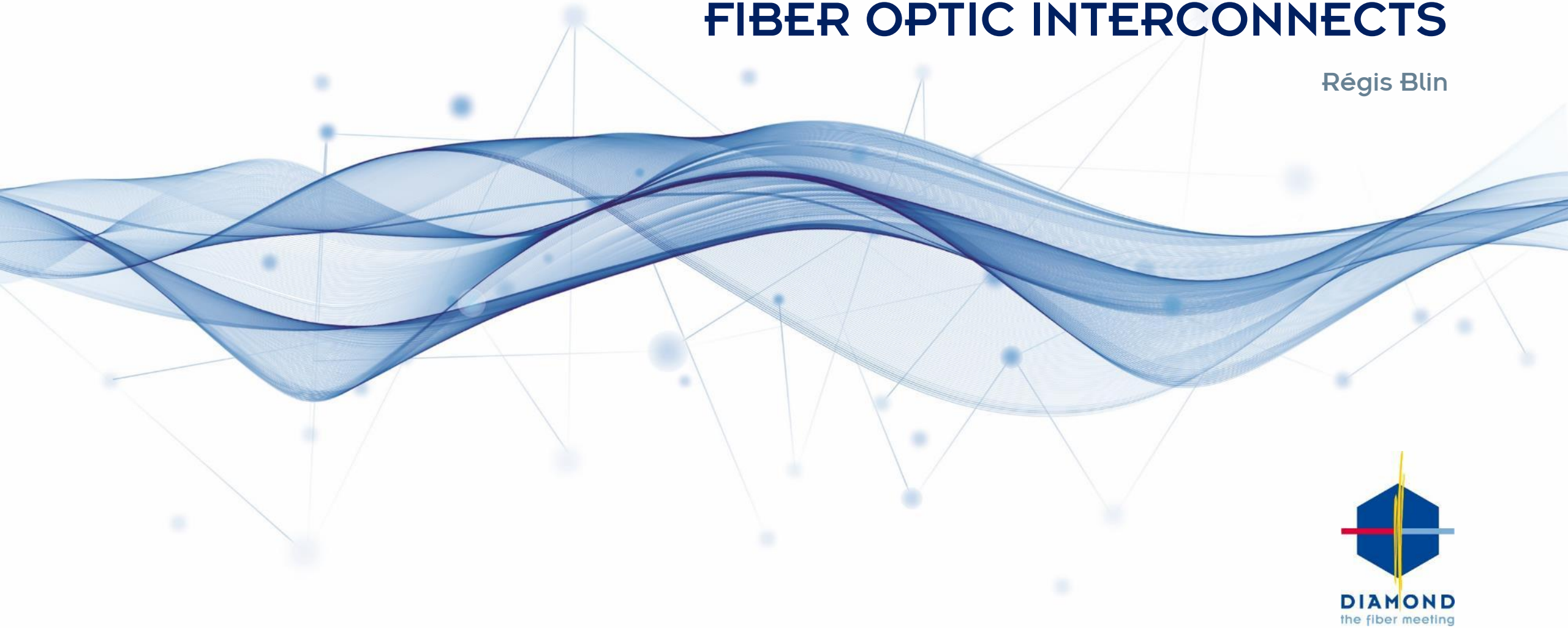
REDEFINING LOW-LOSS FIBER OPTIC INTERCONNECTS

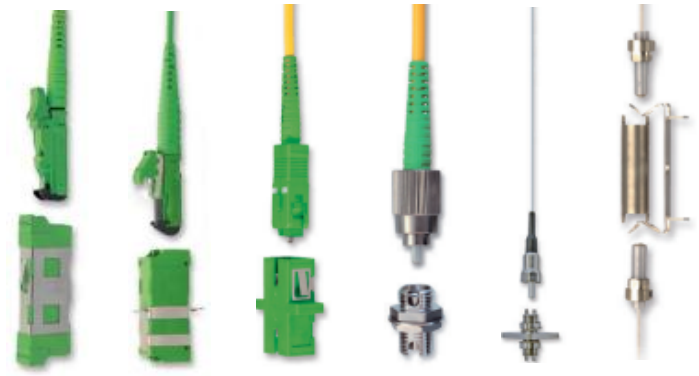
Régis Blin



DIAMOND
the fiber meeting

EPIC Online Technology Meeting on Photonics for Quantum Industry - 11 May 2026

Ultra-Low Loss Interconnects for Quantum Photonics advancements



DIAMOND has been offering **Low Loss Fiber Optic Interconnects** with losses as low as **0.1 dB since early 2000**

"Low Loss" typically refers to IL_{typ} < 0.1 dB & **IL_{max} < 0.15 dB**

➔ THIS IS NO LONGER LOW ENOUGH

New class of **Ultra-Low Loss (ULL) connectors** is introduced to support the development of robust quantum technologies

"Ultra-Low Loss" can reach **IL_{max}** values below **0.04 dB**

The Path Toward Ultra-Low Loss (ULL) Manufacturing

2025
High Purity Cleaning

2023
Introduction of ULL Class:
IL < 5 x 10^{-3} (~0.02 dB)
T ~ 99.5%

2002
ISO / IEC 17025
Accreditation testing
and calibration laboratory

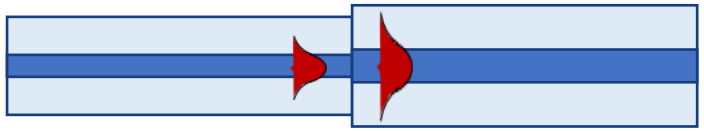
2000
Introduction of 0.1 dB Class:
IL ~ 3 x 10^{-2} (~0.12 dB)
T ~ 97%

1994
Certification ISO 9001
and 14001 (in 2003)

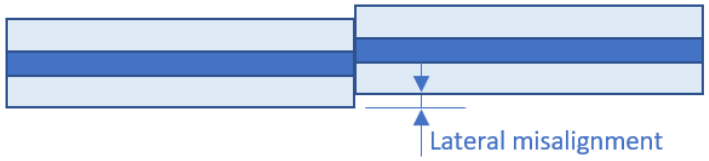
1992
Grade B:
IL < 5 x 10^{-2} (~0.25 dB)
T ~ 95%

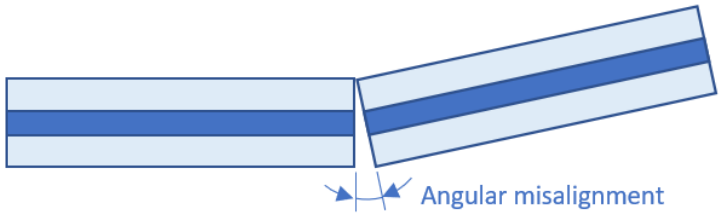
1980
First series of
high-precision fiber
optic connectors

The Causes of Insertion Loss (IL) in Fiber Connectors



Fiber & mode mismatch





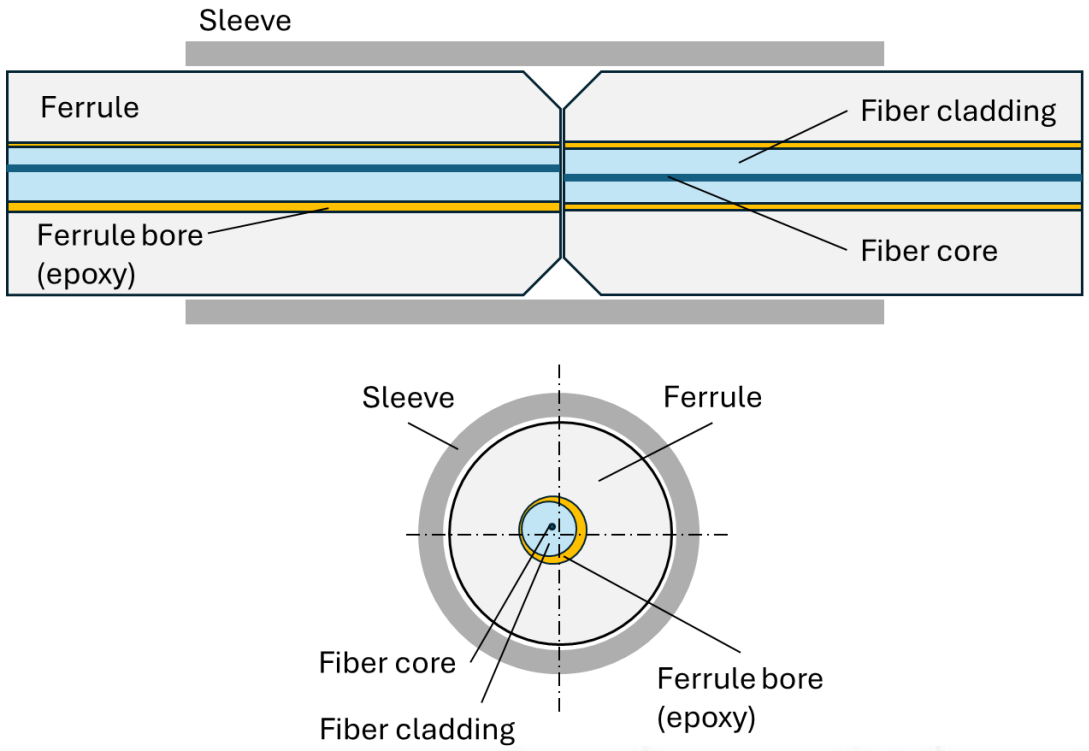
At a fiber interface, loss is affected both by geometrical as well as by surface quality aspects.

Geometrically, the loss is the consequence of how well, or how badly, the input and output mode field profiles are matched.

There are 3 main contributions to the losses:

- Mode field mismatch (different fibers)
- Lateral misalignment (axial alignment)
- Angular misalignment

Origin of the Lateral Misalignment



Main contributors to lateral misalignment in a ferrule:

- Fiber level ➔ core-to-cladding eccentricity
- Ferrule level ➔ ferrule bore eccentricity
- Assembly ➔ fiber-bore diameter mismatch

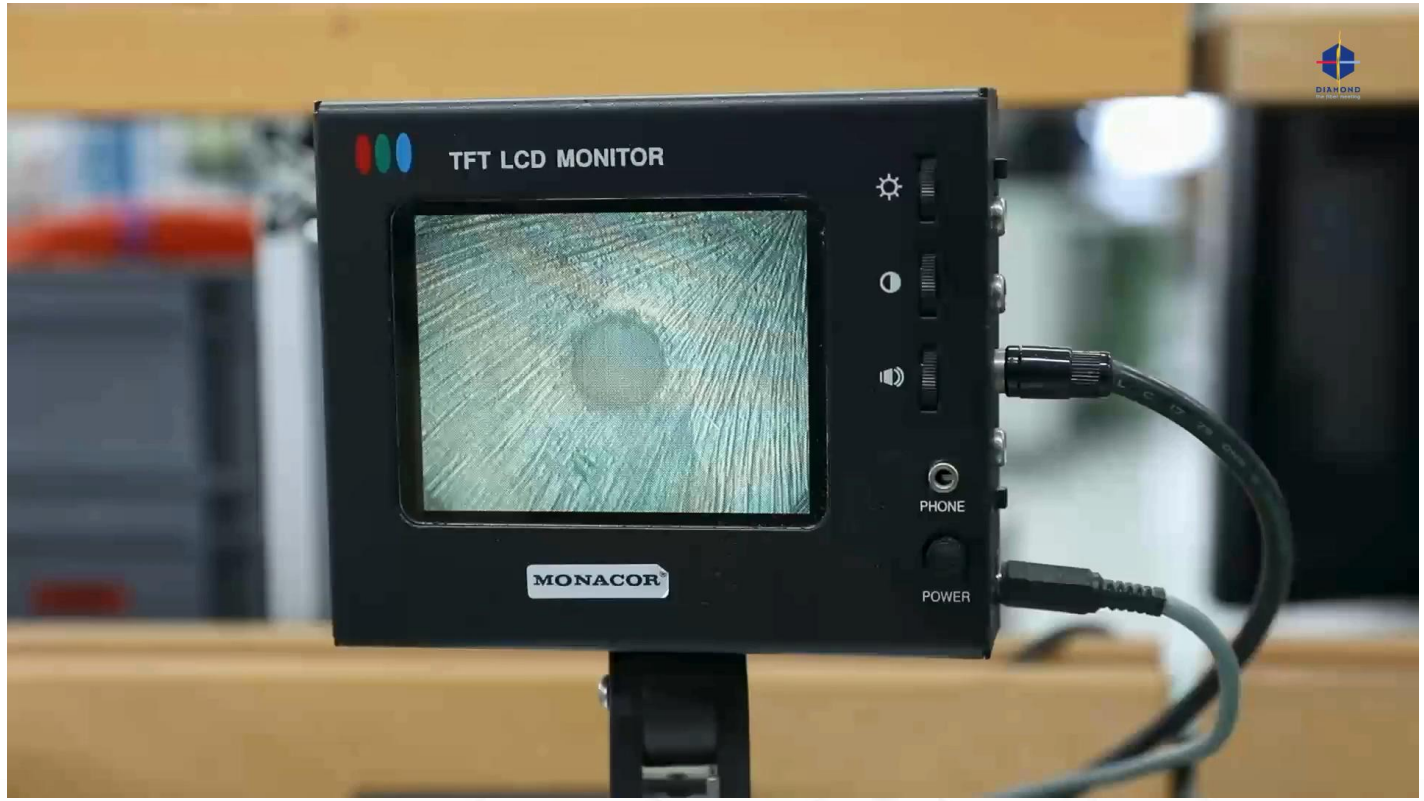
These factors add up statistically

Total lateral misalignment (“offset”):

- Std connectors ➔ d ~ 1 - 1.5 µm
- High precision ferrule with ACA[1)] ➔ d ~ 0.5 - 1 µm

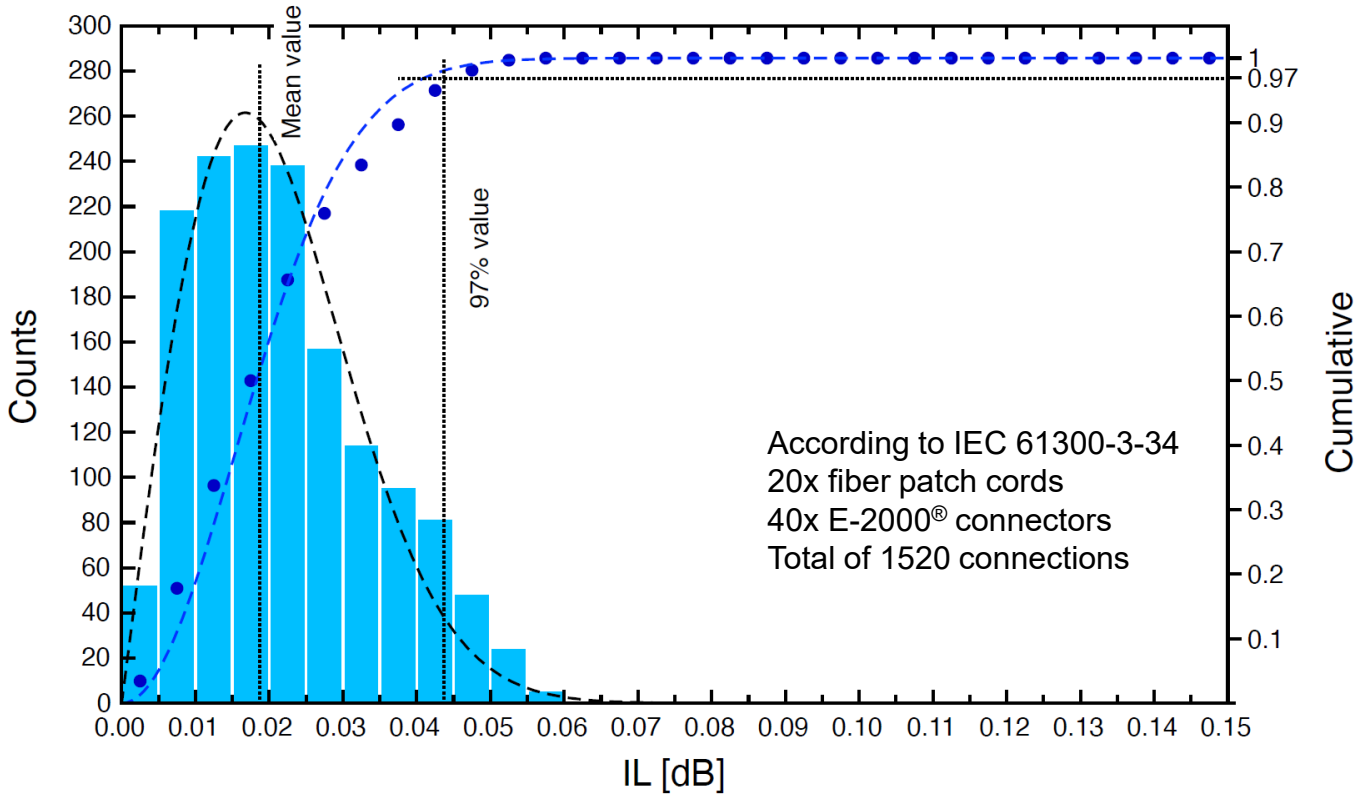
[1)] Active Core Alignment

Lateral Offset Suppression: DIAMOND's Active Core Alignment (ACA) Process



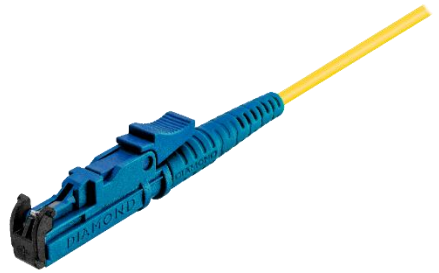
- **Ferrule OD** tolerance < 0.2 µm
  ➔ perfect matching within mating sleeve
- Direct control over fiber core-to-ferrule **eccentricity**
  ➔ no worries about fiber or ferrule bore diameters

Ultra-Low Loss Connectors (ULL) - Measurement @1550 nm



Single-mode SMF G.657 at 1550 nm

terminated with E-2000® 0° PC ULL



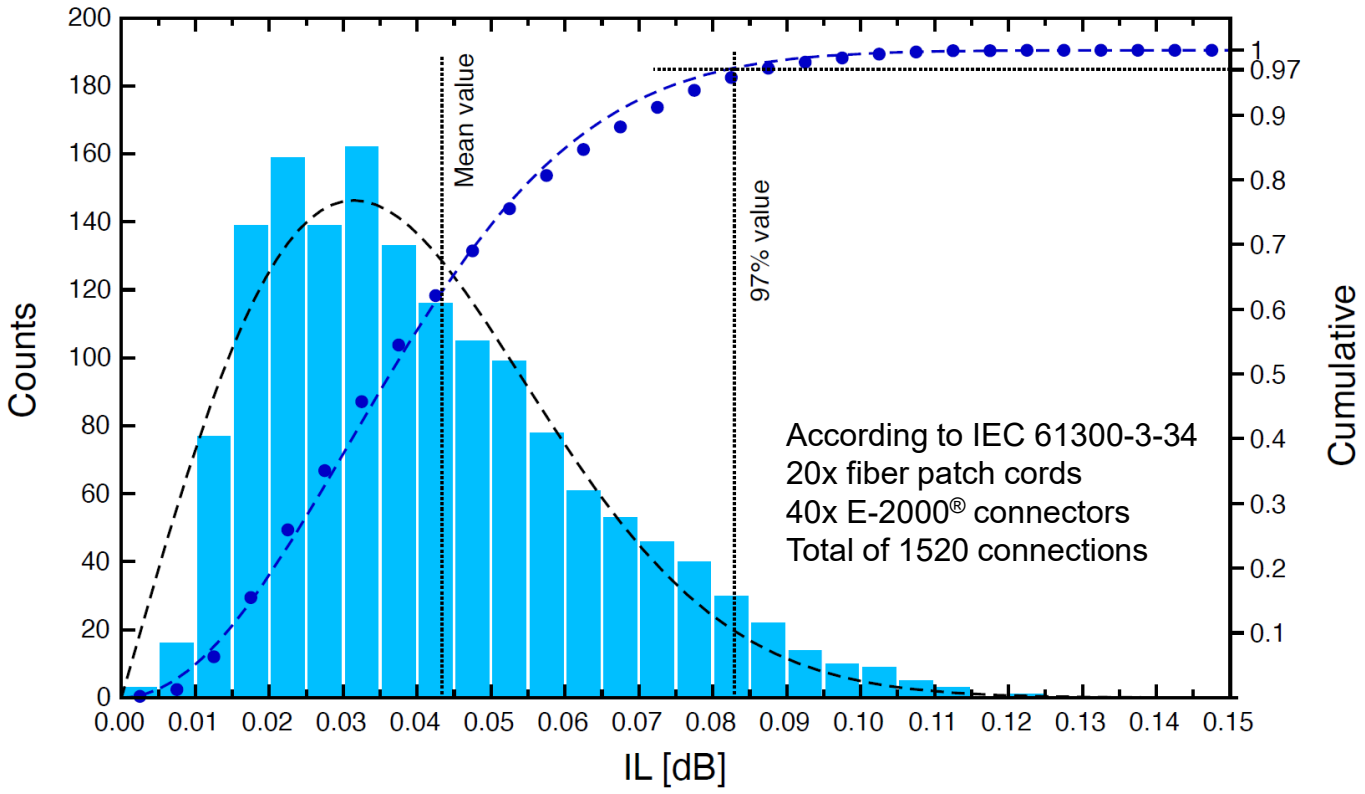
Statistical loss values

- Mean insertion loss: **0.017 dB**
- Max 97% insertion loss: **0.042 dB**

Results confirmed by cross-check measurements performed by US National Institute of Standards and Technology (NIST) (results to be published)

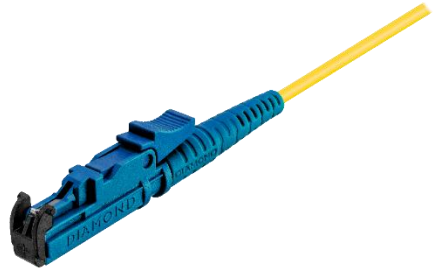
NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

Ultra-Low Loss Connectors (ULL) - Measurement @780 nm



Single-mode fiber at 780 nm

terminated with E-2000® 0° PC ULL



Statistical loss values

- Mean insertion loss: **0.044 dB**
- Max 97% insertion loss: **0.082 dB**

Results confirmed by cross-check measurements performed by US National Institute of Standards and Technology (NIST) (results to be published)

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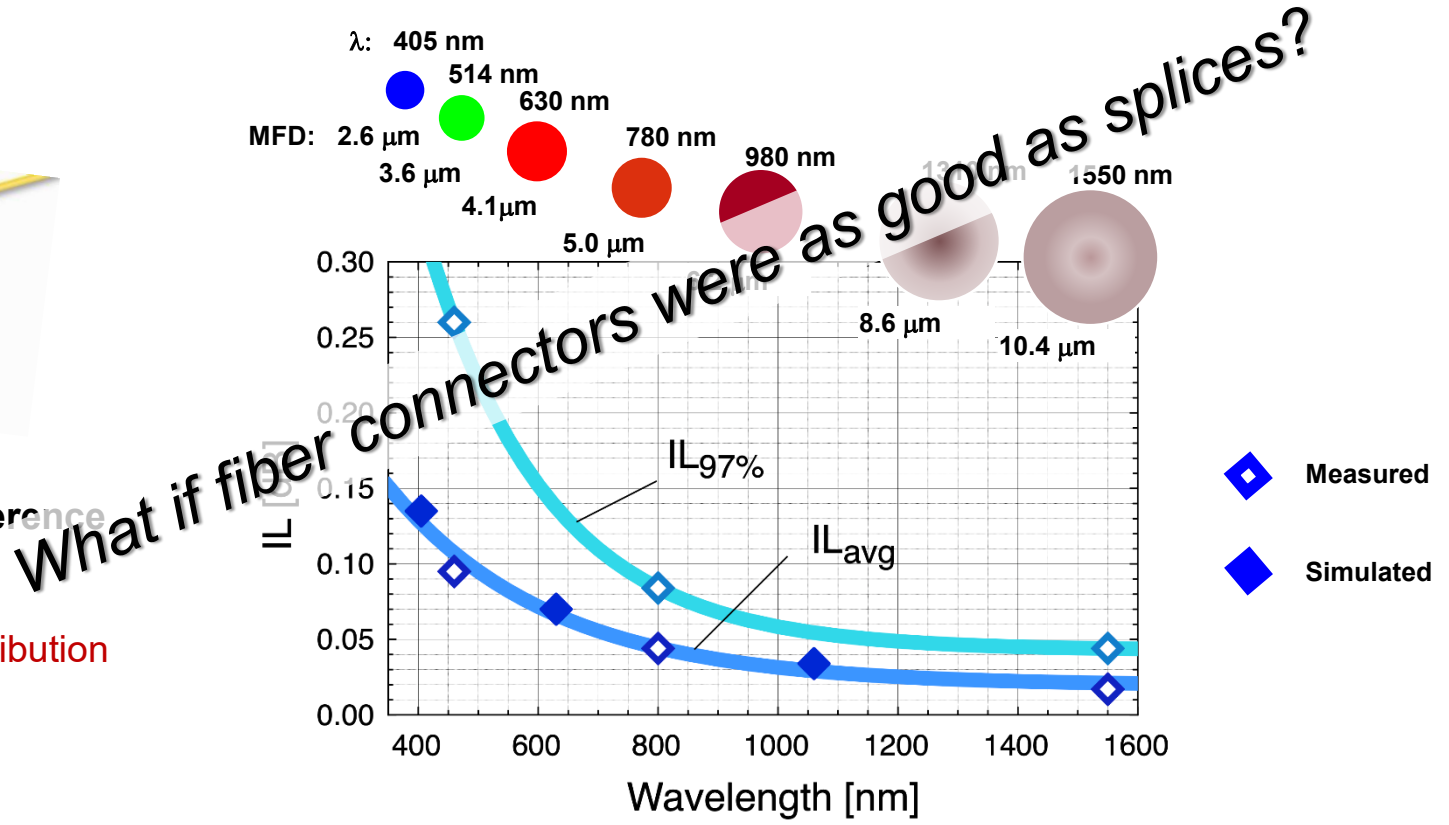
ULL Connectors - High Performance from VIS to NIR

Since random mating tests are impractical for each production lot, to guarantee performance, the **entire** manufacturing process must be perfectly under control, from the fiber to the ferrule, to the assembly.

- Direct IL measurements **against reference**
  - → Eliminate outliers
  - → Provide extra control on loss distribution



ULL Connectors - Configuration Guide

- Connector: E-2000®, FC, Mini AVIM®, DMI
- Assemblies: Patch cords, Pigtails, Vacuum Feedthroughs (V-FT)
- Fiber type:
  - → Singlemode (SM)
  - → Polarization maintaining (PM)
  - → Photonic Crystal Fiber (PCF)
- Jacket type: Ø3 mm - 900 µm
- Polishing: PC 0°, APC 8°

Wavelengths: from 405 nm to 1650 nm

Special Products available on request

From modified standard products to fully customized solutions

Why meet DIAMOND

Diamond SA Headquarter in Losone, Switzerland

ISO 9001 ISO 14001 ESA SPACE QUALIFIED

Vertical integration

Clean Room Manufacturing 1,000m²

In-house accredited test and calibration lab

13,500m² production space

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Save my contact information