Main magnets for LHeC ERL Test Facility

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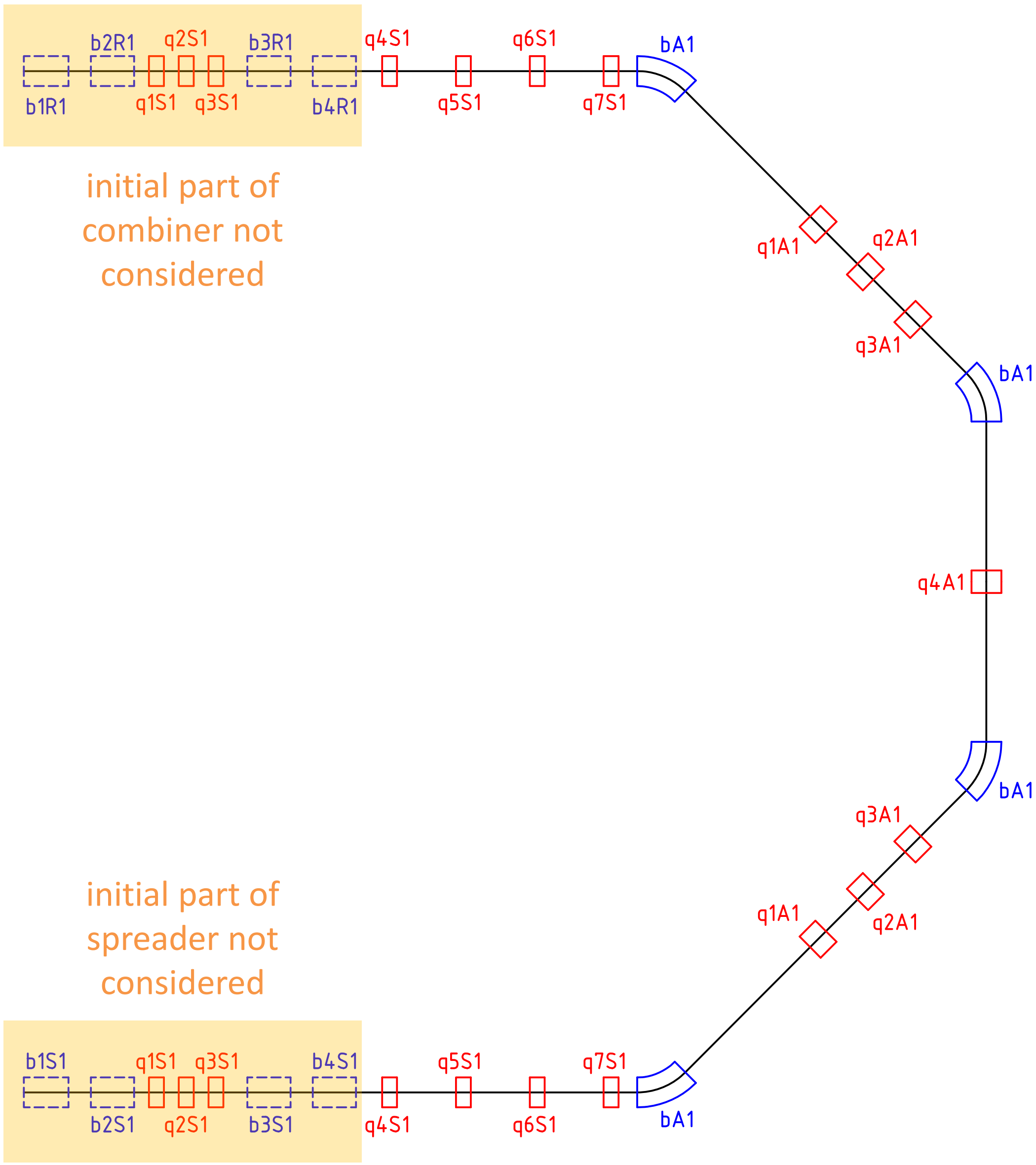
Inventory of main magnets in the arcs

Arc 1, 155 MeV



Dipoles

- 4 dipoles
  - ❖ +8 in initial parts of spreader / combiner
- aperture ±20 mm in both transverse and vertical directions

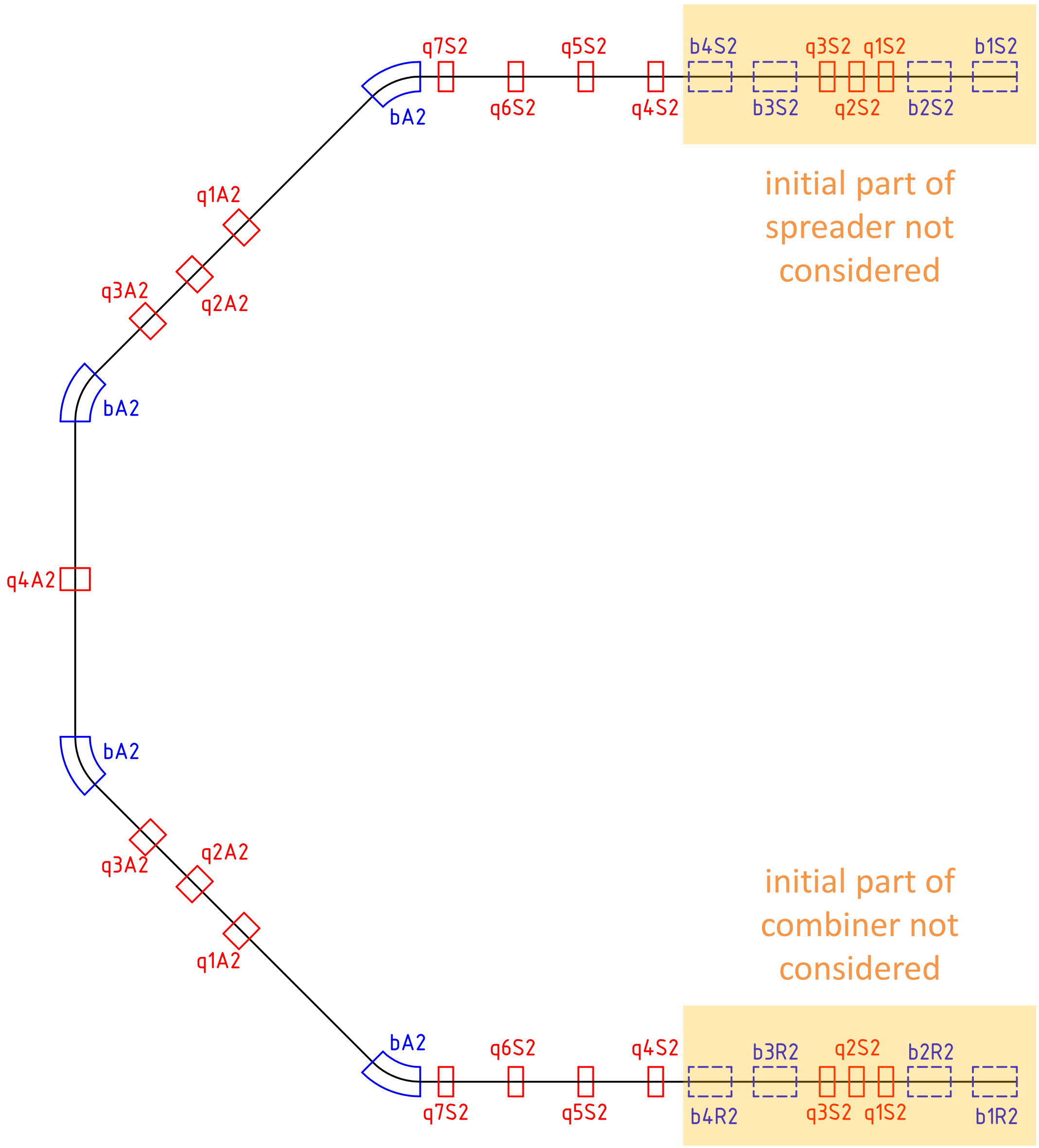
type	count	B [T]	L [mm]
bA1	4	0.57	718

Quadrupoles

- 15 quadrupoles
  - ❖ +6 in initial parts of spreader / combiner
- aperture diameter 40 mm

type	count	G [T/m]	L [mm]
q4S1	2	3.79	200
q5S1	2	-0.61	200
q6S1	2	1.05	200
q7S1	2	-0.93	200
q1A1	2	-0.66	300
q2A1	2	1.85	300
q3A1	2	-1.05	300
q4A1	1	2.09	300

Arc 2, 305 MeV



Dipoles

- 4 dipoles
  - +8 in initial parts of spreader / combiner
- aperture ±20 mm in both transverse and vertical directions

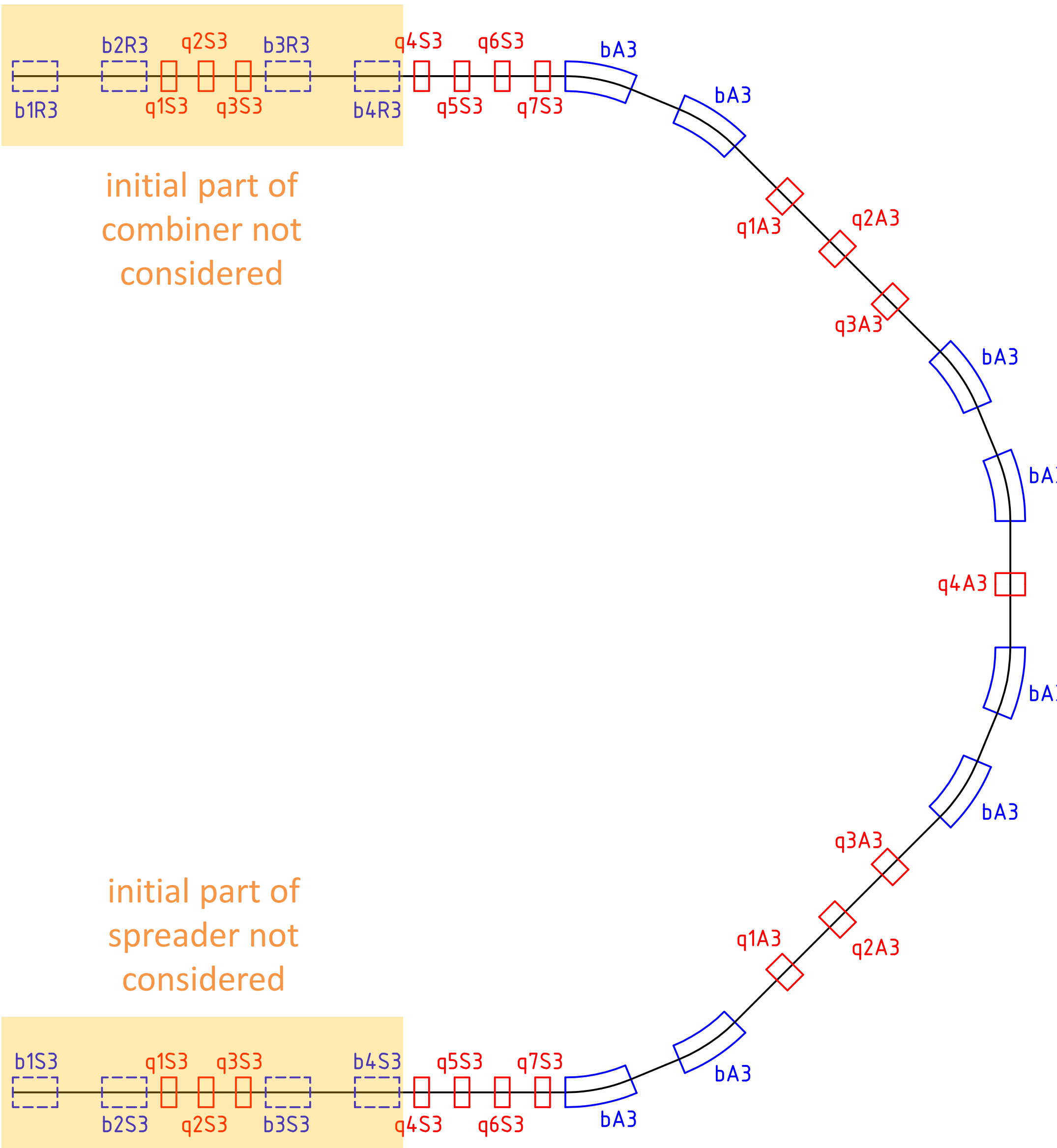
type	count	B [T]	L [mm]
bA2	4	1.11	718

Quadrupoles

- 15 quadrupoles
  - +6 in initial parts of spreader / combiner
- aperture diameter 40 mm

type	count	G [T/m]	L [mm]
q4S2	2	4.99	200
q5S2	2	-0.07	200
q6S2	2	-2.51	200
q7S2	2	-0.75	200
q1A2	2	3.27	300
q2A2	2	-3.05	300
q3A2	2	0.21	300
q4A2	1	1.25	300

Arc 3, 455 MeV



Dipoles

- 8 dipoles
  - +8 in initial parts of spreader / combiner
- aperture ±20 mm in both transverse and vertical directions

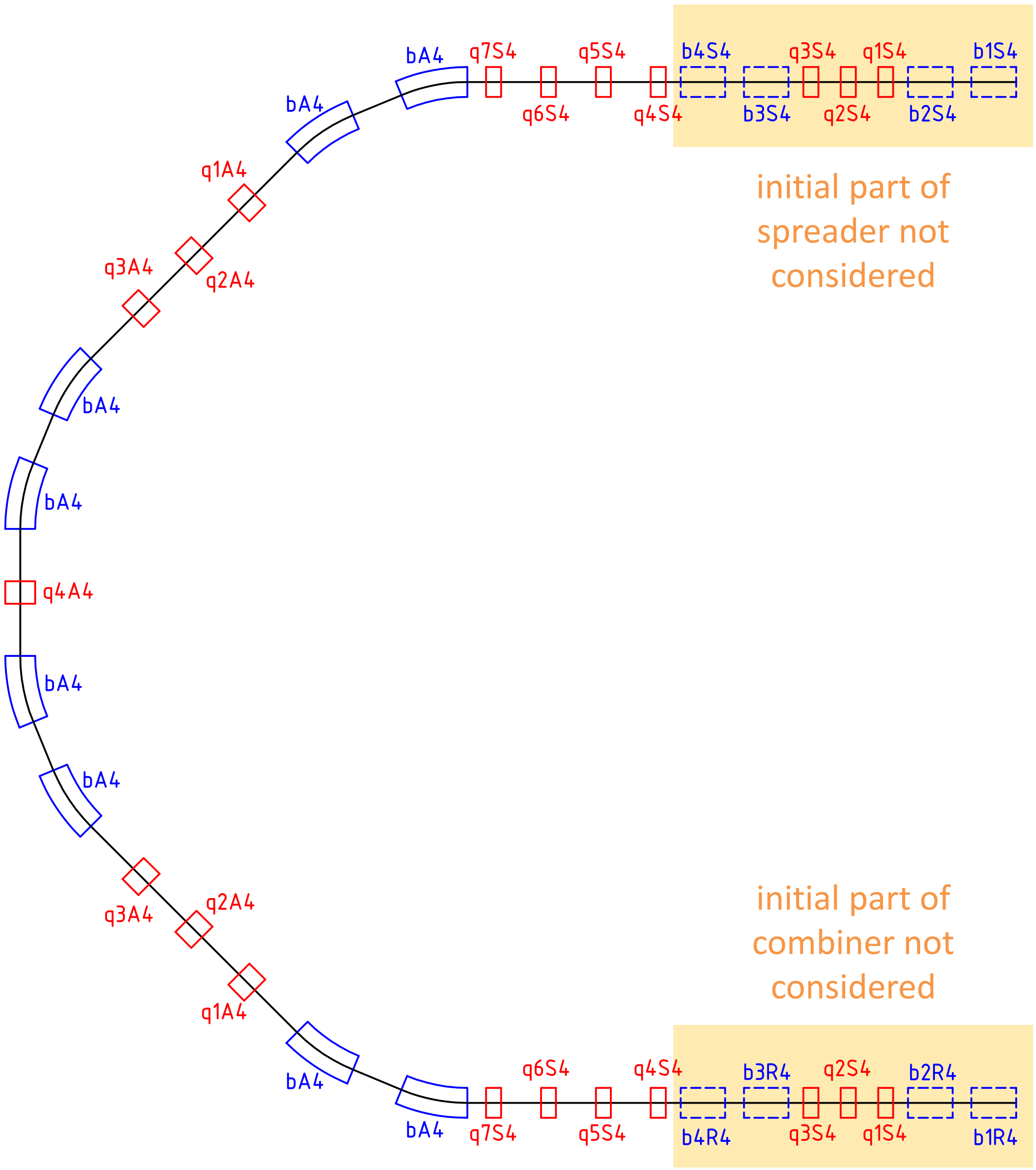
type	count	B [T]	L [mm]
bA3	8	0.66	906

Quadrupoles

- 15 quadrupoles
  - +6 in initial parts of spreader / combiner
- aperture diameter 40 mm

type	count	G [T/m]	L [mm]
q4S3	2	-5.81	200
q5S3	2	8.61	200
q6S3	2	2.27	200
q7S3	2	-7.86	200
q1A3	2	-3.80	300
q2A3	2	6.01	300
q3A3	2	-3.36	300
q4A3	1	0.78	300

Arc 4, 605 MeV



Dipoles

- 8 dipoles
  - +8 in initial parts of spreader / combiner
- aperture ±20 mm in both transverse and vertical directions

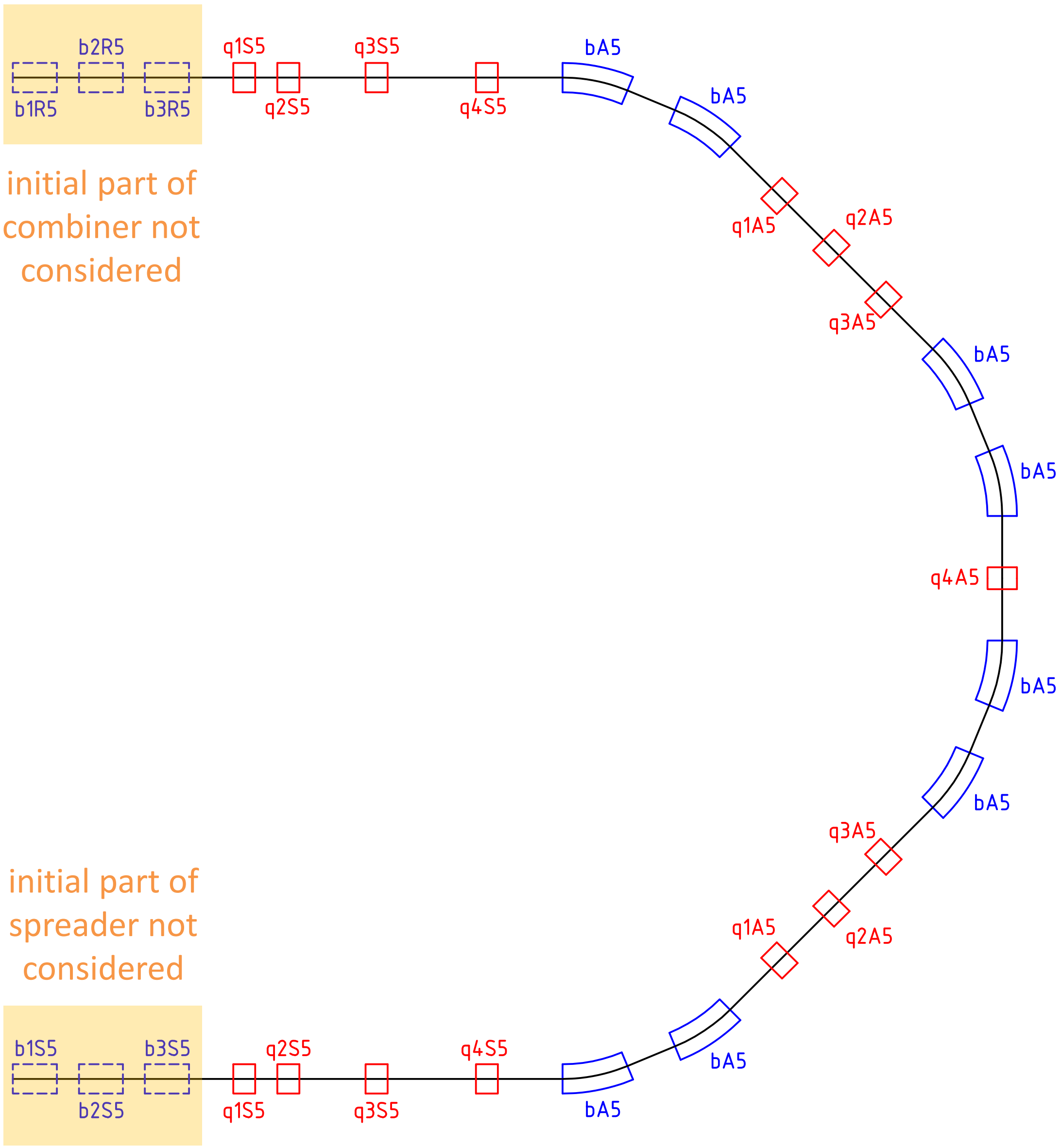
type	count	B [T]	L [mm]
bA4	8	0.88	906

Quadrupoles

- 15 quadrupoles
  - +6 in initial parts of spreader / combiner
- aperture diameter 40 mm

type	count	G [T/m]	L [mm]
q4S4	2	-10.27	200
q5S4	2	14.68	200
q6S4	2	-6.25	200
q7S4	2	-14.53	200
q1A4	2	-6.14	300
q2A4	2	7.63	300
q3A4	2	-2.04	300
q4A4	1	3.11	300

Arc 5, 755 MeV



Dipoles

- 8 dipoles
  - +6 in initial parts of spreader / combiner
- aperture ±20 mm in both transverse and vertical directions

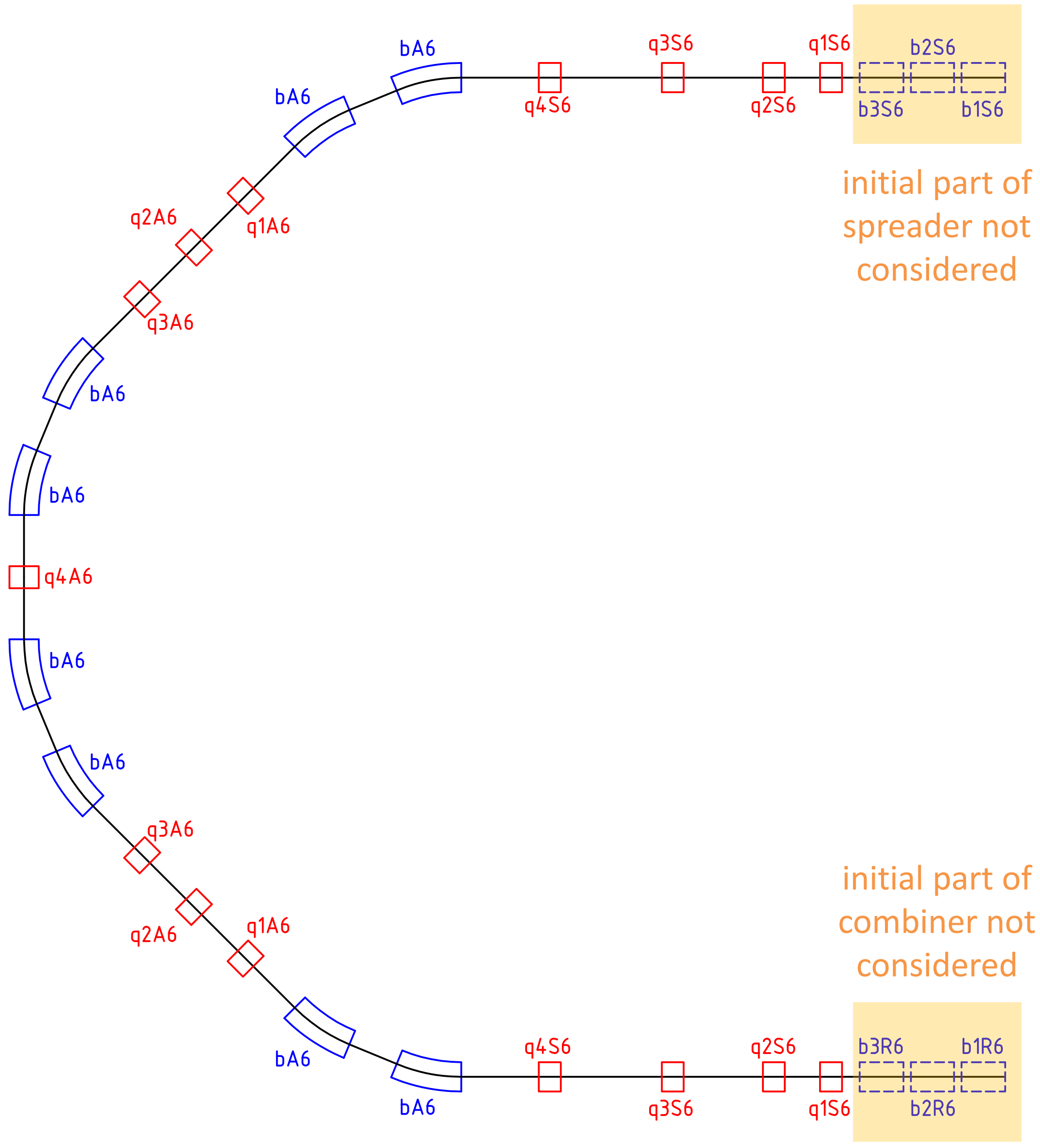
type	count	B [T]	L [mm]
bA5	8	1.09	906

Quadrupoles

- 15 quadrupoles
- aperture diameter 40 mm

type	count	G [T/m]	L [mm]
q1S5	2	-4.46	300
q2S5	2	9.98	300
q3S5	2	-7.13	300
q4S5	2	6.53	300
q1A5	2	-6.58	300
q2A5	2	9.13	300
q3A5	2	-2.36	300
q4A5	1	2.92	300

Arc 6, 905 MeV



Dipoles

- 8 dipoles
  - +6 in initial parts of spreader / combiner
- aperture ±20 mm in both transverse and vertical directions

type	count	B [T]	L [mm]
bA6	8	1.31	906

Quadrupoles

- 15 quadrupoles
- aperture diameter 40 mm

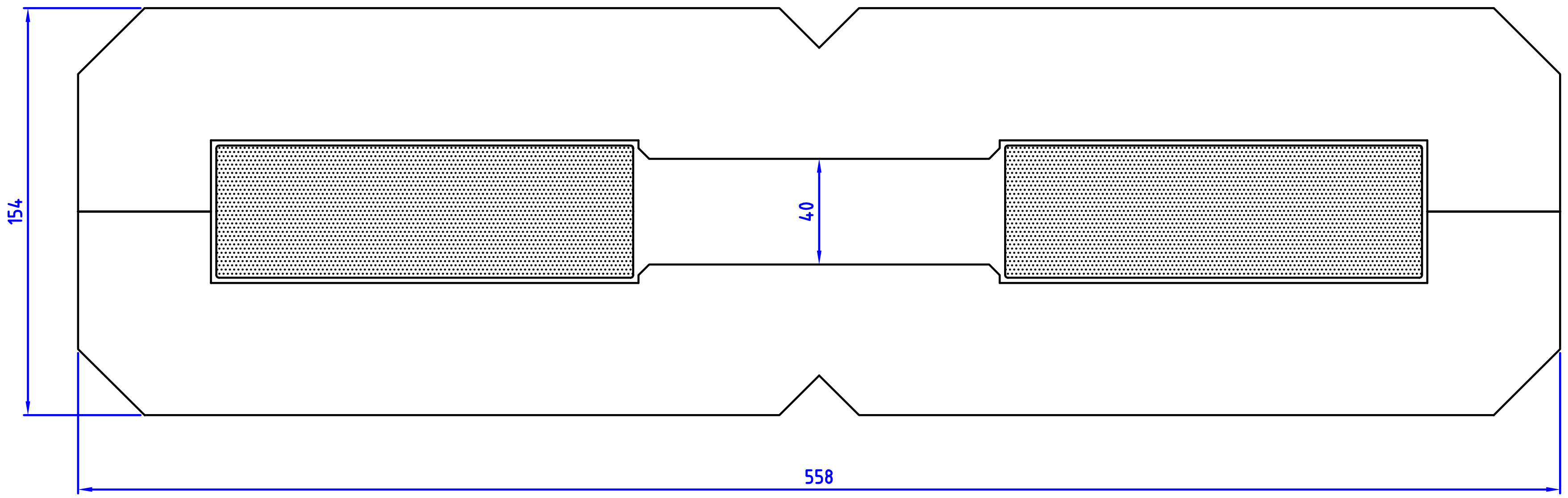
type	count	G [T/m]	L [mm]
q1S6	2	-4.80	300
q2S6	2	-1.56	300
q3S6	2	5.13	300
q4S6	2	-3.83	300
q1A6	2	10.87	300
q2A6	2	-3.86	300
q3A6	2	2.21	300
q4A6	1	3.50	300

Bending magnets

Bending magnets: 2 families

arc	count	angle [deg]	B [T]	L [mm]	curv. radius [mm]	pole gap [mm]	GFR width [mm]	
#1	4	45	0.57	718	915	±20	±20	MBA
#2	4	45	1.11	718	915	±20	±20	
#3	8	22.5	0.66	906	2307	±20	±20	MBB
#4	8	22.5	0.88	906	2307	±20	±20	
#5	8	22.5	1.09	906	2307	±20	±20	
#6	8	22.5	1.31	906	2307	±20	±20	

Bending magnets: cross-section



- same cross-section for MBA and MBB
- curved magnets
- yoke possibly machined, narrow in vertical direction (for stacking)
- water cooled coils, to be designed as part of overall optimization, including power converters (the shaded area corresponds to 6-7 A/mm^2 at max field)

Quadrupoles

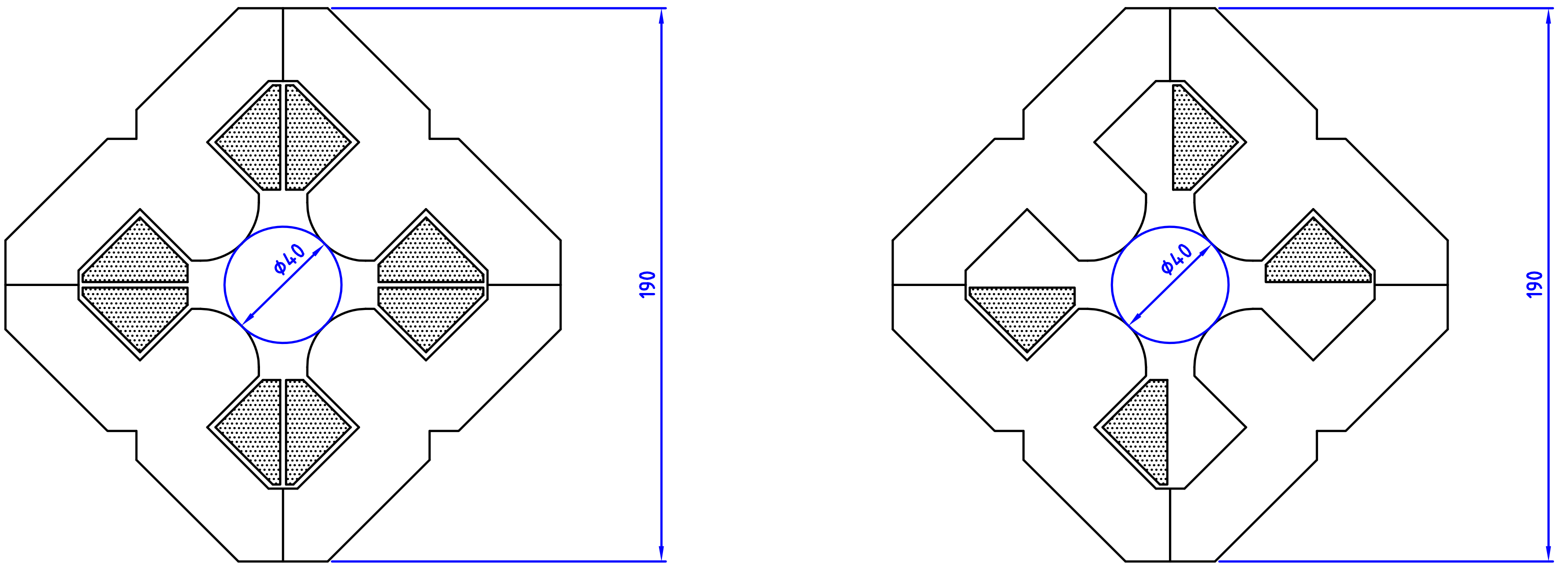
Quadrupoles

- same aperture diameter of 40 mm for all arcs
- 2 magnetic lengths in the lattice, 200 mm and 300 mm
- wide range of GL and B_{pole}
- some GL rather low, they could be possibly avoided with a slightly different optics
- the optics would anyway need to be iterated including edge effects on the bending magnets

arc	$\|GL\|_{max}$ [T]	$\|GL\|_{min}$ [T]	$\|B_{pole}\|_{max}$ [T]	$\|B_{pole}\|_{min}$ [T]
#1	0.76	0.12	0.076	0.012
#2	1.00	0.01	0.100	0.001
#3	1.80	0.23	0.172	0.016
#4	2.94	0.61	0.294	0.041
#5	2.99	0.71	0.200	0.047
#6	3.26	0.47	0.217	0.031

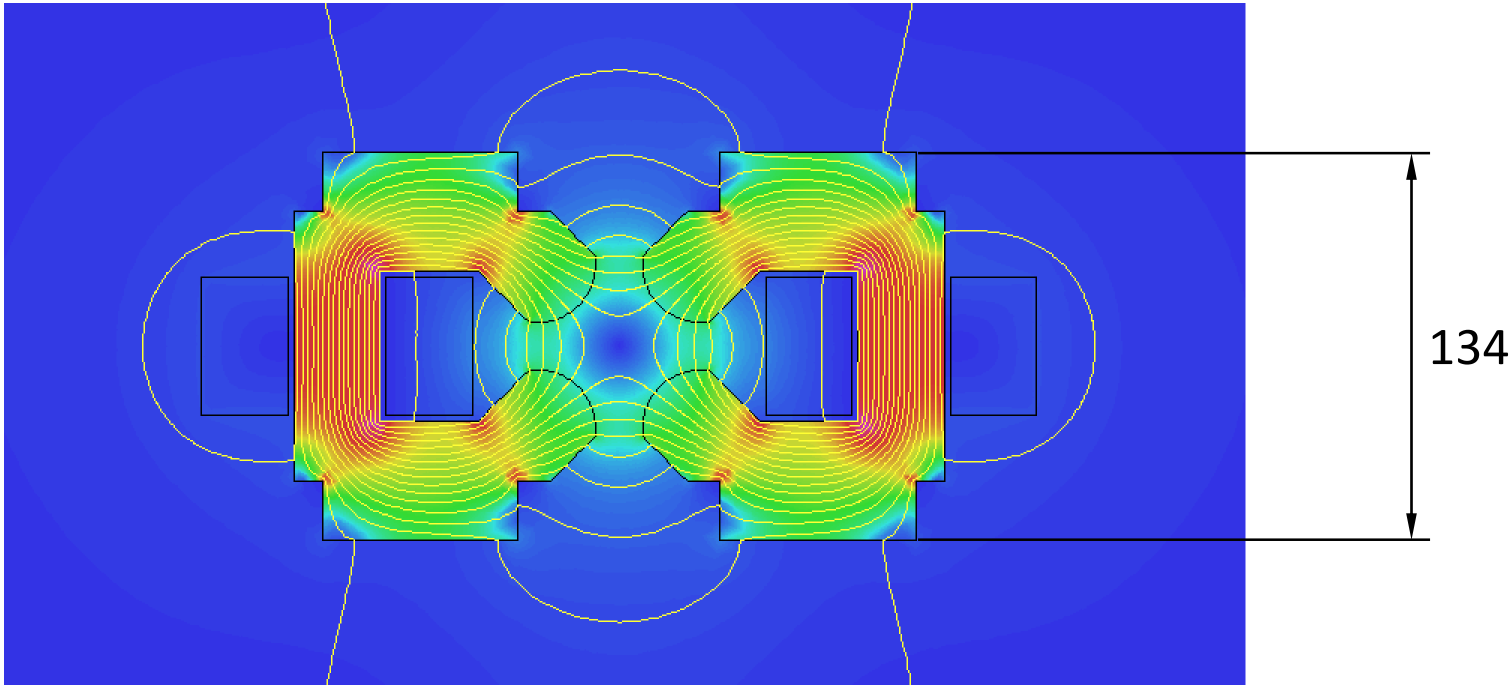
possibility of making families to be discussed

Quadrupoles: cross-section



- water cooled coils, to be designed as part of overall optimization including yoke height for vertical stacking, power converters, magnet manufacturing cost and operational scenario (the shaded area corresponds to 7-8 A/mm^2 at max field)
- same aperture makes possible the same cross-section, with possibly different
  - lengths
  - number of coils (running with 2 instead of 4 coils cuts the gradient in half and introduces negligible field distortions, of the order of $2\cdot10^{-4}$ of a_4)

Quadrupoles: alternative cross-section



- alternative cross-section, narrow in vertical direction, for stacking
- the cross-talk between the apertures needs to be evaluated, as it is an open magnetic circuit
- removes much of the geometry constraints for designing the coil

Conclusion

Conclusions

- A preliminary inventory of the magnets of the LHeC ERL Test Facility lists:
  - 40 bending magnets (vertical field)
  - 114 quadrupole magnets
  - a few bending magnets (horizontal field) and quadrupoles in the spreaders / combiners
  - a few magnets in the injection / extraction parts
- Conventional iron-dominated resistive magnets can be used
- Grouping the magnets in families – in particular for the quadrupoles – has to be analysed to consolidate the number of magnet types
- The spreader and combiner regions need to be studied in detail since space is rather tight.
- The need for dipole correctors has to be evaluated; they could possibly be added to some quadrupoles.
- Multiple aperture magnets – like PSB type, though with separate powering) might be interesting to reduce overall cost.

Many thanks to Alessandra Valloni.

Thank you.