Lattice optimization for collimation

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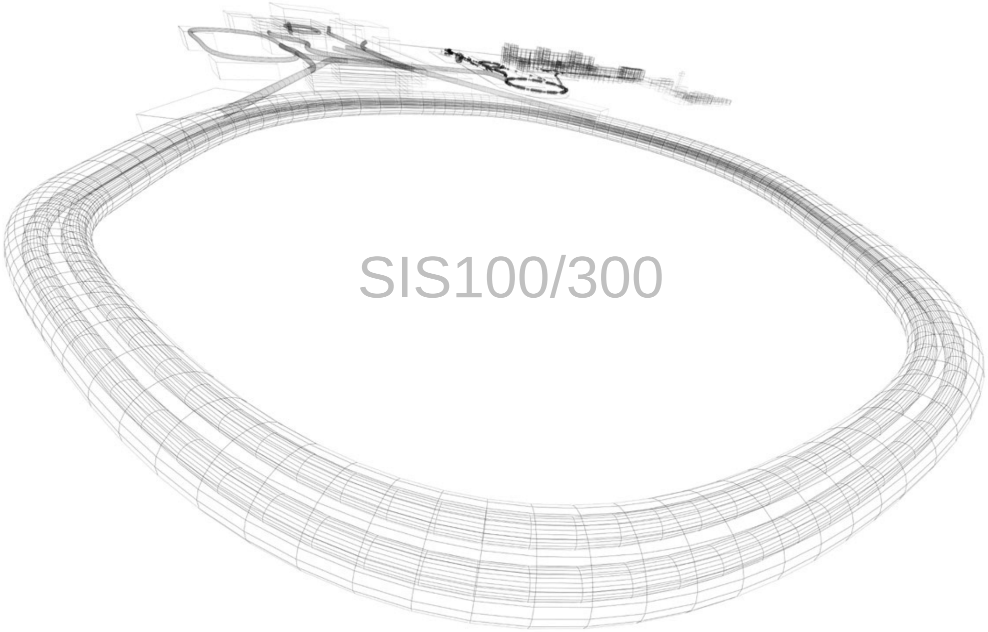


Introduction and motivation

- Ions in an accelerator may change their charge state due to charge exchange or decay harming the stable operation of an accelerator.
- Uncontrolled losses might cause dynamic vacuum effects, activation or significantly reduce the lifetime of the magnets.

Question: Which lattice layout allows me to control the losses best?

Collimation efficiency for different lattice layouts

Basic principles

- The ions should not be lost at arbitrary positions.
- The losses should be peaked in sections with sufficient space for a dedicated collimation system or even septa with dumps (decay ring).
- The collimators should not reduce the acceptance.
- The circulating beam and the contaminants should be clearly separated at the positions of the collimators which requires a waist in the beam envelope and dispersive elements upstream.
- Ideally all unwanted ions which are produced in the downstream section after one collimator should be able to be transported at least to the next collimator. (High tune or increased aperture)

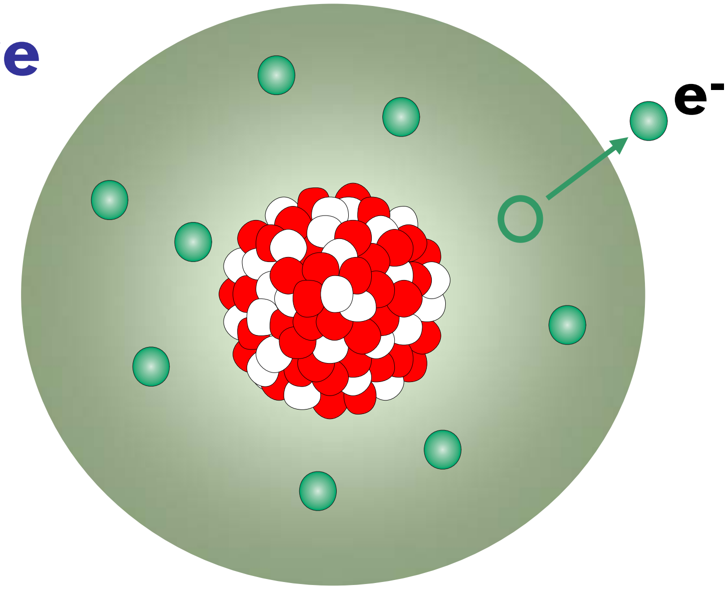
Peaked!

Separated!

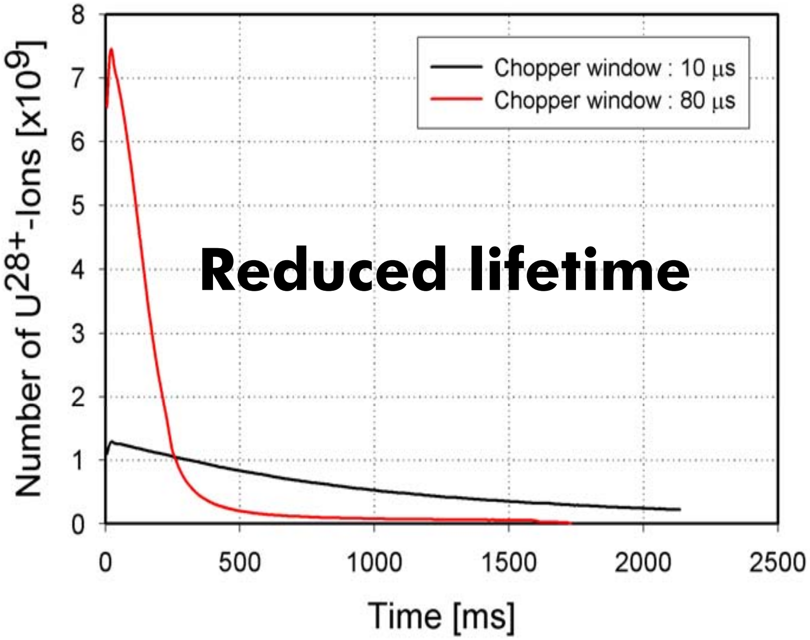
Acceptance!

Example: SIS100 design I

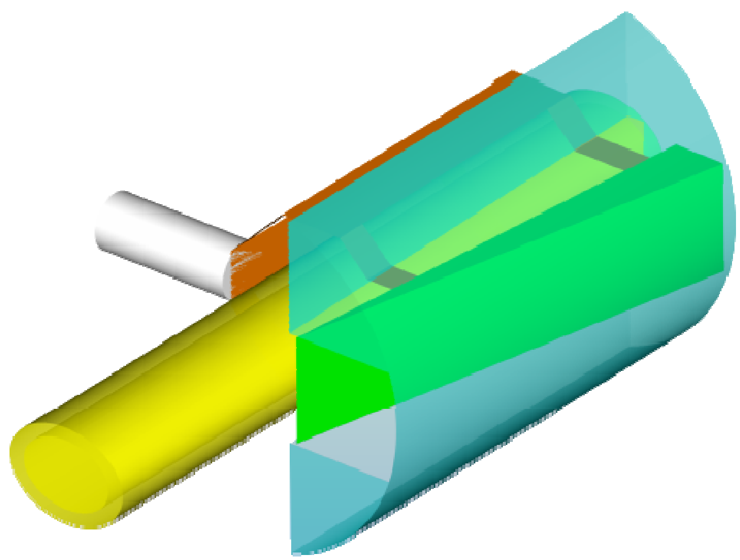
Starting point according to Tsun Tze



"Know your enemy":
U^{28+} -> U^{29+}

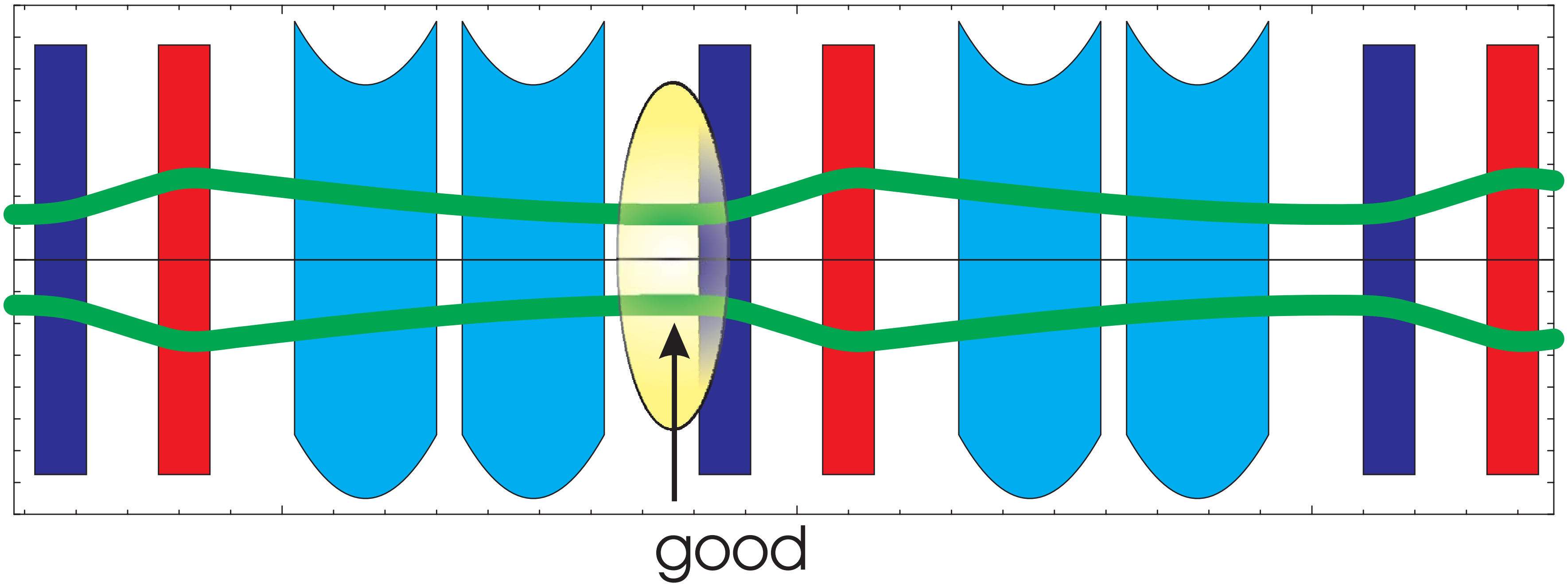


"Chose the terrain":
Wedge collimator



Example: SIS100 design II

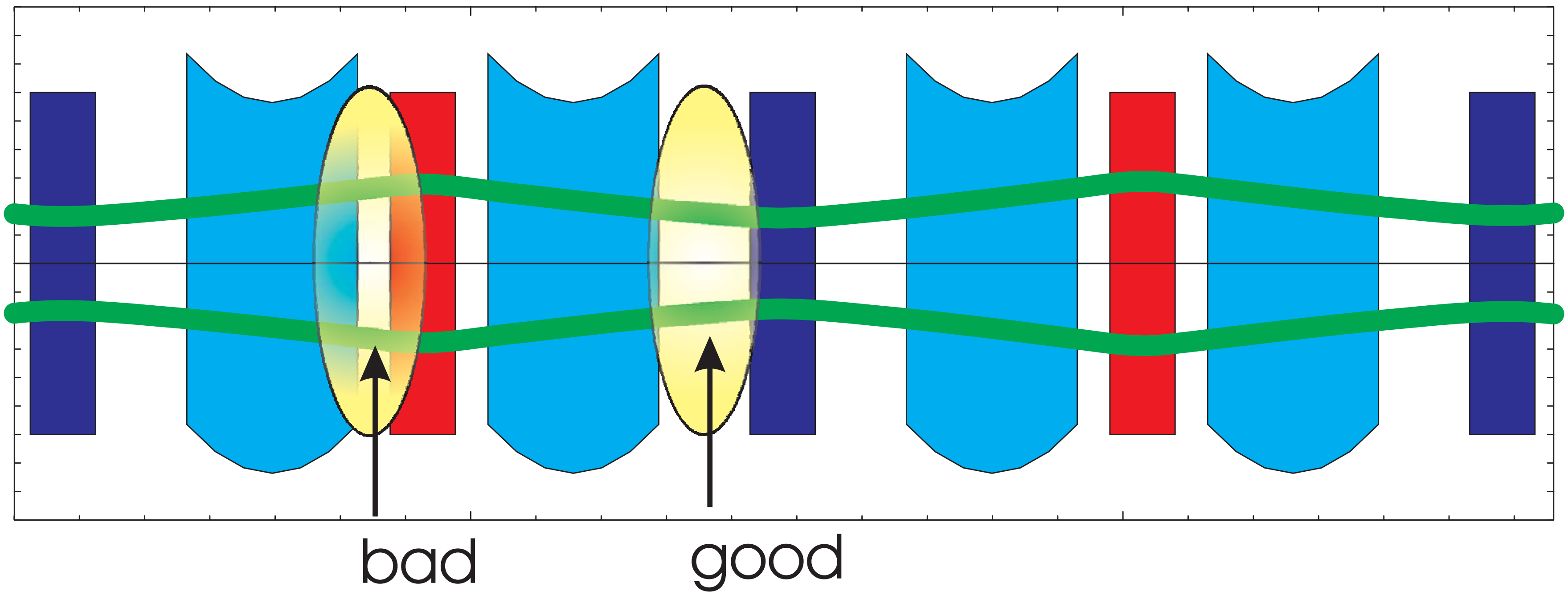
Weapon of choice: DF doublet lattice



A waist after the dispersive elements.

Example: SIS100 design III

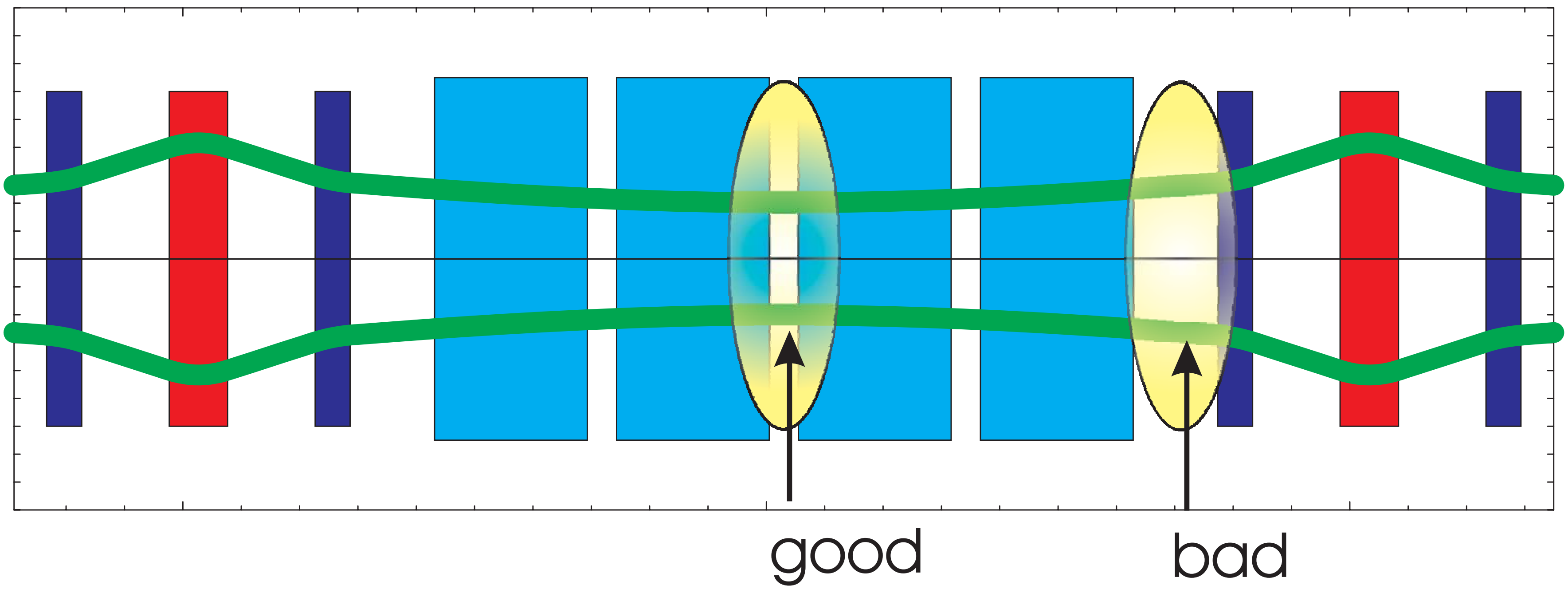
Problematic: FODO structure



One half cell is ok, next one is bad.

Example: SIS100 design IV

Not optimal: triplet structure

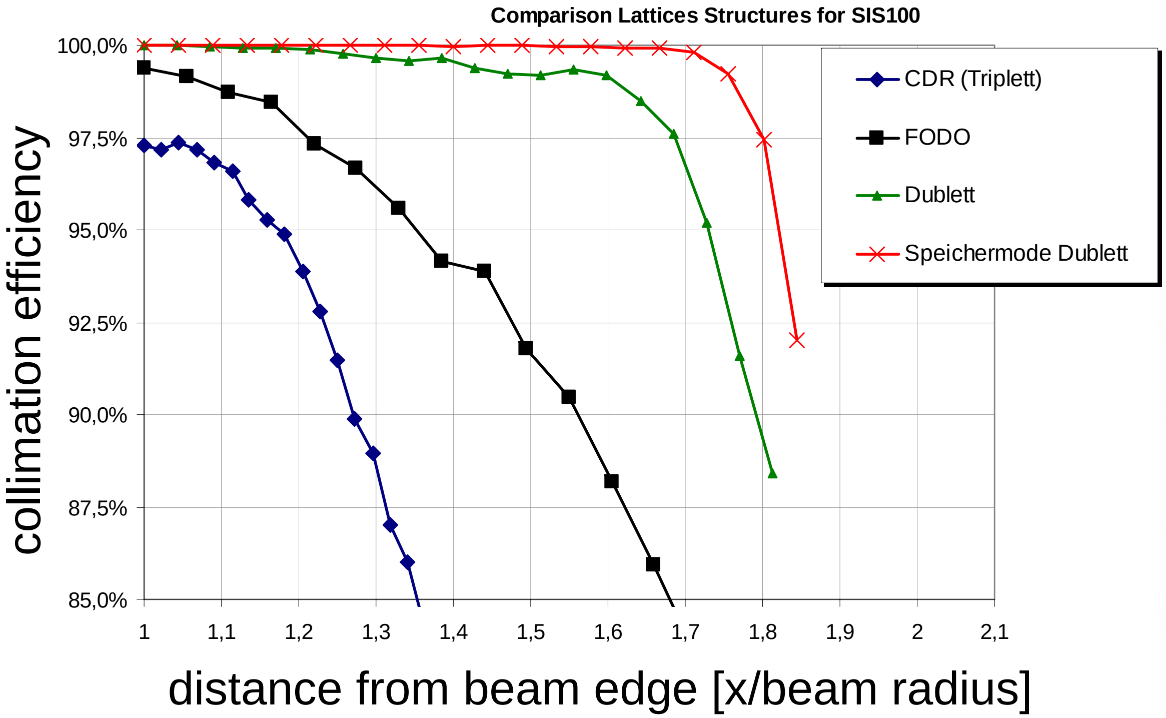


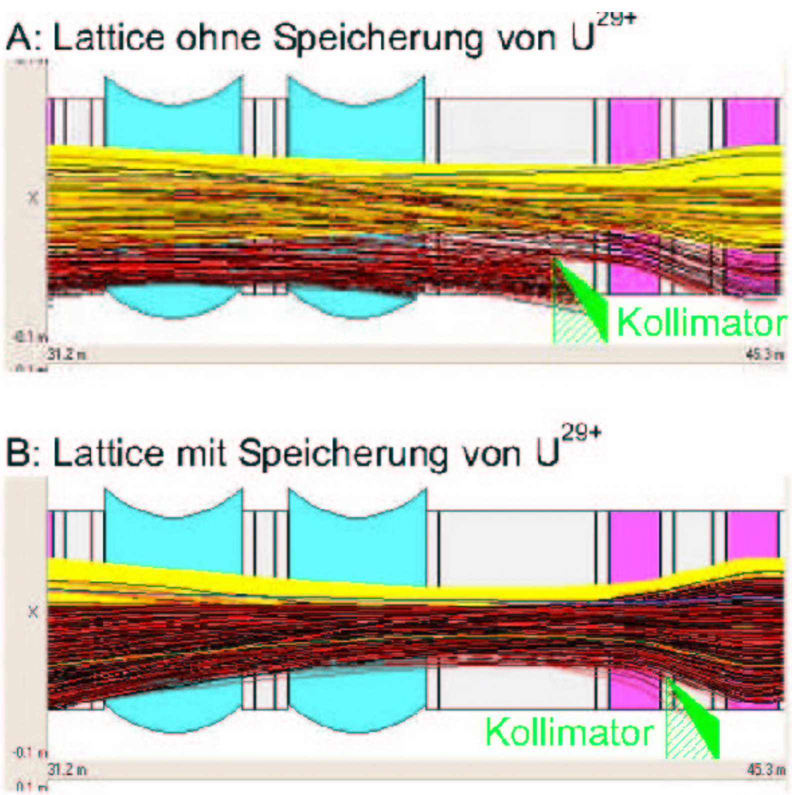
Would work, if all dispersive elements are in the first half of the cell.

Example: SIS100 design V

Results and influence of better transmission

The doublet structure with high momentum acceptance delivers best results. An unwanted particle just missing one collimator is "stored" and can be collimated later.

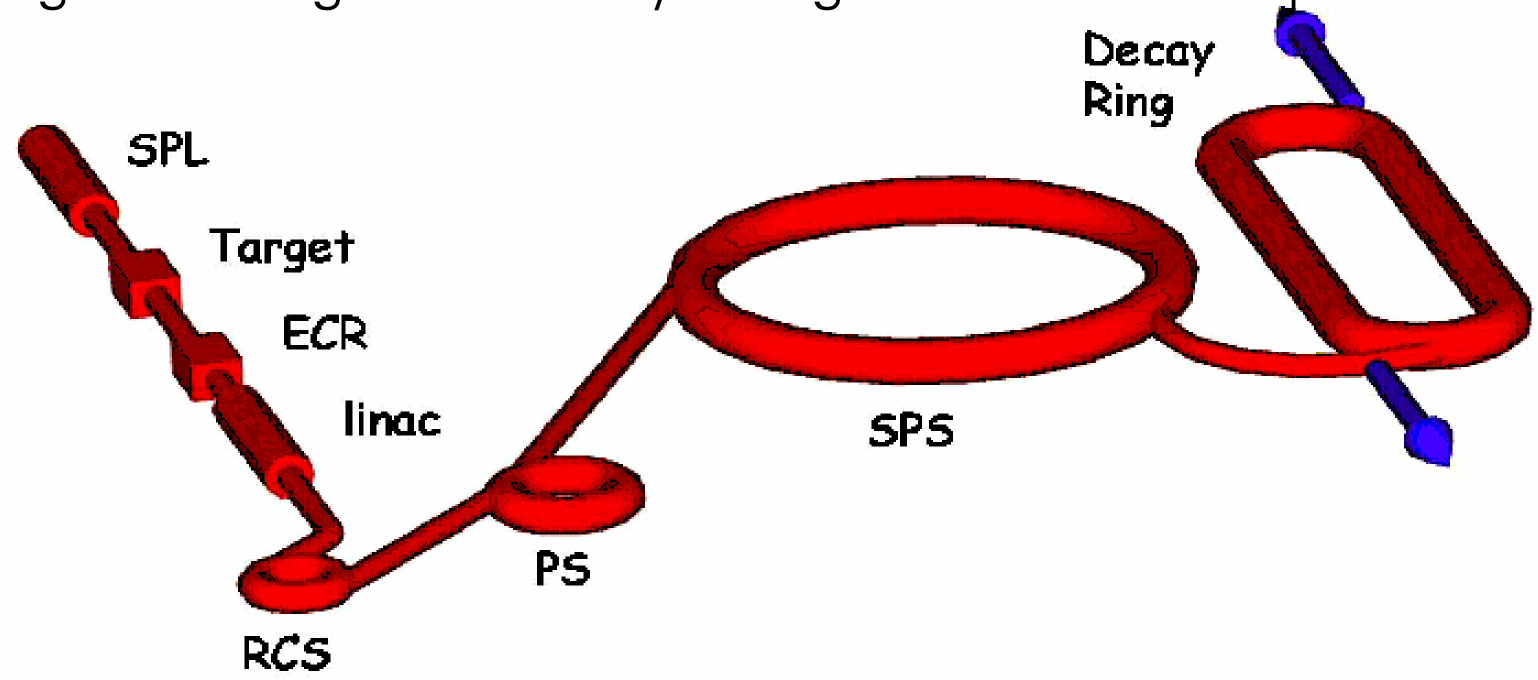




Considerations for Beta Beams

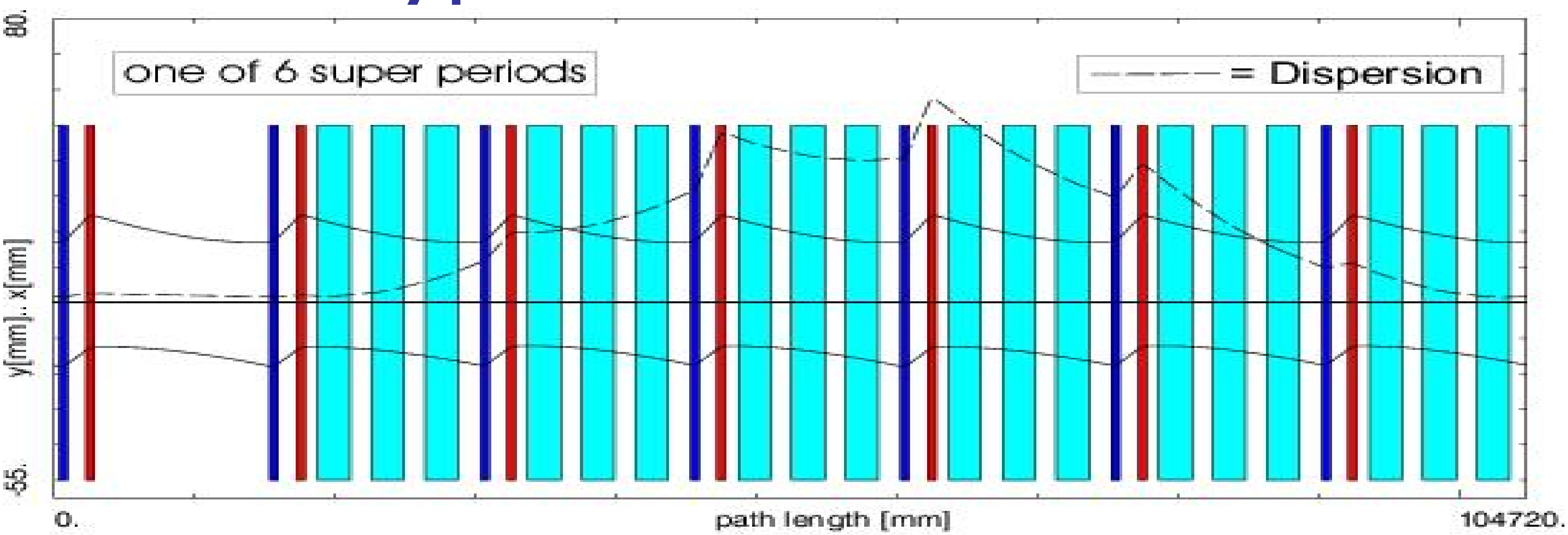
What is different for our Beta Beam scenario?

- We have two types of beams. The decay products have an increasing and decreasing m/q ratio.
- The decay products may result in dynamic vacuum problems but very good initial vacuum conditions will not prevent the decays.
- Charge exchange of the fully charged ions is not important.



Example: PS replacement

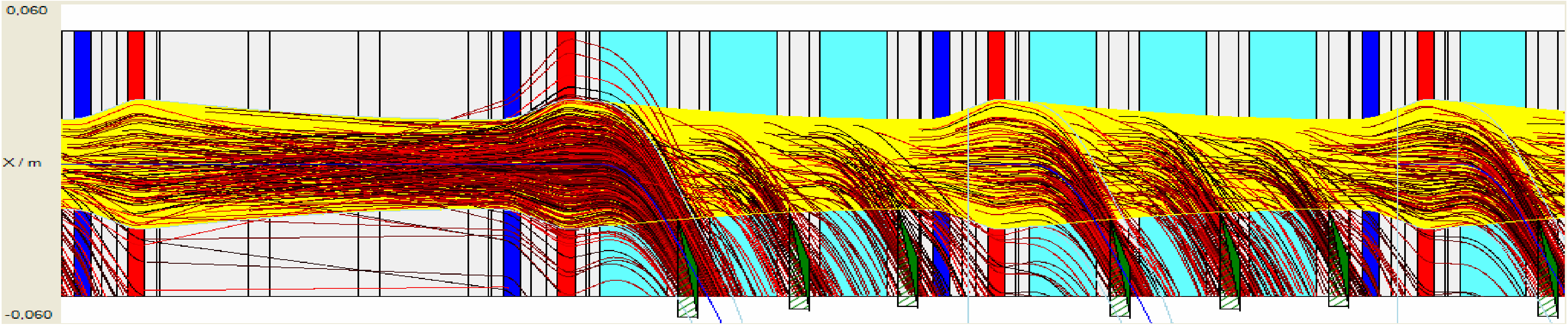
Doublet lattice with the option to collimate He and Ne decay products.



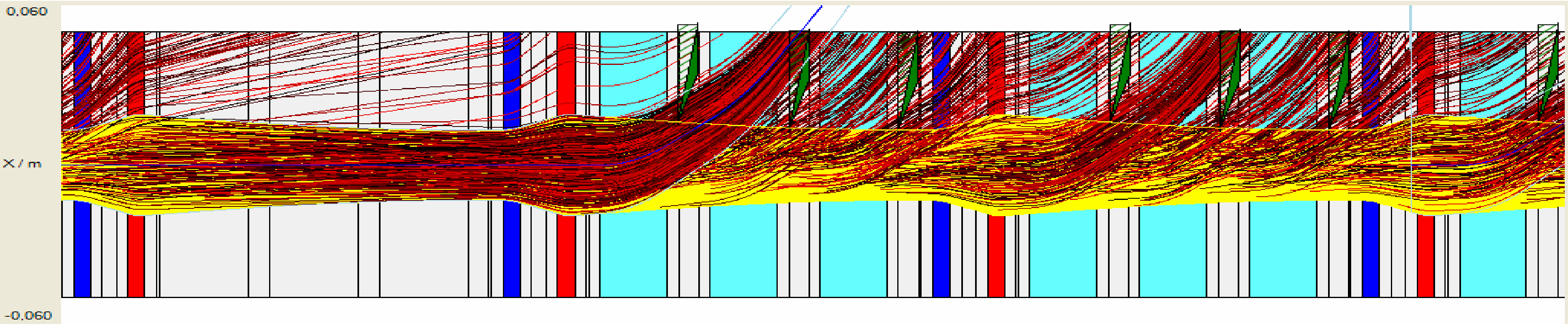
- It matches the existing PS geometrically
- The performance beats the PS with our assumptions (SC ..)
- The decay products of both beta-beams can be collimated

Loss trajectories in the PS replacement lattice

He_β beam

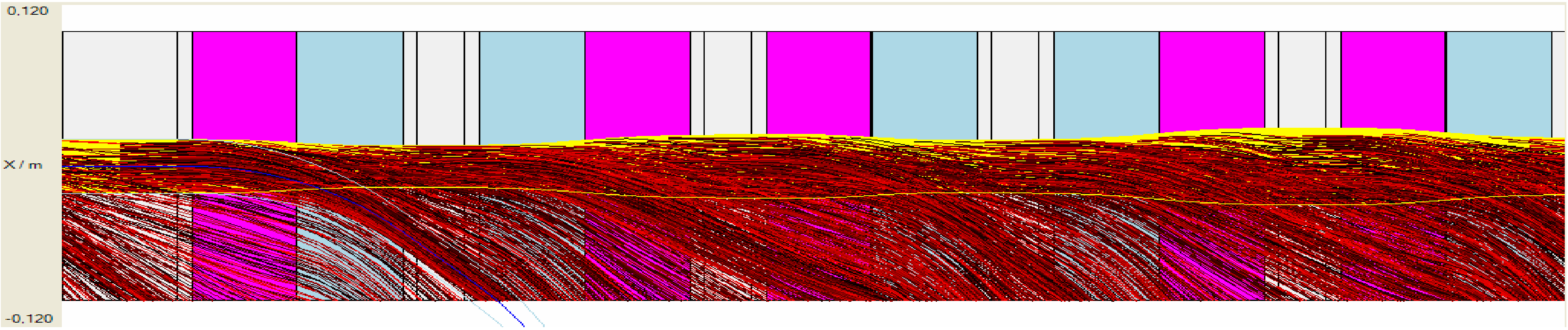


Ne_β beam

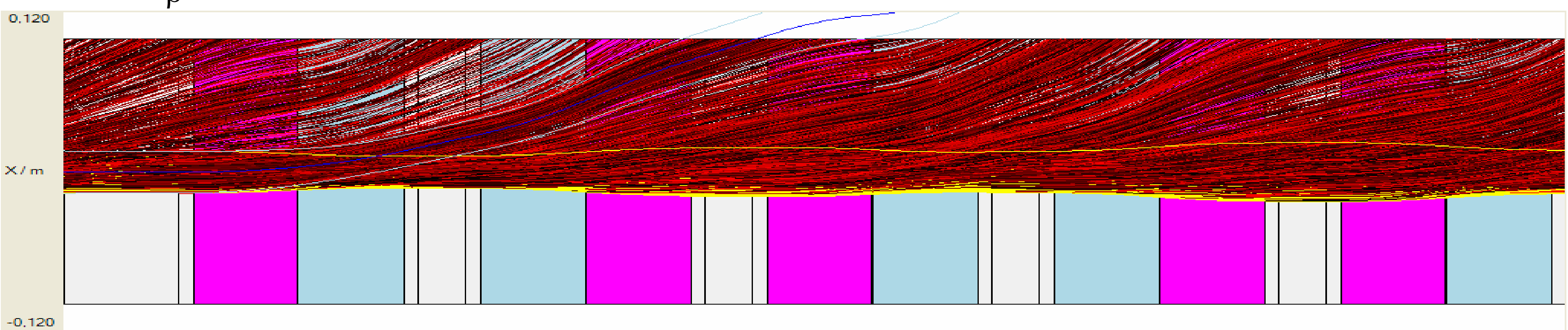


Beam loss in existing PS

He$_\beta$ beam



Ne$_\beta$ beam



Conclusion and outlook

- A general method for dealing with unwanted decay products is the use of a DF doublet lattice which is geometrically adjusted to the change in the ion's magnetic rigidity.
- To optimize the lattice for the very different mass to charge ratios of the two beta beams it is possible to use a design with three short dipoles to get fair(tm) collimation efficiency.

Open questions:

- Is it possible to adjust the lattice in a different way to the two ion species (i.g. mechanically) to have good collimation efficiency for both decay products?
- How to protect the existing machines?
- How to optimize the PS replacement and RCS lattice further?