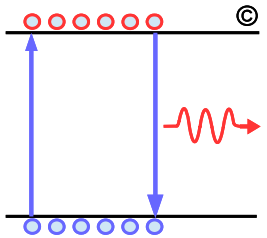

Evolution of 200G PMDs and AUIs with Concatenated FEC

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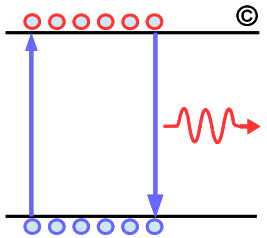
802.3df Task Force Meeting

Montreal

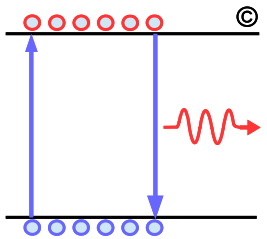
July 12, 2022

Overview



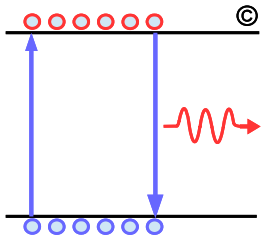
- Different classes of AUI
- Evolution from 100G AUI to 200G AUI
- Scaling BS FEC architecture to DF
- 1st Gen host with 1st Gen PMDs
- 1st Gen host with 2nd Gen PMDs
- 2nd Gen host with 2nd Gen PMDs
- Summary.

How to Define 200G/lane Optical PMDs Prior to 200G/lane AUIs

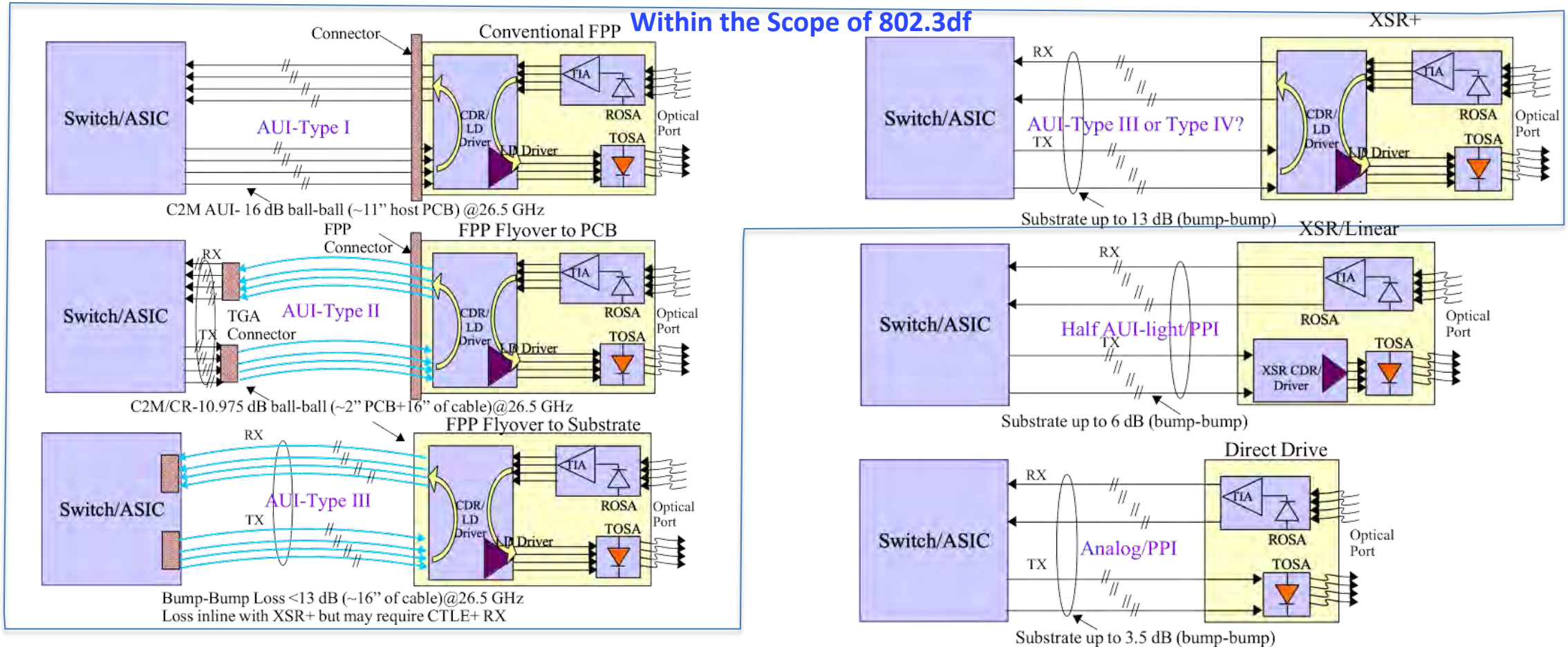


- **Early data indicate potential feasibility even conventional 200G-AUI to operate at pre FEC BER of 1E-5**
  - Nonconventional AUI with Flyover Cu and co-packaged expect to operate at 1E-5 BER with simpler equalizer
  - Nonconventional AUIs expect to operate on the electrical segments at 1E-5 pre-FEC BER with end-end RS (514,544) FEC for both 100G and 200G optical PMDs
  - 200G optical PMDs with SFEC in the module based on interleaver will have 1.35-2.95 dB of additional NCG, see bliss_3df_01a_220517
  - Conventional 200G-AUI due to high loss and ILD may benefit operating at 1E-4
- **Based on early data on 200G-AUI and 200G-CR with addition of SFEC with high confidence we can follow 802.3bs architecture that operated with an end-end FEC and by allocating 0.1-0.2 dBo to electrical sub-links**
  - There are potentially 3-4 types of AUIs some expect to operate with end-end FEC with 0.1-0.2 dBo allocation to the electrical sublinks
  - With emergence of optics/Cu co-packaging there are more implementation options than traditional AUIs
  - Some of the optics co-packaging may use low speed parallel buses, PPIs, or even PMD interfaces
  - It is plausible that future 200G system may not have any conventional PCB based AUIs
- **Conventional 200G AUI expect to be have substantially higher loss, ILD, and reflections**
  - 802.3df should not tax everyone for implementation that may not get used broadly
  - Segmented FEC based on termination of KP4 FEC in the module is an option that may be required
- **SFEC+KP4 provides seamless migration from Gen 1 host (100G-AUI) with Gen 1 optics (100G/lane), to Gen 1 host (100G-AUI) with Gen 2 optics (200G/lane), to Gen2 host (200G-AUI) with Gen 2 optics (200G/lane).**

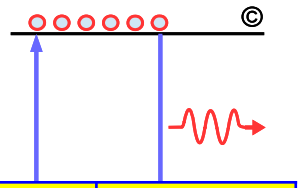
AUI and PPI Interfaces



- **XSR/Direct drive generally require optics engine to be bumped and the interface is an engineered analog drive – not an AUI interface**
  - With in the scope of 802.3df we have potentially up to 4 AUI classes and as few as 2 classes!



Potential Evolution of AUI from 100G to 200G



- **Conventional C2M (AUI Type-I)**
  - Min required PCB assumed 10” drives the loss budget at 200G
  - Likely need to increase loss from 16 dB to 21 dB
  - Likely require terminated FEC
- **CR/C2M (Subset of AUI-I/II/III)**
  - Max CR loss of 10.975 dB TP0-TP2 drives the loss budget for dual use port
  - Type II can be an implementation of Type I or Type III
  - Conventional PCB not practical but 5.975 dB loss will support 300 mm Flyover cable
  - Operate with end-end FEC
- **NPO/CR with Flyover cable (AUI-III)**
  - 75 mm NPO substrate + 300 mm cable drives the loss of 11 dB
  - Budget is nearly identical to CR/C2M and can be merged with CR/C2M
  - Operate with end-end FEC
- **NPO (AUI Type-IV)**
  - Min 75 mm/ 3” drives the loss for 200G NPO
  - Operates with end-end FEC.

Can be Merged

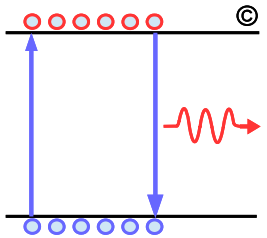
53 GBd (26.55 GHz) AUIs	C2M	CR/C2M	NPO
TP0-TP1a Loss (dB)*	**16**	**10.975**	~7
PCB/Substrate Loss (dB)	11.9	6.875	~7*
Bump-TP1a Loss (dB)	20	14.975	~11**
Bump-Bump Loss (dB)	~22	~16.975**	**13**
Loss Adv PCB(C2M) or HDI(NPO) dB/in	~1.1	~1.1	~1.8
PCB/HDI Length Supported (in)	~10.8	~6.25	~3.8

*Assume 1st level package loss 4 dB. ** PMA package loss assumed 2 dB.

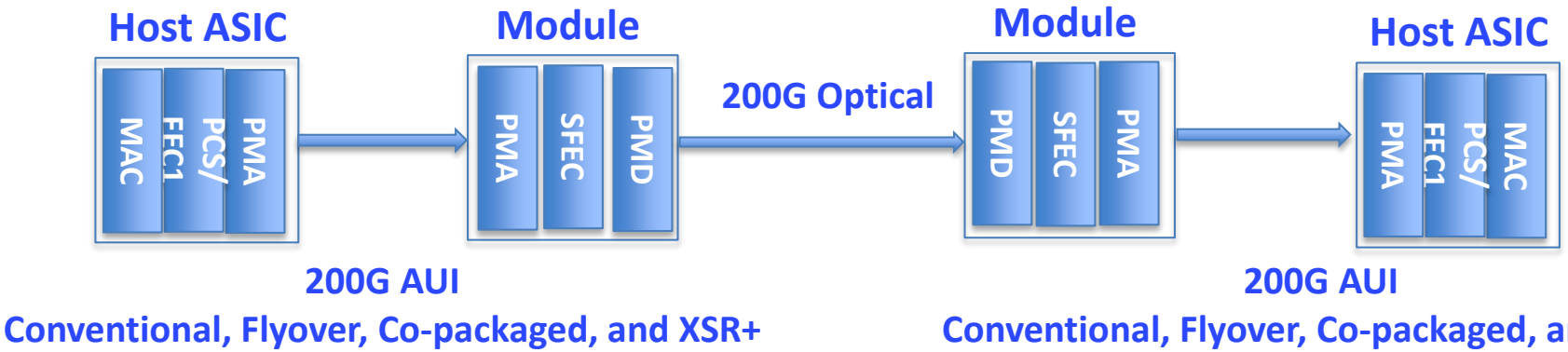
~110 GBd (55 GHz) AUIs	C2M	CR/C2M	NPO	NPO/CR
TP0-TP1a Loss (dB)*	**21**	**10.975**	~6.75	16
PCB/Substrate Loss (dB)	16	5.975	~6.75*	**11.0**
Bump-TP1a Loss (dB)	26	15.975	~11.75**	16
Bump-Bump Loss (dB)	~28.5	~18.475**	**14.25**	**18.5**
Loss Adv PCB/HDI/Cable (dB/in)	~1.6	~1.6	~2.25	~0.45
PCB/HDI Length Supported (in)	~10 (PCB)	~3.7 (PCB)	~3 (HDI)	~12 (cable)

*Assume 1st level package loss 5.0 dB. ** PMA package loss assumed 2.5 dB.
Package assumption here are very aggressive and require improved material and wider traces.

802.3bs FEC Architecture Can be the Template for 802.3df

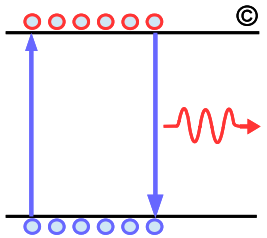


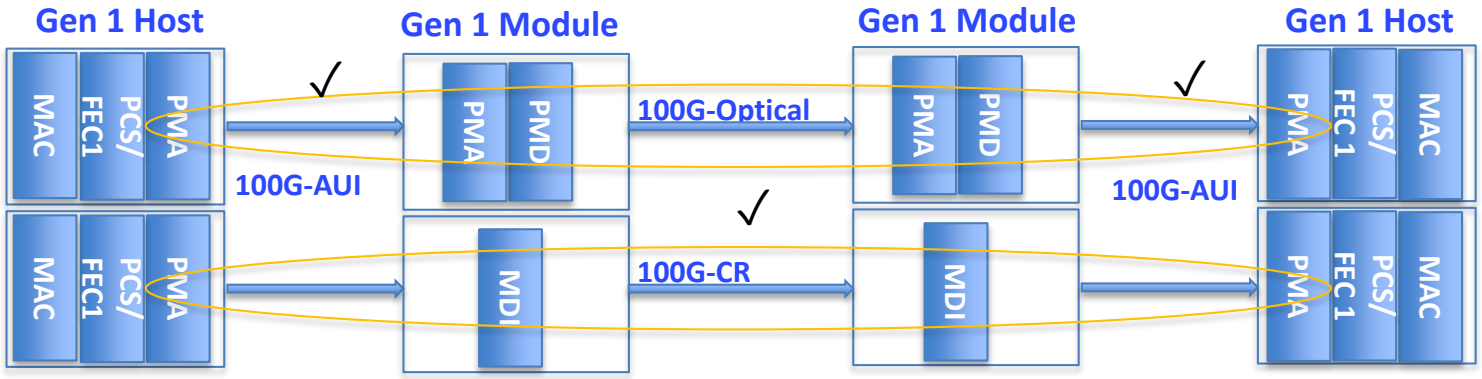
- **802.3df task force need to define a new 200G/lane optics FEC with 0.1-0.2 dBo reserved for PMA/PMD/PPI sub-links as shown below**
  - SFEC+RS(514,544) allow seamless upgrade of 100G-AUIs to 200G/lane optics without rate increase on the 802.3ck interfaces
  - It is also expected the end-end SFEC+RS(514,544) to support a range of AUIs plus optical PMDs
  - Conventional AUI based 10” host PCB loss will be 16* dB (~1.6 dB/in) may require FEC termination
    - Expect to push 100G-AUI bump-bump loss to 28.5 dB!

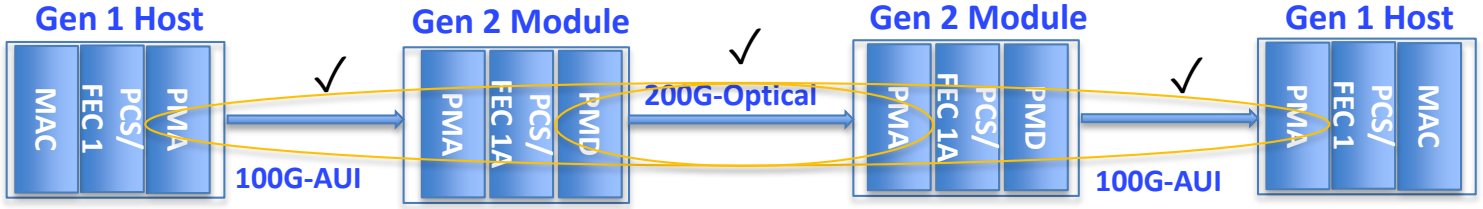


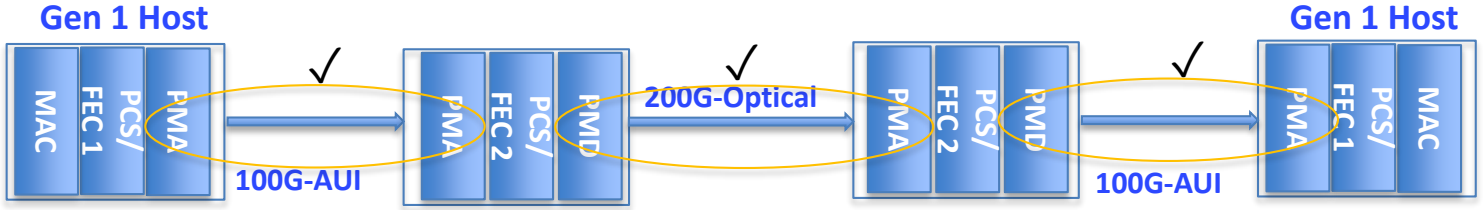
* Assumes 6.5 mils wide striplines with DK=3.0, DF=0.0015, 1 μm finish.

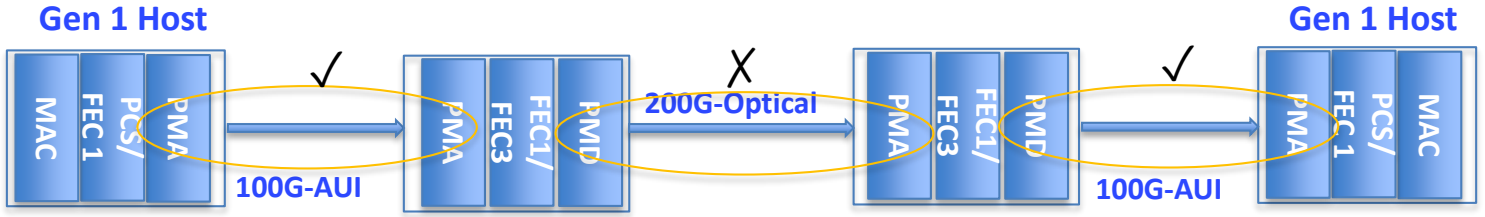
1st Generation 800 GbE Systems Based on 100G AUI











I. **1st 800 GbE deployment will be based on 100G/lane and end-end RS (514,544) FEC "KP4"**

- 1st 800 GbE optical deployment
- 1st CR/KR deployment

II. **2nd Gen 800 GbE will be based on 200G/lane optical PMDs and end-end RS (514,544) FEC**

- These PMDs will plug into the Gen 1 host
- Concatenated RS(514,544)+ SFEC (soft decision) on top of FEC1 is the only compatible option
- SFEC can have 1.61-2.7 dB additional NCG

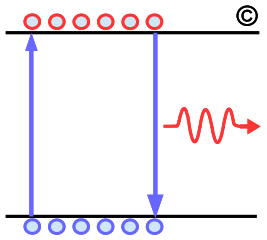
III. **1st Gen 800 GbE coherent based on segmented FEC**

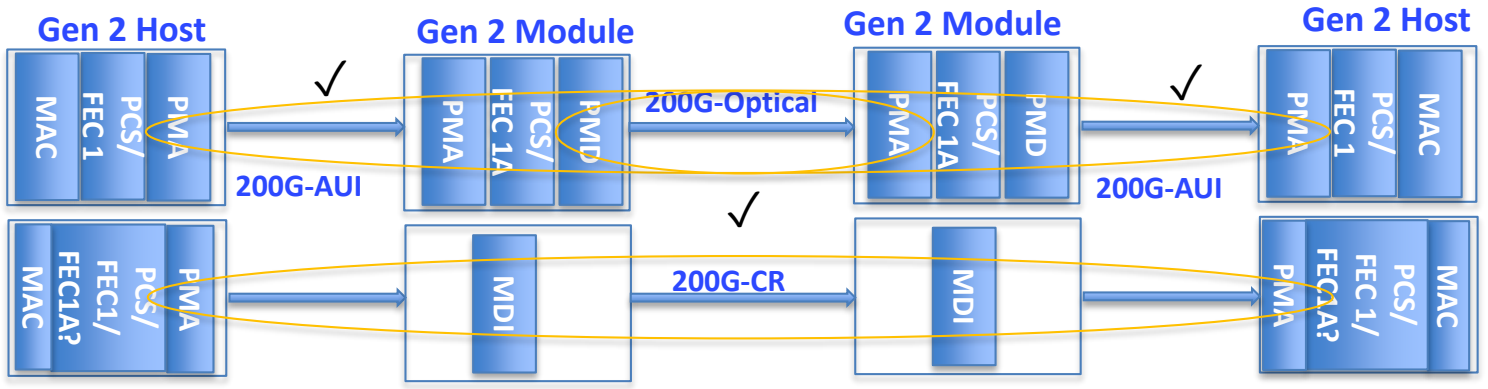
- Example of FEC2 are CFEC, SFEC+, etc.

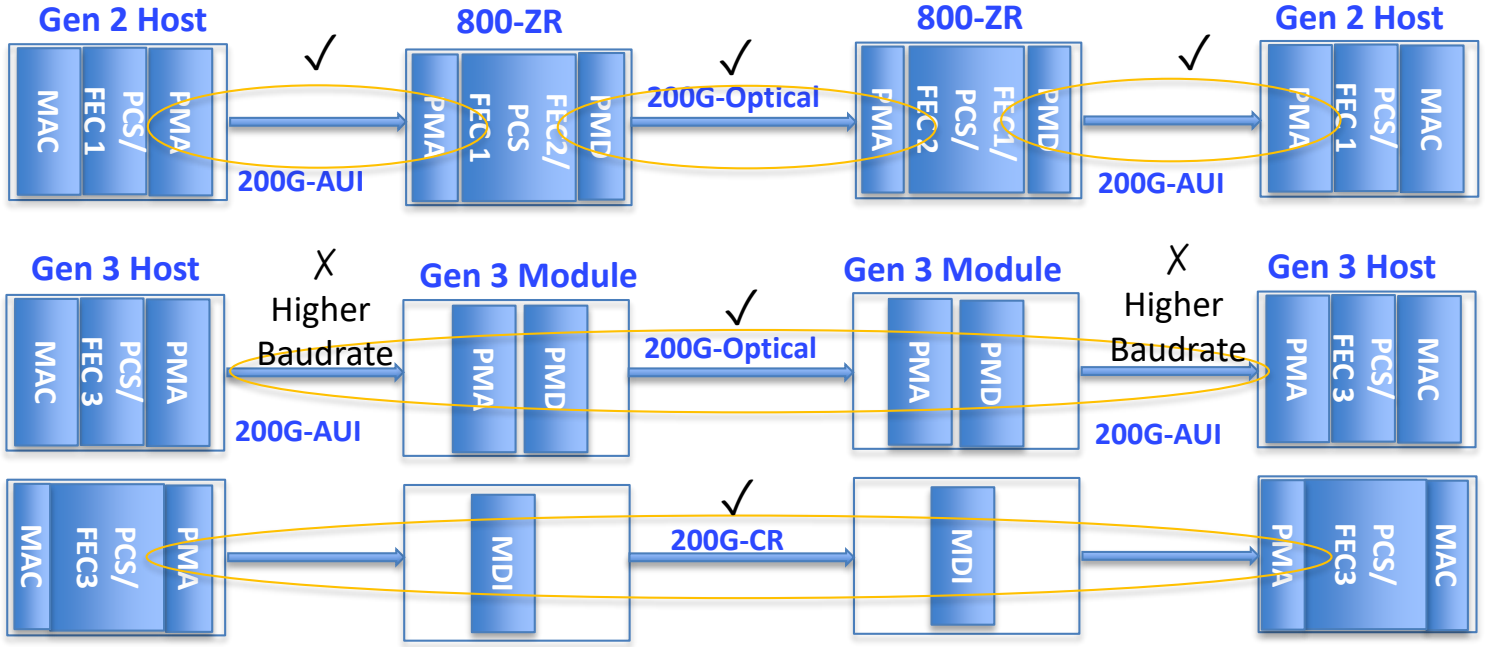
IV. **2nd Gen 800 GbE PMDs (200G/lane) based on new strong FEC3 must plug into systems with RS (514, 544) FEC**

- Example of FEC3 is RS (514, 576) FEC
- Require termination of (514, 544) in modules!

2nd Generation 800 GbE Systems Based on 200G AUI







I. 2nd Generation 800 GbE system based on 200G I/O with end-end RS (514,544) FEC offer seamless upgrade path

- Optical PMDs based on 200G/lane replace 100G-AUI with 200G–AUI
- CR PMDs based on 200G/lane may operate with just FEC1 or optionally for greater reach may utilize FEC1A

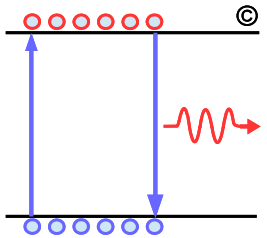
II. 2nd Gen 800 GbE system with coherent

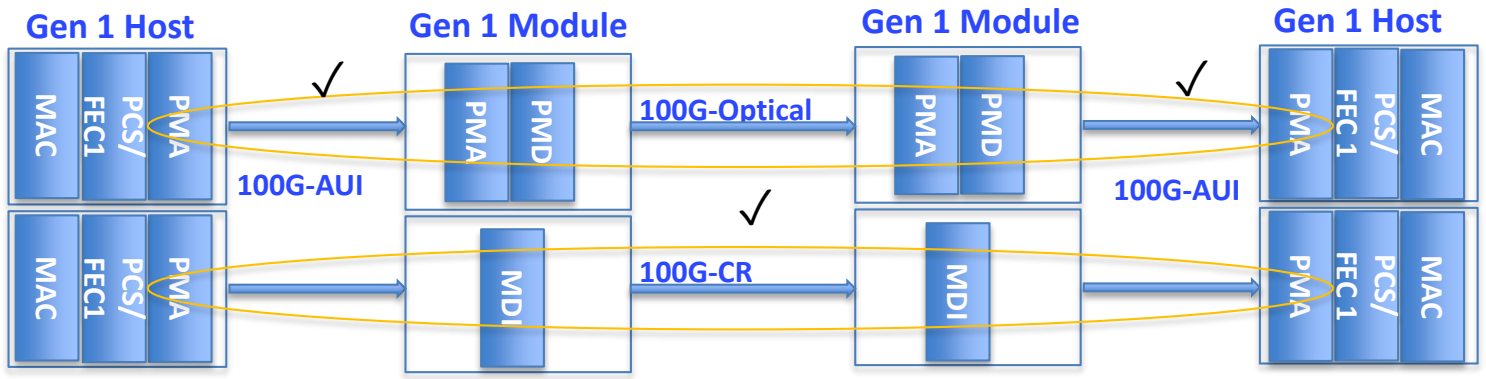
- Segmented RS(514,544)+CFEC, SFEC+, etc.
- Replace 100G-AUI with 200G-AUI

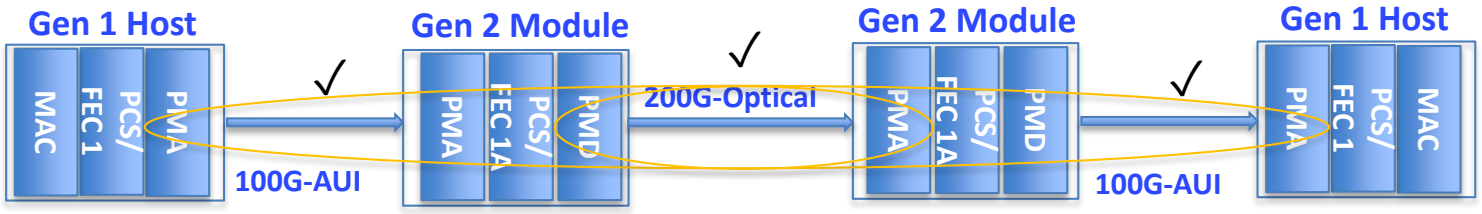
III. 2nd Gen 800 GbE will be based on 200G/lane optical PMDs and end-end RS (514,576) FEC3

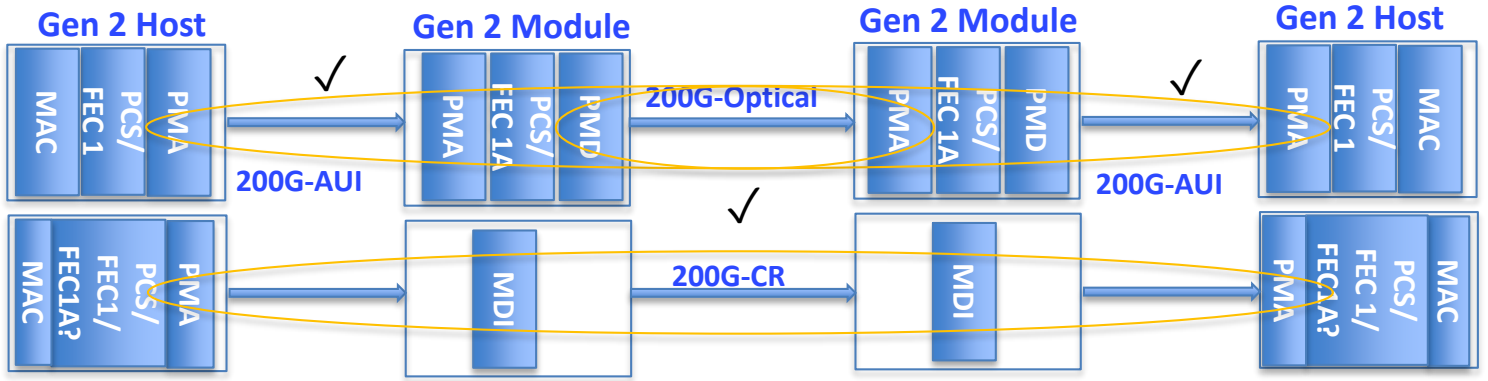
- To realize the benefits require forklift upgrade to Gen3 host and Optics
- Forces 200G-AUI and 200G-CR to higher Baudrate!

1st and 2nd Gen 800 GbE Evolution with Concatenated SFEC









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- These PMDs will plug into the Gen 1 host
- Concatenated RS(514,544)+ SFEC (soft decision) on top of FEC1 is backward compatible
- SFEC NCG 1.61-2.9 dB

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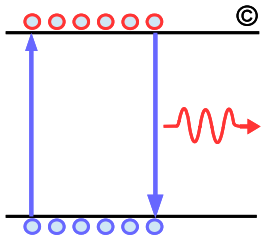
Summary



- **Adopting CL119 style PCS with RS (514, 544) FEC "KP4" shrikhande_3df_01_220517 for 800 GbE based on 32 VLs allow 800 GbE eco-system proceed to deployment based on 100G PMDs and 100G-AUI**
  - Need to get to D2.0 given that products are already in development
- **Concatenated SFEC bliss_3df_01a_220517 and patra_3df_01_220518 provides 2+ dB of NCG on top of RS(514,544) FEC assuming at least 4-way interleaving**
  - The combination of RS(514,544) FEC with concatenated SFEC provide seamless migration from 100G-AUI systems to 200G-AUI systems
  - Stronger RS FEC such as (514,576) doesn't provide seamless migration
- **Based on initial analysis need to define 3 classes of 200G AUIs**
  - Conventional C2M TP0-TP1a loss increases from 16 to 21 dB – likely will operate with terminated FEC
  - C2M/CR or NPO/CR with Flyover cable the TP0-TP1a loss remain at 11 dB to support optics and CR – operates with end-end FEC
  - NPO bump-bump loss will increase from 13 dB to ~18.5 dB supports optics/active Cu – operates with end-end FEC
- **RS(514, 544) in conjunction with concatenated SFEC not only provide seamless migration but also offer more flexible overall solution for 200G-CR and 200G-AUI than new end-end FEC such as RS(514,576)!**