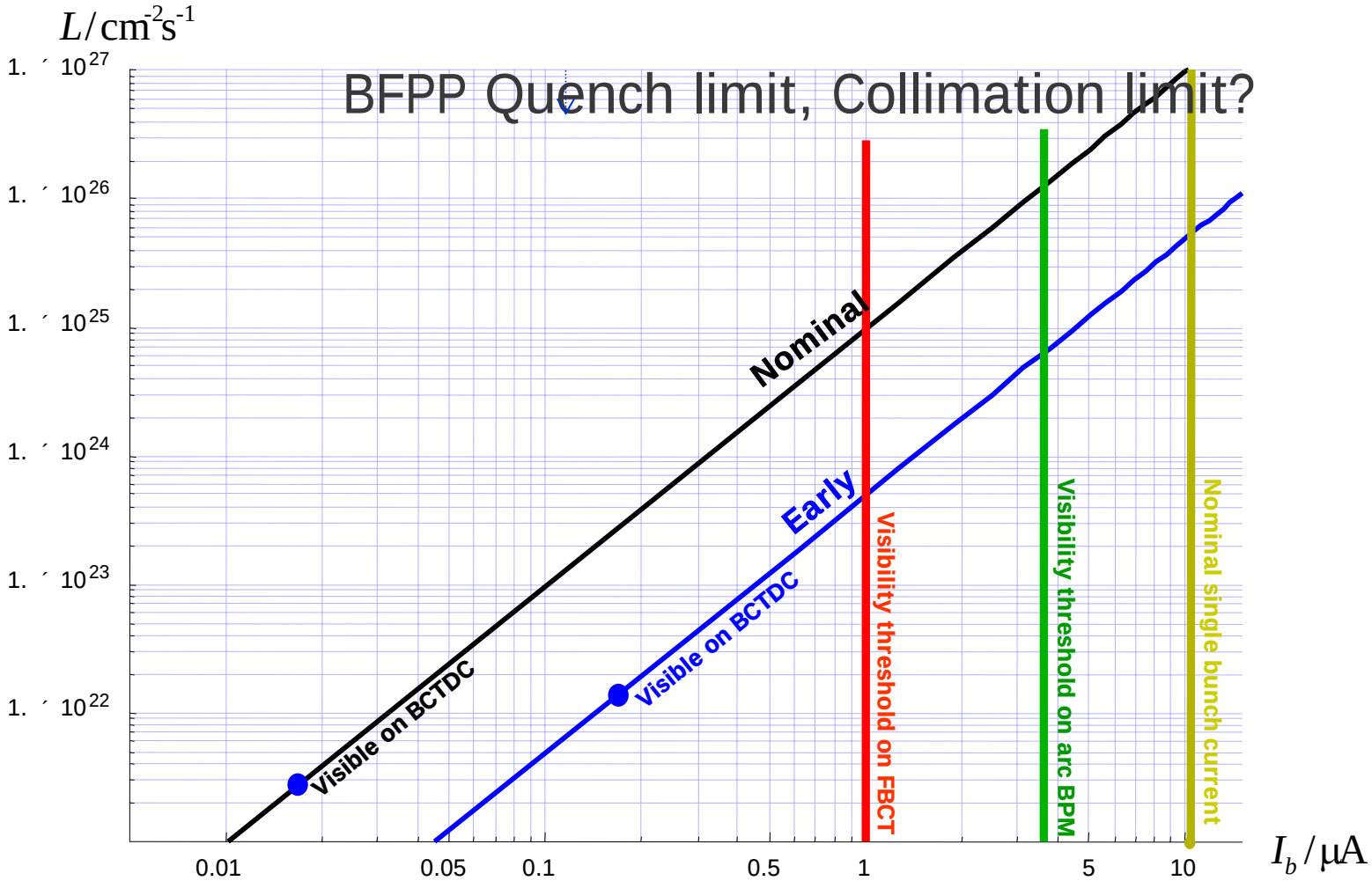
LTC Open action on β*-tuning for lead ions

(a.k.a. luminosity levelling)

Specification of operation for ion operation with varying β	LHCCWG / Roger Bailey	12.4.2005 / 53.LTC 2006 Chamonix	open

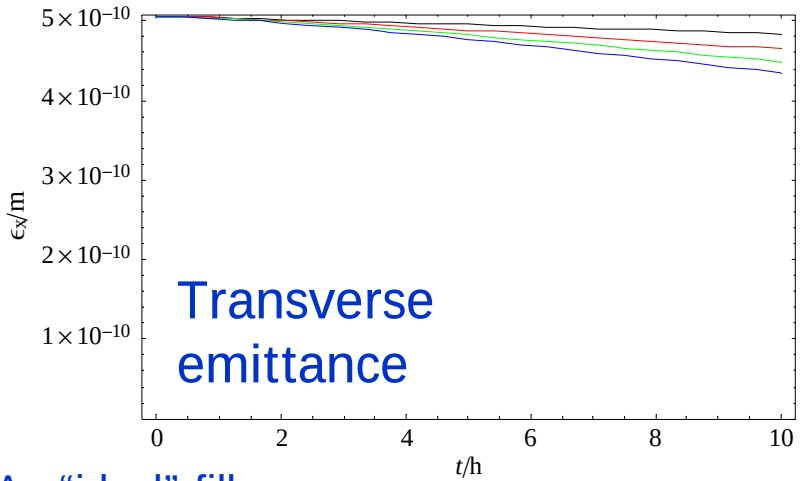
John Jowett AB-ABP

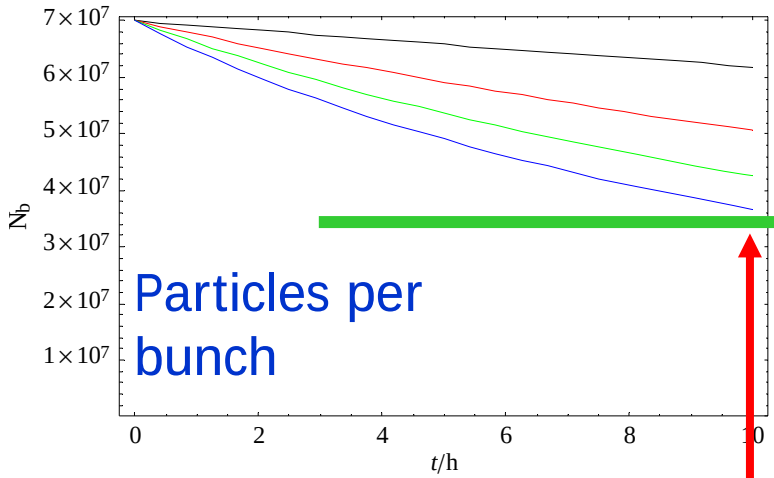
Operational parameter space with lead ions



Thresholds for visibility on BPMs and BCTs.

Luminosity evolution during a fill: Early scheme $\beta^* = 1\,\mathrm{m}$



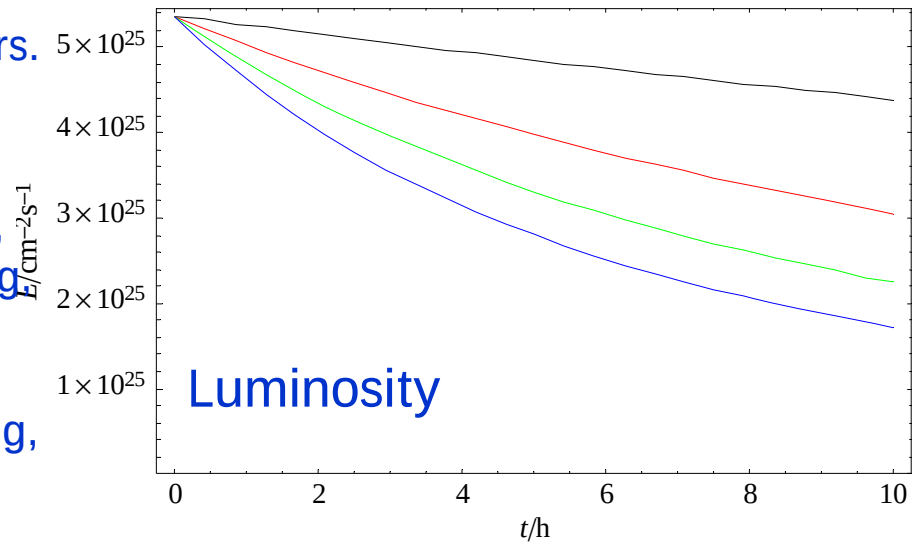


Arc BPM visibility threshold

An "ideal" fill, starting from design parameters.

Luminosity burn-off,
IBS (pessimistic),
radiation damping,
RF noise,
beam-gas,
multiple scattering,
etc.

No. of experiments: $n = 0.1.2.3$

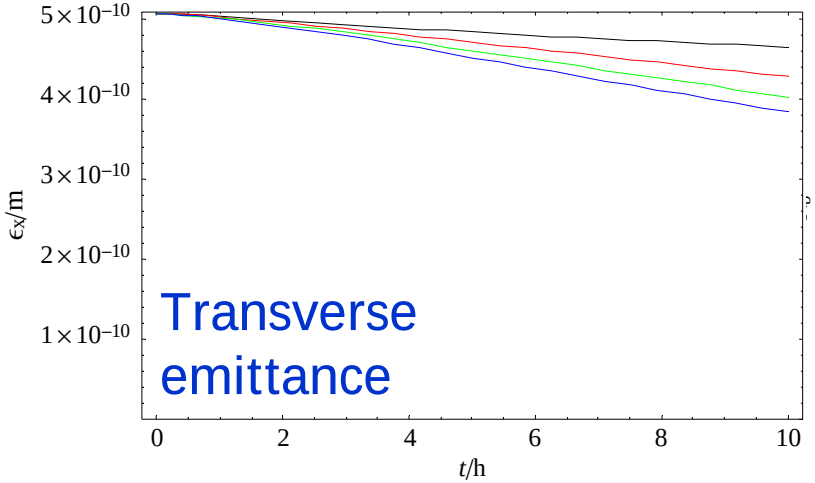


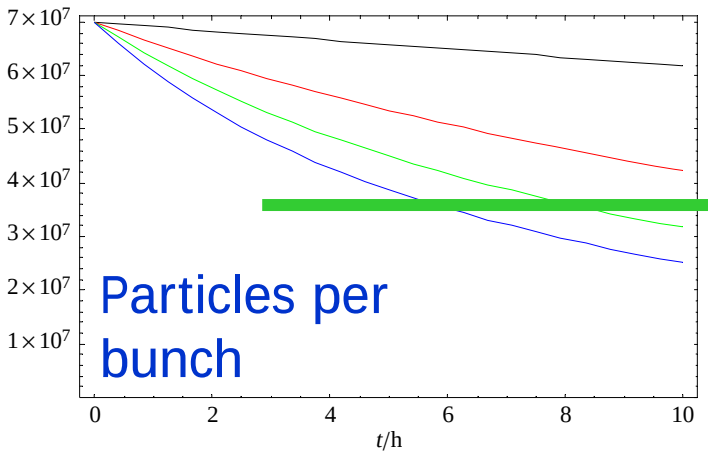
Increasing number of experiments reduces beam and luminosity lifetime *but* we can still keep fills for a long time (useful if turn-round time is long).

all effects.

Luminosity evolution: Nominal scheme

$\beta^* = 0.5\,\mathrm{m}$



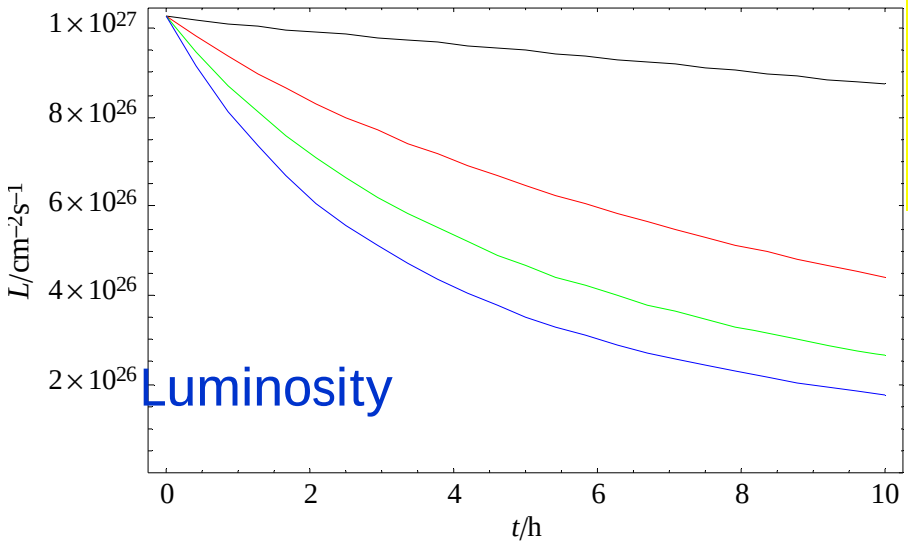


BPM visibility threshold

An "ideal" fill, starting from design parameters.

Luminosity burn-off,
IBS (pessimistic),
radiation damping,
RF noise,
beam-gas,
multiple scattering,
etc.

No. of experiments: $n_{\mathrm{exp}} = 0, 1, 2, 3$



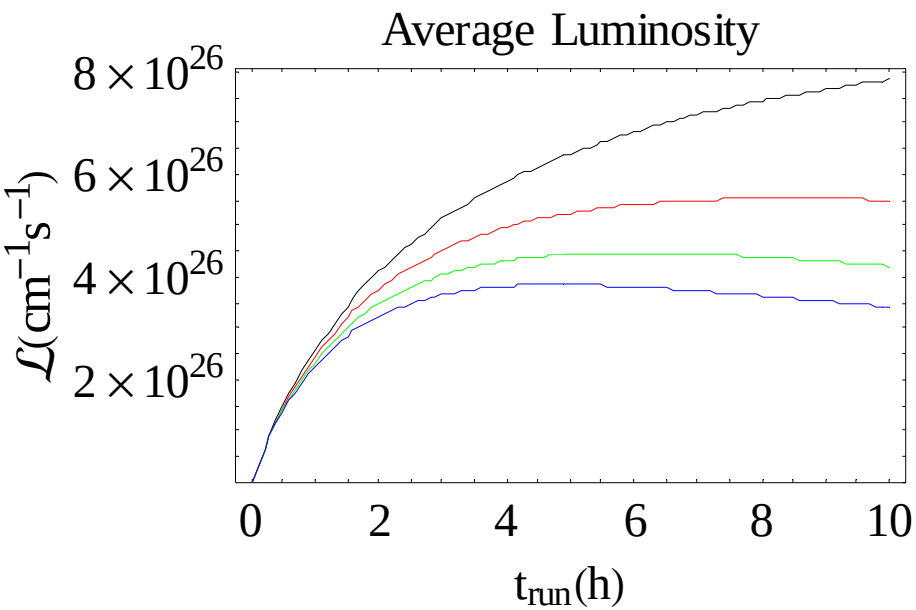
Increasing number of experiments reduces beam and luminosity lifetime.

Example: average luminosity

Average luminosity depends strongly on time taken to dump, recycle, refill, ramp and re-tune machine for collisions.

Average luminosity with 3h turn-around time, in ideal fills starting from nominal initial luminosity.

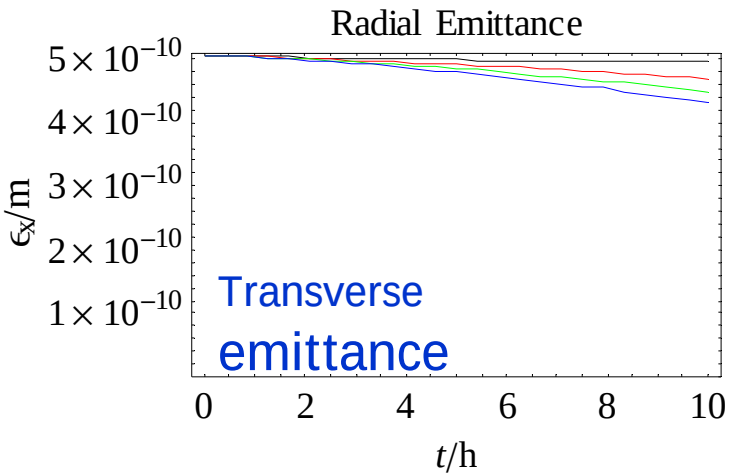
Maximum of curve gives optimum fill length.

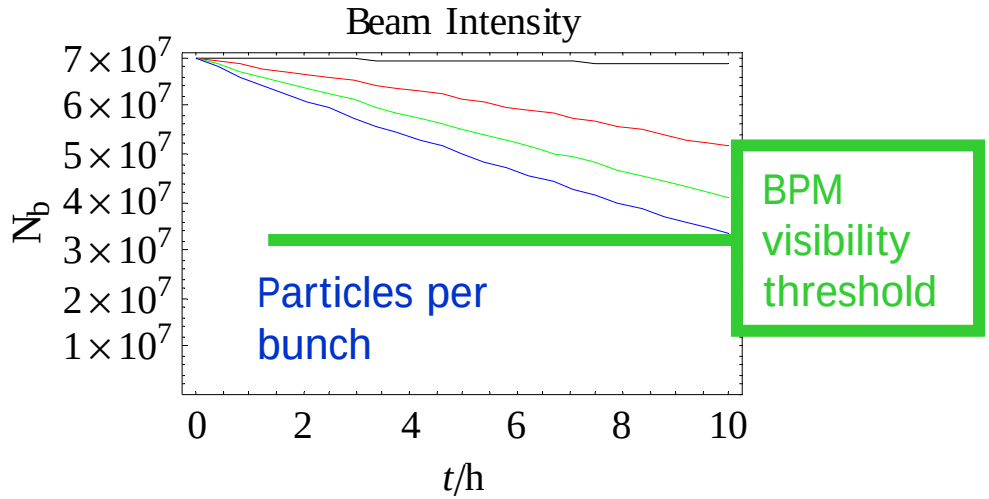


No. of experiments: $n_{exp} = 0, 1, 2, 3$

If turn-around time is short enough, beams may be dumped to maximise average $\mathcal{L}$ **before** BPM visibility threshold is reached.

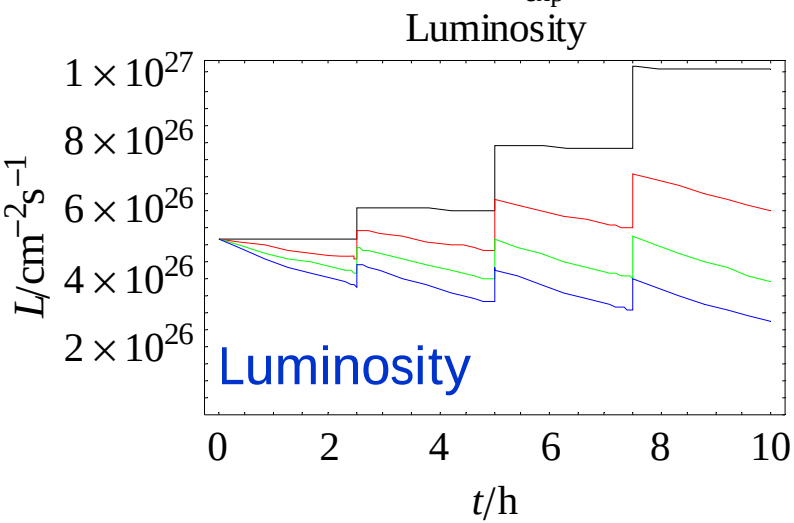
Luminosity evolution: β*-tuning





No. of experiments: $n_{exp} = 0, 1, 2, 3$

A. Morsch proposed adjusting β* as intensity decays to maximise integrated luminosity.



Beams can be kept longer.

Operational feasibility in LHC to be demonstrated (to some extent in studies at RHIC).

Gain from higher initial bunch current

Beam Physics Note 79
06 August, 2004

Luminosity Evolution for Lead Ion Beams in the LHC

Amy Nicholson

Pb Betastar change with time

The capability for beta-tuning has been implemented into the Mathematica notebook. As an example, we consider the case where the beta function is lowered at four instances during the run-time in an attempt to keep the luminosity approximately constant. The intial value for beta is 1.25 m. It reaches its minimum value of 0.5 m after 7 hours. The initial intensity has been raised to its maximum possible value, about 10^8 ions per bunch. Fig. 10 shows the resulting luminosity. With this scheme, the average luminosity increases by approximately a factor of 1.3.

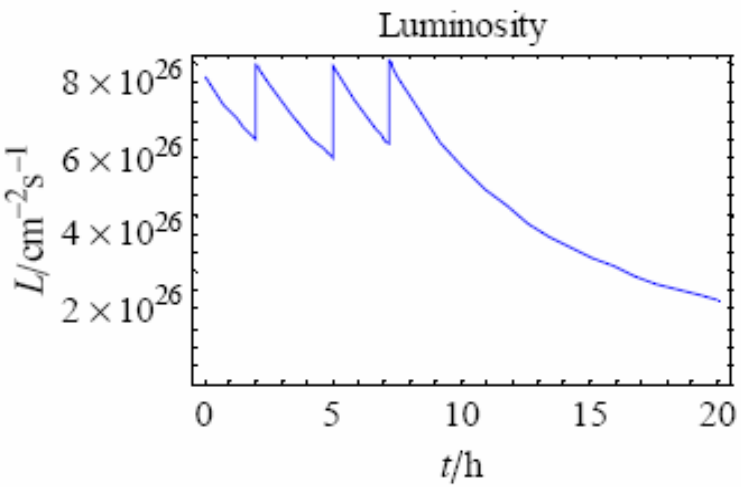


Fig. 10 Luminosity evolution for 2 experiments, showing the effects of beta-tuning.

Remarks

- β*-tuning (or luminosity levelling) will be important for heavy ion operation since no. of experiments is large
  - Good proving ground for LHC luminosity upgrade for protons
  - Technique is useful for HI operation with fewer bunches (eg, in case of limits on total current)
- Not yet clear how difficult this will be operationally
  - Essentially a slowed-down squeeze with beams colliding
  - Coupling of squeeze and crossing angle (if any) bumps
  - Potential for orbit drifts, optical errors, etc.
  - All the more difficult with 3 low-β (maybe do two at a time ?).
  - Should be tried out when LHC operation is stable
  - Simulations possible with complete magnetic model etc.
- Some attempts in MD at RHIC
  - Wittmer et al knobs
- My opinion
  - Probably not worth investing effort on details now. Ready for 2010 ?