Progress of
D05V1 Collimator Installation

2022/12/14

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What's NLC

- NLC(Non Linear Collimator) is constructed by...
  - Quadratic(Non Linear) Kick by Skew Sextupole: $\Delta\theta_y \propto K2\,(y^2-x^2)$
  - Quasi-π/2 Telescope: $L_{tele.} \equiv TM_{34}(\text{sext.}\rightarrow\text{coll.})$ => $\Delta y_{coll.} \propto L_{tele.}\,K2\,(y^2-x^2)$
  - D05V1 Collimator with variable vertical aperture: $A_{coll.}$
    - Collimator kick factor correlates with $A_{coll.}^{-1}$ & $\beta_y^{coll.}$.
  - -I' cell for Skew Sextupole pair to hide quadratic kick from global beam dynamics
    - In minimum design, $TM_{34}(\text{sext.}\rightarrow\text{coll.})$ is constant of device geometry due to -I' cell matching.
    - $TM_{34}(\text{sext.}\rightarrow\text{coll.}) \sim (\beta_y^{sext.}\,\beta_y^{coll.})^{1/2}$
- Effective Normalized Vertical Aperture at Skew Sextupole: $N_{eff} \equiv A_{sext.} / \sigma_y^{sext.}$
  - $N_{eff}^2 \propto \frac{1}{L_{tele.}\,\varepsilon_y}\frac{A_{coll.}}{K2\,\beta_y^{sext.}} \sim \frac{1}{L_{tele.}^3\,\varepsilon_y}\frac{A_{coll.}\,\beta_y^{coll.}}{K2}$ $\quad\sigma_y^{sext.} \equiv \sqrt{\varepsilon_y \beta_y^{sext.}},\ |x| \ll |y|$
- Merit compared with usual collimator
  - Lower kick factor than usual collimator is available by choosing suitable skew sextupole strength & device geometry.

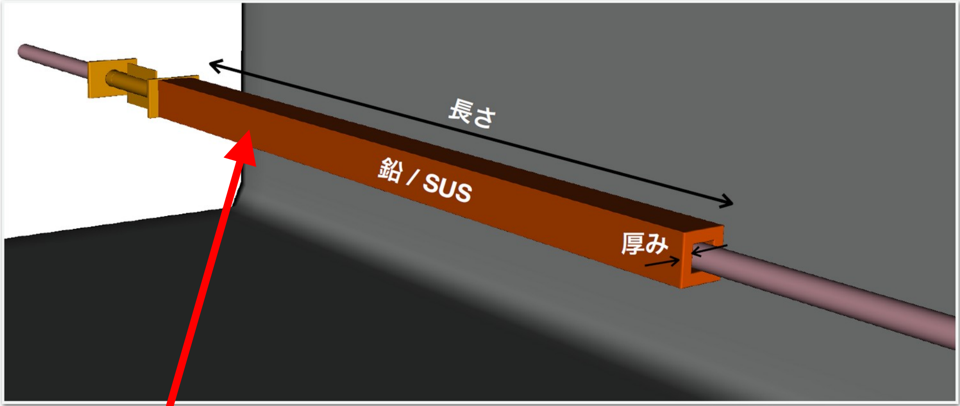
NLC Installation Side Effects

- Lose a part of damping wiggler units (10/56)
  - Longer damping time on default wiggler setting
    - Damping time COULD be recoverd by wiggler strength, however, more heat load for wiggler vacuum pipes & heavier wiggler magnet PS load are expected.
- Require additonal radition sheild for operation
  - Considering & Preparing additonal sheilds:
    - Pb beam pipe cover
    - Concreate sheild to cover air duct

Considering Additonal Radiation Sheild

カバーシールド

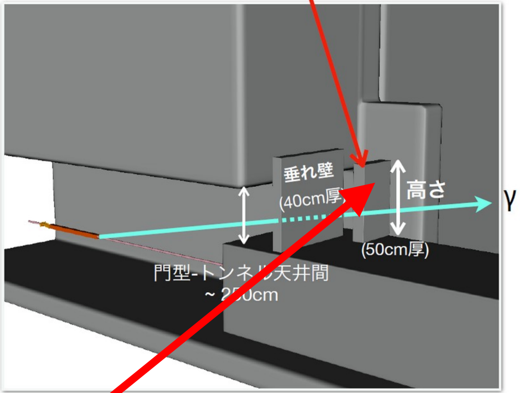
- ビームパイプの上下左右を鉛またはSUSで覆う
- ビームパイプ：アルミ、厚み6mm（内径90mm、外径102mm）

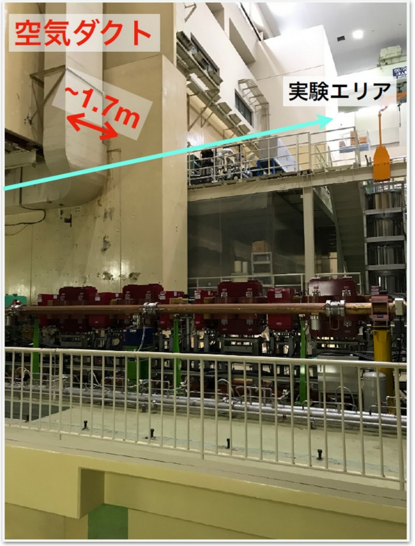


Pb Sheild around Vacuum Pipe

垂れ壁横のコンクリートシールド

- **空気ダクト**により垂れ壁では塞げない領域が存在する
- それにより大穂の立ち入り可能な場所からビームラインが見えうる
- **隙間を塞ぐコンクリートシールド**を置いた場合の線量変化を見る





Concreate sheild to cover air duct space

NLC Lattice Design Works

- Original lattice is proposed by Oide-san.
- Revise device layout for reusing vacuum pipes.
- Rearrange steering magnet position for vacuum componets.
- Change D05V1 collimator install position to downstream side of center QUAD (QN3OP) of -I’ cell for avoiding interference to HER beamline during collimator maintenance works.
- Finalize major componet layout for device installtion works.
  - Critical collimator performance regression due to D05V1 layout minor changes is not observed in BG simulation results.
  - Detail BG simulation to optimize optical parameters is ongoing by Andrii.

Checked Optics Issues

- Optimized Touscheck lifetime(DA) regression
  - Almost same lifetime is obtained at NLC off case.
  - 10% lifetime regression by NLC sextupole.

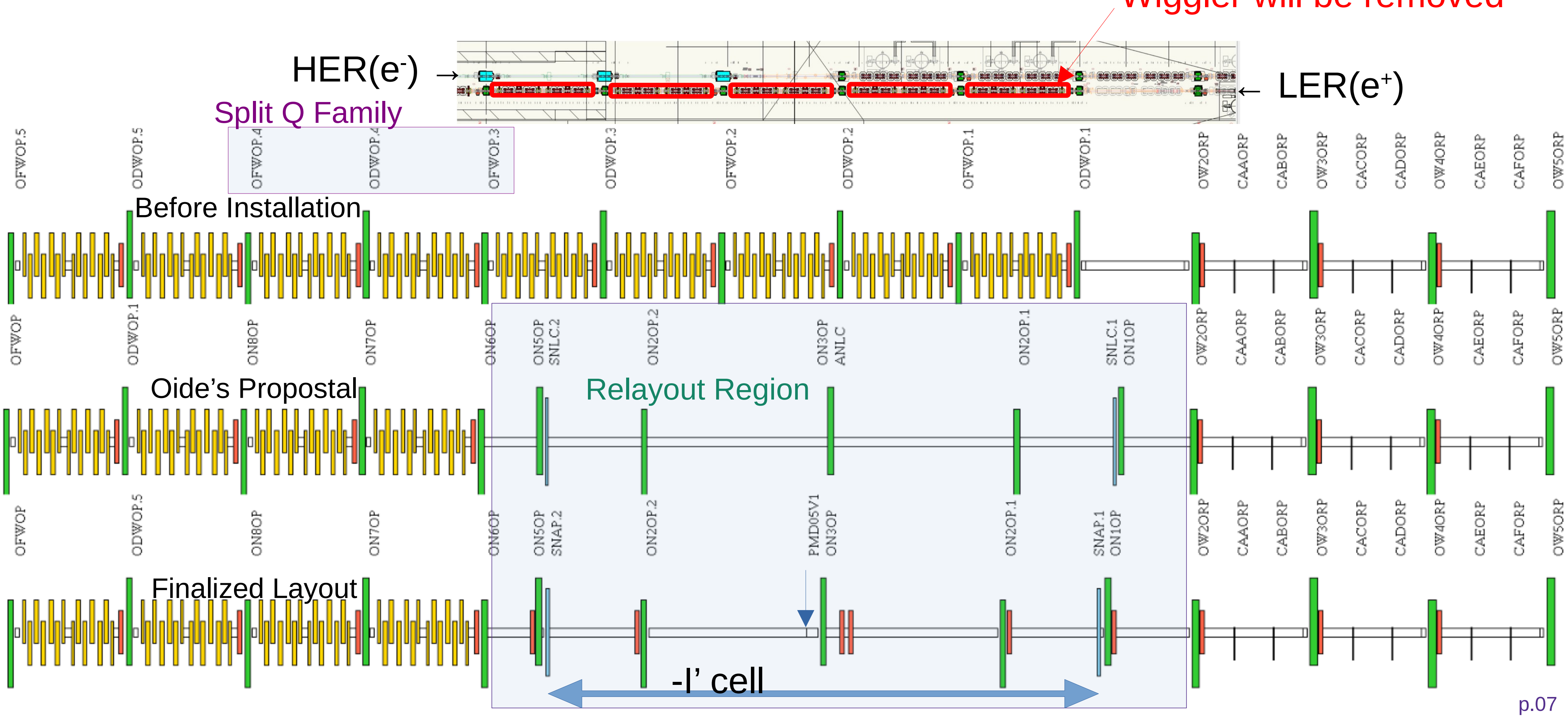
Optimized Lifetime
@ β^*_y = 1mm (sec)

CW	80%		60%	
κ	3%	2%	3%	2%
before	1405	1349	2092	1549
NLC(off)	1430	1336	2104	1837
NLC(on)	1274	1201	1769	1647

- Local Bump around D05V1 collimator for BG study etc...
  - A few millimeter bump height WOULD be available.

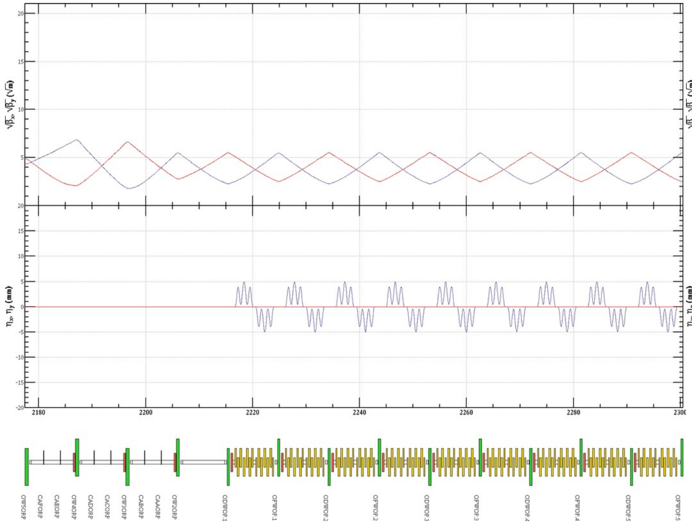
- BG dependence with D05V1 minor layout variation.
  - Typical checked D05V1 layouts:
    - D05V1 upstream of QN3OP
    - D05V1 downstream of QN3OP (*)
    - D05V1 between splited QN3OP
  - Critical regression is detected in Andrii’s BG simulation, therefore, we choose (*) layout suitable for collimator maintenance works.

Device Layout

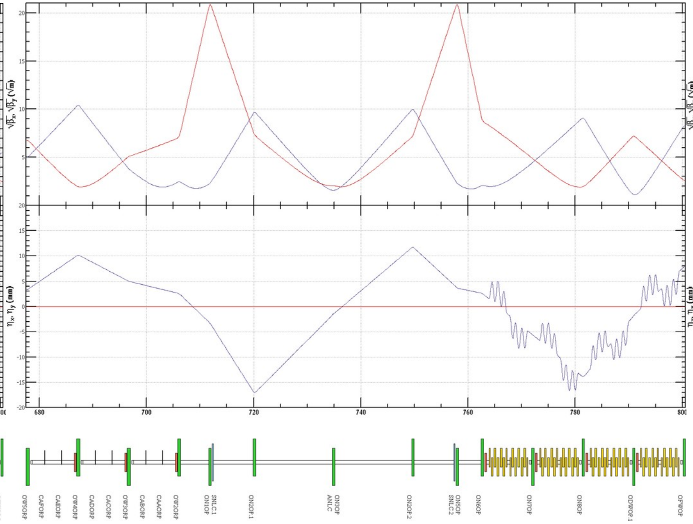


Optical Function

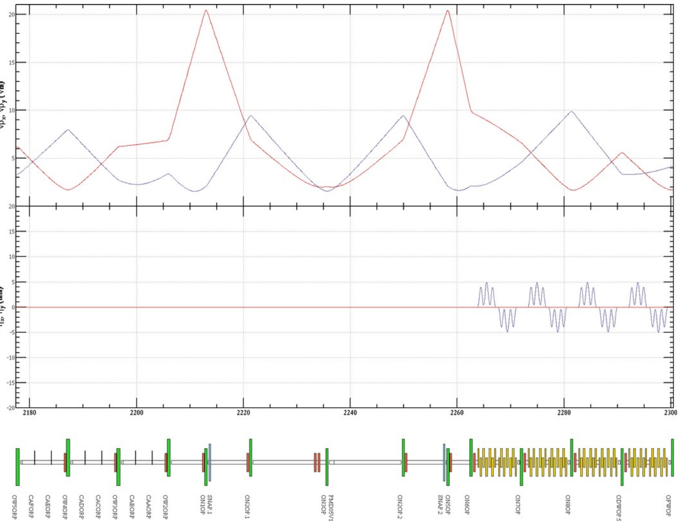
Before Installation



Oide's Proposal



Finalized Layout



LER(e^+) →

Completed Construction Works

- Open & Remove concrete radiation shield blocks for construction works.
  - They WOULD be reinstalled in late August 2023.





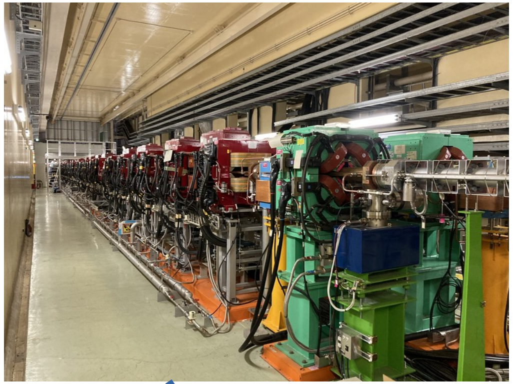
Ongoing Construction Works

- Remove 10 wiggler unit & vacuum pipes.
  - 50 dipole magnets (~ 6.5 ton)
  - 10 vacuum pipes
  - Wiggler magnet power cables (~ 3 ton)

Almost finished at this moment

Wiggler Removal Works

Before removal works

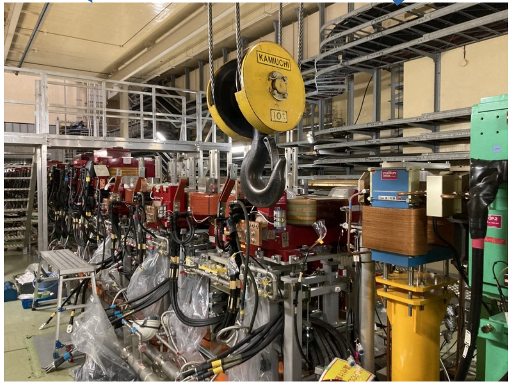


Remove vacuum pipes

After removal works

Removed wigglers

Removed cables

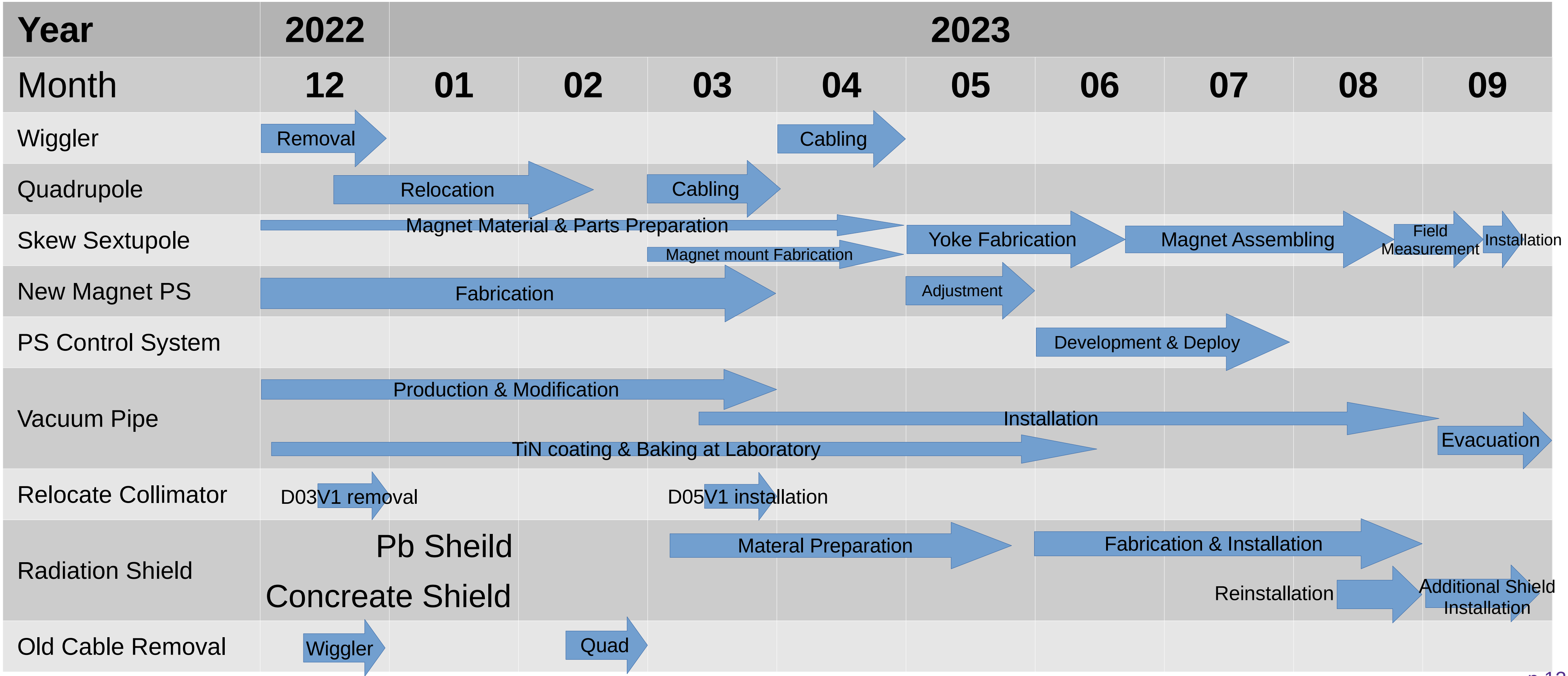


Detach upper pole for access

Restore upper pole for transfer

Upcoming Construction Schedule

Installation works are planned to complete until October 2023.

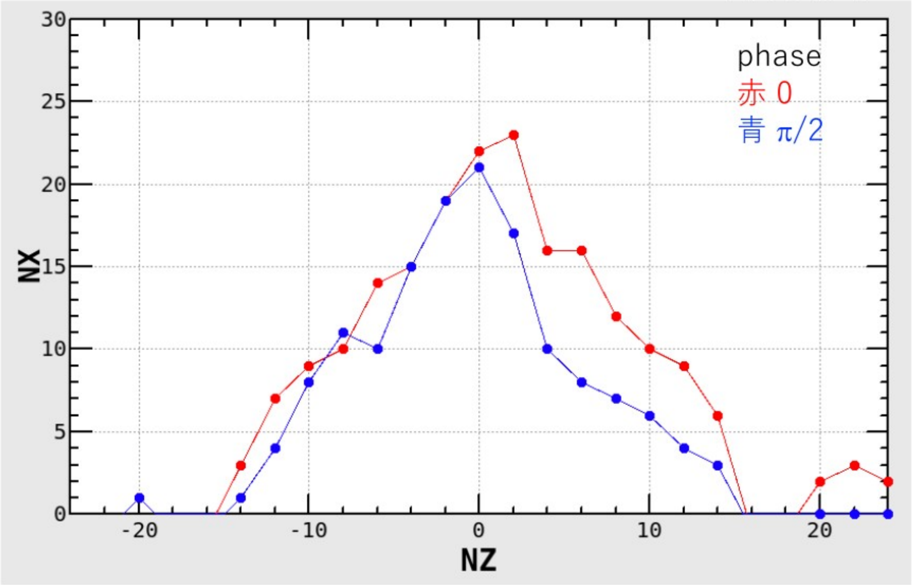


Backup(Optics Isssue)

Dynamic aperture nonlinear collimator 有無

- 森田さんによる六極最適化後（図はMINCOUP 3%, CW 80%の場合）
- NLCなしの方がやや寿命が長いが、大きな違いはない。

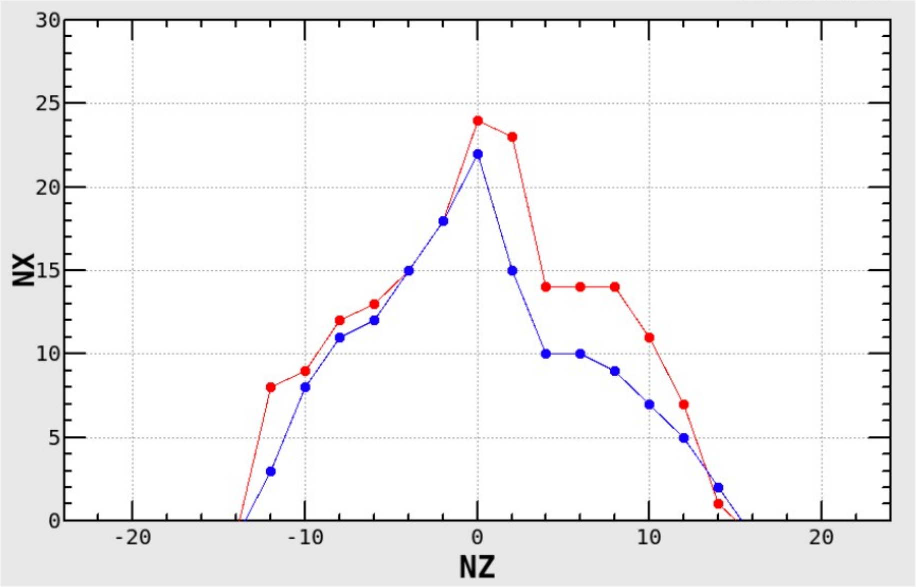
sler_1707_80_1_cw80_NL_03.sad NLCあり



[sler_1707_80_1_cw80_NLC03.sad]

MINCOUP	CW = 80%	CW = 60%
3.0%	1273.9sec	1769.0sec
2.0%	1201.2sec	1646.8sec

sler_1707_80_1_cw80_noNLC.sad NLCなし



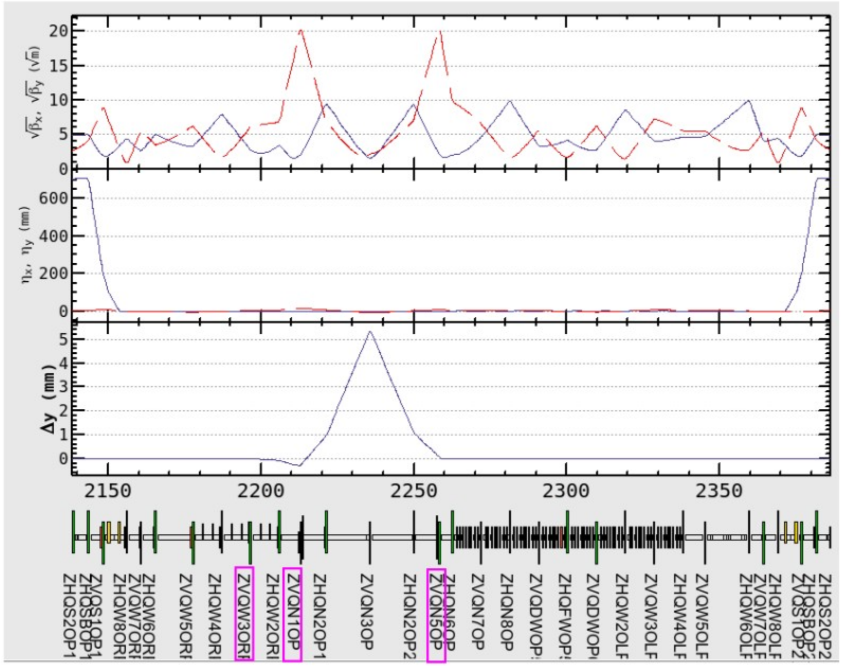
[sler_1707_80_1_cw80_noNLC.sad]

MINCOUP	CW = 80%	CW = 60%
3.0%	1404.6sec	2091.9sec
2.0%	1349.0sec	1548.9sec

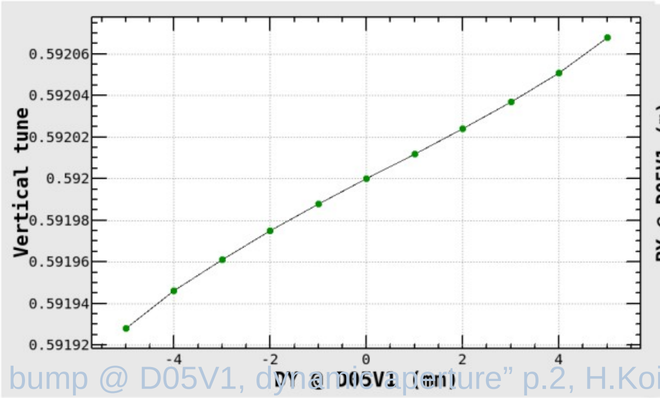
“Local bump @ D05V1, dynamic aperture” p.4, H.Koiso
http://kds.kek.jp/event/43435/

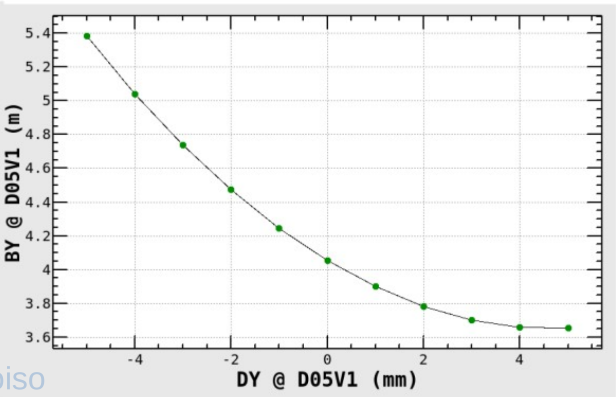
Local bump の影響

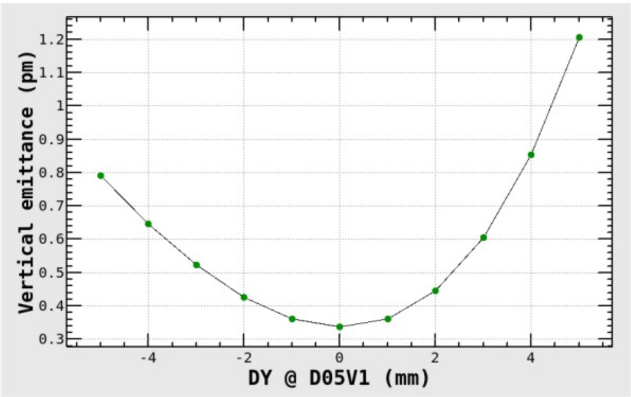
調整やスタディのためコリメータのところに一時的に vertical bump を立てる場合、歪 6 極ペアの外側の垂直ステアリングを使えば、オプティクスへの影響は許容範囲内に収まると思われる。



DY @ PMD05V1 = 5 mm の場合
ZVQW3ORP K0 9.707086490E-6
ZVQN1OP K0 -1.35986938E-4
ZVQN5OP K0 -1.35052511E-4
DY @ PSNAP1,2 = {-.00015677,.00015672}





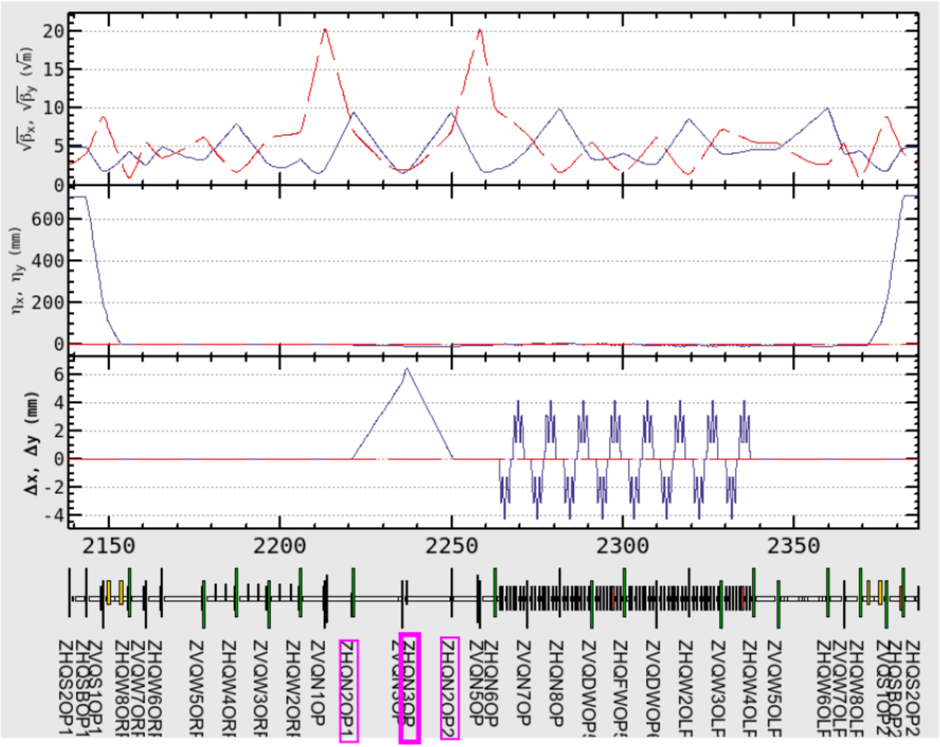


“Local bump @ D05V1, dynamic aperture” p.2, H.Koiso
http://kds.kek.jp/event/43435/

Local bump の影響

コリメータのところに horizontal bump を立てる場合

- 歪６極ペアの内側にもう1台水平ステアリングを追加すると（例えばZVQN3OPの隣）、歪６極に被らないバンプが立てられる。
- D05V1に 5 mm のバンプを立てるには、~1.5 mrad のキック角が必要。

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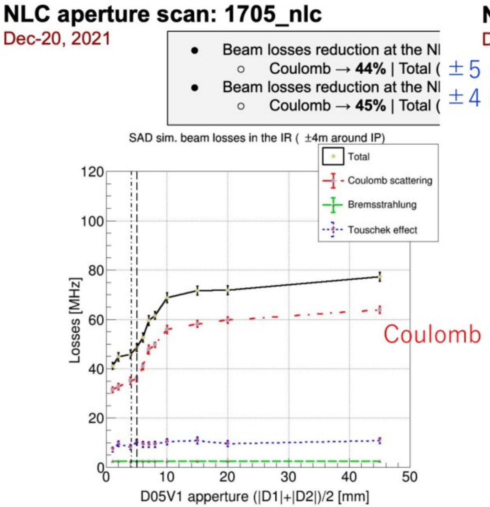
DX @ PMD05V1 = 5 mm の例
ZHQN2OP1   K0   -4.02252156E-4
ZHQN3OP    K0    .001482851389
ZHQN2OP2   K0   -5.23014504E-4

EMITX 3.96918E-9 -> 3.99730E-9 m
EMITY 3.3707E-13 -> 3.3706E-13 m
```

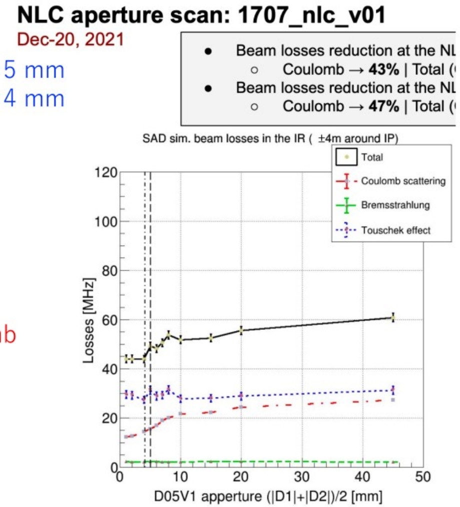
AX	BX	NX	EX	EPX	Element	Length	Value	s(m)	AY	BY	NY	EY	EPY	DetR	#
1.67E-6	.08000	.00000	-2.6E-5	.00137	IP.1	.00000	0	.000000	-1.1E-5	.00100	.00000	1.6E-14	1.9E-13	4.E-24	1
.68473	3.55028	32.9951	-.00477	2.74E-4	PMD05V1	.00000	0	2234.31091	.08511	4.05318	34.0408	-2.E-13	1.0E-14	5.E-24	5229
1.67E-6	.08000	44.5270	-2.6E-5	.00137	IP.2	.00000	0	3016.30649	-1.1E-5	.00100	46.5920	1.8E-14	-1.E-12	5.E-24	7946

"Local bump @ D05V1, dynamic aperture" p.3, H.Koiso
http://kds.kek.jp/event/43435/

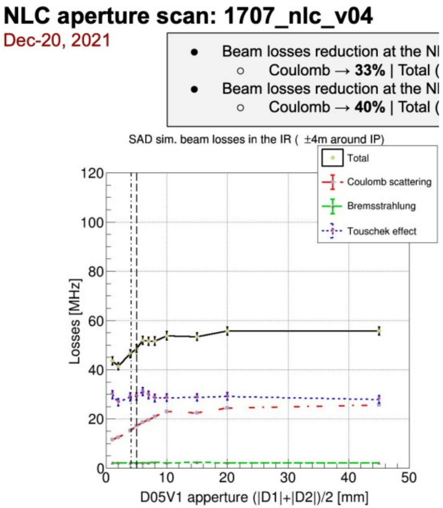
Oide’s original



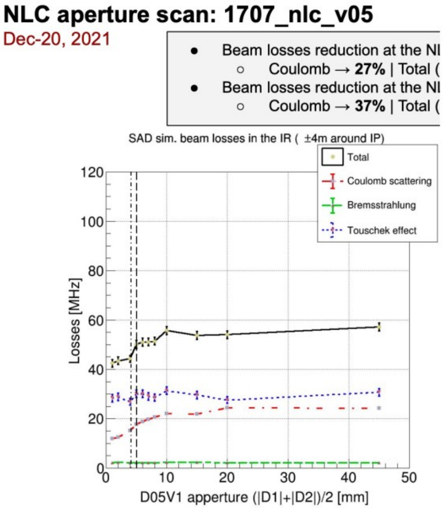
Reimplement on current lattice



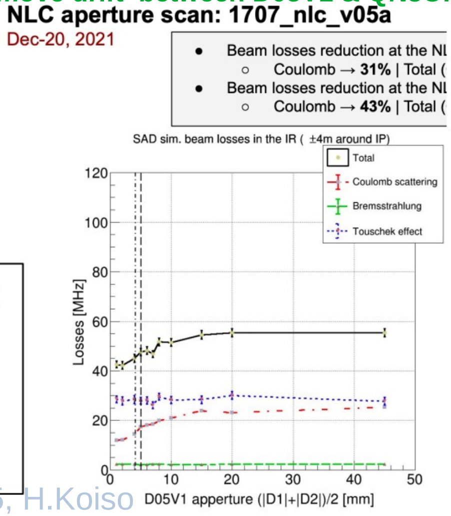
D05V1 upstream of QN3OP



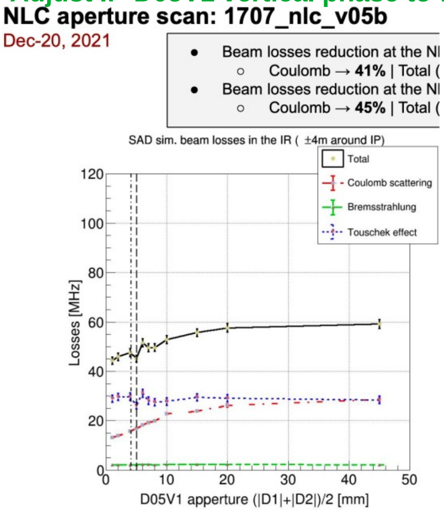
D05V1 downstream of QN3OP (*)



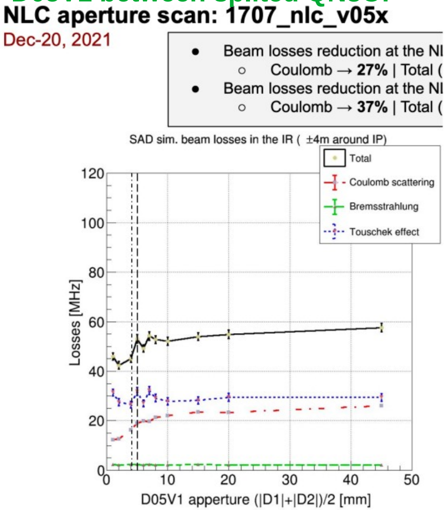
Remove drift between D05V1 & QN3OP



Adjust IP-D05V1 vertical phase to π



D05V1 between splited QN3OP



Andriiさんの報告から
注目すべき部分（たぶん）
をまとめました

Shifted NLC impact on
storage beam losses,
Nov. 15,2022
By Andrii Natochii
より

“LER optics for nonlinear collimator” p.5, H.Koiso
http://kds.kek.jp/event/44526/