LCU meeting
25 / 01 / 2010

Latest revisions of nominal 7 TeV IR8 crossing.

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Today the crossing angle, in the nominal LHC files in collision, is 310 μrad with a separation of 0.5 mm.

These values were selected to work with 5 TeV; for higher energies the angle must be scaled because there is not enough strength in the correctors to create the bump for such angle.

After several discussion with Massimo, Stephane and Werner, it seems better to define the “default” at 7 TeV and to scale it, during the operations, down to the run energy.

At top energy we have the pre-squeeze (no collisions) and the squeeze (any step of squeeze could be, a good point to stop and make collisions).

From injection we have:

170 μrad of crossing angle and
2 mm of separation.

For pre-squeeze we could, in principle, keep the same configuration, because we do not need to make collisions, but it is not possible to create a separation of 2 mm at 7 TeV using only 2 MCBX as in the present configuration, the other 2 are required in order to split the force.

Moreover the strength of MCBX seems to be limited to 60% of the nominal (cryogeny issues?).

To provide collisions I assume that:

- the first parasitic encounter must be at least at 10 σ

- the LHCb spectrometer can work with both polarities

- the β^* can change from 10 m to 2 m

- we do not, obviously, exceed the limits of aperture and maximum strength

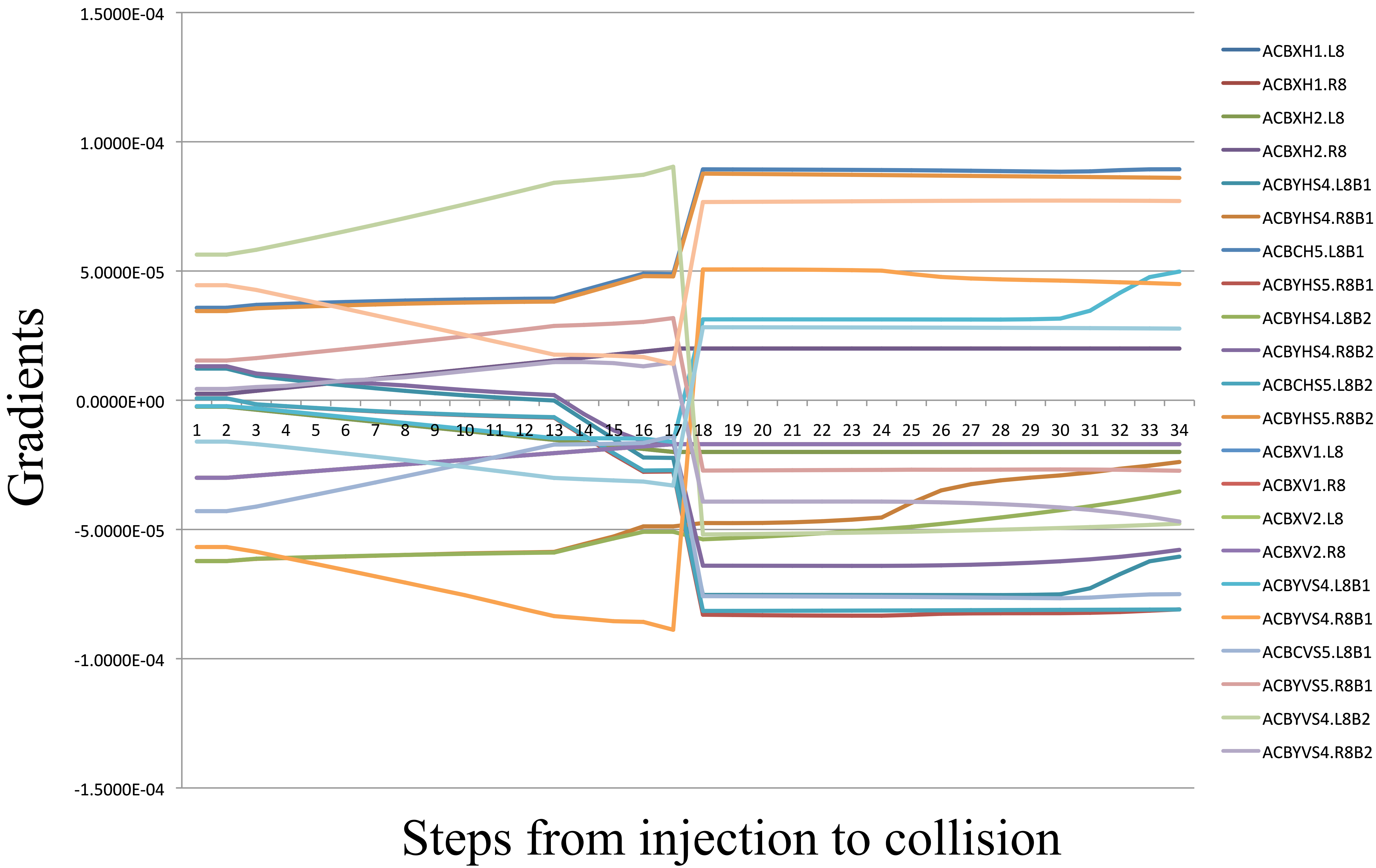
Numbers:

- 10 σ at 7 TeV at 3.75 m from IP8 requires 90 (β^*=2 m) or 100 (β^*=10 m) μrad

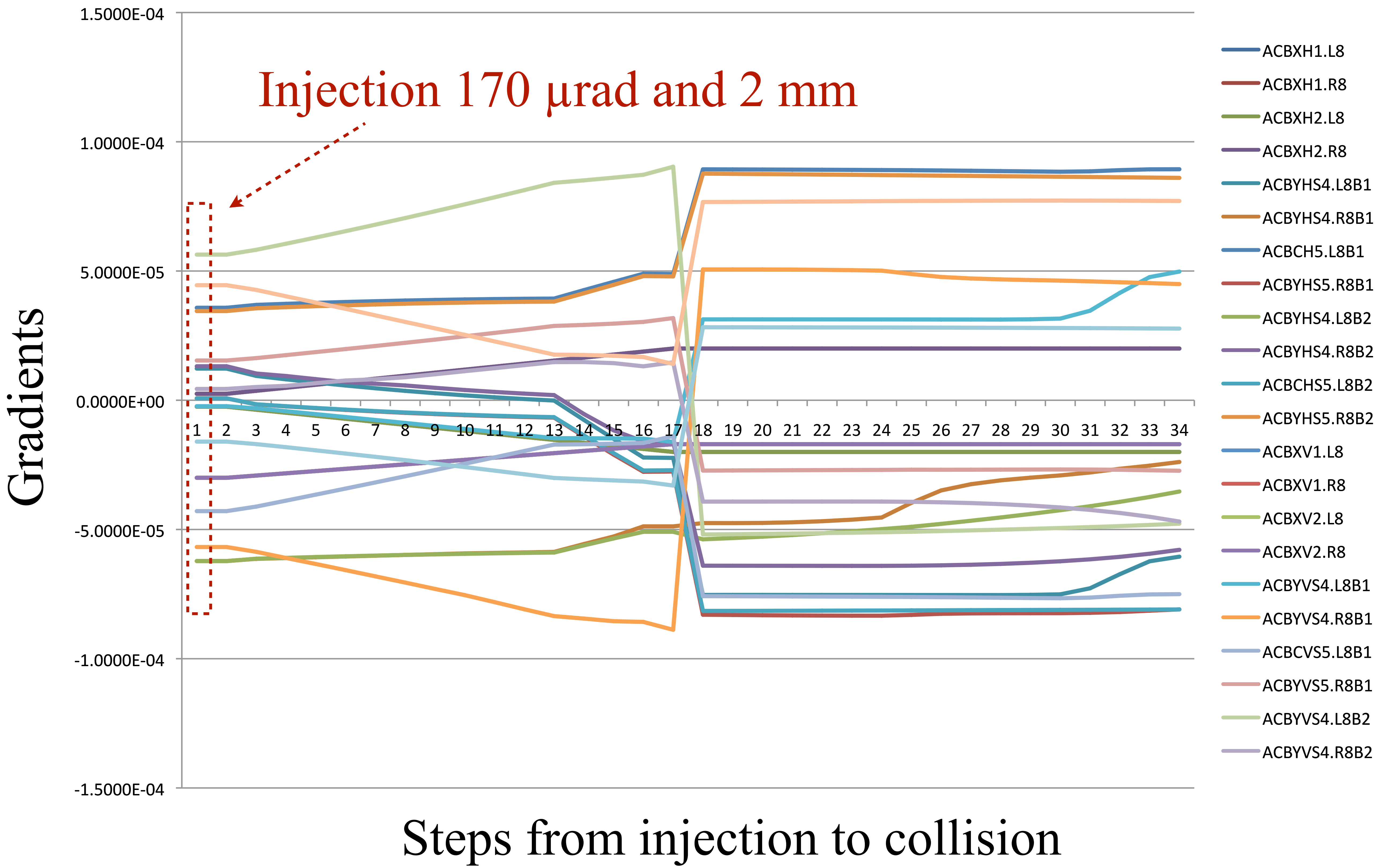
- the spectrometer create an angle of ±135 μrad

- The maximum strength allows an angle of 287 μrad and the aperture is not a problem even if the angle is 287 μrad ($n_1 > 8$ σ)

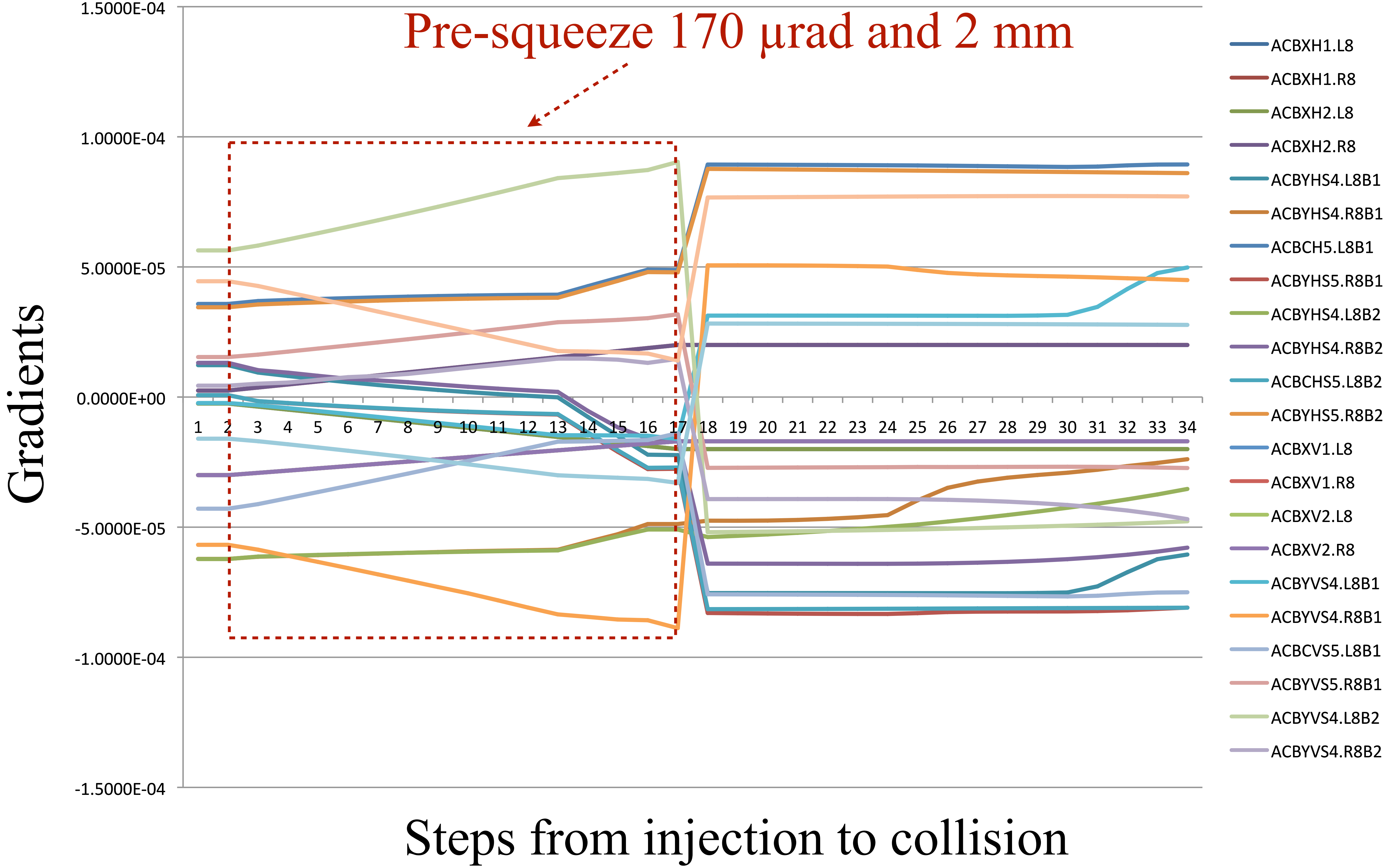
- The maximum current for MCBX is limited to 315 A (60% of the nominal)



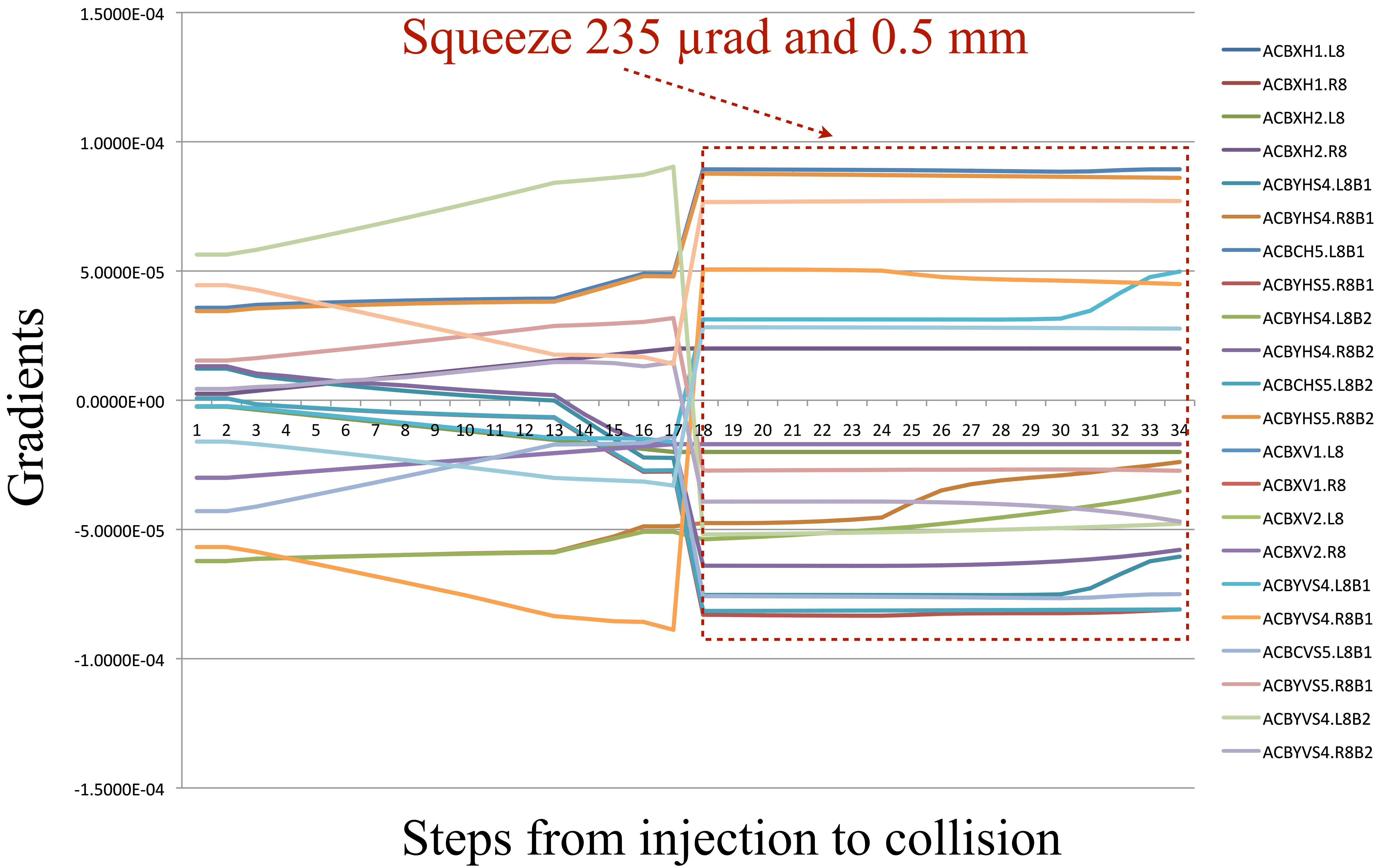
1.5000E-04
1.0000E-04
5.0000E-05
0.0000E+00
-5.0000E-05
-1.0000E-04
-1.5000E-04
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Gradients
Steps from injection to collision
ACBXH1.L8
ACBXH1.R8
ACBXH2.L8
ACBXH2.R8
ACBYHS4.L8B1
ACBYHS4.R8B1
ACBCH5.L8B1
ACBYHS5.R8B1
ACBYHS4.L8B2
ACBYHS4.R8B2
ACBCHS5.L8B2
ACBYHS5.R8B2
ACBXV1.L8
ACBXV1.R8
ACBXV2.L8
ACBXV2.R8
ACBYVS4.L8B1
ACBYVS4.R8B1
ACBCVS5.L8B1
ACBYVS5.R8B1
ACBYVS4.L8B2
ACBYVS4.R8B2



Injection 170 µrad and 2 mm
Gradients
Steps from injection to collision
1.5000E-04
1.0000E-04
5.0000E-05
0.0000E+00
-5.0000E-05
-1.0000E-04
-1.5000E-04
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
ACBXH1.L8
ACBXH1.R8
ACBXH2.L8
ACBXH2.R8
ACBYHS4.L8B1
ACBYHS4.R8B1
ACBCH5.L8B1
ACBYHS5.R8B1
ACBYHS4.L8B2
ACBYHS4.R8B2
ACBCHS5.L8B2
ACBYHS5.R8B2
ACBXV1.L8
ACBXV1.R8
ACBXV2.L8
ACBXV2.R8
ACBYVS4.L8B1
ACBYVS4.R8B1
ACBCVS5.L8B1
ACBYVS5.R8B1
ACBYVS4.L8B2
ACBYVS4.R8B2



Pre-squeeze 170 µrad and 2 mm
Gradients
Steps from injection to collision
1.5000E-04
1.0000E-04
5.0000E-05
0.0000E+00
-5.0000E-05
-1.0000E-04
-1.5000E-04
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
ACBXH1.L8
ACBXH1.R8
ACBXH2.L8
ACBXH2.R8
ACBYHS4.L8B1
ACBYHS4.R8B1
ACBCH5.L8B1
ACBYHS5.R8B1
ACBYHS4.L8B2
ACBYHS4.R8B2
ACBCHS5.L8B2
ACBYHS5.R8B2
ACBXV1.L8
ACBXV1.R8
ACBXV2.L8
ACBXV2.R8
ACBYVS4.L8B1
ACBYVS4.R8B1
ACBCVS5.L8B1
ACBYVS5.R8B1
ACBYVS4.L8B2
ACBYVS4.R8B2



Squeeze 235 μrad and 0.5 mm
Gradients
Steps from injection to collision
1.5000E-04
1.0000E-04
5.0000E-05
0.0000E+00
-5.0000E-05
-1.0000E-04
-1.5000E-04
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
ACBXH1.L8
ACBXH1.R8
ACBXH2.L8
ACBXH2.R8
ACBYHS4.L8B1
ACBYHS4.R8B1
ACBCH5.L8B1
ACBYHS5.R8B1
ACBYHS4.L8B2
ACBYHS4.R8B2
ACBCHS5.L8B2
ACBYHS5.R8B2
ACBXV1.L8
ACBXV1.R8
ACBXV2.L8
ACBXV2.R8
ACBYVS4.L8B1
ACBYVS4.R8B1
ACBCVS5.L8B1
ACBYVS5.R8B1
ACBYVS4.L8B2
ACBYVS4.R8B2

The speed of operations, even for the transition point between pre-squeeze and squeeze, is not a big problem because the slowness of quadrupoles dominates the time scale.

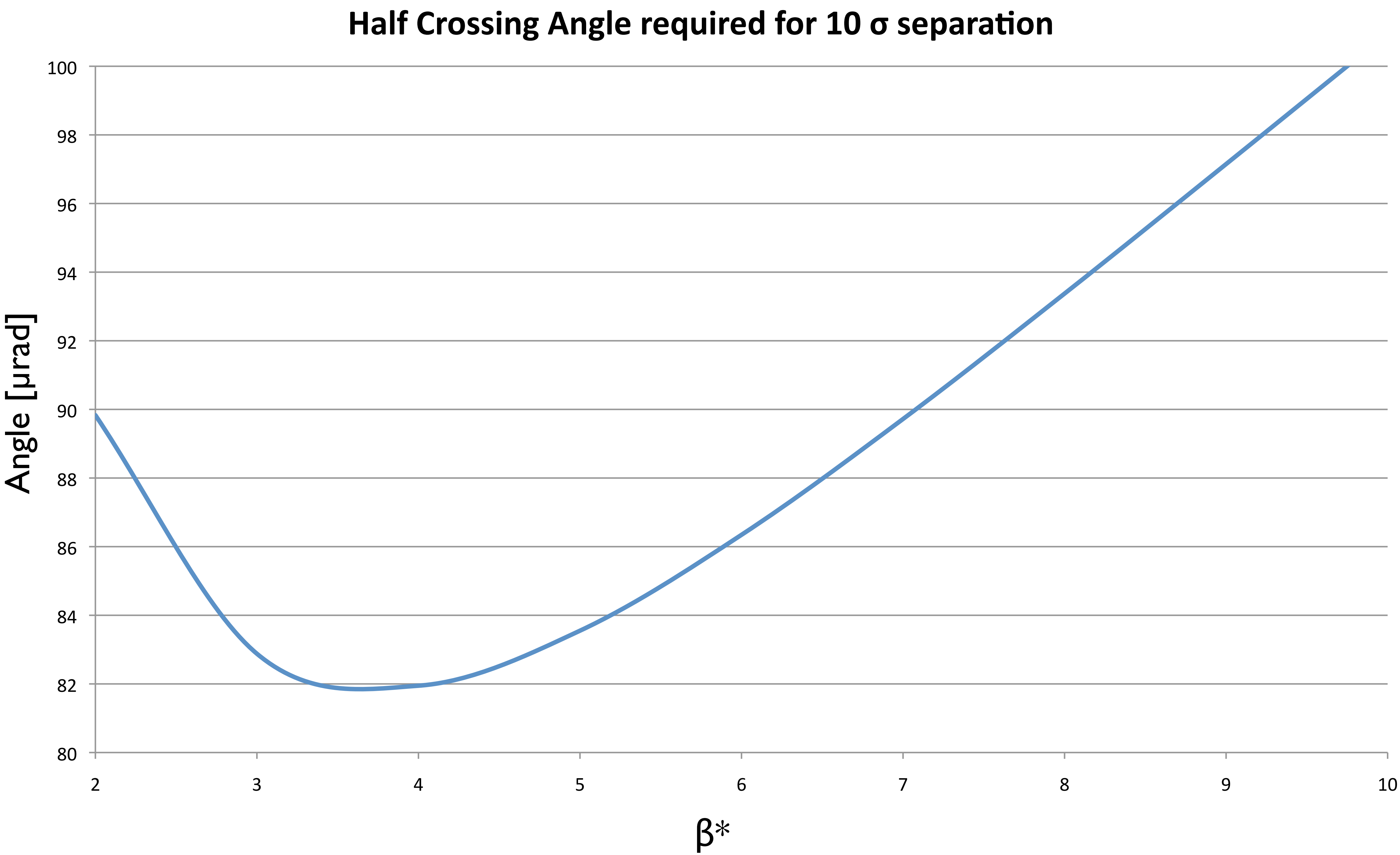
Only the time to collapse the separation, to go in collision, can be optimized according to Simon. But we have to consider that we can collide with a β^* that changes from 10 to 2 m; the strengths of the orbit correctors must change to compensate the orbit and consequently the optimization must be different for each step.

A consideration: MCBX are 5 times slower than other correctors so I tried to keep their value as low as possible during the squeeze.

I have to optimize the new injection with Masamitsu scheme, and the collapsing time in the squeeze at least for one point that could be the 10 m of β^* (the reference point at 7 TeV).

Spare Slides

$$
\begin{aligned}
\sin(\theta)s &= \frac{n\sigma}{2} \\
\theta s &= \frac{n\sqrt{\frac{\epsilon_n}{\gamma_r}\beta(s)}}{2} \\
\theta &= \frac{n\sqrt{\frac{\epsilon_n}{\gamma_r}(\beta* + \frac{s^2}{\beta*})}}{2s} \\
\theta &= \frac{10\sqrt{\frac{3.75\times10^{-6}}{7461}(10 + \frac{3.75^2}{10})}}{2 \times 3.75} \\
\theta &\approx 100 \ \mu\text{rad}
\end{aligned}
$$



Half Crossing Angle required for 10 σ separation
100
98
96
94
92
90
88
86
84
82
80
Angle [μrad]
2
3
4
5
6
7
8
9
10
β*

Aperture worst case: crossing angle 287 μrad and β* = 2 m