Investigation of the 10GBASE-LRM Encircled Flux: Support for changing the specification.

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Outline

- Background
- TP2 Encircled Flux (EF) Measurement Results.
- Theoretical investigation of EF and Mode Group Power Distribution (MGPD) including parameter variation.
- Calculated PIE_D distribution for proposed EF specification.
- Recommendation.

Background

D2.2 TP2 Requirements include EF limits for direct launch into MMF:

>30% within 5um radius

>86% within 11um radius

Finisar presented EF data at the September meeting indicating that a relaxation of the EF specification is required to ensure high transmit optical subassembly (TOSA) yield.

Vote to adopt a new EF specification failed at the September meeting mainly due to the need for more information and analysis.

This presentation provides a more complete experimental and theoretical analysis of the need for a new specification and its effect on PIE_D.

Updated EF Measurements

- Finisar presented EF data at the September meeting on a set of TOSAs designed for –LRM applications

- Measurement Accuracy Has Since Been Improved Significantly:

  – EF results are dependent on the accuracy of the focus of the camera on the fiber endface. Poor focus yields pessimistic results

  – Camera focus now set by independent means resulting in consistent best EF results
    - Imaging of surface of output ferrule with external illumination
    - Imaging of output ferrule with LED launch input to fiber

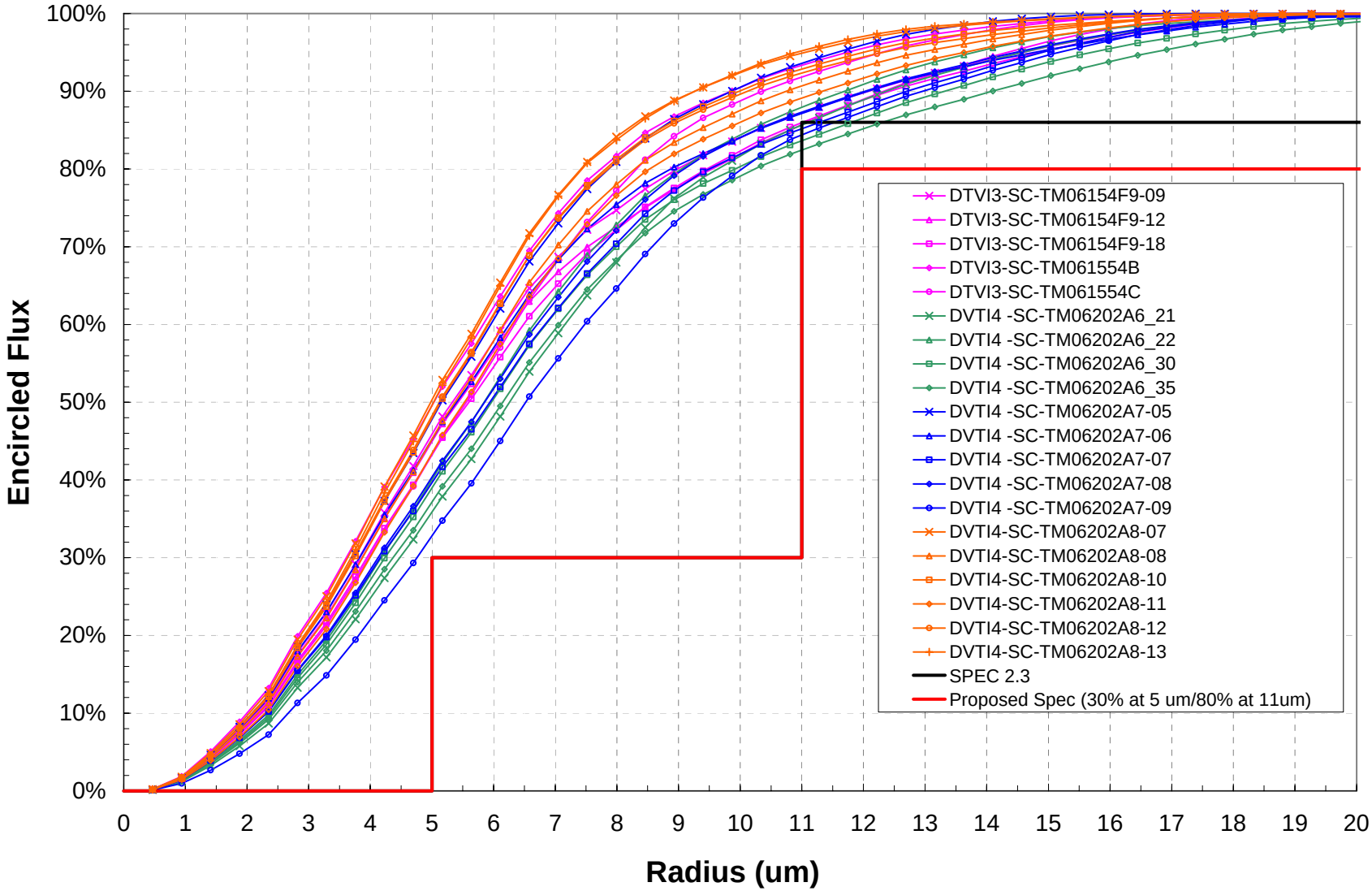
  – Measurement of EF vs Z-focus confirmed best results at above focus point.

  – Eliminated an extraneous patchcord not required by IEC 61280-1-4 .

- Measurements done with both 50/125 and 62/125 Setups

  – Results surprisingly similar. Generally more measurements done since with 50/125.

Encircled Flux Measured per IEC 61280-1-4 with 50/125 MMF



- EF Measurements on 20 TOSAs in groups representing slightly different designs/processes

Theoretical investigation of EF and Mode Group Power Distribution (MGPD) including parameter variation.

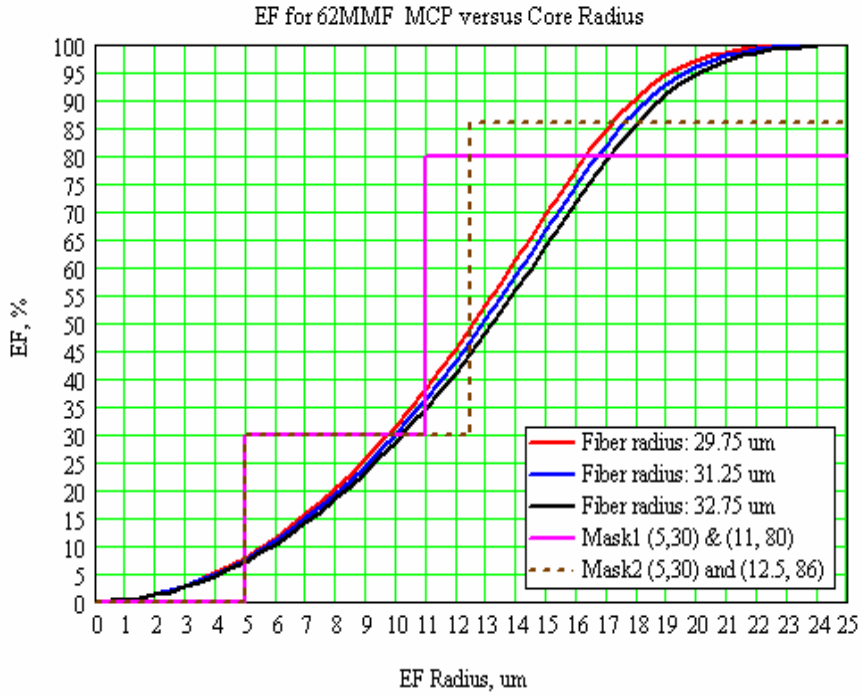
Encircled Flux and Fiber Parameter Variation

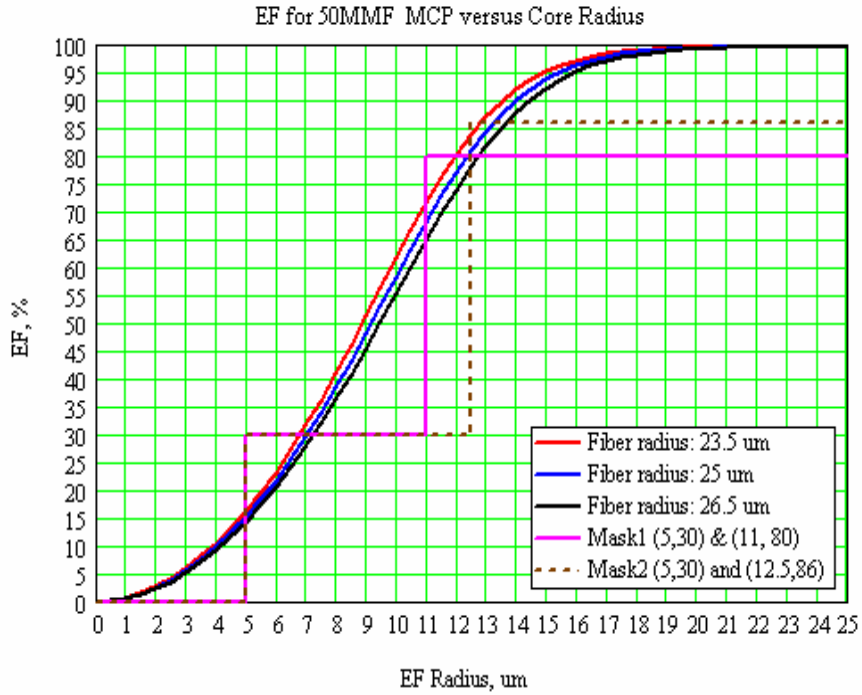
- The 802.3aq fiber and coupling models use nominal fiber parameters.
- EF will be sensitive to parameter variation at the MDI and between different test MMF.
- Need to take this into account to be sure EF specification is not too tight.

	MMF	SMF
Core diameter:	+/- 3 um	
Cladding Diameter:	+/- 2 um	+/- 0.7 um
Core/Cladding Concentricity:	< 3 um	< 0.5 um

- Use these to estimate sensitivity of EF to parameter variation.
- Plots in this presentation indicate limiting cases.

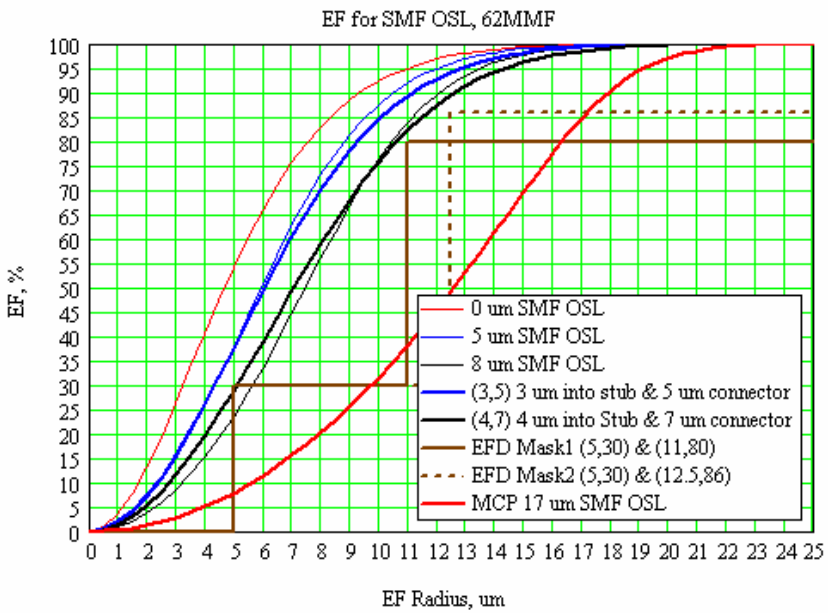
Dual Launch Diversity

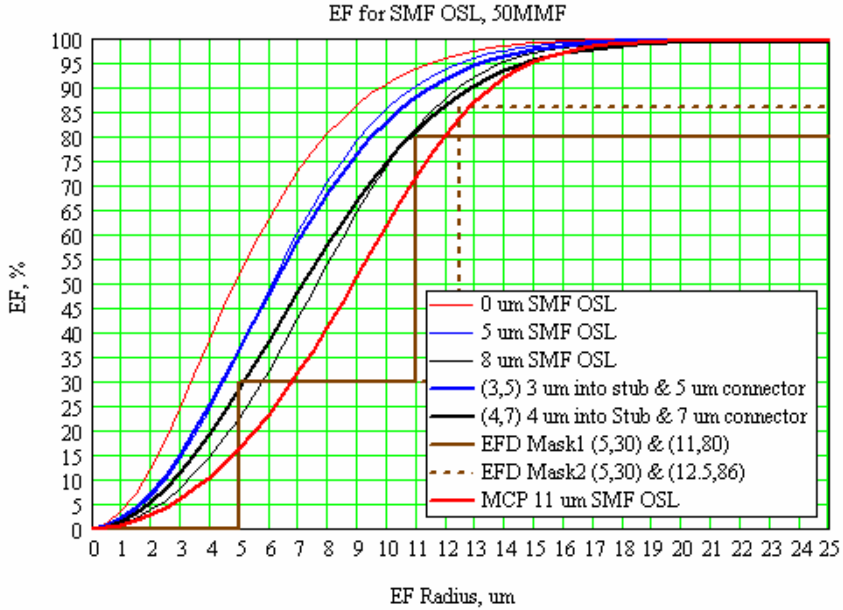


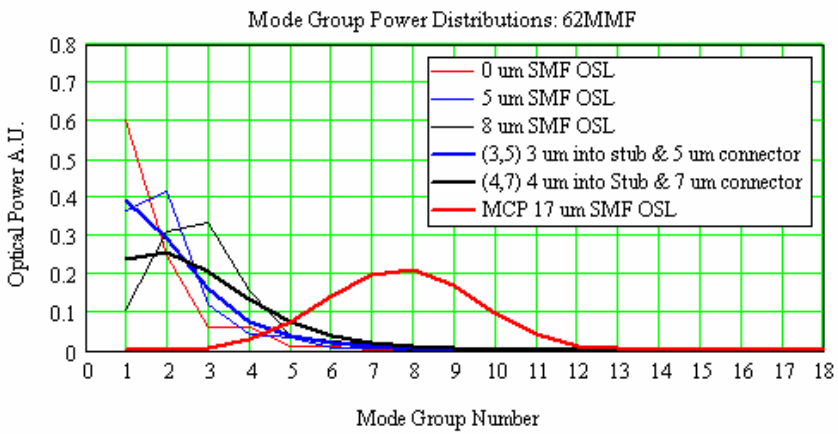


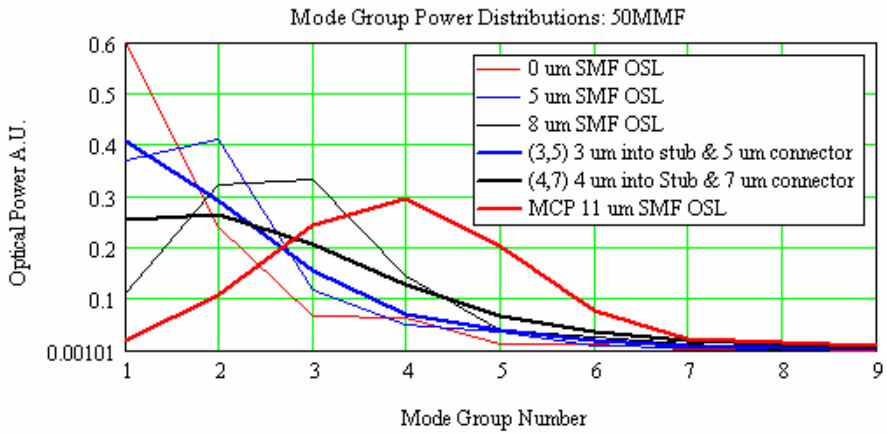
- The EF specification must ensure that center launch occupies a different MGPD space to that of the MCP.

Modelling EFD limits and MGPD with SMF OSL and MMF Connector Coupling Models









Modelling EFD limits and MGPD with SMF OSL and MMF Connector Coupling Models

The launch curves have been calculated with core radii of 32.75 um and 26.5 um. The MCP curves have been calculated with a core radius of 29.75 um and 23.5 um. This minimizes the difference between the EFD of the launch and MCP.

For 62MMF there is clear separation between the EFD for the two launches with either mask. Even with the D2.3 mask, not shown, there is clear separation between the EFD curves.

However, for 50MMF there is only a little separation between the EFD for the two launches with either mask. For the D2.3 mask, not shown, there is no separation between the EFD curves.

Having considered the tolerances of the various connector and fiber parameters the (4,7) curves seem to be the worst case that could reasonably be justified. For 50MMF this curve also just touches mask1.

A separate study verified that the limiting EF and MPD obtained using a more realistic TOSA model closely matches the limits predicted by the SMF OSL and connector coupling analysis reported here.

Calculated PIE_D distribution for proposed EF specification.

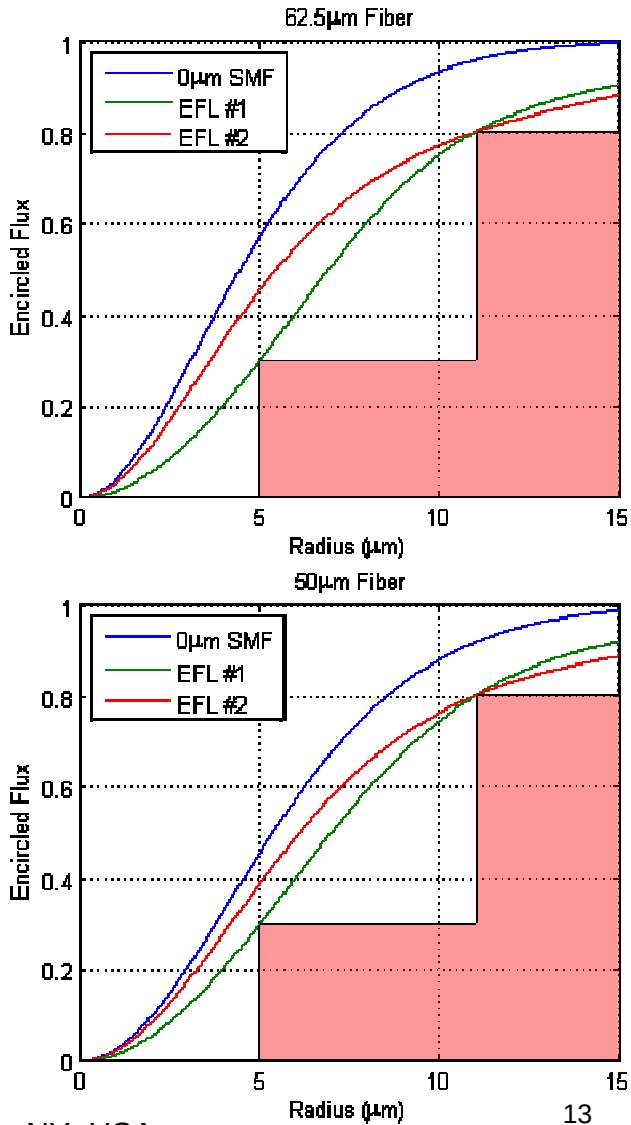
Simulation Parameters

- Delay Sets
  - MC67 (≥ 500 MHz·km, 18 mode-groups)
  - MC50 (≥ 500 MHz·km, 10 mode-groups)
  - OM3 (passing fibers, 10 mode-groups)
- Connectors
  - Random offset from Rayleigh distribution
    - mean = 3.58μm, truncated at 7μm
  - Total loss ≤ 1.5 dB
    - loss computed with OFL launch
- Link Configuration
  - fibers randomly chosen from set
  - 1-1-Lx-1

- Offset Launch (OSL):
  - 17μm → 23μm for 62.5μm fiber
  - 10μm → 16μm for 50μm fiber
- Center Launch (CL)
  - Previous work: SMF launch with offsets varied from 0μm → 3μm
  - Current work: create MGPD that matches encircled flux limits
- Joint Launch: best chosen for each pair-wise combination of OSL & CL

Encircled Flux MGPD Assumptions

- Assume “best case” CL is 0μm SMF launch
- Encircled Flux Launch #1
  - Create MGPD that intersects both corners of EFD mask
  - Tends to maximize offset of MGPD from the center
- Encircled Flux Launch #2
  - Create MGPD that intersects only the upper corner of the EFD mask
  - Create with linear combination of 0μm SMF launch + 20μm SMF launch
  - Tends to spread MGPD across broadest range
- Joint Launch
  - Compare OSL against each of these three center launches
  - Assume equal weighting of 0μm SMF, EFL #1, and EFL #2 launches



Simulation Results

	PIE-D	
	0μm → 3μm SMF	0μm SMF, EFL#1, EFL #2
OM1 (99th %-tile)	4.08dB	4.17dB
OM2 (85th %-tile)	3.38dB	3.53dB
OM3 (99th %-tile)	3.77dB	4.20dB

- Encircled flux mask: 30% at 5μm / 80% at 11μm
- 1-1-220-1 simplex link configuration
- Comparison %-tiles chosen as in ewen_1_0905.pdf
- PIE-D increases slightly relative to previous results
  - 0.1dB for OM1 → 0.4dB for OM3
  - OM3 most sensitive to power in higher-order mode-groups

Recommendations

- Change the EF flux specification for OM1 and OM2 to:

  > 30% at 5 um
  > 80% at 11 um

- This will ensure launch diversity.

- This will greatly improve TOSA yield.

- The 99 percentile PIE_D of the dual launch is ~ 4.2 dB even with this change in EF specification.