

- ★ Goals & new Baseline 3.0
- ★ Lumi ramp-up in Run 4
- ★ Filling schemes
- ★ Beams request versus time
- ★ MD schedule for 2021
- ★ Ions

★ **Nominal goal:**  $250 \text{ fb}^{-1}/\text{year}$  to reach  $3000 \text{ fb}^{-1}$

	injection	→	collision
ppb [ $10^{11}$ ]	2.3	95% transmission	2.2
$\epsilon_{ave}$ [ $\mu\text{m}$ ]	2.1	IBS+10% blow-up	2.5
$N_{bunches}$	2760		

- Luminosity leveled with  $\beta^*$  @  $5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ , PU=132
- Injection with  $4 \times 72\text{b}$ .
- 50% machine efficiency (39% stable beam time)

★ **Ultimate goal:**  $320 \text{ fb}^{-1}/\text{year}$  to reach  $4000 \text{ fb}^{-1}$

- leveling @  $7.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ , PU=200
- 50% efficiency (34% stable beam time)
- Turn-around-time of 2.5 h



# New Baseline 3.0: Additional scope



- ★ Hollow Electron Lens (HEL) for halo removal.
- ★ A new LHC Beam Dump System (LHC BDS) with two more horizontal dilution kickers per beam.
- ★ Crystal Collimation in a basic configuration.



# Luminosity & intensity ramp-up in Run 4

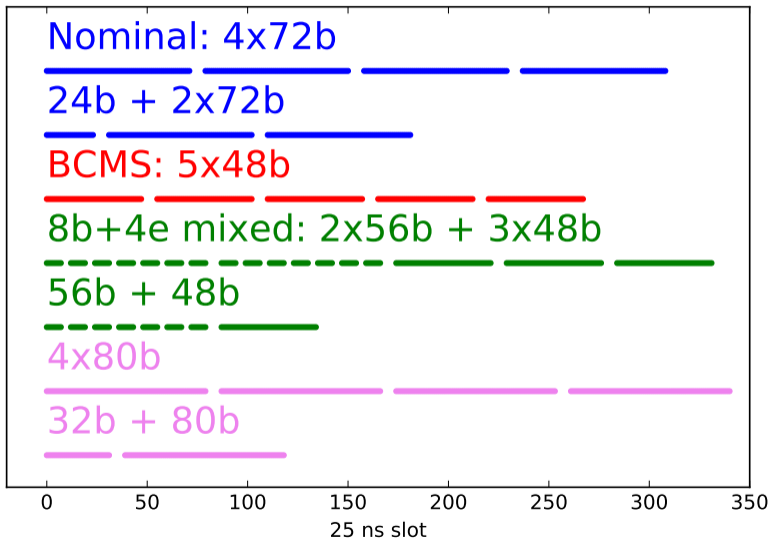


*Preliminary*

Year	ppb [ $10^{11}$ ]	Virtual lumi. [ $10^{34}\text{cm}^{-2}\text{s}^{-1}$ ]	Int. lumi. [ $\text{fb}^{-1}$ ]	$\beta^*$ [cm]	Crab cavity	HEL
2027	1.7	3.22	123	30	off	off
2028	2.2	6.01	202	25	off	on
2029	2.2	13.5	254	20	on	on
2030	2.2	16.9	262	15	on	on

Assuming for all:  $\epsilon = 2.5 \mu\text{m}$  and 160 days of operation (to be rescaled once it is decided).

# Key filling schemes from injectors





# Filling schemes performance

	Colliding bunches in			Heat-load
	IP1/5	IP2	IP8	
72b	2748	2495	2560	
72b+24b	2832 <b>+3.1%</b>	2560 <b>+2.6%</b>	2631 <b>+2.8%</b>	<b>+2%</b>
48b	2736 <b>-0.4%</b>	2246 <b>-10%</b>	2370 <b>-7.4%</b>	<b>-8%</b>
8b+4e mixed	2360 <b>-14%</b>	1784 <b>-28%</b>	2216 <b>-13%</b>	<b>-40%</b>
80b+32b	2896 <b>+5.4%</b>	2656 <b>+6.5%</b>	2734 <b>+6.8%</b>	<b>+7%</b>



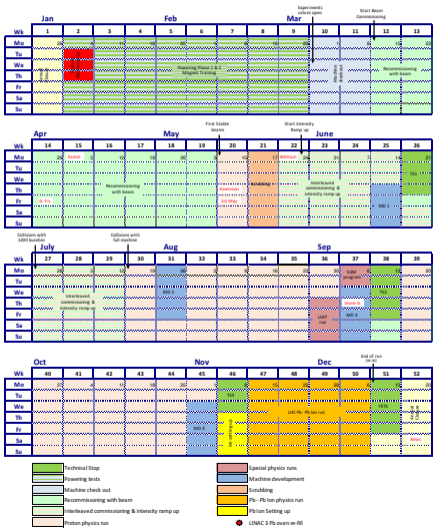
# 2021 MD schedule (To be updated - LMC)



25

LHC Schedule 2021  
DRAFT FOR DISCUSSION

November 21, 2019  
ver 002



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# LHC MDs for HL related to LIU in Run 3



- ★ Injection losses and TCDQ load from secondary halo
- ★ RF Voltage/power limitations and full detuning
- ★ e-cloud and beam-induced RF heating (MKI?)
- ★ Halo population and repopulation
- ★ Losses along the cycle
- ★ Impedance and instabilities
- ★ Emittance preservation and beam-beam
- ★ Bunch-by-bunch fluctuations
- ★ Ion crystal collimation (single ion bunch before ion run in 2021?)
- ★ BI coronagraph?





# RF voltage/power limitations

## Preliminary Settings for Run III (More Conservative)

- Based on 2018 experience & LIU-SPS parameters

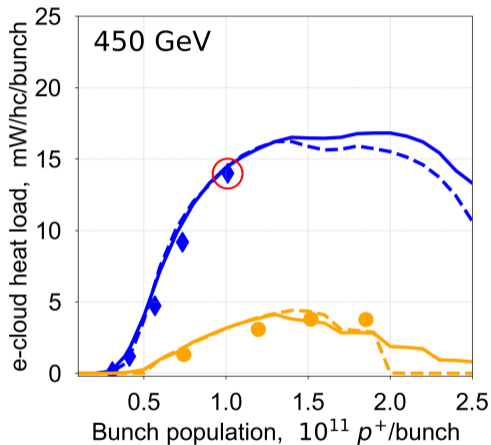
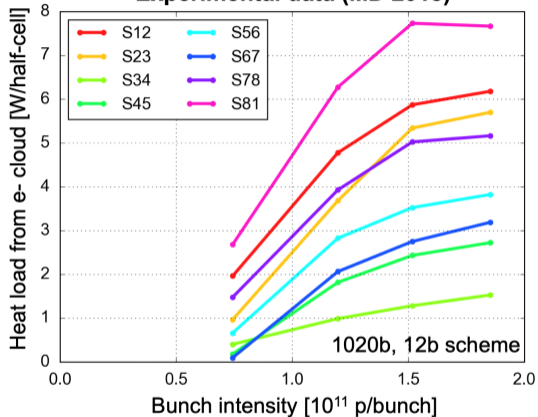
- Scaling the voltage according to momentum spread arriving

$$V' = \left(\frac{\delta'}{\delta}\right)^2 V$$

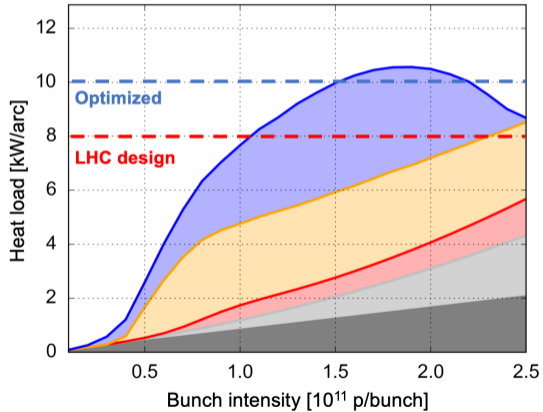
- Open question: how much can the LHC voltage be further reduced with improved energy matching, without compromising machine availability?

Era	Beam	V <sub>SPS,200</sub>	V <sub>SPS,800</sub>	Intensity	SPS beam parameters	V <sub>LHC</sub>
2018	BCMS	7 MV	-	1.15x10 <sup>11</sup> p/b	1.50 ns, 3.79x10 <sup>-4</sup>	4 MV
Run 3	STD	10 MV	-	1.8x10 <sup>11</sup> p/b	1.52 ns, 4.59x10 <sup>-4</sup>	5.9 MV
<b>Run 3</b>	<b>STD</b>	10 MV	2 MV	1.8x10 <sup>11</sup> p/b	1.52 ns, 5.05x10 <sup>-4</sup>	<b>7.1 MV</b>
HL-LHC	STD	10 MV	-	2.3x10 <sup>11</sup> p/b	1.65 ns, 4.95x10 <sup>-4</sup>	6.8 MV
<b>HL-LHC</b>	<b>STD</b>	10 MV	1.6 MV	2.3x10 <sup>11</sup> p/b	1.65 ns, 5.24x10 <sup>-4</sup>	<b>7.7 MV</b>

### Experimental data (MD 2018)



- E-cloud quadrupoles
- E-cloud dipoles
- E-cloud drifts
- Impedance
- Synchrotron radiation



# MD needs



2021:

- ★ RF, any intensity, LIU longitudinal emittance
- ★ Coll/Imp, Single bunch  $2.3 \times 10^{11}$  ppb with 2  $\mu$ m emittance

2022:

- ★ RF,  $\geq 1.8 \times 10^{11}$  ppb,  $4 \times 72$ b
- ★ e-cloud/heating,  $\geq 1.8 \times 10^{11}$  ppb, at least  $2 \times 48$ b
- ★ ABT, collimation, beam-beam etc, align to these 2022 requests

★ **Pb-Pb goal:** Reach  $10 \text{ nb}^{-1}$  in Run 4

	injection	→	collision
ipb [ $10^8$ ]	1.9	95% transmission	1.8
$\epsilon_{ave}$ [ $\mu\text{m}$ ]	1.5	10% blow-up	1.65
$N_{bunches}$	1232		

- Luminosity leveled with offset @  $6\text{-}7 \times 10^{27} \text{ cm}^{-2} \text{ s}^{-1}$
- Injection with 56 bunch trains

★ **Pb-Pb special run:**  $3 \text{ nb}^{-1}$  at low ALICE magnetic field

★ **p-Pb goal:** One run ( $190 \text{ nb}^{-1}$  achieved in 2016)

J. Jowett's Evian 2019 slides