Problems with Stirred Immunity Measurements in a Reverberation Chamber

Corrections to RTCA DO-160 Section 20.6

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Outline

- Reverberation Chamber Basics
- DO-160 Section 20.6 and IEC 61000-4-21 Harmonization
- Electromagnetic Relationships
- Biased Results
- Remedies
- Conclusion

Reverberation Chamber Basics

Field measured with 3-axis probe

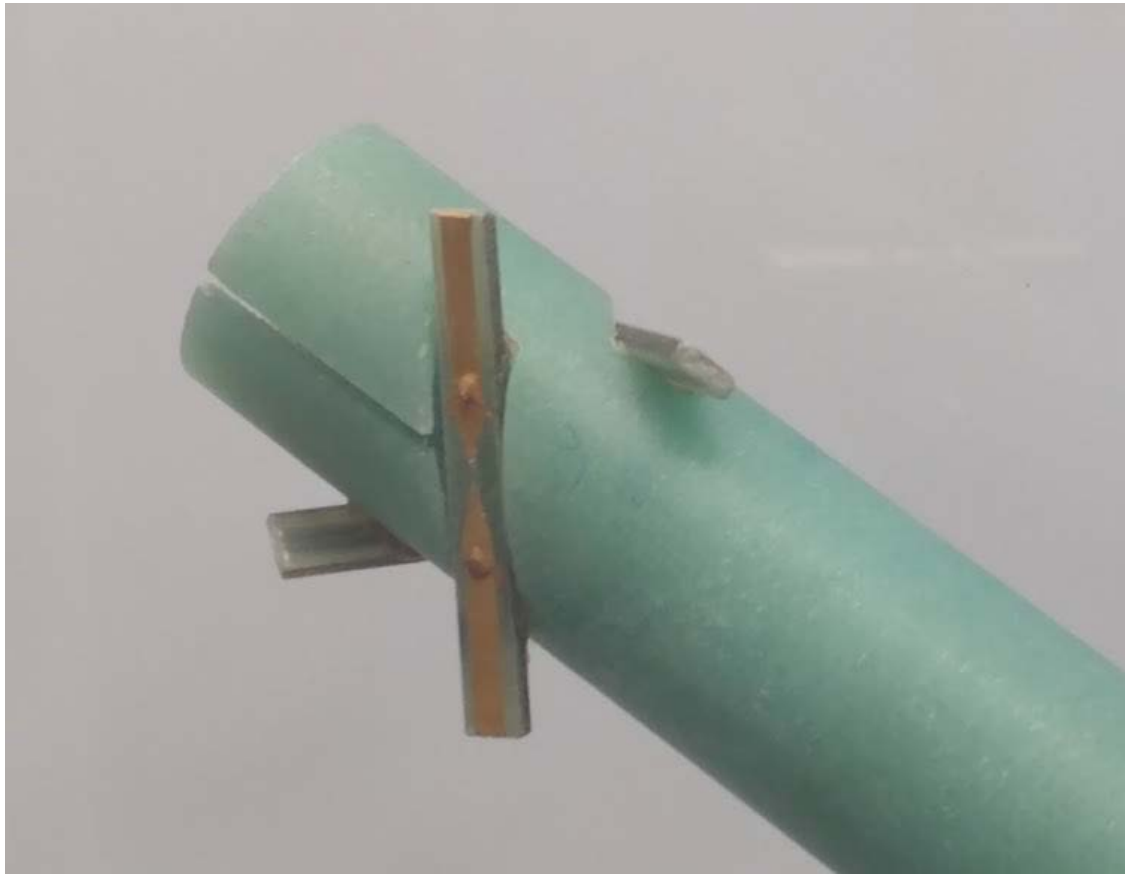
E_x, E_y, E_z … rect. component E_R

Approximately equal and uniform

Total Field = $E_T = \sqrt{E_x^2 + E_y^2 + E_z^2}$

$\langle E_T^2 \rangle \approx 3 \langle E_R^2 \rangle$ 4.77 dB higher

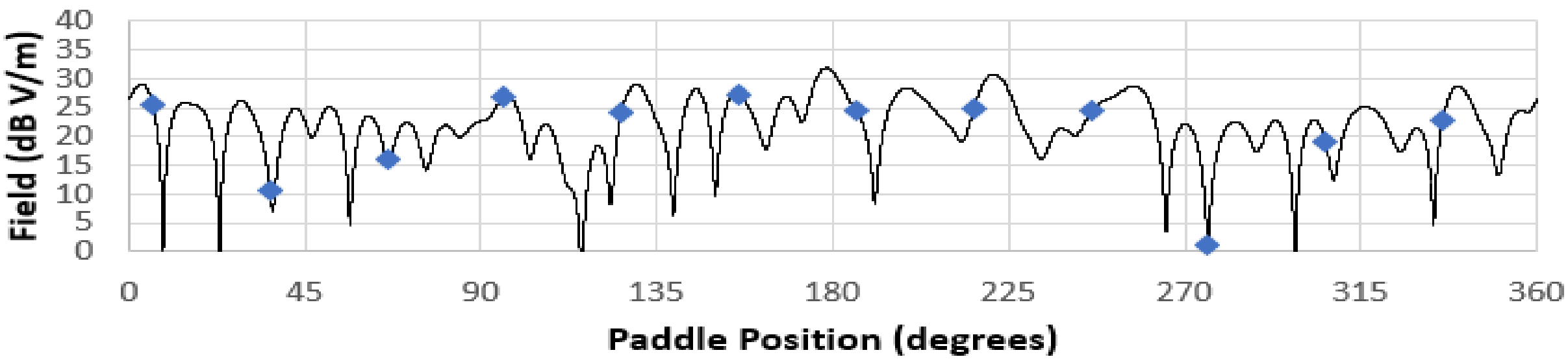
$\langle |E_T| \rangle \approx \frac{15}{8} \langle |E_R| \rangle$ 5.46 dB higher



For antenna, received power closely related to E_R^2

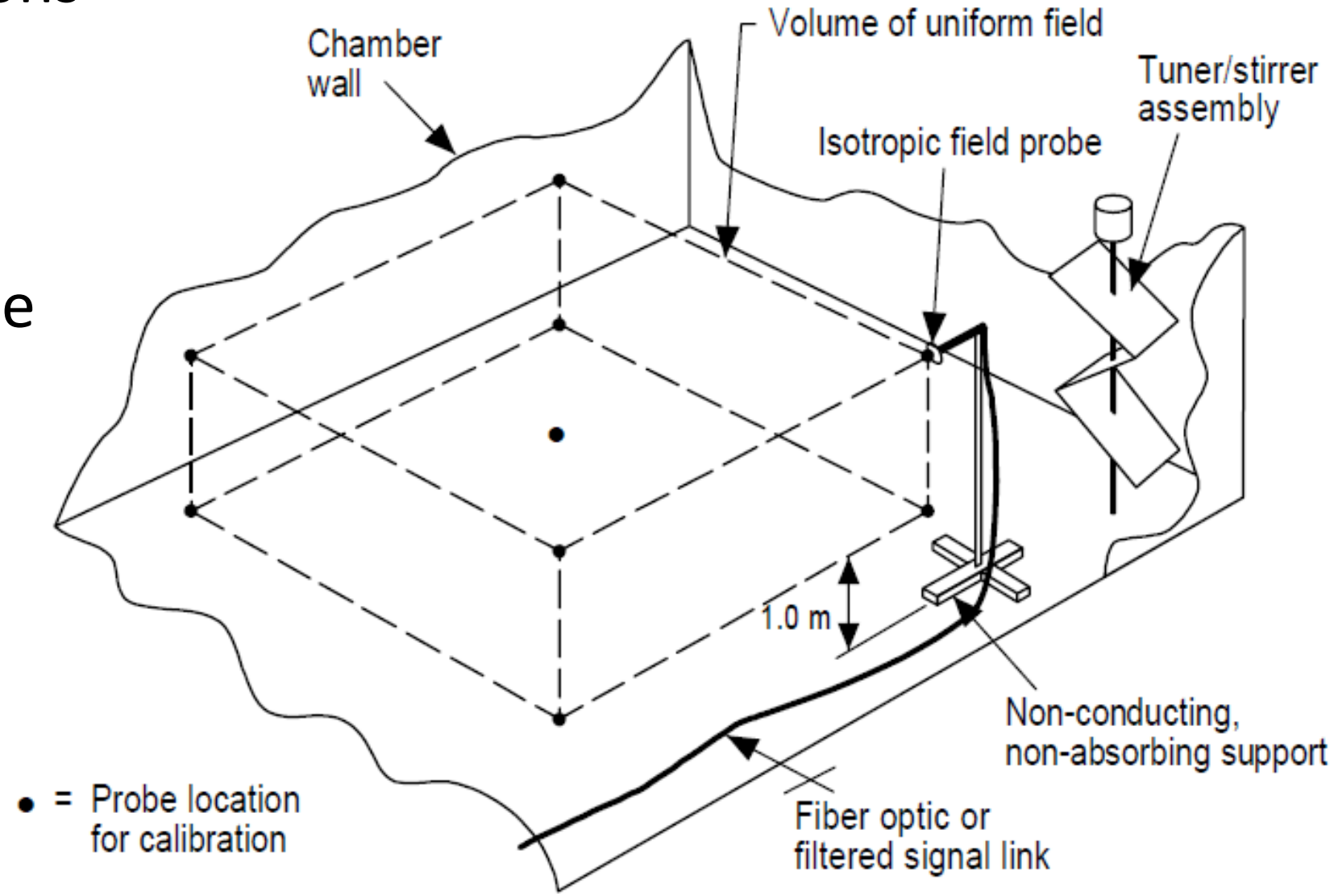
Stirring vs Tuning (perceived characteristics)

Tuning (stepped operation)	Stirring (continuous motion)
Slow	Fast
Stable	More thorough
Reliable	Simple
Strong theoretical support	Higher fields
Good measurement support	More accurate



Reverberation Chamber Calibration

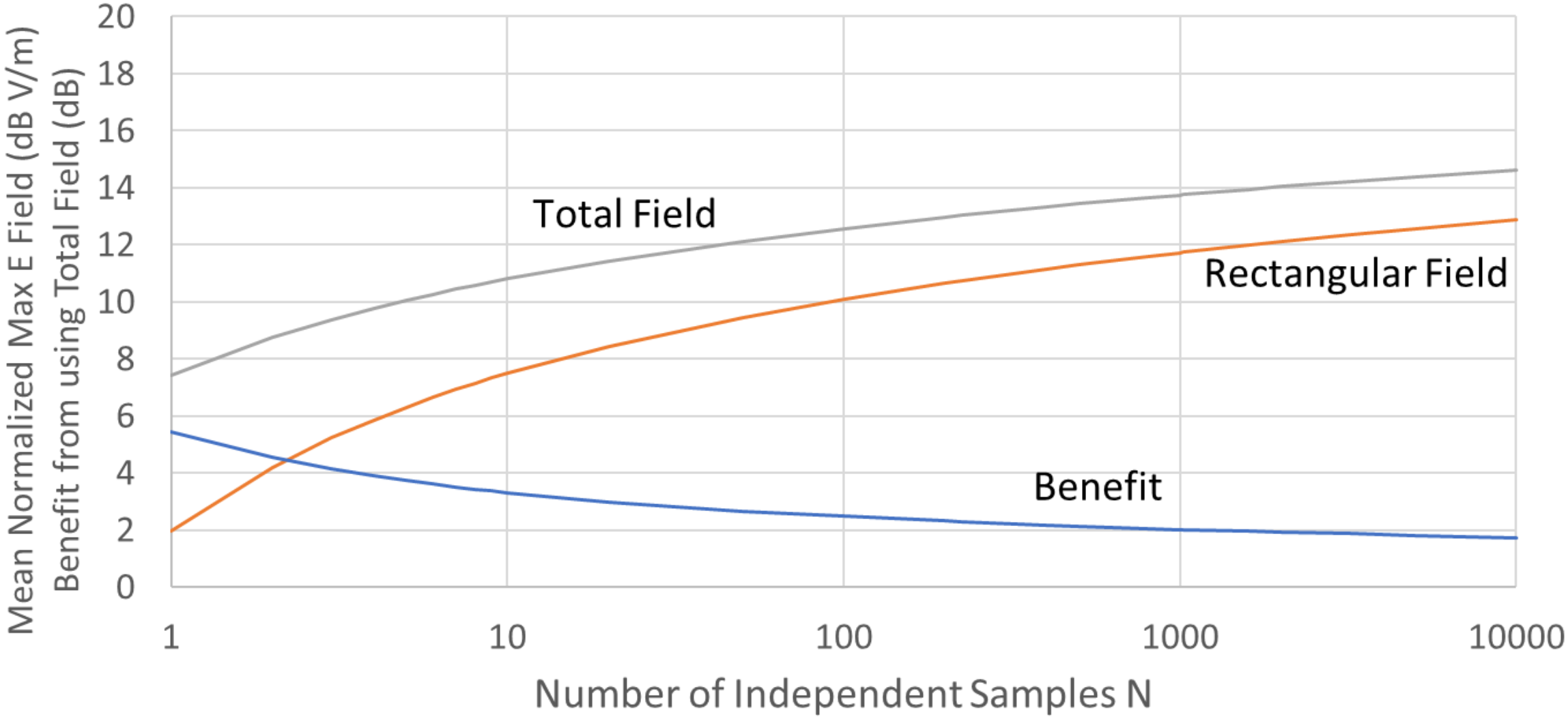
- 9 probe locations
- 3 orthogonal sensors/probe
- Stepped paddle
- *N* paddle positions
- Our Focus is Radiated Immunity



Once upon a time…

IEC 61000-4-21	RTCA DO-160
• 8 Probe Positions	• 9 Probe Positions
• Rectangular Field	• Total Field
• Stepped paddle	• Stirred paddle

Benefit from using Total field



*Benefit decreases with to stirring

Mathematical "Relationships"

Many relationships between ***AVERAGE*** field values available.

Squared Field Terms: $\langle E_T^2 \rangle,\ \langle E_R^2 \rangle,\ \langle H_T^2 \rangle,\ \langle H_R^2 \rangle, \langle P_{Rec} \rangle$

Field Terms: $\langle E_T \rangle,\ \langle E_R \rangle,\ \langle H_T \rangle,\ \langle H_R \rangle,\ \left\langle \sqrt{P_{Rec}} \right\rangle,\ \sqrt{\langle P_{Rec} \rangle}$

Similar Distributions

What electromagnetic parameters have similar distributions in a RC?

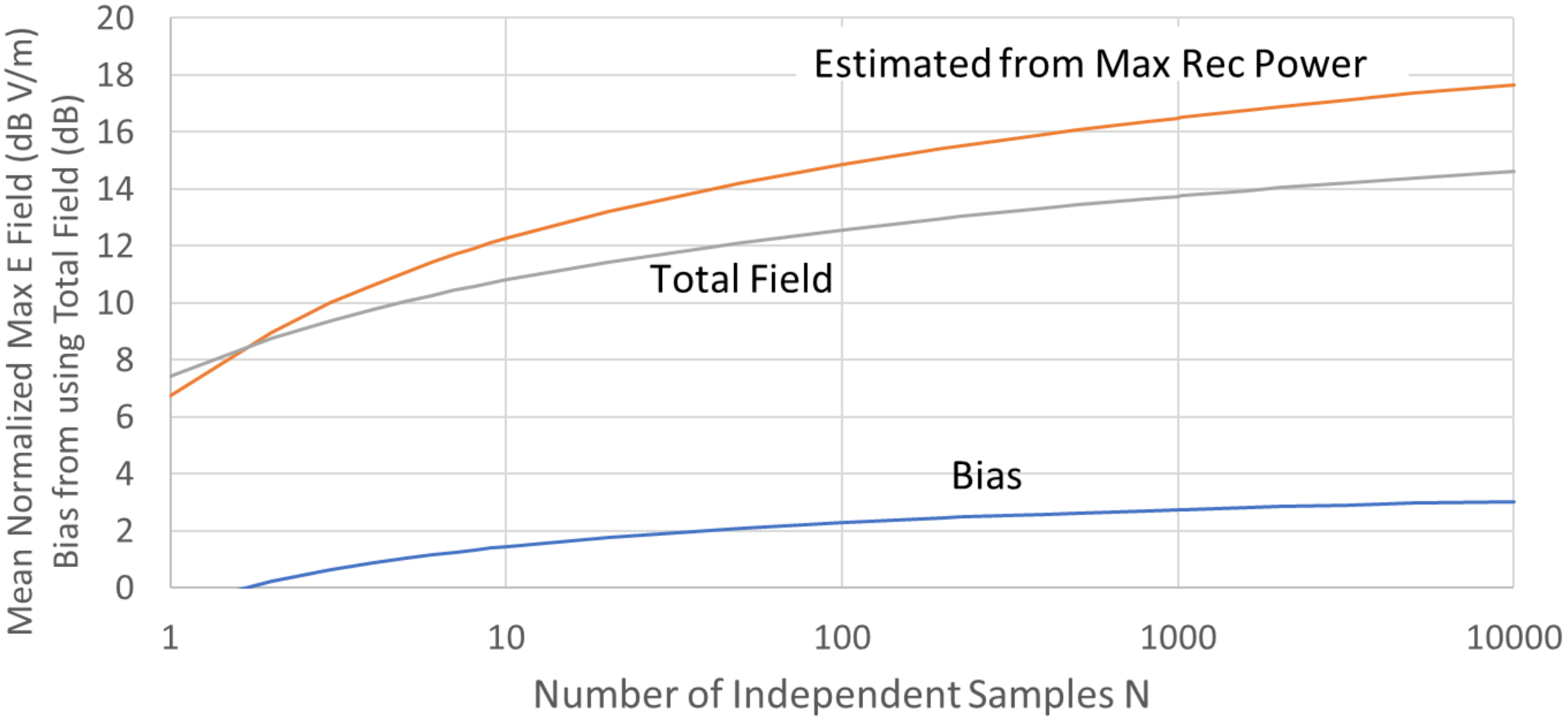
Squared Field Terms: E_R^2, H_R^2, P_{Rec} E_T^2, H_T^2

Field Terms: $E_R, H_R, \sqrt{P_{Rec}}$ E_T, H_T

Assumption: P_{Recmax} can be used to estimate E_{Rmax}^2 or E_{Rmax}, ***NOT*** E_{Tmax}

Caveat: $P_{Rec} \leq P_{In}$ so if losses are low (low frequencies), this approach will underestimate field.

Bias due to estimating max total field from received power



*Bias increases with to stirring

Remedies I

- Re-unify IEC 61000-4-21 and RTC DO-160
  - Advantages
    - Less expensive combined tests
    - Defensible
  - Disadvantages
    - Lose about 5 dB in field strength for a given input power
      - (but ~3 dB of that is from an error)
    - Impacts existing test results since 2000
- Accept the error
  - It's "only" ~3 dB
- Drop estimated test level by a constant offset
  - Say, about 3 dB

Remedies II

- Estimate number of samples
  - Very complicated

- Measure power from 3 antennas and compute $P_{Total} = P_1 + P_2 + P_3$
  - Requires 3 synchronized spectrum analyzers or power meters
  - Requires 3 antennas with known mismatch and efficiency values

- Use a power combiner and 3 antennas
  - Requires 3 matched antennas and cables

Conclusions

- Introduce stirring with care
- Order of operations matter
- Distributions matter
- Use care interchanging probes and antennas.
- Approach in RTCA DO-160G Section 20.6 introduced an error
- Requires a correction ~3 dB (needs twice the power)
- Several possible remedies
- Recommend 3-antenna and combiner approach