SNS Ring/RTBT Fault Study Progress

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Ring Fault Study

- **A study is being conducted to determine the impact of potential errors and faults in the ring and RTBT on losses and on the beam-on-target distribution:**
  - **“Normal” losses - alignment and magnet errors, fringe fields, space charge and impedances.**
  - **“Failures” - injection, extraction, or beam-in-gap kicker failures.**
- **The strategy is to conduct numerical studies using the codes MAD, ORBIT, UAL, TRANSPORT, PARMILA as appropriate.**
  - **These codes have complementary capabilities and domains.**
  - **This presentation contains initial ring studies using MAD and ORBIT.**

Ring Fault Study - MAD and ORBIT

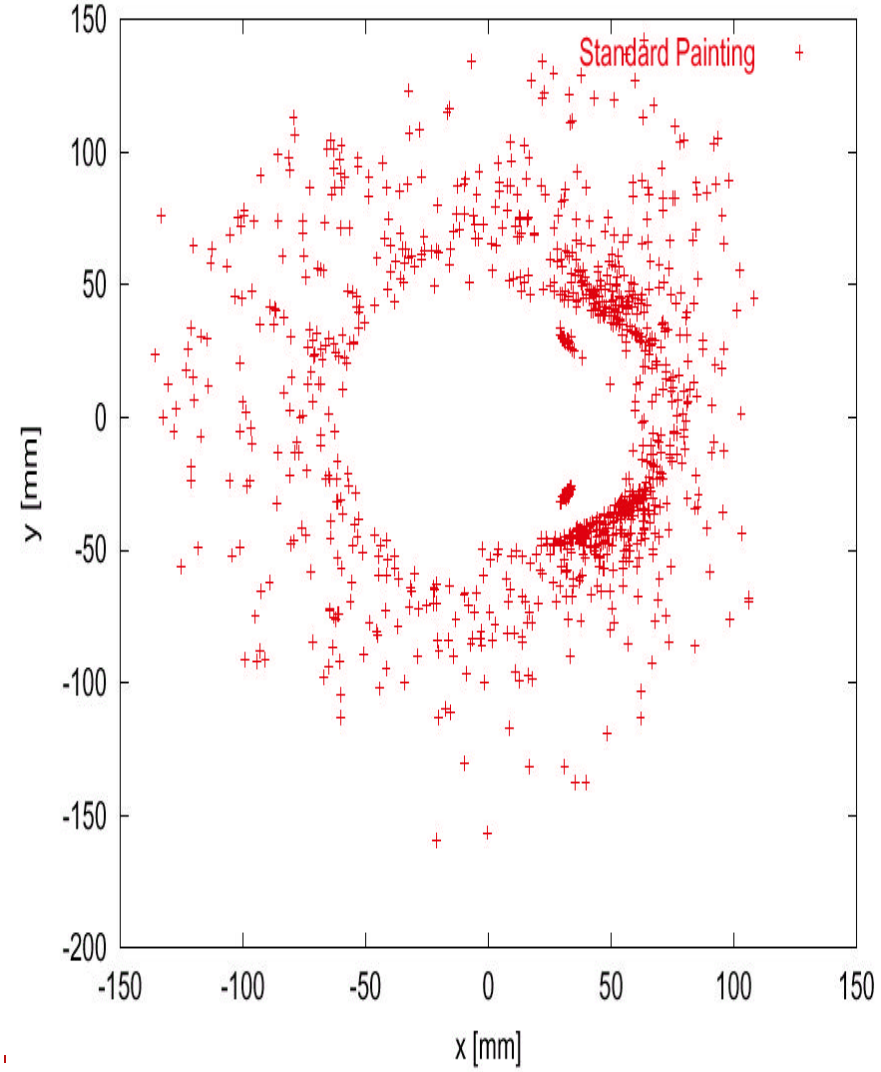
- **ORBIT calculations:**
  - Inject 1000 particles/turn (105200 particles at completion).
  - Do the full injection cycle with a "standard" correlated painting scheme and operating point (Q_x = 6.23, Q_y = 6.20).
  - Include all ring apertures and collimators as perfect absorbers, with the exception of the scrapers which, as the limiting apertures, are treated using the full collimation model.
  - Include space charge (assuming $2.0*10^{14}$ protons) and linear magnetic focusing fields.
  - So far, ignore higher order (nonlinear) magnet fields and impedance effects.

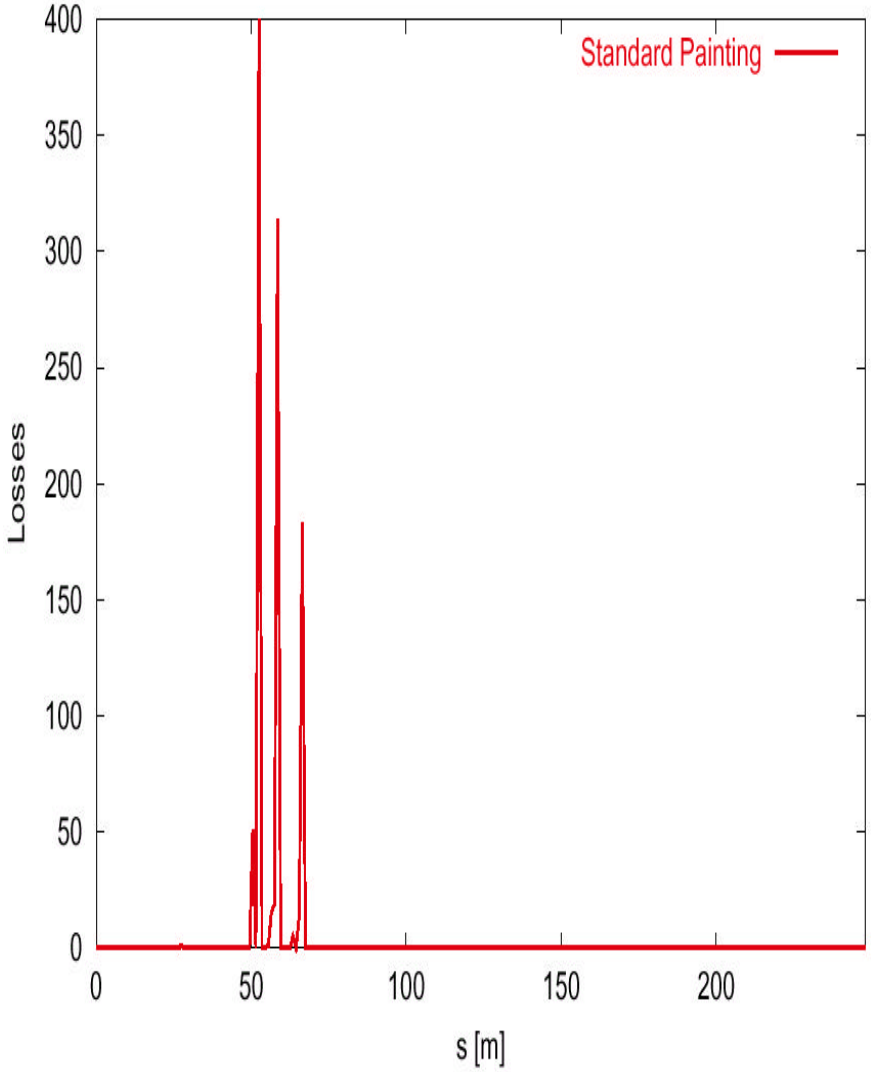
- **Base assumptions:**
  - To achieve good efficiency in collimation studies, scrapers are placed at 200-pi mm/mr.
  - To avoid large tune depression, "standard" scheme paints broad beam, resulting in ~1% of beam outside 200-pi mm/mr.

Ring Fault Study - MAD and ORBIT Results to Date

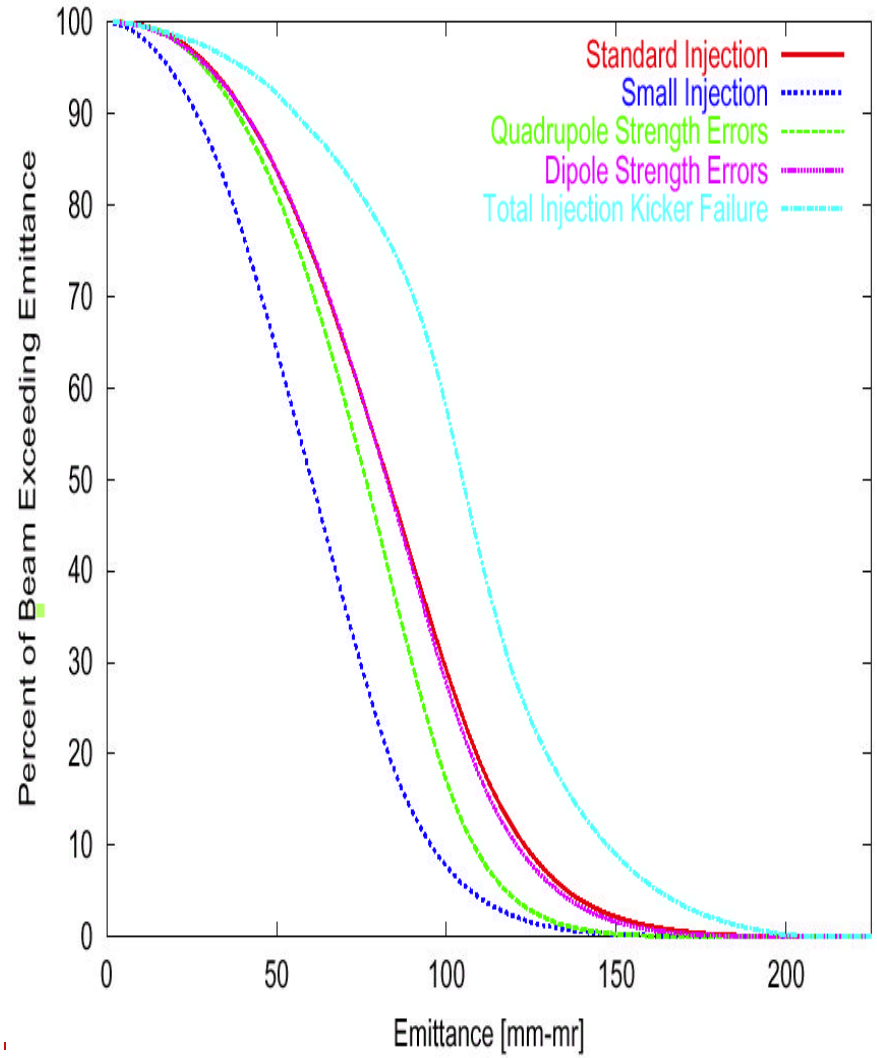
- **Base Case:**
  - About 1% beam loss (1003 particles), all but 1 particle to ring collimators.
- **Quadrupole Strength Errors (unrealistically severe assumptions):**
  - Absolute integrated error 0.002 m^{-1} with Gaussian distribution applied to all quads. Yields >20% beta-beating.
  - Less than 2% beam loss (1803 particles), all but 6 particles to collimators.
- **Dipole Strength Errors:**
  - Absolute integrated error 0.00002 with Gaussian distribution applied to all dipoles. Yields maximum 0.8 mm closed orbit deviation.
  - About 1% beam loss (988 particles), all but 3 particles to ring collimators.
- **Total Injection Kicker Failure (no injection bump):**
  - Inject "smoke rings" in each transverse phase plane.
  - Nearly 70% beam loss (69071 particles), all but 116 particles to collimators.
- **Inject Smaller Beam (4 mm bump adjustment in both planes):**
  - No beam loss, but "early" space charge broadening in vertical plane.

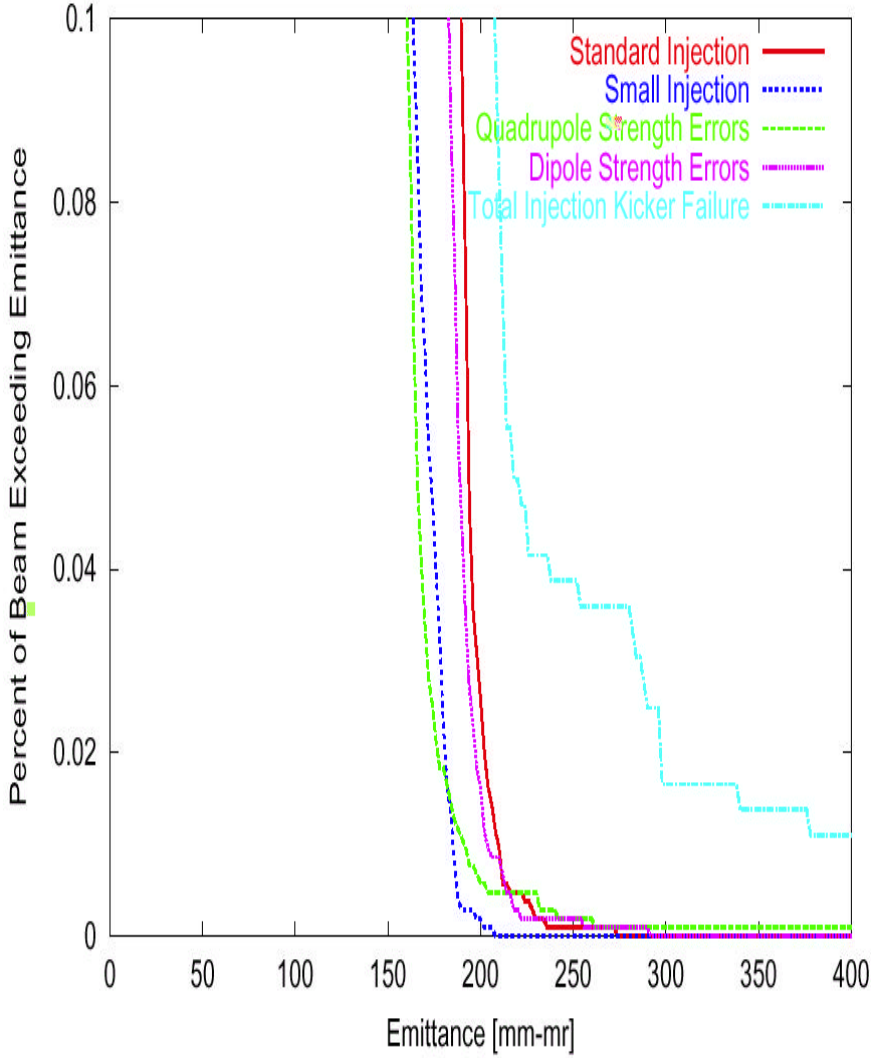
Ring Loss Distributions for Standard Painting



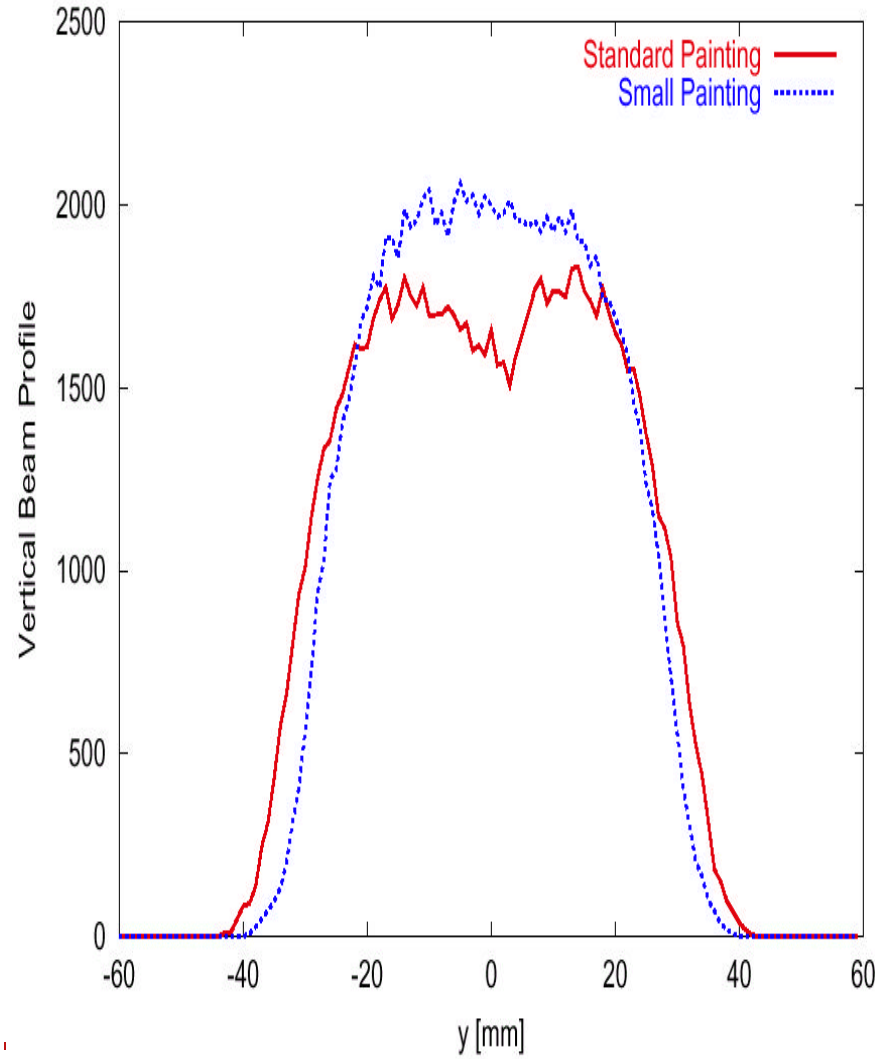


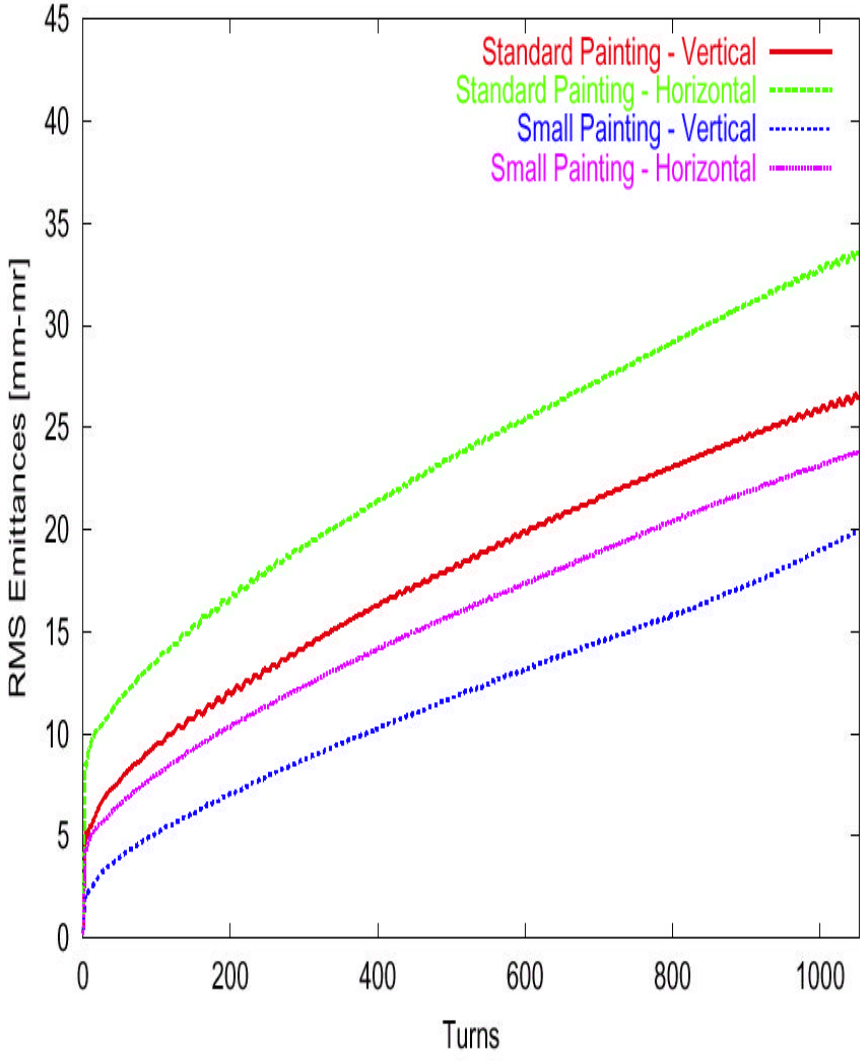
Emittance Profiles of Surviving Particles Following Injection



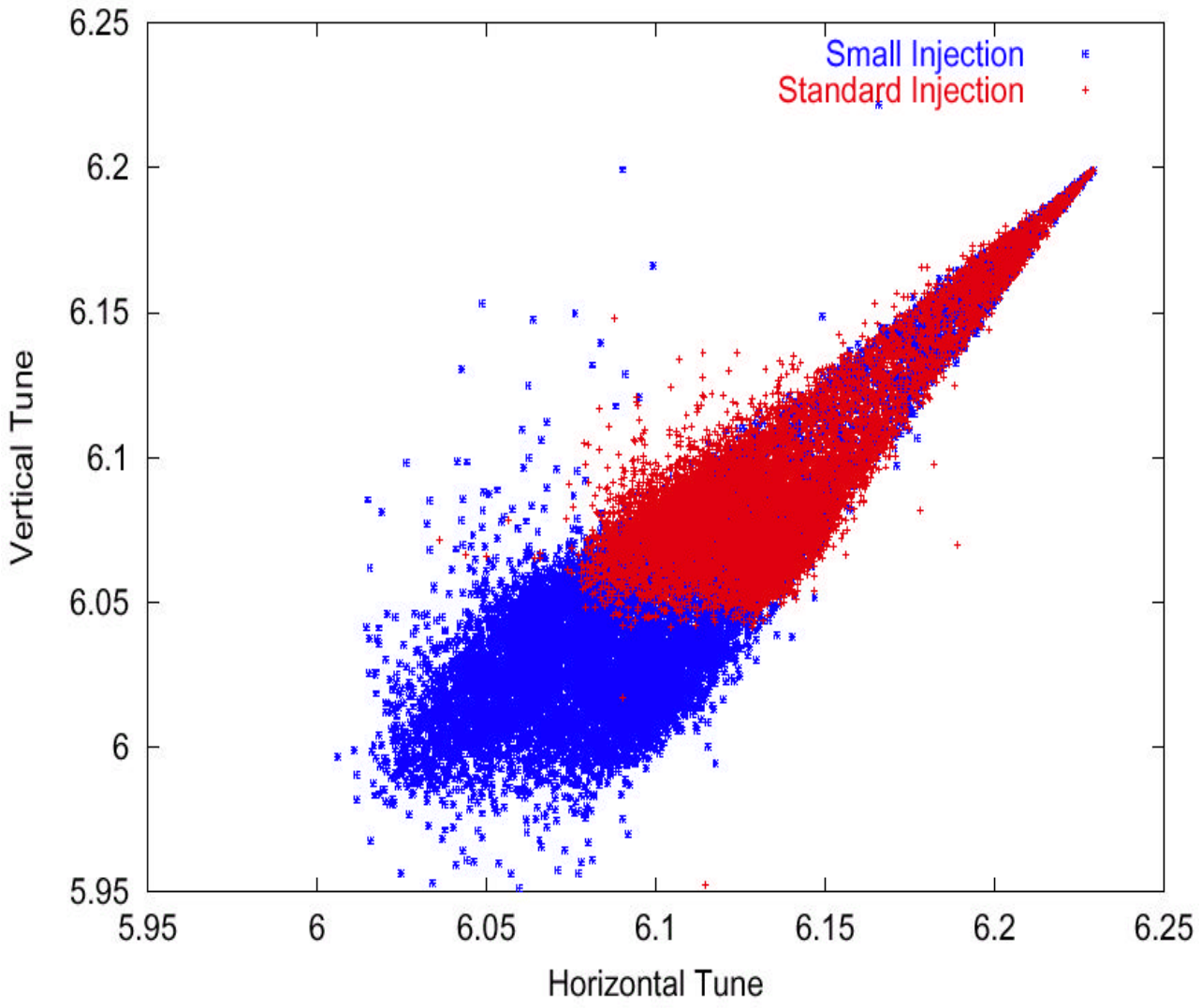


Small Injection Profile is Narrower, but Onset of Coherent Space Charge Occurs





Onset of Coherent Space Charge Resonance



Conclusions

- A study to determine the impact of potential errors and faults in the ring and RTBT on losses and on the beam-on-target distribution has been initiated.
- The recommended scraper and painting settings lead to 1% beam loss to collimators during painting.
- Likely dipole and quadrupole strength errors do not affect losses during painting significantly.
- Simultaneous failure of all injection kickers would lead to catastrophic losses.
- Injecting a smaller beam appears reduces losses under the assumptions used here, although the coherent space charge resonance is a potential problem.
- Much work remains to be done: various dynamic failures, impedance effects, higher order effects.