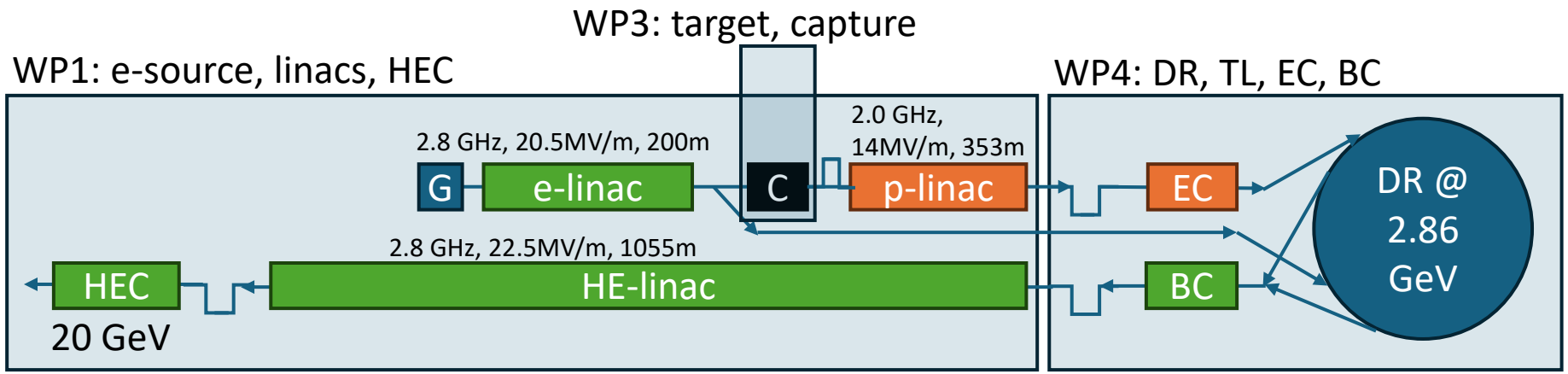
WP1: FCCee injector linacs status report

Alexej Grudiev on behalf of the WP1

29/08/2024

New baseline layout (4 AS/module, 4 bunches@100 Hz)



Running mode	Z	WW	ZH	ttbar	Unit
Beam energy at inj. end	20				GeV
Number bunches/ring	11200	1780	440	60	
Maximum bunch charge	≥ 4				nC
Bunch charge in top up	3.43	1.39	1.11	1.49	nC
Number of bunches	~~2~~ -> **4**	2	2	2	
Linac rep. rate	~~200~~ -> **100**	100	50	50	Hz
Bunch spacing	25	150	**600 ?**	**4400 ?**	ns
Norm. emittance (x, y) (rms) (BR)	~~<10,10~~ -> **20, 2**				mm mrad
Energy spread (rms) (BR)	~0.1				%
Bunch length (rms) (BR)	~1 -> 6mm				mm

For filling from scratch

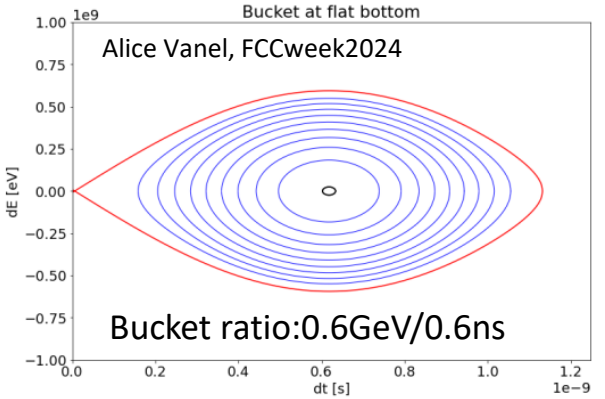
For top-up injection

Too large for ttbar and ZH

Can be larger before DR

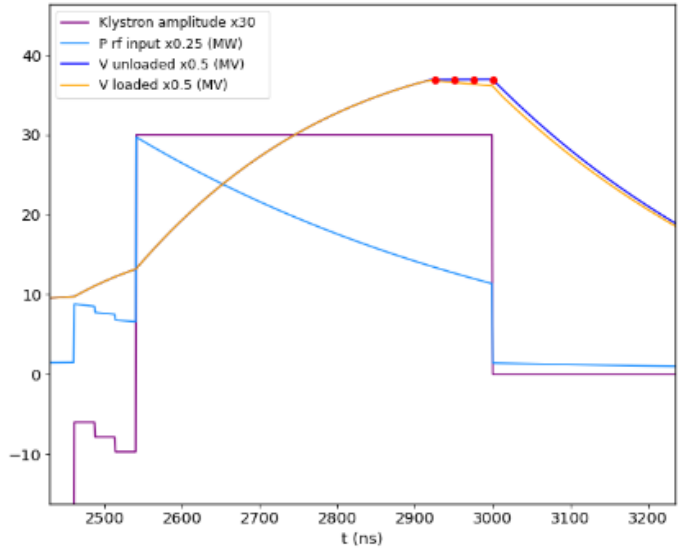
Target values for HEC design

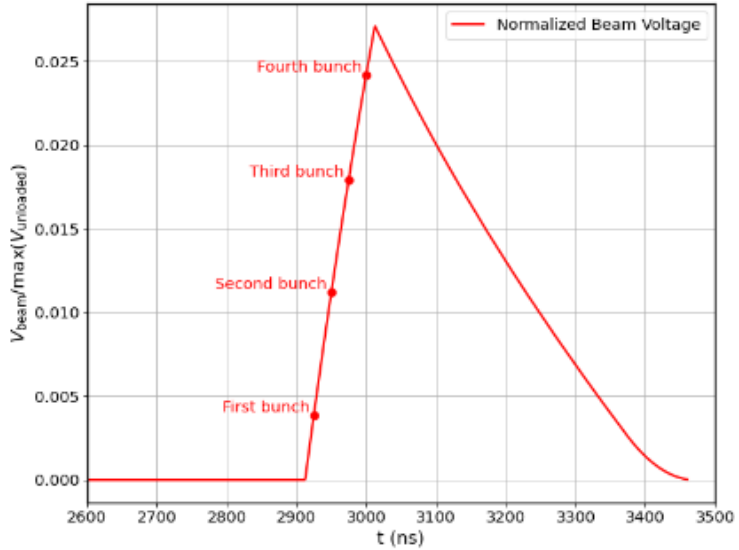
6mm if matched to the BR bucket



RF design studies in HE-linac

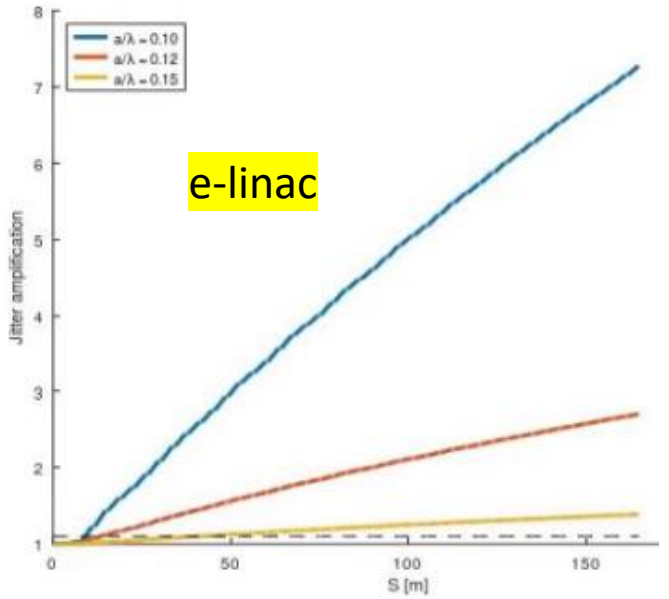
- RF parameters updated for new baseline
- Bunch to bunch energy spread compensation has been studied. It can be reduced to the level below the single-bunch energy spread. <0.1%
- Beam loading is increased at lower gradient in the new baseline up to 2.5% for the 4th bunch.
- Same method is used to compensate beam loading energy spread to the level <0.1% for a given bunch intensities
- Accelerating voltage for 4 bunches is ~4% lower compared to 1 bunch. This must be accommodated in the new baseline:
  - ~ 4% longer linac
  - Longer RF pulse length: 3 us -> 4 us
- …

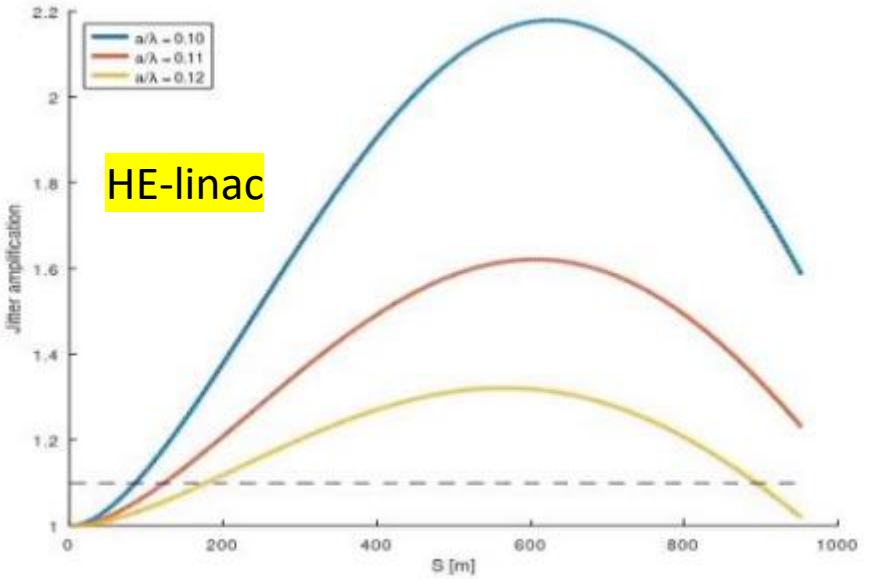




Beam dynamics in e- and HE-linac

- Static effects in the new baseline have been studied. Emittance growths is acceptable:
  - e-linac, Δε=0.3 mm.mrad for a/l = 0.15, Δε=**1.2 mm.mrad** for a/l = 0.12
  - HE-linac, Δε=**0.6 mm.mrad** for a/l = 0.12, (ε_y=1mm.mrad after DR)
- Dynamic effects:
  - Single-bunch litter amplification ----------→
    - e-linac: 1.4 for a/l = 0.15, 2.7 for a/l = 0.12 (is it OK ?)
    - HE-linac is very small ~1 due to BNS-like damping
  - Multi-bunch jitter amplification in
    - HE-linal is well below 1.1, very good
    - e-linac is twice higher ~1.3, still good since we have DR
- Still several questions to be addressed before final design:
  - Jitter at the DR extraction? Extraction kicker?
  - Requirements for e-linac: DR or p-production target? What is more critical? What are the beam parameters?
  - Can the small aperture AS a/l=0.12 be used in the e-linac?
  - Can we rely on the damping in HE-linac? Need to do more parametric stidies



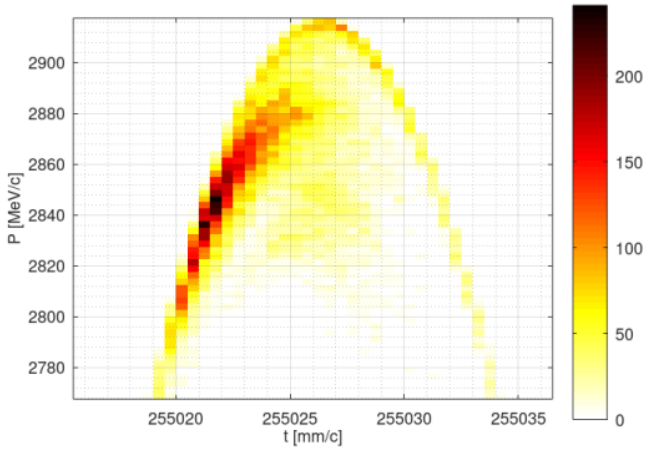


Beam dynamics in p-linac

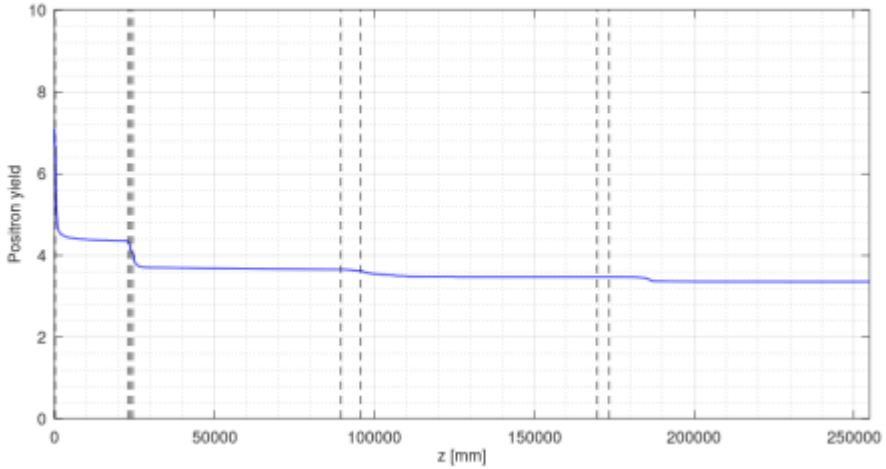
- New baseline (14MV/m) is compared to the old (20 MV/m):
  - Positron yield is very similar: 3.35 vs 3.2. No cuts for DR acceptance
- Similar losses in the chicane. New one with larger aperture is under design
- Solenoidal focusing up to 1 GeV, we will investigate the impact of shorter solenoid section on the positron yield
- **Energy compressor is not included yet. We need the EC design from WP4 as well as acceptance of the DR@2.86GeV**

- At PL exit (without DR acceptance cuts)

Positron yield: 3.35



- **Yield evolution**



New specification on the required bunch spacing granularity in the FCCee collider: 2.5 ns -> 5 ns

FUTURE CIRCULAR COLLIDER

CERN
1211 Geneva 23
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Minutes of the
152nd Coordination Group Meeting and joint 41st Technical Coordination Group Meeting

Written by Frank Zimmermann

Date: 9 August 2024

Location: 30/6-019 and Zoom

Indico: https://indico.cern.ch/event/1408235

Participants: W. Bartmann, M. Benedikt, O. Brunner, P. Charitos, P. Craievich, F. Eder, A. Grudiev, K. Hanke, P. Janot, R. Losito, E. Tsesmelis, T. Watson, G. Wilkinson, F. Zimmermann

7 AoB

A. Grudiev commented that, for FCC-ee, a linac RF frequency of 3 GHz had been excluded at some past review since it ruled out bunch spacing changes in steps of 2.5 ns.

F. Zimmermann and **M. Benedikt** replied that 3 GHz would be fine, and that spacings equal to multiples of 5 ns would offer sufficient flexibility for the operational scenarios.

- 5 ns granularity (bunch spacing = N*5ns) means that the RF frequency in the injector linacs can be harmonics of 200 MHz
- ☺ This opens the possibility to use **3 GHz** RF frequency instead of 2.8 GHz in the e- and HE- linacs
- Unfortunately, due to un-availability of resources we will have to stay at 2.8 GHz for the feasibility report and change to 3 GHz only next year

- 😐 The exact RF frequency is 400.8*15/2 = **3006 MHz.** It is not exactly the commercial EU S-band frequency: **2998.5 MHz**
- The difference is **7.5 MHz** which is not negligible compared to the typical high power klystron bandwidth and has to be addressed:
  - Injecting on the BR slightly off centre of the bucket: up to few sigma_z depending on the number of bunches: injection oscillation at the flat bottom, stability. ?
  - Using HEC to adjust the bunch spacing after HE-linac: large R56 and/or energy spread. ?
  - Operating at 3006 MHz, still much better than 2.8GHz: use of existing (narrow band) hardware is limited
- ..