Stacking mini-bunches for Emittance Exchange

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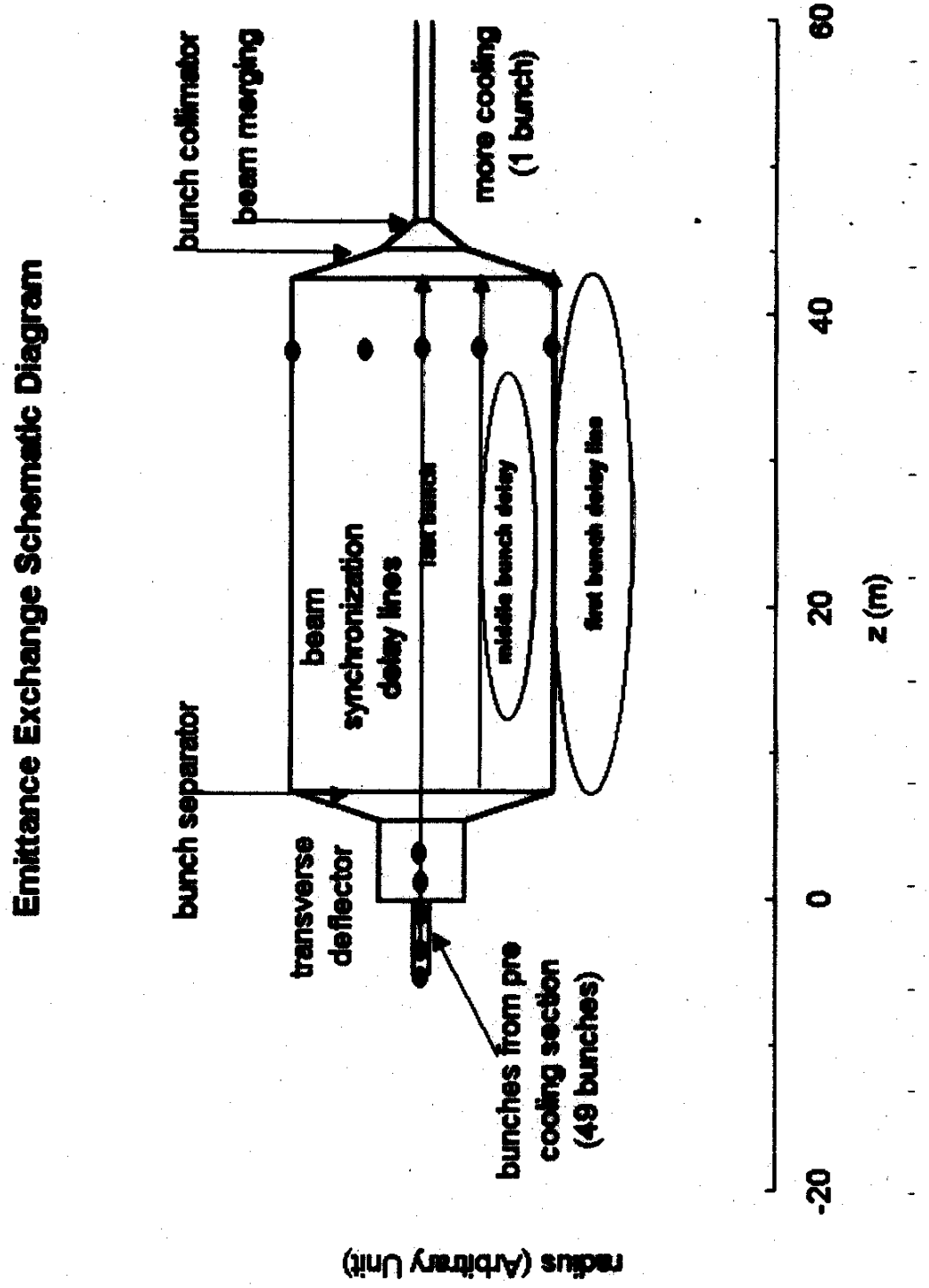
- History
  - Muon Collider Note 70 by C.H. Kim
  - bunching scheme in the ν Factory
  - difficulty in p_z - x,y exchange
- Scheme is simple. But some problems.
  - No multiple central trajectories are available in ICOOL for delay channels/lines.
  - Made one of the simplest model and ICOOL simulation is in progress with a kicker magnet and the solenoid channel.
- Challenges
  - make an ICOOL model to stack 10-100 mini bunches matching solenoid-conventional quads.
    RING delay lines, Kickers (?)
  - recycle a cooling channel in ICOOL(need tracking history management)

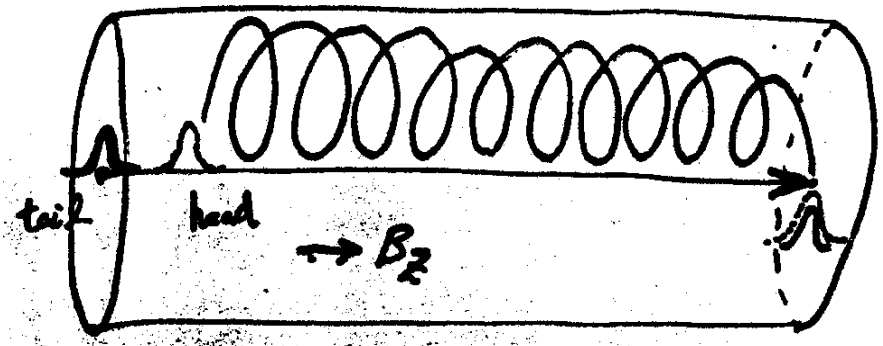
Figure 1

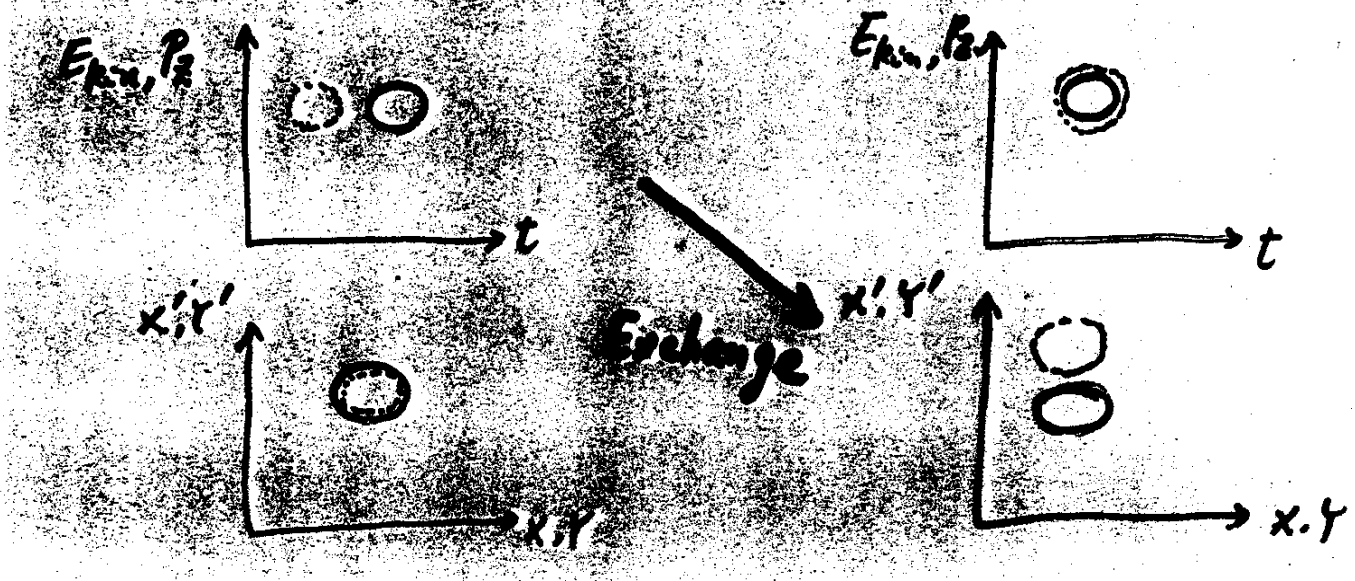
MC Note 72
C. H. Kim

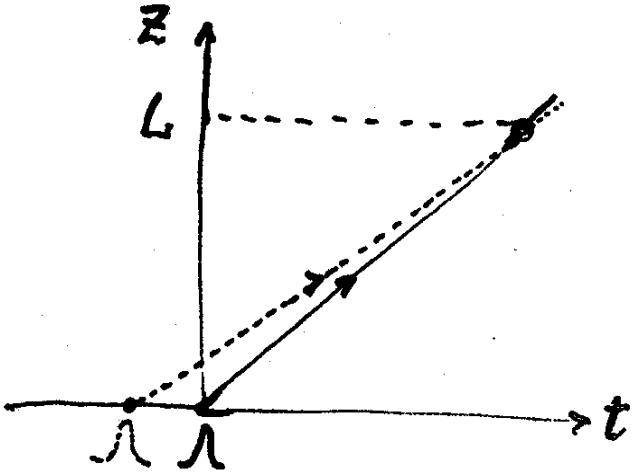


Conserve $|\vec{P}|$

transverse kick $\Rightarrow$ delay







n Larmor rotation

n'

$$\lambda_L = \beta_z c \frac{2\pi}{\omega}$$

($\Rightarrow$ bunch space)

$$L \Rightarrow N \lambda_L$$

$$\beta_z' = \frac{N-1}{N} \beta_z$$

```
 Bunch Stacking Test Model in a Huge Solenoid
 $cont npart=2000 nsections=1 timelim=500. bgen=.false.
 varstep=.false. nprnt=1 prlevel=-1 epsstep=1e-4 ntuple=.false.
 phasemodel=3 neighbor=.false. dectrk=.true.
 fsav=.true. izfile=175  bunchcut=1. spin=.true. output1=.true.
 timelim=9999 $
 $ints ldecay=.flase.  declev=1  ldedx=.true. lstrag=.true. lscatter=.true.
  delev=2 straglev=4 scatlev=4  $
 $nrh nrhist=0 $
 $nem nemit=2 sig_cut=10. pxycorr=.true. $
 4  202
 $ncv ncovar=2 $
 4  202
SECTION
REFP
2   .2   0.   0  3
CELL
100
.false.
SOL
1   0   0   0  5.913   0 0 0 0 0 0 0 0 0 0 0
OUTPUT
SREGION   !  DRIFT
0.3313   1   0.001
1   0.   1.0
NONE
0   0   0   0  0  0 0 0 0 0 0 0 0 0 0 0
VAC
CBLOCK
0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
ENDCELL
ENDSECTION
```

ICOOL forcool.dat

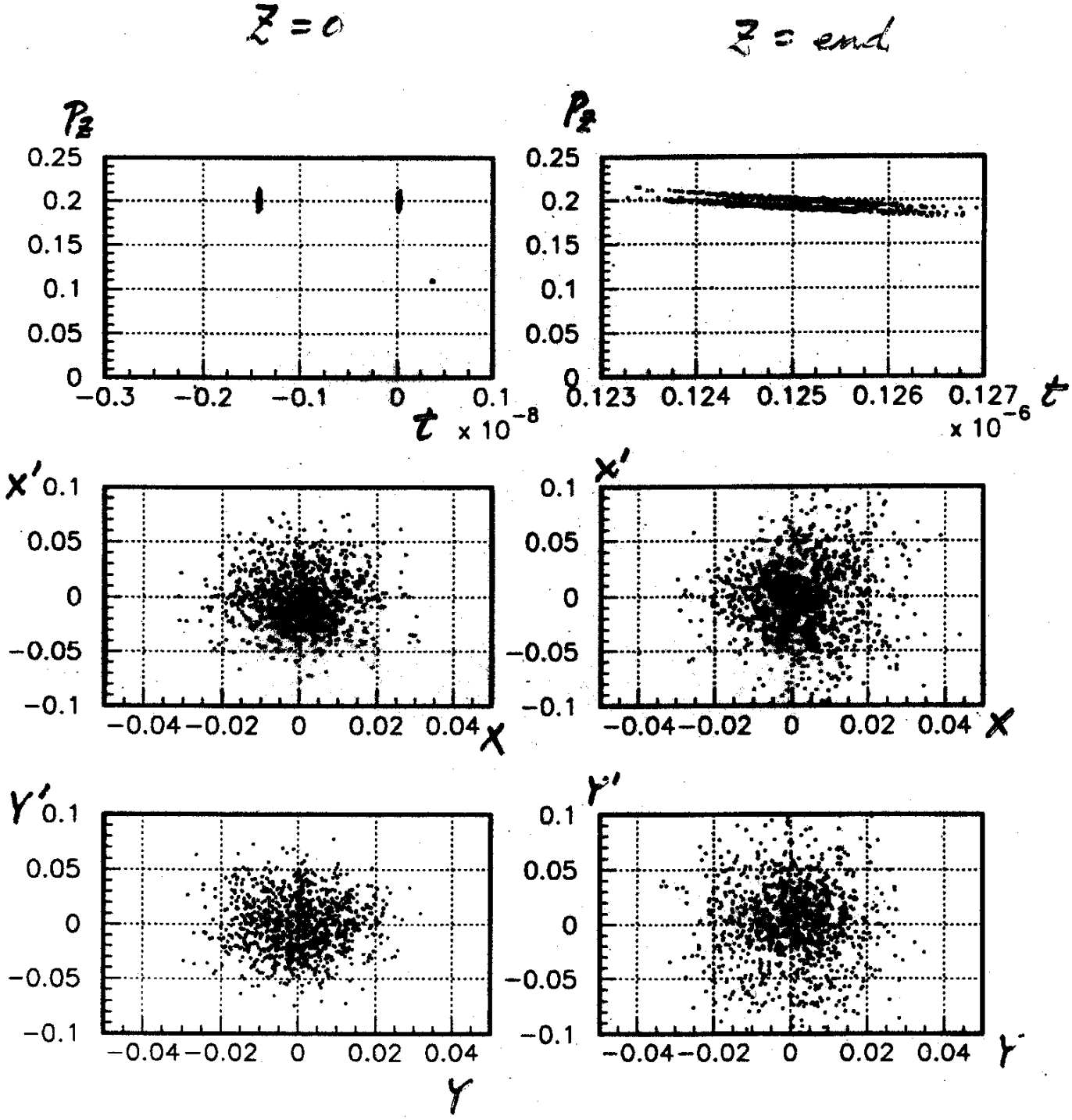
V. 2.08

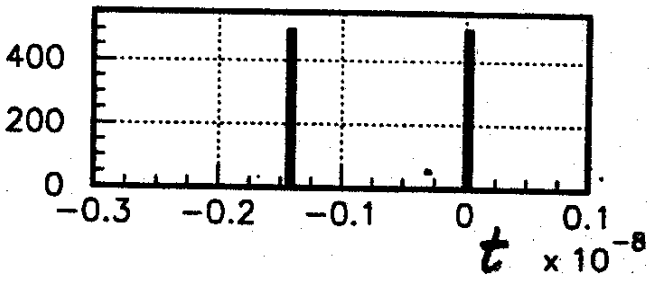
$B_z = 5.9\,T$, 33 m

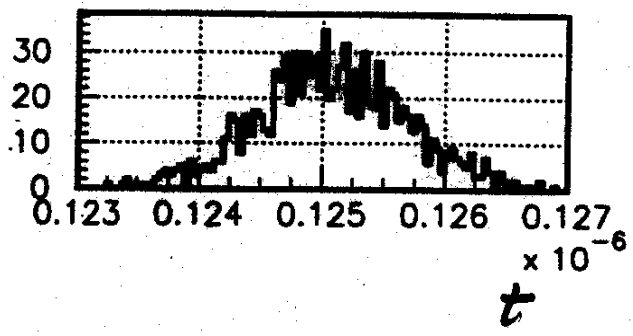
$P_z = 0.200\,GeV/c$

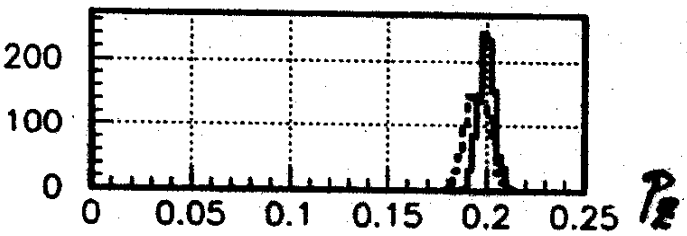
$\left.\begin{array}{l} P_t' = 60\,MeV \\ P_z' = 0.192\,GeV/c \end{array}\right\}$ bent

Bunch separation 0.33 m

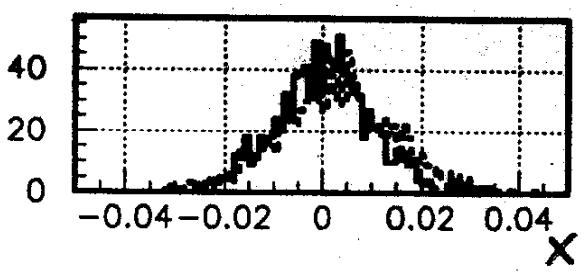

Z = 0
Z = end
P_z
0.25
0.2
0.15
0.1
0.05
0
−0.3 −0.2 −0.1 0 0.1
t x 10^-8
0.123 0.124 0.125 0.126 0.127
t
x 10^-6
x'
0.1
0.05
0
−0.05
−0.1
−0.04 −0.02 0 0.02 0.04
x
y'
y

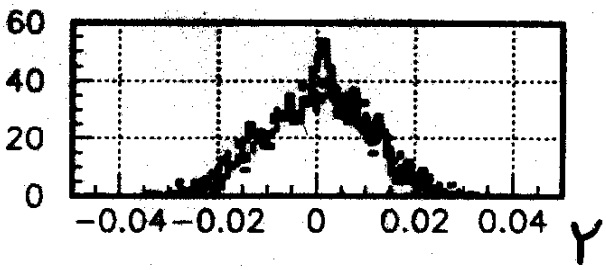

400
200
0
−0.3
−0.2
−0.1
0
0.1
t
x 10^-8

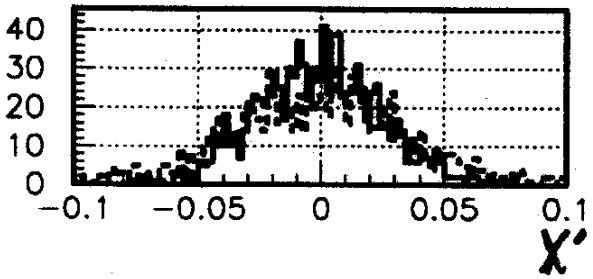

30
20
10
0
0.123
0.124
0.125
0.126
0.127
x 10^-6
t

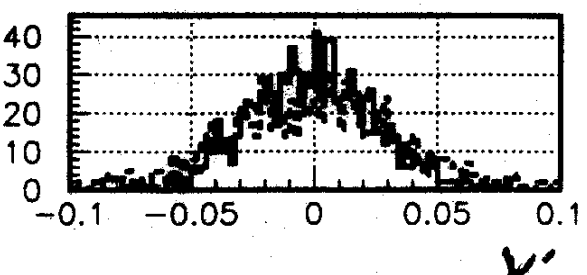

200
100
0
0
0.05
0.1
0.15
0.2
0.25
Pz

z = end


40
20
0
−0.04
−0.02
0
0.02
0.04
X


60
40
20
0
−0.04
−0.02
0
0.02
0.04
Y


40
30
20
10
0
−0.1
−0.05
0
0.05
0.1
X'


40
30
20
10
0
−0.1
−0.05
0
0.05
0.1
Y'

********** Weighted NORMALIZED 2-D EMITTANCES **********
SIGMACUT = T PXYCORR = T PZCORR = F SIG_CUT = 50.0

des	No	N	emitX [m]	emitY [m]	emitZ [m]	Tr	fET	fEL
4	2000.	2000.	0.9653E-03	0.9695E-03	0.7254E-02	1.000	1.000	1.000
104	2000.	2000.	0.1091E-02	0.1071E-02	0.6834E-02	1.000	1.059	0.947

+13% +10% -6%

Summary

- The scheme is SIMPLE which should work. But it has to be simulated with tracking.
- Orthogonal to other emittance exchange schemes. Possible recycling of a cooling channel.
- Actual stacking process has to be tricky(can not be perfect).