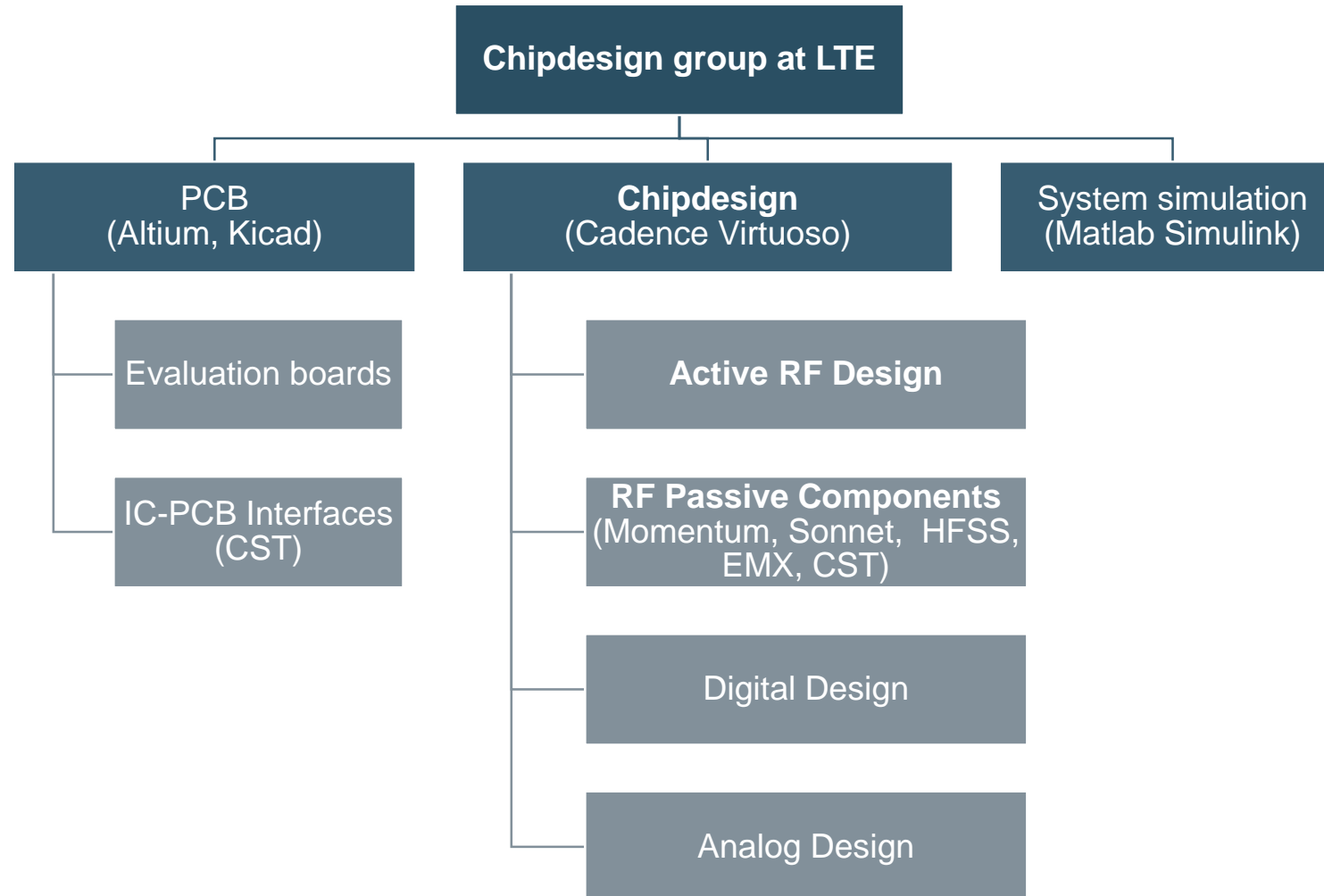# Design-flow approaches for mmWave and sub-THz integrated transceiver circuits for radar and communication
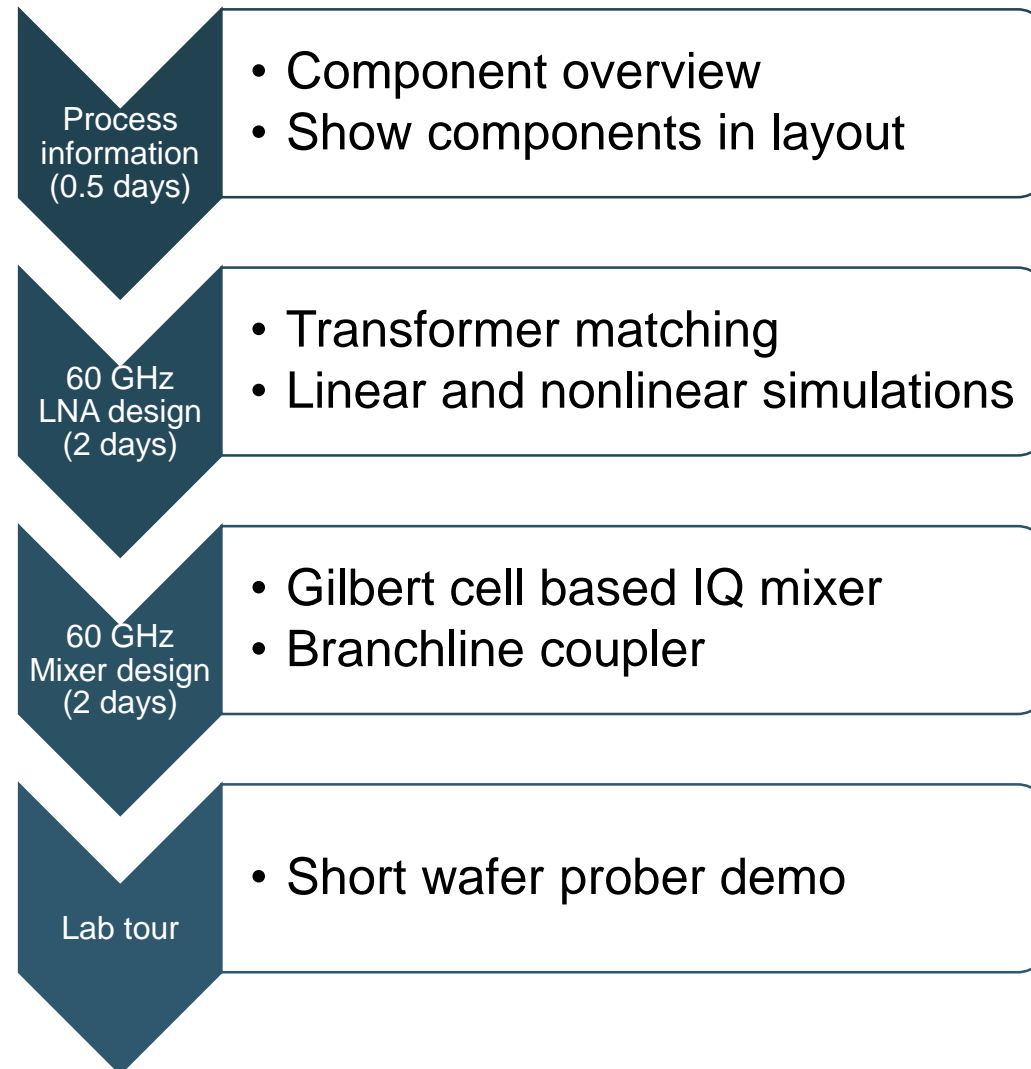## From a design tools user perspective

Manuel Koch

Institute for Electronics Engineering
Prof. Dr.-Ing. Dr.-Ing. habil. Robert Weigel
Friedrich-Alexander-Universität Erlangen-Nürnberg

Agenda

Our Designs and Design Flows


```
                    Chipdesign group at LTE
              ┌──────────────┼──────────────┐
        PCB              Chipdesign        System simulation
   (Altium, Kicad)    (Cadence Virtuoso)   (Matlab Simulink)
        │                    │
   Evaluation boards    Active RF Design
        │                    │
   IC-PCB Interfaces    RF Passive Components
       (CST)            (Momentum, Sonnet, HFSS,
                             EMX, CST)
                             │
                        Digital Design
                             │
                        Analog Design
```

Chip design lab course

Process information (0.5 days)
- Component overview
- Show components in layout

60 GHz LNA design (2 days)
- Transformer matching
- Linear and nonlinear simulations

60 GHz Mixer design (2 days)
- Gilbert cell based IQ mixer
- Branchline coupler

Lab tour
- Short wafer prober demo

Lab course – Getting started
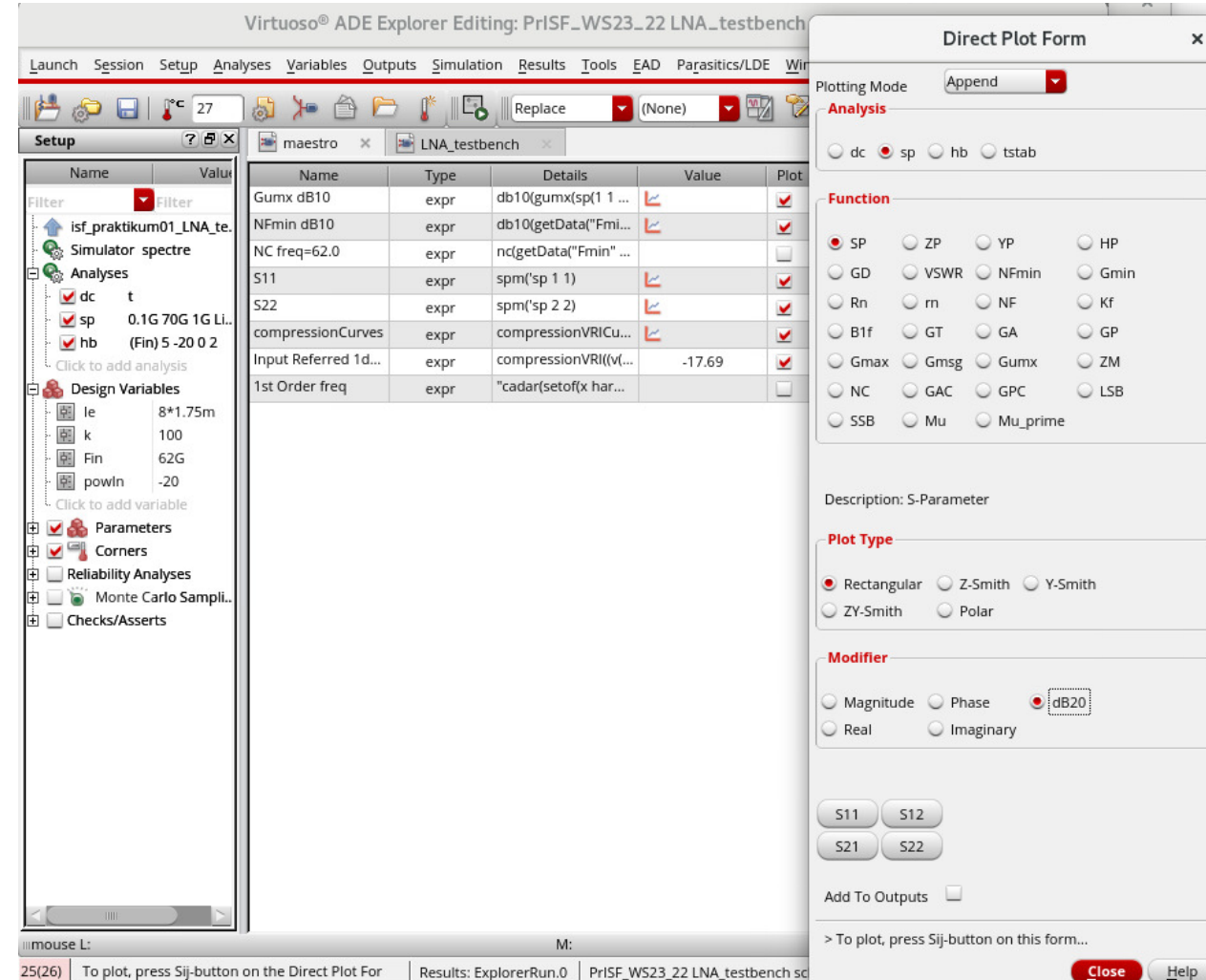
- HBTs, Resistors, Capacitors…

- Transmission Lines

  - PDK models

  - Cadence rfTlineLib

- Inductors and Transformers

  - Ideal Components with Q factor

  - EM Simulated Structures

- Testbench

  - Sources, ideal balun, …

Lab course - Simulation
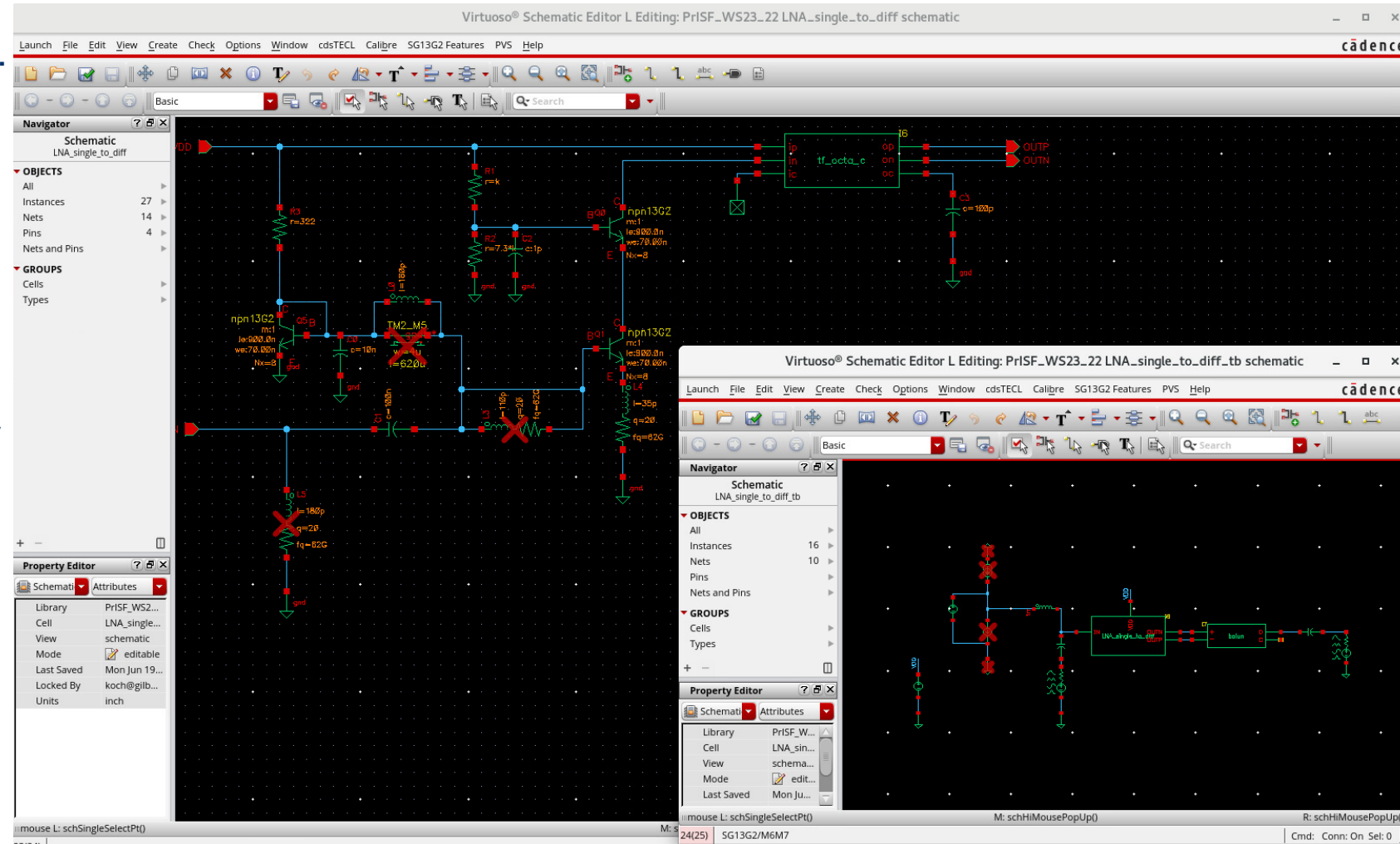
- S-parameter / Z-parameter simulation

  - Differential mode, common mode, …

  - Noise simulation

- Harmonic Balance / Periodic steady state

  - Noise simulation

  - Large signal S-parameter

  - Intermodulation

- Transient simulation

Design-flow approaches for mmWave and sub-THz integrated transceiver circuits for radar and communication

Layout – Core Cells

- Small cell with Transistors, Vias, Crossings, …

- Layout with Transmission line interfaces

- Parasitic Extraction (C, RC)

- Annotation in schematic
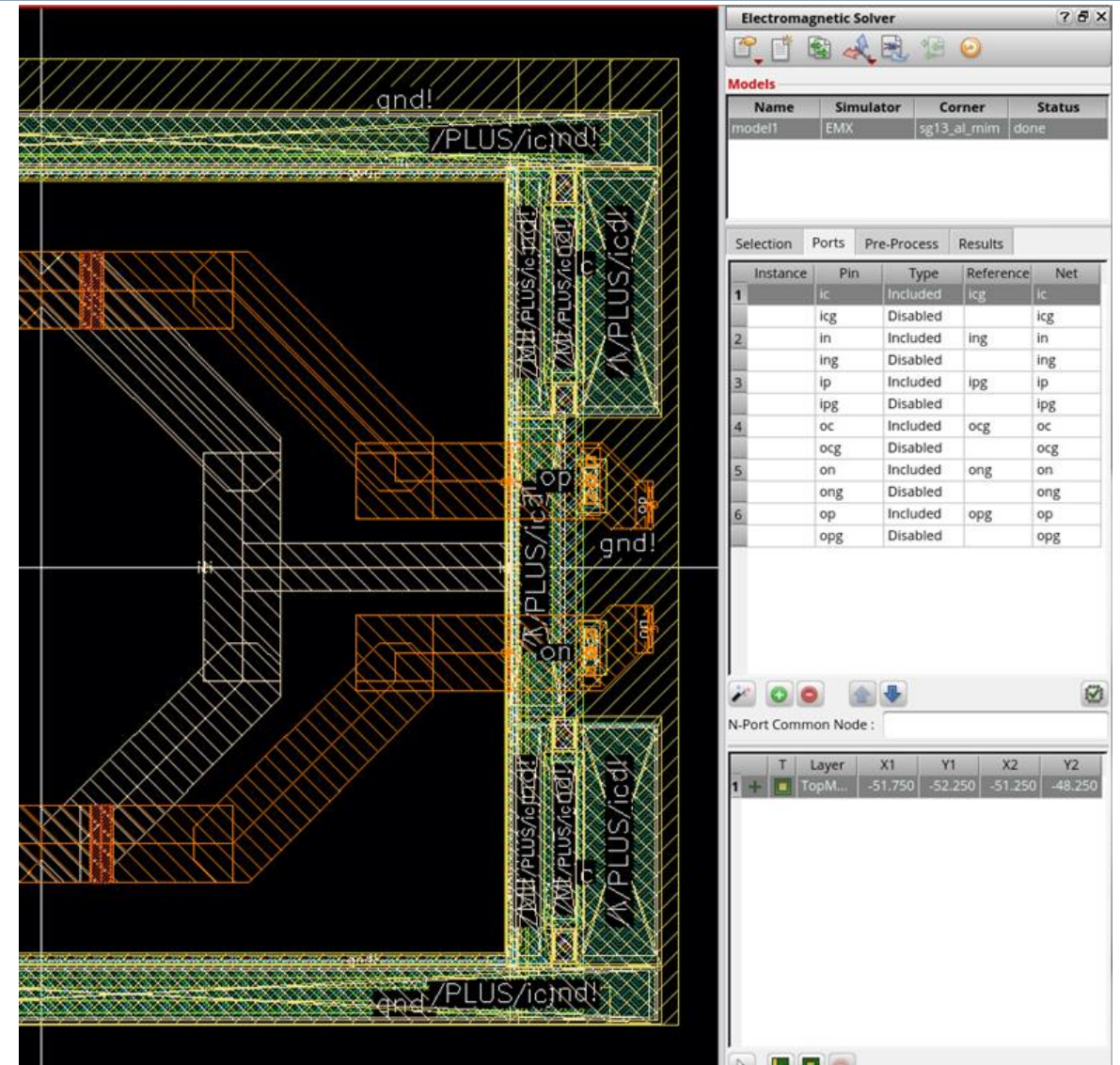
Design-flow approaches for mmWave and sub-THz integrated
transceiver circuits for radar and communication

Layout – Passive Components

- Transmission lines, inductors, transformers, Lange coupler, Baluns, slow wave lines, …

- Testbenches e.g. for inductance and quality factor extraction

- S-parameter best to be saved in design library

- Coupling effects of multiple passive components

- Speeding up the cycle:
  1. Saved simulation settings, automatic pin adjustment
  2. Parametric models
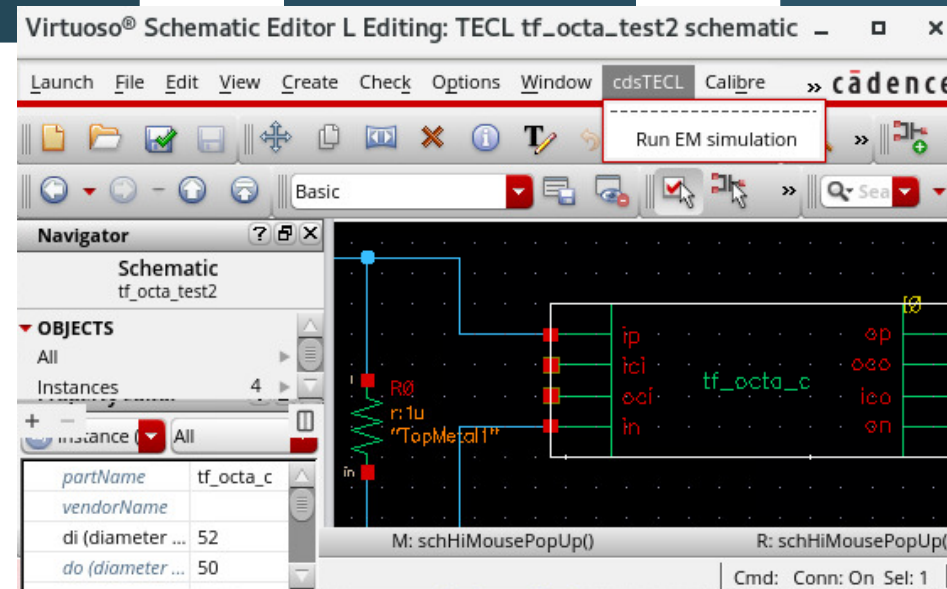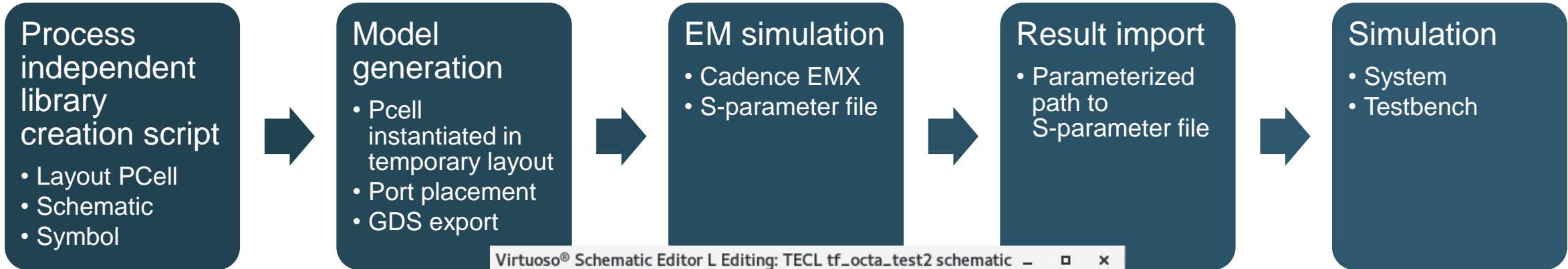 3. Automated EM simulation

Layout – Passive Components

- Transmission lines, inductors, transformers, Lange coupler, Baluns, slow wave lines, …

- Testbenches e.g. for inductance and quality factor extraction

- S-parameter best to be saved in design library

- Coupling effects of multiple passive components

- Speeding up the cycle:

  1. Saved simulation settings, automatic pin adjustment

  2. Parametric models

  3. Automated EM simulation

Layout – Passives - cdsTECL

- Automated simulation of typical passive components

Process independent library creation script
- Layout PCell
- Schematic
- Symbol

→

Model generation
- Pcell instantiated in temporary layout
- Port placement
- GDS export

→

EM simulation
- Cadence EMX
- S-parameter file

→

Result import
- Parameterized path to S-parameter file

→

Simulation
- System
- Testbench

Auxiliary circuits

- Bandgap reference, current mirrors, DACs for biasing

  - Substrate PNPs, Mosfets

  - Monte Carlo Simulation

- Digital Designs

  - Synthesized from VHDL with Cadence Genus / Innovus with IHP stdcell library

  - Mixed signal simulation

Library Management

OpenAccess Database

- Hierarchically stored data

- Cells / Directorys with different views:
  schematic, layout, s-parameter, vhdl, …

Summary - Helpful resources
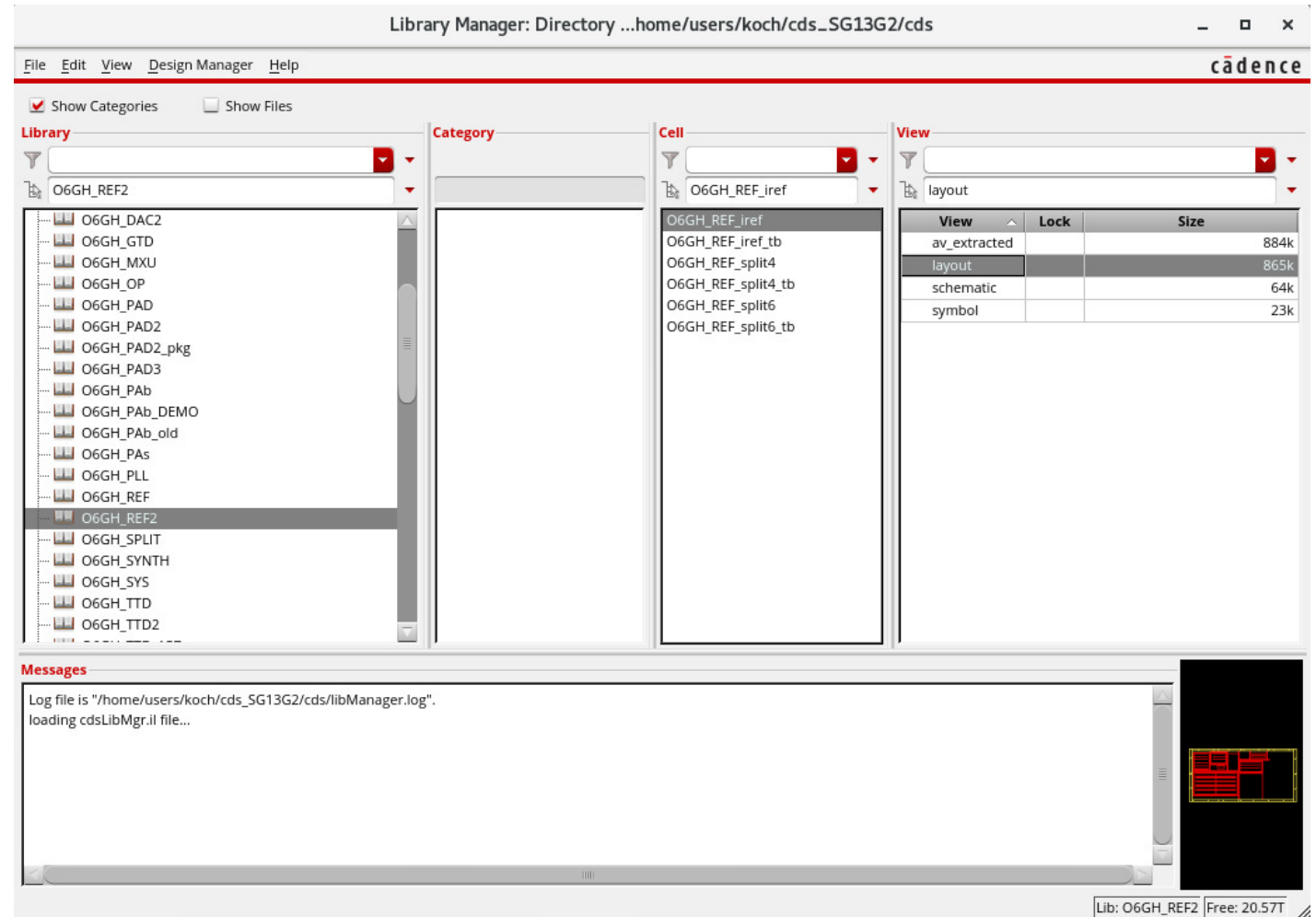
	Lab course	Thesis	Ph.D. students
Setup manual / Training videos	++	++	++
Simulation	sp, hb/pss with sp, transient	sp, hb/pss with sp, transient, pss for oscillator, (PVT)	sp, hb/pss with sp, transient, pss for oscillator, PVT
Simulation models	HBT, t-lines	HBT, t-lines, inductors, capacitors, Mosfets	HBT, t-lines, inductors, capacitors, Mosfets, transformers
Layout	Only visualization	Pcells, DRC, LVS, PEX	Pcells, DRC, LVS, PEX, Pads
Digital flow	o	o	++
EM simulation	o	+	++