Compatible Susceptibility Measurements in Fully Anechoic Room and Reverberation Chamber

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Summary

By considering that an **immunity testing is a binomial process** [1], measurements performed with deterministic fields like a fully anechoic room (FAR) and measurements performed with random fields like a reverberation chamber (RC) can give very similar values.

Motivation

The comparison of testing facilities is a subject of interest in the EMC community. The confidence intervals (generally ± 3 dB) provided by standard measurements [2, 3] does not allow a good agreement between the measurements.

Solution

If the susceptibility of a device is a random variable, we can develop a **common statistical framework** to extract with a controlled uncertainty the susceptibility levels of the equipments tested in our lab.

Statistical characterization of the susceptibility of a non-intentional emitter

In order to extract the statistics of the E-field radiated by a non-intentional emitter, we use a model of non intentional emitter used by P. Wilson [4]. n random Hertz dipoles are placed arbitrary on a sphere of radius a.

We study the effects of the complexity (number of dipoles n) and the electrical size $ka = \frac{2\pi}{\lambda}a$ on the statistics of the radiated E-field.

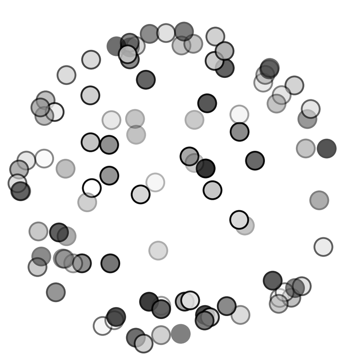
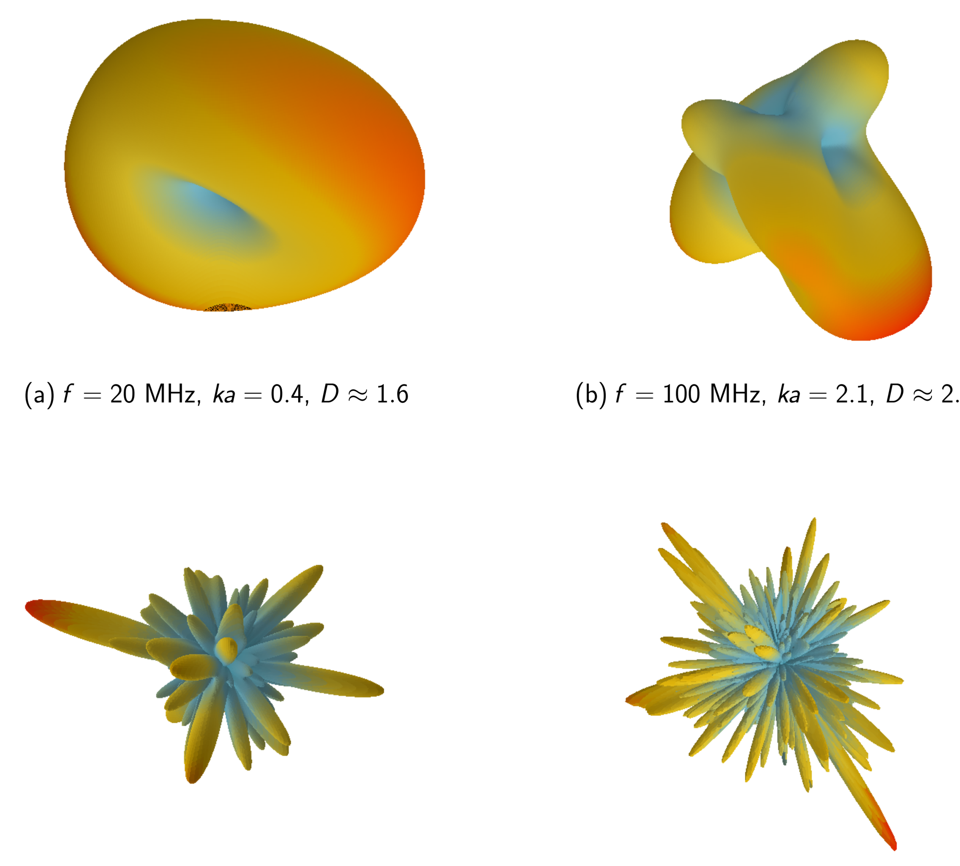


Figure: A non-intentional emitter

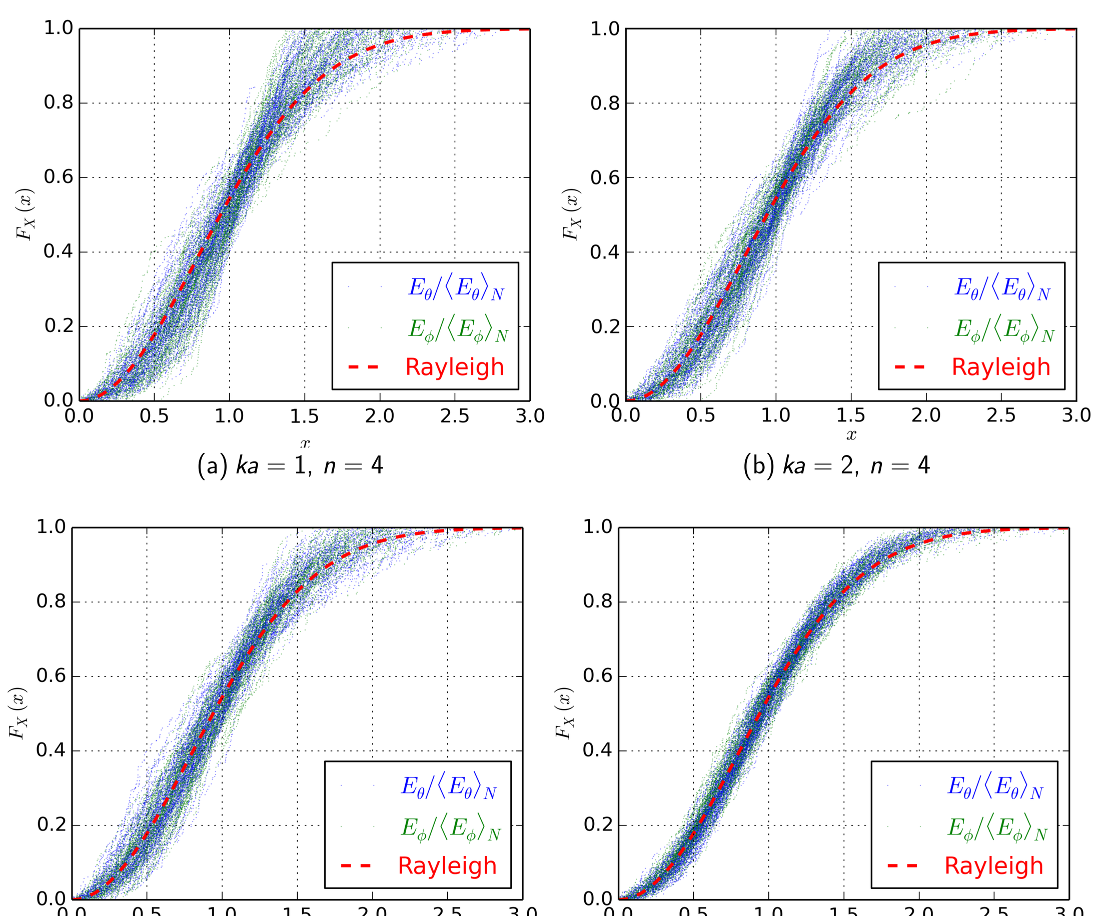


(a) $f = 20$ MHz, $ka = 0.4$, $D \approx 1.6$ (b) $f = 100$ MHz, $ka = 2.1$, $D \approx 2.3$

(c) $f = 500$ MHz, $ka = 10.5$, $D \approx 5.2$ (d) $f = 1000$ MHz, $ka = 21.0$, $D \approx 5.7$

Figure: Radiated power (linear values) of a random EUT with $a = 1$ m and $n = 100$ dipoles

Monte Carlo simulations give an idea of the statistics of the E-field rectangular components radiated by such emitters:



(a) $ka = 1$, $n = 4$ (b) $ka = 2$, $n = 4$

(c) $ka = 3$, $n = 4$ (d) $ka = 10$, $n = 10$

Figure: Cumulative distribution functions of the E-field rectangular components vs. theoretical Rayleigh distribution

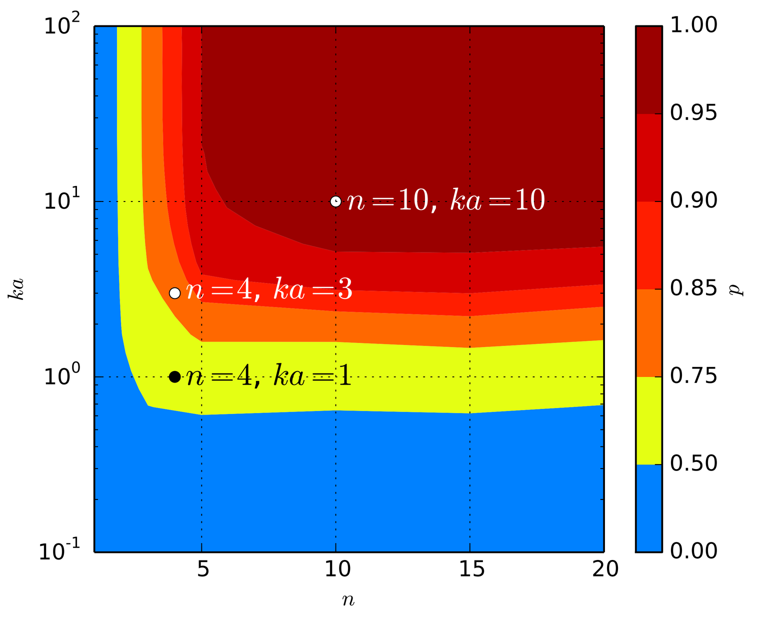


Figure: Probability to get a Rayleigh distributed E-field component according to the Anderson-Darling statistical test, 10^5 Monte Carlo trials for every point

Statistical estimation of the susceptibility

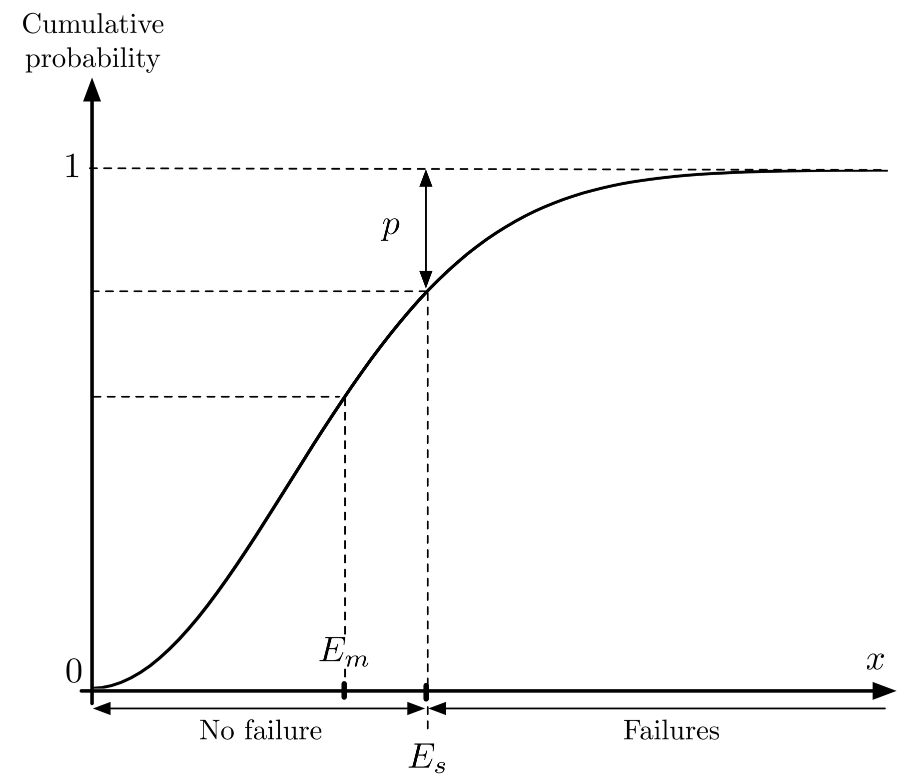


Figure: Statistical estimation of the susceptibility E_s [1] of an EUT if the impinging E-field components follows a Rayleigh distribution with mean value E_m.

$$\hat{E}_s = 2E_m\sqrt{\frac{\ln(1/\hat{p})}{\pi}}$$

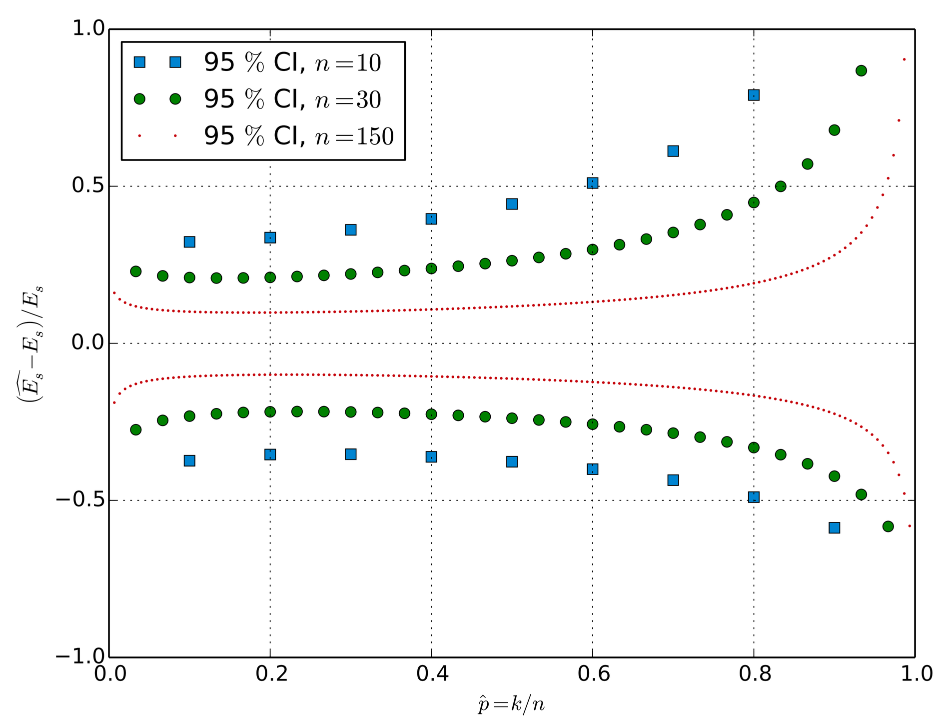
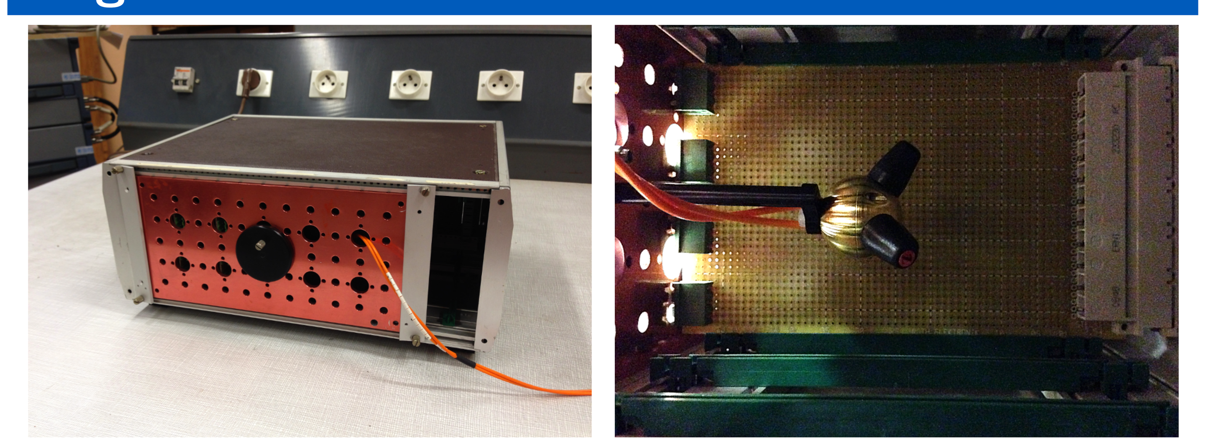


Figure: Confidence intervals of $\hat{E}_s$.

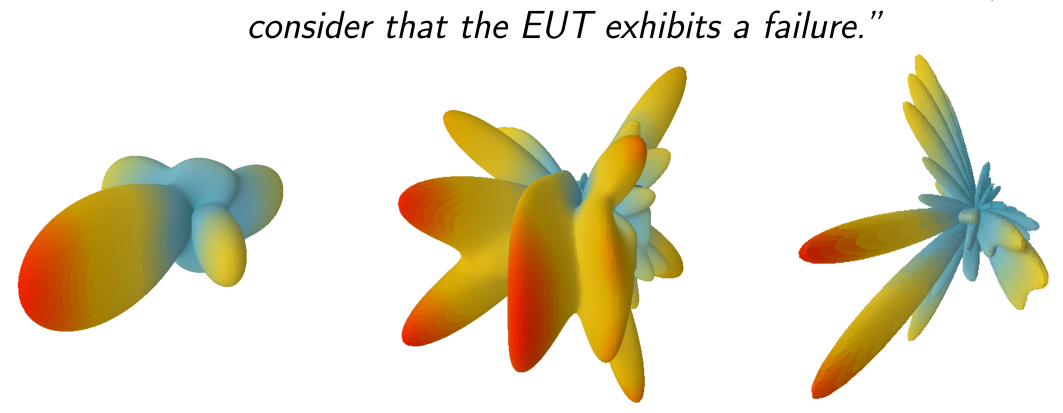
A generic EUT



(a) (b)

Figure: External (a) and internal (b) views of the generic EUT.

"If the level on the z axis exceeds the critical value $E_c = 10$ V/m, we consider that the EUT exhibits a failure."



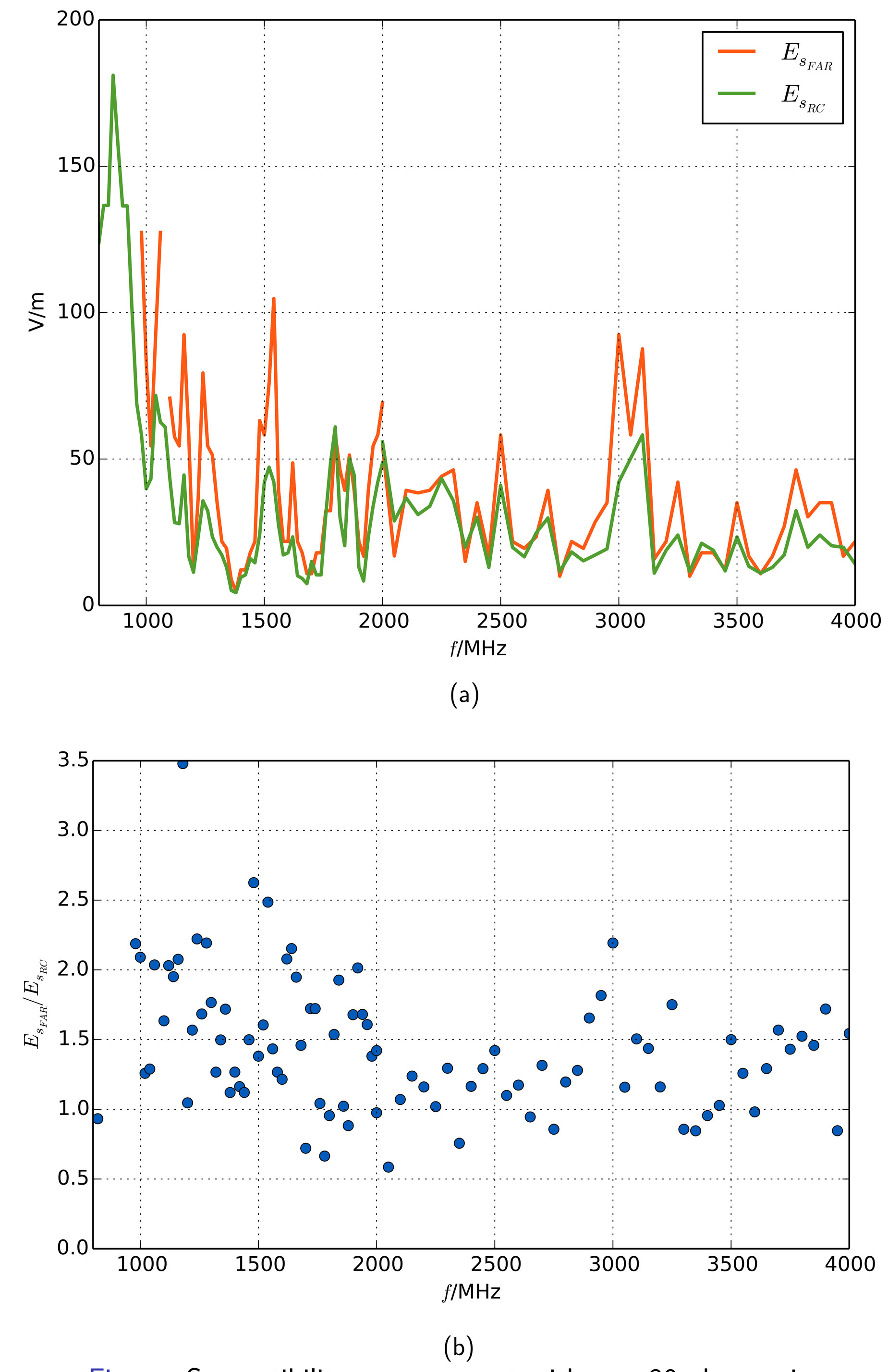
(a) 800 MHz (b) 2 GHz (c) 4 GHz

Figure: Radiation patterns at different frequencies (CST simulations).

Measurements

- Measurements are performed between 800 MHz and 4 GHz
- Calibration of the RC and the FAR is done for **every** frequency tested
- n angles of incidence are randomly chosen for the FAR measurement. n stirrer positions in the RC
- Tested levels E_m are 5, 10 , 20, 40, 80 V/m.

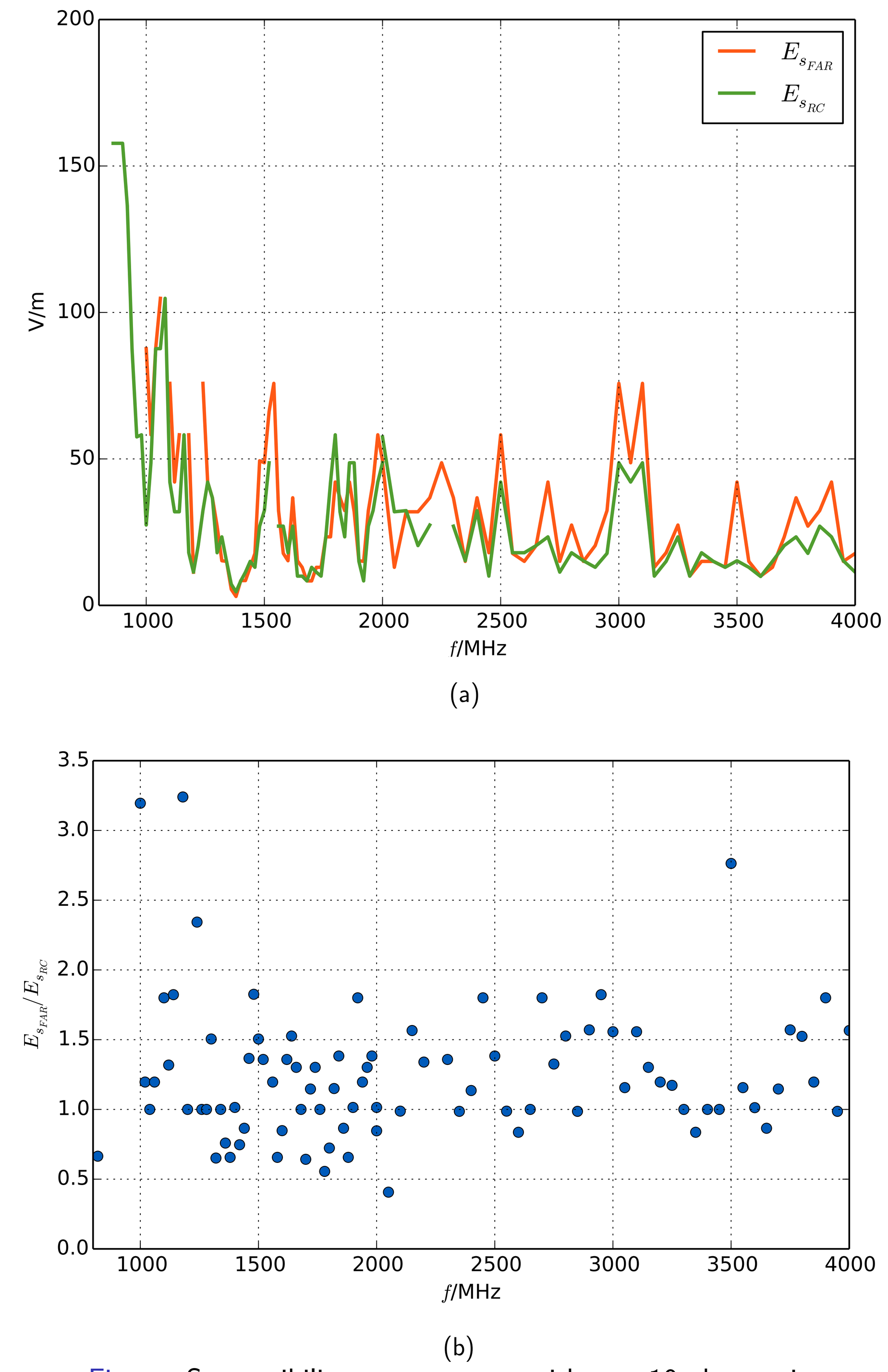
Results



(a)

(b)

Figure: Susceptibility measurement with $n = 30$ observations.



(a)

(b)

Figure: Susceptibility measurement with $n = 10$ observations.

As long as the EUT is electrically large enough:

- Good agreement of the measurements
- With $n = 10$, the agreement is good enough for EMC purpose

Conclusion

By using a common statistical framework for both the FAR and the RC and as long as the EUT is electrically large and complex, we can extract with a good agreement the immunity levels of an EUT. By giving a statistical dimension to FAR measurements, we can control and enhance the accuracy of the measurement.

References

[1] E. Amador, H. G. Krauthäuser, and P. Besnier, "A binomial model for radiated immunity measurements," *Electromagnetic Compatibility, IEEE Transactions on*, vol. 55, no. 4, pp. 683–691, Aug. 2013.

[2] IEC, *IEC 61000-4-21 Ed. 2 : Testing and measurement techniques — reverberation chamber test methods*, IEC, Geneva, Switzerland, Feb. 2010.

[3] ——, *IEC 61000-4-22 Ed. 1 : Testing and measurement techniques — radiated emissions and immunity measurements in fully anechoic rooms (FARs)*, IEC, Geneva, Switzerland, Nov. 2010.

[4] P. Wilson, D. Hill, and C. Holloway, "On determining the maximum emissions from electrically large sources," *Electromagnetic Compatibility, IEEE Transactions on*, vol. 44, no. 1, pp. 79 – 86, feb 2002.

Acknowledgments

Measurements and simulations made with:
python julia

Poster, data, scripts available at:
https://github.com/manuamador/EMCEurope2014