Impact of collimator geometric impedance on tuneshift measurements - the case of **TCP.C6L7.B1**

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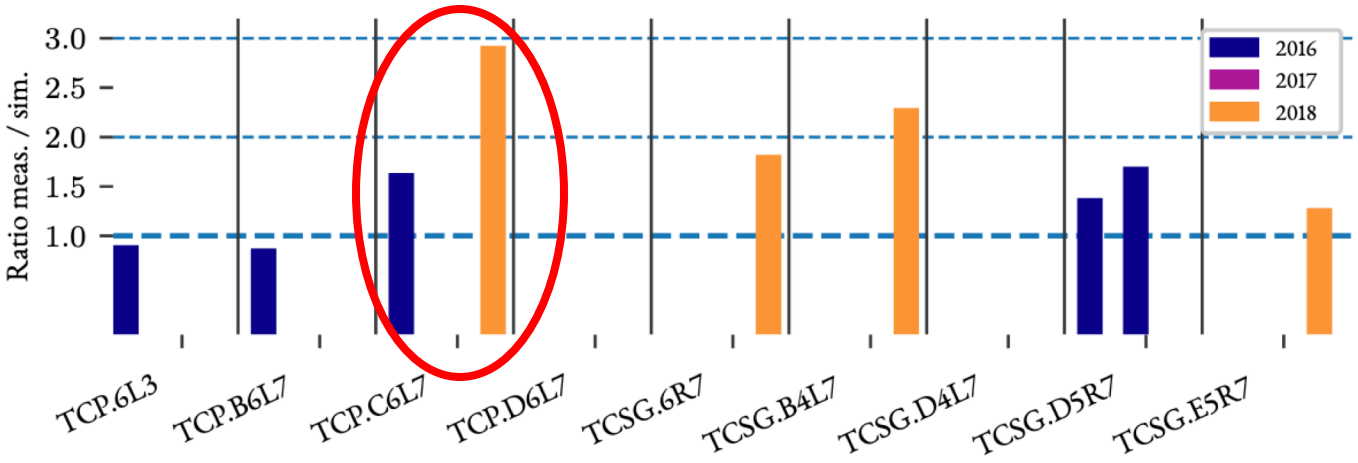
F. Carra, L. Carver, L. Gentini, A. Mereghetti, S. Redaelli.

The issue – tuneshift measurements variability

- The discrepancy between model and tuneshift measurement for the horizontal, primary collimator TCP.C6L7 in beam 1, seems to have doubled between 2016 and 2018:



(a) Ratios B1H

From ***D. Amorim*** PhD Thesis, CERN-THESIS-2019-272.

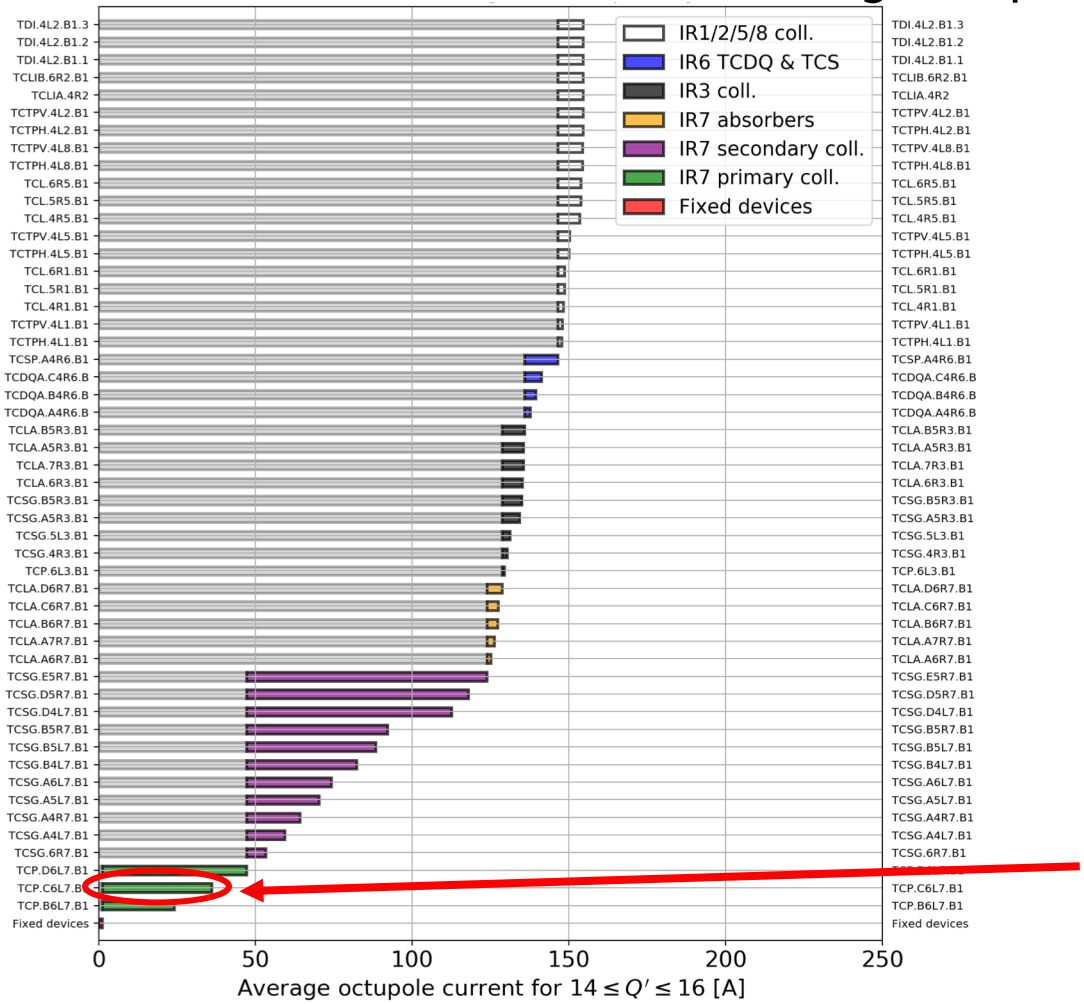
Summary presented by ***X. Buffat*** at 170th WP2 meeting, 10/03/2020

- During the WP2 meeting, ***R. Bruce*** mentioned that "the TCP.C6L7.B1 collimator was changed in the 2016-17 EYETS, when a new collimator with BPM buttons was installed. The hardware used in the measurements was thus not the same."

⟹ **what is the (theoretical) impact of this change of hardware?**

Contribution of TCP.C6L7 to the impedance

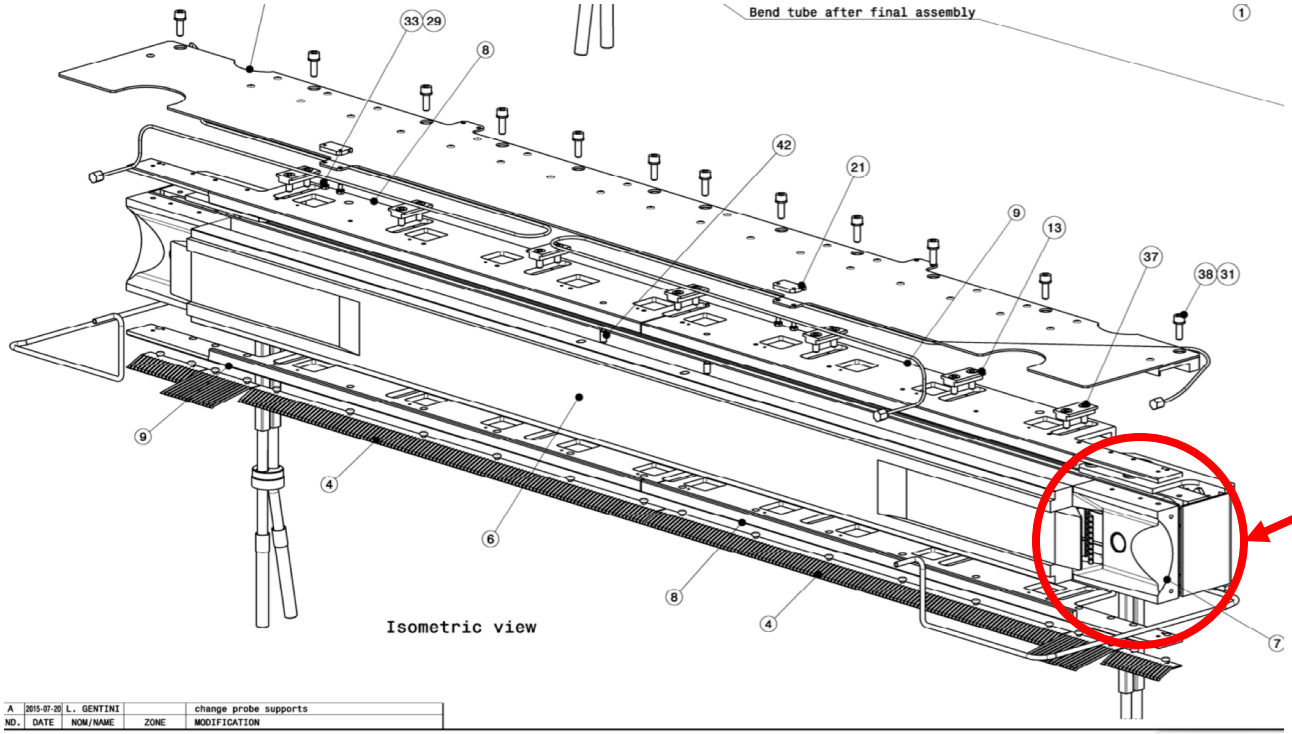
Approximate **cumulative** contribution of each element to the total octupole threshold (horizontal instabilities, negative polarity, 2018 impedance):



~8% of total octupole threshold (~10A without factor 2).

Design of TCP.C6L7 after 2016-2017 EYETS

- From ***L. Gentini / F. Carra / S. Redaelli***: this is a specific design, "**TCPP**"



From **LHCTCPP_0003** drawing

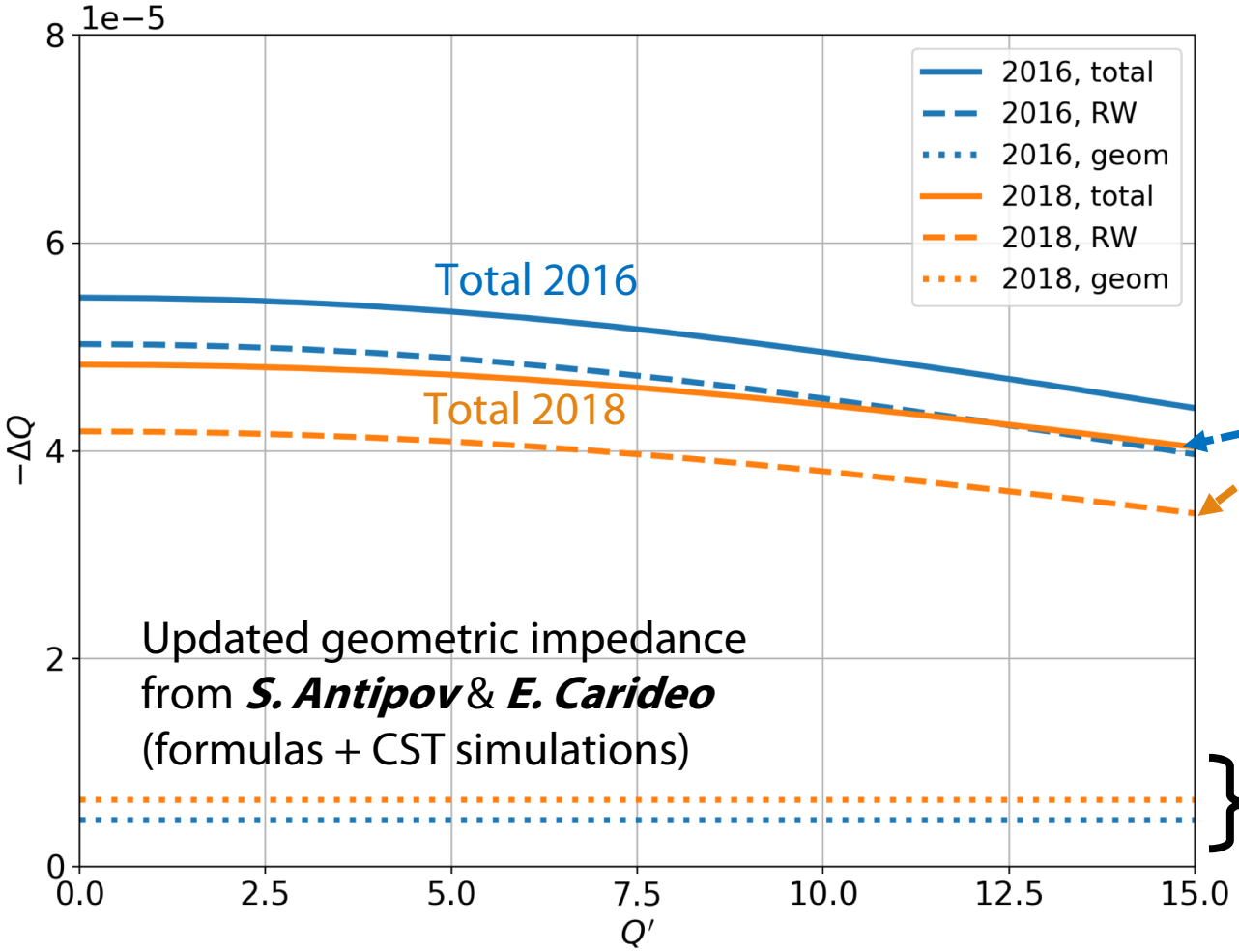
BPM button with taper

⟹ same BPM button design as TCSP…

… but it has RF-fingers instead of ferrite ⟶ no high order mode at ~100 MHz (the so-called "TCTP mode").

Impact of geometric impedance

- Using Sacherer formula (dip+quad), normalizing some of the parameters (bunch length 1ns, 1e11 p+/b): **horizontal tune shift** vs chromaticity

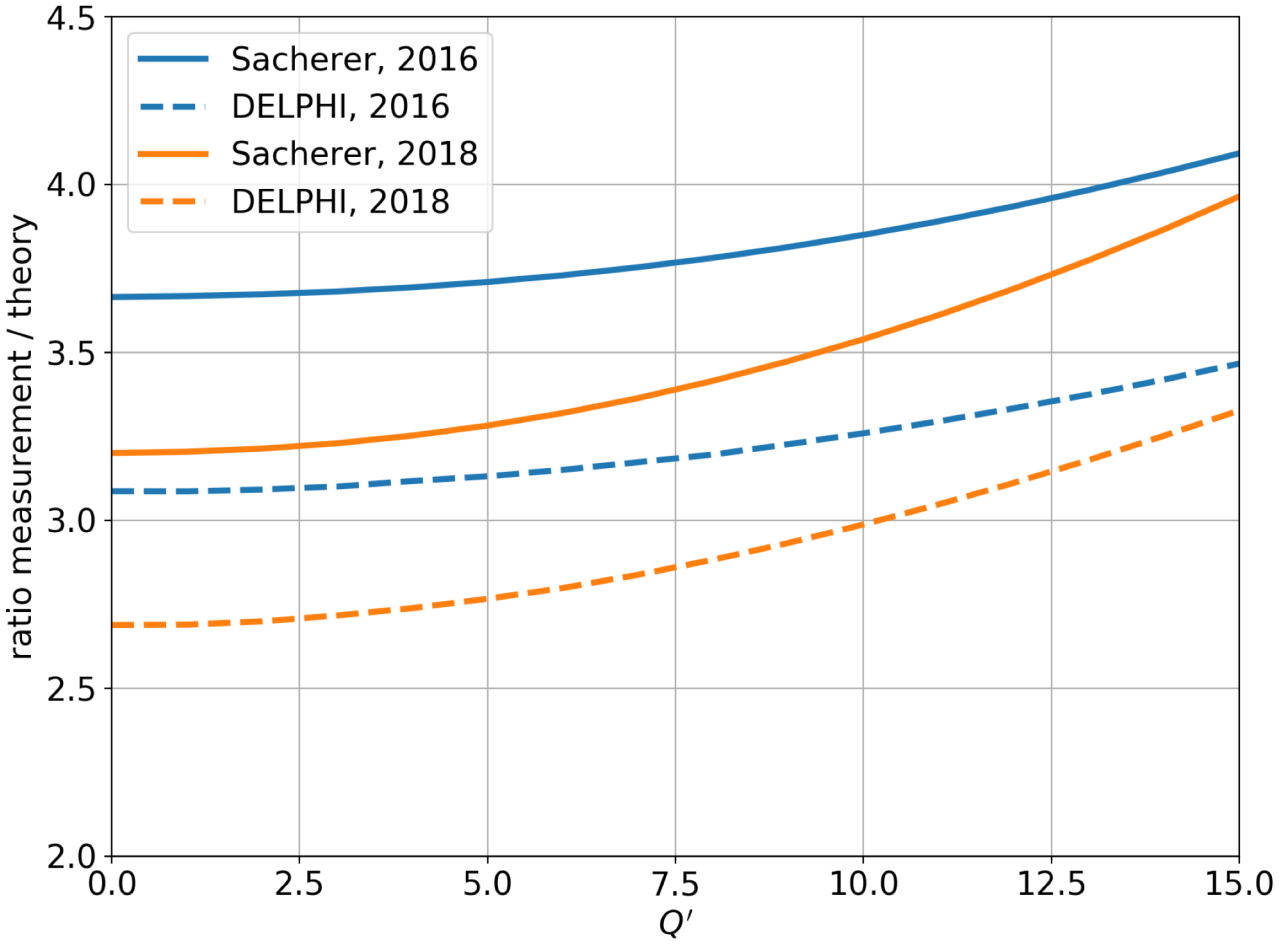


Resistive-wall impedance is the largest contribution

Geometric impedance (tapers) is **<15%** of total tuneshift
⟹ cannot explain a much higher tuneshift.

Checking again theoretical values

- Ratio of horizontal tune shift measured vs theoretical (Sacherer formula or DELPHI Vlasov solver), vs chromaticity:



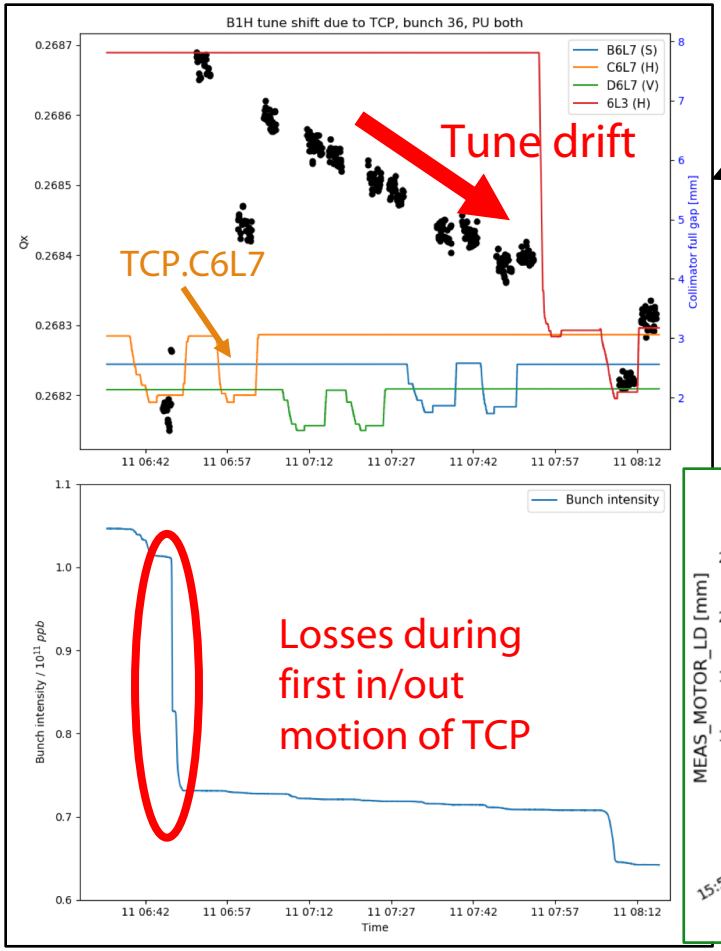
$\Longrightarrow$ I cannot recover the reported discrepancy factor (~2) of 2016 MD.

$\Longrightarrow$ Instead one finds a similar one as from 2018 MD (~3).

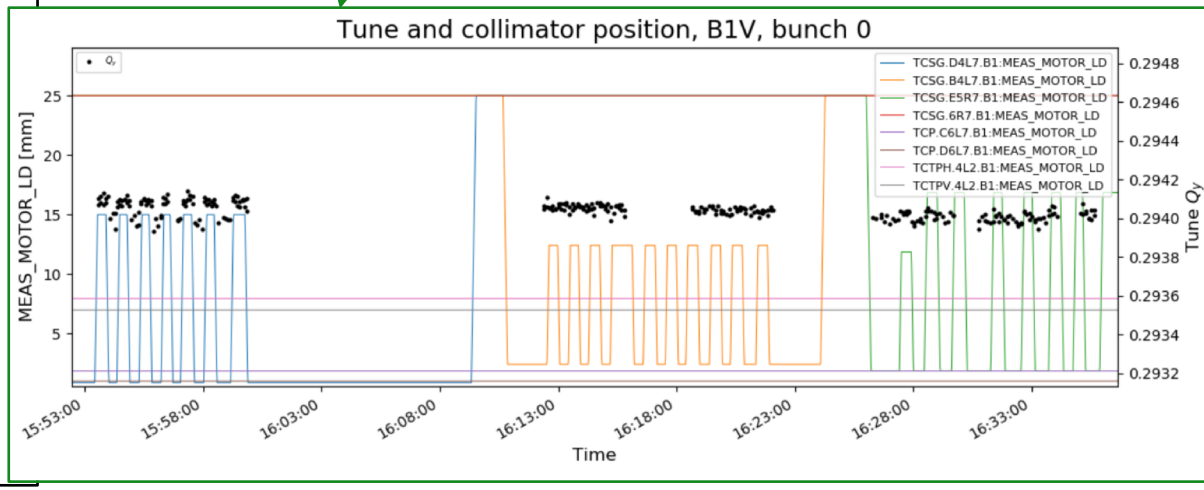
One possible explanation: change of model in-between.

Measurement improvements

- All along Run 2 the quality of tuneshift measurements has continuously improved (**D. Amorim, S. Antipov, N. Biancacci, L. Carver, B. Salvant**):



- 2016 measurement relied on tune drift compensation & a single in/out motion of the TCP.C6L7.
- 2018 measurement much cleaner.



Conclusion

- The change of design of TCP.C6L7 has slightly increased the geometric impedance (from tapers).
- But it cannot explain an increase of discrepancy between 2016 & 2018 MDs and impedance model as even with the new design, the impedance is largely dominated by the resistive-wall contribution (>85%).
- Furthermore, calculations with an updated impedance do not show a strong discrepancy anymore between the two measurements.

  $\Longrightarrow$ any remaining difference can probably be explained by the strong improvements in the MD procedure & conditions over Run 2,

  $\Longrightarrow$ this also confirms that the **discrepancy between measurements & model is very high for the TCP.C6L7** (~factor 3).

  Possible explanations:

  - Collimator misalignment during MD (to be studied in MDs)
  - Radiation damage leading to resistivity change

  } Seem unlikely (see ***A. Mereghetti***, 176th WP2, 02/06/2020)

  - Non-conformity? Collimator has been taken out, endoscopy performed ⟶ to be followed-up.

Additional remarks

- **We need more data points** ⟶ tuneshift measurements in Run 3 – they have improved a lot during Run 2 (precision down to a few 10^{-5}).

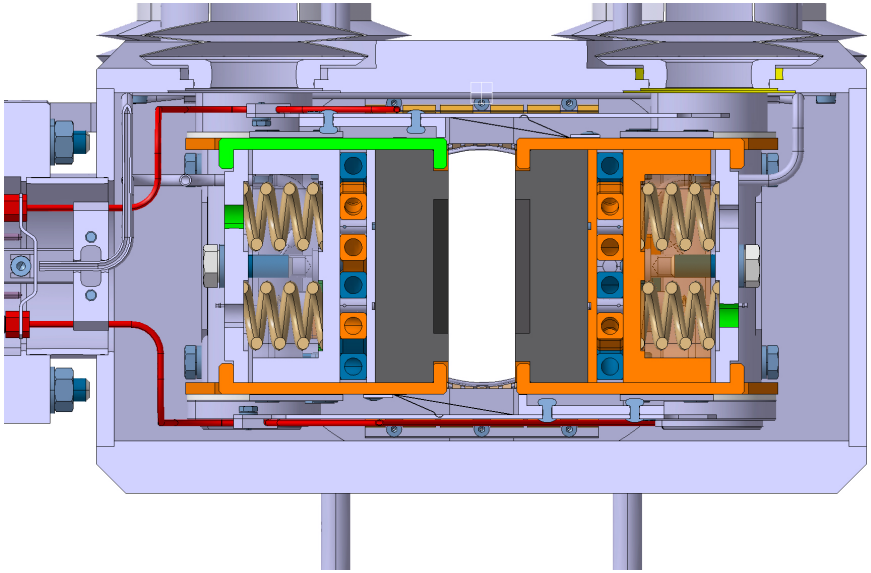
- The **TCP.C6L7 is out now**, and replaced by a Mo-graphite primary for Run 3 ⟶ whatever issue that could have been there, will probably disappear.

Appendix

TCPP vs. TCSP design – RF fingers

- From ***L. Gentini***:

TCPP



TCSP