



Machine development - results and plans – critical results, what's to be done?

R. Assmann

for the LHC MD coordination team

(R. Assmann, Frank Zimmermann, Giulia Papotti)

See **LSWG presentations of MD teams and the ATS MD notes** for details!



Web Site for LHC MD's

Welcome Ralph



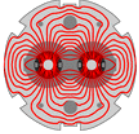
Web Site for LHC MD's

This Site: Web Site for LHC MD's

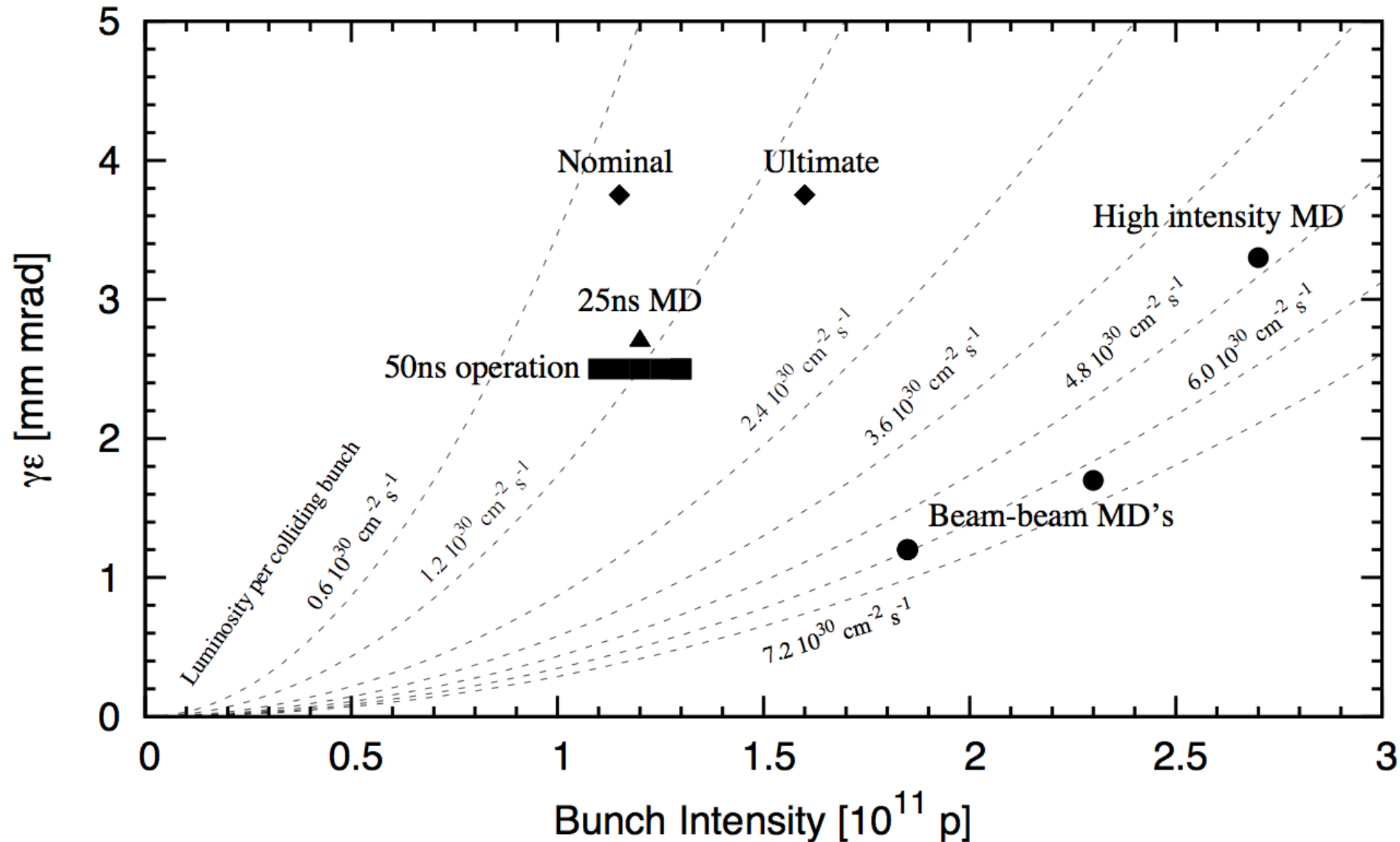
[Home](#) | [MD Requests 2011](#) | [MD Notes 2011](#) | [LSWG Minutes](#) | [ATS Notes MD \(from CDS\)](#) | [Next MD schedule](#) | [Next MD injector schedule](#)

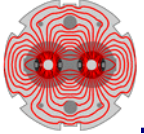
LHC-MD web site holds detailed info, ATS MD notes by the teams, MD requests, LSWG minutes and presentations, ...

Here I will be generic, focusing on issues relevant for this meeting!



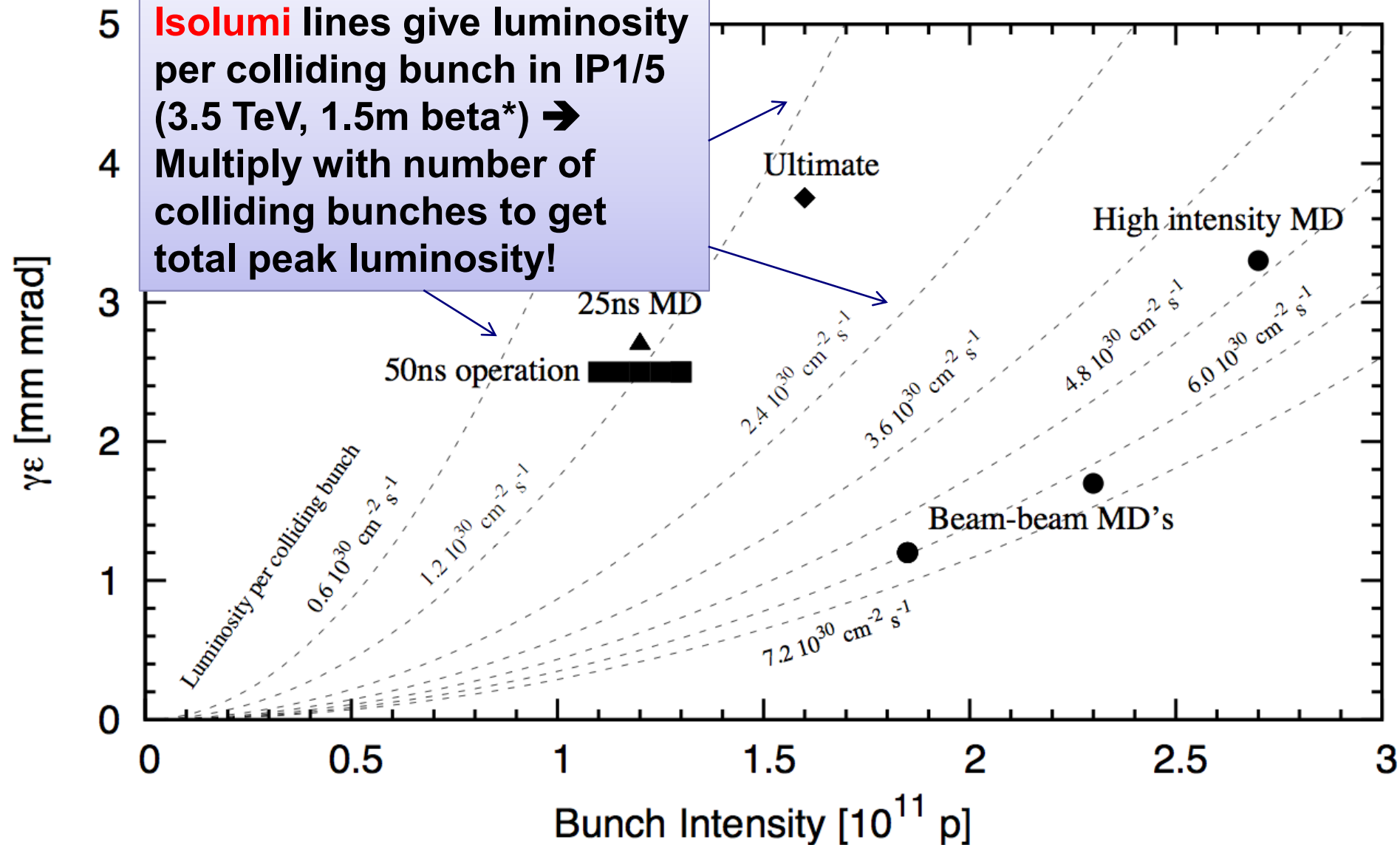
MD Results: Bunch Intensity and Emittance

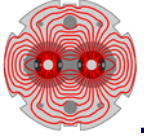




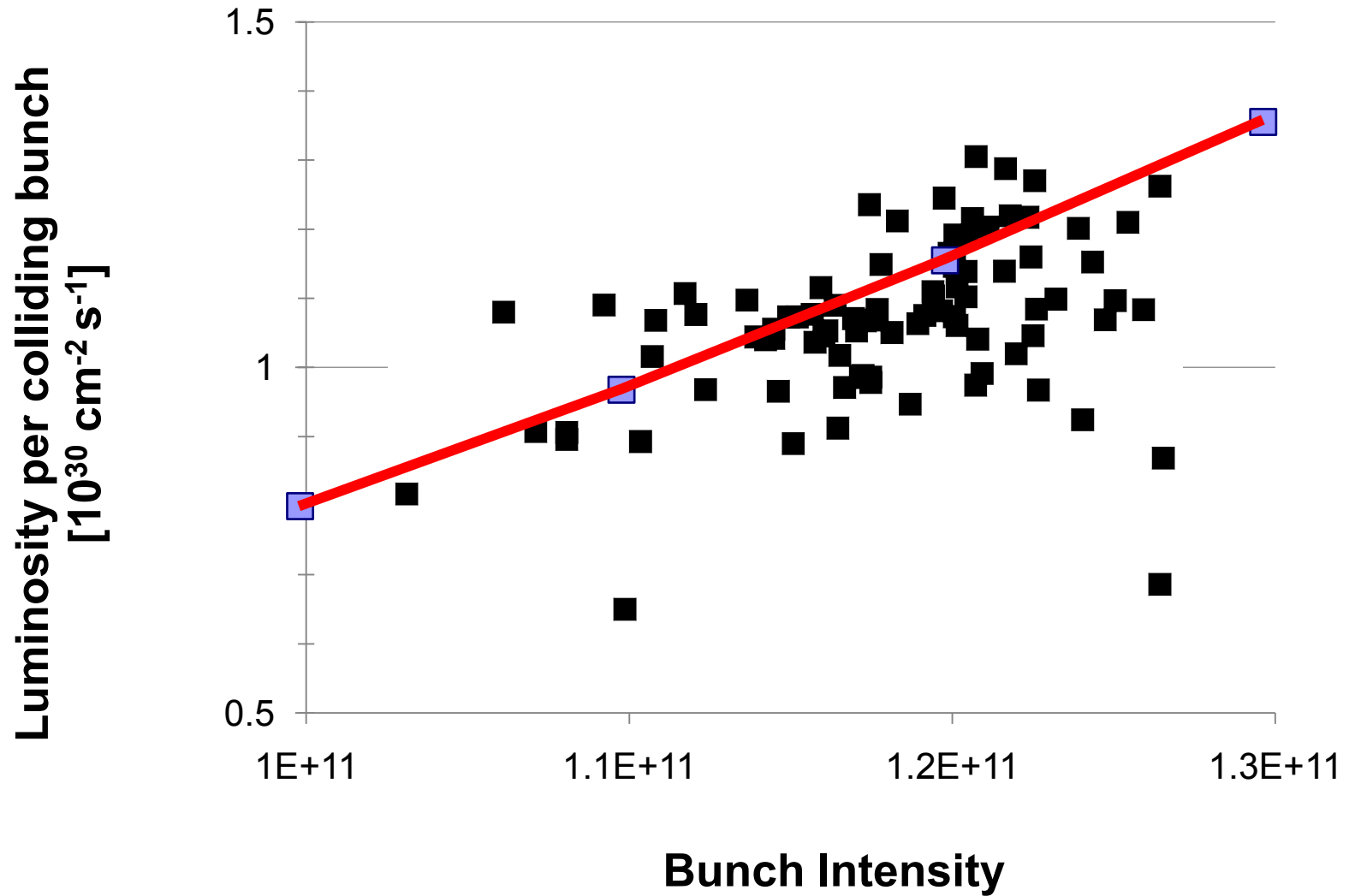
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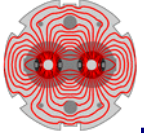
5 **Isolumi** lines give luminosity per colliding bunch in IP1/5 (3.5 TeV, 1.5m beta*) →
4 Multiply with number of colliding bunches to get total peak luminosity!



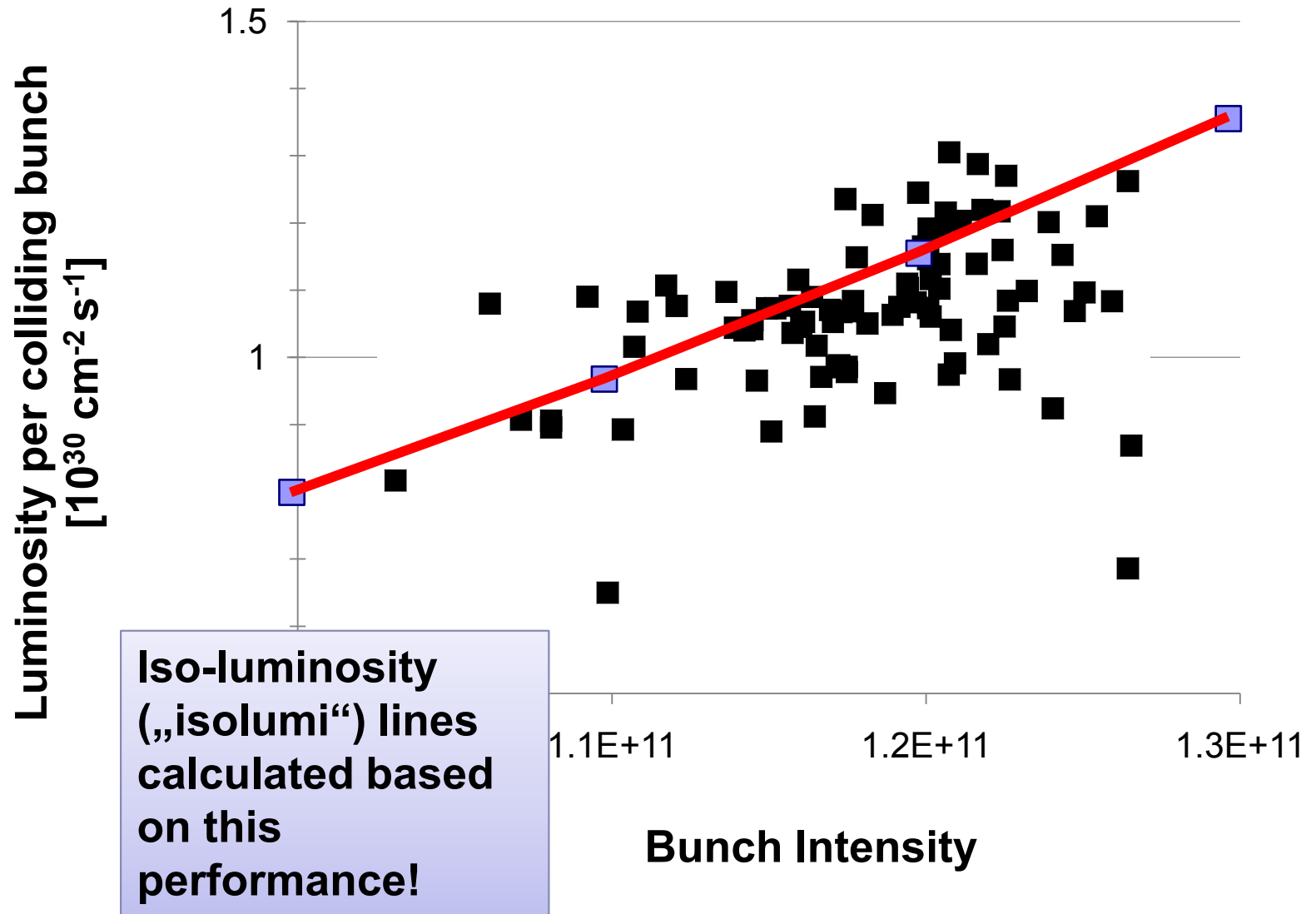


Reached: Luminosity per coll. Bunch (IP1/5)



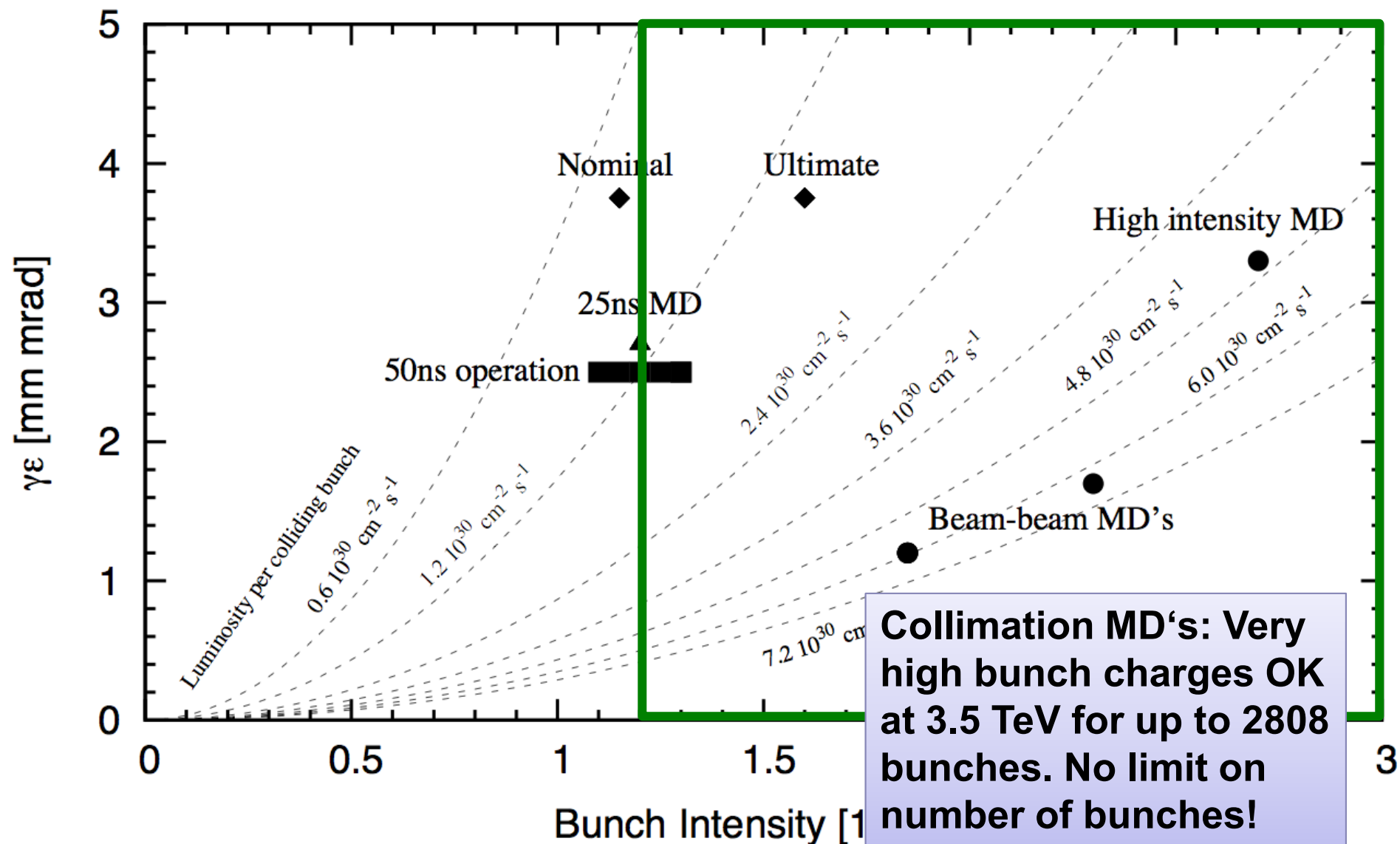


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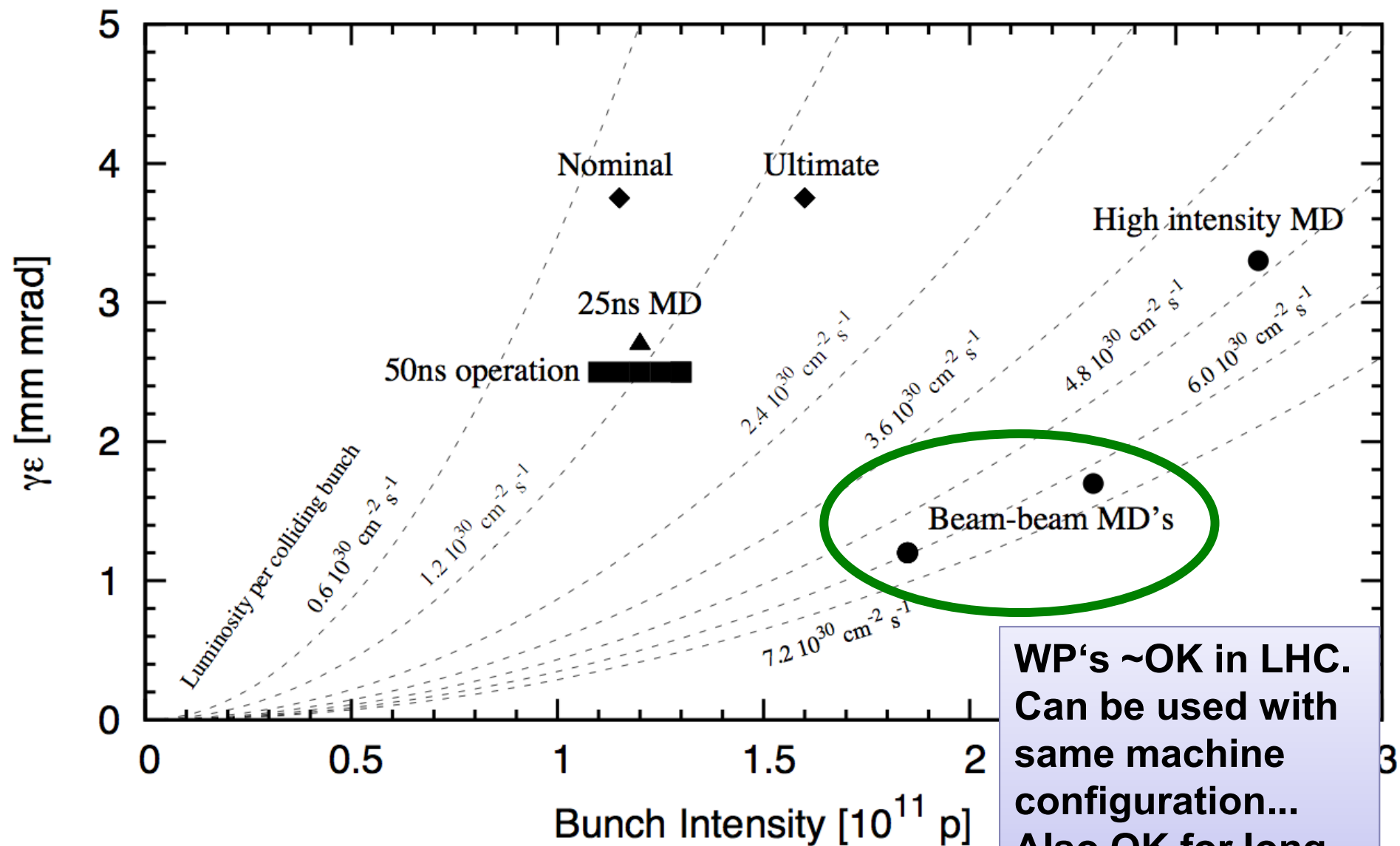


MD Results: Bunch Intensity and Emittance





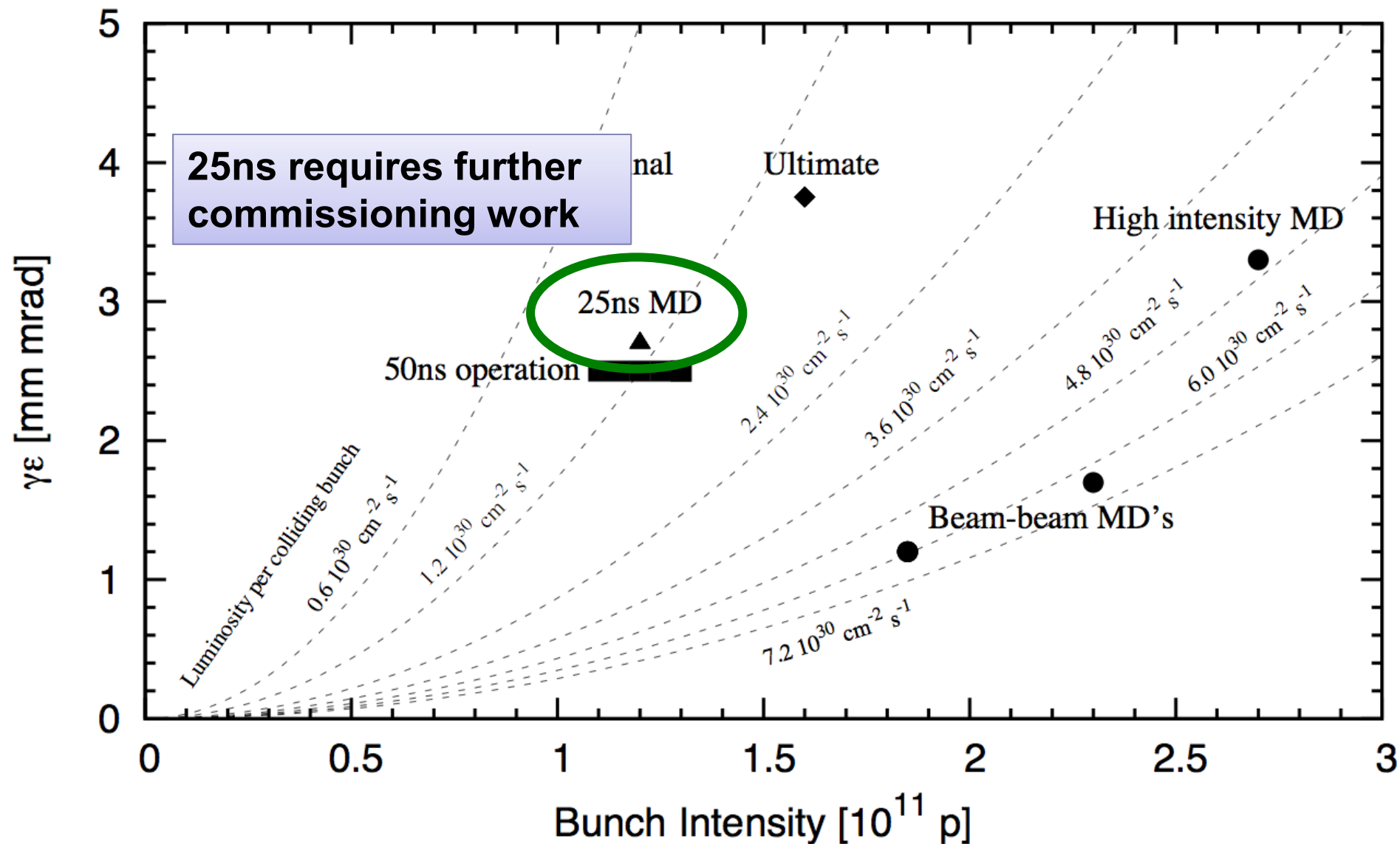
MD Results: Bunch Intensity and Emittance



**WP's ~OK in LHC.
Can be used with
same machine
configuration...
Also OK for long-
range beam-beam!**

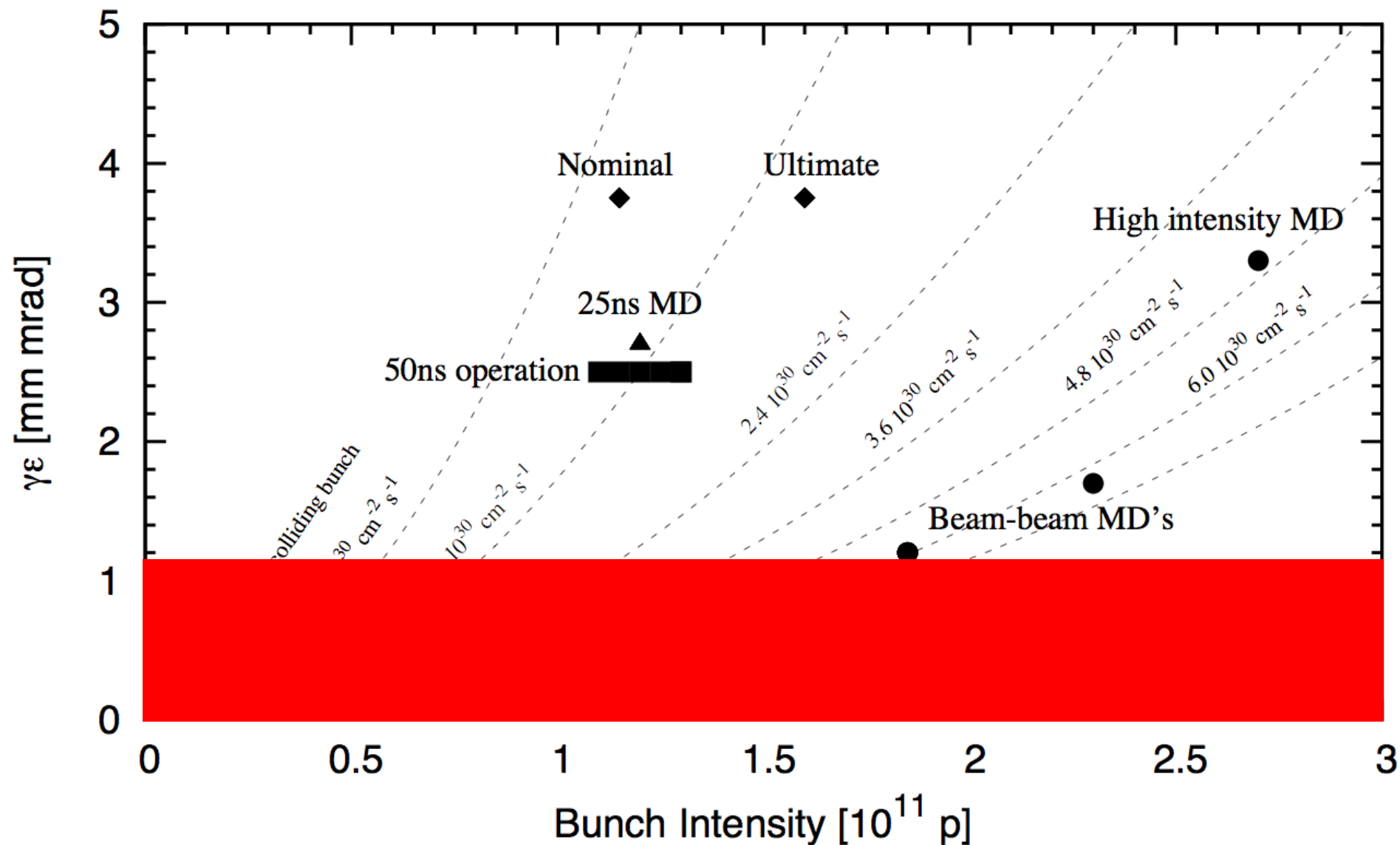


MD Results: Bunch Intensity and Emittance

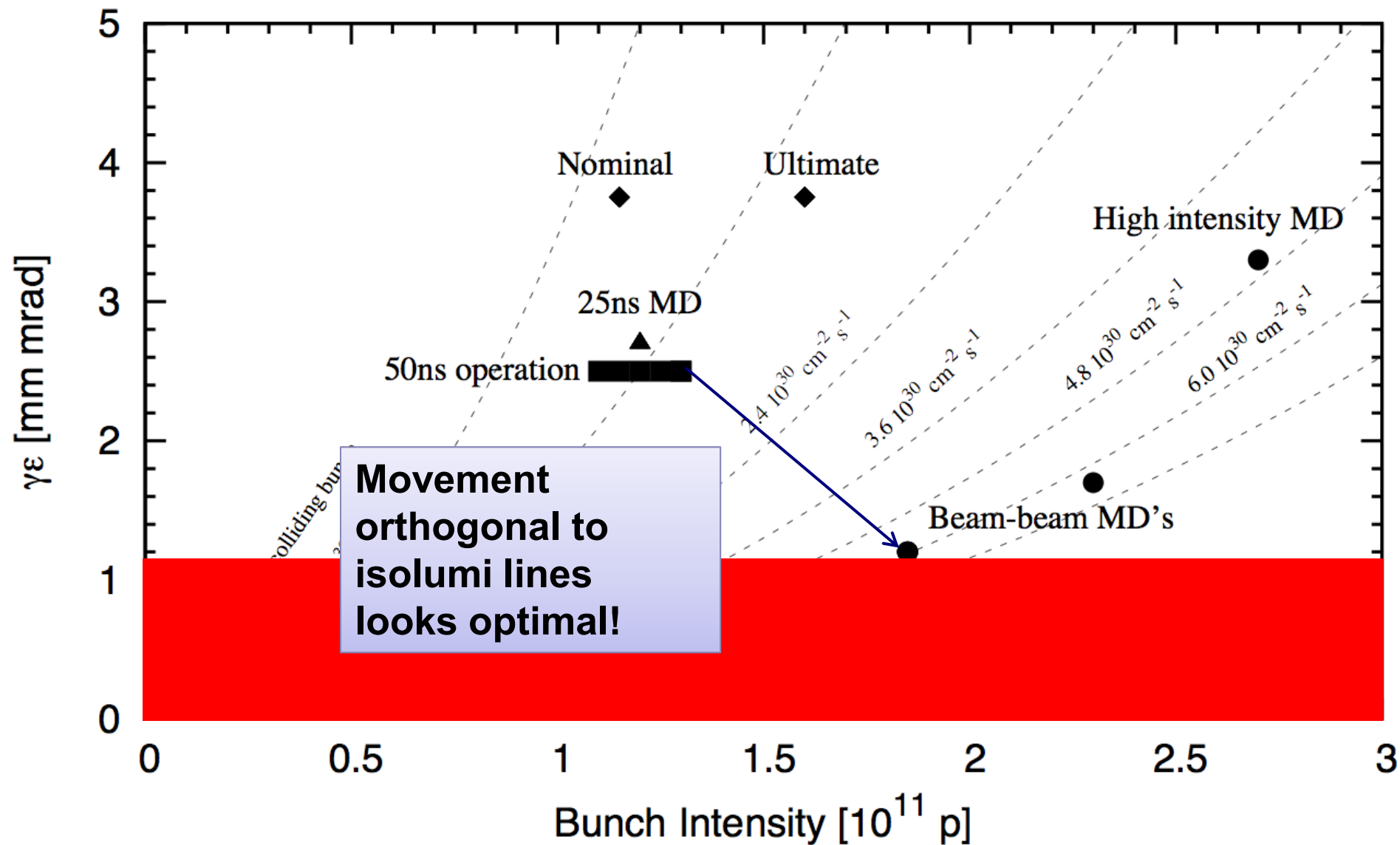




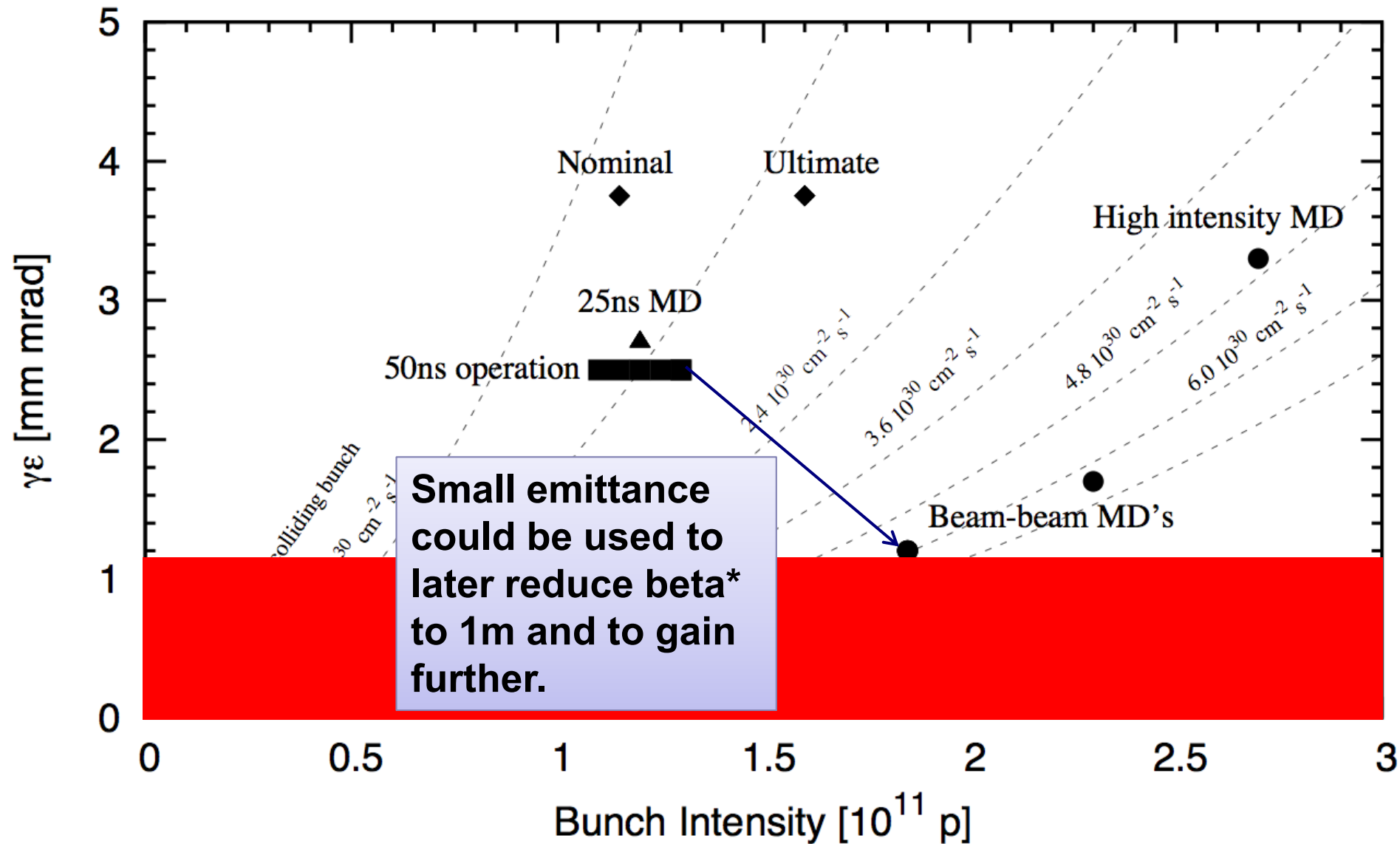
Assume 1.2 mm mrad minimum emittance

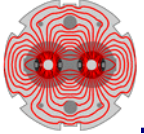


Optimal performance improvement

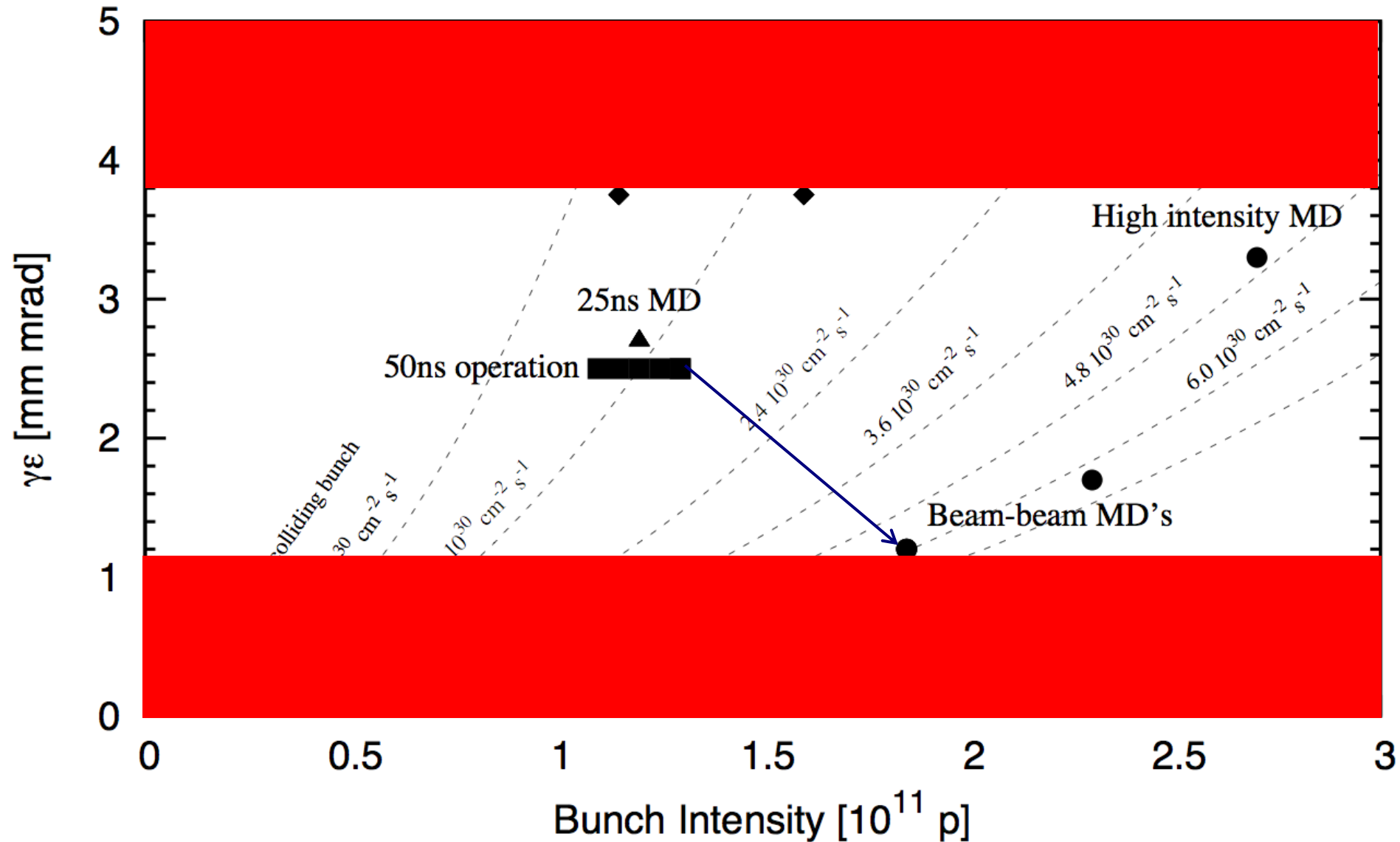


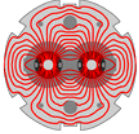
Optimal performance improvement



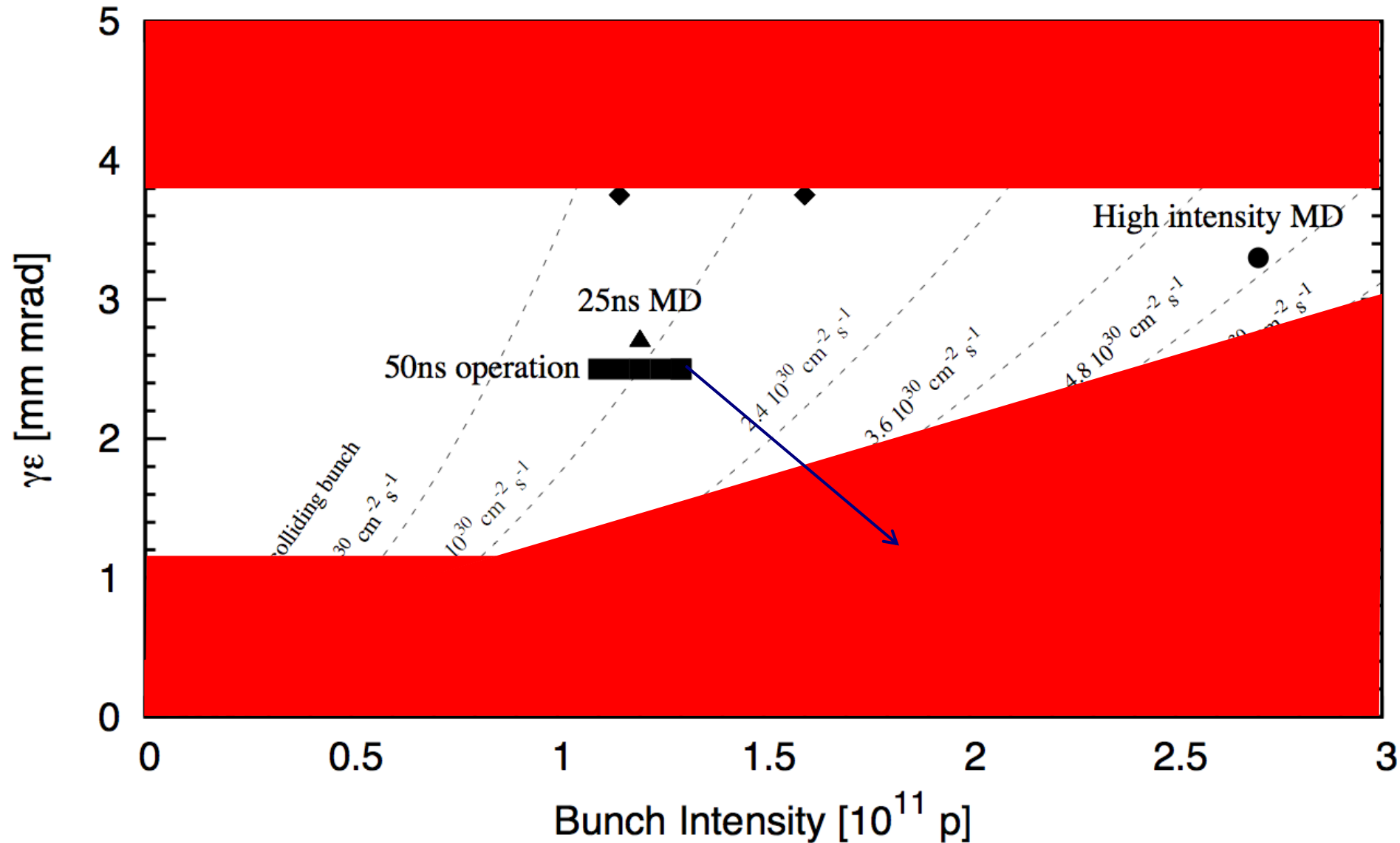


Injection limit on high emittance



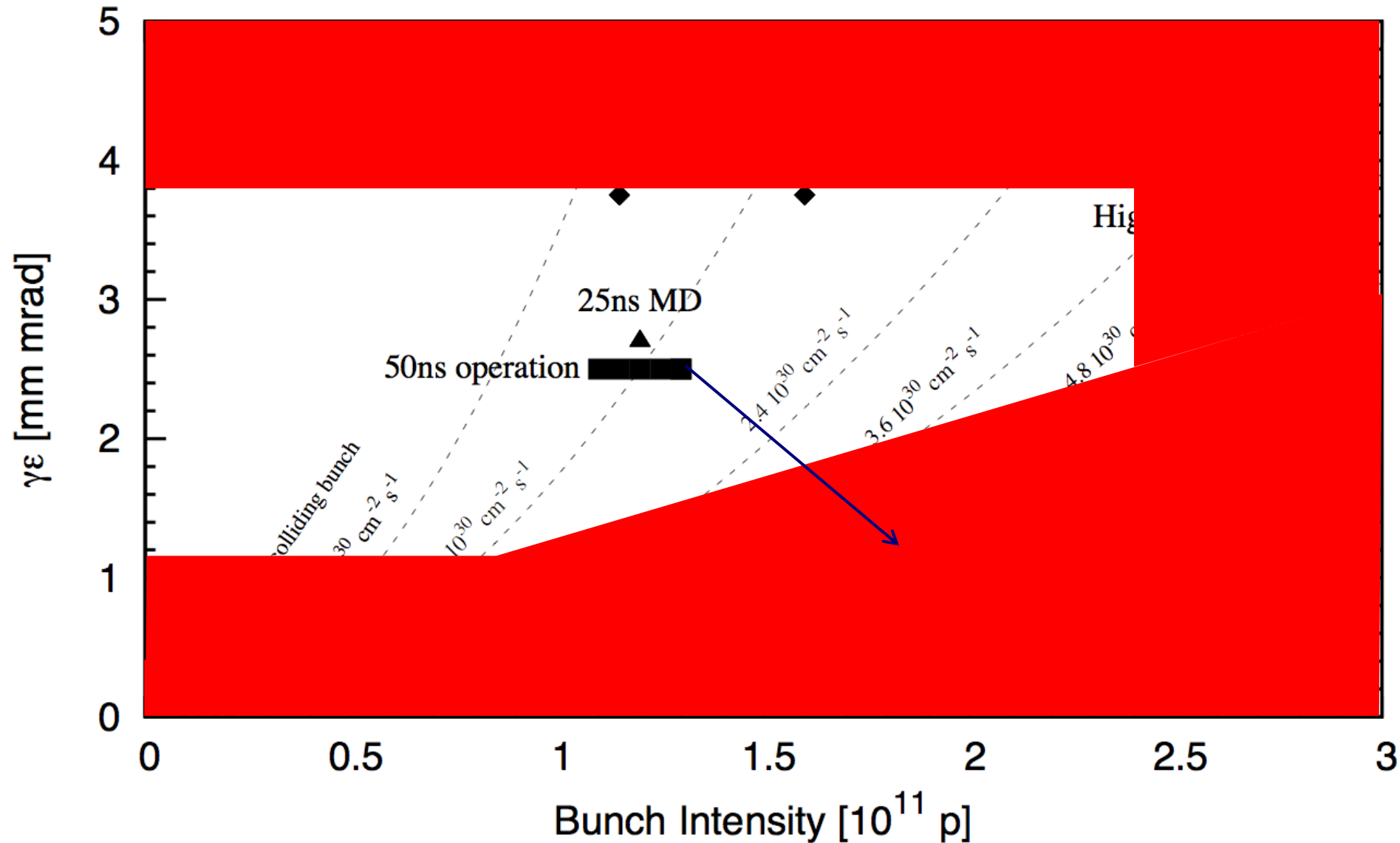


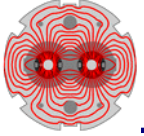
Robustness limit from TCDQ



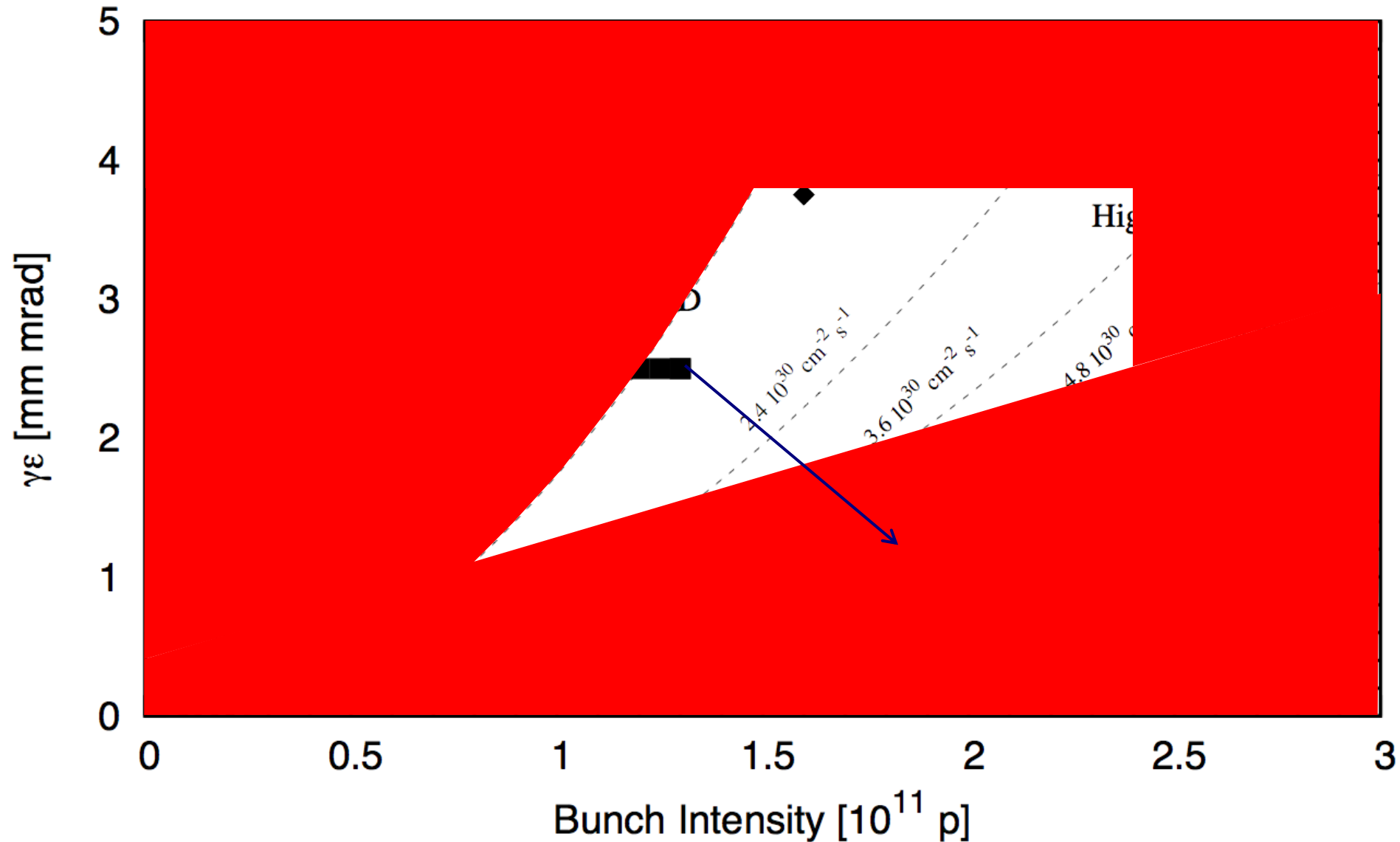


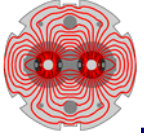
Intensity Limit for Smallish Emittance



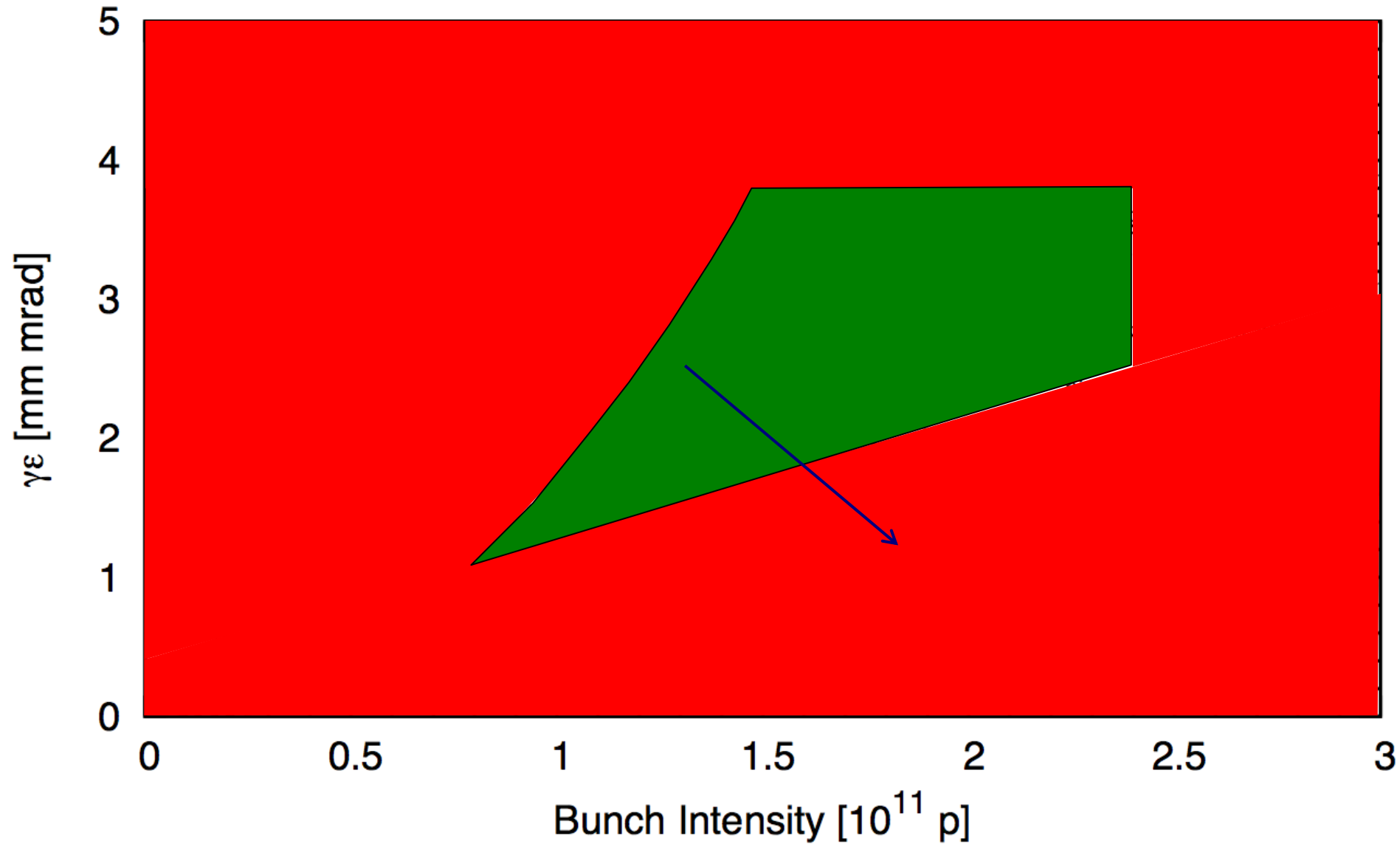


Exclude Region with Lower Luminosity

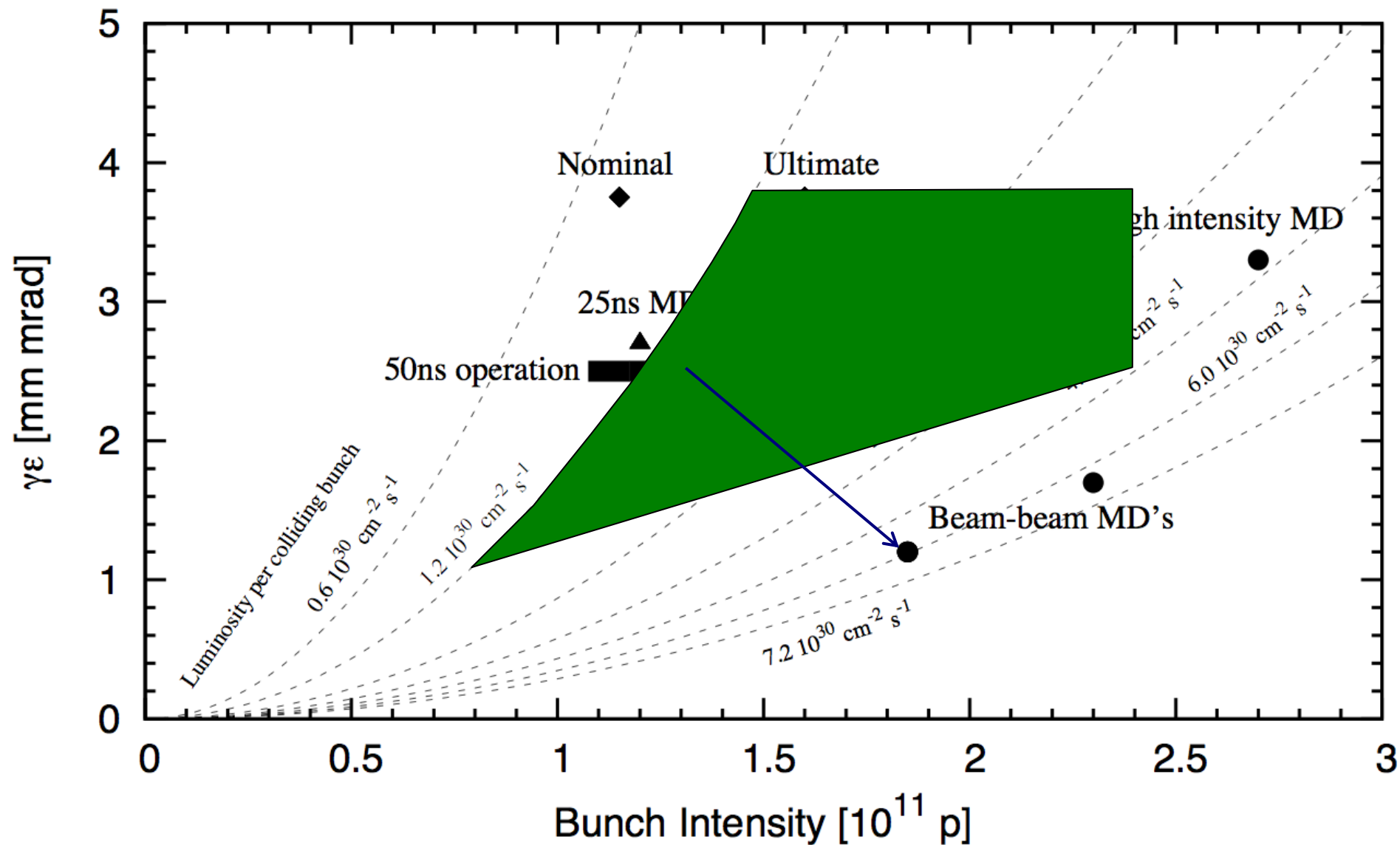


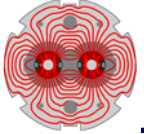


Room for Improvements

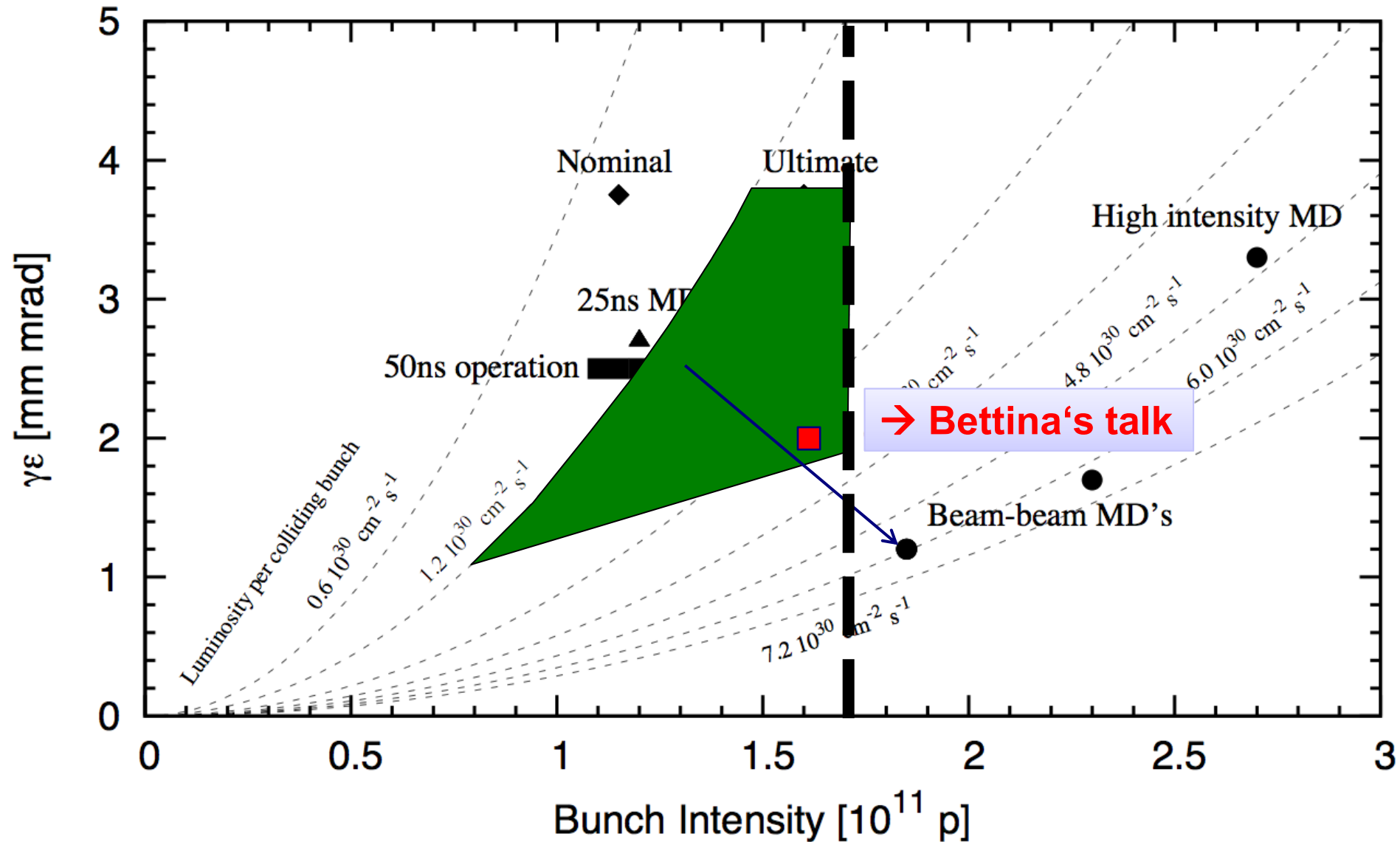


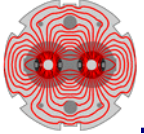
Room for Improvements (LHC only)



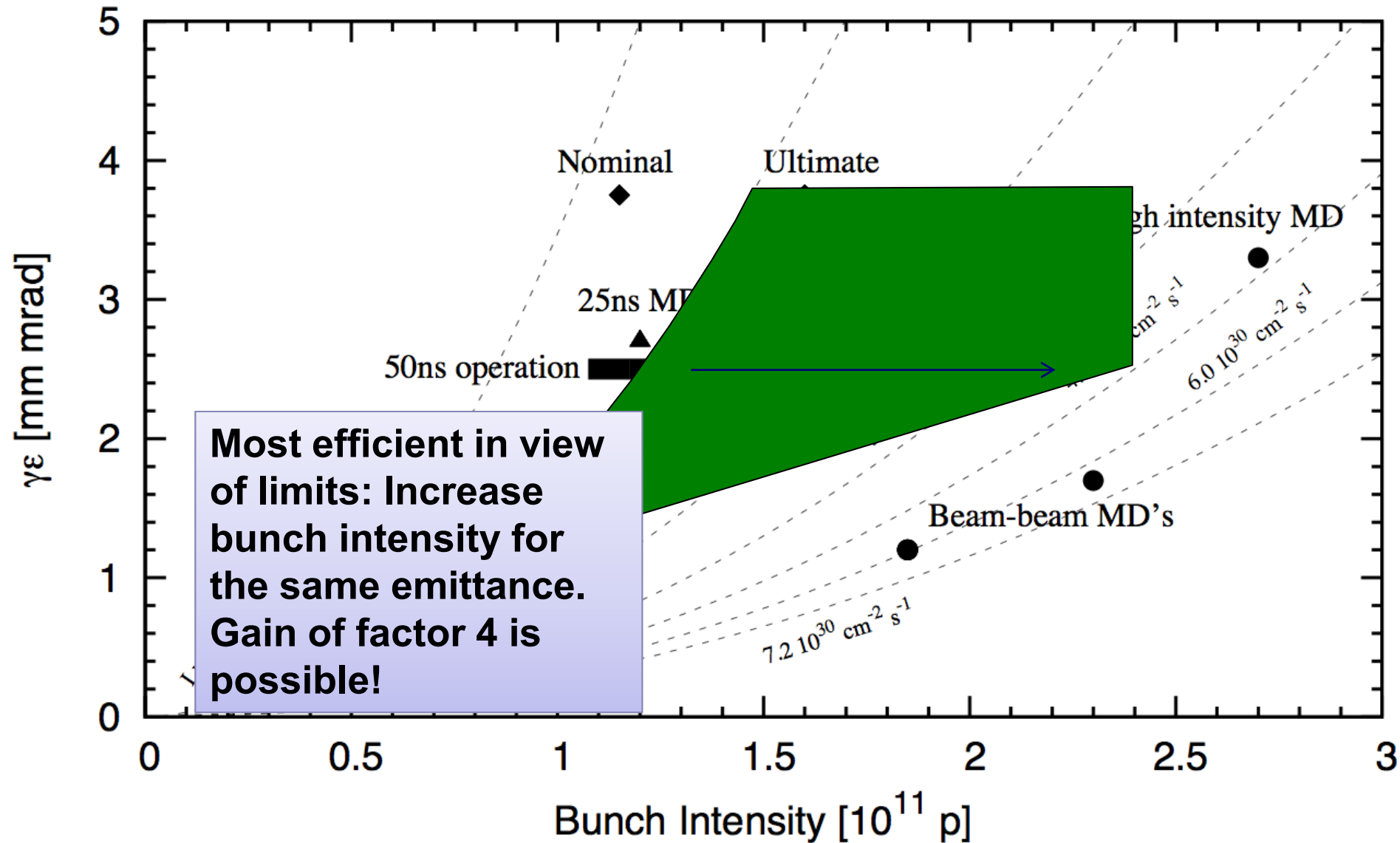


Room for Improvements (with injector limit)

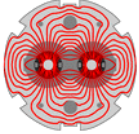




Room for Improvements (LHC only)

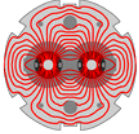


Most efficient in view of limits: Increase bunch intensity for the same emittance. Gain of factor 4 is possible!



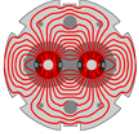
Room for Improvements: Beta*

- Optics MD's (90m, ATS) very successful:
 - Demonstrates efficiency in increasing/reducing beta*.
 - Optics errors small and controllable.
 - No major problem from non-linearities even for very small beta* (0.3m with ATS) → reduces overhead for squeezing further.
- Beta* can be reduced to 1m (→ Roderik).
- Smaller beta* requires tight collimation settings:
 - Machine in a different regime (impedance).
 - Would be useful to test this year to see whether this is workable with high intensity.
 - If successful, could use it as baseline for 2012.



Addressing LHC limits in MD's I

- Small transverse emittance and bunch length → emittance growth can become limiting:
 - Mechanisms for emittance growth in the LHC
 - Longitudinal instabilities
 - Understanding diffusion process, when beams are brought into collision.
 - IBS, longer bunch length, noise of transverse damper, ...
 - High bunch charge effects:
 - Instabilities
 - Emittance growth versus bunch intensity
 - Luminosity lifetime
- ➔ Many of these issues only seen in long stable physics fills
- ➔ Beneficial to push bunch intensity and emittance early to learn about the most important problems. Then study in MD!



Addressing LHC limits in MD's II

■ Beam-beam limits:

- Not yet for head-on. Continue exploring it. Study as function of noise?
- Further tests on long-range beam-beam, versus emittance and bunch spacing, ...

■ Tight collimation settings and impedance:

- High current MD with robust (CFC) collimators moving in
- Most efficient: end of fill MD → go to adjust mode after end of long, high intensity physics fill

■ Lower beta*:

- Tight collimation settings, low beta* and protection can be tested (partly) in MD (no new collimation setup)

■ More bunches → 25 ns:

- Longer trains, e-cloud, beam-beam effects, ...
- Goal: Firm plan and time line for 25 ns scrubbing run



Addressing LHC limits in MD's III

■ Beam instrumentation:

- Smaller emittance requires better calibration, for example to be sure about emittance growth
- Intensity dependent effects
- Bunch by bunch variation stronger close to limit

■ Quench limits:

- Tests at 3.5 TeV to further determine quench limit in dispersion-suppressors and maximum BLM threshold.
- Tests at injection → conclusive or more

■ Heating effects:

- Determine longest acceptable bunch length in LHC.
- Dependence of heating effects on size of “cavity” (can be studied with movable collimator jaws).



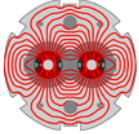
Addressing LHC limits in MD's IV

■ UFO mechanism:

- Understand mechanism at the injection kickers, which have 100 times higher rate than other locations
- UFO's faster than gravity → acceleration towards beam (really?) or evidence for EM effect?

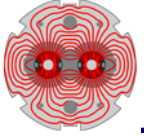
■ Injection limits:

- Extracting beam with Q20 optics in SPS and inject into LHC → long-term program



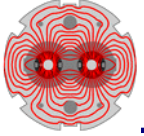
Addressing LHC limits in HiRadMat

- Robustness limits of LHC collimators and protection devices:
 - Cannot be addressed in the LHC with beam tests.
 - Very expensive to learn about damage limits by trial and error in the LHC.
 - This is why the HiRadMat test facility was proposed and constructed.
- HiRadMat tests for addressing robustness limits in LHC:
 - TCT limits for catastrophic damage → propose to equip one spare TCT for a destructive test in HiRadMat.
 - CFC and C collimators: HiRadMat beam parameters allow to test with higher power densities than in 2004 and 2006. Push test intensity to gain margin!
 - TCDQ: ?

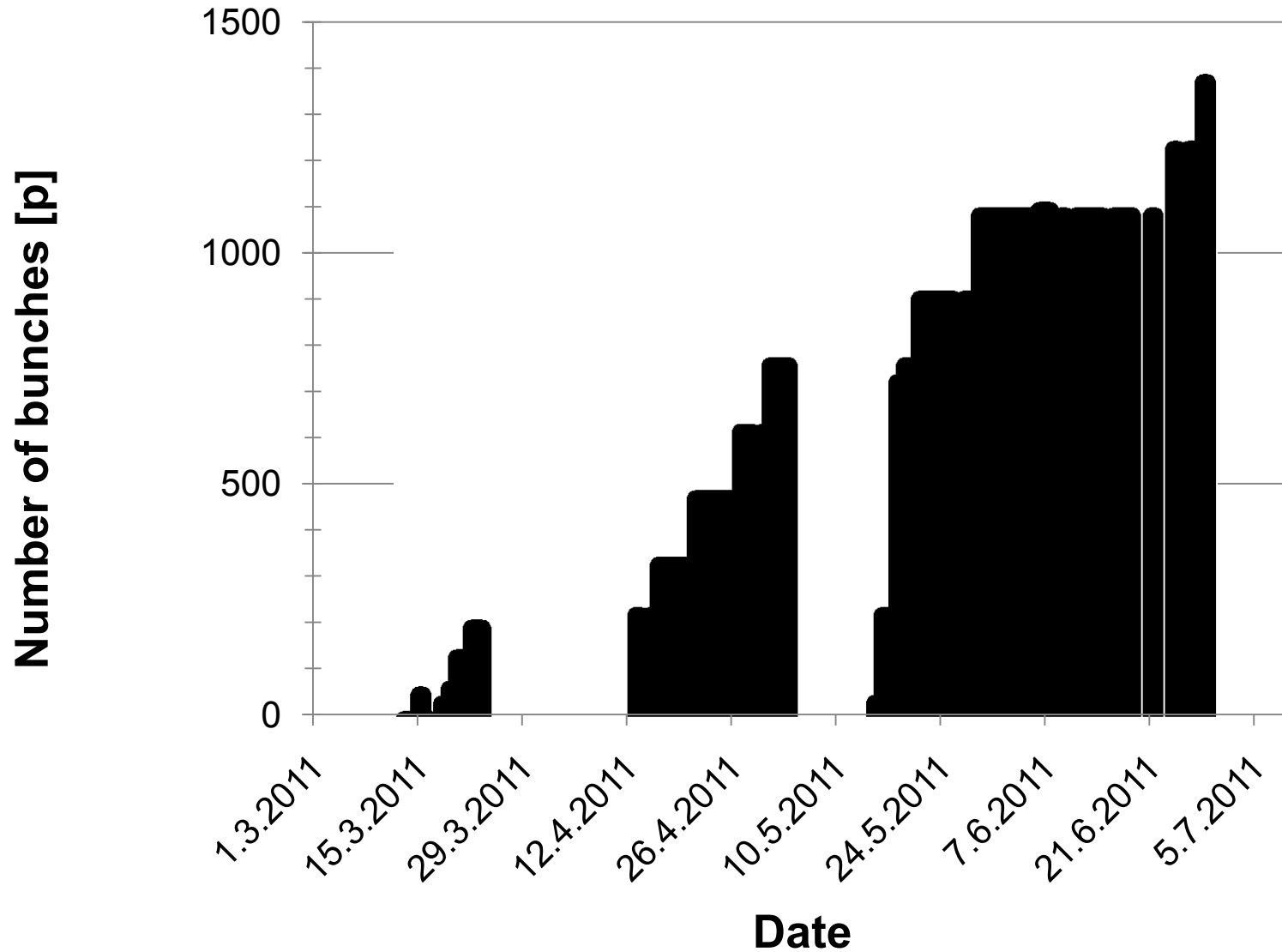


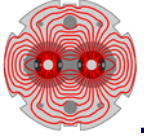
Comments and Feedbacks Welcome...

- Outcome of Mini-Chamonix will impact plans for next MD's
- Start discussing draft plan for end-of-August MD next week...

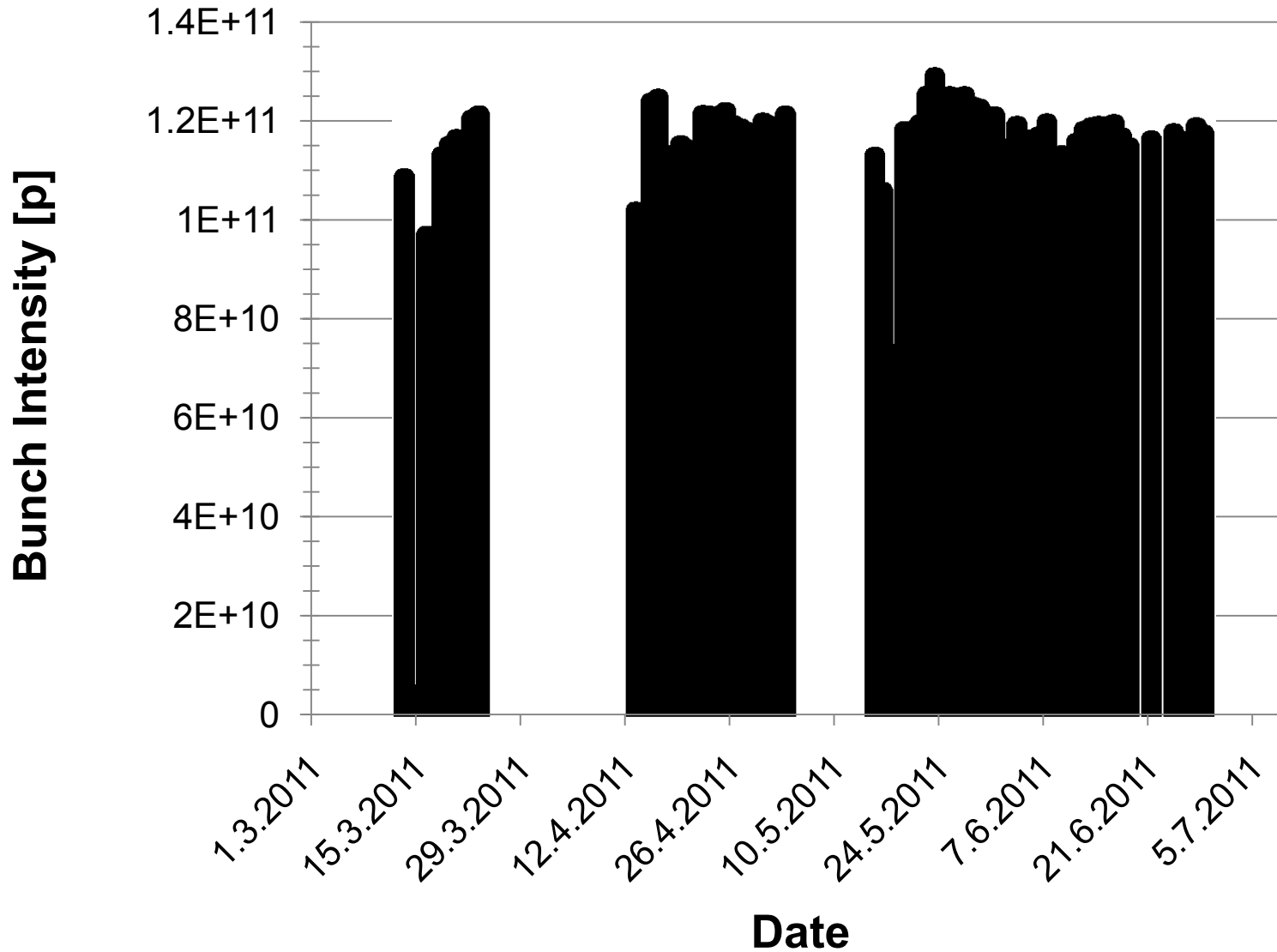


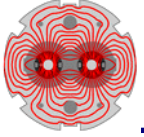
Reached: Number of bunches



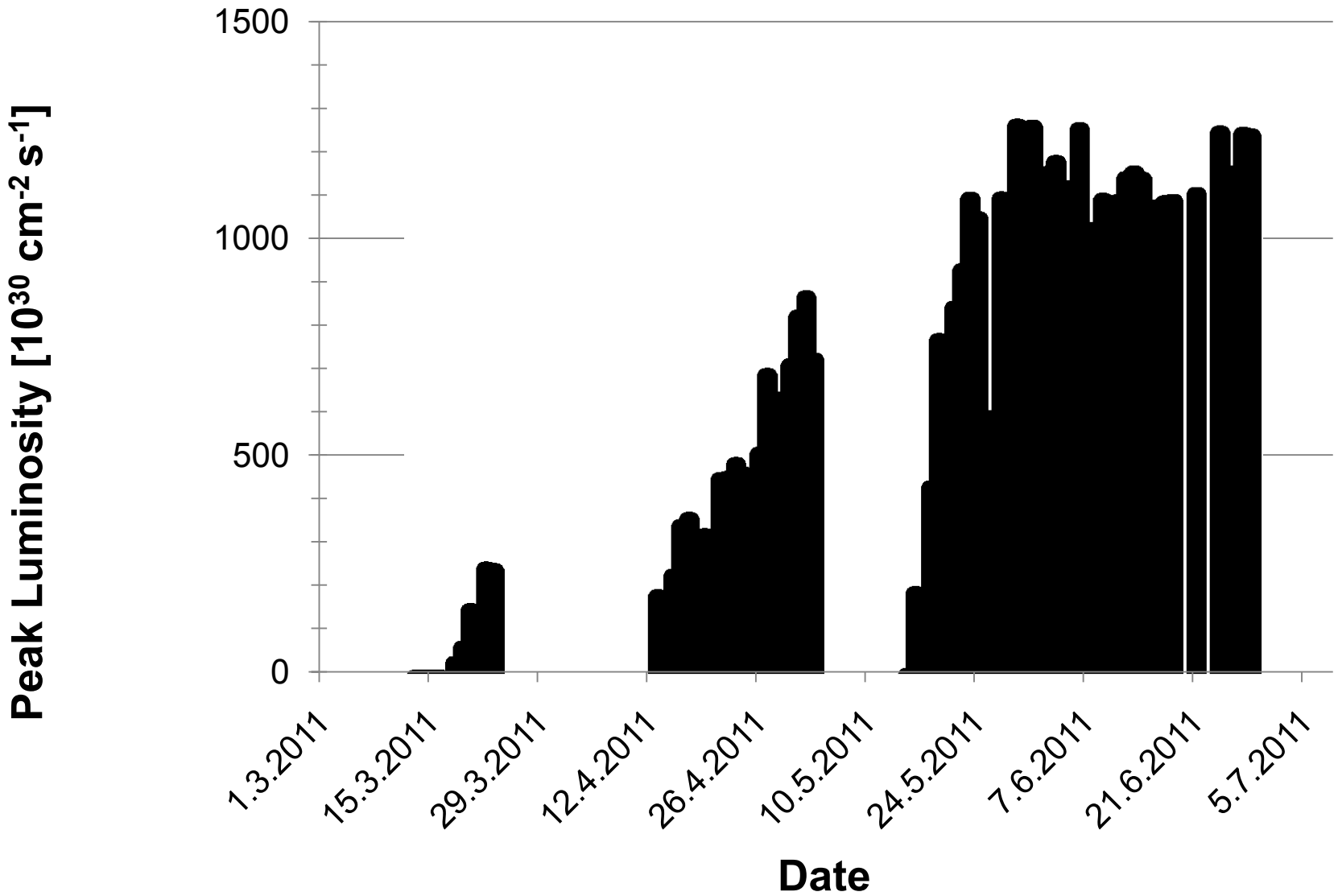


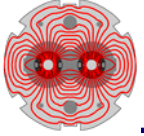
Reached: Bunch intensity





Reached: Peak luminosity





Reached: Stored energy

