Dispersion Suppressor Protection

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CERN

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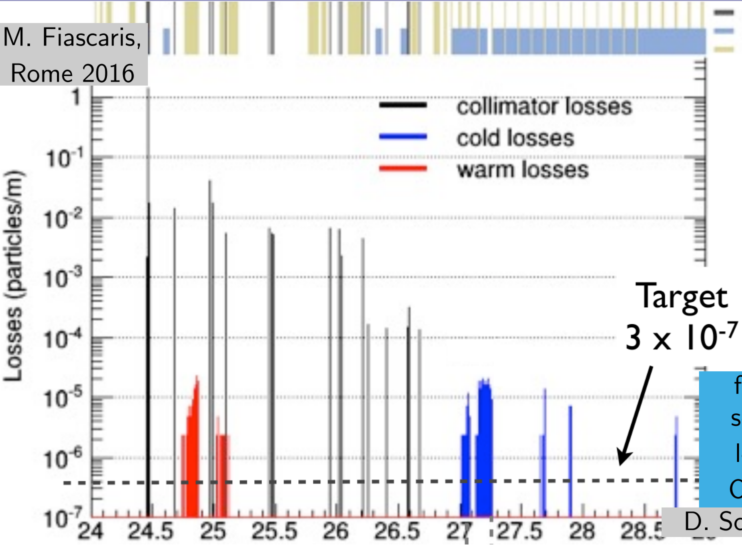
J. Molson, H. Rafique, D. Schulte

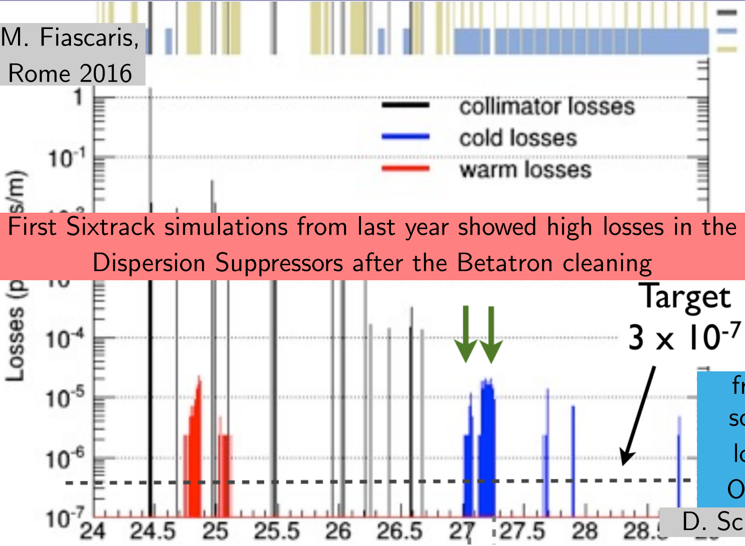
M. Fiascaris, Rome 2016



from tentative scaling of LHC lossrate about O(70) too high

D. Schulte, Rome 2016

M. Fiascaris, Rome 2016



First Sixtrack simulations from last year showed high losses in the Dispersion Suppressors after the Betatron cleaning

from tentative scaling of LHC lossrate about O(70) too high

D. Schulte, Rome 2016

Proposal at FCC-Week 2016:
Dispersion Suppressor collimators

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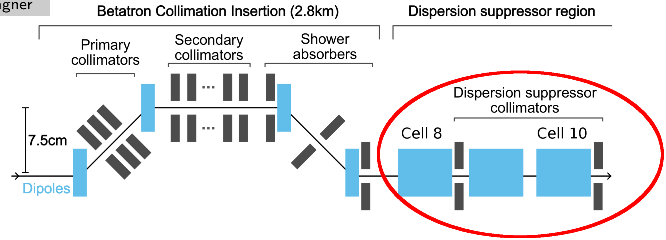

Proposal at FCC-Week 2016: Dispersion Suppressor collimators

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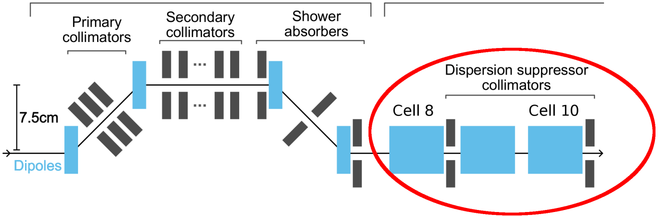
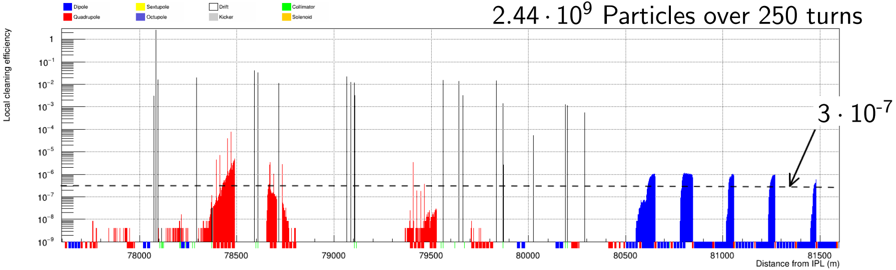


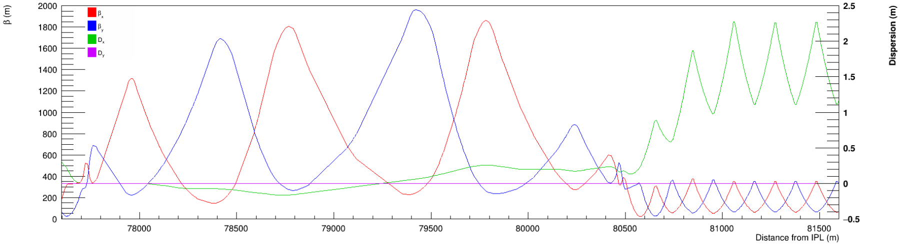
- Efficiency of collimation system
- Impact of showers generated in the DS collimators

- Energy collimation has been included
- Beta function and Dispersion in the DS region have been optimized to improve efficiency of collimators.

Lossmaps with Merlin

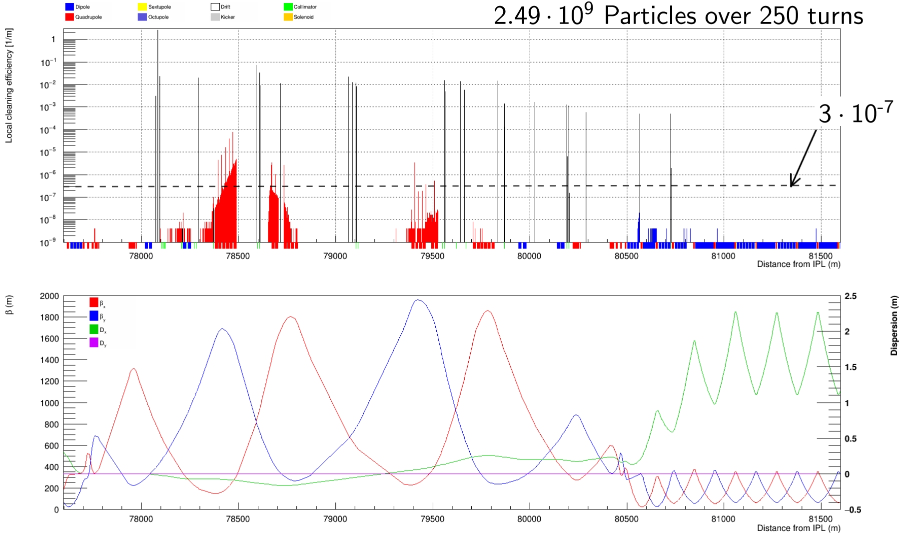
$2.44 \cdot 10^9$ Particles over 250 turns





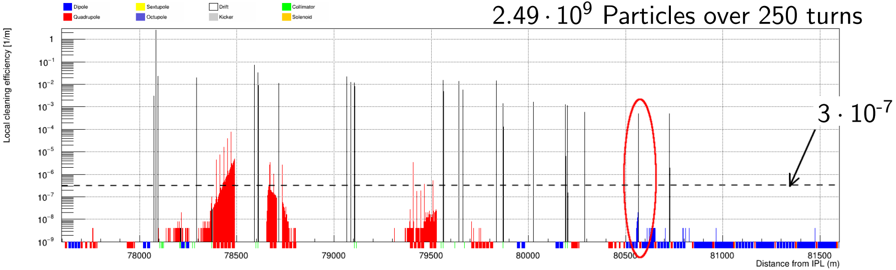
Lossmaps with Merlin, DS included

CERN

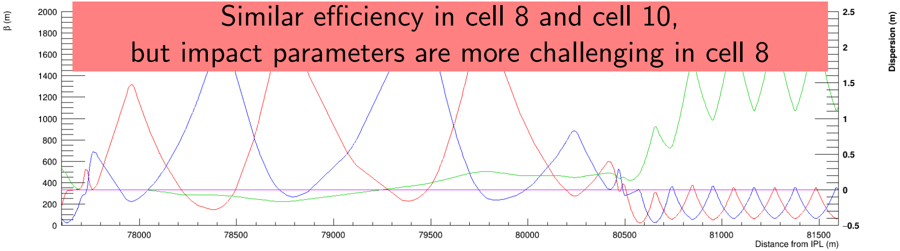


Lossmaps with Merlin, DS included

$2.49 \cdot 10^9$ Particles over 250 turns



Similar efficiency in cell 8 and cell 10,
but impact parameters are more challenging in cell 8



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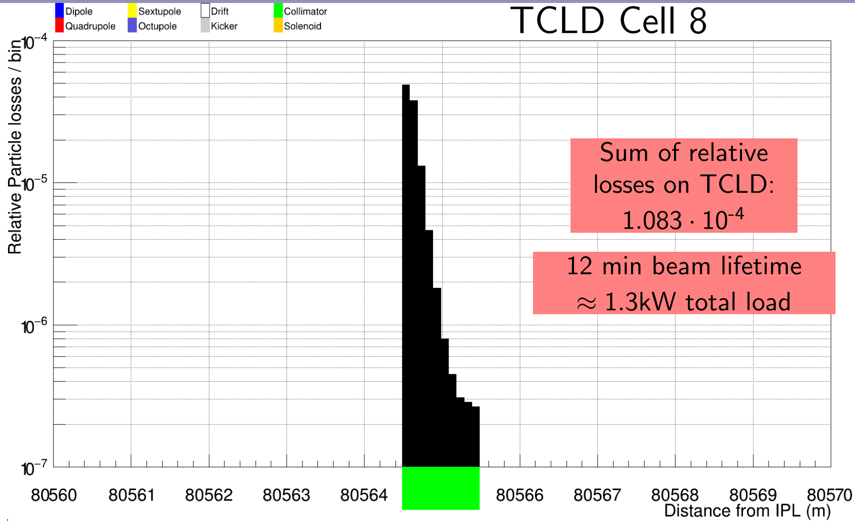
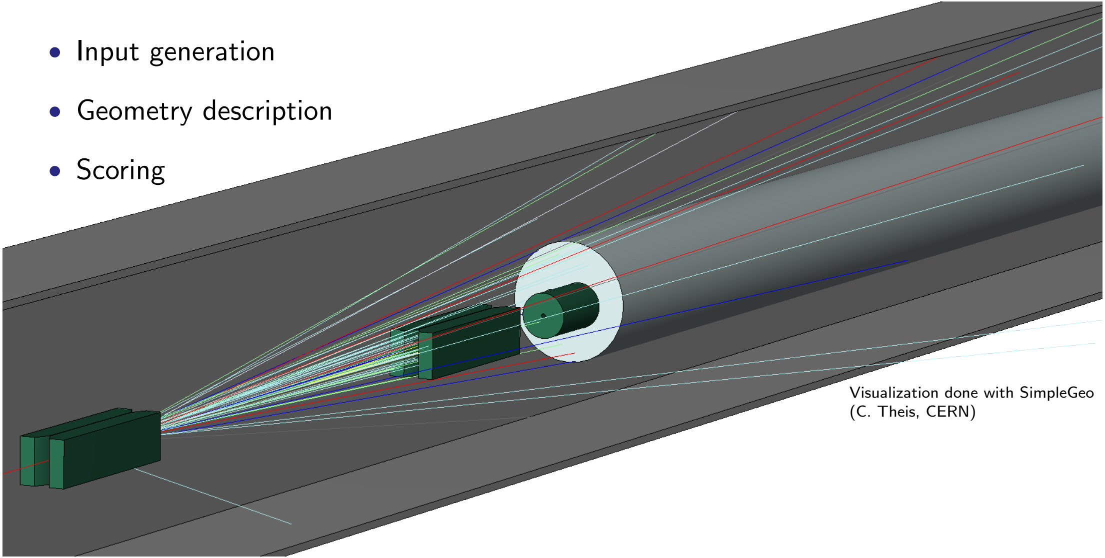


- Input generation
- Geometry description
- Scoring

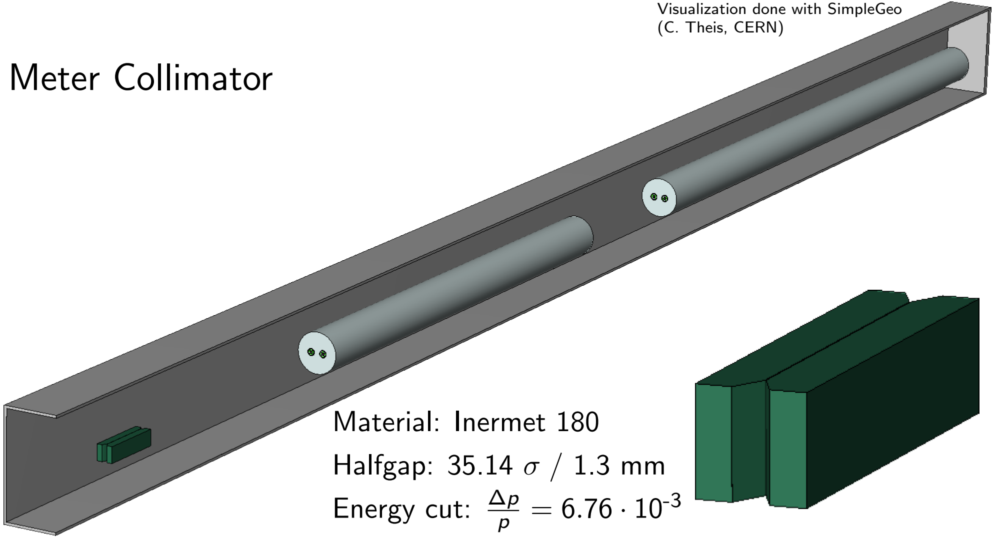


Visualization done with SimpleGeo
(C. Theis, CERN)

- Input distribution is generated from Merlin tracking
  - Every turn the whole bunch is recorded before the collimator.
  - Particles which hit the collimator are selected.
  - This distribution is loaded into FLUKA
    and particles are randomly selected from it.
- Energy deposition is scored in a meshgrid of bins.
  - Scoring in the coils with 0.5 cm radial, 2° angular
    and 5 - 10 cm longitudinal binning.

Visualization done with SimpleGeo (C. Theis, CERN)

1 Meter Collimator



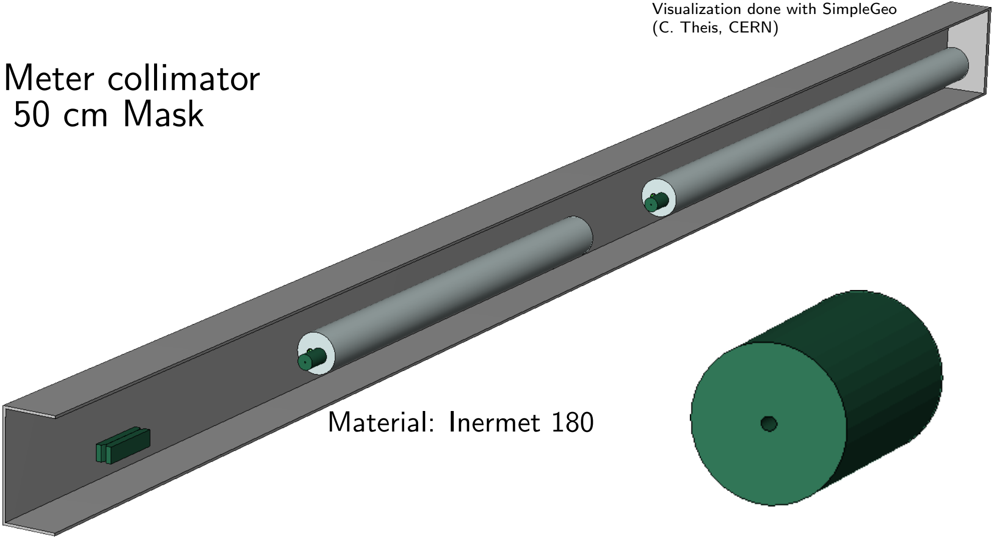
Material: Inermet 180

Halfgap: 35.14 σ / 1.3 mm

Energy cut: $\frac{\Delta p}{p} = 6.76 \cdot 10^{-3}$

Visualization done with SimpleGeo (C. Theis, CERN)

1 Meter collimator
+ 50 cm Mask



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1 Meter collimator

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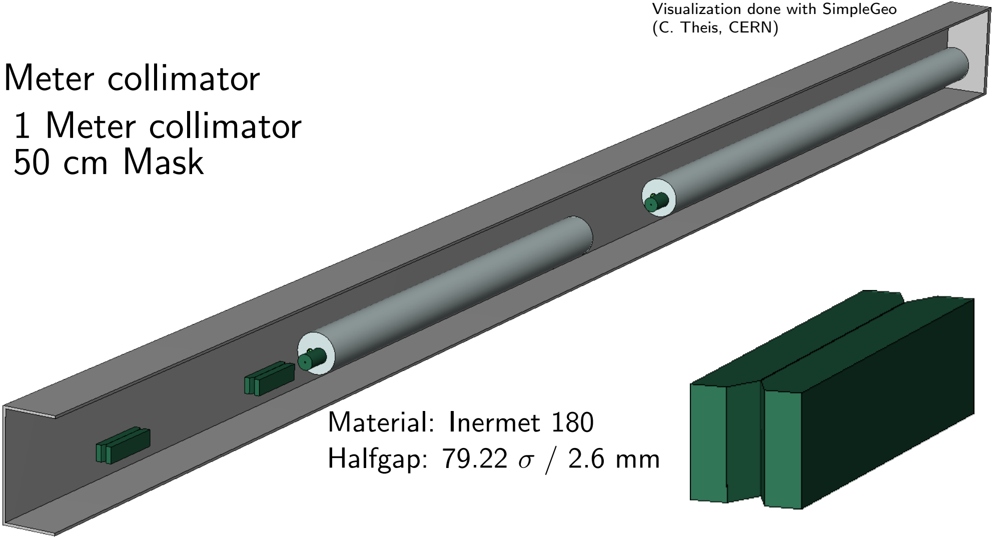
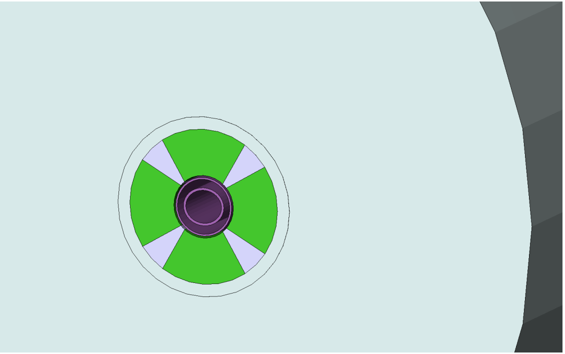
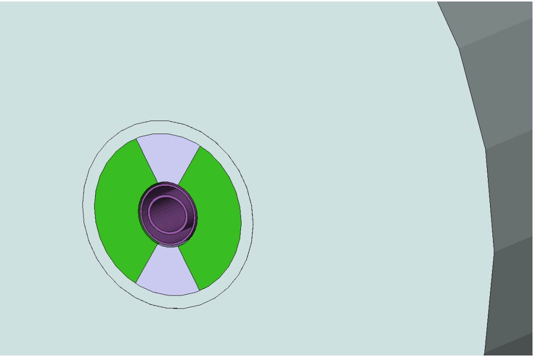


Material: Inermet 180
Halfgap: 79.22 σ / 2.6 mm



Simplified MQ coil model (based on P. Vedrine, Rome 2016)

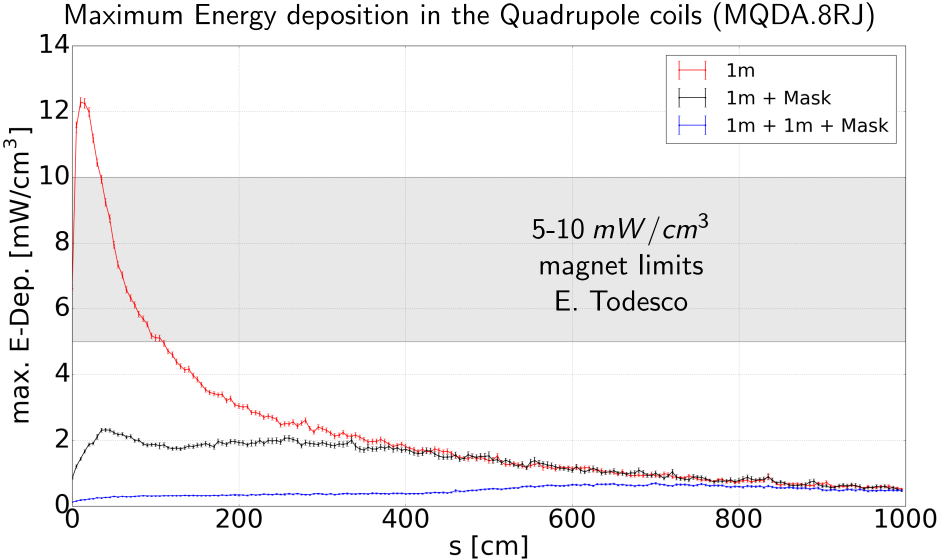


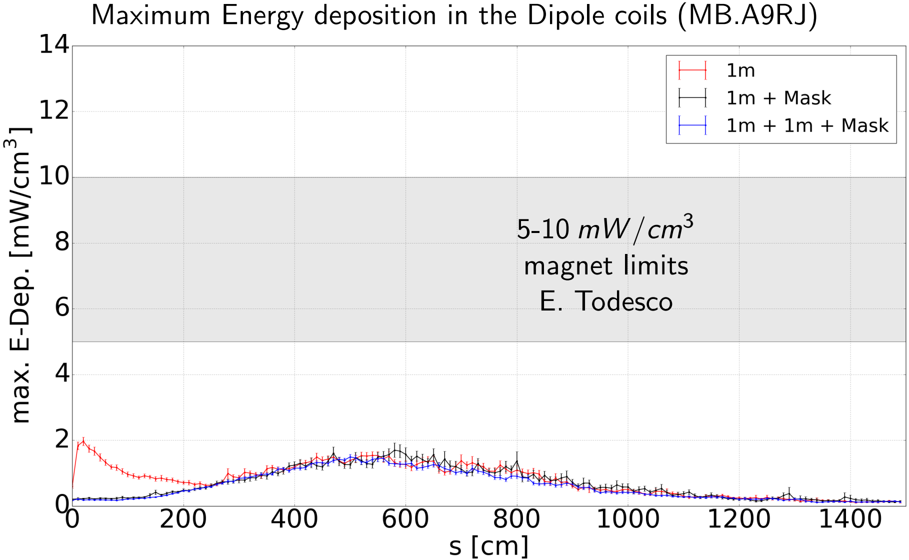
Simplified MB coil model (based on V. Marinozzi, Rome 2016)

Confirmed with D. Schörling

Coil material:

50% Nb_3Sn, 50% Cu


Maximum Energy deposition in the Quadrupole coils (MQDA.8RJ)
max. E-Dep. [mW/cm3]
s [cm]
0
2
4
6
8
10
12
14
0
200
400
600
800
1000
1m
1m + Mask
1m + 1m + Mask
5-10 mW/cm3
magnet limits
E. Todesco


Maximum Energy deposition in the Dipole coils (MB.A9RJ)
1m
1m + Mask
1m + 1m + Mask
5-10 mW / cm^3
magnet limits
E. Todesco
max. E-Dep. [mW/cm^3]
s [cm]
0
2
4
6
8
10
12
14
200
400
600
800
1000
1200
1400

Energy Deposition

- Merlin and Sixtrack with FLUKA coupling
  show good agreement in the DS region (difference O(5 - 10 %)).

  (J. Molson, "A Comparison of Interaction Physics for Proton Collimation Systems in Current Simulation Tools", IPAC17, ISBN 978-3-95450-182-3)

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  (R. Bruce et. al. Phys. Rev. ST Accel. Beams 17, 081004 (2014))

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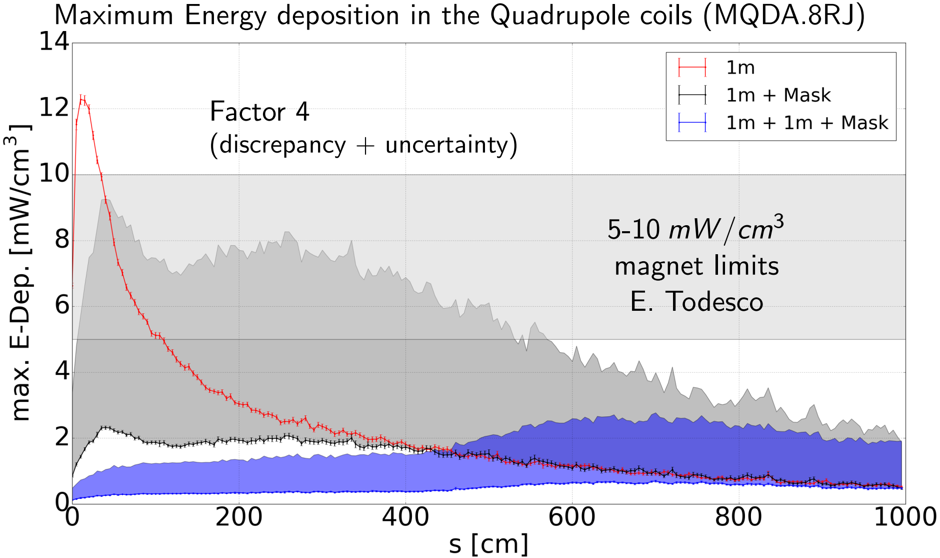
  (R. Bruce et. al. Phys. Rev. ST Accel. Beams 17, 081004 (2014))
- No imperfections or magnet errors have been taken into account.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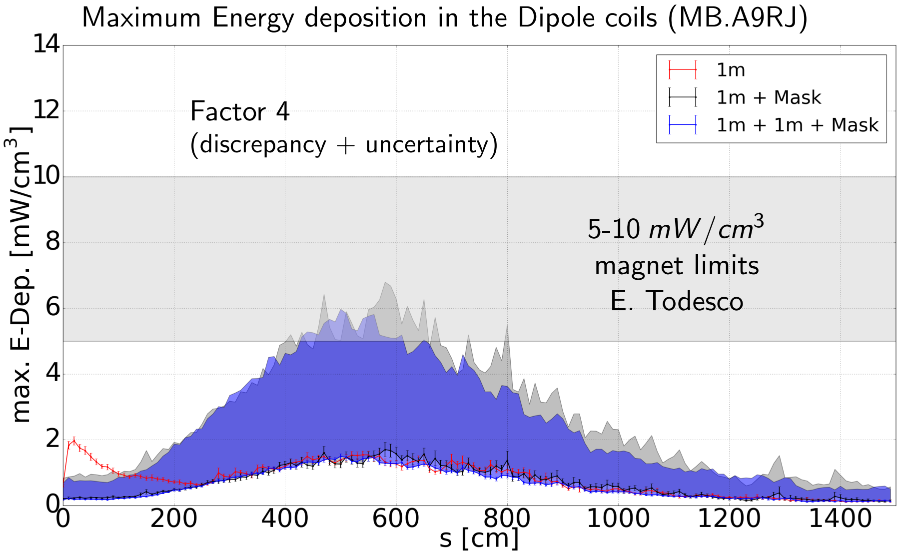
400
600
800
1000
1m
1m + Mask
1m + 1m + Mask
Factor 4
(discrepancy + uncertainty)
5-10 mW/cm3
magnet limits
E. Todesco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max. E-Dep. [mW/cm^3]
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1m + Mask
1m + 1m + Mask
Factor 4
(discrepancy + uncertainty)
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magnet limits
E. Todesco
0
2
4
6
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10
12
14
0
200
400
600
800
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1200
1400

Conclusion

- The critical problem of cold losses in the Dispersion Suppressors has been addressed.
  - Energy deposition studies have been carried out for the most critical case in cell 8 after the Betatron cleaning insertion.
- Inclusion of energy collimation and optimizations in optics gave a factor $\sim$ 2-3 reduction of cold losses.
- Placement of collimators and masks in cell 8 and cell 10 reduces the direct cold losses below the tentative goal of $3 \cdot 10^{-7}$
- Additional elements are needed to protect the magnets from the particle showers
- With additional 1 meter collimators an important safety margin could be obtained and also gives possibilities for future upgrades.
- The same protection system proves to be effective to protect the Dispersion Suppressors around the experiments from continuous collision debris losses.

Outlook

- Optimization of DS collimator gaps around the ring
  - Especially concerning changes of the energy collimation hierarchy
- Stress and heat-transport studies for the DS collimators
- Verification with energy deposition simulations that cell 10 is less problematic.
- Tracking studies for injection, ramp and squeeze.
  - DS collimator gaps for the respective operation modes.
  - Energy deposition studies, if impact parameter differ significantly from top energy case.
- Further studies to validate if the current DS collimation system is sufficient for Ion operation as well.

Reserve Slides

Energy deposition in the Dispersion Suppressors after IPA from collision debris.