

# **A Non-Linear Description of the Bias Dependent Parasitic Resistances of Quarter Micron MOSFETs**

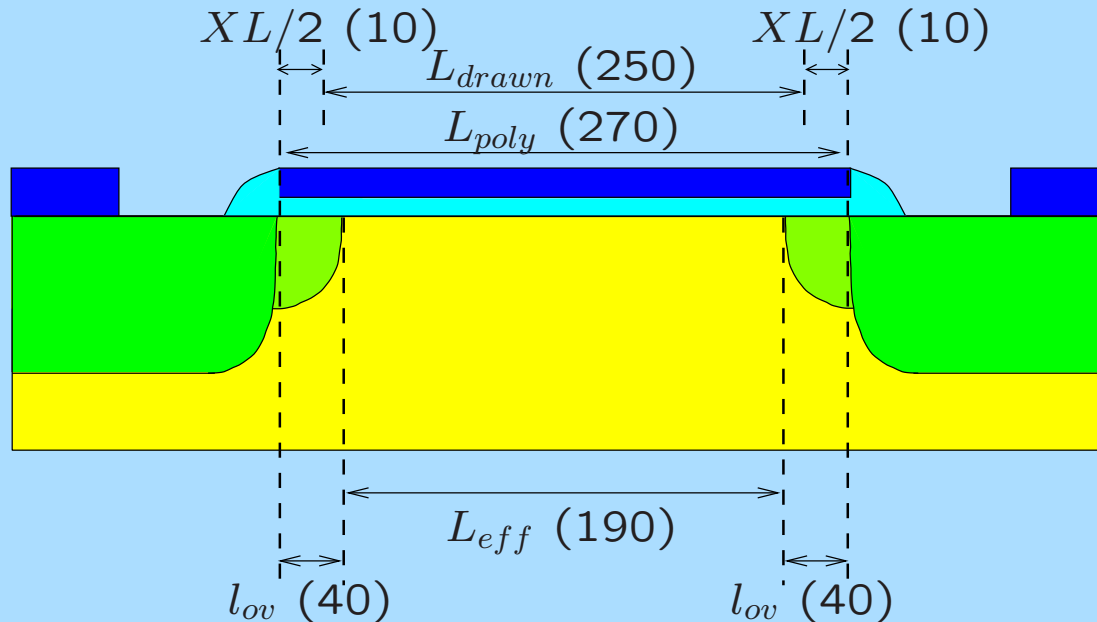
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## Motivation



BSIM3 V3.1:  $XL = 0 \Rightarrow dL \neq l_{ov} \Rightarrow L_{int}$  is fitting

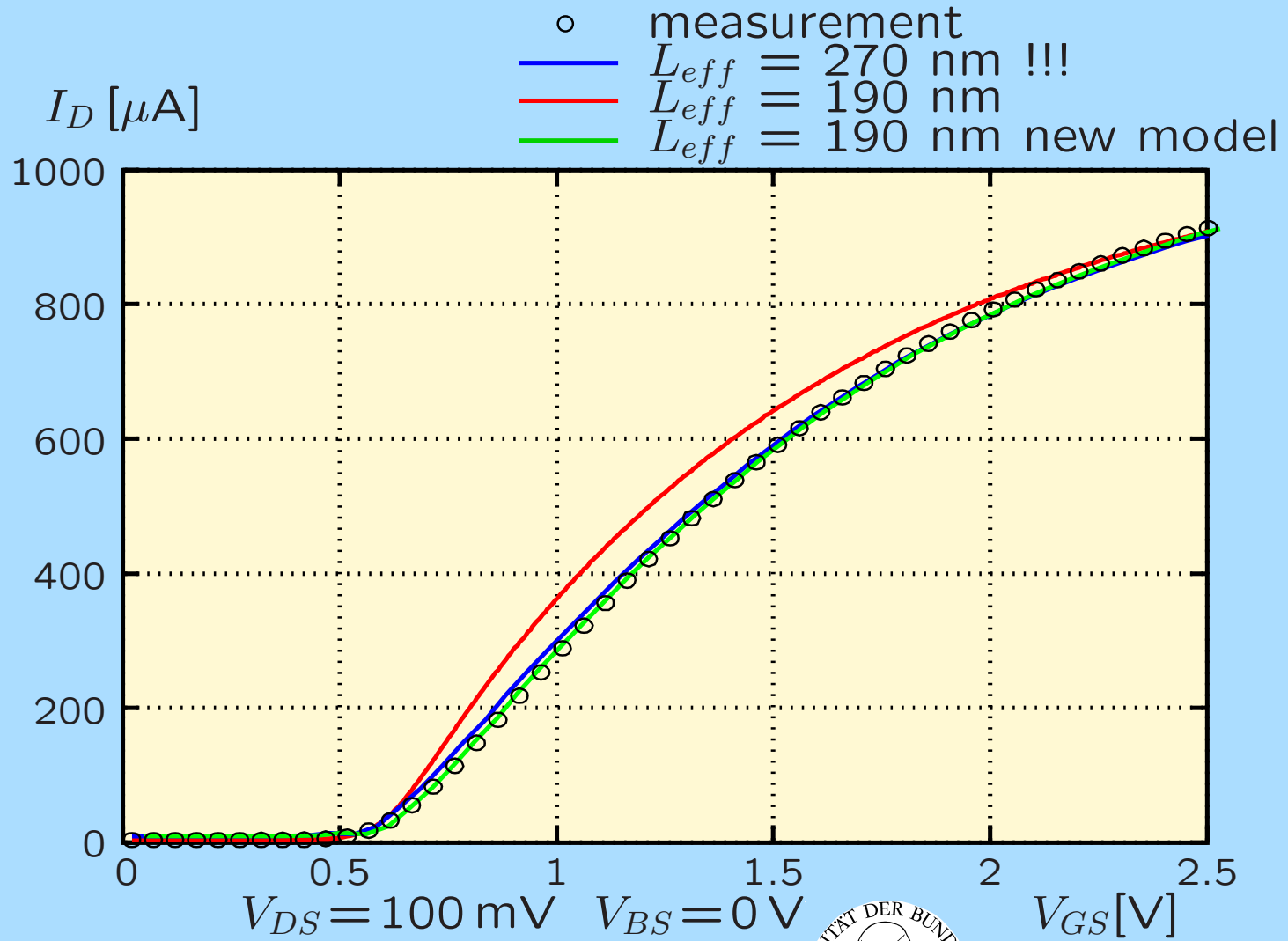
DC:  $L_{eff} = L_{drawn} - 2 dL = L_{drawn} - 2 (L_{int} + \dots)$

AC:  $L_{active} = L_{drawn} - 2 (DLC + \dots)$

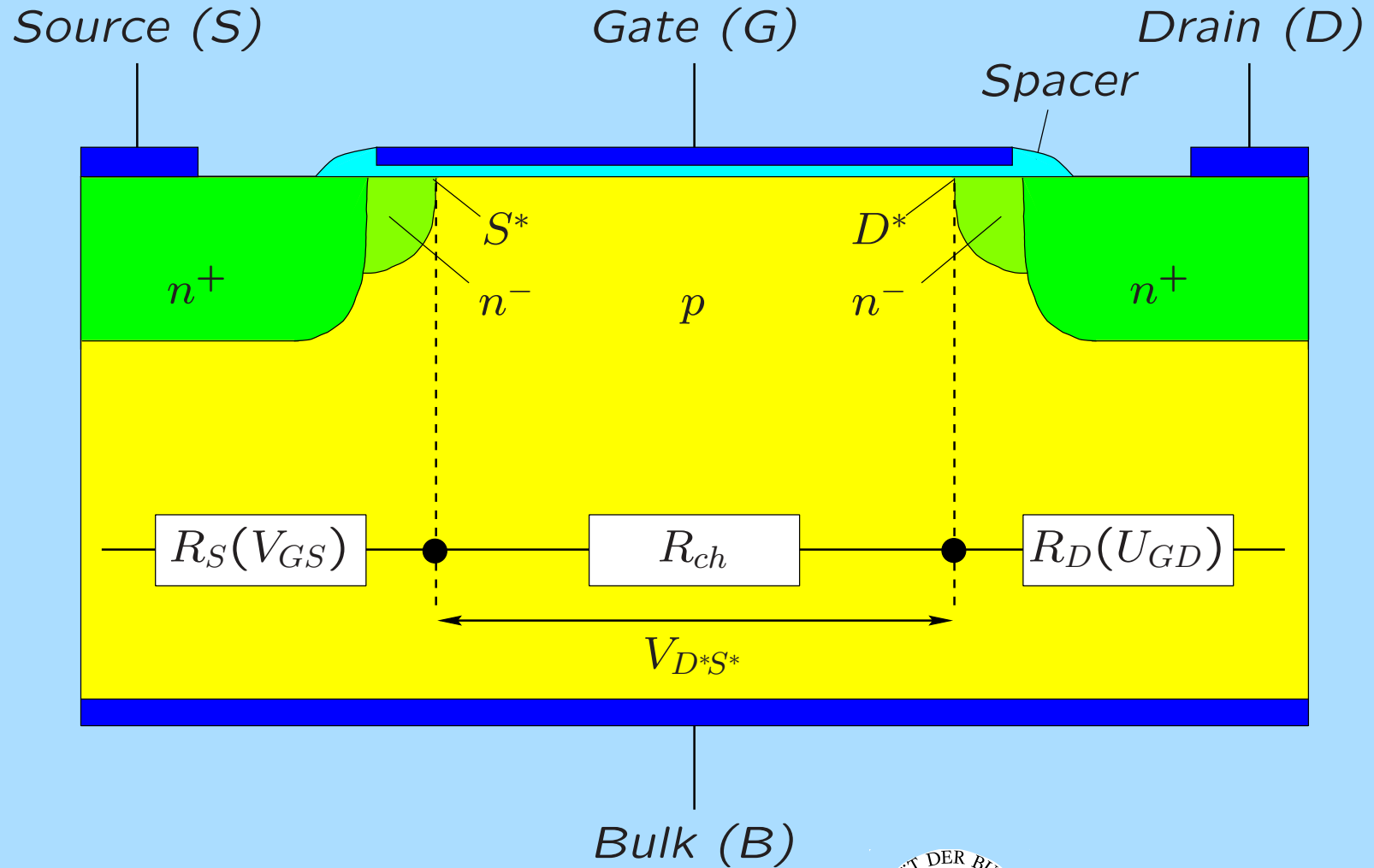
extraction:  $L_{int} = -10\text{nm}$   
 $DLC = 50\text{nm}$  (30)

physical model:  $L_{active} \stackrel{!}{=} L_{eff}$

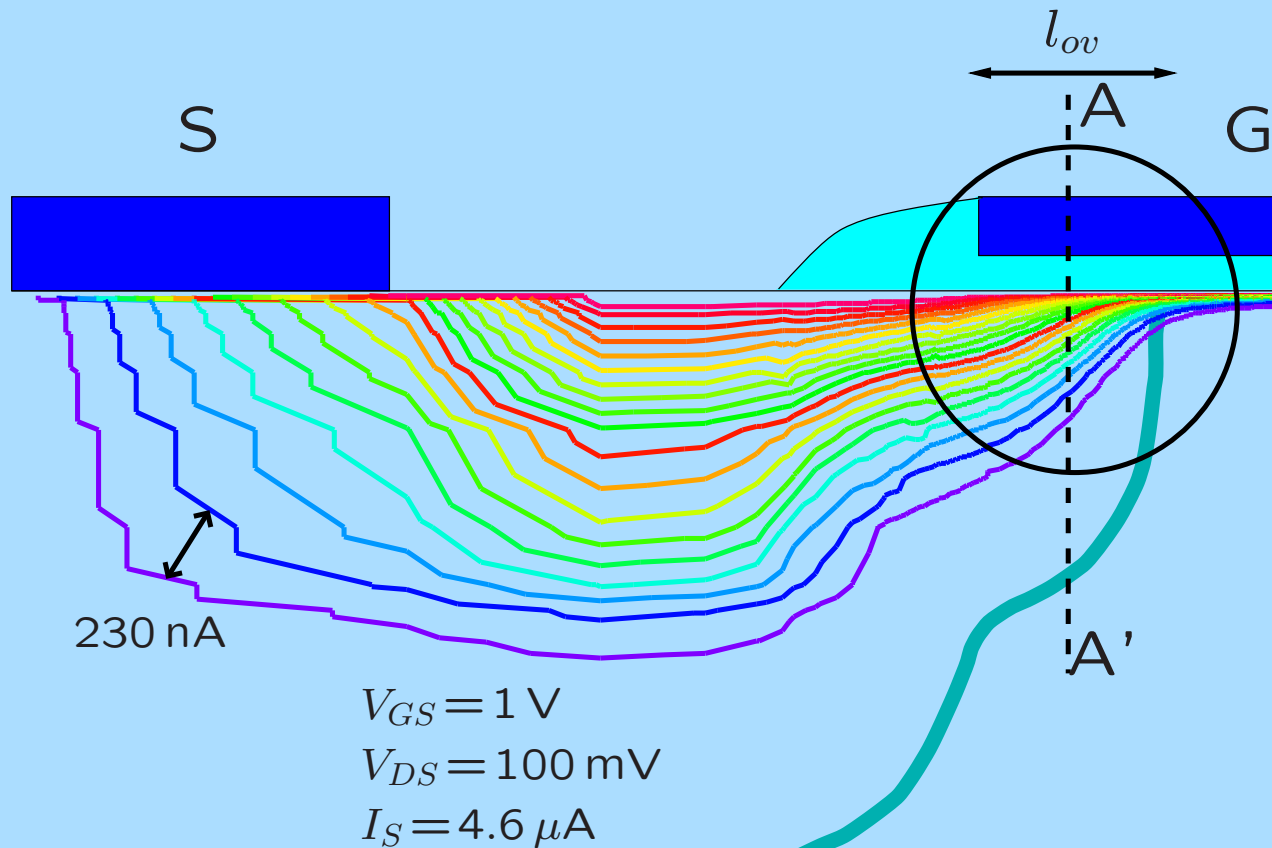
# Measurement and Parameter Extraction



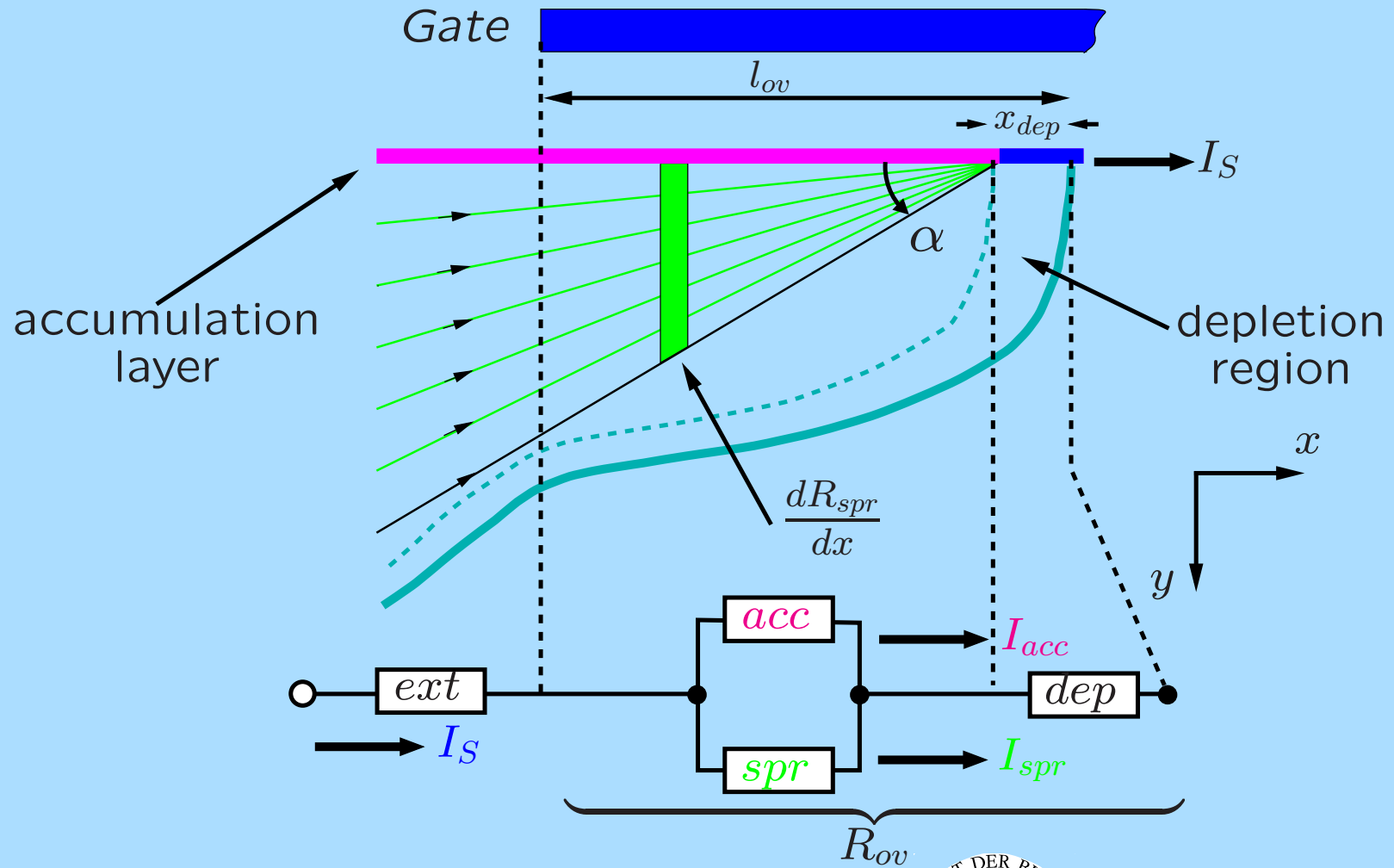
# Inner and Outer Transistor



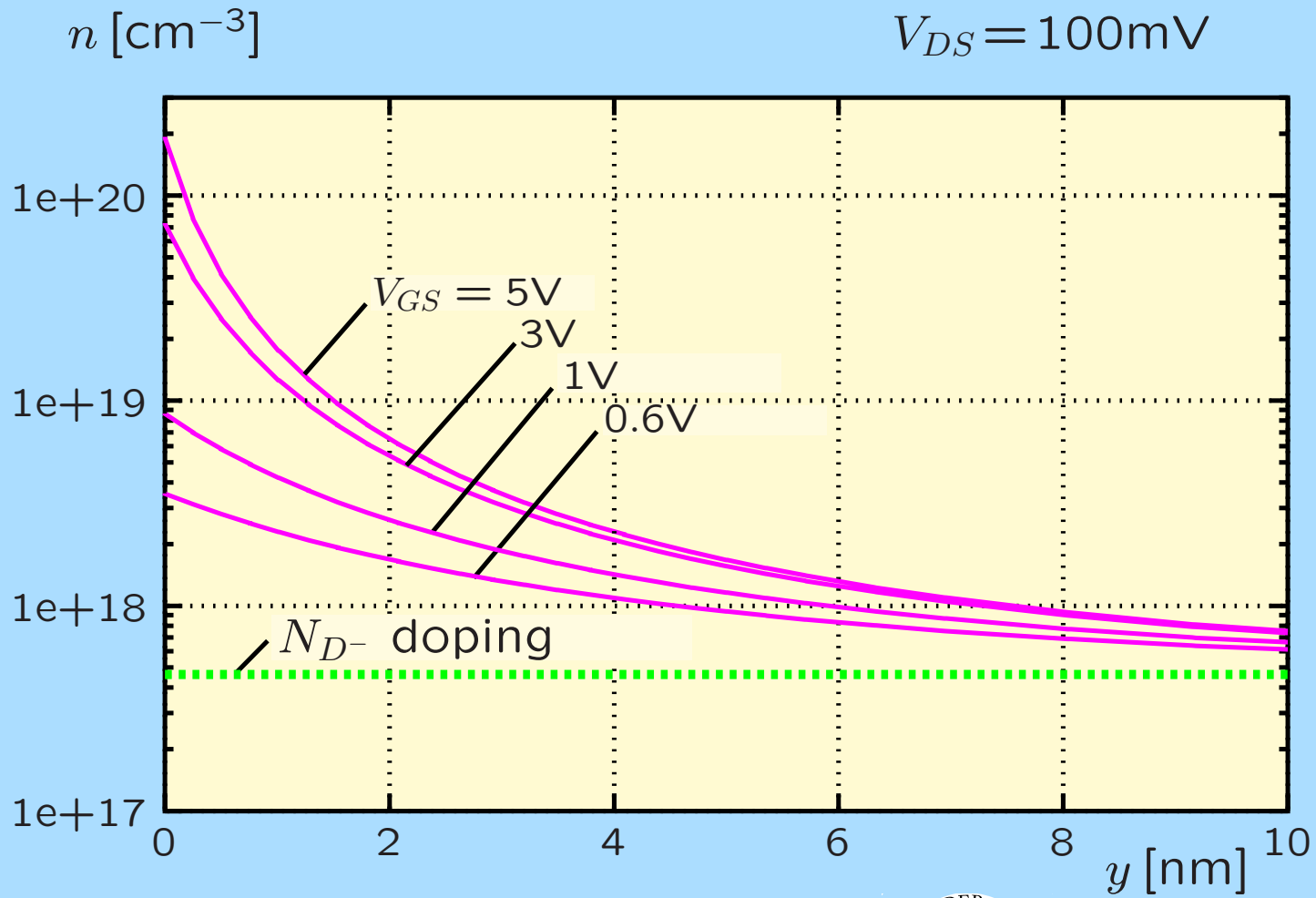
## Current Pathes in the Source



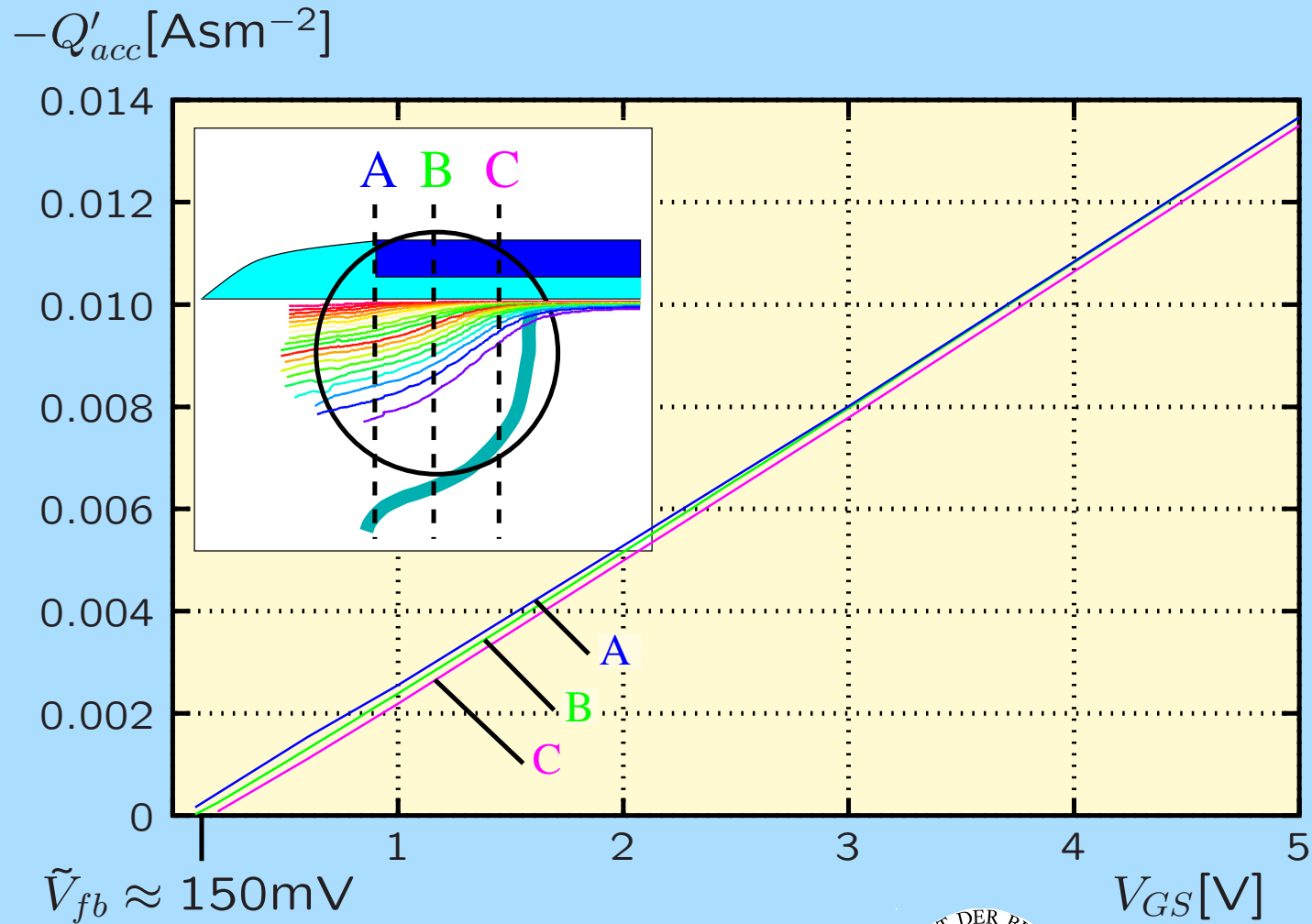
# Model Scheme



# Electron Accumulation

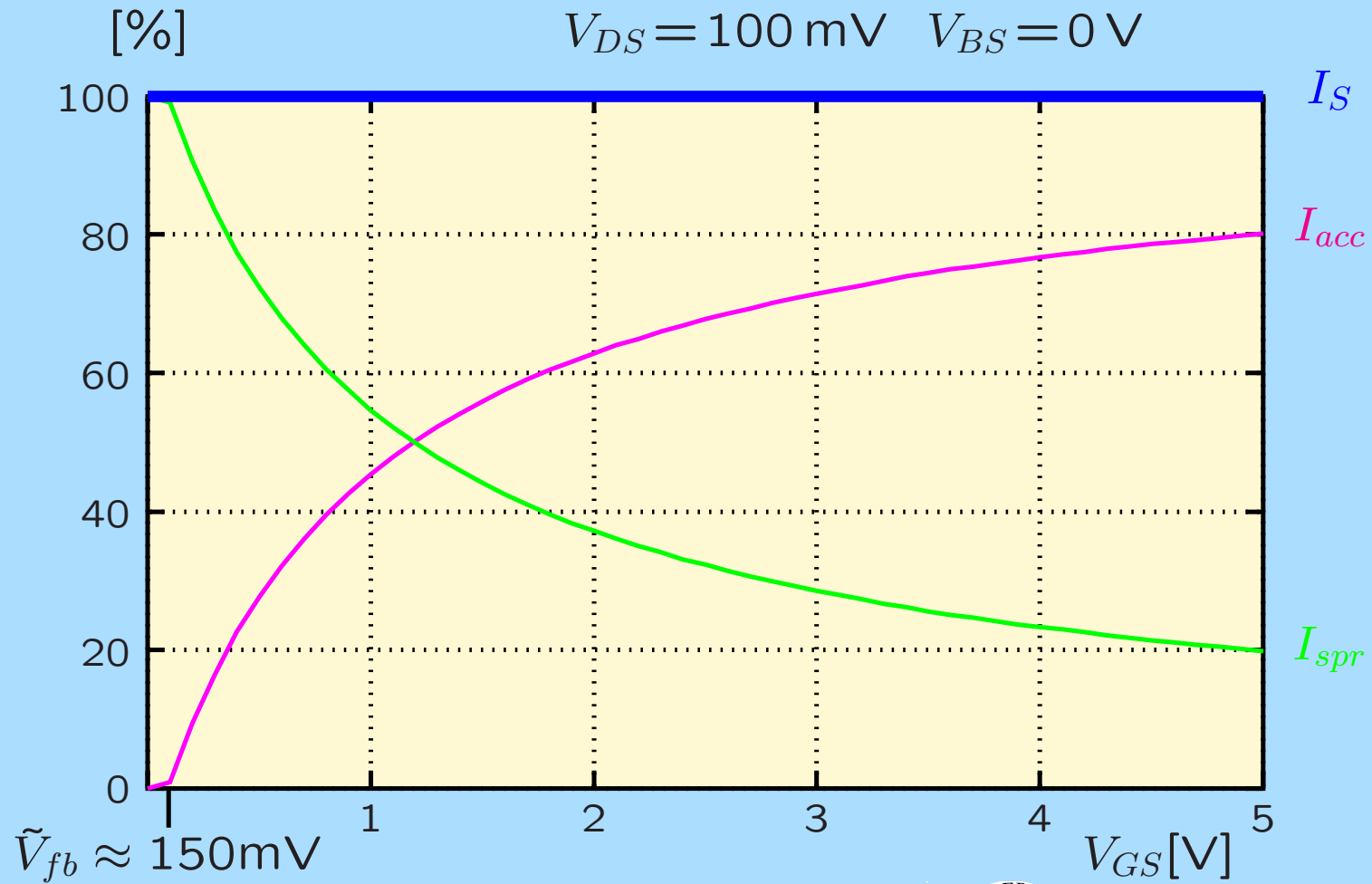


# Integrated Electron Accumulation

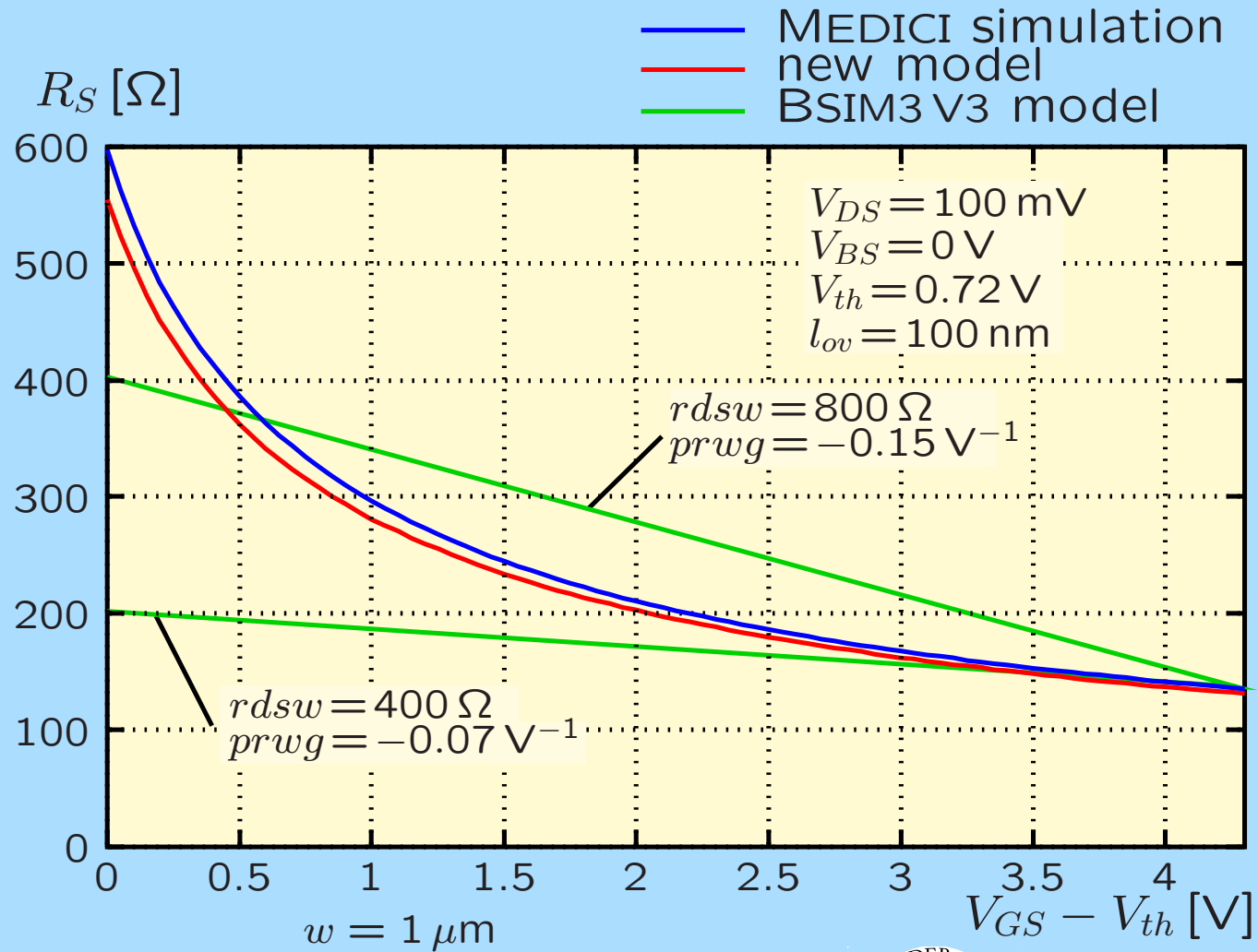




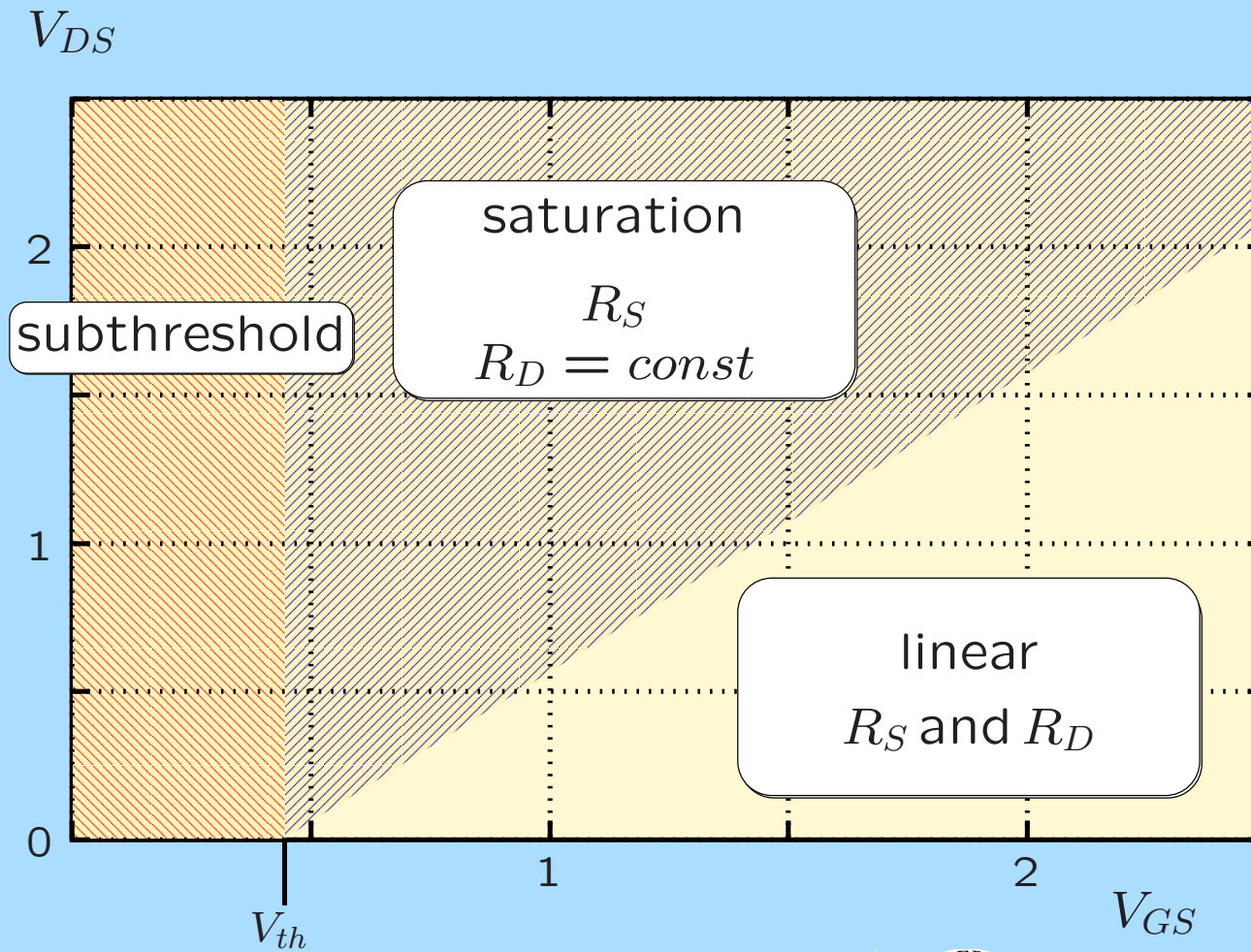
# Accumulation and Spreading Current



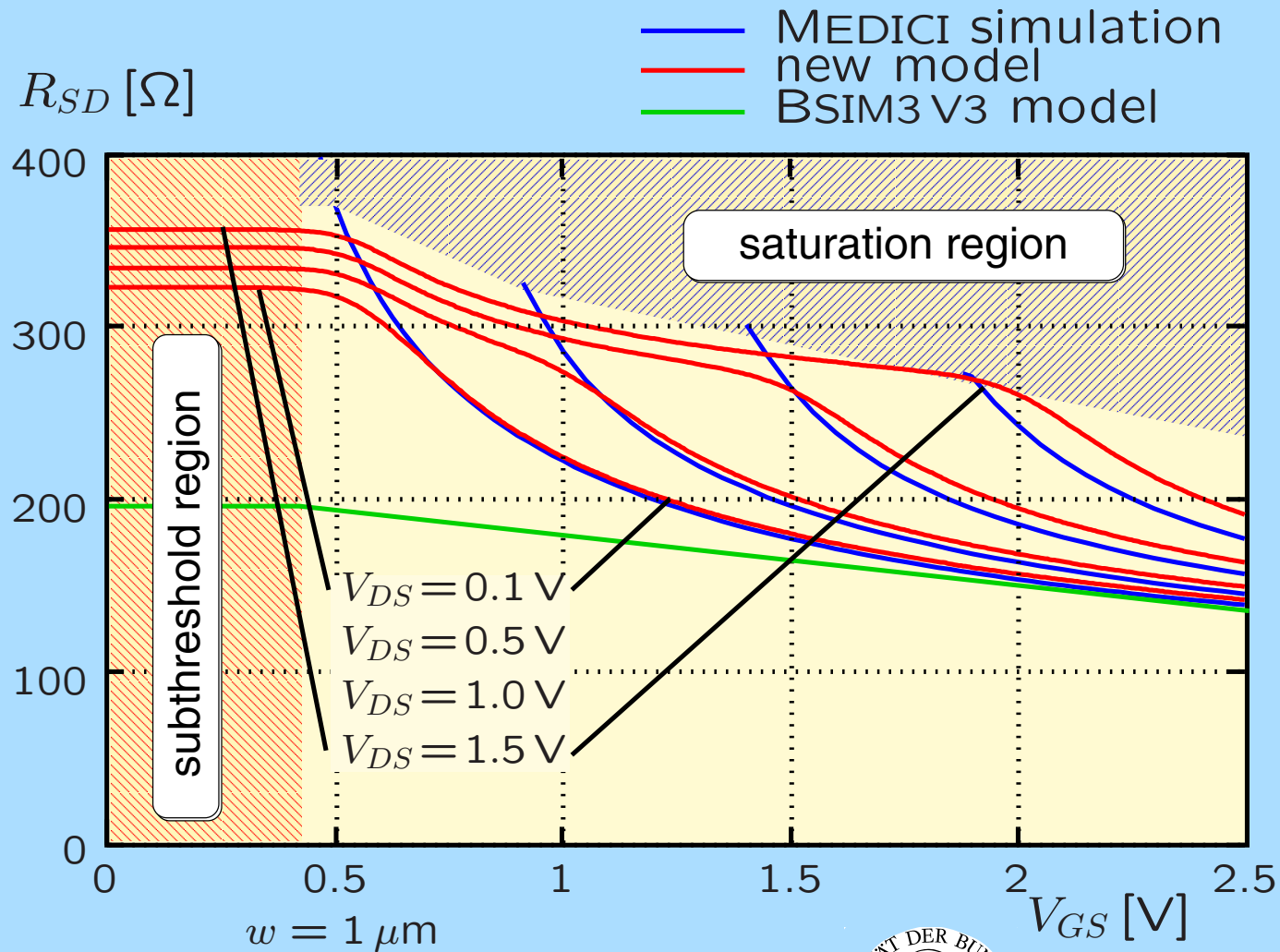
## Source Resistance



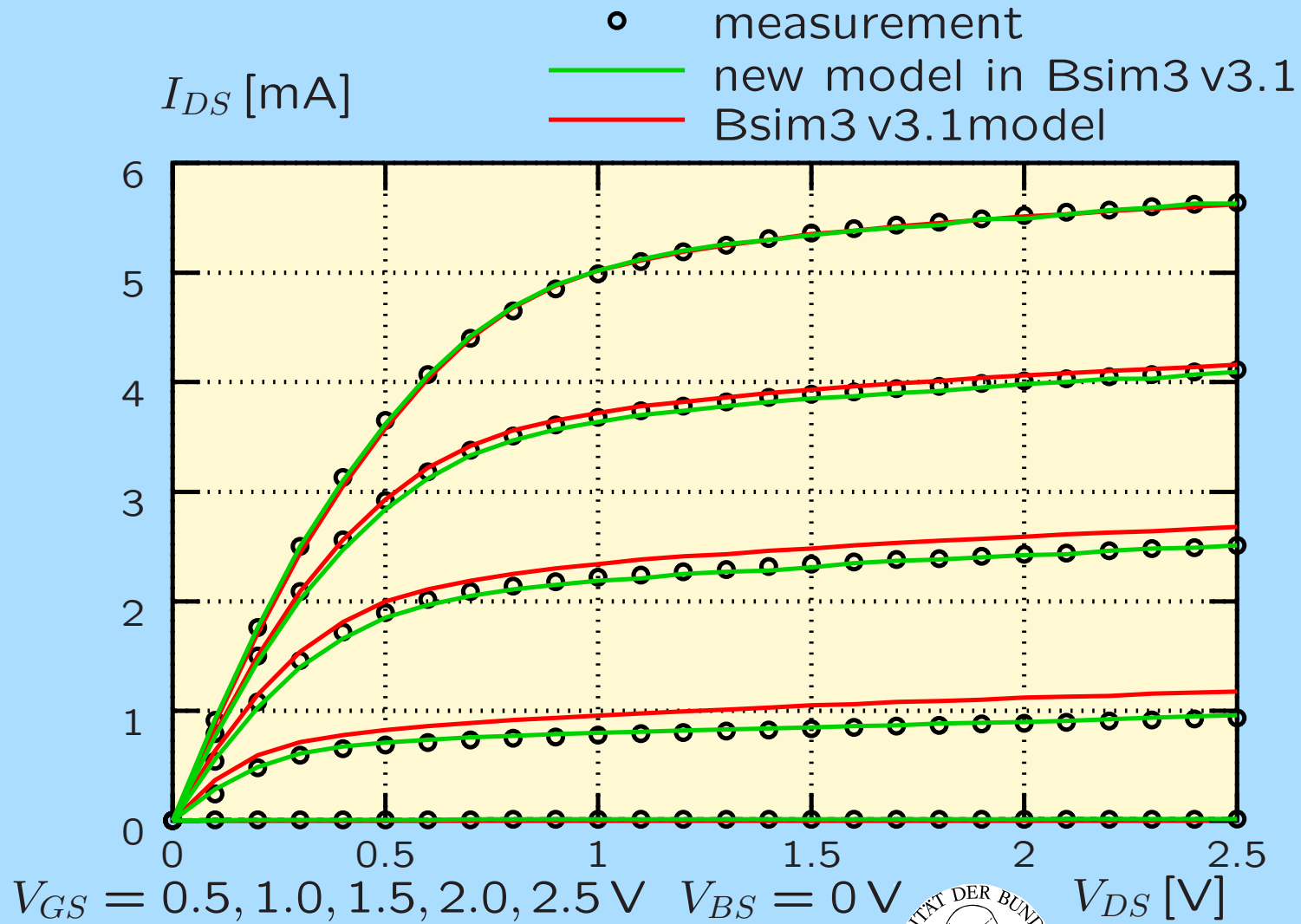
## Regions of Interesting Biases



## Source and Drain Resistances



# Output Characteristic



## Conclusion

- Increasing importance of parasitic resistances
- New physics based resistance model
  - separation of accumulation/spreading components
  - geometric parameters, no fittings
- Consistent AC/DC description of Bsim3 v3.x
  - $L_{CH}$  as channel length for both DC *and* AC
  - $L_{int} \stackrel{!}{=} l_{ov}$
- $V_{GS} \rightarrow V_{GS}^* = V_{GS} - I_S \cdot R_S$

## Model equations

$$R_S = R_{ext} + \left( \frac{1}{R_{acc}} + \frac{1}{R_{spr}} \right)^{-1} + R_{dep} \quad (1)$$

$$R_{acc}(V_{GS}) = \frac{l_{ov} - x_{dep}}{w\mu_n C'_{ox} (V_{GS} - \tilde{V}_{fb})} \quad (2)$$

$$R_{dep}(V_{GS}, V_{BS}) = \frac{x_{dep}}{w\mu_n C'_{ox} (V_{GS} - \tilde{V}_{fb})} \quad (3)$$

$$x_{dep} = \sqrt{\frac{2 \varepsilon_0 \varepsilon_{si}}{q \bar{N}_D \left( 1 + \frac{\bar{N}_D}{N_A} \right)} \left( -V_{BS} + \phi_t \ln \frac{N_A \bar{N}_D}{n_i^2} \right)} \quad (4)$$

$$\left( \frac{1}{R_{acc}(V_{GS})} + \frac{1}{R_{spr}} \right)^{-1} = \frac{1}{w\mu_n} \int_{x=0}^{x=l_{ov}-x_{depl}} \frac{1}{C'_{ox} (V_{GS} - \tilde{V}_{fb}) + q \bar{N}_D \tan \alpha \cdot x} dx \quad (5)$$

$$= \frac{1}{w\mu_n q \bar{N}_D \tan \alpha} \ln \left( 1 + \frac{q \bar{N}_D \tan \alpha (l_{ov} - x_{dep})}{C'_{ox} (V_{GS} - \tilde{V}_{fb})} \right) \quad (6)$$

$$R_D \sim R_S (V_{GS} \Rightarrow V_{GD}) \quad (7)$$