
austriamicrosystems
EKV at austriamicrosystems
EKV 2.6 implementation and parameter extraction status at austriamicrosystems
Ehrenfried Seebacher
EKV Workshop
Lausanne 2004-11-04
A leap ahead in mixed signal

Outlook

- Motivation
- CMOS modelling activities at AMS.
- EKV 2.6 evaluation
  - Implementation
  - Benchmarks for different simulators.

Motivation

austriamicrosystems AG:

Three SBUs:

- Communication
- Industry
- Automotive
- FSF

Foundry:

- 200mm, 100mm Wafer Fab

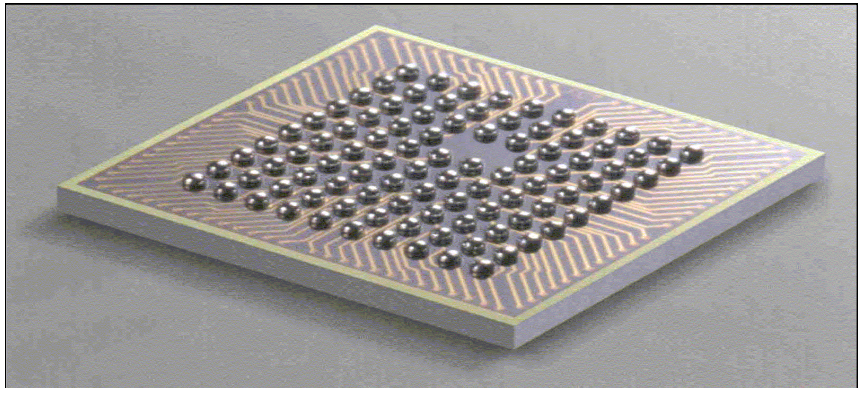
Process:

- ?0.35µm CMOS, SiGe BiCMOS, HV CMOS, EEPROM, OTP, Opto

Products: ASICS, ASSP, Standard Linear.

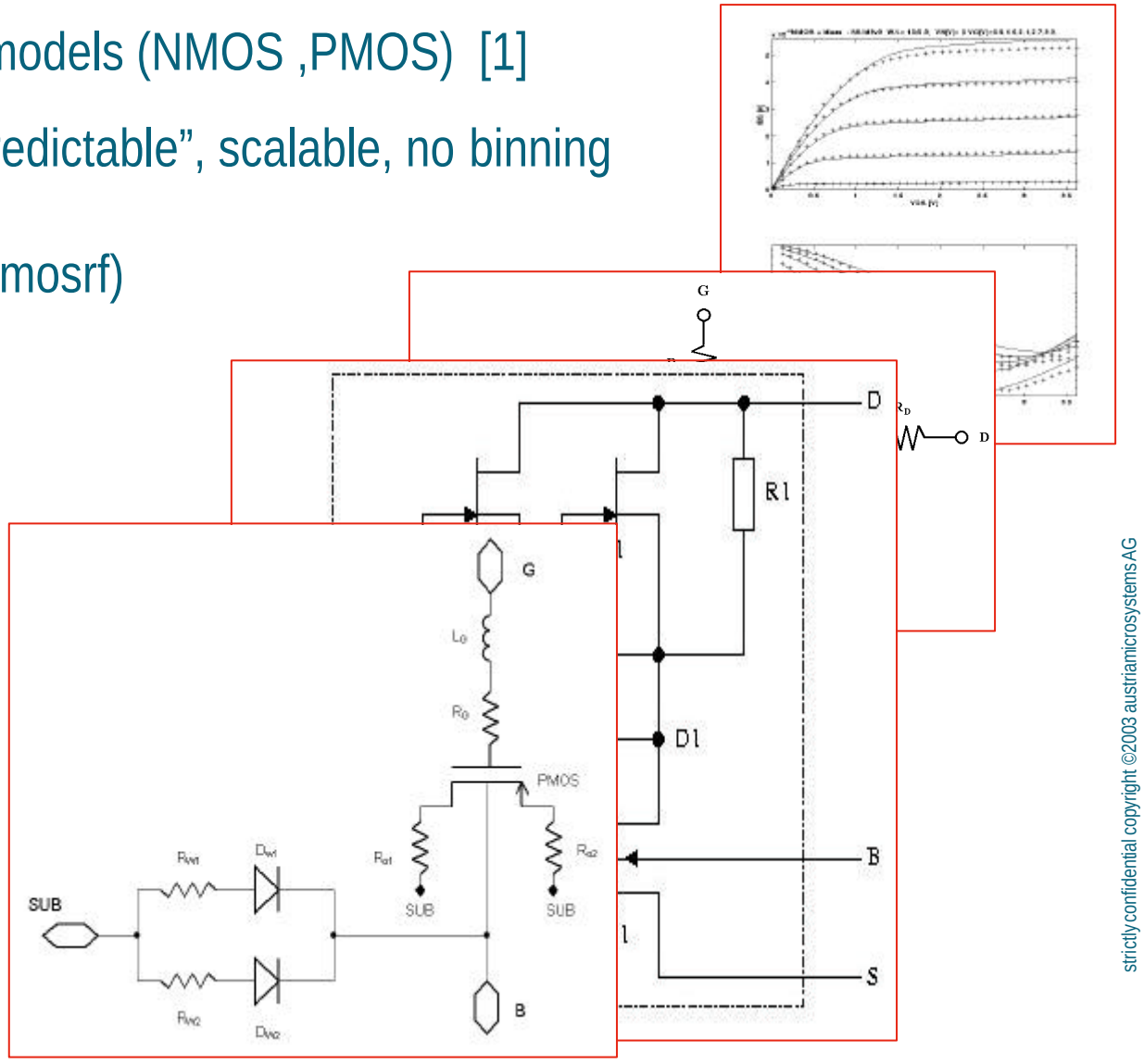
Compact Modelling:

- analog/RF and HV



CMOS Compact Modelling at austriamicrosystems

- Standard analog/ms MOS models (NMOS ,PMOS) [1]
  - BSIM3v3, “physical”, “predictable”, scalable, no binning
- RF MOS models (nmosrf, pmosrf)
  - BSIM3v3 sub-circuit
- HV MOS model [2,5]
  - BSIM3v3 sub-circuit
- RF MOS varactor model [3]
  - BSIM3v3.2 sub-circuit

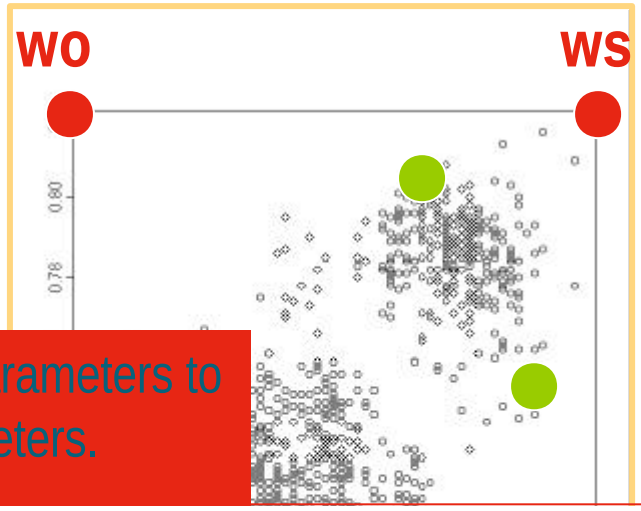


Statistical modelling

Worst Case Models and Simulation Setup

- MOS transistor (BSIM3V3):

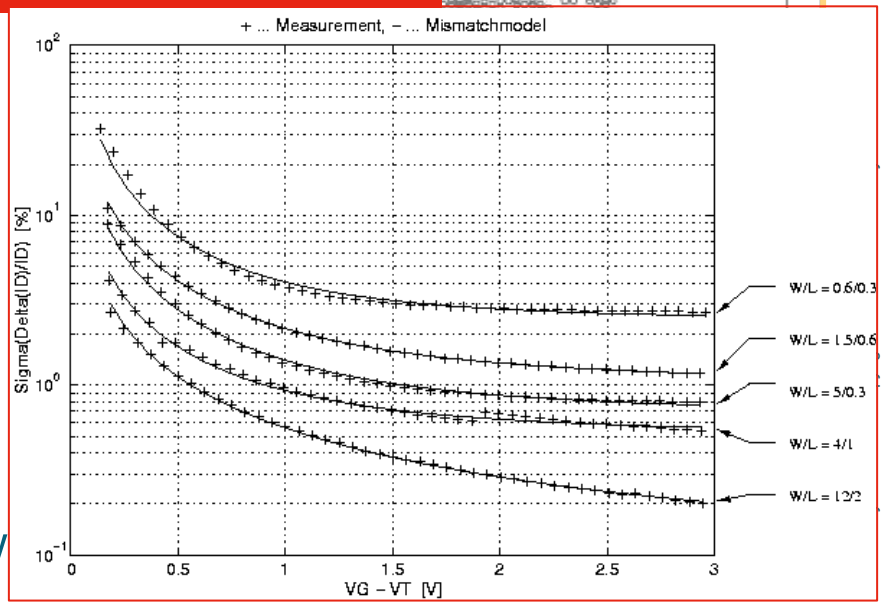
  tm, wp, ws, wo, wz



Statistical Corner Mod and Simulation Setup

Transformation of MAP parameters to simulation parameters.

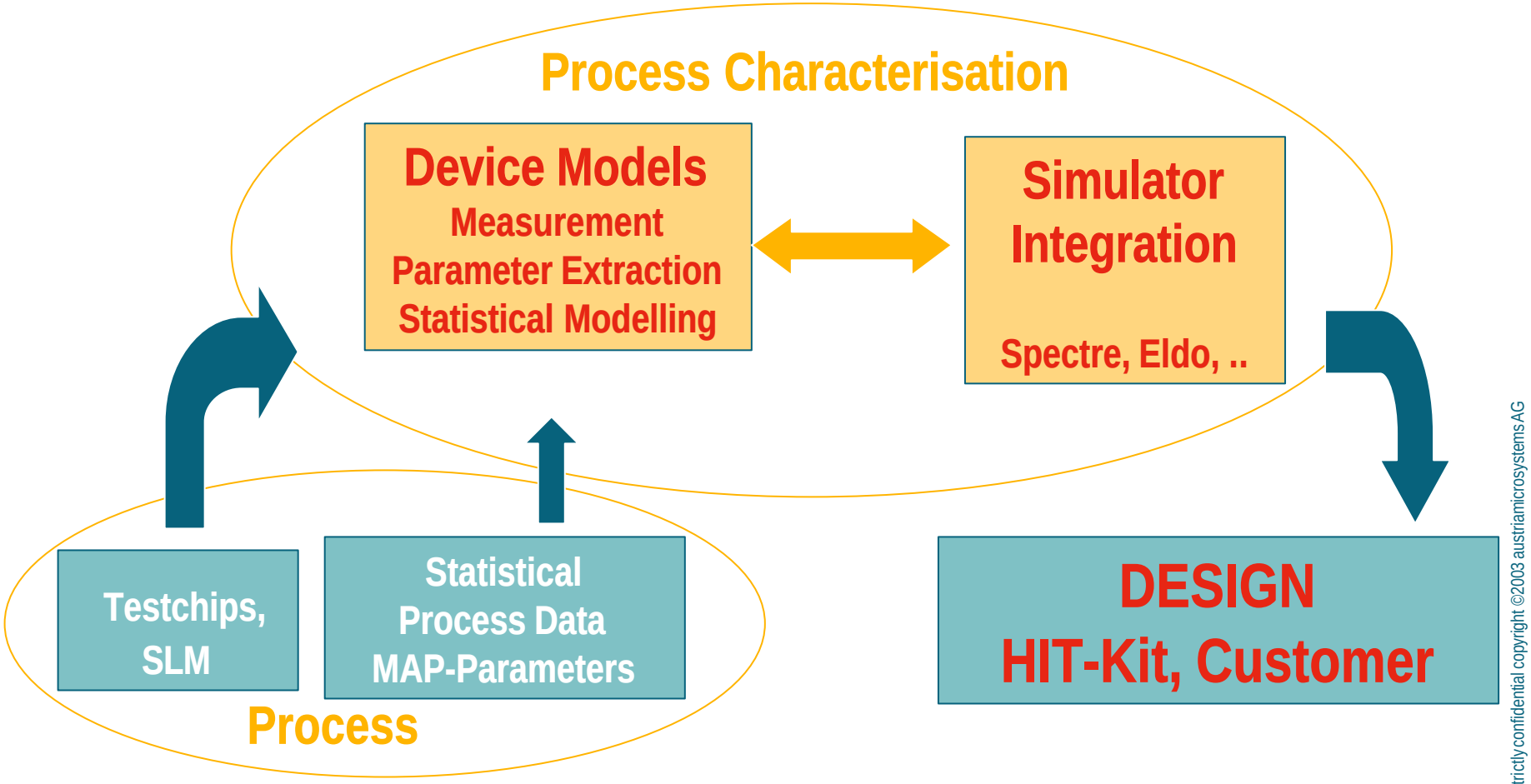
- Based on full process control data statistics.
- Corner wafer selection by multivariate ranking algorithm (location depth method).



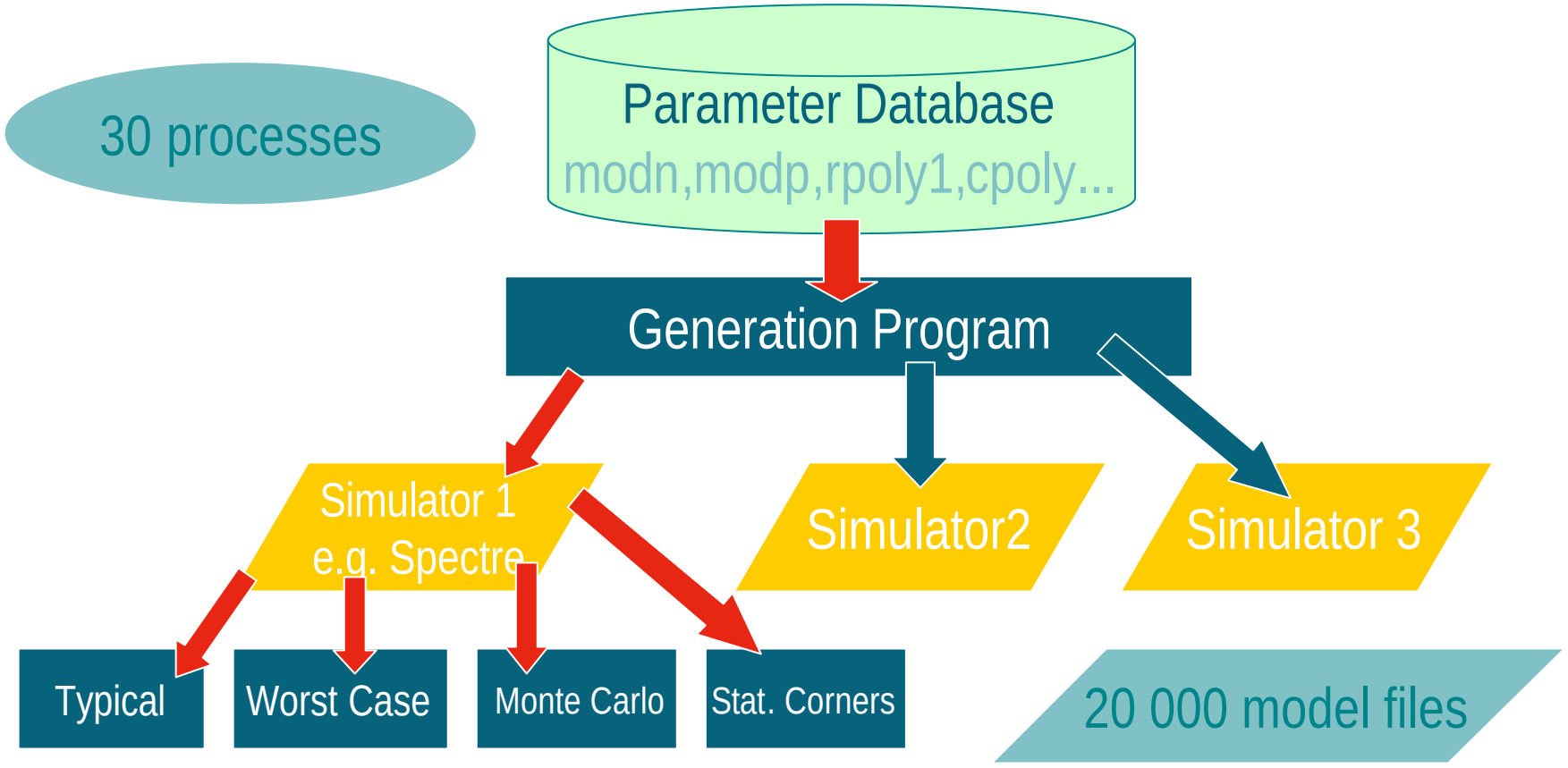
MC and Mismatch Models

- Pelgrom's Low for geometry dependency
- Variance Model for the voltage dependency

Simulator Integration Flow



Simulator Model Generation Flow



Circuit Simulators and Models

Simulator	Model		
	MOS	Bipolar	Statistical simulation
	BSIM3v3	VBIC	Monte Carlo Matching
Agilent ADS	v2001	v2001	
Eldo	5.9	5.9 (level 21)	5.9
EldoS	5.9	5.9 (level 21)	
Hspice	2001.5 level49		
Pspice	v9.1		
SmartSpice	2.0.8.C	2.0.8.C	
Saber	4.3		
Smash	4.3.5 (level 8)	4.3.5 (level 2)	
Spectre	4.4.6	4.4.6	4.4.6
SpectreS	4.4.6	4.4.6	4.4.6

Literature

[1] “Process Characterisation for low VTH and low Power Design”

Proceedings of the 13th International Workshop of Integrated Circuit and System Design pp 70-79 PATMOS03

E.Seebacher, G.Rappitsch, H.Höller

[2] “MOS TRANSISTOR MODELING FOR HV PROCESSES”

Proceedings of the 9th International Conference
Mixed Design of Integrated Circuits and Systems
Wraclaw, 20-22 June 2002, pp 79-83 E. Seebacher, G. Rappitsch, H. Höller and W. Posch*

[3] “MOS varactor modeling with a subcircuit utilizing the BSIM3v3 model”

IEEE Transactions on ELECTRON DEVICES July 2002 Volume 49 Number 7 Page 1206

Kund Molnar, Gerhard Rappitsch, Zoltán Huszka and Ehrenfried Seebacher

[4] “SPICE Modeling of Process Variation Using Location Depth Corner Models”

IEEE TRANSACTIONS ON SEMICONDUCTOR MANUFACTURING, VOL. 17, NO. 2, MAY 2004

Gerhard Rappitsch, Ehrenfried Seebacher, Michael Kocher, and Ernst Stadlober

[5] “Investigations on the High Current Behavior of Lateral Diffused High-Voltage Transistors”

IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 51, NO 10 OCT. 2004.

Martin Knaip, Georg Roehrer, Rainer Minixhofer and Ehrenfried Seebacher

Outlook

- Motivation
- CMOS modelling activities at AMS.
- EKV 2.6 evaluation
  - Implementation
  - Benchmarks for different simulators.

Why AMS is interested in EKV?

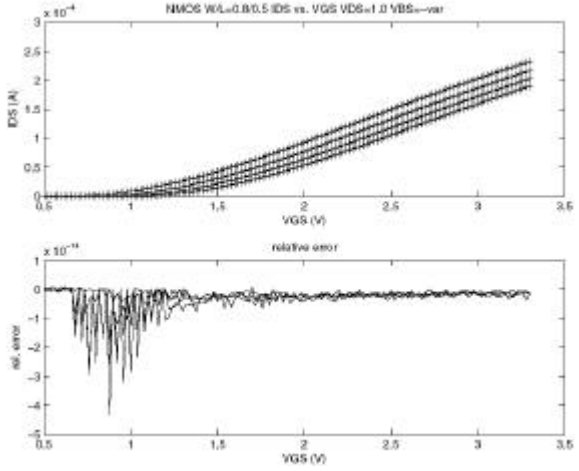
- Need of a physical scalable analog/ms model for future process generations.
- Extendable for HV and RF applications.
- EKV can fulfil the AMS statistical modelling concept.
  - WC Corner, MC, Matching, Statistical Corner modelling.
  - The need of transforming PCM parameter to SPICE parameter.

Evaluation Target EKV2.6.III

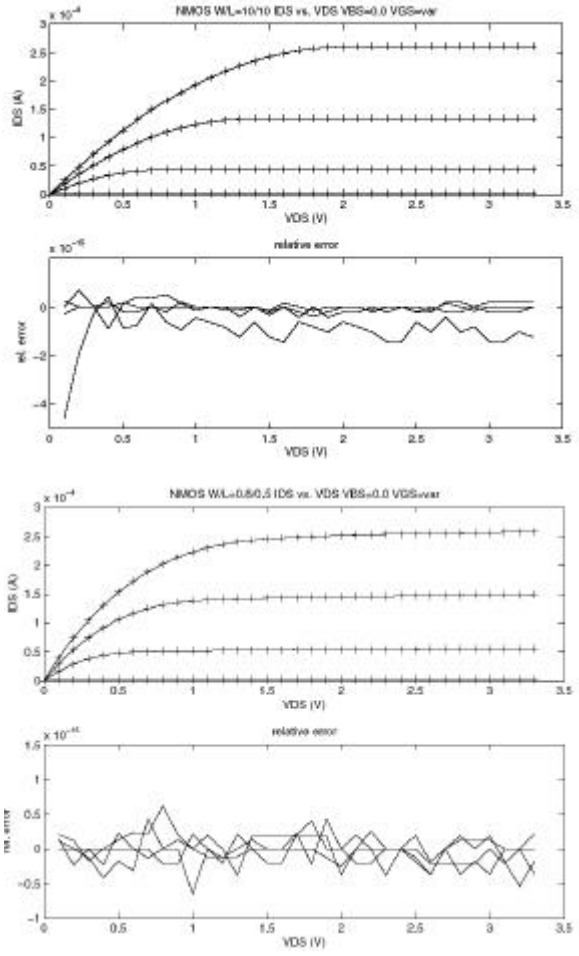
- Implementation in the Matlab environment
  - Faster parameter extraction.
  - Better understanding of the model.
- Parameter extraction for sophisticated processes.
- Comparison with state-of-the art.
- Simulator benchmarks.

EKV 2.6.III – MATLAB Implementation

- *Sucessfule Matlab implementation.*
  - Rendom error between Matlab and C-Code
- Full implementation of EKV2.6 in the AMS Matlab parameter extraction environment.
- Development of a parameter extraction strategie.
- Extraction of full parameter sets for 0.8um and 0.35um CMOS processes.

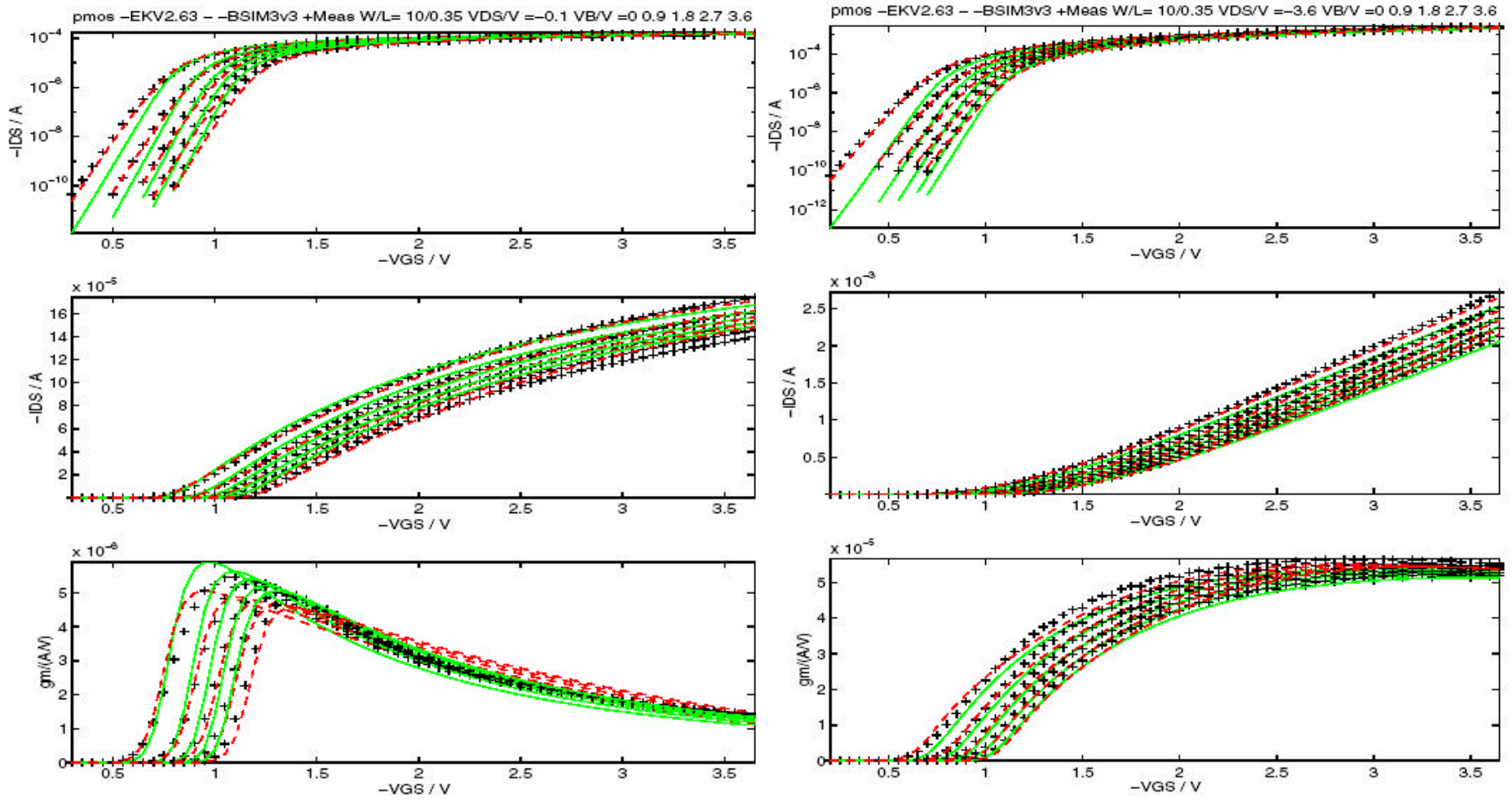


MATLAB vs. C-Code (Referenzcode):



Parameterextraktionsstrategie für EKV 2.63

Ergebnisse für 0.35µ PMOS



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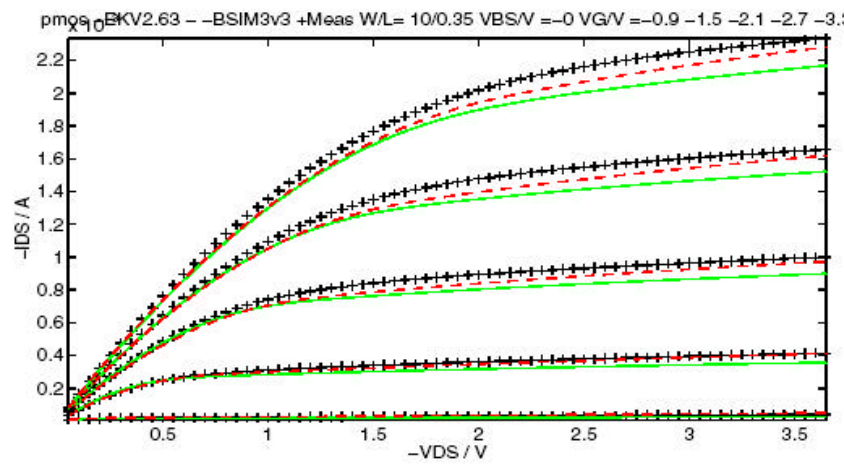
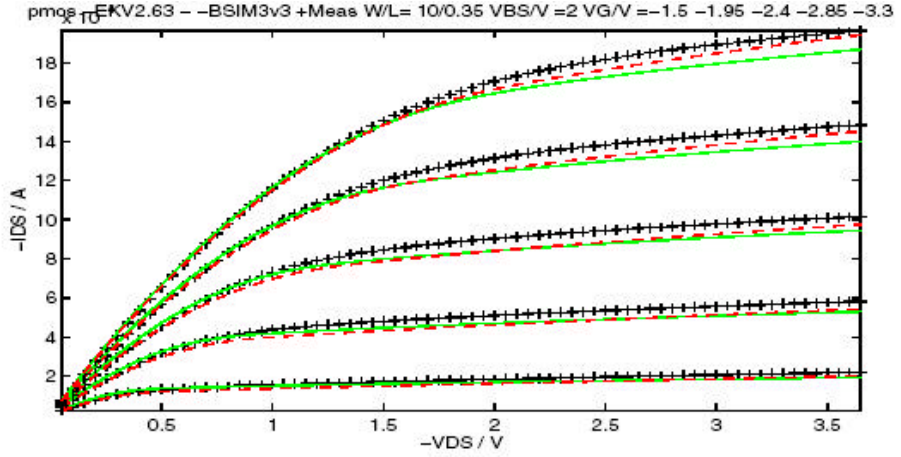
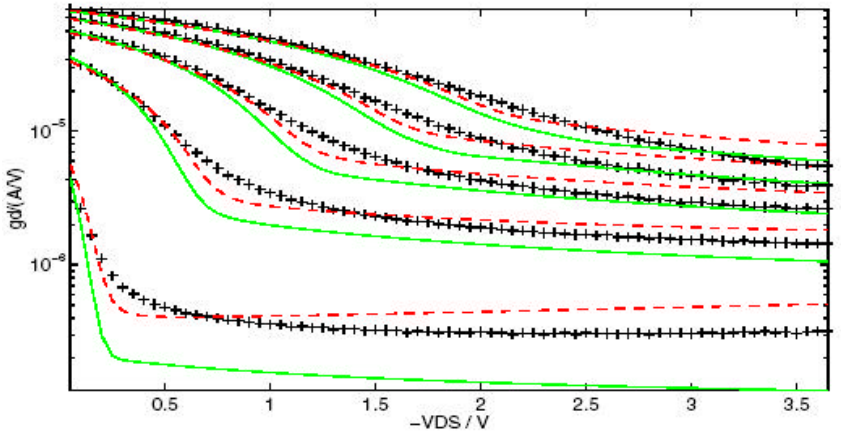
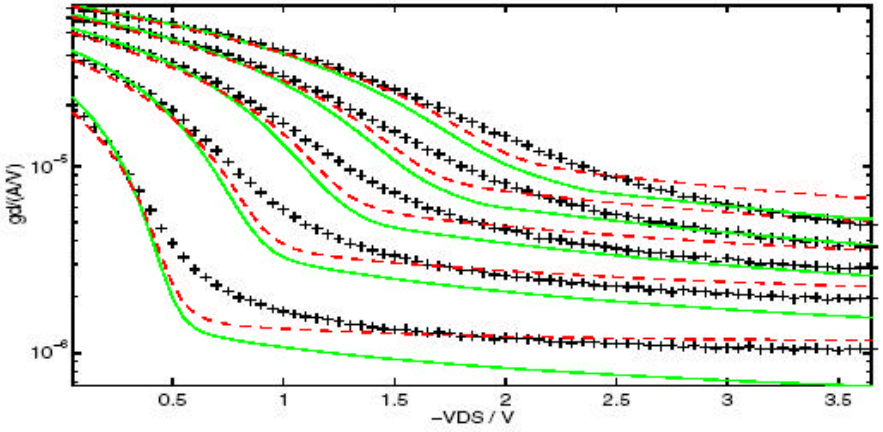
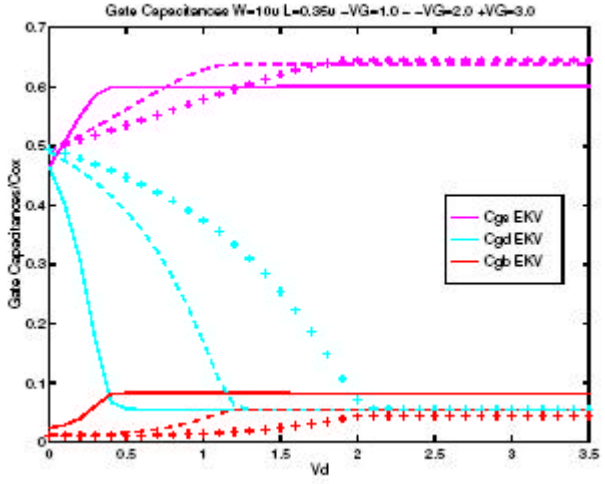


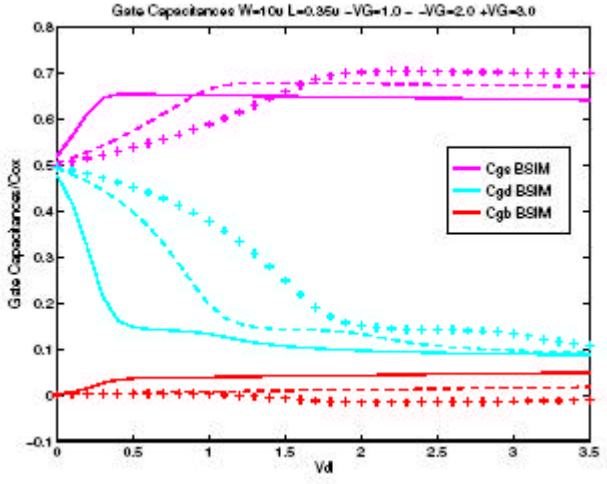






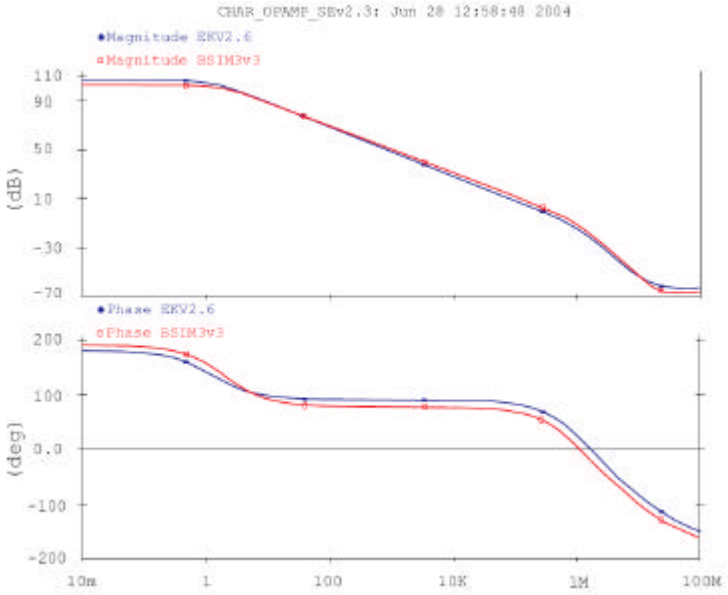
EKV2.6 and BSIM3v3 Cgx Caps.



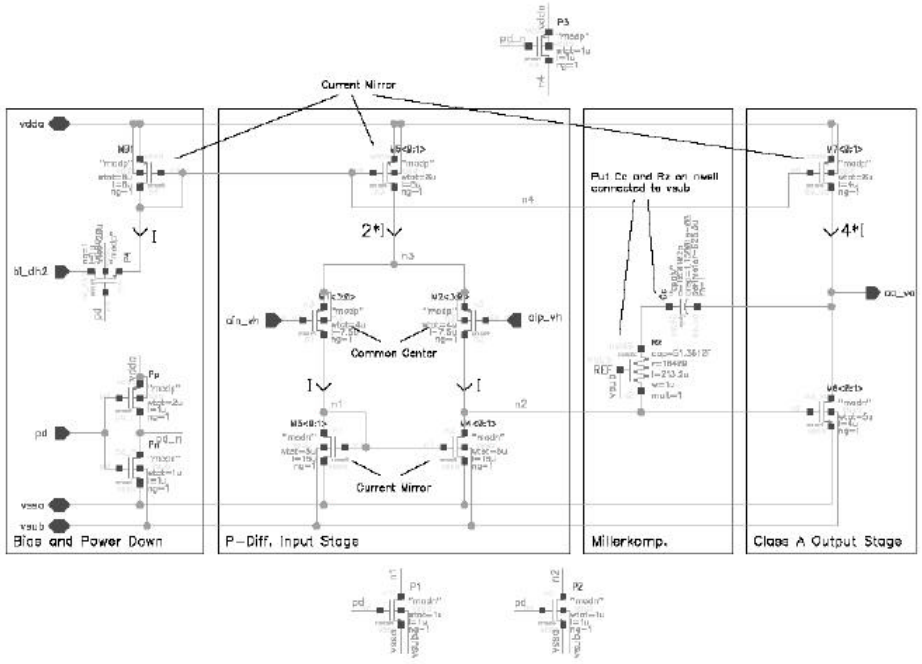


Analoge Circuit: OPAMP

Results:



	EKV 2.63	BSIM3v3.2	Measurement
Open Loop Gain	105 dB	103 dB	102 dB
Gain Bandwidth	0.28 MHz	0.29 MHz	0.294 MHz
Phase Margin	69 deg	70 deg	68 deg
Gain Margin	-21.2 dB	-25.6 dB	-



Comparison EKV 2.6 und BSIM3v3

- EKV 2.63
  - Faster Parameter Extraction (less parameters)
  - Physical parameters
  - Correlation of the parameters is low
  - EKV 2.63 parameter fit not always acceptable.
    - Especially for extreme geometries.
- BSIM3v3.2
  - Higher amount of parameters ✍ time consuming Parameter Extraction
  - Not all parameters are physical
  - Most parameters are correlated.
  - Excellent fitting results.

Outlook

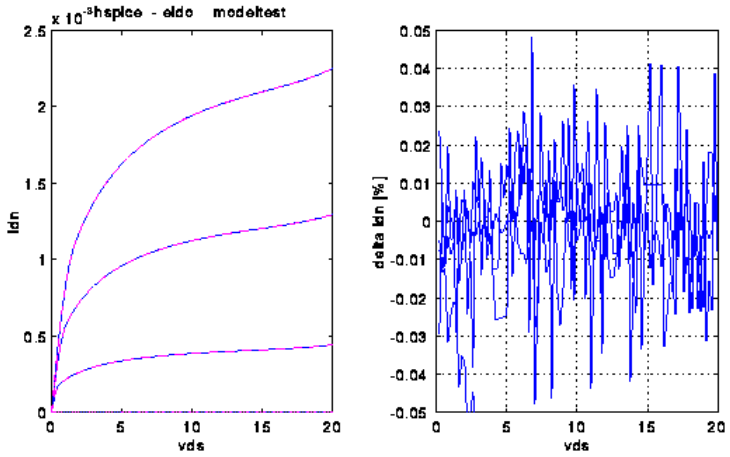
- Motivation
- CMOS modelling activities at AMS.
- **EKV 2.6 evaluation**
  - Implementation
  - **Benchmarks for different simulators.**

Simulator Benchmark

E.g. BSIM3v3 Simulator Benchmark
Eldo - HSPICE

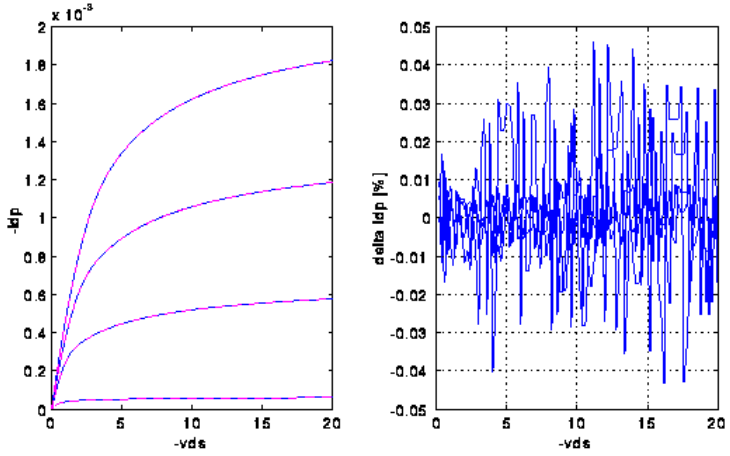
Our Criteria

- error < 0.5%
- no systematic error



AMS Benchmarks MOS:

- idvd, idvg, gm, gds, gmb
- 1/f noise, Cxy, Cgg transient
- ring-oscillator-delay, temp modelling

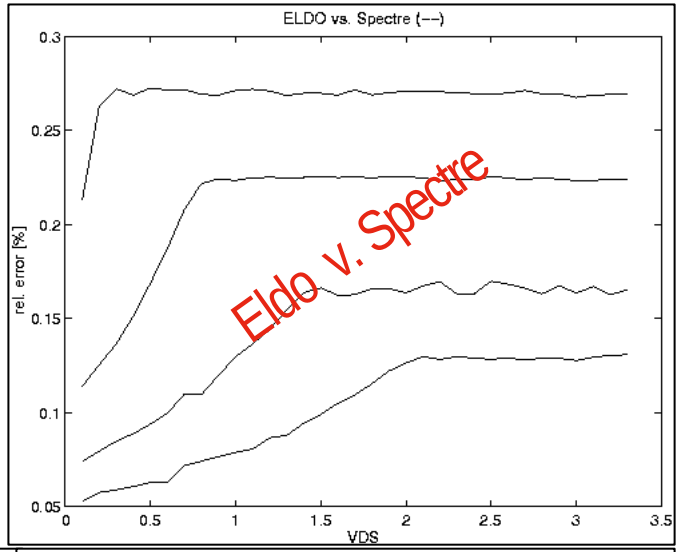


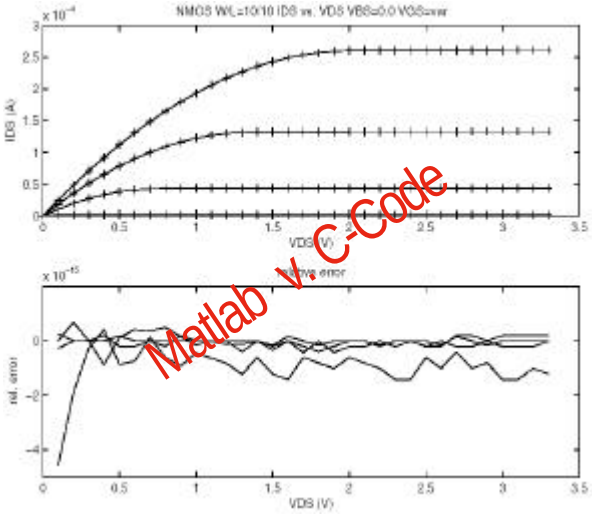
EKV 2.6 Simulator Benchmark

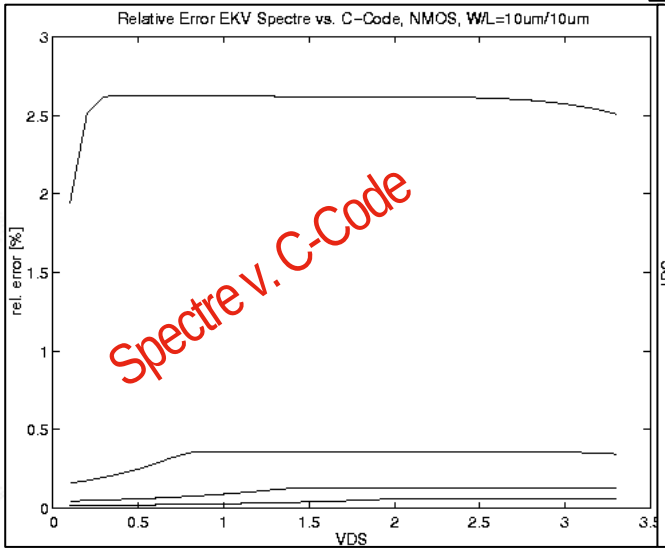
Parameters downloaded from the EKV web side.

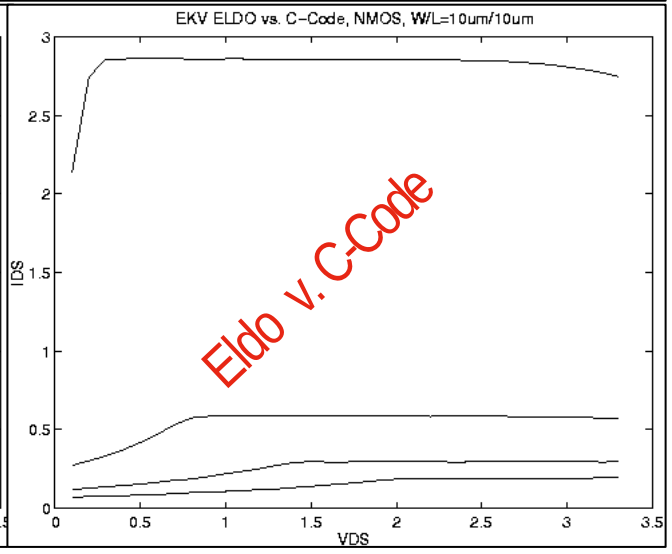
Systematic error between c-code and Eldo-Spectre-HSPICE.

Error > 2.5 %









EKV 2.6.III *Comparison*

	C-Code Matlab	Spectre	Eldo	HSPICE
C-Code=Matlab	✍	? 2.5%	? 3%	? 3%
Spectre	? 2.5%	✍	? 0.3%	-
Eldo	? 3%	? 0.3%	✍	(=)
HSPICE	? 3%	? 2.5%	(=)	✍

Summary

- EKV 2.6 project: “Diploma Thesis” to get in touch with EKV
- EKV 2.6 do not fulfil the requirements concerning simulator implementations.
- Fitting results not acceptable in general.
- Applicable as second advanced analog model.
- AMS is looking for EKV 3.0