HXRSS simulations

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HXRSS simulation status

- Input for SASE2 HXRSS simulation (up to now used from Guangyao's simulation for SASE1)

- Simulated working points

	100 pC	250 pC
3 keV	Yes, with 8 GeV beam (by me)	No
9 keV	No	Yes, with 17.5 GeV beam (by Vitali)
14.4 keV	Yes, with 17.5 GeV beam (by me)	No

- Reminder: experimentally we have only tried 14 GeV, 250 pC with 8 keV and 9 keV

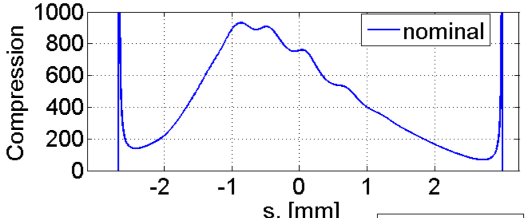
O. Chubar et al. J. (2016). J. Synchrotron Rad. 23, 410-424.

S. Liu et al. PRAB 22.6 (2019):060704.

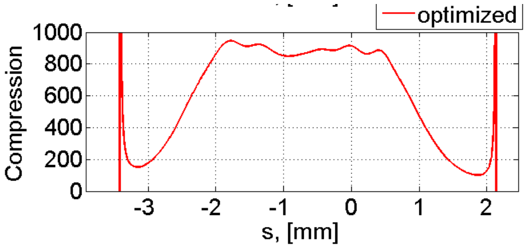
100 pC input

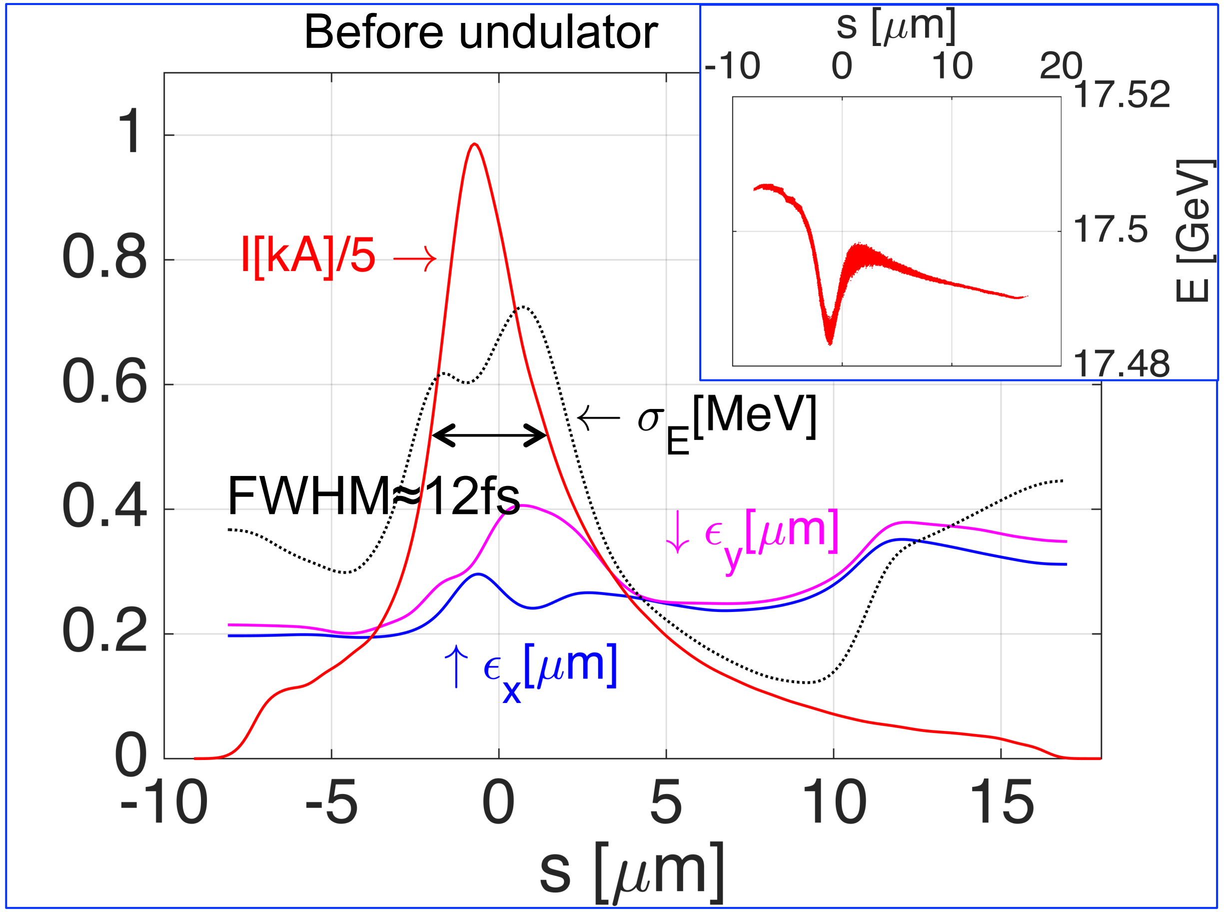
- Originally from Guangyao
- Optimization done in 2017 -> used in HXRSS simulations

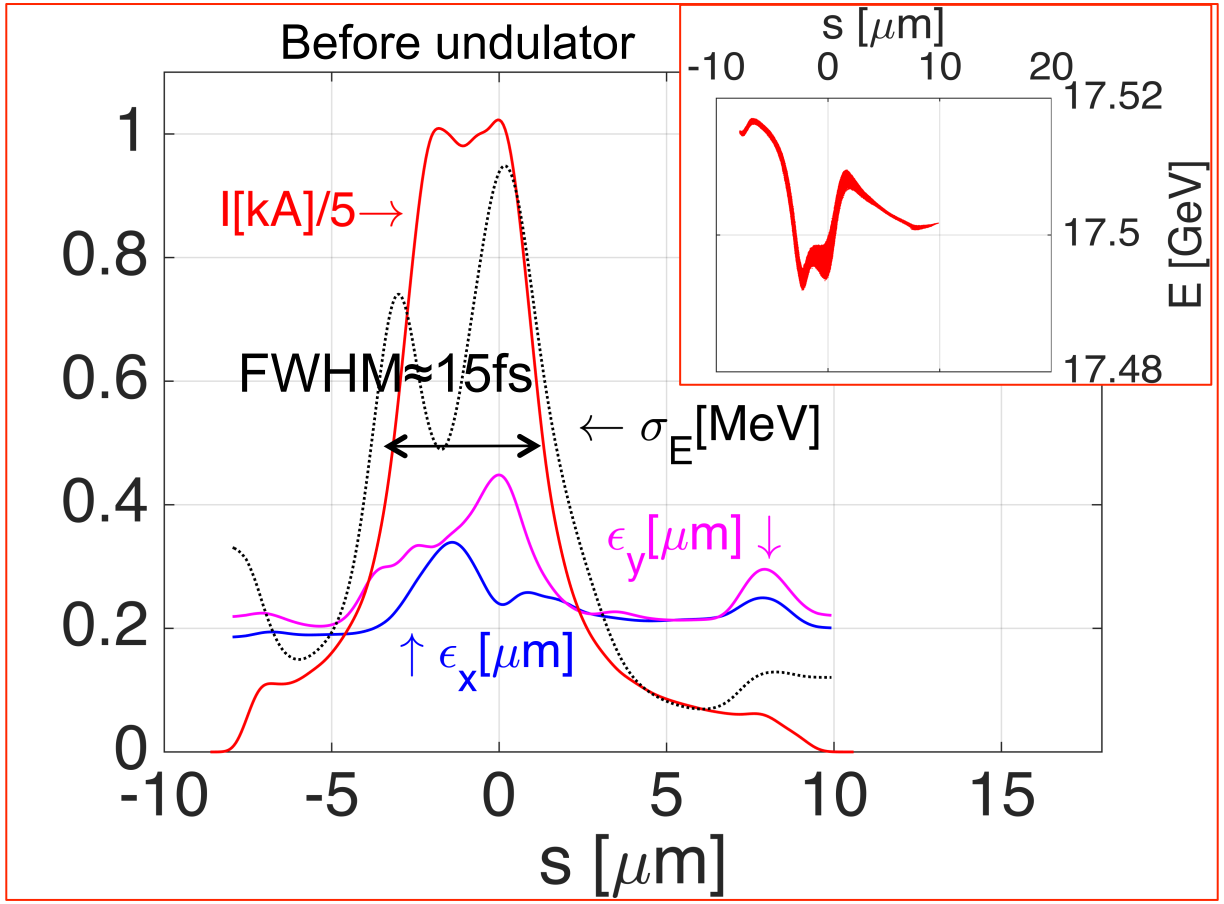
Before Optimization



After Optimization

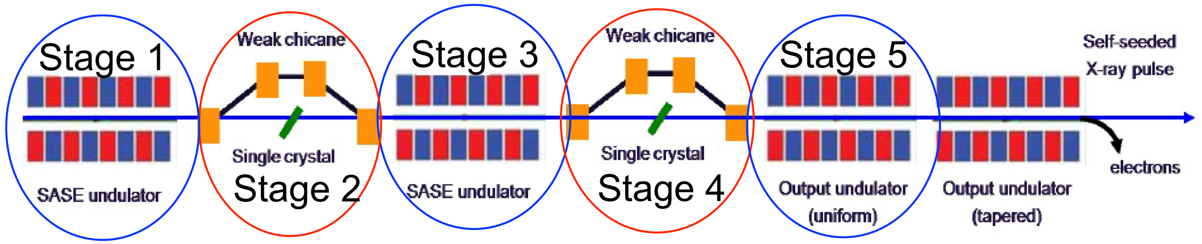


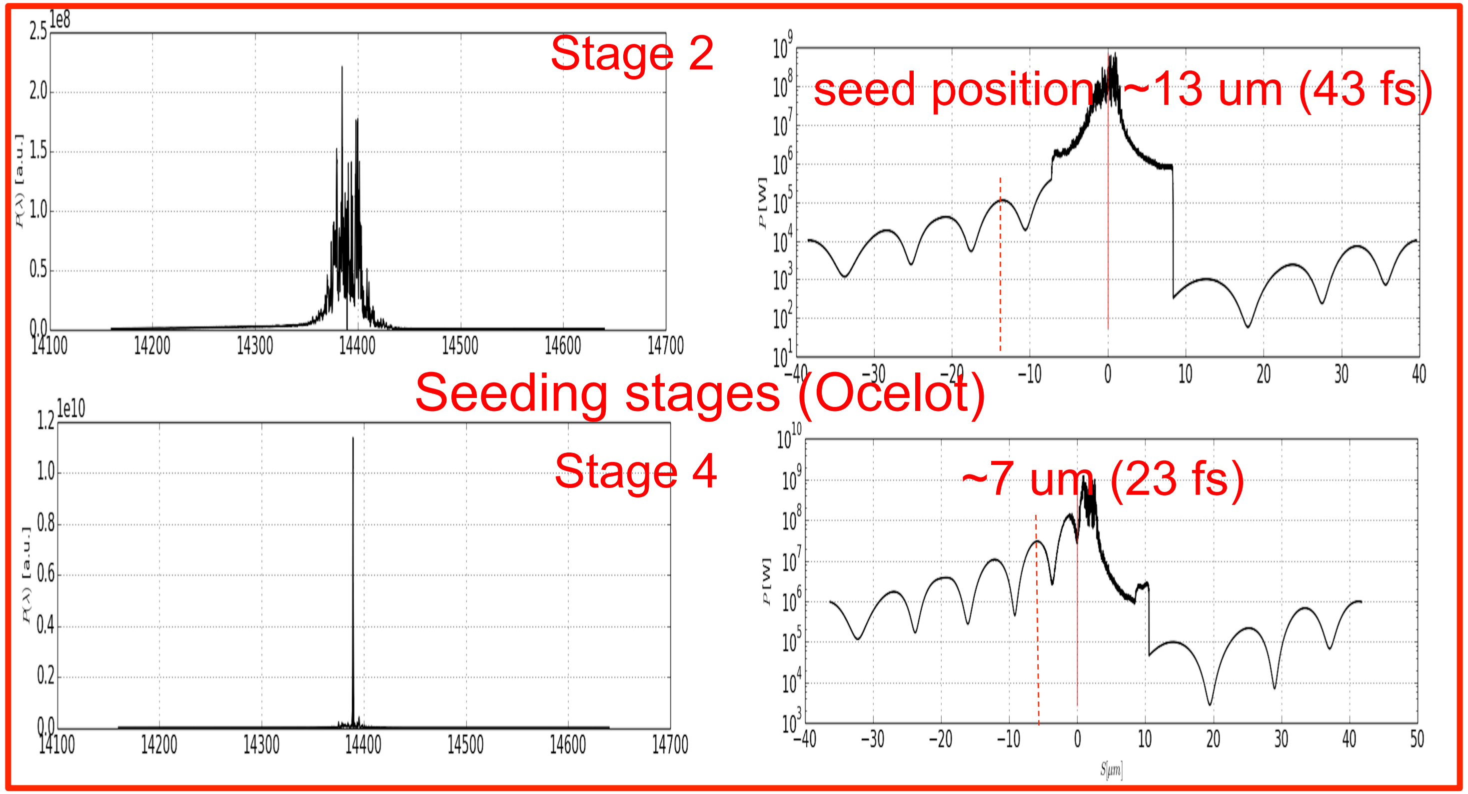


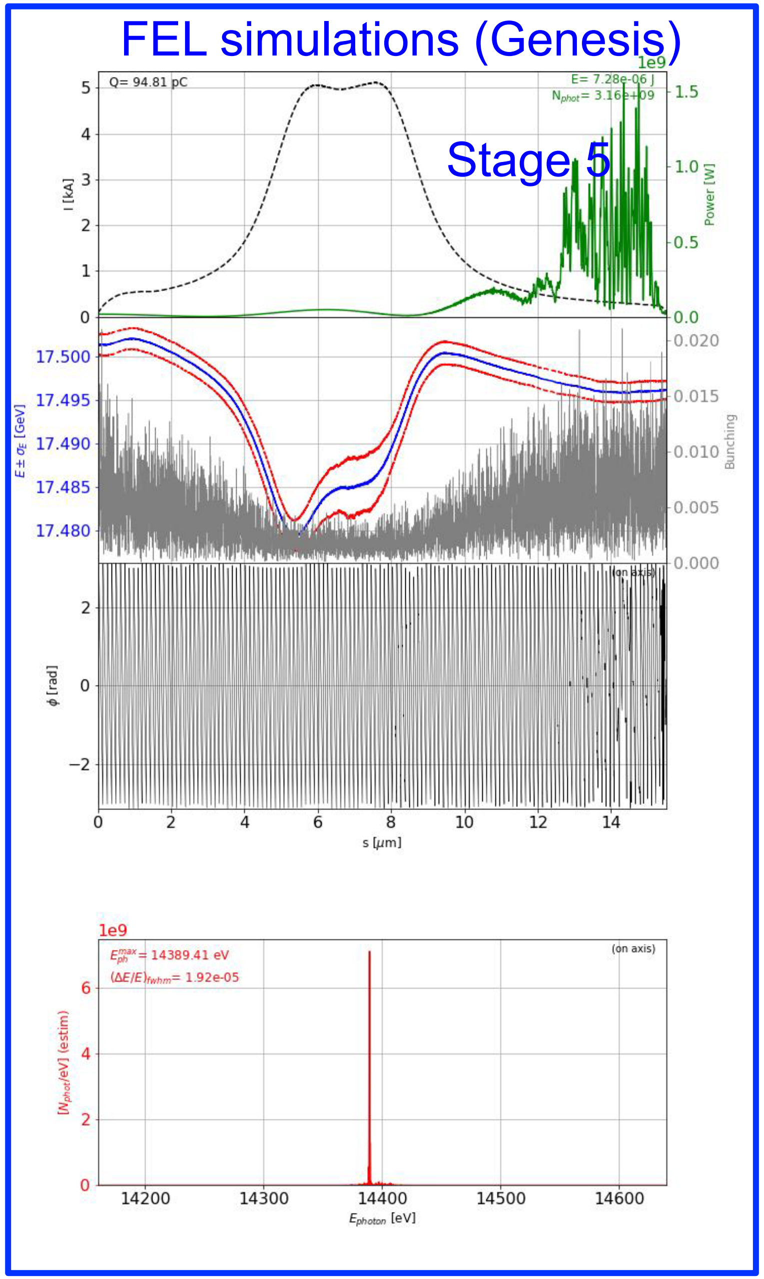


HXRSS Simulation procedures

- Example with 17.5GeV, 100 pC, 14.4keV, C400 reflection





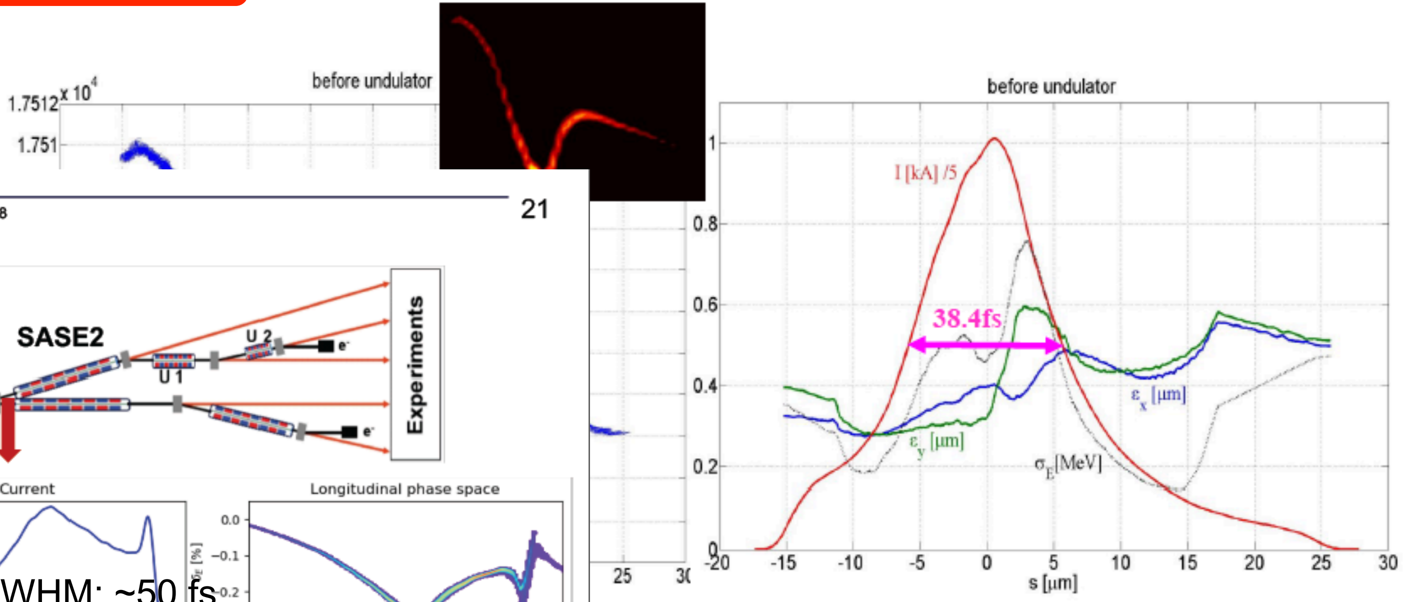


250 pC input

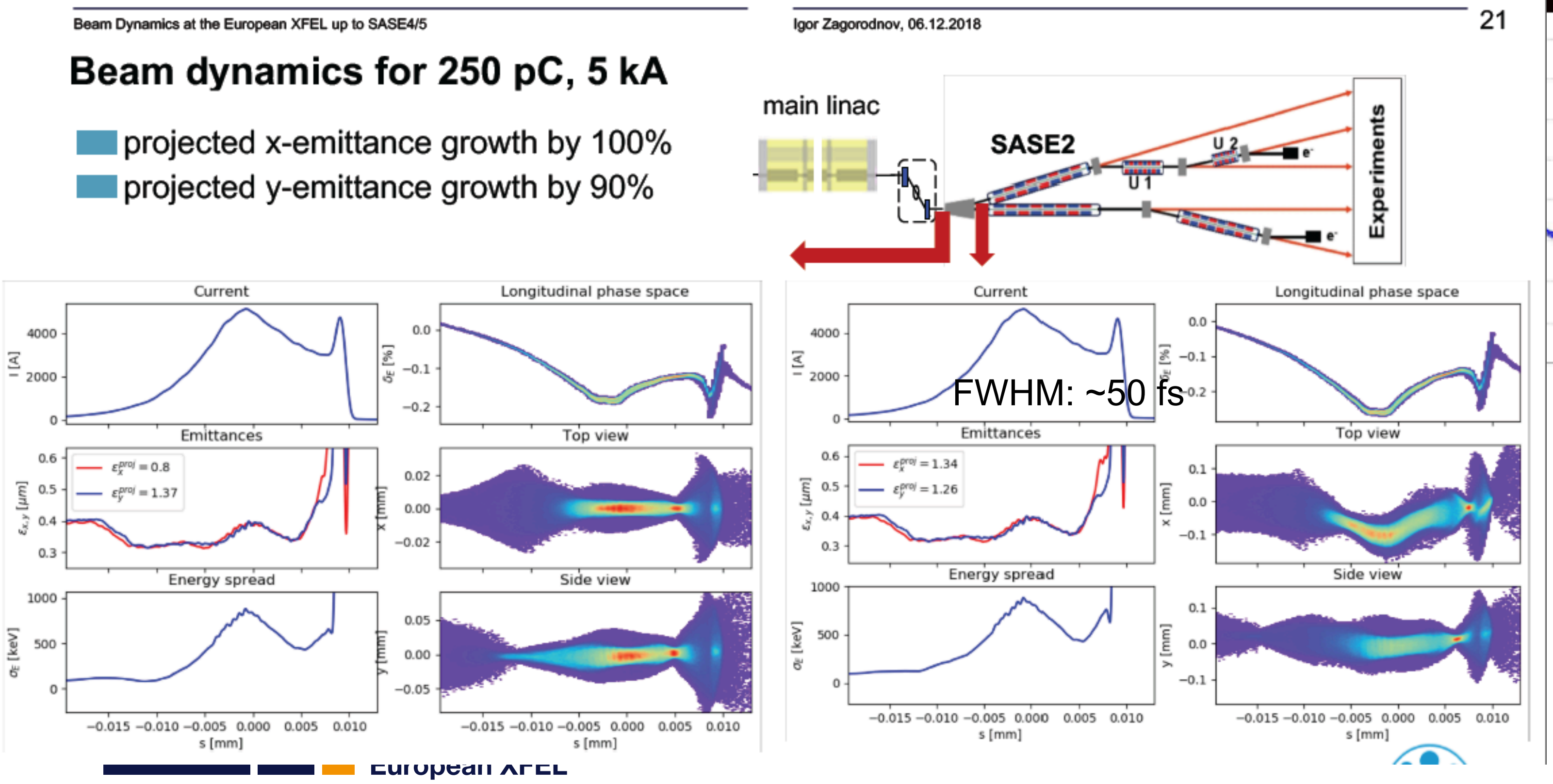
Beam dynamics simulation for EXFEL for different bunch charge cases

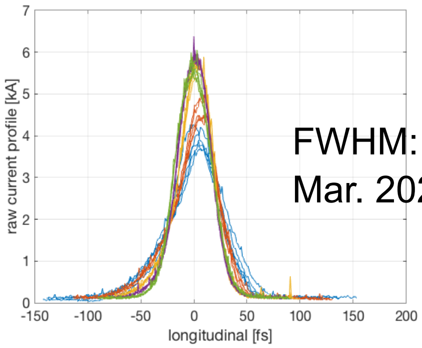
- From Guangyao (2013) -> used in the old HXRSSsimulations
- From Igor (2018)
- Measured at B2D (2020)

Q=0.25nC



$\varepsilon_x^{proj} = 0.5\mu m \cdot rad, \varepsilon_y^{proj} = 1.6\mu m \cdot rad$

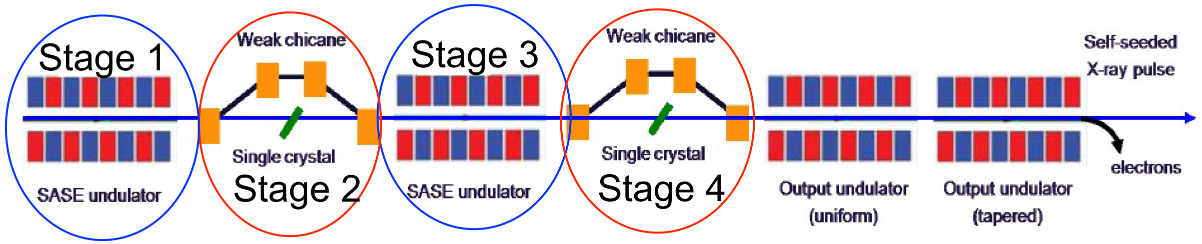


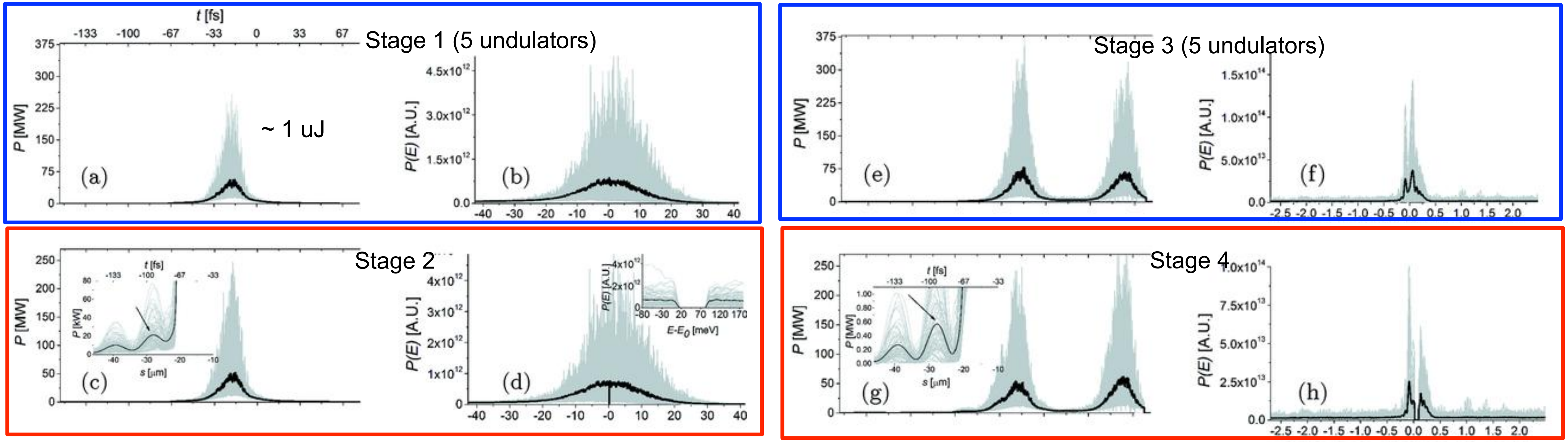


FWHM: ~45 fs
Mar. 2020

17.5 GeV, 250 pC, 9 keV, C400 reflection

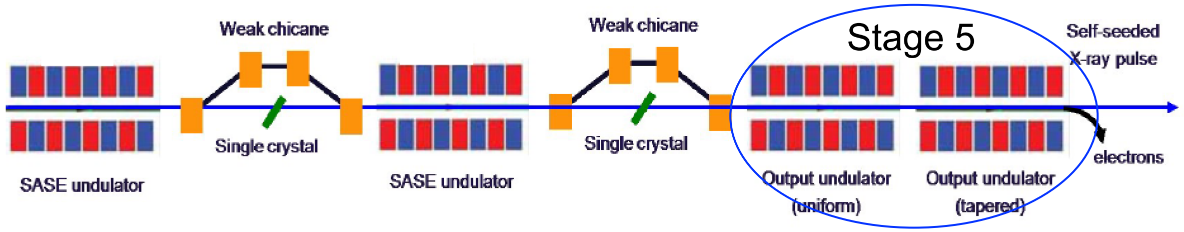
*Chubar, O., Geloni, G., Kocharyan, V., Madsen, A., Saldin, E., Serkez, S., Shvyd'ko, Y. and Sutter, J. (2016). J. Synchrotron Rad. 23, 410-424.

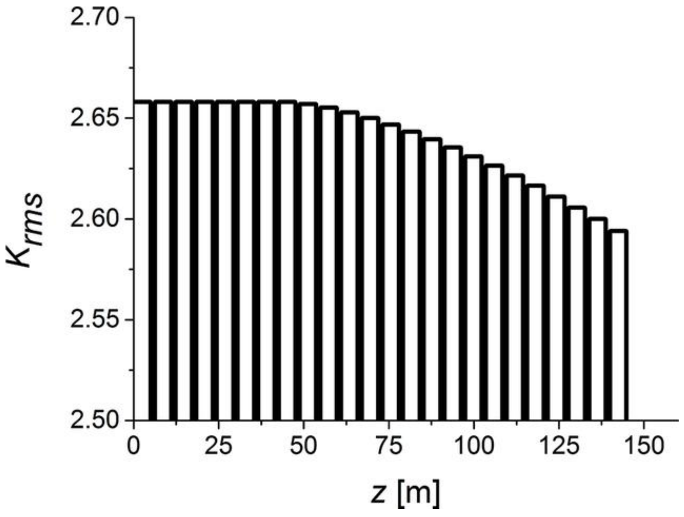


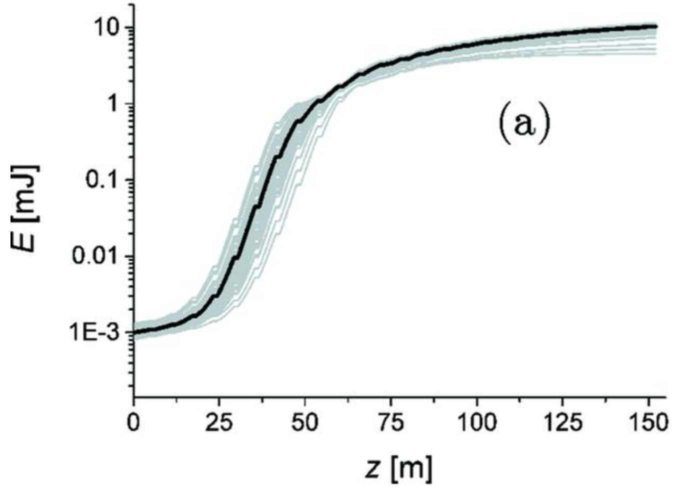


- Output from 5 undulators is around 1uJ
- Seeding position is at ~ 100 fs (in commissioning we were at ~ 20 fs delay) !
- Bunch length matters -> longer the initial SASE pulse, the larger the delay before the first bump

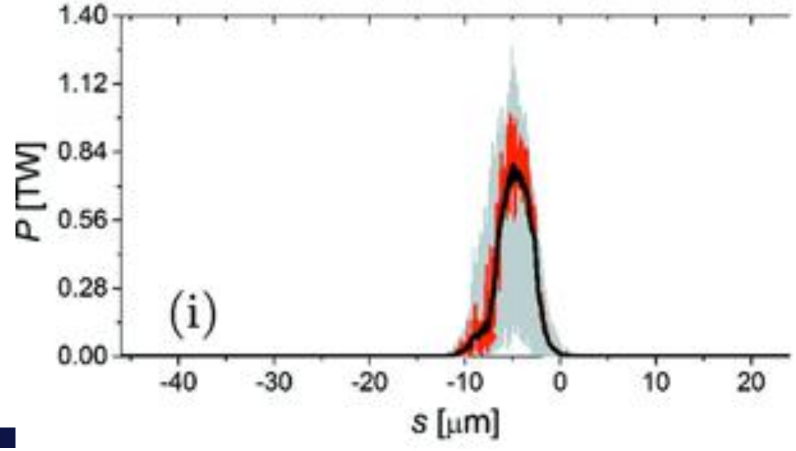
17.5 GeV, 250 pC, 9 keV, C400 reflection

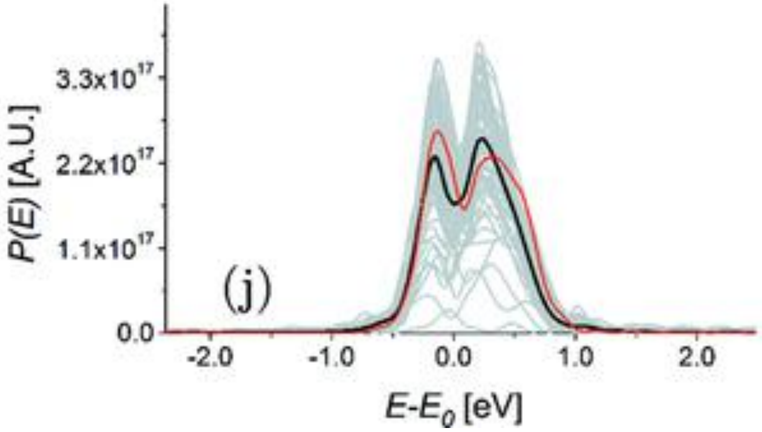






- Output with optimized taper in stage 5
- Saturation reached after 8 undulators (500-600 uJ) -> start quad. taper





Summary

- Simulations showed that **several uJ level of SASE input** is enough for seeding, however **transverse overlap** between e- and seed after chicane is crucial to get saturation!

- Position of the **first bump** of monochromatic wake (delay for e- beam) depends on photon pulse length (lasing window)
  - **bunch length** can be measured by TDS BC2 and **lasing window** by DD scan -> should be documented!
  - **delay scan VS seed signal** (in a good seeding condition) can be performed to find the optimum delay position
  - previous success of self-seeding **(up to 200 uJ)** with a delay of ~20 fs indicates a very short lasing window (**~10 fs**? with 250 pC beam)
  - in the case of **long bunch** (and long lasing window, e.g. > 25 fs as in Mar. 2020), **longer delay** should be scanned

- **250 pC, 9 keV case in simulation**: saturation in stage 5 is around 500 uJ (8 undulators) and above mJ can be reached with quadratic taper

Discussions and future plans

- Get new input beam from Igor/Segey with “realistic” profile (as close as possible to the TDS measurements)
  - can we do s2e simulations based on the TDS measurements?
  - can we measure the increase of projected emittance (using wire scanners) after switchyard and compare with Igor’s simulation?
- Start with 14GeV, 250 pC, 9keV
  - from "above" we start with the newest s2e simulations by Igor for SASE2
  - from "below" we start with a simple Gaussian model, where we put our best guess of parameters (like lasing window, current, emittance, energy spread, chirp) from machine data.
  - we keep on comparing with reality
- At first, we can keep the undulator ideal, then introduce other effects like launching, angle kicks in the undulator, misalignments and so on, also based on diagnostics.
- Prepare a working point for 100 pC run?