A Physics Based Resistance Model of the Overlap Regions in LDD-MOSFETs

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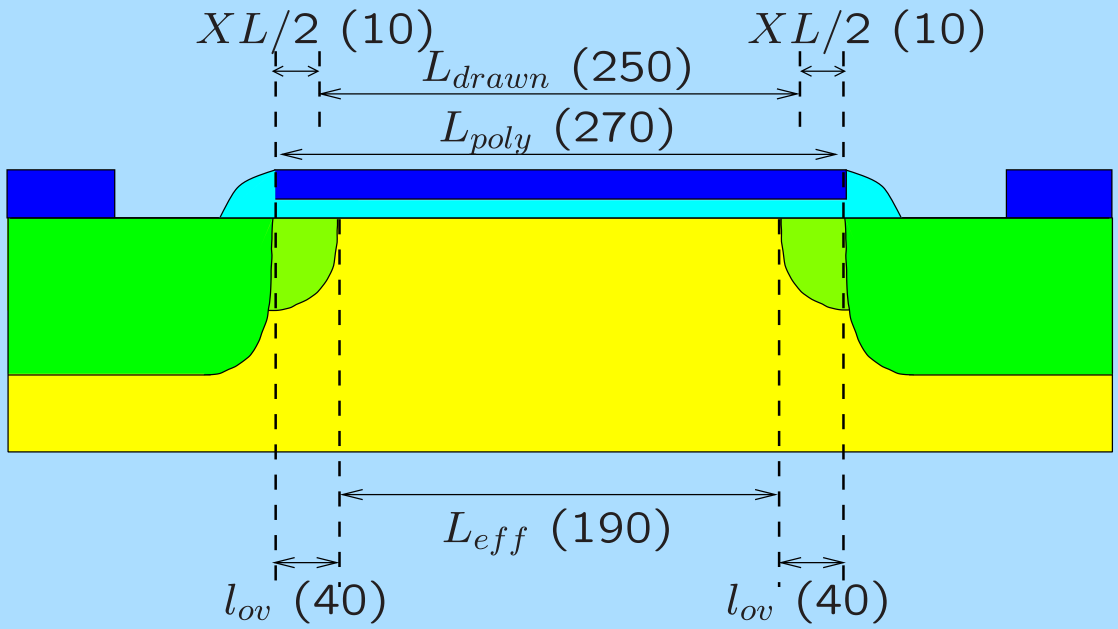
Motivation



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

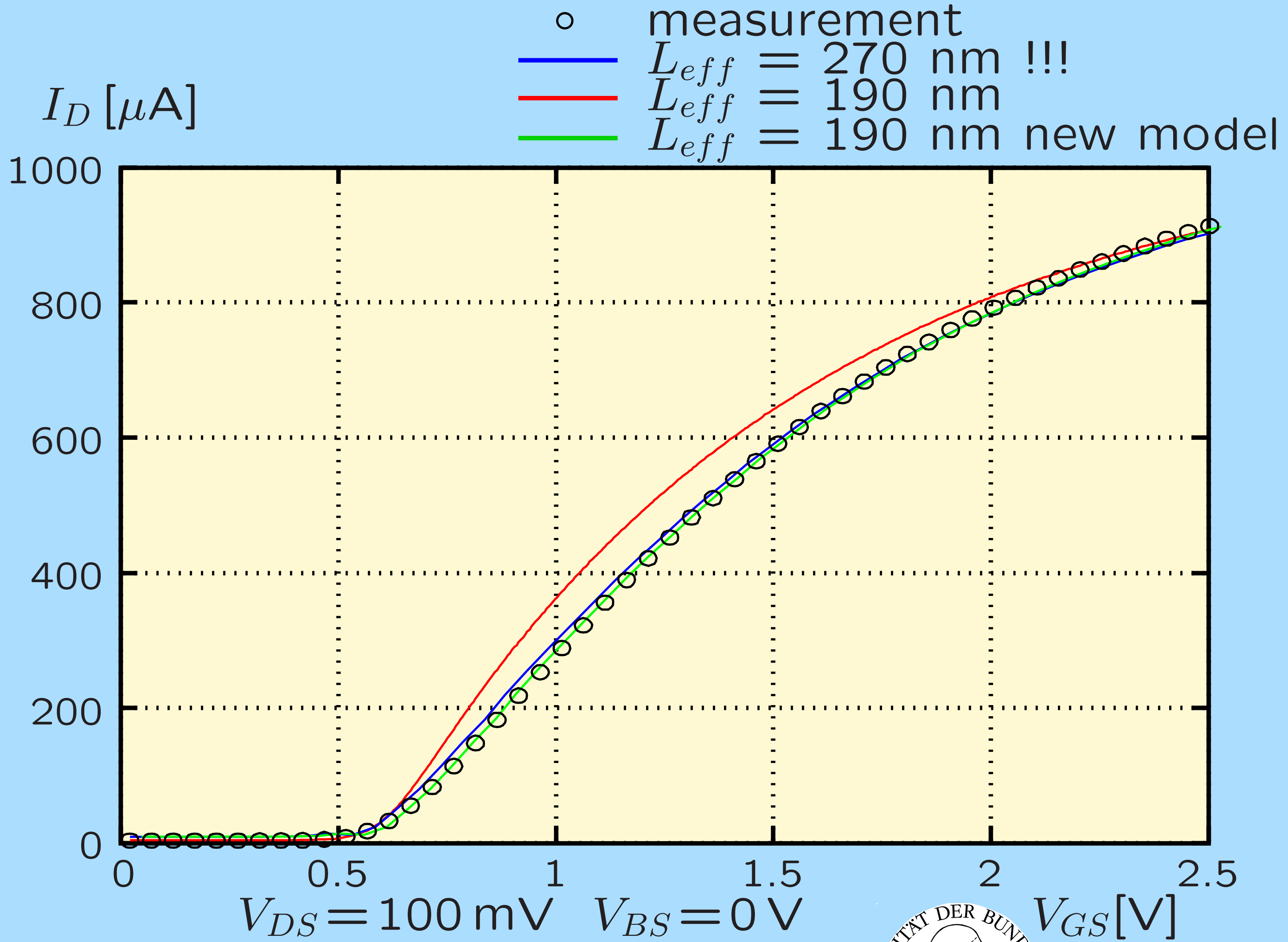
DC: $L_{eff} = L_{drawn} - 2\,dL = L_{drawn} - 2\,(L_{int} + \ldots)$

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

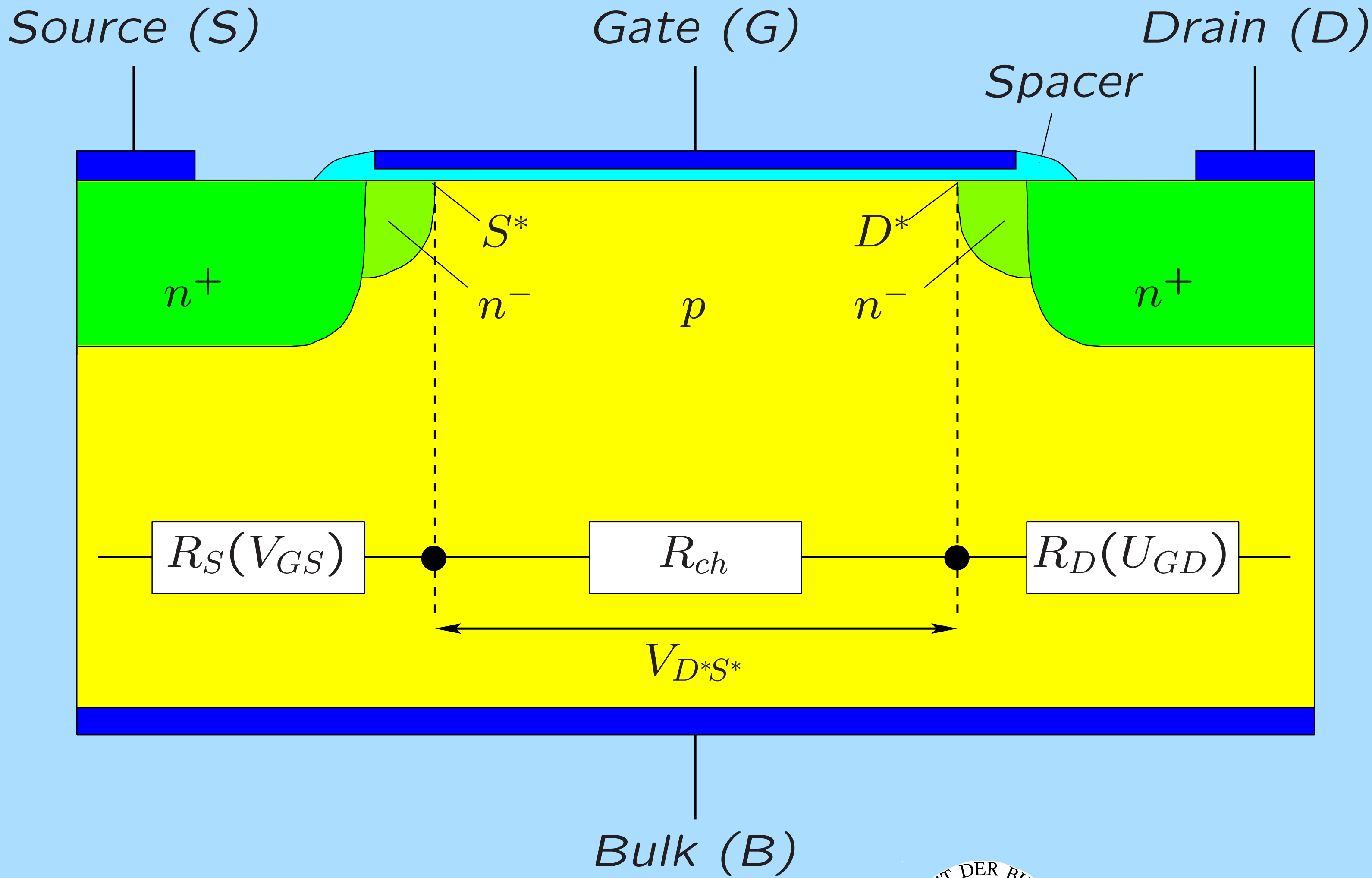
extraction: $L_{int} = -10\text{nm}$ (30)
$DLC = 50\text{nm}$

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

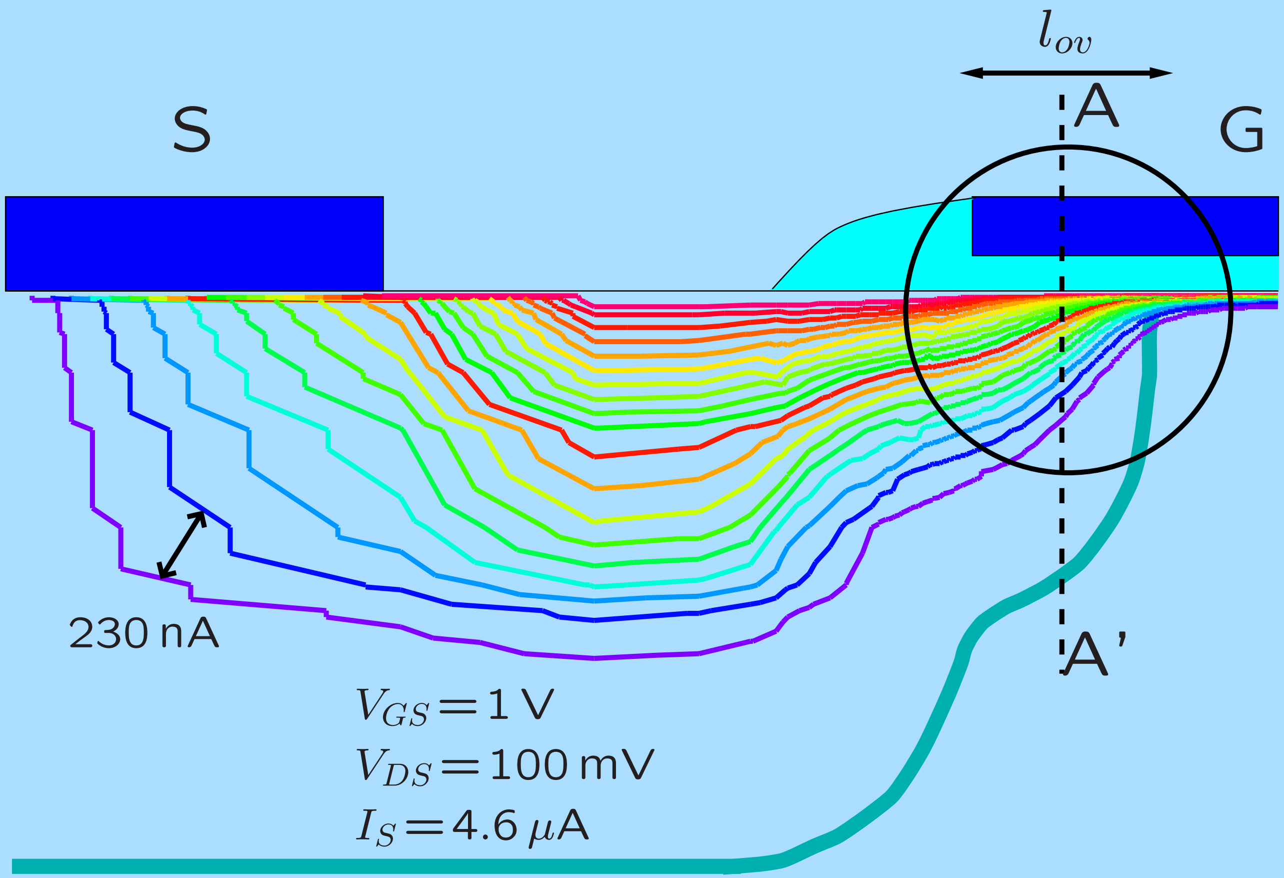
Measurement and Parameter Extraction



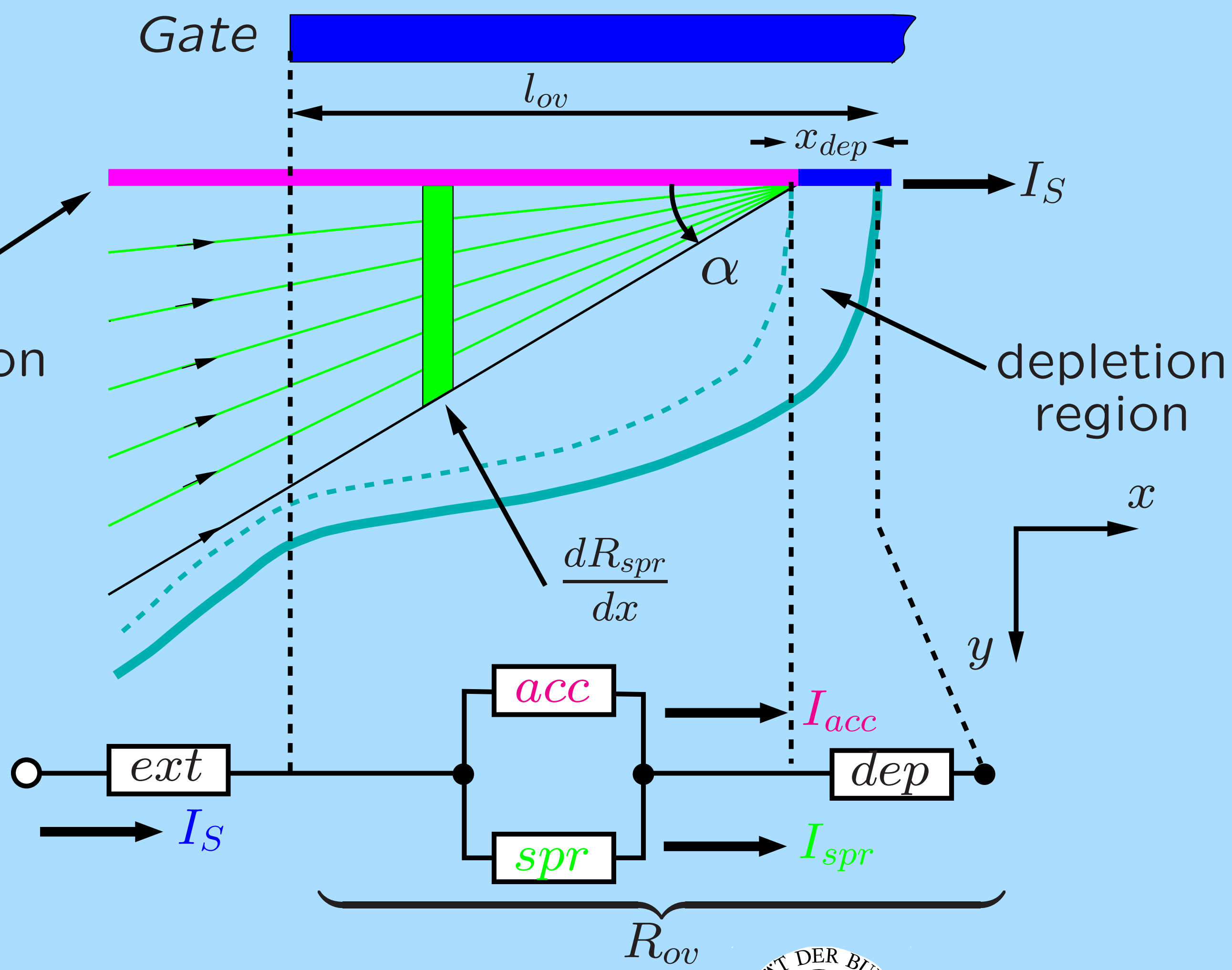
Inner and Outer Transistor



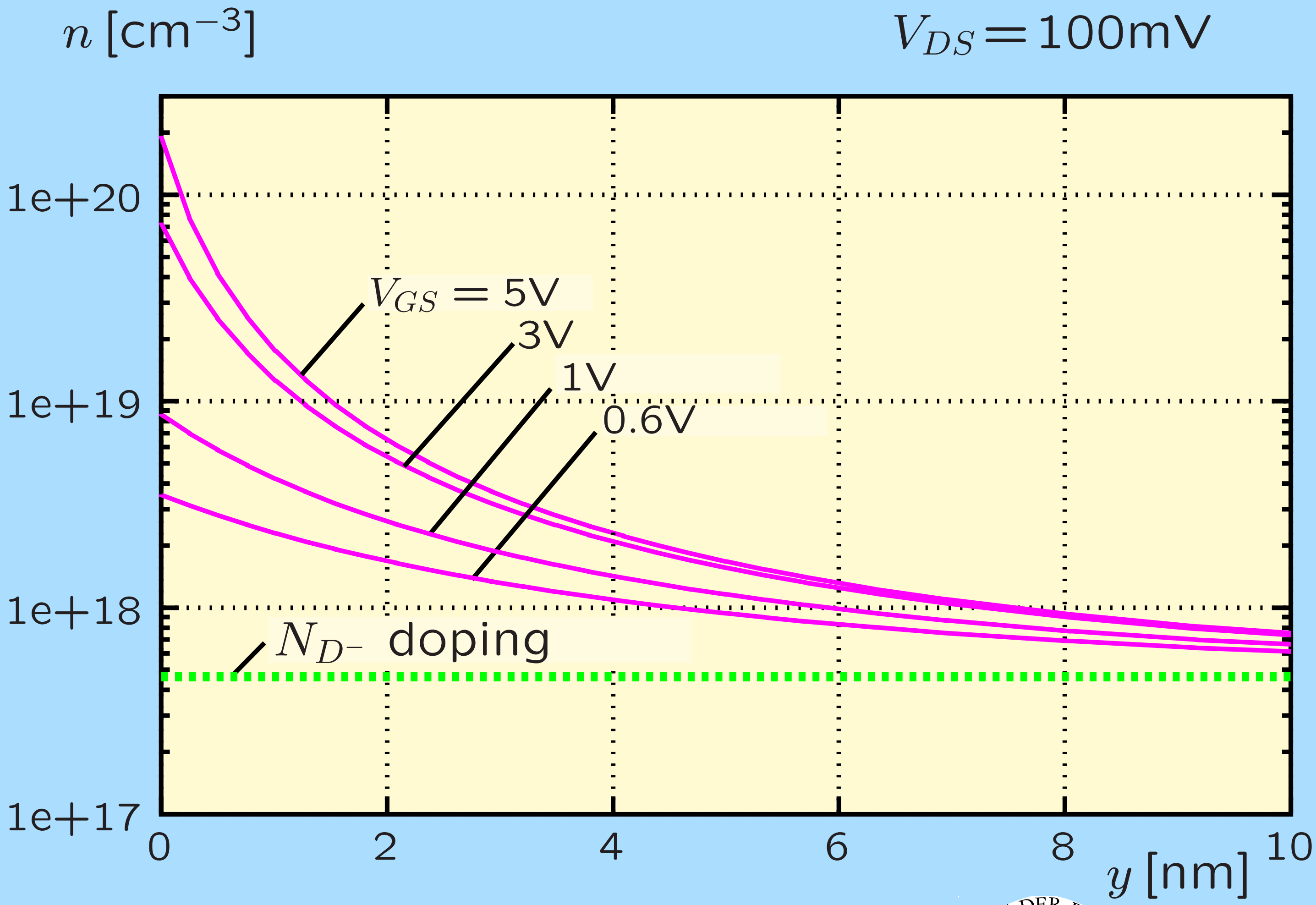
Current Pathes in the Source



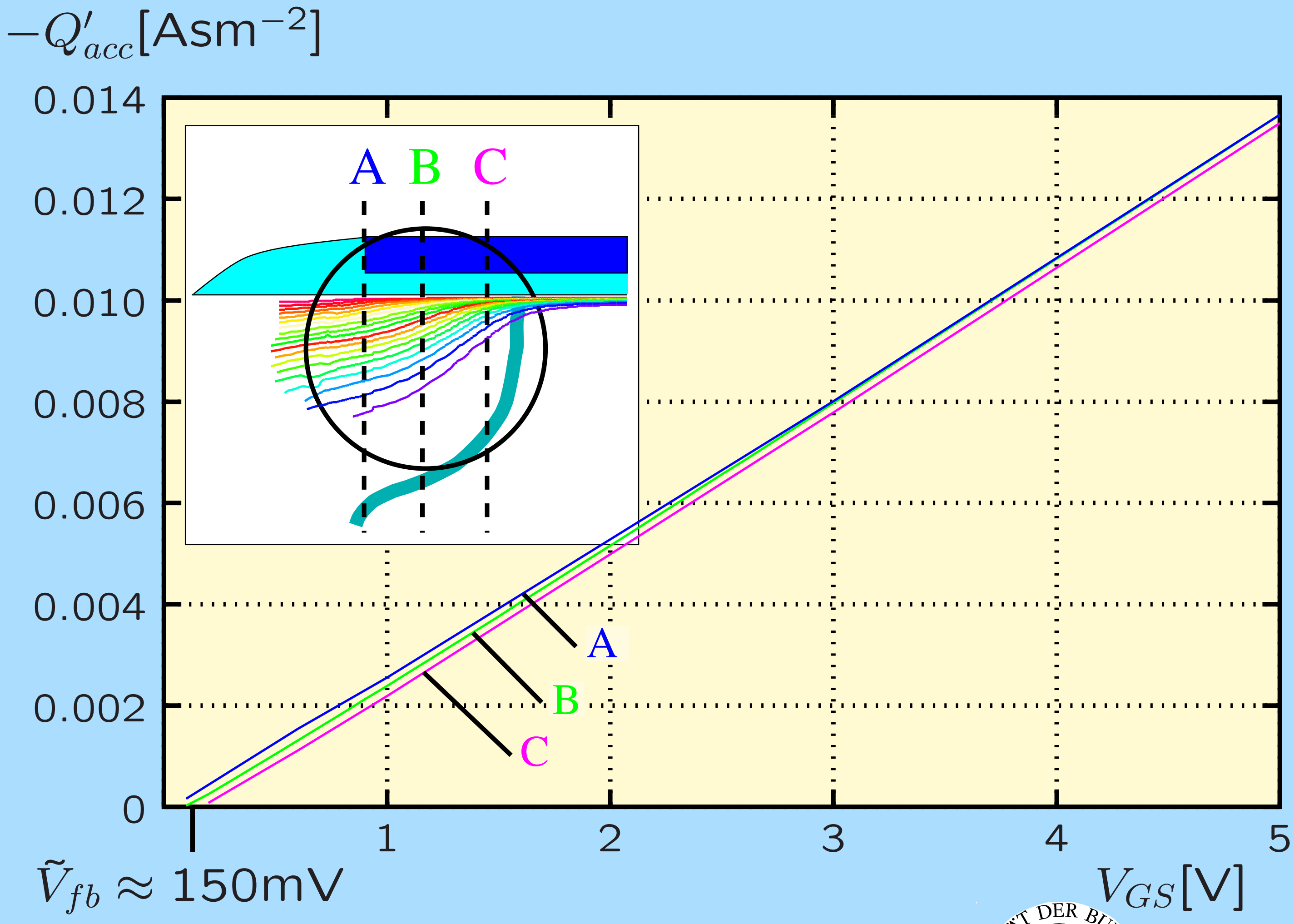
Model Scheme



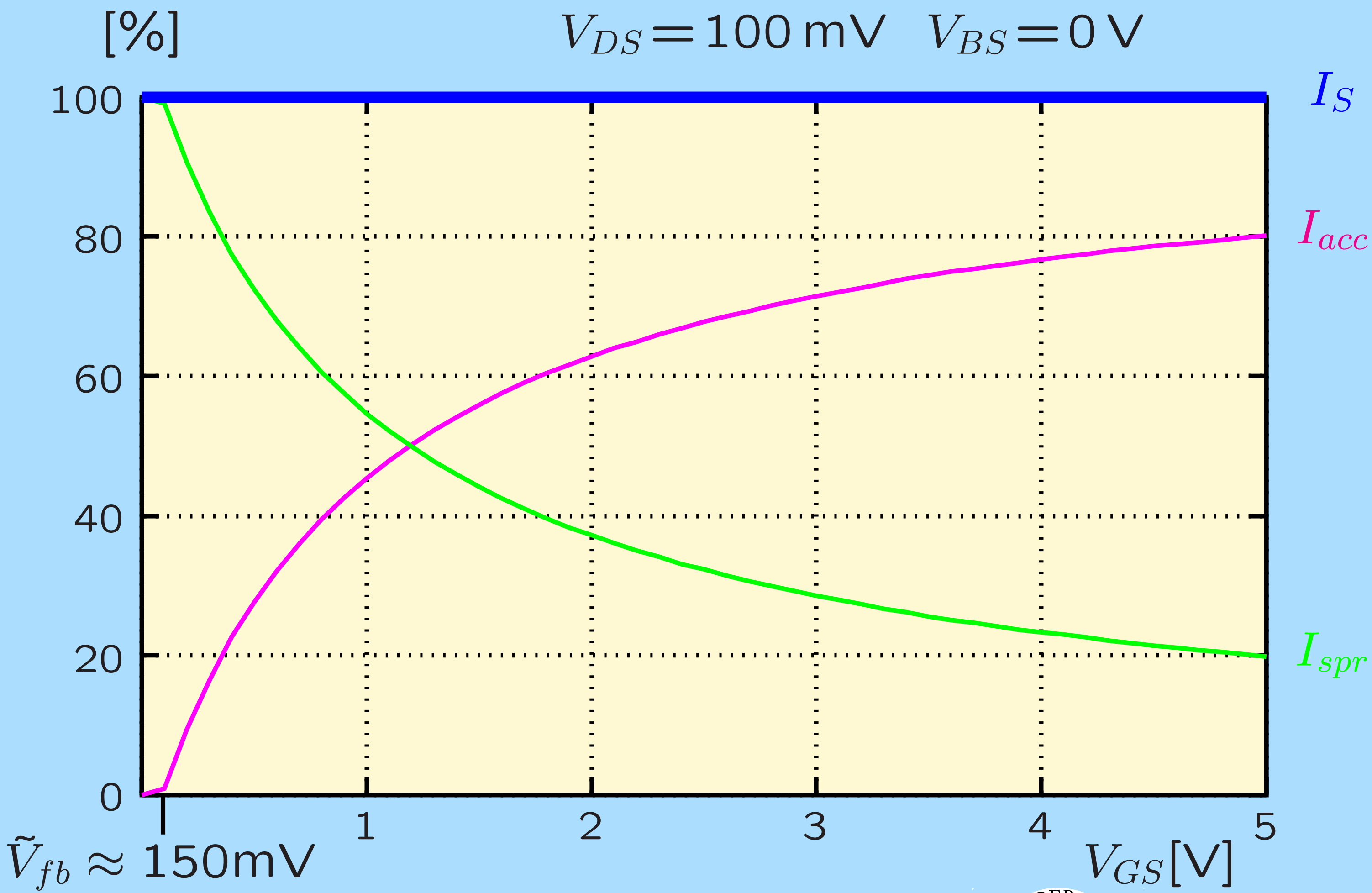
Electron Accumulation



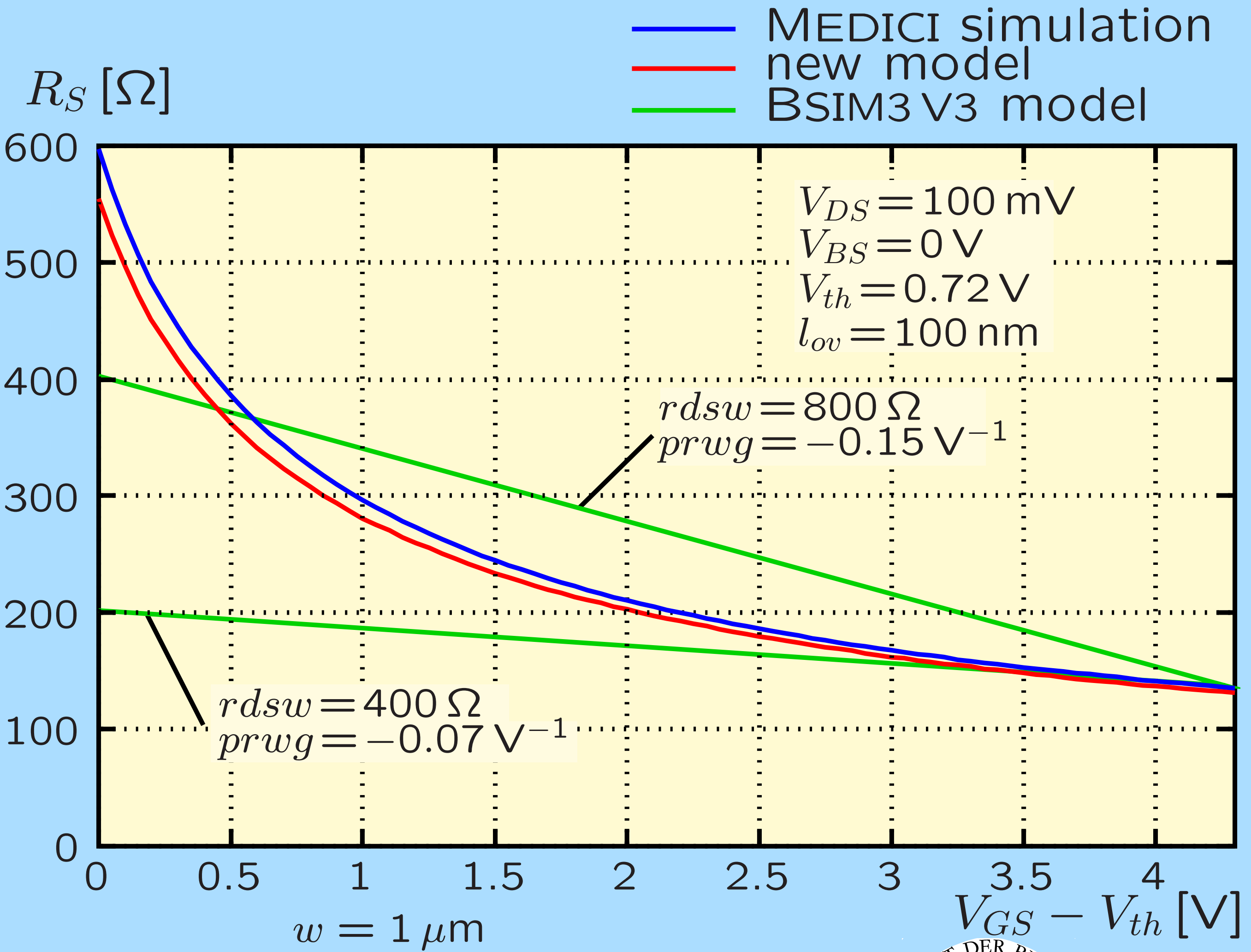
Integrated Electron Accumulation



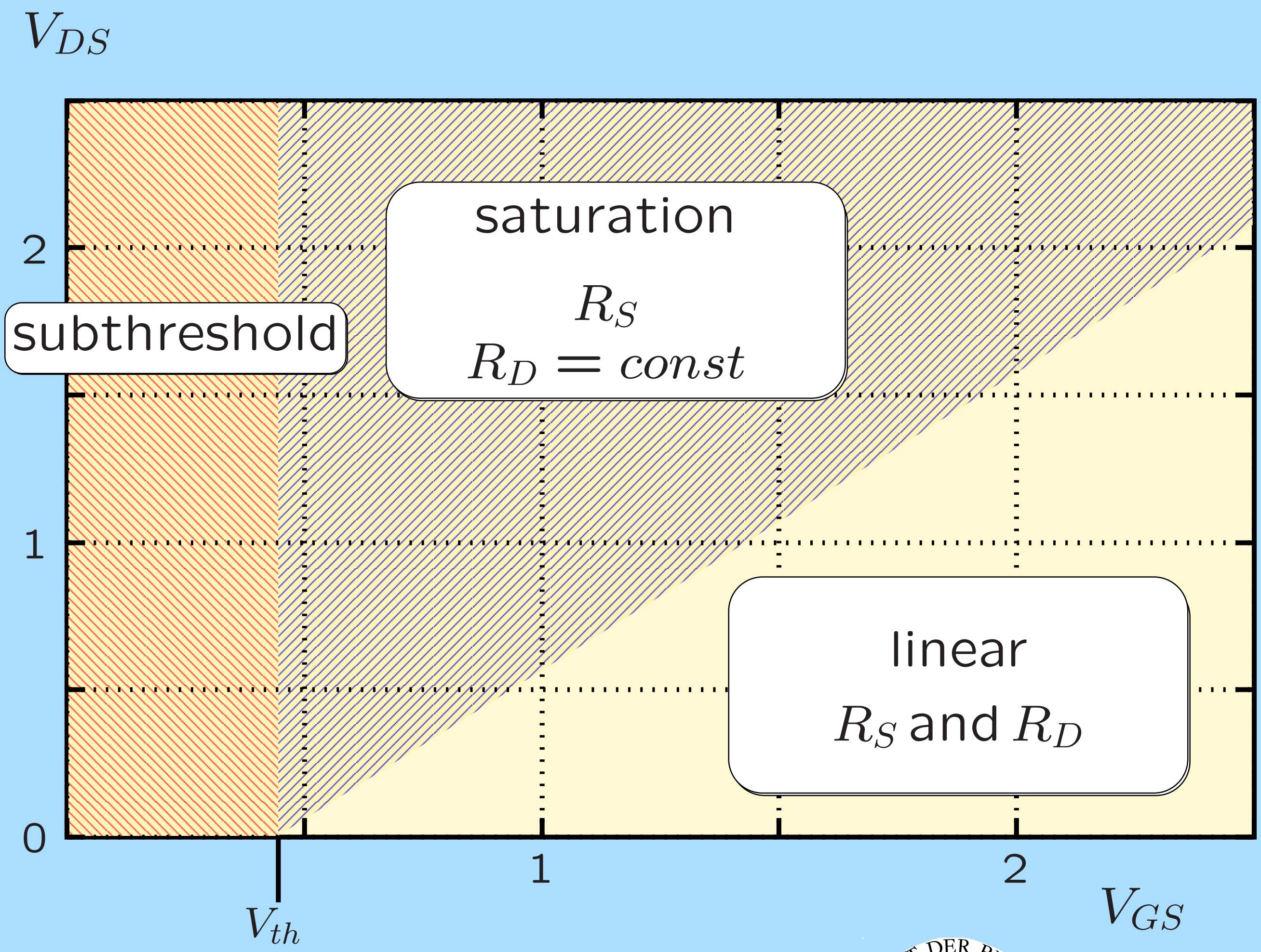
Accumulation and Spreading Current



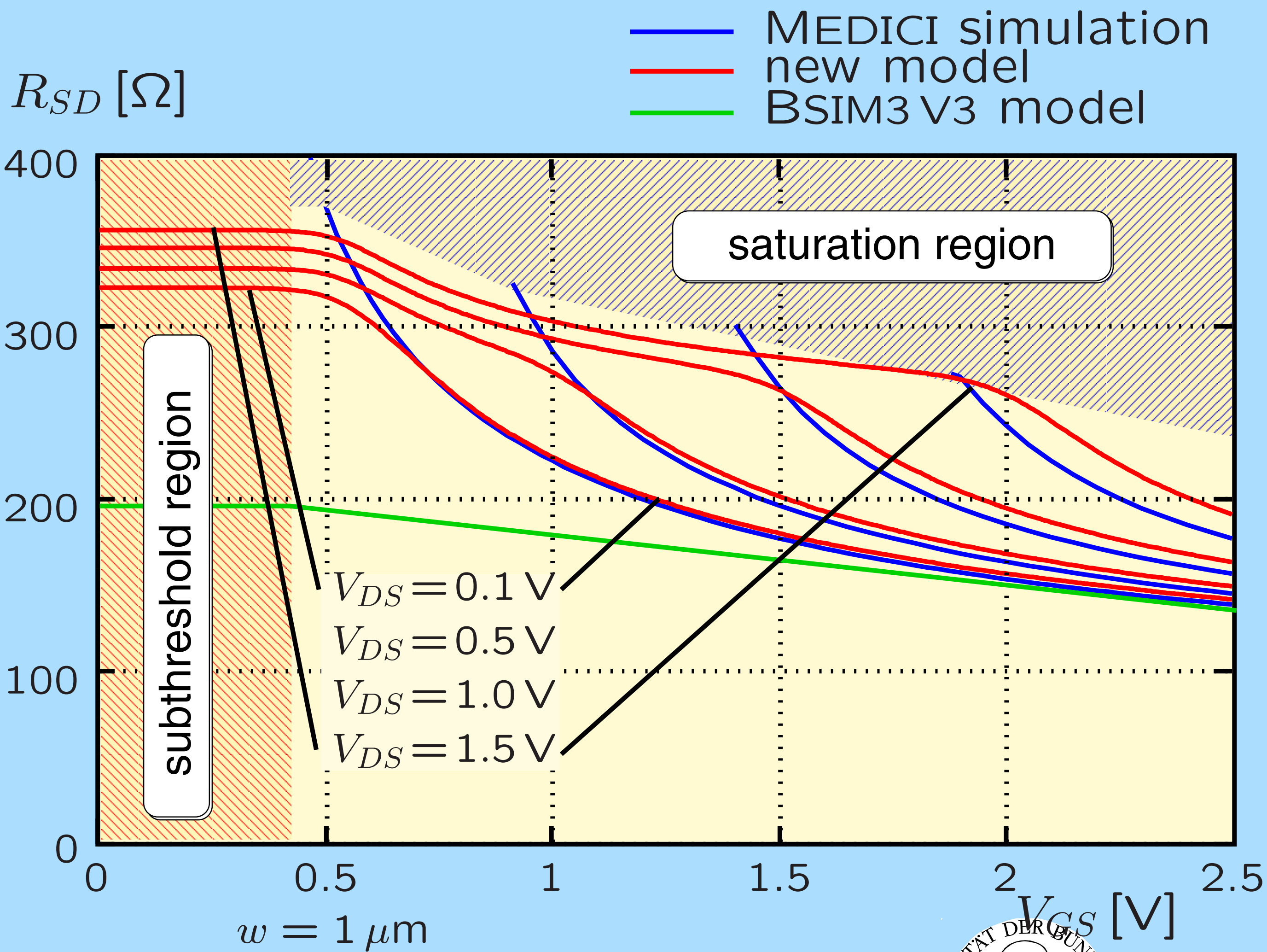
Source Resistance



Regions of Interesting Biases



Source and Drain Resistances



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

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

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

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

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

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

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

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