Charge recombination for the muon collider

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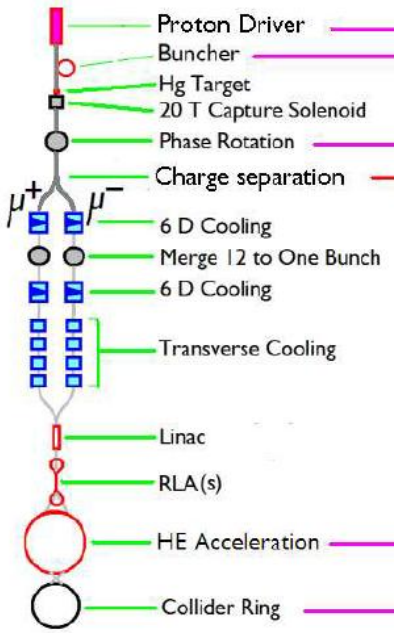
Introduction

- the two charged muon beams need to be recombined somewhere in the cooling channel
- take a first look here at what issues might be involved
- assume here that this is done at the end of the Guggenheim channel
- look at a design modeled on our charge separation design

  Norem matching (tapered bent solenoid field and curvature)

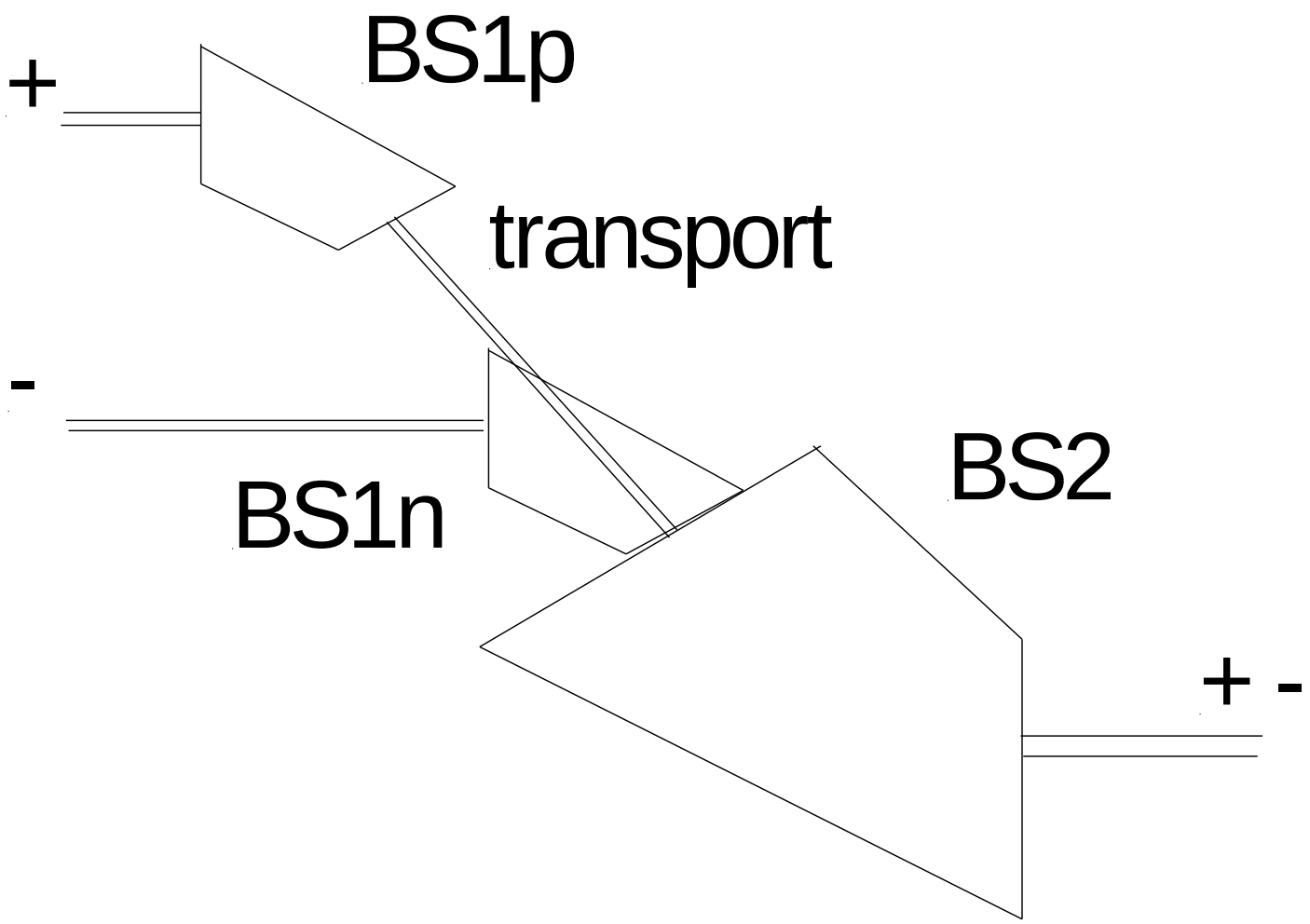
  two bent solenoids with opposite curvature to remove dispersion

  allow acceleration to higher momentum to reduce emittance growth



Bob's scheme at Telluride shows recombination after final cooling

Layout



Assumptions

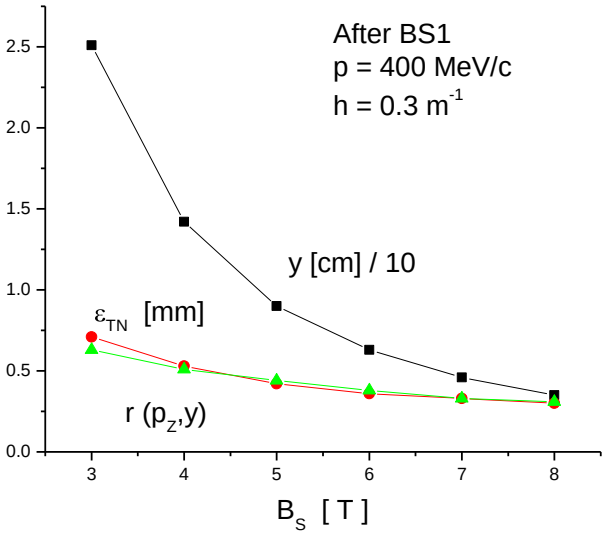
ε_{TN} = 0.24 mm (Bob's design at SLAC)
ε_{LN} = 2.2 mm
β_T = 2.8 cm * (p / 160 MeV/c)
σ_{ct} = 1.9 cm

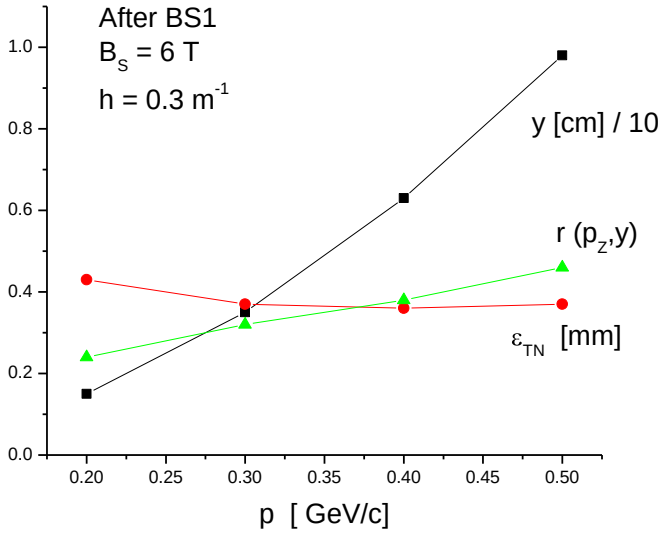
Norem matching (λ = Larmor wavelength, h = geometric curvature)

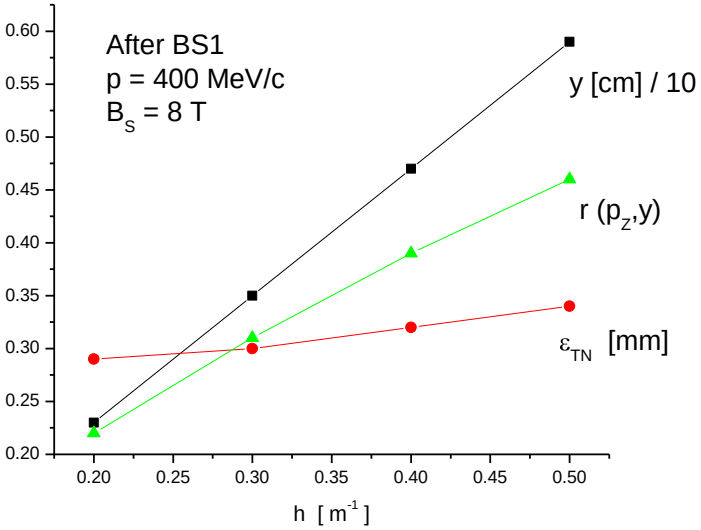
part 1	$L = \lambda / 2$	$\kappa = h / 2$
part 2	$L = 0.18\ \lambda$	$\kappa = h$
part 3	$L = \lambda / 2$	$\kappa = h / 2$

- want two beam pipes separated by ≥ 2 cm going into 2nd bent solenoid
- positive transport pipe doesn't go thru BS1 for negative beam ??

BS1 properties



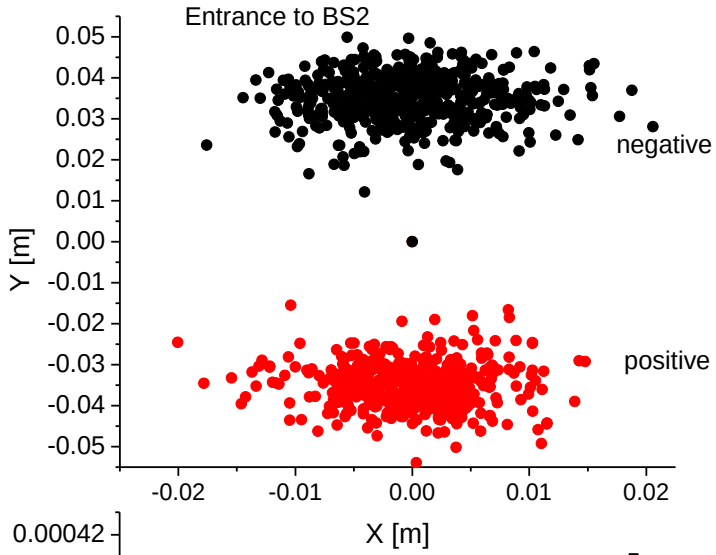


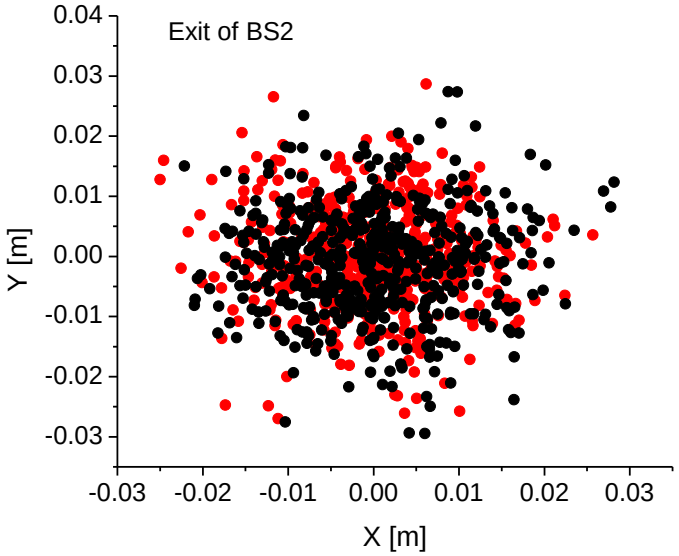


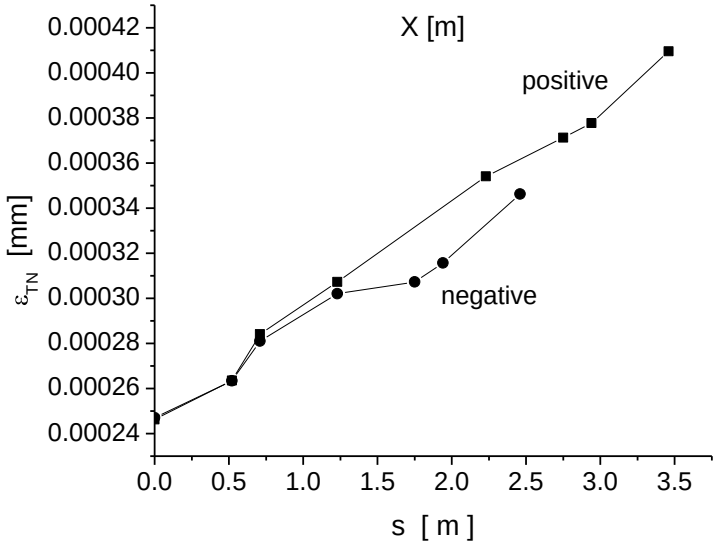
- need large B_S and large p

Full channel

- chose p = 400 MeV/c, B_S = 8 T, h = 0.3 m^{-1} , 1 m transport line







- significant transverse emittance growth
  - 70% for positives
  - 45% for negatives
- almost all due to momentum spread in beam
- longitudinal emittance growth small ~1%
- transmission very good ~99%

Separation of incoming beam pipes

- bend angle thru each bent solenoid

$$\theta = \tfrac{1}{2}\lambda / 2\rho + L_C / \rho + \tfrac{1}{2}\lambda / 2\rho$$

- for this case with $L_C = 0.18\ \lambda$, $\theta = 0.21$ rad
- horizontal separation

$$HS = L_T \sin\theta$$

- for this case with $L_T = 1$ m, HS = 21 cm
- this can be increased by increasing L_C or L_T, but we're fighting $\Delta\varepsilon_T$
- How much separation do we need between the incoming beam lines?

Next steps

- transverse emittance growth shows recombination should be done before final cooling
- get initial beam distribution from end of Guggenheim post-merge study
- design acceleration up to ~400 MeV/c
- design proper match into bent solenoids
- determine required horizontal separation of two incoming beam lines
- adjust channel lengths so two charges end up separated in time by ½ λ_{RF}
- reoptimize using the simple ICOOL bent solenoid model used here
- make G4beamline model
    - use the ICOOL results for initial layout and parameters
    - watch out for geometry overlap errors for discrete coils
    - can positive transport pipe really avoid going thru BS1 for negative beam?
    - check additional emittance growth due to solenoid fringe fields
    - can we correct for chromatic aberrations in the channel?