17TH ADVANCED BEAM DYNAMICS WORKSHOP ON
FUTURE LIGHT SOURCES

Conversion of SURF II to SURF III

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SURF II Sawtooth Instability Simulations

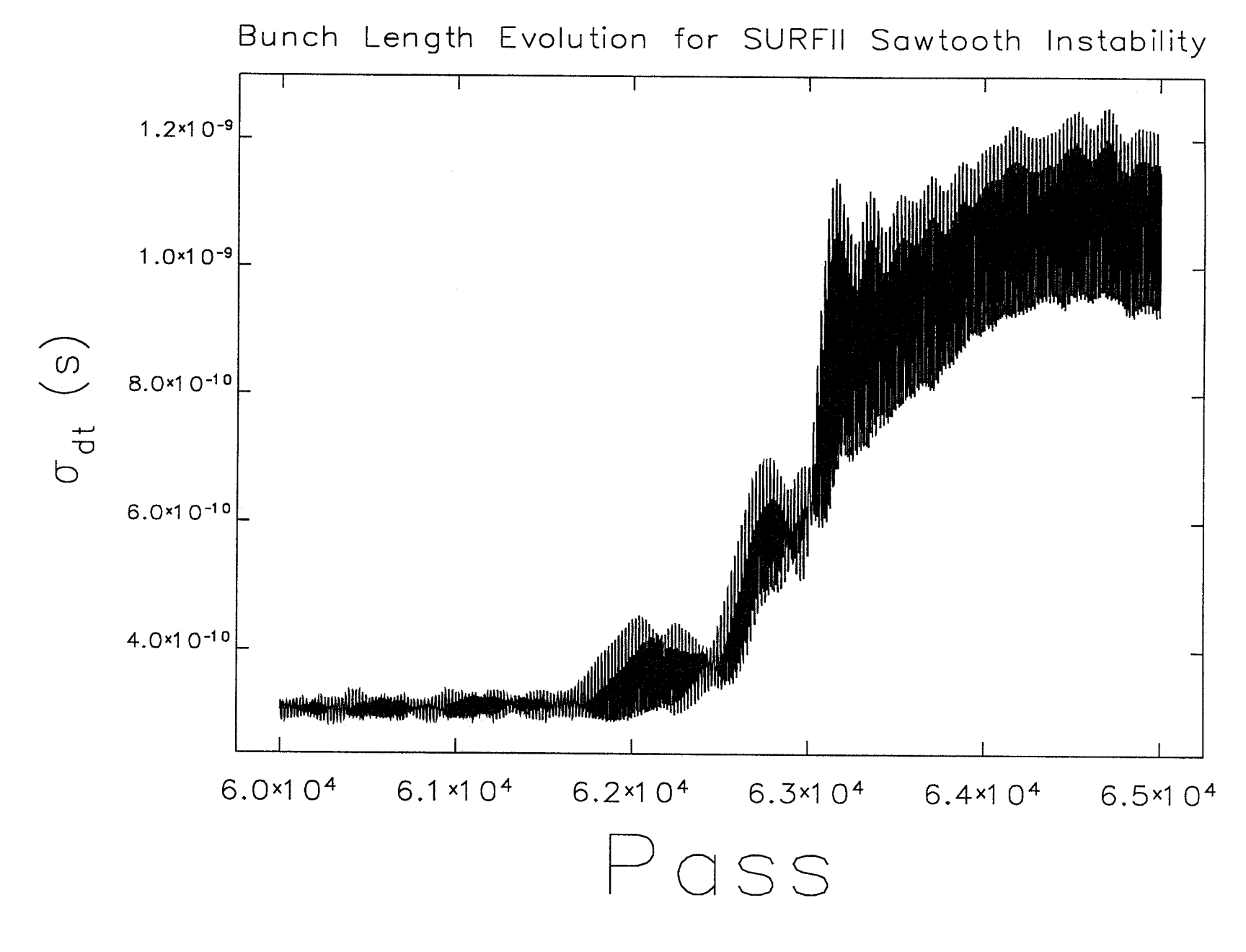
- Use program elegant to track particles for SURFII lattice.
- Lattice is very simple:

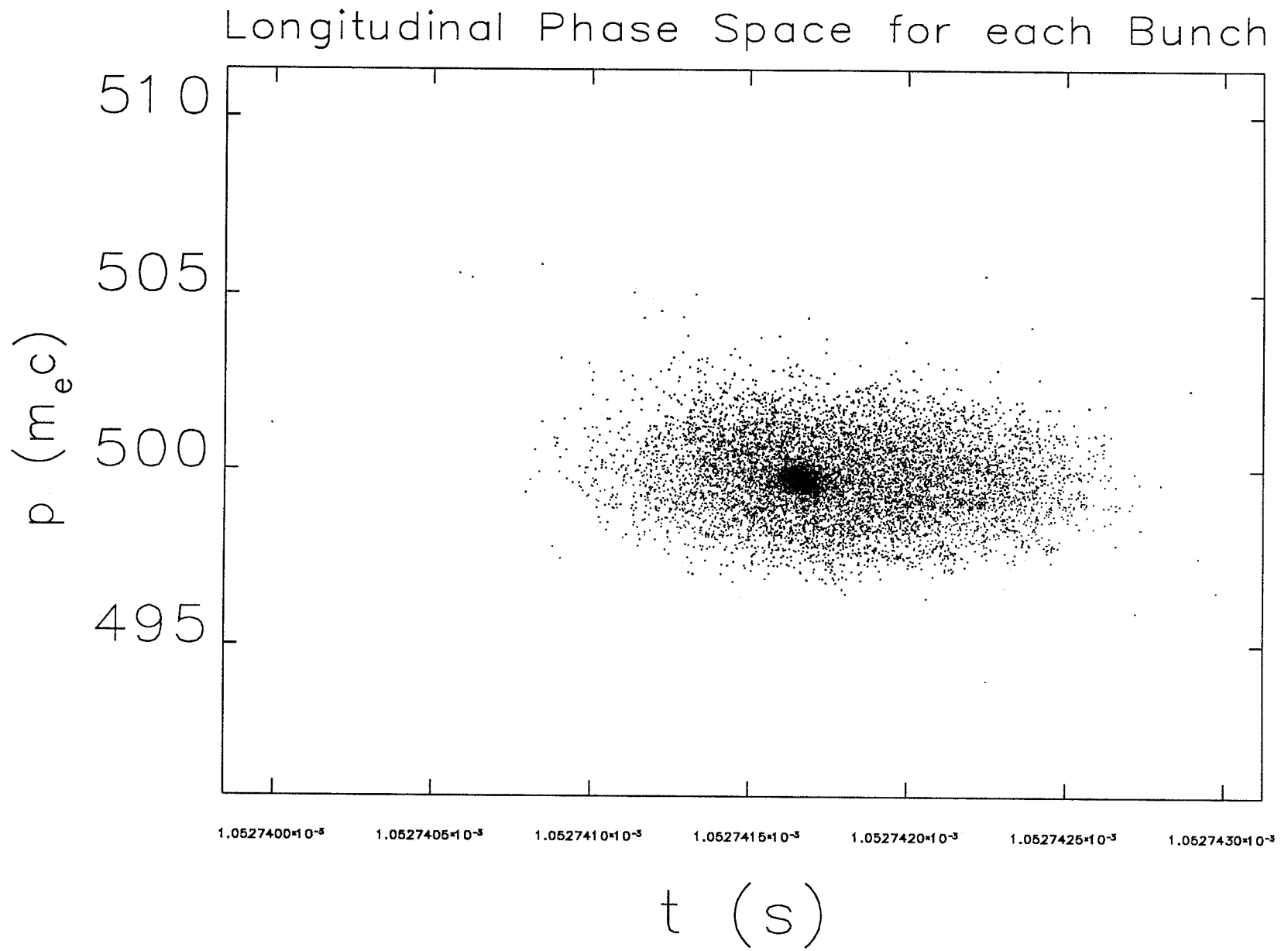
  1 weak focussing dipole magnet.

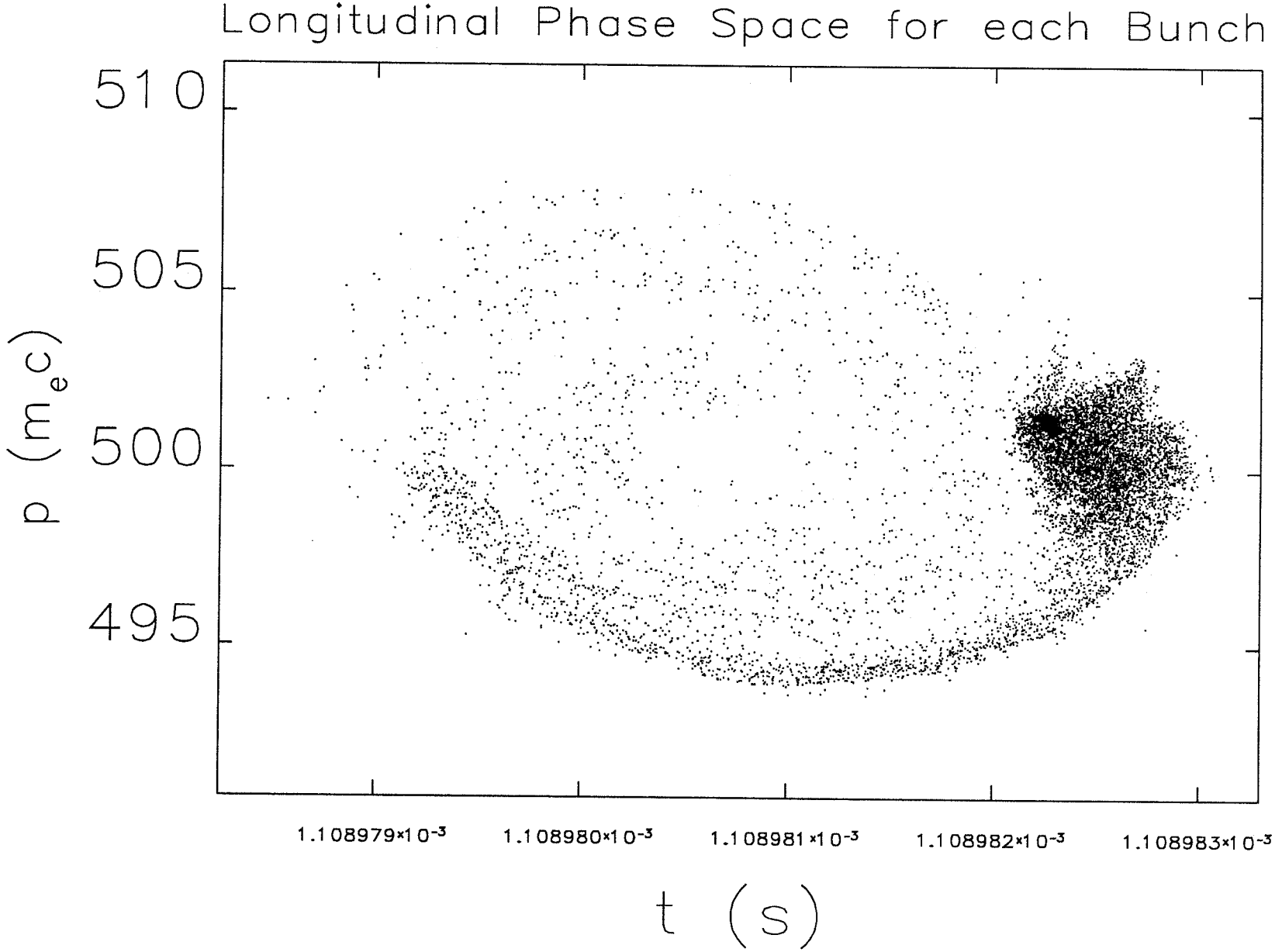
  1 RF cavity (One accelerating mode).

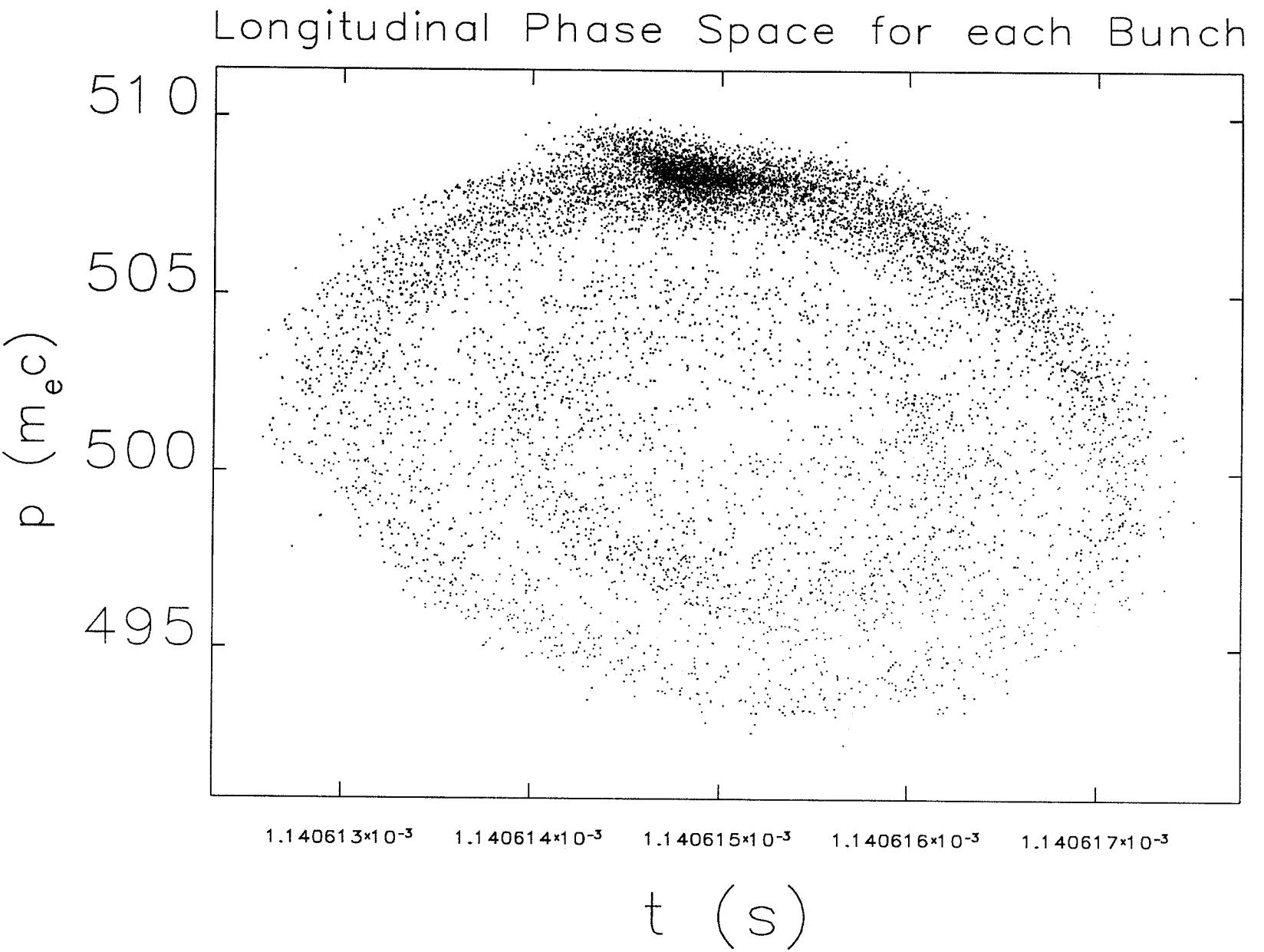
  1 Resonator impedance (Q=1, f_r = 0.7 GHz, Rs = 2 x 10^5 Ω).
- Elegant simulates synchrotron radiation damping and quantum excitation.
- Simulate only a single bunch with N_p=10^4 particles and “scaled” damping to reduce computer time (Keep ϕ_s constant by scaling V_{rf} and U_o by a factor of 100).

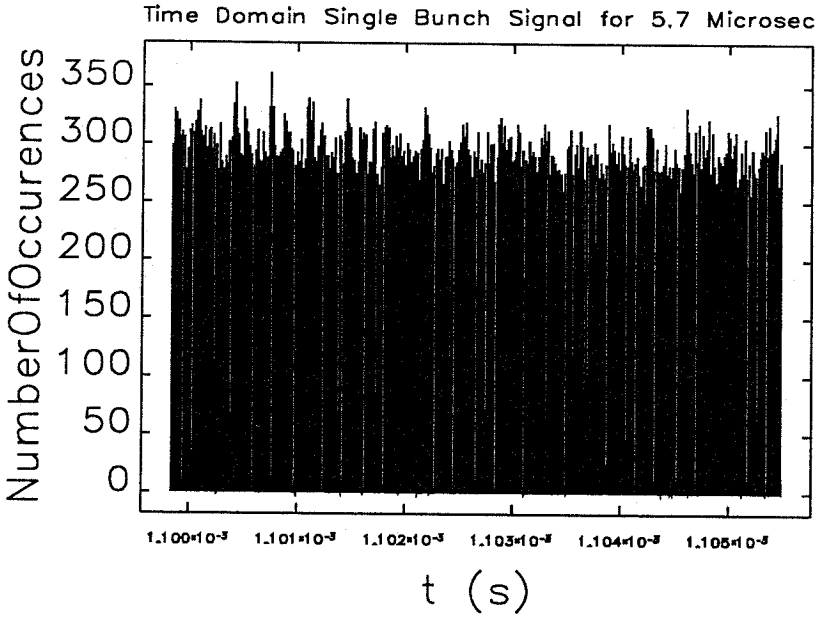
- Track particles for 10^5 turns dumping coordinate data ever 100 turns (Course run).
- Track particles for $5x10^3$ turns dumping coordinates every turn (Fine run) during bunch blowup.
- Histogram phase space data in time and divide interval into 16 time periods.
- FFT each period and connect results to experimental data.

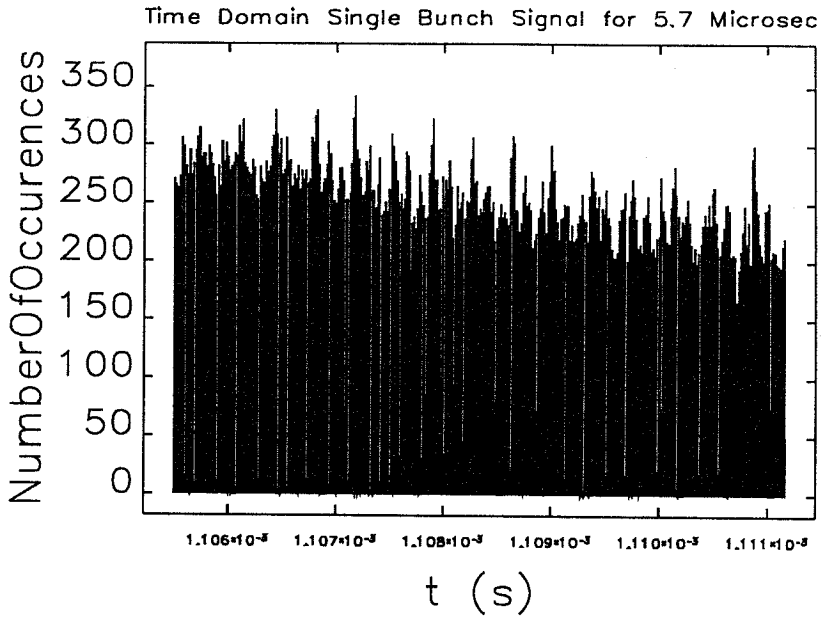

Bunch Length Evolution for SURFII Sawtooth Instability
1.2×10⁻⁹
1.0×10⁻⁹
8.0×10⁻¹⁰
6.0×10⁻¹⁰
4.0×10⁻¹⁰
σdt (s)
6.0×10⁴
6.1×10⁴
6.2×10⁴
6.3×10⁴
6.4×10⁴
6.5×10⁴
Pass

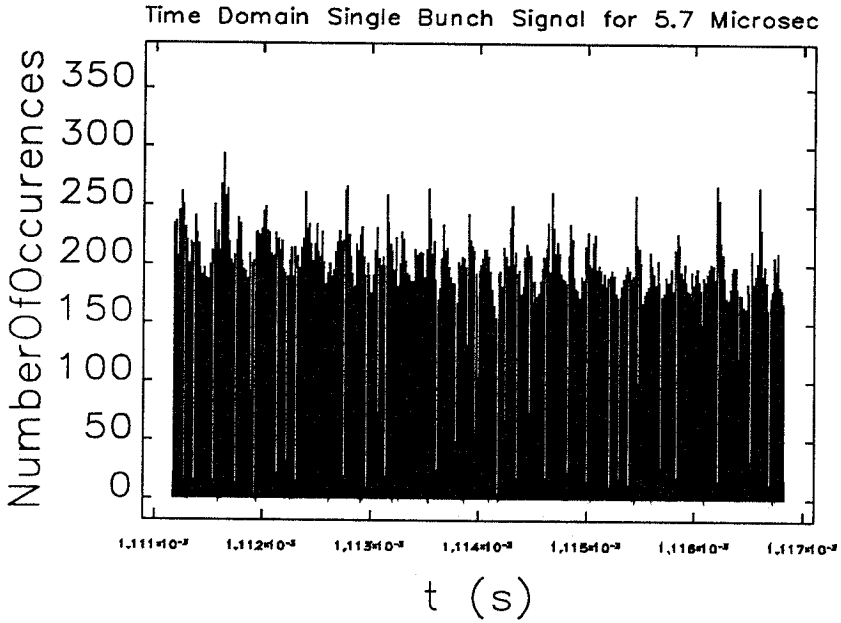

Longitudinal Phase Space for each Bunch
510
505
500
495
p (m_e c)
1.0527400×10⁻³
1.0527405×10⁻³
1.0527410×10⁻³
1.0527415×10⁻³
1.0527420×10⁻³
1.0527425×10⁻³
1.0527430×10⁻³
t (s)

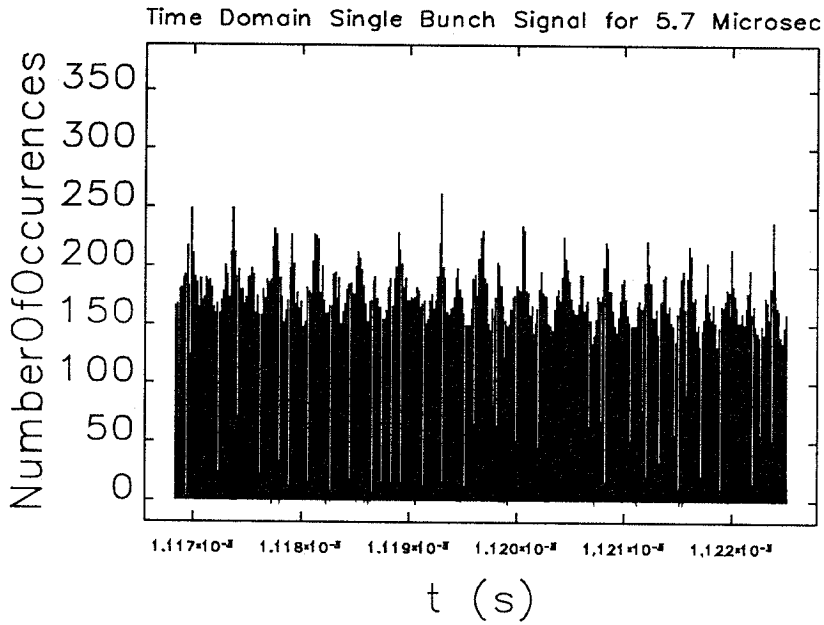

Longitudinal Phase Space for each Bunch
510
505
500
495
p (m_e c)
1.108979×10^-3
1.108980×10^-3
1.108981×10^-3
1.108982×10^-3
1.108983×10^-3
t (s)

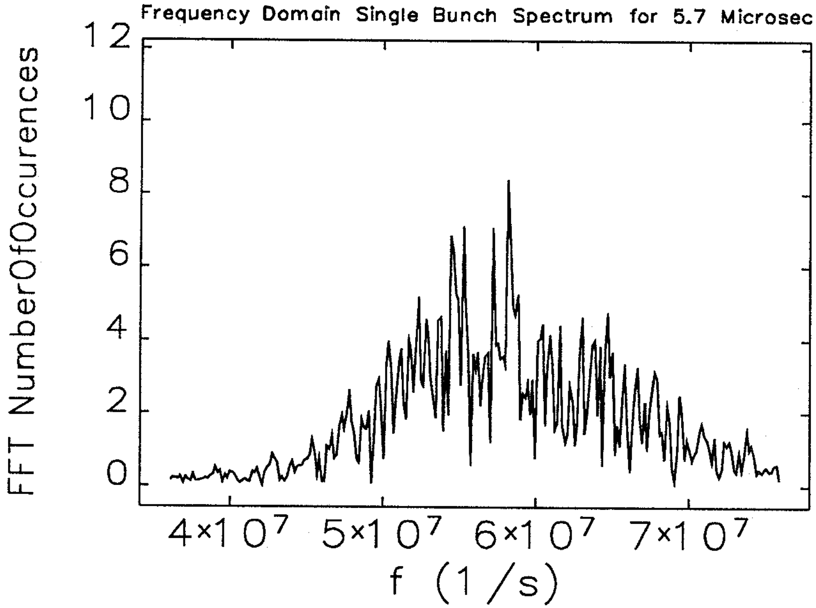

Longitudinal Phase Space for each Bunch
510
505
500
495
p (m_e c)
1.140613×10^-3
1.140614×10^-3
1.140615×10^-3
1.140616×10^-3
1.140617×10^-3
t (s)

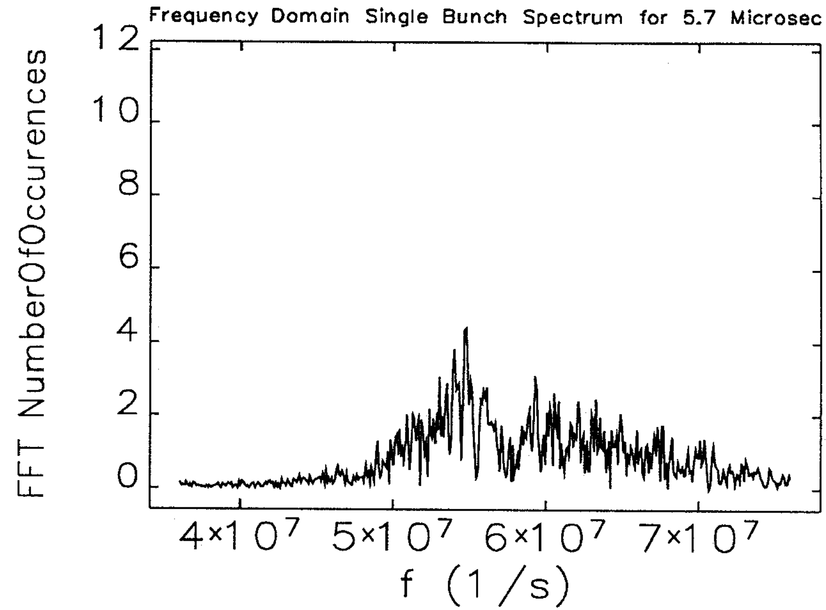

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.100×10⁻³
1.101×10⁻³
1.102×10⁻³
1.103×10⁻³
1.104×10⁻³
1.105×10⁻³
t (s)

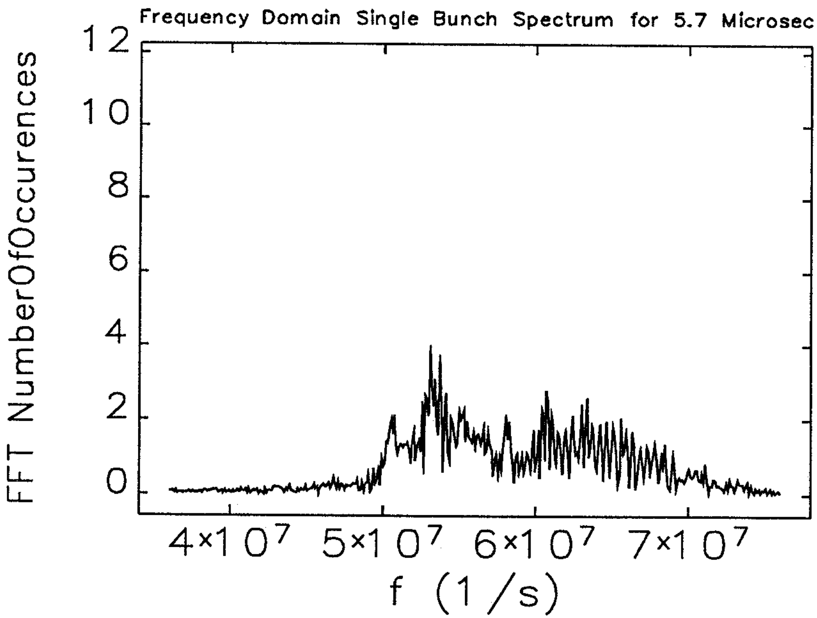

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.106×10⁻³
1.107×10⁻³
1.108×10⁻³
1.109×10⁻³
1.110×10⁻³
1.111×10⁻³
t (s)

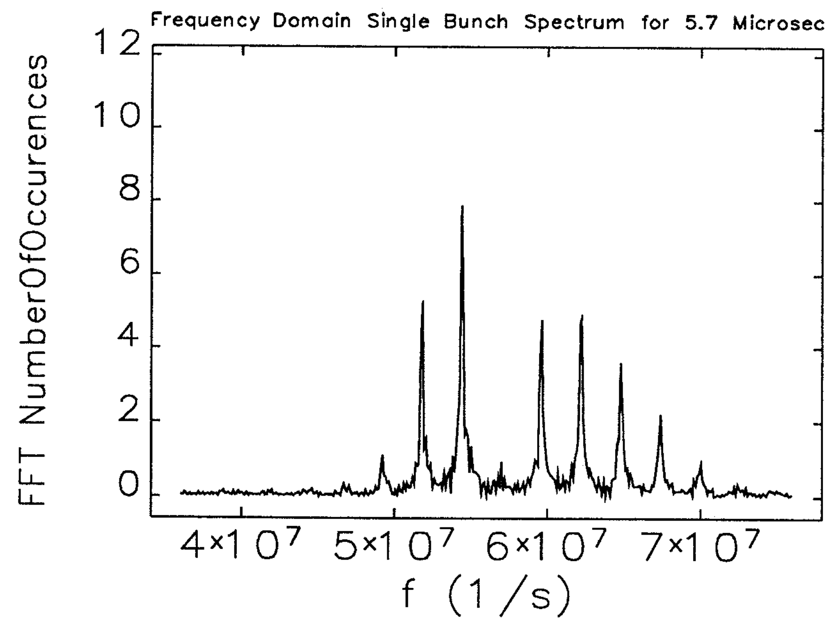

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.111×10⁻³
1.112×10⁻³
1.113×10⁻³
1.114×10⁻³
1.115×10⁻³
1.116×10⁻³
1.117×10⁻³
t (s)

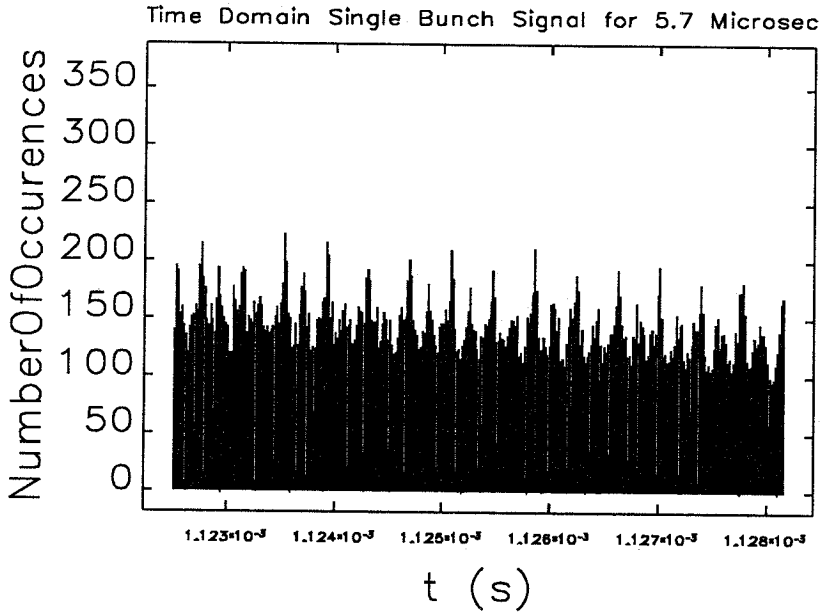

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.117×10⁻³
1.118×10⁻³
1.119×10⁻³
1.120×10⁻³
1.121×10⁻³
1.122×10⁻³
t (s)

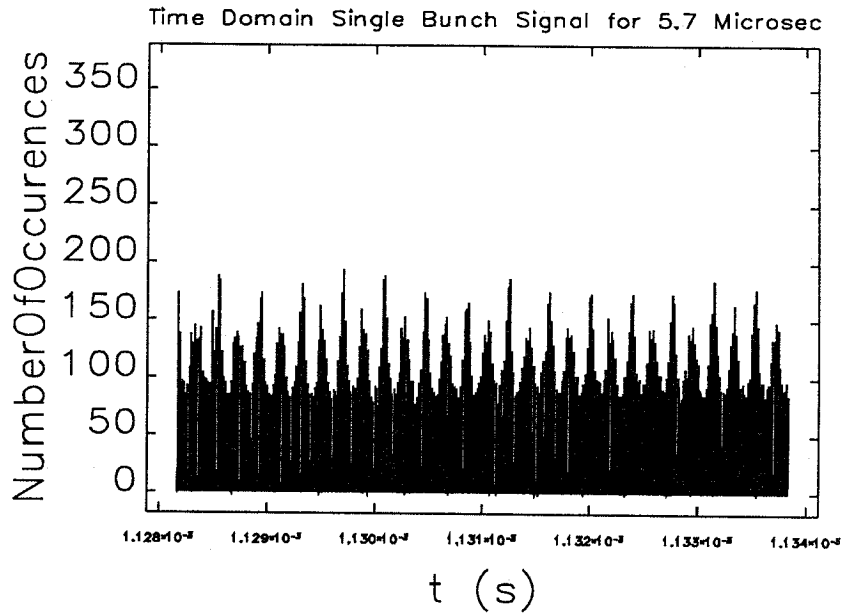

Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
0
2
4
6
8
10
12
4×10^7
5×10^7
6×10^7
7×10^7
f (1/s)

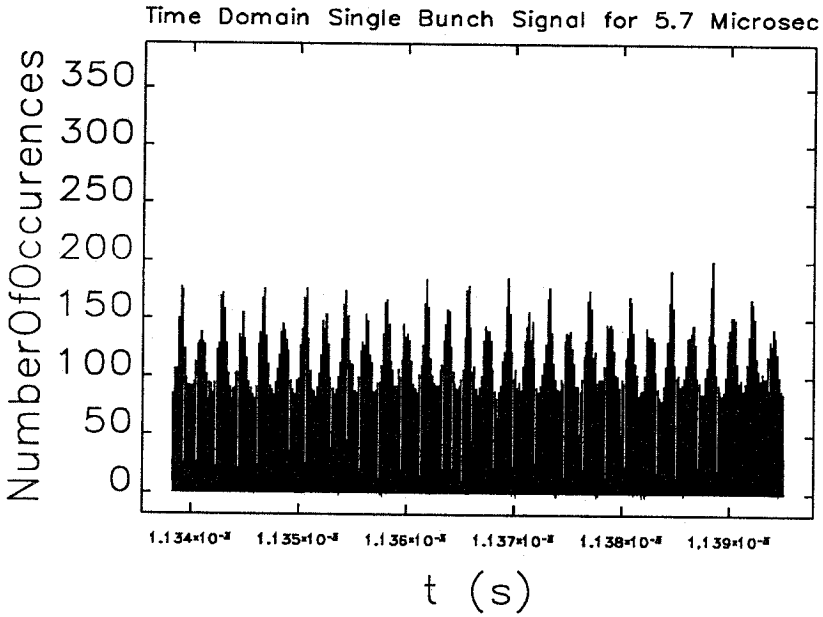

Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
0
2
4
6
8
10
12
4×10^7
5×10^7
6×10^7
7×10^7
f (1/s)

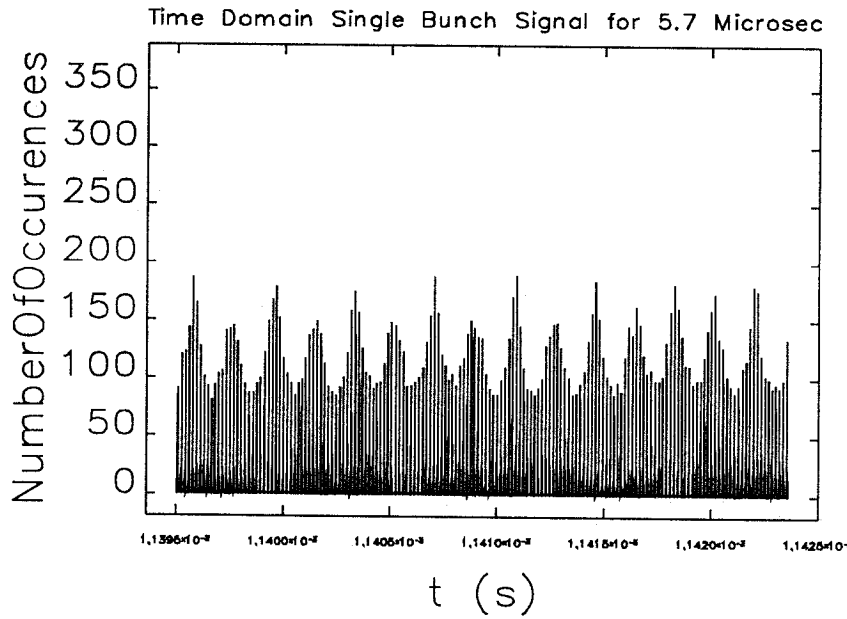

Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
0
2
4
6
8
10
12
4×10^7
5×10^7
6×10^7
7×10^7
f (1/s)

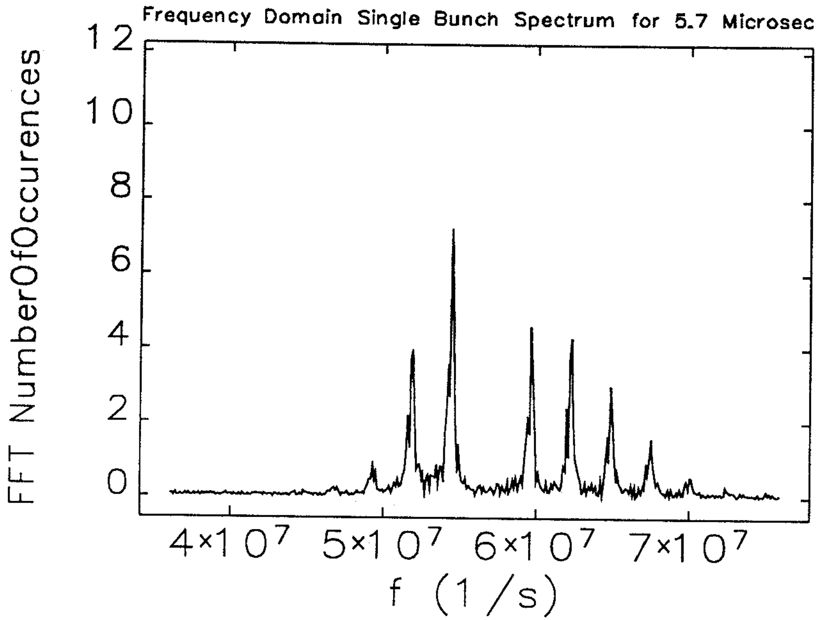

Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
0
2
4
6
8
10
12
4×10^7
5×10^7
6×10^7
7×10^7
f (1/s)

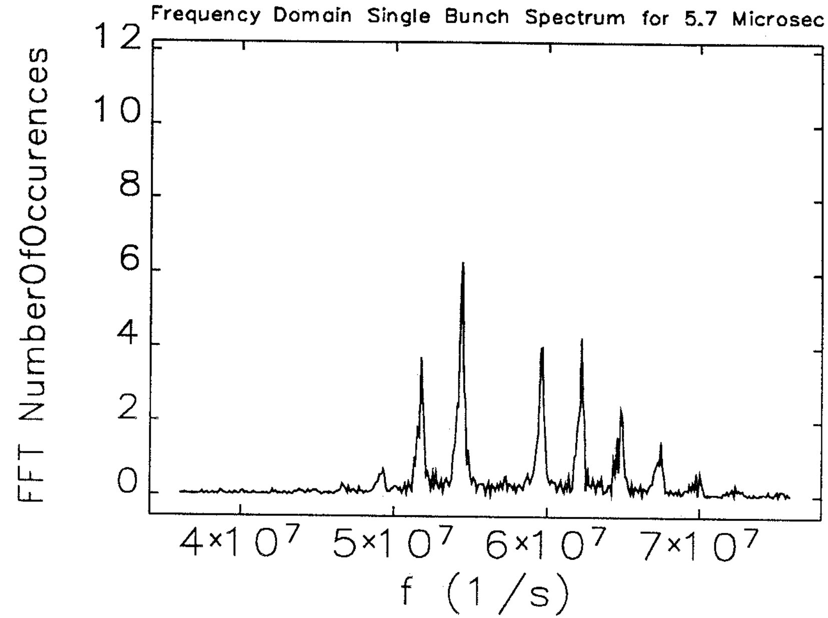

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.123×10⁻³
1.124×10⁻³
1.125×10⁻³
1.126×10⁻³
1.127×10⁻³
1.128×10⁻³
t (s)

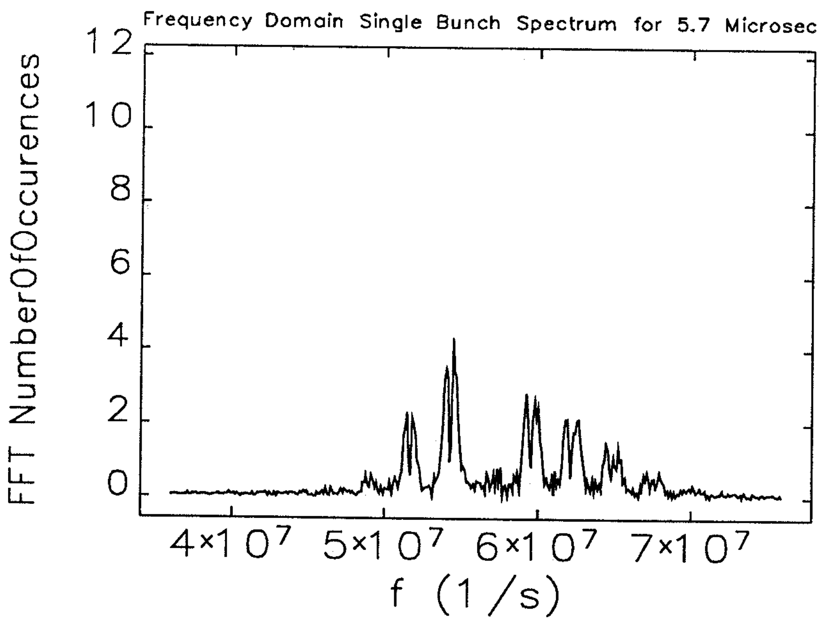

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.128×10⁻³
1.129×10⁻³
1.130×10⁻³
1.131×10⁻³
1.132×10⁻³
1.133×10⁻³
1.134×10⁻³
t (s)

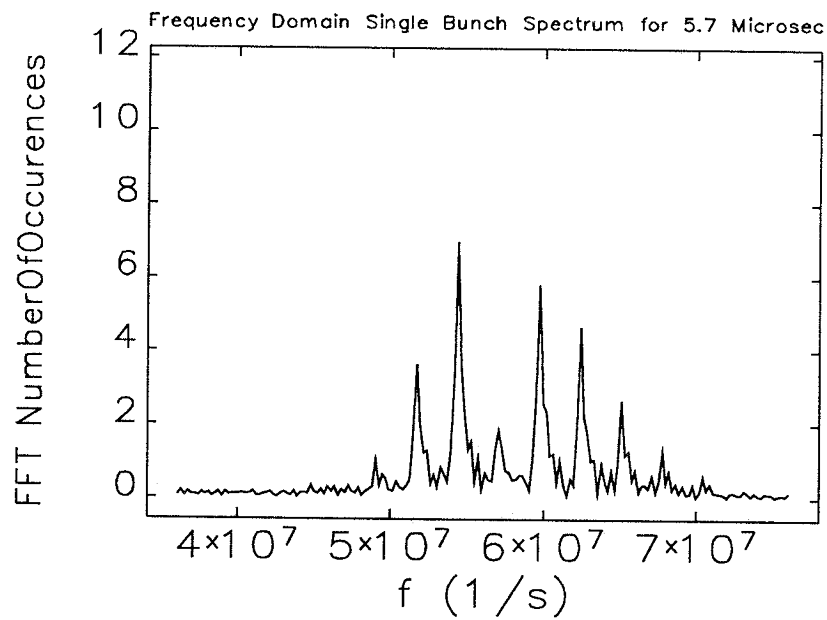

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.134×10⁻³
1.135×10⁻³
1.136×10⁻³
1.137×10⁻³
1.138×10⁻³
1.139×10⁻³
t (s)

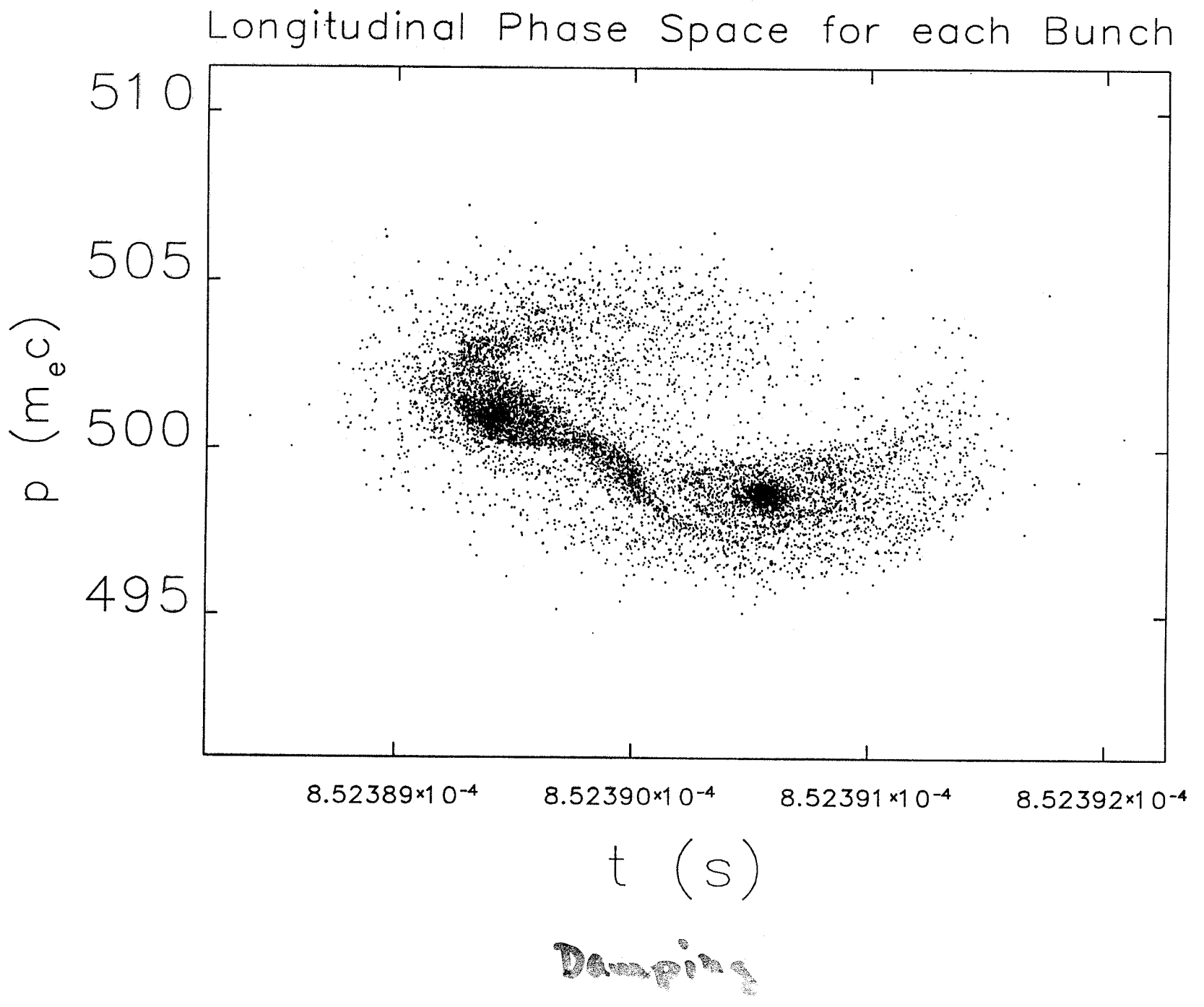

Time Domain Single Bunch Signal for 5.7 Microsec
NumberOfOccurences
0
50
100
150
200
250
300
350
1.396×10⁻³
1.400×10⁻³
1.405×10⁻³
1.410×10⁻³
1.415×10⁻³
1.420×10⁻³
1.425×10⁻³
t (s)


Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
12
10
8
6
4
2
0
4×10^7 5×10^7 6×10^7 7×10^7
f (1/s)

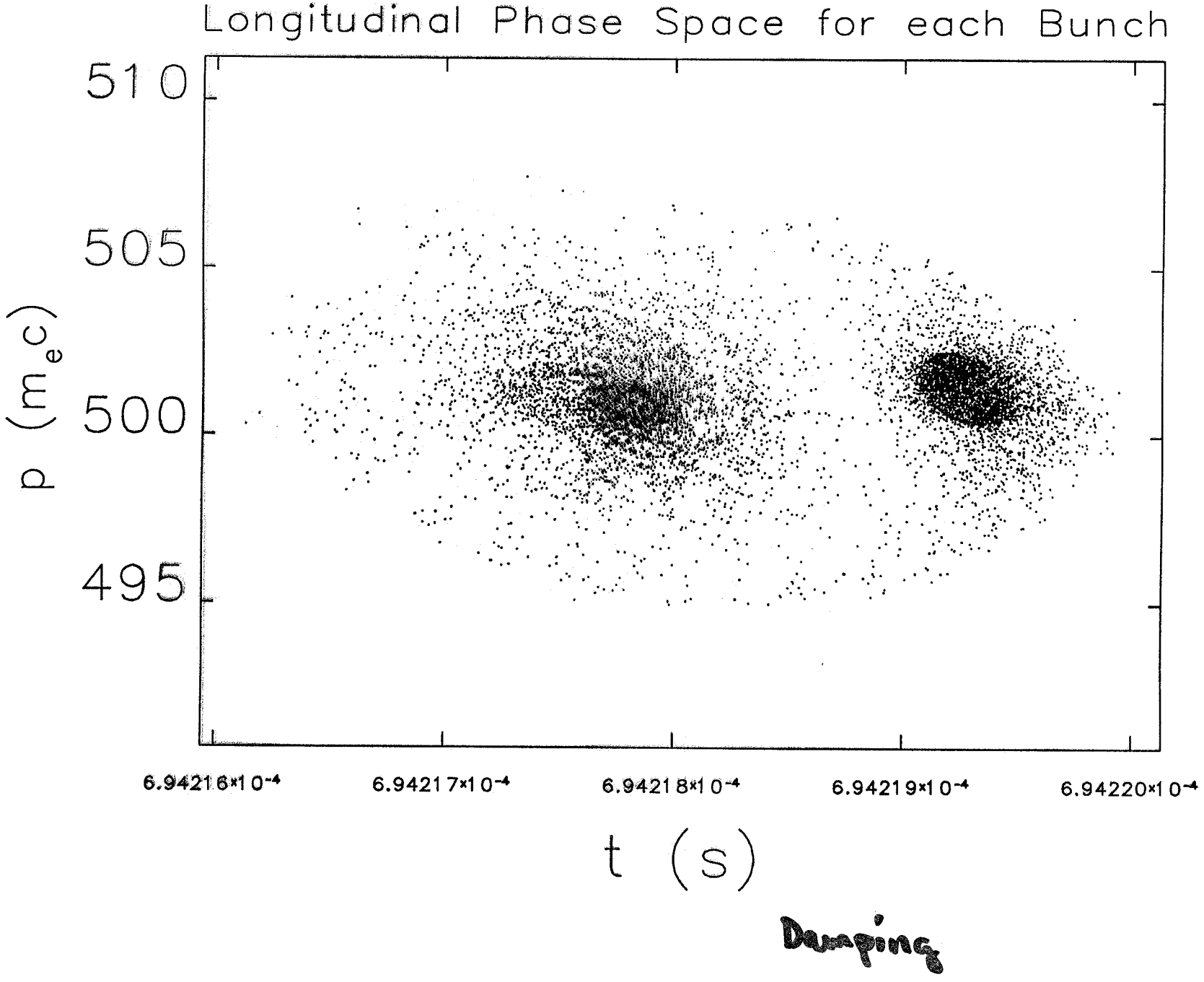

Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
12
10
8
6
4
2
0
4×10^7 5×10^7 6×10^7 7×10^7
f (1/s)

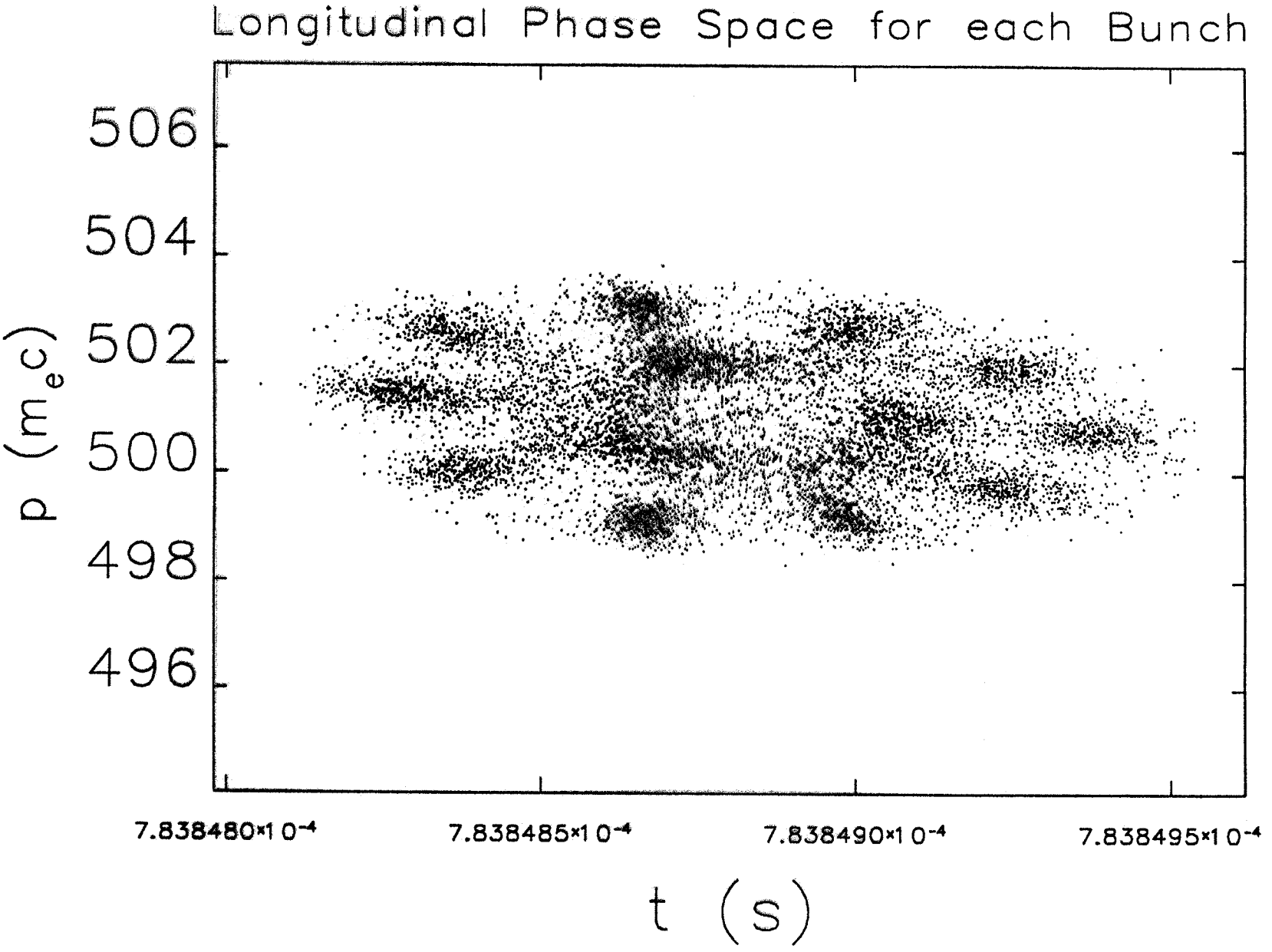

Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
12
10
8
6
4
2
0
4×10^7 5×10^7 6×10^7 7×10^7
f (1/s)


Frequency Domain Single Bunch Spectrum for 5.7 Microsec
FFT NumberOfOccurences
12
10
8
6
4
2
0
4×10^7 5×10^7 6×10^7 7×10^7
f (1/s)


Longitudinal Phase Space for each Bunch
510
505
500
495
p (m_e c)
8.52389×10^-4
8.52390×10^-4
8.52391×10^-4
8.52392×10^-4
t (s)

Damping


Longitudinal Phase Space for each Bunch
510
505
500
495
p (m_e c)
6.94216×10^-4
6.94217×10^-4
6.94218×10^-4
6.94219×10^-4
6.94220×10^-4
t (s)
Damping


Longitudinal Phase Space for each Bunch
506
504
502
500
498
496
p (m_e c)
7.838480×10^-4
7.838485×10^-4
7.838490×10^-4
7.838495×10^-4
t (s)

$f_r = 1.5\ GHz$

Simulation tasks and goals

- Understand how to interpret scaled damping simulation results with simulations using the real damping.
- Reconstruct rf + wakefield potential from the simulation data.
- Do full two bunch simulations.
- Obtain a set of broadband resonator impedance parameters that produce simulations that best match the observed bunch oscillations (and microwave emission).
- Add measured low frequency high Q rf cavity HOMs (less than 1 GHz) in addition to broadband resonator impedance in full 2 bunch simulation.