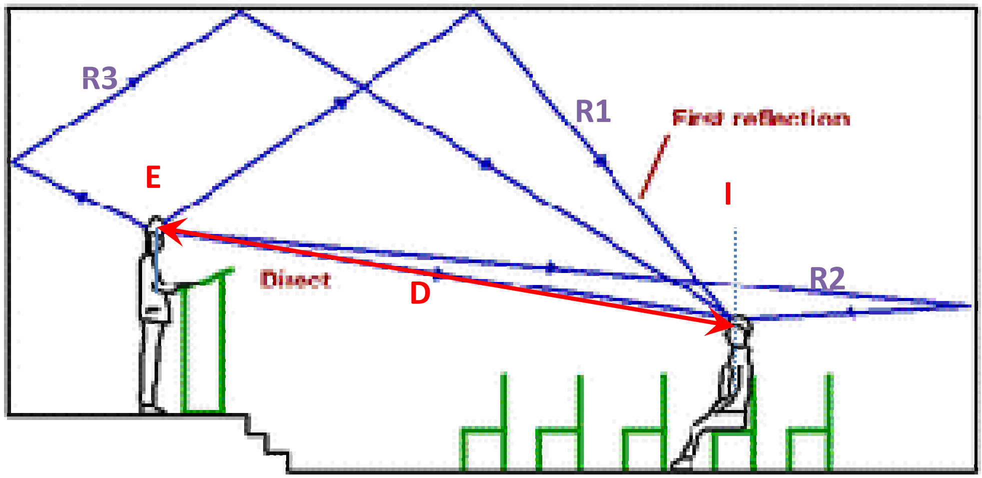
Press-Play : basic acoustics
0. Directiveness & reverberation

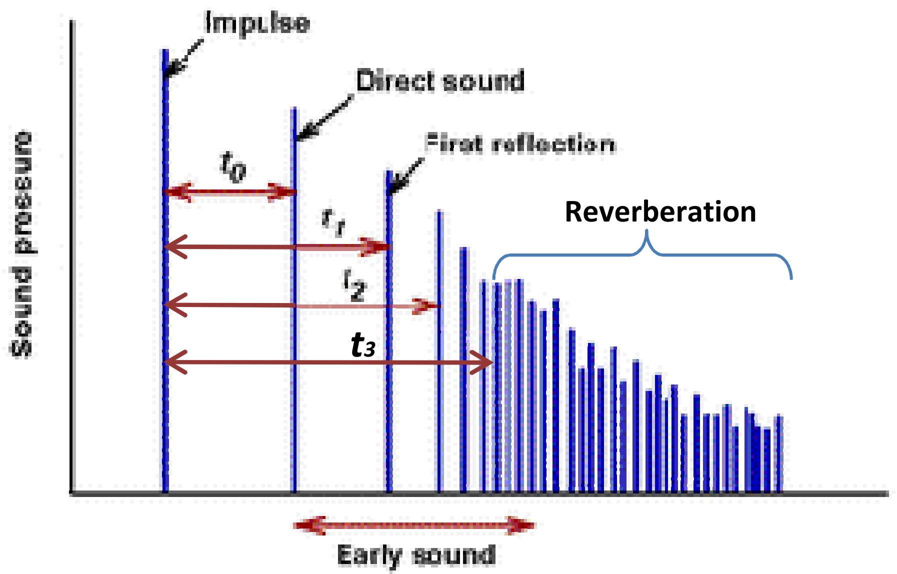
- When a speaker fires a pulse or soundwave it takes some time for the ear to pick it up
- The human ear determines directivity by calculating the differences in time and amplitude between the two ears of the waves captured on each side (resonance within the ear as well as the pinna)
- In a second phase the room acoustics are intepreted as well by calculating differences in the way reflections and reverberation occur and impact the ears
- Thus in order for the brain to perform these calculations, these phases cannot overlap

⇒One can distinguish, on a timescale,
  - a direct path,
  - discrete (first) reflections,
  - reverberation (harmonics)

- As every waveform consists of many frequencies, they are not processed in the same way:
  Low frequencies are not directional
  Differences in amplitude :
    decreasing (damping) can make an overlap not problematic
    sustaining (flutter/resonance) can make an overlap even worse

Press-Play : basic acoustics
1. Direct sound vs. Reflections





Reflections > 5ms but <30 - 80ms do not detract from our ability to localize sounds but are perceived as an increase in spaciousness , reverberations add 'color'.

So if T1-T0 > 5 ms

$\Delta D = 343$ m/s * 0.005 s = 1.72…m

⇒ First reflection should have an approximately 1.75m longer travel path

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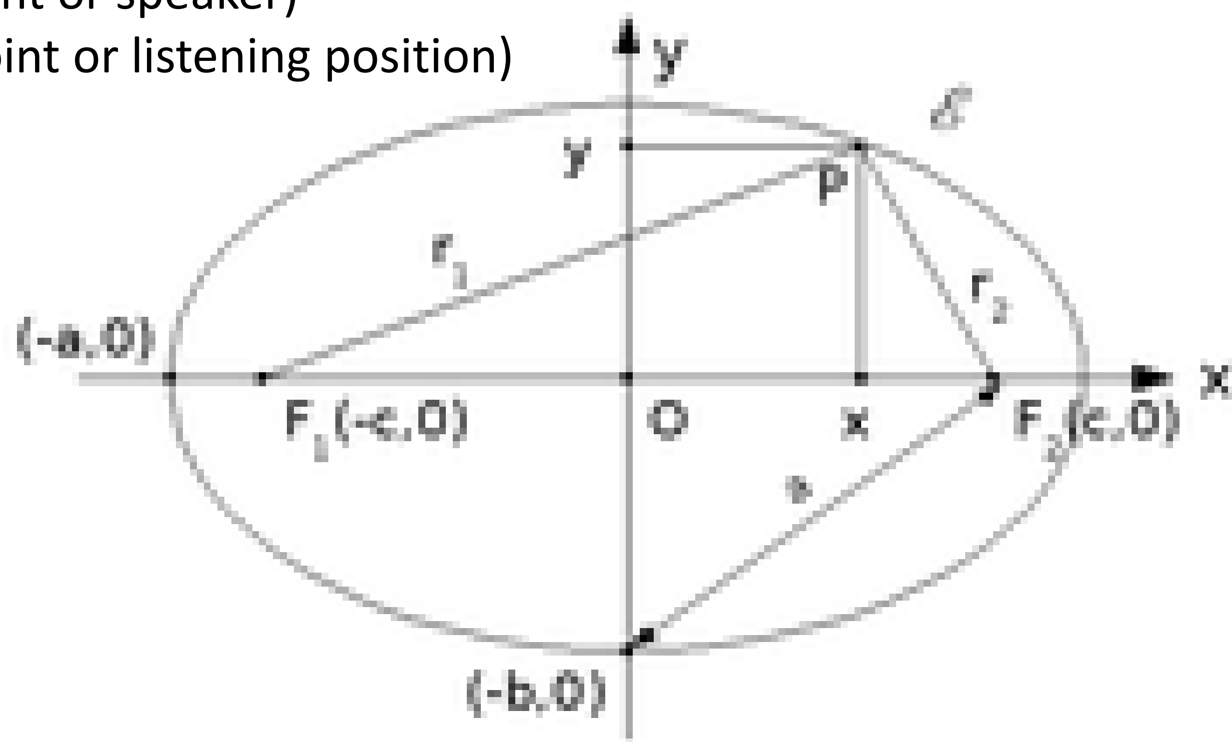
2. First reflections

⇒ all reflections having a travel path longer than D + 1.75m are not an issue as they arrive later than 5ms and provide no overlap with the direct impulse, thus not interfere with directiveness of sound

⇒ To check which reflection paths fall within a path length below D + 1.75m one has to draw an imaginary ellipse with

- a ‘diameter’ of (r1 + r2) <= D + 1.75m
- as foci : F1 = E (emission point or speaker)
  F2 = I (immission point or listening position)



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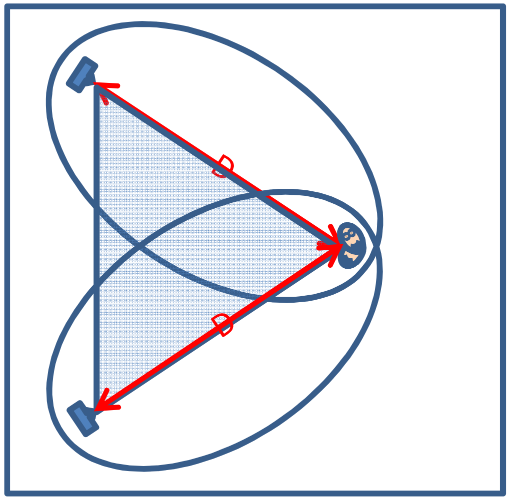
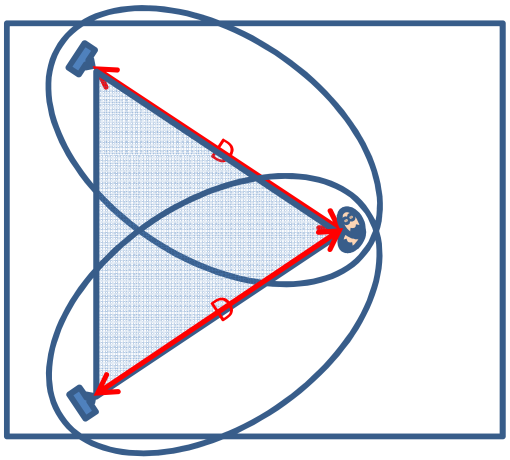
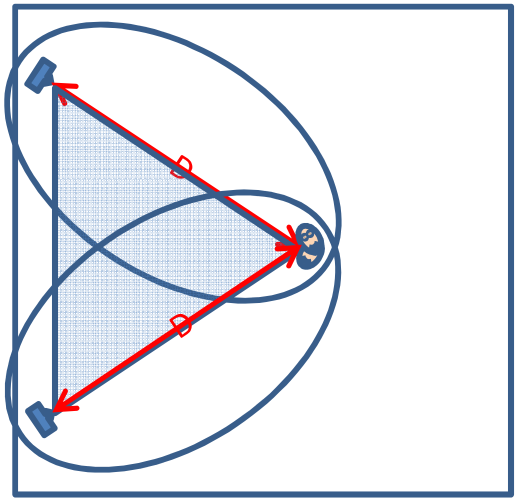
3. Locating first reflections on a plan



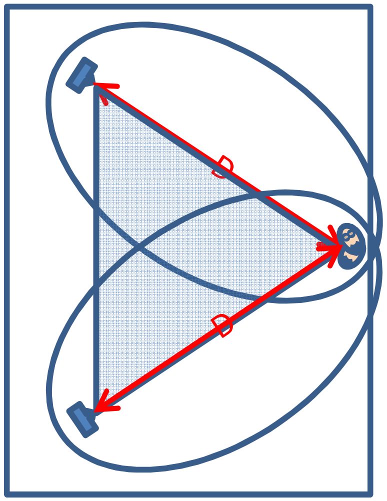
OK
Ellipse touches no walls



NOK
Ellipse touches side walls => Move speakers closer together, reduce stereo triangle



NOK
Ellipse touches front wall => Move speakers further into the room



NOK
Ellipse touches rear wall => Move speakers closer together, reduce stereo triangle, bring listening position further from rear wall

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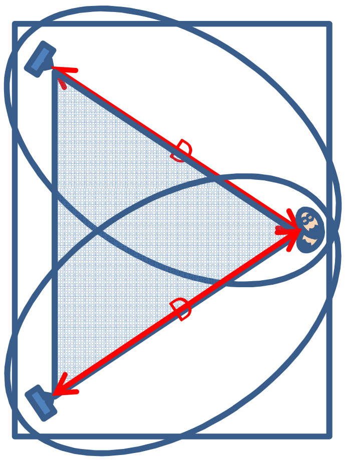
3. Locating first reflections on a plan (cont'd)

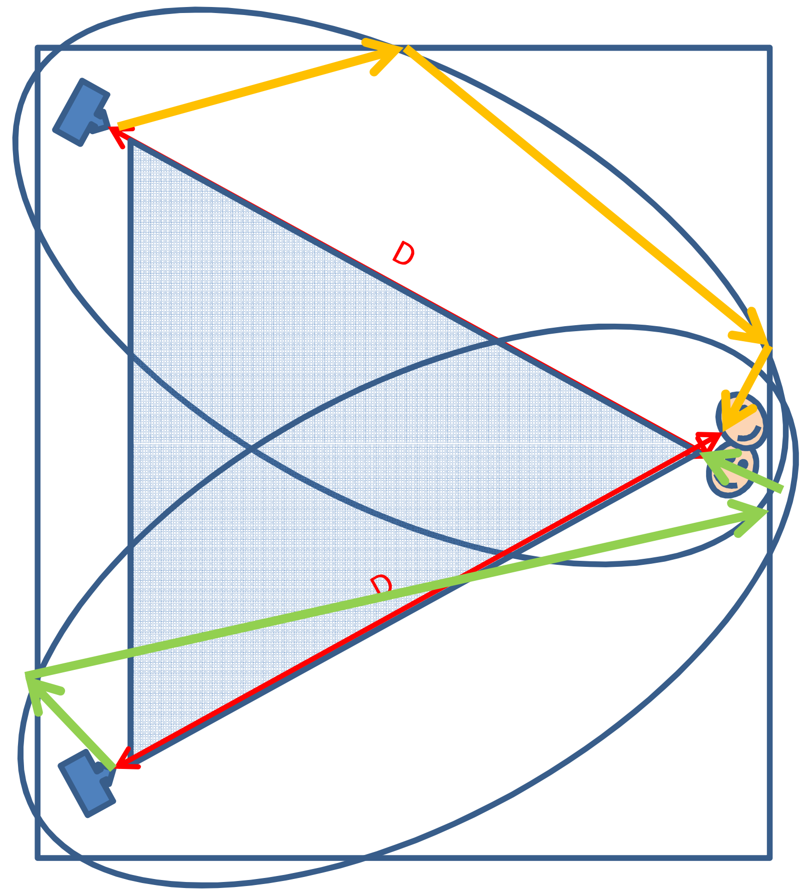


NOK

In the rare case the Ellipse touches many walls =>

- Reduce stereo triangle
- revert to ray tracing to determine the length of additional individual reflections

-All lengths under D + 1.75m are problematic



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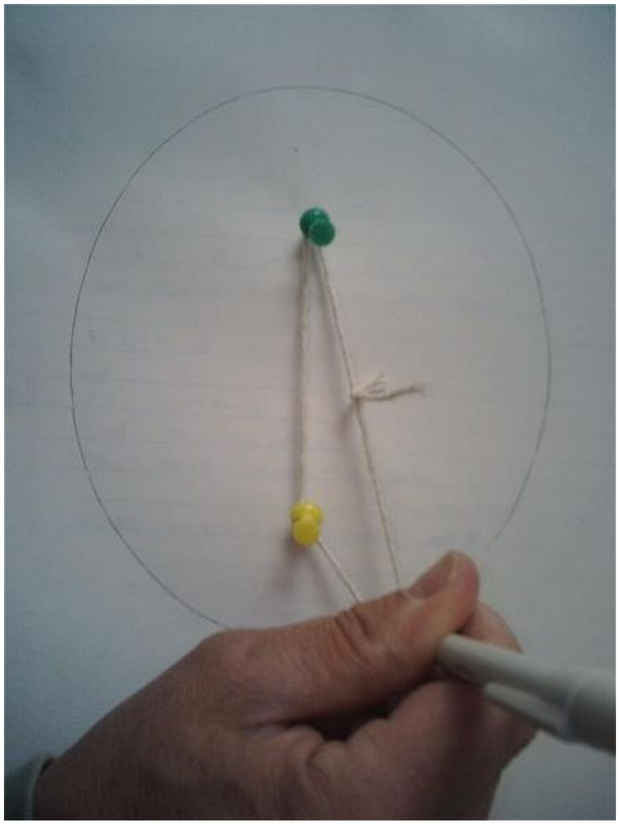
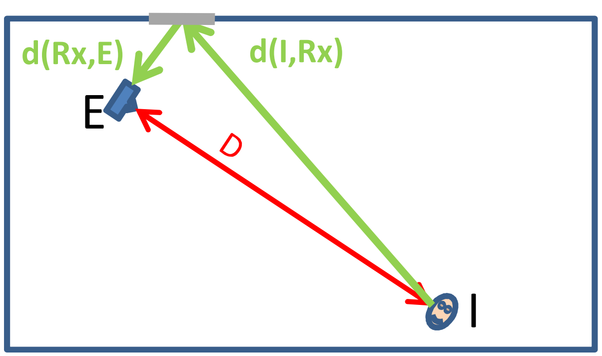
4. Locating first reflections in a room



1. Like the ‘Two pins, a loop and a pen method‘ from primary school:
-make a piece of rope with a length of D + 1.75m
- attach one end to the front of the speaker (E)
- attach other end to the listening position (I)
- put a pole inside the rope and move around on the outline of an ellipse
- put a sticker everywhere you touch a wall

These points indicate a problem with early reflections and should be treated as mentioned on the previous slide or be treated with acoustic dampening material



2. Take a seat in your listening position and ask someone to move along the walls with a mirror. Everywhere you can see the front of your speakers ,is a reflection point. Measure the total length from I (seat) to Rx to E (speaker) : d(Rx) = d(I,Rx) + d(Rx,E) > D + 1.75m

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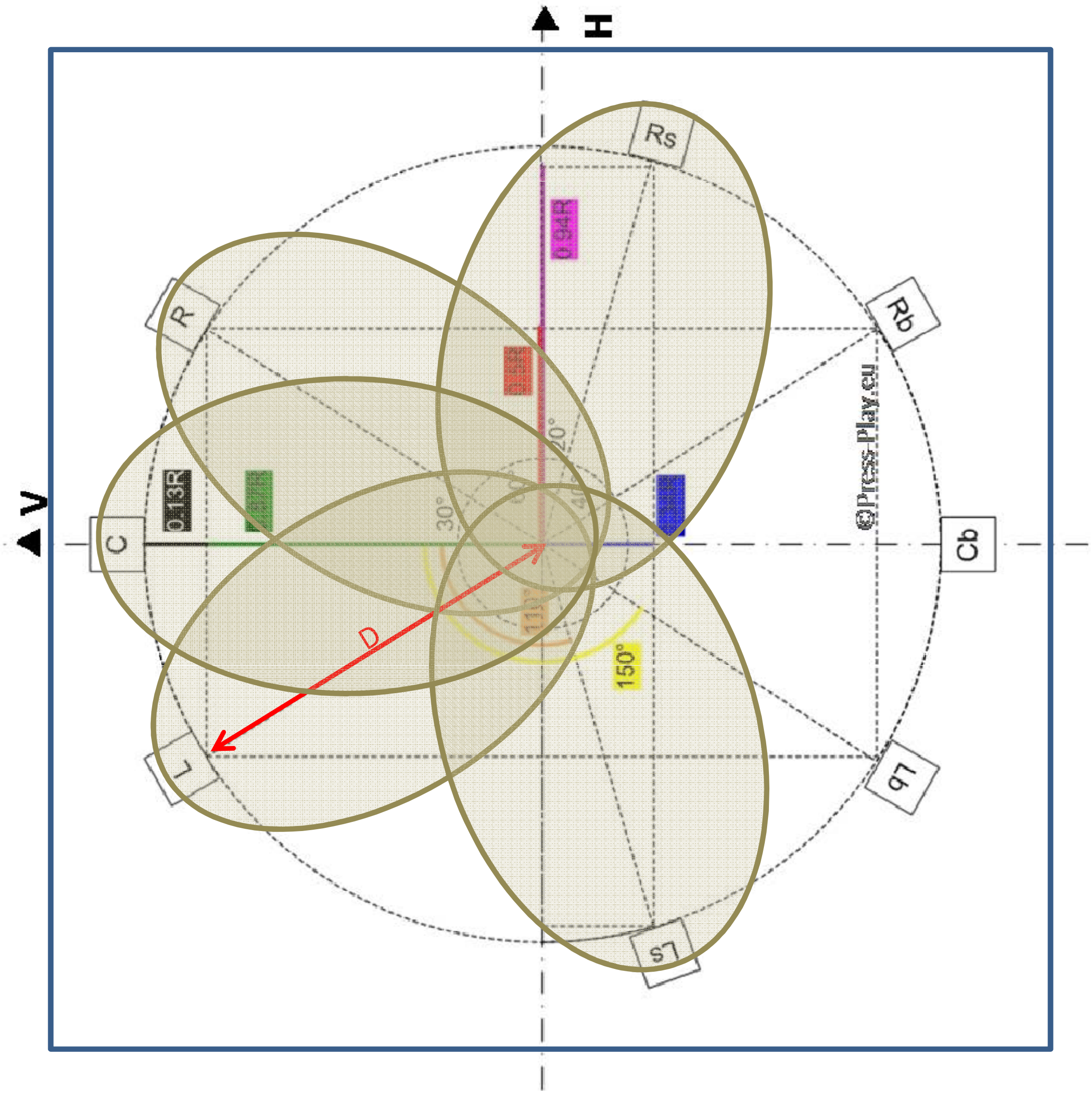
5. Locating first reflections for surround



As indicated here for a 5 channel stereo setup, things can become rather complicated ...

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6. Remarks

- the floor and the ceiling are also walls and must be considered the same way as the surrounding vertical walls, although vertical reflection interference is not perceived as problematic by the human ear.

- Move speakers at least 1m from the walls,to avoid non-linearity due to low freq boost

- Subs can be placed next to the wall and become more efficient from the low freq boost, linearity is not an issue as they only play low freq, that is < 80Hz

- Positioning a sub can be done in reverse placement : put the sub on the listening position and crawl around the room to determine the best sounding location for low frequency response. As low freq are not directional, reverse the 2 locations and your sub will sound great from the listening position when volume levels are adjusted accordingly.

- Dampening material should be used to a minimum, to avoid a ‘dead room’, when the problematic reflection points are treated , continue to add diffusor treatment (panels, open CD rack,etc..) to tackle reverberation