



# Turn-by-Turn Beam Position Measurements at ANKA with LIBERA ELECTRON

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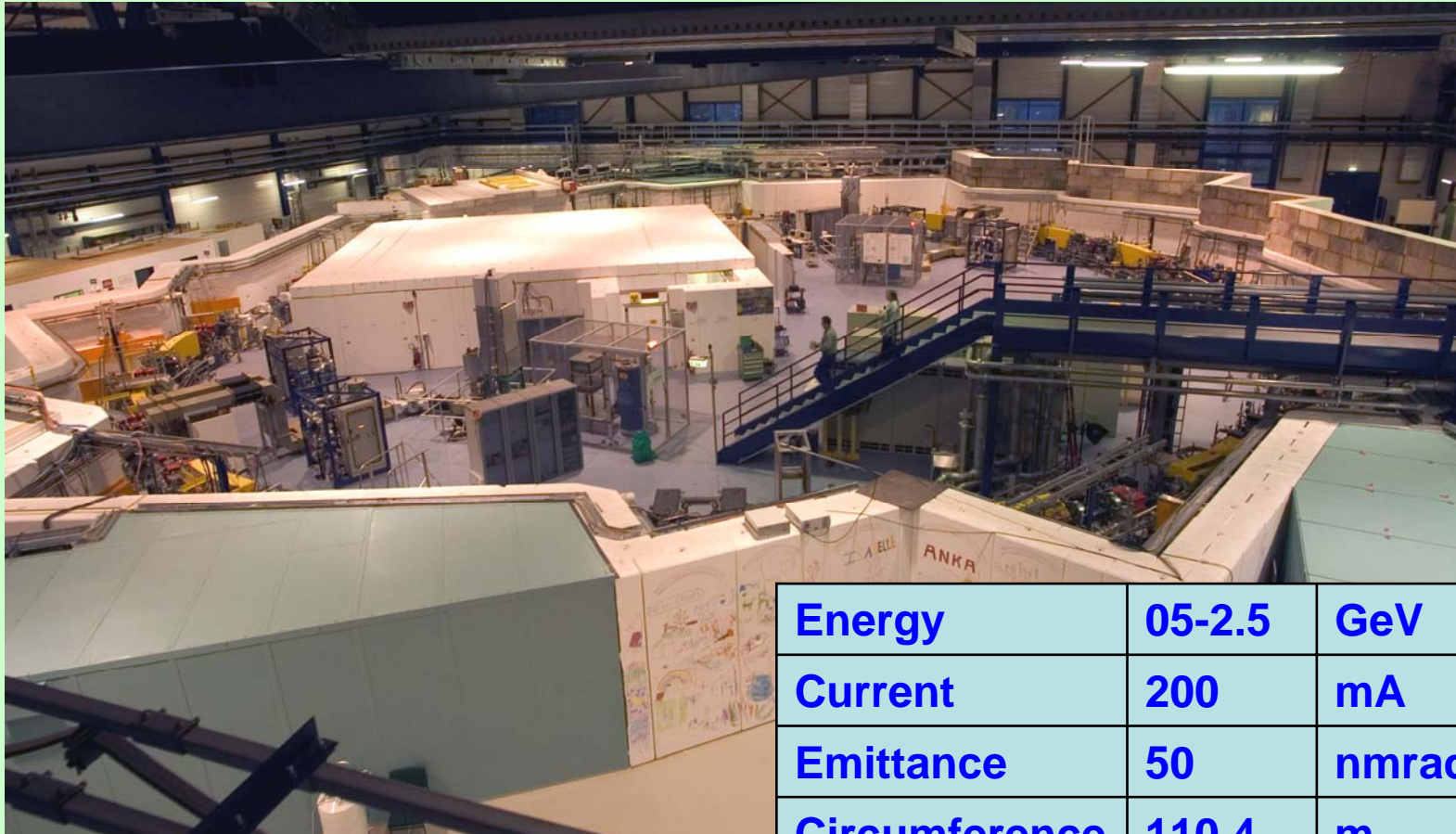
**About ANKA**

**Test by Frequency Generator**

**Experiences in the Booster**

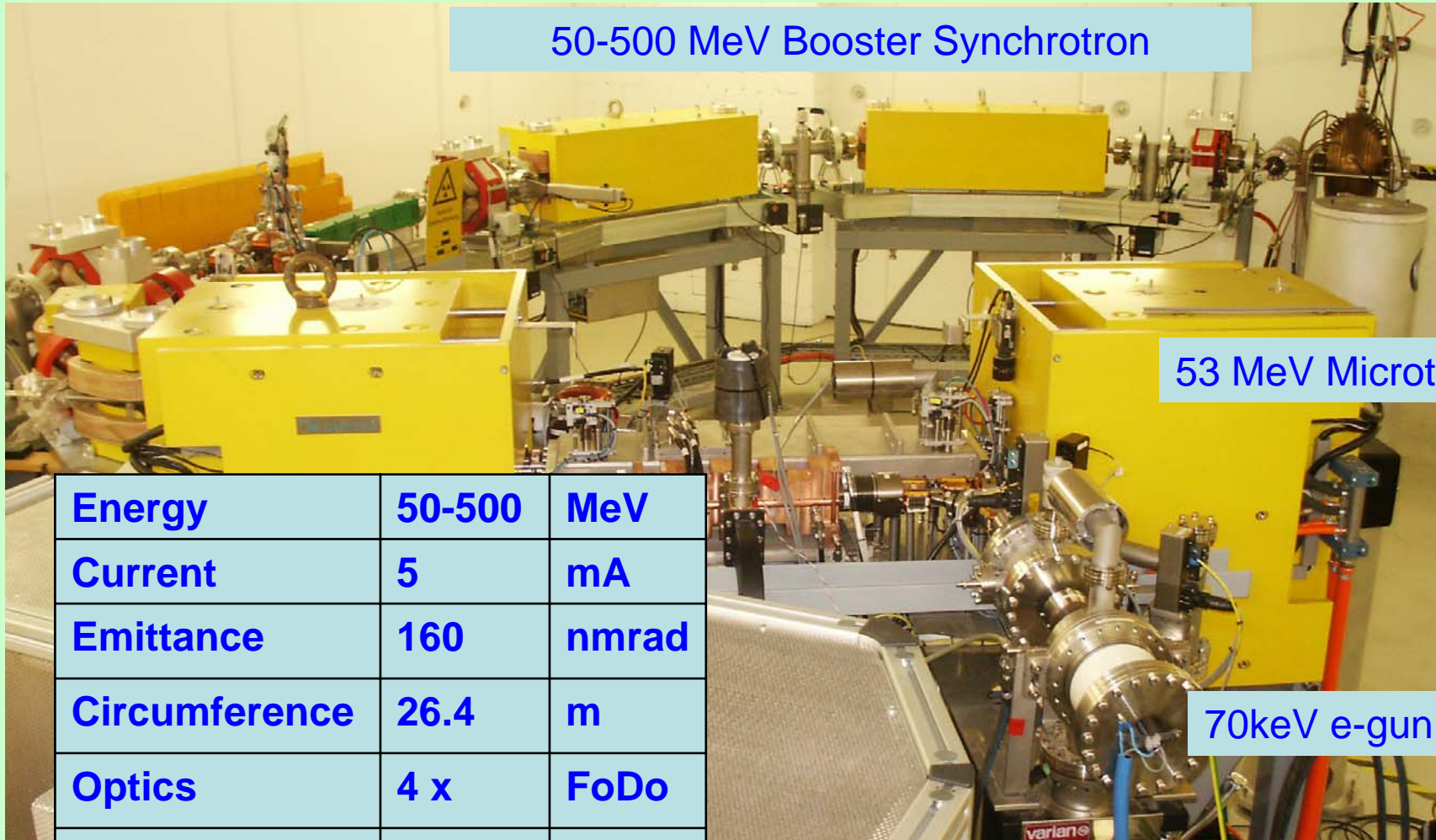
**Experiences in the Storage Ring**

## ANKA Storage Ring



<b>Energy</b>	<b>05-2.5</b>	<b>GeV</b>
<b>Current</b>	<b>200</b>	<b>mA</b>
<b>Emittance</b>	<b>50</b>	<b>nmrad</b>
<b>Circumference</b>	<b>110.4</b>	<b>m</b>
<b>Optics</b>	<b>8 x</b>	<b>DBA</b>
<b>No. BPM</b>	<b>40</b>	

# Injector



50-500 MeV Booster Synchrotron

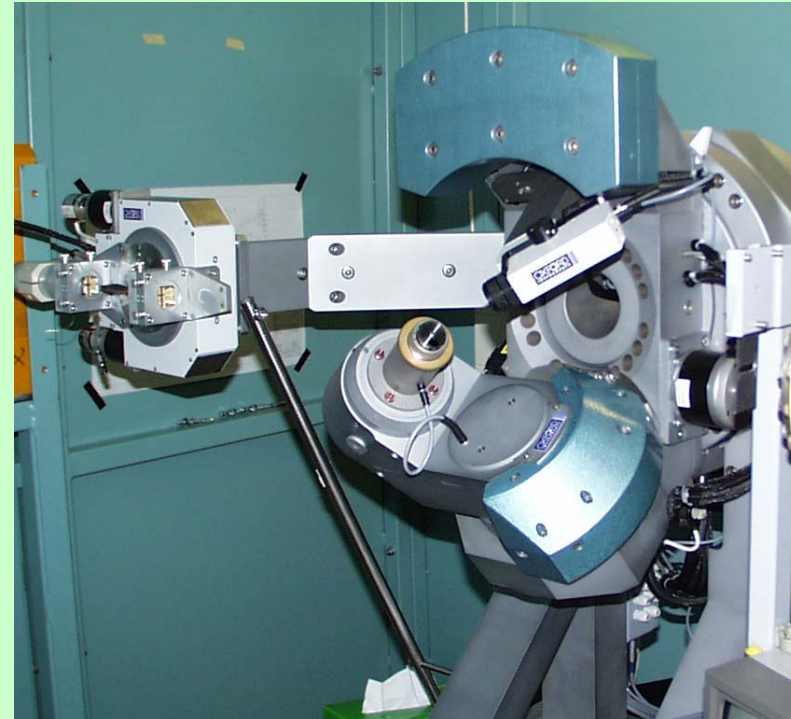
53 MeV Microtron

70keV e-gun

<b>Energy</b>	<b>50-500</b>	<b>MeV</b>
<b>Current</b>	<b>5</b>	<b>mA</b>
<b>Emittance</b>	<b>160</b>	<b>nmrad</b>
<b>Circumference</b>	<b>26.4</b>	<b>m</b>
<b>Optics</b>	<b>4 x</b>	<b>FoDo</b>
<b>No. BPM</b>	<b>8</b>	

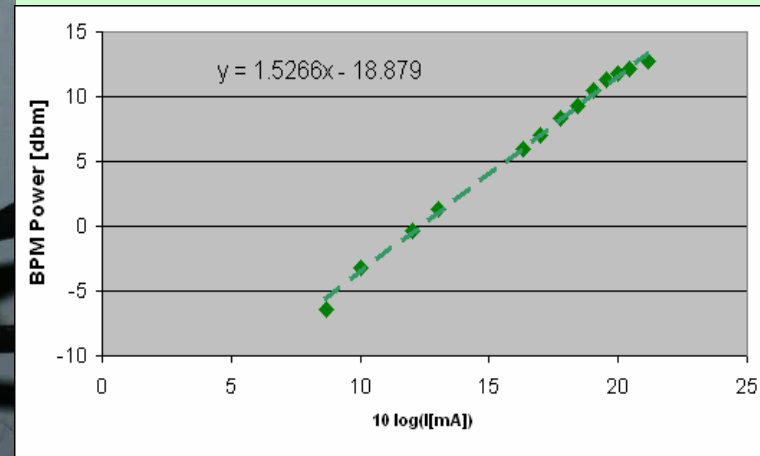


## Beam Lines

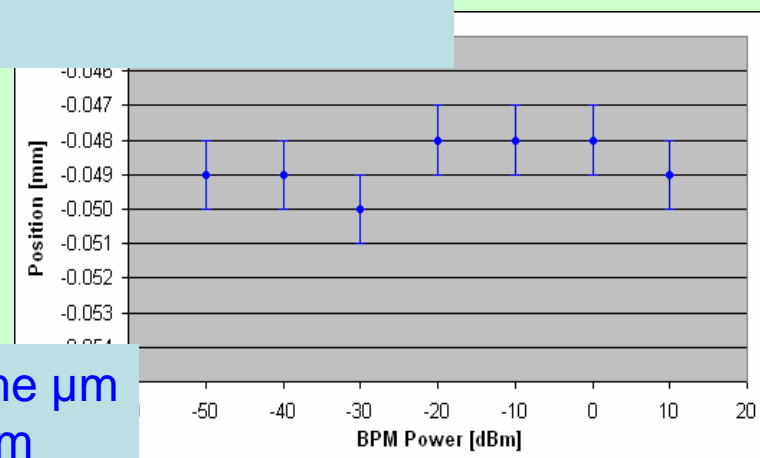
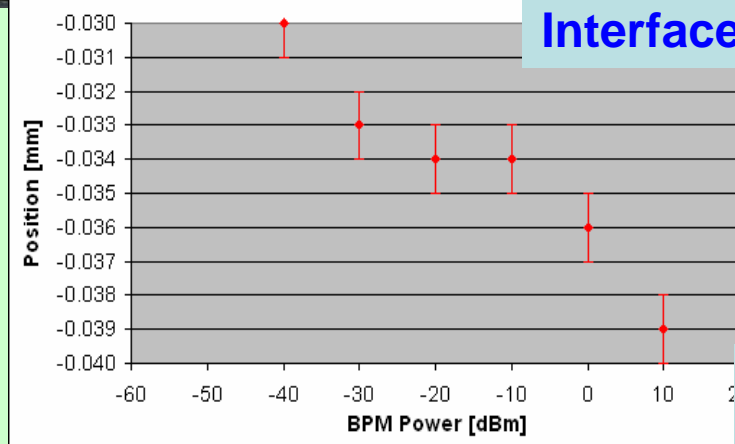


<b>Beam lines in operation (13):</b>	LIGA I	LGA II	LIGA III	ABS	P-DIFF
	SUL	TOPO	INE	FLUO	SC-DIFF
	WERA	IR I	Sf-DIFF		
<b>Beam lines in construction (3):</b>	IR II	NANO	IMAGE		

# Installed BPM System



**Analog:** multiplexed, demultiplexed  
**Digital:** 12 bit ADC, 1-500 Hz  
**Interface:** RS232



**BCD:** some  $\mu\text{m}$   
**RMS:**  $1 \mu\text{m}$

## Why LIBERA Electron



### Look for Turn by Turn Acquisition:

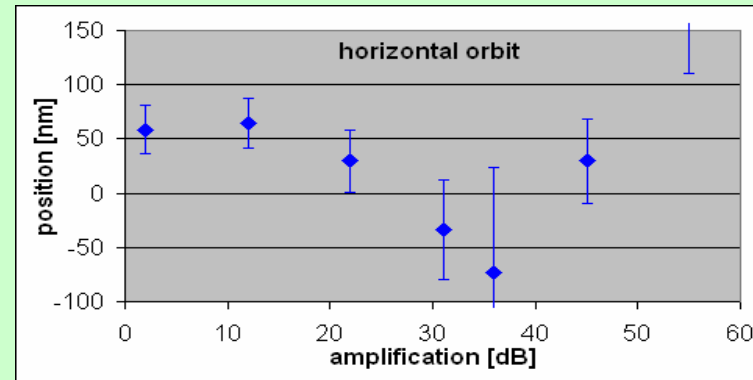
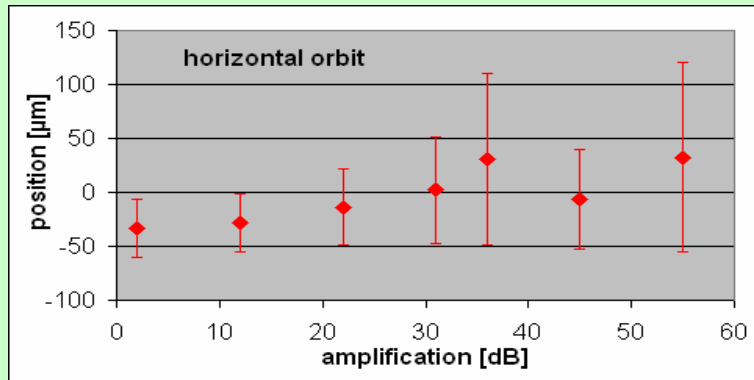
**Booster: Orbit and Tune at Injection and Ramp**  
**Storage ring: Orbit and Tune at Injection, Instabilities**



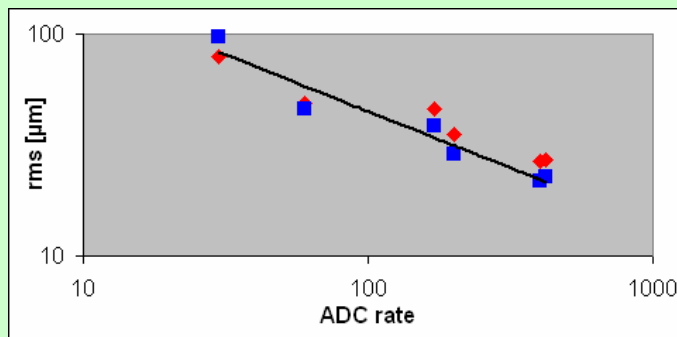
## LIBERA Electron Parameter

		Storage Ring		Booster	
<b>f revolution</b>	<b>MHz</b>	<b>2.71565</b>		<b>11.35</b>	
<b>f ADC</b>	<b>MHz</b>	<b>116.773</b>	<b>f rev x 43</b>	<b>113.56</b>	<b>f rev x 45</b>
<b>f RF</b>	<b>MHz</b>	<b>499.680</b>	<b>f rev x 184</b>	<b>499.680</b>	<b>f rev x 44</b>

## LIBERA TEST TBT (Signal-Generator)



**RMS (20-100  $\mu\text{m}$ ) larger than LIBERA test results (2-60  $\mu\text{m}$ )  
What did we wrong?**

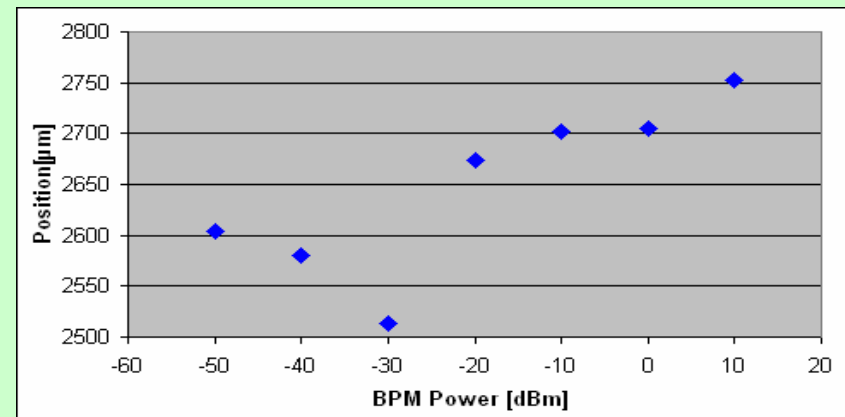
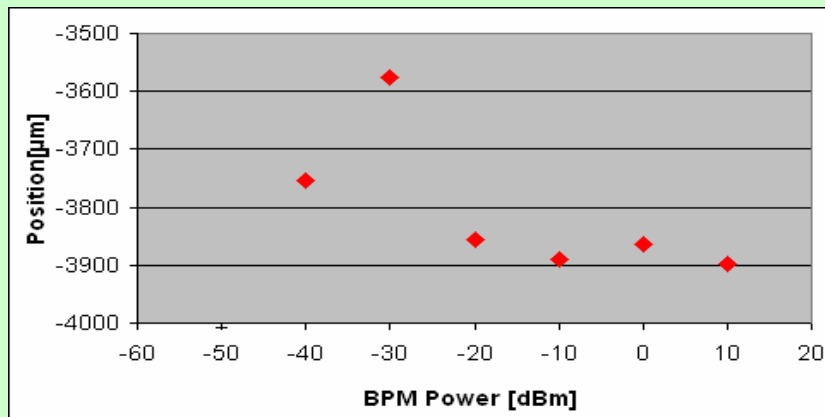
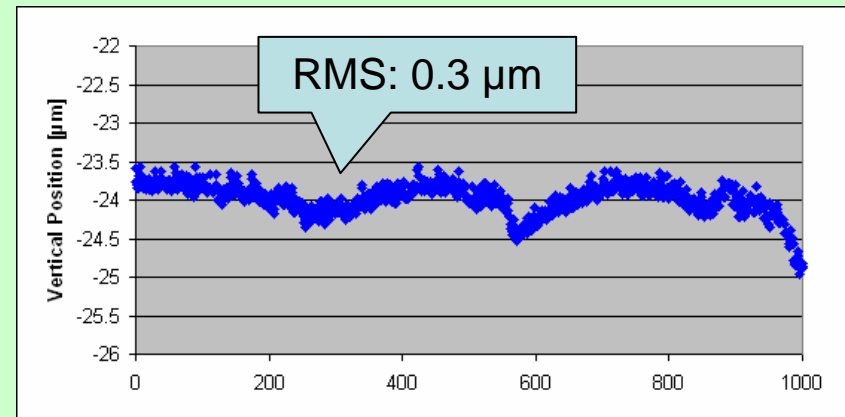
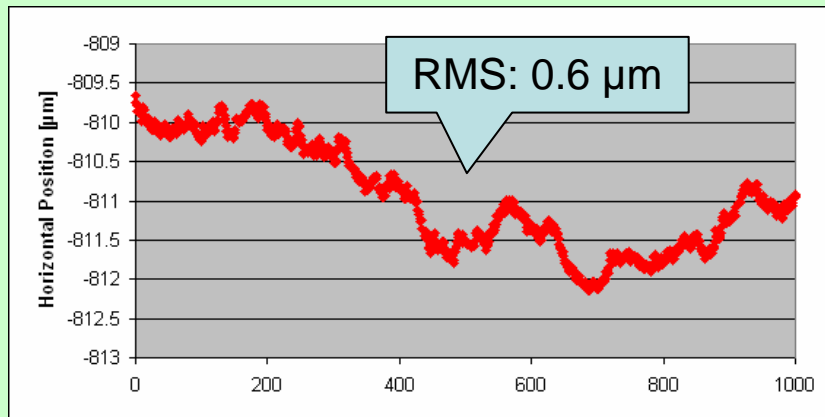


**ADC rate should be less: 2096  
Due to attenuation: 30 - 400**

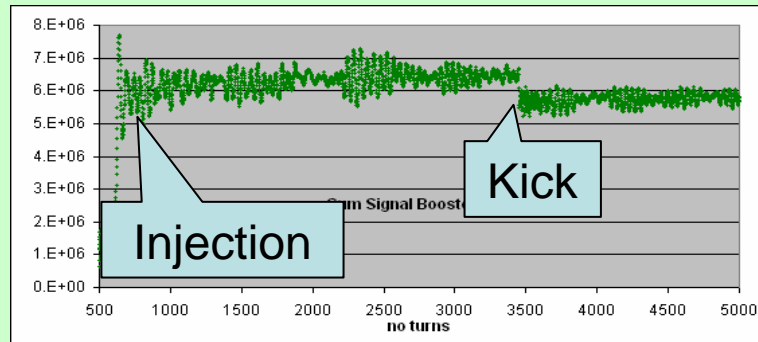
**RMS depends on ADC rate!**



## LIBERA TEST SA (Signal Generator)



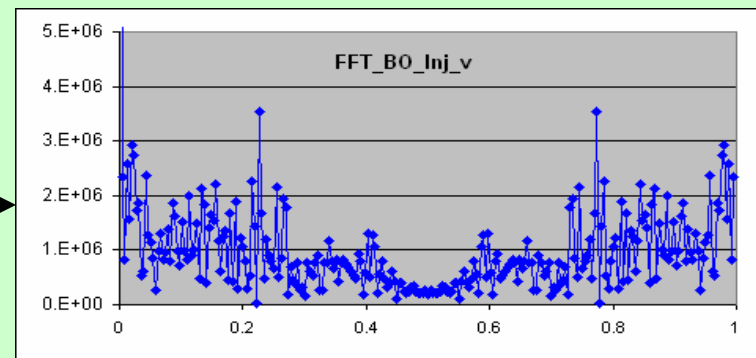
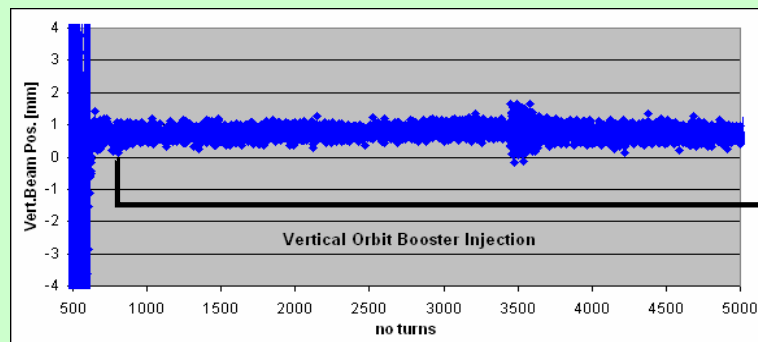
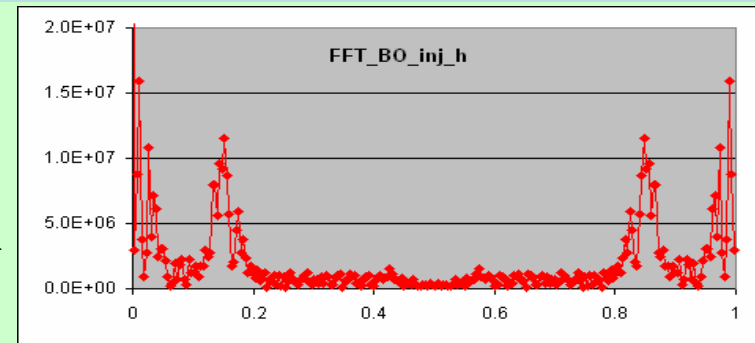
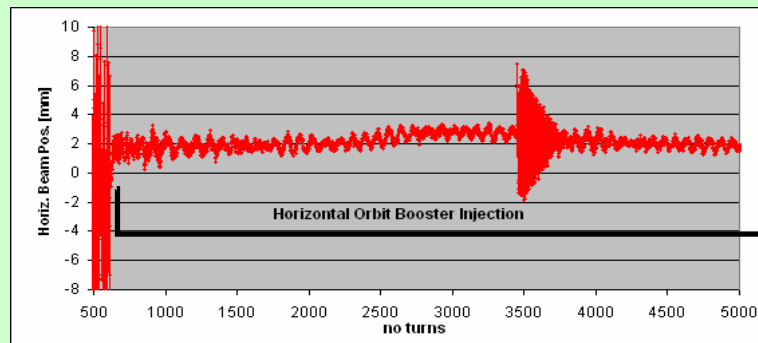
# Injection into the Booster



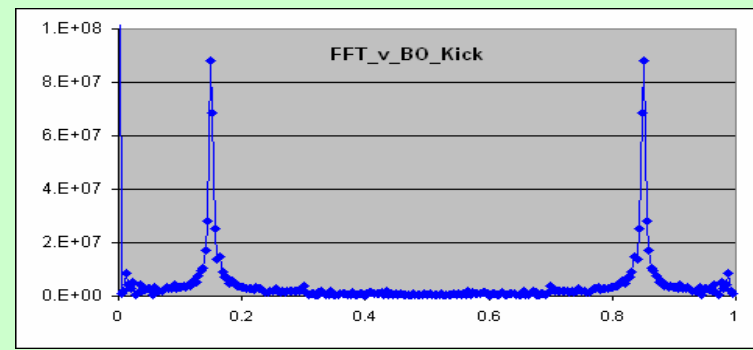
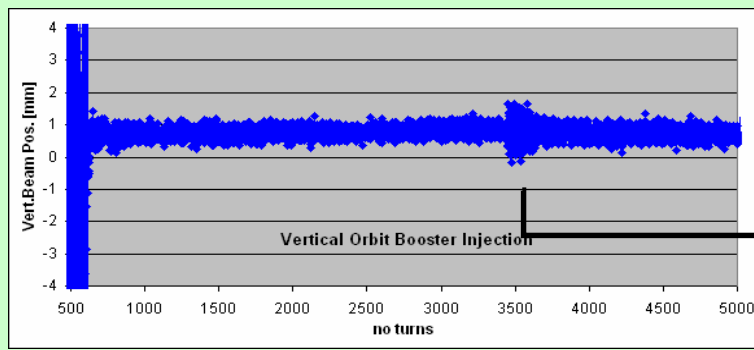
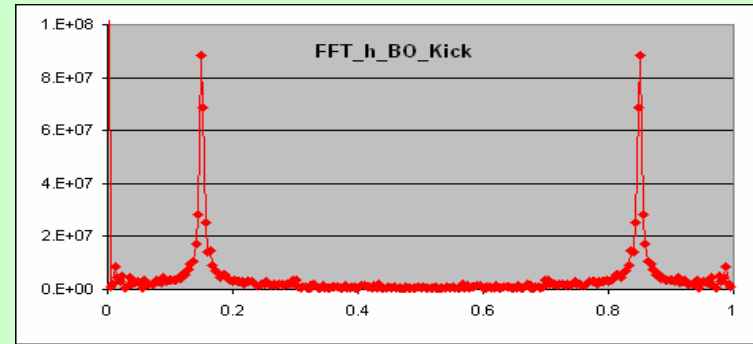
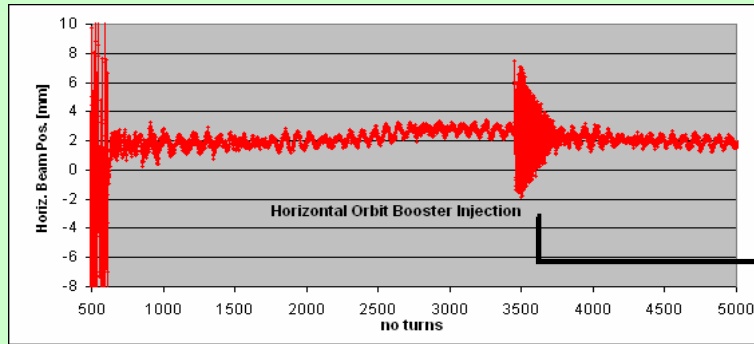
No orbit oscillation from injection due to multi turn injection (averaging)

Kick by reduced Extraction Kicker

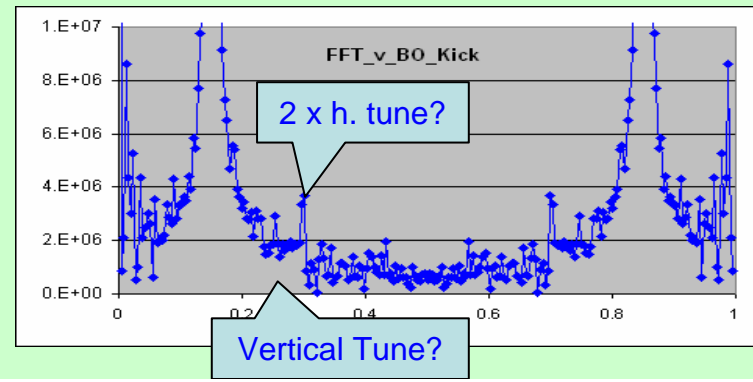
FFT: 256 turns at injection (650-906)



# Booster Orbit Kick by Extraction Kicker



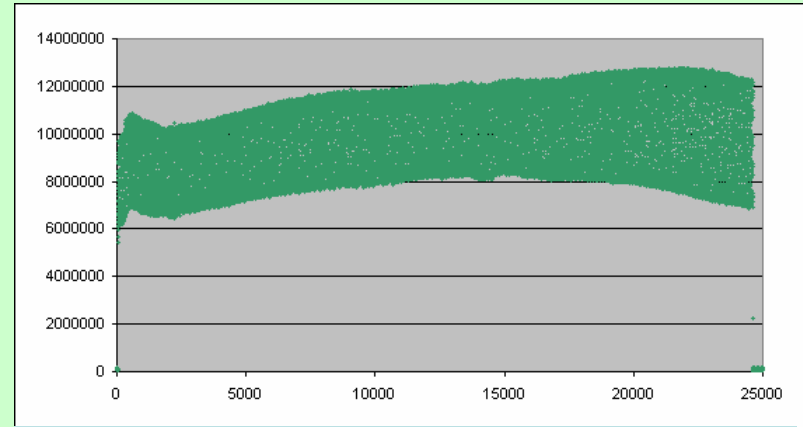
Horizontal tune dominates vertical FFT



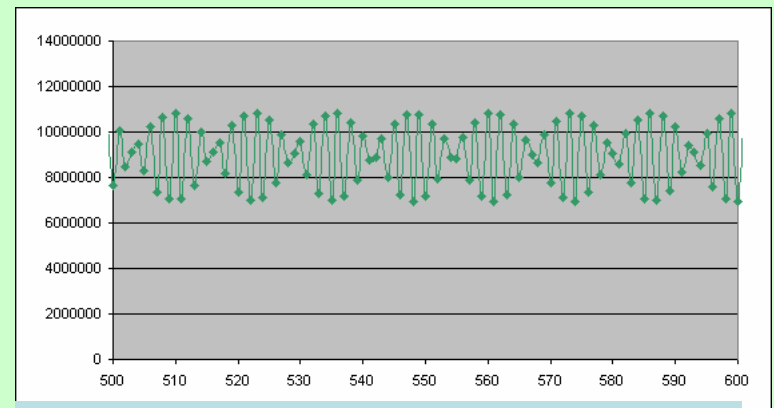
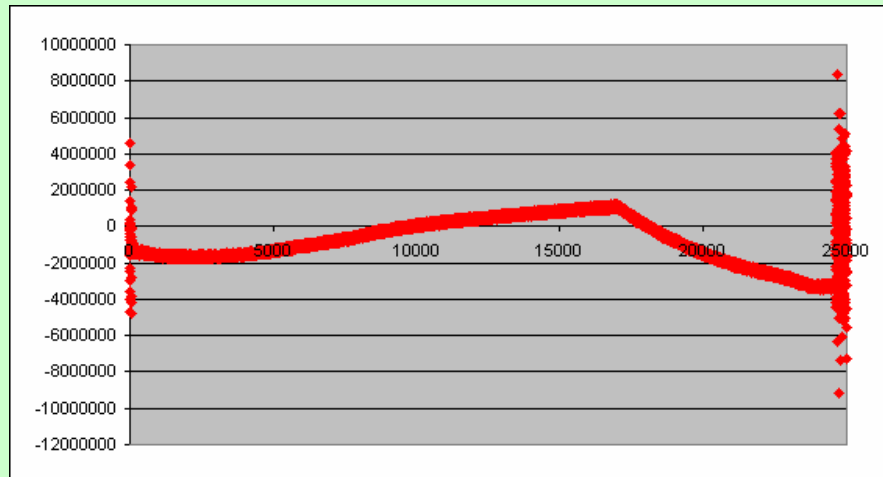


# ANKA Special

Booster Revolution Time	88 ns
Decimation (x64)	5632 ns
File size 64 k	369 ms
	is less
Booster Ramp time	600 ms
Used Storage Ring Parameters:	1.54 s



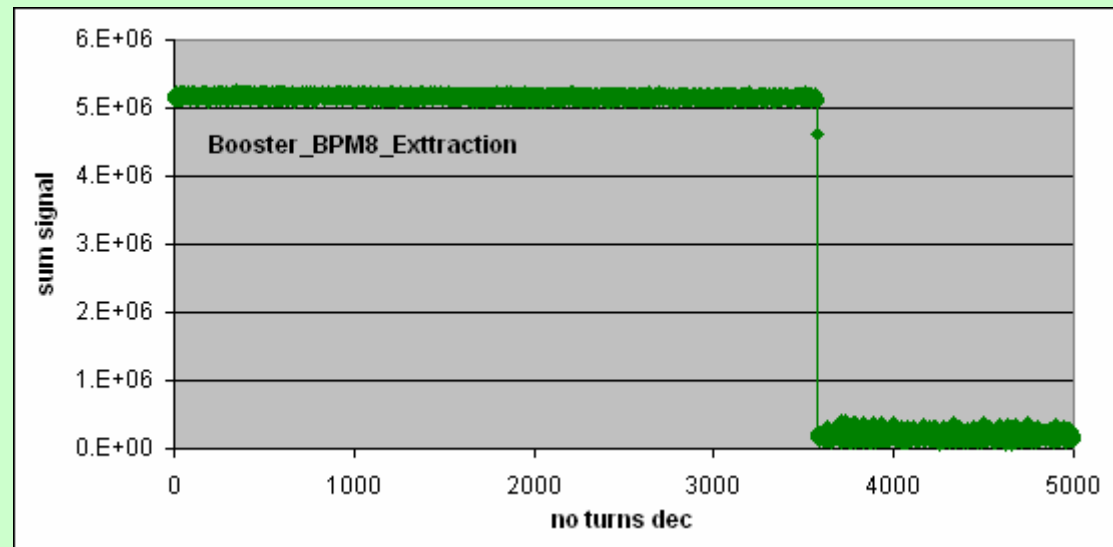
Sum Signal Decimated complete Ramp



Sum Signal 100 decimated SR turns



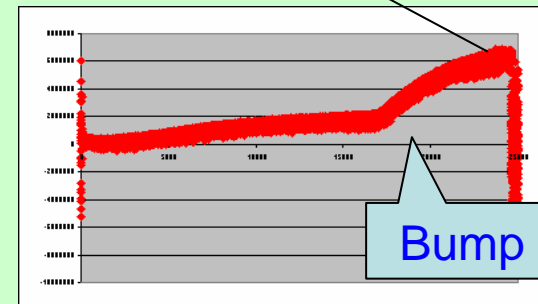
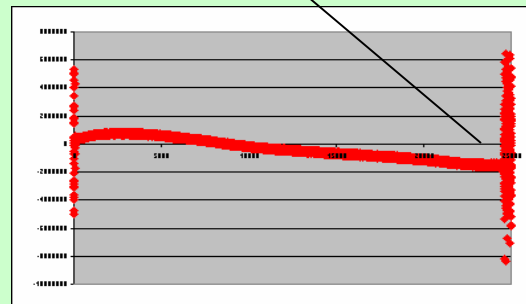
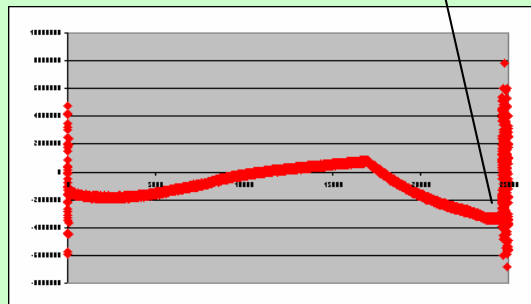
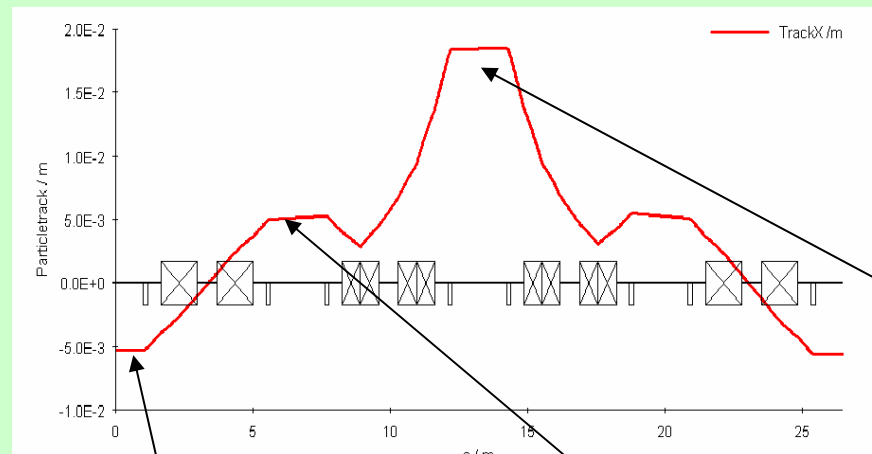
## Used Storage Ring Parameters





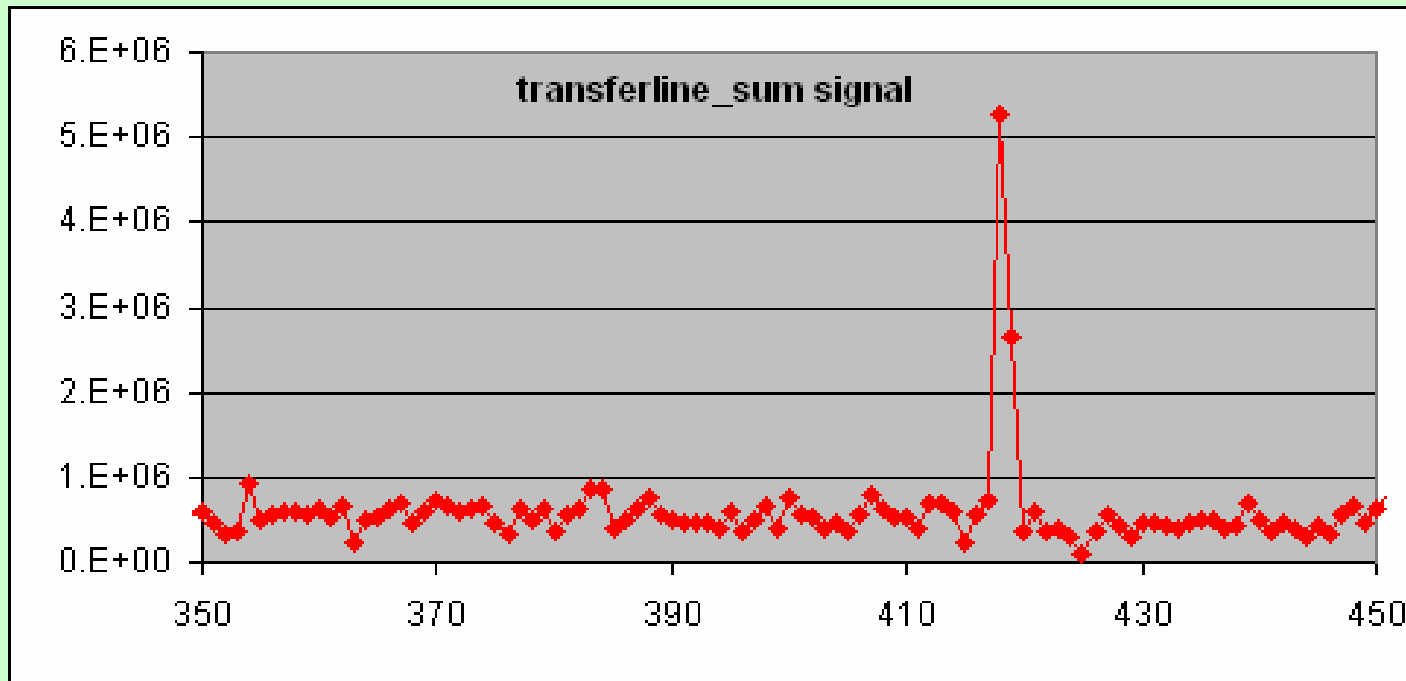
# Orbit during Booster Ramp

Before Extraction a bump moves orbit out  
Bump for extraction is not local  
Bump is negative opposite to Extraction





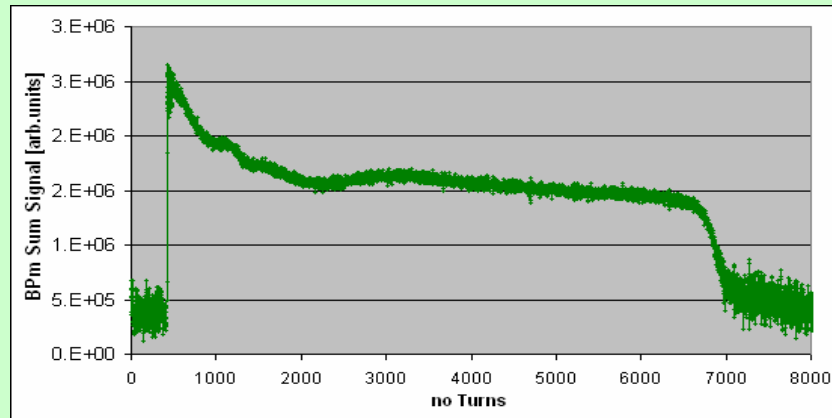
## Injection Line



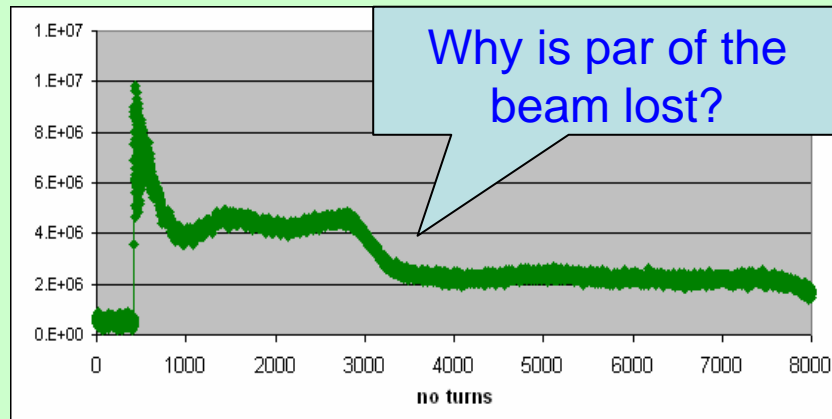
Good: Got signal in transfer line  
Note: Got 2 points (separated 368 ns for 70 ns bunch train)  
Next step: Prepare position signal for regulation (MATLAB)



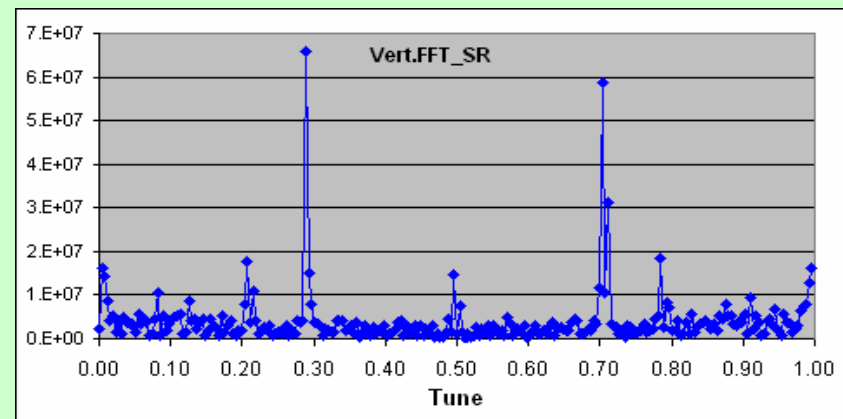
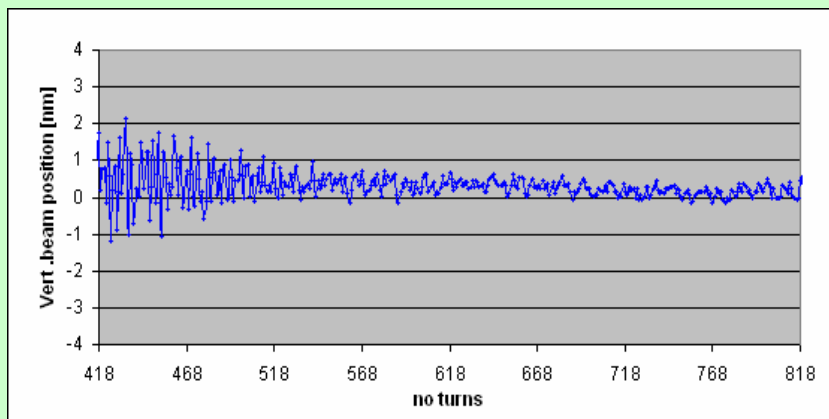
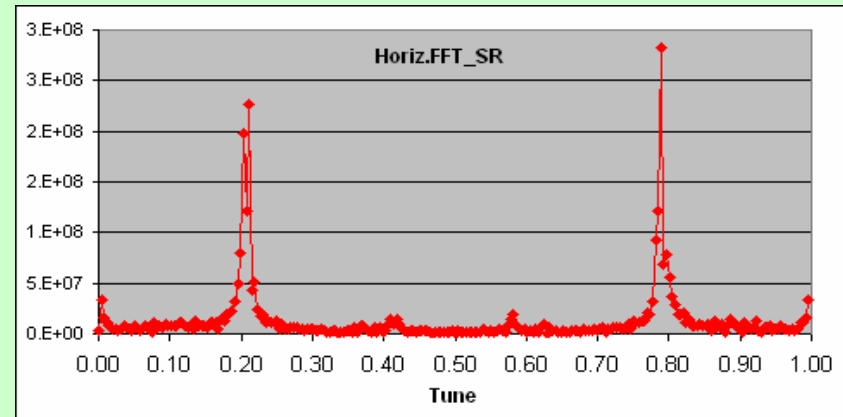
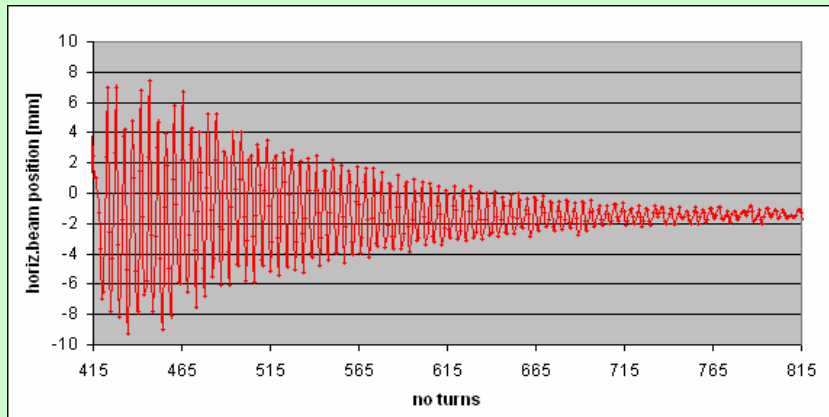
# Storage Ring Injection (No RF) Beam Position (Sum Signal)



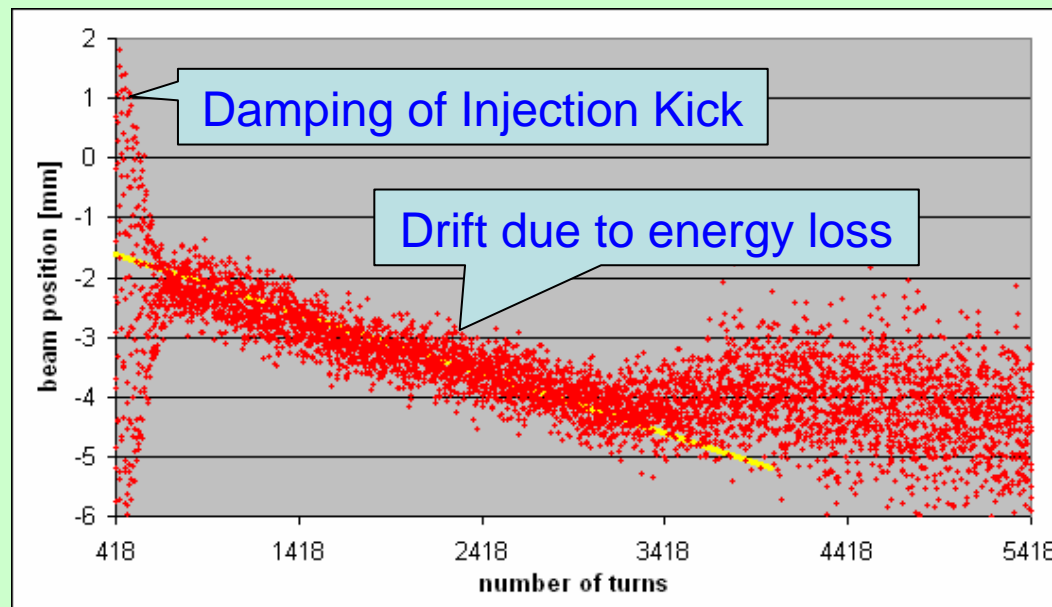
Beam loss after ~8000 turns  
Energy loss per turn: 1 keV  
Energy: 500 MeV  
Energy acceptance: 1.6 %



# Storage Ring Injection Tune (No RF)



## Storage Ring Injection (No RF) Horizontal Orbit in Dispersive Section

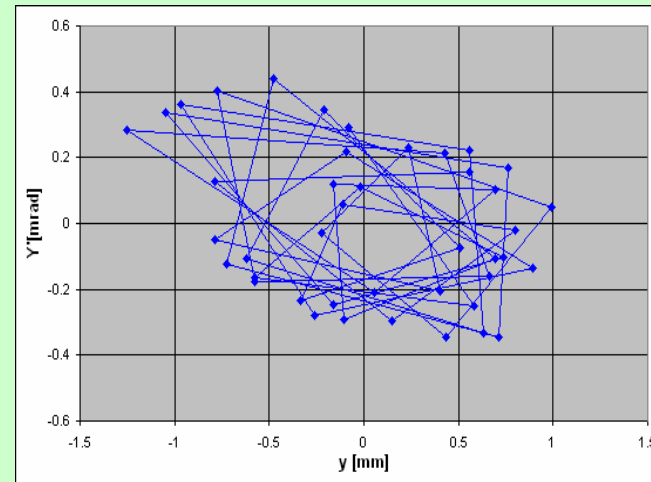
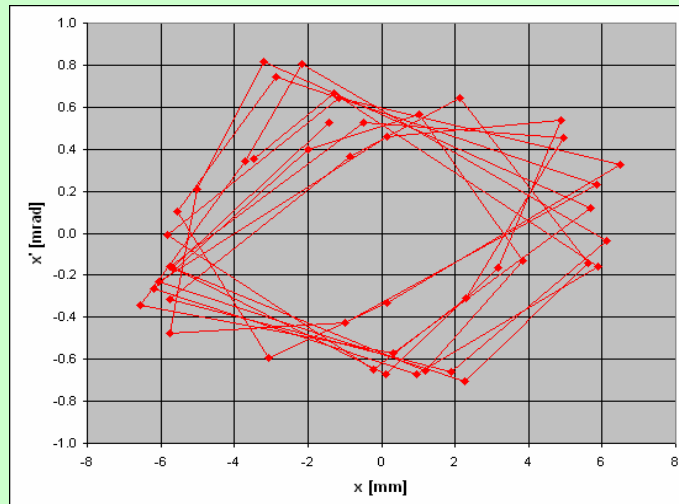


Energy loss:	1 keV/turn
Energy:	500 MeV
Dispersion:	0.5 m



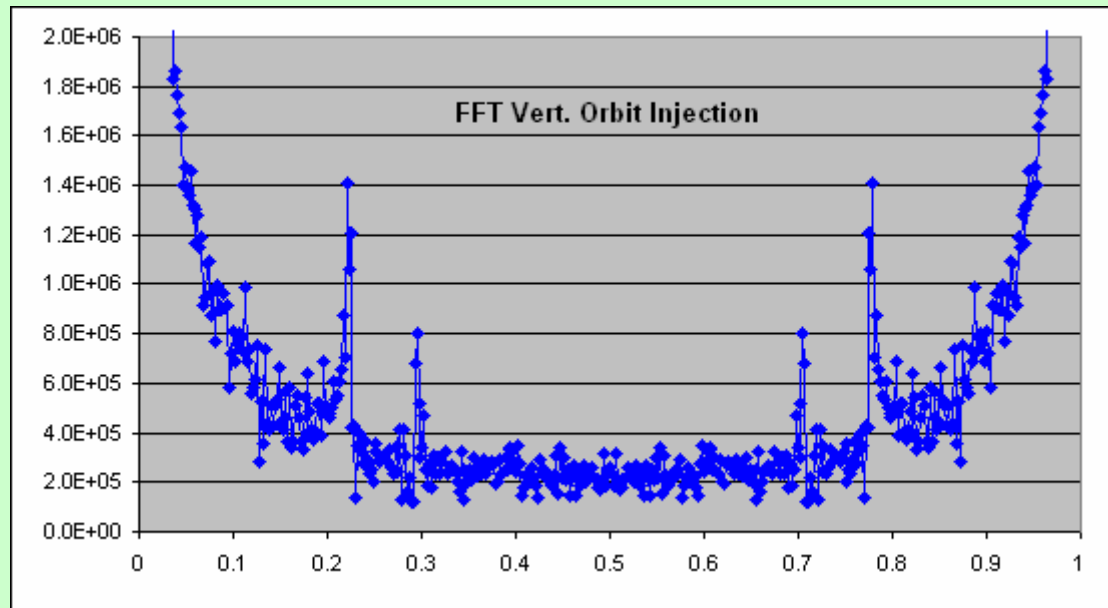


# Storage Ring Injection (No RF) Phase Space

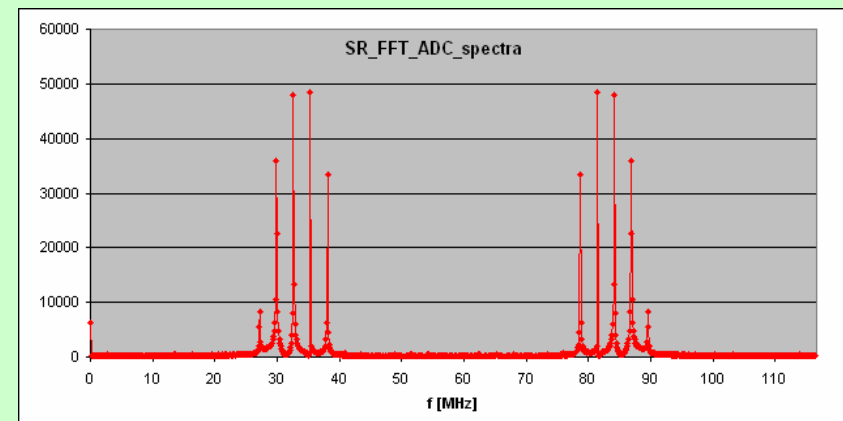
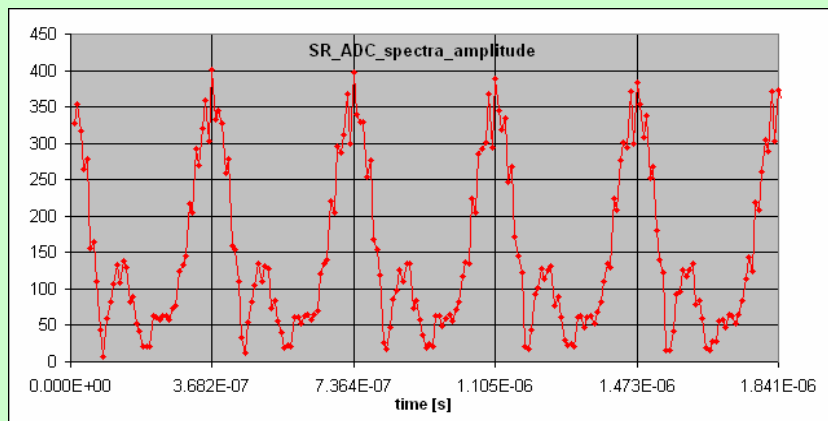
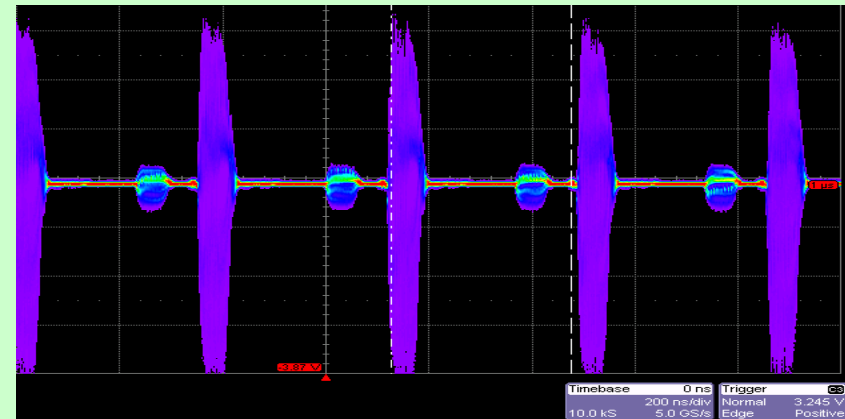
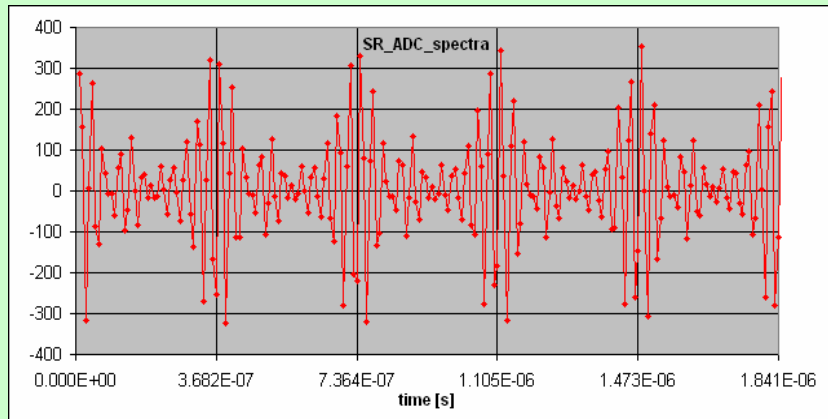




## Storage Ring Injection RF on (100mA)



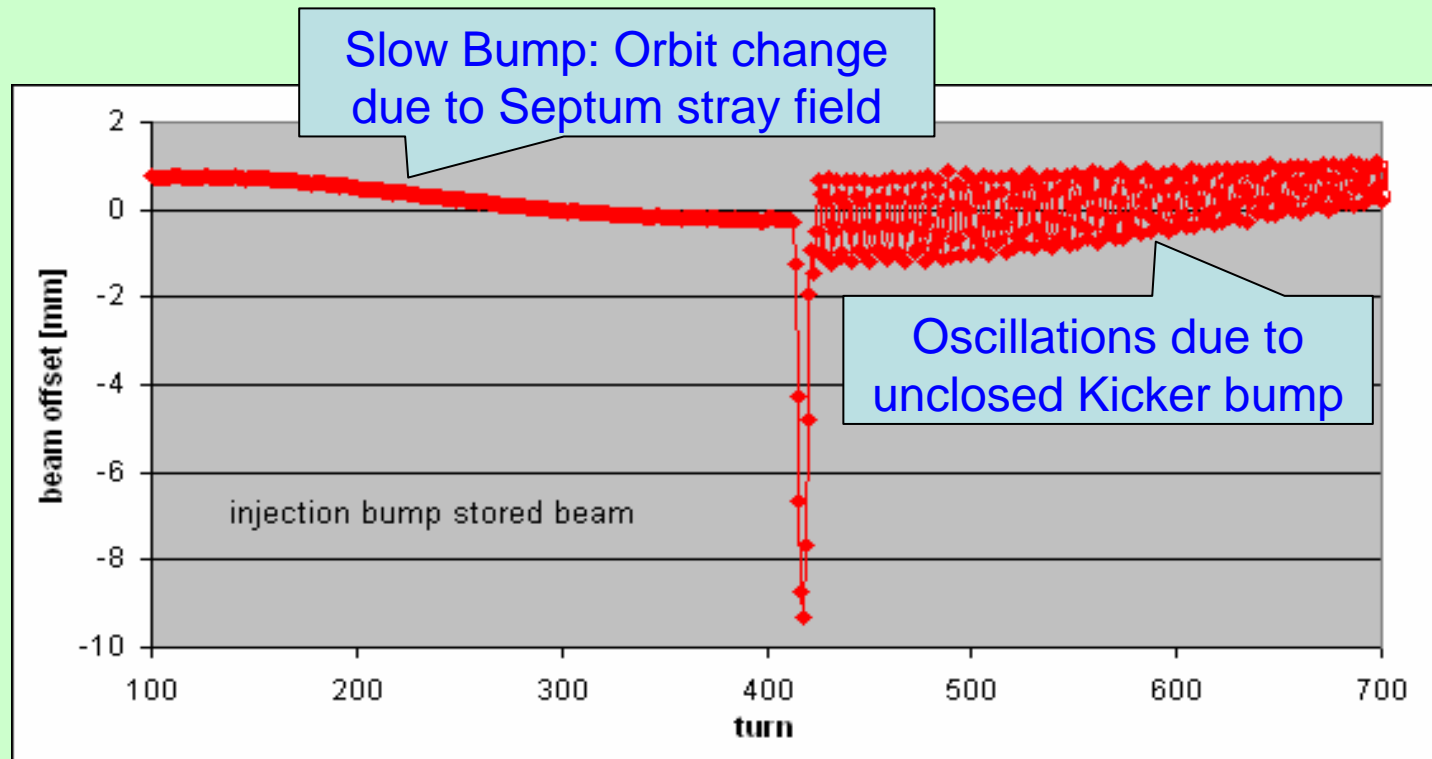
# Storage Ring (No RF) ADC Data



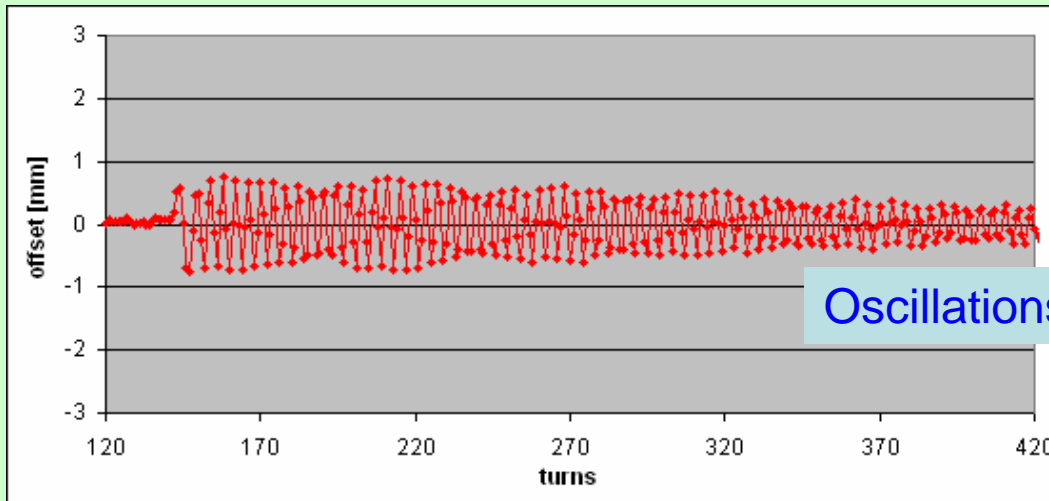
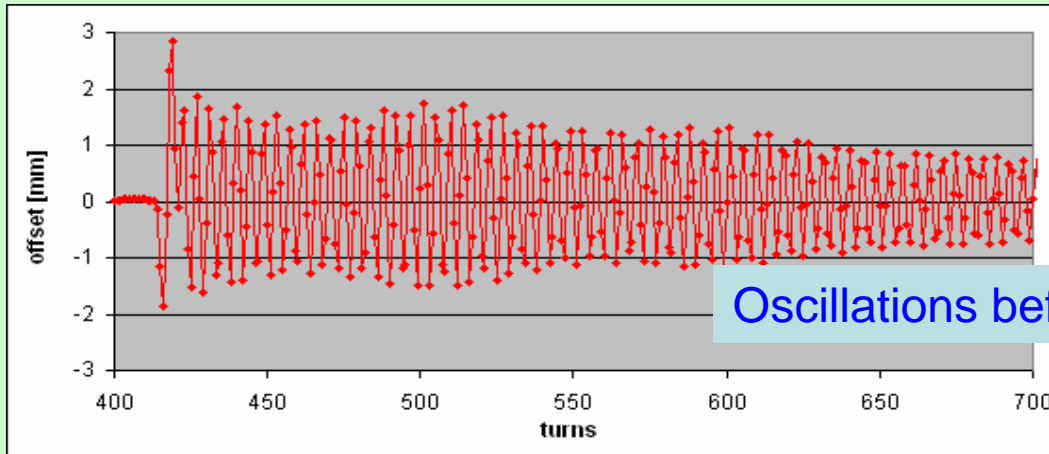
$\text{abs}(I(t) + i I(t+90^\circ))$

$f_{RF}$	:	499.68	MHz
$f_{adc}$	:	116.8	MHz
$f_{RF} - 4 \times f_{adc}$	:	32.6	MHz
$f_{rev}$	:	2.715	MHz

## Storage Ring Injection: Septum Bump

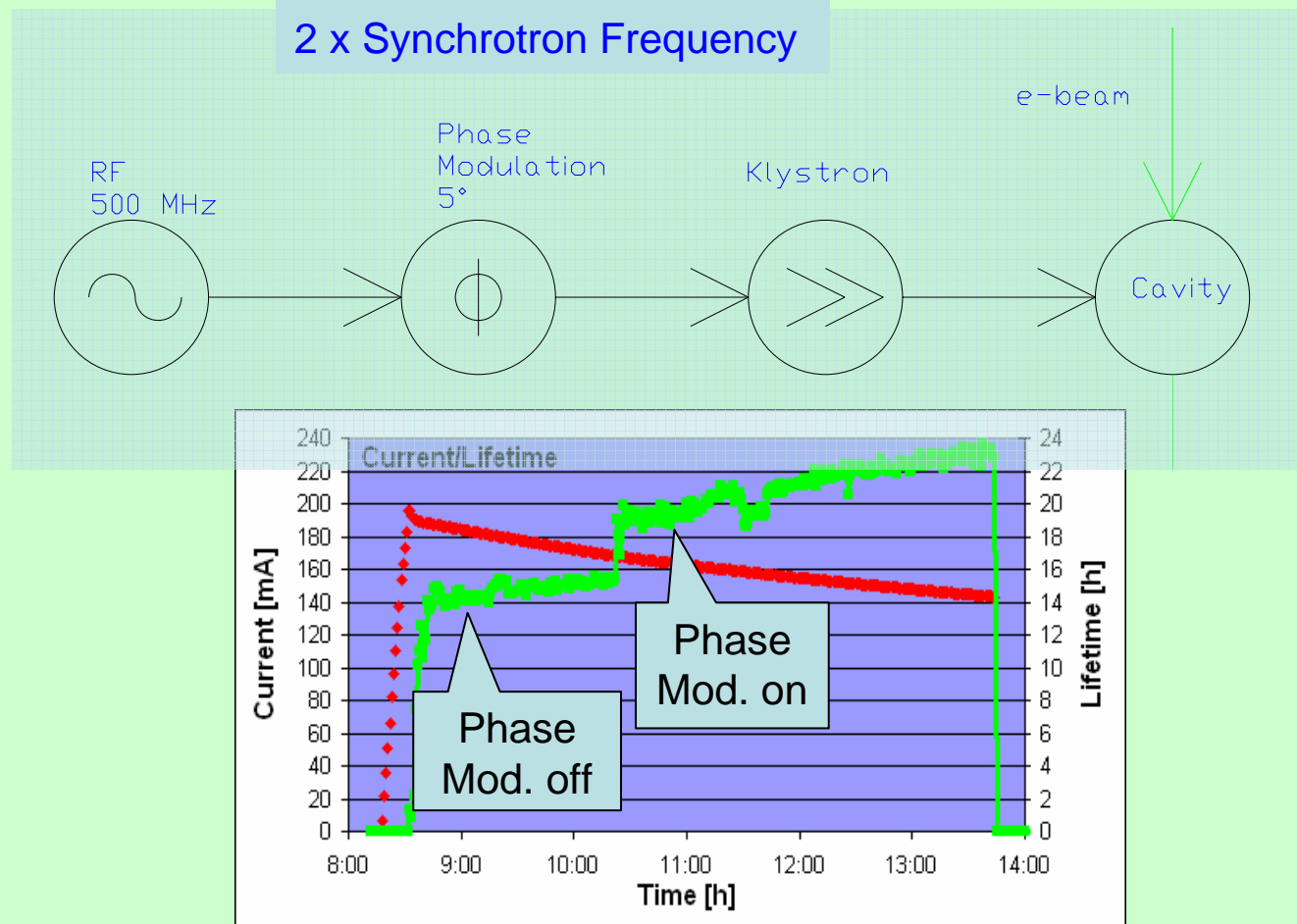


# Storage Ring Injection: Kicker Bump



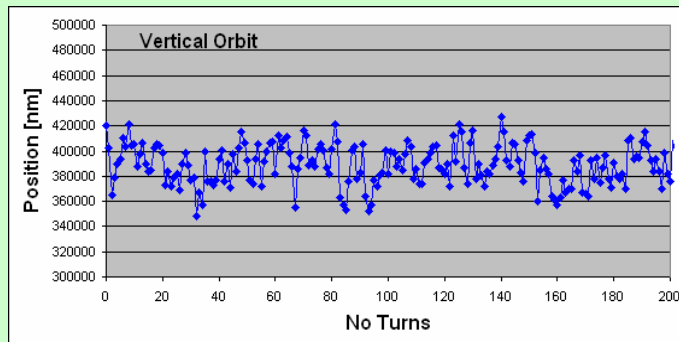
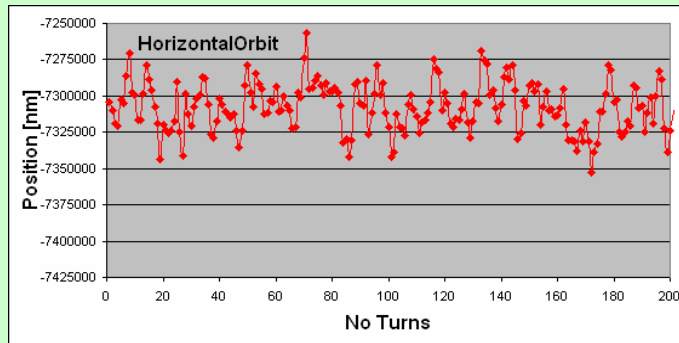


# Phase Modulation and Lifetime

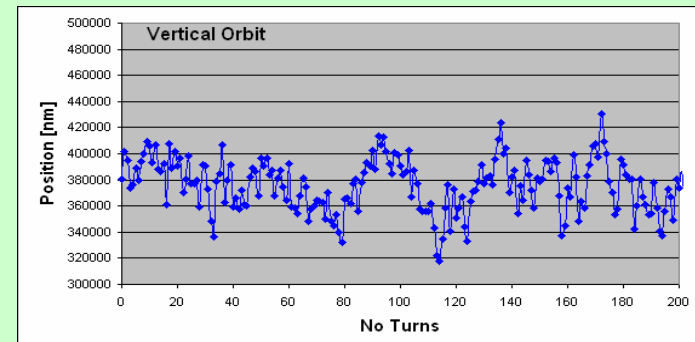
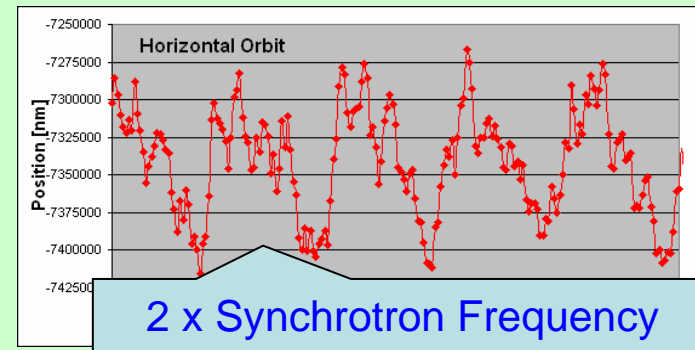


# Phase Modulation and Orbit

Phase Modulation off

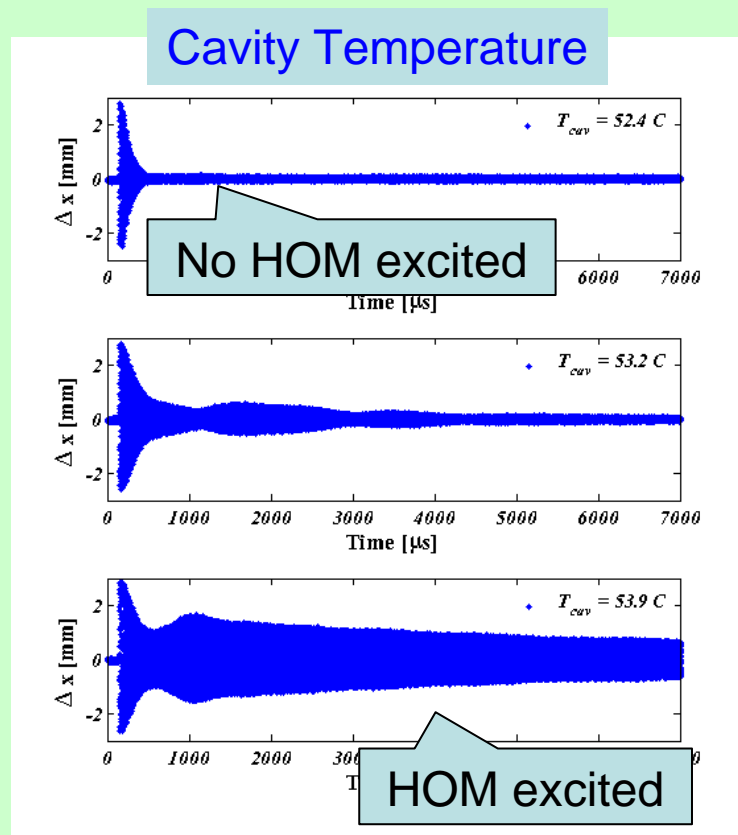


Phase Modulation on

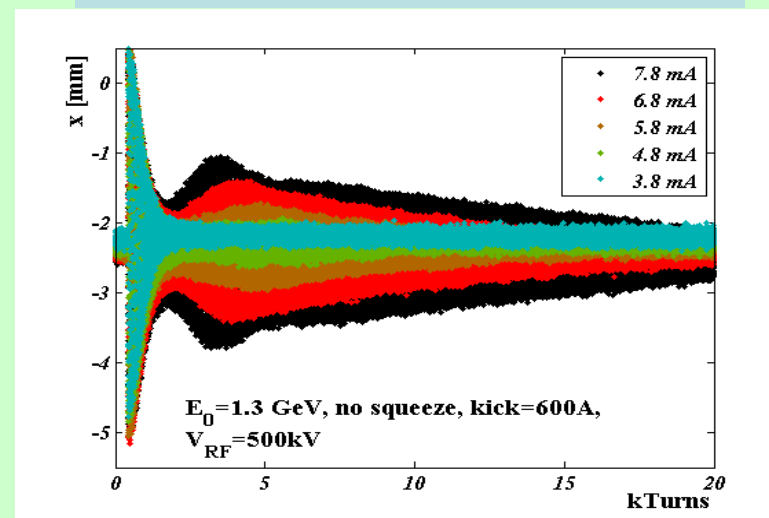


# Kick and Damping

Kick with one of the injection kicker (3  $\mu$ s half sine)



### Current dependent exchange of Excitation and Damping



Damping time: 11ms (1.3 GeV)  
1.5 ms (2.5 GeV)



## Conclusion

Booster:            Got First Turns  
                         Got Tunes  
                         Got Orbit on Ramp

To be done:        Correct Tune  
                         Correct Orbit on Ramp

Storage Ring:     Got First Turns  
                         Got Tunes  
                         Got some 'Beam Dynamics'

To be done:        Optimize Injection  
                         Look for fast (Hz) Oscillations  
                         Fast Feedback

To be done:        Learn to use the LIBERA better