Virtual Equipment
A Test Bench for Virtual Metrology Algorithms
(WP 2 - Task 2.5)

ERIC Conference 2011

Leixlip, October 12th 2011
Speaker: Andreas Mattes (Fraunhofer IISB)
Dirk Lewke (Fraunhofer IISB)
Martin Schellenberger (Fraunhofer IISB)

Outline

- Virtual metrology (VM)
  - Objectives and benefits
  - Challenges
- Virtual Equipment (VE) concept
  - Purpose of the Virtual Equipment
  - From the first to the second approach
- Current implementation of the Virtual Equipment
  - Statistical Simulation
  - Physical Simulation
  - Short demonstration
- Conclusion

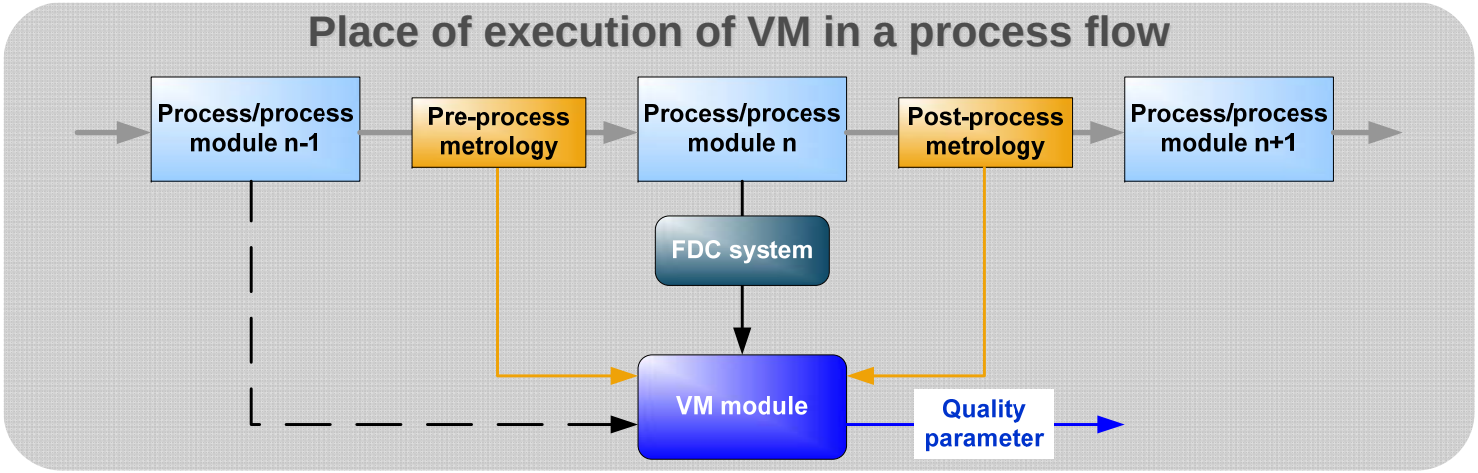
VM objectives and benefits

VM objectives

- Predict post process physical and electrical quality parameters of wafers and/or devices from information collected from the manufacturing tools including support from other available information sources in the fab

VM benefits

- Support or replacement of stand-alone and in-line metrology operations
- Support of FDC, run-to-run control, and PdM
- Improved understanding of unit processes



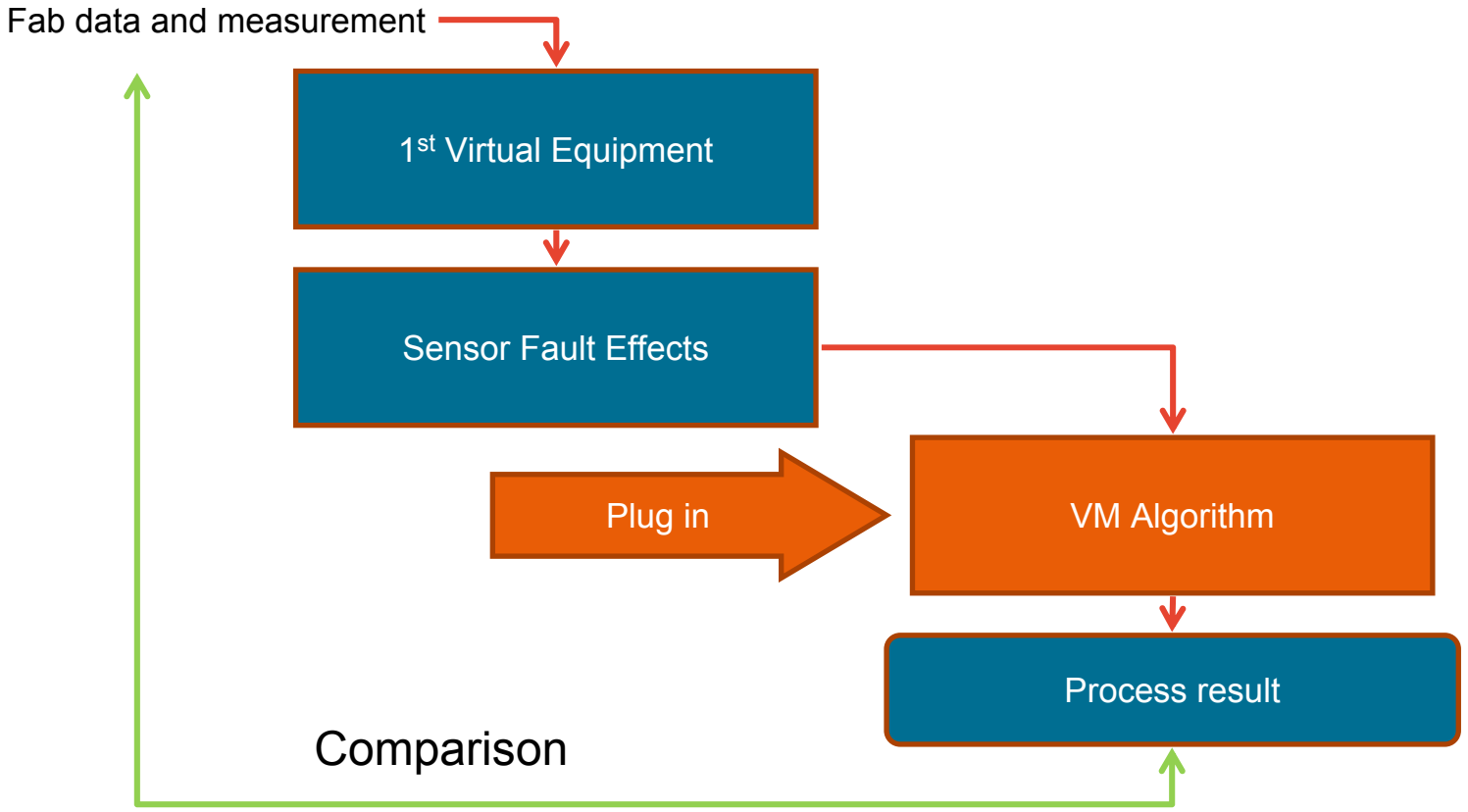
VM challenges and questions

- VM algorithms tend to be at the same time generic statistical modelling as well as very specific in the area they excel
  - Test needed for optimal matching and accuracy of a specific VM technique in an existing fabrication line
  - Test of VM algorithms on real equipment can be expensive and usually does not cover uncommon equipment states
- Solution: Virtual Equipment
  - Comparison of different VM algorithms
  - Evaluation of the sensitivity of VM algorithms to errors

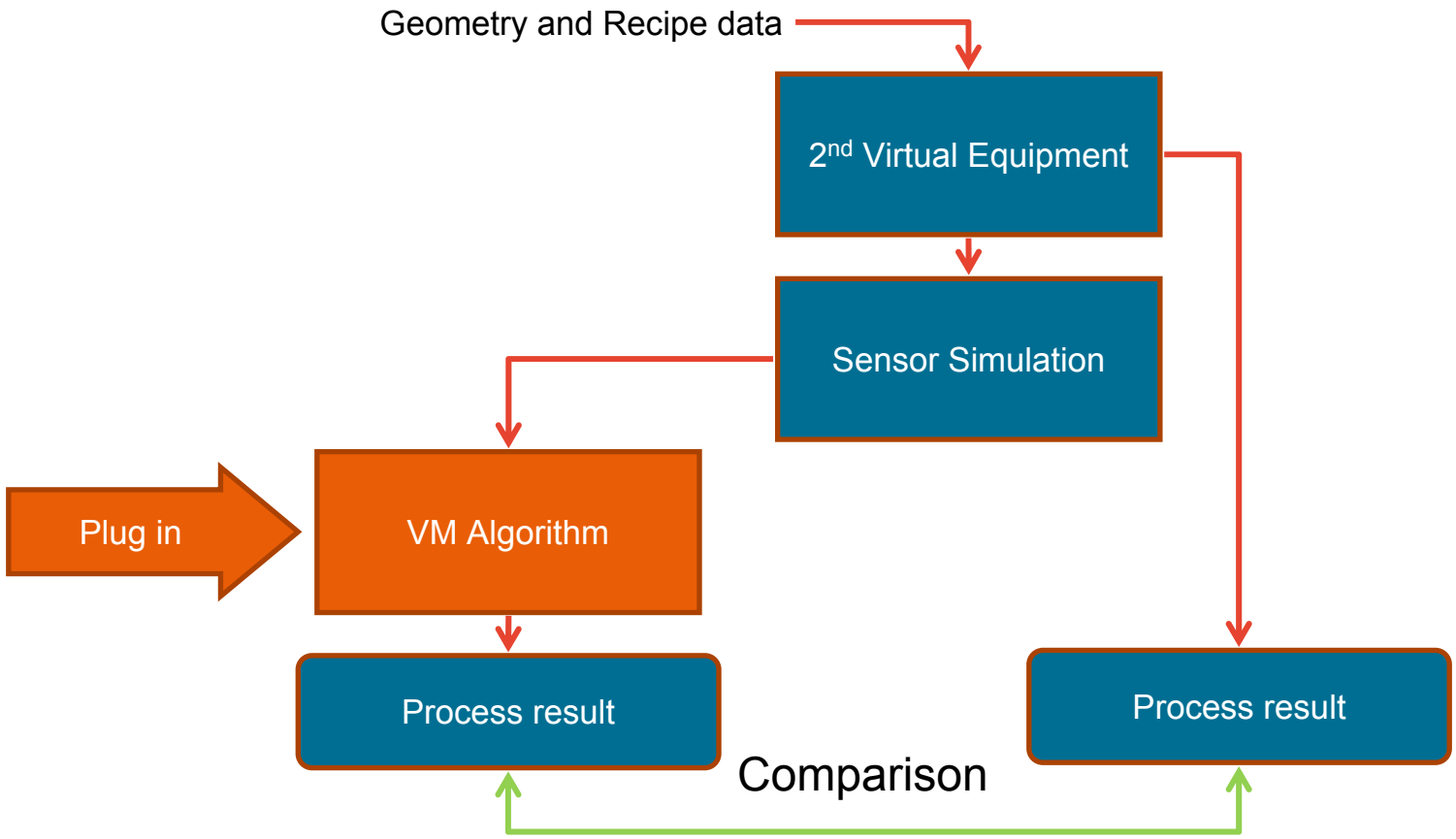
Concept „Virtual Equipment”

- Definition and setup of a Virtual Equipment (VE) as a benchmark tool
  - Utilization of history fab data
  - Simulation of relevant equipment and process behaviour
  - Application of typical faults, process drifts, mix and match scenarios and noise effects
- Convenient operation through a graphical user interface
- Usage of Matlab/Simulink

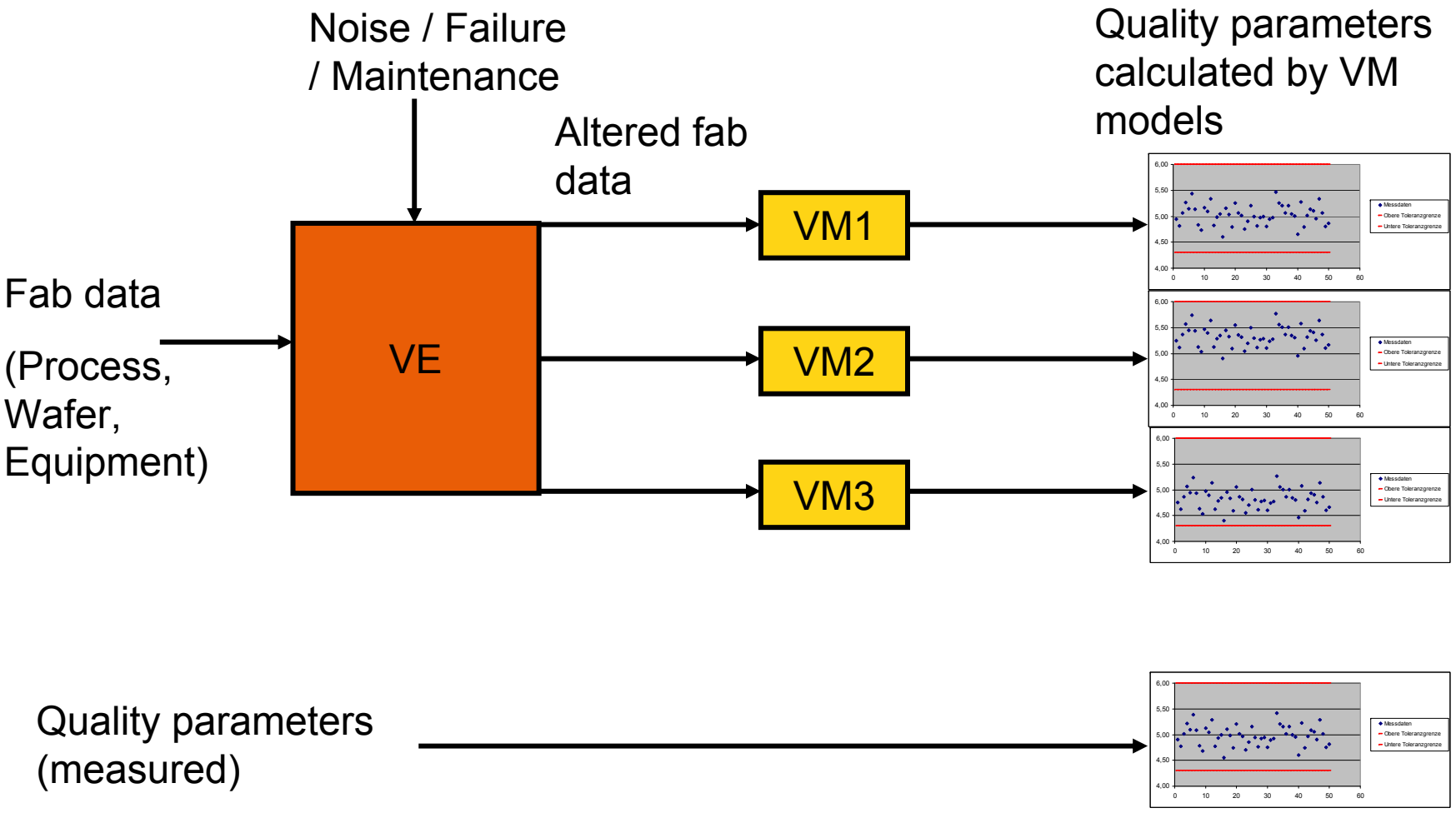
First „Virtual Equipment“



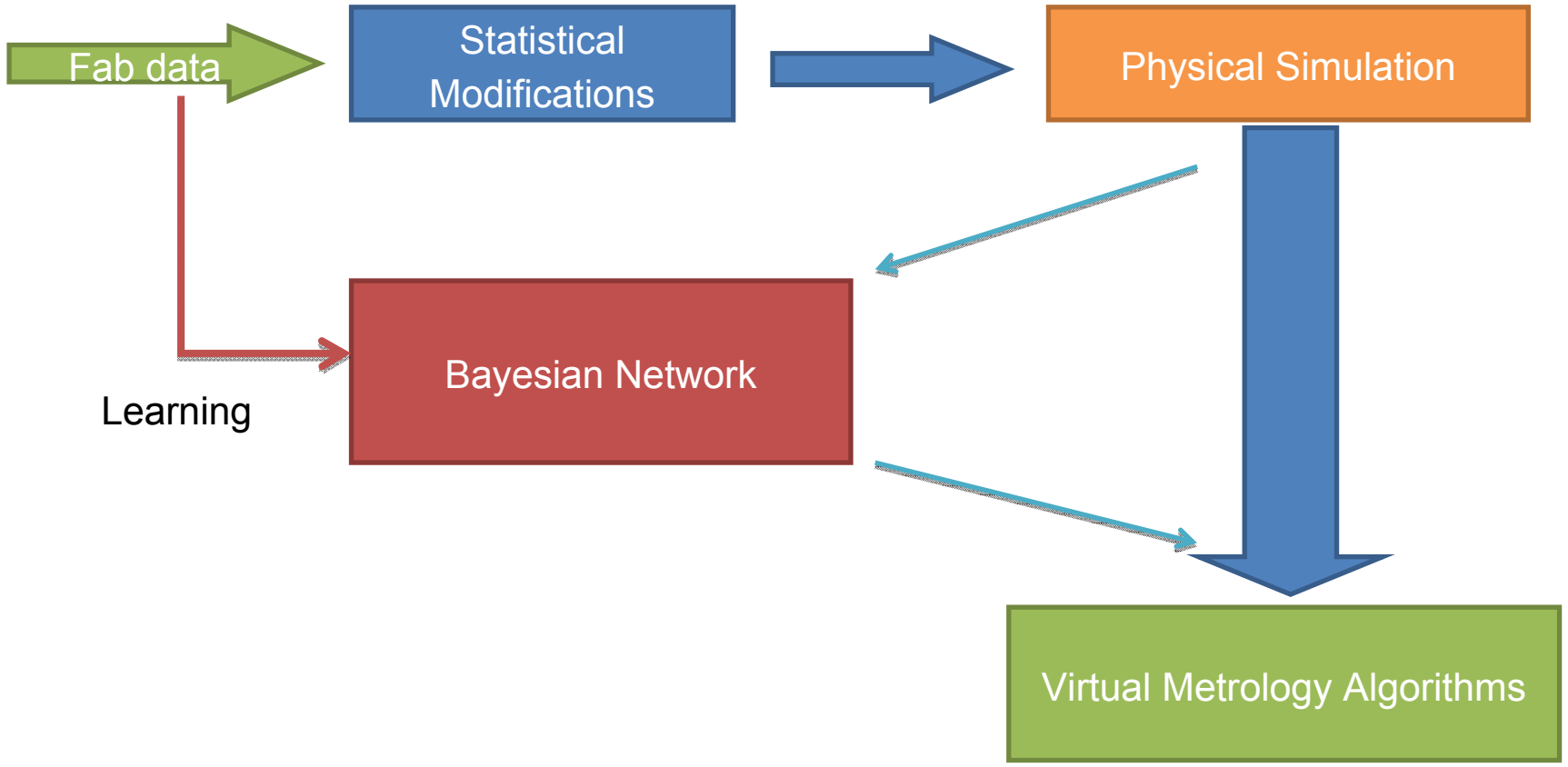
Second „Virtual Equipment“



Concept „Virtual Equipment“

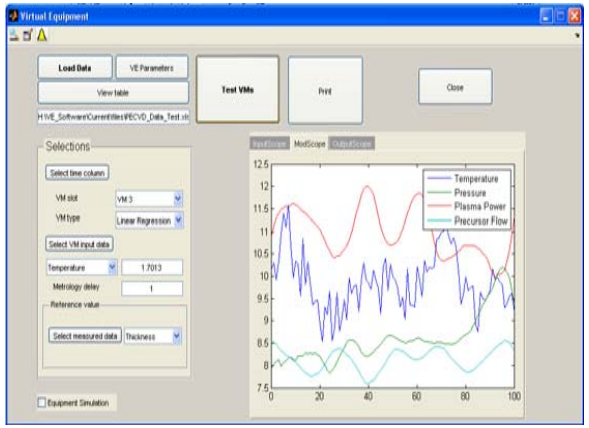


Concept „Virtual Equipment“



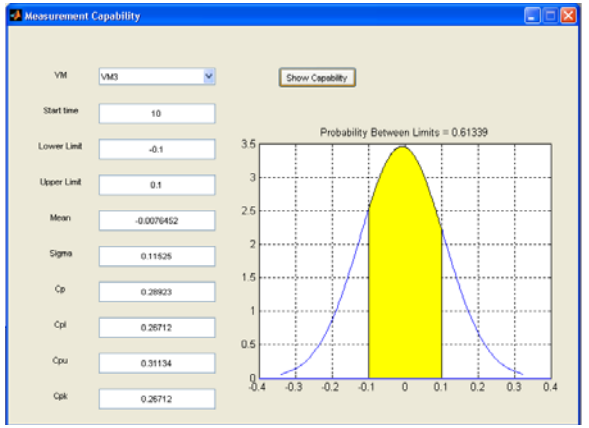
Current implementation

- Fab data input from Excel or CSV table
- Statistical changes to input data:
  - Noise, Drift, …
  - Bayesian Network
    - Fab Data as Learning Data
    - Soft discretization
    - Prediction of signal depending on changed other signals
- Physical simulation
  - Uses Comsol (very flexible, extendable multiphysics simulator for flow, plasma, structure, …)
  - Statistically changed data as boundary conditions
  - Computation of sensor signals
  - Prediction of process result (quality parameters)
  - Interpolation from stored results possible



Current implementation

- Virtual Metrology Algorithms get the generated signals as input data
  - Same input data for all VMs to compare
  - Prediction of the same quality parameter
- Comparison of predicted values
  - between VM algorithms
  - to Metrology data from either fab data or physical simulation
- Computation of Measurement Capability of VM algorithms



Short demonstration „Virtual Equipment“

- Demonstration of a simple exemplary scenario on the Virtual Equipment
- Fictional input fab data set used (not from a real equipment)
- Simple exemplary VM algorithms
  - Linear Combination with fixed coefficients
  - Linear Regression

Conclusion

- Achievements:
  - Capability to compare multiple VM models
  - Generation of test data sets for common and uncommon situations
  - Integration of statistical and physical simulation
  - Evaluation of measurement capability and sensitivity of VM algorithms
- Plans:
  - Nearly ready: Automated studies of VM behavior given a sequence of fault parameters (e.g. gage capability over noise strength)
  - Autumn 2011: Test of VM models with the Virtual Equipment
  - End of 2011: More physical simulation models added to VE
  - End of 2011: Integration with IMPROVE Framework

Acknowledgment

- This research is funded in parts by the German Federal Ministry of Education and Research (BMBF) and the European Nanoelectronics Initiative Advisory Council (ENIAC)
- The work is carried out in the ENIAC project “IMPROVE” (Implementing Manufacturing science solutions to increase equipment PROductiVity and fab pErformance)