Alternative/complementary Possibilities

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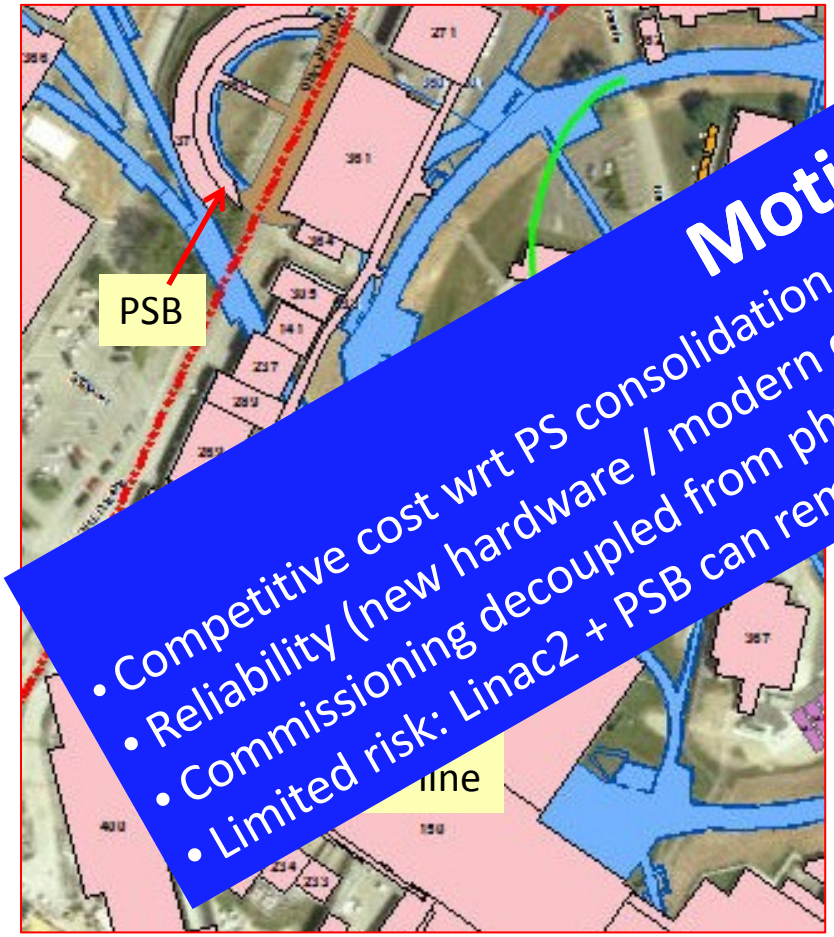
- Introduction
  - Present PS scheme for nominal LHC bunch trains
  - Alternative/complementary Scenarios
- Batch Compression schemes in the PS
  - Filling 8 out h_{PS}=8 or h_{PS}=9 PS buckets?
  - Compression to h_{PS} = 10 and generation of 64 bunches
  - Compression to h_{PS} = 14 and generation of 48 bunches
- RCS as new PS Injector
- Summary and Outlook

Short RCS as new PS Injector

RCS: 1/7 of PS circumference
In this example: $h_{RCS}=3$
6 cycles to fill 18 PS buckets



Motivation:

- Competitive cost wrt PS consolidation and upgrade (?)
- Reliability (new hardware / modern design)
- Commissioning decoupled from physics operation
- Limited risk: Linac2 + PSB can remain available for a few years as back-up solutions.

reach target kin. energy 2 GeV
ightness for given injection energy (for
rmonic number $h_{RCS} > 1$):

- $h_{RCS} = 3$ to fill 18 out of $h_{PS} = 21$ buckets (short kicker gaps) or
- $h_{RCS} = 2$ to fill 12 out of $h_{PS} = 14$ buckets

- Rep. rate ≈10 Hz (required for Linac4 as well)

- (RCS with circumference 4/21 or 3/14 times the PS might be of interest)

Short RCS as new PS Injector

Magnetic cycles assumed

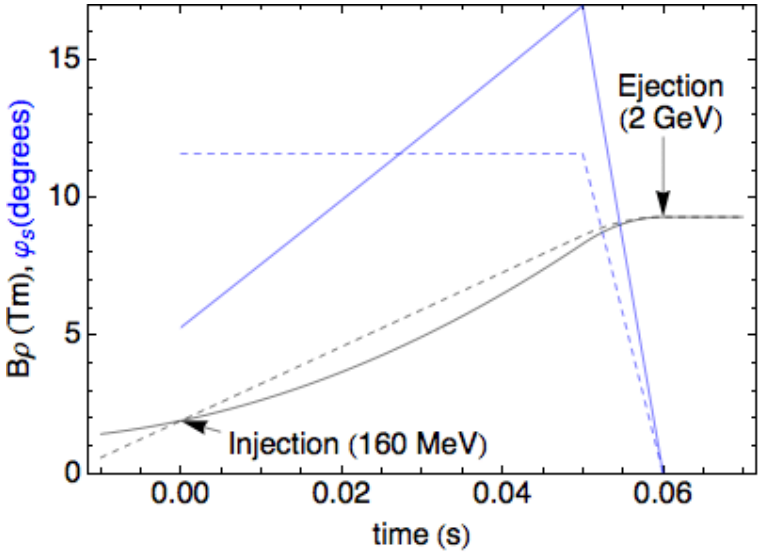
- Solid: Injection with half the average dB/dt, two pieces of parabolas joining at t = 0.05 s
- Dashed: constant dB/dt except rounding during last 10 ms
- Synchronous angles for V_{RF} = 60 kV and circumference 1/7 of the PS

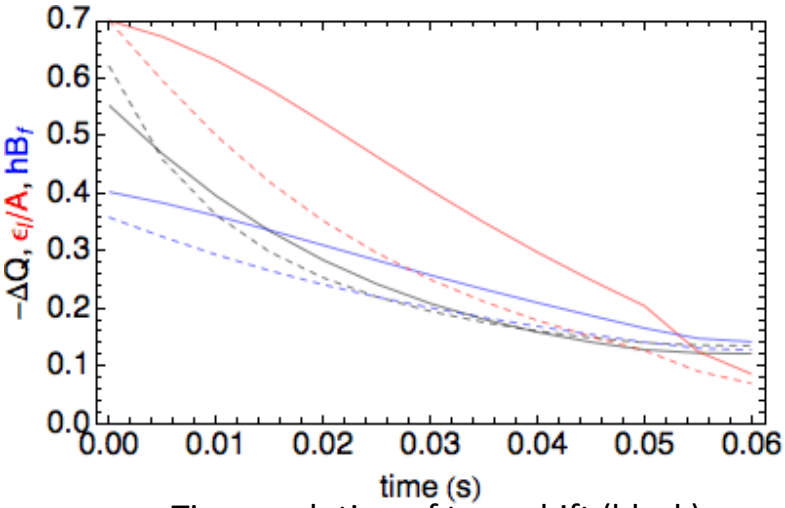
Direct space charge tune shift along ramp

- Long. emittance adjusted to fill 70% of bucket
  - Compatible with maximum long. emittances
- ε^*_{rms} = 2.5 μm and 2.7 10^{11} per LHC 25 ns bunch
- With constant RF voltage along cycle
  - Estimation of height of phase space area occupied by beam used for
  - Estimation of bunching factor and tune shift

- If tune shifts too large for schemes with six transfers
  - Switch to h_{RCS} = 1 and h_{PS} = 14 with 12 transfers

Longitudinal matching at transfer to be studied





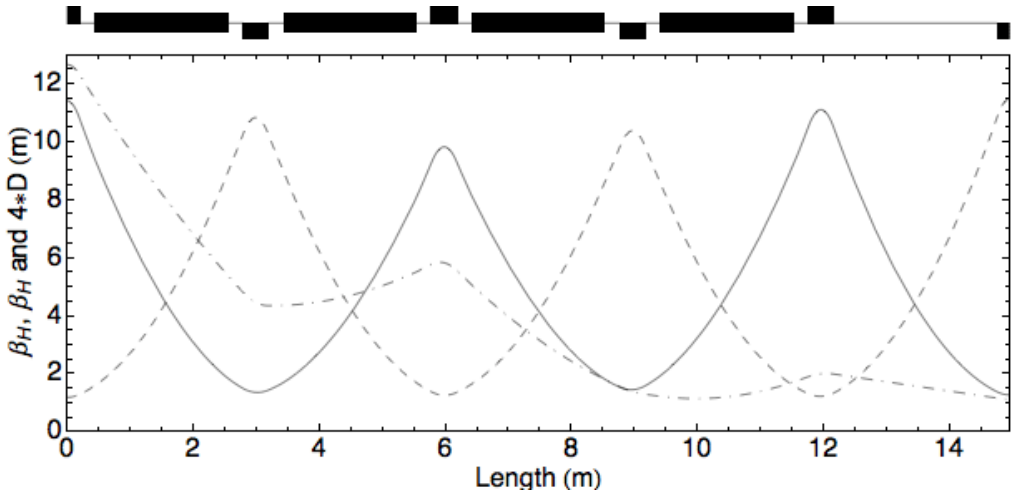
Time evolution of tune shift (black), bunching factor blue and bucket filling (red).

Short RCS as new PS Injector

- First investigations on lattice — Studied by M. Benedikt
  - Periodicity three
    - Straight sections for injection, RF and ejection
  - FODO lattice with 15 cells for efficient focusing
  - ➠ Large bending magnet filling factor (~56%)
  - Tunes around or a bit larger than 4 for suitable transition energy
    - With injection working point of present PSB
    - ➠ up to ~110° phase advance per cell
      … effect on space charge limit?

Envisaged as well
- FODO with 18 cells (5 per arc)
- Triplett for round beams

- Result
  - Working point of PSB at injection
    - ➠ $\gamma_{transition}$ = 3.61
  - 2.1 m long bends
    - ➠ Field at 2 GeV: 1.16 T
  - 0.4 m long quads with |k| ~ 1.4 m^{-2}
    - ➠ quads with ~ 1 T at r = 75 mm
  - 25 cm between quads and bends
  - 2.6 m between quads in straights



Lattice functions for one half-period: solid line denotes β_H, dashed one β_V and dot-dashed one 4*D

- Injection/ejection look feasible … still challenging (preliminary study by B.Goddard)

Short RCS as new PS Injector

Tentative list of main RCS parameter

Energy range	160 MeV to 2 GeV
Circumference	(200/7) π m ≈ 89.76 m
Repetition rate	~10 Hz
RF voltage	60 kV
Harmonics	h = 2 or 3
Frequency range	3.48 MHz (h=2 at injection) to 9.5 MHz (h=3 at ejection)
Beam parameters for LHC (for lower emittances scale down intensity accordingly)	Intensity: up to 12×2.7 10^{11} protons/cycle Transv. emittance: ε^*_{rms} ≈ 2.5 μm Long. emittance: ε_l < 12×0.27 eVs (determined by acceptance for most cases)
Lattice	FODO with 15 cells and 3 periods, 4 cells in arc, straight with one cell
Tunes	$4 < Q_{H,V} < 5$
Relativistic gamma at transition	~4
Bending magnet filling factor	56 %
Maximum magnetic field	1.16 T

Planning

- For end of June:
  - Refined technical design (lattice etc.)
  - Estimate of performance for LHC
  - Technical feasibility
  - Impact on other users
  - Preliminary cost estimate (~25%)

  => Management decision early in July
- If RCS option is felt interesting enough, prepare for early December 2011 a Project proposal with cost estimate and planning