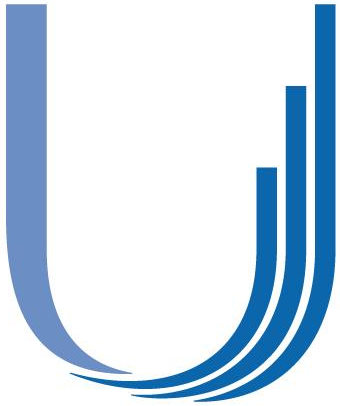

LHC Injectors Upgrade

LHC Injectors Upgrade

Beam Studies: Progress in the PSB

E. Benedetto,
J. Belleman, C. Carli, J-F. Comblin, A. Findlay, V. Forte, M. Gourber-Pace, K. Hanke, G. Kruk, K. Li, M. Martini, M. McAteer, B. Mikulec, A. Molodozhentsev, N. Mounet, V. Raginel, G. Rumolo, J. Sanchez, F. Schmidt, J. Tan, R. Tomas
and all those involved in PSB beam studies

CERN

Outline

- Beam production for LHC:
  - Optimized curve Emittance vs. Intensity (Ring 3)
  - Low emittance beams for BCMS (h=9 injection in the PS)

- MDs for “longer term” studies:
  - Beam-based optics model
  - Space charge
  - Instabilities and impedance

Outline

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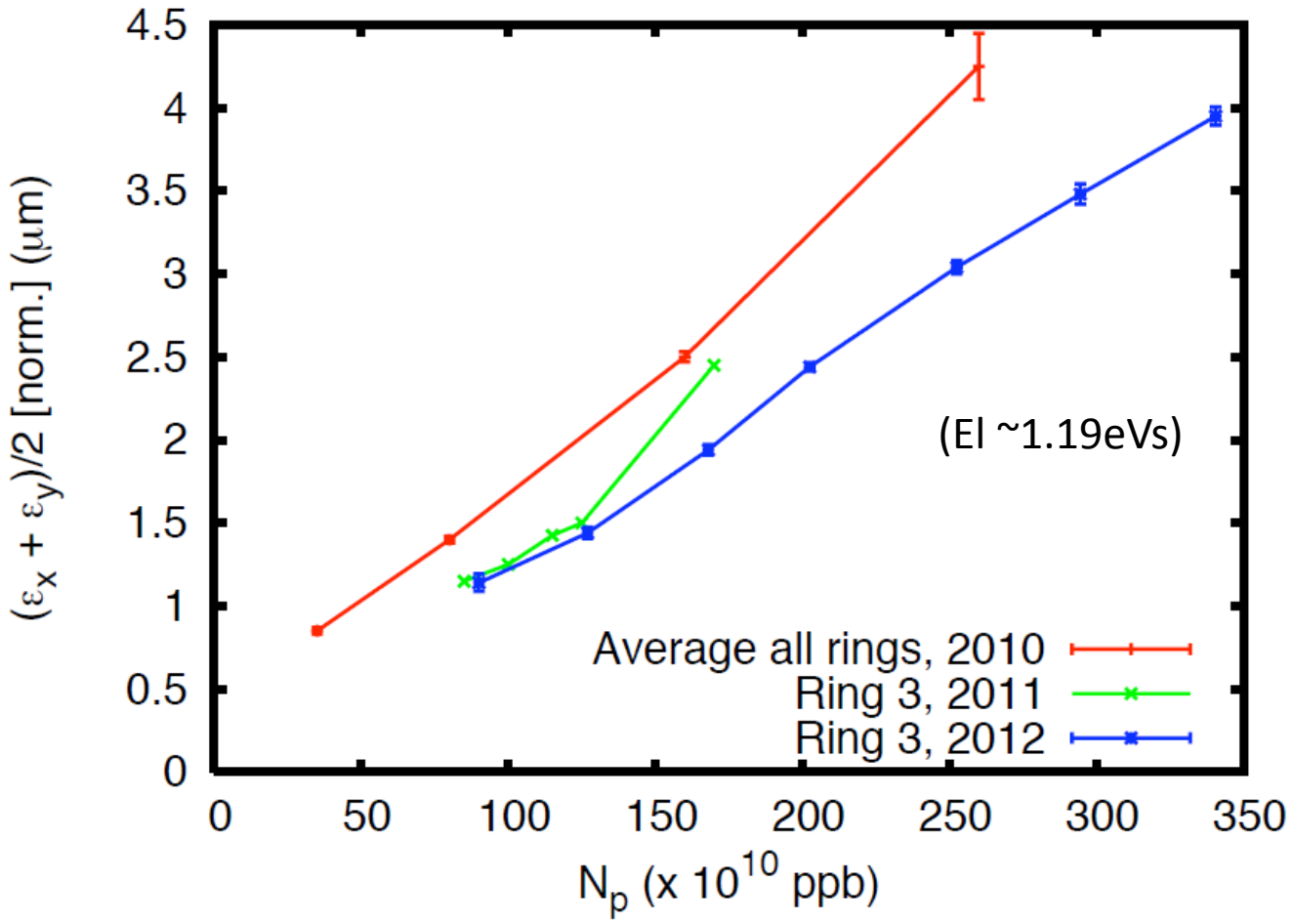
Optimized Emittance vs. Intensity

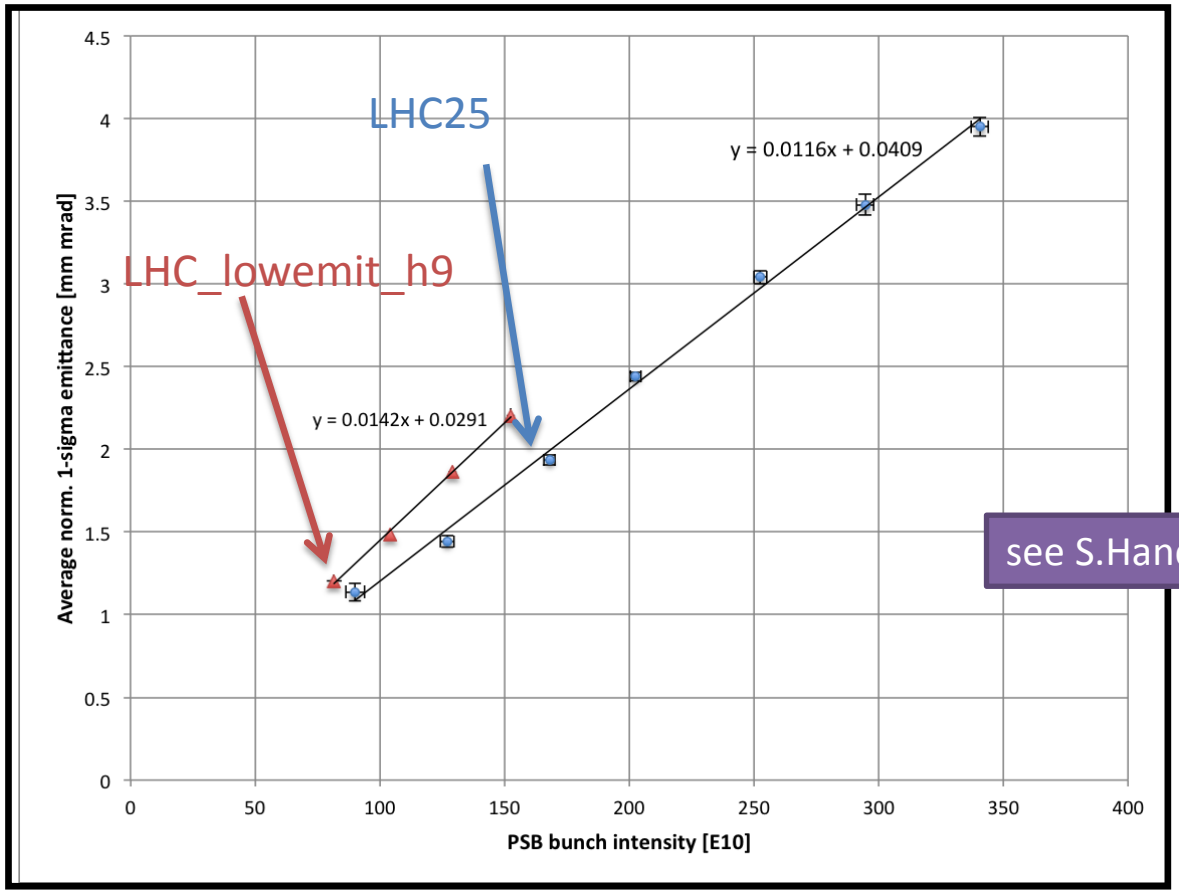
B. Mikulec , K. Hanke



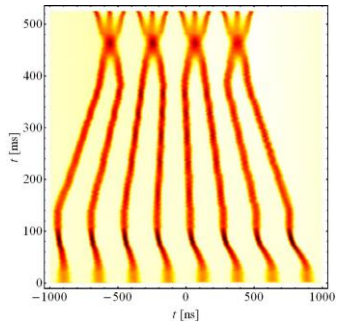
- For every Intensity point: optimized Injection + capture + tune
- (Ring 3)

Low emittance beams for BCMS (h9) in PS

A. Findlay, B. Mikulec



see S.Hancock's presentation

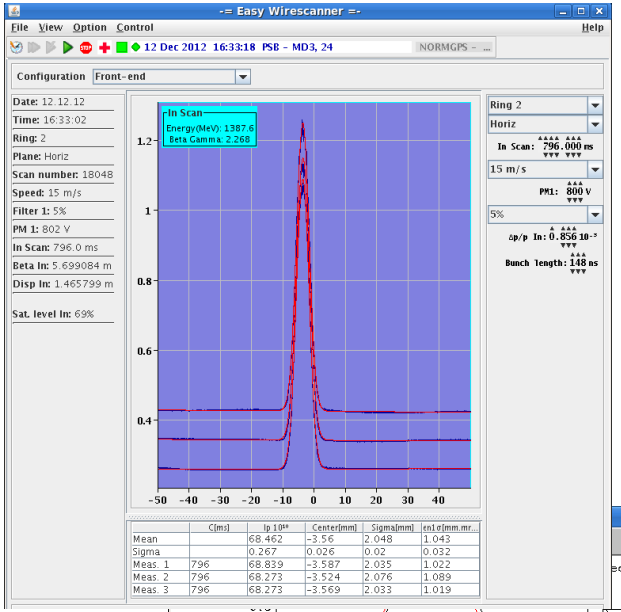


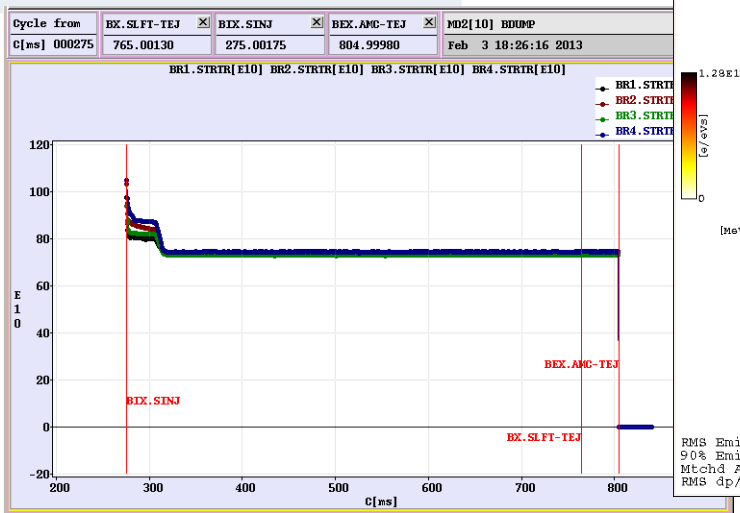
- For a given LHC bunch intensity:
  - Smaller intensity/bunch in PSB ⇒ Smaller transverse emittance (in LHC)

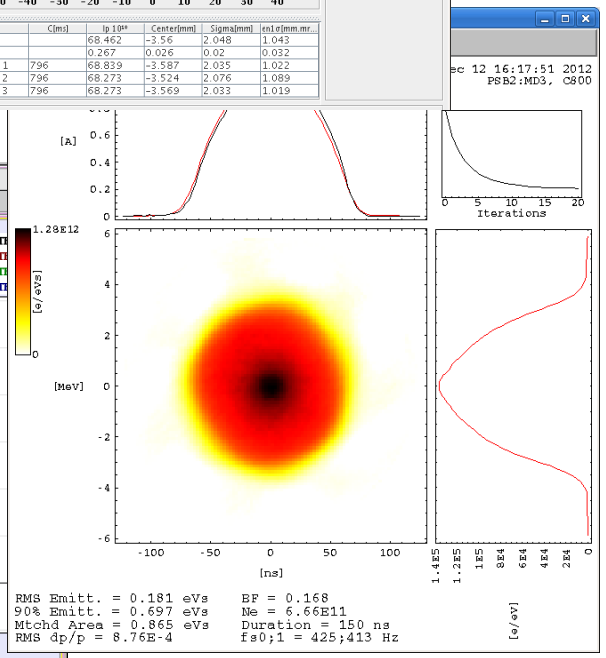
Low emittance beams for h9

A. Findlay

@ PSB extraction	LHC25_el_h9
Intensity	70-75 10^{10}
(Ex+Ey)/2	~1um
Longitud. Emittance	0.8-0.95 eVs
Bunch length	~140 ns
Spacing @ PS inj	257ns (h9)
N of bunches	2 batches x 4 bunches(h1)
Shaving	Vertical
Tune	4.20, 4,40







Outline

- Beam production for LHC:
  - Optimized curve Emittance vs. Intensity (Ring 3)
  - Low emittance (E<1um) beams for LHC 50ns with h9

- MDs for “longer term” studies:
  - Beam-based optics model
  - Space charge
  - Instabilities and impedance

Optics Measurements

M. McAteer, J. Belleman, C. Carli , A. Findlay, B. Mikulec, R. Tomás

- Determine the distribution of focusing errors
- Orbit Response Matrix
  - Using the 13 available* dipole correctors in all 4 Rings
  - Commissioning of corrector dipoles (polarities, calibration,…)

- Turn-by-turn acquisition for optics and resonance driving terms
  - From three BPMs (with turn by turn electronics)
  - Beam excitation with kick (max offset 1mm, 10x > noise level)
  - Beam excitation with TFB system (max peek to peek 3mm, possibly larger in the future as only one plate was firing)

* After LS1, 8 corrector (4 H, 4 V) will be powered per ring

Optics Measurements

M. McAteer, J. Belleman, C. Carli , A. Findlay, B. Mikulec, R. Tomás

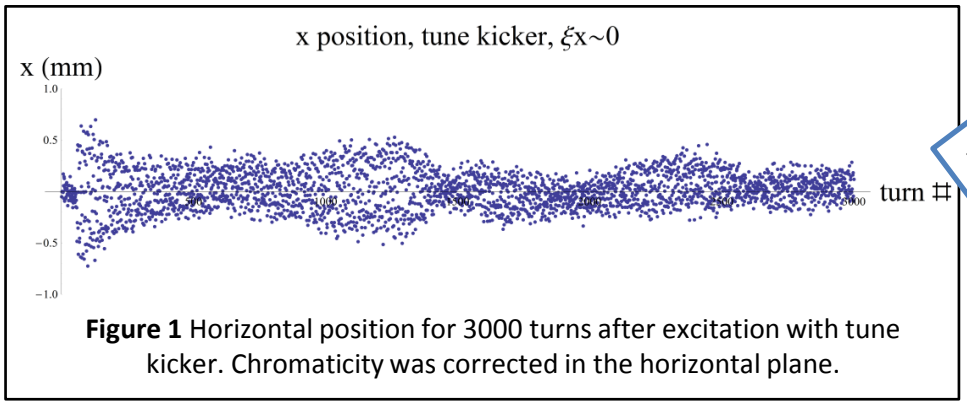


Figure 1 Horizontal position for 3000 turns after excitation with tune kicker. Chromaticity was corrected in the horizontal plane.

PRELIMINARY

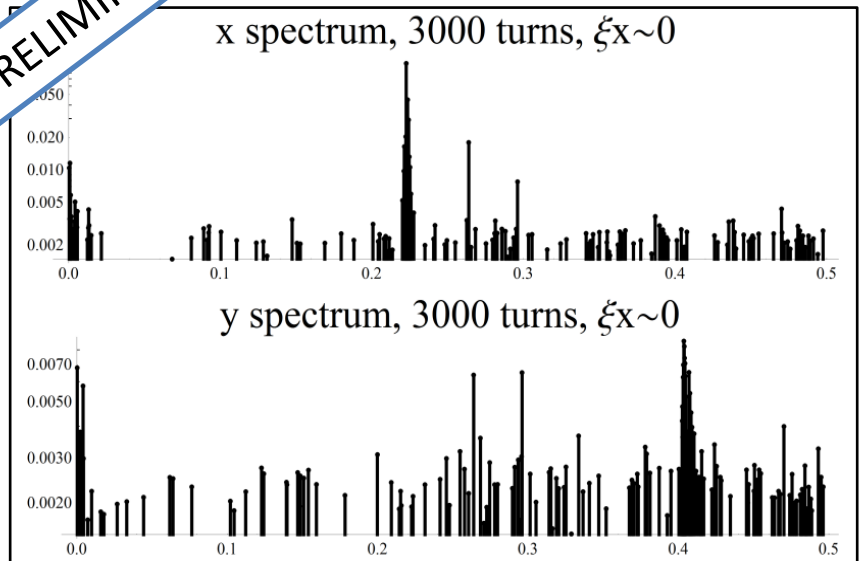


Figure 2 SUSSIX spectrum from measured position for 3000 turns after excitation with tune kicker.

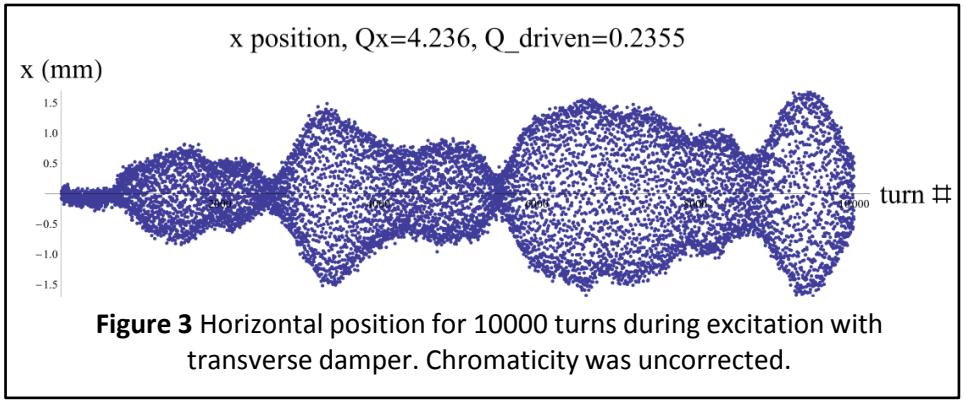
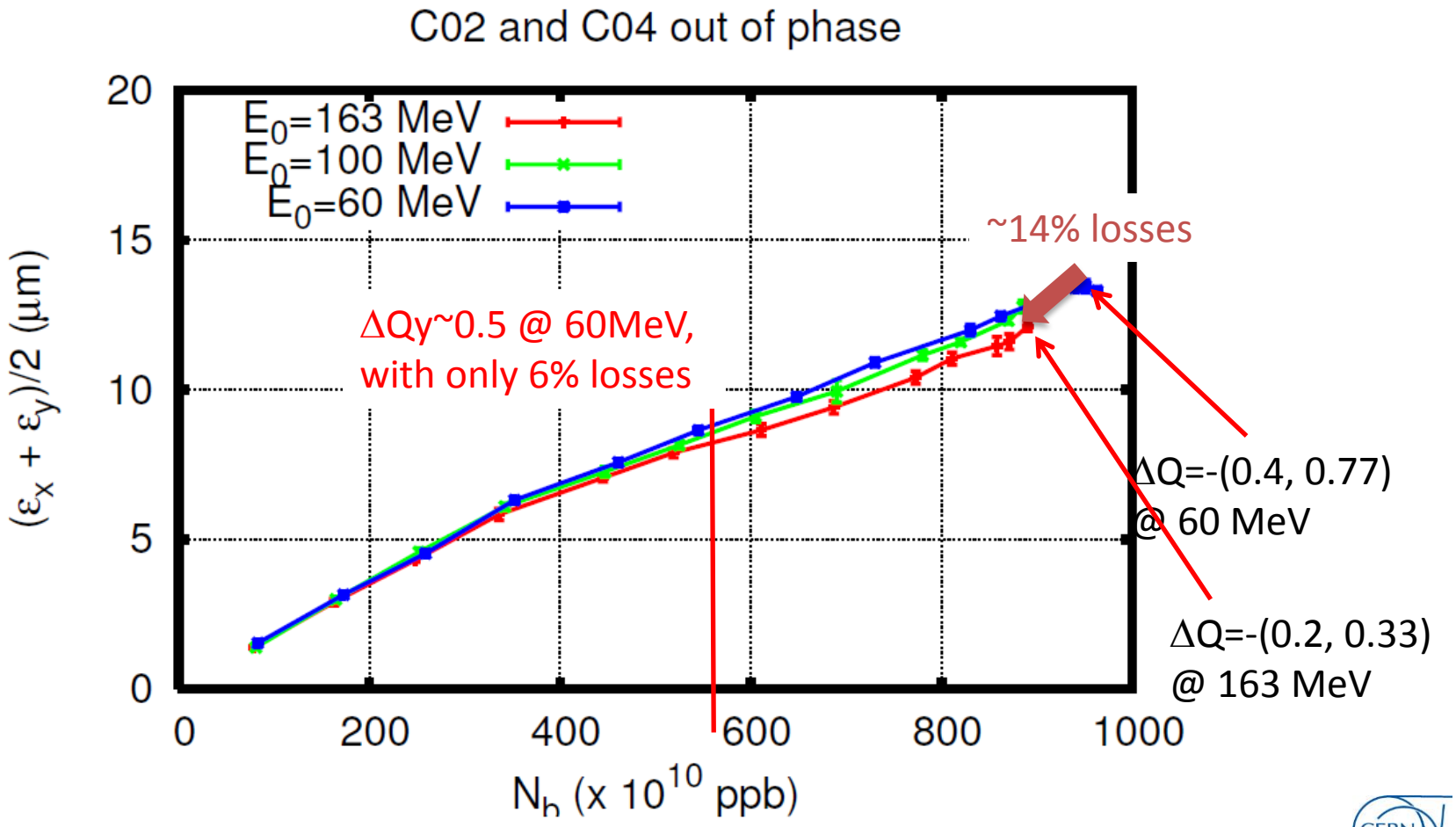


Figure 3 Horizontal position for 10000 turns during excitation with transverse damper. Chromaticity was uncorrected.

Space charge: How much can we “fit in”?

B. Mikulec, A. Findlay, V. Raginel, G. Rumolo, G. Sterbini, (presented @ HB2012)



Space Charge: MDs and simulations

V. Forte, E. Benedetto, C. Carli, M. Martini, A. Molodozhentsev, F. Schmidt

- Simulation campaign to predict emittances & losses (PTC-Orbit code) of high brightness beams (after L4 connection)

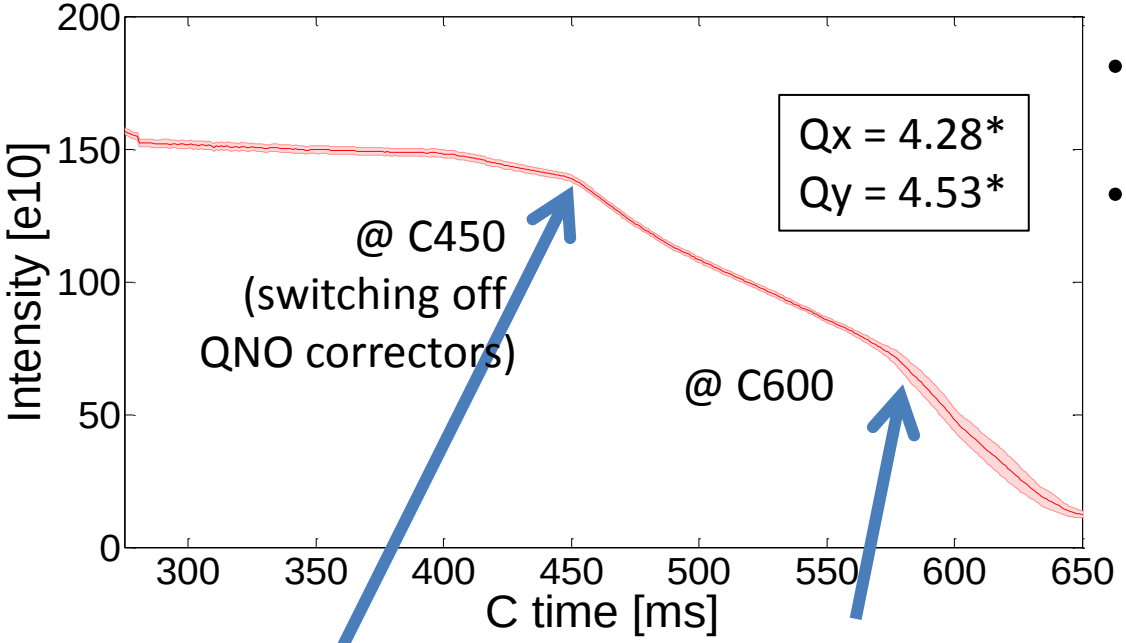
- Working point studies for code benchmark
  - Static working point close to integer
  - Static, close to Half-integer
  - Dynamic tune variation approaching the integer
  - Automatic tune scans (differences between R2 and R4)

- Use of correctors
  - Dipole, normal/skew quadrupoles, sextupoles
  - Efficiency in terms of losses

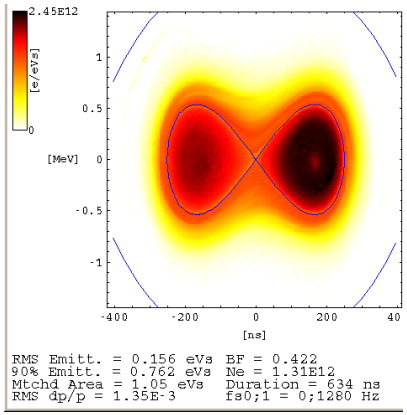
Space Charge: MDs and simulations

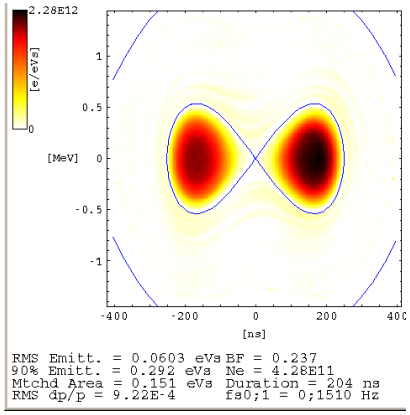
V. Forte, E. Benedetto, C. Carli, M. Martini, A. Molodozhentsev, F. Schmidt

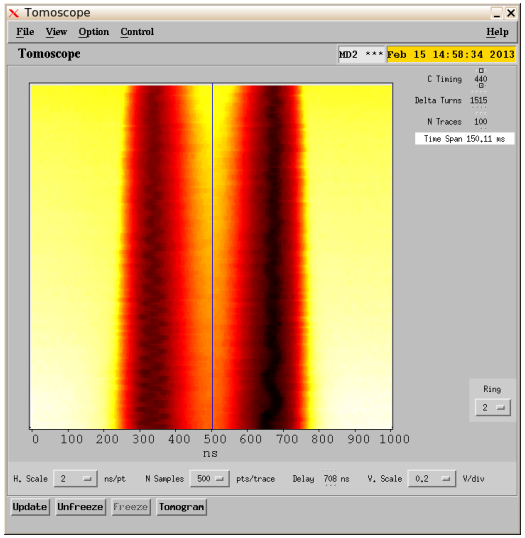
Tune close to the half integer



- Emittances ~constant
- Cfr. Bunch shortening and res-crossing







***programmed tunes**

Transverse instabilities

K. Li, N. Mounet, A. Findlay, G. Rumolo

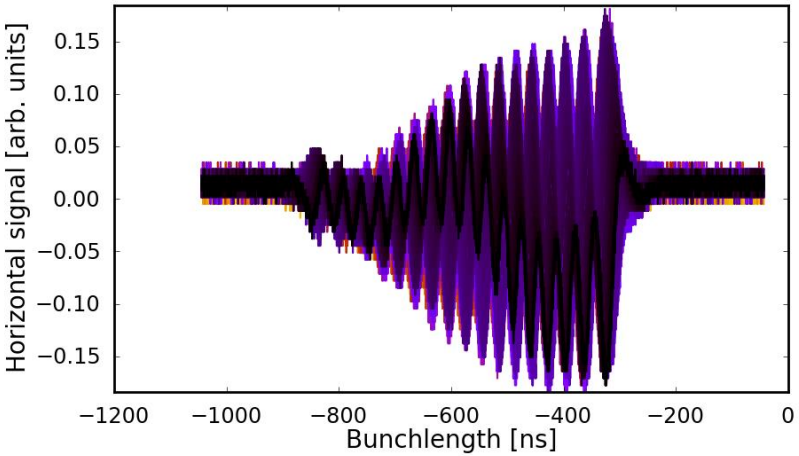
Systematic collection of data to understand the source of instability and thresholds

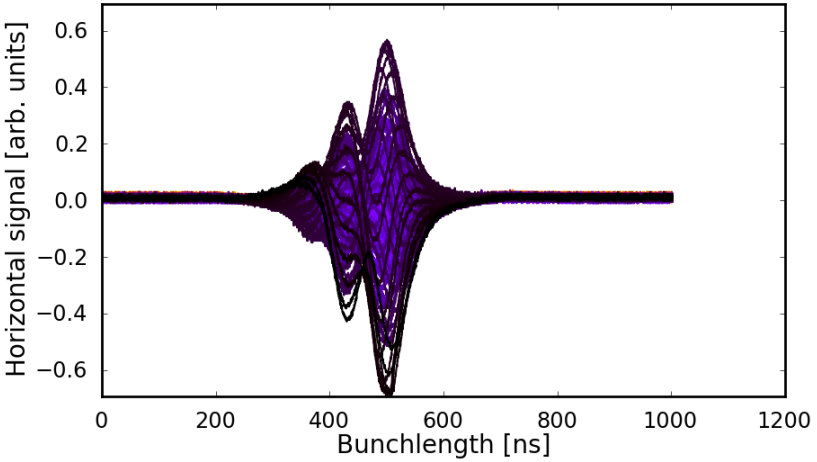
- Detailed study of instability at c370 with scan in:
  - Intensities (find thresholds)
  - Single & double RF, C04 voltage
  - Chromaticity
- Few scans for instability at c480
  - Thresholds in double RF

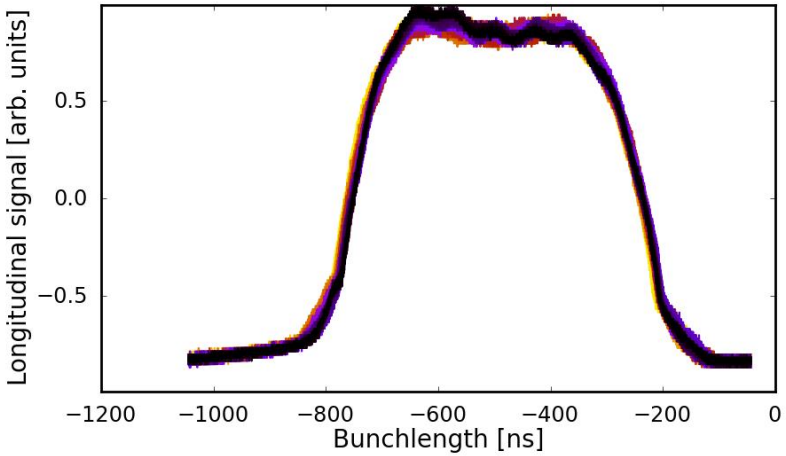
- Record data with Q-meter and with TFB pick-up

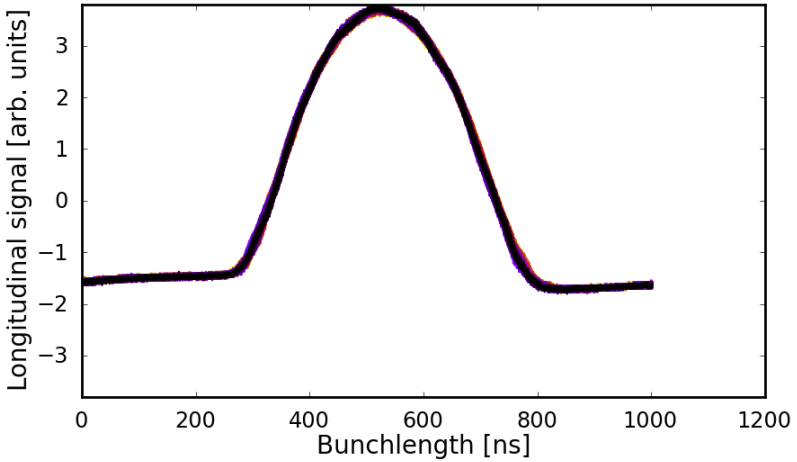
Transverse instabilities

K. Li, N. Mounet, A. Findlay, G. Rumolo









ξ_x=2.5
Nb=760 10^{10}

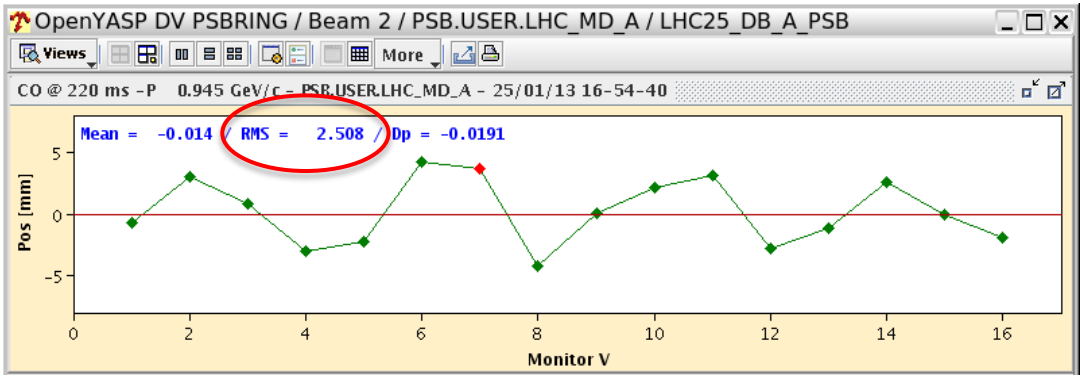
ξ_x=0.9
Nb=350 10^{10}

YASP deployment

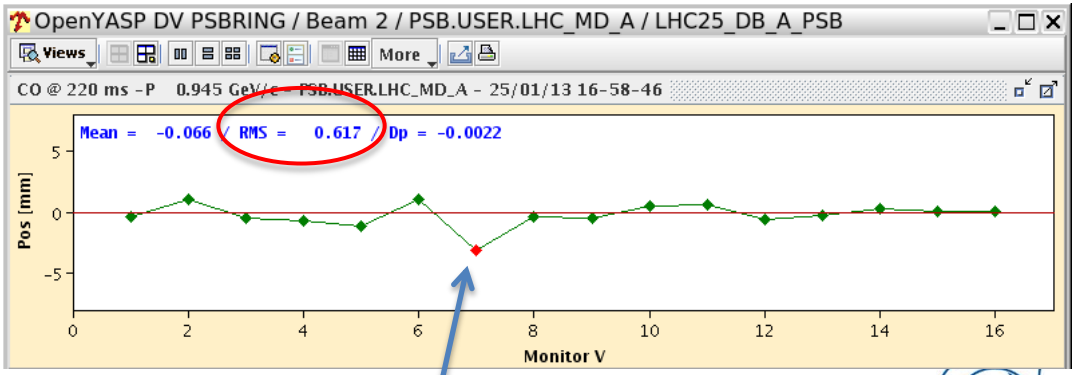
B. Mikulec, V. Raginel, J. Wenninger, J-F. Comblin, O. Berrig, M. McAteer, G. Kruk, M. Gourber-Pace

- YASP correction
  - Injection trajectory
  - PSB orbit correction
  - PSB-to-PS trajectory
  - PSB-to-BTM: pending
  - PSB-to-ISOLDE: pending

Orbit before correction



Orbit after correction



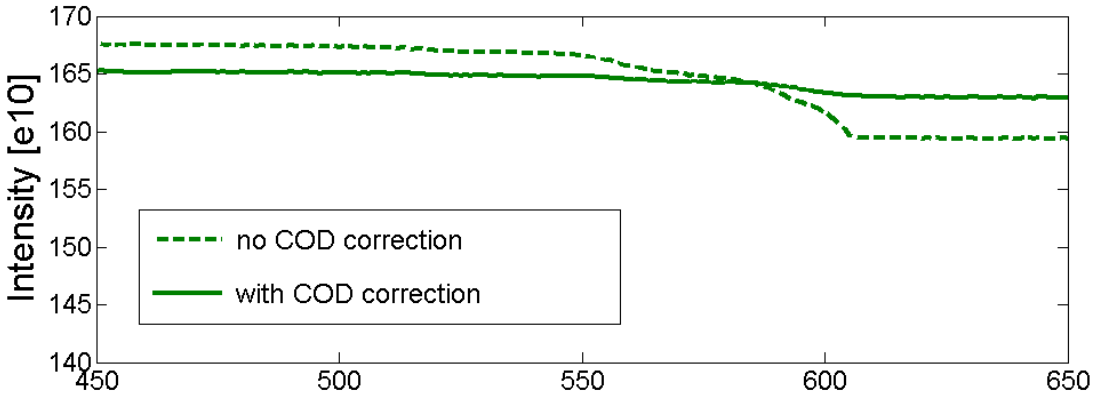
not working

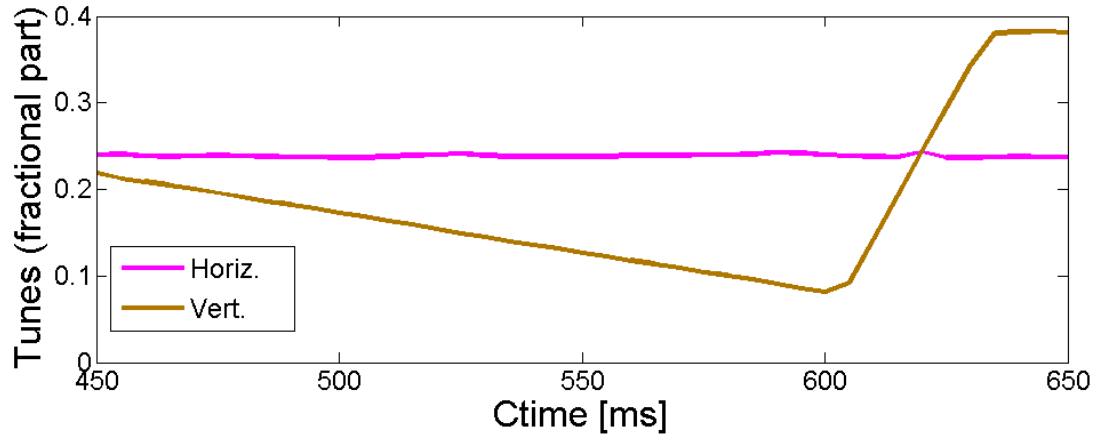
Example: vertical correction in Ring 2 using all 13 correctors

YASP deployment

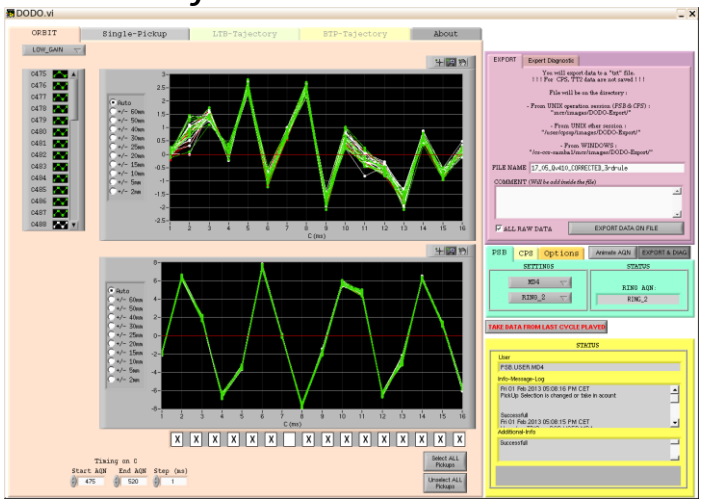
V. Forte, et al

Vertical COD correction & implication for SC measurements close to integer





Orbit before correction

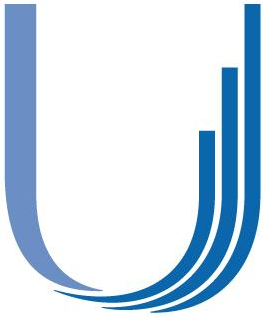


Orbit after correction

To conclude…

- Daily work of fine tuning and optimization lead to:
  - A constant ratio of Emittance/Intensity=1.16 [um/10^{12}] on Ring3
  - Emi~1um for the LHC beam with h9 BCMS in the PS

- Last year have seen a substantial increase of MDs activities (and beam studies) in the PSB, with the ambitious - long term! - goal of:
  - Building a PSB non linear optics model
  - Predicting emittance blow-up and losses of high-brightness beams with space-charge ΔQ~0.5, after the L4 connection.
  - Modeling the machine impedance and understanding source & threshold of instabilities at C370 and C480



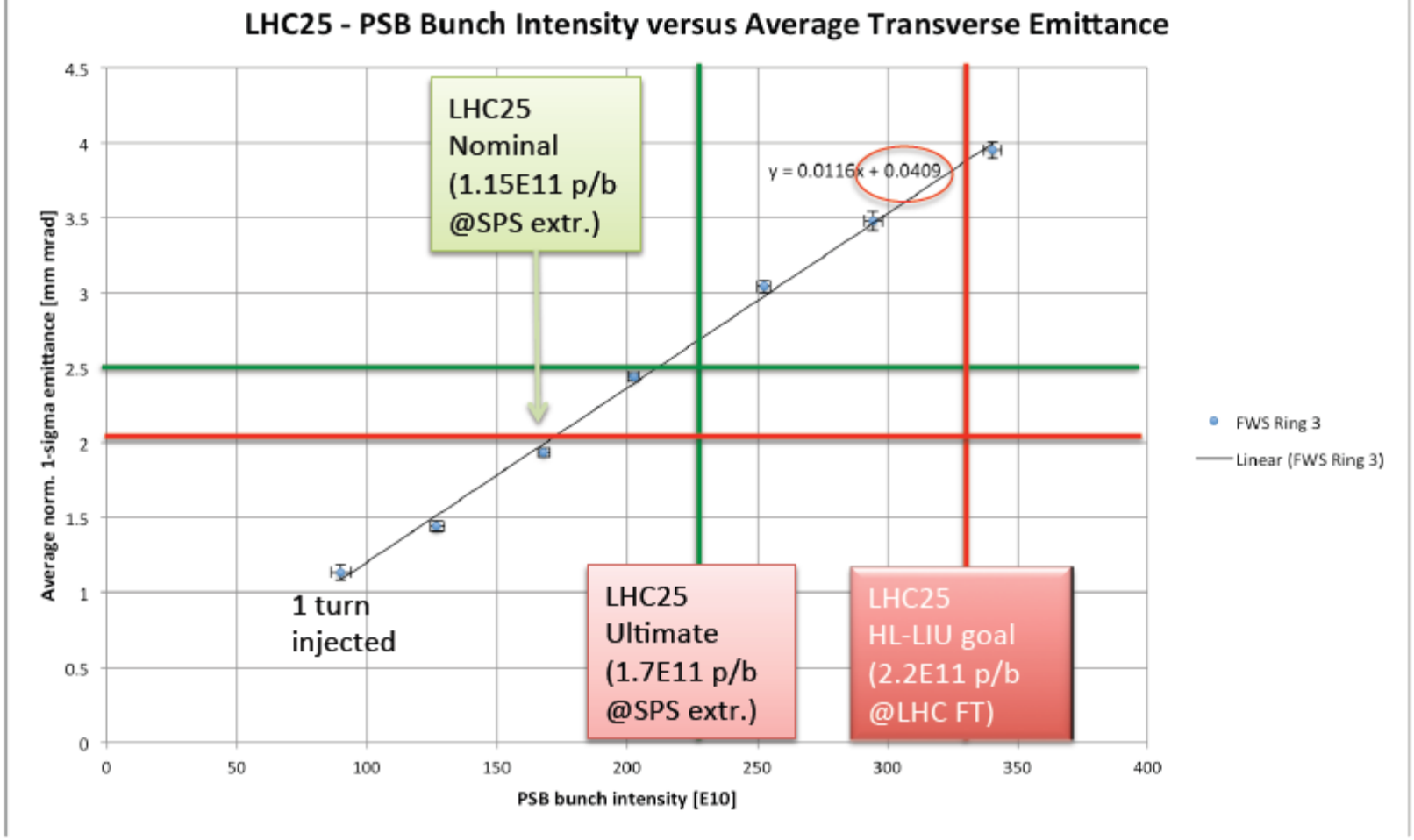
LHC Injectors Upgrade

THANK YOU FOR YOUR ATTENTION!

Back-up

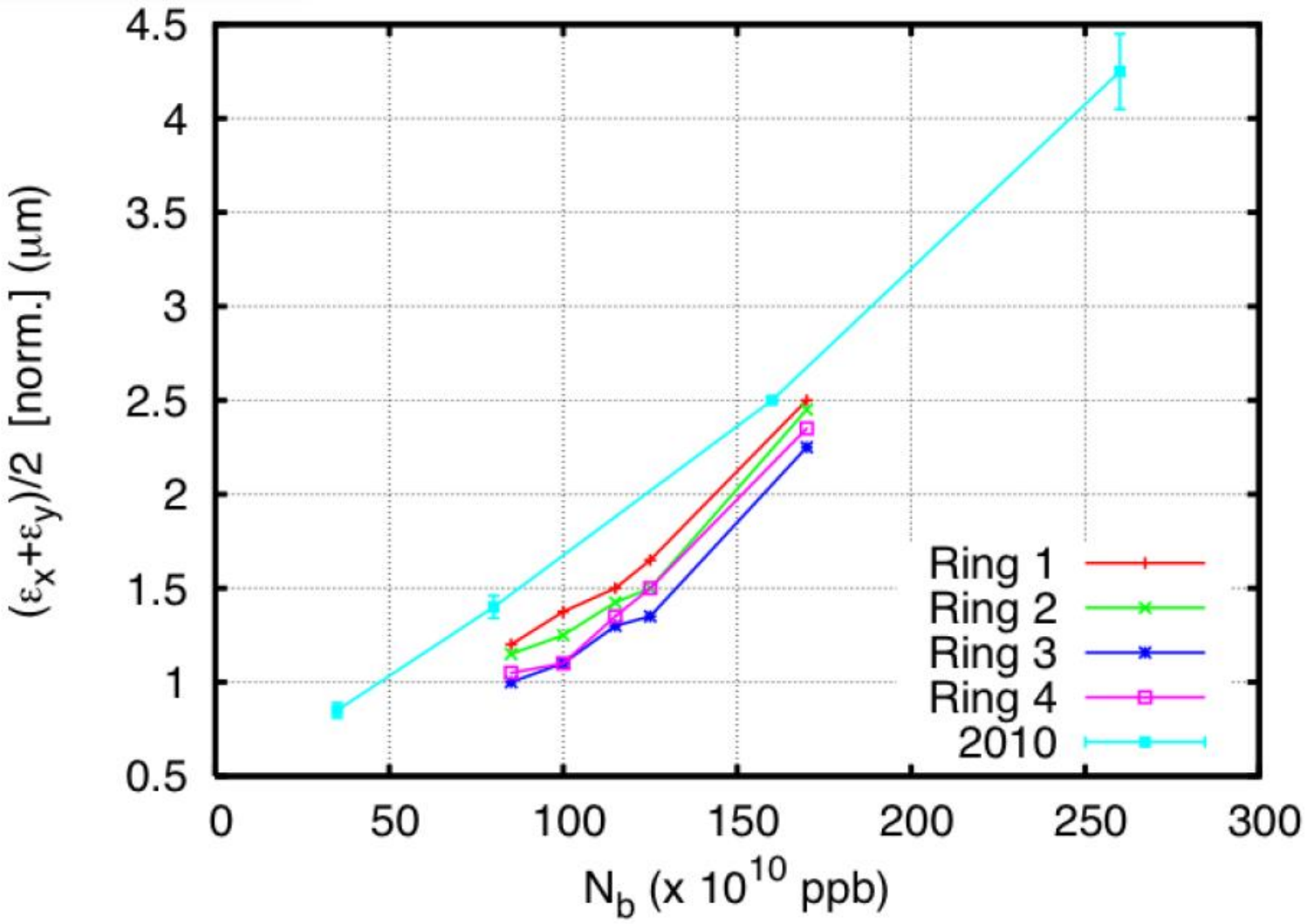
Emittance vs. Intensity

B. Mikulec @ LIU beam studies review, Aug'12



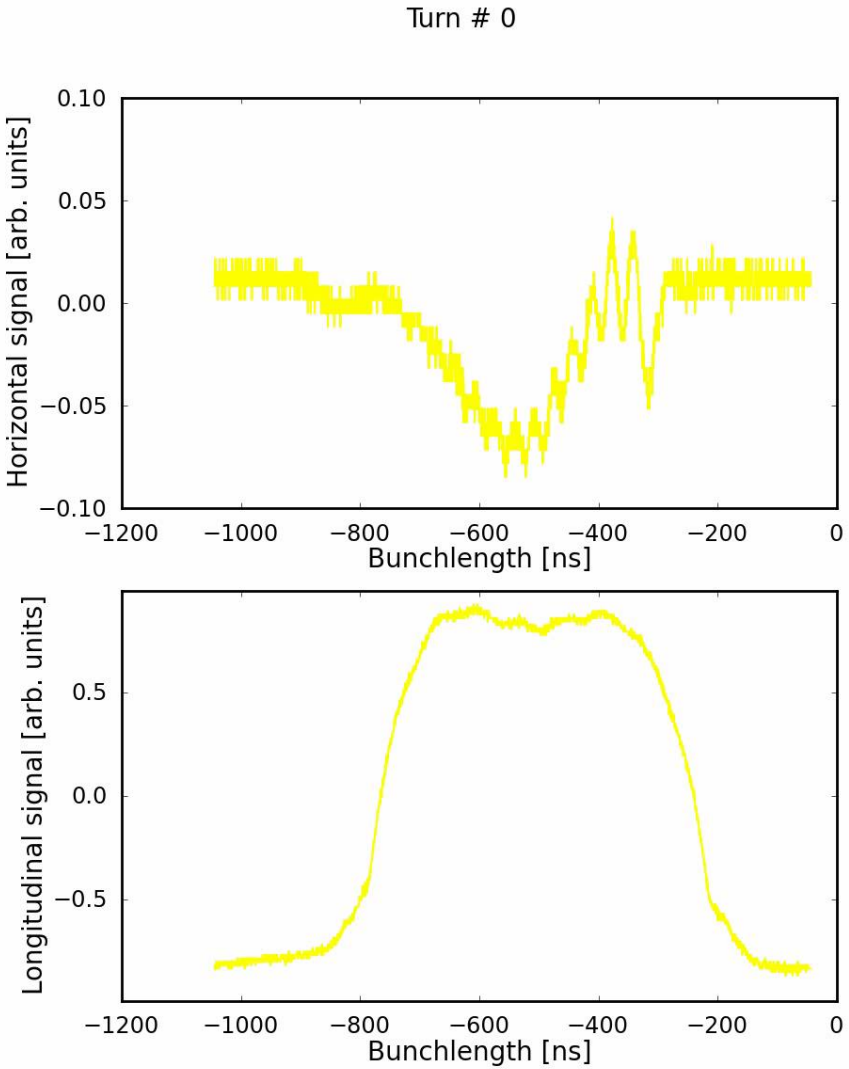
Remark: Constant emittance of ~1.19 eVs and injection parameters+WP tuned for each measurement point.

Emittance vs. Intensity

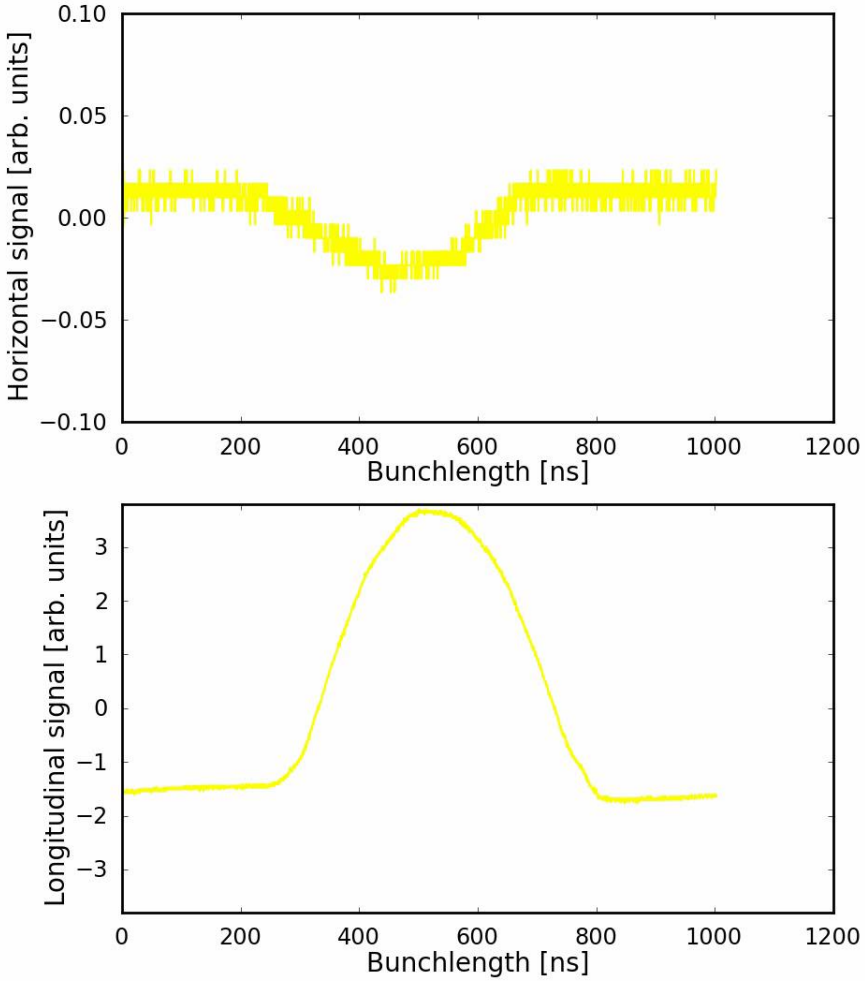


Transverse instabilities: movies

K. Li, N. Mounet, A. Findlay, G. Rumolo



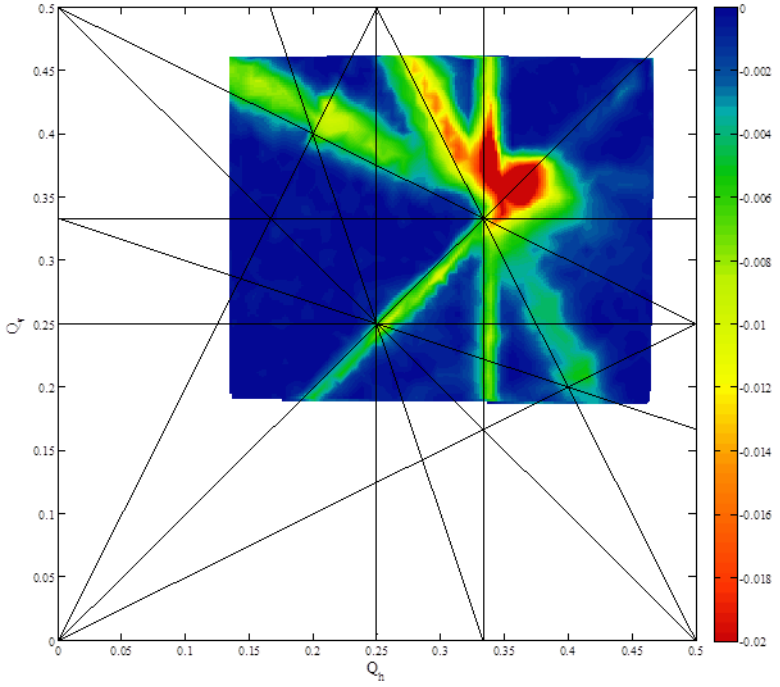
ξ_x=2.5
Nb=760 10^{10}



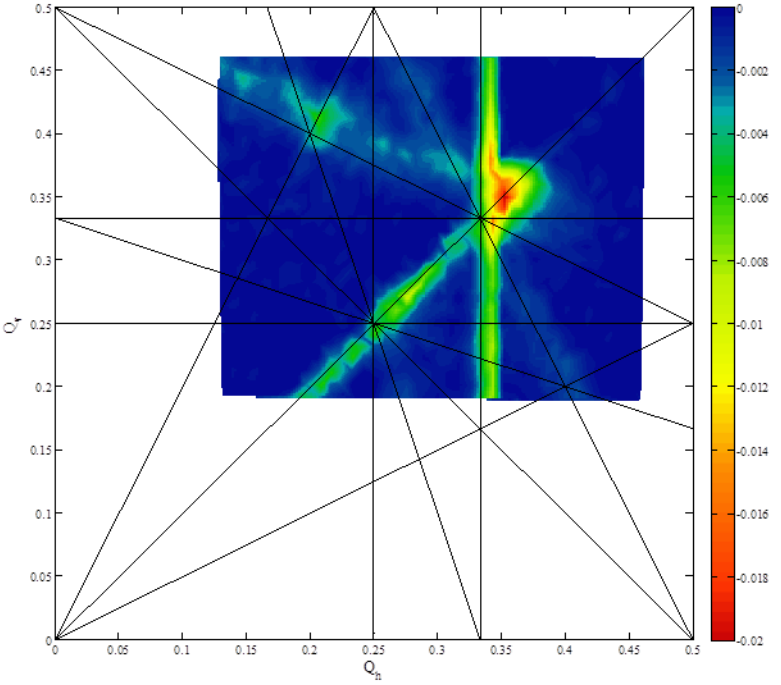
ξ_x=0.9
Nb=350 10^{10}

Tune scans: differences ring 2- ring 4

Ring 2



Ring 4



Scan from right to left