Low-impedance collimators for HL-LHC

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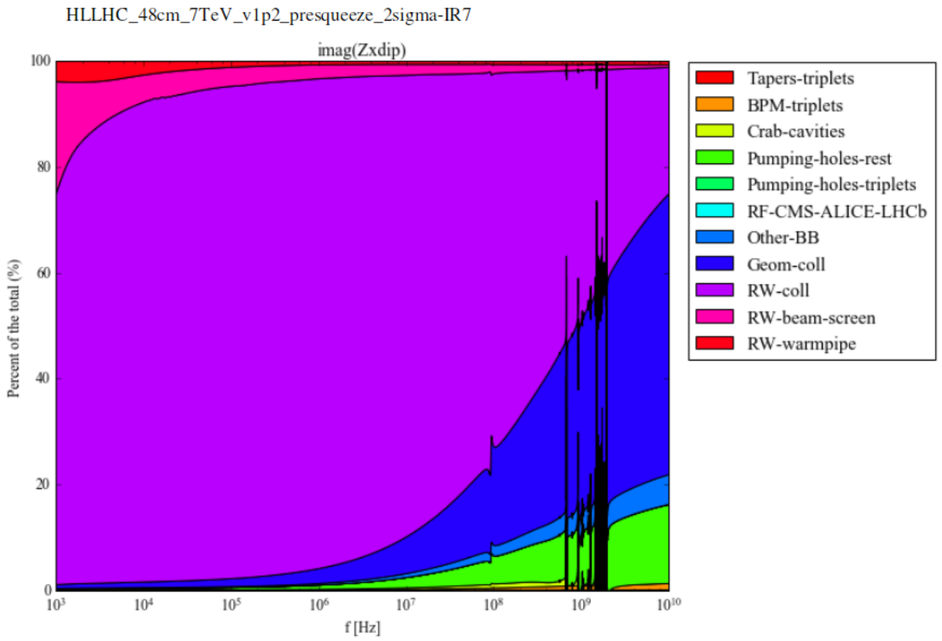
MANY THANKS TO ALESSIO, BENOIT, DAVID, STEFANO, RODERIK

Motivation

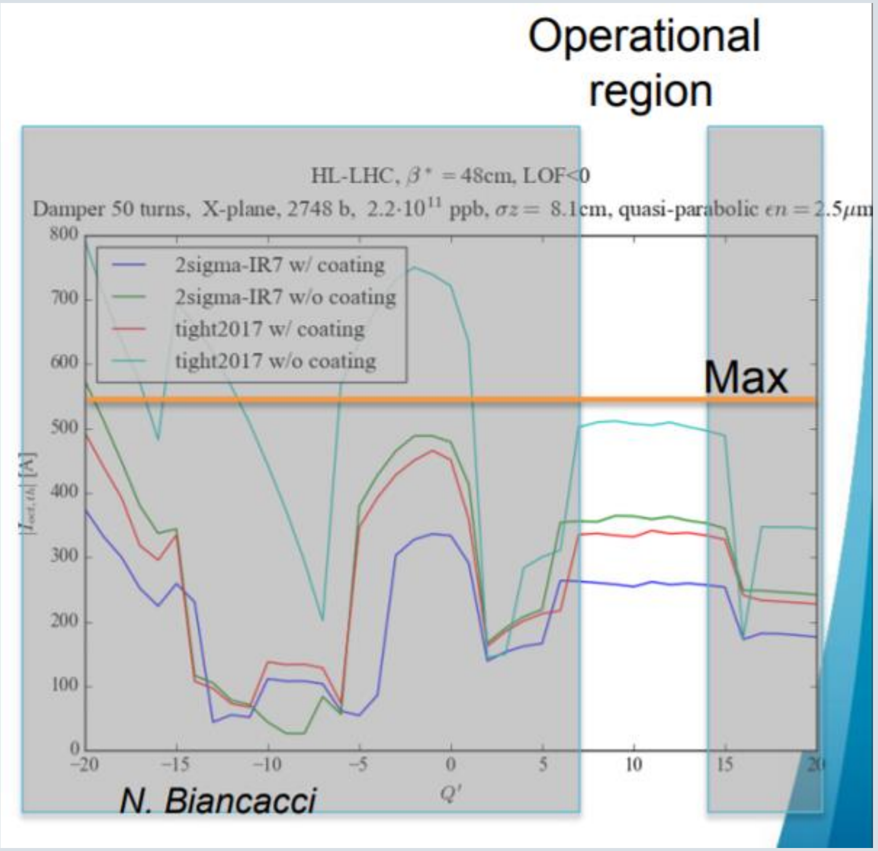
- The HL-LHC transverse impedance is largely dominated by the collimators contribution.



34

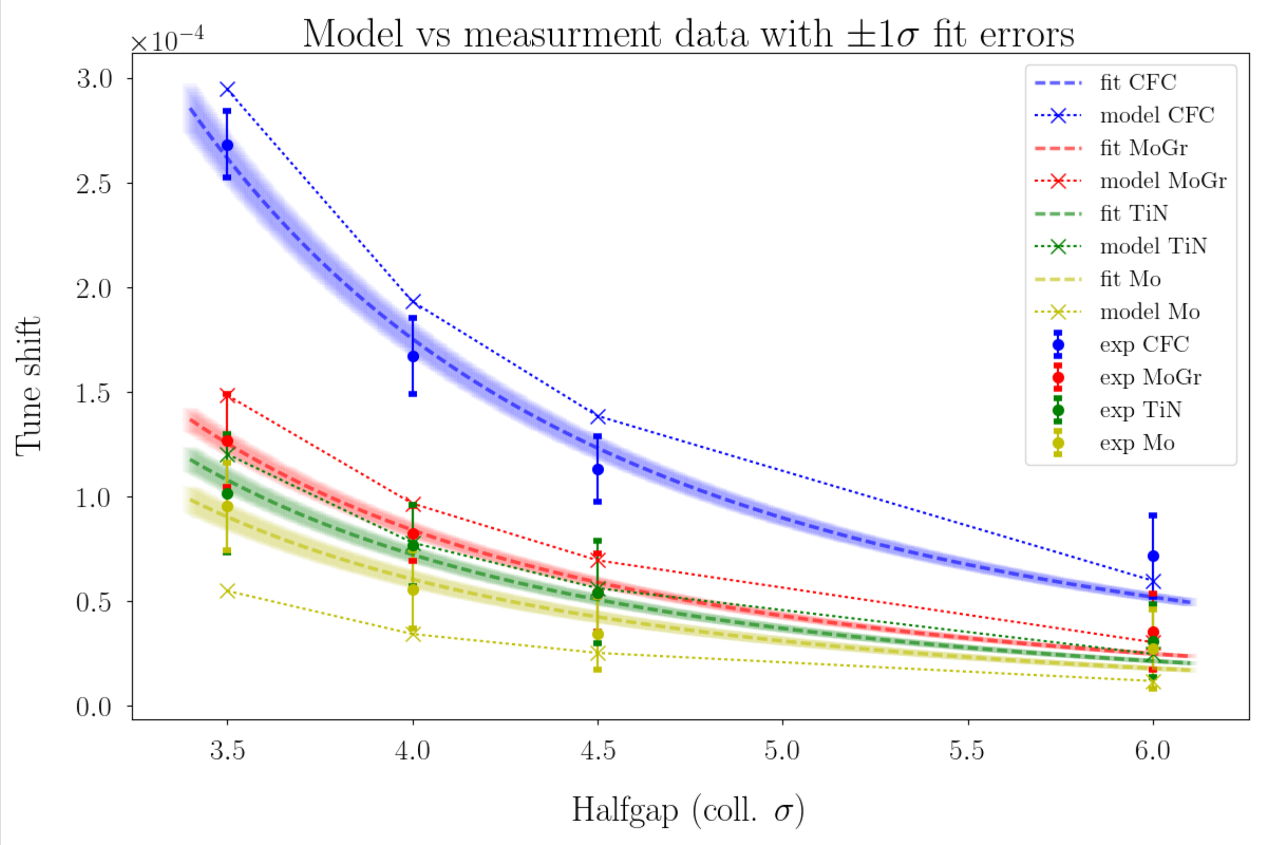
N. Biancacci, *et al.*, Impedance Measurements of Low Impedance Collimator, HL-LHC TCC, 30.03.2017

Reduction of impedance is needed to ensure beam stability at higher intensities



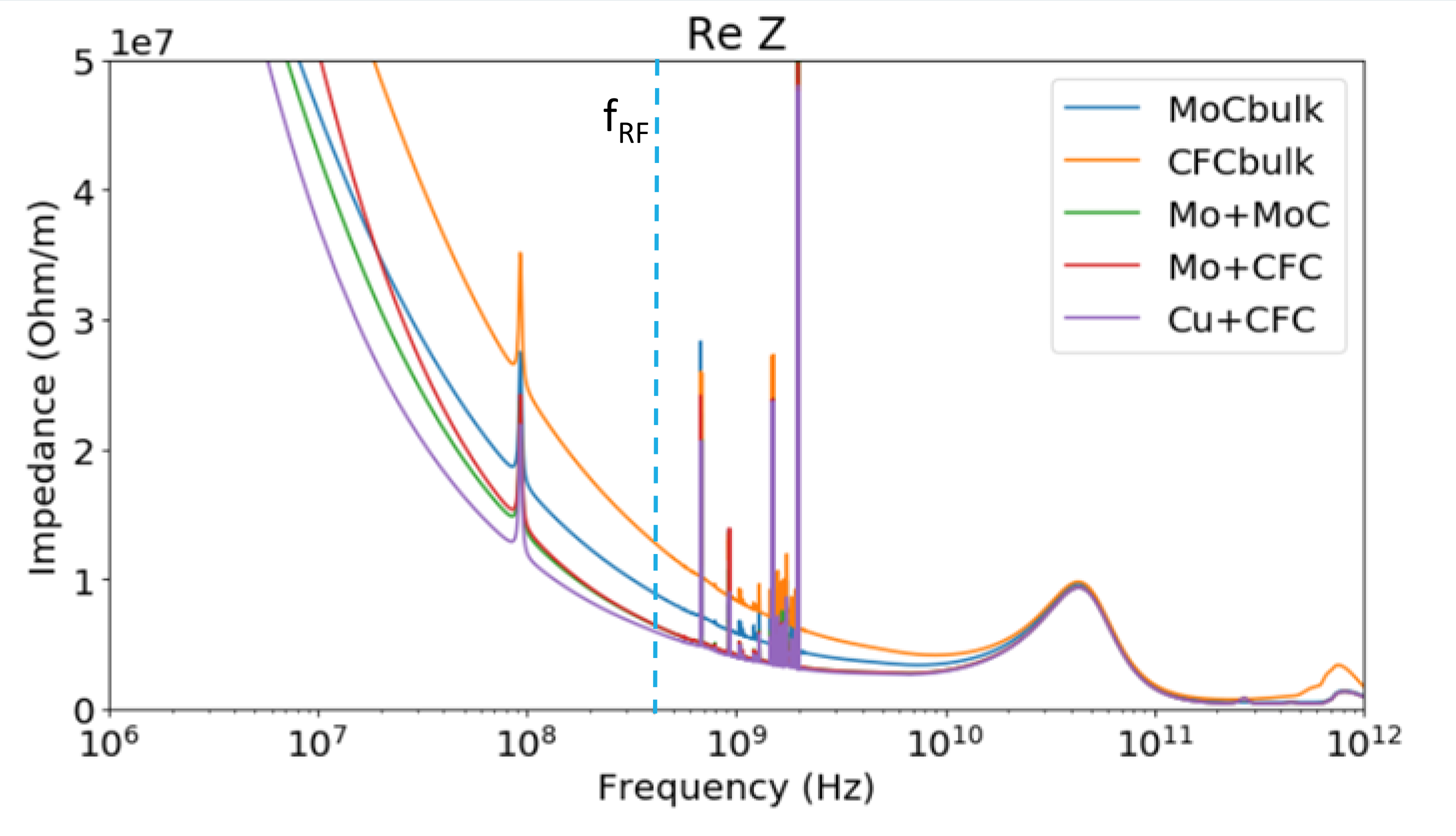
R. Bruce, Is collimation still a limitation for HL-LHC?, Chamonix, Jan. 2017

Mo coating significantly reduces the impedance of a collimator



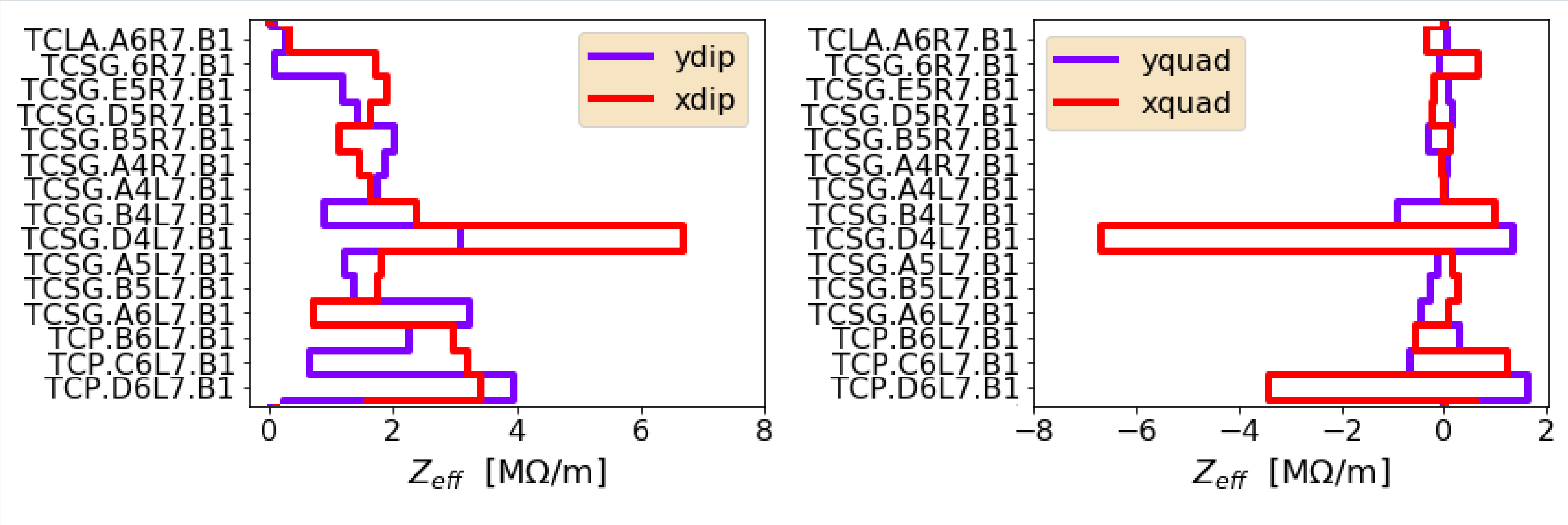
50% decrease of the impedance with Mo coated TCSGs

Using MoGr bulk gives ½ of the improvement



4 TCSGs to be upgraded to Mo + MoGr during LS2

Which ones?



Comparing coating scenarios for IR-7

Goal: Max reduction of impedance, octupole current

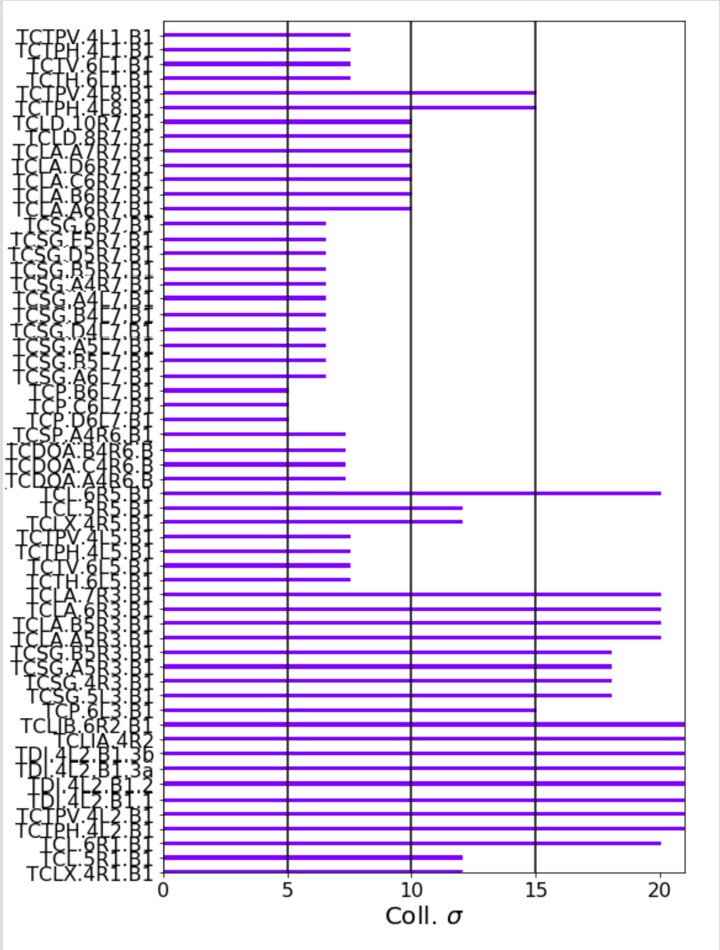
48 cm optics

Tight collimator settings

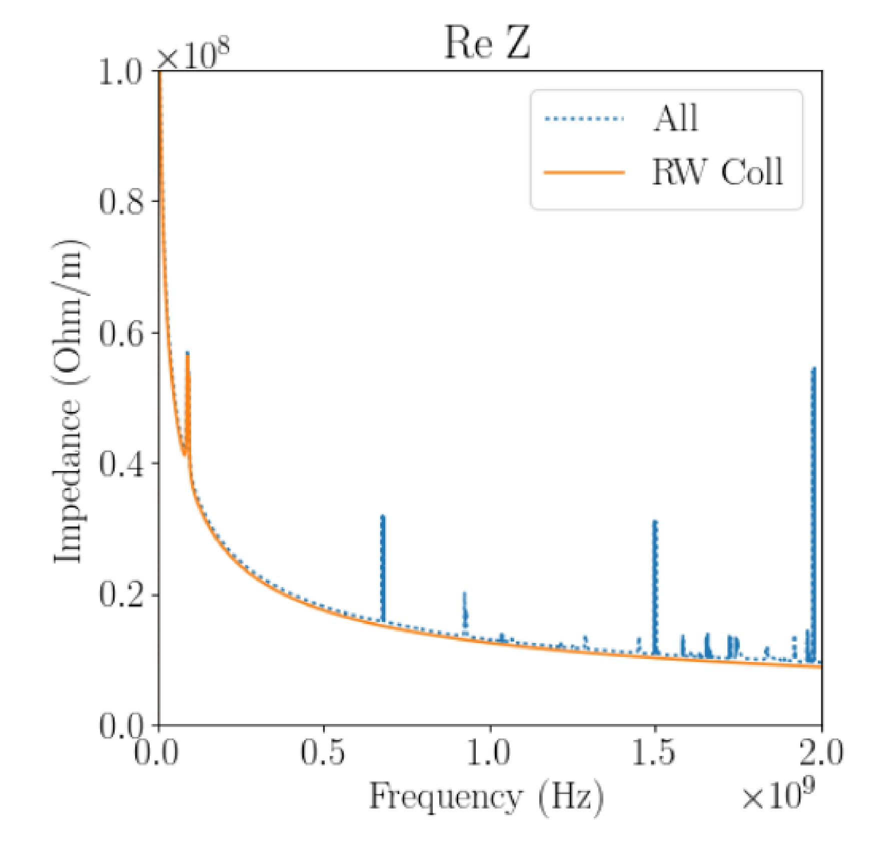
- 1.5 σ retraction of the secondaries

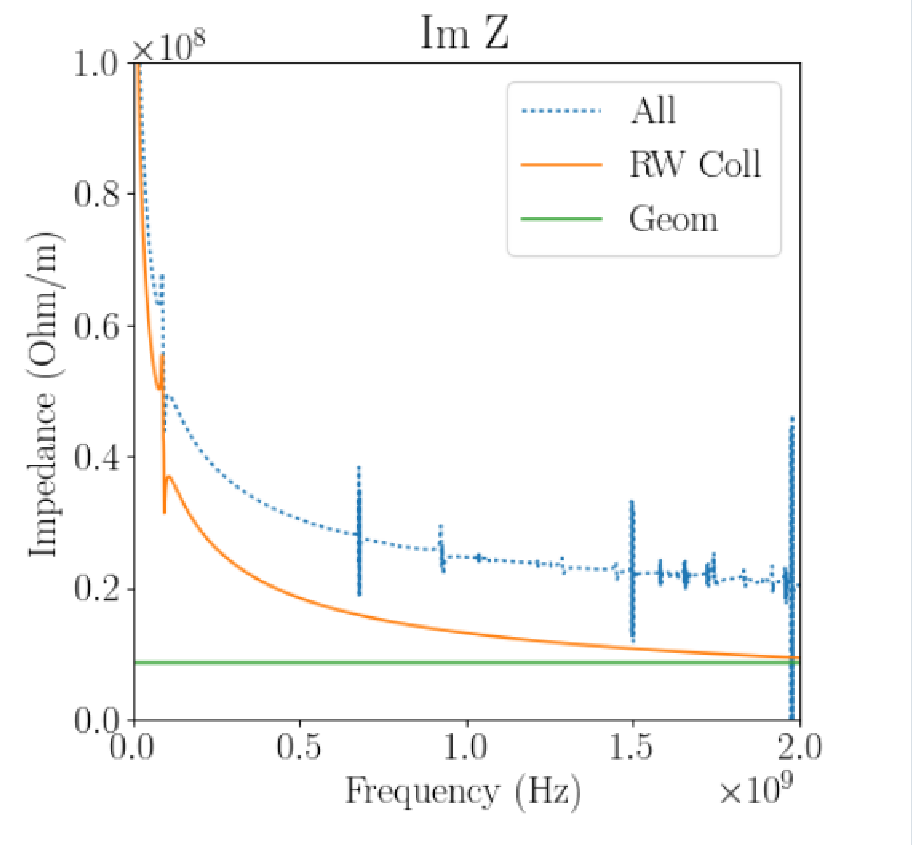
2.5 μm emittance, 8.1 cm bunch length

Negative octupole polarity



We should not forget about the geometric impedance





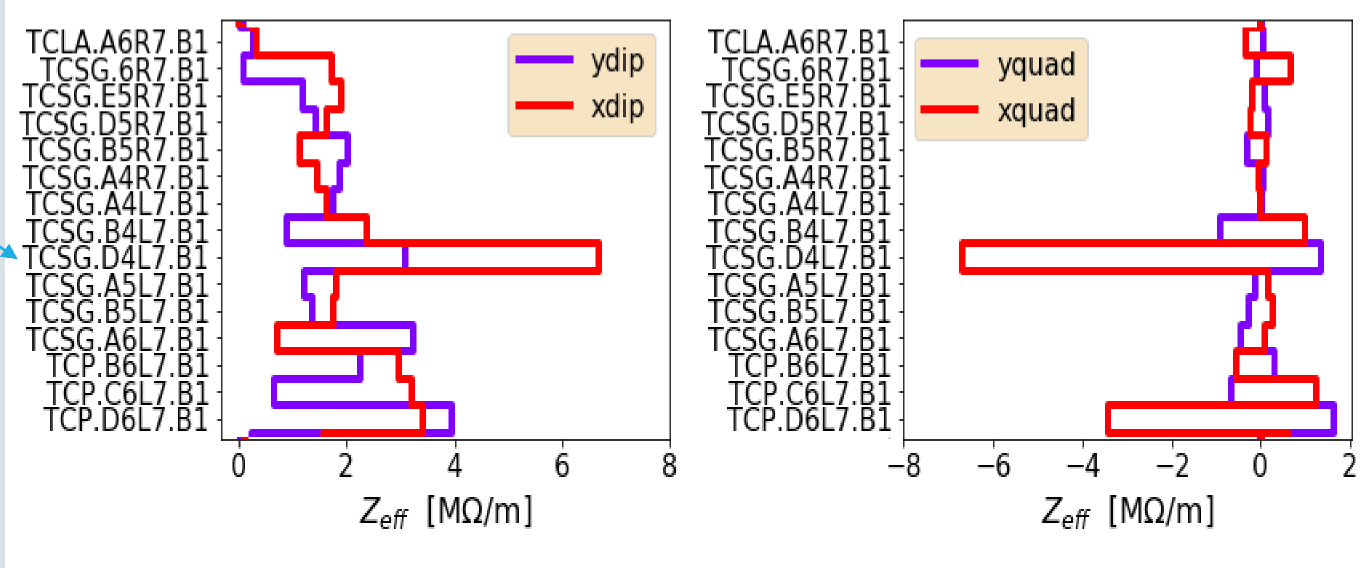
Using Im Z for the impedance comparison

Partial coating scenarios

1. 1 Collimator:
   D4L7
2. 2 Collimators:
   D4L7, A6L7
3. LS2.1:
   D4L7, A6L7, B4L7, B5L7
4. LS2.2:
   D4L7, B4L7, E5R7, 6R8
5. LS2.3:
   A6L7, B5L7, A5L7, A4L7
6. LS2.4:
   D4L7, A6L7, B5L7, A5L7

Dipolar

Quadrupolar



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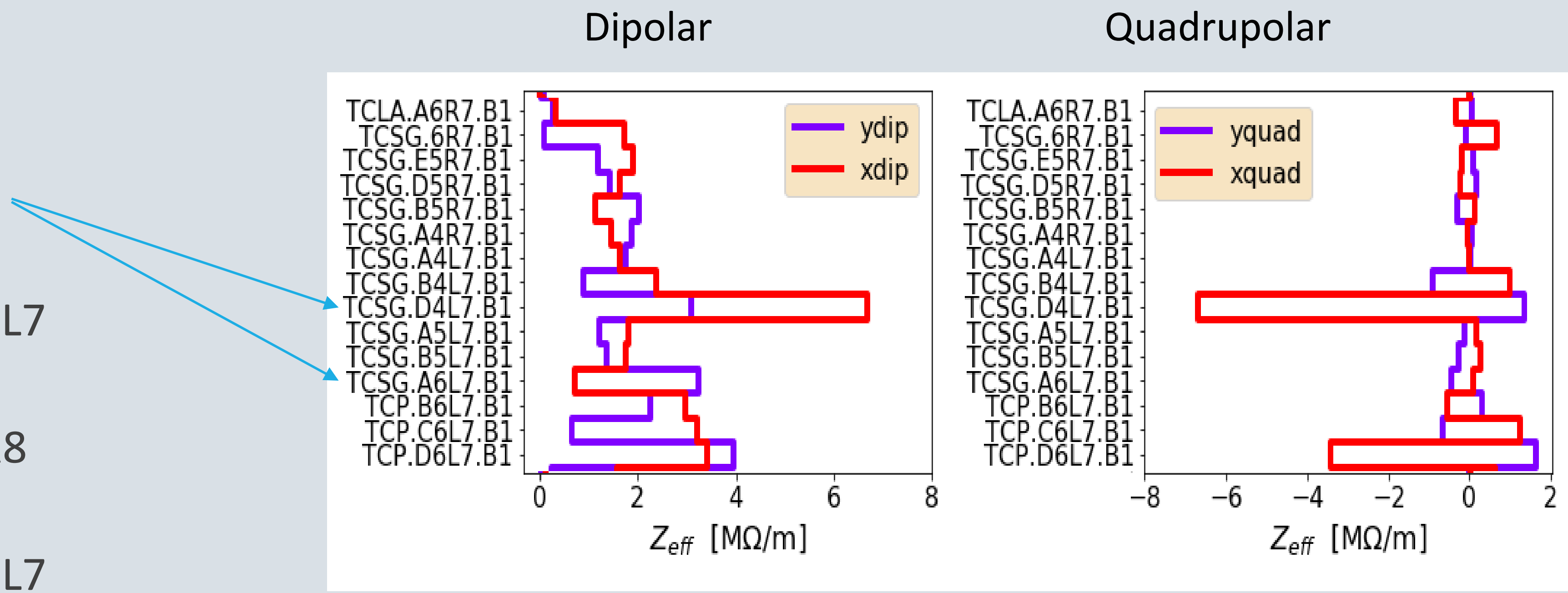
   D4L7, B4L7, E5R7, 6R8
5. LS2.3:
   A6L7, B5L7, A5L7, A4L7
6. LS2.4:
   D4L7, A6L7, B5L7, A5L7



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   A6L7, B5L7, A5L7, A4L7
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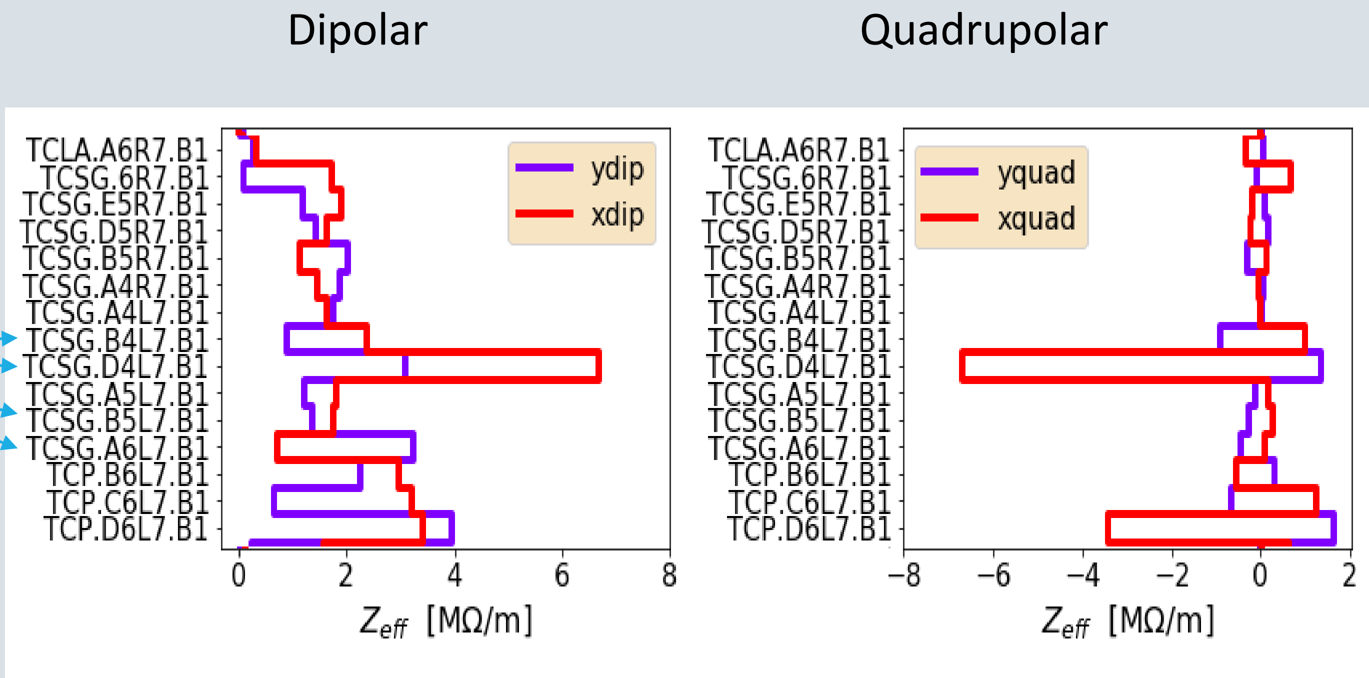
   D4L7, A6L7, B5L7, A5L7



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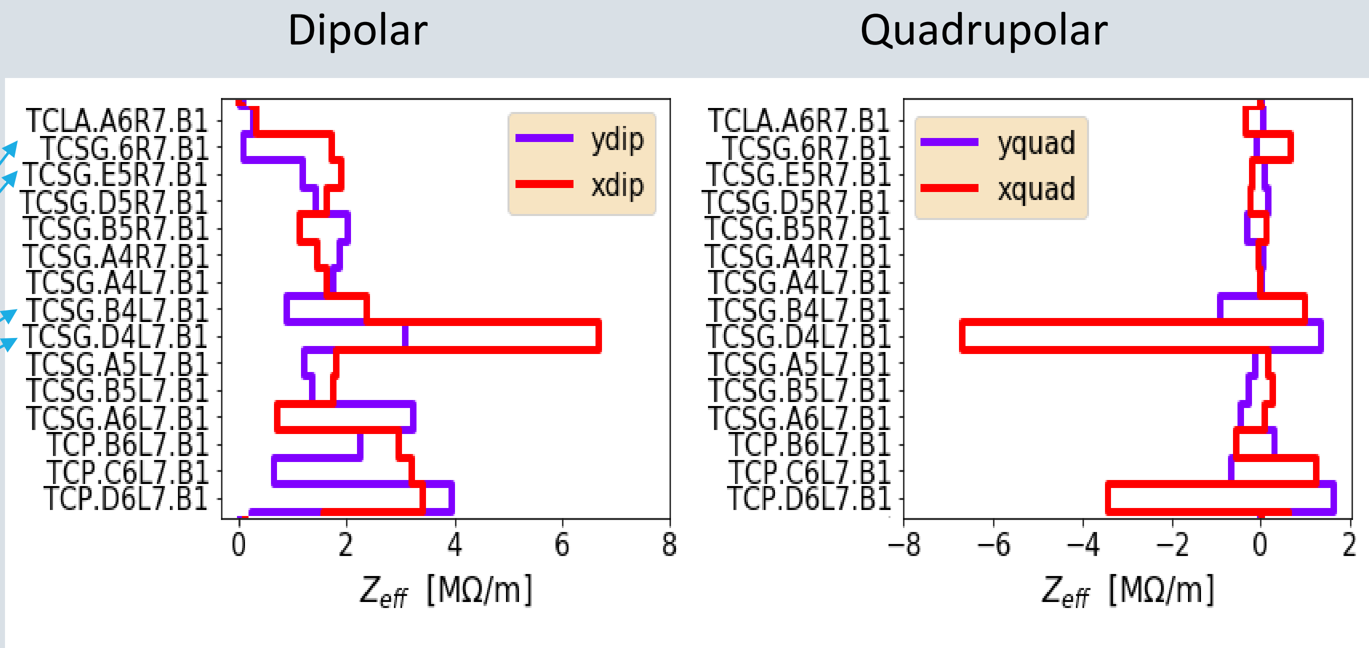

Avoiding the skew collimators most exposed to steady losses

Partial coating scenarios

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   D4L7
2. 2 Collimators:
   D4L7, A6L7
3. LS2.1:
   D4L7, A6L7, B4L7, B5L7
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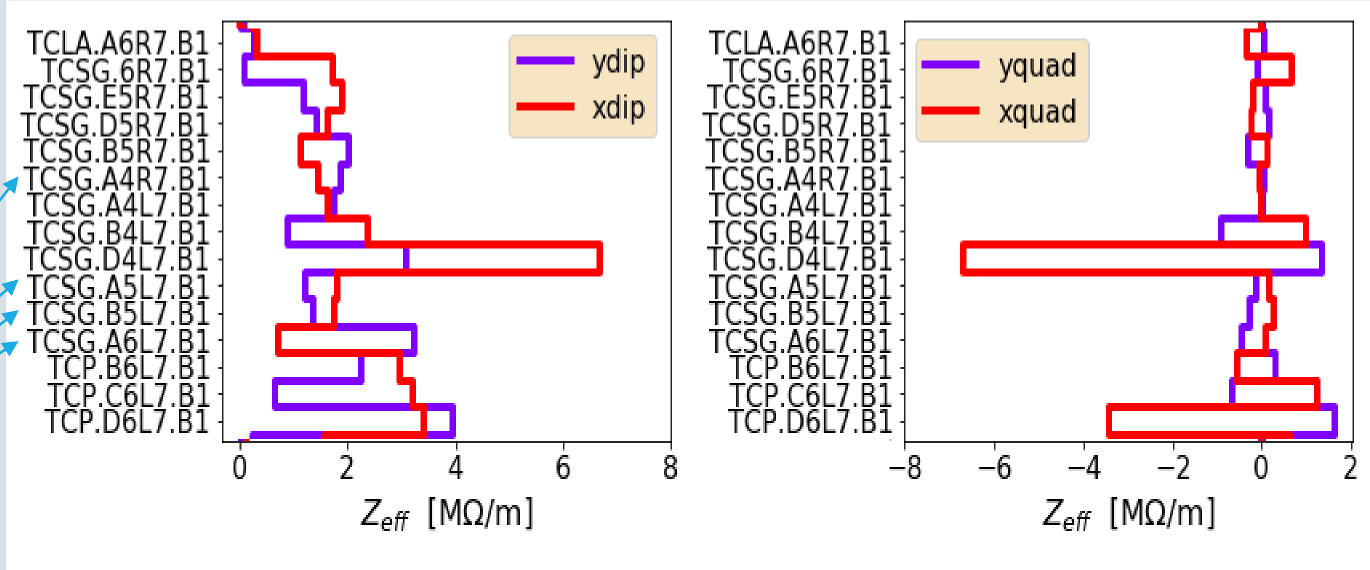
   A6L7, B5L7, A5L7, A4L7
6. LS2.4:
   D4L7, A6L7, B5L7, A5L7

Dipolar Quadrupolar



Avoiding hor. and vert. ones for protection reasons

Partial coating scenarios

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   D4L7
2. 2 Collimators:
   D4L7, A6L7
3. LS2.1:
   D4L7, A6L7, B4L7, B5L7
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   D4L7, B4L7, E5R7, 6R8
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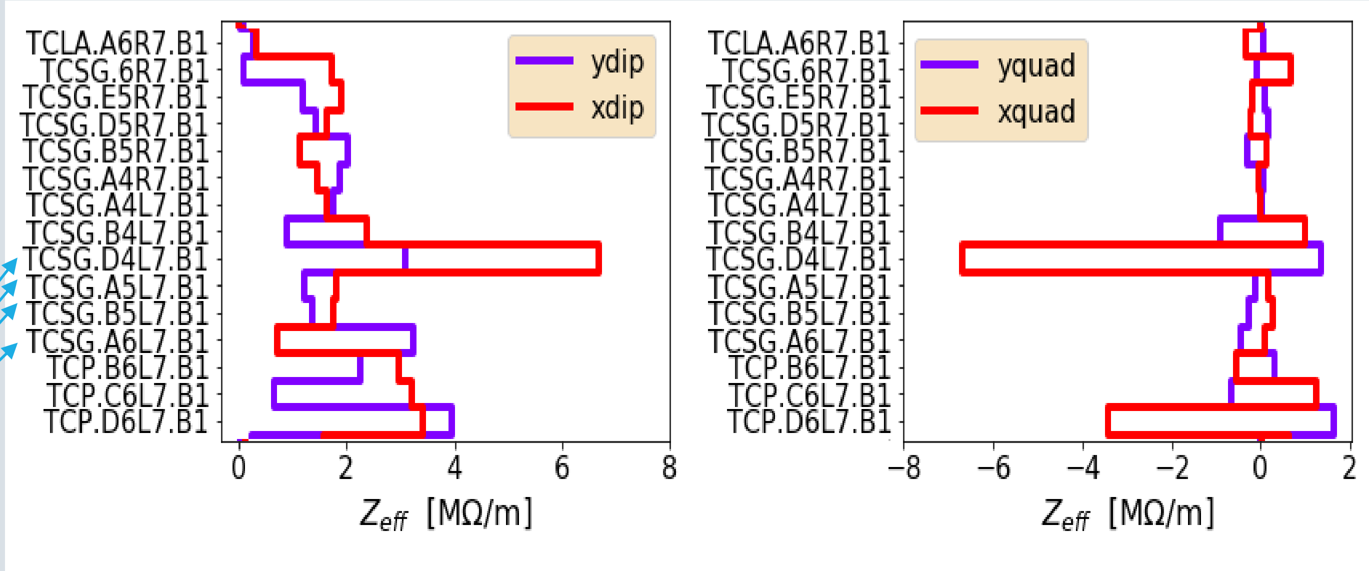
   D4L7, A6L7, B5L7, A5L7

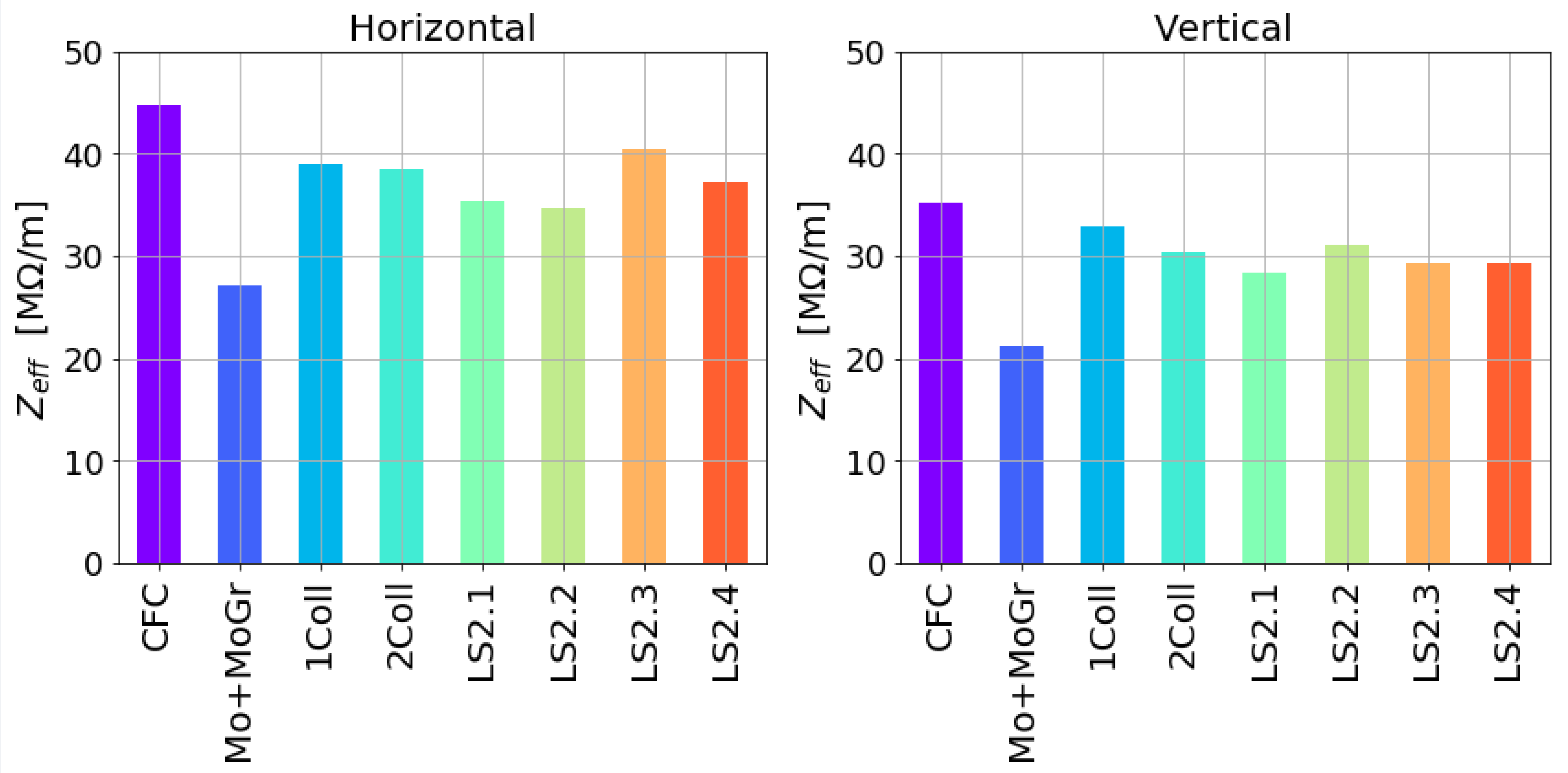
Dipolar

Quadrupolar



Avoiding hor. only for protection at the top energy

Total machine impedance can be decreased by 10-20% using a subset of collimators. Can be done with just 1-2 units



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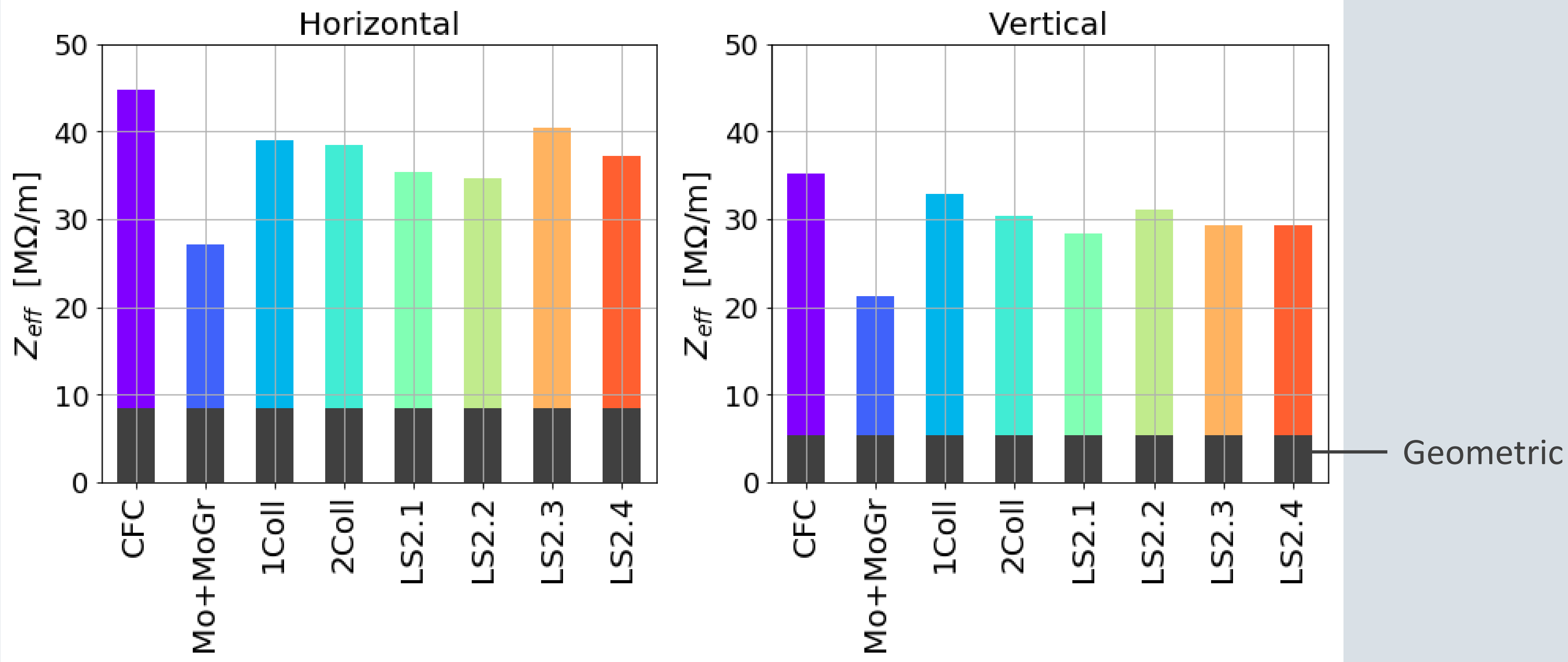
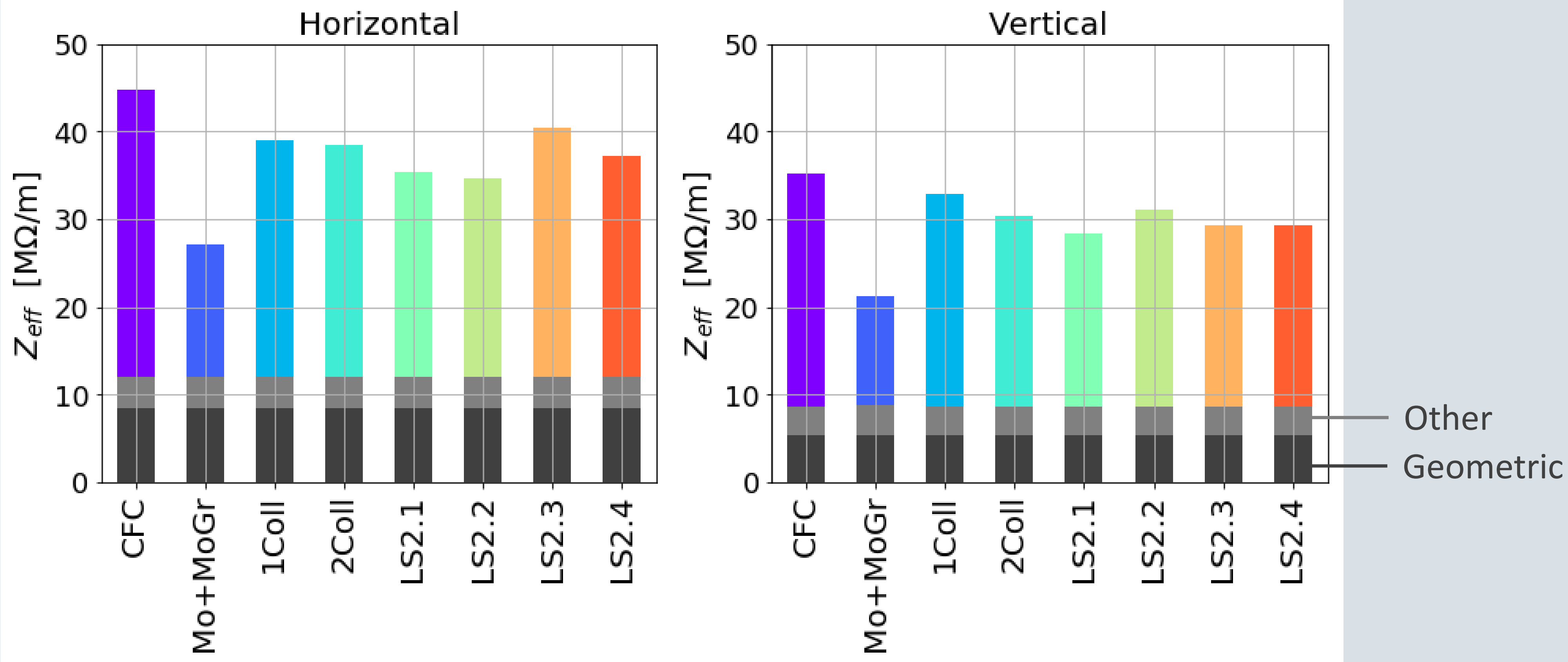
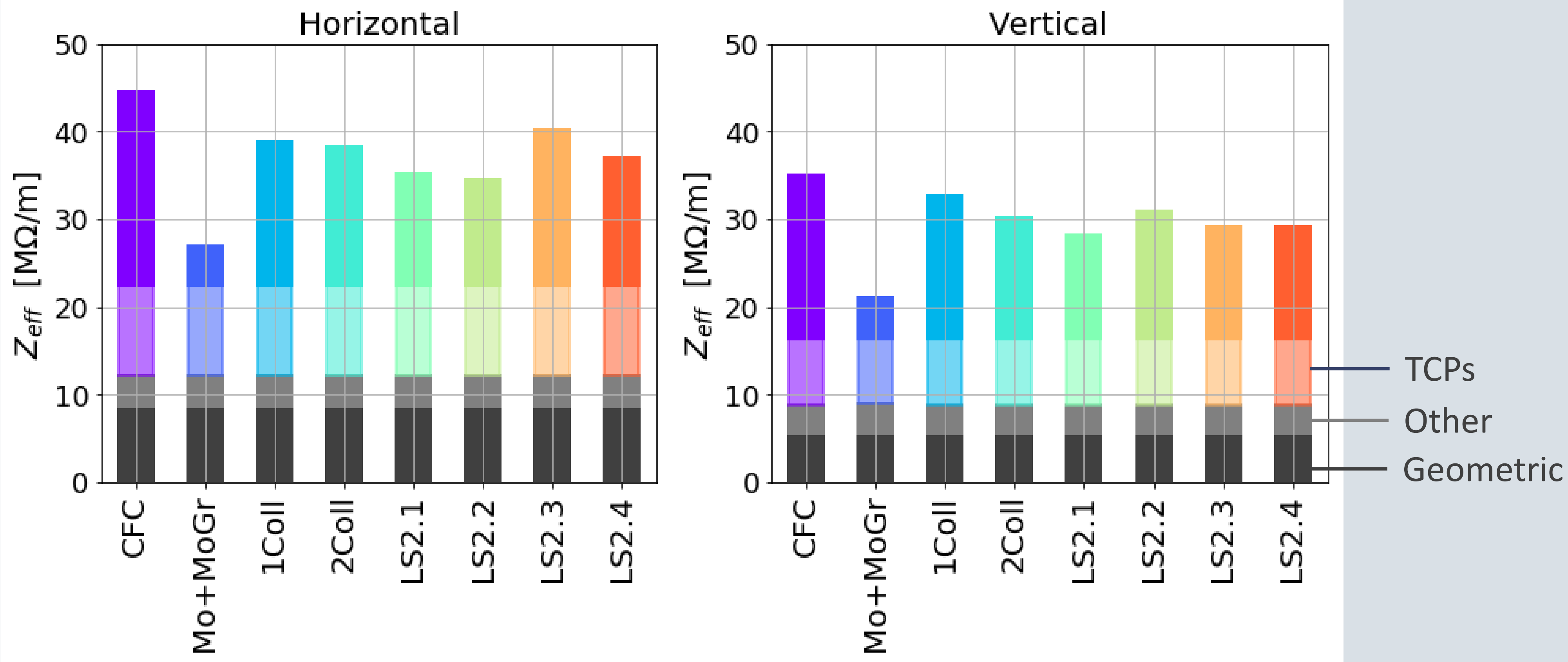


Resistive wall contribution to the machine impedance can be decreased significantly

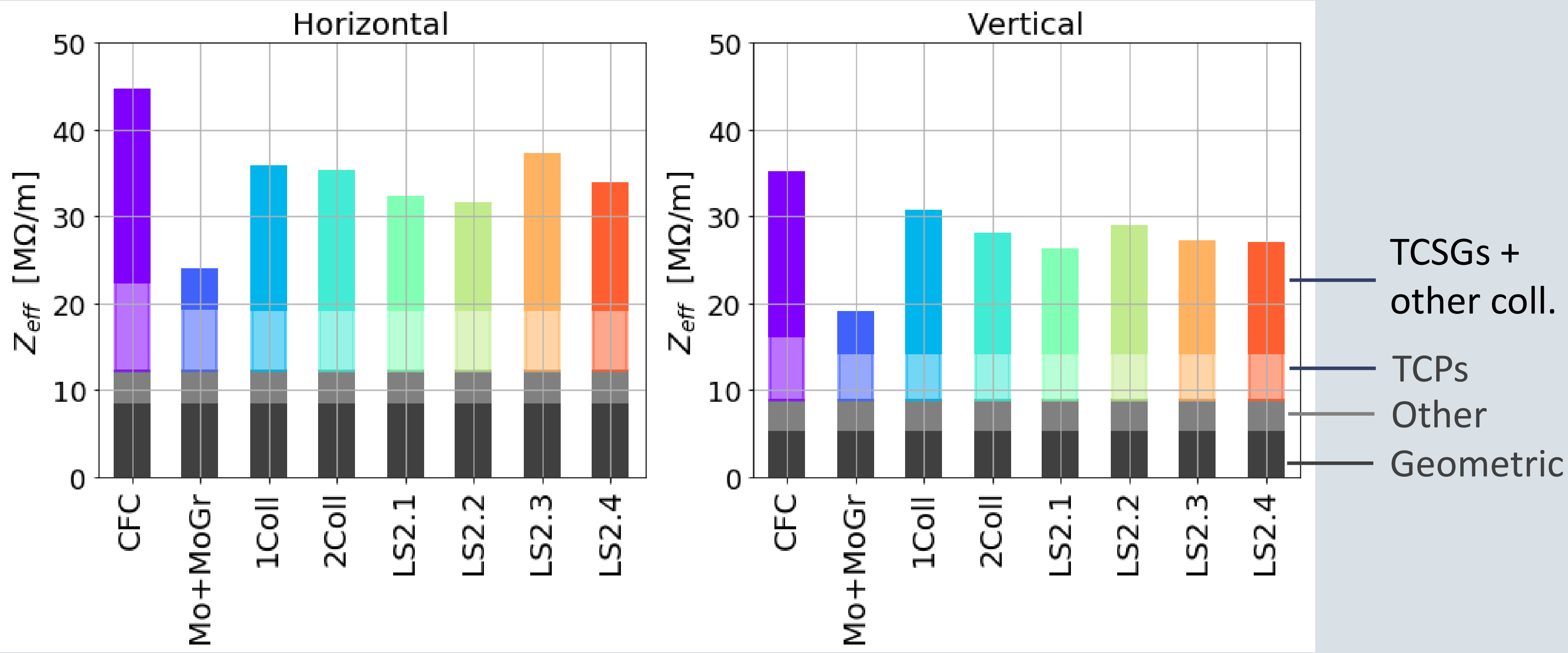


Resistive wall contribution of the secondary collimators can be decreased by 50% using a subset

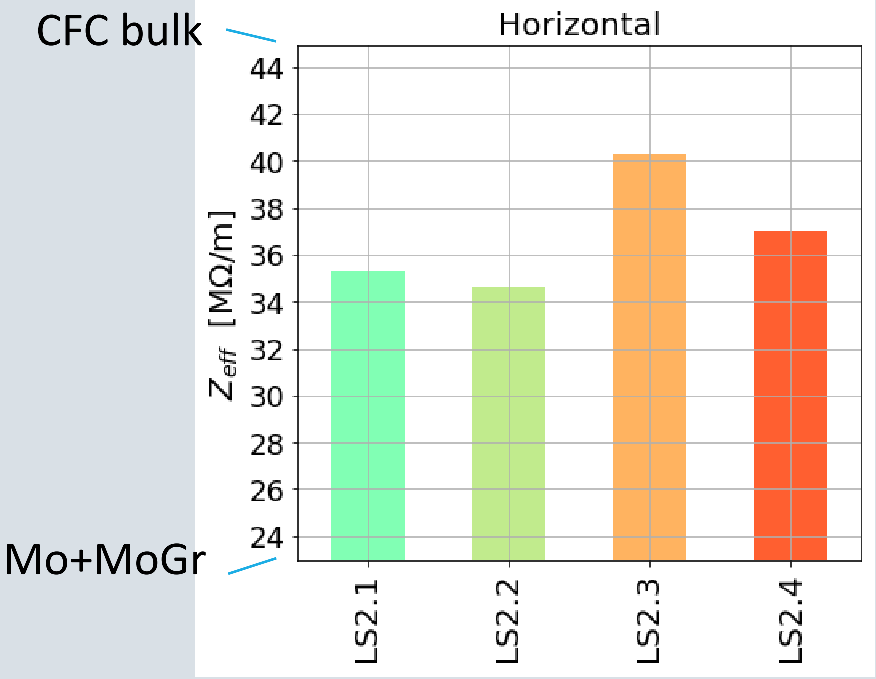


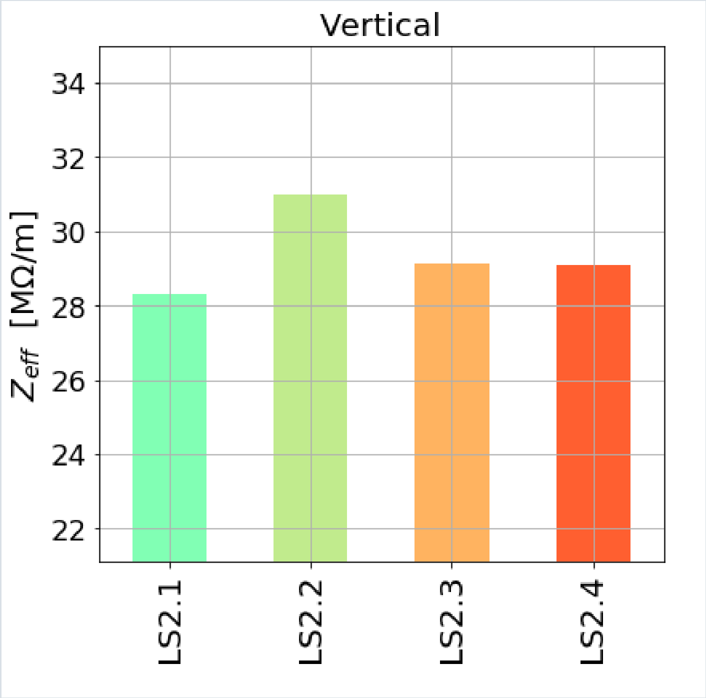
Additional decrease can be achieved from coating the TCPs

2 TCPs: H and V in the IR-7 region to be replaced by MoGr bulk during the LS2

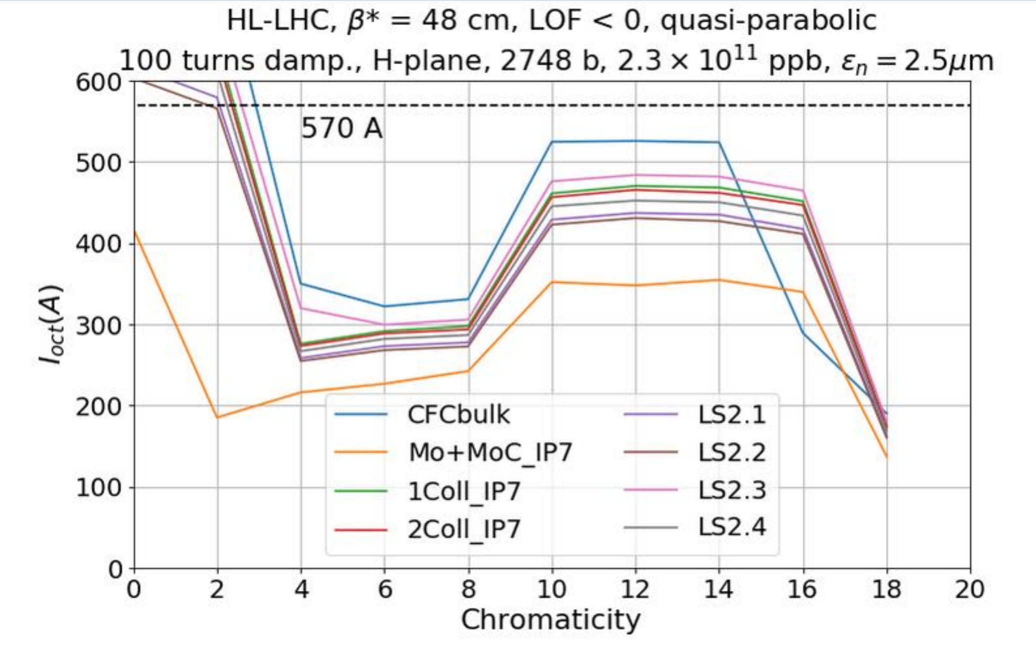


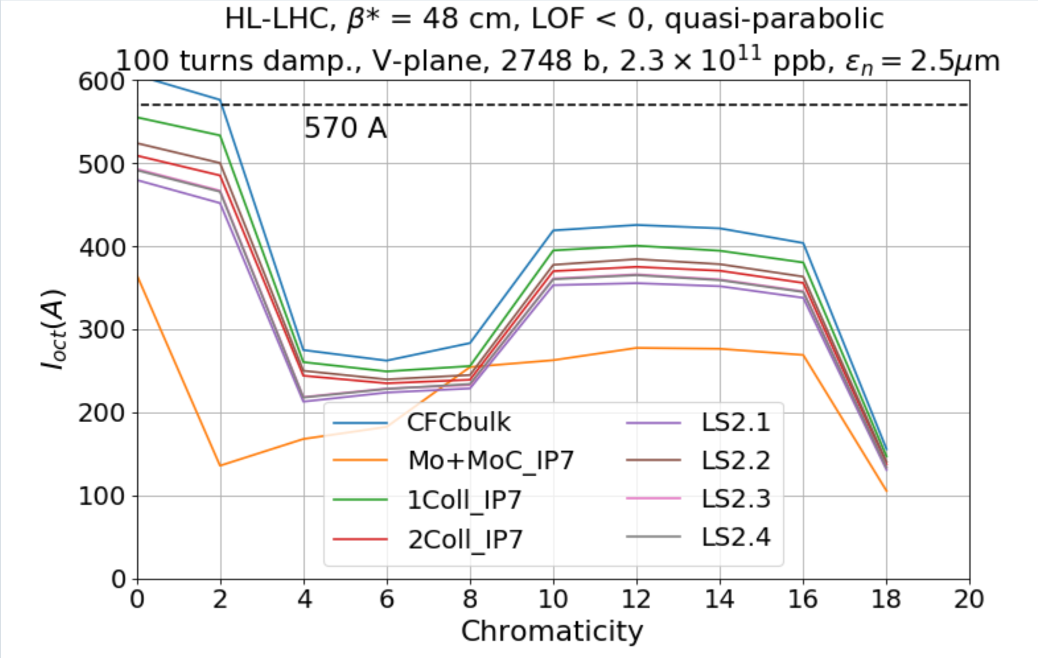
The 2nd option for LS2 offers the largest impedance reduction in the more critical H-plane



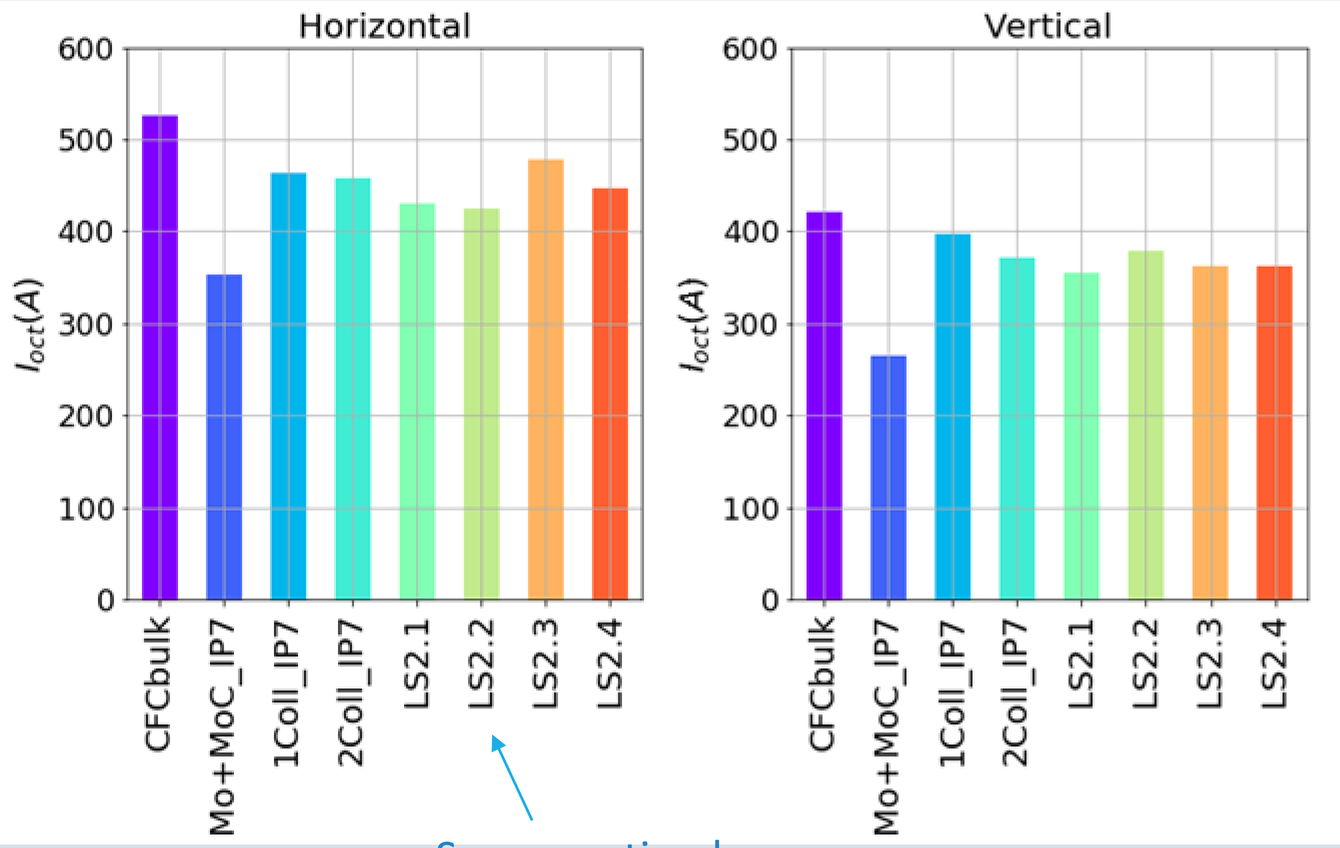


Without the coating the required octupole current is close to the limit





Considerable, up to 100 A decrease of the octupole threshold for the partial coating



Seems optimal

ε_n = 2.5 μm
I = 2.3x10^{11} ppb
σ_z = 8.1 cm
"-" polarity
d = 100 turns
β^* = 48 cm
Q' = 10

Summary

Using Mo coating on TCSGs in IR-7 one can reduce the machine impedance and octupole threshold by ~ 30%

A half of the reduction can be achieved with a subset of 4 collimators

For the tight collimator scenario one can reduce the octupole current by

- 200 A by coating all the TCSGs in IR-7
- Up to 100 A by coating a subset

The option LS2.2 is the most preferable from the beam stability point of view

Back-up

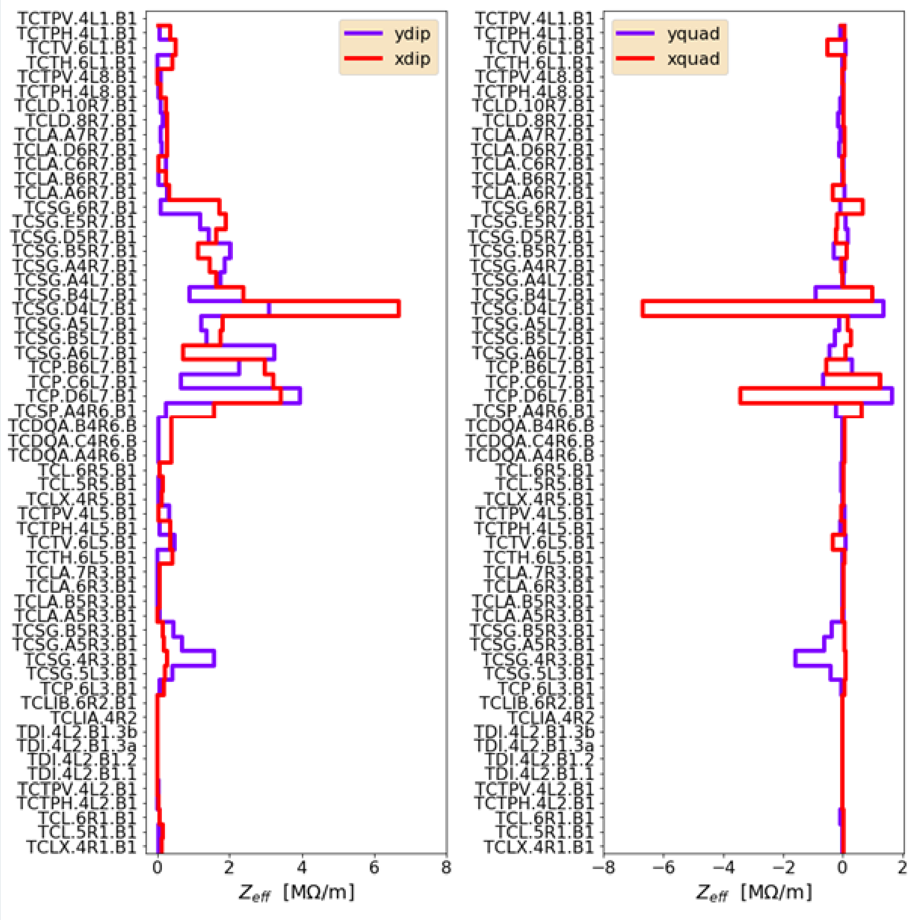
Resistivity of the materials

Material	IW2D Model (Used)	From the TCSPM MD*
CFC	5000 nΩxm	3950 ± 350 nΩxm
MoGr	1000 nΩxm	690 ± 70 nΩxm
TiN	400 nΩxm	310 ± 30 nΩxm
Mo	50 nΩxm	130 ± 20 nΩxm

The fits of the experimental data accounted for only the RW contribution, no geometric
Probably good to 10-20 %

* To be discussed in detail at the Impedance WG Meeting on 25.08.17

The bigger (collimator impedance) picture



β* = 48 cm
2017 tight settings