Orchestra Canopy Arrays

- some significant features

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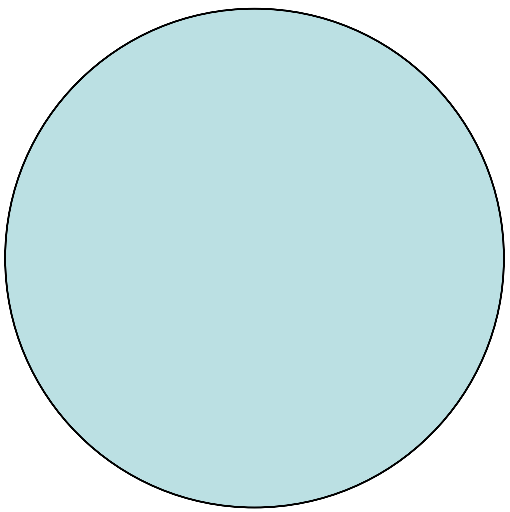
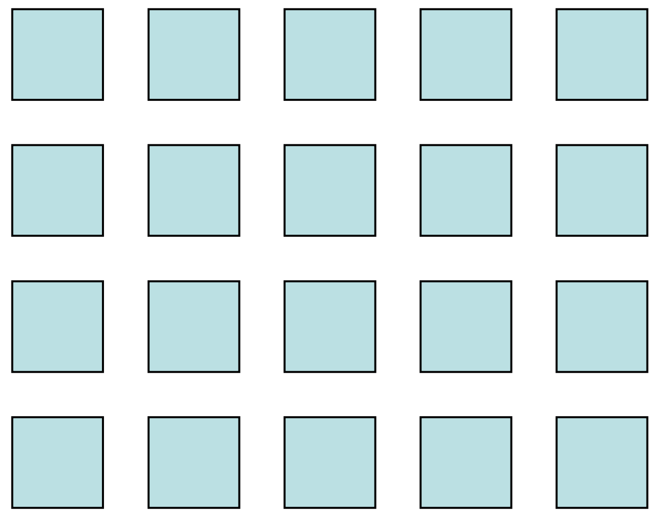
What is an orchestra canopy?

- Horizontal, sound reflecting device
- Suspended, above orchestra, examples:



Single element
μ=100% density



Element array, μ=50% density

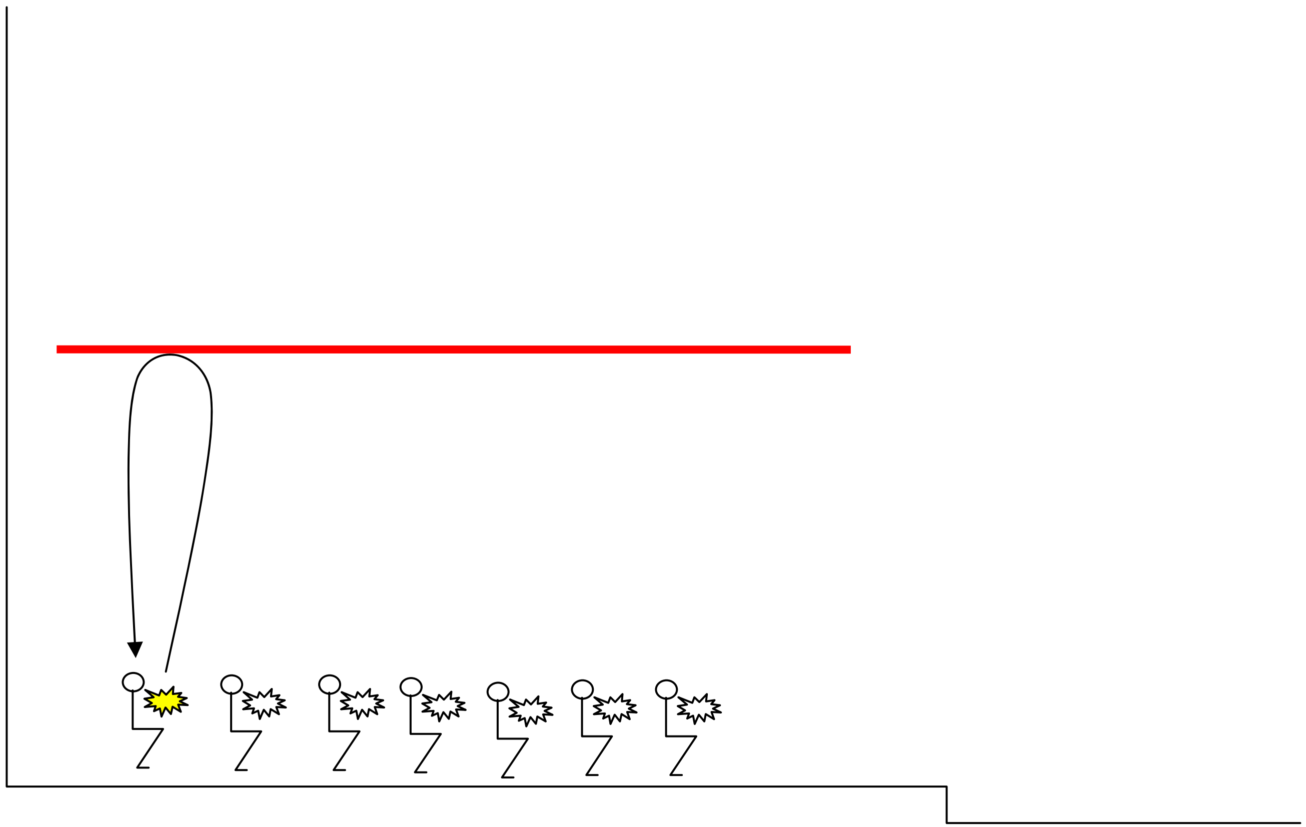
Canopy justification?

- Measured and predicted effect sometimes weak
  - Even if musicians respond positively
- High rated concert halls without a canopy
  - Musikvereinsaal in Vienna
  - Concertgebouw in Amsterdam
  - Boston Symphony Hall

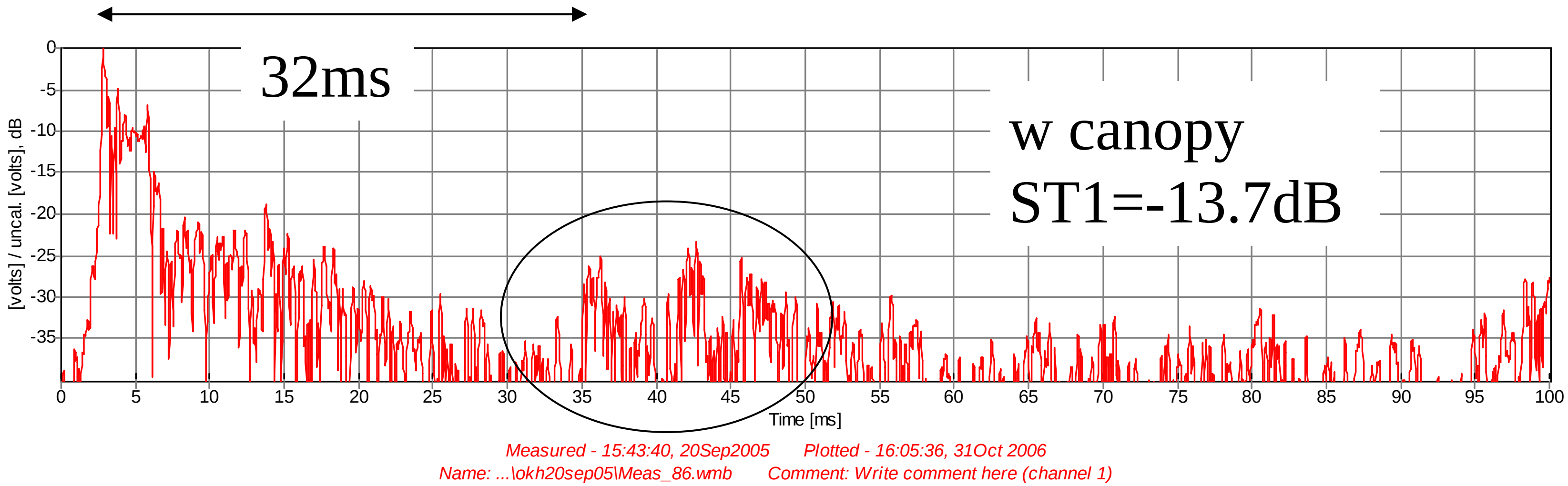
Canopies can provide…

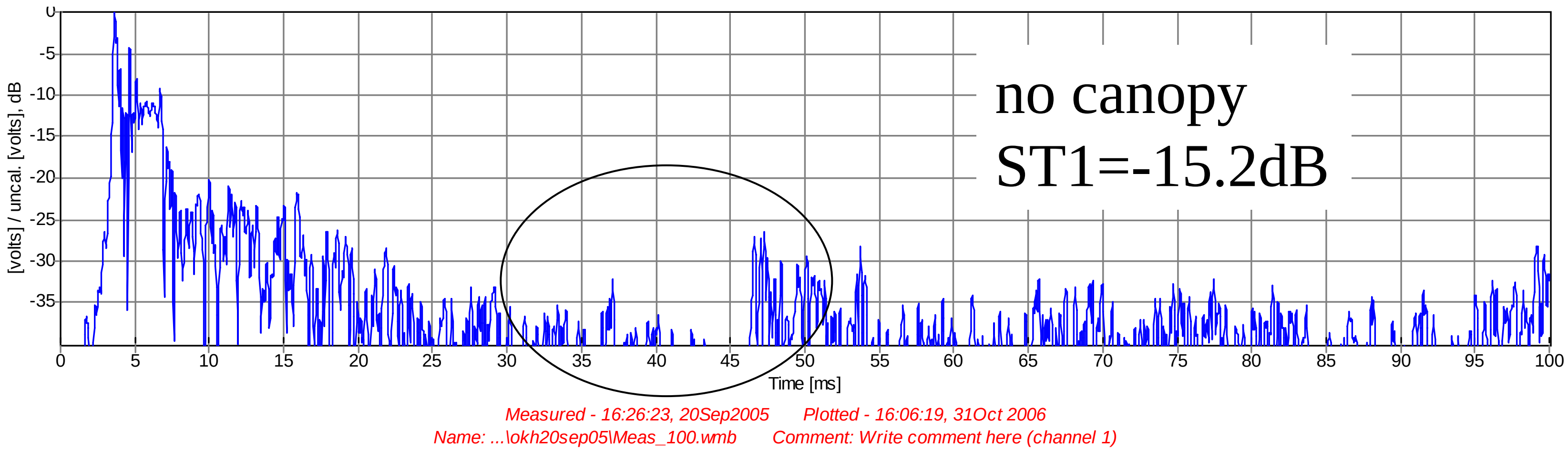
- Support: Musician hearing oneself
- Mutual hearing among musicians at stage
- Several communication channels for mutual hearing
- Preventing echo from high ceiling
- Early sound (<50ms delayed) to the audience

Support – hearing oneself

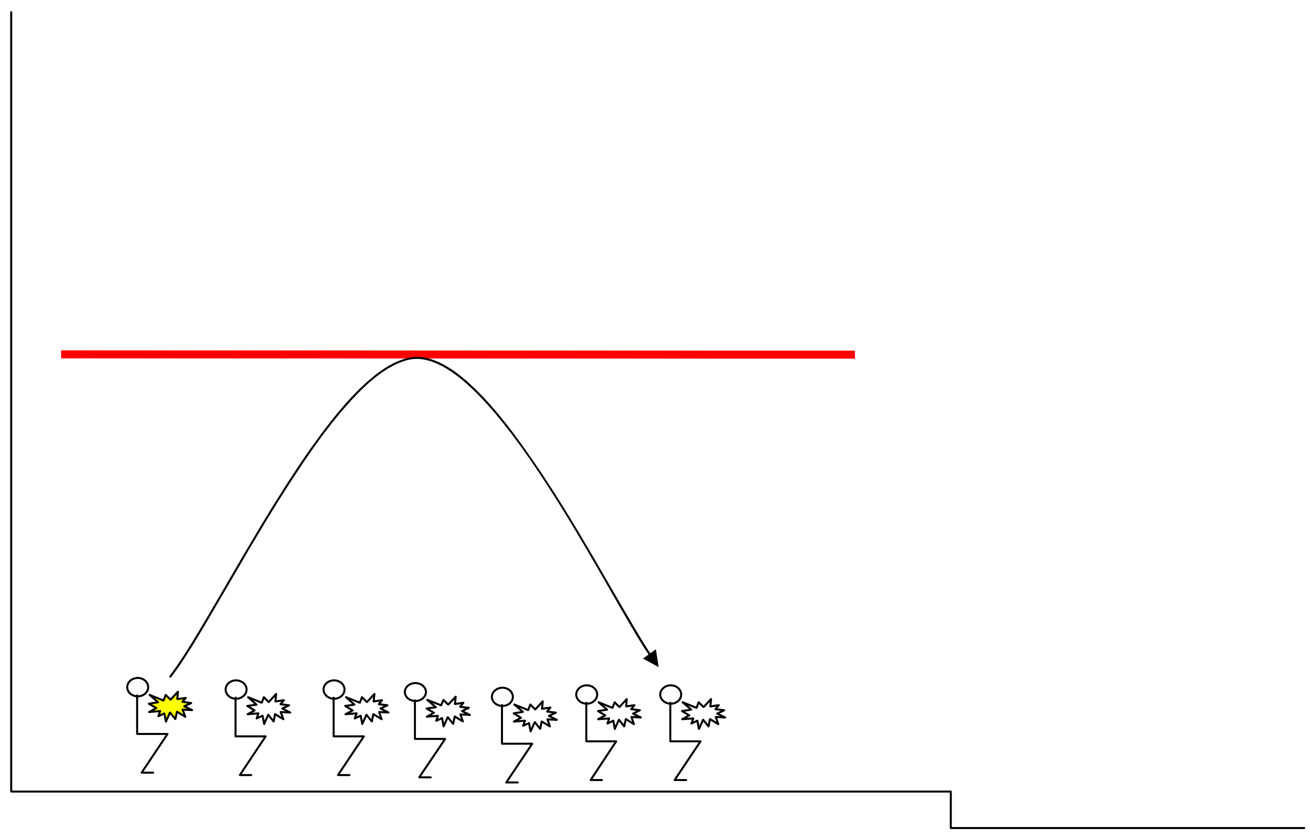


Support – fill-in-effect





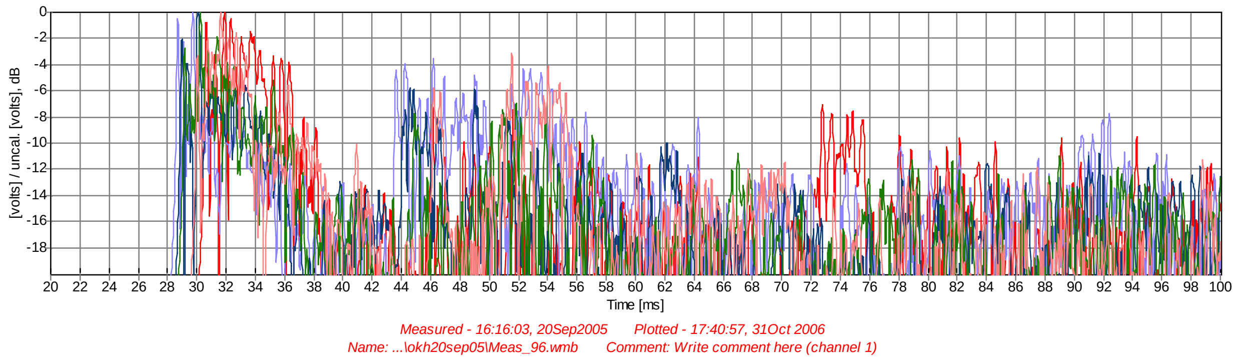
Mutual hearing



Mutual hearing

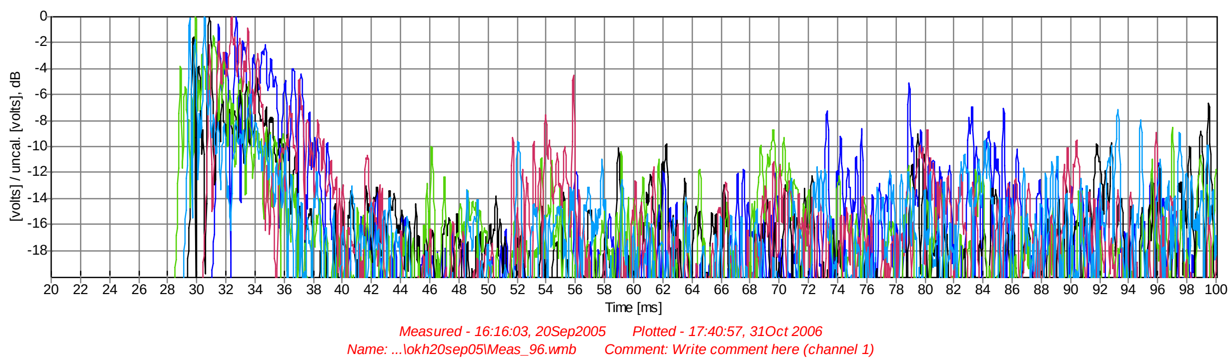
- 5 measurements, 10m source-receiver distance

20dB



w canopy

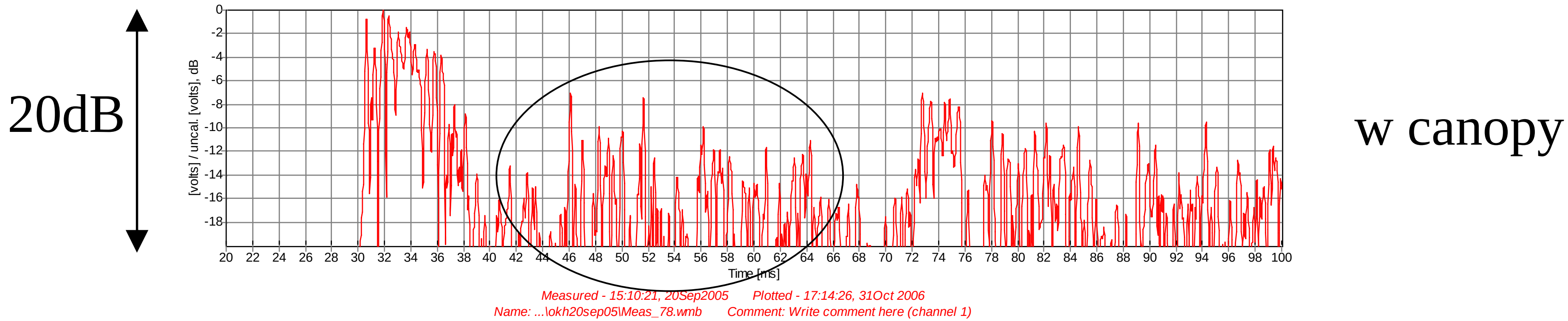
20dB

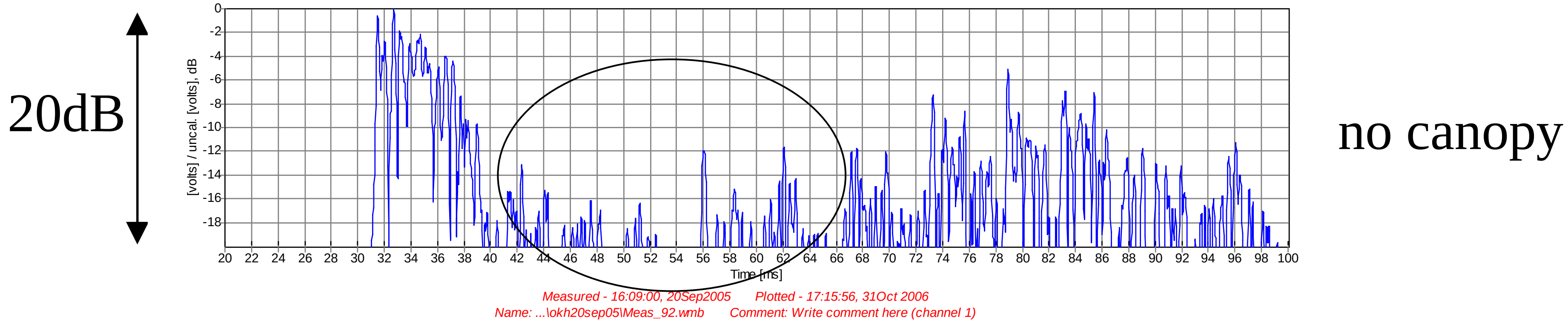


no canopy

Mutual hearing

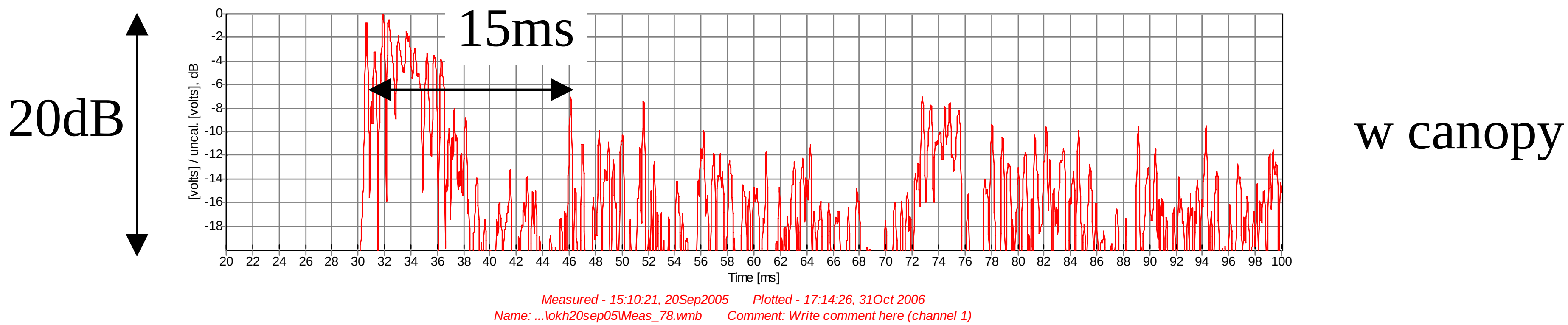
- Fill-in-effect, 10m source-receiver distance

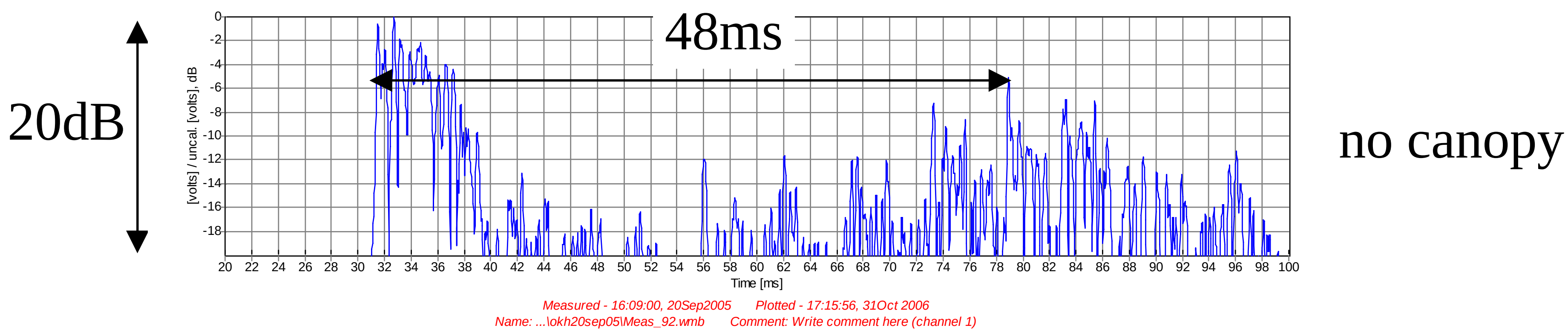




Mutual hearing

- Initial time delay gap ITDG, at 10m distance

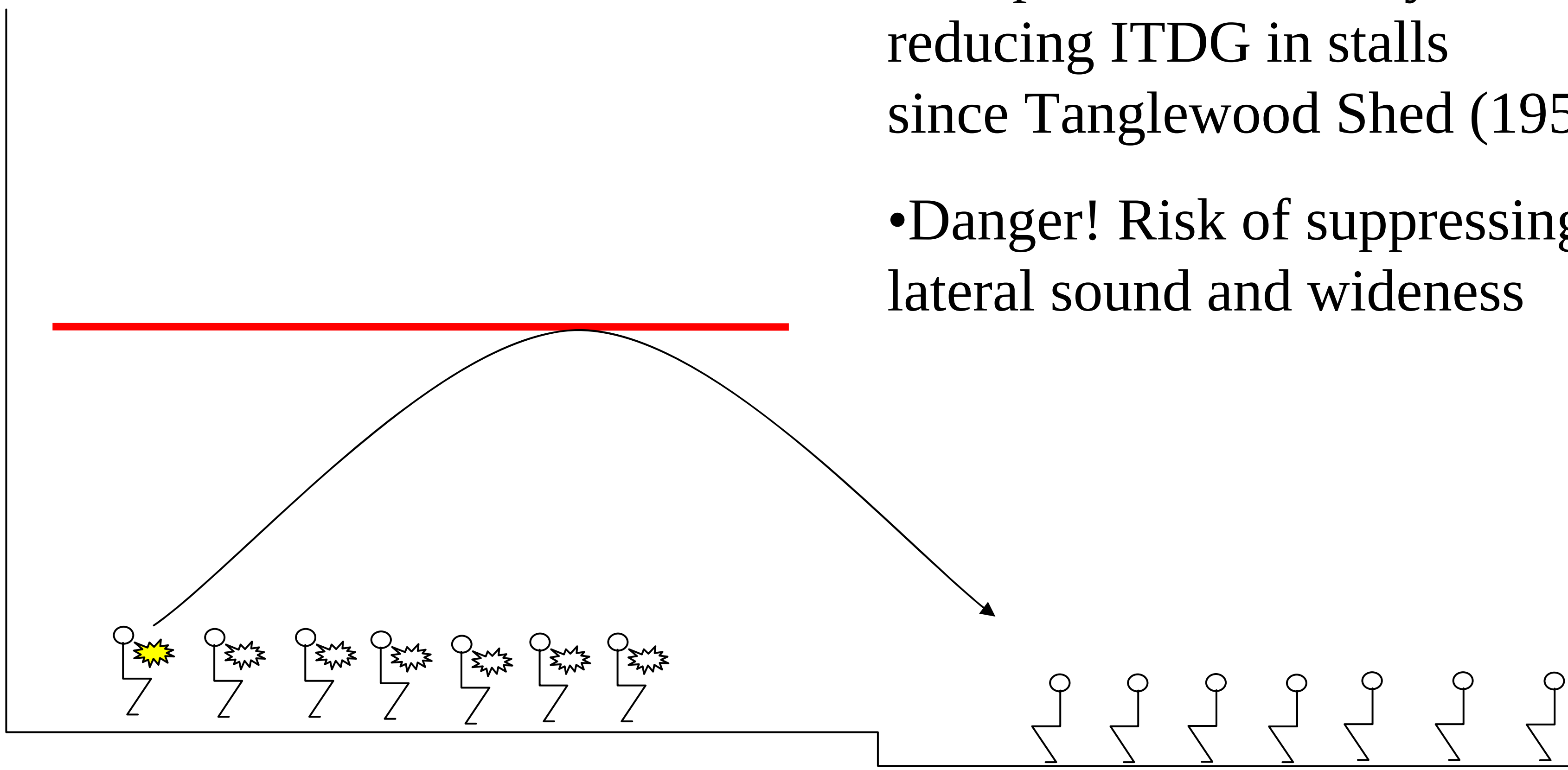




Early reflection to front seats

Canopies motivated by reducing ITDG in stalls since Tanglewood Shed (1950es)

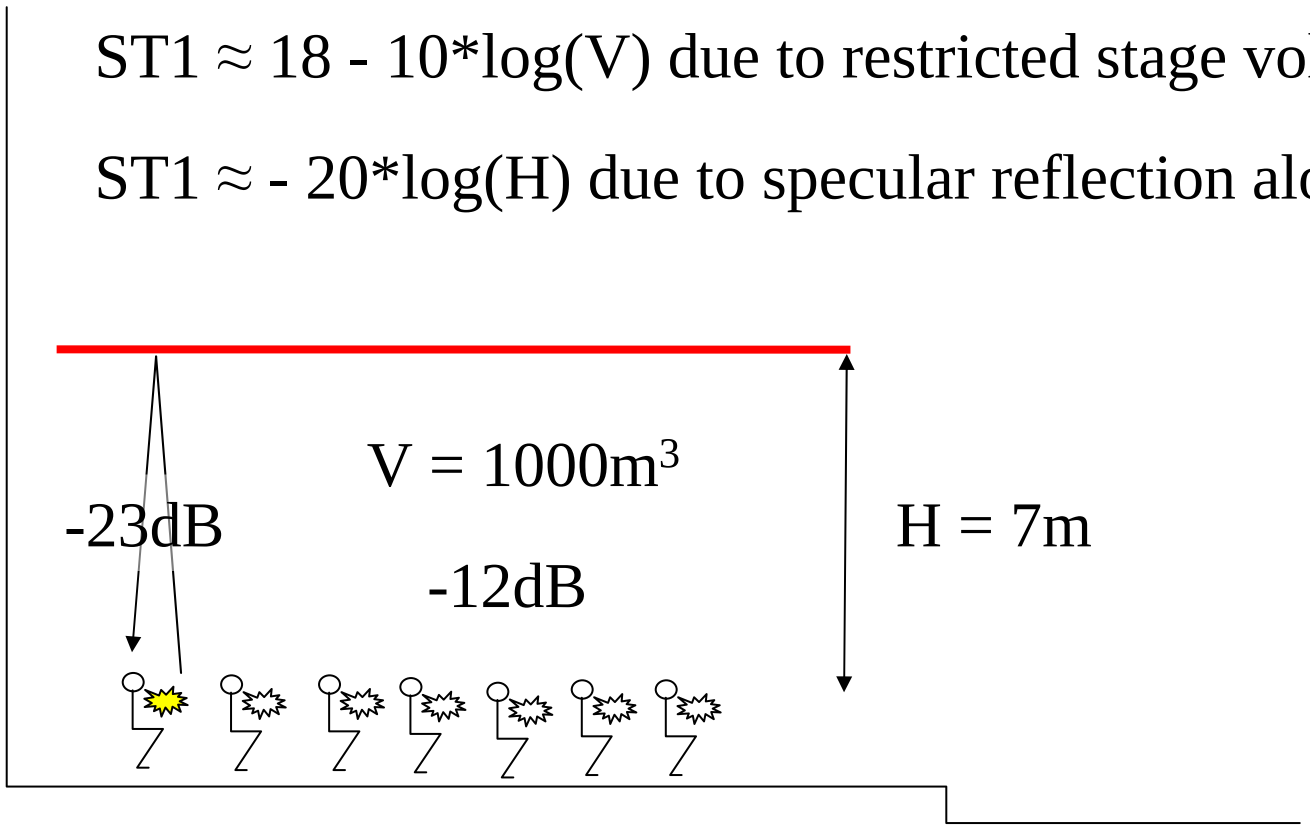
•Danger! Risk of suppressing lateral sound and wideness



Early energy control by stage volume

ST1 ≈ 18 - 10*log(V) due to restricted stage volume V

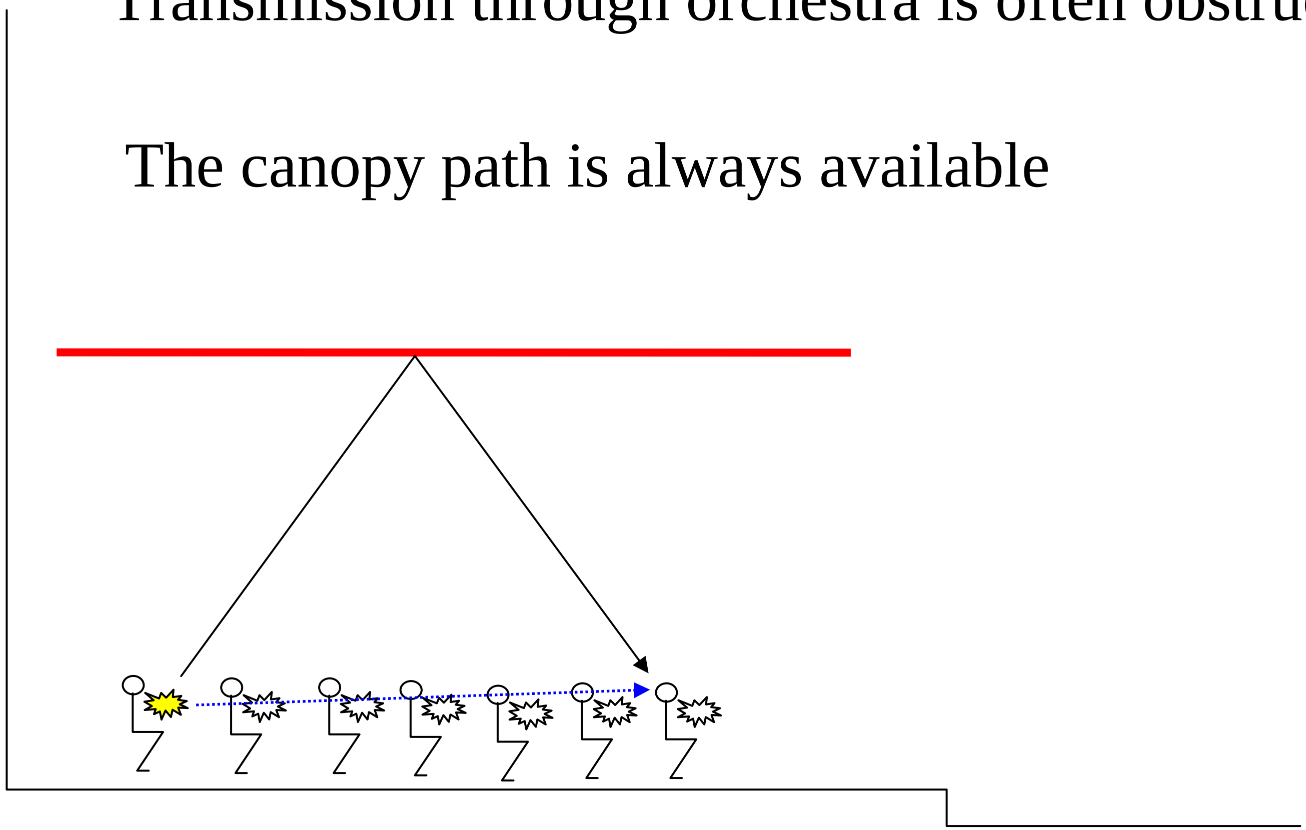
ST1 ≈ - 20*log(H) due to specular reflection alone



Unobstructed transmission

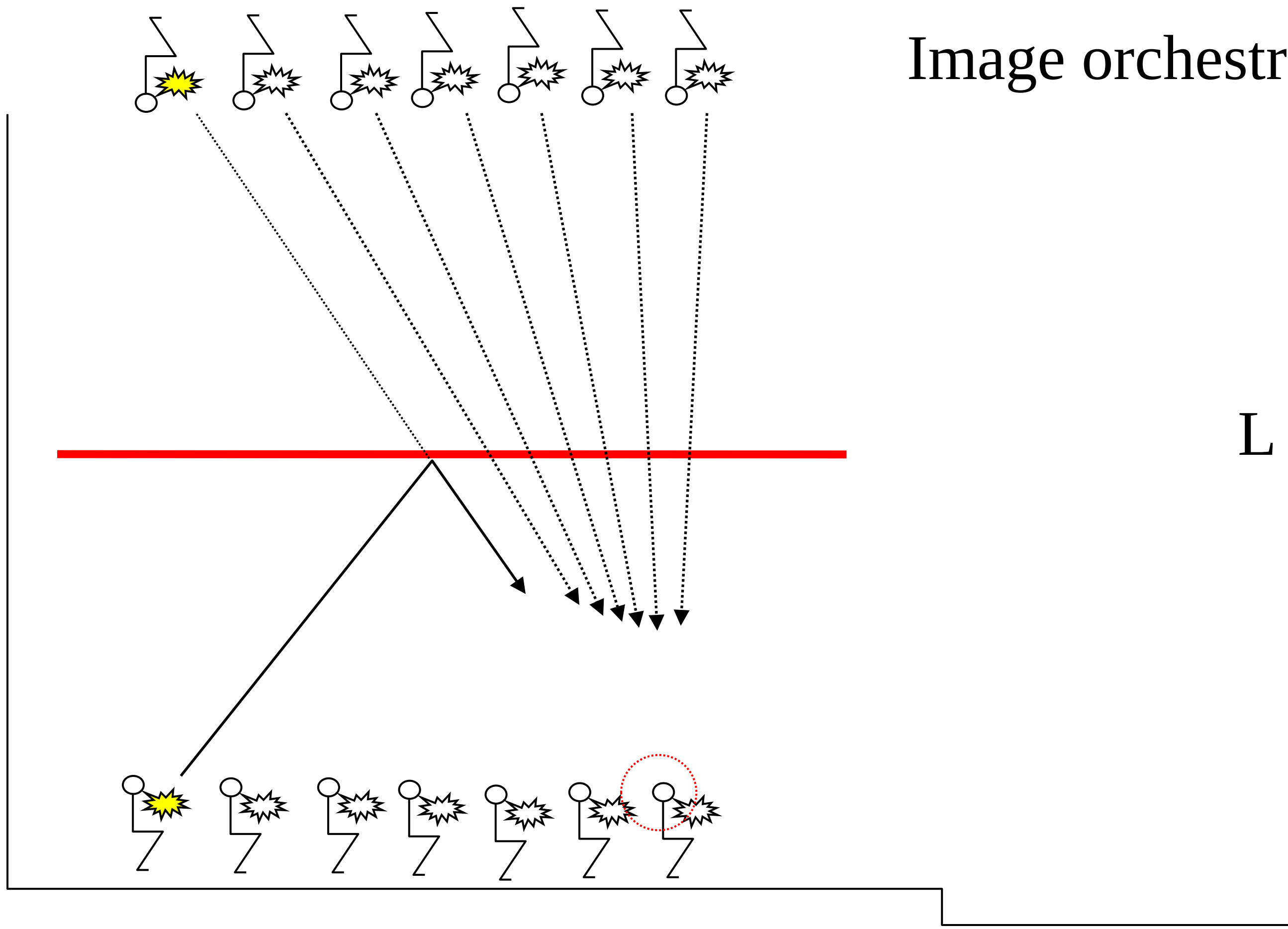
Transmission through orchestra is often obstructed

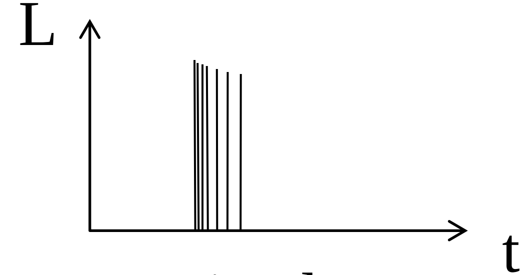
The canopy path is always available



Synchronism

Image orchestra





Received:
- In sync
- Equal levels

Wall reflections

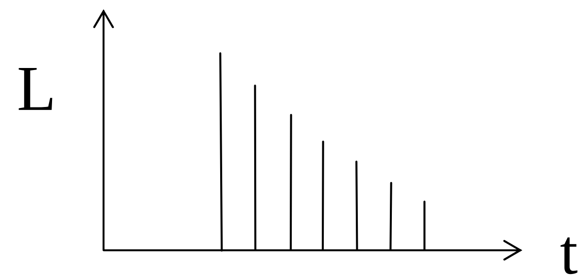
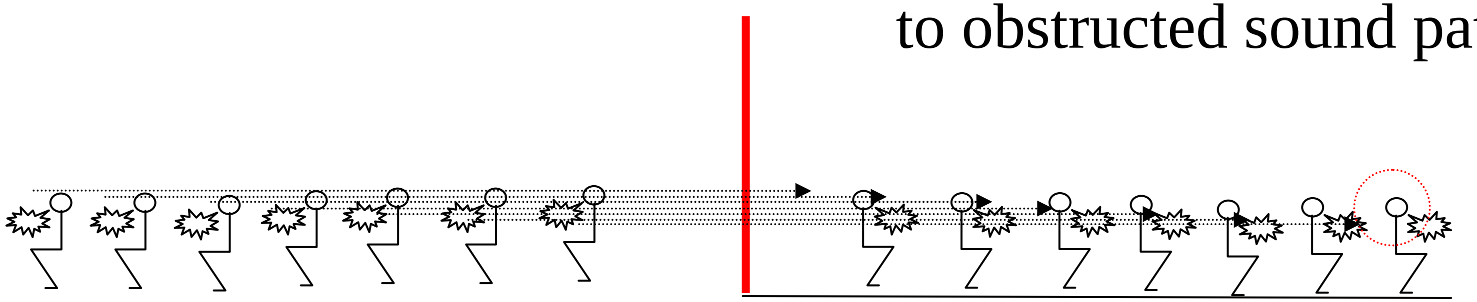


Image orchestra

Received:

- Out of sync
- Level differences dB/m, due to obstructed sound path



Wall + Balcony soffit

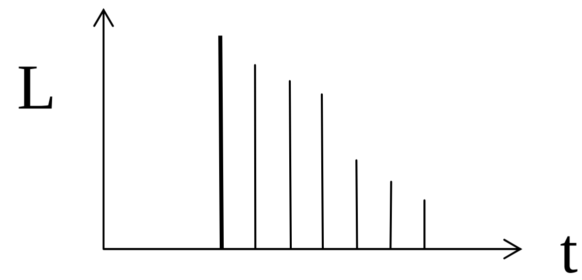
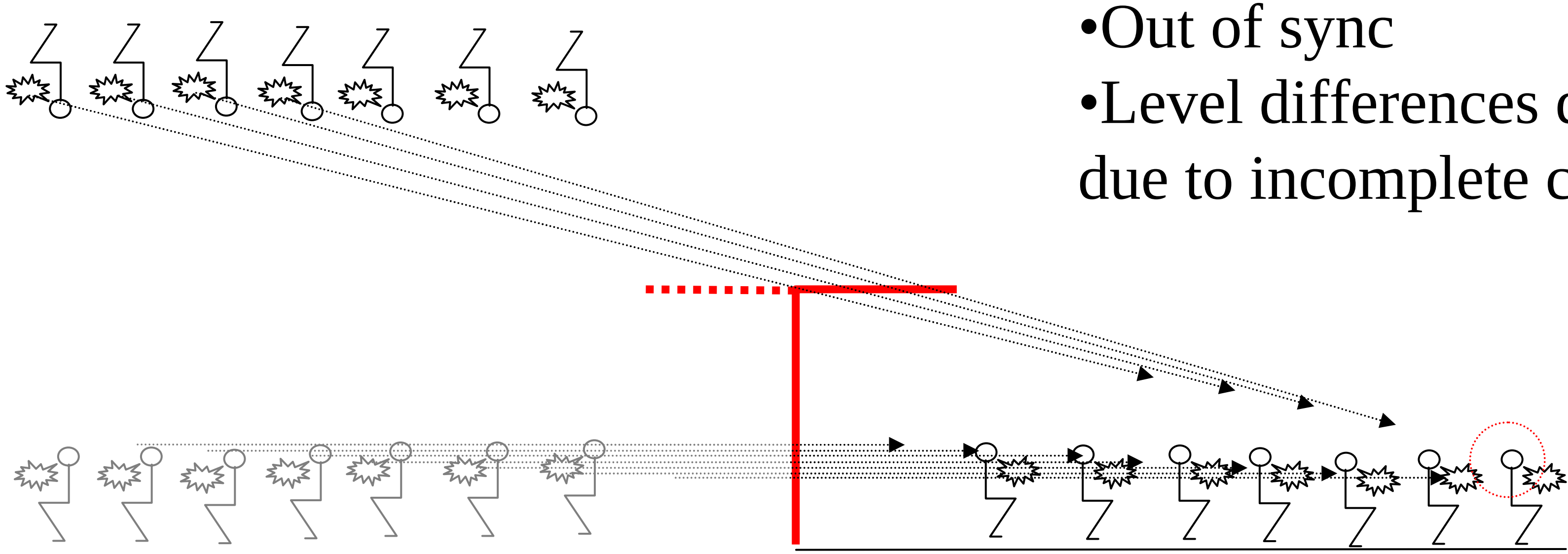


Image orchestra

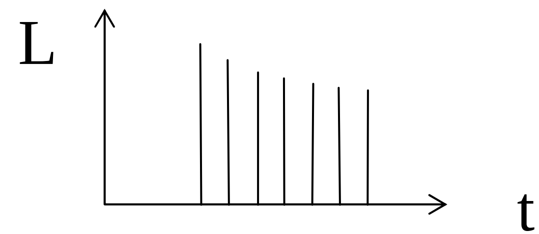


Received:

- Out of sync
- Level differences dB/m, due to incomplete coverage

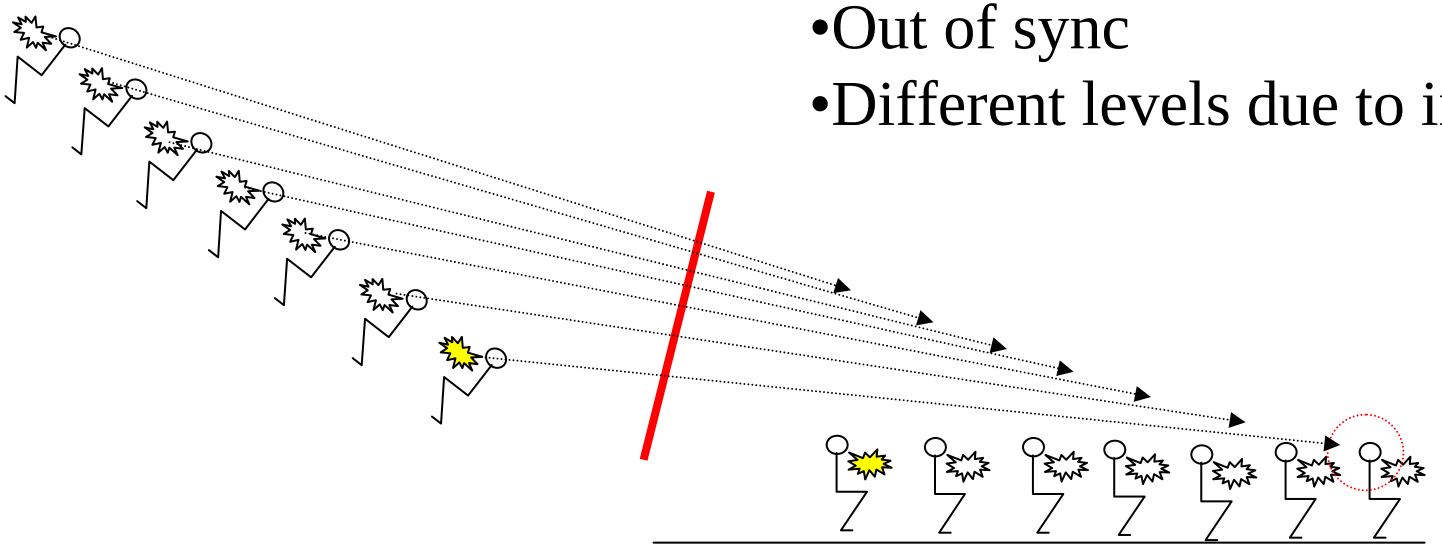
Tilted reflector

Image orchestra

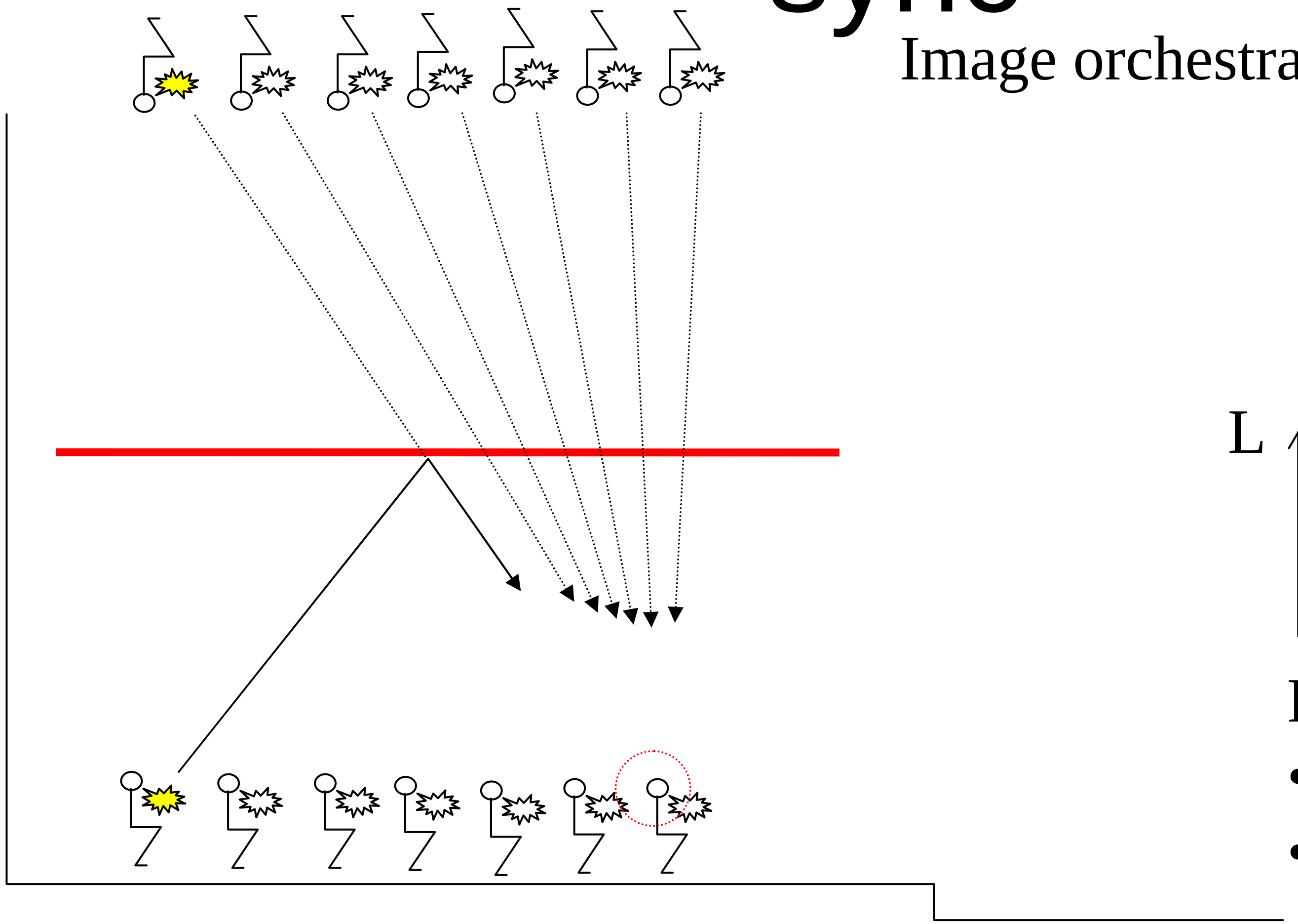


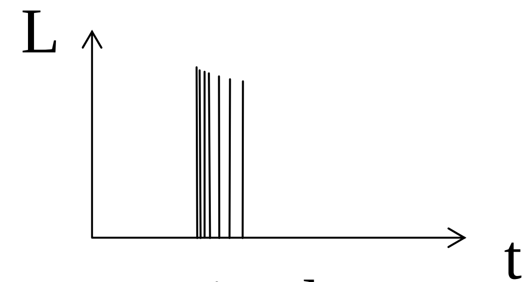
Received:

- Out of sync
- Different levels due to inverse square law



Canopy – image orchestra in sync





Received:

- In sync
- Equal levels

Canopy caveats and pitfalls

- To low / to dense
  - stage acoustically separated from hall
  - to much sound from above, on stage
  - suppressing lateral sound and wideness (ASW), in stalls
  - obstruction of sightlines from galleries, lighting and stage machinery, and air-circulation
- To high
  - to late reflection
  - to weak effect
- To open
  - to weak effect

Design issues

- Sound level and balance control
- Diffusivity
- Reflection frequency range
- Flexibility – variable or fixed in height and angle, individually or grouped
- Coordination with architecture, stage equipment, lighting, ventilation, structural engineering, etc.

Design parameters → Design issues

- Overall size of the canopy → Level & Balance
- Surface density (typical 50%) → Level & Balance
- Element size → Frequency Range (important 500-2k)
- Height → Delay & Synchronicity
- Element shape and scattering

  → Diffusivity and Frequency Range

Conclusions

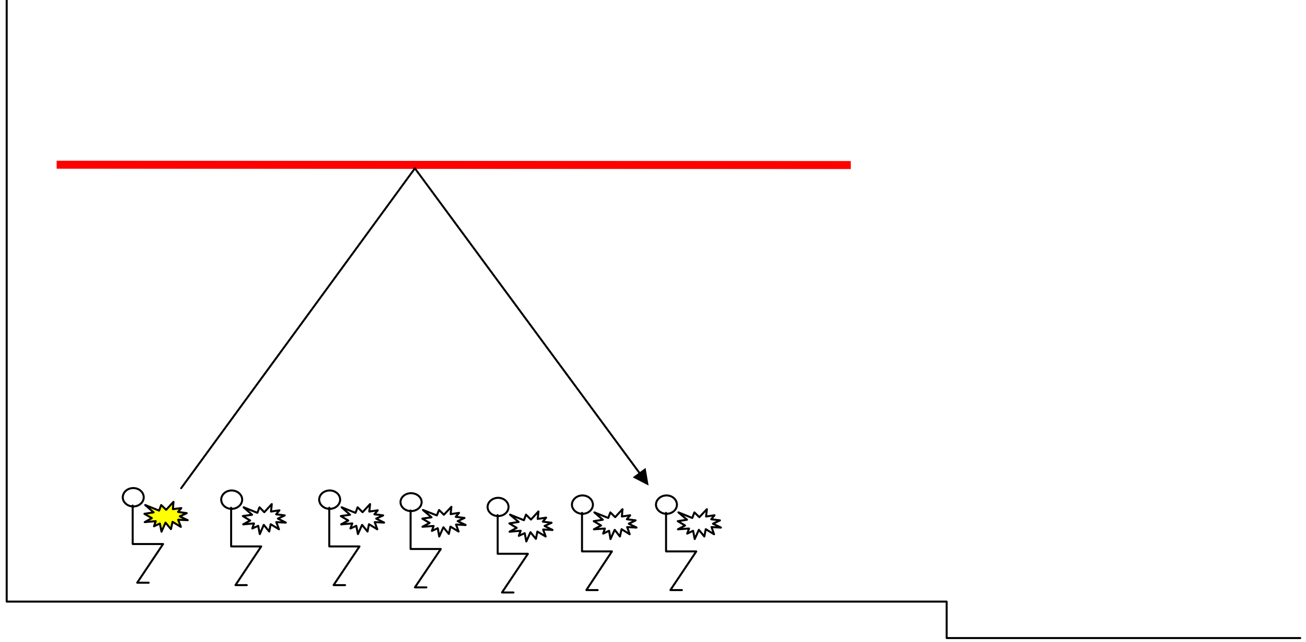
- Canopies - not a “must have”
  - If ceiling and walls provide adequate over-stage volume and height
- Canopies can provide
  - Support & Early Energy control
  - Unobstructed Sound Link (always “visible”)
  - Early Energy to audience (careful – not too much)
  - Synchronized orchestra foldback (good or bad?)
  - Fill-in-effect
  - Diffusivity
  - Evenness, rather than strong effect

Further work and development

- Measurement and predictions of stage acoustics, must take into account:
  - Source directivity
  - Obstruction of sound paths
  - Musicians subjective sound level – self and others
  - Masking effects (own instrument, other instruments)
- Investigate significance of
  - Diffusivity and Fill-in-effect
  - Synchronism
  - Frequency range
  - Evenness vs strength (like with reading lights)

Diffusivity

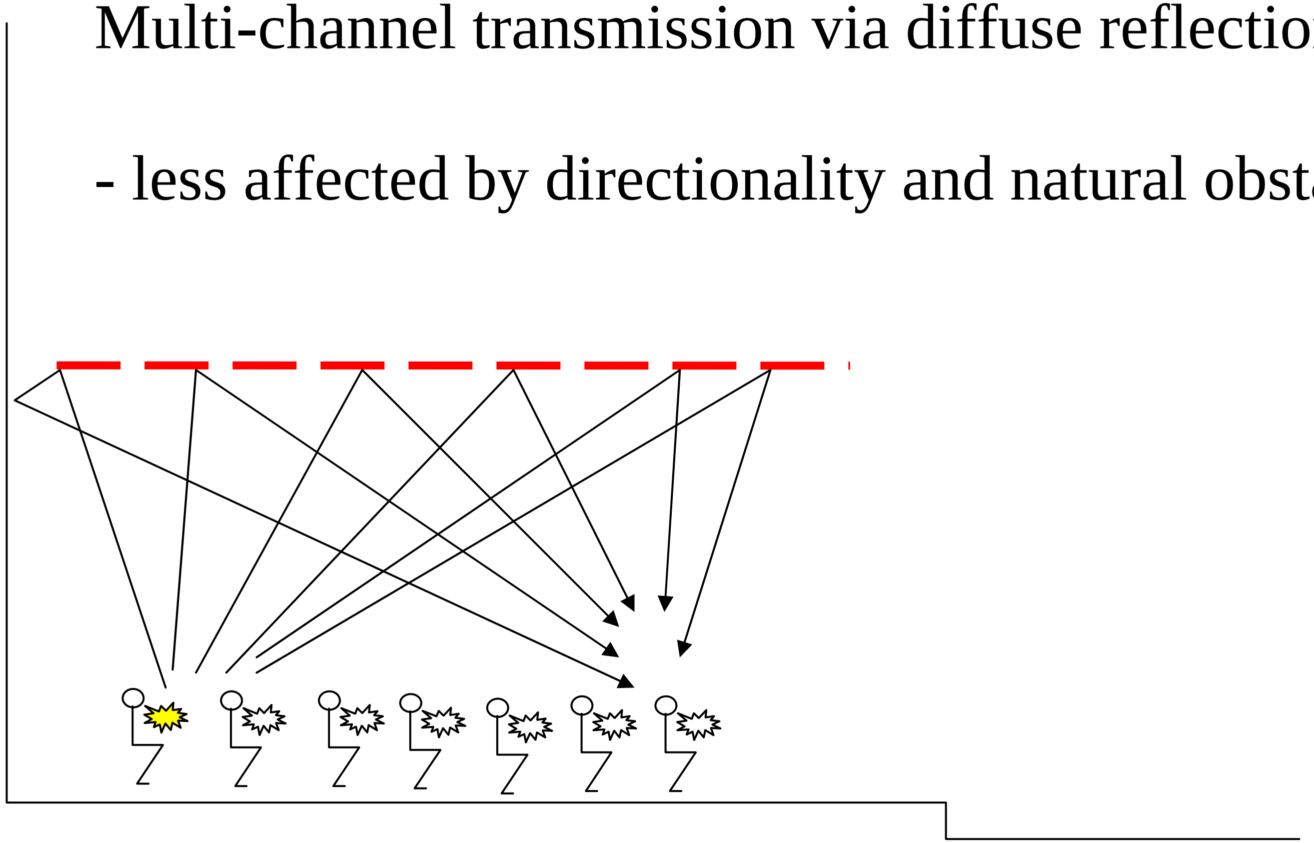
Single channel transmission via specular reflection



Diffusivity

Multi-channel transmission via diffuse reflections

- less affected by directionality and natural obstacles



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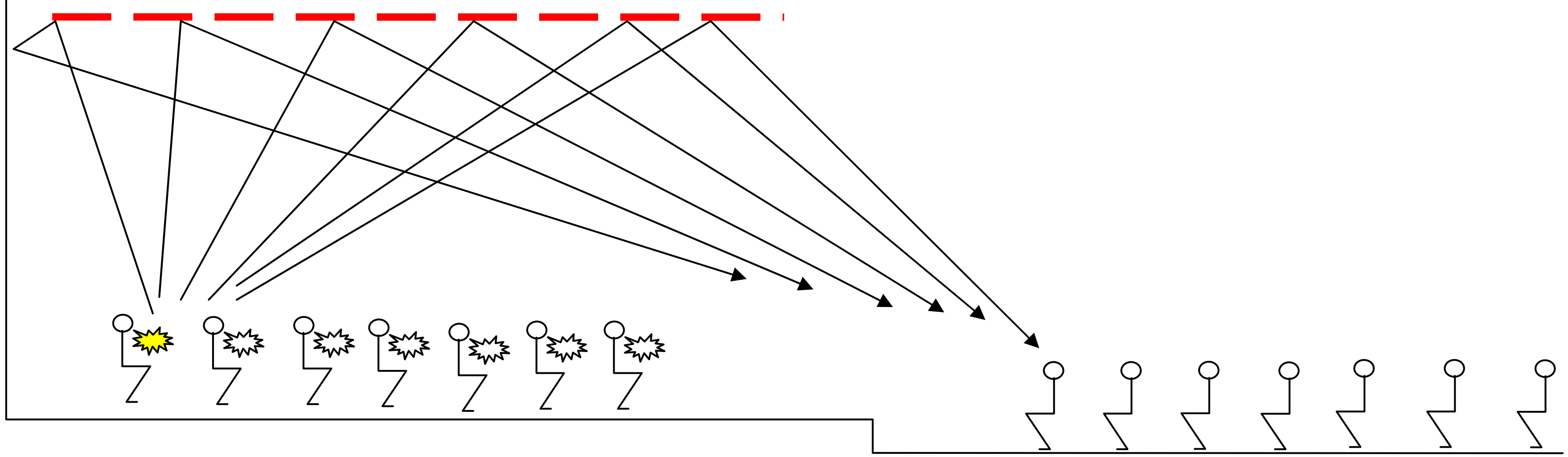
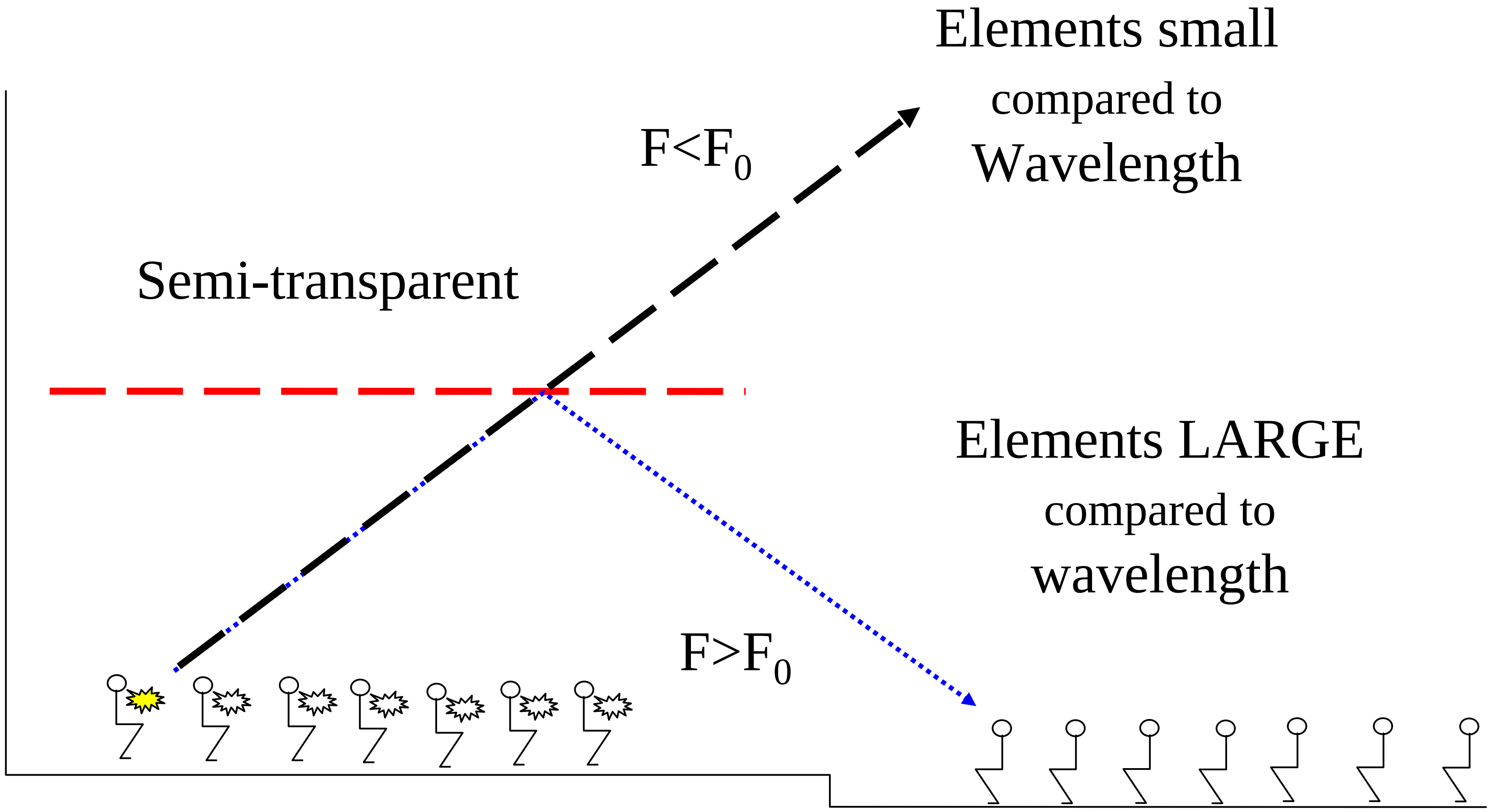


Low frequency response



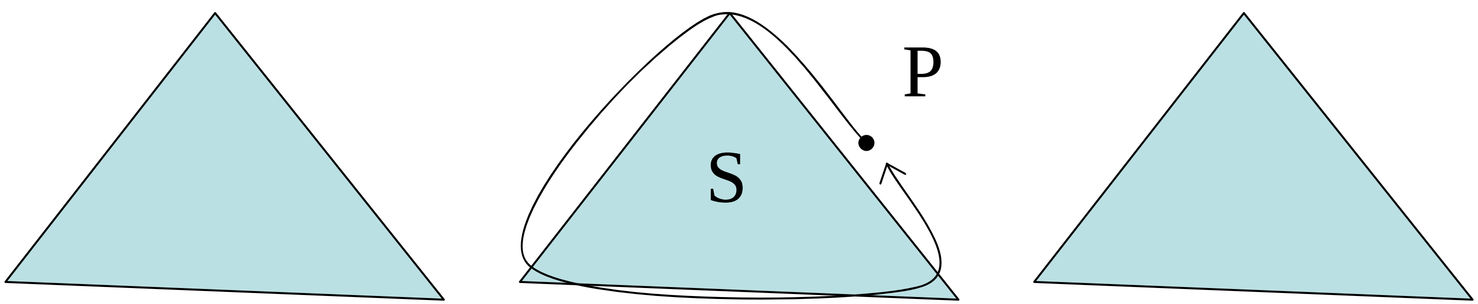
Low frequency response

Low cut frequency at normal incidence

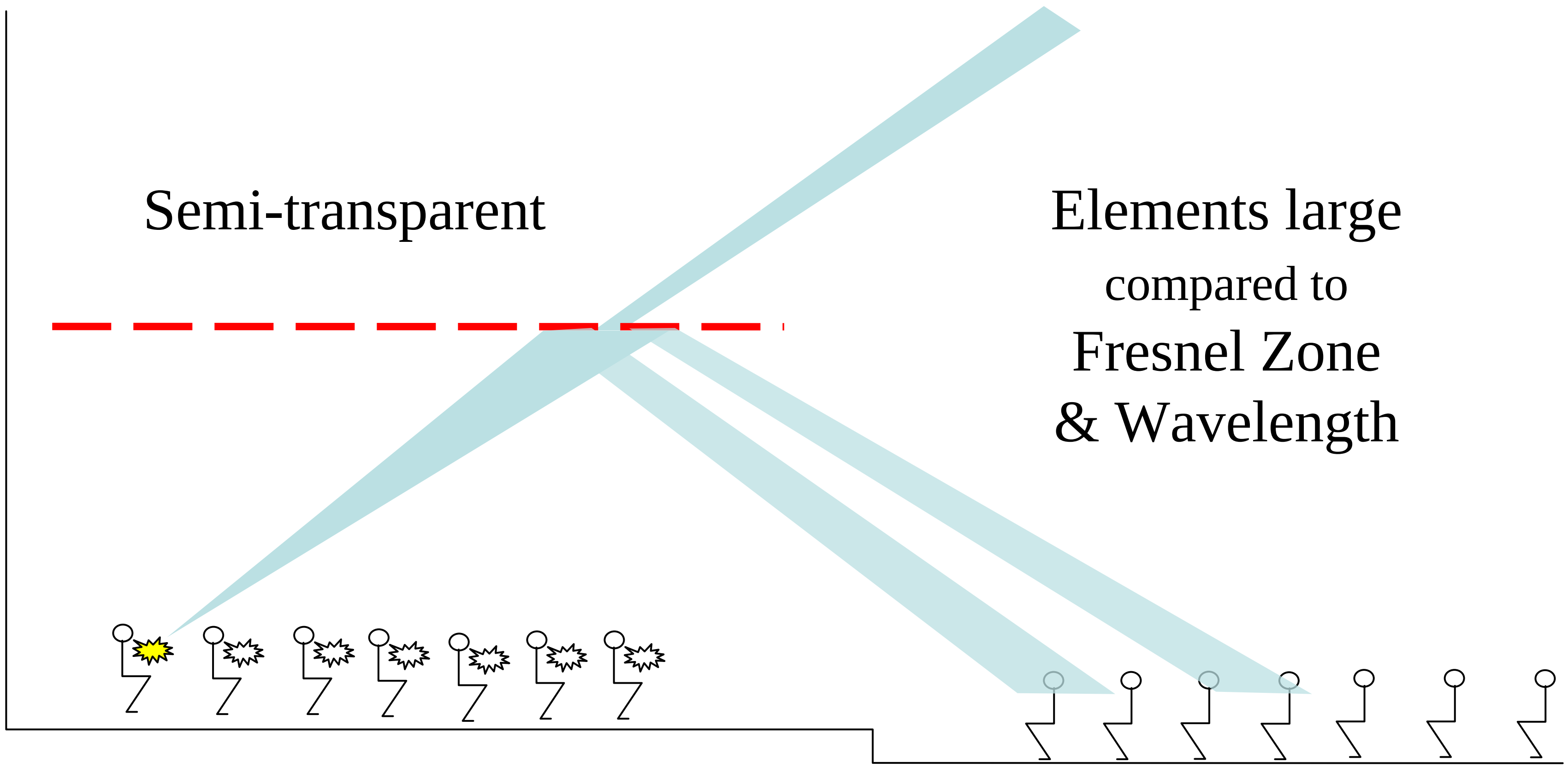
$$F_0 \approx 68 \cdot \varepsilon$$

where ε is the edge density P/S

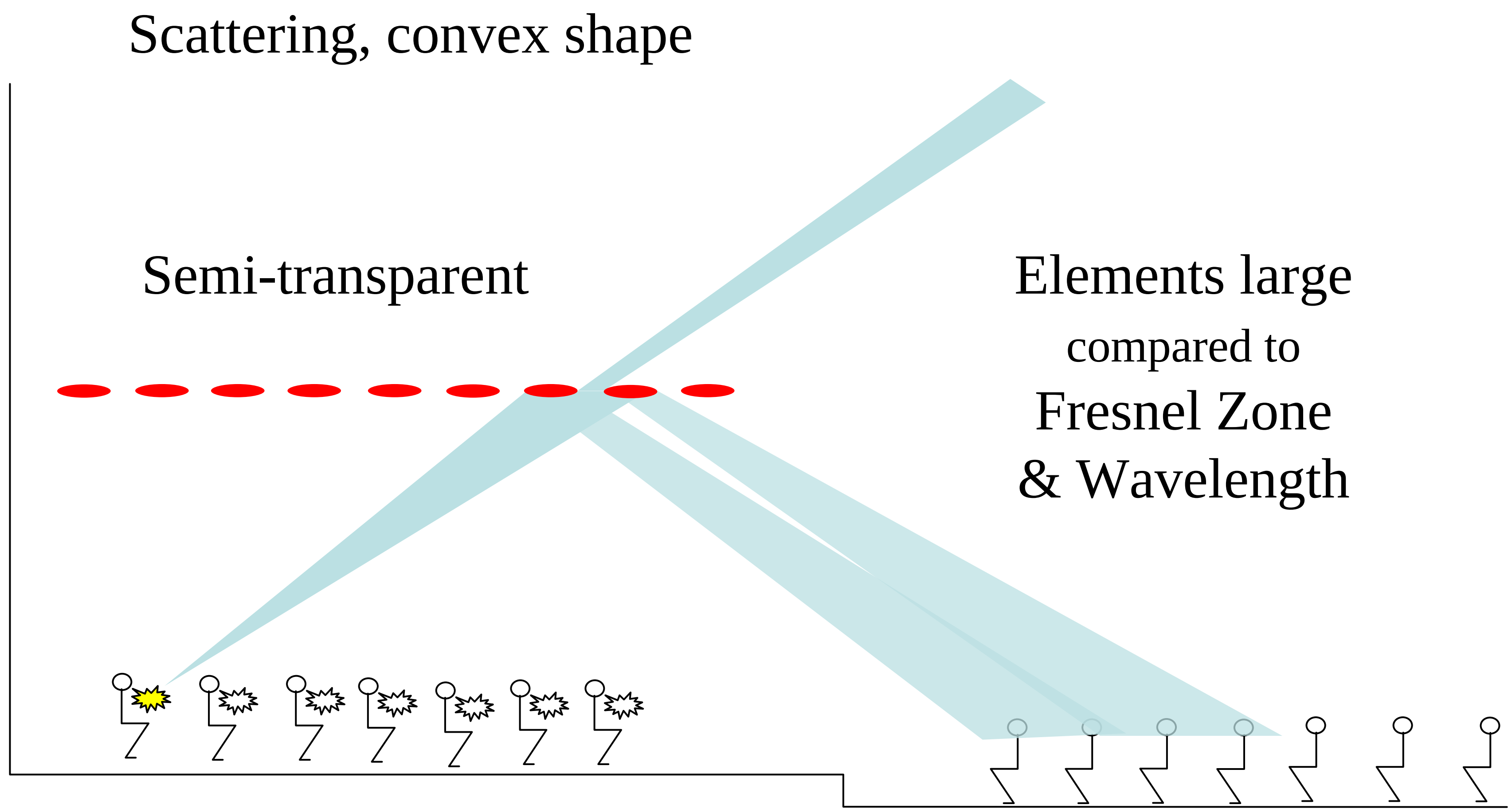
perimeter P, surface area S



High frequency response



High frequency response



Thank you for your time!

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