HE-LHC Parameter Update

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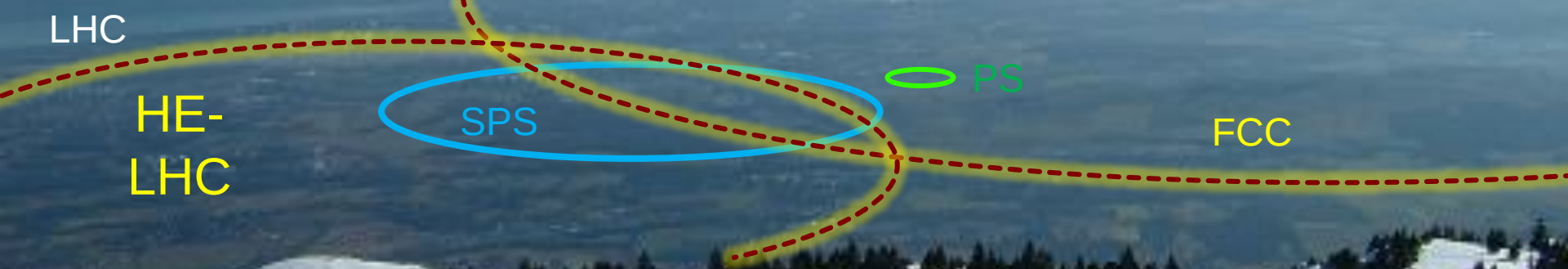
gratefully acknowledging input from FCC coordination group,
global design study team and all contributors



http://cern.ch/fcc

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photo: J. Wenninger

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changes / updates since FCC Week 2018

more realistic turnaround time
→ larger β*, longer physics fills, lower peak luminosity

pushed parameters of Nb_3Sn cable (APCs) & modified layout of the 16 T dipole magnets → revised field errors
+ refined optics → J. Keintzel, L. Van Riesen-Haupt
→ updated dynamic-aperture → M. Hofer
→ re-evaluation of injector options (scSPS)

longitudinal beam parameters → E. Shaposhnikova

cleaning & beam-loss studies including dispersion-suppressor collimators,revised settings → M. Crouch, M. Varasteh, H. Pikhartova

updated impedance model & instability growth rates → D. Amorim

Performance Assumptions

- 160 days scheduled for physics per year for HL-LHC, HE-LHC, FCC-hh

- Availability: (LHC 2017: 83%); HL-LHC: 80%; HE-LHC 75 %, FCC-hh: 70%

corresponding to the following fractions of "time in physics":

HL-LHC:	54%
HE-LHC:	39%
FCC-hh phase I (initial):	49%
FCC-hh phase II (nominal):	34%

FCC-hh, HE-LHC, HL-LHC performance

parameter	FCC-hh$_{nominal}$	FCC-hh$_{initial}$	HE-LHC	HL-LHC	LHC 2017
allocated physics time T [days]	160	160	160	160	160
peak luminosity $\hat{L}$ [10^{34} cm^{-2}s^{-1}]	30	5	**16**	5 (levelled) [7.5 ult.]	1.5 (levelled)
availability A [%]	70	70	75	80 [85 ult.]	82
average turnaround t_{ta} [h]	4	5	**5**	4 [4]	5 (w/o faults)
(optimum) run time t_{run} [h]	3.7	11.6	**5.3**	8-13 [6.5]	~10
nominal luminosity / day L_{av} [fb^{-1}]	9.0	2.2	4.2	1.9 [2.3]	0.4
time-fraction in physics t_{phys} [%]	**34**	**49**	**39**	**54** [53]	**55**
int. luminosity L_{int} [fb^{-1} / year]	**1000**	**250**	**500**	**250** [310 ult.]	**60**

$$t_{\mathrm{phys}} \approx A \frac{t_{run}}{t_{run} + t_{ta}} \qquad L_{\mathrm{int}} \approx A\, T\, L_{\mathrm{nominal\ per\ day}}$$

all these hadron machines feature two high-luminosity experiments and up to two lower-luminosity (or special) interaction points

HE-LHC parameters

parameter	FCC-hh		HE-LHC	HL-LHC	LHC 2018
c.o.m. collision energy [TeV]	100		27	14	13
injection beam energy [TeV]	3.3		1.3 (0.9)	0.45	0.45
dipole field [T]	16		16	8.33	7.74
circumference [km]	97.75		26.7	26.7	26.7
beam current [A]	0.5		1.12	1.12	0.49
bunch intensity [10^{11}]	1	1	2.2	2.2	1.1
bunch spacing [ns]	25	25	25	25	25
synchr. rad. power / ring [kW]	2400		100	7.3	2.3
SR power / length [W/m/ap.]	28.4		4.6	0.33	0.11
long. emit. damping time [h]	0.54		1.8	12.9	16.1
initial proton burn-off time [h]	17	3.4	4.3	15	16
beta* [m]	1.1	0.3	0.45	0.15 (min.)	0.30 (0.25)
normalized emittance [μm]	2.2		2.5	2.5	2.0
peak luminosity [10^{34} $cm^{-2}s^{-1}$]	5	30	16	5 (levelling)	2.1
int. luminosity / year [fb^{-1}]	250	1000	500	250	63
events/bunch crossing	170	1000	460	132	60
stored energy/beam [GJ]	8.4		1.3	0.7	0.28