# Measuring the Modal Properties of Multimode Fibers

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**IEC SC86B WG4**
**20th April 2005**

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- Modal Descriptors
- Measuring the Mode Distribution
- MPD Template
- Controlling the Mode Distribution
- Measurement results

# Modal Descriptors

- Coupled Power Ratio (CPR)
- Higher Order Mode Power (HOMP)
- Mode Power Distribution (MPD)
- Encircled Flux (EF)

# Modal Descriptors - standards

- CPR: IEC 61300-3-31 & 61280-4-1
- HOMP: TIA/EIA 455 FOTP-34
- MPD: TIA/EIA TSB62-3
- EF: TIA/EIA 455 FOTP-203

# Modal descriptors - relationships

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Near-field power distribution, NF(r):
where MTF(m) is the Mode Transfer Function,
m is the relative mode group number, $m=(r/a)^2$,
and a is the fiber radius

$$NF(r) = \int_{(r/a)^2}^{1} MTF(m) \cdot dm$$

MTF(m) is given by:

$$MTF(m) = \frac{dNF(r)}{dr} \cdot \frac{1}{r}$$

Mode Power Distribution, MPD(m):

$$MPD(m) = MTF(m) \cdot m$$

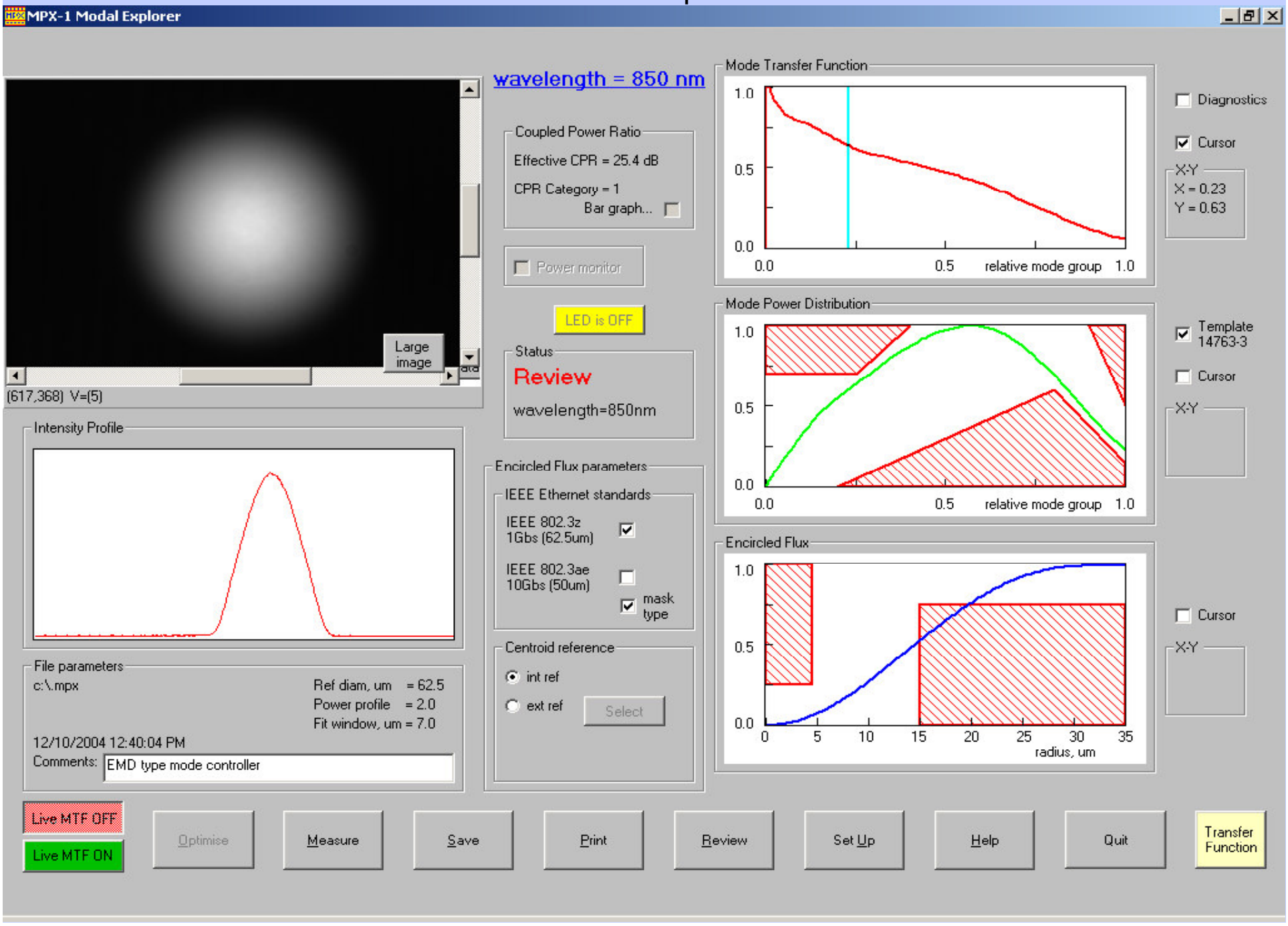
Effective Coupled Power ratio from MPD, CPRe:
where Ng is the number of mode groups,
(Ng=19 for 50um fibre, 0.2NA, 850nm)

$$CPRe = 10 \cdot \log\left( \frac{\int_{0}^{1} MPD(m) \cdot dm}{\int_{0}^{1/Ng} MPD(m) \cdot dm} \right)$$

Encircled Flux, assuming circular symmetry, EF(r):

$$EF(r) = \int_{0}^{r} NF(r) \cdot r \cdot dr$$

# MPX-1 Modal Explorer



# MPX-1 Modal Explorer

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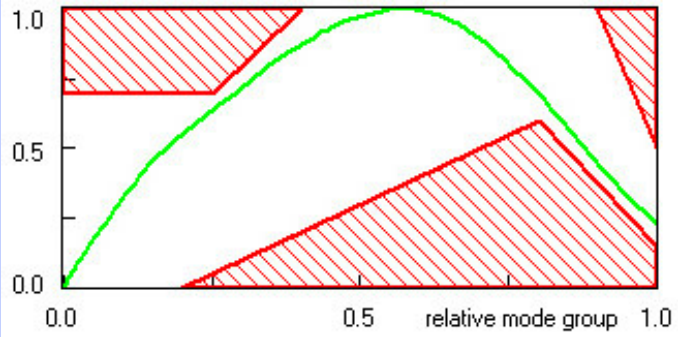
# The MPD template

(ISO/IEC JTC1/SC25/WG3 Jan '05)




- checks the overall shape of the mode distribution.
- enables real-time testing of launch conditions.
- one template applies to 50/62.5um and 850/1300nm.

# MPD template

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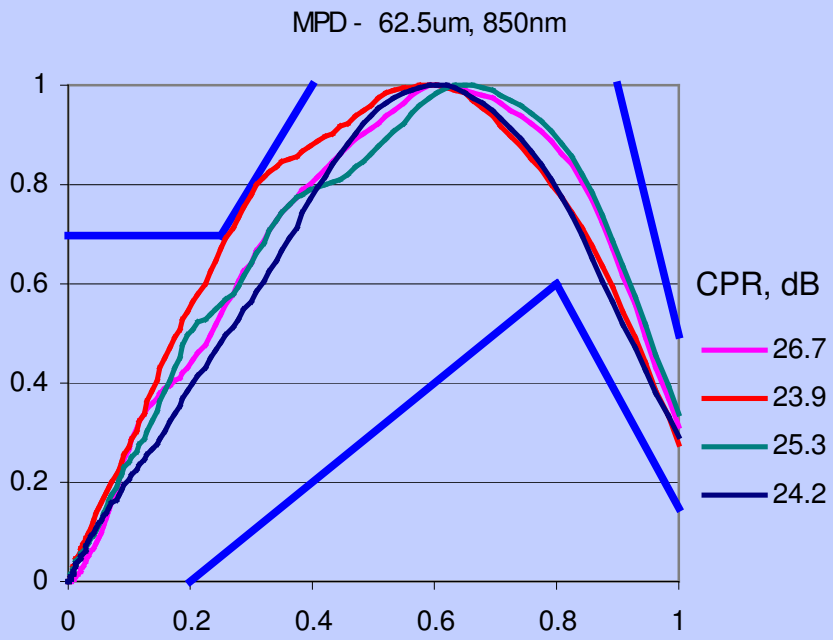


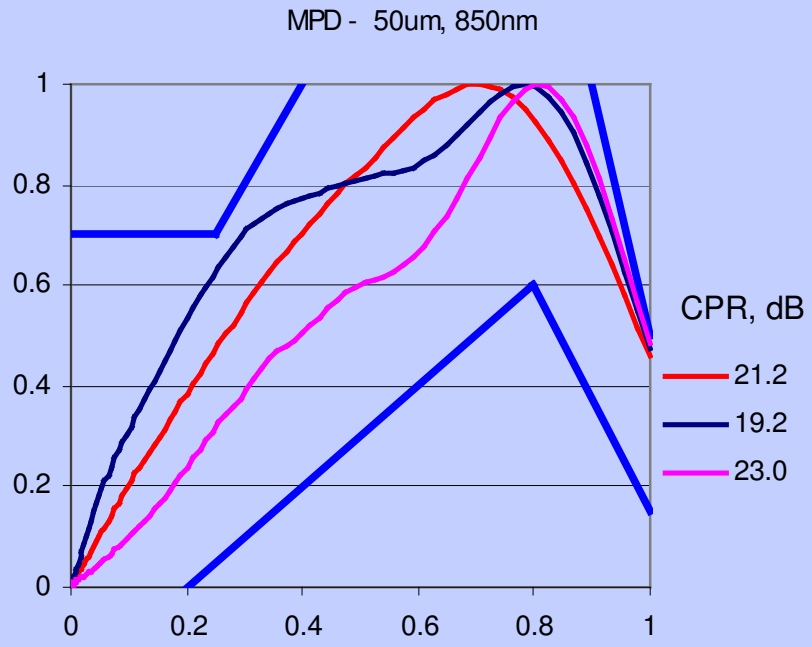


Sources that pass the MPD template, but have different CPRs

# Controlling the Mode Distribution

## - FIA Round Robin -

# Mode Controller (62.5um)

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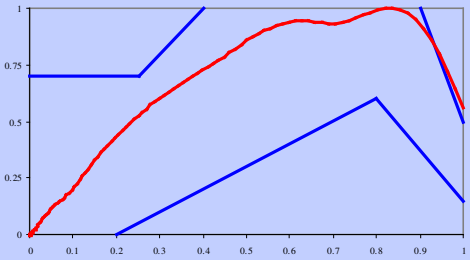
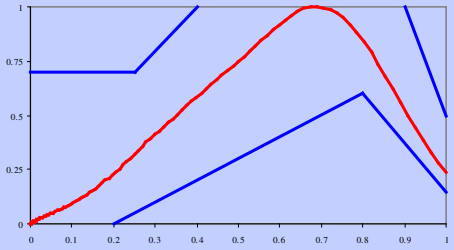
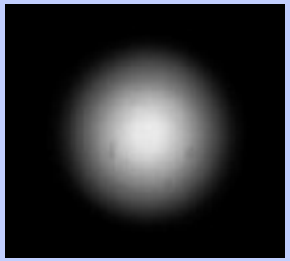
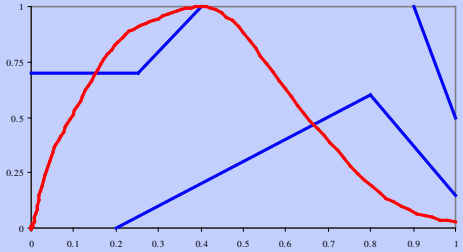
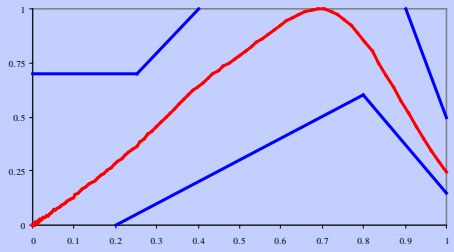
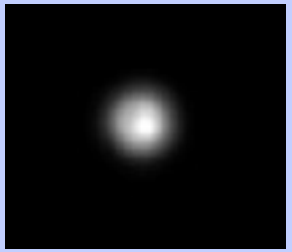
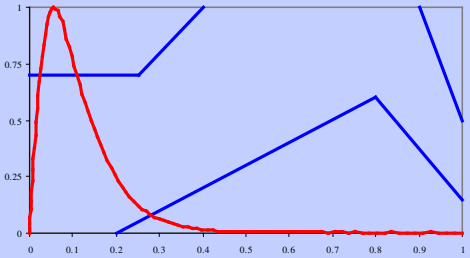
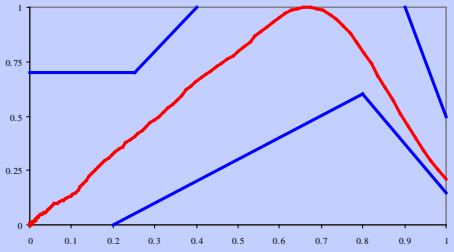
| | Input near-field | Input MPD | mode controller | Output MPD |
|---|---|---|---|---|
| Full launch |  |  | |  |
| Mid launch |  |  | |  |
| Low launch |  |  | |  |

# Mode Controller

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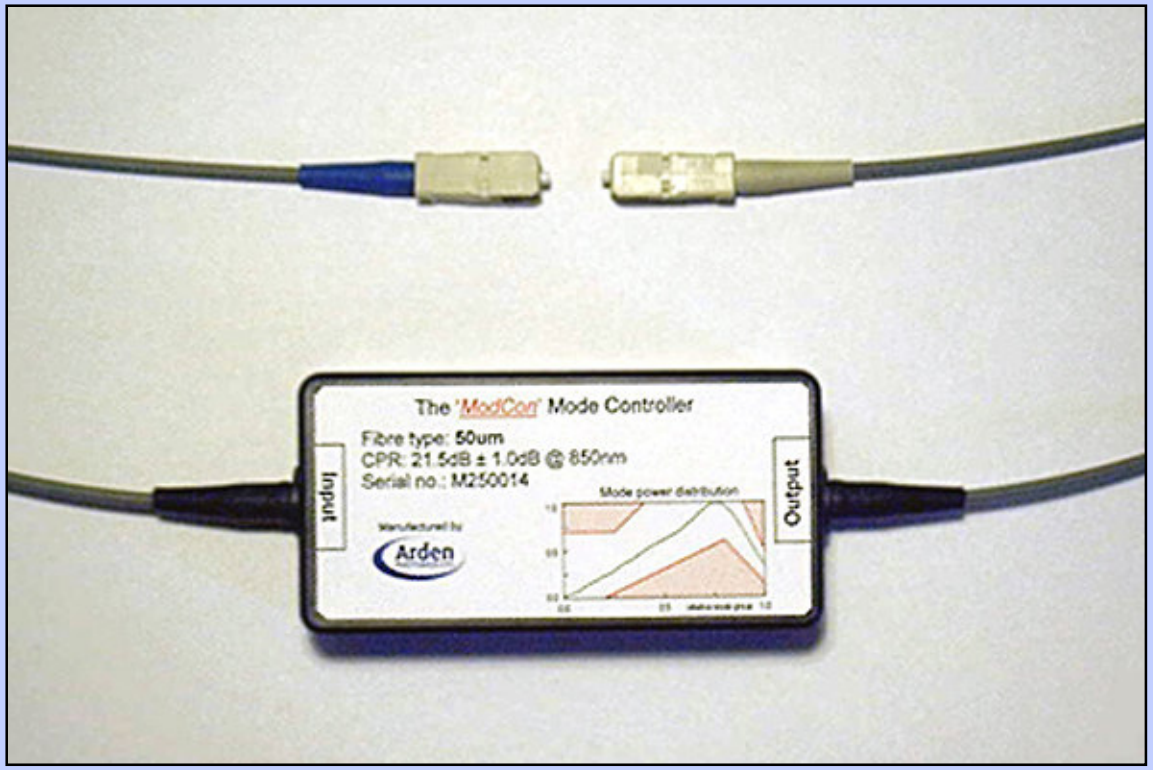


100mm

# FIA round robin measurements (2)

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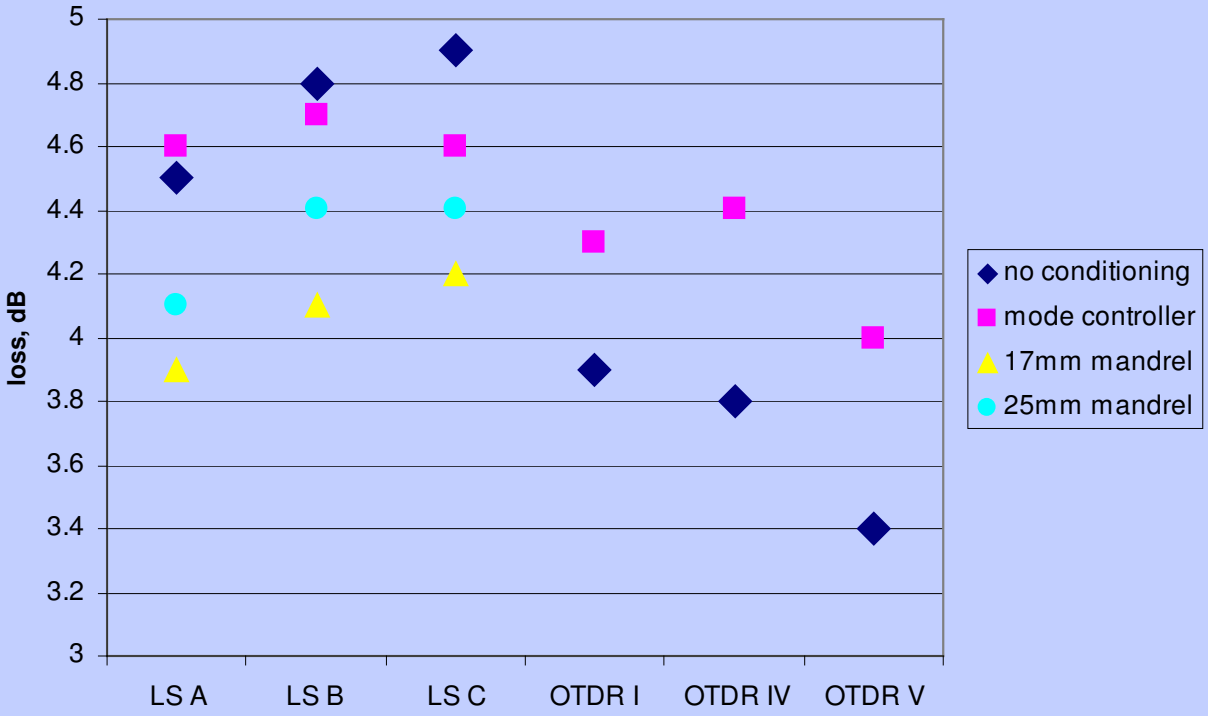
## 50um test results




## 600m fiber with 19 connections

(FIA report MG/L4546)

# FIA round robin measurements (3)

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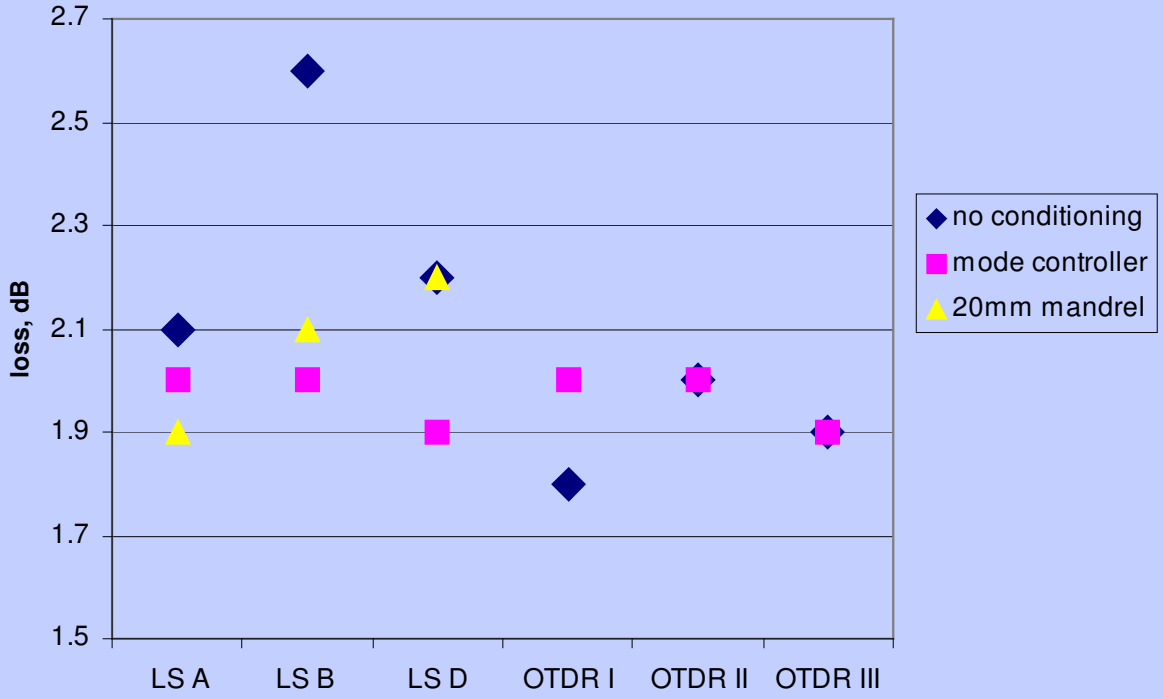
## 62.5um test results




## 450m fiber with 3 connections

(FIA report MG/L4546)

# Some measurement examples:

## - Long fiber lengths -

# MPD and Fiber Length (1)

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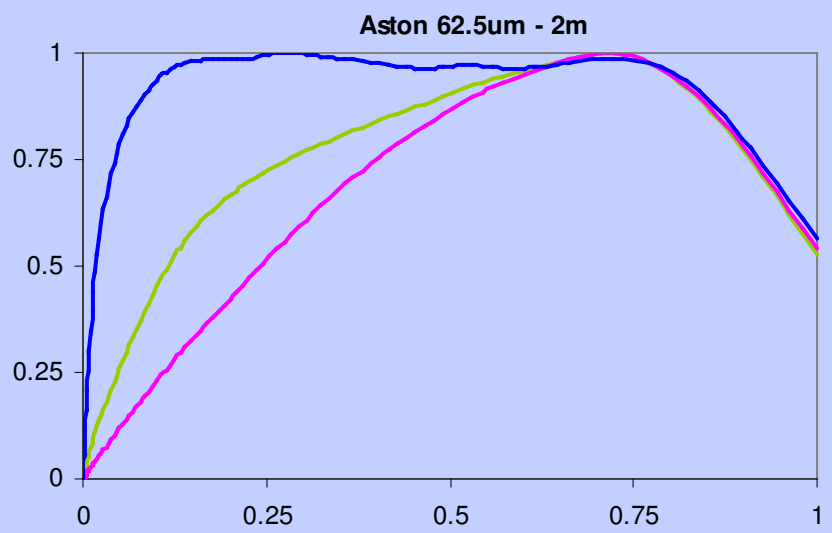


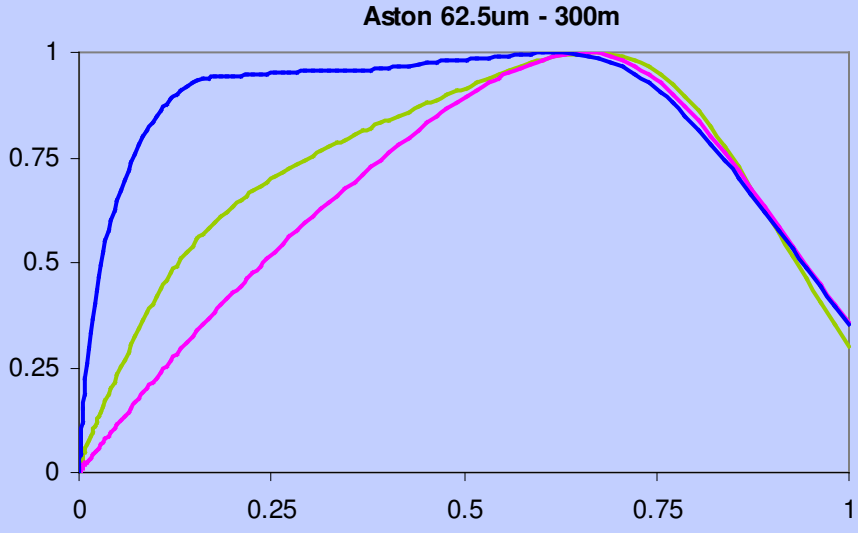


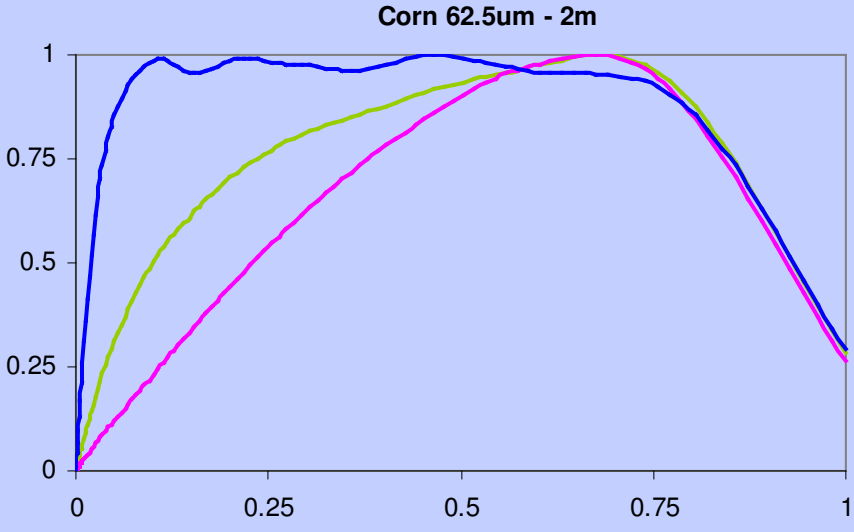


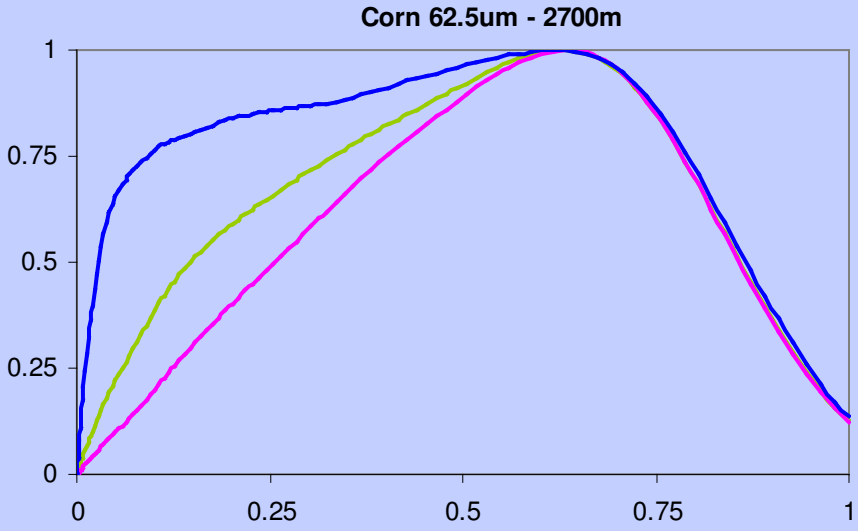

# MPD and Fiber Length (2)

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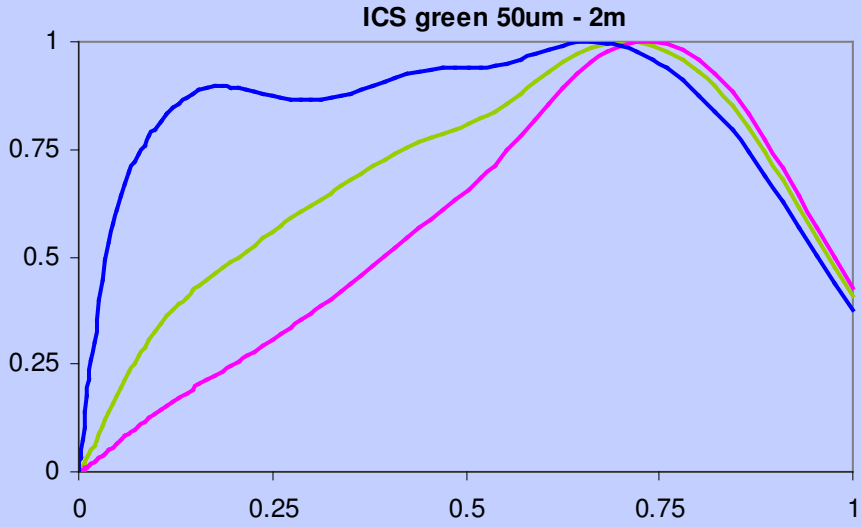


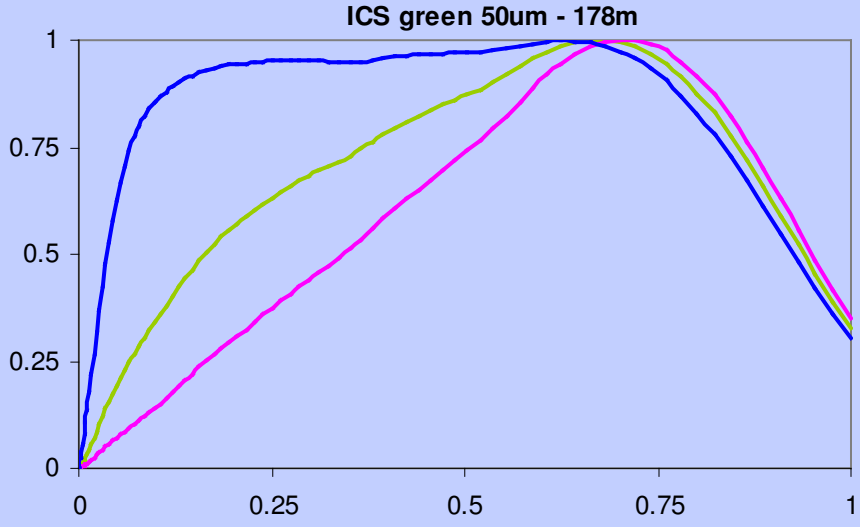


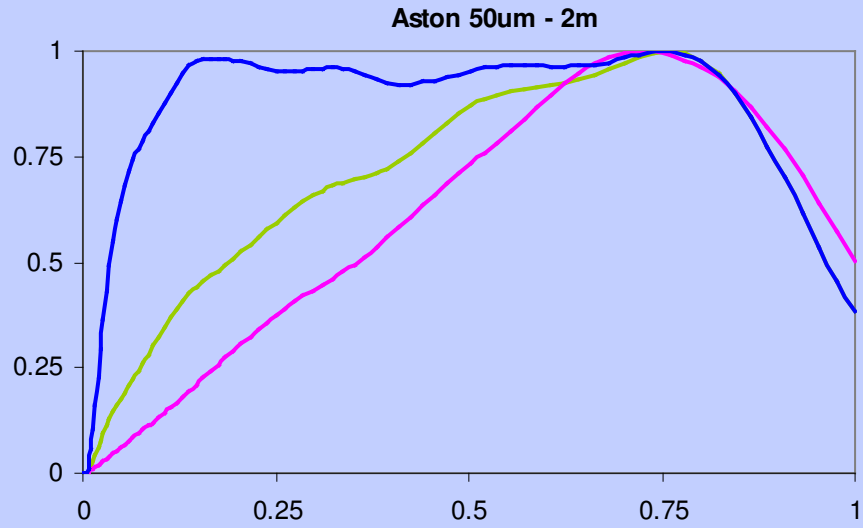


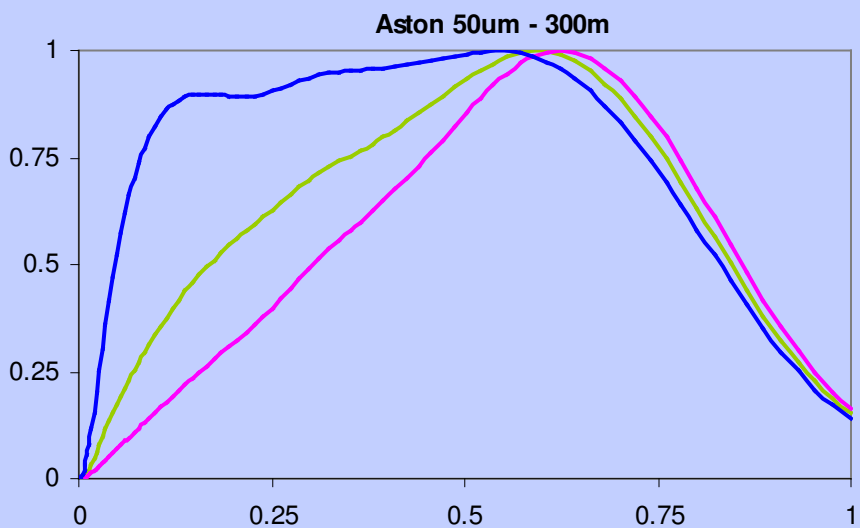

# - Mandrel Wrapping -

# Mandrel Wrapping

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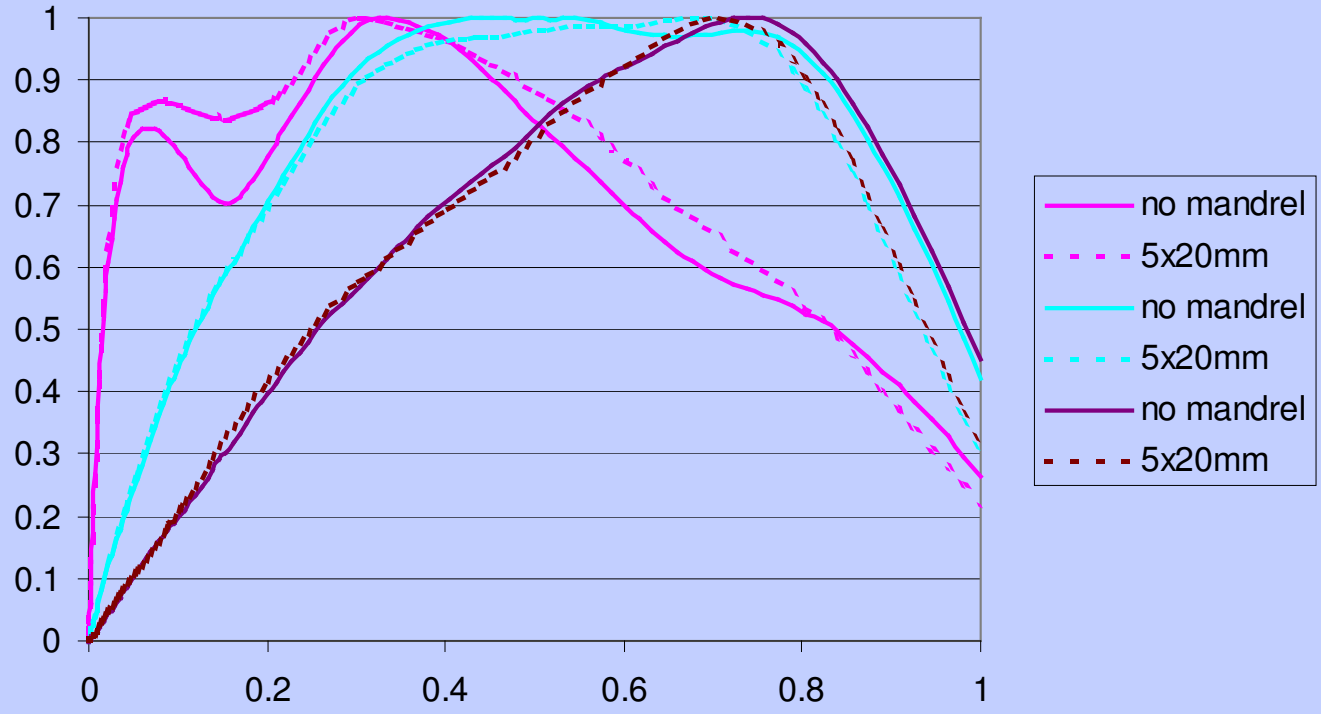


62.5um patchcord with different launch conditions

## Summary

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- Mode Profiling gives a direct, real-time, measurement of the MPD.
- Controlling the MPD improves measurement reproducibility.
- EMD does not readily occur in long fiber lengths or with mandrel wrapping.
- An MPD template provides test for the overall mode distribution.

(Thank you for your attention)

For more details contact Andrew Hallam: ahallam@halcyon-optical.co.uk