Process Enabled Custom Component Design Flow for Photonic Integrated Circuits

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Outline

- Motivation
- Enabling a complete photonic design ecosystem
- Custom component design with Layer builder
- Support for active components
- See it in action
- Support for process variations
- Q&A

Foundry Compatible Custom Component Design

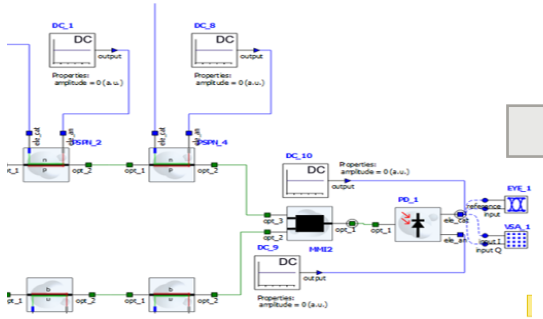
INTERCONNECT (PIC Suite)

Photonic circuit simulation

Circuit Designer

Foundry PDK

Off-the-shelf Components



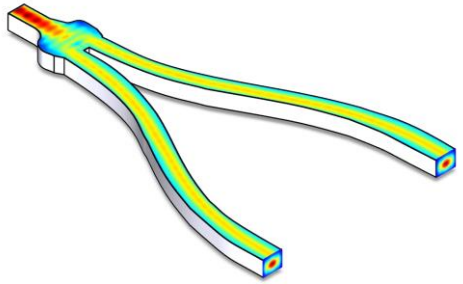
Foundry

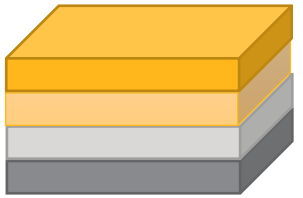
PIC

Compact Model

?

Component Designer





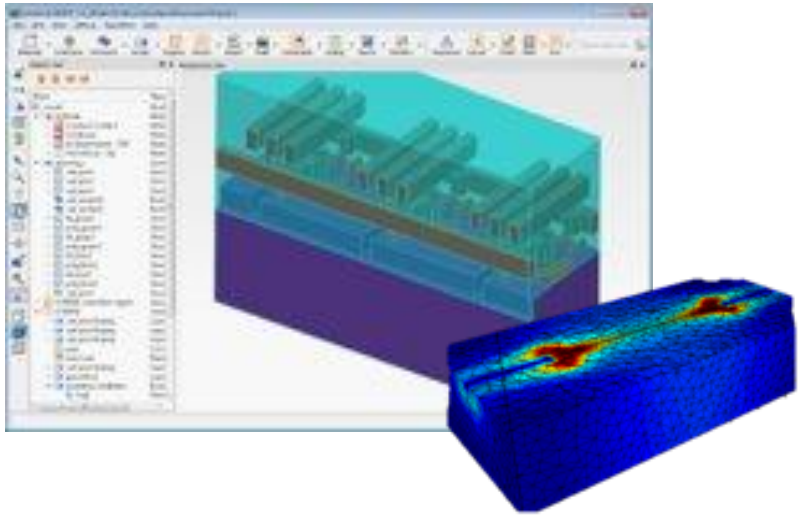
? Thickness
? Order
? Materials

Custom Component

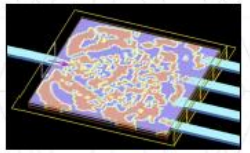
https://www.ansys.com/blog/design-foundry-compatible-photonic-components

A Comprehensive Suite of Leading Photonic Design Tools

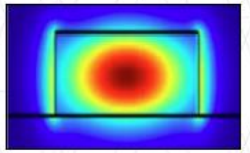
PHOTONIC MULTIPHYSICS SIMULATION



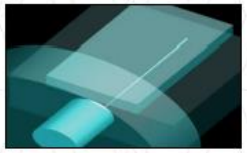
FDTD
3D Electromagnetic Solver



FDE
Finite-difference Eigenmode Solver

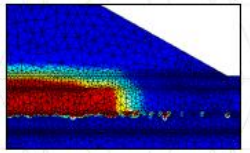


EME
Finite-Difference Eigenmode Expansion Solver

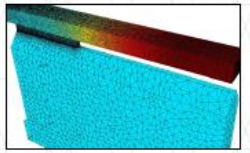


varFDTD
2.5D variational FDTD Solver

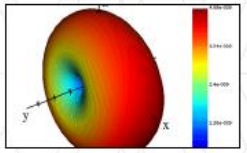
CHARGE
3D Charge Transport Simulator



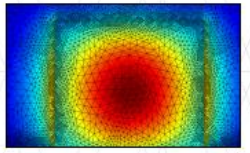
HEAT
3D Heat Transport Solver



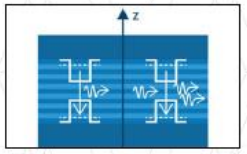
DGTD
3D Electromagnetic Solver



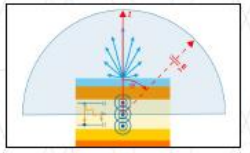
FEEM
Waveguide Solver



MQW
Quantum Well Gain Solver



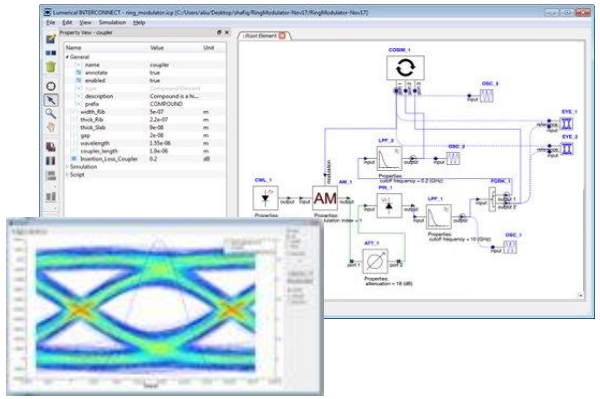
STACK
Optical Multilayer Solver



A Comprehensive Suite of Leading Photonic Design Tools

PHOTONIC INTEGRATED CIRCUIT SIMULATION

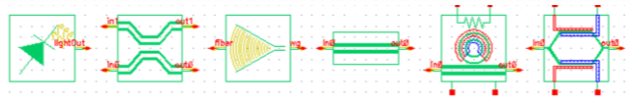
INTERCONNECT



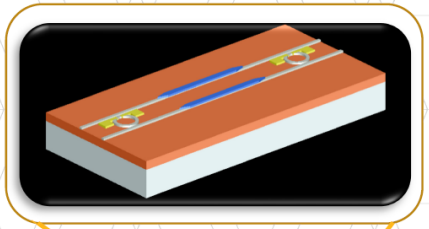
CML Compiler

INTERCONNECT compact models

Photonic Verilog-A models (Virtuoso)



Laser



Electro-Optic Modulator

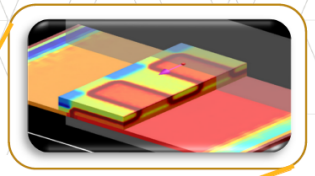
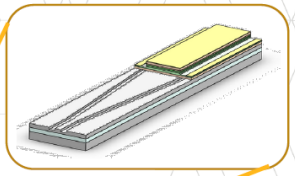
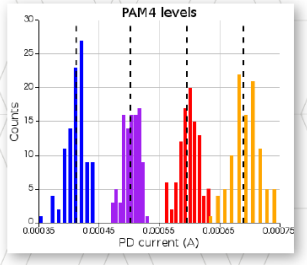


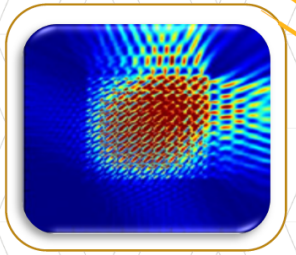
Photo-detector

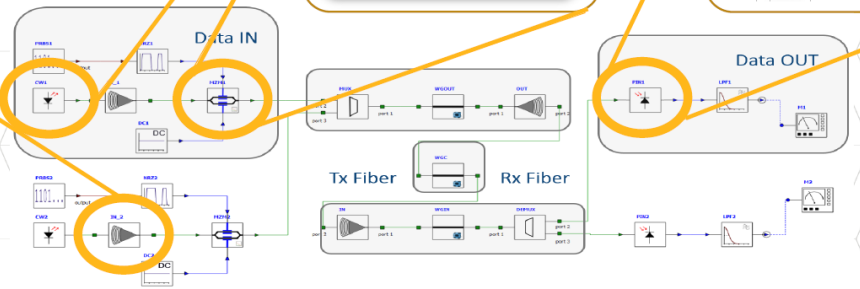


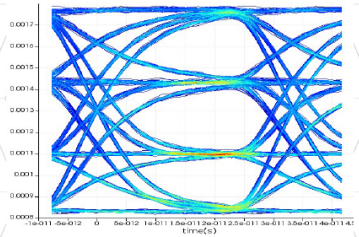
Communication Link Characterization & Yield Analysis



Grating Coupler







Open Ecosystem

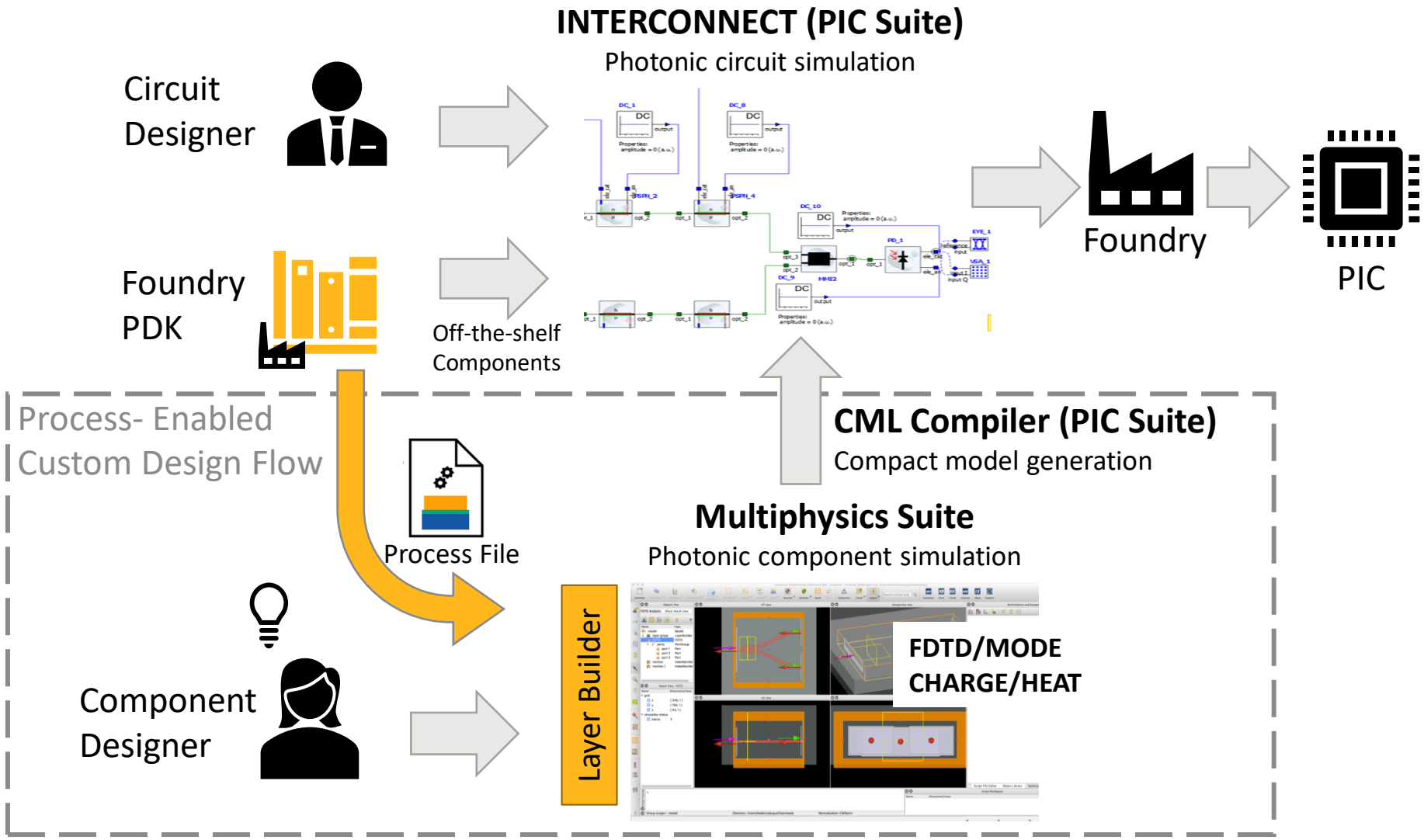
Automation

Optimization

Cloud & HPC Acceleration

Foundry PDK Enablement

Process-enabled Custom Component Design

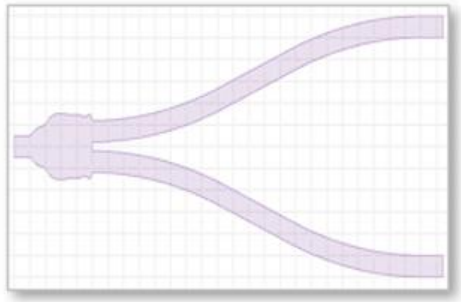


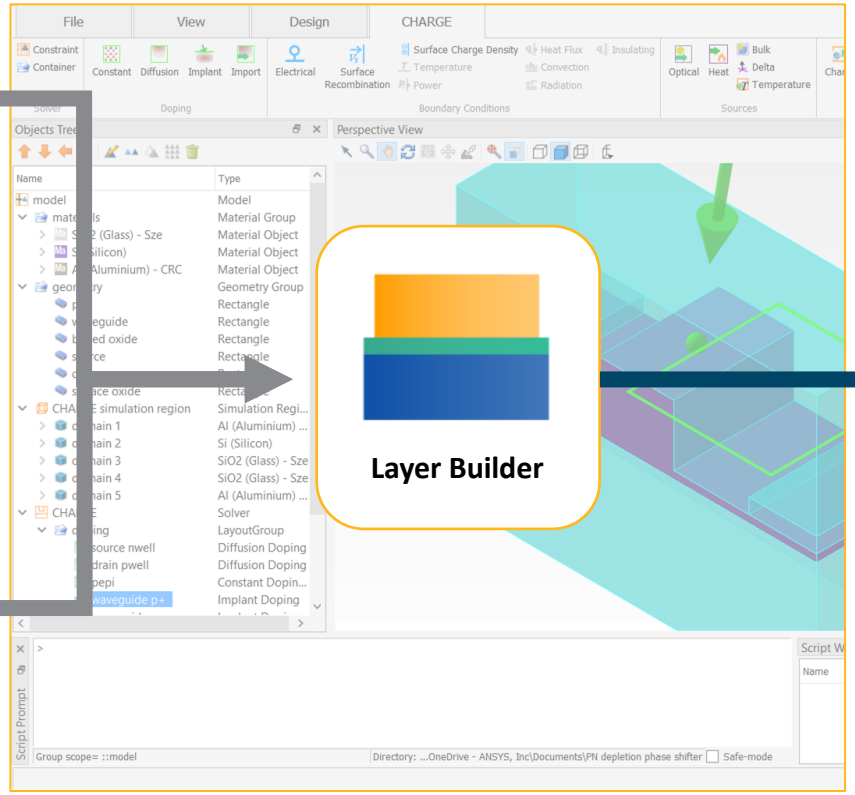
https://www.ansys.com/blog/design-foundry-compatible-photonic-components

How Does Layer Builder Work?

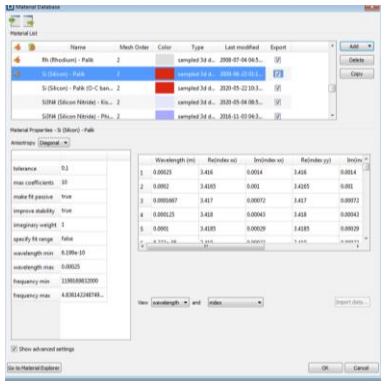
Process file with layer definition

GDS-II file with geometry definition

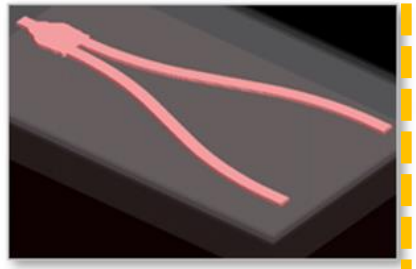




Optical material data

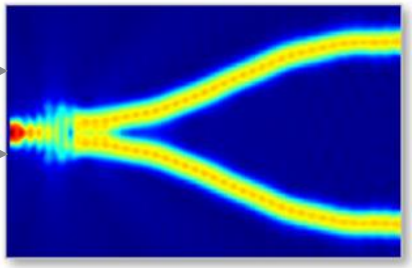


3D geometry



Simulation settings

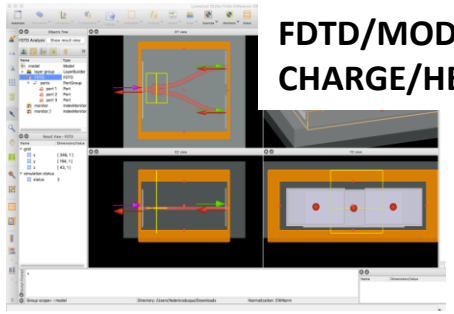
Simulation results



Automated Data Collection Workflows

Component Design

Multiphysics Suite



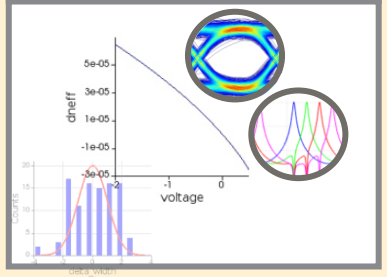
FDTD/MODE
CHARGE/HEAT

CMLC data

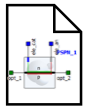
Data collection workflow

Compact Model Generation

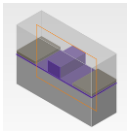
CML Compiler



External data



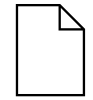
Element config



Simulation/process set-up

Controls

- ✓ Identifies missing external data
- ✓ Extracts supplementary data from simulation
- ✓ Enforces physical behaviour (optional)



CML Compiler data file

Data visualization

https://support.lumerical.com/hc/en-us/articles/360059773793-Automated-data-collection-workflows

Foundry Process Files Currently Available

GlobalFoundries™

CompoundTek

AIM photonics

Tower Semiconductor

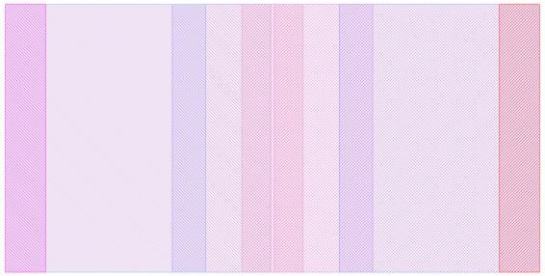
LIGENTEC

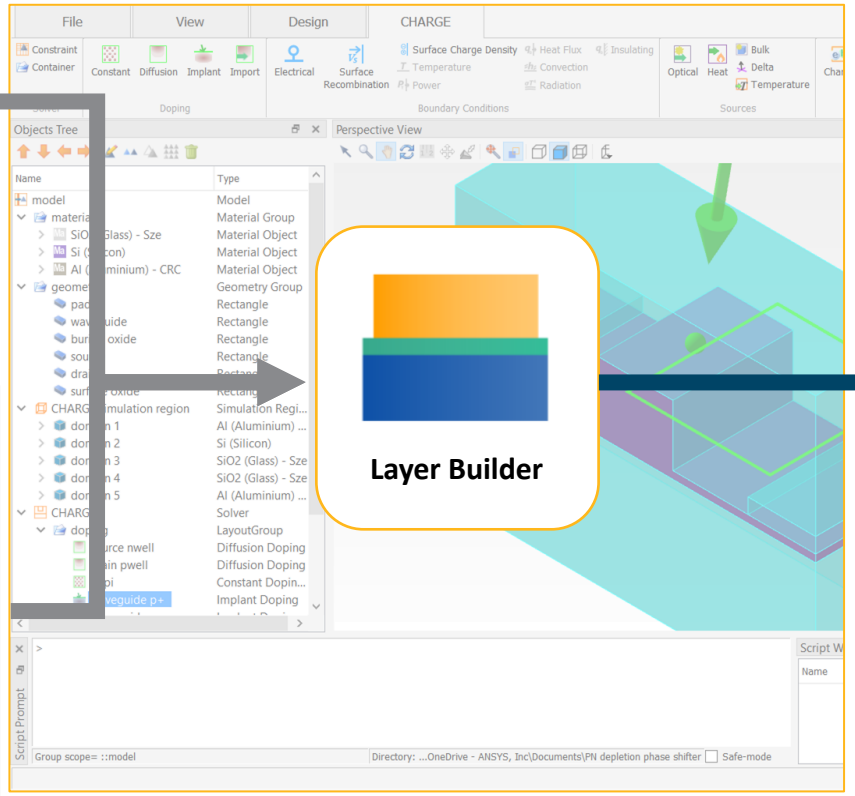
More to come…

Support for Active Devices

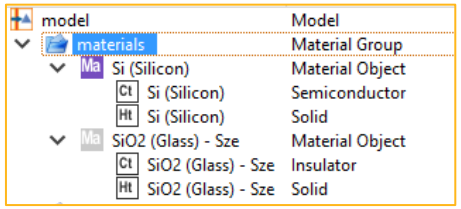
Process file with layer definition and doping information

GDS-II file with geometry and doping patterns

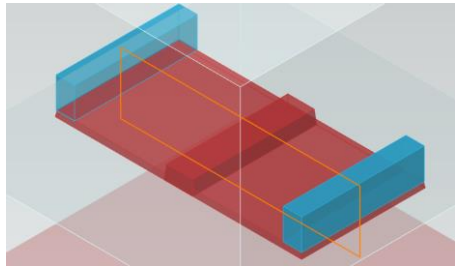




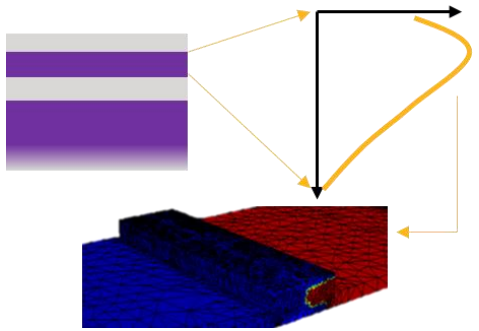
Optical/electrical/thermal materials



3D geometry

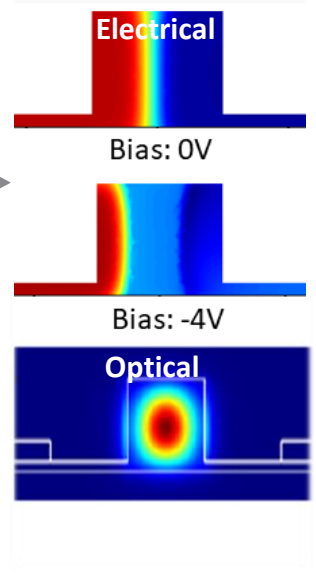


Doping



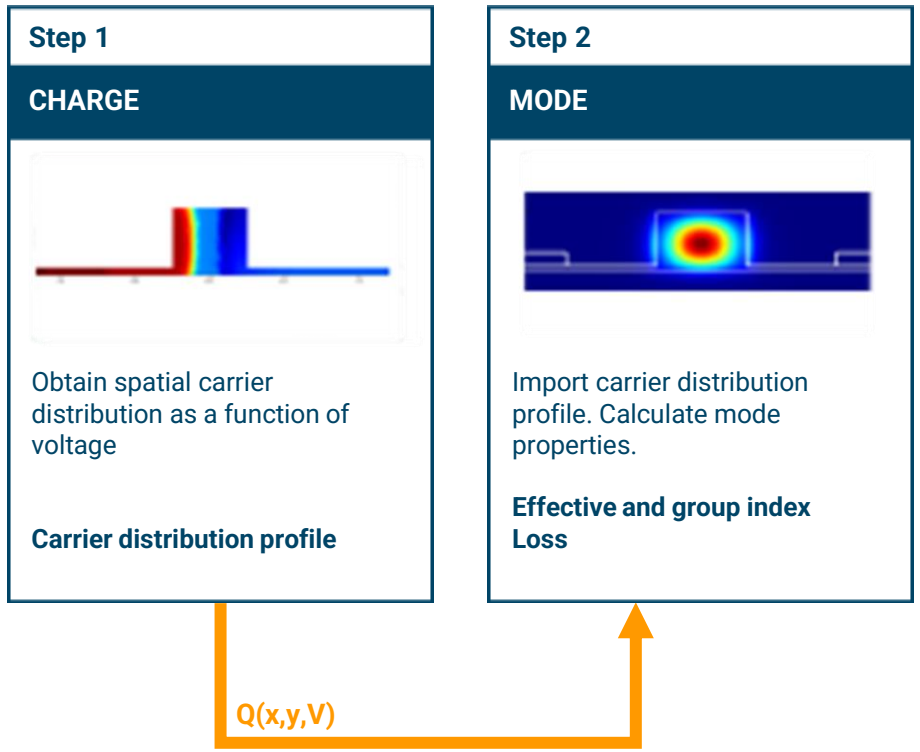
Simulation settings

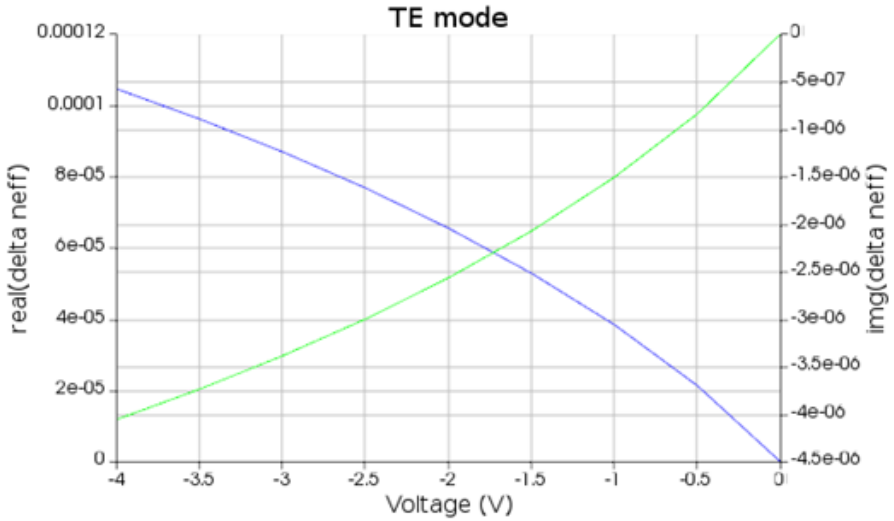
Simulation results



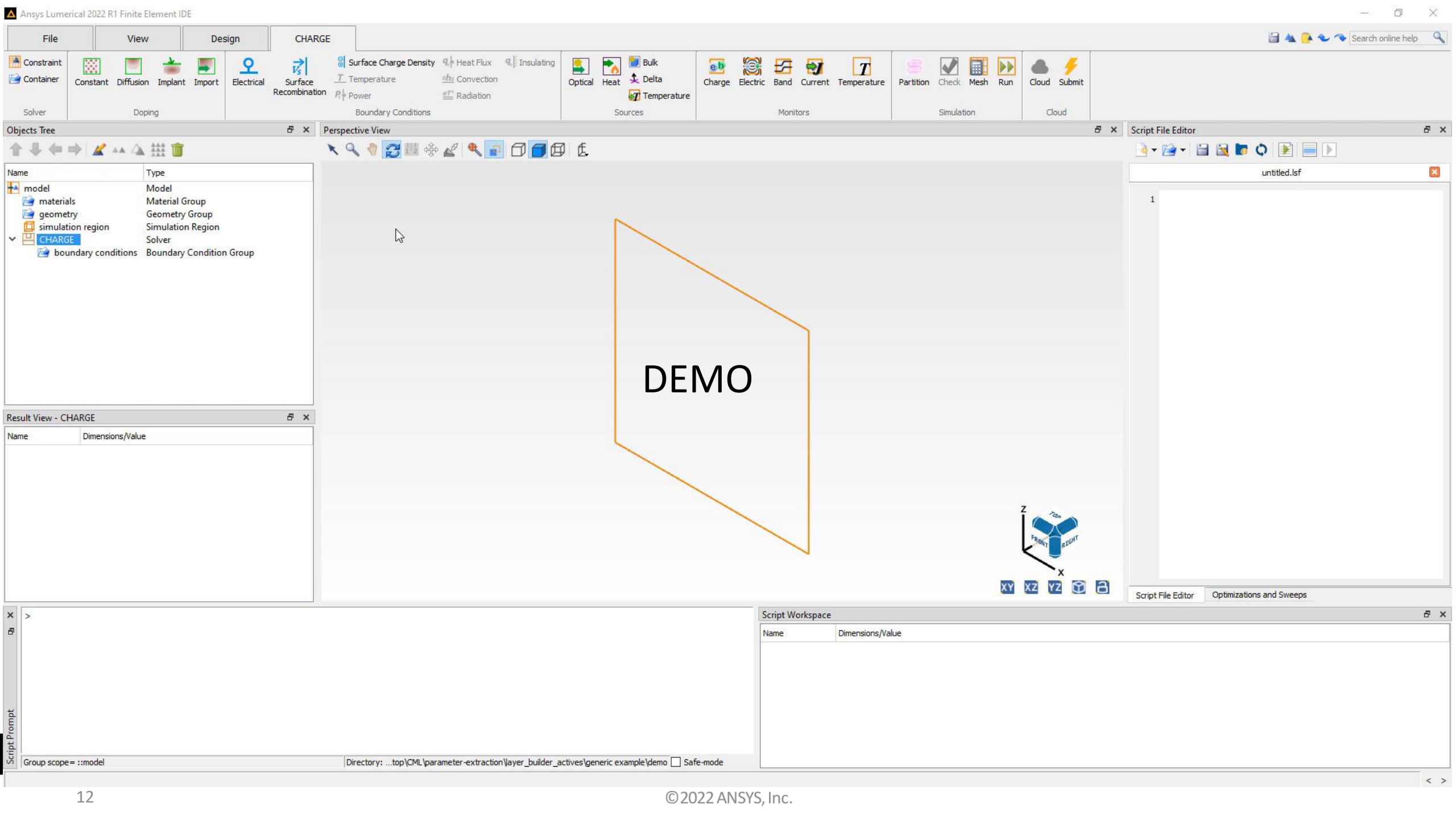
Let’s See It in Action!

Simulation workflow of an Electrical Phase Shifter





https://support.lumerical.com/hc/en-us/articles/360042328674-PN-depletion-phase-shifter



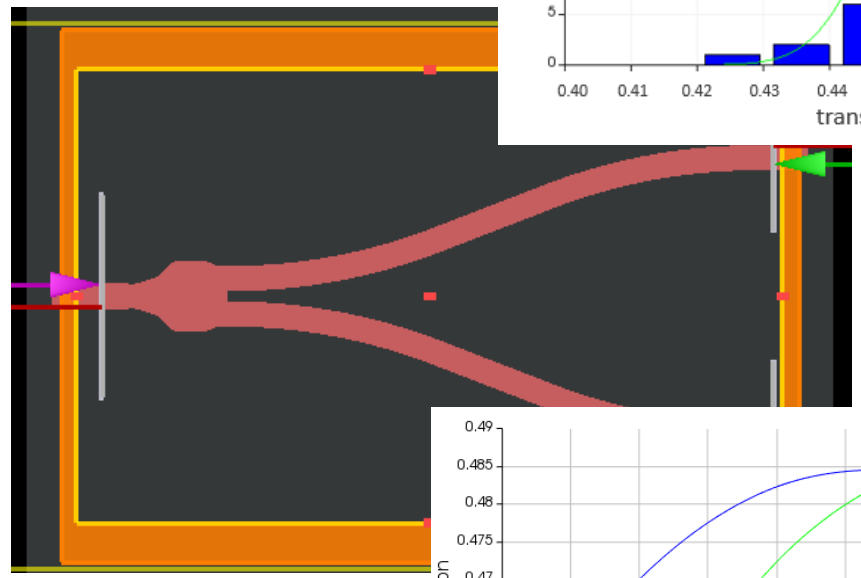
Process Variations During Component Design

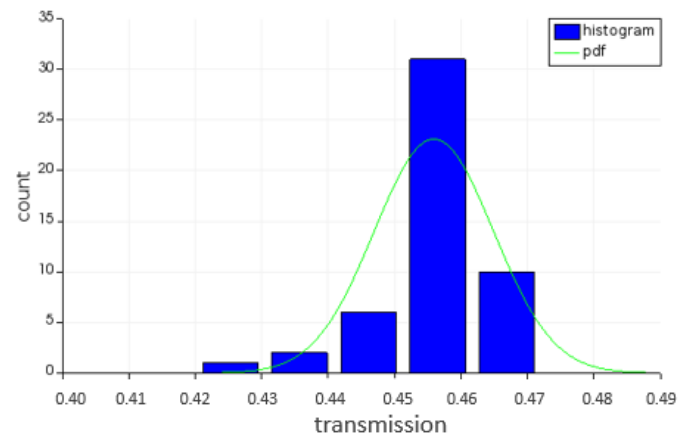
- Process file to include statistical information:
  - Pattern process parameters: layout bias
  - Stack process parameters: layer thickness, etch depth, etc.

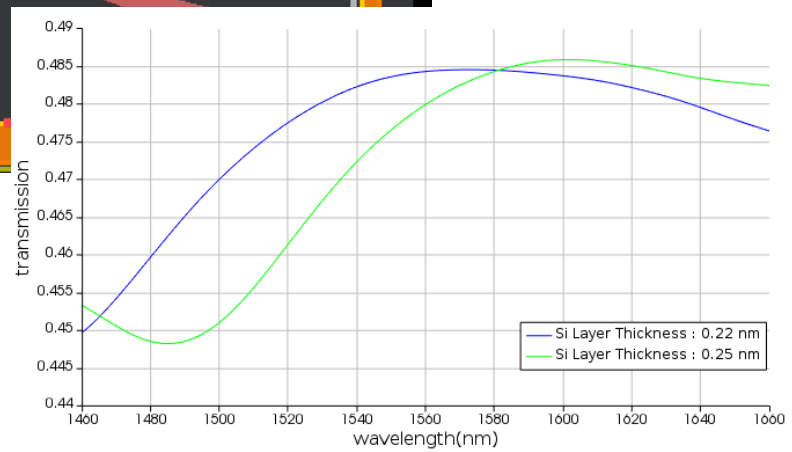
- Statistical simulation methods:
  - Monte Carlo:
    - Statistical variables are randomly varied for a defined number of times and FOMs are studied
    - Most complete, but more expensive
  - Corners:
    - Worst case values of statistical variables are used and FOMs are studied
    - Multiple corner cases can exist

Example: Process Variation for Y-branch

- SOI layer thickness as a process variable.
- The process variable can be changed randomly and extract transmission results: **Monte Carlo analysis.**
  - Statistical distribution of process variations are required. (for normal distribution: sigma and mean)
- The worst case scenario for the physical process variable can be determined and extract transmission results: **Corner analysis.**
  - Corner cases should be provided
- Superposition of effects of multiple process variables can be modeled.







End User Workflow

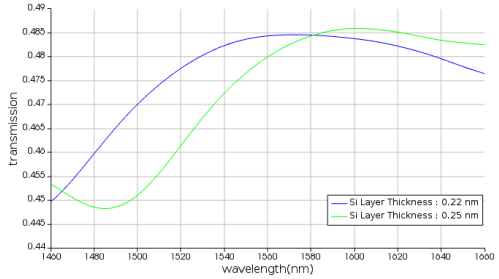
Foundry

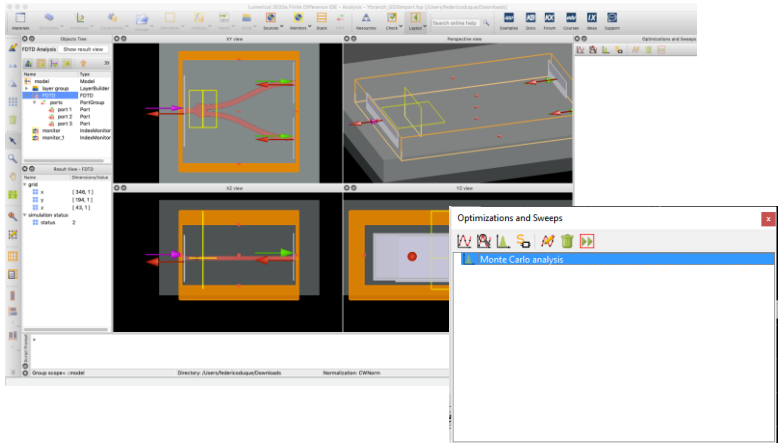
Process file including process variations

Component designer

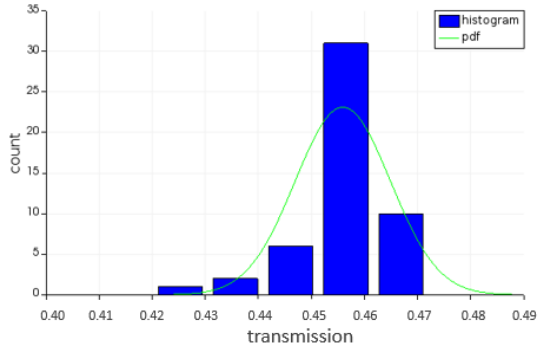
Layer builder

Corner Analysis





Monte Carlo Analysis



Thank You

Questions?


Ansys