

Introduction

The design of the collimation system is one of the biggest challenges for the FCC-hh. The collimation system is generally optimized for proton operation. Because of fragmentation in the collimator jaws, the efficiency is reduced in heavy-ion operation. Losses of ion fragments in the cold region of the Dispersion Suppressor (DS) could limit machine performance, if not sufficiently absorbed.

This study evaluates the betatron collimation efficiency for heavy ions in the collimation system designed for protons.

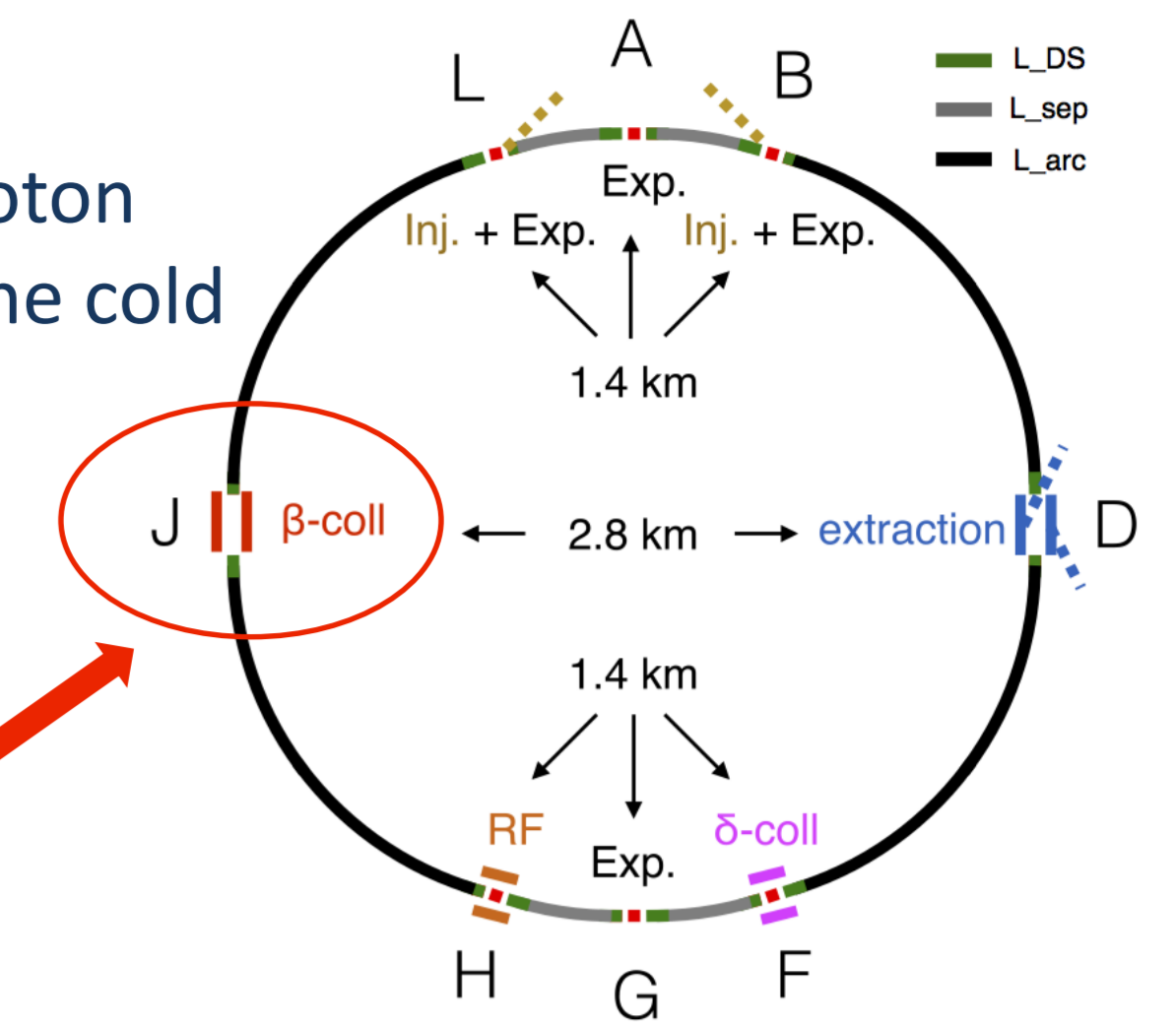
Assumptions

- $^{208}\text{Pb}^{82+}$ ion beam
- Beam energy = 50Z TeV = 19.7 TeV per nucleon
- Lattice Version: 9.0

Goal:

Simulate the first impact locations of primary ion fragments produced in the horizontal primary collimator (TCP).

Betatron Collimation Insertion



STIER Approach

For this study, the **SixTrack with Ion-Equivalent Rigidities (STIER)** approach [1] is used: initial ion distributions are generated with **FLUKA**. These particles are then tracked in **SixTrack** as "protons" with the respective ion rigidities. The simulation is deployed in three steps:

MAD-X

The initial phase space parameters of the nominal ion beam are calculated using MAD-X in order to determine the impact conditions on the TCP.

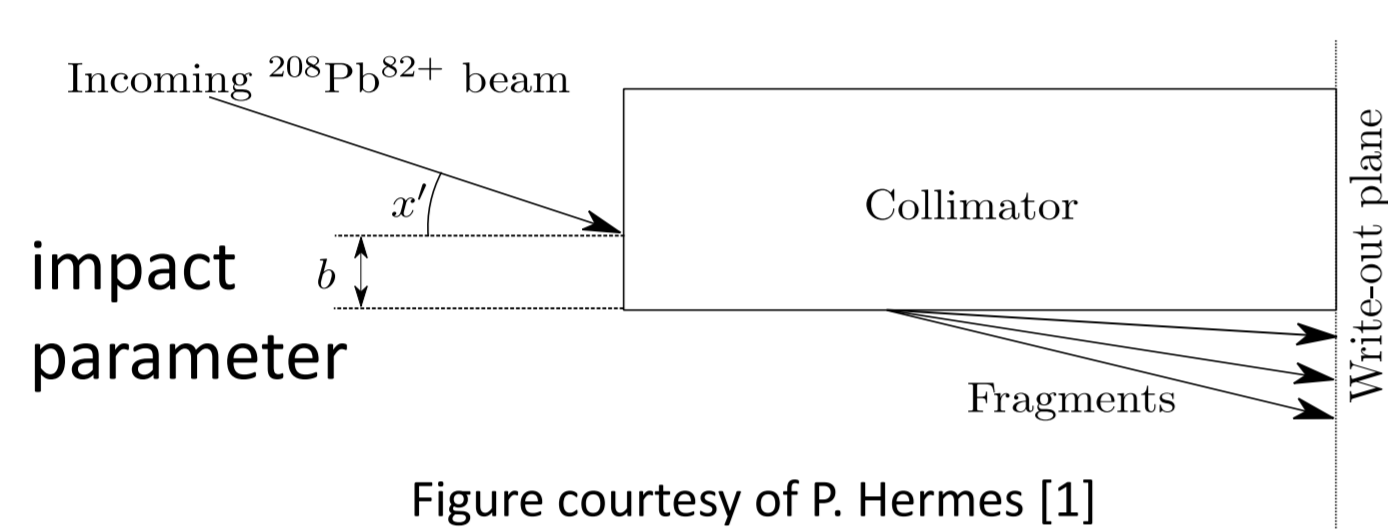


Figure courtesy of P. Hermes [1]

FLUKA

Given the impacting particles on the TCP, FLUKA computes the full Monte Carlo simulation of the ion-matter interactions with the collimator material (0.6m long block of graphite).

Input: pencil-beam impacting on TCP at an angle x' with an impact parameter b .

Output: spectrum of ion fragments exiting the collimator.

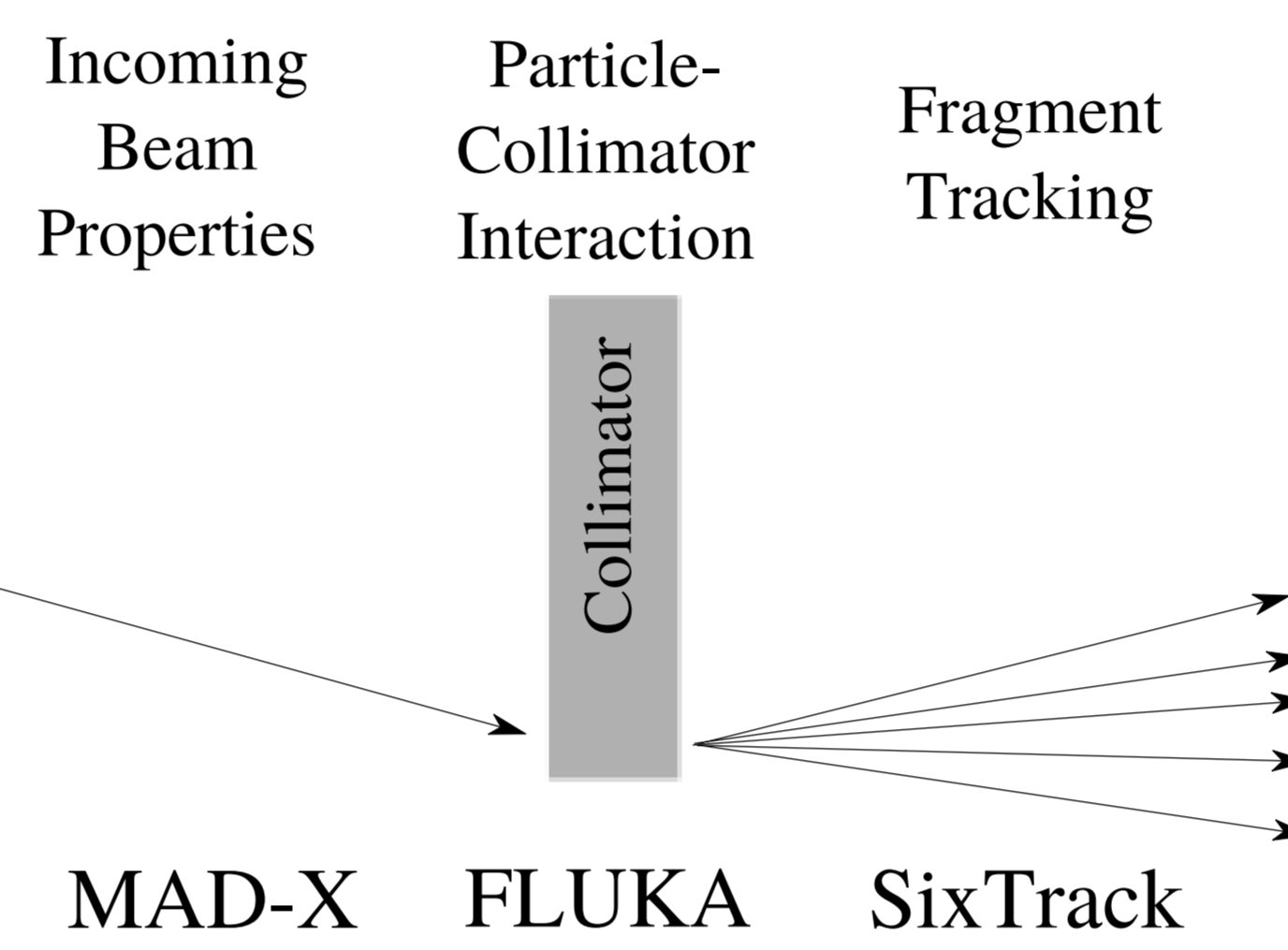


Figure courtesy of P. Hermes [1]

SixTrack

The ion fragments emerging from the TCP are tracked along the circumference. To do so, they are converted to protons with equivalent ion rigidities.

The computed trajectory of each particle is scanned for impacts with the collimators and element apertures. The locations of the losses are identified with an accuracy of $\pm 10\text{cm}$ and displayed in loss maps.

The following assumptions are made:

- Fragments emerging from secondary impacts on secondary and tertiary collimators are ignored.
- Only horizontal collimation plane studied.
- Only impacts on left TCP jaw are simulated - equivalent results expected for right jaw.

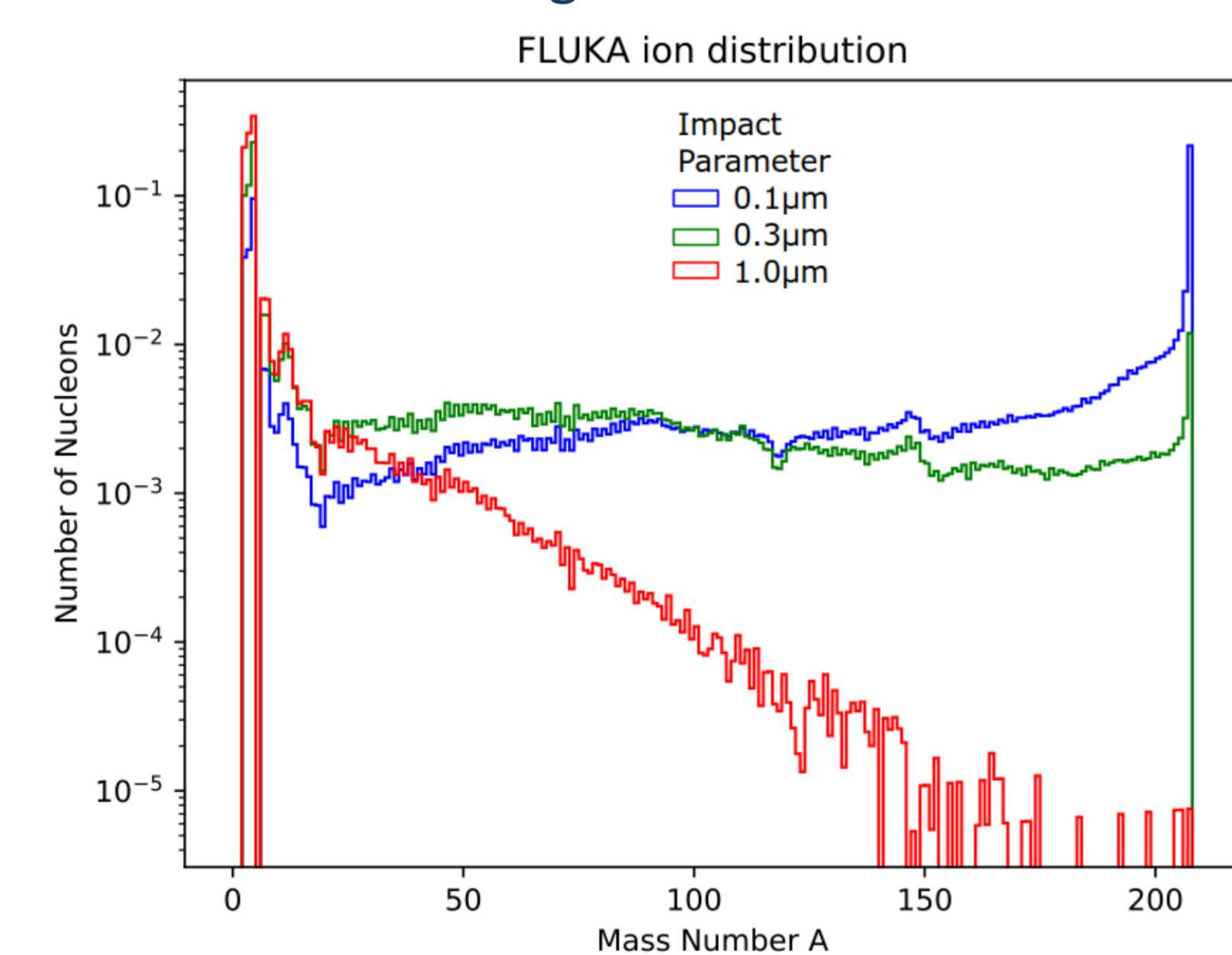
➤ Only qualitative conclusions may be drawn.

Results

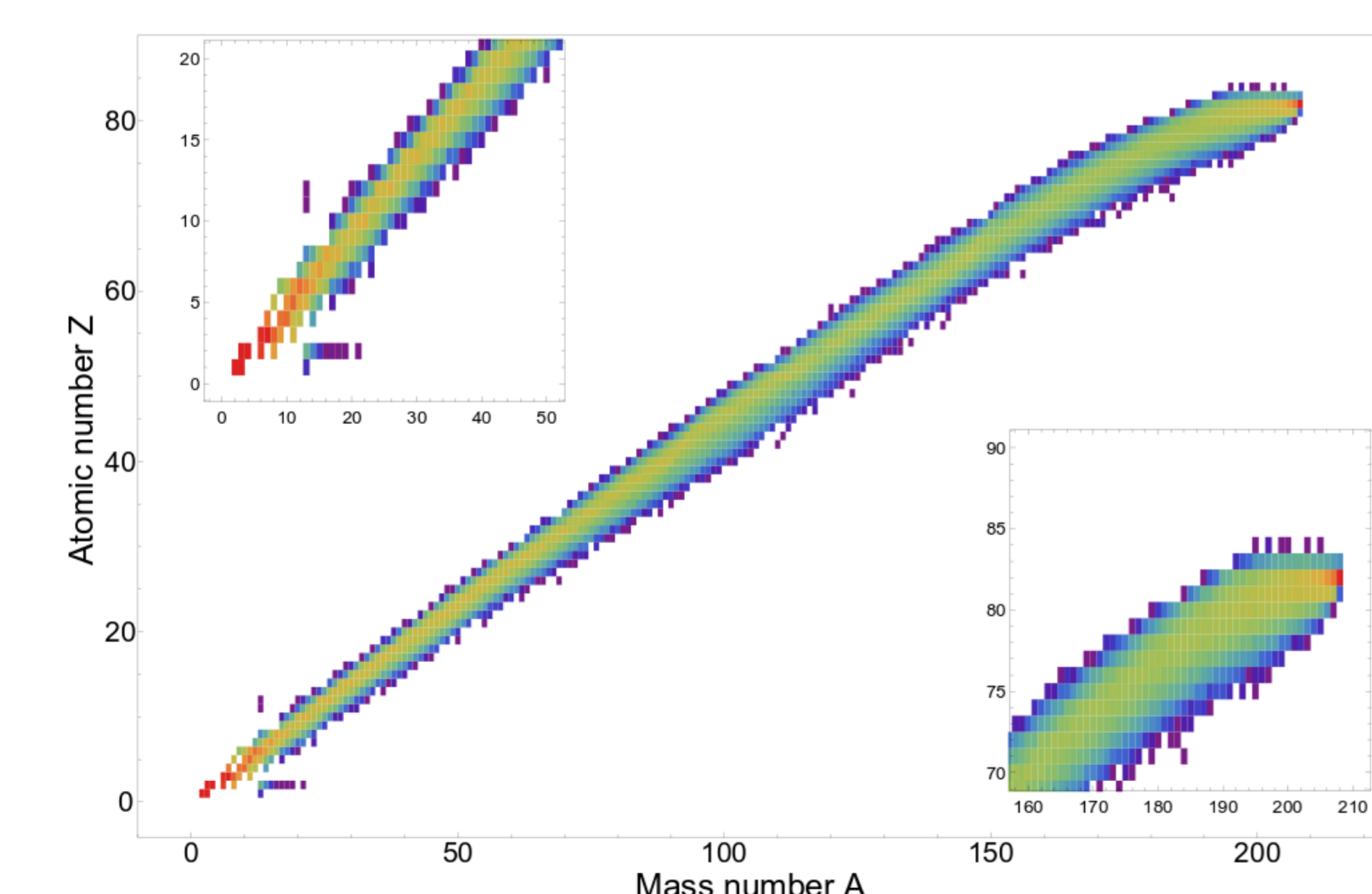
Initial Distribution of Ion Fragments

The larger the impact parameter, the better the cleaning efficiency of the TCP. In order to identify design limits of the collimation system, the worst case scenario has to be investigated.

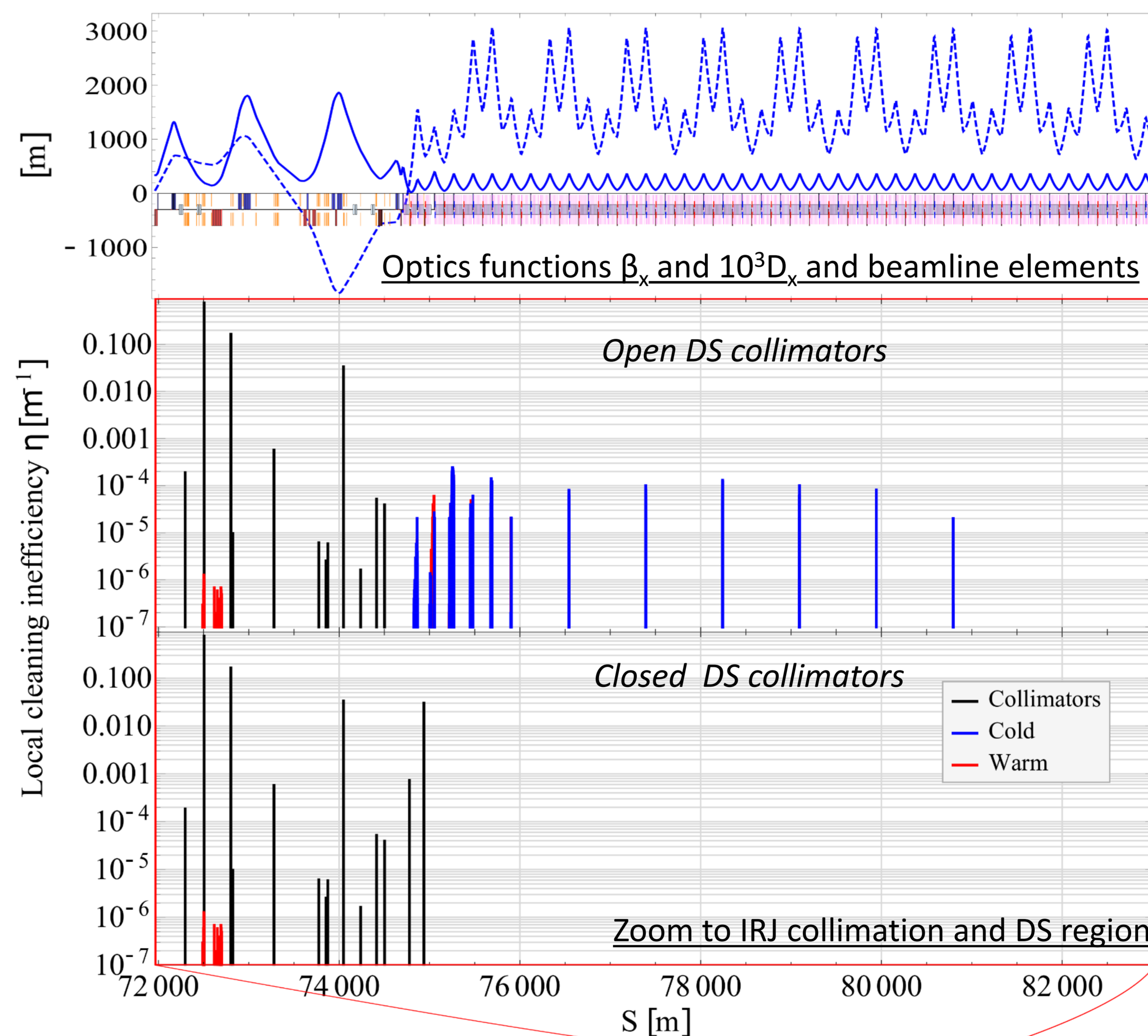
An impact parameter scan was performed with FLUKA, which identified $b = 0.1 \mu\text{m}$ (blue) as the scenario to be studied with tracking simulations.



For $b = 0.1 \mu\text{m}$, 10^6 impacting $^{208}\text{Pb}^{82+}$ ions were simulated with FLUKA, generating the following distribution of ion fragments at the exit of the TCP:



First Impact Loss Map



Two DS collimator settings were studied:

- fully open
- closed to proton settings

Case 1: Open DS collimators
Intense clusters of cold losses in DS region, where the dispersion is high.

Case 2: DS collimators closed to proton settings
Successful absorption of the primary ion fragments coming from the TCP. Protection of the DS superconducting elements.

Note: secondary fragments which emerge from other collimators including the DS collimators may still lead to losses in the arc.

DS collimators installed for proton operation can protect the DS from losses of ion fragments as well. This study confirmed that the chosen positions of the DS collimators are valid for ion operation, while the material and collimator design still need to be studied further.

References:

- [1] P. Hermes, CERN-THESIS-2016-230.
[2] J.M. Jowett et al., 2AMS01D, this conference.

Abbreviations:

- Pb = lead
DS = Dispersion Suppressor

- TCP = Primary Collimator
IR = interaction region
DS = dispersion suppressor

Acknowledgements:

I would like to thank P. Hermes for developing STIER and for all his support. This CERN study is part of my MSc thesis for NTUA, Athens. I would like to express my gratitude to all the people that contributed to this opportunity.

Ef.Logot@cern.ch
Michaela.Schaumann@cern.ch