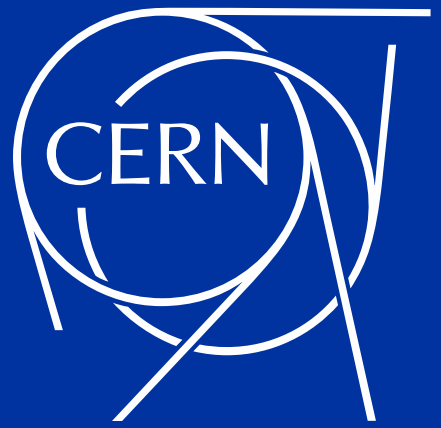

Influence of Transverse Motion on Longitudinal Space-Charge in the PS

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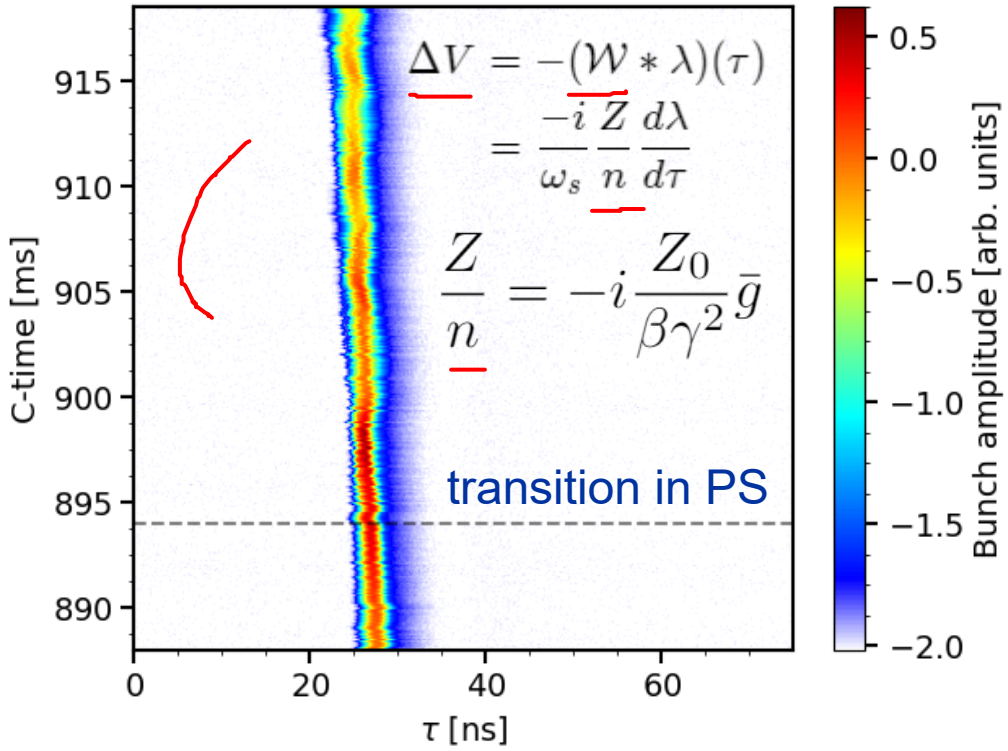
CERN | SY-RF-BR

HB2021 | 64th ICFA Advanced Beam Dynamics Workshop

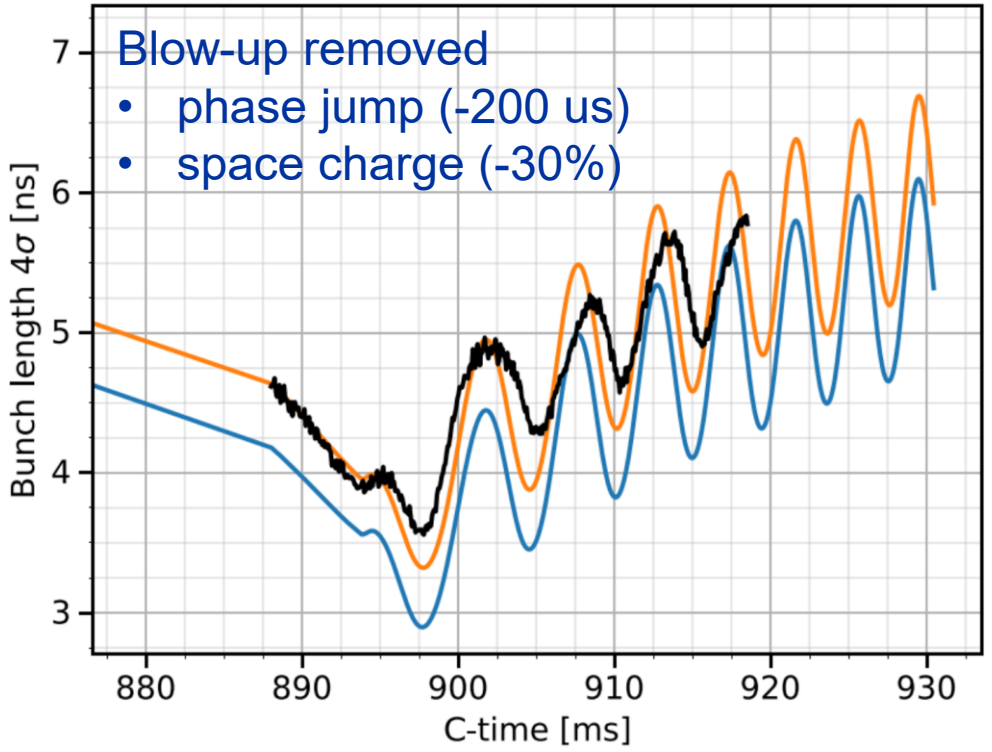
Motivation

A. Lasheen, “Transition crossing studies Microwave instability with ion beam,” 2019.

Microbunching Instabilities & Beam Break-Up



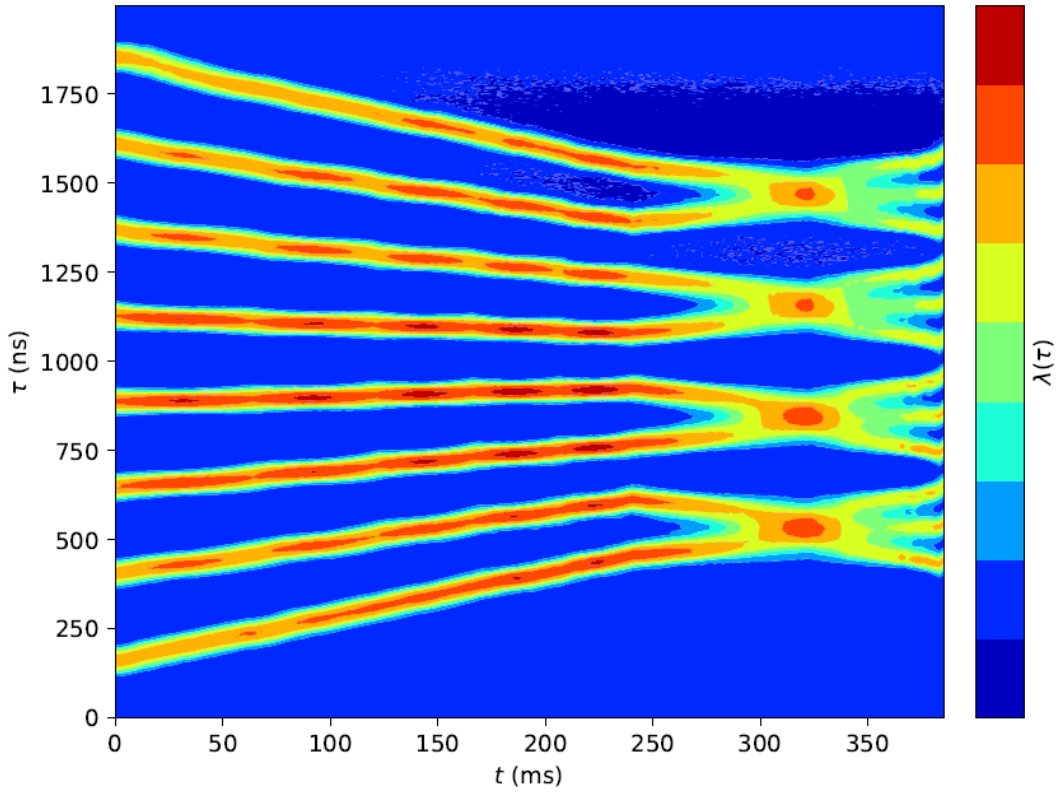
Validation of Tracking Codes



RF Manipulations & BCMS in the PS

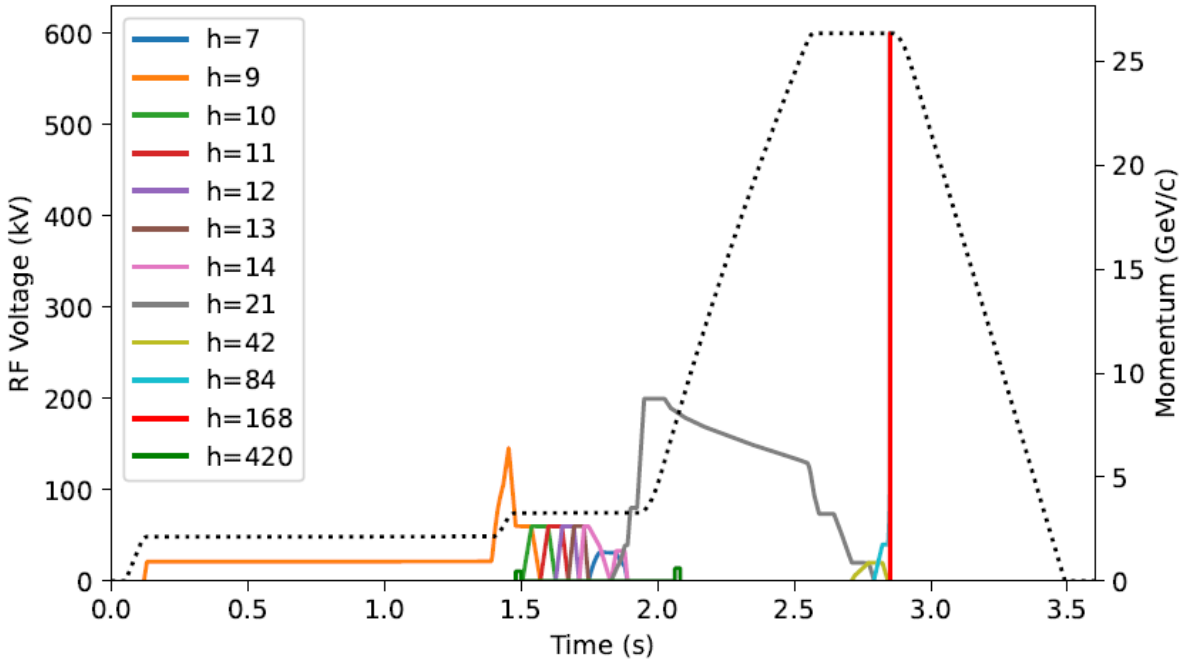
Batch Compression Matching Splitting

PSB Rings fill (4x2)

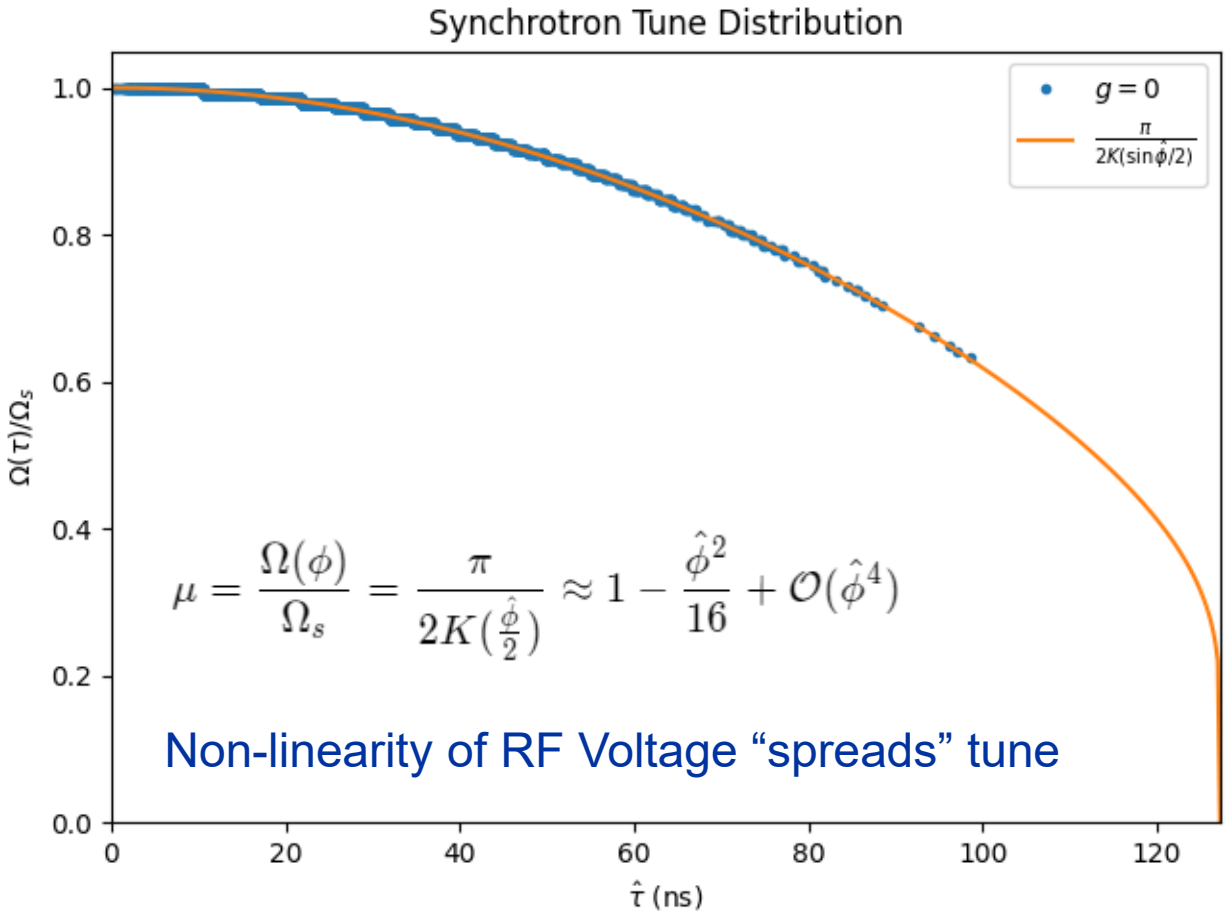


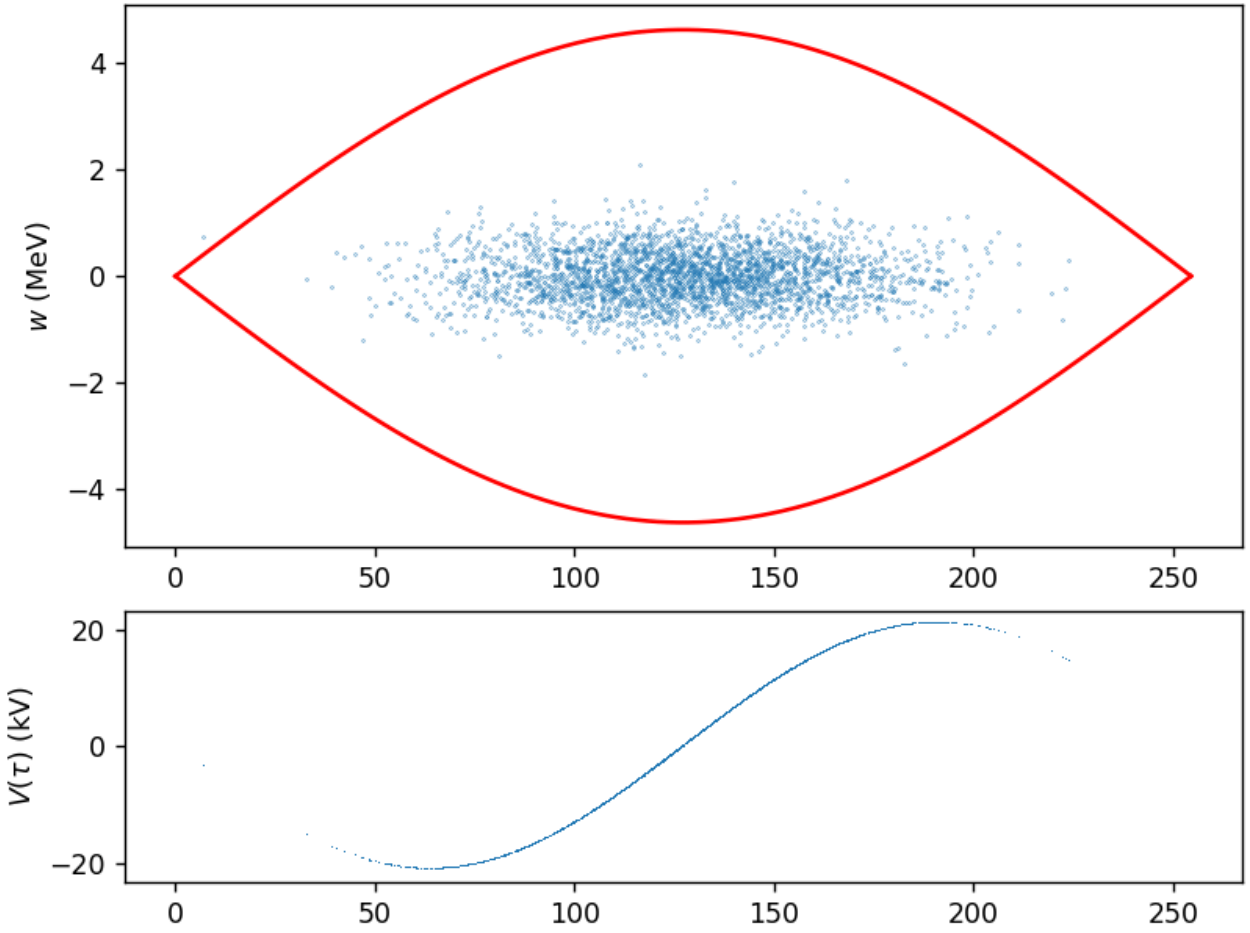
RF Harmonics Ramping Sequence

PS accelerates to reduce SC, then merges bunches
Splits bunches to match SPS acceptance

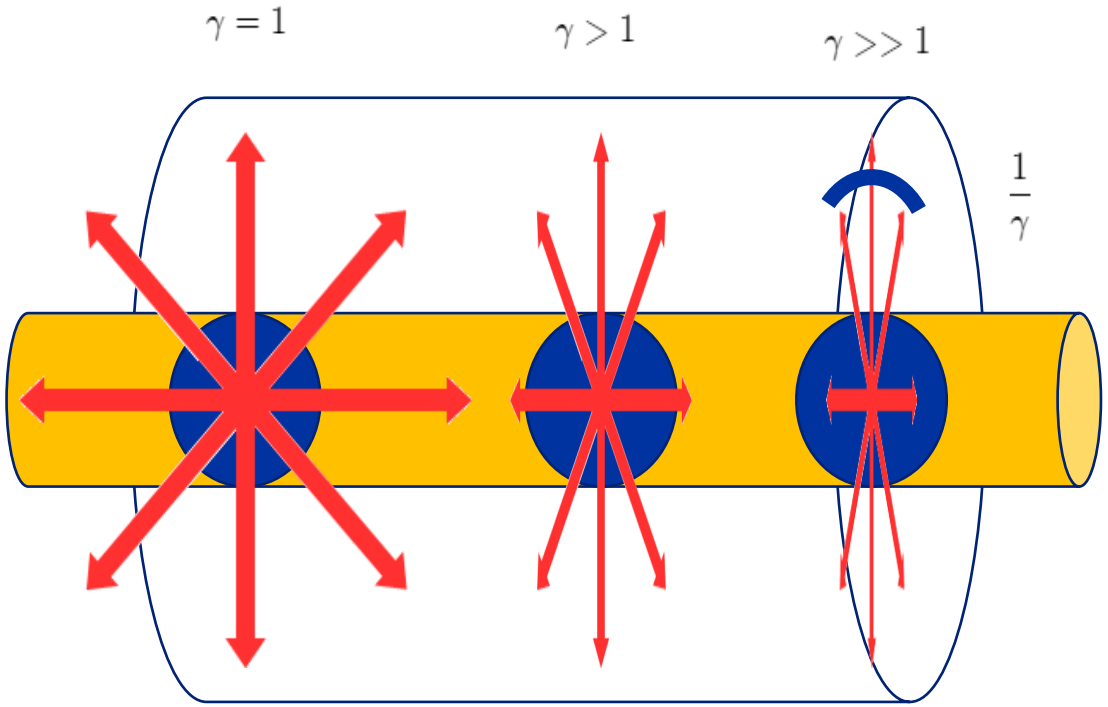


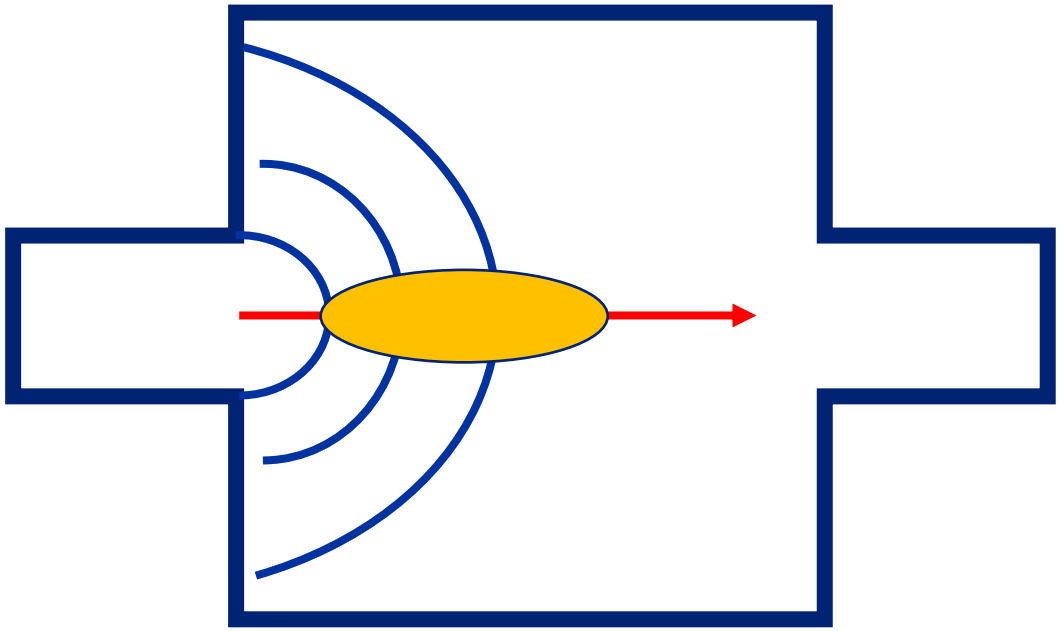
Synchrotron Motion





Intensity Effects





Space Charge Geometry Factor

For a long round beam in a conductive pipe

$$\bar{g} = \int_r^b \frac{f(r')}{r'} dr' \qquad f(r) = \frac{\int_0^r \rho(r') r' dr'}{\int_0^\infty \rho(r') r' dr'} = \frac{Q'}{Q}$$

Uniform:

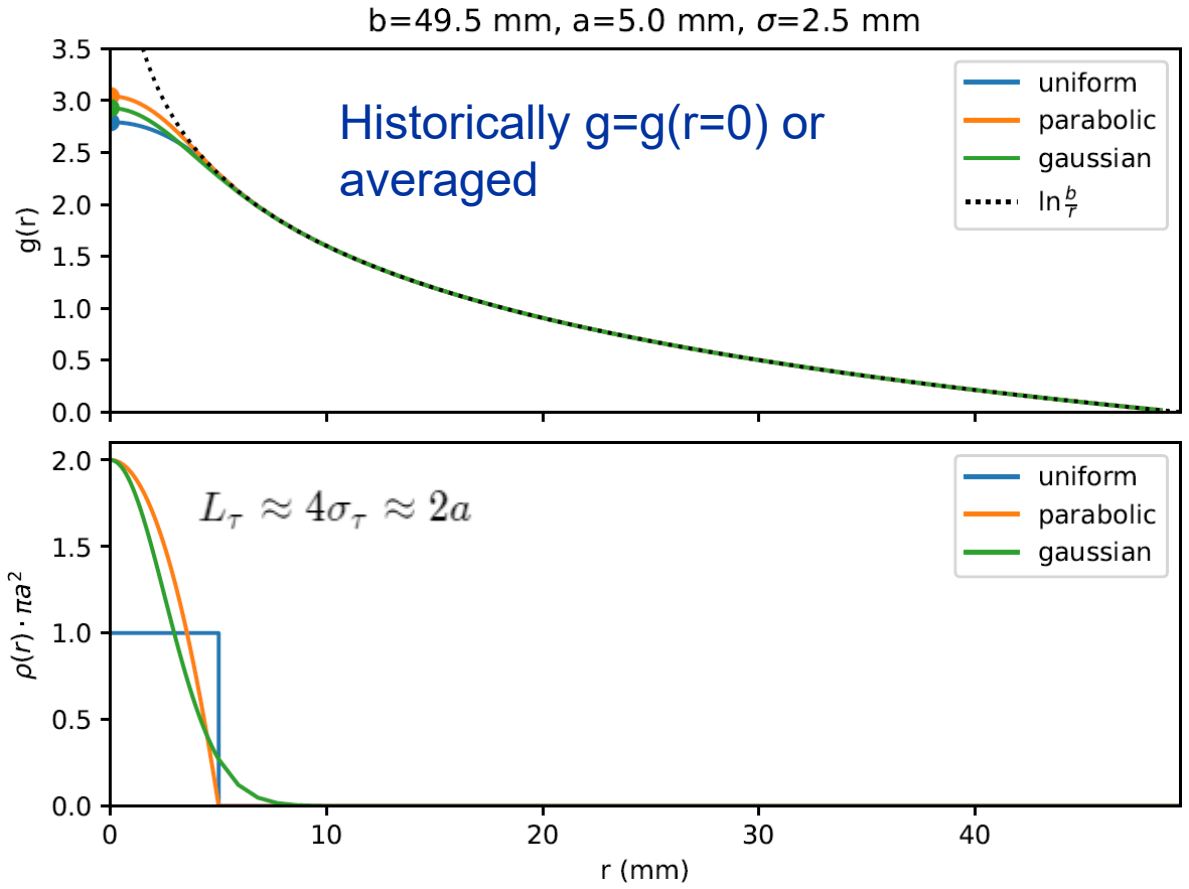
$$\bar{g}(r) = \begin{cases} \ln(\frac{b}{a}) + \frac{1}{2} - \frac{1}{2}\frac{r^2}{a^2} & r < a \\ \ln(\frac{b}{r}) & r > a \end{cases}$$

Parabolic:

$$\bar{g}(r) = \begin{cases} \ln\left(\frac{b}{a}\right) + \frac{a^2 - r^2}{a^2} - \frac{a^4 - r^4}{4a^4} & r < a \\ \ln(\frac{b}{a}) & r > a \end{cases}$$

Gaussian:

$$\bar{g}(r) = \ln\frac{b}{r} + \frac{1}{2}\left(\mathrm{Ei}(-\frac{1}{2}\frac{\mathrm{r}^2}{\sigma_\mathrm{r}^2}) - \mathrm{Ei}(-\frac{1}{2}\frac{\mathrm{b}^2}{\sigma_\mathrm{r}^2})\right).$$



Effective Geometry Factor

Geometry factor tracked and averaged for particles tracked transversally along ring

$$g_0 = \frac{1}{2} + \ln\frac{b}{a} \qquad g_{eff}(\epsilon_x, \epsilon_y, \delta) \approx g_0 - \frac{1}{2}\frac{\beta(\epsilon_x + \epsilon_y) + D^2\delta^2}{a^2}$$

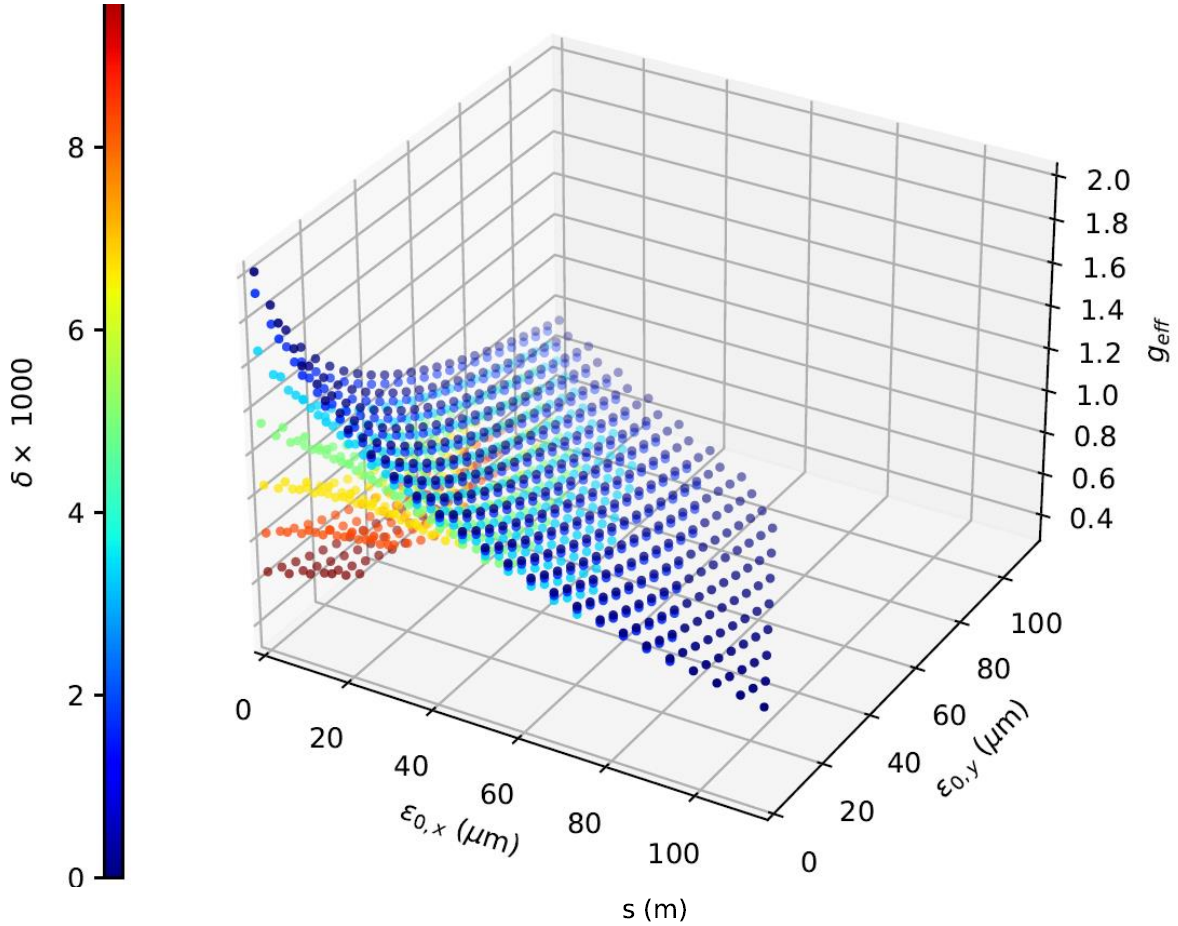
Scales with dispersion squared

Sinusoidal scaling with phase advance

Scales linearly with emittance

Domain limited by beam aperture

Response matrix developed to characterize g-factor for a particle in 6D phase-space



Tune “Blurring”

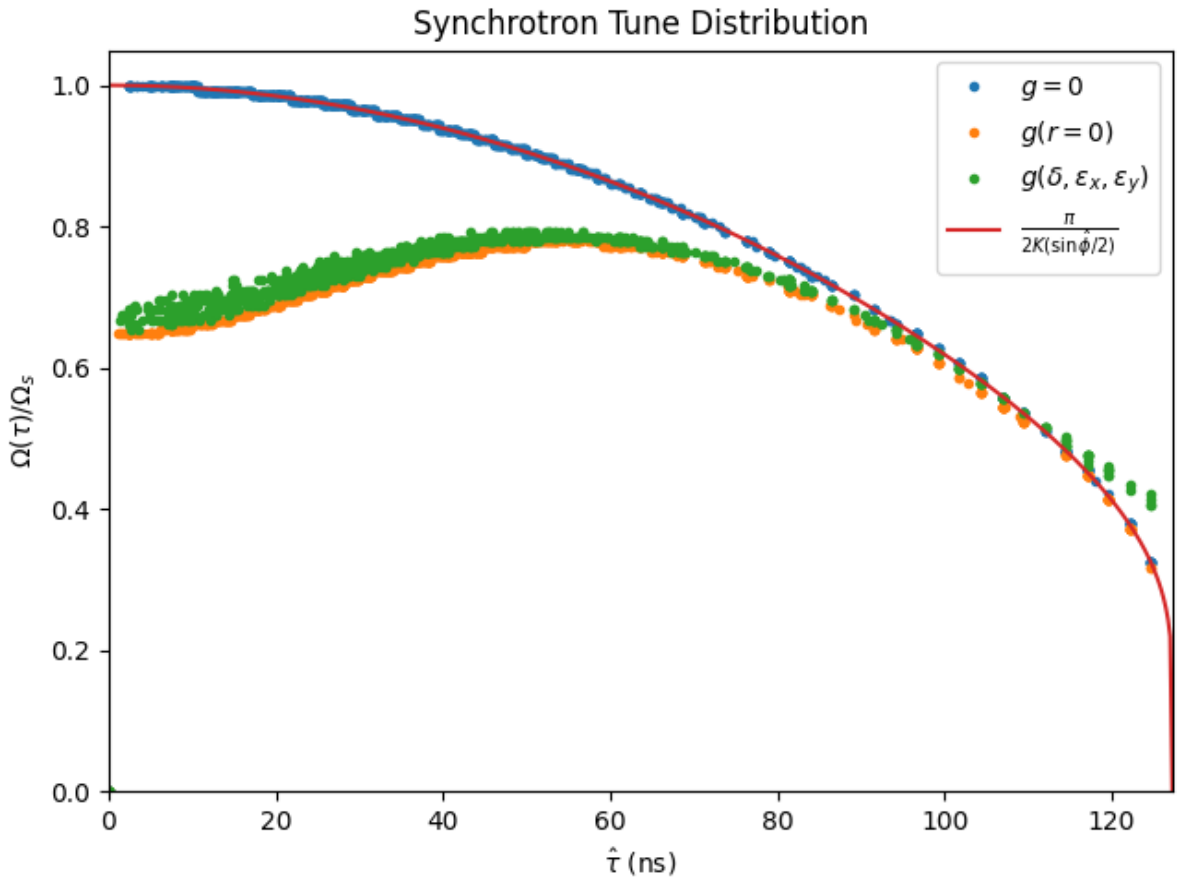
Effective Geometry Factor Implemented in BLonD longitudinal tracker

Geometry factor variance yields variance in synchrotron frequency or tune

Tune “Blurring” highest near center where voltage gradient and dispersion is highest

Additional tune variation towards bunch center may increase bulk filamentation rate

Additional tune variation may describe an additional stabilizing effect of longitudinal space-charge



Questions?

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