



Serving the photonics community for over
30 years with market leading simulation tools

No Cloud Computing Required

Simulating large scale photonic
components on a laptop.

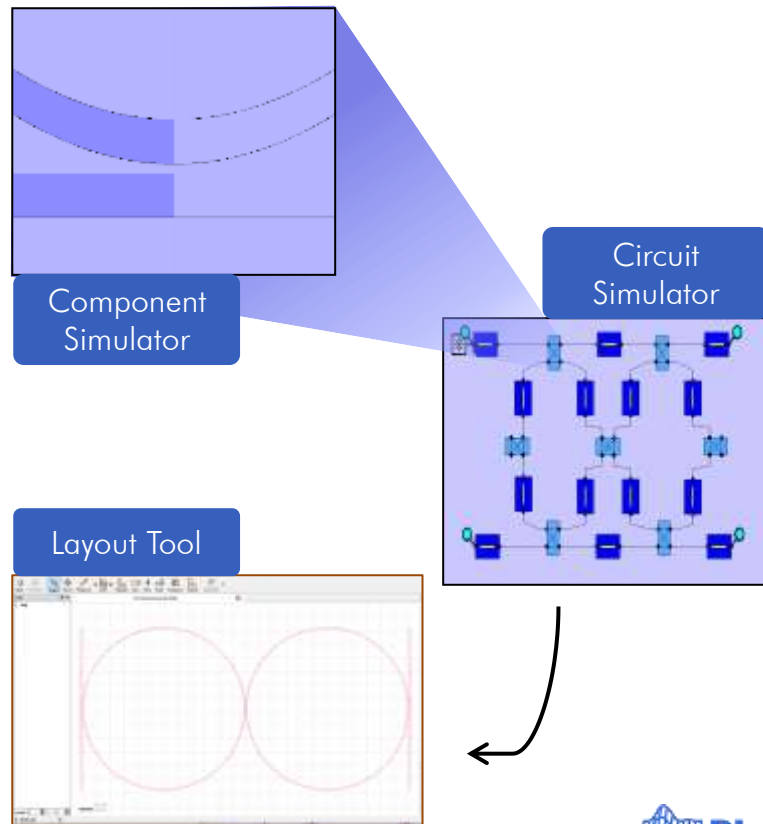
Dr Dominic Gallagher | Founder and CEO of Photon Design

MZM, optical simulations simulated in under a minute

Simulating individual components is a well known craft, Photon Design have been doing this for decades with a variety of methods.

Simulating large scale devices is more challenging:

- Some opt to use multiple tools (lots of back and forth between environments + paying for many tools).
- Some opt to use cloud computing with methods like FDTD.
- Photon Design have pioneered an easy-to-use, single environment approach that can run locally.

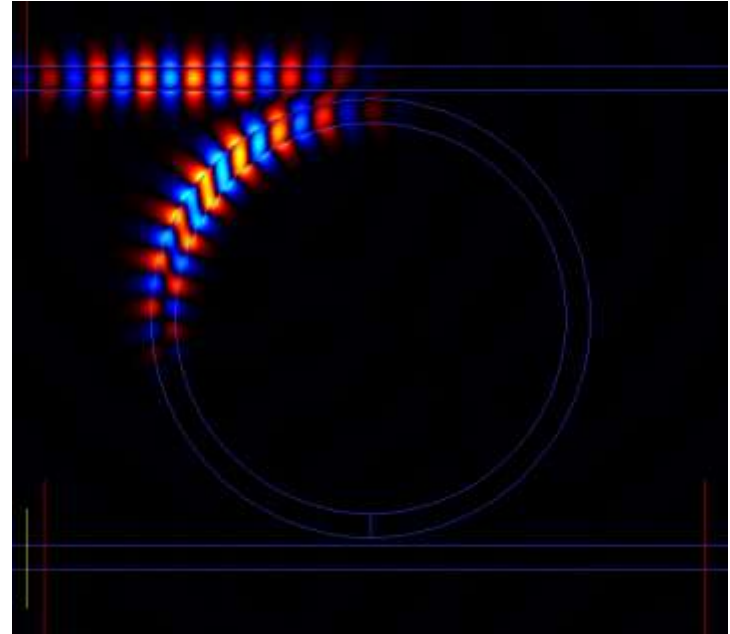


Solves Maxwell's equations using the famous time-domain Yee algorithm.

- A mesh splits up the entire canvas into many 3D cells (Yee cells)
 - Compute the H field at each cell in 3D space
 - Evolve a small time step
 - Compute the E field at each cell in 3D space
 - Evolve a small time step
 - (Repeat)...

The result:

- Simulation time scales with **simulation volume** and **duration**.
- Can require *trillions*[1] of FP calculations making “expensive” cloud computing all but a necessity.

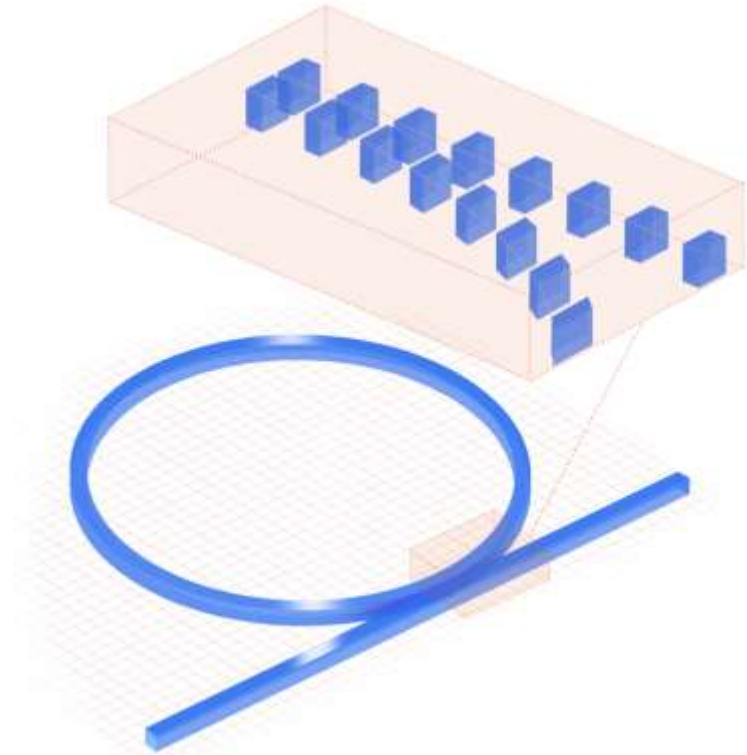


- Split devices into the unique cross sections
- Solve modes in those cross sections
- Evolve the light to next cross-section.

This is *EigenMode Expansion* (EME).

This means:

- Simulations do **not** scale with volume
(suits large scale simulations)
- Simulations do **not** scale with path length/
durations
(no long runtimes for high Q factor cavities)



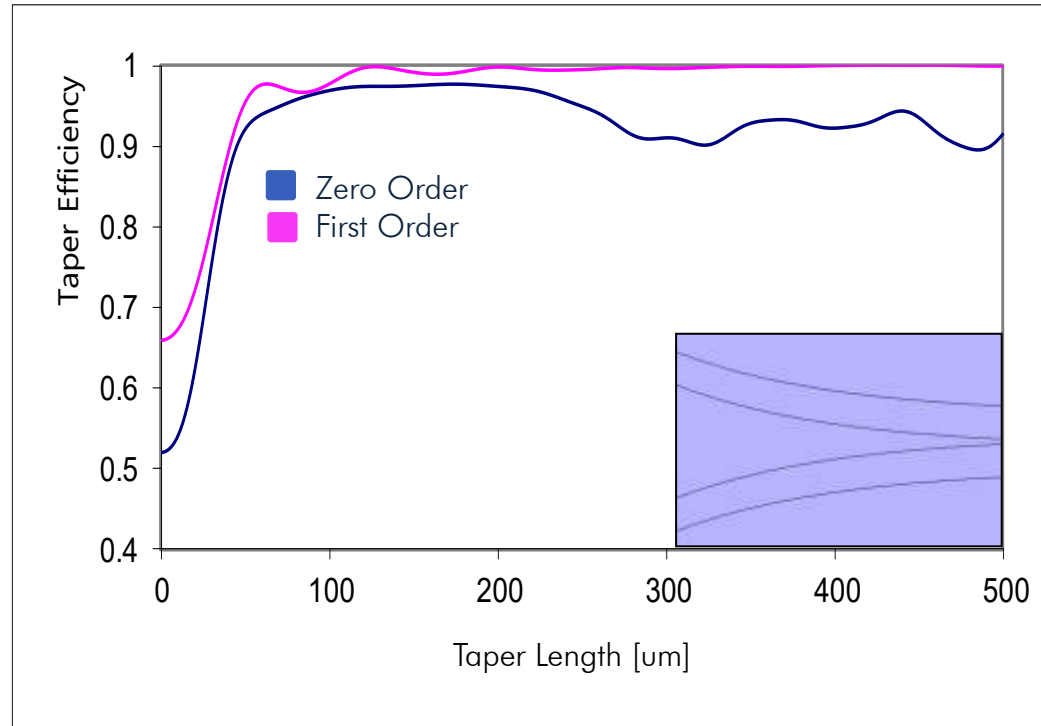
Photon Design invented first industrially useful version of EME back in the late 1990

- Advanced integration methods avoid staircasing problems

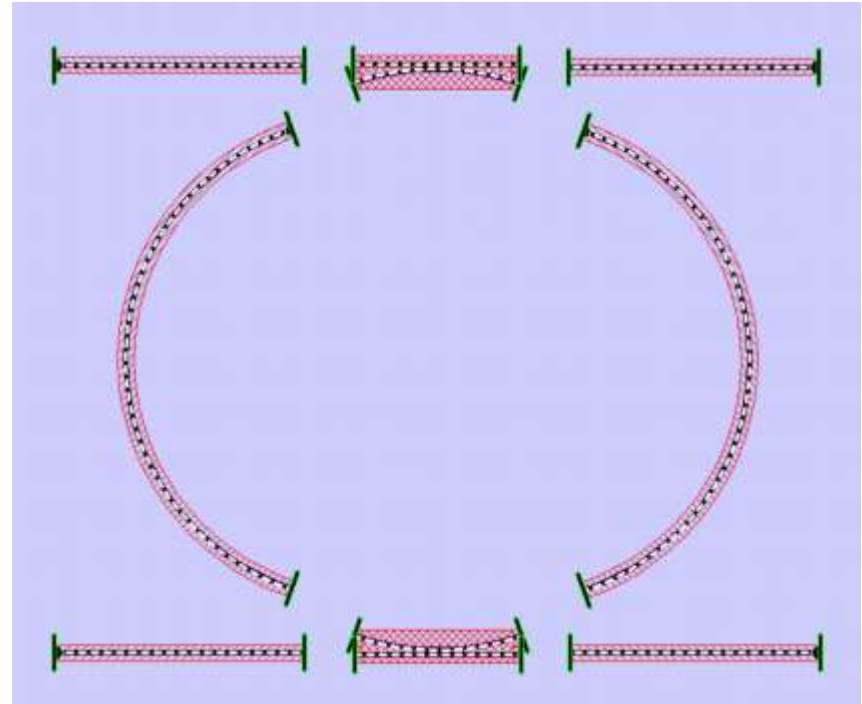
⇒ Lower errors

⇒ Higher speed

Photon Design has pioneered advances in EME since.



- Photon Design's MT-FIMMPROP allows EME simulations to be snapped together to build full devices.
- Straight waveguide simulations + Bend Waveguides + Coupling Regions = Full Ring Resonator.
- We're not simulating full volume/ empty space, just the cross sections that follow the waveguides.



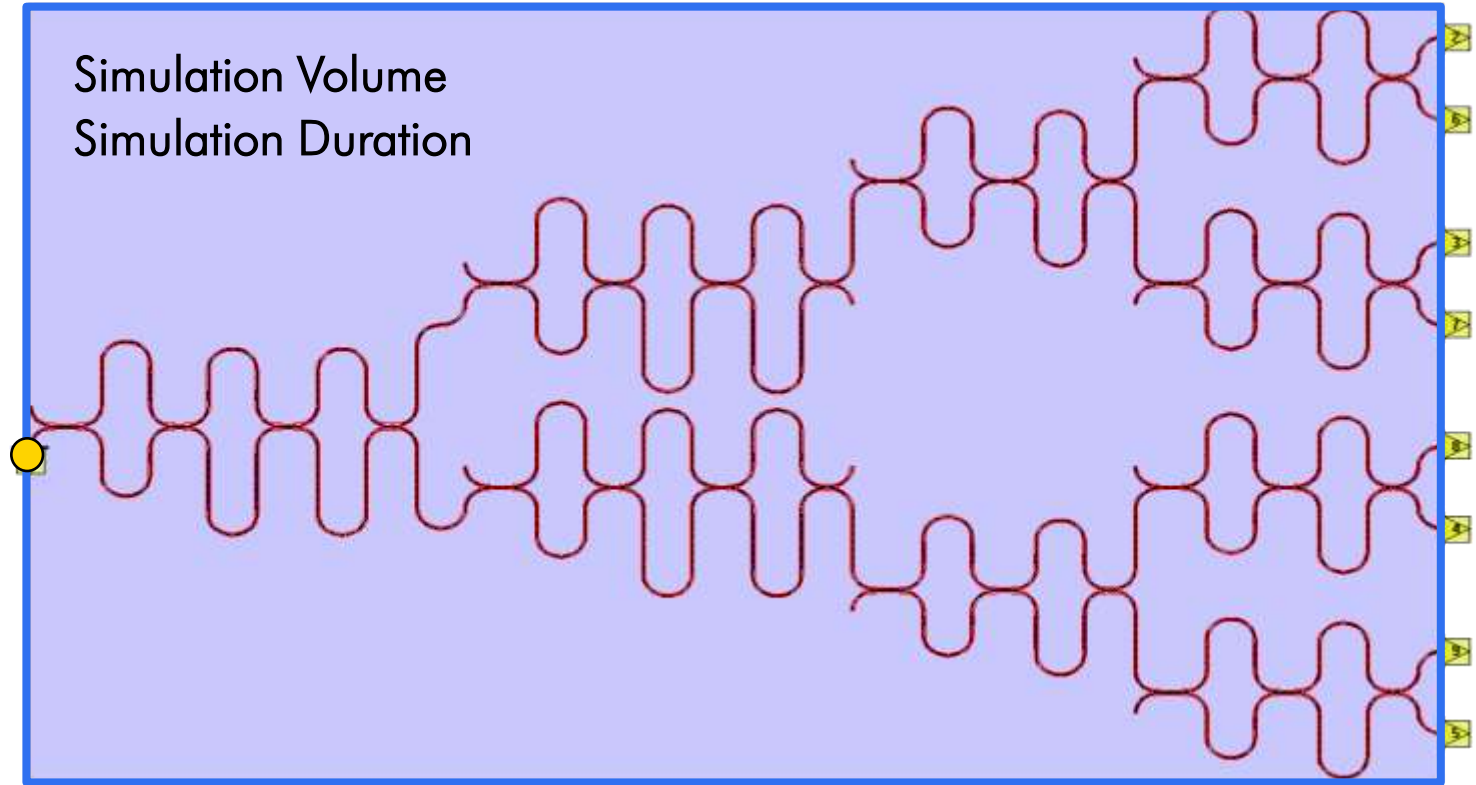
Live Demo

How fast do you expect a 3D ring resonator (30um radius) to take?

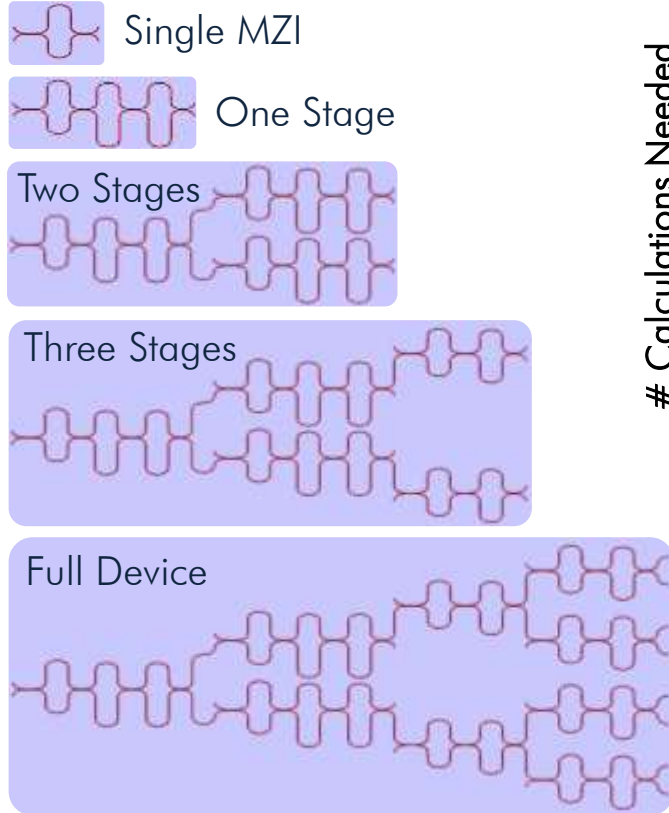
Results from [1] suggest over 70 hrs for running on desktop
or 2 hrs run on cloud with reputable FDTD providers.

Further Examples

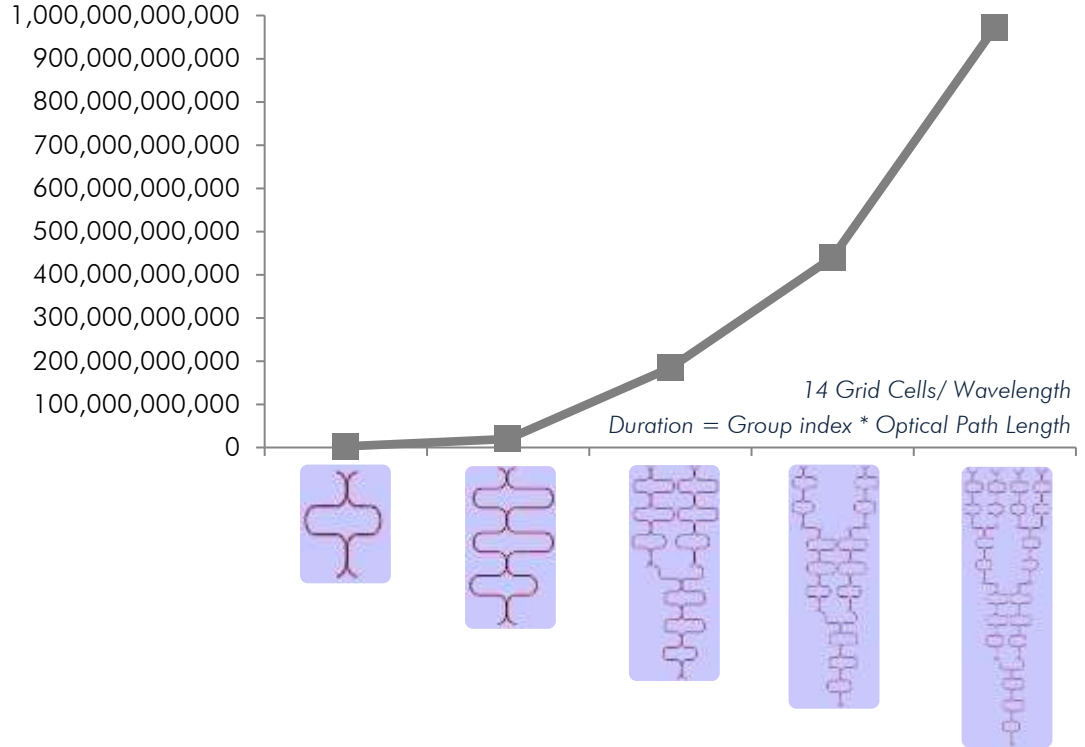
That only MT-FIMMPROP can perform with EME



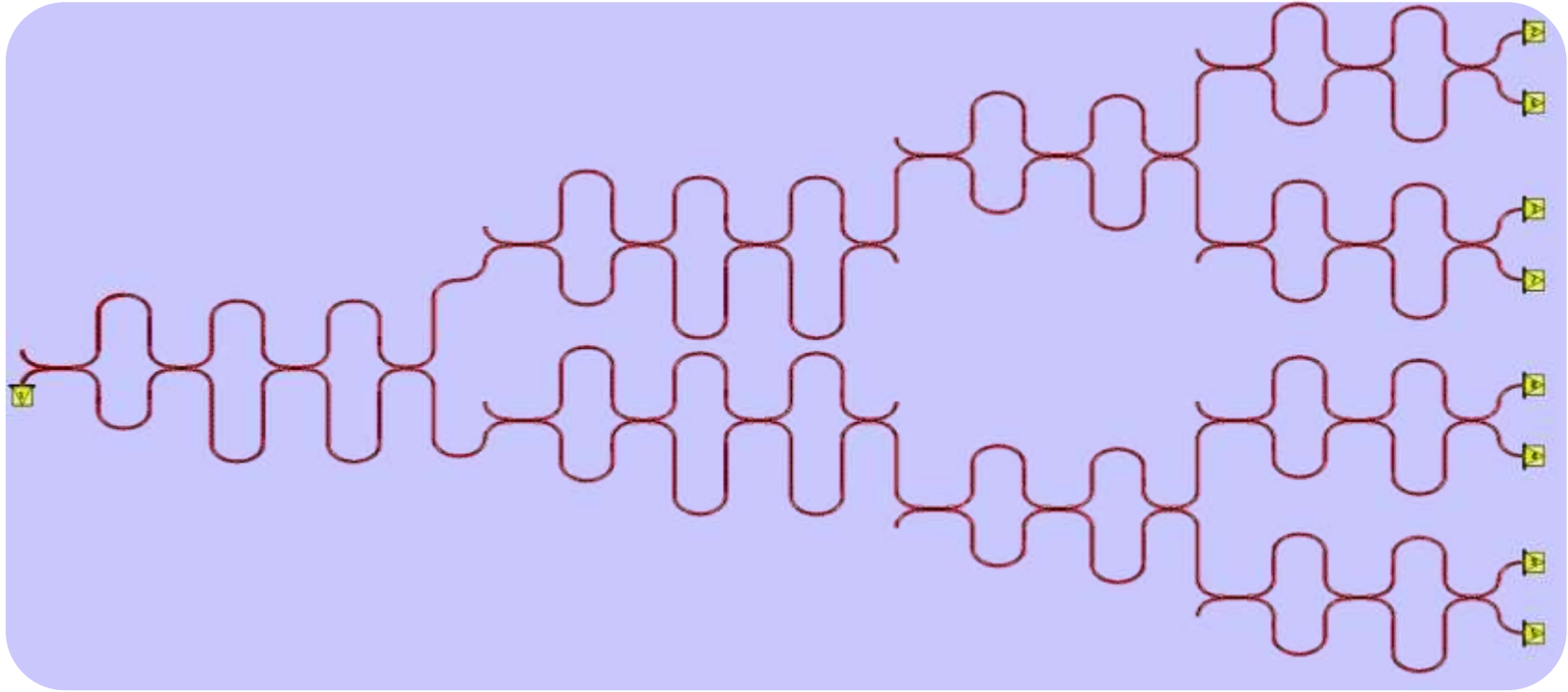
What effects Computation Time when run in FDTD?



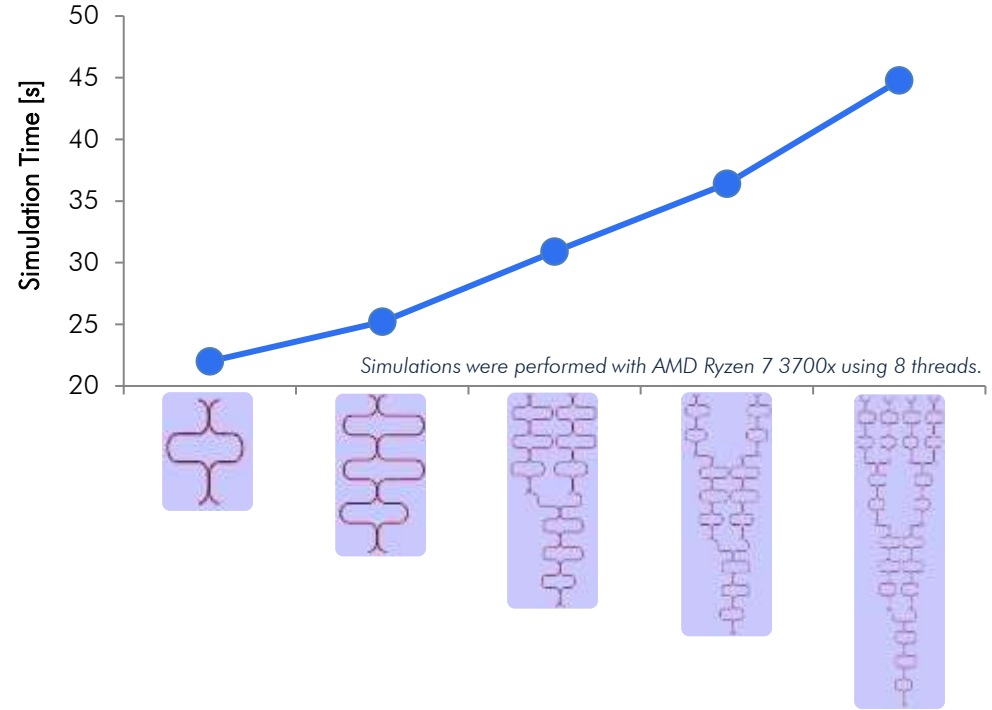
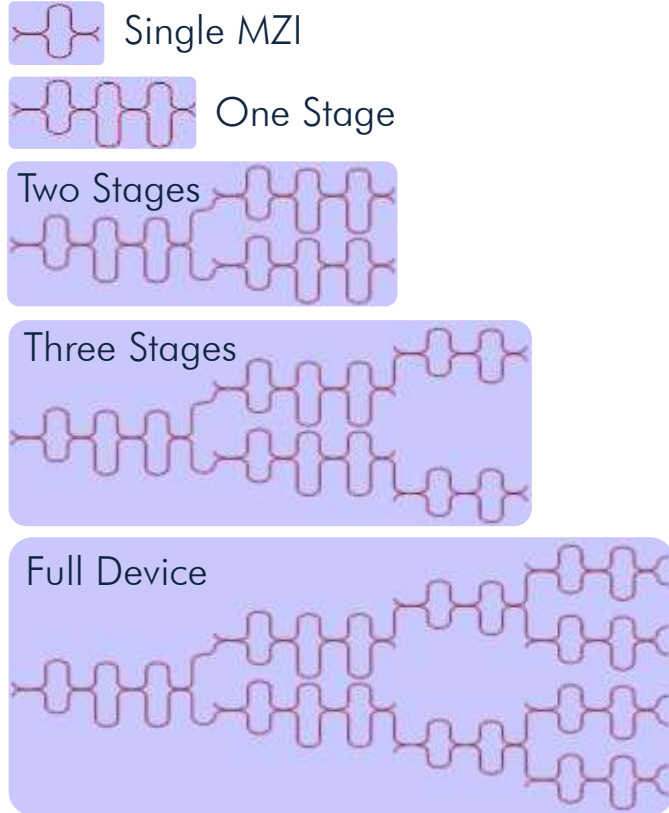
Calculations Needed
(FDTD)



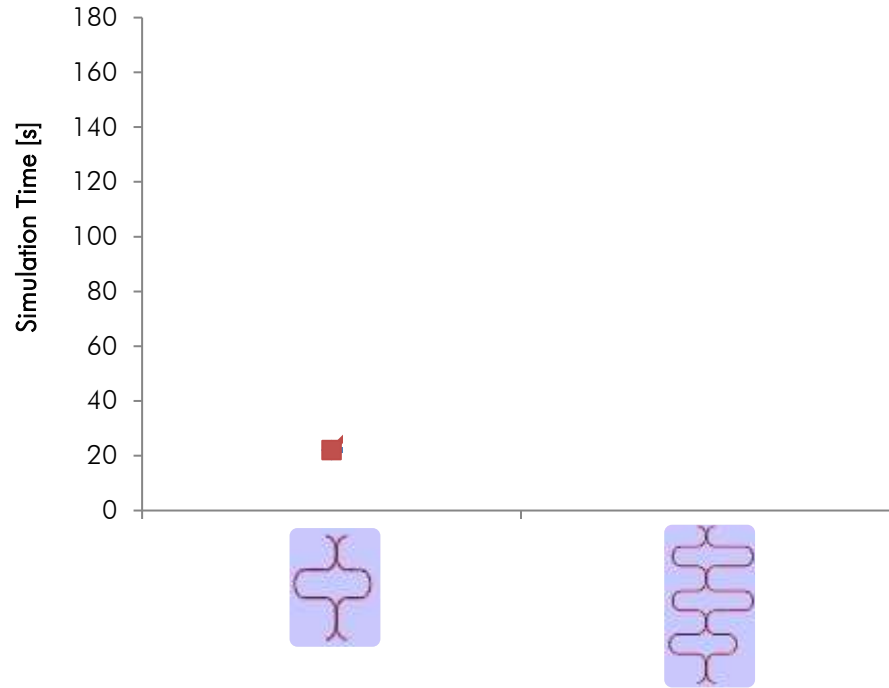
If Grid Cells/ Wavelength is a more sensible 30,
'Three Stages' becomes around 1B Grid Cells in size



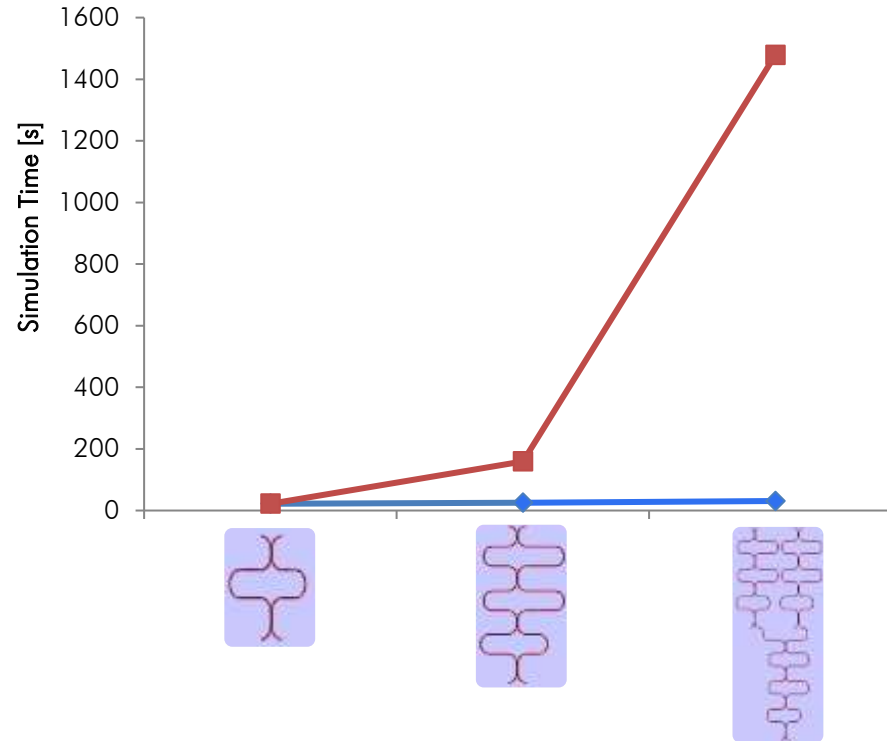
Repeated simulation regions recycle results – only unique simulation regions need calculation



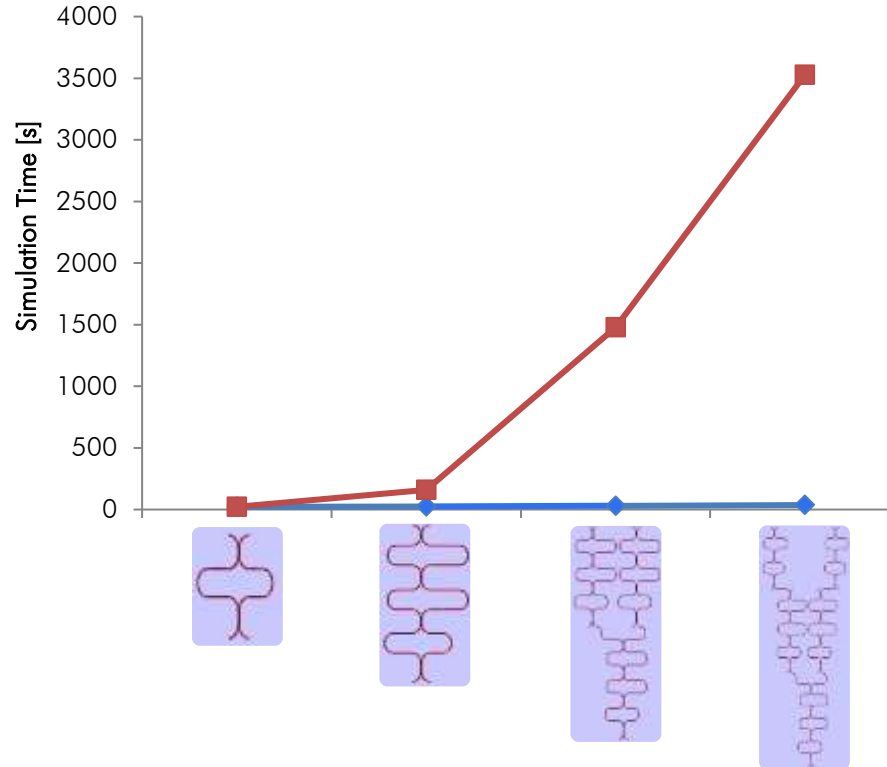
Suppose results took the same amount of time for a single MZI (EME almost certainly faster!)



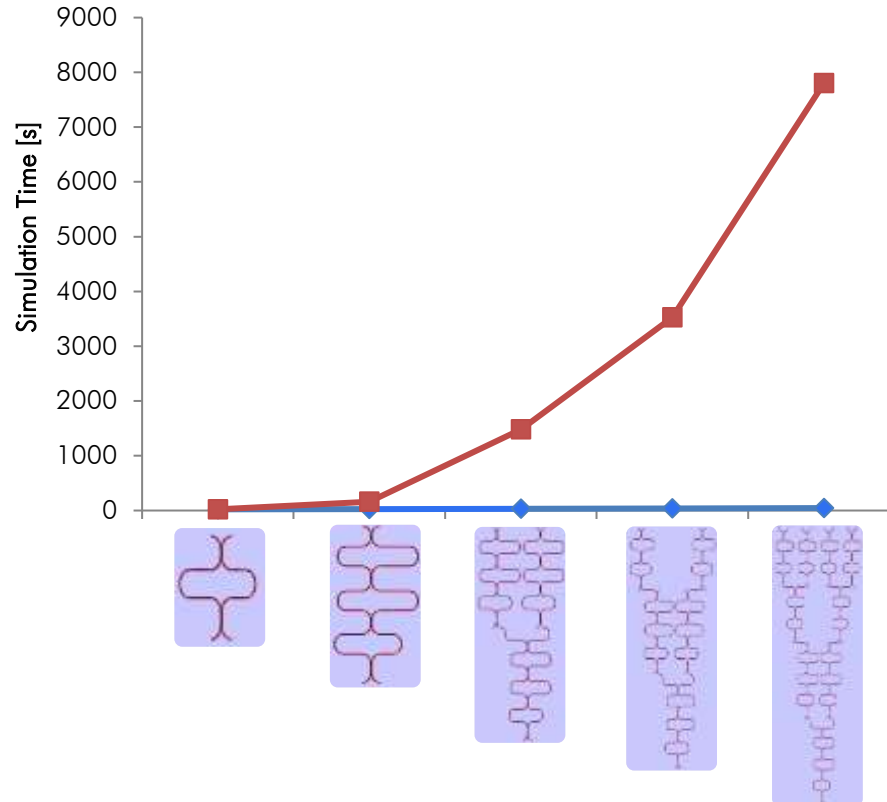
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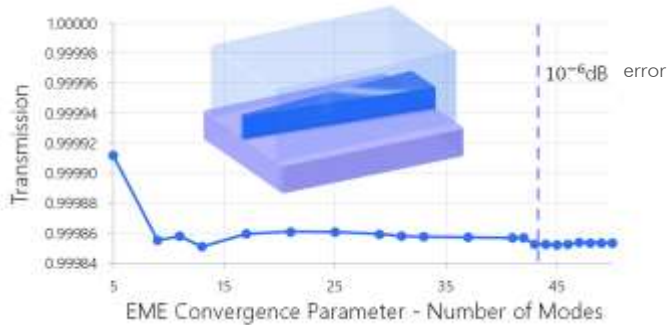
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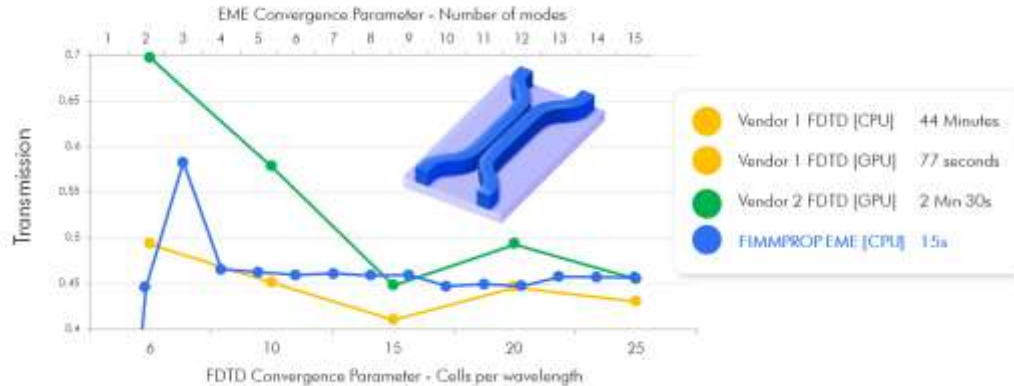
MZIs could be placed end on end to get best FDTD scaling
(quadratic with number of MZIs)



Suppose results took
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time for a single MZI
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- EME Simulations shows convergence to 10-6 dB of error, that's results consistent within ($\sim 0.0000025\%$).
- Very important in quantum device applications

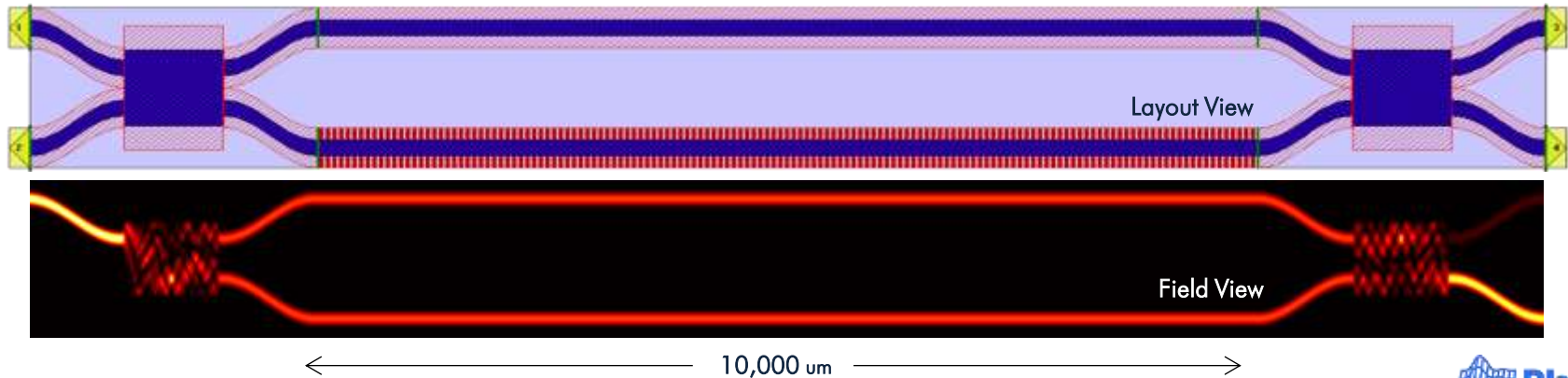


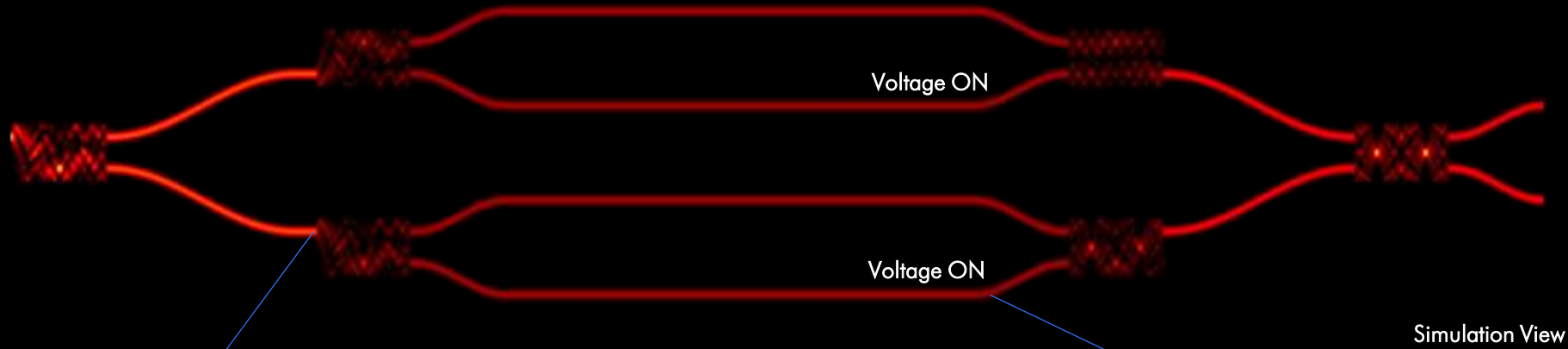
- Compared with FDTD results are shown to agree^[1].
- Simulations converge much more quickly

Further Applications

That only MT-FIMMPROP can perform with EME

- **Length independent** – millimeter straight waveguides require just one mode list to simulate regardless of length (a few seconds of runtime)
- **Component design** – splitters and bends are designed and rigorously simulated in the same environment.
[More info on EME for bends, splitters, and tapers available]
- Includes electro-optic and thermo-optic effects on mode effective index.

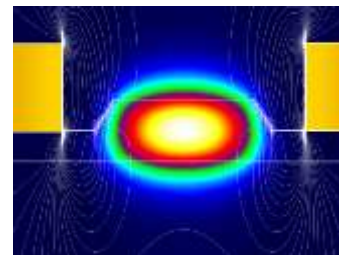
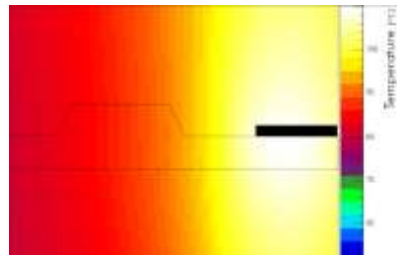




Thermal Phase Shift

Thermal contacts with applied power P . $n_{\text{eff}}(P)$ solved in FIMMWAVE thermo-optic solver.

90 degree phase shift introduced to place signals in quadrature.

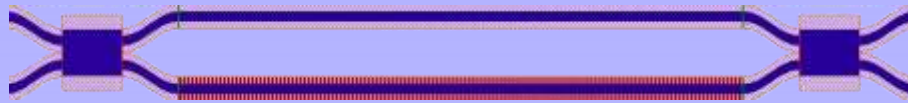


Push Pull Modulator

$n_{\text{eff}}(V)$ from EO Solver calibrates four arms
Calculated with FIMMWAVE electro-optic solver.

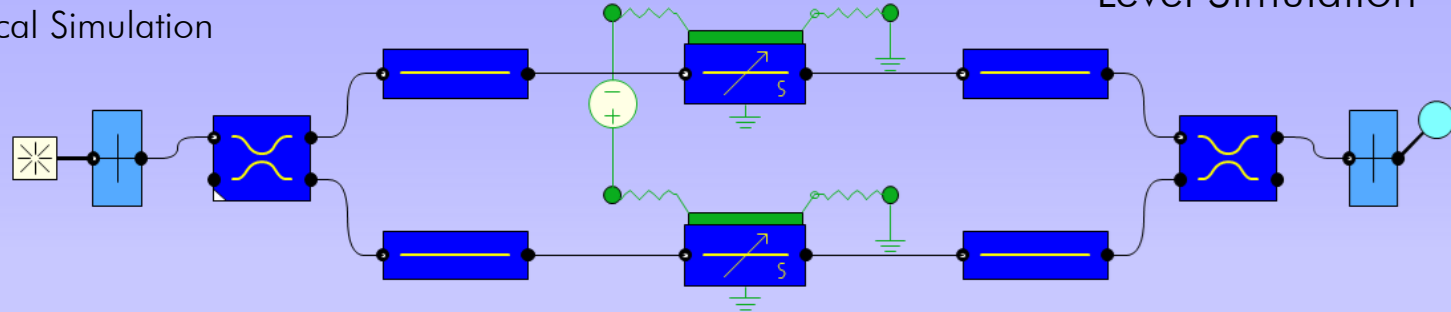
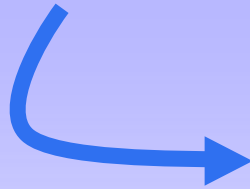
Green – Push (reverse bias)

Red – Pull (forward bias)



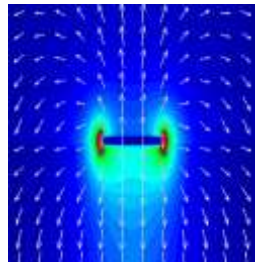
Rigorous Optical Simulation

3D Dynamic Circuit Level Simulation



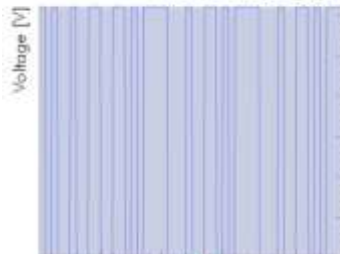
Micro-Strip Modes

Impedance of TWE

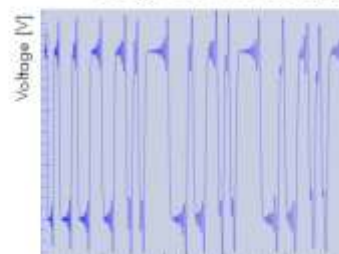


Travelling Wave Electrodes

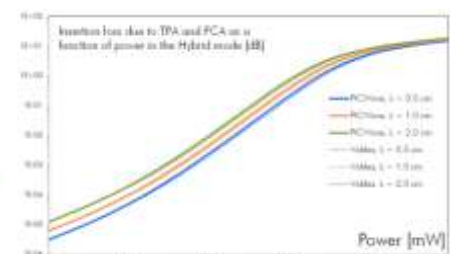
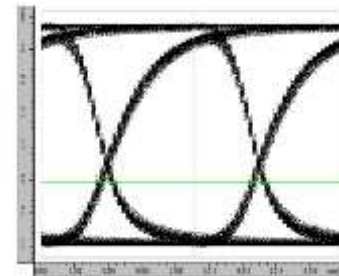
Input voltage signal



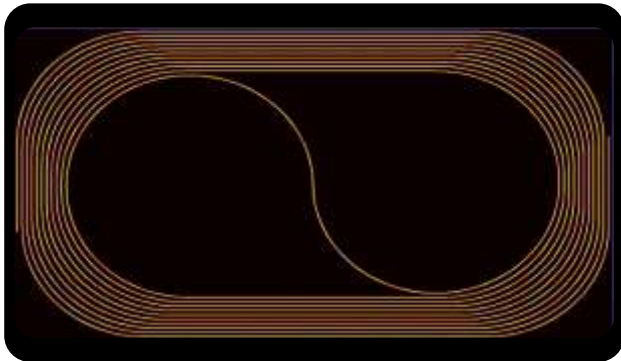
Voltage over contact length



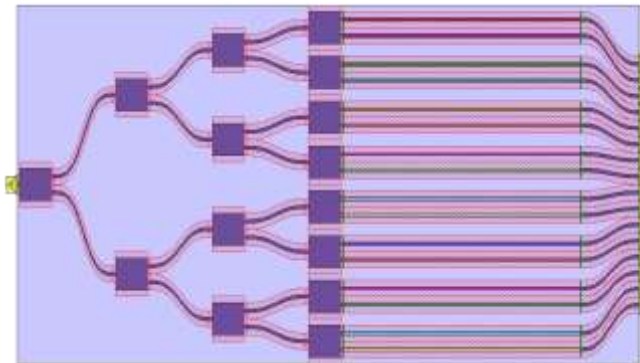
Dynamic Simulations



Non-linearity validated



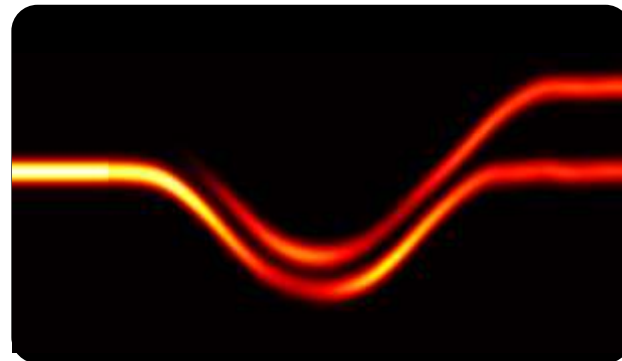
Centimeter Delay Line



Beam Steering + Cascaded MMIs

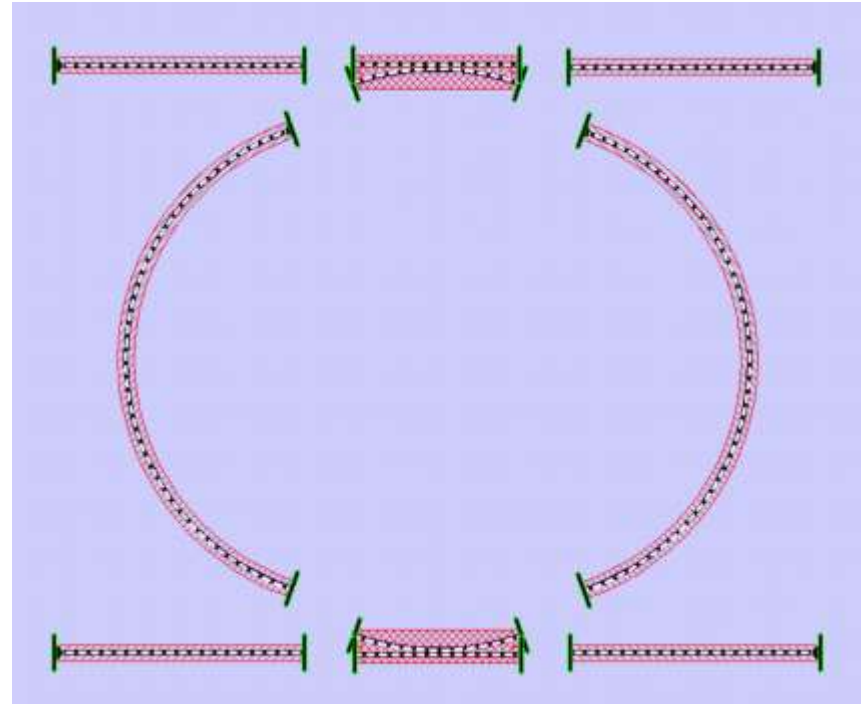


Vernier Ring (tuneable laser applications)



Broadband Directional Coupler

- Photon Design's advanced software enables EME simulations that cannot be done with any other vendor
- Simulations can be orders of magnitude shorter meaning 1000s of simulations in a day rather than 10s.
- Combines 3 tools into 1 for simplicity and cost savings.





Leading EME Simulations

Exhibition Booth 1456

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