



# Review on (two) shorter PSB main bending magnets (before and after the injection section) --

# Impact on beam dynamics

C. Carli presenting results mainly by E. Benedetto with contributions by V. Forte, A. Molodozhentsev and LIU-PSB

21<sup>st</sup> June 2012

Question to be answered:

“Does a reduction of the lattice periodicity with two shorter bending magnets before and after the injection straight, together with strong direct space charge effects, compromise PSB performance reach”

..... Note that this is one of the most tricky accelerator physics and beam dynamics questions; team “space charge working group” set up recently to study that kind of problems for LIU

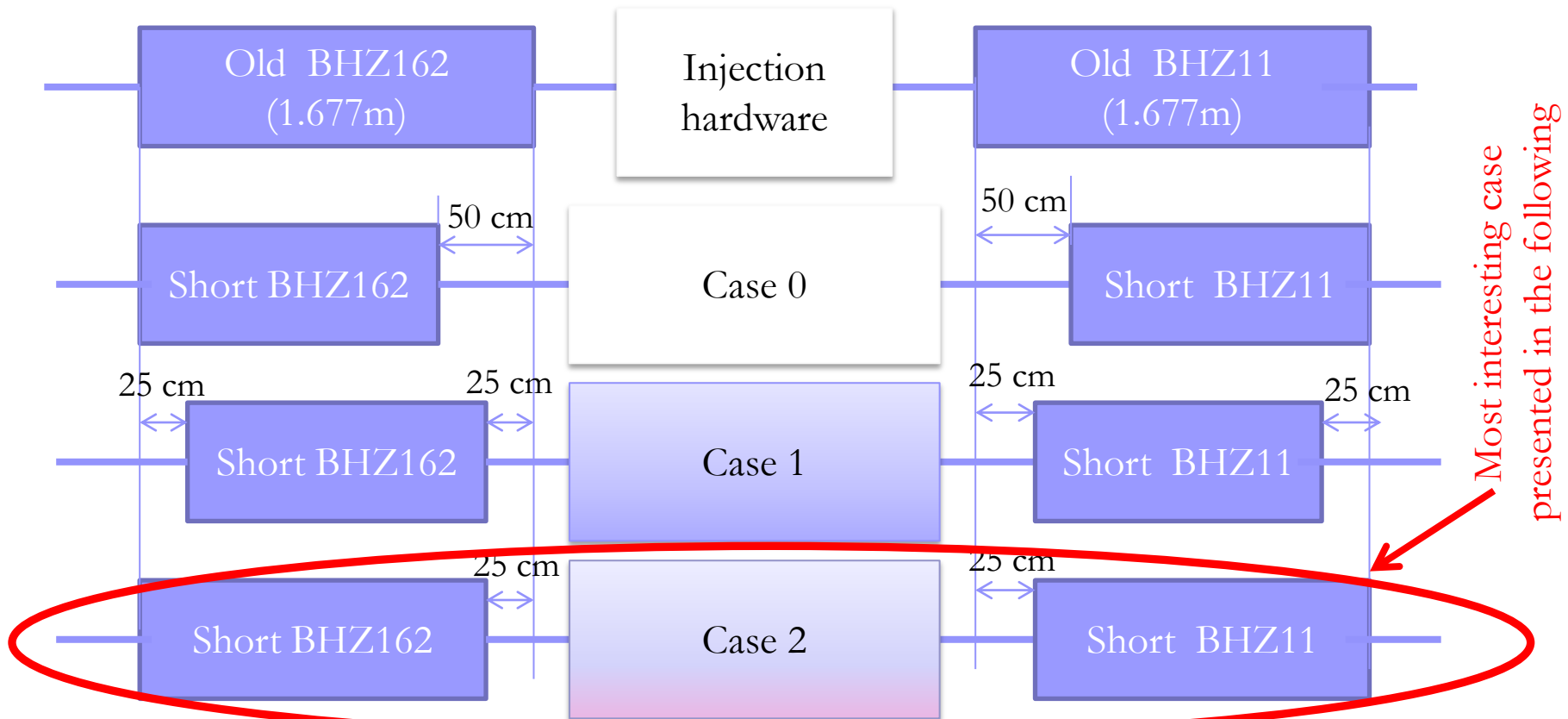
Outline of the presentation:

- Introduction (options considered)
- Impact on linear optics (beta-beating)
- Very first preliminary PTC-ORBIT Simulations
- Geometry and impact on optics of the injection line
- Perturbations keeping present bending magnets (magnetic cross-talk with chicane BSW magnets)
- Conclusions and Outlook

# Introduction

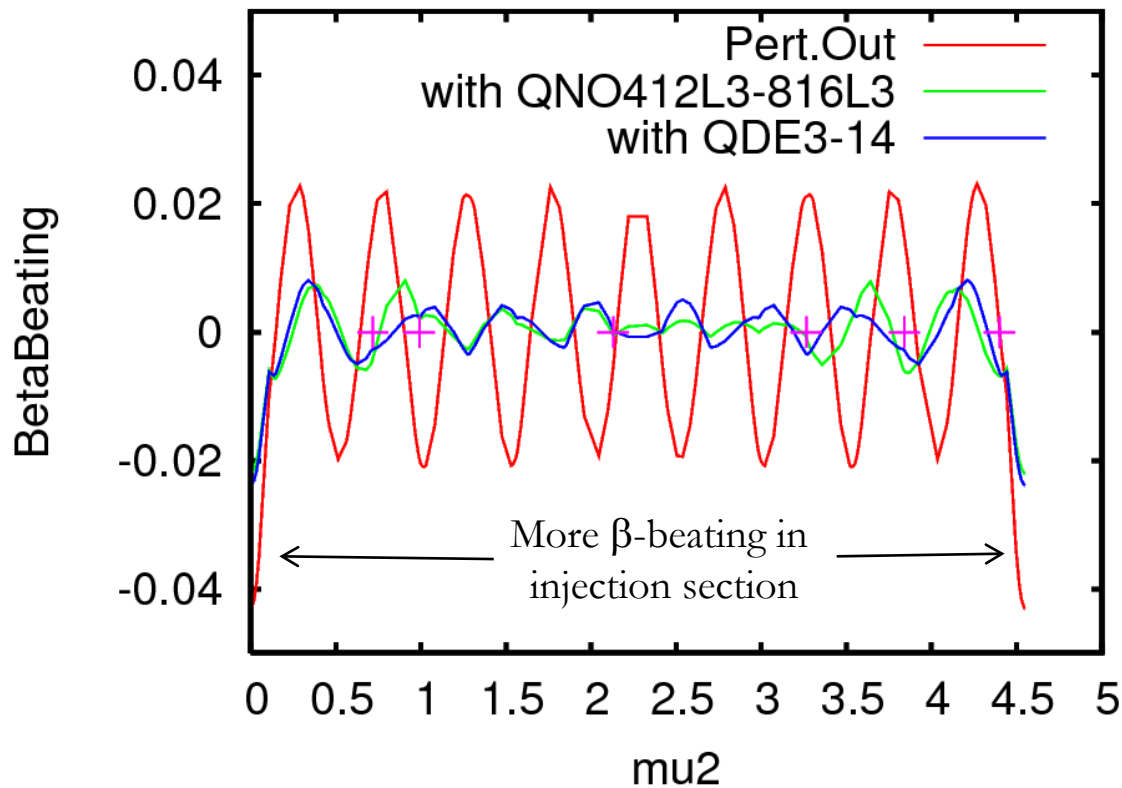


- Shorter bendings before and after injection brought up already quite some time ago
  - (Gain space for injection equipment)
  - Ruled out since high lattice periodicity is broken ... expected to compromise performance
- Brought up again by review last autumn on H<sup>-</sup> charge exchange injection
  - Several cases considered ... “only” Case 2 presented here



# Impact on linear optics (beta-beating)

- Perturbation of present PSB as well due to imperfections
  - Main impact of (two) shorter bends: linear optics (beta-beating) in vertical plane
  - Quantify and compare these perturbations (from shorter bends and from imperfections)
- Vertical tune  $Q_V = 4.55$  just above half-integer resonance
  - Effect comparable to the one from imperfections (known from resonance compensation)
  - From these considerations (surprisingly) no strong argument against shorter bends

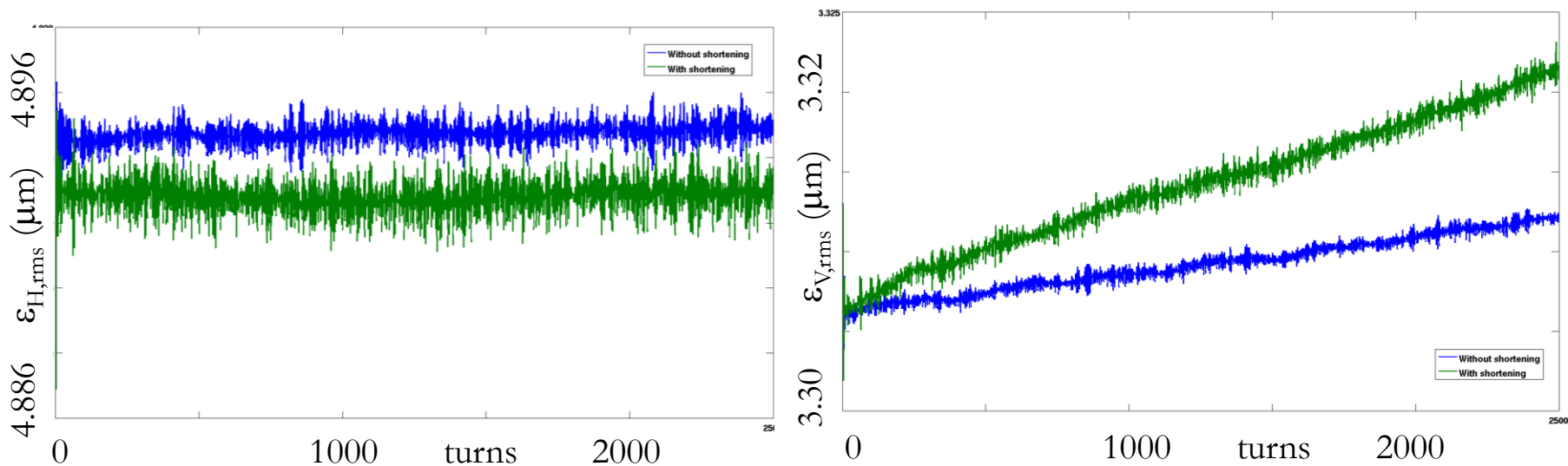


Relative change of beta-function  $\beta_{\text{pert}}/\beta_{\text{ref}}$  as function of phase (divided by  $2\pi$ )

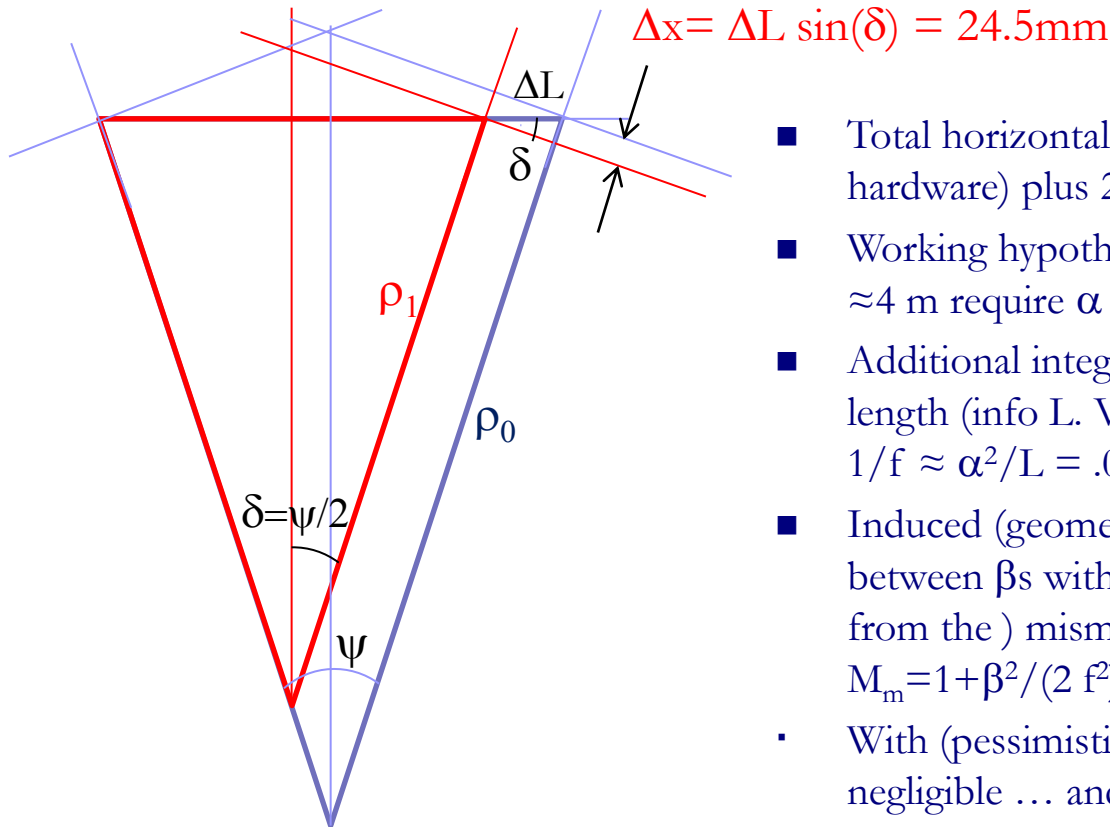
# Very first preliminary PTC-ORBIT Simulations



- First simulations started by V. Forte with A. Molodzhentsev
  - Mainly convergence studies to determine suitable simulation parameter
  - Comparison with perfect lattice – somewhat “unfair” for case with (two) shorter bends
  - Result (very preliminary – work just started):
    - Blue: perfect lattice, Green: lattice with (two) shorter bends
    - Significantly more (vertical) blow-up ... but
    - Vertical tune below the half-integer resonance and
    - Smaller intensity and tune spread (from convergence studies)
  - Note: somewhat similar (preliminary as well) observation by Miriam comparing different lattices



- Change of geometry of the PSB

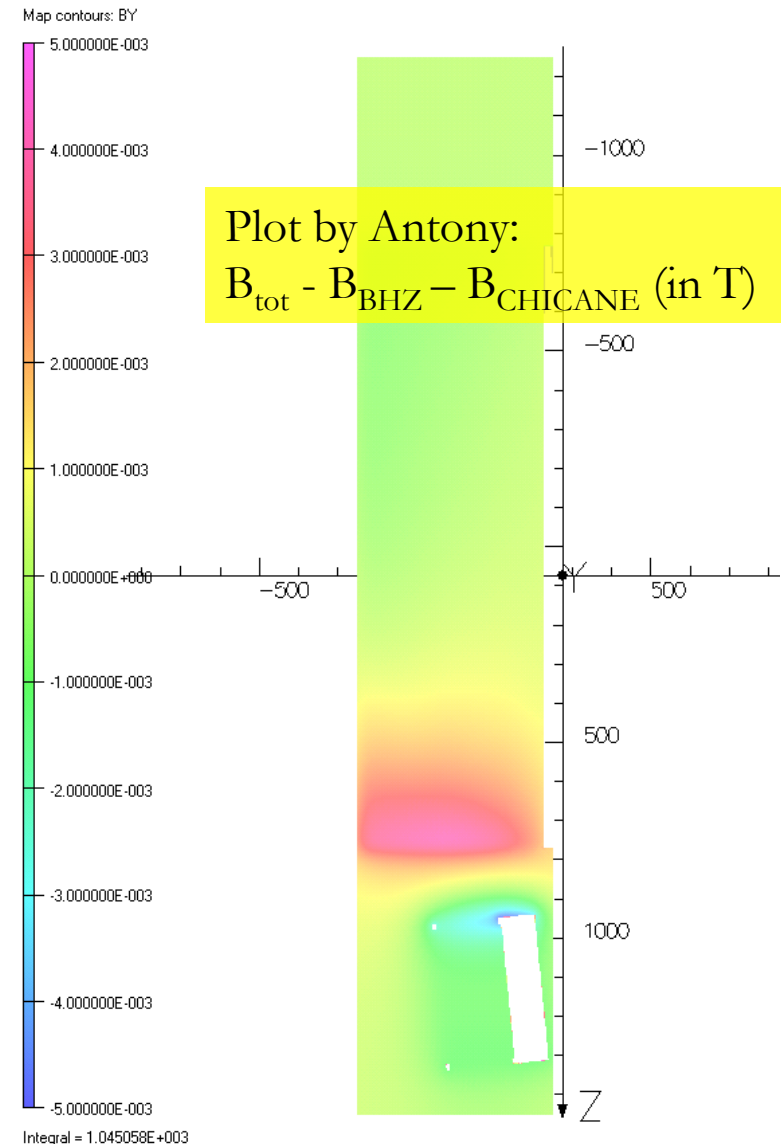


- Total horizontal offset of 10 mm (foreseen for injection hardware) plus 24.5 mm: 34.5 mm
  - Working hypothesis: two steerers (or bends?) spaced by  $\approx 4 \text{ m}$  require  $\alpha \approx 35 \text{ mm}/4 \text{ m} \approx 9 \text{ mrad}$  deflection
  - Additional integrated focusing strength with a magnetic length (info L. Vanherpe) of  $L = 0.4 \text{ m}$ :  
 $1/f \approx \alpha^2/L = .0002 \text{ m}^{-2}$  (per steerer)
  - Induced (geometric, describing the maximum ratio between  $\beta$ s with and without perturbation downstream from the ) mismatch:  $M_g = M_m + (M_m^2 - 1)^{1/2}$  with  $M_m = 1 + \beta^2/(2 f^2)$ 
    - With (pessimistic)  $\beta = 35 \text{ m}$ ,  $M_g = 1.008$ , which is negligible ... and line could be easily rematched
    - Dispersion  $\approx 0.035 \text{ m}$  (negligible as well)
- (A little bit off topic: after design of these two steerers, integration should be looked at ... and magnetic cross-talk with PSB main bend)

# Perturbations keeping present bending magnets



- Problems due to magnetic cross-talk with chicane BSW magnets?
  - Reduction of equivalent lengths (as expected)
  - At a first glance: no significant (transverse) gradients and/or multipoles visible



- Shorter bending magnets reduce the lattice periodicity to one
  - PSB lattice initially designed with high periodicity (and triplets) to allow for large direct space charge tune shifts and spreads
  - Option with bendings shortened by 25 cm adjacent to injection straight retained for further considerations
    - Small change of PSB geometry
  - Nevertheless no strong argument against shorter bends from considerations on induced  $\beta$ -beating
  - Assessment with (ORBIT-PTC) simulations a very challenging (feasible?) task
    - Only very first preliminary simulation results available ... indicating more blow-up with shorter bends
    - For a fair comparison machine imperfections/errors should be added (long term task)
  - Change of PSB geometry not an issue for the injection (and extraction) line
- Recommendation: envisage implementation of shorter bends only in case very strong arguments in favor