Highly Efficient FBG DFB Tm-doped Fiber Laser Source at 2039 nm

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Cybel
LIGHTING THE WAY

Talk Outline

- **Motivation and Objectives**
- **Distributed Feed-Back Fiber Bragg Grating (DFB FBG) laser technology**
- **MOPA pump**
- **Traditional pumping configuration**
- **Recycling the pump**
  - Faraday mirror
  - Advantages of new pumping schemes
- **Pumping within the ring laser**
- **Conclusions and Perspectives**

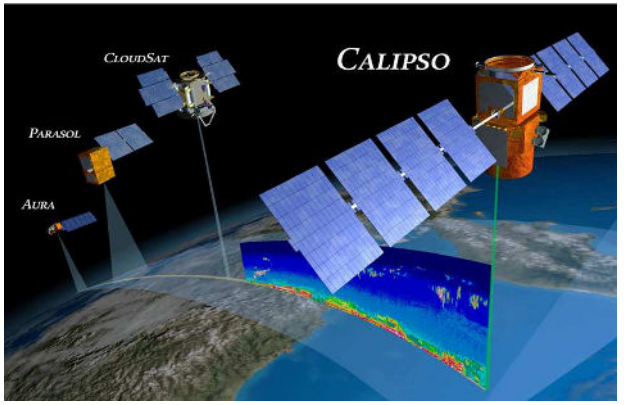
Motivation and Objectives

DFB FBG fiber lasers:

- Large available wavelength choice in 2 µm range
- Narrow linewidth < 10 kHz
- Single mode operation
- Compact, all-fiber Non-PM or PM design
- High power (> 300 mW)

W. Walasik, S. Asoda, R. E. Tench, J. Delavaux, and E. Pinsard,
in *ECOC 2022*, Technical Digest Series, paper Tu5.3.

Goal: Improve efficiency

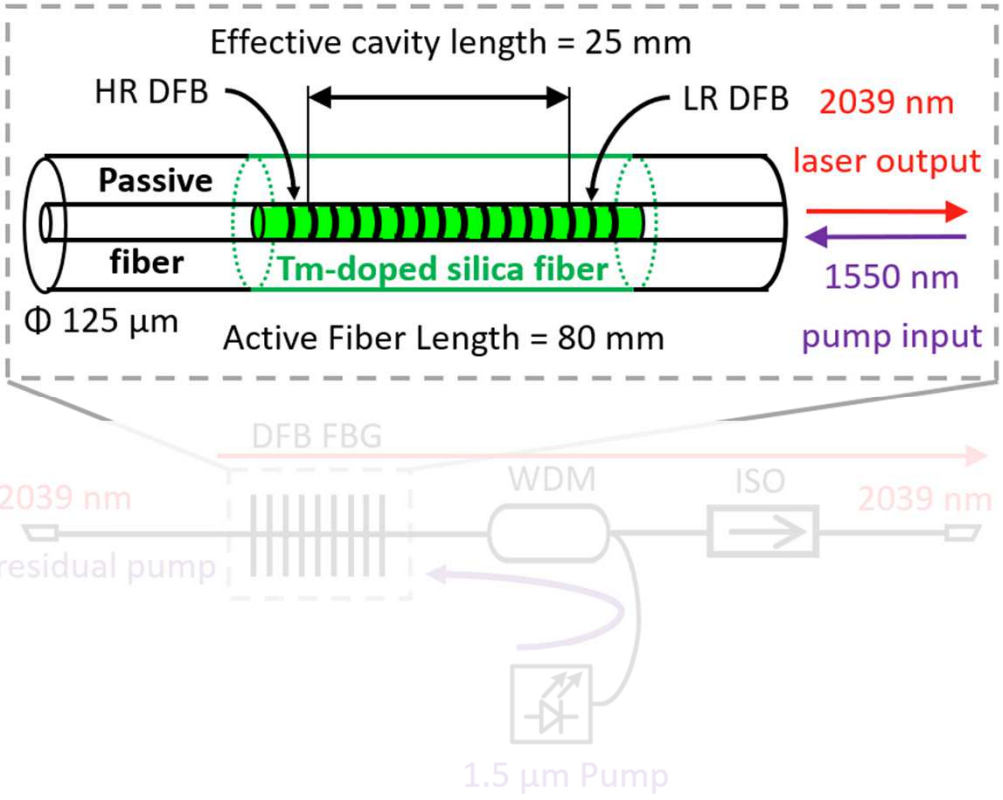


Applications:

- Light Detection and Ranging (LIDAR)
- Optical sensors
- Spectroscopy
- Telecommunications
- Medicine

Source: NASA

DFB FBG concept and operation



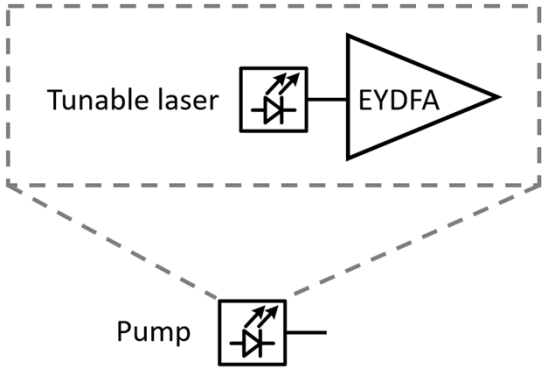
DFB FBG concept:

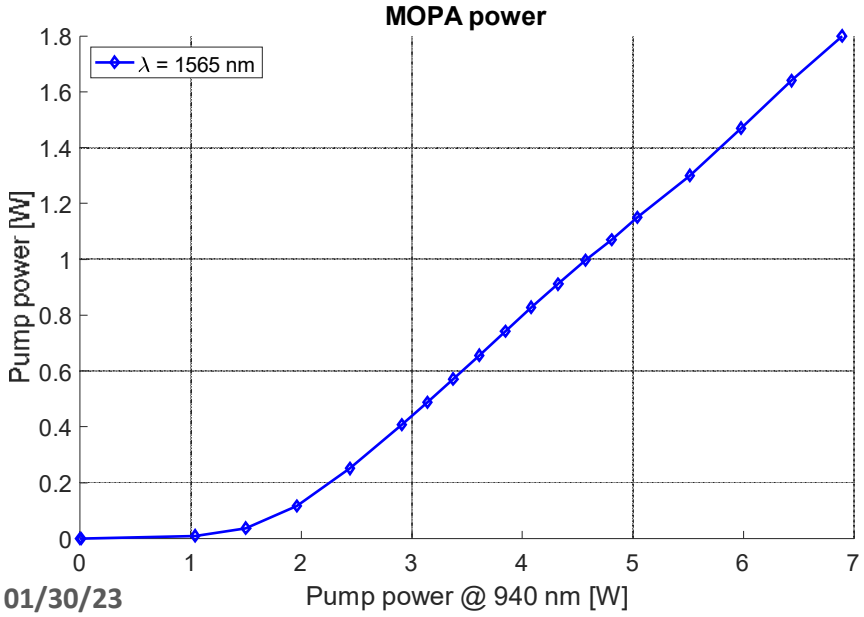
- Single 60-mm-long apodized Distributed Feed-Back Fiber Bragg Grating
- π/2 phase shift in the center
- 4 GHz longitudinal mode spacing

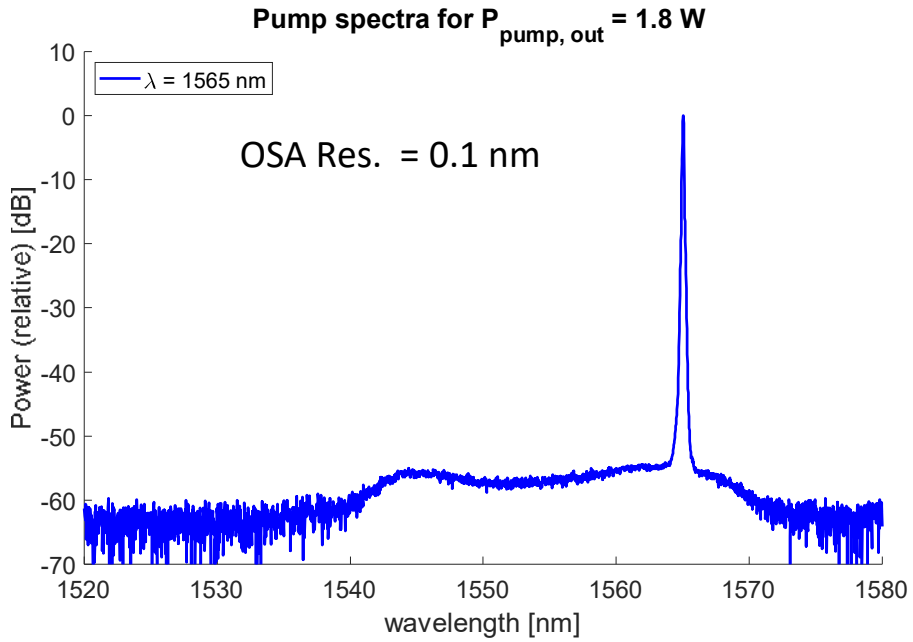
Previously used pumping configuration:

- Counter-pumping
- Semiconductor laser
- Cavity Fiber Laser

MOPA pump

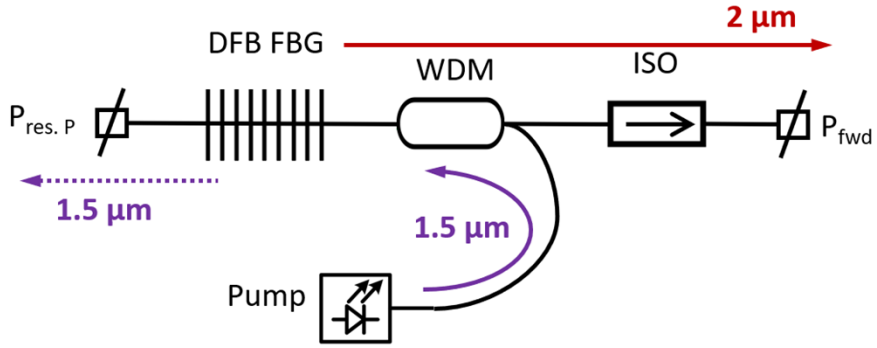


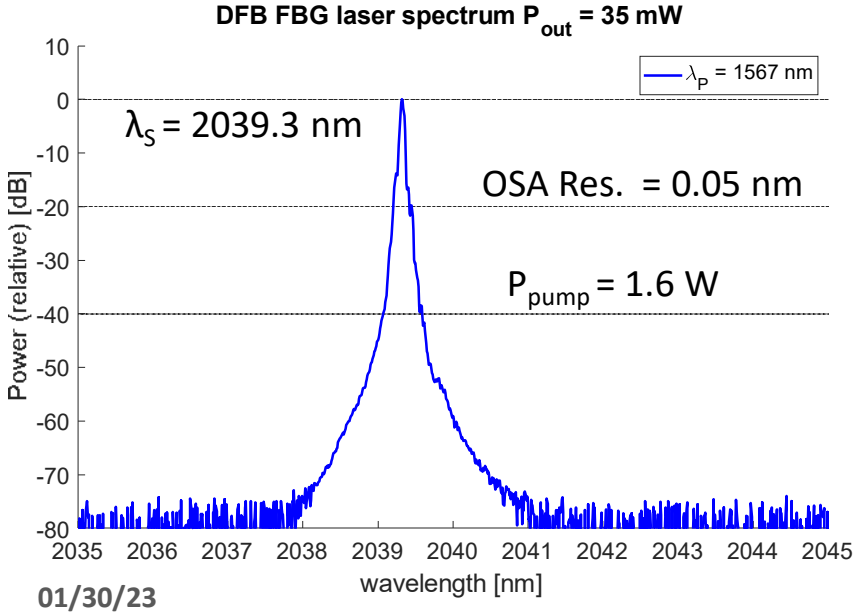


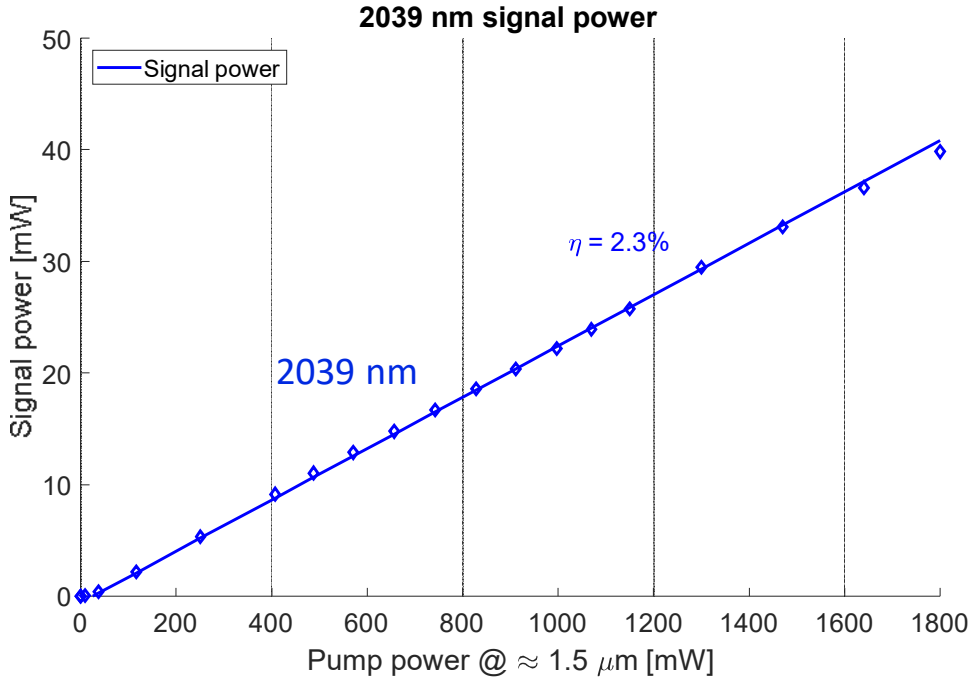


- **EYDF pumped at 940 nm**
- **Seed: 20 mW from tunable laser**

Traditional pumping configuration

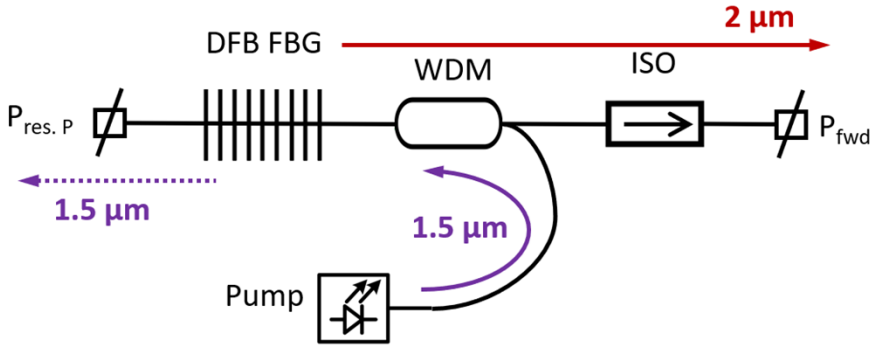


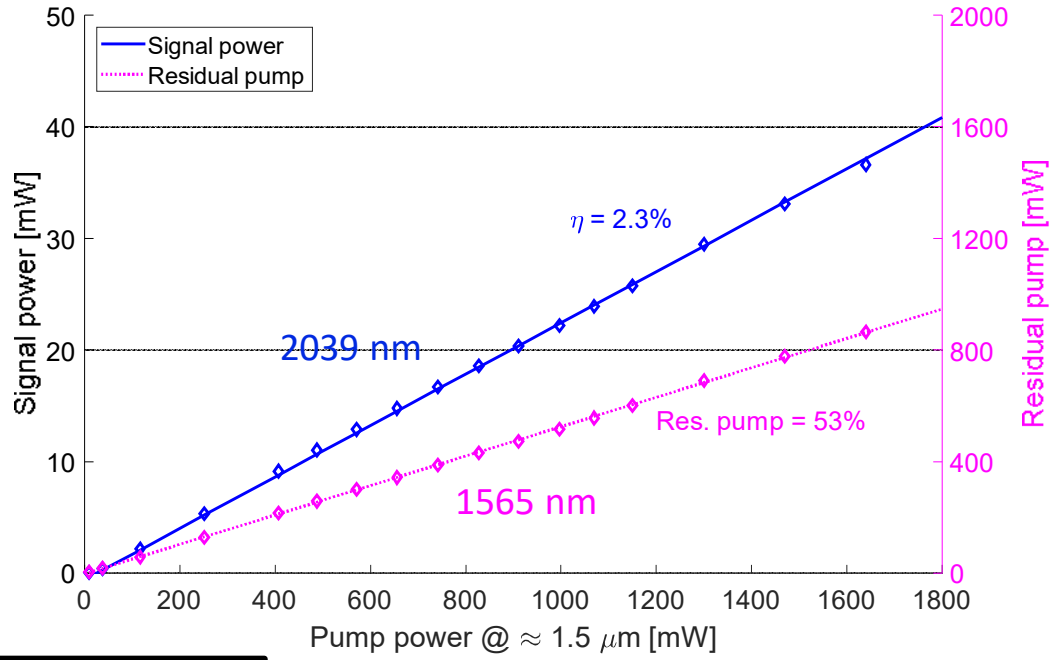




- **Low optical-to-optical efficiency η**
- **Signal with OSNR > 70 dB/0.1 nm**

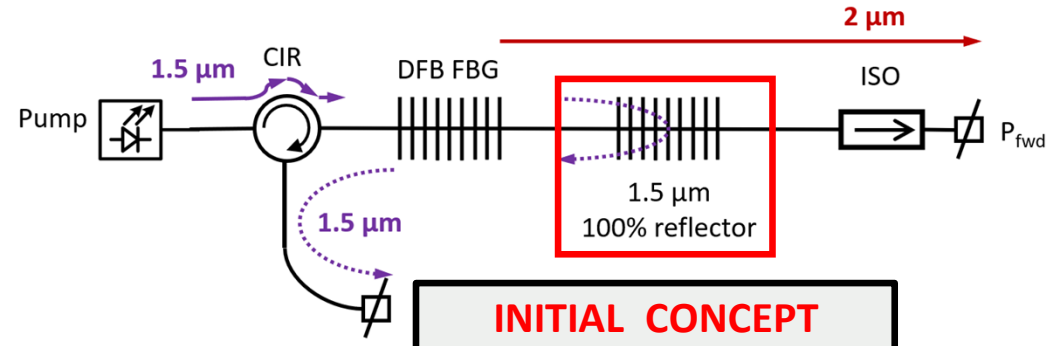
How much pump are we wasting?





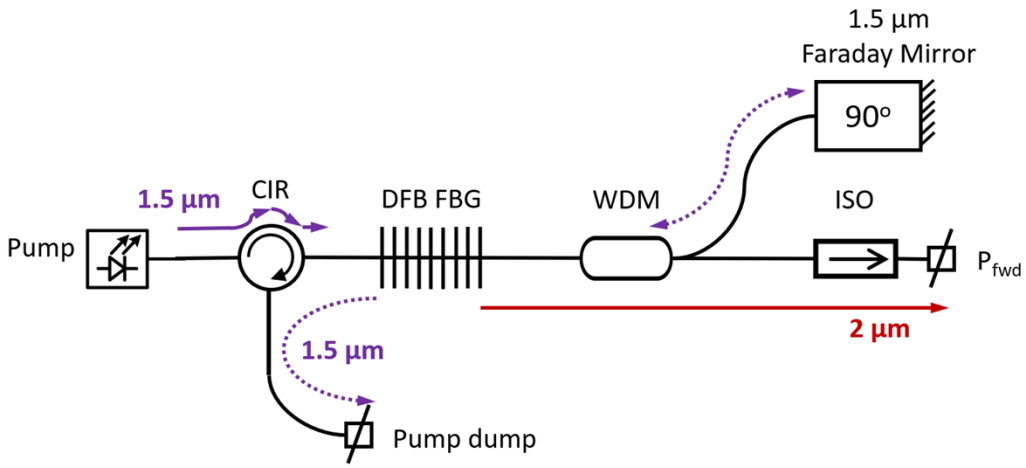
- **Efficiency η and pump absorption ∝ active fiber doping level**
- **20 – 90% of the pump absorbed (here 40 – 50%)**
- **Up to 80% of pump can be reused (here ≈ 50%)**

Recycling of residual pump



INITIAL CONCEPT
Grating Not Available

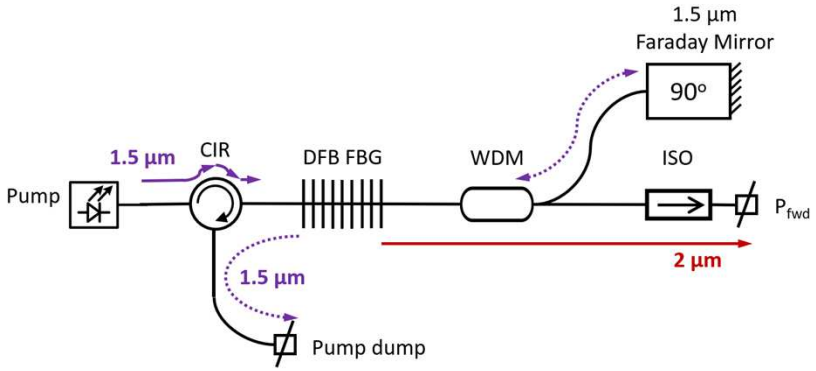
- Pump through a 1.5 µm circulator
- Use 100% reflector for at the pump wavelength to:
  - Separate residual pump from the signal
  - Reflect pump for second passage

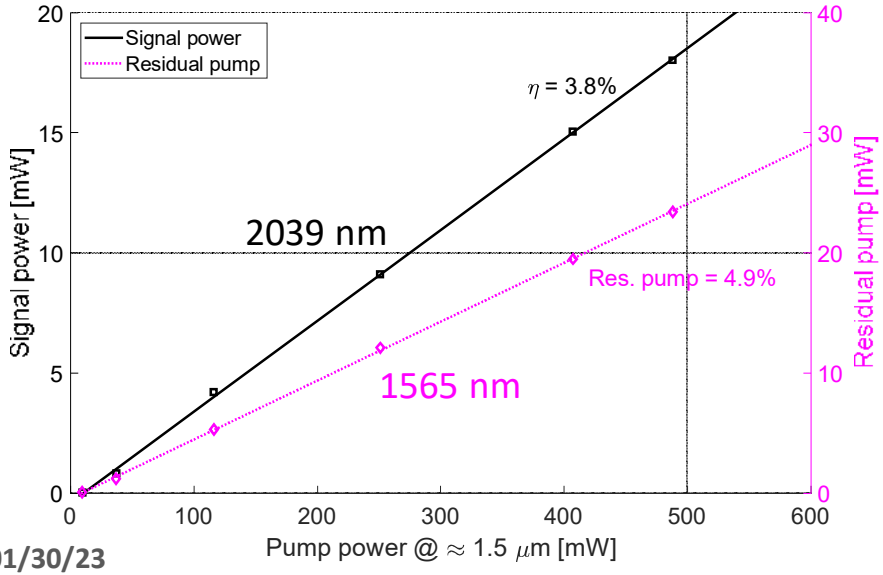


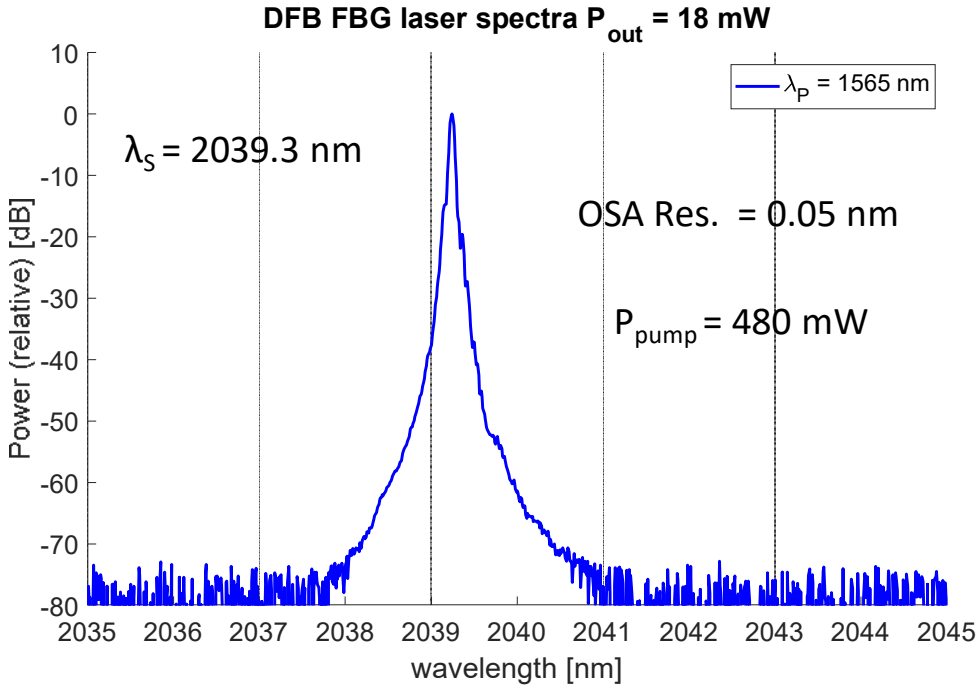
- WDM separate residual pump from the signal
- Faraday mirror rotates the pump polarization

Patent submitted

Recycling of residual pump



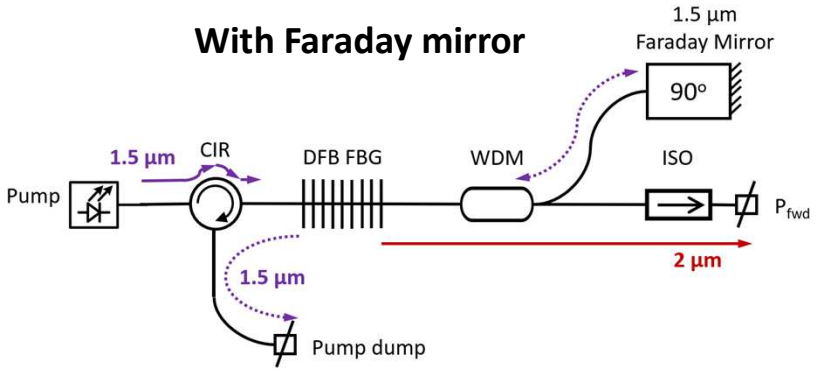


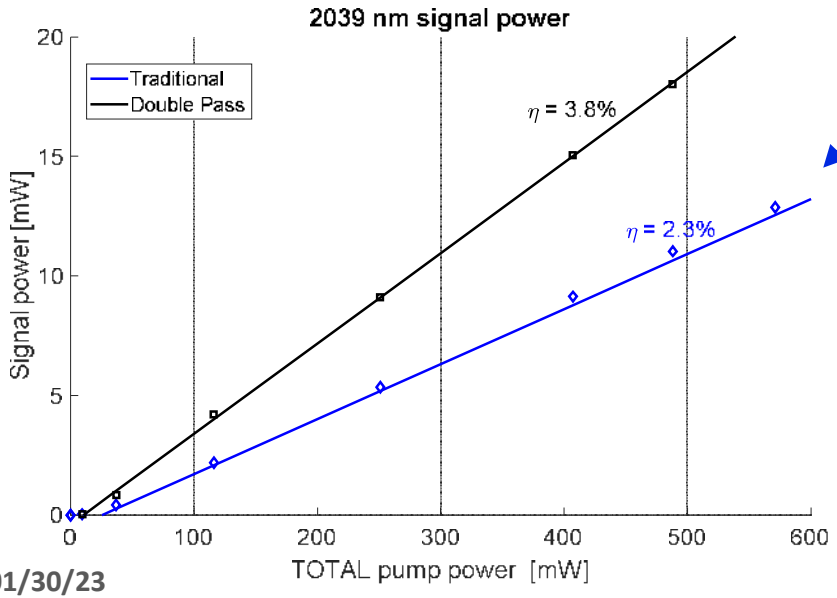


- **Output power linear with pump power**
- **No change in spectral quality**

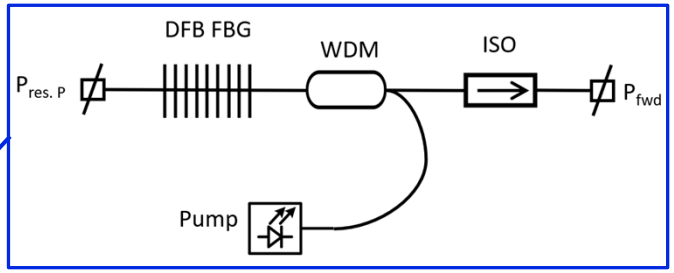
Performance comparison

With Faraday mirror



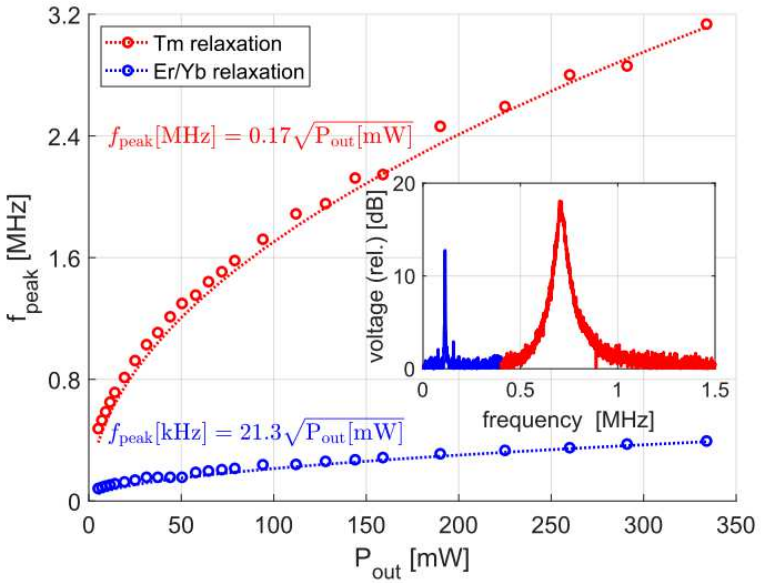


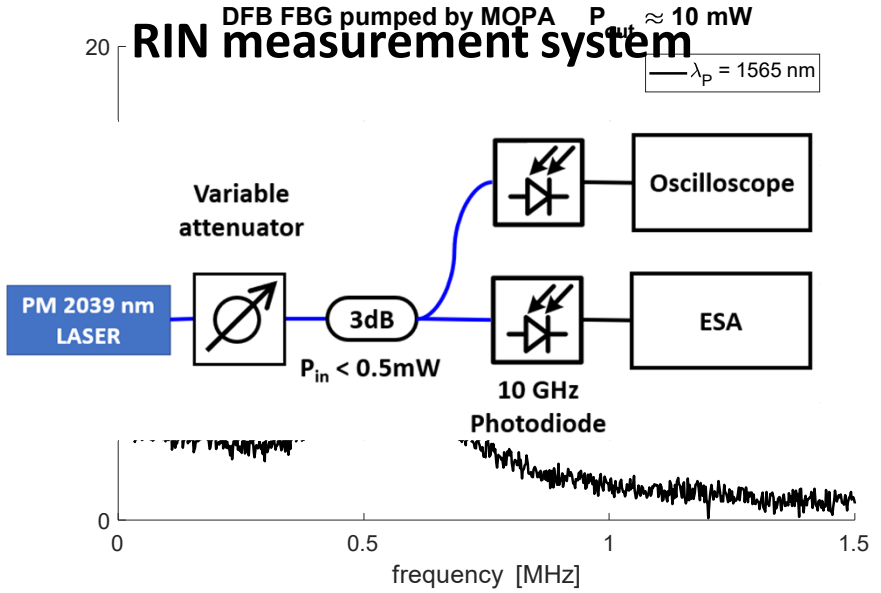
Traditional configuration



- Up to (65%) 2.2 dB increase in optical-to-optical efficiency
- Residual pump only 5% (down from 50%)
- Further topology optimization for better signal/pump separation

Low frequency noise





DFB FBG pumped with:

- **Semiconductor Laser: only RED peak observed**
- **Cavity Fiber Laser: both BLUE & RED peaks observed**

MOPA pumping:

Only peak related to Tm ion relaxation

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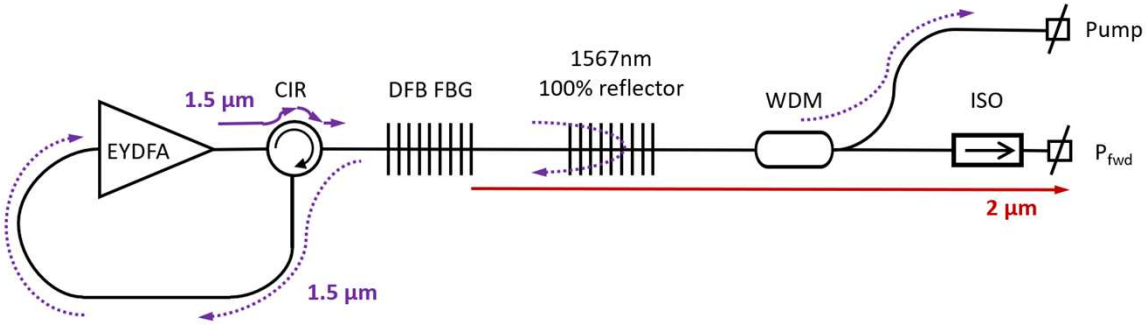
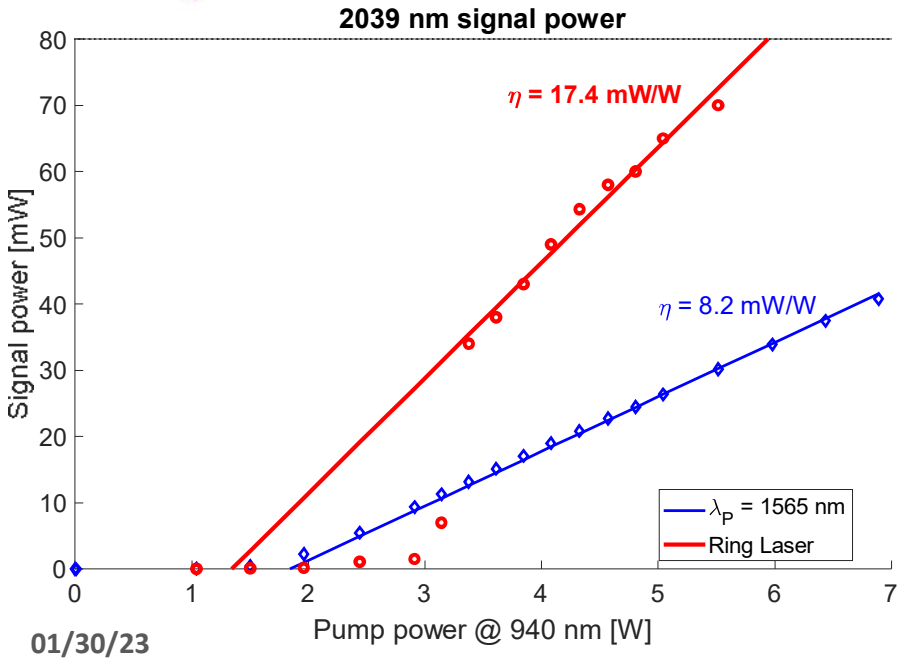
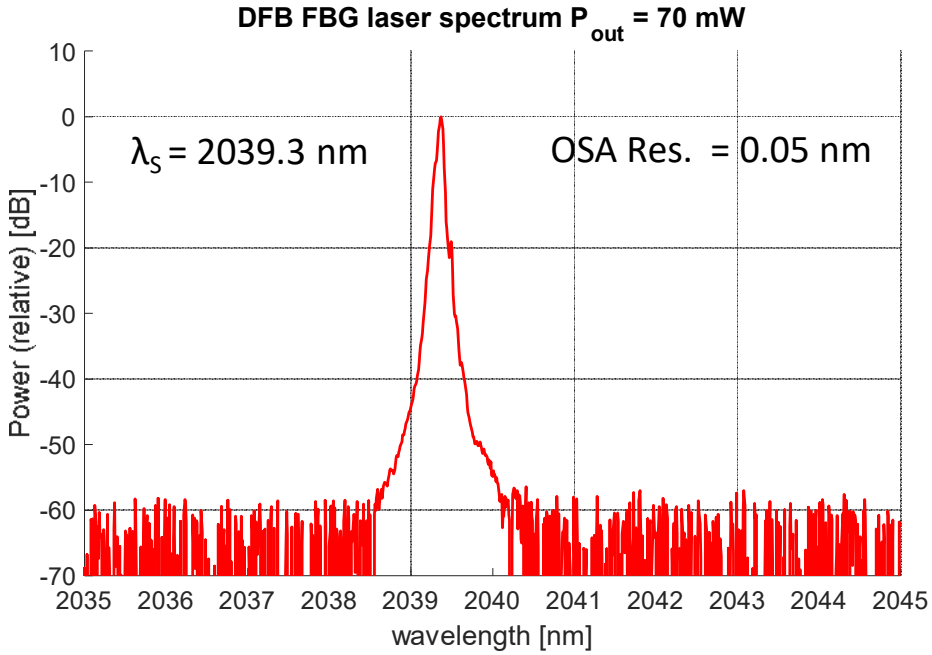
Pumping within the ring laser







- **> 2x higher signal generation efficiency**
- **Clean spectrum with OSNR > 55 dB/0.1 nm**

Patent submitted

Conclusions and Perspectives

New pump configurations for DFB FBG Lasers at 2 µm :

- Allow for efficient use of the pump
- Laser efficiency increased by 65% by recycling the pump
- x2 increase possible in ring laser configuration

- How are the short-term stability and linewidth affected?
- Can low frequency noise be removed by changing the doping?

Thank you for your attention

More information in:
W. Walasik, D. Traoré, A. Amavigan, R. E. Tench, J.-M. Delavaux, and E. Pinsard
2-µm narrow linewidth all-fiber DFB fiber Bragg grating lasers for Ho- and Tm-doped fiber-amplifier applications
Journal of Lightwave Technology, 39, 5102 (2021)