Politecnico di Torino

MOG

PHOTONIC INTEGRATED SWITCHING AND ROUTING

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PHOTONEXT

PHOTONIC INTEGRATED CIRCUITS

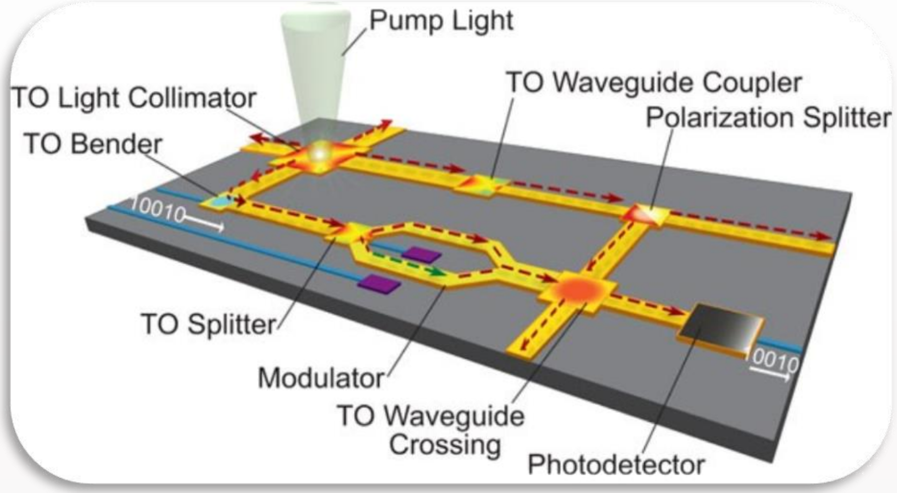
Photonic integrated circuits are showing ever-increasing *Technology Readiness Levels*, with new applications becoming available with each passing year.

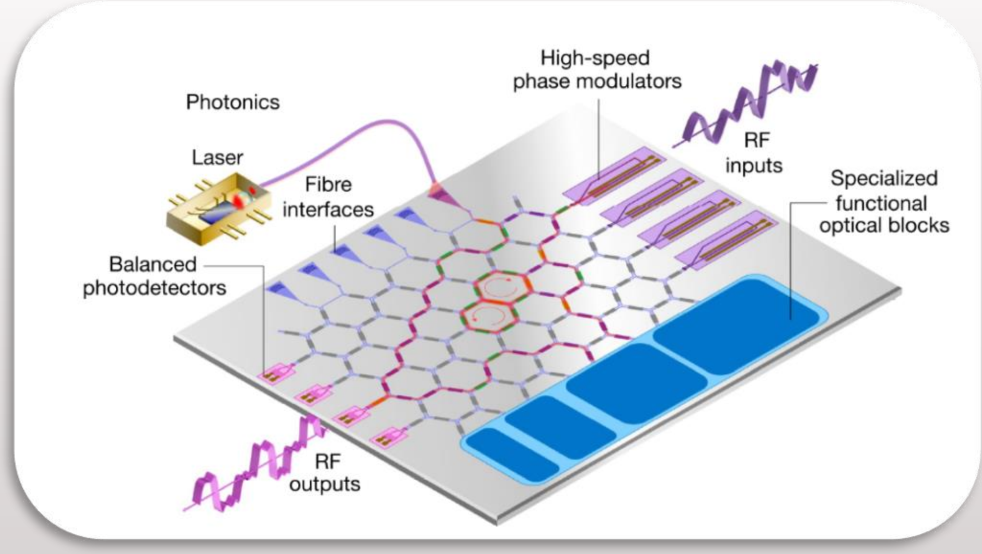
Many advantages:

- Batch Fabrication Economy.
- Large bandwidth and high speed
- Low power and high reliability

Not only limited to communications and data transfer → *General-purpose* programmable photonic devices

To this end, the research activity focuses on the *vertical bottom-up* design and simulation of *complex PICs*, abstracting the performances from the *device layer* to the *circuit and application*.

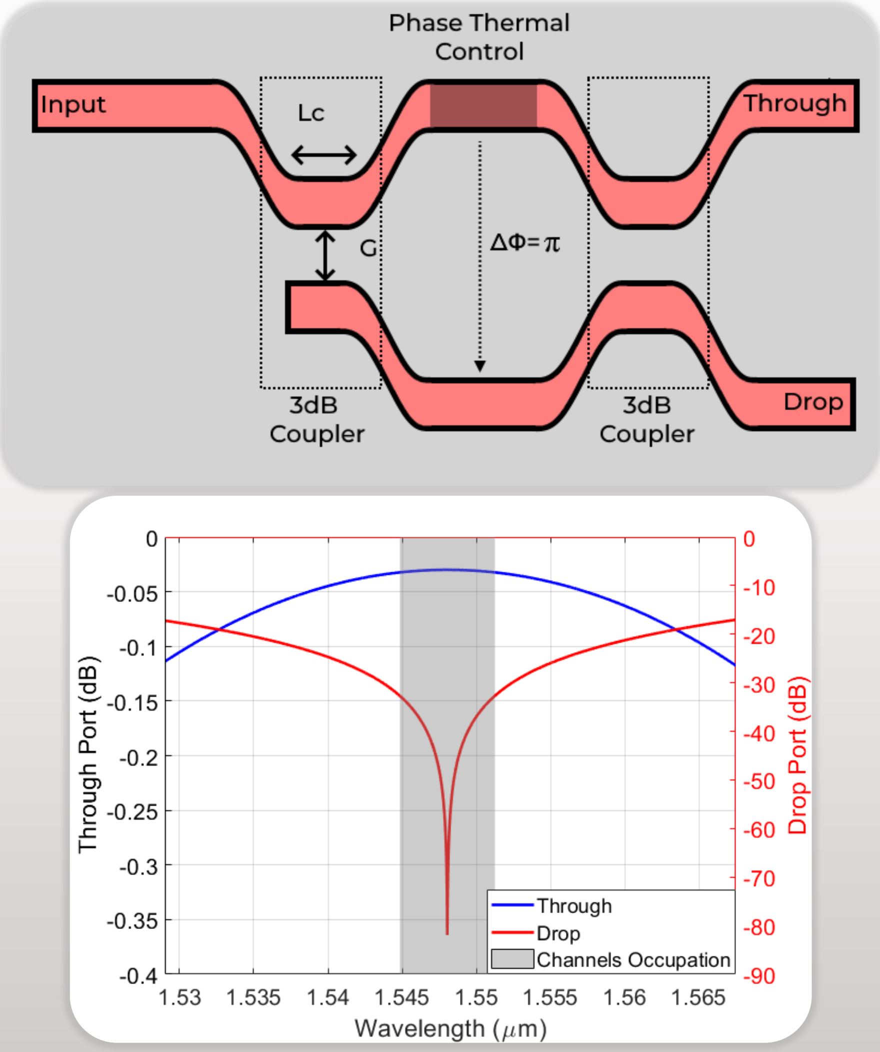




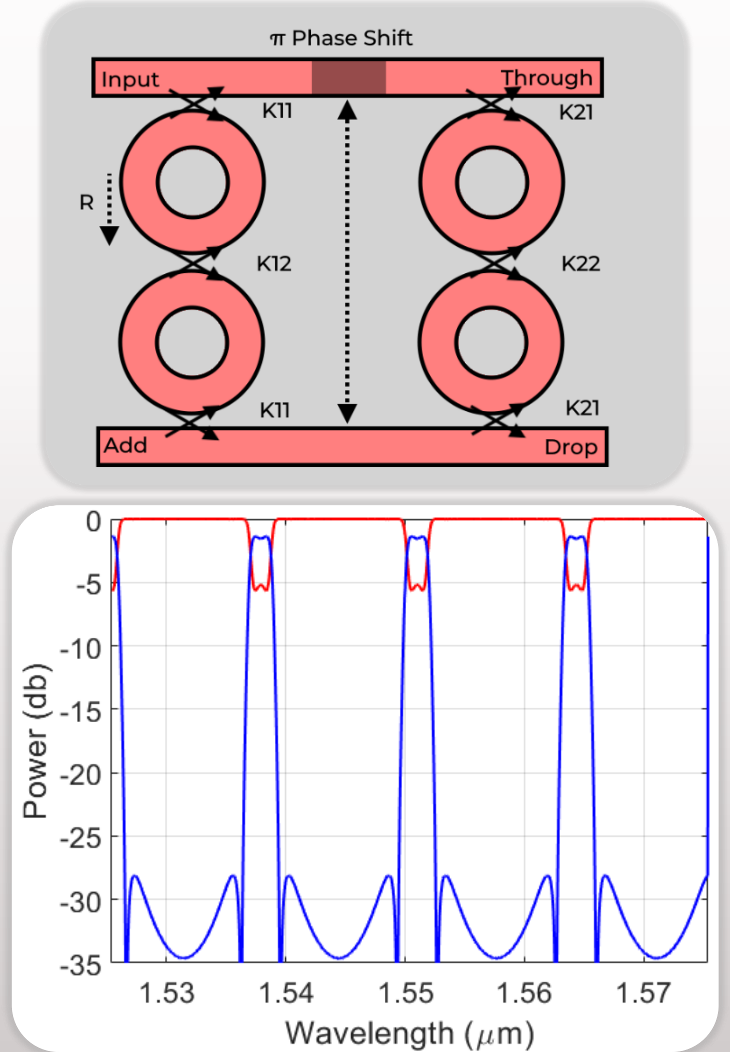
PICs - DEVICES

Many fundamental devices can be used as *building blocks* for more complex functionalities:

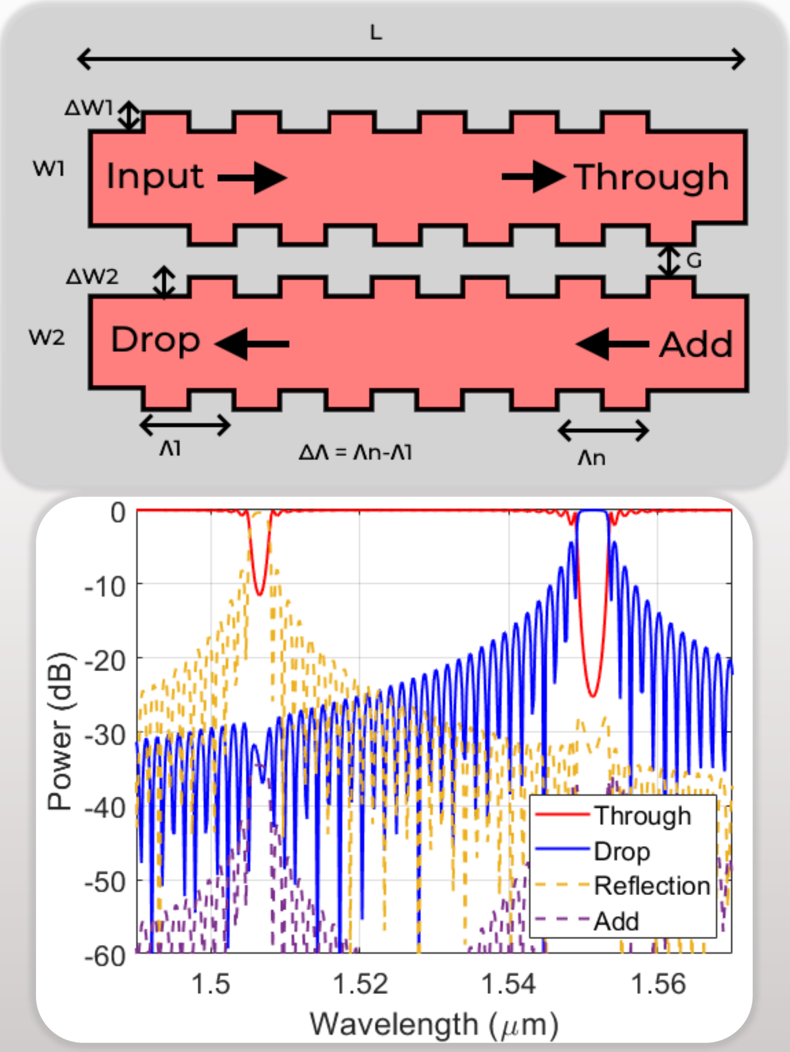
Mach Zehnder Interferometers



MicroRing Resonators



Grating-Assisted Couplers

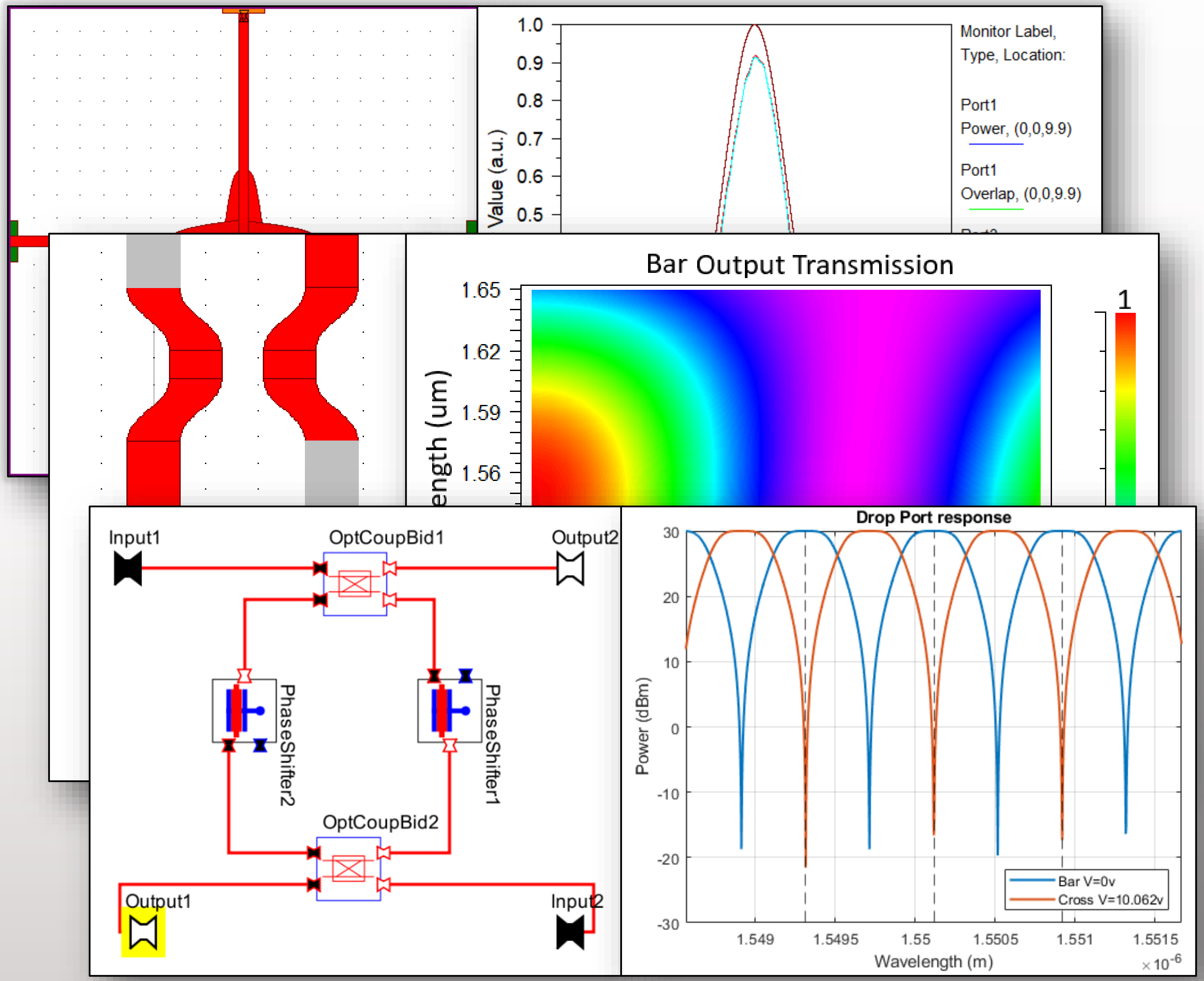


SIMULATION & DESIGN METHODS

Following the vertical approach, different models and simulation methods are used for the *design and validation* of the fundamental components:

- **Numerical simulations** in the available Synopsys platforms (BPM, CMT, ModeSolve, FDTD, MultiPhysisics)
- **Analytical models** (when available and effective)
- **Circuit-model** abstraction for the higher layer simulations (Optsim DSP)

By combining the appropriate methods the simulation of large-scale circuits can be made more *efficient and fast* while retaining the same *accuracy*.

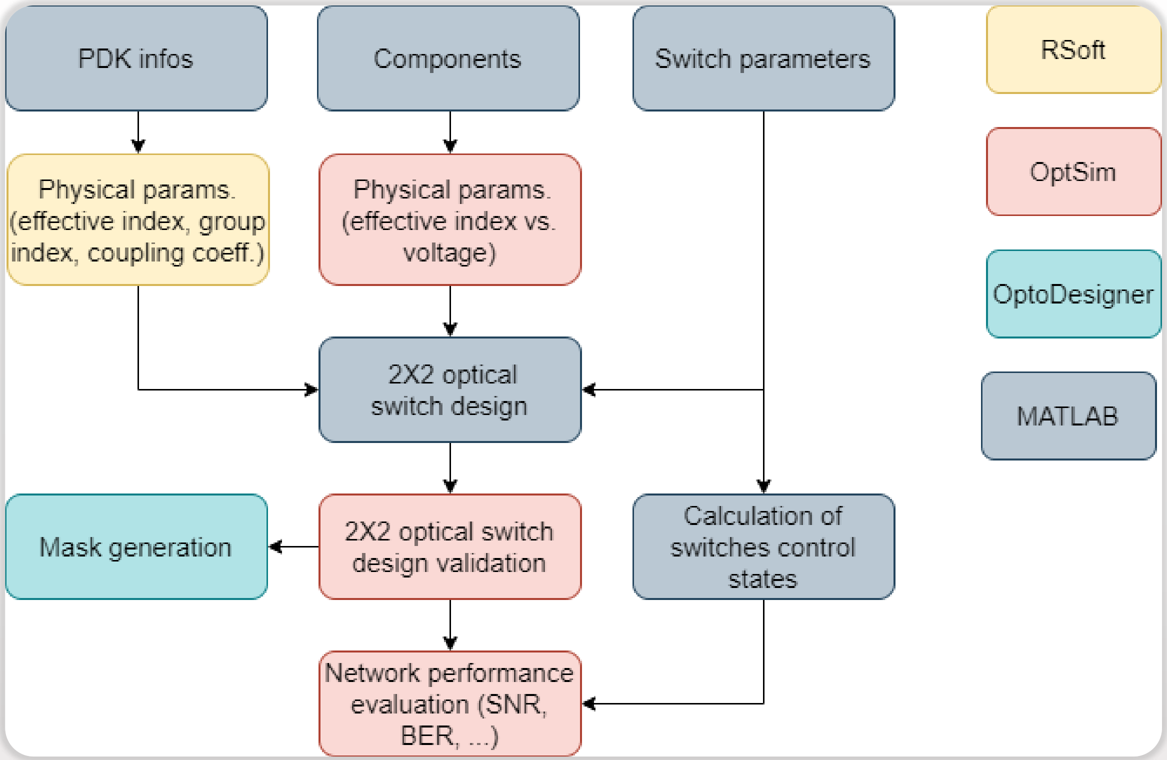


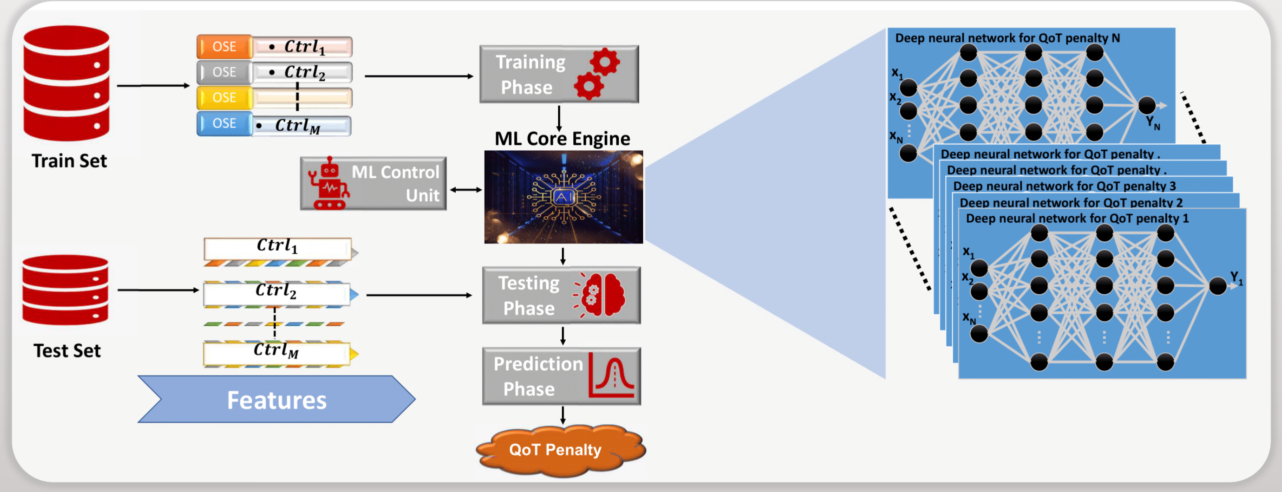
VERTICAL DESIGN APPROACH

The response of the designed component is then used to compile and simulate the larger-scale PICs, trying to maintain the *bottom-up approach and generality.*

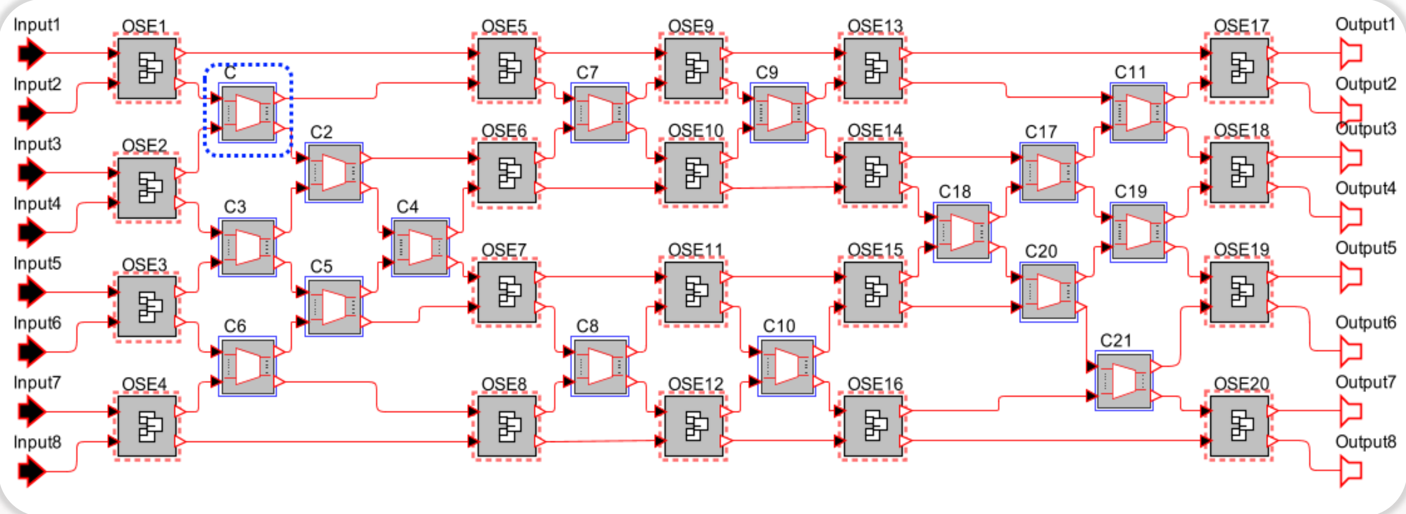
A *cohesive design pipeline* can be established for *multi-faceted* problems by interfacing the different simulation platforms, ranging from the production mask requirements to the materials and waveguide geometry.

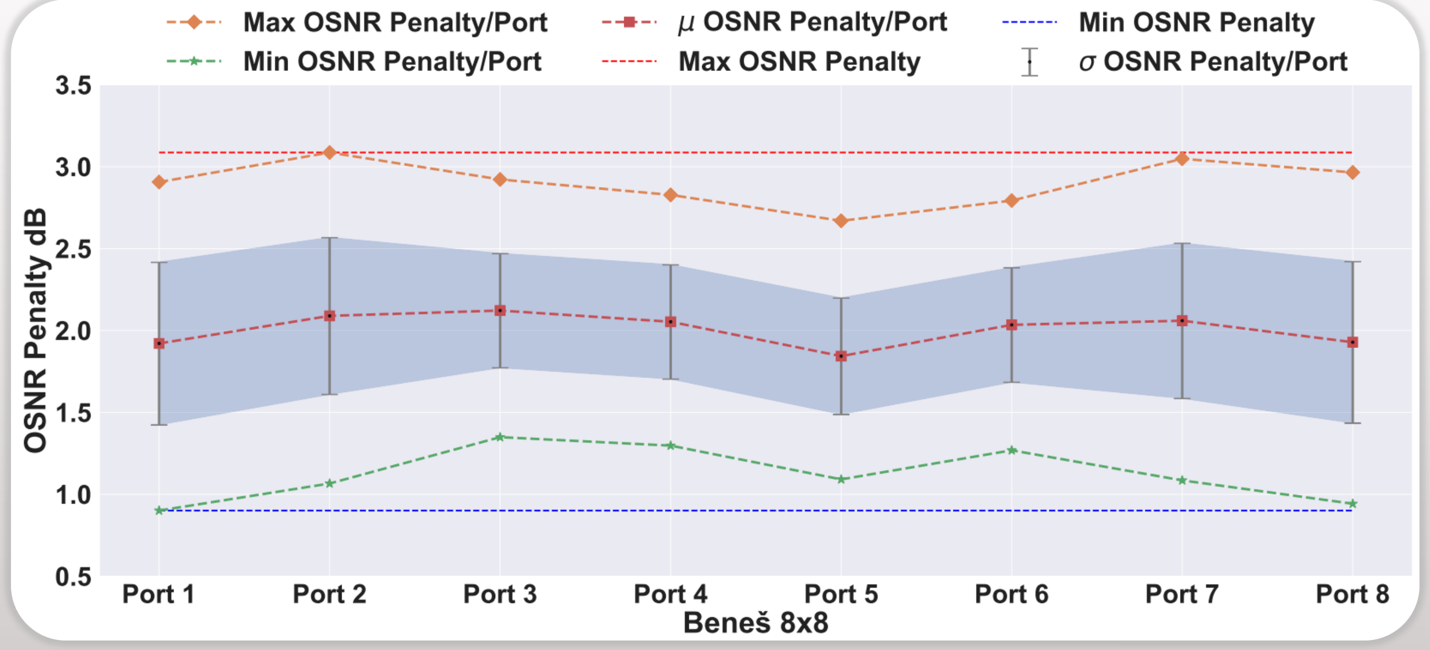
Machine-Learning (ML) and optimization techniques have also been deployed in the *inverse-design* of components and their characterization for large-scale circuits.





APPLICATION – BENEŠ NETWORKS





<u>NxN Beneš switching networks</u> represent a typical multistage topology both in photonic and electronic switching systems.

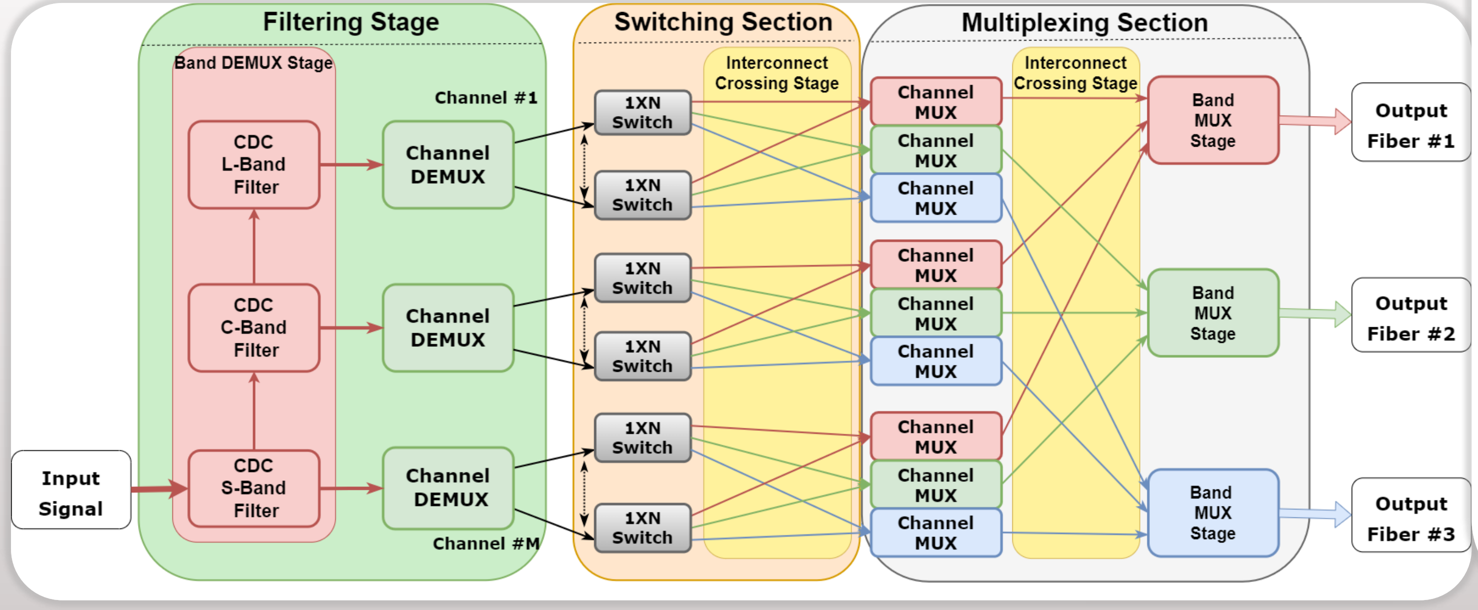
We developed a design suite to automate the design of *<u>arbitrary-size</u>* topologies, allowing *<u>quick testing</u>* and comparison of different device implementation and control strategies.

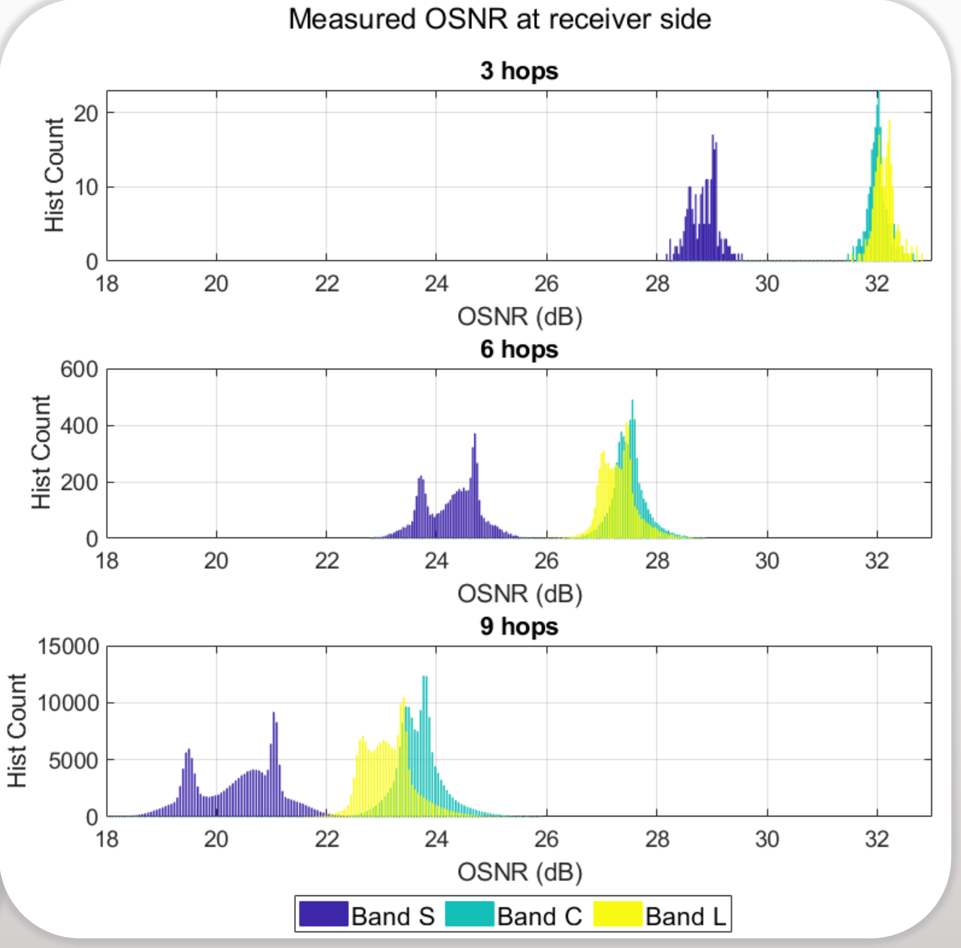
Based on the gathered data we deployed a ML agent to estimate the *<u>transmission impairments</u>* and optimal *<u>routing strategies</u>* for these devices, reducing the complexity and computational cost of the analysis.

APPLICATION - WSS

Targeting Dense WDM applications we developed and simulated a *modular and scalable* architecture for a multi-band *Wavelength-Selective Switch (WSS).*
Due to the large component number and footprint, the vertical approach is mandatory to ensure the *reliability and accuracy* of the model.

We showcased a fully integrated solution capable of DWDM switching coupled with a straightforward *penalty prediction scheme*, allowing the abstraction of the component penalties from the device to the network level.





THANK YOU FOR YOUR ATTENTION

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