FCC-hh heavy-ion collimation

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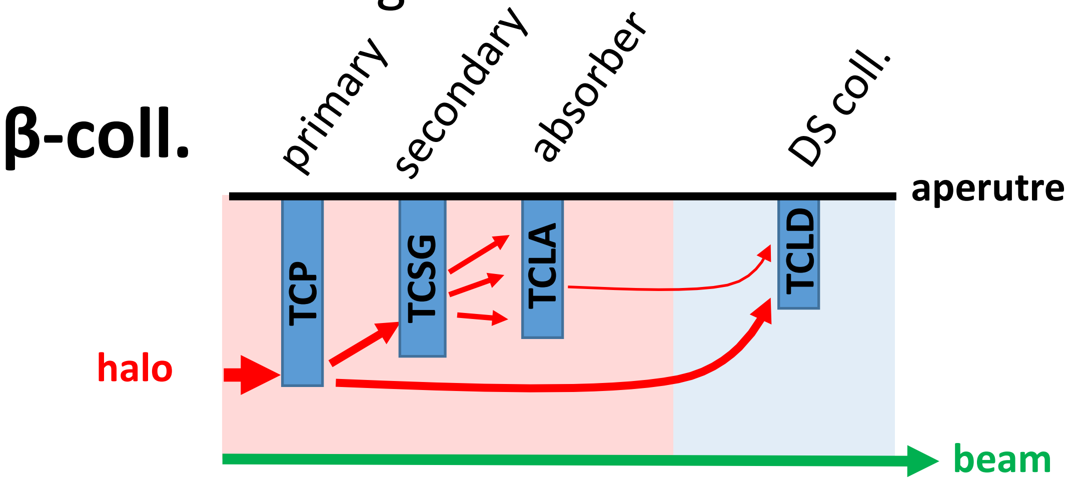
25.06.2019, FCC week 2019

Introduction

- The FCC-hh includes a mutli-stage collimation system:
  - Designed to clean the beam halo and protect the ring from beam losses.
  - See earlier talks by R.Bruce and J. Molson.
- Heavy-ion operation involves additional challenges:
  - Ion collimation efficiency in the LHC is a ~2 orders of magnitude worse for ion than for protons
  - The stored ion beam energy in the FCC-hh is a factor ~25 larger than in the LHC.



FCC-hh layout

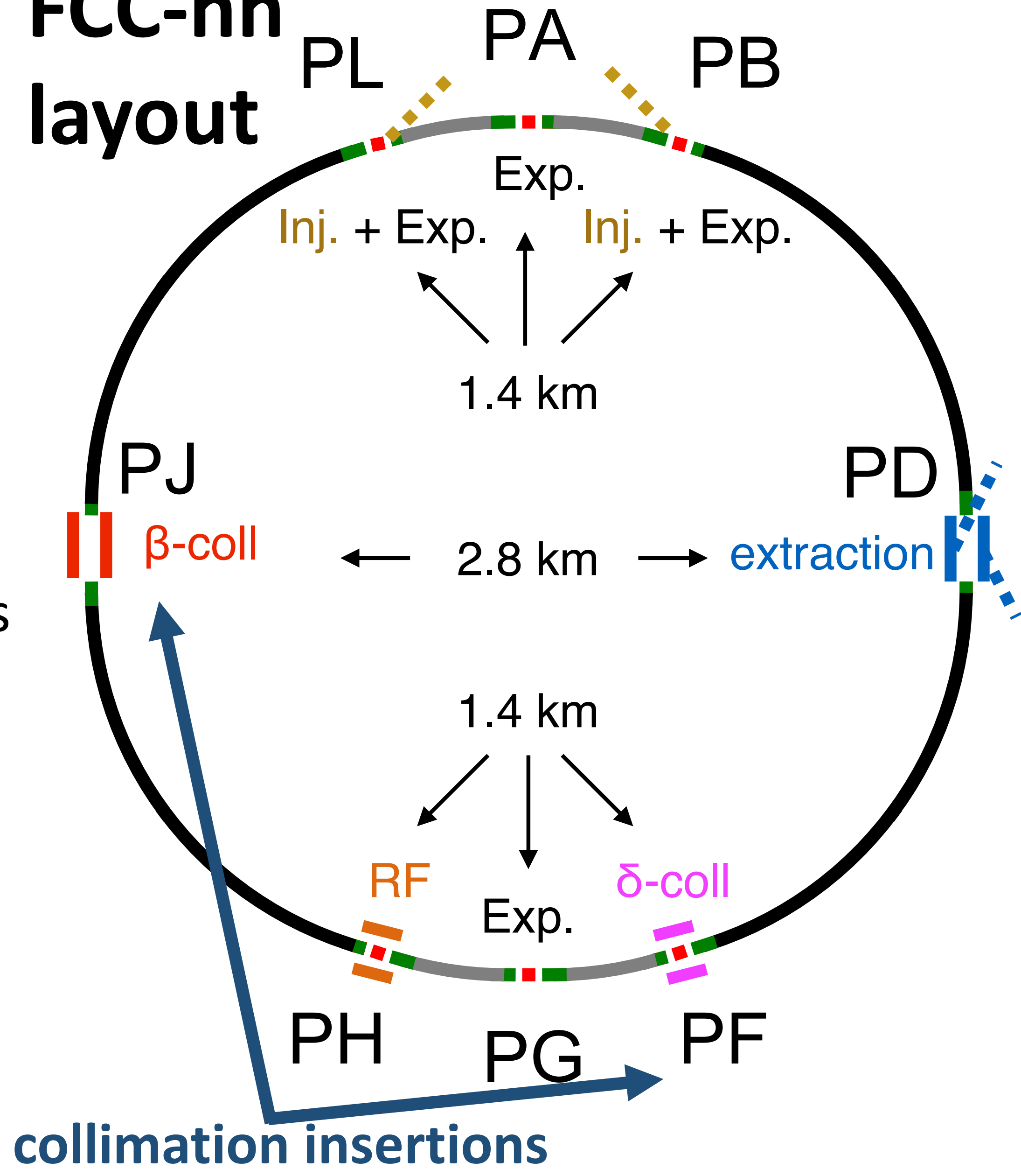
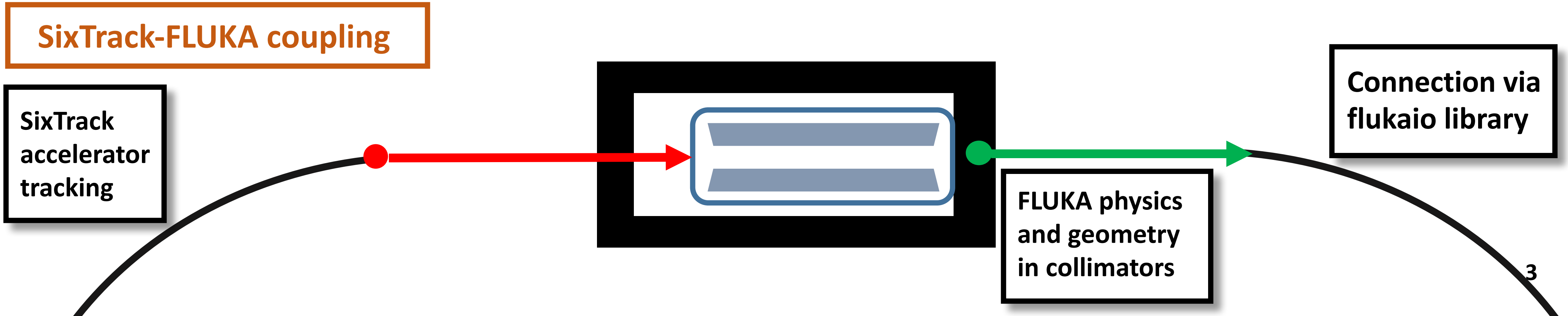


*Figure from FCC-hh long CDR

Simulation tools

- Studying ion collimation requires specialised tools:
  - Beam ions can undergo nuclear fragmentation and electromagnetic dissociation in the primary collimator, producing multi-species secondary ion beams.
- The simulations are performed using the **SixTrack-FLUKA active coupling**.
  - Thanks to A. Mereghetti, J. Molson, P. Hermes and the FLUKA team
- Combination of tracking and physics interactions:
  - Symplectic tracking in the accelerator magnetic lattice is performed by SixTrack.
  - Monte Carlo simulation of beam ion interaction with the collimators is performed in FLUKA.

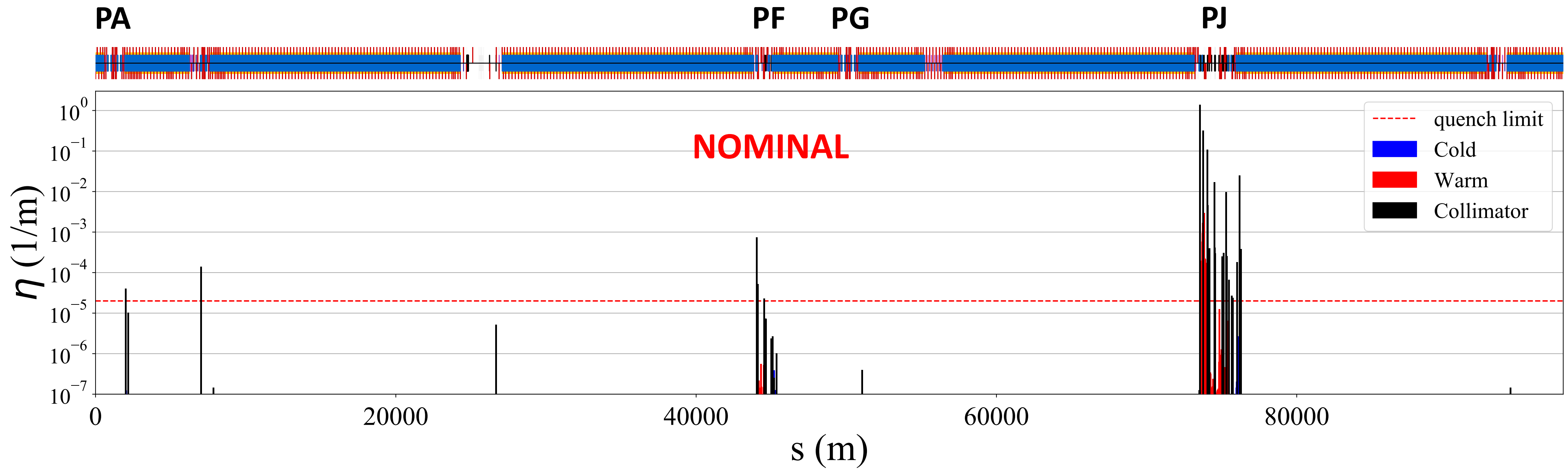


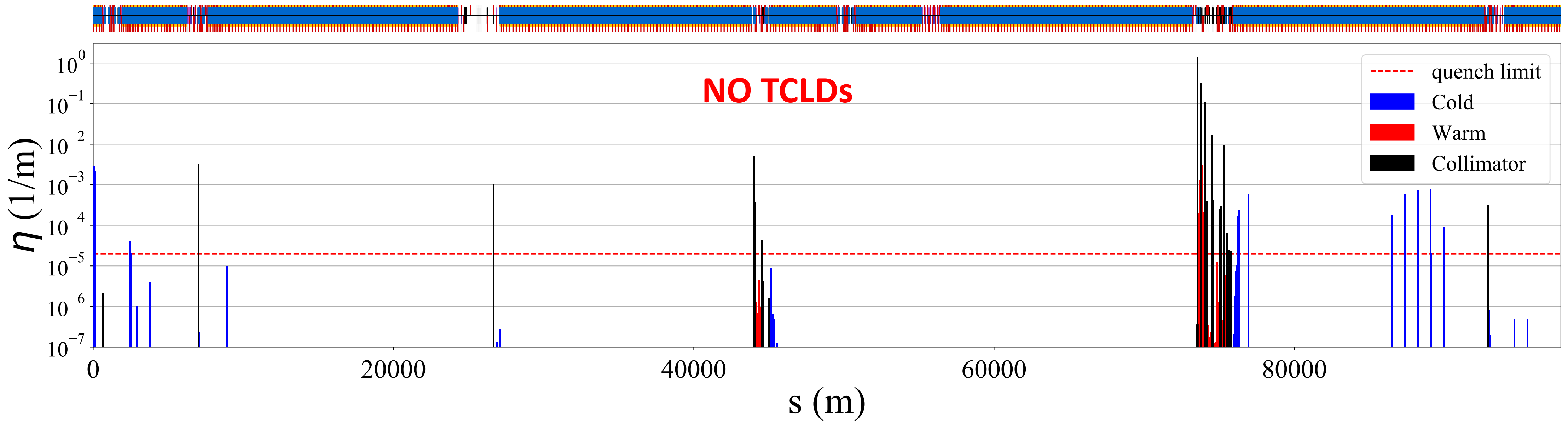
Simulation

- Study the collimation system performance for Pb ion beams:
  - Investigate the most demanding cases – betatron collimation in collision mode and off-momentum collimation in injection mode.
  - Evaluate the performance of the dispersion suppressor collimators (TCLDs)
- Simulation procedure:
  - Perform loss studies for Beam 1 in the horizontal (B1H) using a halo beam.
  - Compare the results against an estimate of the quench limit. (See talk by M. Varasteh)
  - Analyse in more detail the losses in DS.

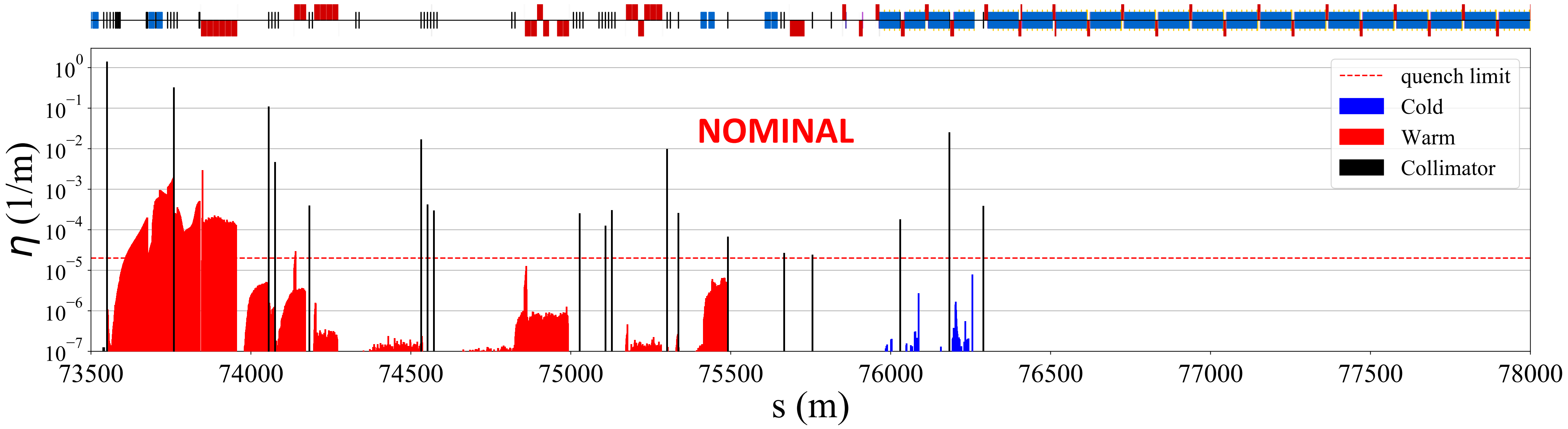
Parameter	Value
Beam particle	$^{208}\mathrm{Pb}^{82+}$
Number of bunches	2760
Ions per bunch	2×10^{8}
Injection energy	3.3 Z TeV
Collision energy	50 Z TeV
Beam lifetime	12 min
Quench limit	2×10^{-5} 1/m

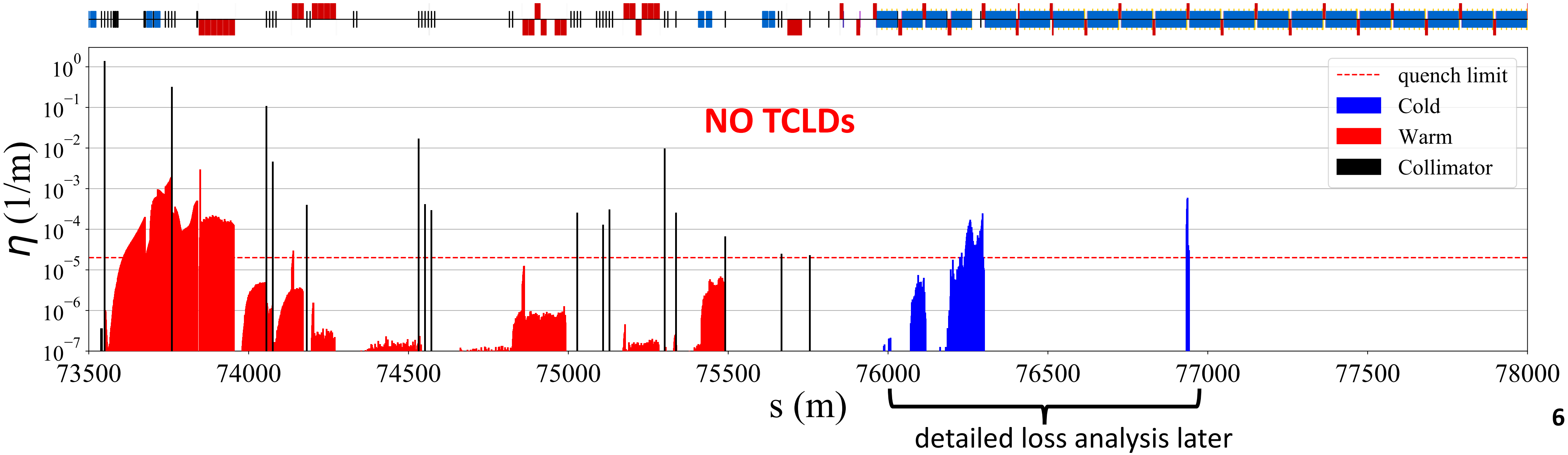
Betatron cleaning at collision – B1H



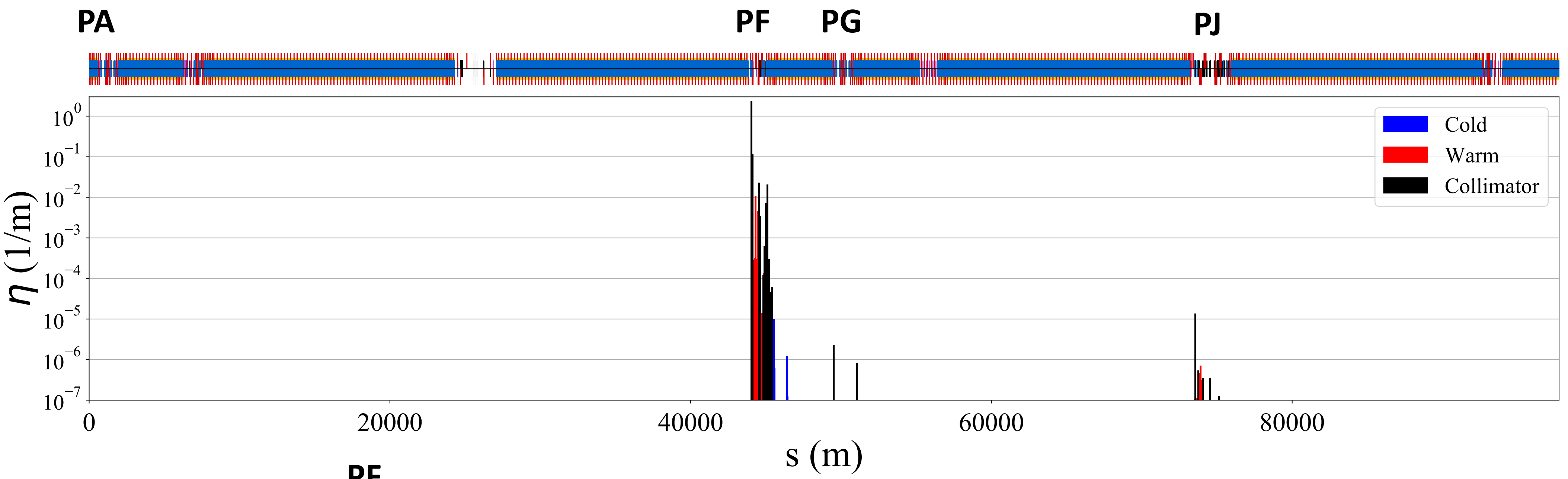


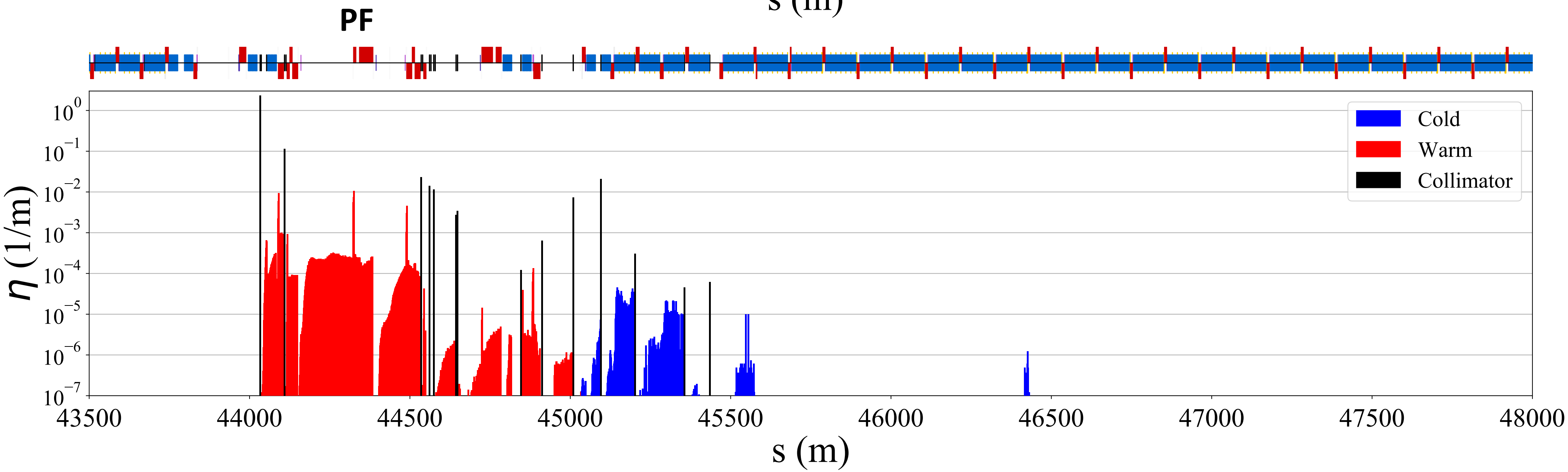
Betatron cleaning at collision – B1H IRJ





Momentum cleaning at injection – B1H

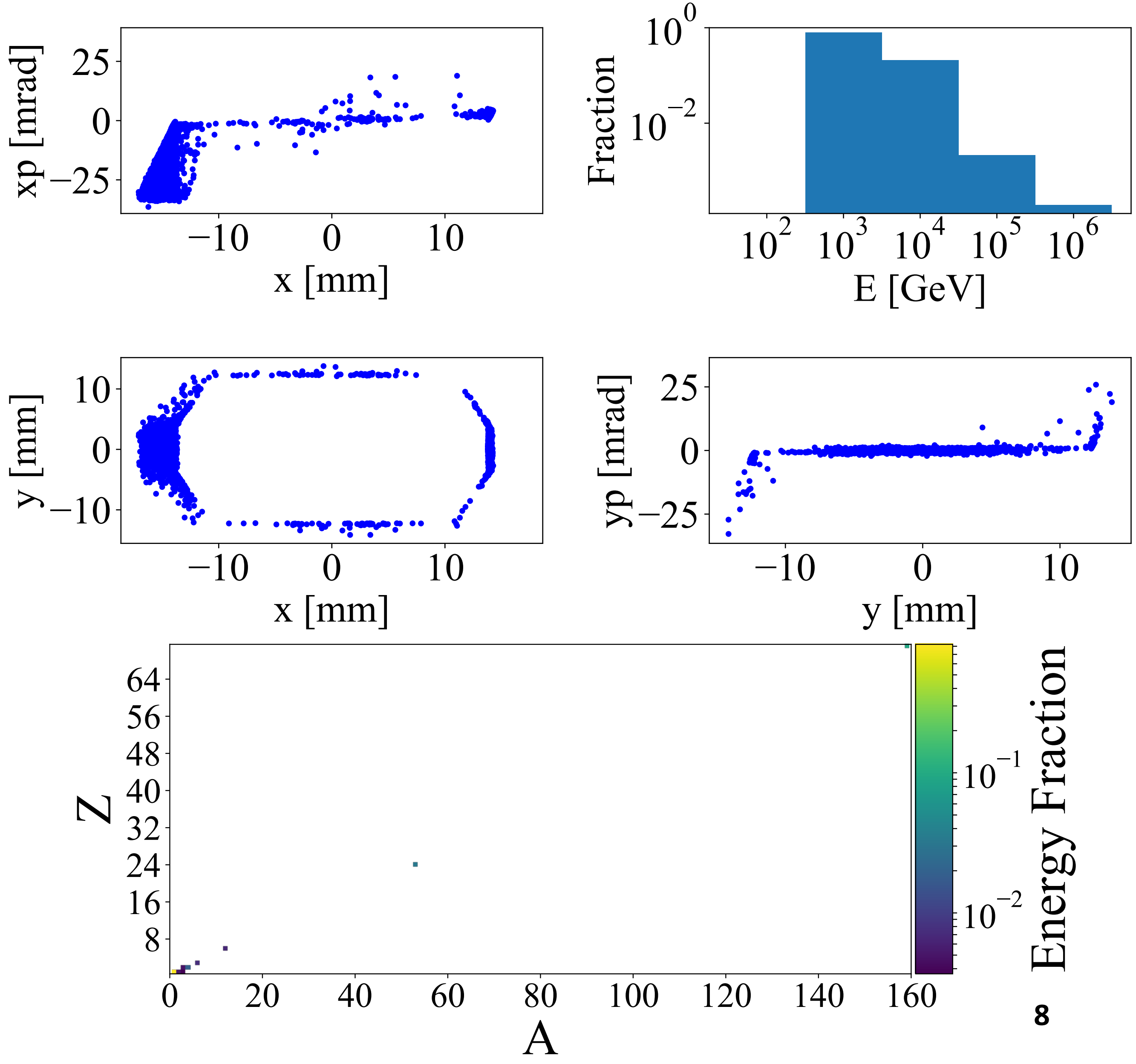




DS losses analysis – B1H collision, S = 76000 – 77000 m

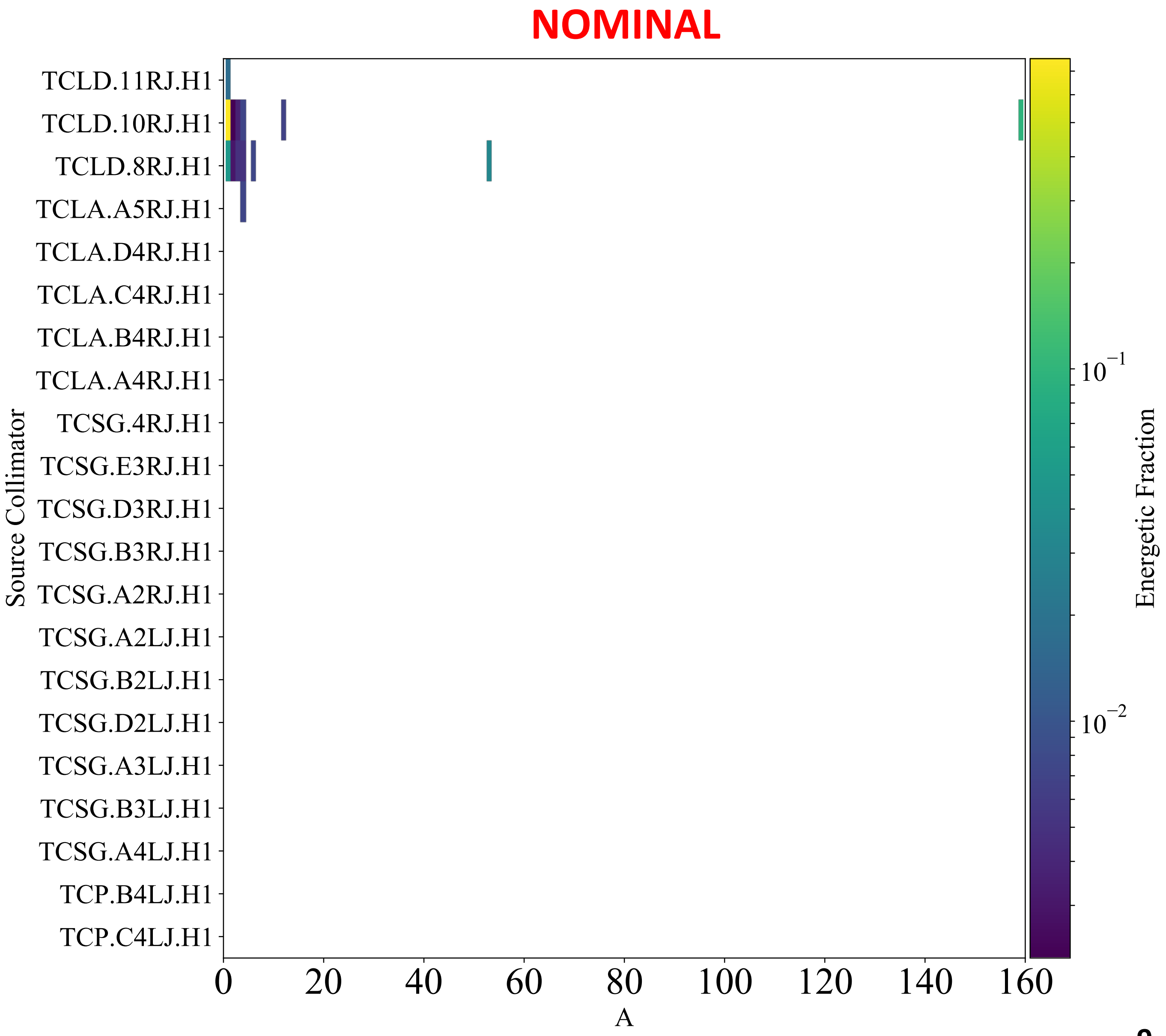
- The dispersion suppressor of the betatron cleaning insertion is one of the critical areas for losses.
- Analysis of the losses on the cold aperture shows more losses on the inside of the ring.
- Light ion fragments make up most of the losses on the aperture.

NOMINAL



DS losses analysis – B1H collision, S = 76000 – 77000 m

- Connect the aperture losses to the collimator where they originated.
- All the fragments coming from the TCPs and TCSGs are successfully intercepted by the TCLDs.
- The dominant contribution to energy lost in the DS are light fragments leaking out from the TCLDs



Conclusions

- The study of ion collimation for the FCC-hh shows good cleaning performance. Beam losses can be sustained without quenching within the specification for 12 minute beam lifetime.
- The TCLD collimators are shown to be critical for ion operation as they intercept heavy-ion fragments coming from warm collimation insertion upstream.
- Further energy deposition studies are necessary to fully asses the quench risk.