PSB-PS MAGNET SPECIFICATIONS - UPDATE

Existing specifications
Distinction between LHC and HI beams

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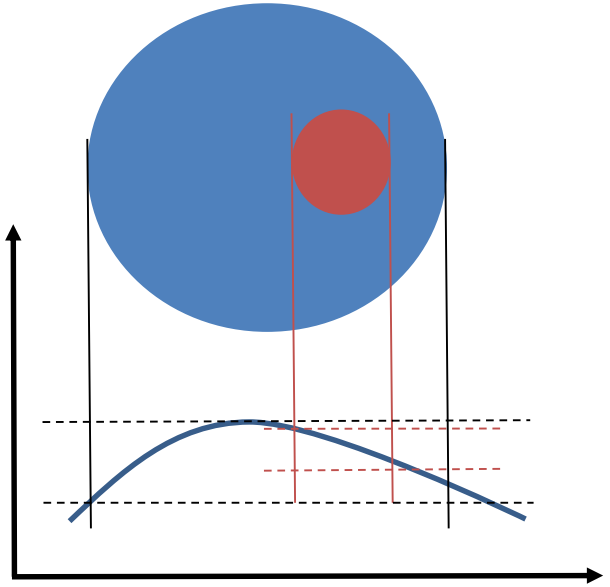
Aperture calculation

- $A_{x,y} = \pm n_{sig} \cdot \sqrt{k_\beta \cdot \beta_{x,y} \cdot \frac{\epsilon_{N;x,y}}{\gamma_r \beta_r}} \pm 2|D_{x,y} \cdot \sigma_\delta| \pm CO \cdot \sqrt{\frac{\beta_{x,y}}{\beta_{MAX;x,y}}}$
  - n_{sig} = 3
  - k_β = 1.2
  - *CO* = 3 mm
  - $E_k = 1.4/2.0$ GeV
- Emittances
  - HIE-ISOLDE: 13/6 um
  - HI (PS): 10/5 um
  - LHC: 2/2 um
- Good field region:
- BT.BVT10:
  - HIE-ISOLDE: ±26/16 mm
  - LHC ±12/10 mm
- BT.BVT20:
  - HIE-ISOLDE: ±48/15 mm
  - LHC ±21/10 mm

Distinguish field quality for beam type

- BT.BHZ10
- Field homogeneity of 1e-4 rms → max value of ±2e-4
- Possible approach:
  - use this requirement only for LHC beam size (±19/21 mm instead of ±51.5/51.5 mm)
    → optimize for emittance
  - Accept higher field inhomogeneities for HI beams as long as they fit into the acceptance
    → optimise for losses



LHC beams - emittance growth

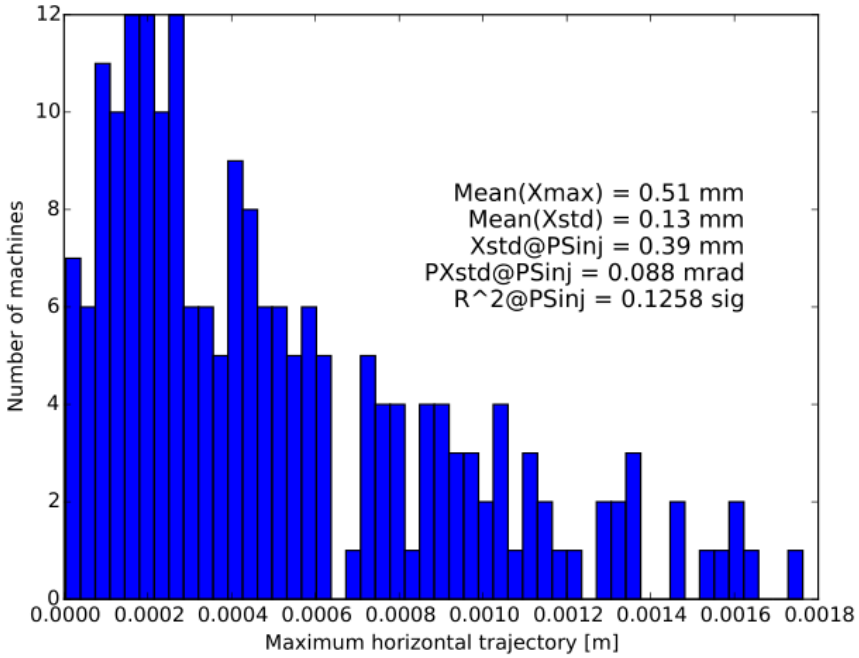
- Keep random errors of both planes balanced
  - Many small/medium error sources in vertical plane
  - One strong error source in horizontal plane

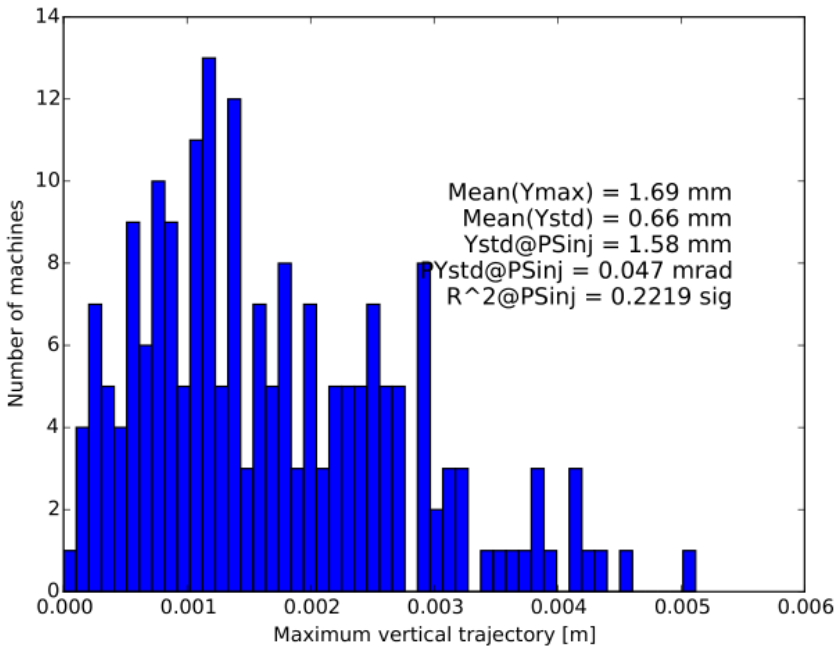
- OK for LHC beam as agreed in review on 24th September 2015

Error source	Tolerance ΔI/I	x rms (mm)	px rms (μrad)	R_x^2/ε_0 [1e-3]	y rms (mm)	py rms (μrad)	R_y^2/ε_0 [1e-3]
Random effects							
PSB orbit ± 0.15/0.10 mm (h/v)		0.04	4	0.4	0.04	2	0.2
BVT10	1e-4				0.08	1	0.3
SMV10	1e-4				0.13	1	1
QNO10	5e-4				0.11	1	1
QNO20	5e-4				0.03	1	0.06
KFA10	3e-4				0.02	1	0.06
SMV20	1e-4				0.01	4	1
KFA20	3e-4				0.01	0	0.02
BVT20	1e-4				0.05	3	1
BT.BHZ10	1e-4	0.07	0.02	4			
All random effects		0.08	17	5.1	0.21	6	4.0
Systematic effects							
KFA10	5e-3				0.39	15	17
KFA20	5e-3				0.22	8	5

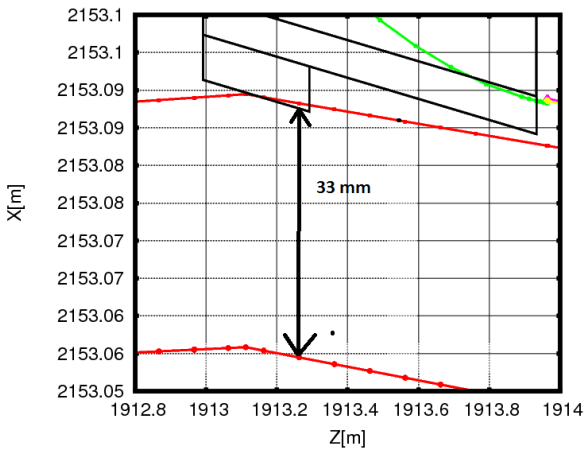
HI beams - particle loss

- Assuming ∫ΔB/B for the large GFR
  - BT.BHZ10: 5e-4 rms (max at ±1e-3)
  - BT.BVT10/20: 5e-4 rms (max at ±1e-3)
- Together with other recombination error sources leads to steering error of 0.4 (hor) and 1.6 mm (vert) → comparable to the assumed orbit tolerance of 1.5 mm in the ring

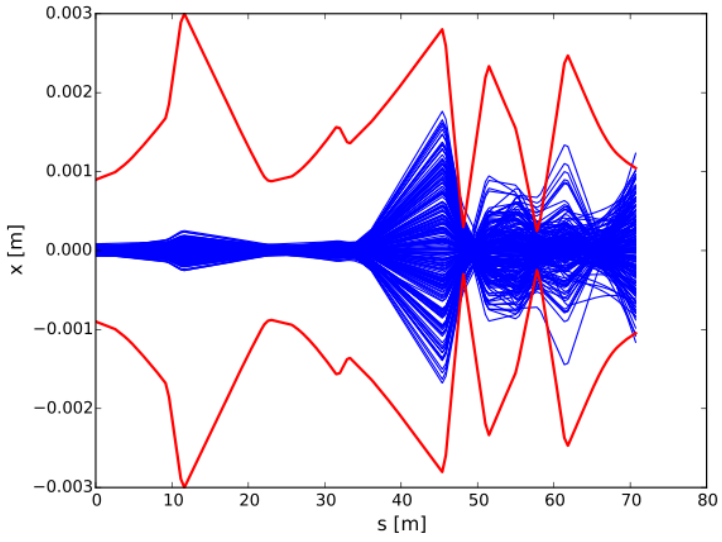


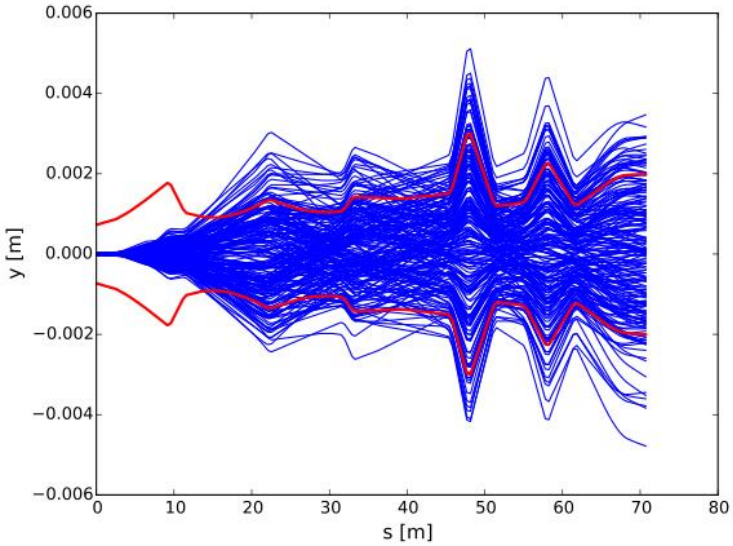


HI beams - particle loss



- Aperture bottleneck at PS injection when bump is fully on:
  - 33 mm radial aperture
  - Subtract 2 mm for alignment errors
  - 3 mm for the orbit already included in beam size
  - Fit 3.3 sigma horizontally of HI beam at 1.4 GeV
  - New septum will have increased vertical aperture (4.1 sig)
- Beam size changes by 0.8% due to optics mismatch after filamentation has taken place
  - Bump is collapsed within 500 turns





Conclusions

- Up to now used HI beams to define GFR and LHC beam requirements to define field homogeneity
- Proposal to distinguish requirements for LHC and HI beams
- LHC beams with smaller GFR require tight settings to limit emittance growth
  → keep settings as agreed upon on 24th Sept. 2015
- HI beams with large GFR limited by losses/dose
  - Relaxed field homogeneity leads to increased trajectory variations at PS injection
  - Bottleneck during injection when bump is fully on in horizontal plane
  - Fit 3.3 sigma at 1.4 GeV
- If agreed, should update specification table in magnet design report
- Also add tolerances for as-built and as-measured