LCLS-I undulator horizontal gradient modeling for THz@PITZ

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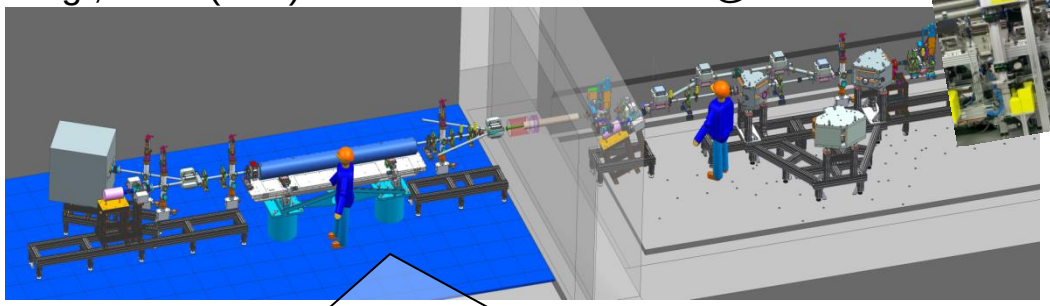
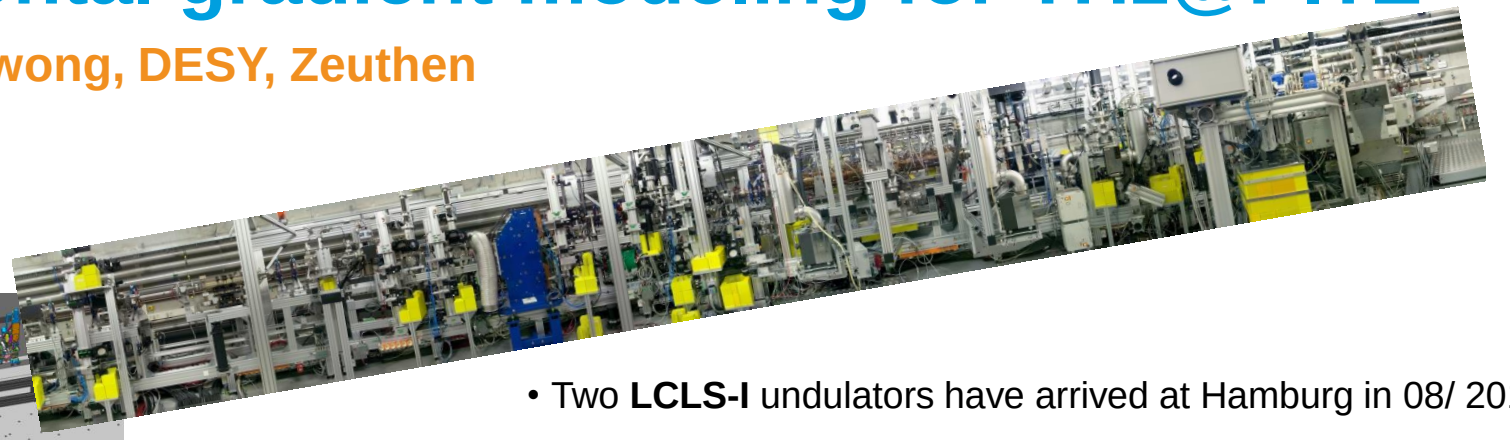
THz SASE FEL

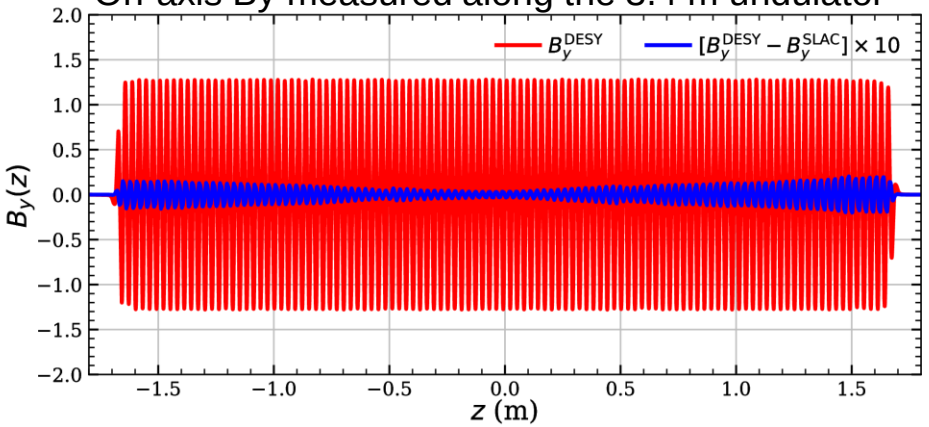
e.g., 200A (4nC) 17 MeV beam → 1.2 mJ@100um





- Two **LCLS-I** undulators have arrived at Hamburg in 08/ 2019
- The fields of the undulator L143-112000-**26** have been re-measured at DESY Hamburg and are **consistent** with SLAC measurement (discrepancy < 0.02 T)

On-axis By measured along the 3.4 m undulator



LCLS-I undulators (on load from SLAC)

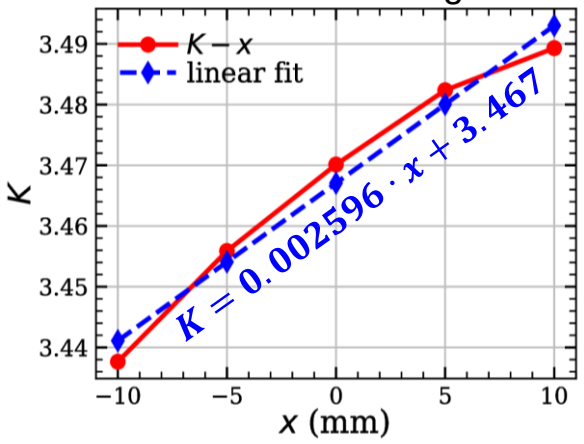
Properties	Details
Type	**fixed gap planar hybrid** (NeFeB)
Nominal gap	6.8 mm
K-value	3.49
Support diameter / length	30 cm / 3.4 m
Vacuum chamber	11 mm x **5 mm**
Period length	30 mm
Poles / a module	226 poles (= 113 periods)
Total weight w/o vac. chamber	1000 kg

LCLS-I undulator field: horizontal gradient modeling

Based on measured profiles

Besides longitudinal profile By(z)
transverse gradient By(x) has been measured

Measured horizontal gradient

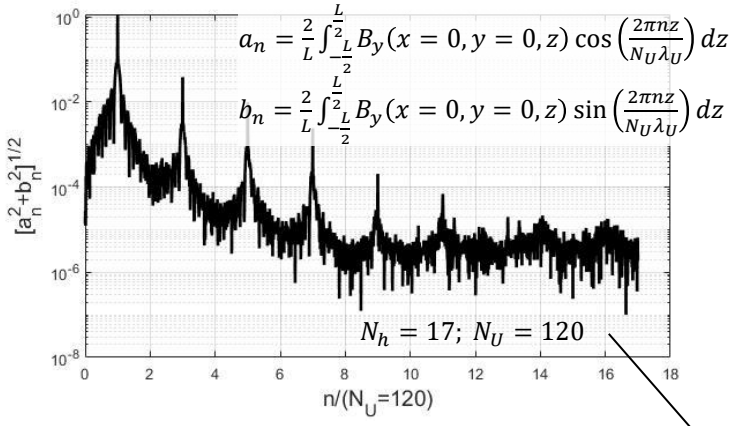


$$\frac{B_y(x,y,z)}{B_0} \propto \frac{\cosh[k_x(x_0+x)]}{\cosh[k_x x_0]}$$

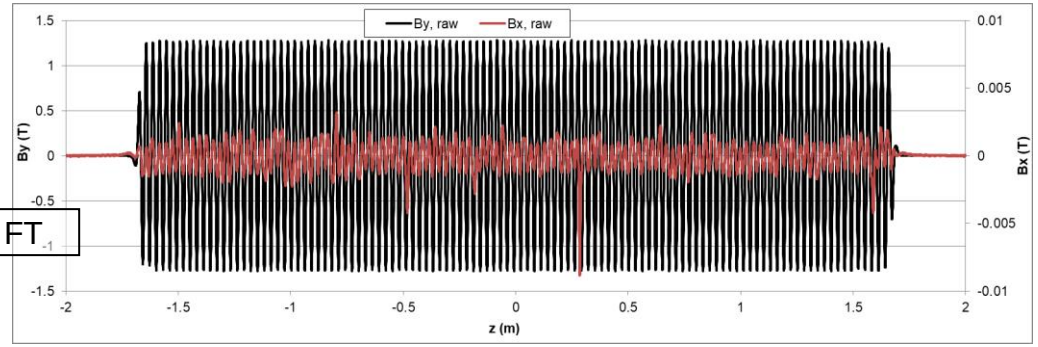
$$k_x \cdot \tanh[k_x x_0] = \frac{d}{dx}\left(\frac{K(x)}{K_0}\right)$$

$$x_0 \approx 1.33m$$
$$k_x \approx 0.916\, m^{-1}$$

$$k_x^2 + k_{yn}^2 = k_{zn}^2 = \left(\frac{2\pi n}{N_U \lambda_U}\right)^2$$



On-axis By and Bx measured along the 3.4 m undulator



FT

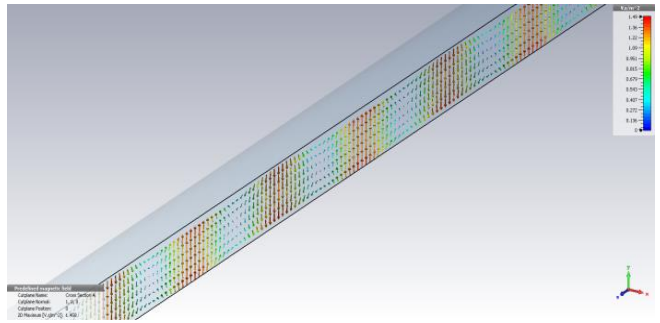
$$\chi(x,y,z) = -\frac{\cosh[k_x(x_0+x)]}{\cosh[k_x x_0]} \cdot \sum_{n=1}^{N_h \cdot N_U} \{a_n \cos(k_{zn} z) + b_n \sin(k_{zn} z)\} \cdot \frac{\sinh(k_{yn} y)}{k_{yn}}$$

3D Field map $\vec{B} = -\frac{\partial \chi}{\partial \vec{r}}$, including horizontal gradient

$$B_x(x,y,z) = \frac{\sinh[k_x(x_0+x)]}{\cosh[k_x x_0]} \cdot \sum_{n=1}^{N_h \cdot N_U} \{a_n \cos(k_{zn} z) + b_n \sin(k_{zn} z)\} \cdot \frac{k_x}{k_{yn}} \cdot \sinh(k_{yn} y)$$

$$B_y(x,y,z) = \frac{\cosh[k_x(x_0+x)]}{\cosh[k_x x_0]} \cdot \sum_{n=1}^{N_h \cdot N_U} \{a_n \cos(k_{zn} z) + b_n \sin(k_{zn} z)\} \cdot \cosh(k_{yn} y)$$

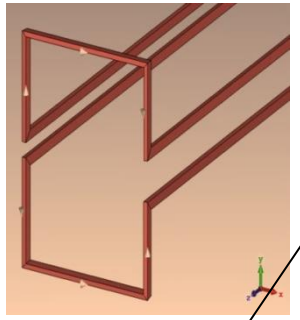
$$B_z(x,y,z) = \frac{\cosh[k_x(x_0+x)]}{\cosh[k_x x_0]} \cdot \sum_{n=1}^{N_h \cdot N_U} \{-a_n \sin(k_{zn} z) + b_n \cos(k_{zn} z)\} \cdot \frac{k_{zn}}{k_{yn}} \cdot \sinh(k_{yn} y)$$

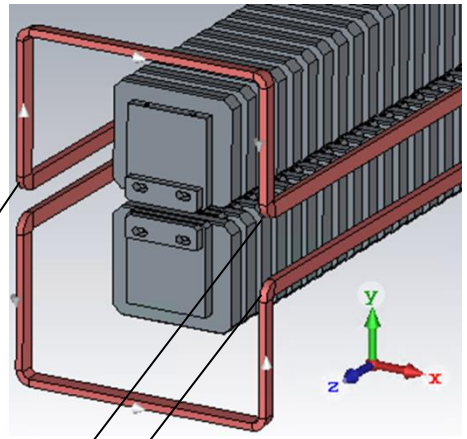


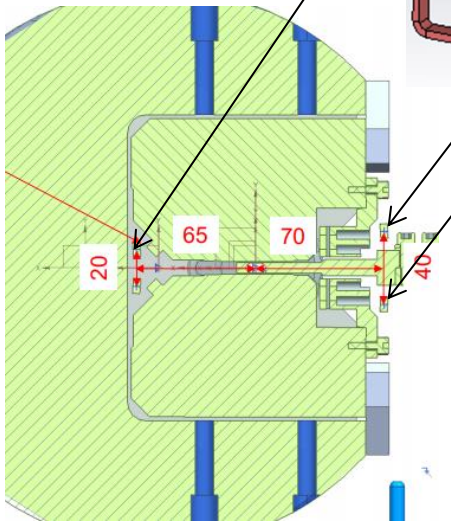
Design and modeling of correction coils

Horizontal undulator gradient impact onto beam transport and THz SASE FEL

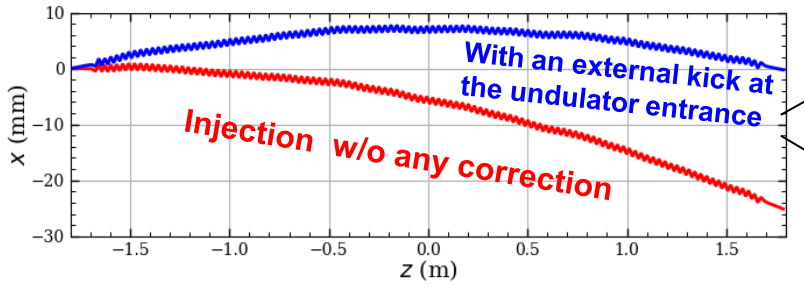
- **Transverse gradient** will lead to an off-axis (~25 mm) trajectory in the horizontal plane; **steering coils are** considered to correct it

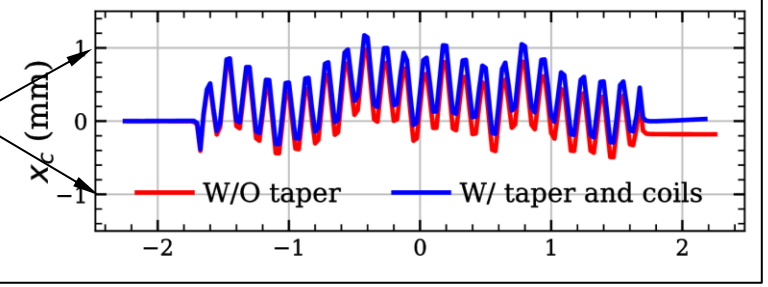






Off-axis trajectory due to the transverse field gradient





FEL simulation with air coils by Warp (X.-K. Li)