PMD Considerations

802.3cz Multi-Gigabit Optical Automotive Ethernet Task Force

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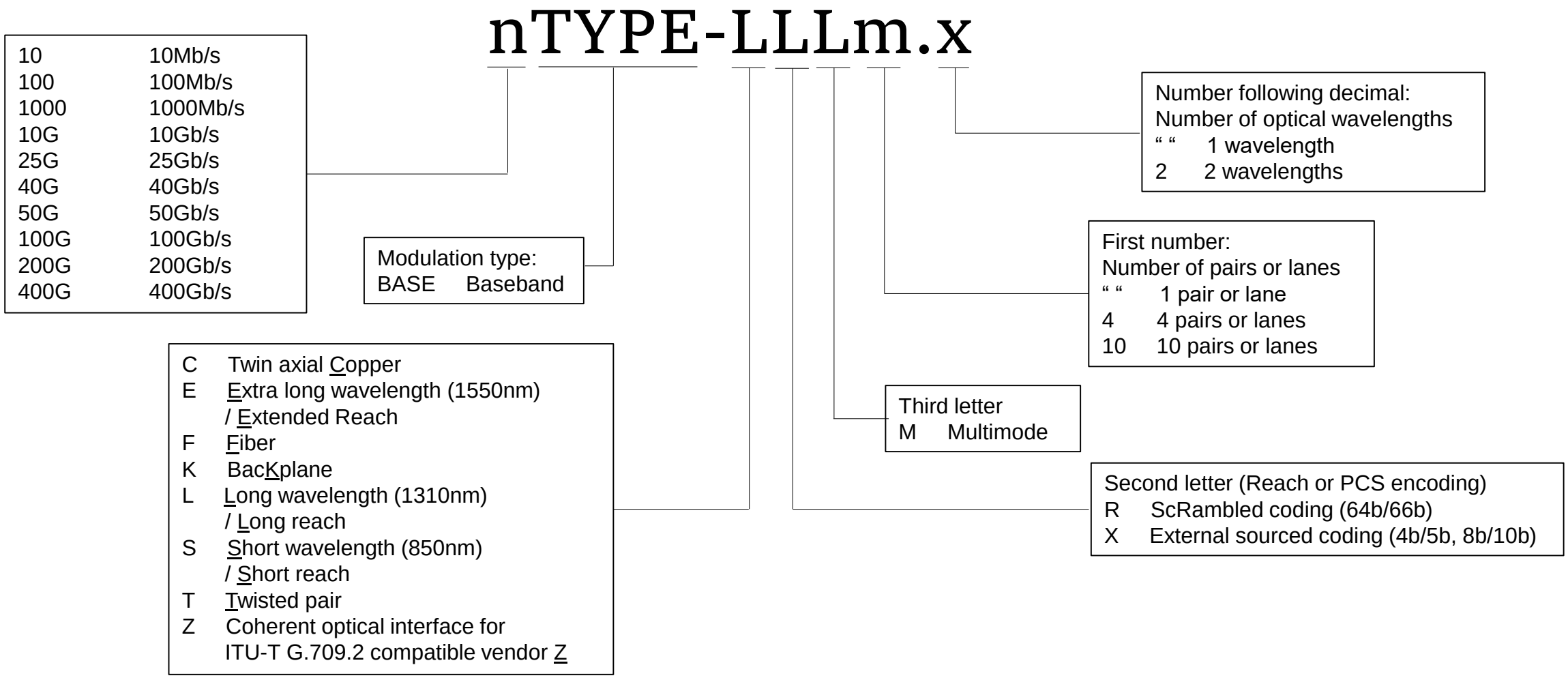
Topics

- PMD Nomenclature
- Selecting an optical fiber type
- Selecting an optical connector type

IEEE 802.3 Ethernet Nomenclature



- **A Automotive** **Ex. 5GBASE-AR**

Selecting optical fiber

- Laser Optimized “Optical Multimode” fiber is required for these high speeds
- Millions of kilometers shipped annually
- Should specify OM3 to support the maximum reaches for lowest cost
- Include reaches over OM4/OM5 for future applications
- Enables use of current tables

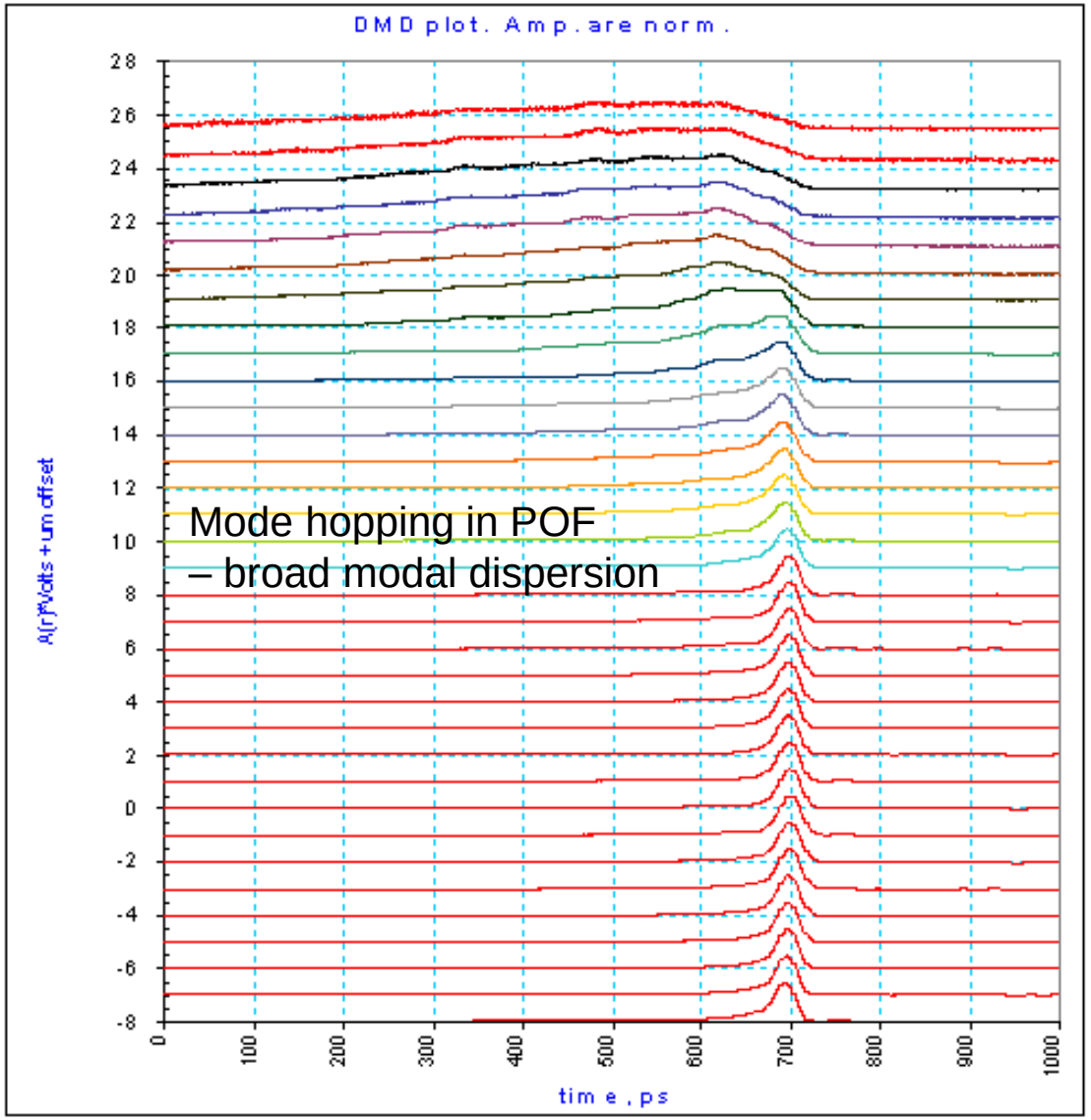
Table 123–7—Optical fiber and cable characteristics

Description	OM3[a]	OM4[b]	OM5[c]	Unit
Nominal core diameter	50			µm
Nominal fiber specification wavelength	850			nm
Effective modal bandwidth (min)[d]	2000	4700		MHz.km
Cabled optical fiber attenuation (max)	3.5			dB/km
Zero dispersion wavelength (λ_0)	$1295 \le \lambda_0 \le 1340$		$1297 \le \lambda_0 \le 1328$	nm
Chromatic dispersion slope (max) (S_0)	0.105 for $1295 \le \lambda_0 \le 1310$ and $0.000375 \times (1590 - \lambda_0)$ for $1310 \le \lambda_0 \le 1340$		$-412/(840(1-(\lambda_0/840)^4))$ for $1297 \le \lambda_0 \le 1328$	ps/nm^2 km

[a] IEC 60793-2-10 type A1a.2.
[b] IEC 60793-2-10 type A1a.3.
[c] IEC 60793-2-10 type A1a.4.
[d] When measured with the launch conditions specified in Table 95–6.

Mode hopping

OM3 Glass	50/125 μm POF
L = 300 m, 0μm offset	L = 300 m, 0μm offset
ϕ_{eff} = 16.5μm	ϕ_{eff} = 43.5μm
L = 300 m, 25μm offset	L = 300 m, 25μm offset



Bend insensitive glass optical fiber

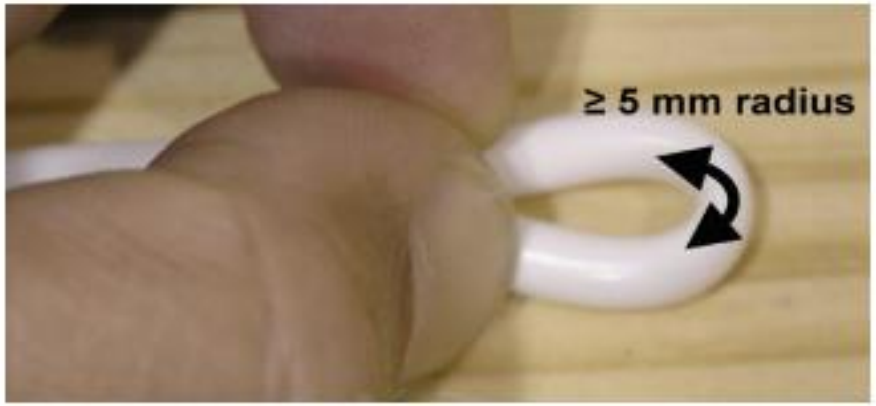


Figure 4.
Bend-Limiting Design

Corning Optical Communications

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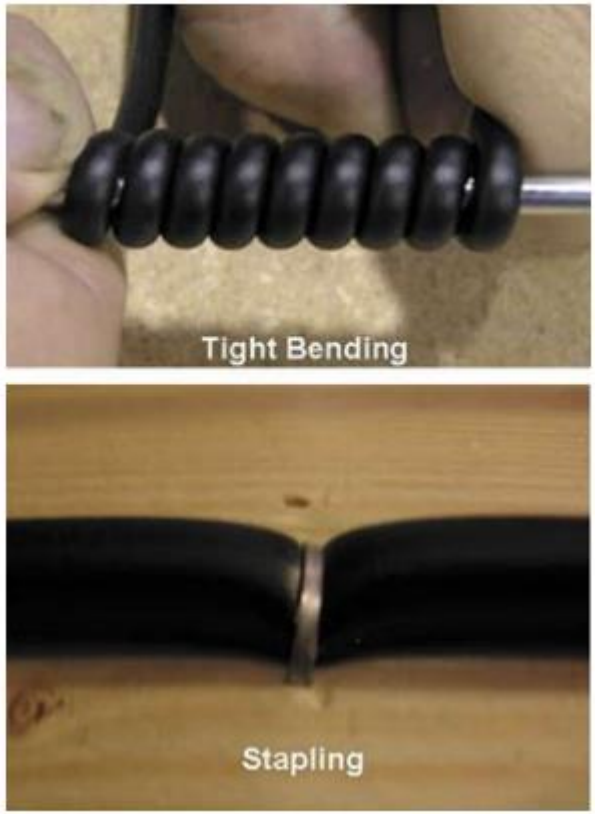

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Fiber optic cabling (channel) characteristics

- Reduce minimum reach from 0.5 to 0.1 due to the short reaches objectives for this application
- Primary medium should be OM3 for lowest cost
- We can specify OM4 reach once the power budget and transceiver parameters are determined

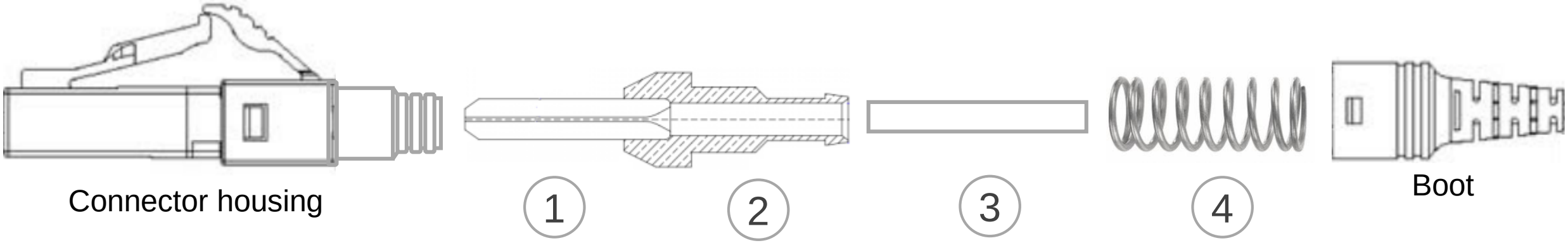
Example

PMD type	Required operating range
2.5GBASE-AR	0.1 to 40 m for OM3 TBD for OM4
5GBASE-AR	0.1 to 40 m for OM3 TBD for OM4
10GBASE-AR	0.1 to 40 m for OM3 TBD for OM4
25GBASE-AR	0.1 to 40 m for OM3 TBD for OM4
50GBASE-AR	0.1 to 15 m for OM3 TBD for OM4

Selecting a Connector Type

Butt Coupling vs. Expanded Beam

Comparing bare minimum components

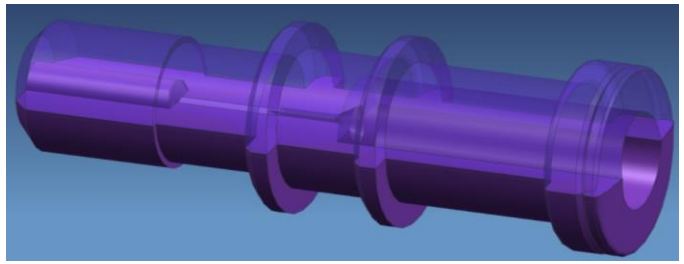


Connector housing

Boot

1. Ferrule
2. Ferrule holder
3. Glue tube
4. Spring

- Plus component assembly & polishing



MOST Ferrule form factor

Can be molded as a single plastic part

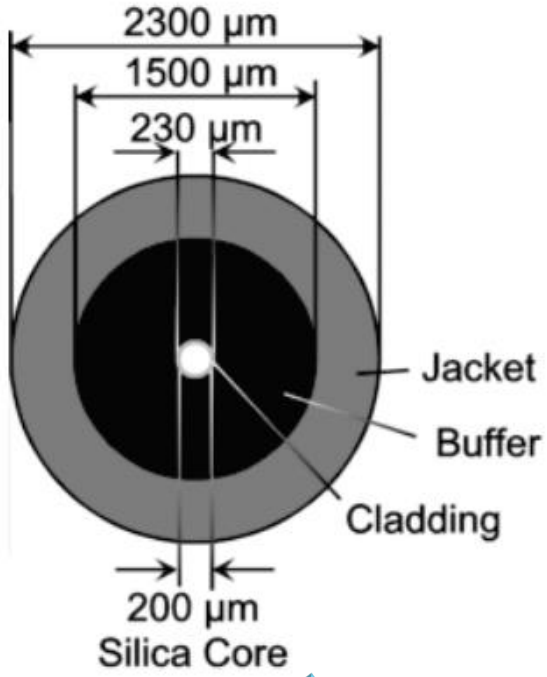
Integrates:

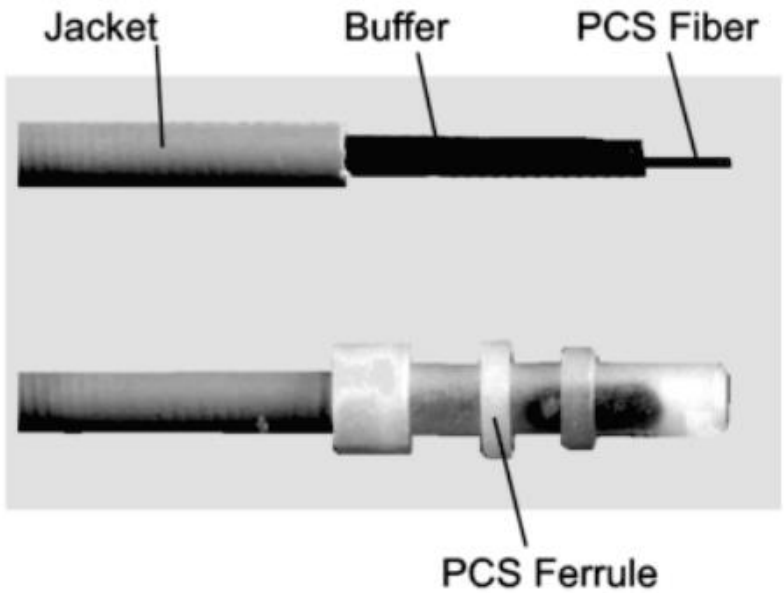
1. Lens
2. Ferrule

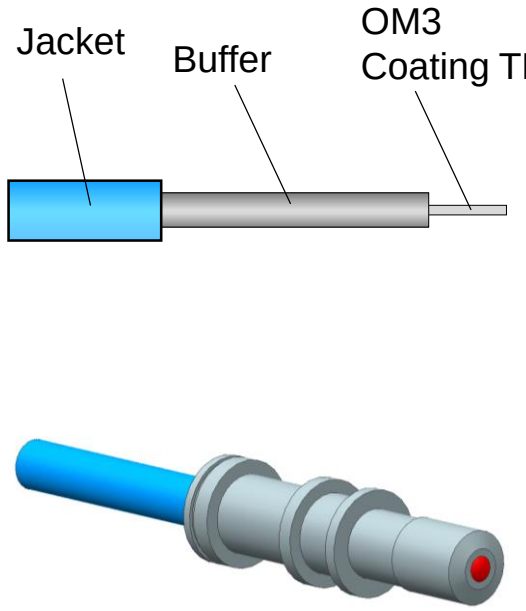
- No ferrule holder required
- No Assembly
- No Polishing

Utilize existing optical cable for MOST ferrule

- Low risk
- Reduced time to market







- Replace HCS Specialty fiber with 50/125 µm OM3

Butt Coupled vs. Expanded Beam MDI

Butt Coupled

Pros

- Lowest Insertion Loss
- Deployed in high volume

Cons

- Higher cost than expanded beam
- Tight alignment tolerances
- Sensitive to contamination

Expanded Beam

Pros

- Lowest cost
- More reliable under adverse conditions
- Relaxed alignment tolerances
- Can be made to comply with existing MOST form factor – utilize adapters

Cons

- Higher IL compared to Butt coupling

Trade low loss for low cost & reliability under adverse conditions

Example of specification for expanded beam

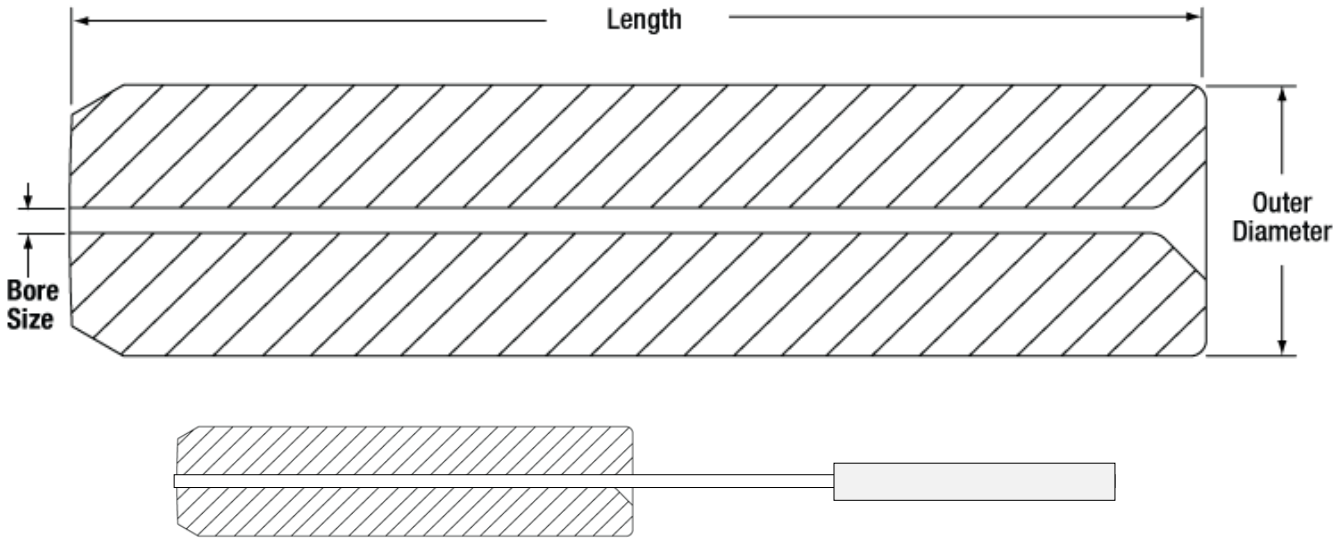
Description	nGBASE-AR	Unit
Beam diameter	1	mm
Maximum Insertion Loss	1.5	dB
Optical Return Loss (min)	20	dB
Lens-to-lens separation	0.1 to 5	mm

Summary

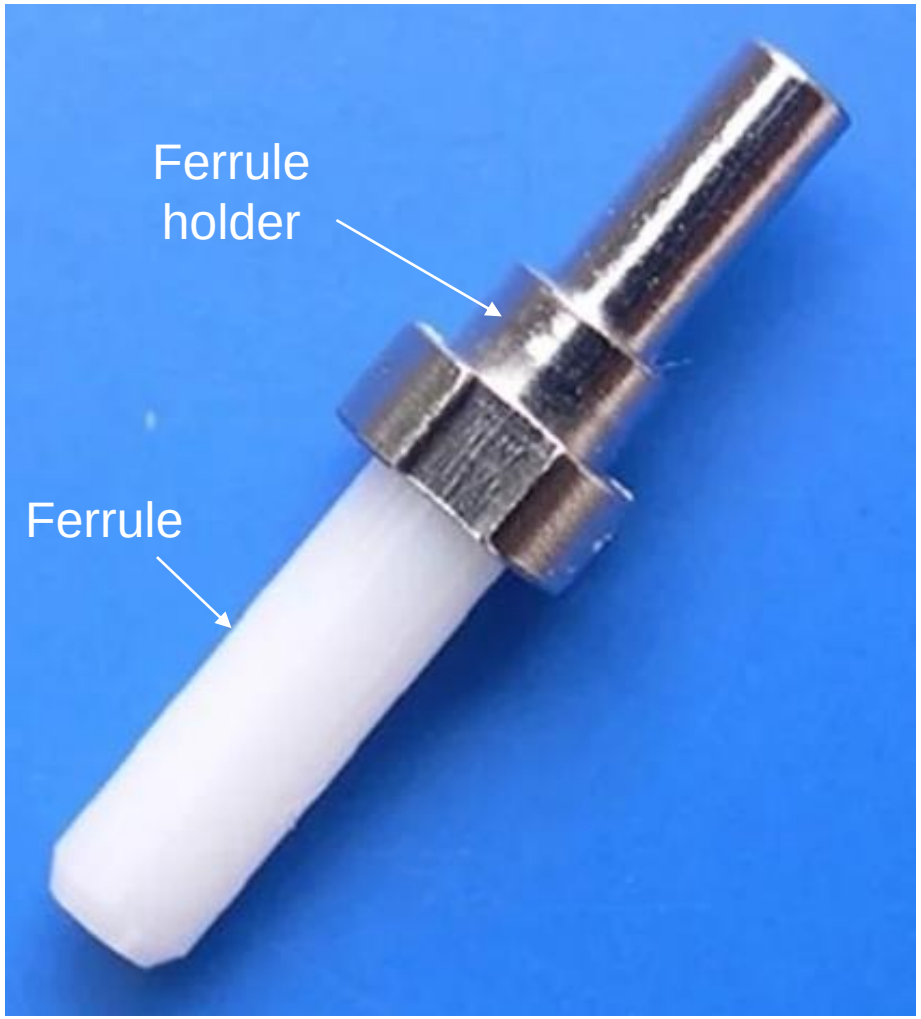
- The new PMDs can use the letter “A” nomenclature
- Standard OM3 fiber would be the best solution for lowest cost
- Manufacturers can make use of existing cable constructions developed for (MOST) HCS fiber – Not typically specified by IEEE
- High-speed channels are bandwidth limited and therefore, connector insertion loss is not an important parameter making expanded beam connectors the better choice
- Specifying the lowest cost optical connectivity can potentially be cheaper than the copper solution being specified in P802.3cy.
- Lowest cost optics will provide the automotive industry with the best connectivity solution (immunity to EMI, reduced weight, longer reach, etc.)

BACKUP

Connector ferrule critical dimensions



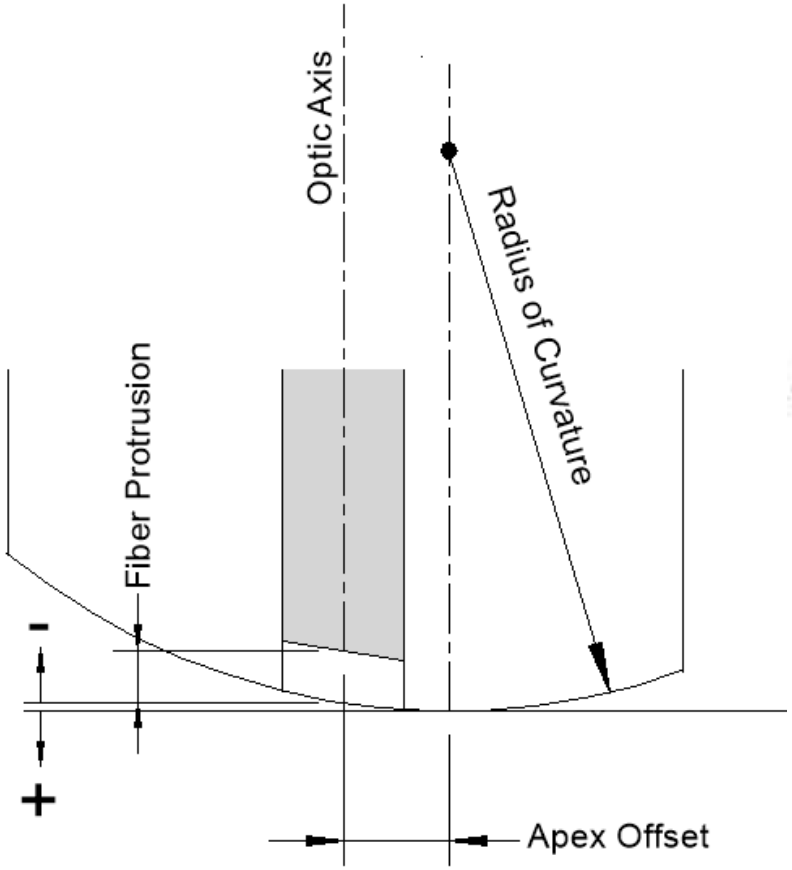
1. Ferrule outside diameter
2. Ferrule inside diameter
3. Circularity
4. Bore concentricity
5. Bore angular offset



Standards specified end face geometry

Critical specifications

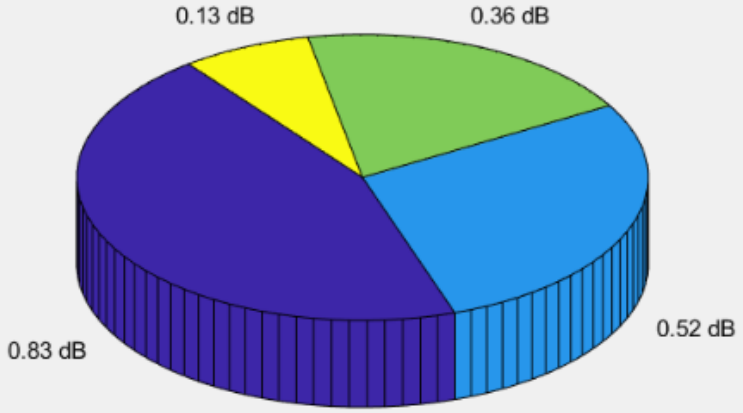
1. Radius of curvature
2. Apex offset
3. Protrusion
4. Scratches
5. Cracks
6. Pits

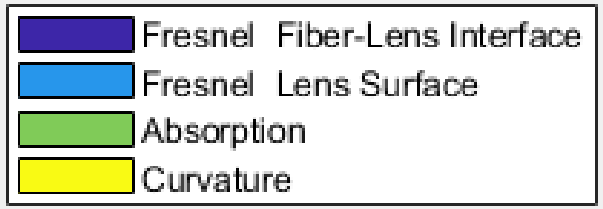


Polishing

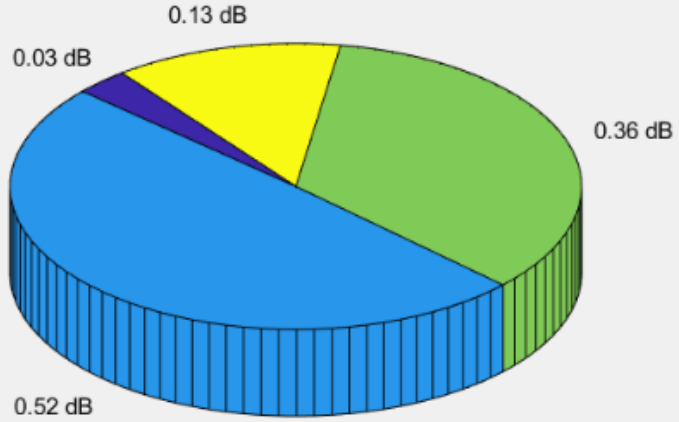
Modeled Insertion Loss – Polymer Lens

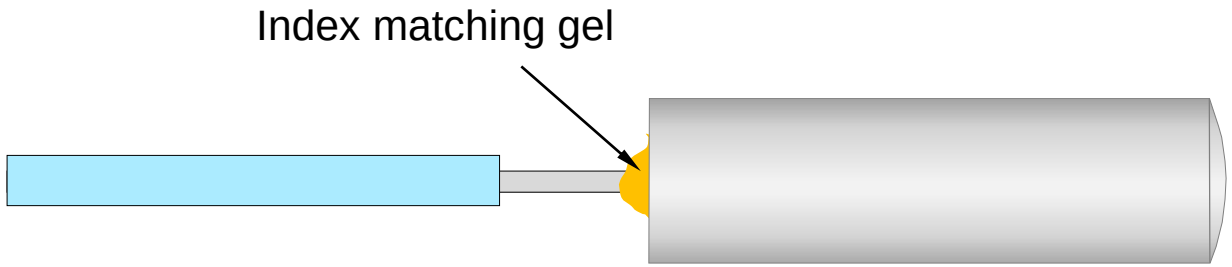
Without Index Matching Gel, Total Loss= 1.85dB



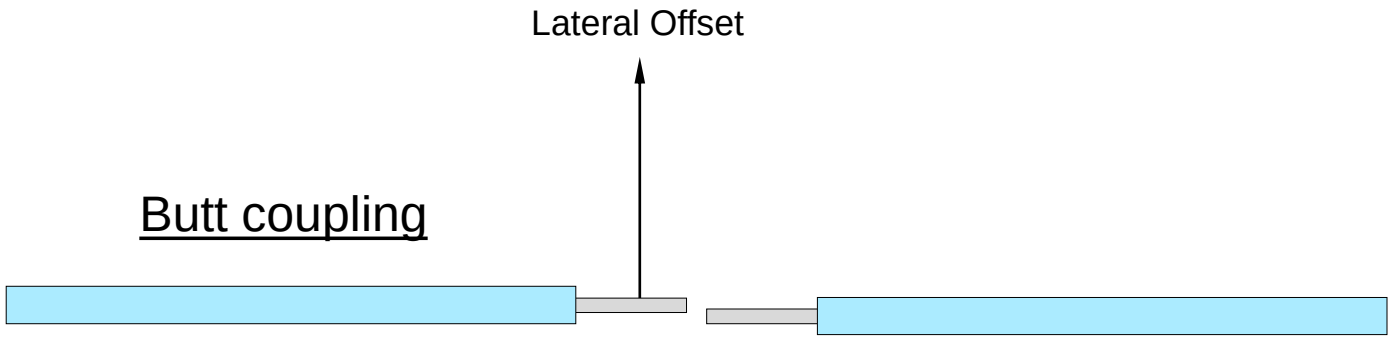


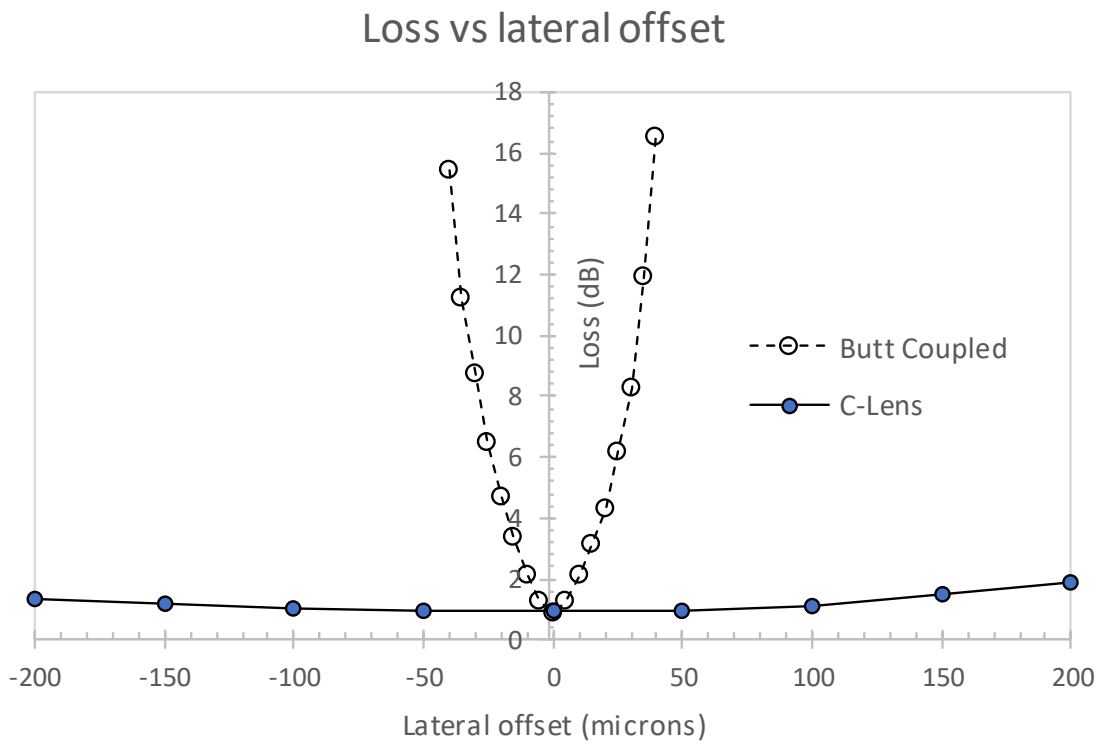
With Index Matching Gel, Total Loss= 1.05dB

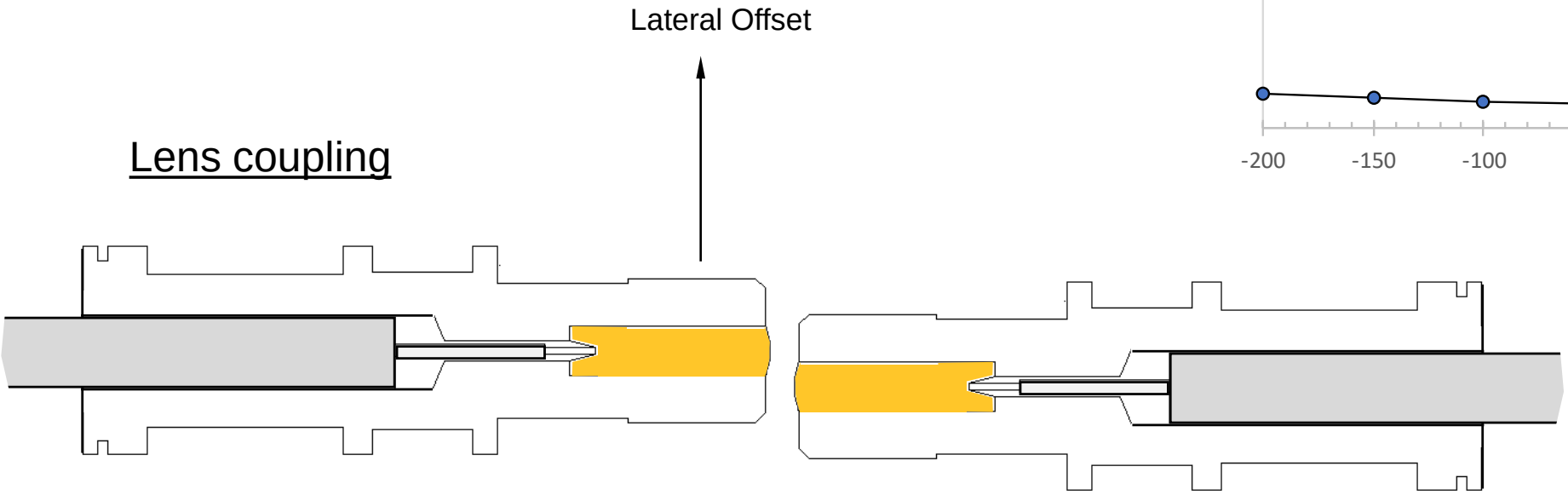




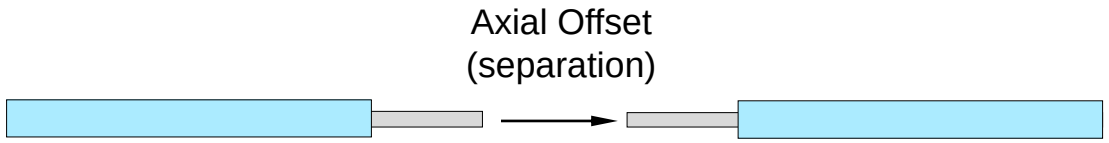
Lateral offset IL measurement results

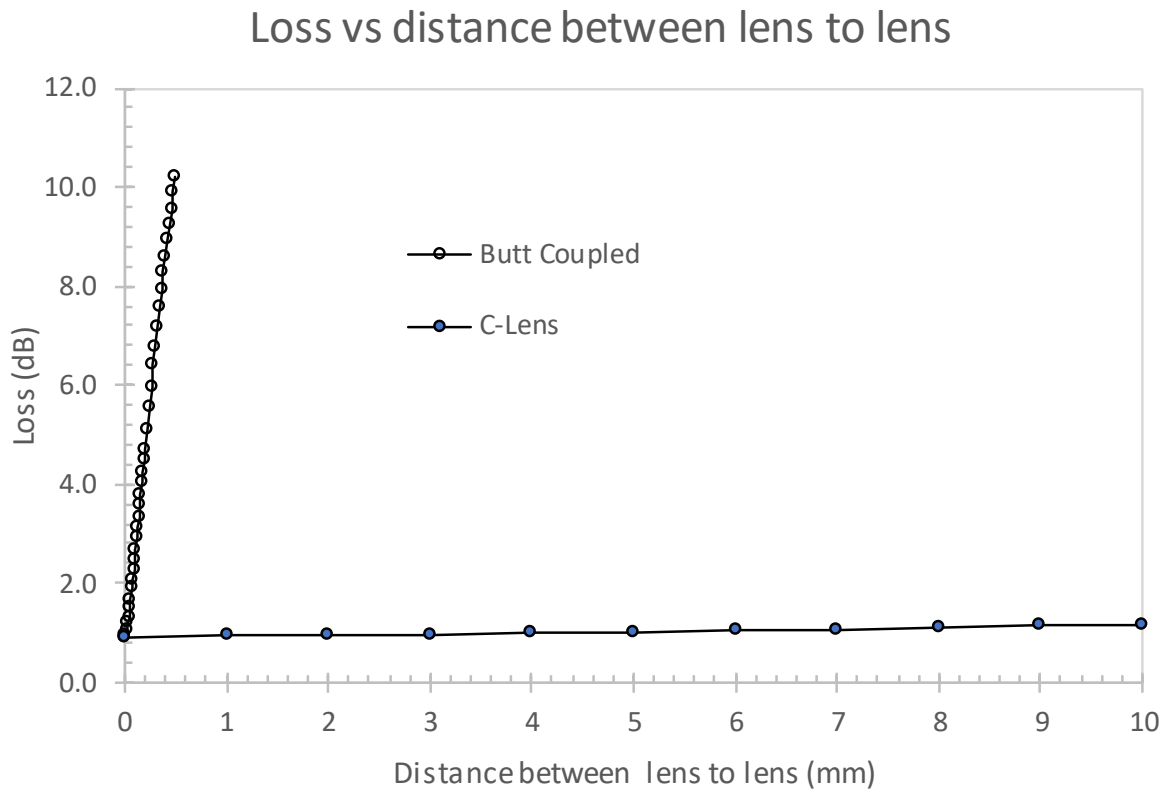


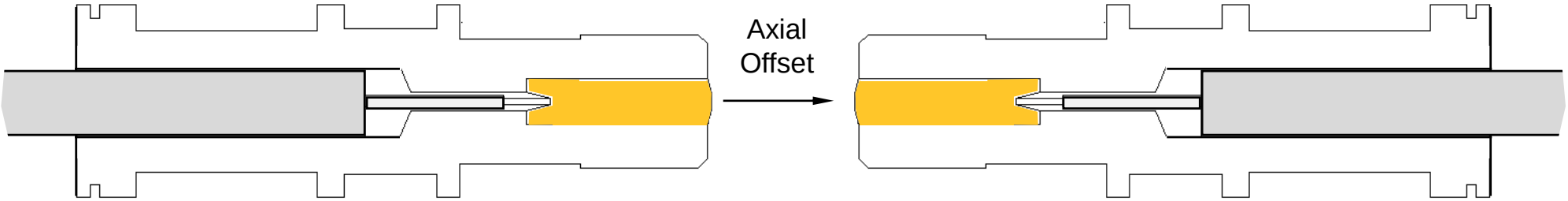




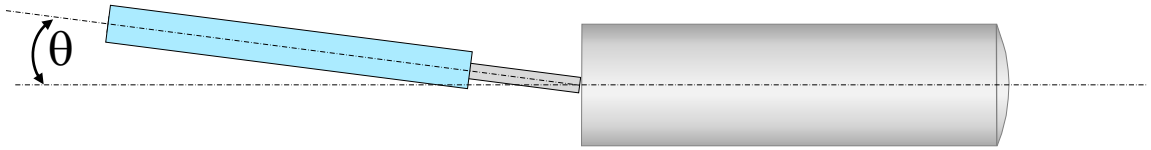
Axial offset IL measurement results

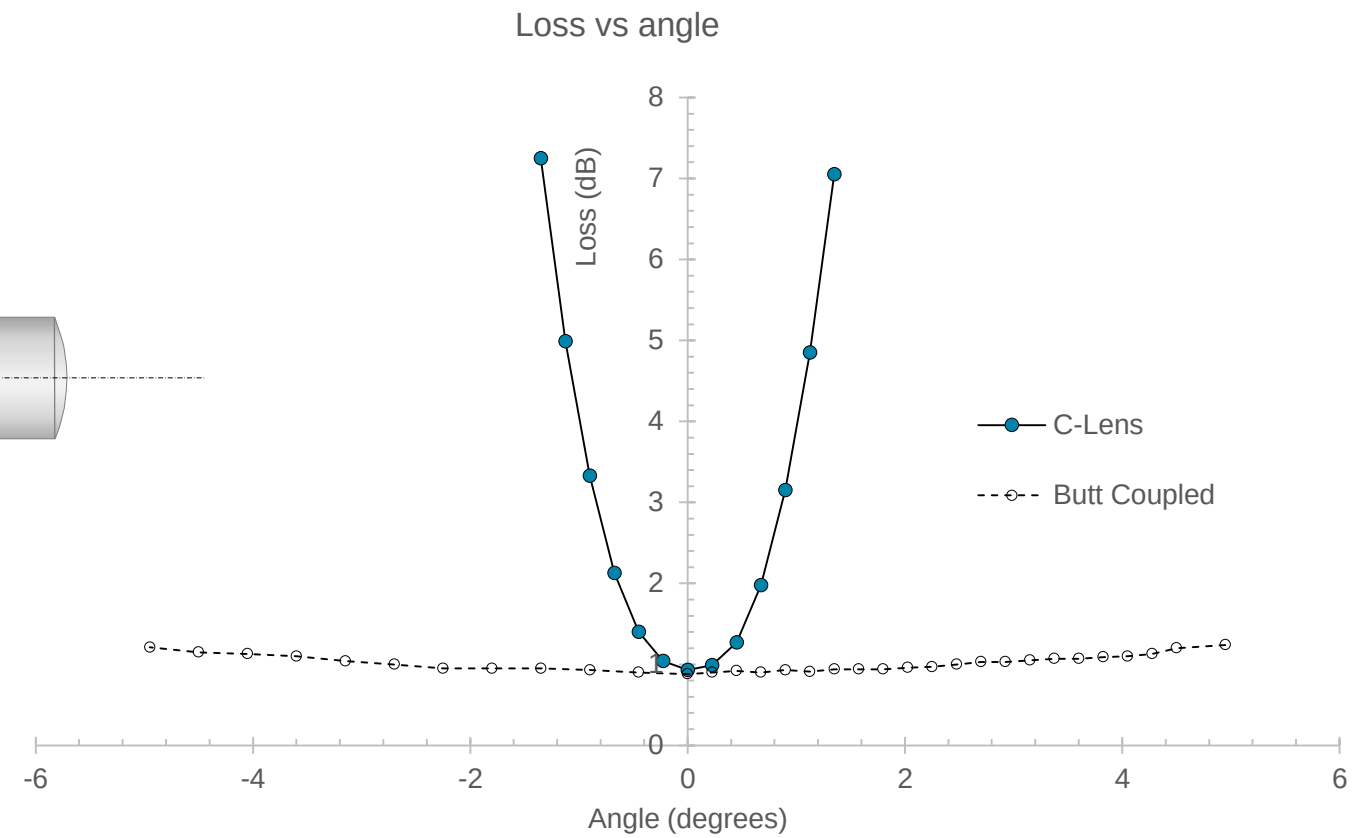






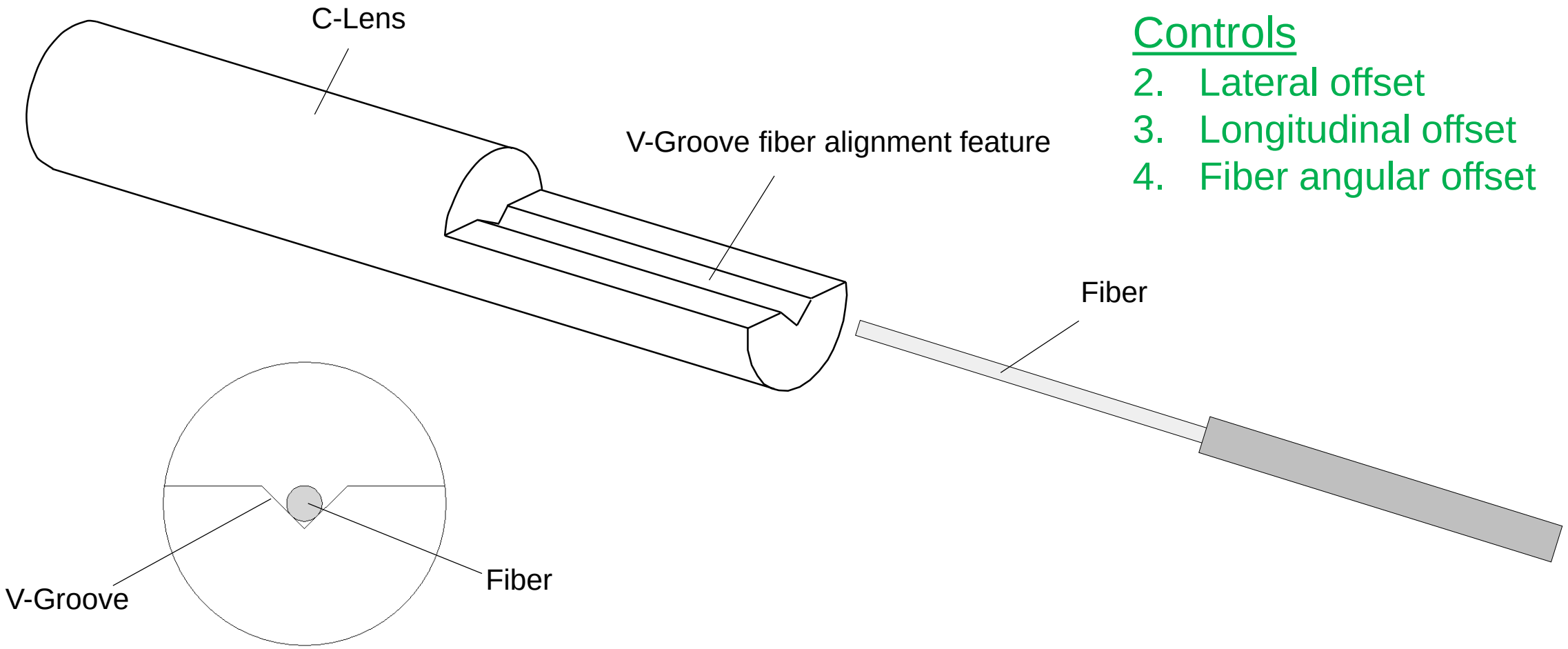
Angular misalignments





Alternative C-Lens design

C-Lens designed to minimize angular displacement



Controls

2. Lateral offset
3. Longitudinal offset
4. Fiber angular offset