Quest for Designing the Perfect Ultrafast Fiber Laser Power Amplifier

Jacek Sobków, Tomasz M. Kardaś

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European Funds Smart Growth

Republic of Poland

NCBR National Centre for Research and Development

European Union European Regional Development Fund

About Fluence

2003 — 2016 — 2024

13 YEARS OF PRE-COMMERCIAL TECHNOLOGY DEVELOPMENT

8 YEARS OF CORPORATE EXPERIENCE

- Femtosecond laser manufacturer
- Unique all-fiber technology, perfected since 2003
- Founded in 2016*

  * Leveraging 13 years of fs product and application development in academia
- High power, industrial-grade lasers for materials microprocessing, research and medicine

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Warsaw HQ - High Production Standards

Think ahead

- ✓ Cleanroom assembly environment
- ✓ Quality Control
- ✓ Standardized procedures
- ✓ Customization expertise
- ✓ Remote service capabilities

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Wrocław – Ultrafast Laser Application Laboratory (ULAL)

Hands on experience that we share

- ✓ Laser demonstration
- ✓ Process demonstration
- ✓ Process development
- ✓ Micromachining consultation
- ✓ Integration support

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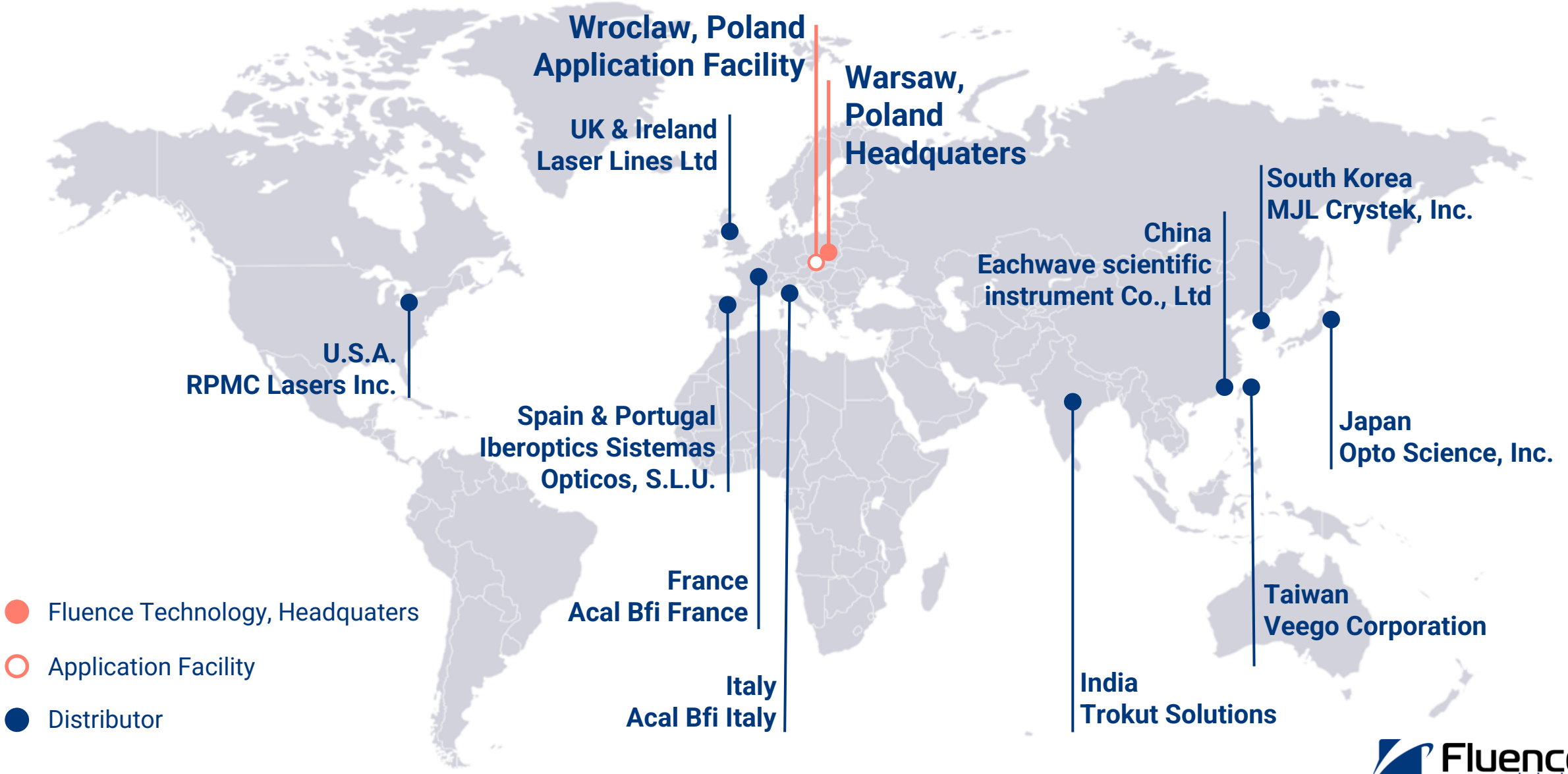
Our Presence Worldwide



FEMTOSECOND FIBER LASERS: BASIC PRODUCT PORFOLIO

5 YEAR WARRANTY on the Oscillator

Halite
All-Fiber Amplified Femtosecond Oscillator

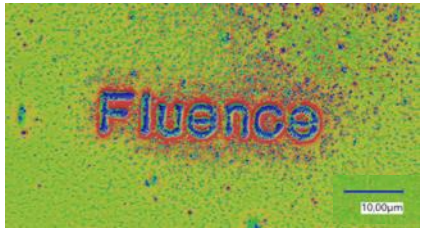
2 W
100 nJ
100 fs

- ✓ 2 photon polymerization
- ✓ 2-photon imaging
- ✓ Optogenetics

NEW

Jasper Micro
Compact Femtosecond Fiber Laser

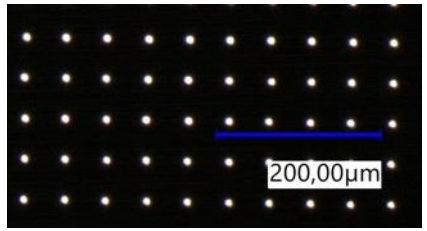
7 W
5 µJ



- ✓ Marking
- ✓ Ophthalmology
- ✓ OEM integration

Jasper Flex
Compact High Power Femtosecond Fiber Laser

30 W
30 µJ



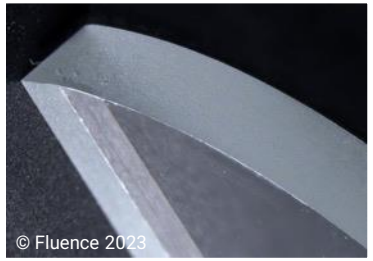
- ✓ Micromachining
- ✓ Surface structuring
- ✓ Waveguide writing

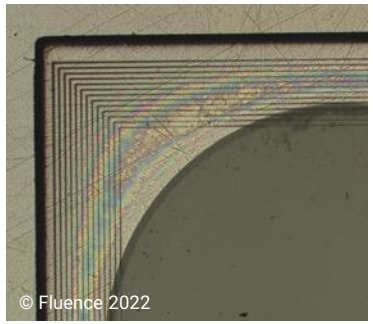
Jasper X0
High Power Femtosecond Fiber Laser

HGM
Harmonic Generation Module

Average power: **60 W** (100 W)
Max. Energy: **200 µJ**
Max. Peak Power: **~1 GW**
Pulse duration: **<270 fs – 20 ps***
HGM wavelengths: **515, 343, 258 nm**

Most powerful and versatile





Quest for Designing the Perfect Ultrafast Fiber Laser Power Amplifier

Challenges

1. nonlinear effects
2. destruction due to average pump power
3. thermal effects
4. limited knowledge on fiber parameters

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$$B \sim \int_0^L n_2 I(z)\, dz \qquad I = \frac{E}{S\,\Delta t}$$

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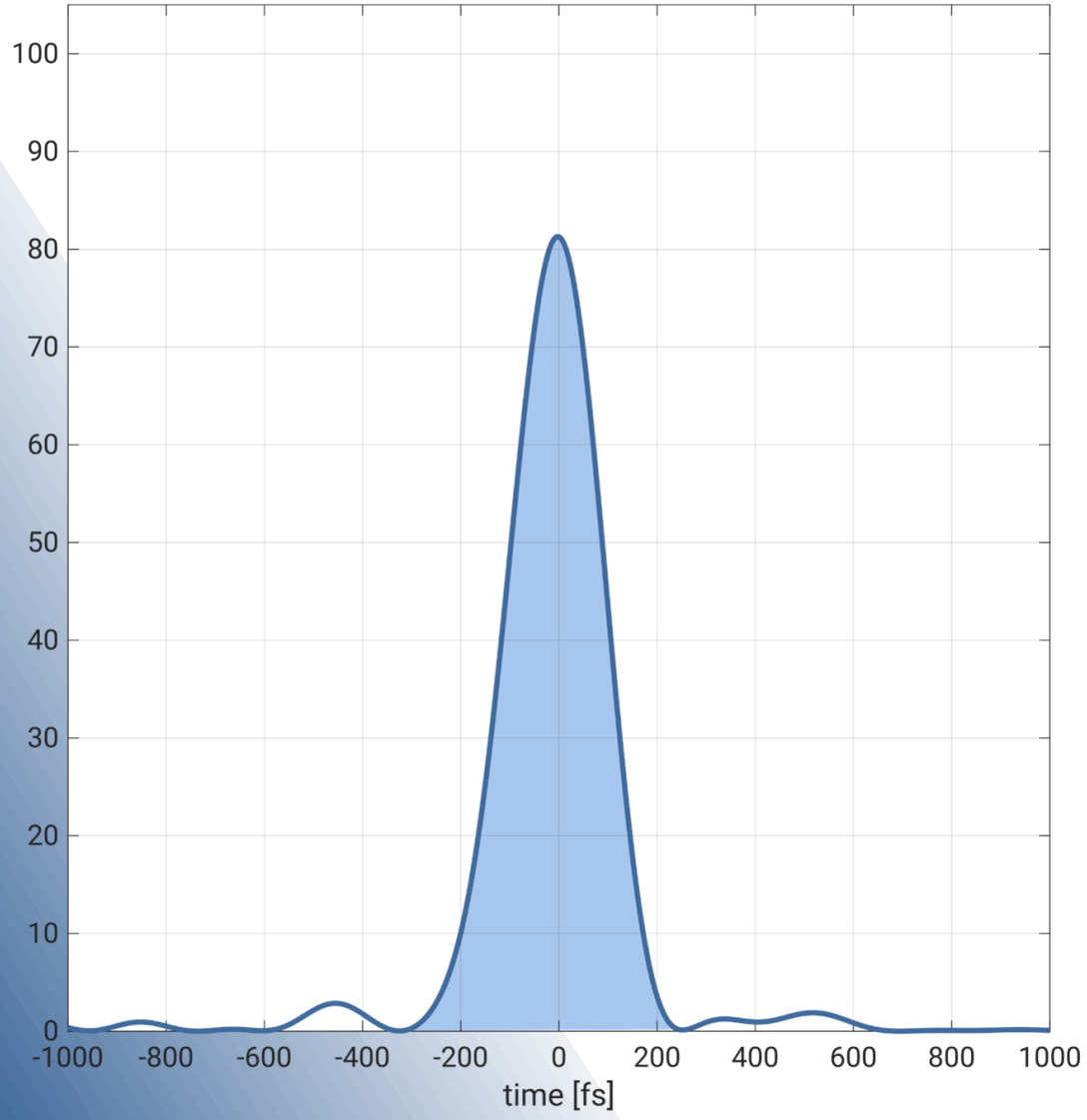
QUALITY OF FEMTOSECOND PULSE



Energy within peak

How much energy is concentrated within the main peak of the pulse

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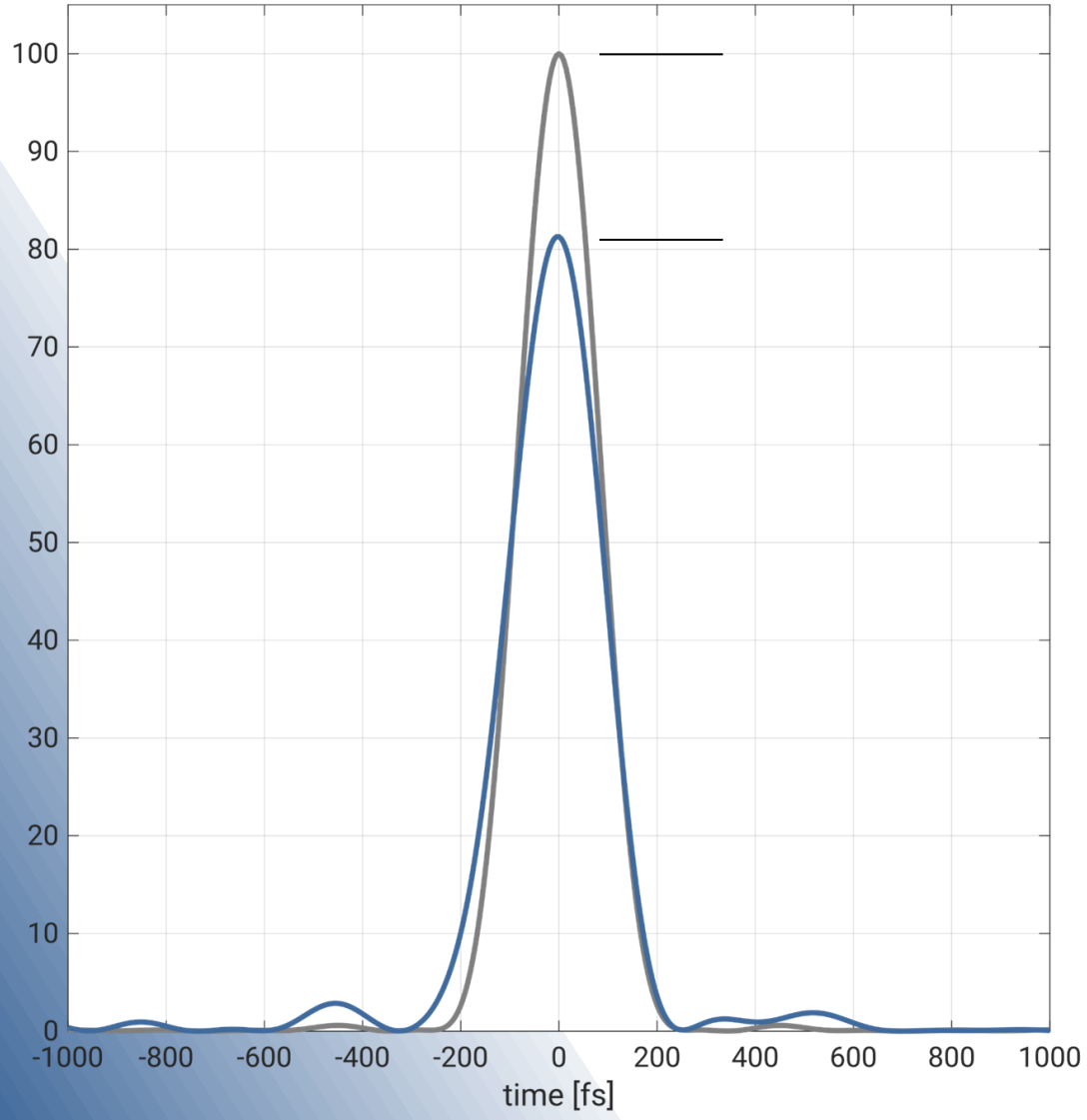

Energy within peak

How much energy is concentrated within the main peak of the pulse

Strehl ratio

How short is the pulse with respect to Fourier limited pulse with the same spectrum

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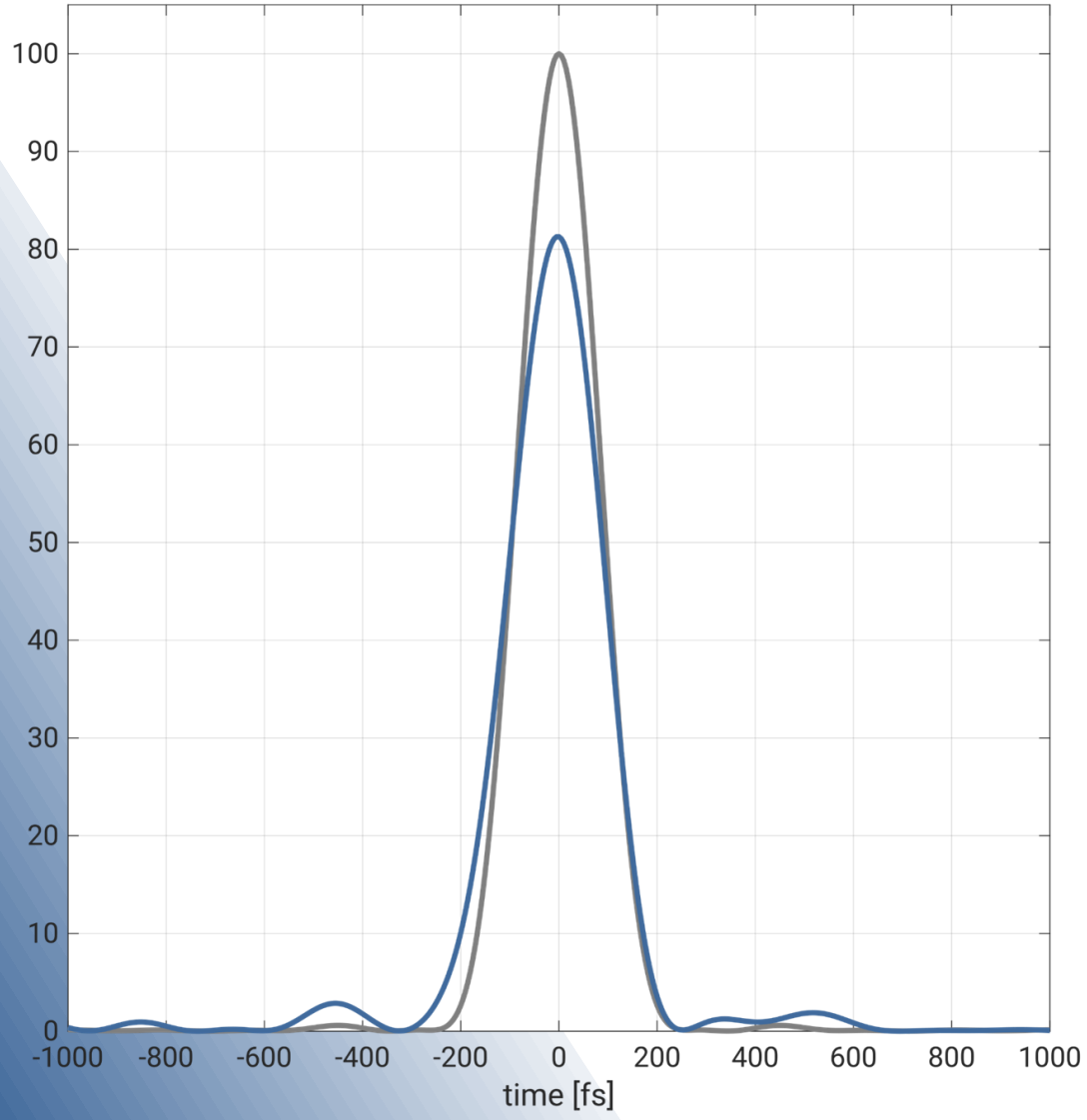

Energy within peak

How much energy is concentrated within the main peak of the pulse

Strehl ratio

How short is the pulse with respect to Fourier limited pulse with the same spectrum

Efficiency of SHG

How much of the pulse energy can be converted into second harmonic

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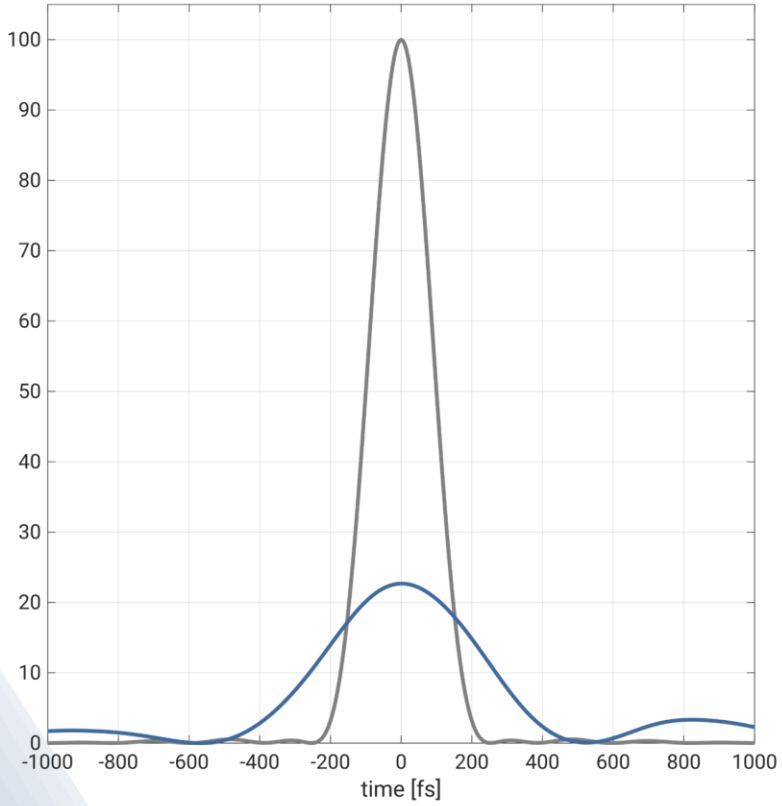

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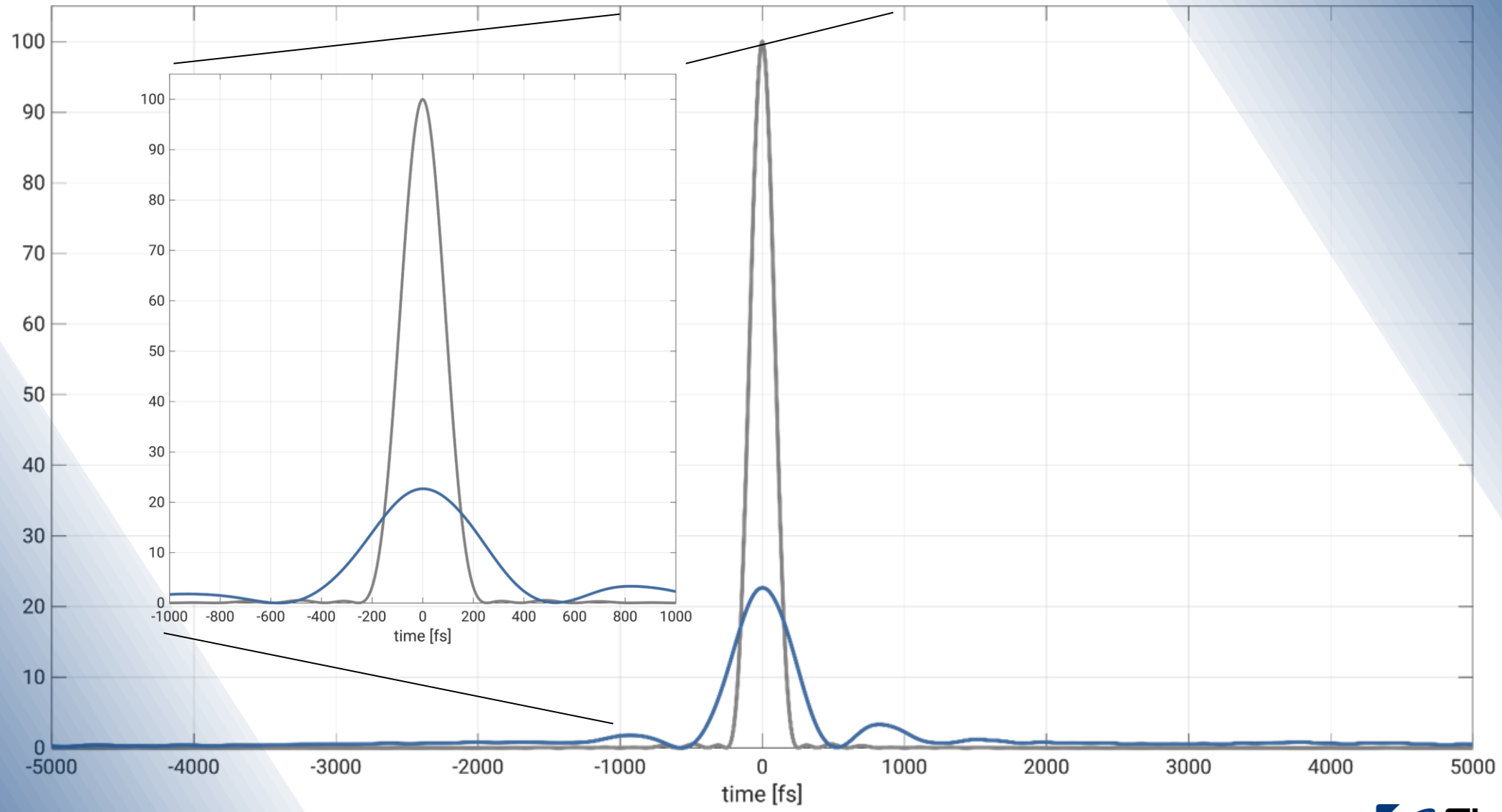
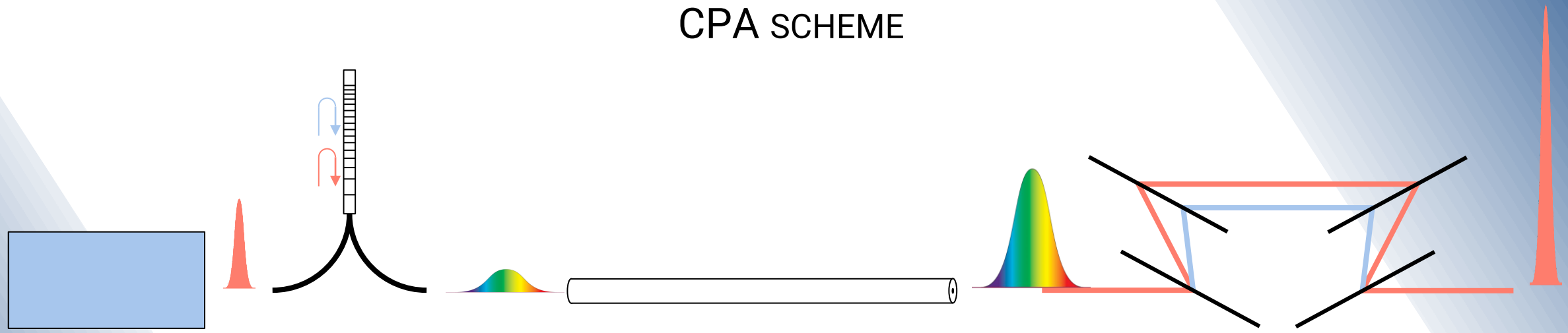


FEMTOSECOND LASER

CPA SCHEME

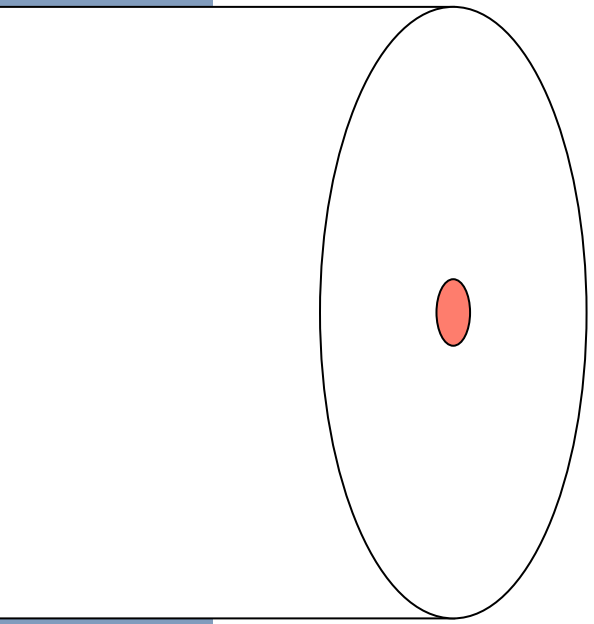


oscillator stretcher amplifier compressor

$$I = \frac{E}{S\,\Delta t}$$

PERFECT FIBER

LARGE MODE AREA - BUT FEW MODES



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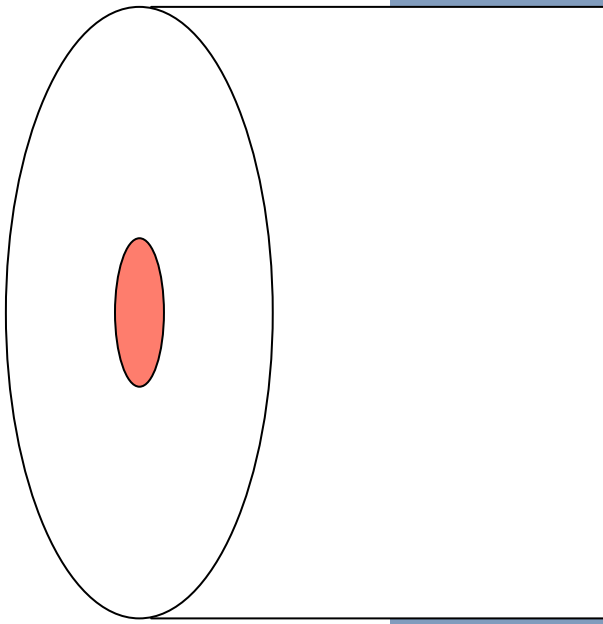
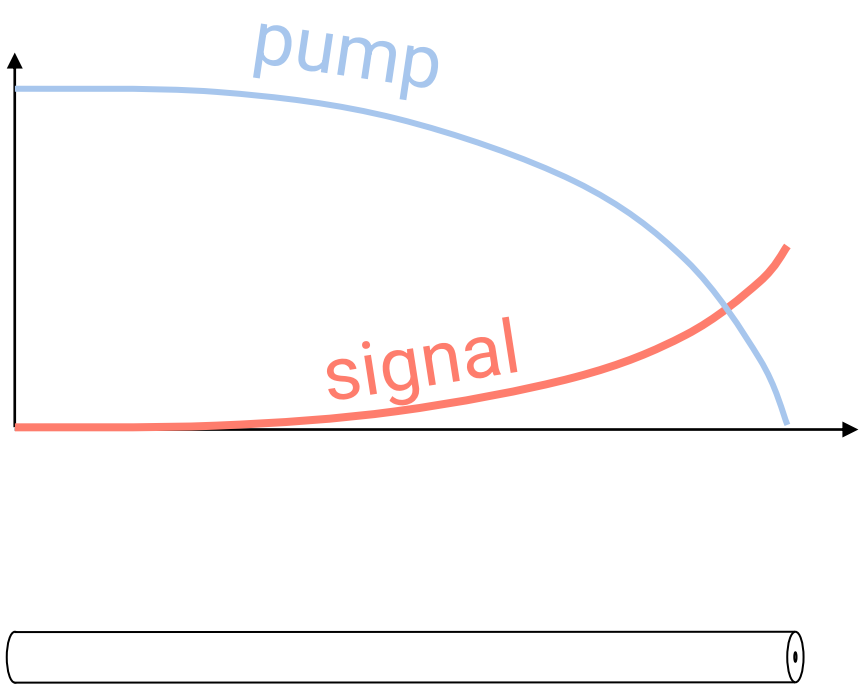
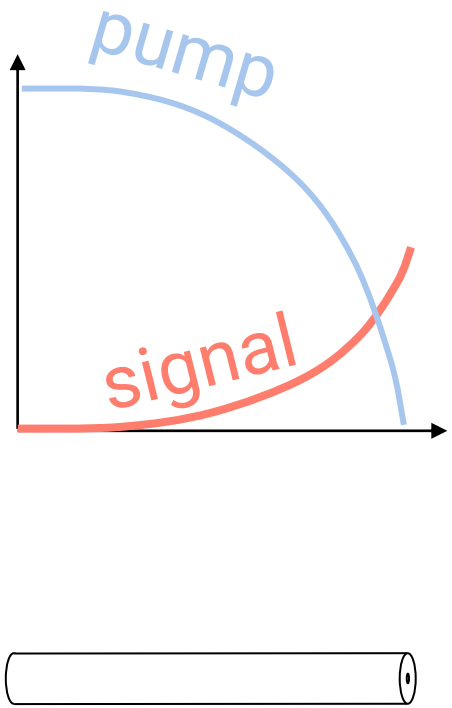


PERFECT FIBER

HIGH ION CONCENTRATION

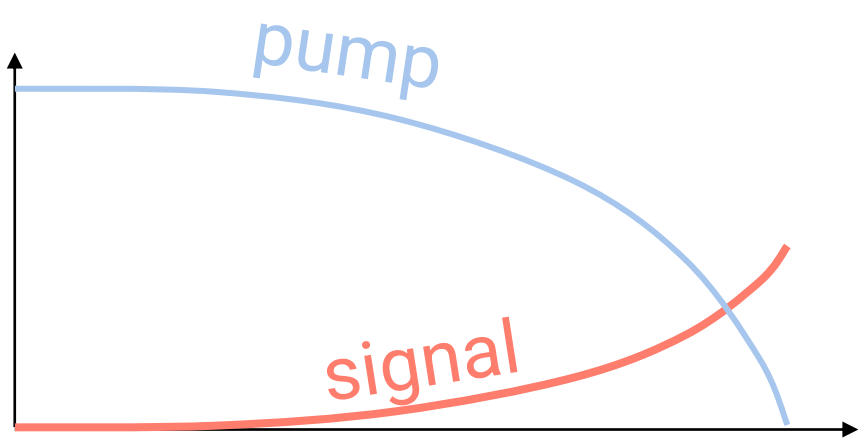


$$B \sim \int_0^L n_2 I(z)\, dz$$



PERFECT FIBER

LARGE CORE / CLAD SIZE RATIO



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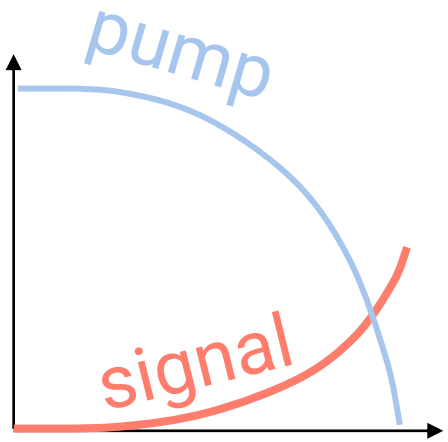
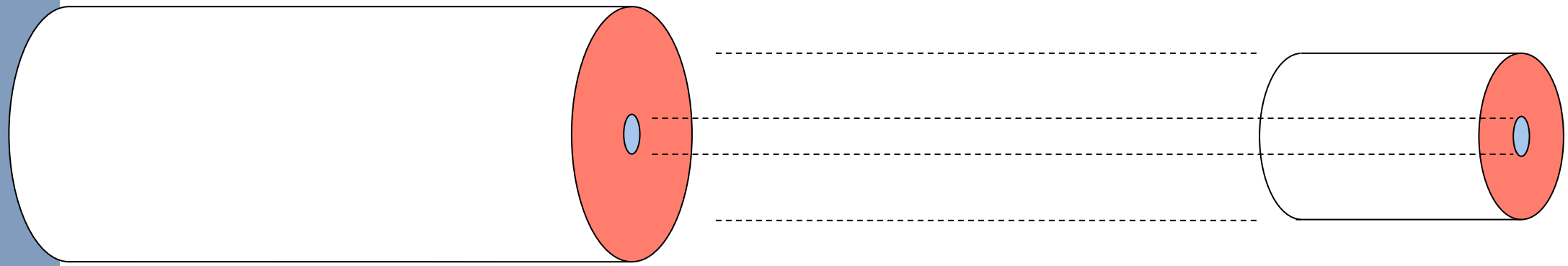
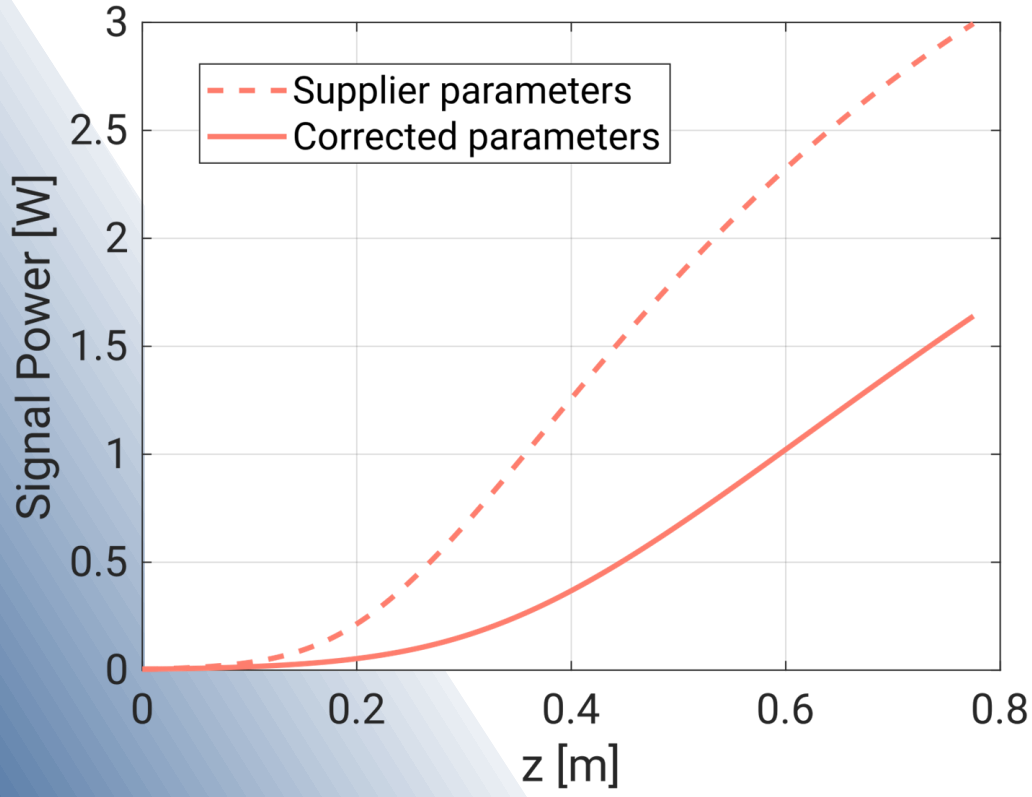
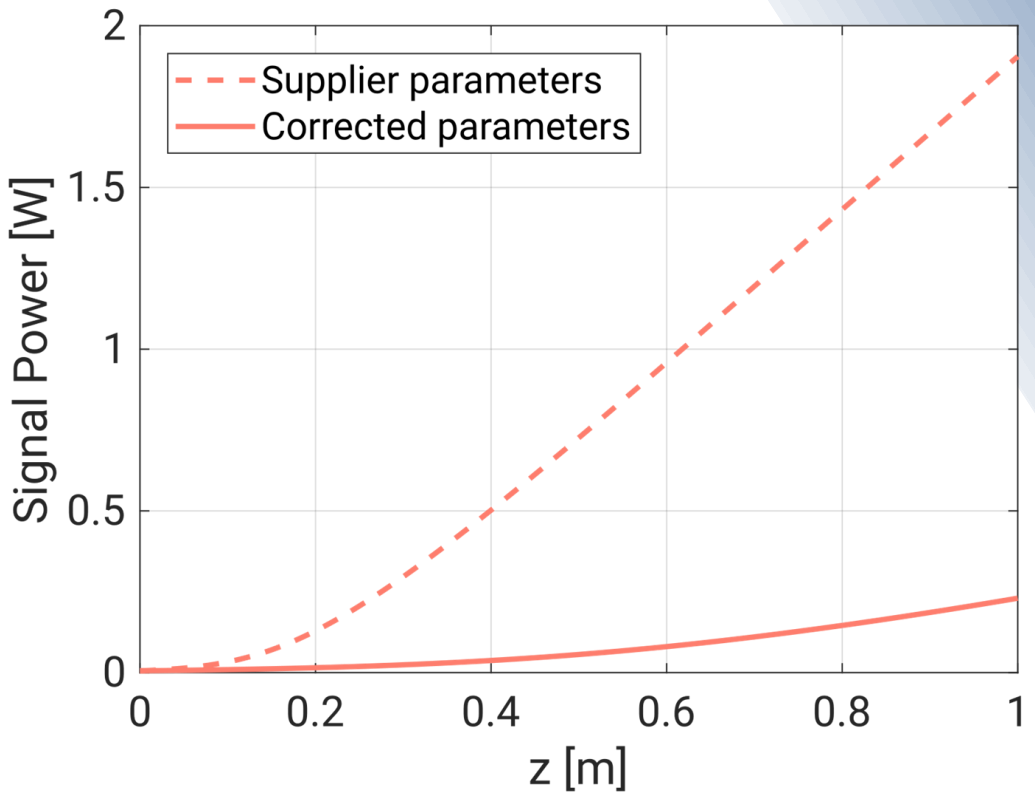




FIBER PARAMETERS

DECLARED VS MEASURED





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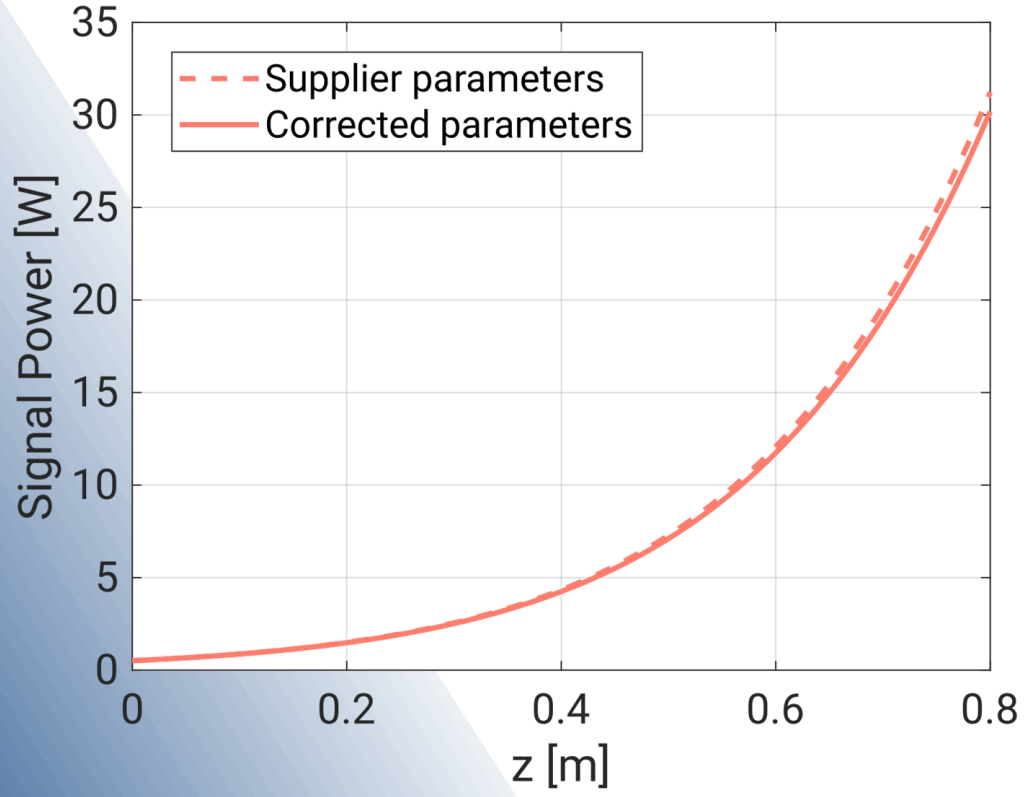

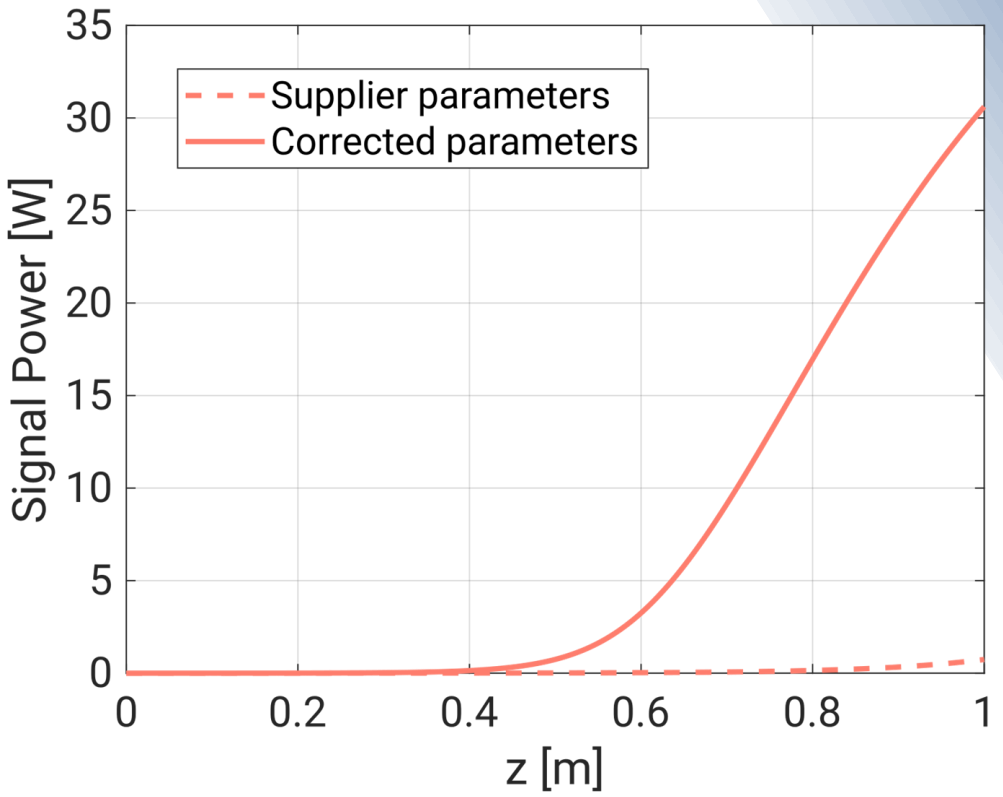

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