LATERAL EFFICIENCY IN SMALL AUDITORIUMS

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ABSTRACT

The paper will examine the measured lateral efficiency parameters measured in small and medium sized halls, that is halls with less than 750 seats. Comparisons between measured LF and IACC parameters will be presented as well as a study of the correlation between the lateral efficiency parameters and the width and other geometrical attributes of the halls. The measurements were done as part of a larger survey of the Finnish halls that were built between 1980 and 2000.

1. INTRODUCTION

This paper is based on the measurements done as part of the PhD project of one of the authors (Möller) at the Theater Academy of Finland, Department for Light and Sound Design as well some halls measured as part of the BINA project. The preliminary results of the study has been presented in [1] and the BINA project in [2] and [3]. In total 35 halls has been measured for these projects, of which 21 is include in the studies presented in this paper.

In general LF is thought to be the acoustic parameter the has the direct correlation with geometrical features of a hall. Gade found in [4] found a high correlation between the LF parameter and the width of the hall, even in cases where the walls of the hall was not parallel. He found that the relationship between LF (LEF) and width could be described the following equation:

$$LF = 0{,}47 - 0{,}0085 * Width \quad (1)$$

When the connection between LF and seat-count shown in figure 1 was found, this came as somewhat of a surprise for the authors.

2. DESCRIPTION OF THE HALLS

In order to do a more thorough analysis, geometrical data has been collected for the halls included in this paper. The halls represent a variety of size, from 350 seats to a maximum of 750 seats. Most of the halls are either rectangular (paralle side walls) or slightly fan shaped and .

It should be emphizized that these halls are build “for music” that is with performance of acoustic musical in mind. The halls of Joensuu, Lappenranta, Lohja and Rauma are however to some degree more auditoriums than actual concert hall, both from shape and volume. But both Joensuu, Lappeenranta and Lohja have a resident, professional orchestra. The size of these orchestras is between 25 and 60 persons.

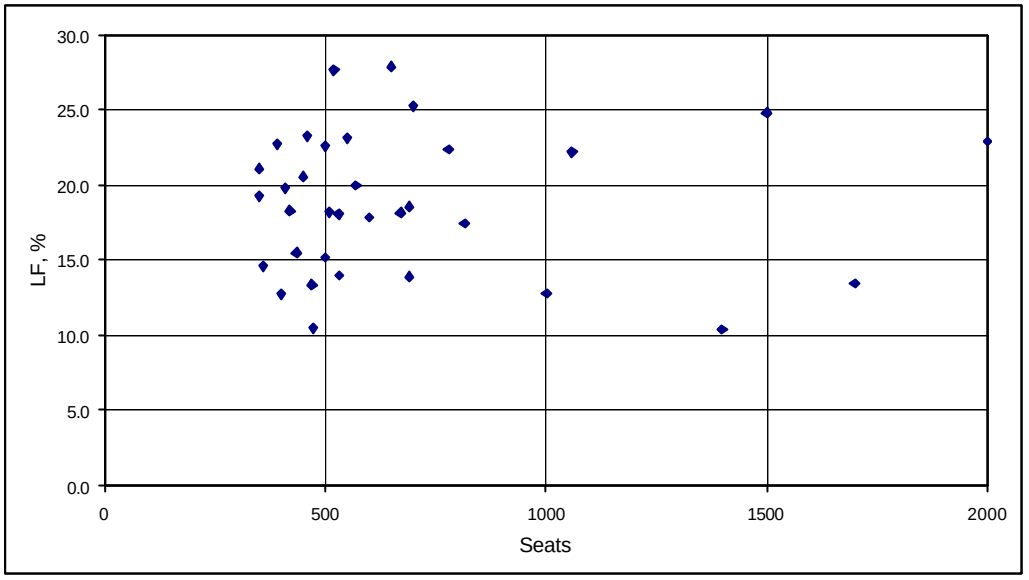

Figure 1. *Relationship between measured LF and seat-count in Finnish concert spaces. Data from [1]*

Name	Seats	Width	Width stage	Form, plan	Form, elevation
Sibelius Akatemia Konserttisali,Helsinki	650	14.5 m	10.5 m	Rec	Flat/sloped stage
Konservatorion Iso Sali,Helsinki	520	16 m	16 m	Rec	Flat
Hyvinkään Sali,Hyvinkää	450	14 m	12 m	MF, NS	Flat
Eino Säisä–Sali,Iilsalmi	470	22 m	14.5 m	MF	Sloped
Carelia Sali,Joensuu	600	26.5 m	18 m	Fan	Sloped
Kansantaidekeskuksen Sali, Kaustinen	390	13.6 m	13.6 m	Rec	Flat
Snellman Sali, Kokkola	500	19 m	18 m	Rec	Flat
Lentua Sali, Kuhmo	670	19.5 m	14 m	MF	Sloped
Kuusa Sali, Kuusankoski	510	18.5 m	14.5 m	NS/MF	Flat/sloped stage
Lappeenranta Sali, Lappenranta	690	33 m	20 m	Fan	Flat/sloped stage
Laurentius Sali, Lohja	473	23.5 m	15 m	Fan	Sloped
Poleeni, Pieksämäki	350	17.6 m	12.8 m	MF	Sloped
Promenaadikeskus, Pori	700	16.4 m	16.4 m	Rec	Flat/sloped
Rauma-Sali, Rauma	435	20 m	15 m	MF	Sloped
Seinäjoki Sali, Seinäjoki	360	18.5	13.5 m	MF	Sloped
Tamperetalo Kammarimusiikkisali, Tampere	500	17 m	10 m	NS	Flat
Sigyn Sali, Turku	350	16 m	16 m	Rec	Flat
Martinus Sali, Vantaa	410	17 m	14 m	Med Fan	Sloped

Fan: More than 45^{o} angel between the sidewalls
MF: Medium Fan shape, side walls
Rec: Rectangular
NS: Non-symmetric

The width measures are average, in general measured in the halfway between the stage front and the backwall. In halls with balconies, the width is measured between balcony fronts.

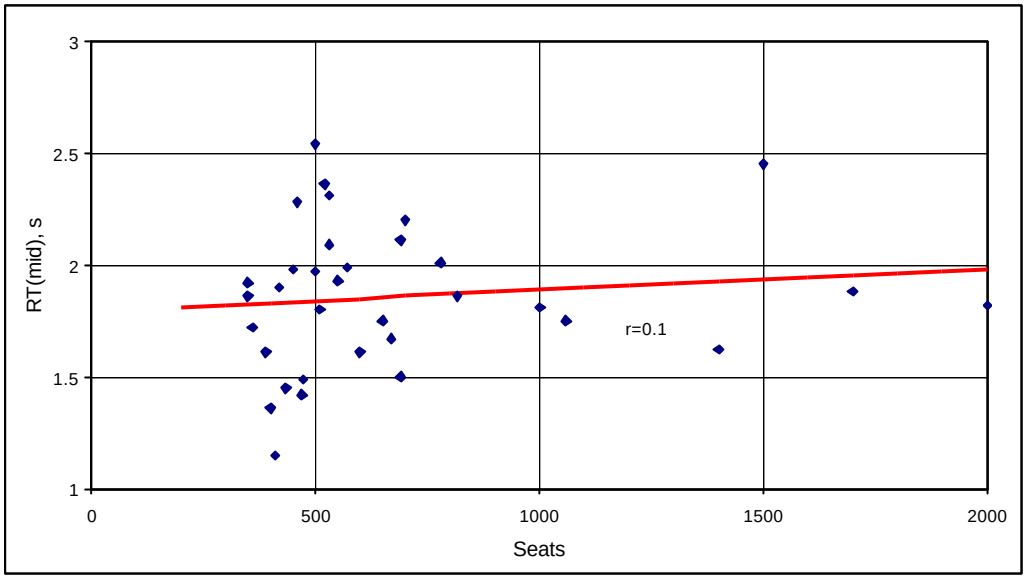

Figure 2: *Rt(mid frequencies) vs. seat count for all the halls of the original study. As can be seen there are essentially no correlation between the data.*

3. ANALYSIS

Figure 3 shows the relationship between LF and hall width, with the correlation curve of Gade shown.

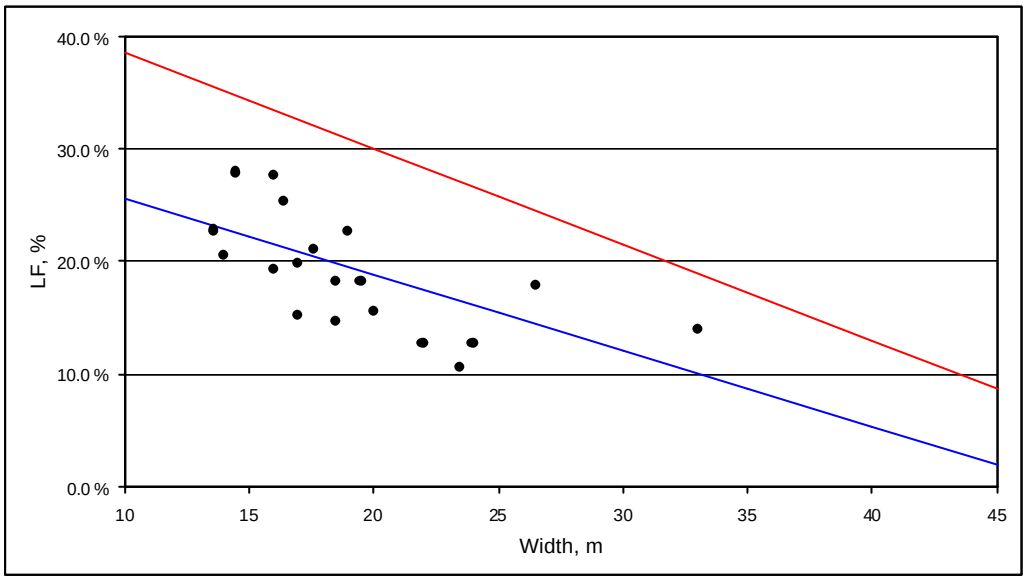

Figure 3. *Relationship between measured LF and width. Upper line expected value in accordance to Gade, lower line first order regression.*

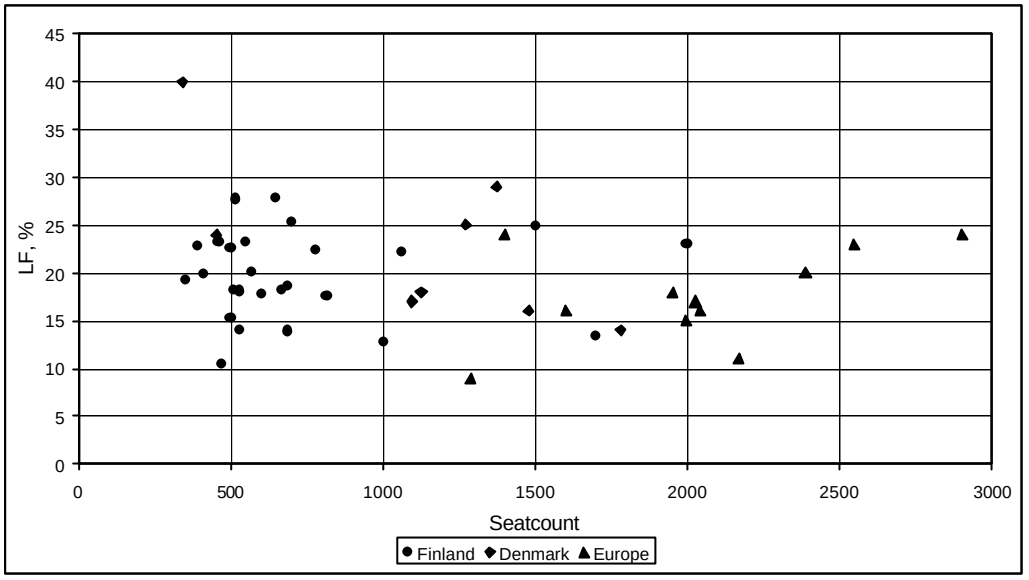

Figure 4: *Measured LF (LEF) vs. seat count in Finnish, Danish and European halls. Data from [1],[4], [5] and [6]*

As can be seen there seems to be a clear offset between the Finnish halls and the halls described by Gade. The correlation between the measured LF values and the width of the halls is –0,63, or close the correlation coefficient reported by Gade. If these results are compared to other halls, as measured by Barron and others [4] [5] , and [6], it seems clear that the LF measured in the Finnish halls are in general lower than other halls.

From figure 5 it can be seen that there is a very good agreement between measured LF and $IACC_e$.

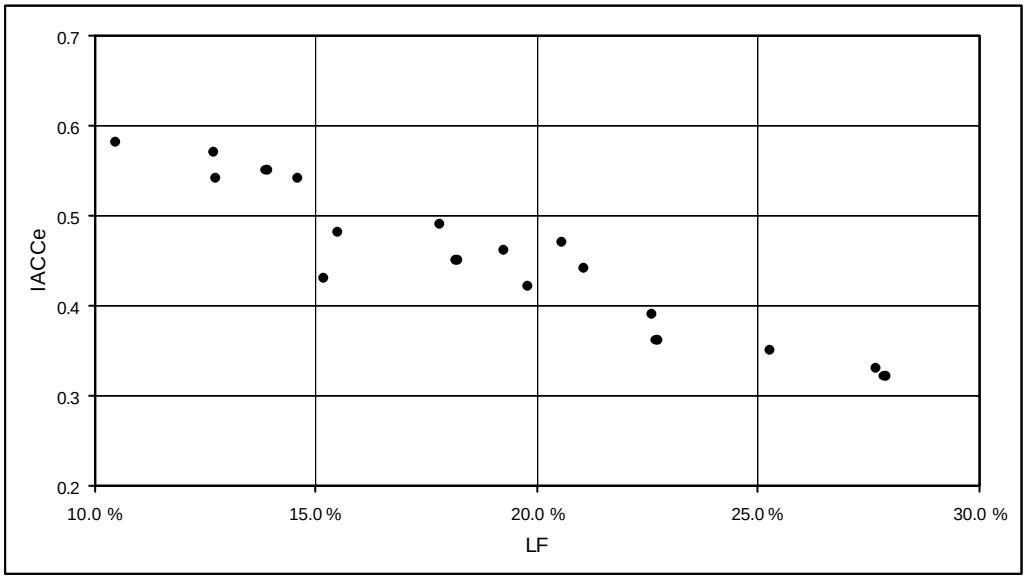

Figure 5: *Relation between measured LF and $IACC_e$*

Most of the halls with measured LF below 20% are fans or for the most medium fans. What is however interesting is that for most of the hall, angel between the sidewalls are by no means large.

If one looks at the ration between the width of the stage and the width of the audience chamber, it is found that the correlation between this and measured LF is -0,72. This does seem logical, as a large ratio basically implies a steep angel between the side walls, i.e. a fan.

Another feature that might explain some of the low measured LF values is the fact that most of the Finnish halls has a "directed energy" design, that is the ceiling is tilted or profiled to reflect sound energy at the audience, not at the stage. It is not quite clear how much of LF offset can be attributed to this, but in any case it is clear that the G values in these smaller Finnish halls are sufficiently larger that other some size halls, see figure 6.

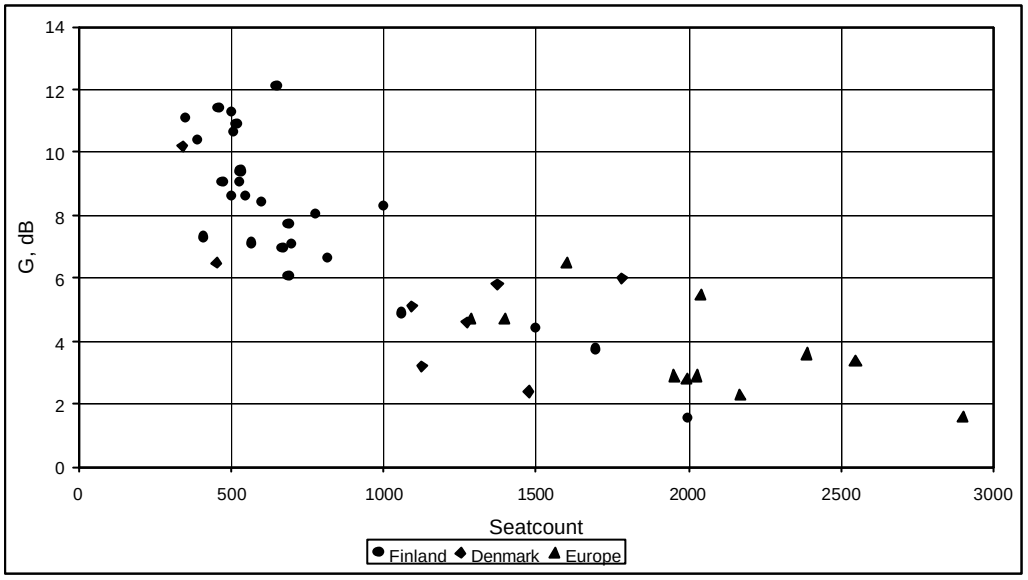

Figure 6: *Measured G vs. seat count for halls in Finland, Denmark and Europe. Data from [1],[4], [5] and [6]*

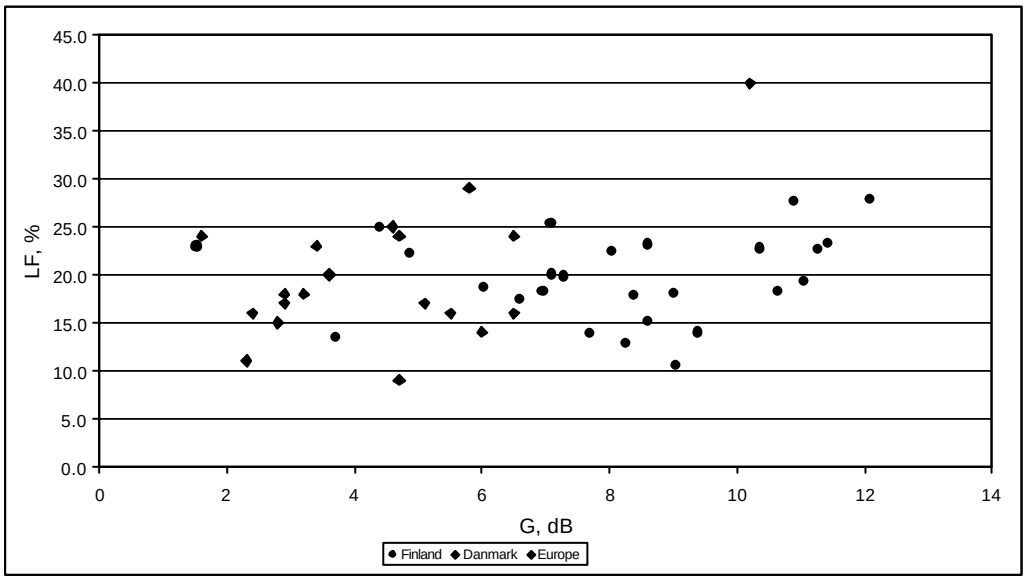

Figure 7: *Measured G vs. LF for halls in Finland, Denmark and Europe, Data from [1],[4], [5] and [6]*

4. CONCLUSIONS

The measurements shows that first of all, highly lateral sound fields does not come automatically with a small hall. Even with halls with width of less that 20 m, it is possible to measure a value of LF closer to 15% that to 20%. It was also shown the correlation between the ration of (Width of audiences chamber/Width of stage) and measured LF was higher than the correlation between just (Width of the audience chamber) and LF.

So far no clear reason has been found for the low measured LF in Finnish halls. It does however seem likely that at least the ceiling profiling and through that the general amount of early energy has an influence on measured LF.

5. FUTURE STUDIES

From the measurement data, it seems evident that other factors apart from the width of the hall, has a significant influence on the lateral sound-field in small halls. This connection will be investigated, when geometric data for all the halls in the original study has been gathered.

6. ACKNOWLEDGEMENTS

Henrik Möller wish to thank the Theater Academy of Finland for financial support.

7. REFERENCES

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