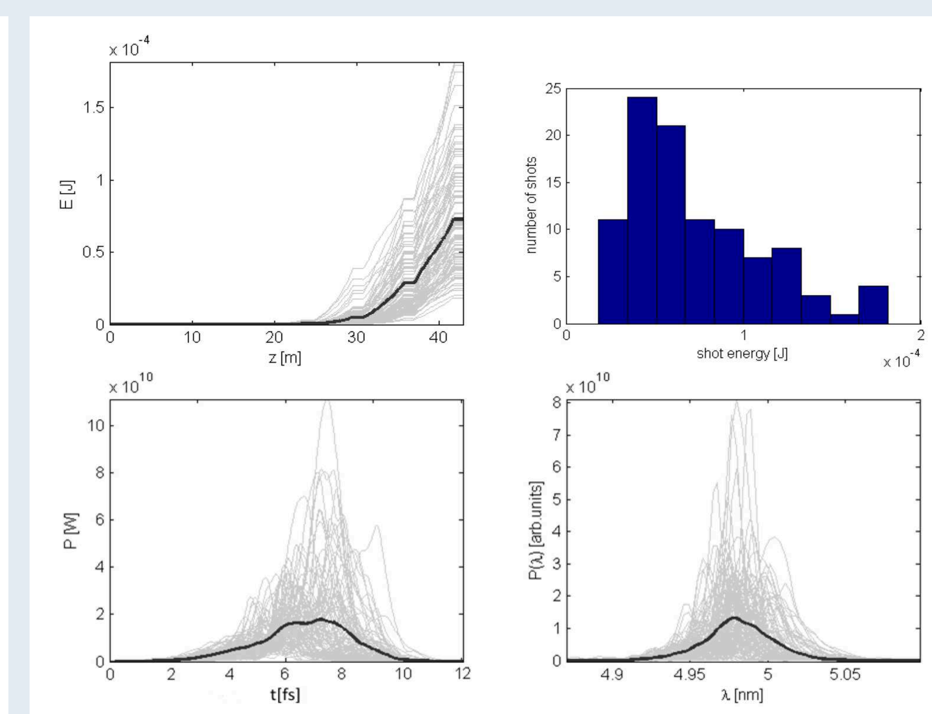
FEL Simulations

- Performed with GENESIS simulation code

Radiation after **U1 @ 630 eV**:
Mean energy per pulse is 50 μJ,
(5×10^{11} photons/pulse avg.)



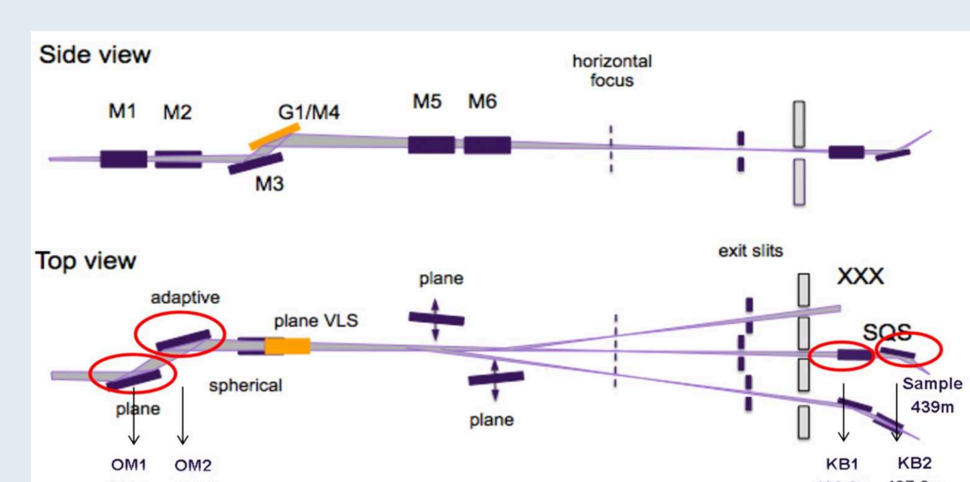
Radiation after **U2 @ 250 eV**:
Mean energy per pulse is 70 μJ,
(1.7×10^{12} photons/pulse avg.)



- *Top left: pulse energy growth along the undulator*
- *Top right: distribution of FEL shots with different energies per pulse*
- *Bottom left: power along the FEL pulses*
- *Bottom right: corresponding spectra.*

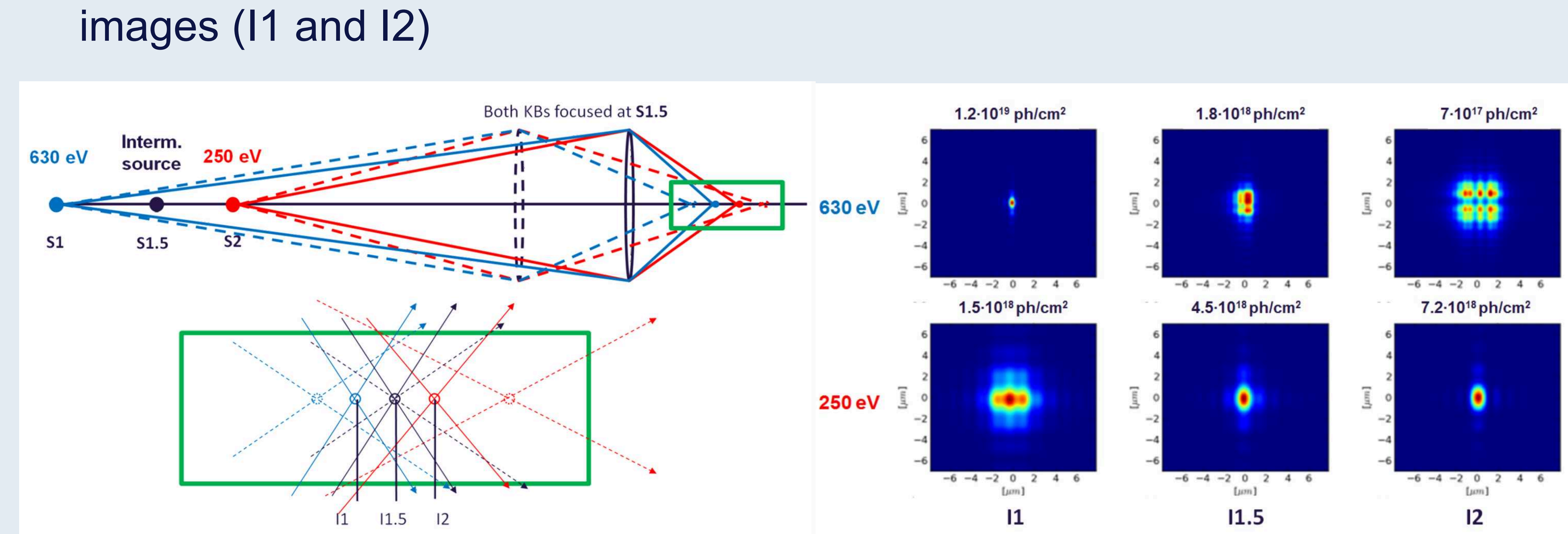
Wavefront propagation

- Performed with SRW simulation code
- Optical elements considered: offset mirrors and KB mirrors (grazing incidence of 9mrad is assumed for all)
- Accounted for: reflectivity of B4C on Si substrate, mirror height errors, diffraction on edges.



Focusing on the sample

- In a single optical system, two distinct sources (S1 and S2) imply two distinct images (I1 and I2)



- Reimaging artificial intermediate source S1.5 onto the sample, assumed at I1.5 allows to minimize aberrations and obtain comparable radiation size and photon flux density (reaching beyond 10^{18} photons/cm^2 per pulse).

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