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SPX Lattice Studies

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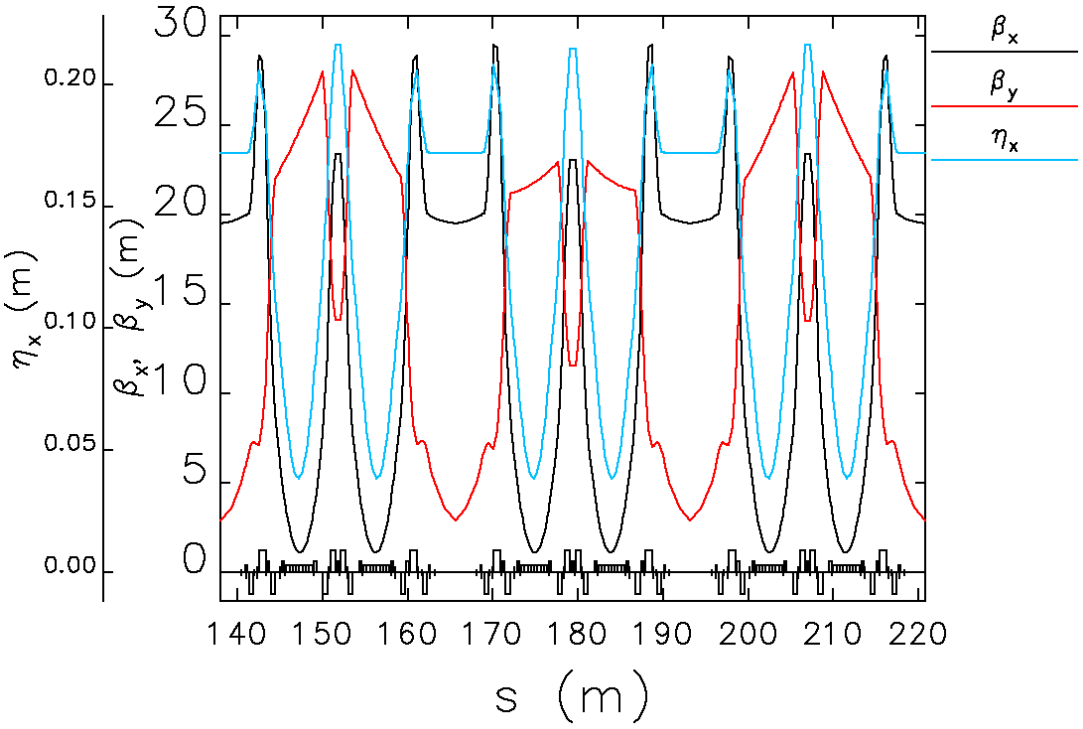
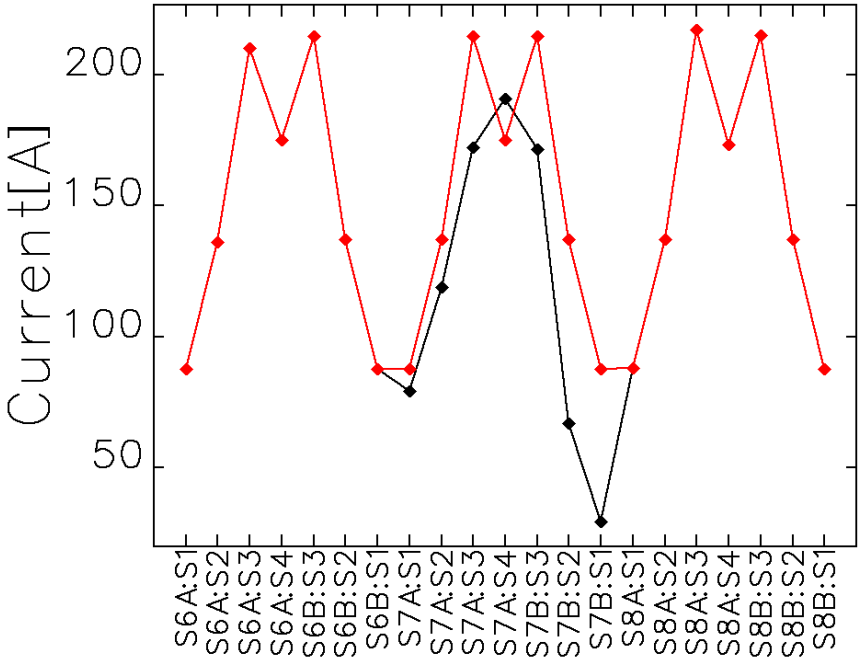
Sector 7 lattice for normal conducting cavities

- Linear lattice needs to be adjusted to provide phase advance of 0.5 between cavities
  - Normal phase advance is 0.48, therefore only small adjustments are required
  - Minimal beta function symmetry breaking is desired



Sector 7 lattice for normal conducting cavities

- Non-linear elements (sextupoles) need to be adjusted to minimize emittance blow-up[1]
  - Only sextupoles between cavities are affected
  - Minimal sextupole symmetry breaking is desired to avoid excitation of additional resonances



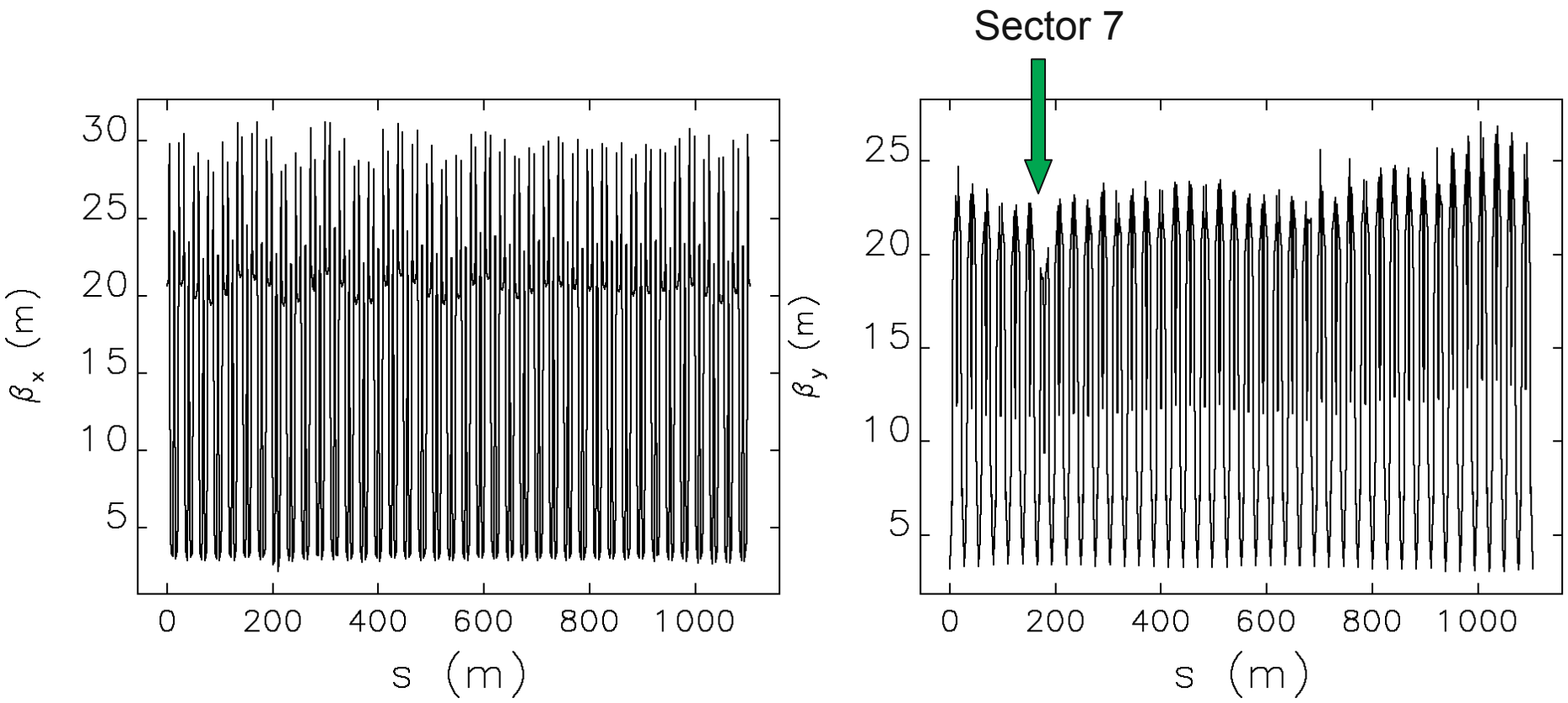
[1]M. Borland, V. Sajaev, Proceedings of PAC'05; A. Zholents, V. Sajaev, LBL 62852

Machine tests

- In 2007 we had 6 study shifts (about 4 hours each) devoted to setting up and testing the lattice
- Results that we were able to achieve so far:
  - Lifetime – 180 minutes with 24 singlets (but with high chromaticity)
  - Injection efficiency – about 80%
  - Accumulation limit – 8 mA (should be 20 mA)
- Lifetime and injection efficiency are comparable to normal APS hybrid lattice, increase of the accumulation limit would require more studies
- Beta function correction was not performed at the time because beta function beating was not bad

Machine tests

- Measured beta functions (left – horizontal, right – vertical), July 2007



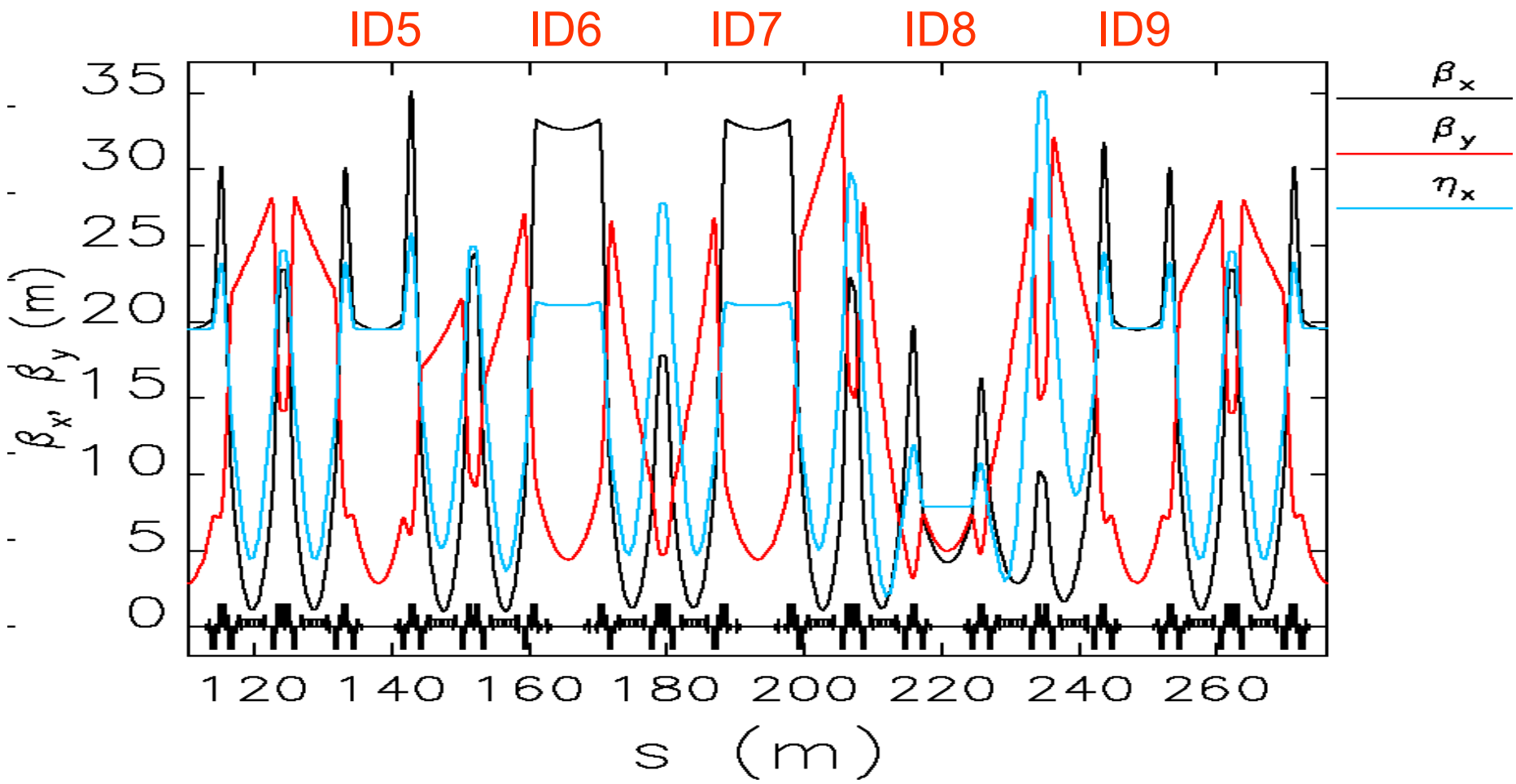
- Beta function beating here is of the same scale as we often have in operation

Lattice for superconducting cavities

- Undulator A and superconducting cavity don't fit inside standard APS ID straight section (SS), therefore straight section length has to be increased
  - Most reasonable way to increase SS length is to remove one quadrupole from each side of the SS
  - Tests of such lattice modification were performed some time ago by turning off corresponding quadrupoles in one SS
- Installation of two cavities will require modification of ID6 and ID7 straight sections
- One also needs to remember that ID8 is a special location that operates at Reduced Horizontal Beamsize (RHB) mode several weeks a year
- Combination of two longer Straight Sections and RHB straight section in one location makes lattice design challenging

Lattice for ID7 superconducting SPX and ID8 RHB

This is one example of lattice that gives natural emittance of 2.7 nm rad.



Lattice for ID7 superconducting SPX and ID8 RHB

Beam sizes for suggested lattice (standard lattice beam sizes are in brackets)

	Beta X (m)	Sigma X (μm)	Sigma X' (μrad)	Eff. Emittance (nm rad)
ID6	32.6 (19.5)	345 (275)	9.1 (11.3)	3.1 (3.1)
ID7	32.6 (19.5)	345 (275)	9.1 (11.3)	3.1 (3.1)
ID8	4.2 (3.6)	125 (120)	25 (29)	3.2 (3.5)

ID8 beam size differences are just a matter of different optimization; they can be made equal.

Lattice tests

- Feasibility of a lattice with 2 long SS next to each other needs to be tested
  - Can be tested during machine studies by turning off quadrupoles
- Even symmetric hybrid lattice is very demanding, so developing hybrid lattice with such modifications will be very challenging.
- Impact on lifetime is expected and likely to require more frequent topup.

- RHB lattice is never operated in hybrid mode – combination of 2 long SS and ID8 RHB only needs to be operated with weaker sextupoles corresponding to 24 singlets mode
  - Two lattices need to be tested:
    - *2 long SS with hybrid sextupoles and modified sextupoles between cavities*
    - *long SS + ID8 RHB with 24-singlets symmetric sextupoles*

More sectors between cavities

- Any number of sectors between cavities would require 2 long SS – effect on linear optics is about the same
- More sectors between cavities would mean more sextupoles between cavities
  - If not optimized, sextupoles lead to emittance blow-up[1]
  - Sextupole optimization allows to limit emittance blow-up but breaks sextupole symmetry
    - *The more sextupoles between cavities, the less emittance blow-up is possible to achieve after the sextupole optimization*[2]
    - *The more sextupoles changed by sextupole optimization, the the more symmetry breaking introduced*
- Lattice studies would be required to confirm feasibility of any lattice including lattices with more sectors between cavities

[1]M. Borland, Phys. Rev. ST-AB, 8, 074001 (2005)
[2]M. Borland, V. Sajaev, Proceedings of PAC'05

Conclusions

- We have tested lattice for normal conducting cavities for one sector between cavities
  - We have found that the lattice is nearly operational except for the accumulation limit of 8mA which can be further studied (and possibly improved)
- Lattice for super conducting cavities needs to be developed first, optimized, and then tested during machine studies

- We cannot predict lifetime with reasonable accuracy, we can only make relative comparison of lattices (better or worse); therefore any new lattice needs to be tested