Assessment of the vertical dimension of the glottic wave: Its clinical value

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Refined diagnoses of laryngeal disorders

Instead of stroboscopy with an average of 25 pictures pr second:

- High speed films
- Kymography and electroglottography
- Phonovibrograms
- The prospects of calculation of ”Stiffness”
- (and others as Optical coherence tomography and Narrow band imaging)

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High speed films

Superior to clinical laryngo-stroboscopy in areas of voice diagnostics

able to capture 4000 or more images per second

data are acquired with a high-speed camera recording in real-time during phonation of a vowel.

A rigid endoscope (90^0 optic, 9-mm diameter) is placed into the oropharynx coupled to a high-speed camera, flexible endoscope can also be used.

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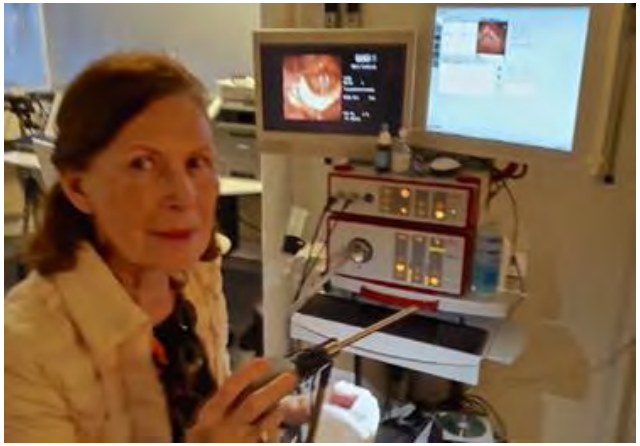
High speed endocam system

- With the High Speed Endocam system* there has been developed a software reproduction of the stiffness of single vocal fold movements with the “Glottis Analysis Tools” by M. Döllinger et al.



* Wolf Ltd. HRES Endocam 5562 analytic system (Richard Wolf GmbH, Pforzheimer Strasse 32, 75438 Knittlingen, Germany)

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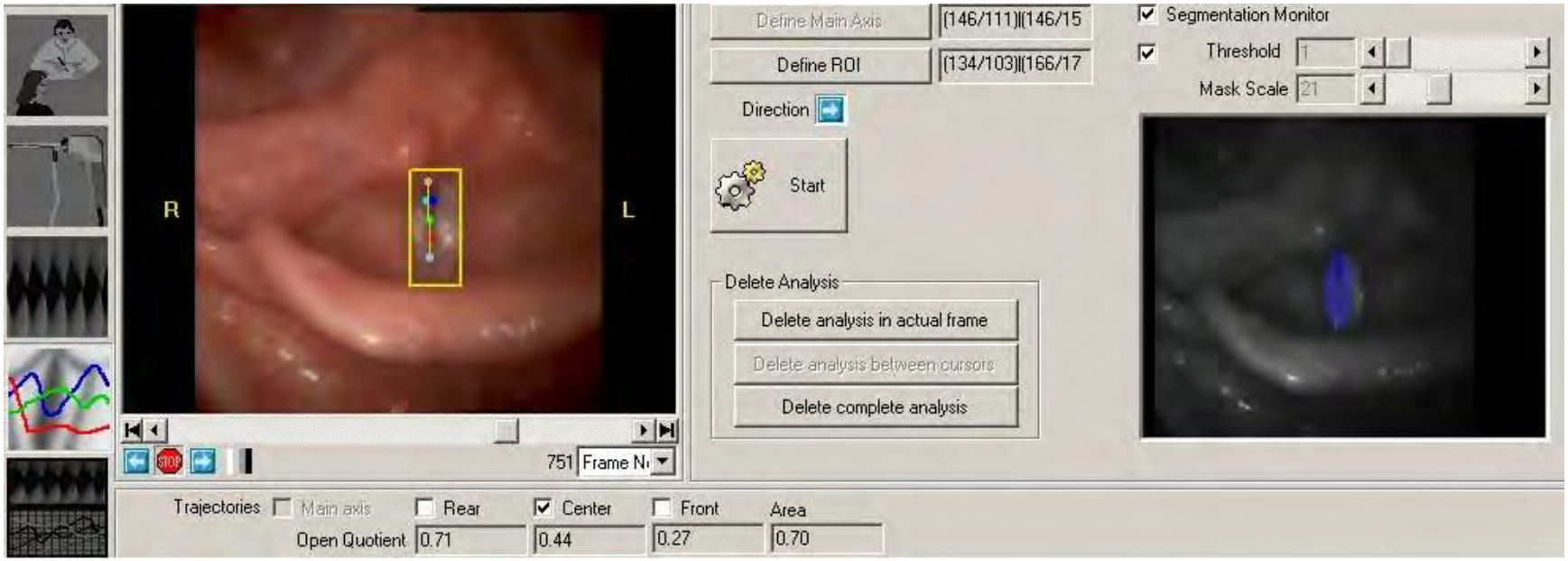
High speed films

Segmentation of the open quotients can be calculated in front – center – rear area –between the vocal folds.



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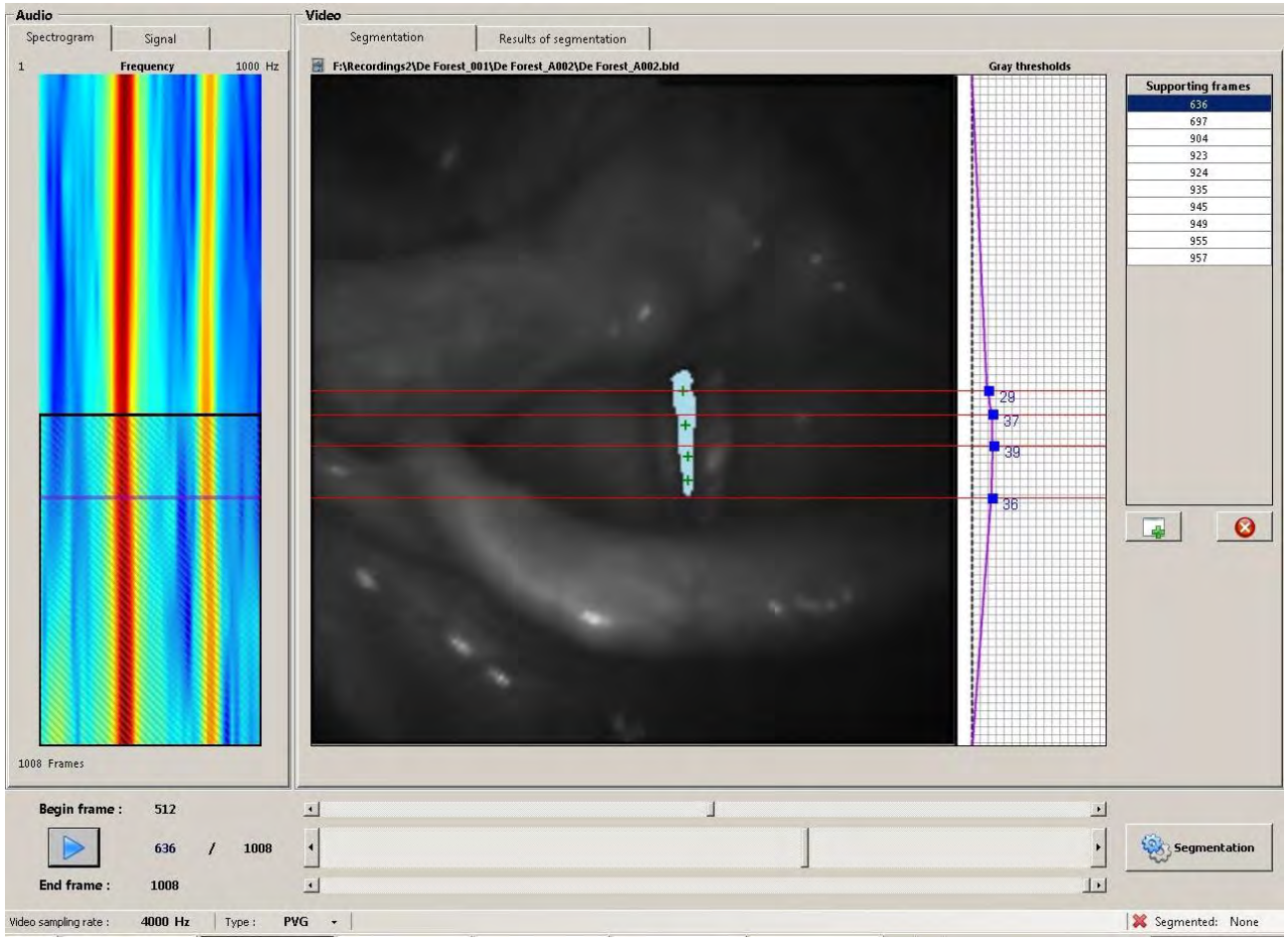
High speed films and mean stiffness

Segmentation: The setup for calculation of measurements of mean stiffness of the Glottal Area Wave form (GAW)



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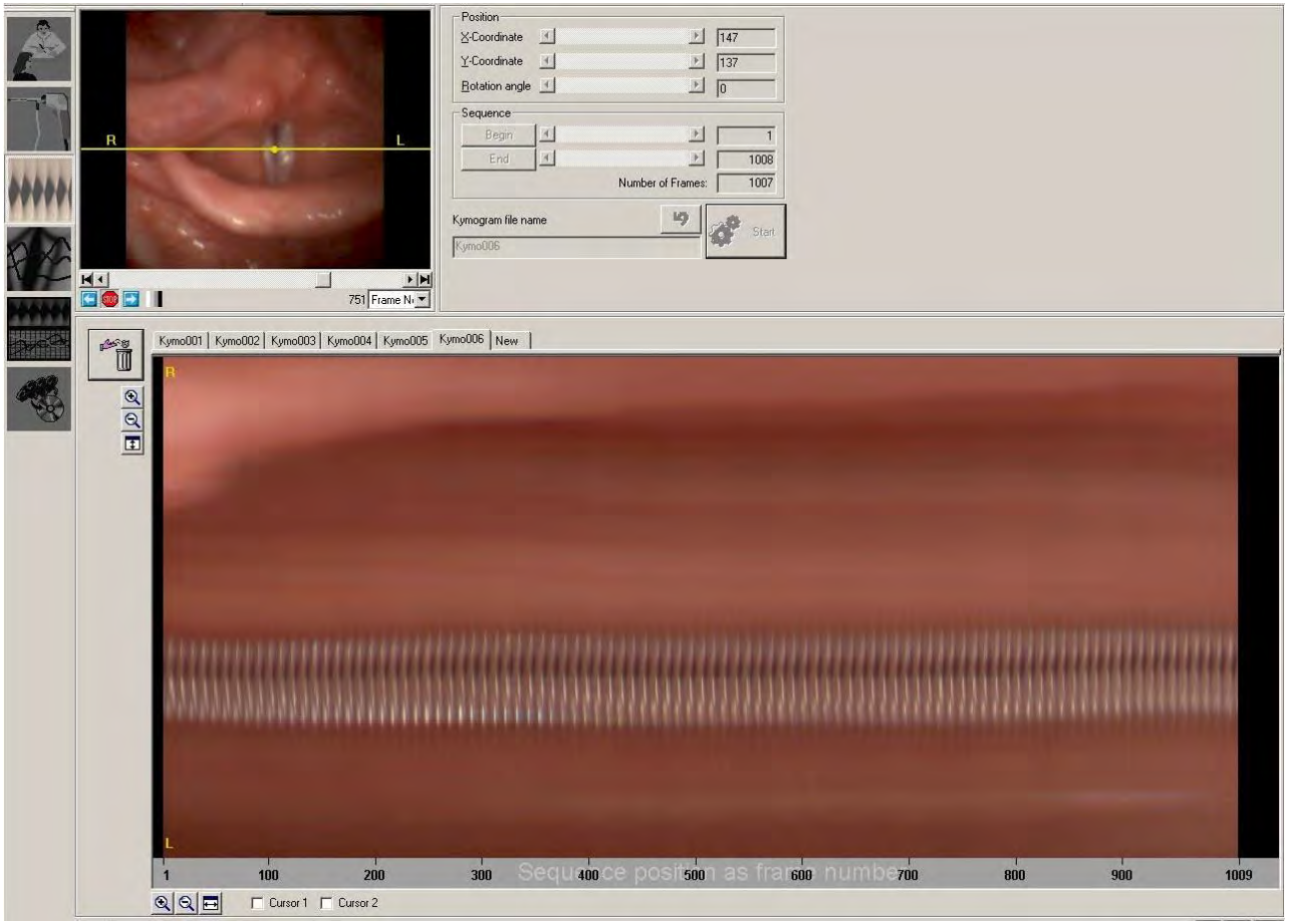
High speed films and kymography

Kymography shows single movement of the vocal folds from above – here they are regular



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Difference in stiffness

- A difference in stiffness of the vocal folds is measured
- The objective was to evaluate the new method based on software reproduction of the vocal fold movements, that is included in - Glottis Analysis Tools - used together with highspeed films.

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The formula for stiffness

$$Stiffness = \frac{max_{t \in T_i}(s(t))}{A_i}$$

Where T_i is the duration of i^{th} cycle in miliseconds (ms), A_i is the dynamic range (max-min) for i^{th} cycle and s(t) is the magnitude of the 1^{st} derivative of considered signal for i^{th} cycle (t C T_i).

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Trajectories

- Trajectories are like kymograms
- The diagrams show the vocal folds in a 50% distance from the posterior border (therefore called [Traj-50%])

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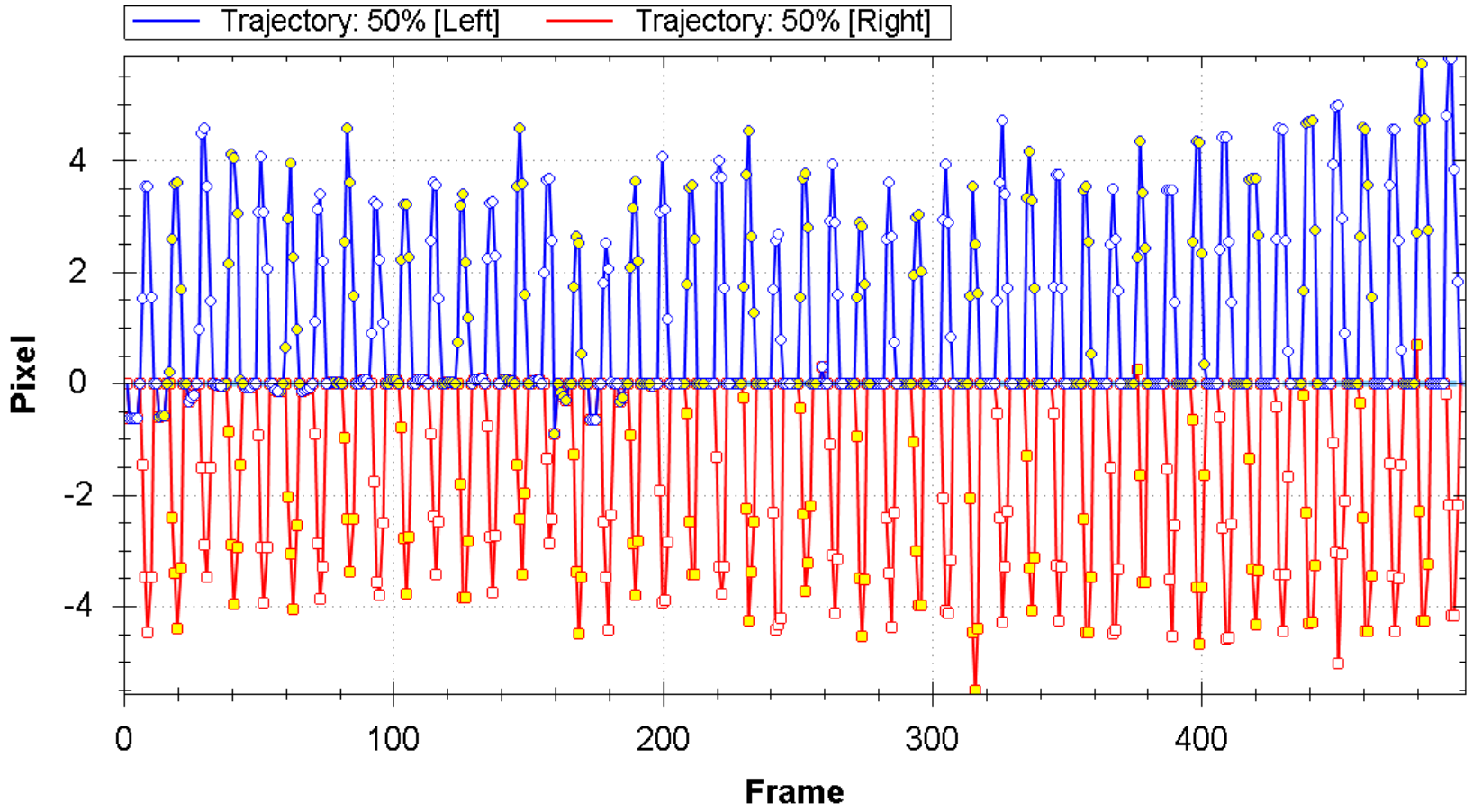
Trajectories of a contest winning female



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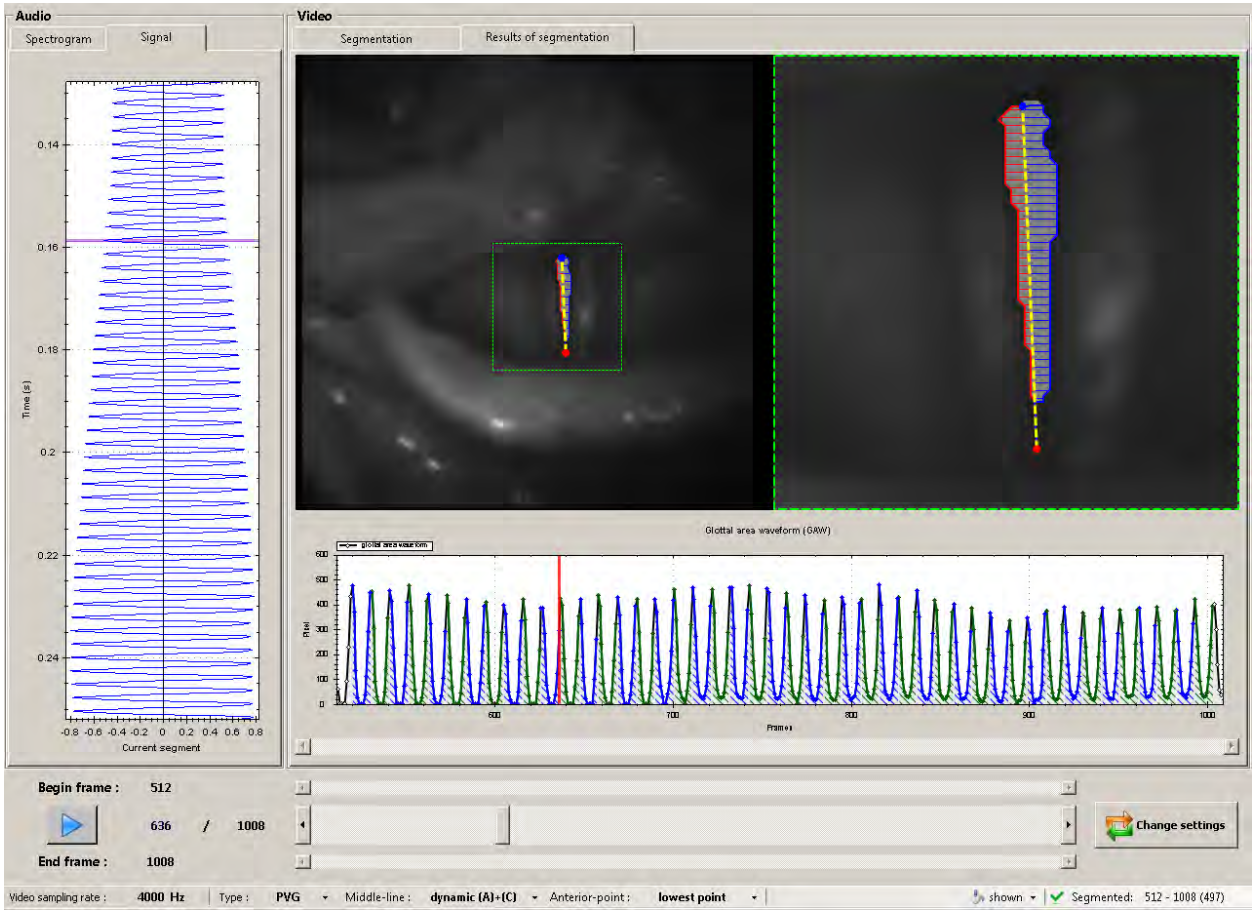
Highspeed films and phonovibrograms

The results* of the segmentation. The Glottal Area Wave form (GAW) are shown with frames on the horizontal axis and pixel on the vertical axis



*a contest winning female

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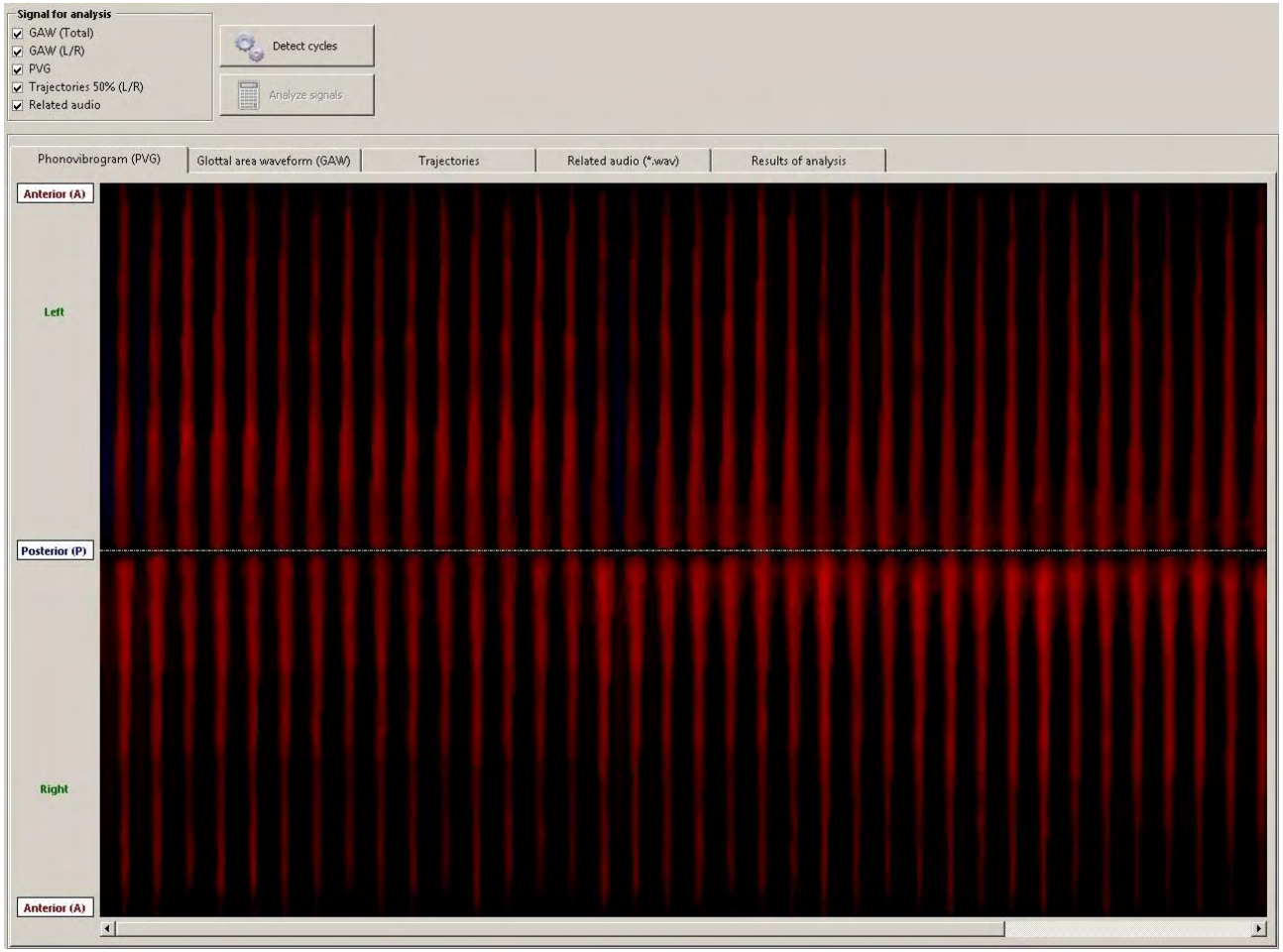
High speed films and phonovibrograms

Phonovibrogram of a contest winning female, showing the regularity of single movement of the right and left vocal folds



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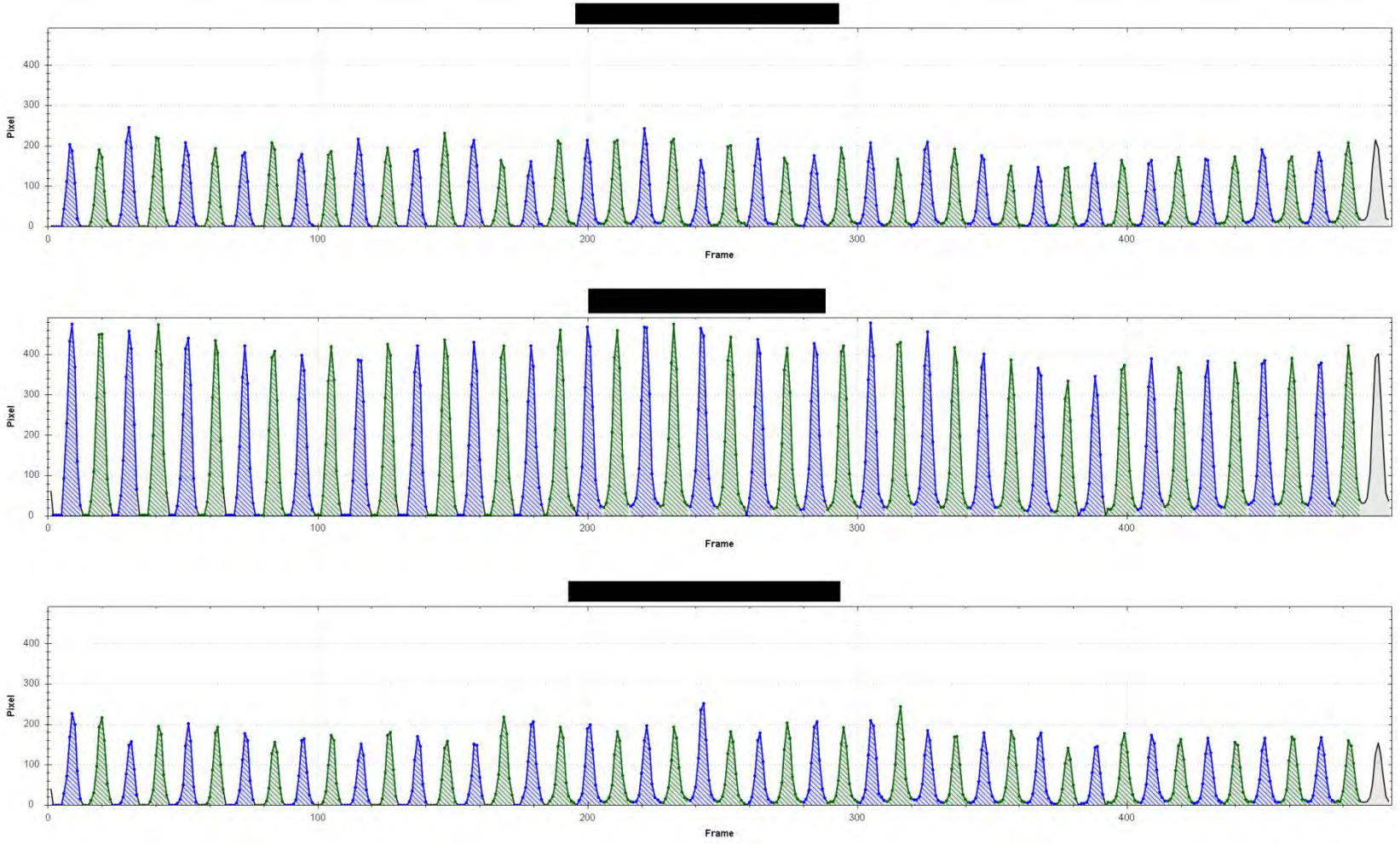
Glottal Area Waveform cycles of a contest winning female (right – left and combined)



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Calculated measures for the signals of Glottal Area Waveform and Glottal Trajectories - note the standard deviations of the mean which was 0,38 out of 42 measured cycles

From a contest winning female

			[MEAN]	[STD]	[MIN]	[MAX]
Stiffness	[GAW]		0,38	0,02	0,333	0,413
Stiffness	[GAW]	[Left]	0,391	0,024	0,338	0,432
Stiffness	[GAW]	[Right]	0,395	0,024	0,352	0,451
Stiffness	[Traj-50%]	[Left]	0,483	0,043	0,371	0,625
Stiffness	[Traj-50%]	[Right]	0,486	0,029	0,392	0,513

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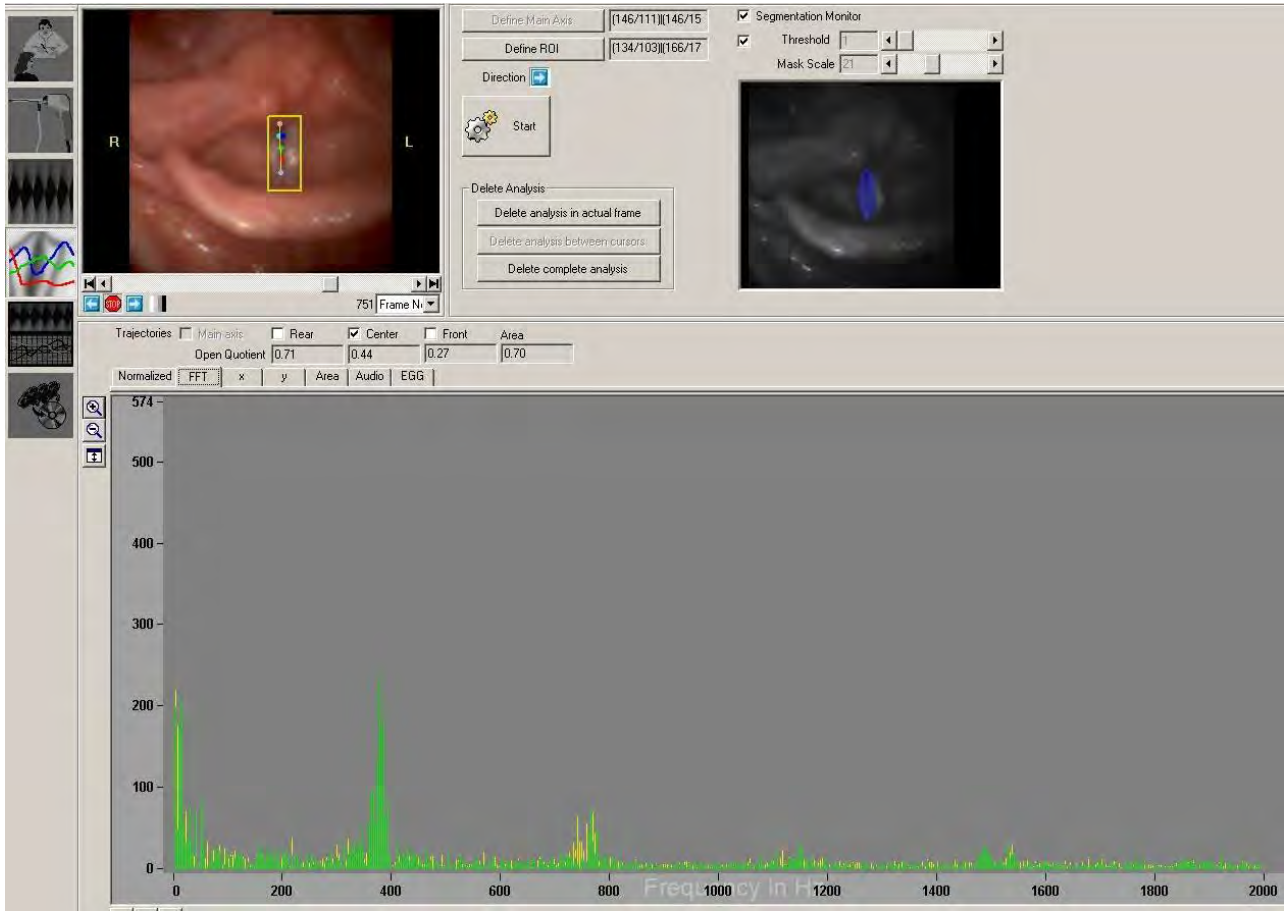
Spectral analysis up to 2000 Hz

The analysis is based on high speed films of 4000 pictures pr second



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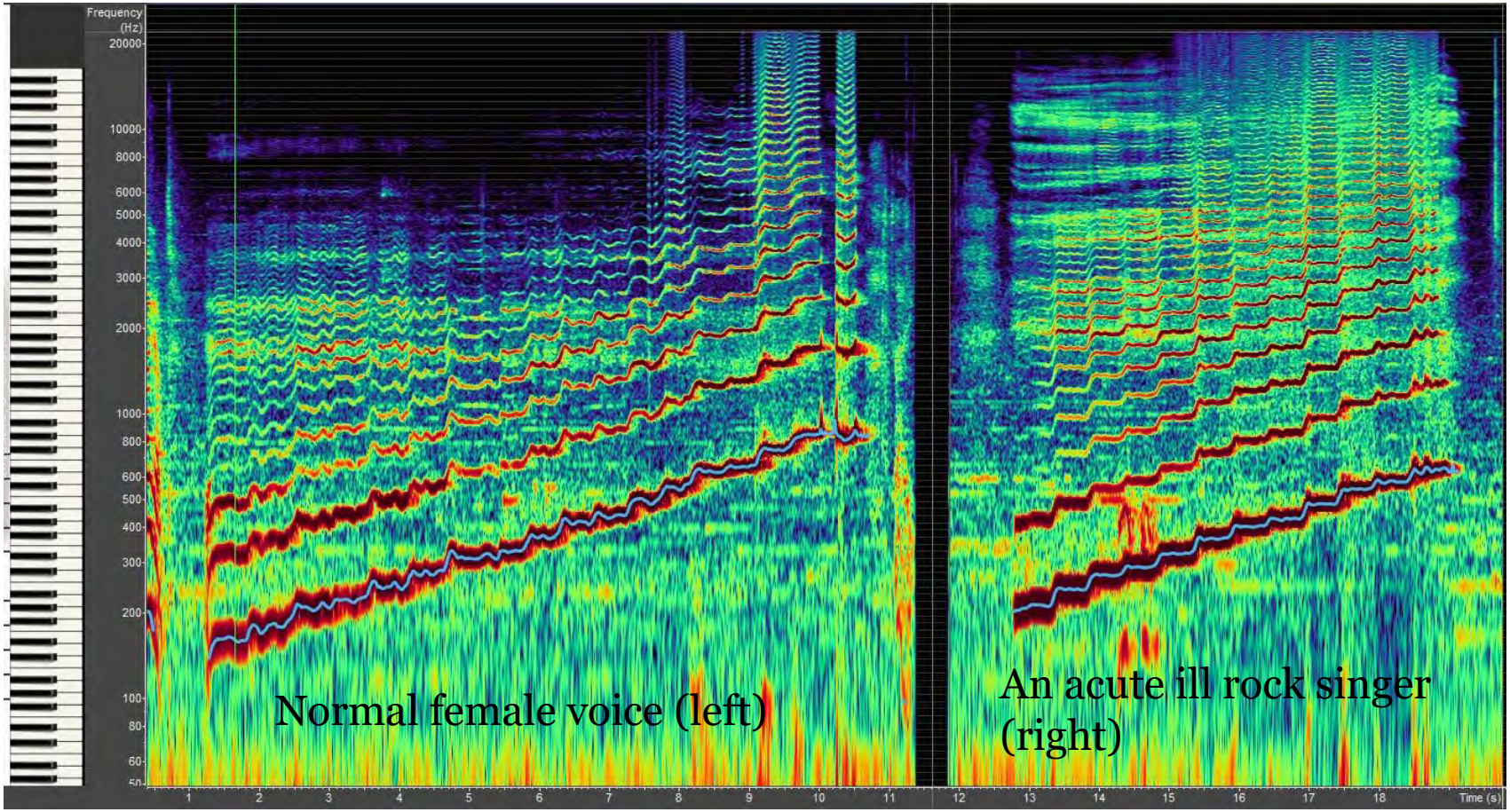
Further development includes e.g.comparison of normal and acute ill voices with overtones and highspeed films



The normal female voice has overtones and a fundamental frequency up to about 850 Hz. The pathological voice had no tones over 600 Hz.

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Conclusions

- We are focusing on high quality voices compared with other voices and pathology.
- In this study we presented a quantified measure of the vocal fold stiffness calculated from individual vocal fold cycles with average measures, standard deviations –and minimum and maximum values.
- It is our impression that the system –" Glottis Analysis Tools" stiffness calculations can be used clinically to differentiate between high and low quality voices.
- In the future, stiffness might be used to determine the treatment effect in voice pathology.

- Find the slides on: http://www.mpedersen.org

Thank you for your attention!

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References

- Deliyski, D., Hillman, R., 2010. State of the art laryngeal imaging: Research and clinical implications. Curr. Opin. Otolaryngol. Head Neck Surg. 18, 147-152.
- Pedersen, M., Eeg, M., Jønsson, A., 2013. Video stroboscopy and high-speed films of pathological voices. Presented at 4th Symposium of Advanced Voice Assessment, Copenhagen.
- Döllinger, M., Hoppe, U., Hettlich, F., Lohscheller, J., Schubert, S., Eysholdt, U., 2002. Vibration parameter extraction from endoscopic image series of the vocal folds. IEEE Trans. Biomed. Eng. 49, 773-781.
- Lohscheller, J., Eysholdt, U., Toy, H., Döllinger, M., 2008. Phonovibrography: mapping high-speed movies of vocal fold vibrations into 2-d diagrams for visualizing and analyzing the underlying laryngeal dynamics. IEEE Trans. Med. Imaging 27, 300-309.
- Pedersen, M., Eeg, M., Jønsson, A., Mahmood, S., 2015. Chapter 8. Working with Wolf Ltd. HRES Endocam 5562 analytic system for high-speed recordings.
- Pedersen M., Eeg M., Agersted AA., Jønsson A., 2015. Can phonovibrograms be used in clinical voice pathology? JJ Otolaryn. 2015, 1(1): 005.
- Pedersen M., Akram BH., Agersted AA., 2015 Technology advances in diagnostics of vocal folds function. Otolaryngology 5: 191.