Beta Beams Synchrotrons (incl. PS2) –

Loss Analysis and Dynamic Vacuum

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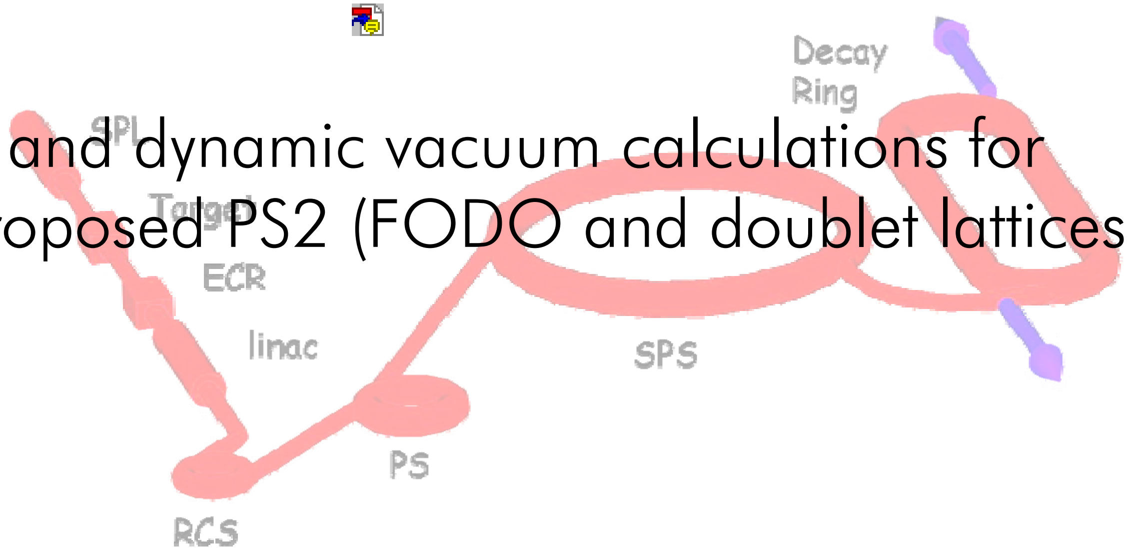


Dynamic Vacuum Simulation Code STRAHLSIM

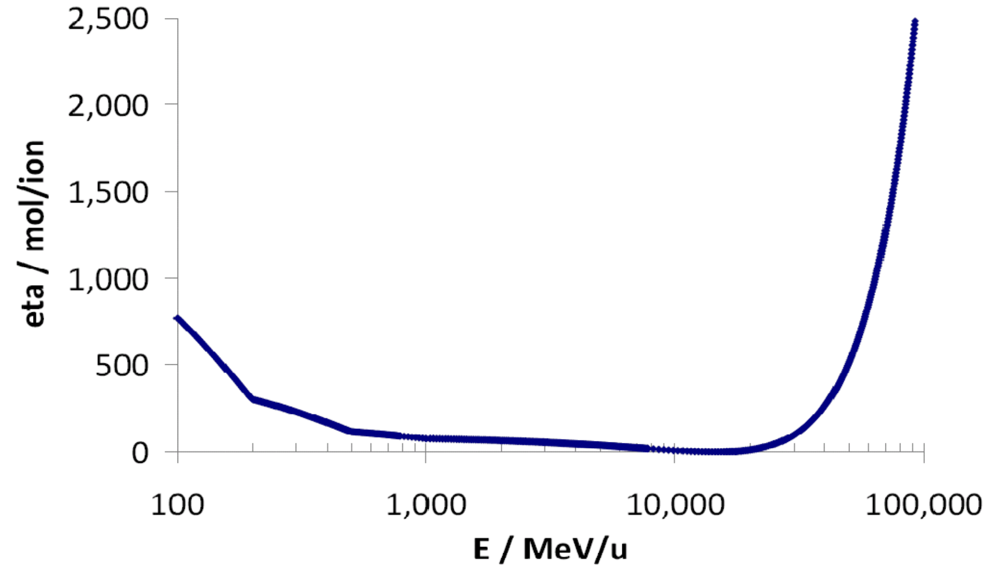
Integrated time resolved, loss and pressure calculation:

- Initial residual gas composition (mass spectrum).
- Initial systematic beam loss (e.g. multi turn injection, Rf capture..).
- Projectile and target ionization and multiple ionization cross sections (ionization degree).
- Desorption rate of projectile and target ion and scaling with energy (e.g. dE/dx^2 and angel of incidence).
- Composition (mass spectrum) of desorption gas.
- Realistic pumping speed and pumping power for the different residual gas consitutents.
- Pumping power of cold surfaces.
- Collimation efficiency for each generated ionization degree (loss distribution).
- Effective desorption rate of the collimation system.
- Energy dependence of collimation efficiency and cross sections.
- Beta decay (loss distribution) and energy dependence.

Static, spatial pressure distribution implemented

Changes in StrahlSim

- Desorption rate $\eta_{\angle}$ (high energy, grazing angle of incidence) is now scaled during the cycle with $(dE/dx)^2$ of the projectile ion
  - Basis: Desorption measurements by A. Molvik and H. Kollmus
  - Calibration: Machine experiments in SIS-18, fixed $\eta_{\angle}$ to 22000 at 11.4 MeV/u (U^{28+}).
  - Source of dE/dx: ATIMA
  - ➔ $\eta_{\angle}$ is lower at all energies in the beta beams accelerator chain
- Improved accuracy and bug fixes

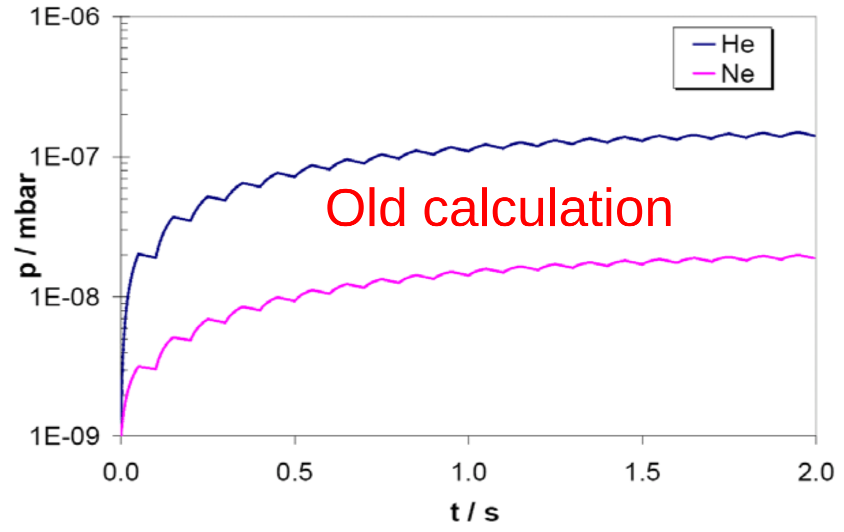


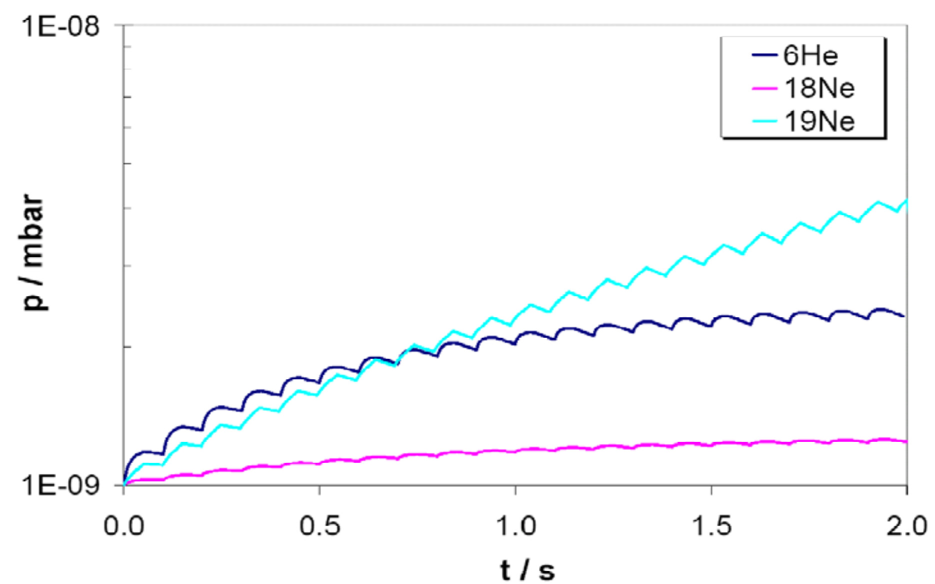
RCS Dynamic Vacuum Evolution

- $V = 1,5\ m^3$
- $S_{eff} = 2\ m^3/s$ for N_2 ($\tau = 0,75$ s)
- $p_0 = 1*10^{-9}$ mbar

- 38 % H_2
- 54,4 % H_2O
- 7,6 % N_2

- Long term pressure evolution (calc. with StrahlSim) seems to be stable in terms of maximum pressure for all ions.





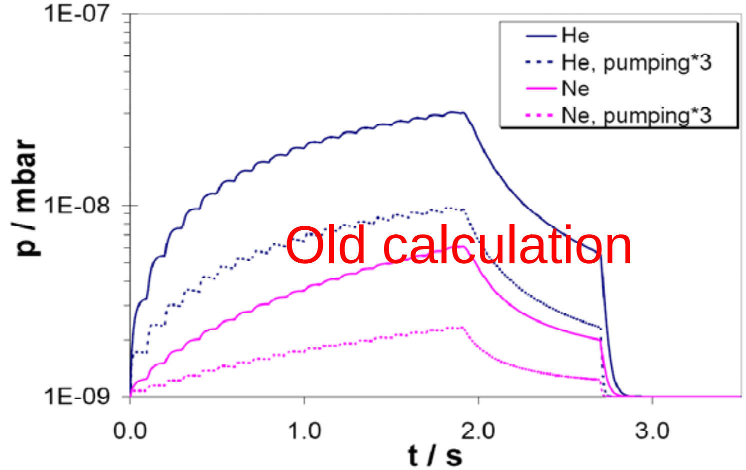
PS Dynamic Vacuum Evolution

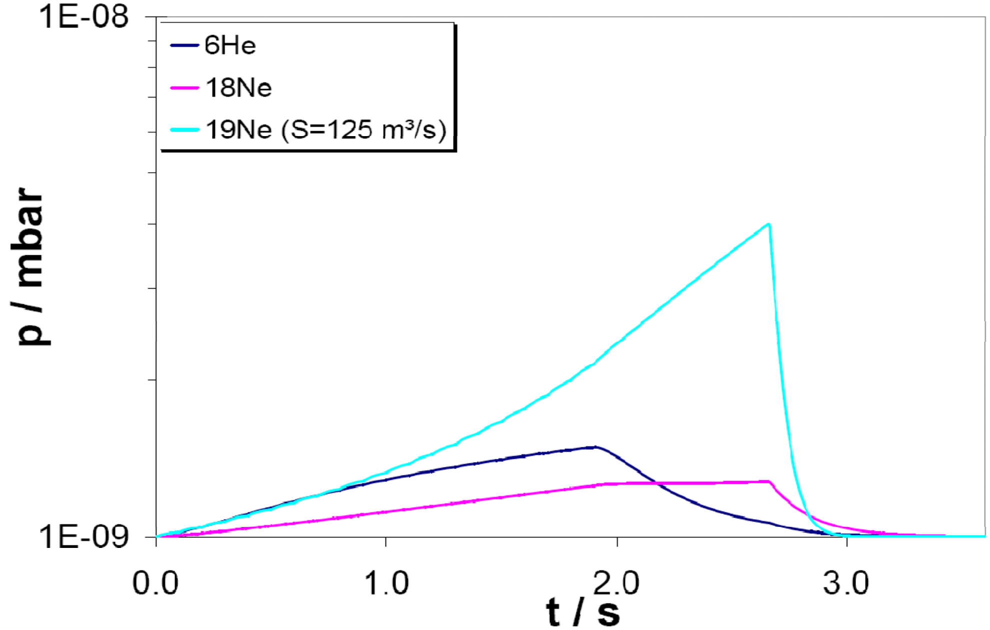
- $V = 6{,}3\ m^3$
- $S_{eff} = 37.65\ m^3/s$ for N_2 ($\tau = 5{,}98$ s)
- $p_0 = 1 \cdot 10^{-9}$ mbar

- 38 % H_2
- 54,4 % H_2O
- 7,6 % N_2

- For ^6He and ^{18}Ne, the pressure evolution (calc. with StrahlSim) seems to be stable in terms of maximum pressure.

- For ^{19}Ne, the target ionization process dominates. An upgrade of the PS UHV system (factor 3 in pumping speed) would be needed to stabilize conditions.



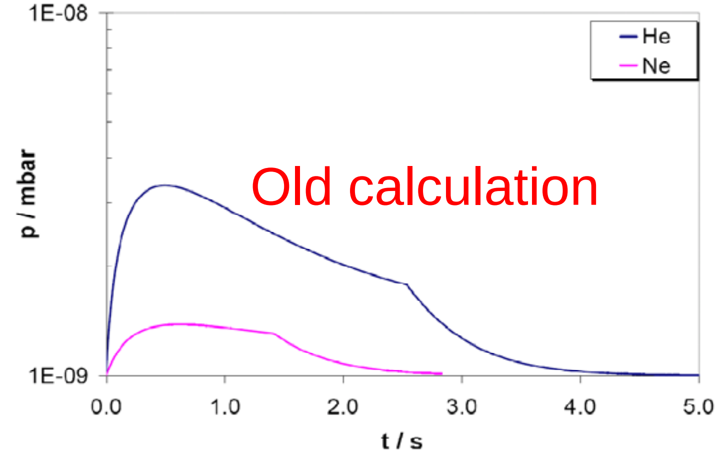


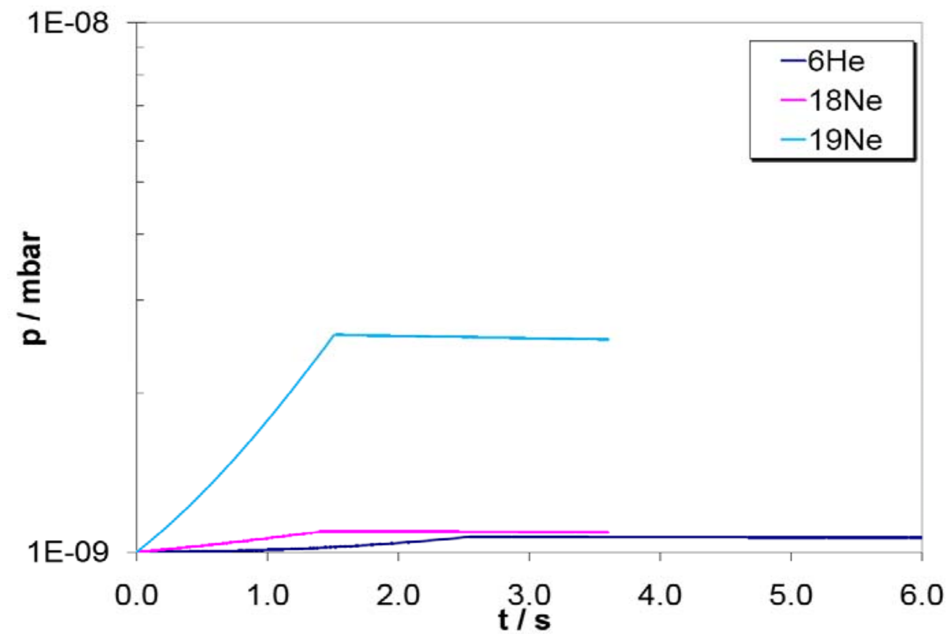
SPS Dynamic Vacuum Evolution

- $V = 149\ m^3$
- $S_{eff} = 2.28\ m^3/s$ for N_2 ($\tau = 65{,}35$ s)
- $p_0 = 1*10^{-9}$ mbar

- 38 % H_2
- 54,4 % H_2O
- 7,6 % N_2

- For ^{6}He and ^{18}Ne, the pressure evolution (calc. with StrahlSim) seems to be stable in terms of maximum pressure.
- For ^{19}Ne, target ionization dominates again, but is no problem in SPS.

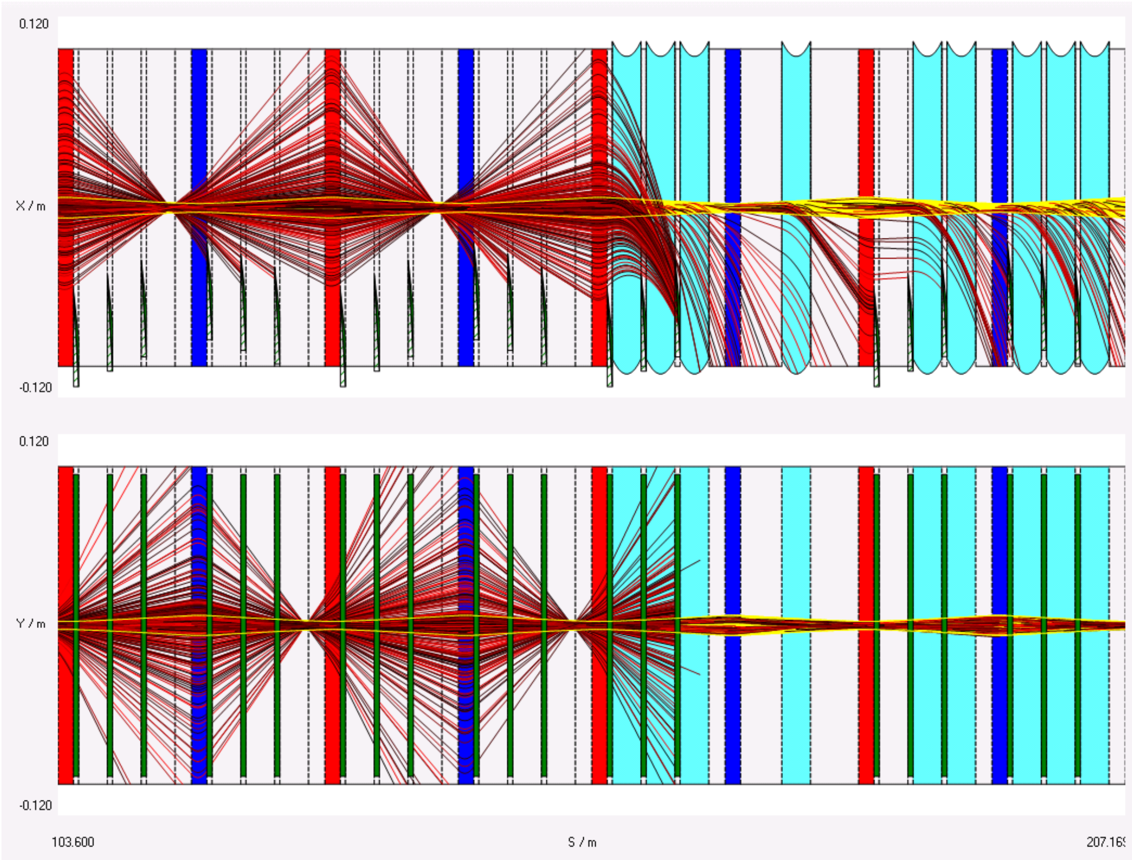




Tracks of ^{6}He Daughter Product in the PS2 FODO Lattice

horizontal

vertical

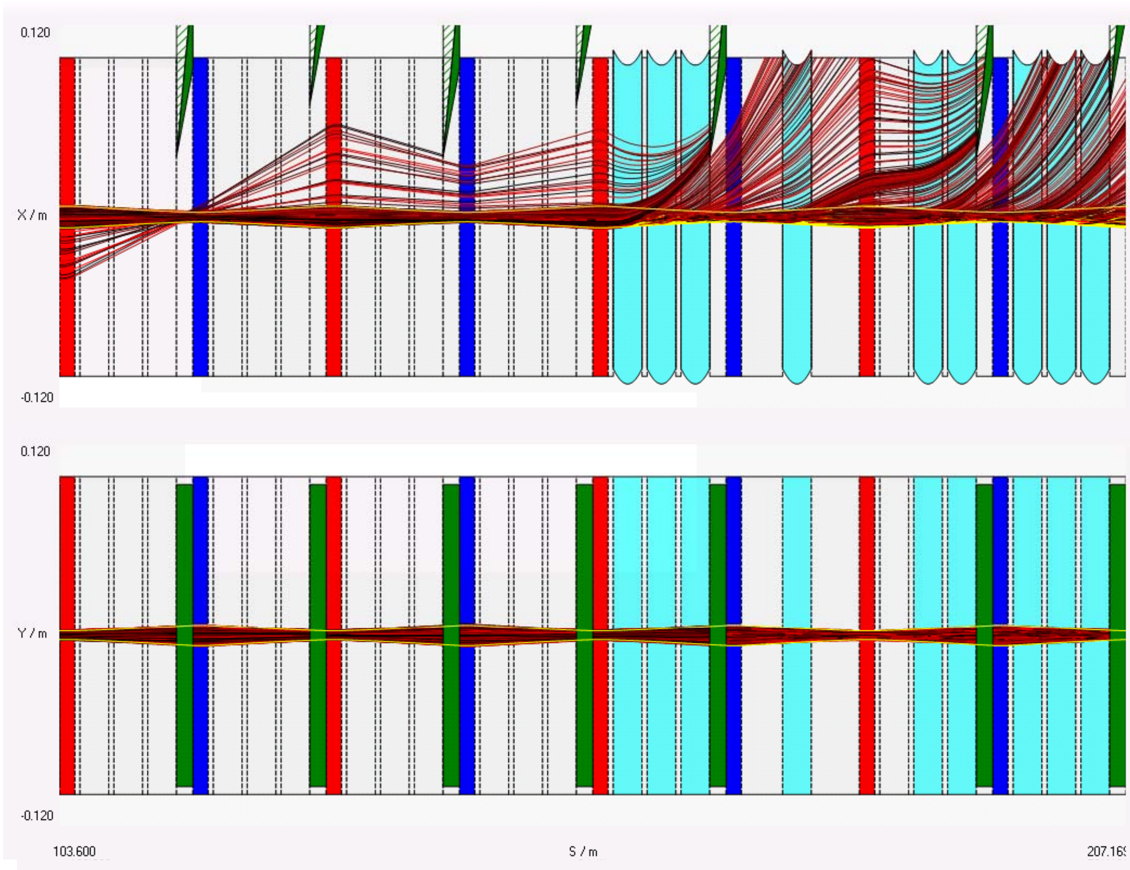


FODO structure causes alternating horizontal and vertical impact on the beam pipe in the straights. Loss peak of He will be **in** the 3rd dipole. When placing collimators in between dipoles, most of the losses are under controle.

Tracks of ^{18}Ne Daughter Product in the PS2 FODO Lattice

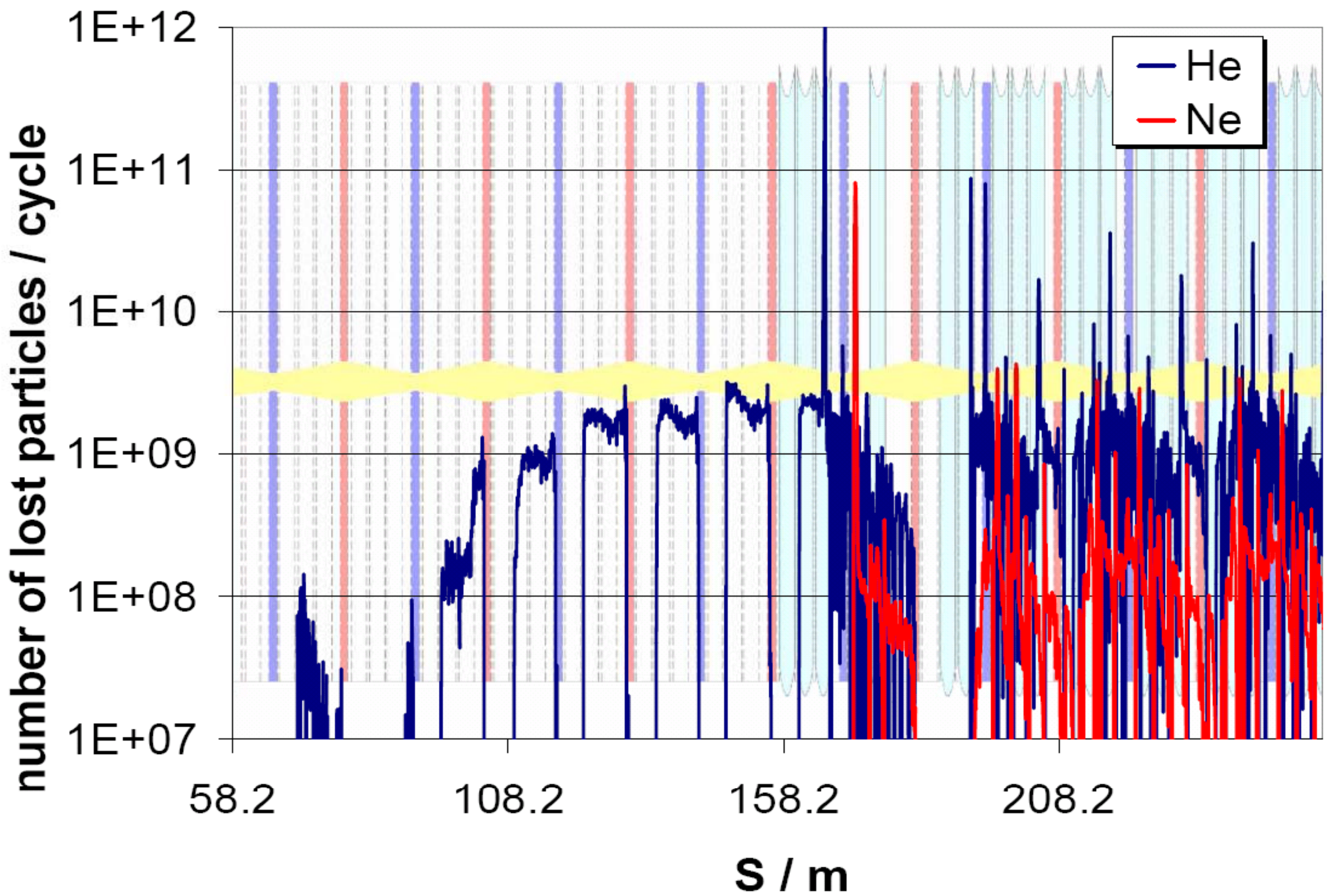
horizontal

vertical



No losses in vertical plane of beam pipe. Well suited for collimation.

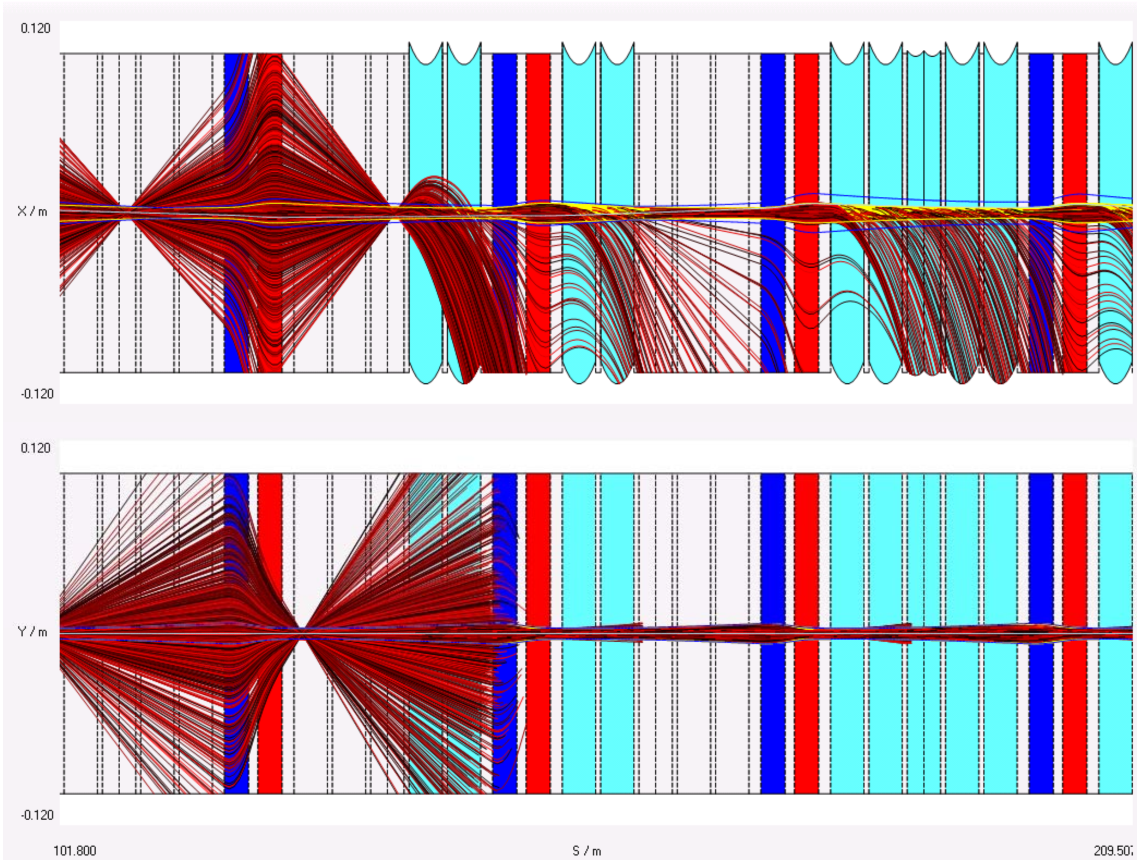
Loss Distributions in the PS2 FODO Lattice



Tracks of ^{6}He Daughter Products in the PS2 Doublet Lattice

horizontal

vertical

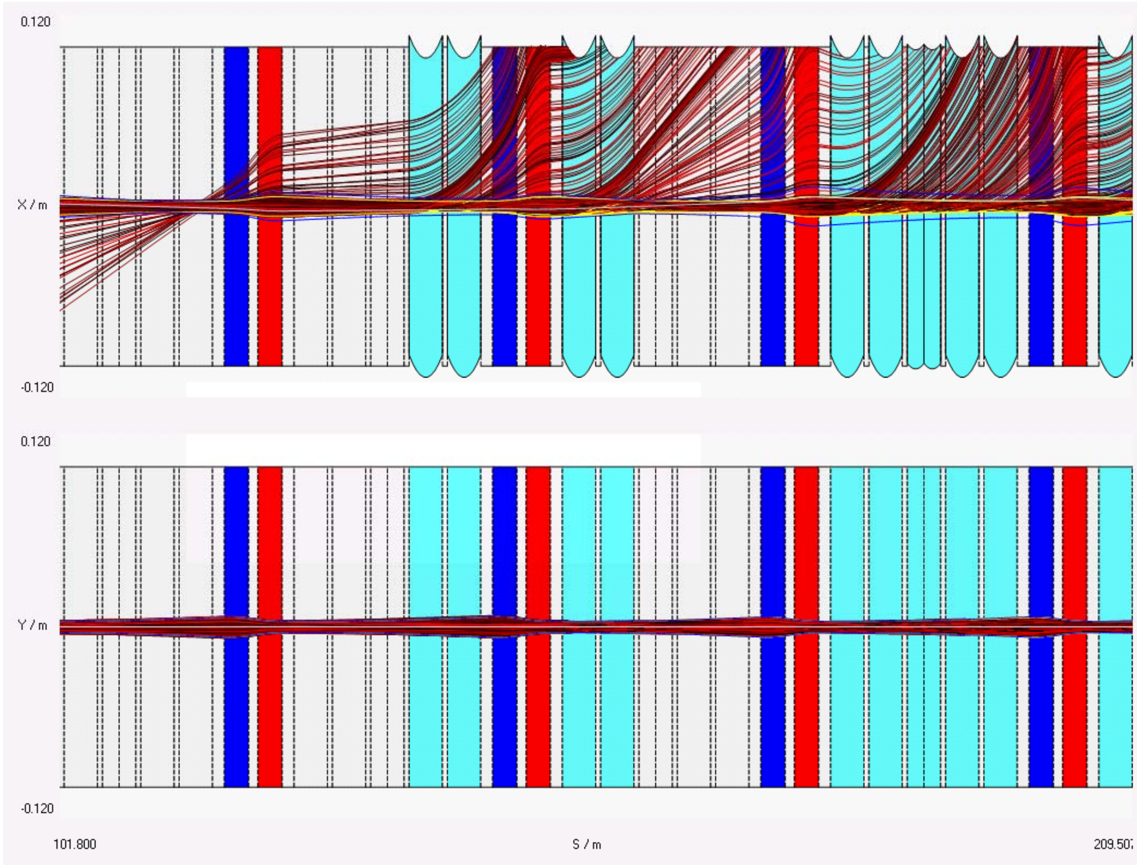


Doublet structure causes virtually no loss in the straigths.
Loss peak behind the 2nd dipole.

Tracks of ^{18}Ne Daughter Products in the PS2 Doublet Lattice

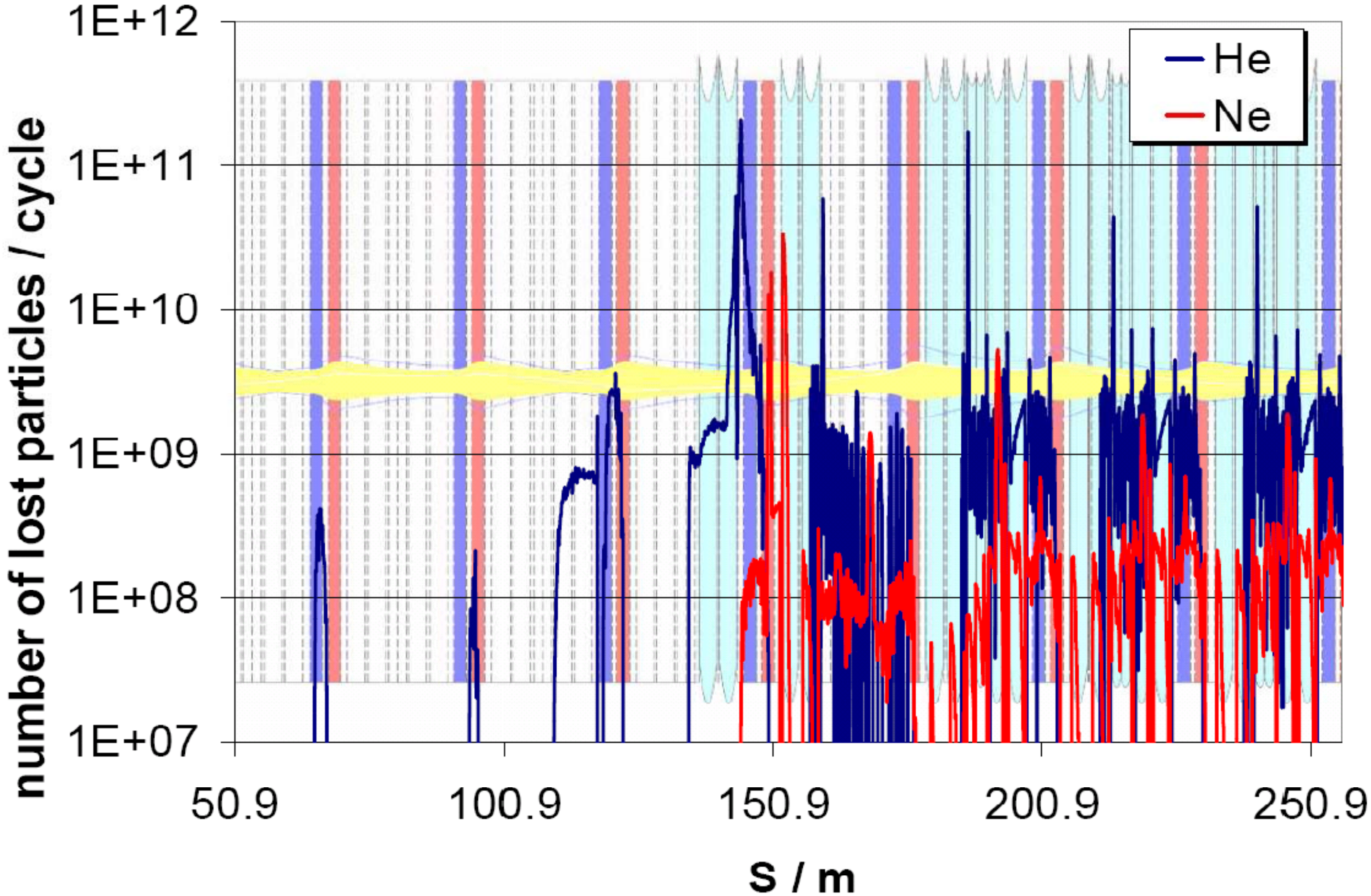
horizontal

vertical



No beam loss in vertical plane - loss peak befor the 3. dipole.

Loss Distributions in the PS2 Doublet Lattice

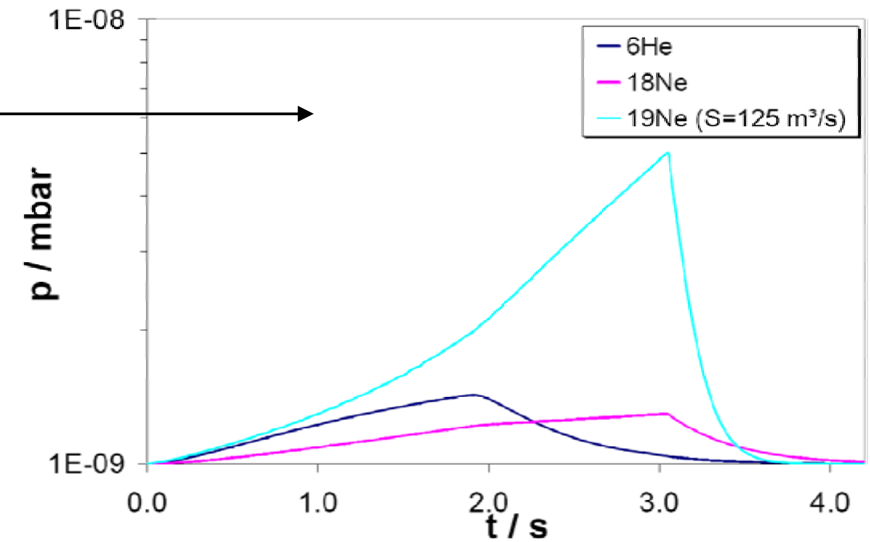


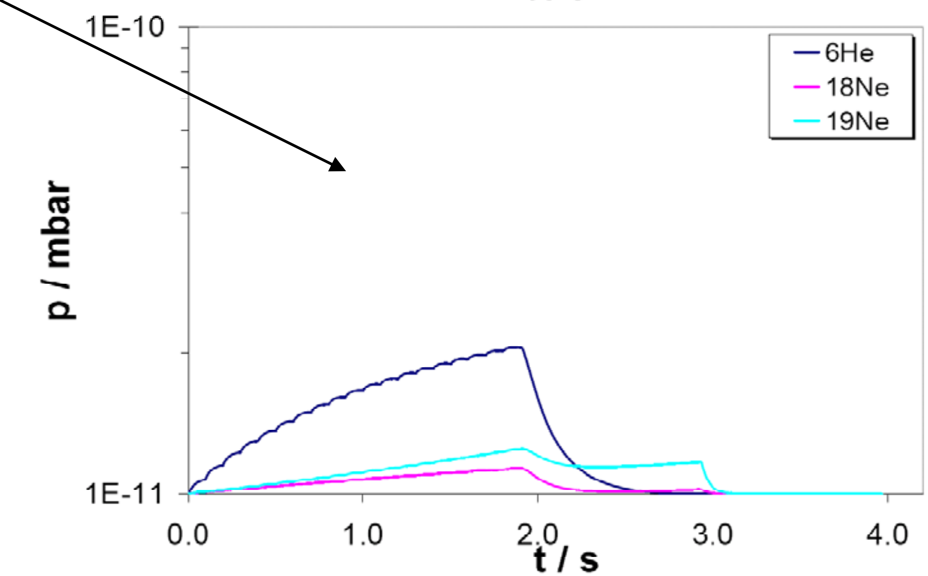
Additional collimation in between the dipoles (not much space)?

PS2 Dynamic Vacuum Evolution (preliminary)

- $V = 13.46\ m^3$
- For warm machine:
  - $S_{eff} = 37.65\ m^3/s$ for N_2 ($\tau = 0{,}36$ s)
  - $p_0 = 1*10^{-9}$ mbar
  - 38 % H_2
  - 54.4 % H_2O
  - 7.6 % N_2
- For cold machine:
  - Magnets at T = 10 K
  - $S_{eff} = 329.34\ m^3/s$ for N_2 ($\tau = 0{,}04$ s), calculated from cold surface area and temperature
  - $p_0 = 1*10^{-11}$ mbar
  - 94.7 % H_2
  - 1.6 % N_2
  - 1.2% CO
  - 2.5 % CO_2

- For ^{6}He and ^{18}Ne, the pressure evolution (calc. with StrahlSim) seems to be stable in terms of maximum pressure.
- For ^{19}Ne, target ionization dominates again and has to be compensated with an enhanced UHV system (analogous to PS). In the cold machine, this is no issue (pumping speed is high enough).





Conclusions

- For ^{6}He and ^{18}Ne, the maximum dynamic pressure doesn't exceed a reasonable operation regime (< 10^{-8} mbar) in RCS, PS and SPS - the pumping speed is sufficient for the volume.
- For ^{19}Ne, the pressure rise will be larger and dominated by target ionization process.
  - For the PS, an enhanced UHV system (pumping speed a factor of 3 higher) seams to be needed to stabilize the pressure dynamics.
- PS2 lattice: Further lattice optimization is required for integration of a collimation system. In principle feasible.