# LMCI WITH BB IMPED. (Q=1) => COMPARISON BETWEEN
# 1) GALACLIC (Vlasov solver)
# 2) SIMPLE FORMULA (2-mode approach)
# 3) BLonD and SBSC (Tracking codes)

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- **Parameters used**

$$f_r\,\tau_b = 2.7 \qquad f_0 = 43350.8\ \text{Hz}$$

$$f_r = 1\ \text{GHz} \qquad B_0 = f_0\,\tau_b$$

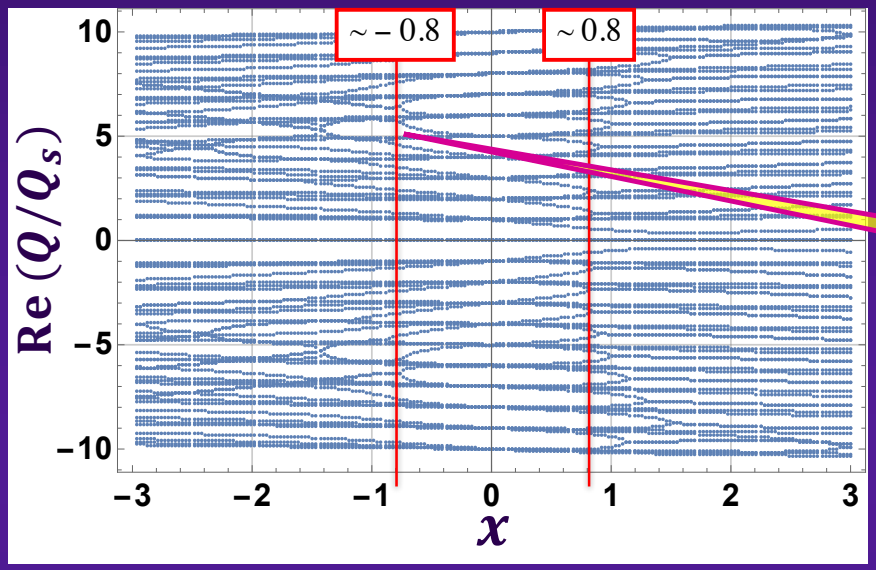
$$\left[\frac{Z_l}{p}\right]_{p=0} = 8.67\ \Omega \qquad V_{RF} = 6\ \text{MV}$$

$$\omega_{s0} = 889\ \text{rad/s} \qquad h = 462$$

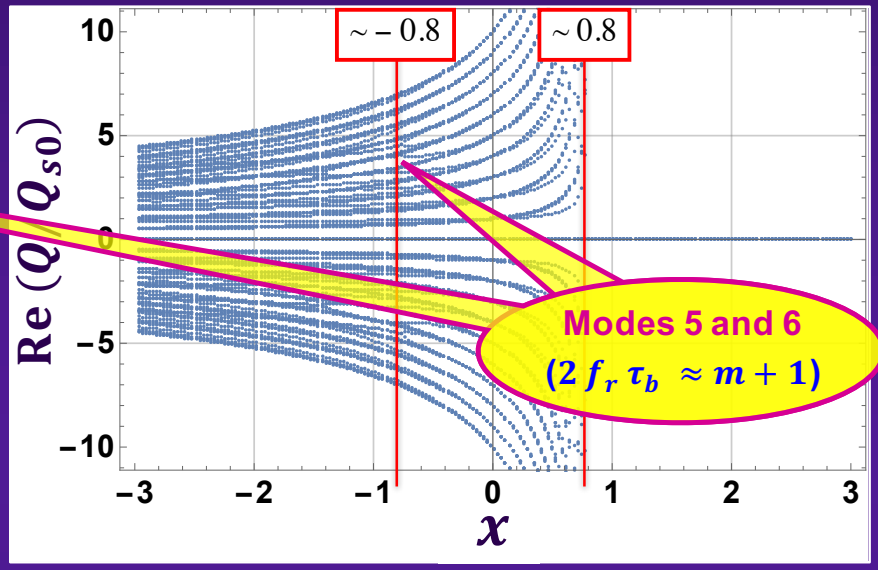
# REMINDER

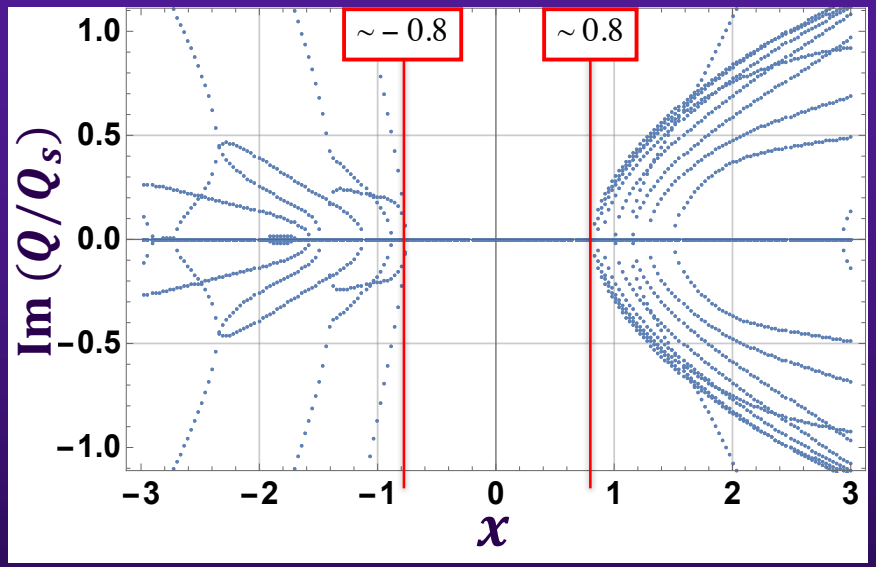
## GALACLIC => For PAD distribution: $f_r\,\tau_b = 2.8$

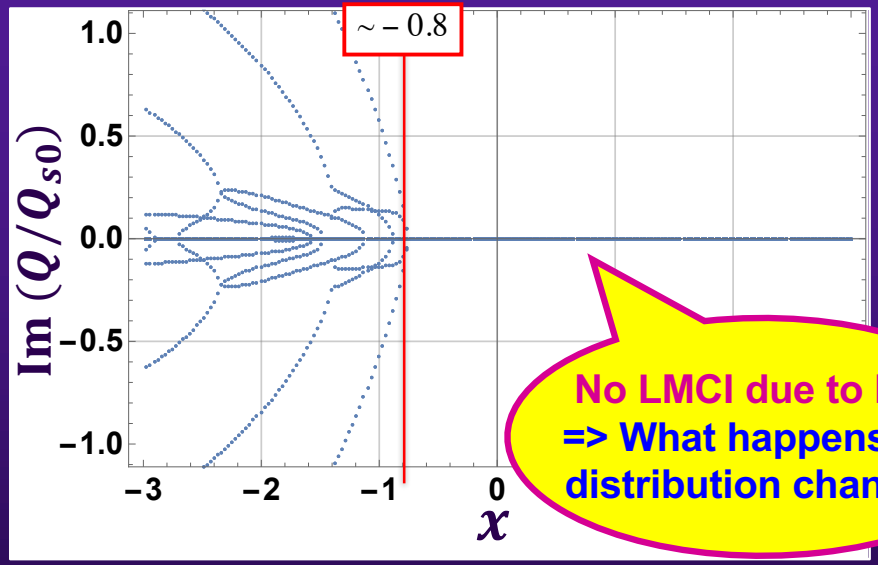
- GALACLIC (using $Q_s$)



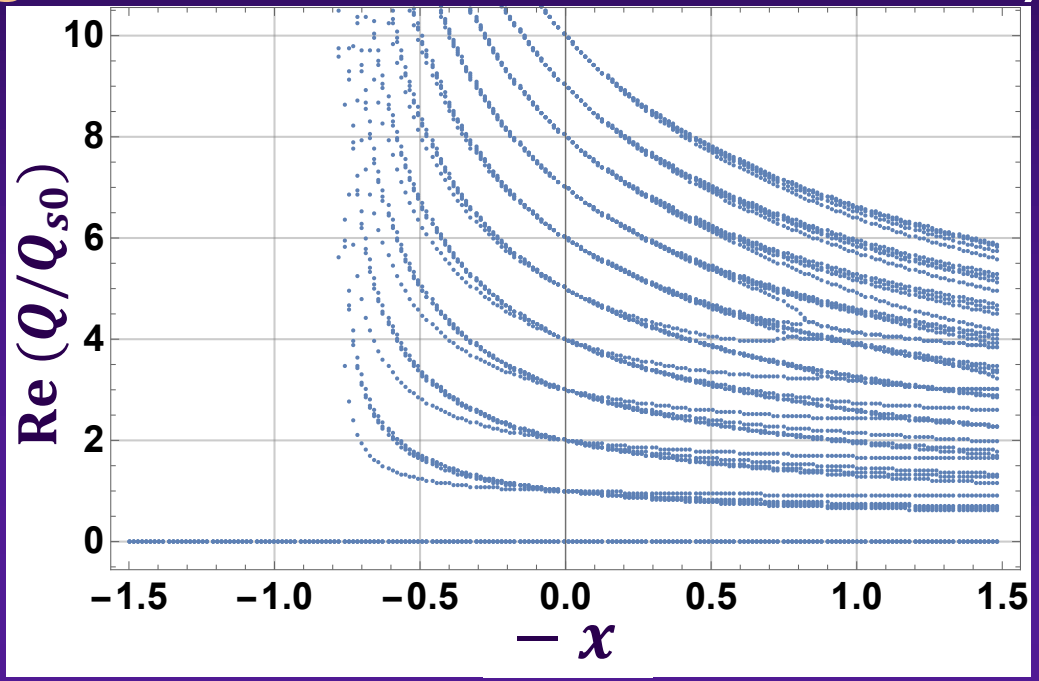

- GALACLIC (using $Q_{s0}$)

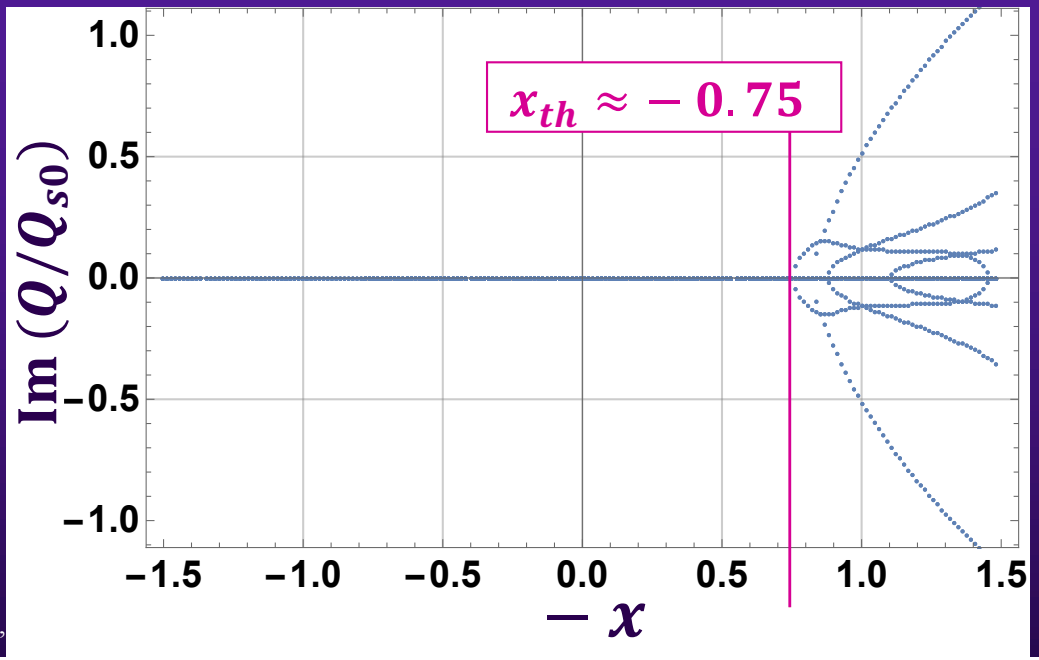


# 1) GALACLIC => For PAD distribution (& computing PWD also for PAD distribution): $f_r\,\tau_b = 2.7$



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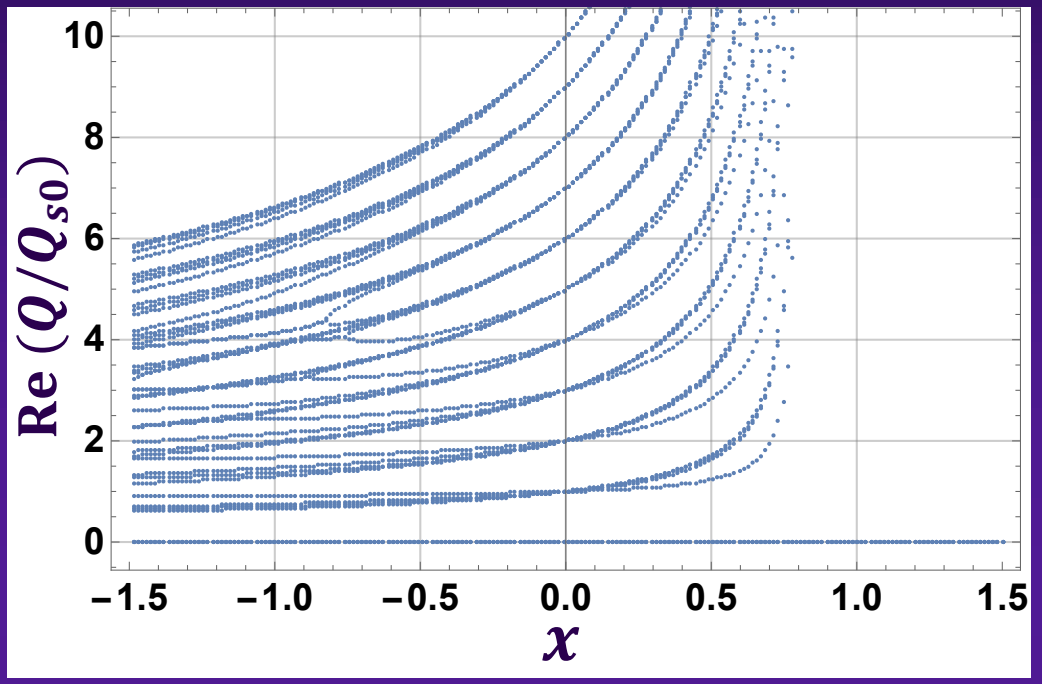
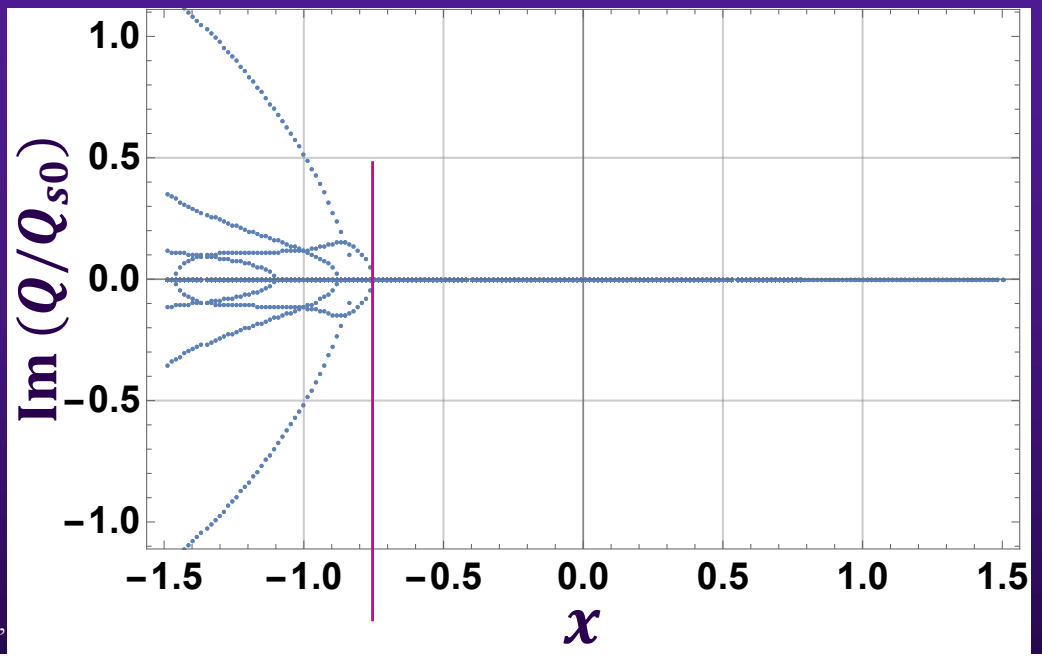
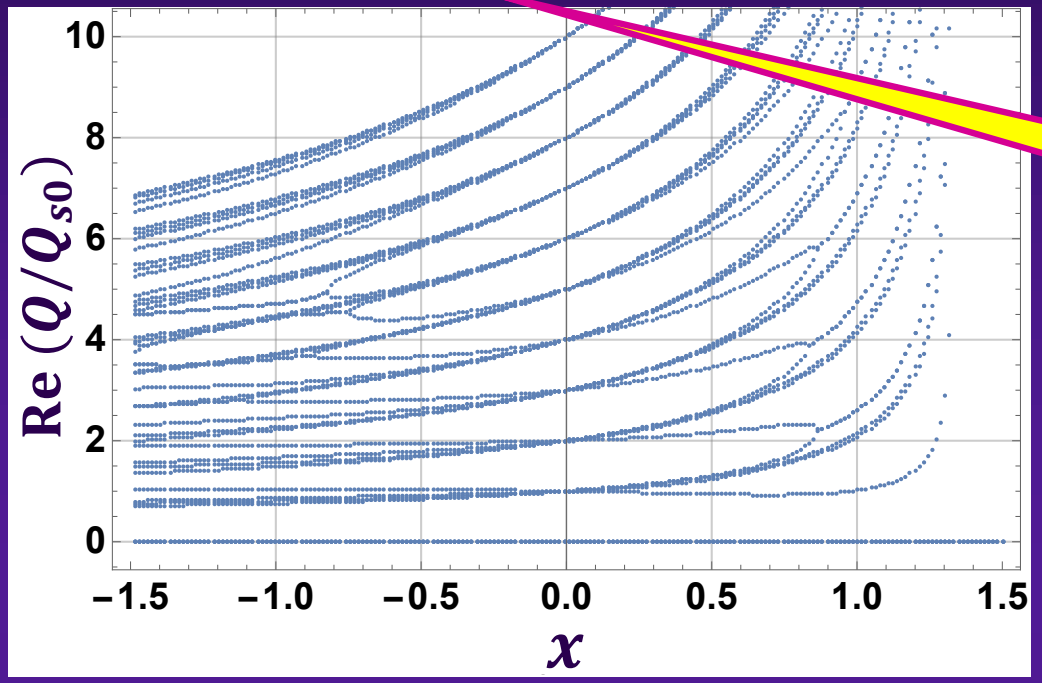


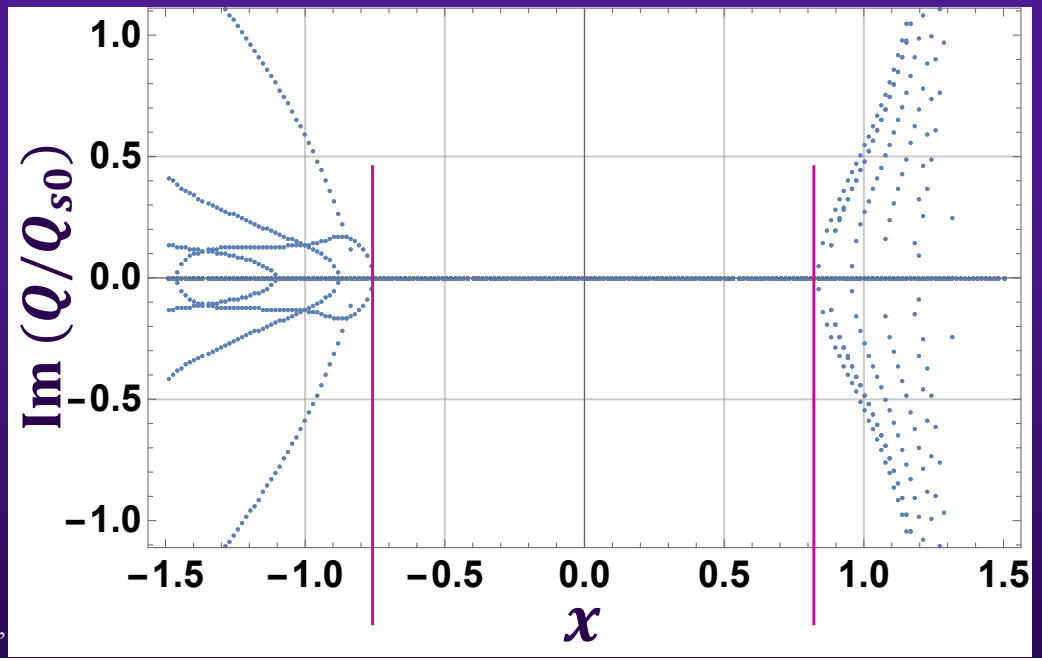




$$x_{th} \approx -0.75$$

# 1) GALACLIC => For PAD distribution (BUT computing PWD for PLD distribution …): $f_r\,\tau_b = 2.7$




Parabolic Line Density




$x_{th} \approx -0.75$

$x_{th} \approx +0.82$

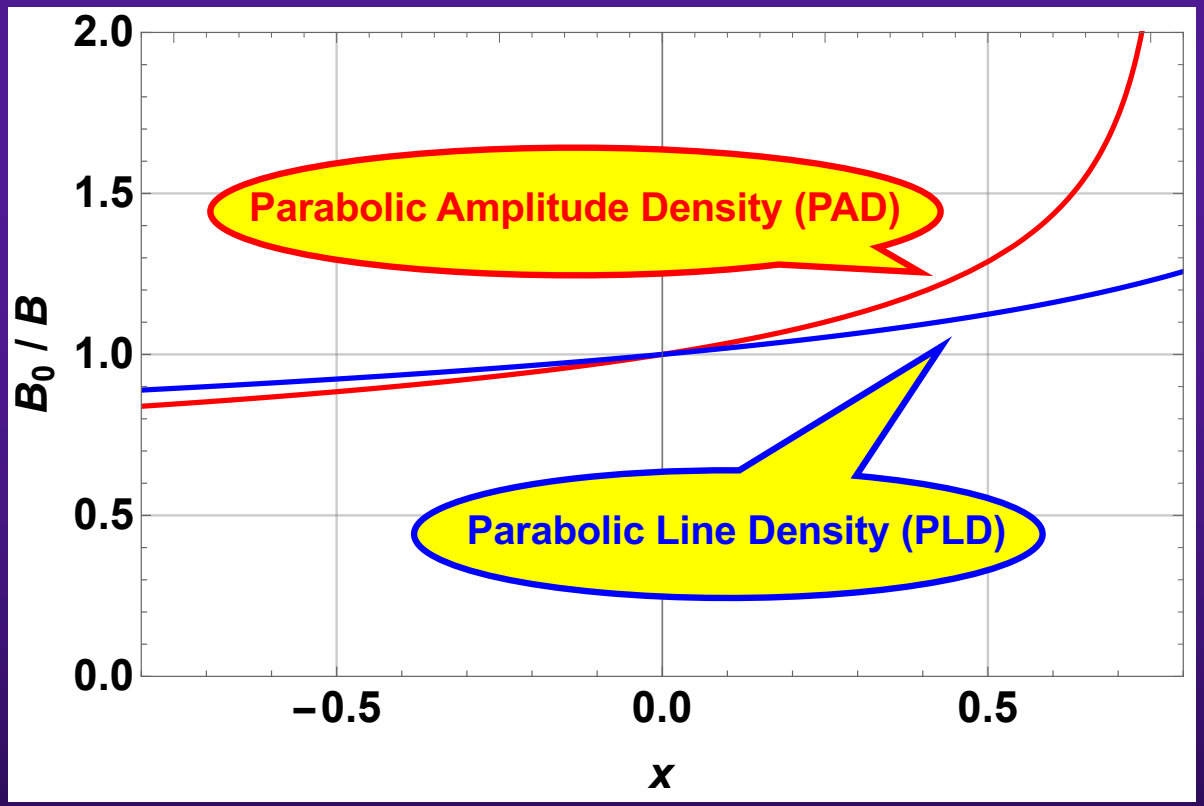
# 1) GALACLIC => $f_r\,\tau_b = 2.7$

$$N_b^{th} = \frac{|x_{th}|\,\pi^2}{4}\,\frac{B_0^3\,V_{RF}\,h}{e\,f_0\,\left|\frac{Z_l}{p}\right|_{p=0}}\,\frac{B_0}{B}$$

$$\frac{\sim 0.8\,\pi^2}{4} \approx 2$$

$$\left(\frac{B_0}{B}\right)_{PAD} = \left(1 - \frac{4}{\pi}x\right)^{-1/4}$$

$$\left(\frac{B_0}{B}\right)_{PLD} = \left(1 - \frac{3}{4}x\right)^{-1/4}$$




Above Transition

$N_b^{th}(-0.75)_{PAD} = 1.15\times10^{11}$ p/b

$N_b^{th}(-0.75)_{PLD} = 1.2\times10^{11}$ p/b

$N_b^{th}(+0.82)_{PAD} = \infty$

$N_b^{th}(+0.82)_{PLD} = 1.9\times10^{11}$ p/b

$\approx 1.6\,N_b^{th}(-0.75)_{PLD}$

Below Transition

# 2) SIMPLE FORMULA

- **Formula based (as in transverse) on the coupling between the 2 modes overlapping the peak of the real part of the impedance and taking into account the PWD for PLD => See http://cds.cern.ch/record/524139/files/ps-2001-063.pdf**

$$N_b^{th} = \frac{1}{0.4} \frac{B_0^3 V_{RF} h}{e f_0 \left|\frac{Z_l}{p}\right|_{p=0}} \frac{B_0}{B}$$

$$\left(\frac{B_0}{B}\right)_{PLD} = \left(1 \pm \frac{3}{4}\right)^{-1/4}$$

Above Transition

Below Transition

$$\frac{1}{0.4} \approx 2.5$$

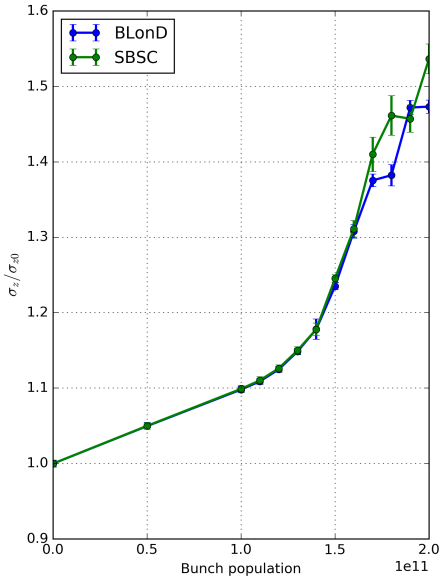
$$N_b^{th,AT} = 1.6 \times 10^{11} \text{ p/b}$$

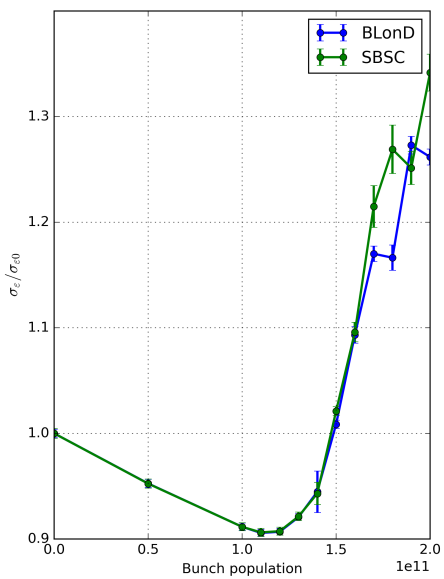
$$N_b^{th,BT} = 2.6 \times 10^{11} \text{ p/b} \approx 1.6\, N_b^{th,AT}$$

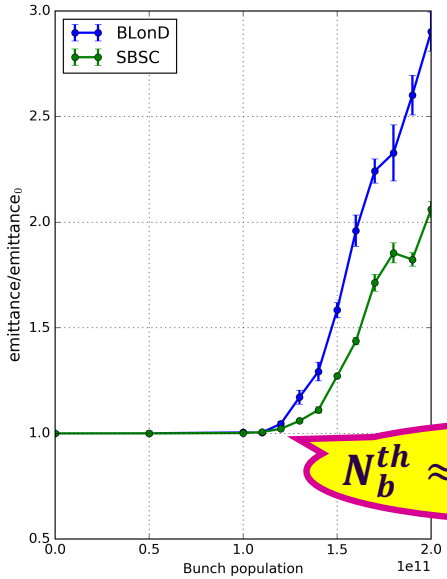
**=> It is the same as with GALACLIC (PWD with PLD) with $|x_{th}| = 1$ instead of ~ 0.8**

# 3) TRACKING CODES

## Above Transition

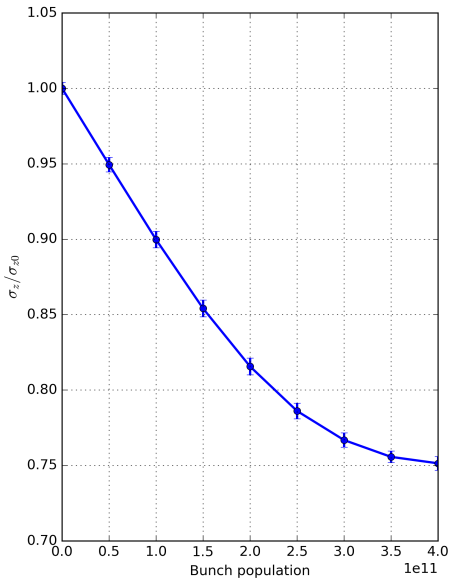


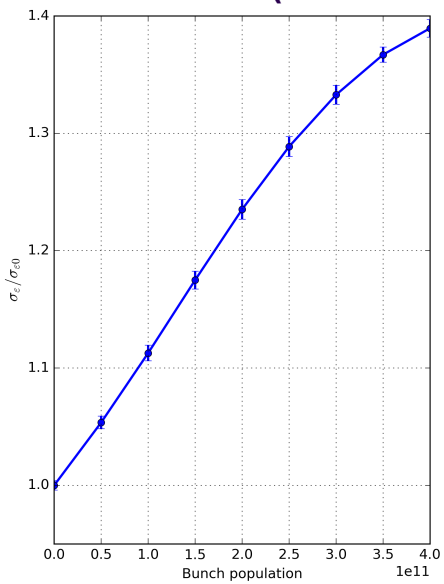



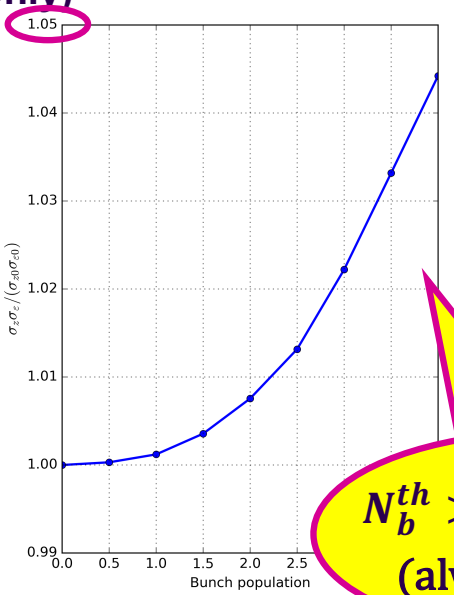




$N_b^{th} \approx 1.15\times10^{11}$ p/b

## Below Transition (BLonD only)




$N_b^{th} > 4\times10^{11}$p/b? (always stable?)

# CONCLUSION (1/2)

- **PWD**

| Bunch length variation for $10^{11}$ p/b [%] | Above Transition | Below Transition |
|---|---|---|
| Tracking codes | + 10 (BLonD and SBSC) | - 10 (BLonD only) |
| GALACLIC (PAD) | + 16 | - 19 |
| GALACLIC (PLD) | + 10 | - 11 |
| Simple formula (has same scaling) | + 10 | - 11 |

  - **Very good agreement between Tracking codes, GALACLIC and simple formula with PLD**

# CONCLUSION (2/2)

- **Instability threshold**

| Bunch intensity threshold [$10^{11}$ p/b] | Above Transition | Below Transition |
|---|---|---|
| Tracking codes | 1.15 (BLonD and SBSC) | > 4 (always stable?) (BLonD only) |
| GALACLIC (PAD+PAD) | 1.15 | ∞ |
| GALACLIC (PAD+PLD) | 1.2 | 1.9 (= 1.2 × 1.6) |
| Simple formula (has same scaling) | 1.6 | 2.6 (= 1.6 × 1.6) |

  - **Very good agreement between Tracking codes and GALACLIC above transition => *Next: check mode-coupling pattern***
  - **Simple formula reveals same scaling but slightly larger (by ~ 30-40%) numerical factor**
  - **Case below transition needs more analysis, checks, etc.**
    - **A threshold was observed in the past with HEADTAIL in good agreement with simple formula (see http://emetral.web.cern.ch/emetral/LMCI_ATandBT.pdf)**
    - **All analyses reveal however larger intensity threshold BT vs. AT**