Update on transverse instability studies

- **Fedotov et al.**

August 13, 2002

AP Ring Topics for the ASAC

- **Results of measurements of the complete sets of shimmed dipoles and quadrupoles:**

  P. Wanderer will summarize the status

2. **Studies of e-cloud and corrective actions:**

   Update on simulation, theory and experiment. Threshold predictions for the SNS with detailed explanation of the SNS difference from other machines. Detailed discussion of cures including clearing electrodes: M. Blaskiewicz et al.

3. **Update on impedance budget. 4. Effort to minimize extraction kicker impedance. 5. SNS intensity threshold due to transverse instability. 6. In-depth survey of collective instabilities:**

   Presentation on instabilities with updated impedance budget – A. Fedotov/ M. Blaskiewicz/S. Danilov et al.

7. **Resonance-based loss with applied corrections:**

   Depending of the effort something can be presented.

AP topics continued

8. Survey of halo generation mechanisms:

- **at CD4 intensity**
- **at high-current intensity**

9. Summary of other beam dynamics studies

- **Items 3 - 9: " Ring Collective Effects Overview"**

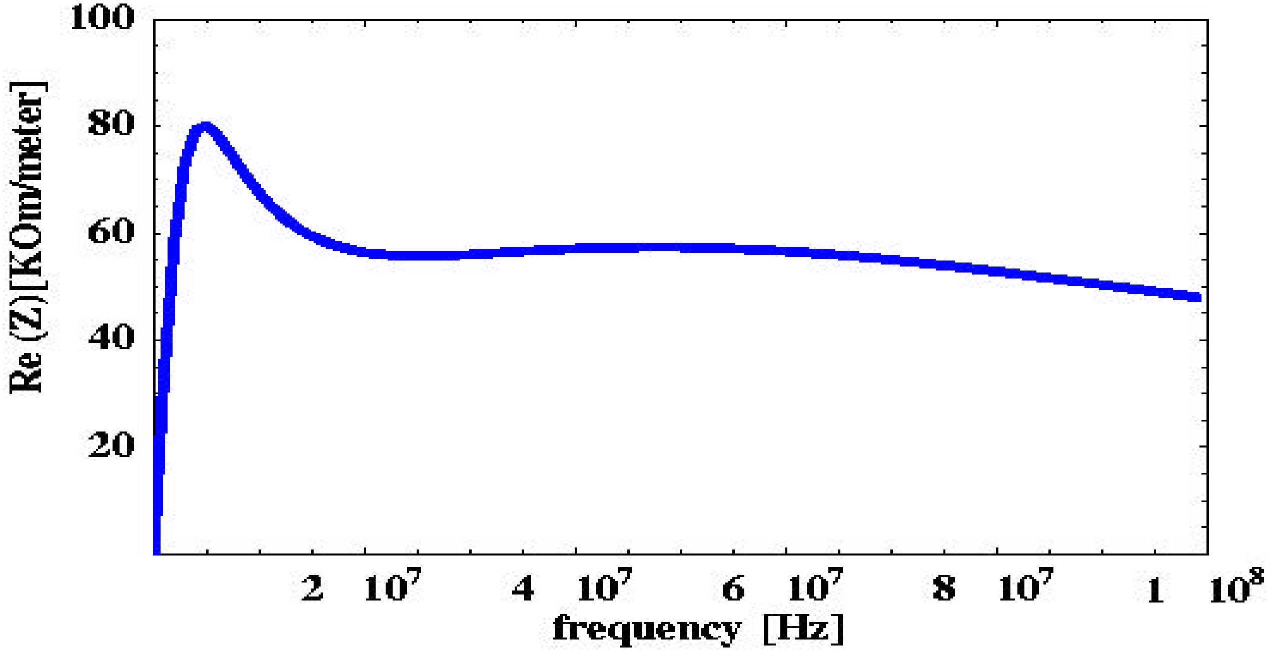
S. Danilov – will cover cures of all types of instabilities relevant to the SNS (both longitudinal and transverse) and will present corresponding feedback systems.

Effect of transverse instability on intensity threshold (A. Fedotov, M. Blaskiewicz, J.Wei, S.Danilov, J.Holmes, A. Shishlo et al.)

- Numerical implementation and preliminary conclusions were presented last ASAC (February 2002).
- Since February we performed numerical studies to obtain saturation of simulation parameters (using 40 parallel CPU) and then proceeded with beam dynamics studies.
- Summary of major effects on beam stability were presented at AP video (May 2002) and EPAC'02.
- This summer

- Extraction kicker impedance was significantly reduced
- RF impedance measured
- Corresponding beam dynamics studies were performed.

Re(Z) for full 14-kicker system (May 2002)



Impedance model (EK) used in simulations January- June'02

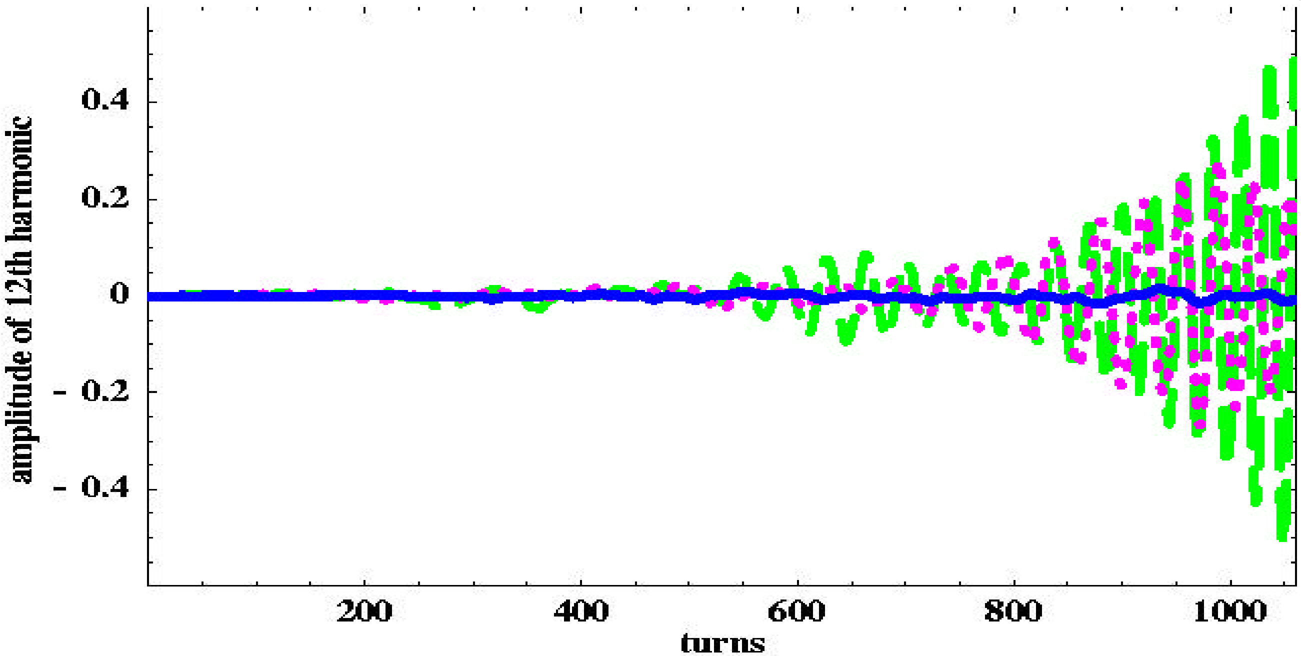
Outline of instability studies (May 2002)

- Instability thresholds due to old EK impedance were identified.

- The following study topics were performed with realistic full 1060-turn injection:
- Open vs 25 W termination impedance
- Low frequency (1-2 MHz) and space charge stabilization (with zero chromaticity)
- Stabilization with b/a (effective tune spread along the bunch due to longitudinal current density)
- Small b/a , quadrupole effect
- Destabilizing effect of space charge

6. Stabilization with chromatic tune spread

N=2.0*10^14 at the end of accumulation - unstable harmonics around 6MHz (May 2002)

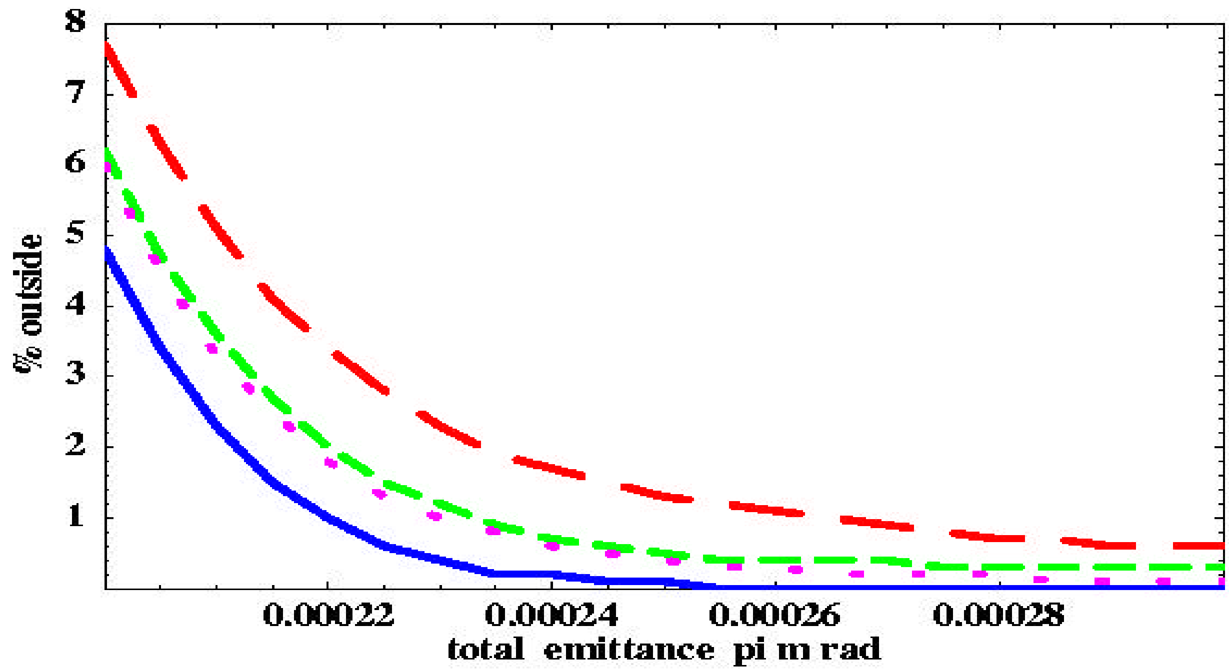


Blue – no SC, nat. chromaticity (-7)

Green – SC, zero chromaticity

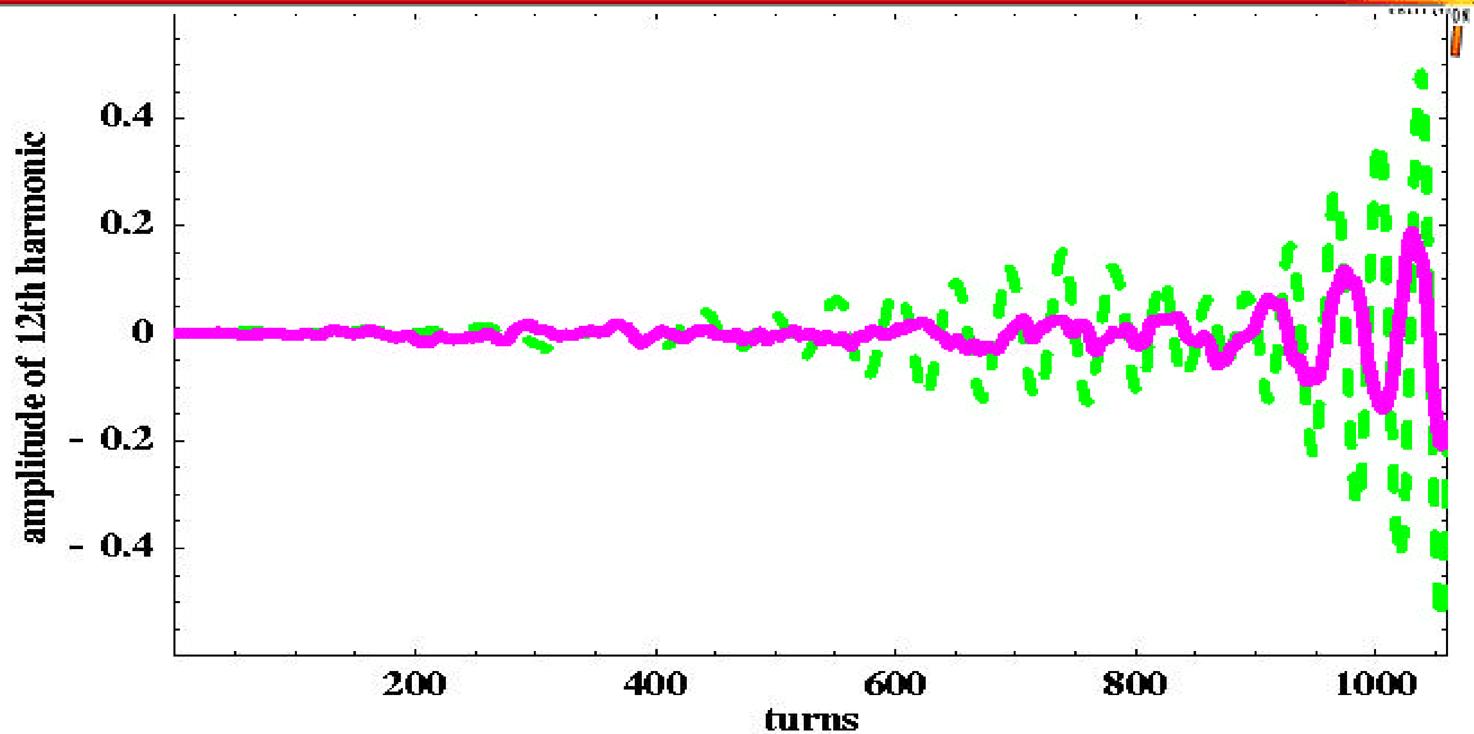
Pink – SC, nat. chromaticity

Resulting beam halo for N=2.0*10^14 - effect of b/a on instability (May 2002)



Blue – no SC, nat. chromaticity (-7), b=11cm
Green – SC, zero chromaticity, b=11cm
Pink – SC, nat. chromaticity, b=11cm
Red - SC, zero chromaticity, b=20 cm

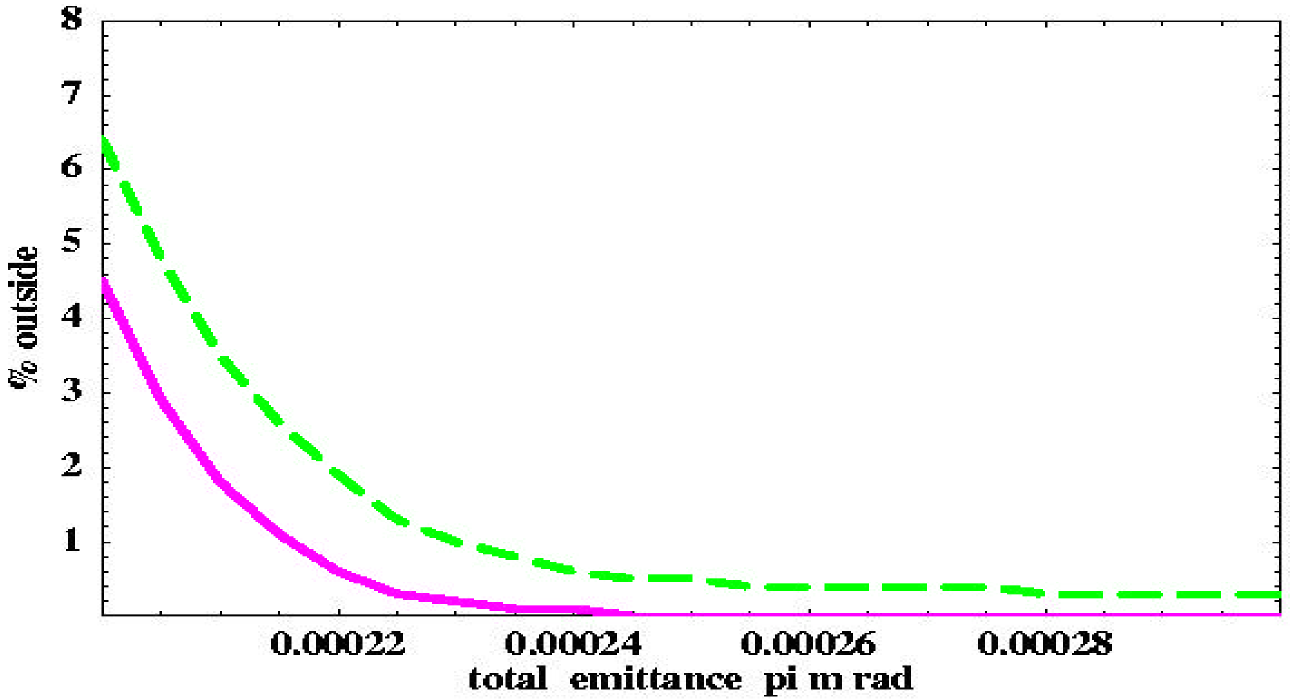
N=1.5 *10^14 at the end of accumulation –base line intensity - unstable harmonics (May 2002)



Green – SC, zero chromaticity - unstable

Pink - SC, nat. chromaticity (-7) – "stable"

Resulting beam halo for N=1.5*10^14 (May 2002)



Green – SC, zero chromaticity – unstable

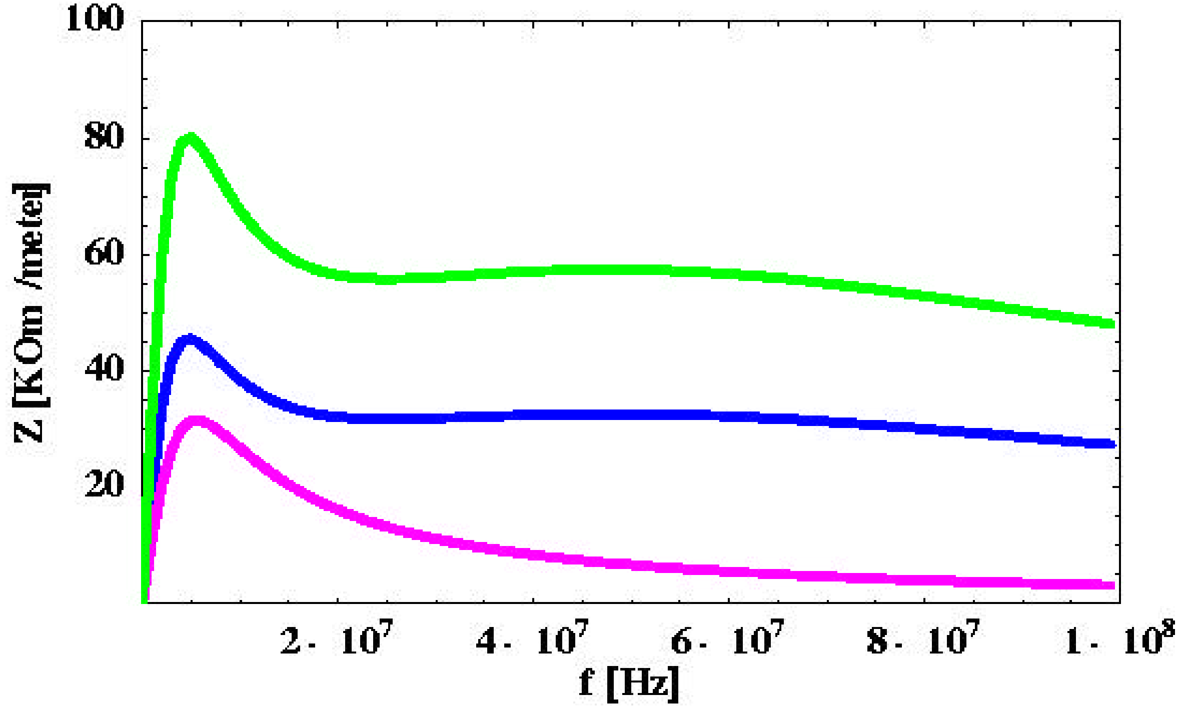
Pink - SC, nat. chromaticity (-7)- stable during accumulation

Intensity limitation (May 2002)

- **N=2.0*10^14 – Unstable, using natural chromaticity is not enough, additional damping with non-linear spread due to octupoles but most likely unsufficient for this intensity. Needs feedback system or minimization of impedance.**
- **N=1.5*10^14 – Unstable with zero chromaticity. Marginally stable with natural chromaticity. Additional small damping with octupoles can help. Feedback system is not required (when working with nat. chromaticity) but it is recommended.**
- **N=1.0*10^14 – Stable with natural chromaticity. With zero chromaticity no significant halo is observed by the end of accumulation.**

Since May'02 the EK impedance was significantly reduced (Davino et al.) which improved intensity limitation.

Updated extraction kicker impedance - July’02

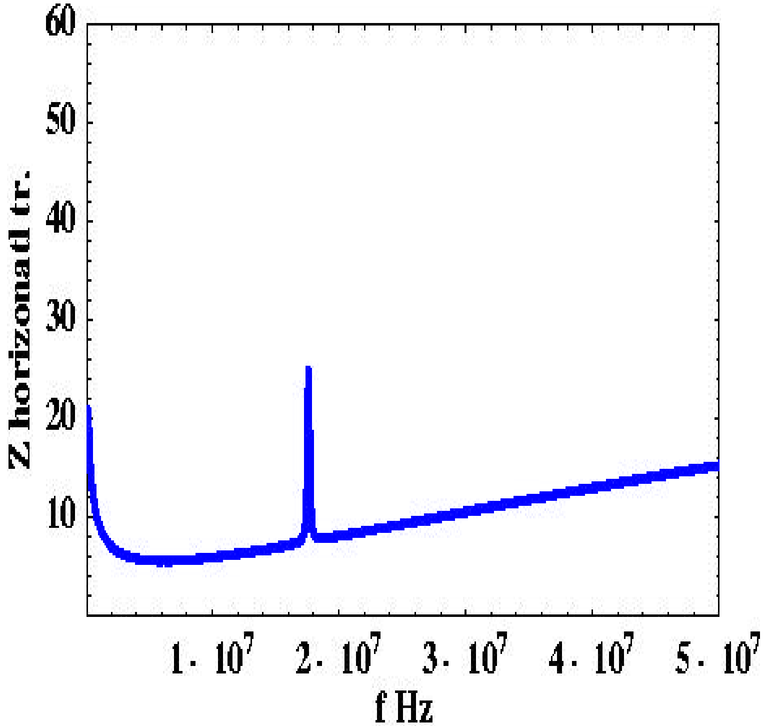


Green – EK impedance – May’02

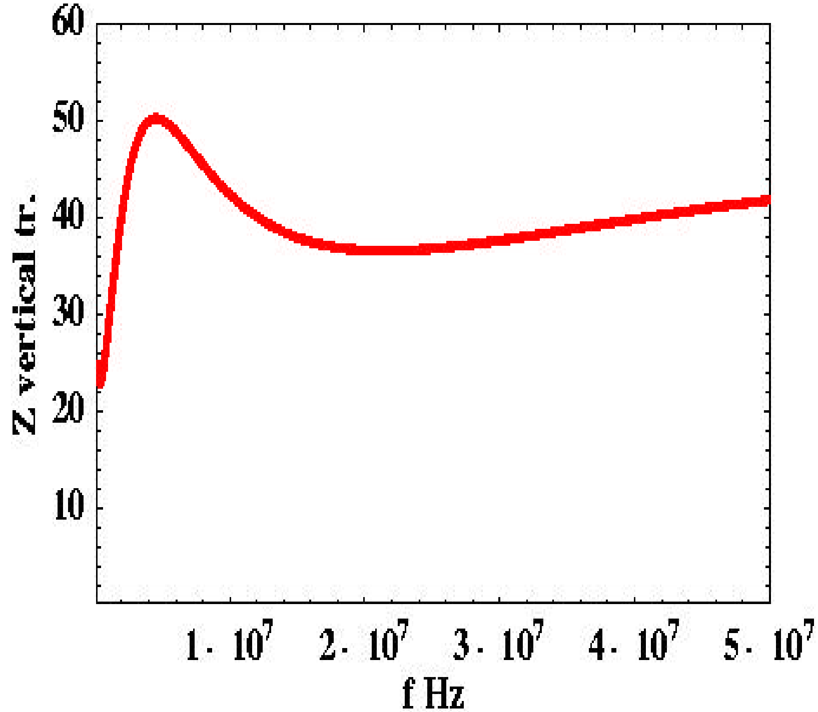
Blue – reduced EK impedance, 2-resonator model

Pink – reduced EK impedance, 1-resonator approximation

Contribution to Re(Z_transverse): Resistive wall, Ext.Kick. & BPM's {K Om/meter}



Horizontal (RW, RF & BPM)



Vertical (RW, EK & BPM)

Measurements of RF impedance (D.Davino et al.) are preliminary and will be repeated shortly

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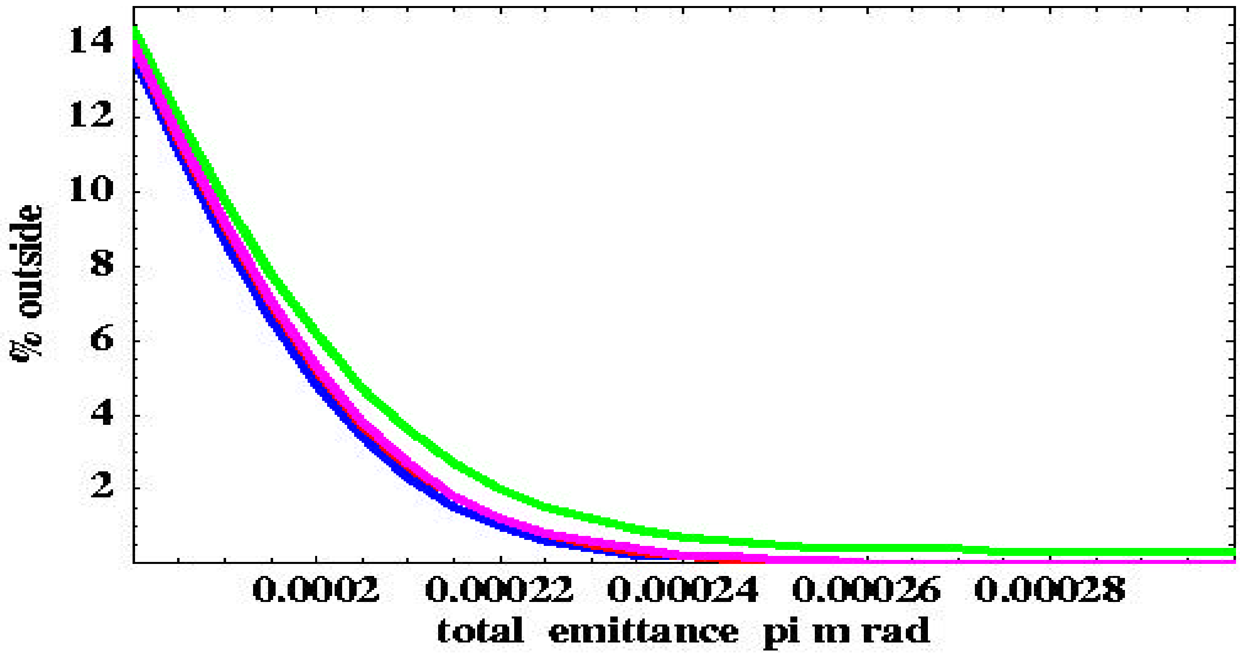
Beam halo at the end of accumulation (2*10^14) due to RF and EK impedances

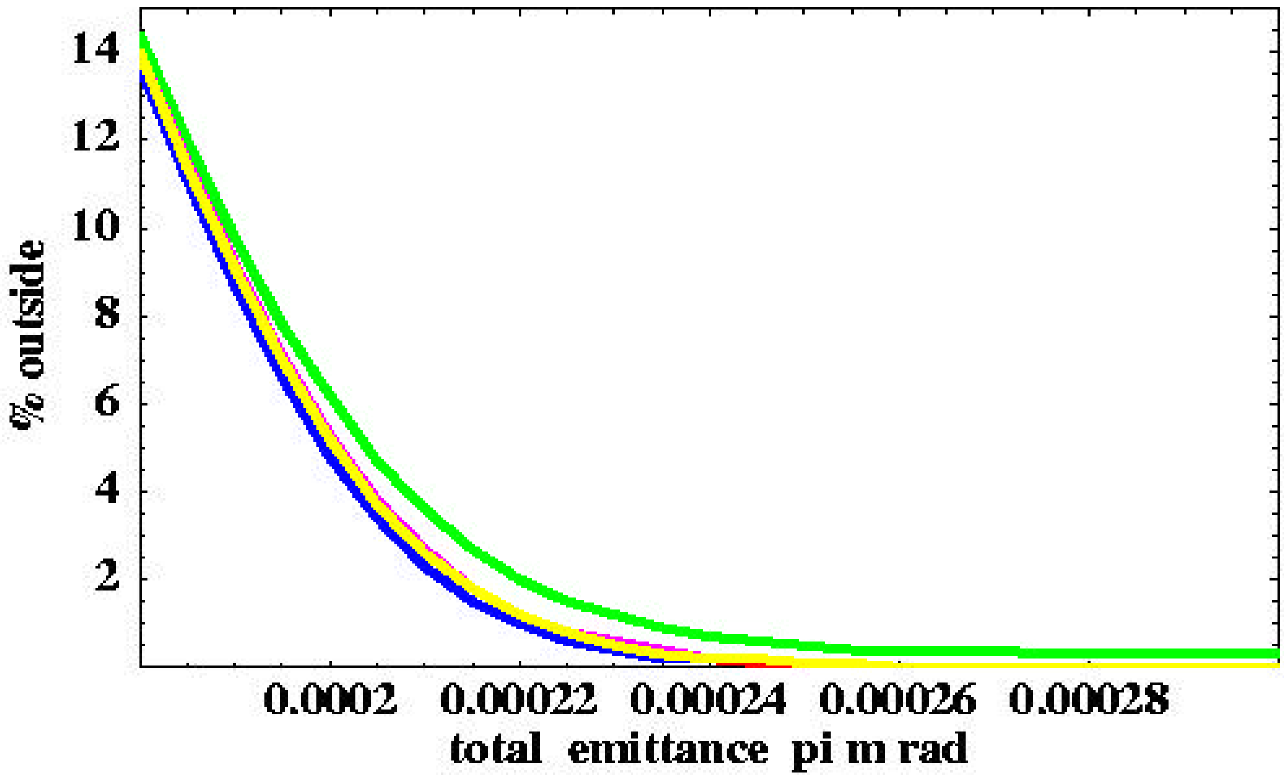


Blue – no impedance – stable

Pink – RF impedance – stable

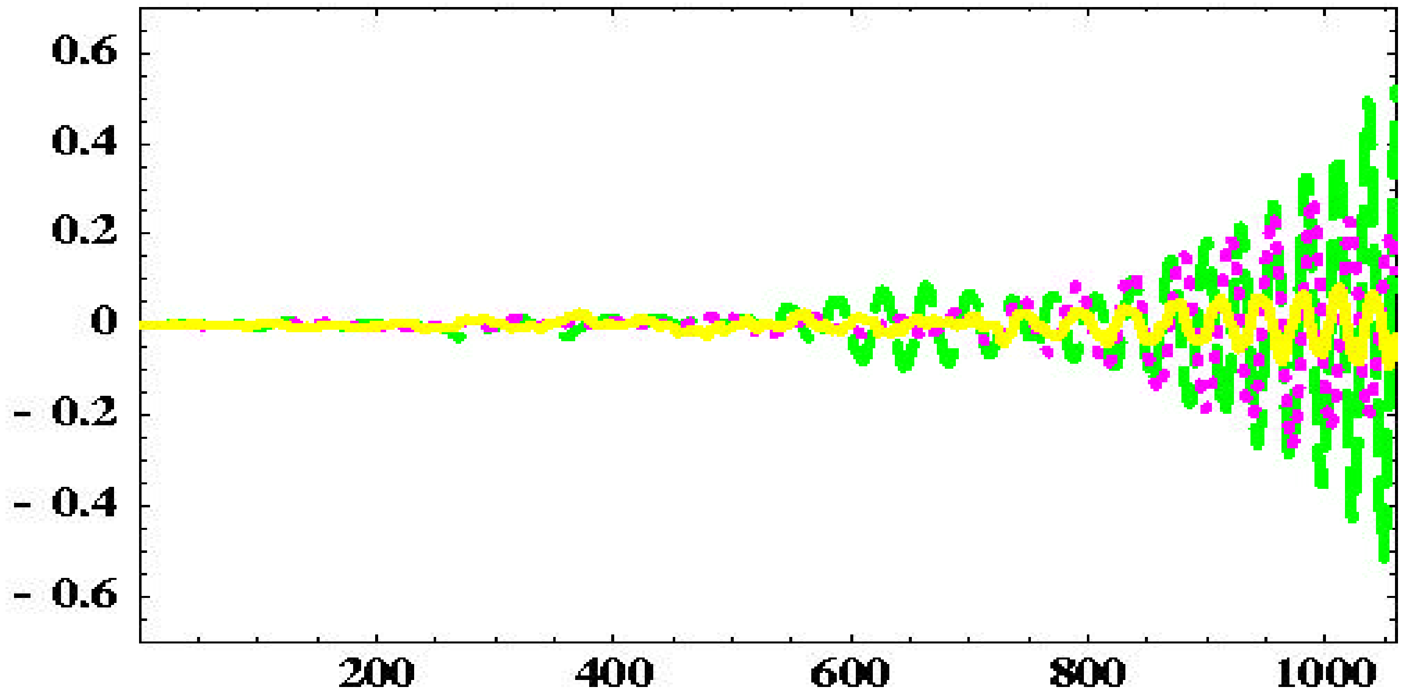
Green – EK impedance (old) - unstable

Reduced EK impedance (2*10^14)



Yellow- reduced EK & RF impedances - stable

N=2*10^14 with reduced impedance of EK –unstable harmonics



2*10^14 beam is now stable with new reduced impedance

Thresholds and intensity limitation

- **With new reduced EK impedance the instability threshold was moved above intensity 2*10^14 (with natural chromaticity).**

- **Beams with both base-line intensity (1.5*10^14) and upgrade-intensity (2*10^14) are stable. Chromaticity control and nonlinear correctors may be used to introduce additional sufficient Landau damping if it be necessary.**