



HAL
open science

Cavity Resonator Integrated Guided mode resonance Filter : Spectral & Modal Reflector

Romain Laberdesque, Olivier Gauthier-Lafaye, Henri Camon, Antoine Monmayrant, Marlène Petit, Olivier Demichel, B. Cluzel

► **To cite this version:**

Romain Laberdesque, Olivier Gauthier-Lafaye, Henri Camon, Antoine Monmayrant, Marlène Petit, et al.. Cavity Resonator Integrated Guided mode resonance Filter : Spectral & Modal Reflector. The 5th International Topical Meeting on Nanophotonics and Metamaterials (NANOMETA 2015), Jan 2015, Seefeld, Austria. 48, pp.1619 - 1621, 2015. hal-01931258

HAL Id: hal-01931258

<https://laas.hal.science/hal-01931258>

Submitted on 22 Nov 2018

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.

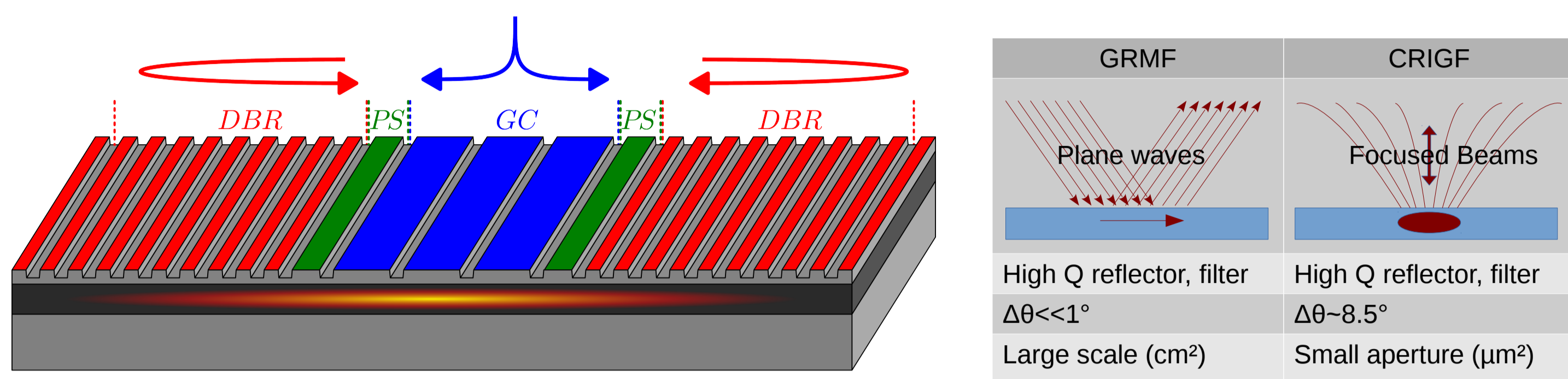
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Cavity Resonator Integrated Guided mode resonance Filter : Spectral & Modal Reflector

Romain Laberdesque, Olivier Gauthier-Lafaye, Henri Camon, Antoine Monmayrant, PHOTO, CNRS, LAAS, 7 avenue du Colonel Roche, F-31400 Toulouse, France, Marlène Petit, Olivier Demichel, Benoît Cluzel, Optique de Champ Proche, Laboratoire Interdisciplinaire Carnot de Bourgogne, Université de Bourgogne, 9 avenue Alain Savary, F-21078 Dijon, France

CRIGF : What is it ?

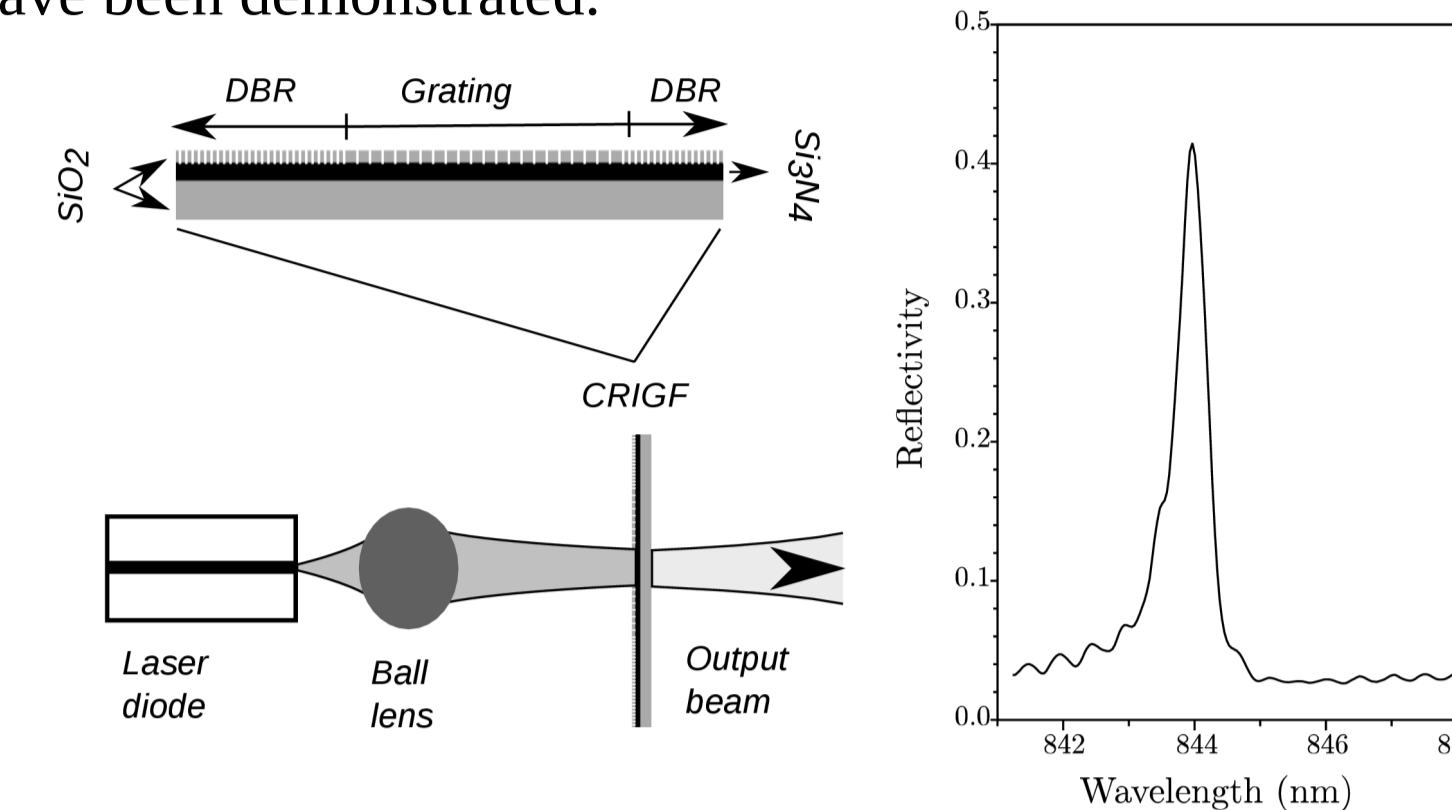
CRIGF is a new generation of narrowband filter. It consists of subwavelength gratings nearby or upon a waveguide. At the center, a small **GMRF (Guided Mode Resonance Filter)** or **GC (Grating Coupler)** coupled radiated & guided mode, then, **DBR (Distributed Bragg Reflector)** at each side localise mode inside a horizontal Fabry-Pérot cavity. Two **PS (Phase sections)** are used to fine tune the Fabry-Pérot modes with the grating coupler.



Kenji Kintaka, Tatsuya Majima, Junichi Inoue, Koji Hatanaka, Junji Nishii, and Shogo Ura, "Cavity-Resonator-Integrated Guided-mode Resonance Filter for aperture miniaturization," Opt. Express 20, 1444-1449 (2012)

CRIGF : What is it for?

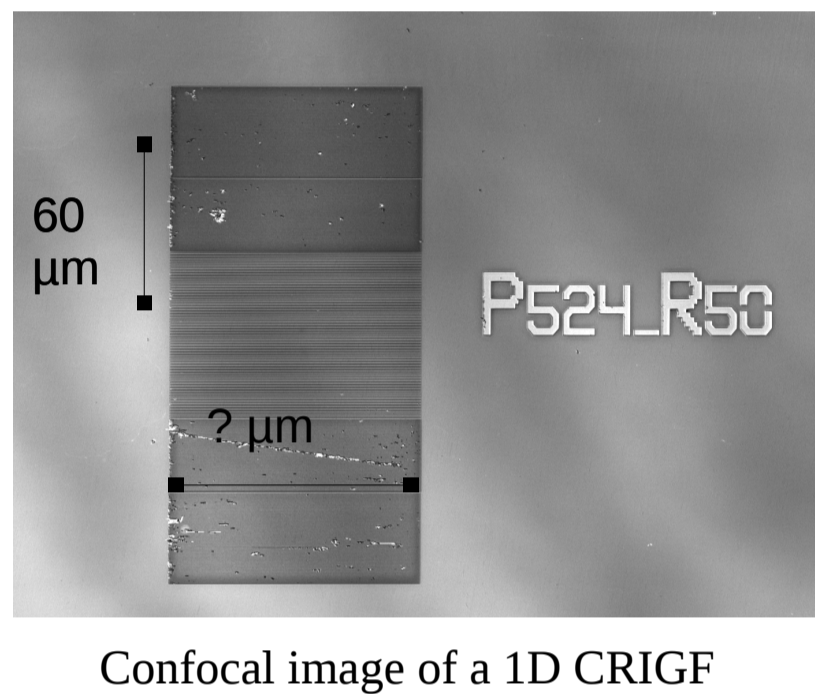
Extended Cavity Diode Lasers (where a laser diode is inserted in an optical cavity with a spectrally selective element) can benefit from CRIGFs high angular acceptance. Wavelength stabilization in small and robust cat's eye cavity have been demonstrated.



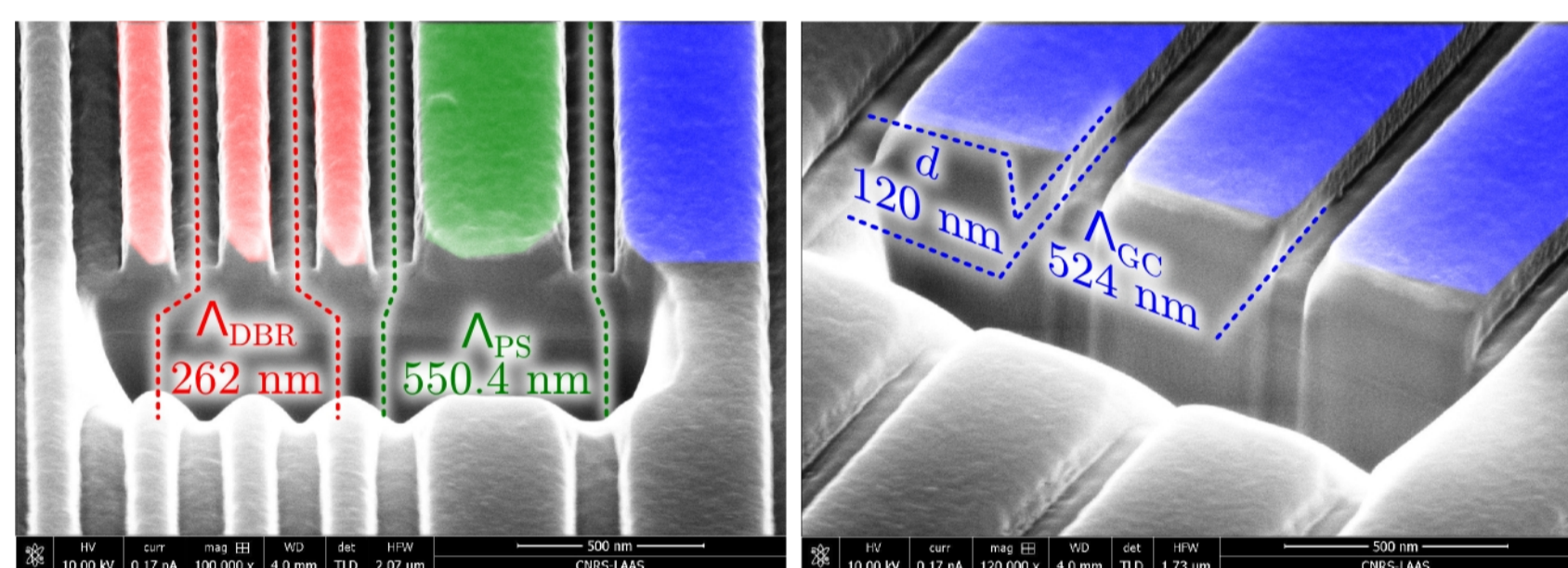
Buet, X.; Guelmami, A.; Monmayrant, A.; Calvez, S.; Tourte, C.; Lozes-Dupuy, F.; Gauthier-Lafaye, O., "Wavelength-stabilised external-cavity laser diode using cavity resonator integrated guided mode filter", Electronics Letters, vol.48, no.25, 1619-1621, 2012

Fabrication

A stack is defined by PECVD deposit :
SiO₂ (111nm, n=1.46)-
Si₃N₄ (165nm, n=1.97)-
SiO₂ (substrat, n=1.50).
Then, several CRIGFs are obtained using e-beam, then ICP etching,

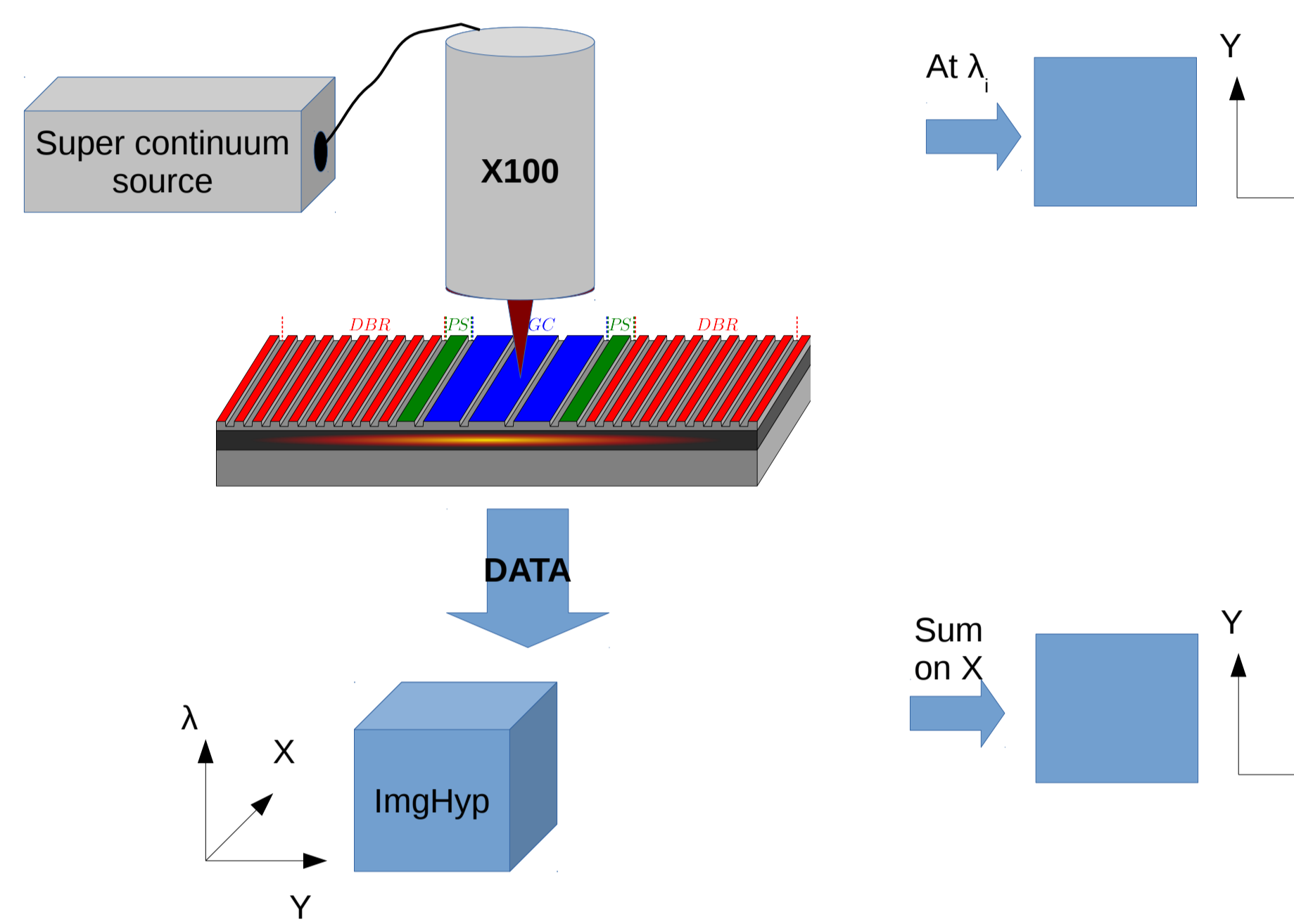


Confocal image of a 1D CRIGF



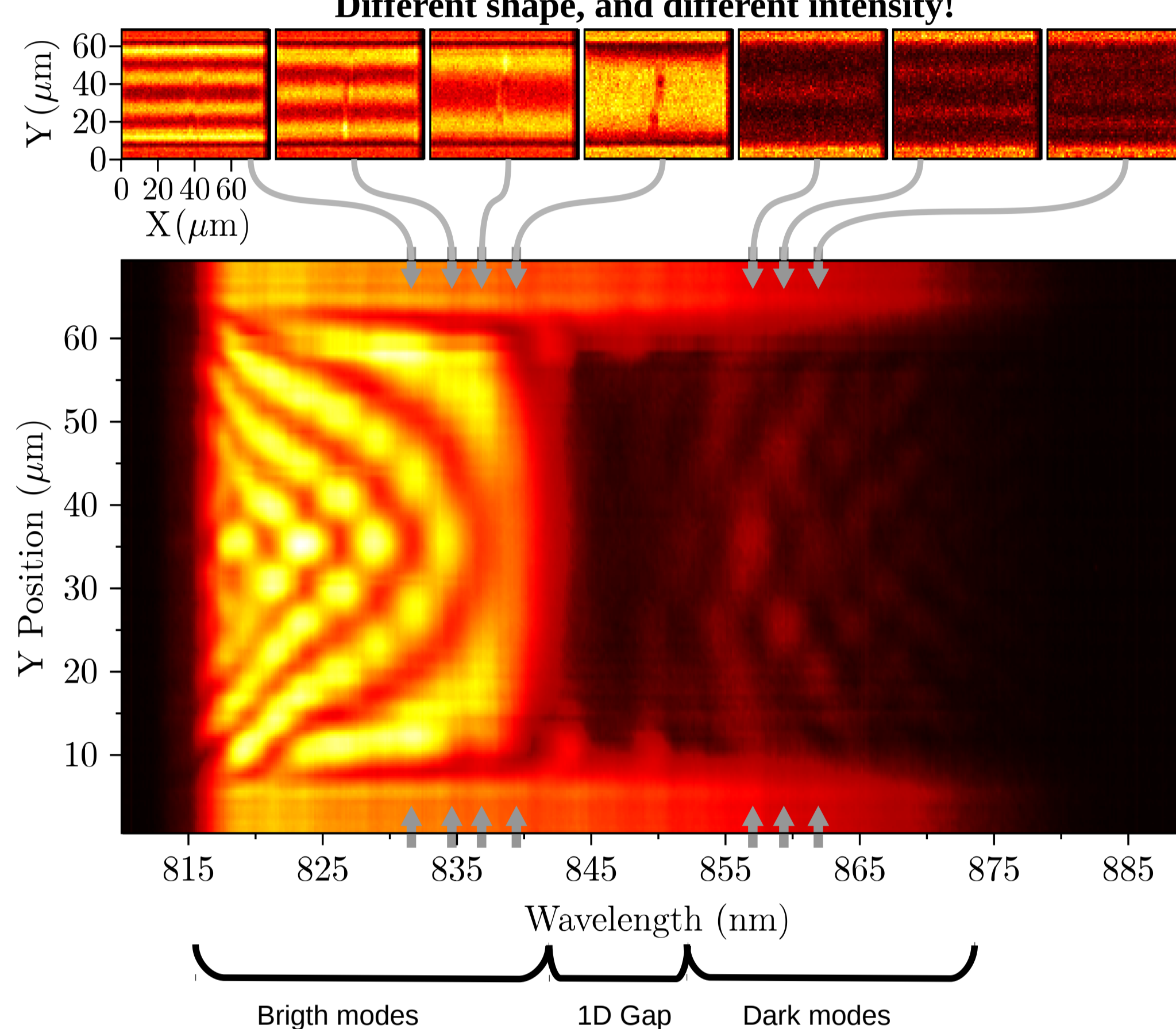
FIB cut and observations have been realised to inspect the length, the height and the profil of the gratings

Experimental Observations



The pattern of the shape modes, the symmetry between bright & dark modes suggest standing wave confinement, like quantum system but with a 60 μm x ? μm element !

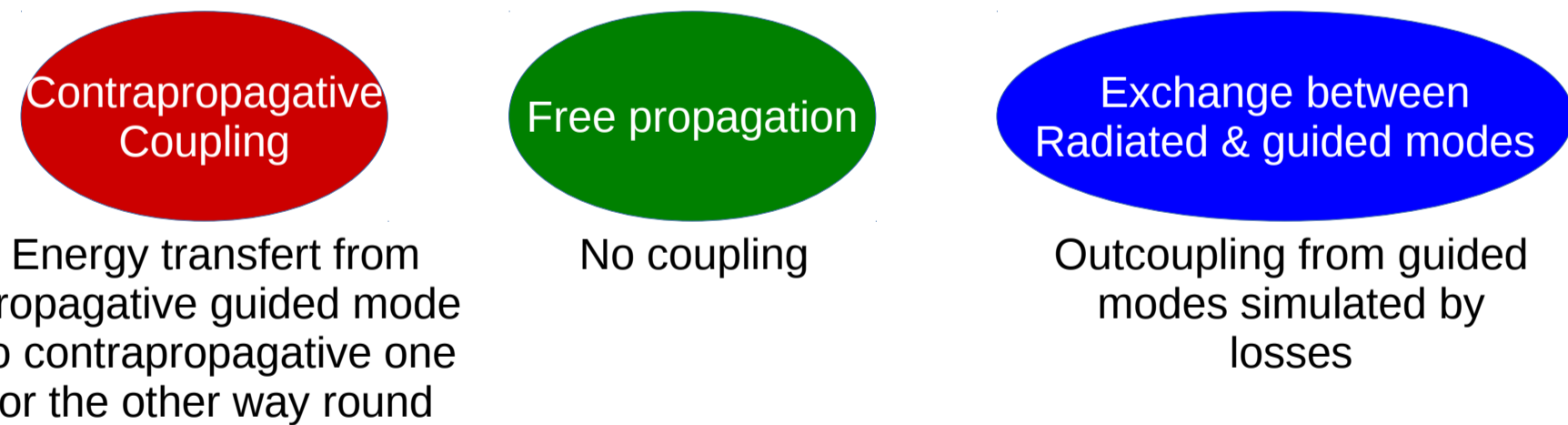
High order reflected modes observed ! Different shape, and different intensity!



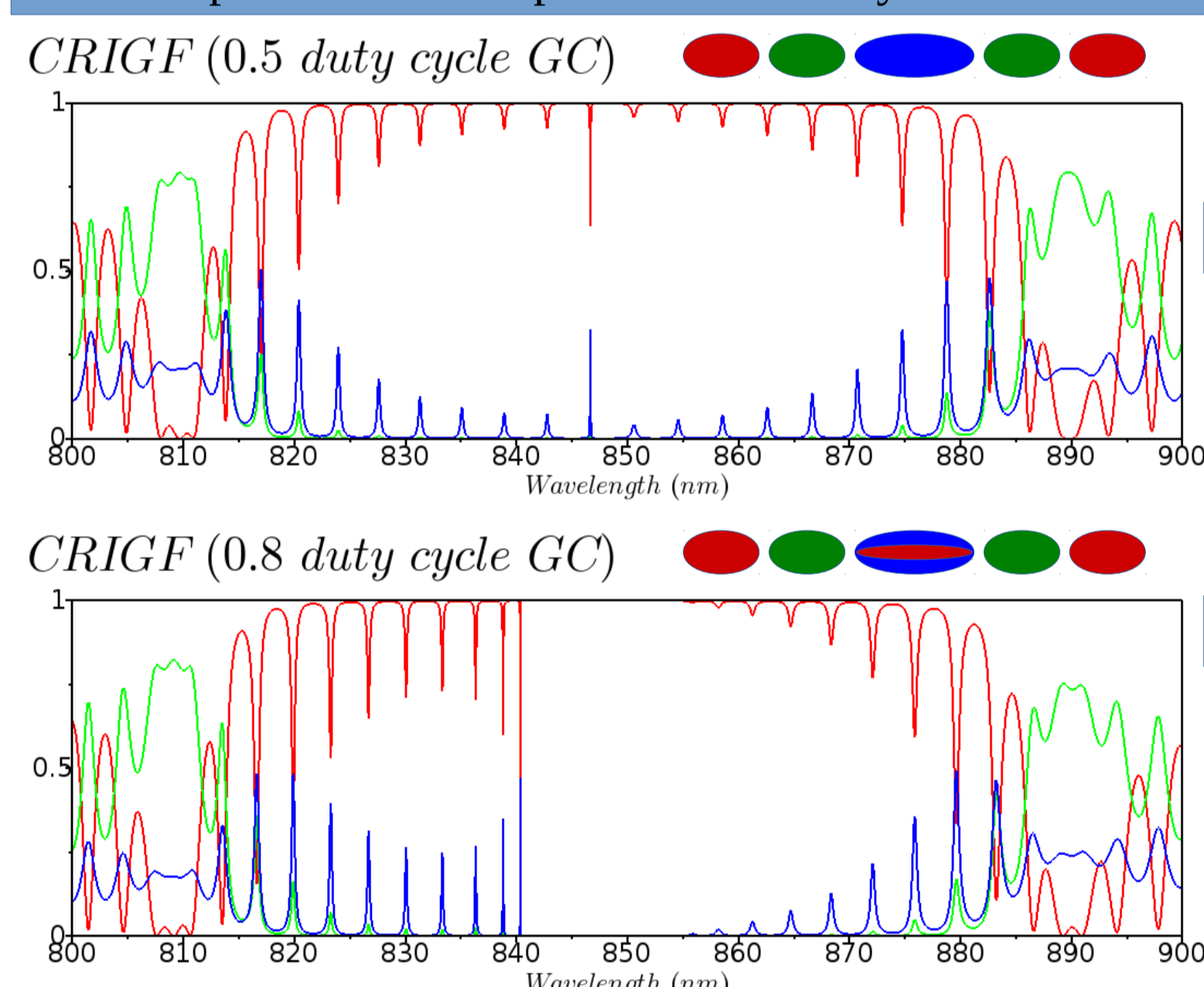
CRIGF Modelling

Several long periodic elements of finite length:
No RCWA
No FDTD
Coupling, resonator, modes :
Theory of coupled modes

Based on "Design of resonance grating coupler," Opt. Express 16, 12207-12213 (2008) : Each block is a 1D effective medium where specific coupling occurs. All the coupling impact the guided mode. So we focus only on them, with the coupler point of view.

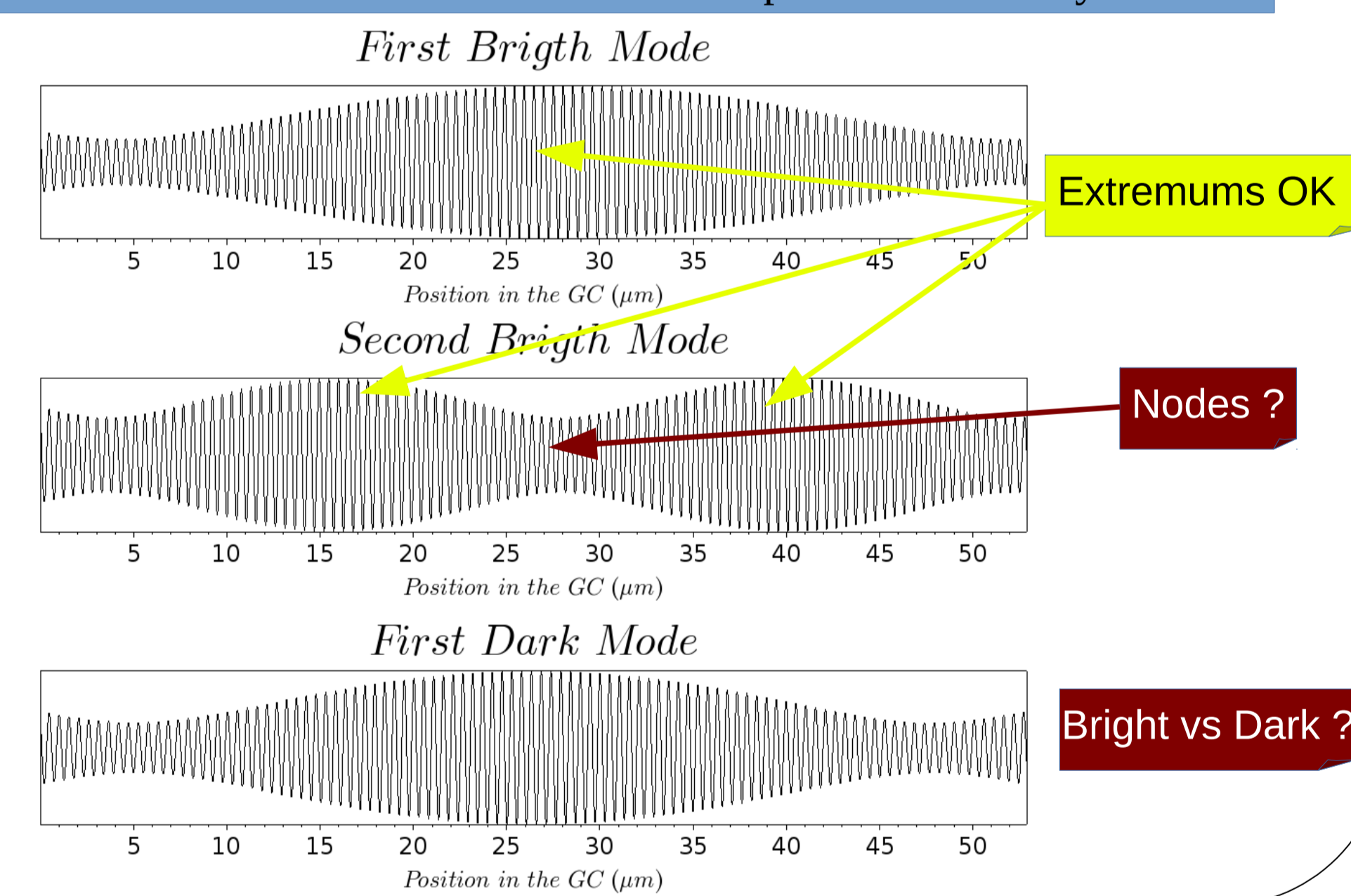


Spectra from Coupled Mode Theory Model



outcoupling
1D Gap OK ! a duty cycle different from 0.5 for the GC leads to contrapropagative coupling
Multimodes OK ! The long length GC set a long cavity. Therefore these modes are firstly FP modes

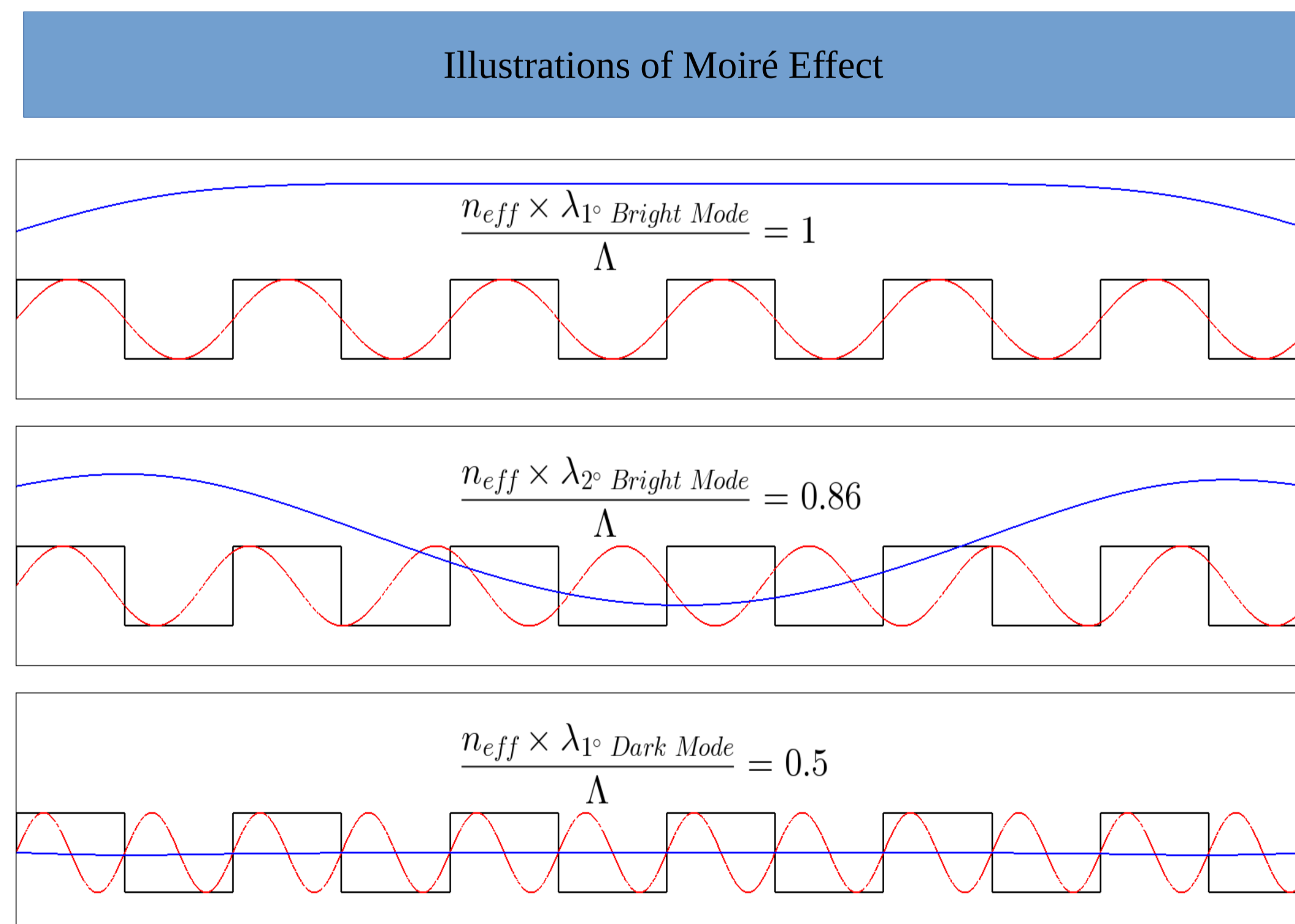
Guided Mode Field Profile in GC from Coupled Mode Theory Model



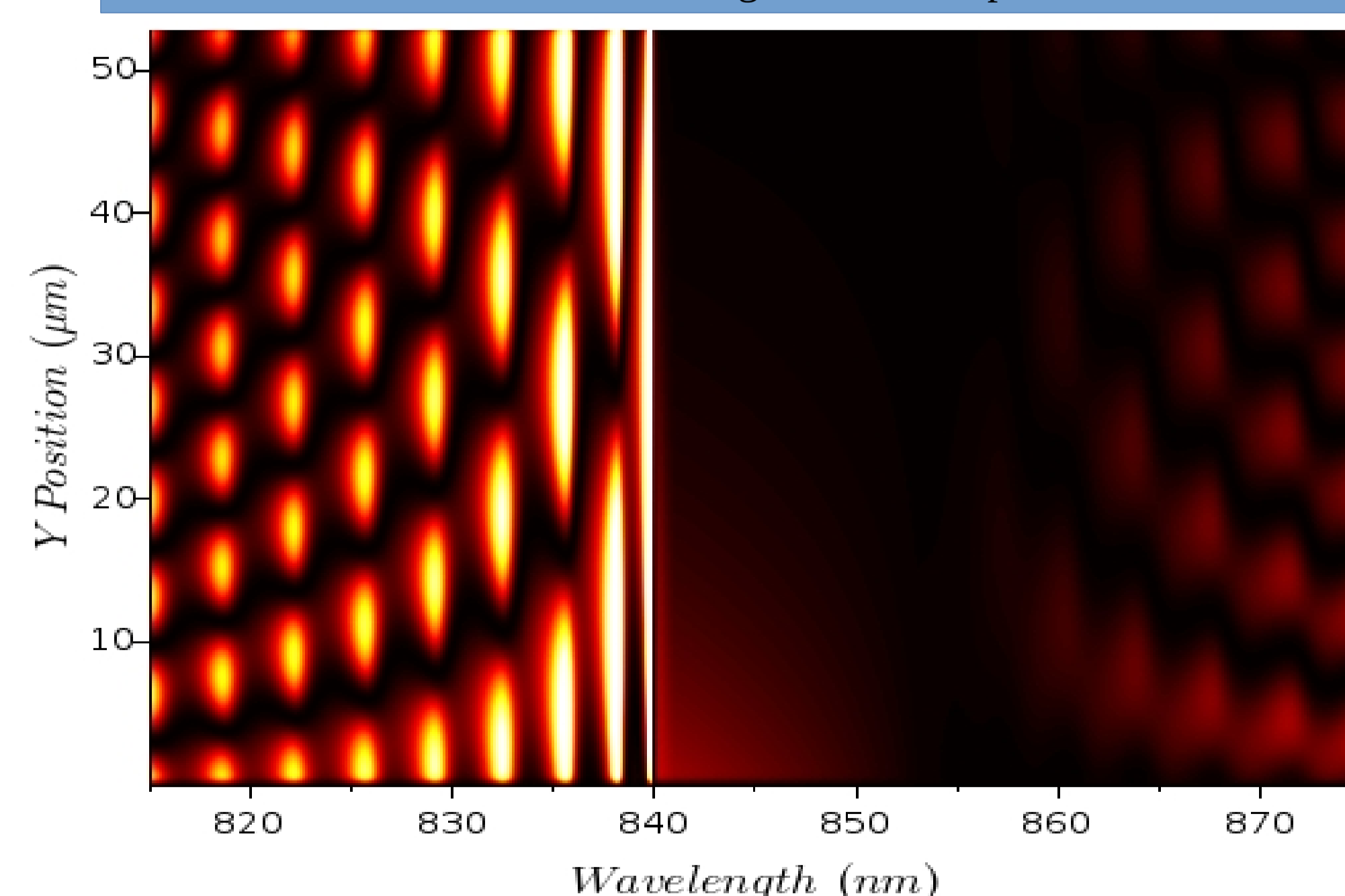
Usually, GMRF + guided mode => infinity grating + propagative wave
No Phasing

Black curves = GC profil
Red curves = standing wave for the FP mode
Blue curves = Moiré

CRIGF Short GMRF (GC) + Modes FP
=> Phasing between GC profile & standing wave
=> Moiré Effect

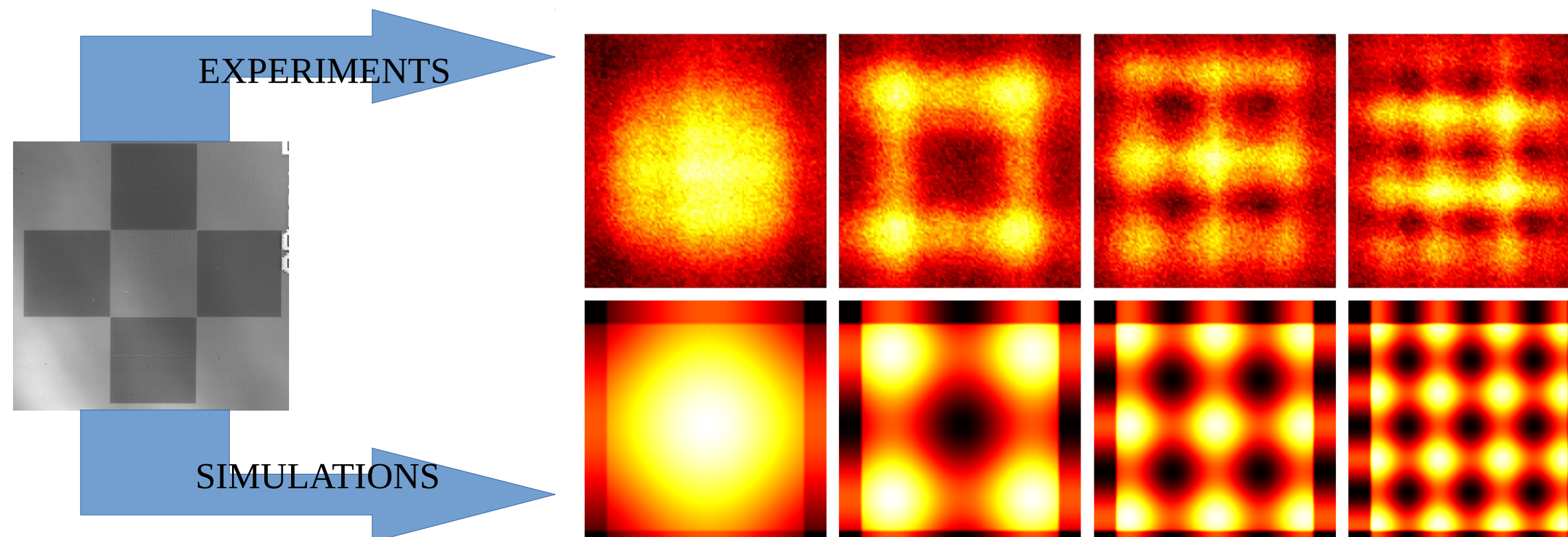


CRIGF + Moiré Modelling : simulation of the image from the experiment



What about 2D CRIGF?

=> both the cavity have the same resonance modes, they don't interact since they are orthogonal.



-> Experimental demonstration of intricate spectral and modal filtering.
-> Modelling combining coupled modes and Moiré analysis to explain all observed features.
-> Simple and Fast model adapted to design of multimodal spectral and modal couplers/reflectors

CRIGFs are both spectral and modal reflectors where both complex modal and spectral properties can be tuned at will