EUROPEAN PLASMA RESEARCH ACCELERATOR WITH EXCELLENCE IN APPLICATIONS

WP6 : FEL Pilot Application

Collaboration week-June 23,

M. E. Couprie, F. Nguyen, A. Maier,

I. Andriyash, F. Massimo, E. Roussel

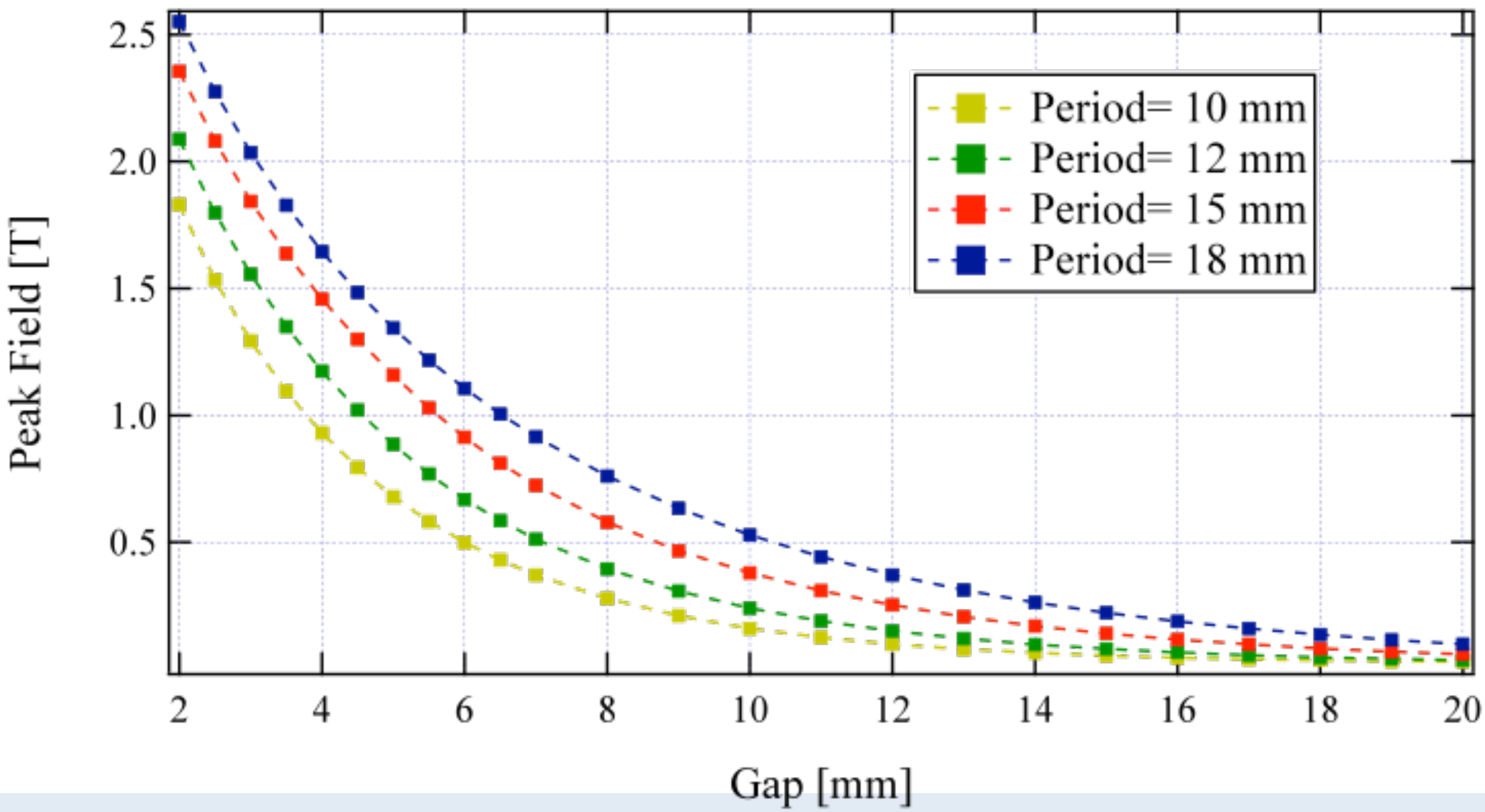
A. Bernhard, S. Bielawski, J. Clarck

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653782.

FEL components : undulator

- New grade for CPMU

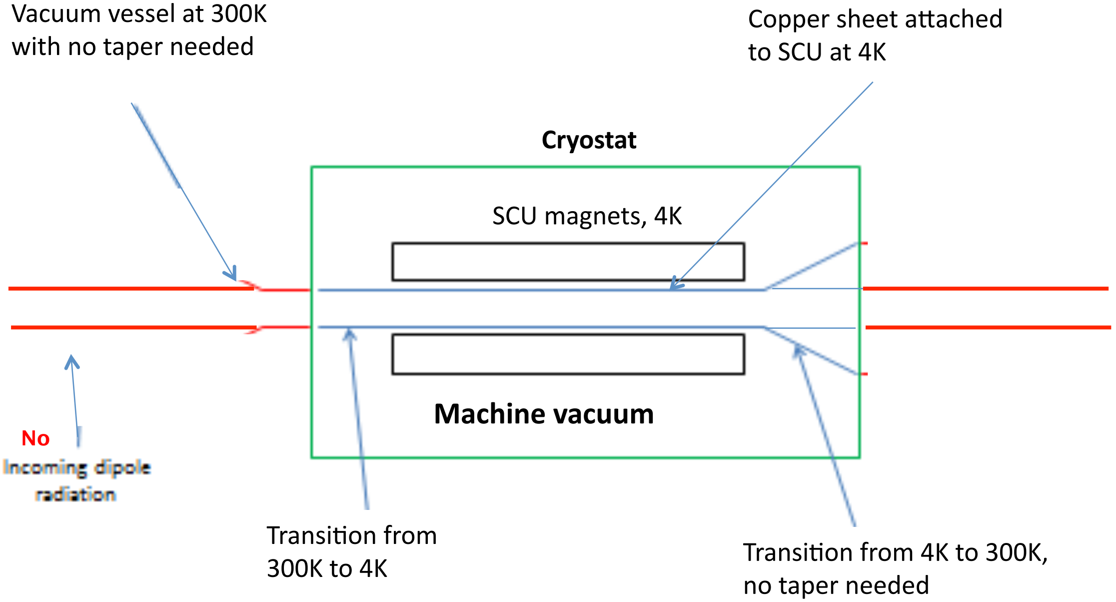
Revised performance (A. Ghaith, SOLEIL)



FEL components : undulator

- Further studies on superconducting undulator (J. Clarke, STFC, Daresbury)

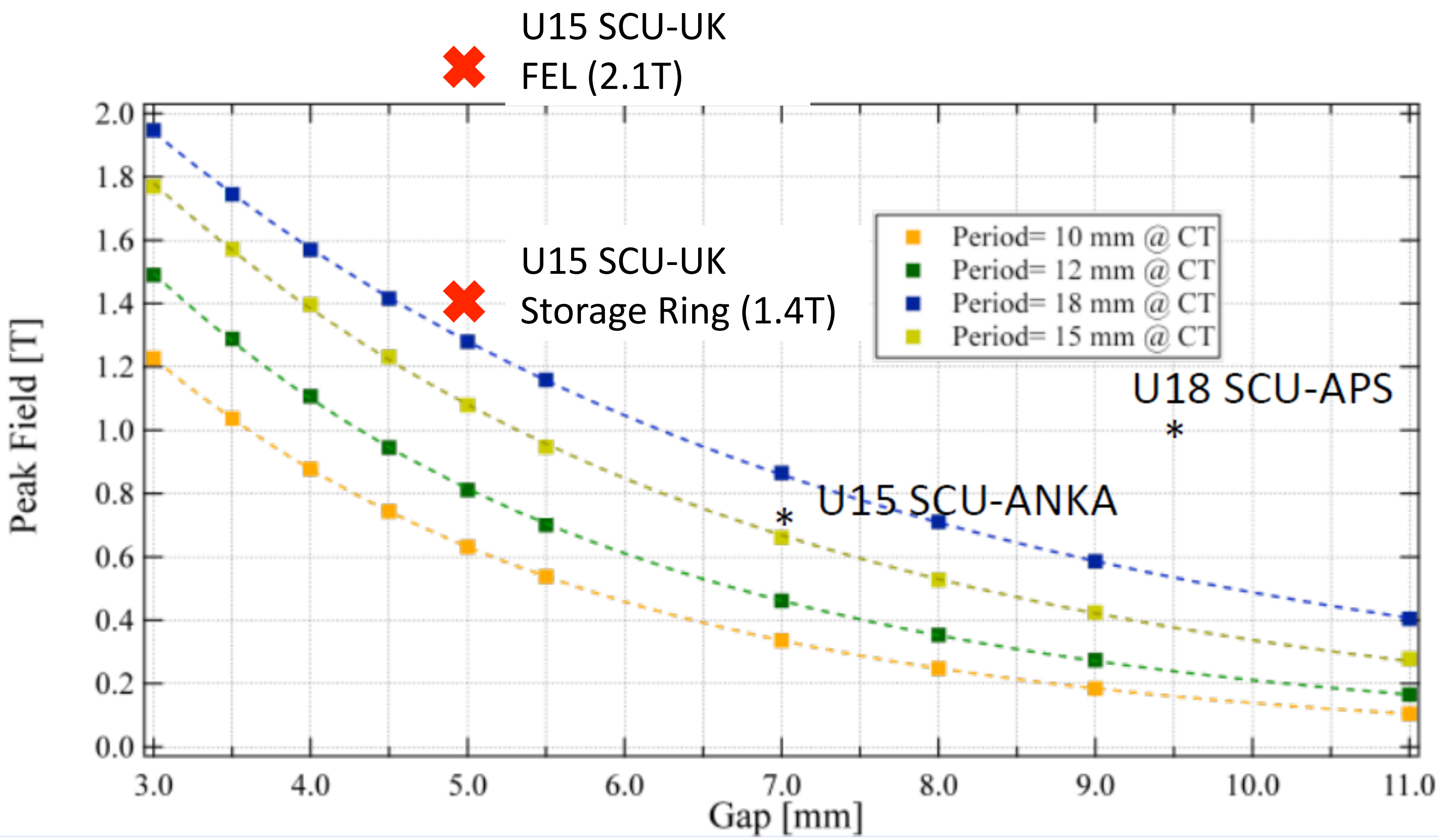
FEL/ SR application requirements (wakefield, vacuum)



FEL Example:

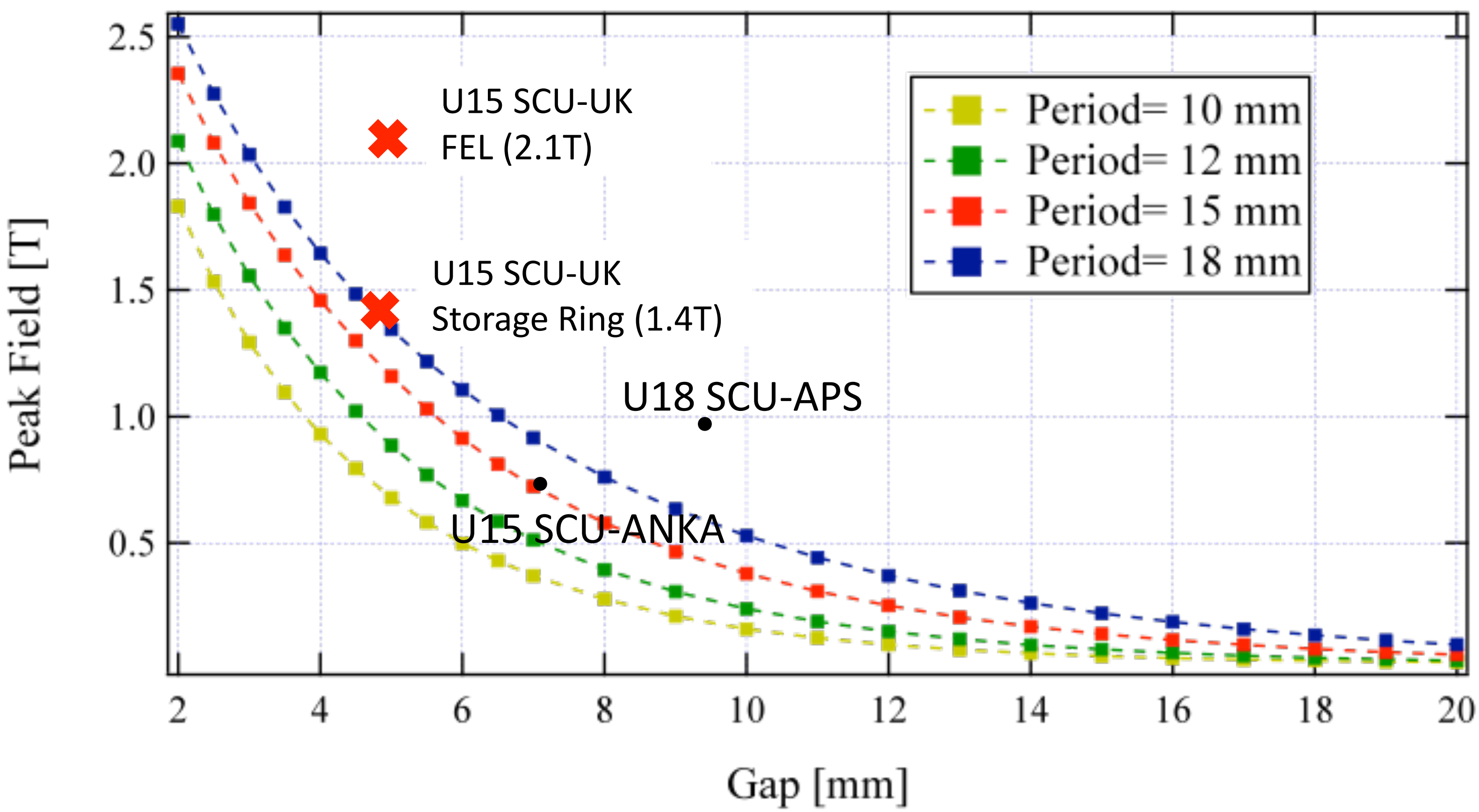
- Beam stay clear = **5.0mm**
- Vacuum chamber **not required**
- Copper conducting sheet = **2 x 0.1mm**
- Insulating gap between vac chamber and 4K magnet **not required**
- **Magnet aperture 7 mm=> 5.2mm**

FEL components : undulator

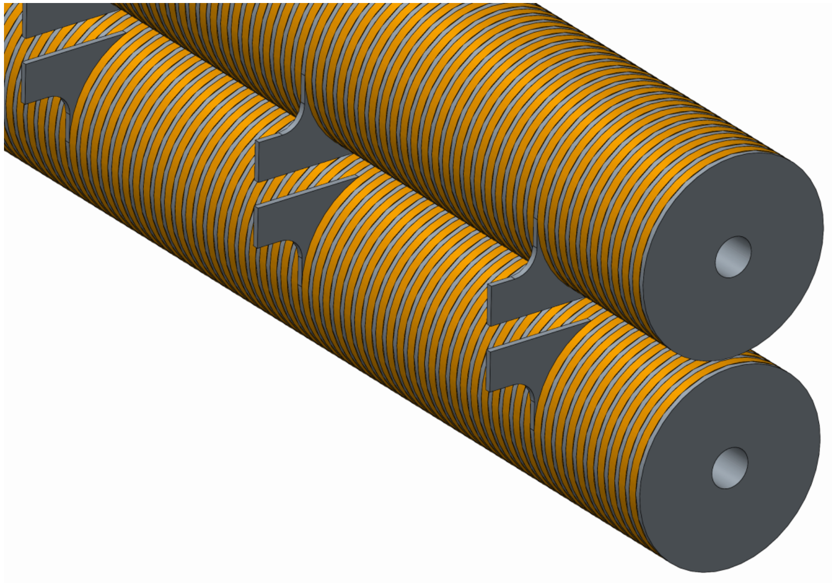


Old CPMU graph

FEL components : undulator



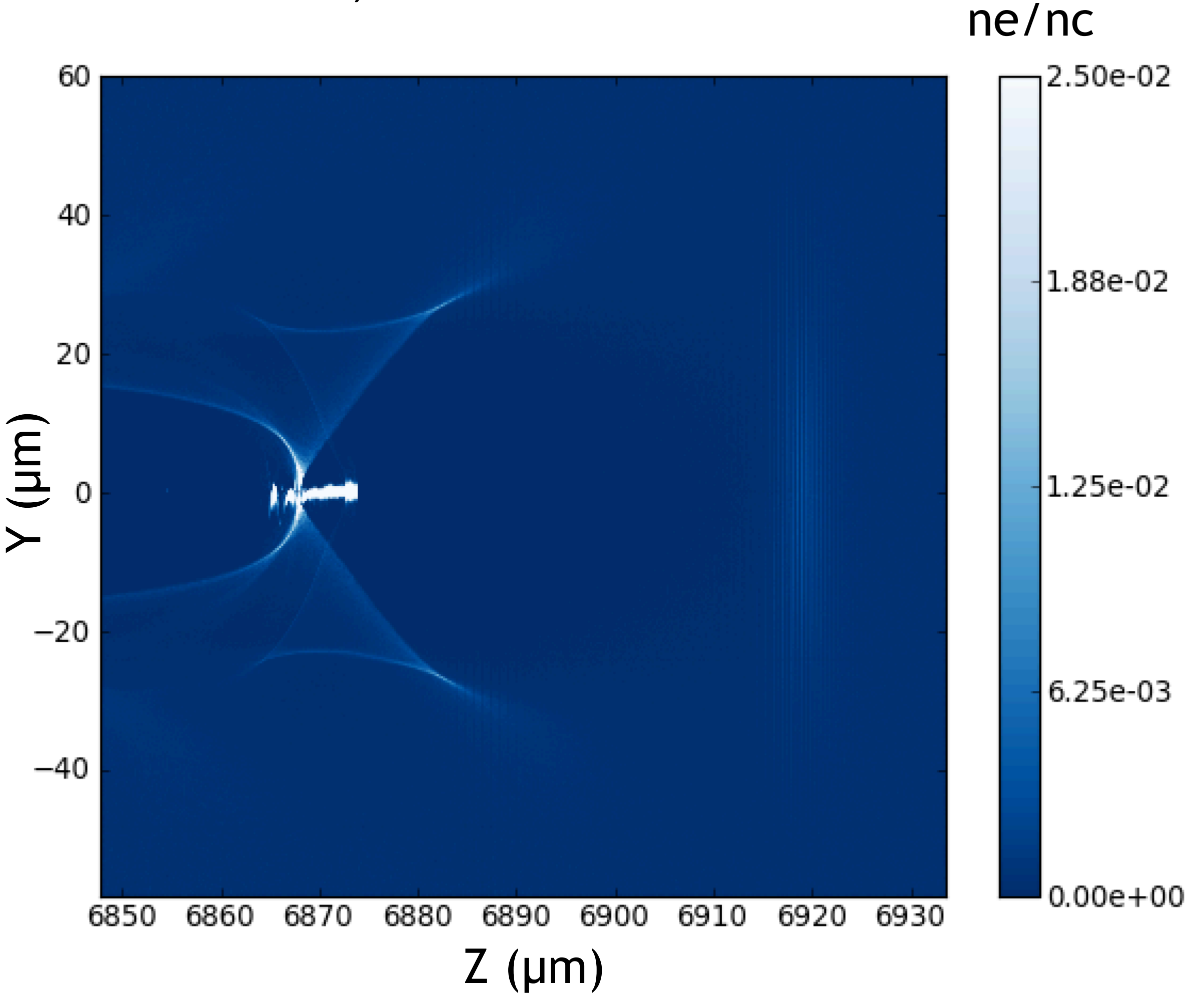
FEL components : undulator



Keep the reference baseline CPMU U12 undulator for EuPRAXIA
Consider SCU as a future option

Electron beam distribution , Calder-CIRC (Francesco Massimo)

AntiCerenkov, 0.7 cm



Q = 0.61 nC

E = 1.16 GeV

$w_{0y} = w_{0x}$ = 1 μm

L_{FWHM} = 11.2 fs

$\Delta\gamma/\gamma$ (rms) = 6.6 %

$\Delta\theta_y$ (rms) = 1.5 mrad

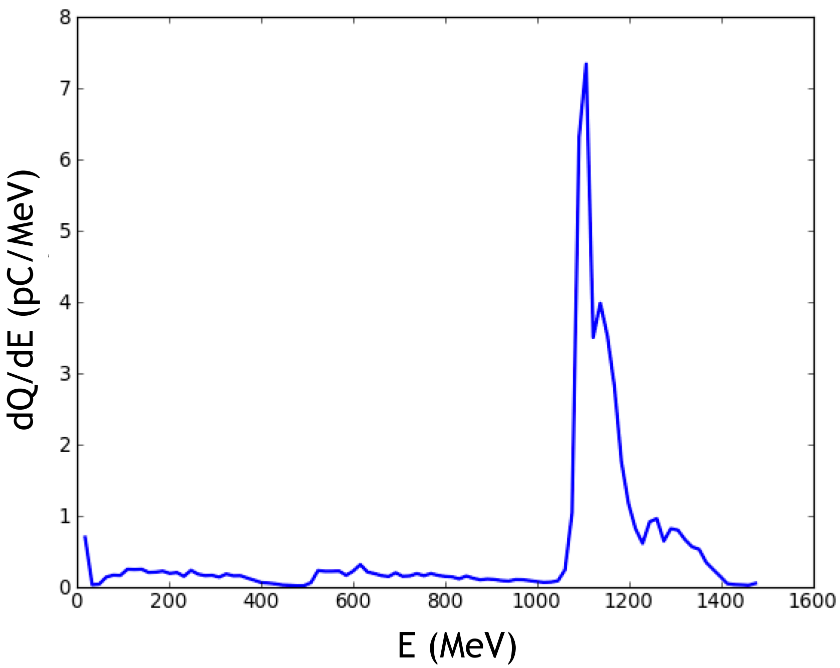
$\Delta\theta_x$ (rms) = 1.4 mrad

ε_{ny} = 1.5 mm-mrad

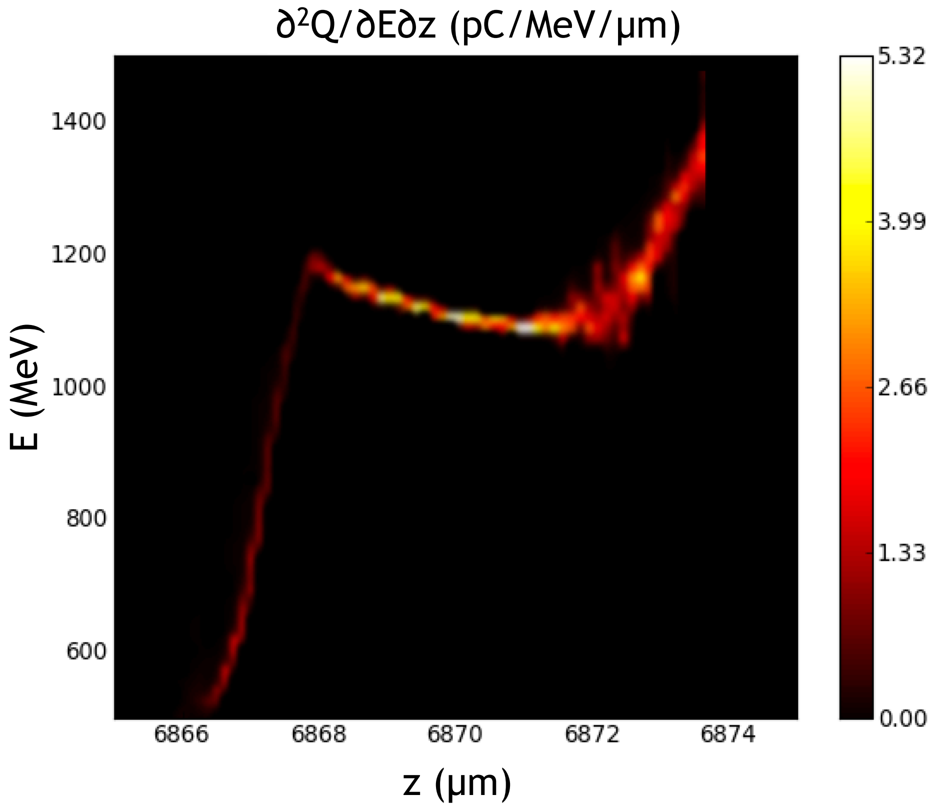
ε_{nx} = 1.5 mm-mrad

Particles in the diagnostics:
iteration 440000, R<100 c/ω_0 = 12.73 μm, E > 1 GeV

FEL components : electrons



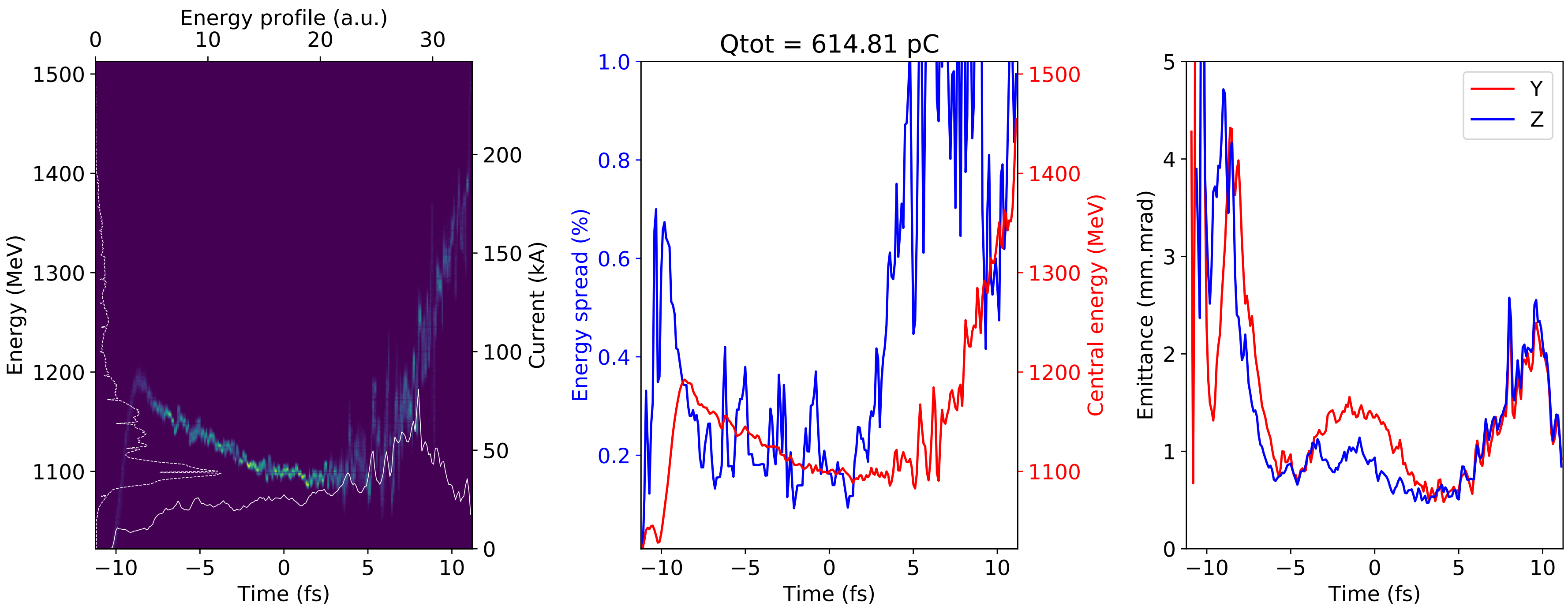
Particles in the diagnostics:
iteration 440000, R<100 c/omega0 = 12.73 um, E > 10 MeV



Particles in the diagnostics:
iteration 440000, R<100 c/omega0 = 12.73 um, E > 10 MeV

FEL components : electrons

Analysis of the slice emittance (E. Roussel, I. Andriyash)



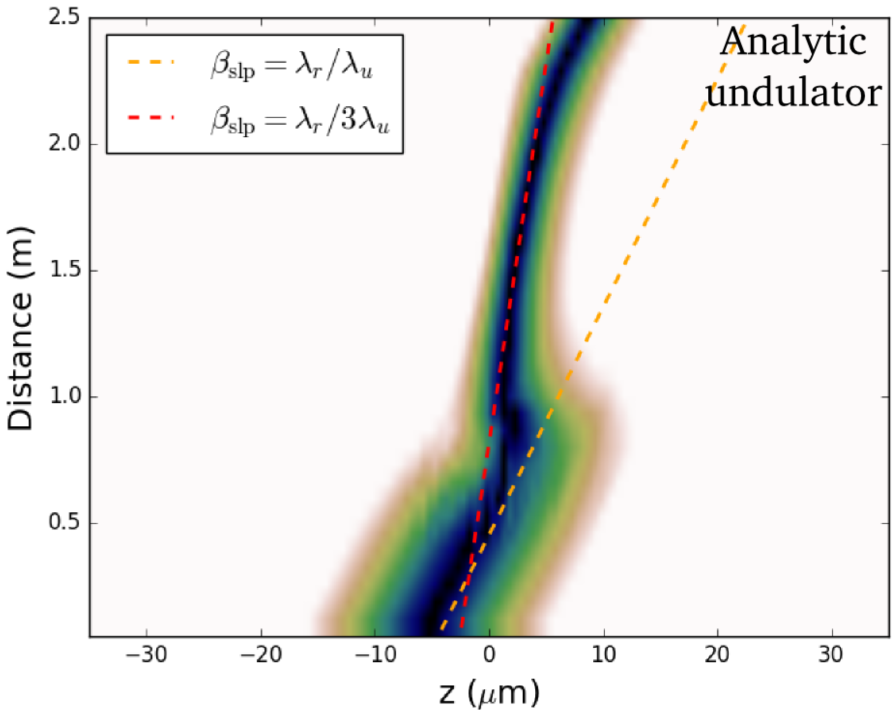
- Pb of numerical noise? higher nb of particles?
- «Good» zone for starting investigation FEL simulation
- Little chirp

Modelling LPA based FEL : Ex. of COXINEL

CHIMERA / OCELOT (I. Andriyash)

Simulation setup

- Grid: $L_z = 200\ \mu$m, $L_R = 600\ \mu$m, $c\Delta t/\lambda_u = 1/40$
  $\{N_z \times N_r \times 2m+1\} = \{400 \times 150 \times 5\}$
- Beam: $6 \cdot 10^5$ macro-particles, completely denoised at H1
- Seed: λ=200nm, P=200 kW, τ=33 fs, $w_0 = 80\ \mu$m (focused at 50 cm)



Scaling laws

Horizon 2020

F. Nguyen

EUPRAXIA: MILESTONE REPORT

Project Number: 653782

Project Acronym: EuPRAXIA

Project title: European Plasma Research Accelerator with eXcellence In Applications

Milestone Report

M 6.3 WP6 Models and scaling laws for Plasma FEL dynamics

Abstract:

We present a collection of scaling laws as analytical functions of the relevant Free Electron Laser (FEL) parameters. These formulae describe the main FEL dynamics and are the result of more than thirty years of FELs study and development. Starting from first principles, and improved by the relevant effects of electron beams far from ideal, these scaling laws provide a quick understanding of a generic FEL design and performance estimate.

3

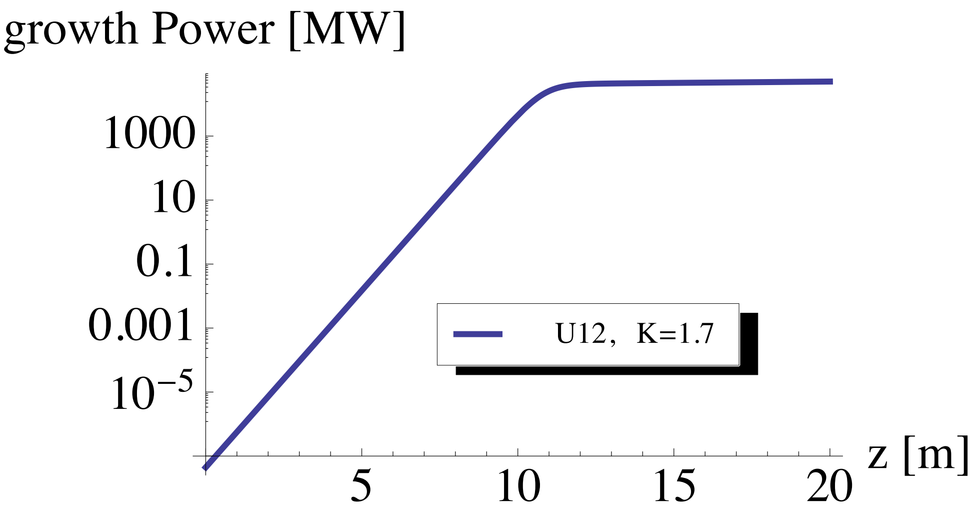
Importance of semi-analytical approach.

FEL simulation

F. Nguyen

Slice parameters from E.Roussel, F.Massimo…

Slice parameters	
beam energy [GeV]	1.2
current intensity [A]	20 000
norm. emittance [mm×mrad]	1.5
energy spread σ_E/E (%)	0.3
Undulator parameters	
undulator period [cm]	1.2
deflection parameter	1.7
Output FEL parameters	
FEL wavelength [nm]	2.66
Twiss β [m]	3.73
Pierce parameter ρ	0.0026
inh. broad. gain length [m]	0.4
saturation power [MW]	34 350
saturation length [m]	11.7



18