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

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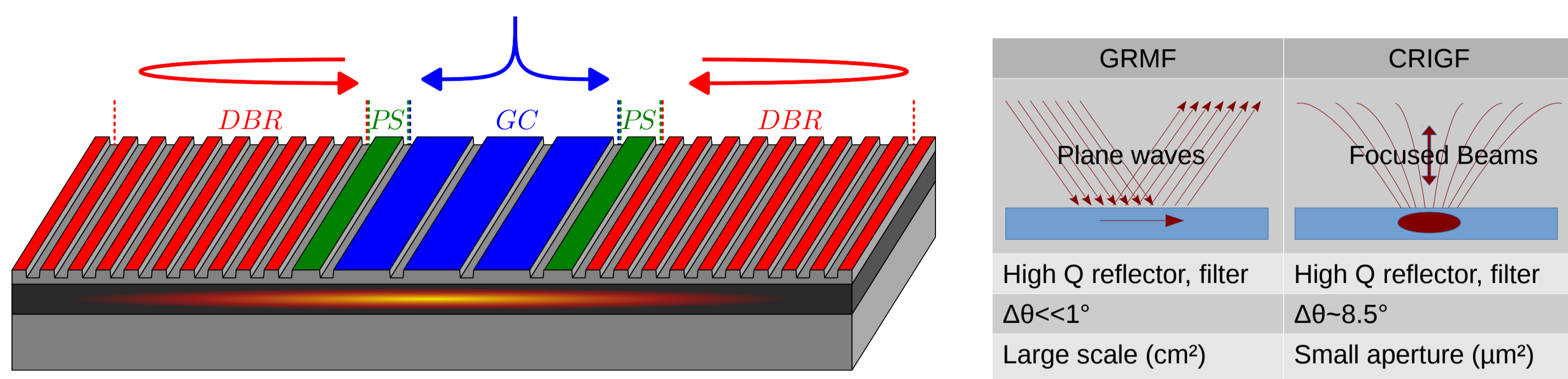
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# Cavity Resonator Integrated Guided mode resonance Filter : Spectral & Modal Reflector

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## CRIGF : What is it ?

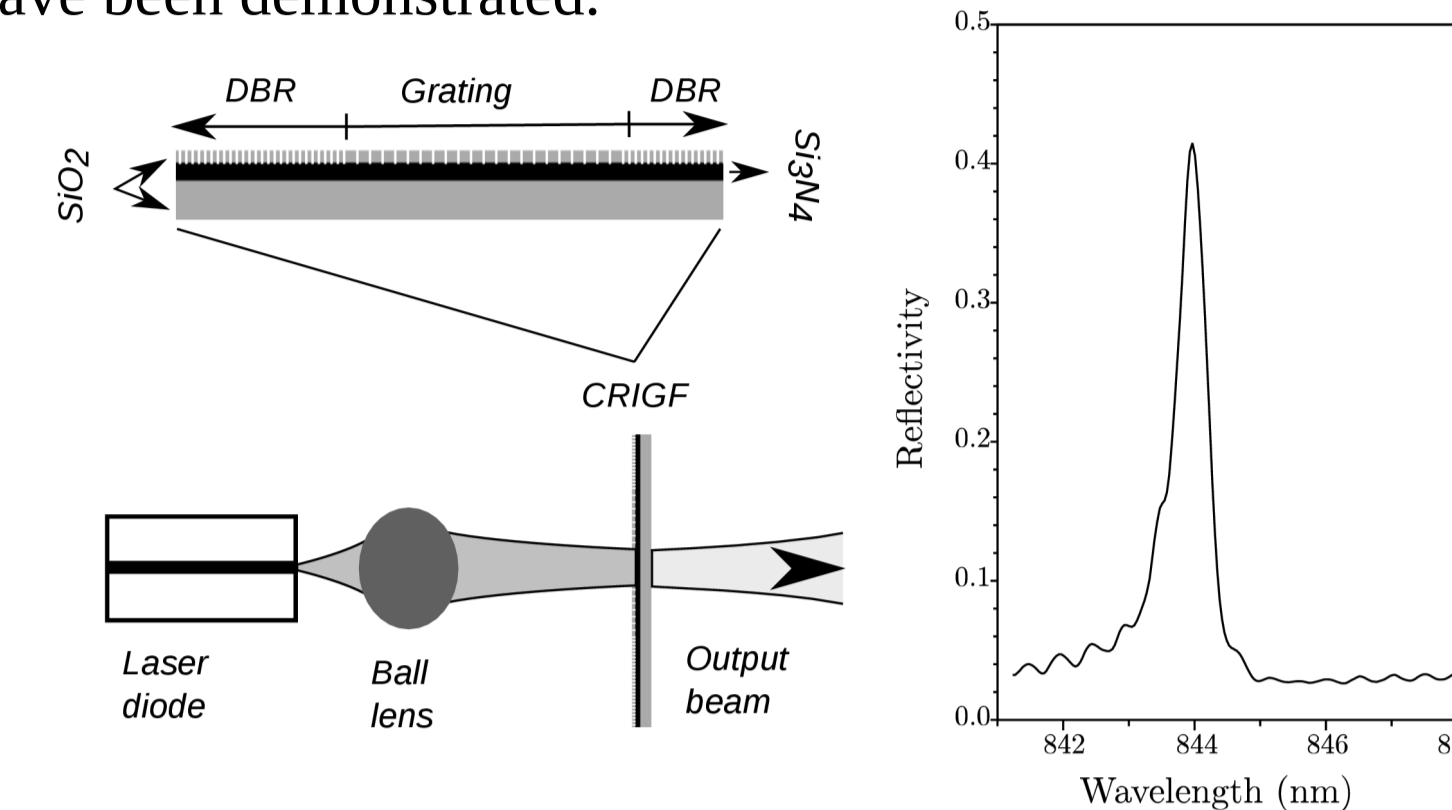
CRIGF is a new generation of narrowband filter. It consists of subwavelength gratings nearby or upon a waveguide. At the center, a small **GMRF (Guided Mode Resonance Filter)** or **GC (Grating Coupler)** coupled radiated & guided mode, then, **DBR (Distributed Bragg Reflector)** at each side localise 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?

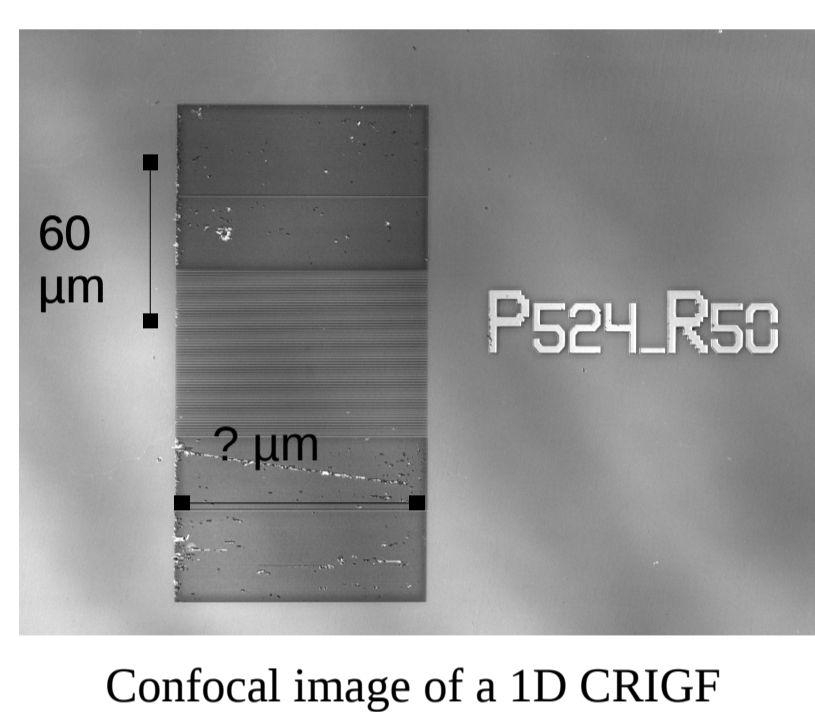
Extended Cavity Diode Lasers (where a laser diode is inserted in an optical cavity with a spectrally selective element) can benefit from CRIGFs high angular acceptance. Wavelength stabilization in small and robust cat's eye cavity have been demonstrated.



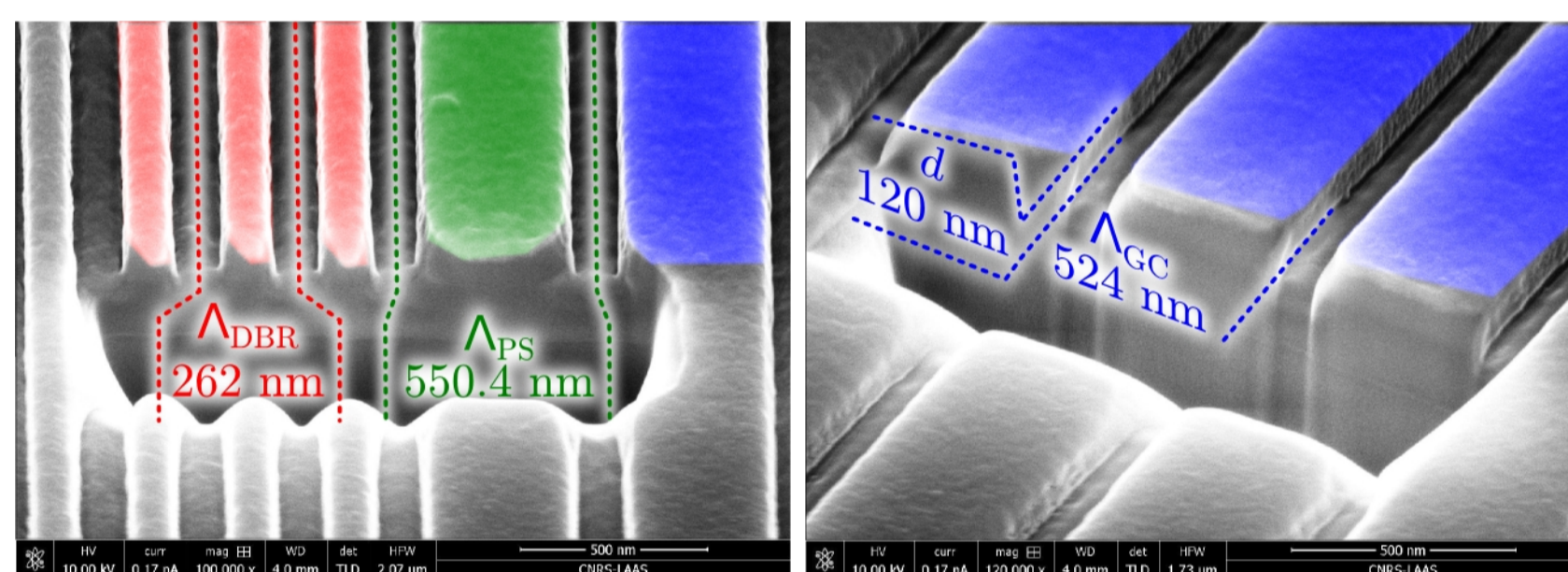
Buet, X.; Guelmami, A.; Monmayrant, A.; Calvez, S.; Tourte, C.; Lozes-Dupuy, F.; Gauthier-Lafaye, O., "Wavelength-stabilised external-cavity laser diode using cavity resonator integrated guided mode filter", Electronics Letters, vol.48, no.25, 1619-1621, 2012

## Fabrication

A stack is defined by PECVD deposit :  
SiO<sub>2</sub> (111nm, n=1.46)-  
Si<sub>3</sub>N<sub>4</sub> (165nm, n=1.97)-  
SiO<sub>2</sub> (substrat, n=1.50).  
Then, several CRIGFs are obtained using e-beam, then ICP etching,

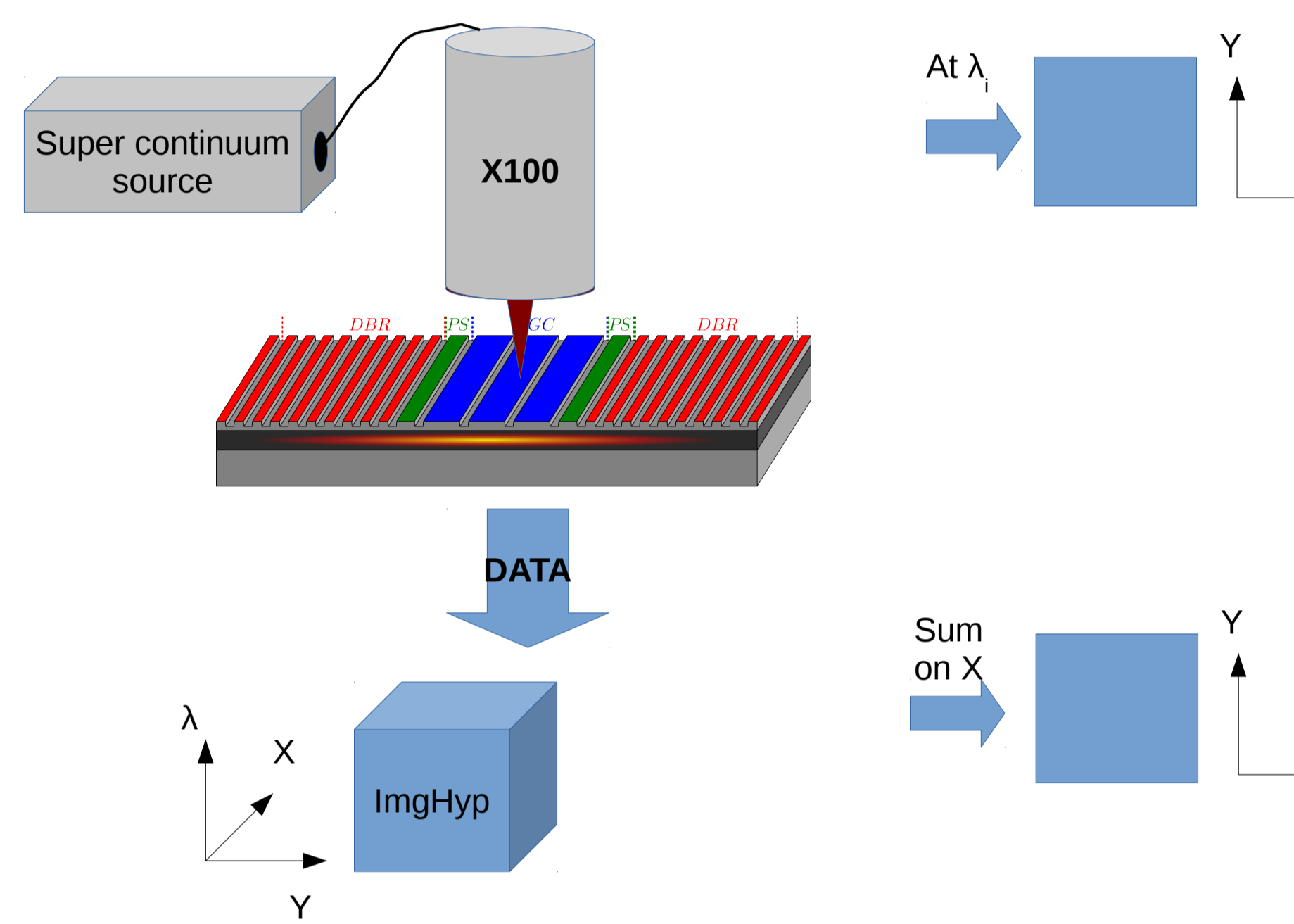


Confocal image of a 1D CRIGF



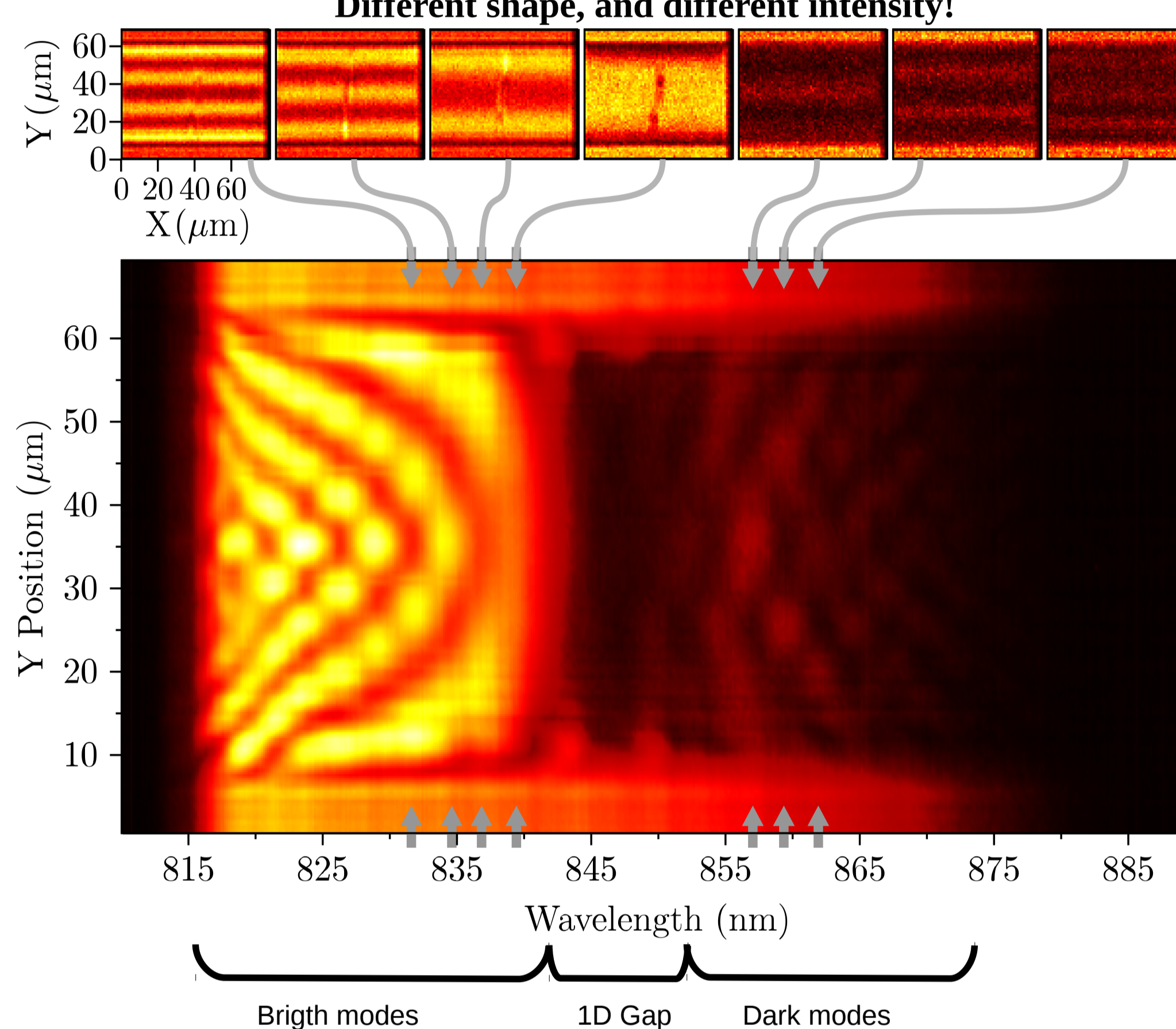
FIB cut and observations have been realised to inspect the length, the height and the profil of the gratings

## 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 !

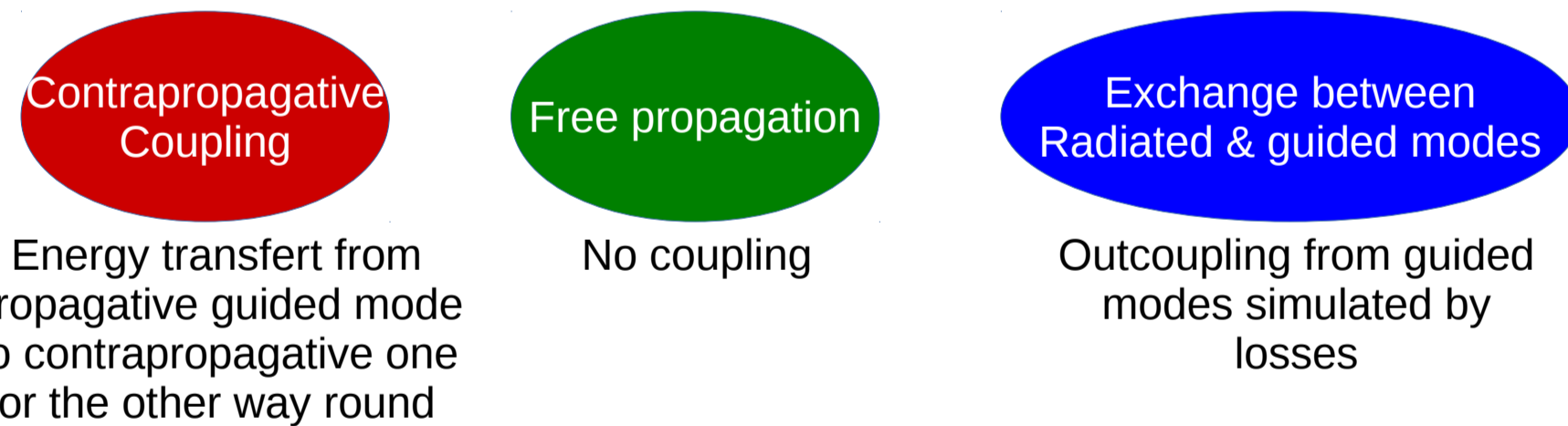
## High order reflected modes observed ! Different shape, and different intensity!



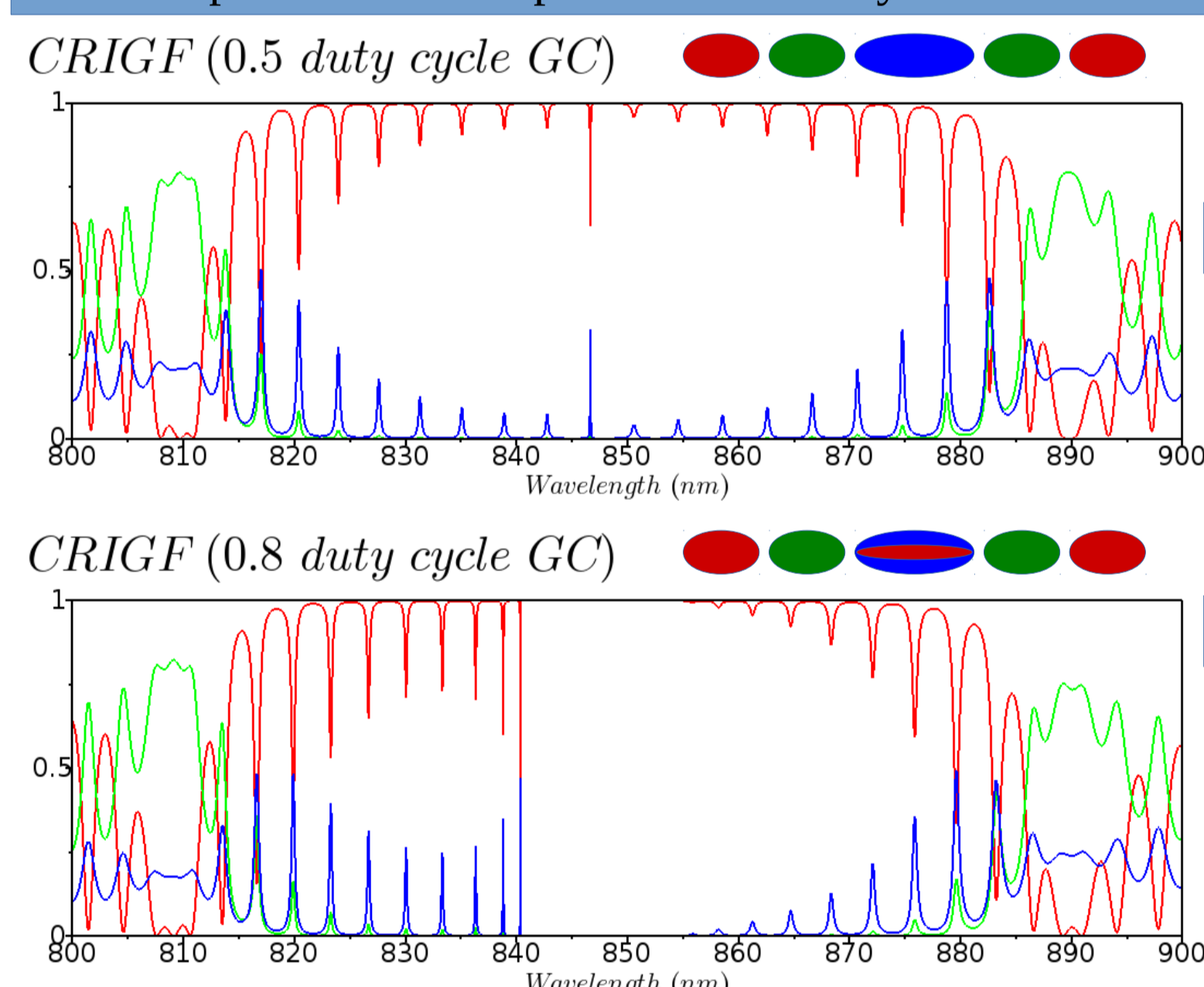
## CRIGF Modelling

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.

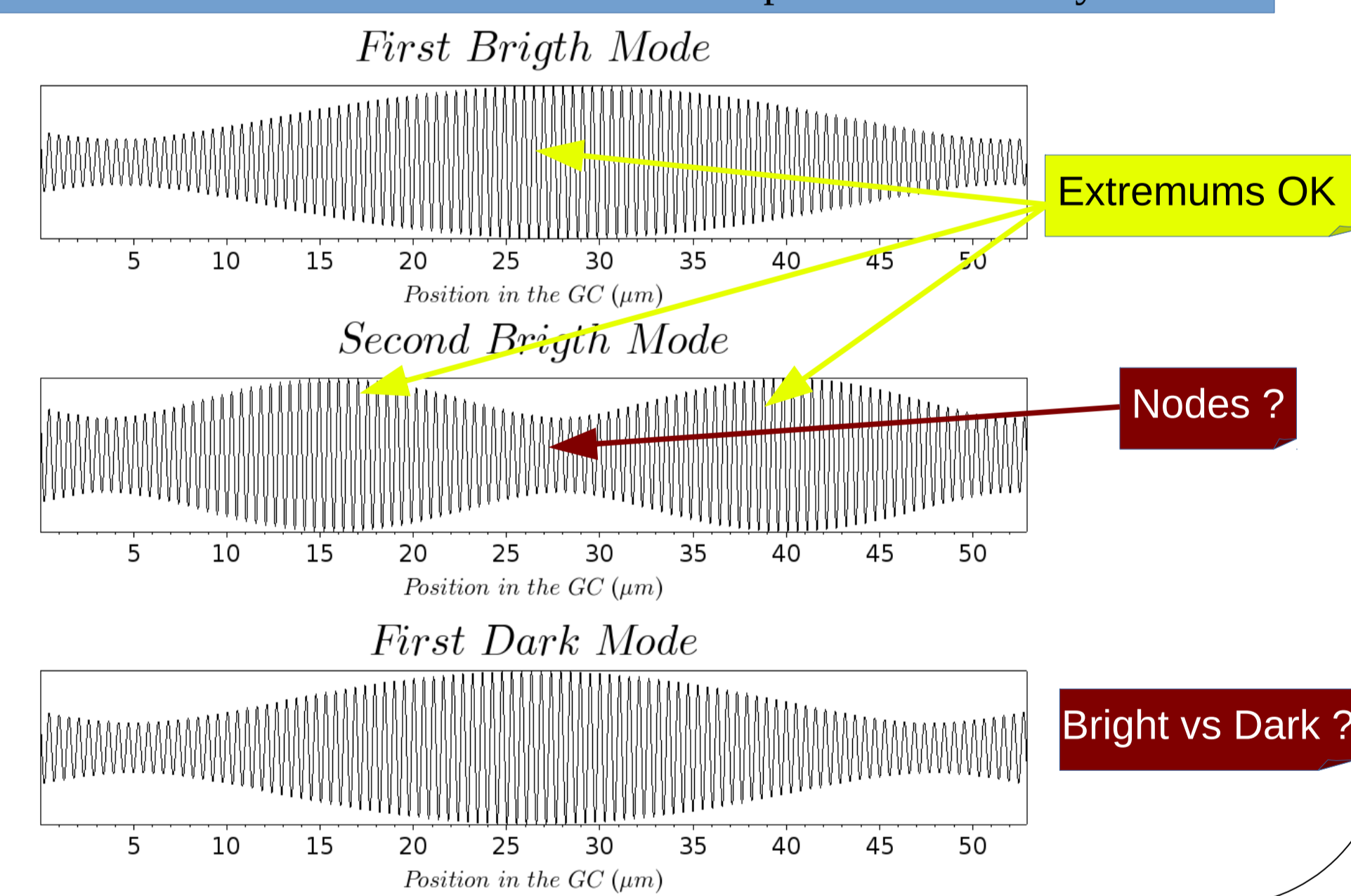


## Spectra from Coupled Mode Theory Model



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

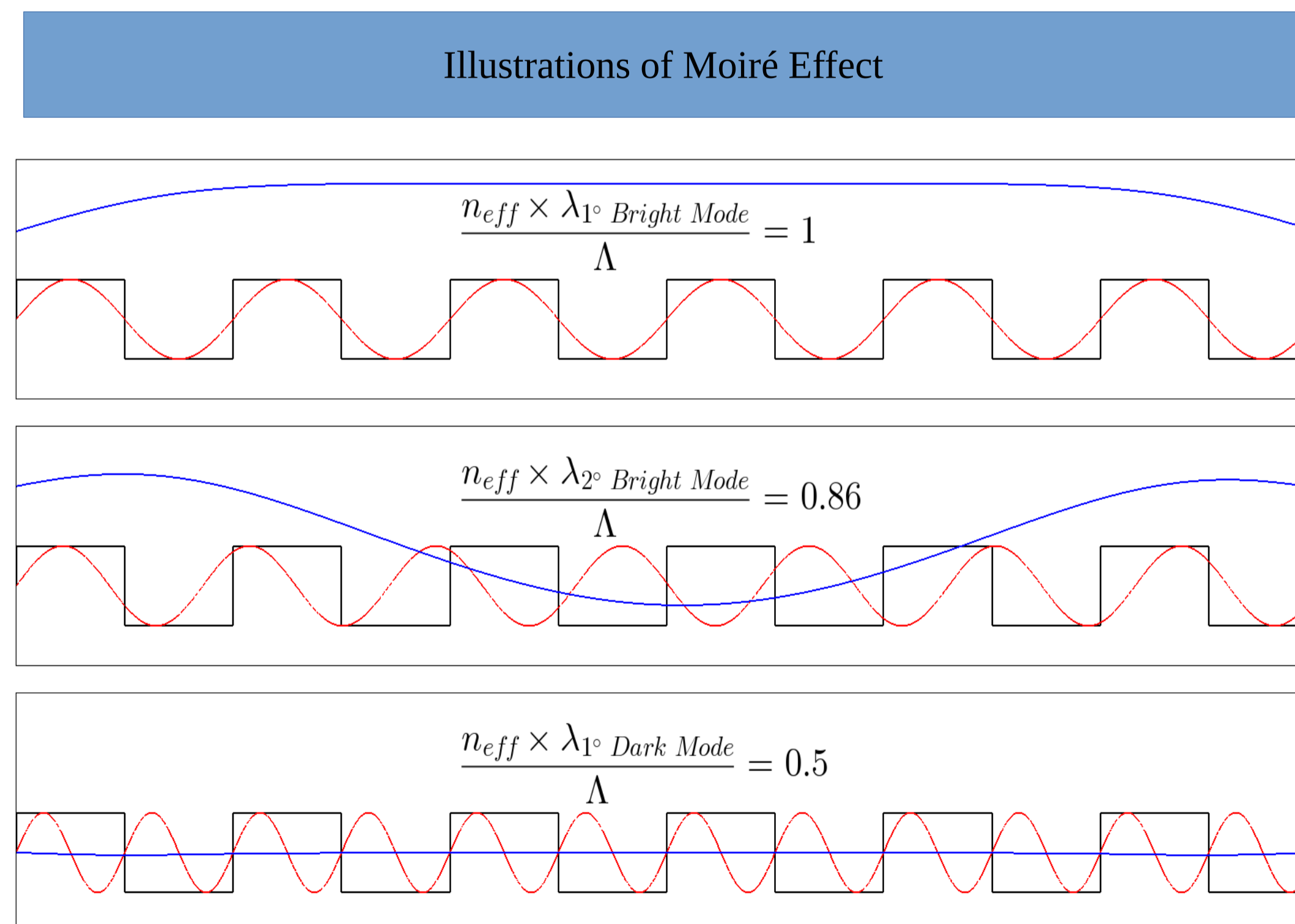
## Guided Mode Field Profile in GC from Coupled Mode Theory Model



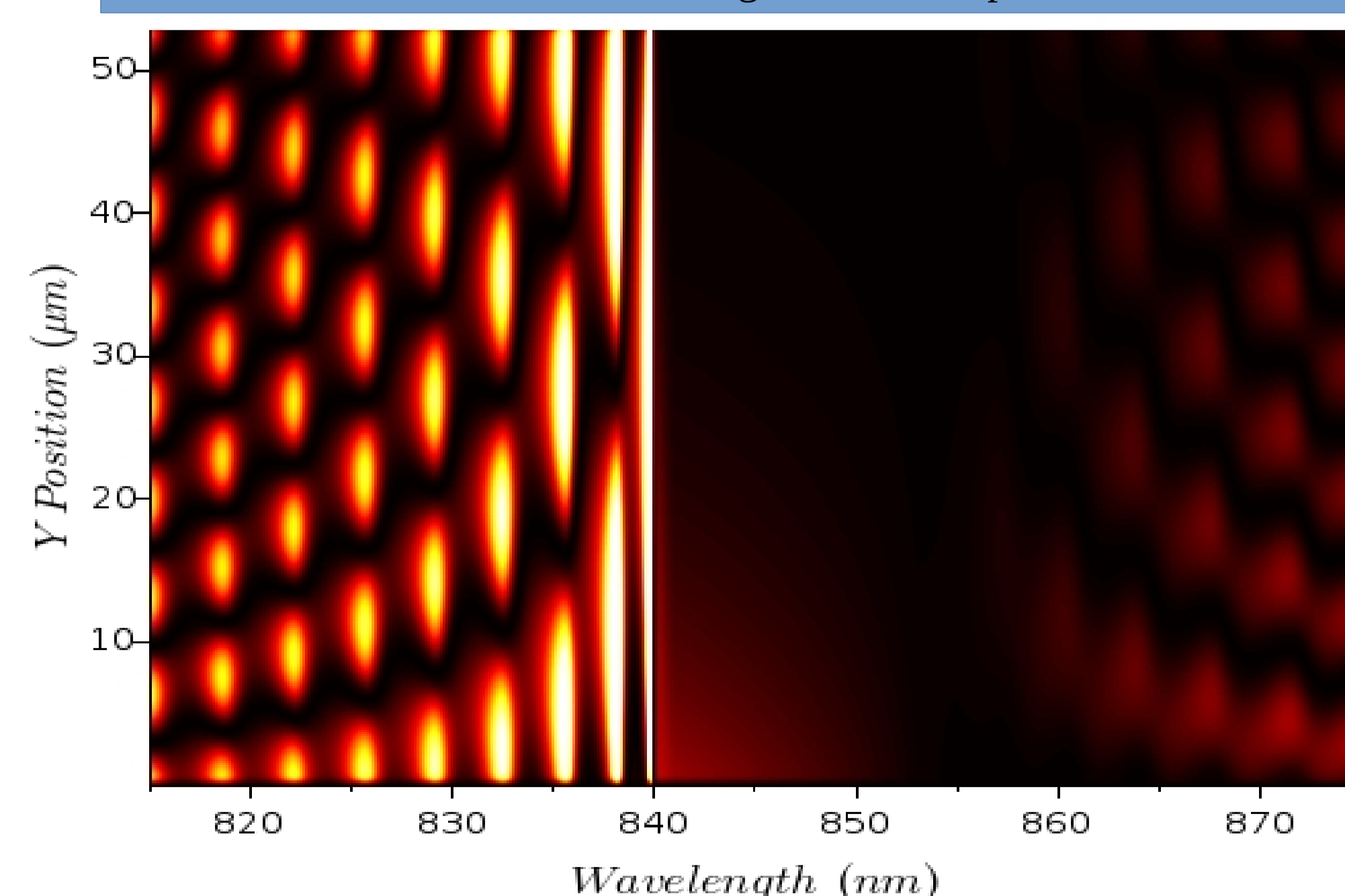
Usually, GMRF + guided mode => infinity grating + propagative wave  
No Phasing

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

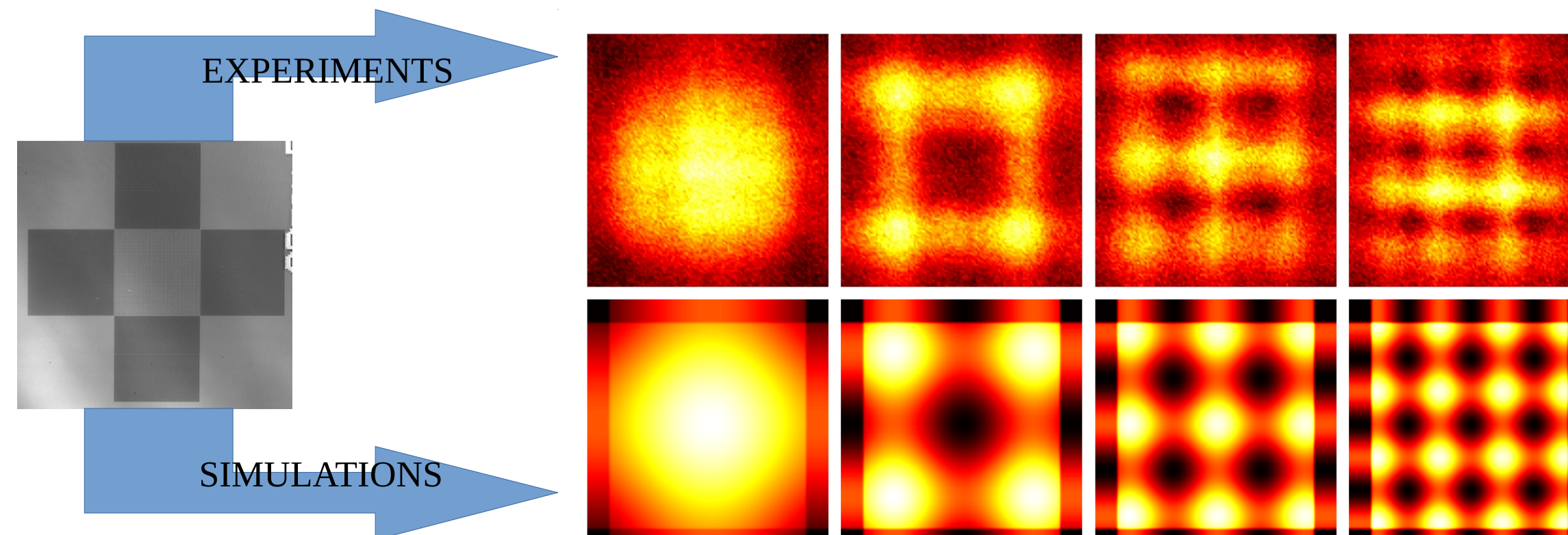


## CRIGF + Moiré Modelling : simulation of the image from the experiment



## 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**