# Early Design Criteria for Multipurpose Cultural Houses

by Anders Buen

# Early design criteria for multipurpose cultural houses

## A statistical study of measured hall data

Anders Buen, Brekke & Strand akustikk as

# Sources - Reference data

**Objective evaluation of chamber-music halls in Europe and Japan**[a)]

Takayuki Hidaka[b)] and Noriko Nishihara
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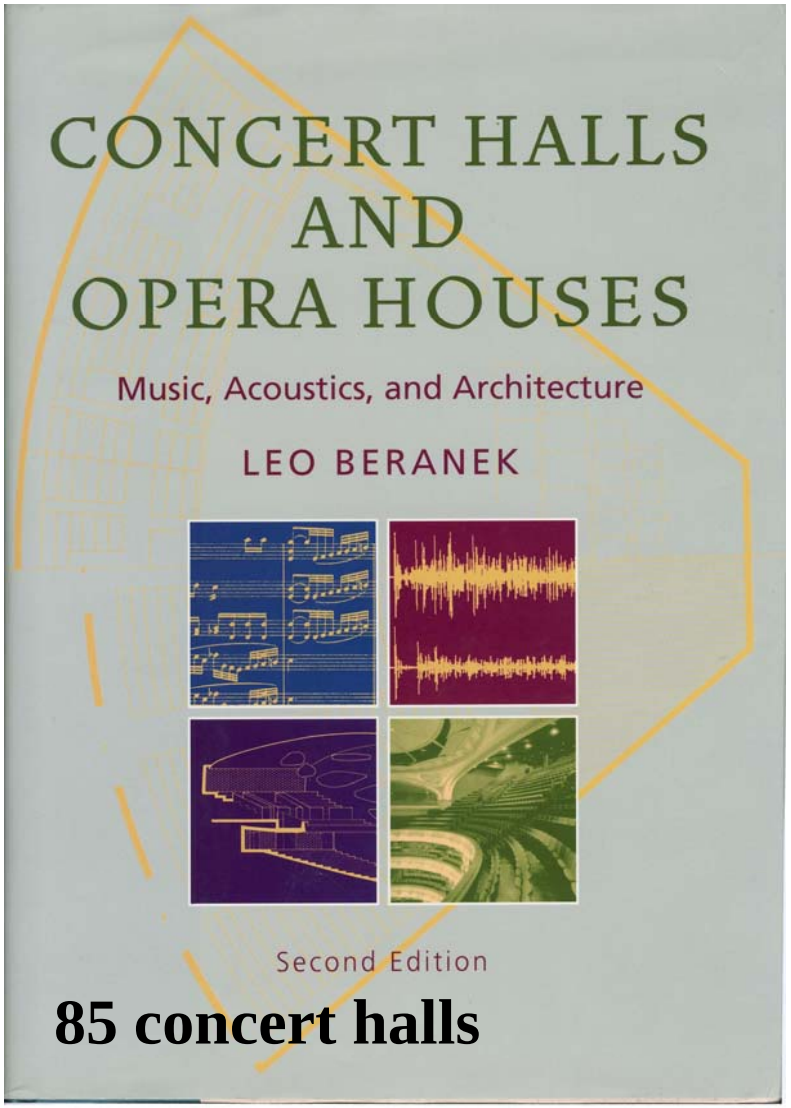
The room acoustical parameters reverberation time, RT; early decay time, EDT; clarity, $C_{80}$; time gravity, $T_g$; bass ratio, BR; strength, $G$; initial time delay gap, ITDG; interaural cross-correlation coefficient, $IACC_E$, the where binaural quality index BQI equals $[1\text{-}IACC_{E3}]$; and stage support, ST1 were measured in 18 major chamber-music halls in Austria, Germany, the Netherlands, Czech Republic, Switzerland, and Japan, employing procedures in accordance with ISO 3382 (1997). In combination with the architectural data, the intrinsic objective parameters for the acoustics of chamber-music halls and their variation range were examined. The results of these studies reveal four pertinent orthogonal parameters: RT, $G$, ITDG, BQI. General design guidelines for a chamber-music hall are presented. © *2004 Acoustical Society of America.*
[DOI: 10.1121/1.1760112]

PACS numbers: 43.55.Fw, 43.55.Gx, 43.55.Hy [MK] Pages: 357–372

**18 chamber music halls**

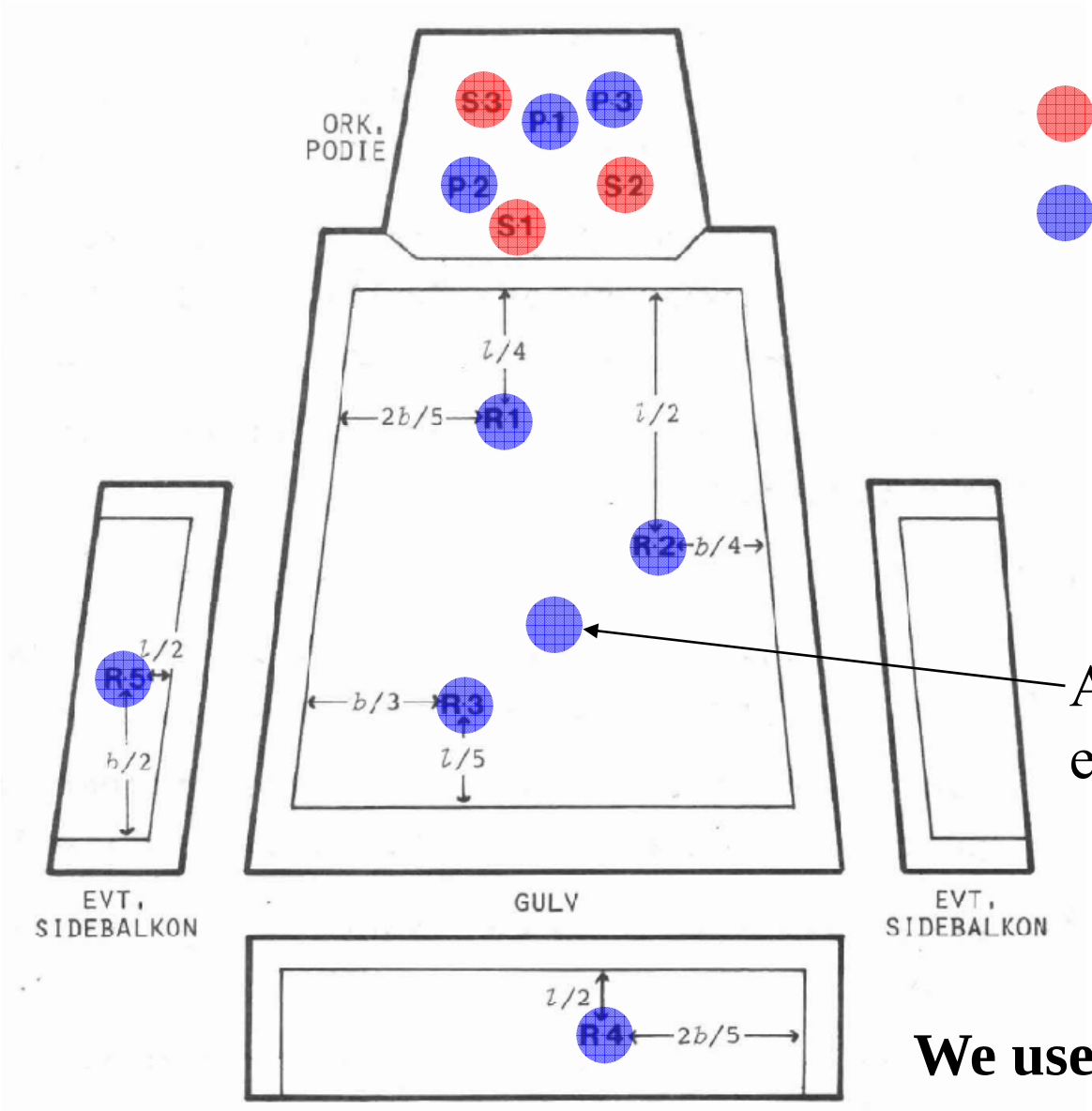



**85 concert halls**

# Sources - recommendations

- NBI Handbook 20 ”Room acoustic projecting”
- Recommendations from the Council for Musical Organizations in Norway (CMON)


# Measurement positions from A. C. Gade



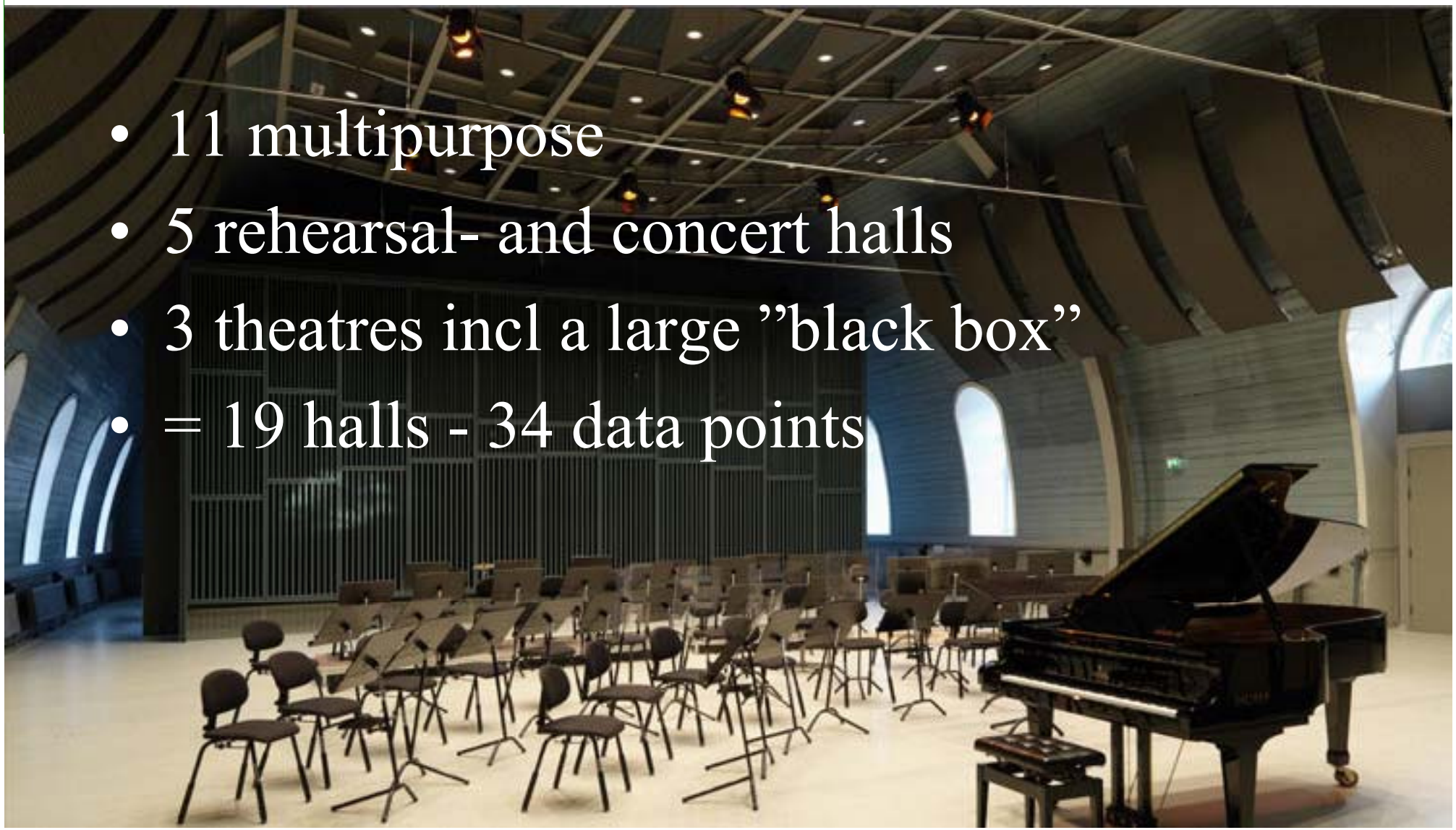

Sources (Loudspeaker)

Receivers (Microphone)

A receiver also in the sound engineers position

**We use hall averages in this study**

# Measured halls



- 11 multipurpose
- 5 rehearsal- and concert halls
- 3 theatres incl a large ”black box”
- = 19 halls - 34 data points

# Some definitions

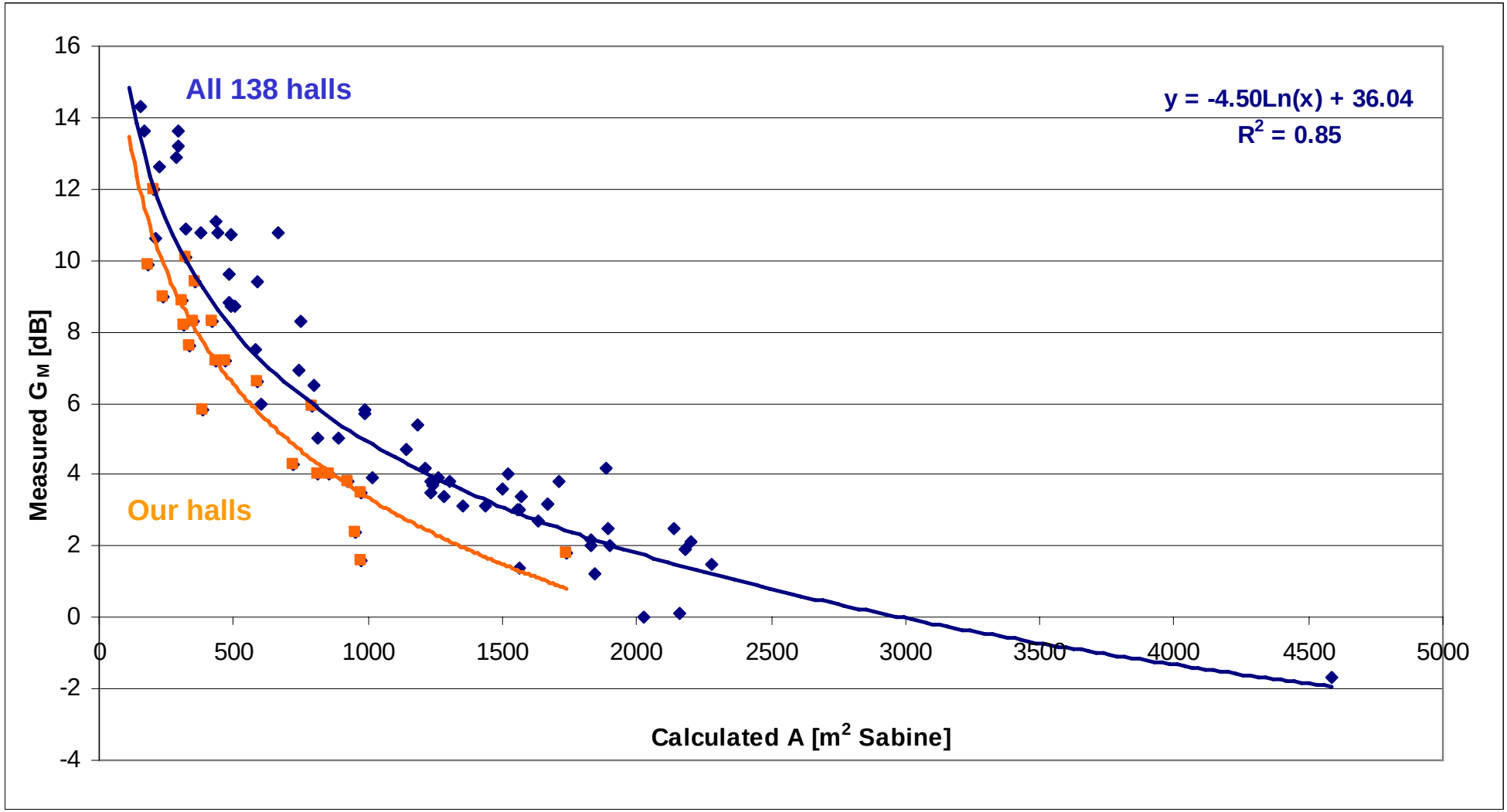
- V = hall and scene volume [$m^3$]
- N = Number of seats
- V/N = Volume per seat [$m^3$]
- $RT_M$ = Mid frequency reverberation time [s]
- G = Loudness, the measured sound pressure level in relation to the $SPL_{free\ field}$ at 10m [dB]
- $A_M$ = Calculated absorption area [$m^2$ Sabine]

# Some hall data averages

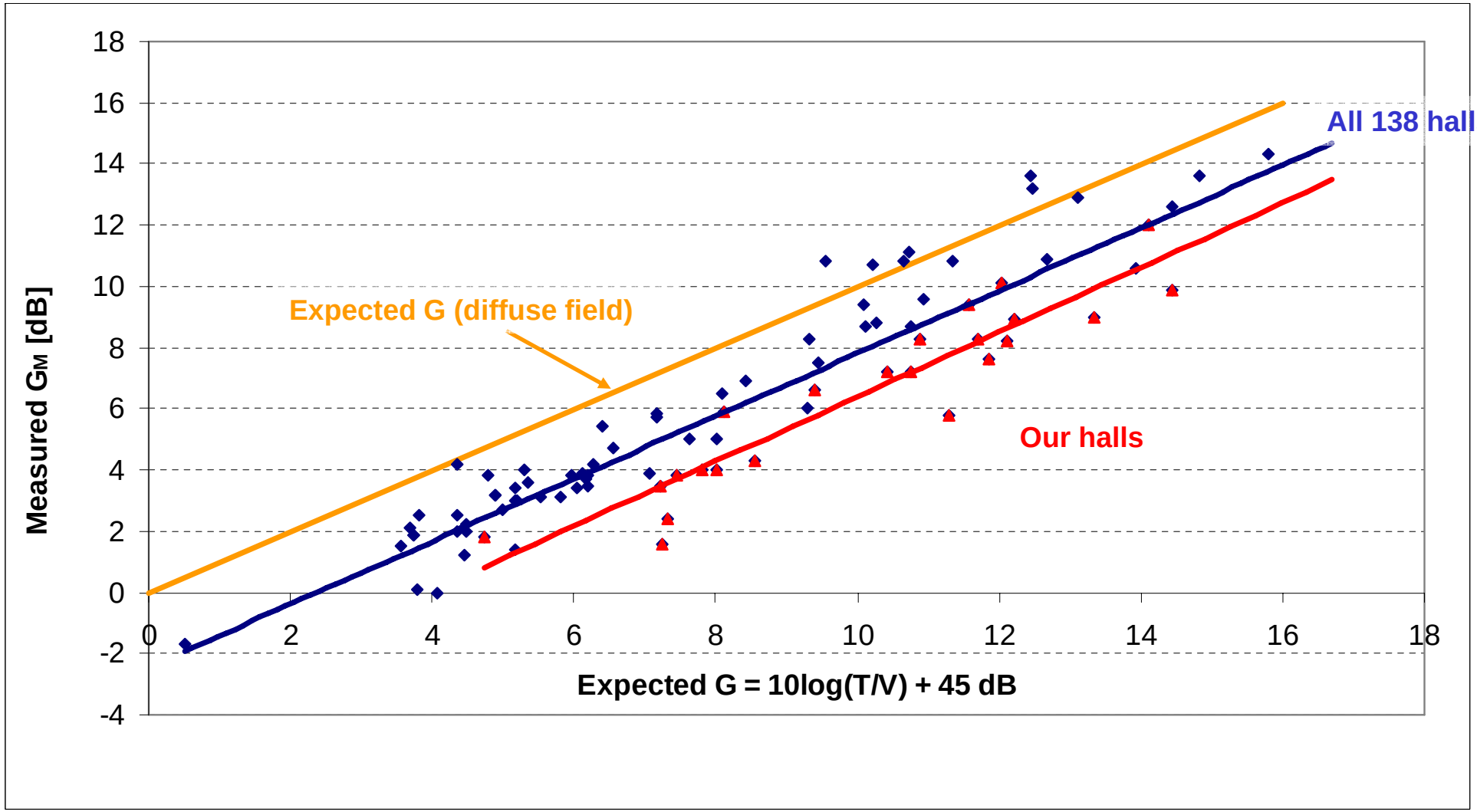
| Type hall | V [$m^3$] | N | V/N [$m^3$] | $RT_M$ [s] | $G_M$ [dB] | $A_M$ [$m^2$ Sabine] |
|---|---|---|---|---|---|---|
| Chamber | 4100 | 530 | 8 | 1.8 | 11 | 400 |
| "Our" | 4900 | 360 | 14 | 1.4 | 7 | 600 |
| Concert | 20500 | 2200 | 10 | 2.2 | 4 | 1500 |

- Our halls are:
  - less reverberant, in spite of larger volumes per seat and
  - moderately loud

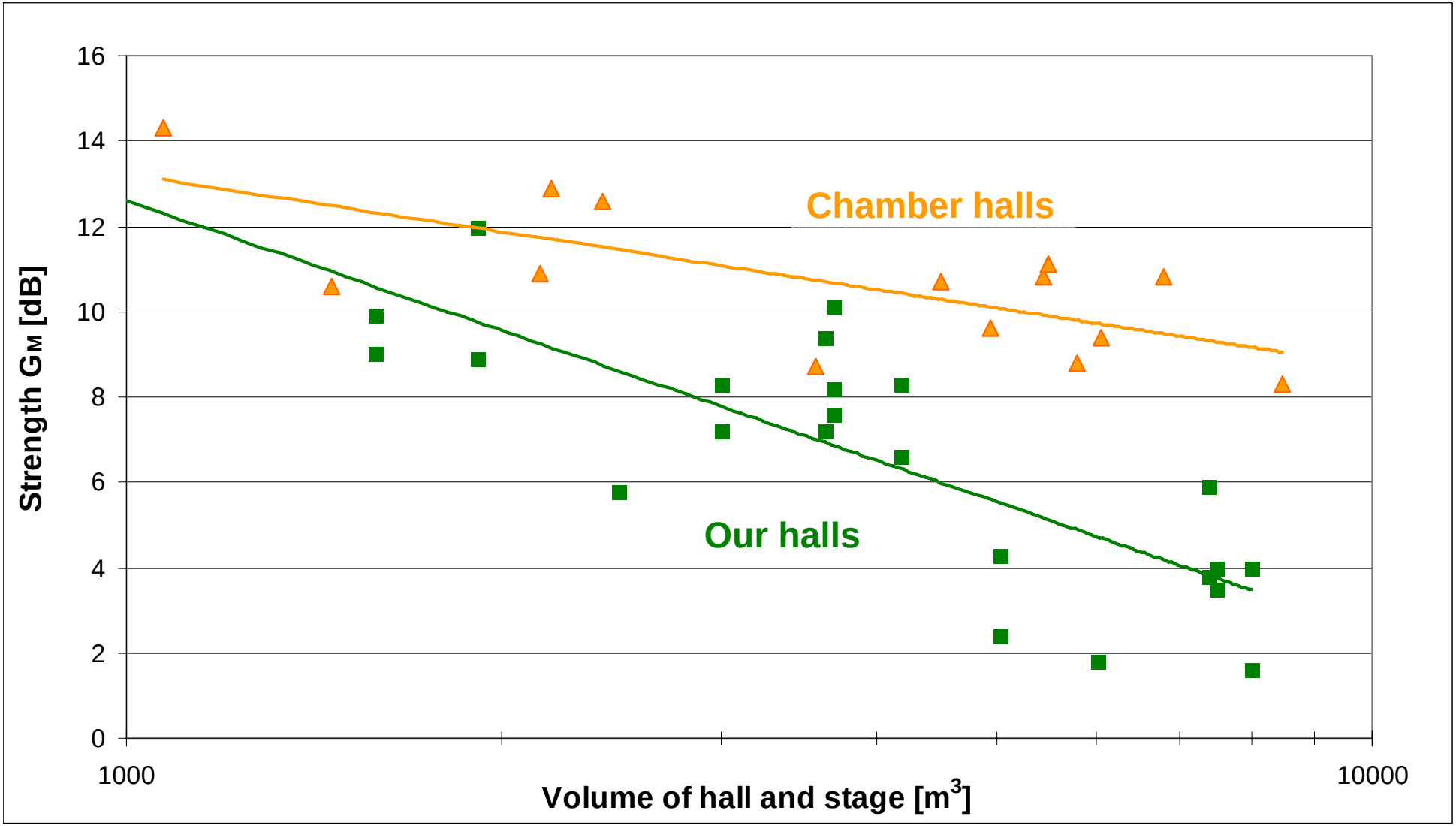
# Measured G versus absorption area, A



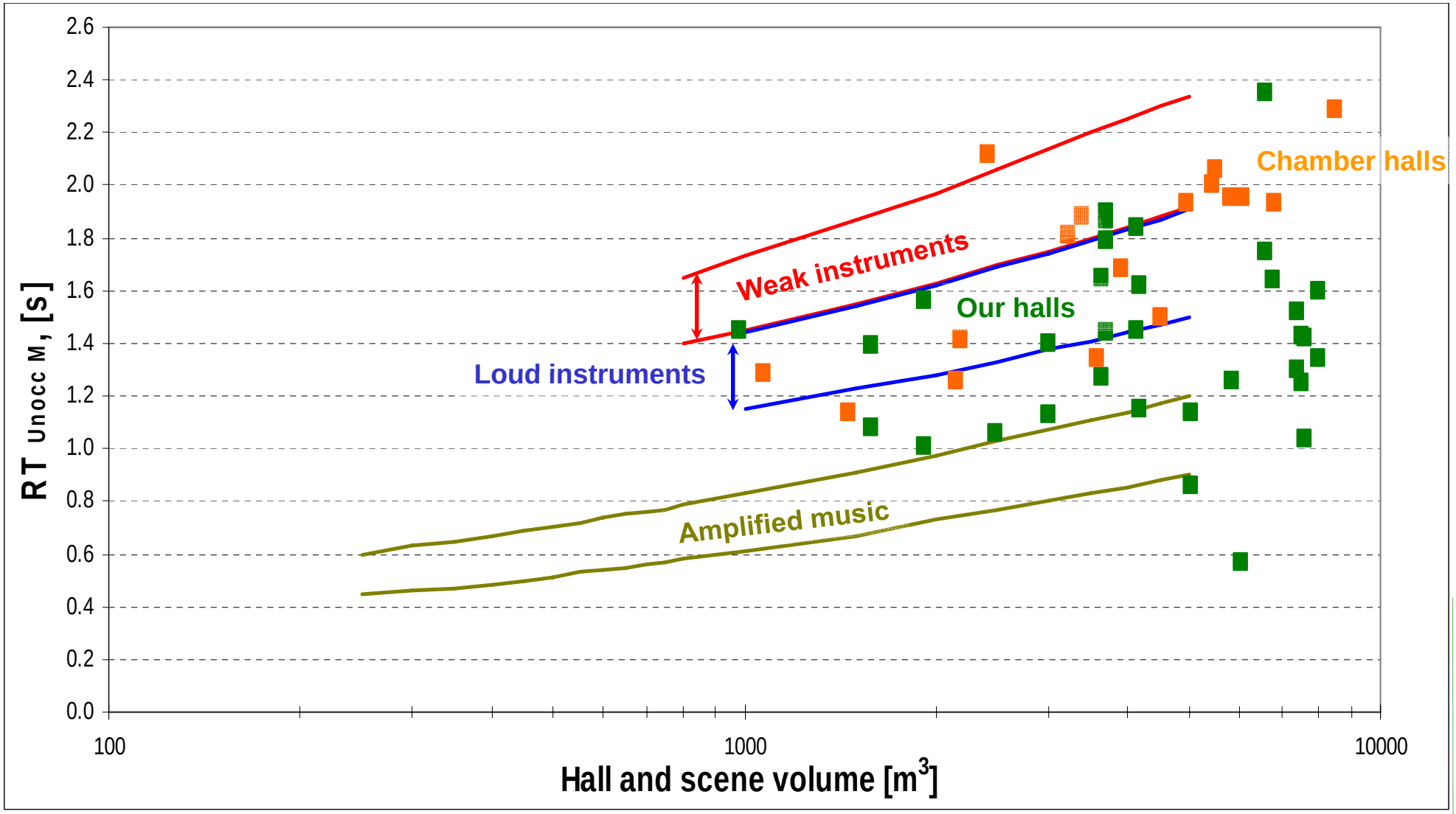
# Measured versus expected G



# Measured Strength G and volume



# Meas RT and CMONs (Musikkrådets) requirements

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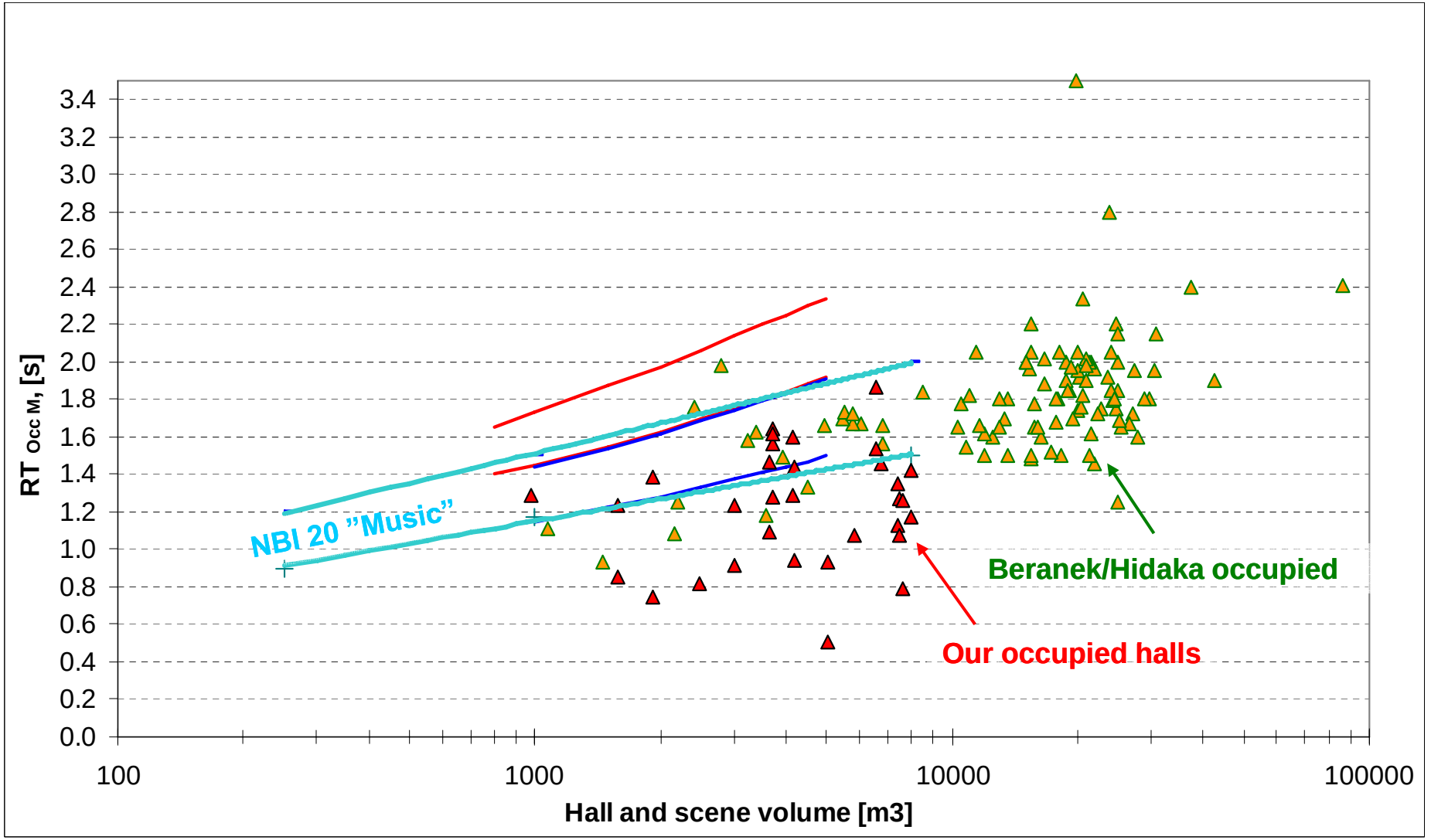
# NBI 20 and CMON (Musikkrådet) RT requirements

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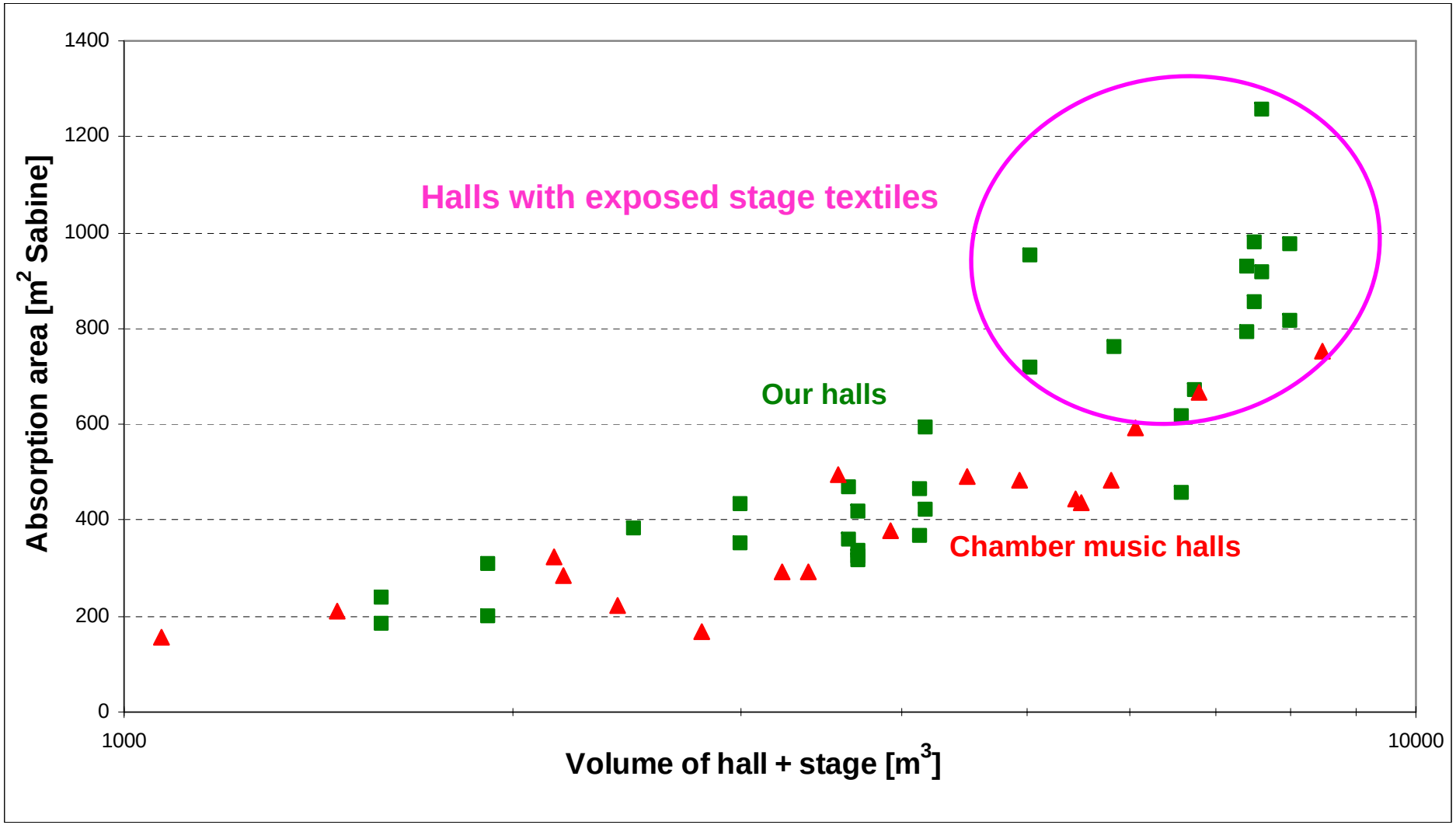
# How much variation can be achieved?



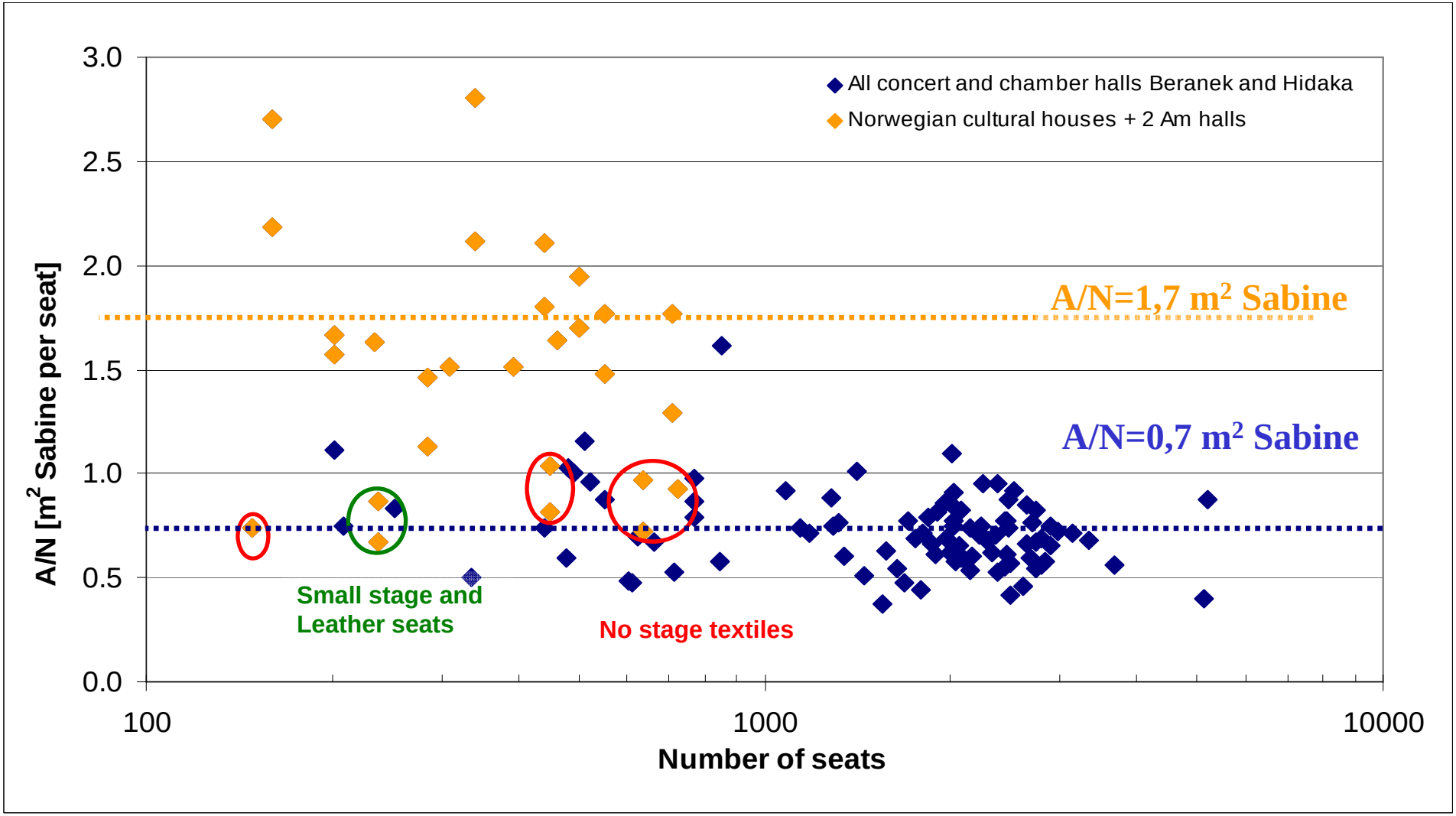
# How much variation can be achieved?

- Larger halls: A ≈ 800m$^2$
- 33% variation from 1,5s to 1 s:
  - Needed var abs: 500m$^2$ Sabine = 1000m$^2$ ($\alpha$ = 0.5)
  - Available surfaces: < 700m$^2$

- Our best results: 250m$^2$ and 340m$^2$ Sabine

- Achieveable variation with stage textiles:
  - $\Delta$RT = 0,2 - 0,3s
  - $\Delta$G = 1 -2 dB

# Unoccupied absorption per seat A/N



# Volume per seat requirement

## Halls with stage textiles:

A/N = 1,7 $m^2$ Sabine per seat

RT ≥ 1.6s -> V/N > 21$m^3$ per seat

Ceiling height: ≥ 15 m

## Halls with no stage textiles:

A/N = 0,7 $m^2$ Sabine per seat

RT ≥ 2s -> V/N > 11$m^3$ per seat

# Conclusions

- The absorption in halls with stage textiles is about 1m$^2$ Sabine per seat larger than in halls without
- These halls are less loud at the same volume
- Variations in RT of about 0,2-0,3 s is achieveable. If more is needed, the stage textiles will need to be removed
- We need investigations into how well the multipurpose halls are functioning acoustically