Conception du lattice et optimisation de l'optique faisceau de la machine PERLE

Journées Accélérateurs de la SFP

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Presenté par

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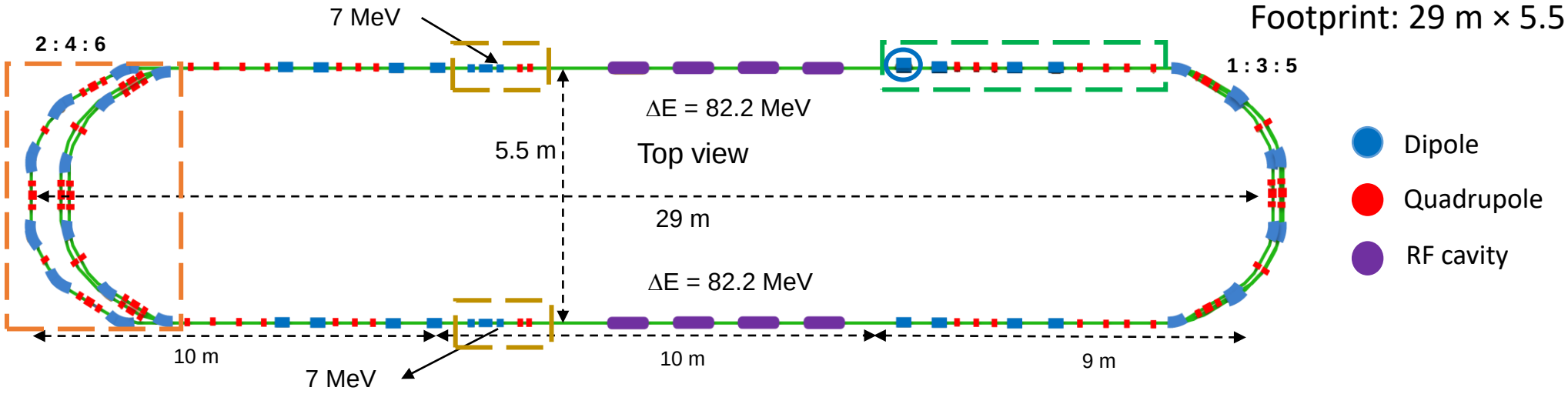
Outline

- Introduction to PERLE optics
- B-com magnet
  - Specification and design
  - Field calculation and Harmonic content
  - Cooling system calculation
- Preliminary study of PERLE lattice errors
  - Field errors
    - B-com magnet harmonics

PERLE Optics

Footprint: 29 m × 5.5 m × 0.9 m



I. Chicane magnets for injection and dump

II. LINAC

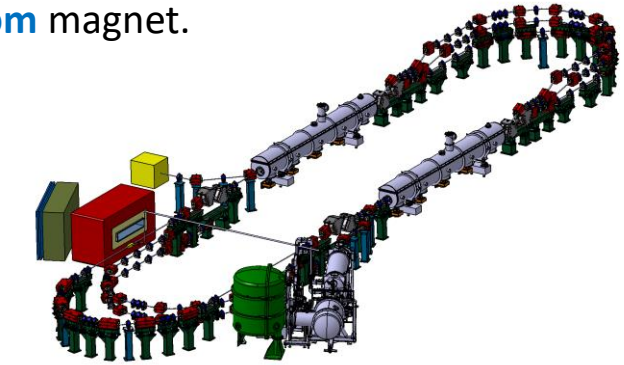
Two cryomodules each of four 5-cell SRF cavities.

III. Arcs

6 arcs for a three-turn configuration.

IV. Spreader/Recombiner

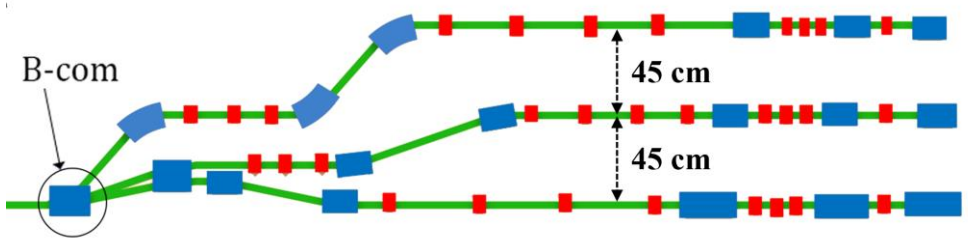
- Connect LINAC to arcs section.
- One common dipole magnet for the three arcs at each side called the **B-com** magnet.



Voir la présentation de Julien Michaud demain à 15:20

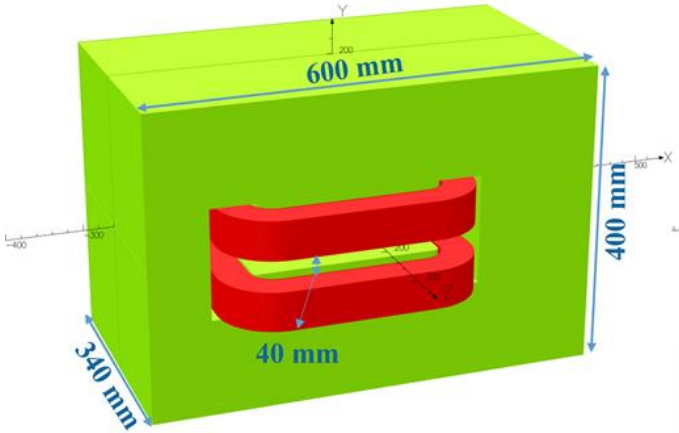
B-com Magnet

Specification and design



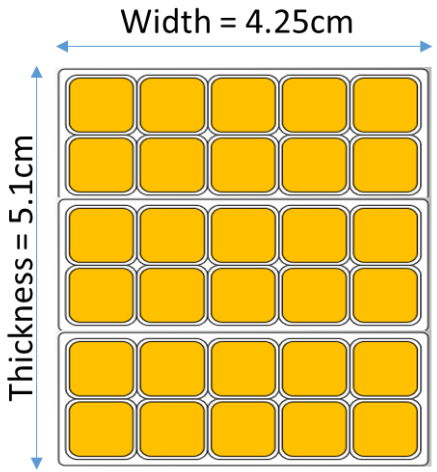
- Common between the three arcs.
- Horizontal field magnet → Vertical beam split at three different energies.
- 30° bending angle.

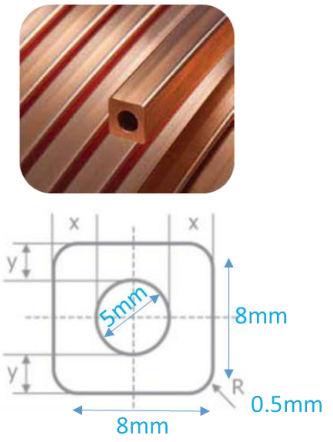
Tool: Opera 3D



Yoke material: standard steel (C content < 0.1%)

Coil design

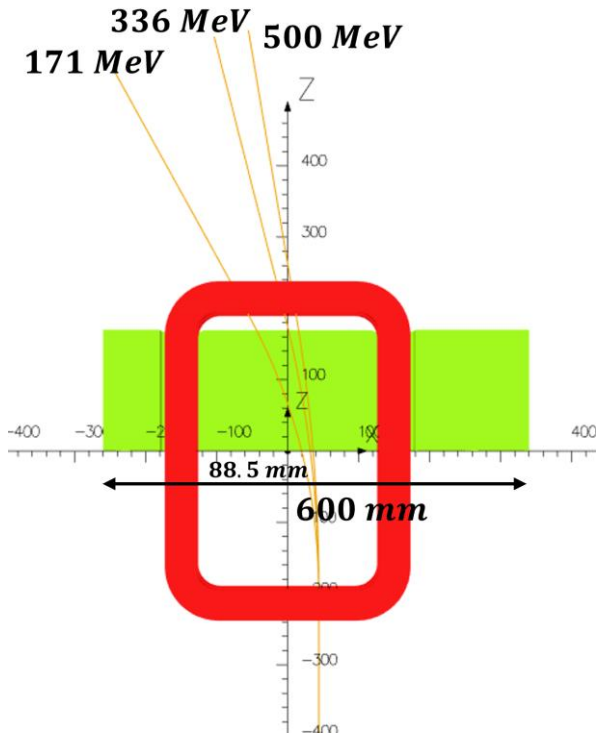




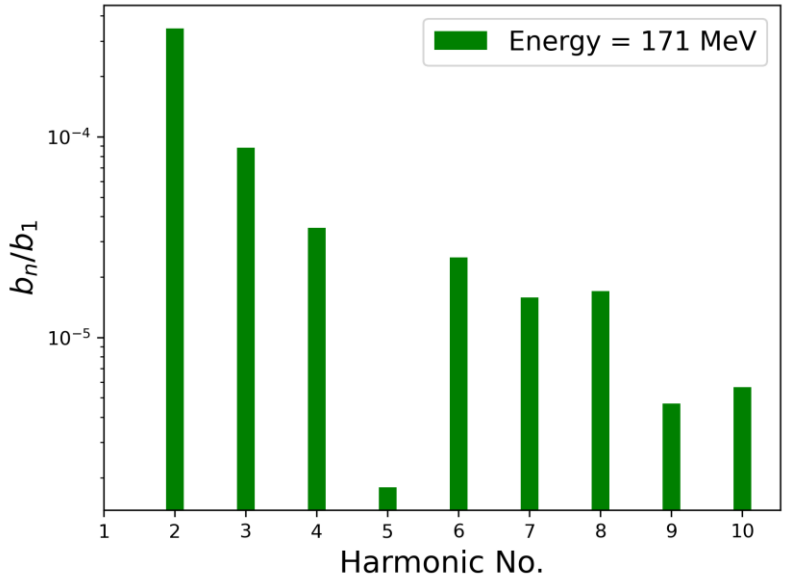
This work is in collaboration with Jay Benesch from JLab.

B-com Magnet

Harmonic content



Energy	b1	b2	b3	b4	b5	$\sqrt{\sum_{n=1}^{5} b_n^2}/b_1$
171MeV	-2.90E+01	-1.11E-02	3.06E-03	2.19E-04	-4.99E-04	3.594E-04
336MeV	-2.81E+01	1.84E-03	1.14E-04	1.05E-04	-4.69E-04	6.79E-05
500MeV	-2.79E+01	2.77E-03	3.85E-04	-1.77E-06	-2.49E-04	1.01E-04



- 0.036% field homogeneity along the beam path.
- Quadrupole and sextupole components can be dealt with in the lattice.
- Initial design: 0.1% field quality

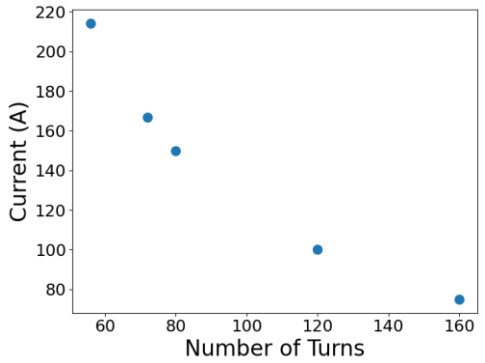
Improvement by one order of magnitude.

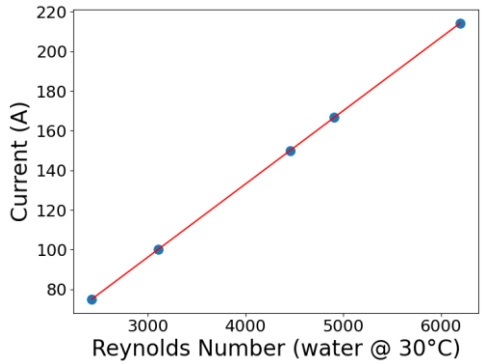
Coil and cooling circuit

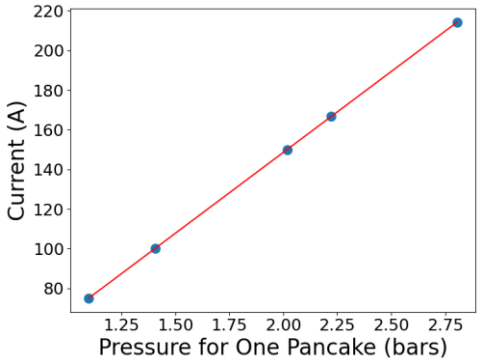
Excitation current calculated for **B = 0.87 T** is **NI = 11520.263 A.turn**

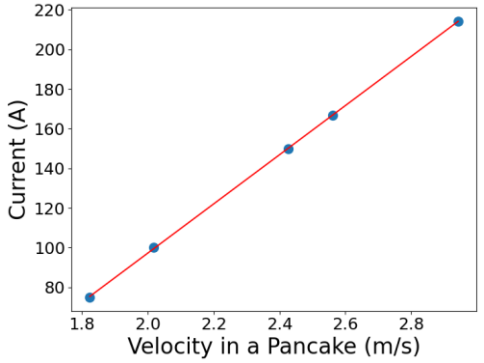
- The cooling circuit parameters were calculated for different current values.
- Goal: achieve the minimum possible current to power the magnet while ensuring adequate cooling of the coil.
- Turbulent water flow must be achieved →Reynolds number > 4000

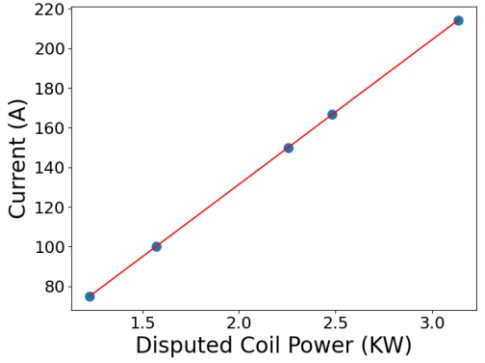
$I = 166.67\ A$ is the minimum value possible.







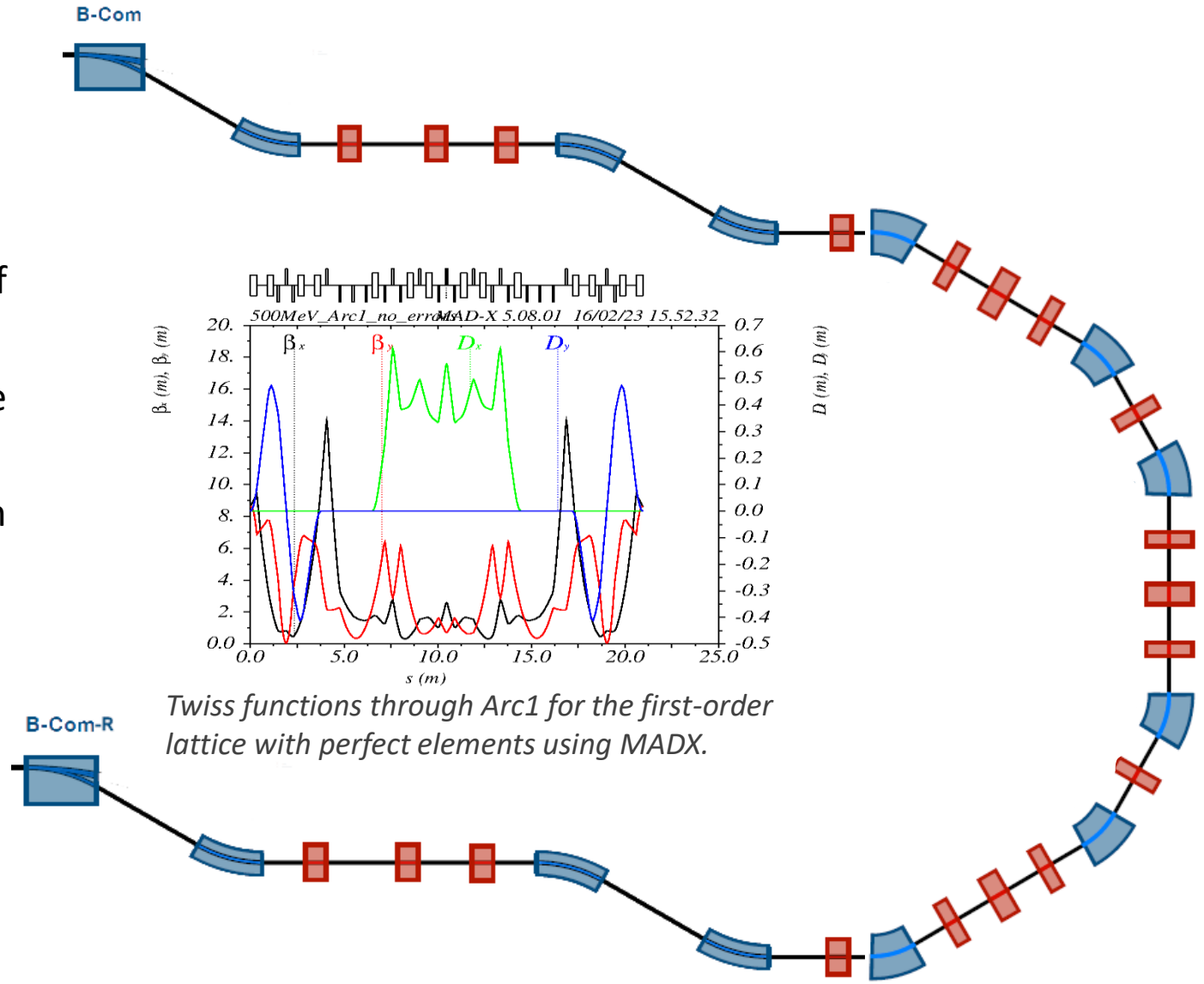




Introducing Errors

The lattice is tuned so that

- The Dispersion function is Zero at the exit of each arc.
- The Beta function is the same at the entrance and exit of each arc.
- The Alfa function changes the sign between the arc entrance and exit.



Twiss functions through Arc1 for the first-order lattice with perfect elements using MADX.

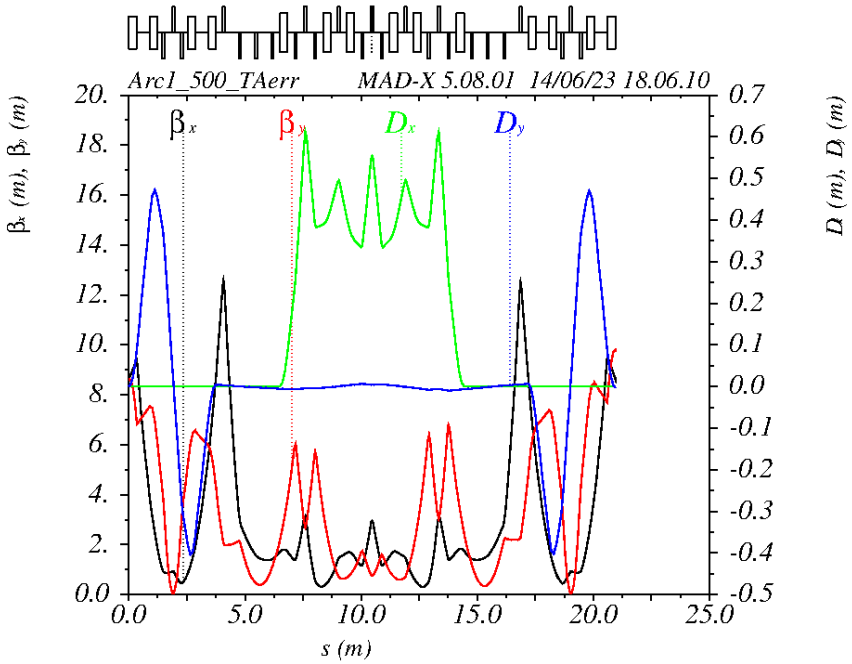
Field errors

- Relative field errors were introduced to the first B-com in the spreader and the B-com-R in the merger section.

- The values of the first four higher relative harmonics (b_n/b_1) were considered. *{see slide 5}*

Twiss	Perfect element	With field errors
D_x [m]	0.00	0.00
D_y [m]	0.00	-0.00301
DP_x	0.00	0.00
DP_y	0.00	0.00059
β_x [m]	8.63544	8.70493
β_y [m]	8.63478	9.73175

Twiss functions at the exit of Arc1



An increase in the Beta function is noticed at the exit.

Conclusion

- The B-com magnet is designed to generate vertical field of 0.7 T and field integral of 0.88 T along the magnet length with harmonic content in the order of 10^{-4} meeting the accepted tolerances of the beam dynamics.
- Cooling circuit parameters are calculated for the B-com coil used in the design.
- Different configurations (conductor area, number of turns, different arrangements) have been investigated to decrease the current from the power supply.
- The B-com field harmonics were introduced to the lattice, further investigation on its effect is undergoing.

Merci beaucoup!