Update on simulations

M. Fiascaris
• Follow-up from Rome on loss maps at collision energy:
  • main outstanding question was the efficiency of the system with DS collimators: sufficient to achieve a cleaning inefficiency $< 3 \times 10^{-7}$ (assumed quench limit)?
  • statistics was not sufficient: today I will show results with 10 times more stats.
  • effect of initial distribution and impact parameter on cleaning inefficiency
    • simulations with pencil beam and different impact parameters (this is also useful to increase the statistics of simulations)
• First loss maps at injection
Loss maps at top energy

- Simulation with DS collimators shown in Rome were not conclusive → need large statistics to reach required accuracy of ~ $10^{-7}$
- Increased the statistics by a factor of 10!

Energy distribution of particles lost in DS

- **1st cluster:** $\Delta p/p < -0.02$
- **2nd cluster:** $-0.02 < \Delta p/p < -0.005$

Parameters of DS collimators

<table>
<thead>
<tr>
<th>Collimator</th>
<th>$\beta_x$ [m]</th>
<th>$\beta_y$ [m]</th>
<th>$D_x$ [m]</th>
<th>setting [$\sigma$]</th>
<th>$dp/p$ cut</th>
<th>$h/2$ [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCRYO.8RD</td>
<td>72.2</td>
<td>164.2</td>
<td>0.100</td>
<td>24</td>
<td>$1.3 \times 10^{-2}$</td>
<td>1.31</td>
</tr>
<tr>
<td>TCRYO.10RD</td>
<td>54.2</td>
<td>447.0</td>
<td>0.685</td>
<td>24</td>
<td>$1.7 \times 10^{-3}$</td>
<td>1.13</td>
</tr>
</tbody>
</table>
Loss maps at top energy

No DS collimators

With two DS collimators at $24\sigma$

Target $3 \times 10^{-7}$
Loss maps at top energy

No DS collimators

~4 M particles absorbed
Cluster 1:
average ineff: $3.0 \times 10^{-6}$
max ineff.: $(7.7 \pm 4.5) \times 10^{-6}$

Cluster 2:
average ineff: $4.5 \times 10^{-6}$
max ineff.: $(2.1 \pm 0.7) \times 10^{-5}$

With two DS collimators at $24\sigma$

~56 M particles absorbed
Cluster 1:
max ineff.: $(1.8 \pm 1.8) \times 10^{-7}$

Cluster 2:
max ineff.: $(1.8 \pm 1.8) \times 10^{-7}$

Target $3 \times 10^{-7}$
Effect of input distribution

Annular horizontal halo: initial distribution at s=0

Pencil beam: initial distribution at horizontal TCP
Impact parameter on TCP

Annular halo

Pencil beam - 3 different simulations varying the impact parameter

mean $b = 3.5 \mu m$

mean $b = 1.4 \mu m$

mean $b = 4.2 \mu m$

mean $b = 12.7 \mu m$
Inelastic impacts on TCPs

Annular halo

Pencil beam
Loss maps

Annular halo: mean b = 3.5 μm

- Cluster 1:
  - max ineff.: $(8.3 \pm 4.2) \times 10^{-6}$
  - av. ineff.: $(4.0 \pm 0.3) \times 10^{-7}$
- Cluster 2:
  - max ineff.: $(3.5 \pm 0.9) \times 10^{-5}$
  - av. ineff.: $(3.7 \pm 0.1) \times 10^{-6}$

Pencil beam: mean b = 4.2 μm

- Cluster 1:
  - max ineff.: $(6.3 \pm 3.1) \times 10^{-6}$
  - av. ineff.: $(3.6 \pm 0.3) \times 10^{-7}$
- Cluster 2:
  - max ineff.: $(3.0 \pm 0.7) \times 10^{-5}$
  - av. ineff.: $(3.3 \pm 0.1) \times 10^{-6}$

Pencil beam: mean b = 1.4 μm

- Cluster 1:
  - max ineff.: $(6.3 \pm 3.2) \times 10^{-6}$
  - av. ineff.: $(4.0 \pm 0.3) \times 10^{-7}$
- Cluster 2:
  - max ineff.: $(2.8 \pm 0.7) \times 10^{-5}$
  - av. ineff.: $(3.7 \pm 0.1) \times 10^{-6}$

Pencil beam: mean b = 12.7 μm

- Cluster 1:
  - max ineff.: $(4.7 \pm 2.7) \times 10^{-6}$
  - av. ineff.: $(3.4 \pm 0.3) \times 10^{-7}$
- Cluster 2:
  - max ineff.: $(1.9 \pm 0.5) \times 10^{-5}$
  - av. ineff.: $(3.2 \pm 0.1) \times 10^{-6}$
Cleaning ineff. vs. impact param.

Average ineff. cluster 1

Average ineff. cluster 2

Global cleaning inefficiency
Simulations at injection: setup

21 M particles tracked for 200 turns.

- Horizontal annular halo
  - Energy 3.3 TeV, $\beta^* = 4.6$ m, $L^* = 36$ m
  - Betatron cleaning plus tertiary collimators

<table>
<thead>
<tr>
<th>Collimator settings [$\sigma$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
</tr>
<tr>
<td>TCS</td>
</tr>
<tr>
<td>TLCA</td>
</tr>
<tr>
<td>TCT</td>
</tr>
</tbody>
</table>

First impacts on primary collimator

Average $b = 5.6$ $\mu$m
Cleaning inefficiency

![Graph 1: Cleaning inefficiency, $\eta_c(A_0)$ vs. Radial Amplitude, $A_0 [\sigma]$](image1)

![Graph 2: Cleaning inefficiency, $\eta_c(\delta p/p)$ vs. $\delta p/p (%)$](image2)
Loss maps

Peak losses around IPL (RF)

\((9.3 \pm 2.1) \times 10^{-6}\)
Loss maps: IPD

Peak losses in the DS: \((2.8 \pm 1.1) \times 10^{-6}\)
Loss maps: IPF and IPG
Loss maps: IPH and IPJ
Losses: IPL and IPA
Conclusions

• Simulations with DS collimators showed we can achieve the target cleaning inefficiency $< 3 \times 10^{-7}$

• Crucial next step: energy deposition studies to assess the load on the collimators

• Simulations with pencil beam and different impact parameter showed no effect on the cleaning inefficiency: propose to use pencil beam from now on with impact parameter of $\sim 4 \, \mu m$ to increase the statistics of the simulations

• First loss maps shown at injection: compare to quench limits?

• Should converge on simulations for input to energy deposition studies and HW design:

  • Repeat injection/collision loss maps with latest lattice (that includes momentum cleaning and $L^*=45m$)?
EXTRAS
First impacts on TCPs

Annular halo

Pencil beam