CORNING

Estimated minEMB for OM3 at 1300nm

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Supporters

Goal of presentation

1. Provide benchmark estimate of EMB at 1300nm for SiP sources meeting the IEC EF requirement for 10+Gb/s VCSELS
   In addition, provide comparison with small-spot-launch from 802.3aq
2. Provide starting point for consensus-building for fiber manufacturers and SiP manufacturers.

Outline

1. Summary/Introduction/802.3aq background
2. Background of OM3 Monte Carlo data set and 10-DMD-weight-minEMB
   2b. Methodology for the EMB 1300 estimate
3. OFL 850 vs. OFL 1300 for 5000 TIA Monte Carlo set
4. OFL 850 vs. OFL 1300 for TIA Monte Carlo 'fibers' meeting OM3 EMB criteria
5. minEMB 1300 vs. OFL 1300 for TIA Monte Carlo 'fibers' meeting OM3 EMB criteria
   Apply OFL 1300 > 500MHz.km for OM3 fibers
   Worst case minEMB(1300nm) is approximately 400MHz.km
6. Conclusion/Discussion/Followup
7. References
8. Backup

1a. Summary

If the SiP launch is assumed to look like a “small spot launch launch” (like SMF launch with an offset of 4-5um), estimates from the 802.3aq project indicate an EMB of 700-800MHz.km for a lower bound (depending on assumptions of index perturbations affecting inner modes).

If the looser tolerance of the EF bounds for 850nm VCSELS are assumed, the preliminary results indicate that the worst case minEMB is less than the OFL BW and that the **worst case EMBs at 1300nm are about 400MHz.km**. This needs to be checked with other fiber manufacturers but can be used as an initial working estimate.

The EF values for SiP might be different from VCSELS.

1b. Introduction

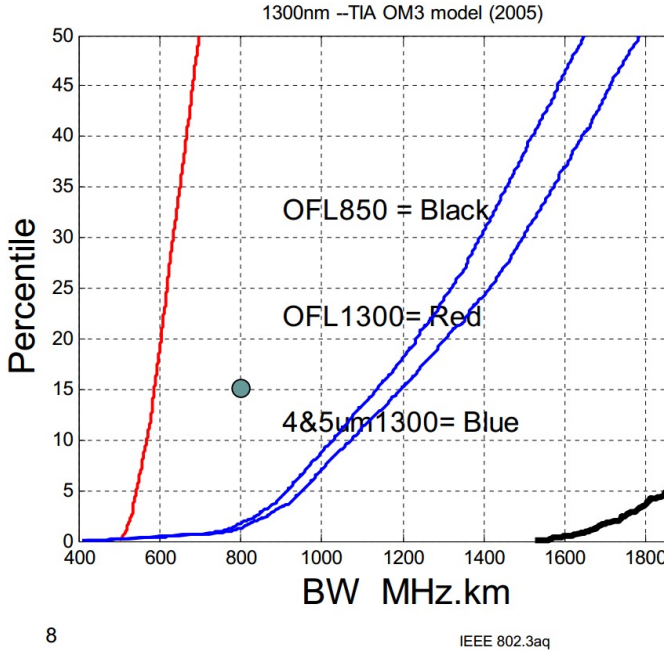
Just as the performance of OM3-VCSEL links depends on the Bandwidth of the fiber and the Mode Power Distribution due to the VCSEL, OM3-SiP s depend on the MPD generated by the SiP launch. In the same way as VCSELS meet an EF spec, the SiP launch needs to be specified to estimate the performance.

1. If the SiP launch is assumed to look like a “single mode launch” with an offset of 4-5um, estimates from the 802.3aq project estimate an EMB of 700-800MHz.km for a lower bound

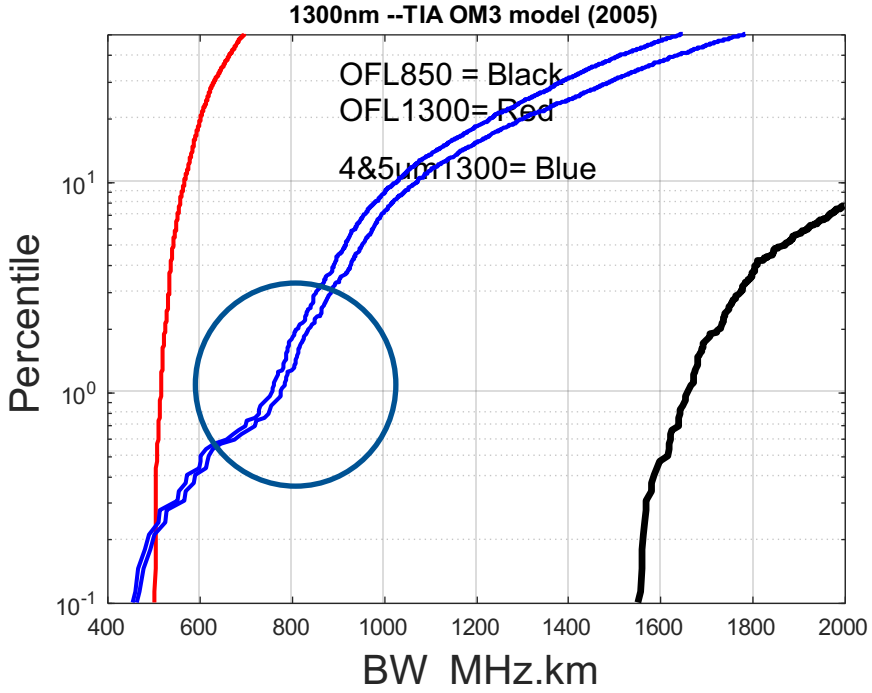
2. If the looser tolerance of the EF bounds for 850nm VCSELS are assumed, the preliminary results indicate that the typical minEMB is less than the OFL BW and that the **worst case EMBs at 1300nm are about 400MHz.km**. This needs to be checked with other fiber manufacturers but can be used as a working estimate.

1c. 802.3aq (small spot launch) suggests lower limit ~800MHz.km

2005: Reference [3] slide 8

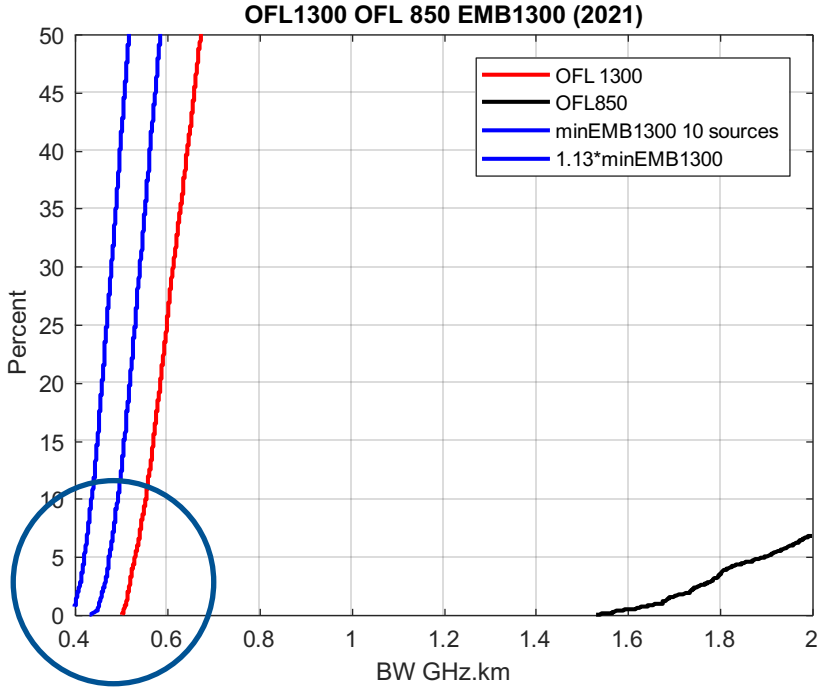


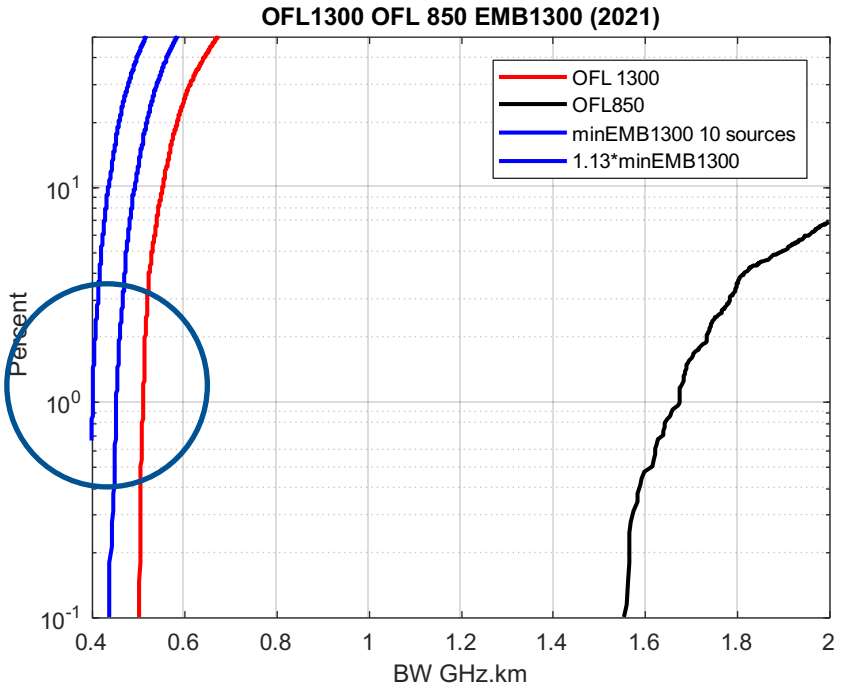
Same data log scale



10source EMB1300 vs. OFL1300 – fibers with EMB850>1770

At the 1% level the minEMB1300 is about 400MHz.km; if we define EMB(1300) as 1.13*minEMB1300 this would be about 450Mz.km.





Methodology and Details

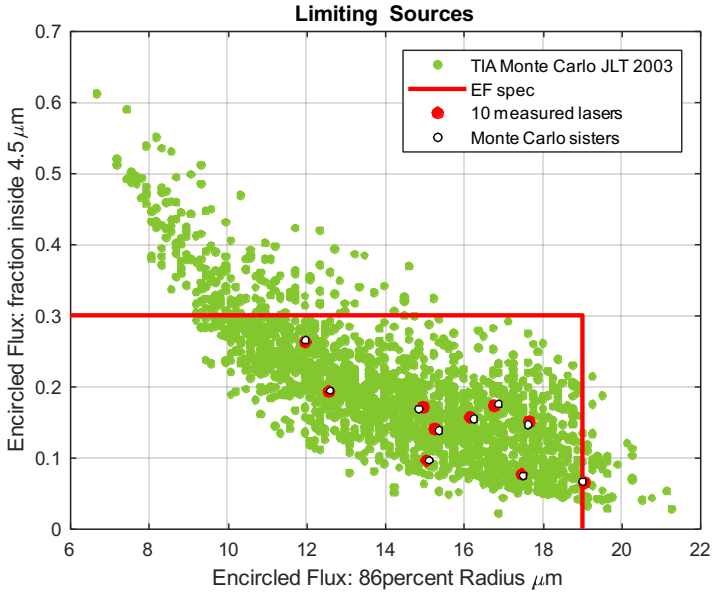
2a. Background of OM3 Monte Carlo data set and 10-wt-EMB

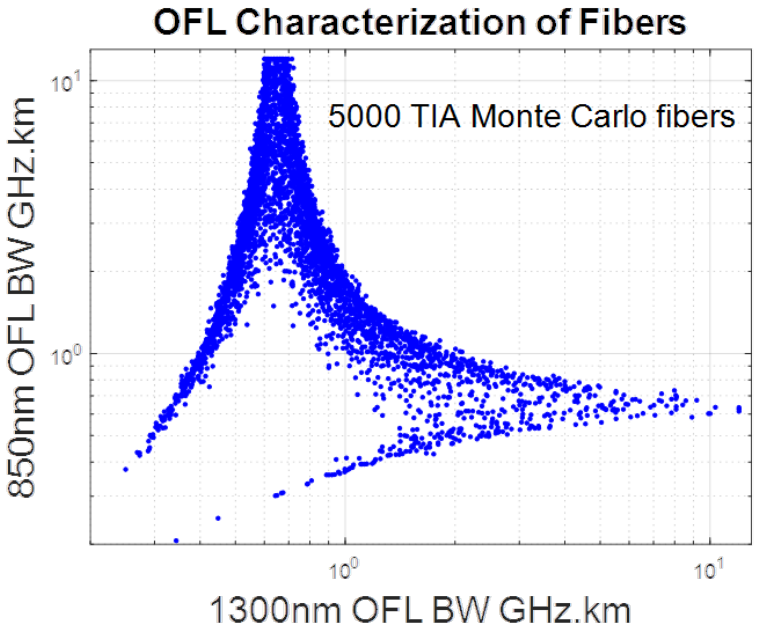
The 2000-2003 TIA/IEEE project to develop 10GbE developed both a spec for the laser (EF) and a spec for the fiber (eventually EMBc). Summarized in abbott_3cz_01_250521_Laser_Optimized_Fiber.pdf [1]

See also May 2003 JLT p.1256 Pepeljugoski et al.[2]

Modeling used 10,000 random laser-fiber pairs with various connections in the link (40,000 total).

The EF characterization is used in transmitter spec, the fiber spec involves taking the minimum of 10 BWs corresponding to 10 benchmark lasers.



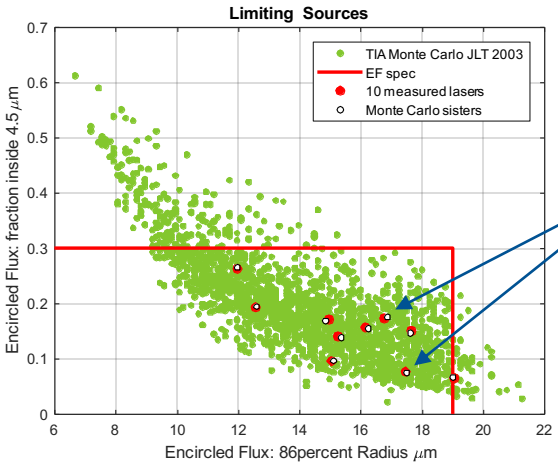


2b. Methodology for minEMB850 and minEMB1300

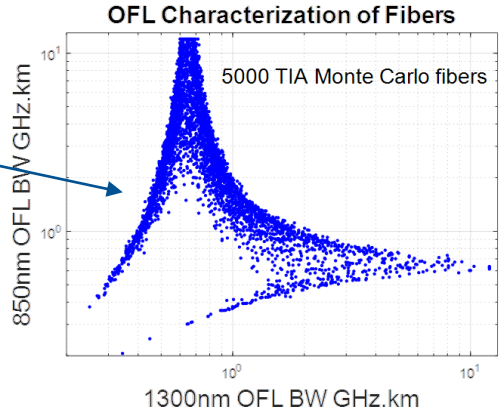
The term EMB = bandwidth of one fiber with one laser ("Effective Modal Bandwidth")
minEMB = minimum EMB with the set of 10 lasers (either Monte Carlo sisters below or EMBc with "DMD weights"
The term EMB also means 1.13*minEMB (in spec) to align with initial OM3 spec using "DMD mask".

We calculate minEMB at both 850nm (for OM3 spec) and at 1300nm, scaling the mode power distribution at 1300nm to match the number of mode groups.

OM3 specification: OFL1300>500MHz.km, OFL850>1500MHz.km, 1.13*minEMB850 >2000MHz.km

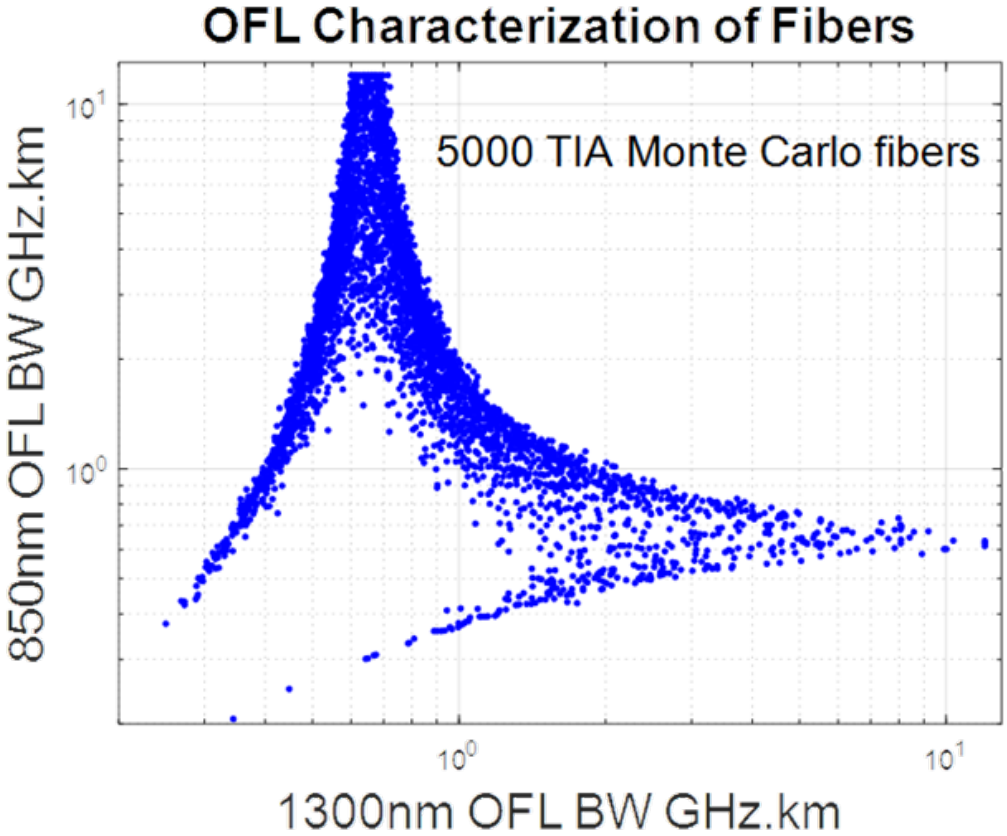


For each 'fiber' we calculate the EMB with the 10 "Monte Carlo sisters" and take the minimum value. Do this at both 850nm and 1300nm.



3. OFL 850 vs. OFL 1300 for 5000 TIA Monte Carlo set

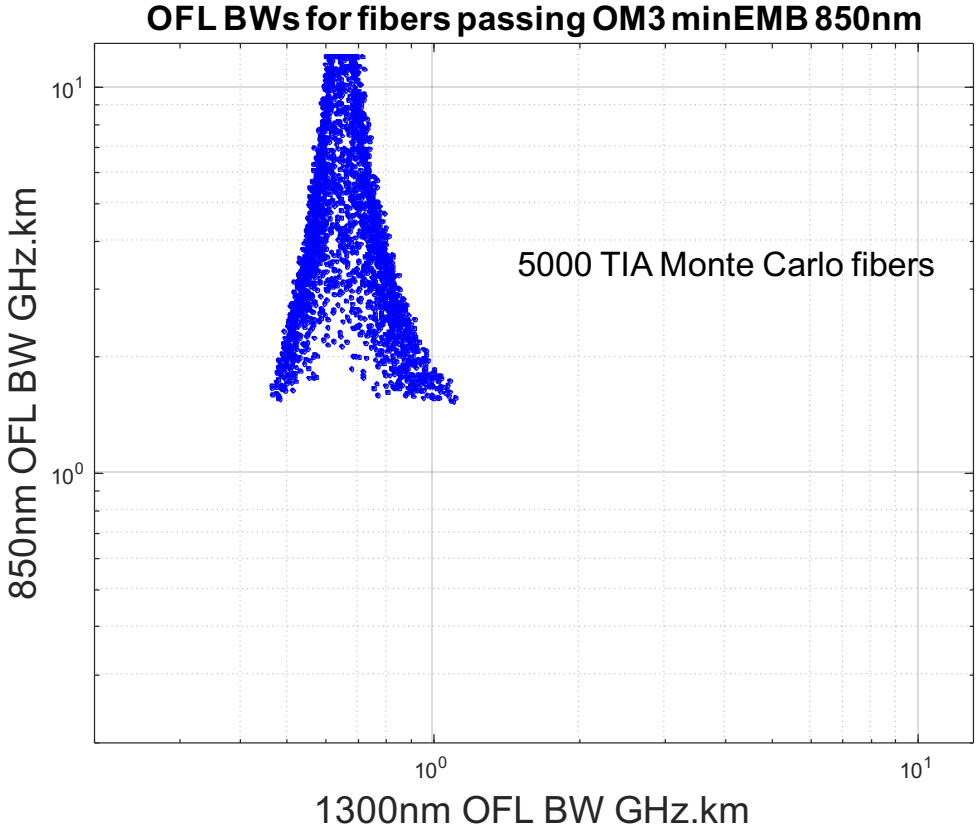
All 5000 “fibers”



4. OFL 850 vs. OFL 1300 for fibers meeting OM3 criteria

Just the "fibers" meeting EMB850 criteria

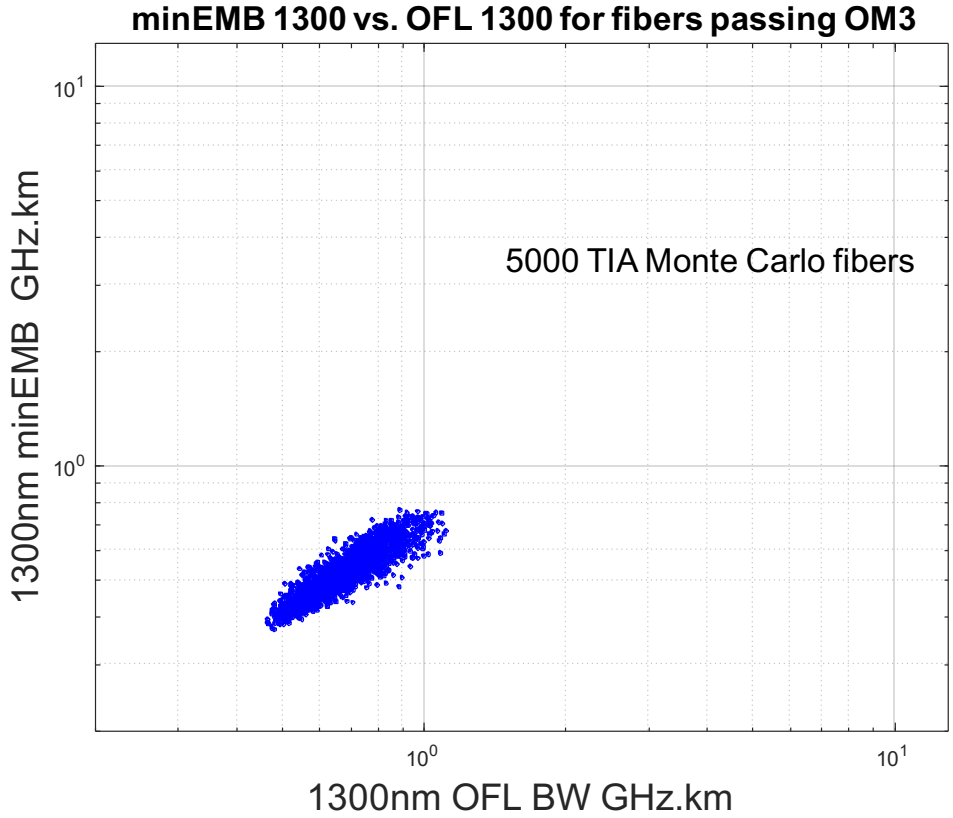
PLOT is OFL vs. OFL; changes next slide



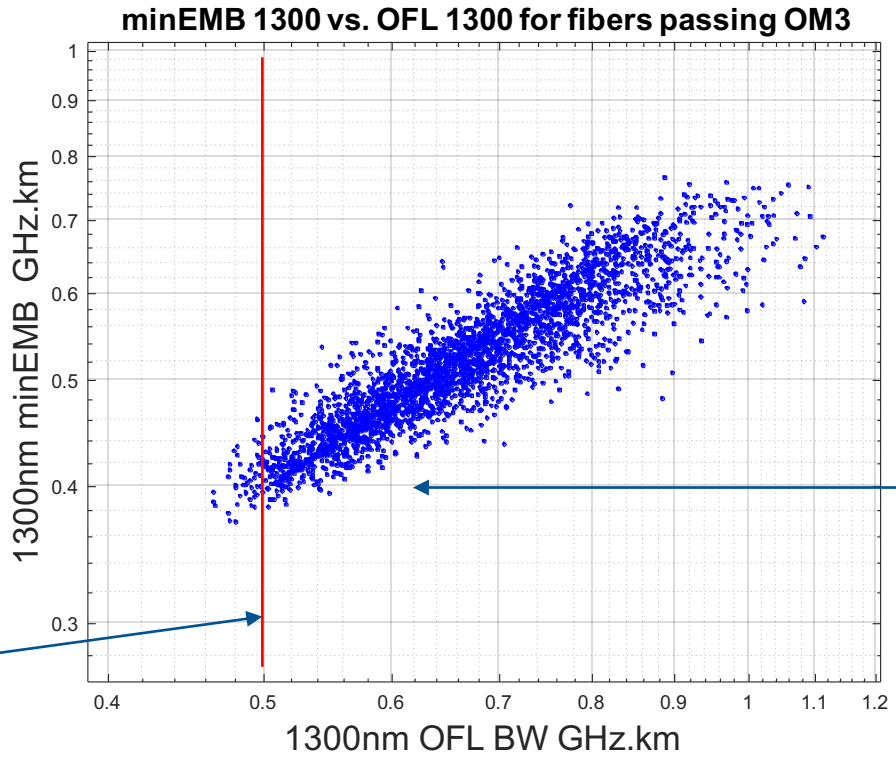
5. minEMB850 vs. OFL 1300 for fibers meeting OM3 criteria

Just the "fibers" meeting EMB850 criteria

Y axis is minEMB at 1300nm



5b. minEMB850 vs. OFL 1300 for fibers (expanded plot)

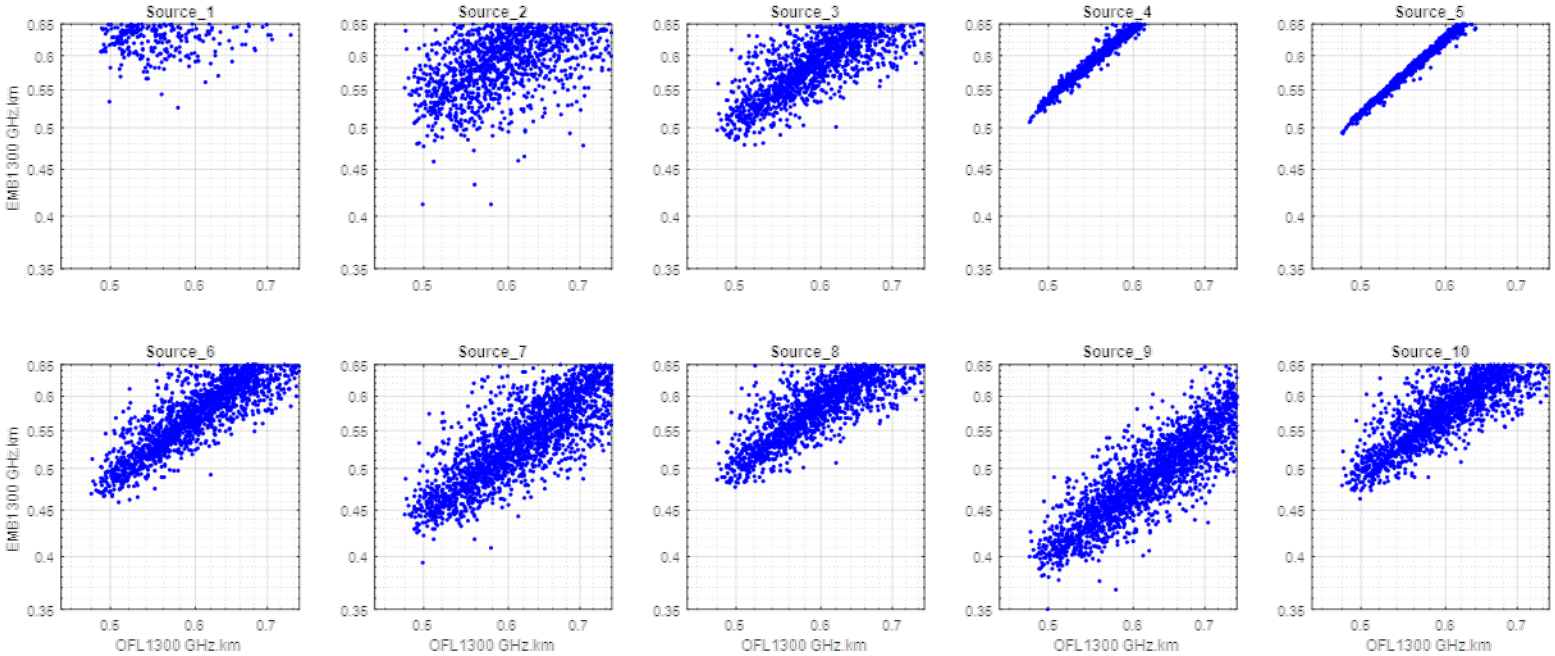


This is a new result and should be considered preliminary – checked with other manufacturers

Worst case 1300nm EMB is about 400MHz.km

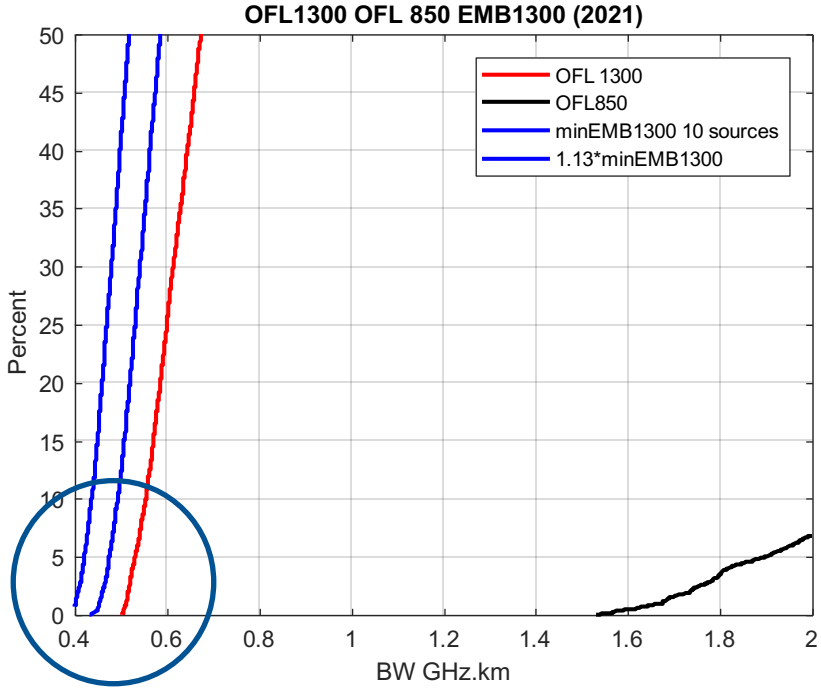
1300nm OFL spec=500MHz.km

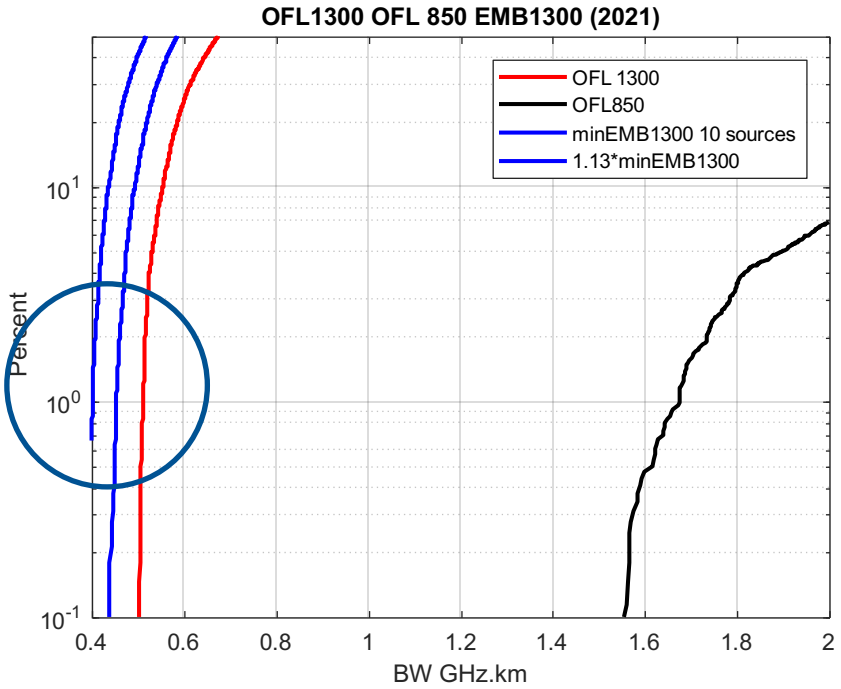
EMB1300 vs. OFL1300 – fibers with EMB850>1770



repeating EMB1300 vs. OFL1300 – fibers with EMB850>1770

At the 1% level the minEMB1300 is about 400MHz.km; if we define EMB(1300) as 1.13*minEMB1300 this would be about 450Mz.km.





6. Conclusion/Discussion/Followup

The rough 400MHz.km estimate is a preliminary estimate and should be checked with other fiber manufacturers doing similar modeling.

Note the TIA Monte Carlo distribution (and the EF distribution) is not a manufacturing distribution and care needs to be taken to avoid using it as a quantitative distribution– mostly useful for ‘worst case’ estimates.

The result assumes SiP launch is similar to VCSEL launch and that the 10 “DMD weights” apply. It is likely that SiP launch could have a different EF specification; however, the EF spec covers a variety of offset and tilts that could be seen in SiP packaging.

7. References

[1] Abbott, “Laser Optimized Fiber for 10+ Gb/s Applications, https://www.ieee802.org/3/cz/public/may_2021/abbott_3cz_02_0521_Laser_Optimized_Fiber.pdf .
[2] Pepeljugoski et al., “Development of System Specification for Laser-Optimized 50-μm Multimode Fiber for Multigigabit Short-Wavelength LANS”, *Journal of Lightwave Technology* Vol. 21, No.5, May 2003 pp. 1256-1275. https://www.osapublishing.org/jlt/abstract.cfm?uri=jlt-21-5-1256
[3] Abbott, slide 8, “Issues with LRM OM3 Monte Carlo modeling set”, https://www.ieee802.org/3/aq/public/nov05/abbott_2_1105.pdf

8. BACKUP