

Nonlinear conversion in Cavity-Resonant Integrated Grating Filters

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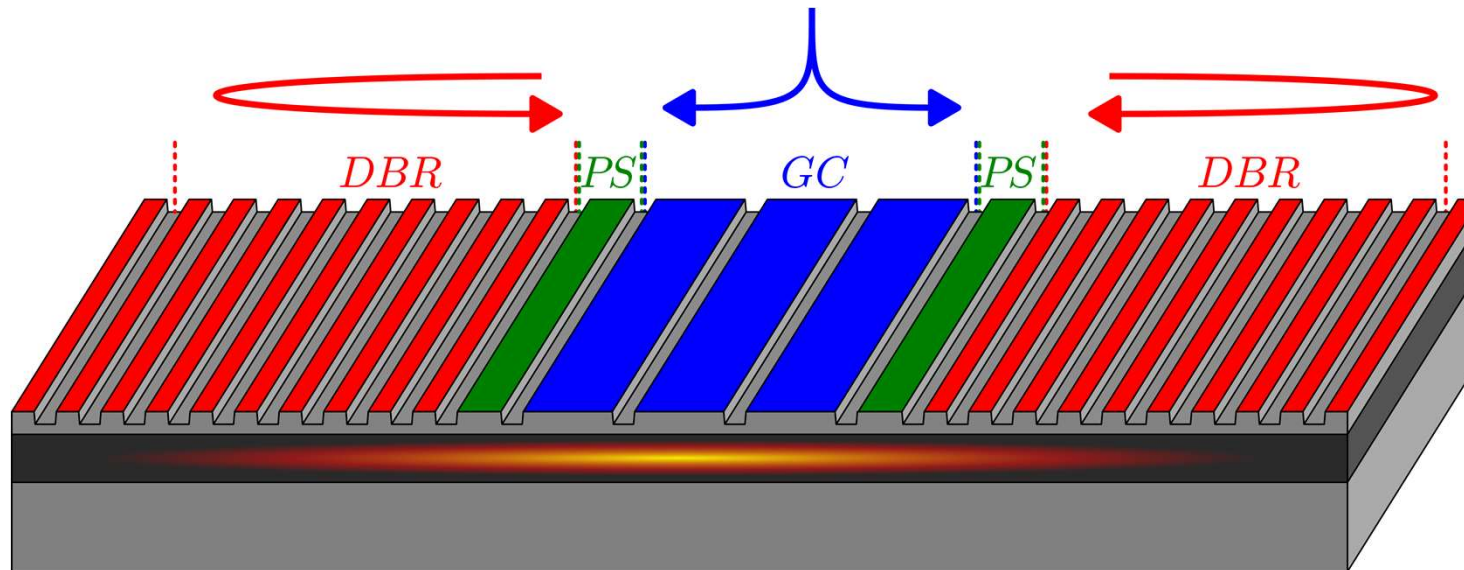
² Fresnel Institute, Marseille, France

ICTON 2023, Tu.B6.2

Outline

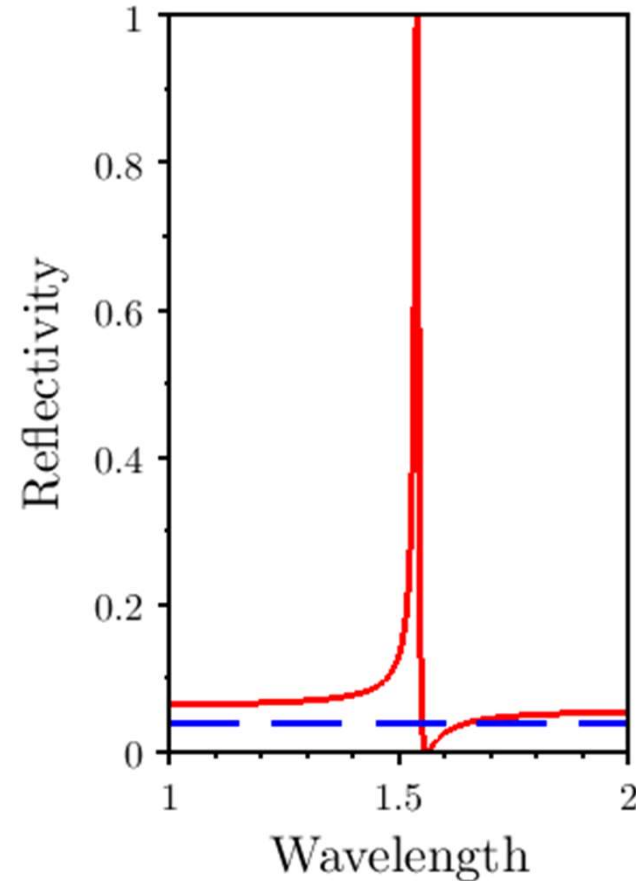
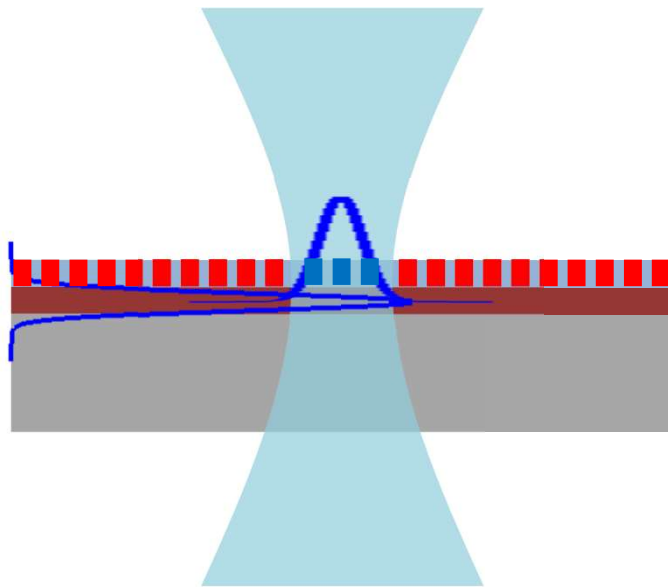
- > Introduction
- > First demonstration of NonLinear Conversion in CRIGFs
- > Theoretical considerations of NLC improvement
- > Experimental demonstrations
- > Conclusions

A CRIGF ?



Kintaka et al, Opt. Express **20**, 1444-1449, (2012)

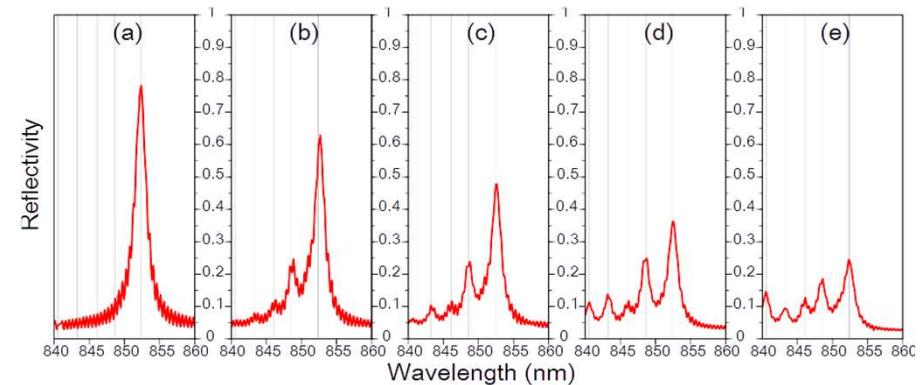
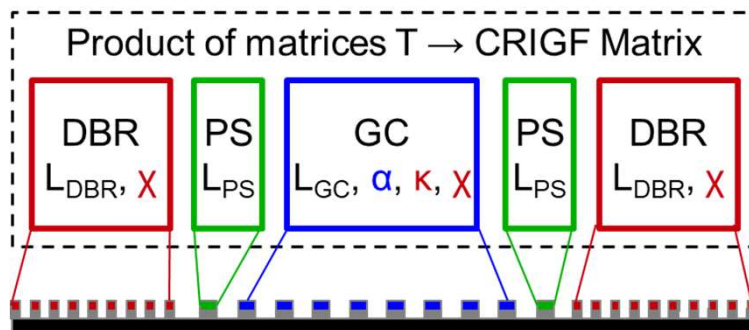
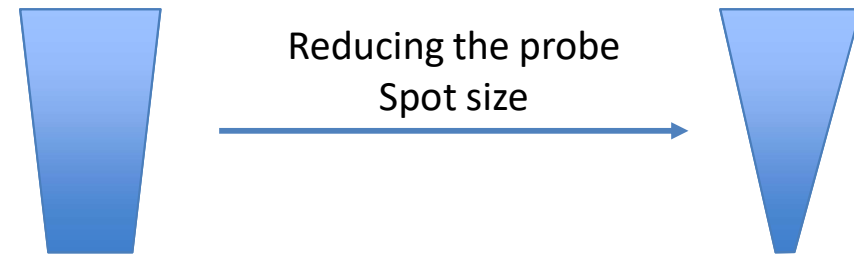
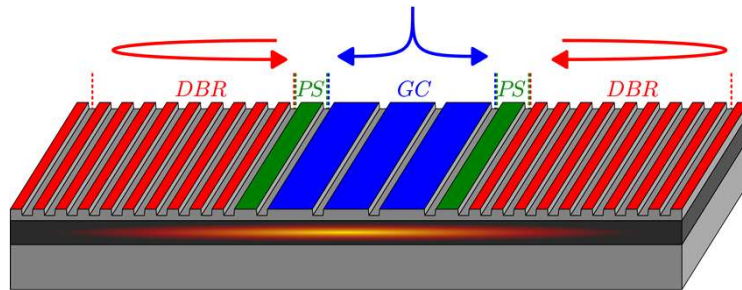
CRIGFs in a nutshell: FP with a grating coupler



Stack : AR coating with a waveguide

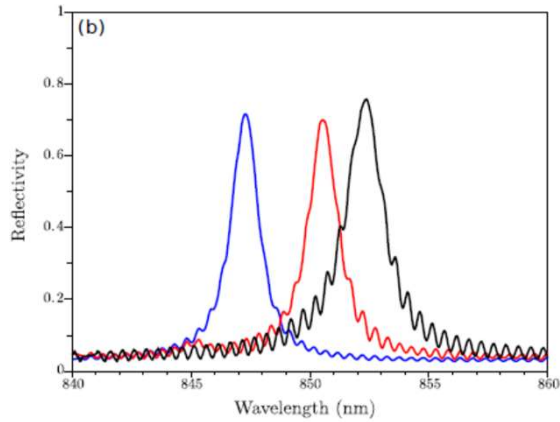
2 DBRs to provide a localized mode and a grating coupler

CRIGF : localized modes coupled via a grating

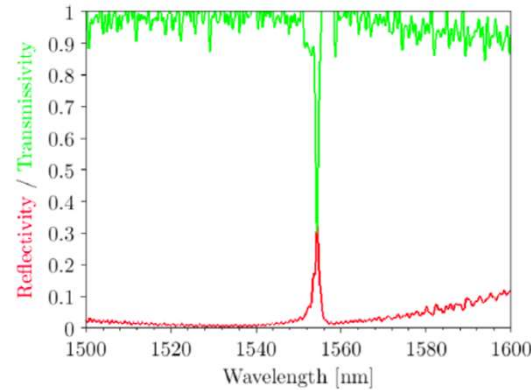


R. Laberdesque *et al.*, *Journal of the Optical Society of America A*, vol. 32, n° 11, p. 1973, nov. 2015.

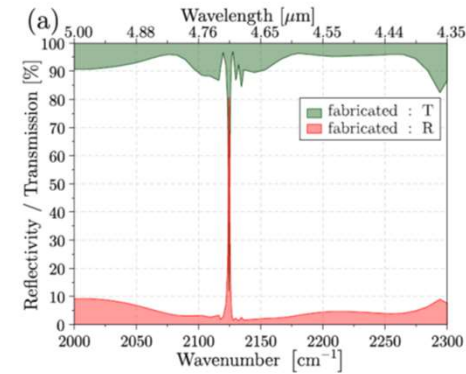
CRIGF : an overview of linear results



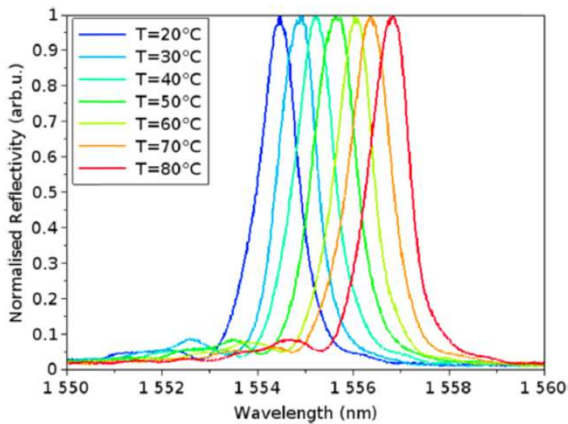
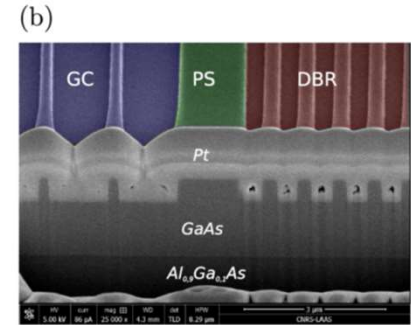
NIR ($\text{Si}_3\text{N}_4/\text{SiO}_2$)
10.1364/OE.20.009322



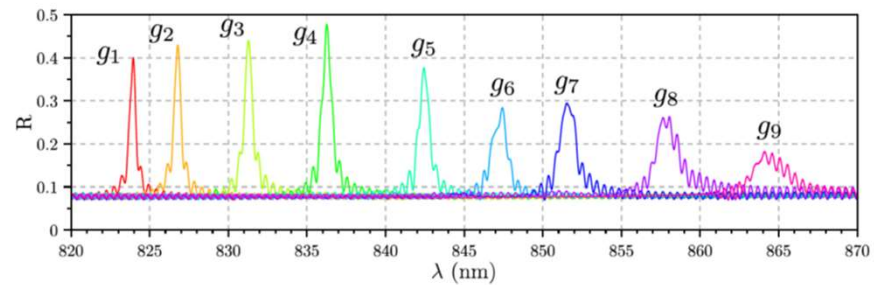
Telecom (LNOI or GeO/SiO_2)
10.1364/OSAC.2.003204



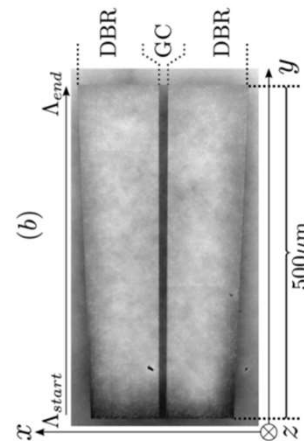
MIR ($\text{Ga}(\text{Al})\text{As}$)
10.1364/OE.26.027014



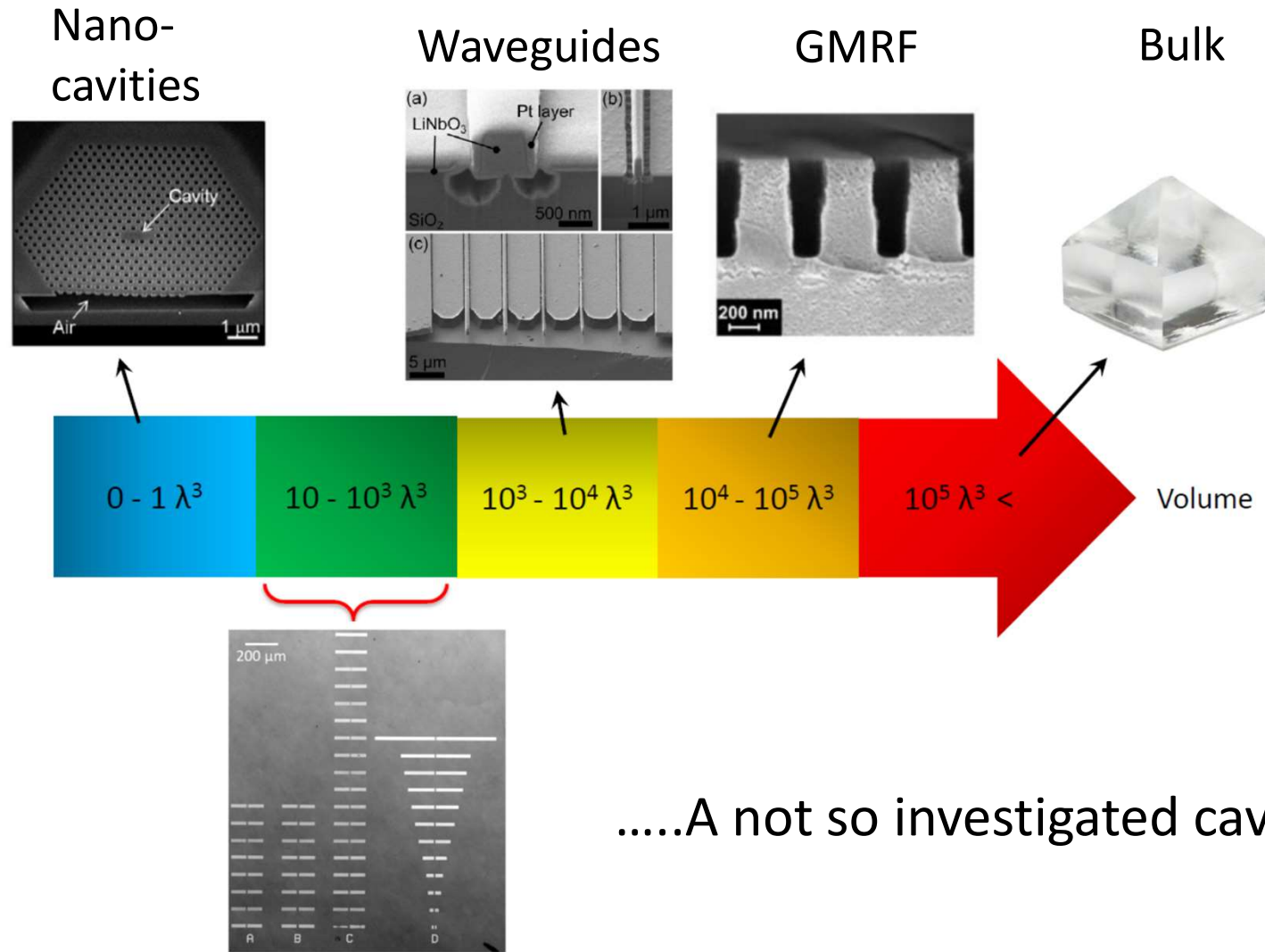
T° tuning
10.1364/OSAC.2.003204
10.1364/OE.457149



Geometrical tuning
10.1364/OE.25.012415



CRIGFs and Non-Linear Optics

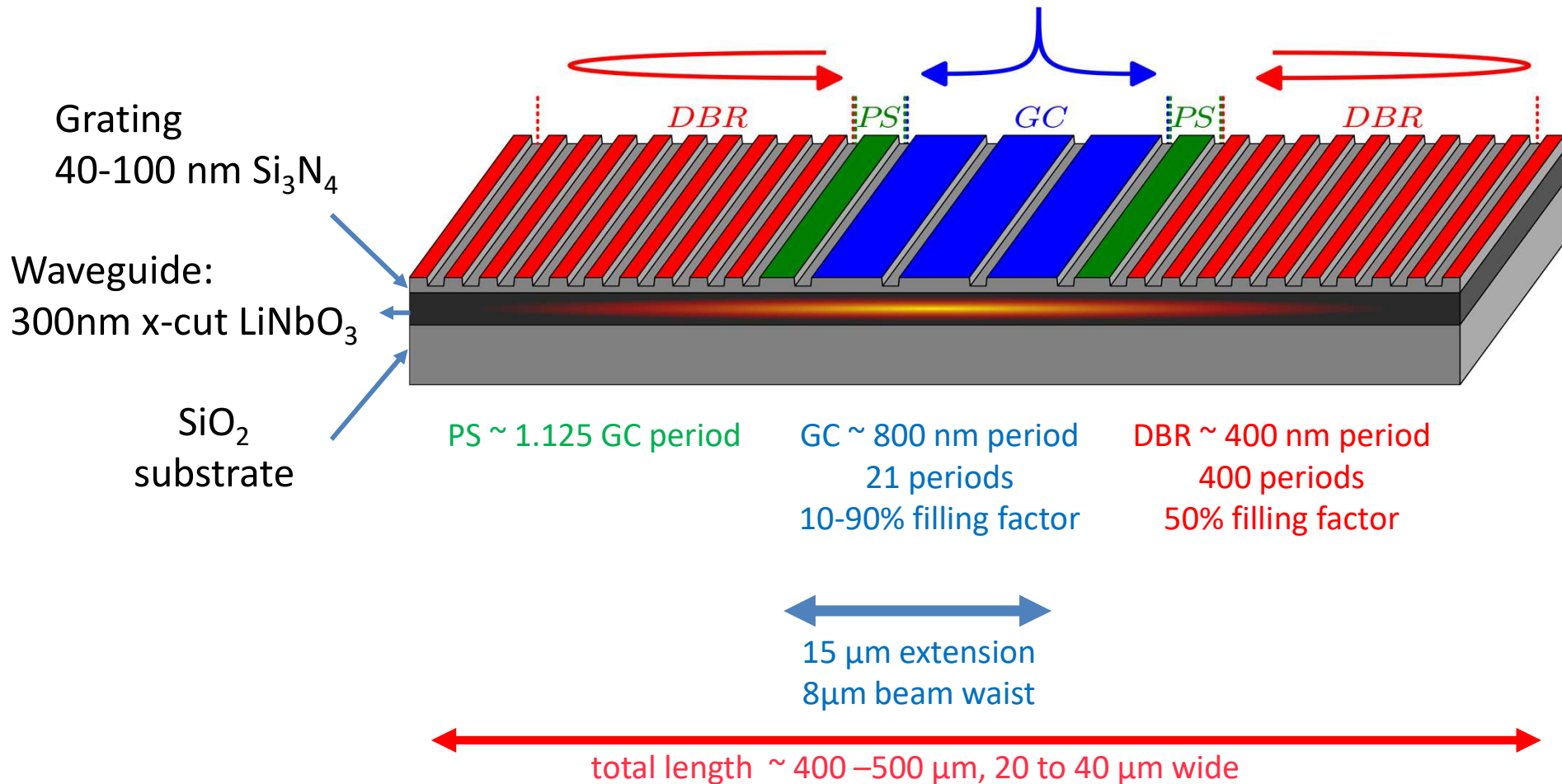


.....A not so investigated cavity volume

First NLC demonstration in CRIGFs

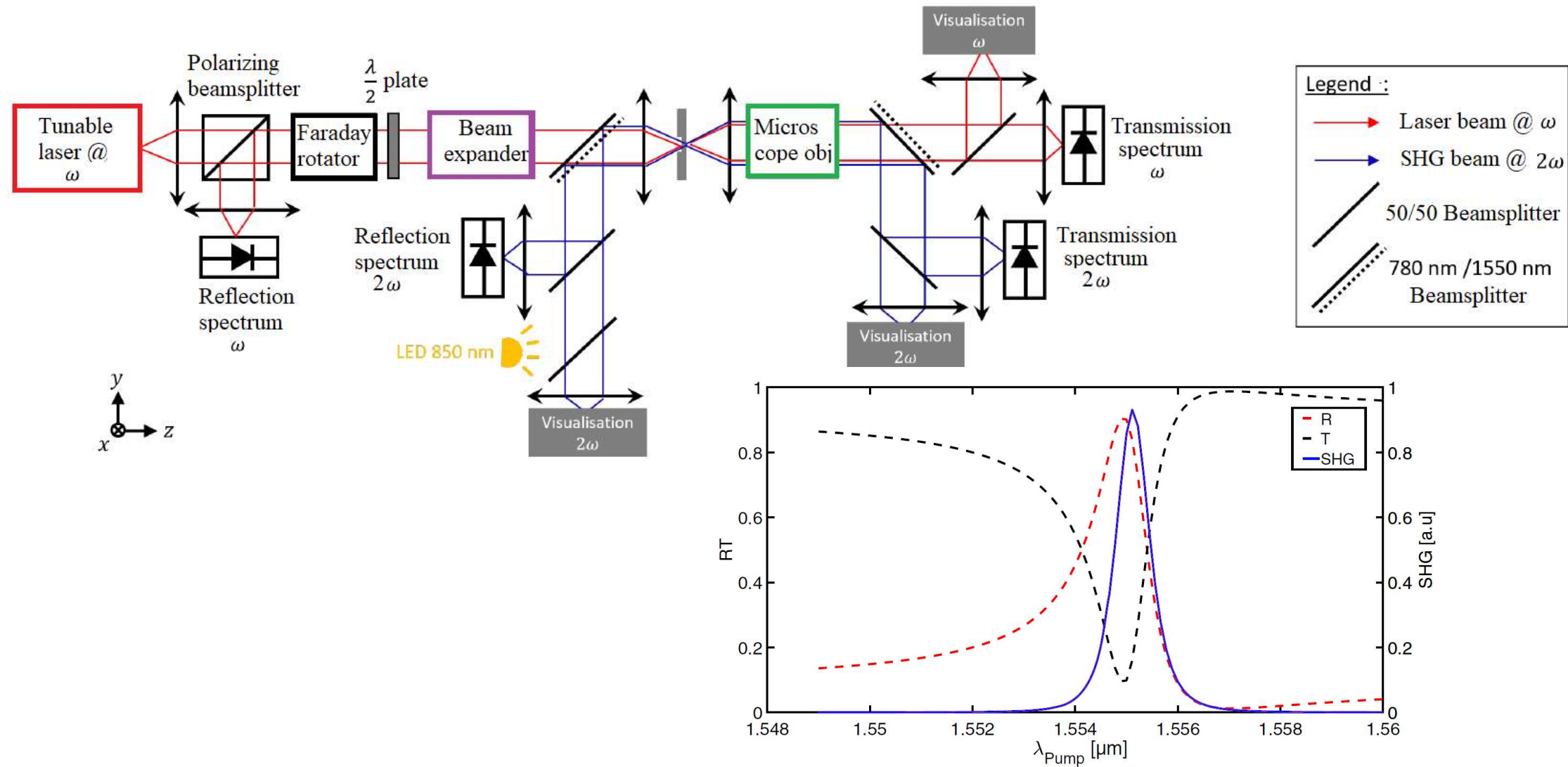
SHG in 1550-nm LNOI CRIGF

A typical CRIGF @ $\lambda=1550$ nm for NLO



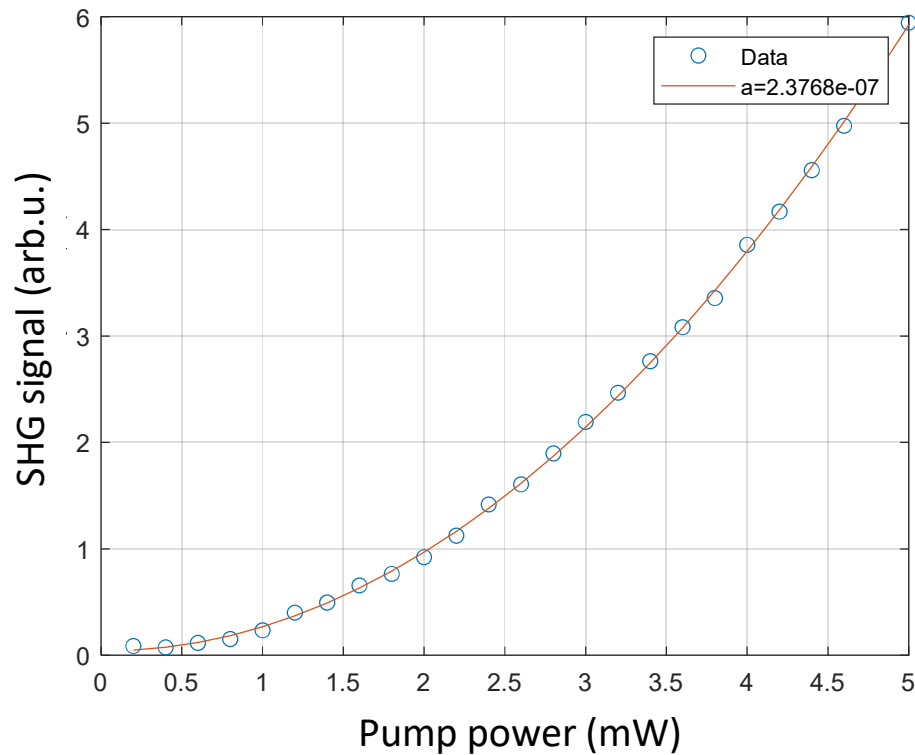
F. Renaud et al, *Optics Letters*, **44** (21), 5198-5201 (2019)

Characterization setup

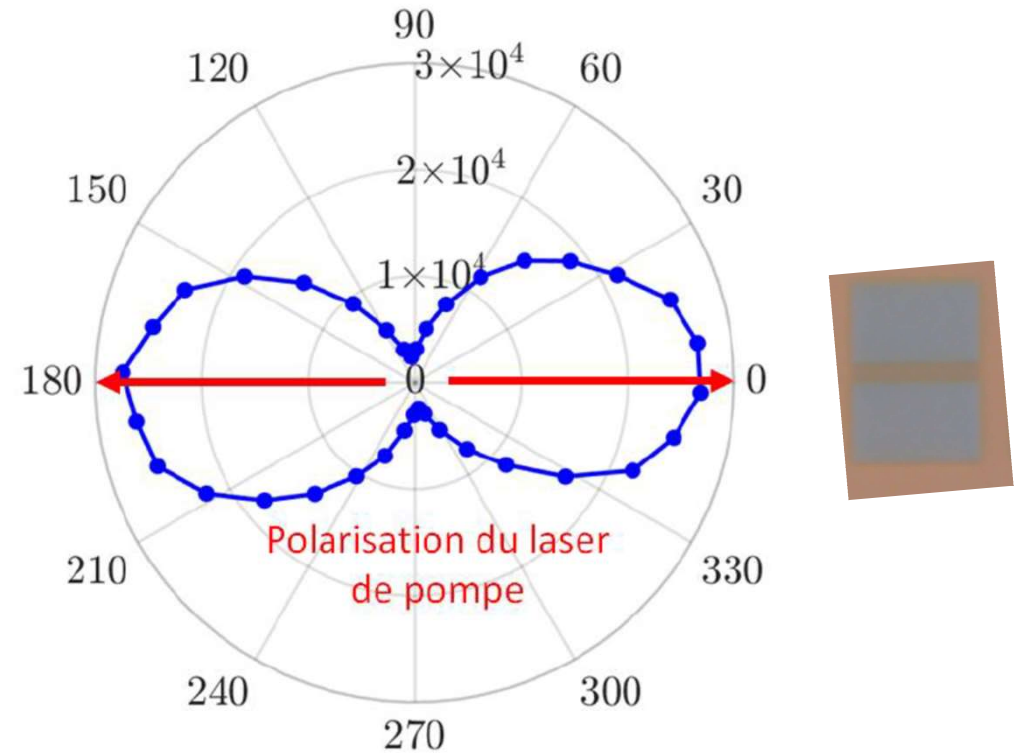


F. Renaud et al, *Optics Letters*, **44** (21), 5198-5201 (2019)

SHG emission characterization



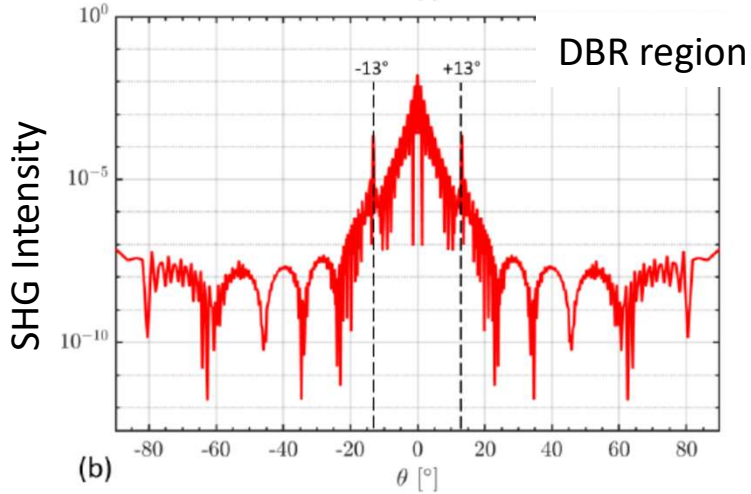
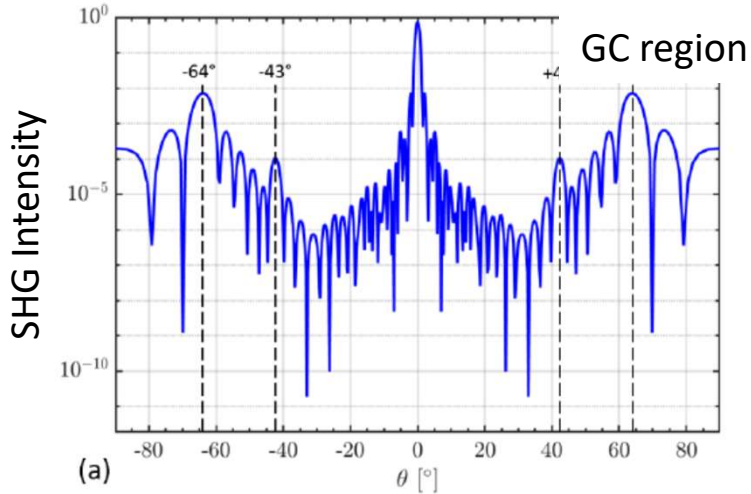
Purely quadratic power relation



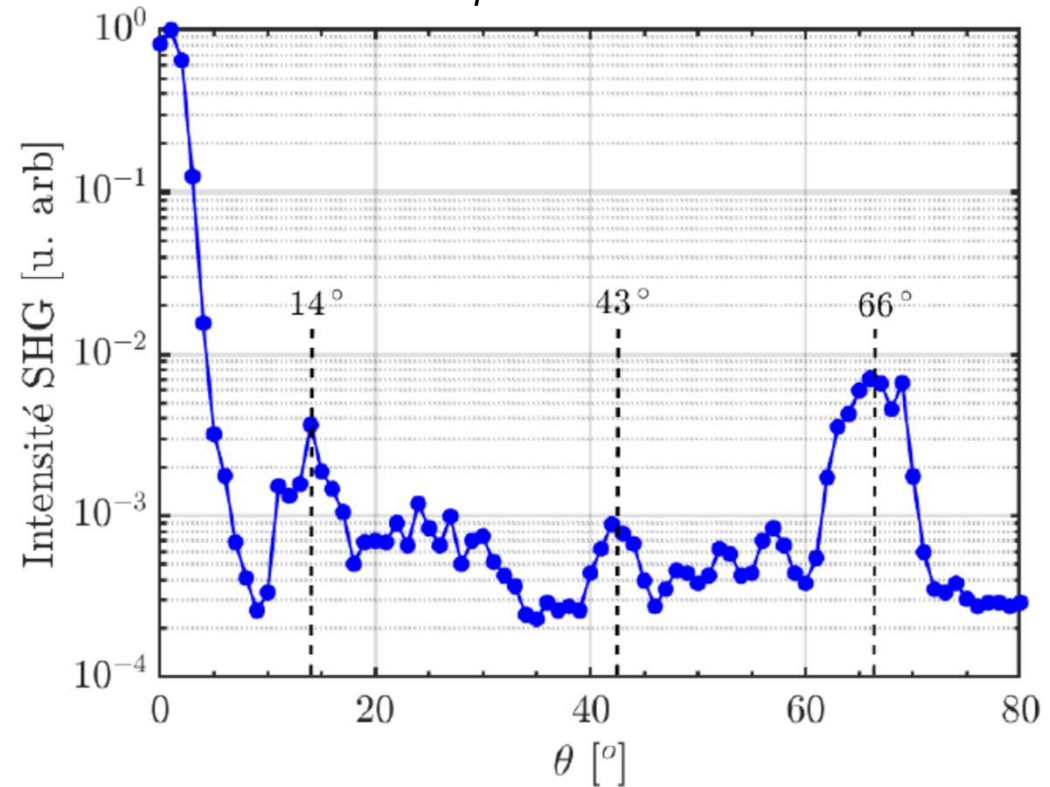
Related to the pump coupling to the CRIGF

F. Renaud et al, *Optics Letters*, **44** (21), 5198-5201 (2019)

Theoretical



Experimental



Most (~98%) of the SHG emission occurs perpendicularly to the sample plane

F. Renaud et al, *SPIE Proc*, **11290**, 112900D-6 (2020), PhD Thesis (2021)

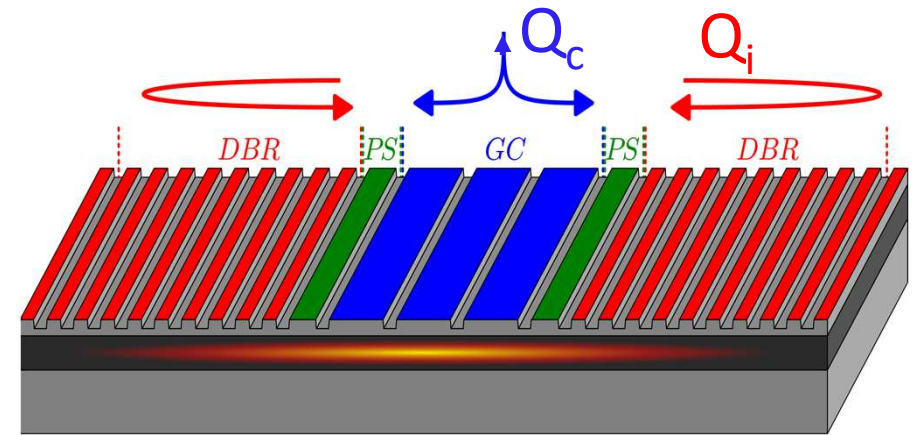
Towards nonlinear conversion with improved efficiencies

Theoretical considerations

> CRIGF = Resonator

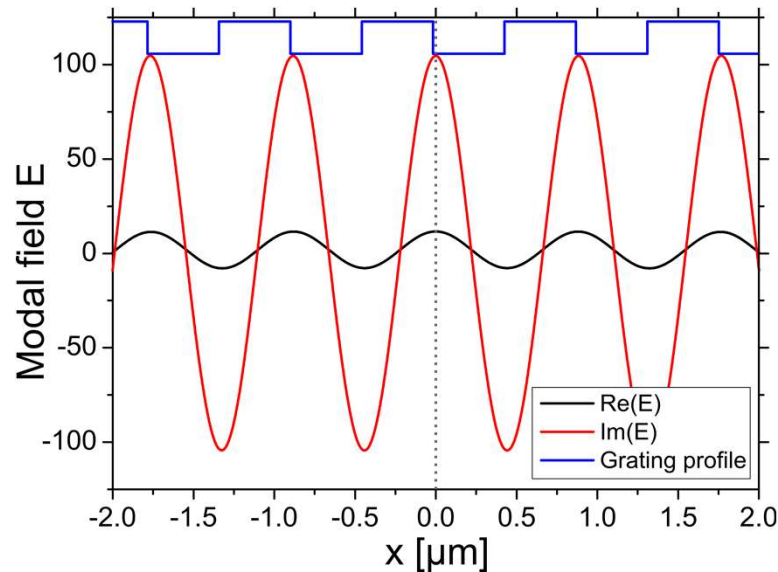
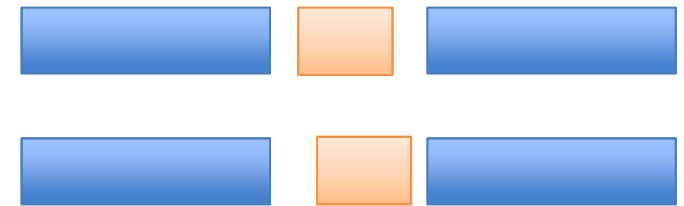
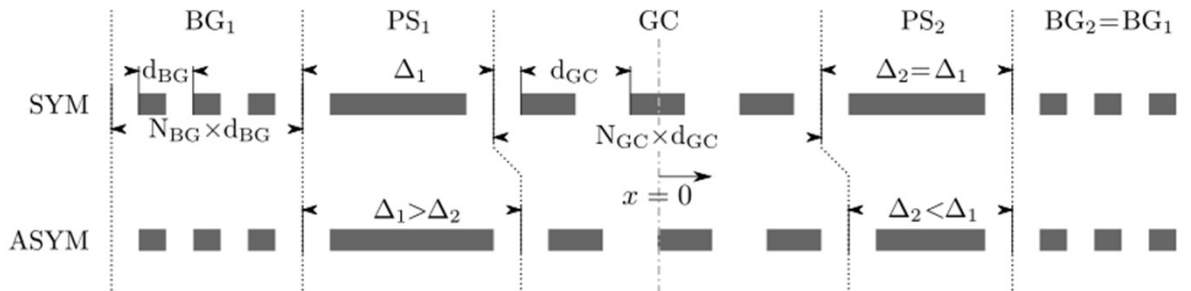
■ Q factor

- $1/Q = 1/Q_i + 1/Q_c$
- Q_i internal Q factor (losses except in-out/coupling losses)
- Q_c coupling Q factor (GC-induced losses)



- **Maximum SHG efficiency** (undepleted regime) occurs for maximum internal pump field i.e. **at critical coupling condition ($Q_c = Q_i$)**

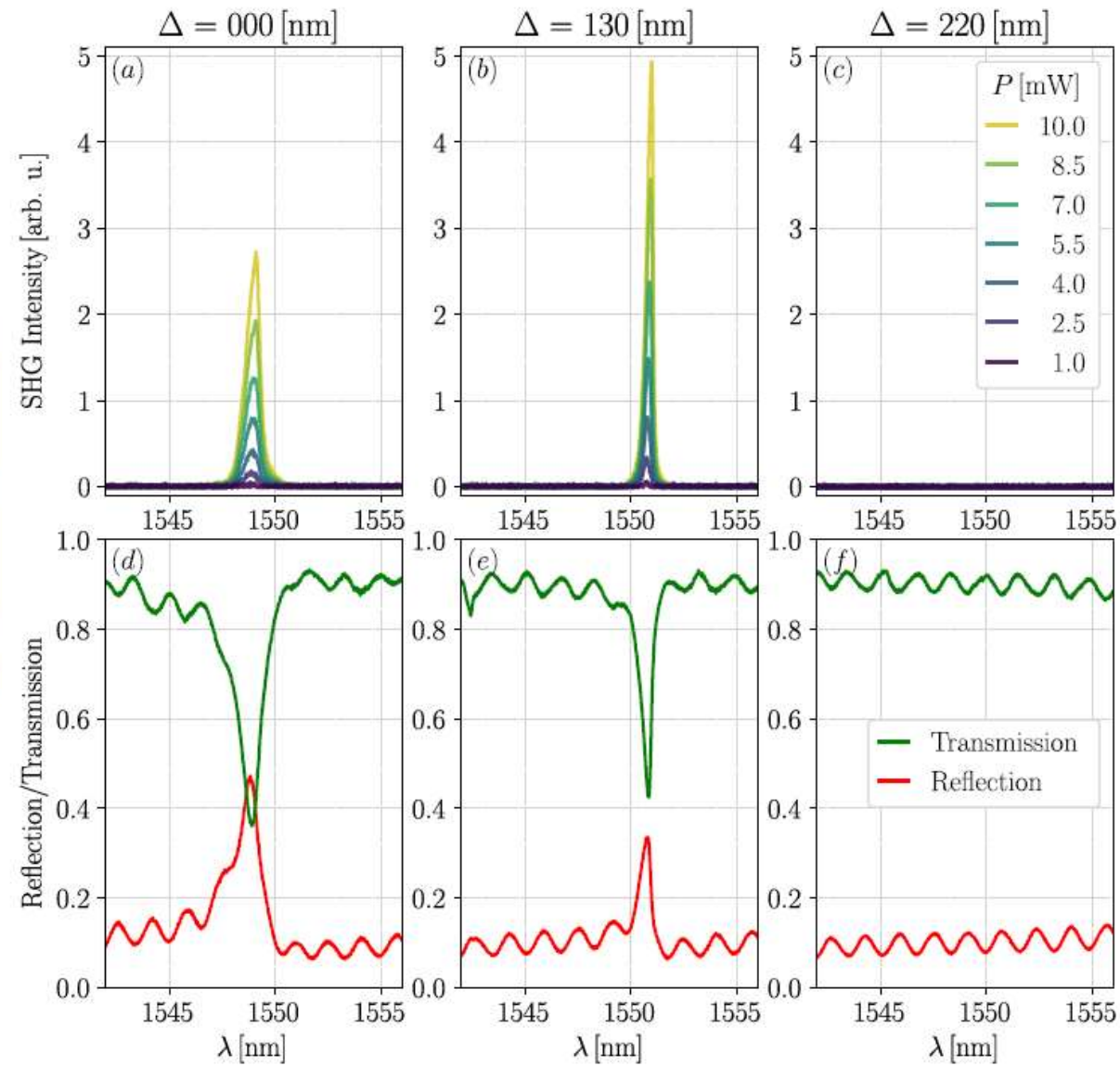
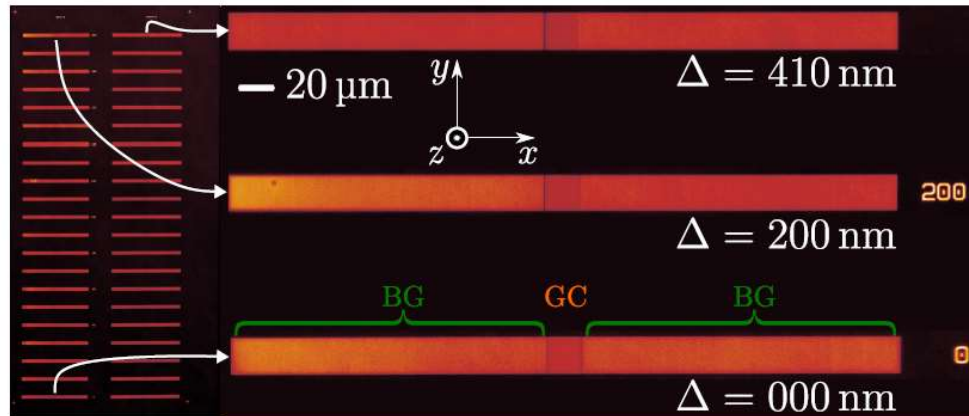
Varying the CRIGF coupling Q-factor



A.-L. Fehrembach & al,
Optics Express, **29** (25), 40981 (2022)

K. Kintaka et al, *IEEE PTL*, **29**, 201 (2017)

Exp. assymmetric CRIGFs responses

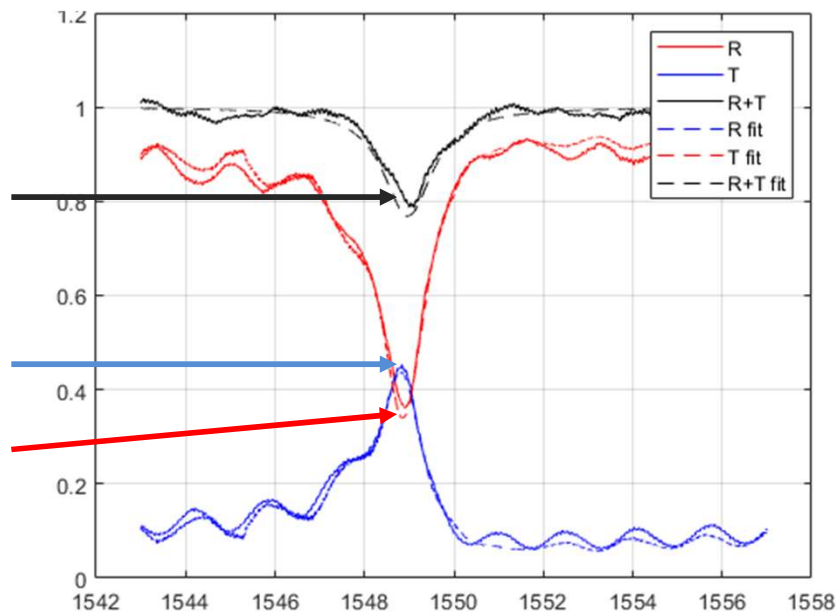


Scanning the offset of the asym. design

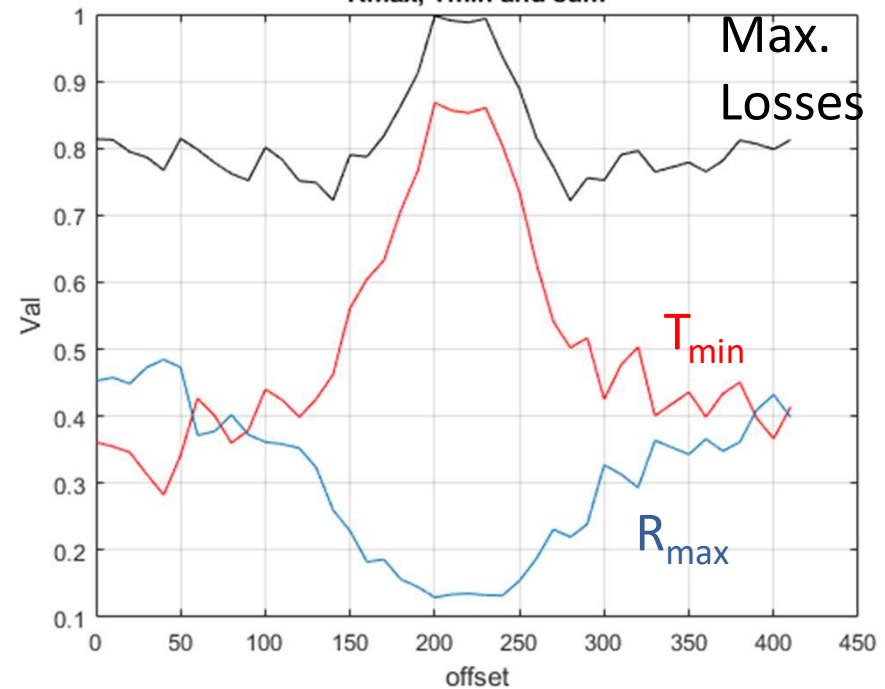
Max.
Losses

R_{max}

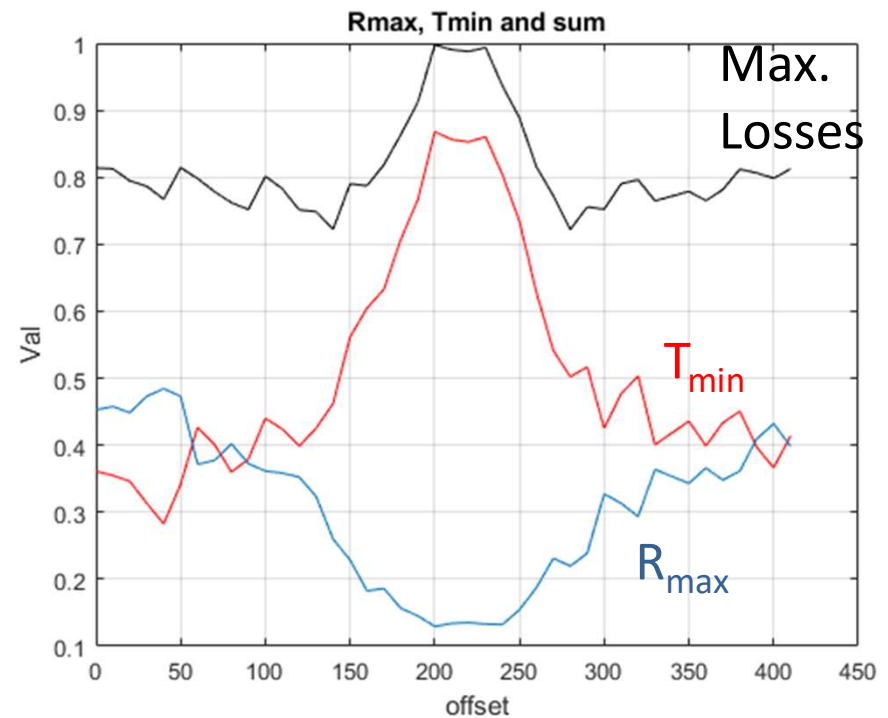
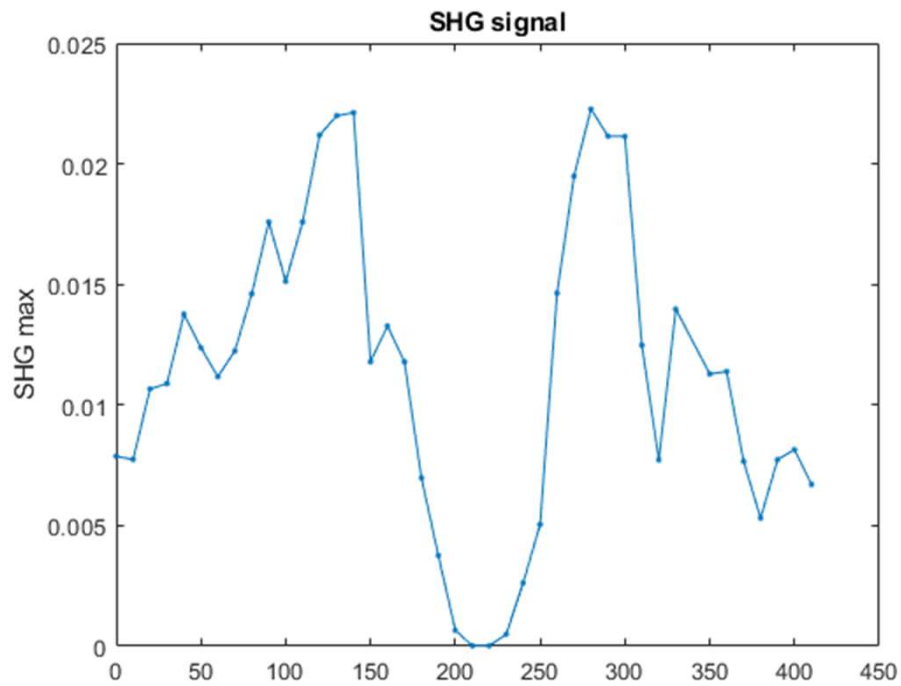
T_{min}



Rmax, Tmin and sum



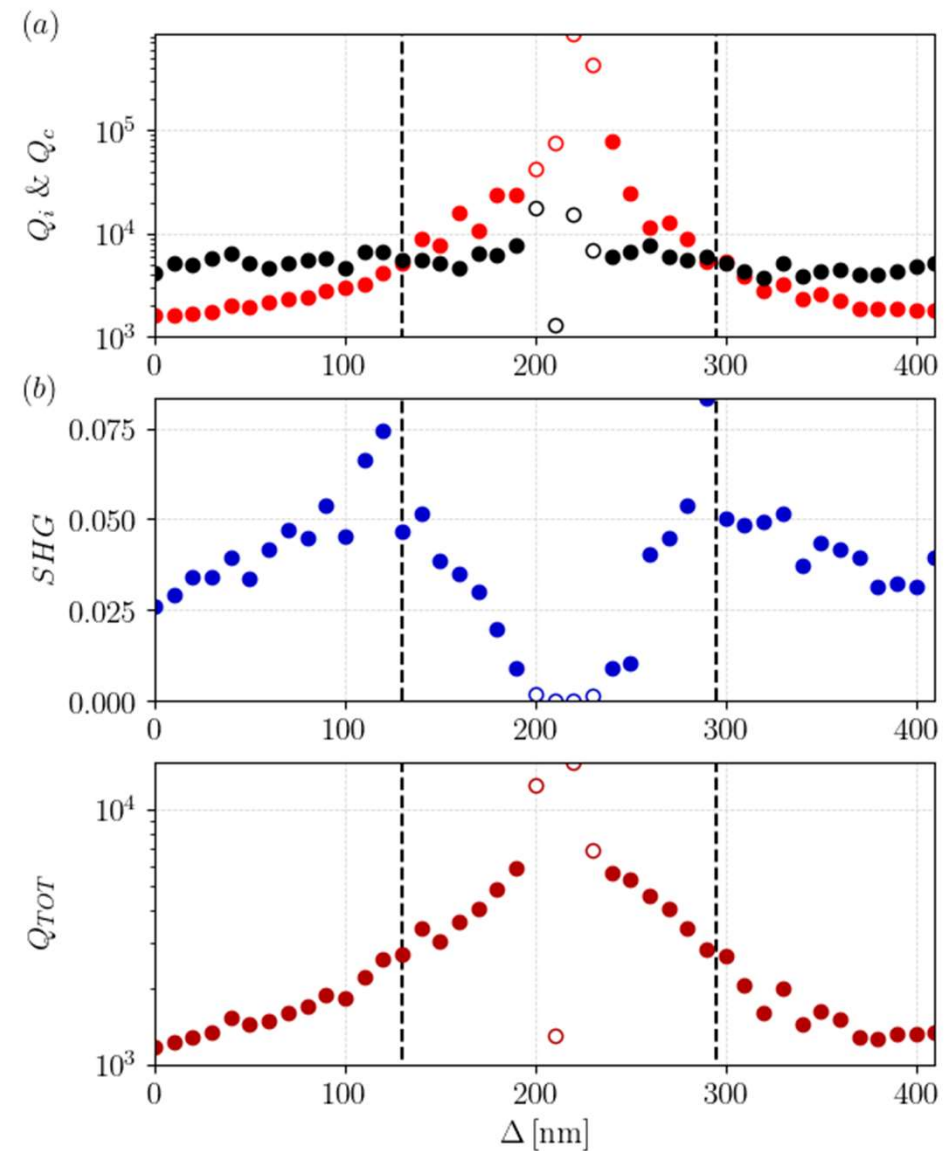
Scanning the offset of the asym. design



CRIGF CMT model : parametric extraction

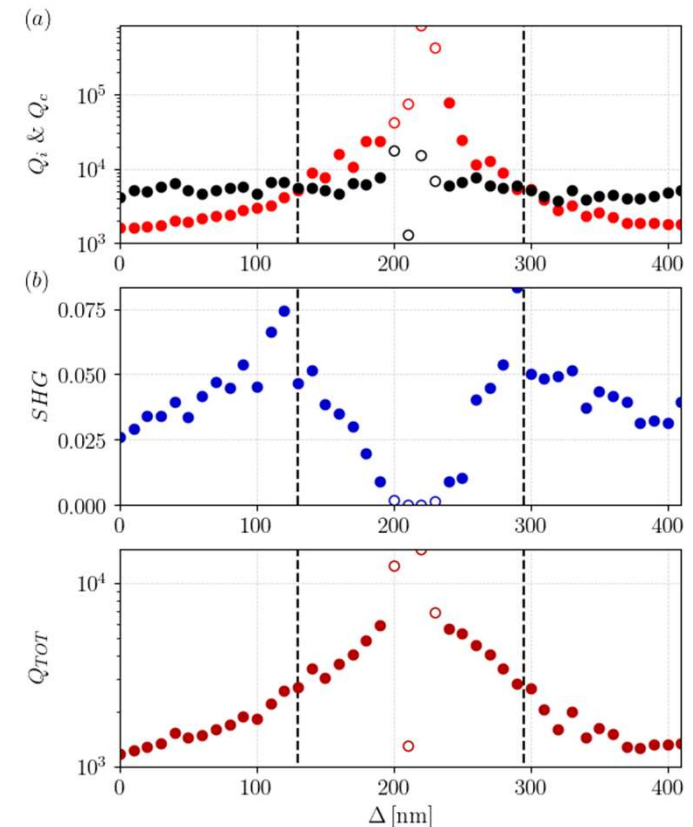
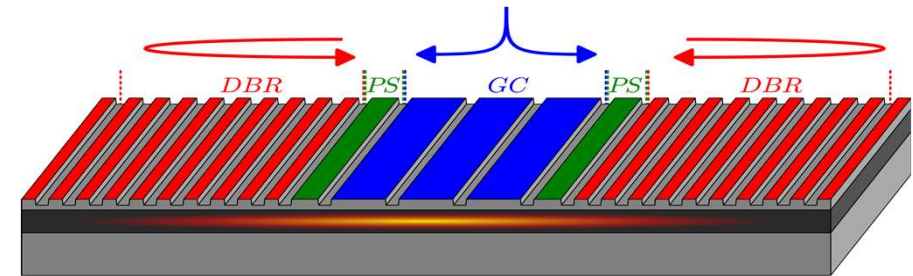
> Coupled-Mode Theory Model

- 3 contributions
 - Direct path
 - Resonator path
 - Interference term
- Special consideration
 - Excitation beam/mode overlap



CRIGFs for NLO :

- thin film geometry
- large design freedom
- Easy tailoring of the coupling of an external beam to the resonator
- Critical coupling achieved
- Conversion efficiencies are currently limited by the internal losses.



Acknowledgements



Thank you for your attention