ビームロスシミュレーション& スタディ報告

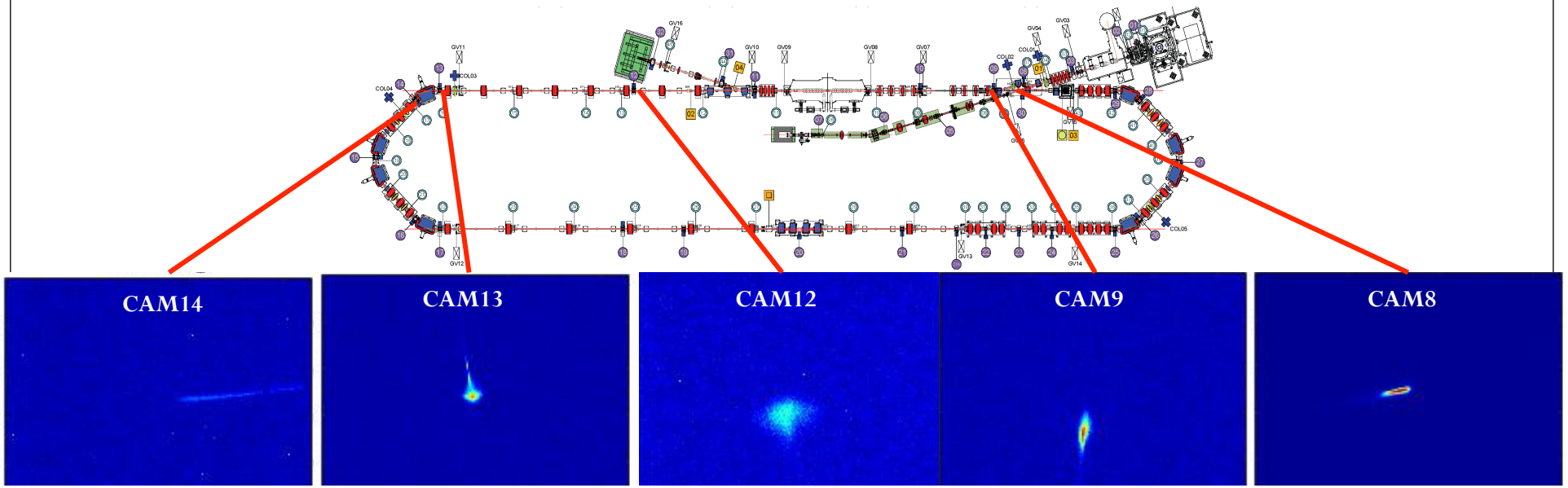
Beam tail propagation & beam loss simulation

- 40 ps tail propagation through the beam line (2015/3/13 measurement)
- Tail loss points and lost current simulation
- Impact of collimators into the beam loss
- Injector cavity misalignment influence to the tail profile

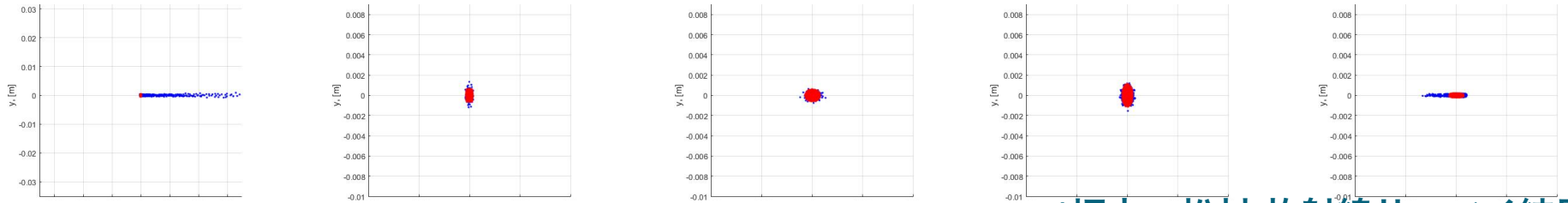
2015年04月15日(水)14時00分
ビームダイナミクスWG打ち合わせ
オリガ　タナカ

40 ps tail propagation through the beam line

- During 2015/03/13 measurement tails 21 ps (laser phase +10 deg.), 42 ps (laser phase +20 deg.), and 64 ps (laser phase +30 deg.) were tested
- It was found that the tail of 21 ps reaches the dump, the tail of 42 ps goes up to CAM 22 and the tail of 63 ps lost before CAM15
- Thus, for the simulation purpose the tail of approximately 40 ps and of particular distribution was generated in order to fit the measurement conditions and to keep the beam loss rate on the realistic level of some a few tenths of a percent*



03/13 measurement レーザ位相+20度(～42psテール) http://erlserv1.kek.jp:8081/cERL/scrshot/ScreenLog/2015/03/13/202203



GPT+ELEGANT simulation results for 40 ps tail

***坂中、松村 放射線サーベイ結果**

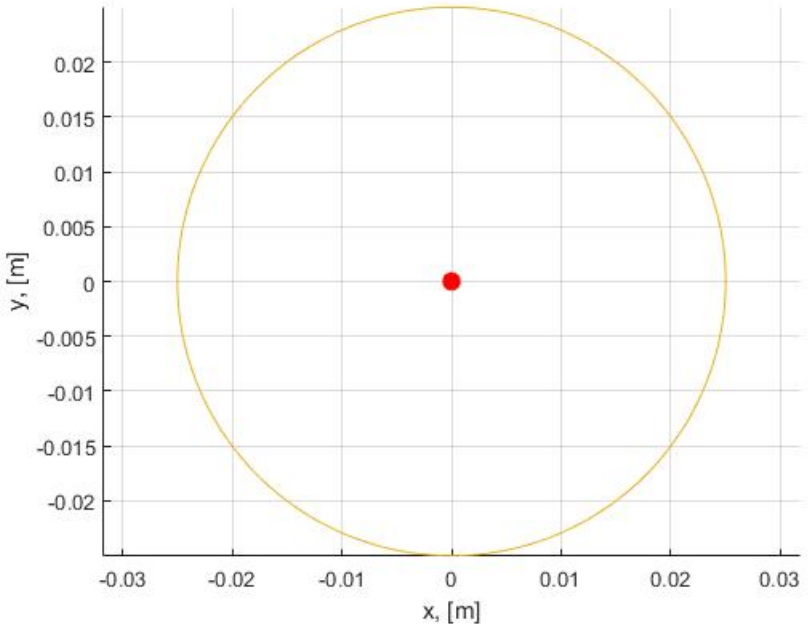
Tail loss points and lost current simulation

Simulation background:

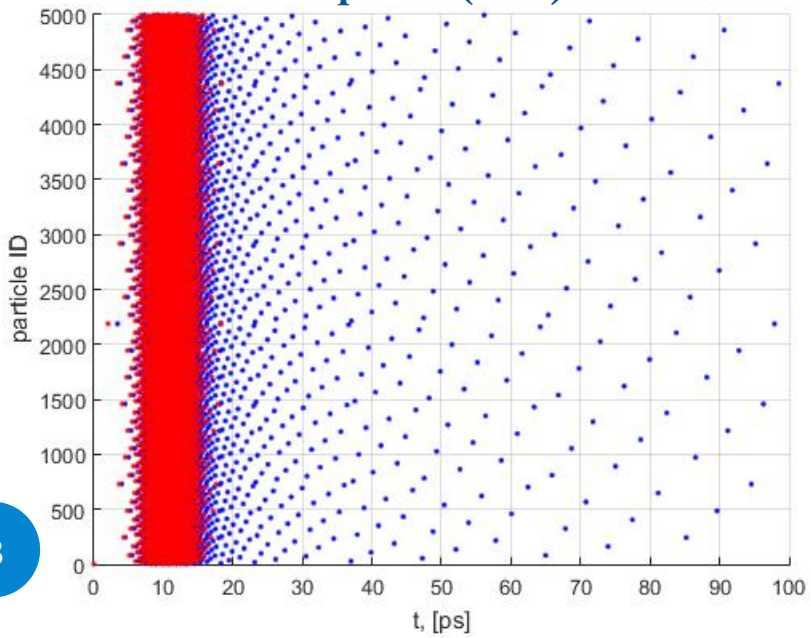
- GPT tracking: 100 ps tail, no SC, N_particles=5000, Qtot=0.5 pC
- ELEGANT tracking: LCS optics
- COLs out
- Red – gaussian+tail distribution (setttailgauss*("beam", sigma=2.2e-12, ttail=0, tcutoff=10e-12))
- Blue – gaussian+tail distribution (setttailgauss*("beam", sigma=2.2e-12, ttail=0.5e-12, tcutoff=100e-12))

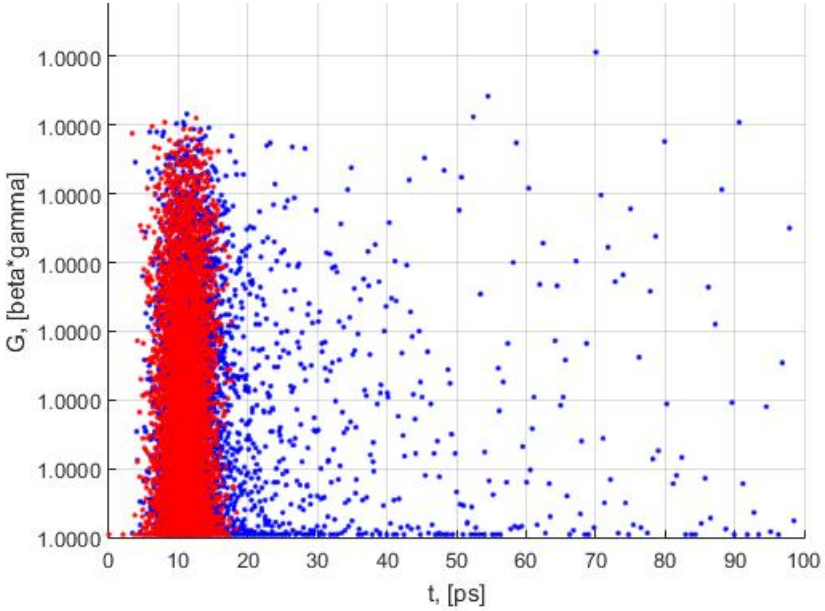
*宮島さん製のルチーン

Transverse XY

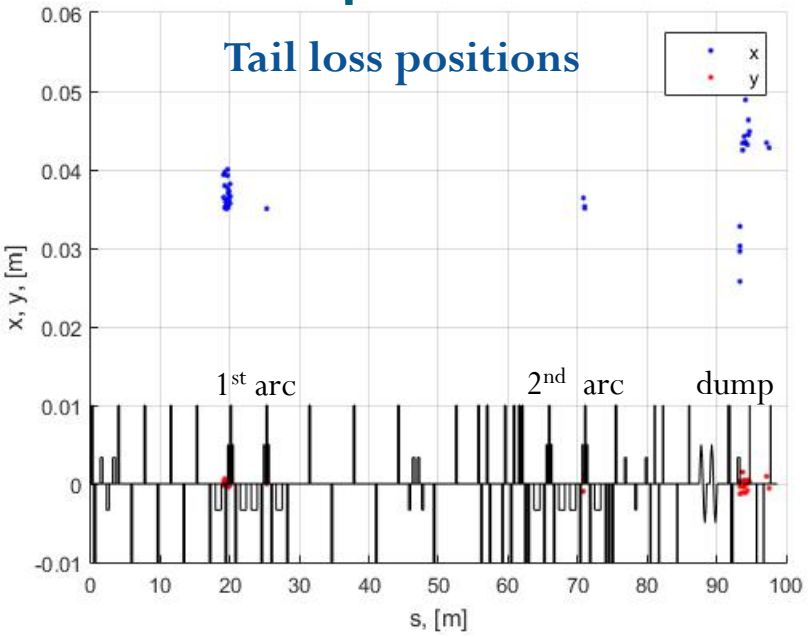


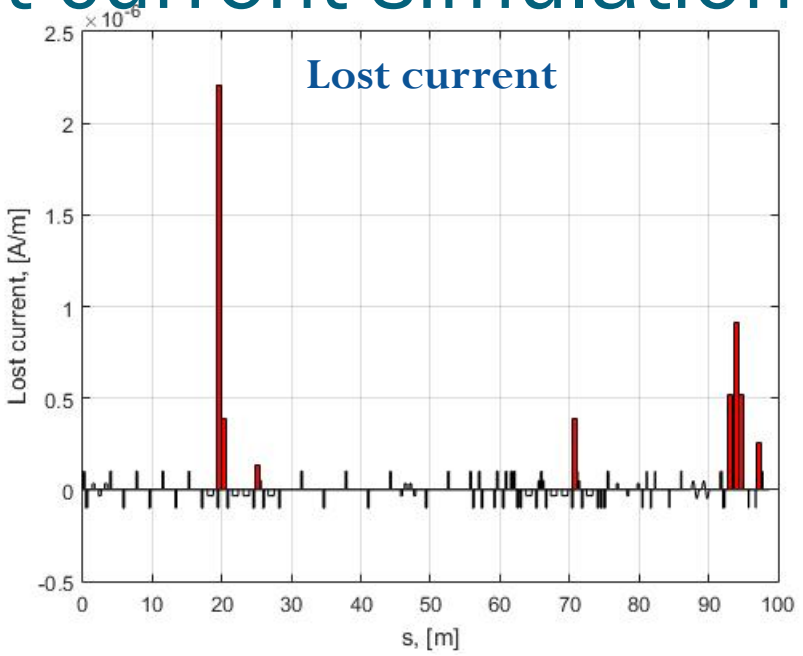
Temporal (z=0)

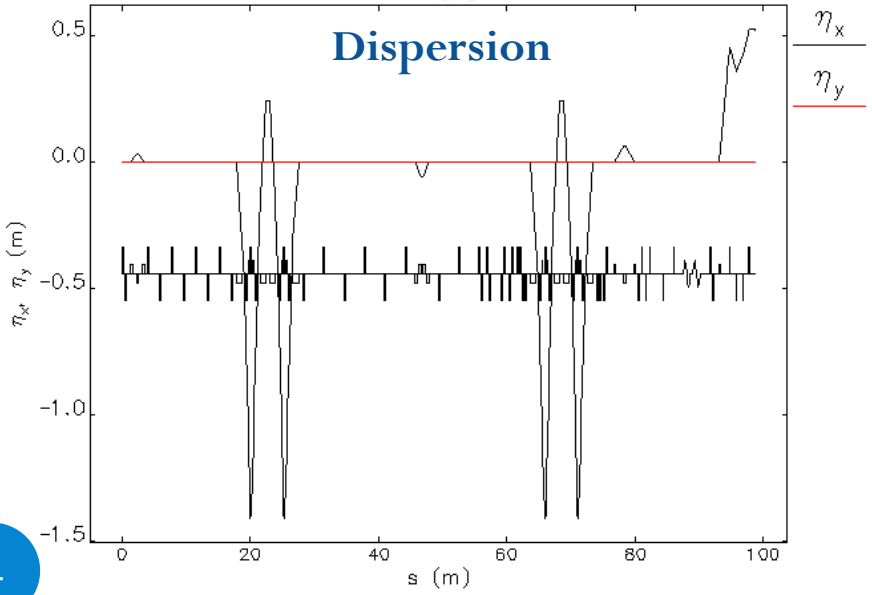


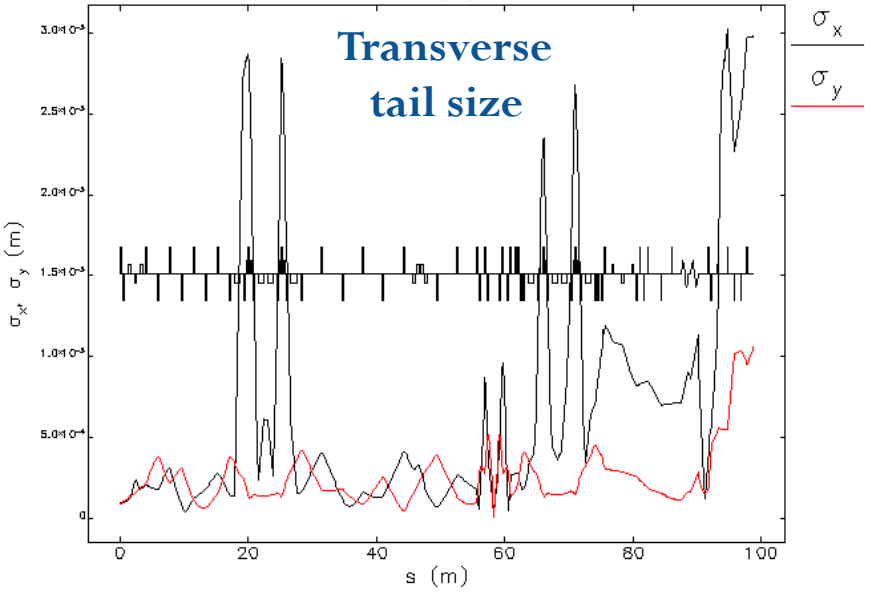


Tail loss points and lost current simulation









No losses in the injector line were found!

Tail loss points and lost current simulation

Loss point	Peak current, [uA/m]	Average current, [uA/m]	Tail losses, %
cERL	2.21	0.04	0.82

- Peak current:

$$PC = maximum(Qtot*f*n/N)$$

  - Qtot is the charge per bunch (0.5 pC)
  - f is RF frequency (1.3 GHz)
  - n is the number of lost particles per one meter
  - N is the number of particles per bunch (5000)

- Average current:

$$AC = Int(Qtot*f*n/N)/S$$

  - S is the length of the beam line (~98 m)

- Tail losses:

$$TL = ntot*100\%/N$$

  - ntot is the total number of lost particles

Impact of collimators into the loss

	Tail			Tail +COL1			Tail +COL2			Tail +COL2+COL3			Tail +COL2+COL4		
Insertion method				top 0.98 mm			right 0.94 mm			right 2.40 mm top 0.45 mm			right 2.40 mm left 5.19 mm		
Loss value	Peak uA/m	Ave., uA/m	% of tail	Peak uA/m	Ave., uA/m	% of tail	Peak uA/m	Ave., uA/m	% of tail	Peak uA/m	Ave., uA/m	% of tail	Peak uA/m	Ave., uA/m	% of tail
Loss at inj. line	–	–	–	0.26	0.05	0.18	0.39	0.15	0.50	0.13	0.007	0.04	0.13	0.007	0.04
Loss at 1st arc	2.21	0.16	0.42	1.95	0.14	0.38	–	–	–	1.82	0.21	0.34	5.98	0.08	1.22
Loss at 2nd arc	0.39	0.001	0.06	0.39	0.002	0.06	–	–	–	0.39	0.002	0.06	–	–	–
Loss at dump	0.91	0.32	0.34	0.91	0.31	0.32	0.39	0.02	0.32	0.91	0.32	0.34	–	–	–
Total loss	2.21	0.04	0.82	1.95	0.04	0.94	0.39	0.02	0.82	1.82	0.05	0.78	5.98	0.08	1.26

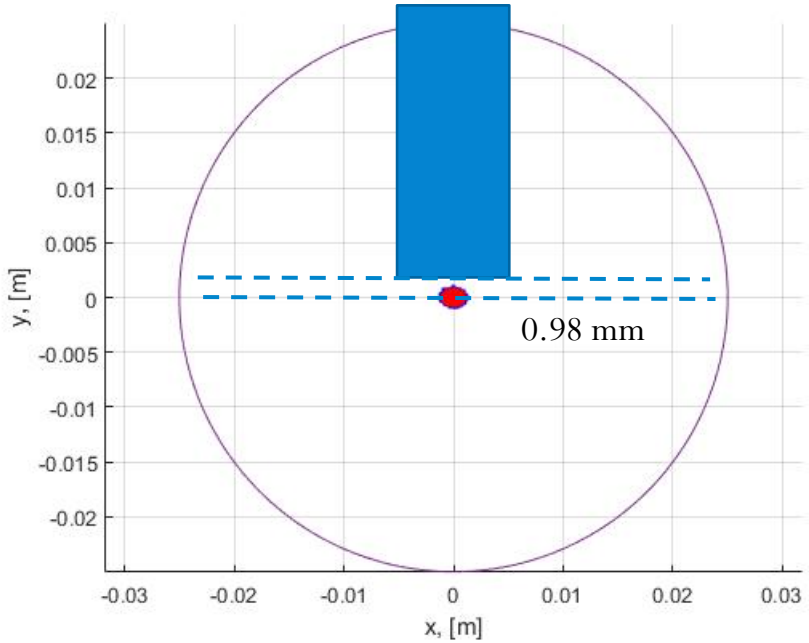
- 2015/3/12 measurement*
  - COL2 right 2.40 mm + COL3 top 0.45 mm: cam28を見ながらでCOL3の上からを中心0.45mmまで挿入 COL2-rightは2.4mmのまま。 しかし、大きな変化はなかった。
  - COL2 right 2.40 mm + COL4 left 5.19 mm: COL4-leftを5.19mm(limit) COL2はそのまま。COL3は抜いた。 少し、右側のテールが消えたように見える。
- 2015/3/27 measurement*
  - COL1 top 0.98 mm: 付近から、コアを削り始める。 第一アークでのロスは減らず (少しは減っているのだが、従来の効き方にくらべれば全然ダメ)
  - COL2 right 0.94 mm: 1st arc entrance loss and 1st arc loss decrease

*島田、帯名、本田、中村、 下ヶ橋、高井

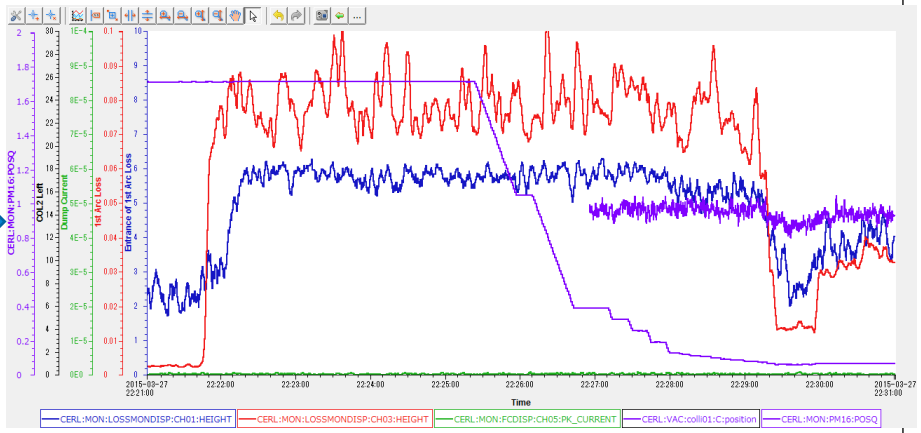
Impact of collimators into the beam loss

COL1

- During the measurement on 2015/3/27 we tested COL1 and COL2 concerning its influence on the beam losses in the recirculating loop
- First, COL1 (before the merger section) was inserted from the top up to 0.98 mm to the beam center while the beam was stretched by the laser phase to produce the tail
- The same conditions were reproduced in GPT +ELEGANT simulations to reproduce the COLs influence on the beam loss, observed during the measurement



COL1 top 0.98 mm 付近から、コアを削り始める。第一アークでのロスは減らず (少しは減っているのだが、従来の効き方にくらべれば全然ダメ)

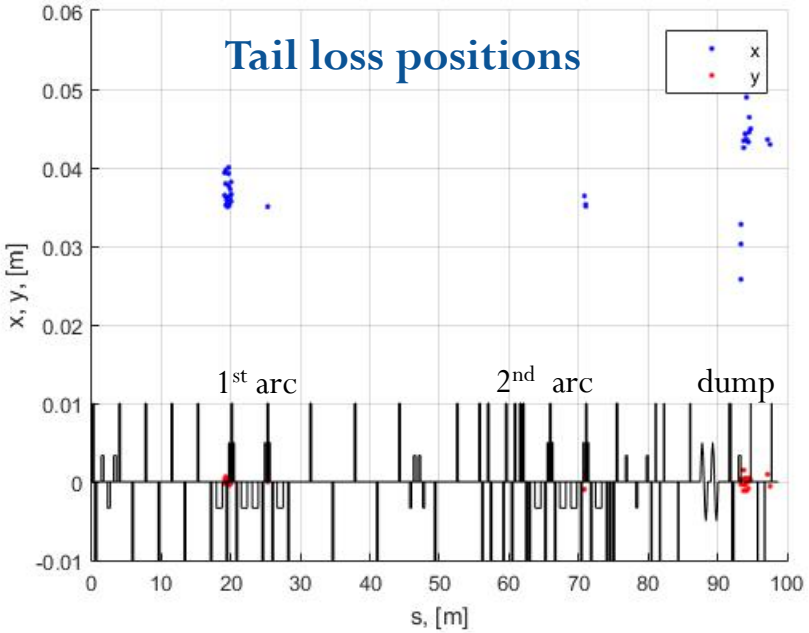


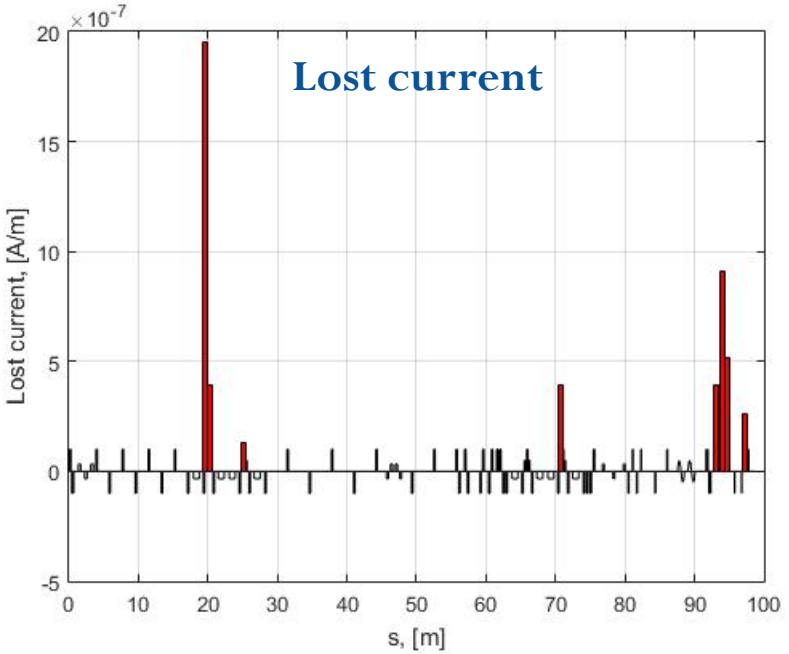
2015/3/27 measurement

COL1	Limit[mm]	
A(Left)	: 2.00	3.5mmでコア削る
B(Right)	: 0.78	効果なし
C(Top)	: 0.91	2.2mmで第1アークでのロス減少、1.5mmでコア削る
D(Bottom)	: 1.11	効果なし

***2015/2/6、帯名さん測定結果**

Impact of collimators into the beam loss – COL1



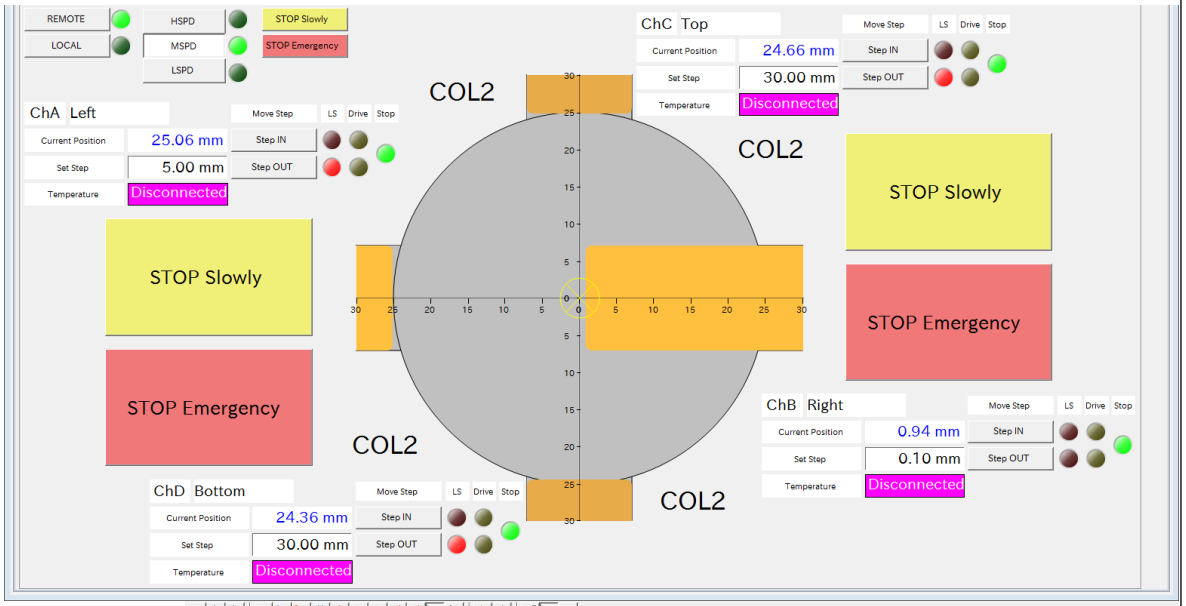


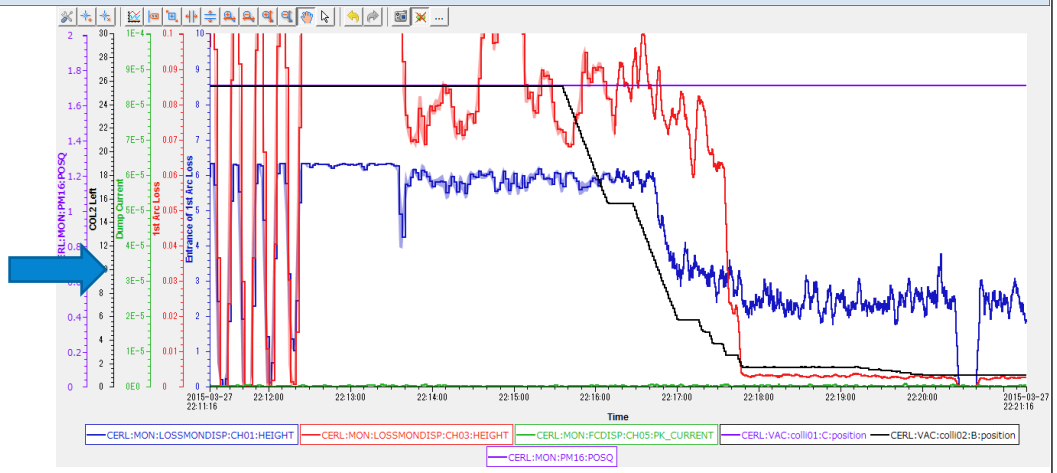
Loss point	Peak current, [uA/m]	Average current, [uA/m]	Tail losses, %
cERL	1.95	0.04	0.94

Impact of collimators into the beam loss

COL2

- Step 2 of 2015/3/27 measurement. COL2 (merger section) was inserted from the right up to 0.94 mm to the beam center while the beam was stretched by the laser phase to produce the tail
- As the simulation result expected the 1st arc loss will decrease and 2nd arc loss will be almost the same





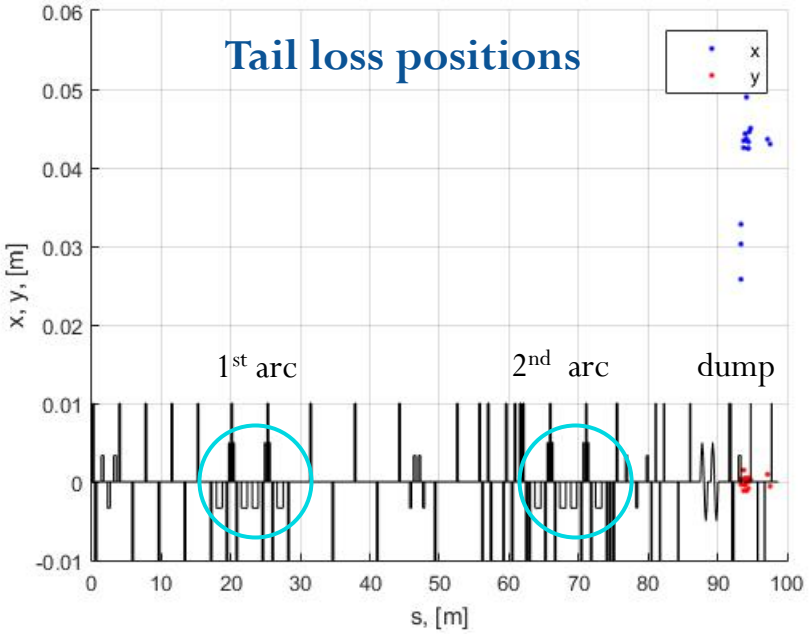
COL2 right 0.94 mm
1st arc entrance loss and 1st arc loss decrease
2015/3/12 measurement

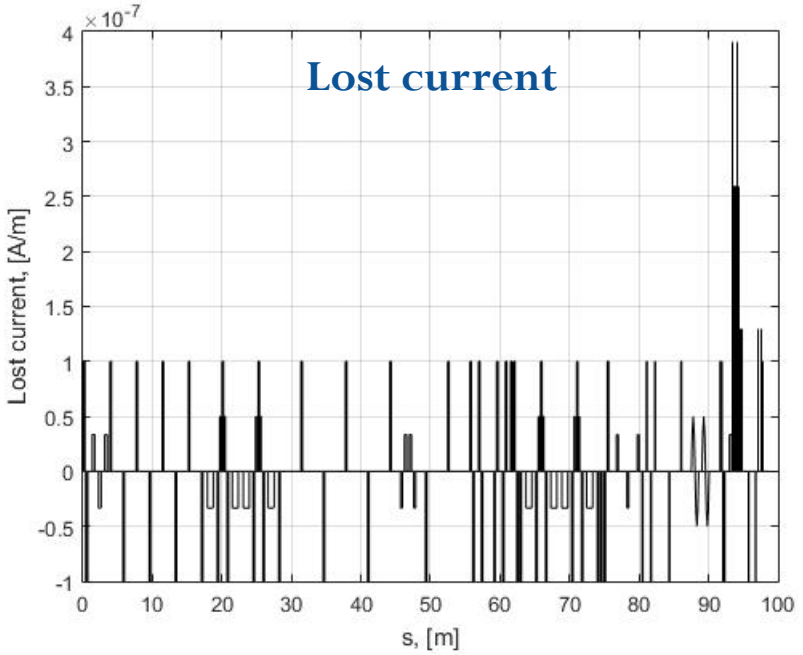
COL2

A(Left)	: 4.27	効果なし
B(Right)	: 0.00	6.0mmから第1アークでのロス減少、1.7mmでコアを削る
C(Top)	: 0.05	1.1mmでコア削る
D(Bottom)	: 0.00	効果なし

*2015/2/6、帯名さん測定結果

Impact of collimators into the beam loss – COL2



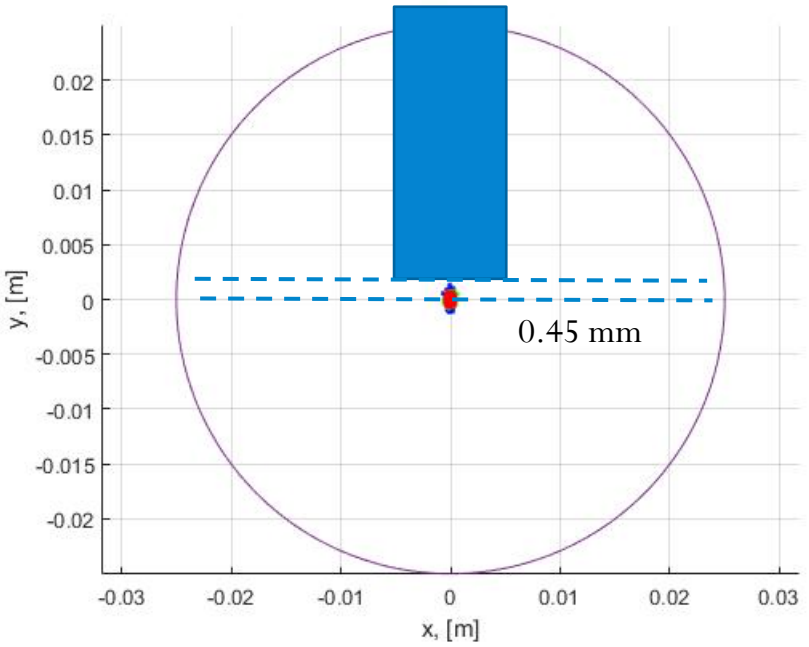


Loss point	Peak current, [uA/m]	Average current, [uA/m]	Tail losses, %
cERL	0.39	0.02	0.82

Impact of collimators into the beam loss

COL2 + COL3

- To observe the impact of COL3, the data of 2015/3/12 measurement was used. COL3 was inserted up to 0.45 mm from the top, while COL2 was inserted from the right up to 2.4 mm from the beam center.
- COL3 insertion from the right side (low energy) is known to lead to the big increase of the 1st arc loss, so it is ignored

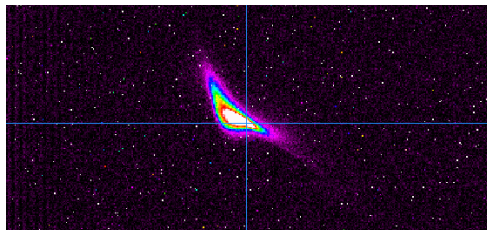


COL3 top 0.45 mm

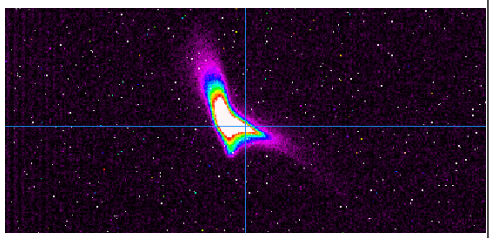
cam28を見ながらでCOL3の上からを中心0.45mmまで挿入 COL2-rightは2.4mmのまま。 しかし、大きな変化はなかった。

2015/3/12 measurement

CAM28 COL3 IN



CAM28 COL3 OUT

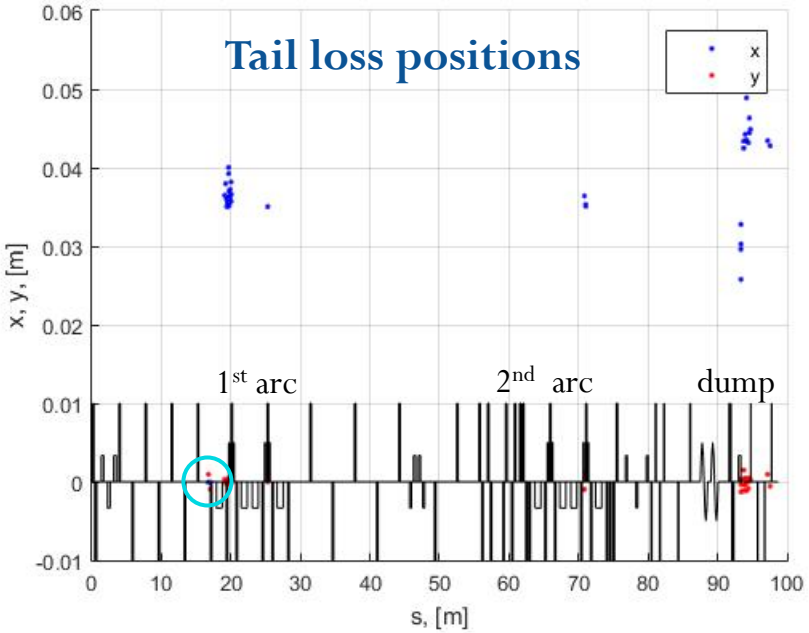


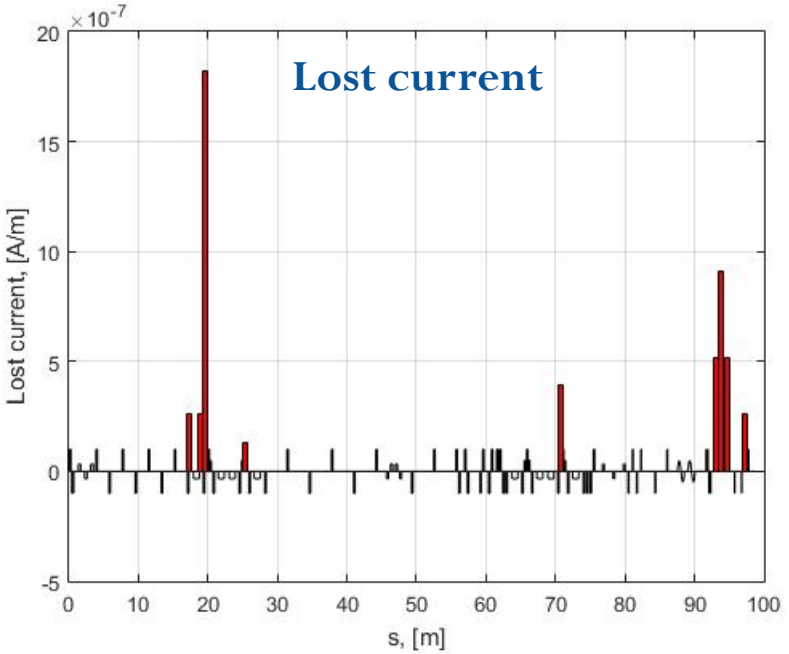
COL3

A(Left) : 0.28	1.3mmで第1アークロス増える、0.6mmでコアを削る
B(Right) : 0.82	効果なし
C(Top) : 0.44	5.0mmで第2アークロスが減少する。2.5mm以降でゆるやかにコア削りはじめる
D(Bottom): 0.70	3.4mmで第1アークロス増える、2.8mm以降でゆるやかにコア削りはじめる

*2015/2/6、帯名さん測定結果

Impact of collimators into the beam loss – COL2+COL3



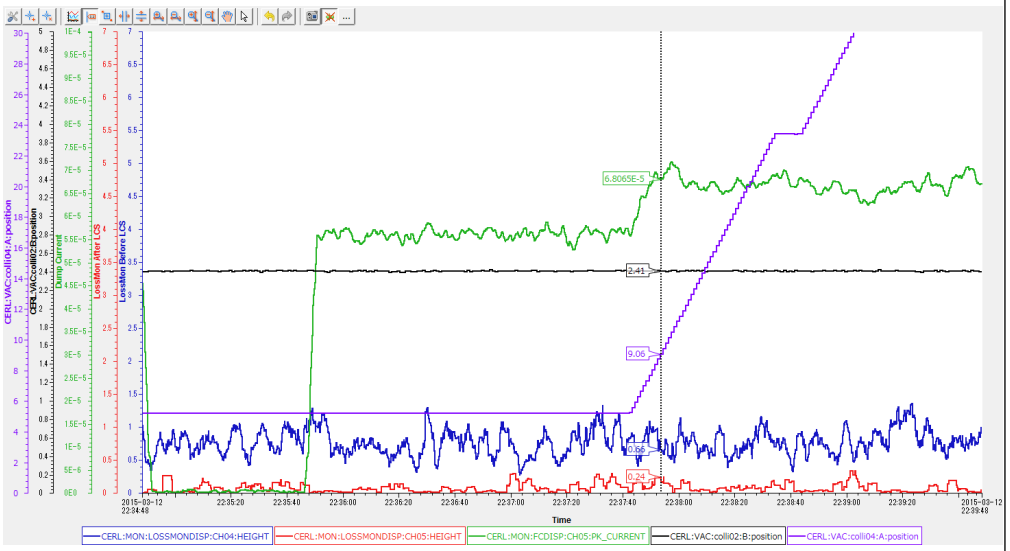


Loss point	Peak current, [uA/m]	Average current, [uA/m]	Tail losses, %
cERL	1.82	0.05	0.78

Impact of collimators into the beam loss

COL2 + COL4

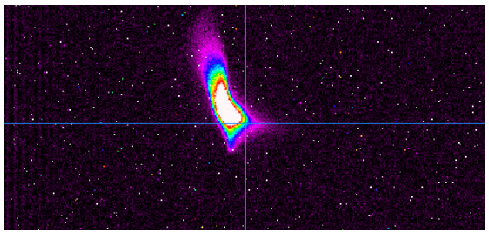
- Last step of 2015/3/12 measurement was COL4 insertion left up to 5.19 mm, while COL2 was inserted from the right up to 2.4 mm from the beam center (as before).
- From the Obina-san measurement 2015/2/9 , the insertion of COL4 from top is recommended (to avoid the loss growth in 1st arc). However we inserted it from the low energy side to get rid of the tail (see picture below)



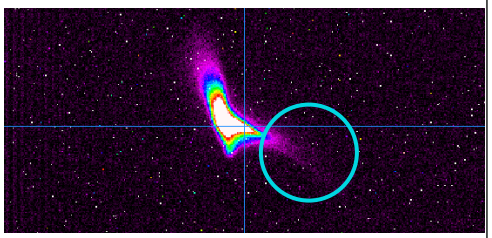
COL2Right:2.4mm, COL4Left:5.19mm, dump電流

COL4 left 5.19 mm
COL4-leftを5.19mm(limit) COL2はそのまま。
COL3は抜いた。 少し、右側のテールが消えたように見える。
2015/3/12 measurement

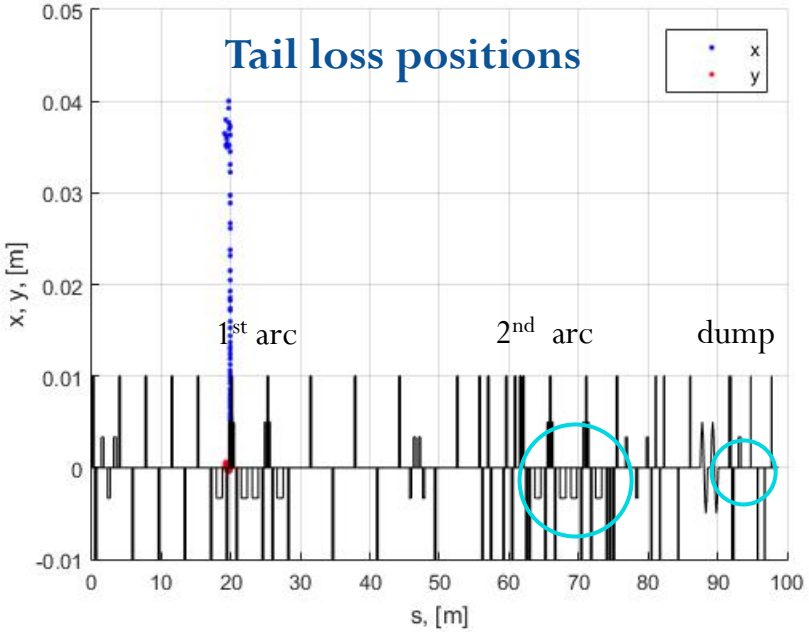
CAM28 COL4 IN

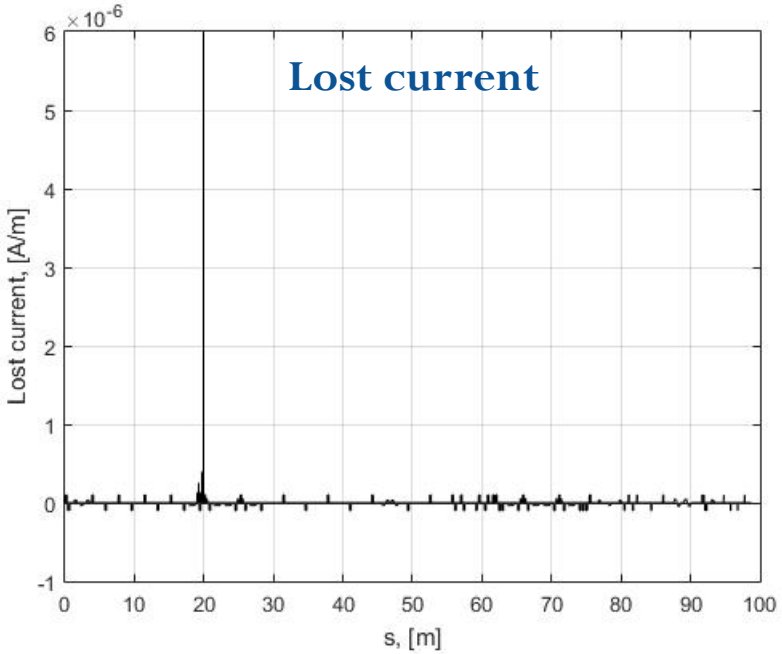


CAM28 COL4 OUT



Impact of collimators into the beam loss – COL2+COL4

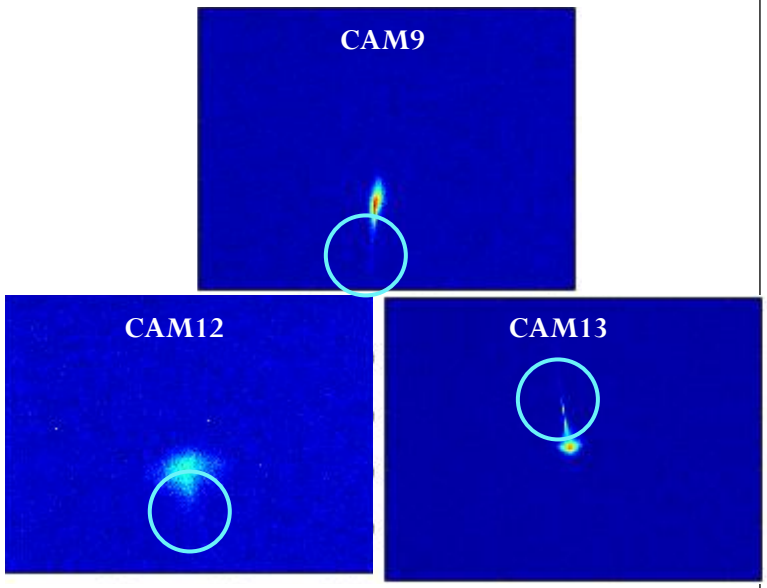




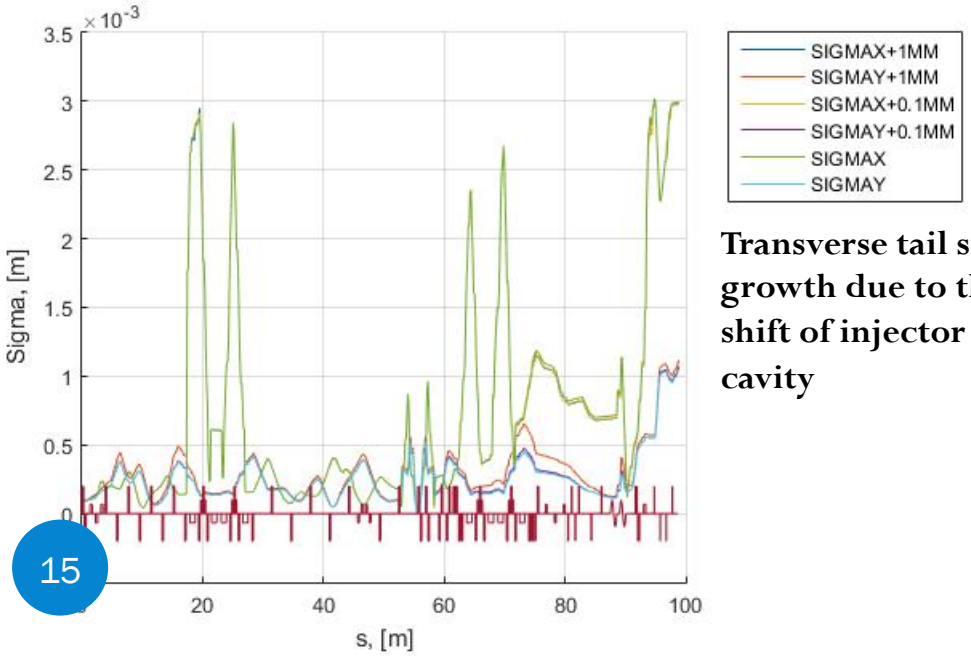
Loss point	Peak current, [uA/m]	Average current, [uA/m]	Tail losses, %
cERL	5.98	0.08	1.26

Injector cavity misalignment influence to the tail profile

- Tails that can be seen at CAM9, 12, 13 have no explanation in terms of beam optics
- A possibilities of misalignments in buncher, injector cavity and main cavity were simulated
- It was found that the y-shift of 1mm in injector cavity position yields tails similar with those once at the tail profiles
- The influence of the y-shift become negligible at the first arc section



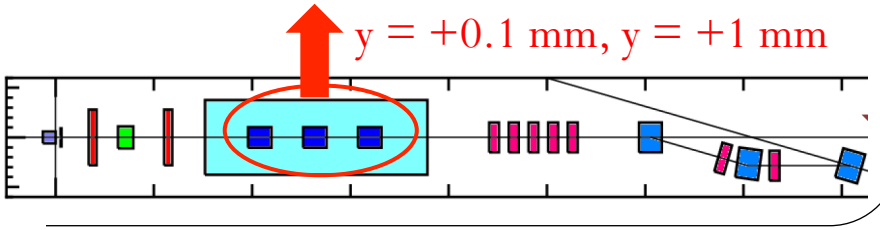
Tail profiles:
http://erlserv1.kek.jp:8081/cERL/scrshot/ScreenLog/2015/03/13/202203/



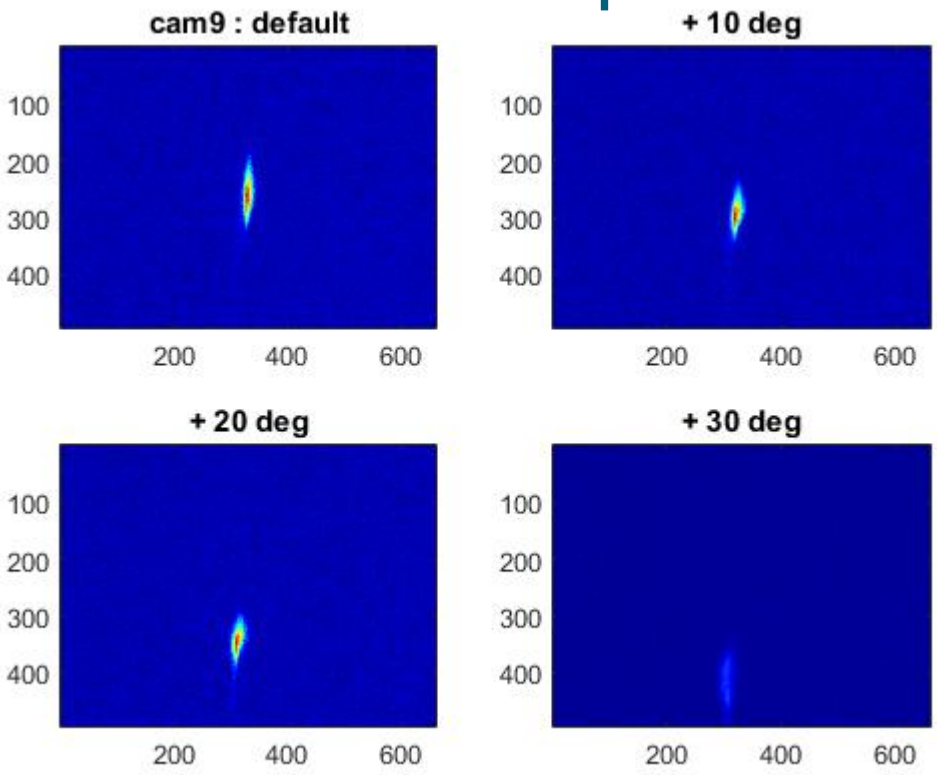
Transverse tail size growth due to the y-shift of injector cavity

Simulation background:

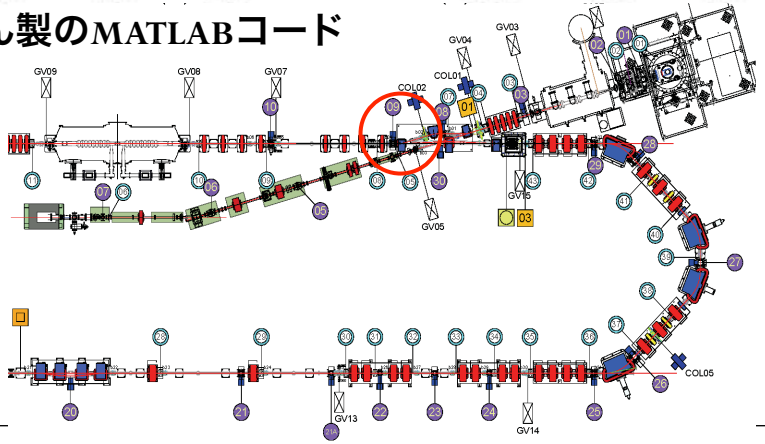
- GPT tracking: 100 ps tail, no SC, N_particles=5000, Qtot=0.5pC
- ELEGANT tracking: LCS optics

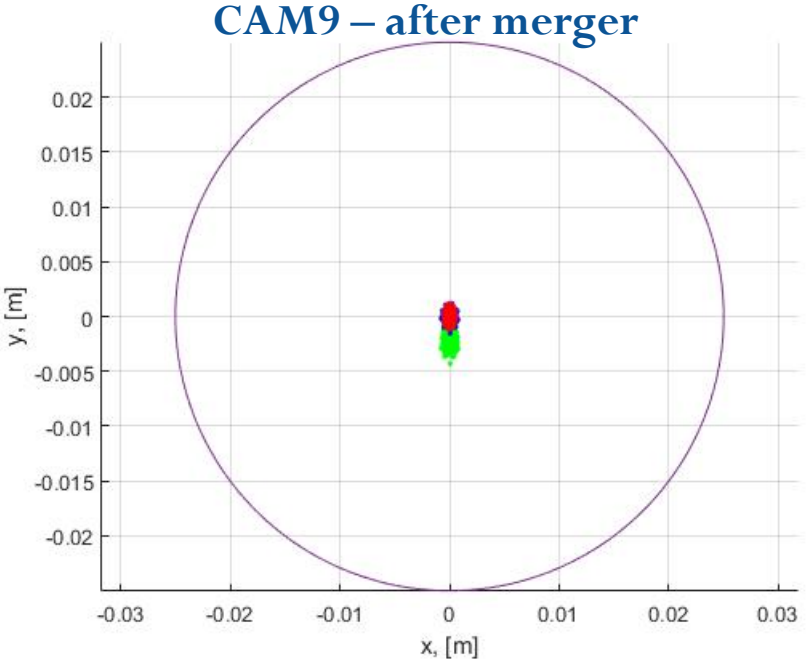


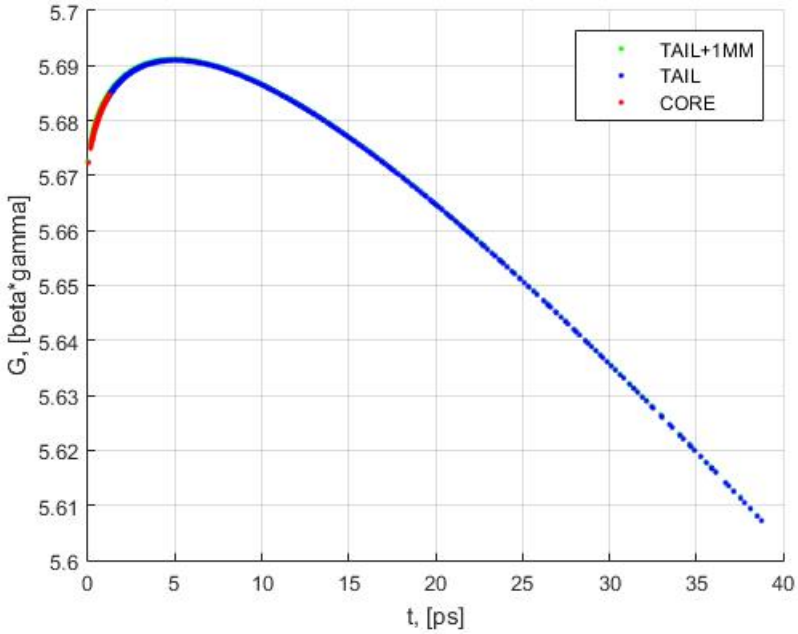
Injector cavity misalignment influence to the tail profile



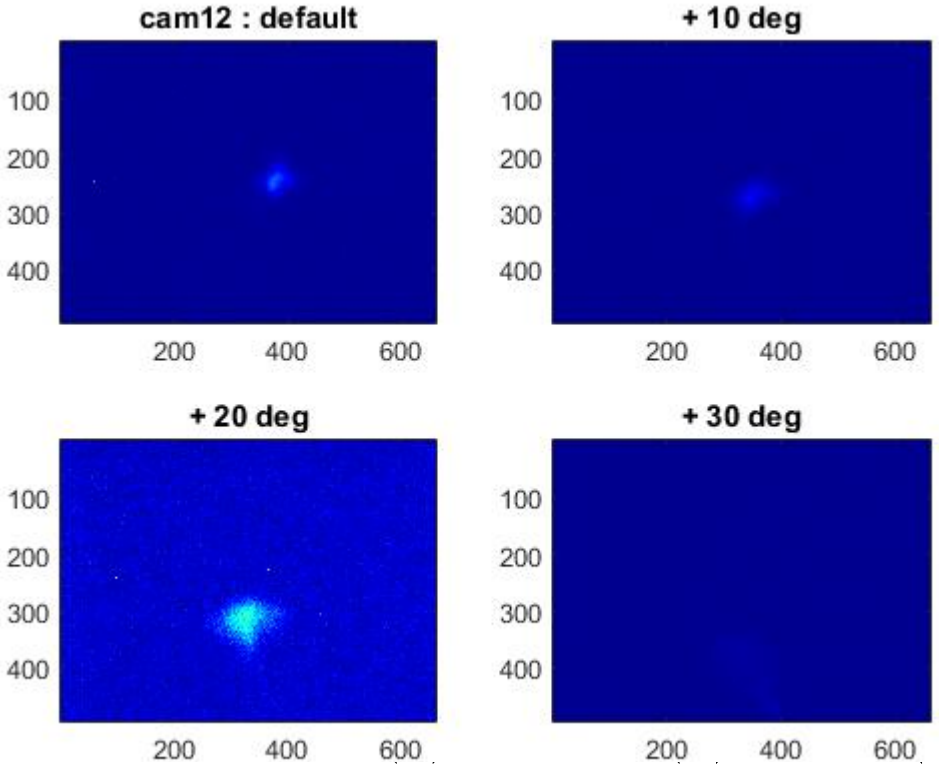
*帯名さん製のMATLABコード

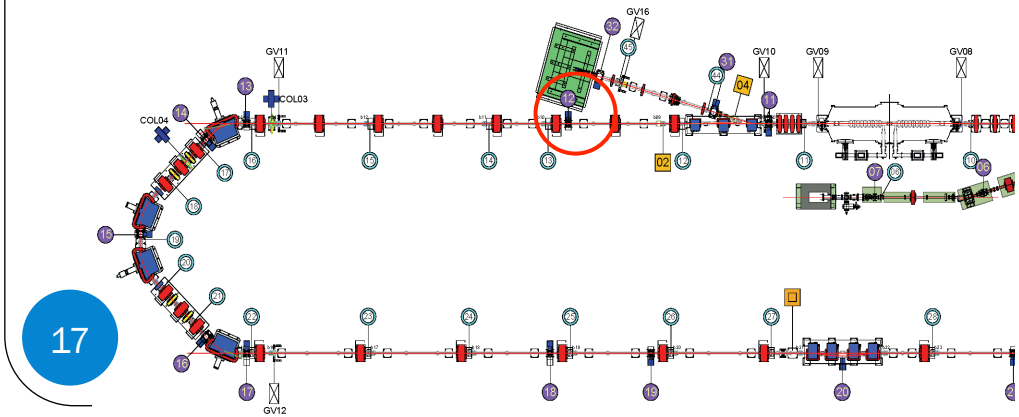


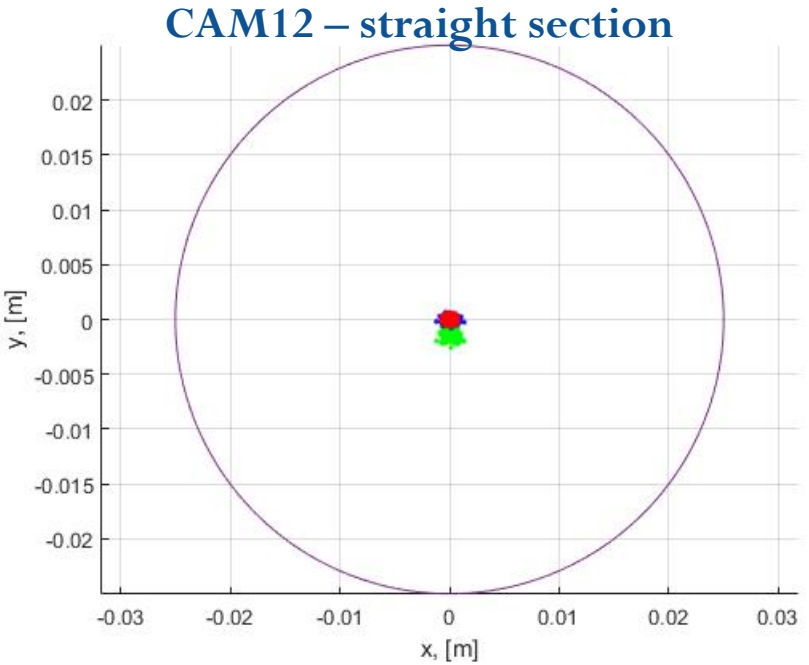


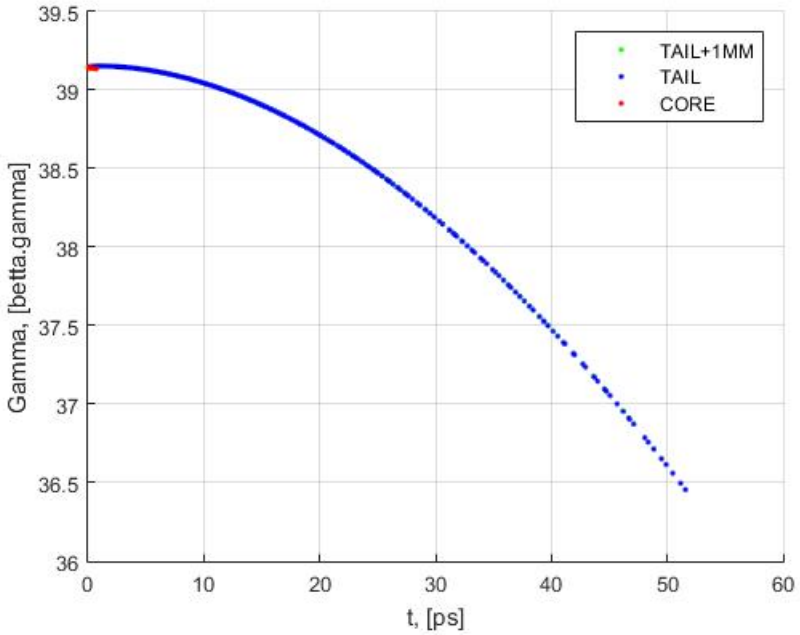


Injector cavity misalignment influence to the tail profile

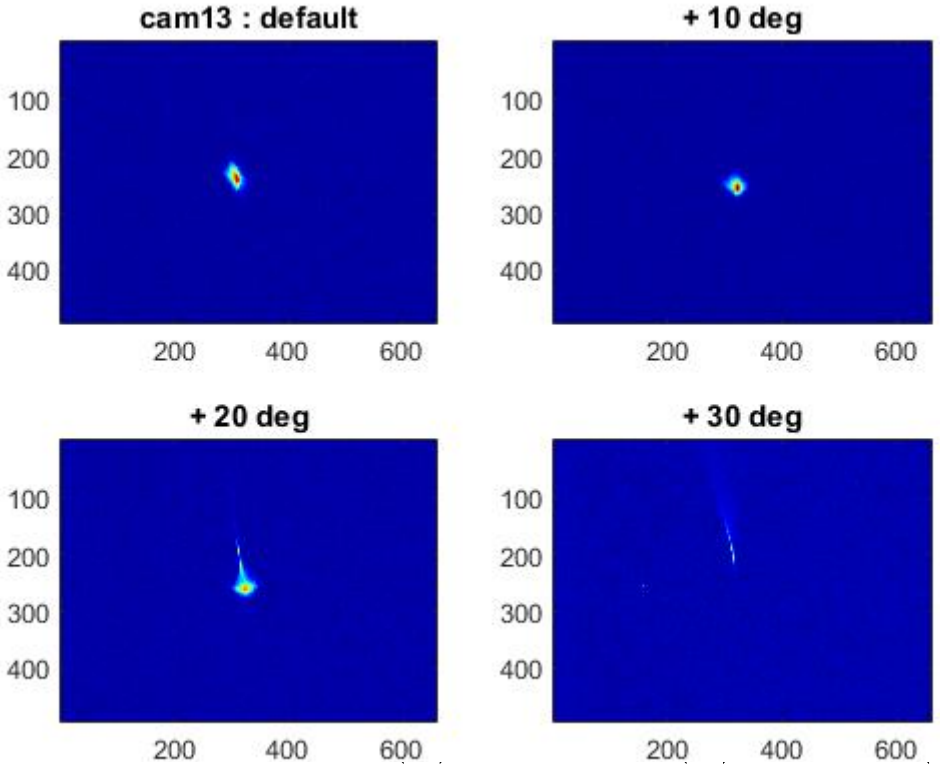


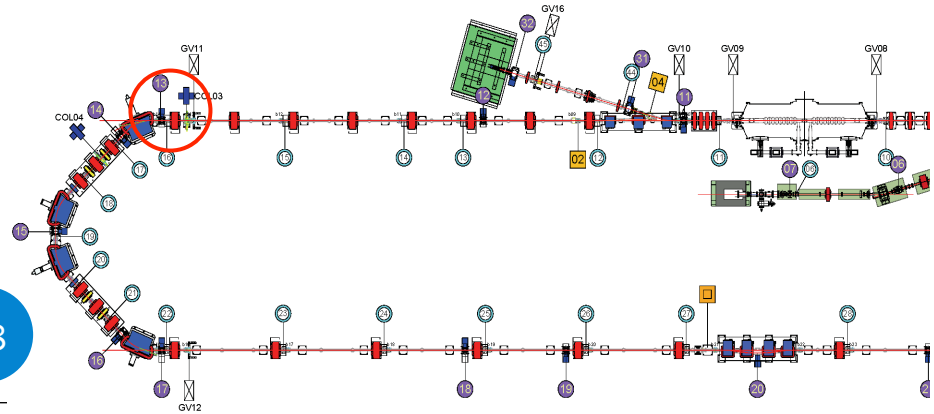


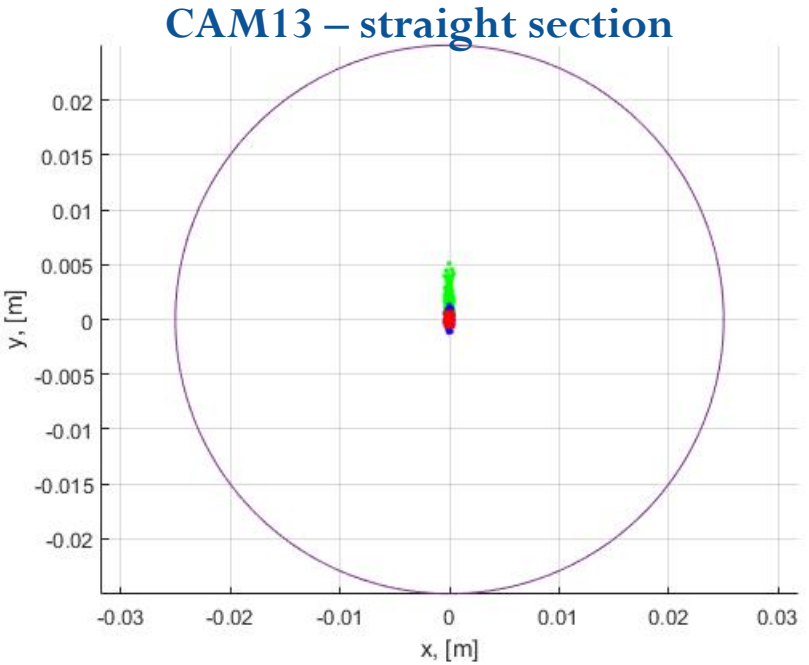


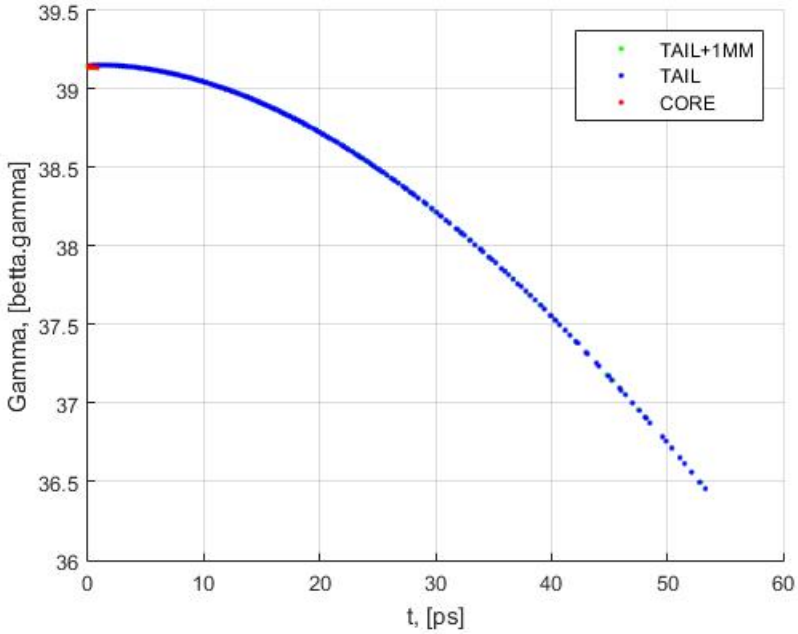


Injector cavity misalignment influence to the tail profile









Summary & prospect

- Several beam tail measurement results were compared with the corresponding simulated results
- Summary on the beam tail:
  - According to the simulation results, reproducing the tail measurements conditions, losses due to low energy tail (~40 ps) could be up to 0.82% of the beam
- Summary on the collimator's impact to the loss:
  - COL2 inserted from the right side is a best candidate to decrease the beam loss in 1st and 2nd arc sections of the recirculating loop. However, the total loss (0.82%) doesn't change.
  - One should take care of using COL4, because as the worst scenario it could increase the loss in the recirculating loop from 0.82% up to 1.26% of the beam. But it seems to help to get rid of the loss in the 2nd arc section and in the dump line
  - Insertion of COL1 slightly increasing the total loss (from 0.82% up to 0.98%) and insertion on COL3 slightly decreasing the loss (from 0.82% up to 0.78%), while the loss points stay the same
- Summary on tail profiles of CAM9, 12, 13:
  - Tail profiles on CAM9, 12, 13 (stretched upwards or downwards) are probably due to injector cavity misalignment. Other possible source of the "beard" could be kicks from the steering coils, and kicks from the HOM/input couplers
- To understand the tail dynamics properly, such kicks should be studied in details