Physical Models: Particles

**Whistle: Single particle influences oscillator**

**Homeraca: Many particles launch PCM or parametric sounds**

Also good for "flock-like" sounds: applause, rain, birds, etc.
Stochastic Event Synthesis

Run model w/ lots of particles

Collect statistics -> Poisson

System energy decays exponentially.

Particle collision causes decaying burst of filtered noise
PhISEM Algorithm

Exponentially decaying system energy

**Particle sound energy** is exponentially (fast) decaying white noise. Sum of exponentially decaying noises is an exponentially decaying noise.

Each time step, compute likelihood (based on # of particles) of new sound-producing event

If so, add to net particle sound envelope energy

Filter result with system resonances, with reallocation if needed
PhISEM Code Example

```c
#define SOUND_DECAY 0.95
#define SYSTEM_DECAY 0.999

EACH SAMPLE:

shakeEnergy *= SYSTEM_DECAY; // Exponential system decay

if (random(1024) < num_beans) // If collision
    sndLevel += gain * shakeEnergy; // add energy

input = sndLevel * noise_tick(); // Actual Sound is Random

sndLevel *= SOUND_DECAY; // Exponential Sound decay

input -= output[0]*coeffs[0]; // Do simple

input -= output[1]*coeffs[1]; // system resonance

output[1] = output[0]; // filter

output[0] = input; // calculations
```
PhISEM: Stochastic Modal Synthesis

The diagram illustrates the process of stochastic modal synthesis. It starts with the control energy decay and the system energy decay. Depending on the Poisson collision, the signal is either allowed to proceed or is terminated with stochastic excitation. The noise decay follows, leading to stochastic resonances. Filters at system resonances then process the signals to determine the output, which includes the amplitude (Amp(t)), resonances (Reson(t)), and frequencies (Freq(t)).
Particles, PhIISM

**Strengths:**

- Cheap
- Meaningful parameters
- Good for lots of real-world sounds

**Weaknesses:**

- Not “exact” (statistical)
- No complete system ID (analysis) process (yet, hang on, we’ll talk about this later)
Related Techniques

**Particles:**

- **Granular Synthesis** *(Many authors)*
  - Cut sound and randomly remix

- **Wavelets** *(Miner ’99)*
  - Time/Freq transform

**Modes:**

- **Independent Components** *(Casey 98)*
- **Interactive Sinusoidal Modeling** *(Pai et al)*
References: Waveguide & FE Modeling


Refs: PhlSEM, Wavelets, Grains