Concept of emittance exchange using two bending magnets and two transverse deflectors at CLEAR (CERN Linear Electron Accelerator for Research)

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MOPO002: Oral poster

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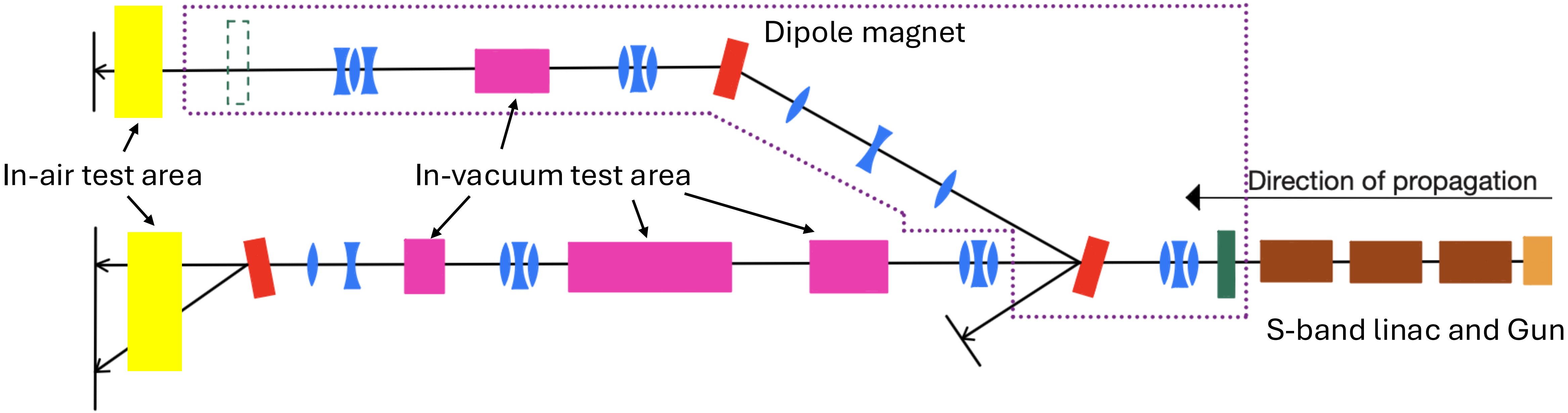
Simplified layout of CLEAR



- CLEAR (CERN Linear Electron Accelerator for Research) is a user facility providing 200 MeV electron beam for different type of irradiation experiments (https://clear.cern)
- We recently installed and commissioned 2nd beamline at CLEAR and conducted initial experiments there
- It features two large test areas (in-vacuum and in-air) and large beam-pipe aperture

- *In this work, we investigate if 2nd beamline can be used as a transverse-to-longitudinal emittance exchange scheme by complementing it with one deflecting structure downstream*

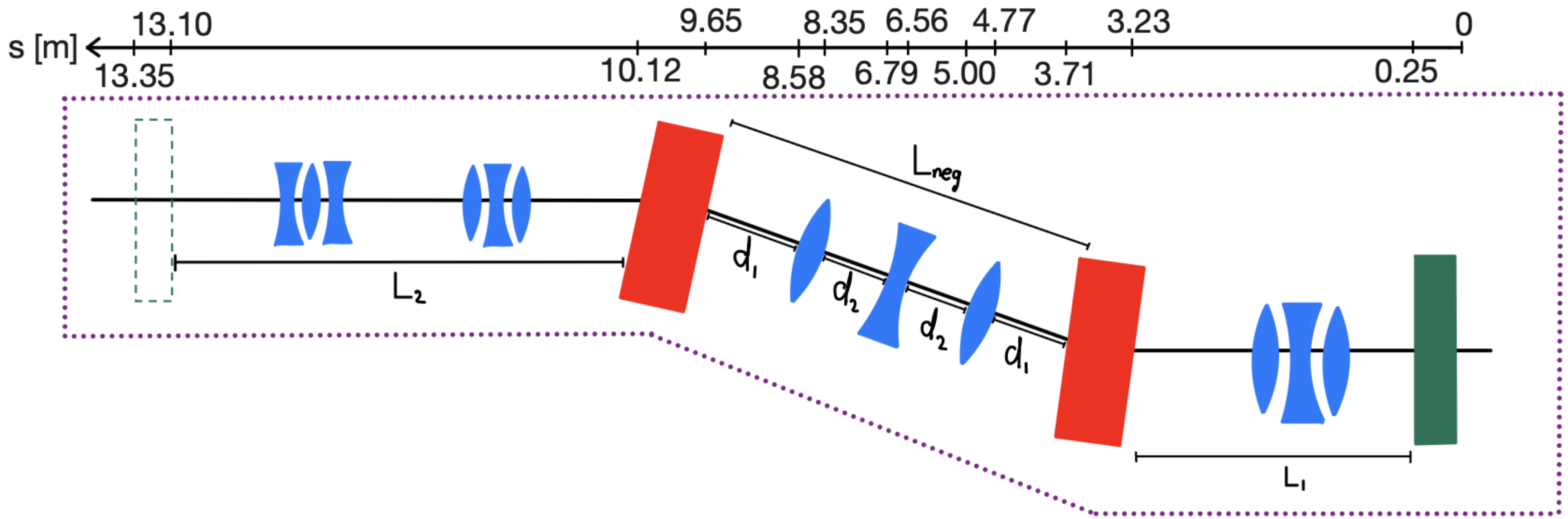
Emittance exchange scheme (EEX)

- Original EEX scheme utilizes 2-dogleg (4 bending magnets) and one transverse-deflecting structure [M.Cormacchiaet al.,"TransversetoLongitudinalemittance exchange", vol. 5, 2002]

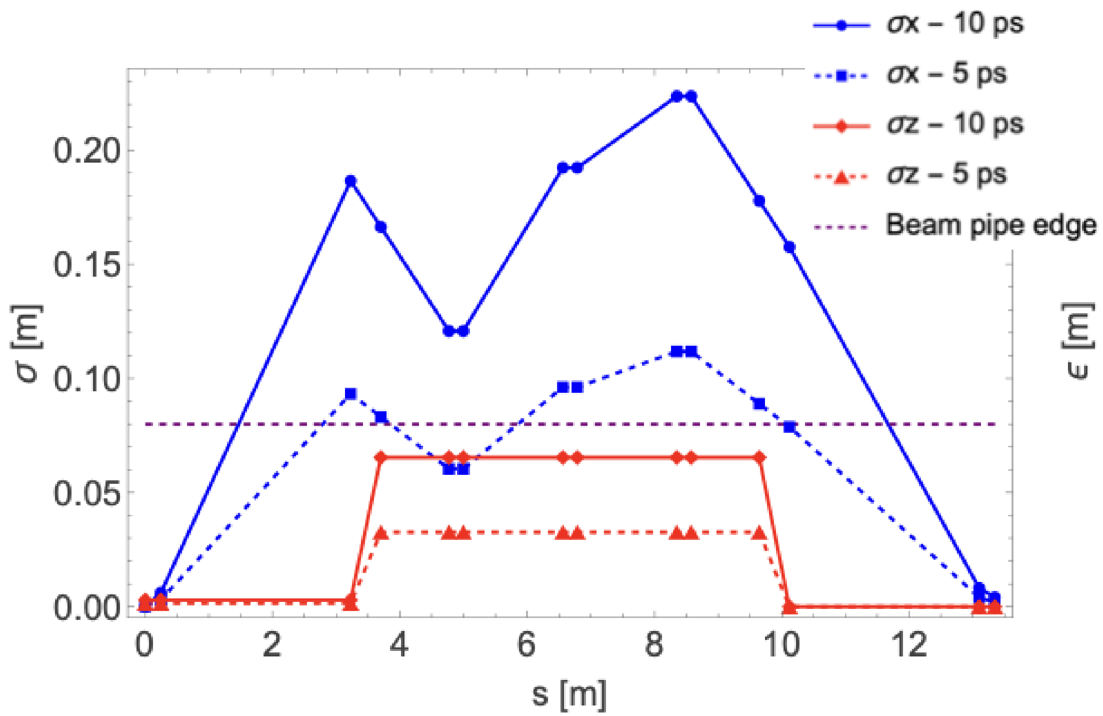
- Alternative exact EEX scheme is possible with a single dogleg and two deflectors
- These scheme requires at least two “negative drift” sections which can be realized with quadrupoles
- The scheme is feasible at CLEAR and allows to reach the exact EEX (in the 1st order)

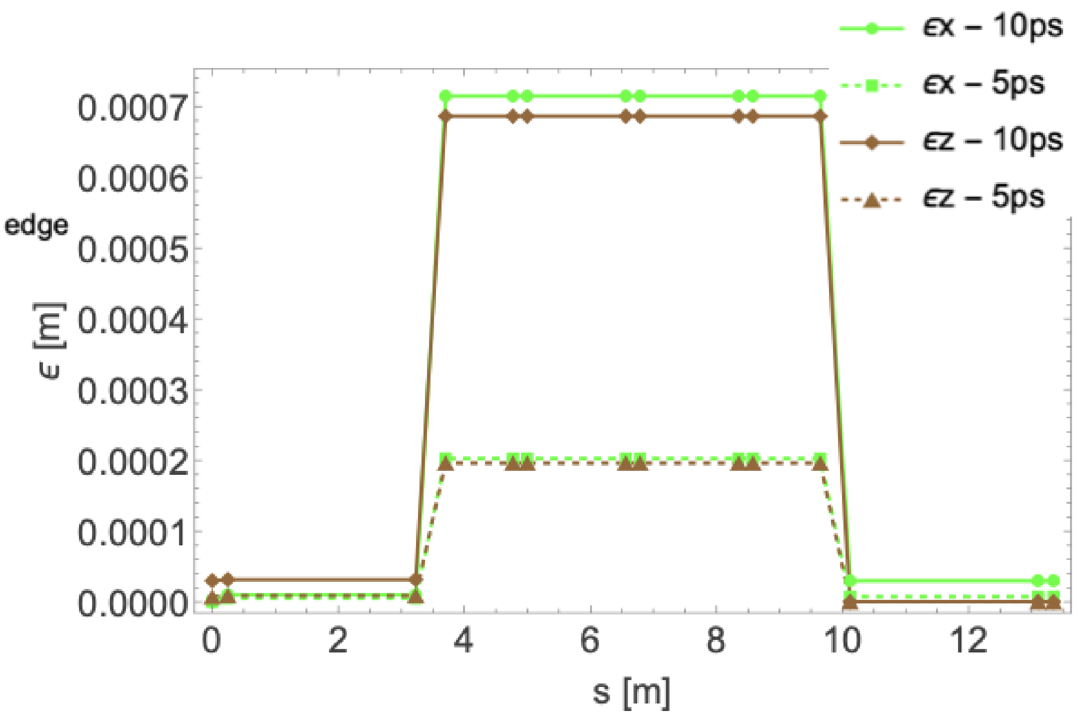
Quantity	Value at CLEAR
d_1	1.07 m
d_2	1.56 m
L_m	0.47 m
L_{neg}	-0.31 m
L_{eff}	0.62 m
f_1	-0.74 m
f_2	-0.41 m
κ	-16.70 m^{-1}
η	0.06 m

Beam Parameter	Value
σ_x	2×10^{-4} m
α_x	0
α_z	0
σ_t	10, 5 ps
σ_δ	1%, 0.5%
$\gamma_{\mathrm{Lorentz}}$	391.40
ϵ_x	0.02755 μm
ϵ_z	3 μm
E	200 MeV



Linear Single-particle beam dynamics: ideal exchange





$$M_{DogLeg} = \begin{bmatrix} R_{11} & R_{12} & R_{15} & R_{16} \\ R_{21} & R_{22} & R_{25} & R_{26} \\ R_{51} & R_{52} & R_{55} & R_{56} \\ R_{61} & R_{62} & R_{65} & R_{66} \end{bmatrix} = \begin{bmatrix} 1 & L_{eff} & 0 & \eta \\ 0 & 1 & 0 & 0 \\ 0 & \eta & 1 & \psi \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$M_{EEX*} = \begin{bmatrix} 0 & 0 & 0 & \eta \\ 0 & 0 & -\frac{1}{\eta} & 0 \\ 0 & \eta & 0 & 0 \\ -\frac{1}{\eta} & 0 & 0 & 0 \end{bmatrix}$$

$$M_{EEX} = \begin{bmatrix} 0 & 0 & -\frac{L_{TDC}}{3\eta} & \eta \\ 0 & 0 & -\frac{1}{\eta} & 0 \\ 0 & \eta & 0 & 0 \\ -\frac{1}{\eta} & -\frac{L_{TDC}}{3\eta} & 0 & 0 \end{bmatrix}$$

* Thin TDC approximation

Summary and outlook

✓ Ideal exchange with a single-dogleg EEX is feasible within current layout CLEAR 2nd beamline layout (if one extra transverse deflector is added downstream)

✓ Thick deflector in a single-dogleg EEX does not require additional compensation of R_{65} with an accelerating cavity as in the original double-dogleg EEX

✓ Since longitudinal emittance is several order larger than transverse emittance, the scheme can extend the range of available machine parameters:

- Additional bunch compression to reach shorter beam and energy spread
- Enlarging transverse beam size
- Beam shaping
- Transverse mask for advance longitudinal and energy profile shaping

❑ High-order effects and collective effects (e.g. CSR) to be investigated

❑ If results are promising – we will consider trying it experimentally