Uncertainty evaluations in EMC measurements

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Non - reproducibility of radiated emission tests

- Presentation mainly focused on this topic
- The contribution due to test site imperfections will be analyzed
- Important subject per se
- All the typical ingredients of EMC measurement uncertainty evaluation are involved

Sources of non – reproducibility of radiated emission tests

- Imperfections of:
  - Test sites
  - Antennas
  - Receivers
  - Connections
  - Set-up (geometry)
- EUT (intrinsic instability, layout of cables and auxiliary equipment)

Isolating the contribution due to test site imperfections

- Collaborative exercise performed: radiated emission measurement repeated in several different test sites
- Same instrumentation involved in each site (field source, receiving antenna, spectrum analyzer, cables)
- Same geometry, same measurement procedure (pre-defined measurement protocol), same personnel

Test sites involved

- Compact size fully anechoic rooms
- 14 nominally equivalent sites investigated
  - 30 – 300 MHz frequency range
  - Vertical polarization
  - Received power (dBm) is the measured quantity

Resolving power of the method

- Ability to discriminate a site from another
- Limited by measurement non repeatability

Achieving repeatability

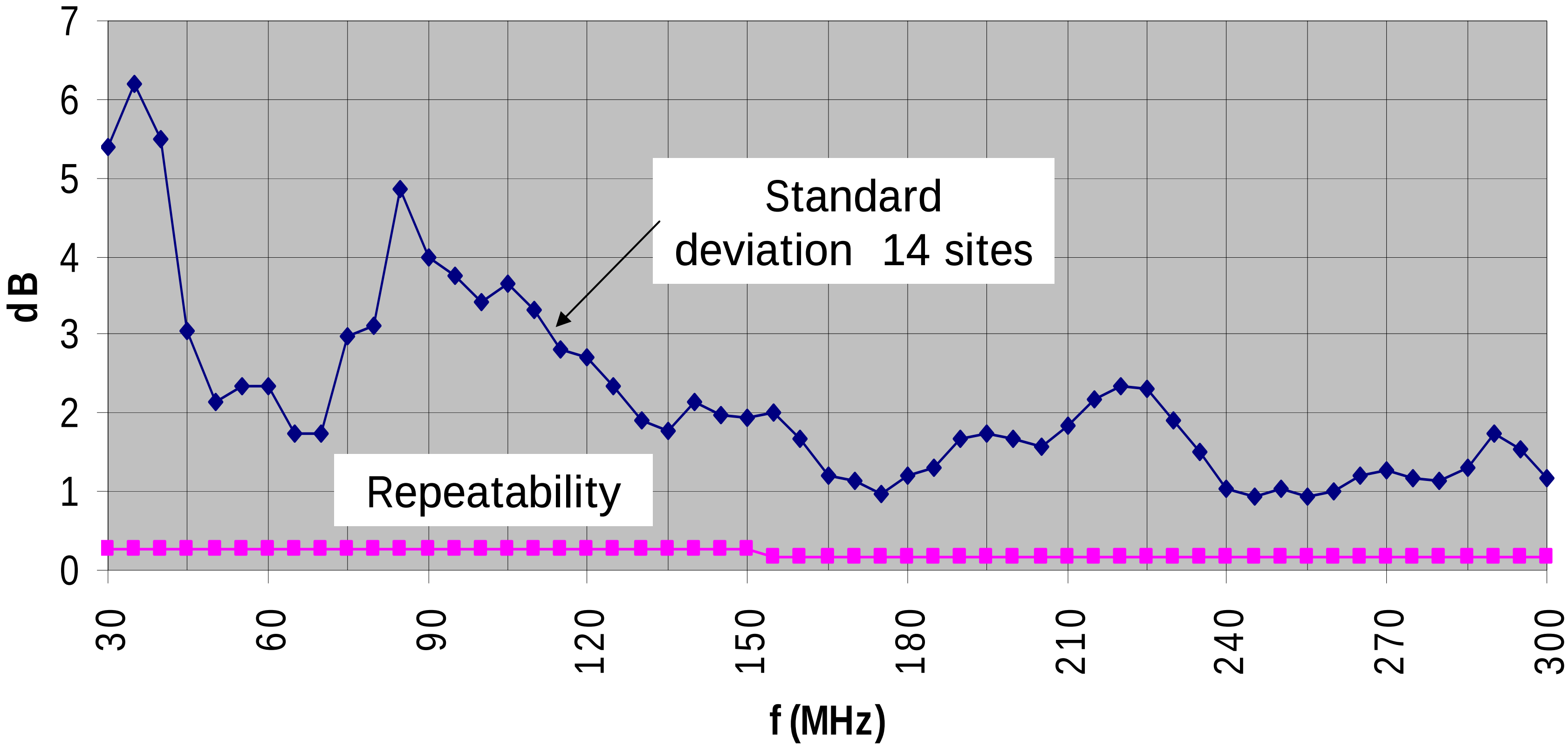
- Stable field source, battery operated
- Care of positioning (distance and mutual alignment)
- Well balanced receiving antenna
- Weak coupling with and reflections from the length of cable inside the room
- High signal to noise ratio and numerical averaging
- Spectrum analyzer warm-up and self calibration
- Automatic measurement

Repeatability quantified

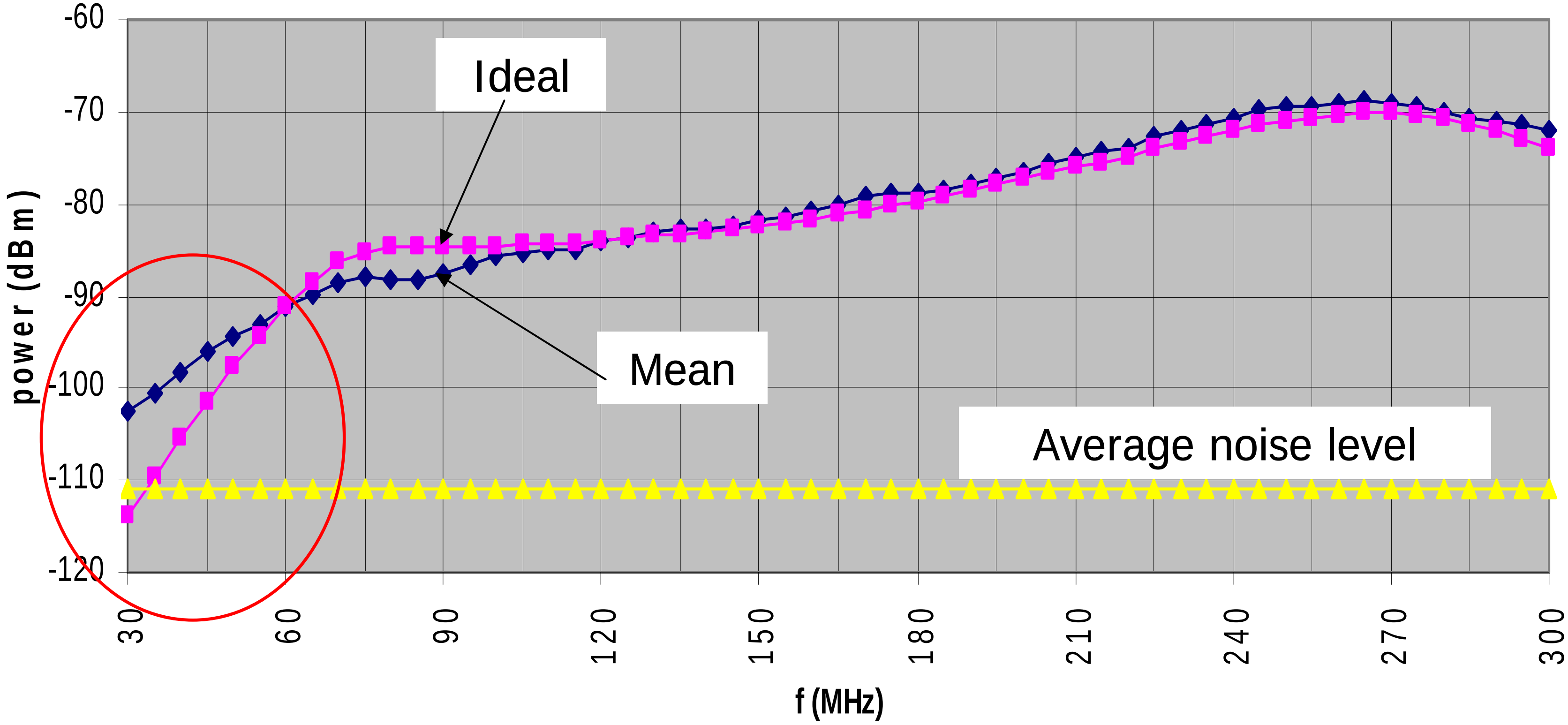
Spectrum Analyzer noise	± 0.2 dB (± 0.02 dB)
Spectrum Analyzer amplitude resolution and repeatability	± 0.1 dB
Generator instability (intrinsic + thermal fluctuations)	± 0.05 dB
Positioning uncertainty	± 0.02 dB
Inversion test	± 0.14 dB
Total	± 0.27 dB (± 0.18 dB)

- Repeatability better than 0.3 dB or 0.2 dB (1 std. dev.), depending on the signal to noise ratio

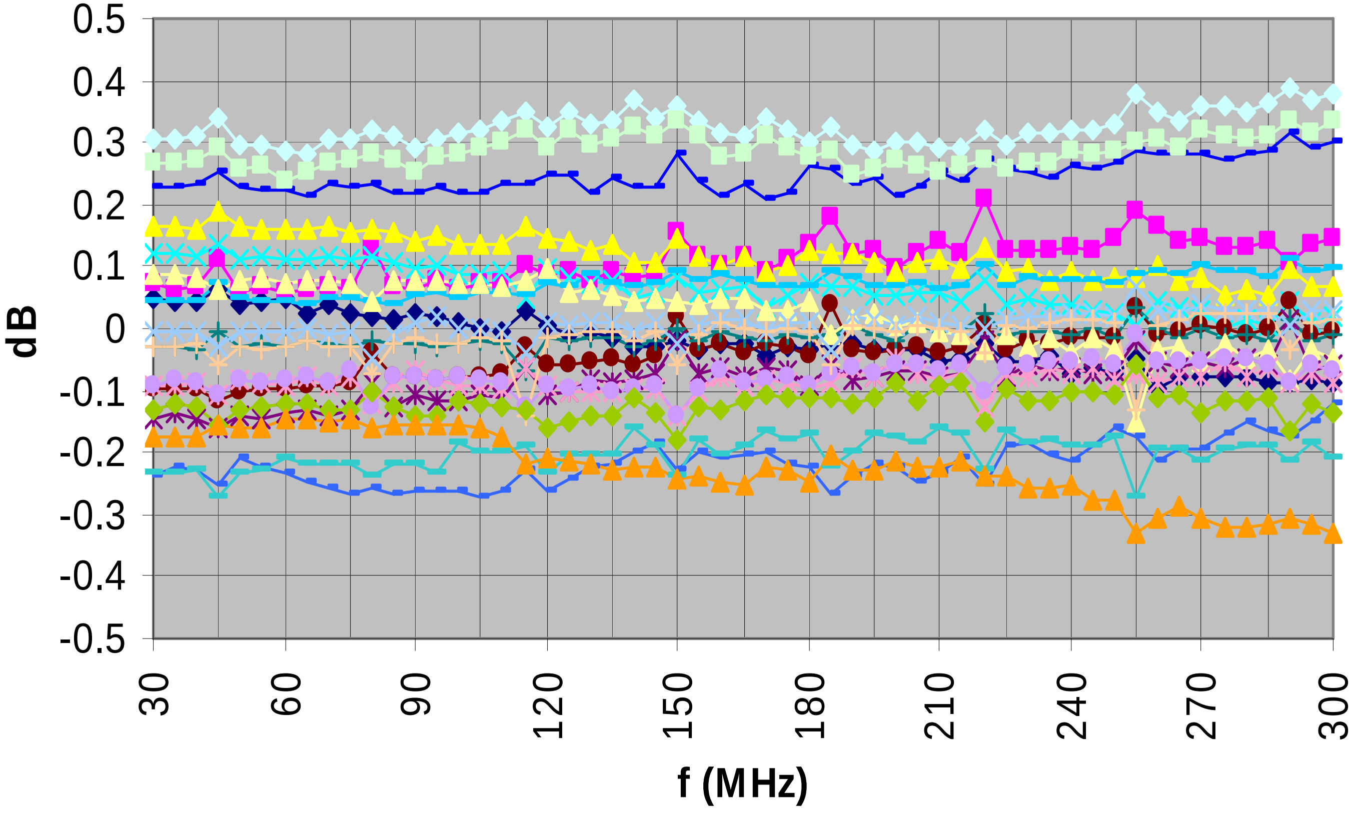
Results: dispersion among sites



Results: mean received power vs. prediction in ideal empty space



Results: source + spectrum analyzer observed instability

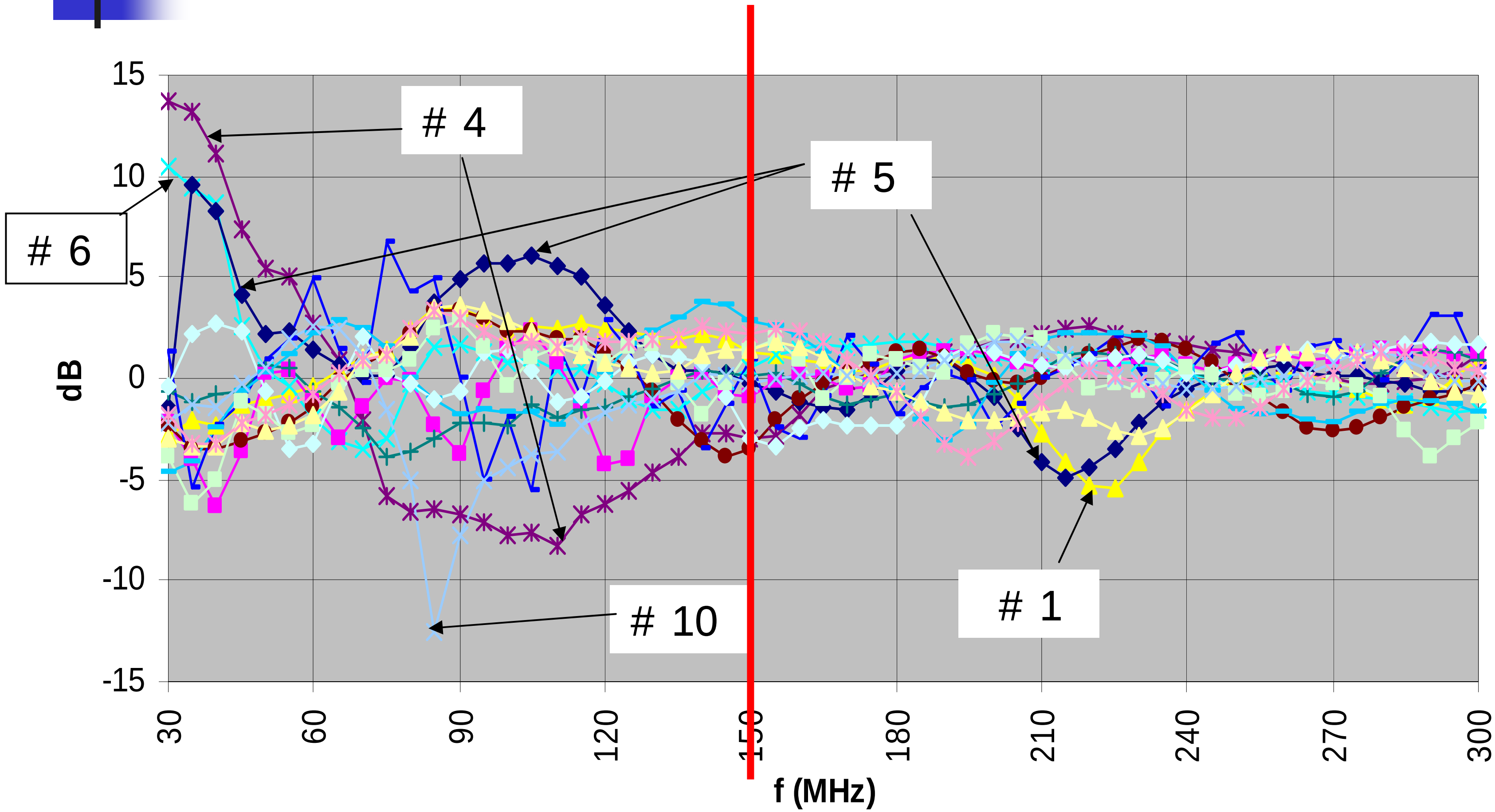


- Observed
  0.16 dB std. dev.
- Predicted
  0.11 dB std. dev.

Questions

- Sites investigated “equivalent”?
- Deviation dominated by a minority of bad performing sites?
- Correlation with sites’ physical structure possible?
- Site correction factor?

Deviations from the mean



Sites' structural characteristics

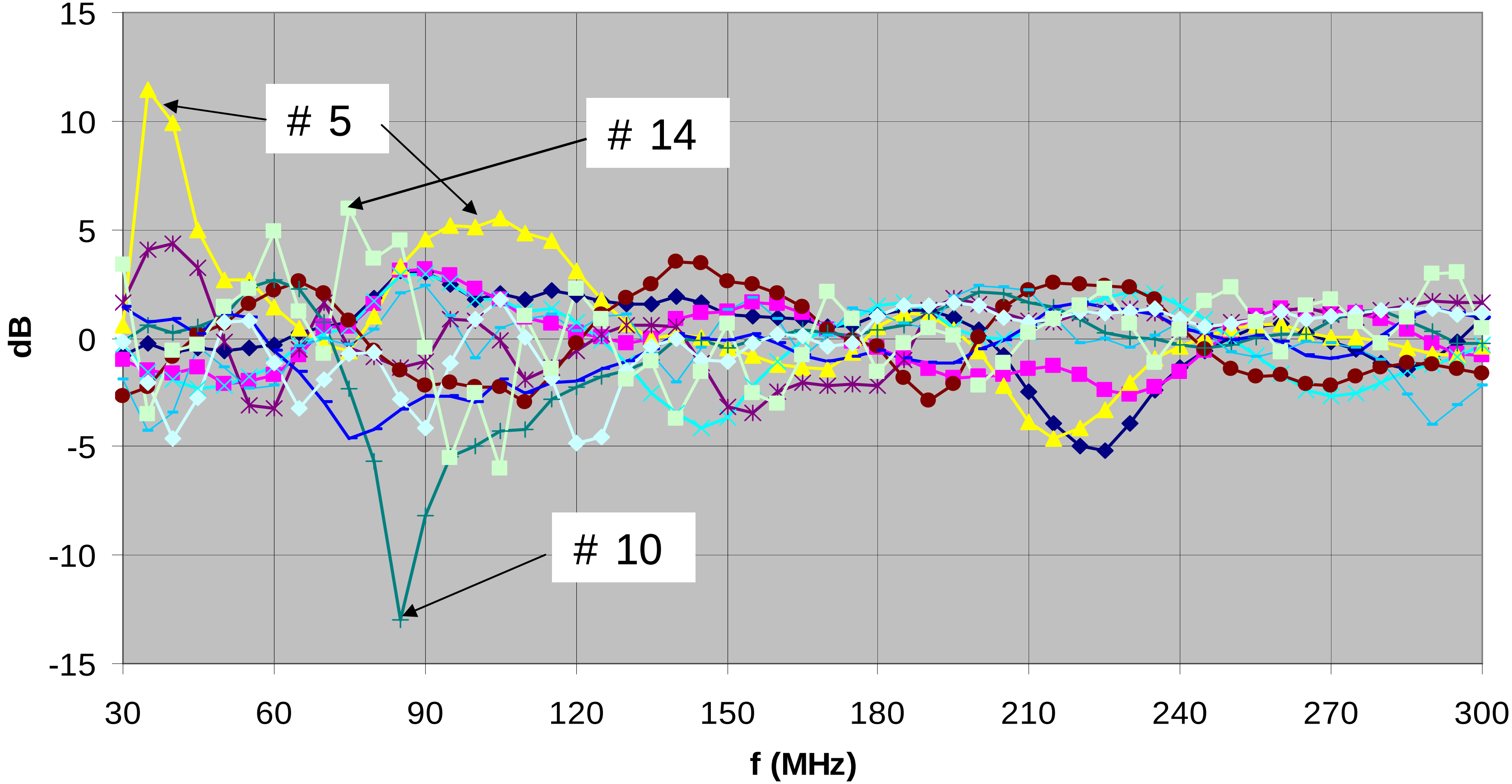
Site #	Volume (m^3)	Absorbing lining
1	63	Ferrite
2	93	Ferrite + Pyramid 45/60 cm
3	101	Ferrite + Pyramid 50 cm
4	105	Pyramid 60 cm
5	112	Ferrite + Pyramid 32/50 cm
6	134	Pyramid 30/55/65 cm
7	150	Ferrite + Pyramid
8	216	Ferrite + Pyramid 10/30/50 cm
9	321	Ferrite + Pyramid 45 cm
10	323	Ferrite
11	324	Ferrite + Pyramid 50 cm
12	371	Ferrite + Pyramid 50/200 cm
13	743	Pyramid 60 cm
14	1152	Pyramid 60 cm

small

medium

large

Deviations from the mean (removed small sites without ferrite)

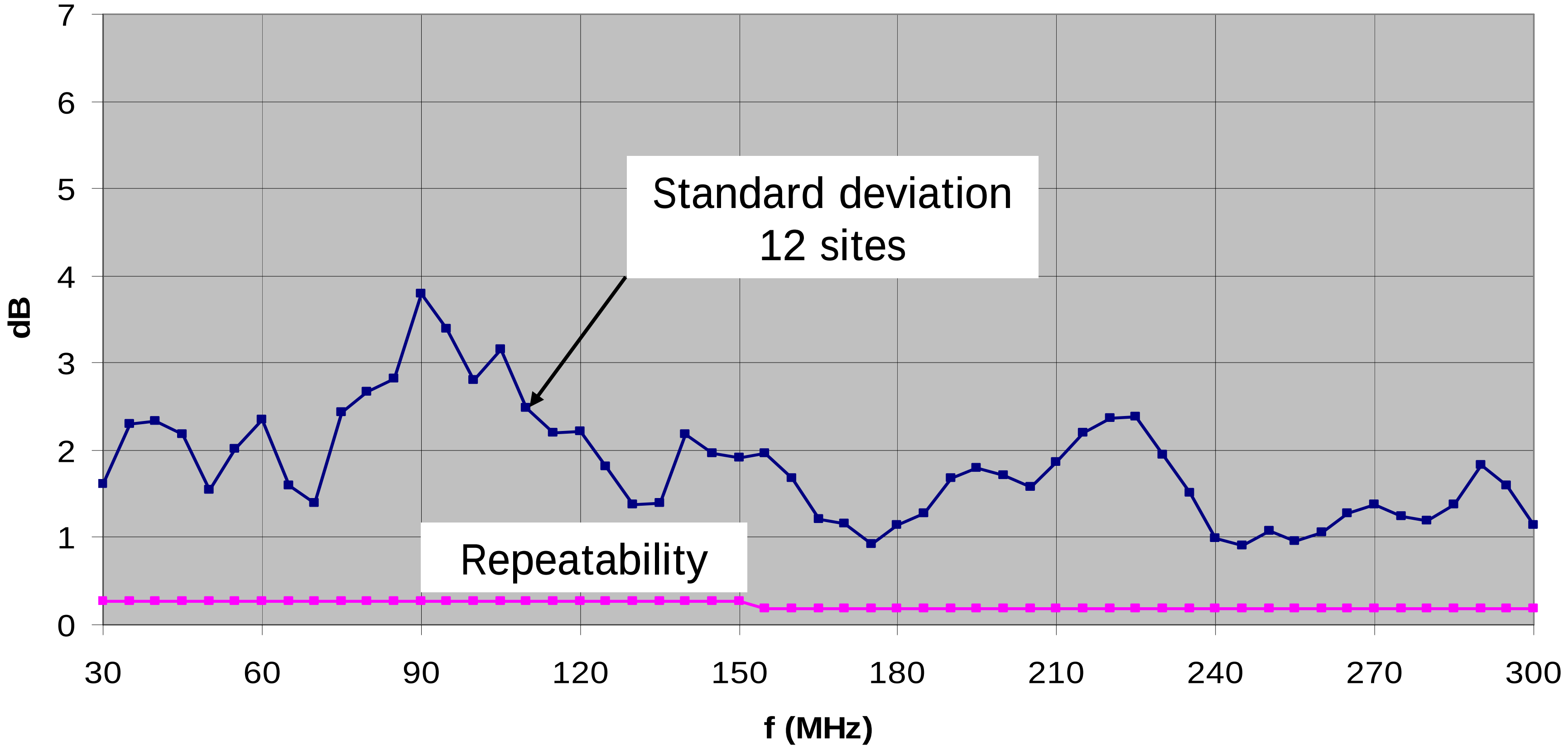


Rejecting outliers

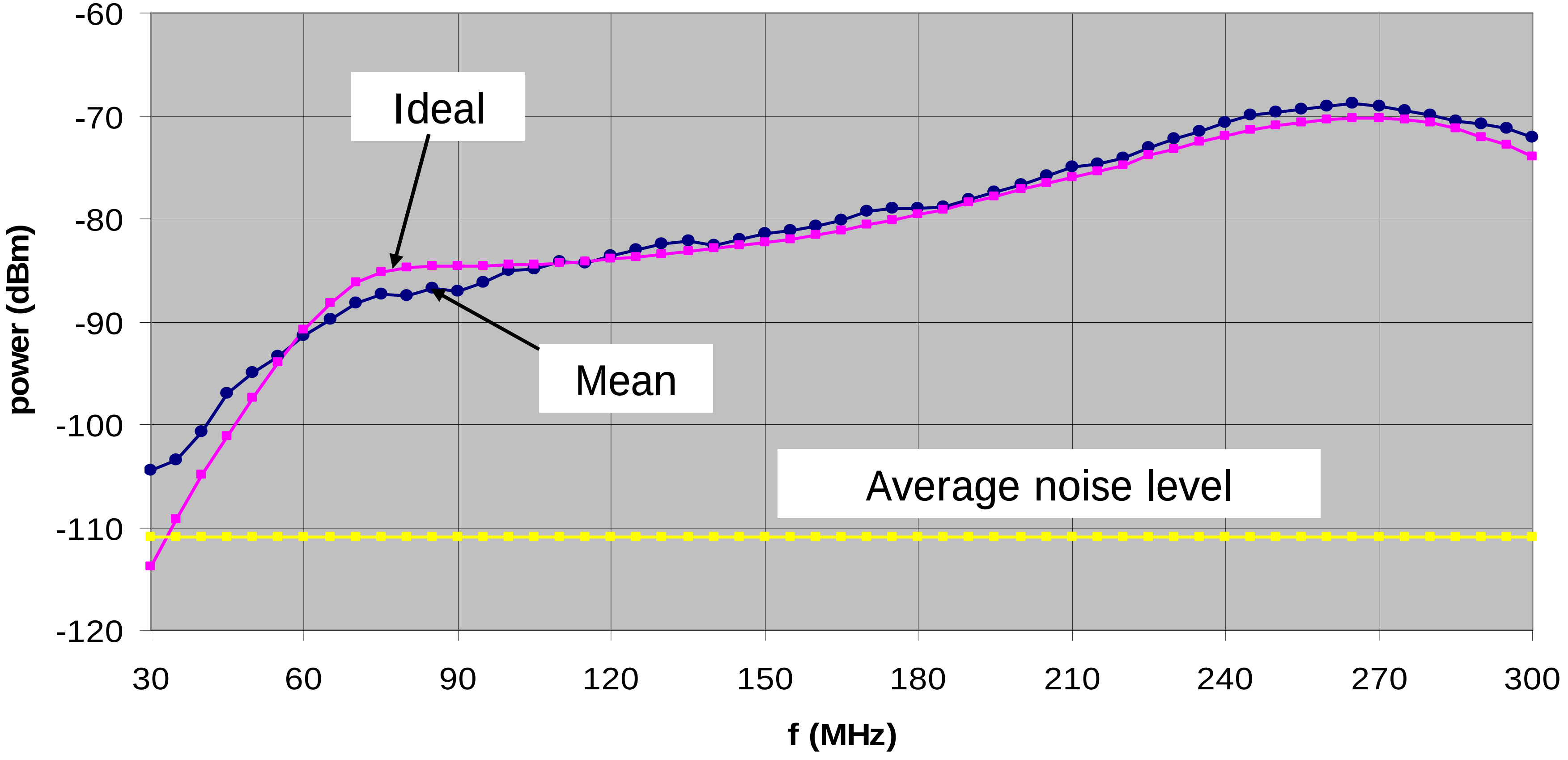
# outliers	site #
6	5
4	14
3	10
2	13
2	1
2	7
1	8
1	2
1	12
1	11

- Chauvenet's rejection criterion applied at each frequency
- 23 outliers distributed over 10 sites
- Site #5 worst performing: 6 outliers
- Decision to reject 3 measured values: 2 (site 5) + 1 (site 10)
- We are not rejecting blunders (risk missing information)

Dispersion:
2 sites removed and 3 outliers rejected



Mean:
2 sites removed and 3 outliers rejected



What we conclude

- Need of inter-laboratory comparisons (both collaborative exercises and proficiency tests)
  - Reproducibility quantified
  - Get physical insight
  - Uncertainty evaluation applied
  - Lab personnel involved in non-standard experiments
  - Not expensive practice
  - If well designed can cover any type of EMC test (RE, RS, CE, CS)

A note on uncertainty calculations in EMC

- Quite large deviations
- Extensive use of dB units
    - A problem when mixing natural and logarithmic quantities
- Specific asymmetric probability density functions involved
    - Log-normal
    - Rice (weak signal plus receiver noise, strong multipath interference)
- All these analytical aspects dealt with in GUM supplement 1

Thank you for your kind attention