Status of RF parameters in RLA2

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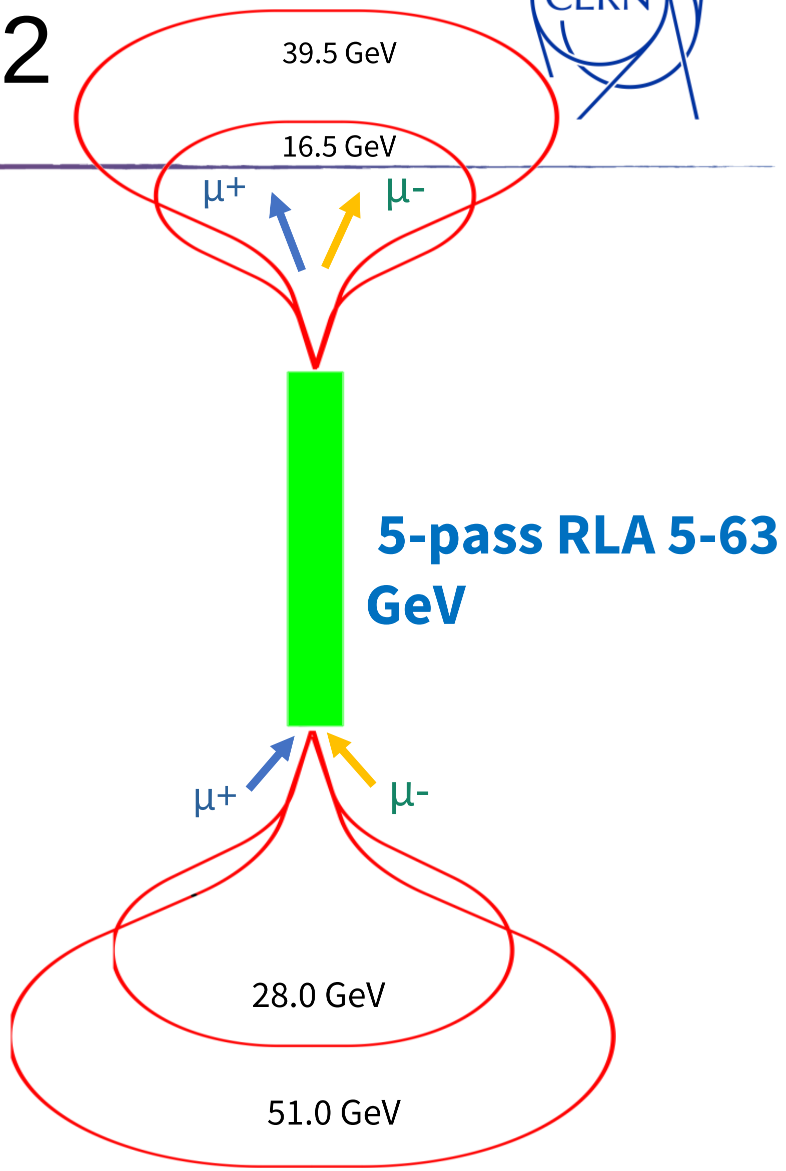
Assumptions for RLA2

Parameter	Unit	Value
Number of LINAC passes	[-]	5
Energy gain per pass	[GeV]	11.5
Energy loss from linearizers per pass	[GeV]	1.4
LINAC length	[m]	1600
Cavity frequencies	[MHz]	352, 1056
Arc lengths	[m]	426, 560, 709, **710?**
Acceleration time	[µs]	34
Number of 352 MHz accelerating cavities	[-]	512
Number of 1056 MHz linearizer cavities	[-]	98
Cavity gradients	[MV/m]	15 @ 352 MHz 24 @ 1056 MHz

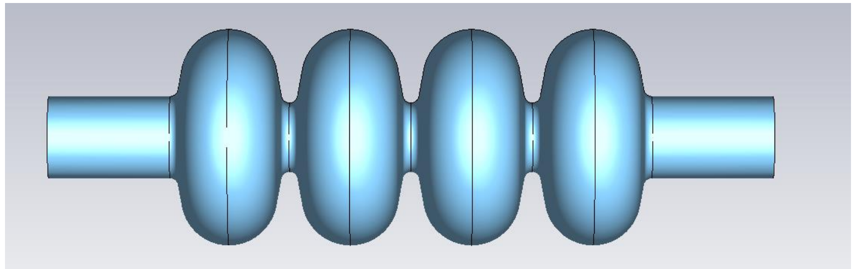


All accelerator data was taken from Avni's talk at the 24th HEMAC meeting: https://indico.cern.ch/event/1382603/

Cavity parameters for LEP2 cavity

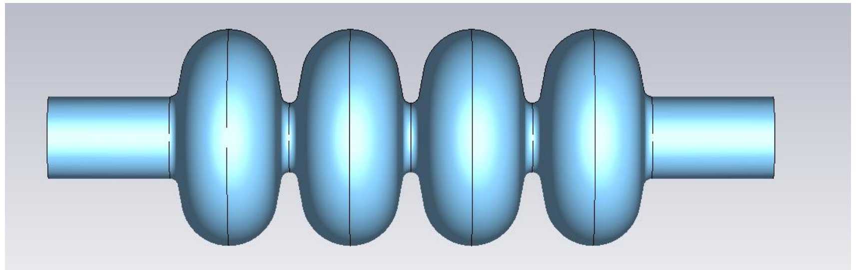
Parameter	Unit	Value
Operating Frequency	[MHz]	352
Longitudinal R/Q	[Ω]	232
Active length	[m]	1.7
Operational gradient	[MV/m]	6
E_pk/E_acc	[1]	2.3

LEP2 SC cavity (352 MHz)



Parameter	Unit	Value
Operating Frequency	[MHz]	**1056**
Longitudinal R/Q	[Ω]	232
Active length	[m]	**0.56**
Operational gradient	[MV/m]	-
E_pk/E_acc	[1]	2.3

Scaled LEP2 SC cavity (1056 MHz)



Acceleration parameters for RLA2

Parameter	Unit	RLA2 acceleration	RLA2 linearizer
Repetition frequency	[Hz]	5	
Total length	[m]	10400	
Bunch population at injection	[1 x 10^{12}]	3.32	
Acceleration time	[μs]	34	
Combined avg. beam current (μ^+ and μ^-)	[mA]	153	
Assumed existing cavity type	[-]	LEP2	Scaled LEP2
Cavity frequency	[MHz]	352	1056
Designed bunch phase	[°]	95	275
External *Q*-factor	[1 x 10^6]	0.33	0.18
Optimal cavity detuning	[kHz]	0.05	0.24

RF parameters for RLA2

Parameter	Unit	RLA2 acceleration	RLA2 linearizer
Beam acceleration time	[μs]	34	
Cavity filling time	[μs]	300	55
RF pulse length	[ms]	0.33	0.09
RF duty factor	[%]	0.16	0.05
FPC peak power	[kW]	3900	2100
FPC average power	[kW]	6.24	1.05
Average total RF power (incl. power distribution losses)	[MW]	4.44	0.12
Average total wall plug power (incl. klystron eff.)	[MW]	6.83	0.19
Number of cavities	[-]	510	98

Conclusion and Outlook

- All accelerator data was taken from Avni's talk at the 24th HEMAC meeting: https://indico.cern.ch/event/1382603/
- Arc lengths for arcs 3 and 4 seem inconsistent.
  - But are consistent with the plots he showed.
- Parameters for both the linearizer and acceleration cavity seem to be feasible from a powering perspective.
- Transient beam loading needs to be studied in detail.
  - Will depend on the cavity location for each pass (cavities towards the end of the LINAC are more affected by transients than the ones in the middle).
- The design for RLA1 or the Pre-accelerator is not done yet.
- Power sources for 352MHz as well as 1056MHz need to be determined

→ LEP2 like as well?

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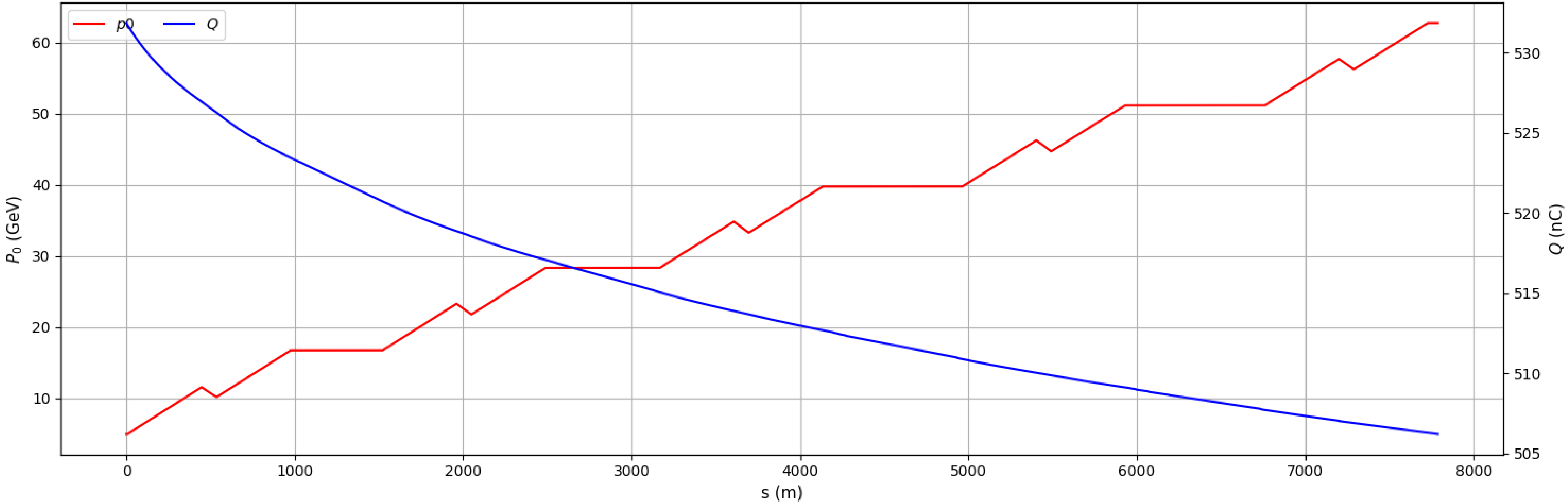
Energy profile RLA2



Plot from Avnis talk at the 25th HEMAC meeting: https://indico.cern.ch/event/1382603/

RF parameters in the high-energy chain
Klystron assumptions

- Klystron and distribution losses are assumed to be the same as for the ILC DKS (Distributed Klystron Scheme) [2]
- In this scheme, the klystrons are located underground next to the accelerator tunnel and close to the cavities
- Repetition rate and fundamental frequency are equal to muon collider RCS chain

Klystron Parameter	Value
Max. power [MW]	10
Wall plug efficiency [%]	65
Repetition rate [Hz]	5
RF pulse length [ms]	1.65
RF duty factor [%]	0.83
Power distribution losses in DKS [%]	32
Output frequency [GHz]	1.3

Thales TH1801, picture from [3],
parameter values from [2]

Appendix
Generator and reflected current

$$I_g = \left[\frac{V}{2(R/Q)}\left(\frac{1}{Q_{ext}} + \frac{1}{Q_0}\right) + I_{b,DC}F_b \sin(\phi_s)\right] + i\left[I_{b,DC}F_b \cos(\phi_s) - \frac{V\Delta\omega}{\omega(R/Q)}\right]$$

$$I_r = \left[\frac{V}{2(R/Q)}\left(\frac{1}{Q_{ext}} - \frac{1}{Q_0}\right) - I_{b,DC}F_b \sin(\phi_s)\right] - i\left[I_{b,DC}F_b \cos(\phi_s) - \frac{V\Delta\omega}{\omega(R/Q)}\right]$$

Aims when specifying the modifiable parameters

- Set the imaginary part of both formulas to 0 → $\frac{\Delta\omega_{opt}}{\omega} = \frac{I_{b,DC}F_b\cos(\phi_s)(R/Q)}{V}$
- Set the real part of the reflected current to 0 → $Q_{ext,opt} = \frac{V}{2I_{b,DC}F_b\sin(\Phi_s)(R/Q)}$

The formulas used were derived in [1]

References

[1]: Cavity-Beam-Transmitter Interaction Formula Collection with Derivation: http://cds.cern.ch/record/1323893/files/CERN-ATS-Note-2011-002%20TECH.pdf

[2]: ILC TDR: https://linearcollider.org/files/images/pdf/Acceleratorpart2.pdf

[3]: https://www.desy.de/xfel-beam/mlin_klyst.html