100 pC for XFEL
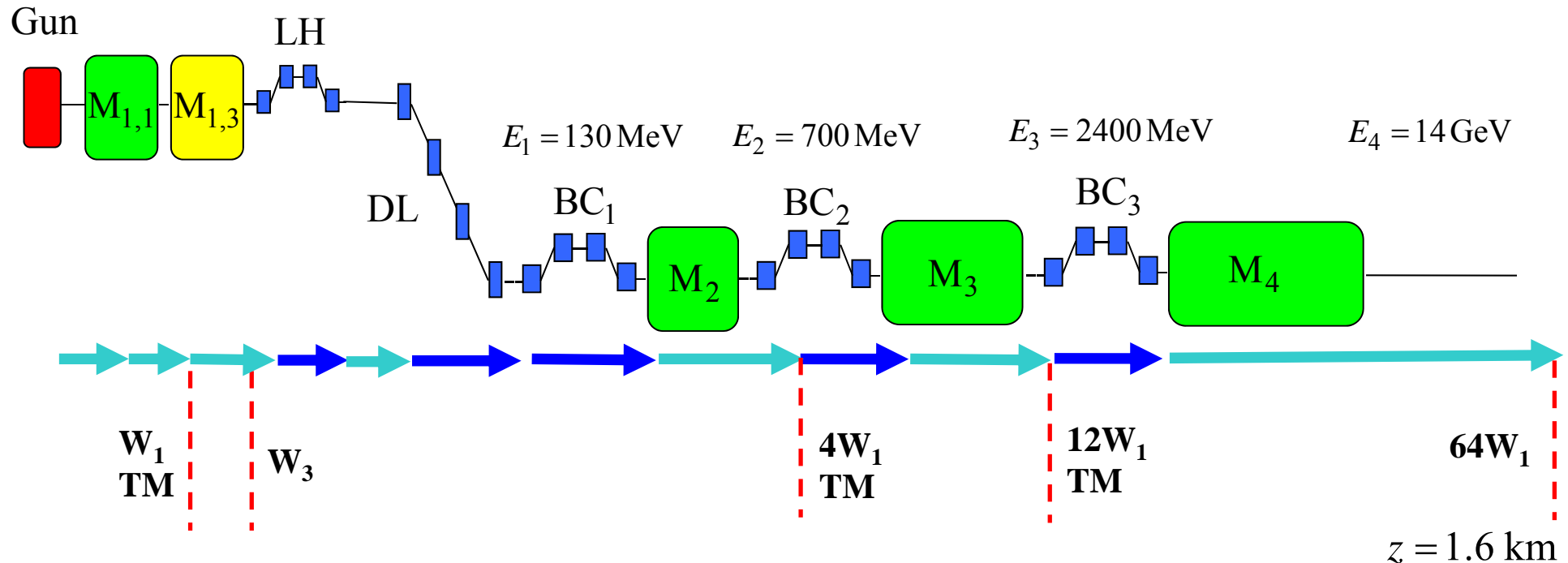
Igor Zagorodnov

20.03.2011

DESY

Beam dynamics simulations for the European XFEL

Full 3D simulation method (200 CPU, ~10 hours)

Gun

LH

$M_{1,1}$ $M_{1,3}$

$E_1 = 130\,\text{MeV}$ $E_2 = 700\,\text{MeV}$ $E_3 = 2400\,\text{MeV}$ $E_4 = 14\,\text{GeV}$

DL

BC_1 BC_2 BC_3

M_2 M_3 M_4

W_1
TM W_3 $4W_1$
TM $12W_1$
TM $64W_1$

$z = 1.6\ \text{km}$

→ **ASTRA** (tracking with **3D space charge**, DESY, K. Flötmann)

→ **CSRtrack** (tracking through dipoles, DESY, M. Dohlus, T. Limberg)

W1 -TESLA cryomodule wake (TESLA Report 2003-19, DESY, 2003)

W3 - ACC39 wake (TESLA Report 2004-01, DESY, 2004)

TM - transverse matching to the design optics

# Choosing of machine parameters

Macro-parameters

Charge Q, nC	Momentum compaction factor in BC$_1$ R$_{56,1}$, [mm]	Compr. in BC$_1$ C$_1$	Momentum compaction factor in BC$_2$ R$_{56,2}$, [mm]	Compr. in BC$_2$ C$_2$	Momentum compaction factor in BC$_3$ R$_{56,3}$, [mm]	Total compr. C	First derivative Z', [m^{-1}]	Second derivative Z", [m^{-2}]
0.1	-71	3.5	-50	8	-20	870	0	1000

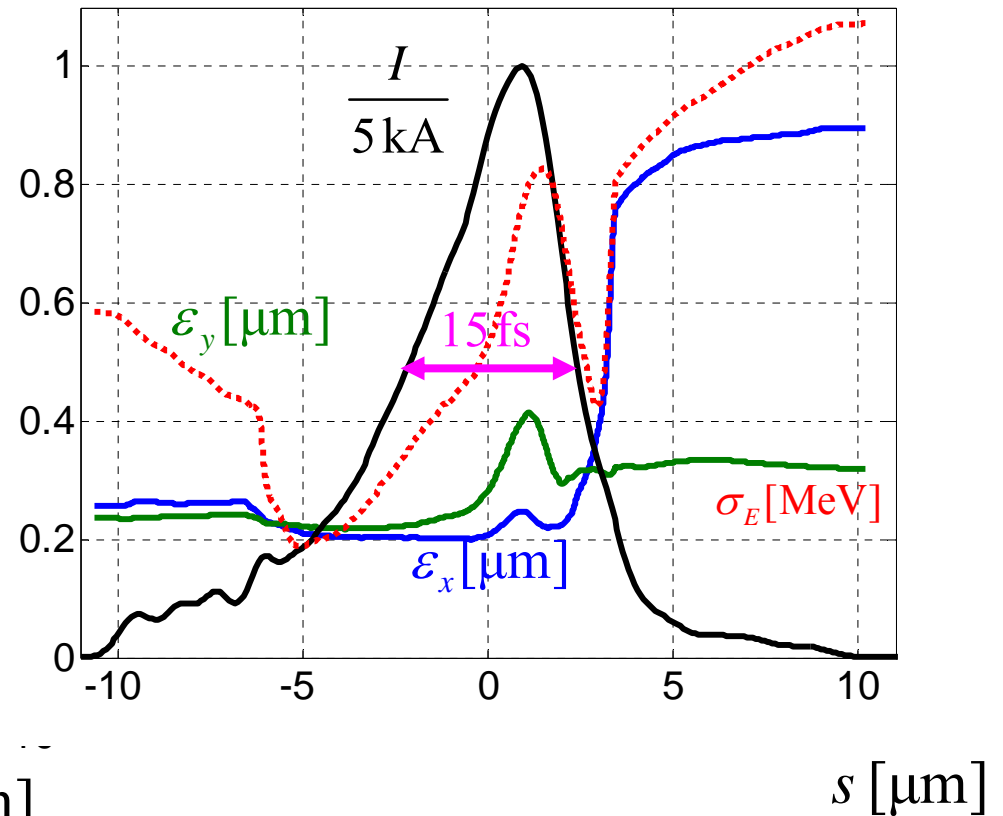$$E_1 = 130\,\text{MeV} \qquad E_2 = 700\,\text{MeV} \qquad E_3 = 2400\,\text{MeV}$$

I. Zagorodnov, M. Dohlus, *A Semi-Analytical Modelling of Multistage Bunch Compression with Collective Effects*, Physical Review STAB 14 (2011), 014403.

XFEL beam dynamic simulations for different charges (full)

Q=100 pC

E[MeV]   Phase space
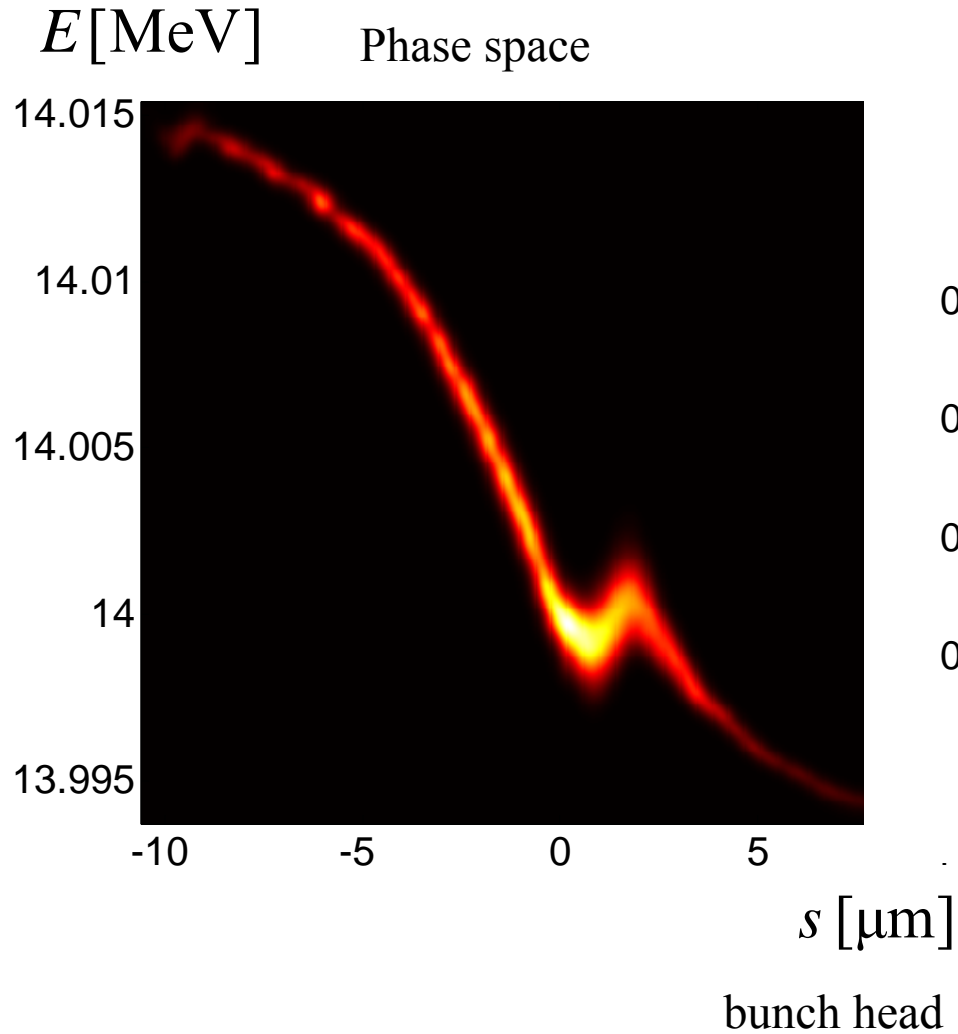
Current, emittance, energy spread

s [μm]

bunch head

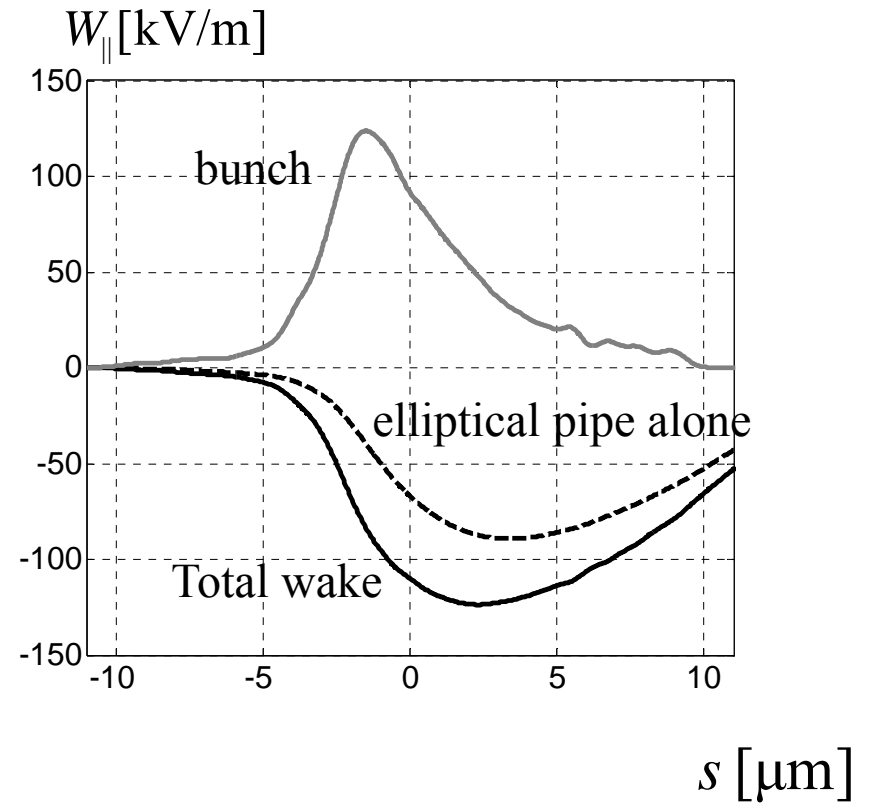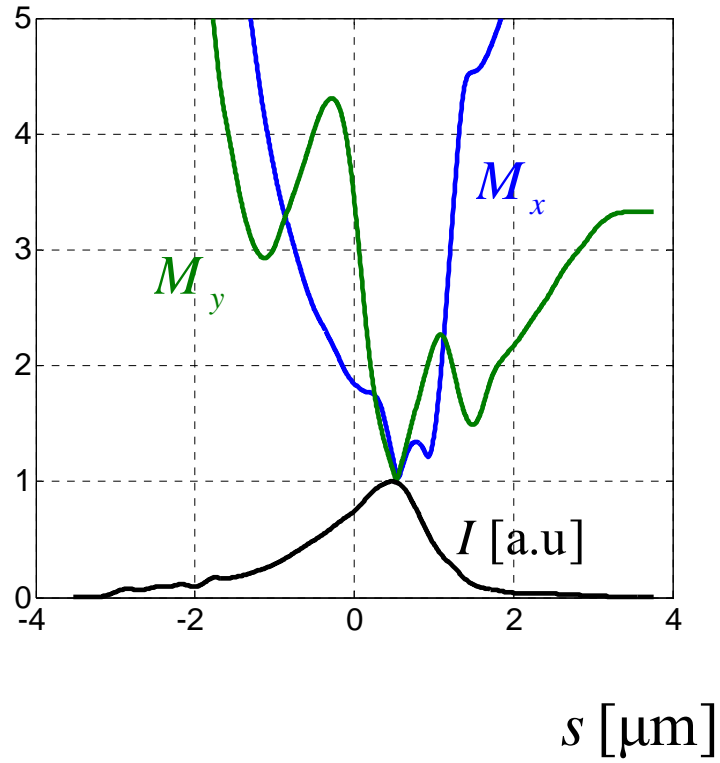$\varepsilon_x^{proj} = 0.35\,[\mu m]$

$\varepsilon_y^{proj} = 0.84\,[\mu m]$

We have removed 6% of bad particles in the analysis (Q = 94 pC!)

Mismatch and undulator wake.

Accelerator wakes. Q=100 pC

$W_{\parallel}$ [MV]

I [a.u.]

Cavities wake

Full wake

$$\frac{E - E_0}{E_0 \rho}$$

$\rho = 5.3e - 4$

With full wake
(xfel_all_wakes.ast)

With cavities
wake only
(xfel_only_cavity_wakes.ast)

s [μm]

s [μm]