For headphones auralization the sound contribution coming from a given direction of incidence (first reflections) or from a given solid angle (other contributions) must be convolved with the corresponding HRTF.

\[ s_{\text{Headphones}} = \sum_{m=1}^{M} \left( (s(m) \otimes IR_{m,0}) \times \text{HRTF}(\theta_m,\phi_m) \right) \]

\[ + \sum_{n=1}^{N} \left( (s(n) \otimes IR_{n,0}) \times \text{HRTF}(\theta_n,\phi_n) \right) \]

**Echograms to Impulse responses**

Comparison between echogram and reconstructed echogram for IR:

- Ray tracing
- Directional echogram
- Phase is recreated for every direction during the conversion

**Algorithm with separate first reflections**

\[ s_{\text{Real-Time}} = \sum_{m=1}^{M} \left( (s(m) \otimes IR_{m,0}) \times \text{HRTF}(\theta_m,\phi_m) \right) + \sum_{n=1}^{N} \left( (s(n) \otimes IR_{n,0}) \times \text{HRTF}(\theta_n,\phi_n) \right) \]

- Real-time partitioned convolution (low latency)

** Aurralization**

For example, in case of headphones:

\[ y_n = \text{anecho} * \text{IR}_{n,0} \]

\[ y_n = \text{anecho} * \text{BRIR}_n \]

- Output on soundcard (alsa driver)
- Interactivity (GUI, head-tracker, mouse, keyboard)

It is interesting for some particular virtual spaces, to reproduce the effects of directional RIRs, not only for the first-orders mirror sources, but also for the whole echogram.

This technique is mostly useful in spaces where diffusion is not predominant, and particularly at low and medium frequencies.

Instead of traditional spatial parameters (for example IACC or Lateral fraction), we suggest the use of directional parameters such as $T_{30,\text{Dir}}$, $E_{80,\text{Dir}}$ or $E_{160,\text{Dir}}$.