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Update on PSB – PS optics studies

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LHC Injectors Upgrade

LIU-PSB Meeting

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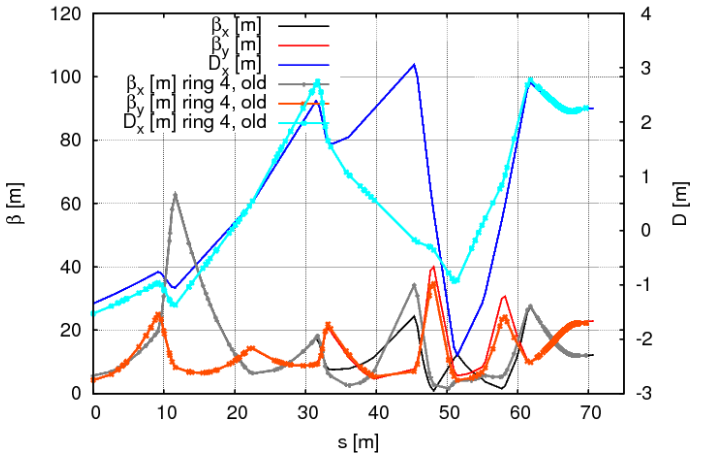
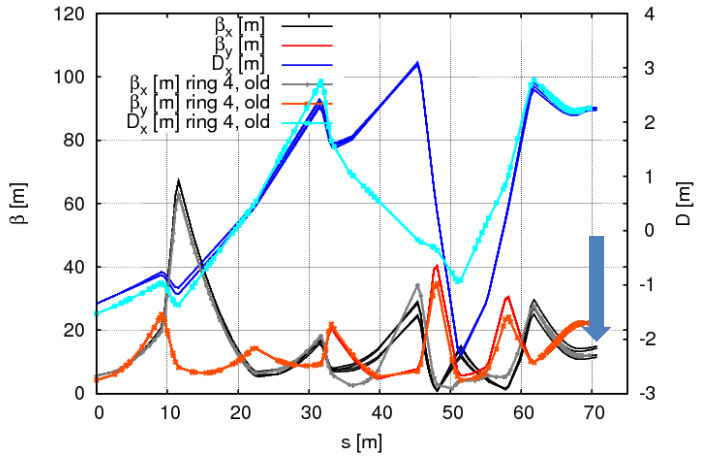
  - Matchability to ISOLDE
  - LIU MAD-X model in repository
- Conclusions

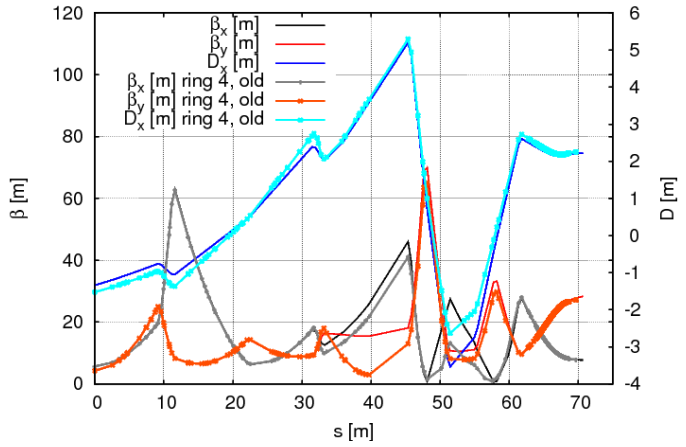
PSB ejection lines review (24/09/2015)

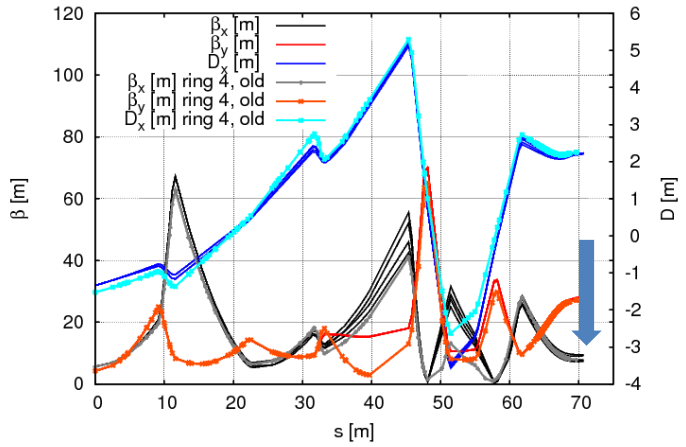
- In the PSB ejection lines review (24/09/2015) we found a significant optics disagreement for the different lines (coming from the different weak focusing of the vertical dipoles). It is **not possible to fully match the four BT_BTP lines to the PS**.





LHC optics





Fixed target (FT) optics

PSB ejection lines review (24/09/2015)

- In the PSB ejection lines review (24/09/2015) we found a significant optics disagreement for the different lines (coming from the different weak focusing of the vertical dipoles). It is **not possible to fully match the four BT_BTP lines to the PS**.

Therefore, an emittance increase associated with it was found.

↳ *action: optics rematch to reduce overall emittance increase*

Rematched the two optics: HI and LHC beams due to

-new magnetic length

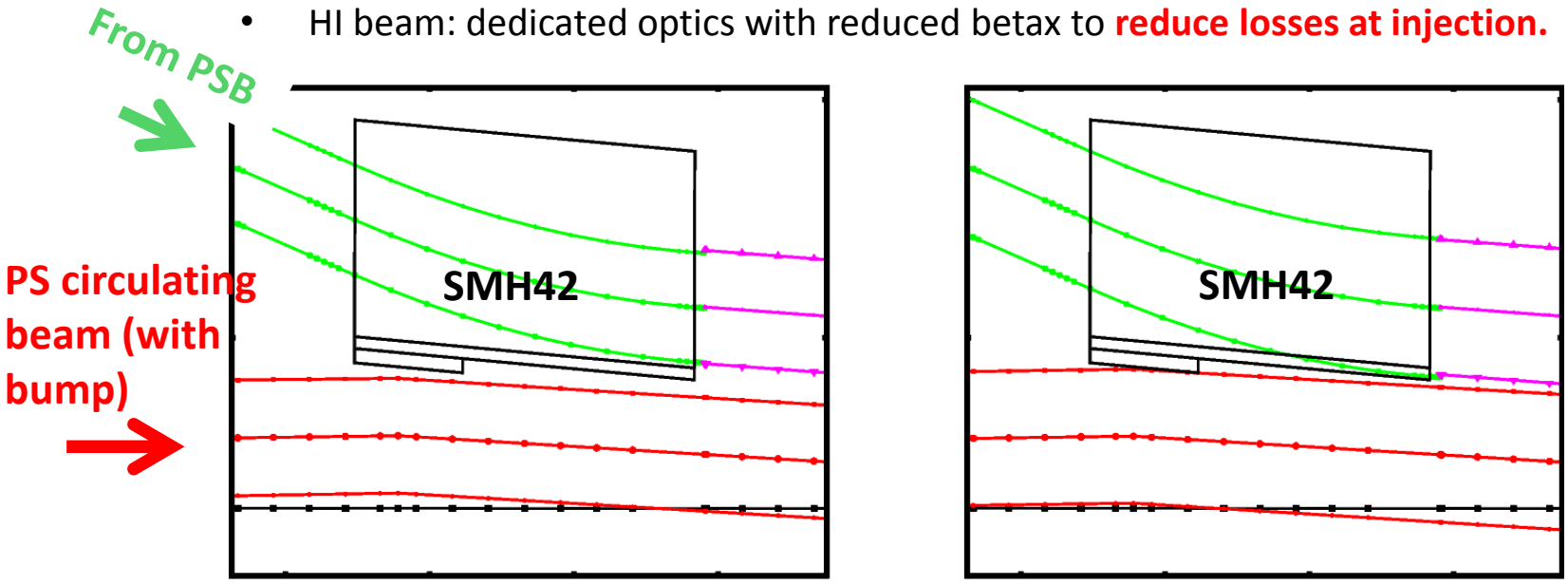
-reduce emittance growth

And keeping:

-maximum GFR / gradients for the quadrupoles already specified

BTP: reason for two optics

- HI beam: dedicated optics with reduced betax to **reduce losses at injection.**



FT beam with FT optics

FT beam with FT optics

$$A_{x,y} = n_{sig} \cdot \sqrt{k_\beta \cdot \beta_{x,y} \cdot \frac{\epsilon_{N;x,y}}{\gamma_r \beta_r}} + 2\left|D_{x,y} \cdot \frac{\Delta p}{p}\right| + CO \cdot \sqrt{\frac{\beta_{x,y}}{\beta_{MAX;x,y}}}$$

n_{sig}= 3
k_β = 1.2
$\epsilon_{N;x}$ = 10 µm
$\epsilon_{N;y}$ = 5 µm

$\frac{\Delta p}{p} = 1.35x10^{-3}$
CO = 3mm
E_k = 1.4 GeV

- EDMS: 1557577. Study and Optimization of the PS Injection Septum Position and of the Injection Bump at 2.0 GeV.

BTP rematched (LHC beams)

Optics at injection:

	betx [m]	alfx	bety [m]	alfy	Dx [m]	Dpx	Dy [m]	Dpy
PS ring	12.18	-0.13	22.16	-0.03	2.22	0.00	0.00	0.00
BT1_BTP	13.50	-0.11	22.2	-0.03	2.28	-0.01	-0.19	-0.03
BT2_BTP	12.89	-0.18	22.22	-0.02	2.26	0.00	0.29	-0.02
BT3_BTP	10.35	-0.13	22.17	-0.02	2.23	0.00	0.05	0.00
BT4_BTP	11.04	-0.06	22.15	-0.03	2.26	-0.01	0.53	0.01

Rel. Emittance growth:

	(Δϵ/ϵ) due to betatron mismatch [%]		(Δϵ/ϵ) due to dispersion mismatch [%]	
	Hor.	Ver.	Hor.	Ver.
Ring1	0.58	0.00	0.17	2.38
Ring2	0.28	0.01	0.02	1.21
Ring3	1.34	0.00	0.00	0.01
Ring4	0.61	0.00	0.11	1.37
Max	1.34	0.01	0.17	2.38

BTP rematched (FT beams)

Optics at injection:

	betx [m]	alfx	bety [m]	alfy	Dx [m]	Dpx	Dy [m]	Dpy
PS ring	7.52	0.12	28.04	-0.27	2.83	0.11	0.00	0.00
BT1_BTP	8.04	0.07	28.29	-0.41	1.99	-0.05	0.05	-0.03
BT2_BTP	7.86	-0.03	28.50	-0.40	1.98	-0.04	0.47	-0.01
BT3_BTP	6.34	-0.06	28.33	-0.41	1.97	-0.03	0.06	0.00
BT4_BTP	6.58	0.02	28.12	-0.41	1.98	-0.04	0.47	0.02

Rel. Emittance growth

	(Δϵ/ϵ) due to betatron mismatch [%]		(Δϵ/ϵ) due to dispersion mismatch [%]	
	Hor.	Ver.	Hor.	Ver.
Ring1	0.35	0.88	8.36	1.48
Ring2	1.15	0.78	7.61	0.68
Ring3	3.18	0.83	7.49	0.01
Ring4	1.37	0.94	8.26	0.99
Max	3.18	0.94	8.36	1.48

BTP rematched

- Comparative Rel. Emittance growth (Δϵ/ϵ) before/after rematching

	(Δϵ/ϵ) for LHC beams [%]		(Δϵ/ϵ) for HI beams [%]	
	hor.	ver.	hor.	ver.
betatron mismatch	2.3/1.3	0.0/0.0	2.0/3.2	0.0/0.9
dispersion mismatch	0.1/0.2	5.4/2.4	0.0/8.4	5.2/1.5
total mismatch	2.3/1.4	5.4/2.4	2/8.9	5.2/1.75

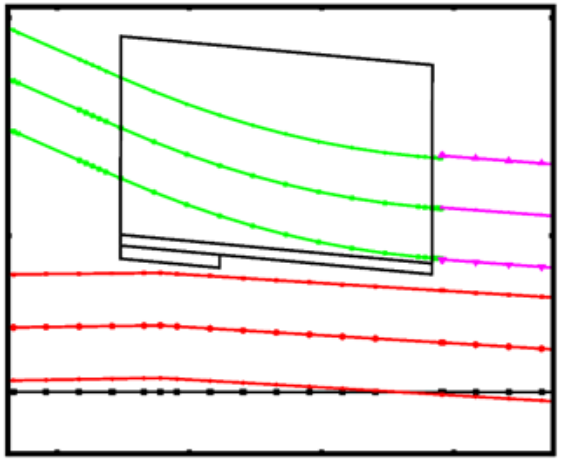
- For the LHC beams, the emittance increase has been reduced in both planes.
- For the HI beams:
  - Reduced vertical emittance increase
  - horizontal emittance increase larger

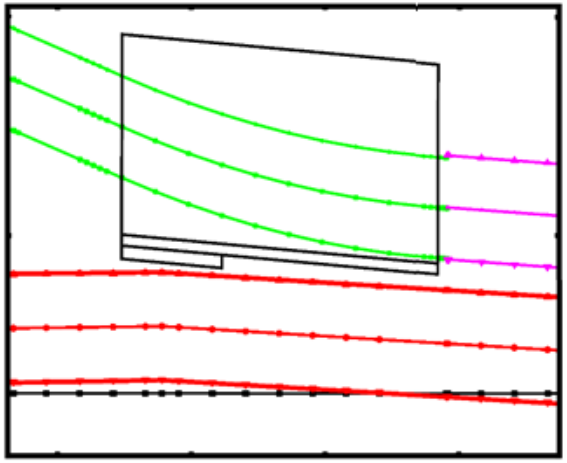
- Figure of merit for HI beams is not emittance increase but losses

- Relative increase in beam envelope: 3.4 % (hor.) and 0.8 % (ver.)

BTP rematched

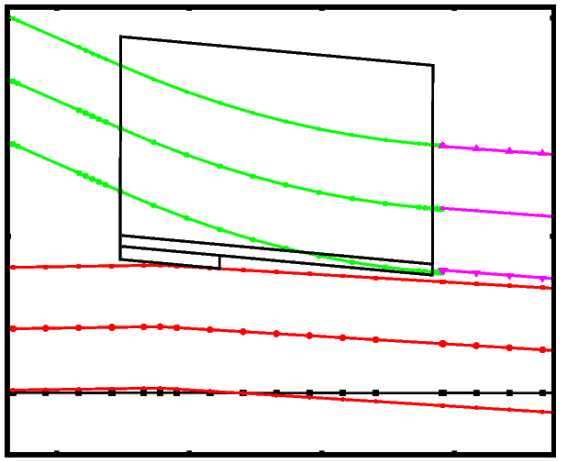
Effect of hor. emittance increase for the HI optics: No effect on beam losses





HI beam with HI optics

FT optics better in terms of acceptance, even with the emittance increase

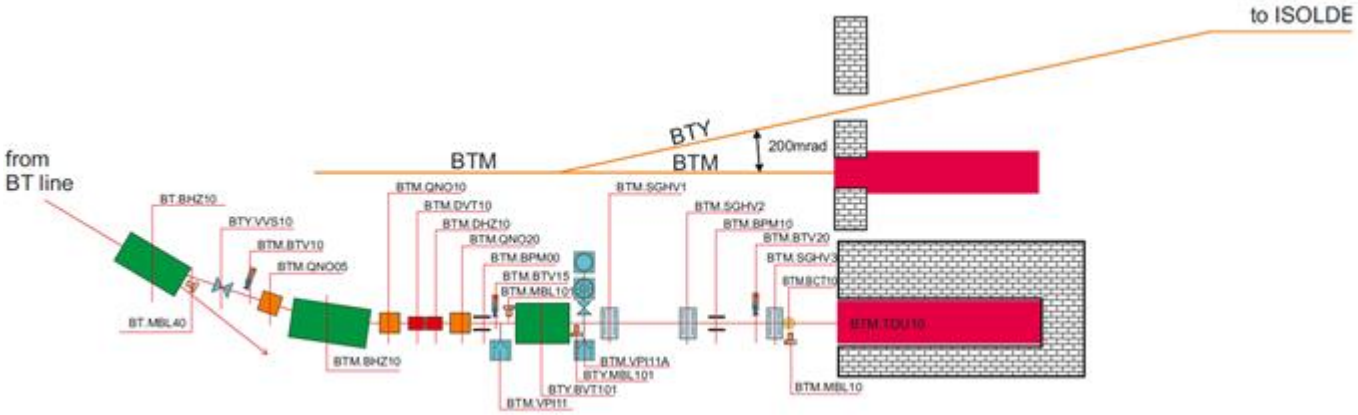


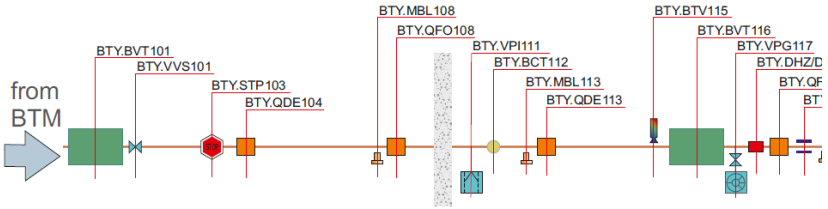
HI beam with LHC optics

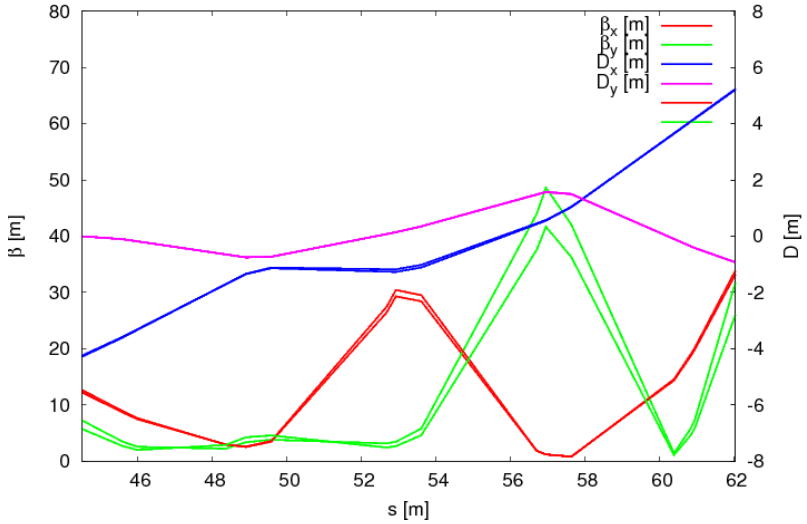
Other things

- Beam specifications for beam stopper (EDMS 1557914). Limit cases for the beams to the STP studied and specified for simulations (document sent for approval).
- Element positions and maximum beam envelopes provided for integration (BT, BTM, BTP)
- Impact of new optics to BTY
- LIU MAD-X model in repository

Other things: impact of new optics in BTY







BTM dump optics shared with BTY.

Model of BTY in the AFS repository (B. Mikulec, GP di Giovanni, O. Berrig)

Impact of the new optics analysed. No major effect, but may need rematching at the end of the line

Other things: LIU MAD-X model in repository

- BT-BTP model updated
  /afs/cern.ch/eng/ps/cps/TransLines/PSB-PS/2015/cmd/PSB-PS-LIU-proj/LIU_PSB-PS_transfer_lines
- BT part
  - Introduced new septa (vertical dipole strengths adjusted)
  - Updated BT.QNO40, BT.QNO50 (position and Lm)
- BT-BTP part
  - Updated BT.BHZ10 (Lm=1.53 m->2.2 m)
  - Updated BT.QNO40, BT.QNO50 (position, Lm, strengths)
  - Updated BTPQNO20,BTPQNO30,BTPQNO35, BTPQNO40, BTPQNO50, BTPQNO55, BTP.QNO60 (position, Lm, strengths)
- BT-BTM part
  - Updated BT.BHZ10 (Lm=1.53 m->2.2 m)
  - BT.QNO40, BT.QNO50, BTM.QNO05, BTMQNO10, BTMQNO20 (with present Lm).

Lm=640 mm
(EDMS 1549299)

Not fixed by hardware yet. New optics (5 quadrupole strengths) to be adjusted once Lm is fixed.

→ Strengths from LIU-PSB WG meeting (08/05/2014)

Conclusions

- The emittance increase for LHC beams at PS injection due to optics mismatch has been reduced.
- A new optics has been produced for FT beams, keeping the constraints from gradients and GFR in the new quadrupoles.
- The new FT optics shows a small increase in terms of beam size (no impact in beam losses).
- The benefit of using a dedicated optics (in BTP and PS) for FT beams has been shown.
- The impact of the new BTM optics in the BTY is minimal.