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In Memoriam Engin Arık and Her Colleagues

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COMPARISON OF DOUBLE BEND AND TRIPLE BEND ACHROMATIC LATTICE STRUCTURES FOR TAC TDR-SR

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- Global Requirements; size, brightness, stability…
- Lattice Structure Blocks; magnet and other devices…
- Emittance; lattice cell, minimum emittance, horizontal emittance…
- Other Lattice Parameters; damping, tune and chromaticity…
- Acceptances; lifetime and injection, physical, dynamic and energy acceptance…
- Lattice Errors; misalignments, multipolar errors

Global Requirements

- Number and length of "Straight Section" → maximum size
- "Available area" → maximum size
- "Synchrotron Radiation Properties"
  - → Radiation Spectrum
  - → Insertion Device types
  - → Beam Energy
  - → Brightness
  - → Emittance
  - → Energy Spread
- "Stability Requirements" → current and orbit stability
- "Flexibility and Future upgrade potential"
- "Budget"

Designing Low Emittance Lattices

- Weak focusing
- Strong focusing
- The FODO cell
- Separated-function low-emittance cell
- Combined-function low-emittance cell
- Low-emittance FODO cell
- Dispersion matching
- Matching cell
- Double-bend achromat
- Triple-bend achromat

Double-Bend Achromat : The structure [-*M*/*M*] is called a double-bend achromat (DBA), because it contains two bending magnet. The first one builds up *dispersion* and the second one *suppresses* it, making the whole structure achromatic.

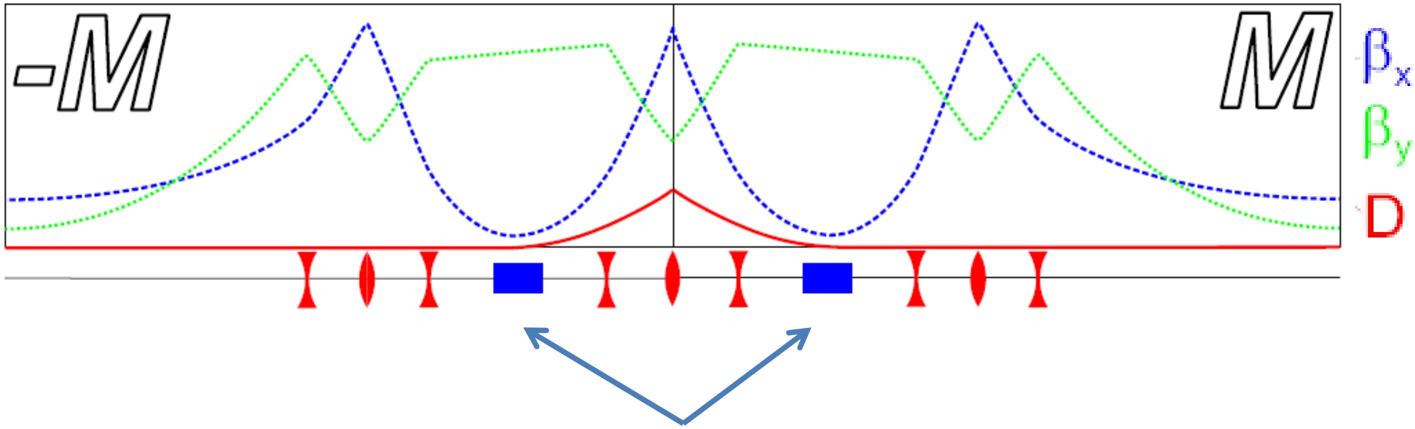

Fig.1: Double Bend

Triple-Bend Achromat : The structure [-*M/P/M*] is called a triple-bend achromat (TBA). It is more compact than a DBA lattice of *the same emittance,* however, it provides fewer straight sections.

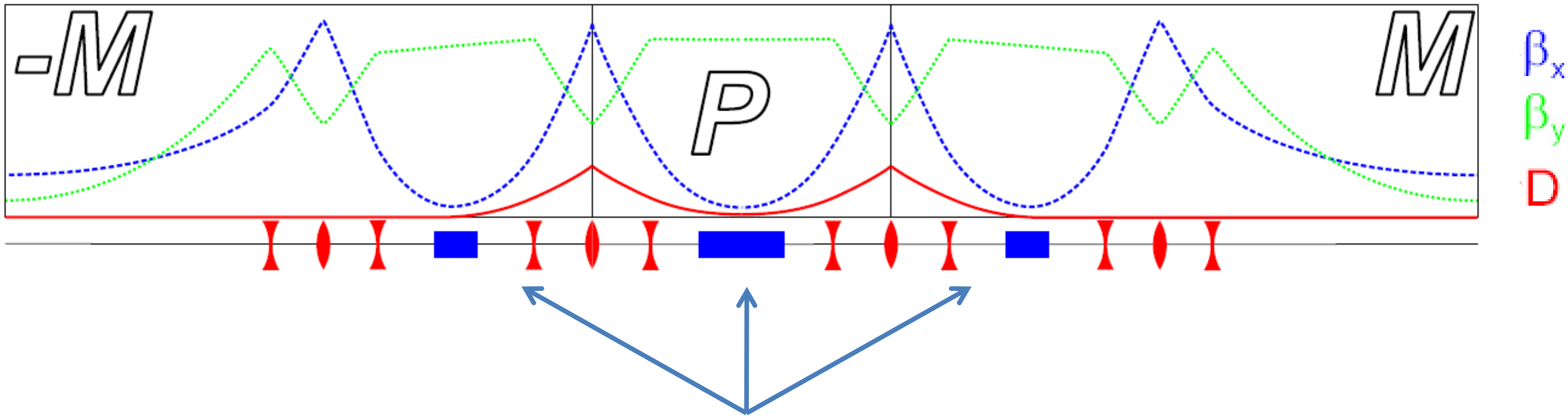

Fig.2: Triple Bend

Double-Bend Achromat

For the TAC at 3.56 GeV [1], the DBA lattice has been studied with a type of lattice composed of cf-bending magnets and quadrupole doublet.

The unit cell with a defocusing bending magnet (cf-magnet) has a threefold advantage [5]:

- The number of magnets per achromat is reduced,
- The partition number J_x is larger than 1 and thus reduces the emittance,
- The length of the cell is small, therefore reducing the total circumference.

$$\varepsilon_{MEDBA} = C_q \frac{\gamma^2}{4\sqrt{15}} \frac{\theta_p^3}{J_x} \frac{1}{8}$$

$$\varepsilon_{MEDBA} = 3.064\ [nm.rad]$$

TAC SR TDR

	DBA*	DBA
Energy [GeV]	3.56	3.56
Circumference[m]	264	301.76
Current [mA]	400	400
Energy lost per turn [keV]	1163.2	883.153
Tune [Qx, Qy]	11.5-2.4	20.6-5.8
Emittance [nm-rad]	20	3.066
Energy spread %	0.09	0.09
Momentum compaction factor	0.043	0.0011
Chromaticity	-18, -39	-37, -27.4

Table: 1

* The earlier work of Zafer Nergiz (Nigde University)

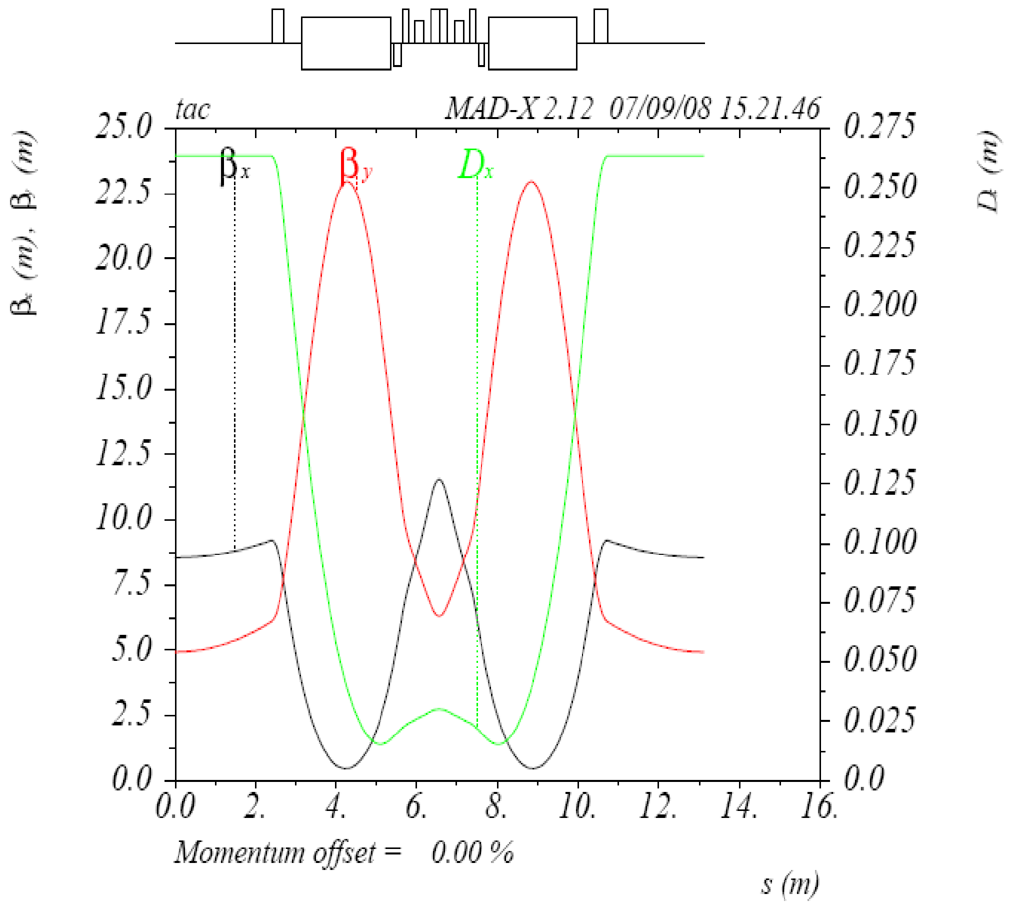

Fig. 3: Lattice functions for 23 period DBA lattices.

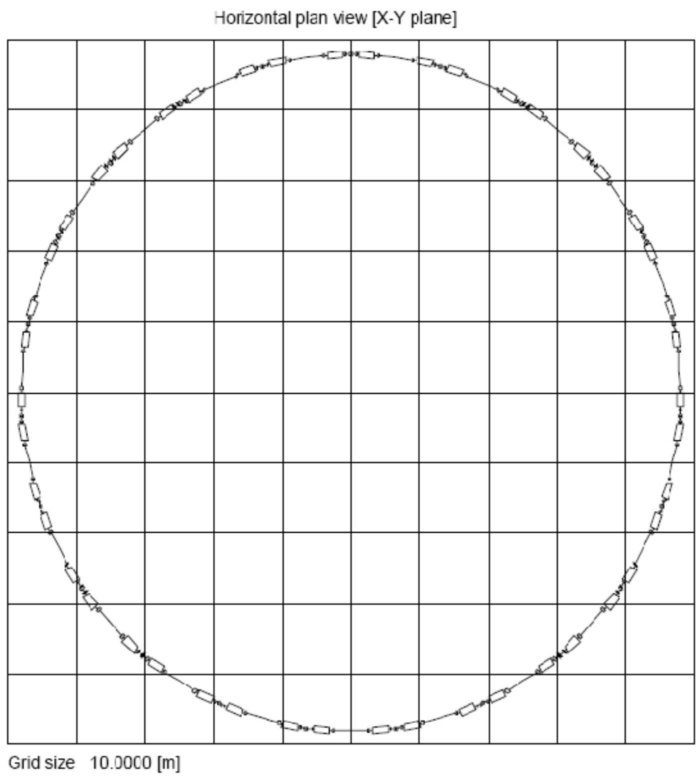

Fig. 4: Around 36.6% of the circumference is devoted to straight sections.

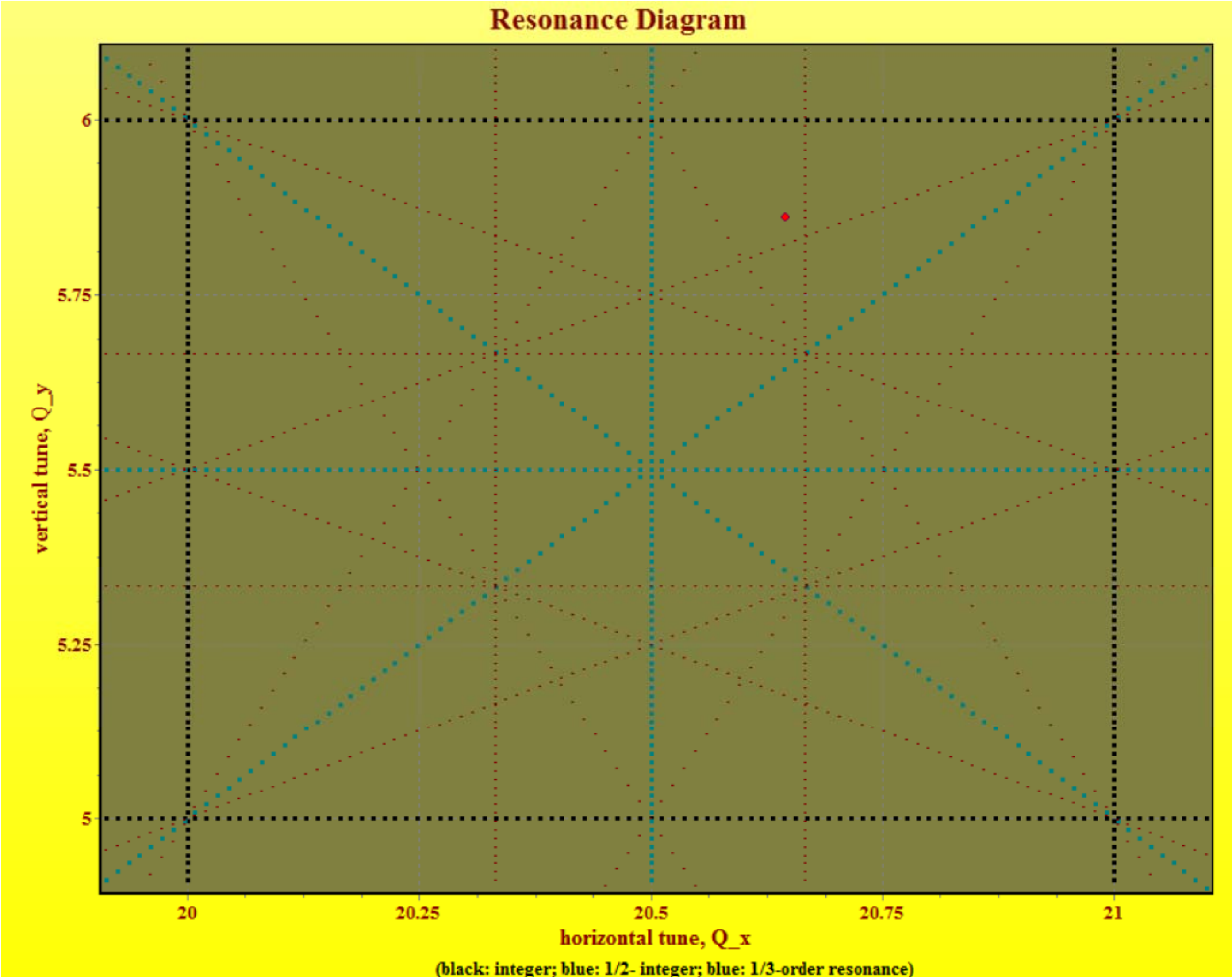

Fig. 5: The layout of the Betatron Tunes

Triple-Bend Achromat

For the TAC at 3.56 GeV, the TBA has been studied with the equal length dipoles which are the magnetic field of the middle dipoles by a factor of √3 larger than that of outer dipoles.

$$\varepsilon_{METBA} = C_q \frac{\gamma^2}{4\sqrt{15}} \frac{\theta_p^3}{J_x} \frac{1}{40.707}$$

$$\varepsilon_{METBA} = 0.334\ [nm.rad]$$

TAC SR TDR

	DBA	TBA
Energy [GeV]	3.56	3.56
Superperiod	23	28
Circumference[m]	301.76	336.56
Current [mA]	400	400
Energy lost per turn [keV]	883.153	716.352
Tune [Qx, Qy]	20.6, 5.8	17, 6.4
Emittance [nm-rad]	3.066	54.223
Energy spread %	0.09	0.06
Momentum compaction factor	0.0011	0.001075
Chromaticity	-37, -27.4	-21.7, -47.8
Total Straight Section [m]	110.4	123.2

Table: 2

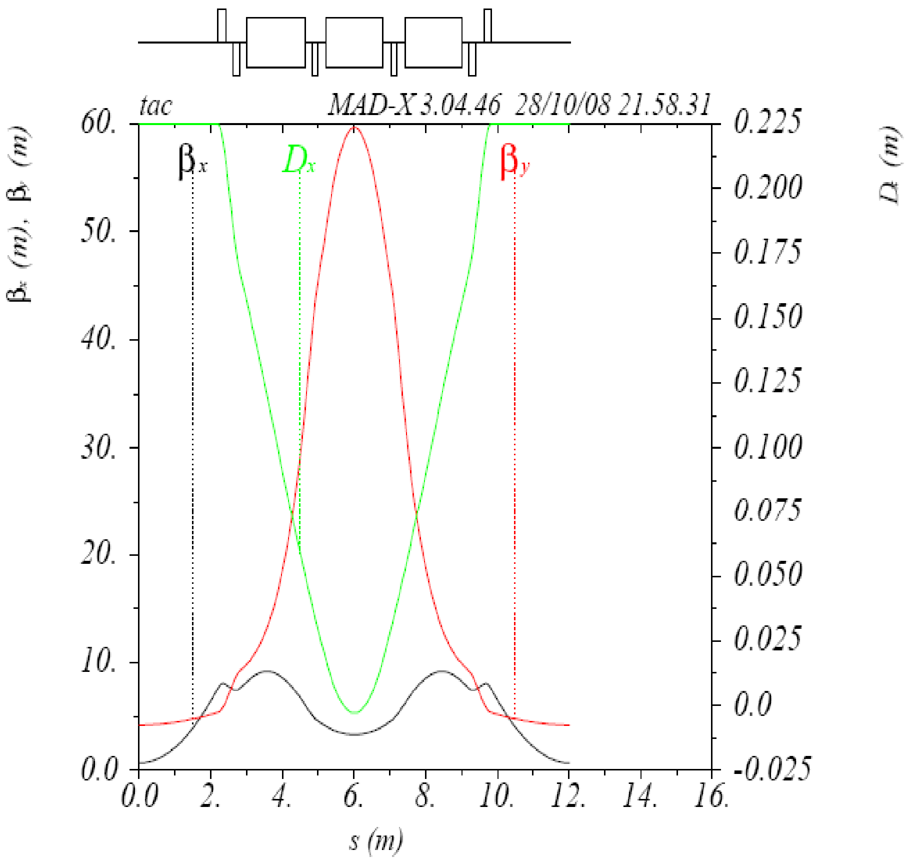

Fig. 6: Lattice functions for 28 period TBA lattices.

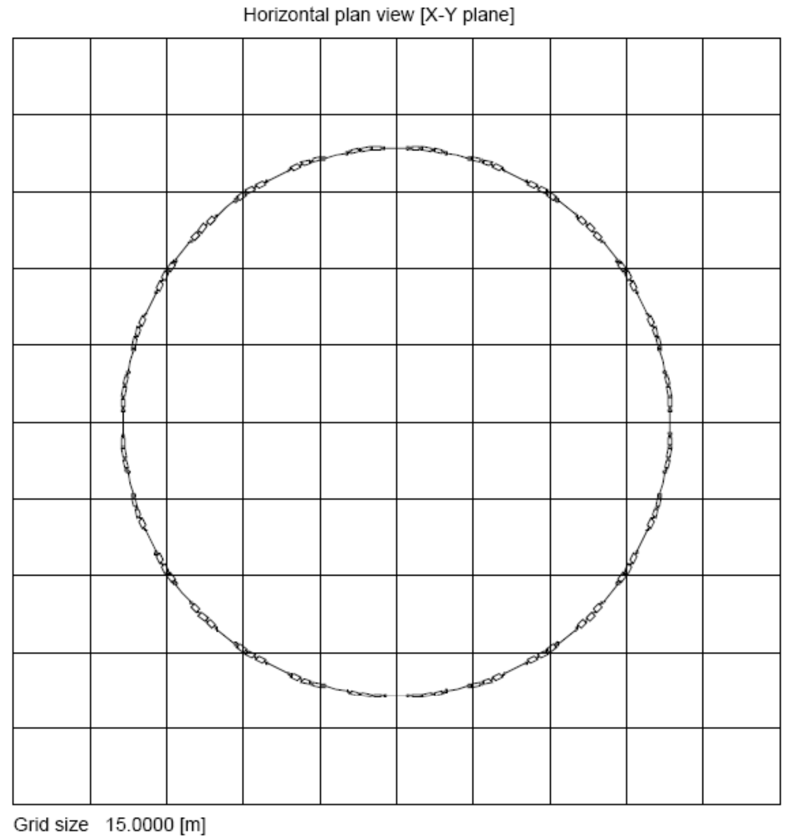

Fig. 7: Around 36.6% of the circumference is devoted to straight sections.

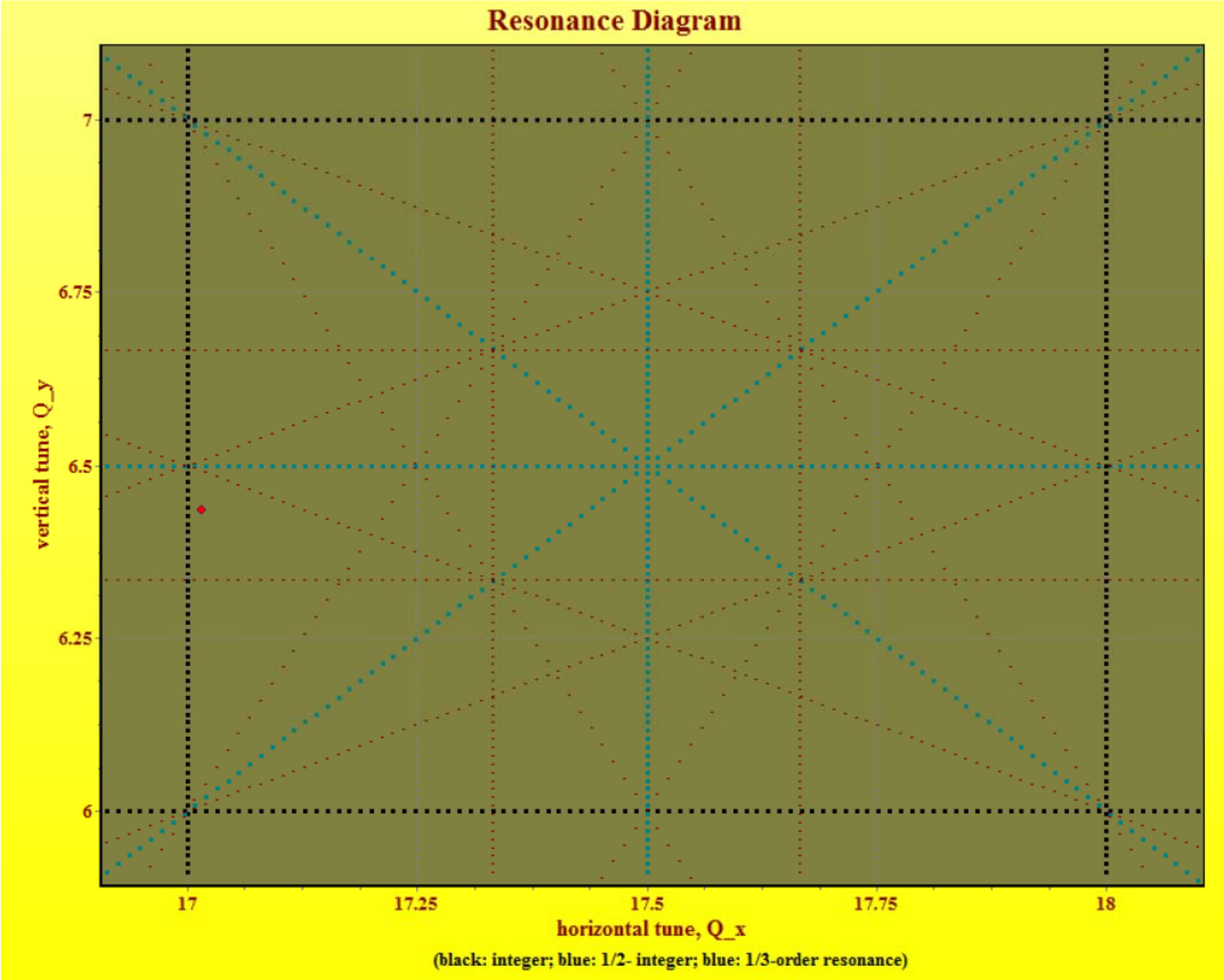

Fig. 8: The layout of the Betatron Tunes

CONCLUSION

We have studied DBA and TBA lattices according to design goal for TAC 3.56 GeV. However, they need to be optimized according to Dynamic Aperture(DA) and alignment tolerances.

The optical results of the DBA lattice that is a type of lattice composed of cf-bending magnets and quadrupole doublet, look better than theTBA lattice.

To obtain the better results for TBA, the length of the center dipole should be longer by a factor of $3^{1/3}$ than length of outer dipoles.

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thanks attention...