Fermilab

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Reverse emittance exchange at MICE

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Wedge absorbers and emittance exchange

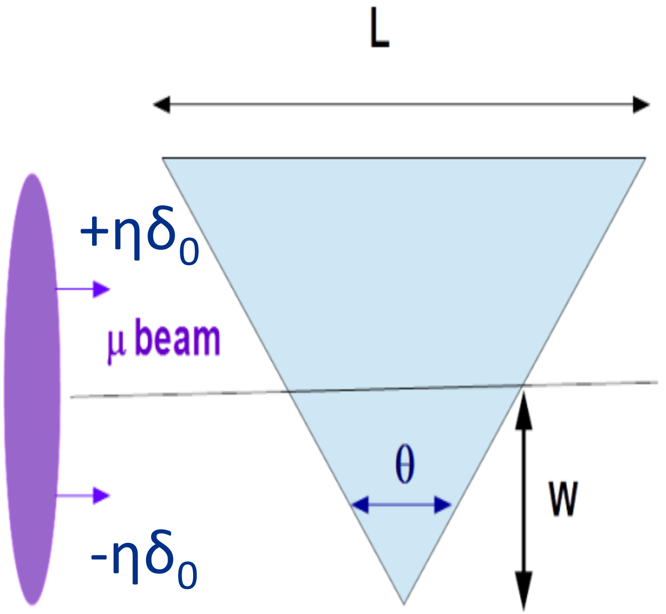
- Matrix formalism:

$$\mathbf{M}_\delta = \begin{bmatrix} 1 & 0 \\ -\delta' & 1 \end{bmatrix} \qquad \mathbf{M}_\eta = \begin{bmatrix} 1 & \eta_0 \\ 0 & 1 \end{bmatrix}$$

  – wedge is δ' = **dp/ds 2 tan[θ/2]/p**

$$\boxed{\delta_1 = \delta_0 \left[(1-\eta_0\delta')^2 + \frac{\delta'^2 \sigma_0{}^2}{\delta_0{}^2} \right]^{1/2}}$$

  – $\varepsilon_{L,1} / \varepsilon_{L,o} = \delta_1/\delta_0$; $\varepsilon_{t,1} / \varepsilon_{t,o} = \delta_0/\delta_1$



Can decrease ε_L and increase ε_t (or reverse)

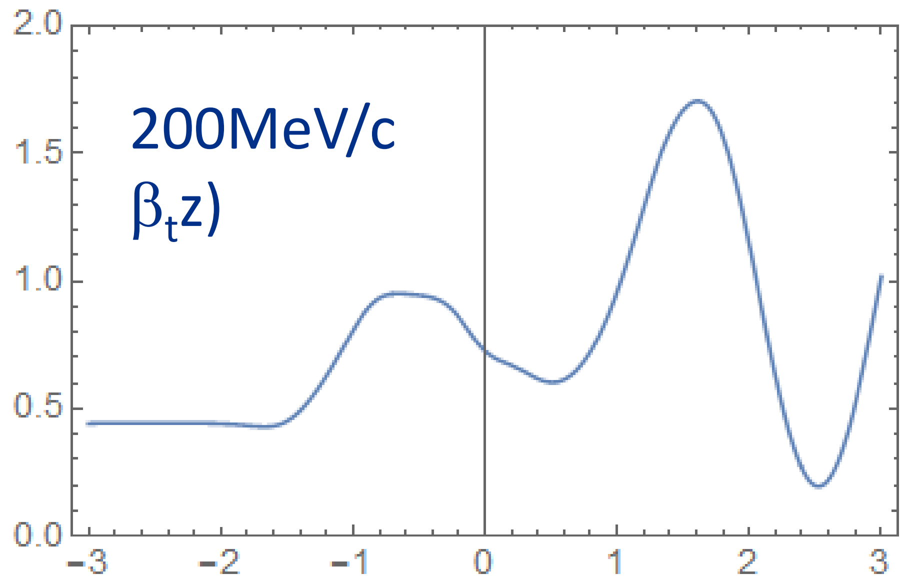
- **Reverse emittance exchange (at η=0):**

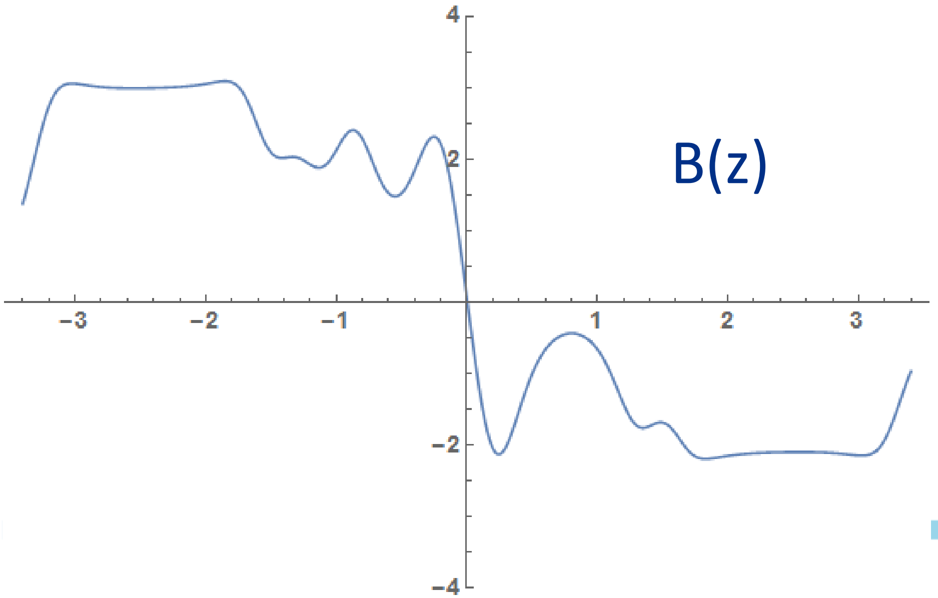
$$\frac{\varepsilon_{t,1}}{\varepsilon_{t,0}} = \sqrt{\frac{\delta_0^2}{\delta_0^2 + \delta'^2\sigma_0^2}}$$

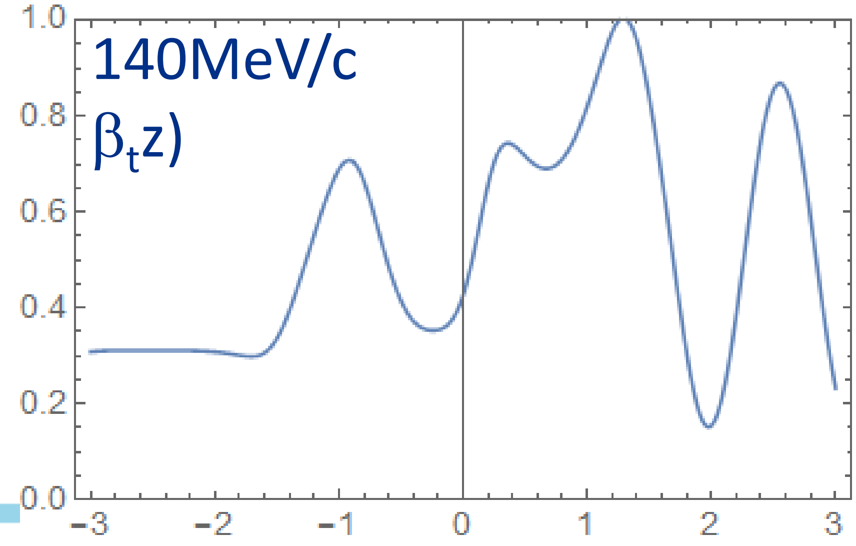
  – **large effect, with small δ_0; used δp = 2MeV/c for MICE**

Optics for MICE system

- 2017-02-07
  - B(Z)
  - 200 MeV/c
  - 140MeV/c





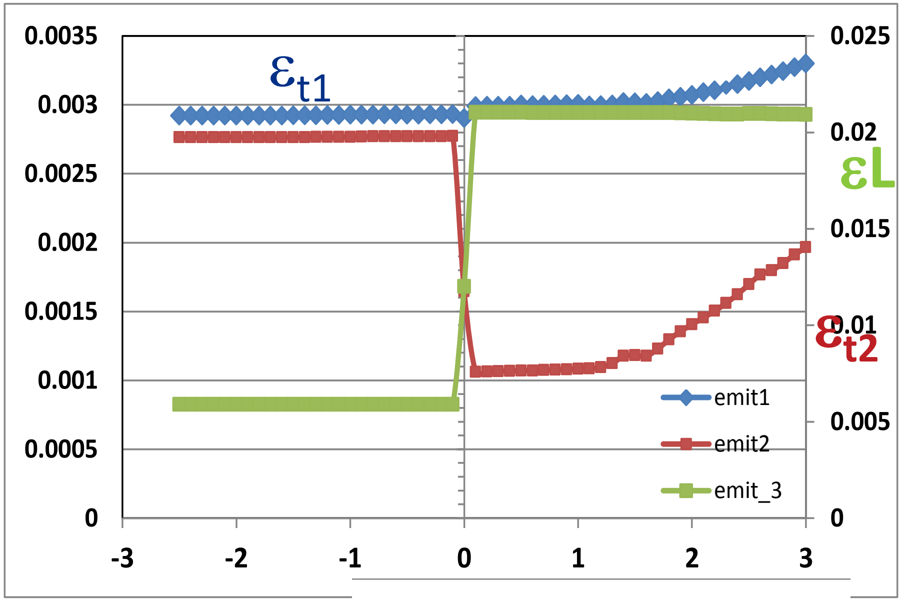


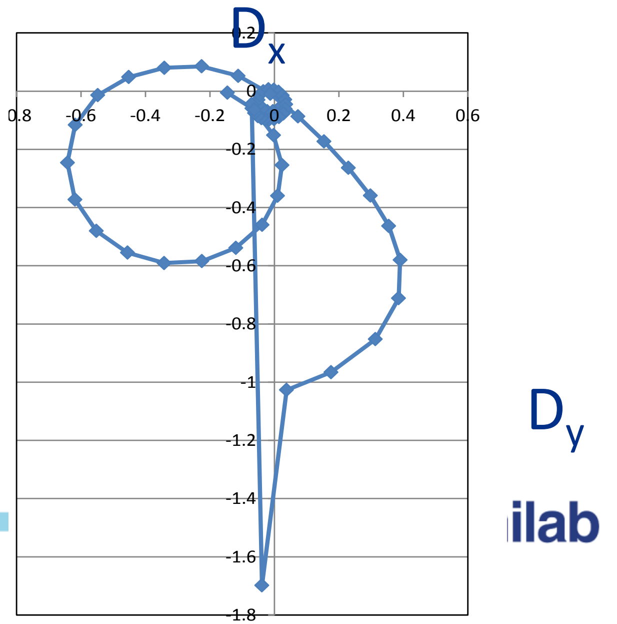
MICE with M2 (2017-02-7 settings)

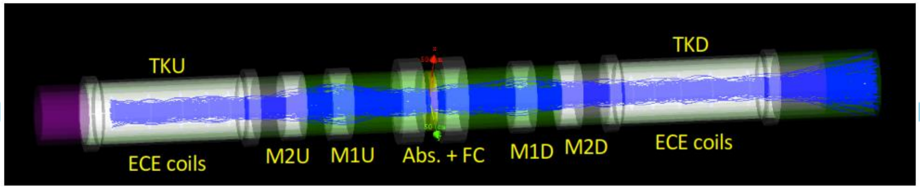
- 200MeV/c; ε_t=3mm; δp_0=2 MeV/c
- with M2 on (-195 A)
  - 3T→2T in DS
- good behavior
  - less emittance dilution in DS
    - 1.05 → 2.0mm
    - 3.0→3.3mm

Dispersion in DS is well behaved

200 MeV/c-3mm is a good beam setting to include in the experiment

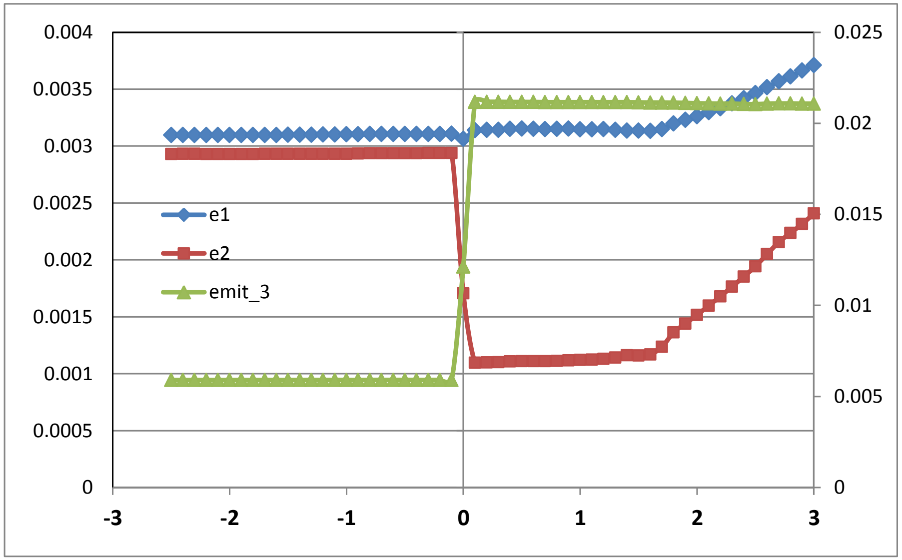




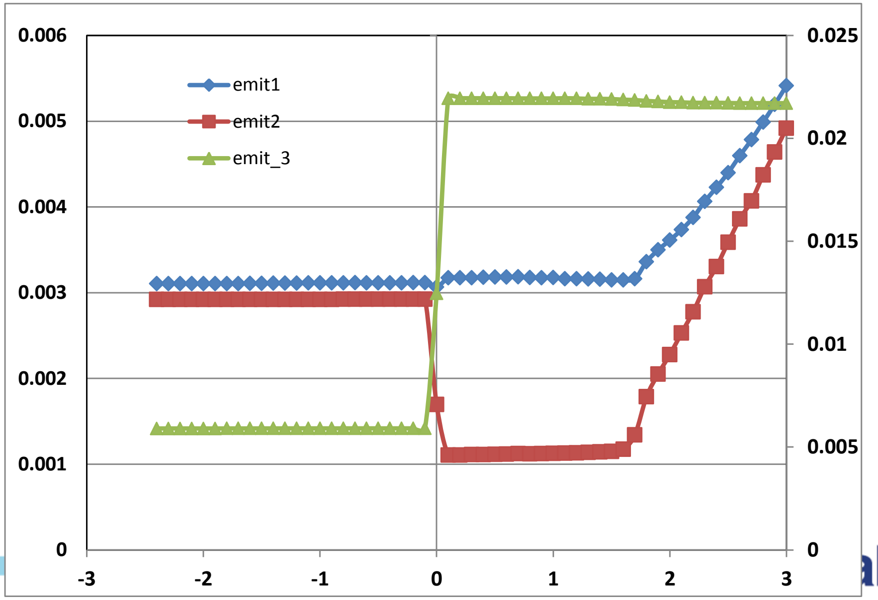


Other cases

- M2D reduced to -110
  – reverse emittance exchange about as good as 2017-02-7



- M2D off (2016-05-1)
  – not as good
  – nonlinear emittance growth in DS much larger
  – effect still visible at DS entrance



Summary

- **Wedge emittance exchange is an important part of beam cooling**
- Experiment at MICE could demonstrate the principle
  - in both “direct “ and “reverse” exchange
- **Large** effect in reverse exchange could be measured