A New, M. Karlowicz Philhamonic Orhestra in Szczecin Poland.

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This paper describes a new concert Hall named: "M.Karlowicz Philharmonic, Szczecin". The acoustic design of the project was finished in 2009. It was built later and finally opened on 6nd September 2014. The acoustics of the new Philharmonic hall have been very well received by audience public.
In this report, we outline several acoustic aspects of design which were developed, obtaining a very result very excellent. Furthermore we show all acoustic results in detail.

1. INTRODUCTION

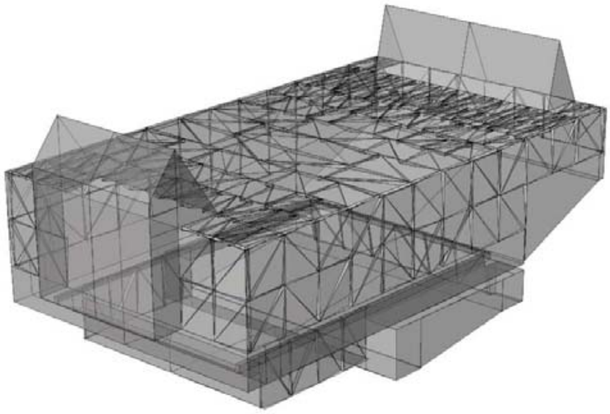
This paper describes the design of a new concert Hall named: **"M.Karlowicz Philharmonic, Szczecin".** The acoustic design of the project was finished in 2009. It was built later and finally opened on September 6nd 2014. The acoustics of the new Philharmonic hall have been very well received by public audience.

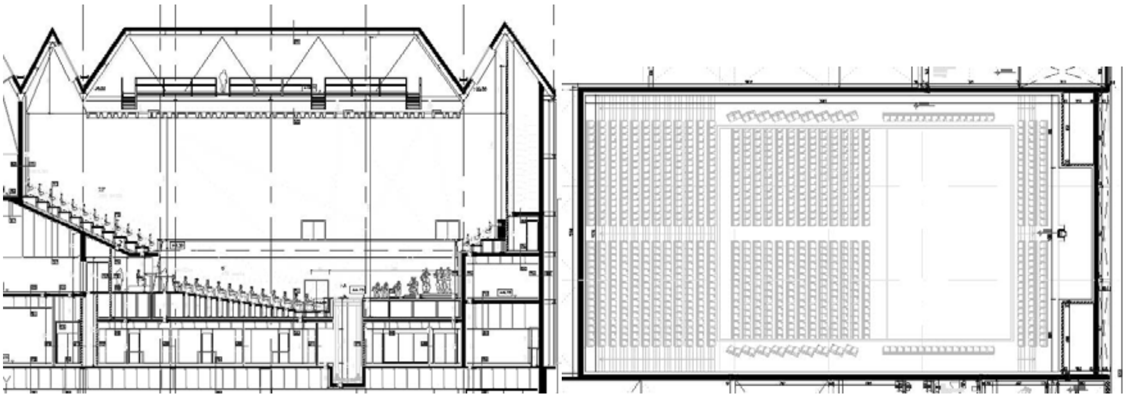
"The symphonic hall, also known as the Sun Hall, may accommodate nearly 1000 people.The magnificent acoustics of the Sun Hall originates from special geometry of the walls and ceiling. All parameters of the symphonic hall (strength, uniformity of sound, delay and lateral energy fractions), produce an effect comparable to the model of such undertakings – the Concert hall Musikverein in Vienna."

2. GEOMETRY OF THE HALL, AUDIENCE SIZE

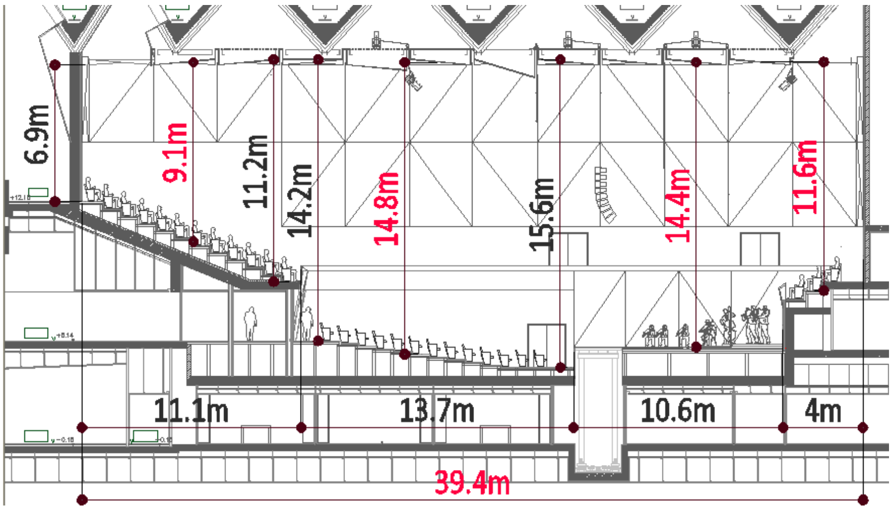
Our purpose was to design the best rectangular auditorium in the world, even better than the Vienna Musik Verein Saal. Because it is known by all experts of the acoustic that type surround concert halls it is impossible to meet all requirements of acoustic criteria symphonic music. On the other hand we set out to do two configurations: 1. A concert hall by the standards even stricter symphonic music, and 2. An ideal space also for electro acoustics concert hall.

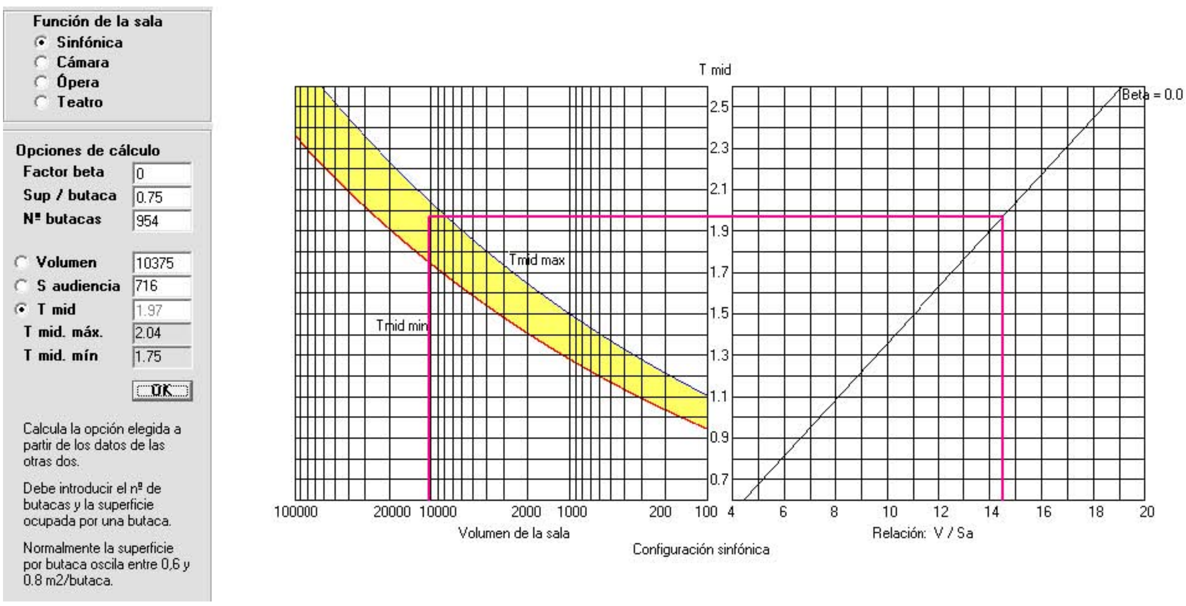
This room is rectangular such as we have explained above. We estimate of Reverberation Time function of the volume according to the laws of acoustic dimensioned to concert halls given from **, [1], [2],** we have a Volume = 10375 m^3 and audience N = 954 seats. The Reverberation Time, T mid calculated by dimensioned was T mid = 1.97 s.





This format plan is: the length of the hall is 39.4 m and its width is 22.64 m, practically complies with the law of the golden ratio.





CONCERT HALL FOR CLASSICAL MUSIC

WALLS:

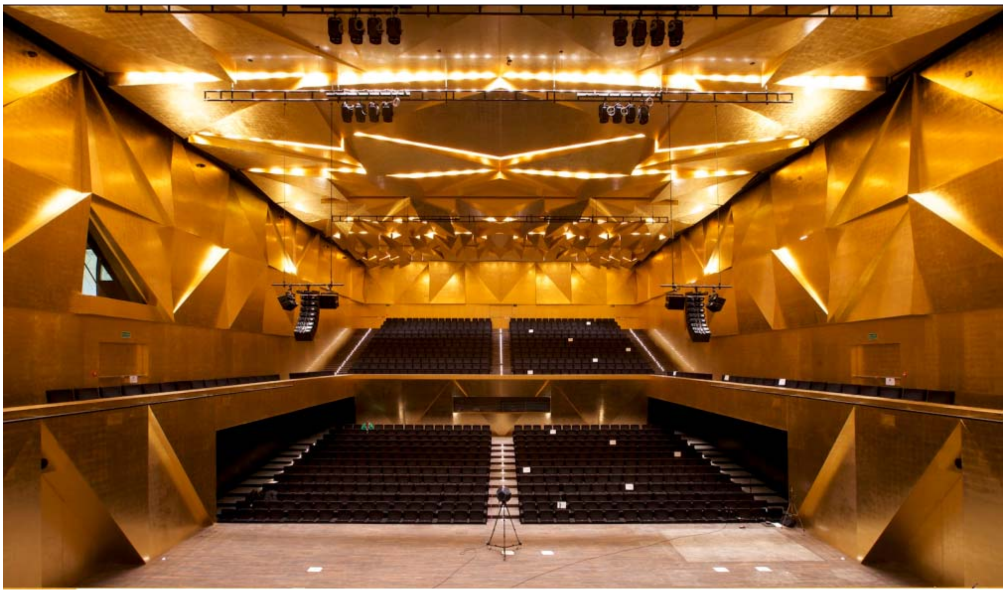
As can be seen the walls have large, almost rectangular plates of 3.5m x 3 m, each is divided into two sub-triangular plates inclined in opposite space and also opposed to the two sub-plates of adjacent positions. The reflection of sound on each triangular plate is the mirror according to the laws of Snell-Descartes, but in different directions. Due to the different direction of the sub- triangular plates, and also due to the different direction that produce the different sub-plates of each rectangle we ensure that the sound is distributed over the concert hall 3D practically all directions getting a space homogeneous almost perfectly diffuse sound distribution.

We know that if the wave length of sound were enough minor than surface dimensions of each plates, then will obtain a mirror reflection on each plates. If this were not the case, then diffraction would be significant, something that is, much harder to evaluate, and can completely alter the resulting sound behaviour within a space. For there to be a reflection mirror at least the lengths x, y plane reflector must be: $L_x, L_y > 3\lambda$, **[3],** being λ the sound wave. So, therefore playing with the size of the plate we can get to control the length of the sound wave that produces a mirror reflection or diffraction of sound.

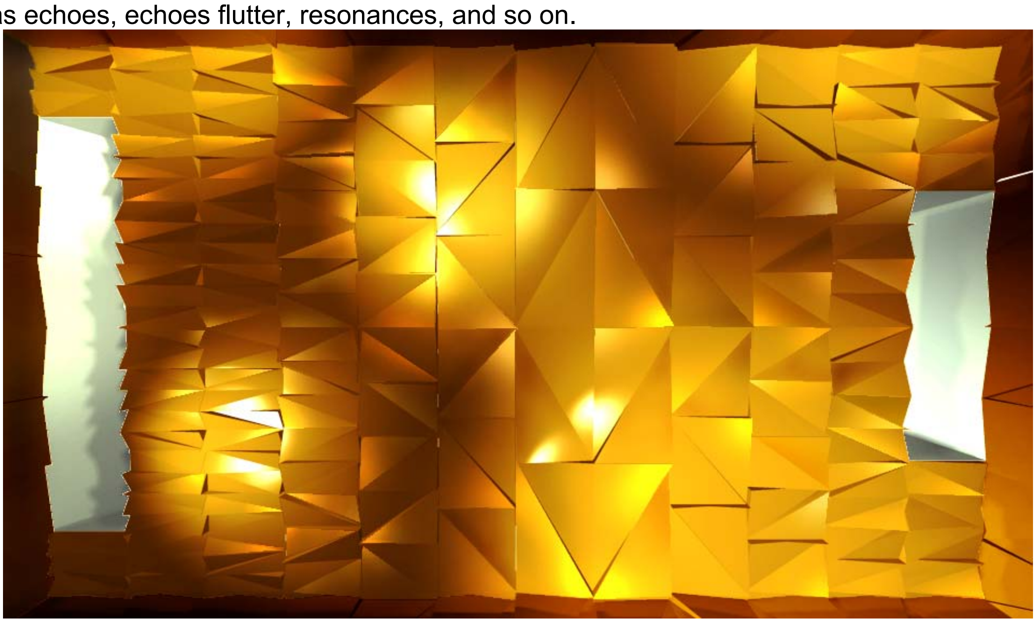
We understand the diffraction of the sound wave breaking on plate, because of which the plate has similar length of the obstacle on which is breaking, as it is indicated by the Principle of Christian Huygens **[4], [5].**

We know that the reference rooms have diffraction to some extent which, has always believed to be good, because the diffuse energy delivered by scattering is less strong than a mirror sound energy produced above a smooth wall. In our case the smooth plates of the walls acts as mirror but also with some diffraction; while the ceiling plates, in the central one of hall among amphitheatre and stage, acts as mirror sound with certain small diffraction, (as in the plates of the walls of the hall).

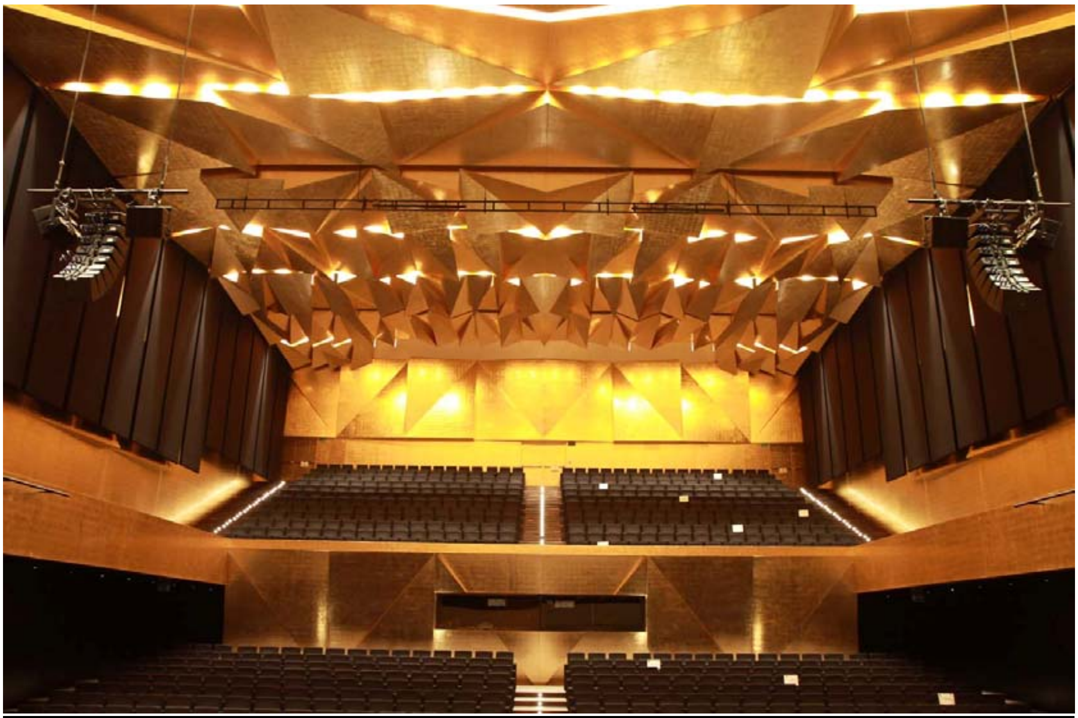
But there is two areas of high diffraction as are the zones of ceiling above stage, as also the ceiling of the amphitheatre besides of both skylights proposed by Architects, with great success and very beautiful.



CEILING: The ceiling of the hall has been divided into 12 sections of plates among the skylights in the hall. These zones of the ceiling more fragmented, have been achieved with a subdivision that does not follow any mathematical or geometrical law, only has followed the law mentioned before.
The aim of this areas fragmented is to obtain by diffraction a loss of sound energy to get the viewer a feeling of a soft enough sound, since sound mirror is almost nonexistent in these zones.
In the central position of the hall, between the stage and the amphitheater, we have placed great plates of dimensions 3.08 x 5.56 m and 3.08 mx 3.70 m, divided by triangular plates, which produce a reflection 3D sound mirror, similar to the plates of the walls.The maximum height of the deviation among all vertex more separated in relation to horizontal plate is 300 mm. This is so for all plates of walls and ceiling of the hall. With this geometrical disposition we are sure to get a good projection of sound from 125 m to 4000 Hz frequencies, with reflections mirror and sound diffraction. Therefore all acoustic problems of a hall are avoided, as echoes, echoes flutter, resonances, and so on.



OTHER CONFIGURATION: CONCERT HALL FOR ELECTROACUSTICAL MUSIC
The ceiling hides sound curtains, while the black seats have been designed in such a way that they do not creak. Nothing can affect the pureness of sound.



3. EXPERIMENTAL MEASUREMENTS

The experimental procedure was carried out according to the - ISO 3382-1[3], by the Politechnika Wroclawska Katedra Akustyki i Multimediów Laboratorium Badawcze Akustyki. http://www.akustyczna.pl/pl/nowosci/pomiary-akustyczne-filharmonioniaszczecinska .

https://www.youtube.com/watch?v=OqmY9TMSUe8 .The values of RT measured are:

- **CONCERT HALL**

FILHARMONIA SZCZECIN		125	250	500	1000	2000	4000	MID
T30 (Hall) (s)	Unocc, seat	2.19	2.02	1.98	2.1	2.17	1.95	**2.04**
	Occ, seat	1.84	1.82	1.86	1.99	2.05	1.87	**1.93**
T30 (Stage) (s)	Unocc, seat	2.24	2.02	1.99	2.09	2.16	1.93	**2.04**
	Occ, seat	--	--	--	--	--	--	**--**
EDT (s)	Unocc, seat	2.14	1.97	1.94	2.03	2.09	1.82	**1.98**
	Occ, seat	2.01	1.98	1.96	2.01	2.02	1.77	**1.98**
G (dB)	Unocc, seat	9.4	7.1	6.8	7.8	8.2	6.4	**7.3**
	Occ, seat	9	5.4	6.3	6.8	7.7	6.5	**6.55**
C80 (dB)	Unocc, seat	-1.4	-0.6	0.1	0	-0.2	1	**0.05**
	Occ, seat	-1.8	-1.2	-0.2	-0.3	-0.5	0.1	**-0.25**

LE_F	Unocc, seat	0.26	0.28	0.26	0.26	0.24	0.26	**0.26**
	Occ, seat	--	--	--	--	--	--	**--**
STearly (dB)	Unocc, seat	-15.06	-12.86	-13.5	-11.84	-9.38	-10.94	**-11.9**
	Occ, seat	--	--	--	--	--	--	**--**
STlate (dB)	Unocc, seat	-12.32	-11.46	-12.54	-12	-9.52	-11.62	**-11.4**
	Occ, seat	--	--	--	--	--	--	**--**
Distribution L_p (dB)	Unocc, seat							**88.3 - 84.7**
	Occ, seat							**66.4 - 64.1**
ITDG[-5dB] (ms)(*)	Unocc, seat							**17**
	Occ, seat							**20**
ITDG[-10dB] (ms) (*)	Unocc, seat							**14**
(*) Average value	Occ, seat							**19**

- **MID GLOBAL EVALUATION MASUREMENT IN RELATION TO ACOUSTIC CRITERIA**

FILHARMONIA SZCZECIN		MID	ACOUSTIC CRITERIA	FULFILLMENT
T30 (Hall) (s)	Unocc, seat	**2.04**	**1.75 < Tmid < 2.15**	**OK**
	Occ, seat	**1.93**	**1.95**	**OK**
T30 (Stage) (s)	Unocc, seat	**2.04**		**OK**
	Occ, seat	**--**		**--**
EDT (s)	Unocc, seat	**1.98**	**EDT ≈ 0.90 Tmid**	**OK**
	Occ, seat	**1.98**		**OK**
G (dB)	Unocc, seat	**7.3**	**G > 0**	**OK**
	Occ, seat	**6.55**		**OK**
C80 (dB)	Unocc, seat	**0.05**	**-2 < C80 < 4**	**OK**
	Occ, seat	**-0.25**		**OK**
LE_F	Unocc, seat	**0.26**	**LE_F > 0.2**	**OK**

	Occ, seat	**--**		**--**
STearly (dB)	Unocc, seat	**-11.9**	**ST1 > -14 to -15**	**OK**
	Occ, seat	**--**		**--**
ITDG[-5dB] (ms)	Unocc, seat	**17**	**ITDG < 20**	**OK**
	Occ, seat	**20**		**OK**
ITDG [-10dB] (ms)	Unocc, seat	**14**	**ITDG < 20**	**OK**
	Occ, seat	**19**		**OK**

We can say that technically all magnitudes of this enclosure obey the acoustic criteria of design.

4. CONCLUSIONS

Can we can to describe the sound in the Symphonic Hall?

1. The technical opinion of the experts and music lovers are very important. They are who have heard the opening concerts and who have issued their opinion. The press in general says, for example: The symphonic hall, also known as the Sun Hall, may accommodate nearly 1000 people. The magnificent acoustics of the Sun Hall originates from special geometry of the walls and ceiling, developed by the architects together with Dr. Higini Arau, a specialist in architectural acoustics from Barcelona. All parameters of the symphonic hall (strength, uniformity of sound, delay and lateral energy fractions) produce an effect comparable to the model of such undertakings – the concert hall Musikverein in Vienna.(to see: http://filharmonia.szczecin.pl/the_building).

2. However, I (the author)), I only can to explain my sensations, these are: At the opening of the Symphony hall, when I heard the music of a Polish composer called Marek Jasiński, and even more so after the 9th Symphony Bethoveen, from my seat, I noticed an extraordinary feeling that the sound came over me throughout my being causing me extraordinary emotion that was impossible to explain, when the sound invaded my senses producing much joy and cry of emotion.

5. REFERENCES

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[4].G,R, Baldock&T.Bridgenman., 1981,The Mathematical Theory of Wave motion. Ellis Horwood Limited, a division of John Wiley ¬ Sons.

[5]. A.P.French, 1974, Vibrations and Waves.W,W, Norton & Company, Inc.,New York