LONGITUDINAL-TO-TRANSVERSE LANDAU DAMPING FOR HL-LHC

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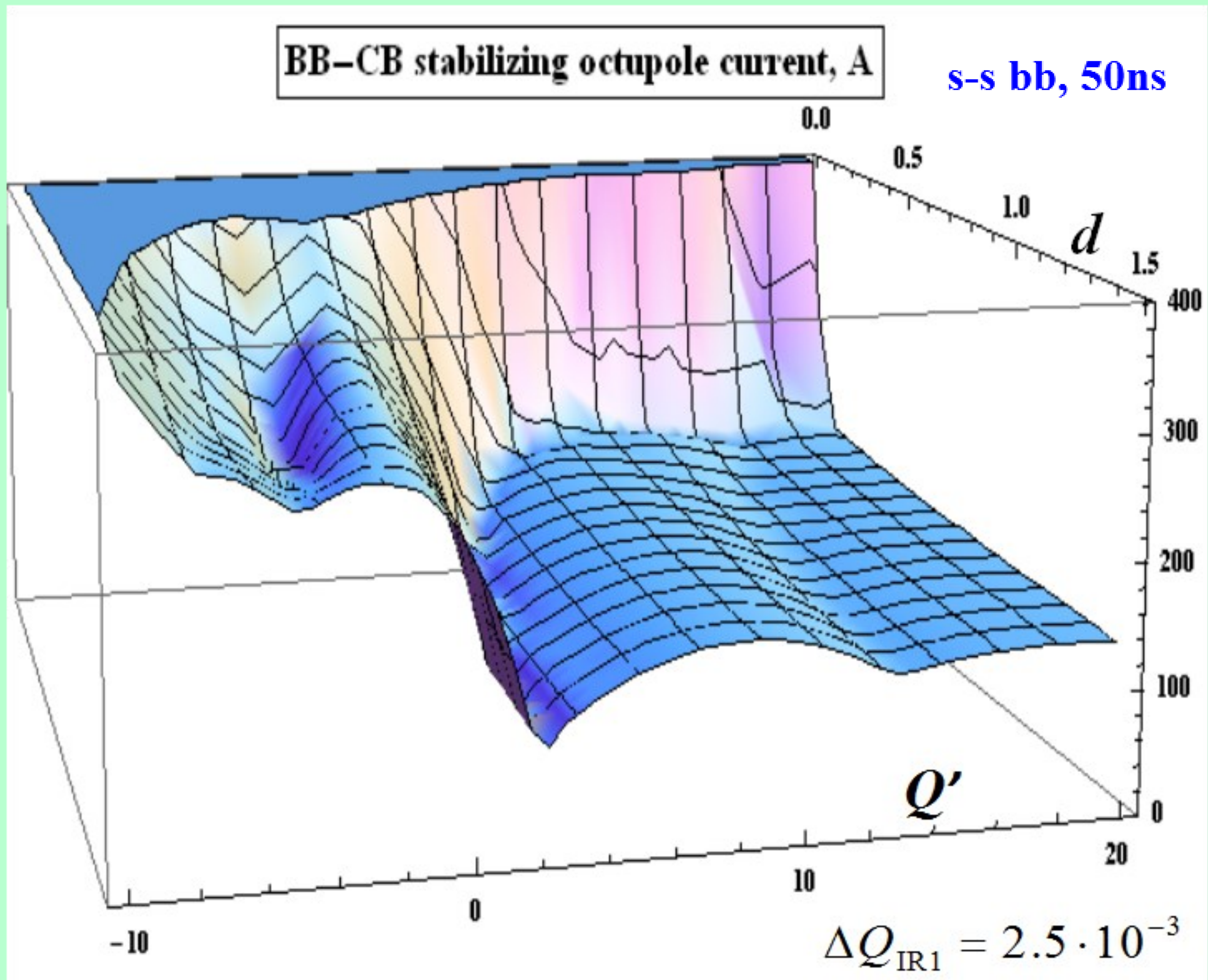
Aims

- Transverse coherent beam stability was a limitation for the LHC performance in 2012. In the HL(High-Luminosity)-LHC era, the requirements will be even more stringent and solutions to stabilize the beam need to be found.
- One possibility is to use the stability coming from the longitudinal plane.
- The analytical Nested Head-Tail Vlasov Solver (NHT) [1] code has been developed recently but the longitudinal degree of freedom on the transverse Landau damping is missing. The challenge of this study is to include it in the NHT code and to make it as user-friendly as possible.



NHT for LHC (end of squeeze) by Alexey Burov

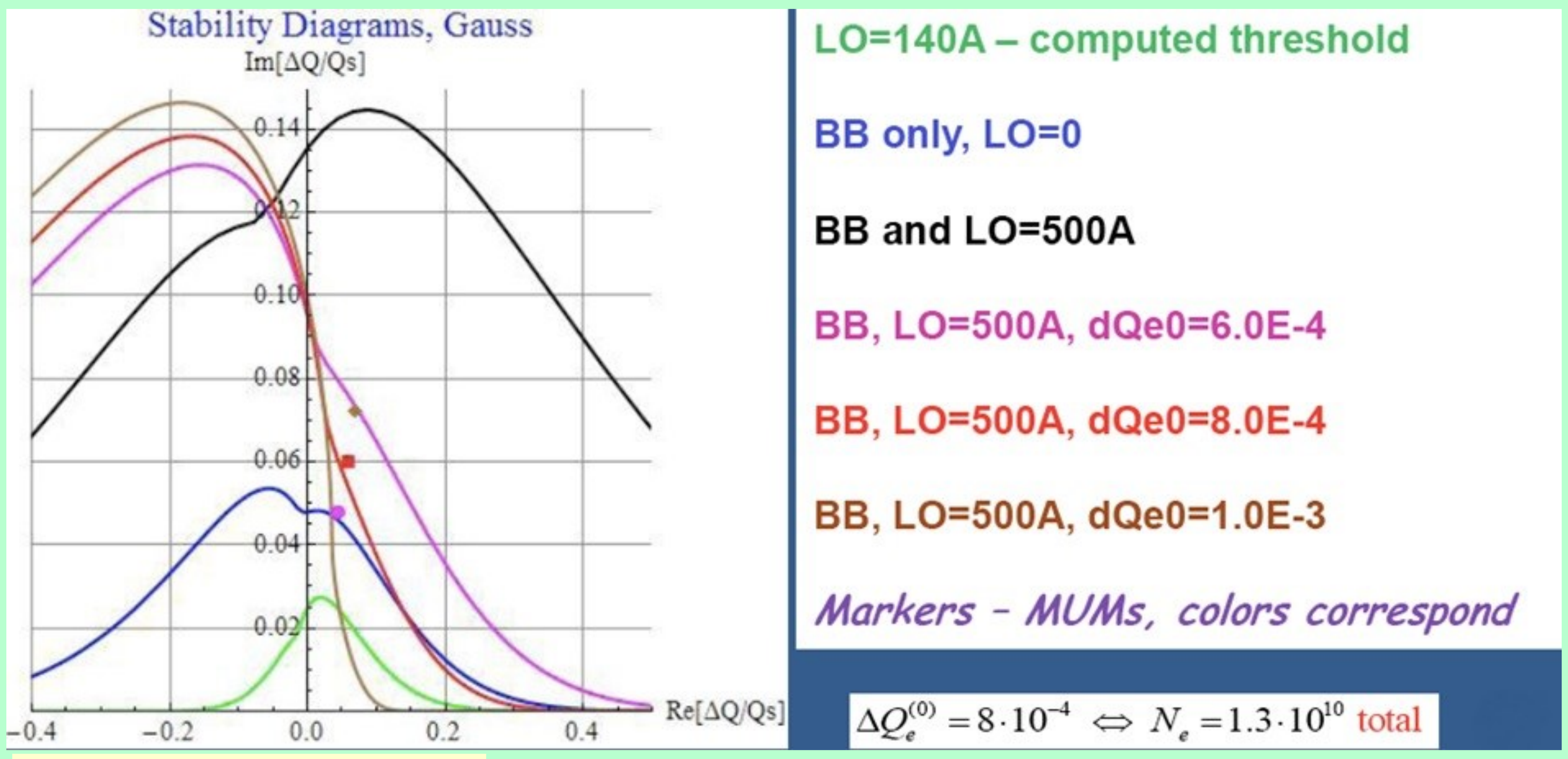
WHY DO WE NEED IT?

Transverse collective instabilities of high-intensity and high-brightness beams are one of the most important limitations to achieve the highest luminosities in the LHC and an instability at the end of the squeeze has been regularly observed during the LHC Run I, but not understood yet, however there is a hypothesis of Three-Beam Instability, which suggests explanation and suggests simulations for confirmation [2]. Therefore it represents a potential serious limitation for the future, which gives a strong motivation to look for additional ways of beam stabilization.

WAYS FOR BEAM STABILITY

To provide a better stability, the LHC is equipped by a bunch-by-bunch transverse damper. If the damper gain is sufficiently high, the collective modes, still remaining unstable, are only those with zero centroid motion. For their stabilization, the LHC is equipped by Landau octupoles giving rise to Landau damping. However, with higher energy, the efficiency of the octupoles as Landau elements will drop; thus, their capabilities may be insufficient for the future high-energy and high-intensity LHC operations. On top of that, octupole fields may lead to lifetime degradation, which can set another limitation for their use. That is why beam stabilization introduced both by the damper and the octupoles can be insufficient for the future high-luminosity goals. This danger is stressed by the fact that an instability at the end of the squeeze has been regularly observed during the LHC Run I at the maximally available damper gain and octupole current [3].

INTERPLAY BETWEEN IMPEDANCE, BEAM-BEAM AND E-CLOUD



Alexey Burov [2]

LANDAU DAMPING

One more possible resource for that is a nonlinearity coming to the transverse oscillations from the longitudinal degree of freedom, leading to longitudinal-to-transverse Landau damping (LTLD). This sort of Landau damping affects the transverse oscillations both by means of the bucket nonlinearity and by the second-order chromaticity. For the theoretical part, LTLD is supposed to be introduced in the Nested Head-Tail Vlasov Solver (NHT), which already includes many important features of the LHC beams.

EXPECTED RESULTS:

- Implement the bucket nonlinearity and the second-order chromaticity in the NHTVS and benchmark the results with the HEADTAIL code [4].
- Compare HEADTAIL simulation results with results done in NHT and BeamBeam3D (Simon White).
- Compare the new theoretical (NHT) and simulation (HEADTAIL) results with past measurements in the LHC in 2012 and hopefully new results in 2015 when the machine will restart.
- Make some predictions for the HL-LHC era.

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