TMC "SIMPLE" FORMULA VS. MOSES CODE

E. Metral

- **Moses code (Y.H. Chin)**

  ⇒ Computations by Elena Shaposhnikova for SPS in 1993 for leptons at 3.5 GeV
  (using a Broad-Band impedance)

- **The "simple" formula (for a Broad-Band impedance)**

- **Comparison between the 2**

Moses code (Y.H. Chin)
⇒ Computations for SPS in 1993 for leptons at 3.5 GeV

⇒ cf paper "Analysis of the Transverse Mode Coupling Instability of the Leptons in the SPS", T. Linnecar, E.N. Shaposhnikova, CERN/SL/93-43 (RFS)

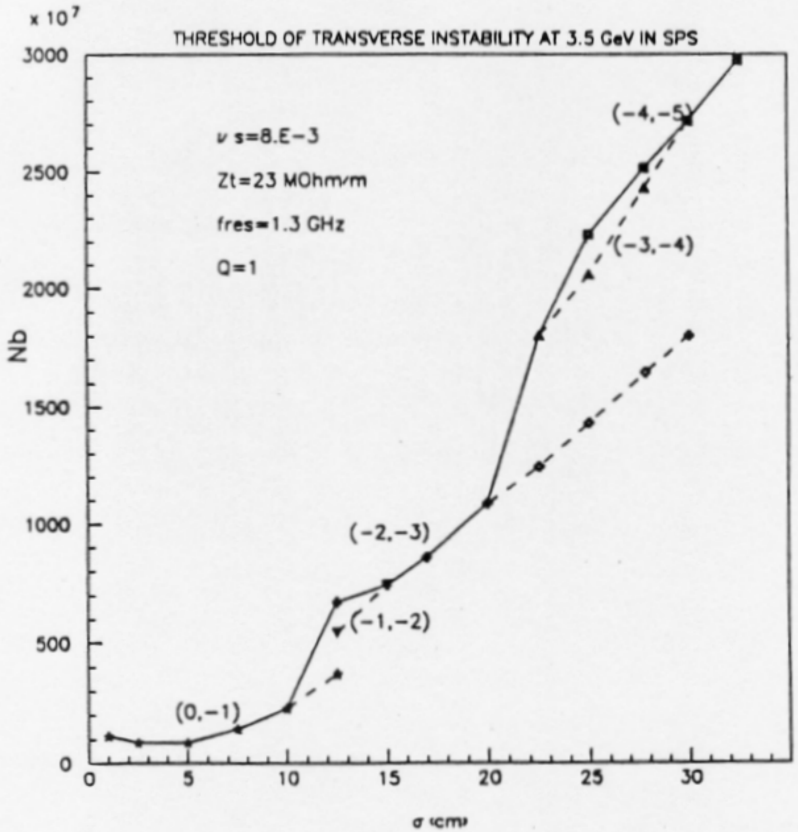


Figure 3: Threshold calculated at injection in the SPS as a function of the bunch length.

for $\xi_y = 0$

The "simple" formula (for a Broad-Band impedance) (1/2)

$$N_{b,th} = \frac{4\,\pi^3\, f_s\, Q_{y0}\, E\, \tau_b^2}{e\, c} \times \frac{f_r}{\left| Z_y \right|} \times \left(1 + \frac{f_{\xi_y}}{f_r} \right)$$

1

or

$$N_{b,th} = \frac{8\,\pi\, Q_{y0} \left| \eta \right| \varepsilon_l}{e\, \beta^2\, c} \times \frac{f_r}{\left| Z_y \right|} \times \left(1 + \frac{f_{\xi_y}}{f_r} \right)$$

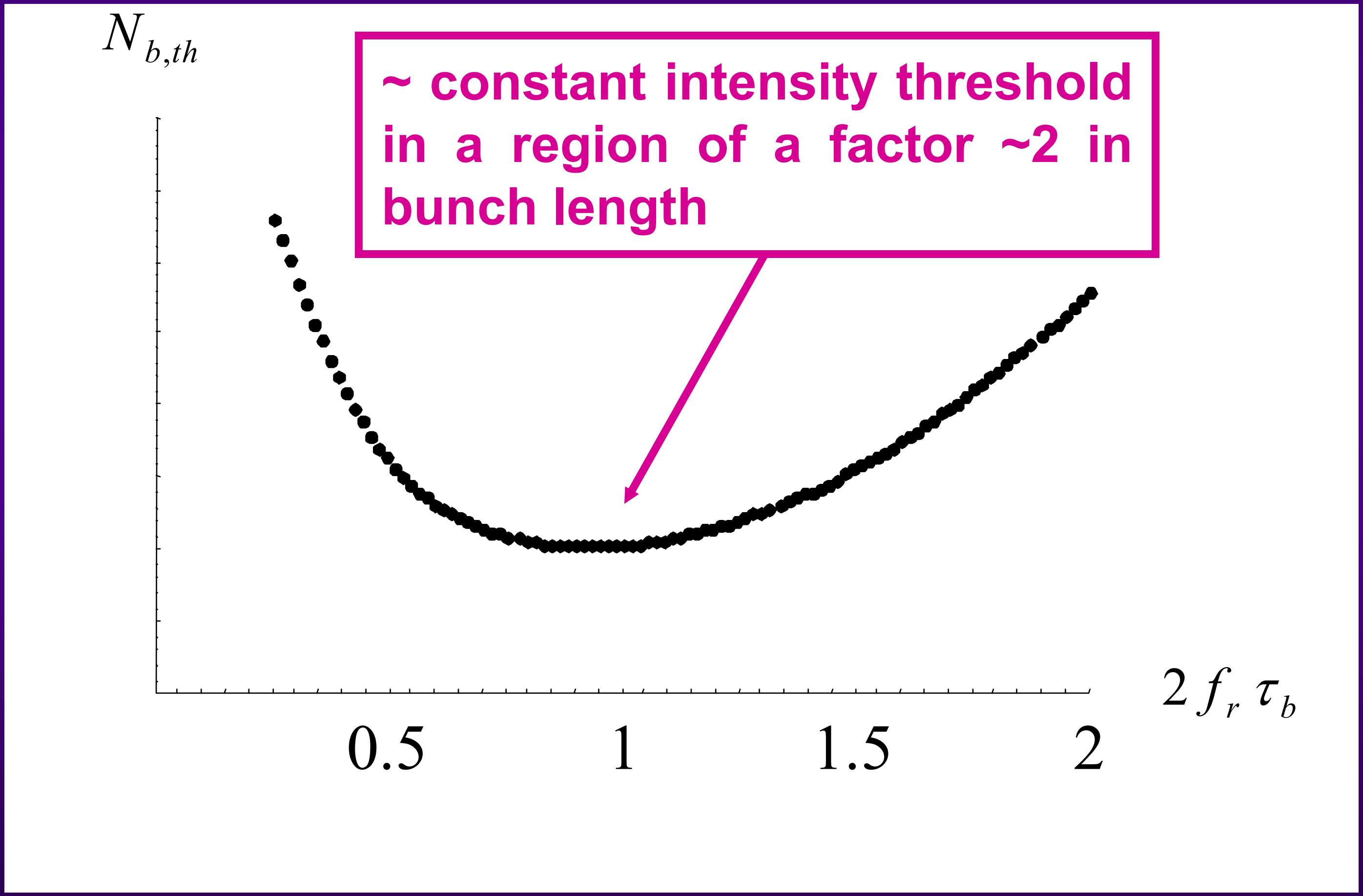
2

⇒ **cf paper "Effect of bunch length, chromaticity, and linear coupling on the transverse mode-coupling instability due to the electron cloud", E. Metral, CERN/PS 2002-009 (AE), ECLOUD'02 Workshop, April 15-18 2002, CERN**

The “simple” formula (for a Broad-Band impedance) (2/2)

$$N_{b,th}\left(\tau_b \geq \sim \tau_b^{\min}\right) = N_{b,th}\left(\sim \tau_b^{\min}\right) \times 2 f_r \tau_b$$

3

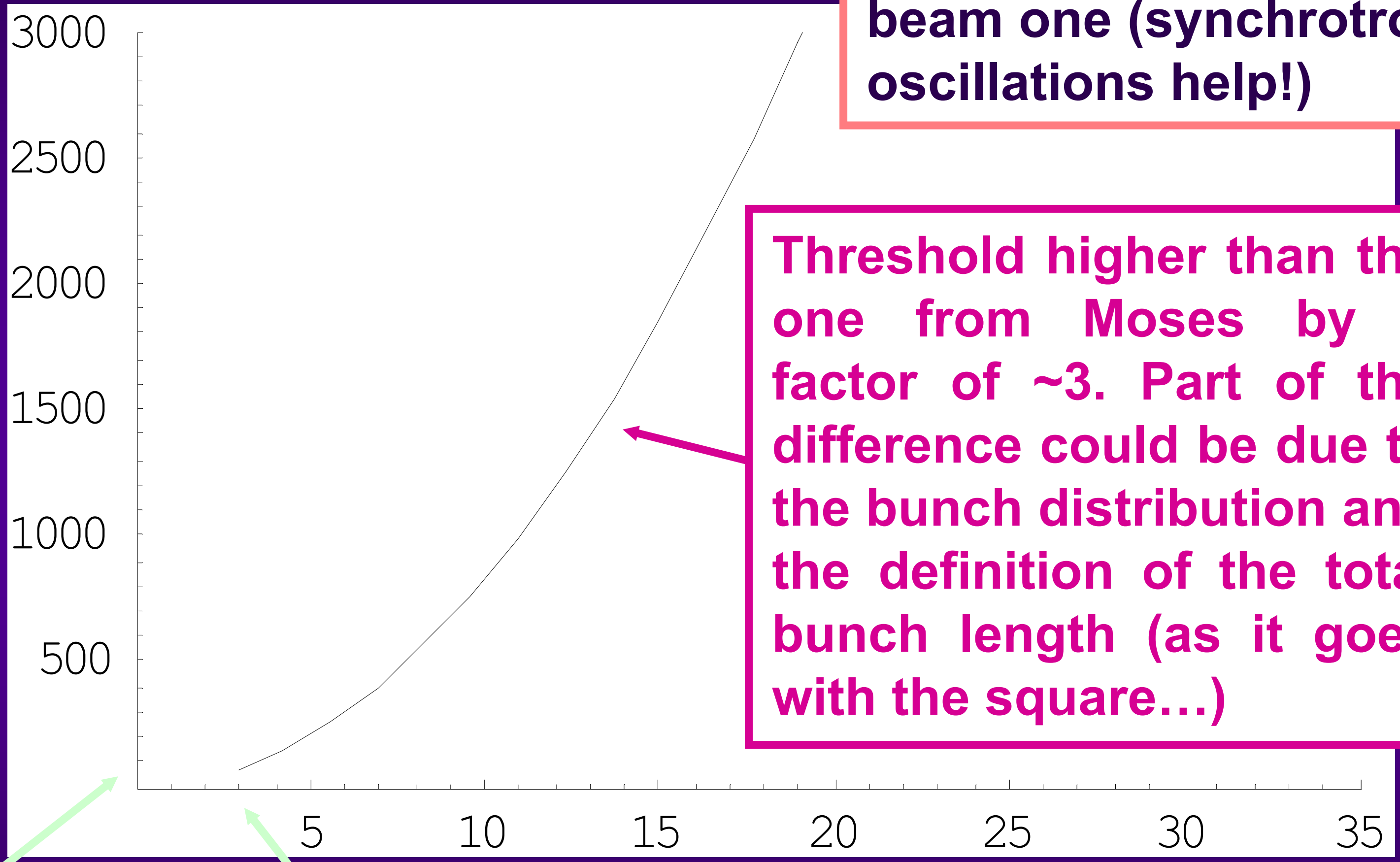


$$\tau_b^{\min} \approx \frac{1}{2 f_r}$$

Comparison between the 2 (1/2)

- **Applying the formula as given in (1)**

The TMC intensity threshold cannot be below the coasting-beam one (synchrotron oscillations help!)



$N_{b,th}\ [\times 10^7]$

$\sigma\ [\mathrm{cm}]$

Threshold higher than the one from Moses by a factor of ~3. Part of the difference could be due to the bunch distribution and the definition of the total bunch length (as it goes with the square…)

$N_{b,th}(\sigma_{\min}) \approx 70 \times 10^7$

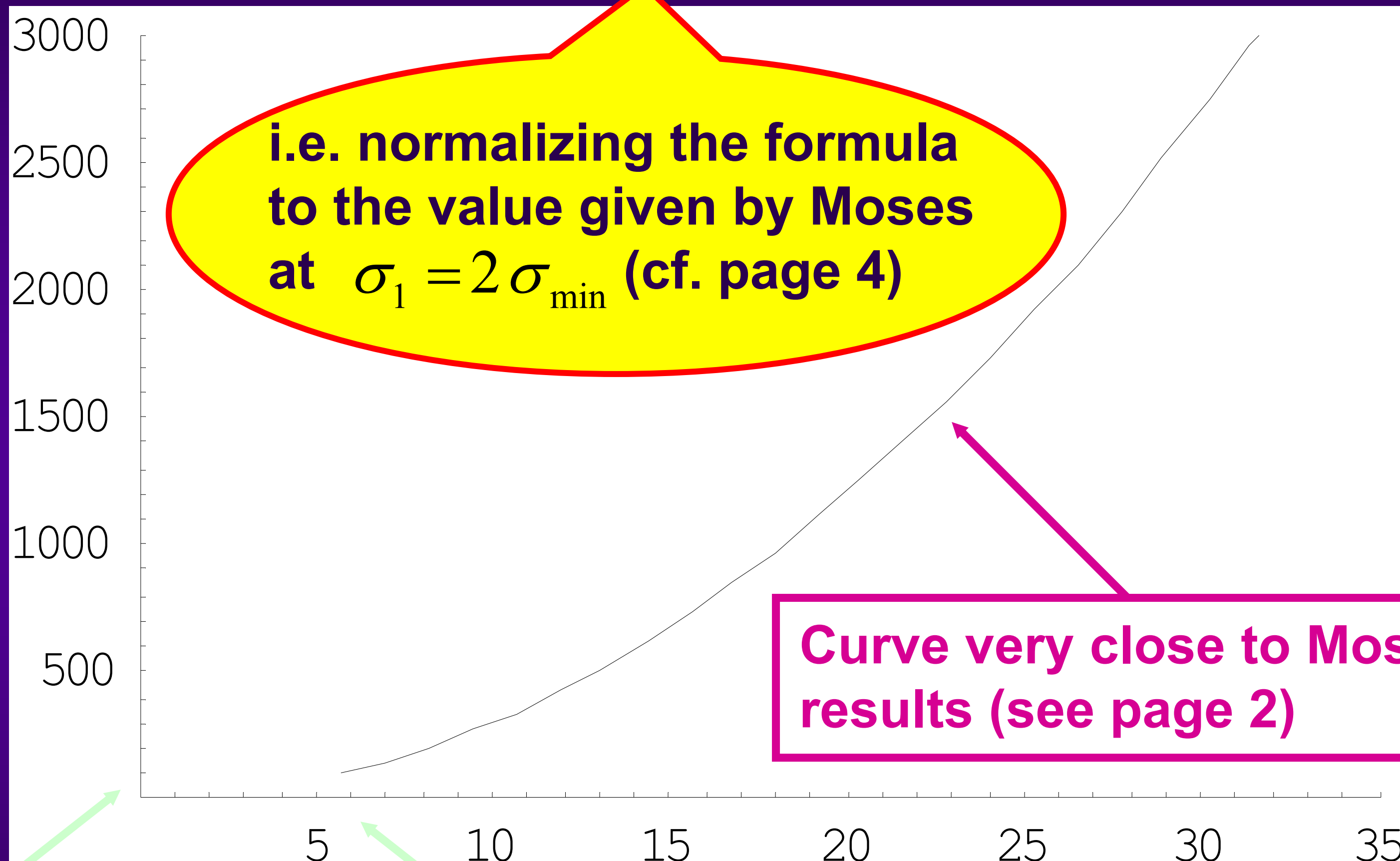
$\sigma_{\min} \approx 3\,\mathrm{cm}$

Good agreement for these 2 values

Comparison between the 2 (2/2)

- **Applying the formula** $N_{b,th} = N_{b,th}^{Moses}\left(\sigma_1\right) \times \left(\sigma / \sigma_1\right)^2$

i.e. normalizing the formula to the value given by Moses at $\sigma_1 = 2\,\sigma_{min}$ (cf. page 4)



$N_{b,th}\ [\times 10^7]$

σ [cm]

Curve very close to Moses results (see page 2)

$N_{b,th}^{Moses}\left(\sigma_1\right) \approx 100 \times 10^7$

$\sigma_1 = 2\,\sigma_{min} \approx 6$ cm

Conclusion (1/5)

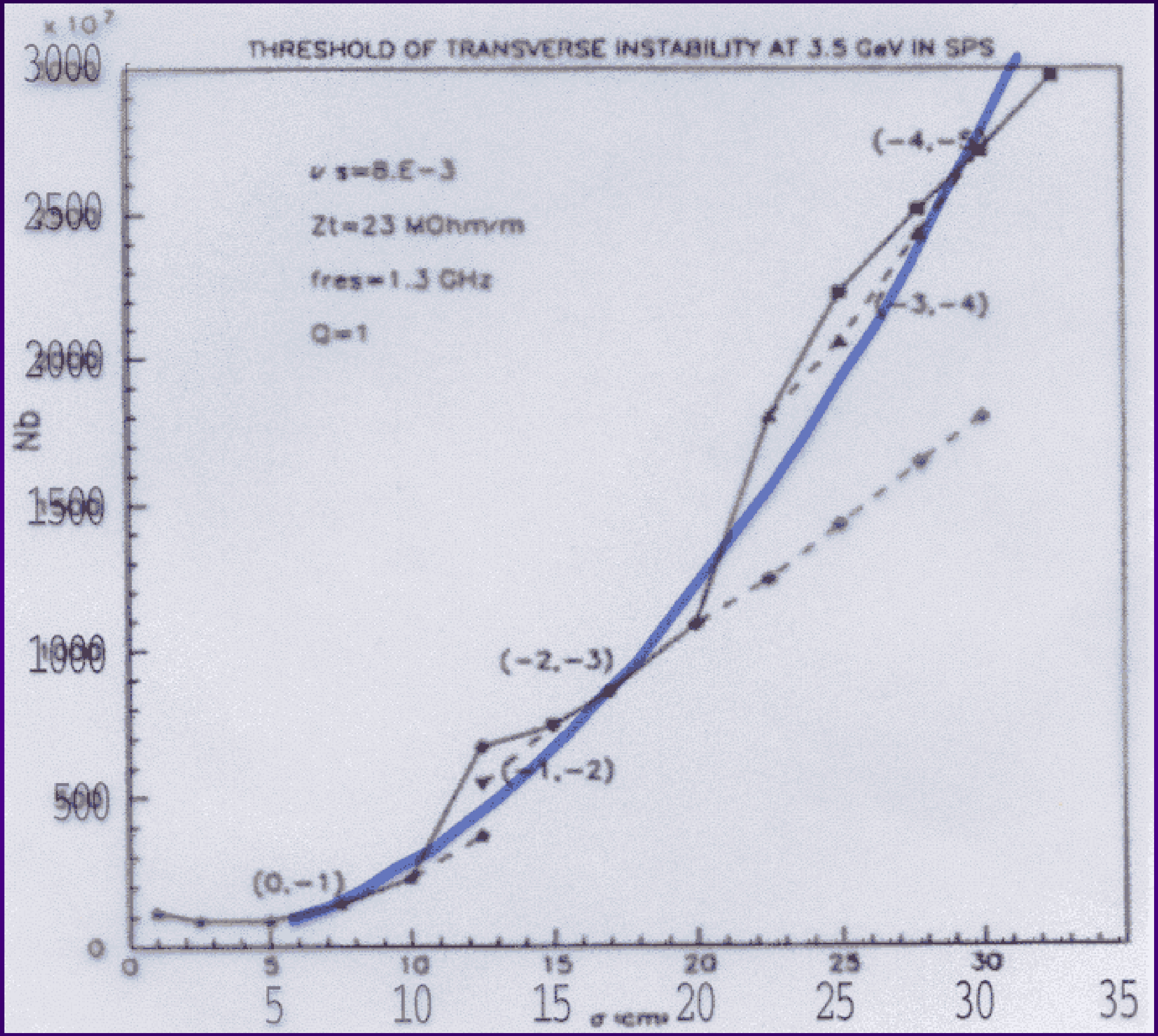
- **The "simple" formula and the Moses code give (for the present example)**
  - **The same value for the minimum intensity threshold and the same value for the corresponding bunch length**

$$N_{b,th}\left(\sigma_{\min}\right) \approx 100 \times 10^{7} \qquad \sigma_{\min} \approx 3\,\mathrm{cm}$$

  - **The same variation with respect to the bunch length for constant synchrotron frequency**

$$N_{b,th} \propto \tau_b^2$$

Conclusion (2/5)



Further investigations in detail for the SPS by Elena … (Effect of chromaticity with Moses code ?…)

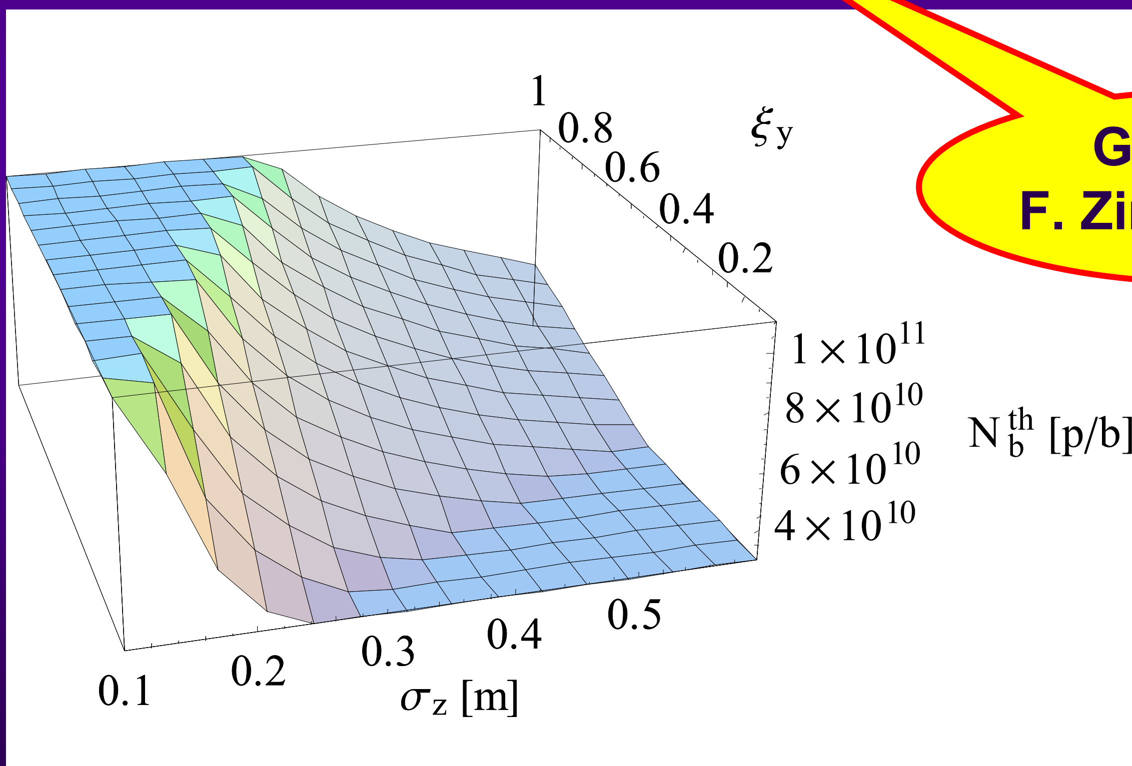
Conclusion (3/5)

- **The same formula can be applied (in a 1st approximation) for the vertical single-bunch ecloud instability in the SPS**

$$\left| Z_y \right| = \left| Z_{y0} \right| \times \frac{\sigma_z}{\sigma_{z0}} \times \frac{\sigma_{y0}\left(\sigma_{x0} + \sigma_{y0}\right)}{\sigma_y \left(\sigma_x + \sigma_y\right)}$$

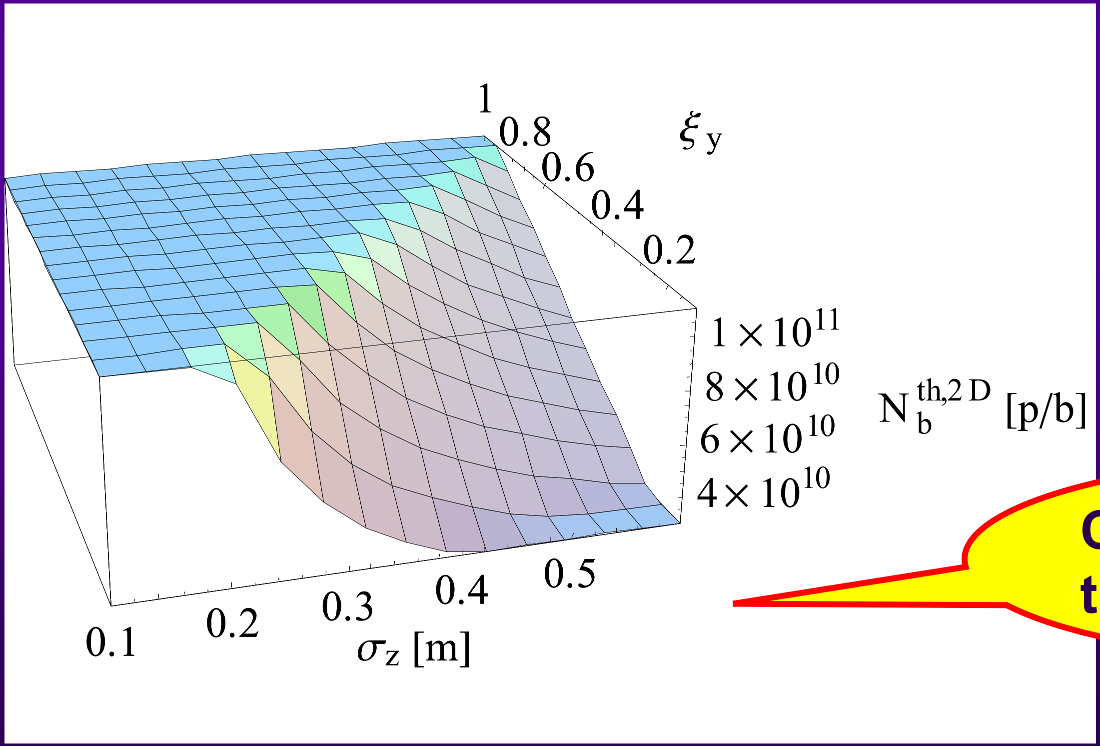
$$f_r = f_{r0} \times \sqrt{\frac{\sigma_{z0}}{\sigma_z}} \times \sqrt{\frac{N_b}{N_{b0}}} \times \sqrt{\frac{\sigma_{y0}\left(\sigma_{x0} + \sigma_{y0}\right)}{\sigma_y \left(\sigma_x + \sigma_y\right)}}$$

Given by F. Zimmermann



Conclusion (4/5)

- **The same formalism can be used to find the 2D instability threshold (i.e. with linear coupling between the transverse planes)**
  - **Beneficial effect as the horizontal impedance is usually smaller**
  - **It has been proposed to use this in the SPS for the ecloud instability**



Considering here only the dipole-field regions

Conclusion (5/5)

- **The same formalism can be used for the longitudinal mode-coupling instability. In this case the potential-well distortion from both Broad-Band and Space-Charge impedances also has to be taken into account**