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# Modified Lattice of the compact Storage Ring in the cSTART project at Karlsruhe Institute of Technology

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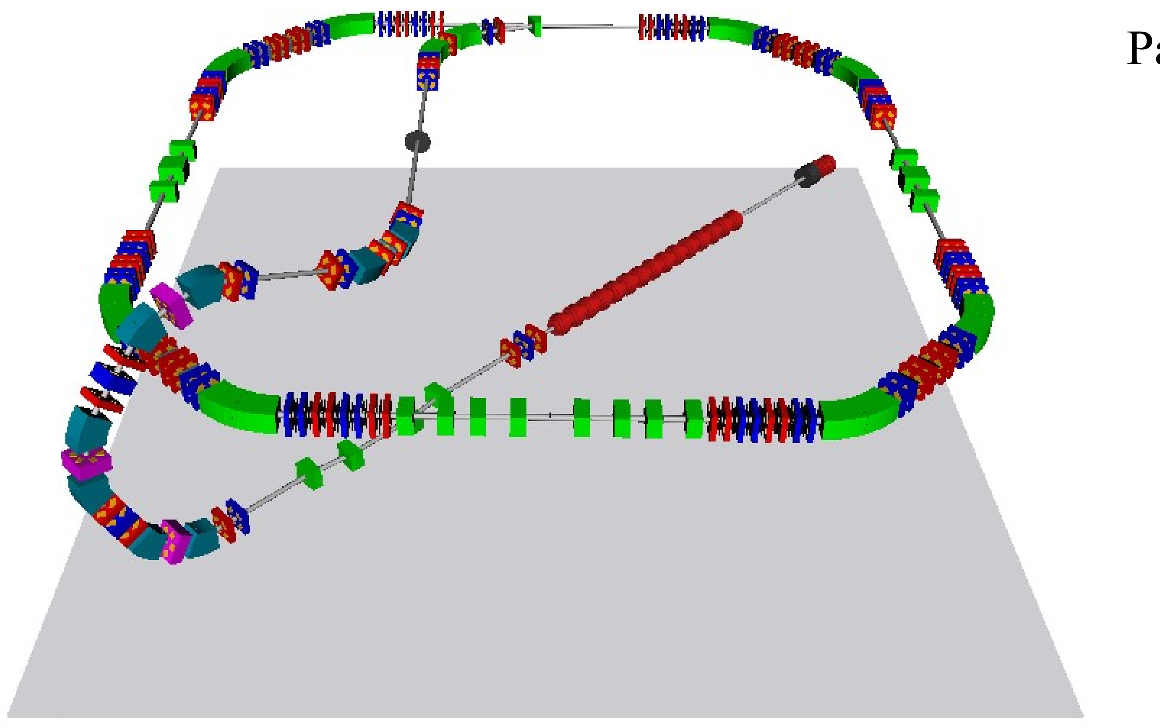
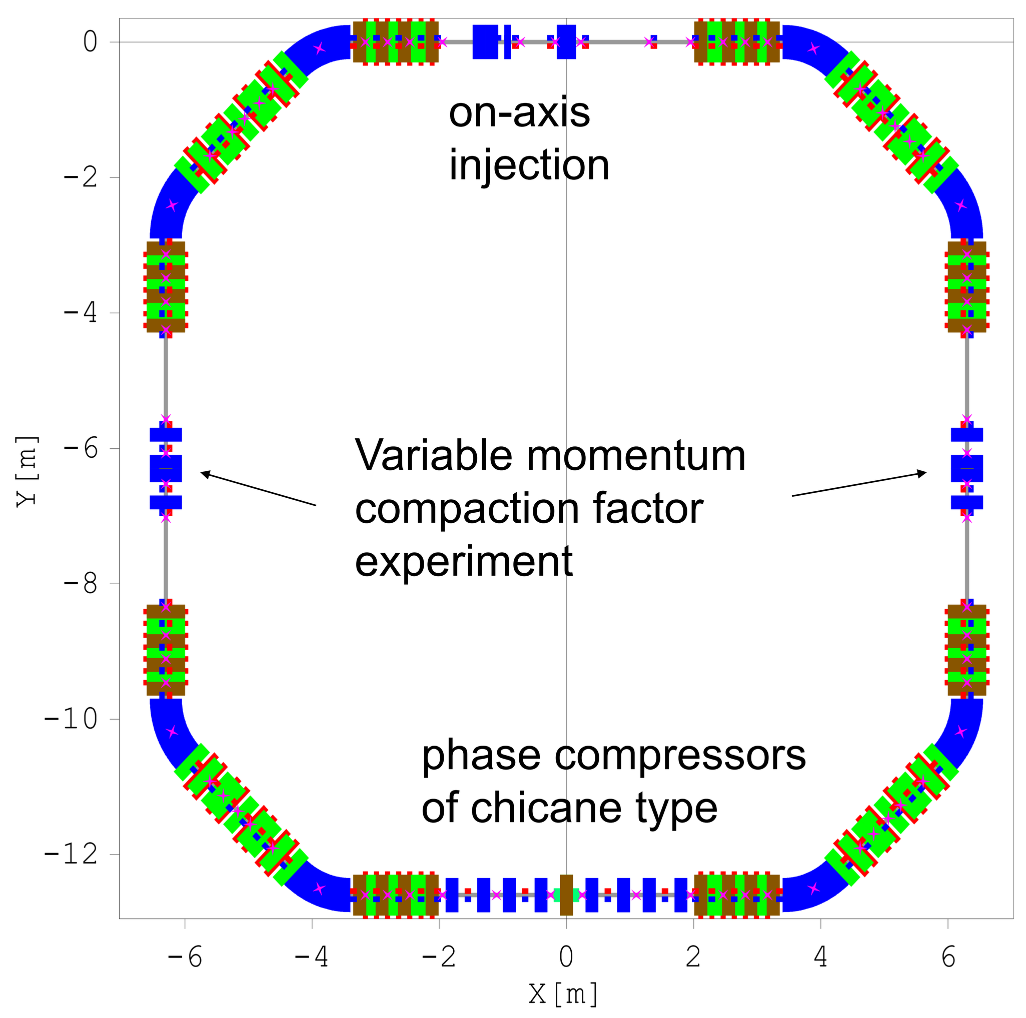
**Absrtact**

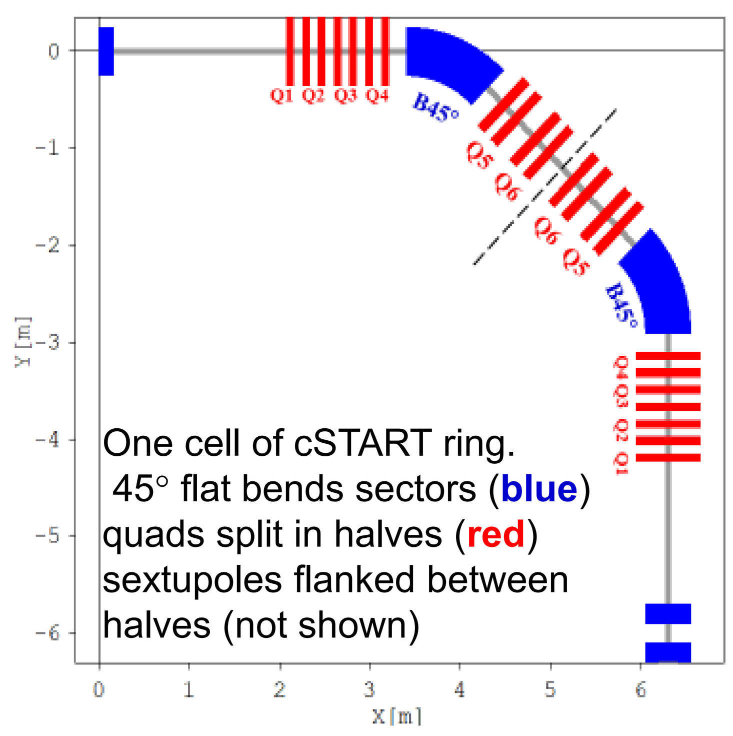
The compact storage ring project for accelerator research and technology (cSTART) is realized at the Institute for Beam Physics and Technology (IBPT) of the Karlsruhe Institute of Technology (KIT). Combination of a storage ring and a laser wake-field accelerator (LWFA) might be the basis for future compact light sources and advancing user facilities **[1]**. Meanwhile the post-LWFA beam should be adapted for storage and accumulation in a dedicated circular accelerator. Modified geometry of compact ring operating at 50 MeV energy range has been studied and main features of a new model are described here. The new design, based on 45° bending magnets, is suitable to store a wide momentum spread beam as well as ultra-short electron bunches in the fs range from the Plasma cell as well as from the ferninfrarot linac- und test- experiment (FLUTE) **[2]**. The DBA lattice with different settings and relaxed parameters, split elements and higher order optics of tolerable strength allows improving the dynamic aperture and momentum acceptance to acceptable level. This contribution discusses the lattice features in details and different possible operation schemes of a ring.



Artistic view of the cSTART facility. The FLUTE test bench is located on the ground floor, the compact storage ring is lifted at a height of about 3 m. Transfer line delivers short bunches from the 50 MeV linac to the ring and includes focusing elements, energy analyzer and bunch compressor that maintains the ultra-short bunch length of FLUTE **[7]**.




Compact ring is composed of flat 45° sector bends, split quadrupoles, sextupoles flanked in-between quads and octupoles. Four meter long straight sections accommodate elements of injection, equipment for dedicated diagnostics and physical experiments




One cell of cSTART ring.
45° flat bends sectors (**blue**)
quads split in halves (**red**)
sextupoles flanked between
halves (not shown)

–momentum acceptance is increased to ±6%;
–dynamic aperture (DA) is opened to ±20 mm
–strength of sextupoles is limited
–straight sections designed as modular units
–arc sections – solid block magnets (MAX-IV **[10]**)

Ring satisfies contradictory features:
–accommodate wide beams with large momentum spread
–ultra-short bunches at non-equilibrium conditions

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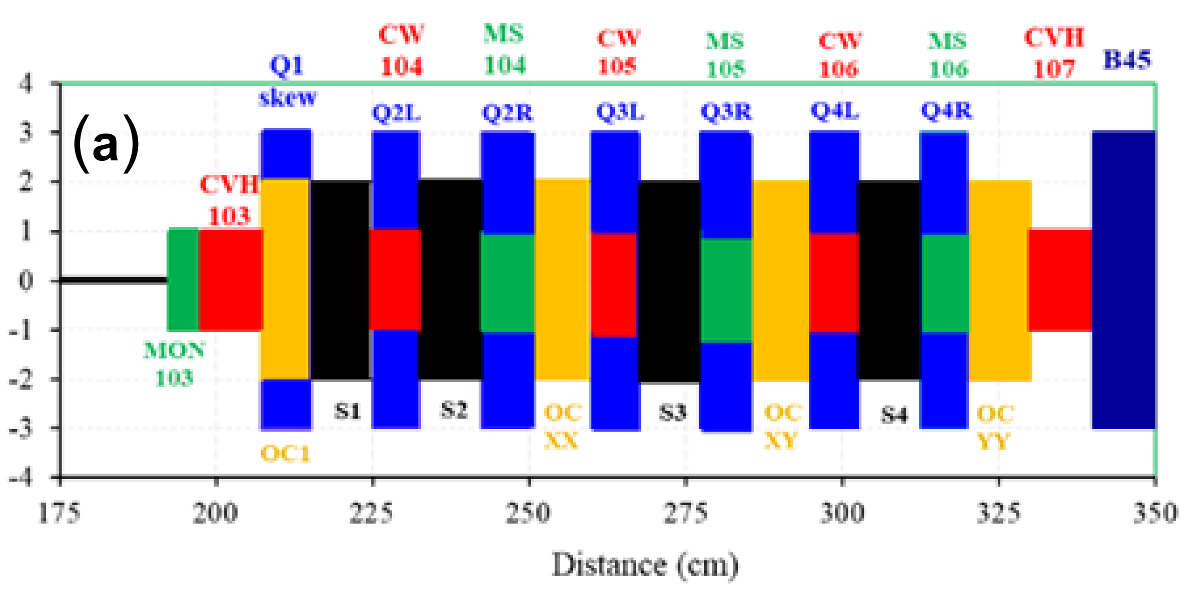
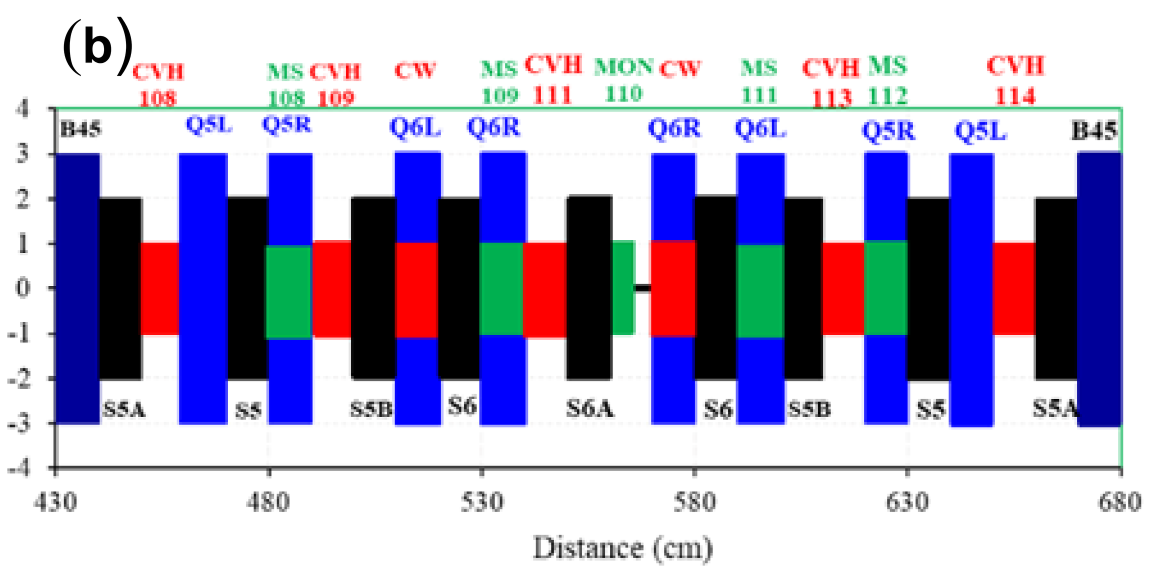
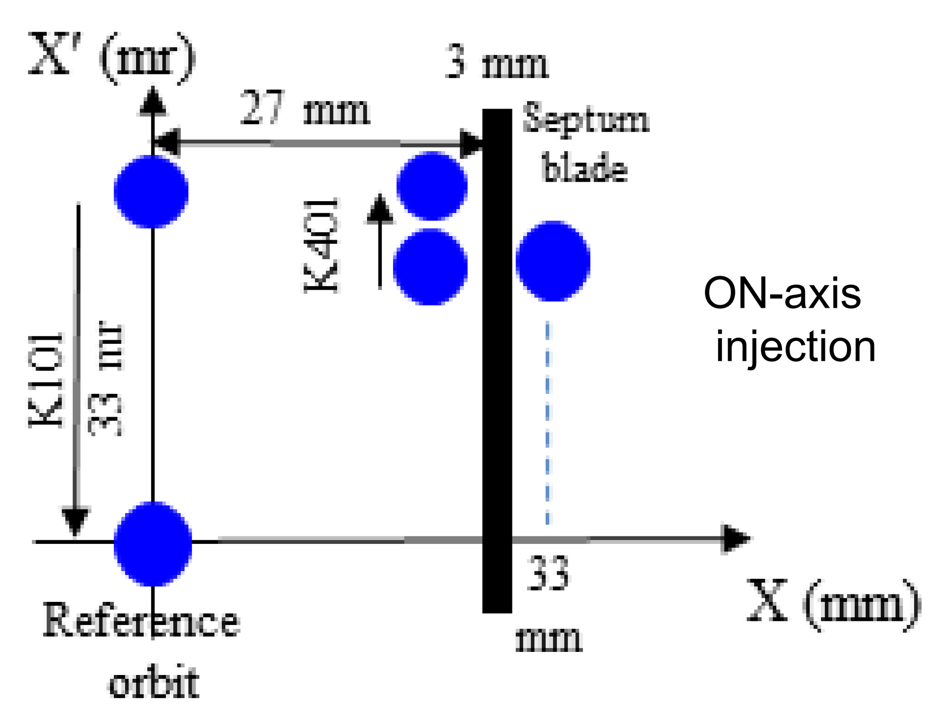
Parameters of the cSTART ring

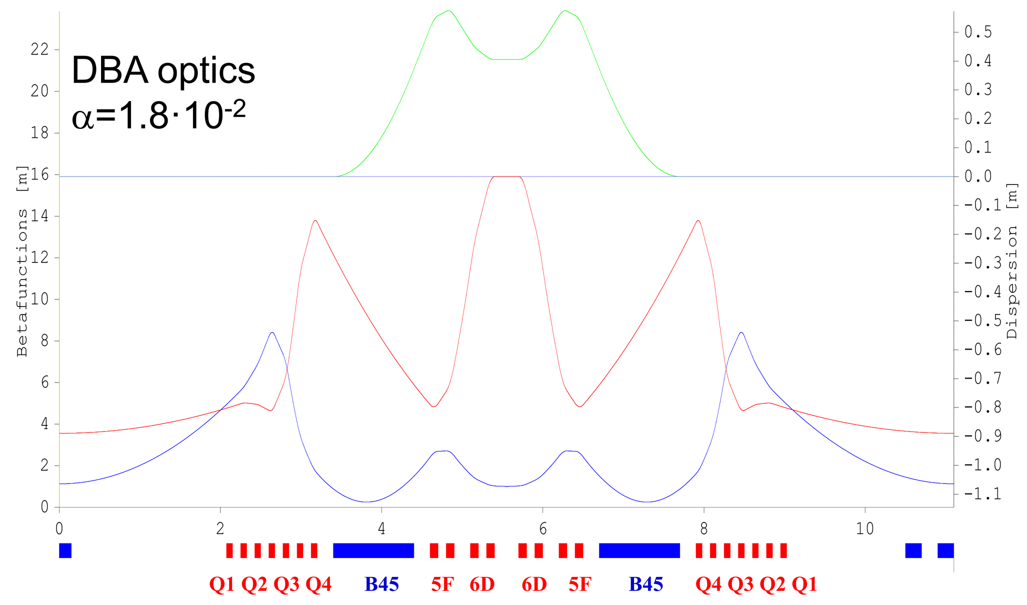
| Parameter | split Q lattice |
|---|---|
| Energy range | 50 MeV |
| Magnetic rigidity, $B{\cdot}R$ | 0.167–1.67 T·m |
| Circumference (footprint) | 44,4 m (13×13 m) |
| Periodicity / cell | 4 / DBA 2×45° bends |
| Straight sections $N \times L$, m | 4 × 4 m |
| Mom. Comp. factor variable | $+2{\cdot}10^{-2}\ldots-1{\cdot}10^{-2}$ |
| SR losses/turn (50 MeV) | < 1 eV |
| Natural Chromaticity | $\xi_{x,y} = -24 / -20$ |
| Damping time $\tau_x/\tau_y/\tau_s$(50 MeV) | h/v/l = 37/34/16 s |
| Energy spread variable | $\sigma_E = 10^{-4}$ to $10^{-2}$ |
| Momentum acceptance lattice | ± 5.5% |
| RF frequency / $F_{ROT}$ / $h_{RF}$ | 500 MHz/6.8 MHz/73 |
| Betatron tunes $Q_x/Q_y$ | 5.652 / 1,265 (DBA) |
| Vacuum chamber (full size) | 60 × 40 mm |
| Dynamic Aperture (h/v) | 20 / 14 mm |
| Dynamic Acceptance (h/v) | 100 / 20 mm·mr |
| Unnorm / norm emittance (h) | 10 nm/1 mm·mr (rms) |
| Betatron tunes $Q_X / Q_Y$ | 5,844 / 8,461 (DBA) |
| Bunch length – Gauss equivalent | ~1 fs to 1 ps (rms) |
| Bunch charge | 1.6 to 160 pQ/bunch |
| Bunch intensity | $10^7$ to $10^9$ part/bunch |
| Lifetime at 50 MeV | 20 ms to 20 minutes |

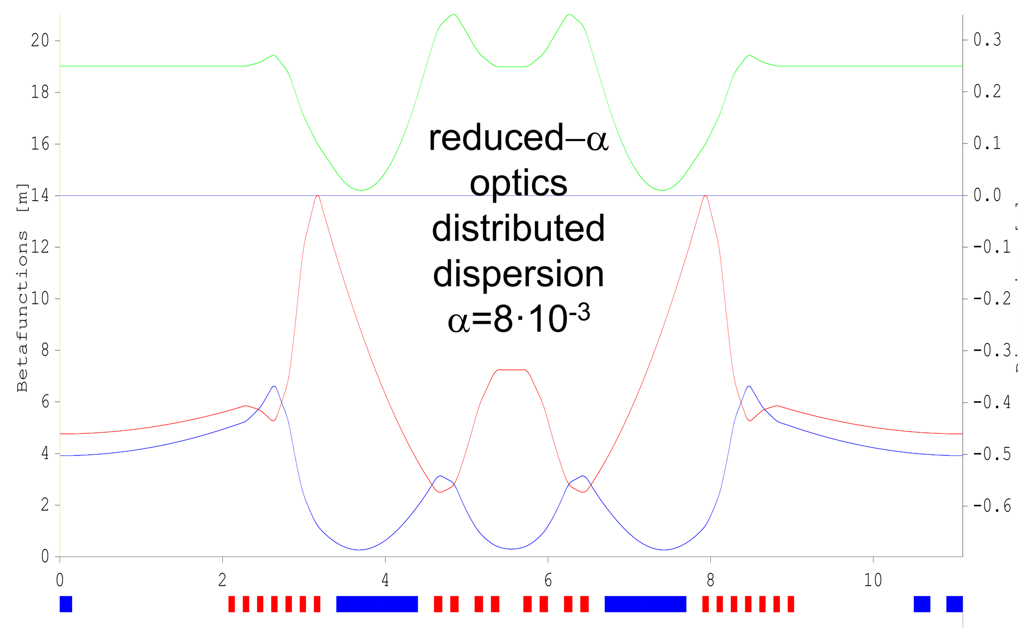


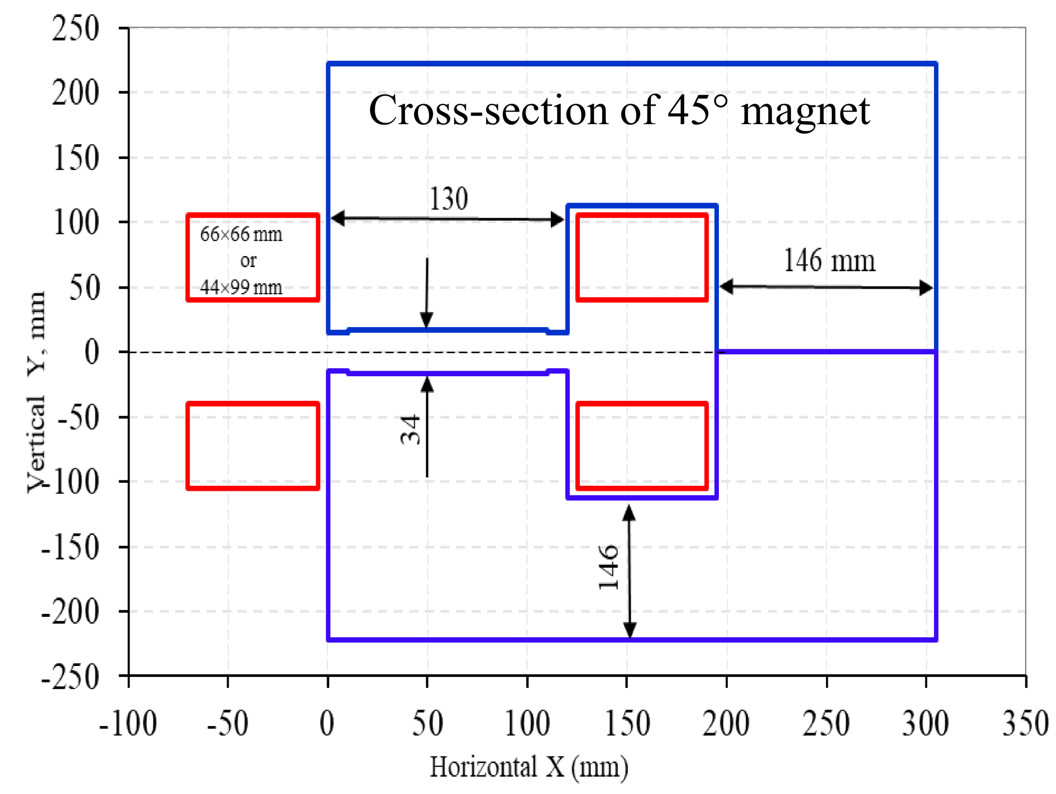

Zoomed view of focusing and diagnostic elements: a) magnet block in front of first 45° bending magnet (**B45**); (b) blocks between two 45° sector magnets. Dedicated correctors (**CHV**) as well as additional wiring correctors (**CW**) inside quadrupole magnets are marked by **red**; Monitors (**MON**) and srtipline BPM (**MS**) are marked by **green**; **Quads – by blue** color, **sextupoles** – by **black**, **octupoles** – by **brown**.




90° cell with FDDF quads. **βx–blue**, **βy–red**, **D–green**. 45° bends shown as **blue** strips, double split quads – as **red** blocks




## CONCLUSION

.Detailed design of a very large acceptance compact storage ring have been done so far. Studies of the CSR effects, lifetime, beam injection and diagnostics, orbit correction were performed and reported at this conference.

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