Update meeting n. 20

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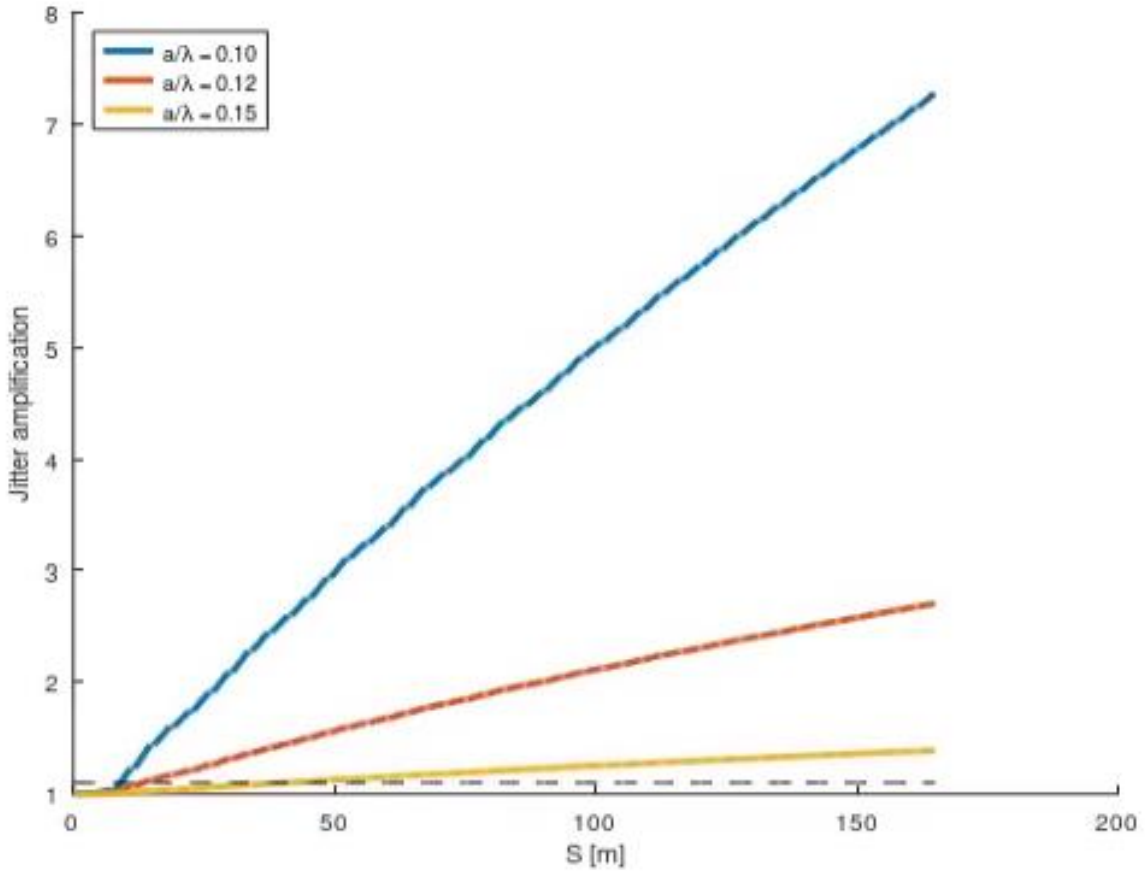
Outlook

- **Electron linac: do we want to shrink the RF aperture?**
- **HE linac energy compressor**
  - Possible layout identified
  - Advantages and disadvantages
  - Discuss the parameters with the booster people?
- **More consideration on the present and future design (tbd-extra slides)**
- **Conclusions**

From meeting n. 18

- G = 20.5 MV/m
- L = 3 m
- Scan a/l = 0.10, 0.12, 0.15



	L = 3 m	L = 4 m
a/l = 0.10	7.25	13.40
a/l = 0.12	2.73	4.15
a/l = 0.15	1.40	1.75

How much can we tolerate for the DR injection?
How much is the reduction due to the DR?

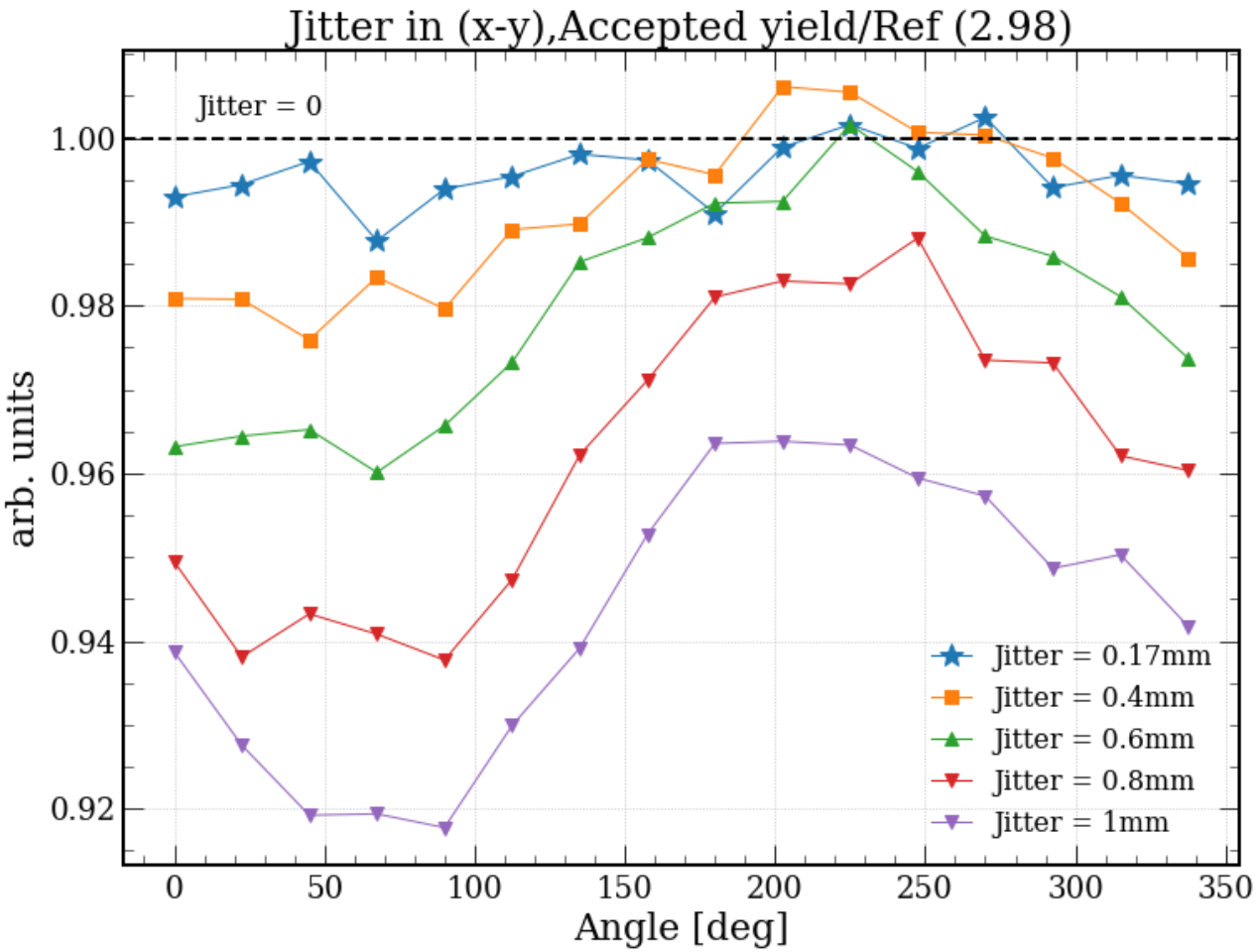
Discussion ongoing on the jitter only in position from the JA

Jitter tolerance from the positron group

Reminder:

- Jitter of 0.17mm → presently a/l = 0.15
- Jitter of 0.4mm → presently a/l = 0.12

Courtesy of Fahad and Iryna



In my slides we investigated the maximum Jitter which was 1mm (in x,y most critical) results in 10% drop in the yield => not acceptable.

However, attached you can find the results of a jitter scan based on the values you provided : 0.17mm, 0.4mm, 0.6mm, 0.8mm, 1mm

- Jitter of 0.17mm => yield drops by ~ 1% => **acceptable**
- Jitter of 0.4mm => yield drops by ~ 2% => **tolerable**

Above 0.4mm is **not tolerable**.
Fahad

Same question made to the DR group

HE energy compressor

Possibility 1: residual chirp from BC downstream DR (asked in the past to Simone Spampinati):

- We need a chirp opposite to that used for BC
- Simone should invert the sign of R56
- The chirp must be very large: 0.3-0.4% at 20 GeV, which corresponds to few % at ~3 GeV. This would correspond to large chromaticity

Possibility 2: we use as extra knob the bunch length after BC

- No issues with the chromatic effects
- Better for emittance and jitter
- More loading

Option 2: shortening the electron bunch from BC

Along HE I put the bunch length = 0.8 mm, and I tune R56 to have around 4 mm bunch length. I vary the voltage to have ~0.1%

V = 542 MV (S-band, G = 22.5 MV/m)
R56 → angle_d = 0.1124*1.45;
L_dip = 5*1.45;
L_dr1 = 6;
Bunch length ok
R56 ok → ~0.6 m
Single bunch energy spread ~0.04-0.06%
Distance among the bunches~2.3 mm per bunch → 6.9 mm maximum

Final bunches n. 1
rms bunch length = 3.9365 mm
rms dp/p = 0.041172%

Final bunches n. 2
rms bunch length = 3.9001 mm
rms dp/p = 0.037975%
Dt = -2.3386 mm/c
Dp = 13.9035 MeV/c

Final bunches n. 3
rms bunch length = 3.8643 mm
rms dp/p = 0.039568%
Dt = -2.3118 mm/c
Dp = 15.9625 MeV/c

Final bunches n. 4
rms bunch length = 3.829 mm
rms dp/p = 0.057925%
Dt = -2.2855 mm/c
Dp = 19.2377 MeV/c

V = 663 MV
Between 0.10-0.15%
Multi-bunch = 2.2e-4
Bunch length ok
R56 ok → ~0.6 m
Single bunch energy spread ~0.1-0.16%

Final bunches n. 1
rms bunch length = 3.9365 mm
rms dp/p = 0.16362%

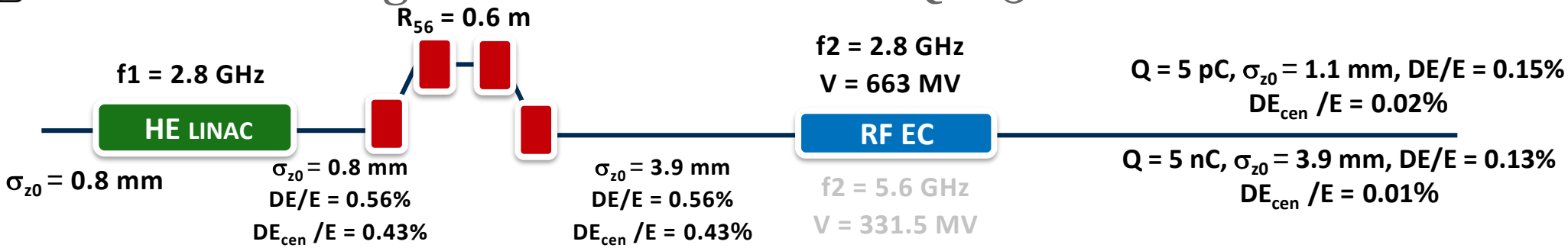
Final bunches n. 2
rms bunch length = 3.9001 mm
rms dp/p = 0.15135%
Dt = -2.3385 mm/c
Dp = -2.1511 MeV/c

Final bunches n. 3
rms bunch length = 3.8642 mm
rms dp/p = 0.12741%
Dt = -2.3117 mm/c
Dp = 0.36662 MeV/c

Final bunches n. 4
rms bunch length = 3.8289 mm
rms dp/p = 0.094818%
Dt = -2.2853 mm/c
Dp = 4.3707 MeV/c

Results: single and multi-bunch at Q = 5 nC

To be included autophasing if different versus charge



At the exit of the EC (Q = 5 nC)

	Bunch 1	Bunch 2	Bunch 3	Bunch 4
Single bunch DE/E (%)	0.16	0.15	0.13	0.10
Rms bunch length (mm)	3.94	3.90	3.86	3.83
DE/E centroid from bunch 1 (%)	0	-0.018	-0.019	-0.042
Dt from bunch 1 (mm/c)	0	2.34	4.65	6.94

At the exit of the EC (design)-"null" bunch charge (5 pC)

	Bunch 1	Bunch 2	Bunch 3	Bunch 4
DE/E (%)	0.16	0.16	0.15	0.15
Rms bunch length (mm)	1.1	1.1	1.1	1.1
DE/E centroid (%)	0	-0.0325	-0.0207	-0.0007

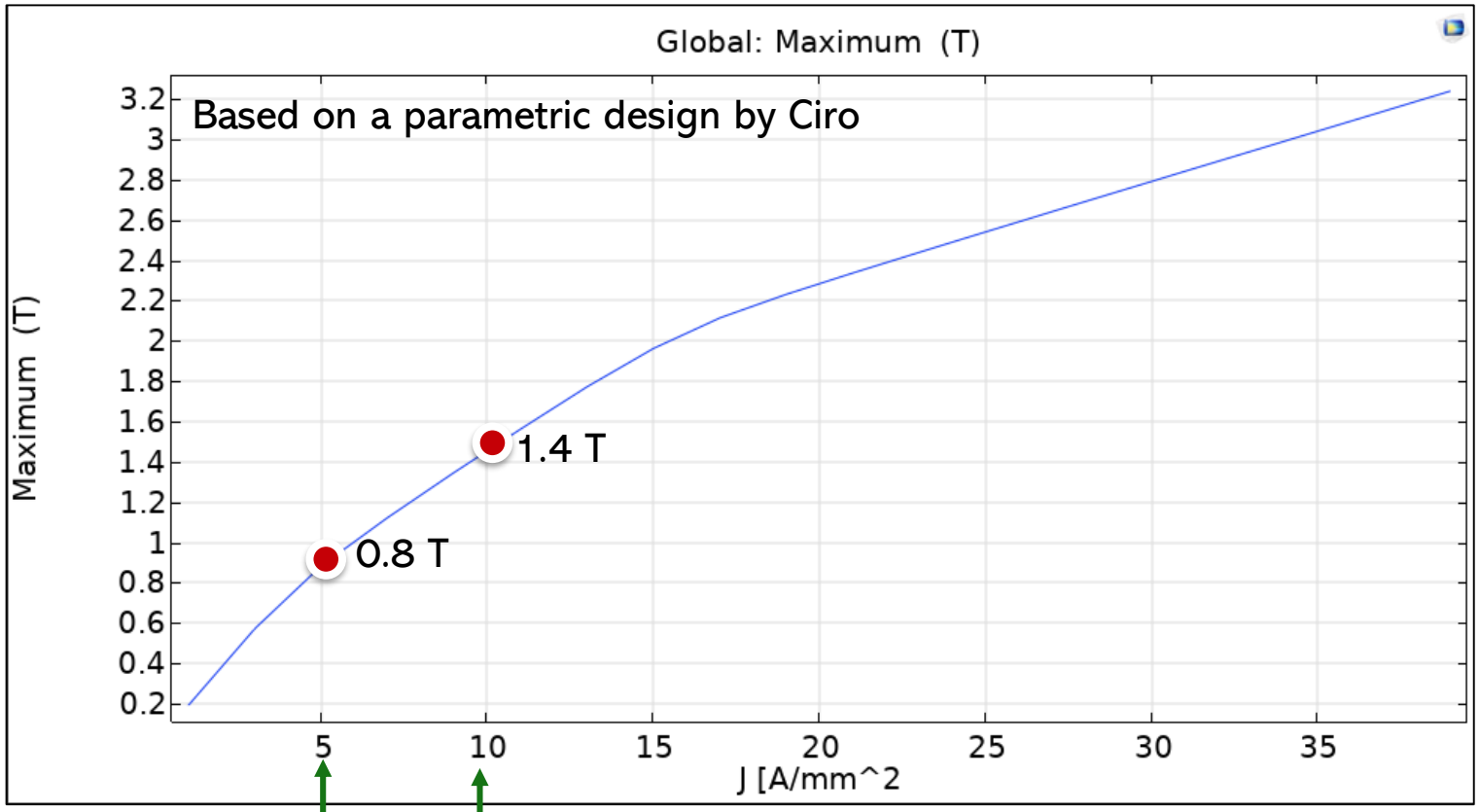
Conclusions and proposal:

- This seems to be a good setting for DE/E and bunch length
- Is the extra time separation among the bunches acceptable?
- Minimum bunch length and minimum DE/E for instabilities mitigation → can the low Q parameters be acceptable?
- Call a short meeting or send an e-mail to them to have the ok from them?

My view
(maybe wrong, maybe not)

	Min DE/E	Max DE/E	Min Dt	Max Dt
Low Q	Important?	Dynamic aperture	Important?	Filamentation? Bucket?
High Q	Instabilities	Dynamic aperture	Instabilities	Filamentation? Bucket?

Field in a NC bend

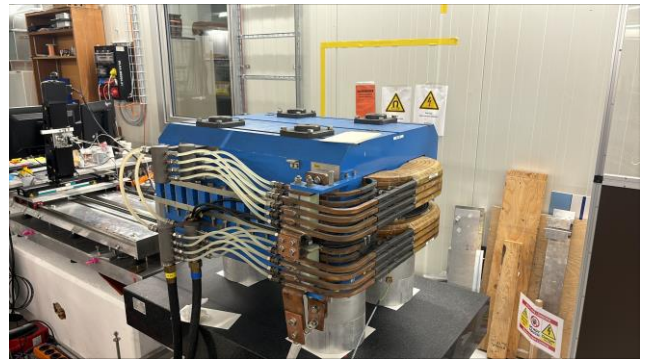


Air cooled (5 A/mm^2)

Water cooled (~10 A/mm^2)

Conservative numbers

Great courtesy of Ciro Calzolaio (PSI)

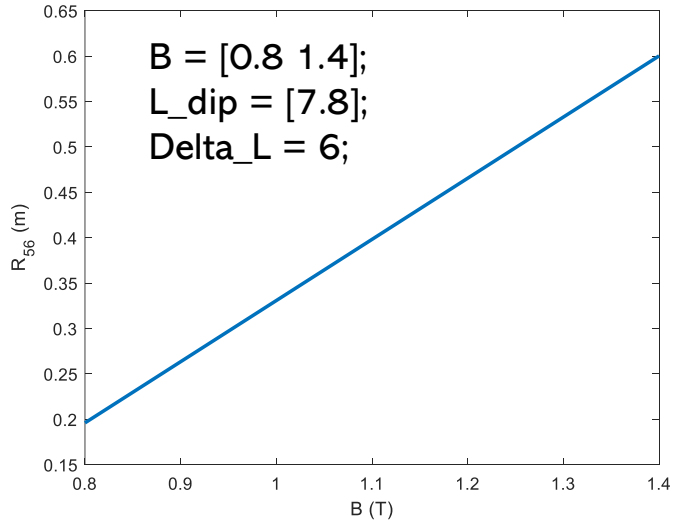


Length = 0.5 m

Full gap = 32 mm

Dimensioning

Chicane NC dipoles (thanks to the computations by Ciro):



Computed:
R_{56}: 0.60019 m
R_{56_2}: 0.60019 m

Total length = 7.8*4+6*2+central drift = 19.8 + central drift ~ 25 m

RF voltage (using the 0.1-0.15% case for DE/E-the other one less voltage required)

Voltage: 803.5-663 = 140.5 → 140.5/22.5 = 6.24 m less than before with even larger R56 (meeting n. 19)

Full length

HE LINAC	MATCHING SECTION	CHICANE	RF STRUCTURES	MATCHING SECTION
NC, S-band → L_TOT = 5	+	(40-15)	+ (35.71-6.24)*1.2	+ 5

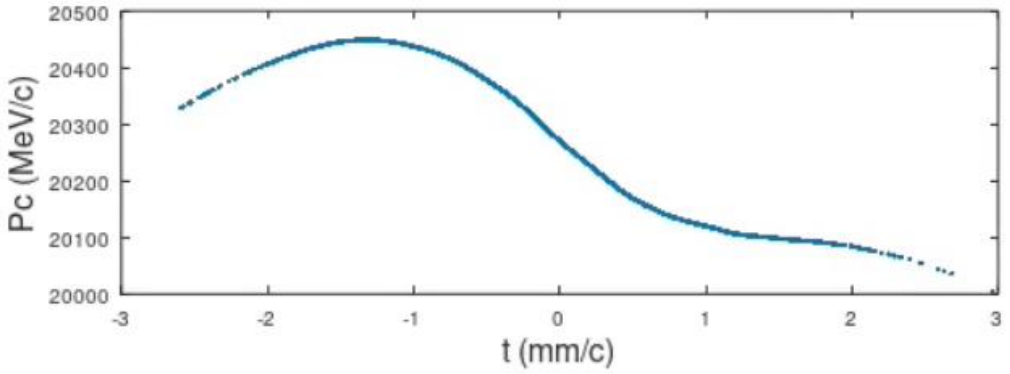
= 92.9-22.5 m ~70 m

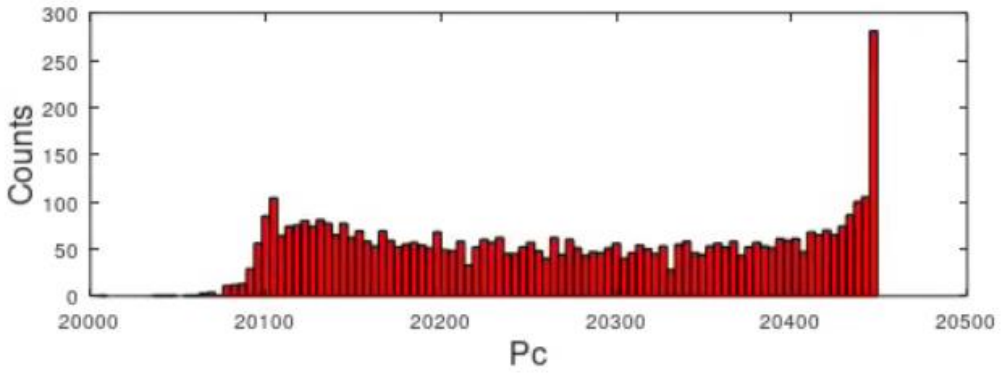
How the beam longitudinal phase space looks like

Single bunch here, because after there is the manipulation in RF-Track

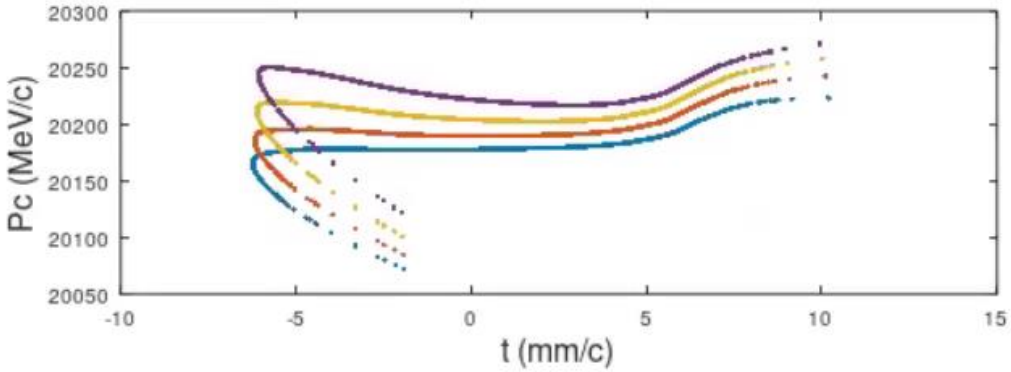
Check
Lstr_EC = 542/22.5 and G = 22.5 MV/m. Is that ok? Is that the maximum?

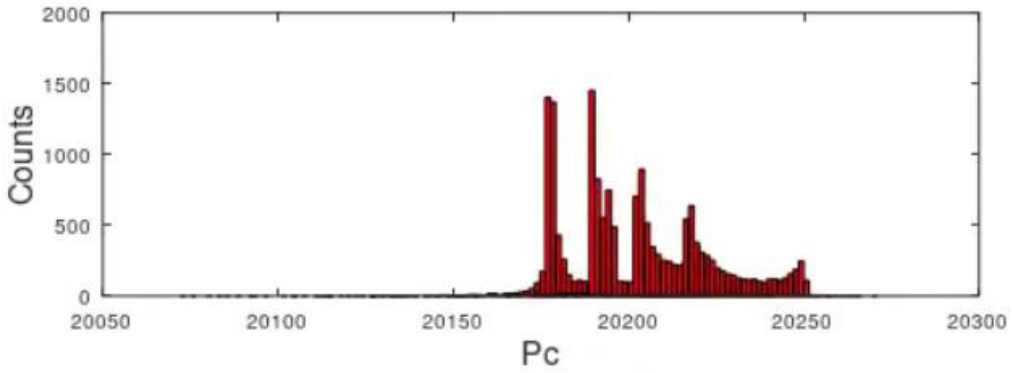
Bunch at the end of HE linac
rms bunch length = 0.79805 mm
rms dp/p = 0.57153%





Bunches at the end of EC
I move them by the initial separation (lambda of the RF of HE linac)



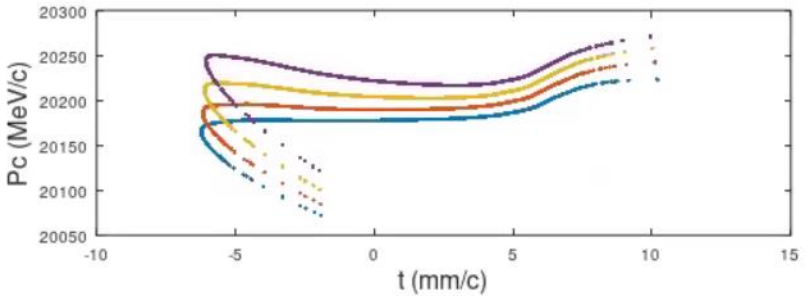


Lstr_EC = 24.08888888888889
Final bunches n. 1
rms bunch length = 3.9107 mm
rms dp/p = 0.045413%
Final bunches n. 2
rms bunch length = 3.8748 mm
rms dp/p = 0.042099%
Dt = -2.3384 mm/c
Dp = 13.9315 MeV/c
Final bunches n. 3
rms bunch length = 3.8395 mm
rms dp/p = 0.042609%
Dt = -2.3117 mm/c
Dp = 16.0859 MeV/c
Final bunches n. 4
rms bunch length = 3.8047 mm
rms dp/p = 0.059161%
Dt = -2.2853 mm/c
Dp = 19.4509 MeV/c

Case corresponding to low DE/E

Reducing the voltage (same case as before)

V = 542 MV



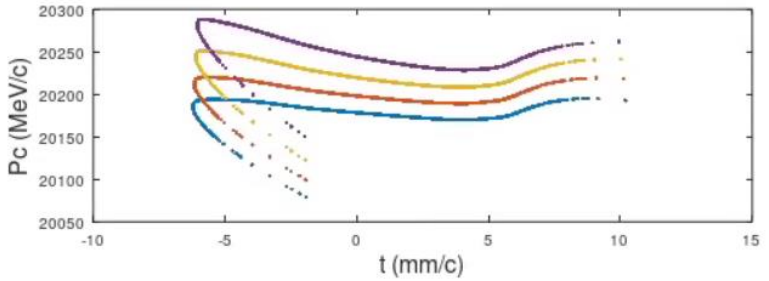
Lstr_EC = 24.08888888888889
Final bunches n. 1
rms bunch length = 3.9107 mm
rms dp/p = 0.045413%

Final bunches n. 2
rms bunch length = 3.8748 mm
rms dp/p = 0.042099%
Dt = -2.3384 mm/c
Dp = 13.9315 MeV/c

Final bunches n. 3
rms bunch length = 3.8395 mm
rms dp/p = 0.042609%
Dt = -2.3117 mm/c
Dp = 16.0859 MeV/c

Final bunches n. 4
rms bunch length = 3.8047 mm
rms dp/p = 0.059161%
Dt = -2.2853 mm/c
Dp = 19.4509 MeV/c

V = 542*0.9 MV



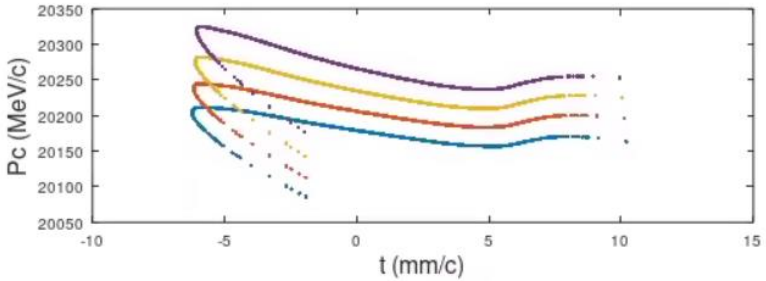
Lstr_EC = 21.68000000000000
Final bunches n. 1
rms bunch length = 3.9107 mm
rms dp/p = 0.04552%

Final bunches n. 2
rms bunch length = 3.8749 mm
rms dp/p = 0.055319%
Dt = -2.3385 mm/c
Dp = 21.3141 MeV/c

Final bunches n. 3
rms bunch length = 3.8396 mm
rms dp/p = 0.073602%
Dt = -2.3117 mm/c
Dp = 23.2478 MeV/c

Final bunches n. 4
rms bunch length = 3.8048 mm
rms dp/p = 0.10043%
Dt = -2.2854 mm/c
Dp = 26.2686 MeV/c

V = 542*0.8 MV



Lstr_EC = 19.27111111111111
Final bunches n. 1
rms bunch length = 3.9107 mm
rms dp/p = 0.095481%

Final bunches n. 2
rms bunch length = 3.8749 mm
rms dp/p = 0.10507%
Dt = -2.3385 mm/c
Dp = 28.3758 MeV/c

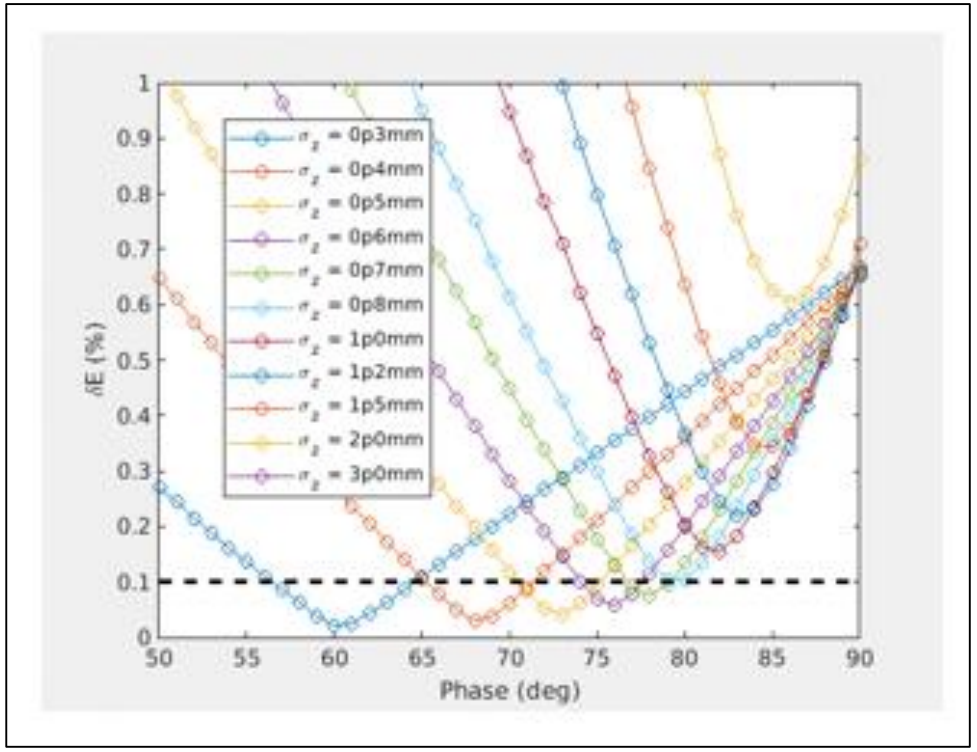
Final bunches n. 3
rms bunch length = 3.8396 mm
rms dp/p = 0.12283%
Dt = -2.3118 mm/c
Dp = 30.0985 MeV/c

Final bunches n. 4
rms bunch length = 3.8049 mm
rms dp/p = 0.14798%
Dt = -2.2855 mm/c
Dp = 32.79 MeV/c

Without EC

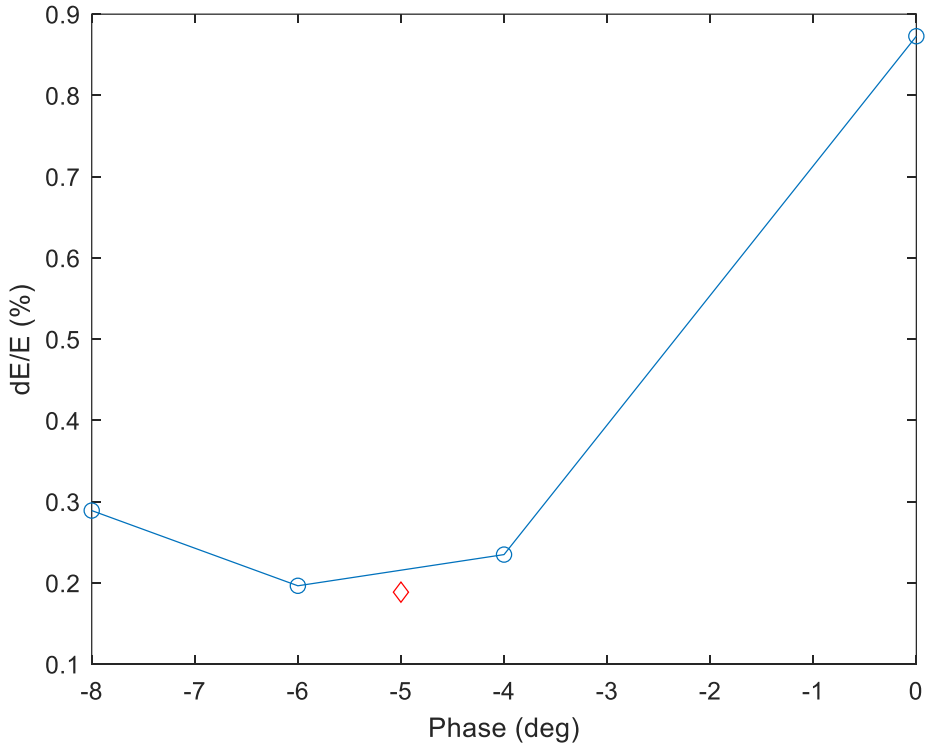
To be included autophasing if different versus charge

Scans done at the beginning (previous design)



At 1 mm we cannot have less than 0.18%
I should tune the bunch length like done at the beginning (if no EC).
We will need a shorter bunch length

New layout: at 1 mm rms bunch length



No EC, Q = 5 nC, phi = -5 deg → rms bunch length = 0.98816 mm
rms dp/p = 0.18869%

No EC, Q = 5 pC, phi = -5 deg → rms bunch length = 1.0034 mm
rms dp/p = 0.49162%

Conclusions

Electron linac:

- Considerations about the tolerated jitter from the positron source received also very quickly. Thanks Fahad and Iryna
- After that, asked the same question asked to the DR group

HE linac:

- Identified a layout for the energy compressor:
  - Max. DE/E in the HE linac ~ 0.55%
  - Bunch length at the exit of the BC = 0.8 mm. This is better for the transport of the beam in case of static misalignments and the jitter. Achievable by BC with an acceptable emittance increase?

Open points/how to proceed for the present design:

- Contact the booster people to verify of the obtained parameters are acceptable → ready to do if ok
- Check the case for no EC → shorter bunch, more off-crest assuming that the LLRF will take care of the multi-bunch energy difference among the bunches → before January 2025
- In the latter case, is the emittance ok from the BC? Question for Simone Stampinati → ready to discuss
- Consider the higher beam loading in the RF in case of shorter bunch→for Jean-Yves and by WP1

Open points/how to proceed for the new design→ next year

- Now that we can use BC, and that the DR allows “forgiving” what we do before (“disconnected” from the gunsection), it would be very interesting and opportune to revise the HE linac design. In particular, is a shorter bunch length possible? Limit?