Recent results on single-mode single-polarization Tm:fiber laser

Separate components and assembled laser system

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01-19-2012

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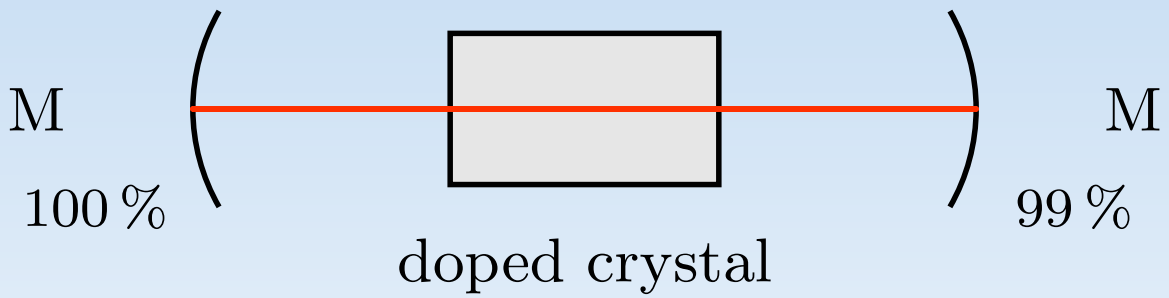
Outline

Why fiber lasers?

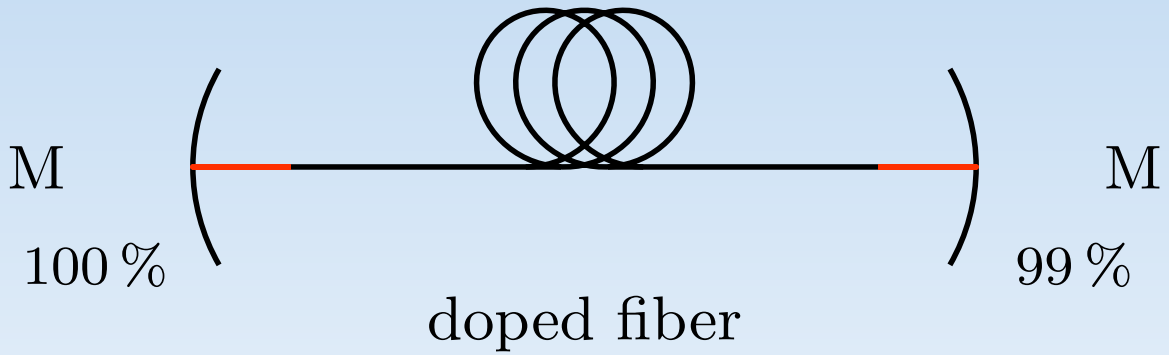
Simplified solid state laser:



- adjustable mirrors
- field distribution must match the cavity eigenmodes
- laser performance affected by environment
- optical misalignment due to thermal drift possible

Why fiber lasers?

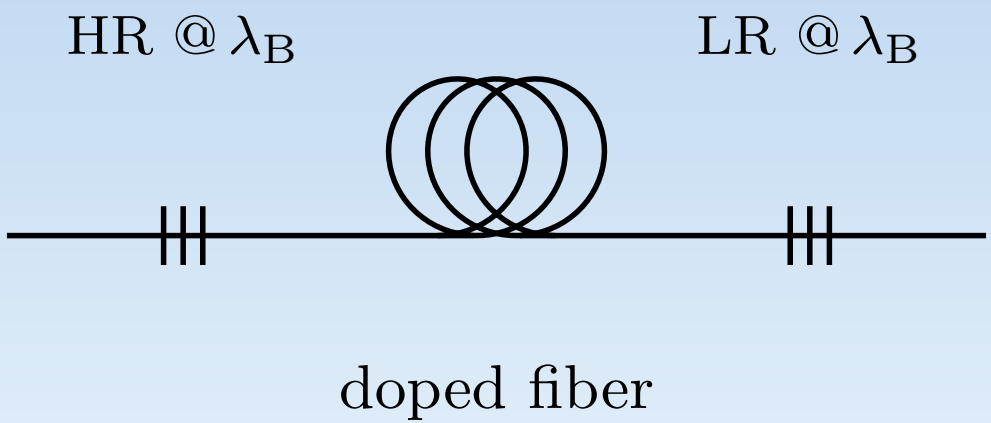
Simplified fiber laser:



- adjustable mirrors
- fewer cavity / fiber modes
- environmental influences less significant
- optical misalignment due to thermal drift possible

Why fiber lasers?

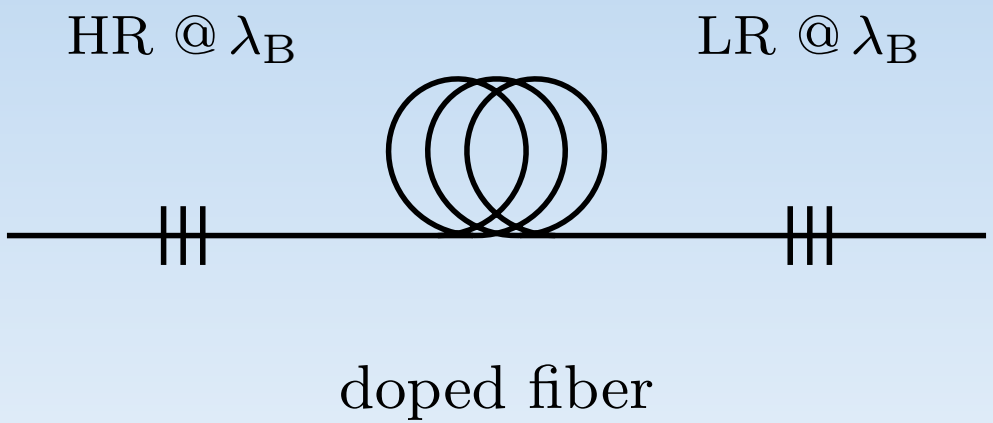
Simplified fiber laser with fiber Bragg gratings (FBG) to feedback:



- no external mirrors
- fewer cavity / fiber modes
- environmental influences less significant
- optical misalignment due to thermal drift still possible

Why fiber lasers?

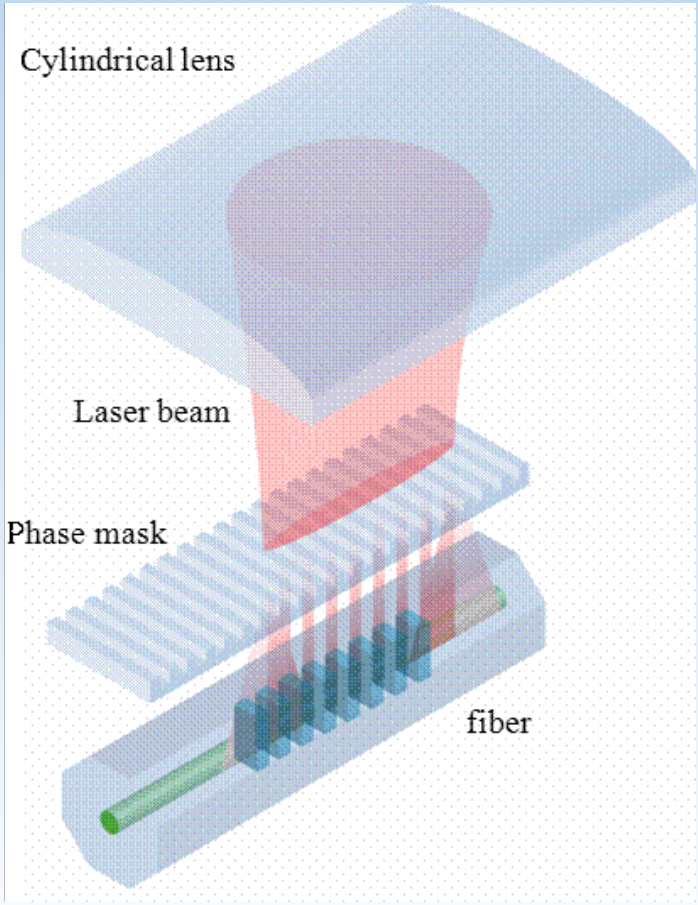
Requirements:



- single-mode
- narrow linewidth
- wavelength tunability by direct temperature control

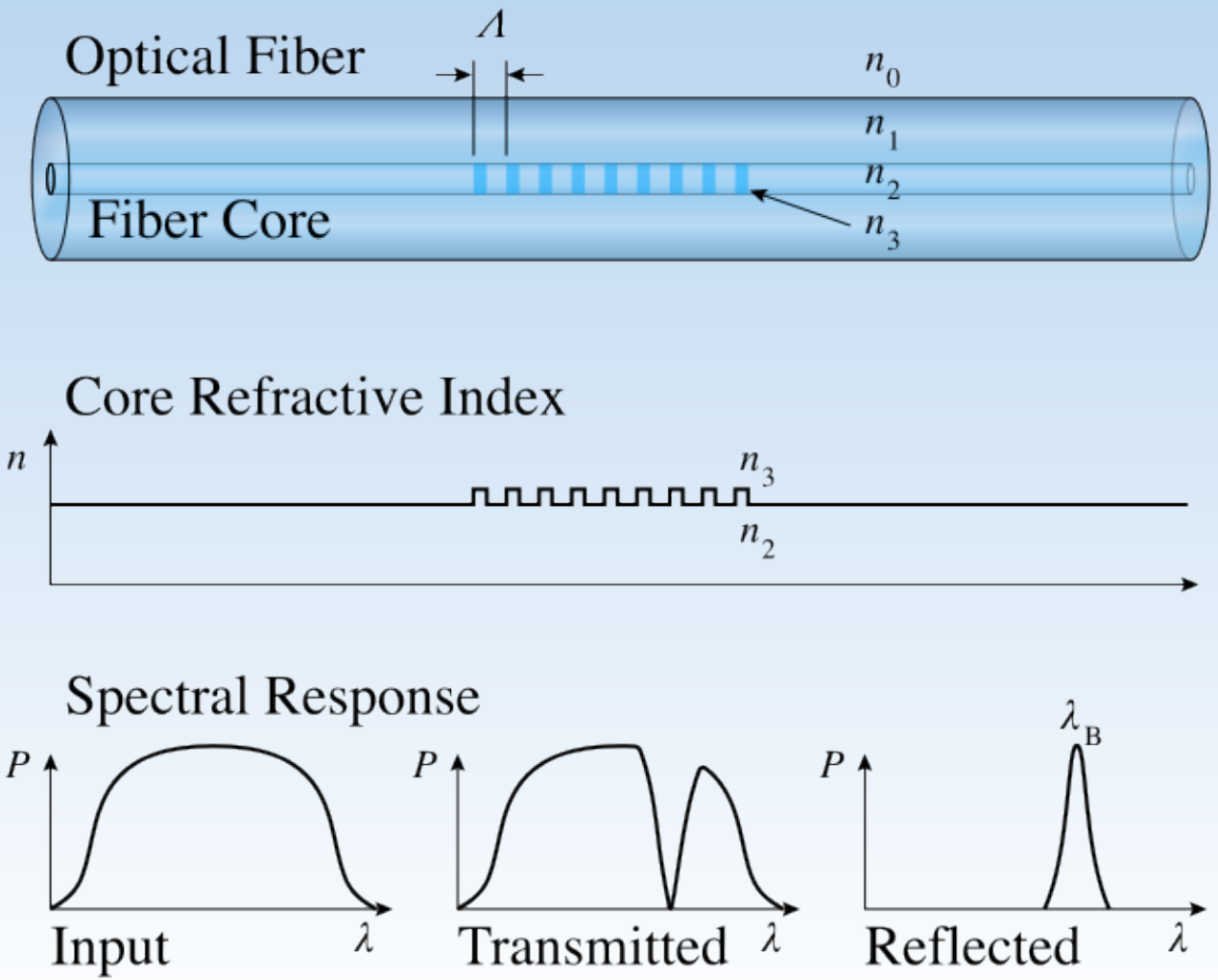
e. g. pumping of holmium lasers

"Writing" a grating into the fiber

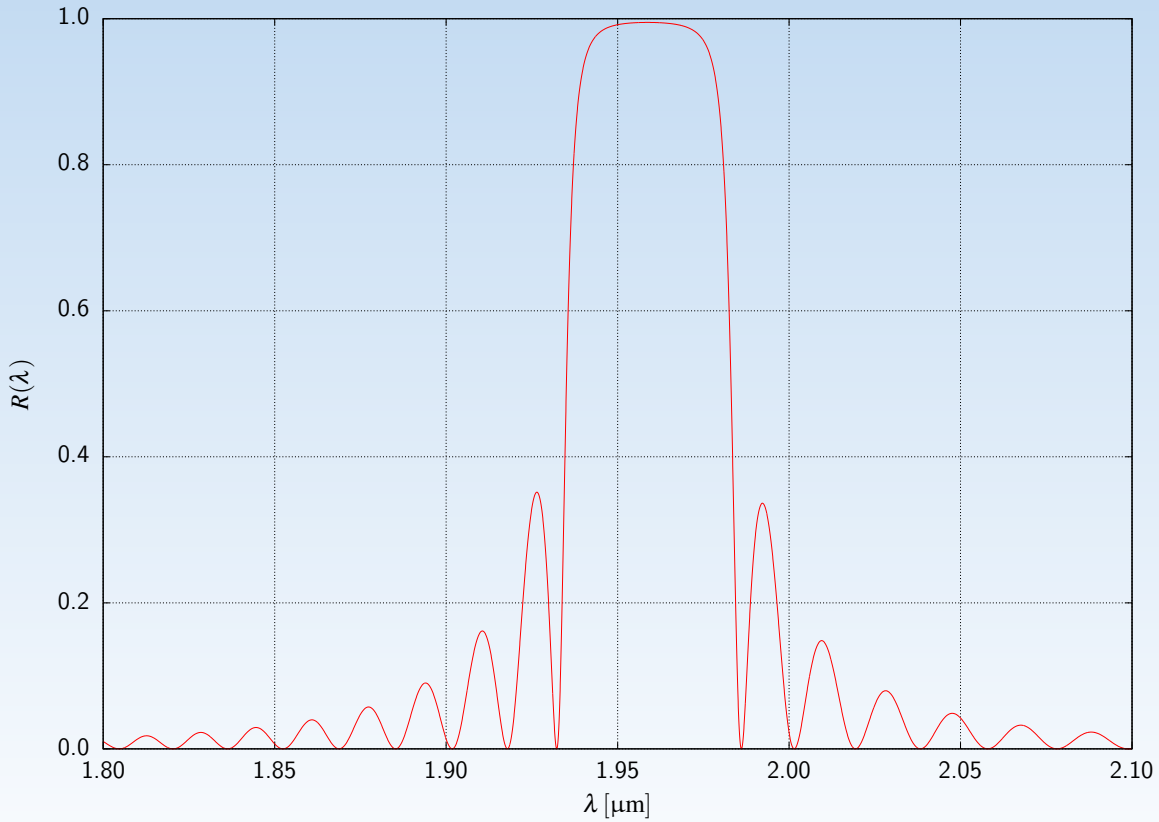


- illuminating phase mask with fs laser beam
- local change of n in core and cladding
- Δn, Λ, N

Local index modulations cause Fresnel reflections



Local index modulations cause Fresnel reflections



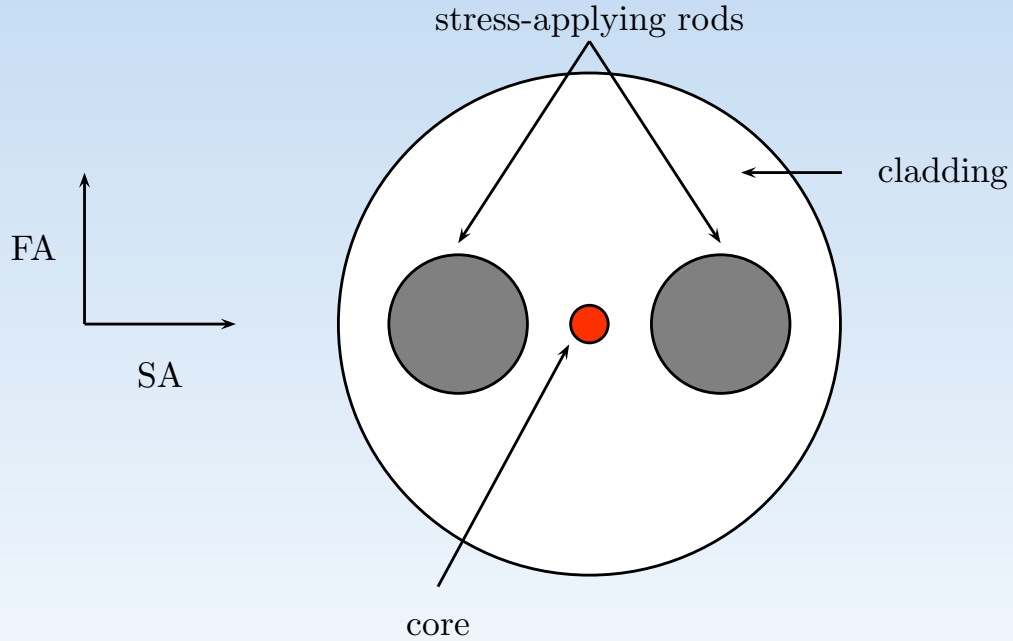
$$\uparrow \Delta n \quad \rightarrow \quad \uparrow R, \uparrow \Delta\lambda_{\mathrm{B}}$$

$$\uparrow N \quad \rightarrow \quad \uparrow R, \downarrow \Delta\lambda_{\mathrm{B}}$$

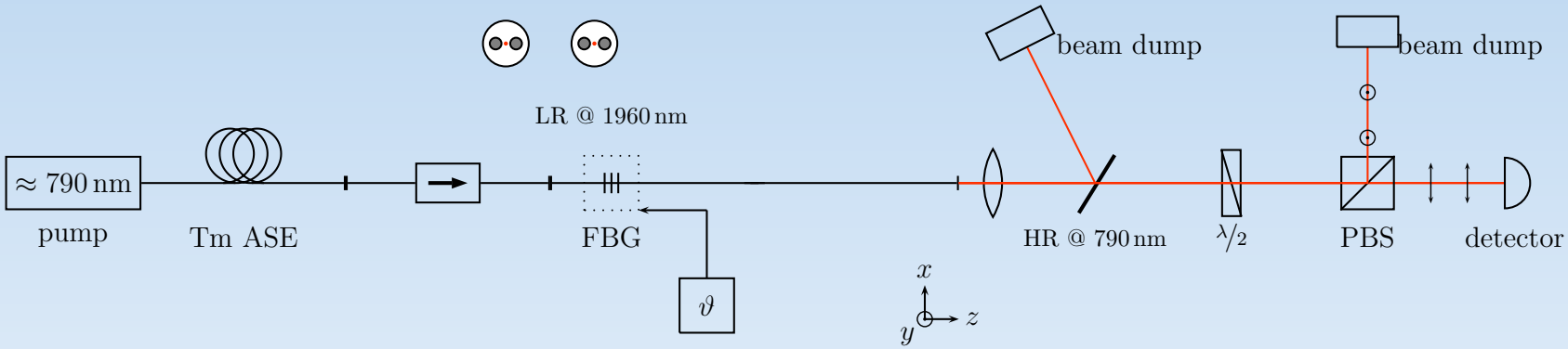
The panda

The PANDA fiber

cladding diameter 130 µm
core diameter 10 µm
rod diameter 35 µm

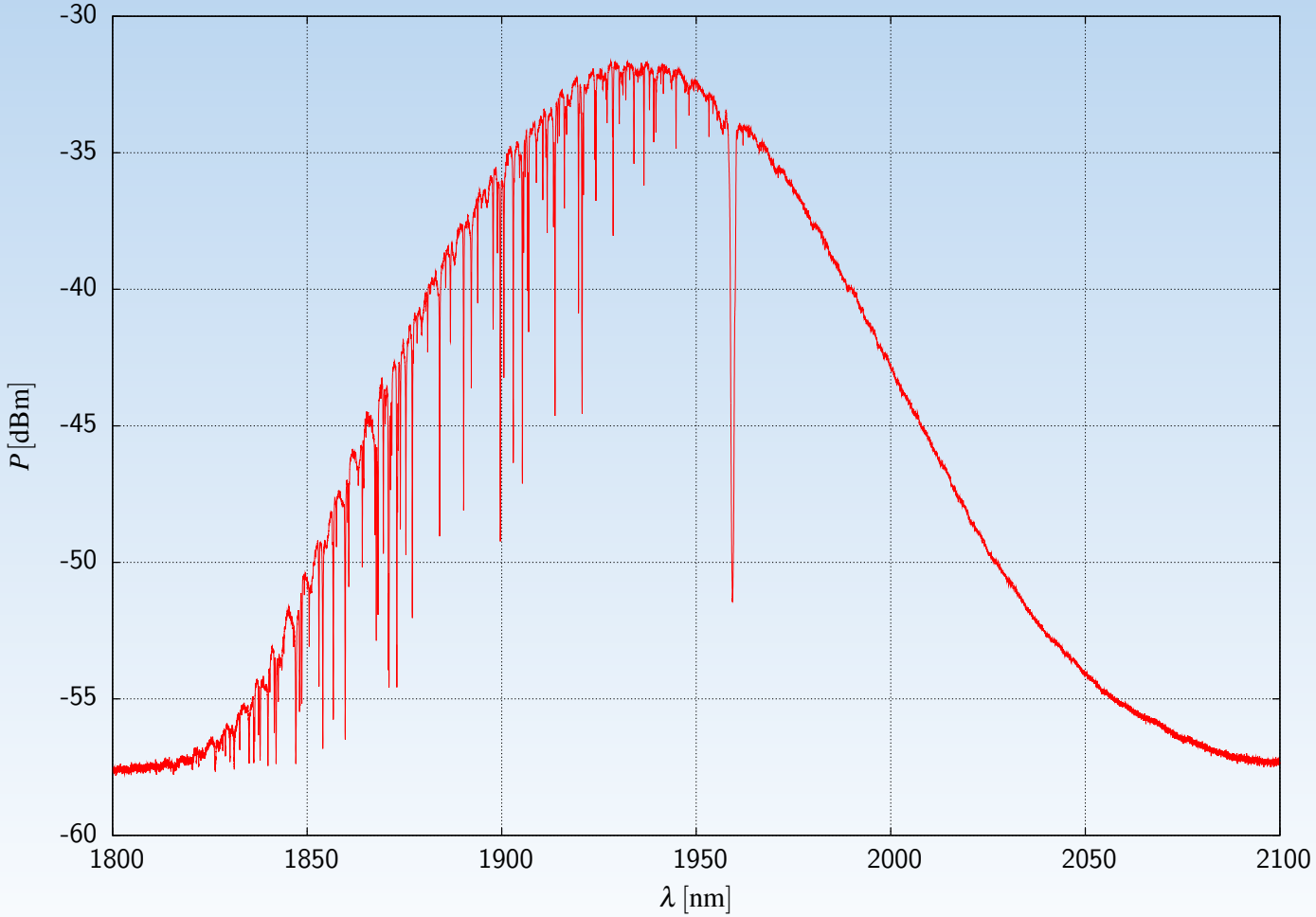


Set-up



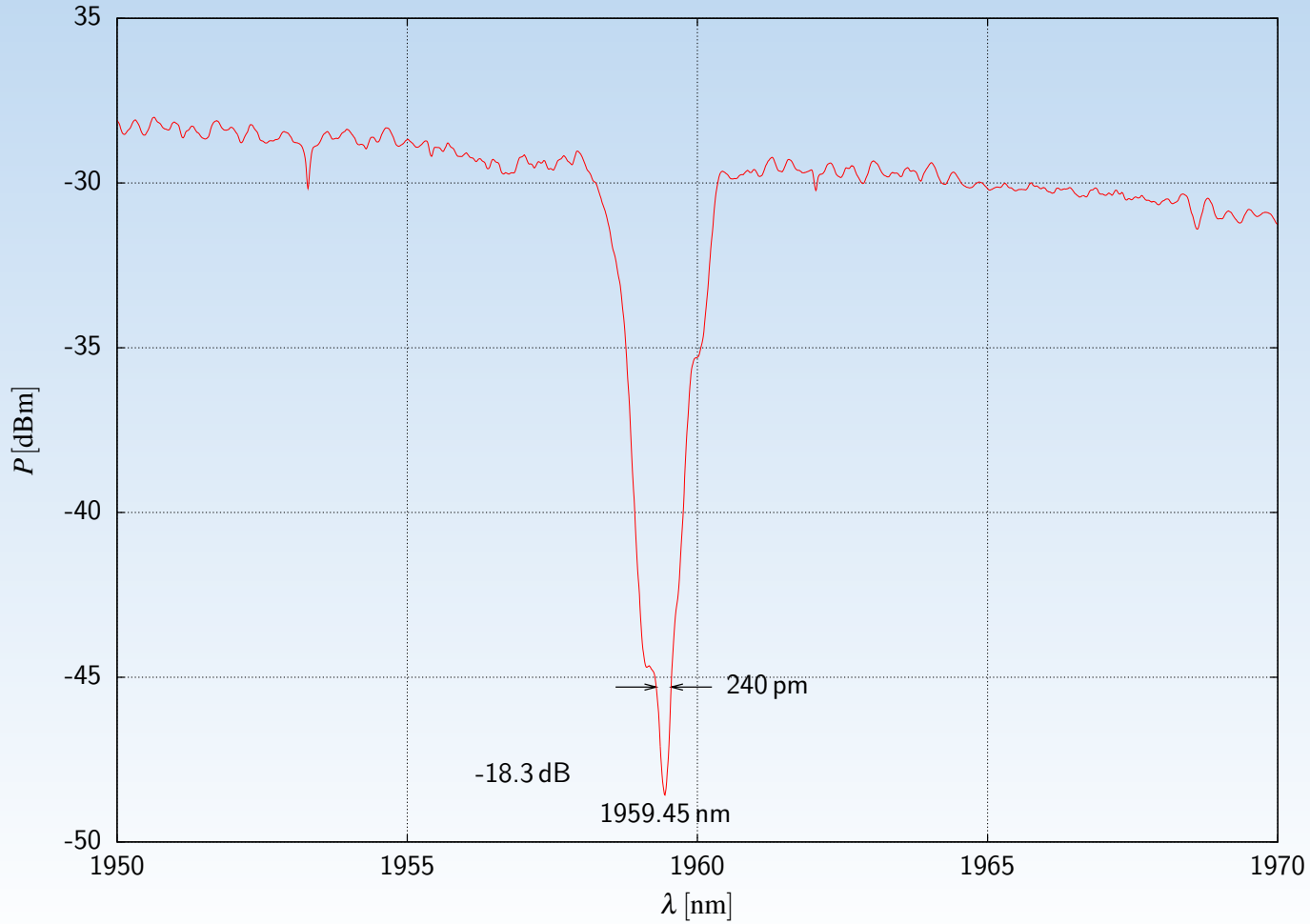
- ASE signal as optical input
- temperature control of FBG
- analysis of Bragg wavelength and tunability

Broadband Tm ASE source



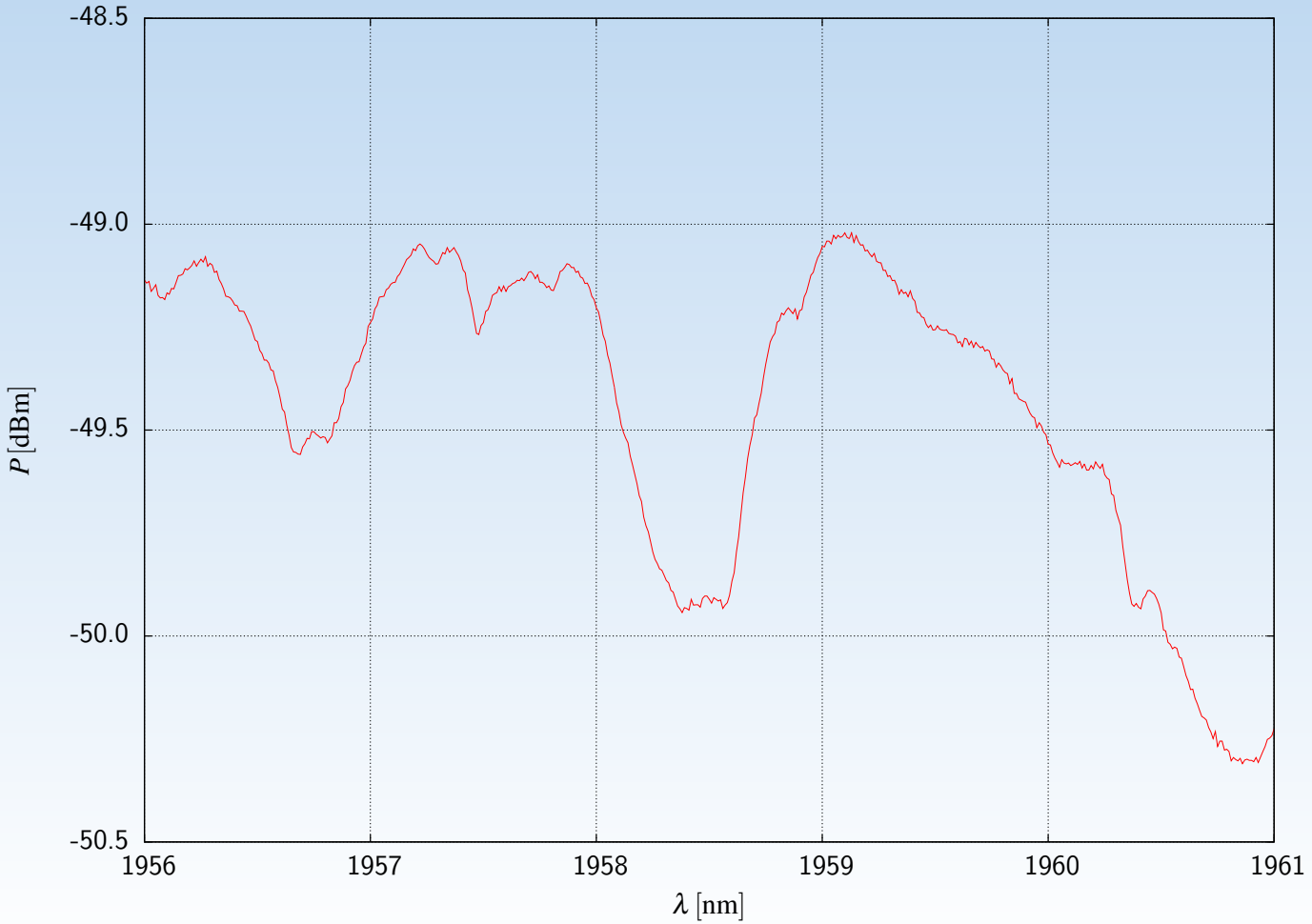
High-reflectivity FBG

Separate fiber with high-reflectivity (HR) FBG

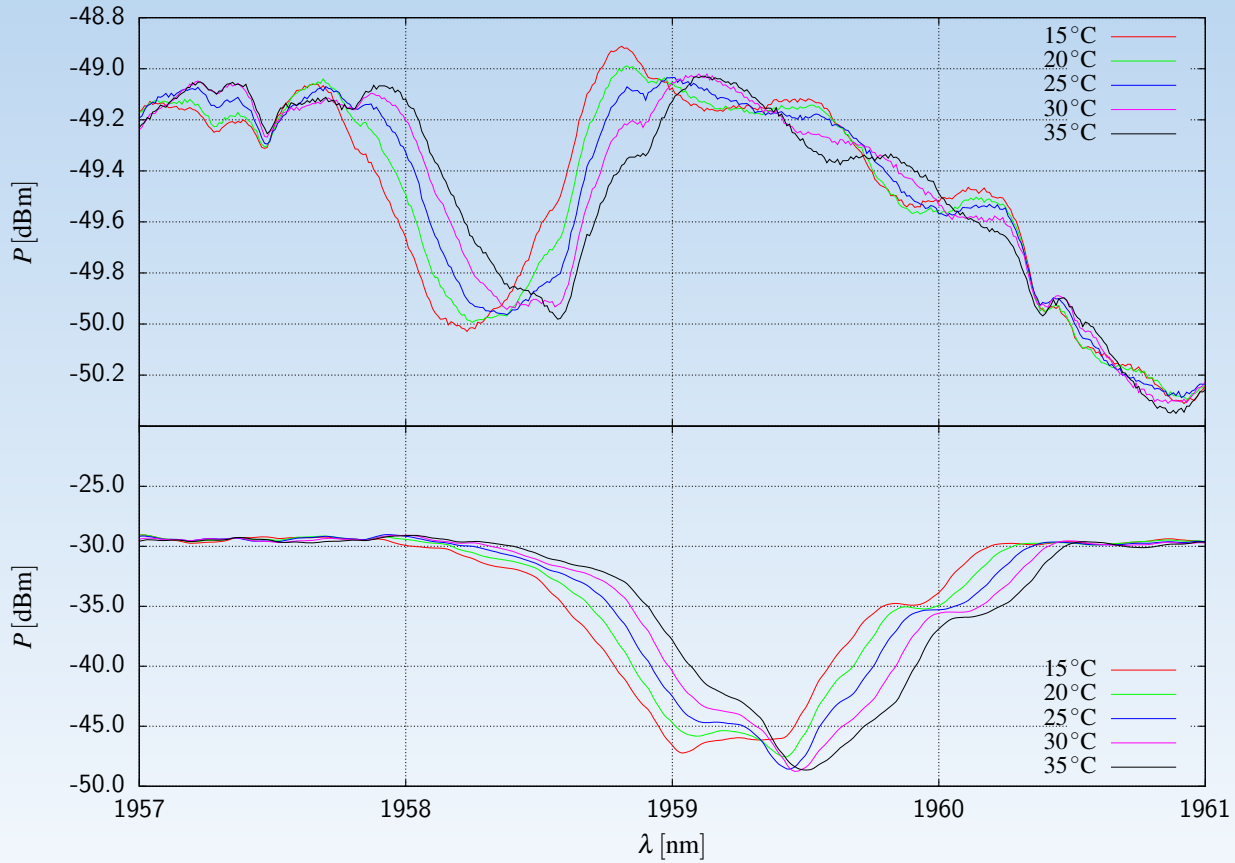


Low-reflectivity FBG

Separate fiber with low-reflectivity (LR) FBG

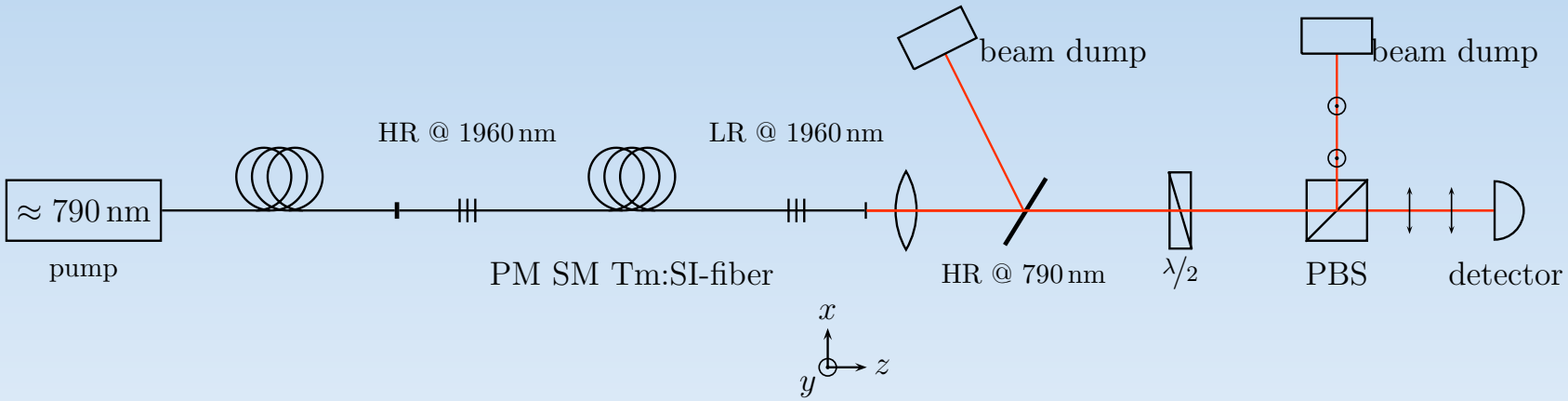


High- and low-reflectivity FBG



slope $\approx 15\,\mathrm{pm/K}$

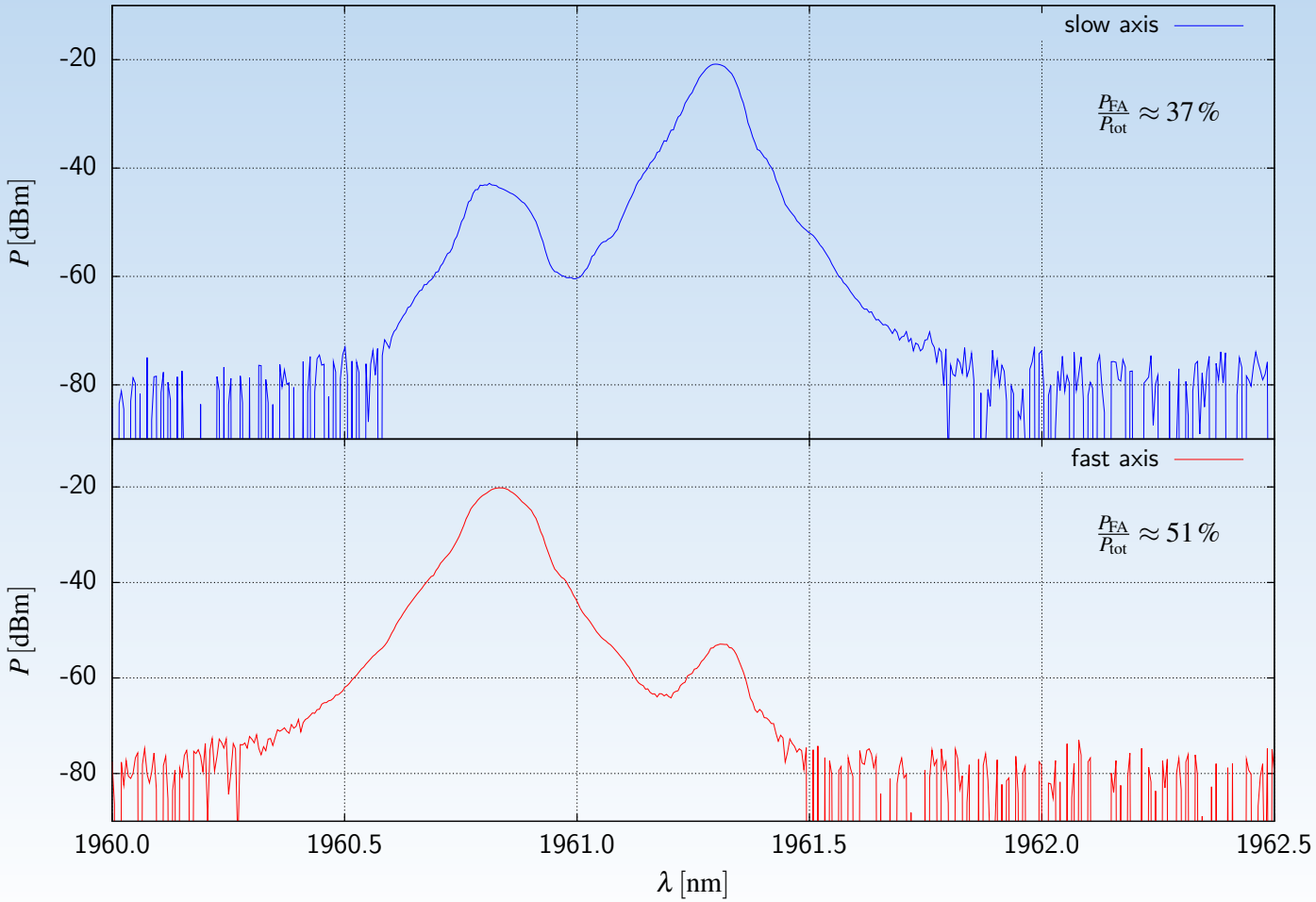
Monolithic set-up



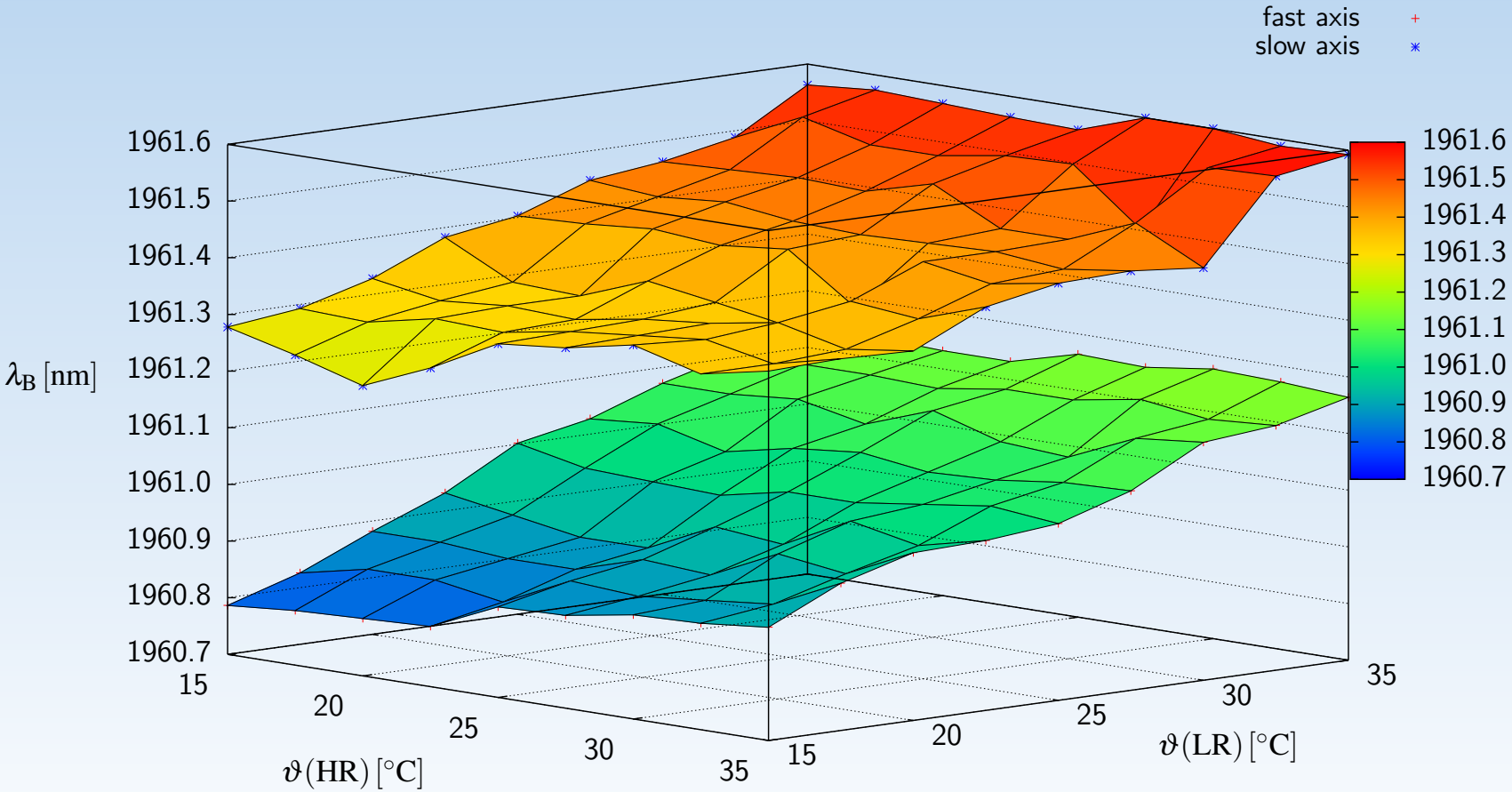
- monolithic laser with inscribed FBGs, only 1 splice required
- temperature control of both FBGs independently
- tunability and polarization

Polarized spectrum

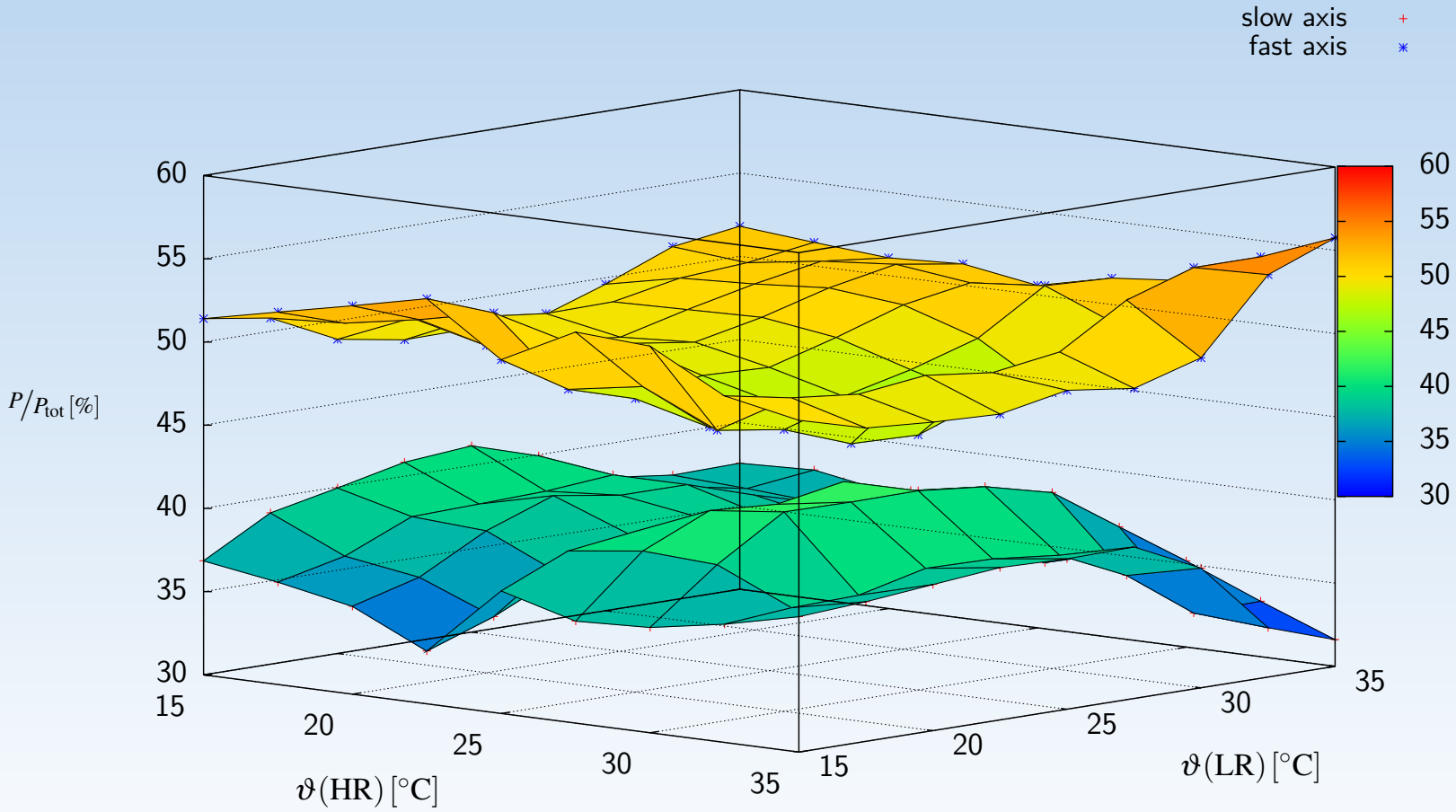
$$\lambda_B = 2 n_e \Lambda$$



Temperature tuning



Polarized output power

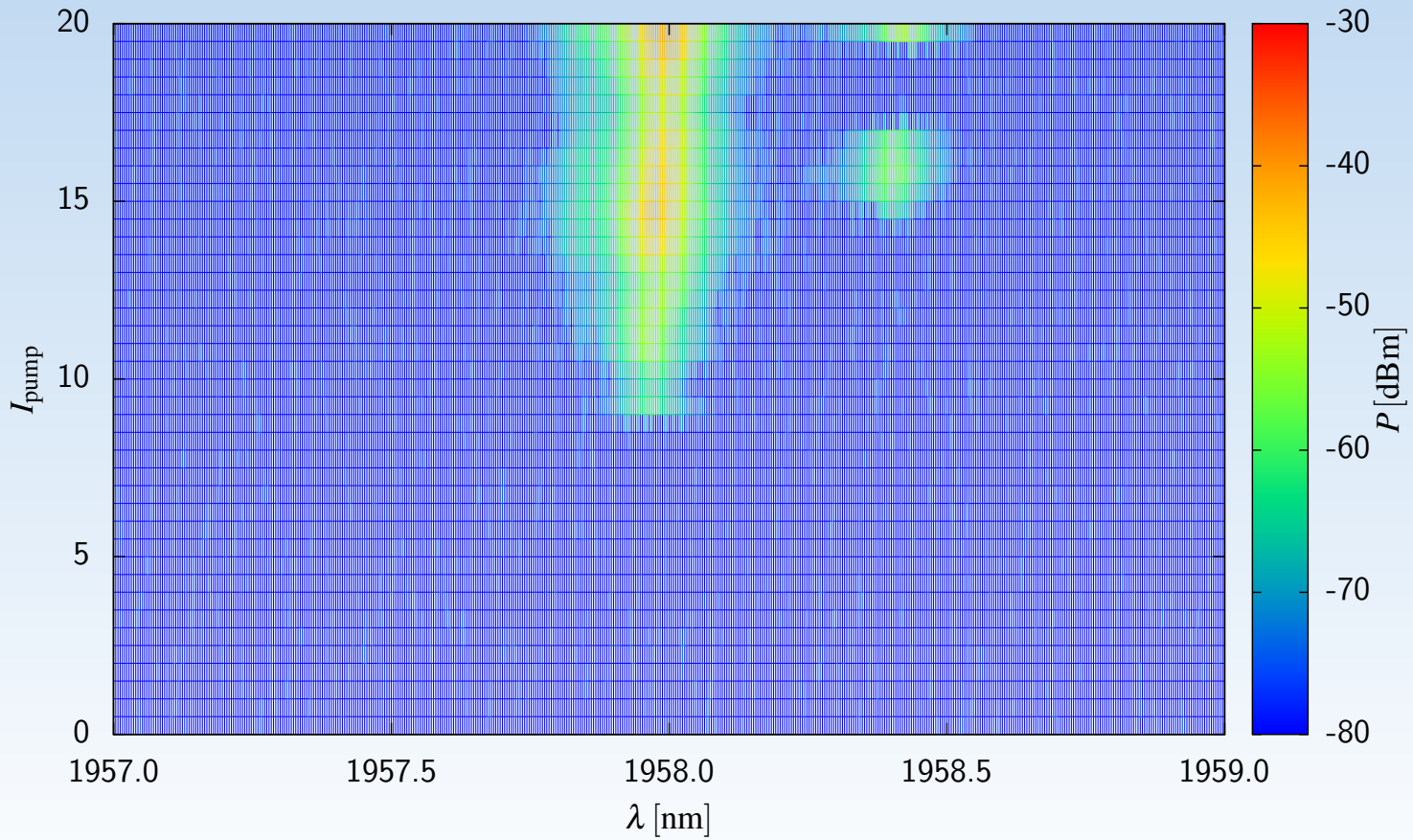


Results so far

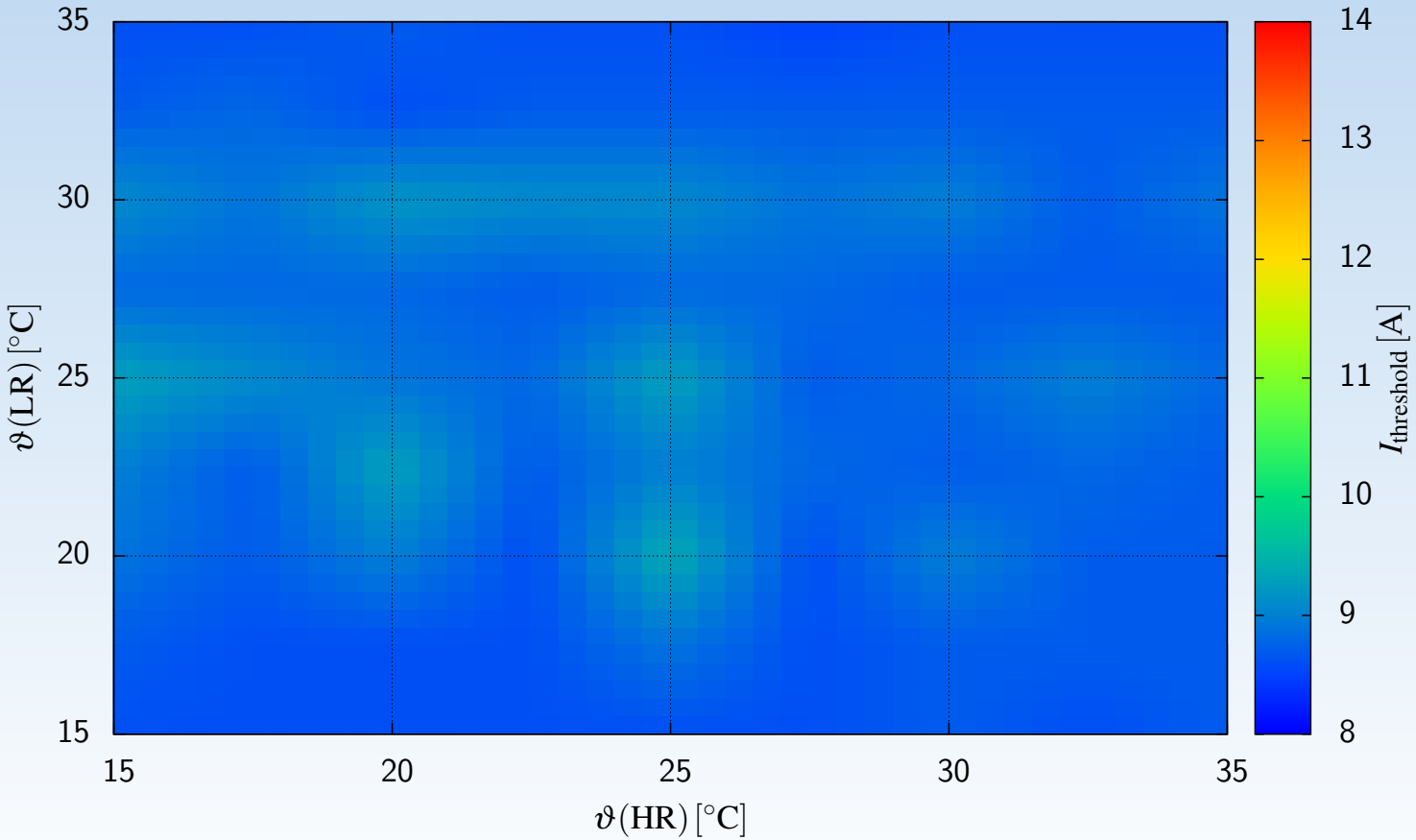
- ☑ wavelength tunable
- ☑ total output power of about 2 W
- ☑ polarization extinction ratio of up to 41 dB

- ☒ single-polarization

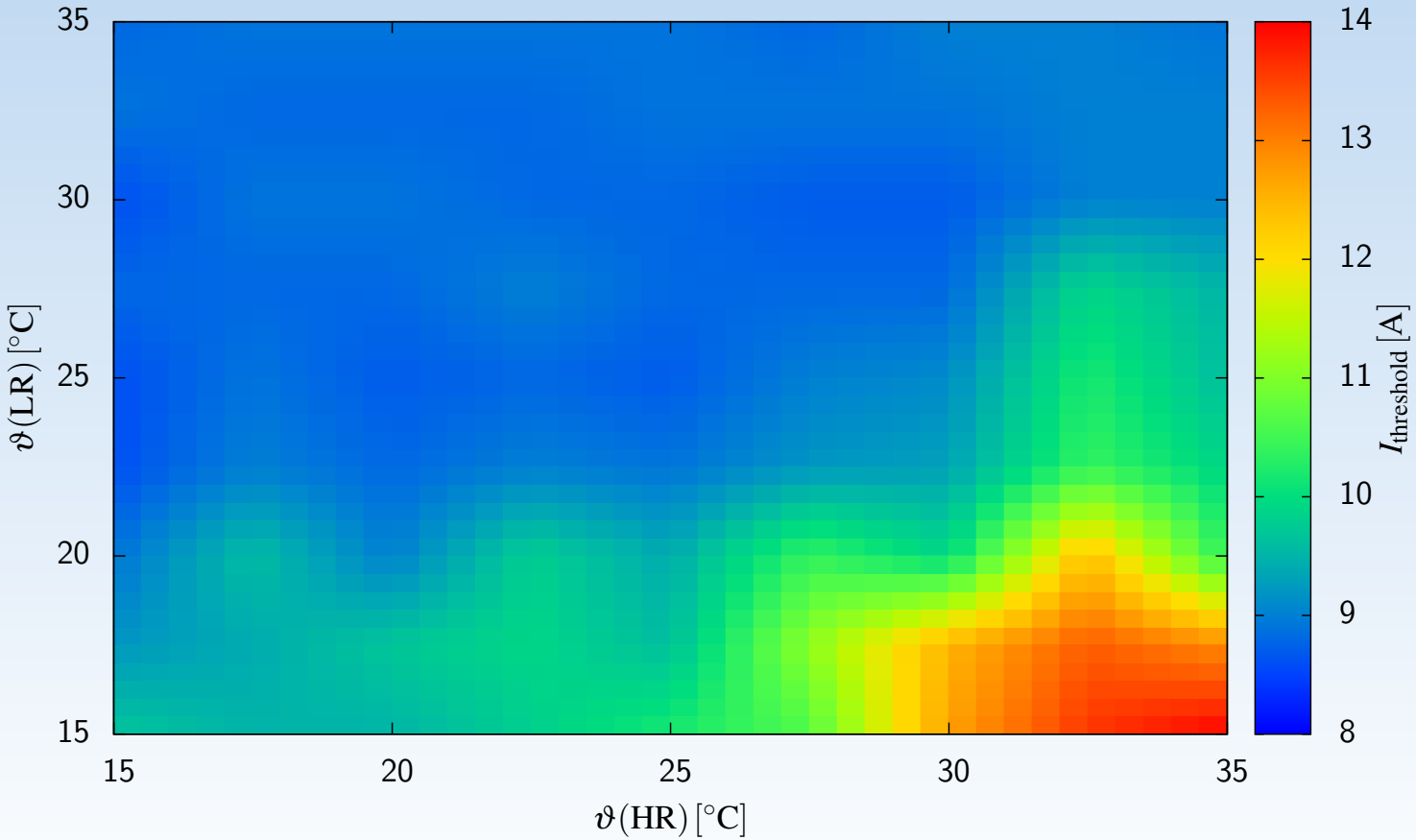
Spectrum in terms of pump power



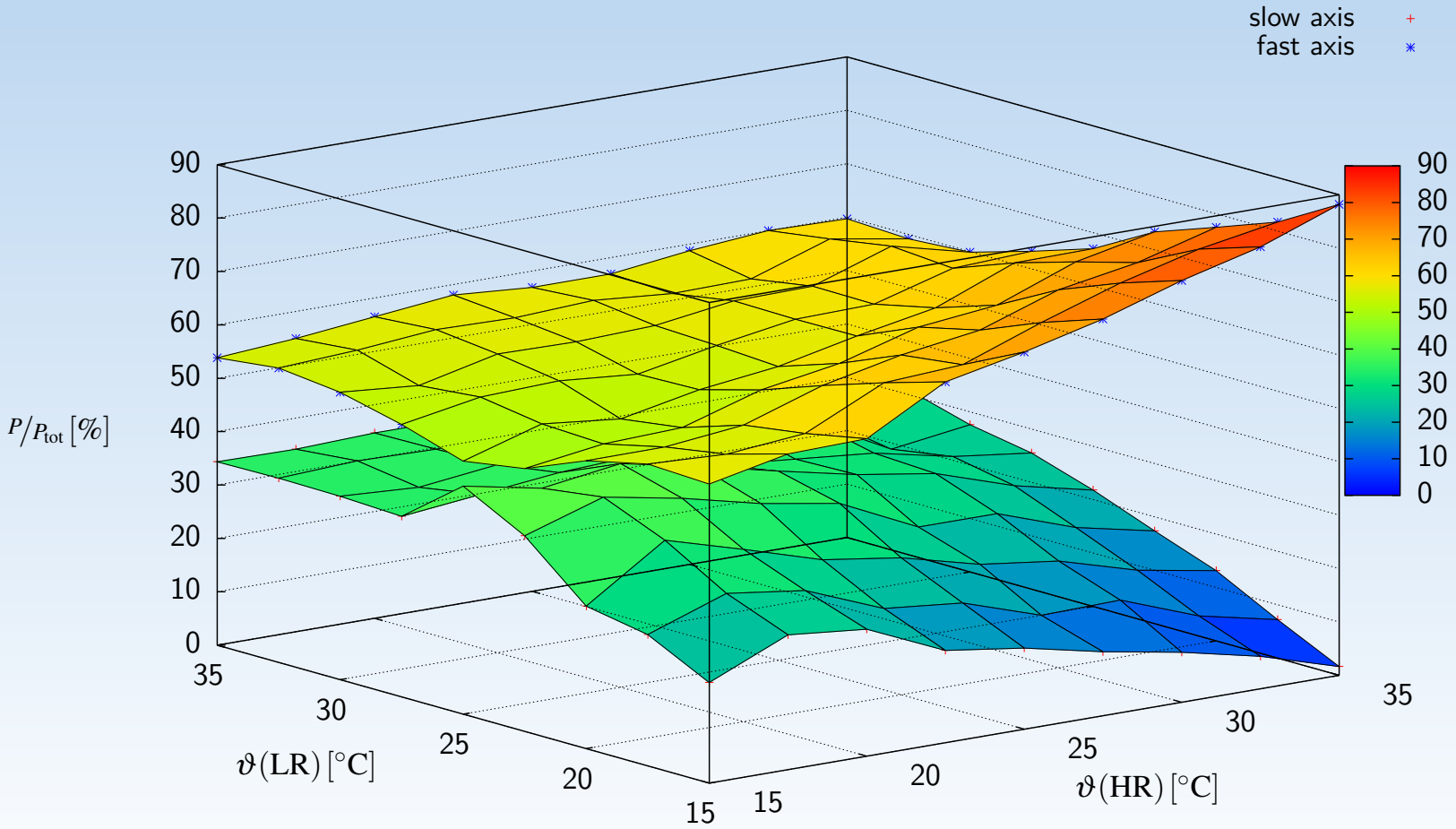
Threshold of fast axis peak



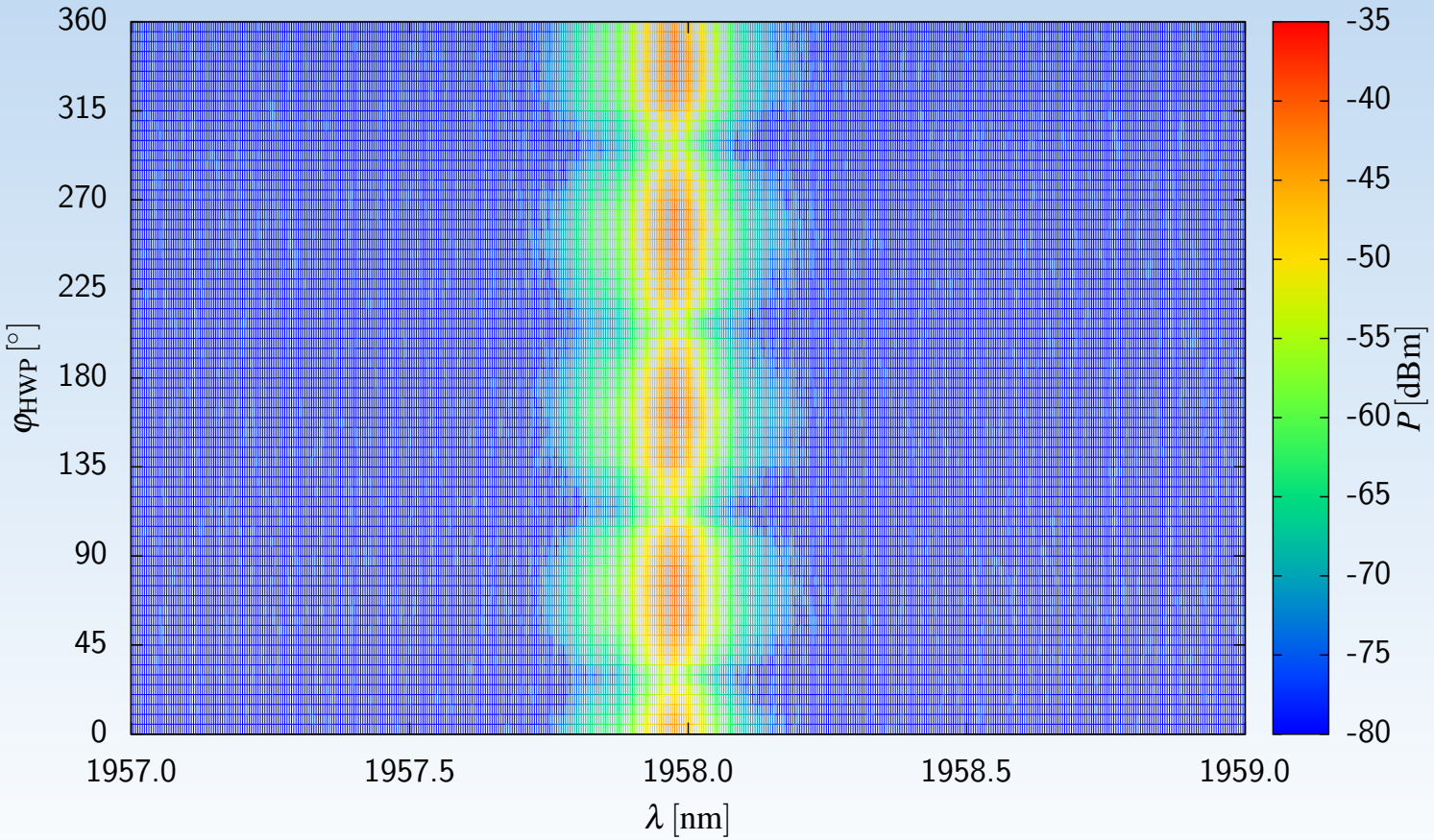
Threshold of slow axis peak



Output power

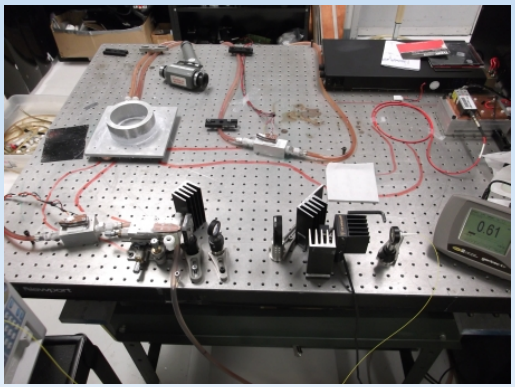


Single-polarization *possible*



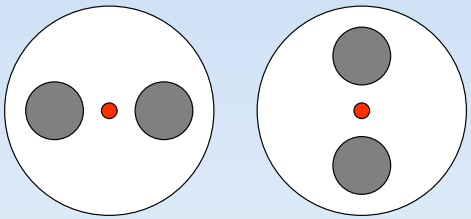
Resumée

- ☑ wavelength tunable
- ☑ total output power of about 3.5 W
- ☑ single-polarization

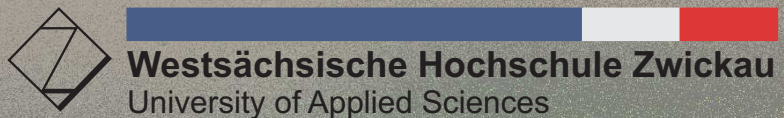


Outlook

- orthogonal splice with respect to stress rod axes
- further investigation of the splices
- thermally induced change of the stress field (stress rods)?



Thank you!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UNIVERSITY OF CENTRAL FLORIDA
1963

$$R_{\mathrm{B}}(\lambda_{\mathrm{B}}) = \frac{\sinh^2\left(\eta\Delta n\sqrt{1-\Gamma^2}N\Lambda/\lambda\right)}{\cosh^2\left(\eta\Delta n\sqrt{1-\Gamma^2}N\Lambda/\lambda\right)-\Gamma^2} \tag{1}$$

$$\lambda_{\mathrm{B}} = 2n_{\mathrm{e}}\Lambda \tag{2}$$

$$\Gamma(\lambda) = \frac{1}{\eta\Delta n}\left(\frac{\lambda}{\lambda_{\mathrm{B}}}-1\right) \tag{3}$$