Charge recombination for the muon collider-3

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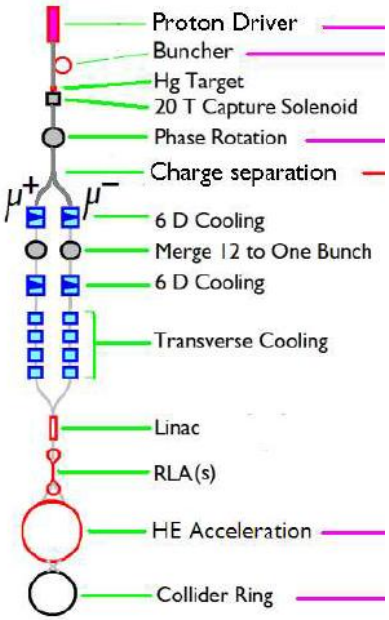
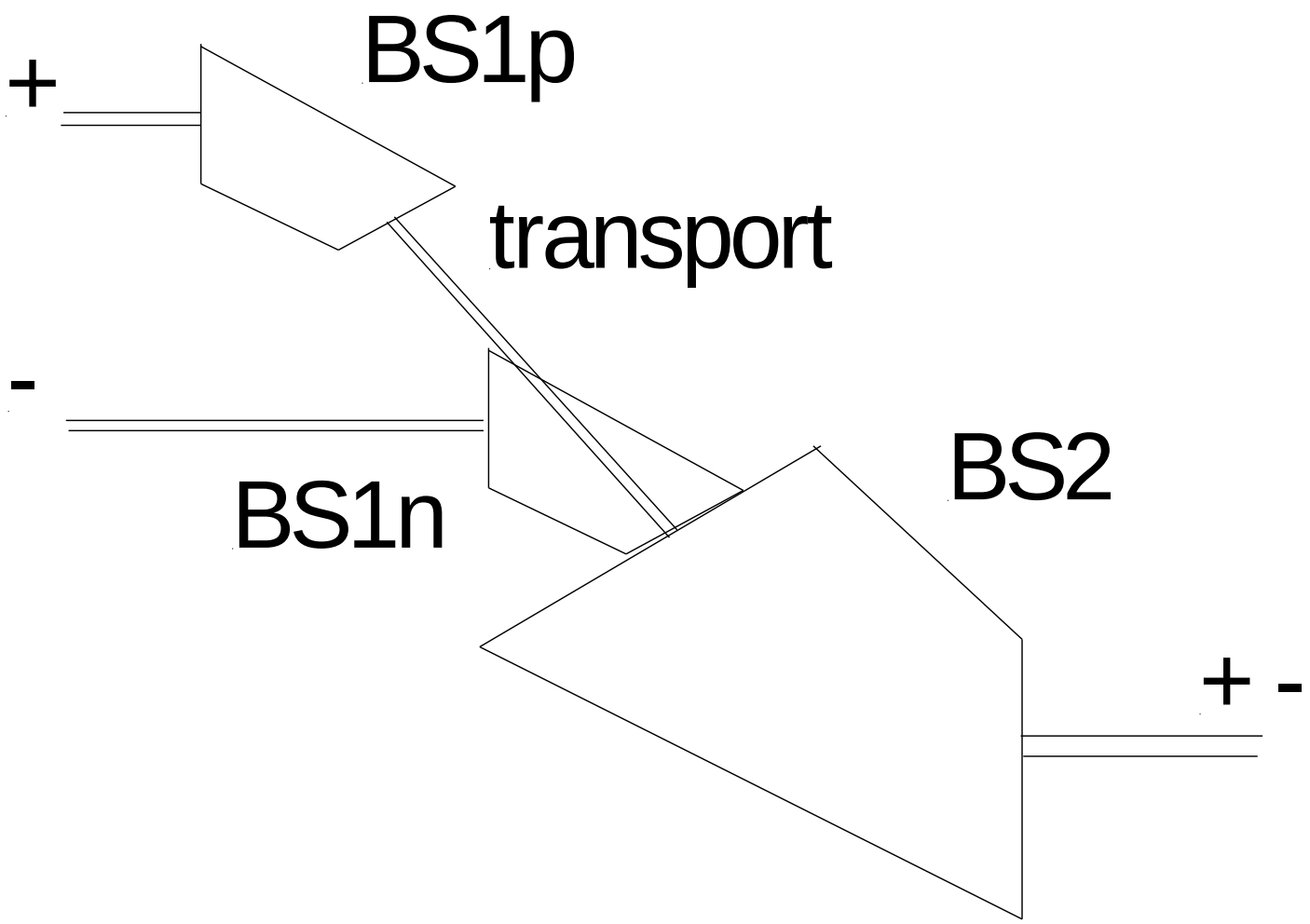
Introduction

- the two charged muon beams need to be recombined somewhere in the cooling channel
- look here at an alternate design to avoid intersecting beam lines
    1. Norem matching (tapered bent solenoid field and curvature)
    2. allow acceleration to higher momentum to help reduce emittance growth
    3. each charge sees two bent solenoids with opposite curvature
        - first bent solenoid is same for both charges
        - properties of 2nd bent solenoid differs from the first
        - B_S is same, but θ_{bend}, Δy, h, and coil dimensions are different
        - only partially removes dispersion in exit beam
        - try to minimize emittance growth in exit beam

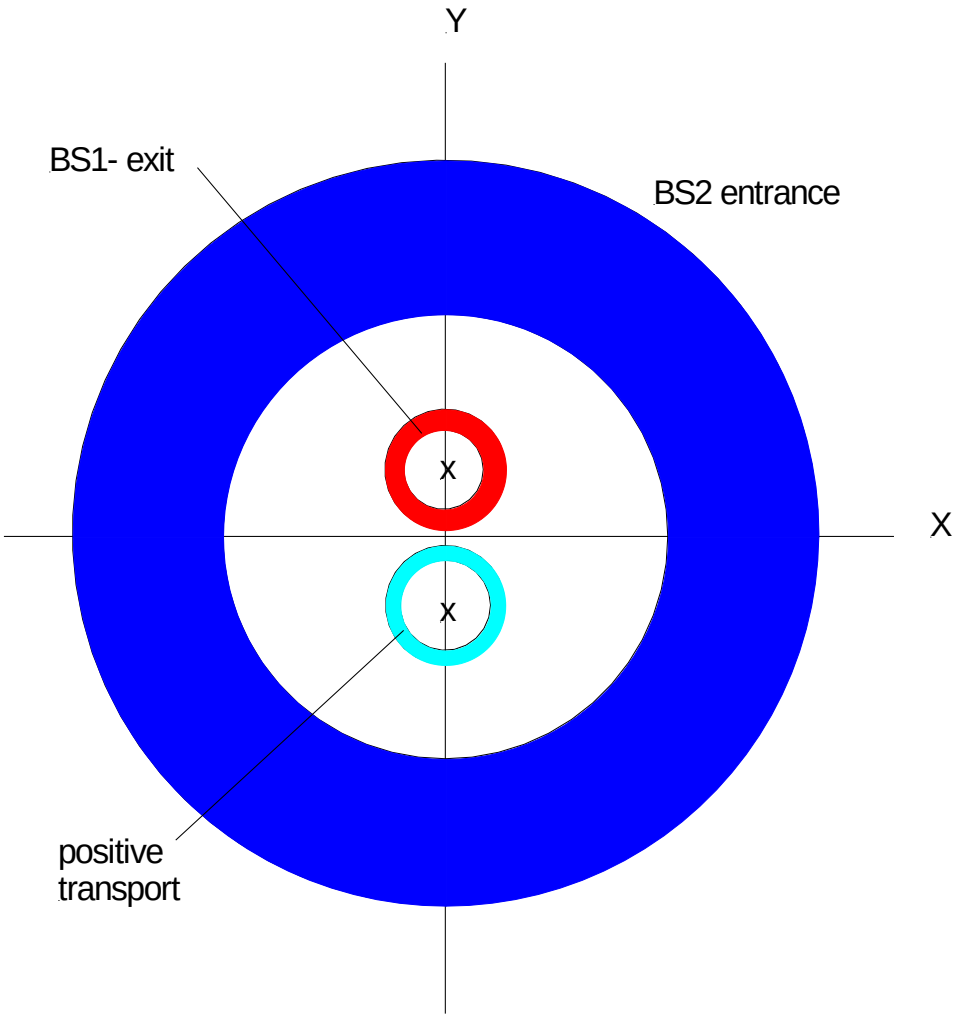


Bob's scheme at Telluride shows recombination after final cooling

Schematic layout



Entrance to BS2



Make smaller deflection in BS1 than BS2
- straightforward magnet design
- external beam lines are not in a plane
- exit beam likely has dispersion & $\Delta\varepsilon$

Input beam parameters

ε_{TN}	22	μm
ε_{LN}	72	mm
p	400	MeV/c
σ_X	2	mm
σ_{PX}	1.16	MeV/c
β_T	69	cm
σ_Z	300	cm
σ_{PZ}	2.47	MeV/c

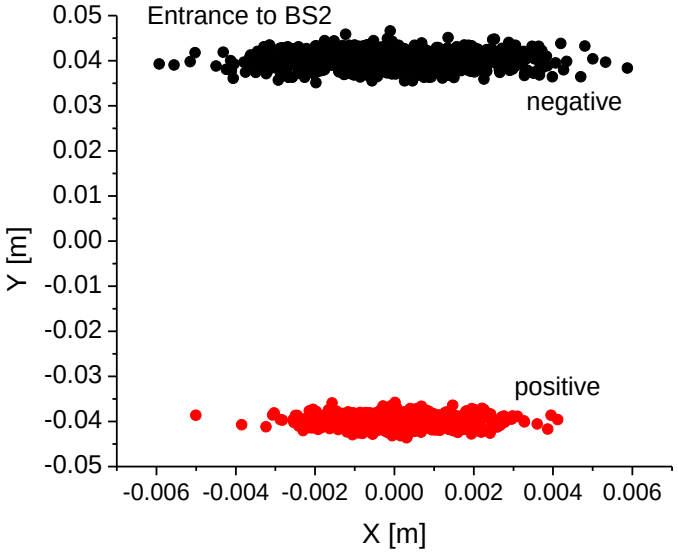
- σ_Z is at maximum for 4 MHz following RF

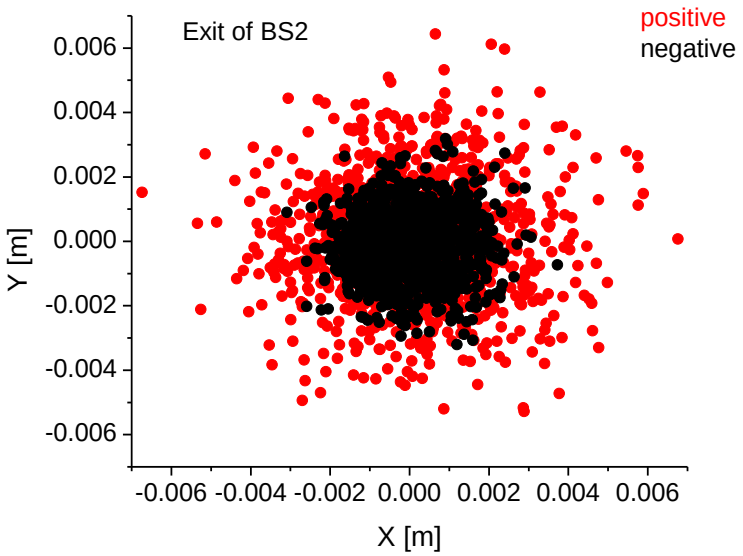
Solenoid channel parameters

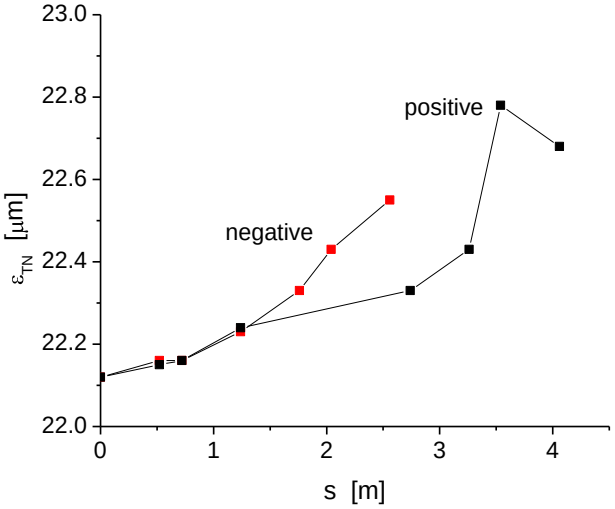
B_S	8	T
λ_L	1.047	m
Le	52	cm
Lc1	20	cm
h1	10	cm
Δy1	±1.2	cm
Lc2	28	cm
h2	30	cm
Δy2	±4	cm
LT	1.5	m

- incoming beam lines are offset by ±2.8 cm

Full channel

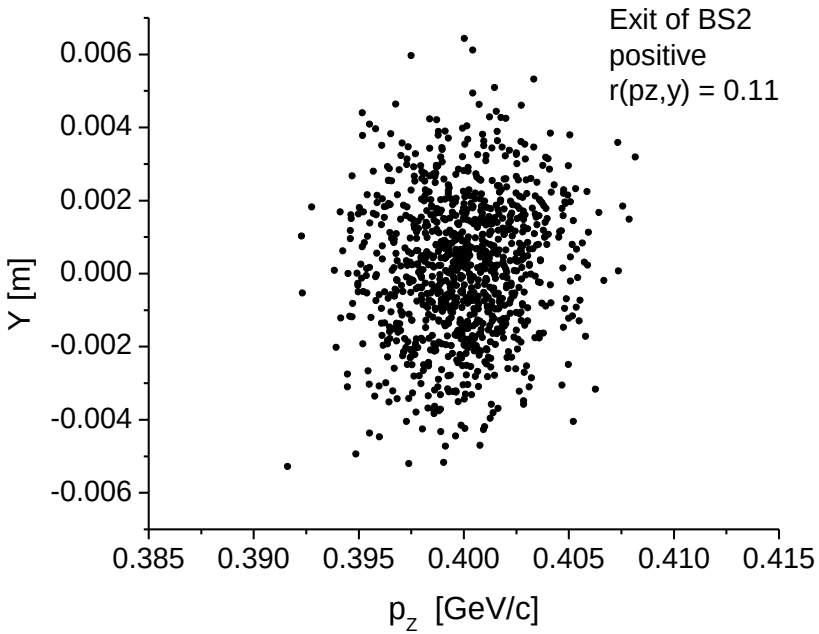


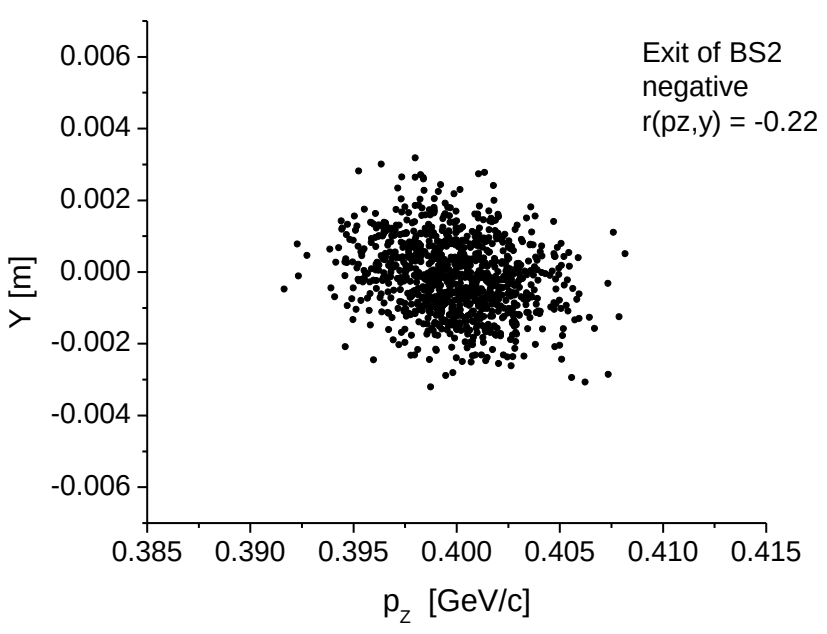




- transverse emittance growth ~3.2%
- longitudinal emittance growth small ~0.1%
- transmission very good ~99%

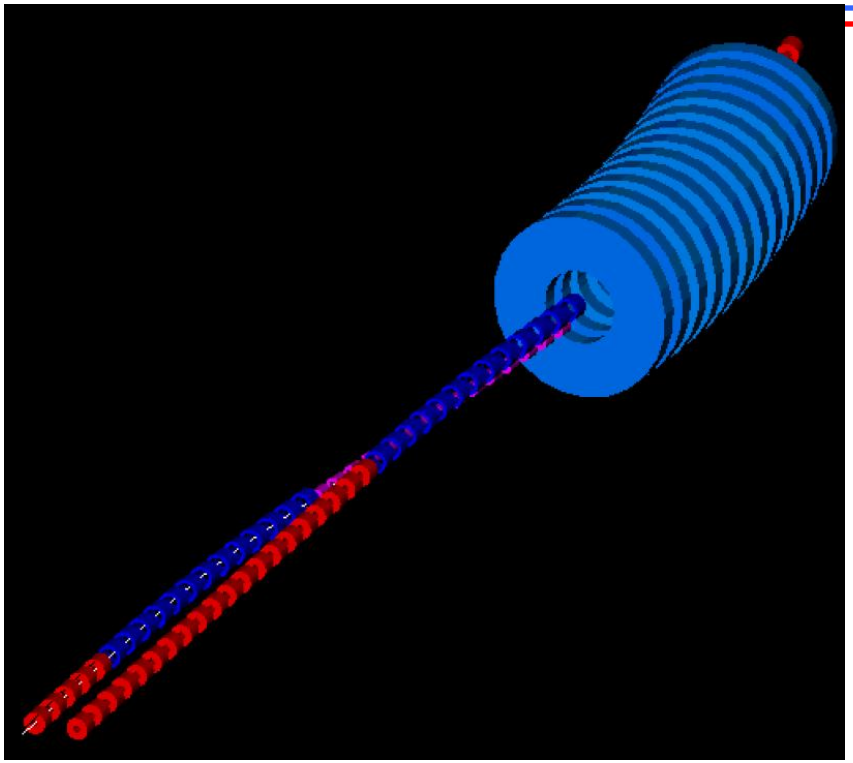
Full channel



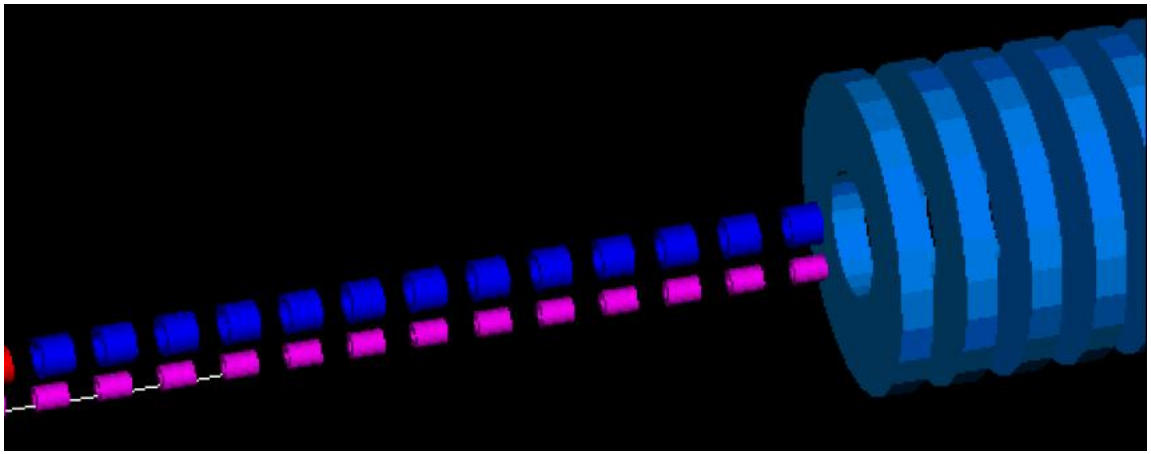


- dispersion is mostly removed

G4beamline model



- beam lines do not intersect



Coil properties

- adjusted coil dimensions to avoid overlap
- adjusted current densities to give roughly 8 T in all beamlines

	L [cm]	**a [cm]**	**b [cm]**	**J_E [A/mm^2]**
external	5	1	3	394
BS1	5	2.2	3.2	882
transport	5	1	2	743
BS2	5	10	25	89

- are these current densities feasible?
- is enough room available for cryostats and mechanical supports?
- many of the coils can be made longer in a practical design

Summary

- this design uses non-symmetric bent solenoids
- makes it possible to avoid intersecting beam lines
- no problem with transmission or longitudinal emittance growth
- ~3% growth in transverse emittance
- small dispersions in the exit beam bunches
- requires large current densities in some of the coils
- design may need to be iterated if the required coil properties are not feasible