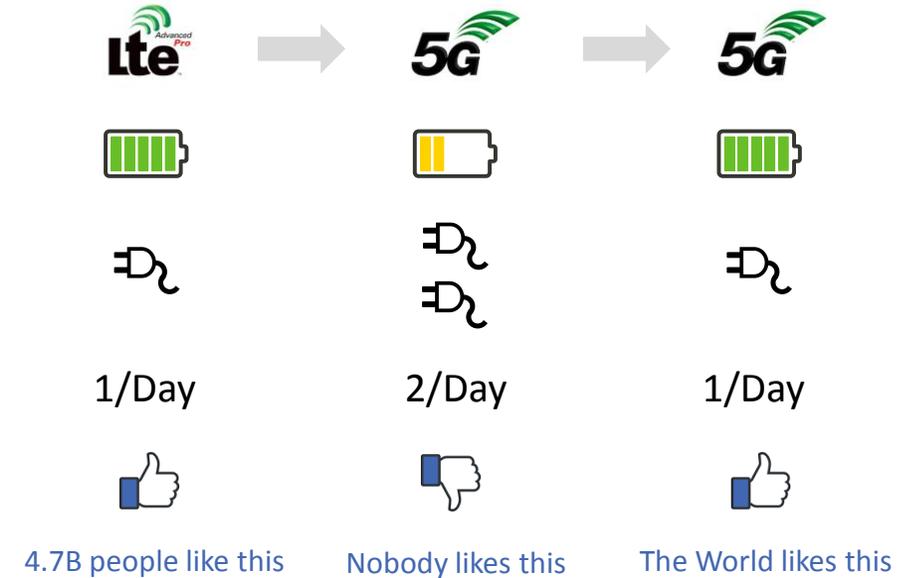


# Considerations of UE Power Saving Enhancements for Rel-17

# Motivation

- User expectations set on 4G experience
  - Good progress for Rel-15 and Rel-16
    - Primary focus: connected state, FR1
  - Major gaps remain for NR SA and for FR2
    - a) NR SA idle mode: 40% - 50% worse<sup>1</sup> than NR NSA
    - b) FR2 connected mode: 56% worse than FR1
  - Challenges migration from NR NSA to NR SA
  - Challenges viability of FR2:
    - critical issue for operators heavily relying on FR2 to provide 5G
    - Inconsistent battery life for “same” 5G services in FR1 vs. FR2
- **Essential network features for healthy ecosystem growth**

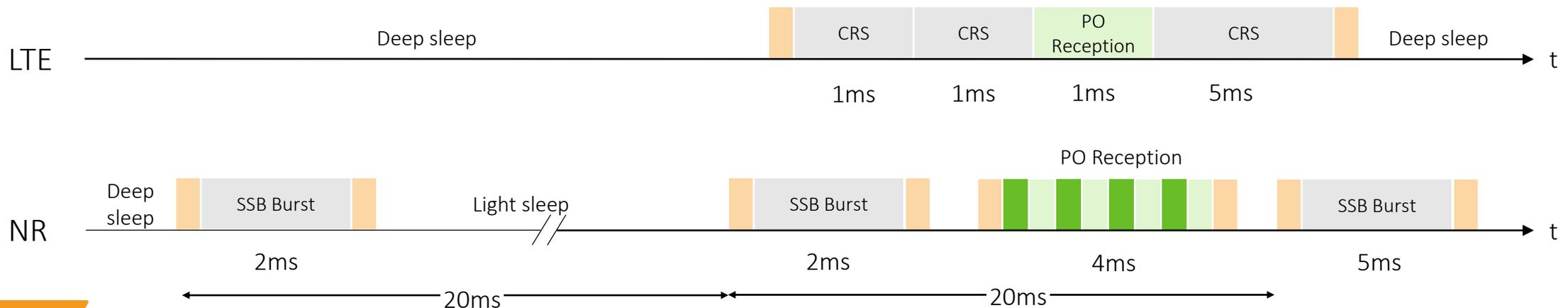
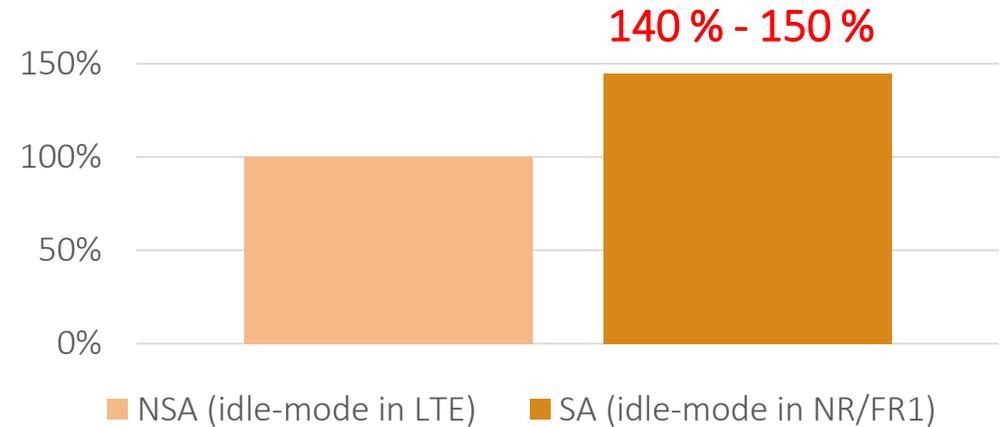


Note 1: R1-1909740

# SA Idle Mode (1/2)

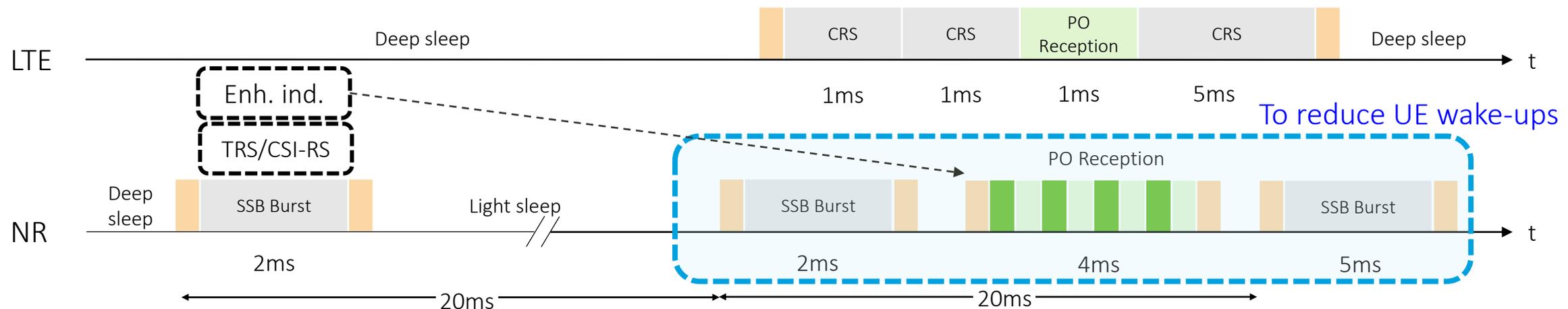
- 40% ~ 50% higher UE idle-mode power consumption observed in SA than that in NSA
  - Energy overhead due to multiple UE wake-ups for processing distributive SSB bursts
  - Longer UE active time for gNodeB beam-formed transmissions
  - More details can be checked in backup slides

Relative UE power consumption (idle-mode)



# SA Idle Mode (2/2)

- Idle-mode power saving enhancements:
  - ✓ Assistance information of potential TRS/CSI-RS resource(s)
  - ✓ RRM relaxation enhancements (including serving cell measurement relaxation)
  - ✓ paging indication enhancements (reducing paging false-alarm, early indication)
- To achieve similar to lower idle-mode power consumption than LTE



# FR2 Connected Mode (1/2)

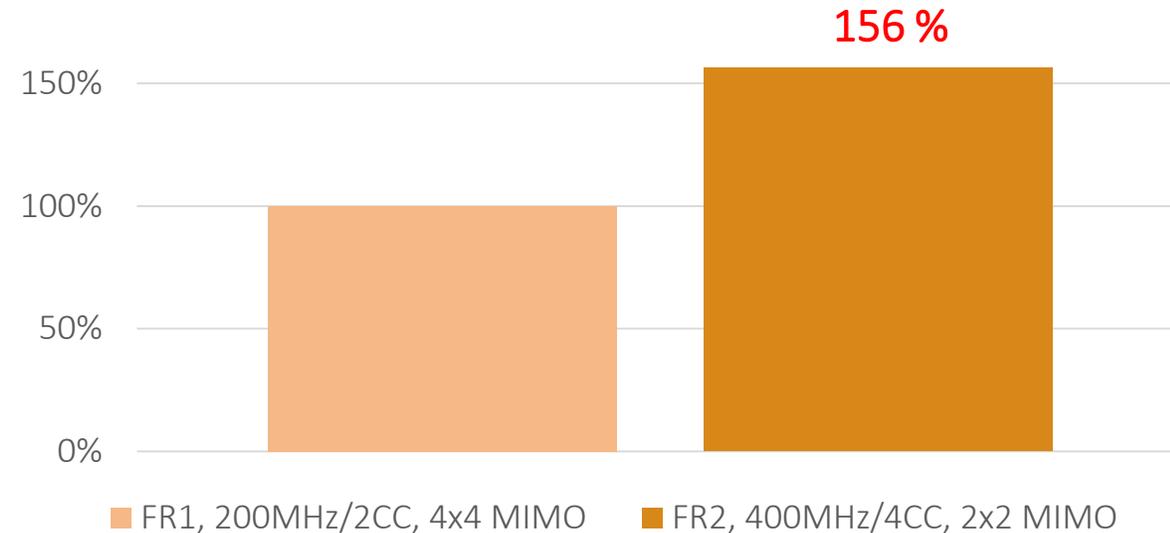
- Power consumption comparison:

- ✓ FR1 (200MHz/2CC, 4x4) vs. FR2 (400MHz/4CC, 2x2)
- ✓ 1920x1080p video/gaming
- ✓ cDRX (80 ms, 8 ms, 8 ms)
- ✓ Rel-16 WUS PDCCH
- ✓ Rel-16 BWP framework based power saving:
  - ✓ Pcell: Adaptation to cross-slot scheduling and max. # MIMO layers
  - ✓ SCell(s): Dormancy behavior
  - ✓ 2-ms BWP time out (after no data activity)

- Observation:

- UE power consumption is relatively higher in FR2
- Further enhancements for FR2 connected-mode needed

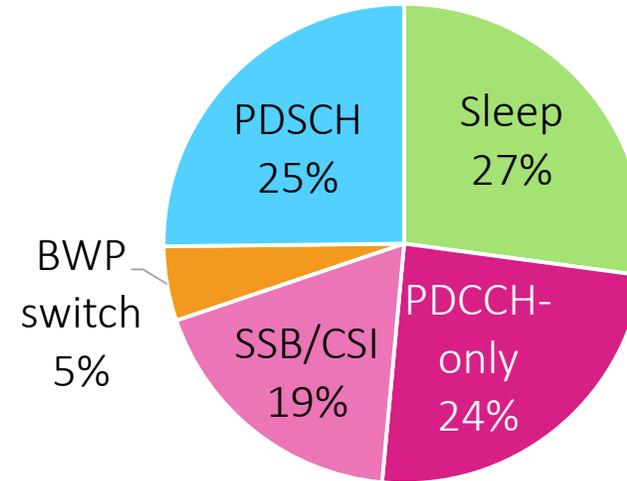
Relative UE power consumption (connected-mode)



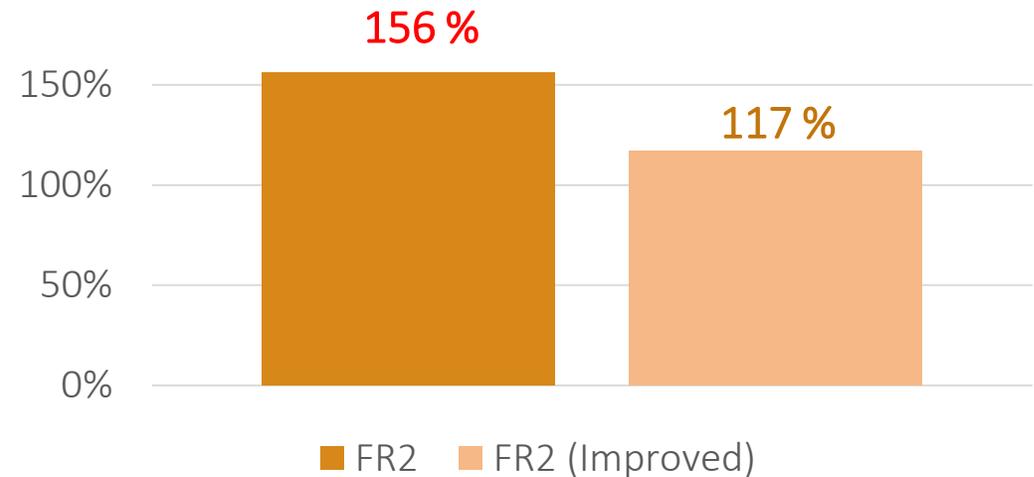
# FR2 Connected Mode (2/2)

- FR2 Power saving enhancements:
  - ✓ Reduction of PDCCH monitoring
  - ✓ Beam and cell measurement relaxation
  - ✓ Shorter BWP switch delay
- To achieve <20% UE power consumption difference between FR1 and FR2 connected-mode

FR2 power consumption break-down



UE power consumption



# Summary

- Two remaining UE power consumption issues impact user experience with NR SA and FR2
  - NR SA idle mode: **40% - 50% worse** than NR NSA
  - FR2 connected mode: **56% worse** than FR1
- Enhancements targeting the major power consumption factors are to achieve
  - Similar to lower idle-mode power consumption in NR SA than that in LTE
  - **<20% power consumption difference between FR2 and FR1 connected-mode**
- Rel-17 UE power saving enhancements can **minimize the risks for expanding NR SA and FR2 deployments**

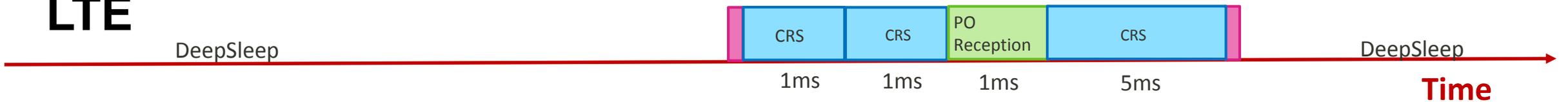
**MEDIATEK**

*everyday genius*

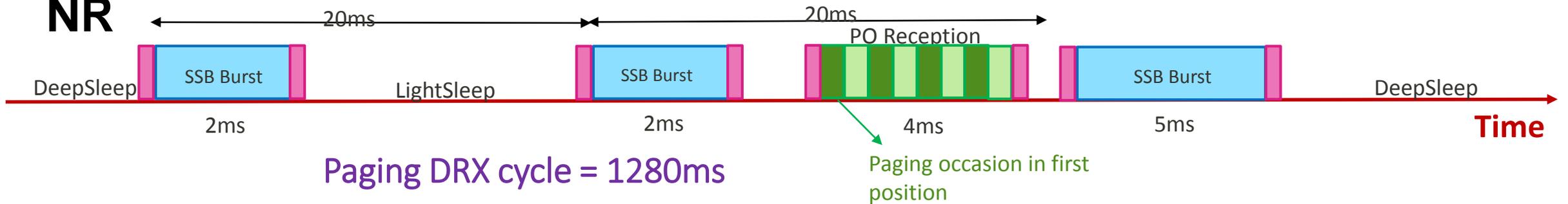
# Assumption Update for Paging Power Consumption Analysis

- Before paging occasion (PO), two SSB bursts are typically used for intra-frequency measurement and time/frequency sync for paging reception.
- After PO, one SMTC window is typically needed for inter-frequency measurement.
- For inter-frequency measurement, RAN4 do not have any requirement on the timing alignment, so UE needs to receive the whole 5ms SMTC window.

## LTE

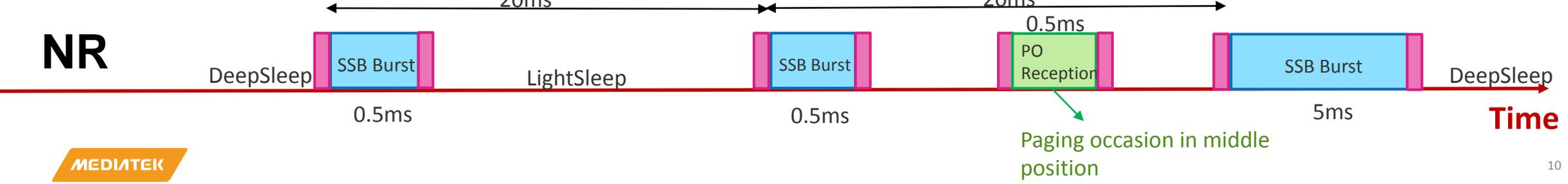
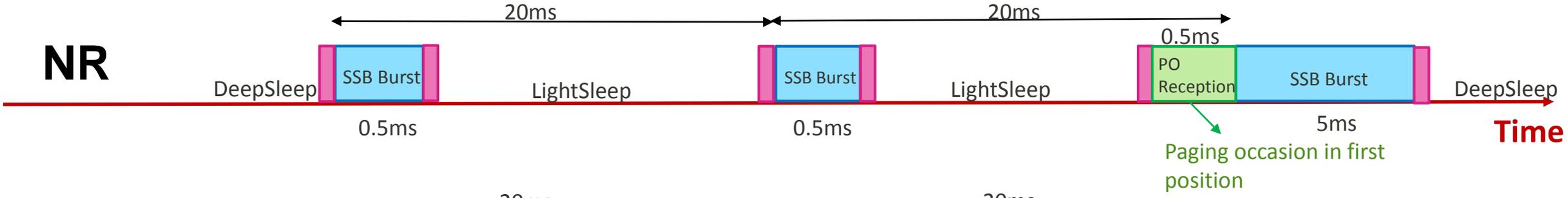
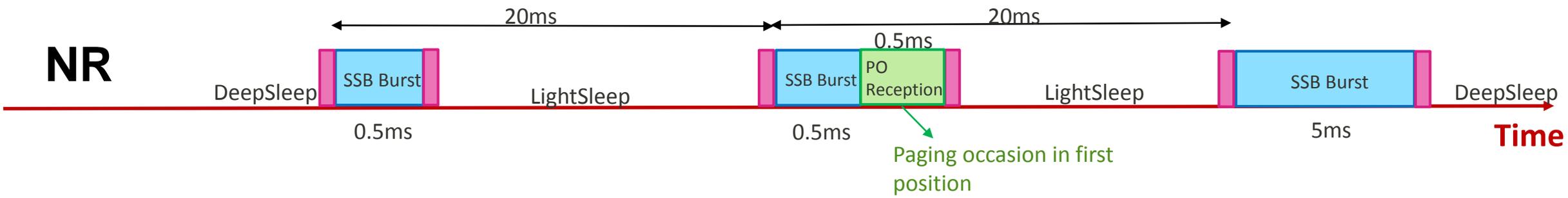
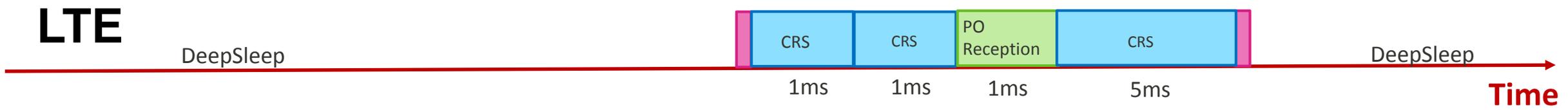


## NR



- We also consider one SSB in each SSB burst and variable paging occasion position.

 : Warm-Up and Cool-Down



# NR Idle Mode Power Consumption Increment Compared with LTE

Assumption: 50% of RRM relaxation condition holds

