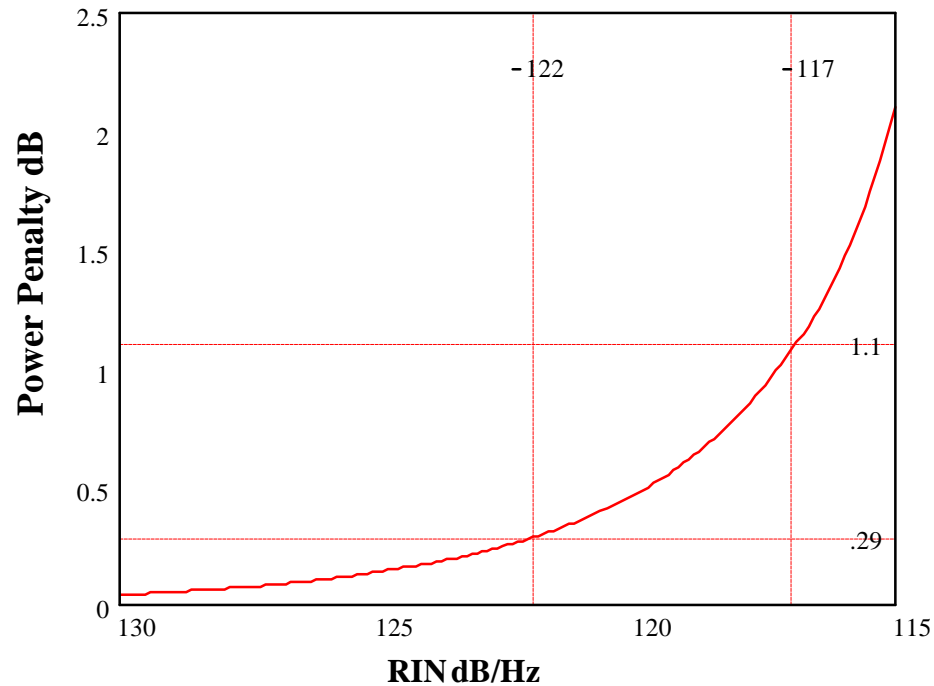


Technical Presentation to  
IEEE 802.3z  
*Gigabit Ethernet* Working Group

David Smith

# RIN Measurements

## Power Penalty vs RIN



- Results of Honeywell RIN measurements
  - 10 VCSELs (850 nm.)
    - -129 dB/Hz -1dB/+2 dB
  - 20 CD Lasers (790 nm.)
    - -123 dB/Hz -3 dB/+1dB
  - All measurements measured worst case integrated noise into 1GHz BW.

# RIN Measurements

- Conclusions
  - A worst case RIN of -122 dB/Hz is acceptable.
  - This would allow a total penalty of 0.3dB
    - Some receivers may already have some RIN in the receiver measurement unless a low noise laser is used to measure receiver sensitivity.
    - Recommend that the penalty be 0.3dB maximum.
    - When fiber filtering is included the worst reasonable case is 0.1dB.

# Conversion factor for Optical Bandwidth to fiber response time

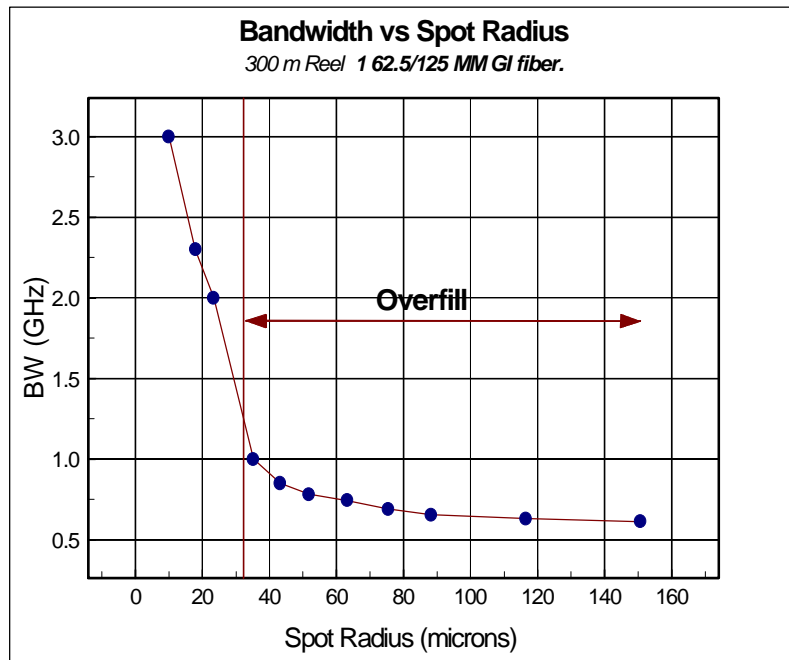
- Theory
  - $t(\text{ns}) = .48/\text{BW}(\text{GHz})$  is correct value to use for most pulse shapes.
- Measurement results
  - Measurements on 5 links using overfilled and underfilled launch gave an average of  $C = 0.466 \pm 0.03$
  - Uncertainty due to difficulty measuring fiber BW.

# Conversion factor for Optical Bandwidth to fiber response time

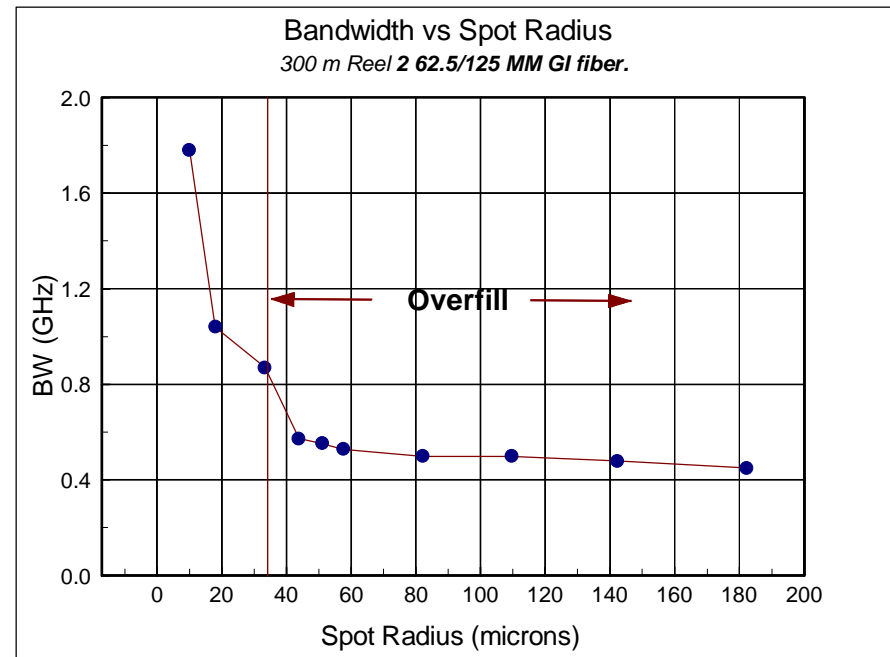
- Conclusions
  - A value of  $C=0.48$  is correct.
  - If we feel that the minimum fiber bandwidth of 160MHz-km is unrealistic for laser launches we should apply a scaling factor that permits us to scale it to what is reasonable.
-

# Effect of Spot size on Fiber BW

## Fiber #1

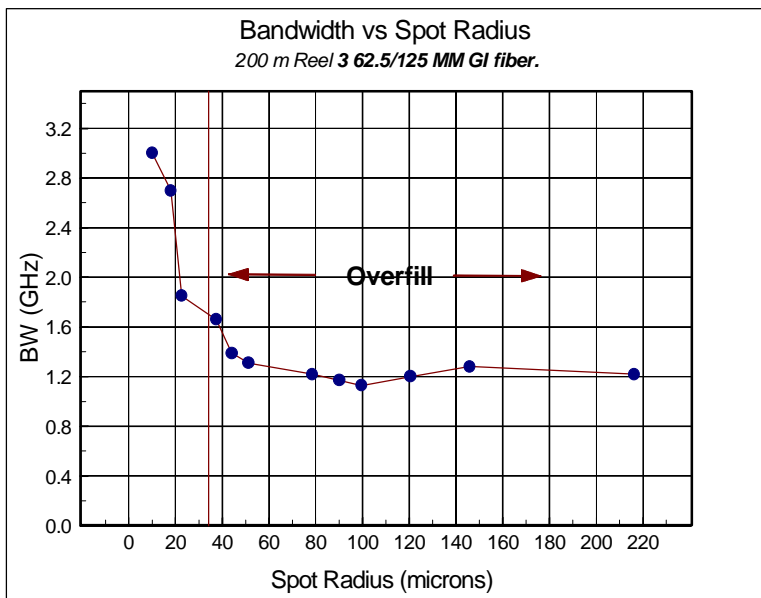


## Fiber #2

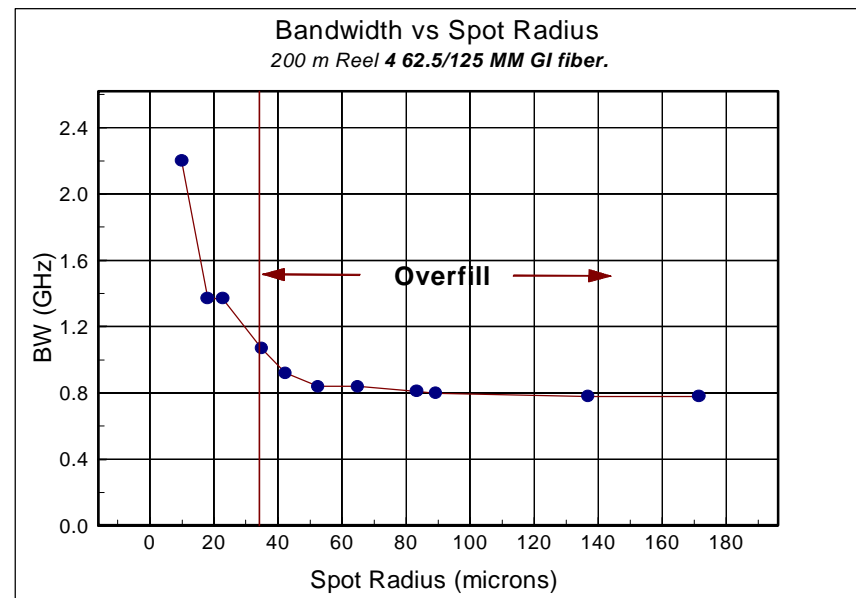


# Effect of Spot size on Fiber Bandwidth

## Fiber #3



## Fiber #4



# Effect of Spot size on Fiber Bandwidth

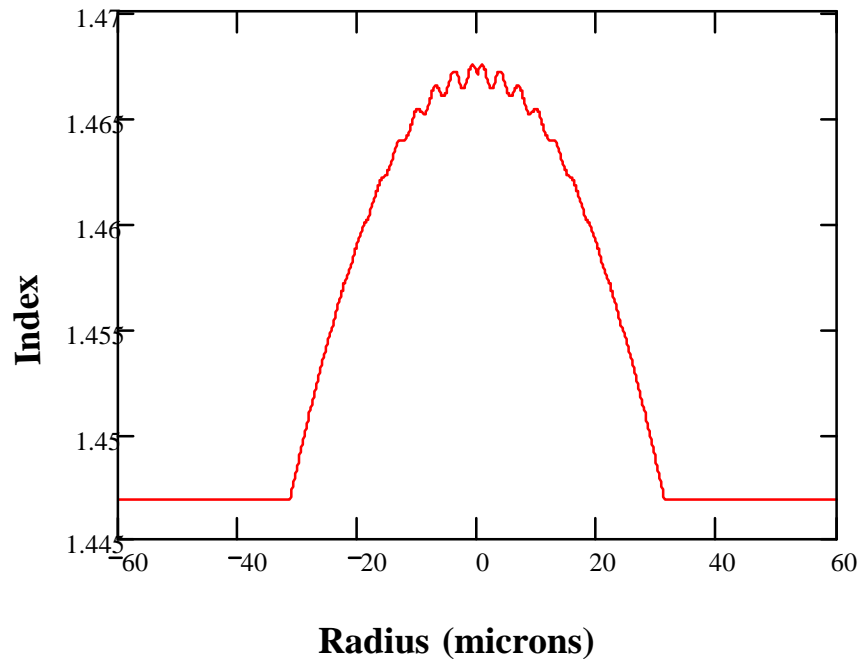
**Experimental Bandwidth Gain on reduction of  $1/e^2$  spot size to 50 microns from an overfill condition**

<b>Fiber</b>	<b>Bandwidth Gain</b>
1	3.17
2	1.80
3	1.50
4	1.56

- Fiber bandwidth gain can be variable
  - A scaling of 1.25 for a modest reduction of spot size is likely to be repeatable.
  - This would allow 200MHz-km to be used for a fiber which is specified a 160MHz-km

# DMD of high order modes

Typical Refractive Index Profile



Mode #	Delay (ps/km)	Prop Const
0	0	10.8756572
1	526	10.8639831
2	923	10.8527515
3	1919	10.8415394
4	2968	10.8301314
5	1178	10.8196247
6	3333	10.8094061
7	2883	10.7984193
8	3269	10.7881857
9	3150	10.7774782
10	3828	10.7671469
11	3284	10.7566445
12	5510	10.746324
13	26501	10.7369664
14	51913	10.7345887

# Effect of Spot size on Fiber Bandwidth

- Conclusion
  - Modes near cut-off have very large DMDs.
  - Reduction of spot radius tends to eliminate the modes with large differential modal delays.
  - Elimination of these modes justifies the scaling factor of 1.25

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# Parameters that can be varied in the Power Budget

- Scaling Factor on Fiber BW
  - factor of 1.2-125 on min BW of 160MHz-km
  - goal 200MHz-km
  - Keep  $C=0.48$  as rise time bandwidth product
- Drop RIN from -117dB/Hz to -122dB/Hz
  - This would reduce penalty from 1.1 dB to 0.3 dB
  - Introduce fiber BW filtering. The worst case is still longest fiber since the RIN penalty trades off against attenuation and ISI penalty.

# Parameters that can be varied in the Power Budget

- RIN cont.
  - Remaining penalty can be referred to the receiver sensitivity measurement.
  - Recommend dropping RIN as a penalty, but keep a limit on its level.
- Add 0.5dB-1dB to the link budget.