HL-LHC filling schemes

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Many thanks to:

R. Tomas, G. Rumolo, H. Bartosik

C. Schwick and the LPC for filling scheme webtools

A. Poyet and G. Sterbini for the beam-beam analysis tool

Updated **filling schemes** for the different operational scenarios were made available on the [WP2 webpage](#) (no major change, just some cleanup)

In the following we make the following **assumptions** (based on the LHC Run 2):

- **Gap between injections into the SPS (T_{MKP}):** 200 ns (7 slots)
- **Gap between injections into the LHC (T_{MKI}):** 800 ns (31 slots)

- **Abort gap length:** 3.05 µs (121 slots)

- **Kicker pulses** (MKI, MKE) long more than 8.55 µs

- The **first injection** consists in a short batch (8b or 12b)
 - These are left **non-colliding** in IP1/5

- **All other bunches are colliding in IP1/5**

- As close as possible to **four-fold symmetry** to maximize number of collisions in **IP8**

- Filling schemes generated using the [LPC tool](#) and analyzed with [FillingPatterns](#) python package (which now includes also beam-beam pattern calculations by A. Poyet and G. Sterbini)

25ns_2760b_2748_2492_2574_288bpi_13inj_800ns_bs200ns

25 ns slot
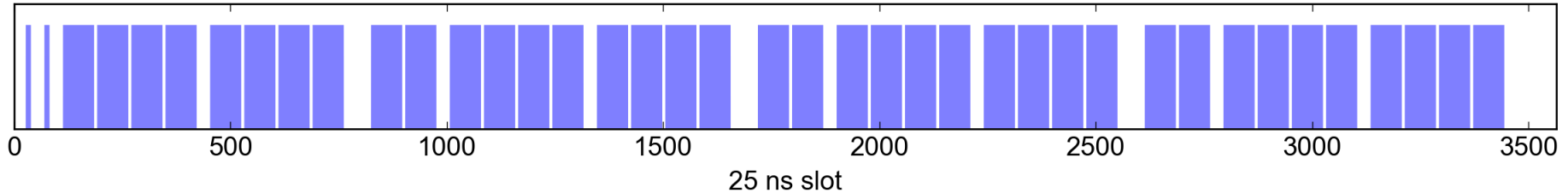
25ns_2760b_2748_2492_2574_288bpi_13inj_800ns_bs200ns

N. collisions:	
ATLAS/CMS:	2748
LHCb:	2574
ALICE:	2492

Patterns from SPS:
    [12]
    [72, 72, 72, 72]
    [72, 72]

N. bunches: 2760

N. injections: 13

Additional info for burn-off calculations

		IP15 partner collides in LHCb	
		Yes	No
Bunch collides in LHCb	Yes	2376	186
	No	186	0

25ns_2744b_2736_2246_2370_240bpi_13inj_800ns_bs200ns_BCMS_5x48b

25 ns slot
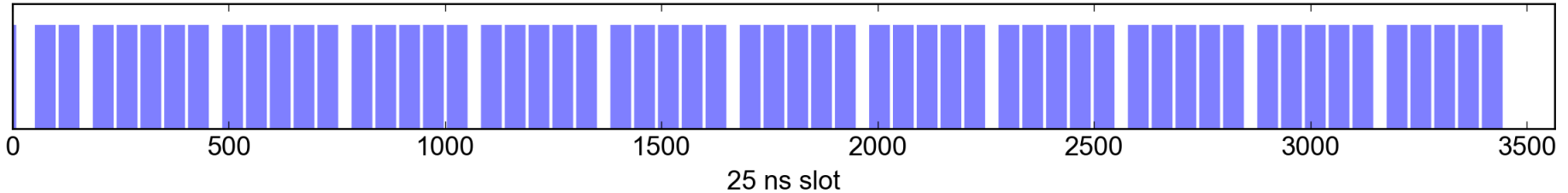
25ns_2744b_2736_2246_2370_240bpi_13inj_800ns_bs200ns_BCMS_5x48b

```
    N. collisions:
ATLAS/CMS:      2736
LHCb:           2370
ALICE:          2246
```

```
Patterns from SPS:
   [8]
   [48, 48]
   [48, 48, 48, 48, 48]
```
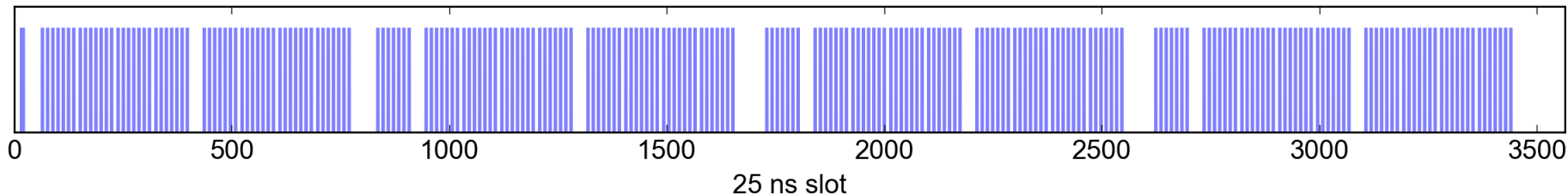
```
N. bunches:     2744
```

```
N. injections: 13
```

Additional info for burn-off calculations

		IP15 partner collides in LHCb	
		Yes	No
Bunch collides in LHCb	Yes	2017	345
	No	345	29

8b4e_1972b_1960_1178_1886_224bpi_12inj_800ns_bs200ns

25 ns slot

8b4e_1972b_1960_1178_1886_224bpi_12inj_800ns_bs200ns

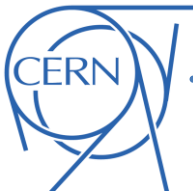| N. collisions	
ATLAS/CMS:	1960
LHCb:	1886
ALICE:	1178

```
Patterns from SPS:
   [12]
   [56, 56, 56, 56]
   [56]
```

N. bunches: 1972

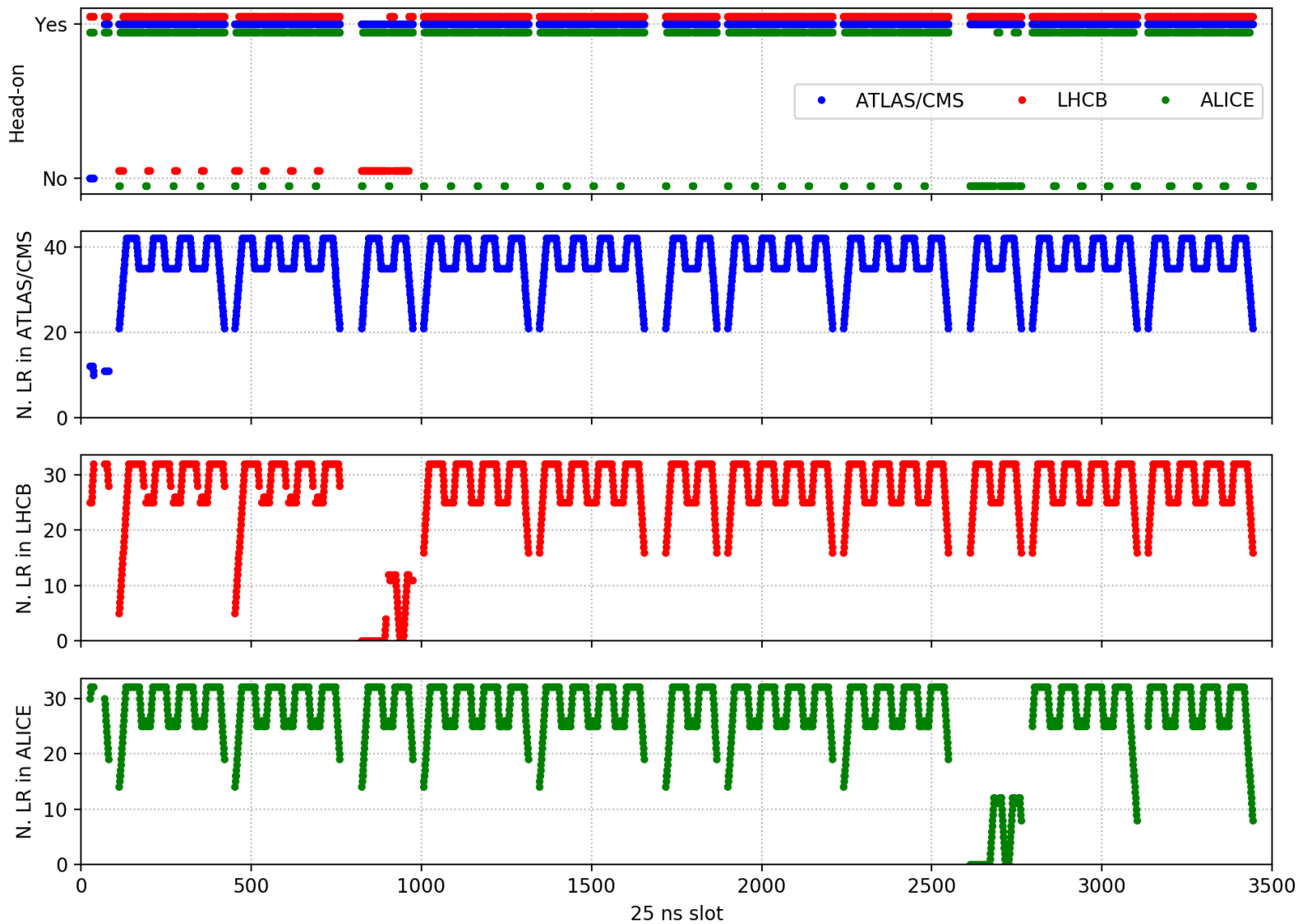N. injections: 12

Additional info for burn-off calculations

		IP15 partner collides in LHCb	
		Yes	No
Bunch collides in LHCb	Yes	1796	82
	No	82	0

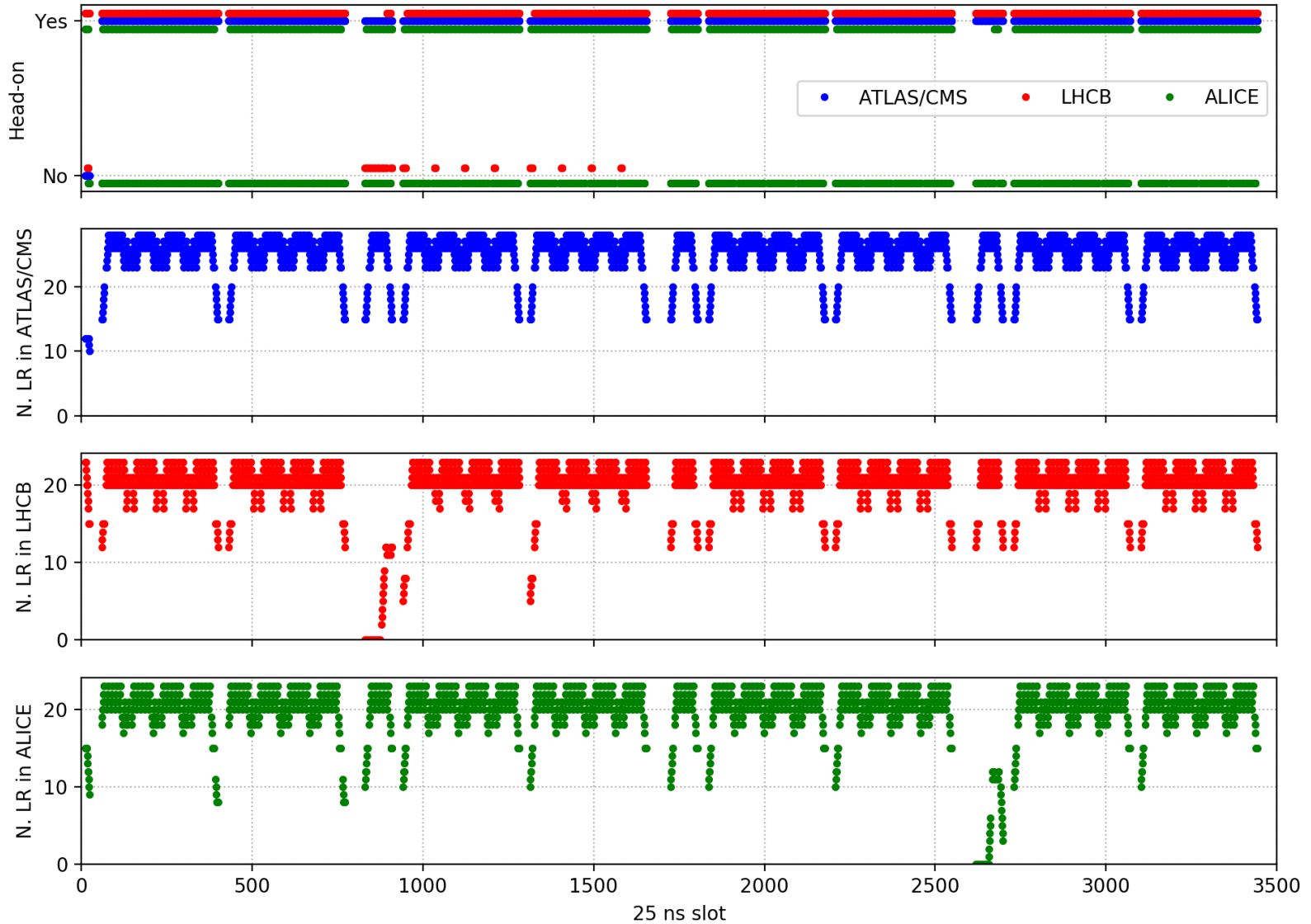# Beam-beam pattern analysis

CERN

25ns_2760b_2748_2492_2574_288bpi_13inj_800ns_bs200ns - beam 1

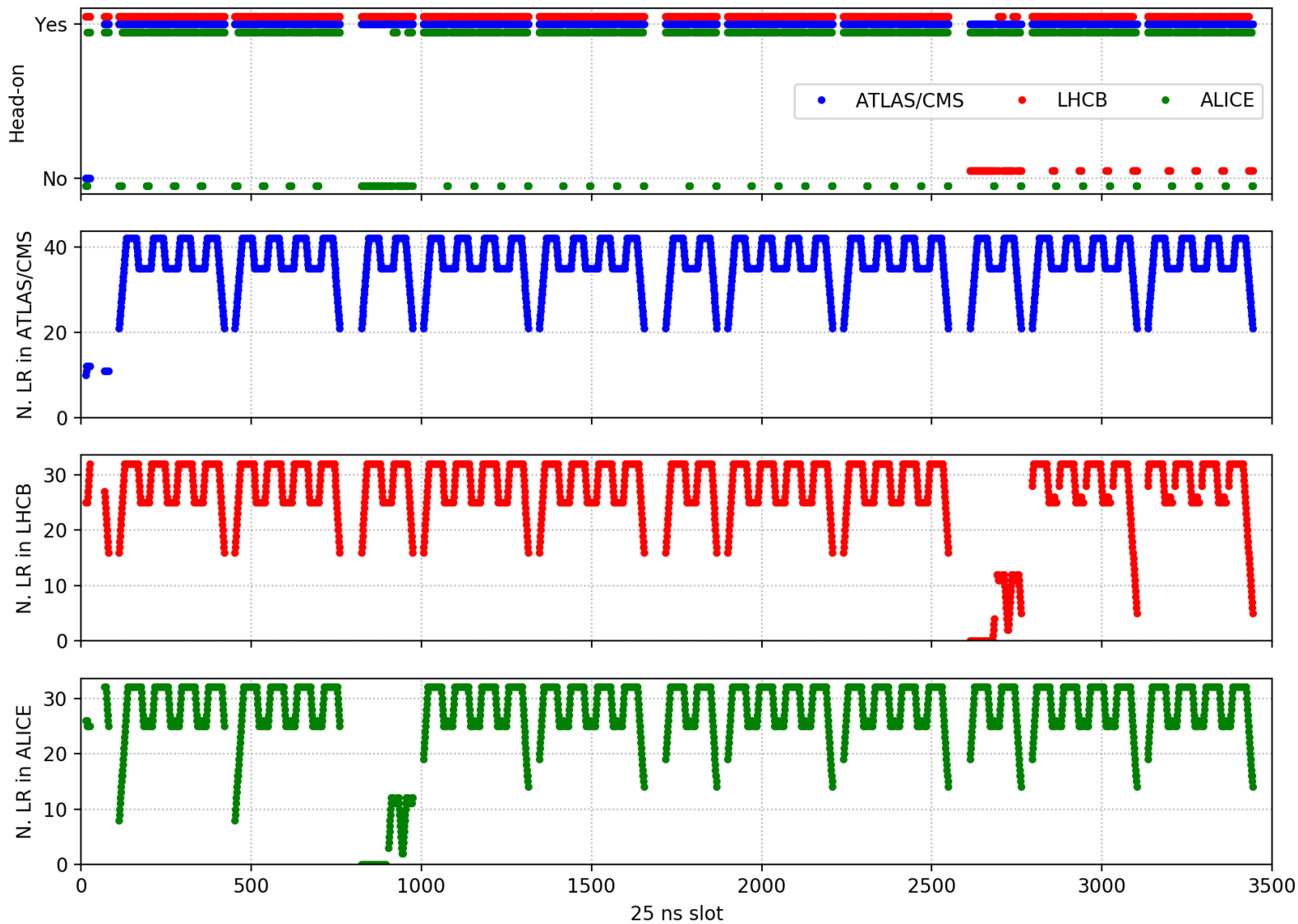25ns_2744b_2736_2246_2370_240bpi_13inj_800ns_bs200ns_BCMS_5x48b - beam 1
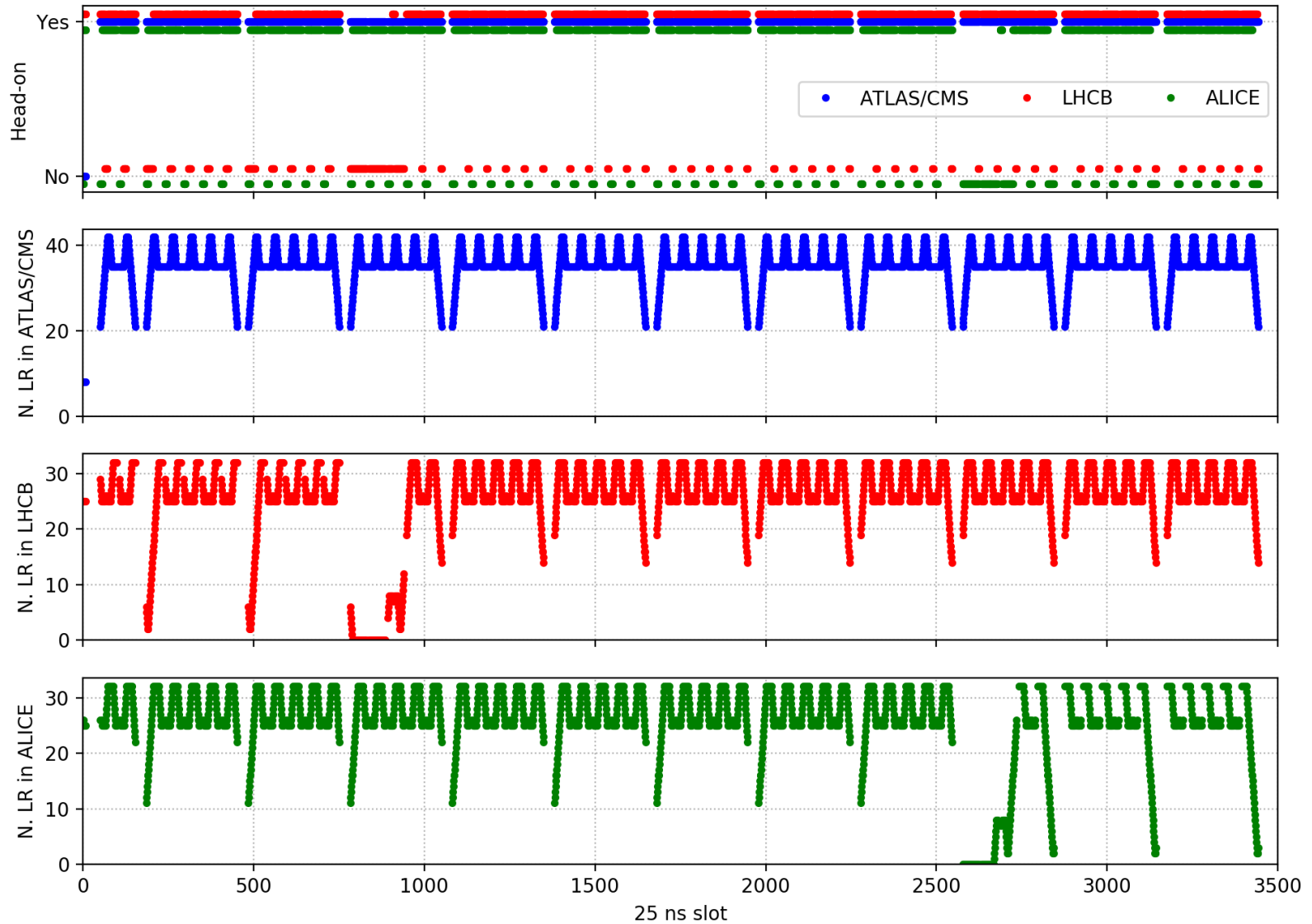
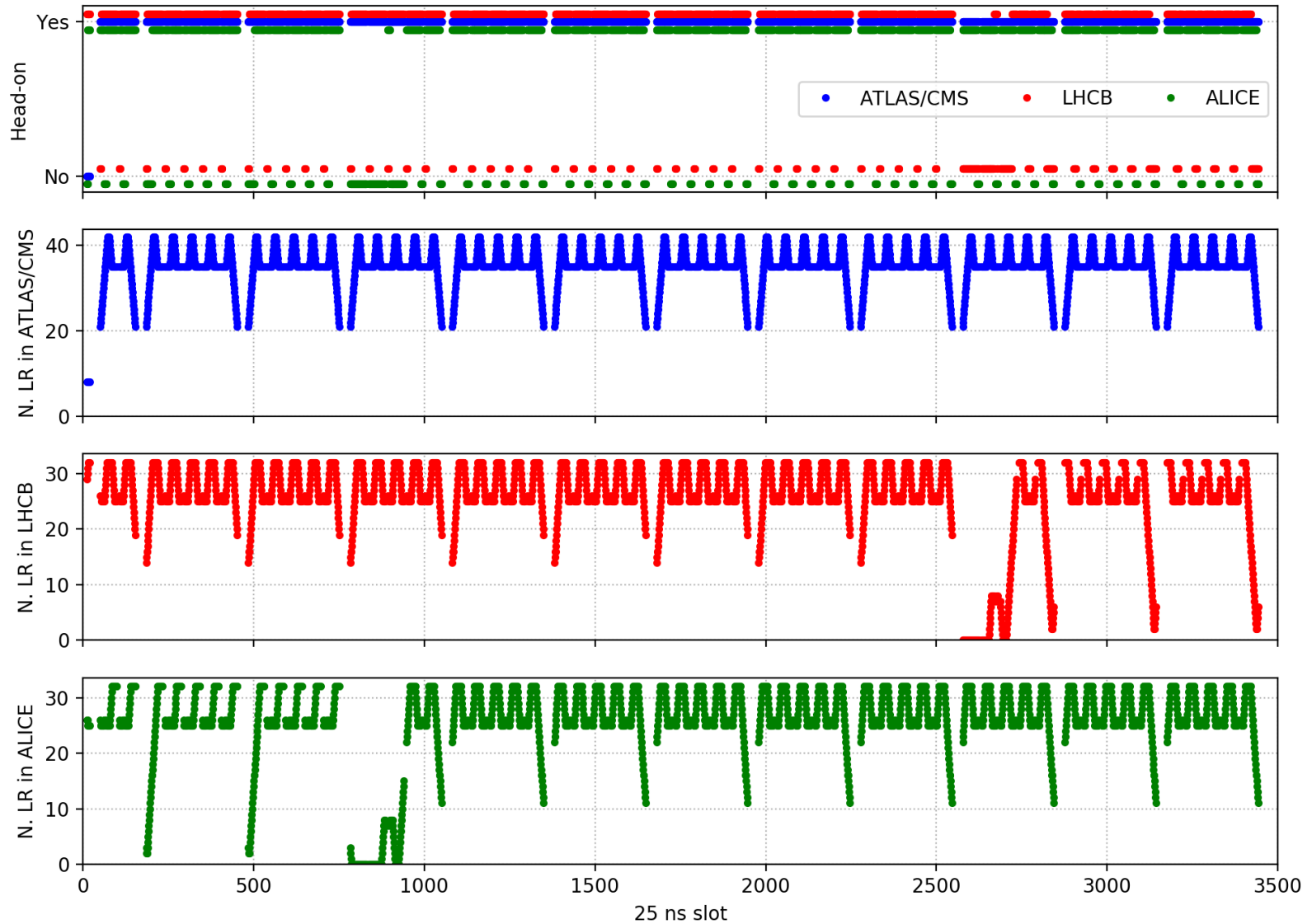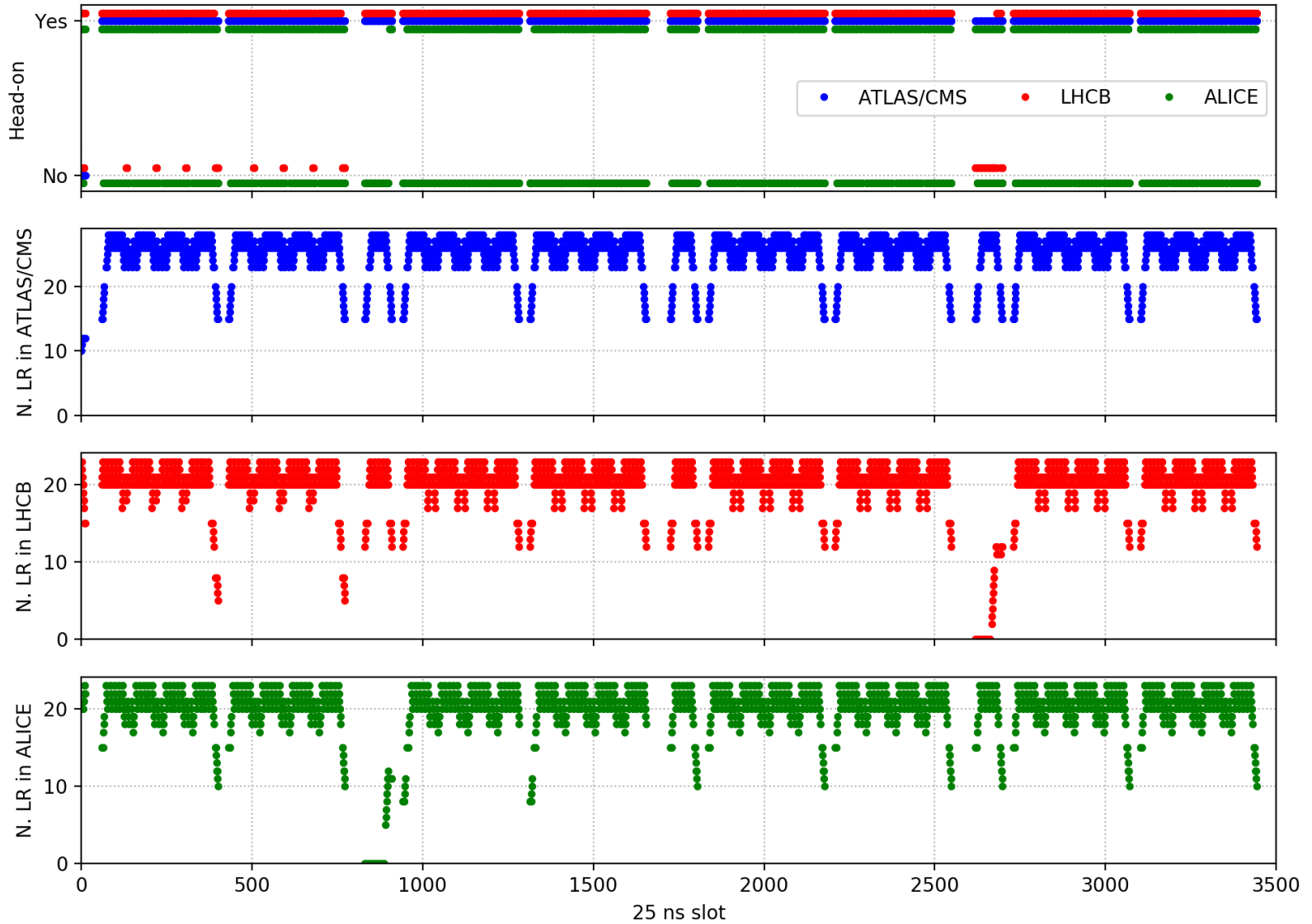8b4e_1972b_1960_1178_1886_224bpi_12inj_800ns_bs200ns - beam 1

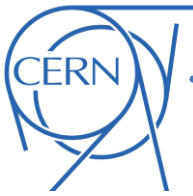25ns_2760b_2748_2492_2574_288bpi_13inj_800ns_bs200ns - beam 2

25ns_2744b_2736_2246_2370_240bpi_13inj_800ns_bs200ns_BCMS_5x48b - beam 2

8b4e_1972b_1960_1178_1886_224bpi_12inj_800ns_bs200ns - beam 2

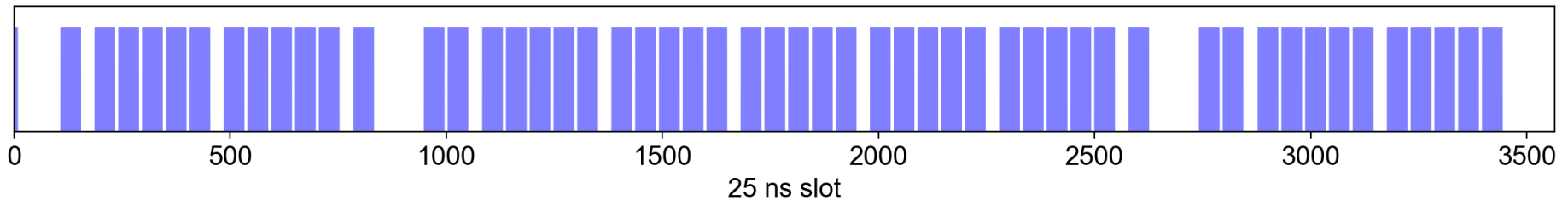**Filling scheme for coupling measurements**

BCMS coupling-measurement scheme

The OMC team asked to make a filling schemes having a **small number of bunches with no beam-beam encounters** (HO and LR) anywhere

- Modified the 48b scheme (thinking of Run 3) to get **8 bunches** with these characteristics
- On a first attempt this could be achieved with a loss of **~9% on the number of bunches** (considered acceptable if this scheme is used for example once every ~20 fills)

25ns_2504b_2496_1987_2092_240bpi_15inj_800ns_bs200ns_coupling

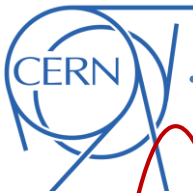25ns_2504b_2496_1987_2092_240bpi_15inj_800ns_bs200ns_coupling

N. collisions:		Patterns from SPS:
ATLAS/CMS:	2496	[8]
LHCb:	2092	[48, 48]
ALICE:	1987	[48, 48, 48, 48, 48]

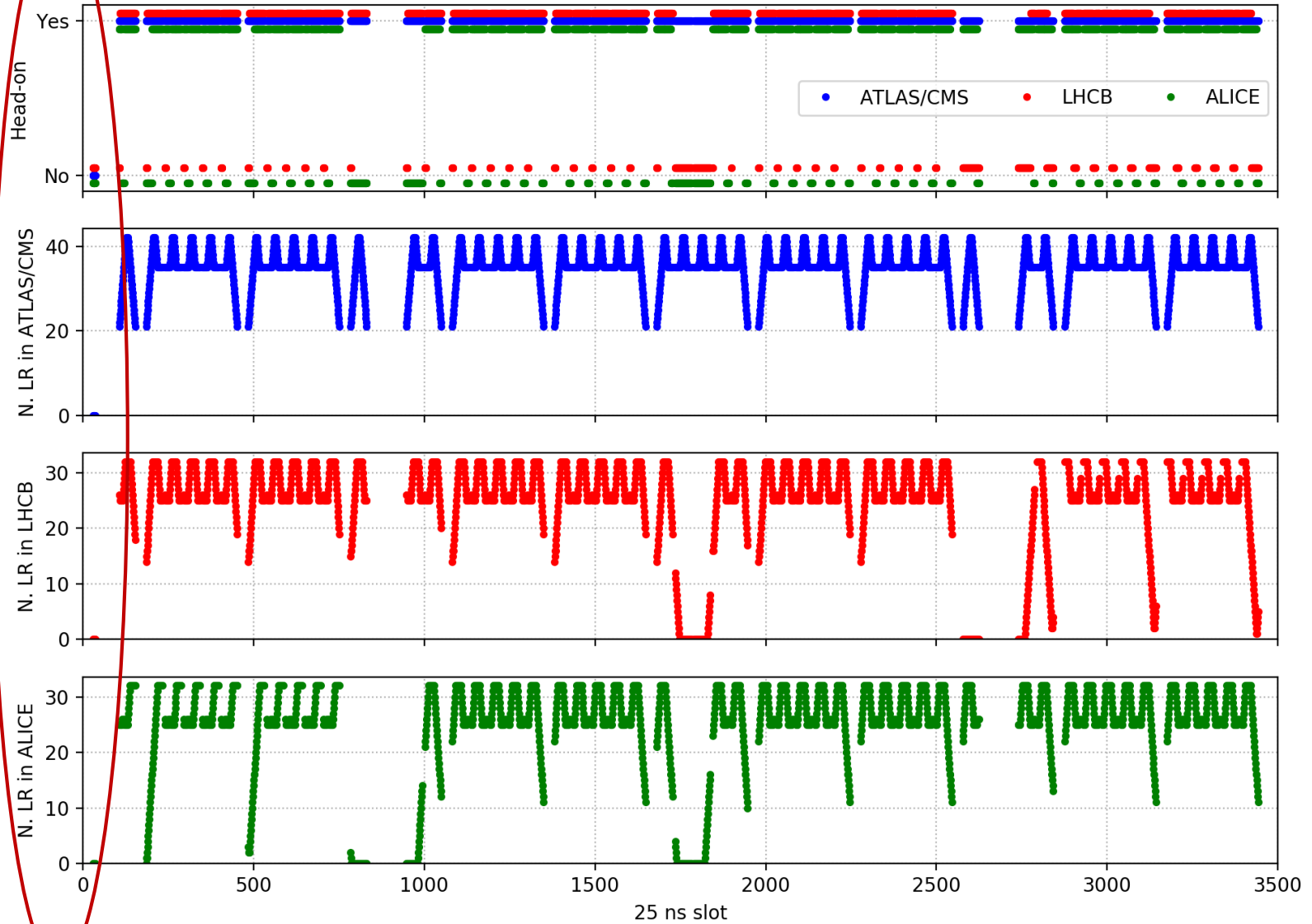| N. bunches:	2504	N. injections: 15

25ns_2504b_2496_1987_2092_240bpi_15inj_800ns_bs200ns_coupling_HL - beam 1

BCMS coupling-measurement scheme

25ns_2504b_2496_1987_2092_240bpi_15inj_800ns_bs200ns_coupling_HL - beam 2

Thanks. For your attention