Issues with LRM OM3 Monte Carlo modeling set.

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IEEE P802.3aq 10GABSE-LRM Task Force

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Summary

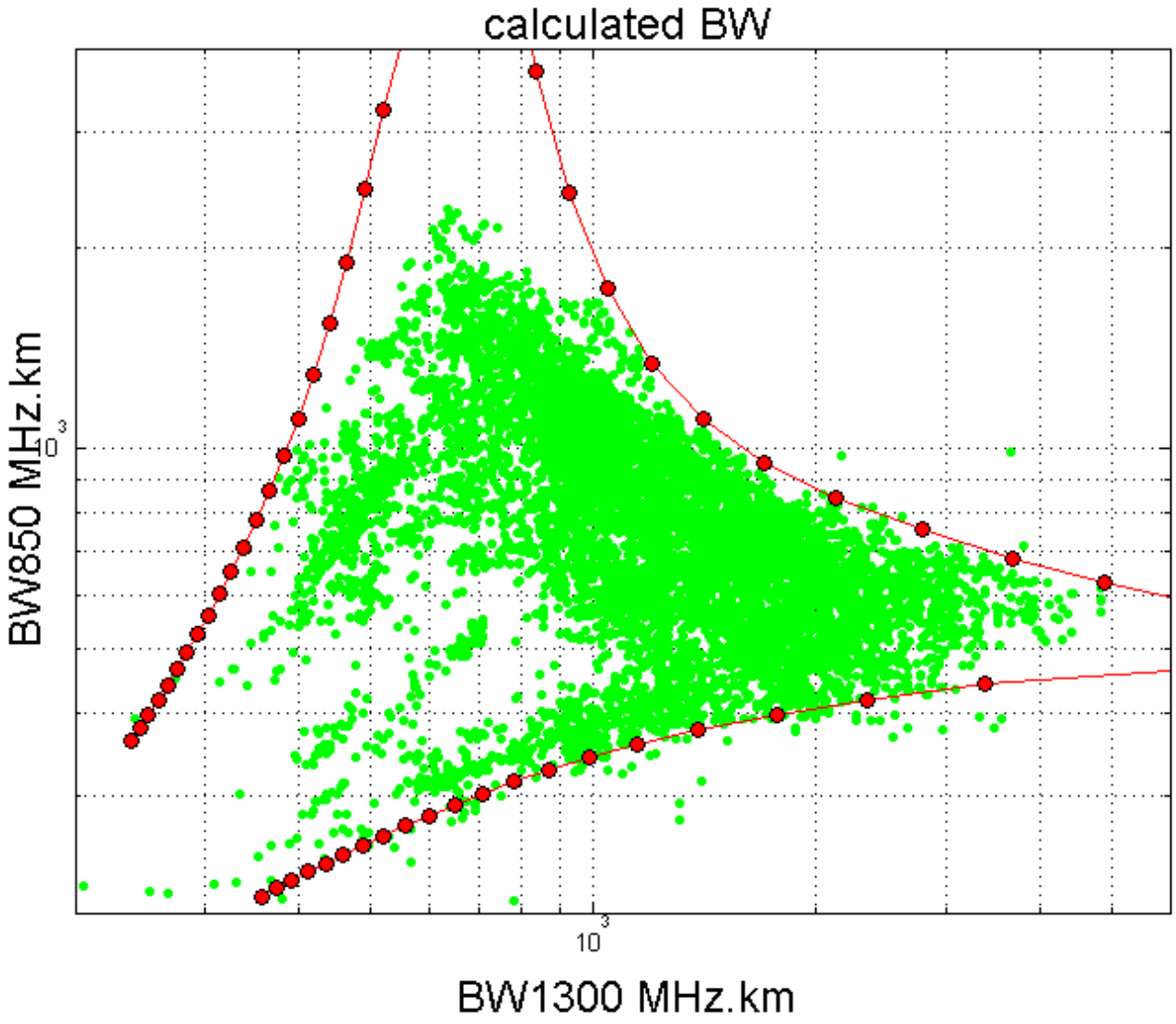
In Nov 2004 P. Pepeljugoski took the 850nm mode delays from the TIA OM3 modeling set (used for OM3 specification development) and calculated an approximate 1300nm mode delay set.

In this note the 850nm/1300nm OFL BWs are plotted to better understand the fiber distribution.

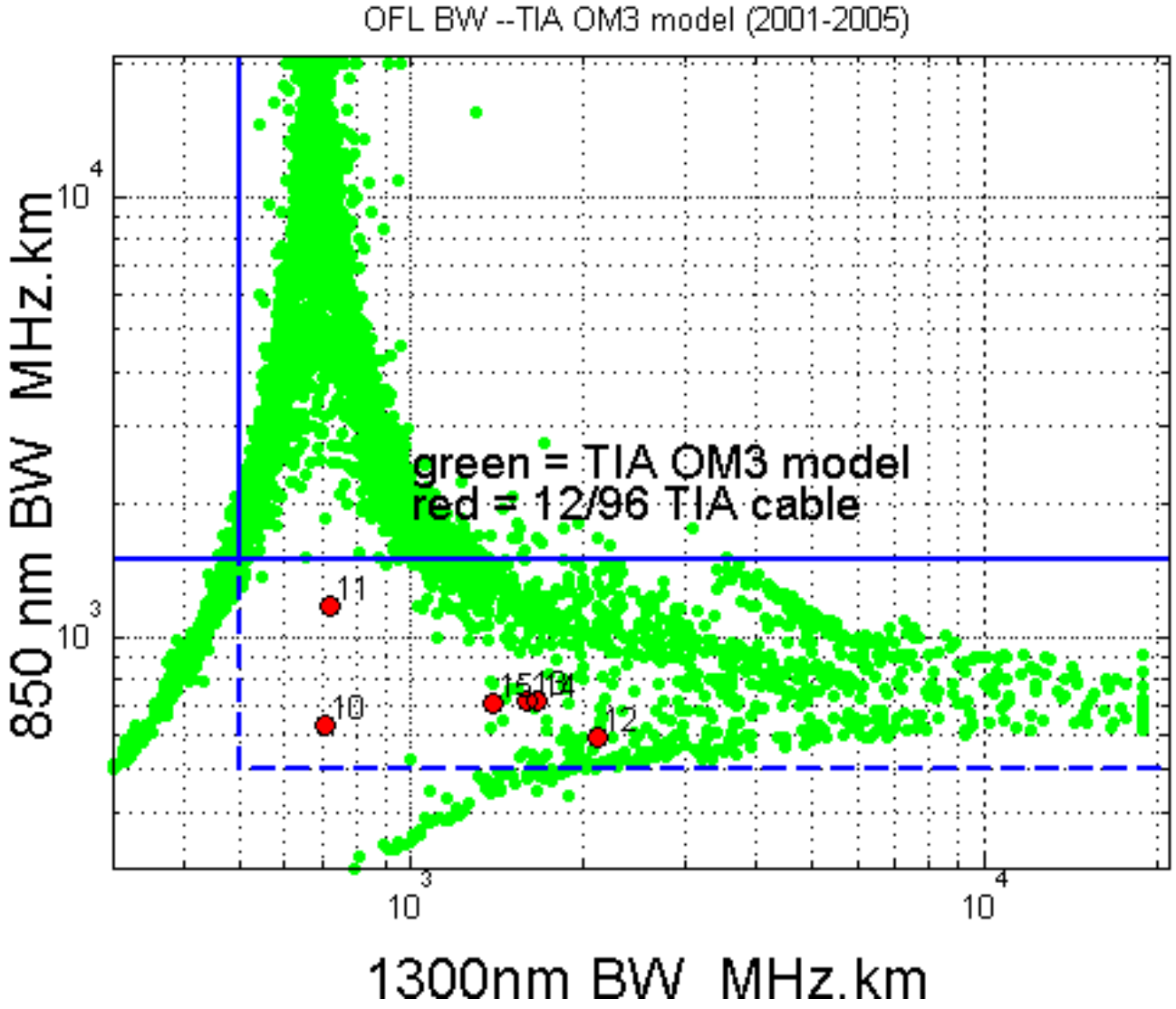
The OM3 set seems to have a relatively large variation in "alpha" but less variation in center perturbations than might be expected in practice.

Comparison with actual OM3 fibers points out that fibers whose center profile is optimized below 850nm but still passes OM3 specifications will have higher PIE-D than previously estimated. This is a problem somewhat analogous to the 1300-1355nm laser issue for OM1. It means that the current stressors will not guarantee 220m for a fiber meeting OM3 specifications.

1999 OM2 data for comparison: OFL850,1300



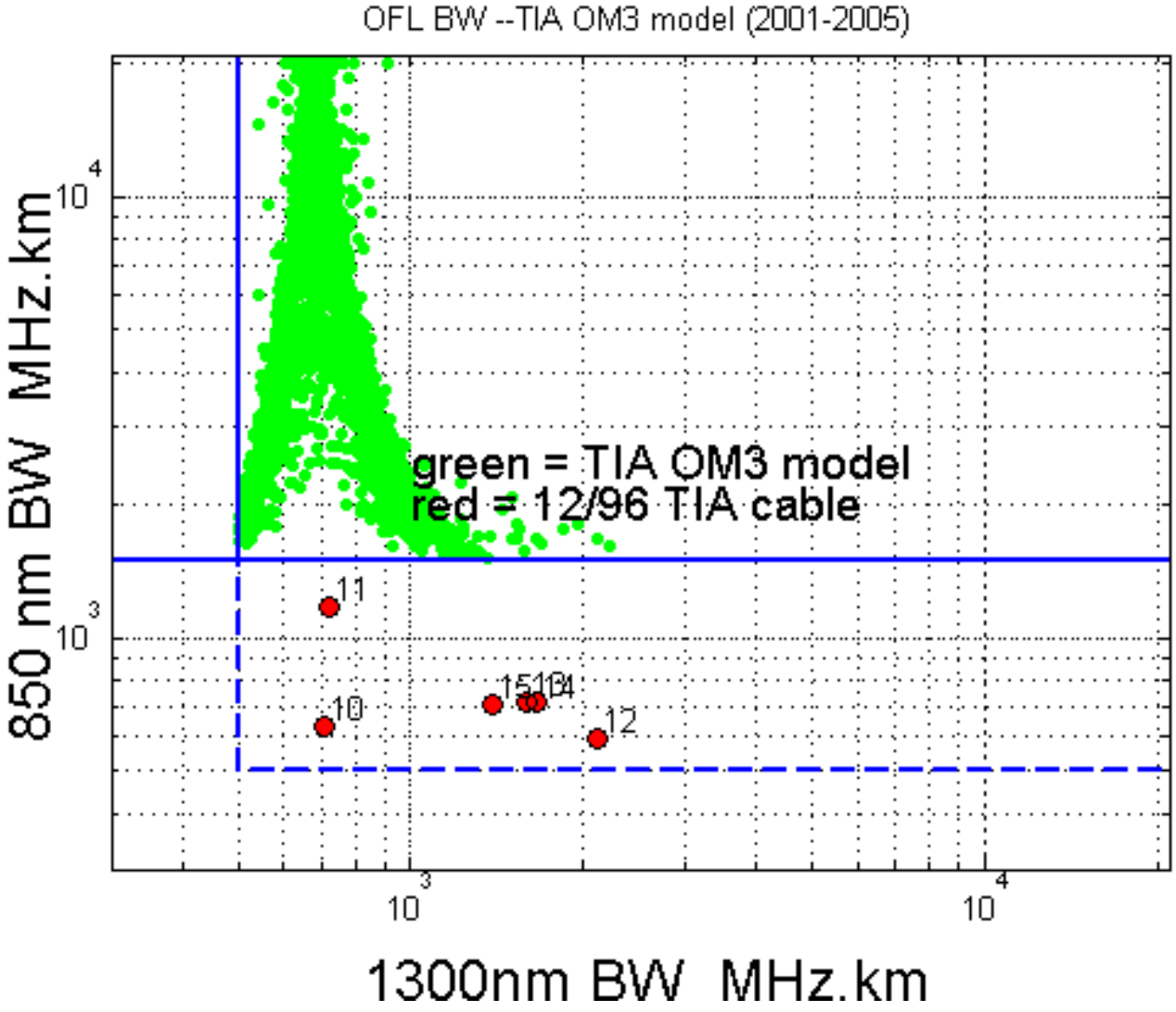
OM3 model OFL BW 850, 1300



Passing OM3 fiber must meet:

1. **DMD criteria**
2. **OFL850>1500**
3. **OFL1300>500**

OM3 model : passing OM3 fibers only



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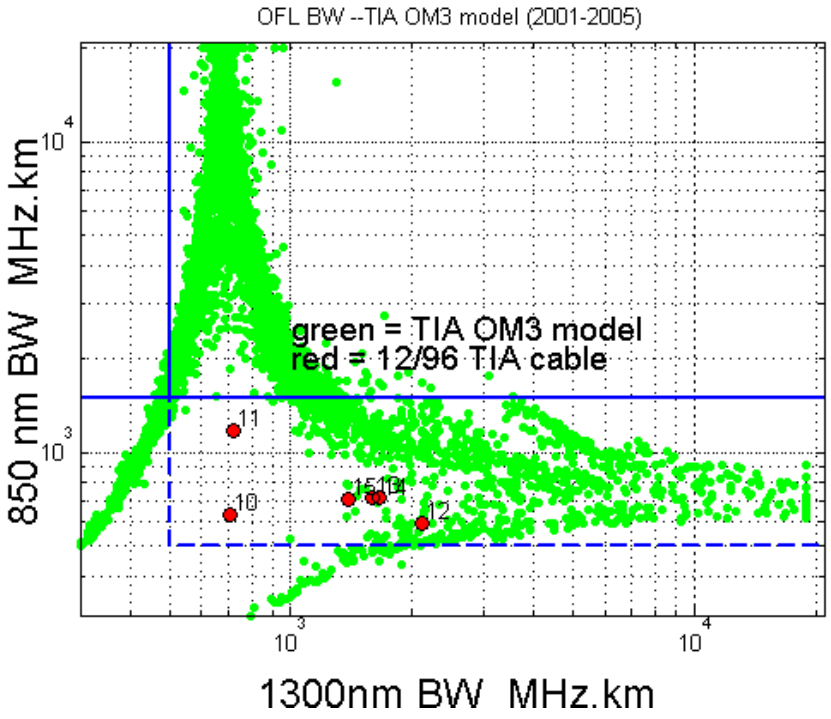
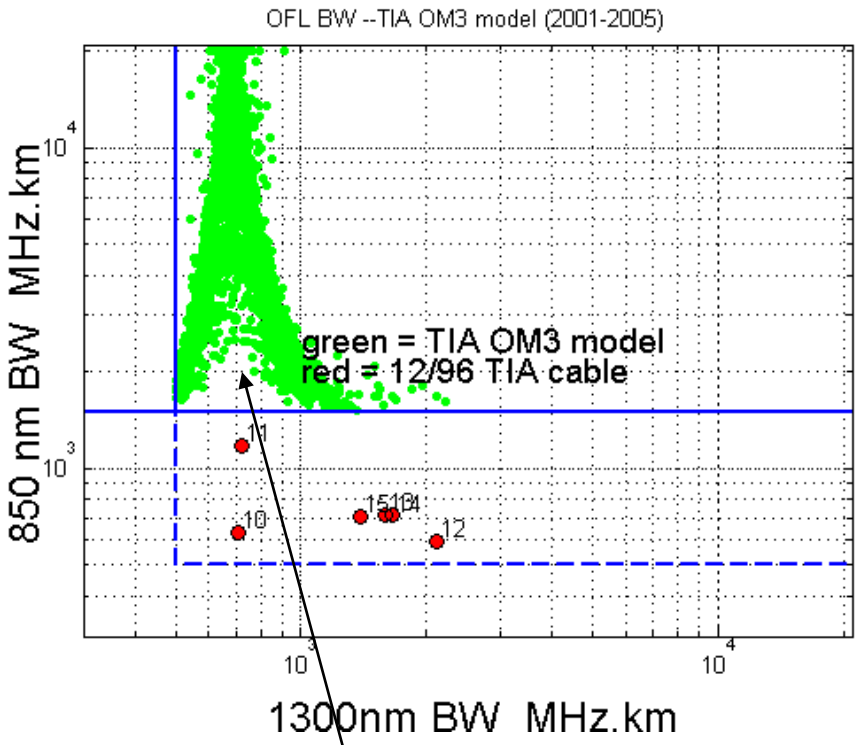
OM3 model : Discussion

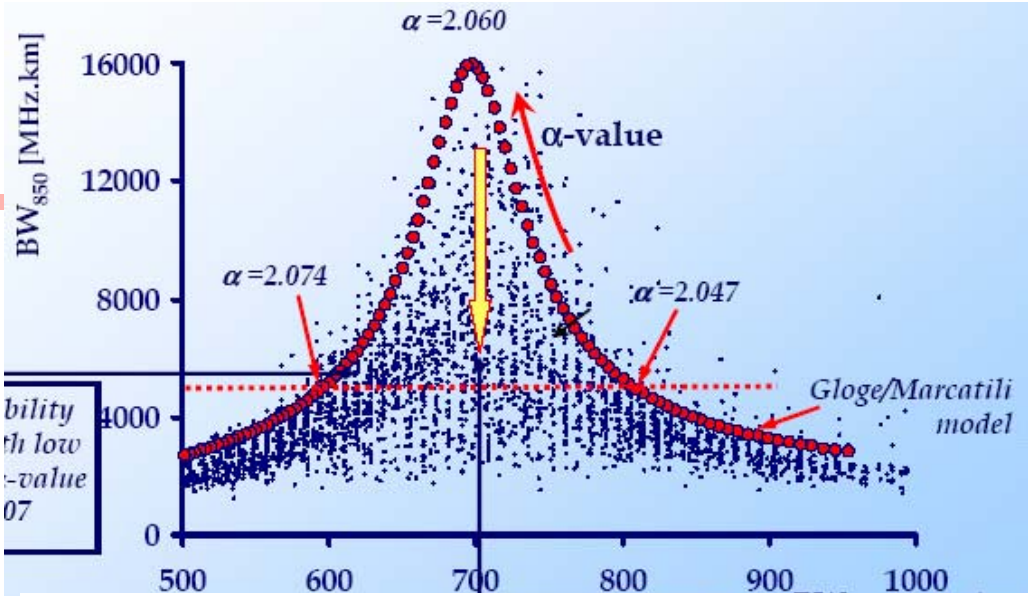




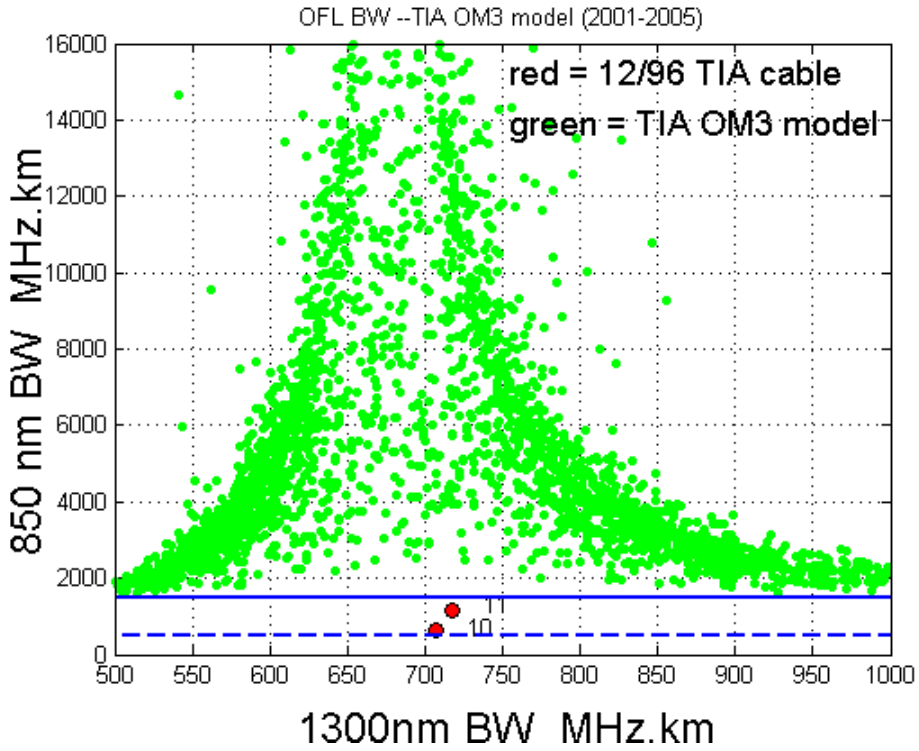
We expect to see some dots in the 850nm-optimized area here. This area would correspond to fibers having center perturbations comparable to the alpha perturbations at the limits of the OM3-passing distribution.
It is odd for the supposed manufacturing distribution to be capable of making 20GHz.km fiber at 850nm but have such variability in "alpha" (but control in all other aspects of the profile) that unintentionally the process makes 20GHz.km at 1300nm as well. This is not likely to occur in practice.

Comparison with data

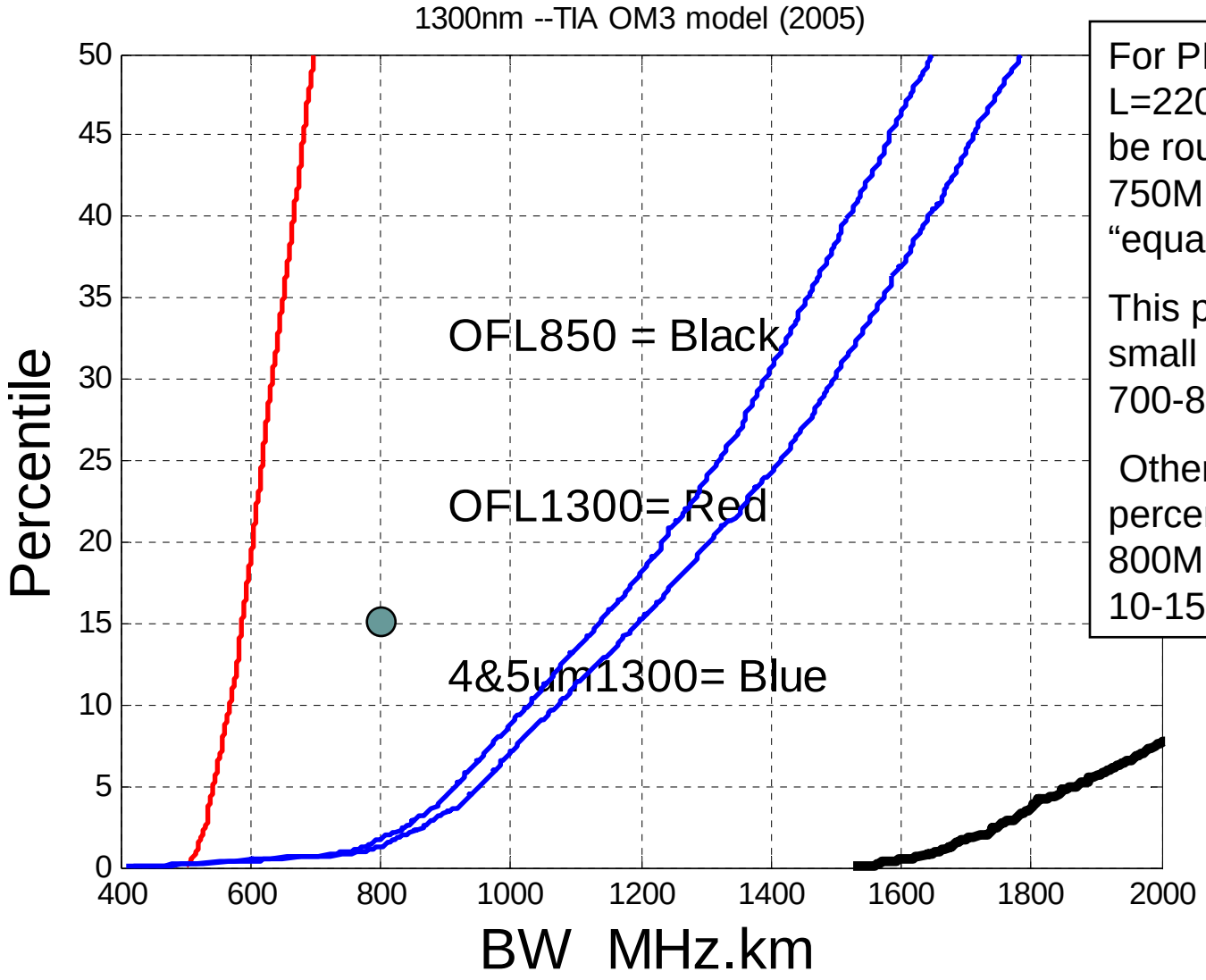
Draka 6/2005 FO4.1.2 presentation: "OM3+" (500-600m)



TIA OM3 model



Cumulative BW distributions – tail (OM3model)



For PIE-D=4.2 and L=220m, the BW needs to be roughly 700-750MHz.km to be "equalizable".

This plot suggests only a small percentage misses 700-800MHz.km

Other data suggests the percentile at 700-800MHz.km is more like 10-15%,

OM3 results from Experiments

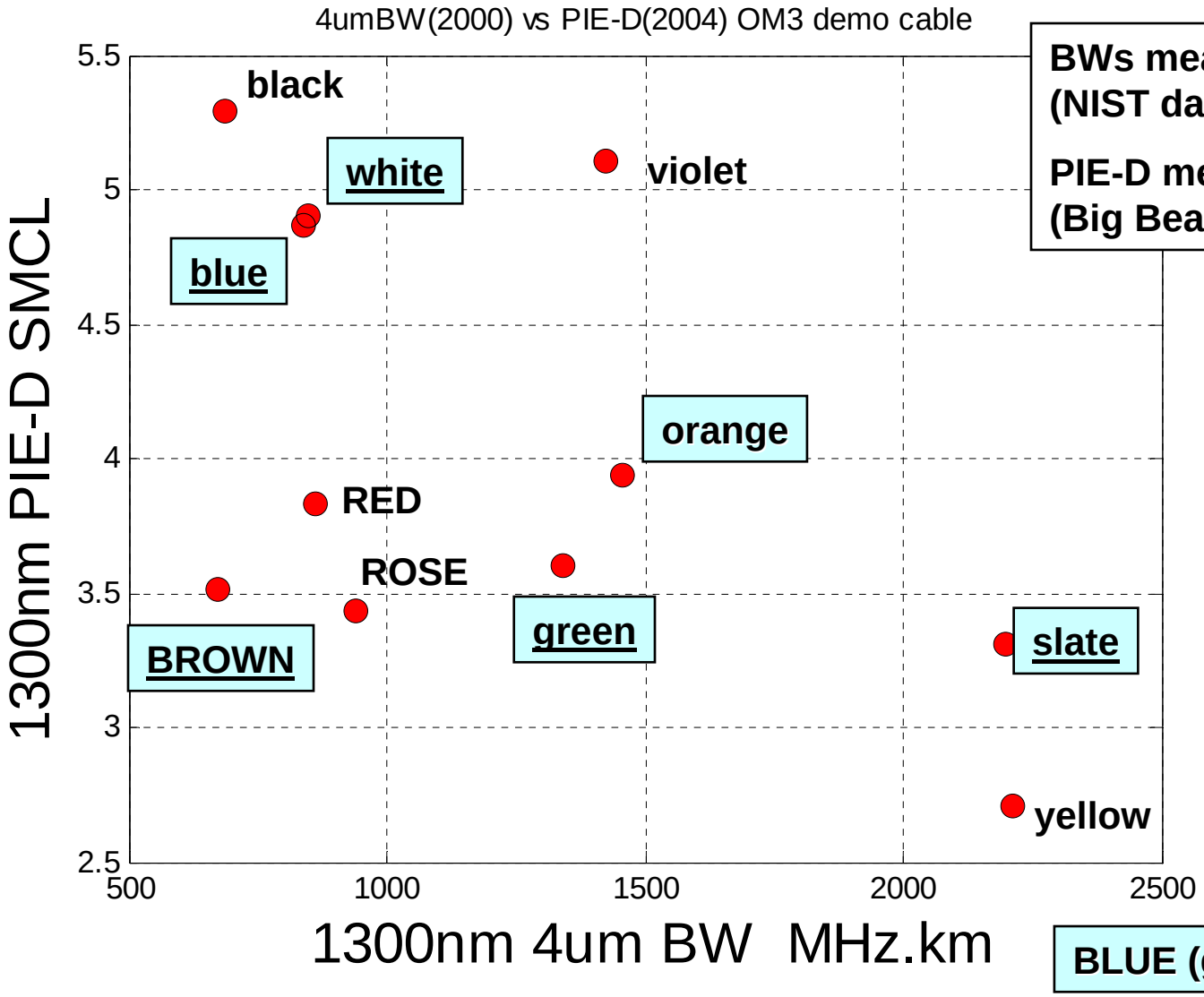
Jonathan King Dec 2004: measurements on OM3 cable

	SMC L	SMCL + offset	50μm MCP	50μm MCP + offset	MMCL
B-Blue	2.784	4.866	3.685	5.969	3.905
B-Brown	2.511	3.517	5.034	7.5	3.335
B-Gray	2.388	3.311	5.416	7.601	3.336
B-Green	2.589	3.601	4.958	5.988	3.375
B-Orange	2.554	3.936	5.487	6.573	3.526
B-White	2.673	4.904	5.067	7.560	3.668
O-Aqua	2.422	3.003	4.604	6.980	3.260
O-Black	2.621	5.288	5.050	7.318	3.597
O-Pink	2.588	3.435	3.992	4.968	3.584
O-Purple	2.579	5.102	5.774	5.668	3.858
O-Red	2.408	3.828	5.343	7.672	3.298
O-Yellow	2.270	2.708	4.441	6.367	3.044

- Worst case PIE-D
- Color code
  - Red: >5.5dB PIE-D
  - Yellow: 4-5.5dB PIE-D
  - Green: <4dB PIE-D
- Best launch for OM3 fibers is single-mode centre launch

White fiber is a near perfect OM3 fiber.

PIE-D vs 4um offset BW –TIA OM3 democable



BWs measured in 2000 (NIST data distribution)

PIE-D measured in 2004 (Big Bear Networks)

PIE-D of "4" is passing..

BLUE (good) cable

Initial BW measurements on OM3 cable + Big Bear PIE-D results

Fibers for TIA 10 Gigbit Experiment

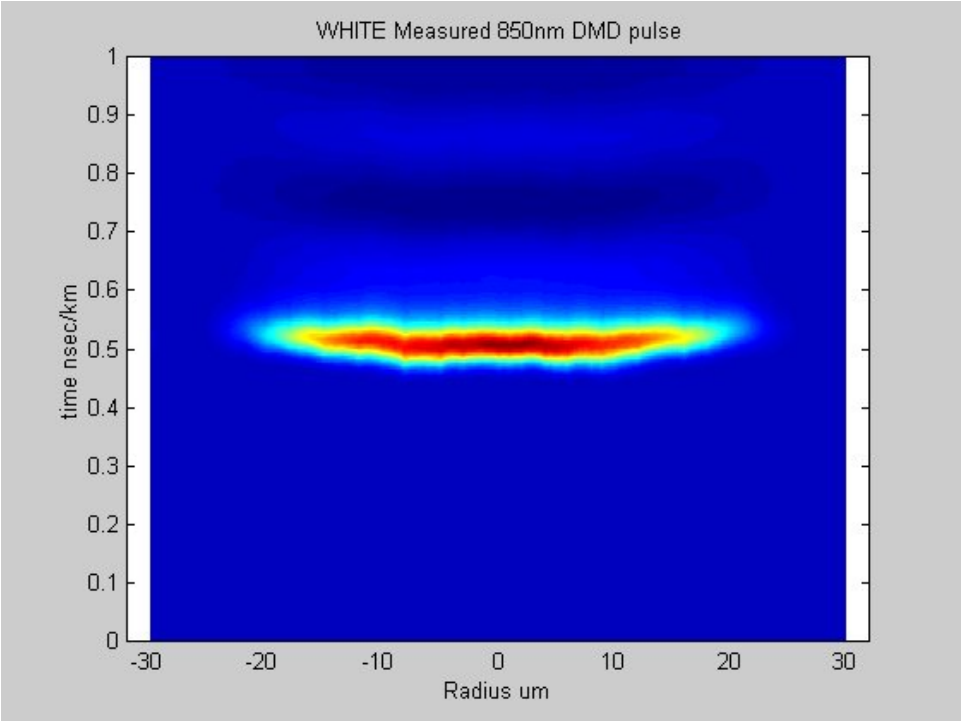
OFL BW (MHz-km)		RML BW (Mhz-km)		SMCL+offset PIE-D	%	cable	buffer
850 nm	1300 nm	850 nm	1300 nm		%		
2357	574	3077	861	3.828	%	Orange	Red
3164	616	2177	688	5.288	%	Orange	Black
2286	882	3287	838	4.866	%	Blue	Blue
3142	679	3330	2212	2.708	%	Orange	Yellow
4643	611	>3301	1456	3.936	%	Blue	Orange
2220	819	2285	1426	5.102	%	Orange	Violet
1265	1105	>3102	940	3.435	%	Orange	Rose
2215	801	2786	1339	3.601	%	Blue	Green
2955	543	3431	673	3.517	%	Blue	Brown
3218	515	2969	2196	3.311	%	Blue	Slate
5398	591	>3942	847	4.904	%	Blue	White
4122	620	NA	NA	3.003	%	Orange	Aqua

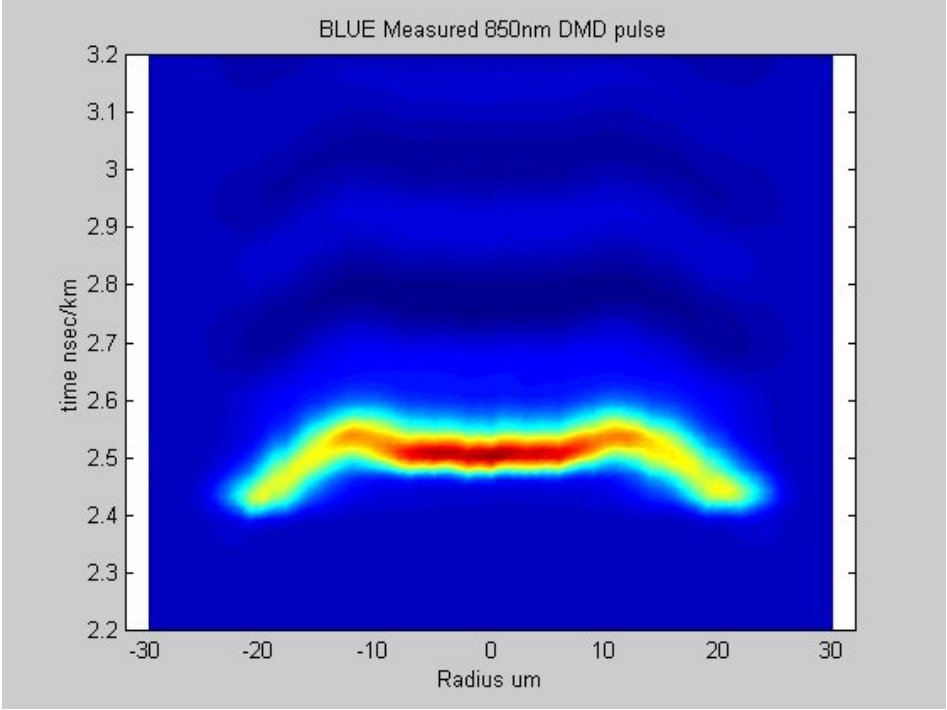
PIE-D (BigBearNetworks 2004)

1300nm 4um offset BW(NIST distribution of measurement results)

OM3 demo cable DMDs

White & Blue fibers meet OM3 specifications
but had elevated PIE-D at 1300nm





BACKUP

HISTORY OF UNDERPREDICTION OF PIE-D for OM1,OM2

ESTIMATE OF FAILURE RATE FROM INTEROPERABILITY RESULTS

PREDICTION OF INTEROPERABILITY RESULTS FROM EWEN OM1 MODEL

History of model under-predicting center PIE-D

OFS: Jan 2005 1423 fibers

http://www.ieee802.org/3/aq/public/jan05/balemarthy_1_0105.pdf

99% coverage at 300m = 5.2dB

Corning Mar 2005 1806 fibers

http://www.ieee802.org/3/aq/public/mar05/abbott_1_0305.pdf

99% coverage at 300m = 5.1dB, assuming no additional connector effect needed.

Reasons for models under predicting PIE-D

a. Measurements show some correlation between center & offset

b. MPD for center launches is more 'worst case' as in http://www.ieee802.org/3/aq/public/nov04/king_2_1104.pdf : Split Symmetric Pulses

EMB and PIE-D on OM1, OM2

For an LX-4 link to work at 300m, the offset BW needs to be 500MHz.km = OFL BW.

For an LRM link to work at 220m with a PIE-D of 4.2dB, either the offset BW or the center BW (with connectors) needs to be > 700-800MHz.km, or failures begin. EMB is not synonymous with PIE-D; but if the EMB is too low, the fraction of fibers with a 220m PIE-D above 4.2dB begins to grow.

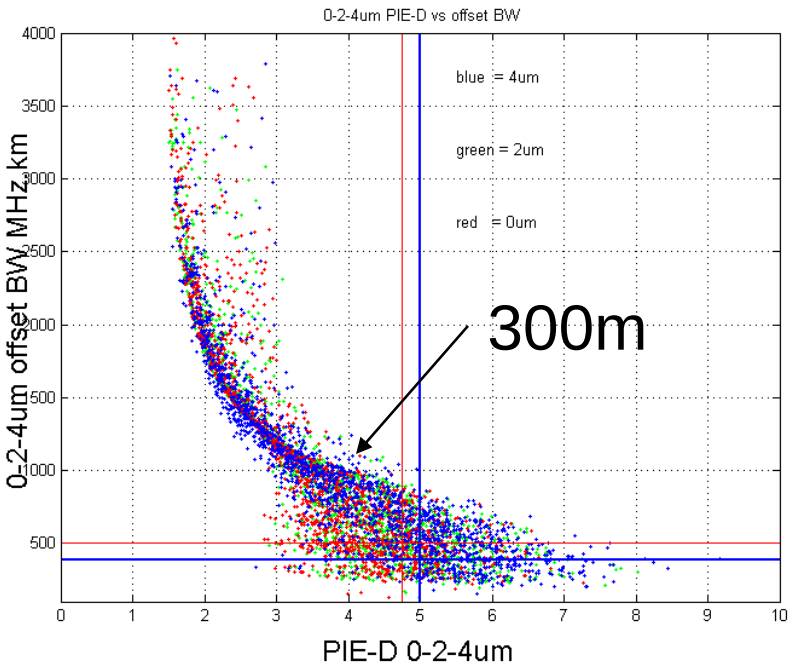
The dual launch statistics try to guarantee that one of the launches will always be > 700-800MHz.km.

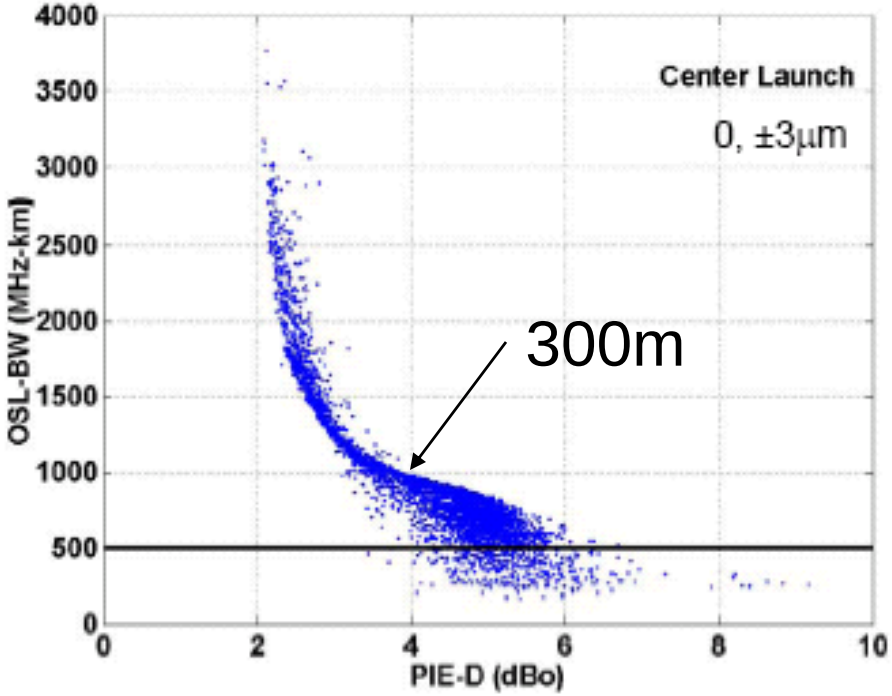
References on EMB and PIE-D on OM1, OM2

EMB and PIE-D using DMD pulse data on OM1 fibers

http://www.ieee802.org/3/aq/public/jan05/balemarthy_1_0105.pdf

http://www.ieee802.org/3/aq/public/mar05/abbott_1_0305.pdf





Estimated Link failures from Interoperability tests

Probability of dual launch failure = probability of center launch>PIE-D * probability of offset launch > PIE-D

http://www.ieee802.org/3/aq/public/mar05/bhoja_1_0305.pdf

Estimated probability of dual failure 5-17%.

				CL	Offset	dual	fiber850	fiber1300
OM1	2Orange		433	OK	FAIL	OK	416	454
OM1	1Green		585	OK	OK	OK	459	713
OM1	2Blue		723	OK	FAIL	OK	232	825
OM2	4Green		788	OK	OK	OK	1175	717
OM2	4Blue	1200+		OK	OK	OK	593	2122
OM2	5Orange	1200+		FAIL	OK	OK	717	1588
OM3	Orange-Re		574	OK	NotTested	OK		
OM3	Blue-Slate		801	OK	NotTested	OK		

Estimate 1a for OM1-OM2 failure: (2/6) offset patch cord, (1/6) CL
Estimated probabilyt of dual failure = 2/36 = 5.5%
Estimate 1b for OM1-OM2 failure. All 3 tube 5s for OM2 will fail CL (and have OFL BW > 1200), hence CL failure is 3/6
Estimated probablity of dual failure = (2/6) * (3/6) = 6 /26 = 16.6%

Estimated Link failures from Interoperability tests

Probability of dual launch failure = probability of center launch>PIE-D * probability of offset launch > PIE-D

http://www.ieee802.org/3/aq/public/oct05/rausch_1_1005.pdf

Estimated probability of dual failure =1/3*1/3 = 1/9=11%

Oct-05			CL	Offset	dual	fiber850	fiber1300	expect
OM1	1Green	585			OK	459	713	both OK in Mar05?
OM1	2Orange	433		(fail)?	OK	416	454	offset fails in Mar05
OM2	4Orange	654			OK	631	707	4Green-4Blue were OK-OK?
OM3	Orange-Re	574		NotTested	OK			OK in March 05

Estimate 2a for OM1-OM2 fibers.
"Success on Either Launch is Reported as a Pass"
"On Some Fibers the Preferred Launch Always Succeeded, On others the Alternate Launch Always Succeeded"
Conclusion: for 3 OM1-OM2 fibers, at least one CL failed and at least one offset failed
Estimated probability of dual failure = (1/3) * (1/3) = 1/9 = 11.1%

Estimated Interoperability results from JE OM1 model

http://www.ieee802.org/3/aq/public/sep05/ewen_1_0905.pdf

%tile at 300m with PIE-D of 4.0dB = 95% (simplex).

Hence simplex failure rate = 5% and duplex failure rate = 10%.

This may be in the ball park of what is estimated from the interoperability work, or it may be low (simplex vs. duplex – should we be squaring the failure rates in the interoperability results?)