24 September 2015

PSB ejection lines review

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with many inputs from:

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Scope of the review

- Basis is the design as presented in Oct-13 (http://indico.cern.ch/event/274495/)
- Revisit the ejection line design after iterations on integration, magnet design and accordingly optics
- **Two presentations:**

Geometry, optics, integration

- TL geometry, PS injection geometry
  - BT.BHZ10 center of deflection, position of upstream quadrupoles
- Optics
  - Rematched optics to the PS
  - Dispersion at PSB extraction
  - Upgraded BTM optics versions to improve beam size in BTM.BHZ10
- Updated list of quadrupole gradients and GFR
- Overall status of integration
- Instrumentation/special elements

Stability studies:

- Error sources
- Stability calculations from dynamic errors
- Emittance growth from different sources and losses

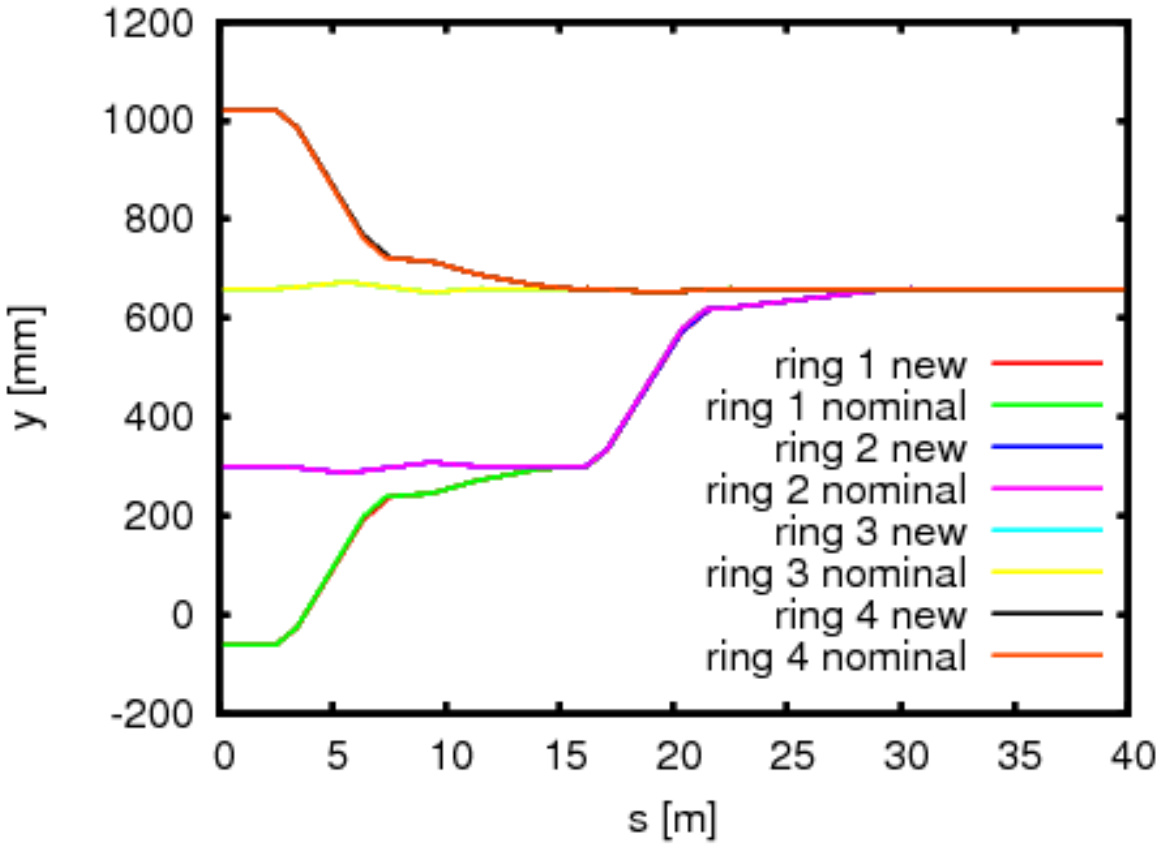
Contents of the first presentaition

- 1. New geometry for BT lines
- 2. New optics for BT-BTM
- 3. PSB-PS optics
- 4. BT/BTP quadrupole gradients and GFR
- 5. Integration studies
- 6. Beam instrumentation

1. New geometry for BT lines

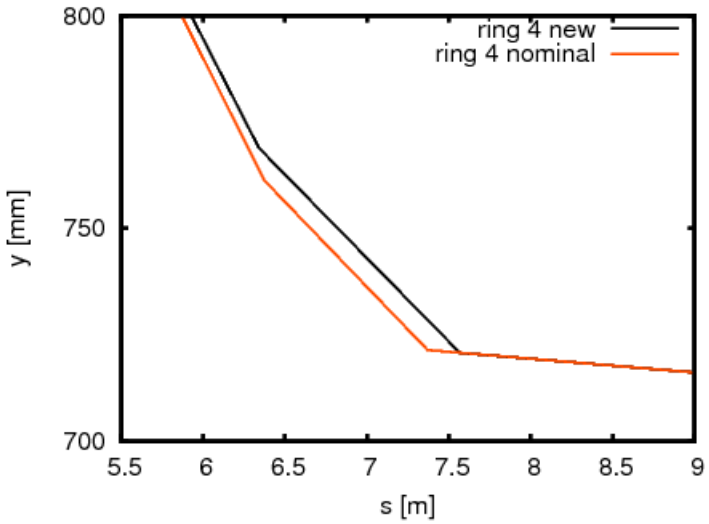
- Geometry of the line changed for the longer septa
- Same geometry after BT. SMV20.

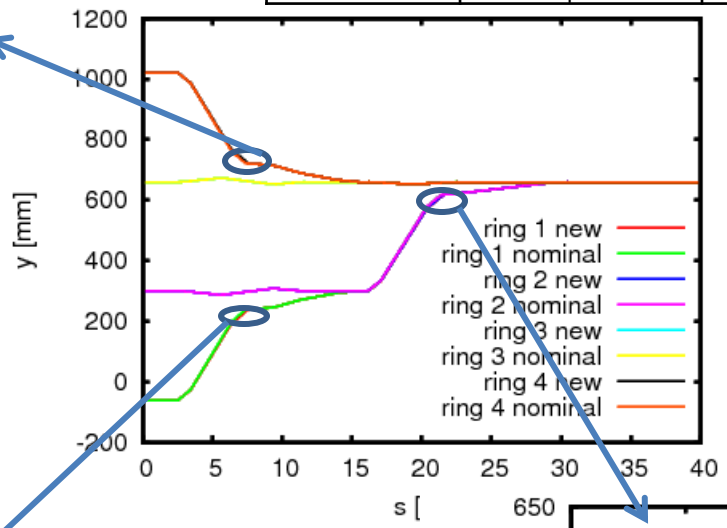
Ref: LIU-PSB Working Group Meeting. 6/11/2014

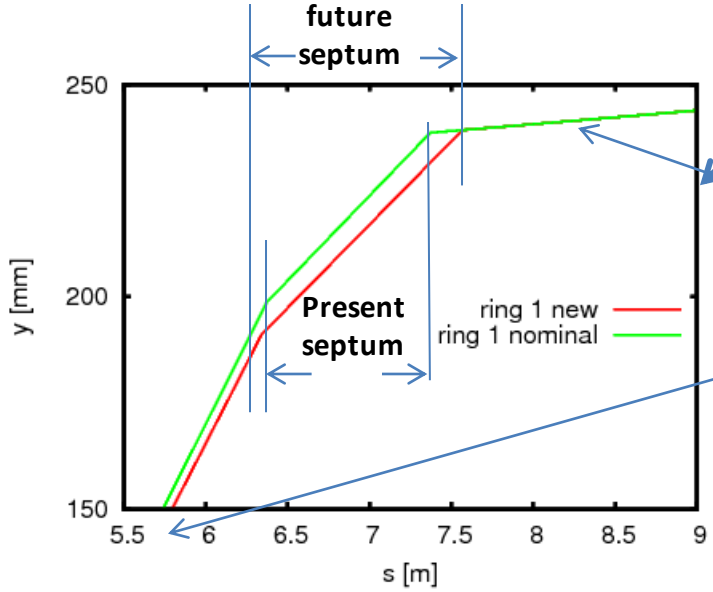


1. New geometry for BT lines

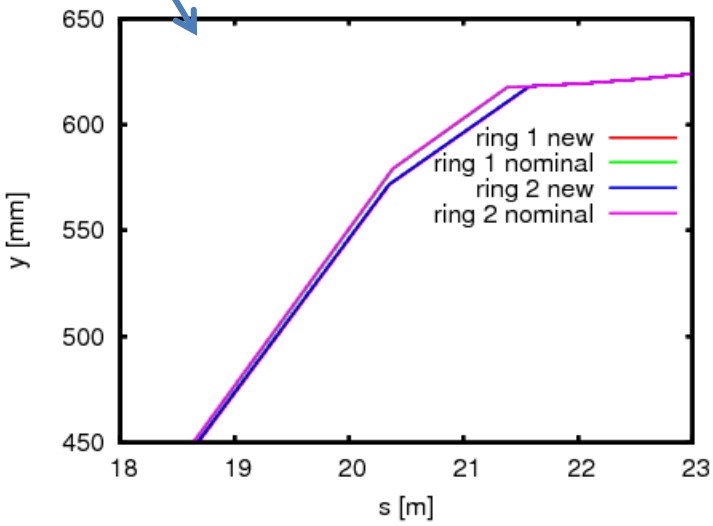
	Element	Present [mrad]	Upgraded [mrad]
dbt1bvt10	Bending magnet	76.80	75.27
dbt1smv10	Septum	73.56	72.03
dbt4bvt10	Bending magnet	76.80	75.27
dbt4smv10	Septum	73.56	72.03
dbtbvt20	Bending magnet	74.17	72.82
dbtsmv20	Septum	71.31	69.96







In order to
to keep same orbit at
SMV exit, trajectories are
rematched



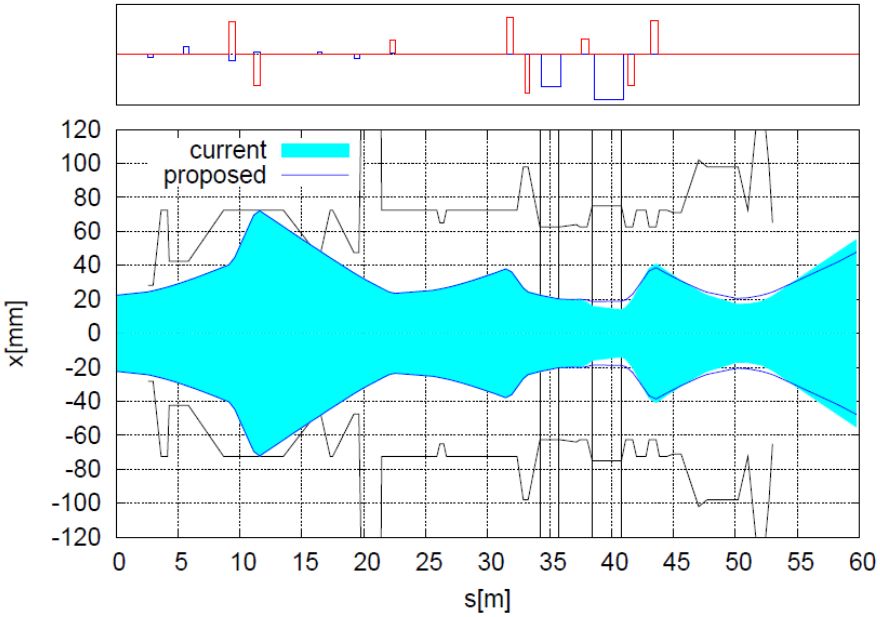
2. New optics for BT-BTM

- The reason: last review 2013 showed BTM.BHZ10 as the bottleneck of the line. Need to reduce beam size to reduce aperture.
- New set of optics:
  - Dump optics
  - Horizontal measurement optics (large DX)
  - Horizontal measurement optics (small DX)
  - Vertical measurement optics

Ref: LIU-PSB Working Group Meeting. 8/05/2014

- Optics settings successfully tried in the control room with beam.
- Analysing the reduction in losses for the new dump optics

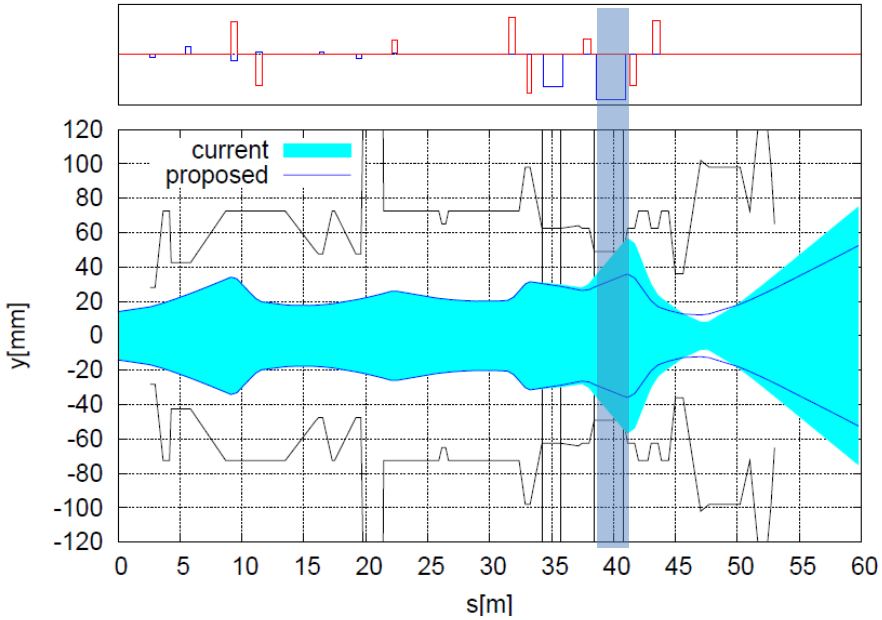
2. New optics for BT-BTM



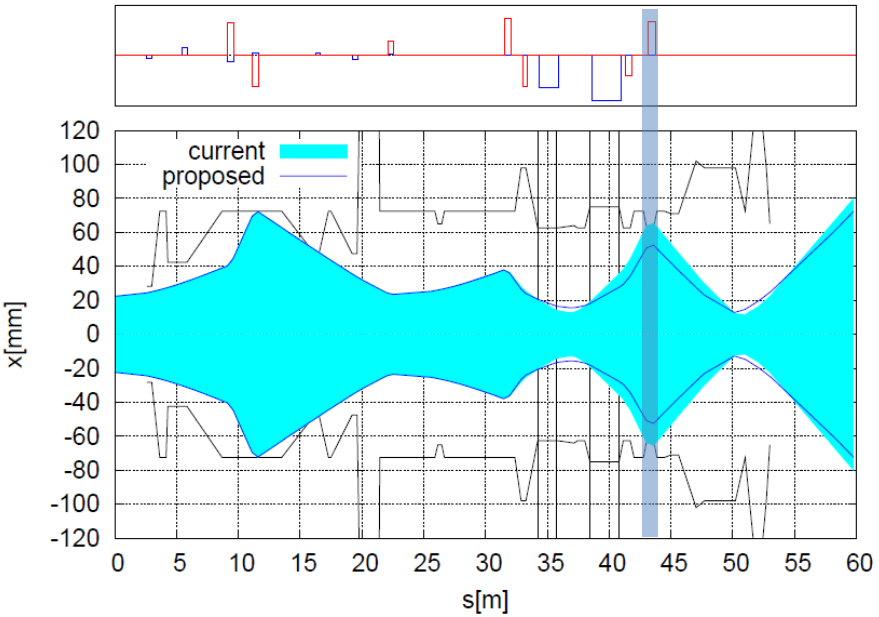
Dump optics

BTM.BHZ10

Beam size reduced from 55.7 mm to 36.2 mm

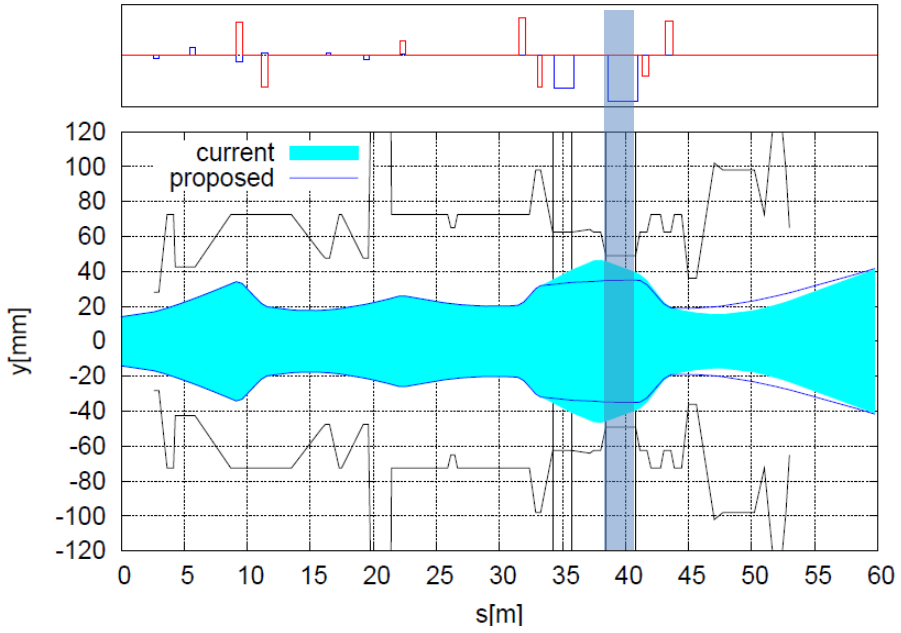


2. New optics for BT-BTM



BTM.QNO20
Beam size reduced from 65.1 to 52.2 mm

BTM.BHZ10
Beam size reduced from 47.0 mm to 36.2 mm



Hor. measurement optics (large Dx)

3. PSB-PS optics

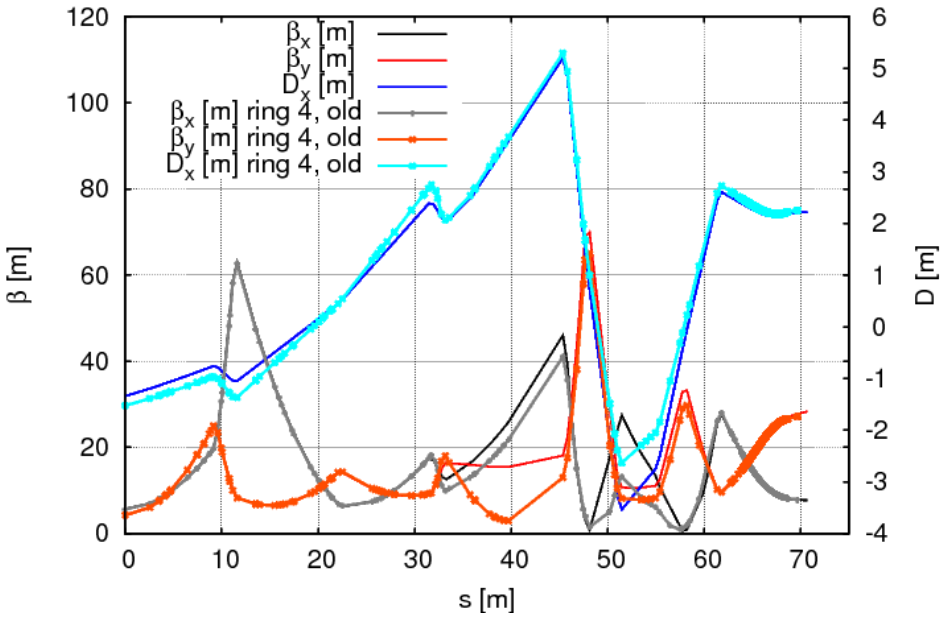
- Two main changes with respect to 2013 review:
  - Quadrupoles BT.QNO40 & BT.QNO50 moved to present location.

    Deflection center of BT.BHZ10 kept
  - Dedicated model of the BT lines included

    4 different optics for the BT line

- We have kept 3 sets of BTP optics:
  - Fixed target (matched to the PS with the magnet insertions)
  - LHC (matched to the PS)
  - LHC (mismatched as today): same values at PS injection as we have today.

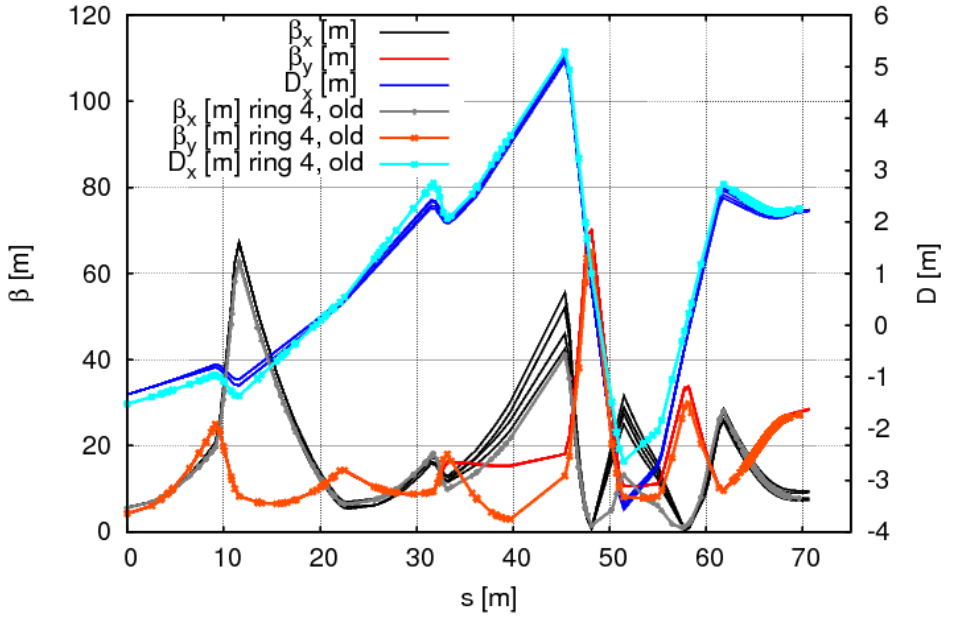
3. PSB-PS optics



Ring 4

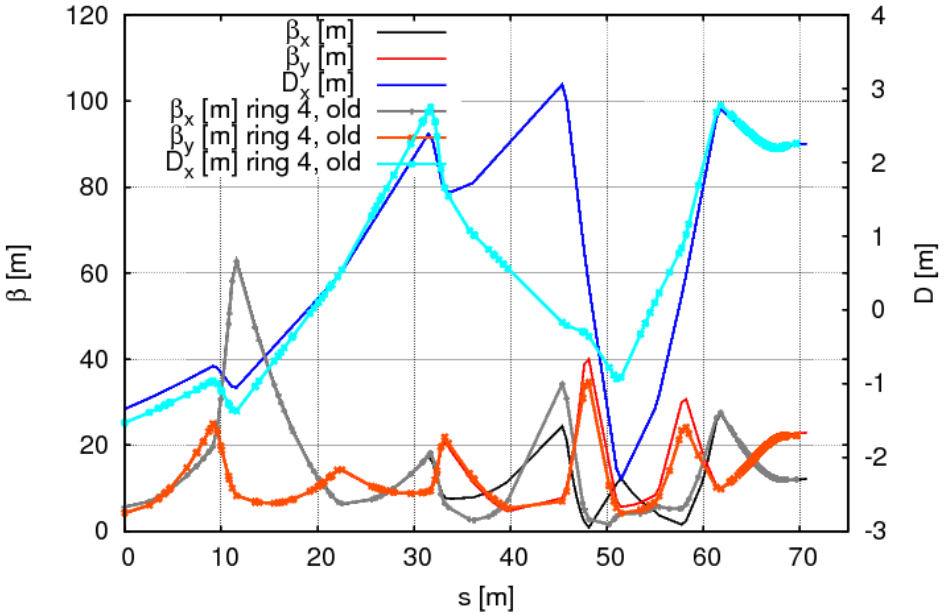
Difference in the horizontal betatron function as a consequence of different weak focusing of the vertical dipoles

Fixed target (matched)



All rings

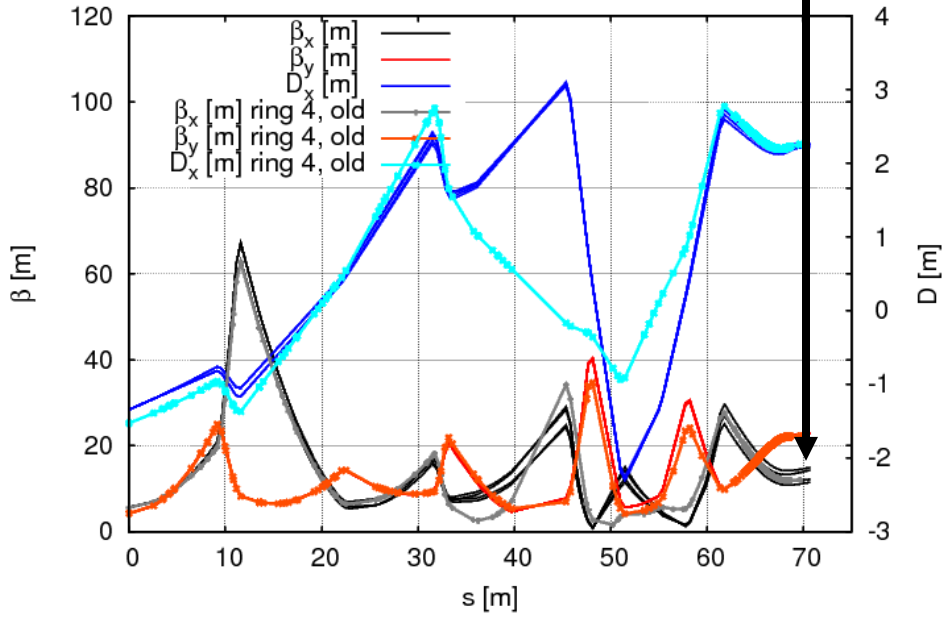
3. PSB-PS optics



Ring 4

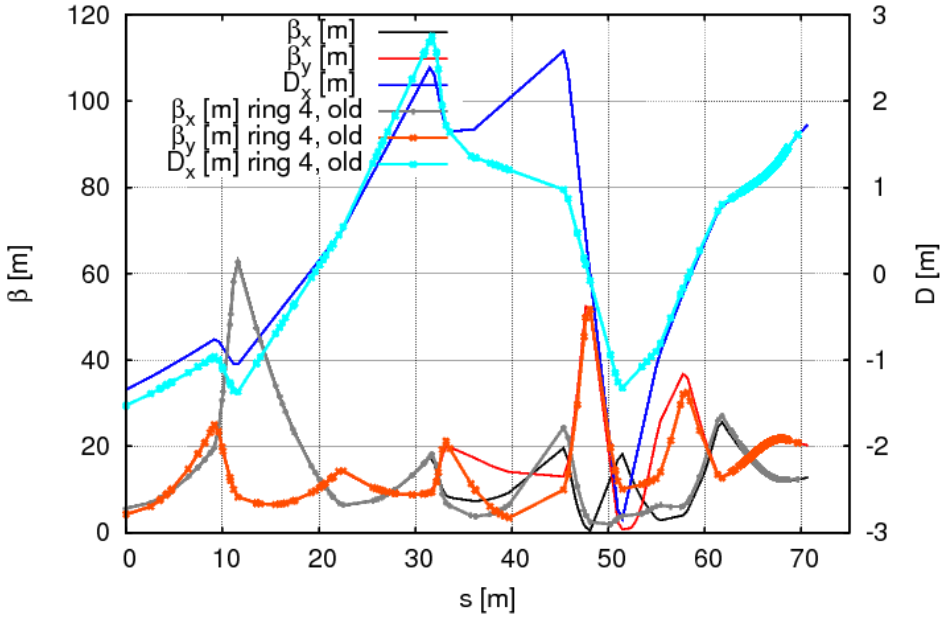
LHC (matched)

Significant spread in the horizontal betatron function at PS injection



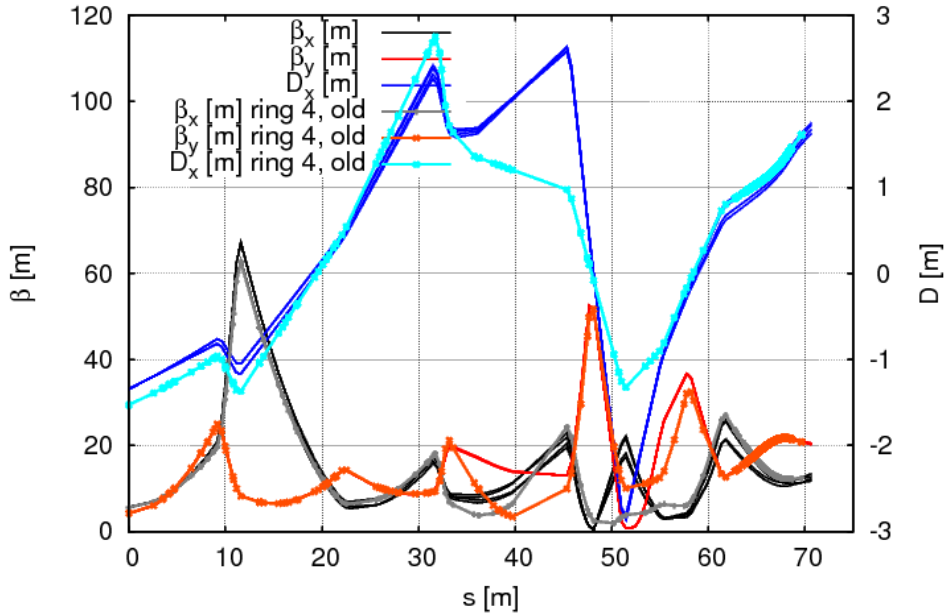
All rings

3. PSB-PS optics



Ring 4

LHC (mismatched as today)

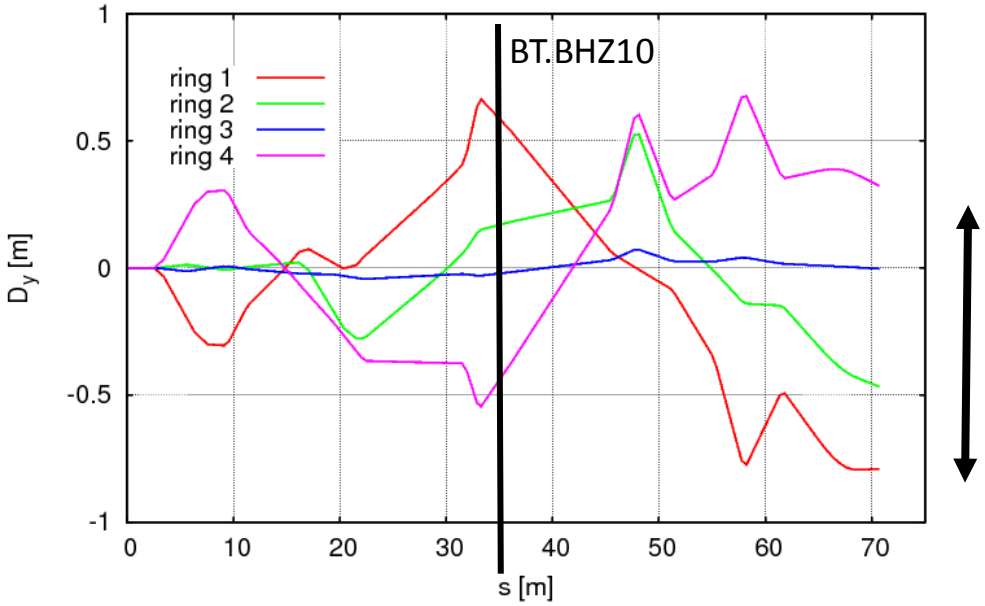


All rings

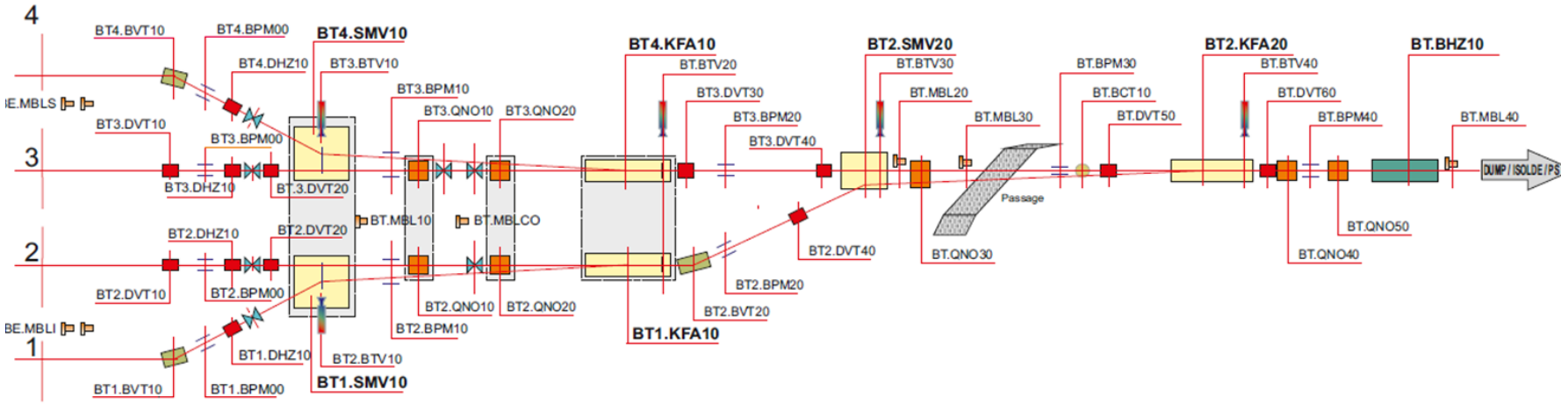
3. PSB-PS optics

- Vertical dispersion is very different at PS injection

LHC matched optics



1 m difference!



4. BT/BTP quadrupole gradients and GFR

- Good field region radius (GFR) computed as

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

n_{sig}= 3
k_β = 1.2
CO = 3 mm
$E_k = 1.4$ GeV

- Fixed target (matched)

$\epsilon_{N;x}$ = 10 µm
$\epsilon_{N;y} = 5$ µm
$\sigma_\delta = 1.35\text{x}10^{-3}$

- LHC (matched)

$\epsilon_{N;x}$ = 2 µm
$\epsilon_{N;y} = 2$ µm
$\sigma_\delta = 1.07\text{x}10^{-3}$

- LHC (mismatched as today)

$\epsilon_{N;x}$ = 10 µm
$\epsilon_{N;y} = 5$ µm
$\sigma_\delta = 1.35\text{x}10^{-3}$

4. BT/BTP quadrupole gradients and GFR

	element	L [mm]	K1 [1/m^2]	Gradient @ 2 GeV [T/m]	Max Gradient (x1.2) [T/m]	GFR radius H/V [mm]
Fixed target matched	BT.QNO10	466.1	0.66749	6.20	7.44	40 / 26
	BT.QNO20	466.1	0.63160	5.87	7.04	63 / 16
	BT.QNO30	466.1	0.28709	2.67	3.20	21 / 21
	BT.QNO40	466.1	0.44604	3.19	4.97	38 / 18
	BT.QNO50	388.0	-0.51933	-3.71	-5.79	33 / 23
	BTP.QNO20	465.0	0.89556	6.40	9.98	66 / 27
	BTP.QNO30	465.0	-0.91271	-6.52	-10.17	9 / 48
	BTP.Q35	466.0	0.99760	7.13	11.12	52 / 19
	BTP.QNO50	465.0	0.52838	3.77	5.89	34 / 20
	BTP.Q55	466.0	-0.65410	-4.67	-7.29	7 / 33
	BTP.QNO60	465.0	0.76173	5.44	8.49	47 /18
LHC matched	BT.QNO10	466.1	0.66749	6.20	7.44	20/18
	BT.QNO20	466.1	0.63160	5.87	7.04	31/11
	BT.QNO30	466.1	0.28709	2.67	3.20	20/13
	BT.QNO40	466.1	0.73043	5.22	8.14	20 / 13
	BT.QNO50	388.0	-0.91415	-6.53	-10.19	14 / 18
	BTP.QNO20	465.0	0.90472	6.46	10.08	25 / 12
	BTP.QNO30	465.0	-0.98691	-7.05	-11.00	4 / 24
	BTP.Q35	466.0	1.07388	7.67	11.97	19 / 9
	BTP.QNO50	465.0	0.51312	3.66	5.72	10 / 12
	BTP.Q55	466.0	-0.67356	-4.81	-7.51	7 / 22
	BTP.QNO60	465.0	0.63564	4.54	7.08	26 / 13
LHC pres. mismatched	BT.QNO10	466.1	0.66749	6.20	7.44	40 / 27
	BT.QNO20	466.1	0.63160	5.87	7.04	21 / 21
	BT.QNO30	466.1	0.28709	2.67	3.20	21 / 21
	BT.QNO40	466.1	0.67177	6.24	7.49	37 / 19
	BT.QNO50	388.0	-0.71038	-6.60	-7.92	27 / 26
	BTP.QNO20	465.0	0.980264	9.10	10.92	40 / 23
	BTP.QNO30	465.0	-1.094192	-10.16	-12.19	5 / 42
	BTP.Q35	466.0	1.091352	10.14	12.16	44 / 5
	BTP.QNO50	465.0	-0.46441	-4.31	-5.18	16 / 30
	BTP.Q55	466.0	-0.41218	-3.83	-4.59	18 / 35
	BTP.QNO60	465.0	0.52735	4.90	5.88	39/ 21

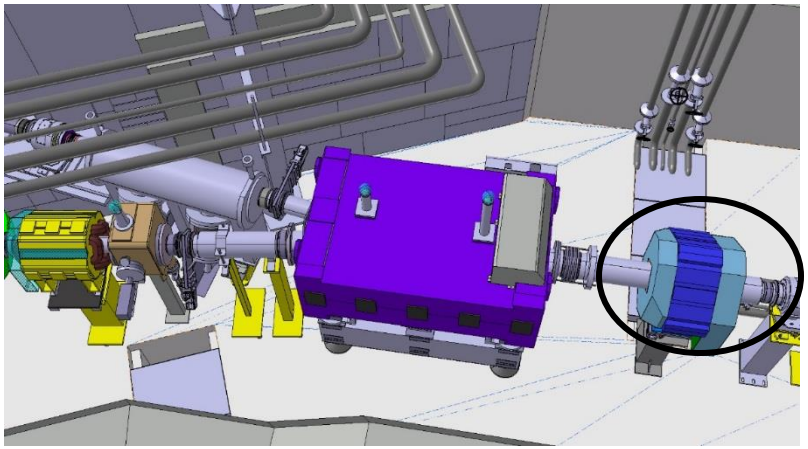
- Matched within the max. spec. gradients @ 2013 review
- Some numbers have changed due to different betatron for the lines and position of the BT.QNO40, BT.QNO50.
- Increased GFR from 59/23 but gradient below overall max.

5. Integration studies

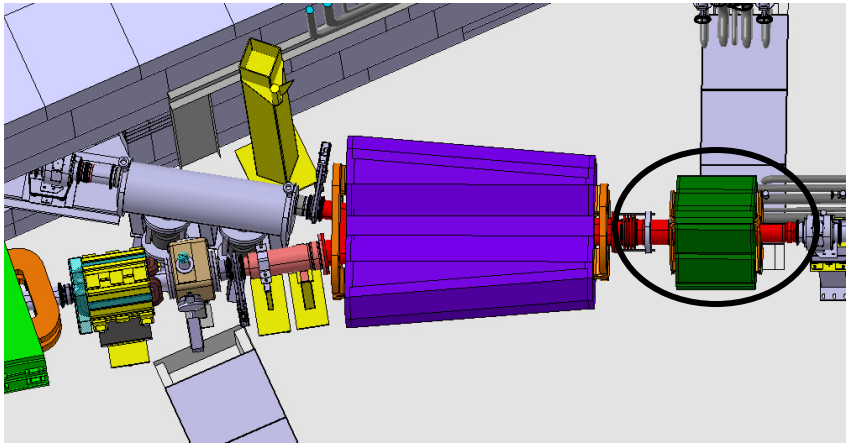
Input for integration:

- New quadrupole:
  - For slots BT.QNO40, BT.QNO50, BTP.QNO20, BTP.QNO30, BTP.Q35, BTP.QNO50, BTP.Q55, BTP.QNO60
  - 3D model provided for integration
  - Engineering spec draft
- Bending magnets BT.BHZ10 & BTM.BHZ10
  - 3D model provided for integration
  - Engineering spec draft

5. Integration studies



Present BT.BHZ10



LIU BT.BHZ10

BT.BHZ10 Deflexion center unchanged

Final 3D model for the new quad.

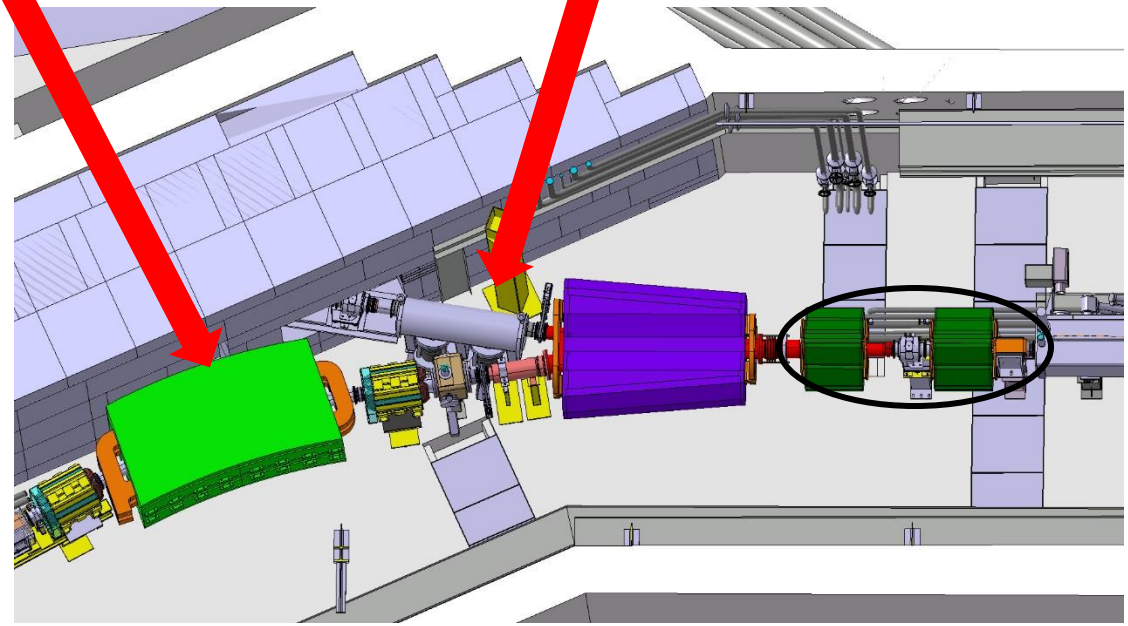
5. Integration studies

Future BTM.BHZ10

Present beam stopper

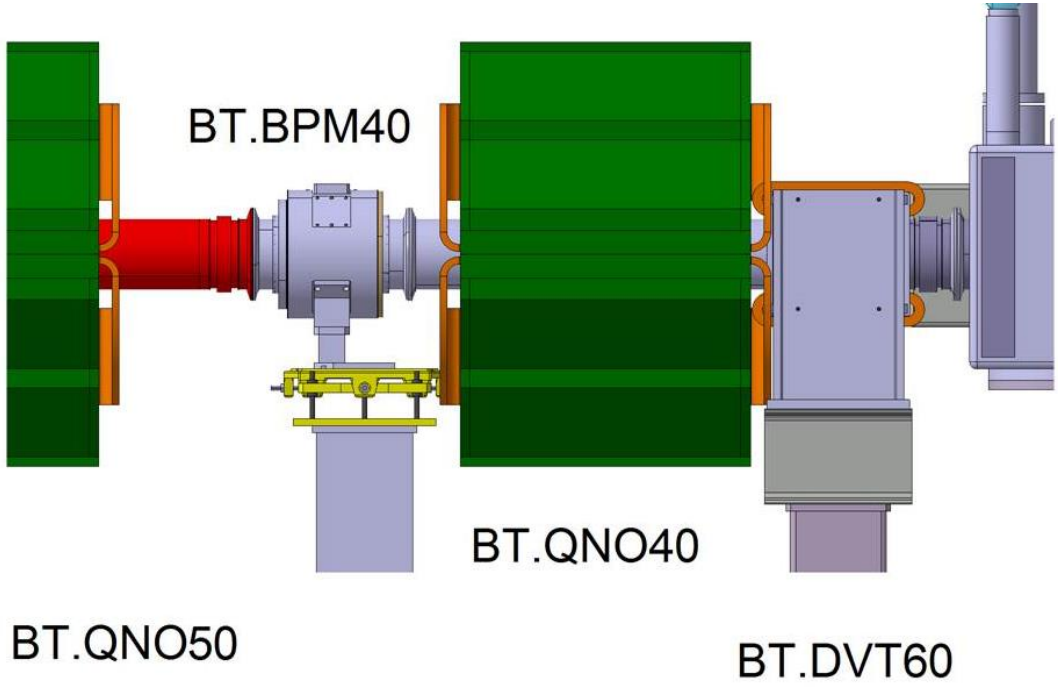
Enough space,
but at the limit

New one at 2.0 GeV?



BT.QNO40, BT.QNO50 at the same position.
Some small integration issues

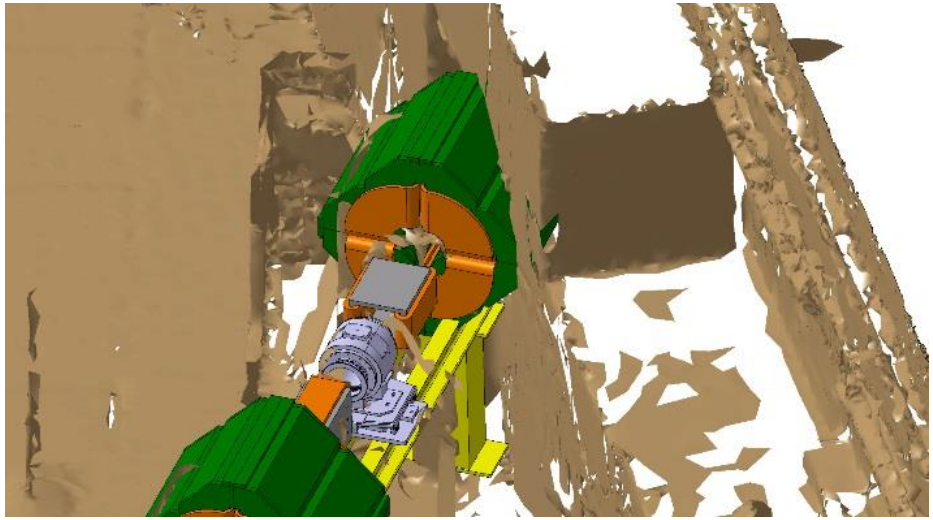
5. Integration studies



- Vacuum chamber QNO50 must be replaced as present diameter is excessive (Ø199)
- Collision problem between QNO40 and DVT60
- Collision problem between QNO40 and BPM40 support

5. Integration studies

BTP.QNO20



Collision with the 'blindage' of the wall

Need removal/redesign of the blocks ?

Present situation

6. Beam Instrumentation

- Electrostatic Pick-Up in the BTP Line: EDMS: 1514958
- BPMs positions to be frozen integration studies provides available space (integration model of BPMs needed)
- New BLMS proposed
- BTV moved. EDMS: 1494823