AN ELECTRON SYNCHROTRON LATTICE BASED ON THEORETIC MINIMAL EMITTANCE CELL

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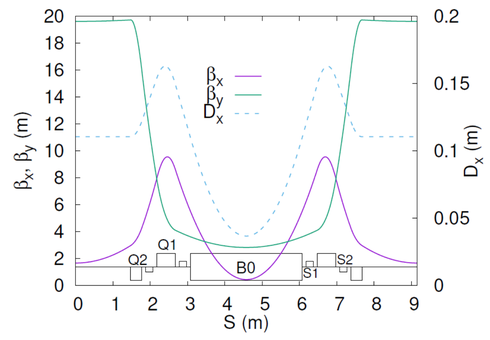
Introduction

The PETRA IV project toward a diffraction limit synchrotron light source at 6 GeV features an ultra low emittance storage ring. It has a very small dynamic aperture (DA) so the beam to be injected must has very low emittance.

The current booster DESY II having FODO lattice does a good job preparing the beam to be injected and accumulated in PETRA III. It has been in service for more than 50 years and is still reliable. However, its emittance (350nm-rad) is too large for PETRA IV so a new synchrotron is always needed as a booster or an accumulator.

This new ring has to be in the existing old tunnel which can accommodate rings of sizes between 292 to 316 m. The key goal of the injector upgrade project is to achieve the equilibrium emittance <30 nm-rad at 6 GeV [1].

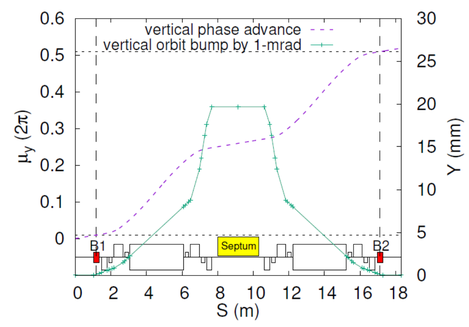
TME CELL



TME32 RING

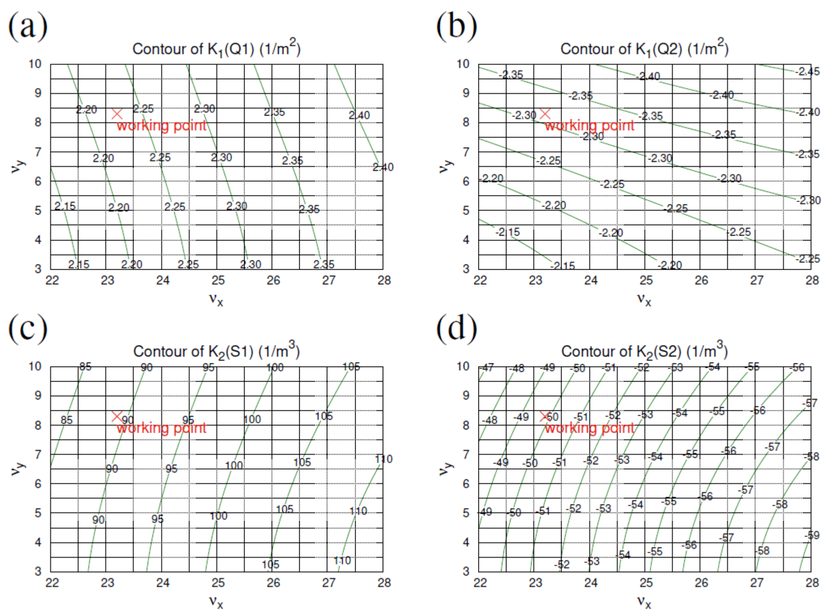
Periodicity	32
Circumference	292.8 m
Working Tune	23.20 / 8.30
Natural Chromaticity	-39.4 / -34.6
Momt. Compaction	1.3 E-3
Energy	6 GeV
Energy Loss per Turn	7.5 MeV
Natural Emittance	9.9 nm-rad
Energy Spread	1.3 E-3
Damping Time	1.6 / 1.6 / 0.8 ms

2-kicker Orbit Bump



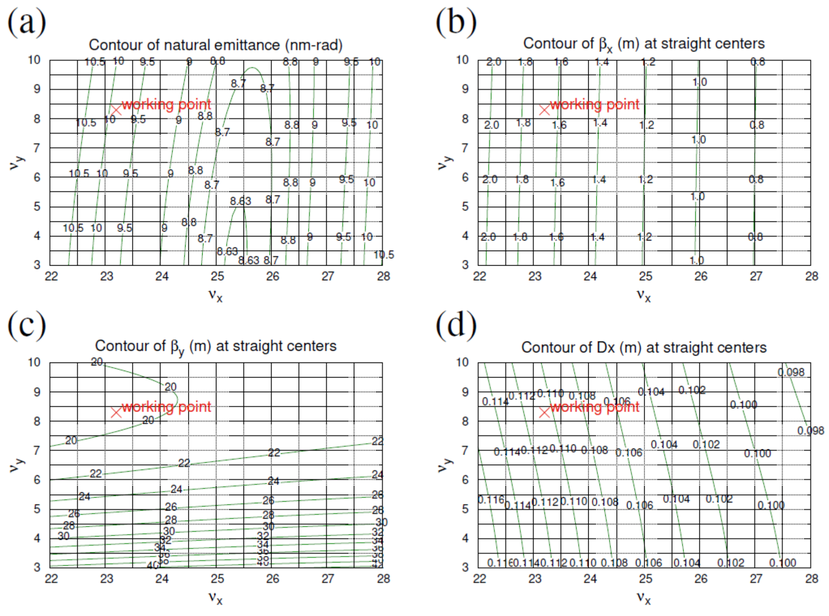
- Vertical phase advance π across two sections
- 16 slots for efficient 2-kicker bump
- Kicker leverage is 20 mm/mrad
- Vertical bump with horizontal injection/extraction with Lambertson septum
- Some magnets have to be properly designed so that the injection/extraction trajectory can go through them without begin blocked

Tune Scan -- Strengths



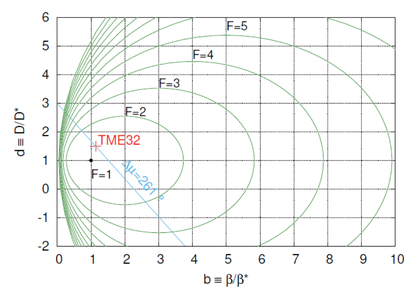
- Moderate strengths

Tune Scan -- Optics



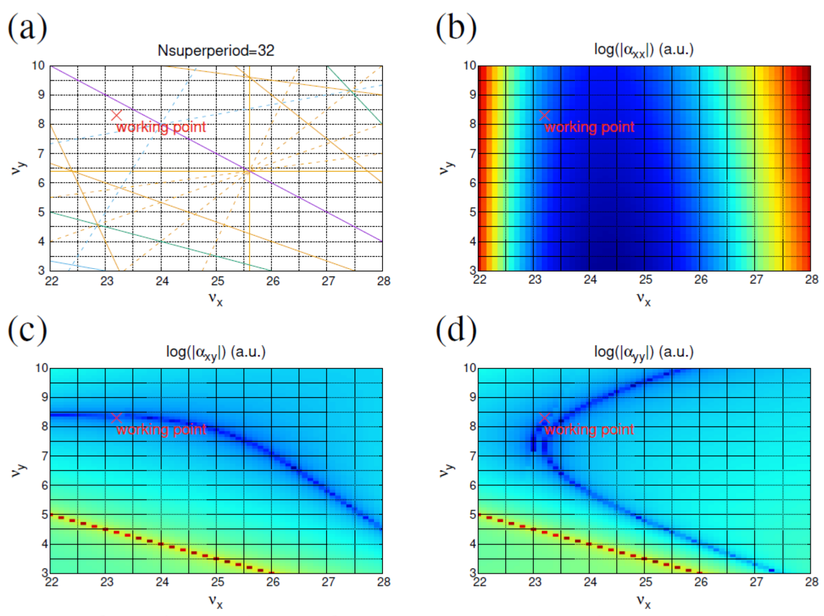
- Near TME working point

Iso Emittance Contour



- At bending center, $\beta^* = L/(2\sqrt{15})$ and $D^* = L\theta/24$ for a TME lattice
- TME at E=6 GeV,
  ε(N=30)=6.1 nm-rad
  ε(N=32)=8.6 nm-rad
  ε(N=36)=10.5 nm-rad
- Emittance , F=1 for minimal
- Emittance contour in parameterization (d=D/D*, b=β/β*)
- F=1.15 in this case

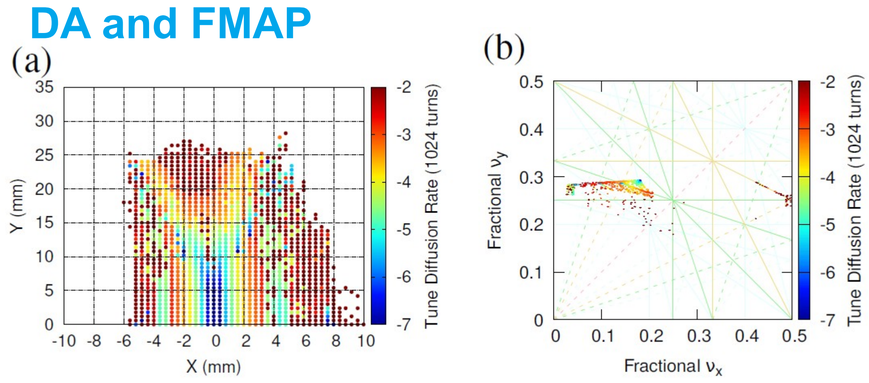
Tune Scan – Detuning Factor



first order tune detuning factors $\alpha_{xx}, \alpha_{xy}, \alpha_{yy}$ w.r.t. the particle actions J_x and J_y are defined as

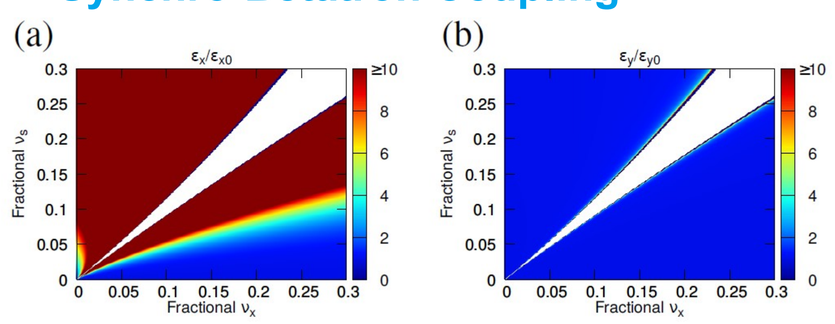
$$\Delta\nu_x = \alpha_{xx} J_x + \alpha_{xy} J_y,$$
$$\Delta\nu_y = \alpha_{xy} J_x + \alpha_{yy} J_y.$$

DA and FMAP



- Tune at a sweet spot of big vertical DA

Synchro-Betatron Coupling



- Emittance growth due to synchro-betatron coupling is negligible

Summary

- The goal of designing a low emittance synchrotron with TME lattice is achieved.
- With 32 superperiods, its equilibrium emittance is about 10 nm-rad at 6 GeV, just 15% more than the TME condition.
- It can be an option of the booster or accumulator for the PETRA IV project.
- Moreover, its energy can go up to 7.5 GeV and many other versatile usages are possible.