Ion quench test MD: motivation and proposal

MPP meeting – 25/11/2011

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Ion quench test MD: motivation

Following the results of the proton DS quench test (May 2011), we tried to estimate by extrapolation the ultimate collimation-related intensity limit for Pb ions:

$$\eta N_{MAX} = \tau R_q$$

$\tau = 3600$s, $\eta = 0.045$ exper. values from ion loss maps,
Rq from proton MD results (~100W in DS)

Expected performance limit for ion beams (IPAC'11 paper) →

- 1.7×10^{11} ions at 3.5 Z TeV (~4x the nominal ion intensity)
- 3.2×10^{10} ions extrapolating at 7 Z TeV (or 80% of the nominal ion intensity)

Several assumptions:

- ❑ minimum beam lifetime independent of beam energy and intensity,
- ❑ identical cleaning inefficiency
- ❑ lower quench limit scaling with magnet current (x2.5)

Substantially higher than nominal intensities could be within reach by the injectors → interest to push for limits

Ion quench test MD: motivation

Moving backwards and in parallel to protons :

100W DS leakage ≈ 500kW primary proton losses
Due to x100 worse η, set the ions limit at 5kW:

5kW=1E8 ions/8.9E9 charges at 3.5 Z TeV in 1 s

Independent validation of the assumed lower DS quench limit came from the analysis of ion loss maps measured during the ion run setup in November 2010:

two cases were identified for worst collimation efficiency:

i. a vertical loss map with B1 taken on 07/11/2010, where 4.88E9 charges were lost (nearly a quarter of a bunch).
ii. a horizontal loss map with B2 taken on 08/11/2010, where 8.89E9 charges were lost (about one full bunch).

Further proof that ~1E10 charges can be safely dumped in IR7 without quenching a magnet ..

Ion quench test MD: procedure

Following the proton case:

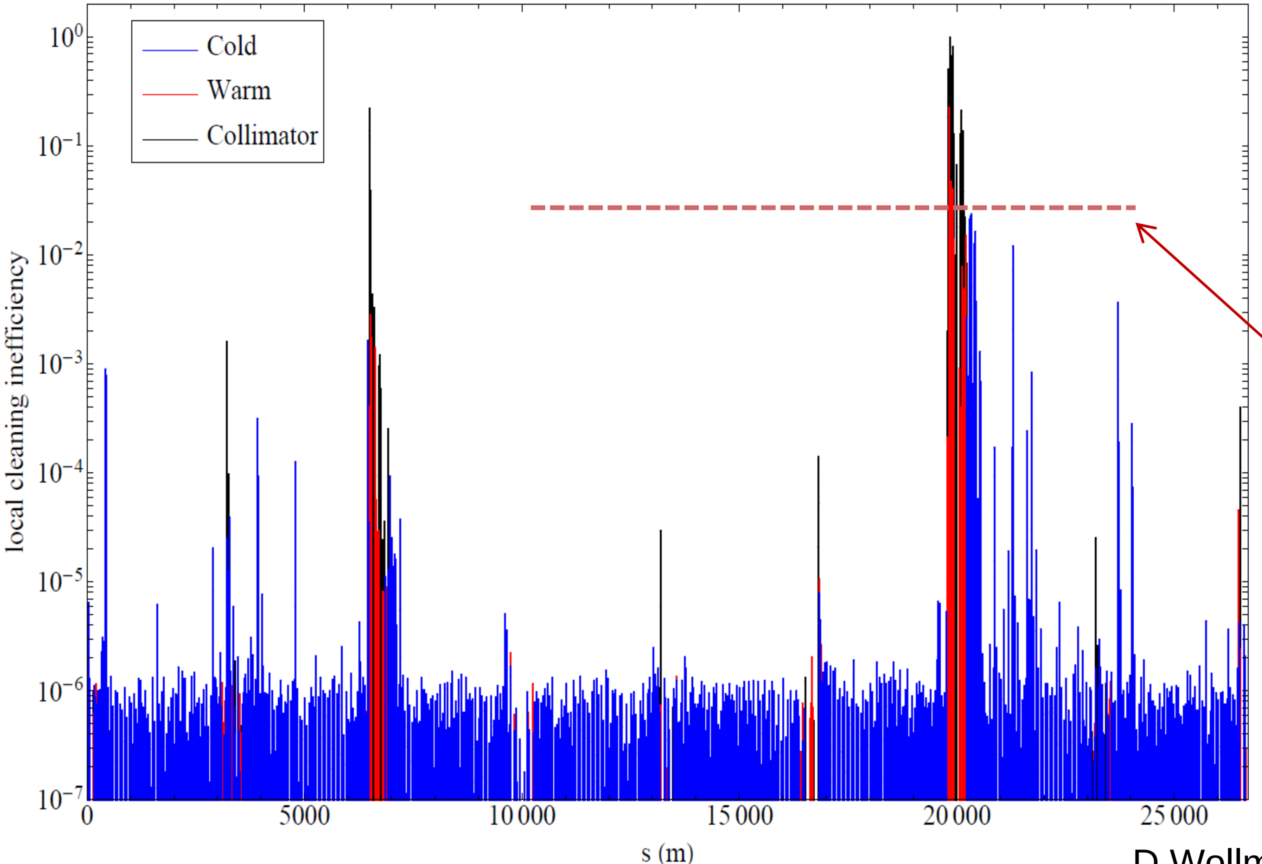
Number of MD's	1
Time required per MD [h]	8, 2 fills minimum
Beams required [1, 2, 1&2]	1&2 (one at a time)
Beam energy [GeV]	3.5TeV
# of bunches	Rescale to quench limits (*)
Optics (injection, squeezed, special)	Nominal optics, un-squeezed, non-colliding
Bunch intensity [No. of Pb ions]	Nominal bunch (~7E7 ions)
Transv. emittance [m rad]	Not relevant
Bunch length [ns @ 4s]	Not relevant
Optics change [yes/no]	Reduced crossing/separation (if beam-beam allows) to minimize losses in the IRs.
Orbit change [yes/no]	No
Collimation change [yes/no]	No: nominal settings validated at injection.
RF system change [yes/no]	No
Feedback changes [yes/no]	No
What else will be changed?	No
Are parallel studies possible?	No
Other info/requests	Changes of BLM thresholds, relaxed setup beam flags

1. Adjust BLM thresholds and drive to HW.
2. First fill at near to quench limit beam intensity, ramp to flat top.
3. Switch tunes (hor/ver).
4. Perform horizontal loss-maps with both beams (one beam at a time) by going onto 3rd integer resonance. (Alternative approach by exciting some bunches with the use of the ADT transverse dumper not fully validated yet- ?).
5. During ramp down:
    1. calculate maximum loss rate (i.e. loss power) achieved.
    2. Extract BLM signals during highest losses and plot ratio of BLM-signal to threshold for the whole ring.
6. Step up in intensity by factor of 2-3.
7. Repeat exactly the same procedure as done before.
8. If there is enough time left for a third ramp: repeat analysis, refill, ramp and repeat losses with an additional step up in intensity.

(*) Rescale 2011 losses to assumed quench limits to find beam intensity settings for for the two fills.

Loss maps 06/11/2011- squeezed optics, separated beams

1) B1 horizontal – normalised losses



2 ion bunches per beam
Peak loss rate: 6.3e9 charges/s, i.e. ~3.5kW

Highest leakage into cold aperture on Q9R7:

2.39% normalised to primary losses or 84W (absolute)

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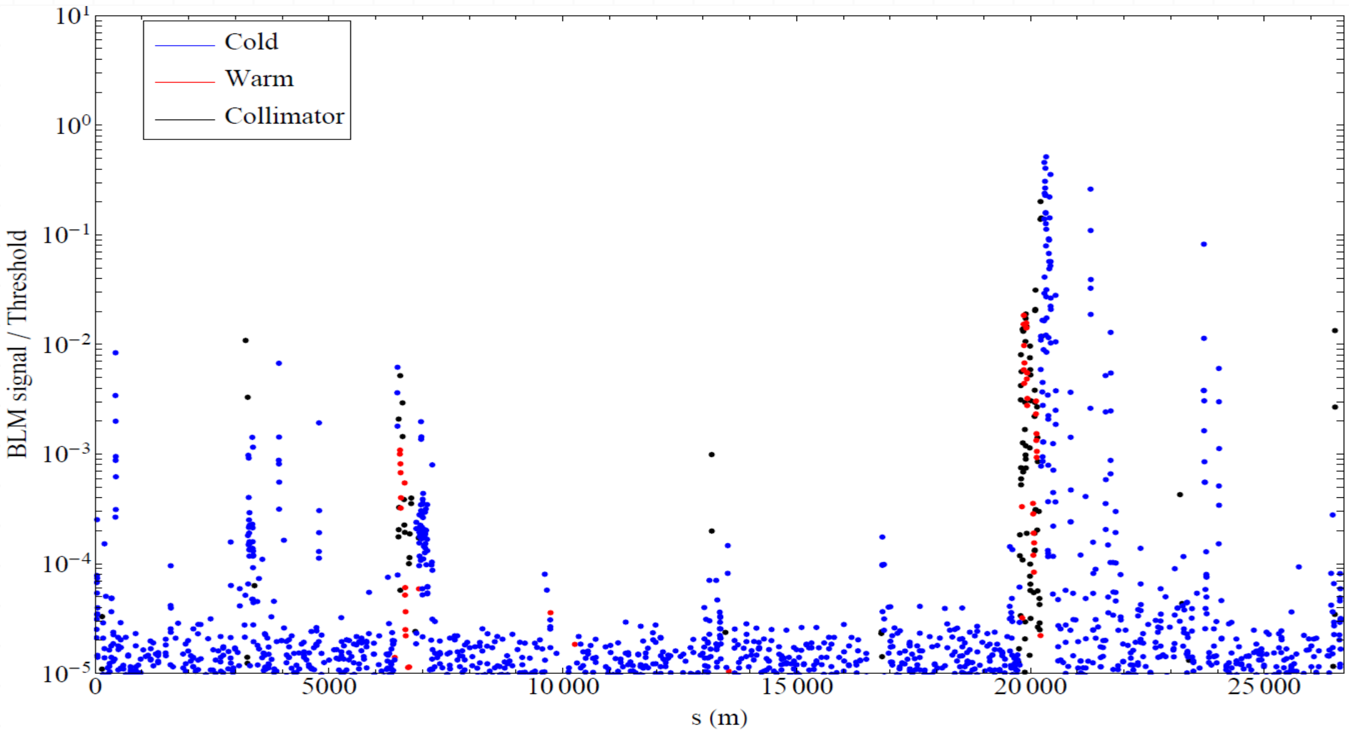
Ratio of losses to BLM thresholds – B1 horizontal



highest ratio of losses to thresholds:
Q9R7: 51.5%
BLMQI.09R7.B1E10_MQ

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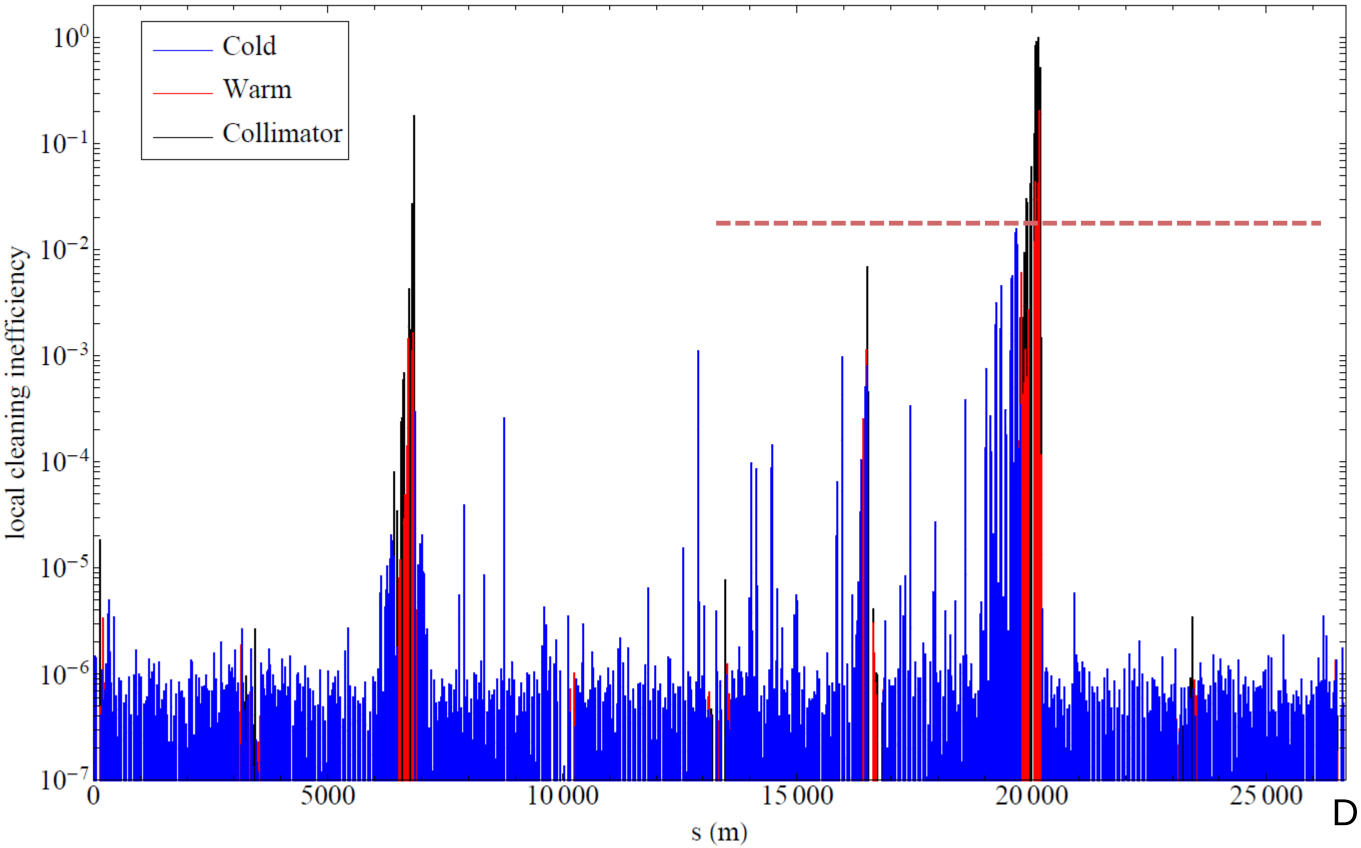
Fill #1: scale to assumed quench limit (x3 dump threshold) and assume constant loss rates
factor of 3/0.515 ~=6 → inject 12 bunches (~ 1.6e11 charges)

Fill #2: scale to 3x assumed quench limit (x9 dump threshold) and assume constant loss rates
factor of 6x3 = 18 → inject 36 bunches (~ 4.8e11 charges)

Loss maps 06/11/2011- squeezed optics, separated beams

1) B2 horizontal – normalised losses

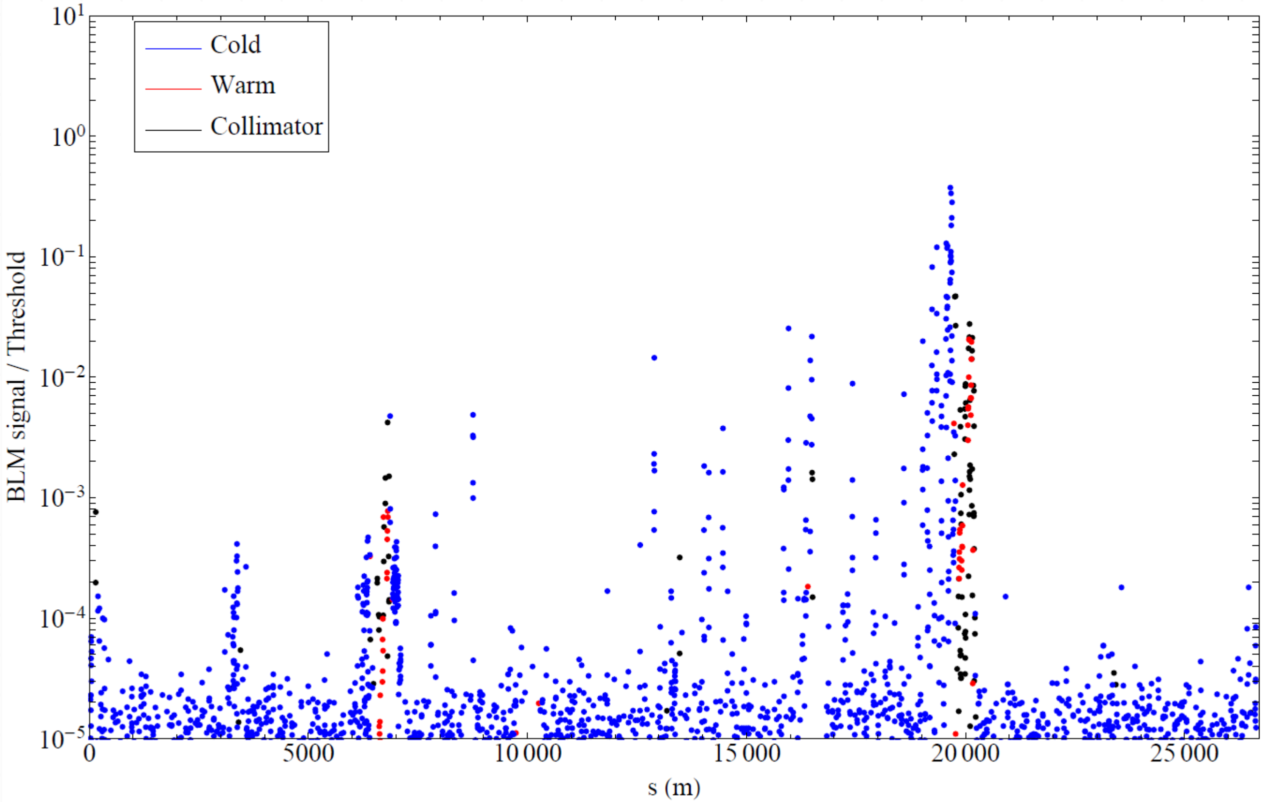


2 ion bunches per beam
Peak loss rate: 7e9 charges/s, i.e. ~3.9kW,

highest leakage into cold aperture on MB9L7: 1.55% normalised to primary leakage or 60 W (absolute level)

D Wollmann

Ratio of losses to BLM thresholds – B2 horizontal



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highest ratio of losses to thresholds:
Q9L7: 37.5%
BLMQI.09L7.B2I10_MQ

Fill #1: scale to assumed quench limit (x3 dump threshold) and assume constant loss rates

factor of 3/0.375 = 8 → inject 16 bunches (~ 1.9e11 charges)

Fill #2: scale to 3x assumed quench limit (x9 dump threshold) and assume constant loss rates

factor of 8x3 = 24 → inject 48 bunches (~ 5.7e11 charges)

Procedure

Before the MD:

Adjust BLM thresholds and monitor factors for the IR7 tests.
Drive the new thresholds to hardware.
Perform MCS check.
Perform BLM sanity check

During the MD

Inject 12(16) bunches (B1/B2), ramp to flat top.
Force very relaxed SFB true.
Mask MASKABLE BLMs.
Switch tunes (hor/ver). Perform horizontal loss-maps with both beams (one beam at a time) by going onto 3rd integer resonance.
During ramp down recalculate scaling factors
Step up in intensity by a factor of 3 (36/48 bunches for B1/B2).
Repeat loss maps.
If there is enough time left → third ramp?

After the MD

Remove all masks and revert to normal thresholds.

Procedure (ii)

- BLM threshold changes required in:
-B1: 25 cold magnets, 3 collimators and no warm magnets
-B2: 22 cold magnets, 2 collimators and no warm magnets

- Doc in preparation for further checks and approval.

- Proposed time window for the test:
during the last week of ion operation, but not right at the end! Tentatively on Dec 3rd (or between 4th -6th Dec) ?