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Topics

CATT-Acoustic DLL Directivity Interface (DDI)

DDI verification examples

Conclusions

Acknowledgements

CATT-Acoustic DLL Directivity Interface (DDI)

DLL = Dynamic Link Library = a.k.a. “Plug-in”

Background

- **Many types of complex sound sources have extended near-fields (may extend up to > 100 m for some designs):**
    - large arrays
    - V-DOSC
    - distributed mode loudspeakers

- **A single *3D-balloon* at 10°, 5° or 1° resolution is not sufficient:**
    - a 3D-balloon measured at e.g. 10 m distance can be **10-20 dB in error in the main lobe** at other distances
    - **even a 1° resolution would not solve the problem** since it lies in the fixed measurement distance
- **Many array designs are based on DSP for beam-steering:**
    - **hundreds of possible beam shapes and angles -** to measure them all would be a very big task

Implementation

- **The *CATT-Acoustic* Win32 DLL Directivity Interface (DDI) enables:**
  - **distance dependent directivity** (i.e. handling of the near-field)
  - **any angular resolution**
  - **any frequency resolution** (from high-res FIRs to 1/1-octaves)
  - **hiding of intellectual property** (e.g. beam-steering methods)
  - **generic array modeling** based on individual element 3D position and aim, directivity in 15º polars or 10º full-space formats, octave-band or **FIR-filter weight**, delay
  - **specific array modeling** based on detailed manufacturer specifications allowing for beam-steering of e.g. **azimuth, focusdistance, openingangle**

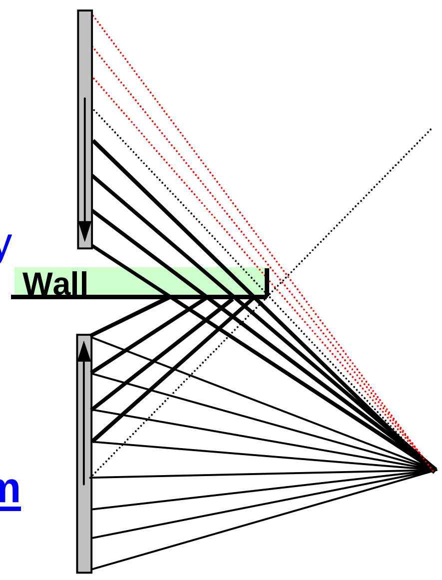
- **interpolated models** based on a set of 10º 3D-ballons. A less accurate but much faster way of modeling arrays
- **analytically modeled sources** (line sources, multi-pole expansions, spherical harmonics, synthesized instruments etc.)
- optional **3D description** of sources (not yet implemented but the interface can be added to using a version-checking API)
- dedicated brand/model **help**
- intended to be an **open interface**

♦ Current utilization of the DDI in *CATT-Acoustic v7.2*:

- the result of the coherent run-time array summation is used **for direct sound and first order reflections**
- the **far-field directivity is used for higher order reflections**

However:

- **only if a reflection takes place on a big, hard and smooth surface** the coherent summation of all array elements is valid
- **reflections in small surfaces** (where only part of the array actually is reflected) or in **rough surfaces** (that scatters the reflection) **destroy the relationship between the sources in the array** and the free-field directivity is no longer valid
- how to best handle late reflections with array modeling is **a problem little discussed and not yet solved**



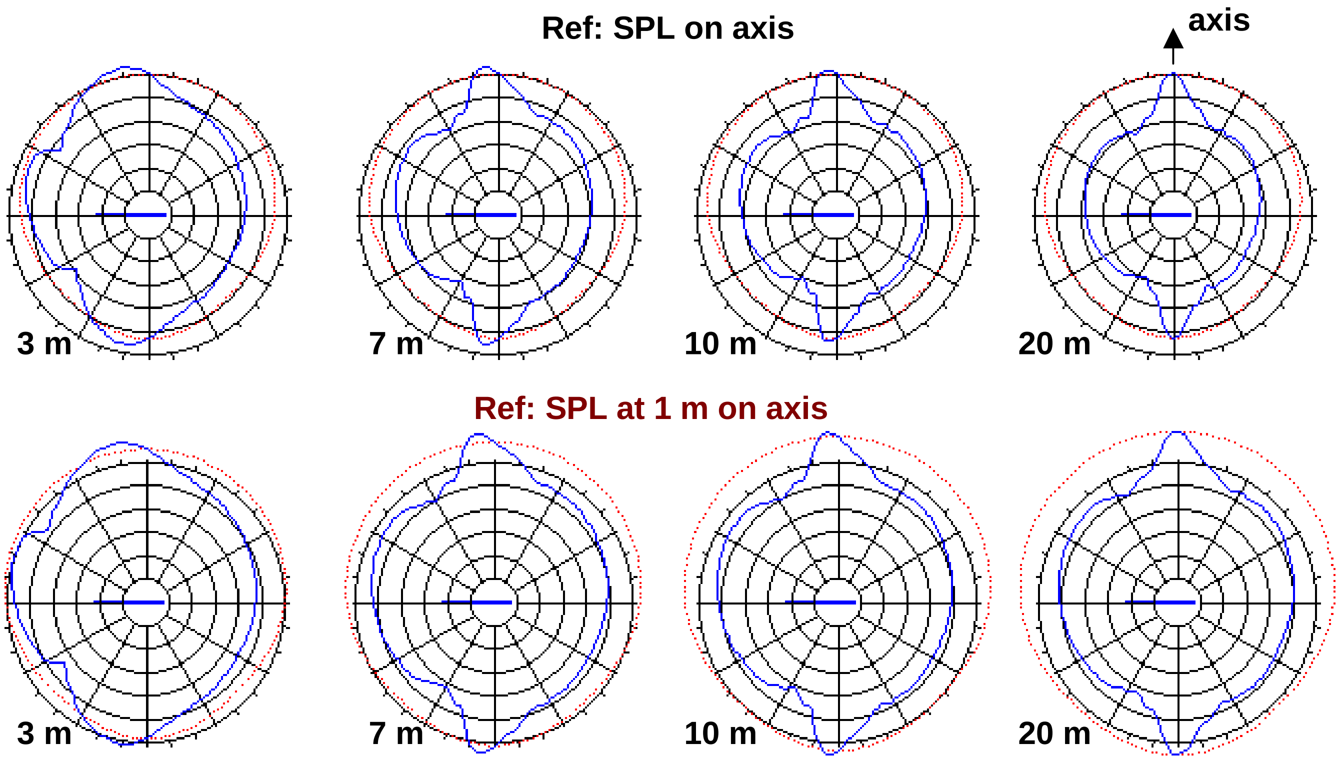
Octave-band averaged 1kHz directivity

Duran Audio Intellivox 2c

2.7 m long DSP-controlled column array

DSP settings: azimuth = -1º, focusdistance = 40 m, openingangle = 6º

Polars plotted at 2º resolution, 10 dB/div



Upper polars show <u>shape variation only</u>

Lower polars show <u>shape plus on-axis variation</u>

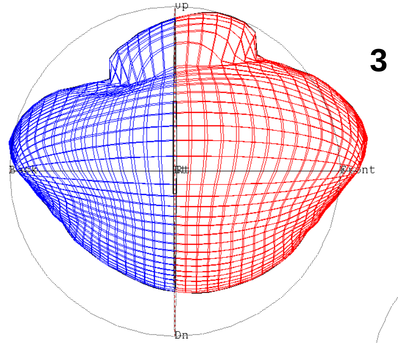
Octave-band averaged 1kHz directivity

Duran Audio Intellivox 2c

2.7 m long DSP-controlled column array

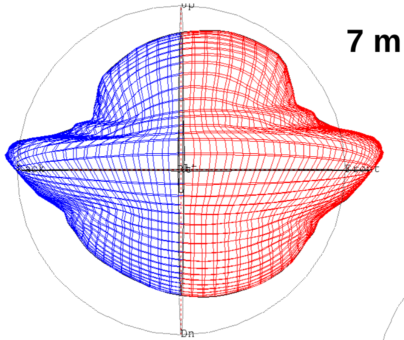
DSP settings: azimuth = -1º, focusdistance = 40 m, openingangle = 6º

3D-ballons plotted at 5º resolution

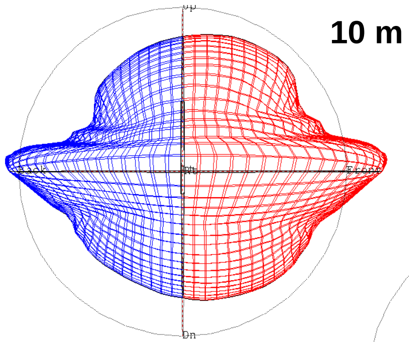


3 m distance

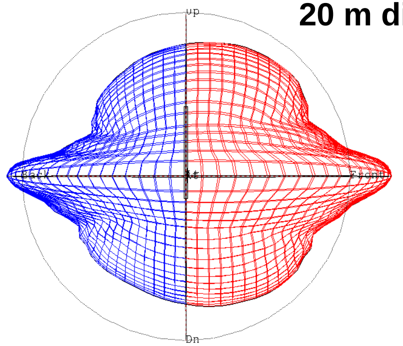
Re. 1m on-axis
50 dB radius



7 m distance



10 m distance



20 m distance

Comparison between Run-time DDI, Interpolated DDI and 10º far-field balloon

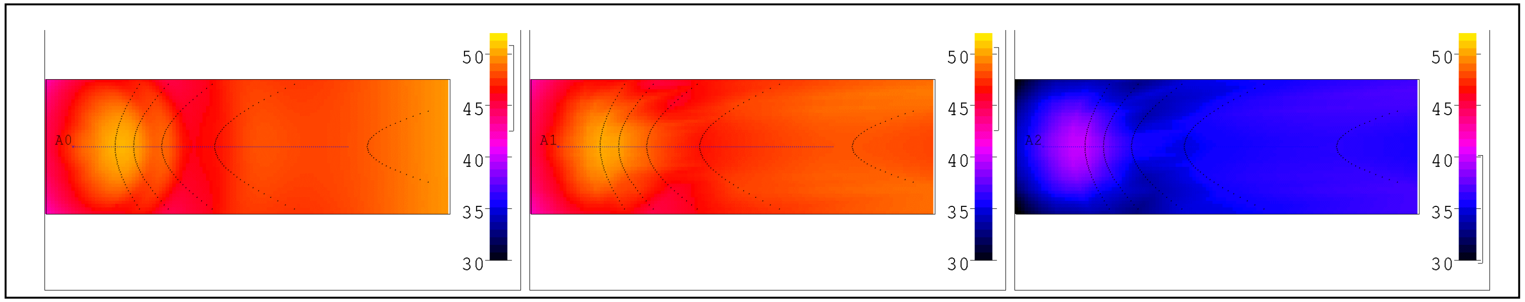
Duran Audio Intellivox 2c

2.7 m long DSP-controlled column array

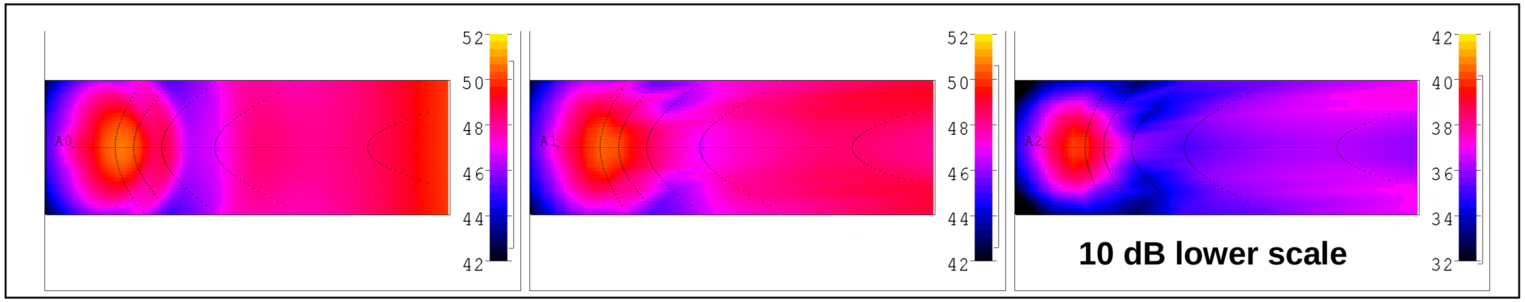
DSP settings: azimuth = -2º, focusdistance = 40 m, openingangle = 8º

Same level at 1 m on axis

Run-time DDI | **Interpolated DDI** | **10º far-field balloon**



Same scale: comparing level

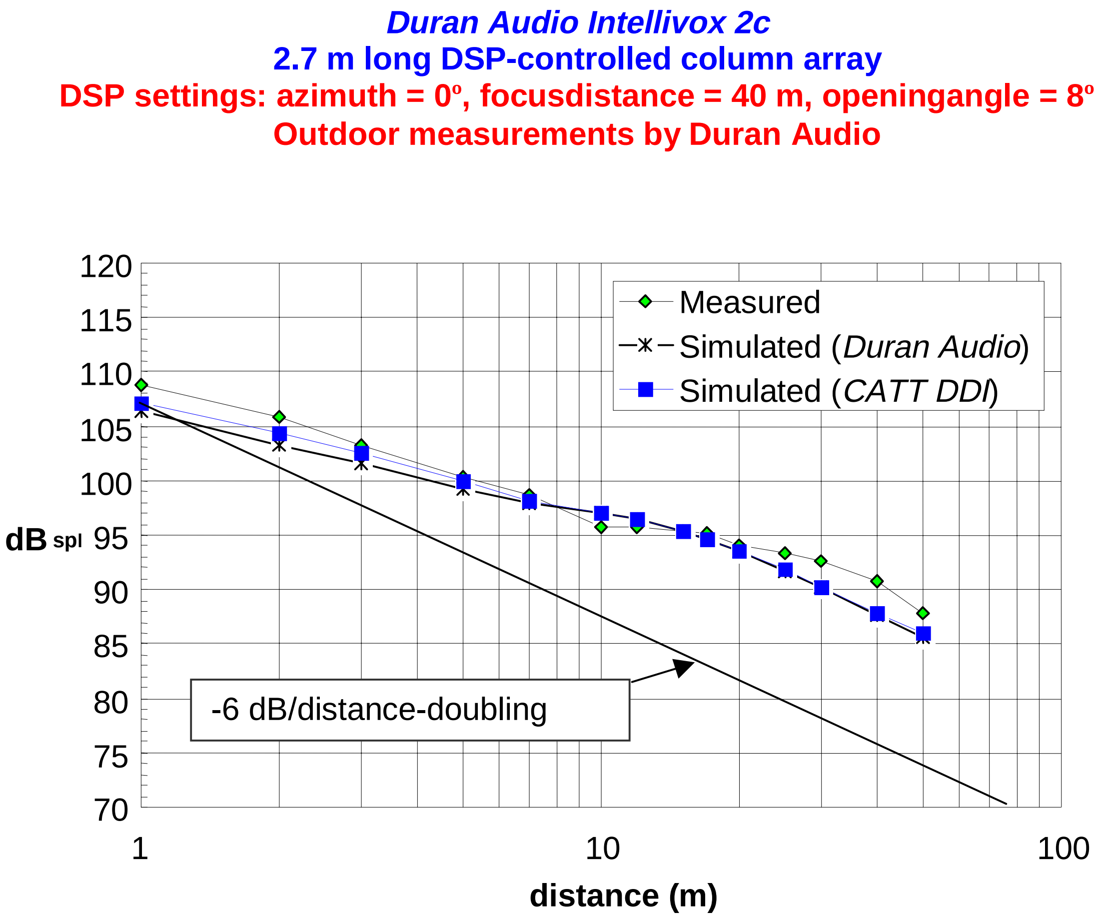


Detailed scale: comparing pattern

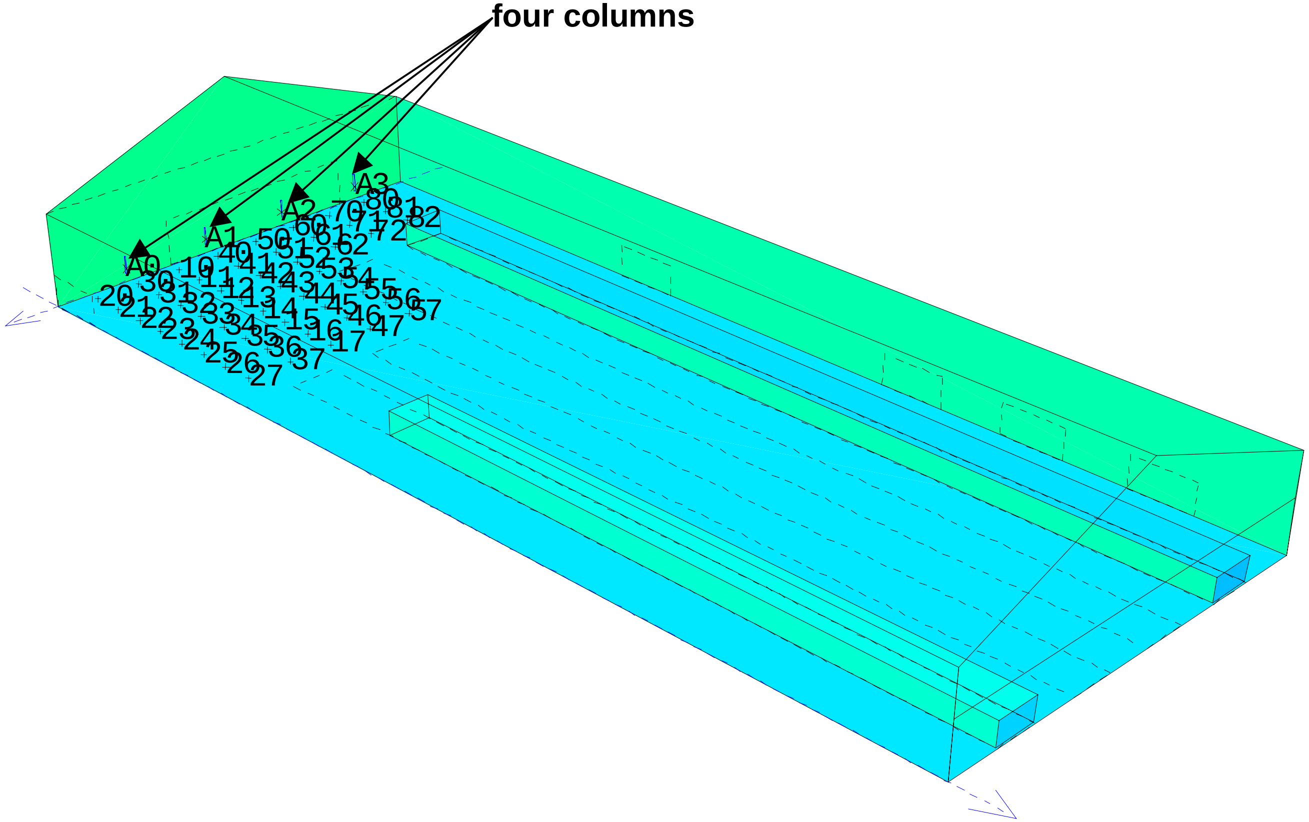
Verification examples

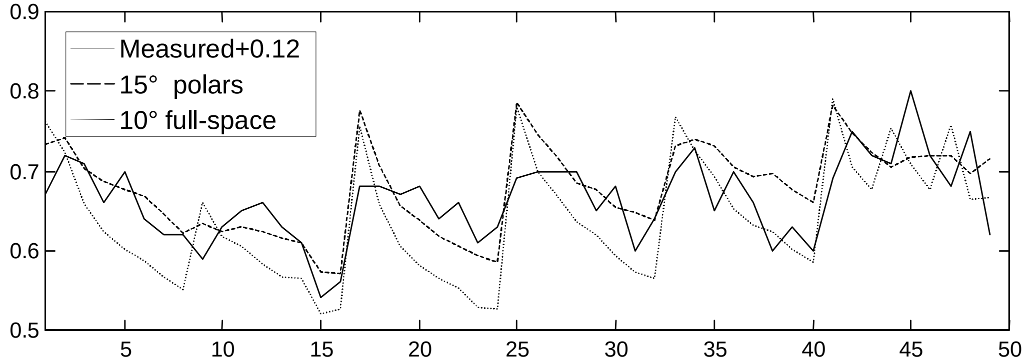
- **Free field SPL on-axis as a function of distance**
- **Two kinds of PA-system verifications:**
  - four 2.7 m long 16-element *Duran Audio Intellivox 2c* DSP-controlled column arrays in a 160 m long trainstation (Lille, France)
  - two *Intellivox 2c* and two *Intellivox 4c* (4.35 m long) DSP-controlled column arrays in a 13th century church with 6 sec reverberation time (Skara, Sweden).

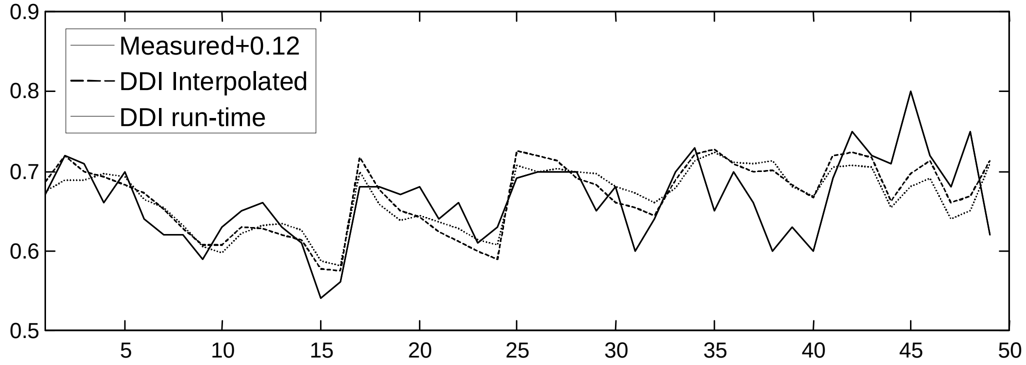
♦ Octave-band averaged 1kHz on-axis free field SPL



- **An installation of four *Intellivox 2c* (DSP-controlled 16-element column arrays) in the Lille Flandres railway station. RASTI measured for 49 locations using *MLSSA*:**

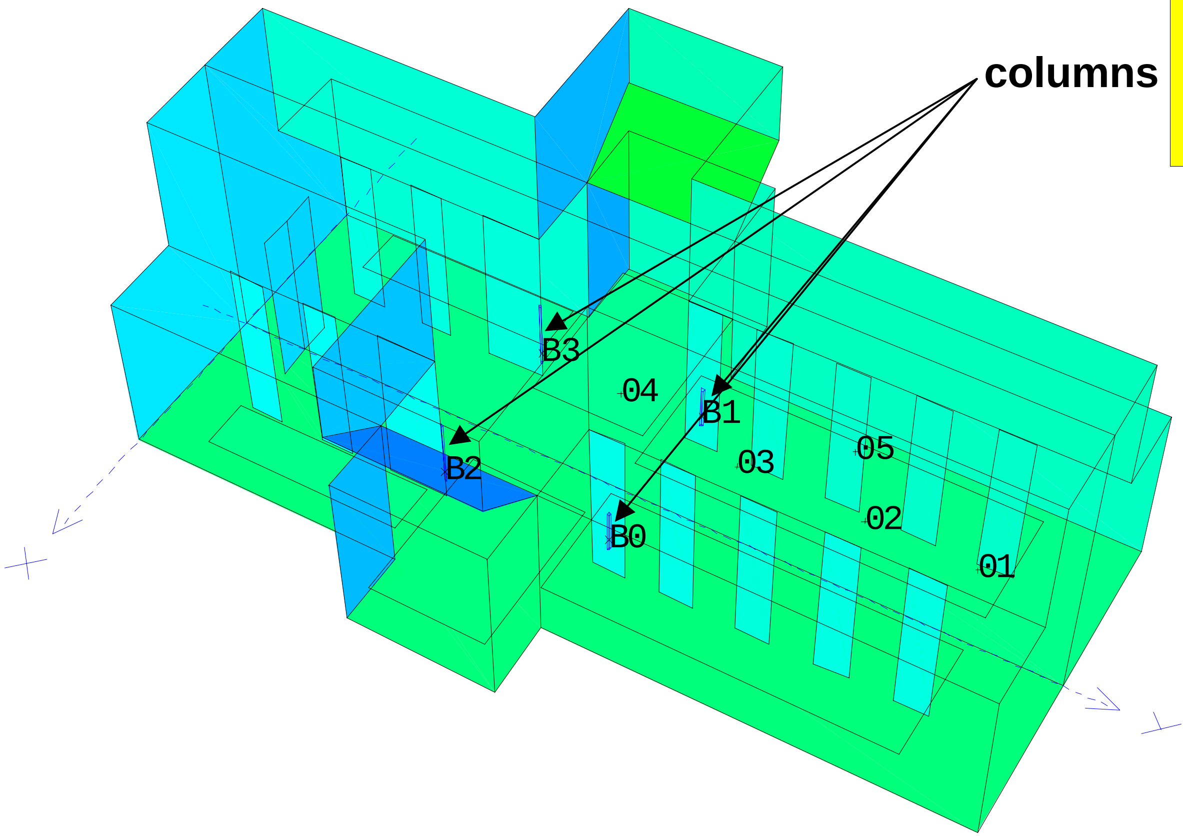




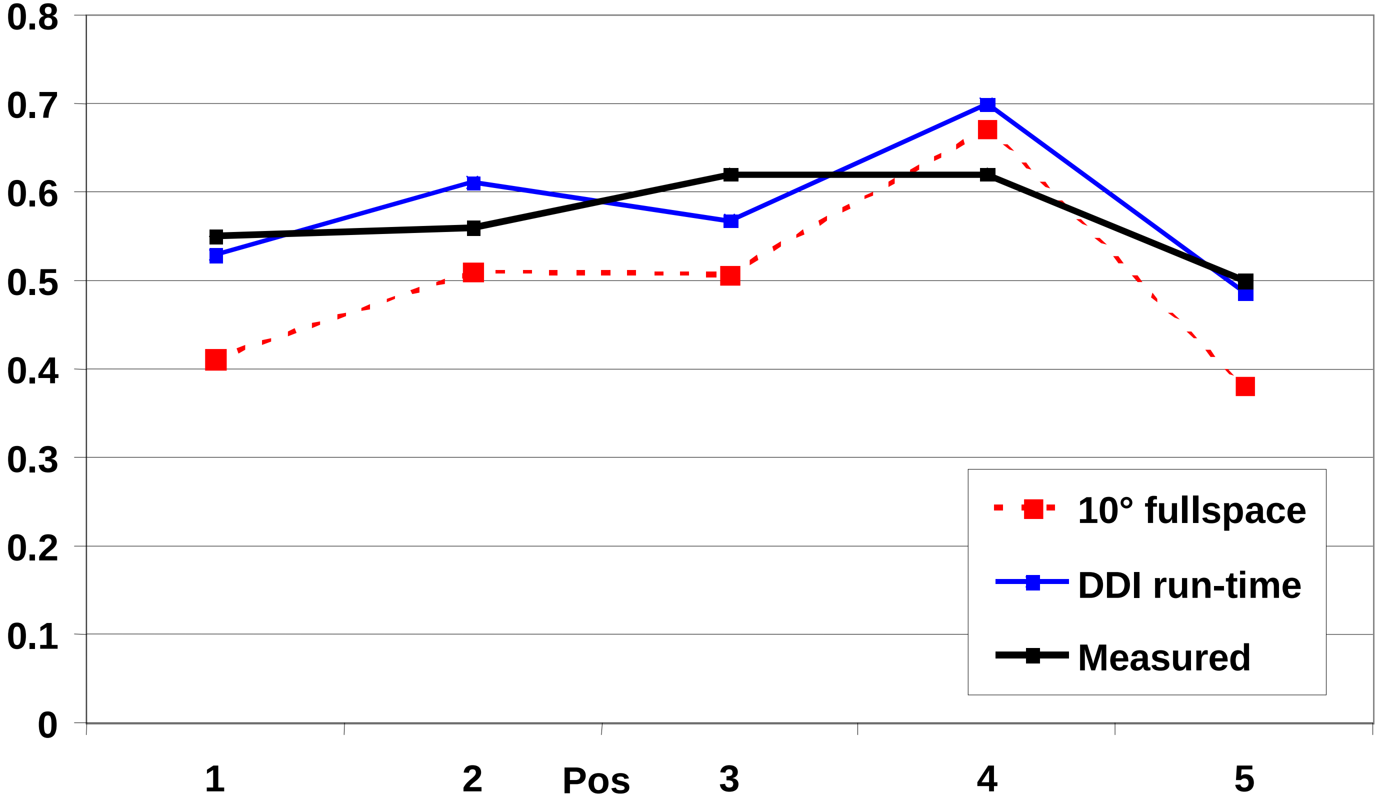


- in the railway station the overall RASTI level is slightly over-estimated as can be attributed to a number of uncertainties and simplifications of the room model as well as to the problem of handling array modeling for higher order reflections

- **Installation of two *Intellivox 2c* (2.7 m long) and two *Intellivox 4c* (4.35 m long) columns in a 13th century church with 6 sec reverberation time (Skara, Sweden). <u>Much simplified room model (see photo)</u>**



- RASTI values show good agreement and **DDI run-time modeling is consistently better than fixed 10° fullspace**. However, far-reaching conclusions cannot be drawn from a **much simplified model** of a complex church and with **only 5 locations** measured



Conclusions

- **that the distance-dependent array-modeling matches the RASTI trend much better than fixed 10° far-field 3D-balloons**
- **that the good results from the interpolated DDI model indicates that the key for RASTI estimates using column arrays is not necessarily to have a high angular resolution but to handle the extended near-field. This conclusion is likely to be mostly valid for arrays of the type used here with small transducers and simple transducer directivities.**
- **For clustering of larger cabinets, with a more complex element directivity, a 10° or 5° element directivity without phase will be insufficient. For such arrays/clusters, also the array-modeling itself is much more complex (due to screening and diffraction effects etc.) but <u>the DDI can handle it if the theory is known and if high-res data is available</u>.**

Acknowledgements

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- *Duran Audio* for use of the measured RASTI and free-field SPL data
- *Akustikon* for the church model and measured RASTI data

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