Collimation efficiency versus active length

G. Burtin (drawings/list on web):

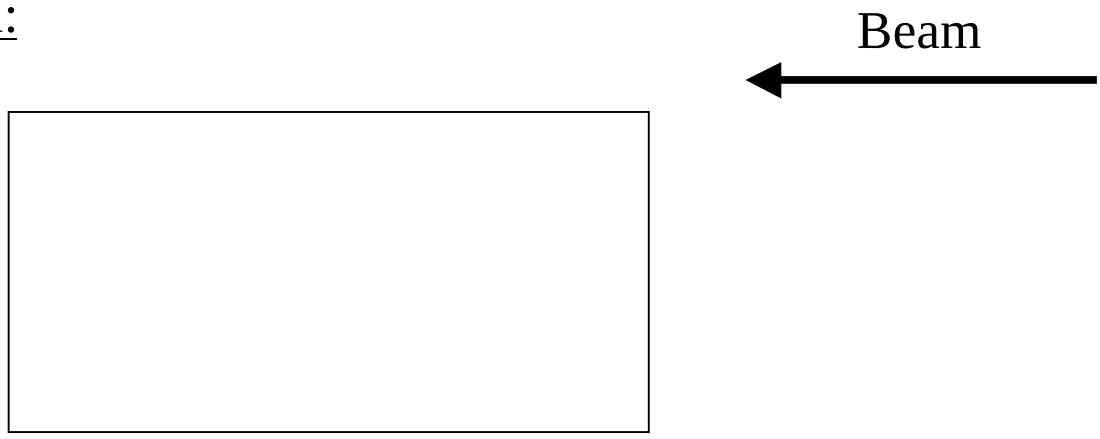
Parameter	LEP specified	LEP achieved	Limit
Flatness[1]	50 μm	120 μm	10-15 μm
Surface roughness[2]	0.8 μm	not measured (2 μm?)	-
Position set size[3]	uncritical	2.5 – 5.0 μm	-
Repeatability	uncritical	½ step ?	-

Compare to ~ μm impact parameter…

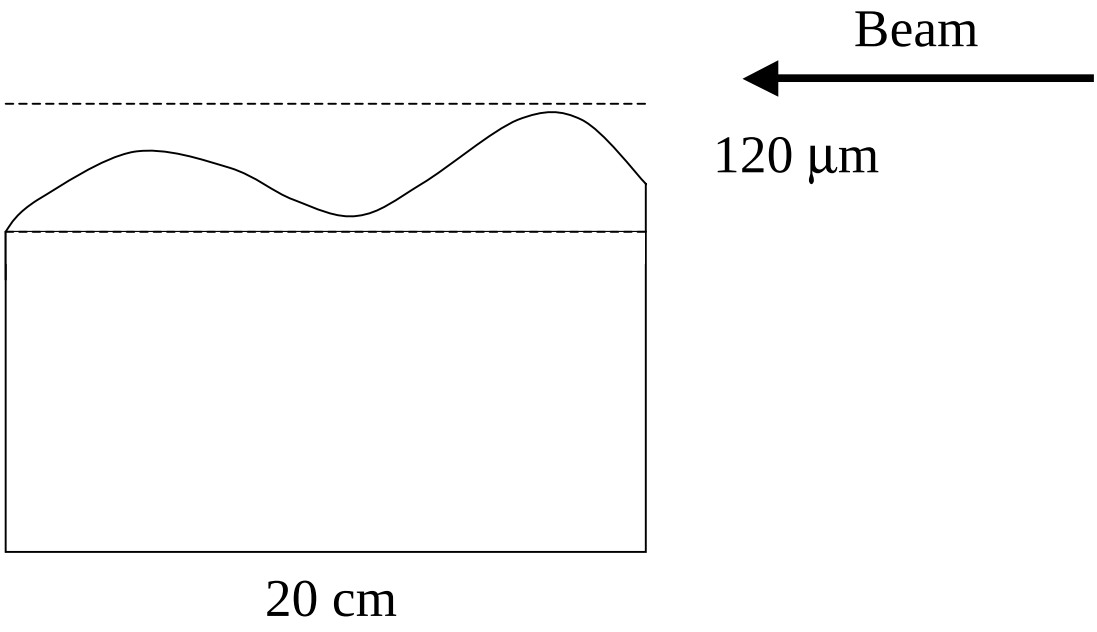
The collimators are referred with about **10 μm accuracy** (at an ambient temperature of 20 °C) to an external reference line, which ideally goes parallel to the beam axis. The reference line is used to set both the horizontal and vertical orientations of the collimator jaw. The **installation error is expected to be about 100 μm**. The accuracy of the reference system and of the installation will determine the angle between the jaw surface and the beam axis (longitudinal tilt). **A non-zero longitudinal tilt can add to the non-flatness of the jaw and can cause a further reduction of the active collimator length.** The collimators are also referred into an external x-y reference plane that is important in order to obtain the correct x-y angle of the collimator surface (transverse tilt).
After installation, only the collimation depth can be adjusted (distance between jaw surface and beam). The longitudinal and transverse tilts cannot be adjusted and must be lived with.

My picture of collimator geometry:

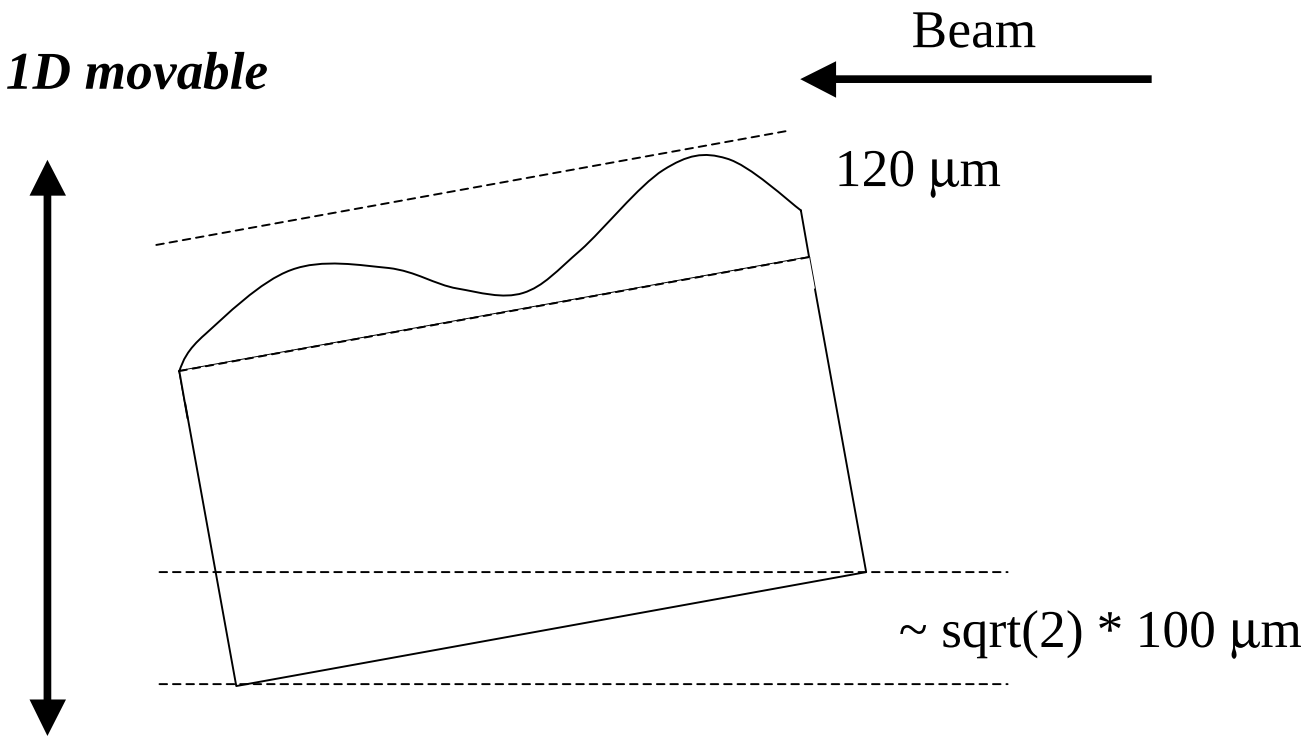
Ideal:



With surface non-flatness:



With surface non-flatness and installation error:



Plus average beam angle (a not equal zero)

~17 μrad for considered collimator…
(~17 μm for 1 m length)

Worst non-flatness with respect to beam direction:

~ 270 μm if we add contributions listed above

Compare to beam sigma of ~ 200 μm at 7 TeV…

Effect of collimator active length?

Consider:

7 TeV

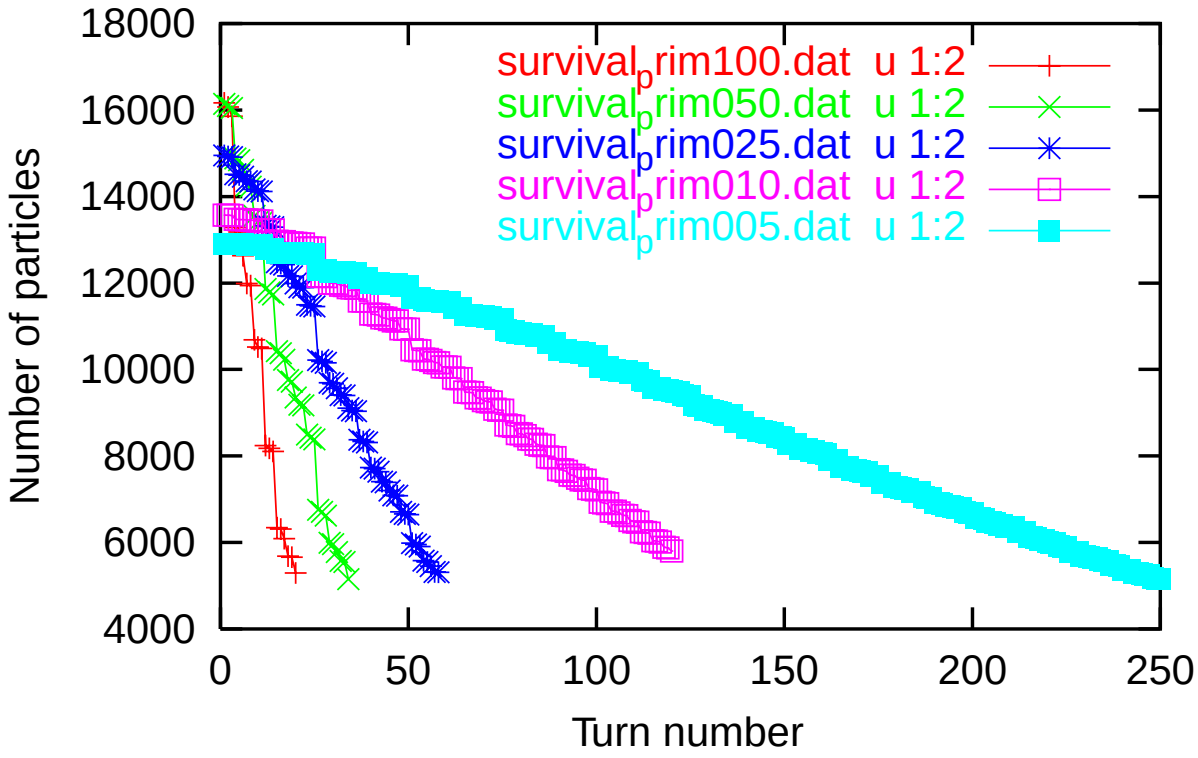
Perfect system

Collimation depth 6/7 sigma

Efficiency of primary vertical collimator

No detailed model of non-flatness yet

Change overall length of primary/secondary collimators


18000
16000
14000
12000
10000
8000
6000
4000
Number of particles
0
50
100
150
200
250
Turn number
survival_prim100.dat u 1:2
survival_prim050.dat u 1:2
survival_prim025.dat u 1:2
survival_prim010.dat u 1:2
survival_prim005.dat u 1:2

Look at survival of particles:

Note: Reduction of number of impacting particles!

Particles survive much longer!

Equilibrium between:

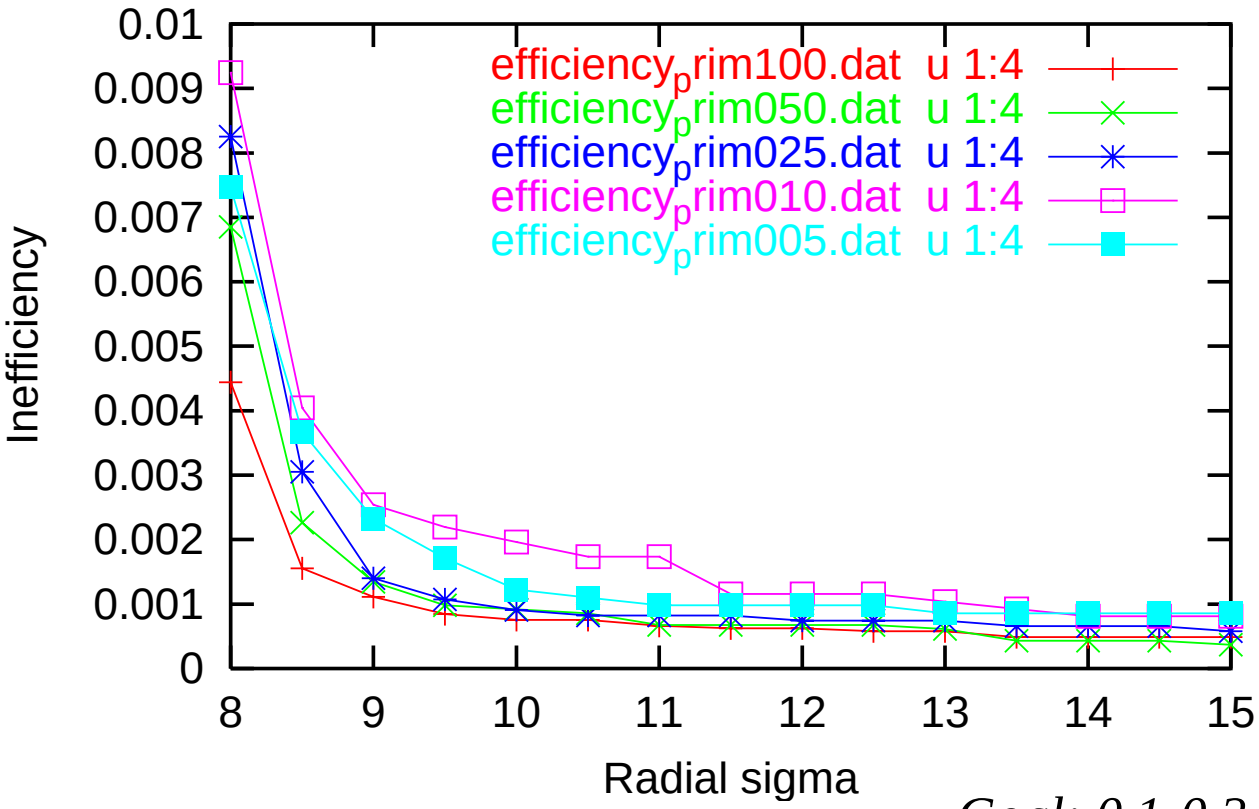
Lost particles		N_p per turn
Absorption efficiency		fraction R per turn
N_p = 10e4/turn	R=5%/turn	2 10e5 part at 6-7 sigma
N_p = 10e4/turn	R=0.1%/turn	1 10e7 part at 6-7 sigma

Another kind of efficiency is here…

Inefficiency at given radial amplitudes:

What fraction of particles escape the collimation system with the given amplitudes?

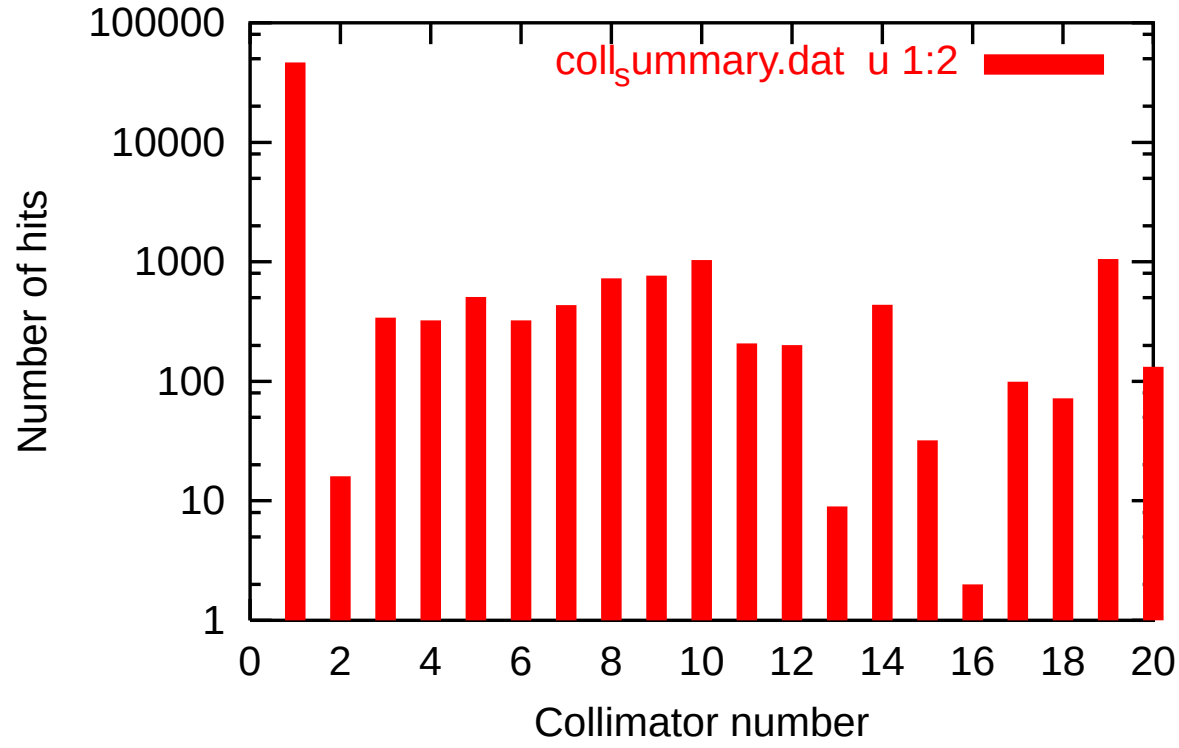
Number of part. at N rad sigma / Number of absorbed part.

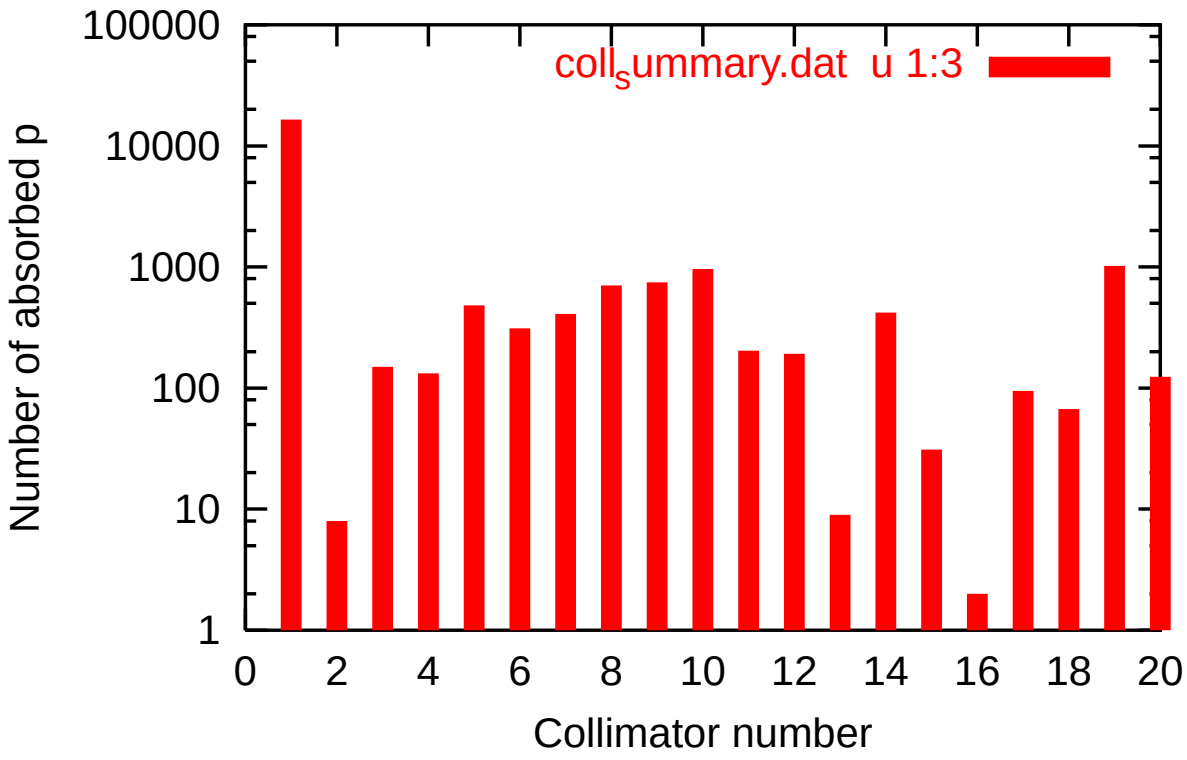


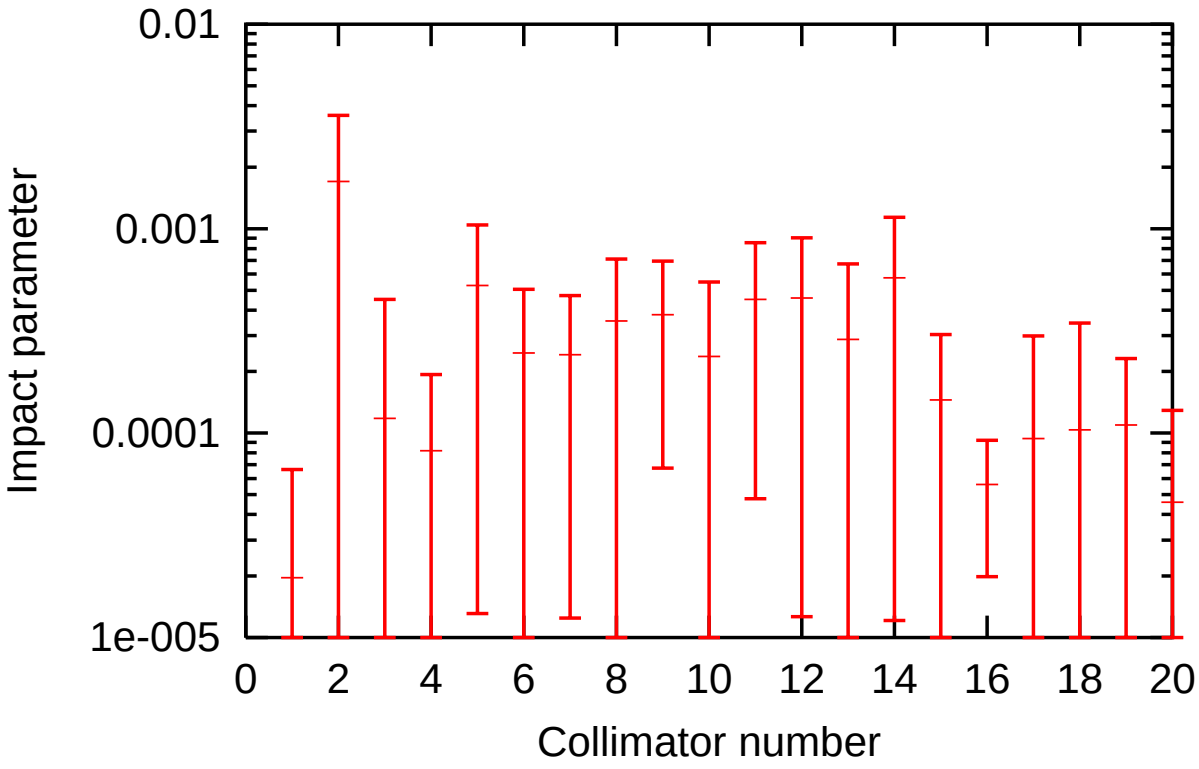
Goal: 0.1-0.2 %

Larger inefficiency for shorter primary jaws!

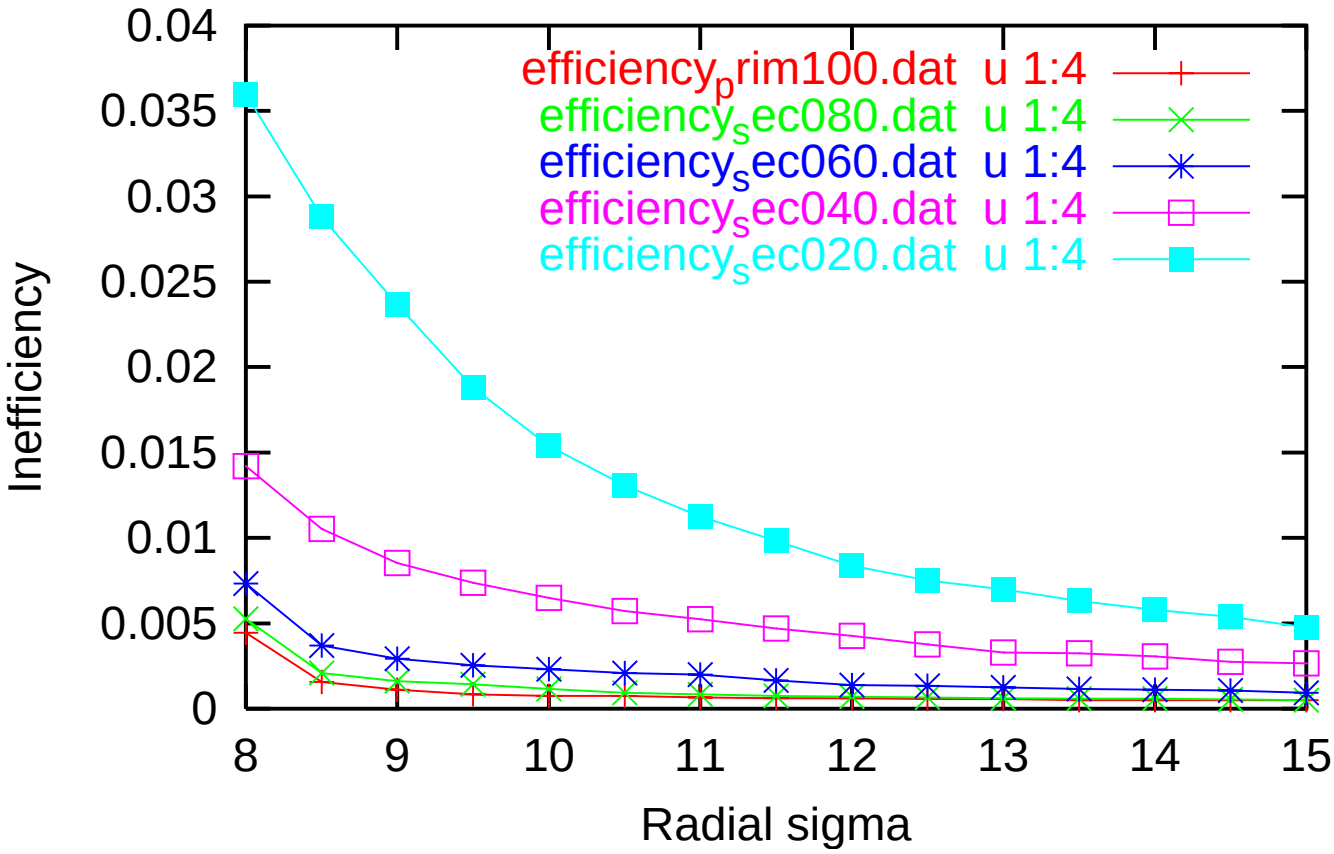
Why: Shorter primary jaws
Smaller scattering angles received
Smaller impact parameters at secondary coll.
Less active length for secondary jaws
More particles in tertiary halo


Number of hits
100000
10000
1000
100
10
1
0
2
4
6
8
10
12
14
16
18
20
Collimator number
coll_summary.dat u 1:2


Number of absorbed p
100000
10000
1000
100
10
1
0
2
4
6
8
10
12
14
16
18
20
Collimator number
coll_summary.dat u 1:3


0.01
0.001
0.0001
1e-005
Impact parameter
0
2
4
6
8
10
12
14
16
18
20
Collimator number

Reduced active length of secondary coll:



Goal: 0.1-0.2 %

As expected: **Active length of secondary collimator is much more critical!**

Action list:

Action: Mechanical deformations due to collimator heating. (tbd)
Action: What do we know about expected heating? (JBJ)
Action: Is the surface flatness acceptable for collimation efficiency (collimation efficiency as function of active collimation length)? (RA)
Action: Is the longitudinal tilt that results from installation accuracy acceptable for collimation efficiency? (RA)
Action: Divergence of particles at given offset amplitudes (e.g. 6-7σ). (SF)

Action: Impedance calculation for the collimator jaws. Specification of eventual transitions (JBJ, RA: D. Brandt's team will be contacted)

Action: Bunch-to-bunch intensity and emittance variations in the transfer line and at LHC injection. (HB)
Action: Maximum level of injection oscillations and protection of the cleaning collimators against destruction. (HB, RA)
Action: Expected changes in beam and accelerator parameters during start of ramp. (MH)
Action: Expected performance of beam instrumentation as function of current, number of bunches, … (JW, ML)

There will be a meeting of the LHC beam cleaning study group this Wednesday

October 24th, 9h30
B. 112 R 4C17

with the following agenda:

1) F. Schmidt: Diffusion rates in the LHC
2) D. Kaltchev: Move of Q7 in cleaning insertion
3) R. Assmann: Collimation efficiency versus active jaw length
4) B. Dehning: BLM work and required simulations
5) J.B. Jeanneret and I. Baishev: Plans for collimator shower studies
6) J.B. Jeanneret: Closed orbit and tune change vs BLM resolution
7) Review of action items
8) AOB

The preliminary agenda of the meeting on 7.11.01 is as follows:

1) Review of action items
2) TBD: News from collimator impedance
3) J. Wenninger: Orbit feedback in cleaning insertions
4) S. Fartoukh: Divergence at collimator jaws (incl CO)
5) V. Kain: Work done so far (tbc)
6) AOB