Status of non-linear collimation system

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Outline

- Introduction to the non-linear betatron cleaning collimation system
- Optics studies (JRL)
- Preliminary Dynamic Aperture studies MD (JRL)
- Cleaning efficiency studies (LL)
- Energy deposition studies (LL)
- Conclusions & Proposal for future work

Introduction (1)

- It is based on the use on non-linear magnets, such as sextupoles and octupoles;
- The purpose of the first non-linear element is to blow up beam size and particle amplitude, in order to place the collimator jaw further away from the beam and, as consequence:
  - to reduce the resistive collimator-induced impedance.
  - to reduce the transverse beam density to decrease risks of collimator damages.
  - to reduce the number of collimators.

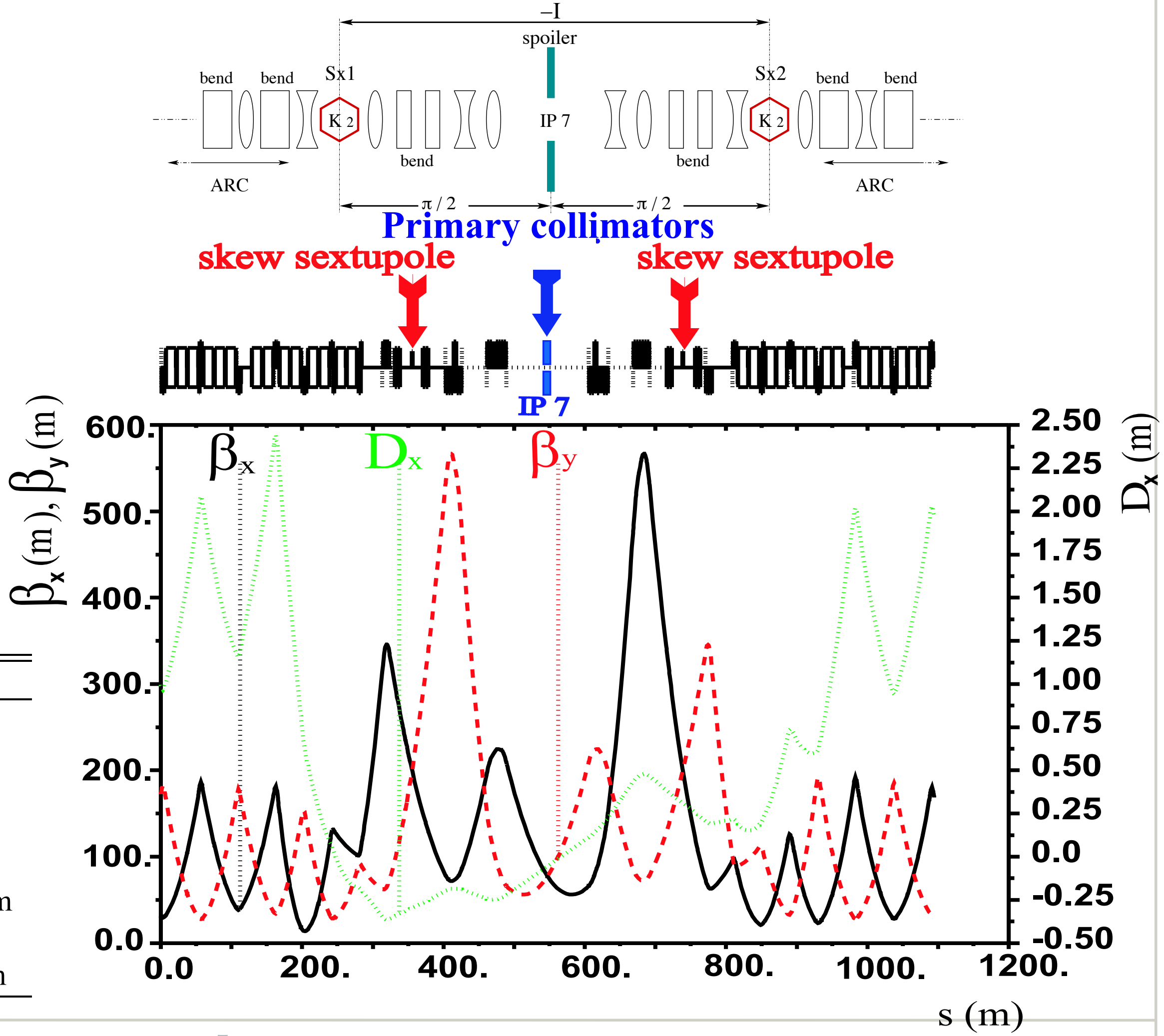
Introduction (2)

- As following previous studies, the proposed layout for LHC includes the installation of 2 strong sextupoles, symmetrically located from the center of the IP7, in the Straight Section.
- Synergy with linear colliders studies: in the case of multi-TeV linear colliders (e.g. CLIC) nonlinear E collimation schemes are being investigated for protection of the Beam Delivery System (BDS)

Optic studies

IR7 layout:

- Based on a skew sextupole pair
- -I between skew sextupoles to cancel geometric aberrations
- Matching section IR7, without affecting the other sections (optics V6.503 'as-built')



Sextupole parameters

variable	value
beta functions (x, y) at skew sext.	$200.0, 200.0$ m
product of skew sextupole pole-tip field and length $(B_T l_s)$	8.1823 T·m
skew sextupole aperture a_s	10 mm
skew sextupole strength K_s	7.0063 m^{-2}
R_{12}, R_{34} from sext. to spoiler	$124.403, 124.404$ m
beta functions (x, y) at spoiler	$77.381, 77.381$ m
rms spot size (x, y) at spoiler	$215.89, 263.96$ μm

Collimator layout and setting

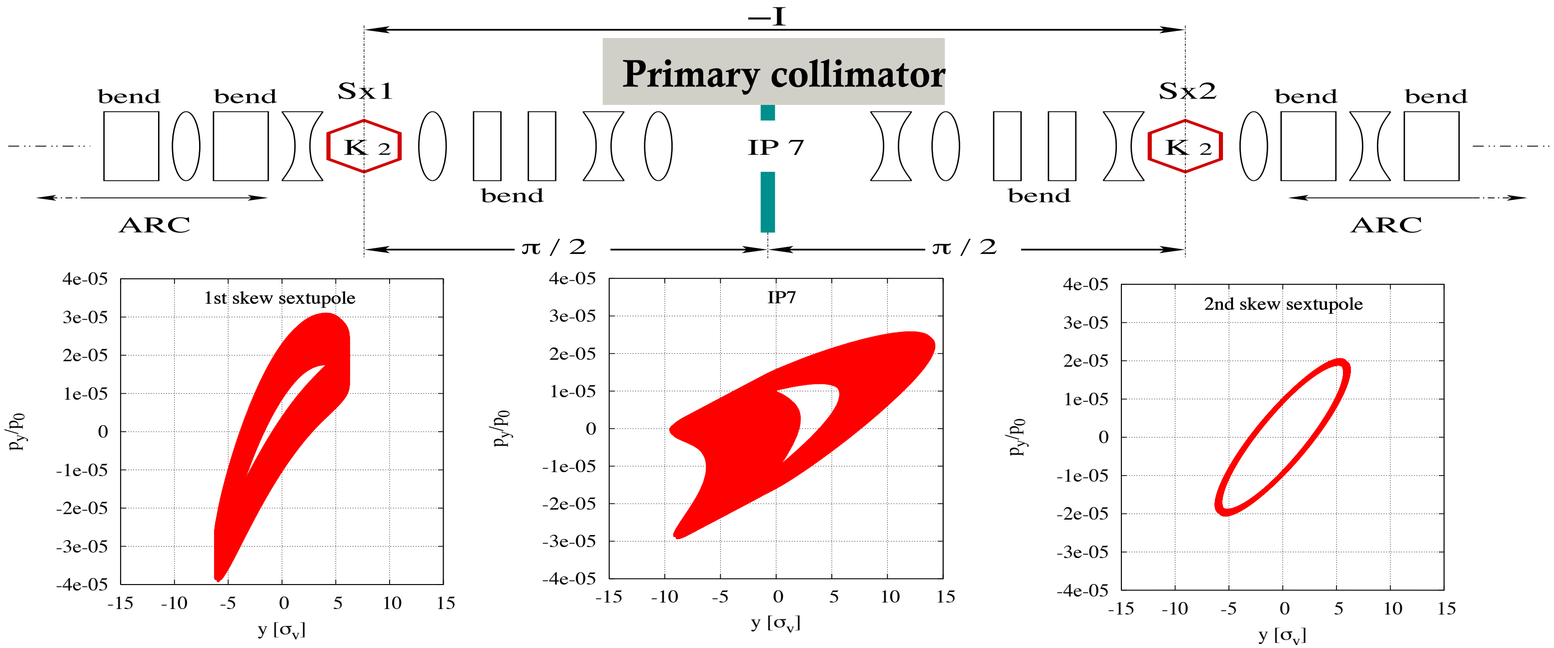
Collimator type	LHC present collimation system (sigma units)	LHC non-linear collimation system (sigma units)
TCP	All @ 6.0	All @ 10.0
TCSG	All @ 7.0	A6L7 - tot opened B5L7 - tot opened A5L7 - tot opened D4L7 - tot opened B4L7 - tot opened A4L7 - 16.0 [0 rad] A4R7 - 8.0[1.571rad] B4R7 - 9.0 [2.37rad] A5R7 - 9.0 [.651rad] B5R7 - 9.0 C5R7 - 9.0[1.571rad] D5R7 - 9.0 E5R7 - 9.0 6R7 - 9.0
TCLA	All @ 10.0	A6R7 - 9.0 B6R7 - 9.0 C6R7 - 7.0 D6R7 - 7.0 A7R7 - 7.0

7 TeV

Primary collimators

3 Additional Secondary collimators

Preliminary beam tracking studies



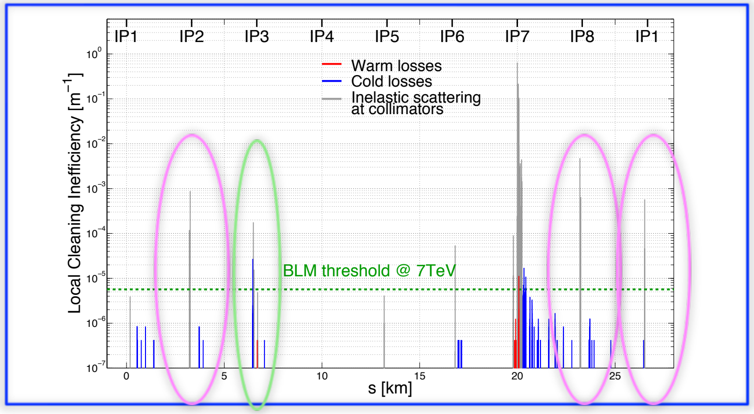
In the past we performed some rough DA estimates using madx:

- Particle tracking studies for 10^5 turns
- $\Delta\beta/\beta \approx 17\%$; $\Delta D_x/D_x \approx 12\%$; $\Delta p/p \approx 0.02\%$
- No additional multipole errors
- DA ≈ 22σ
- Further studies with SixTrack and more realistic conditions are in progress

Cleaning Efficiency studies

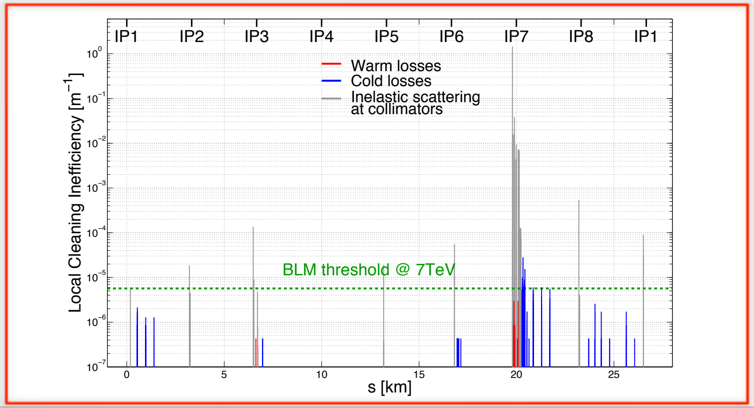
- In order to compare the non linear system with the nominal one, the same halo profile in the hor. and vert. plane has been tracked with SixTrack.

Horizontal halo distribution



Non linear collimation system in IP7

Particle distribution also take into account a fractional energy spread of 1.129x10^{-4}



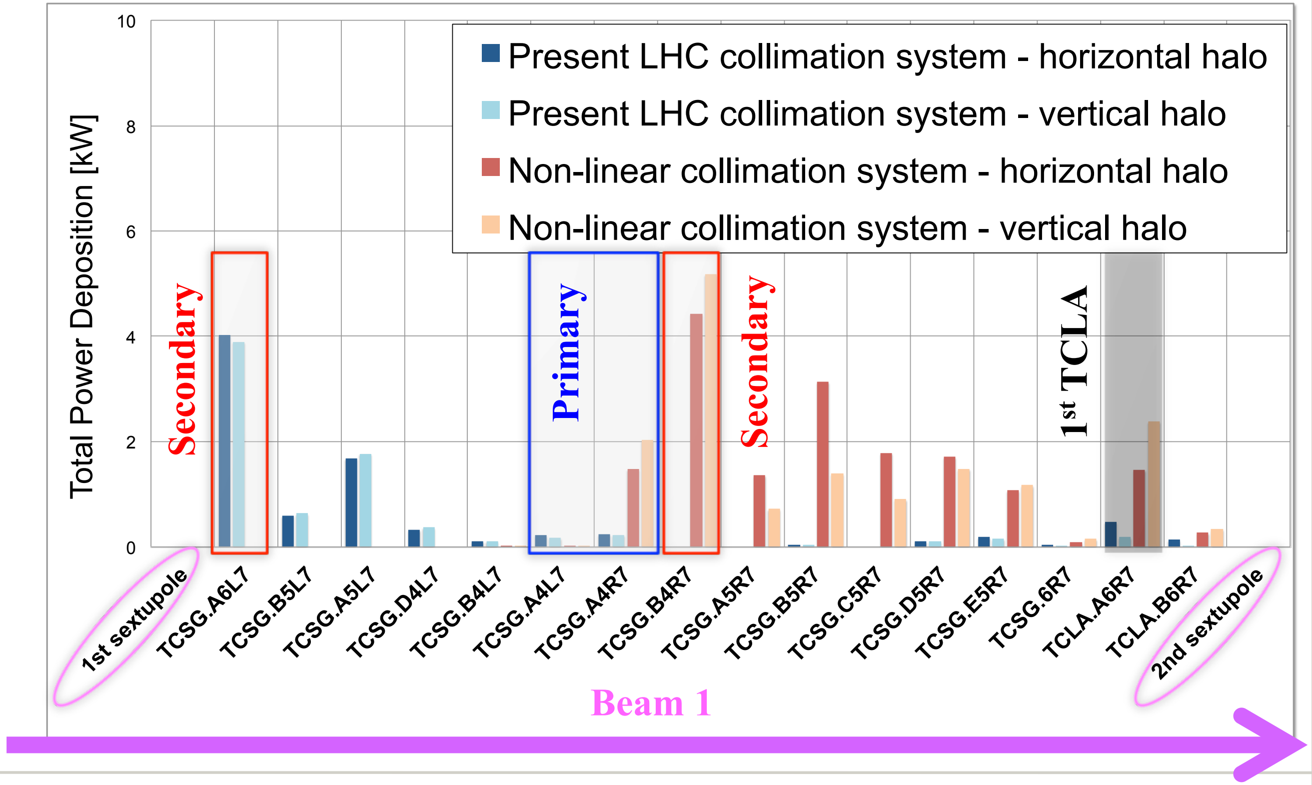
Present collimation system

Energy Deposition studies

- Starting from the maps of primary proton losses non-elastic collisions in the collimators, calculated via SixTrack, a full particle shower study in IP7 was performed with FLUKA.

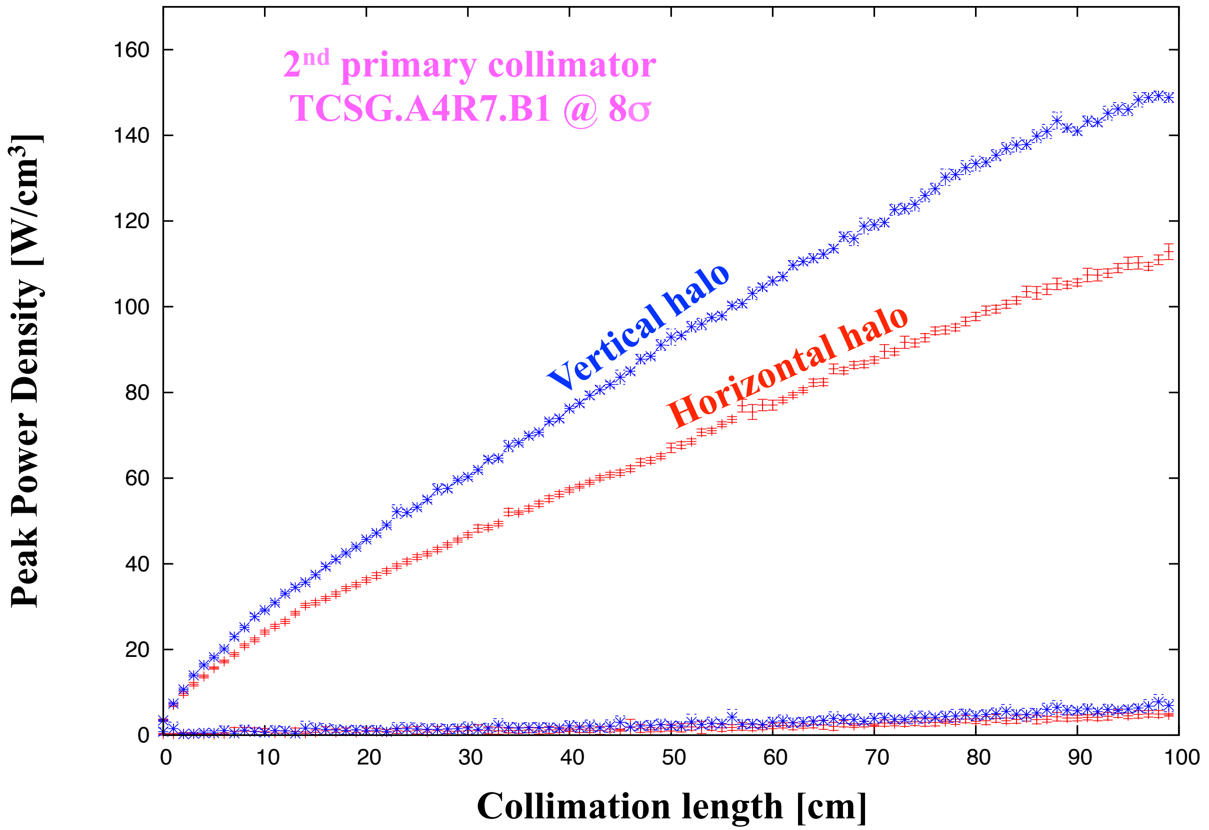
~500 m long Straight Section modeled in FLUKA with more than 100 beam element

Total power deposition distribution on the only collimators @ IP7 (1h beam lifetime @ 7TeV and nominal intensity i.e. 2808 bunches with 1.15×10^{11} p+ each)



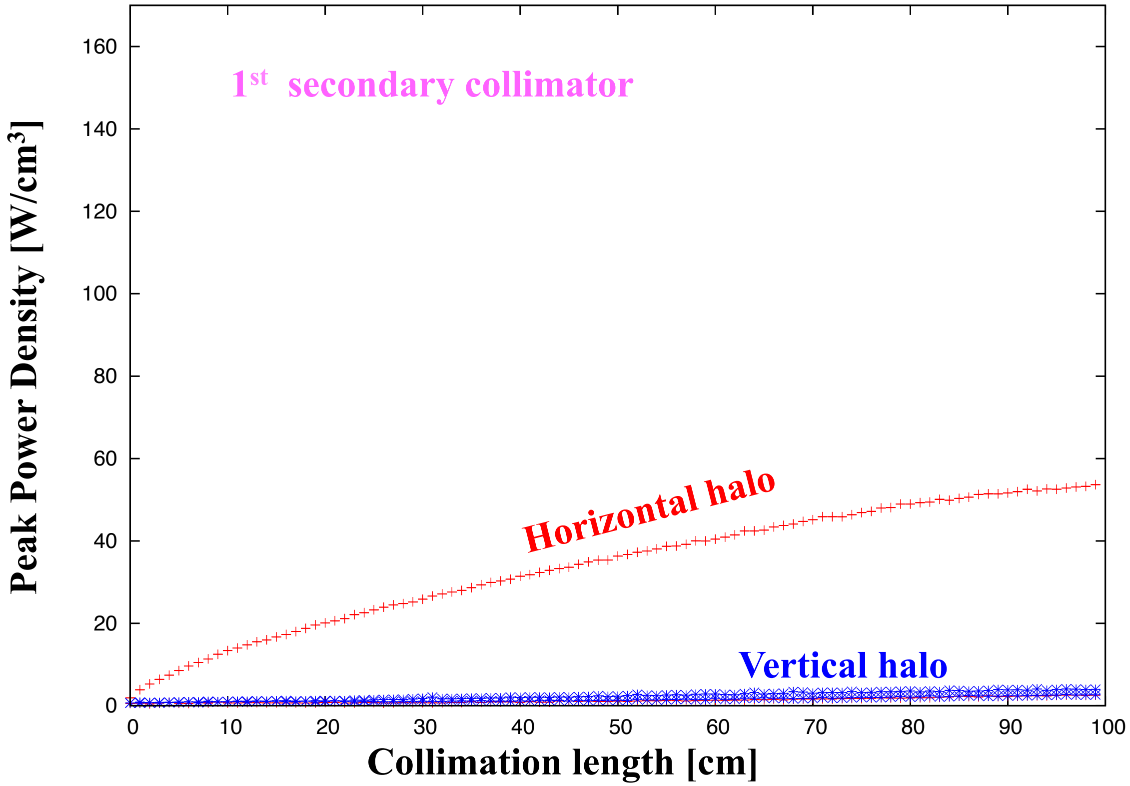
Energy Deposition studies

- Comparison between peak power densities on the jaw surface of the primary collimator



Energy Deposition studies

- Comparison between peak power densities on the jaw surface of the secondary collimators



Conclusion & Proposal for future work

- DA aperture studies for the LHC with nonlinear collimation, using SixTrack, including realistic multipole errors, and other imperfections (e.g. $\Delta\beta/\beta=20\%$, overall beta beat budget).
- Investigate a new nonlinear optics for IR3.
- Investigate the possibility of combining both nonlinear and crystal collimation: since the nonlinear elements guide the particles in a preferred direction, the insertion of crystals could improve the efficiency of the system.
- Design possible experimental tests at the SPS or the LHC.