Photonics Research Labs

iPRONICS Programmable Photonics

Programmable integrated photonics

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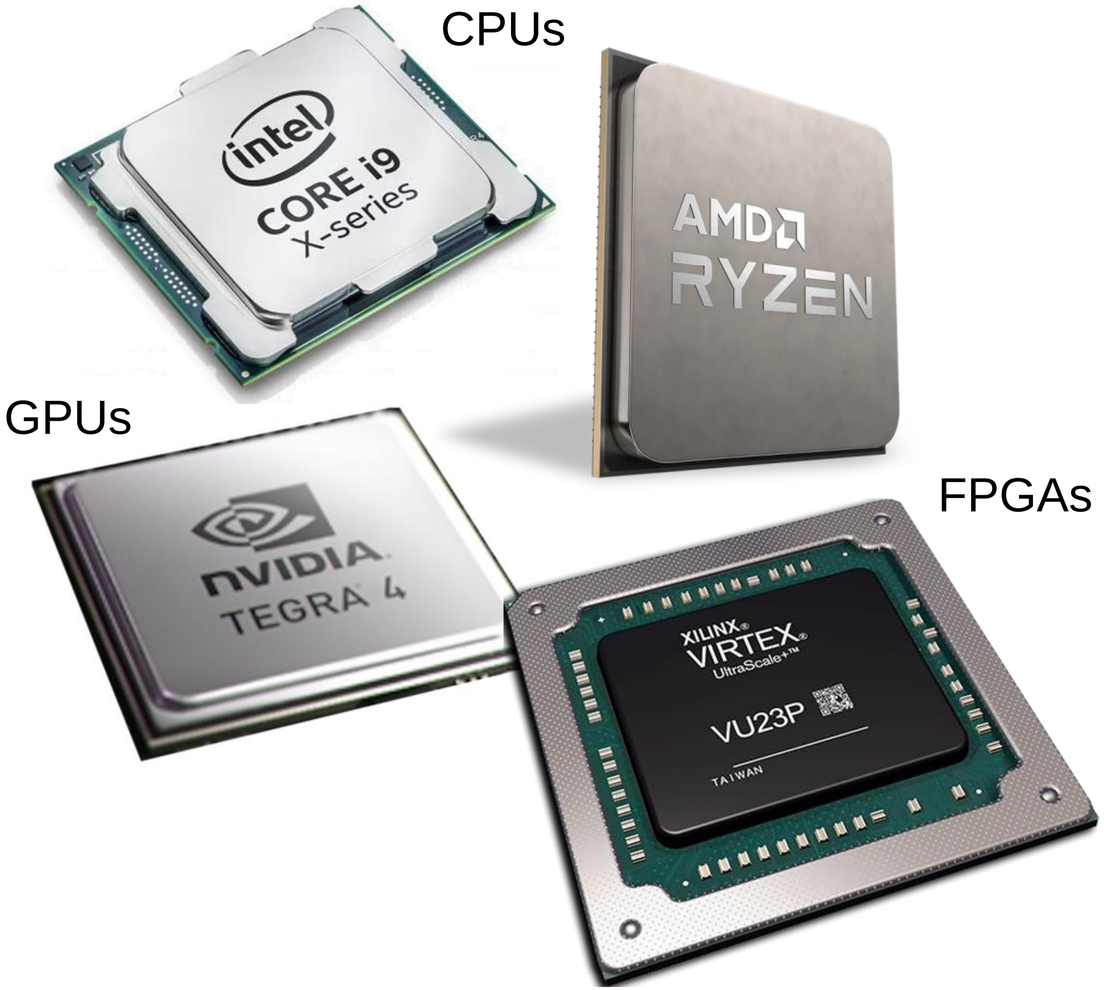
Electronic revolution started with a general-purpose paradigm.



Photonics provides bandwidth, **flexibility**, low power consumption and is **complementary to Electronics,** but has remained focused to application-specific PICs.

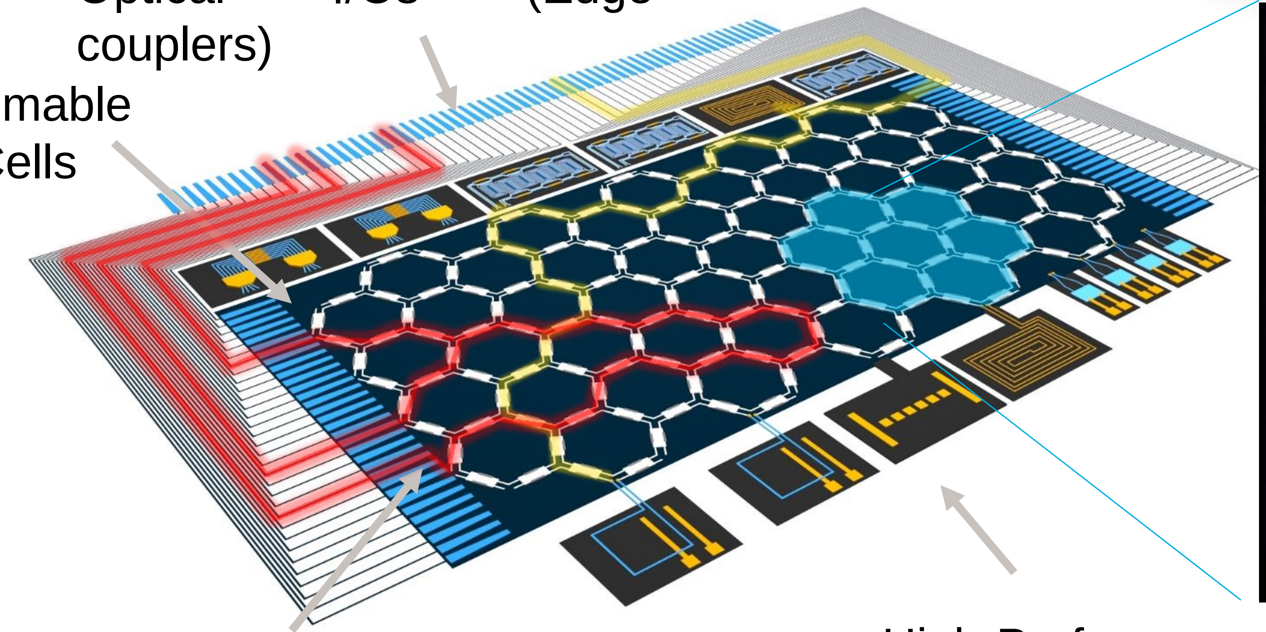
General purpose programmable photonics

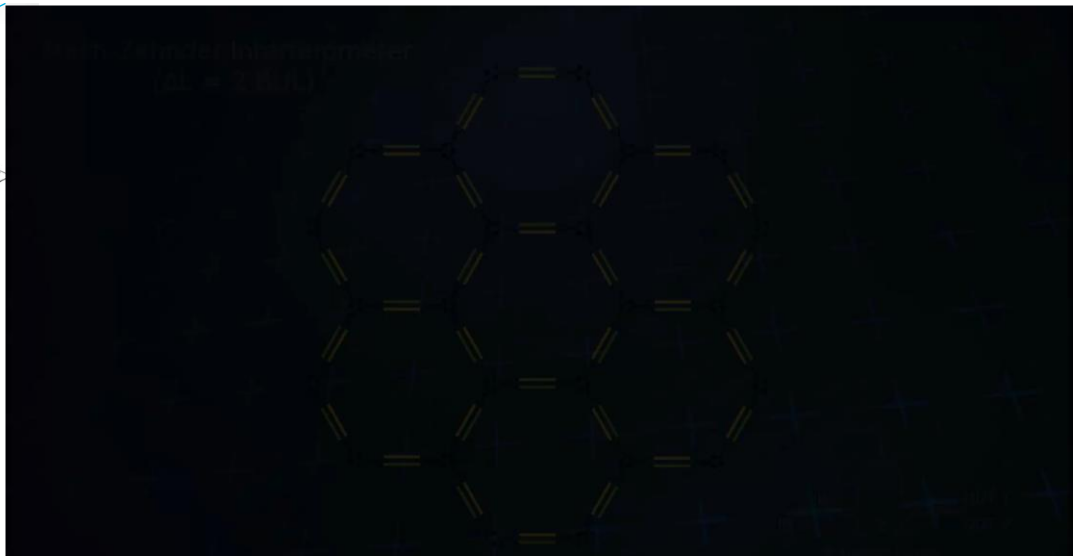
Programmable Multifunctional PICs

General-purpose photonic processor

Optical I/Os (Edge couplers)

Programmable Unit Cells





Nature Communications **8**, 636, 2017

Reconfigurable Optical Core (Hexagonal waveguide mesh arrangement)

High-Performance Building Blocks

Tunable Coupler
Phase Shifter

D. Pérez-López, et al, Multipurpose self-configuration of programmable photonic circuits, ***Nat. Comms***.*,10.1038/s41467-020-19608-w, 2020*

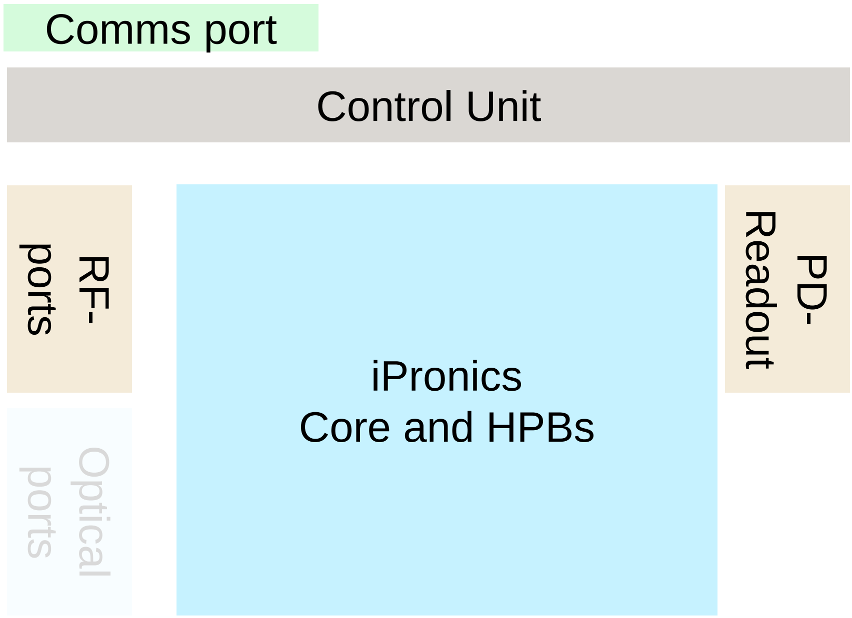
D. Pérez, I. Gasulla, J. Capmany, Field-programmable photonic arrays, **Optics Express, 26, 21**, 2018.

D. Pérez, "Reconfigurable lattice mesh designs for programmable photonic processors," **Opt. Express, 24, 11**, 2016

L. Zhuang, "Programmable photonic signal processor chip for radiofrequency applications," **Optica, 2, 10**, 2015

RF-photonics processing

- Multichannel RF- filters
- Multichannel RF-dispersión compensation
- Multichannel RF- equalization
- RF signal generation
- Arbitrary waveform generation
- RF-photonics MIMO processing for 5G and 6G
- Radar processing



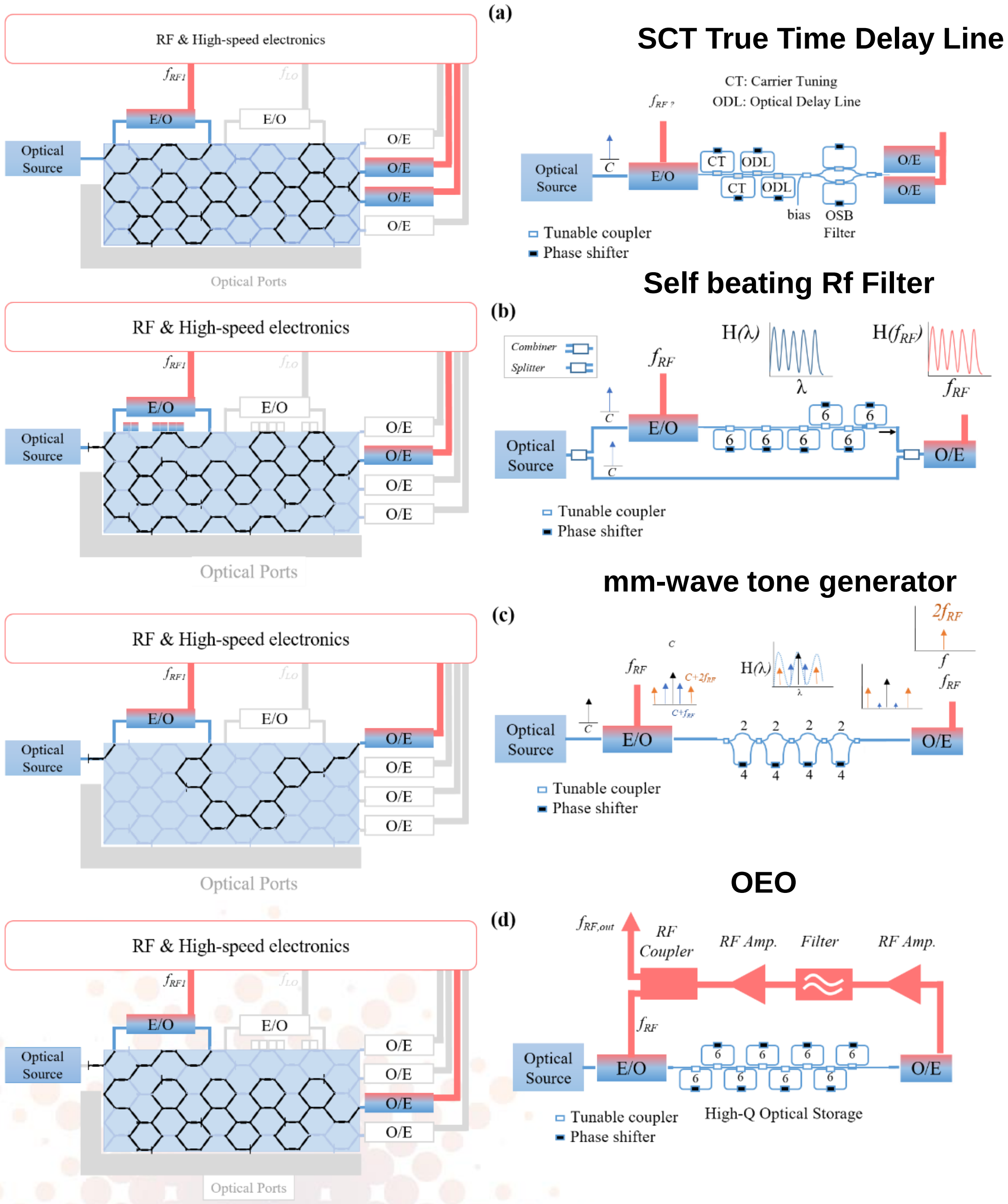
MWP Functionality Programming

SCT True Time Delay Line

Self beating Rf Filter

mm-wave tone generator

OEO

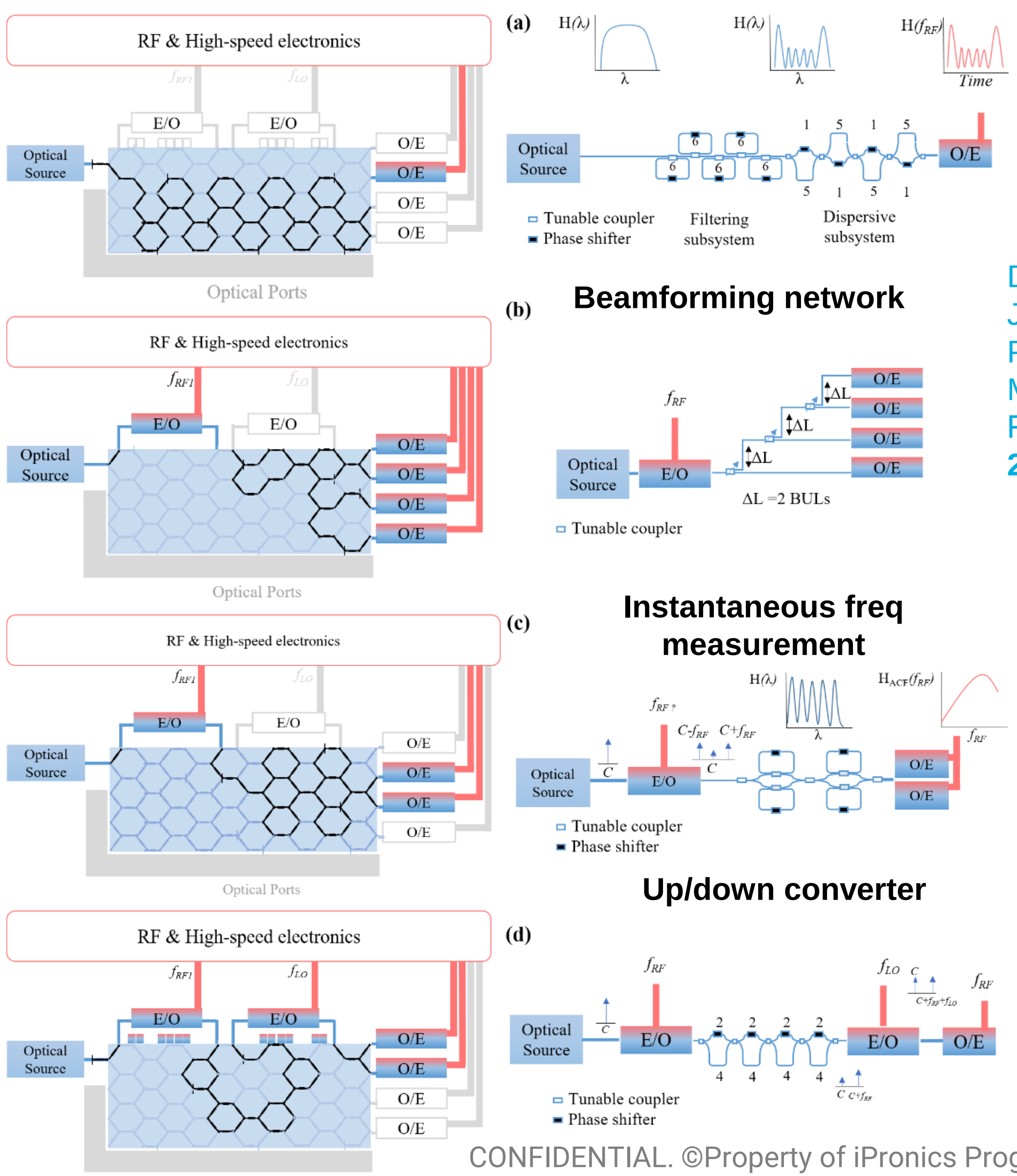


Wavelength to time mapping AWG

Beamforming network

Instantaneous freq measurement

Up/down converter



D. Perez, I. Gasulla, J.Capmany, "Toward Programmable Microwave Photonics Processors", **JLT, 36, 2, 2018.**

D. Pérez, I. Gasulla, J. Capmany, Field-programmable photonic arrays, **Optics Express, 26, 21, 2018.**

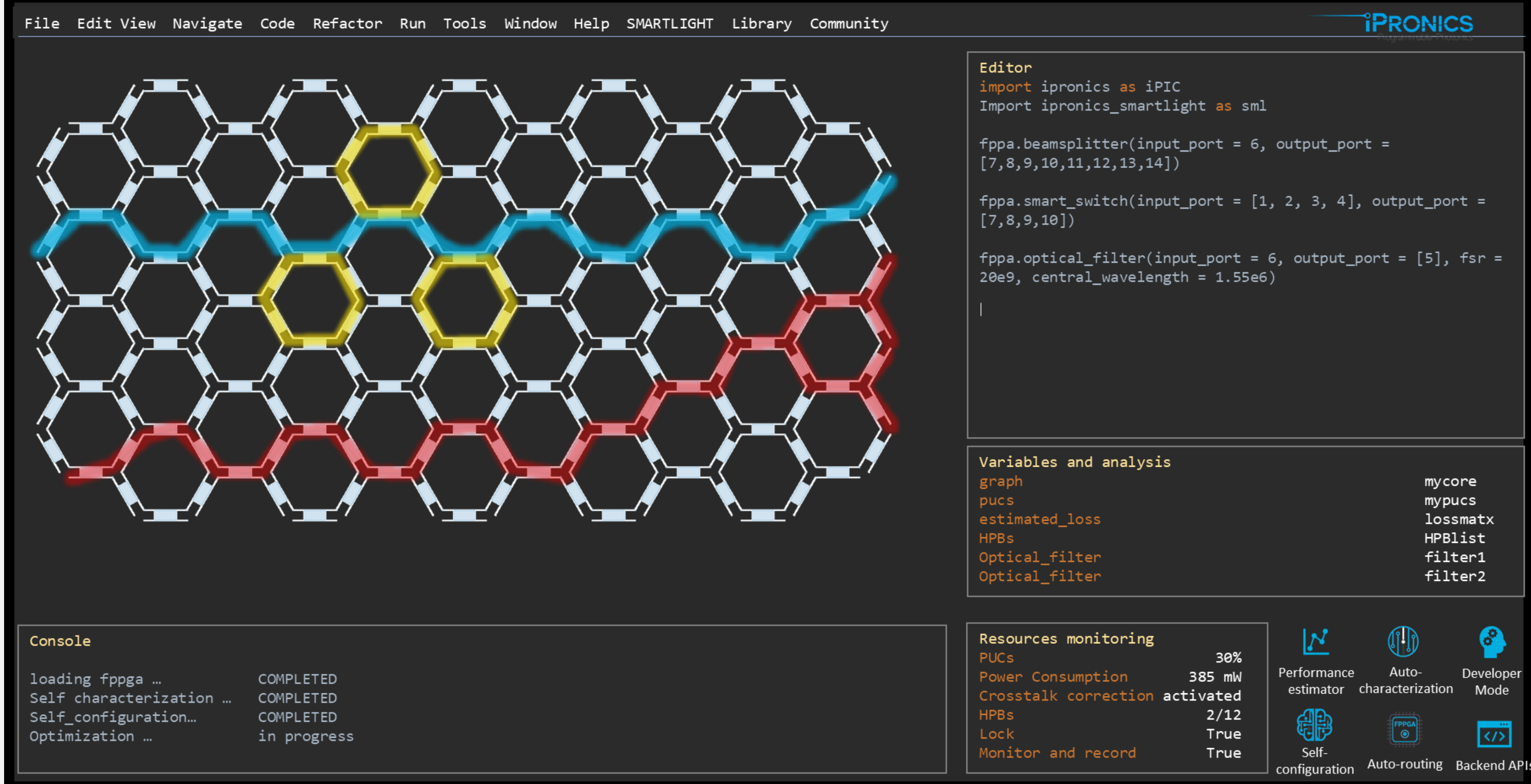
iPRONICS

SMARTLIGHT

iPronics develops the necessary software to program, control and optimize our solutions in a user-friendly yet, powerful way.

Software Framework

- Performance estimator
- Auto-characterization
- Self-configuration
- Auto-routing
- Developer Mode
- Backend APIs



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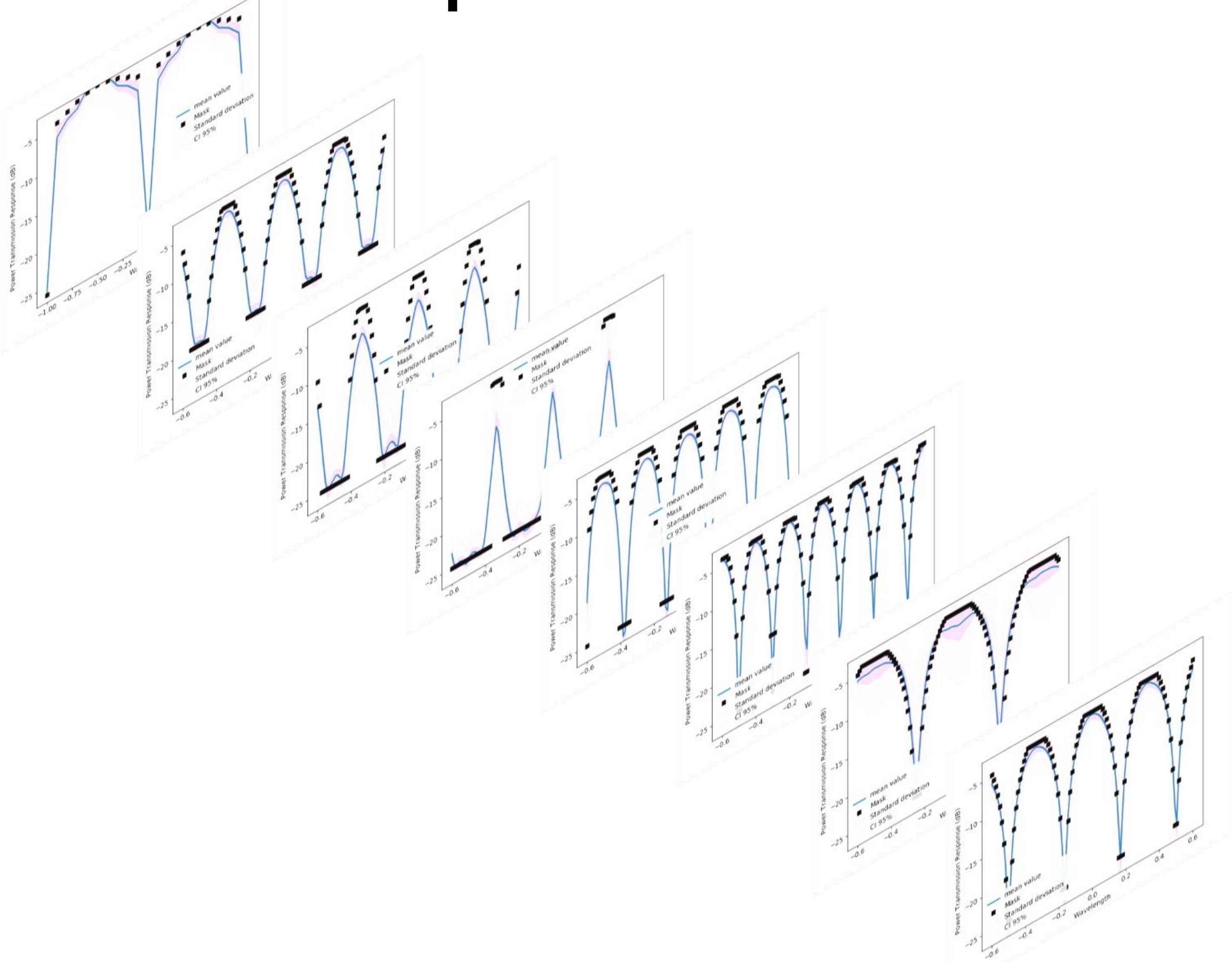
Self-configuring functions can be used to program fault-tolerant photonic interconnections and circuits



Programming Optical filters

We can optimize the error of the obtained response and the targeted spectral mask.

We can optimize additional items like optical signal leakage, ripples, power consumption, etc…

Advanced optimization methods

D. Pérez-López,, Programmable Integrated Silicon Photonics Waveguide Meshes: Optimized Designs and Control Algorithms***JSTQE***, *26(2), 2019*

D. Pérez-López, et al, Multipurpose self-configuration of programmable photonic circuits, ***Nat. Comms***.,*10.1038/s41467-020-19608-w, 2020*

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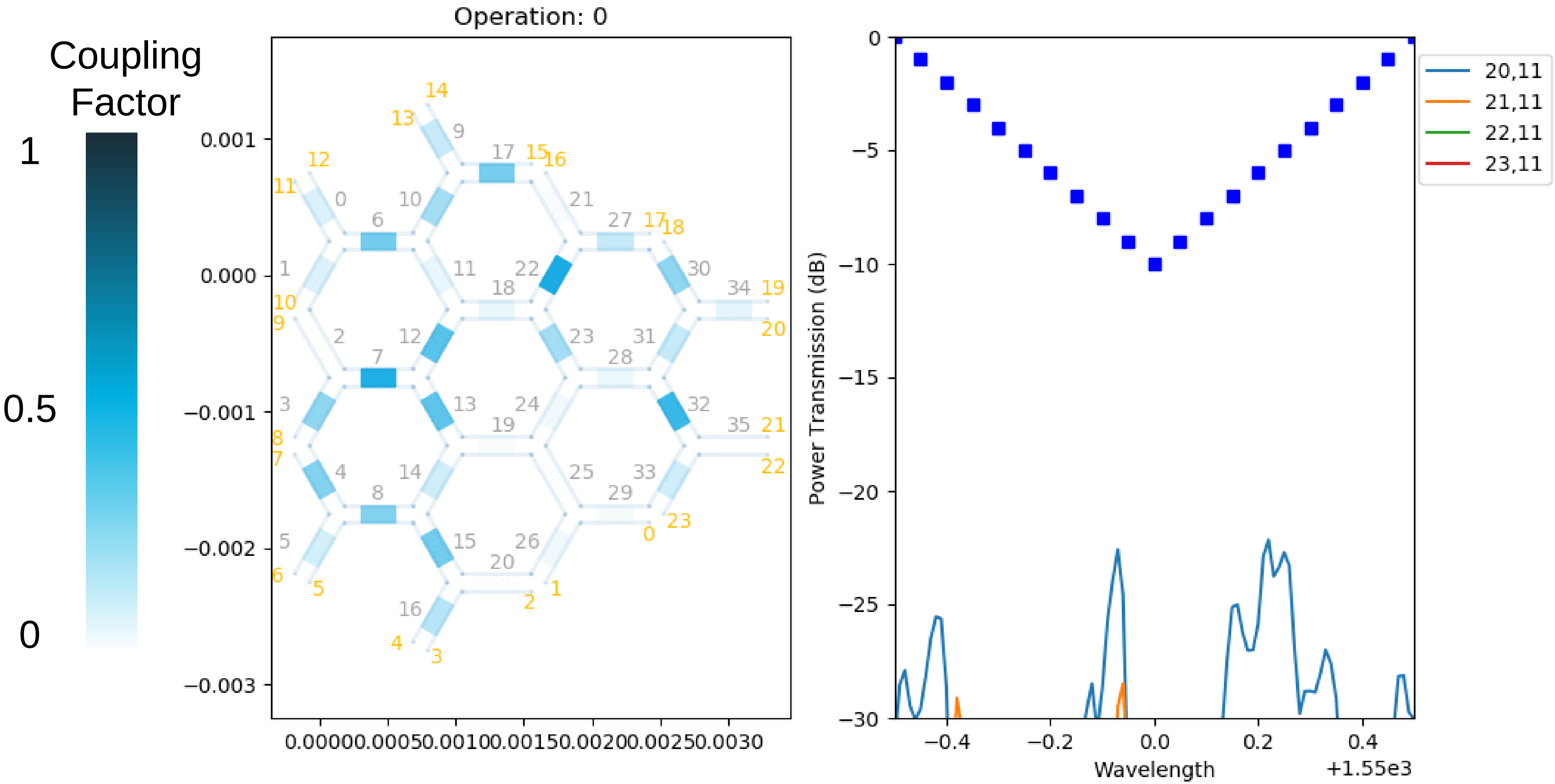
Programming a waveguide mesh arrangement for optical equalization

300ms – 1 s reconfiguration times



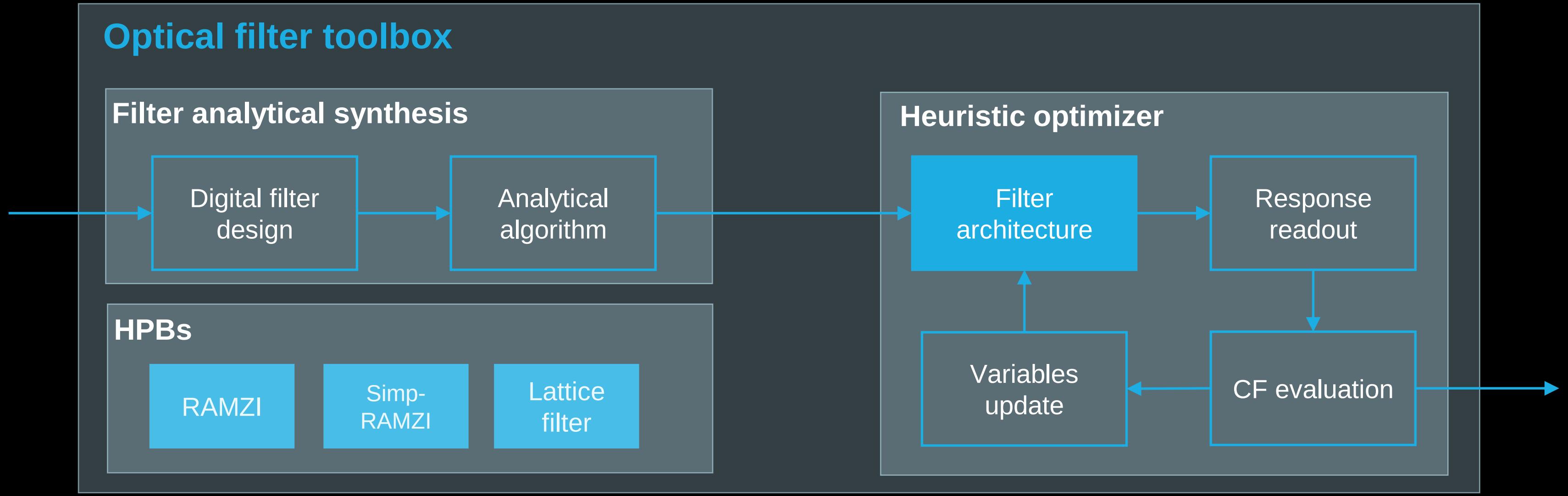
D. Pérez-López, Automated configuration of general-purpose programmable photonic ICs: ***ACP2020***,

D. Pérez-López, Programmable Integrated Silicon Photonics Waveguide Meshes***JSTQE***, *26(2), 2019*

Programming :Optical filters toolbox

Workflow

- Filter Specs
- Filter architecture
- Optimization parameters



Configured filter architecture

Define filter specifications, optimization parameters (optional) and filter architecture

Configure the architecture using the synthesis tool

Visualize the obtained results

```
filter_specs = {
    'type': 'bandpass filter',
    'parameters': {'type': 'ellip’,
                   'args': (order, rp, rs, bw)}}
```

```
ramzi_filter = ramzi(ring_length, order)
ramzi_filter.set_technology_parameters(parameters)
ramzi_filter.set_pucs_ILs(0.3)
ramzi_filter.set_passive_phase(0.01)
```

```
conf_ramzi[0].plot_magnitude_response(wavelengths)
```

CF = Cost function
HPBs = High Performance Blocks

M. Gutierrez, D. Pérez-López, Photonics in Switching and Computing, 2021

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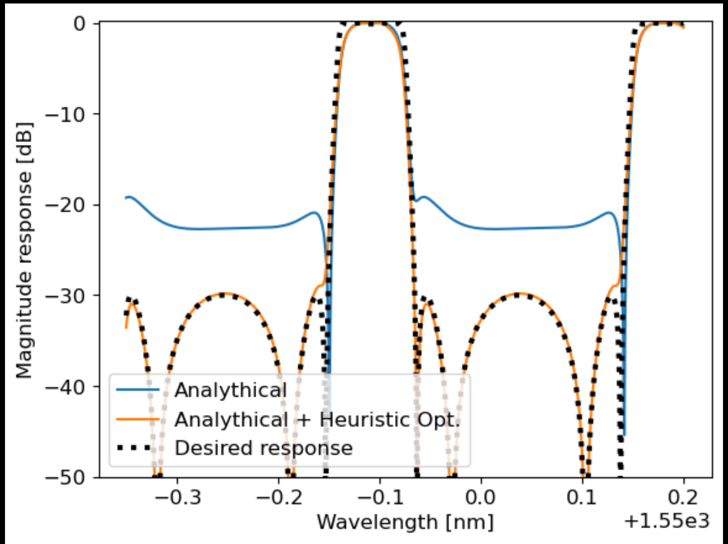
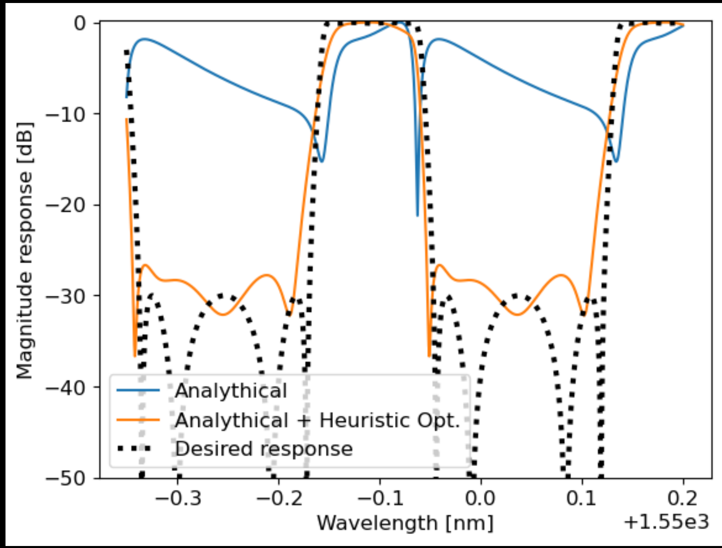
Programming :Optical filters toolbox





- Filter architecture: RAMZI
- Order: 4
- FSR = 36.34GHz
- Bandwidth: 7.27GHz
- Passive phase: 1%
- ER: 30dB
- Optimizer: Nelder-Mead
- Operations: 1346
- CF: MSE

- Filter architecture: RAMZI
- Order: 4
- FSR = 36.34GHz
- Bandwidth: 10.9GHz
- Passive phase: 5%
- ER: 30dB
- Optimizer: Nelder-Mead
- Operations: 3400
- CF: Mask

M. Gutierrez, D. Pérez-López, Photonics in Switching and Computing, 2021