A channel metric to enable separation of transmitter and receiver specifications

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Offset Launch and Alternative Launches

- **1000BASE-LX specified Offset Launch to address Modal Bandwidth..**
  - **Modal Bandwidths ≥ 500MHz.km[1]**
  - **Offset launch family of impulse responses available for 10GBASE-LRM receiver design (Cunningham March 04)**

- **At the March IEEE meeting several new launch methods were presented (Blauvert March 04 and Morris March 04)**

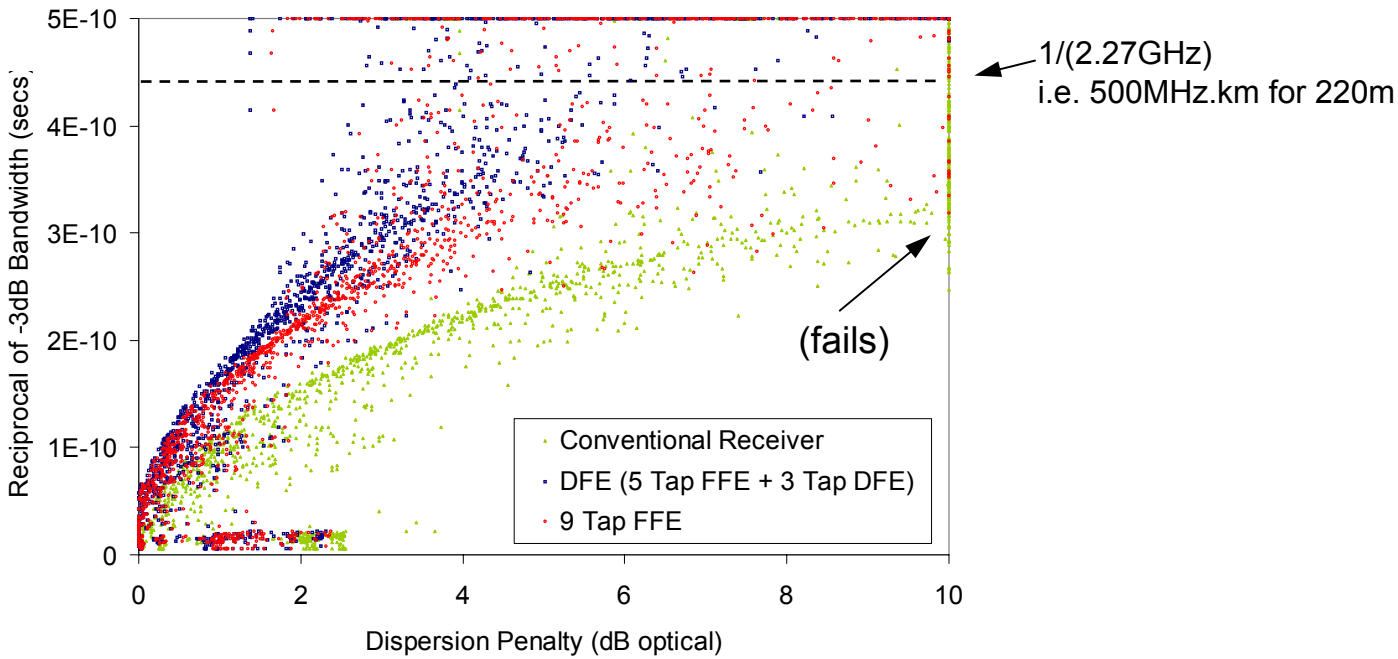
- **Any alternative launch will have a corresponding new family of impulse responses.**

- **For any alternative launch method, the questions arise:**
  1. **Will link yield at least match that for offset launch?**
  2. **And will this be true for <u>all</u> receivers?**

1) A Statistical Analysis of Conditioned Launch for Gigabit Ethernet Links using Multimode Fiber.
M Webster, L. Raddatz, I. H. White, D. G. Cunningham,
Journal of Lightwave Technology, IEEE, Sept. 1999

Comparing channel responses using Modal Bandwidths

- **We have used a large set* of impulse responses to investigate the correlation between -3dB bandwidth and dispersion penalty:**



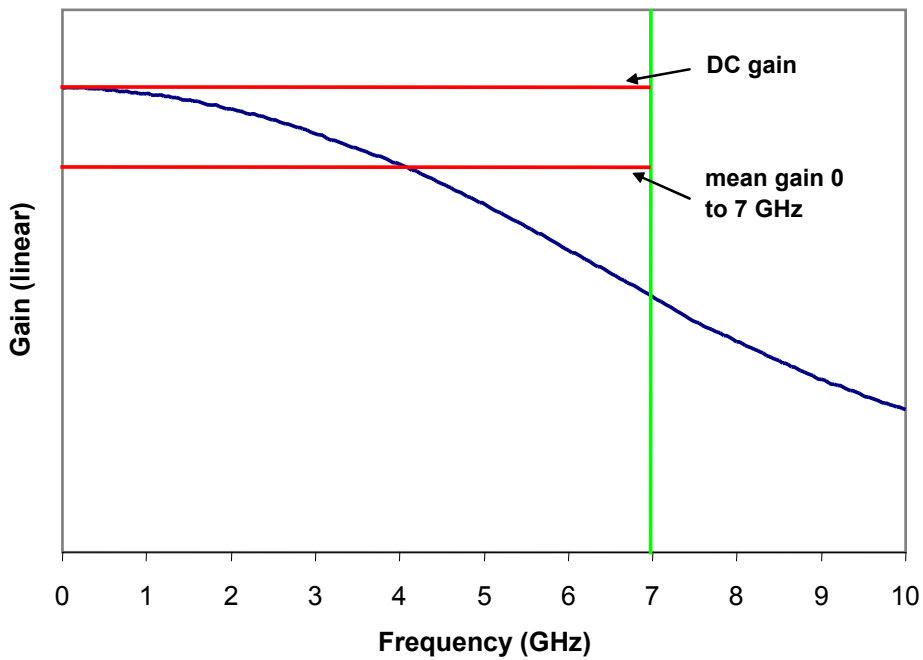
- **These scatter plots shows the poor correlation between -3dB bandwidth (reciprocal plotted) and dispersion penalty.**
  - Receivers make use of the energy across the entire channel spectrum
- **<u>Modal Bandwidth, alone, not a very good predictor of dispersion penalty</u>**

* 2015 responses. In fact for the 65 fibers of the Cambridge/Agilent model, at each of 31 offsets, and for 300m

Integrated Frequency Response (IFR)

A simple metric, which we call here "Integrated Frequency Response" (IFR), is derived from the channel frequency response:

- **IFR is the ratio: (Mean gain up to 7GHz)/(DC gain)**



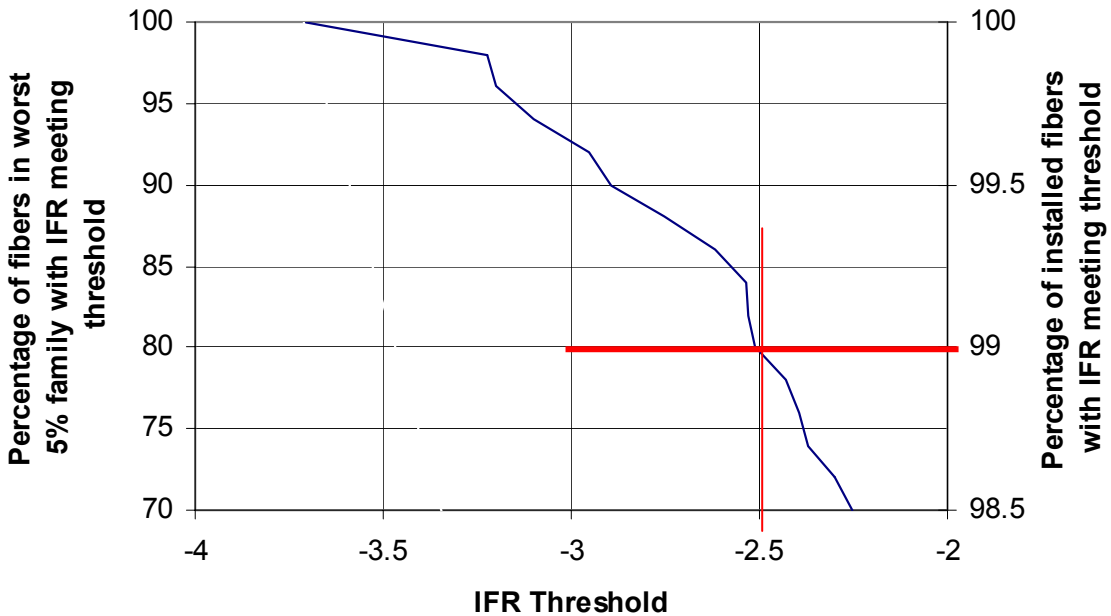
- **The IFR is expressed in dB, and is always negative** (the identity channel having an IFR of 0dB).

Offset Launch IFR Statistics for 220m Links

- **For Cambridge/Agilent family of impulse responses for 220m:**

  For each fiber: Consider worst IFR value across range of launch uncertainties (17μm offset to 23μm offset in this case)

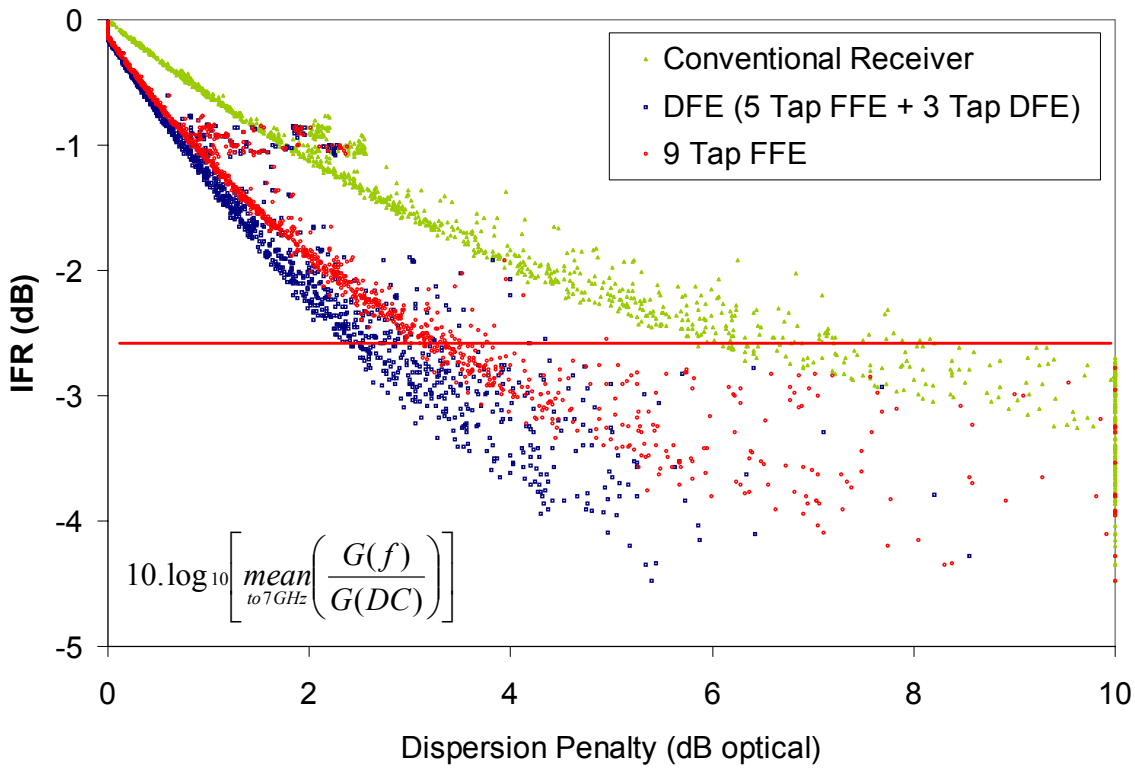
- **Distribution of IFR values:**



For 99% of 220m fibers, IFR ≥ -2.5dB

Comparing channel responses using IFR

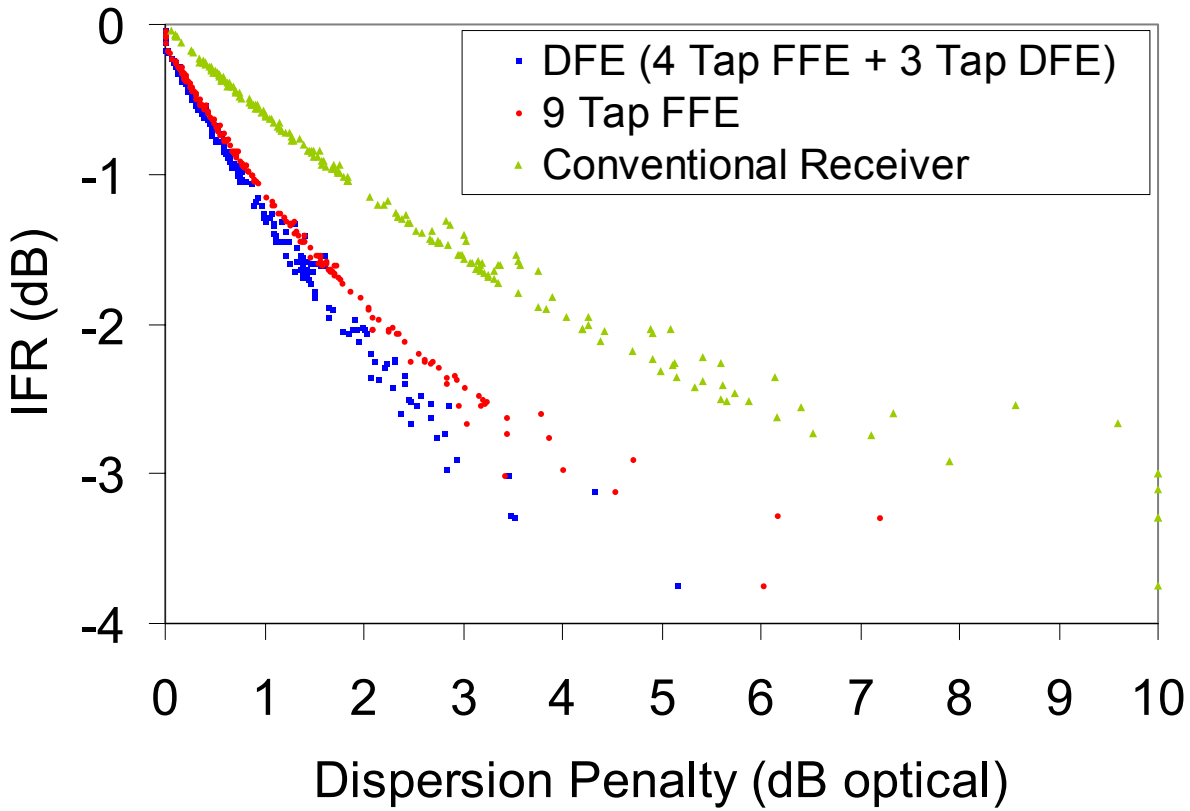
- From the same large set of responses, for those with Modal Bandwidth ≥ 2.27GHz (i.e. 500MHz.km scaled for 220m):



- Reasonable correlation between IFR and power penalties.
- i.e. this metric may be used to compare families of impulse responses.
- Other metrics (see Cunningham Jan 04) investigated. See Appendix

Scatter plots for Offset Launch 220m channels

- All of the Offset Launch channels have Modal Bandwidth ≥ 2.27GHz at 220m.
- Dispersion penalty with respect to IFR:



Conclusions:

A channel metric, that correlates reasonably well with dispersion penalties for different receivers, can help in the comparison of families of channel responses.

IFR (as defined here) is an example of such a metric.

i.e. an alternative launch as good as offset launch if:

- All 220m responses have -3dB bandwidth ≥ 2.27GHz

and

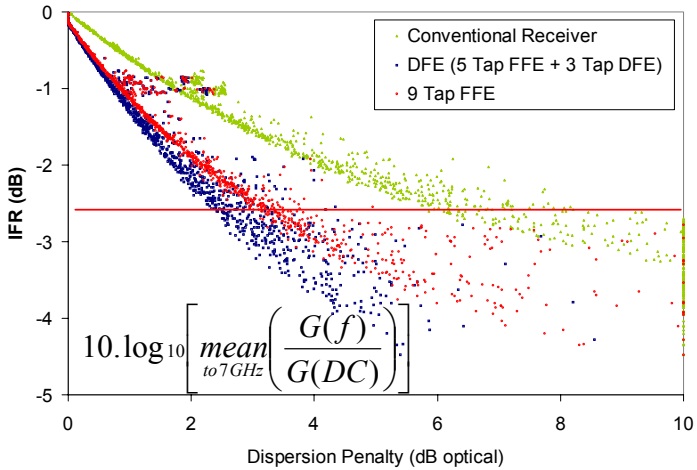
- 99% of 220m fibers have worst IFR value ≥ -2.5dB

Separation of Transmitter and Receiver Specifications

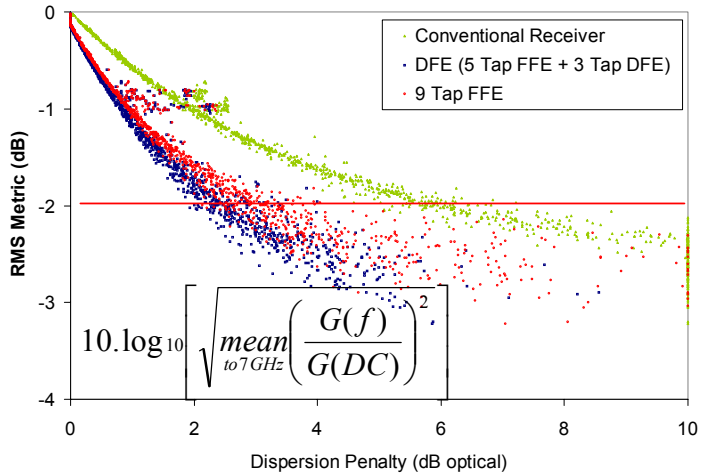
- **Receiver specification:**
  - **99% 220m yield for offset launch**
  - **This can be tested using emulation of Cambridge/Agilent responses**
- **Transmitter as "good" as Offset Launch**
- **Any combination of such compliant transmitter and receiver will deliver 99% link yield**

Appendix: IFR Comparison with other Metrics

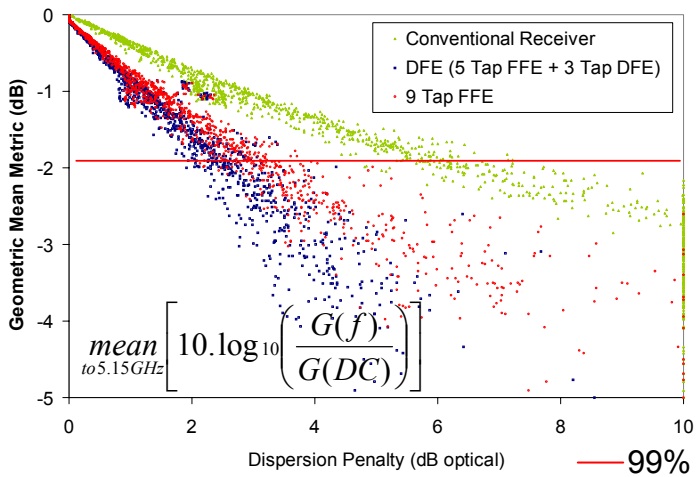
IFR



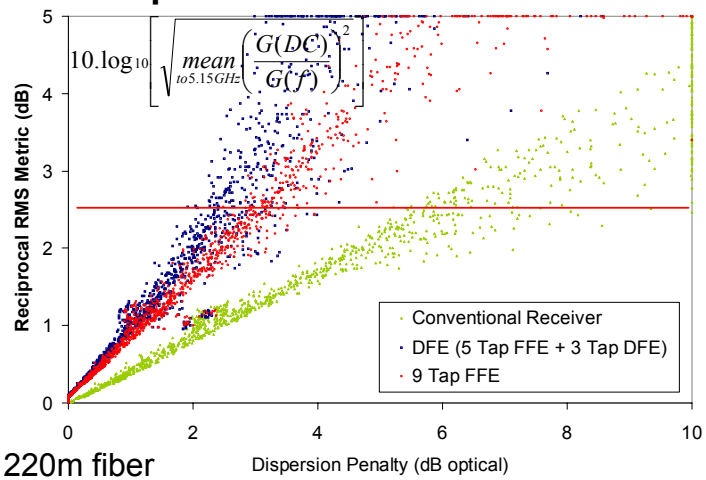
RMS Metric



Geometric Mean Metric



Reciprocal RMS Metric



99% values for 220m fiber