Energy Loss Experiment 2007 APEX Workshop

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Overview

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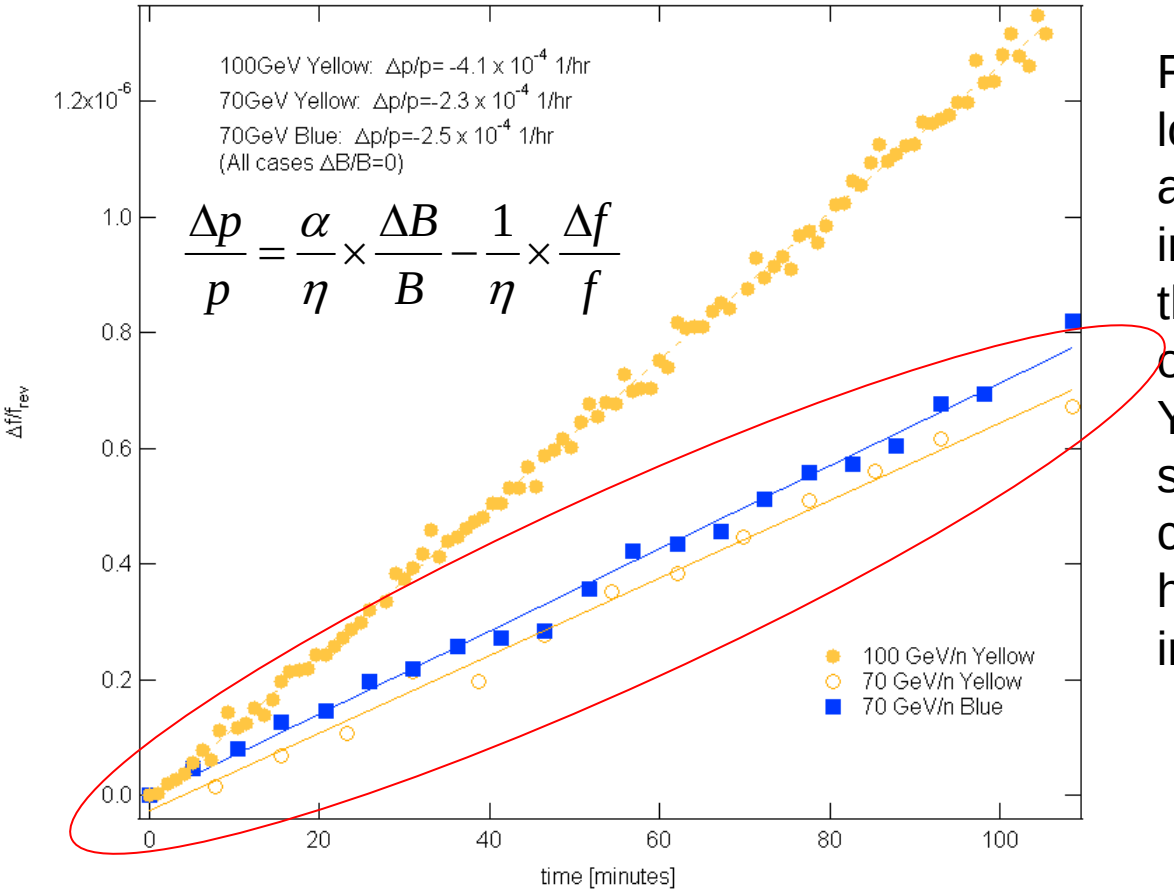
Motivation

- Estimate the resistive and broad band impedance of the machine;
- Verify the prediction of J. Schwinger (1945) that the low energy spectrum of the synchrotron radiation would be suppressed due to the presence of conducting materials like the beam pipe (boundary conditions) and
- The energy loss and heating by synchrotron radiation of heavy particles becomes important in high energy machines like the LHC. Suppression of synchrotron radiation applies also to coherent radiation with application to linear colliders.

Experimental Setup

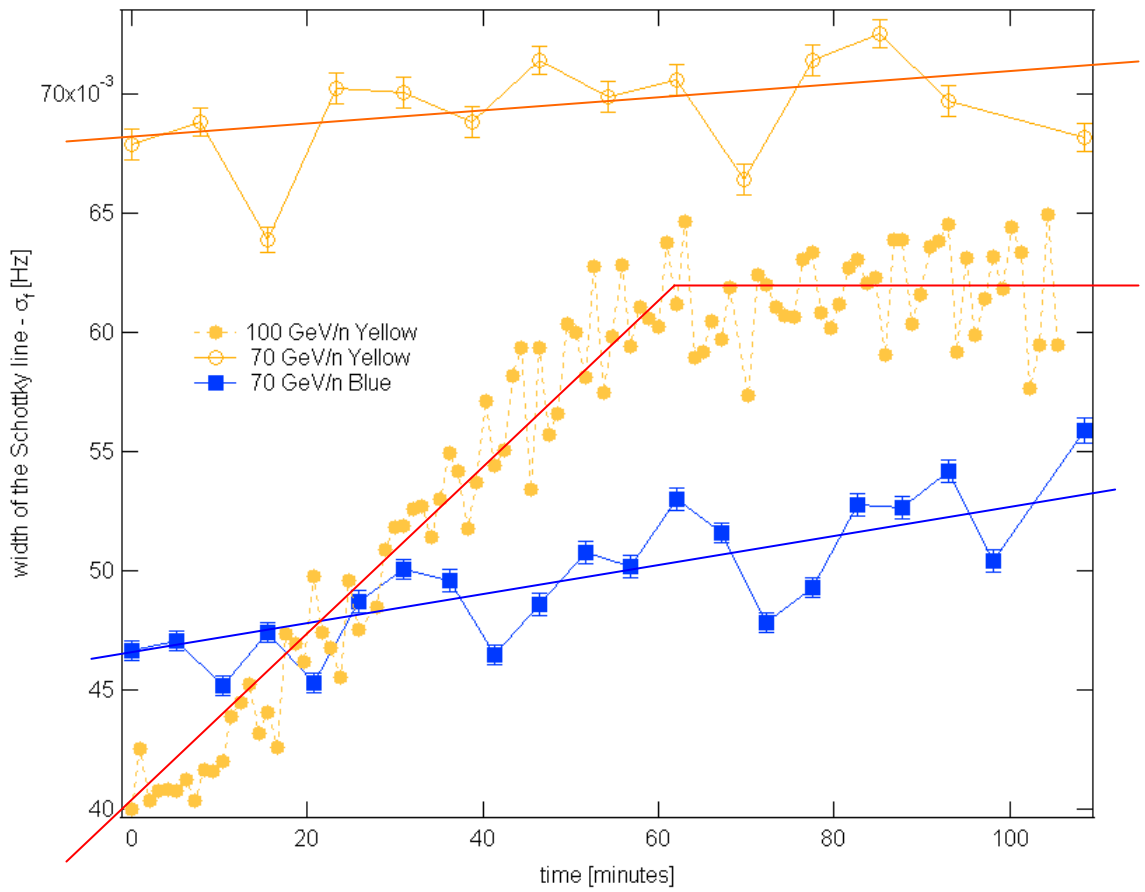
- Measure the revolution frequency of a coasting beam over time (Schottky spectrum);
- The increase in the revolution frequency is a combination of energy loss due to synchrotron radiation, impedance and gas scattering;
- The experiment was performed at two different energies: 100 GeV/nucleon and 70 GeV/nucleon, both with the same intensities: ~ 6×10^9 ions

Results



For the 70 GeV the energy loss measured comes almost only from impedance interaction. In the plot it is possible to observe that the Blue and Yellow curves have the same slope and consequently both rings have similar longitudinal impedances.

Results



Synchrotron radiation is expected to result in a slow, observable energy loss. Damping times are some long and the energy spread is expected to remain about constant. The increase seen, particularly at 100 GeV, is not expected and still under investigation.

Result Analysis

Parameters	particle		Au79+	
	Energy	GeV/n	100	70
	γ		107.4	75.2
	η		0.0018	0.0017
Impedance	σ	mm	0.538	0.79
	k_{loss} - Diffraction	V/pC	4776	4744
	k_{loss} - Resisitive Wall	V/pC	394	230
	U_{ipm}	eV/turn	5.17	4.97
Ionization	P	nTorr	1	1
	U_i	meV/turn	9.7	9.3
Imp+Ion	U_i+U_{ipm}	eV/turn	5.18	4.98
	$\Delta p/p \times 10^{-4}$	1/hour	1.85	1.78
Synchrotron	U_s	eV/turn	20.6	4.95
	$\Delta p/p \times 10^{-4}$	1/hour	7.4	2.5
	supression	%	56	94
	with suppression	eV/turn	3.26	0.15
Total - Calc.	$\Delta p/p \times 10^{-4}$	1/hour	5.10	1.93
Exp. error	$\Delta p/p \times 10^{-4}$	1/hour	0.5	0.2
Total - Measured	$\Delta p/p \times 10^{-4}$	1/hour	4.1	2.4

Re(Z/n) ~ 4 Ω

Consider only the dipole field drift.
0 < DB/B < 1.5e-5 1/hour, which accounts for a 10% error

Calculated for the case of 2 infinite parallel plates (lower limit)

Next Steps

- Repeat the measurement at 100 GeV/nucleon with Au to verify the result obtained and also to understand the broadening in the width of the Schottky line and also with d (no synchrotron emission);
- Use different intensities (3 and 12 x 10^9 particles) to check for intensity dependent effects and
- Repeat the measurement for different energies and different species (d and Au at 85 GeV, for example).

Closing Remarks

- The agreement between theory and experiment is quite good given the limited knowledge of the machine impedances and also that we used the suppression calculated for the parallel plate instead of a round vacuum chamber;
- That is the first clear indication of the suppression of synchrotron radiation due to boundary conditions once the measurement in the SPS and HERA were very limited in precision.
- This measurements, apart from the interest in measuring an interesting effect, can be used to estimate the other components that can lead to energy loss like interaction with impedances and gas scattering.