Thoughts on Emittance Diagnostics for a Neutrino Factory Cooling Test

K.T. McDonald

Princeton U.

Decmeber 14, 1999

Princeton/$\mu\mu$/99-20

http://puhep1.princeton.edu/mumu/tpctrans3.ps

Goal: Measure the emittance of the muon beam to 3% accuracy before and after the muon cooling apparatus.

Overview

Measure muons individually, and form a virtual bunch in software.

Large transverse emittance: $\epsilon_{N,x} = 10,000\pi$ mm-mrad.

$\Rightarrow$ Confine the muon beam in a solenoid channel.

Don't need bent solenoid unless want momentum measurement.

Can we use a low field, such as 1 Tesla?

IF the cooling apparatus has no rf,
and we study only transverse cooling,
and the muon beam has a well defined momentum bite,
THEN could skip momentum measurement,
$\Rightarrow$ Could do tracking at atmospheric pressure.

If want to measure momentum, need low-pressure tracking to avoid multiple scattering.

TPC in a solenoid still the best tracking device.

If the apparatus has 200 MHz rf, need $\sigma_t \approx 50$ psec.

Phase-space parameters of the muon beam at the beginning of the cooling channel at a neutrino factory.

Parameter	Value
P_0 (MeV/c)	185
E_0 (MeV)	198
γ	2.02
β	0.87
$\gamma\beta$	1.76
$\epsilon_{x,N} = \epsilon_{y,N}$ (π mm-mrad)	9,000
$\epsilon_x = \epsilon_y$ (π mm-mrad)	5,100
$\beta^\star$ (cm) [typical]	63
$\sigma_x = \sigma_y$ (mm)	57
$\sigma_{x'} = \sigma_{y'}$ (mrad)	90
σ_P/P	0.10
$\sigma_E/E = \beta^2\sigma_P/P$	0.076
σ_z (cm)	10
$\sigma_t = \sigma_z/\beta c$ (ps)	340

Parameters for 1.25-T Bent Solenoid Channels

Parameter	Targetry Channel	Cooling Channel
P_0	185 MeV/c	185 MeV/c
σ_P/P_0	0.3	0.1
B_s	1.25 T	1.25 T
λ_B	3.1 m	3.1 m
$\theta_{\rm bend}$	0.1 rad	0.25 rad
$R_{\rm bend}$	5 m	3 m
$B_{\rm Guide}$	0.10 T	0.16 T
R_s	40 cm	40 cm
L_s	2.6 m	4.95 m
Cost (for one bend)	0.6M$	0.9M$
$\beta^\star = P_0/eB_s$	49 cm	49 cm
ϵ_x	–	$5,100\pi$ mm-mrad
$\sigma_x = \sigma_y = \sqrt{\epsilon_x \beta^\star}$	–	50 mm
$\sigma_{x'} = \sigma_{y'}$	–	102 mrad
$L_{\rm tracking}$	50 cm	50 cm
n	33 clusters/m	33 clusters/m

Comments

If want momentum measurement:

- Use bent solenoid + TPC.
- If $B \approx 1$ T, need low pressure TPC.
- Need $\pi/\mu/e$ particle ID, $\Rightarrow$ Čerenkov counters.
- Even measure longitudinal emittance, need $\sigma_t \approx 50$ psec,
  $\Rightarrow$ Could use "conventional" timing.

Could we skip the bent solenoid and measure P in a single TPC?

- Longitudinal diffusion $\Rightarrow \sigma_\theta \approx 10^{-4}$.
- In a single TPC, $\sigma_P/P = \sigma_\theta/\theta$, so have $\sigma_P/P < 0.01$ for $\theta > 0.01$.
- Since $\theta_{\rm rms} = 0.09$, this may be adequate(?).