StrahlSim

Catcher Systems and Dynamic Vacuum in Ring Accelerators

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Beta Beam Task Group Meeting
22th May 2006

StrahlSim: Contents

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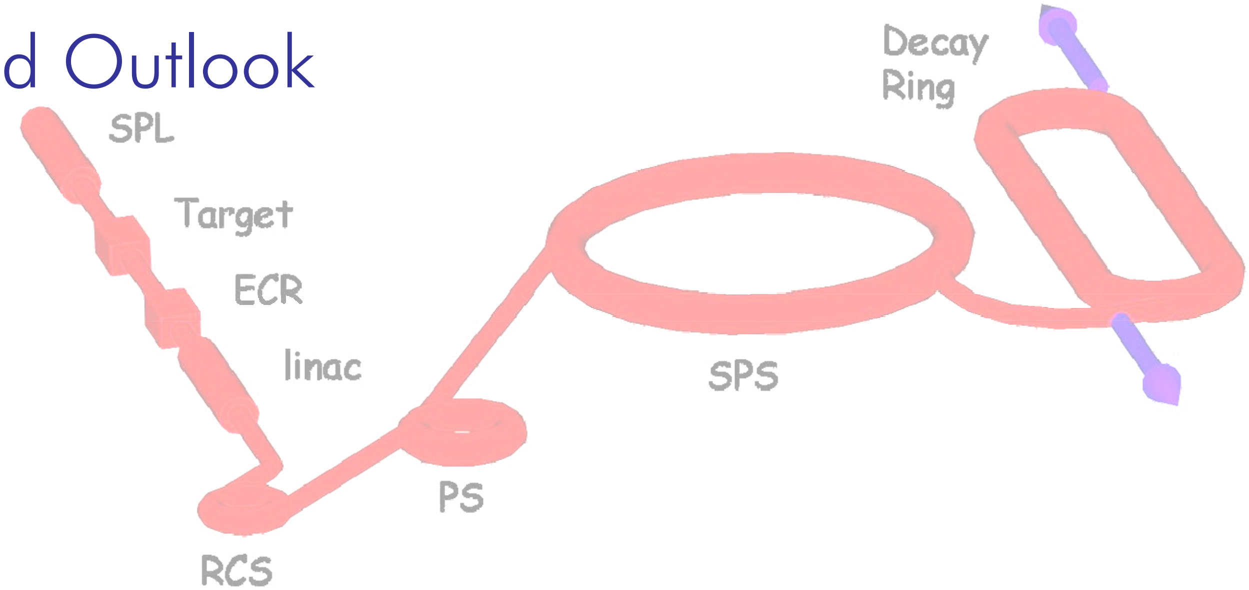
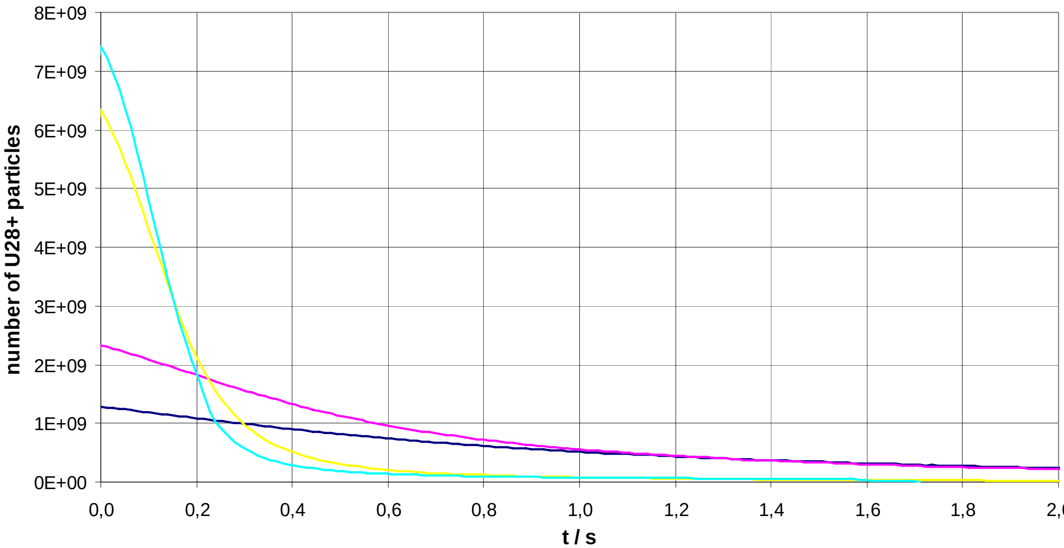


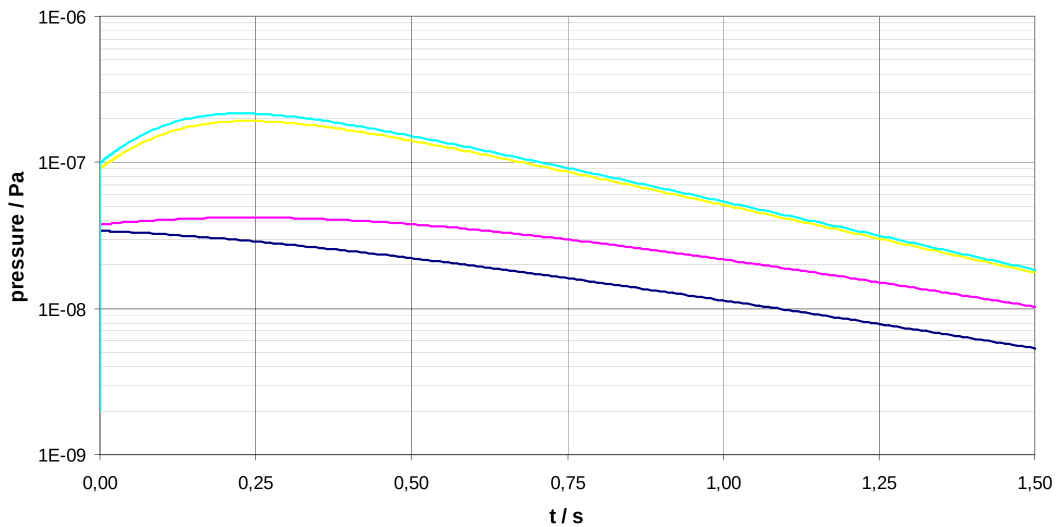
StrahlSim: Introduction and Motivation

- Ions which change their charge state due to collisions (or here: decay products) may harm the stable operation of an accelerator.
- Uncontrolled losses might cause dynamic vacuum effects or damage the accelerator.

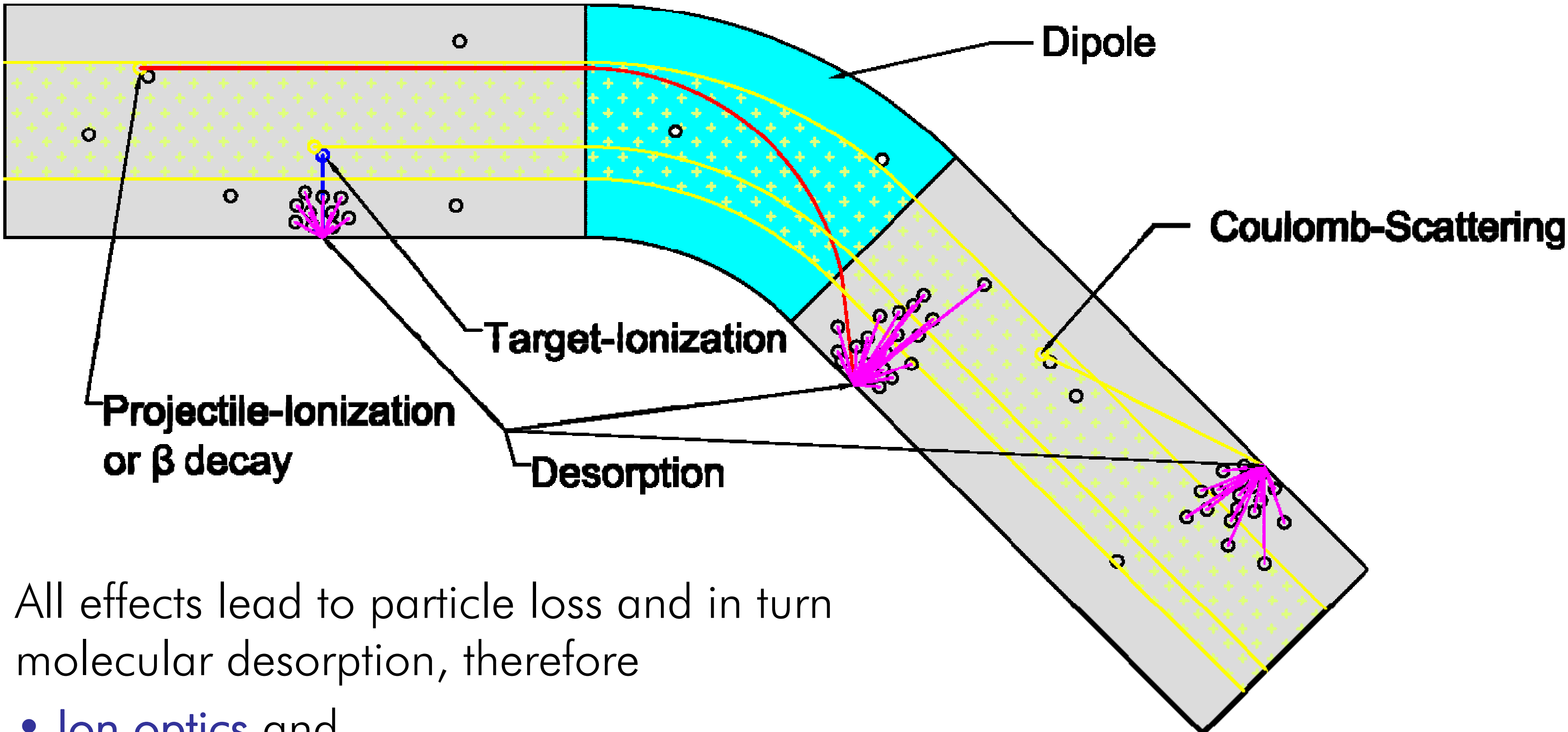
Questions:

- Which lattice layout allows me to control the losses best?
- What is needed to stabilize the dynamic pressure?





StrahlSim: Loss processes in accelerators

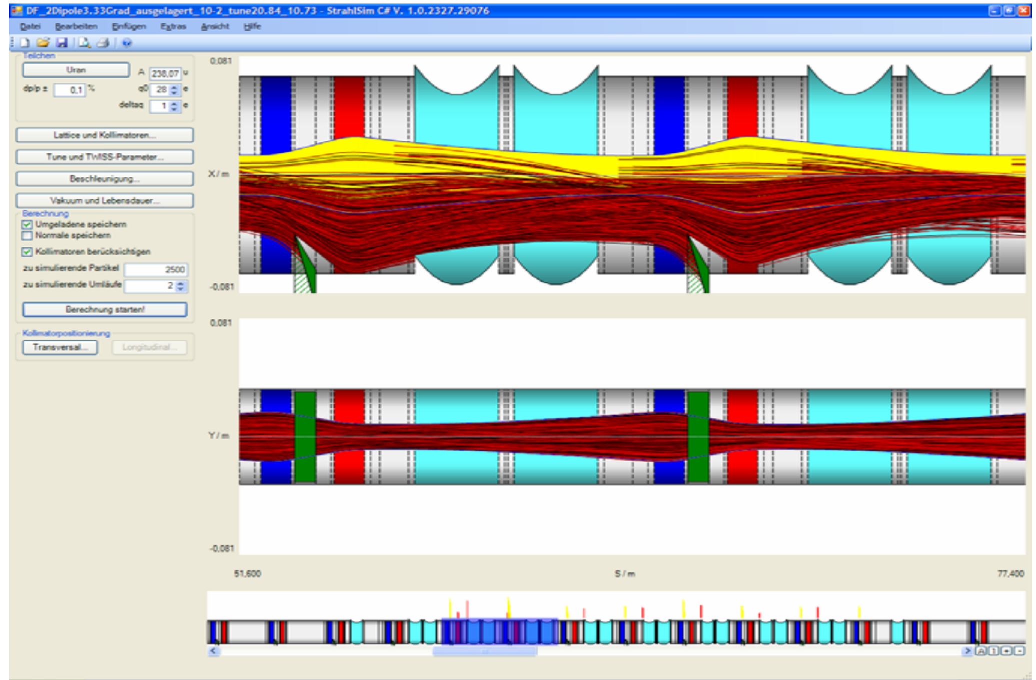


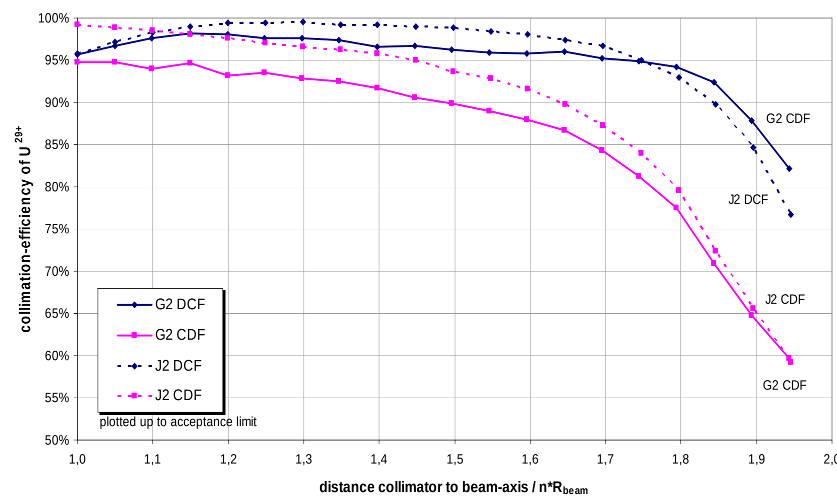
All effects lead to particle loss and in turn molecular desorption, therefore

- Ion optics and
- Dynamic vacuum behaviour has to be calculated

StrahlSim: Ion optics

- Particle trajectories
  - Linear ion optics
    - drifts
    - dipoles
    - quadrupoles (2nd order)
    - sextupoles
  - Limited by realistic apertures
  - Include collimators
- Impact distribution
- Find optimum places for collimators
  - Collimation efficiency
  - Different charge states / ion species





StrahlSim: Loss processes

- Coulomb-Scattering
  - usually low scattering rate
  - desorption under shallow angles

$$\Gamma_{CS} = \frac{2\cdot\pi\cdot Z^2\cdot r_p^{\ 2}\cdot c\cdot n_{sc}}{A^2\cdot\gamma^2\cdot\beta^3}\cdot\left(\frac{\langle\beta_h\rangle}{\varepsilon_{acc,h}}+\frac{\langle\beta_v\rangle}{\varepsilon_{acc,v}}\right)$$

- Target Ionization
  - Bethe formula
  - desorption under perpendicular angle of incidence

$$\sigma_{Bethe} = 4\cdot\pi\cdot a_0^{\ 2}\cdot\frac{\alpha^2}{\beta^2}\cdot\left\{M_{ion}^{\ 2}\cdot\left[\ln\left(\frac{\beta^2}{1-\beta^2}\right)-\beta^2\right]+C_{ion}+\gamma_{ion}\cdot\frac{\alpha^2}{\beta^2}\right\}$$

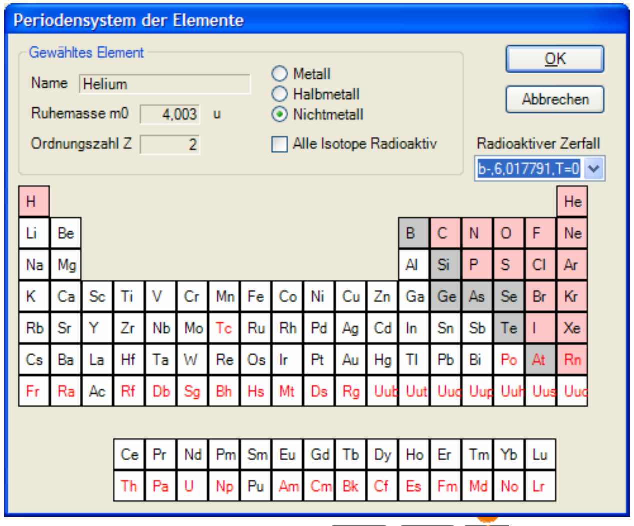
$$\sigma_i = q^2\cdot\exp\left[-\lambda\cdot|q|\cdot\left(\frac{\alpha}{\beta}\right)^2\right]\cdot\sigma_{Bethe}$$

- Projectile Ionization
  - Cross sections σ(E, q, Δq) acc. to Olson or experimental values $\sim 10^{-23}\ldots10^{-21}$ m²/atom
  - no exp. data for beta beams…

$$\Gamma_{PI} = \beta\cdot c\cdot\sum_k\sum_i n_i\cdot\sigma_i(E,q_k)$$

- Radioactive decay
  - β^+ or β^-
  - Half-life times $T_{½}$ from PSE

$$\Gamma_\beta = \frac{\ln(2)}{\gamma\cdot T_{1/2}}$$



StrahlSim: Dynamic vacuum

- Calculation of dynamic vacuum pressure
  - scattering and loss rates
  - rest gas ionization rate
  - pumping (NEG, cryo, traditional) and out gassing
  - collimation and leakage
  - storage
  - desorption
  - for all vacuum components n_i!

$$\Gamma_P = \Gamma_{Streu}(n_i, \beta) + \Gamma_{PI}(n_i, \beta, E) + \Gamma_\beta(\gamma)$$

$$\Gamma_T = \Gamma_{TI}(n_i, \beta)$$

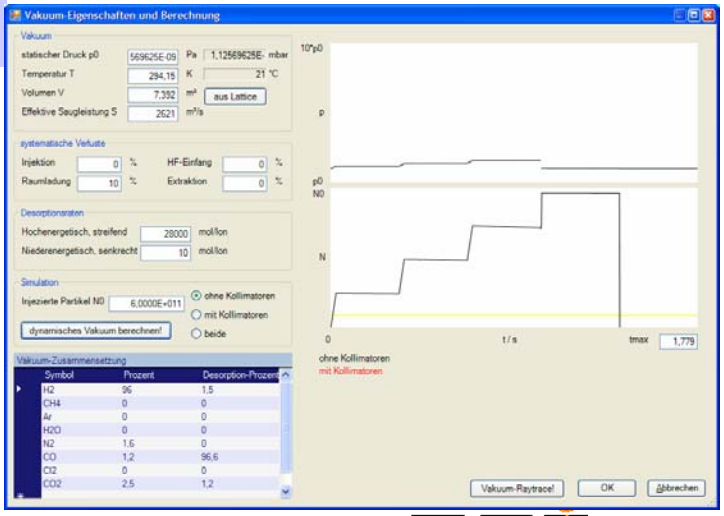
$$\dot{n}_i = -\dot{N} \cdot \eta_{i,\angle}(E) + \Gamma_T(n_i, \beta) \cdot \eta_{i,\perp} + Q_{i,Ausgas} - Q_{i,Saug}(n_i)$$

- Time dependent particle number
  - numerical integration

$$\dot{N} = -N \cdot \Gamma_P(n_i, \beta)$$

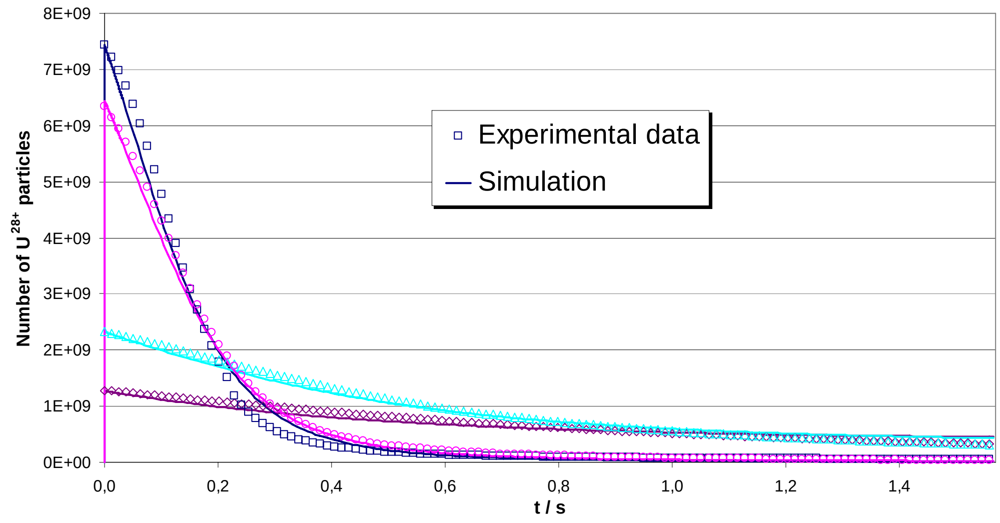
$$\Delta t = t_{turn}$$

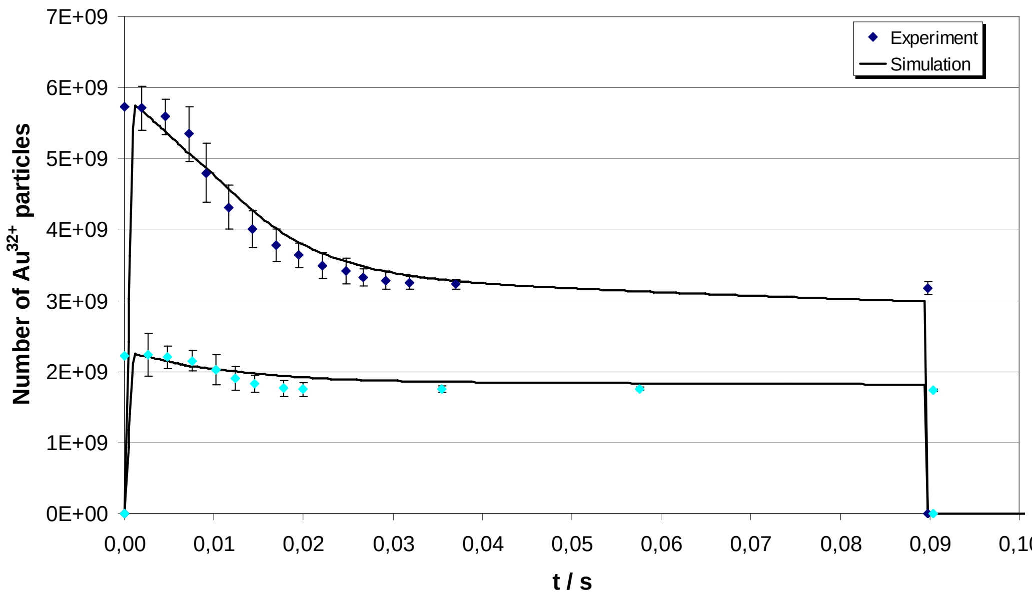
- Include acceleration cycle
  - multiple injections
  - systematic losses (Inj., RF capture)
  - time dependent energy change



StrahlSim: Conclusions

- Ion optics
  - ☑ compared to WinAGILE and MIRKO
- Loss processes
  - ☑ Projectile-Ionization
  - ☑ Target-Ionization
  - ☑ Coulomb-Scattering
  - ☑ Radioactive β-decay
- Time dependent particle number
  - ☑ verified by experiments at SIS18 and AGS Booster





StrahlSim: Outlook

- In preparation:
  - Pressure- and molecule dependent pumping speeds
  - Space resolved pressure distribution
- Not considered so far:
  - Electron clouds and nonlinear effects
  - Resonances
- Open studies
  - Cross sections σ for projectile ionization: more ions/energies
  - η as *f(E, dE/dx, θ)* not known for much ion species
  - Measurements with ERDA in progress (GSI)