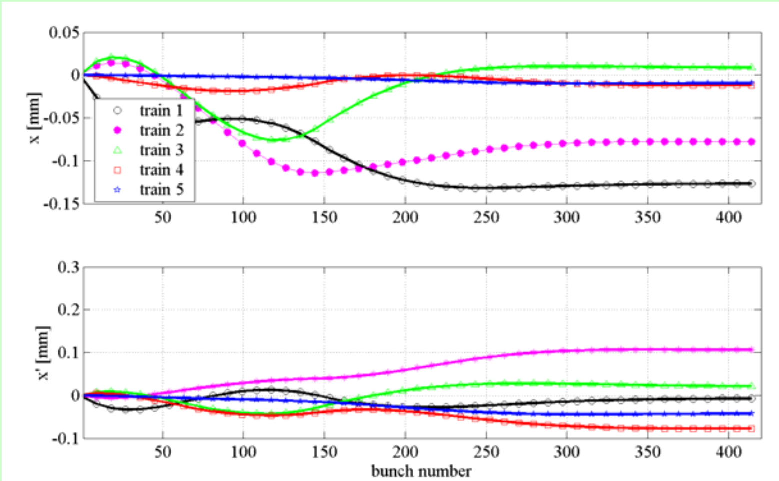
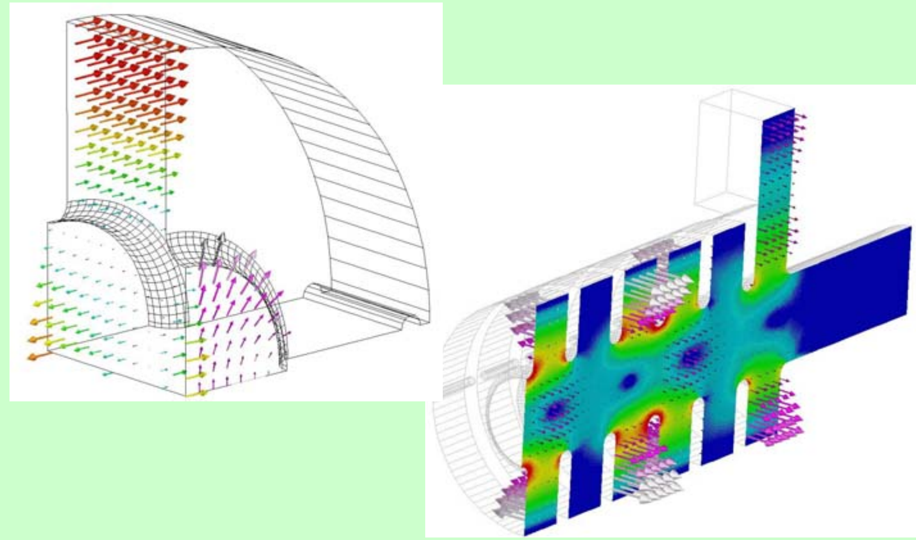
THE 3 GHz RF DEFLECTORS

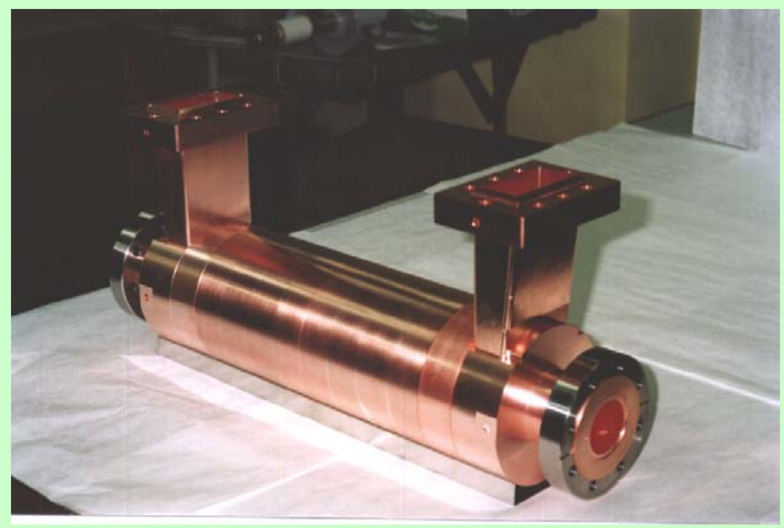
(D. Alesini)

- BEAM DYNAMICS STUDY: BEAM LOADING IN THE RF DEFLECTORS

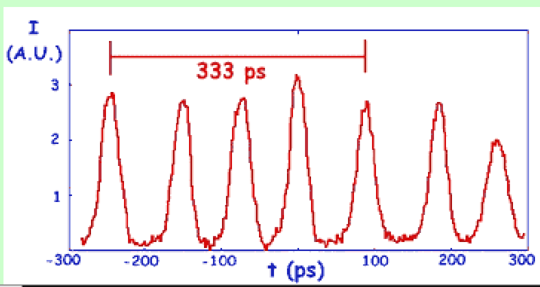


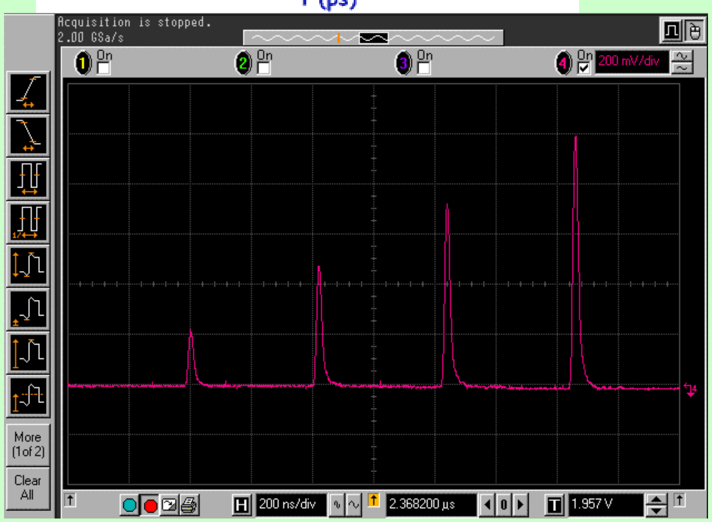
- RF DEFLECTORS DESIGN





Recomb. in the CTF3 Prelim. phase





EFFECT OF THE BEAM LOADING IN DL RF DEFLECTOR(S)

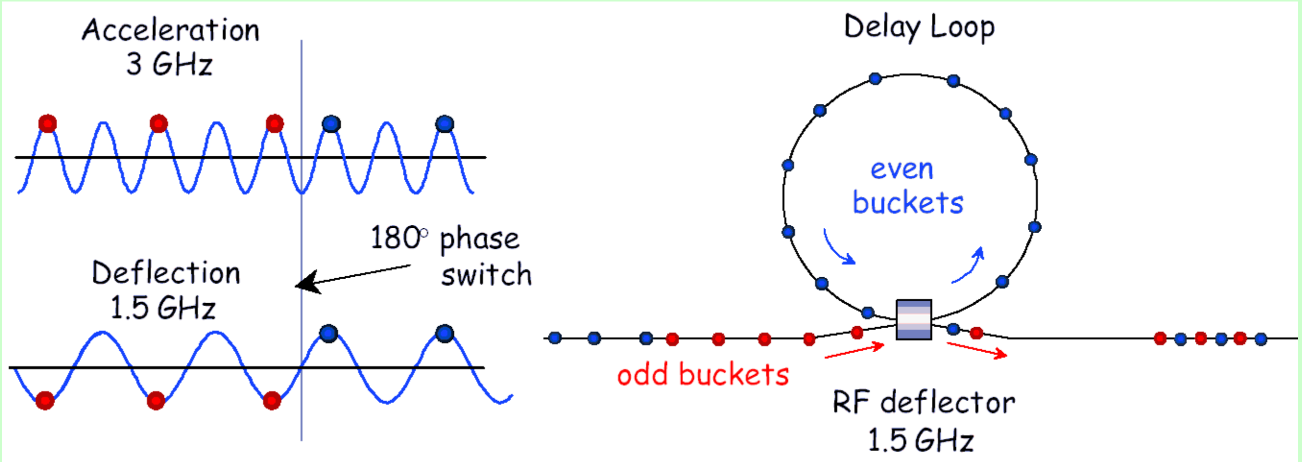
(D. Alesini)

Summary

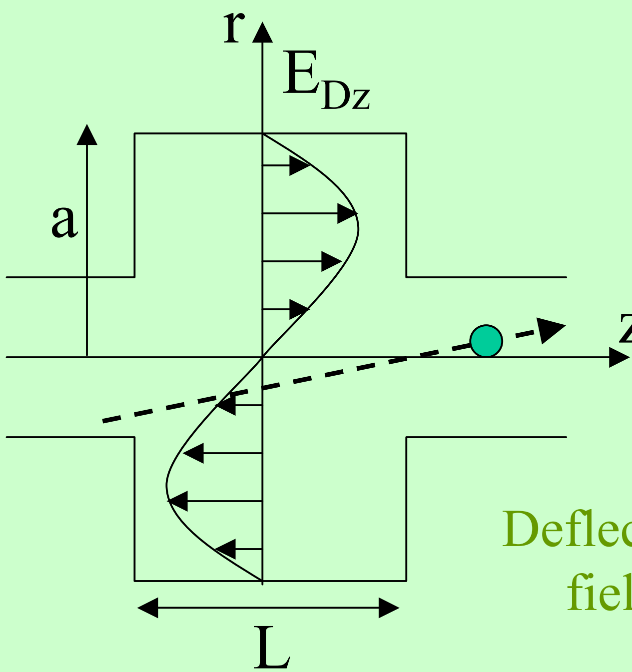
- **Analitycal approach**
- **Tracking code scheme**
- **First tracking code results:**

  -Dynamics with and without beam loading
  -Compare between 1 and 2 Deflectors
  -Effect of different DL phase advances
  -Effect of injection error in position

1) Analitycal approach



90° out-of-phase



$$\underline{E}_D \begin{cases} E_{Dz} = E_0 J_1\left(\frac{p_{11} r}{a}\right)\cos(\vartheta) e^{j\omega t} \\ E_{Dr} = 0 \\ E_{D\vartheta} = 0 \end{cases}$$

$$\underline{B}_D \begin{cases} B_{Dz} = 0 \\ B_{Dr} = -j\omega \frac{a^2}{p_{11}^2 c^2 r} E_0 J_1\left(\frac{p_{11} r}{a}\right)\sin(\vartheta) e^{j\omega t} \\ B_{D\vartheta} = -j\omega \frac{a}{p_{11} c^2} E_0 J_1'\left(\frac{p_{11} r}{a}\right)\cos(\vartheta) e^{j\omega t} \end{cases}$$

Deflecting field

Field excited by charge

$$\underline{E}_{exc}(\omega) = -\frac{1}{1+jQ\left(\frac{\omega_r}{\omega}-\frac{\omega}{\omega_r}\right)}\frac{\underline{E}_D\int_{cavity}\underline{J}\cdot\underline{E}_D^{*}dV}{2P_D}$$

Excited field in the cavity

For a <u>leading charge q_L</u> that passes in the center of the cavity (z=0) at the time t=0

$$\underline{J}(\omega) = q_L\delta(x')\delta(y')e^{-j\frac{\omega}{c}z}\underline{s}_0(z)$$

$$\underline{E}_{exc}(\omega) = -\frac{1}{1+jQ\delta_{cav}}\frac{\underline{E}_D\int_{cavity}q_L e^{-j\frac{\omega}{c}z_1}E_z^{*}\left(r_{q_L}(z_1)\right)dz_1}{2P_D}$$

$$V_{exc\,z}(\omega) = \int_{cavity}E_{exc\,z}e^{j\frac{\omega}{c}z}dz$$

Panofsky-Wenzel theorem $V_{exc\,r} = -\frac{c}{j\omega}\frac{dV_{exc\,z}}{dr}$

$$V_{exc\,r}(\omega) = q_L\frac{c}{j\omega}\cdot\frac{1}{1+jQ\delta_{cav}}\frac{d}{dr}\int_{cavity}E_{Dz}e^{j\frac{\omega}{c}z}dz\frac{\int_{cavity}E_{Dz}^{*}\left(r_{q_L}(z_1)\right)e^{-j\frac{\omega}{c}z_1}dz_1}{2P_D}$$

- ***r<<a*** $E_{Dz} \cong \left.\frac{dE_{Dz}}{dr}\right|_0 r \underbrace{=}_{\text{perfect pillbox}} E_0 \frac{p_{11}}{2a} r$

- ***If the leading particle is not affected by wake field effects, its trajectory is given by:***

$$r_{q_L} \cong a_1 z^2 + a_2 z + a_3$$

$$V_{exc\,r}(\omega) \cong \underbrace{q_L \frac{c}{j\omega} \cdot \frac{1}{1 + jQ\delta_{cav}} \int_{cavity} \left.\frac{dE_{Dz}}{dr}\right|_0 e^{j\frac{\omega}{c}z} dz}_{K} \frac{\int_{cavity} \left.\frac{dE_{Dz}}{dr}\right|_0 \left(a_1 z_1^2 + a_2 z_1 + a_3\right) e^{-j\frac{\omega}{c}z_1} dz_1}{2P_D}$$

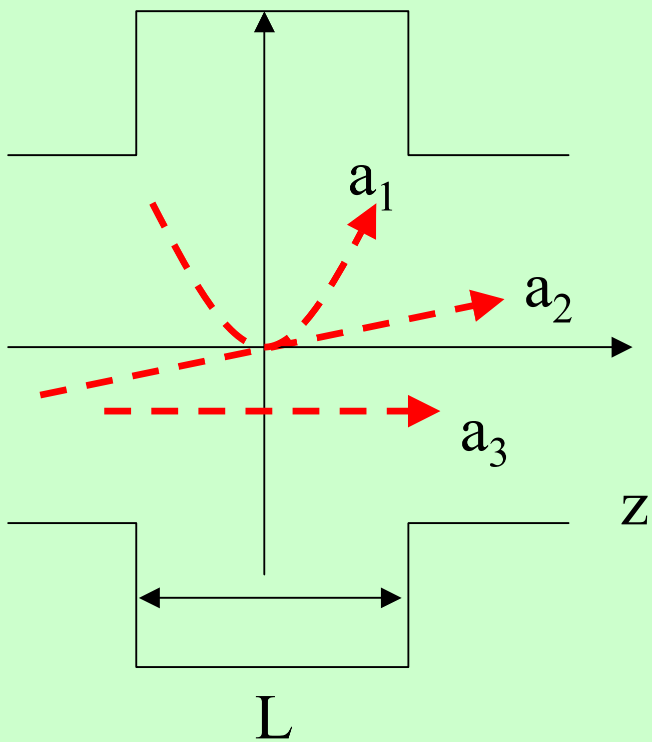
$$V_{1r} = K a_1 R_1 \qquad R_1 = \frac{\int_{cavity} \left.\frac{dE_{Dz}}{dr}\right|_0 z_1^2 e^{-j\frac{\omega}{c}z_1} dz_1}{2P_D}$$

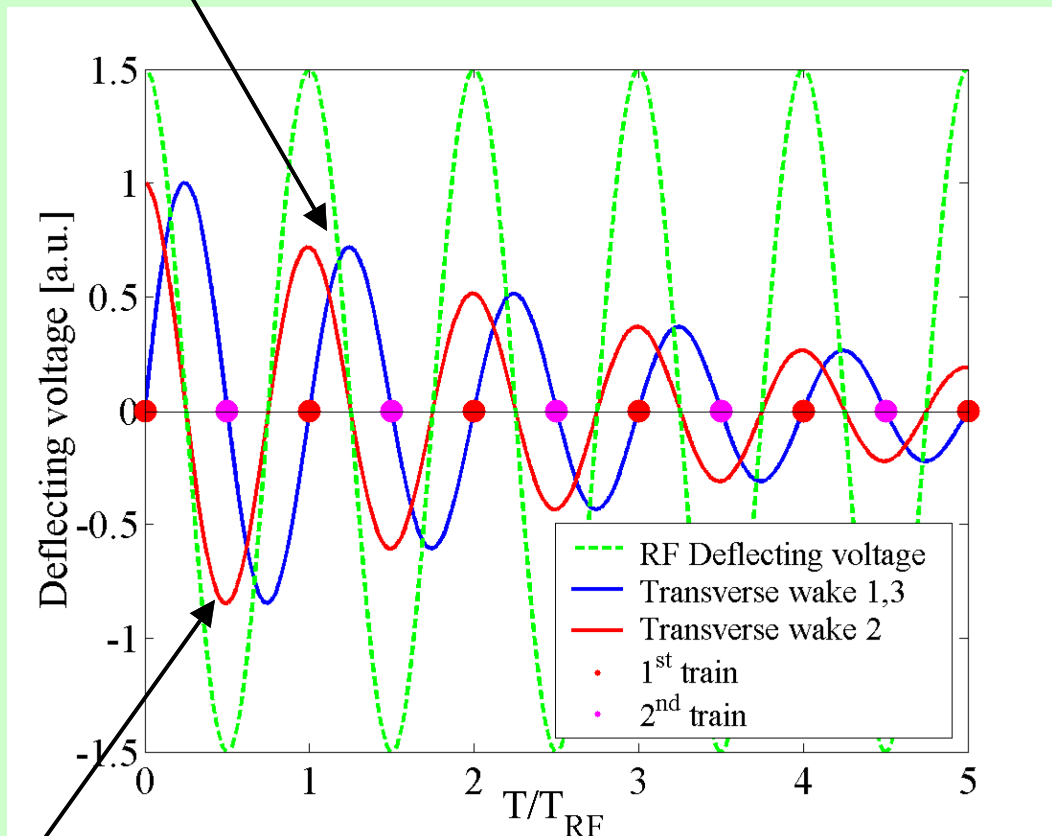
$$V_{2r} = K a_2 j R_2 \qquad R_2 = \frac{\int_{cavity} \left.\frac{dE_{Dz}}{dr}\right|_0 z_1 e^{-j\frac{\omega}{c}z_1} dz_1}{2P_D}$$

$$V_{3r} = K a_3 R_3 \qquad R_3 = \frac{\int_{cavity} \left.\frac{dE_{Dz}}{dr}\right|_0 e^{-j\frac{\omega}{c}z_1} dz_1}{2P_D}$$

$\boldsymbol{a_i R_i}$ are of the same order of magnitude

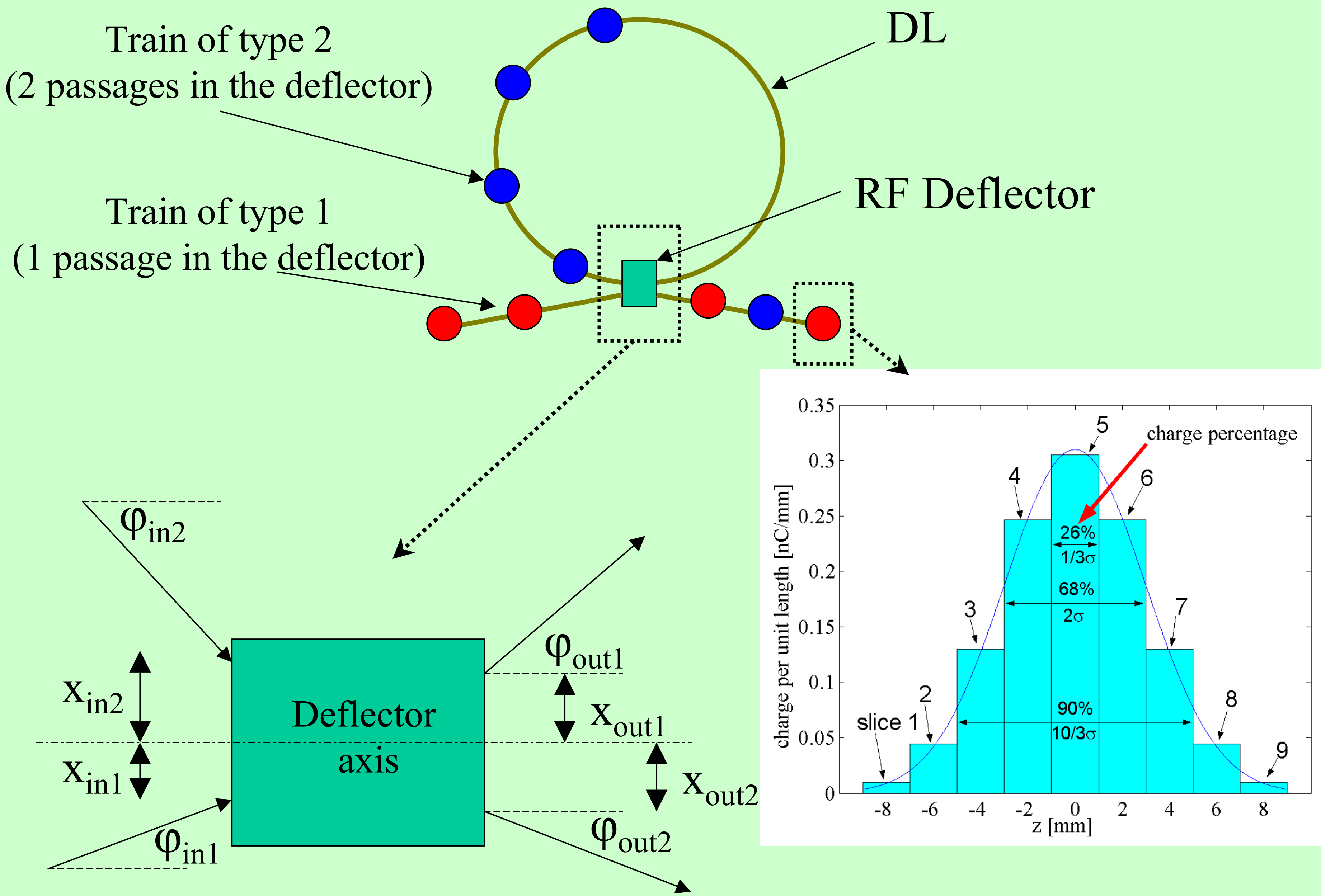
$$V_{1r,3r}(t)=\frac{q_L c a_{1,3} R_{1,3}}{Q\sqrt{1-1/4Q^2}}\,e^{-\frac{\omega_r}{2Q}t}\,\sin\left(\omega_r\sqrt{1-1/4Q^2}\,t\right)$$





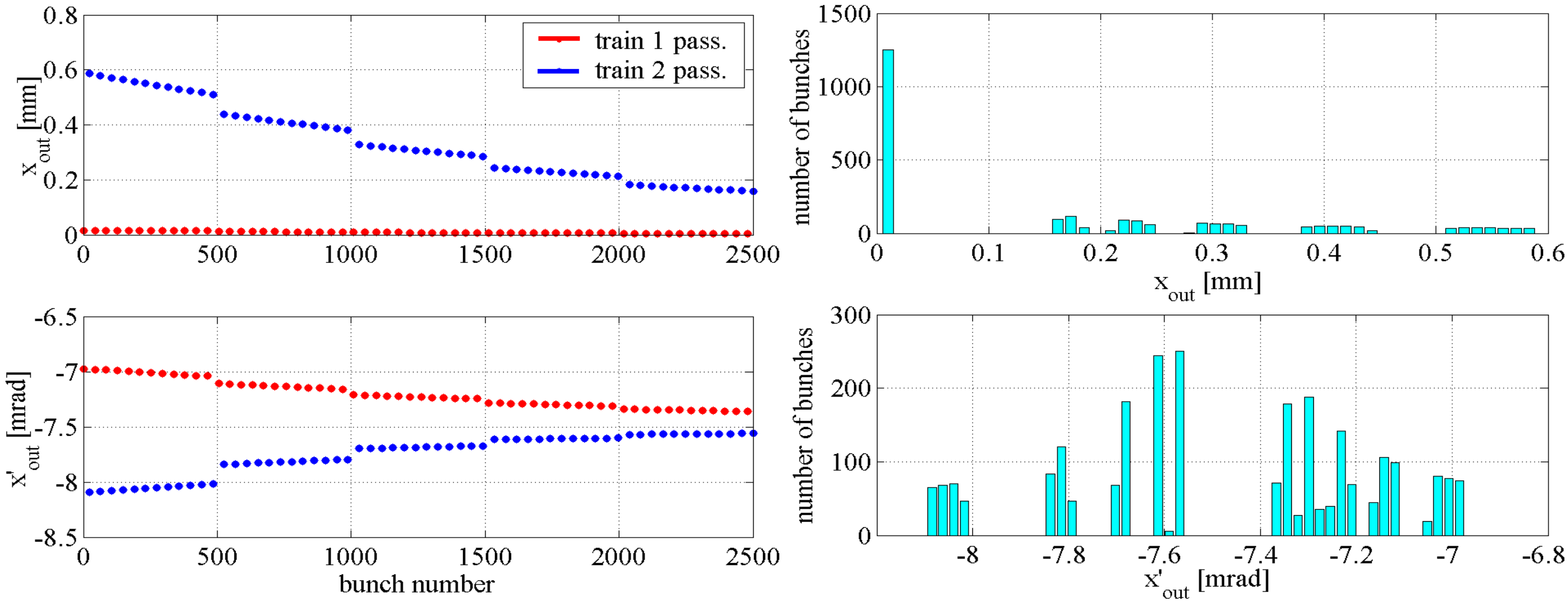
$$V_{2r}(t)=\frac{q_L c a_2 R_2}{Q\sqrt{1-1/4Q^2}}\,e^{-\frac{\omega_r}{2Q}t}\,\cos\left[\omega_r\sqrt{1-1/4Q^2}\,t\right]$$

2) Tracking code scheme

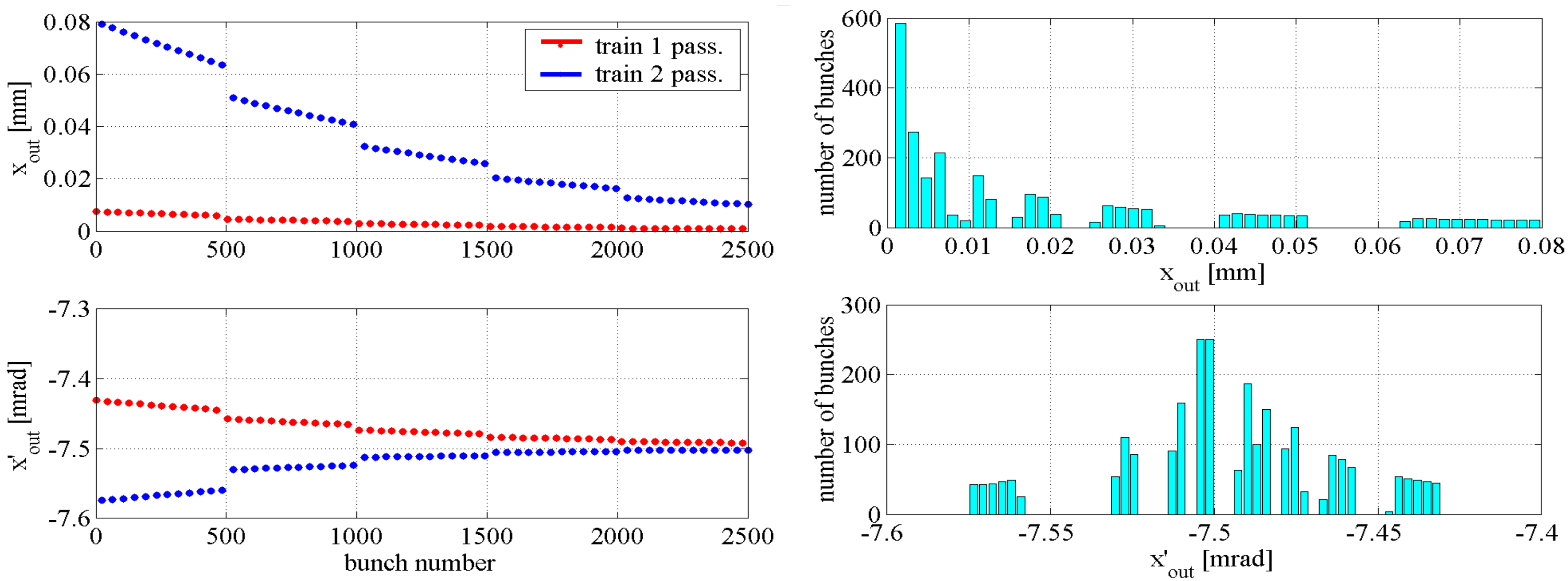


-*No beam loading* -*Perfect injection* -*Nominal DL phase advance*

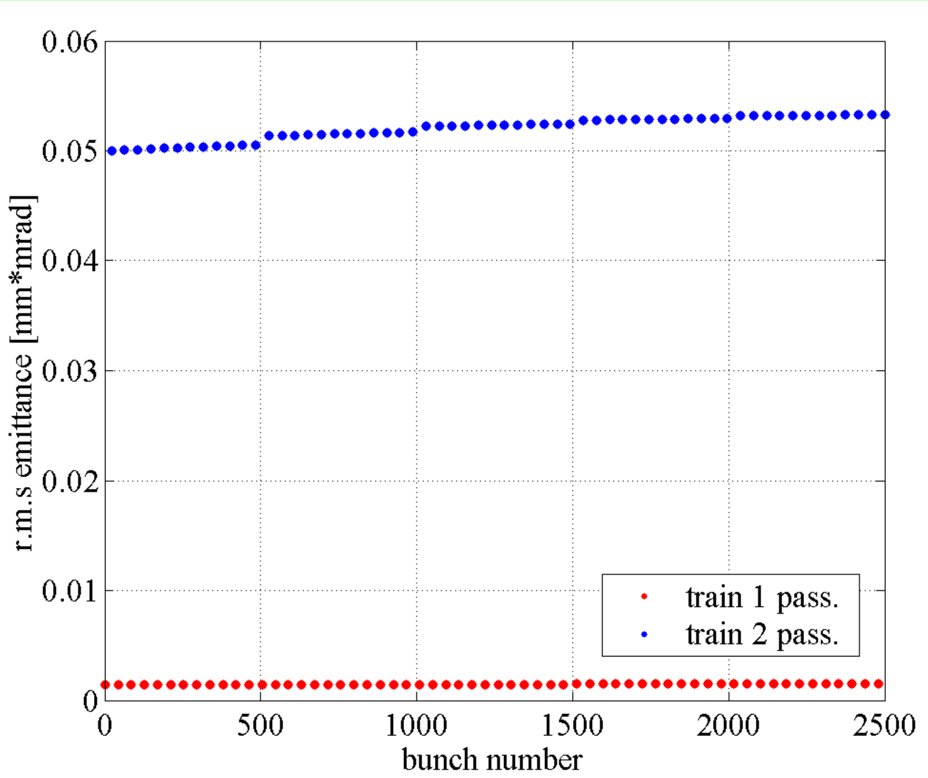
1 RF Deflector



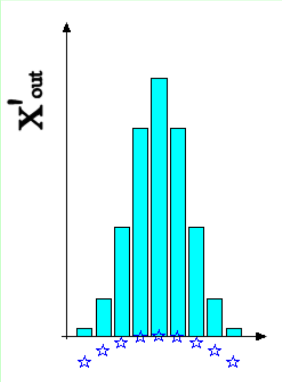
2 RF Deflectors



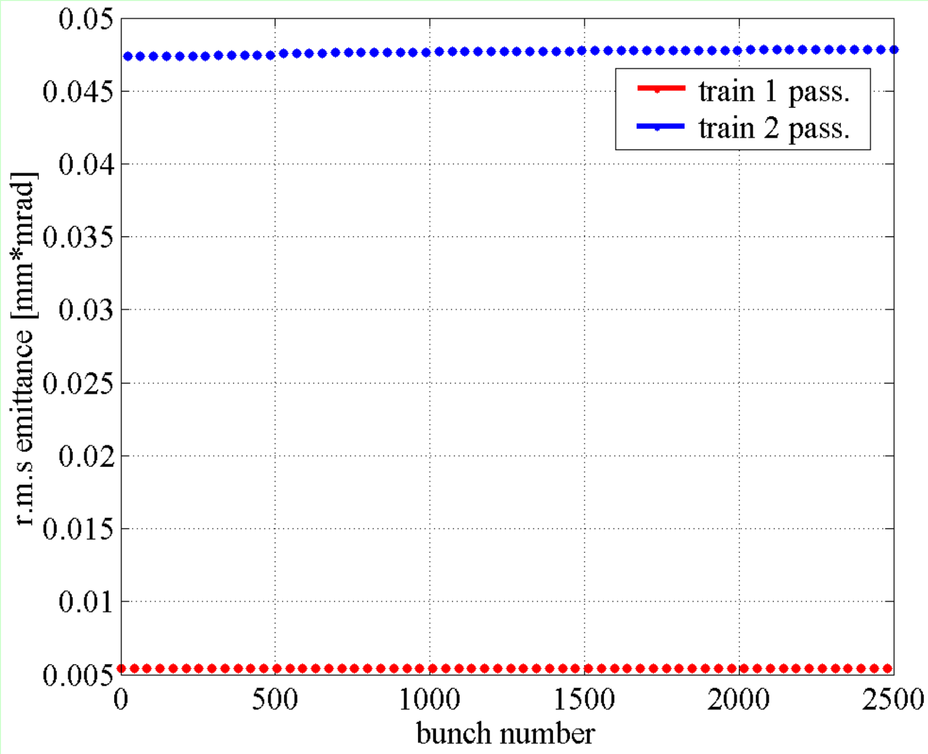
1 RF Deflector



Effect of the finite RF curvature

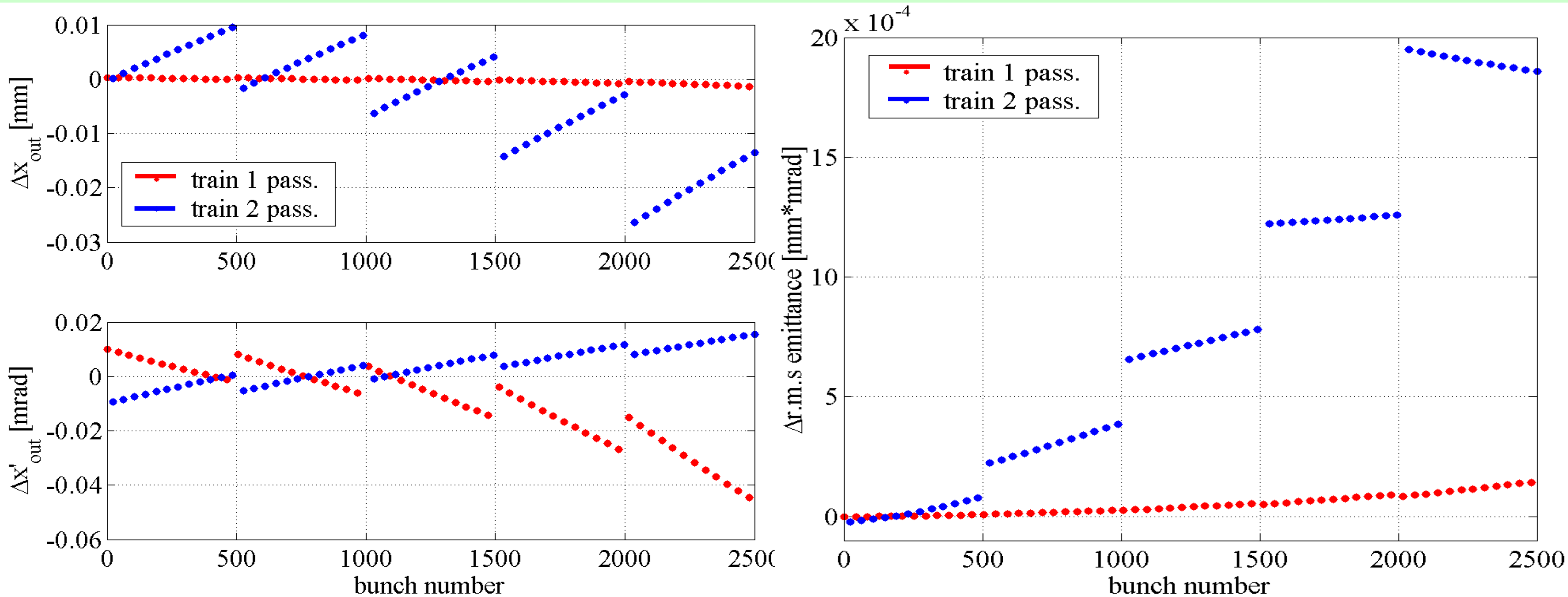


2 RF Deflectors

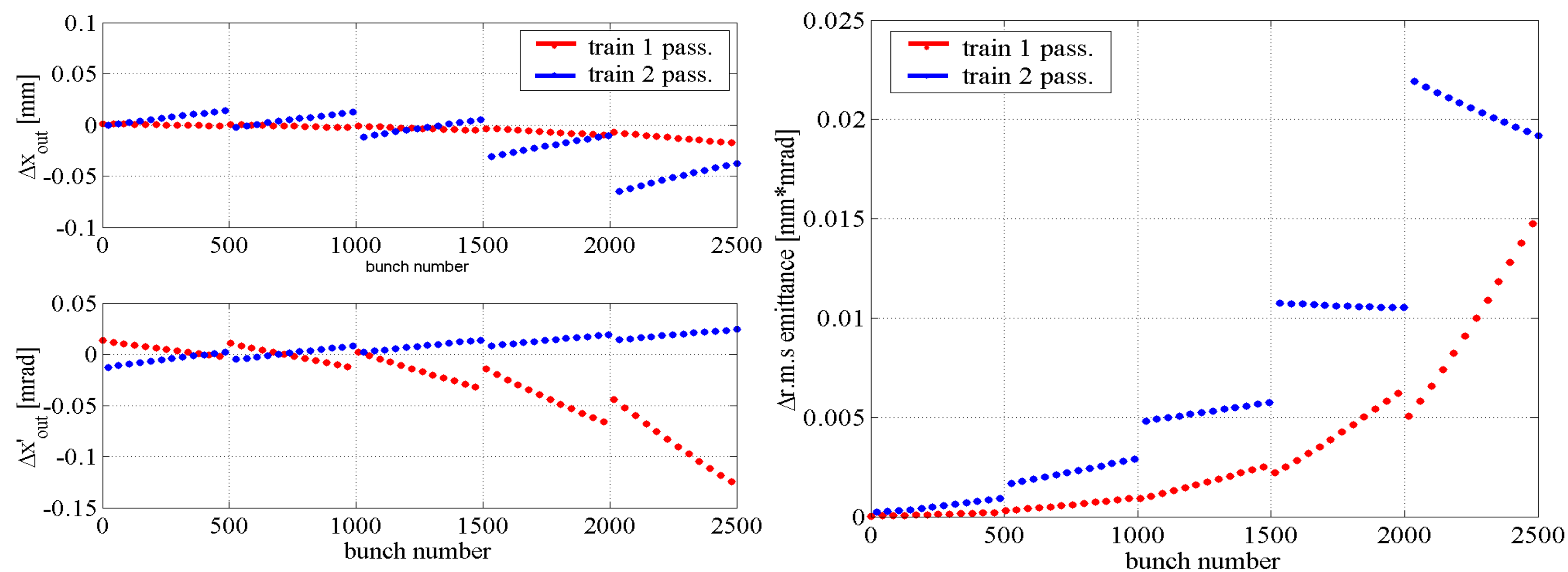


-*With beam loading* -*Perfect injection* -*Nominal DL phase advance*

1 RF Deflector

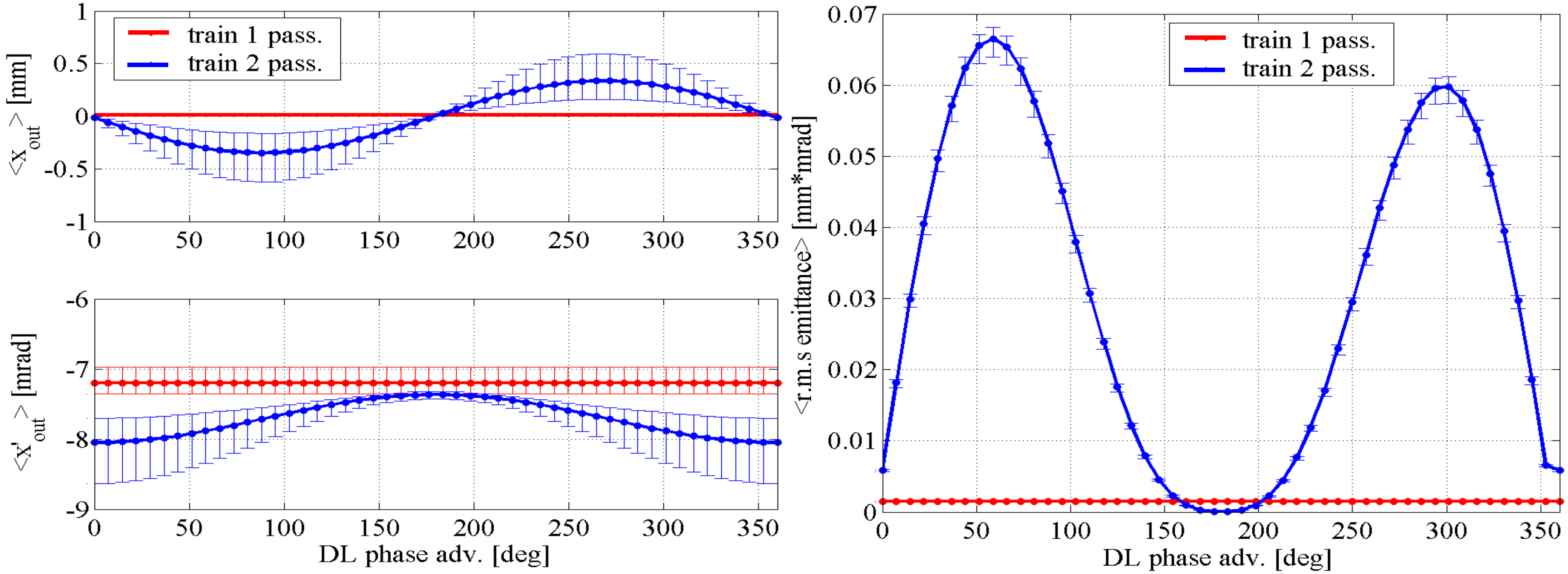


2 RF Deflectors

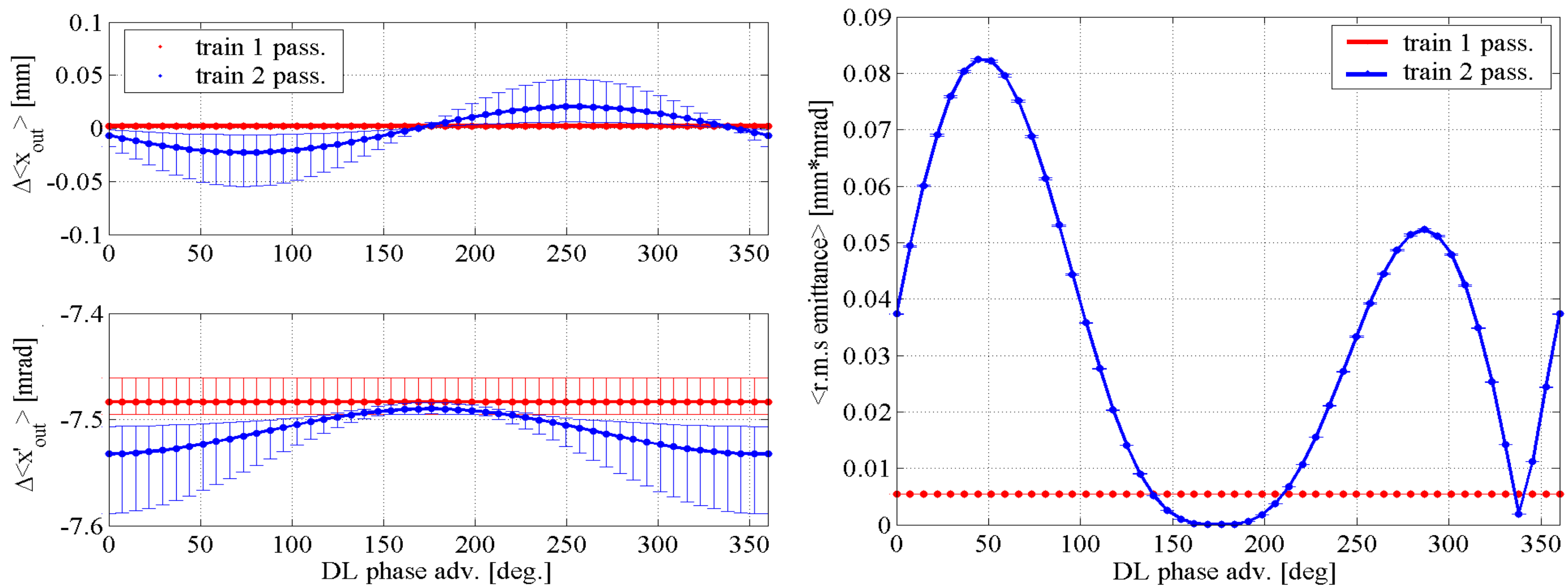


-No beam loading -Perfect injection -DL phase advance scan

1 RF Deflector

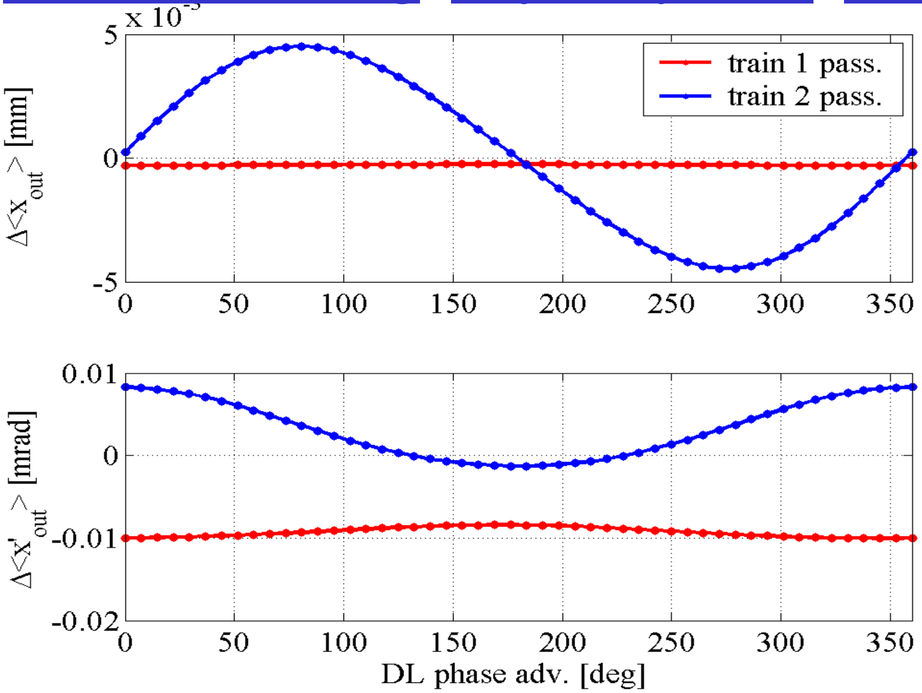


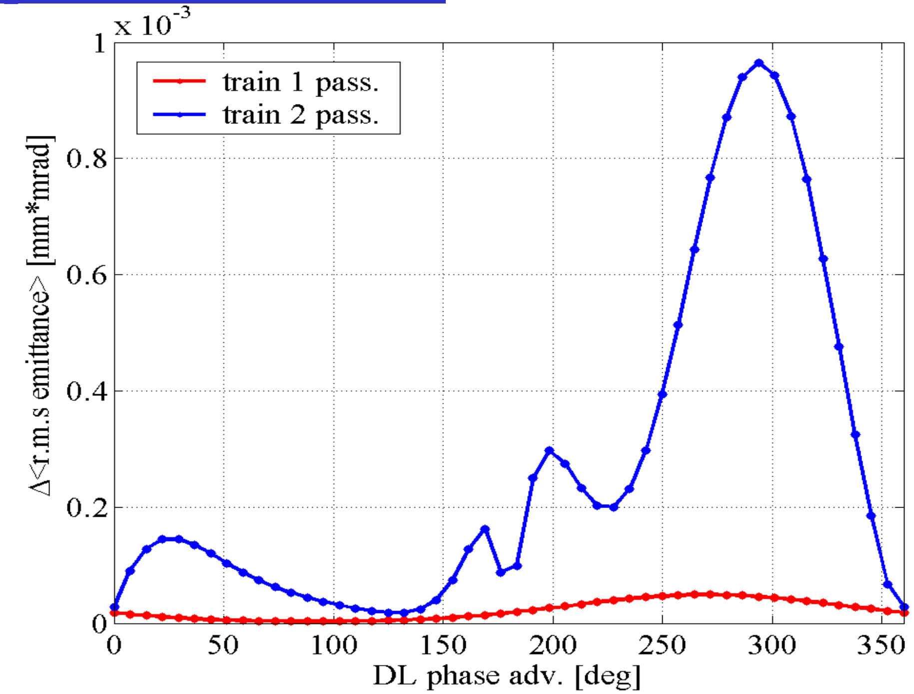
2 RF Deflectors



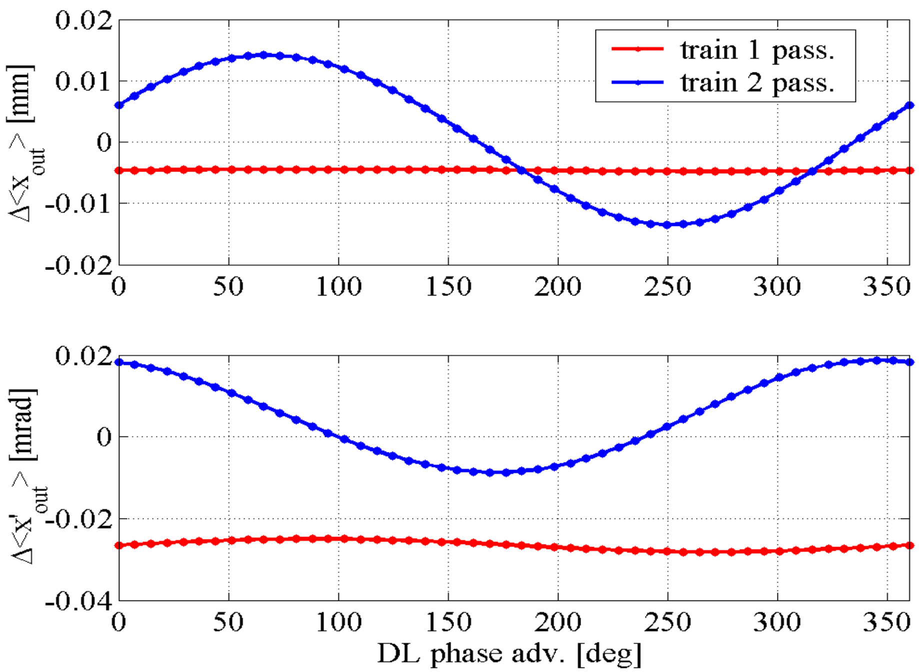
-*With beam loading* -*Perfect injection* -*DL phase advance scan*

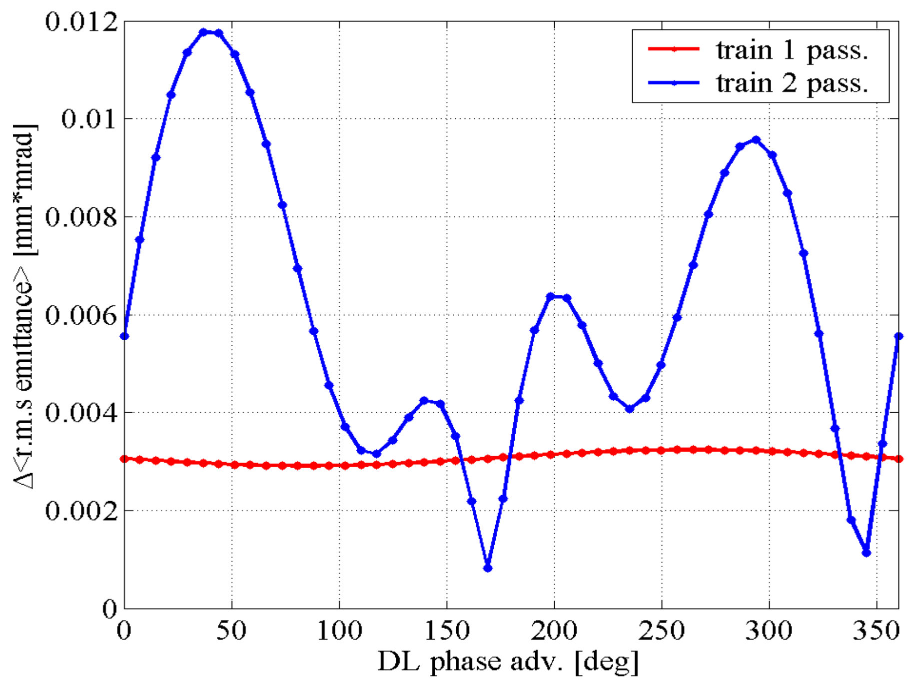
1 RF Deflector



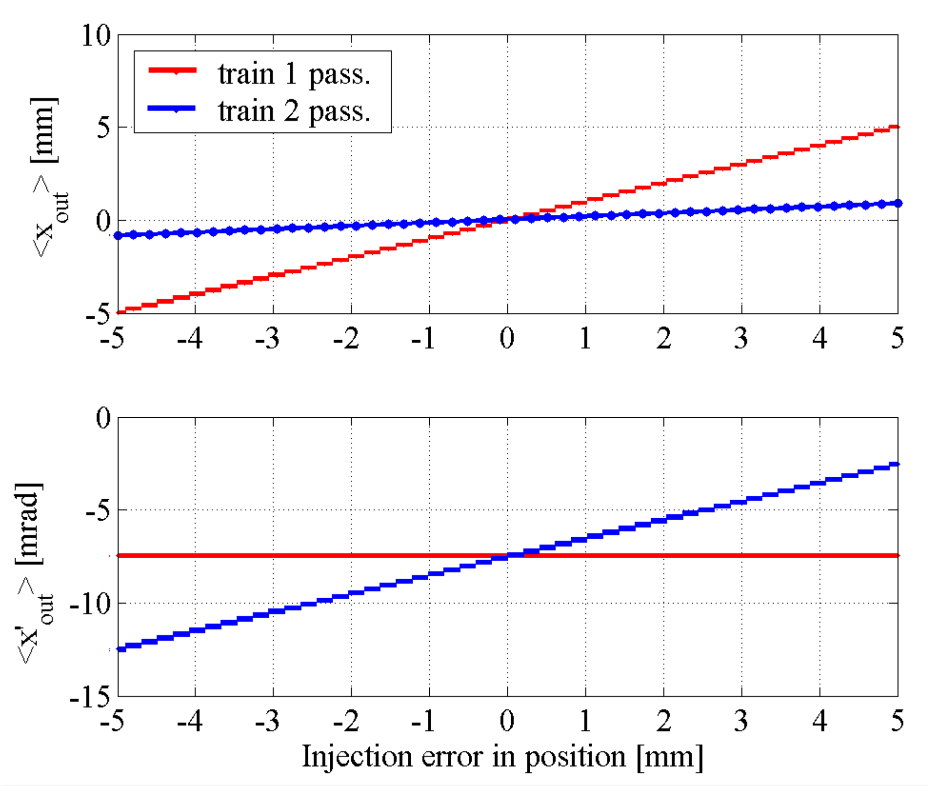


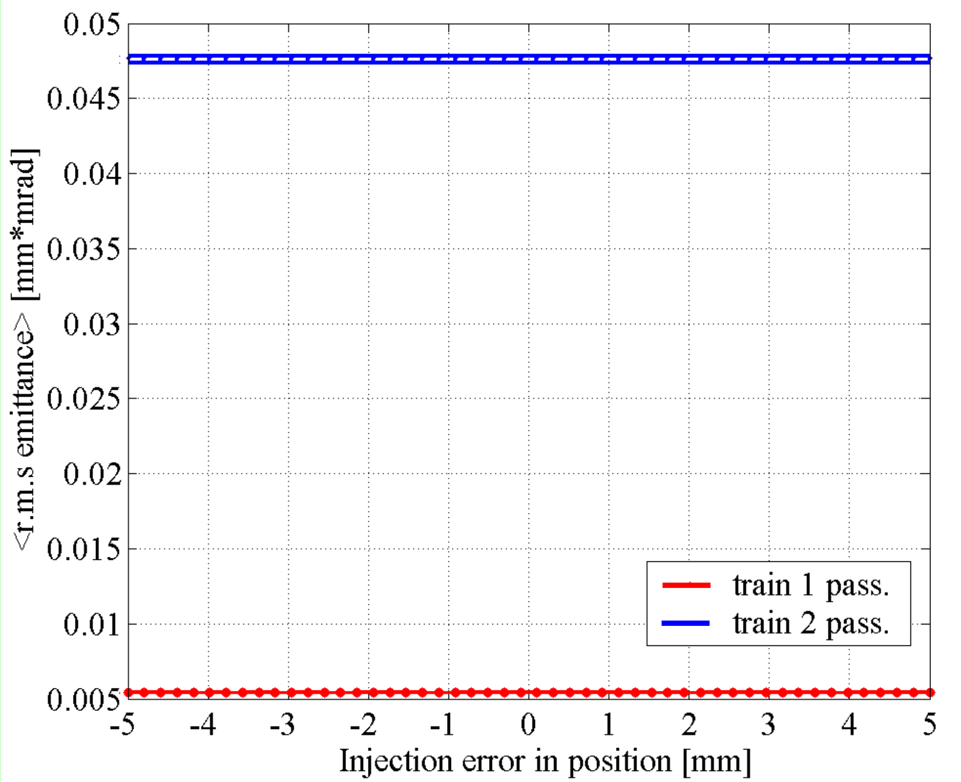
2 RF Deflectors



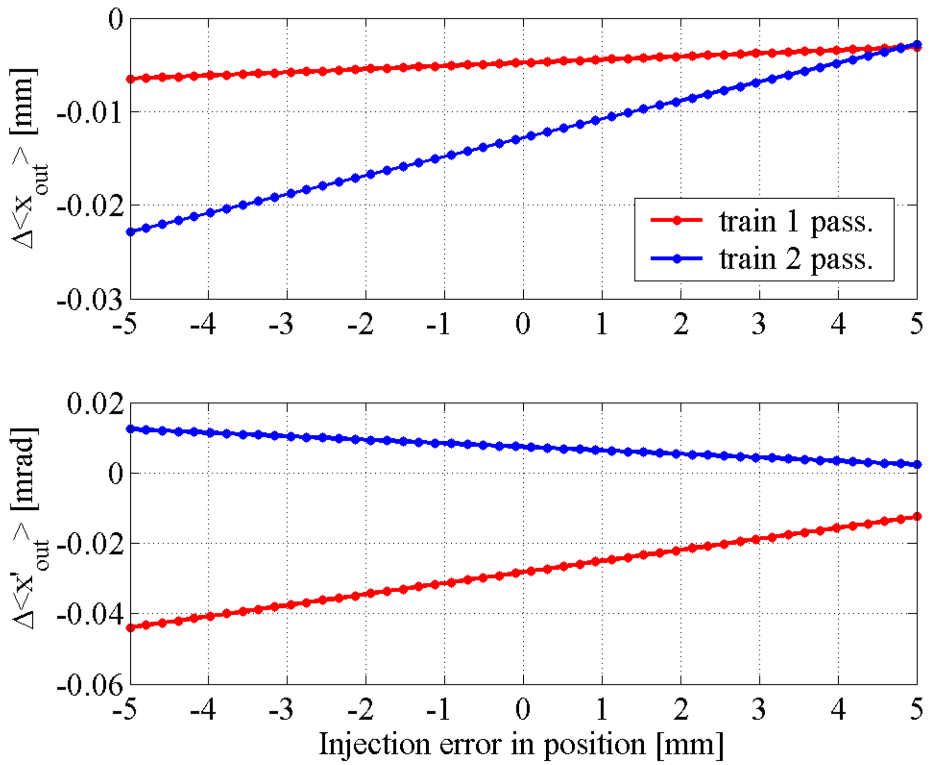


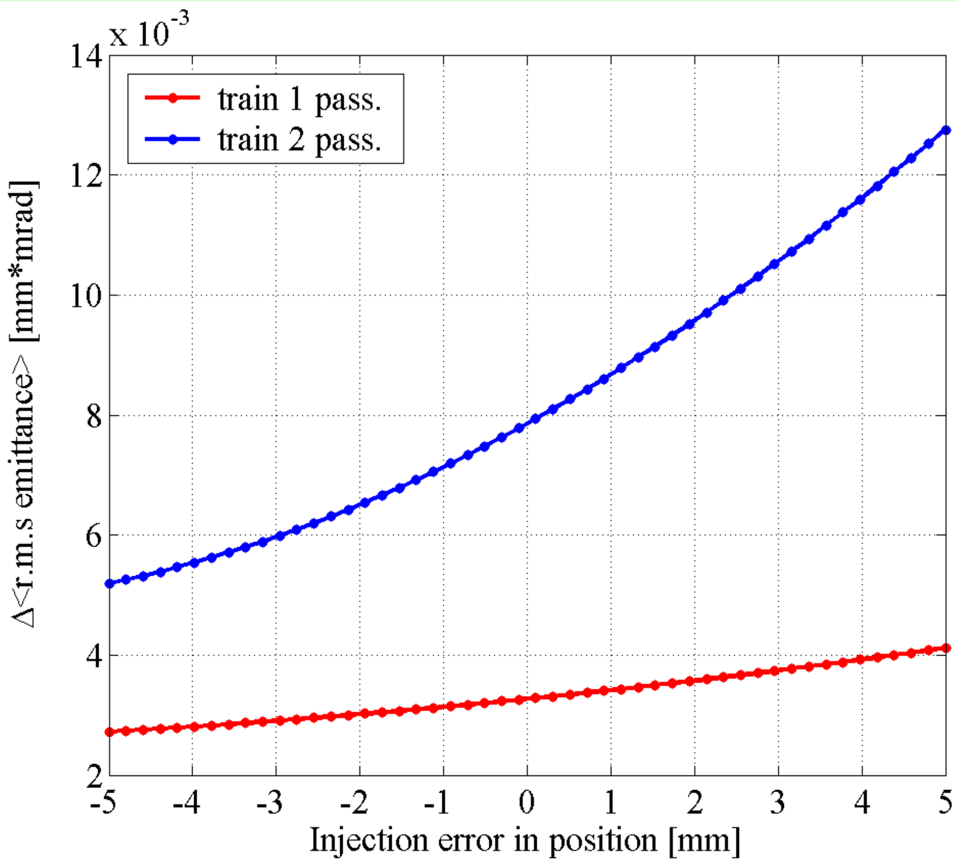
-No beam loading
-Injection error in position
-Nominal DL phase advance
-2 RF Deflectors





-With beam loading –Injection error in position –Nominal DL phase advance





Conclusions

- **Analitycal approach for the beam loading calculations has been used to develop the tracking code**
- **The tracking code results show that:**

-The main effects in term of final positions and angles of the bunches are given by the* finite filling time *of the structure(s). From this point of view 2 Deflectors gives better results. Feedforward or feedback procedures on the signal exciting the klystron can also reduce this problem;

-The power delivered to the cavity(ies) by the beam is a very small fraction with respect to the power delivered by klystron;

-Effect of different DL phase advances have been investigated showing that DL phases advances near* 180 deg *can partially cancel the beam "filling time effects";

-Effect of* injection errors in position *have been investigated showing that the beam loading effects do not magnify the initial errors;

Future developments...

- **Other injection error analyses combined with DL phase advance scan**
- **HOM effects**
- **...**