LER collimator study (D03V4)

Beam Background Monthly Meeting

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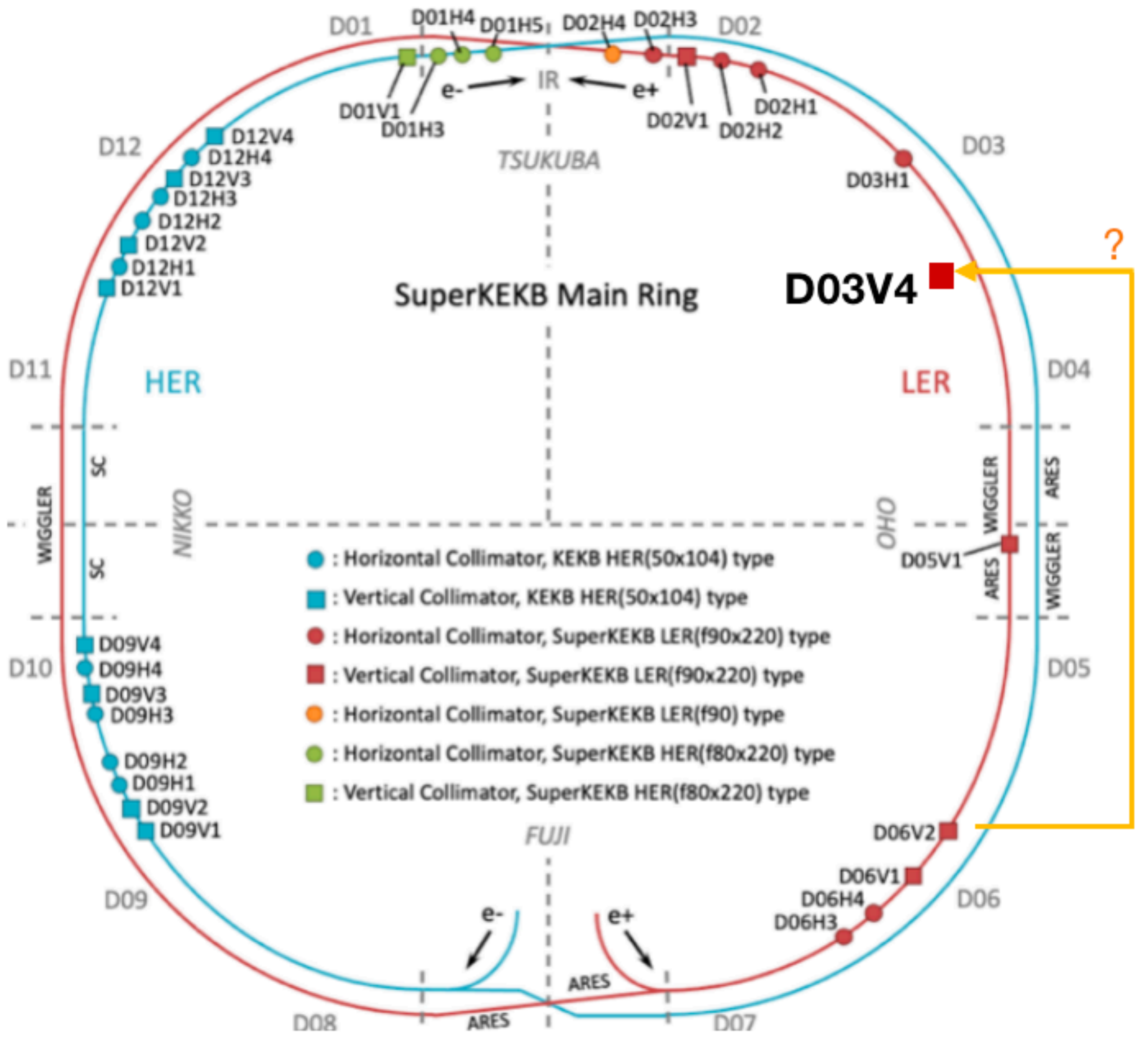
Introduction

- The problem: High particle loss at D02V1 leads to high background (secondary particles) in IR
    - Have studied the possibility to move D02V1 to a new location D02V0 (further upstream) -> increase Coulomb background significantly: slides
    - **New idea to explore**: try to move D06V1 or D06V2 to D3 section -> D03V4 in the lattice
- Optics file: sler_1801_2024-07-01_08_55_59.842_SNAP_K1.sad
    - β_y^* = **0.9** mm, and β_x at NLC is still the old value before summer shutdown
        - Higher background than β_y^* = 1 mm
        - NLC is not effective to reduce injection background
- Simulation config: LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm or larger
- Three configurations are compared for IR loss, loss at D02V1 and loss at D05V1
    - 1) open D06V2 and D03V4, 2) open D03V4 only, and 3) open D06V2 only



Collimator apertures are optimized with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Optimized settings with **D03V4 and D06V2** open *similar to what's used in 2024c*

Fixed →

NAME	D1[mm]	D2[mm]	D1[nSigma]	D2[nSigma]	dNu[1/2pi]
IR	-10.5	10.5	-34.53	34.53	0.8734
PMD06H3	-10.50	10.50	-32.50	32.50	0.8165
PMD06H4	-8.60	8.60	-26.62	26.62	0.2983
PMD03H1	-10.80	10.80	-30.58	30.58	0.0293
PMD02H1	-5.80	5.80	-19.35	19.35	0.8478
PMD02H2	-8.80	8.80	-22.25	22.25	0.3274
PMD02H3	-14.30	14.30	-30.59	30.59	0.0610
PMD02H4	-6.50	6.50	-21.91	21.91	0.8180
IR	-13.5	13.5	**-69.78**	**69.78**	**0.2603**
PMD06V1	-3.20	3.20	**-59.43**	**59.43**	0.2775
PMD06V2	-20.00	20.00	-672.09	672.09	0.9178
PMD05V1	-5.90	5.90	-446.65	446.65	0.5536
PMD03V4	-20.00	20.00	-740.12	740.12	0.2676
PMD02V1	-1.40	1.40	-58.70	58.70	0.2572

73.56 in 1mm optics

54.33 sigma at SNAP.1

↙ Skew sextupole magnet

Open a collimator means setting its aperture to 20 mm

Collimator apertures are optimized with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Optimized settings with **D03V4** open *Close D06V2 can reduce loss rates at other collimators*

Fixed →

NAME	D1[mm]	D2[mm]	D1[nSigma]	D2[nSigma]	dNu[1/2pi]
IR	-10.5	10.5	-34.53	34.53	0.8734
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PMD06H4	-8.60	8.60	-26.62	26.62	0.2983
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PMD02H4	-6.50	6.50	-21.91	21.91	0.8180
IR	-13.5	13.5	**-69.78**	**69.78**	**0.2603**
PMD06V1	-3.20	3.20	**-59.43**	**59.43**	0.2775
PMD06V2	-2.10	2.10	-70.57	70.57	0.9178
PMD05V1	-5.90	5.90	-446.65	446.65	0.5536
PMD03V4	-20.00	20.00	-740.12	740.12	0.2676
PMD02V1	-1.40	1.40	-58.70	58.70	0.2572

73.56 in 1mm optics

54.33 sigma at SNAP.1

Skew sextupole magnet

Open a collimator means setting its aperture to 20 mm

Collimator apertures are optimized with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Optimized settings with **D06V2** open *Close D03V4 can reduce loss rates at D02V1*

Fixed →

NAME	D1[mm]	D2[mm]	D1[nSigma]	D2[nSigma]	dNu[1/2pi]
IR	-10.5	10.5	-34.53	34.53	0.8734
PMD06H3	-10.50	10.50	-32.50	32.50	0.8165
PMD06H4	-8.60	8.60	-26.62	26.62	0.2983
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PMD06V2	-20.00	20.00	-672.09	672.09	0.9178
PMD05V1	-5.90	5.90	-446.65	446.65	0.5536
PMD03V4	-1.70	1.70	**-62.91**	**62.91**	0.2676
PMD02V1	-1.40	1.40	-58.70	58.70	0.2572

73.56 in 1mm optics

54.33 sigma at SNAP.1

Skew sextupole magnet

Open a collimator means setting its aperture to 20 mm

Collimator apertures are optimized with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Optimized settings with **D06V2** open *Close D03V4 narrower than D02V1*

Fixed → (IR row)

NAME	D1[mm]	D2[mm]	D1[nSigma]	D2[nSigma]	dNu[1/2pi]
IR	-10.5	10.5	-34.53	34.53	0.8734
PMD06H3	-10.50	10.50	-32.50	32.50	0.8165
PMD06H4	-8.60	8.60	-26.62	26.62	0.2983
PMD03H1	-10.80	10.80	-30.58	30.58	0.0293
PMD02H1	-5.80	5.80	-19.35	19.35	0.8478
PMD02H2	-8.80	8.80	-22.25	22.25	0.3274
PMD02H3	-14.30	14.30	-30.59	30.59	0.0610
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IR	-13.5	13.5	**-69.78**	**69.78**	**0.2603**
PMD06V1	-3.20	3.20	**-59.43**	**59.43**	0.2775
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PMD05V1	-5.90	5.90	-446.65	446.65	0.5536
PMD03V4	-1.57	1.57	**-58.10**	**58.10**	0.2676
PMD02V1	-1.50	1.50	-62.90	62.90	0.2572

73.56 in 1mm optics (IR vertical row)

54.33 sigma at SNAP.1 → Skew sextupole magnet

Open a collimator means setting its aperture to 20 mm

Comparing IR loss rate

Default D03V4 head: 10 mm Titanium

- The best setting to reduce IR loss is the one with D03V4 open (D06V2 closed)
  - open D06V2 and close D03V4 will increase Touschek loss at IR
    - 1.7 MHz -> 8 MHz, **a factor of 4 ?**

Higher stat.

C: Coulomb   B: Bremss.   T: Touschek

```
C IR losses: 15.3522 +/- 0.259447 [MHz]
C lifetime: 44.9498 +/- 0.548534 [min]
B IR losses: 5.88194 +/- 0.0193734 [MHz]
B lifetime: 1996.97 +/- 3.18653 [min]
T IR losses: 2.38686 +/- 0.264836 [MHz]
T lifetime: 14.0038 +/- 0.0833924 [min]
utput/ana_20240701_opt2_openD03V4D06V2_Z-4_Z4
```

```
--> C IR losses: 12.0187 +/- 0.432954 [MHz]
--> C lifetime: 48.4063 +/- 1.6296 [min]
--> B IR losses: 5.97947 +/- 0.0648969 [MHz]
--> B lifetime: 1988.05 +/- 9.51382 [min]
--> T IR losses: 1.72895 +/- 0.0640224 [MHz]
--> T lifetime: 13.3561 +/- 0.21005 [min]
./output/ana_20240701_opt2_openD03V4_Z-4_Z4_LER
```

```
--> C IR losses: 12.2232 +/- 0.228564
--> C lifetime: 44.6809 +/- 0.574436 [
--> B IR losses: 5.92308 +/- 0.021249
--> B lifetime: 1993.15 +/- 3.03991 [m
--> T IR losses: 8.00231 +/- 0.635974
--> T lifetime: 13.5958 +/- 0.0884598
./output/ana_20240701_opt2_openD06V2_Z
```

open D03V4 & D06V2 — *Current strategy in 2024c*

open D03V4, close D06V2

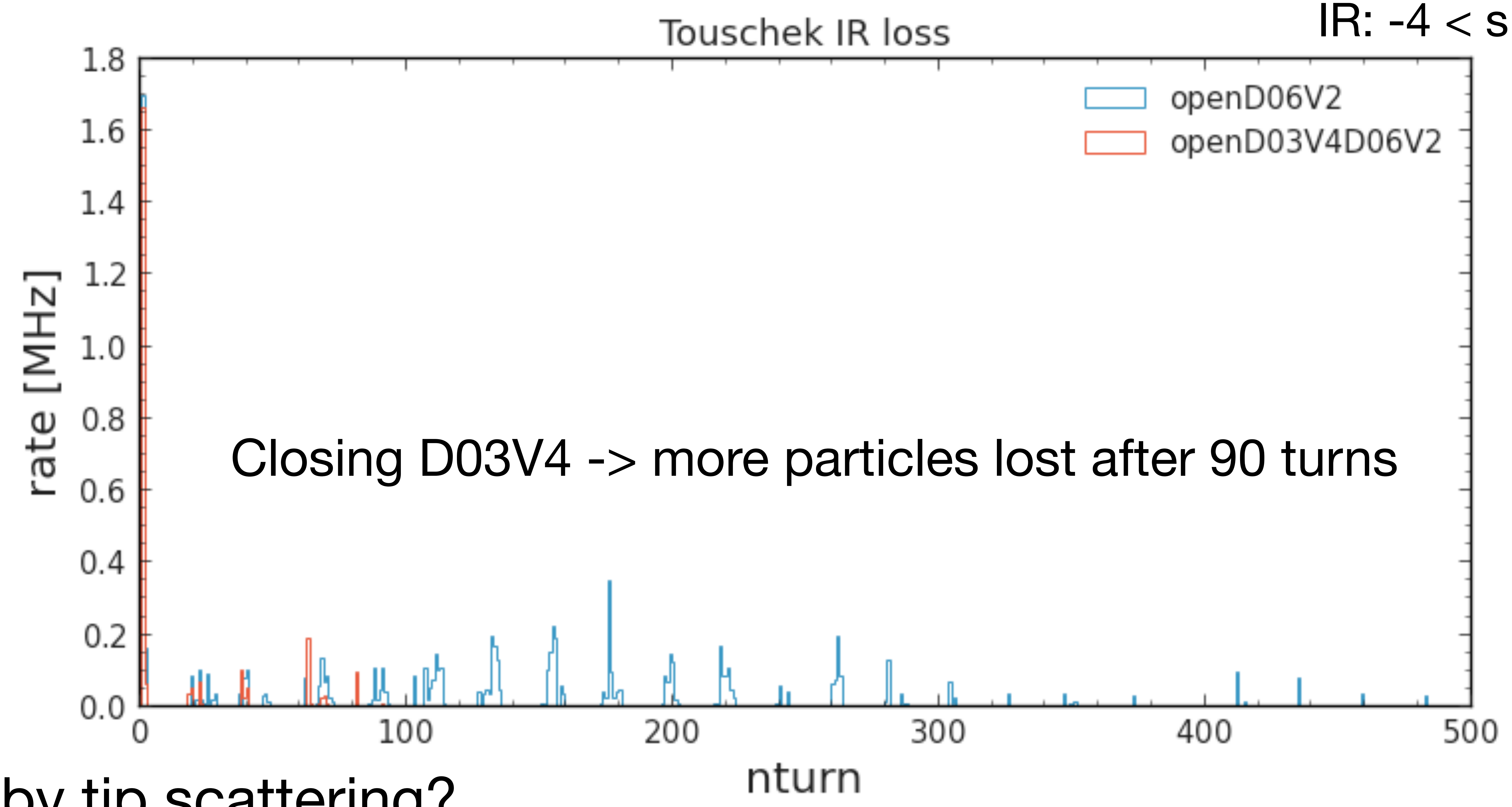
close D03V4, open D06V2

Why increased Touschek loss by closing D03V4?

Default D03V4 head: 10 mm Titanium

- Comparing “openD03V4D06V2” with “openD06V2 only”

IR: -4 < s < 4 m

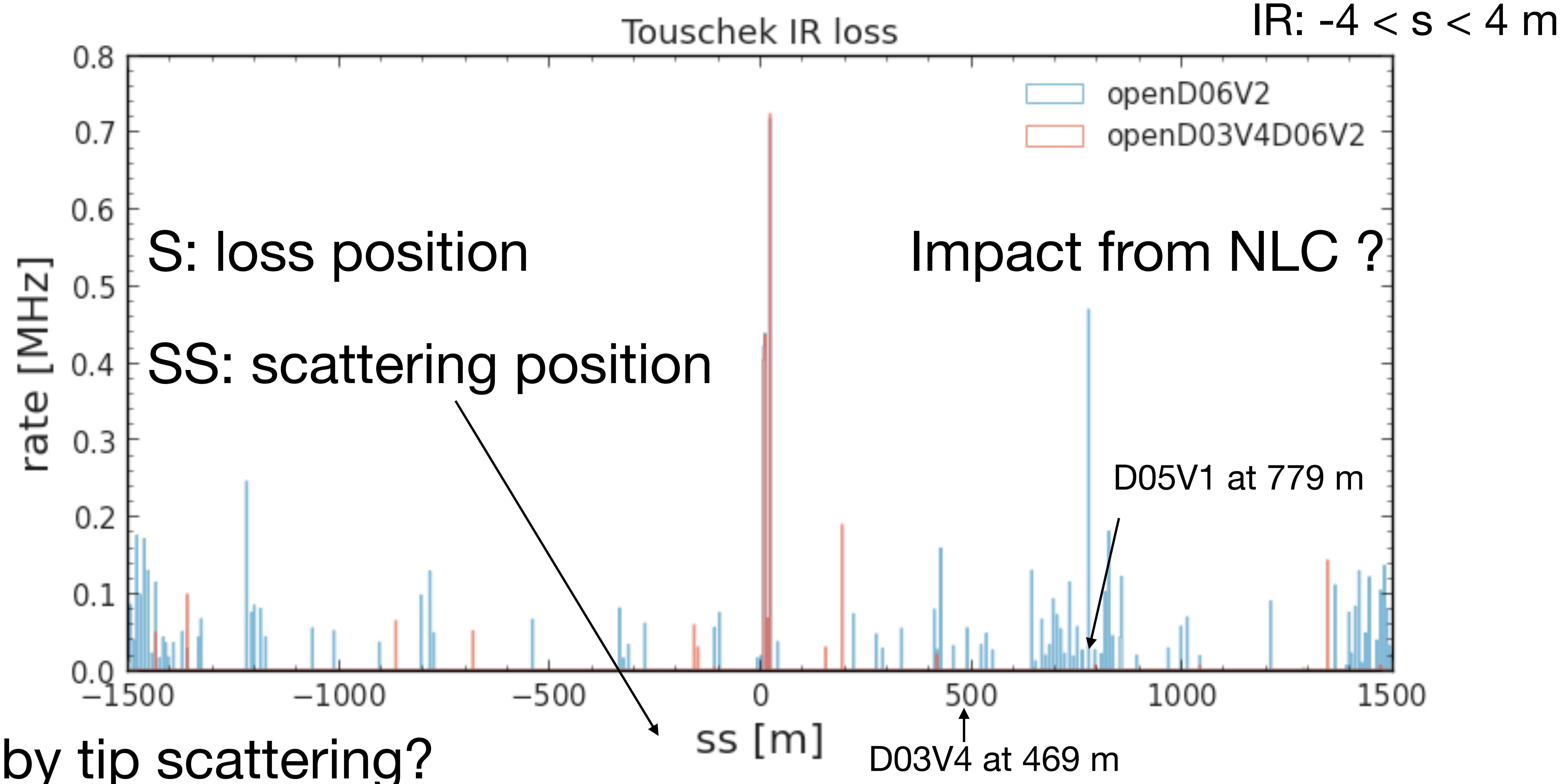


- Caused by tip scattering?

Why increased Touschek loss by closing D03V4?

Default D03V4 head: 10 mm Titanium

- Comparing “openD03V4D06V2” with “openD06V2 only”



- Caused by tip scattering?

Comparing IR loss rates with different D03V4 heads

Try D03V4 head with 10 mm Titanium/Tantalum

- Closing D3V4 reduces Coulomb IR loss
    - Using 10-mm **Ta** has no impact on Touschek IR loss !
    - Using 10-mm **Ti** increases Touschek IR loss

Material effect (tip-scattering) !

10 mm Tantalum

```
C IR losses: 11.8704 +/- 0.142109
C lifetime: 44.3663 +/- 0.571682 [
B IR losses: 5.88374 +/- 0.0190774
B lifetime: 1996.13 +/- 3.0551 [mi
T IR losses: 2.14296 +/- 0.176812
T lifetime: 13.9133 +/- 0.0879214
utput/ana_20240701_opt2_openD06V2_s
```

C: Coulomb   B: Bremss.   T: Touschek

```
C IR losses: 15.3522 +/- 0.259447 [MHz]
C lifetime: 44.9498 +/- 0.548534 [min]
B IR losses: 5.88194 +/- 0.0193734 [MHz]
B lifetime: 1996.97 +/- 3.18653 [min]
T IR losses: 2.38686 +/- 0.264836 [MHz]
T lifetime: 14.0038 +/- 0.0833924 [min]
utput/ana_20240701_opt2_openD03V4D06V2_Z-4_Z4
```

open D03V4 & D06V2

Current strategy in 2024c

```
--> C IR losses: 12.0187 +/- 0.432954 [MHz]
--> C lifetime: 48.4063 +/- 1.6296 [min]
--> B IR losses: 5.97947 +/- 0.0648969 [MHz]
--> B lifetime: 1988.05 +/- 9.51382 [min]
--> T IR losses: 1.72895 +/- 0.0640224 [MHz]
--> T lifetime: 13.3561 +/- 0.21005 [min]
./output/ana_20240701_opt2_openD03V4_Z-4_Z4_LER
```

open D03V4, **close D06V2**

```
--> C IR losses: 12.2232 +/- 0.228564
--> C lifetime: 44.6809 +/- 0.574436 [
--> B IR losses: 5.92308 +/- 0.021249
--> B lifetime: 1993.15 +/- 3.03991 [m
--> T IR losses: 8.00231 +/- 0.635974
--> T lifetime: 13.5958 +/- 0.0884598
./output/ana_20240701_opt2_openD06V2_Z
```

close D03V4, open D06V2

10 mm Titanium

Confirmation using ideal collimators

Remove tip-scattering and realistic modeling of ALL collimators

- Ideal collimators w/o realistic structure: 100% collimation power and ellipse aperture
  - D03V4 has almost no impact on Touschek IR loss and could reduce Coulomb IR loss rate

C: Coulomb   B: Bremss.   T: Touschek

```
C IR losses: 11.444 +/- 0.442513 [MHz]
C lifetime: 48.9874 +/- 1.51512 [min]
B IR losses: 5.95158 +/- 0.0602385 [MHz]
B lifetime: 2001.72 +/- 8.1226 [min]
T IR losses: 1.5696 +/- 0.0638042 [MHz]
T lifetime: 14.0679 +/- 0.2032 [min]
ıtput/ana_20240701_opt2_openD03V4D06V2_notip
```

```
--> C IR losses: 9.76933 +/- 0.238709
--> C lifetime: 45.977 +/- 1.69376 [mi
--> B IR losses: 5.99748 +/- 0.066184
--> B lifetime: 2006.9 +/- 9.19804 [mi
--> T IR losses: 1.67438 +/- 0.059762
--> T lifetime: 14.0421 +/- 0.207069 [
./output/ana_20240701_opt2_openD06V2_n
```

open D03V4 & D06V2 | open D03V4, **close D06V2** | close D03V4, open D06V2

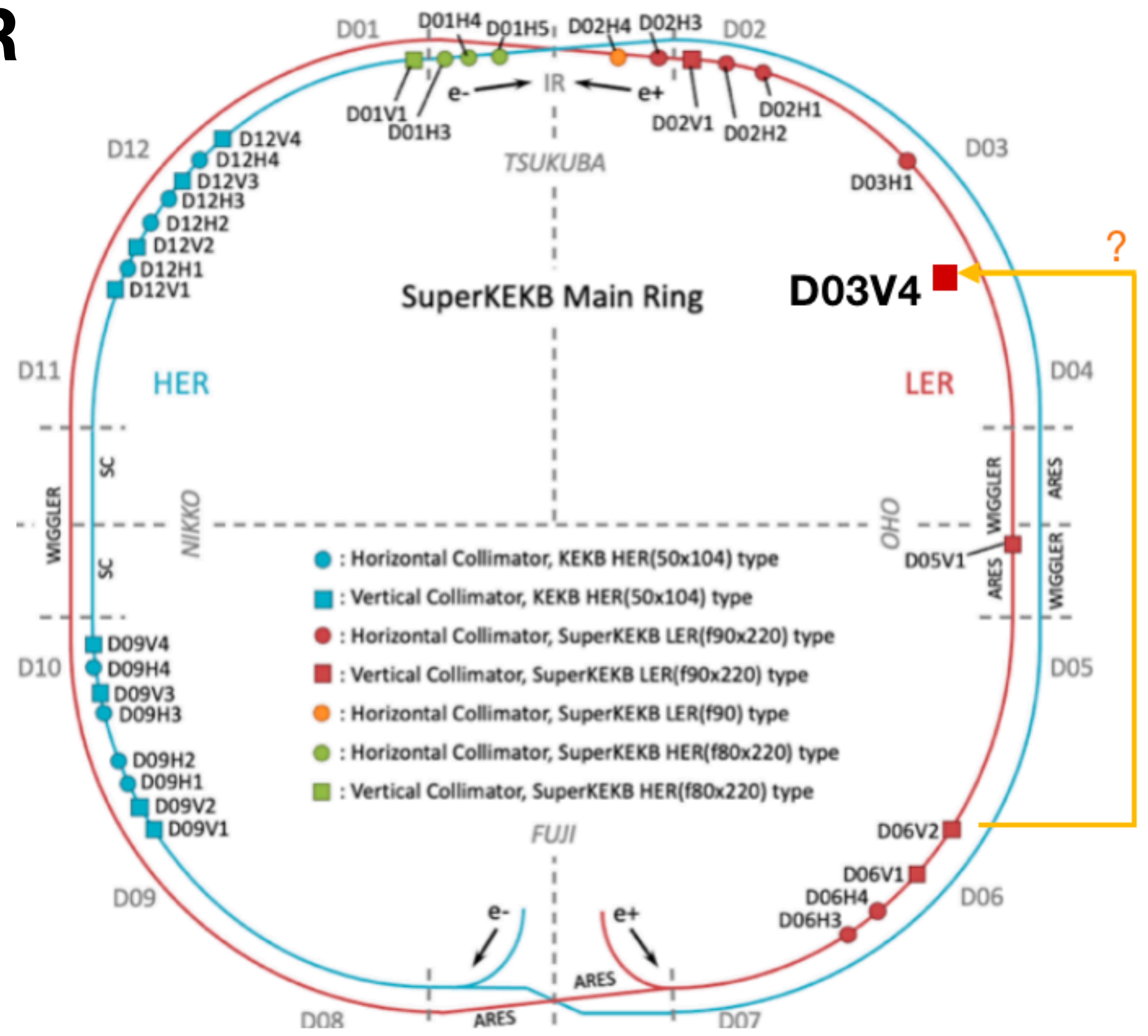
```
T IR losses: 1.6255 +/- 0.0200023 [MHz]
T lifetime: 13.9024 +/- 0.0868002 [min]
```

Higher stat.

```
--> T IR losses: 1.68746 +/- 0.0199181
--> T lifetime: 13.7805 +/- 0.0875974
```

Conclusion of D03V4 study for single-beam BG

- **D03V4** effectively **reduces Coulomb** losses in the **IR**
- **D03V4** reduces D02V1 losses -> fewer tip-scattered particles from D02V1 reach the IR
- **D03V4** can replace D06V2 (***similar*** IR protection performance)
  - Its **Touschek IR loss** rate (2.14MHz) is **slightly higher than D06V2**(1.73 MHz), but within 2.2 standard deviations (statistical uncertainties about 0.19 MHz)
- **High-Z material (e.g., Ta)** is **critical** for the D03V4 head to **prevent multi-turn beam losses** from tip-scattered particles **in the IR**.



Study the potential of D03V4 against SBL

Request: enlarge emittance and start tracking ~5 meters upstream of D03V4

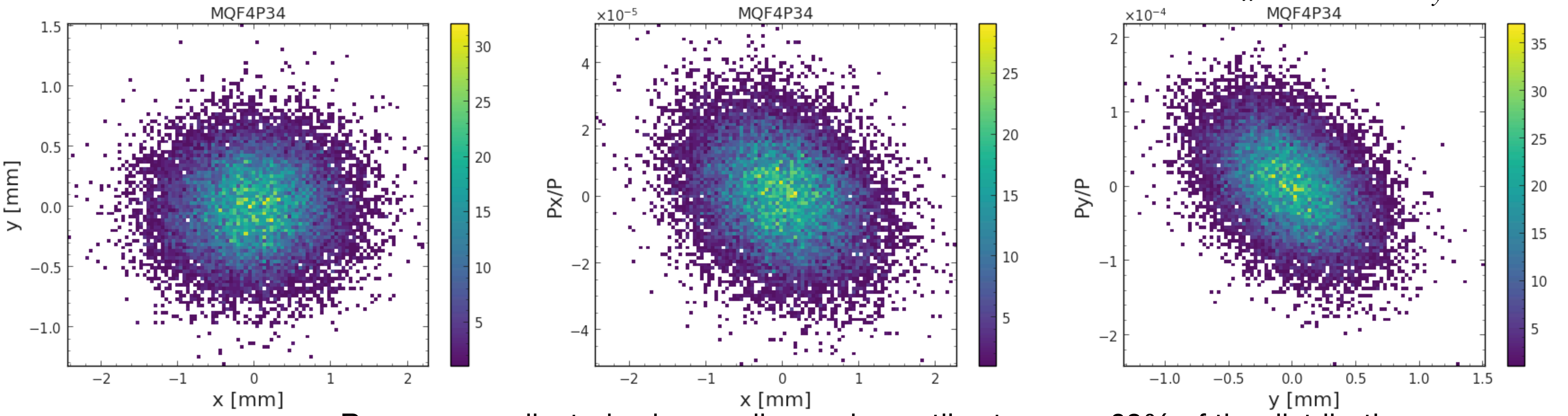
- Sudden beam loss (SBL) is treated as normal beam with enlarged vertical emittance

For example, default ϵ_y x 400

- The element to start tracking is “MQF4P34”

7.67 m upstream of D03V4

$\epsilon_x \approx 4.3\,\mathrm{nm},\ \epsilon_y \approx 17.2\,\mathrm{nm}$



Ranges are adjusted using median and quantiles to cover 68% of the distributions

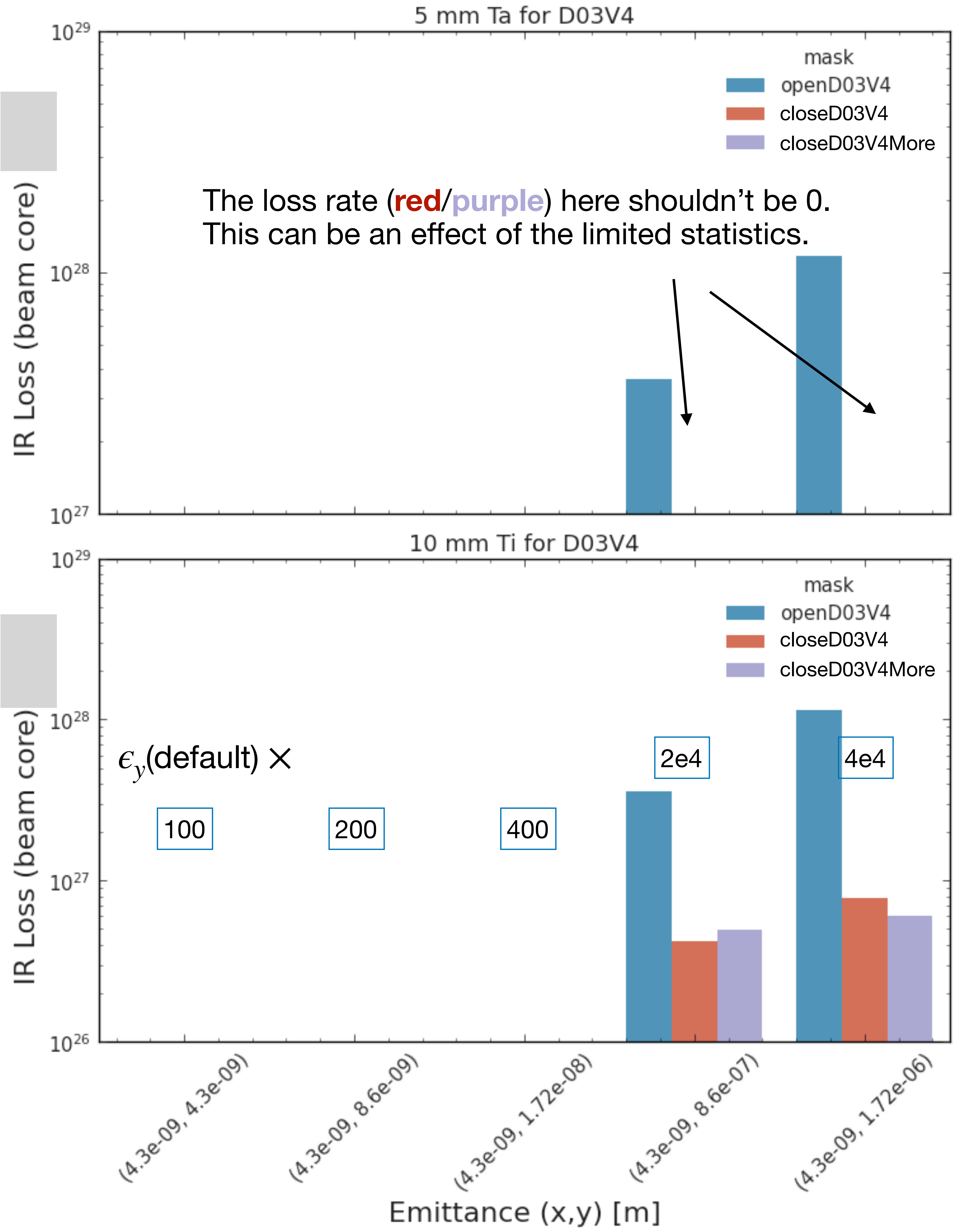
- Simulate both **beam core** and **halo** with <u>20K particles x **200** files</u> for $\epsilon_y \geq$ 0.86 μm

  only <u>20K particles x 1 file</u> for $\epsilon_y \leq$ 17.2 nm

Compare IR loss

IR loss is dominated by particles from beam core

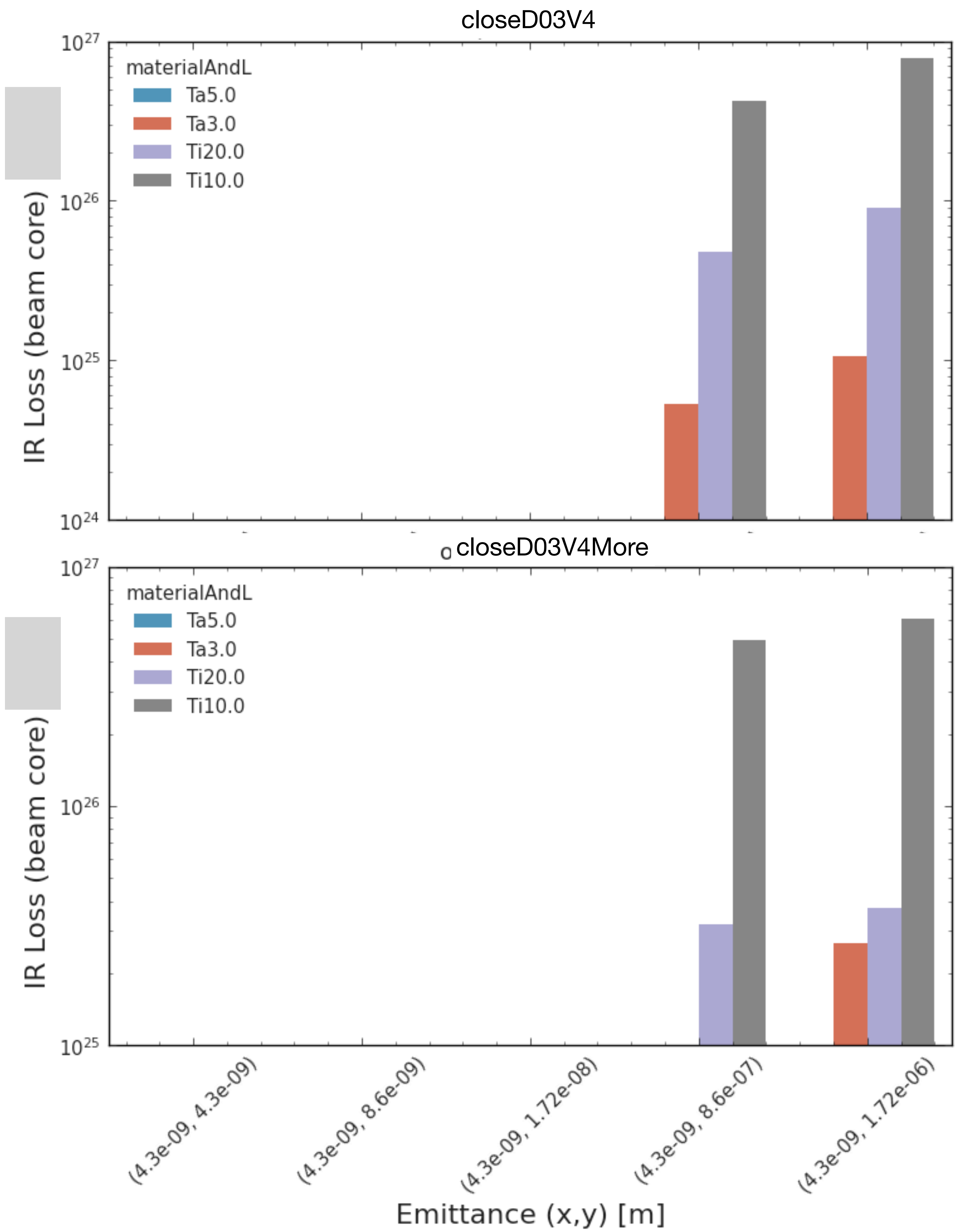
- "openD03V4" is the worst
- "closeD03V4" could reduce IR loss significantly
    - 5-mm Ta is much better than 10-mm Ti
- No IR loss for $\epsilon_y \leq$ 17.2 nm?
    - Either the emittance is still too small to generate IR loss,
    - Or the statistics is too small to estimate the low loss rate



Compare IR loss

IR loss is dominated by particles from beam core

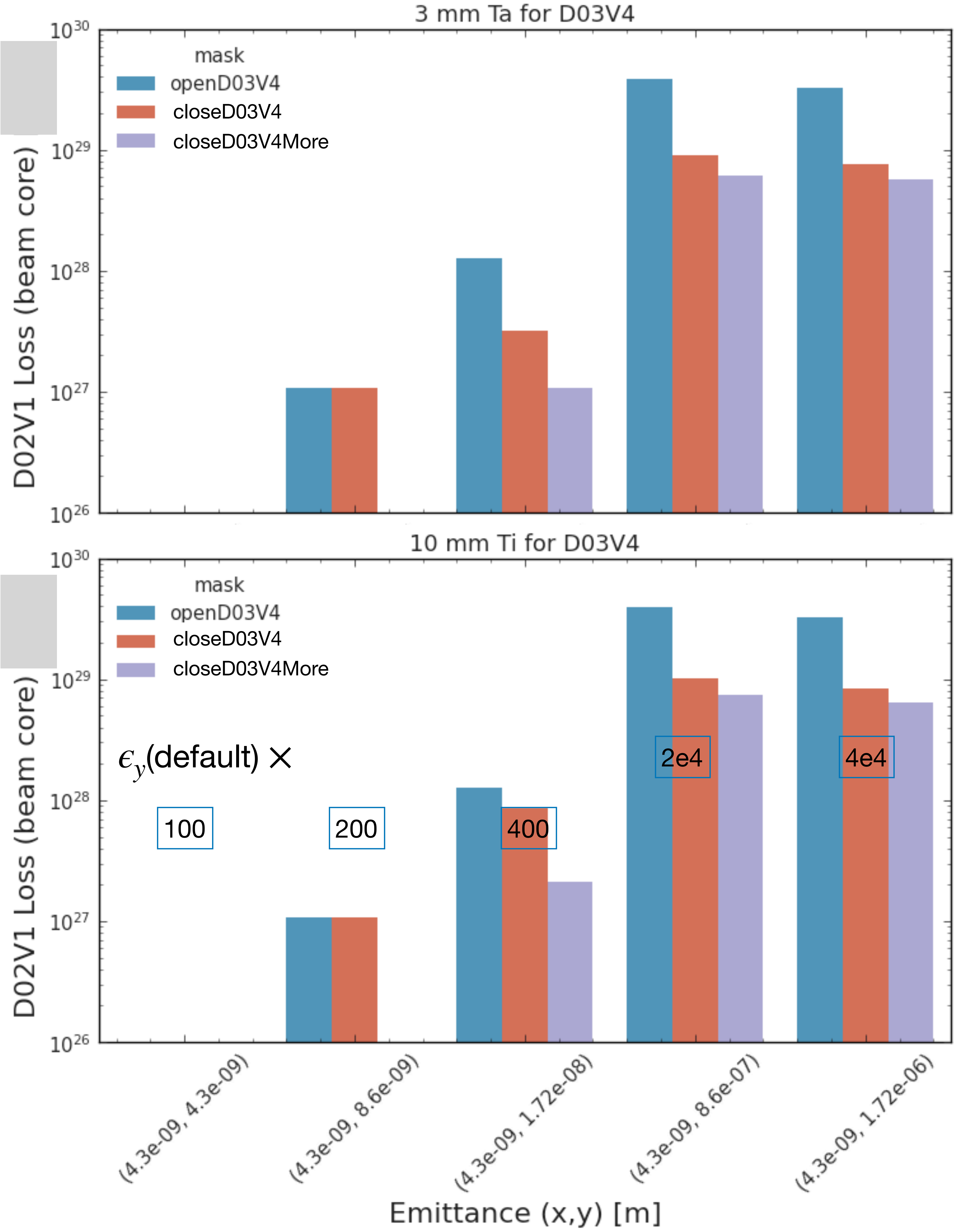
- “closeD03V4”
  - D03V4 aperture = 1.7 mm
- “closeD03V4More”
  - D03V4 aperture = 1.6 mm
  - Better protection for the IR



Compare loss at D02V1

IR loss is dominated by particles from beam core

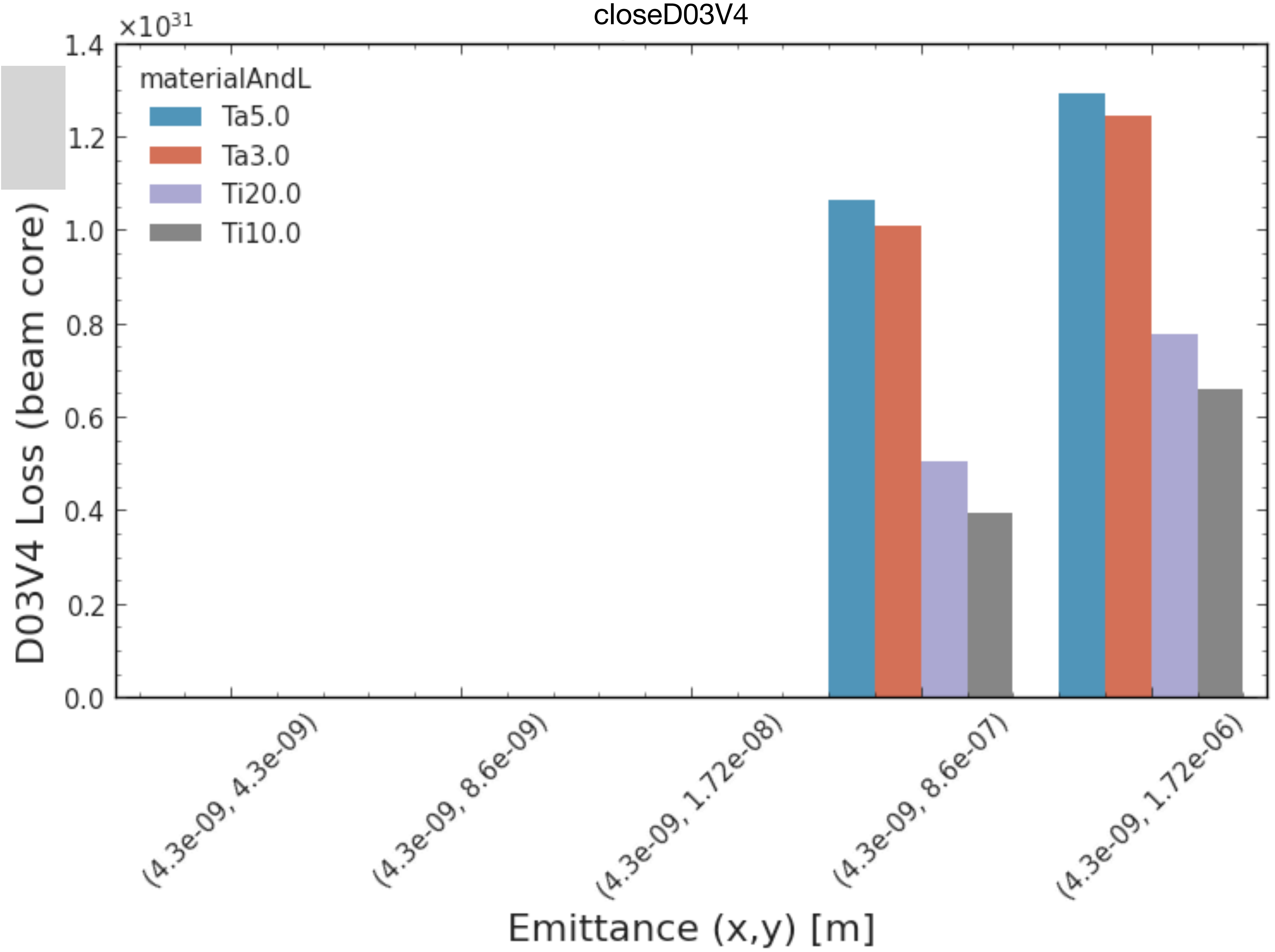
- D02V1 protects the IR
  - Large losses from the simulated “SBL”
- D03V4 can protect D02V1 when $\epsilon_y > 8.6$ nm
  - As expected:
    - 3-mm Ta works better than 10-mm Ti
    - Narrower apertures (if allowed) is preferred



Compare loss at D03V4

IR loss is dominated by particles from beam core

- Loss rate at D03V4 itself looks reasonable too
  - Increased loss rate as a function of material density and length



Conclusion of D03V4 study for SBL

Simply treate SBL as a normal beam with enlarged vertical emittance

- Current statistics is probably still too small to check the loss rates for $\epsilon_y \leq$ 17.2 nm

- D03V4 could reduce the loss rate at IR and D02V1

Backup 1

Comparing loss rate at D05V1

High loss rate at D05V1 leads to high radiation level at OHO hall

- The current setting used in 2024c (open D06V2 and no D03V4) has a very high loss rate at D05V1
- Closing D06V2 (D03V4 open) can reduce it by 50% for beam-gas and 80% for Touschek!
- Closing D03V4 (D06V2 open) can only reduce Touschek loss by 50%

```
C    losses: 2278.71 +/- 162.275 [MHz]
C lifetime: 49.3408 +/- 1.55785 [min]
B    losses: 2.843 +/- 0.252165 [MHz]
B lifetime: 1998.87 +/- 9.03805 [min]
T    losses: 2305.26 +/- 143.074 [MHz]
T lifetime: 13.6371 +/- 0.200656 [min]
tput/ana_20240701_opt2_openD03V4D06V2_Z777.3
```

```
--> C    losses: 1175.92 +/- 106.231 [MHz]
--> C lifetime: 48.4063 +/- 1.6296 [min]
--> B    losses: 1.19889 +/- 0.136978 [MHz]
--> B lifetime: 1988.05 +/- 9.51382 [min]
--> T    losses: 419.971 +/- 31.2593 [MHz]
--> T lifetime: 13.3561 +/- 0.21005 [min]
./output/ana_20240701_opt2_openD03V4_Z777.3714_
```

```
--> C    losses: 2734.4 +/- 333.024 [M
--> C lifetime: 47.4648 +/- 1.65993 [m
--> B    losses: 1.61705 +/- 0.142721
--> B lifetime: 1991.43 +/- 9.10897 [m
--> T    losses: 1085.13 +/- 73.2826 [
--> T lifetime: 13.8491 +/- 0.200833 [
./output/ana_20240701_opt2_openD06V2_Z
```

open D03V4 & D06V2 | open D03V4, **close D06V2** | close D03V4, open D06V2

Current strategy in 2024c

10 mm Titanium

Comparing loss rate at D02V1

Particle loss at D02V1 could increase beam background at IR

- Not a surprise, using D03V4 (open D06V2) gives us the lowest loss rate at D02V1
- The current setting with D06V2 open and no D03V4 has the largest loss rate with a factor 4-5 dominated by Touschek
- Closing D06V2 without using D03V4 is only 50% worse than using D03V4

```
C     losses: 491.162 +/- 39.3973 [MHz]
C lifetime: 49.3408 +/- 1.55785 [min]
B     losses: 5.2586 +/- 0.349371 [MHz]
B lifetime: 1998.87 +/- 9.03805 [min]
T     losses: 4903.82 +/- 322.859 [MHz]
T lifetime: 13.6371 +/- 0.200656 [min]
ıtput/ana_20240701_opt2_openD03V4D06V2_Z83.83
```

```
--> C     losses: 489.945 +/- 44.6693 [MHz]
--> C lifetime: 48.4063 +/- 1.6296 [min]
--> B     losses: 2.62282 +/- 0.183171 [MHz]
--> B lifetime: 1988.05 +/- 9.51382 [min]
--> T     losses: 1538.91 +/- 125.032 [MHz]
--> T lifetime: 13.3561 +/- 0.21005 [min]
./output/ana_20240701_opt2_openD03V4_Z83.8344_Z
```

```
--> C     losses: 325.517 +/- 30.6239
--> C lifetime: 47.4648 +/- 1.65993 [ı
--> B     losses: 2.45799 +/- 0.235724
--> B lifetime: 1991.43 +/- 9.10897 [ı
--> T     losses: 1015.6 +/- 77.112 [MI
--> T lifetime: 13.8491 +/- 0.200833
./output/ana_20240701_opt2_openD06V2_
```

open D03V4 & D06V2
Current strategy in 2024c

open D03V4, **close D06V2**

close D03V4, open D06V2
10 mm Titanium

Conclusion I

- **D06V2** **plays a unique role** in controlling loss rates at IR, D02V1 and especially D05V1
    - To be confirmed with the collimator group
- The **setting without using D06V2** has significantly high loss rates at D05V1 and D02V1 -> also contributes to high beam background in 2024c?
- With **D03V4**, we can have the **lowest loss rate at D02V1** and moderate loss rates at D05V1 and the IR.

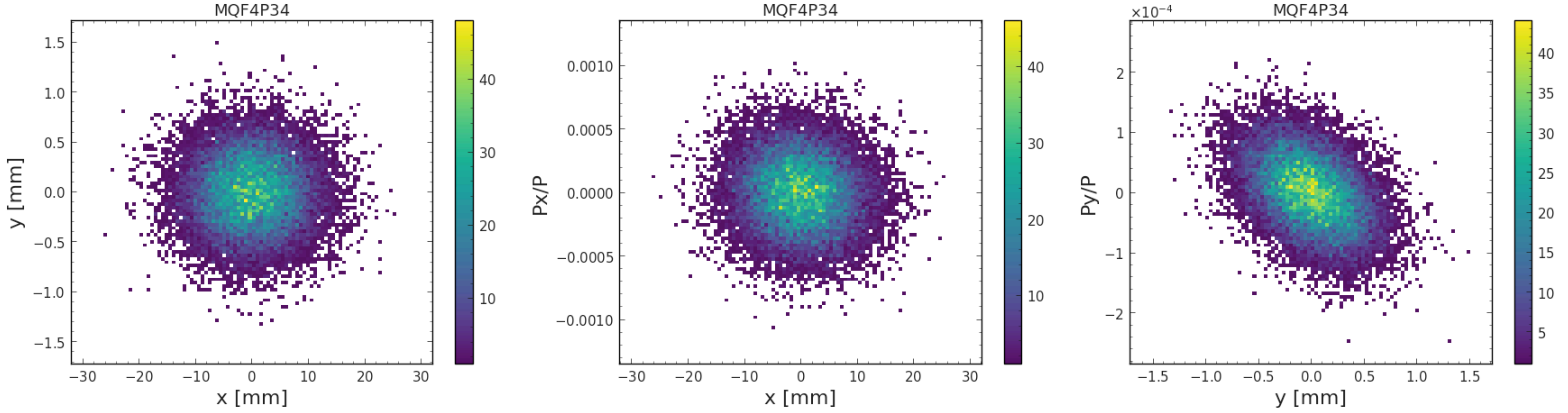
Study the potential of D03V4 against SBL

Enlarge emittance and start tracking ~5 meters upstream of D03V4

- The element to start tracking is "MQF4P34"

7.67 m upstream of D03V4

Default emittance x 400



Ranges are adjusted using σ_{68} calculated with quantiles

- New SAD scripts can specify collimator material and tip length for the study

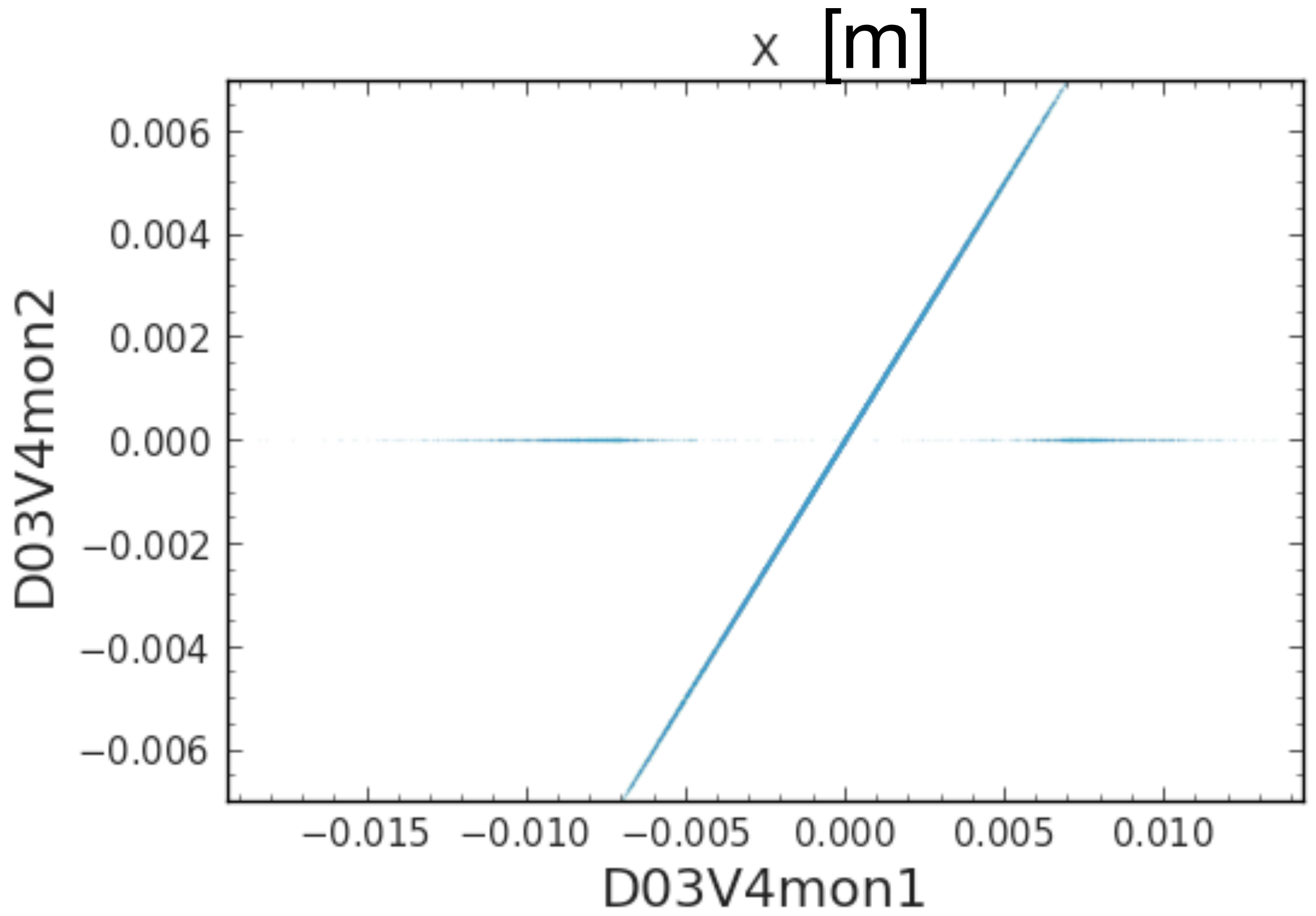
  Simulate both **beam core** and **halo** with 20K particles

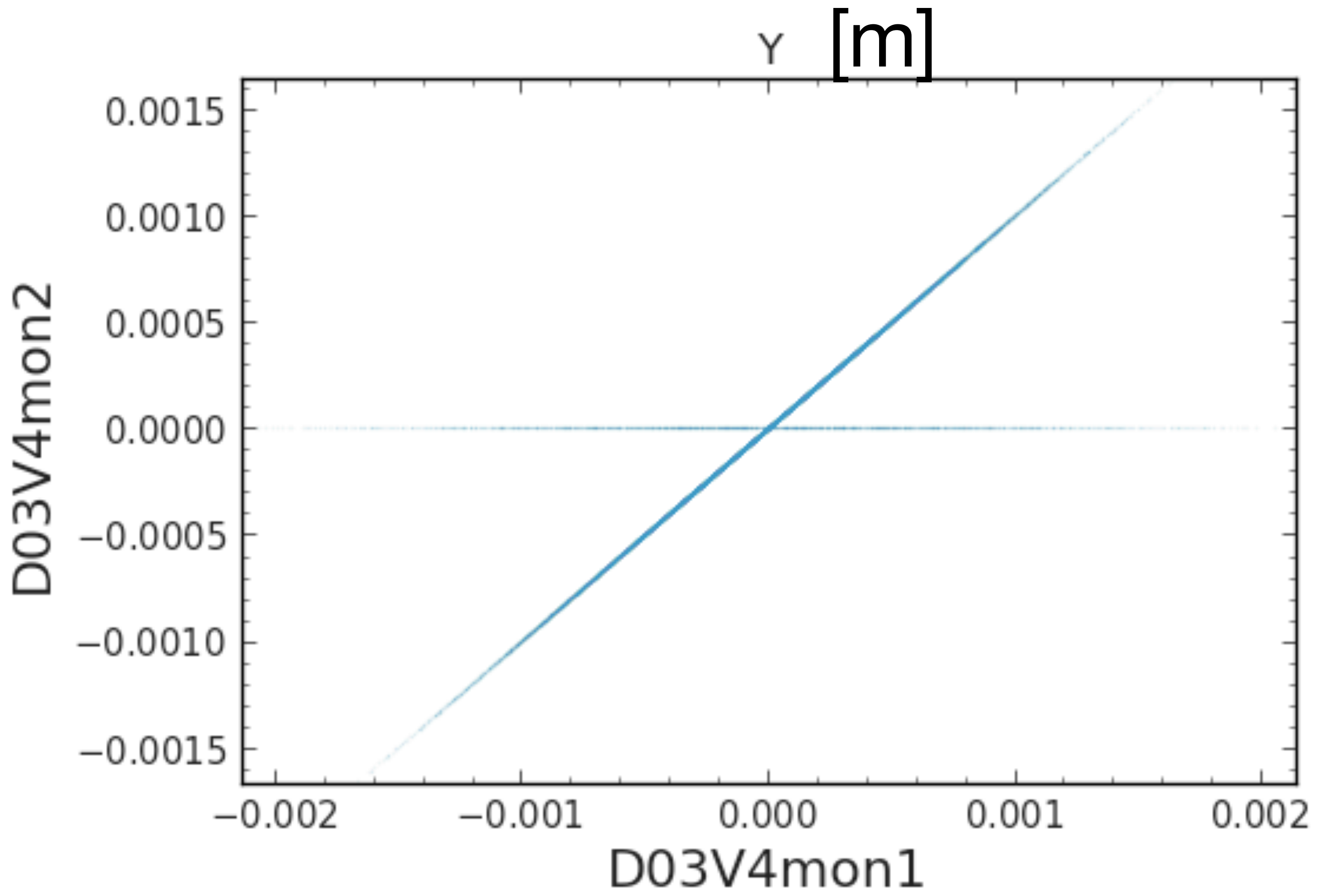
Results below might be unreliable due to the issue we found with enlarged emittance

Issue in the SBL study with enlarged emittance

Strange output from SAD ExternalMap

- Coordinates of lost particles are reset to 0





- We still don’t fully understand this behavior. -> A feature in SAD?
  - The two ExternalMaps are added before and after the collimator D03V4 to monitor beam profiles only.
  - In tip-scattering, we set collimator aperture to 7 mm first (first call of “beam2 = TrackParticles[beam1,destination,nbegin,nend]”)
    - Lost particles are “revived” if they don’t hit the realistic collimator structure
      - Call “TrackParticles[beam11,destination,nbegin,nend];” in a particle-by-particle manner, then update “beam2”

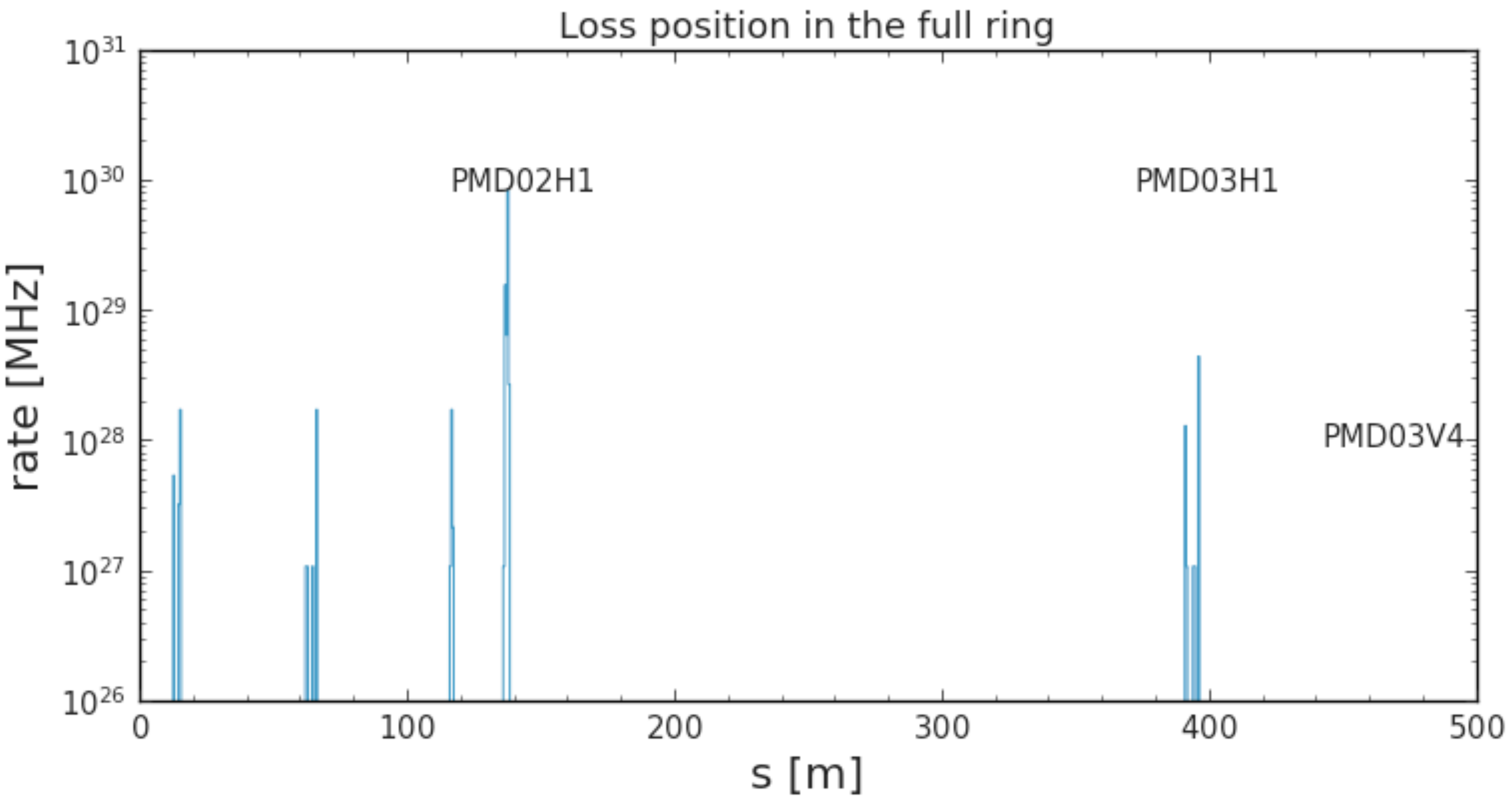
Check loss position from beam core in the full ring

Using emittance (4.3e-7 m, 4.3e-9 m) and 5 mm Ta for D03V4

x100 larger than default

- Significant amount of particles are lost at D02H1 and D03H1

Their beta functions are larger than D03V4



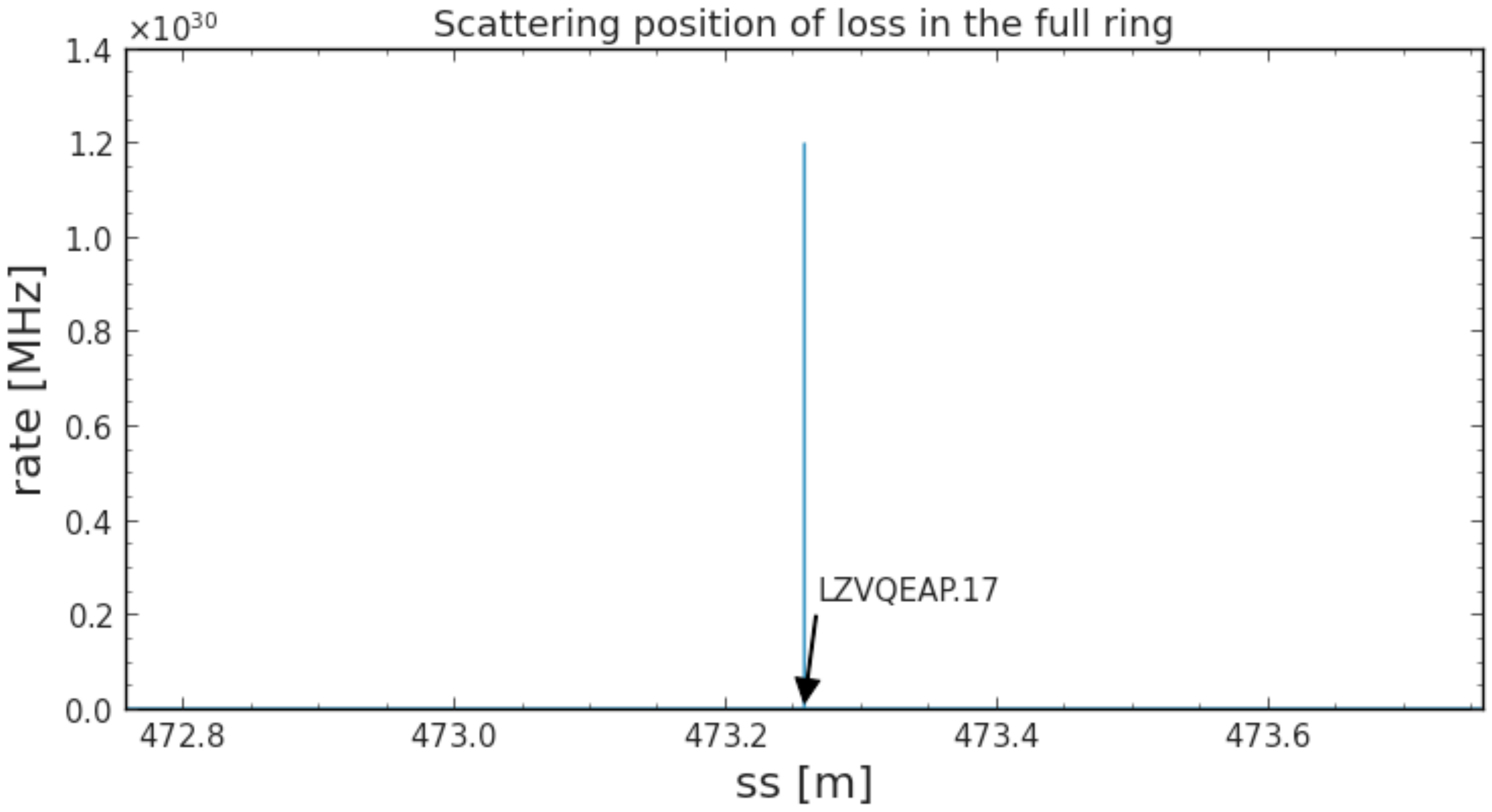
Check scattering position from beam core in the full ring

Using emittance (4.3e-7 m, 4.3e-9 m) and 5 mm Ta for D03V4

x100 larger than default

- Scattering happens only at a specific element LZVQEAP.17

3.86 m upstream of D03V4



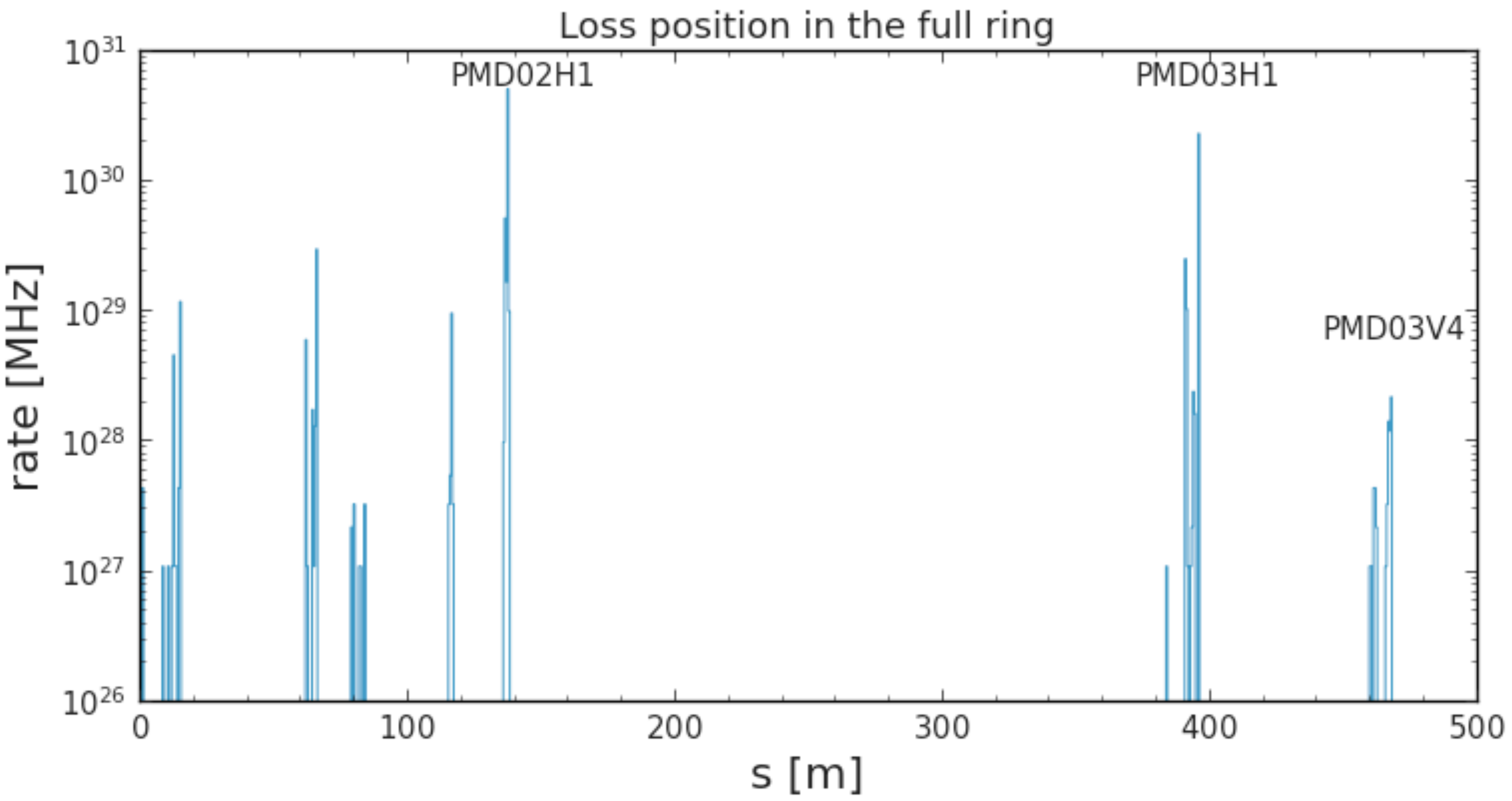
Check loss position from beam core in the full ring

Using emittance (17.2e-7 m, 17.2e-9 m) and 5 mm Ta for D03V4

x400 larger than default

- Significant amount of particles are lost at D02H1 and D03H1

Their beta functions are larger than D03V4



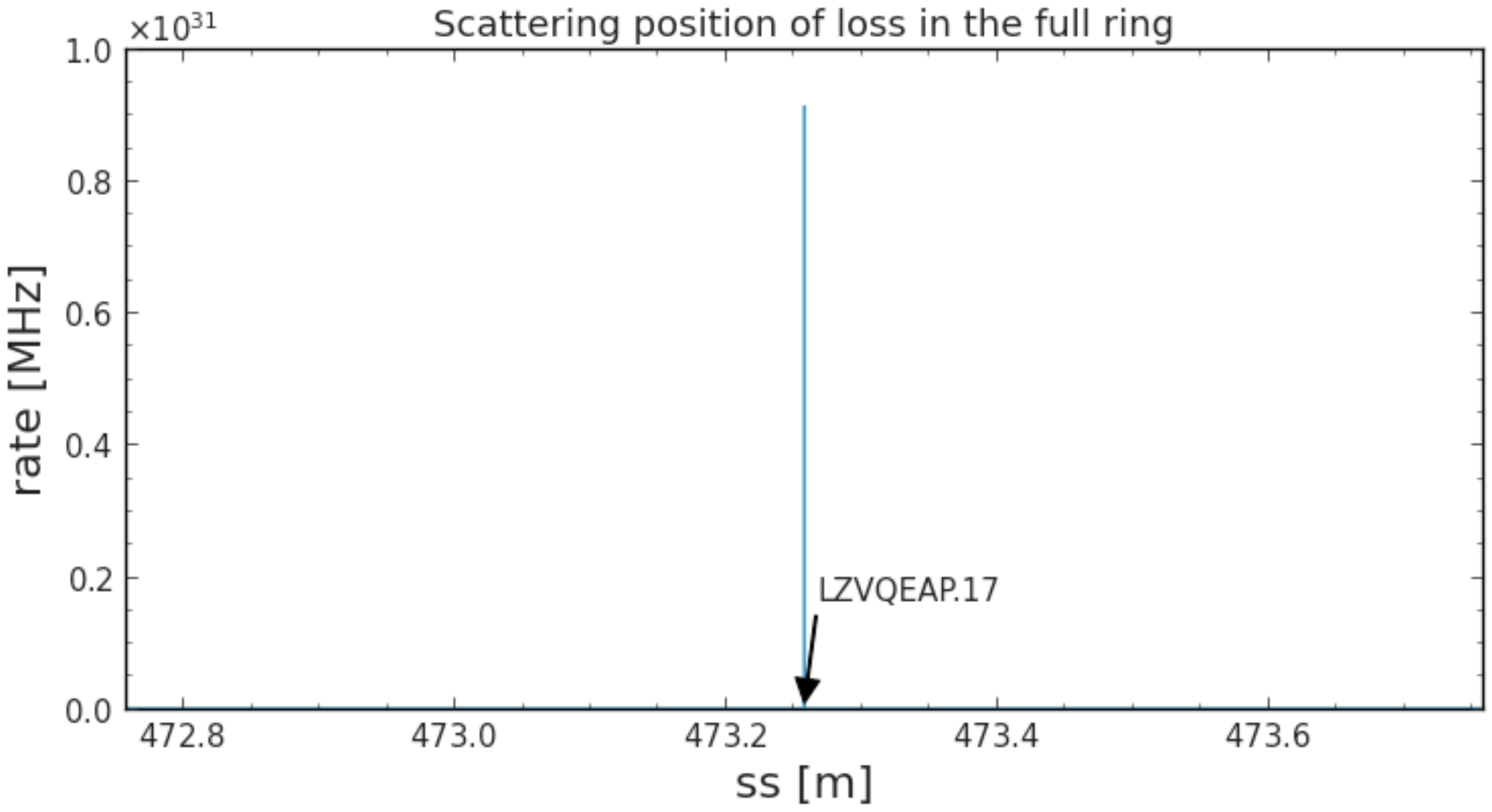
Check scattering position from beam core in the full ring

Using emittance (17.2e-7 m, 17.2e-9 m) and 5 mm Ta for D03V4

x400 larger than default

- Scattering happens only at a specific element LZVQEAP.17

3.86 m upstream of D03V4

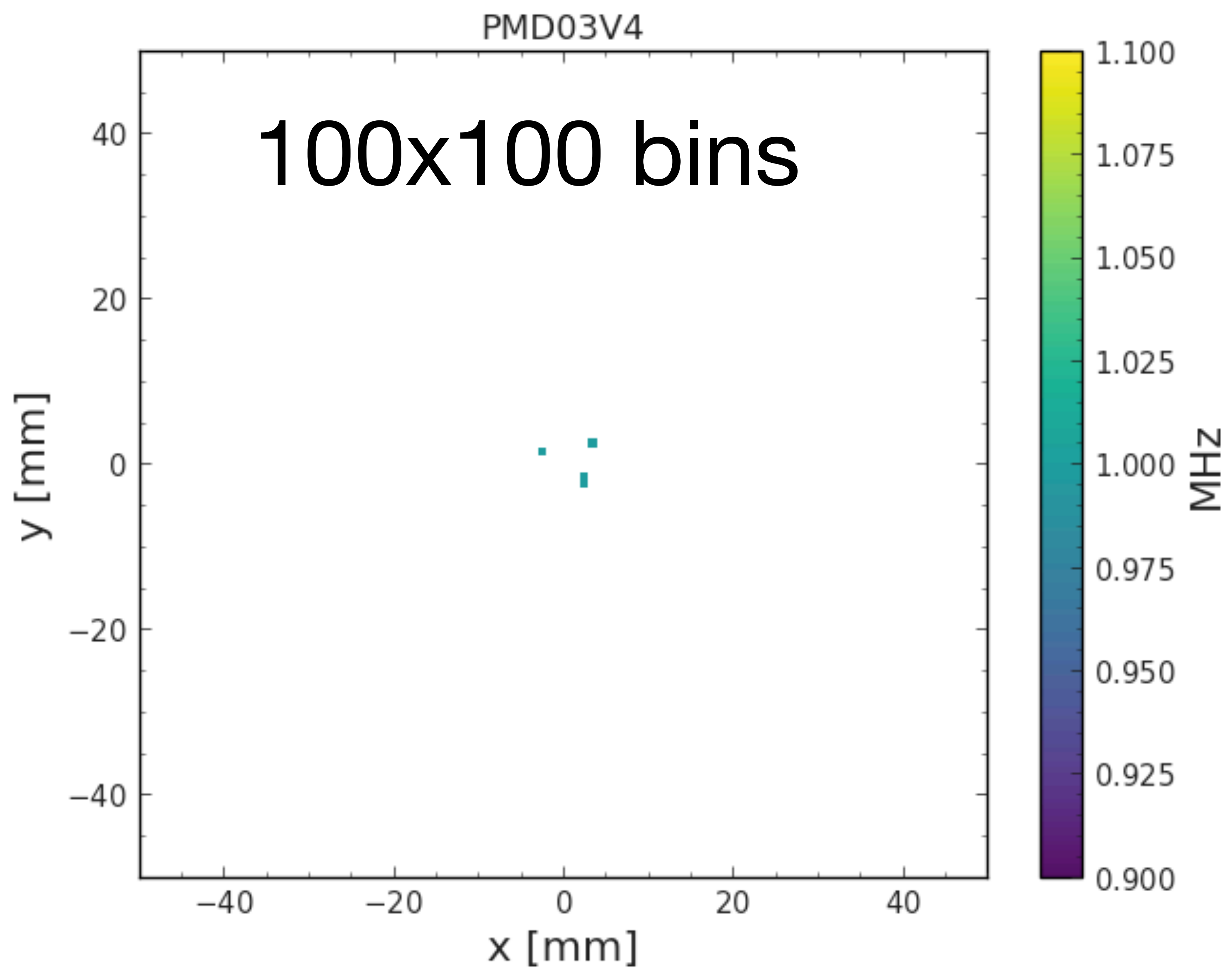


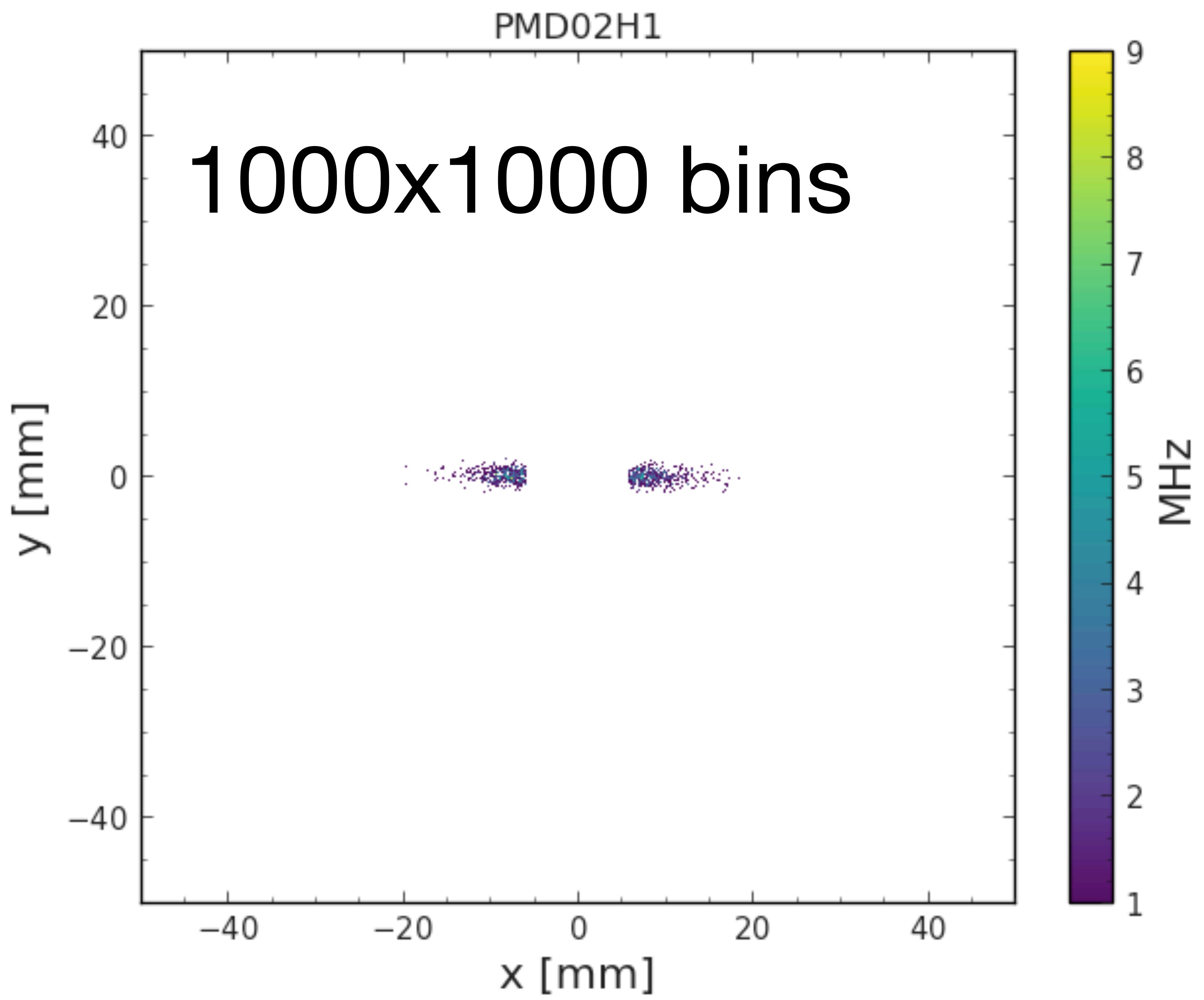
Check tip scattering from beam core in the full ring

Using emittance (17.2e-7 m, 17.2e-9 m) and 5 mm Ta for D03V4

x400 larger than default

- Large loss at D02H1 vs a few particle loss at D03V4

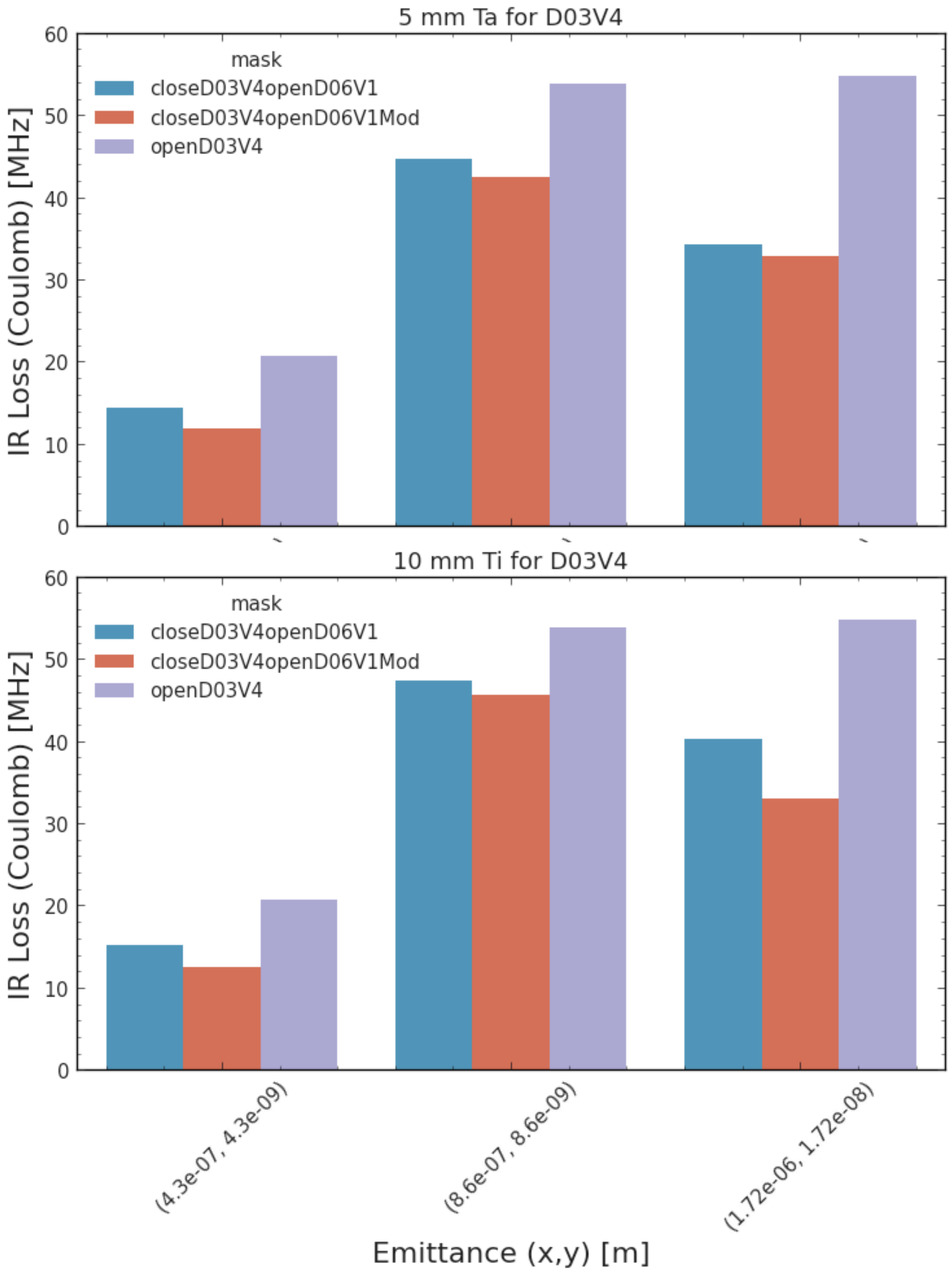




Compare IR loss

Loss from beam halo

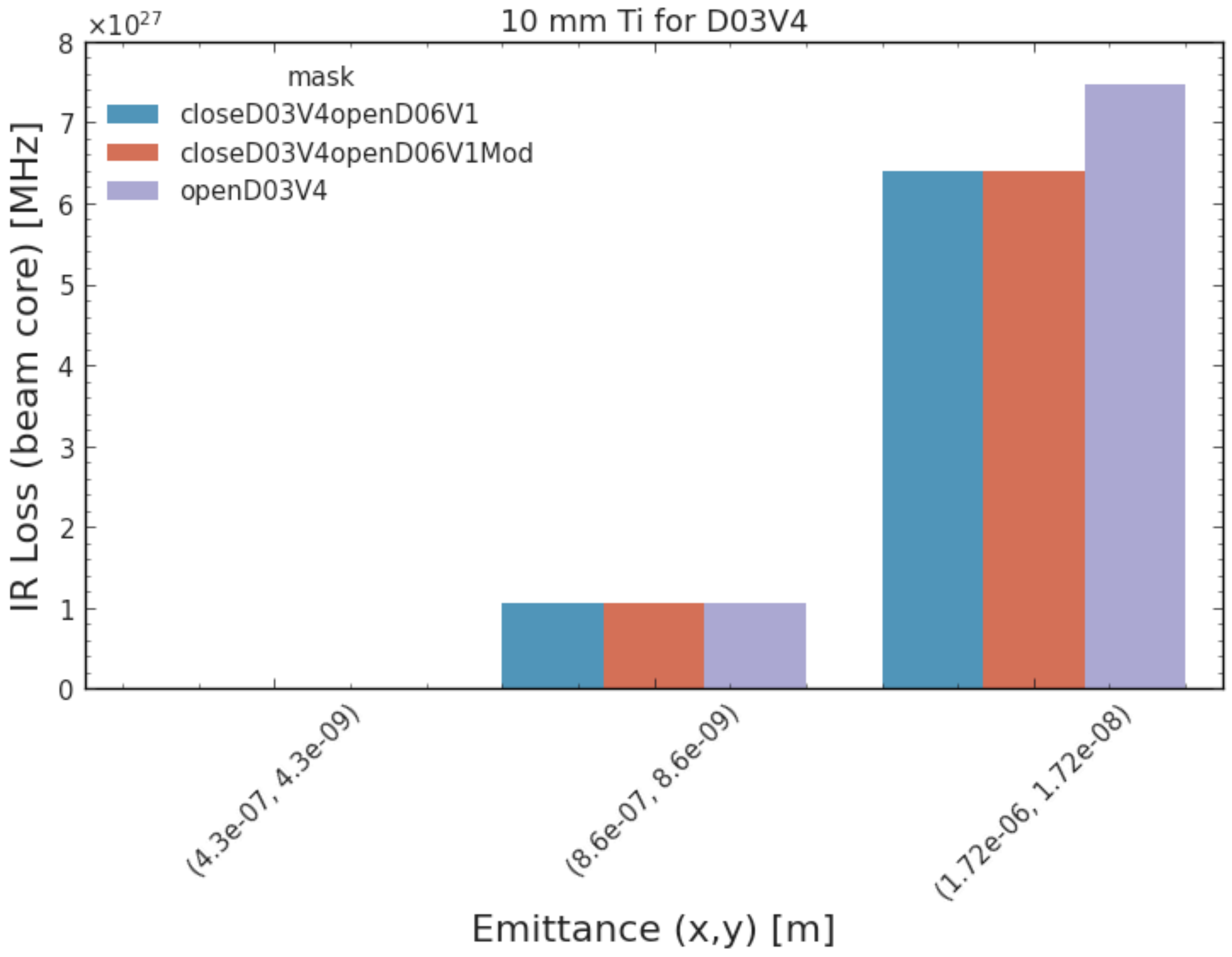
- No loss from Touschek and Bremsstrahlung
  - “openD03V4” is the worst case
  - “closeD03V4openD06V1”
    - D03V4 aperture = 1.7 mm
  - “closeD03V4openD06V1Mod”
    - D03V4 aperture = 1.6 mm
    - The best among the three

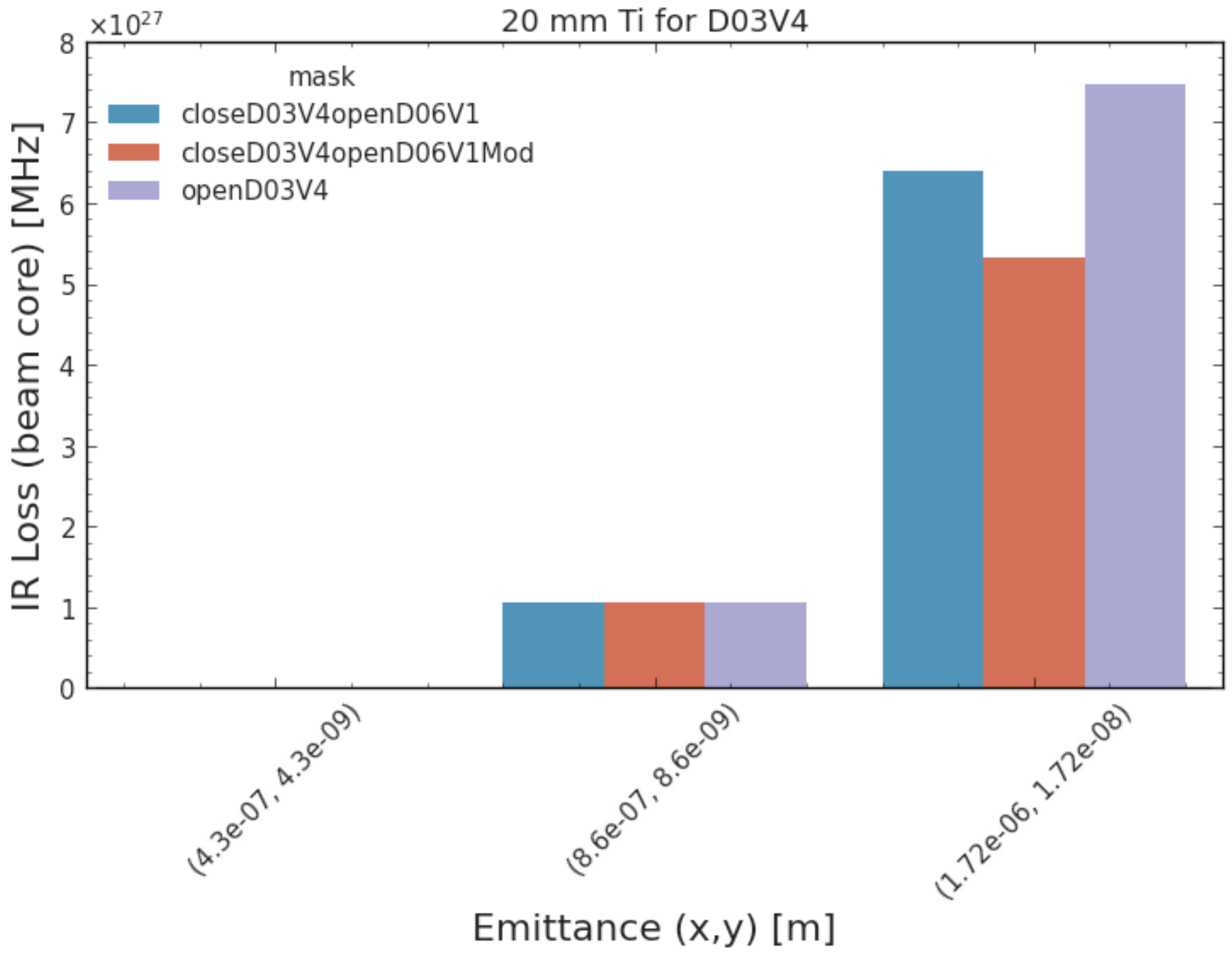


Compare IR loss

Loss from beam core

- Small effect from D03V4 since D02H1 is the main spoiler

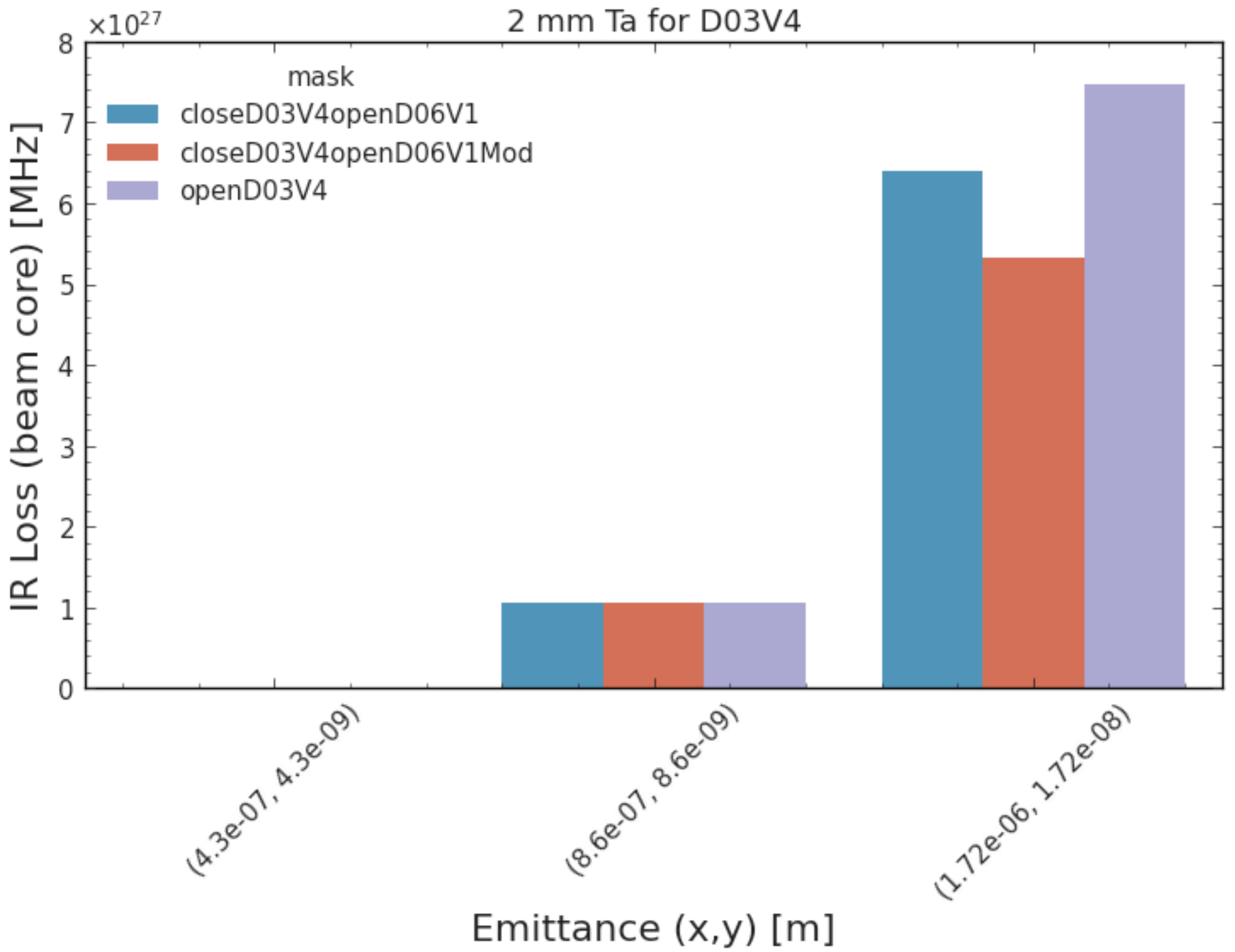


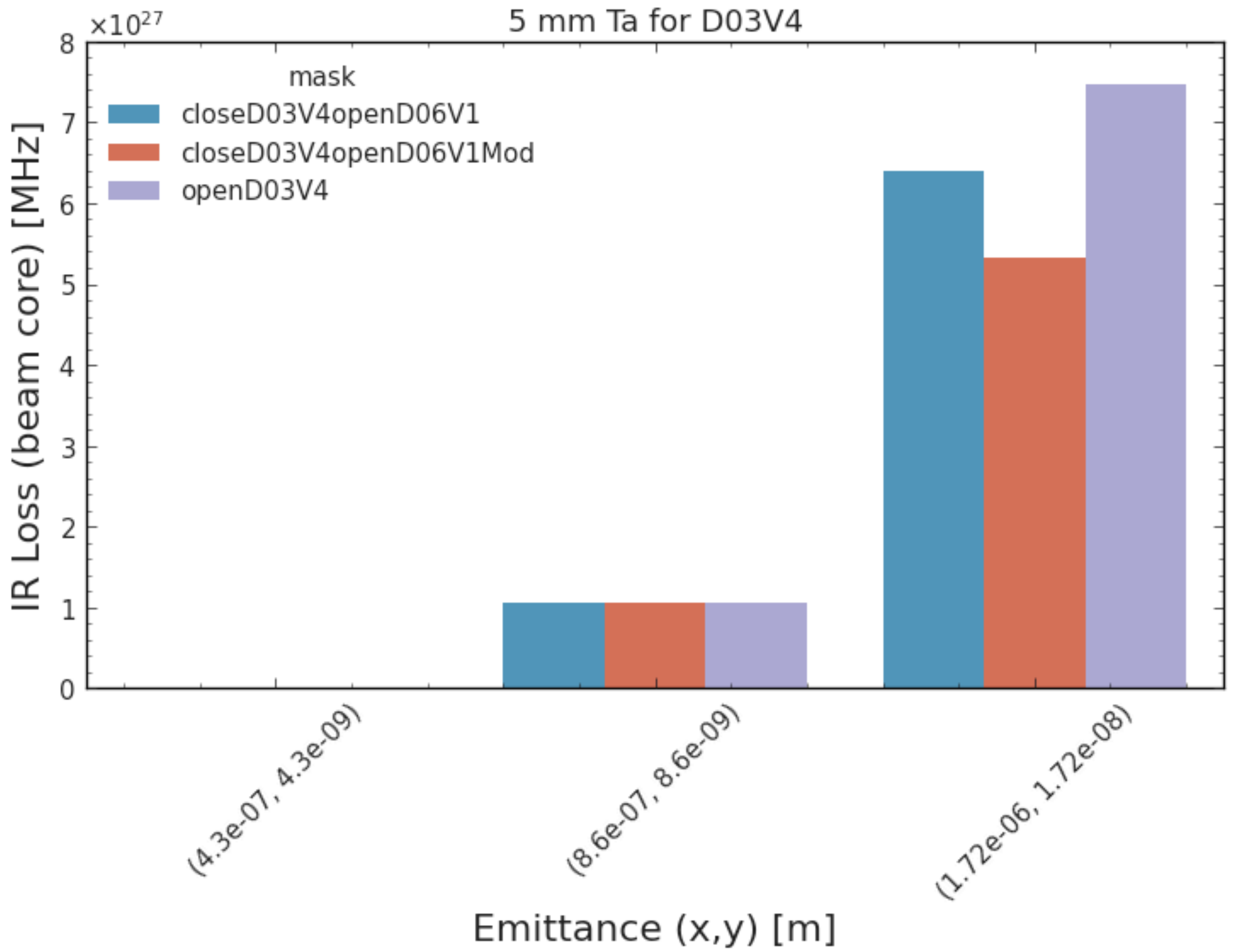


Compare IR loss

Loss from beam core

- Results (using the same seed) are identical for 20 mm Ti, 2 mm Ta and 5 mm Ta

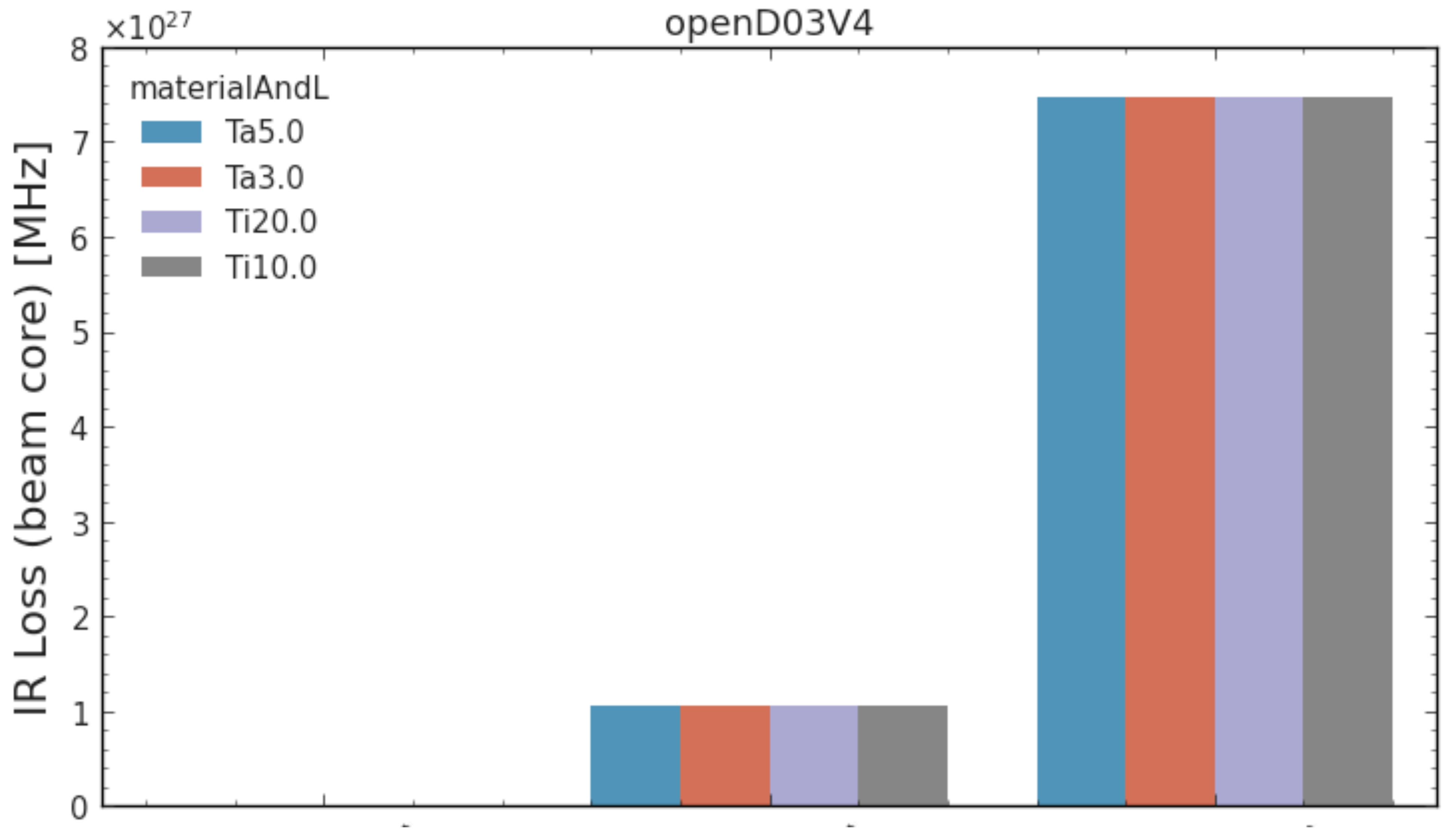


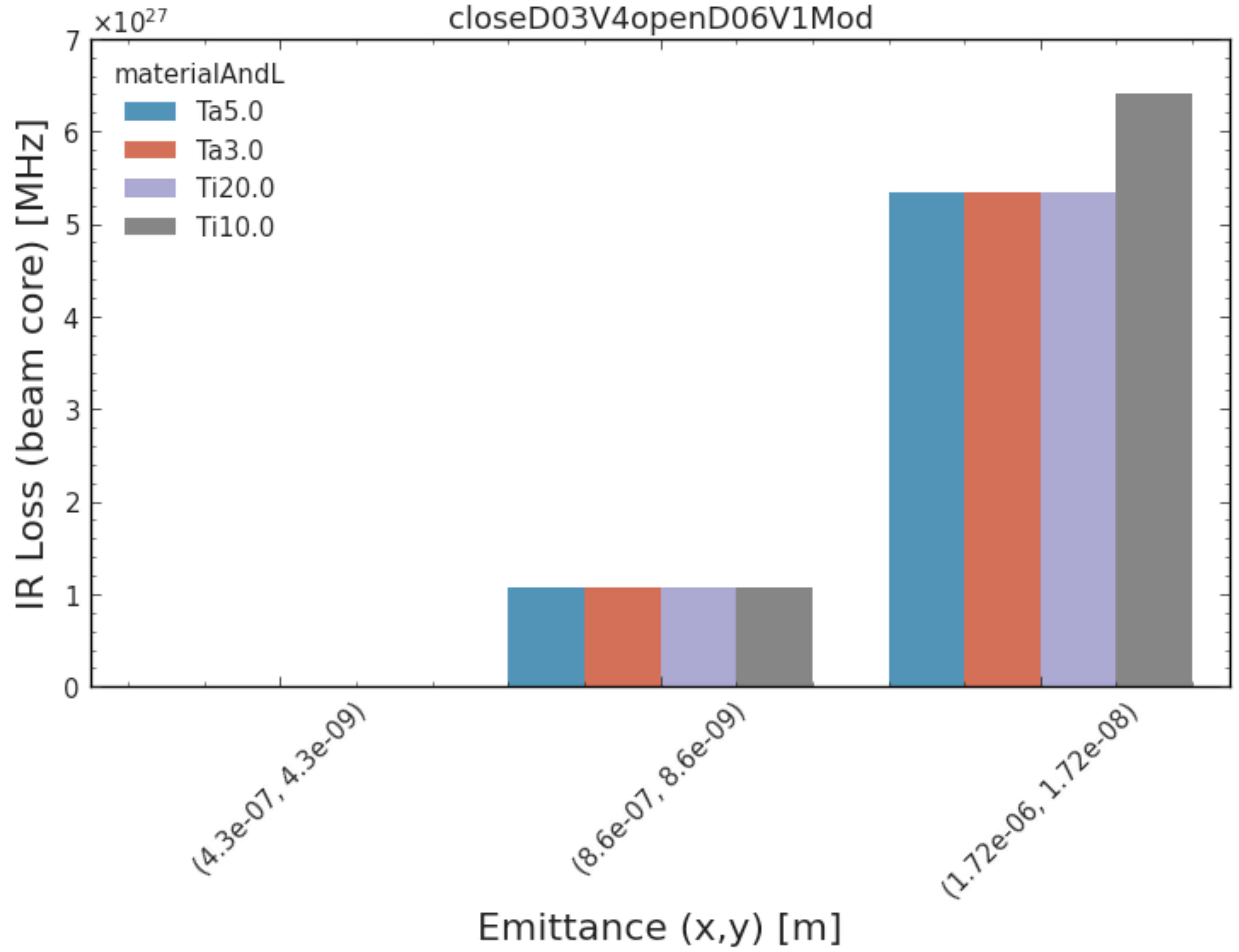


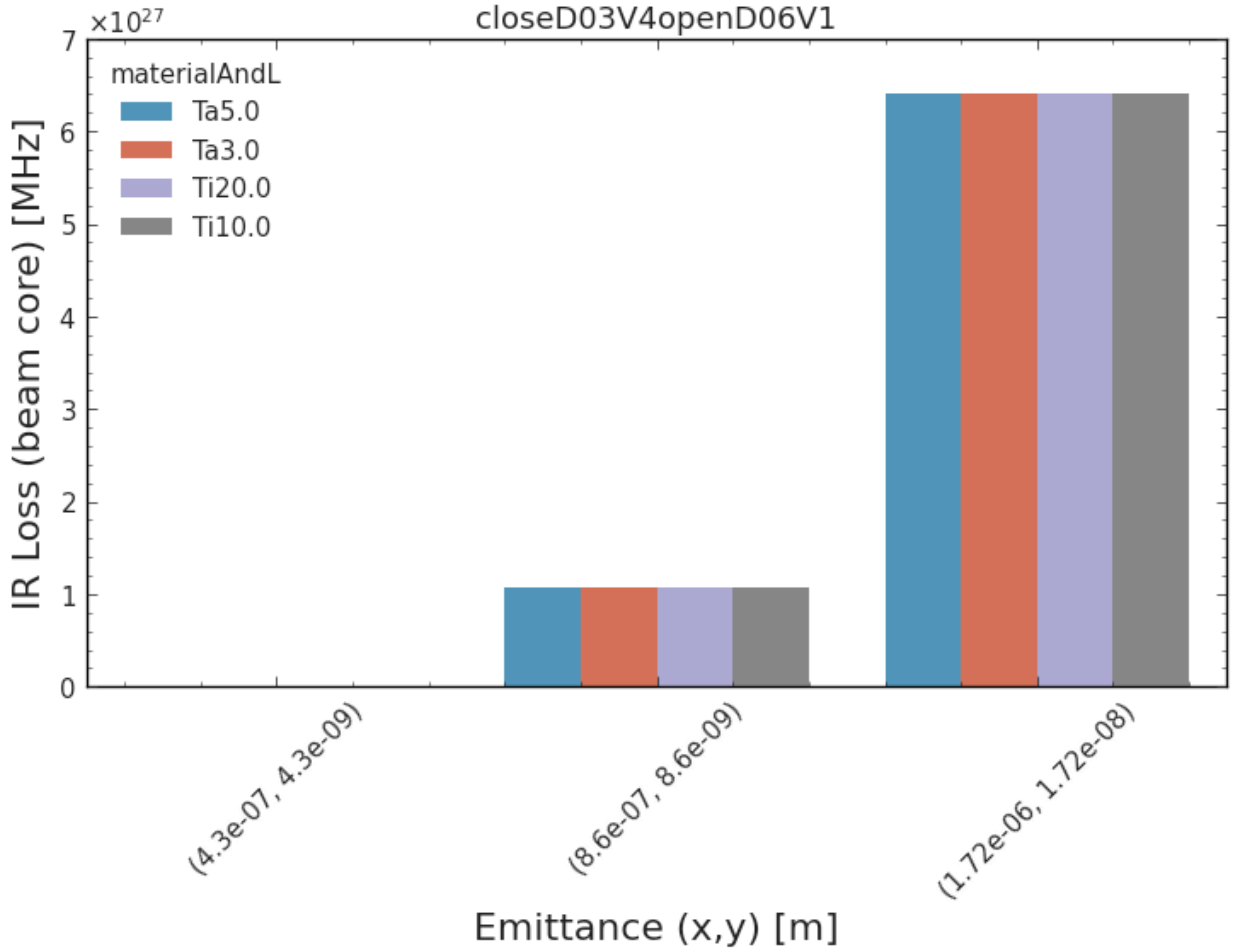
Compare IR loss

Loss from beam core

- Check different material and head length







Conclusion II

Study SBL mitigation with D03V4

- SBL leads to huge radiation at the IR
  - Simulated IR loss rates from beam halo with enlarged emittance (x 100-400) are up to 5 x the nominal IR loss
    - This doesn’t explain the observed high radiation during SBL
    - Therefore we have to estimate the loss rates from beam core
- Loss from beam core
  - Mainly originated at the element LZVQEAP.17 upstream of D03V4
  - Comparing to D02H1 and D03H1, D03V4 doesn’t help so much as a spoiler

Backup 2

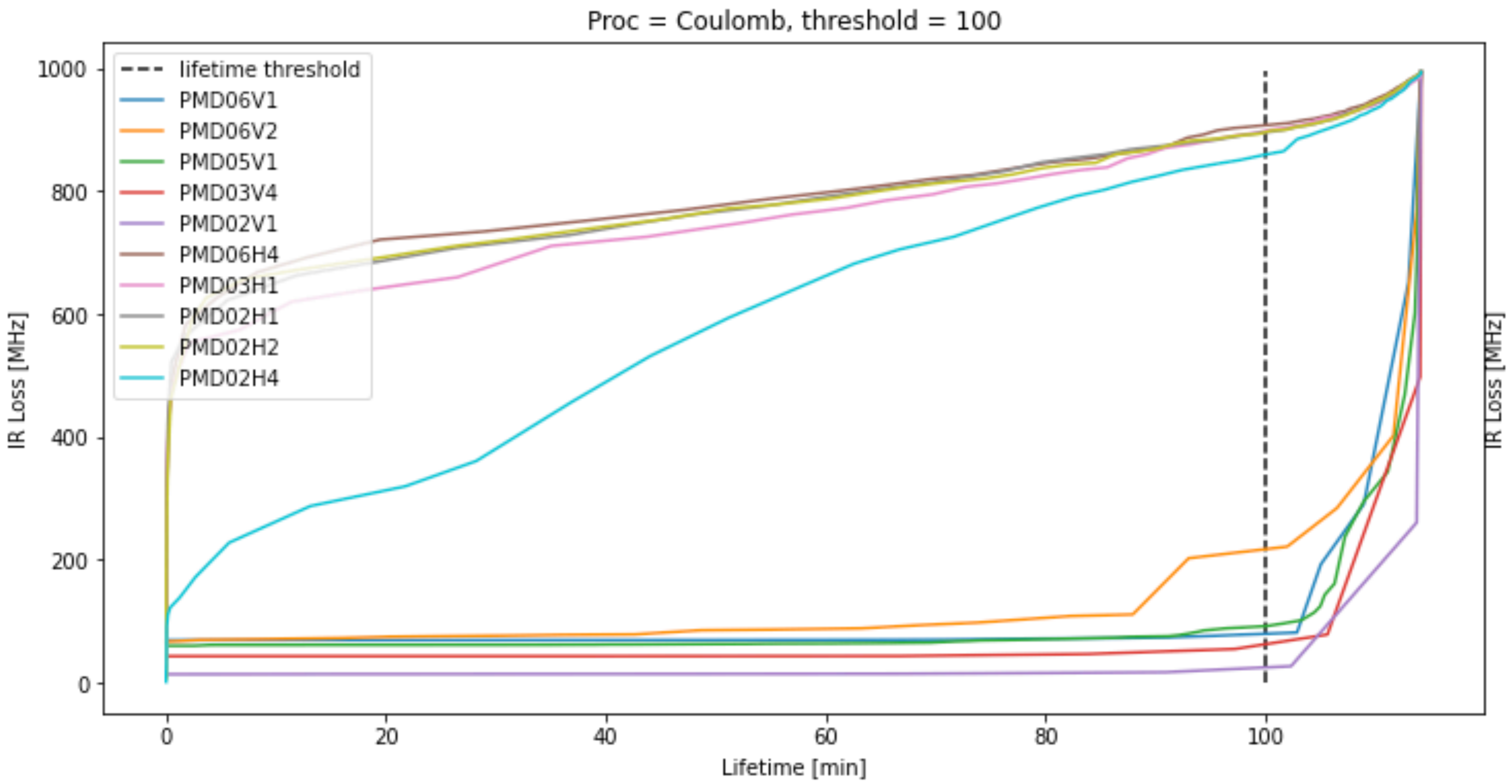
Previous study to compare D03V4 and D06V1

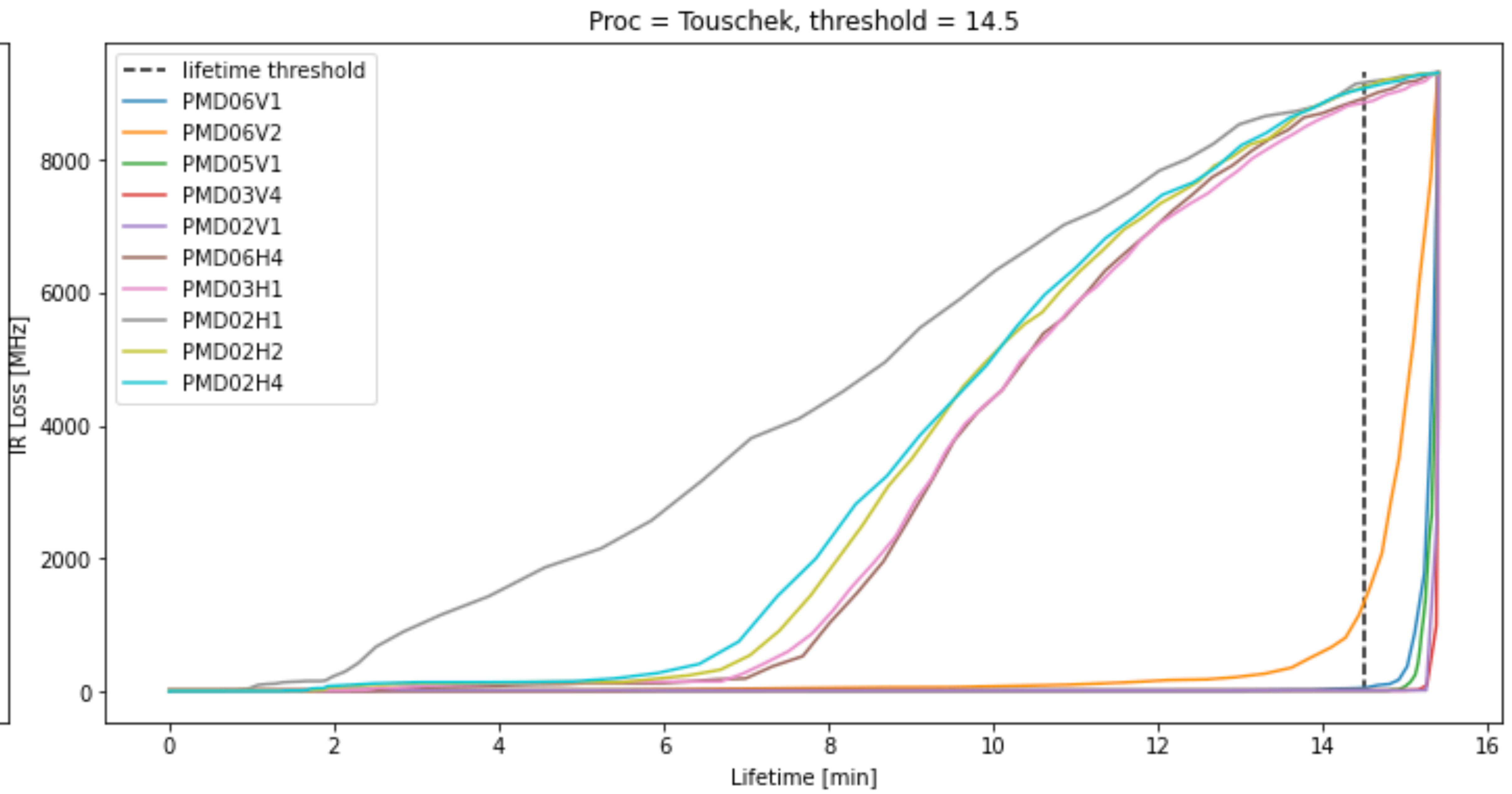
- The problem: High particle loss at D02V1 leads to high background (secondary particles) in IR
  - Have studied the possibility to move D02V1 to a new location D02V0 (further upstream) -> increase Coulomb background significantly: slides
  - **New idea to explore**: try to move D06V1 to D3 section -> D03V4 in the lattice
- Optics file: sler_1801_2024-07-01_08_55_59.842_SNAP_K1.sad
  - β_y^* = **0.9** mm and β_x at NLC is still the old value before summer shutdown
    - Higher background than β_y^* = 1 mm
    - NLC is not effective to reduce injection background
- Simulation config: LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

Collimator optimization with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Collimator setting optimized with lifetime limit 100/14.5 min for Coulomb/Touschek



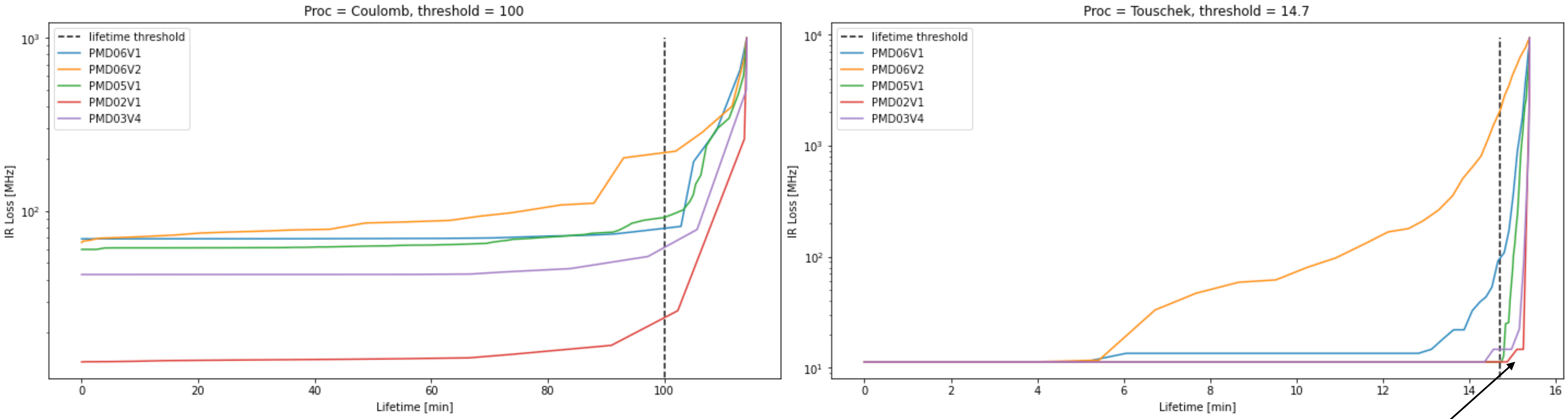


Loss-lifetime plots of all collimators

Collimator optimization with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Collimator setting optimized with lifetime limit 100/14.5 min for Coulomb/Touschek



Loss-lifetime plots of vertical collimators only

D03V4 is slightly worse than D02V1 for Touschek

Collimator apertures are optimized with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Optimized settings with **D03V4** open

Fixed →

NAME	D1[mm]	D2[mm]	D1[nSigma]	D2[nSigma]	dNu[1/2pi]	
IR	-10.5	10.5	-34.53	34.53	0.8734	
PMD06H3	-10.50	10.50	-32.50	32.50	0.8165	
PMD06H4	-8.60	8.60	-26.62	26.62	0.2983	
PMD03H1	-10.80	10.80	-30.58	30.58	0.0293	
PMD02H1	-5.80	5.80	-19.35	19.35	0.8478	
PMD02H2	-8.80	8.80	-22.25	22.25	0.3274	
PMD02H3	-14.30	14.30	-30.59	30.59	0.0610	
PMD02H4	-6.50	6.50	-21.91	21.91	0.8180	
IR	-13.5	13.5	**-69.78**	**69.78**	**0.2603**	73.56 in 1mm optics
PMD06V1	-3.20	3.20	**-59.43**	**59.43**	0.2775	
PMD06V2	-2.10	2.10	-70.57	70.57	0.9178	
PMD05V1	-5.90	5.90	-446.65	446.65	0.5536	54.33 sigma at SNAP.1
PMD03V4	-20.00	20.00	-740.12	740.12	0.2676	
PMD02V1	-1.40	1.40	-58.70	58.70	0.2572	

Open a collimator means setting its aperture to 20 mm

Collimator apertures are optimized with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Optimized settings with **D06V1** open

Fixed →

NAME	D1[mm]	D2[mm]	D1[nSigma]	D2[nSigma]	dNu[1/2pi]	
IR	-10.5	10.5	-34.53	34.53	0.8734	
PMD06H3	-10.50	10.50	-32.50	32.50	0.8165	
PMD06H4	-8.60	8.60	-26.62	26.62	0.2983	
PMD03H1	-10.80	10.80	-30.58	30.58	0.0293	
PMD02H1	-5.80	5.80	-19.35	19.35	0.8478	
PMD02H2	-8.80	8.80	-22.25	22.25	0.3274	
PMD02H3	-14.30	14.30	-30.59	30.59	0.0610	
PMD02H4	-6.50	6.50	-21.91	21.91	0.8180	
IR	-13.5	13.5	**-69.78**	**69.78**	**0.2603**	73.56 in 1mm optics
PMD06V1	-20.00	20.00	-371.42	371.42	0.2775	
PMD06V2	-2.10	2.10	-70.57	70.57	0.9178	
PMD05V1	-5.90	5.90	-446.65	446.65	0.5536	54.33 sigma at SNAP.1
PMD03V4	-1.70	1.70	**-62.91**	**62.91**	0.2676	
PMD02V1	-1.40	1.40	-58.70	58.70	0.2572	

Closed D03V4 (63σ) is wider than closed D06V1 (60σ) for the same optimization procedure!

Collimator apertures are optimized with the nominal beam condition

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Optimized settings with **D06V1** open and close D03V4 a bit more

NAME	D1[mm]	D2[mm]	D1[nSigma]	D2[nSigma]	dNu[1/2pi]
IR	-10.5	10.5	-34.53	34.53	0.8734
PMD06H3	-10.50	10.50	-32.50	32.50	0.8165
PMD06H4	-8.60	8.60	-26.62	26.62	0.2983
PMD03H1	-10.80	10.80	-30.58	30.58	0.0293
PMD02H1	-5.80	5.80	-19.35	19.35	0.8478
PMD02H2	-8.80	8.80	-22.25	22.25	0.3274
PMD02H3	-14.30	14.30	-30.59	30.59	0.0610
PMD02H4	-6.50	6.50	-21.91	21.91	0.8180
IR	-13.5	13.5	**-69.78**	**69.78**	**0.2603**
PMD06V1	-20.00	20.00	-371.42	371.42	0.2775
PMD06V2	-2.10	2.10	-70.57	70.57	0.9178
PMD05V1	-5.90	5.90	-446.65	446.65	0.5536
PMD03V4	-1.60	1.60	**-59.21**	**59.21**	0.2676
PMD02V1	-1.40	1.40	-58.70	58.70	0.2572

In this modified setting, we set D03V4 aperture to around 60 σ as the closed D06V1

Estimated loss rates and lifetime

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Loss rate at IR and beam lifetime

Process	close D06V1 open D03V4	close D03V4 open D06V1	close D03V4 further open D06V1
Coulomb IR loss [MHz]	12.0187 +/- 0.432954	10.1228 +/- 0.22947	**9.13645** +/- 0.207077
Coulomb lifetime [min]	48.4063 +/- 1.6296	46.4772 +/- 1.58268	45.9947 +/- 1.58498
Breams. IR loss [MHz]	5.97947 +/- 0.0648969	6.02995 +/- 0.0736908	**5.9199** +/- 0.0682673
Breams. Lifetime [min]	1988.05 +/- 9.51382	1983.23 +/- 9.81471	2002.02 +/- 8.58048
Touschek IR loss [MHz]	**1.72895** +/- 0.0640224	6.53484 +/- 1.70379	10.2728 +/- 2.16611
Touschek lifetime [min]	13.3561 +/- 0.21005	13.4573 +/- 0.209744	13.7464 +/- 0.214604

Similar loss to the optimization for the 1mm optics

Estimated loss rates and lifetime

LER: n_b=1576, I = 1.2A, ϵ_x = 4.3 nm ϵ_y = 43 pm

- Loss rate at D02V1

Process	close D06V1 open D03V4	close D03V4 open D06V1	close D03V4 further open D06V1
Coulomb loss [MHz]	489.945 +/- 44.6693	295.102 +/- 12.9661	382.669 +/- 28.6157
Breams. loss [MHz]	2.62282 +/- 0.183171	2.06858 +/- 0.231854	1.56108 +/- 0.10251
Touschek loss [MHz]	1538.91 +/- 125.032	404.622 +/- 39.1139	401.8 +/- 39.0957

- D03V4 can suppress particle loss at D02V1

Try to keep higher beam lifetime

Collimators are wider than the optimal settings shown above

- Loss rate at IR and beam lifetime

Process	close D06V1 open D03V4	close D03V4 open D06V1	close D03V4 further open D06V1
Coulomb IR loss [MHz]	53.7492 +/- 4.20636	77.3037 +/- 7.89639	
Coulomb lifetime [min]	50.7459 +/- 1.52973	50.6998 +/- 1.65693	
Breams. IR loss [MHz]	7.42329 +/- 0.230561	6.15258 +/- 0.0933569	
Breams. Lifetime [min]	1998.97 +/- 8.78559	2003.67 +/- 9.16813	
Touschek IR loss [MHz]	**1133.79 +/- 94.7846**	**78.1707 +/- 12.115**	
Touschek lifetime [min]	14.4581 +/- 0.244941	14.6128 +/- 0.221147	

- Background rates are probably too high with higher beam lifetime

D03V4 works better than D06V1 in this case

Summary

- D03V4 could reduce particle loss at D02V1 significantly with relative large apertures (62.9σ)
- However it seems D06V1 can reduce IR loss rate further with a smaller apertures (59.4σ)
  - D03V4 (10 mm Ti) at this aperture doesn't help so much
- Scripts for SBL study are ready
  - Preliminary results showed that D03V4 could stop some beam particles, but it seems the IR loss rate is still very high for large emittance