Revision Suggestion for plan A

Joint

presented by

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Background

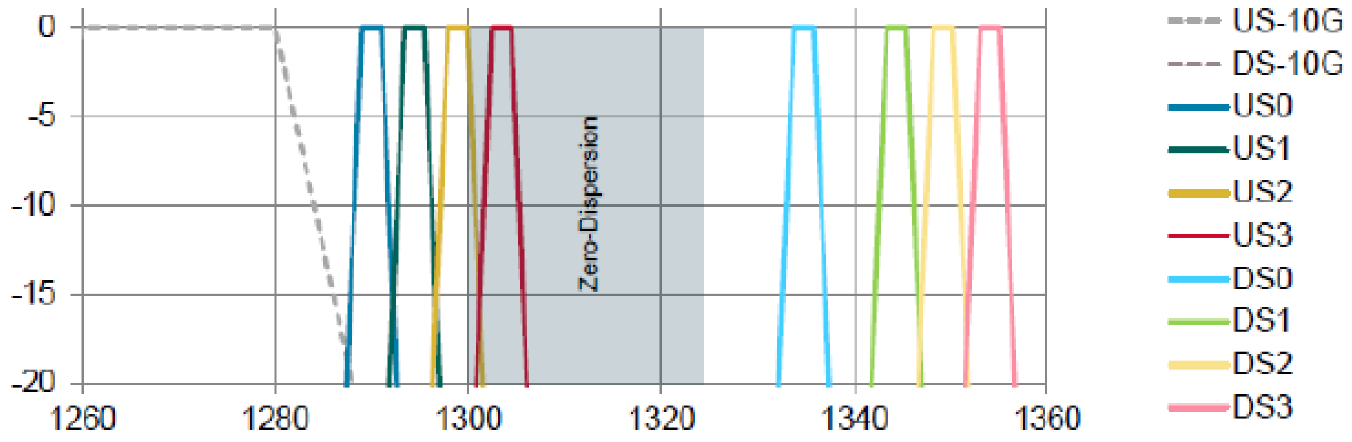
- In the Sept meeting, group agreed to focus on plans A,B,C &D as outlined in harstead_3ca_4b_0916.pdf

- Given the comparison slides (P7-P11) shown in the harstead_3ca_4b_0916.pdf and the result of straw poll (#1) in the Sept meeting, some observations are given below:
    1. No perfect plan which can meet all requirements such as 1+3, both 25G and 100G
    2. Among A/B/C/D plans, plan A seems have more support which may be because of better trade off among all requirements and constrains
    3. When using Plan A to implement 25G, some shortcomings were found (given slide 7 in the harstead_3ca_4b_0916.pdf)

- The intention of the contribution is trying to study plan A, and propose a revised wavelength plan (A2 referred hereafter, based on plan A) to mitigate those identified shortcomings

Some issues for plan A

Plan A
[johnson_3ca_1_0916.pdf]

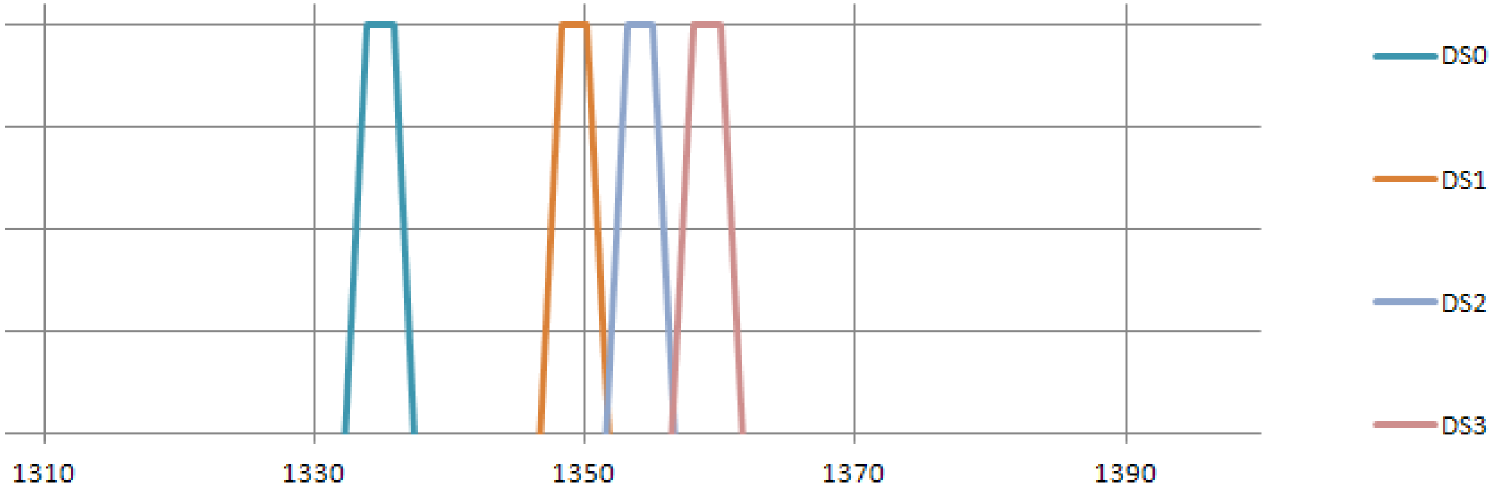


- DS1-DS0 Gap =7.6nm, which is < 10nm (focus beam requirement)
- Guardband between 10G US (1260nm-1280nm) is 9nm, which may not be safe enough
- FWM to be confirmed (upper bound of US2 is 1299.927, which is too close to lower bound of the ZD zone 1300nm)
- 2nm width of each US, which is very tight

Suggestion for DS wavelength plan

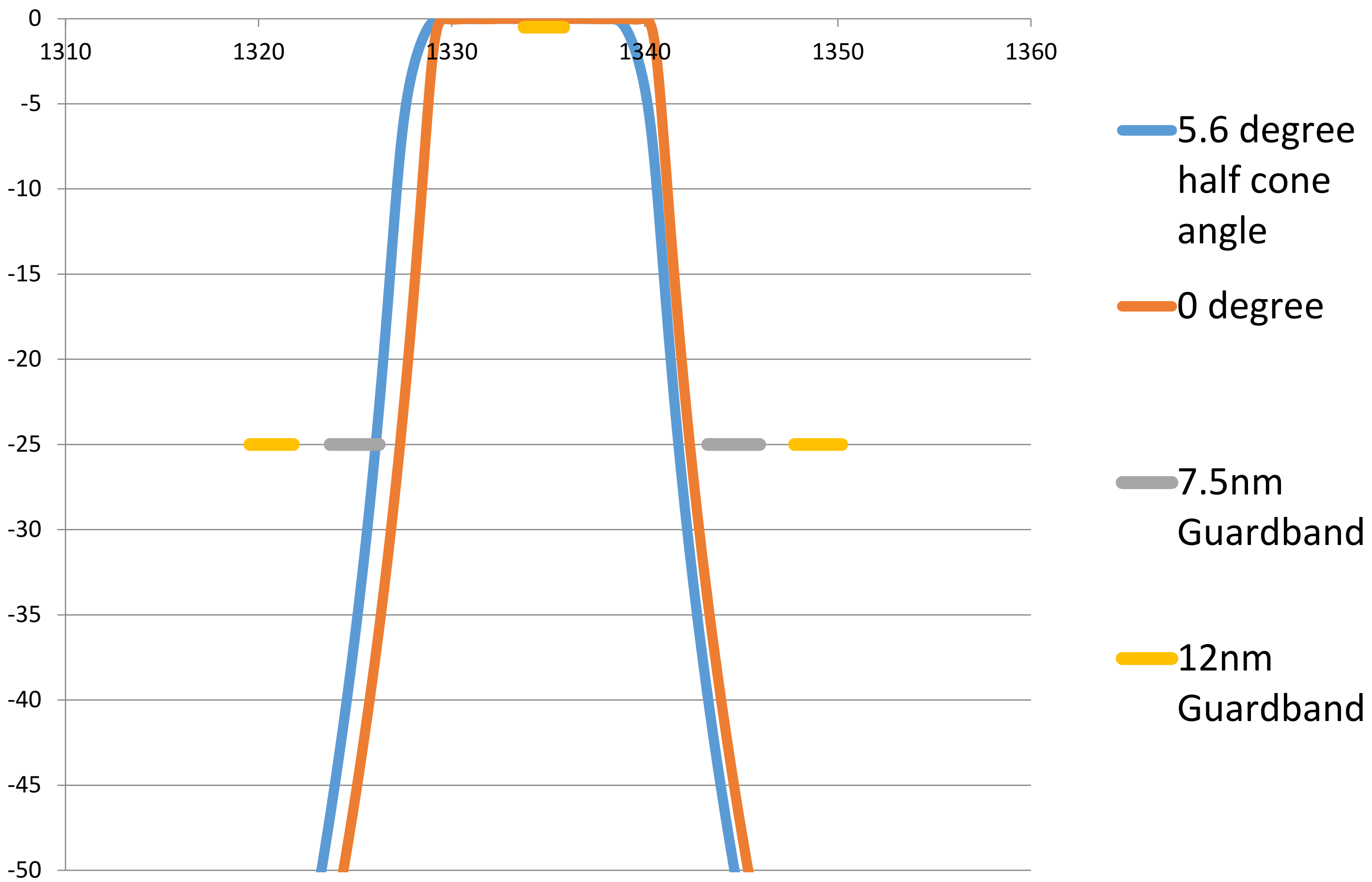
- Pass band for downstream wavelength is 2nm now
- **Gap between DS0 and DS1 can be enlarged from 1.6THz to 2.4THz**
- Channel spacing for DS1 to DS3 is 800G Hz
- >10 nm Guard band for 25G ONU WBF
- Low cost BOSA is still available for 25G ONU

	Center freq	Center WL
DS0	224.600	1334.784
DS1	222.200	1349.201
DS2	221.400	1354.076
DS3	220.600	1358.987

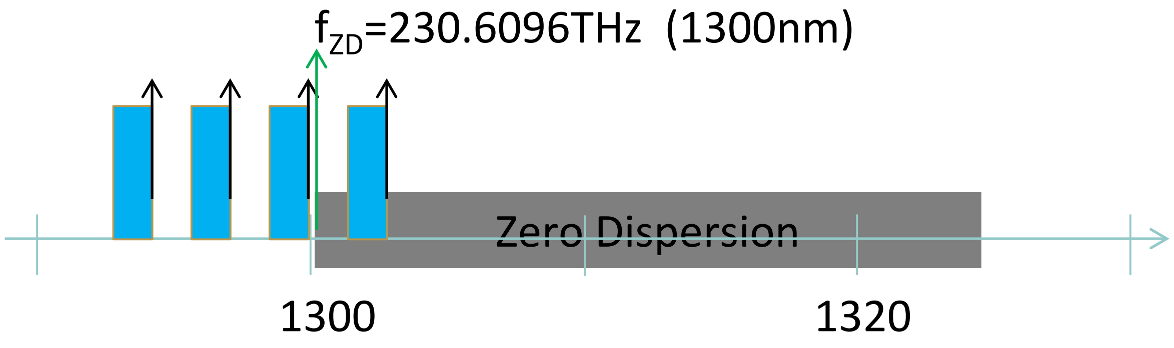


Wavelength blocking filter for 25G ONU

- WBF with 7.5nm guard band is technical feasible, but leads to very tight margin in volume production
- When guard band is enlarged to 12nm (gap between D0 and D1 is 2.4THz), better margin in volume production is possible



FWM analysis for plan A in worst case

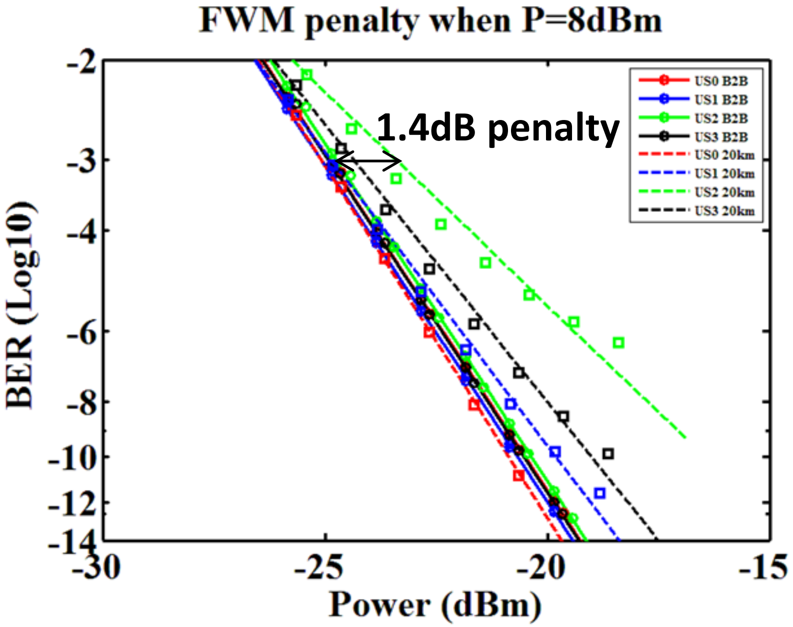


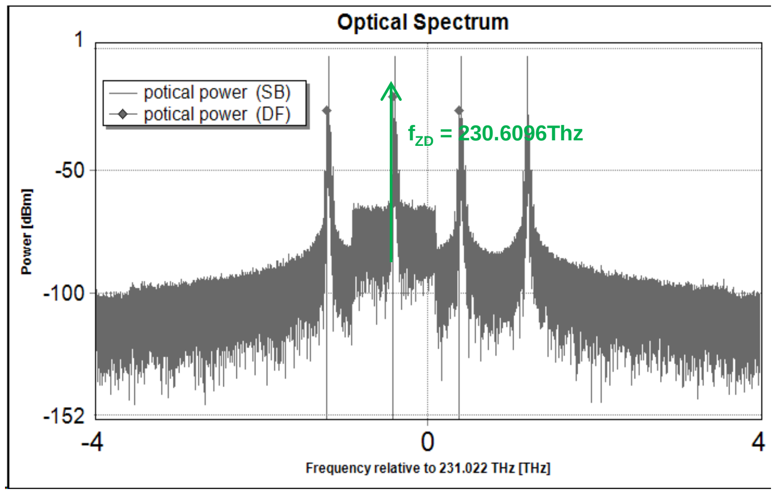
f_0=232.222, f_1= 231.422, f_2=230.622, f_3 = 229.822 THz

	No.	f(THz)	λ(nm)
25G UP	US0	232.4	1289.98 +/-1
100G UP	US1	231.6	1294.44 +/-1
	US2	230.8	1298.93 +/-1
	US3	230	1303.45 +/-1

Due to in worst case, f2 is only 12GHz(0.07nm) away from the zero dispersion zone, so some extent FWM penalty may still happen, especially in US2 channel (1.4dB@1E-3).

The probability and the conditions of the worst case should be considered in decision of final wavelength plan.





Viewpoints feedback from optical vendors (1)

- Cooled DML technique benefits to all yield of wavelength width, launch power, TDP and mitigates filter pressure, so that total cost of cooled DML transmitter might be cheaper than uncooled DML transmitter under the same tight SPECs

- **-1/+0nm extension width might be considered on each US channel**
  - Burst mode transmitters are used in 25G/100G EPON ONUs. In Burst OFF period, both modulation and bias currents of DML have to be shut down， this will result in some wavelength drifting. There are also some spectrum expansion after modulation.
  - So if possible, each channel width (US0~US3) is suggested to be relaxed to wider values, such as :at least +1nm/-2nm
  - If channel spacing is kept constant, it is a trade-off that between channel width and TFF Mux cost. One feedback shows that: the latter TFF Mux cost will be 50% higher than the first one:

Assumptions:

① 0.5dB bandwidth 2nm, 20dB bandwidth 7nm, incident angle 0 degree, ripple within bandwidth <0.25dB

② 0.5dB bandwidth 6nm, 20dB bandwidth 8nm, incident angle 0 degree, ripple within bandwidth <0.25dB

Viewpoints feedback from optical vendors (2)

- **Wavelength accuracy tolerance impact on cost of laser chip**
  - The central wavelength accuracy tolerance has distinct impact on the cost of optical laser
  - Generally, the central wavelength of optical laser distributes in +/- 3nm , the cost impact on narrower wavelength tolerance are evaluated as the following based on statistics data:

Central Wavelength Tolerance	±3nm	± 2nm	± 1.5nm	± 1nm	± 0.5nm
1st vendor's view	X	1.2X	1.6X	2.3X	3.5X
2nd vendor's view	Y	1.4Y	--	2.1Y	--

Note: the spectrum extension , such as by modulation, burst mode wavelength drifting , hasn't been taken account in here.

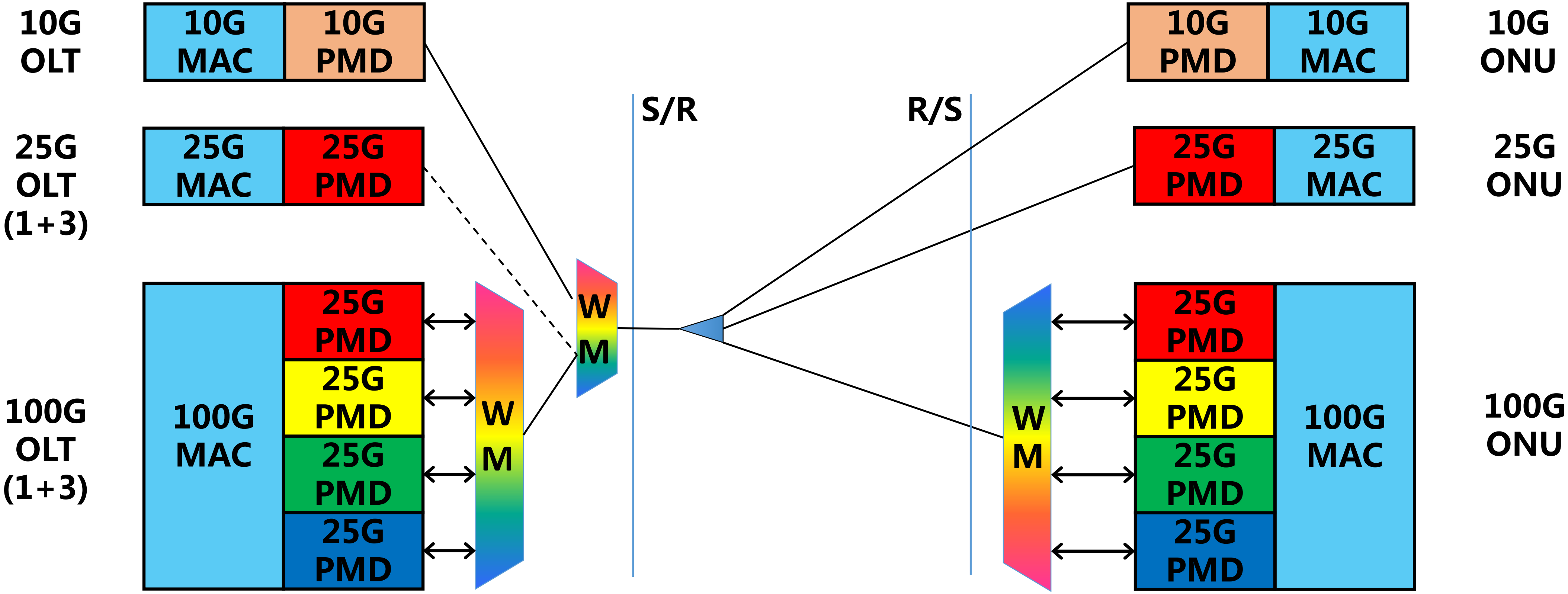
  - Given the burst mode in ONU laser, wavelength control difficulty increased. When sharing TEC for 100G ONU, relaxing channel bandwidth is very helpful for better yield

PR30 Power budget analysis

- **Disclaimer**
  - The power budget analysis is used to better understand the proposed wavelength plan and presented as a strawman for further discussion

- **Assumptions**
  - The power budget analysis is based on wavelength plan A in 'johnson_3ca_1a_0916.pdf'
  - Receiver sensitivity is based on 25G APD ROSA presented in previous meetings, accounting with manufacturing margins and some filter losses
  - WDM losses for 100G and 10G-EPON coexistence are not included in ODN loss
  - Impact on ER difference and SOA performance need further analysis

S/R and R/S Reference Point



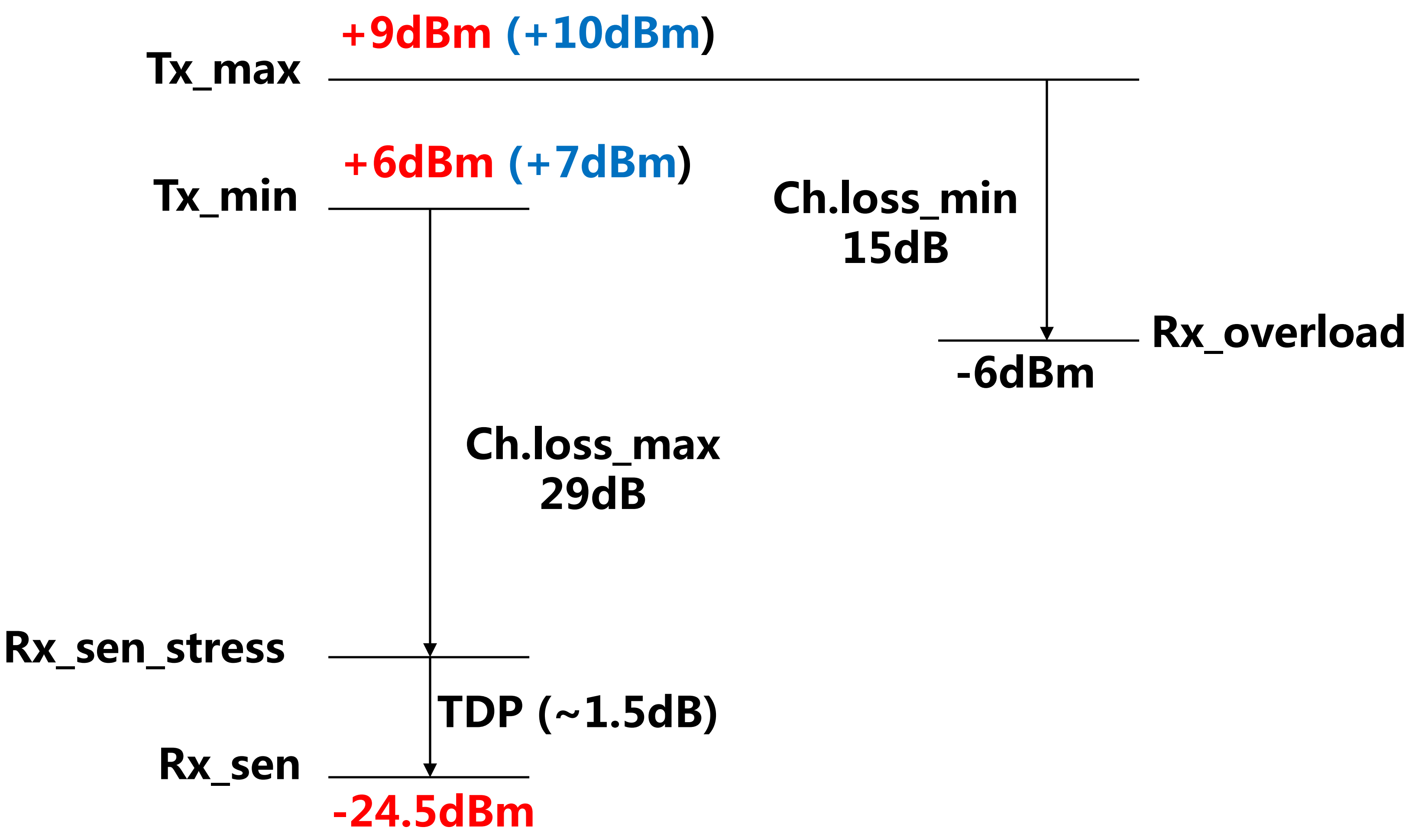
Downstream

- Uses wavelengths above 1340nm in O+ band
- 25G EML in OLT transmitter and 25G APD in ONU receiver
- WM as a part of OLT transceiver

Upstream

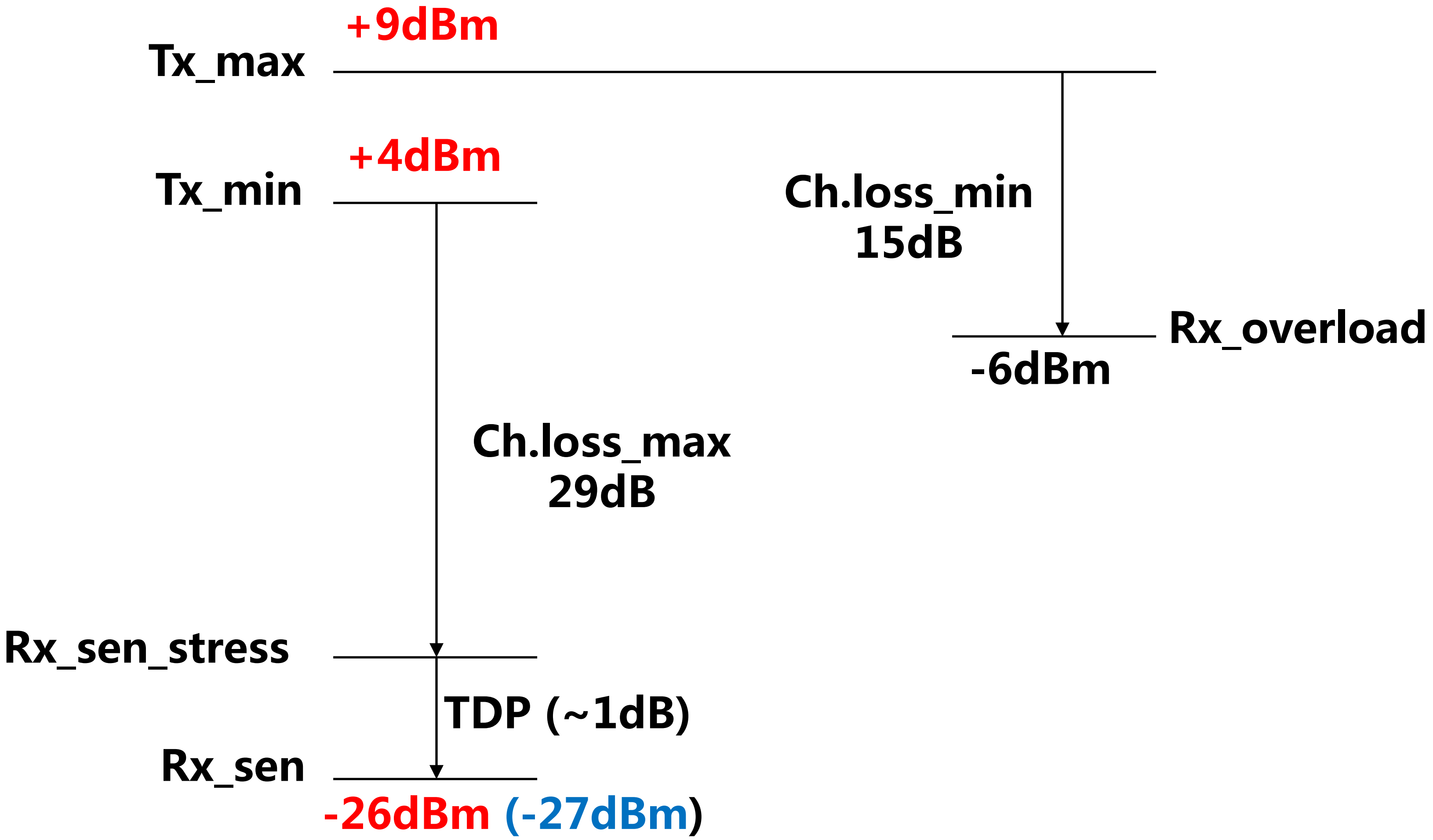
- Uses wavelengths near zero dispersion in O- band
- Cooled 25G DML in ONU transmitter and 25G APD in OLT receiver
- WM as a part of ONU transceiver

Downstream



- **For 25G**
  - +6 - +9 dBm OLT Tx power
  - -24.5dBm ONU Rx sensitivity based on 8dB ER
- **For 100G**
  - Addition 2.5dB insertion loss of WM should be considered for both Tx and Rx
    - OLT needs Tx amplifier
- **For coexistence with 10G-EPON**
  - 1dBm higher OLT Tx power (+7 - +10 dBm) to account WDM insertion loss

Upstream

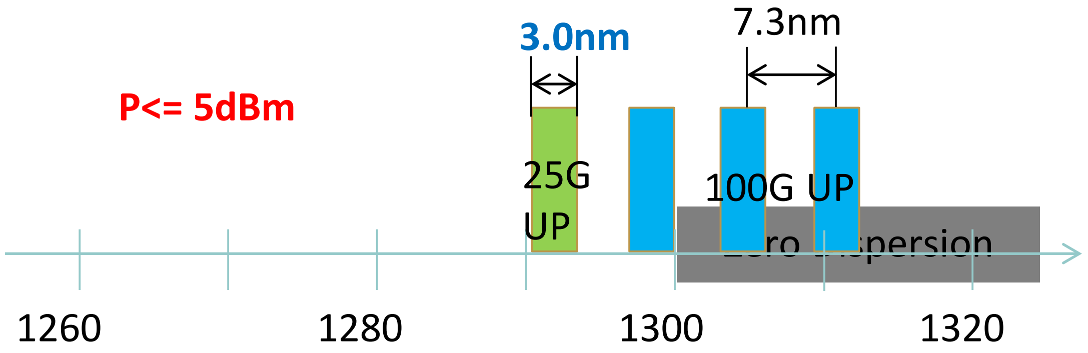


- **For 25G**
  - +4 - +9 dBm ONU Tx power
  - -26dBm OLT Rx sensitivity based on 6dB ER
    - May need Rx amplifier
- **For 100G**
  - Addition 2.5dB insertion loss of WM should be considered for both Tx and Rx
    - OLT needs Rx amplifier
    - ONU needs Tx amplifier
- **For coexistence with 10G-EPON**
  - 1dBm higher ONU Rx sensitivity (-27dBm) to account WDM insertion loss

Thank you!

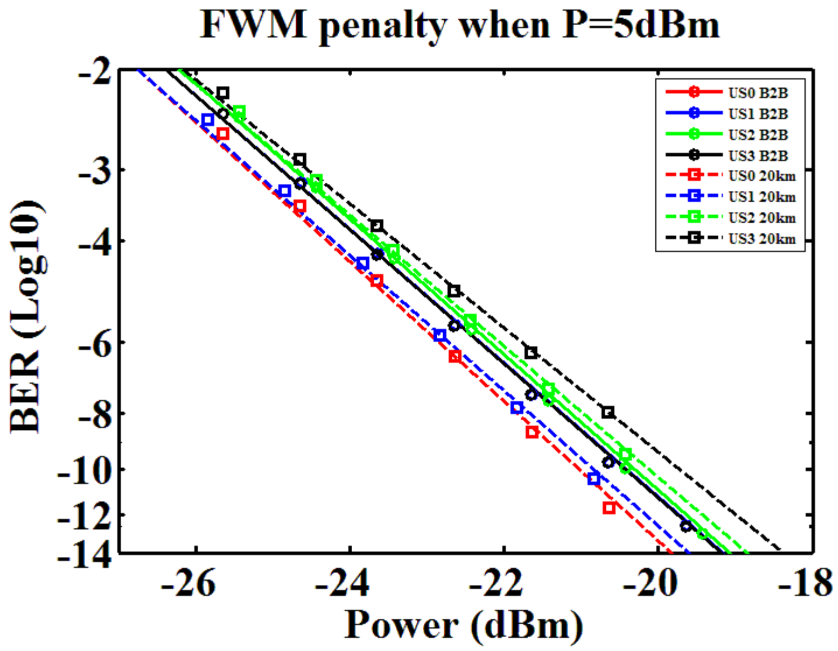
14

One revision for US plan and associated FWM analysis



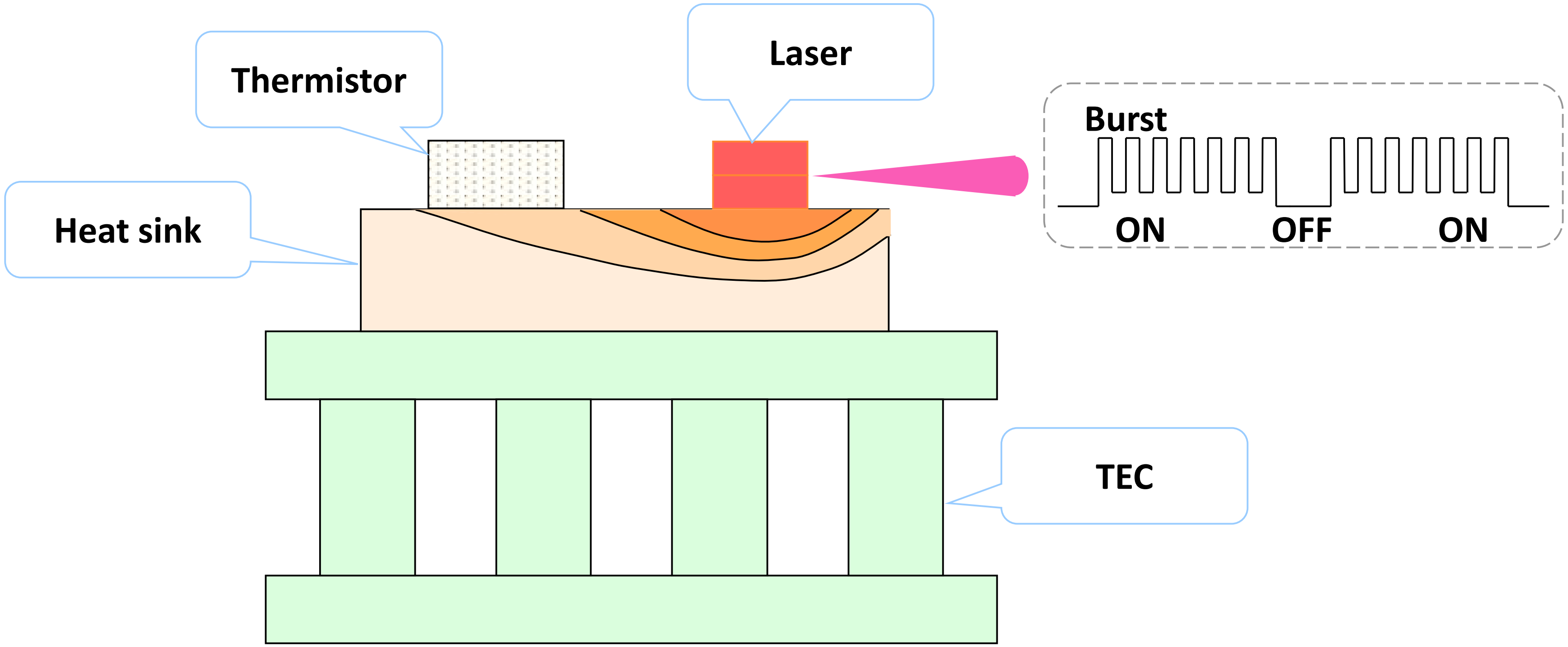
	Center freq	Center WL	PB width (THz)
US0	232	1292.21	0.54
US1	230.7	1299.49	0.54
US2	229.4	1306.85	0.54
US3	228.1	1314.30	0.54

- 5dBm maximal power for each channel is limited to avoid FWM penalty risk
- 3nm width for each US channel relax the ONU wavelength tolerance and decrease the cost of optics
- 10.7nm guard band is left between 10G EPON and 25G EPON upstream
- 5dBm maximal launch power limitation's impact on power budgets and optics cost needs further study



Backup: Burst Mode US wavelength (Part 1)

- Excessive Burst packets situation, means high burst duty cycle
- Laser chip operates at nominal center wavelength under heavy traffic similar with Continuous Mode
- Due to self heating, laser temperature is hotter than TEC set-point temperature



Backup: Burst Mode US wavelength (Part 2)

- Suddenly waked up or few Burst packets situation, means low burst duty cycle
- Laser chip operates at transient wavelength. Under light traffic, laser temperature is close to TEC set-point temperature
- With different burst duty cycles, transient wavelength may drift and be less than nominal center wavelength