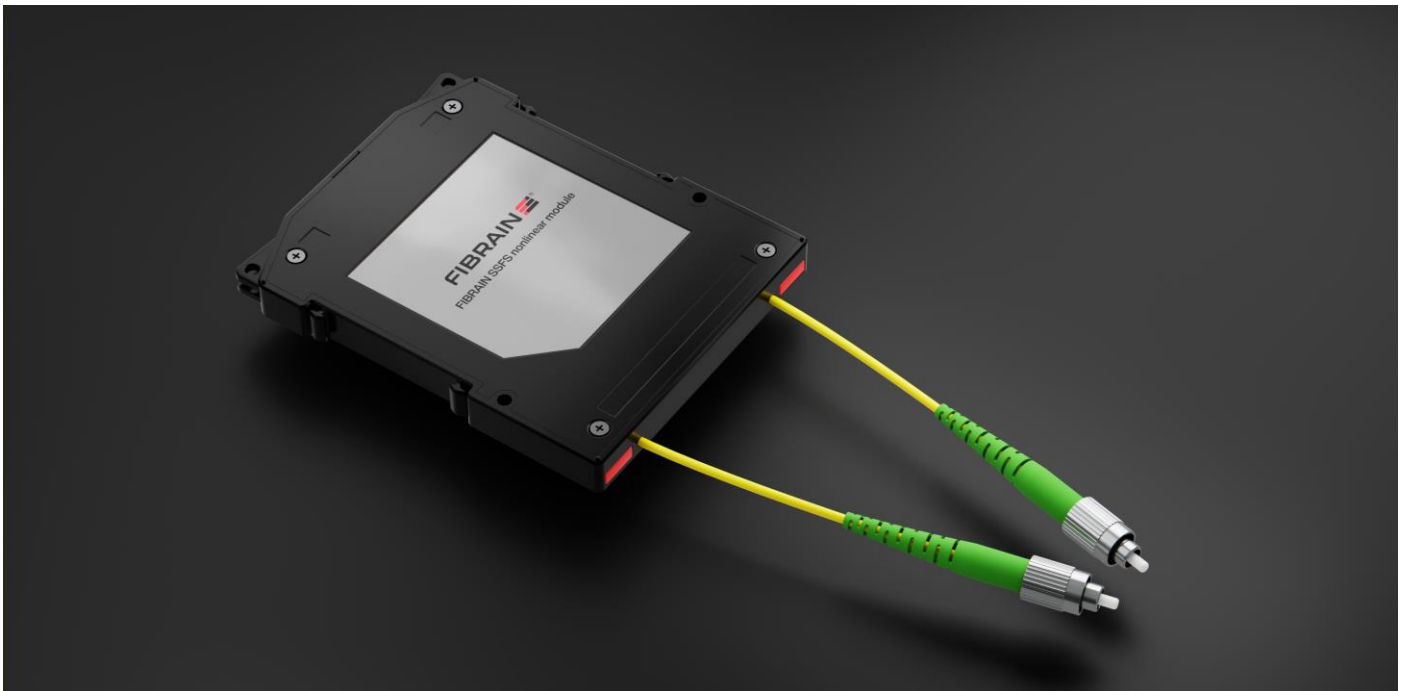


## Photonics

Passive optical nonlinear module for spectral shifting of solitons, 1550-2100 nm



### INTRODUCTION:

Nonlinear optical fiber modules for spectral shifting of femtosecond solitons utilize the phenomenon of soliton self-frequency shift (SSFS). They allow wavelength tuning of femtosecond lasers in the near-infrared range. Typically, a soliton from a fixed wavelength erbium femtosecond source can be tuned from the 1550 nm range up to 2100 nm wavelength. The output wavelength is easily tuned by changing the input optical power. Wavelength-shifted output signal maintains coherence and linear polarization. The modules are fully plug&play. They are passive and require only connecting to the laser source output port.

### APPLICATIONS:

Extending capabilities of femtosecond lasers  
 Nonlinear microscopies, multiphoton microscopy  
 Nonlinear spectroscopies, e.g. CARS  
 Sensing, gas detection  
 Frequency and dual-frequency comb generation  
 Biomedical (e.g. deep-tissue imaging, virtual biopsy)  
 Laboratory experiments  
 Selective ablation

### FEATURES AND ADVANTAGES:

Easily tunable output wavelength  
 Wide tunability range and continuous, no-gaps tuning  
 Preservation of input pulses state of polarization  
 Preservation of input pulses coherence  
 High conversion efficiency  
 Minimum chirp introduced  
 Low loss

### TECHNICAL SPECIFICATION:

Parameter	Unit	Value
Input Wavelength Range	nm	1500-2100
Typ. Input Wavelength Range	nm	~1550, ~1950
Typ. Input Pulse Duration	fs	<300 <sup>1</sup>
Wavelength Shift Range	nm	up to 2100 <sup>2,3</sup>
Typ. Conversion Efficiency	%	55 <sup>2</sup>
Min. Polarization Extinction Ratio	dB	18 <sup>2</sup>

**Photonics**

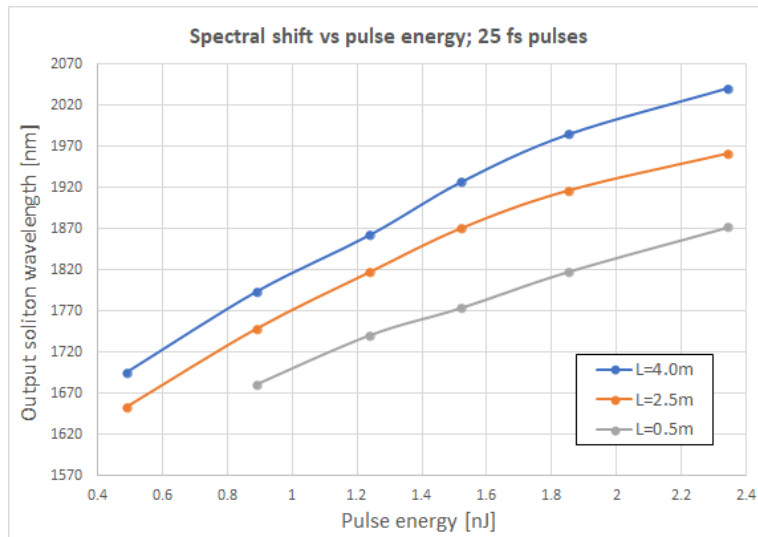
Min. Coherence	%	90 <sup>2</sup>
Max. Linear Insertion Loss	dB	1.5
Default PM connector alignment		Slow axis <sup>4</sup>
Standard connector type		FC APC <sup>4</sup>
Operating Temperature	°C	-10/+65

- <sup>1</sup> Efficiency of SSFS depends significantly on the pulse width
- <sup>2</sup> Dependent on specifics of the input solitons,
- <sup>3</sup> Dependent on nonlinear fiber length, less for shorter modules
- <sup>4</sup> Other types on request

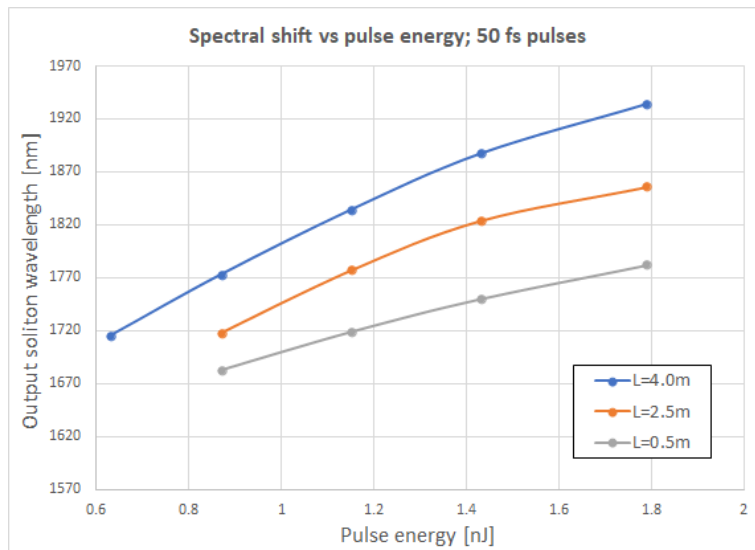
**EXPERIMENTAL DATA:**

The efficiency of the SSFS depends on a number of characteristics of the input pulses, chiefly among them on the pulse duration and energy. There are however also other characteristics, like for example pulse shape, coherence, polarization state and polarization stability or chirp which may impact on the observable wavelength-shifting efficiency. Therefore the below data has been measured for a given seed laser configuration. Although the results are representative, the exact performance with other light sources has to be experimentally determined.

Typical wavelength-tuning characteristics, dependence on the input pulse energy, 25 fs input pulses, for 3 different nonlinear fiber lengths:

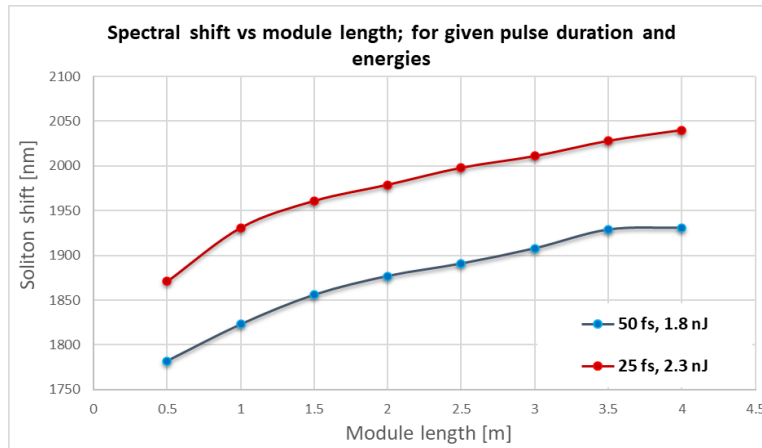


Typical wavelength-tuning characteristics, dependence on the input pulse energy, 50 fs input pulses, for 3 different nonlinear fiber lengths:

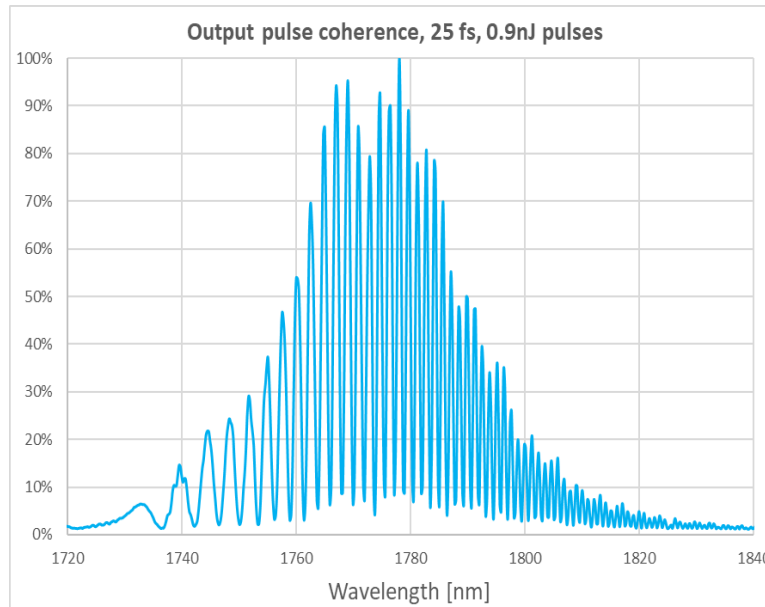


**Photonics**

Typical wavelength-tuning characteristics, dependence on nonlinear fiber length, for 25 fs and 50 fs pulses:



Typical output solitons coherence characteristics, for 25 fs pulses:



**REFERENCE SYSTEM:**

Series	Input fiber type	Input fiber length	Seed wavelength	Nonlinear fiber length	Output fiber type	Output fiber length	Cable type	Packaging options	Input connector	Output connector
SSFS-G0	10 - PM 1310	10 - 10 cm	10 - 1030 nm	050 - 50 cm	10 - PM 1310	10 - 10 cm	25 - 250 um	P - patchcord	XX - no con	XX - no con
	11 - PM 1550	20 - 20 cm	15 - 1550 nm	100 - 100 cm	11 - PM 1550	20 - 20 cm	90 - 900 um	2 - ABS 100x80x10 mm	FC3 - FCA slow axis	FC3 - FCA slow axis
	15 - PM 1950	...			15 - PM 1950		20 - 2.0 mm	3 - ABS 120x80x18 mm	FC4 - FCA fast axis	FC4 - FCA fast axis

Ordering example:

SSFS-G0-11-20-15-200-15-30-20-P-XX-FC3: Nonlinear SSFS module, for 1550nm seed, input pigtail Panda 1550 nm, 20 cm, no connector, nonlinear fiber length 200 cm, output pigtail Panda 1550 nm, 30 cm, FC APC slow axis alignment, 2.0 mm patchcord-type

Important notice

Buyer and/or user of this product has to make sure before using this product that it is suitable for the intended use. All questions of liability relating to this product are subject – in accordance with the prevailing – to the Terms of Sales of the selling Fibrain subsidiary.