



**HAL**  
open science

## Dual wavelength vertical coupling for SHG in GaP microdisks

Alejandro Lorenzo-Ruiz, Alexandre Beck, Charles Cornet, Yoan Léger

► **To cite this version:**

Alejandro Lorenzo-Ruiz, Alexandre Beck, Charles Cornet, Yoan Léger. Dual wavelength vertical coupling for SHG in GaP microdisks. 39<sup>e</sup> Journées Nationales d'Optique Guidée (JNOG 2019), Jul 2019, Palaiseau, France. hal-02293254v2

**HAL Id: hal-02293254**

**<https://hal.science/hal-02293254v2>**

Submitted on 11 Dec 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



# Dual wavelength vertical coupling for SHG in GaP microdisks

A. Lorenzo Ruiz<sup>1</sup>, A. Beck<sup>1</sup>, C. Cornet<sup>1</sup>, Y. Léger<sup>1</sup>

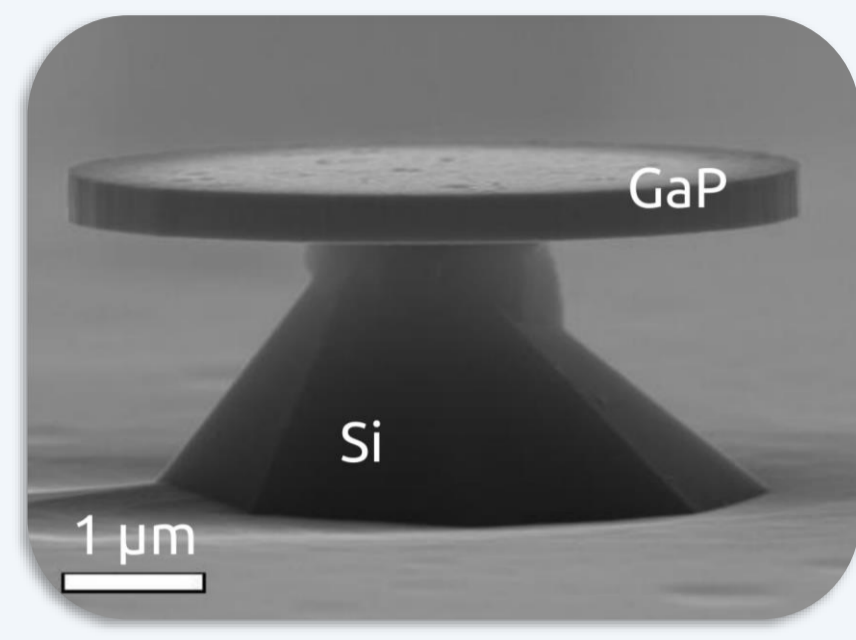
<sup>1</sup> Univ Rennes, INSA Rennes, CNRS, Institut FOTON – UMR 6082, F-35000 Rennes, France

\* alejandro.ruiz@insa-rennes.fr

## Introduction

Wavelength converter is one of the essential blocks of photonic integrated circuits. One of most established configurations is based on  $\chi^2$  nonlinearities in microdisk resonators making use of the Whispering Gallery Modes (WGMs)<sup>(1)</sup>

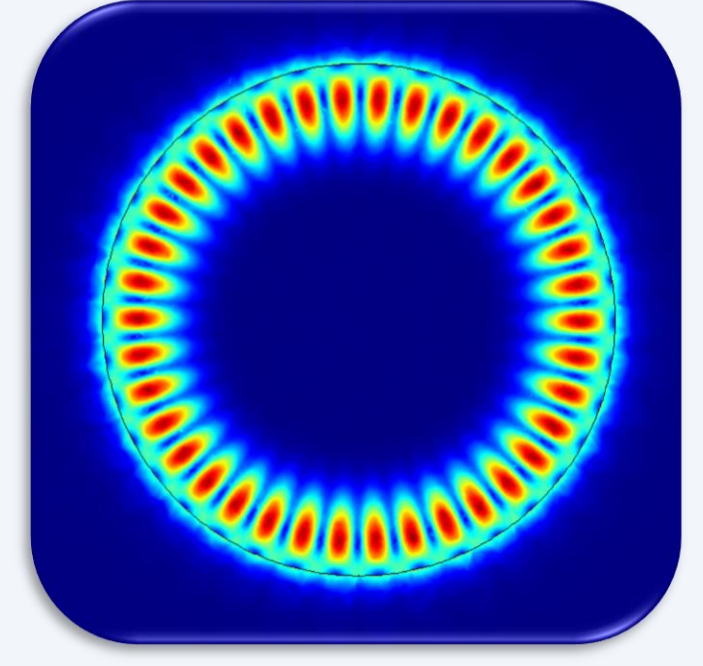
- III-V Semiconductors  $\rightarrow$  strong nonlinear properties and specific  $\bar{4}$  quasiphasematching
- Challenging optical coupling, hard to couple two frequencies with the same system
- No study of different coupling schemes for nonlinear conversion in literature



SEM image of a GaP microdisk over Si made in the laboratory

The wavelength conversion (second harmonic generation):

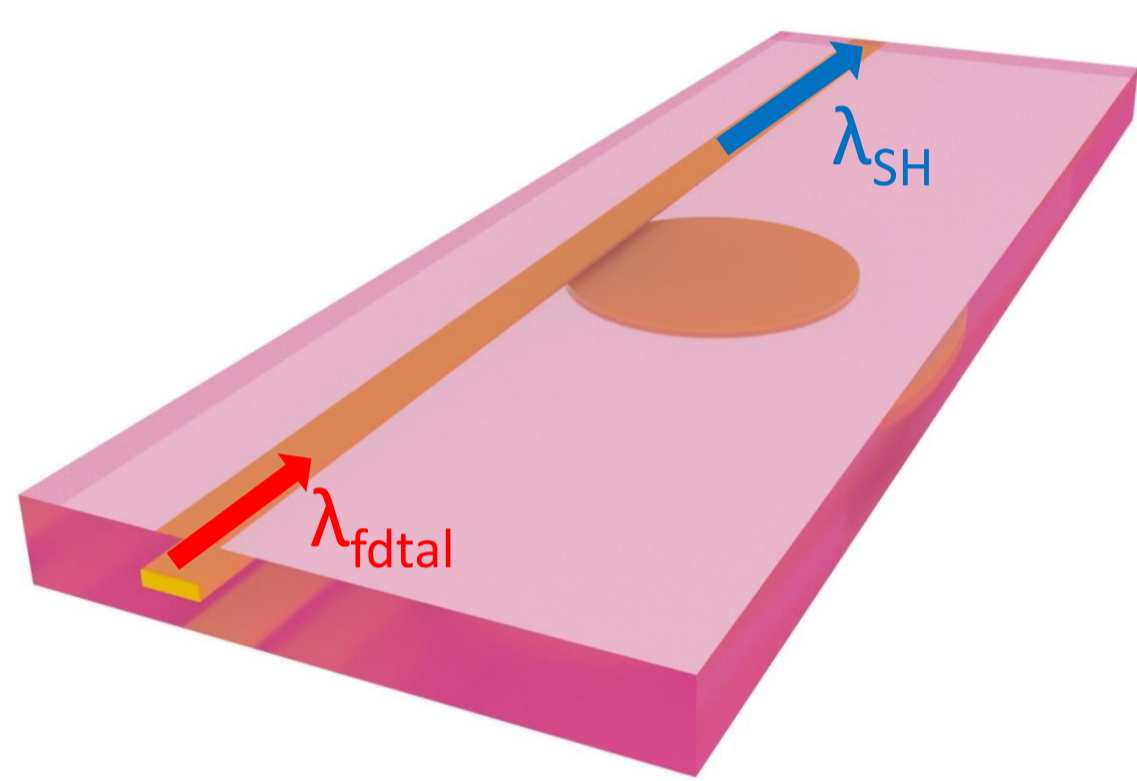
- Fundamental (Fdtal)=2 $\mu$ m  $\rightarrow$  Second Harmonic (SH)=1 $\mu$ m
- TE polarization  $\rightarrow$  TM polarization
- $\bar{4}$  Quasiphasematching possible for GaP microdisks<sup>(2)</sup>



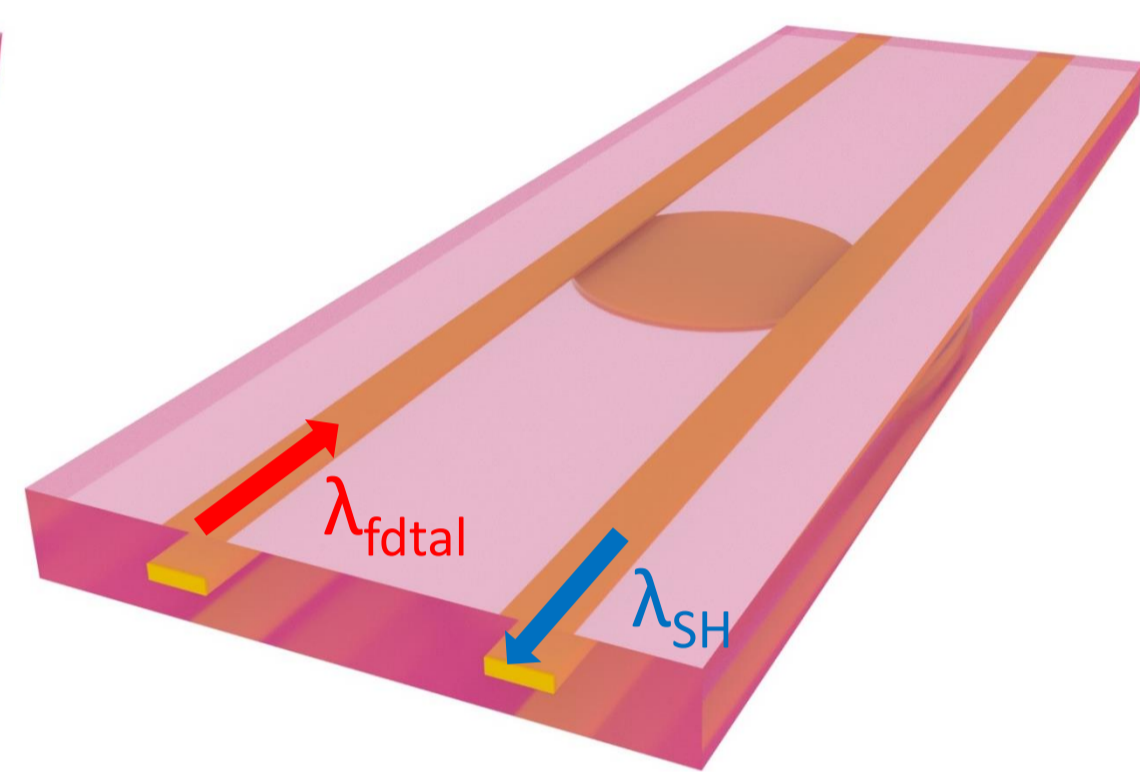
Planar electric field distribution of a WGM for a horizontal plane in a microdisk

## Evanescent coupling configurations

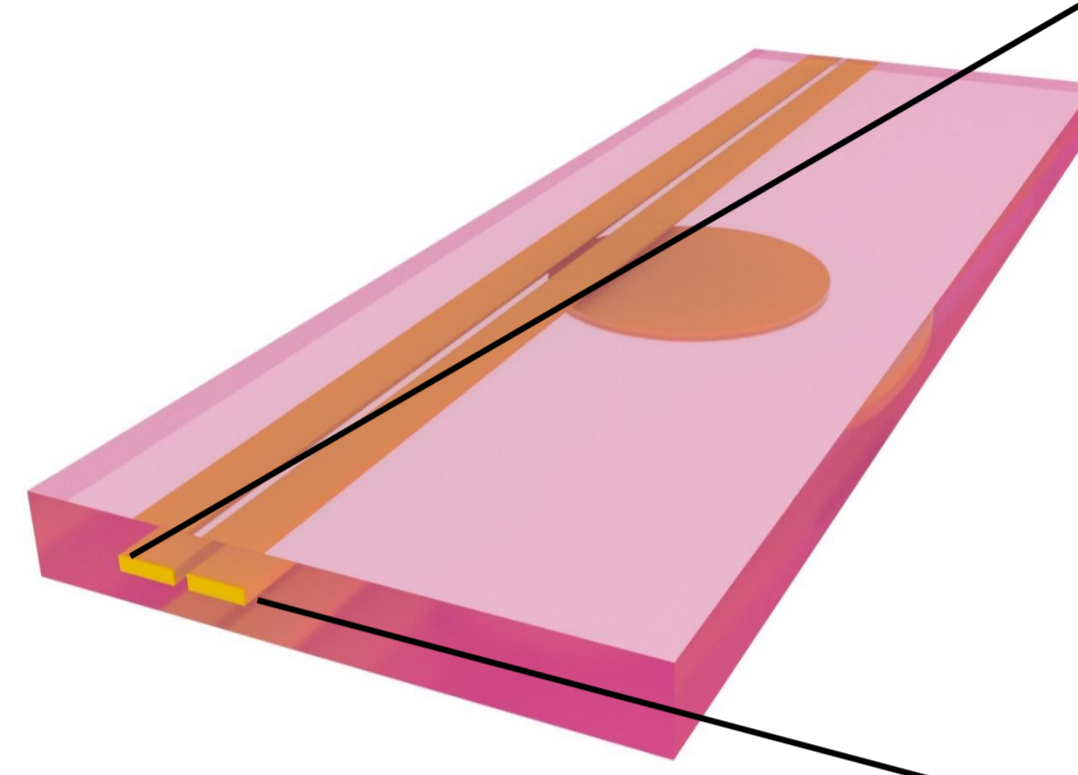
Three coupling schemes studied:



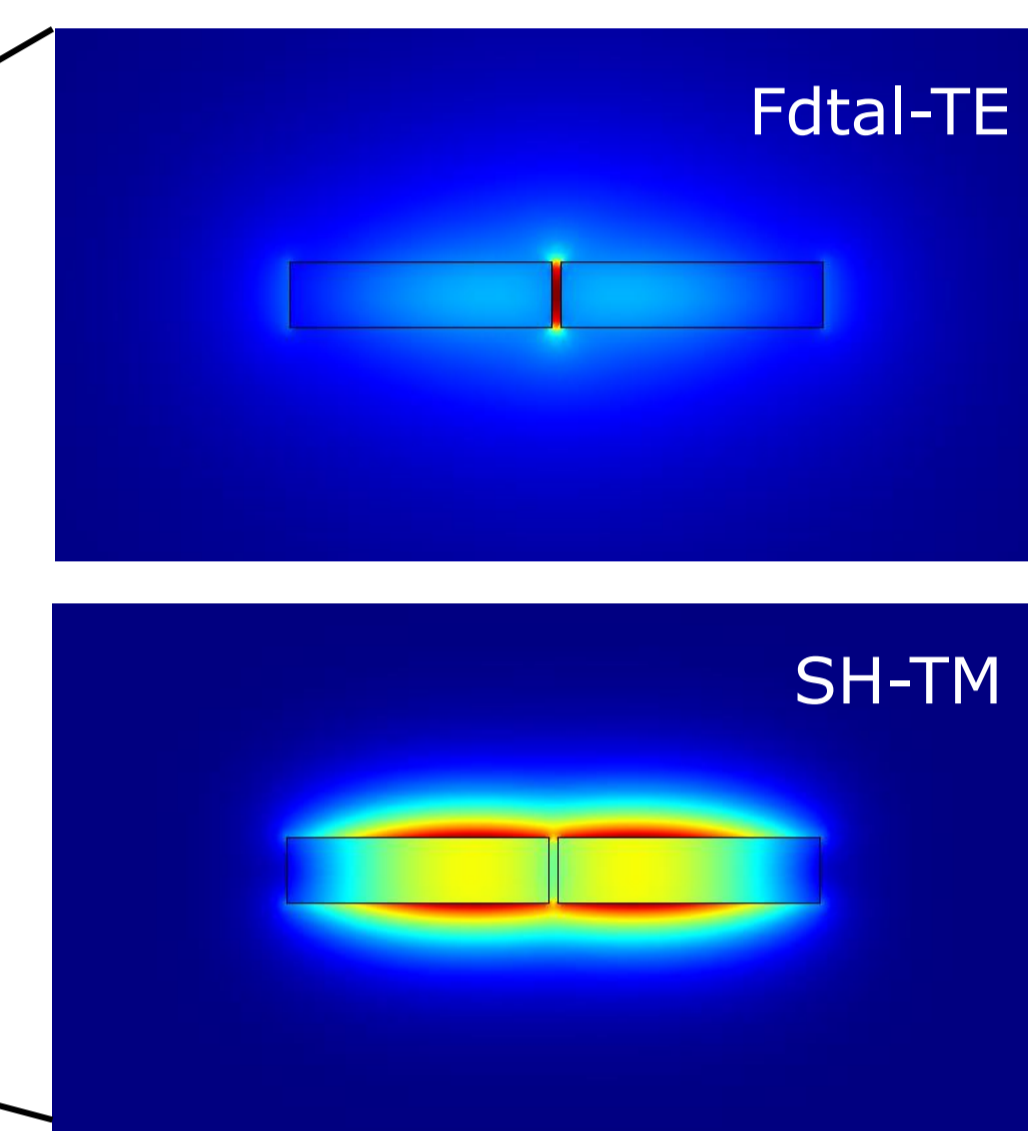
All-pass



Add-drop



Slit



Supermodes

Linear combination of single waveguide modes

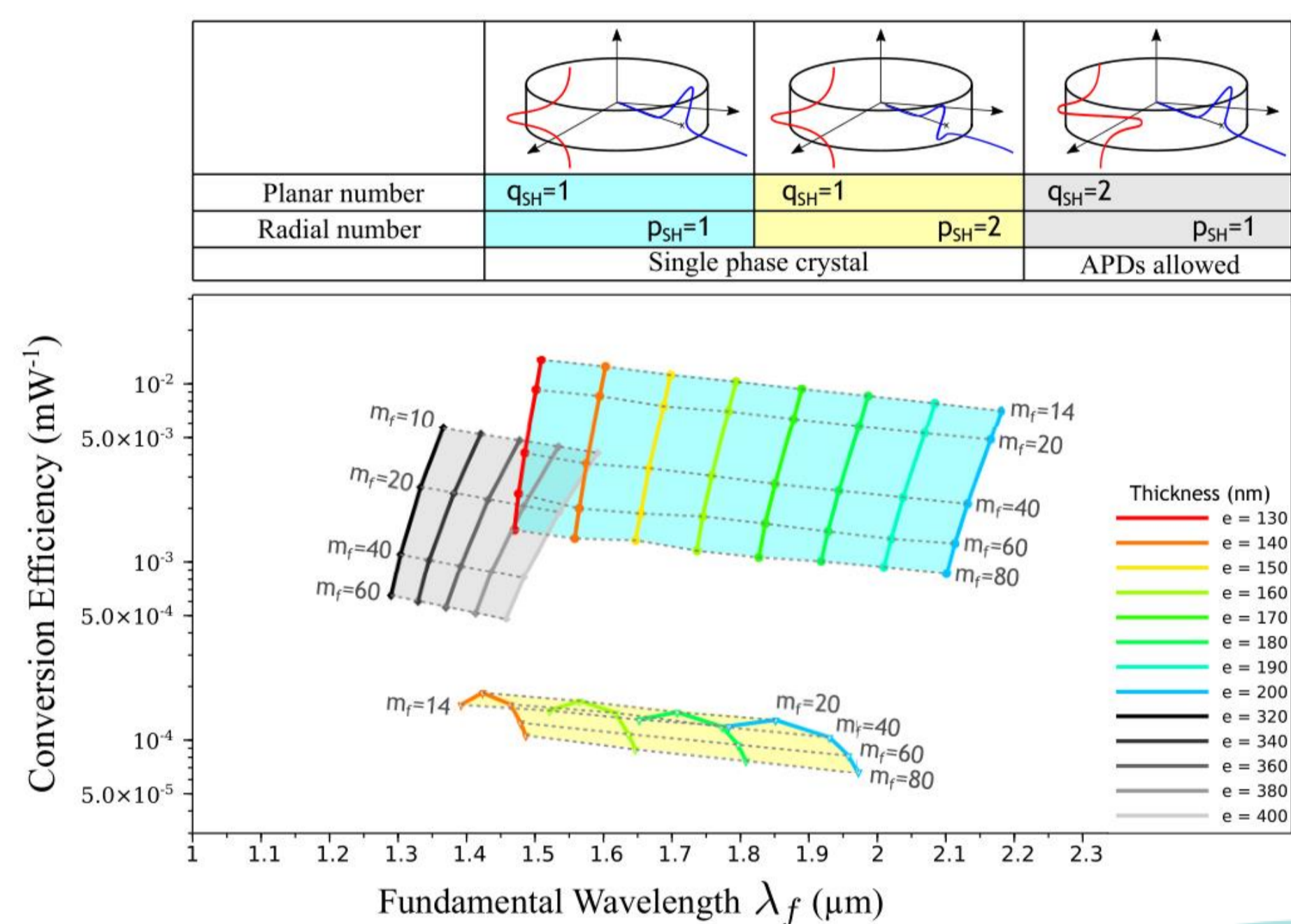
$$E = A(z)E_1 + B(z)E_2$$

$$H = A(z)H_1 + B(z)H_2$$

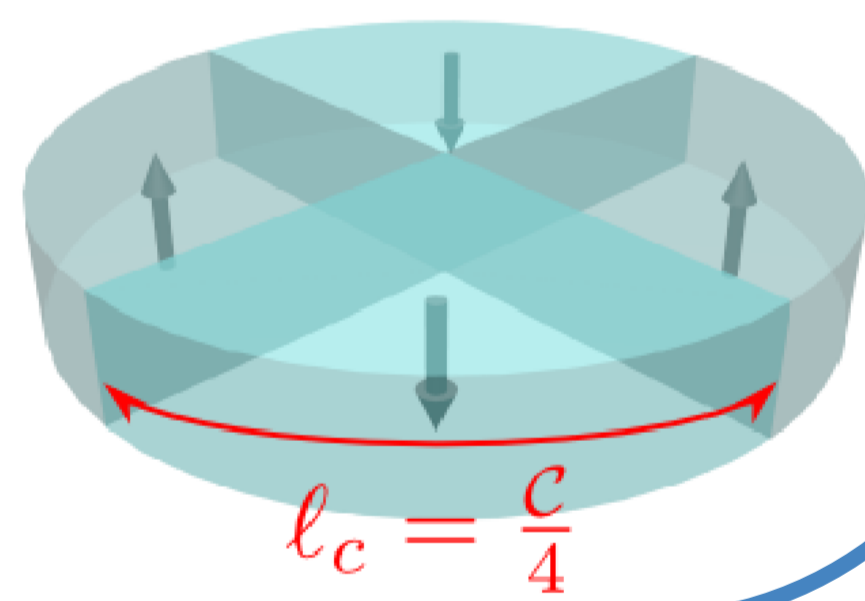
Achieve propagation constant engineering for TE and TM

## $\bar{4}$ Quasiphasematching<sup>(3)</sup>

Possibility of QPM in circular microresonators

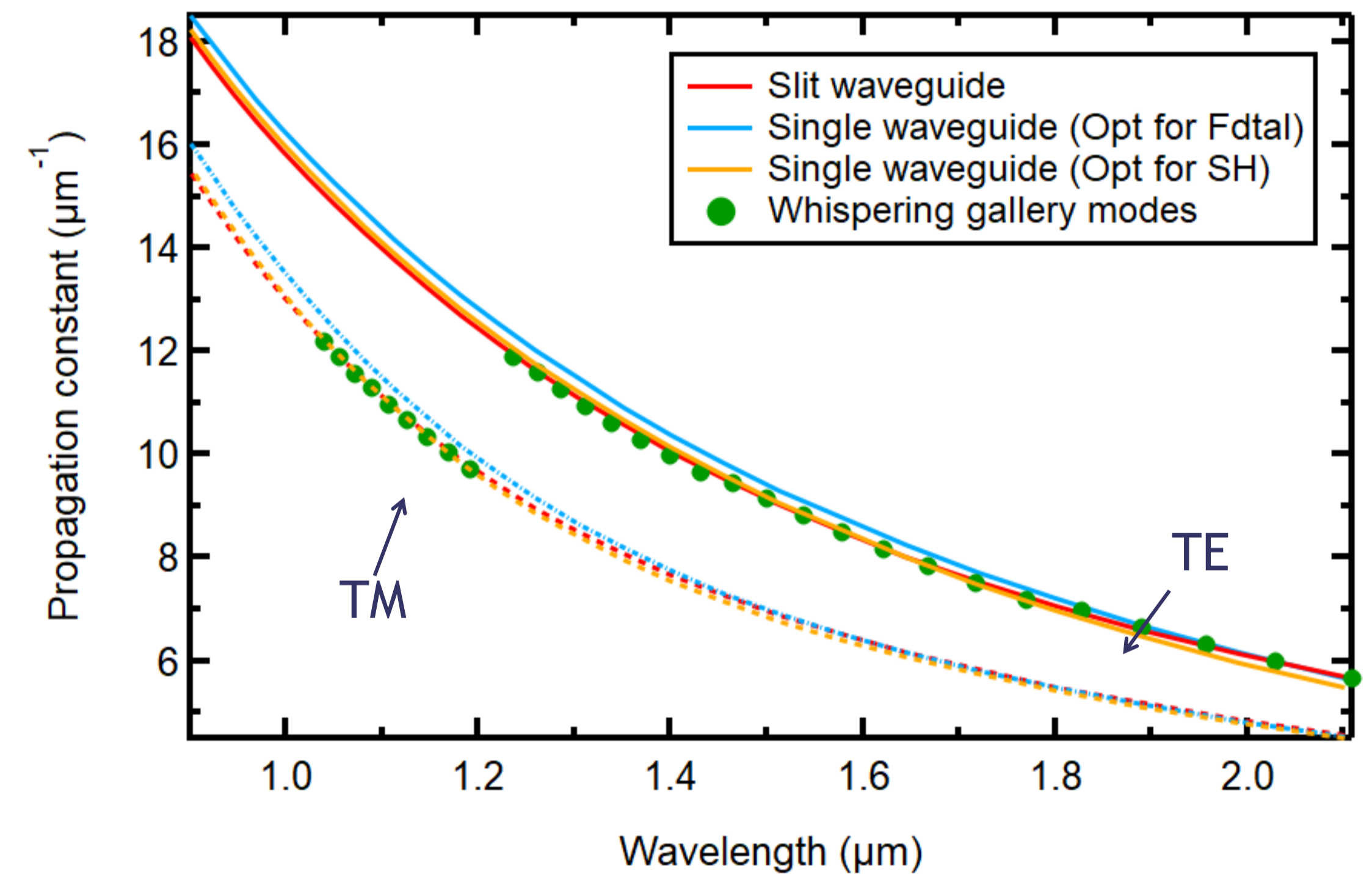


- Strict conditions:
  - $\Delta m = m_{SH} - 2m_{fdtal} = \pm 2$
  - $\omega = TE // 2\omega = TM$
  - Planar and radial numbers = 1



## Study of dispersion

We calculate the dispersion curve for the three configurations

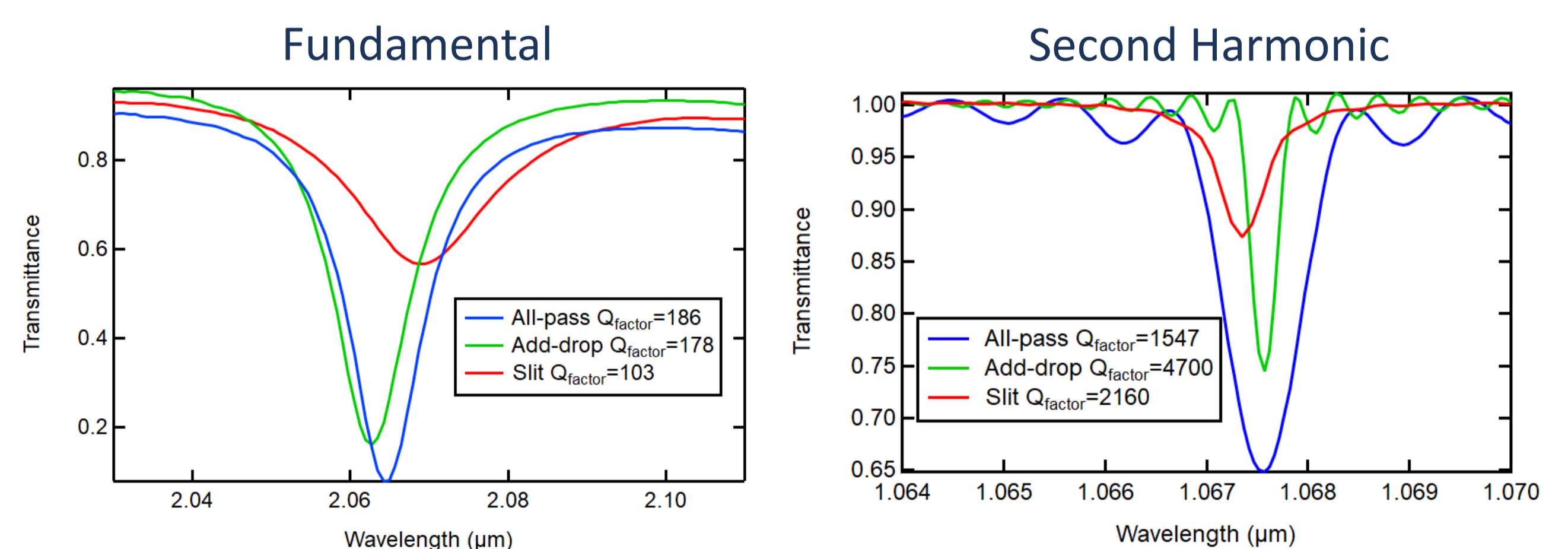


- Modal dispersion  $\rightarrow$  Impossible to couple both at once
- Slit size to control  $\beta$  separately
- Group index matching between guide and disk

## Study of coupling

We compare the coupling for both wavelengths

- Different coupling regimes  $\rightarrow$  Undercoupling/overcoupling cases
- Waveguide vicinity  $\rightarrow$  high insertion losses
- Overcoupling regime well suited for pulsed excitation



## Conclusion

- Comprehensive study of the different coupling configurations available
- Promising dual wavelength optical coupling scheme to microdisk resonators based on slit waveguide
- These configurations remain compatible with conventional semiconductor device processing

This work is funded by the French national research agency through the project ORPHEUS ANR-17-CE24-0019-01

(1) D. P. Lake et al. (2016) Efficient telecom to visible wavelength conversion in doubly resonant gallium phosphide microdisks. Appl. Phys. Lett. 108 031109

(2) P. Guillemé et al. (2016) Antiphase domain tailoring for combination of modal and  $\bar{4}$ -quasi-phase matching in gallium phosphide microdisk. Opt. Express 24, 14608-14617

(3) P. Guillemé et al. (2017). Second harmonic generation in gallium phosphide microdisks on silicon: from strict to random quasi-phase matching. Semiconductor Science and Technology, 32(6), 065004