SWELL SRF multipacting studies

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Presentation outline

Framework

Multipactor problematics

First multipactor studies

Conclusions and future work

Appendix

Framework

SWELL: Slotted Waveguide ELLiptical cavity

- Designed at CERN;
- great candidate to have a single cavity type for (almost) all the FCCee beam energies;
- works @600 MHz;
- seamless, robust against detuning;
- four waveguides slots to extract Higher Order Modes.

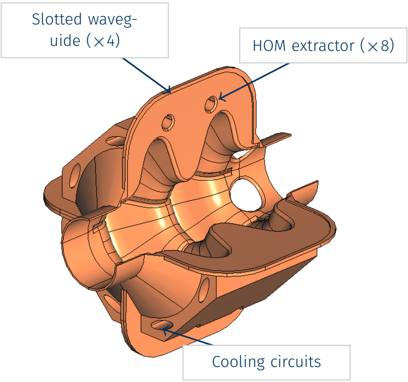


Figure 1: 3D representation of the SWELL cavity, made of four independant quadrants (3/4 represented).

Franck Peauger et al. "The SWELL cavities program: The SWELL cavity development plan". In: *FCC Week 2022*. Paris, France, 2022

The SWELL single-cell prototype

- First prototype @1.3 GHz, single-cell;
- design close to the TESLA cavity;
- multipactor study: simulations (LPSC) + experiments (CERN, IJCLab).

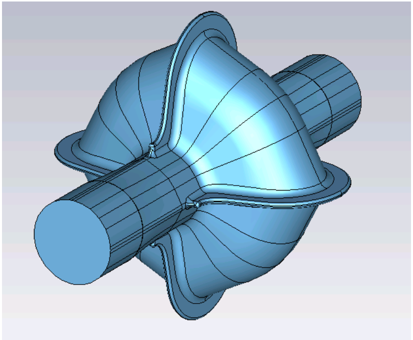


Figure 2: 3D representation of the single-cell SWELL prototype; vacuum is in blue.

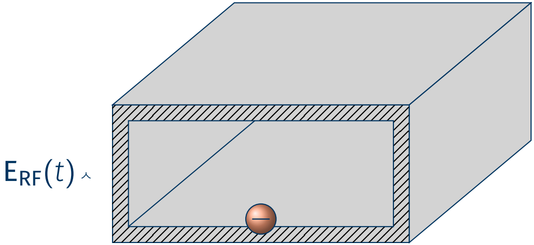
F Peauger et al. "SWELL and Other SRF Split Cavity Development". In: *Proceedings of LINAC2022*. Ed. by Peter McIntosh et al. Liverpool, UK: JACoW Publishing, Geneva, Switzerland, 2022, pp. 300–304

Multipactor problematics

Multipactor consequences in cavities

- Multipactor is an electron avalanche;
- several multipactor zones at different E_{acc} can exist;
- can result in:
  - cavity's surface heating;
    - → quench;
    - → surface desorption and *corona* discharges;
  - RF power dissipation;
  - quality factor spoiling.

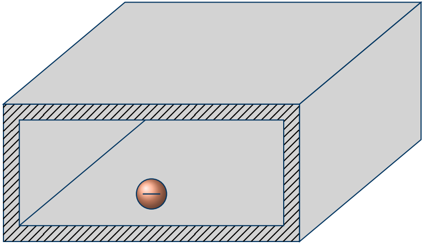
Physics of the multipactor apparition



Multipactor created by the combination of two physical phenomena:

Physics of the multipactor apparition

$E_{RF}(t)\downarrow$



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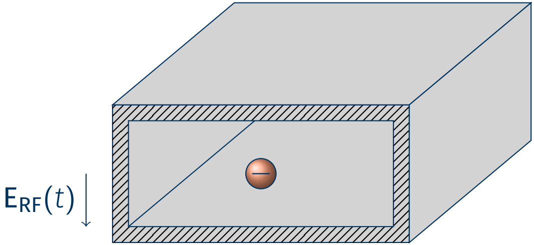

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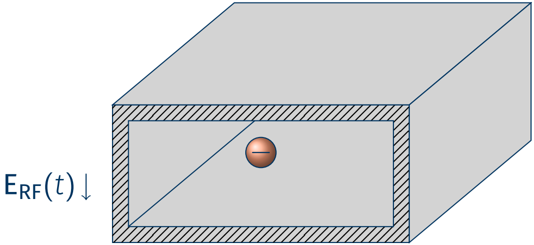

Multipactor created by the combination of two physical phenomena:

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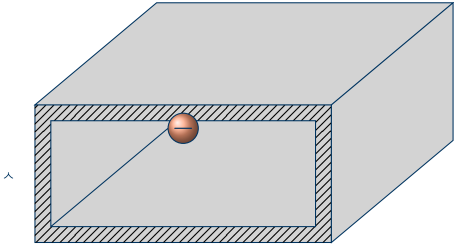

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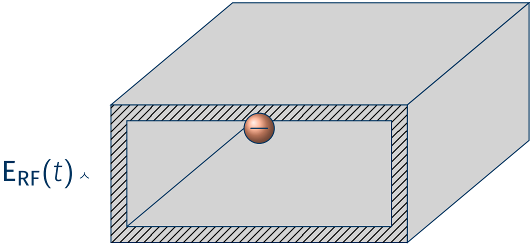

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- electron emission;

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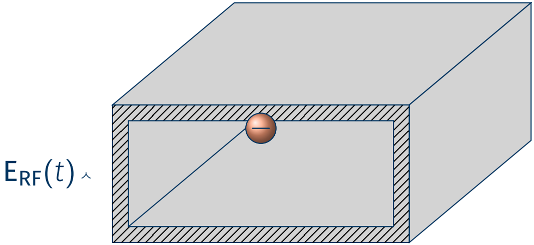

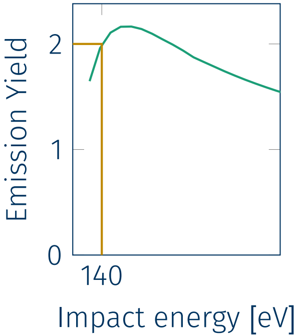

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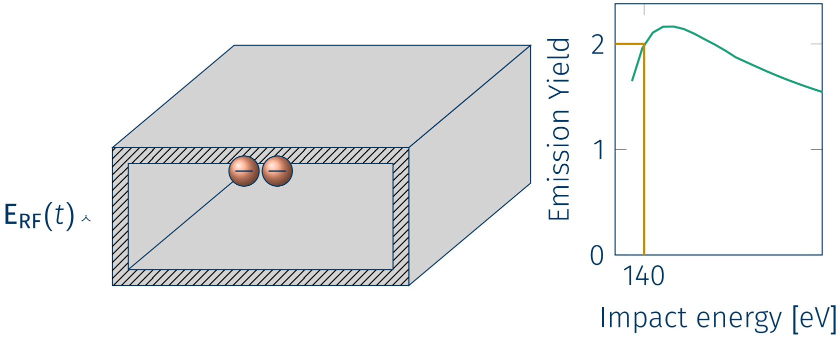

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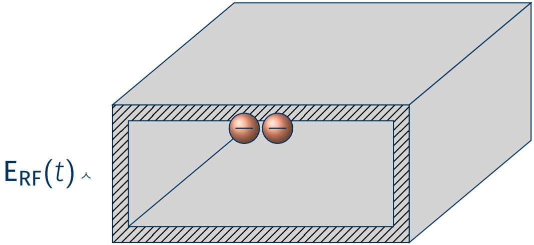

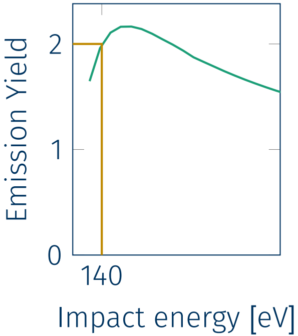

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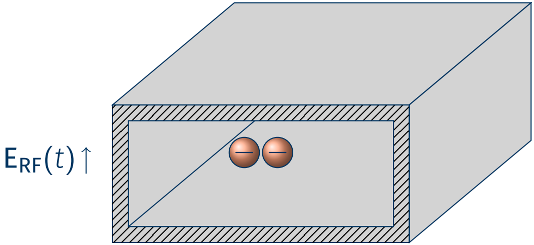

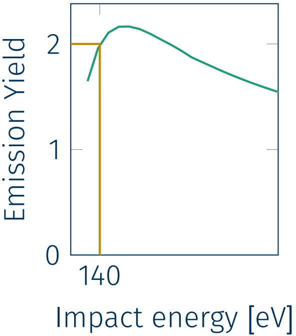

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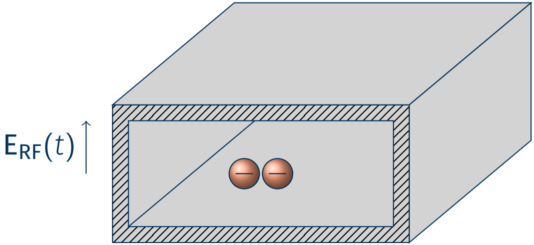

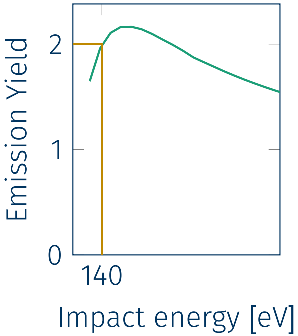

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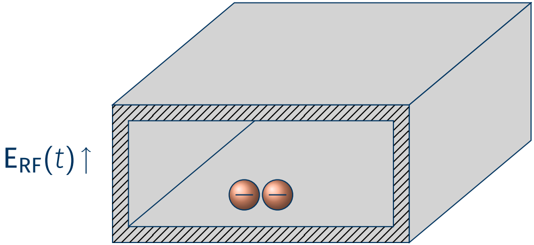

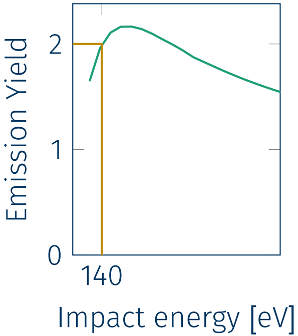

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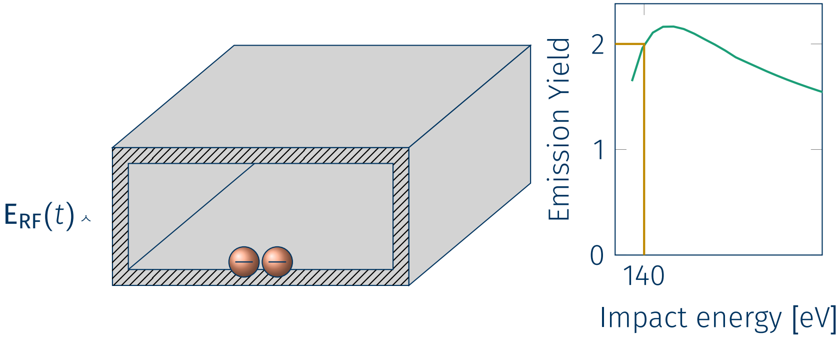

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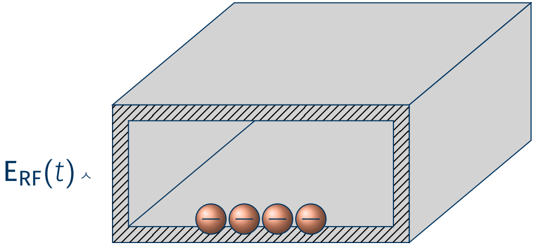

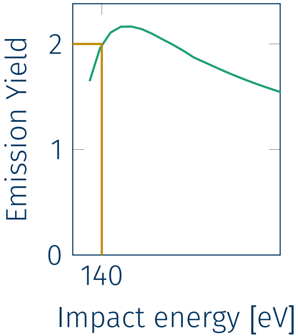

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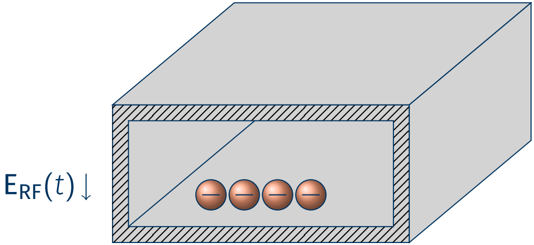

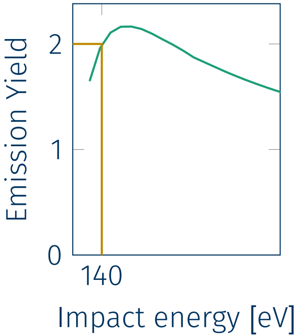

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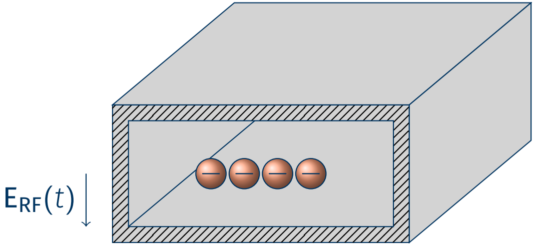

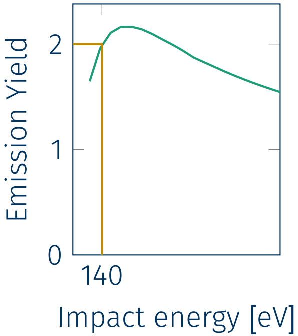

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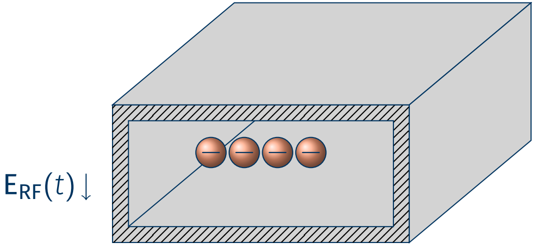

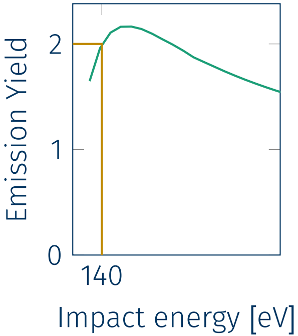

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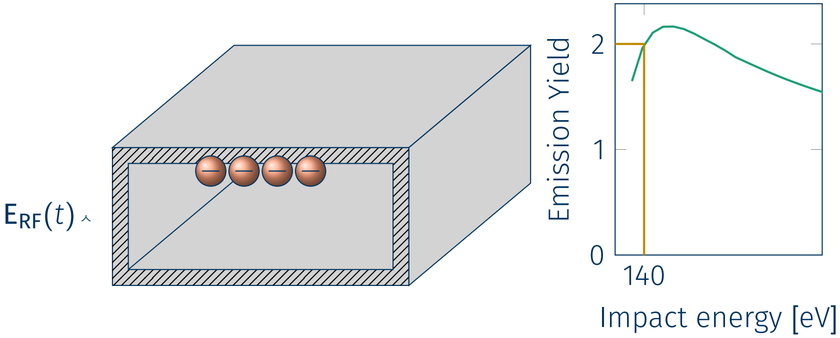

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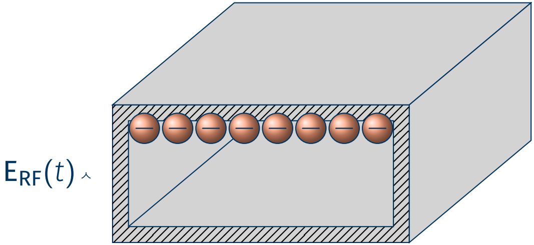

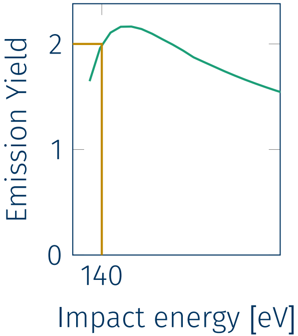

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First multipactor studies

Less surface contamination → smaller multipactor zones

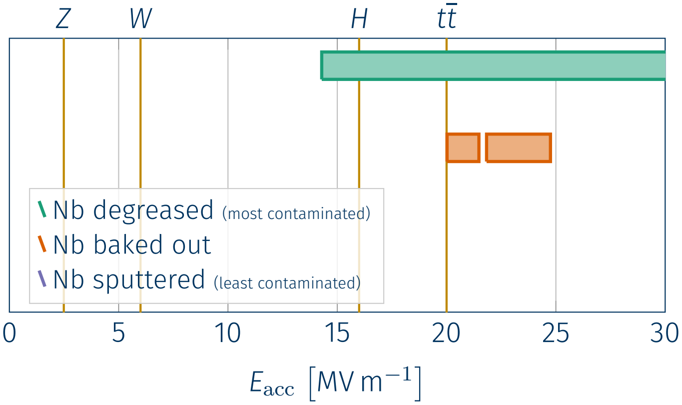

Figure 3: Multipactor zones for different samples and surface states. Simulations with SPARK3D.

S Aull et al. "Secondary Electron Yield of SRF Materials". In: ed. by Robert E. Laxdal, Jana Thomson, and Volker RW Scha. Whistler, BC, Canada: 17th International Conference on RF Superconductivity (SRF2015), Sept. 2015,

H. Piel. *Superconducting cavities.* Tech. rep. Hamburg, Germany: CERN, 1988, pp. 149–196

Two types of multipactor were spotted

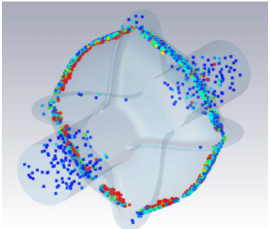

Figure 4: $E_{\mathrm{acc}} = 6\,\mathrm{MV\,m^{-1}}$, multipactor in the equatorial plane. CST simulation, Nb baked (according to SPARK3D, no multipactor at this E_{acc}!).

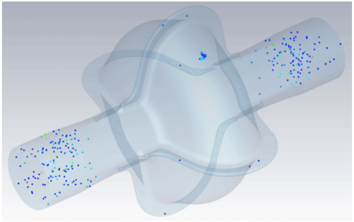

Figure 5: $E_{\mathrm{acc}} = 20\,\mathrm{MV\,m^{-1}}$, multipactor at single point. CST simulation, Nb baked.

TEEY at low energies shall be measured

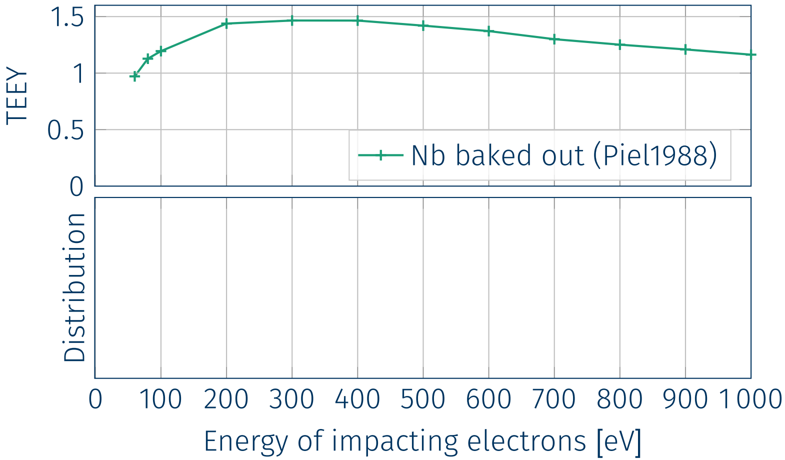

Figure 6: Top: TEEY as a function of electrons impact energy. Bottom: distribution of electrons impact energies.

H. Piel. *Superconducting cavities.* Tech. rep. Hamburg, Germany: CERN, 1988, pp. 149–196

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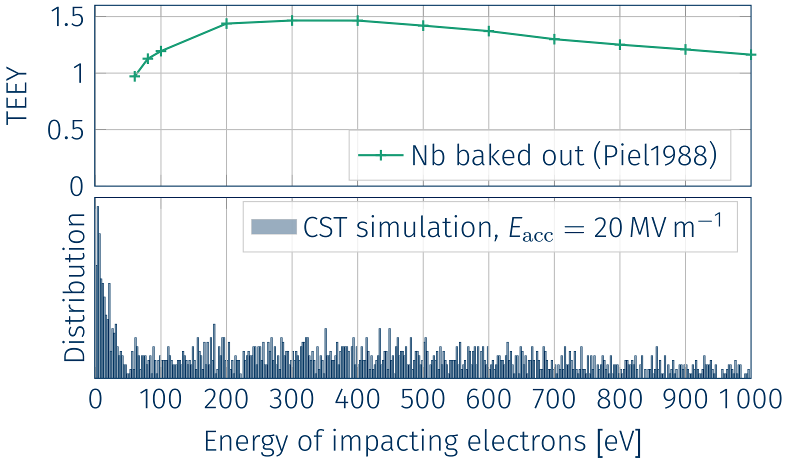

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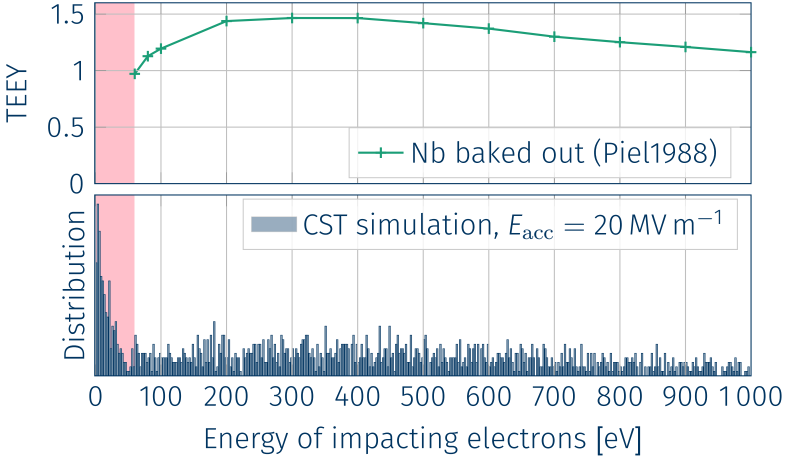

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Conclusions and future work

Conclusions and future work

- Collaboration CERN–IJCLab–LPSC:
    - CERN: cavity design, multipactor measurements;
    - IJCLab: electron emission measurements;
    - LPSC: multipactor simulations;
- multipactor barriers can be processed through by conditioning (*cleaning*) the surfaces;
  → preliminary results;
- multipacting studies on TESLA and two-cell 600 MHz SWELL cavities.

Thanks for your attention!

Questions?

Appendix

1.3 GHz SWELL cavity parameters

Parameter	Value
f [GHz]	1.3
R/Q [Ω]	122.9
L_{acc} [mm]	115.3
$E_{\mathrm{pk}}/E_{\mathrm{acc}}$	2.01
$B_{\mathrm{pk}}/E_{\mathrm{acc}}$	4.61
G [Ω]	265.56
E_{acc}	$>15-18\ \mathrm{MV\,m^{-1}}$
Q_0	$>3\times10^{8}$

Franck Peauger et al. "The SWELL cavities program: The SWELL cavity development plan". In: *FCC Week 2022.* Paris, France, 2022

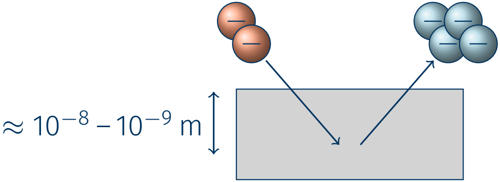
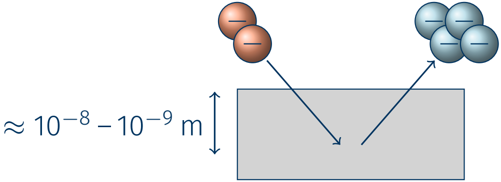


Figure 7: Sample irradiated by an electron flux. It emits a flux of electrons in reaction.

Definition of the Total Electron Emission Yield



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- Total Electron Emission Yield (TEEY) is the number of emitted electrons per incident electron;
  - $\rightarrow$ $\mathrm{TEEY} = 2$ in Fig. 7.

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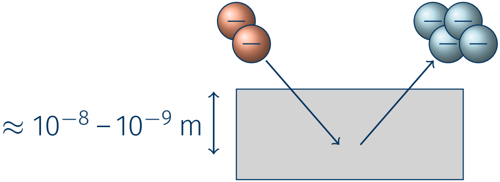

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- Total Electron Emission Yield (TEEY) is the number of emitted electrons per incident electron;
  - $\rightarrow$ $\mathrm{TEEY} = 2$ in Fig. 7.
- extremely important to characterize multipactor
  - $\rightarrow$ $\mathrm{TEEY} > 1$ is a necessary condition for multipactor apparition.