Collimation: First Beam 2 Results and Input for Studies in the IR

Status Report

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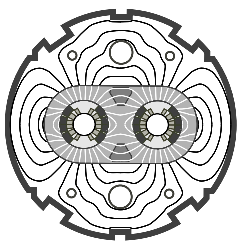
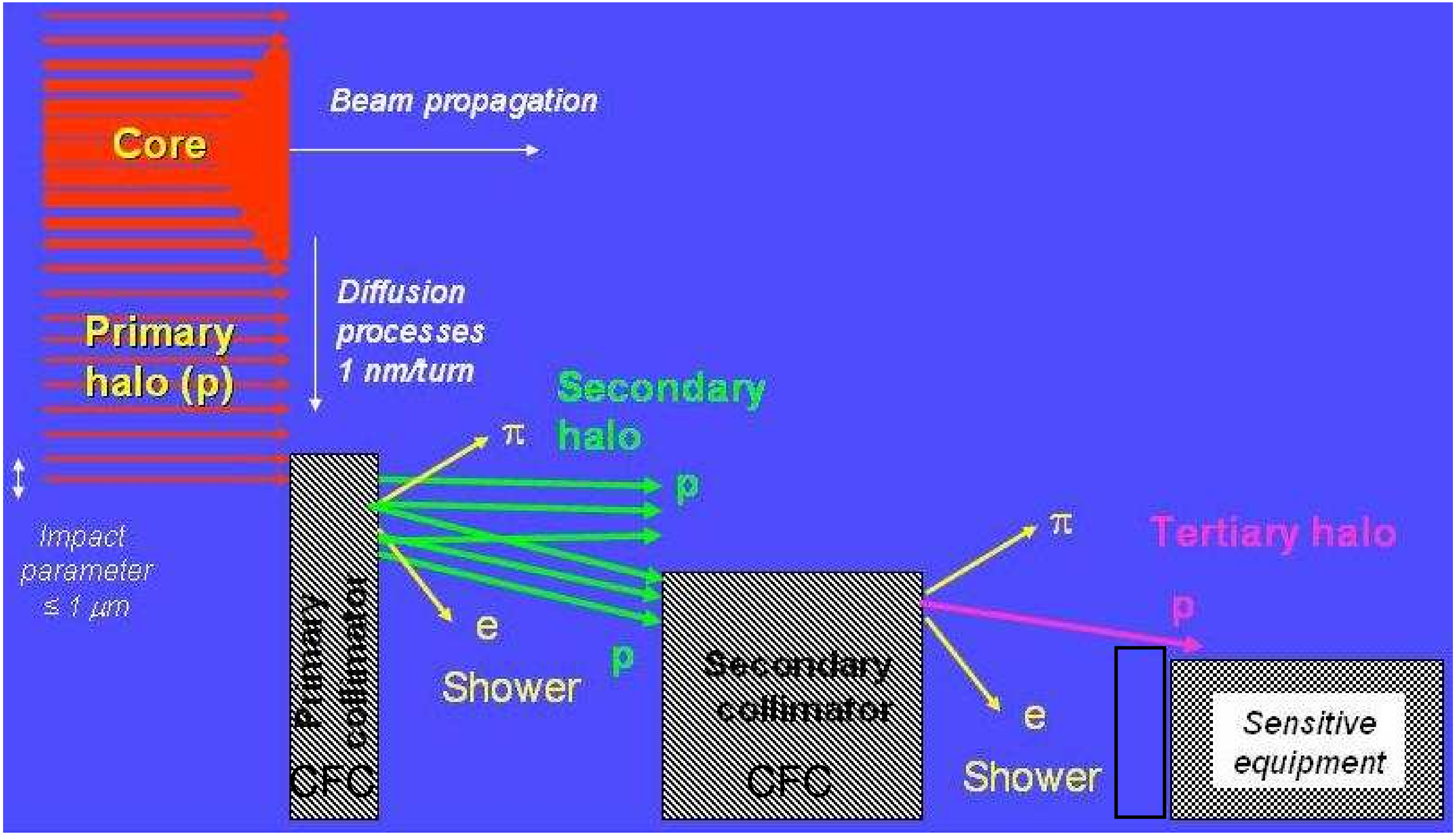


Reminder: Collimation Principle



tertiary collimator: W

Important Parameters

- stored energy ≈ 350 MJ per beam (3.2×10^{14} protons/beam, 2808 bunches a 1.15×10^{11} protons/beam)
- peak loss rate (nominal beam intensities)
  - 1% of beam (≈ 3.5 MJ) lost in 10 s
  - 0.2 h beam lifetime (≈ 440 kJ) lost in 10 s
- quench level for superconducting magnets: ≈ 30 mJcm^{-3}
  for continuous losses ($\tau_{\mathrm{loss}} > 100$ ms) at 7 TeV
  $\Rightarrow$ losses exceed quench level by far
  $\Rightarrow$ allowed local inefficiency of collimation system
  $< 2 \times 10^{-5}$ m^{-1} at 7 TeV and
  $< 1 \times 10^{-3}$ m^{-1} at 450 GeV
  to avoid quench in superconducting magnets

Intensity, Efficiency and Quench Limits

$$N_p^{max} \approx \frac{\tau \cdot R_q \cdot L_{dil}}{\eta_c}$$

Intensity, Efficiency and Quench Limits

allowed
intensity

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Intensity, Efficiency and Quench Limits

beam lifetime
e.g. 0.22h

allowed
intensity

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Intensity, Efficiency and Quench Limits

quench threshold
7.8×10^6 p/m/s at 7 TeV
7.0×10^8 p/m/s at 450 GeV

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e.g. 0.22h

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dilution length

50 m (simplified)

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cleaning efficiency

(for $L_{dil} = 1$ m)

$\eta_c = 2 \times 10^{-5}$ m^{-1} at 7 TeV

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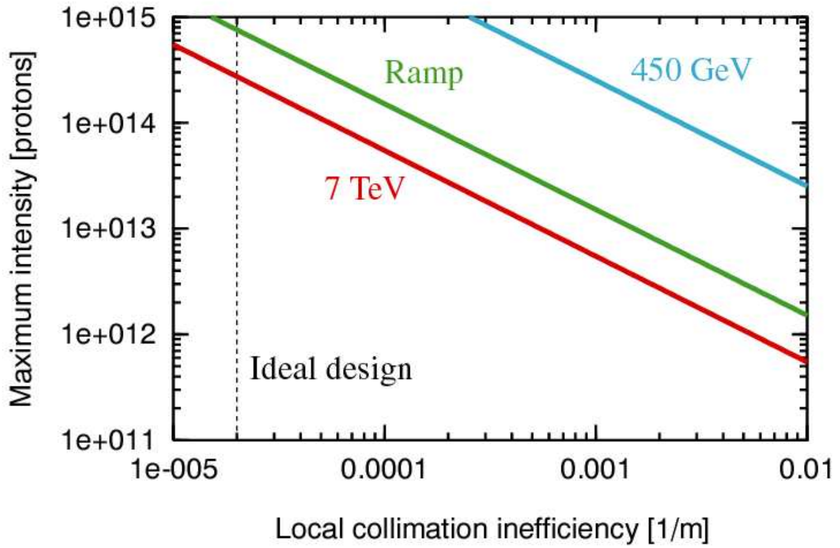


What we do

Since ≈ 2 years collimation studies are performed by simulating ≈ 5 million particles over ≈ 200 turns and recording their loss location with an 10 cm resolution (see presentations given by Guillaume Robert-Demolaize and Stefano Redaelli), resulting in loss maps.

The losses depend on the local optics used for the simulation. What optics do we consider so far?

Available Optics for V6.500

optics name	energy [GeV]	IP1 crossing/separation	IP2 cross./sep.	IP5 cross./sep.	IP8 cross./sep.
inj.450	450	on/on	on/on	on/on	on/on
lowb.coll	7000	on/off	on/on	on/off	on/on
lowb.all	7000	on/off	on/off	on/off	on/off
lowb.ecoll	7000	on/off	on/on	on/off	on/off
lowb.rlc	7000	on/off	on/on	on/off	on/off

optics name	energy [GeV]	IP1 β^* [m]	IP2 β^* [m]	IP5 β^* [m]	IP8 β^* [m]	Alice spectrometer	LHCb spectrometer
inj.450	450	17.0	10.0	17.0	10.0	off	off
lowb.coll	7000	0.55	10.0	0.55	10.0	off	off
lowb.all	7000	0.55	0.5	0.55	1.0	on	on
lowb.ecoll	7000	2.0	10.0	2.0	2.0	on	on
lowb.rlc	7000	0.55	10.0	0.55	2.0	on	off

Simulations done so far

- perfect machine, standard collimator settings, using horizontal and vertical betatron halo for both beams
  - inj.450 (X)
  - lowb.coll (X)
  - lowb.ecoll
  - lowb.rlc (X)
- tests with sheet-beam implementation (speed up simulation by factor 7-8, like used in simplified simulation by Ralph Assmann)
  - lowb.coll

Special Simulations

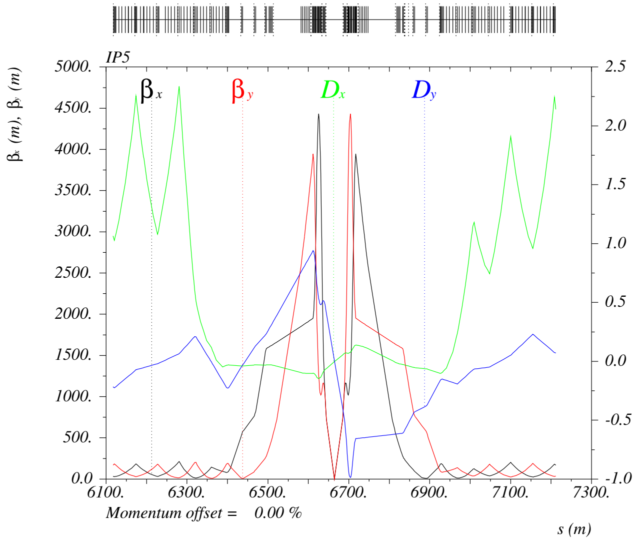
For impedance problems expected for the TCTVs in IP2 and IP8, the impedance group requested studies for increased gaps at the TCTV (all following simulation were done using prefect machine)

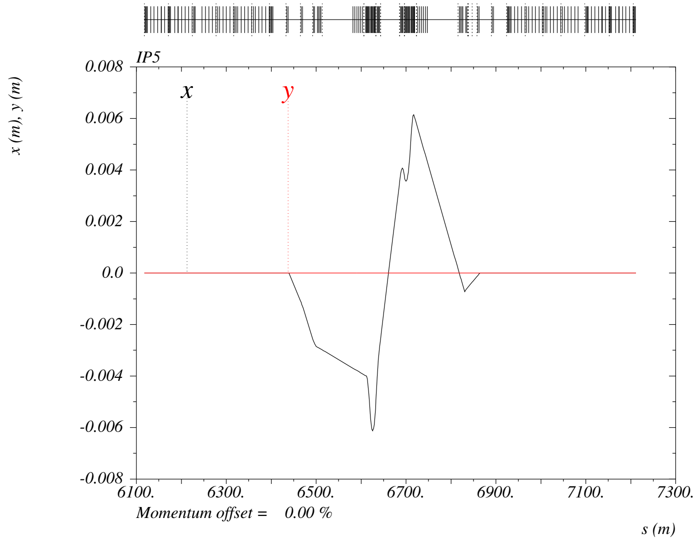
- lowb.coll optics
  - all TCTV at 20σ
  - TCTV at IP2/8 at 125σ
- lowb.rlc optics
  - TCTV at IP2/8 at $117\sigma/40\sigma$ (≈ 40 mm gap)
  - TCTV at IP2/8 at $80\sigma/30\sigma$ (≈ 30 mm gap)

Beta Functions and Crossing at IR5

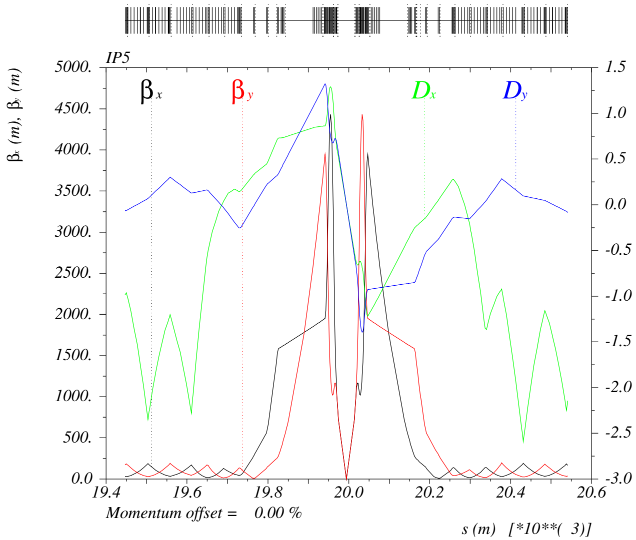
(reminder for lowb.coll optics)

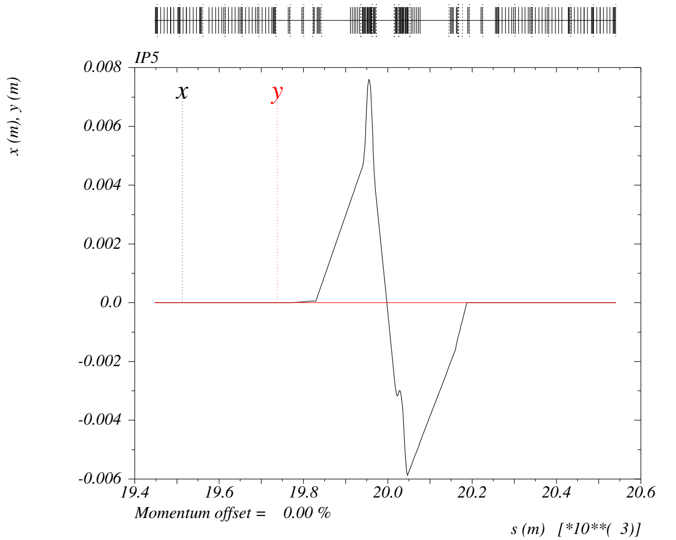
B1



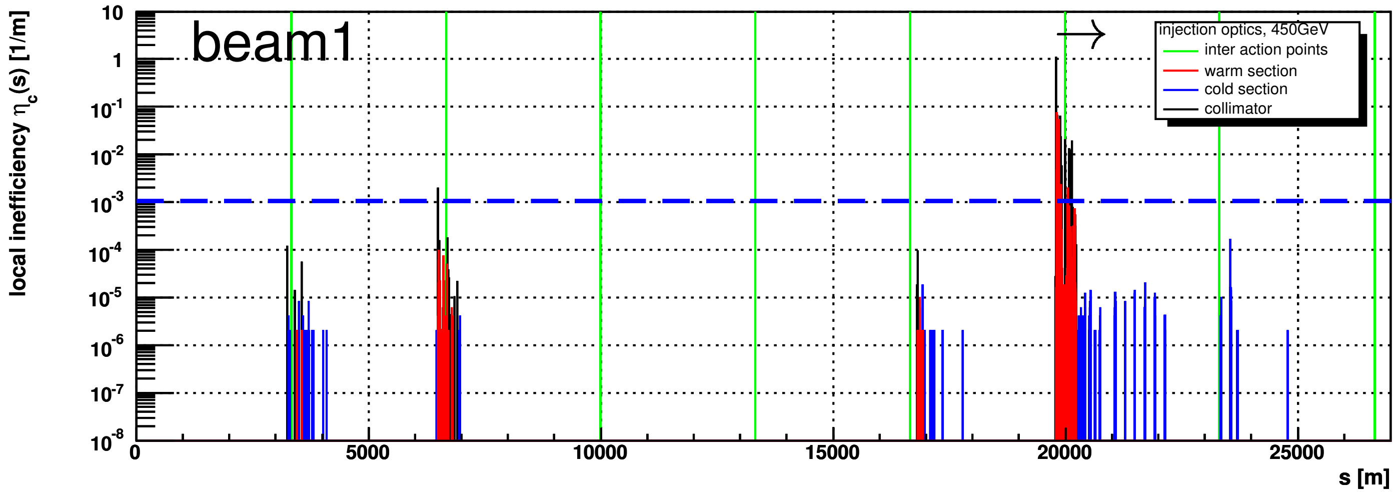


B2



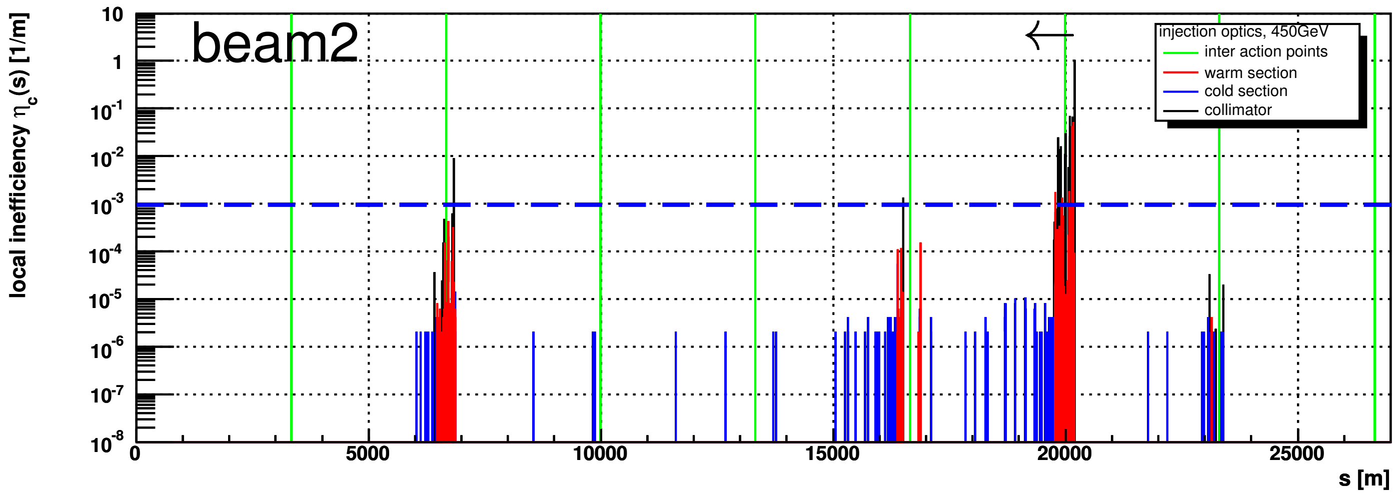


450 GeV Injection: Horizontal Halo



beam 1

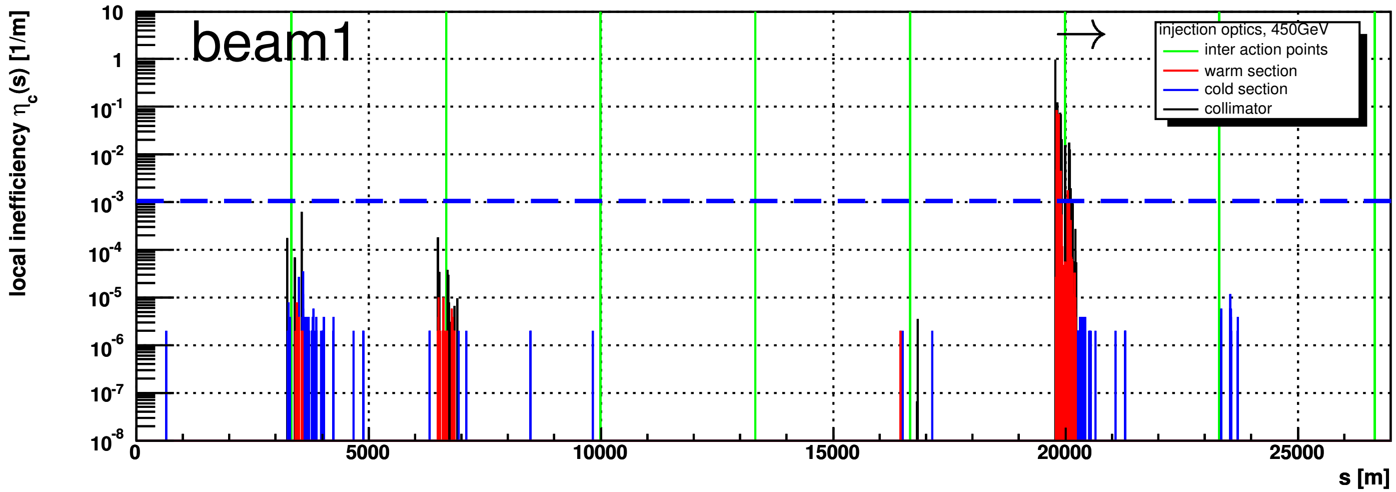
- 450 GeV
- horizontal betatr
  halo
- standard setting
- ideal machine



beam 2

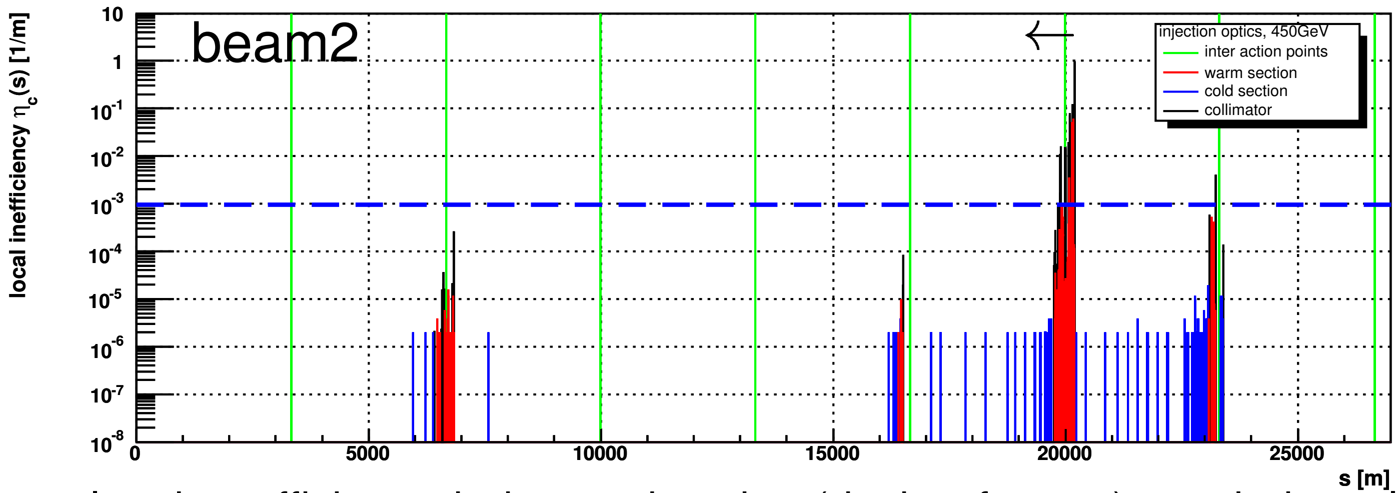
- 450 GeV
- horizontal betatr
  halo
- standard setting
- ideal machine

450 GeV Injection: Vertical Halo



beam 1

- 450 GeV
- vertical betatron halo
- standard setting
- ideal machine

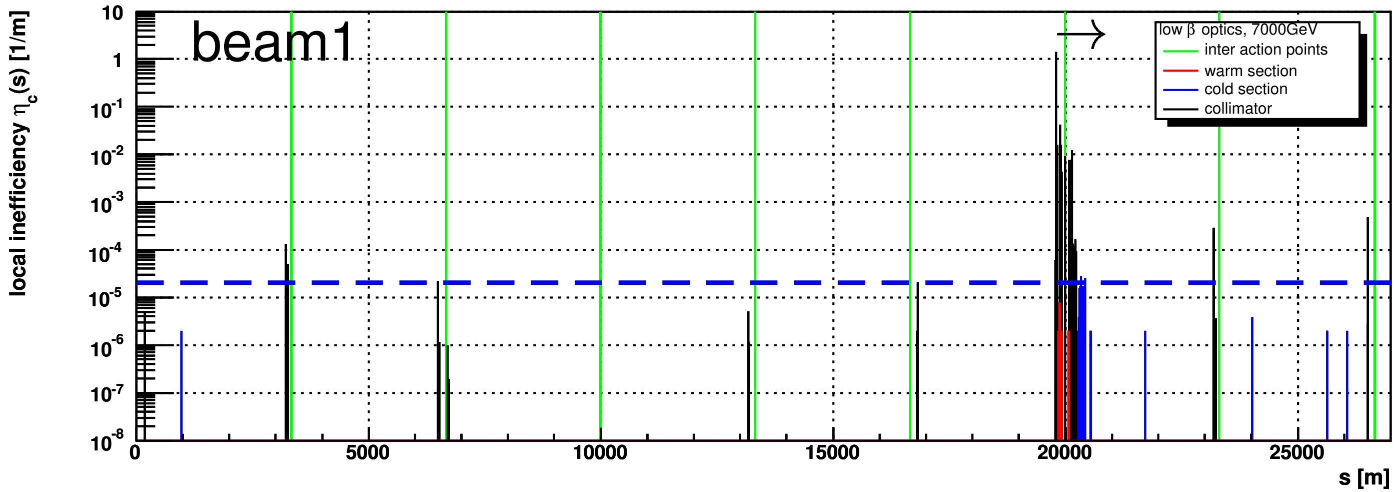


beam 2

- 450 GeV
- vertical betatron halo
- standard setting
- ideal machine

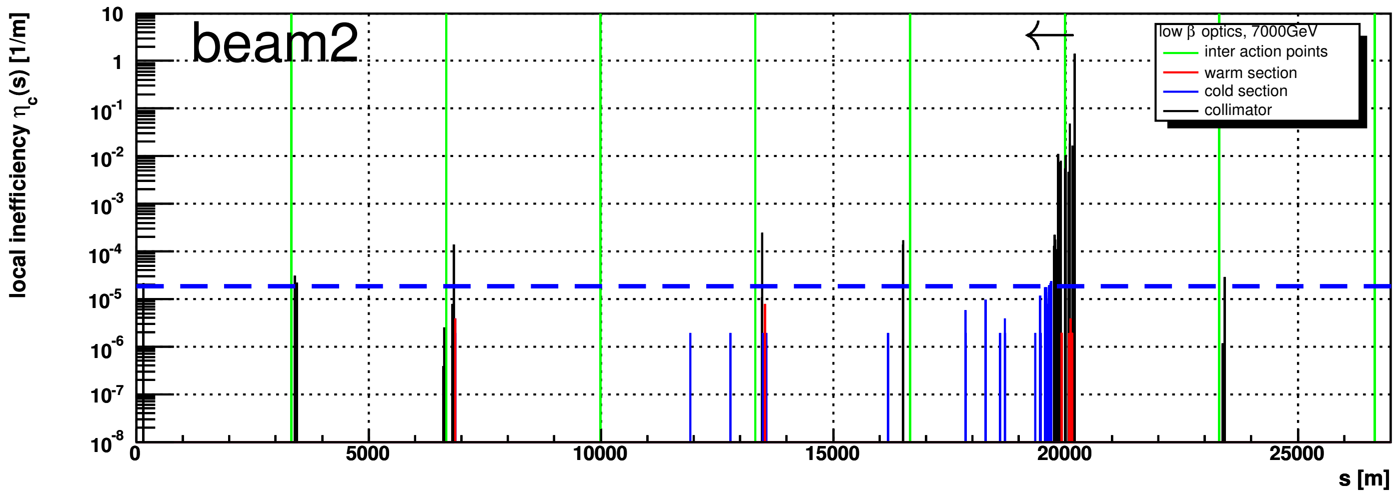
ver. cleaning efficiency is better than hor.(design feature), reminder: almost all off-momentum particles are lost in hor. plane

7 TeV Collision: Horizontal Halo



beam 1

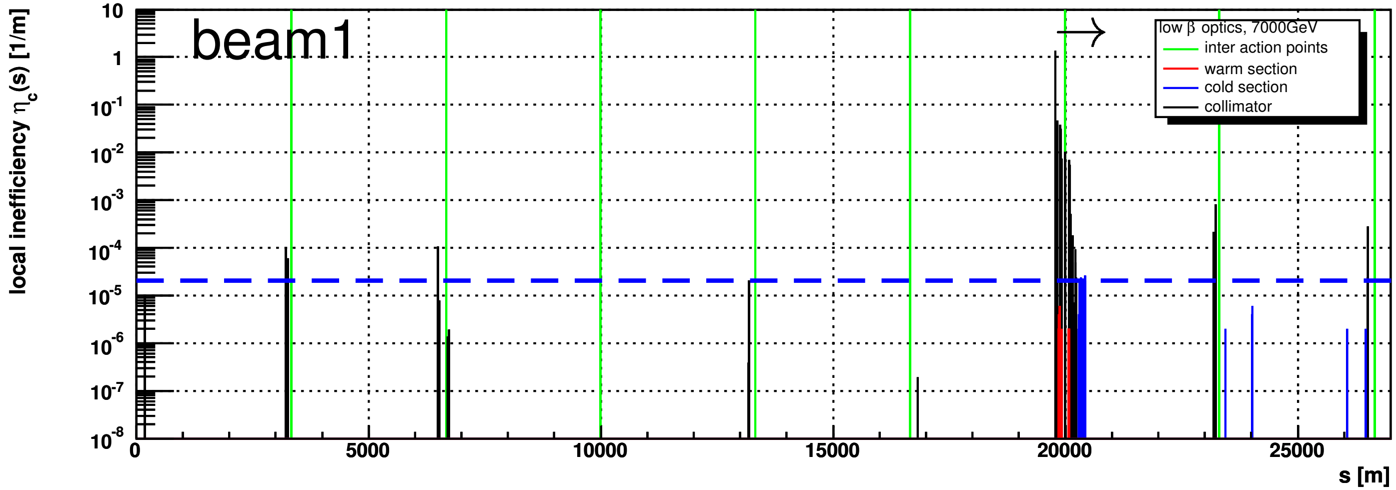
- 7 TeV
- horizontal betatr
  halo
- standard setting
- ideal machine



beam 2

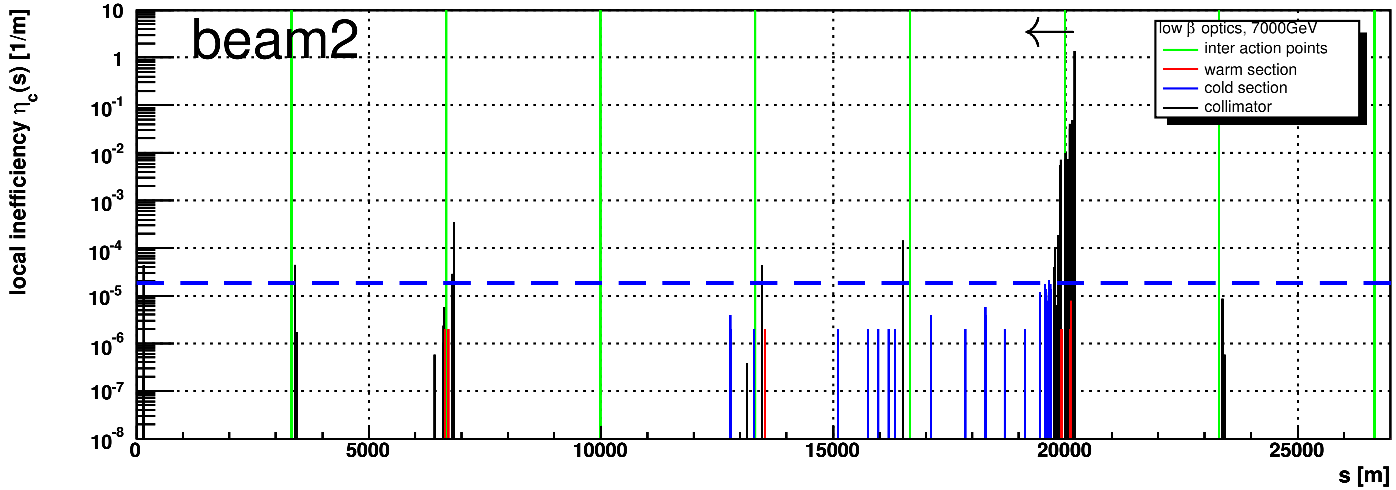
- 7 TeV
- horizontal betatr
  halo
- standard setting
- ideal machine

7 TeV Collision: Vertical Halo



beam 1

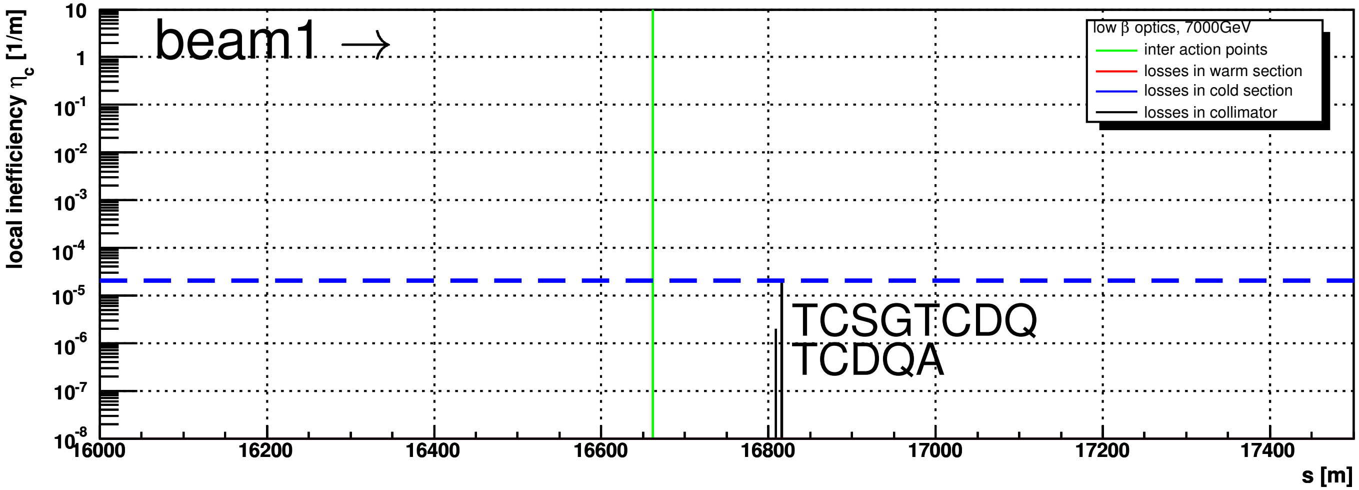
- 7 TeV
- vertical betatron halo
- standard setting
- ideal machine



beam 2

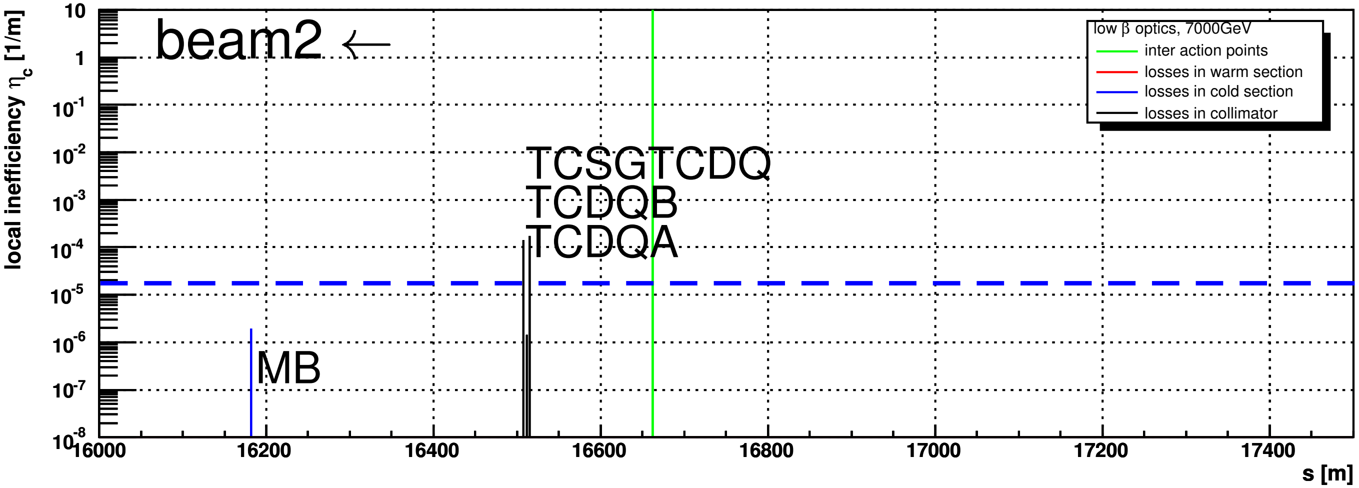
- 7 TeV
- vertical betatron halo
- standard setting
- ideal machine

7 TeV Collision: Horizontal Halo IR6



beam 1

- 7 TeV
- horizontal betatr
  halo
- standard setting
- ideal machine



beam 2

- 7 TeV
- horizontal betatr
  halo
- standard setting
- ideal machine

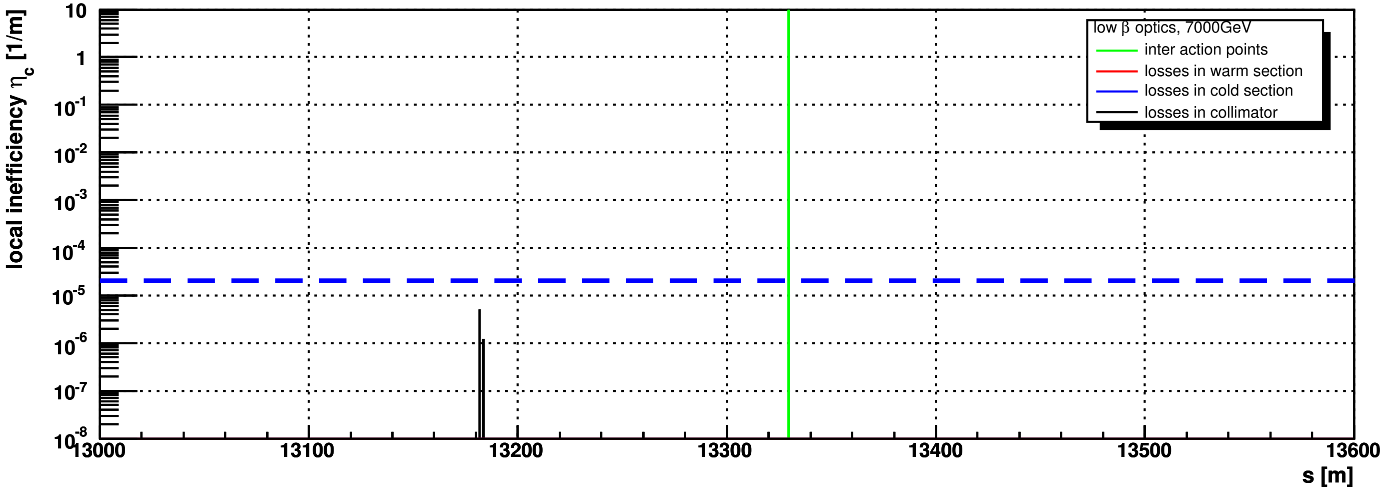
Losses in Experimental Insertions

Why is this important?

- understand quench threshold and cleaning efficiency with tertiary collimator at the triplet
- collimation halo induced background for experiments
- loss maps input to shower studies by N. Mohkov and V. Talanov

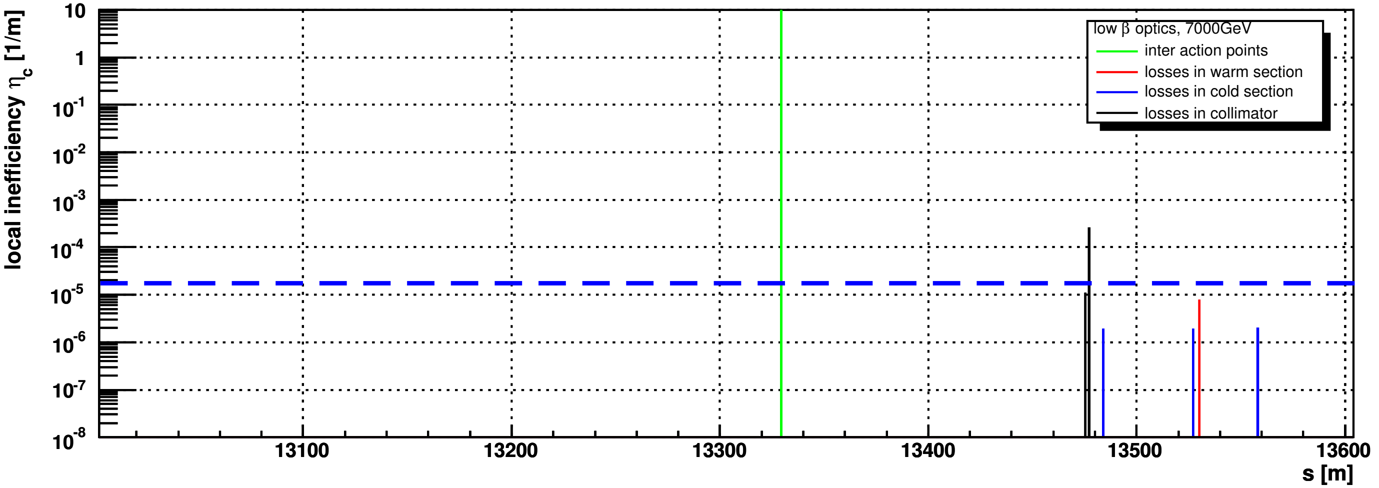
Problem similar to TCDQ example, shower leaves collimator and enters downstream superconducting magnet. TCTs should be better $\rightarrow$ tungsten instead of CFC. But this has to be shown.

Losses at TCTs in IR5



beam 1

- 7 TeV
- horizontal halo
- standard setting
- zoomed IR5
- ideal machine



beam 2

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- horizontal halo
- standard setting
- zoomed IR5
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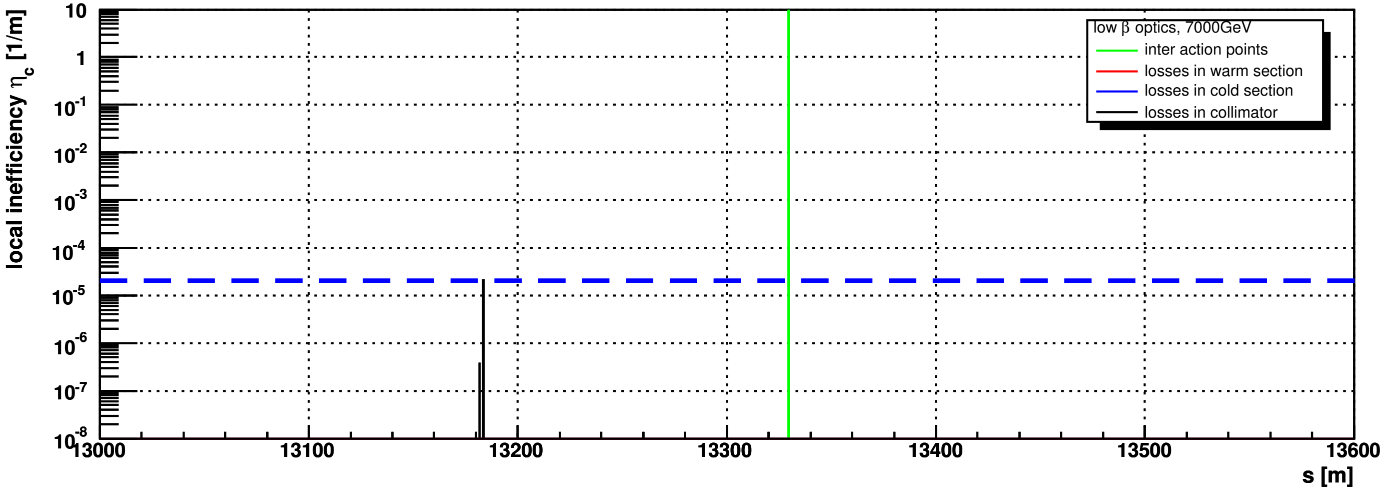
Losses at TCTs in IR5



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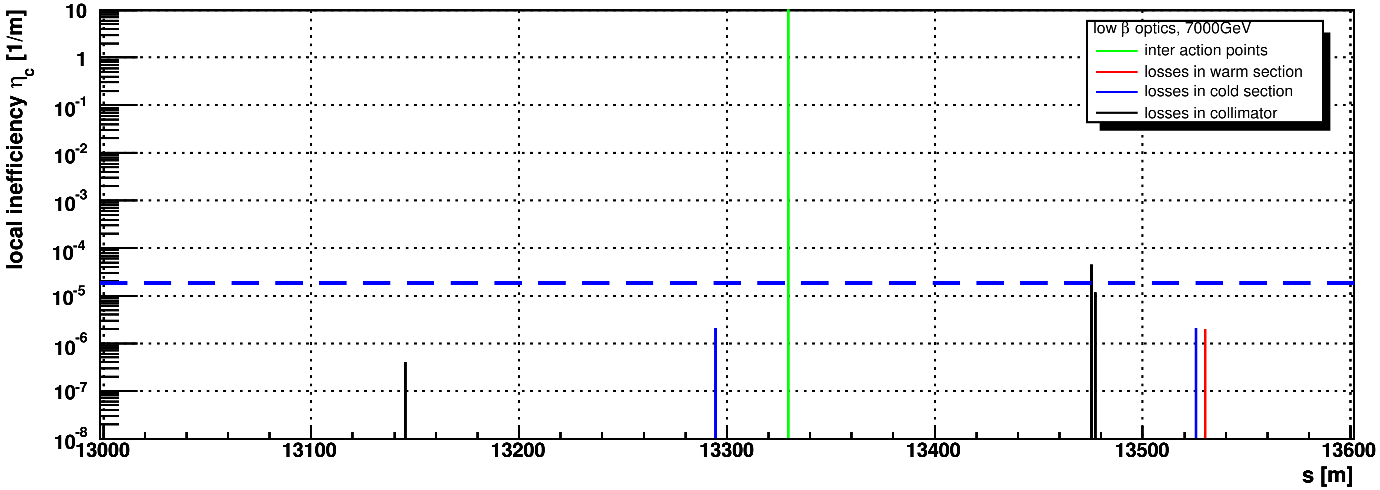

beam 2

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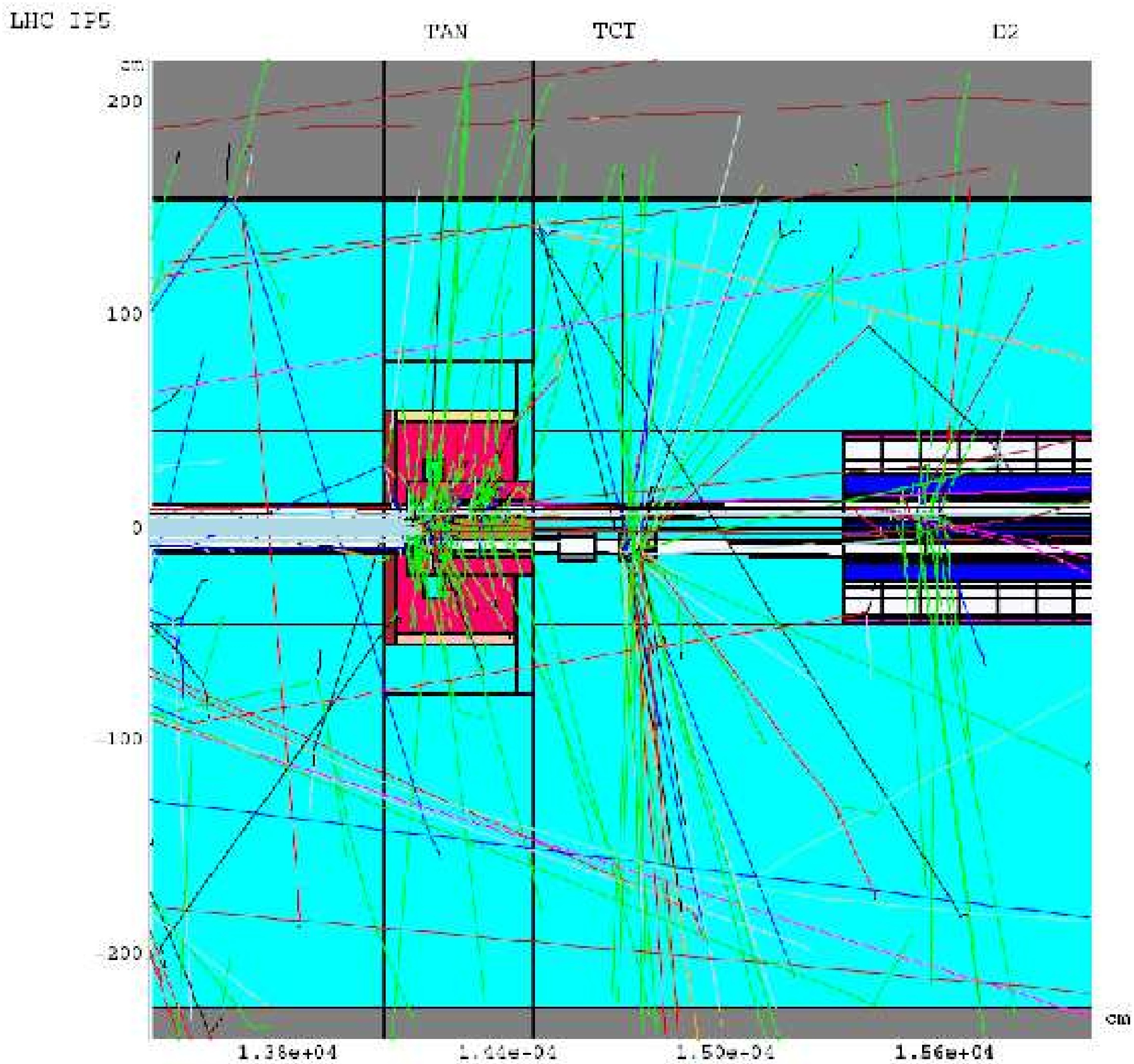
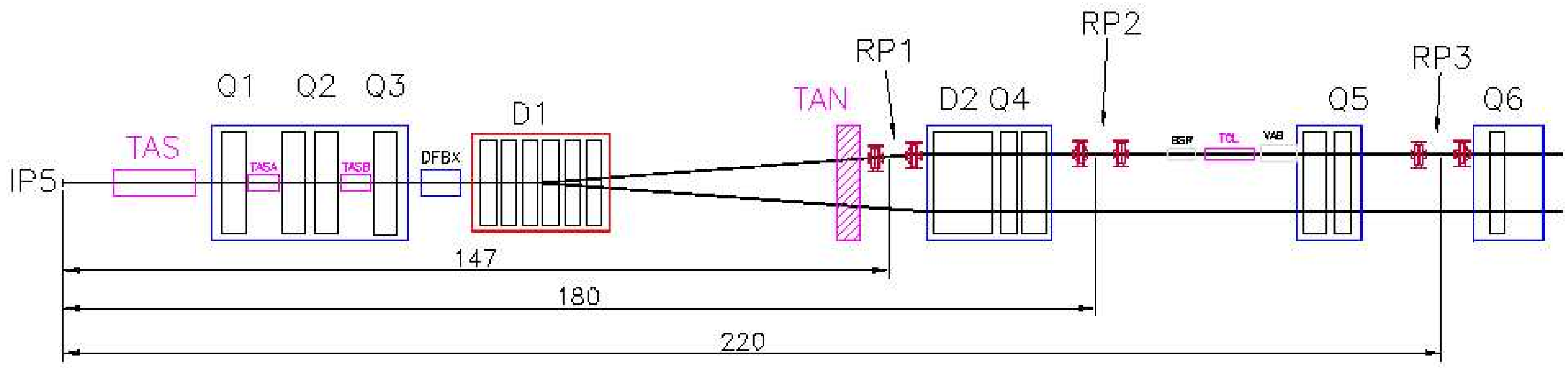
Results from MARS Simulations



presented by Nikolai Mokhov on TAN-workshop 03/2006

- proton losses used as input for MARS simulation
- data for both beam provided (effect of wrong TASB beam screen on data to be checked)
- results important for experiments for expected background
- important to estimate heat load to triplets (quench)
- improved model available

Preparing Additional Studies for Totem



- request: halo distribution at roman pots
- insert collimators at roman pot location
  - represent by effective length of a given material
  - using onesided collimator for horizontal roman pots
  - using doublesided collimator for vertical roman pots
- TOTEM should help for manpower and CPU

Conclusion and Outlook

- beam 2 integrated in collimation studies
- different optics checked
- first input provided background studies (TCTs, TCDQ)
- integration of the roman pots planed
- simulating real machine
- studying and updating sheet-beam to decrease simulation time