The bridge to possible

Routed Optical Networking Solutions with ASR 9000

Cisco Knowledge Network

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Cisco Mass Scale Infrastructure Group

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Agenda

1. Routed Optical Networking – The Architecture Transition
2. ASR 9000 5th Generation Innovations
3. ASR 9000 400GE, QDD-ZR & ZR+ Capabilities
4. Demo

Economics of Networking is Changing…

Incremental Improvements:
Important but not enough

Build faster networks (Moore's Law)

Higher chassis capacities
Higher interface speeds

More capacity at lower cost

Improve network utilization

Better traffic engineering
Telemetry + Analytics

Maximize use of assets

Disruptive Changes:
Critical to the future of networks

Re-architect end-to-end network

Simplify, collapse layers
Remove functional overlaps

Remove complexity

Transform Network Operations

Consistent operations
Automation + Orchestration

Service Agility, Speed

Innovations driving Routed Optical Networking

Optics

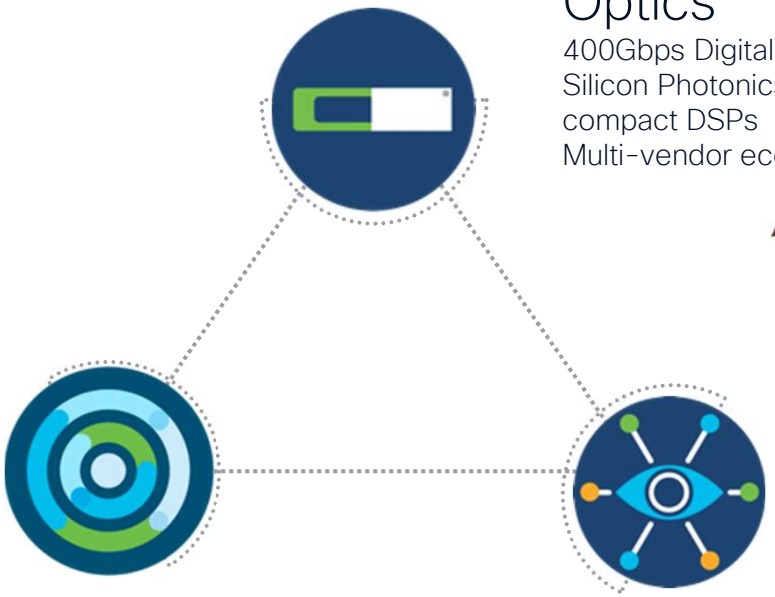
400Gbps Digital Coherent Optics – DCO
Silicon Photonics
compact DSPs
Multi-vendor ecosystem

ACACIA COMMUNICATIONS, INC.

Automation & Management

Multi-Vendor
Cross-domain
Hierarchical Controller
simplify e2e network lifecycle

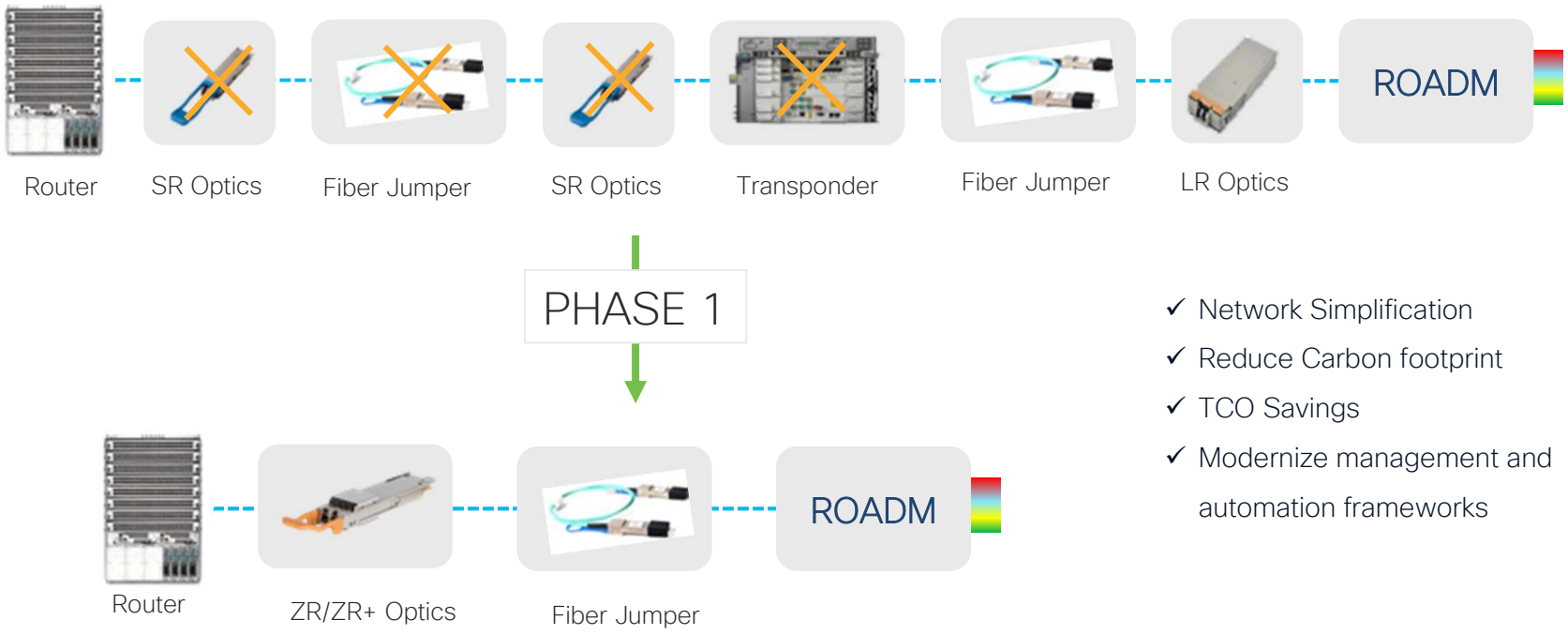
sedona systems



Architecture

Multi Tbps Routers
Secure and resilient
Feature rich Software
Segment Routing and EVPN

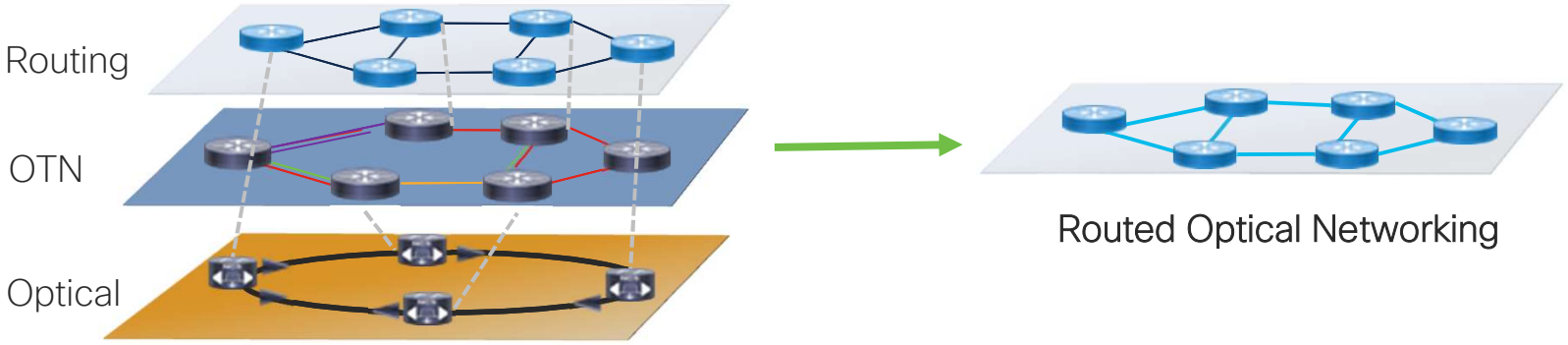
The Twilight of Transponders



- ✓ Network Simplification
- ✓ Reduce Carbon footprint
- ✓ TCO Savings
- ✓ Modernize management and automation frameworks

Routed Optical Networking Architecture

Simplicity is the Ultimate Sophistication – Leonardo Da Vinci



35% CapEx Savings*

57% OpEx Savings*

46% TCO Savings*

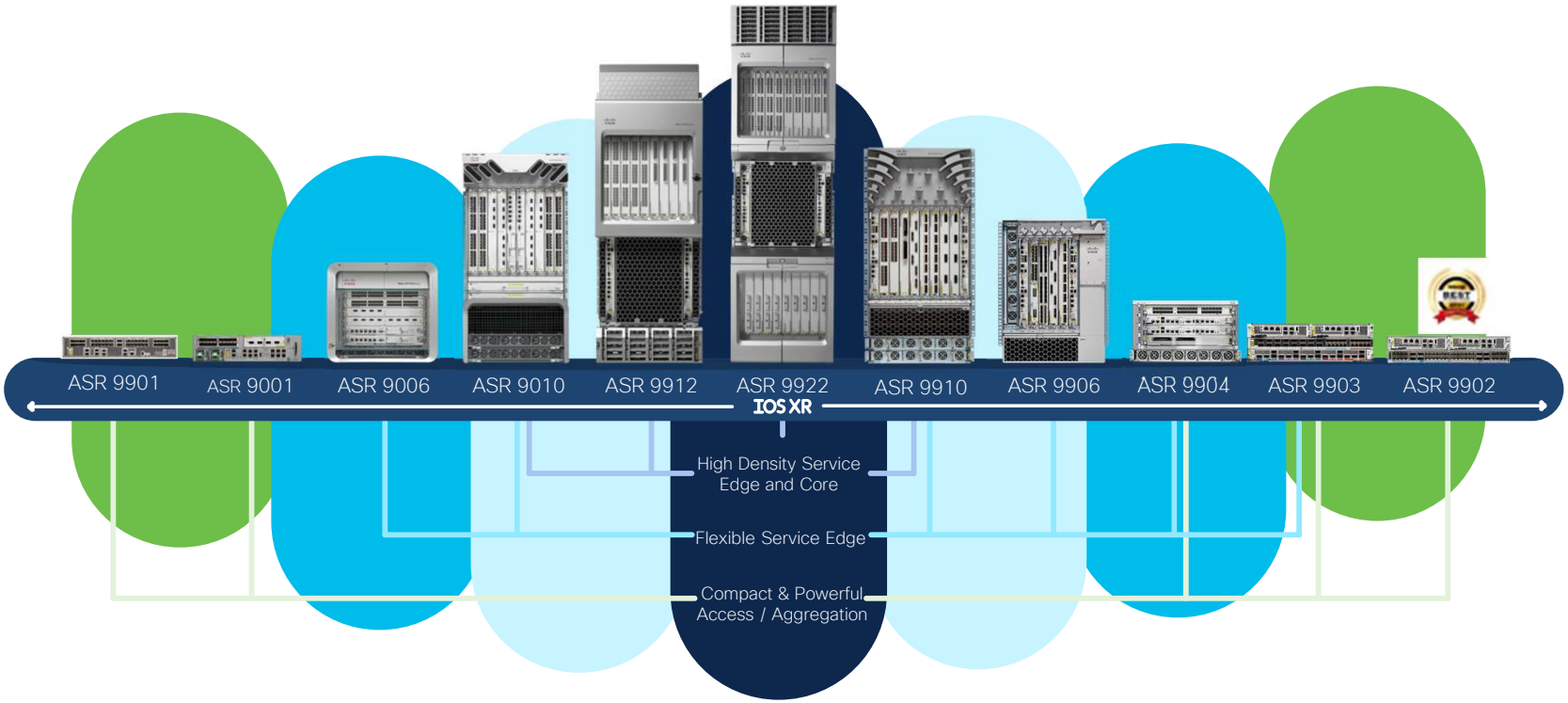
*Source: ACG Research, 2021

ASR 9000 Portfolio Introduction

Enabling Bandwidth & Embedded Intelligence

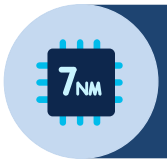
Cisco ASR 9000 Series

Hardware portfolio



ASR 9000 5th Generation

The World's largest networks are built with the ASR 9000



Refined. Cutting edge 7nm silicon for performance & efficiency

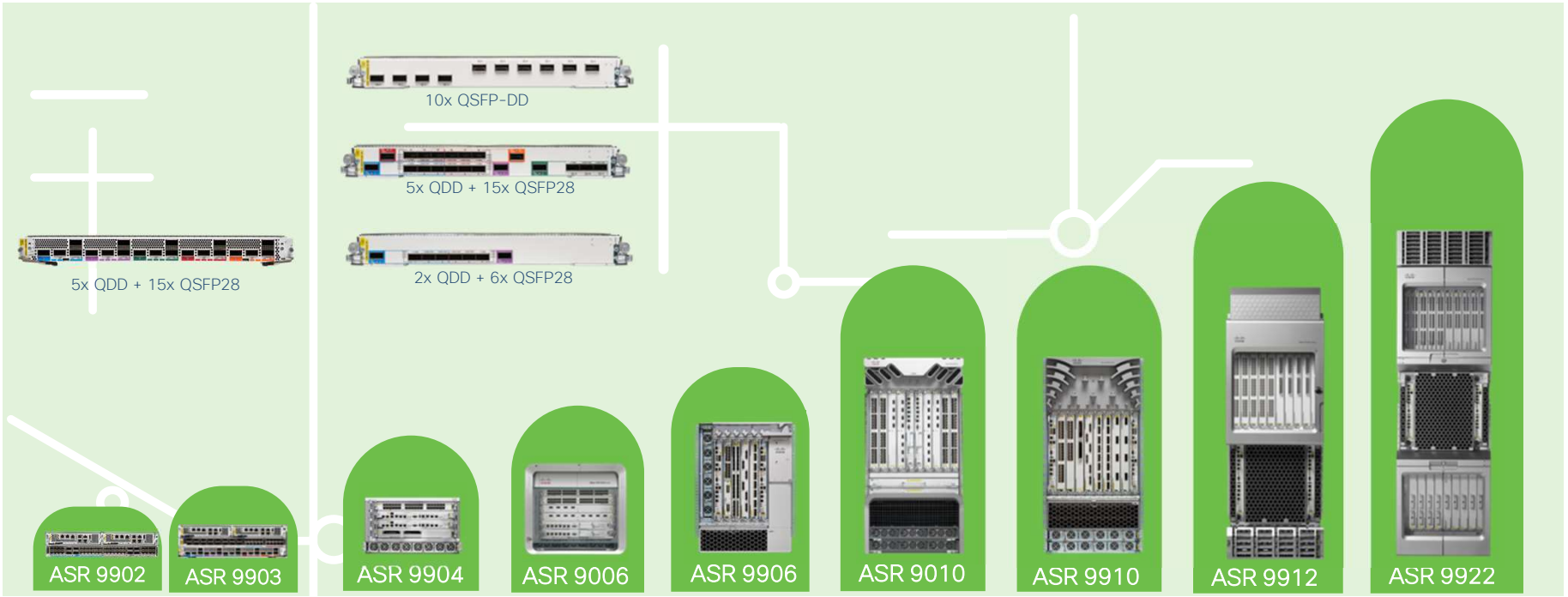
400GE **Reloaded.** Increased capacity with 400GE, port flexibility

Reinforced. Hardware Root of Trust, Full Line Rate MACsec

IOS XR **Service Edge.** Rich feature set and Superior multi service scales

Cisco ASR 9000 Compact and Modular 400GbE Routers

Investment Protection up to 4T per slot



	ASR 9902	ASR 9903	ASR 9904	ASR 9006	ASR 9906	ASR 9010	ASR 9910	ASR 9912	ASR 9922
Capacity	800 Gbps	3.6 Tbps	8 Tbps	8 Tbps	16 Tbps	16 Tbps	32 Tbps	40 Tbps	80 Tbps
QDD Ports	2	5	20	20	40	40	80	100	200

Cisco ASR 9000 Series

Reloaded with 5th Generation Silicon and support for 400GbE

4 Tbps

3.2 Tbps

2 Tbps

0.8 Tbps

0.4 Tbps

5th Gen Line Cards

- 5th Generation Silicon
- Service Edge scale in compact and modular form-factor
- Flexible interface support for 10, 25, 40, 100 & 400G
- 0.4 Watts/Gbps

3.6 Tbps

ASR 9903

2T PEC

0.8T PEC

0.8 Tbps

ASR 9902

5th Gen Compact Chassis

ASR 9000 High Speed Optical Solutions for 5th Generation LCs 100G, 400G, ZR/ZR+

Cisco Optics Investments and Acquisitions

Fiber re-use and <100m

Multimode fiber (MMF) Optics

Cisco innovation & first to market

- 40G Bidi
- 40/100G dual rate Bidi
- Continued investment on next generation multimode optics
- 30% of ports shipped use multimode optics

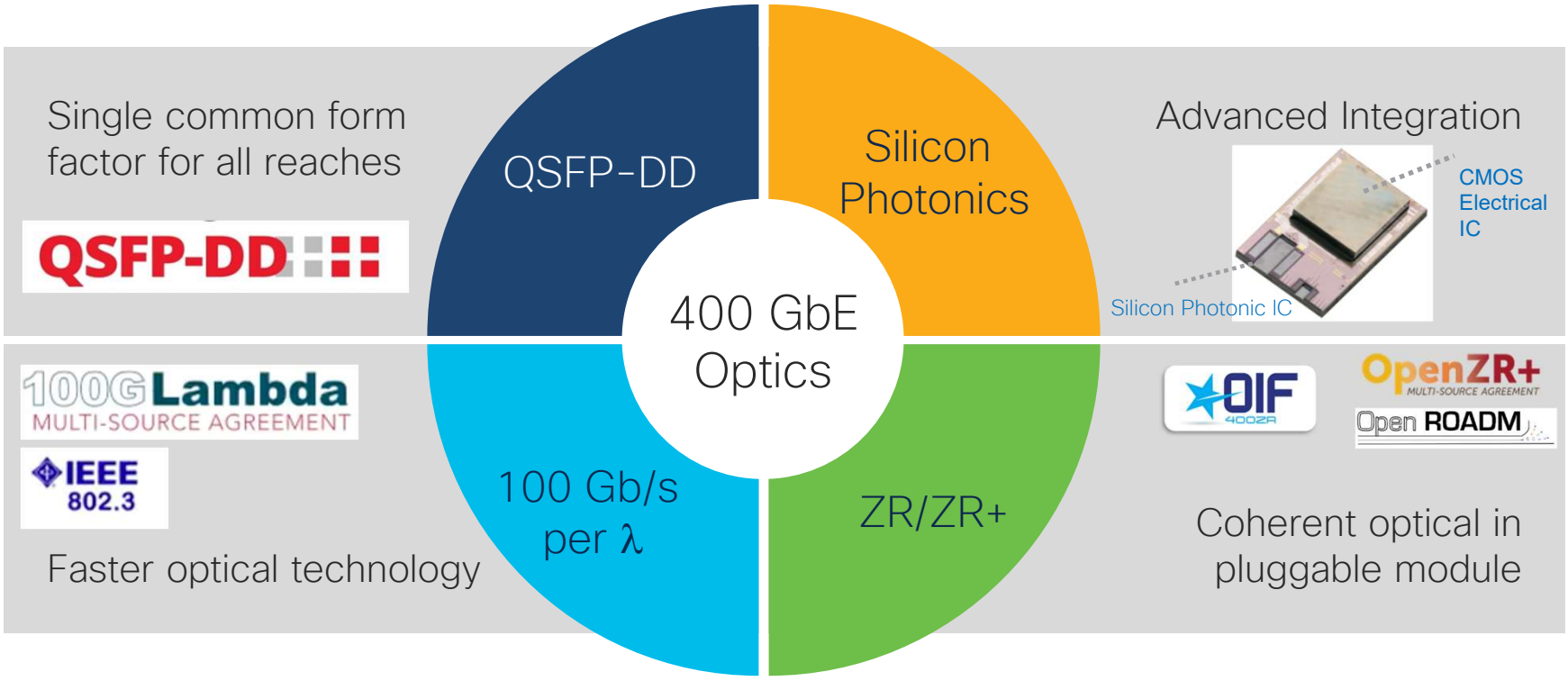
For new deployments and >100m

Single mode fiber (SMF) Optics for new deployment

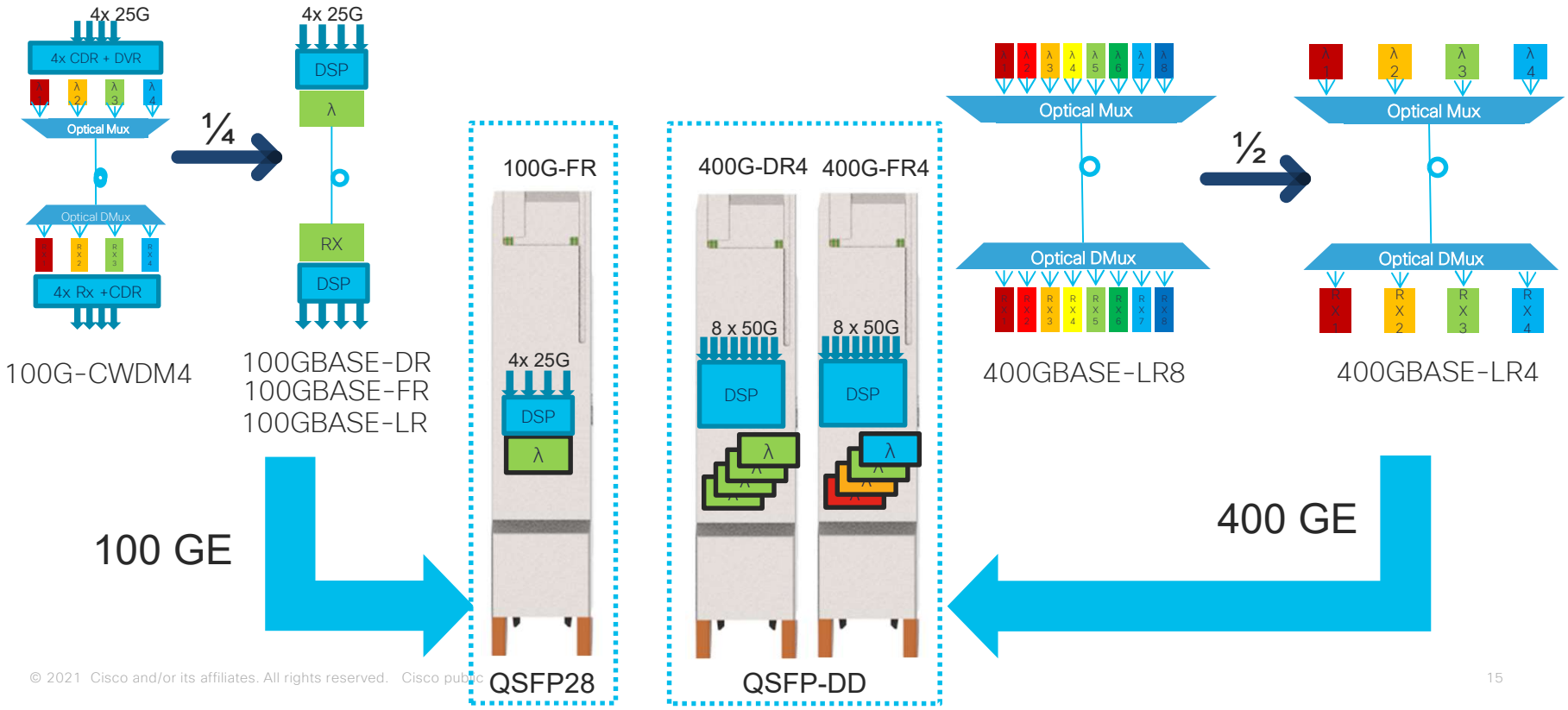
Cisco investments and acquisitions

- LIGHTWIRE — Cisco CPAK 100G
- Cisco — QSFP 100G FR
- LUXTERA — QSFP 100G PSM4, QSFP 100G CWDM4
- ACACIA COMMUNICATIONS, INC. — Coherent Optics for >80km

Making High Speed Optics market ready



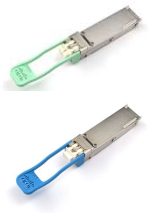
Industry Optics Strategy – Simplifying 100 GbE and 400 GbE



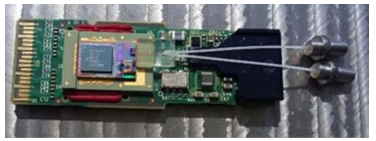
ASR 9000 Next Gen Single-Lambda 100G QSFP28 Optics

A New Generation of QSFP28 100 GbE Single mode optics

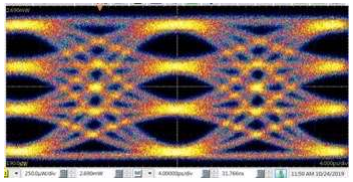
Product	Reach (km)	Power Consumption	PID
FR	2	4.3W	QSFP-100G-FR-S
LR	10	4.0W	QSFP-100G-LR-S



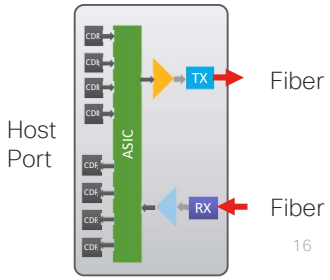
- New portfolio of 100G Single mode optics
- Cisco innovation – first in the industry for 100G PAM4 Silicon Photonics
- Future proofing for transition to next-gen systems
- Supported on 3rd and 5th Generations LCs



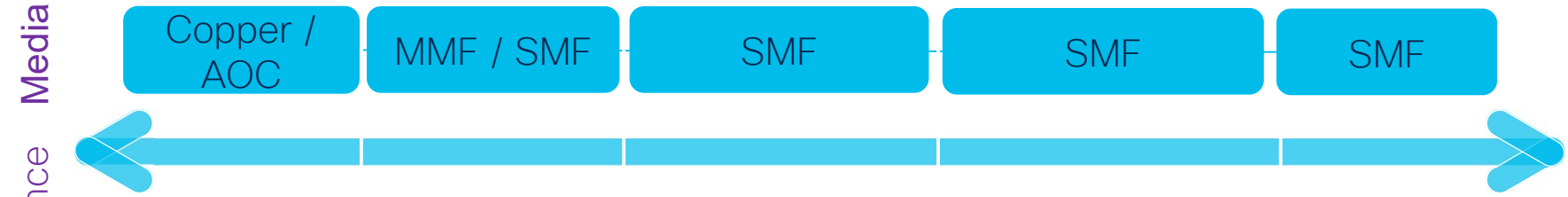
QSFP-100G-FR (2km)



100G PAM4 Transmitter "Golden Eye", used as reference by the IEEE



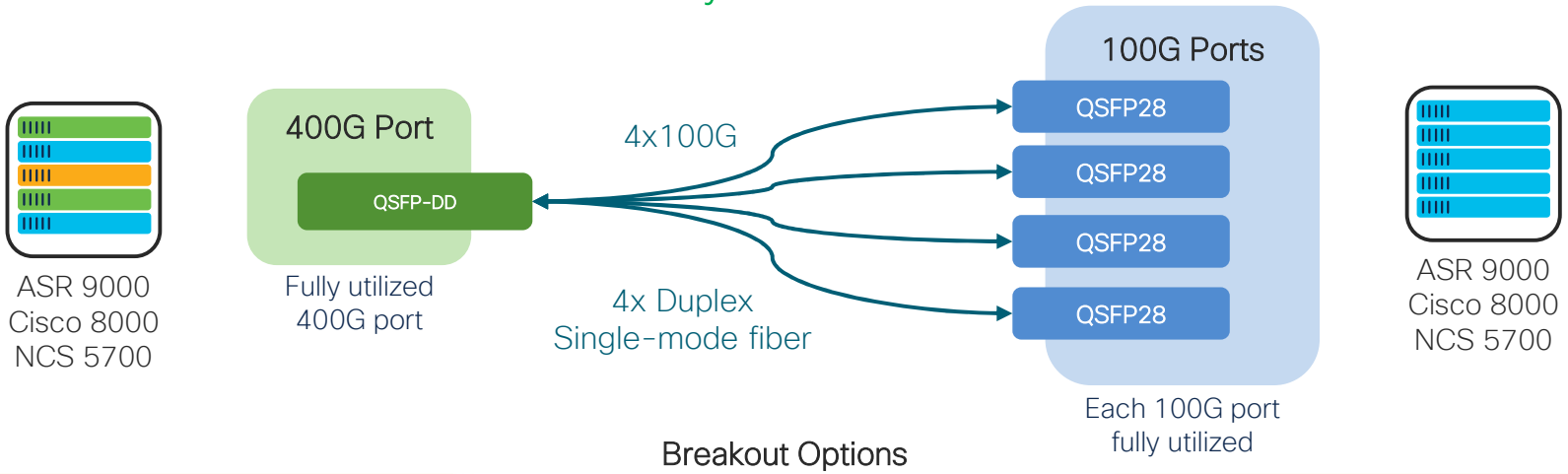
400G/200G/100G Optics and Use Cases



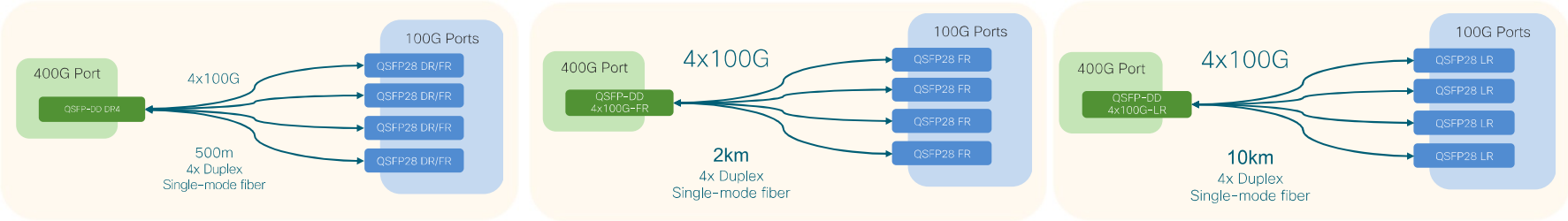
	3+ m	100 m	500m-2km	10 km	40+ km
400G Optics	400G-CR8 400G-AOC 400G-CU	400G-SR8-S 400G-SR4.2 400G-DR4 2x100-SR4	400G-DR4 400G-FR4 4x100G-FR 2X100-CWDM4	400G-LR4 400G-LR8 4x100G-LR 2X100-LR4-S	400ZR 400ZR+
100G Optics	100G-AOC DAC (Copper)	100G SR MM	100G-CWDM4 100G-FR 100G-PSM4 100G-DR	100G-LR 100G-LR4	100 ZR

400G to 100G Connectivity With Breakout

Transition to Next-Generation Systems



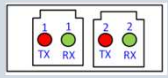
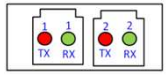
Breakout Options

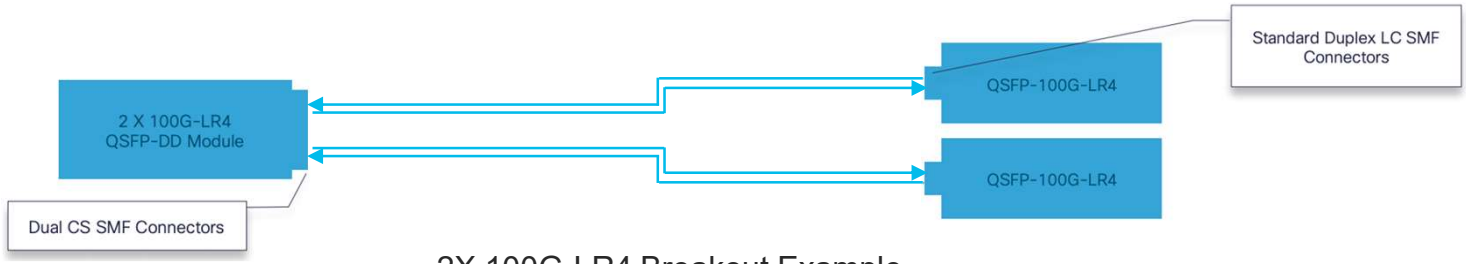


4x 100G breakout for single-mode fiber is only possible with the new QSFP28 Single Lambda 100G optics (100G-FR, 100G-LR), not with first generation of QSFP28 SMF optics (i.e., 100G-LR4)

2x100G QSFP-DD to 100G QSFP28 Breakout

QSFP-DD 2x100G Modules provide ability to connect legacy 100G modules to QSFP-DD ports

Module Type	Range	Mode	Power Consumption	Modulation	Connector
QDD-2X100-LR4-S	10 km (G.652)	SMF	10W	NRZ	CS (Dual Duplex Interface) 
QDD-2X100-CWDM4-S	2 km (G.652)	SMF	7W	NRZ	CS (Dual Duplex Interface) 
QDD-2X100-SR4-S	100m on OM4	MMF	5W	NRZ	MPO-24



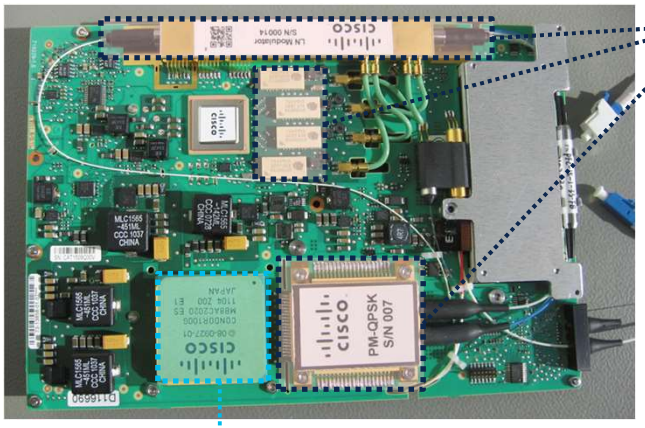
2X 100G-LR4 Breakout Example

QSFP-DD ZR/ZR+

What Is a DCO Transceiver ?

DCO = Digital Coherent Optic

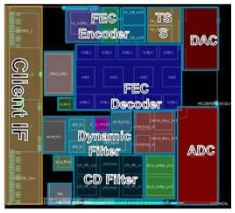
Cisco 100G transponder line card
for 300x300mm layouts



150W

Discrete
Photonic
Elements

Digital Signal
Processor



28nm

Silicon
Photonics
Integration
Advanced
Packaging
Integration

Moore's
Law

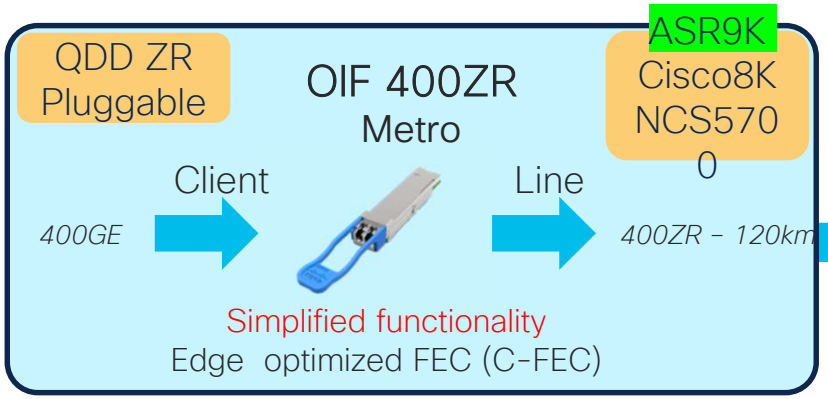
PIC with
Multi Chip
Packaging

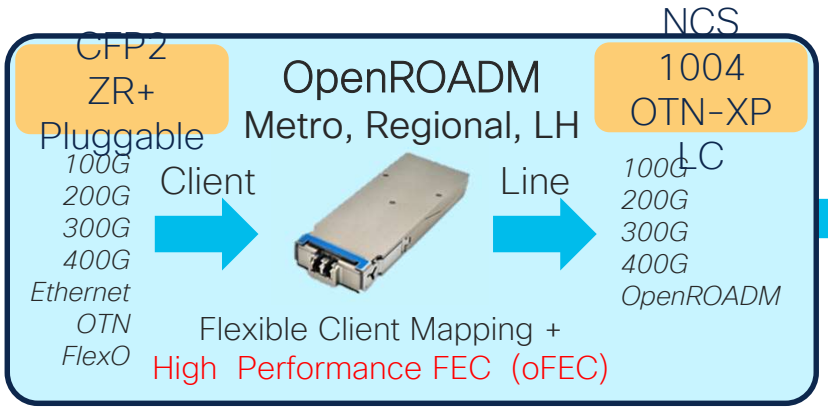
7nm

QSFP-DD
400G DCO

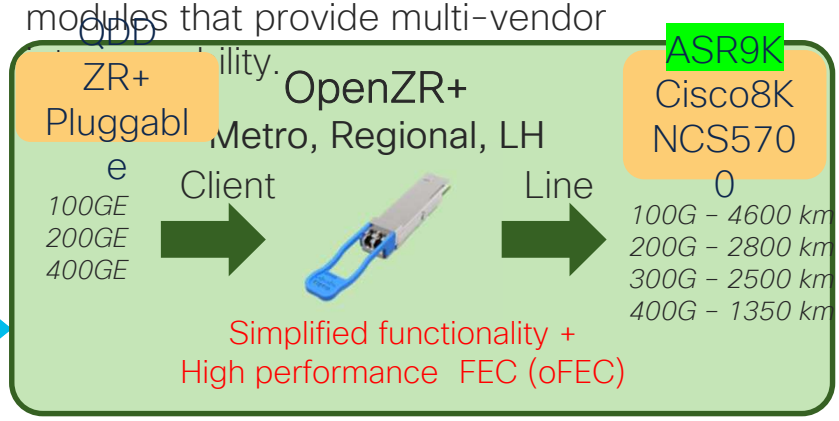
15W

Cisco ZR and ZR+ Portfolio





Combination of two standardization efforts that enables high performance pluggable modules that provide multi-vendor interoperability.



Line Rate	Modulation Format	FEC	P-TX [dB]	Min P-RX [dBm]	Ref Reach [km]	Max Reach P2P w/o OLA [km]*
400G ZR	16QAM	CFEC	-10,0	-20	120	40
400G ZR+	16QAM	OFEC	-10,0	-20	1360	40
300G ZR+	8QAM	OFEC	-10,2	-22	2560	47,2
200G ZR+	QPSK	OFEC	-7,7	-28	2880	81,2
100G ZR+	QPSK	OFEC	-7,5	-28	4640	82

* Engineered link @ 0,25dB/km

ASR 9000 ZR/ZR+ Muxponder and Transponder Modes

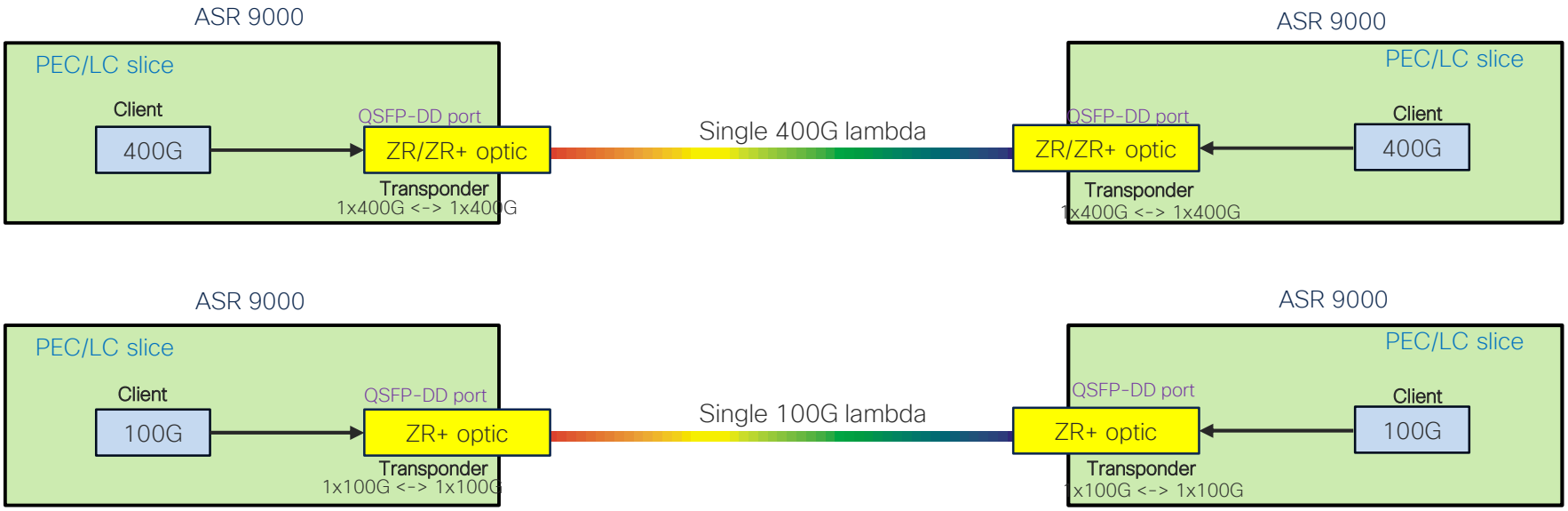
- 400G ZR and ZR+ optics use only single lambda and don't support multiple 100G DWDM channels, which means Point-to-Point topology is only supported in IPoEoF Architecture
- To get more flexibility to provide not only 400G client interface but 100G as well, ZR and ZR+ optics are capable to work in Transponder and Muxponder modes
- Transponder mode can provide both client interfaces 100G & 400G
- Muxponder mode can provide even better flexibility because it can guarantee the ordering of the 4x100G ports after mux/demux, similar to a 4x100G breakout
- Muxponder and Transponder modes cannot interoperate with each other – it means QSFP-DD ports on both ends should be configured in the same mode

ZR/ZR+ Support on ASR 9000 5th Generation Details

5th Gen Product	ZR Mode	ZR+ Mode
A9903-20HG-PEC	Transponder: 1x400G	Transponder: 1X400, 1X100G;
ASR-9902	No support	Transponder 1x100G
A9K-20HG-FLEX-SE/TR	Transponder: 1x400G Muxponder: 4X100G	Transponder: 1X400G, 1X100G; Muxponder: 4X100G,
A99-10X400GE-X-SE/TR	Transponder: 1x400G Muxponder: 4X100G	Transponder: 1X400G, 1X100G; Muxponder: 2X100G, 4X100G;
A9K-8HG-FLEX-SE/TR	Transponder: 1x400G Muxponder: 4X100G	Transponder: 1X400G, 1X100G; Muxponder: 4X100G;

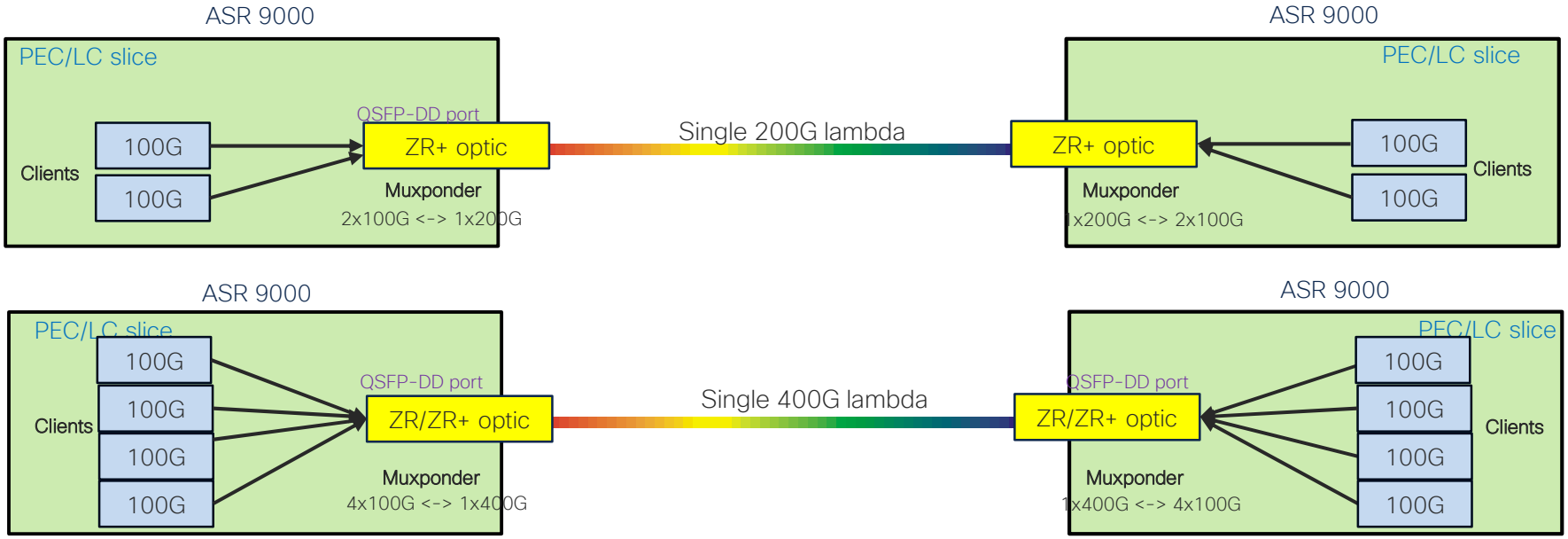
ASR 9000 ZR/ZR+ Symmetric Connectivity Topologies

Transponder Mode: 1x400G & 1x100G

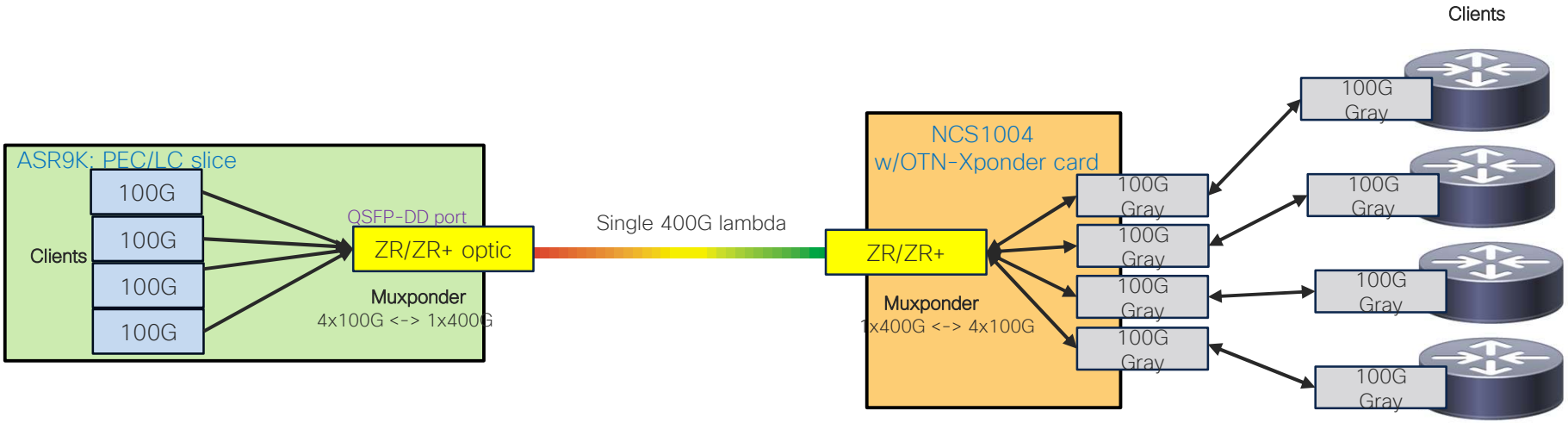


ASR 9000 ZR/ZR+ Symmetric Connectivity Topologies

Muxponder Mode 2x100G, 4x100G



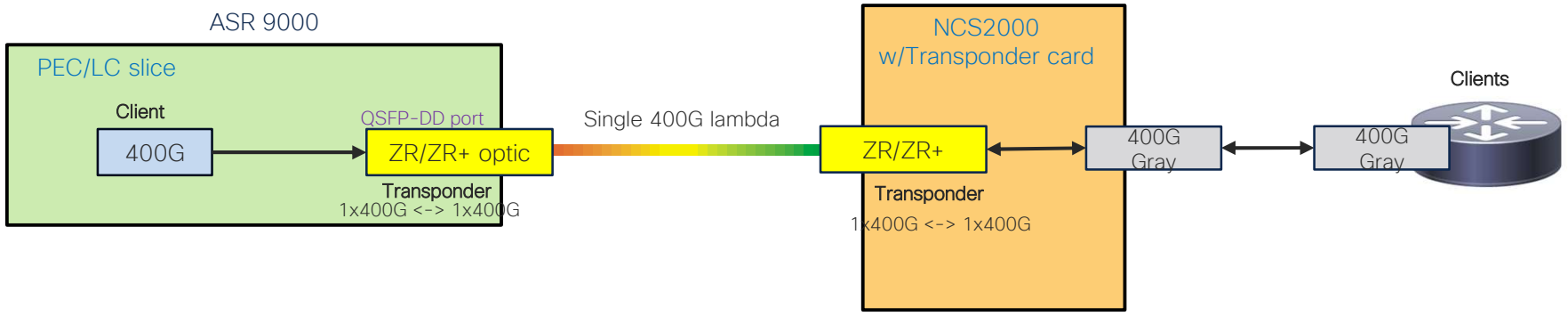
ASR 9000 ZR/ZR+ Connectivity Topologies
Muxponder Mode for 100G Gray Clients



Two muxponder solutions are planned to be interoperable with ZR+

1) NCS 2000 1.2T muxponder Line Card
2) NCS 1004 OTN-Xponder Line card

ASR 9000 ZR/ZR+ Connectivity Topologies
Transponder Mode for 400G Gray Client



ZR/ZR+ Optic Configuration

- ZR and ZR+ optics on ASR9K can be configured on two levels:
  - Controller configuration (configuration of the ZR/ZR+ controller driver)
  - Breakout configuration on the NPU **level (“hw-module” configuration)**
- On the ZR/ZR+ driver level different parameters can be configured: Frequency/Wavelength, Chromatic dispersion, TX power, Modulation, FEC, breakout, DAC-rate*, etc…

```
RP/0/RP0/CPU0:ios#conf t
RP/0/RP0/CPU0:ios(config)#controller optics 0/0/0/0
```

- **“hw-module” breakout** configuration should be configured via CLI:

```
hw-module location <…> bay 1 port <…> breakout <…>
```

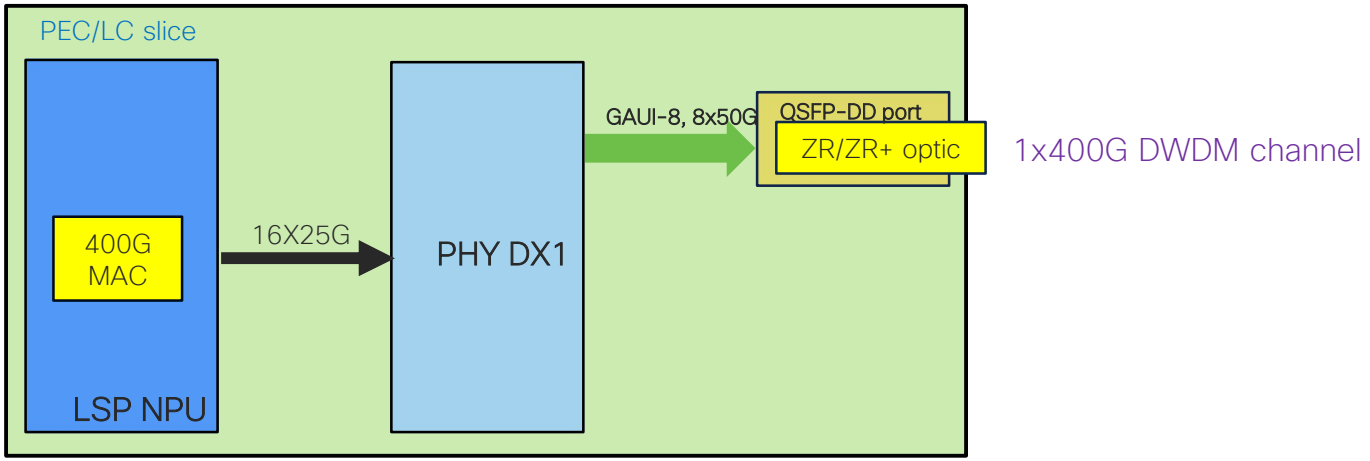
```
hw-module location <…> port <…> breakout <…>
```

-FLEX:

*DAC - digital-to-analog converter

ZR/ZR+ Optic Configuration: 1x400G Transponder Mode

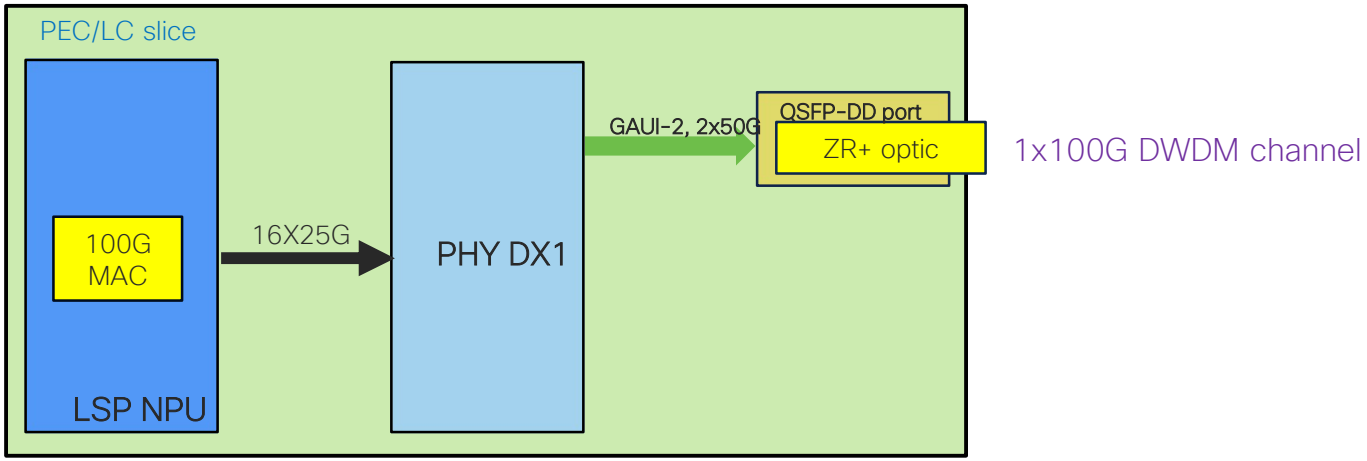
A99-10X400GE-X, A9903-20HG-PEC, A9K-20HG-FLEX, A9K-8HG-FLEX



Mode	"hw-module" Configuration	"controller optics" Configuration
ZR Transponder: 1x400G	breakout 1xFourHundredGigE	Not needed, default config can be used: • FEC: C-FEC, Modulation: 16QAM, DAC-rate: 1:1, Baud Rate: 59.84G Optionally non-default DAC-rate 1:1.25 is supported
ZR+ Transponder: 1x400G	breakout 1xFourHundredGigE	Not needed, default config can be used: • FEC: O-FEC, Modulation: 16QAM, DAC-rate: 1:1.25, Baud Rate: 60.31G

ZR+ Optic Configuration: 1x100G Transponder Mode

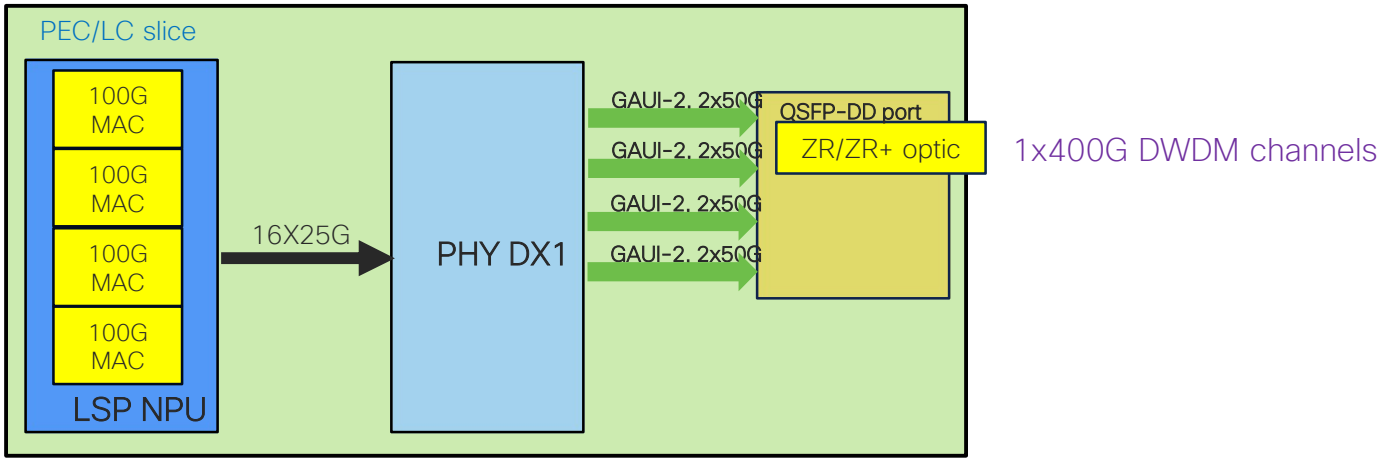
A9903-20HG-PEC, A9K-20HG-FLEX, A9K-8HG-FLEX



Mode	"hw-module" Configuration	"controller optics" Configuration
ZR+ Transponder: 1x100G	Not needed, default config 1xHundredGigE is used	Not needed, default config can be used: • modulation QPSK, baudrate 30.15G, FEC: O-FEC, DAC-rate: 1:1.25

ZR/ZR+ Optic Configuration: 4x100G Muxponder Mode

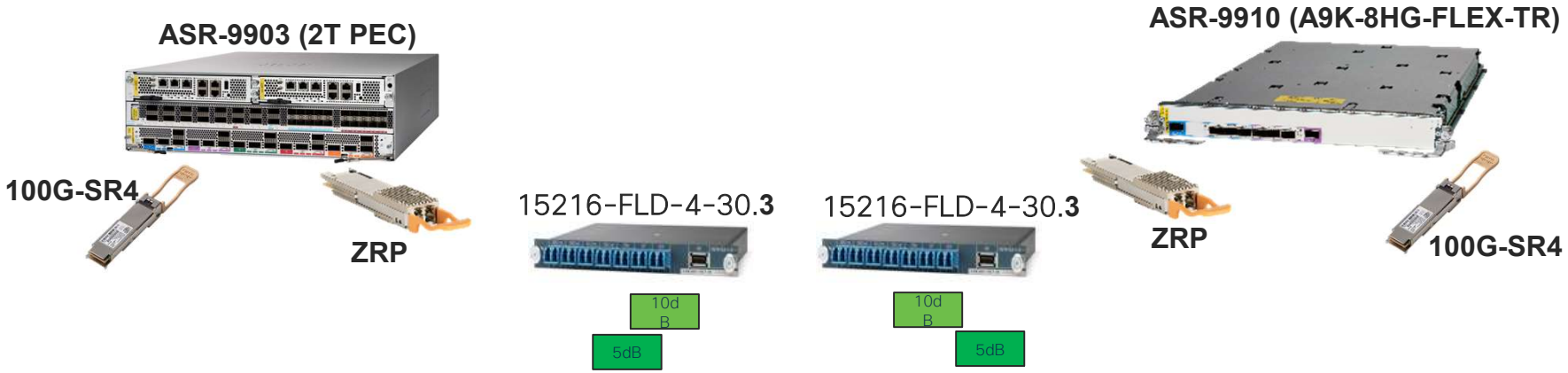
A99-10X400GE-X, A9K-20HG-FLEX, A9K-8HG-FLEX

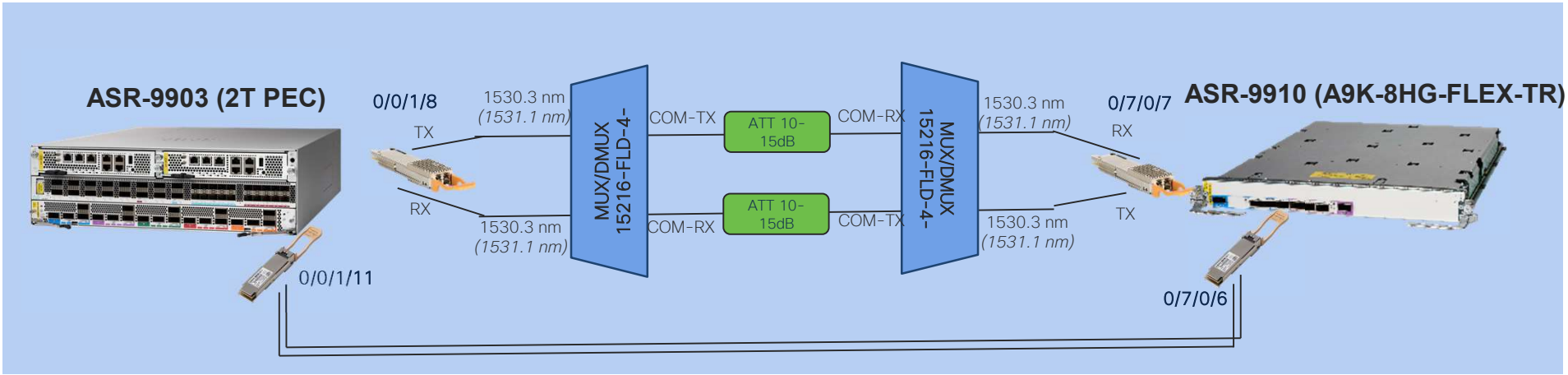


Mode	"hw-module" Configuration	"controller optics" Configuration
ZR Muxponder: 4x100G	breakout 4xHundredGigE	Should be configured: • breakout 4x100 Default config: • FEC: C-FEC, Modulation: 16QAM, DAC-rate: 1:1, Baud Rate: 59.84G
ZR+ Muxponder: 4x100G	breakout 4xHundredGigE	Should be configured: • breakout 4x100 Default config: • FEC: O-FEC, Modulation: 16QAM, DAC-rate: 1:1.25, Baud Rate: 60.31G

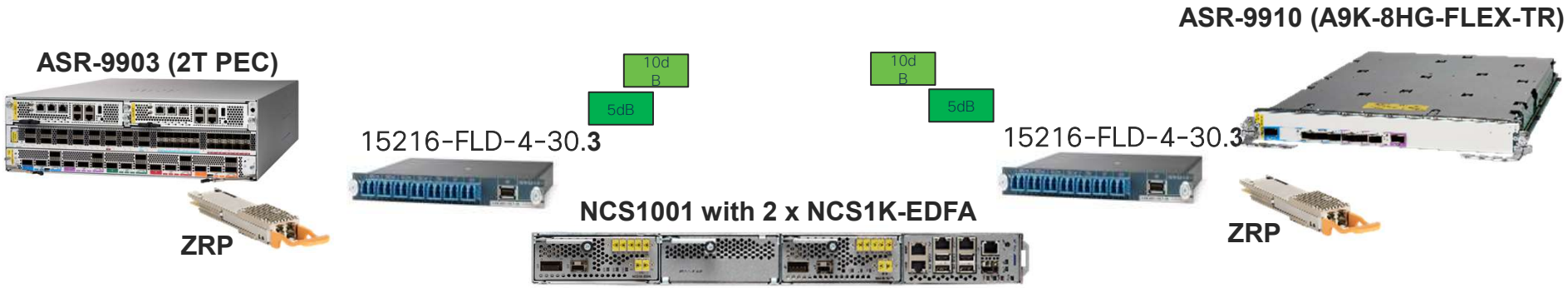
ZR+ Demo Discussion

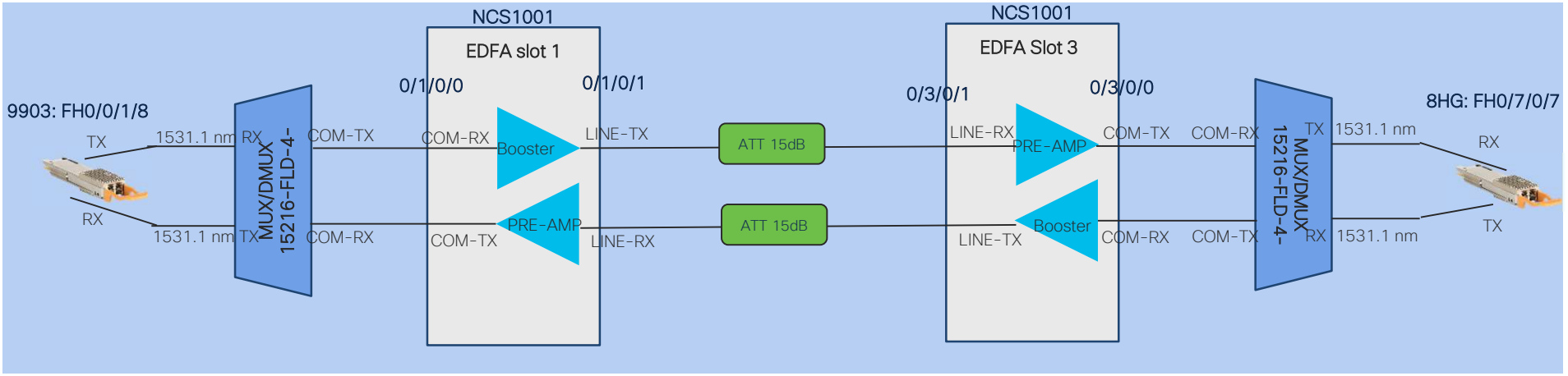
ZRP Demo Topology 1





ZRP Demo Topology 2





1x100G Mode

ASR 9000 Platform Setup

ASR 9903

```
RP/0/RP0/CPU0:9903#sho platform
Fri Oct 22 03:23:20.707 UTC
Node               Type                       State             Config state
--------------------------------------------------------------------------------
-
0/RP0/CPU0         A99-RP-F(Active)           IOS XR RUN        NSHUT
0/RP1/CPU0         A99-RP-F(Standby)          IOS XR RUN        NSHUT
0/FT0              ASR-9903-FAN               OPERATIONAL       NSHUT
0/FT1              ASR-9903-FAN               OPERATIONAL       NSHUT
0/FT2              ASR-9903-FAN               OPERATIONAL       NSHUT
0/FT3              ASR-9903-FAN               OPERATIONAL       NSHUT
0/0/CPU0           ASR-9903-LC                IOS XR RUN        NSHUT
0/0/1              A9903-20HG-PEC             OK
0/PT0              ASR-9900-AC-PEM            OPERATIONAL       NSHUT
RP/0/RP0/CPU0:9903#
```

```
RP/0/RP0/CPU0:9903#show controllers np ports all
Fri Oct 22 03:23:50.572 UTC

                Node: 0/0/CPU0:
----------------------------------------------------------------

NP Bridge Fia                      Ports
-- ------ --- -----------------------------------------------
0  --     0   HundredGigE0/0/0/0 - HundredGigE0/0/0/3
1  --     1   HundredGigE0/0/0/4 - HundredGigE0/0/0/7
2  --     2   HundredGigE0/0/0/8 - HundredGigE0/0/0/9, TenGigE0/0/0/26 -
TenGigE0/0/0/35, HundredGigE0/0/0/11
3  --     3   HundredGigE0/0/0/12 - HundredGigE0/0/0/13, TenGigE0/0/0/16 -
TenGigE0/0/0/25, HundredGigE0/0/0/15
4  --     4   HundredGigE0/0/1/0 - HundredGigE0/0/1/3
5  --     5   HundredGigE0/0/1/4 - HundredGigE0/0/1/7
6  --     6   HundredGigE0/0/1/8 - HundredGigE0/0/1/11
7  --     7   HundredGigE0/0/1/12 - HundredGigE0/0/1/15
8  --     8   HundredGigE0/0/1/16 - HundredGigE0/0/1/19
RP/0/RP0/CPU0:9903#
```

ASR 9910

```
RP/0/RSP0/CPU0:9910#sho platform
Fri Oct 22 03:22:48.036 UTC
Node               Type                       State             Config state
--------------------------------------------------------------------------------
----
0/RSP0/CPU0        A9K-RSP5-SE(Active)        IOS XR RUN        NSHUT
0/RSP1/CPU0        A9K-RSP5-SE(Standby)       IOS XR RUN        NSHUT
0/FT0              ASR-9910-FAN               OPERATIONAL       NSHUT
0/FT1              ASR-9910-FAN               OPERATIONAL       NSHUT
0/5/CPU0           A9K-MOD400-SE              IOS XR RUN        NSHUT
0/5/0              A9K-MPA-20X10GE            OK
0/5/1              A9K-MPA-32X1GE             OK
0/7/CPU0           A9K-8HG-FLEX-TR            IOS XR RUN        NSHUT
0/FC0              A99-SFC3-S                 OPERATIONAL       NSHUT
0/FC2              A99-SFC3-S                 OPERATIONAL       NSHUT
0/FC4              A99-SFC3-S                 OPERATIONAL       NSHUT
0/PT0              A9K-AC-PEM-V3              OPERATIONAL       NSHUT
RP/0/RSP0/CPU0:9910#
```

```
RP/0/RSP0/CPU0:9910#show controllers np ports all location 0/7/CPU0
Fri Oct 22 03:23:41.606 UTC

                Node: 0/7/CPU0:
----------------------------------------------------------------

NP Bridge Fia                      Ports
-- ------ --- -----------------------------------------------
0  --     0   HundredGigE0/7/0/0 - HundredGigE0/7/0/3
1  --     1   HundredGigE0/7/0/4 - HundredGigE0/7/0/7
RP/0/RSP0/CPU0:9910#
```

ASR 9000 Configuration

ASR 9903

```
RP/0/RP0/CPU0:9903#sho run | i breakout
Thu Oct 14 00:17:34.188 UTC
Building configuration...
RP/0/RP0/CPU0:9903#
```

```
RP/0/RP0/CPU0:9903#sho run int hundredGigE 0/0/1/8
Thu Oct 14 00:18:19.523 UTC
interface HundredGigE0/0/1/8
 cdp
!

RP/0/RP0/CPU0:9903#
```

```
RP/0/RP0/CPU0:9903#sho run controller optics 0/0/1/8
Thu Oct 14 00:19:02.091 UTC
controller Optics0/0/1/8
 dwdm-carrier 100MHz-grid frequency 1959000
!

RP/0/RP0/CPU0:9903#
```

```
RP/0/RP0/CPU0:9903#sho cdp neighbors HundredGigE 0/0/1/8
Thu Oct 14 00:19:33.765 UTC
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID       Local Intrfce    Holdtme Capability Platform  Port ID
9910            Hu0/0/1/8        164     R          ASR9K     Hu0/7/0/7
RP/0/RP0/CPU0:9903#
```

ASR 9910

```
RP/0/RSP0/CPU0:9910#sho run | i breakout
Thu Oct 14 00:19:13.488 UTC
Building configuration...
RP/0/RSP0/CPU0:9910#
```

```
RP/0/RSP0/CPU0:9910#sho run int HundredGigE 0/7/0/7
Thu Oct 14 00:19:48.914 UTC
interface HundredGigE0/7/0/7
 cdp
!

RP/0/RSP0/CPU0:9910#
```

```
RP/0/RSP0/CPU0:9910#sho run controller optics 0/7/0/7
Tue Oct 12 00:48:27.256 UTC
controller Optics0/7/0/7
 dwdm-carrier 100MHz-grid frequency 1959000
!

RP/0/RSP0/CPU0:9910#
```

```
RP/0/RSP0/CPU0:9910#sho cdp neighbors HundredGigE 0/7/0/7
Thu Oct 14 00:20:24.658 UTC
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID       Local Intrfce    Holdtme Capability Platform  Port ID
9903            Hu0/7/0/7        144     R          ASR9K     Hu0/0/1/8
RP/0/RSP0/CPU0:9910#
```

ASR 9000 Verification – Controllers Optics Output (1)

ASR 9903

```
RP/0/RP0/CPU0:9903#sho controllers optics 0/0/1/8
Thu Oct 14 00:08:26.854 UTC

 Controller State: Up

 Transport Admin State: In Service

 Laser State: On

 LED State: Green

 FEC State: FEC OFEC

 Optics Status

         Optics Type:  400G QSFP-DD ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=5, Frequency=195.90THz,
         Wavelength=1530.334nm

         Alarm Status:
         -------------
         Detected Alarms: None


         LOS/LOL/Fault Status:

         Laser Bias Current = 67.0 mA
         Actual TX Power = -7.05 dBm
         RX Power = -6.94 dBm
         RX Signal Power = -6.94 dBm
         Frequency Offset = -14 MHz
         Laser Temperature = 42.65 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25

         Performance Monitoring: Enable
```

ASR 9910

```
RP/0/RSP0/CPU0:9910#show controller opt 0/7/0/7
Thu Oct 14 00:12:17.489 UTC

 Controller State: Up

 Transport Admin State: In Service

 Laser State: On

 LED State: Green

 FEC State: FEC OFEC

 Optics Status

         Optics Type:  400G QSFP-DD ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=5, Frequency=195.90THz,
         Wavelength=1530.334nm

         Alarm Status:
         -------------
         Detected Alarms: None


         LOS/LOL/Fault Status:

         Laser Bias Current = 66.2 mA
         Actual TX Power = -7.05 dBm
         RX Power = -7.28 dBm
         RX Signal Power = -7.28 dBm
         Frequency Offset = 0 MHz
         Laser Temperature = 39.25 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25

         Performance Monitoring: Enable
```

ASR 9000 Verification – Controllers Optics Output (2)

ASR 9903

```
        THRESHOLD VALUES
        ----------------

        Parameter                High Alarm  Low Alarm  High Warning  Low Warning
        -----------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         1.9      -28.2           0.0        -23.0
        Tx Power Threshold(dBm)         0.0      -18.0          -2.0        -16.0
        LBC Threshold(mA)              0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)      80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)        3.46       3.13          3.43         3.16

        LBC High Threshold = 98 %
        Configured Tx Power = -7.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 180.00 ps
        Baud Rate =  30.0692729950 GBd
        Modulation Type: QPSK
        Chromatic Dispersion -6 ps/nm
        Configured CD-MIN -80000 ps/nm  CD-MAX 80000 ps/nm
        Second Order Polarization Mode Dispersion = 153.00 ps^2
        Optical Signal to Noise Ratio = 32.30 dB
        Polarization Dependent Loss = 0.06 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps

        Temperature = 41.00 Celsius
        Voltage = 3.27 V

 Transceiver Vendor Details

        Form Factor             : QSFP-DD
        Optics type             : QSFP-DD 400G-ZRP-S
        Name                    : CISCO-ACACIA
        OUI Number              : 7c.b2.5c
        Part Number             : DP04QSDD-E30-190
        Rev Number              : A
        Serial Number           : ACA252200CW
        PID                     : QDD-400G-ZRP-S
        VID                     : V01
        Firmware Version        : 61.20 (Build : 13)
        Date Code(yy/mm/dd)     : 21/06/06

RP/0/RP0/CPU0:9903#
```

ASR 9910

```
        THRESHOLD VALUES
        ----------------

        Parameter                High Alarm  Low Alarm  High Warning  Low Warning
        -----------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         1.9      -28.2           0.0        -23.0
        Tx Power Threshold(dBm)         0.0      -18.0          -2.0        -16.0
        LBC Threshold(mA)              0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)      80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)        3.46       3.13          3.43         3.16

        LBC High Threshold = 98 %
        Configured Tx Power = -7.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 180.00 ps
        Baud Rate =  30.0692729950 GBd
        Modulation Type: QPSK
        Chromatic Dispersion -3 ps/nm
        Configured CD-MIN -80000 ps/nm  CD-MAX 80000 ps/nm
        Second Order Polarization Mode Dispersion = 116.00 ps^2
        Optical Signal to Noise Ratio = 32.30 dB
        Polarization Dependent Loss = 0.12 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps

        Temperature = 33.00 Celsius
        Voltage = 3.32 V

 Transceiver Vendor Details

        Form Factor             : QSFP-DD
        Optics type             : QSFP-DD 400G-ZRP-S
        Name                    : CISCO-ACACIA
        OUI Number              : 7c.b2.5c
        Part Number             : DP04QSDD-E30-190
        Rev Number              : A
        Serial Number           : ACA252200D0
        PID                     : QDD-400G-ZRP-S
        VID                     : V01
        Firmware Version        : 61.20 (Build : 13)
        Date Code(yy/mm/dd)     : 21/06/06

RP/0/RSP0/CPU0:9910#
```

1x400G Mode

ASR 9000 Verification

ASR 9903

```
RP/0/RP0/CPU0:9903#sho run | i breakout
Tue Oct 12 00:56:18.125 UTC
Building configuration...
hw-module location 0/0/CPU0 bay 1 port 8 breakout 1xFourHundredGigE
RP/0/RP0/CPU0:9903#
```

```
RP/0/RP0/CPU0:9903#sho run int fourHundredGigE 0/0/1/8
Tue Oct 12 00:56:41.932 UTC
interface FourHundredGigE0/0/1/8
 cdp
!

RP/0/RP0/CPU0:9903#
```

```
RP/0/RP0/CPU0:9903#sho run controller optics 0/0/1/8
Tue Oct 12 01:15:57.031 UTC
controller Optics0/0/1/8
 dwdm-carrier 100MHz-grid frequency 1959000
!

RP/0/RP0/CPU0:9903#
```

```
RP/0/RP0/CPU0:9903#sho cdp neighbors fourHundredGigE 0/0/1/8
Tue Oct 12 00:53:37.269 UTC
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID       Local Intrfce    Holdtme Capability Platform  Port ID
9910            FH0/0/1/8        128     R          ASR9K     FH0/7/0/7
RP/0/RP0/CPU0:9903#
```

ASR 9910

```
RP/0/RSP0/CPU0:9910#sho run | i breakout
Tue Oct 12 00:55:30.136 UTC
Building configuration...
hw-module location 0/7/CPU0 port 7 breakout 1xFourHundredGigE
RP/0/RSP0/CPU0:9910#
```

```
RP/0/RSP0/CPU0:9910#sho run int fourHundredGigE 0/7/0/7
Tue Oct 12 00:56:15.378 UTC
interface FourHundredGigE0/7/0/7
 cdp
!

RP/0/RSP0/CPU0:9910#
```

```
RP/0/RSP0/CPU0:9910#sho run controller optics 0/7/0/7
Tue Oct 12 00:48:27.256 UTC
controller Optics0/7/0/7
 dwdm-carrier 100MHz-grid frequency 1959000
!

RP/0/RSP0/CPU0:9910#
```

```
RP/0/RSP0/CPU0:9910#sho cdp neighbors fourHundredGigE 0/7/0/7
Tue Oct 12 00:52:20.985 UTC
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID       Local Intrfce    Holdtme Capability Platform  Port ID
9903            FH0/7/0/7        135     R          ASR9K     FH0/0/1/8
RP/0/RSP0/CPU0:9910#
```

ASR 9000 Optics Controller Verification

ASR 9903

```
RP/0/RP0/CPU0:9903#sho controllers optics 0/0/1/8
Tue Oct 12 00:58:48.444 UTC

 Controller State: Up

 Transport Admin State: In Service

 Laser State: On

 LED State: Green

 FEC State: FEC OFEC

 Optics Status

         Optics Type:  400G QSFP-DD ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=5, Frequency=195.90THz,
         Wavelength=1530.334nm

         Alarm Status:
         -------------
         Detected Alarms: None


         LOS/LOL/Fault Status:

         Laser Bias Current = 67.0 mA
         Actual TX Power = -8.46 dBm
         RX Power = -14.37 dBm
         RX Signal Power = -14.36 dBm
         Frequency Offset = 5 MHz
         Laser Temperature = 44.87 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25

         Performance Monitoring: Enable

        <……>
```

ASR 9910

```
RP/0/RSP0/CPU0:9910#sho controllers optics 0/7/0/7
Tue Oct 12 00:56:27.576 UTC

 Controller State: Up

 Transport Admin State: In Service

 Laser State: On

 LED State: Green

 FEC State: FEC OFEC

 Optics Status

         Optics Type:  400G QSFP-DD ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=5, Frequency=195.90THz,
         Wavelength=1530.334nm

         Alarm Status:
         -------------
         Detected Alarms: None


         LOS/LOL/Fault Status:

         Laser Bias Current = 66.0 mA
         Actual TX Power = -9.19 dBm
         RX Power = -14.69 dBm
         RX Signal Power = -14.67 dBm
         Frequency Offset = -17 MHz
         Laser Temperature = 42.48 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25

         Performance Monitoring: Enable
<…>
```

ASR 9903

```
<...>
        THRESHOLD VALUES
        ----------------

        Parameter                High Alarm  Low Alarm  High Warning  Low Warning
        -----------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         1.9      -28.2           0.0        -23.0
        Tx Power Threshold(dBm)         0.0      -18.0          -2.0        -16.0
        LBC Threshold(mA)              0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)      80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)        3.46       3.13          3.43         3.16

        LBC High Threshold = 98 %
        Configured Tx Power = -7.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 180.00 ps
        Baud Rate =  60.1385459900 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 9 ps/nm
        Configured CD-MIN -26000 ps/nm  CD-MAX 26000 ps/nm
        Second Order Polarization Mode Dispersion = 42.00 ps^2
        Optical Signal to Noise Ratio = 21.50 dB
        Polarization Dependent Loss = 0.08 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 4.00 ps

        Temperature = 49.00 Celsius
        Voltage = 3.25 V

 Transceiver Vendor Details

        Form Factor            : QSFP-DD
        Optics type            : QSFP-DD 400G-ZRP-S
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E30-190
        Rev Number             : A
        Serial Number          : ACA252200CW
        PID                    : QDD-400G-ZRP-S
        VID                    : V01
        Firmware Version       : 61.20 (Build : 13)
        Date Code(yy/mm/dd)    : 21/06/06

RP/0/RP0/CPU0:9903#
```

ASR 9910

```
<...>
        THRESHOLD VALUES
        ----------------

        Parameter                High Alarm  Low Alarm  High Warning  Low Warning
        -----------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         1.9      -28.2           0.0        -23.0
        Tx Power Threshold(dBm)         0.0      -18.0          -2.0        -16.0
        LBC Threshold(mA)              0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)      80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)        3.46       3.13          3.43         3.16

        LBC High Threshold = 98 %
        Configured Tx Power = -7.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 180.00 ps
        Baud Rate =  60.1385459900 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion -9 ps/nm
        Configured CD-MIN -26000 ps/nm  CD-MAX 26000 ps/nm
        Second Order Polarization Mode Dispersion = 43.00 ps^2
        Optical Signal to Noise Ratio = 31.70 dB
        Polarization Dependent Loss = 0.16 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 1.00 ps

        Temperature = 41.00 Celsius
        Voltage = 3.31 V

 Transceiver Vendor Details

        Form Factor            : QSFP-DD
        Optics type            : QSFP-DD 400G-ZRP-S
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E30-190
        Rev Number             : A
        Serial Number          : ACA252200D0
        PID                    : QDD-400G-ZRP-S
        VID                    : V01
        Firmware Version       : 61.20 (Build : 13)
        Date Code(yy/mm/dd)    : 21/06/06

RP/0/RSP0/CPU0:9910#
```

NCS1001 Amplifiers Configuration

```
controller Ots0/1/0/0 <<<< Slot 1, PRE-AMP
rx-low-threshold -400
ampli-gain 125
ampli-control-mode manual
safety-control-mode disabled
!
controller Ots0/1/0/1 <<<< Slot 1, BOOSTER
rx-low-threshold -400
ampli-gain 110
ampli-control-mode manual
safety-control-mode disabled
!
!
!
controller Ots0/3/0/0 <<<< Slot 3, PRE-AMP
rx-low-threshold -400
ampli-gain 125
ampli-control-mode manual
safety-control-mode disabled
!
controller Ots0/3/0/1 <<<< Slot 3, BOOSTER
rx-low-threshold -400
ampli-gain 110
ampli-control-mode manual
safety-control-mode disabled
```

NCS1001 Verification

```
RP/0/RP0/CPU0:ncs1001#show hw-module slot 1 ampli-trail-view all
Thu Oct 21 02:05:29.456 UTC

  Ampli Trail View - BST and PRE Amplifiers
=======================================================
Port: 0/COM     Booster Rx Power     Port: 1/LINE        PRE-AMP Rx Power
--------------                       --------------
         Rx Power = -10.70 dBm                Rx Power = -16.30 dBm
   Rx Total Power = -10.70 dBm          Rx Total Power = -16.30 dBm
 Rx Low Threshold = -40.0 dBm         Rx Low Threshold = -40.0 dBm

Port: 1/LINE                         Port: 0/COM
--------------  Booster Tx Power     --------------      PRE-AMP Tx Power
         Tx Power = 9.30 dBm                  Tx Power = -11.30 dBm
   Tx Total Power = 9.40 dBm            Tx Total Power = -8.30 dBm
 Tx Low Threshold = -20.0 dBm         Tx Low Threshold = -20.0 dBm

         Bst Gain = 20.00 dB                  Pre Gain = 5.00 dB
         Bst Tilt = 0.00                      Pre Tilt = 0.00
Bst Channel Power = 0.00 dBm         Pre Channel Power = 0.00 dBm
 Bst Control Mode = Manual            Pre Control Mode = Manual
  Bst Safety Mode = ALS Disabled       Pre Safety Mode = ALS Disabled
         Bst Osri = Off                       Pre Osri = Off
   Bst Gain Range = Normal              Pre Gain Range = Normal

RP/0/RP0/CPU0:ncs1001#
```

```
RP/0/RP0/CPU0:ncs1001#show hw-module slot 3 ampli-trail-view all
Thu Oct 21 02:07:51.024 UTC

  Ampli Trail View - BST and PRE Amplifiers
=======================================================
Port: 0/COM     Booster Rx Power     Port: 1/LINE        PRE-AMP Rx Power
--------------                       --------------
         Rx Power = -10.80 dBm                Rx Power = -16.70 dBm
   Rx Total Power = -10.80 dBm          Rx Total Power = -16.60 dBm
 Rx Low Threshold = -40.0 dBm         Rx Low Threshold = -40.0 dBm

Port: 1/LINE    Booster Tx Power     Port: 0/COM         PRE-AMP Tx Power
--------------                       --------------
         Tx Power = 9.20 dBm                  Tx Power = -11.80 dBm
   Tx Total Power = 9.30 dBm            Tx Total Power = -8.80 dBm
 Tx Low Threshold = -20.0 dBm         Tx Low Threshold = -20.0 dBm

         Bst Gain = 20.00 dB                  Pre Gain = 5.00 dB
         Bst Tilt = 0.00                      Pre Tilt = 0.00
Bst Channel Power = 0.00 dBm         Pre Channel Power = 0.00 dBm
 Bst Control Mode = Manual            Pre Control Mode = Manual
  Bst Safety Mode = ALS Disabled       Pre Safety Mode = ALS Disabled
         Bst Osri = Off                       Pre Osri = Off
   Bst Gain Range = Normal              Pre Gain Range = Normal

RP/0/RP0/CPU0:ncs1001#
```

The bridge to possible