



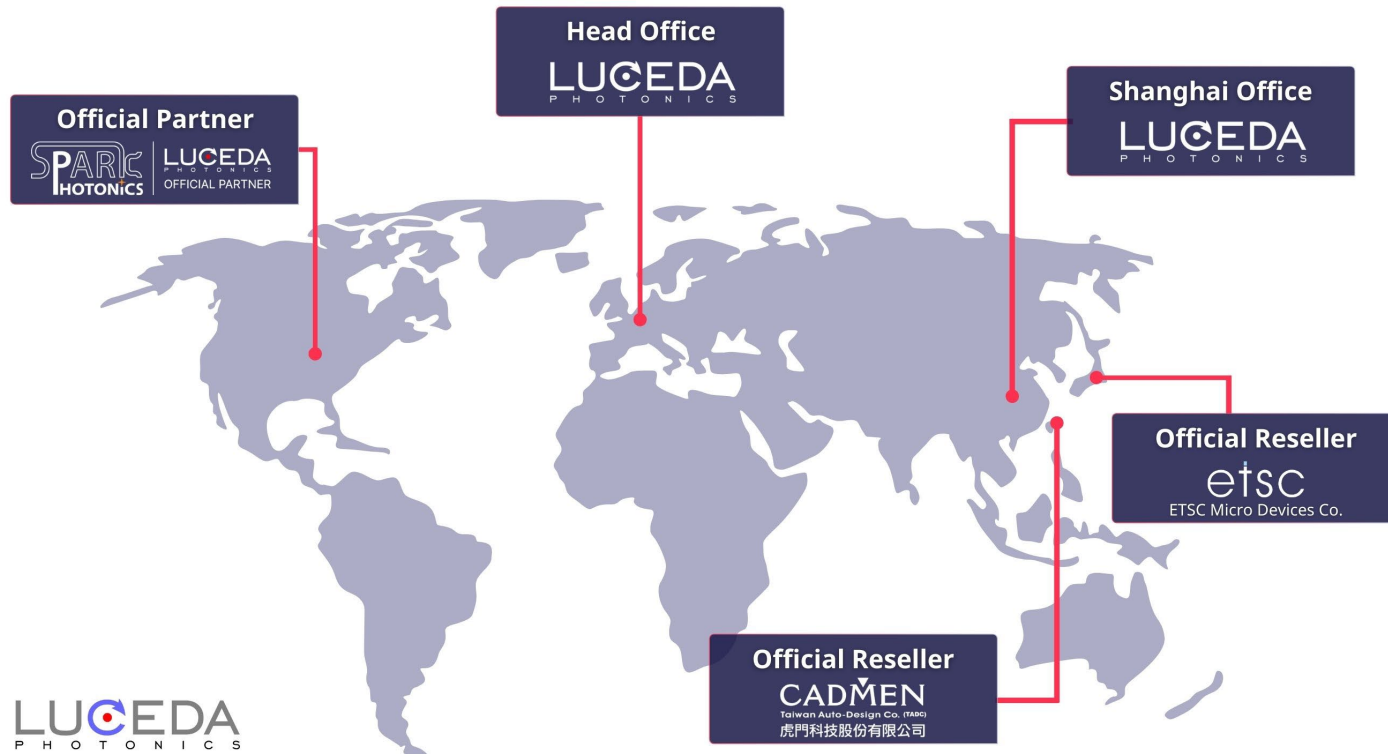
# PIC design: Code-driven flow from idea to tape-out

---

CHIARA ALESSANDRI

Swissphotonics PIC Convention, 21 June 2024

# About Luceda Photonics



**Luceda Photonics** was born in 2014 from the Belgian photonics ecosystem.



**Our vision** is to help photonic IC designers enjoy the same first-time right experience as electronic IC designers.



**Our mission** is to accelerate PIC design teams' time to market, by helping them set up a flexible and efficient PIC design flow.



**Global presence** on all continents, with several offices and 1000+ users worldwide.



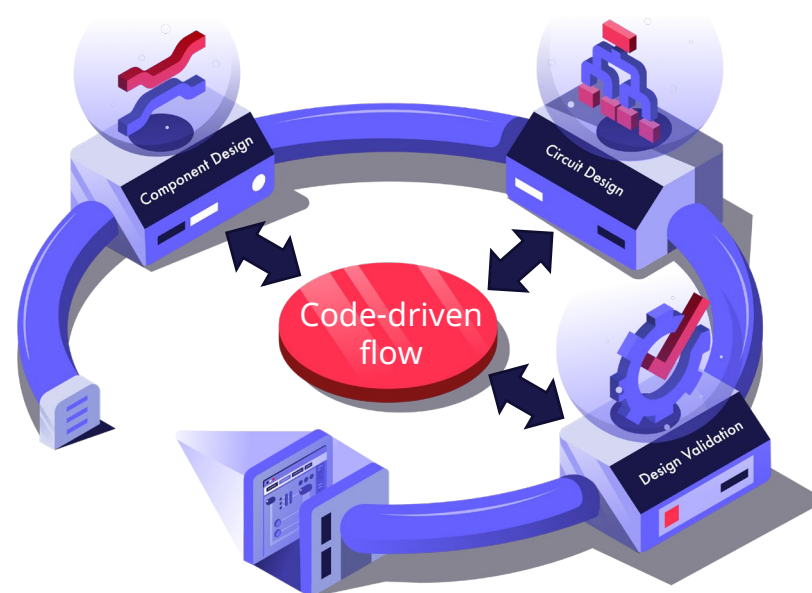
Team of **photonics experts**.

# Luceda Photonics



“ Help photonic IC designers enjoy the same **first-time** right experience as electronic IC designers ”

## Luceda Photonics Design Platform



# PIC: From idea to product

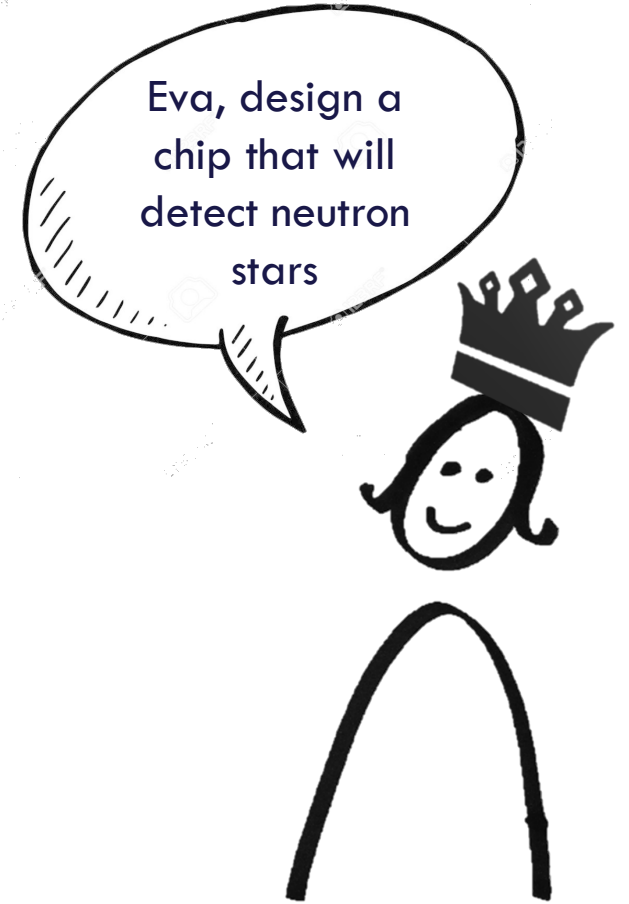
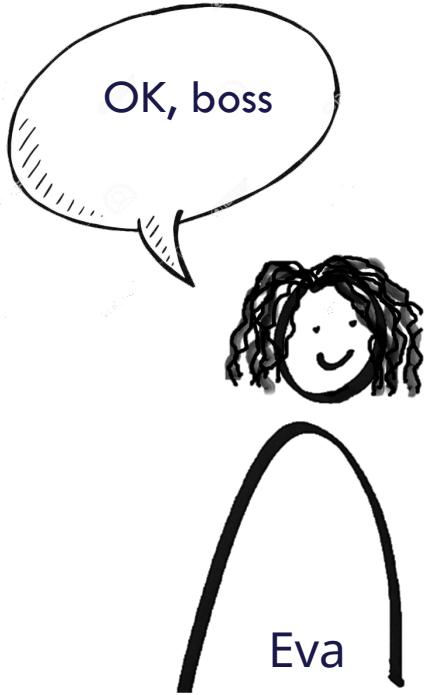


Meet Eva:

- Highly skilled photonics engineer
- Works at a space company
- Designs PICs for satellites

TIME

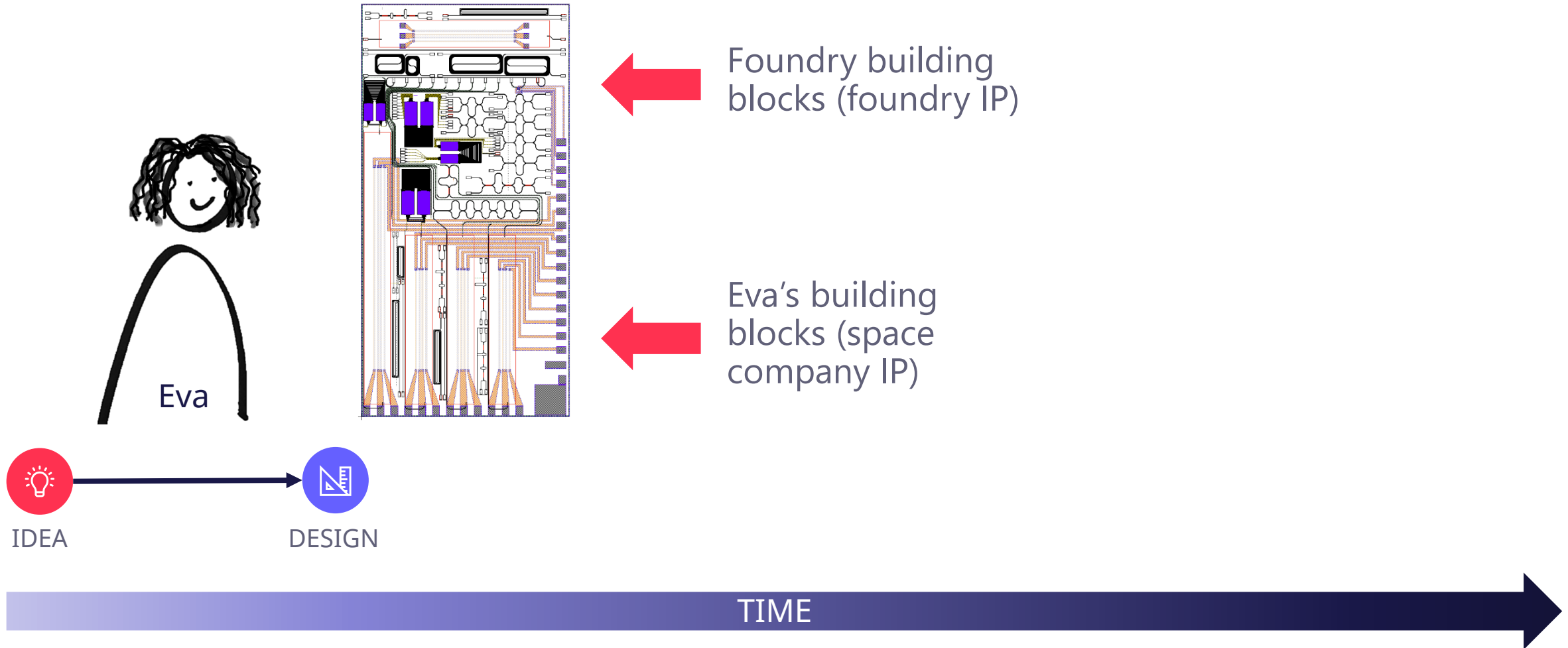
# PIC: From idea to product



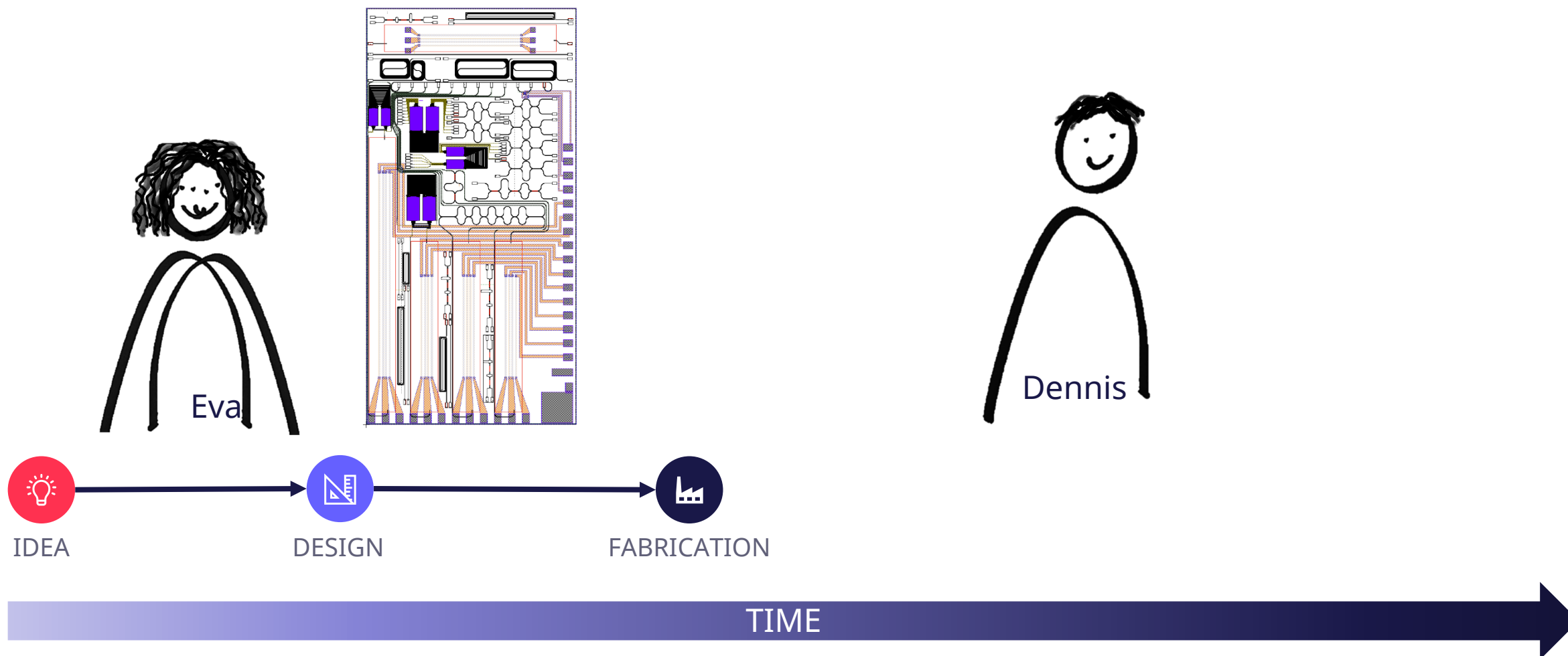
IDEA

TIME

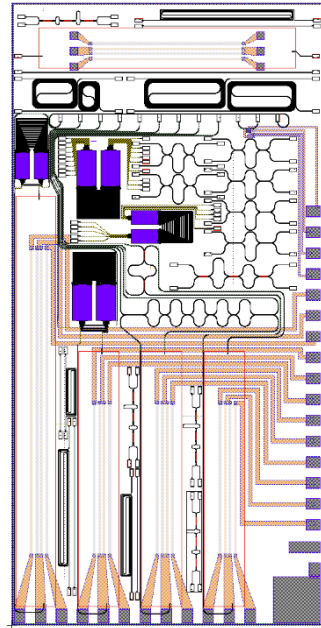
# PIC: From idea to product



# PIC: From idea to product

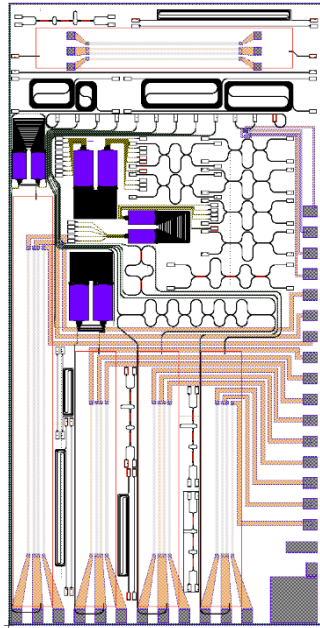


# PIC: From idea to product





# PIC: From idea to product



The measurement results are not so good... We should change X.



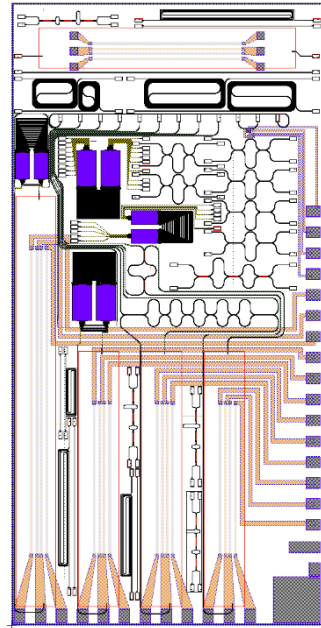
Dennis



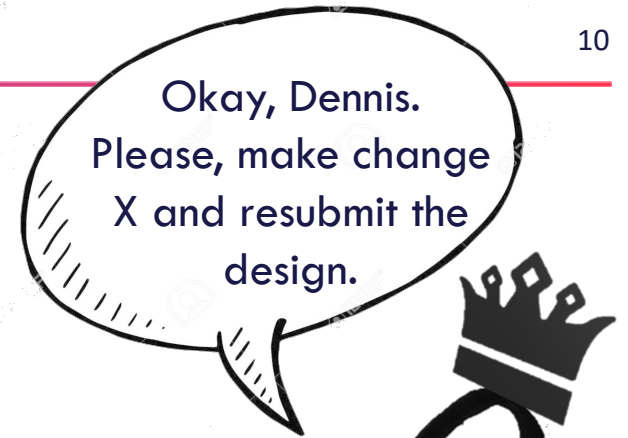
Boss



# PIC: From idea to product



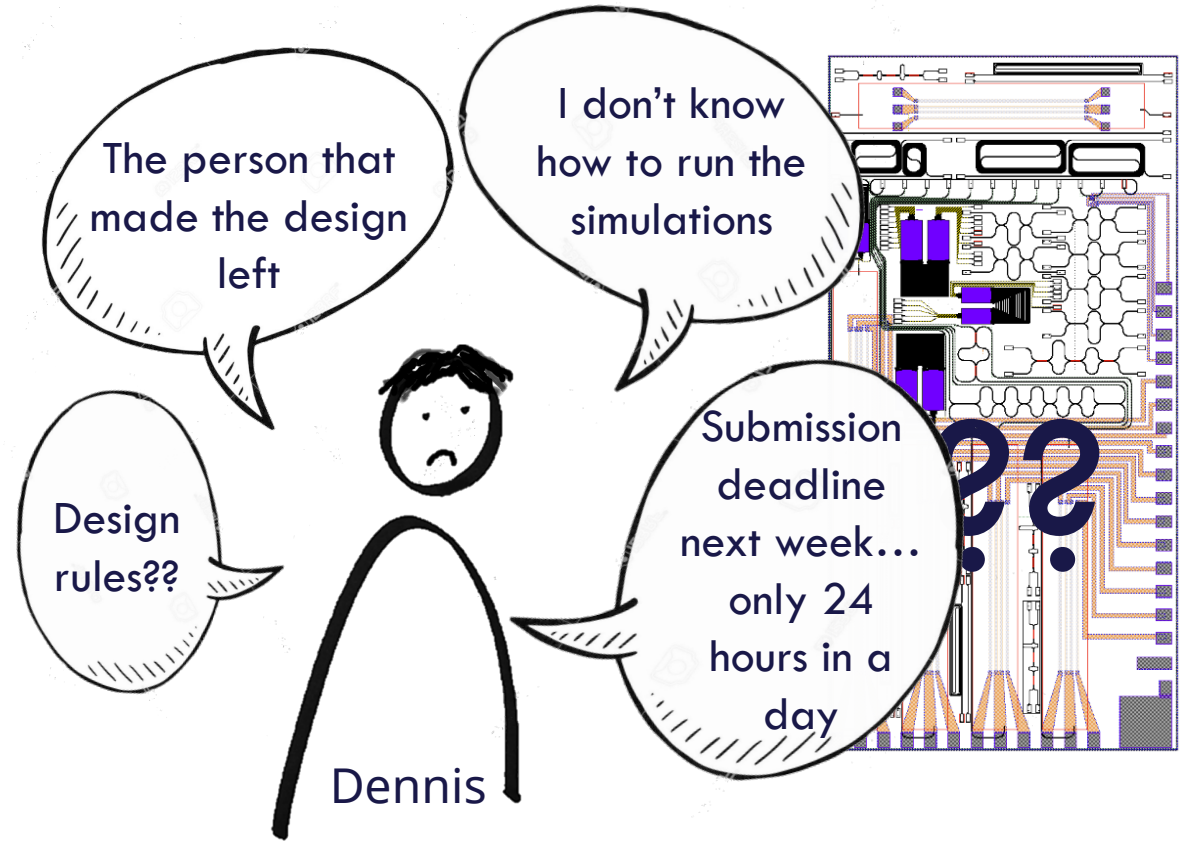
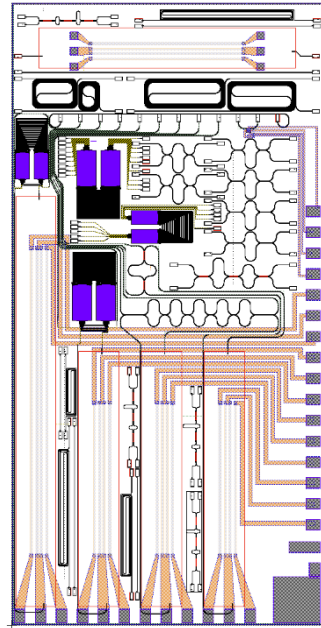
Dennis



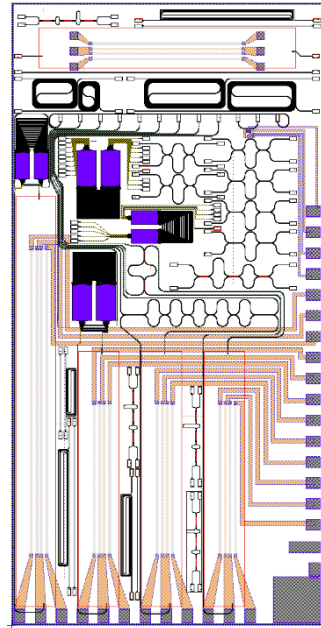
Boss



# PIC: From idea to product



# PIC: From idea to product



The design can't be packaged

The design doesn't allow for automated testing

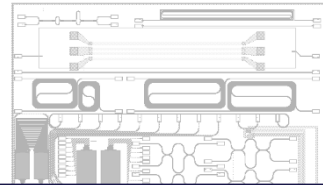
How do I design for hybrid/heterogeneous integration?



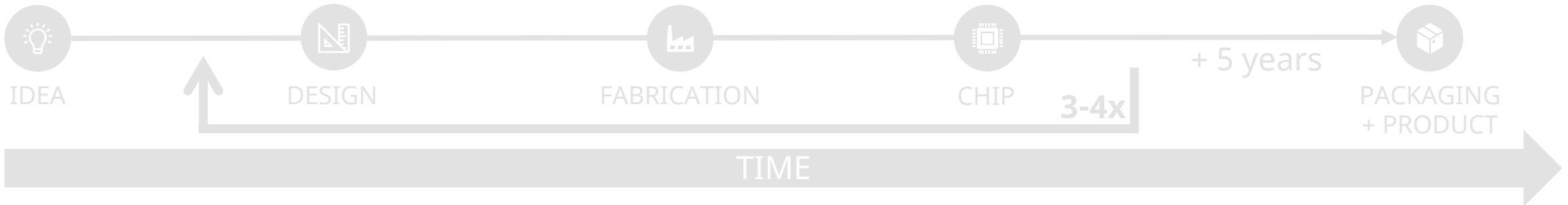
Dennis

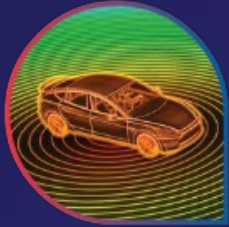


# PIC: From idea to product



The story of Eva and Dennis is not unique...





LIDAR



SPECTROSCOPY



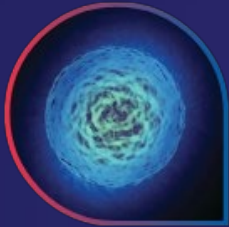
QUANTUM  
COMPUTING



CLOUD  
COMPUTING



TELECOM  
DATACOM



BIOPHOTONICS



AI



AR / VR



METROLOGY

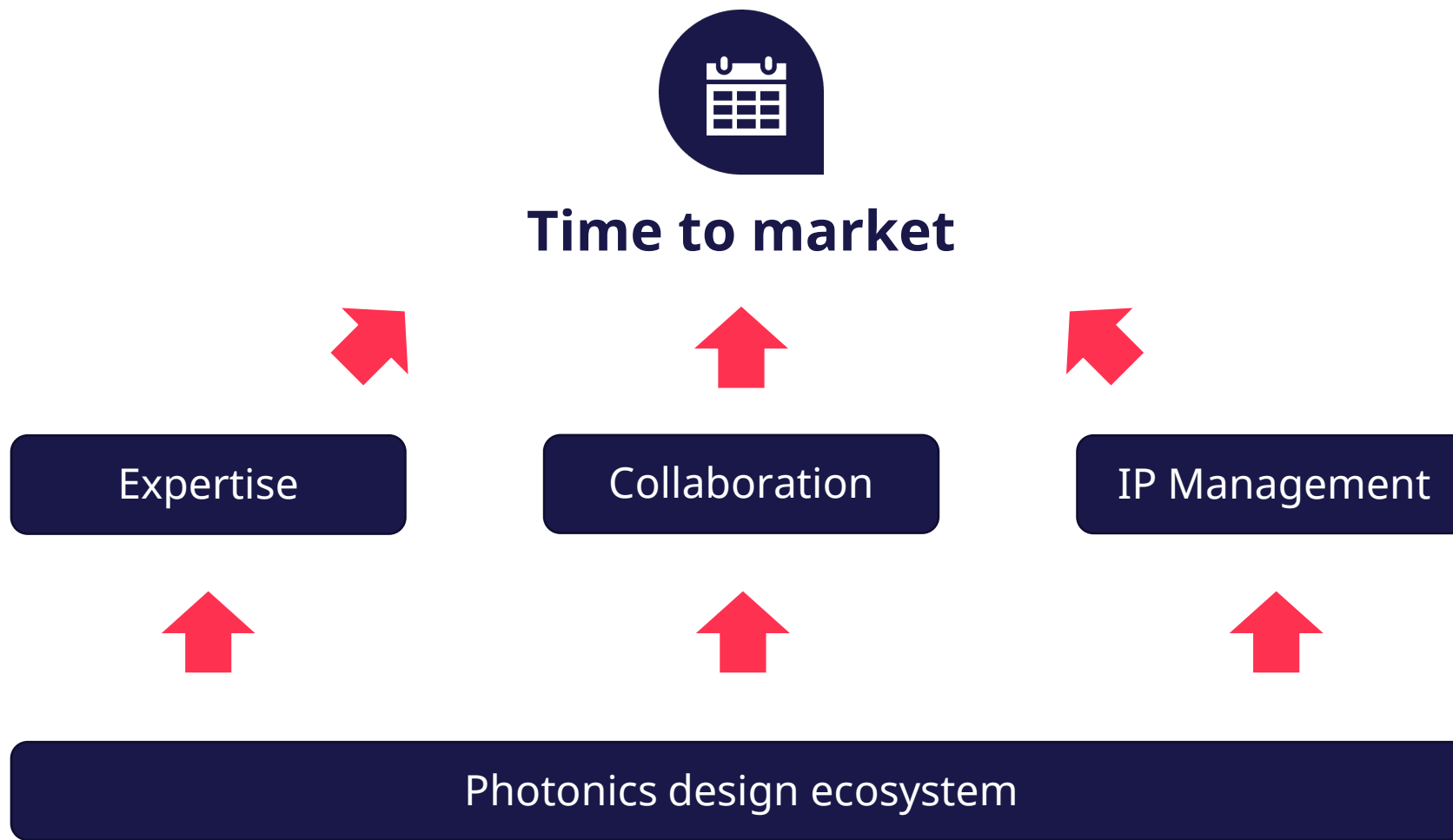


AEROSPACE

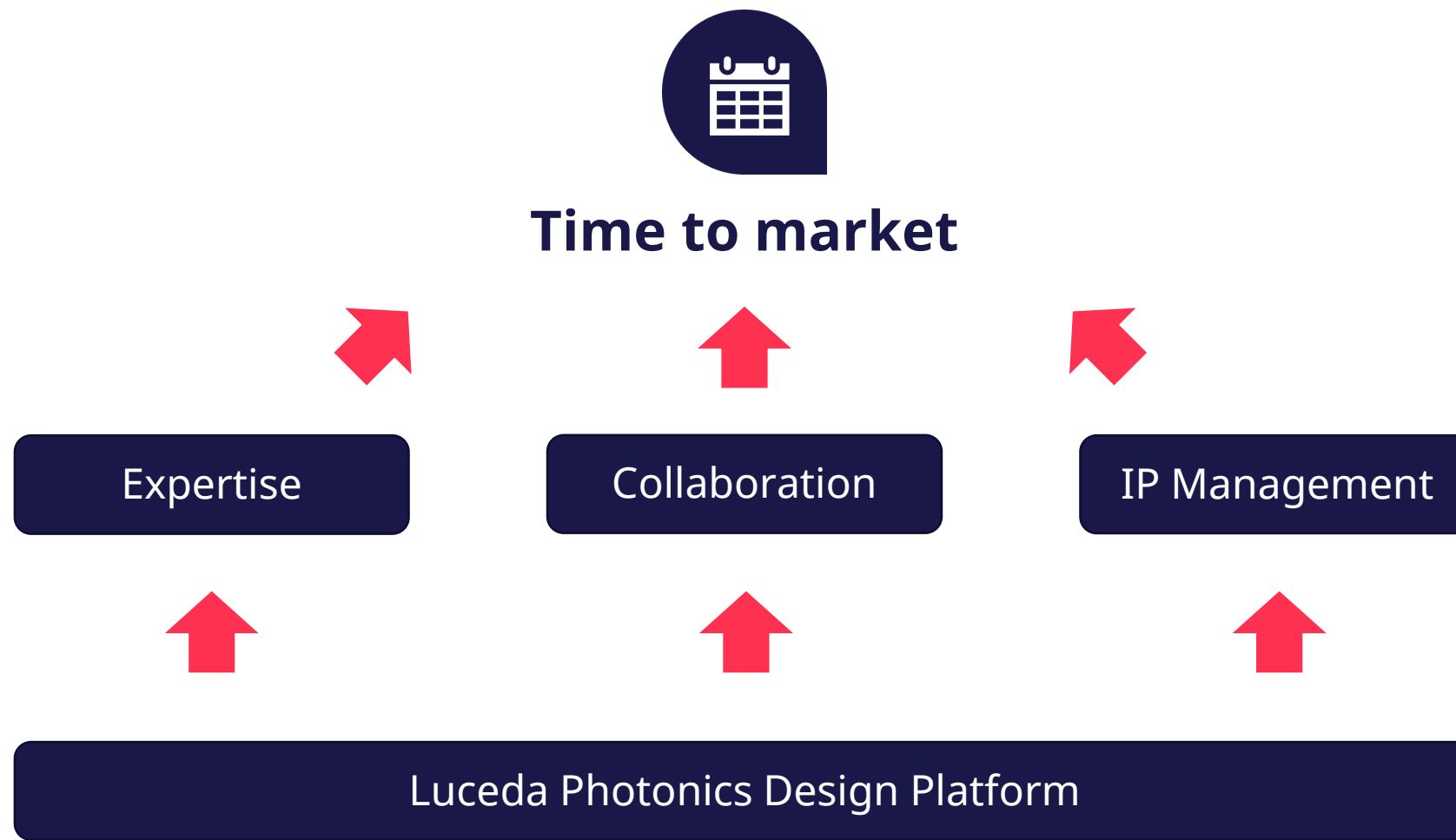
**Large variety of  
applications  
enabled by PICs**

Common:  
They all contain design IP

# Keys to success



# Keys to success





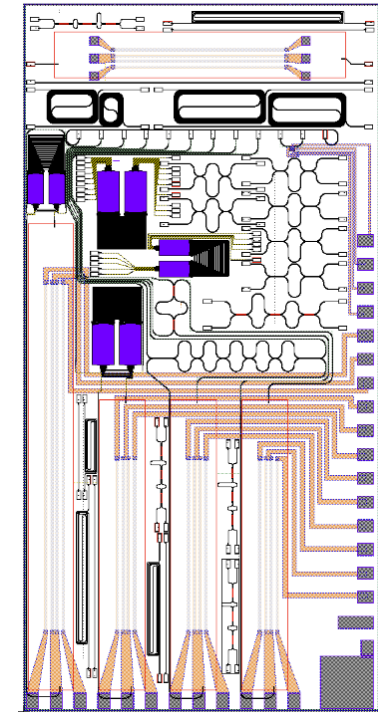
# Level 1



1 Designer



1 Foundry



1 Design

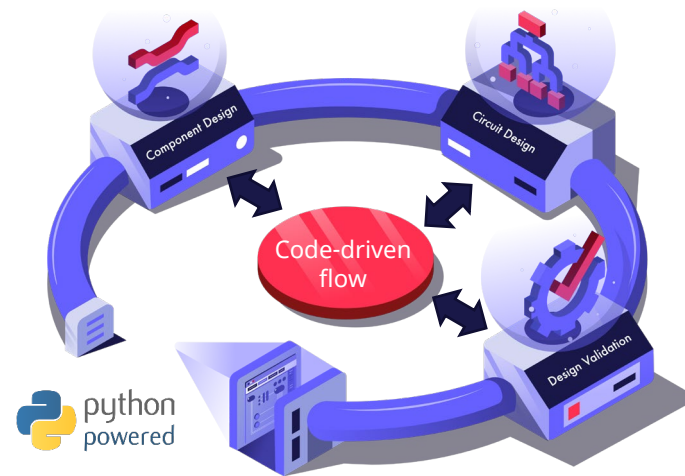


# Luceda Design Kits

LUCEDA DESIGN KITS (PDKs, ADKs, TDKs)			
Silicon (Production)	Silicon (Prototyping)	Silicon Nitride	Indium Phosphide
Lithium Niobate	Aluminum Oxide	Assembly and Testing	

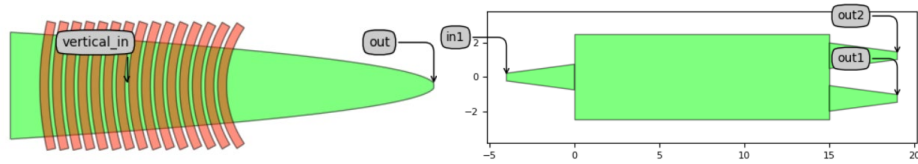
- ✓ Standard language: Python
- ✓ Power of IPKISS: layout + models + simulation
- ✓ Schematic capture & verification in IPKISS Canvas
- ✓ Automated testing and quality assurance
- ✓ Export to OpenAccess, uPDK standards

# Luceda IPKISS

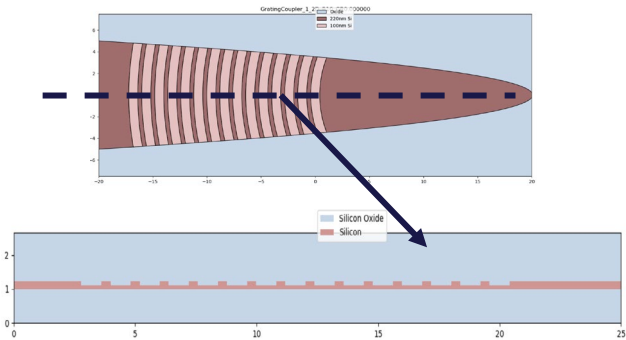


# Luceda IPKISS

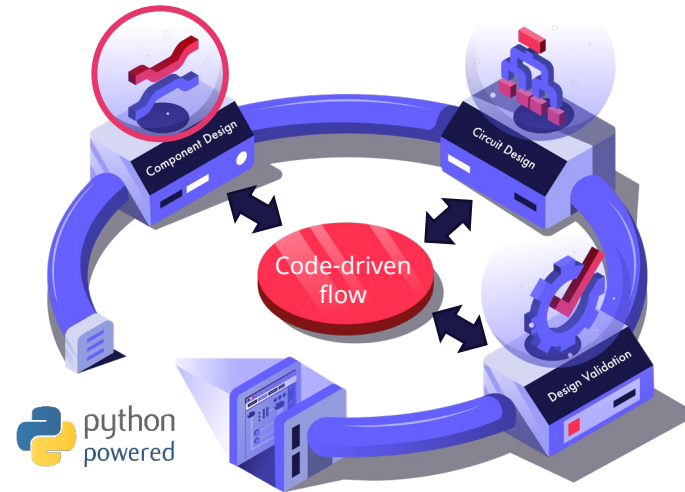
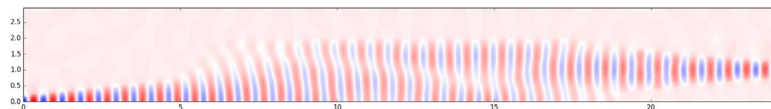
Parametric layout



Virtual fabrication

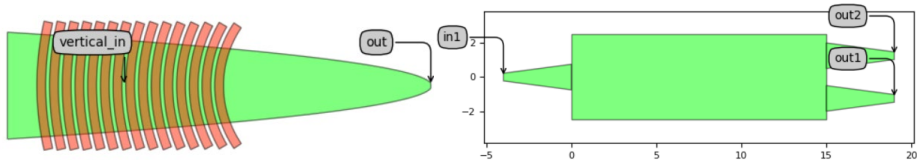


Physical device simulation (e.g. EME)

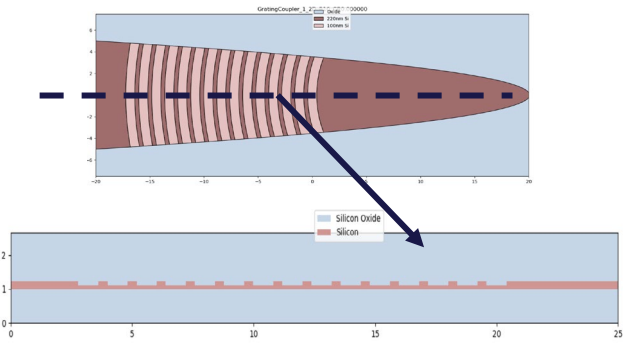


# Luceda IPKISS

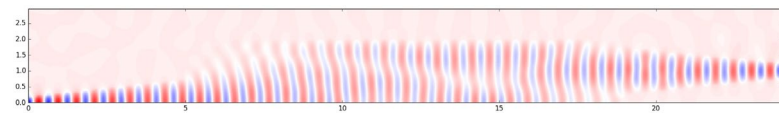
Parametric layout



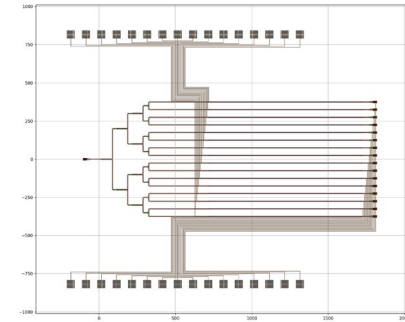
Virtual fabrication



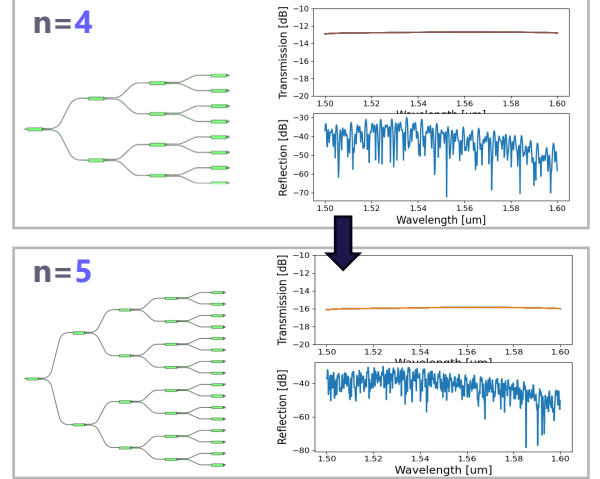
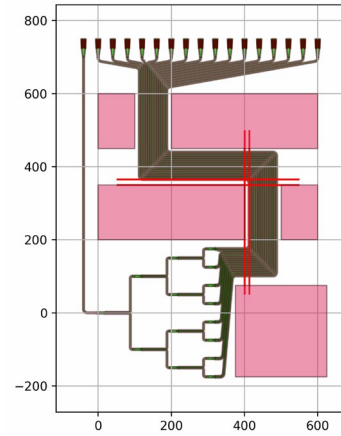
Physical device simulation (e.g. EME)



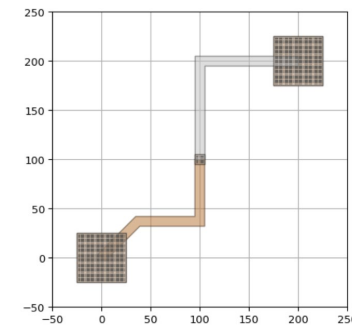
Optical & electrical routing



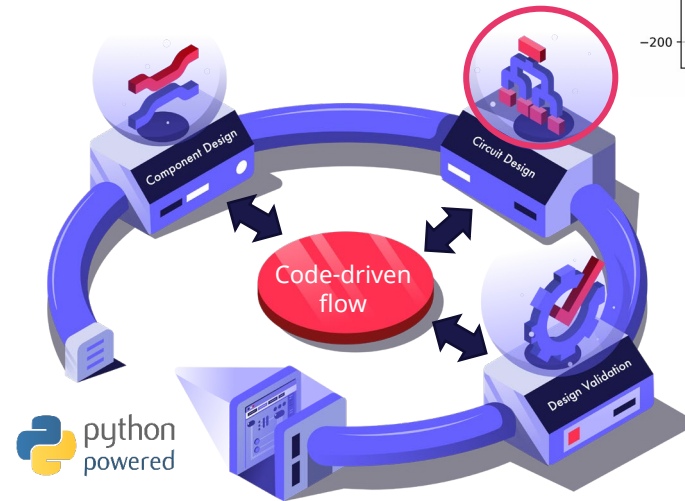
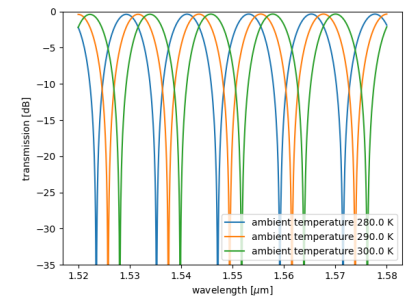
Obstacle avoidance



Automated VIA insertion

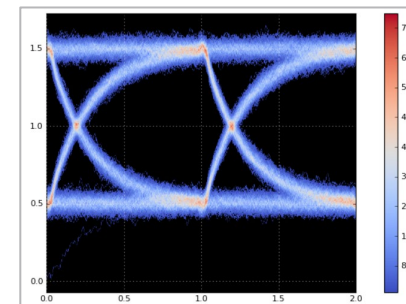
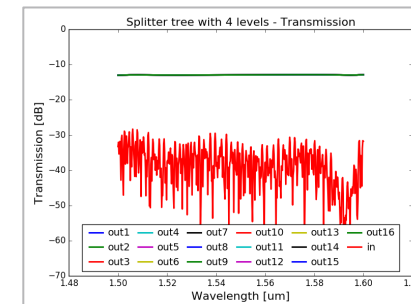


Temperature-dependent simulations



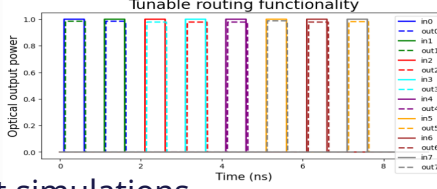
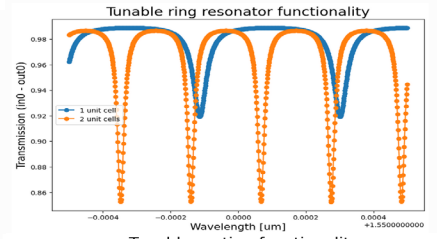
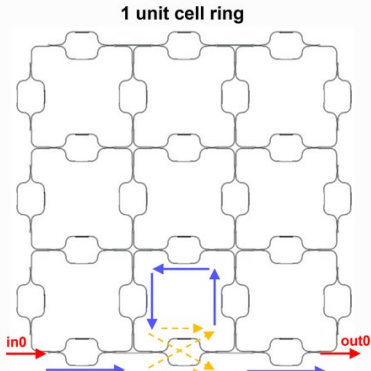
```

class GeneratedSplitterTree(I3.Circuit):
    def __default_insts(self):
        mm1k2Optimized1550 = si_fab.MM1k2Optimized1550(
            fc_te_15500 = si_fab.FC_TE_15500)
        return [
            "mm1_2": mm1k2Optimized1550,
            "mm1_1": mm1k2Optimized1550,
            "gc_in": fc_te_1550,
            "gc_out_0": fc_te_1550,
            "gc_out_1": fc_te_1550,
            "gc_out_2": fc_te_1550,
            "gc_out_3": fc_te_1550,
        ]
    def __default_specs(self):
        return [
            # default connections
            I3.ConnectManhattan(
                "mm1_0:in1",
                "mm1_0:out1",
                "mm1_1:in1",
                "mm1_1:out1",
            )
        ]
  
```

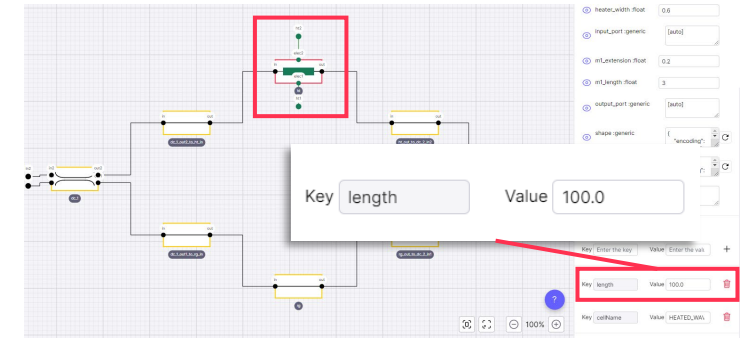
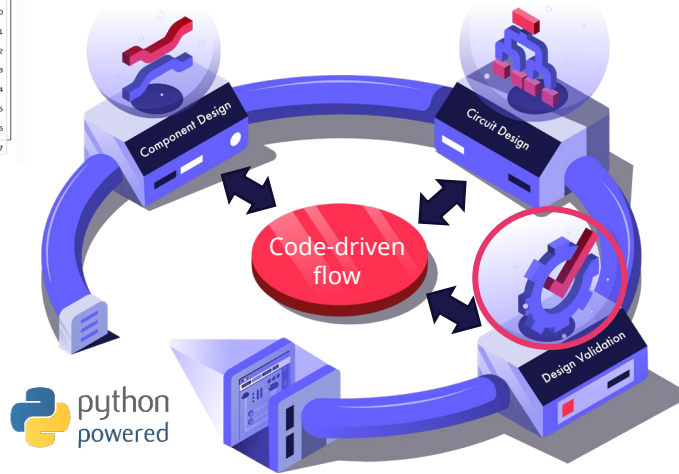
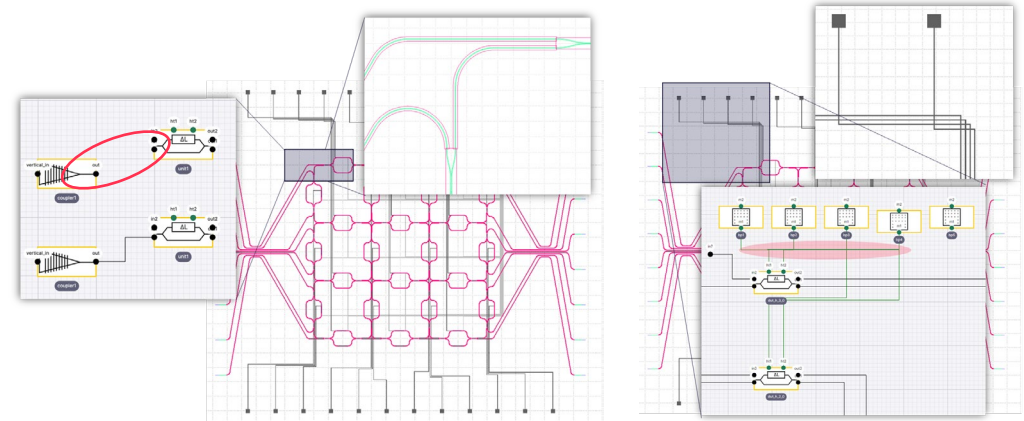
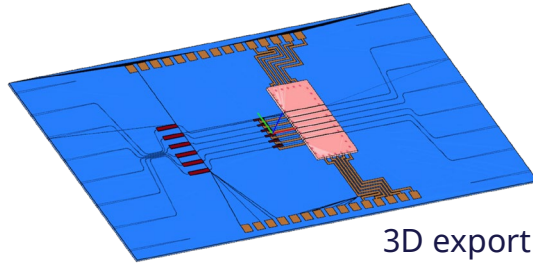


Take control of your photonics design flow

# Luceda IPKISS

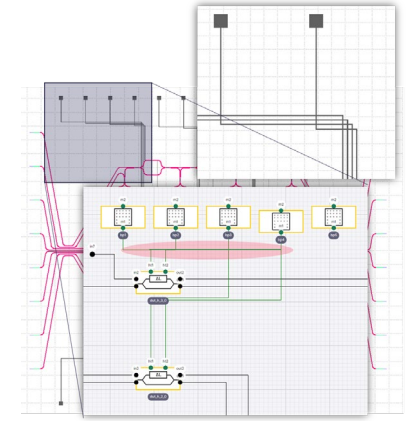
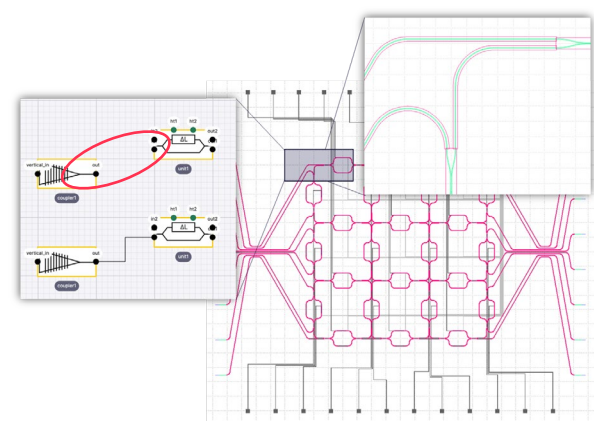
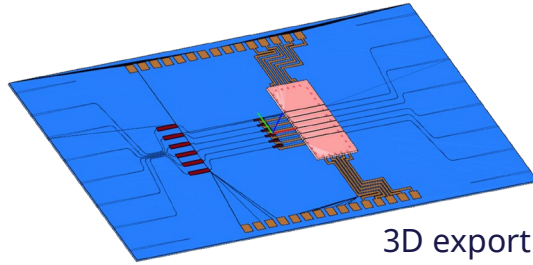
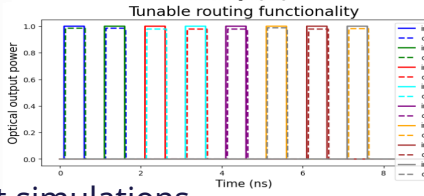
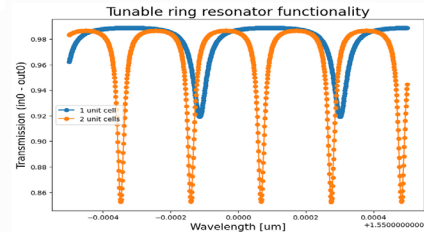
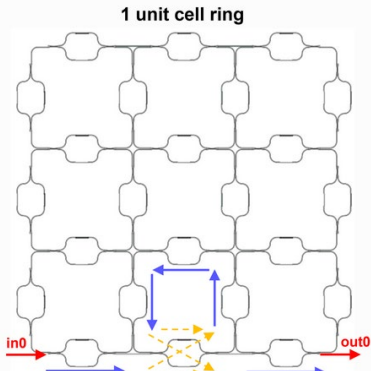


Post-layout simulations



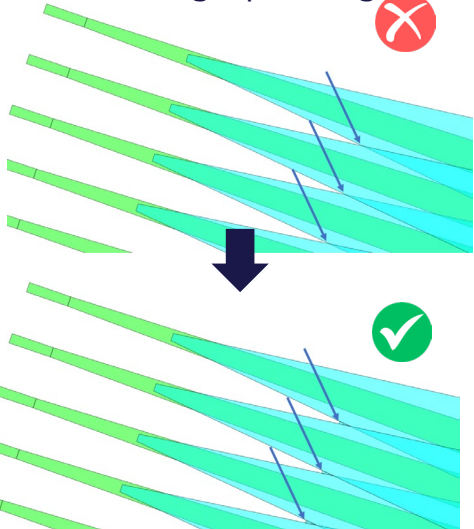
Waveguide length

# Luceda IPKISS



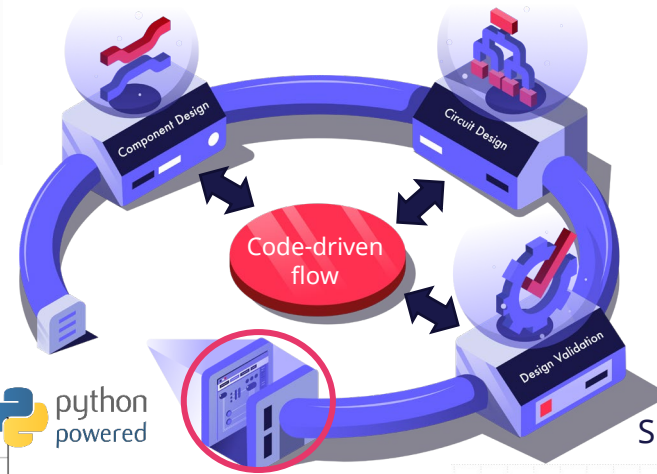
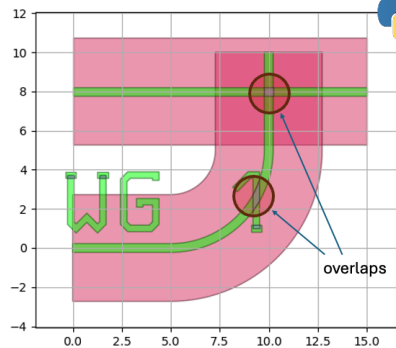
Post-layout simulations

Acute angle patching



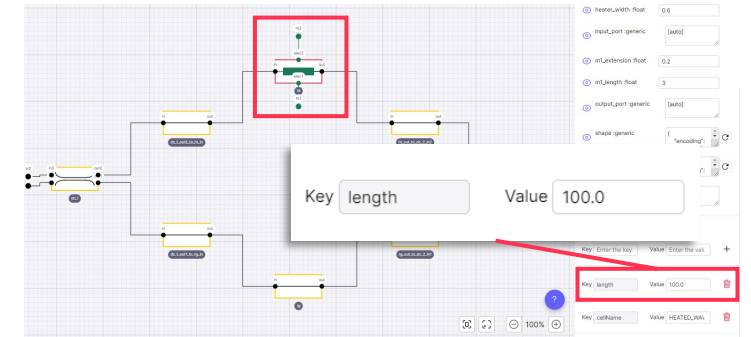
Overlapping layers

python powered

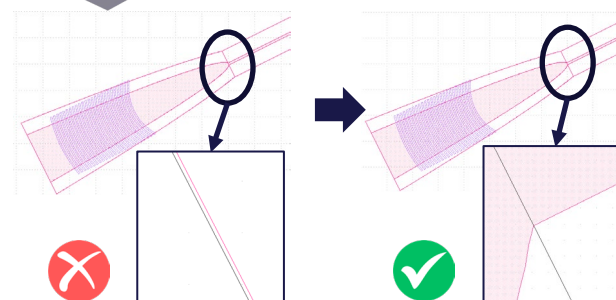


Optical connectivity

Electrical connectivity



Snapping errors



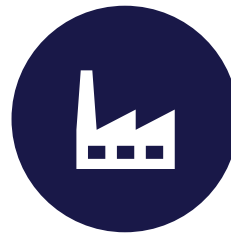
Waveguide length

Take control of your photonics design flow

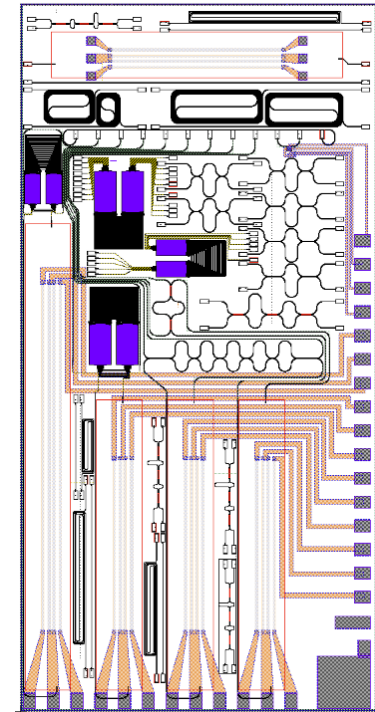
# Level 2



Design team



1 Foundry



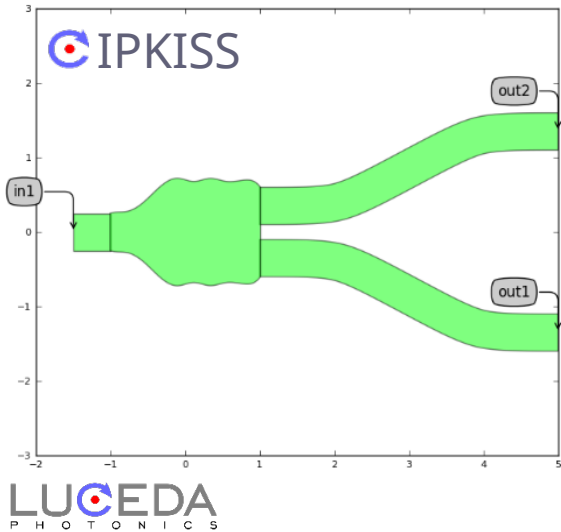
1 Design





# Automated component design flow

## Example: Luceda Link for Ansys Lumerical



```
def simulate_splitter(layout, project_folder, mesh_accuracy=1, wavelengths=(1.5, 1.6, 100)):
    monitors = [i3.device_sim.Port(name=p.name, box_size=(2.0, 1.0)) for p in layout.ports]
    geometry = i3.device_sim.SimulationGeometry(layout=layout)

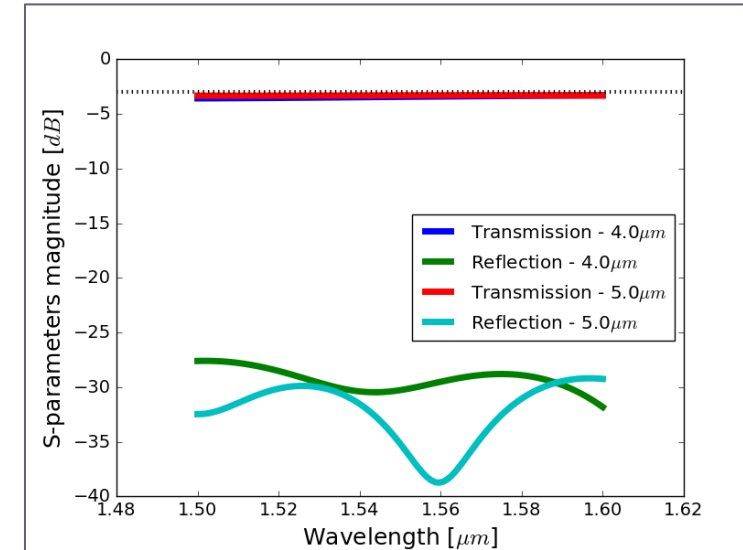
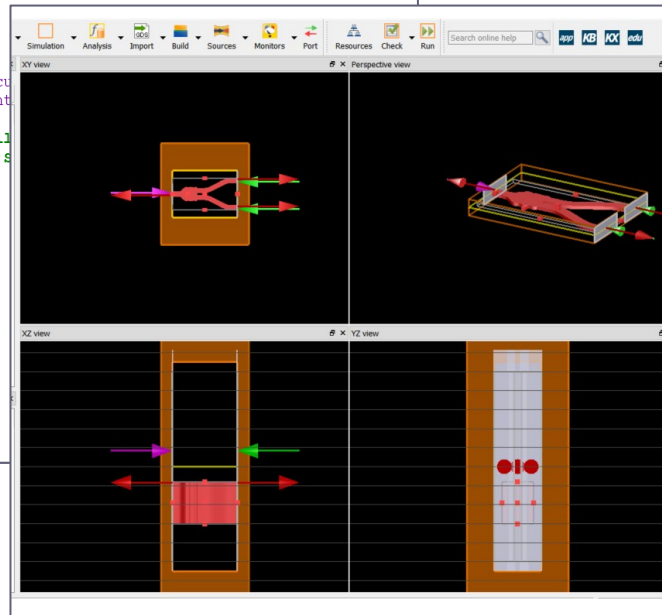
    outputs = [i3.device_sim.SMatrixOutput(
        name="smatrix",
        symmetries=[("out1", "out2")],
        wavelength_range=wavelengths)]

    setup_macros = [fDTD_macros.mesh_accuracy(mesh_accu
                    fDTD_macros.field_monitor(alignment

    material_map = {i3.TECH.MATERIALS.SILICON: 'Si (sil
                    i3.TECH.MATERIALS.SILICON_OXIDE: 'S

    # Simulation job
    simjob = i3.device_sim.LumericalFDTDSimulation(
        geometry=geometry,
        outputs=outputs,
        monitors=monitors,
        setup_macros=setup_macros,
        project_folder=project_folder,
        solver_material_map=material_map,
        verbose=True,
        headless=False)

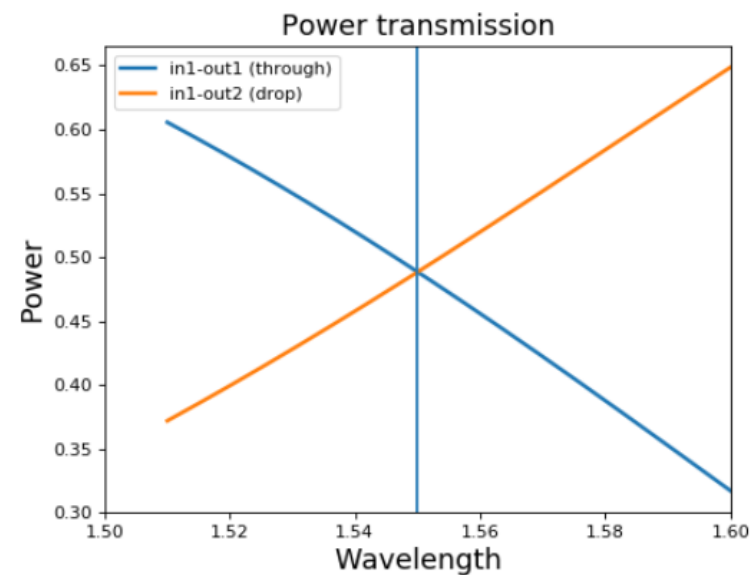
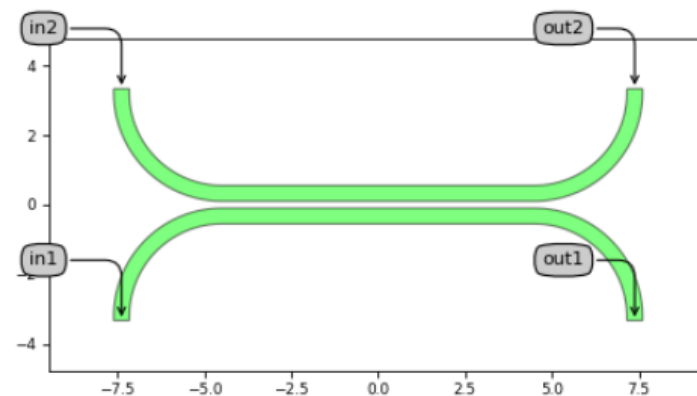
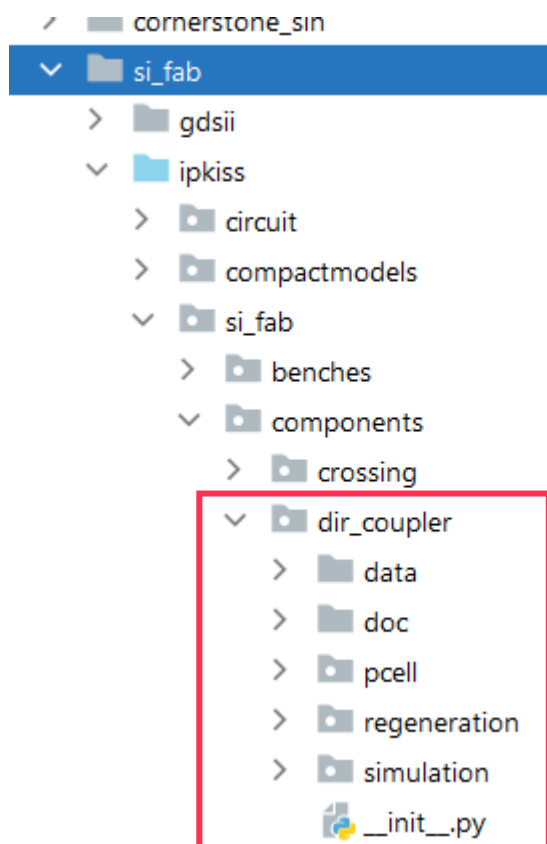
    # Execute and save_results.
    #simjob.inspect()
    smatrix = simjob.get_result(outputs[0].name)
```



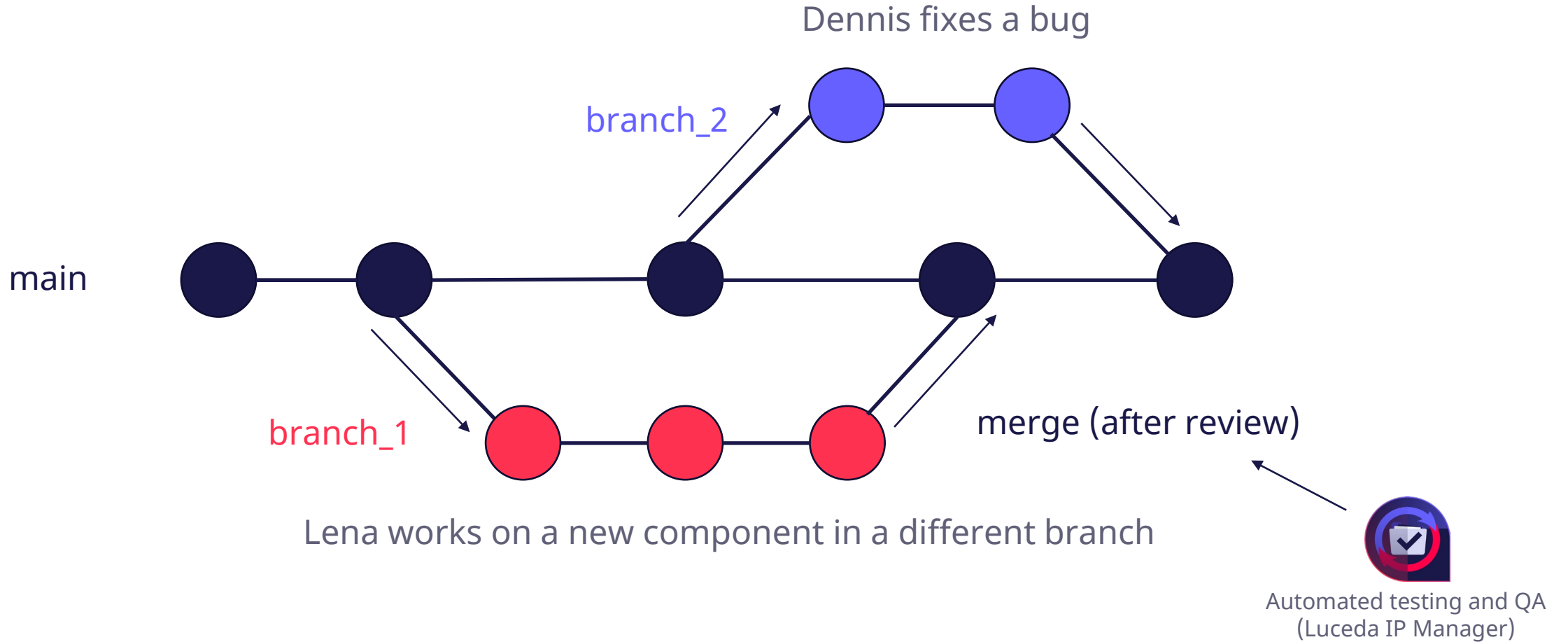
This splitter was the result of an inverse optimization process performed using Lumerical FDTD.  
<https://support.lumerical.com/hc/en-us/articles/360042305274>



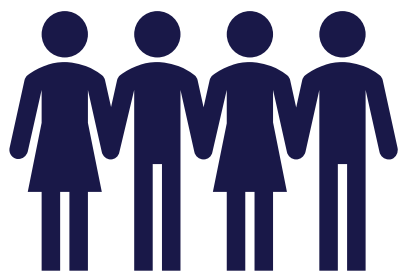
# Example: Directional coupler



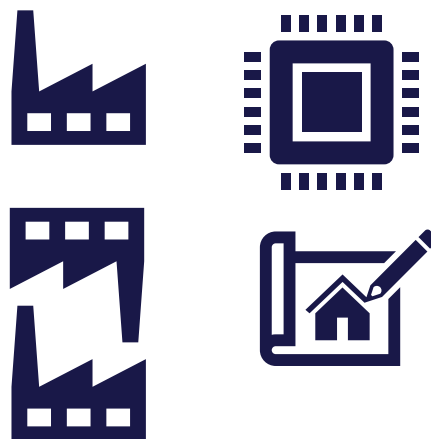
# Version control



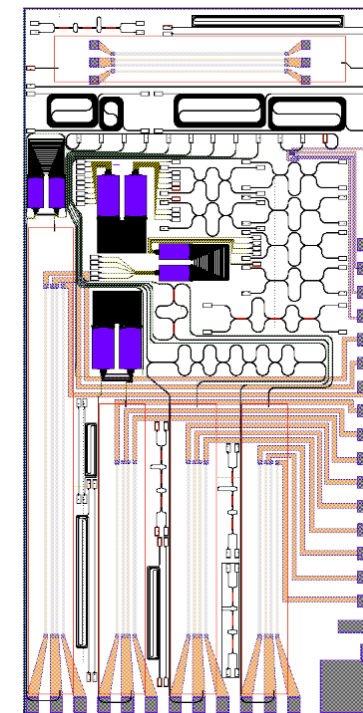
# Level 3



Design team

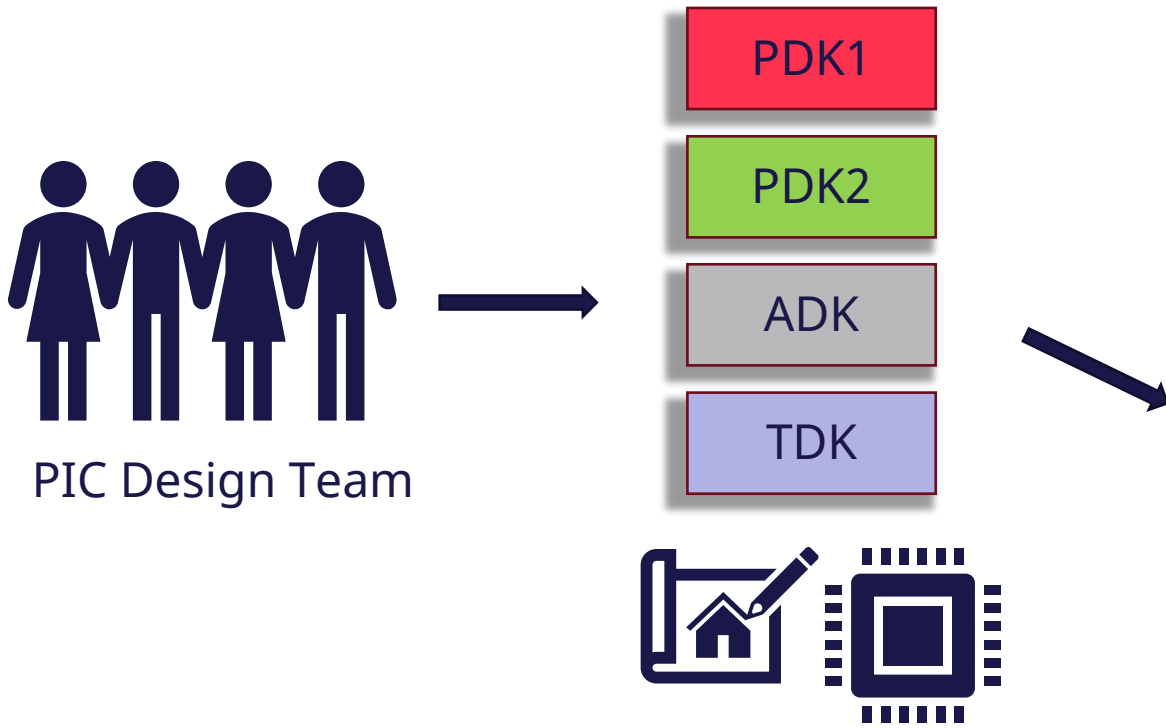


- Foundries
- Heterogeneous integration
- Packaging Foundries
- Testing Houses

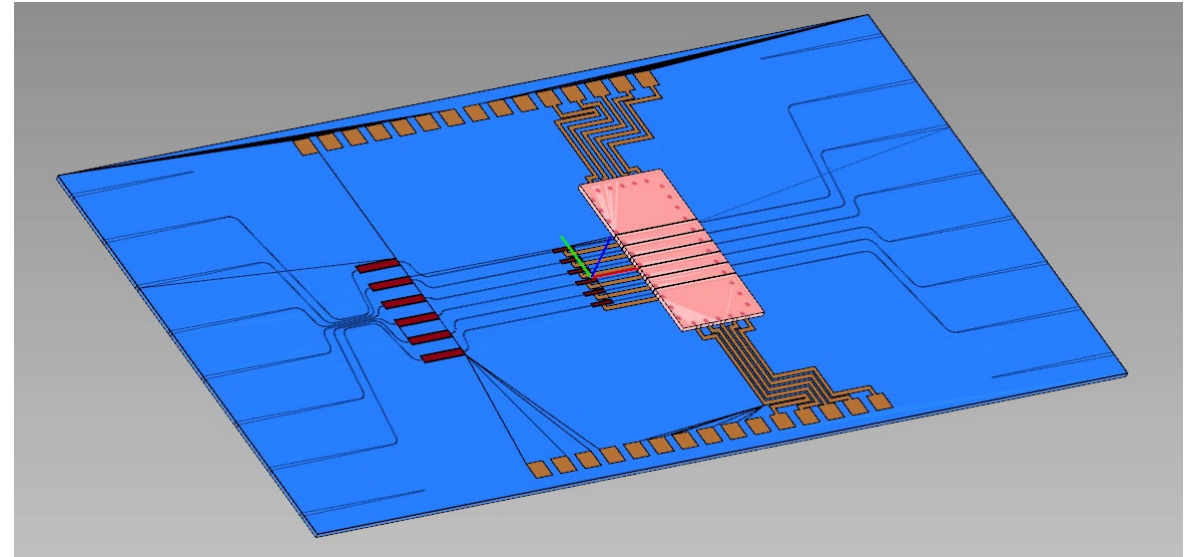


1 Design

# Verticalized design flow is emerging



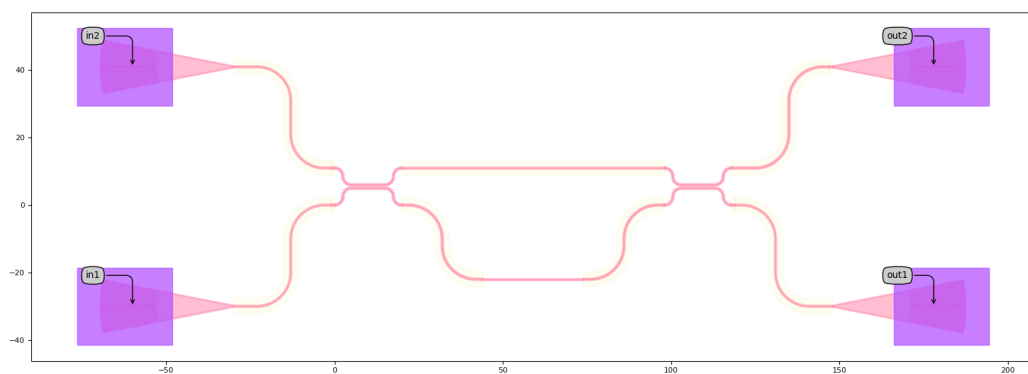
- Foundries
- Heterogeneous integration solutions
- Assembly and packaging solutions
- Test providers



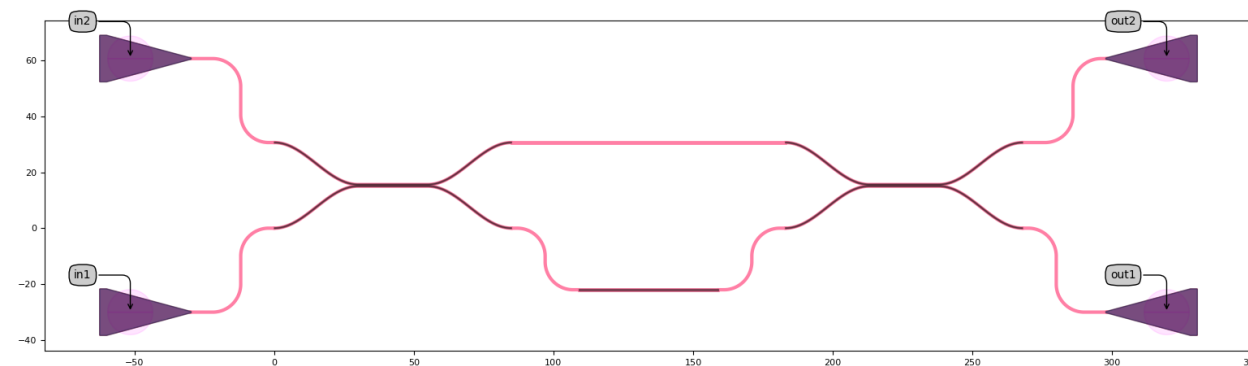
# Retargetable designs and libraries



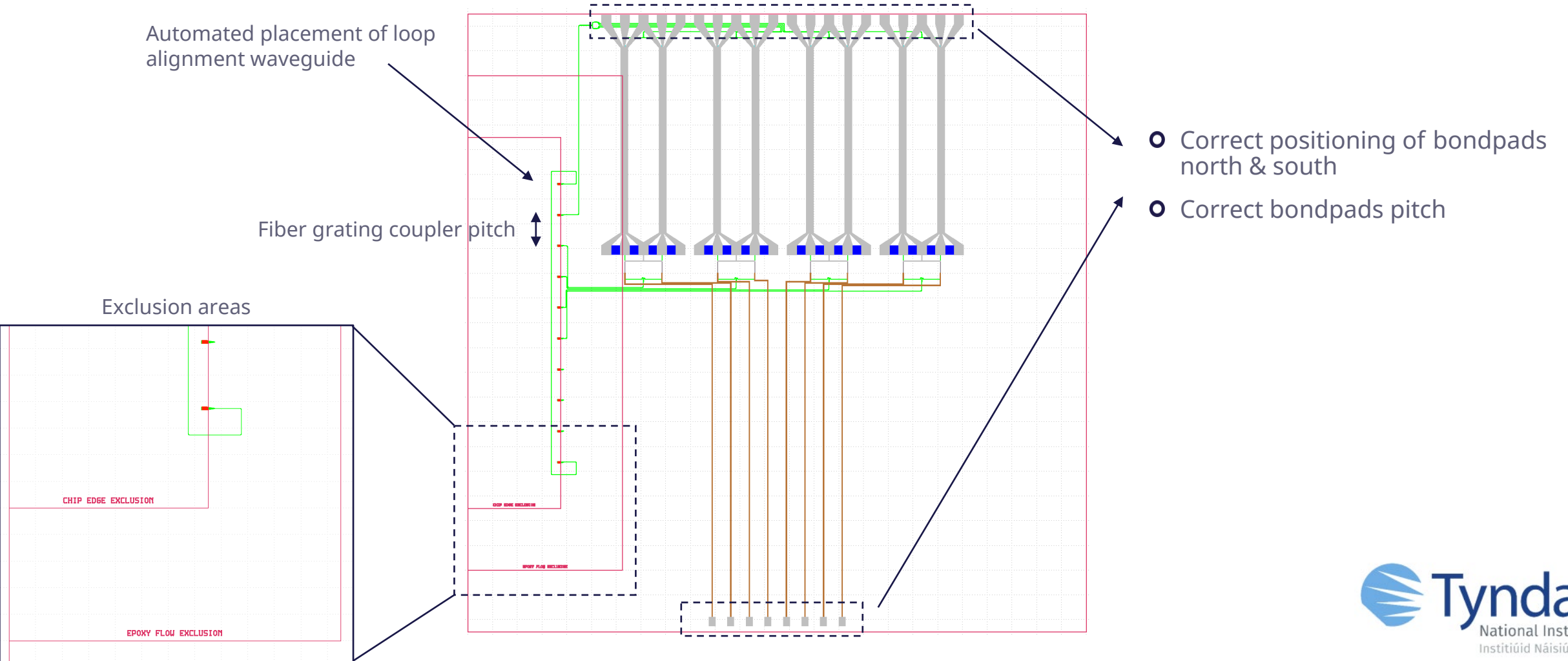
## Foundry A – Prototyping



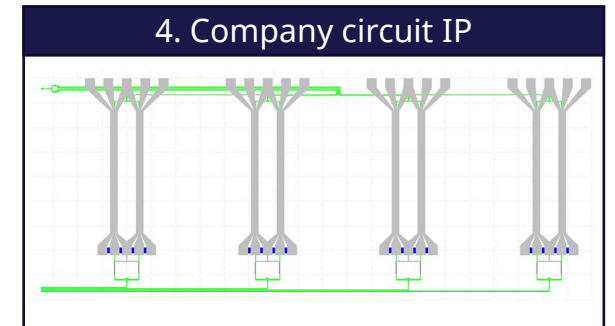
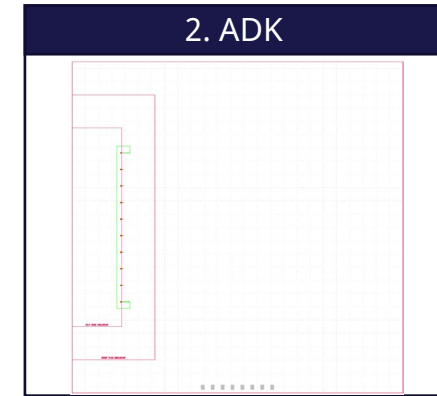
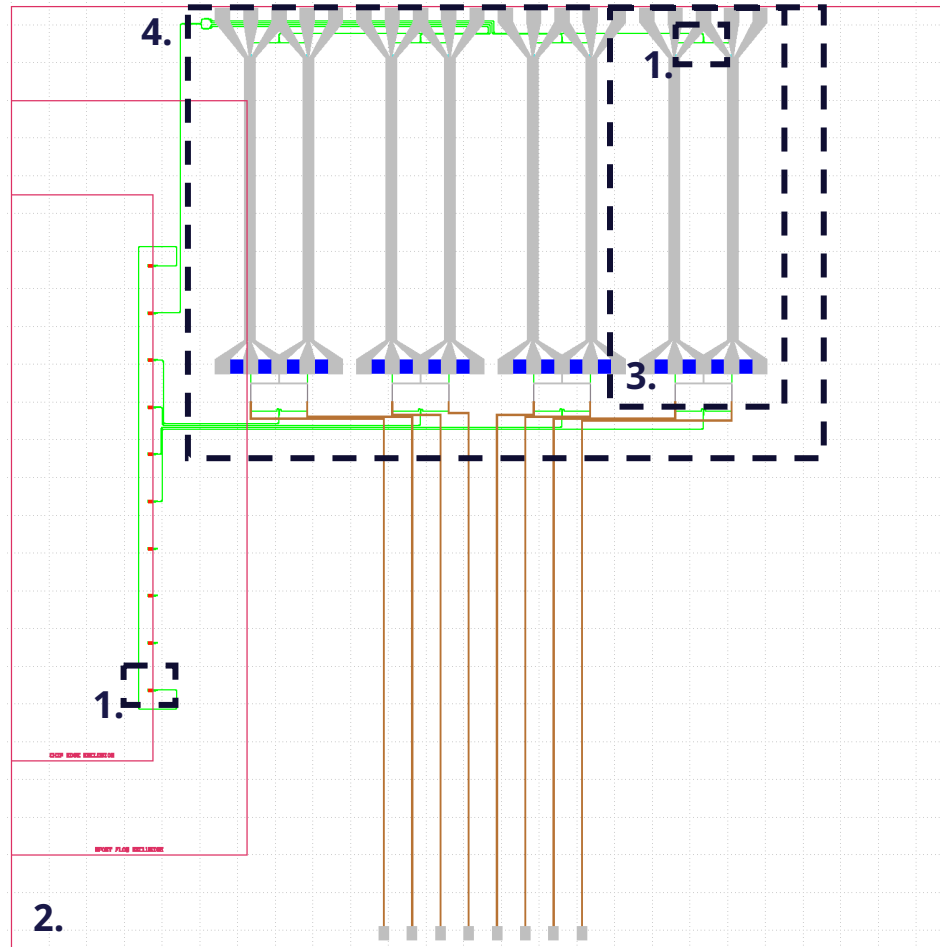
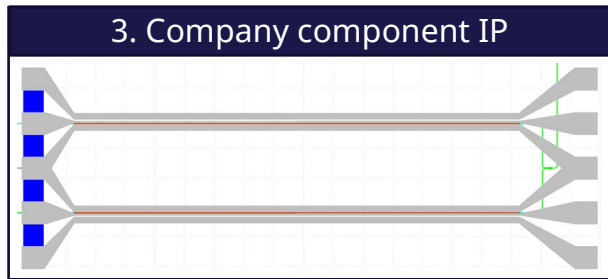
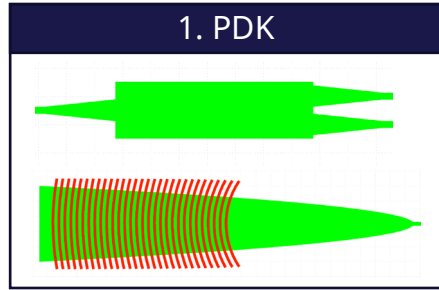
## Foundry B – Production



# Example: Packaged 4-Lane Modulator with Tyndall



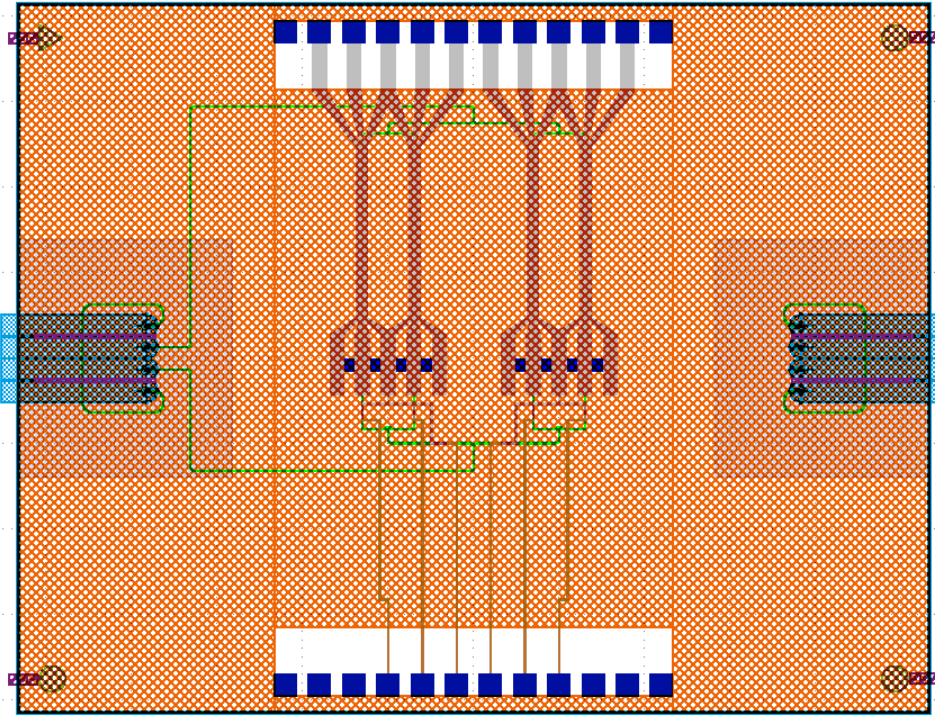
# Manage several sources



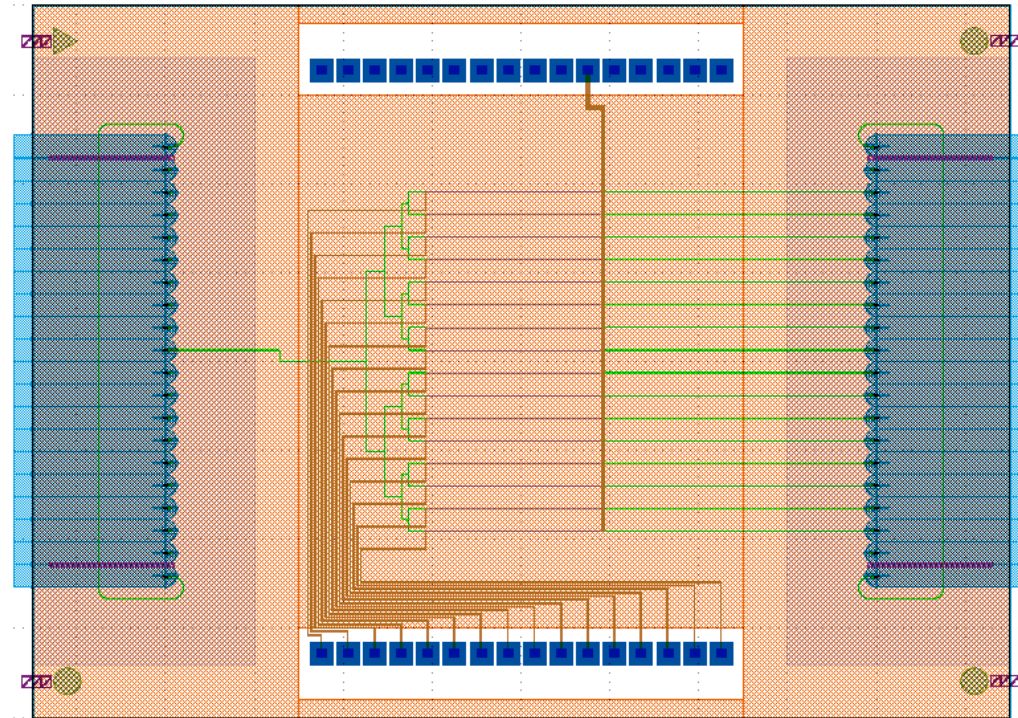




# Example: Packaged designs with the Phix ADK

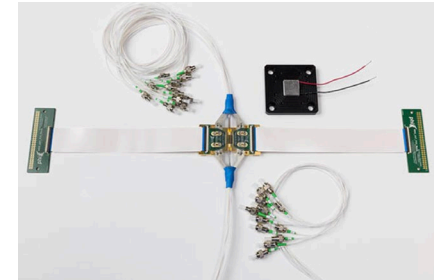


IQ modulator (datacom)

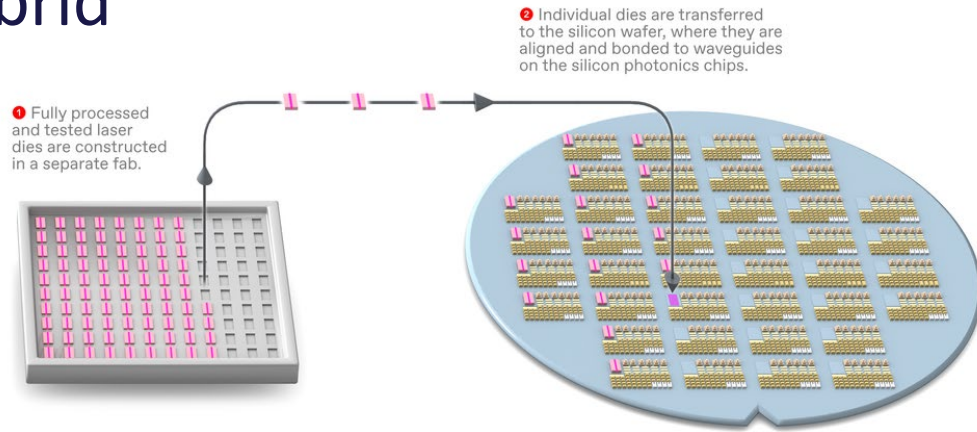


Optical phased array (lidar)

PhiX  
Characterization  
package

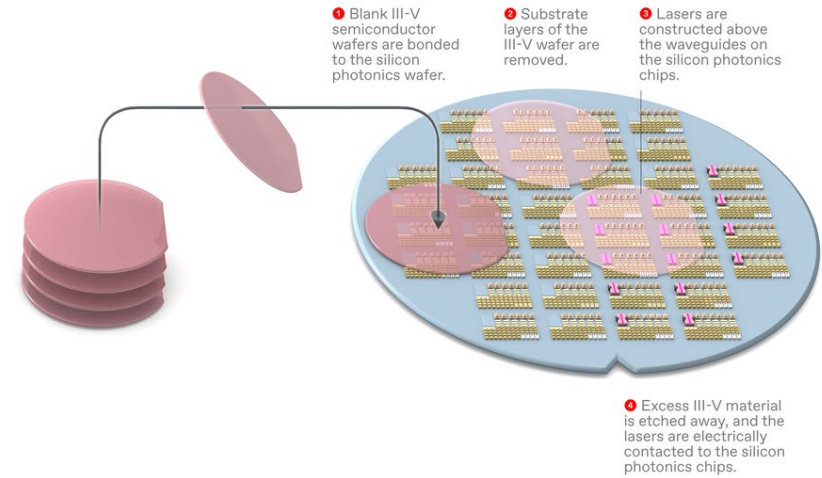


# Hybrid

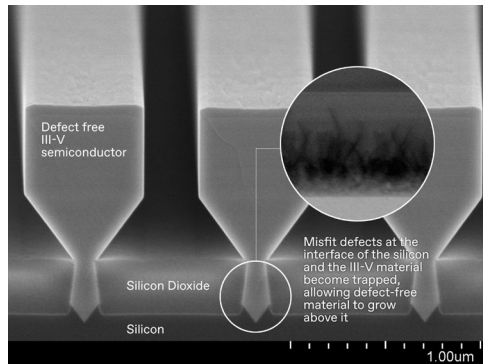


# Heterogeneous

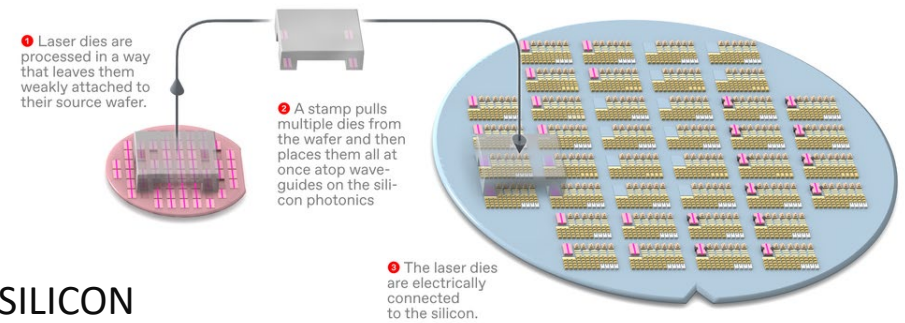
## wafer-to-wafer / die-to-wafer



# Monolithical



## microtransfer printing



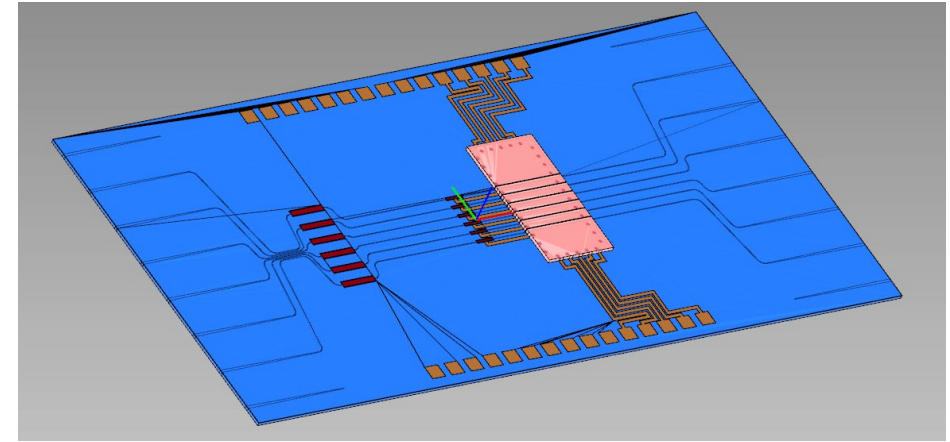
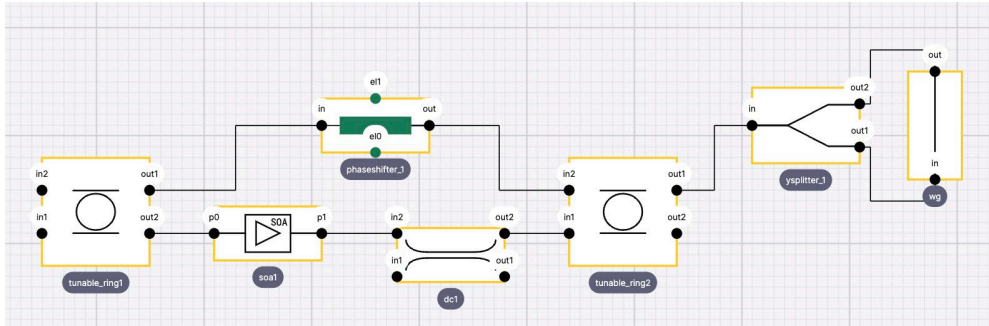
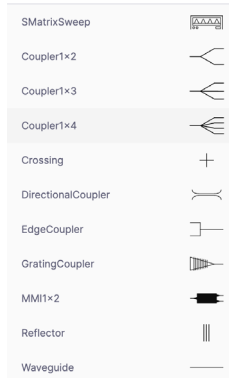
<https://spectrum.ieee.org/lasers-on-silicon> - 4 WAYS TO PUT LASERS ON SILICON

Roel Baets, Joris Van Campenhout, Bernadette Kunert, Gunther Roelkens

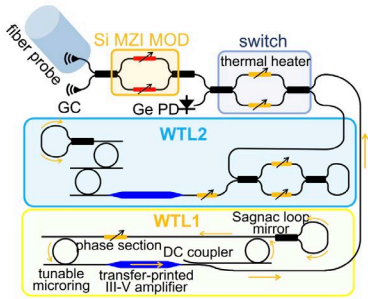
# Efficient hybrid / heterogeneous PIC design

PDK

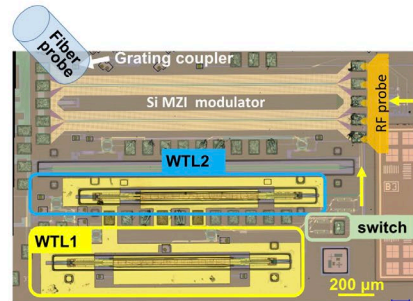
Schematic capture



Layout

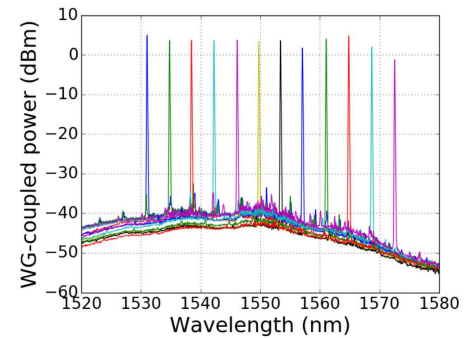


(a) Schematic of the optical transmitter with integrated widely tunable lasers.

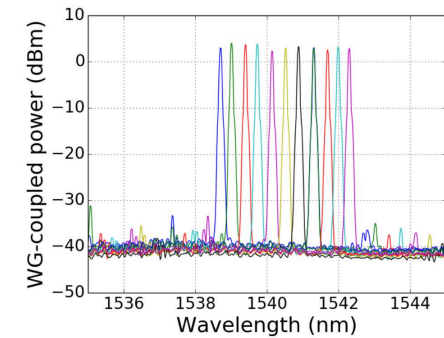


(b) Resulting III-V-on-Si integrated circuits.

## Fabrication & Measurement



(b) Coarse wavelength tuning.



(c) Fine wavelength tuning.

Micro-transfer printing InP C-band SOAs on advanced silicon photonics platform for lossless MZI switch fabrics and high-speed integrated transmitters, Jing et al.

Vol. 31, No. 26 / 18 Dec 2023 / Optics Express 42807

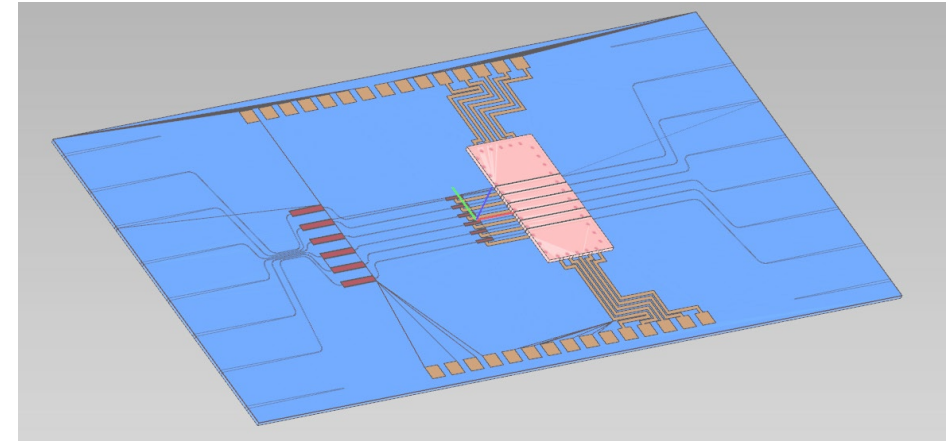
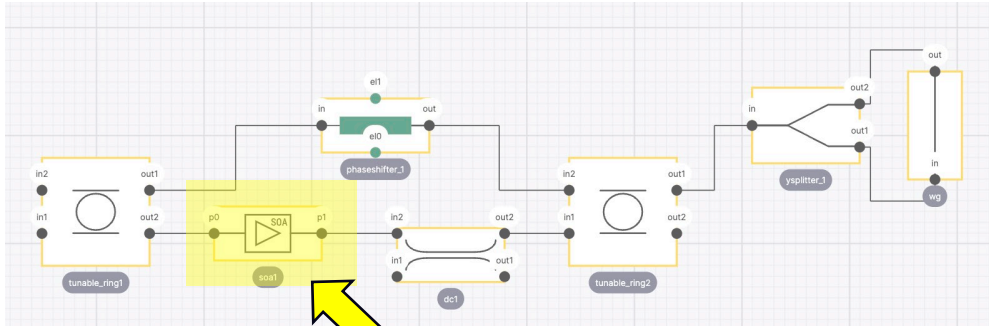
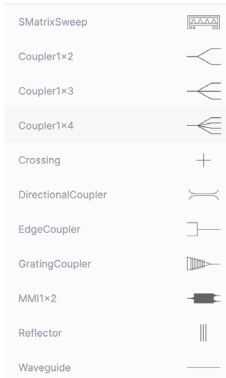


Results shared with permission from UGent - imec

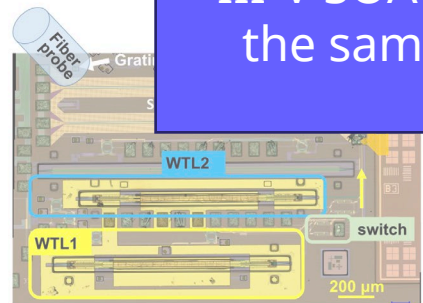
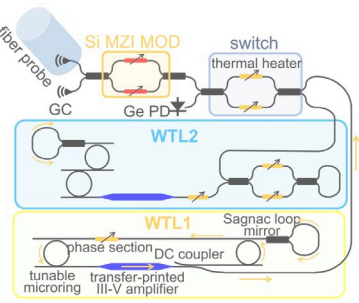
# Efficient hybrid / heterogeneous PIC design

PDK

Schematic capture

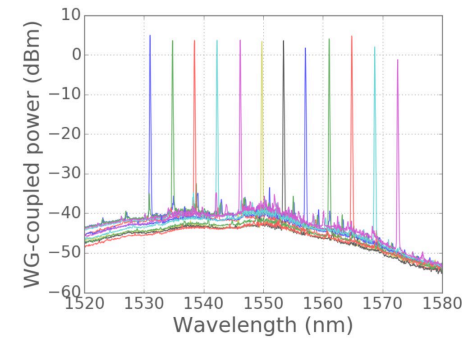


Layout

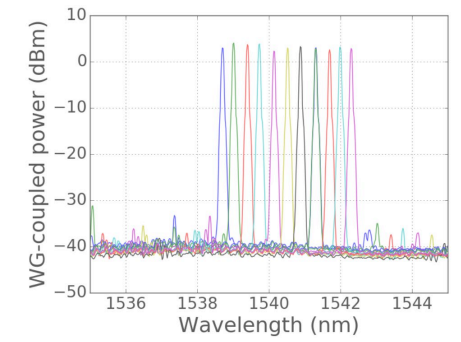


III-V SOA part of the same PDK

Fabrication & Measurement



(a) Coarse wavelength tuning.



(b) Fine wavelength tuning.

(a) Schematic of the optical transmitter with integrated widely tunable lasers.

(b) Resulting III-V-on-Si integrated circuits.

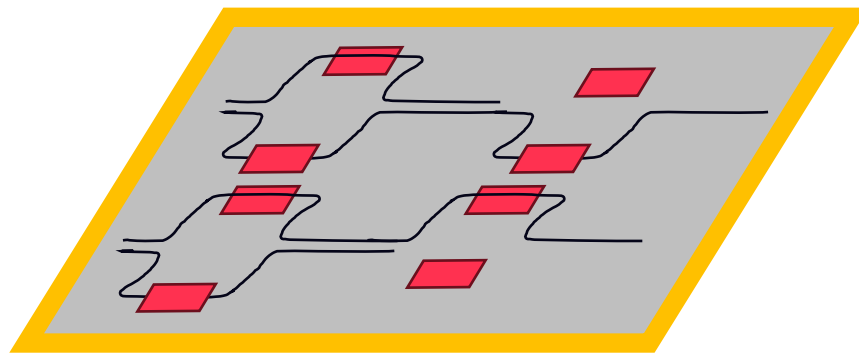
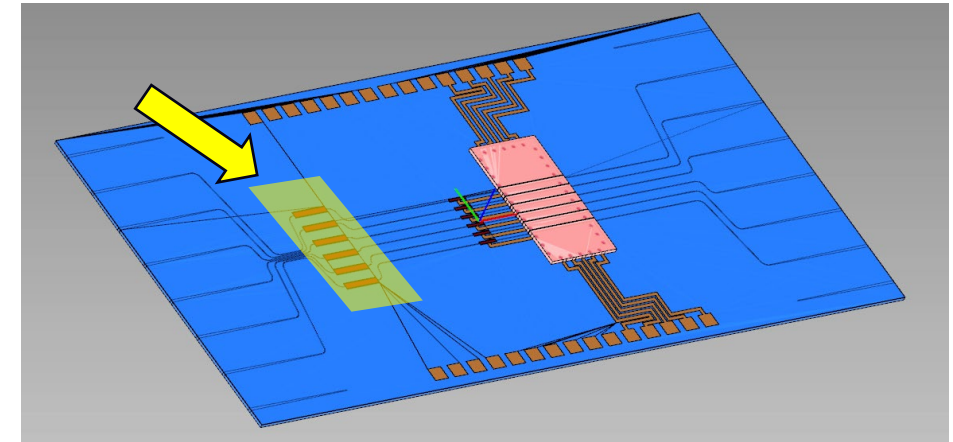
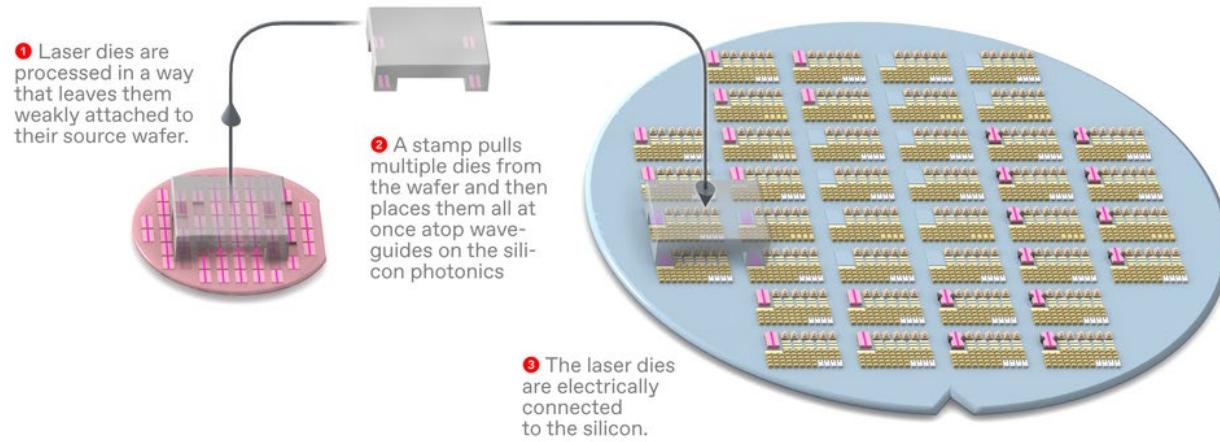
Micro-transfer printing InP C-band SOAs on advanced silicon photonics platform for lossless MZI switch fabrics and high-speed integrated transmitters, Jing et al.

Vol. 31, No. 26 / 18 Dec 2023 / Optics Express 42807

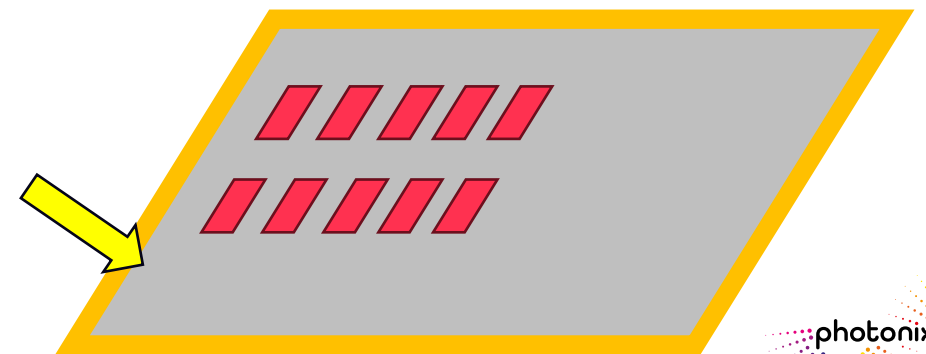


Results shared with permission from UGent - imec

# Efficient hybrid / heterogeneous PIC design



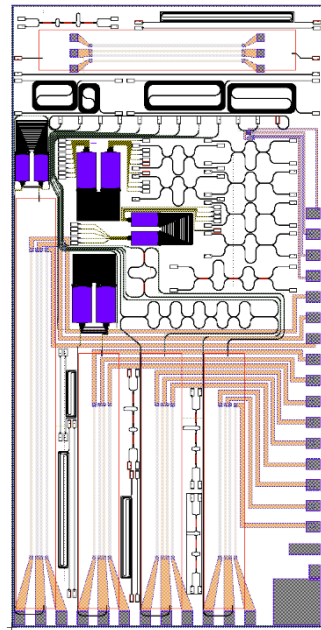
Randomly placed coupons (does not scale)



Design rules based on standard coupon locations



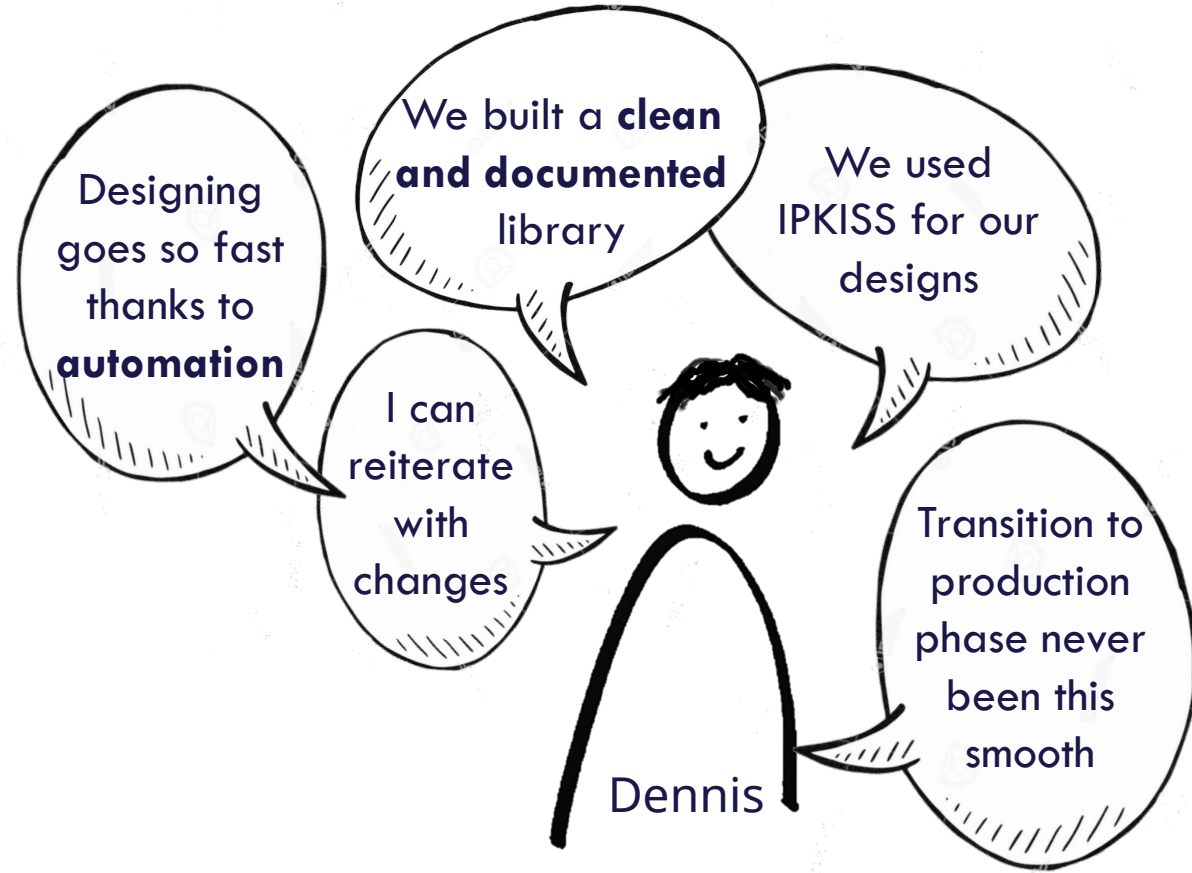
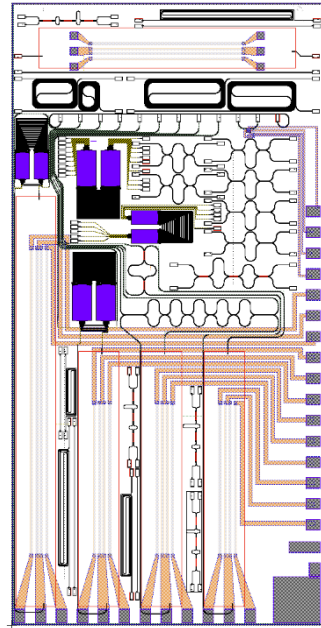
# PIC: From idea to product



We didn't use IPKISS for our designs



# PIC: From idea to product



# We are hiring!

## Open positions

Application engineer

Software engineer

Luceda Academy coordinator

[Apply](#)

## Connect with us on LinkedIn



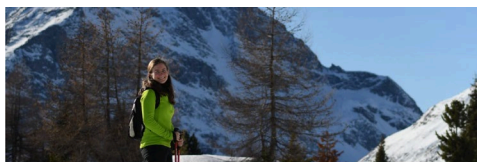
**Pierre Wahl** · 1st  
Founder at Luceda Photonics

[Connect with Pierre](#)



**Joris Geessels** · 1st  
Co-founder & software engineer

[Connect with Joris](#)



### Luceda People | Chiara: Science and core skills, a powerful combination

Chiara, who works as a Marketing, Sales & Application Engineer, appreciates the diversity her job entails. In addition to technical work, Chiara is also responsible for sales and marketing, which tu...

[Read interview](#)



### Luceda People | Miša: At the intersection of different fields

In this 'Luceda People Story', Miša reflects on the road that brought him to become a software developer at Luceda and what this position means for his personal growth. After his master's degree in el...

[Read interview](#)



**Chiara Alessandri** · You  
Sales and Application Engineer at  
Luceda Photonics

[Connect with Chiara](#)



LUCEDA  
P H O T O N I C S

[www.lucedaphotonics.com](http://www.lucedaphotonics.com)

