

Multicore fiber standardization

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SDM Fibers Workshop, ECOC 2021

Overview

Arguments for and against standardization of MCF

Restricting the universe of MCF

MCF – User base and manufacturers

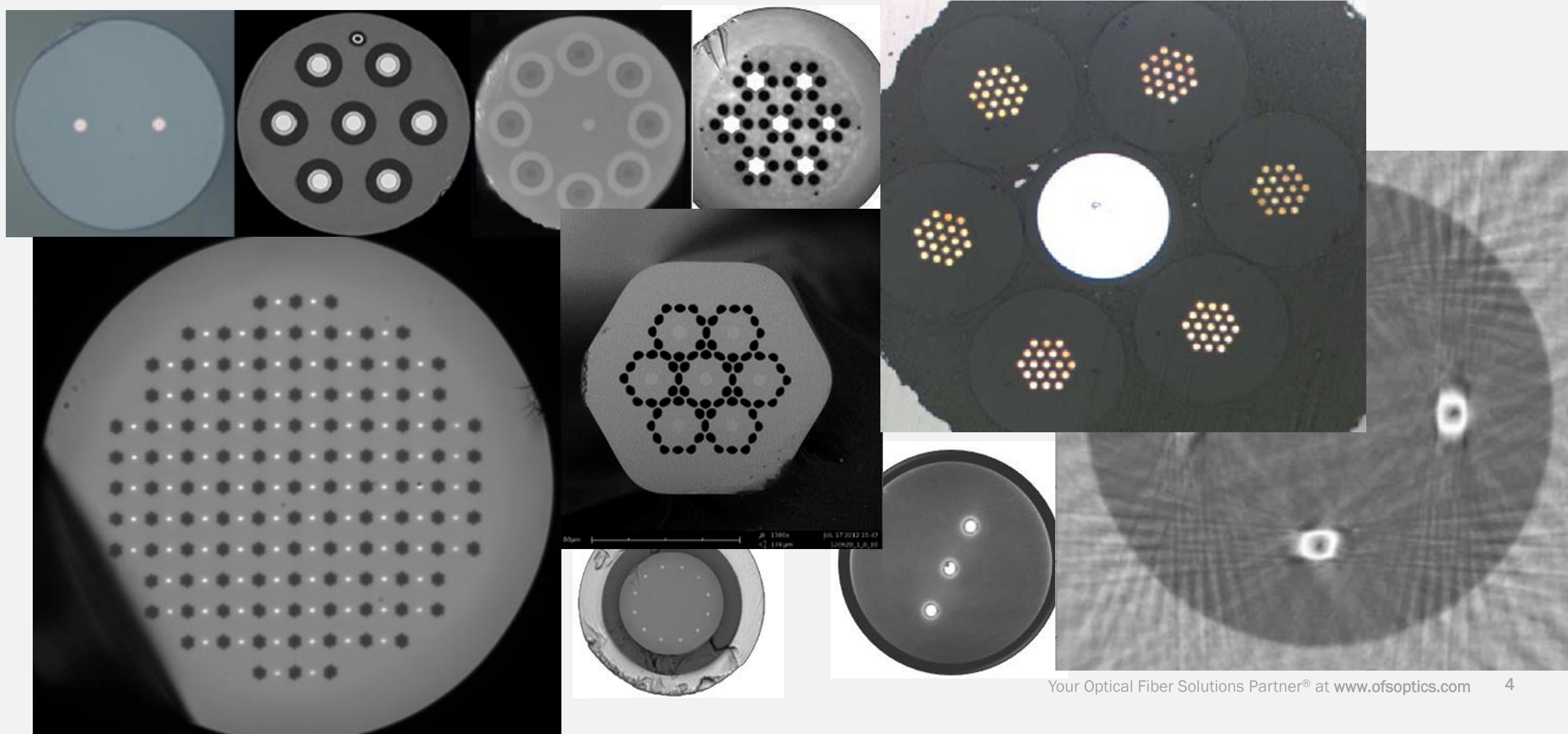
Relevant MCF characteristics for standardization

Is now the time to standardize MCF in communication networks?

Focus here on single mode, telecom fibers

- Yes
 - Everyone is interested in MCF (and has been for the last ~10 years).
 - Popular high fiber count cables have shown the appetite for increased transmission density (rollable ribbons etc).
 - 200 micron fiber coating is being widely accepted.
 - Submarine systems are starting to deploy SDM approaches (higher fiber counts). Cable cross-section is at a premium.
- No
 - No one is lining up to buy MCF for telecom.
 - Business case for MCF is not clear.
 - Will standards lead the market or vice versa?
 - How well can we now predict what the market will actually use? Are there “universal designs”? What core number/patterns/fiber size?
 - Is the infrastructure ready for MCF?

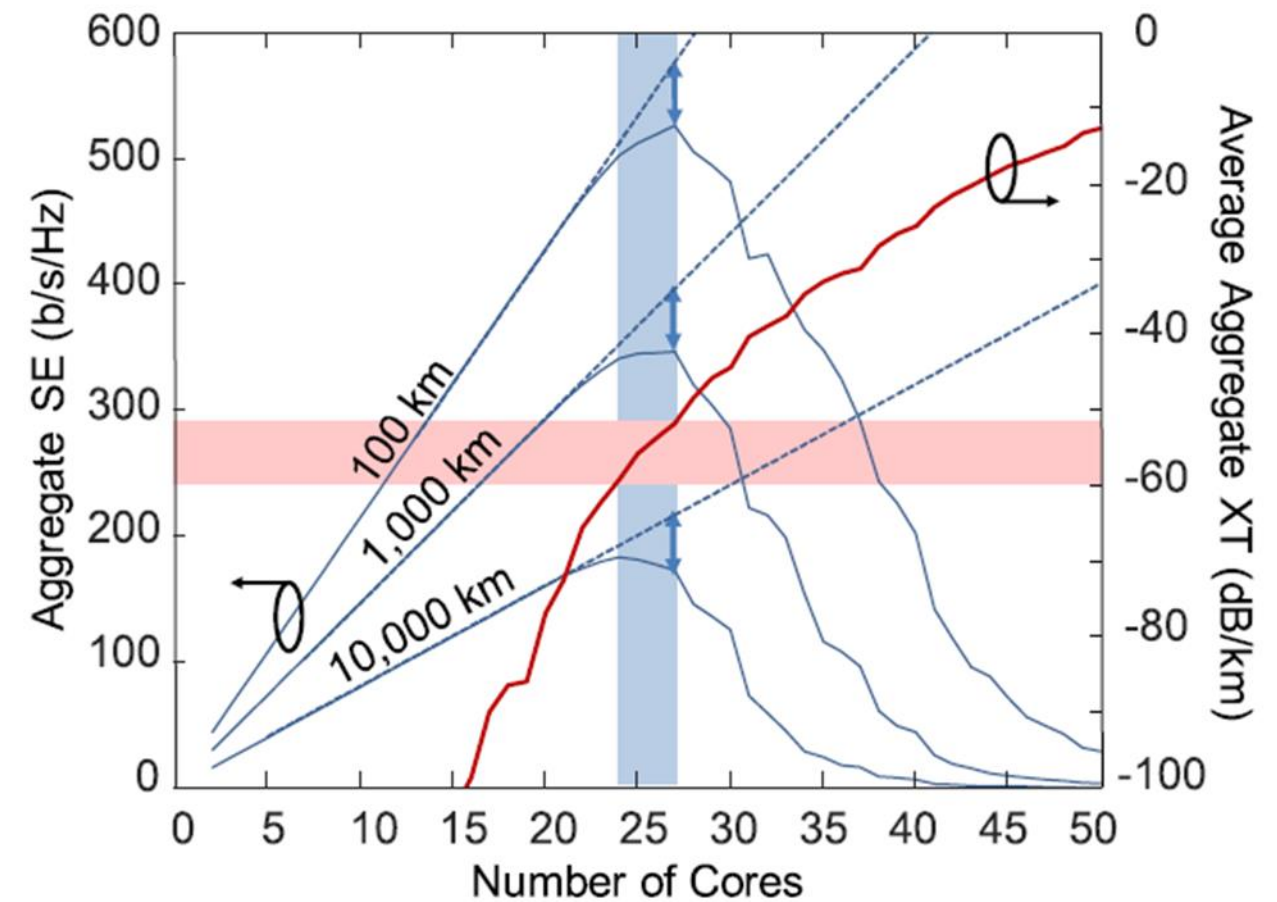
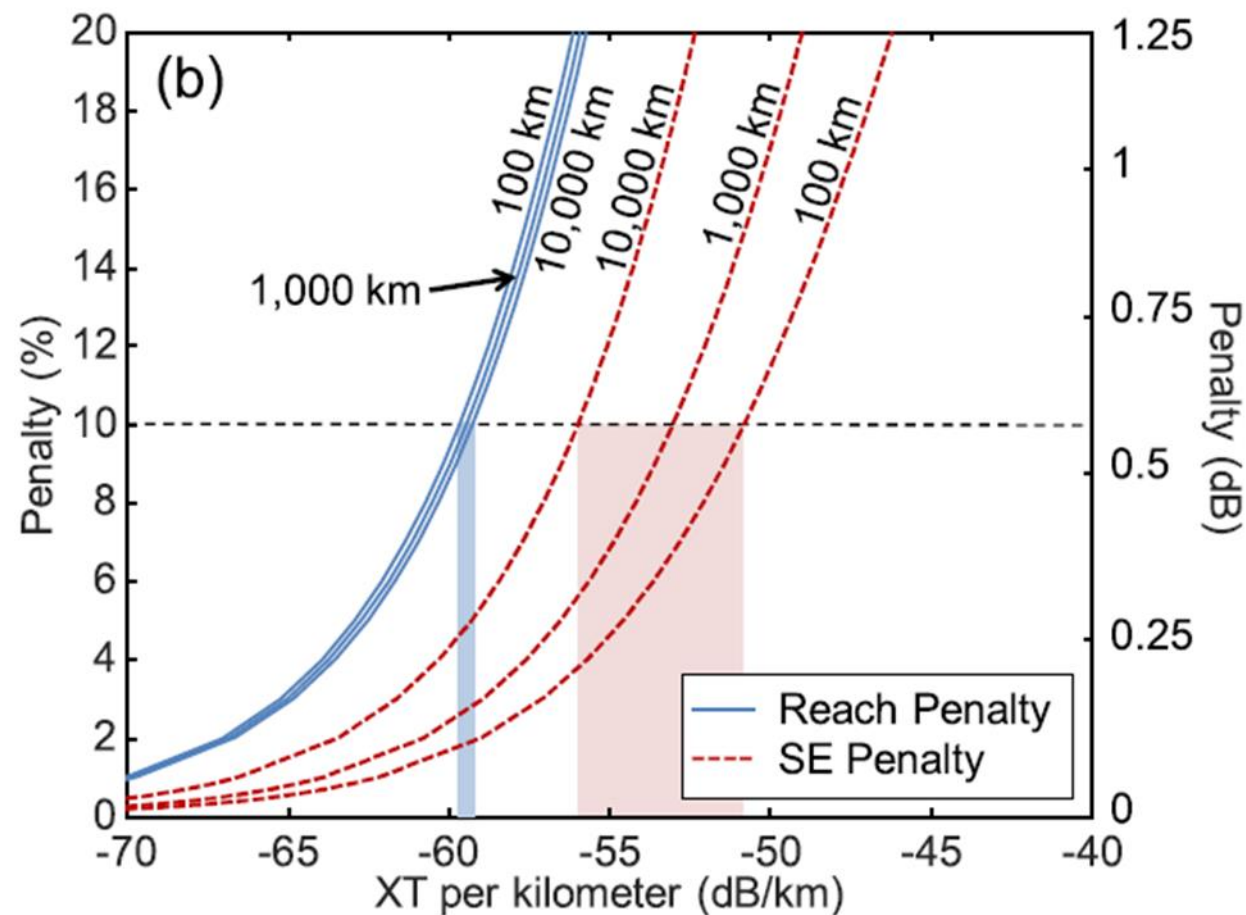
The ever-expanding universe of multicore fibers – which will be worth standardizing?



Universal MCF design - Nokia

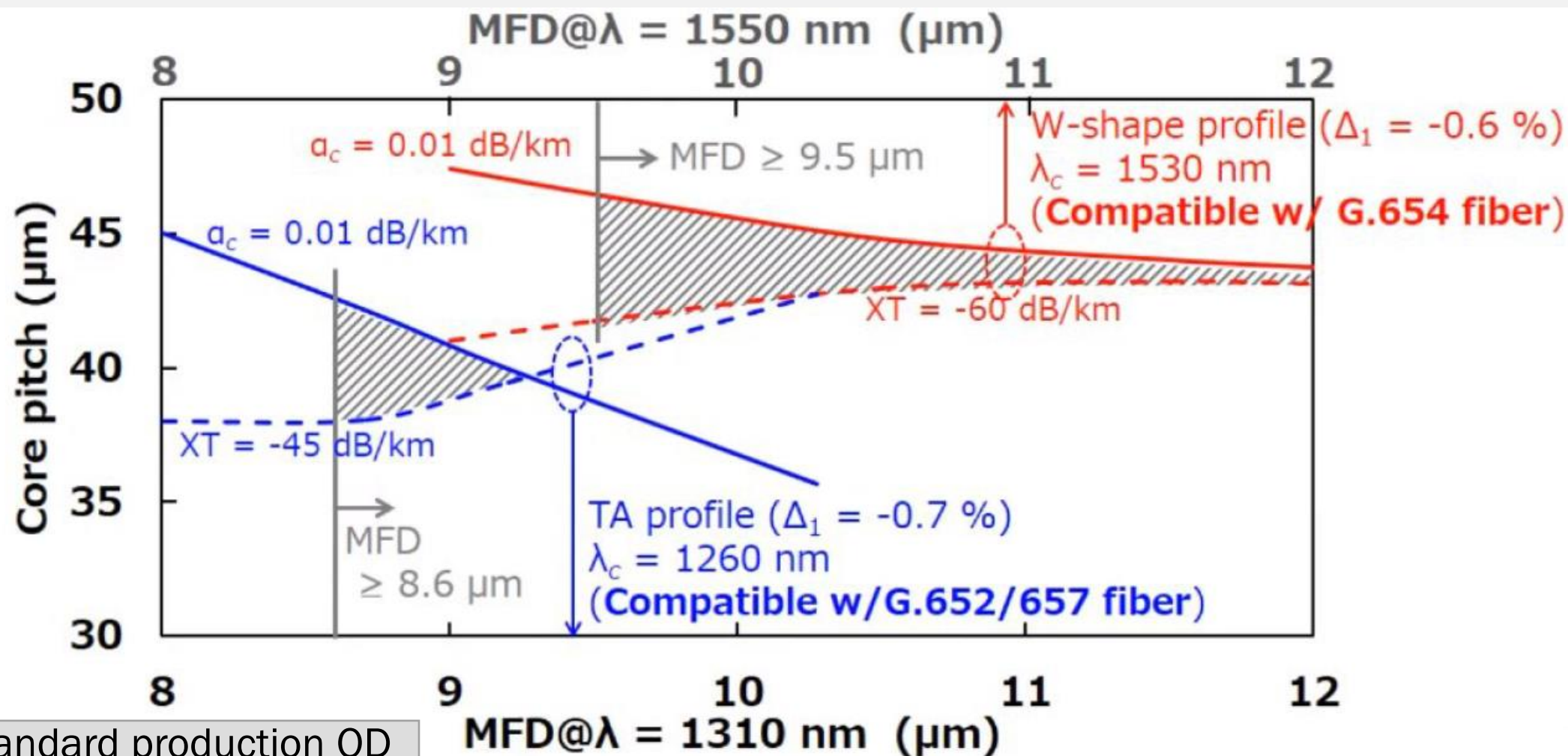
J. Gene and P. Winzer, "A universal specification for multicore fiber crosstalk," IEEE Photon Technol Lett., v31 n9 2019 p. 673.

- Use Gaussian noise model with XT as another AWGN source.
- Predicts net crosstalk (which gives acceptable reach/capacity penalties) is almost independent of link reach (100 – 10,000 km) at roughly -50 to -60 dB/km.
- For fixed core design and clad diameter, the optimum number of cores to maximize capacity also occurs at ~ -60 dB/km.



NTT suggests there is a fairly restrictive range of possible core configurations to consider
Stick to four cores (balance between excess loss and x-talk in 125 micron clad, standard core types to address current fiber markets)

T. Matsui, Y. Yamada, Y. Sagae and K. Nakajima, "Standard cladding diameter multi-core fiber technology," 2021 Optical Fiber Communications Conference and Exhibition (OFC), 2021, pp. 1-3, paper Tu6B.4.



125 micron clad – standard production OD
 4 cores – optimize excess loss and XT
 Conventional RIFs – dependent on reach

Sustainable MCF production ecosystem

Cost effective manufacture

- Can 4-core MCF be produced at costs < four times standard SCF cost
- Tolerances may need to be relaxed
- MCF yield \sim (SCF yield)^{#cores}

Leveraged MCF markets

- Will the narrow business cases of early adopters broaden over time to allow cost reductions in MCF manufacture through a larger addressable market?
- Can other markets be leveraged (high performance computing, shape sensors, power delivery etc.)?

Coupling into those cores!

- Specialized fan-in-fan-out (FIFO) devices for each MCF design. Is there anything more generic (flexible)?
- Is there incentive for transceiver companies to invest in launching directly into MCF?
- Factory testing – how to do core selective optical launch.

New parameters to standardize

Number of cores
Core pitch

Crosstalk:

- FEXT
- NEXT

Homogeneous vs
heterogeneous
cores?

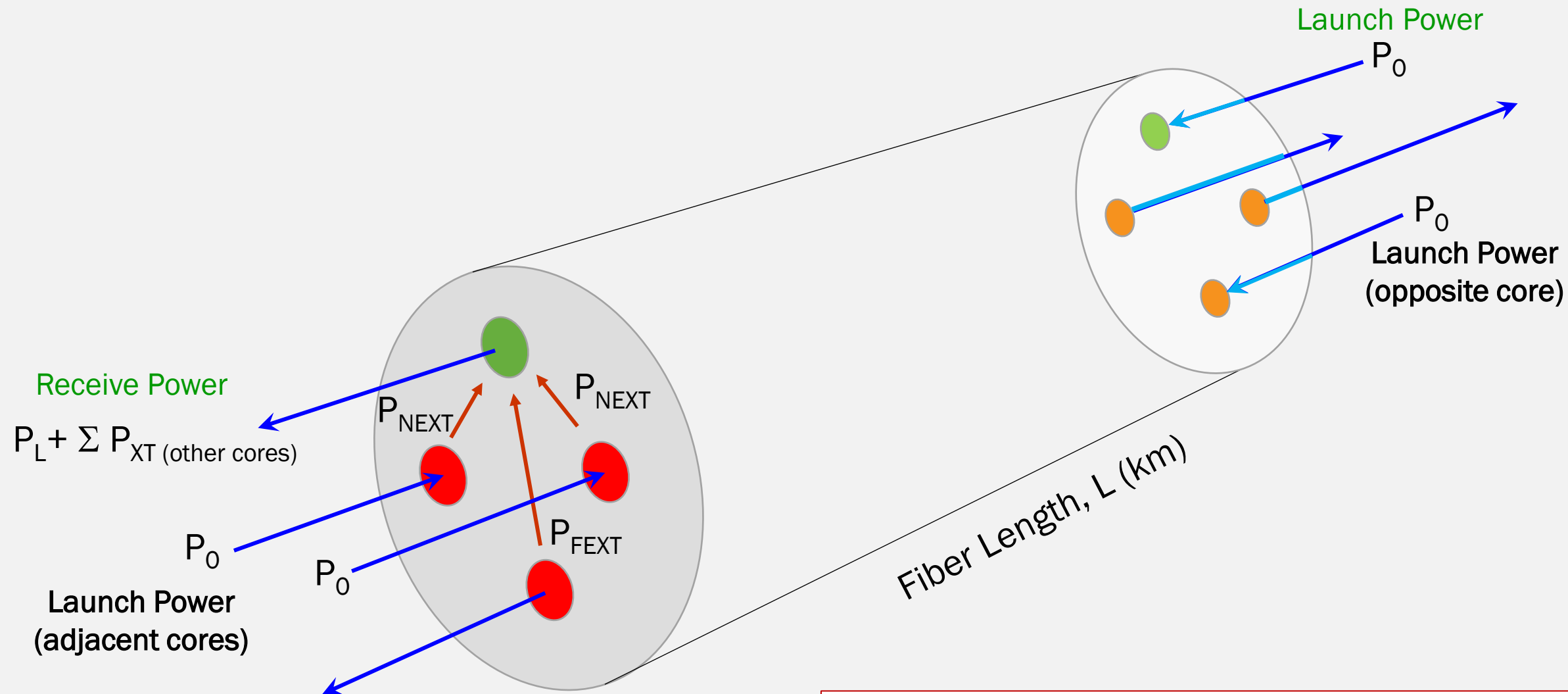
Inter-core skew?

Crosstalk vs
bending

Core markers

Fiber polarity

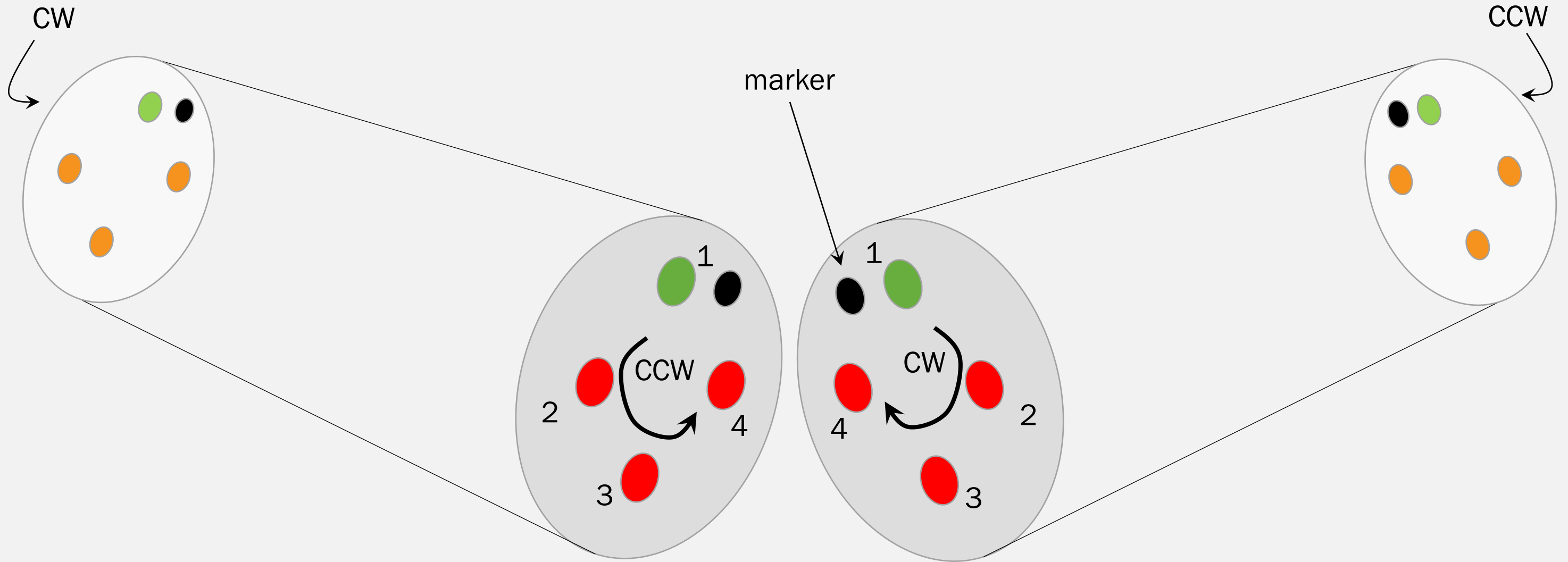
Crosstalk might involve more than that between co-propagating signals
Could assume two cores are illuminated in each direction



$$XT \text{ (dB/km)} = 10 \log_{10} \left(\frac{\sum P_{XT} \text{ (other cores)}}{P_L} \right) - 10 \log_{10} (L / 1 \text{ km})$$

MCF polarity – to maintain core identification, all connections must be between opposite polarities

This could be a hassle! Must track ends of fibers on spools, cable ends, FIFO ends, component ends etc.



Can directional marking be used to indicate MCF polarity?

Conclusions

- Further discussions in standards bodies to track market developments.
 - ITU SG15/Q5 is writing an in-depth technical report on SDM status.
- Is lack of standardization impeding MCF?
 - Probably not. Compelling business case seems more likely.
- Advocacy from intended users
 - NTT has been a big supporter, are other operators/web companies interested?