

# PETRA III Studies July 2013.

Discussion on the operation of PETRA III at  $E < 6$  GeV

- Emittance
- Bunch length
- Instabilities

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# Emittance – a simple model

$$\epsilon = \frac{C_q}{J_x} \left( \frac{E}{m_0 c^2} \right)^2 \frac{I_5}{I_2}$$

$$I_5 = \int ds \frac{\mathcal{H}}{\rho^3}, \quad I_2 = \int ds \frac{1}{\rho^2}$$

**Assumption: Optic unchanged**

**D: bending radius 192 m**

**PDA: bending radius 24 m**

**W: bending radius 19 m @ 6 GeV,  
scaled with Energy**

Energy	Emittance (w/o Wigg)	Emittance	Tolerance D In Wigg.
6 GeV	4.4 nm	1 nm	1.5 cm
5 GeV	3 nm	0.5 nm	1 cm
4 GeV	2 nm	0.2 nm	0.5 cm
3.4 GeV	1.4 nm	0.1 nm	0.2 cm
3 GeV	1 nm	0.07 nm	0.2 cm



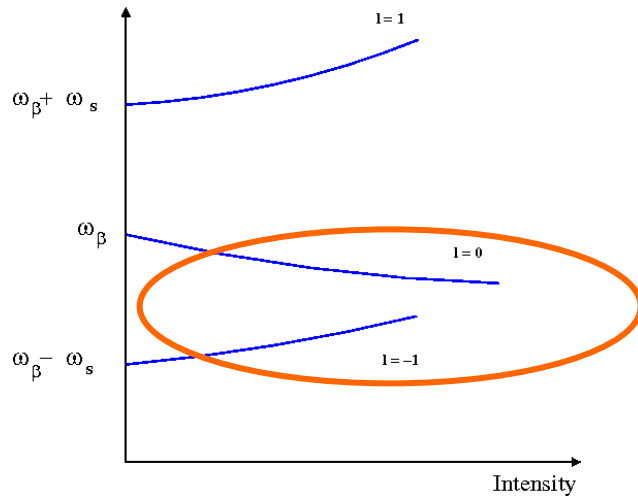
# Bunch length – simplified model

Energy	Energy spread $10^{-3}$	Voltage / MV	$f_s$ / kHz	Bunch length / mm
6 GeV	1.1	20	6.4	10 (12 mm)
5 GeV	1.0	20	7.0	8.5
		15	6.1	9.7
4 GeV	0.9	20	7.9	6.8
		15	6.9	7.8
		<b>10</b>	<b>5.6</b>	<b>9.7</b>
3.4 GeV	0.86	10	6.0	8.2
3 GeV	0.8	20	9.2	<b>5.2</b>
		10	6.5	7.3



# Instabilities

Tune shift with intensity:



$$\Delta Q_{\beta} = \frac{\Delta f_{\beta}}{f_0} = \frac{I_B \langle \beta \rangle T_0}{4\pi E / e} k_{\perp}$$

**Tune shift is increasing with lower E**  
**TMCI , mode coupling m =1, l = 0, -1**

Coupled bunch instabilities:

transverse damping time ~ Energy

$$\frac{1}{\tau_{\parallel}} = \frac{2\pi Q_s}{T_0} \frac{I_{tot} Z_{\parallel eff}}{2 V_{rf}}, \quad \frac{1}{\tau_{\perp}} = \frac{2\pi}{T_0} \frac{I_{tot} \beta_{cav} Z_{\perp eff}}{4\pi E / e}$$

# Conclusion

- Plans and objectives for the studies in July 2013
  - Studies for USR, collective effects at low emittance ?
  - Lower emittance at 6 GeV ?
- Running at 5 GeV with 0.5 nm seems to be realistic
- Running at 4 GeV is more ambitious: smaller tolerance for the max Dispersion in the wiggler, emittance diagnostics (0.2 nm), use the interferometer with horz. slits ?
- Running at 3 GeV is a real challenge, it is not clear that we can identify the causes of possible problems

