Status of the LINAC4-PSB Studies

- Topics studied and discussed recently
  - ☐ Transfer of LHC type beams between PSB and PS
  - ☐ Lattice perturbations due to the injection chicane
  - ☐ PSB injection steering
  - ☐ Simulations of beam dynamics with strong direct space charge effects
 - ☐ Other topics
- Work Plan

Transfer of LHC type beams between PSB and PS

- Transfer of non-LHC beams: similar to present situation (same bunch structures, similar intensities ..)

- LHC type beams:
  - Single batch for nominal LHC operation:
    - Two bunches/ring and some $h=1$ RF to adjust spacing
    - Decreased longitudinal emittance and bunch lengths (increases ΔQ in PS)
    - Increase bunch length after transfer
    - First MDs in PSB started (A. Findlay)
    - 50 ns and 75 ns possible already now with single batch transfer !?
  - Single batch (with exotic schemes?) for ultimate LHC operation:
    - $h_{PS}=14$ and $h_{PSB}=3$ scheme difficult (three RF systems in PSB …)
    - Schemes proposed (need for batch compression $h_{PS}=20 \rightarrow 21$)
      - $h_{PS}=10$ and $h_{PSB}=2$
      - $h_{PS}=5$ and $h_{PSB}=1$ (incompatible with frequency range of PS RF system)

System	V	phase
PSB h=1	2.5 kV	180
PSB h=2	8. kV	180
PSB h=3	0. kV	0
PS h=7	24.⇒12. kV	180

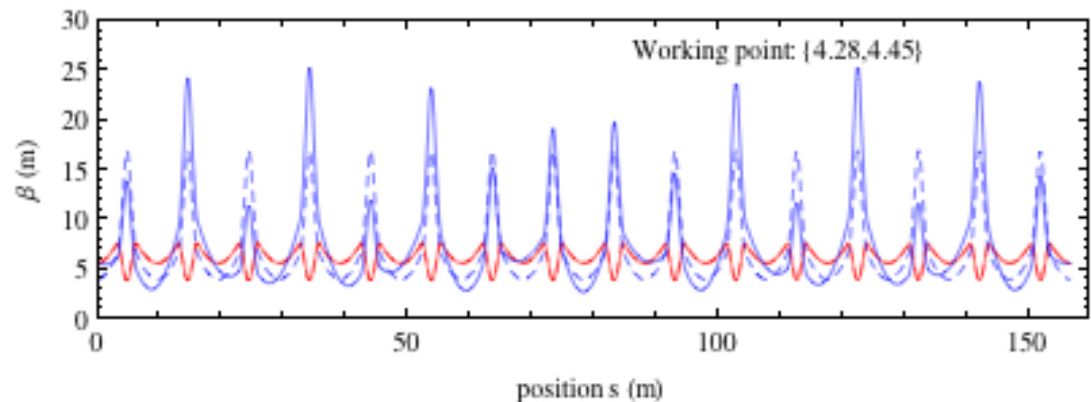$\epsilon_{long} = 2 \times 1.02$ eVs
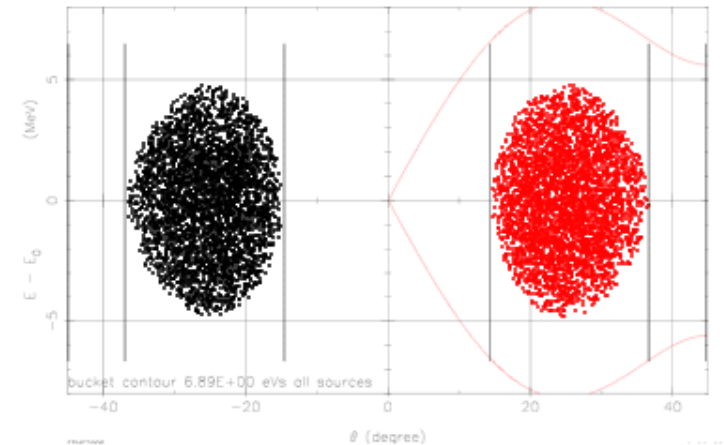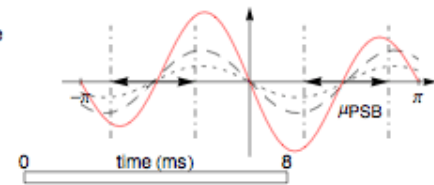
Lattice perturbations due to the injection chicane

- Limitation at FNAL (reported by F. Ostiguy) and other machines?
- "Chicane" (i.e. an orbit bump with one magnet to join injected and circulating beams) needed for charge exchange injection into the PSB
  - Rectangular bends generate vertical focusing and perturb lattice (vertical tune close to halfinteger)


  - Correction difficult:
    - Sector bend? (deflections change with time, perturbation in both planes)
    - Correction with quadrupoles (many … or excite in horizontal plane)
- Actions to mitigate:
  - Reduce deflection angles (asymmetric chicane ruled out?)
  - Make dipoles as long as possible
  - Sufficient distance from half-integer

PSB Injection Steering

- Two steerers/plane and ring to adjust position and angle at the injection point disappeared in proposal for Linac4
  - Needed for operation
  - Installation further upstream: increase strength
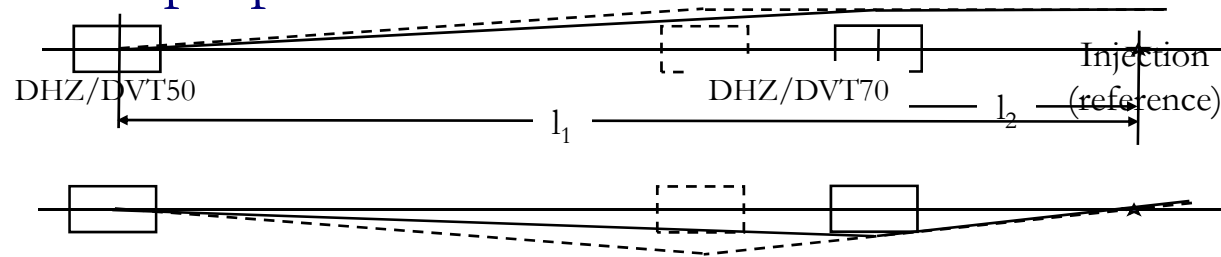
- Analysis of present situation and extrapolation to Linac4:
  - Correction matrix used in operations found wrong (now corrected)
  - Last steerer at present position: strengths about o.k.
  - Steerer further upstream: Increase strength
 - (anyhow probably new magnet)
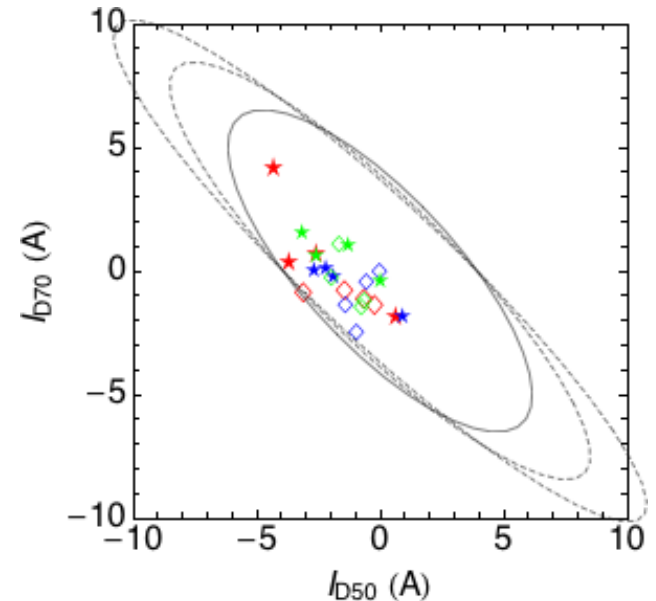
Simulations

- Injection (mainly by M. Aiba with contributions from B. Goddard):
  - Modeling of injection chicane (and bump) as thin elements, longitudinal and transverse painting … but zero Bdot
  - Dispersion mismatch at injection found not to be a concern
  - Slow transverse blow-up (at limit of what is acceptable) possibly dominated by artefacts due to numerics
  - No investigations on influence of transverse matching yet

- Benchmark: Simulations vs observations (Michels)
  - Blow-up rates agree within a factor two or so for first ORBIT runs
  - Refine simulations (# macropart's, binning …) and measurements
  - Disagreement for ACCSIM (F. Jones interested to check - in contact with Michel)
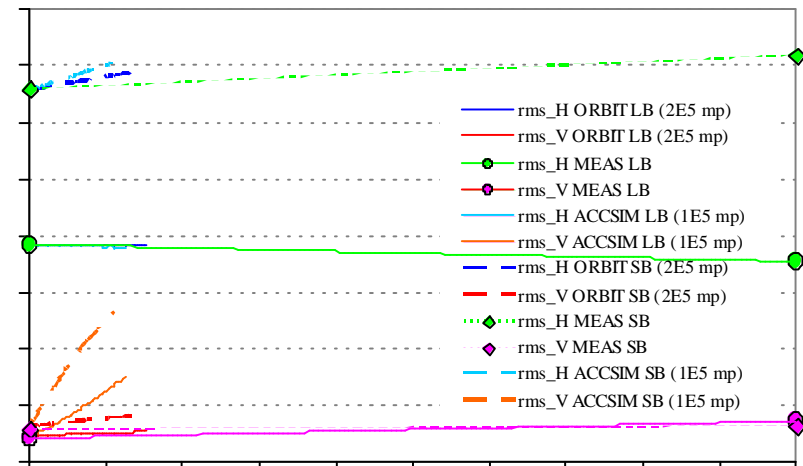
- (A. Adelmann from PSI will present his code in November)

- (Computing: nodes from new cluster for PSB beam dynamics from Linac4 budget)

rms_H ORBIT LB (2E5 mp)
rms_V ORBIT LB (2E5 mp)
rms_H MEAS LB
rms_V MEAS LB
rms_H ACCSIM LB (1E5 mp)
rms_V ACCSIM LB (1E5 mp)
rms_H ORBIT SB (2E5 mp)
rms_V ORBIT SB (2E5 mp)
rms_H MEAS SB
rms_V MEAS SB
rms_H ACCSIM SB (1E5 mp)
rms_V ACCSIM SB (1E5 mp)

Other topics

- Apertures in region distributing the Linac beam to PSB rings:
  - □ Optics had not been optimised (increase of distributor kicks to solve)
  - □ Better optics design by Alessandra and her team
  - □ (improvement of geometry possible ??)
- Instabilities :
  - □ Head-tail modes (azimuthal mode 3) in ring 4 observed by PSB operations team
- Generation of exotic (e.g. very low intensity) beams:
  - □ List of present PSB beams compiled by Bettina
  - □ Develop scenarios to generate them with Linac4
- Collimation (rough):
  - □ P. Jackson (will start as doctoral student in April) started to look into it …. No results yet for the moment.
  - □ Issue: find a scheme within the given lattice of an existing machine
  - □ Collimator may reduce acceptance by a factor ~2 with higher injection energy (easier to intercept proton before hit of the vacuum chamber)

Work Plan -

copy of a transparency from LIS meeting on 19th May

- Injection studies with validation & optimization of the painting scheme (well advanced):
  - □ Add Injection Foil (done), Acceleration and, possibly, machine imperfections
  - □ Tracking over longer times, check parameters to avoid numerics problems
  - □ Check filamentation of structure from injection - especially with dispersion mismatch (seems o.k)
  - □ Limitations: Linac4 energy jitter, energy spread due to debunching in Booster (seems o.k.)
- Integration into the CERN Complex - Elaborate detailed scenarios for all beams needed
- Check limitations of present Booster hardware:
  - □ Instabilities (existing damper with higher intensities)
  - □ (Beam loading problems of h=2 cavities for h=1 beams … limitations ISOLDE beams ?)
- Beam Losses, Activation ("normal" losses, failure scenarios …):
  - □ Losses at Injection (Line and Ring) in collaboration with or by injection hardware team ?
  - □ Feasibility of rough Collimation System
- Possibly Simulations of Dynamics with strong direct Space Charge:
  - □ Are available Programs (e.g. ORBIT) viable Tools for such Studies ?
    (Most (all) accelerators with large direct space charge designed without detailed simulations)
  - ➢ Successful Completion of Benchmark mandatory !
  - □ (Slow) Blow-up and associated Losses, estimate/optimize Performance))