Reinforcement Learning–Guided Dynamic Tuning of a THz Linac

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THz Acceleration Group website

THz acceleration

- Increasing accelerating gradient to GeV/m
- Tabletop accelerators
- Wavelength in a regime of fs-scale bunches
- Laser-based stability & repeatability

THz-driven beamline

- 4 orthogonal DLWs of the same length (~20 mm)
- Each is powered with THz pulse injected at chosen phase
- Orthogonal DLWs substitute focusing and defocusing quadrupoles

This study focus

- Can simple THz-driven structures simultaneously accelerate and transport the beam?
- **Static optimisation** of beamline with MOBO for beam dynamics
- **Dynamic tunning** of beamline for error correction

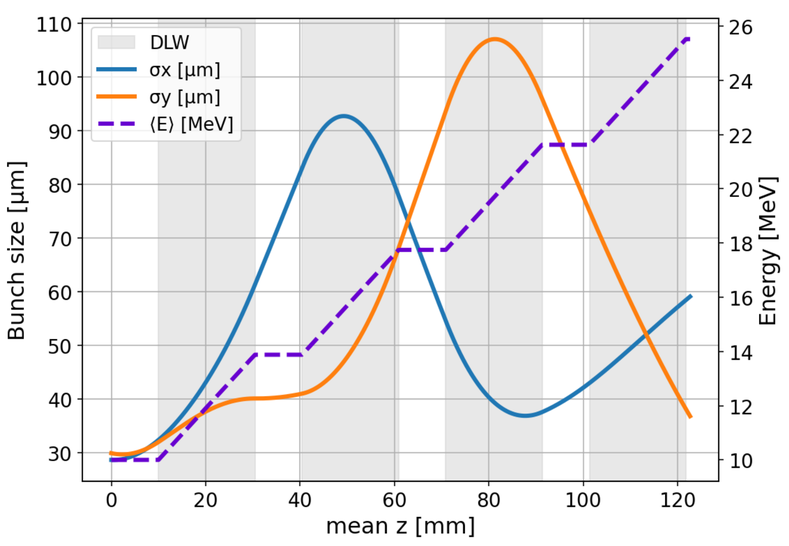

Fig . Energy and bunch size evolution.

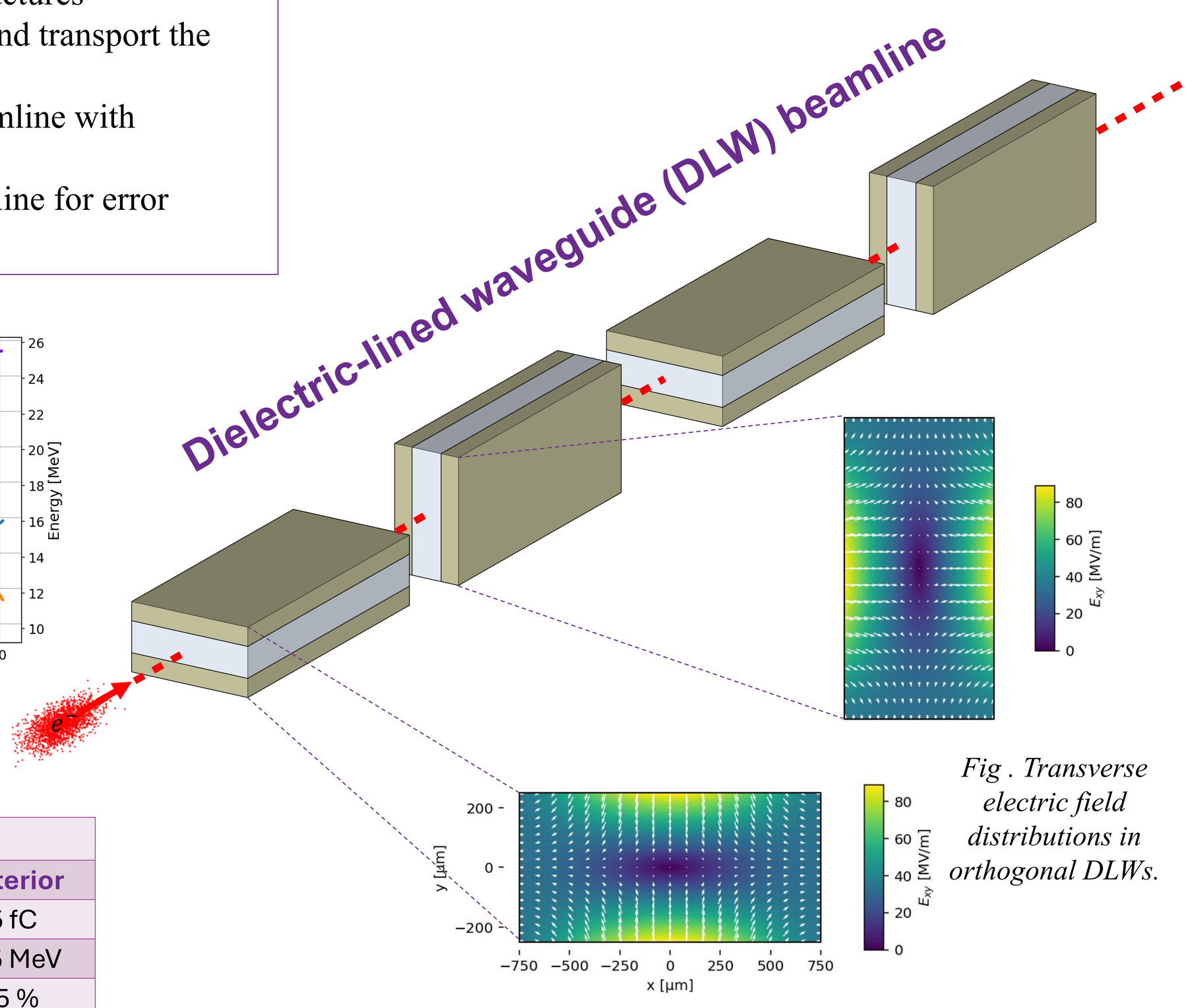

Fig . Transverse electric field distributions in orthogonal DLWs.

Bunch characteristics		
	Prior	**Posterior**
Charge	100 fC	95 fC
Energy	10.0 MeV	25.5 MeV
ΔE_{rms}	0.1 %	0.5 %
σ_{xy}	30 μm	46 μm
ϵ_{xy}	0.54 μm	1.81 μm

Bayesian optimisation of beamline

- **Parameters:** one common length and 4 injection phases of DLWs
- **Objectives:** final energy and transverse emittance of the bunch
- **Acquisition:** constrained qLogNEHVI to maximise expected hypervolume improvement

Next stage: RL tuning

- Manufacturing errors in dielectric lining
- Phase velocity change causes desynchronisation and decrement in bunch quality (energy spread and emittance)
- This can be corrected with phase offset tunning
- RL optimisation approach that adjusts phases learning from acquired beam measurement