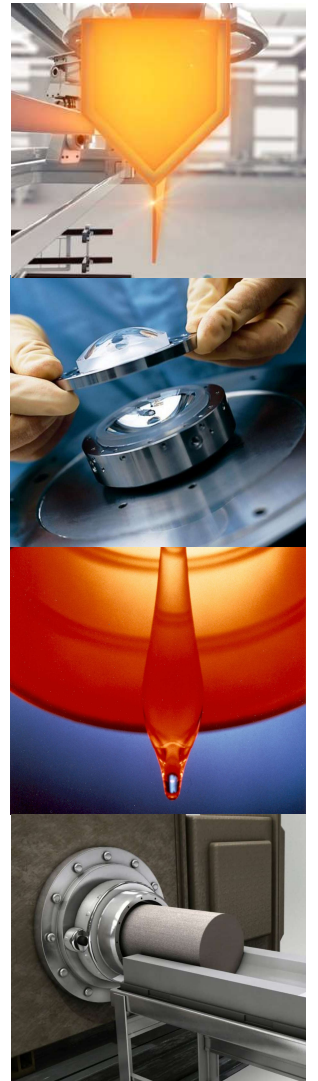


CORNING

## Transceiver Requirements for 802.3cz: SiP

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802.3cz interim September 2021



## Outline

1. Challenges for incorporating SiP transceivers into 802.3cz
2. Challenges for including SiP/OM3 and VCSEL/OM3 in same standard

## SUMMARY

SiP/Single-mode is used in 802.3 400GBASE-DR4 standard and the proposed use in 802.3cz simplifies from 100Gb/s (50Gb/s PAM4) to 10Gb/s and 25Gb/s NRZ, and simplifies the connection from single-mode to multi-mode fiber.

The estimated BW of 800MHz.km is higher than the worst case OFL BW of 500MHz.km at 1310nm, and is achieved with a launch which is more restricted than the general VCSEL launch assumed for OM3. A different launch specification analogous to EF is needed and must be developed for this SiP application

SiP is **technically feasible** on experimental links but requires a clear specification of a robust launch condition enabling broad manufacturing support, including round robins with multiple sources and multiple fiber suppliers, similar to the development of OM3/VCSEL systems

The SiP-MM option is attractive long-term but we need to address timing/rigor/robust specification as well as clarity on the 802.3 desire for “distinct identity”

## 20+ years of OM3/VCSEL experience in data centers

Reference: Pepeljugoski et al., “Development of System Specification for Laser-Optimized 50- $\mu\text{m}$  Multimode Fiber for Multigigabit Short-Wavelength LANs”, *IEEE J. Lightwave Technology*, Vol. 21 No. 5, May 2003 p.1256-1275.

The performance of an optical link depends on complementary specifications on the laser source and the optical fiber, **so that the optical fiber will work with any laser and the laser will work with any fiber**. The complementary specifications were developed in 1999-2003 in a collaboration of manufacturers and end-users, including modeling and extensive experimentation/validation.

Summarized in 802.3cz:

[https://www.ieee802.org/3/cz/public/may\\_2021/abbott\\_3cz\\_02\\_0521\\_Laser\\_Optimized\\_Fiber.pdf](https://www.ieee802.org/3/cz/public/may_2021/abbott_3cz_02_0521_Laser_Optimized_Fiber.pdf)

## ~20 years of OM3/VCSEL development

IEEE multimode projects

<https://www.ieee802.org/3/archive.html>

802.3ae-2002 10Gb/s Ethernet original round robins, DMD & EF development

802.3ba-2010 40Gb/s and 100Gb/s Ethernet (100=10x10 NRZ )

802.3bm-2015 40Gb/s and 100Gb/s Fiber Optic (100=4x25 NRZ )

802.3cd-2018 50Gb/s, 100Gb/s, 200Gb/s Ethernet (200=4x25 PAM4 )

802.3cm-2020 400Gb/s over Multimode Fiber (400=8x25 PAM4 )

802.3db in progress 100Gb/s,200Gb/s, 400Gb/s over MM Fiber (100=1x50 PAM4)

## Corresponding work relevant to SiP/OM3

IEEE multimode projects

<https://www.ieee802.org/3/archive.html>

802.3z – 1998 1Gb/s identified problems with small spot launches into center of pre-OM3 fibers (non-laser-optimized fibers)

802.3aq-2006 10GBASE-LRM 1300nm launch into OM1, OM2 fibers (SiP discussed) using offset launch and electronic dispersion compensation and equalization

---not sure about intermediate projects---

802.3bm-2015 100G CWDM4 (4x25 WDM) (SM)

802.3bs-2017 400GBASE-DR4 100Gb/s Ethernet (100=1x50 PAM4) [SiP](SM) (PSM4)

## **1<sup>st</sup> Missing Piece with SiP -- transceiver specification**

SiP on OM3@1310 is estimated as 800MHz.km but this assumes a specified restricted launch will achieve this EMB at 1310nm on worst case OM3 and “worst case SiP”

The EF criteria for VCELS is not sufficient to give 800MHz.km. OM3 has much more stringent profile control than the OM1, OM2 fibers looked at in 802.3aq (LRM) but OM3 fiber is only screened for 500MHz.km OFL at 1300nm.

A different specification analogous to EF is needed for this SiP application, such that it can be applied by multiple SiP manufacturers and that it will guarantee performance from all OM3 manufacturers.

This seems technically feasible (to JSA) but requires collaboration between transceiver makers and fiber suppliers.

## **2<sup>nd</sup> Missing Piece with SiP -- worst case components**

It is the norm within IEEE 802.3 to design the standard so that it always works with worst case components, not just typical components.

The 802.3cz objectives require multiple connectors.

The SiP option needs to be designed to work with “worst case OM3@1310” and the restricted launch needs to be work with loose connector tolerances.

This seems technically feasible (to JSA) but the transceiver specification needs to allow for robust operation.

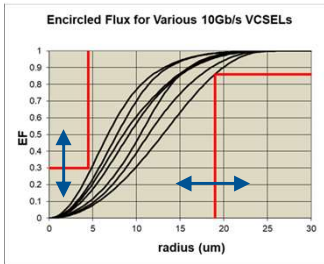
It is difficult to experimentally test for worst-case OM3 because for some large manufacturers OM3 is co-manufactured with higher BW OM4 so that OM3 is less likely to be worst-case; but need to support world-wide manufacturing.



## Recommendations

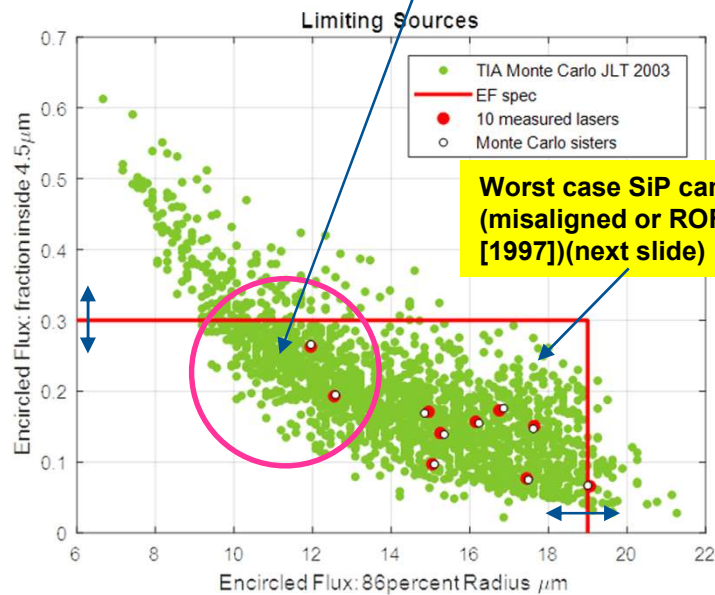
1. Basic presentation on the approach (where does 800MHz.km come from)
2. Modeling analogous to original 10Gb/s fiber-VCSEL modeling (JLT May 2003) developing/validating SiP specification; followed by experimentation by multiple SiP vendors with support of fiber/cable if needed.
3. This work will slow down 802.3cz – it may be that an MSA followed by inclusion in a new project makes sense. The SiP/MM option appears feasible.
4. (**following discussions at 9/22 802.3 interim**). The auto market is different from the data center market and care needs to be taken that SiP is a good fit for auto market.

# Technical Work Analogous to 802.3z, **802.3ae**, and 802.3aq

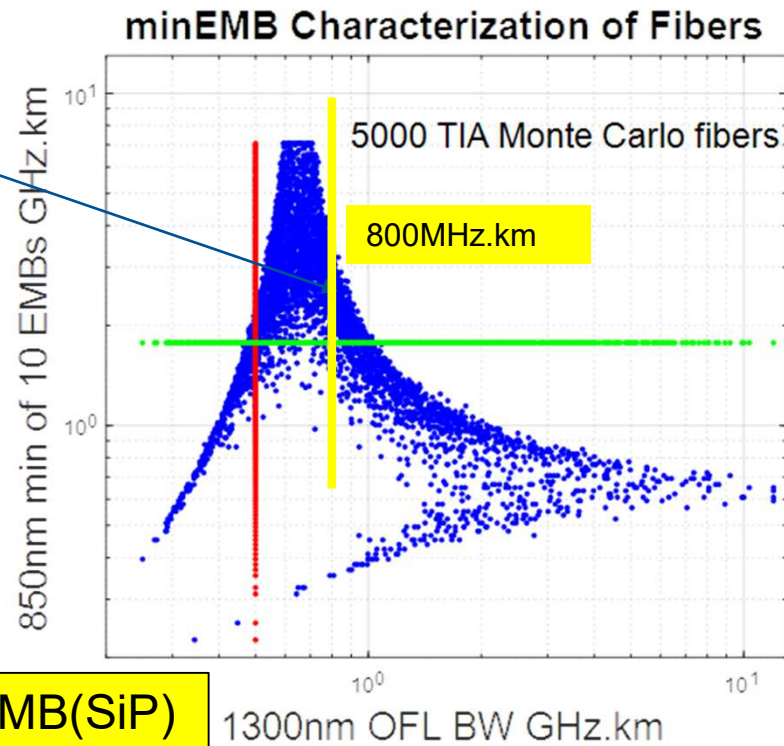


Need to specify the SiP launch at 1310nm (in effect specify 10 launches that span the range) (multiple manufacturers)

Need to model OM3 fiber at 1300nm

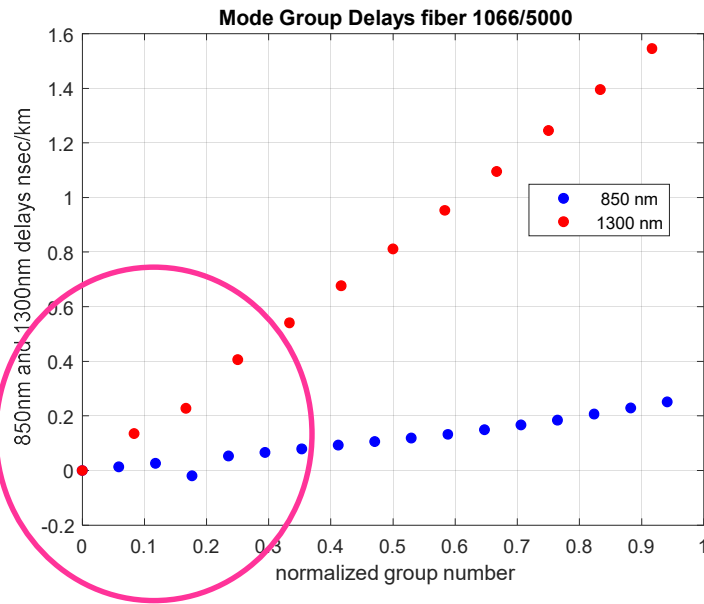


**Worst case SiP can be over here (misaligned or ROFL launch [1997])(next slide)**



**Need EMB(SiP)**

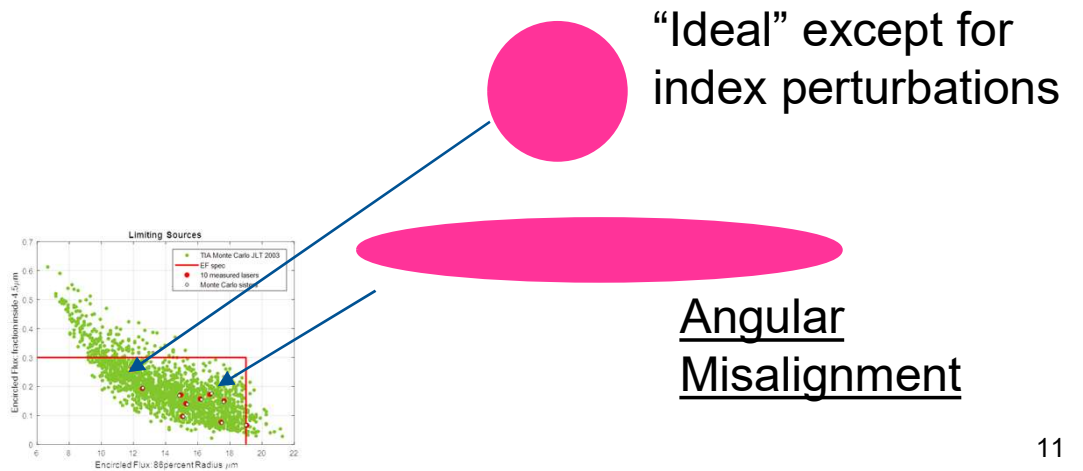
# Long History of this Opportunity and its Challenges



SOFM 1998 (Hackert, 1GbE) and 802.3z project (Cunningham book 1999)-- restricted launch appears to increase BW of OM2 fiber – but OM2 index perturbations prevent it from working in worst case. Same problem in 802.3aq with OM1.

OM3 has smaller perturbations but still tricky.

Ideal SiP launch vs. flawed launch



## Challenges for including SiP and VCSEL in the same standard

1. Differences between SiP/OM3(1300) and VCSEL/OM3
  - a. Need to develop “launch specification” for SiP for OM3 at 1310nm and achieve consensus
  - b. For 980nm VCSEL need consensus on OM3 EMB
2. 802.3cz objective and 802.3 norms specifically limit options for overlapping solutions.
  - a. Same OM3 fiber;
  - b. Same objectives
  - c. Because of SiP connection to established DR4 solution in data centers, may align with future needs (large ships?) (SiP/MM in data centers?) (better scalability? or higher data rate transceivers?) (not clear which is more reliable in the long run?)

Needs clear statement of rationale for including both VCSEL & SiP options.

## Timing Issues (Project Schedule)

In addition to the topic of adding SiP to the project, there is the point of project timing.

The 802.3cy and 802.3cz projects need to be considered somewhat **urgent** based on the CFI approvals, customer support, and WG approval of the project.

If the VCSEL/OM3 option **fits all the objectives** of the project a compelling argument needs to be made for slowing down the project to add additional PMDs.

The route which has worked in the past is to develop an MSA compatible with 802.3cz using SiP, and fold back in with an amendment if it eventually appears to be a successful option.

**BACKUP SLIDES if needed**