



Effect of Launch Conditions on Bandwidth of TIA 12-96 Round Robin Fibers

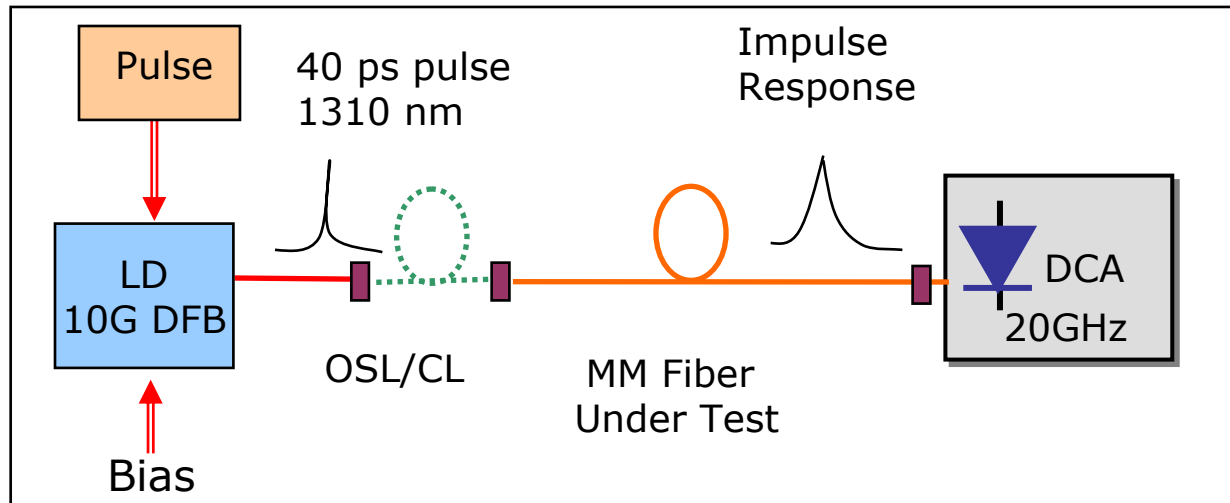
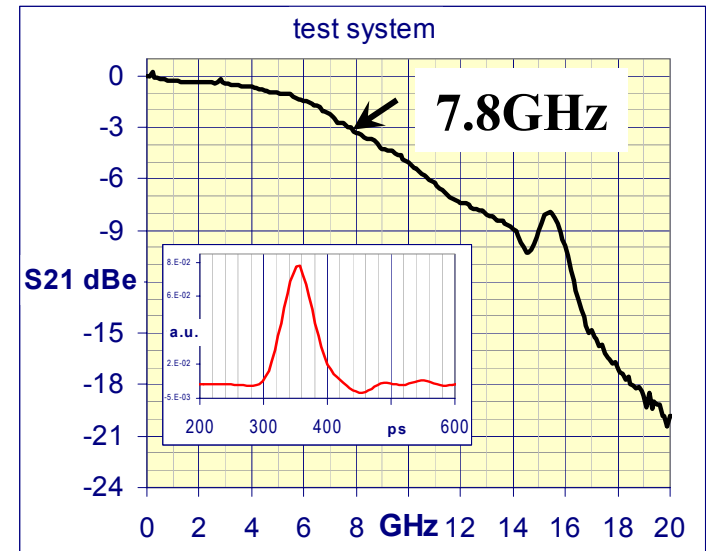
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Summary

- Comparison of bandwidths of TIA 12-96 round robin fiber set for different launch conditions
 - Fiber under test:
 - 15 fibers total; ten 62.5/125 μ m, five 50/125 μ m
 - all 300m in length
 - “FO2.2 12/96 BW Modal Launch Test Cable”
- Bandwidth Results:
 - TIA reported data for OFL & center launch (CL)
 - Recent impulse response measurements made at 1310nm for CL, ROFL , & OSL (Off-set single-mode launch, 1GE compliant MCP)
- Additional examination of impulse response variability with launch condition and worst-case DMD

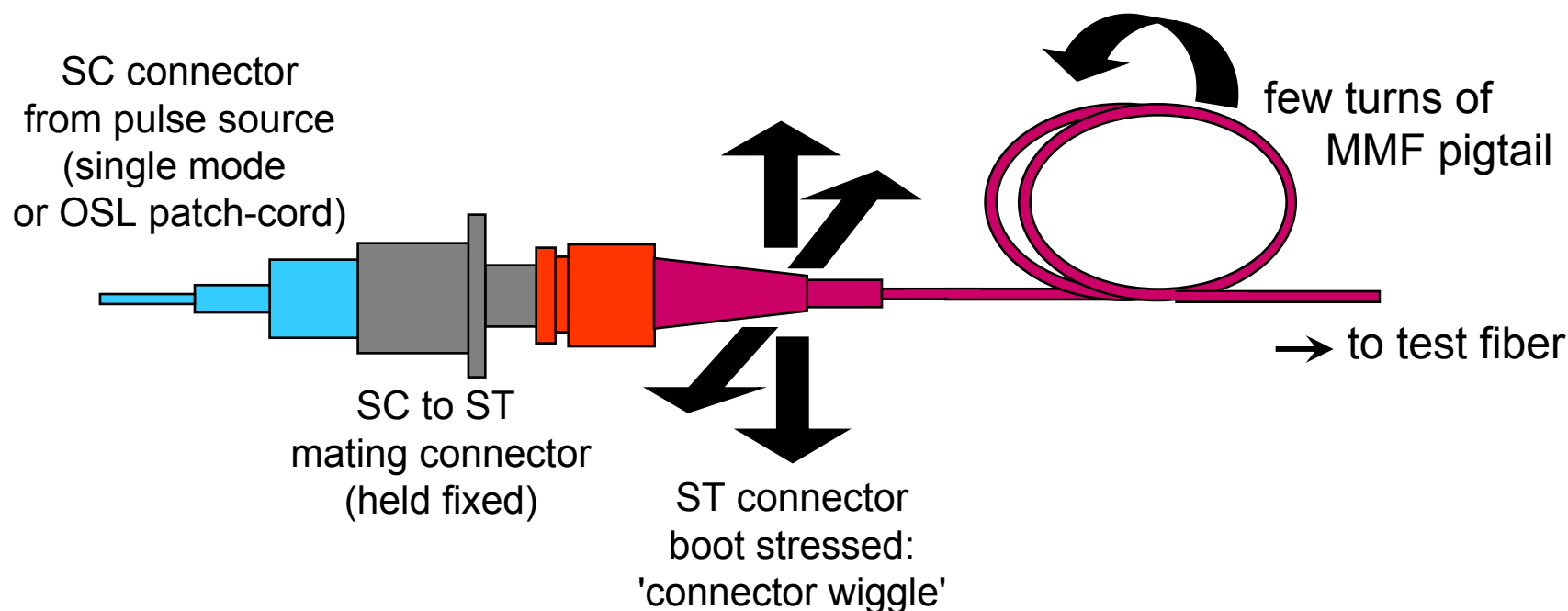
Impulse Response Test Bed

- Gain switched 1310nm DFB
- Test bed bandwidth 7.8GHz
 - 40ps FWHM optical source
 - 60ps FWHM at output of test bed multimode receiver
 - Data good to ~14GHz when corrected for test bed response
- Best/worst response affected by mechanical conditions at MM fiber input



Launch Conditions Affect Fiber Response

- Especially for center launch, single-mode to multi-mode
 - Mechanical arrangement of fiber pigtail at input of MMF under test
 - ST Connector stressed at mating connector



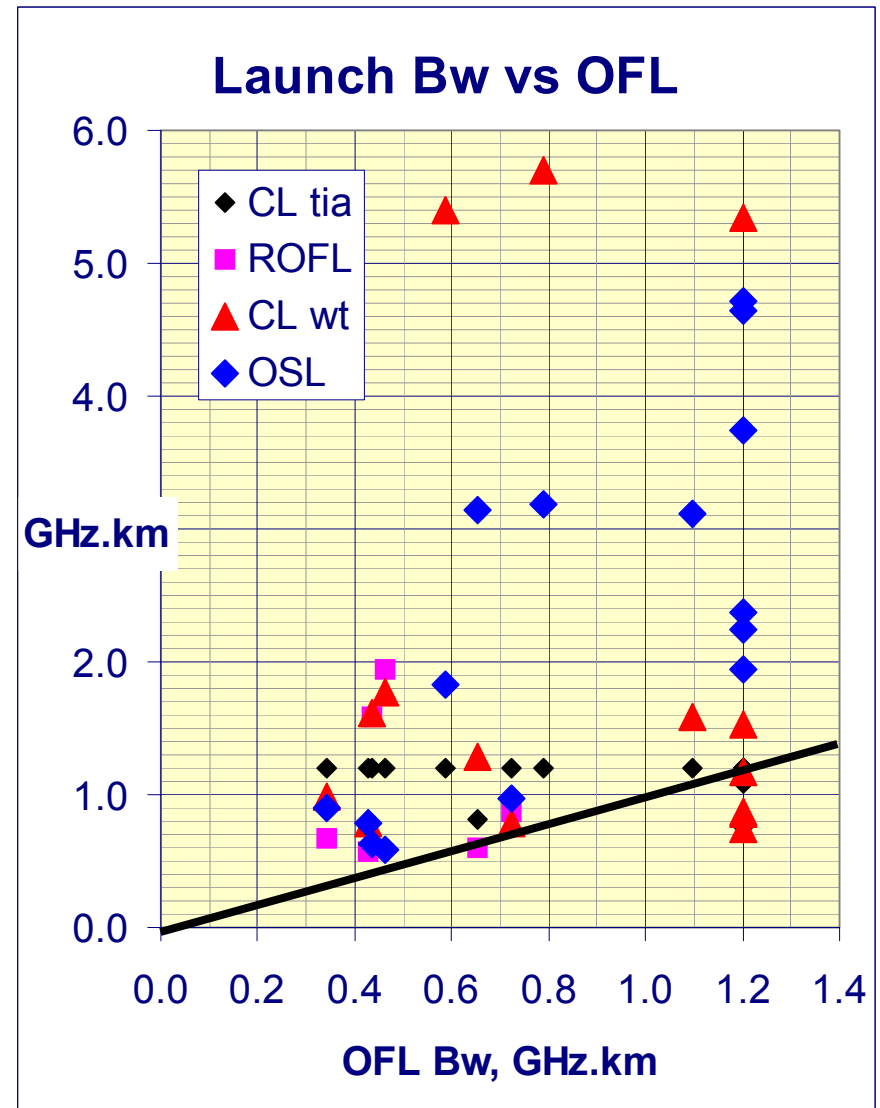
Optical Bandwidths (GHz·km) for OFL, CL, OSL, ROFL

Fiber	Fiber Name	OFL (TIA data)	CL (TIA data)	CL 'connector wiggle'	OSL	ROFL 1dB loss
f1	1 orange	1.10	>1.2	1.59	3.12	
f2	1 green	0.59	>1.2	5.4	1.83	
f3	1 blue	>1.2	>1.2	5.34	4.71	
f4	2 orange	0.43	>1.2	1.62	0.63	1.59
f5	2 green	0.46	>1.2	1.77	0.59	1.95
f6	2 blue	0.72	>1.2	0.78	0.98	0.87
f7	3 aqua	0.43	>1.2	0.78	0.78	0.57
f8	3 blue	0.34	>1.2	0.99	0.90	0.68
f9	3 violet	>1.2	>1.2	0.75	4.65	
f10	4 orange	0.65	0.81	1.29	3.15	0.60
f11	4 green	0.79	>1.2	5.7	3.18	
f12	4 blue	>1.2	>1.2	1.53	3.75	
f13	5 orange	1.20	1.19	0.86	1.95	
f14	5 green	>1.2	1.08	0.87	2.25	
f15	5 blue	>1.2	0.76	1.17	2.37	

OSL provides at least OFL bandwidth for all fibers

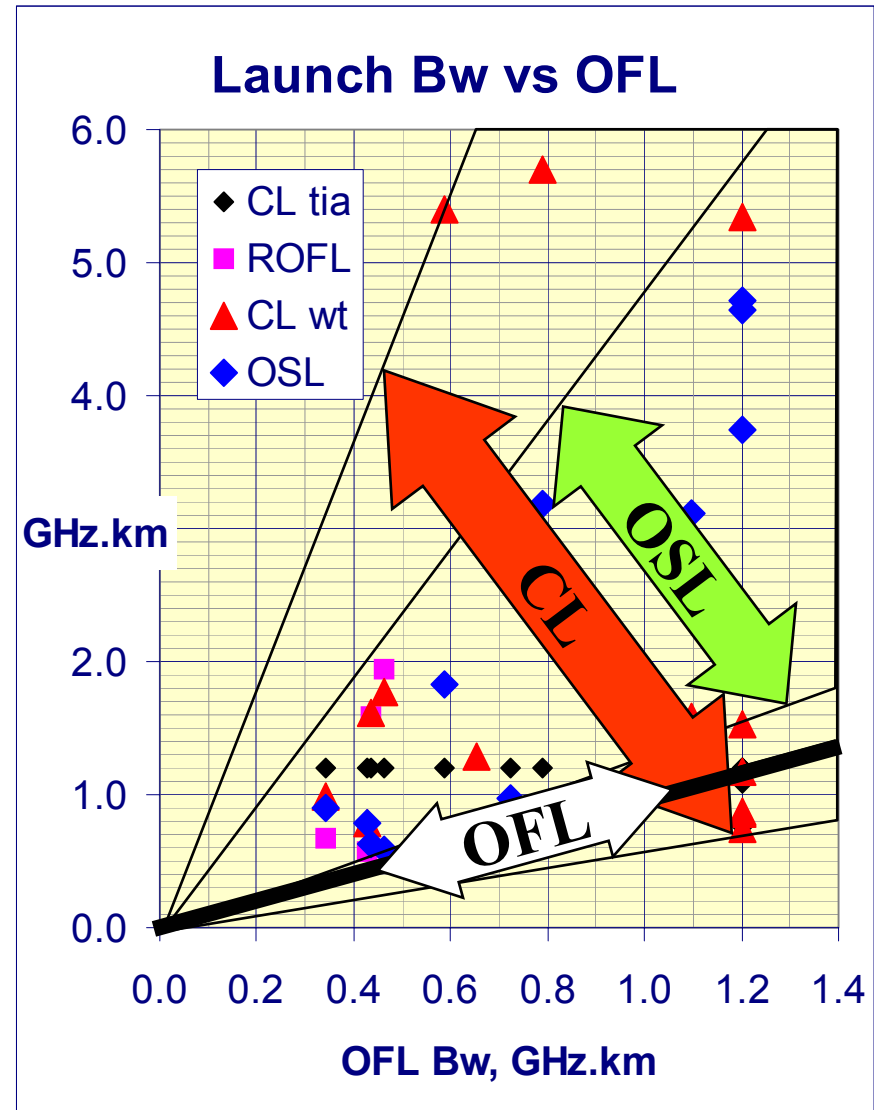
OSL and CL Bandwidths Plotted Against OFL

- CL:
 - Can be high bandwidth, but is not stable, and does not guarantee at least OFL bandwidth
- OSL:
 - Provides at least OFL bandwidth
 - Can be lower than CL
 - More stable with connector and fiber perturbation



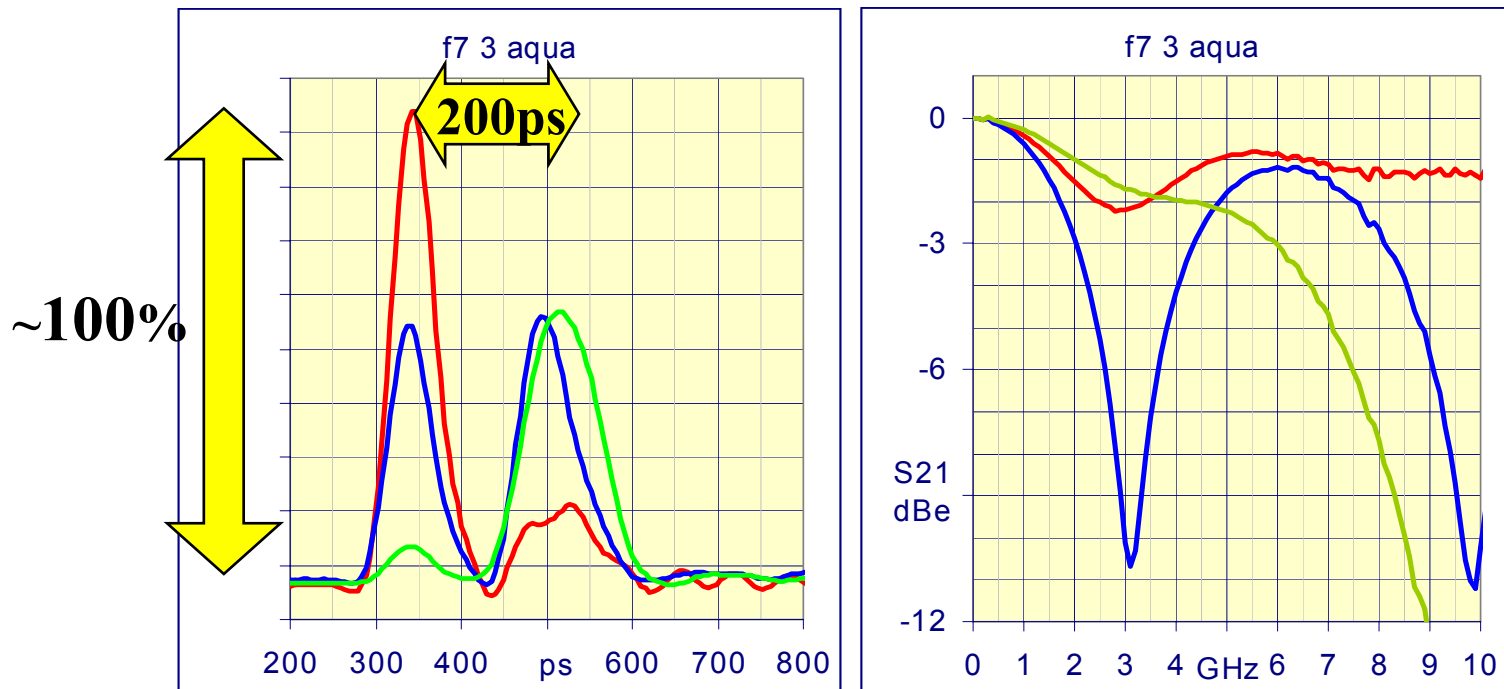
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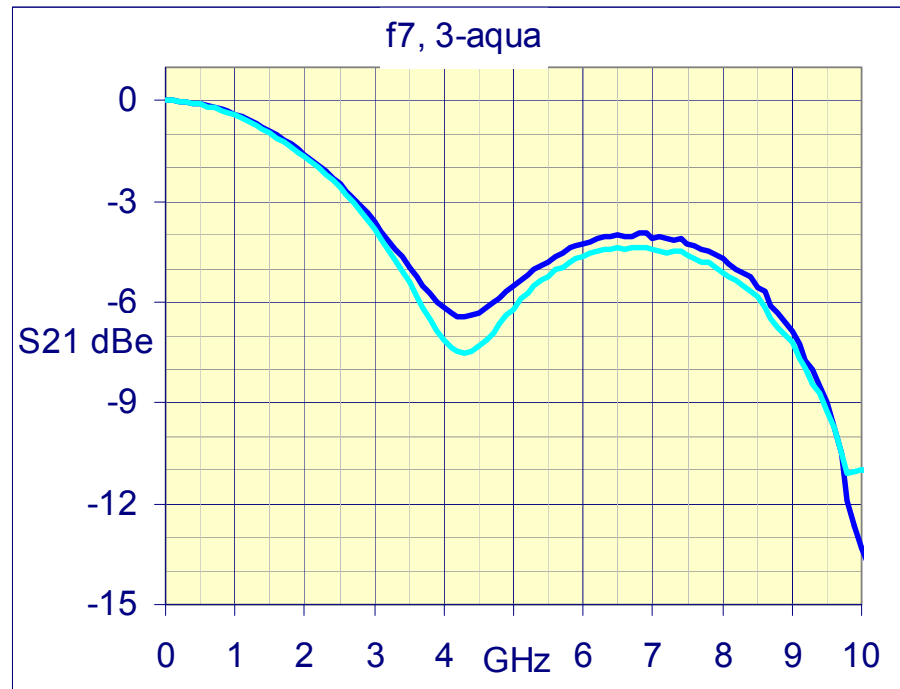
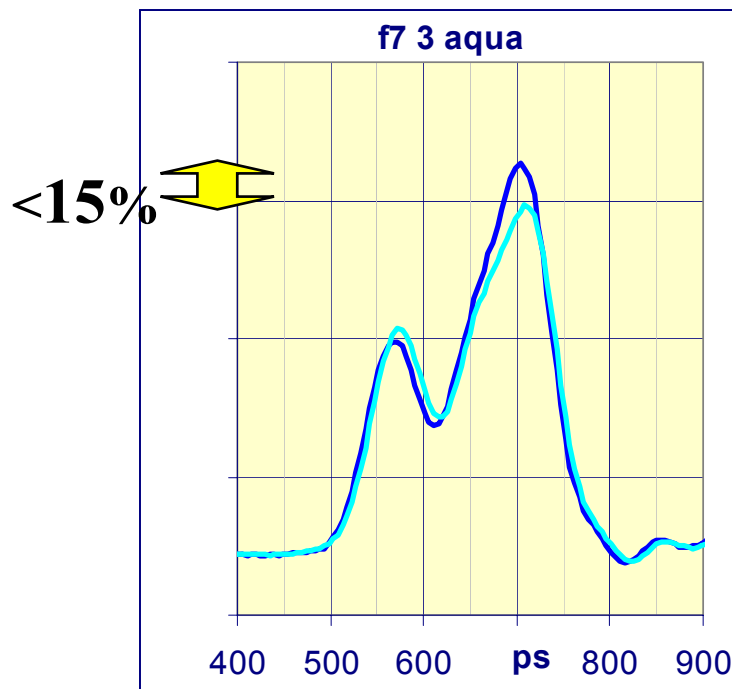
Centre Launch Characteristics

- High bandwidth with good alignment
- Sensitive to slight mechanical perturbation of input connector or fiber
 - ~90% power modulation of main temporal mode
 - Significant temporal wander
 - E.g. 3 aqua (f7) impulse and frequency response



Offset Single-mode Launch Characteristics

- Bandwidth at least as good as OFL, typically higher
- Relatively stable to mechanical perturbation of input connector or fiber
 - <35% power variation of main temporal mode
 - Little temporal wander
 - E.g. 3 aqua (f7) impulse and frequency response

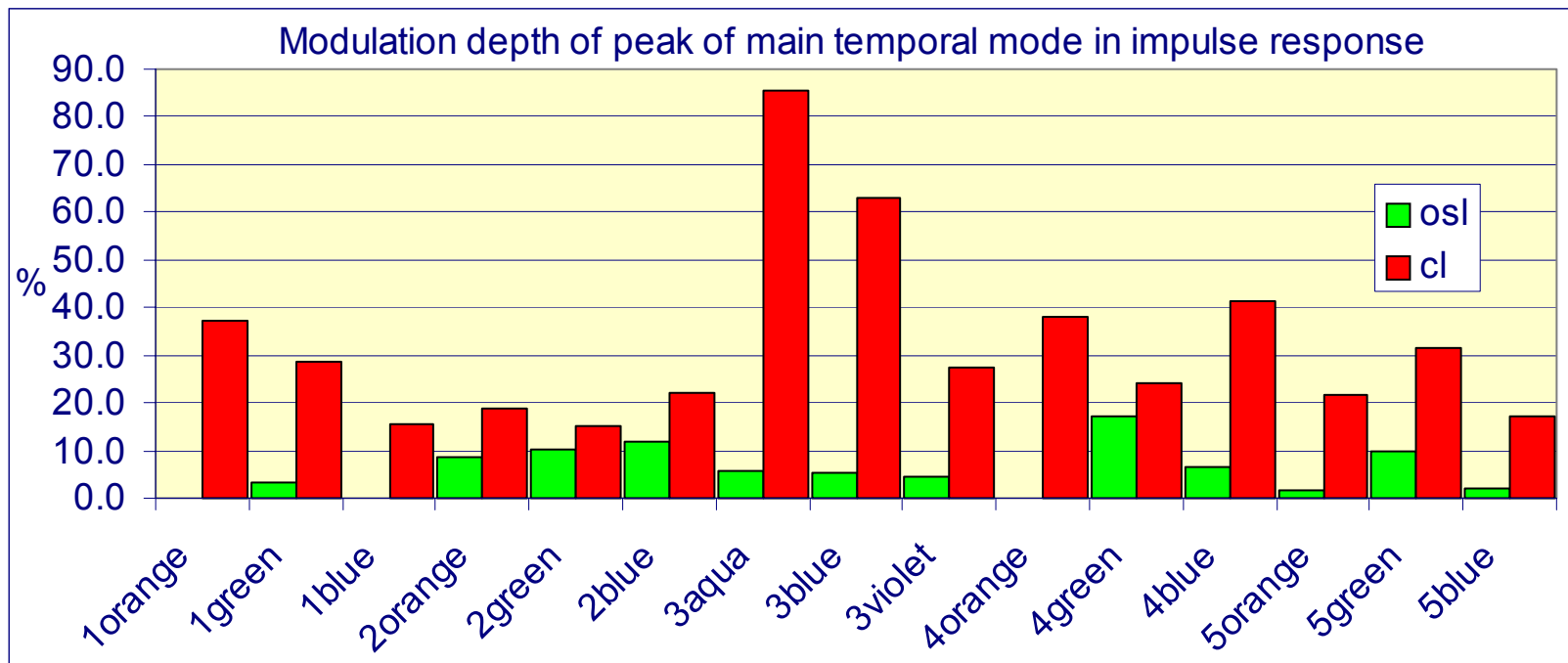


Channel Variability

- Modulation depth of main temporal mode for OSL and CL

$$m = 100 * (P_{\max} - P_{\min}) / (P_{\max} + P_{\min}) \%$$

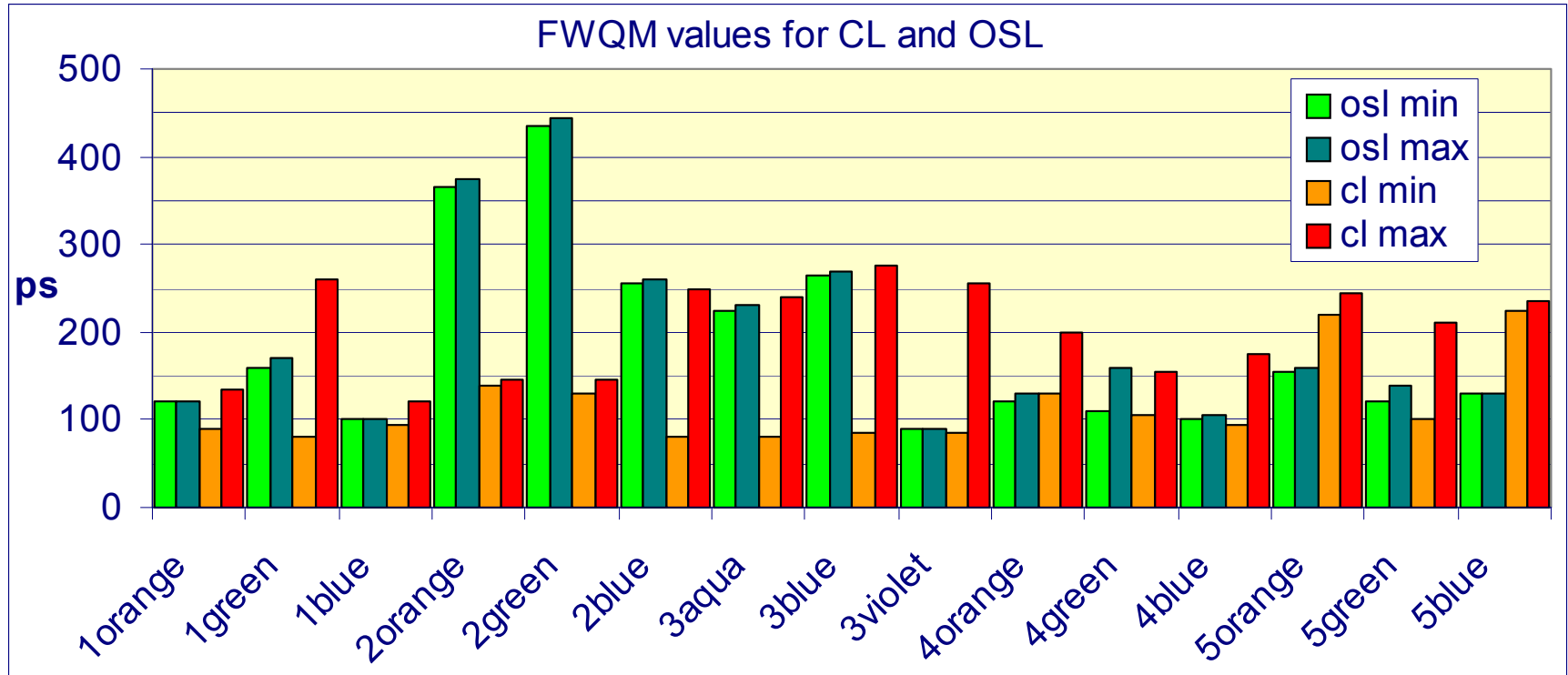
power variation of main mode is 2 x **m**



OSL launches show significantly better stability than CL for all fibres

FWQM Values for all TIA 12-96 fibers

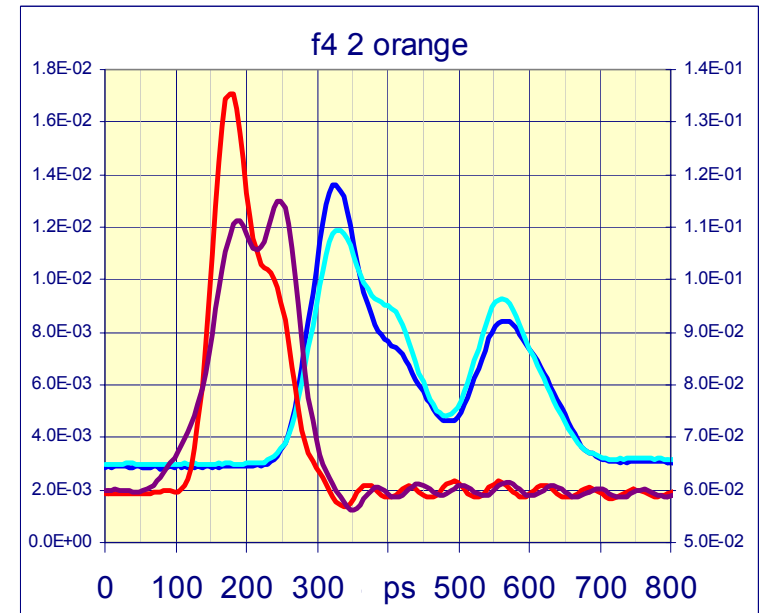
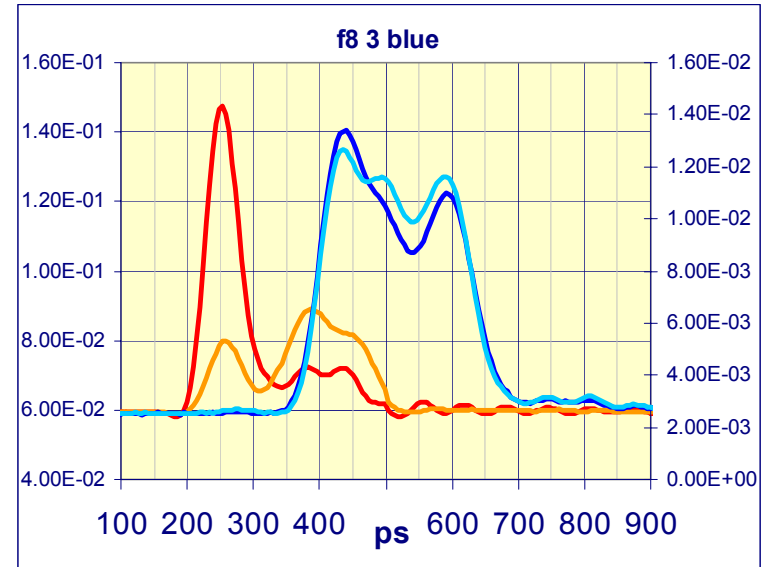
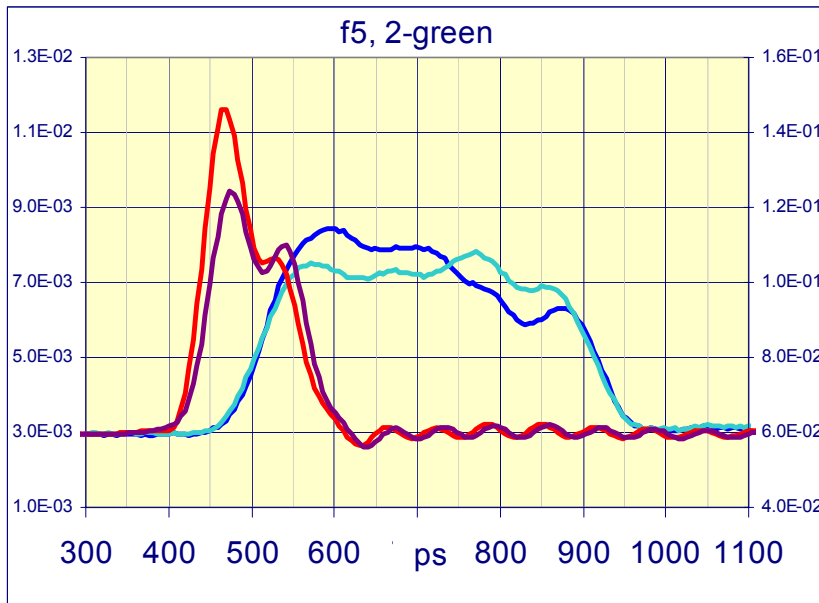
- Full Width Quarter Maximum of the impulse response for CL and OSL



- OSL gives more consistent FWQM values than CL for all fibers

Examples FWQM Fibers OSL and CL

- OSL:
 - FWQM $\sim 450\text{ps}$ (2 green, f5)
 - FWQM $\sim 375\text{ps}$ (2 orange, f4)
- CL:
 - FWQM $\sim 280\text{ps}$ (3 blue, f8)
 - FWQM $\sim 145\text{ps}$ (2 orange, f4)



Summary of Launch Characteristics Based on TIA 12-96 Set

- OSL channel:
 - 2 to 4 temporal modes separated by $<500\text{ps}$
 - Relatively stable with connector and fiber perturbation: $<35\%$ power variation between main modes
 - Negligible temporal wander
- CL channel:
 - Typically 2 dominant temporal modes
 - Power variation between modes varies significantly (up to 90%) with connector and fiber perturbation
 - Temporal wander over $\sim 200\text{ps}$