

3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023
Agenda Item: 5
RWS-230237



NR duplex evolution for Rel-19

China Telecom, ZTE
June 2023

Background for the Rel-18 SI on evolution of NR duplex operation

- » The SI aims to identify and evaluate potential enhancements to support duplex evolution at gNB side for NR TDD spectrum, including subband non-overlapping full duplex (SBFD) study and enhancements on dynamic/flexible TDD.
- » Inter-gNB and inter-UE CLI handling schemes were studied for dynamic/flexible TDD enhancement. For gNB-to-gNB CLI handling schemes, feasibility/potential benefits of gNB-to-gNB co-channel CLI measurement/channel measurement and spatial domain coordination were studied.
- » Work item needs to be carried out in Rel-19 for the standardization work based on the Rel-18 study outcome.

Test scenario and gNB-to-gNB CLI handling scheme

- » Field tests were carried out in gymnasium and factory verifying the benefits of gNB-to-gNB co-channel CLI measurement and spatial domain coordination (beam nulling) to deal with the CLI, when different TDD UL/DL configurations are used in co-channel neighbouring gNBs. Based on the field tests, one of the objective is proposed for Rel-19 NR duplex evolution WI scope.

Multiple TDD UL/DL configurations can be adopt on 3.5GHz

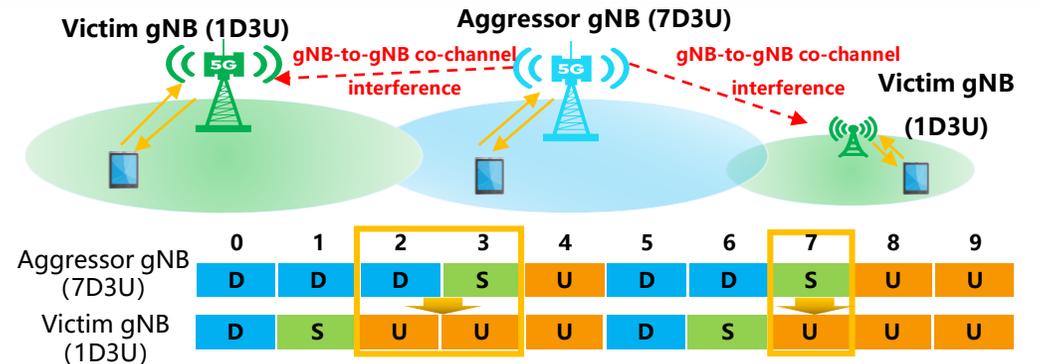
DL dominant: DDDSUDDSUU (7D3U within one period)



UL dominant: DSUUUDSUUU (1D3U within one period)



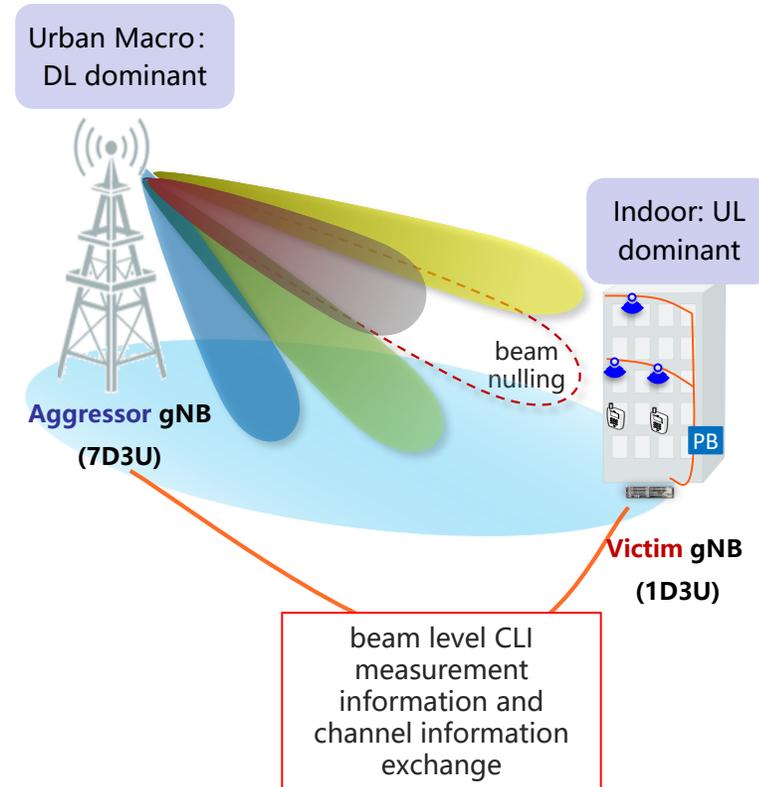
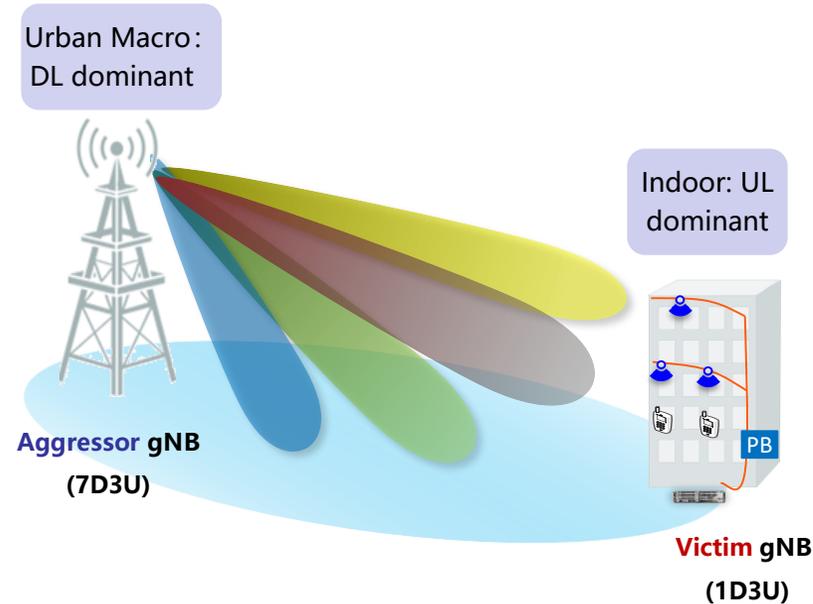
Different TDD UL/DL configurations cause severe gNB-to-gNB co-channel interference



- Slot2/3/7: High-power DL transmission from the Macro aggressor gNB interferes the UL transmission sending from the UEs under the victim gNB.
- In other slots, there is no such interference.

Test scenario and gNB-to-gNB CLI handling scheme

- » The gNB-to-gNB inter-cell co-channel interference handling schemes aim to improve the UL performance of the victim gNB.
- » The gNB-to-gNB interference is handled from victim gNB side and aggressor gNB side in the test.
 - From the victim gNB side, schemes such as slot AMC and IRC receiver are utilized to counter the interference.
 - From the aggressor gNB side, beam nulling is performed on the high interfering Tx beam based on the beam level CLI measurement information and channel information exchanged between the gNBs.



Test in gymnasium (1/5)

Indoor gNB is configured with 1D3U to cover the gymnasium of Xiaoshan District, Hangzhou, and Urban Macro gNB is configured with 7D3U



Comparison of UL throughput w/o and w/ interference suppression at victim side and aggressor side



1. When the frame structure is adjusted to 1D3U in the gymnasium, the UL throughput decreases instead of rising comparing with the baseline 7D3U structure, due to the strong interference from cluster 1 Macro gNB.
2. When the victim gNB counters interference via slot AMC, IRC, etc., the UL throughput increases by 24% compared with the baseline and increases by 97% compared with the 1D3U w/o interference handling.
3. When further beam nulling is done by cluster 1, the UL throughput of cluster 2 can be further increased by 28%.
The overall increase is 60% compared with the baseline 7D3U case.

Test in gymnasium (2/5)

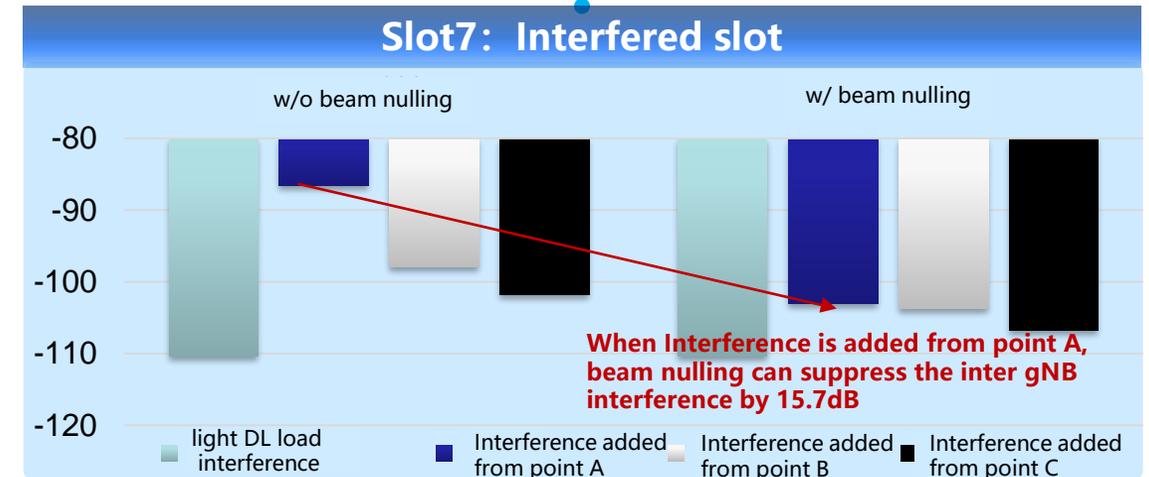
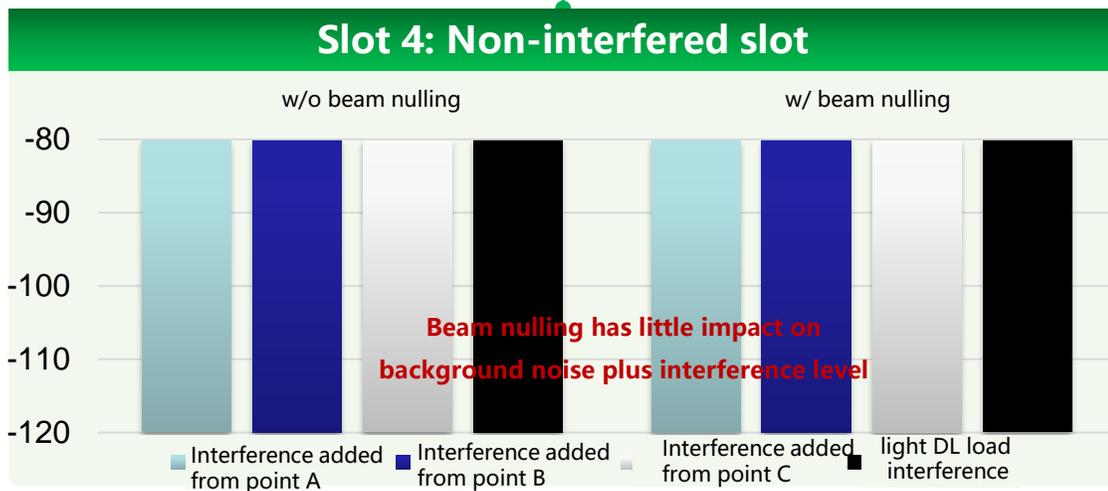
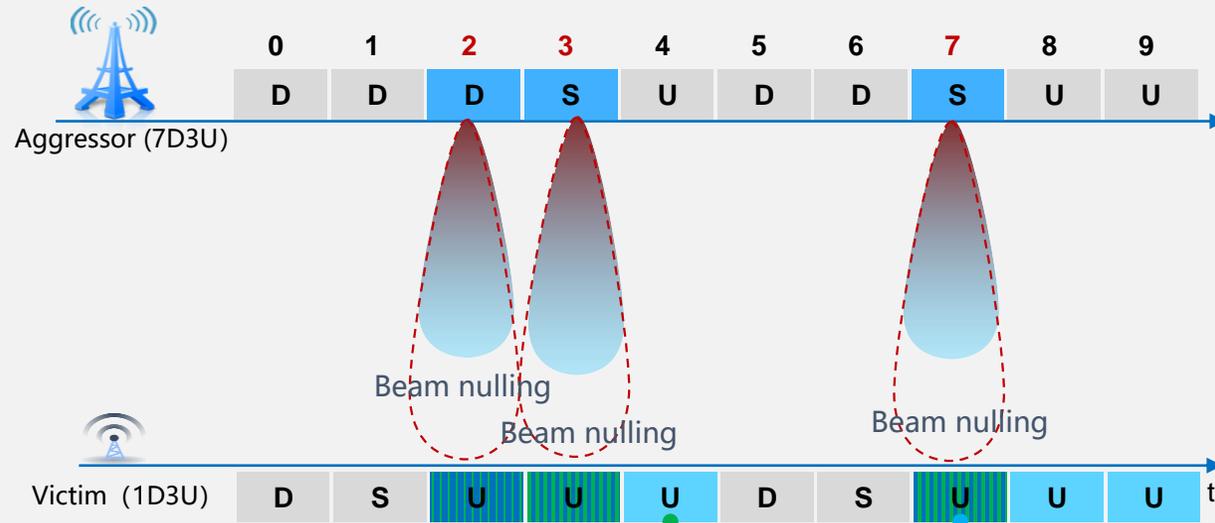
Test case	Inter gNB interference cases	Interference generated point
7D3U configuration as baseline		
1D3U configuration w/o and w/ interference suppression at victim side and aggressor side (beam nulling)	light DL load interference (DL PRB usage < 5%)	
	full DL load interference for UE at different points (DL PRB usage approaches 100%)	Point A
		Point B
Point C		



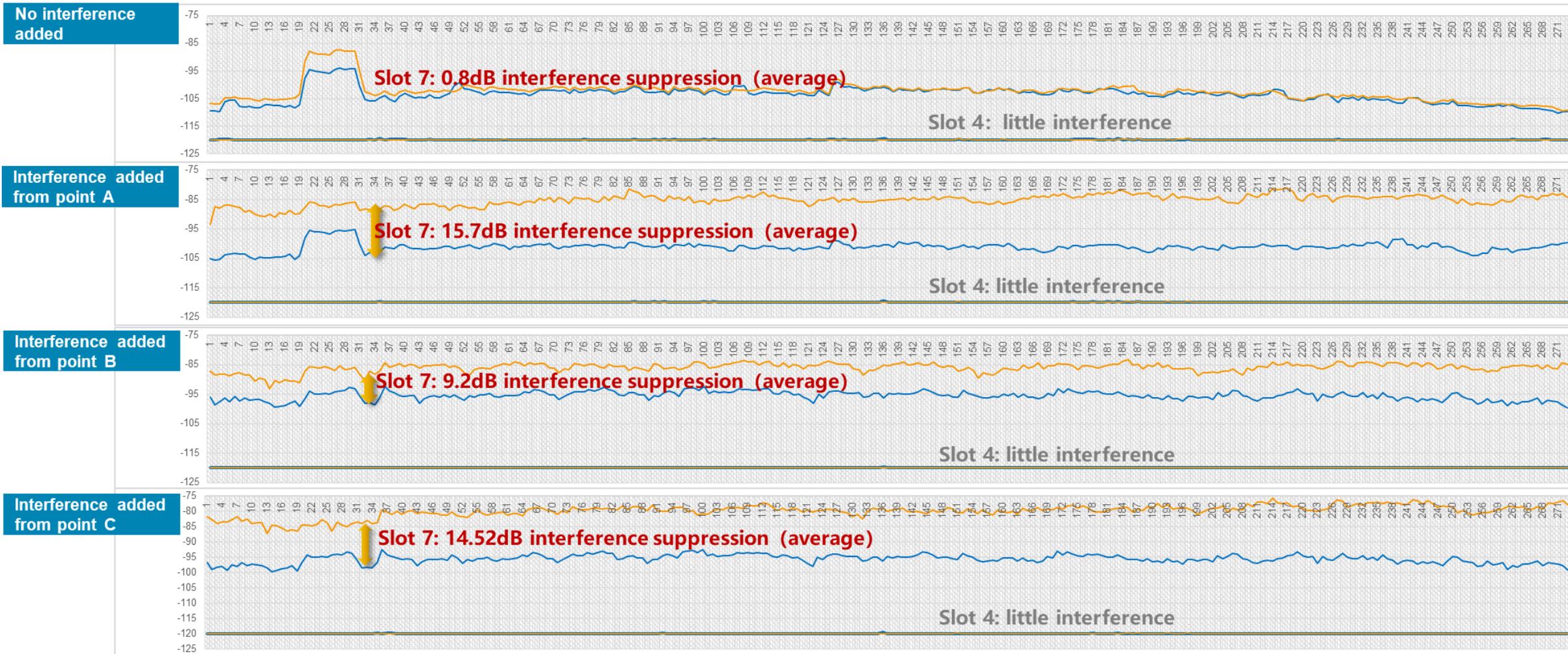
- For full DL load interference, the DL interference is generated by the aggressor gNB to serve full load downloading service for UE at point A, point B, point C.

Test in gymnasium (3/5)

- The Macro aggressor gNB performs beam nulling in slot 2/3/7, which directly reduces interference to these three slots while has little effect on other time slots.



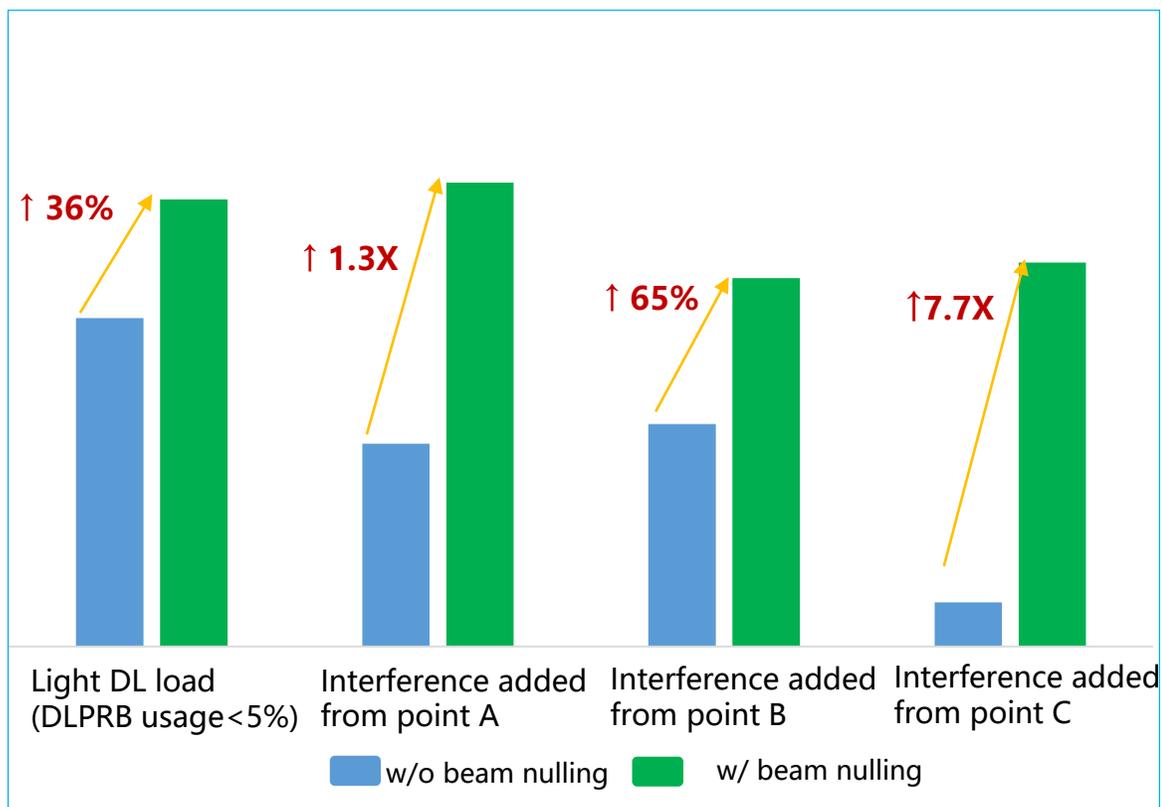
Test in gymnasium (4/5)



Noise plus interference level at victim gNB in slot 7 and slot 4 w/&w/o beam nulling performed at aggressor gNB

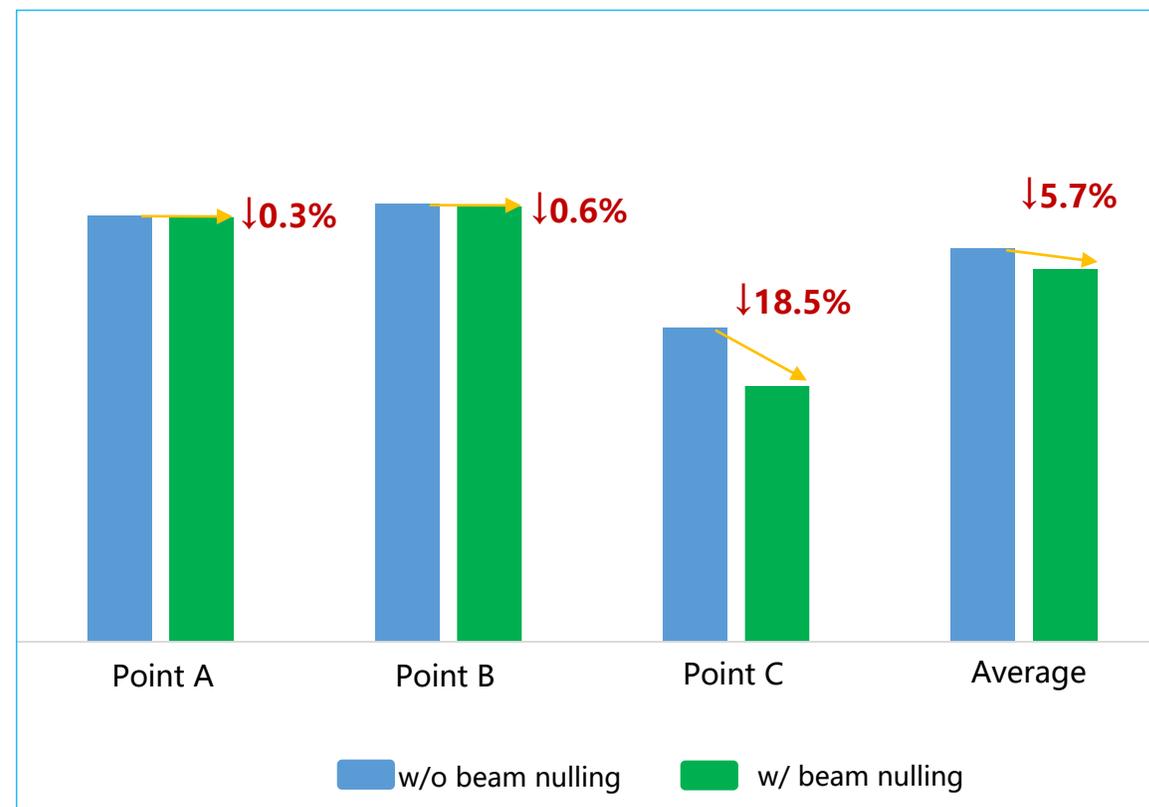
Significant increase of the UL throughput in victim slot owing to beam nulling

UL throughput in victim slot at victim gNB



There is impact on the DL throughput of the aggressor gNB by beam nulling

DL throughput at aggressor gNB



- DL traffic load and DL transmission direction have obvious influence on the interference of the victim.
- Under the light DL load, the DL transmission generates little interference for the UL reception, and the UL throughput improvement by beam nulling is moderate.
- The interference generated by aggressor gNB to serve UE for full load downloading at point C has significant impact on the victim slot UL reception, and beam nulling at this interference case can significantly suppress the interference and improve the UL throughput.

- Beam nulling performed in slot 2/3/7 has impact on the DL throughput of the aggressor gNB.
- Beam nulling for DL traffic serving UE at point A and point B has almost no impact on the DL throughput. However, the beam nulling for DL traffic serving UE at point C affects the DL throughput, which decreases by about 18.5%.
- The average decreasing of DL throughput is 5.7%.

Indoor gNB is configured with 1D3U to cover the factory of Lierda Science & Technology Group, and Urban Macro gNB is configured with 7D3U

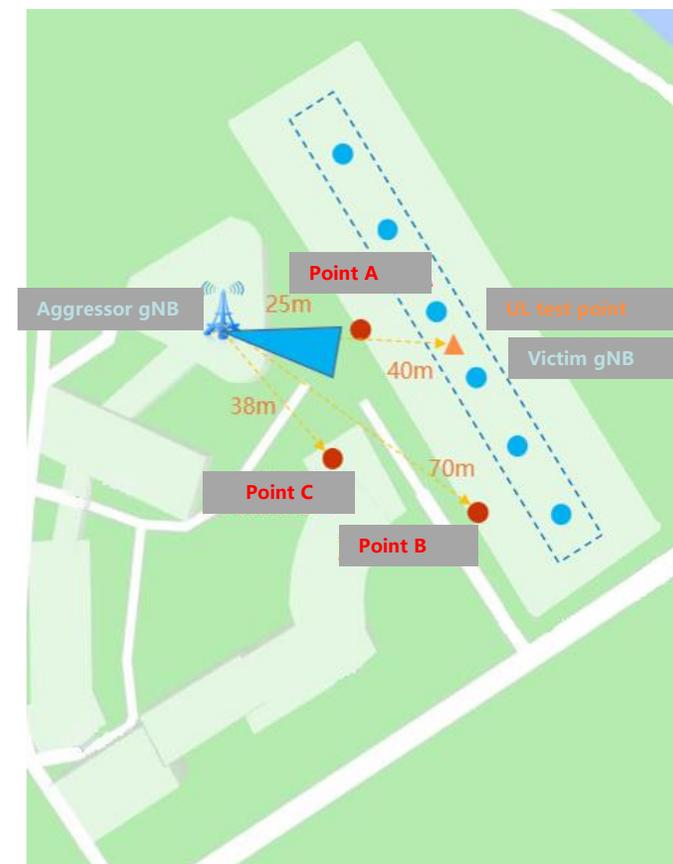


Comparison of UL throughput w/o and w/ interference suppression at victim side and aggressor side



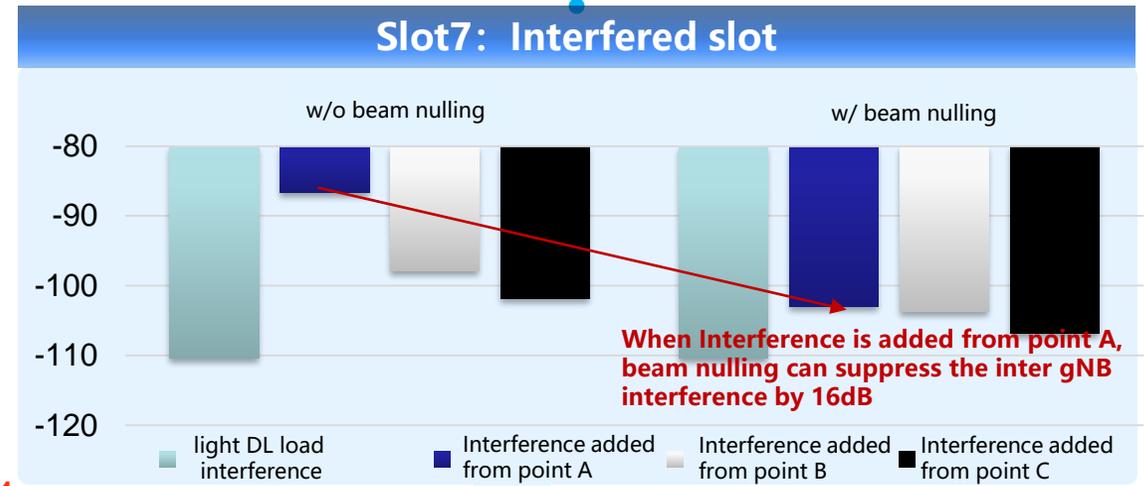
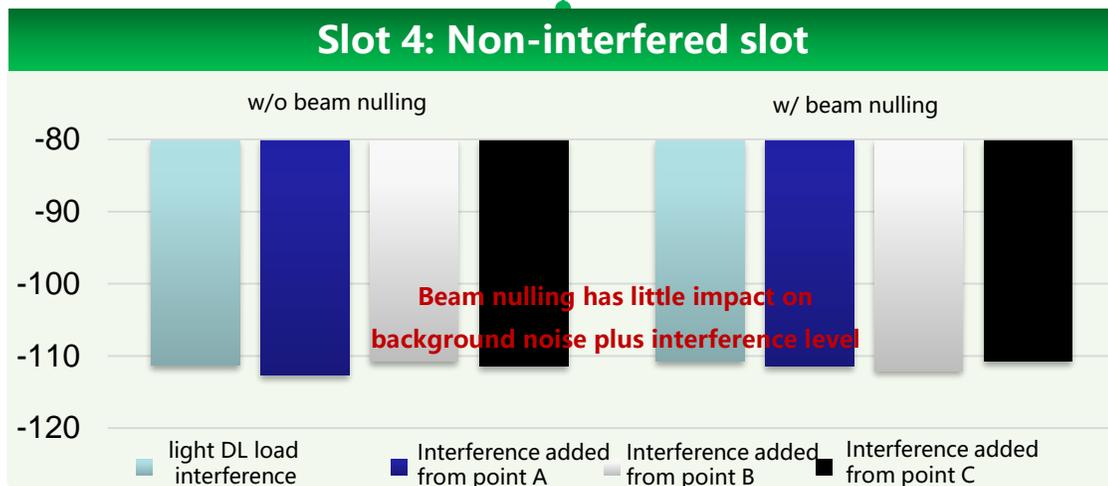
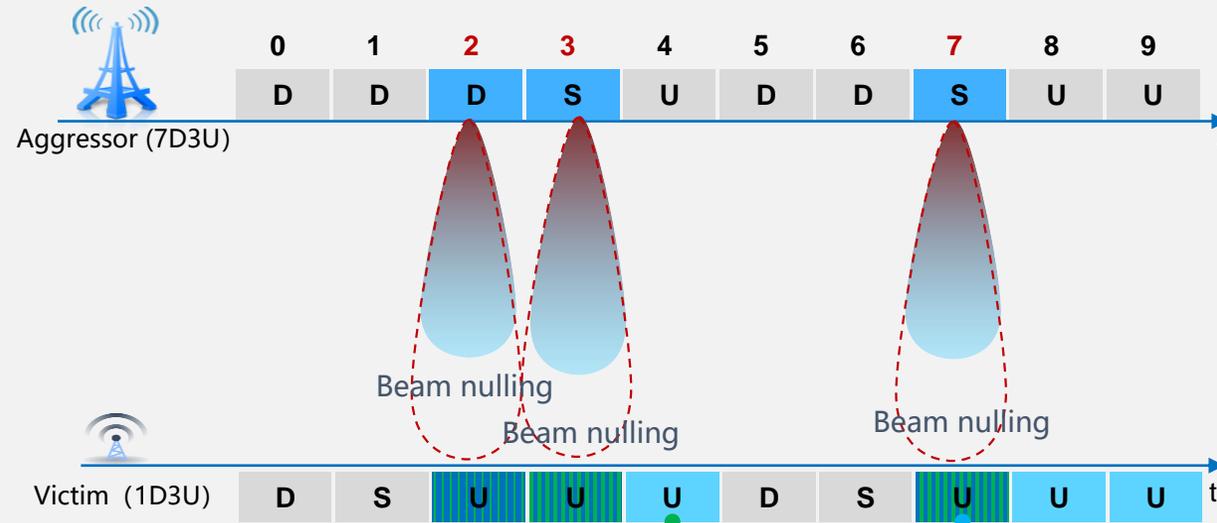
1. When the frame structure is adjusted to 1D3U in the factory, the UL throughput decreases instead of rising comparing with the baseline 7D3U structure, due to the strong interference from cluster 1 Macro gNB.
2. When the victim gNB counters interference via slot AMC, IRC, etc., the UL throughput increases by 43% compared with the baseline and increases by 117% compared with the 1D3U w/o interference handling.
3. When further beam nulling is done by cluster 1, the UL throughput of cluster 2 can be further increased by 21%. The overall increase is 74% compared with the baseline 7D3U case.

Test case	Inter gNB interference cases	Interference generated point
7D3U configuration as baseline		
1D3U configuration w/o and w/ interference suppression at victim side and aggressor side (beam nulling)	light DL load interference (DL PRB usage < 5%)	
	full DL load interference for UE at different points (DL PRB usage approaches 100%)	Point A
		Point B
		Point C



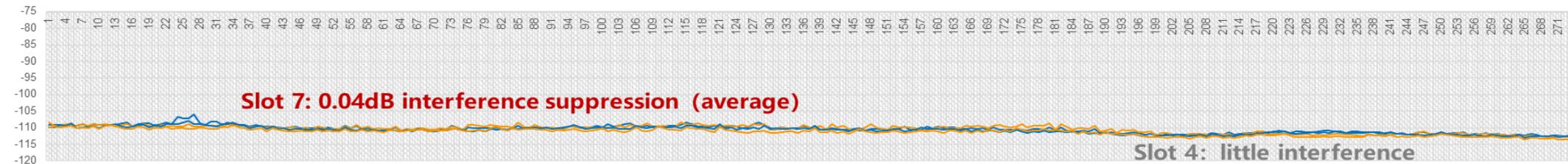
- For full DL load interference, the DL interference is generated by the aggressor gNB to serve full load downloading service for UE at point A, point B, point C.

- The Macro aggressor gNB performs beam nulling in slot 2/3/7, which directly reduces interference to these three slots while has little effect on other time slots.

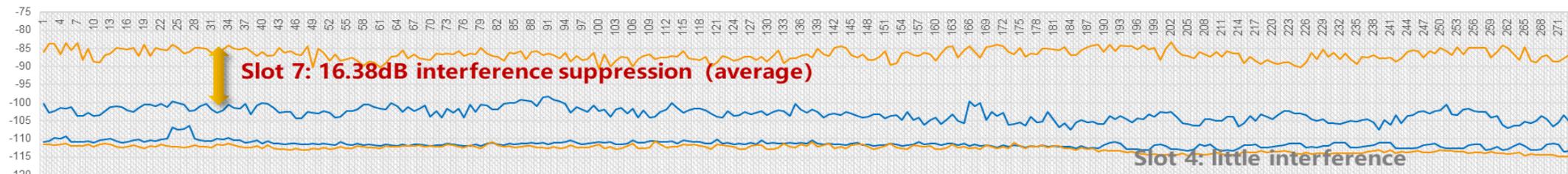


Test in factory (4/5)

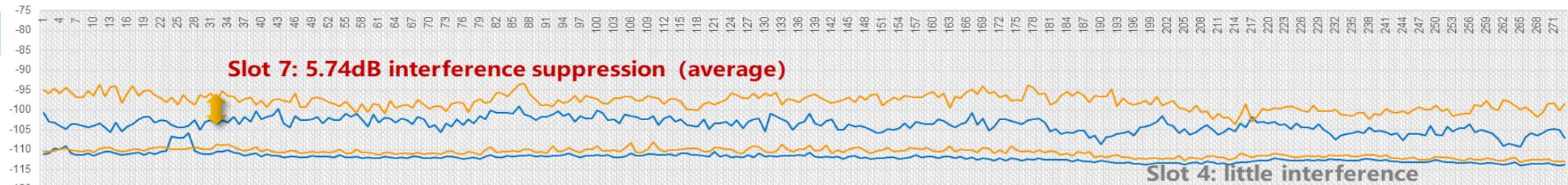
No interference added



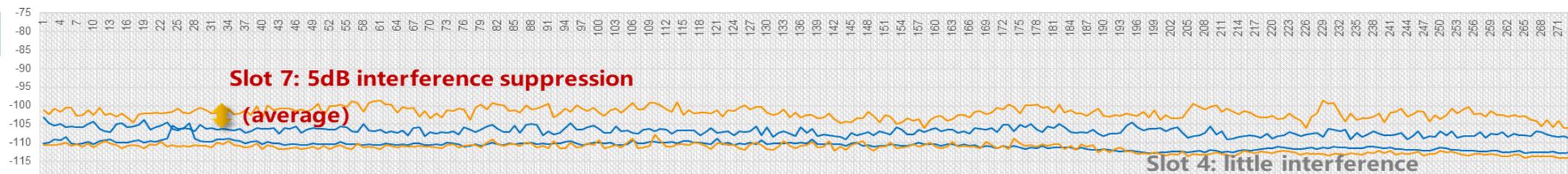
Interference added from point A



Interference added from point B



Interference added from point C

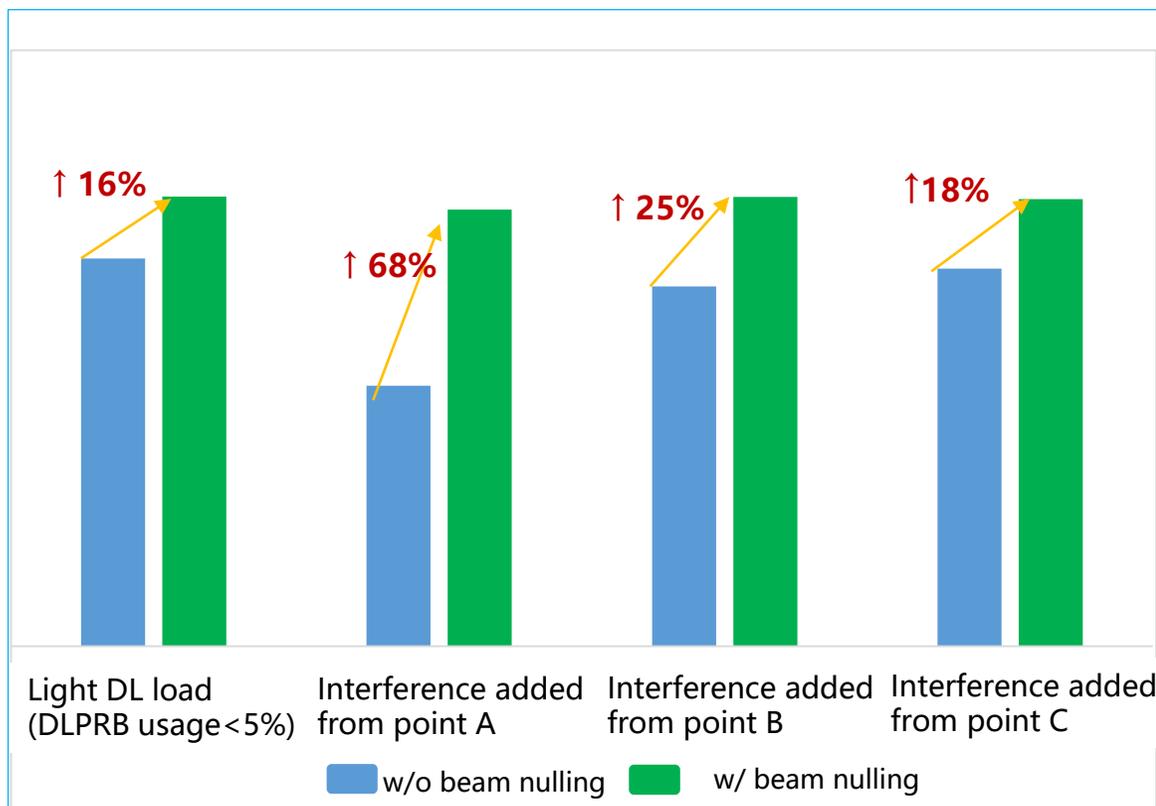


— Slot 7: w/ beam nulling — Slot7: w/o beam nulling — Slot 4: w/ beam nulling — Slot4: w/o beam nulling

Noise plus interference level at victim gNB in slot 7 and slot 4 w/&w/o beam nulling performed at aggressor gNB

Significant increase of the UL throughput in victim slot owing to beam nulling

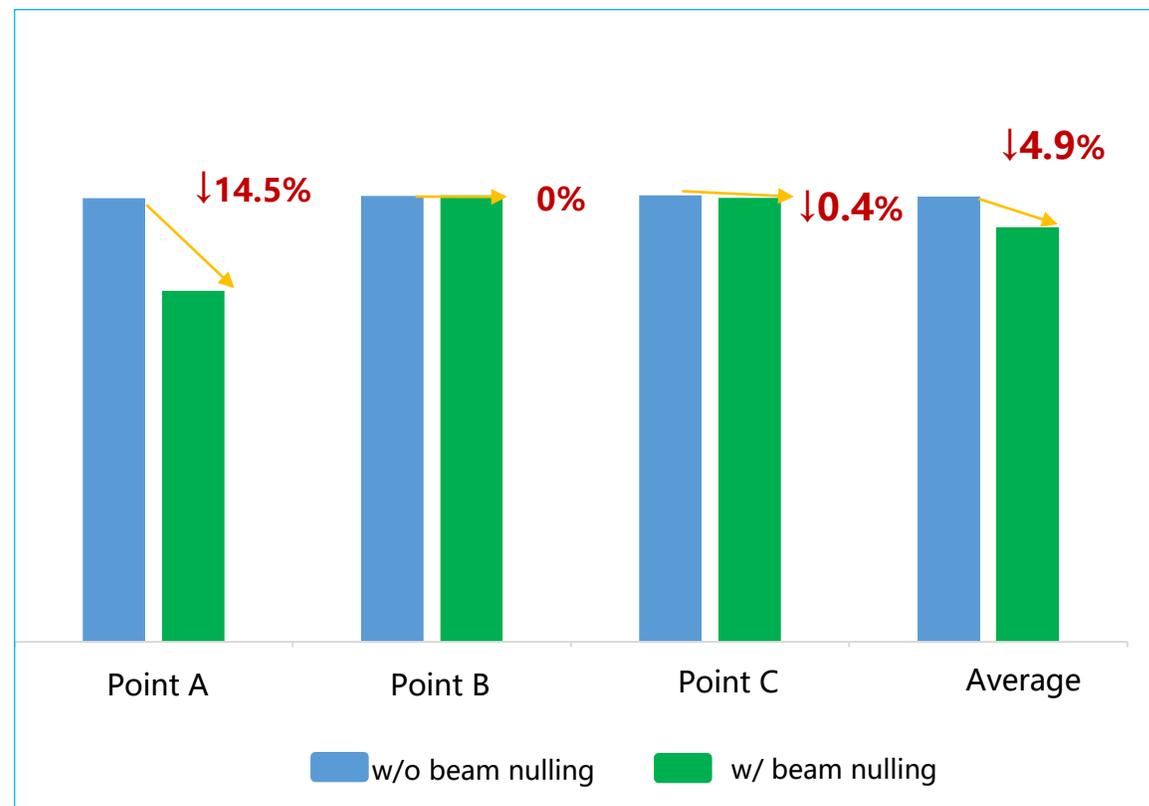
UL throughput in victim slot at victim gNB



- DL traffic load and DL transmission direction have obvious influence on the interference of the victim.
- Under the light DL load, the DL transmission generates little interference for the UL reception, and the UL throughput improvement by beam nulling is moderate.
- The interference generated by aggressor gNB to serve UE for full load downloading at point A has significant impact on the victim slot UL reception, and beam nulling at this interference case can significantly suppress the interference and improve the UL throughput.

There is impact on the DL throughput of the aggressor gNB by beam nulling

DL throughput at aggressor gNB



- Beam nulling performed in slot 2/3/7 has impact on the DL throughput of the aggressor gNB.
- Beam nulling for DL traffic serving UE at point B and point C has almost no impact on the DL throughput. However, the beam nulling for DL traffic serving UE at point A affects the DL throughput, which decreases by about 14.5%.
- The average decreasing of DL throughput is 4.9%.

■ Summary for the field test observation

- » Beam nulling by aggressor gNB at victim slots can suppress the inter gNB interference larger than 15dB for victim slots and have little effect on other slots.
- » When there is serious inter gNB interference, beam nulling can significantly suppress the interference and improve the UL throughput.
- » The percentage of the DL throughput decrease caused by beam nulling is much lower than the UL throughput increasing percentage.

■ Proposal for the Rel-19 NR duplex operation evolution objective

- » Specify scheme to handle gNB-to-gNB CLI for dynamic/flexible TDD and Sbfd in WI, including **gNB-to-gNB co-channel channel/CLI measurement and measurement information exchange for spatial domain coordination (beam nulling)**

Thanks!
