Ionization Losses
and
Cryo-Catcher
for SIS100

Lars Bozyk

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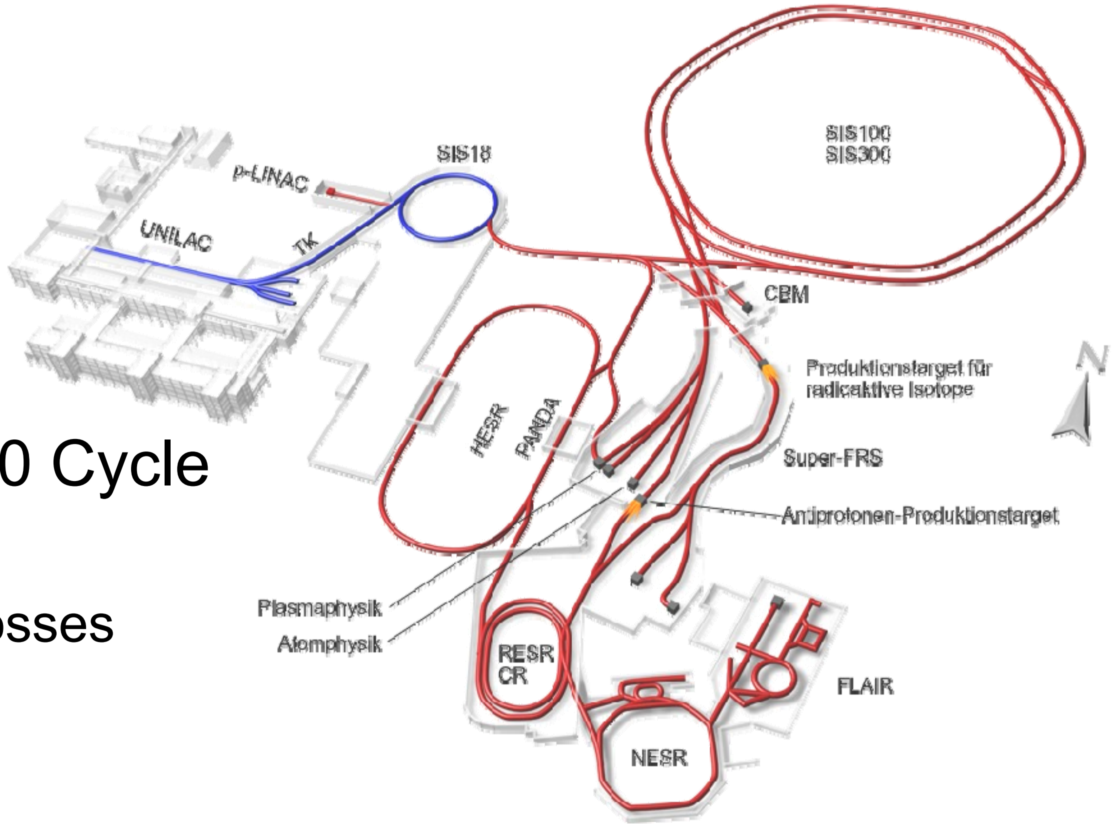
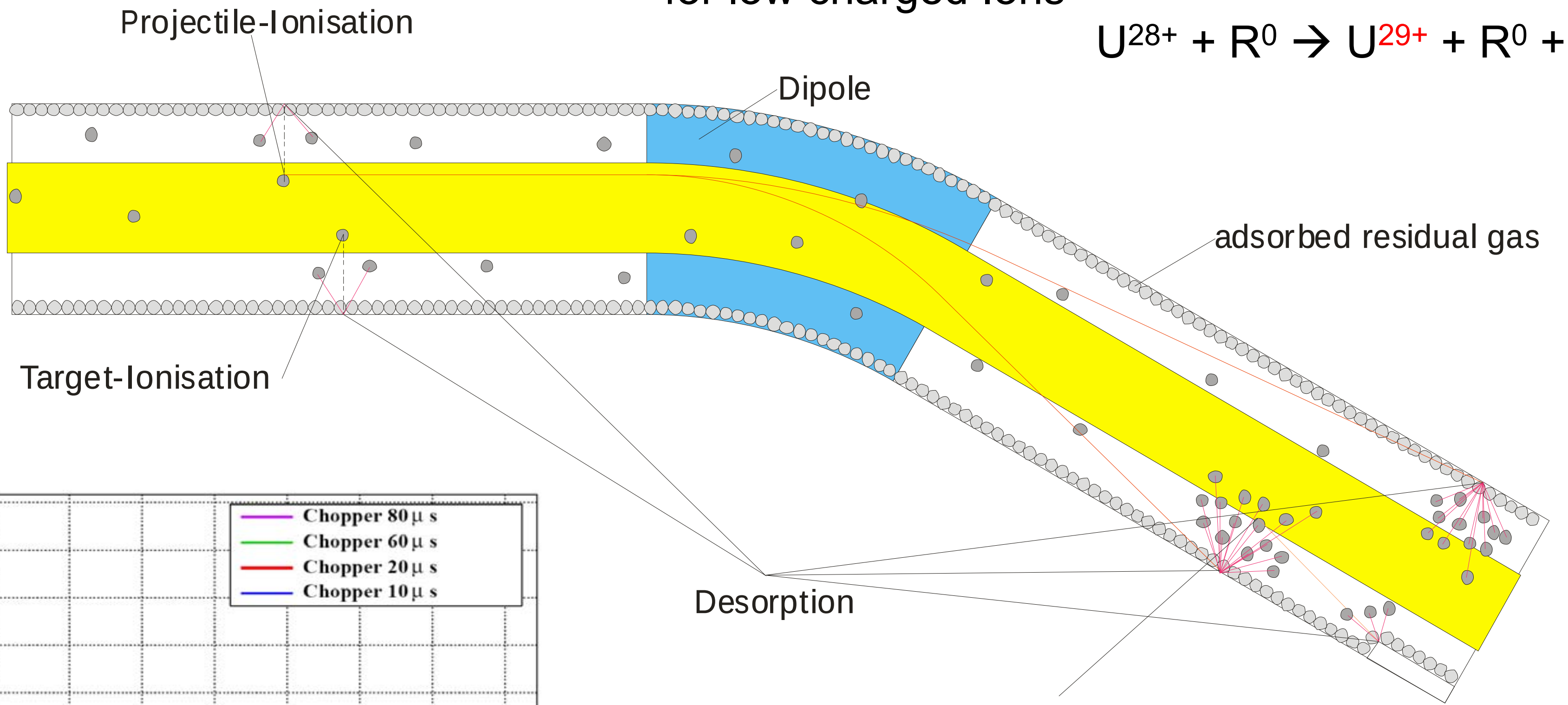
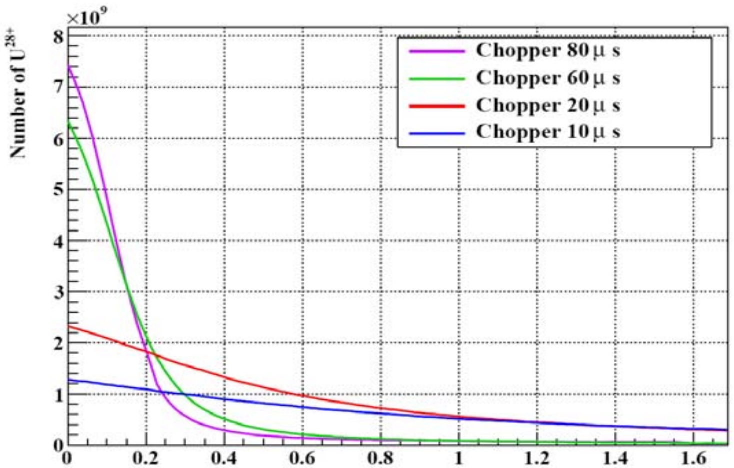


Ionization Loss Mechanism

Projectile Ionisation dominates at SIS Energies for low charged Ions

$$U^{28+} + R^0 \rightarrow U^{29+} + R^0 + e^-$$





P.Spiller, 2001

HELMHOLTZ GEMEINSCHAFT

Ionization Loss Mechanism

- **All** kinds of beam loss produces a local pressure rise via ion stimulated desorption
  - $\eta_{\angle}$~ 3...30·10^3 molecules / Ion
  - $\eta_{\perp}$~100 molecules / Ion

- Probability for beam ion ionization depends on residual gas pressure, ionized ions will get lost
  - Losses drive a pressure bump
  - Self amplification can develop up to complete beam loss
  - Maximum number of particles is limited

- Initial losses dominate the whole cycle

Ion Catcher

- Controlled catching of ionized ions on low desorption surfaces
- Ions hitting the wall release adsorbed gases and produce a local pressure bump
  - Desorption yield is lowest for perpendicular incidence
  - Most ionized ions are caught by ion catcher in SIS100
  - Significant reduction of gas desorption

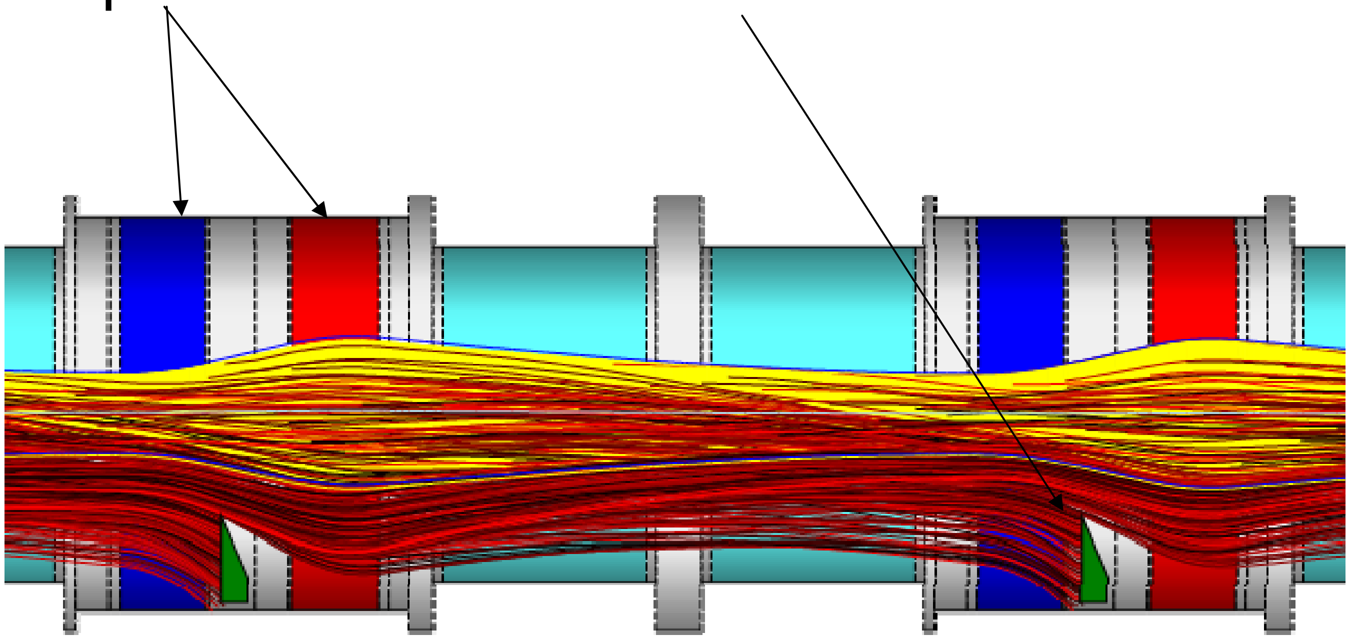
→ Residual gas pressure dynamics are stabilized

→ Lower total ionization loss

  - Activation and radiation damage of magnets by ionization beam loss is reduced

- SIS100 Ion Catcher is part of the EuCARD WP8: ColMat

- SIS100 lattice has been optimized to reach a maximum catching efficiency
- Loss distribution is strongly localized between the quadrupoles where the ion catcher will be installed



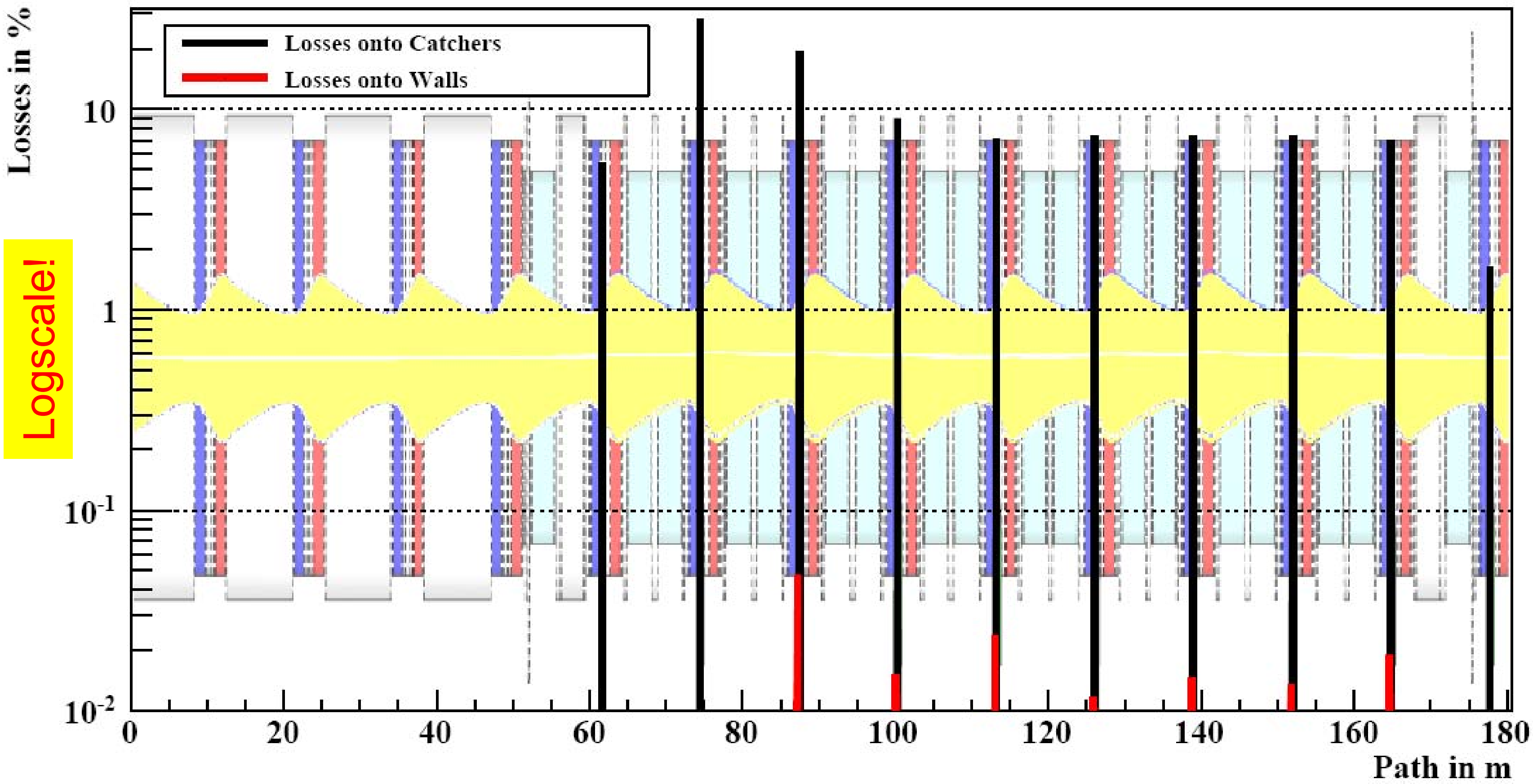
$U^{28+} \rightarrow U^{29+}$

SIS100 Ionization Loss Distribution

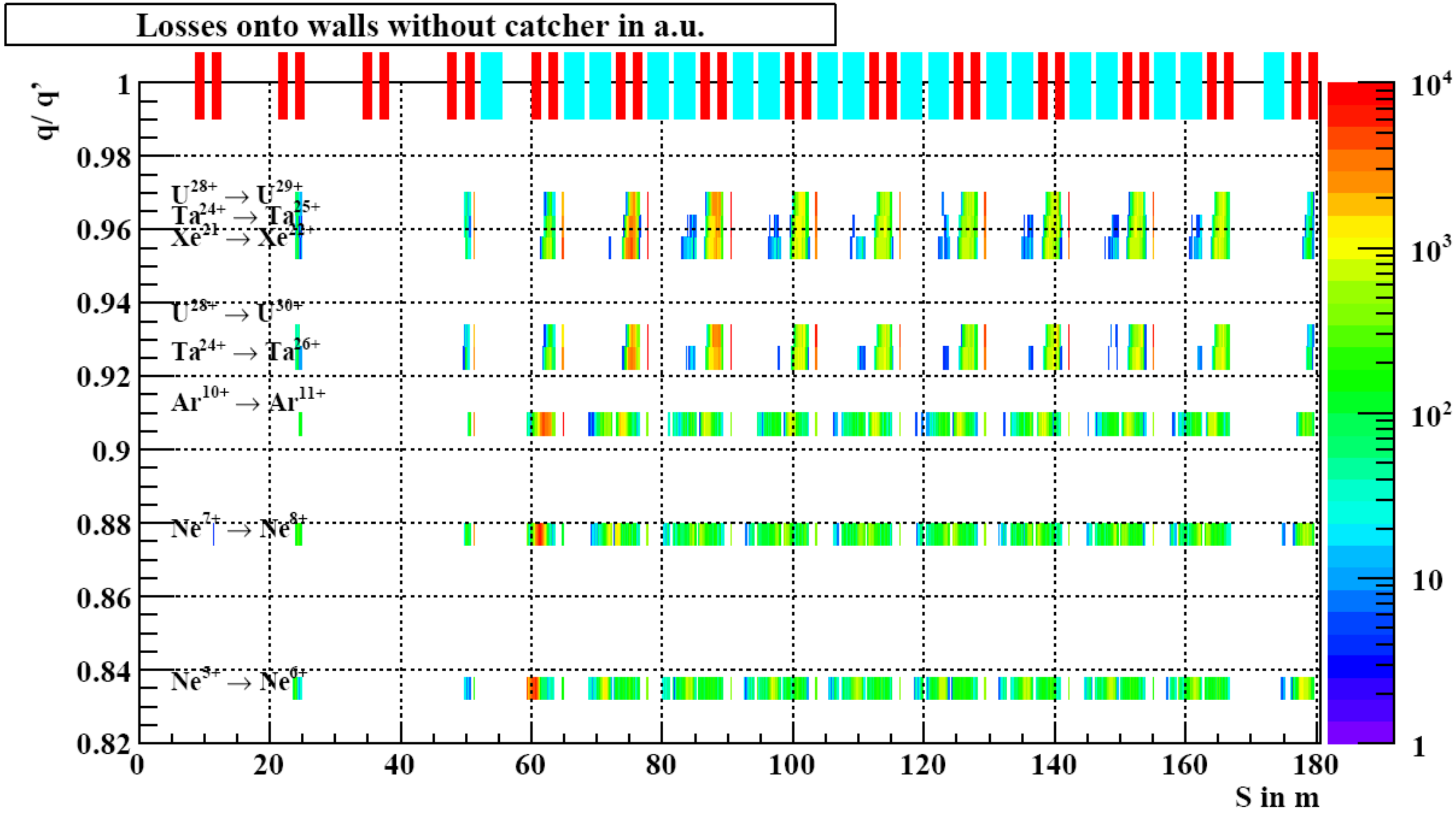
Losses normalized to one arc, $U^{28+} \rightarrow U^{29+}$

99.6% catching efficiency

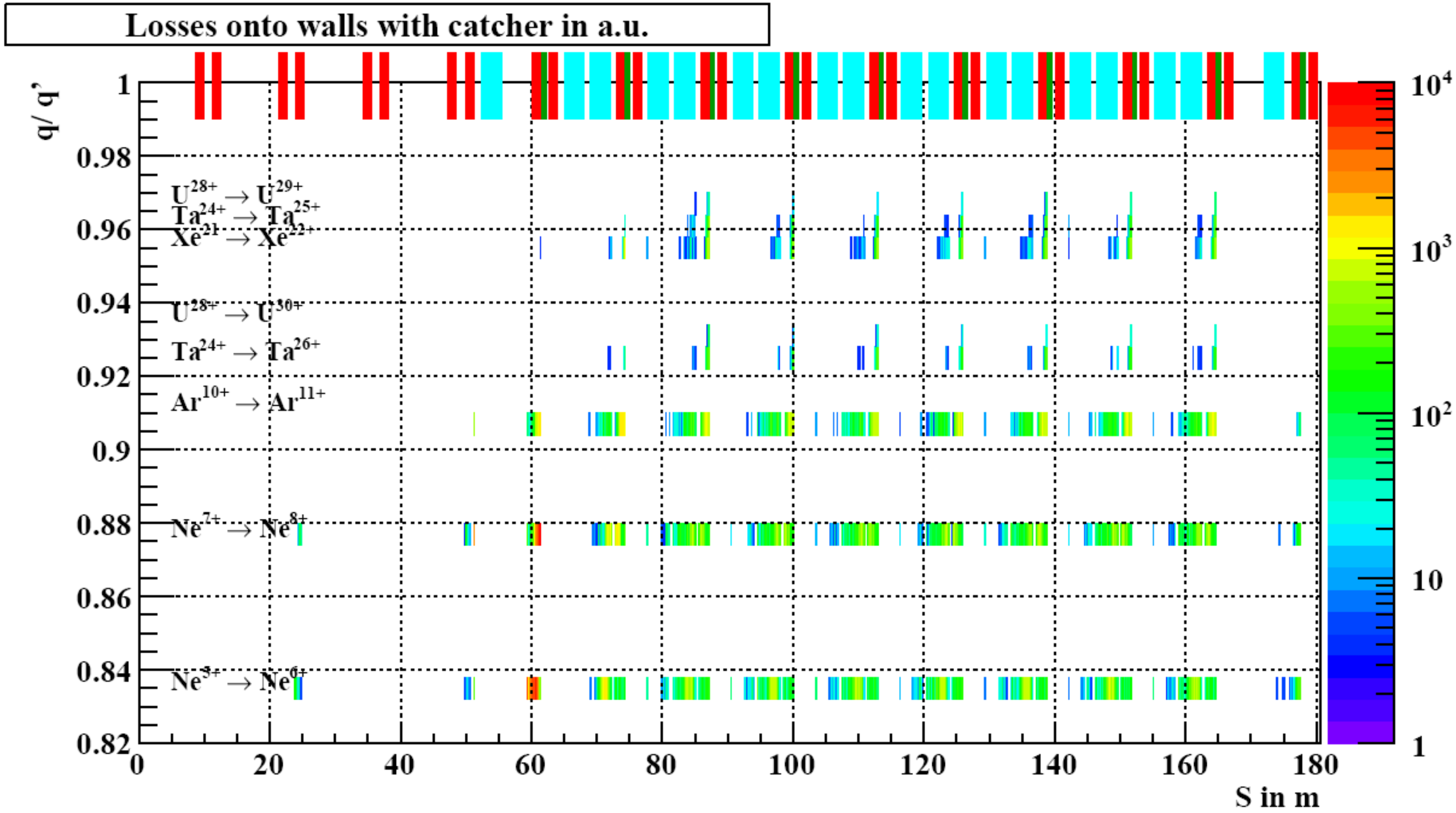
Logscale!



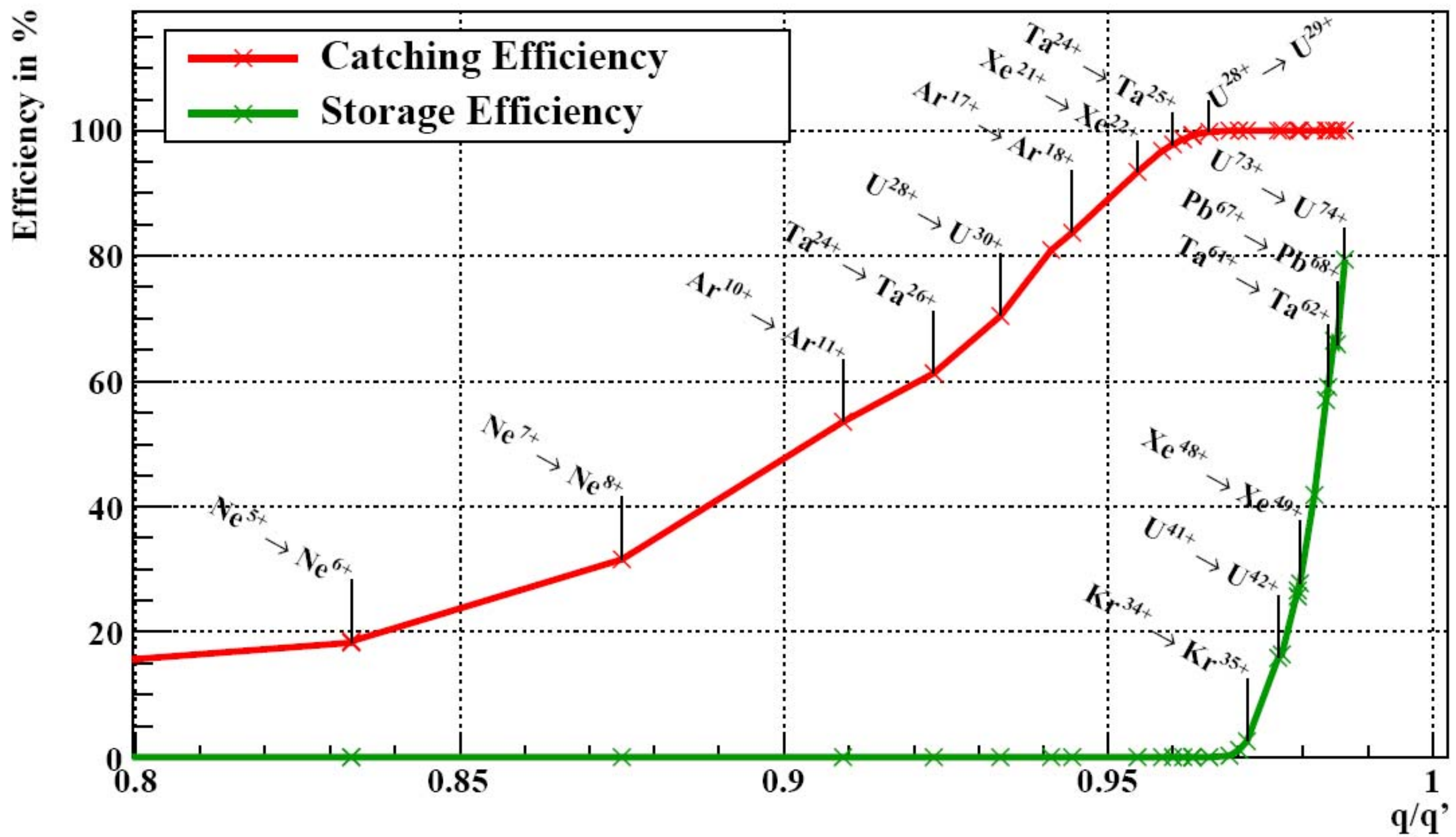
SIS100 Ionization Loss Distribution



SIS100 Ionization Loss Distribution



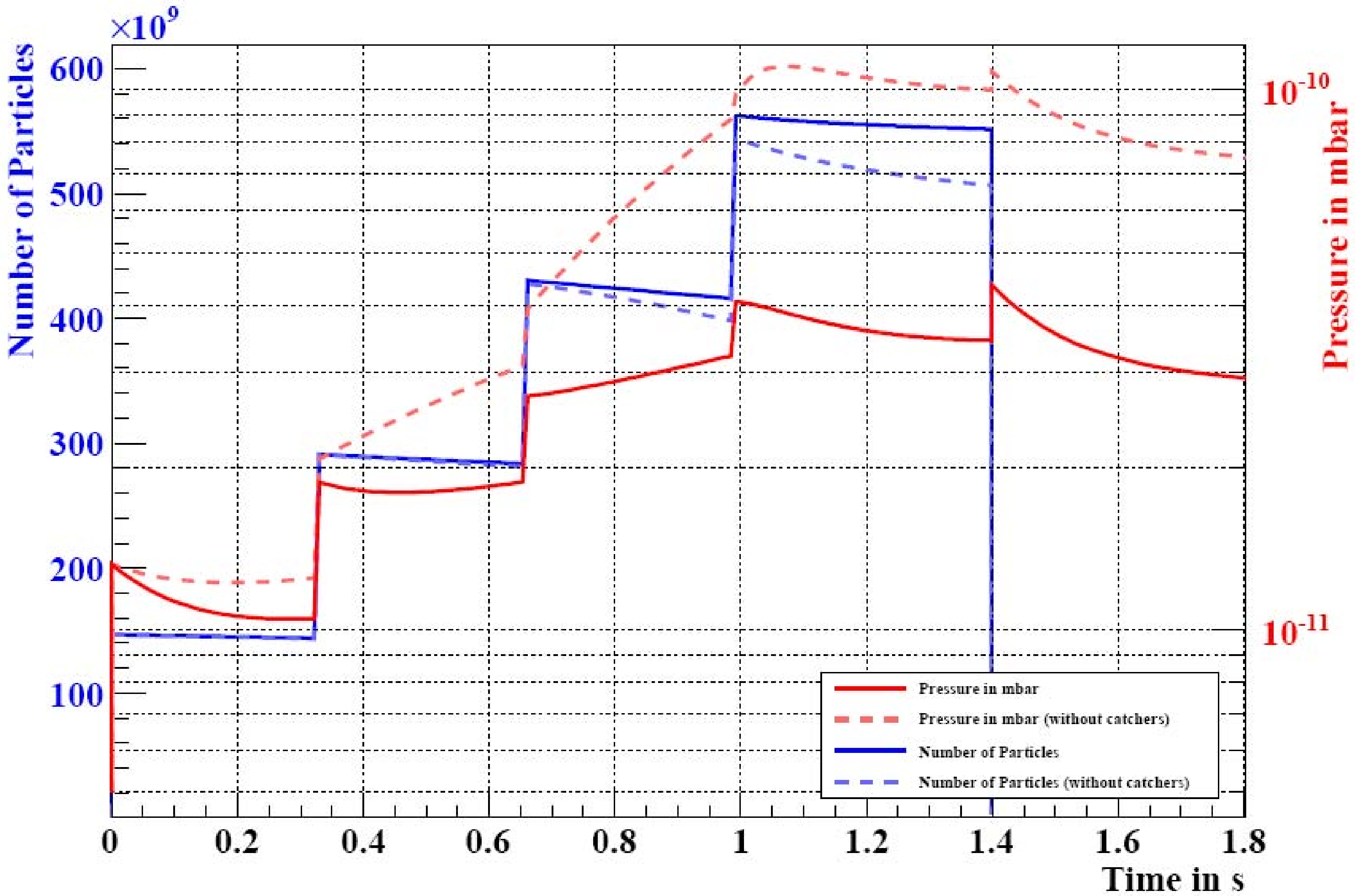
SIS100 Catching Efficiency



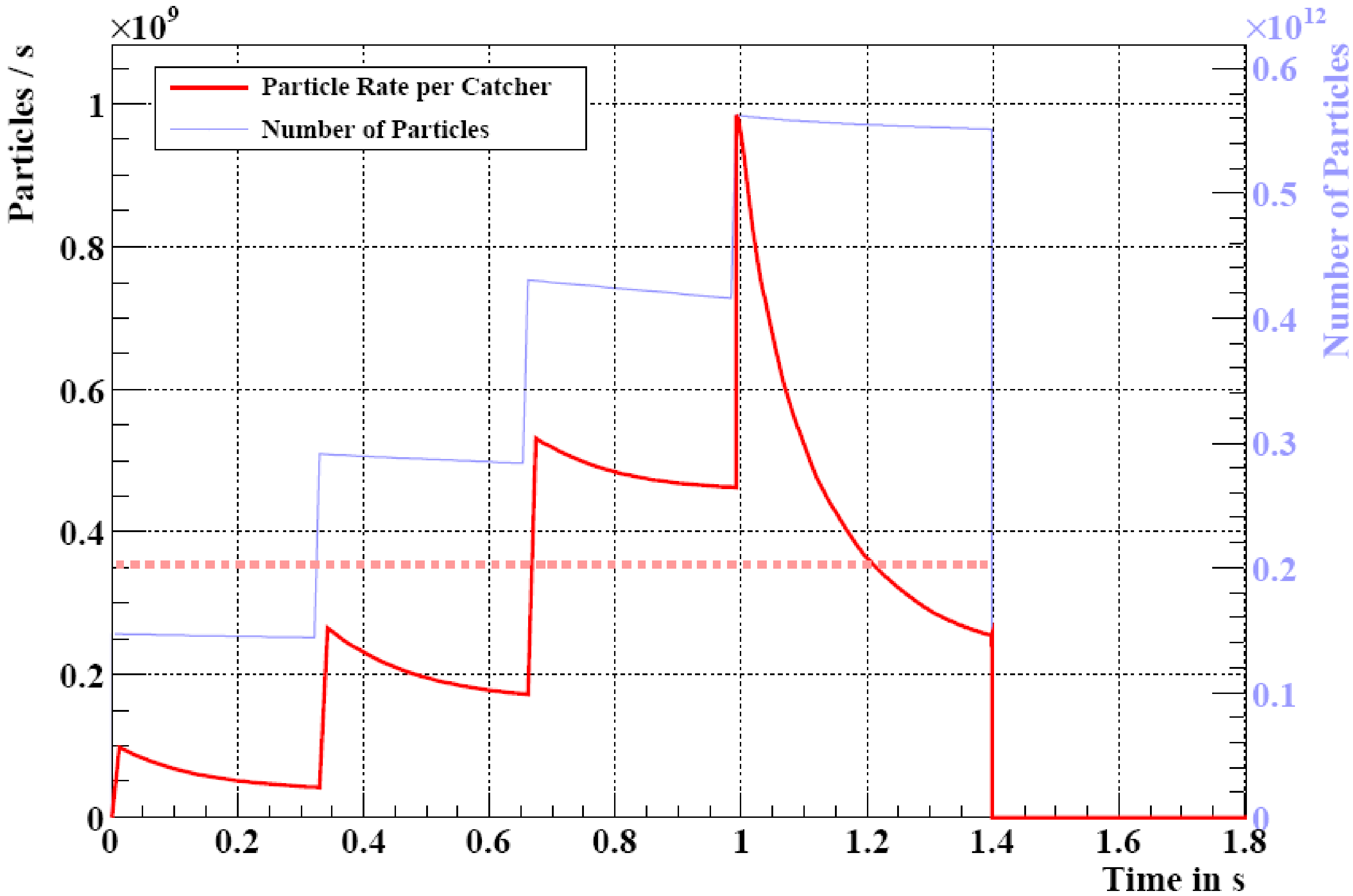
SIS100 Cycle Simulation

- Injection of 4 x $1.5\cdot10^{11}$ U^{28+} particles
- Base pressure $5\cdot10^{-12}$ mbar, residual gas Hydrogen dominated
- 10 K on all cold surfaces, effective pumping speed 74 m³/s
- Desorption yield: 25500 (dE/dx scaled)
  (54.7% CO, 22% H_2, 16.4% CO_2, 4.1% CH_4, 2.8% N_2)
- Low energetic desorption yield: 5 (Target Ionization)
- Systematic losses at injection (4%), and extraction losses (2%)

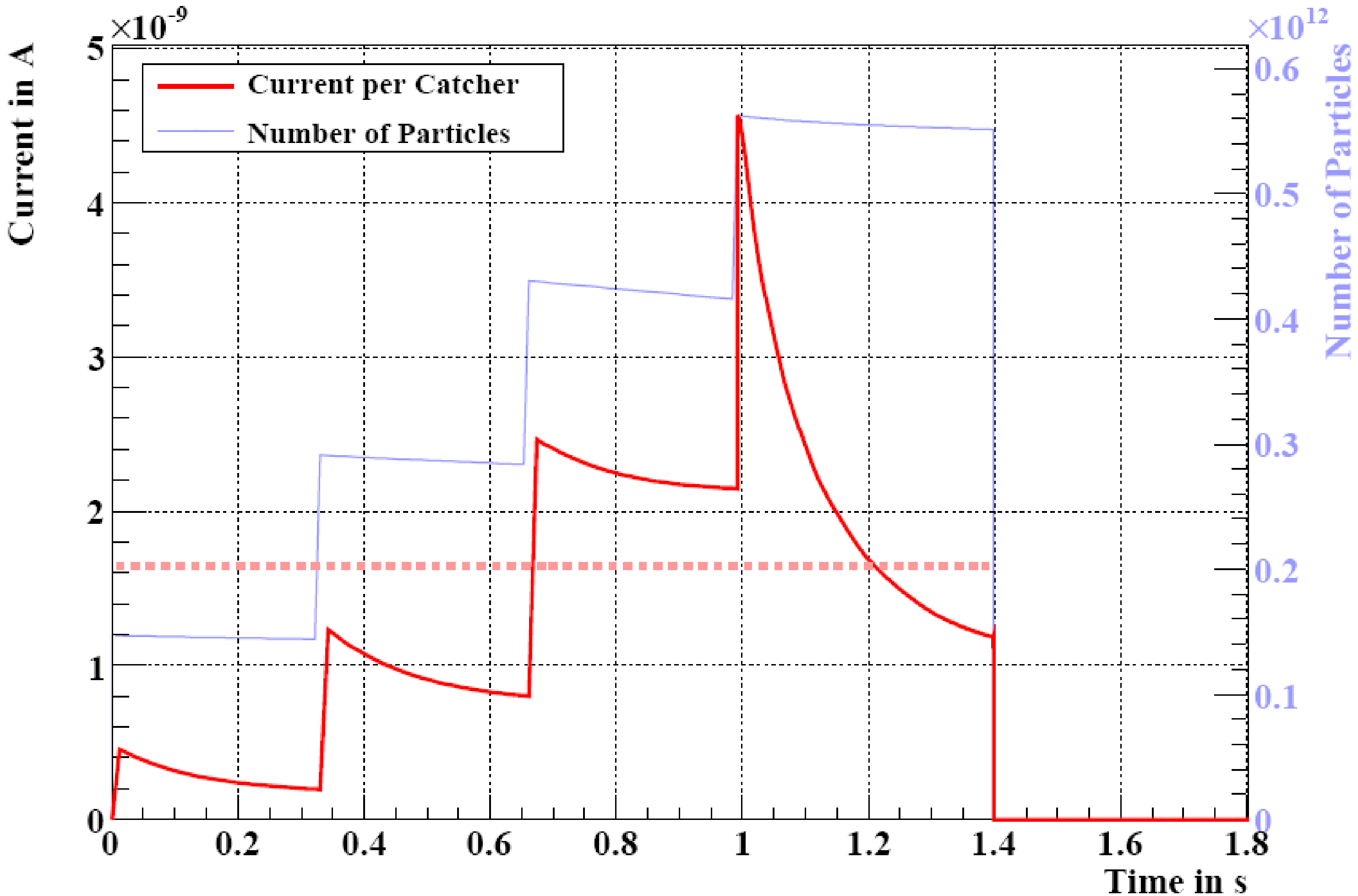
SIS100 Cycle Simulation



SIS100 Cycle Simulation – Loss Rates

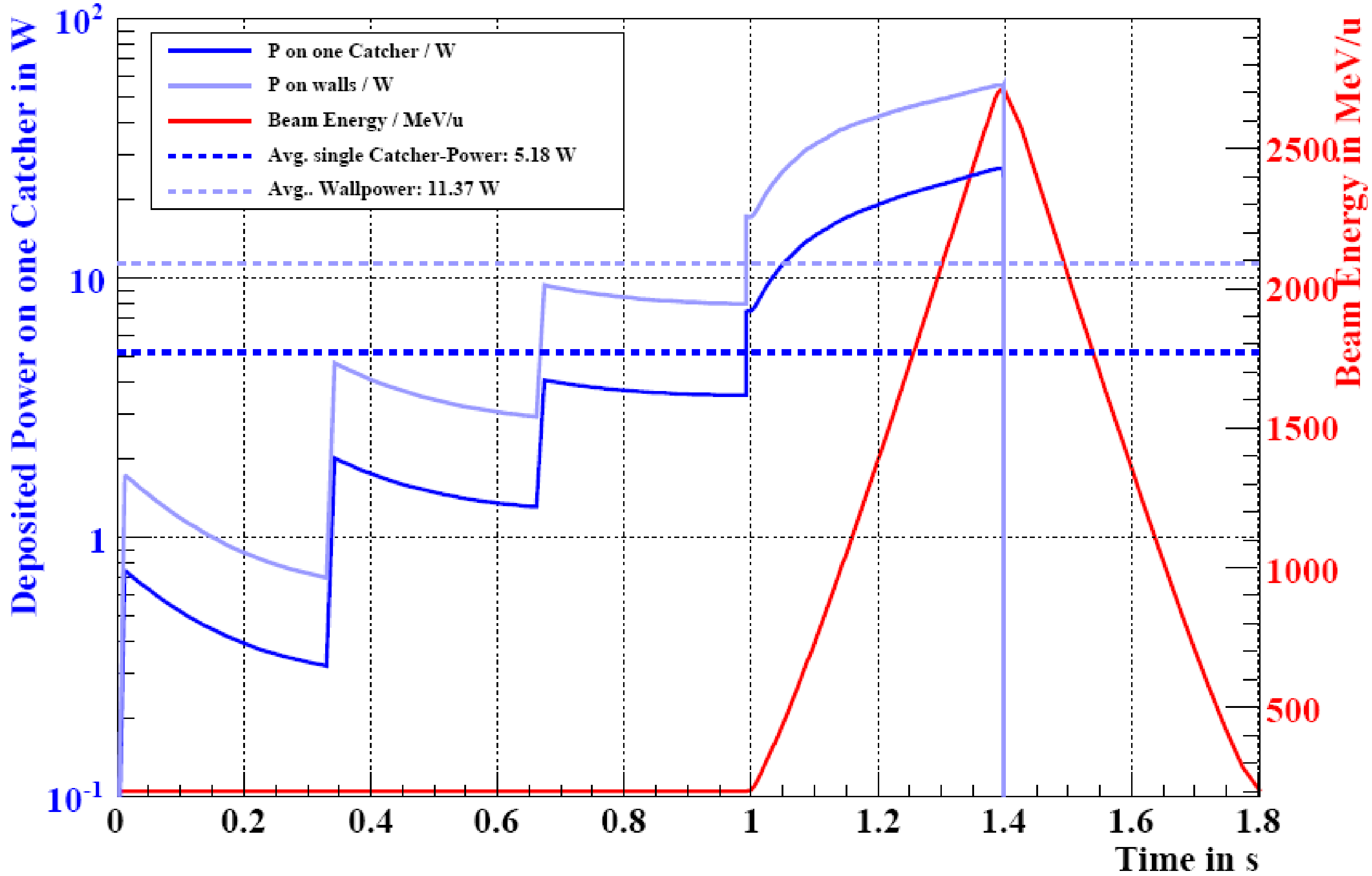


SIS100 Cycle Simulation – Loss Rates



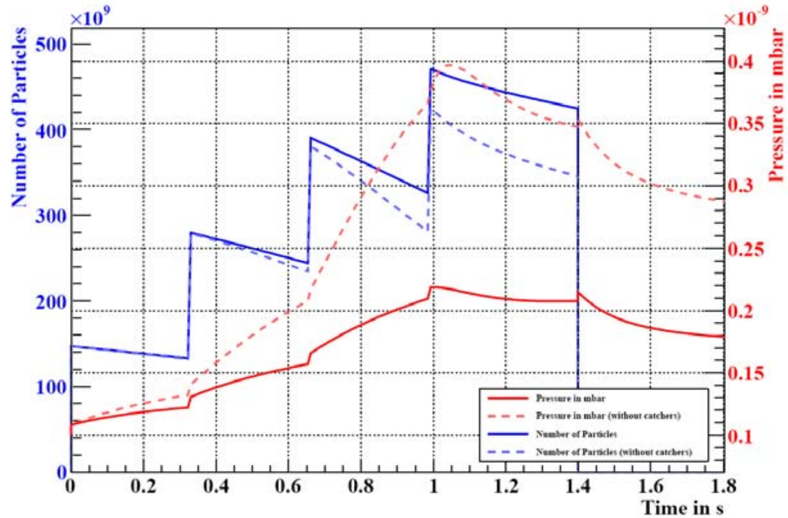
Measurement of electrical current on catcher: Signal for high ionization losses

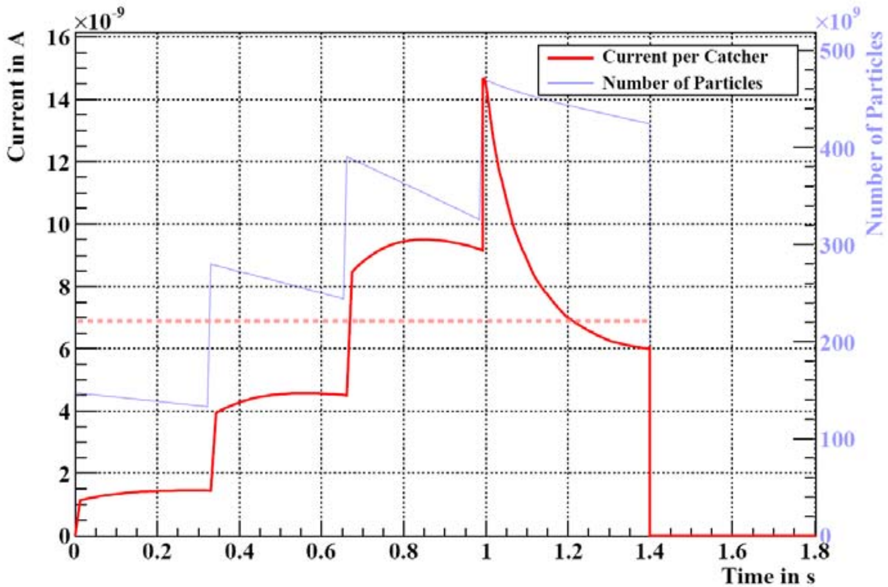
SIS100 Cycle Simulation – Loss Power

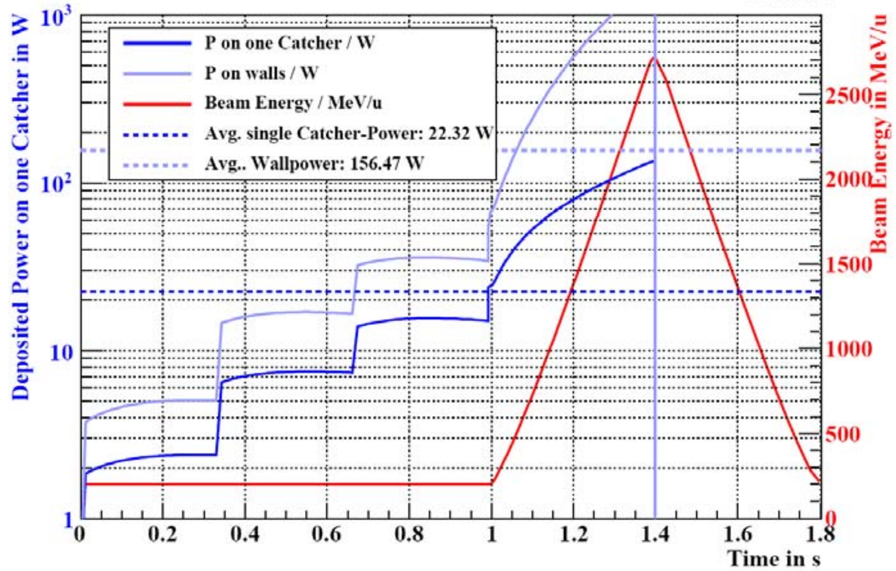


SIS100 Cycle Simulation – Loss Cycle

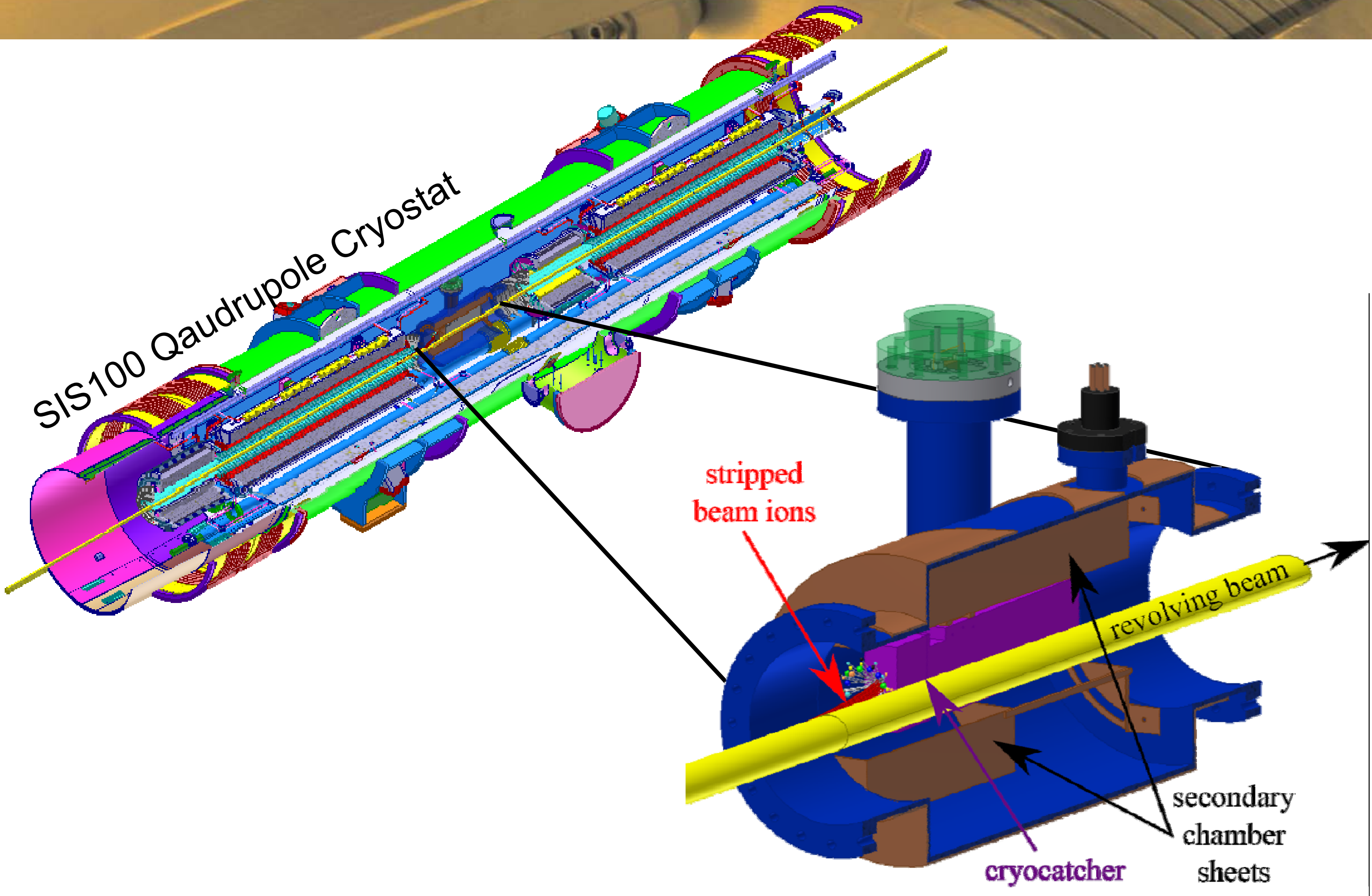
- Cycle at increased inital pressure (10^{-10} mbar)
- Electric current measurement generates an interlock, when increasing losses exceeds a threshold







Cryocatcher



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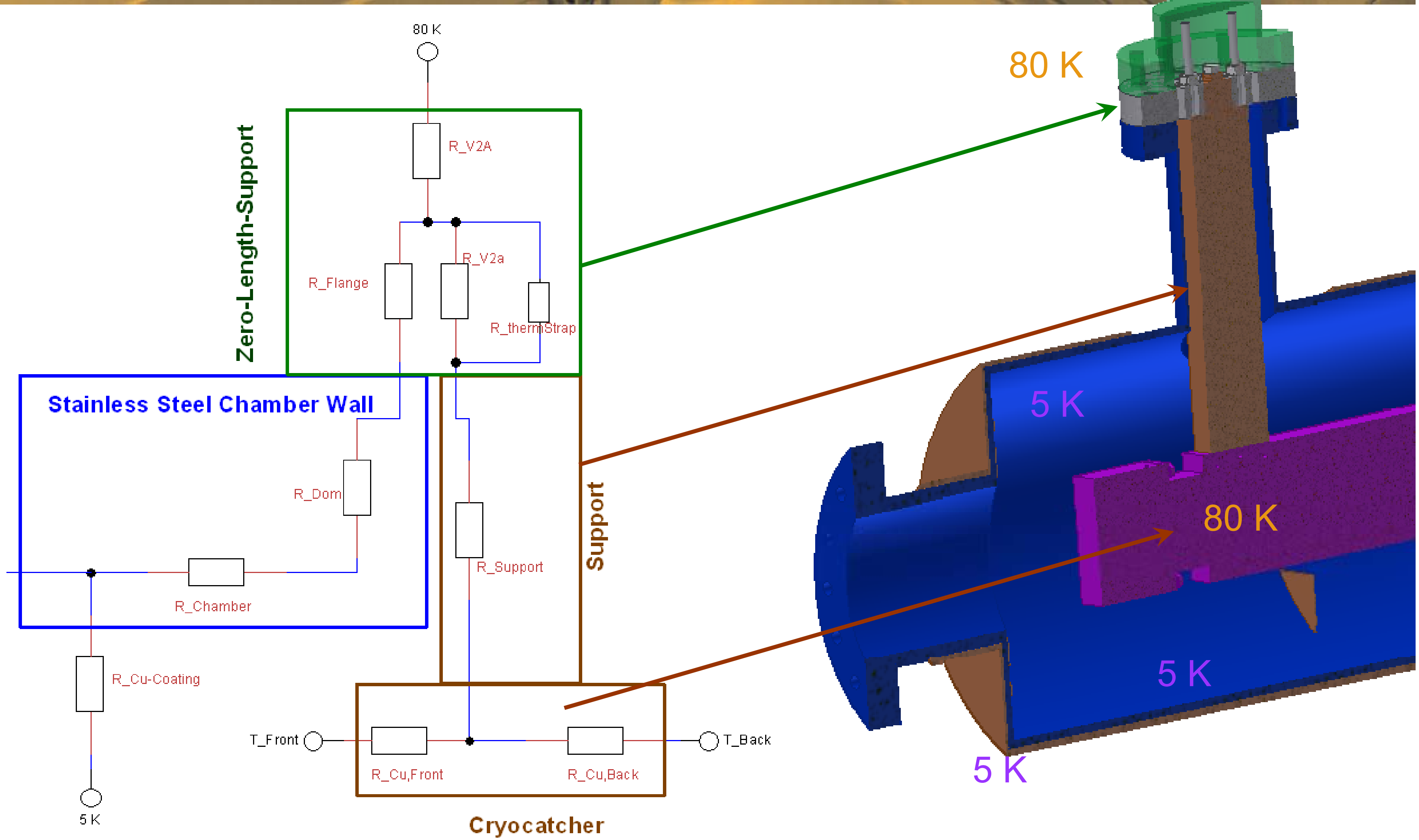
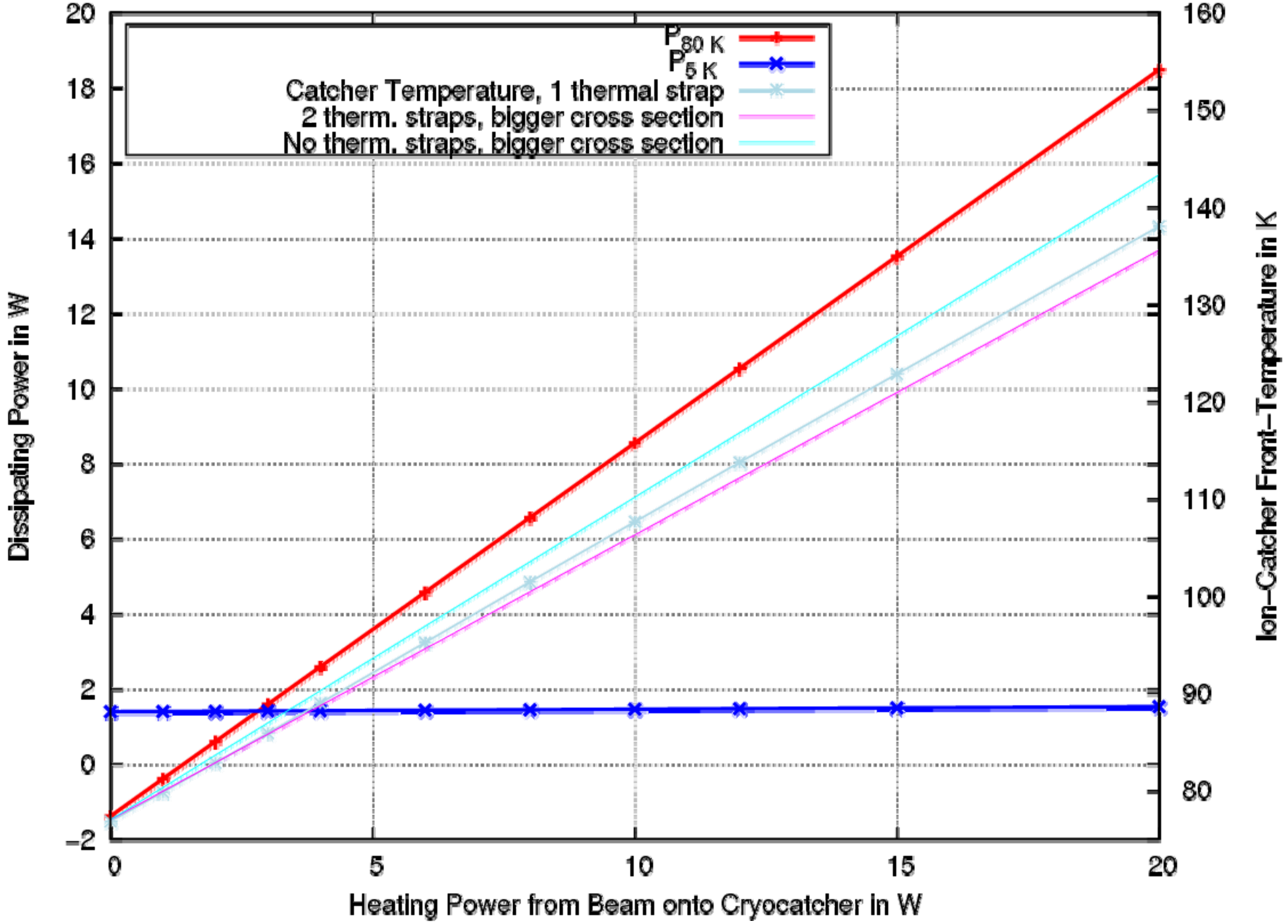
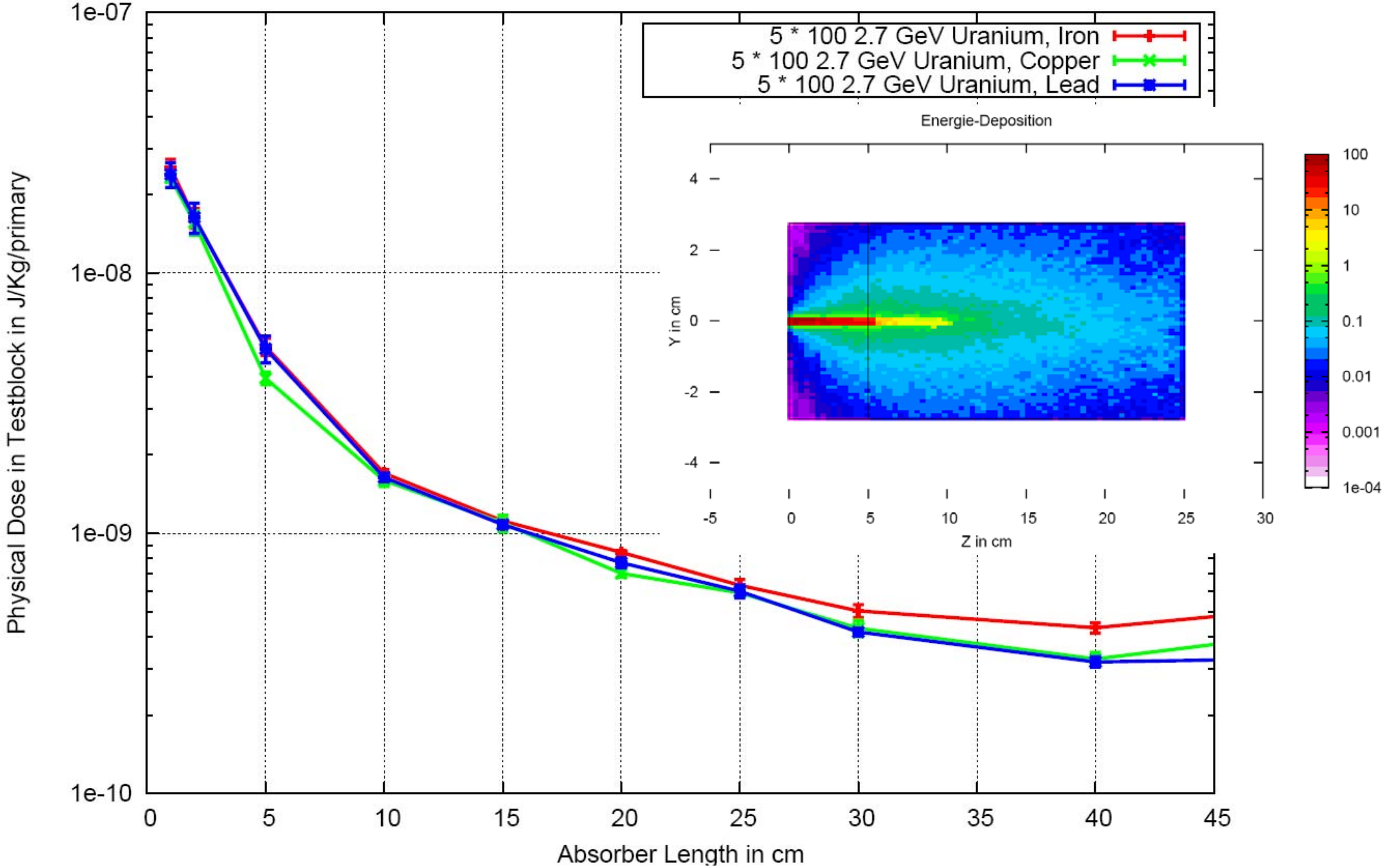


Cryocatcher – Temperature Simulation



Cryocatcher – FLUKA-Simulation



Simulations by M.Kirk show similar results

Summary

- Losses due to ionization are controlled at well defined and known positions
- Cryocatcher are located at these positions to minimize desorption
- Ionization losses will be monitored to trigger an interlock
- Cryocatcher reduces radiation damage and activation of neighboring magnets

Backup Slides

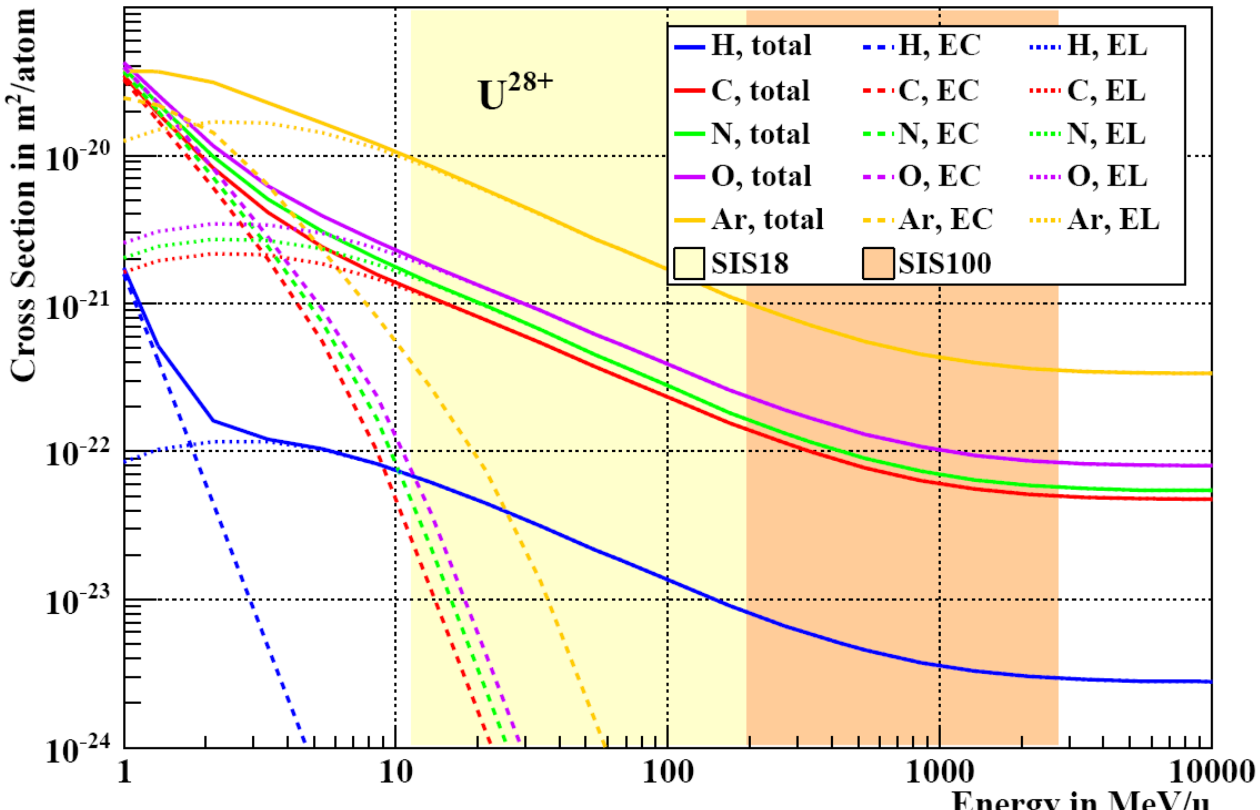
Ionization Loss Distribution

- Magnetic Rigidity $$B\,r = \frac{p}{q}$$
- Deflecting angle $$\varphi = \frac{L}{r}$$
- Magnetic field *B*, dipole length *L* and momentum *p* remain constant, only charge *q* and bending radius *r* change during ionization (U^{28+} → U^{29+})
- Relative change of deflecting angle:

$$\frac{\varphi}{\varphi\prime} = \frac{L\,B\,q/p}{L\,B\,q\prime/p} = \frac{q}{q\prime}$$

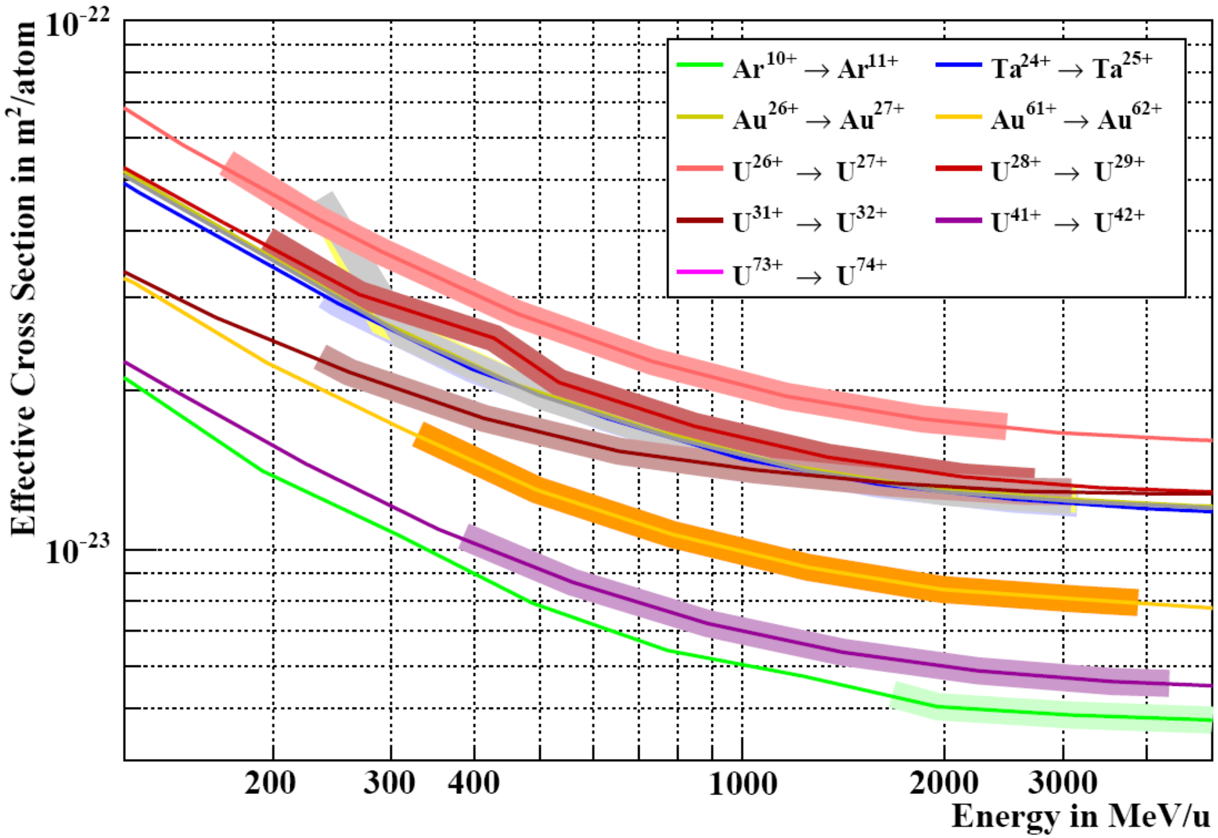
Ionization Loss Mechanisms

- Cross section for charge exchange depends on energy, ion, charge state and residual gas composition



Effective Cross Sections

- All effective Cross Section for assumed residual gas composition for SIS100
  (94.2% H_2, 2.5% CO_2, 1.6% N_2, 1.2% CO)



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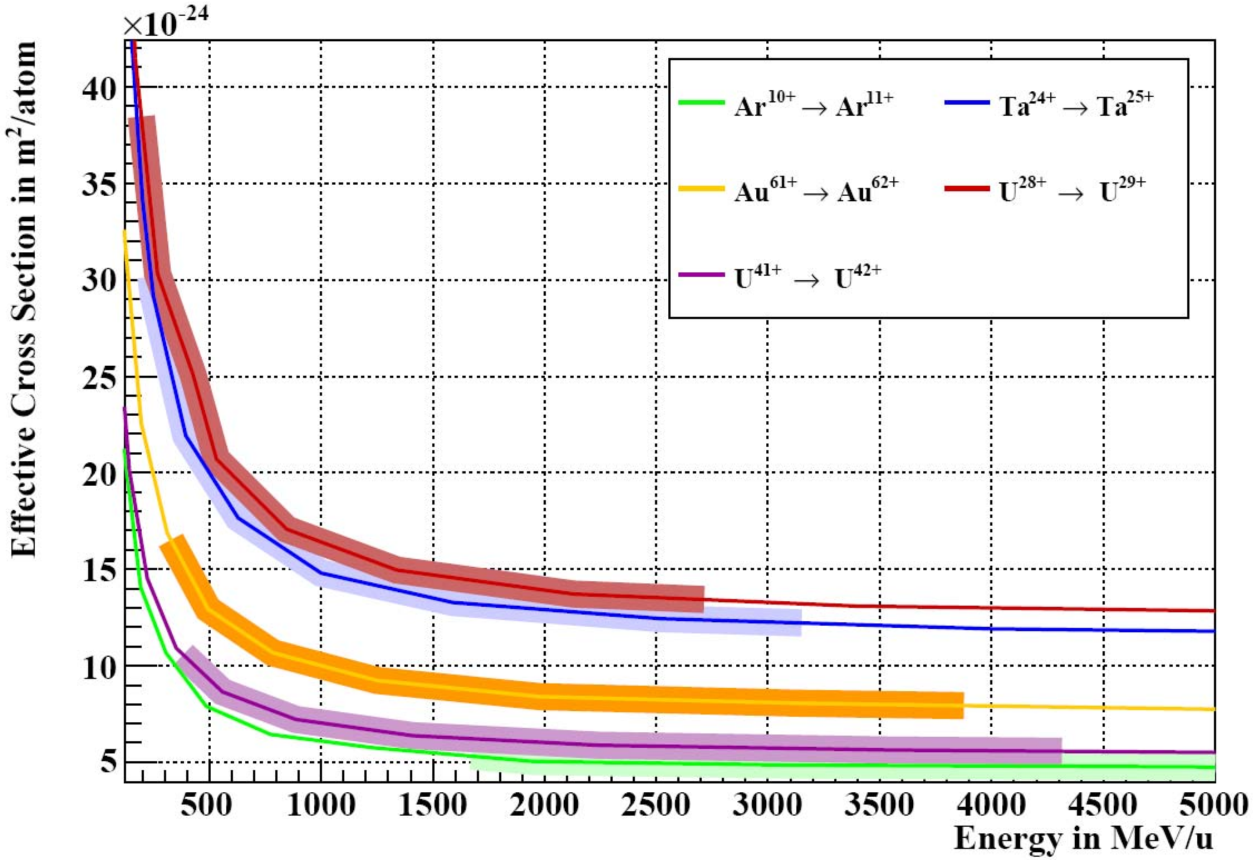
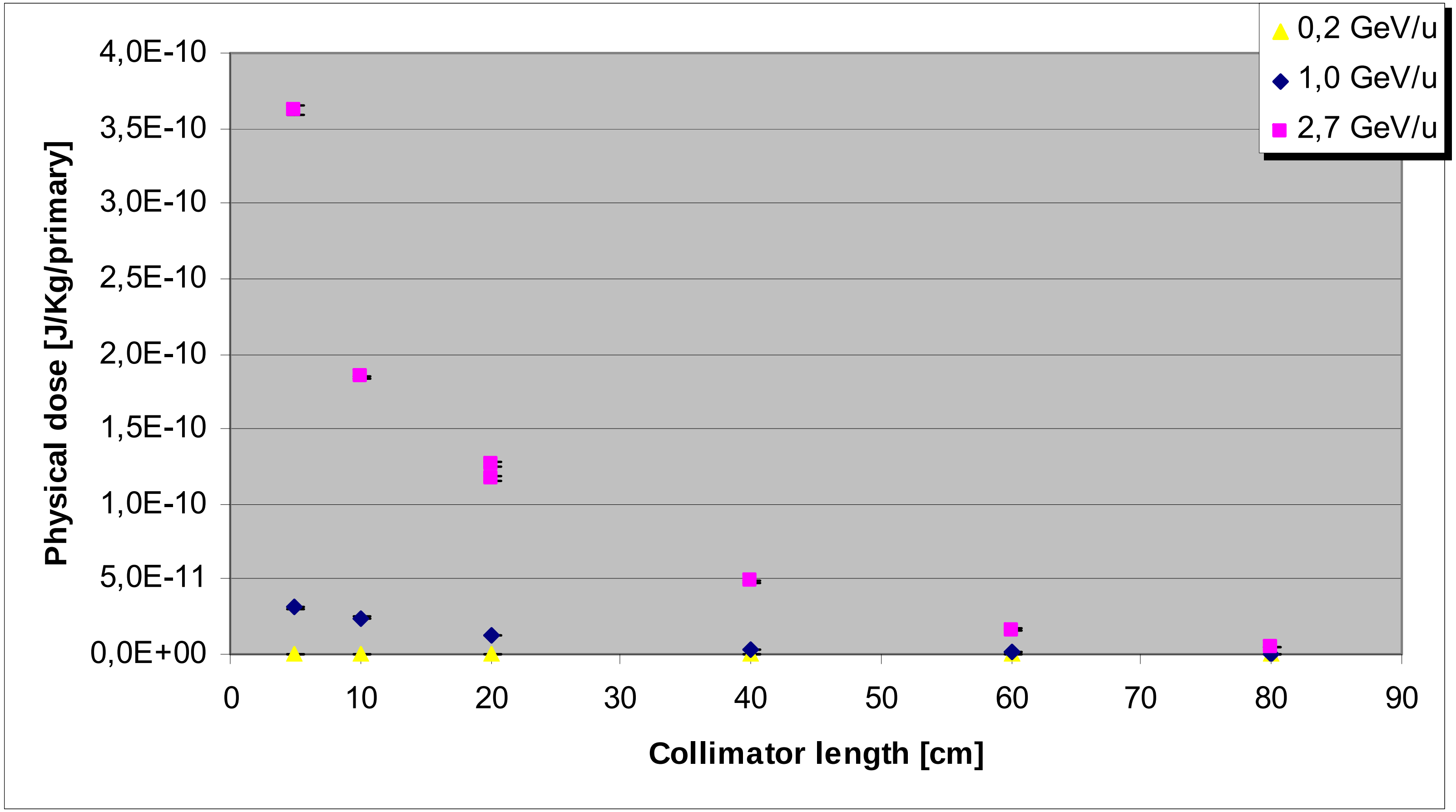


Cryocatcher – FLUKA-Simulation



M.Kirk

Simulation for SIS18 (present status), $2 \cdot 10^{10}$ U^{28+} injected, different amounts of losses at injection