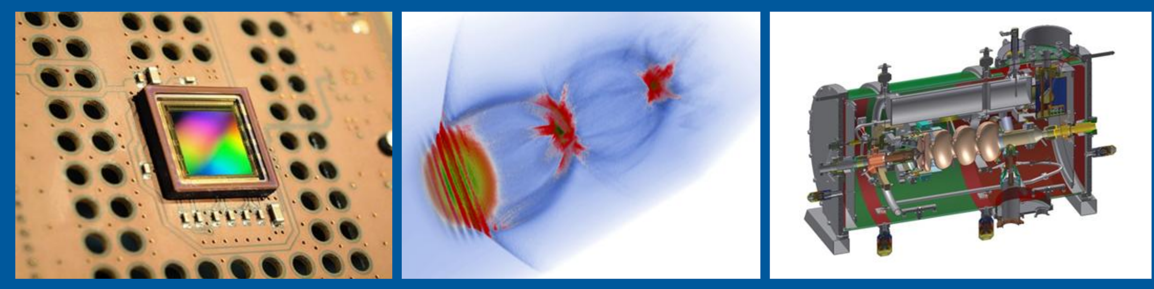
Programme Matter and Technologies

A Superconducting Transverse Gradient Undulator for Laser Wakefield Accelerators



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ARD - Novel Accelerator Concepts

1 MOTIVATION:

Goal: Develop a very compact high-brilliance radiation source with LWFAs

Laser Wakefield Accelerators (LWFAs):

- Several 100 MeV within a few cm
- Very short electron pulse length (a few fs)
- Relatively large electron energy spread ($\gtrsim 1\,\%$) → decreases the monochromaticity of undulator radiation

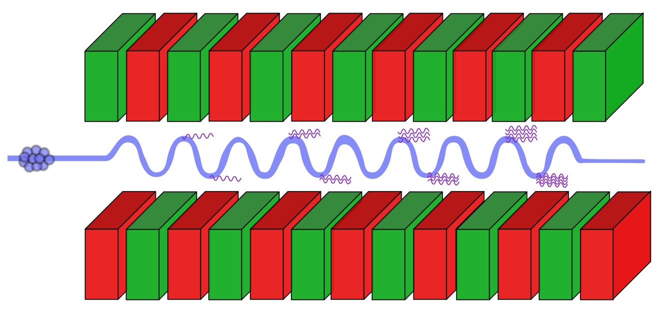
Idea: Energy spread compensation to obtain monochromatic radiation through:

- Chicane [3]: energetic dispersion of the beam
- TGU [1, 2]: B-Field matches energy dispersion

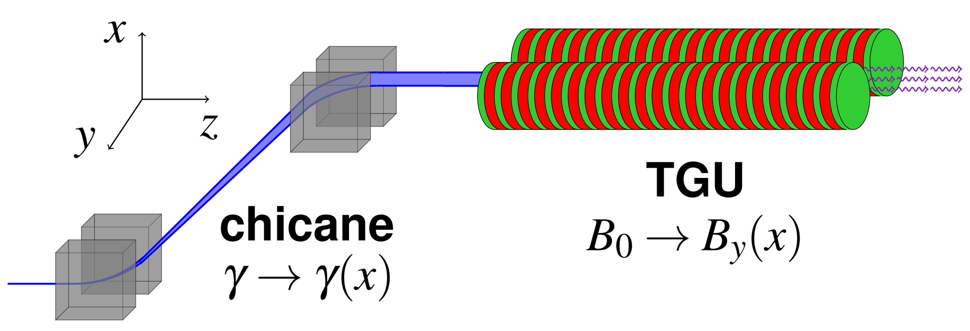
Modified Undulator Equation:

$\lambda_n = \frac{\lambda_u}{2\gamma(x)^2}\left(1+\frac{K(x)^2}{2}\right) = const.$, with $K(x) \propto \lambda_u B_y(x)$

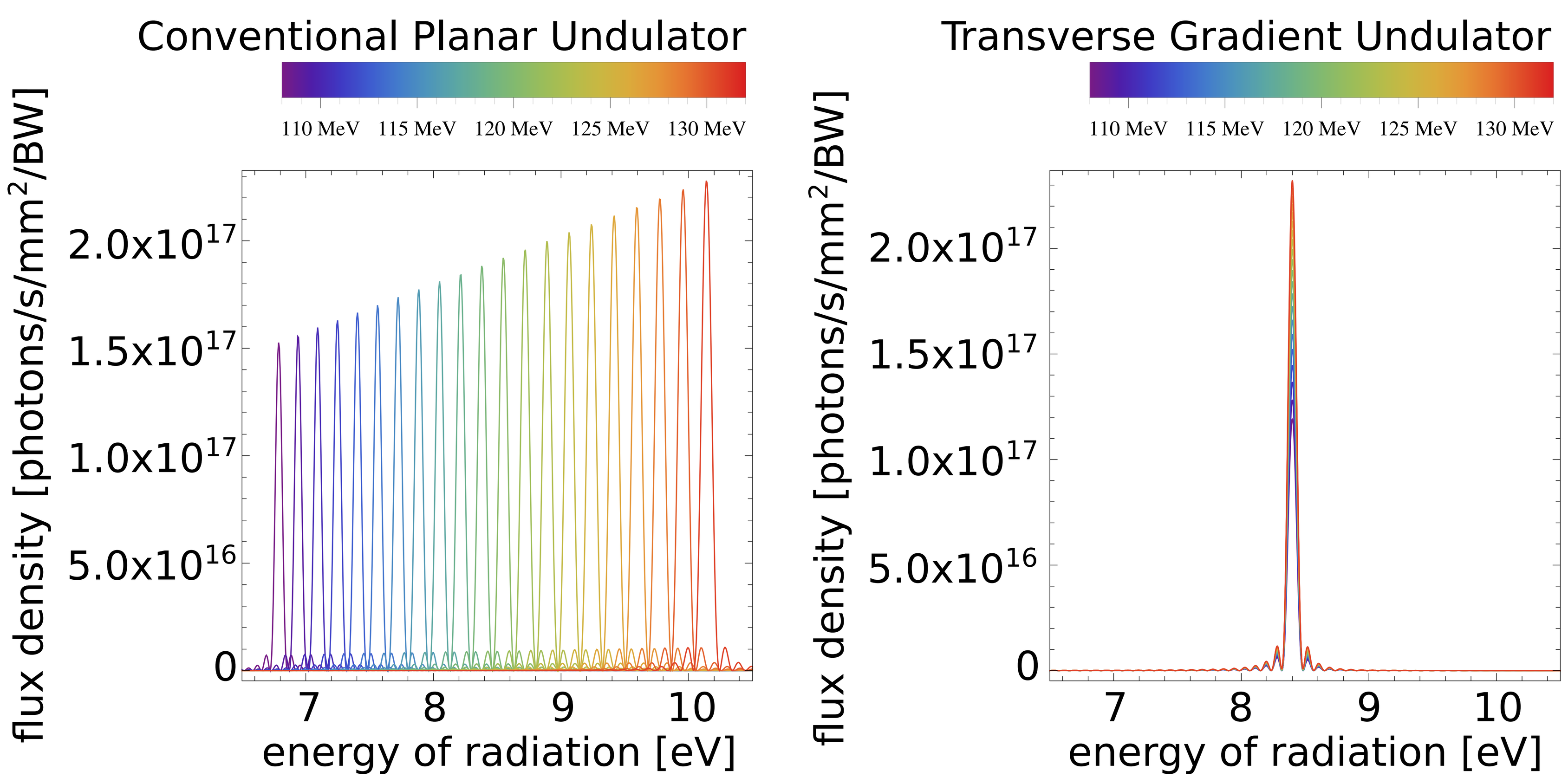
Conventional Planar Undulator:



Transverse Gradient Undulator (TGU):



Single electron Spectra simulated with WAVE [4]:



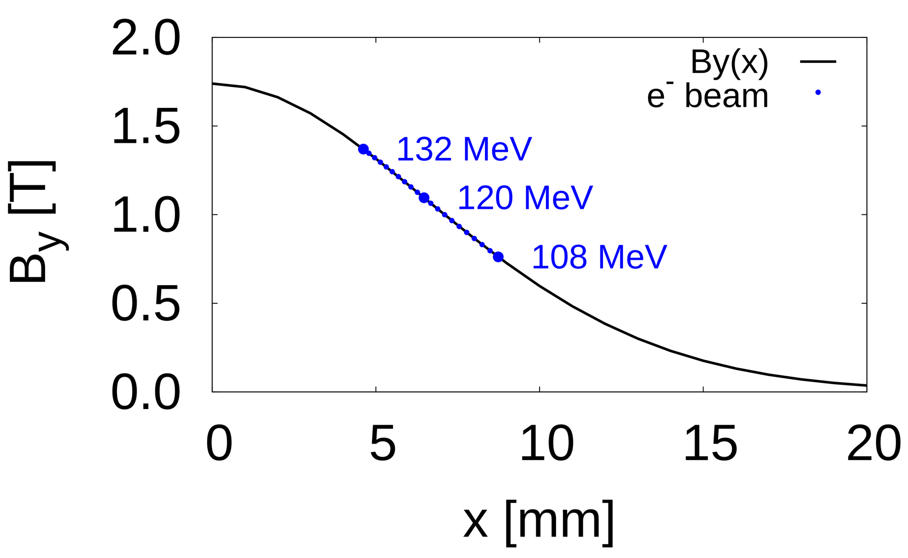
2 SUPERCONDUCTING TGU DEVELOPMENT:

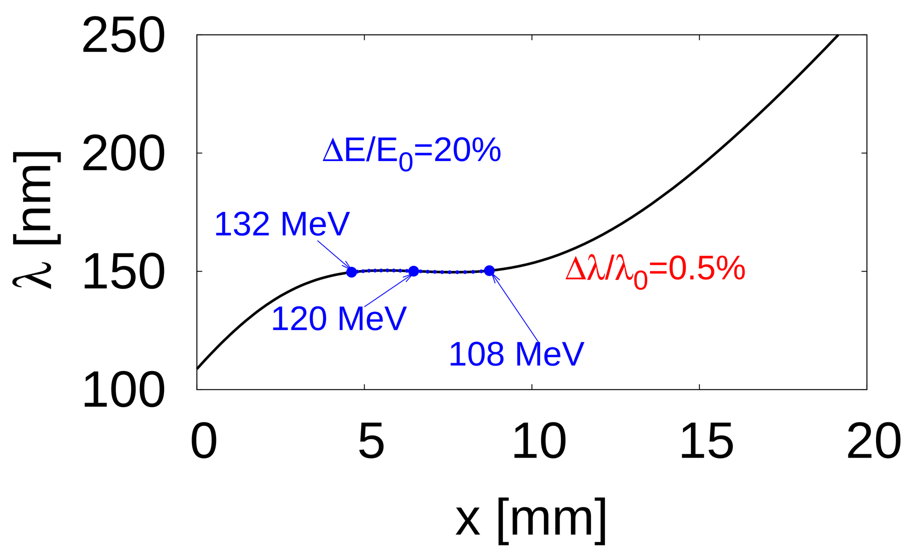
Design:

- TGU with cylindrical geometry: Large transverse gradient and small dispersion of $\sim 20\,\mathrm{mm}$ is necessary.

Geometry optimization results:

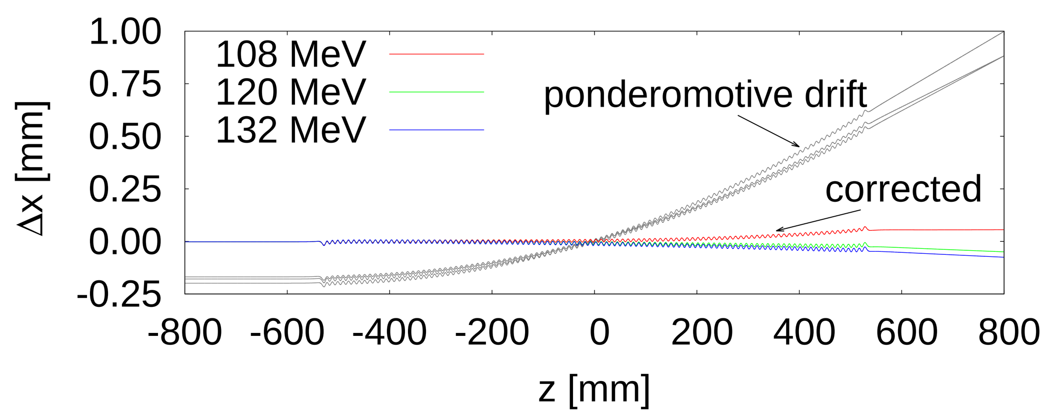
Period length, λ_u:	10.5 mm
Number of full periods, N_u:	100
Pole Radius:	30 mm
Undulator parameter, K @120 MeV:	1.1





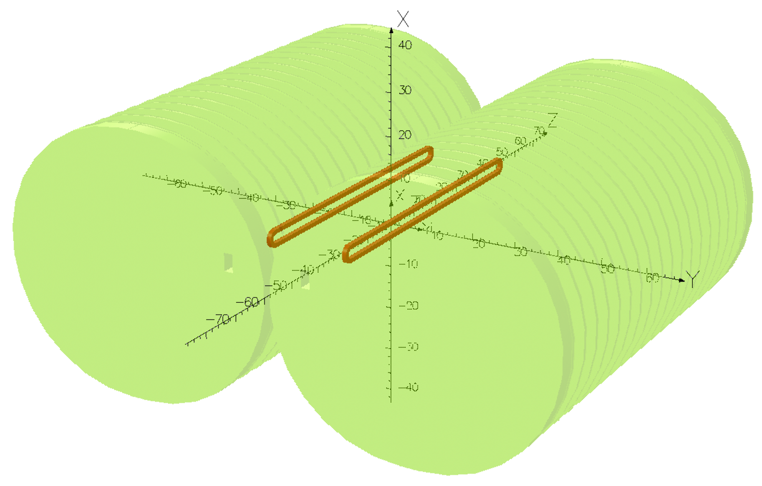
Drift of the electron trajectories:

- Due to the transverse gradient of the B-Field
- If Drift $< \pm 0.1\,\mathrm{mm} \to \Delta\lambda/\lambda_0 < 1/N_u = 1\,\%$

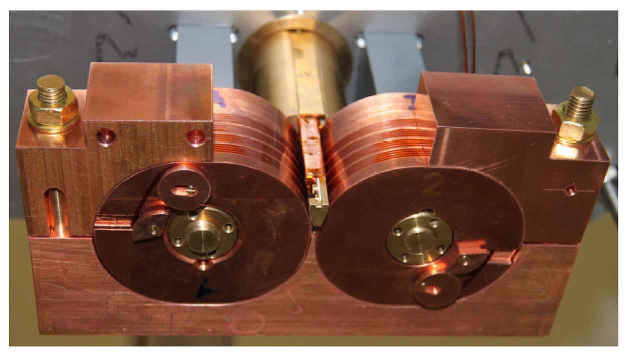


Drift Correction:

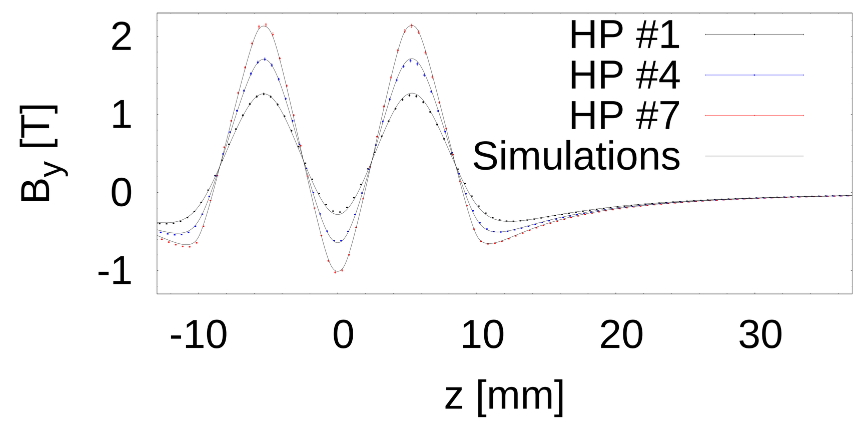
- Superposition of a weak correction field generated by 2 long narrow coils in the TGU
- It must not be disturbed by soft magnetic material → TGU must be iron-free



TGU Short Model Tests:



- Field measurement shows excellent agreement with simulation results.



- Quench test: Critical current reaches short sample limit ($I_c = 990\,\mathrm{A}$ at $4.2\,\mathrm{K}$).

TGU Status:

1st coil finished and 2nd coil winding in process.

3 CONCLUSIONS:

The simulations show that the concept of building a compact, highly brilliant LWFA-driven radiation source with a TGU is valid. The experiments show the technical feasibility of the SCTGU. A proof-of-principle experiment with the whole setup is planned in near future.

4 ACKNOWLEDGEMENTS:

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References

[1] G. Fuchert et al., NIM A, vol. 672, 33-37 (2012)
[2] V. Afonso Rodriguez et al., IEEE Transactions on Appl. Supercond., vol. 23(3), 4101505 (2013)
[3] C. Widmann et al., Proceedings of the IPAC'13, TUPWO013 (2013)
[4] M. Scheer, Proceedings of the ICAP'12 TUACC2 (2012)

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