# Integration of Real-Time OpenGL Graphics with an Algorithmic Music Composition System

# THE GOAL - ALGORITHMIC, REALTIME, FULL-MOTION GRAPHICS & MUSIC

- ## ALGORITHMIC

  connects this aesthetic approach to an existing body of musical composition.

- unifies the musical and visual components of the artwork
  - aesthetic: satisfies first two of Aquinas' three criteria of Beauty (Unity, Harmony, Clarity.)

- connects with the currently developing "Visual Music" aesthetic.

# THE GOAL - REALTIME, ALGORITHMIC, FULL-MOTION GRAPHICS

- REALTIME

  - emphasizes the performative aspect of this research. The goal is to create a "graphics instrument" which can be performed in realtime just as a traditional musical instrument.

- synergistic amplification of creative possibility which occurs with realtime operation that is difficult or impossible to simulate with non-realtime approaches. The classical example of this is in musical instrument performance, where expressive nuance involving the realtime control of loudness and pitch brings a very high aesthetic value to the product.

# THE GOAL - REALTIME, ALGORITHMIC, FULL-MOTION GRAPHICS

- FULL-MOTION
  - emphasizes the fact that this research is technologically state-of-the-art.
- - implies certain technical standards:
  - minimum 24 frames per second (ideally 30 or 60 fps)
    (Douglas Trumbull says 66 fps hits a resonance in the human nervous system, and 120 fps would be a good standard because 24, 30, 60 could all be derived form it without interpolation.)
  - High Definition resolution of at least 1920w * 1080h
    Theatrical releases are rendered at 2048w, IMAX at 4096w
- OpenGL is a state-of-the-art graphics environment, highly developed, extremely sophisticated and yet widely available.

# OpenGL

- present  on virtually every modern personal computer.
- dedicated, specialized highly-parallel hardware to execute it in realtime.

# Harmnonia

- Harmonia (Christos Hatzis)
  - harmonic series expressed simultaneously in visual and audible media.
  - sound generated via a 64-voice additive synthesizer in NI Reaktor
  - visuals generated via openGL 2.1 on a MacPro.

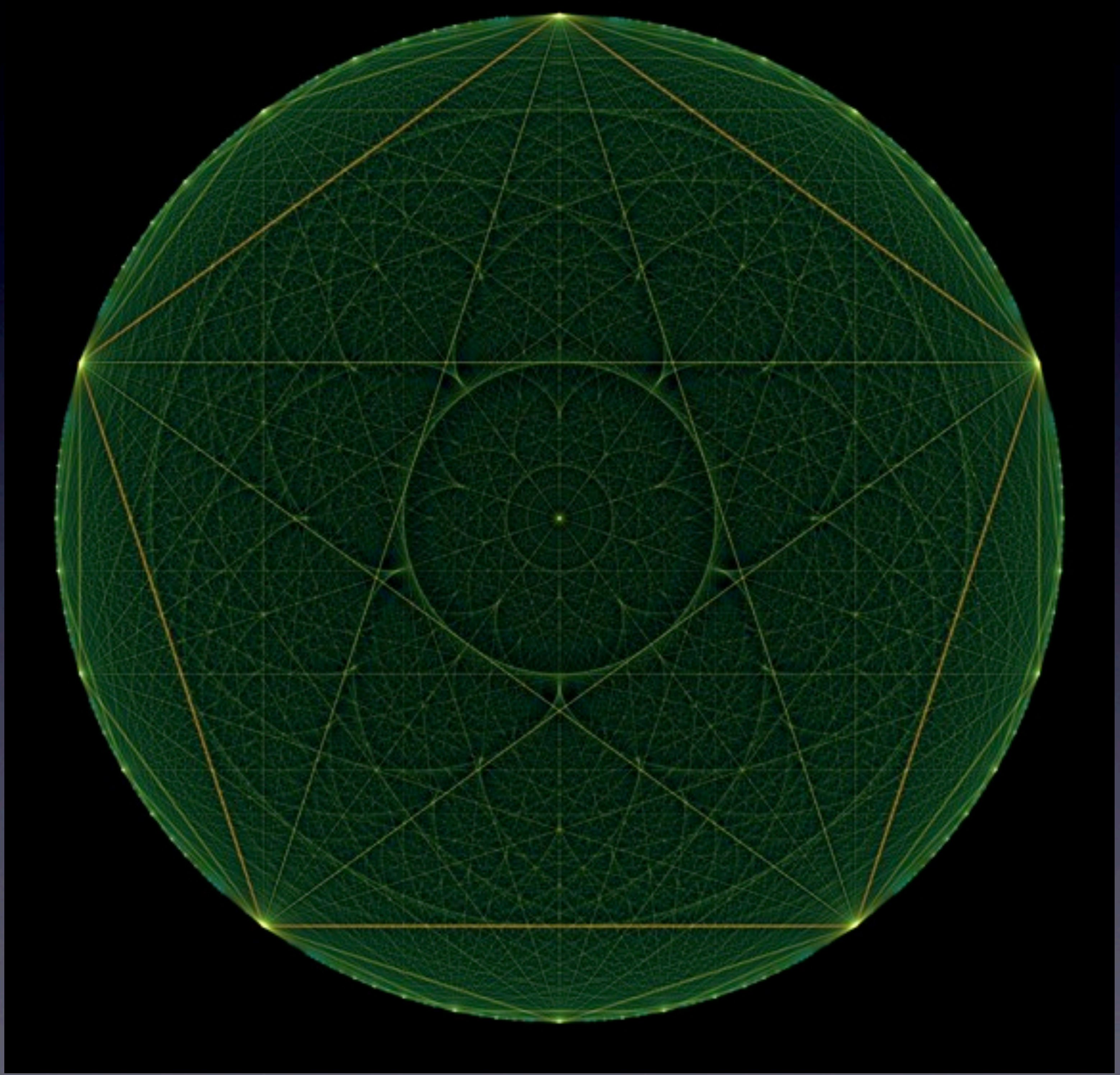


Figure xx: visual harmonics 5, 10, 15, 20, etc in *Harmonia*

# Harmonia

- communicate via MIDI controllers with OpenGL via Transformation Engine (algorithmic composition software)
- each harmonic from 1-64 was independently controlled via MIDI controller 1-64
- additive synth was designed with internal parameter smoothing to make up for MIDI 7-bit resolution.
- worked well for sound

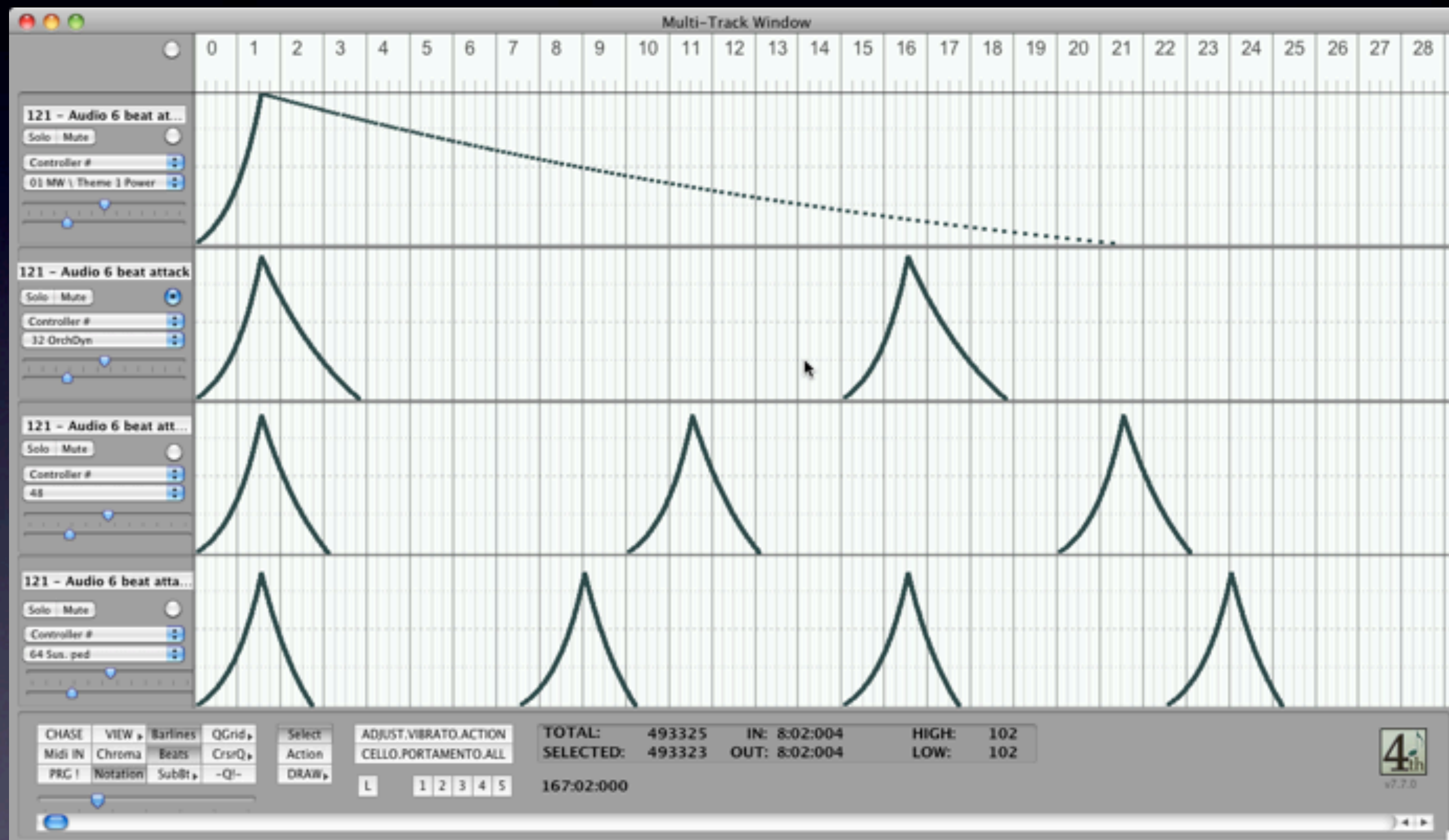



Figure xx: controller data for audio Harmonics 1, 32, 48 and 64 in *Harmonia*

# Harmonia

- PROBLEM !
  - - MIDI controller resolution is 7 bit (only 128 steps between lowest and highest values)
  - most OpenGL parameters are 32-bit floating point (16,777,216 values between lowest and highest, plus scalable range.)
  - MIDI's coarse resolution produced unacceptable "stepping" motions and cross-fades.
    Completely unusable.

# Harmonia

- Solution #1
  - use MIDI's high resolution option (14-bit = 16,384 values
  - surprisingly did not substantially reduce the stepping artifacts much
  - insufficient resolution esp. where it was needed the most - at the "quiet" or "dim" end of the range, where control values are close to zero
  - since each parameter uses TWO controllers, all of MIDI's controller options were used for simply for the harmonic control. Nothing left for Master Volume, panning, etc.

# Harmonia

- Solution #2
    - implement a custom controller type within The Transformation Engine which employs 32-bit floating point values.
    - store 32-bit float values within the MIDI track, and outputs them to external software/device via OSC.( UC Berkeley, CNMAT 1997)
    - This worked beautifully, allowing complete access to the full-range of OpenGL controls.

# Re-Inventing the Wheel

- direct control adequate for a relatively simple piece (graphically speaking) like Harmonia
- breaks down when more advanced graphic processing is required.
- simple example - adding a "glow" to the Harmonia visuals meant I would have to implement my own glow algorithm in OpenGL.
- I needed to find a system that allowed low-level access to OpenGL while also offering high-level processing options.

# EARLIER WORK

- **MaxMSP/Jitter**
  http://cycling74.com/products/maxmspjitter/graphics/
- **Puredata**
  http://puredata.info/
- **Realtime Music Visualization with MIDI and OpenGL**
  http://www.zaposerver.net/projects/midilive/files/midilive.pdf
- **AVSynthesis: Blending Light and Sound with OpenGL and Csound5**
  http://www.linuxjournal.com/magazine/avsynthesis-blending-light-and-sound-opengl-and-csound5?page=0,3
- **Quartz Composer**
  http://developer.apple.com/graphicsimaging/quartzcomposer/

# Quartz Composer

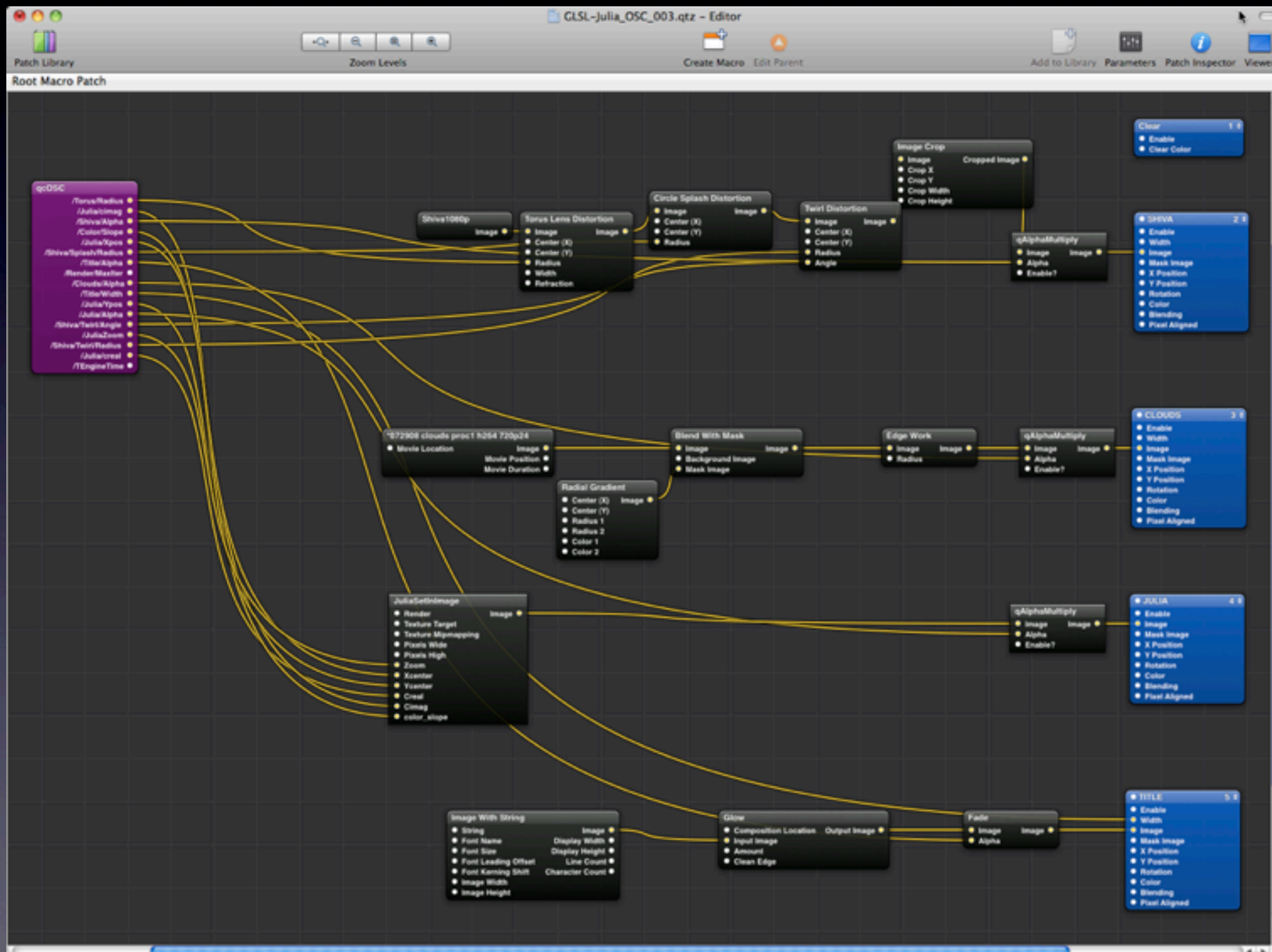
- Apple Computer 2004-11

- free with OS X Developer Tools

- complete access to the OS graphics libraries, including OpenGL, Core Image, Core Video, Quicktime

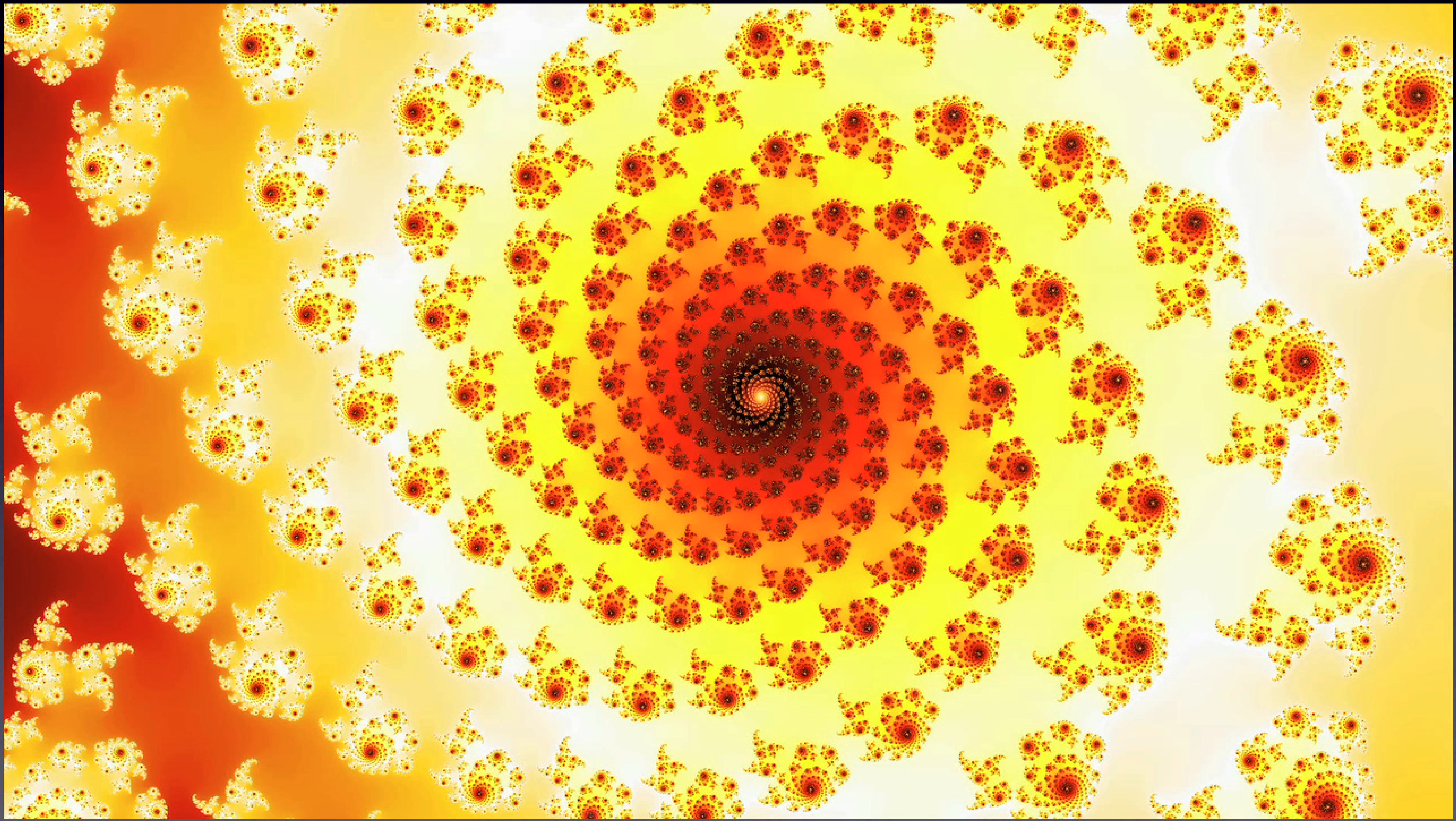
- dataflow programming system, (like Max/MSP or PureData)

- Graphics processing modules, ("patches") programmed by connecting input and output ports in data-processing sequence

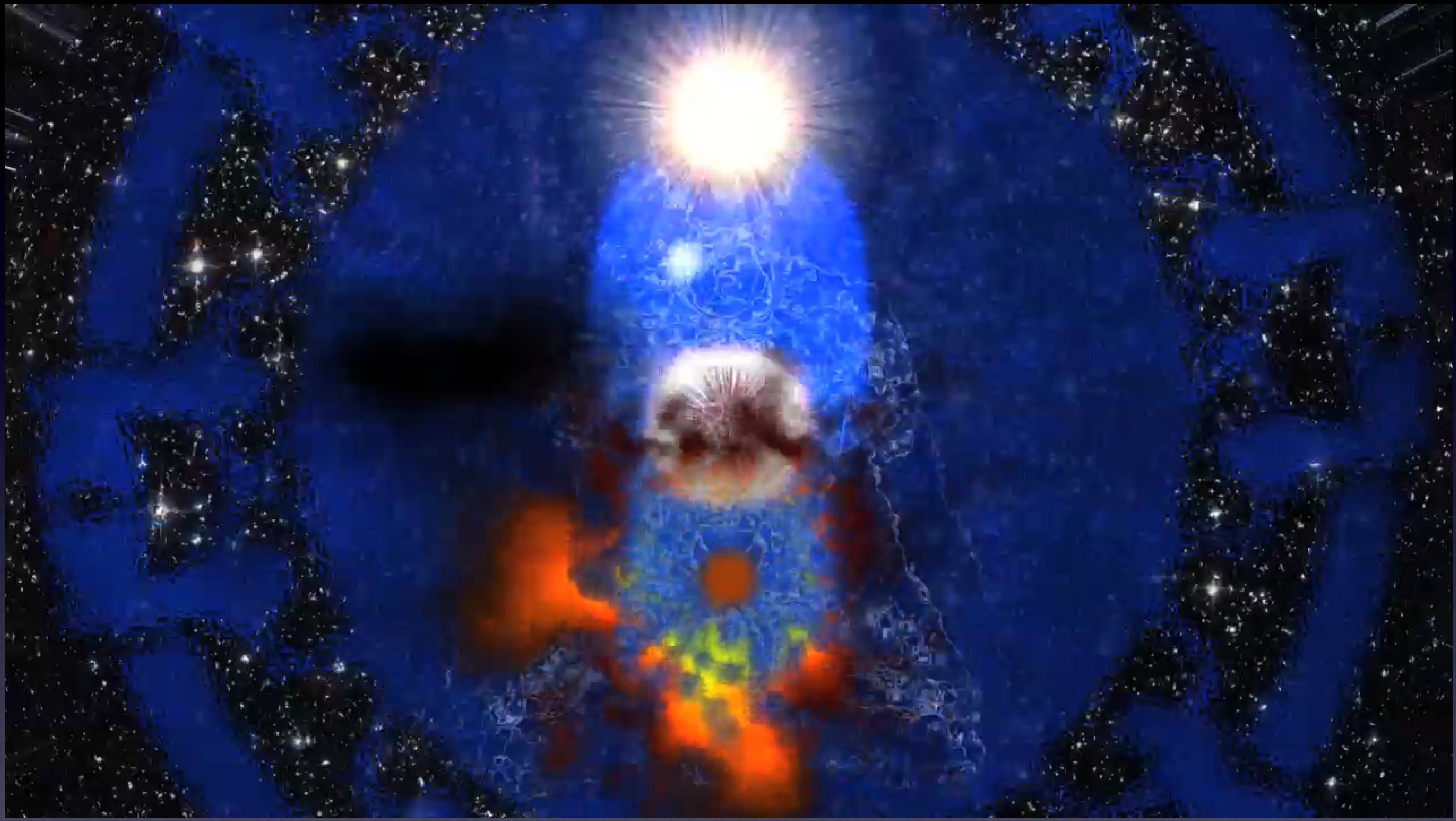


# Fractal Shiva

- with a fast graphics card, OpenGL can calculate a Julia set fractal in less than 1/100 second
- formerly (1980's) would take overnight on an Atari ST
- possible to consider fractal animation as main Julia set parameters are varied
- rhythmically timed to music
- music freely composed in North Indian Classical style - Bhairava raga (sacred to Shiva) and Jhapta Tal



# Anthropos - In Memoriam

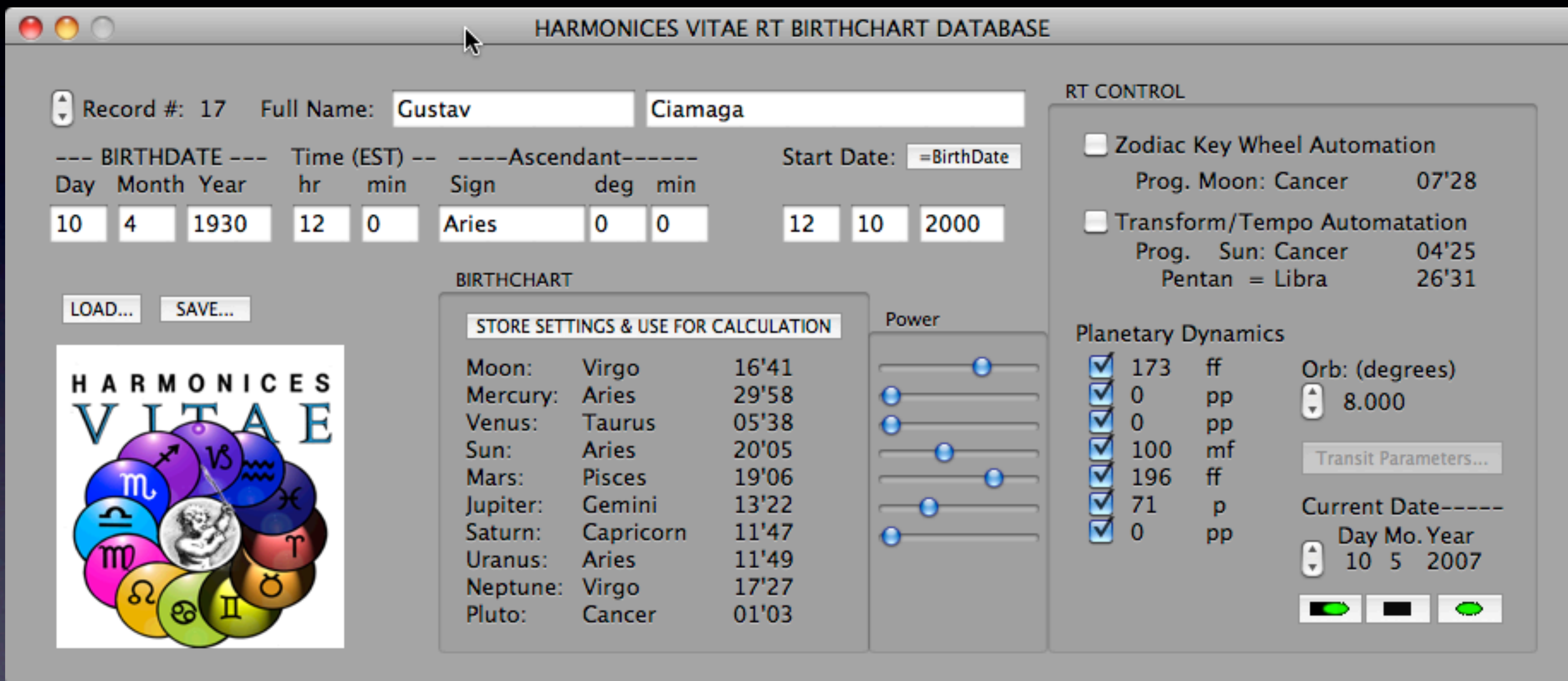


- **algorithmically controlled music and visual**

- Planetary motions from 2000 to 2011 generate musical and visual activity
- Each planet represented musically by a group of orchestral instruments and visually by a particle system.

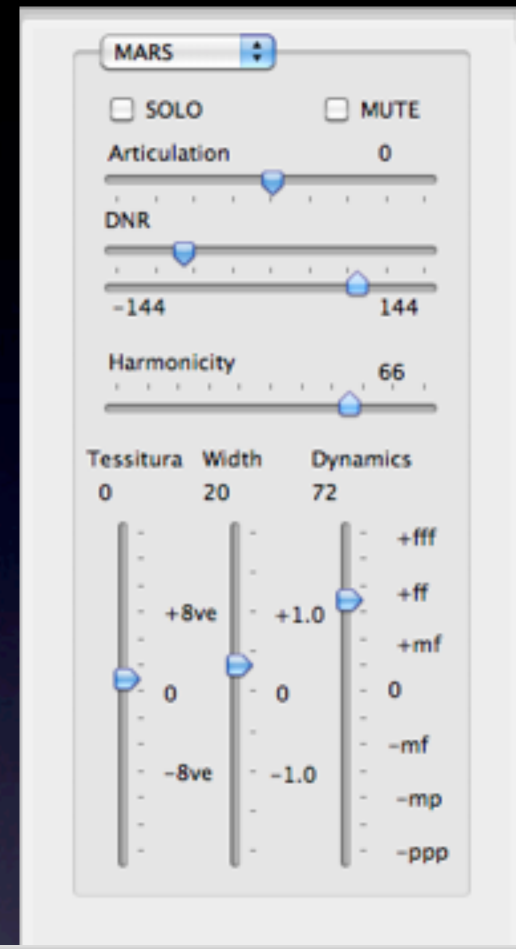
  - TIMEBASE - one minute per year

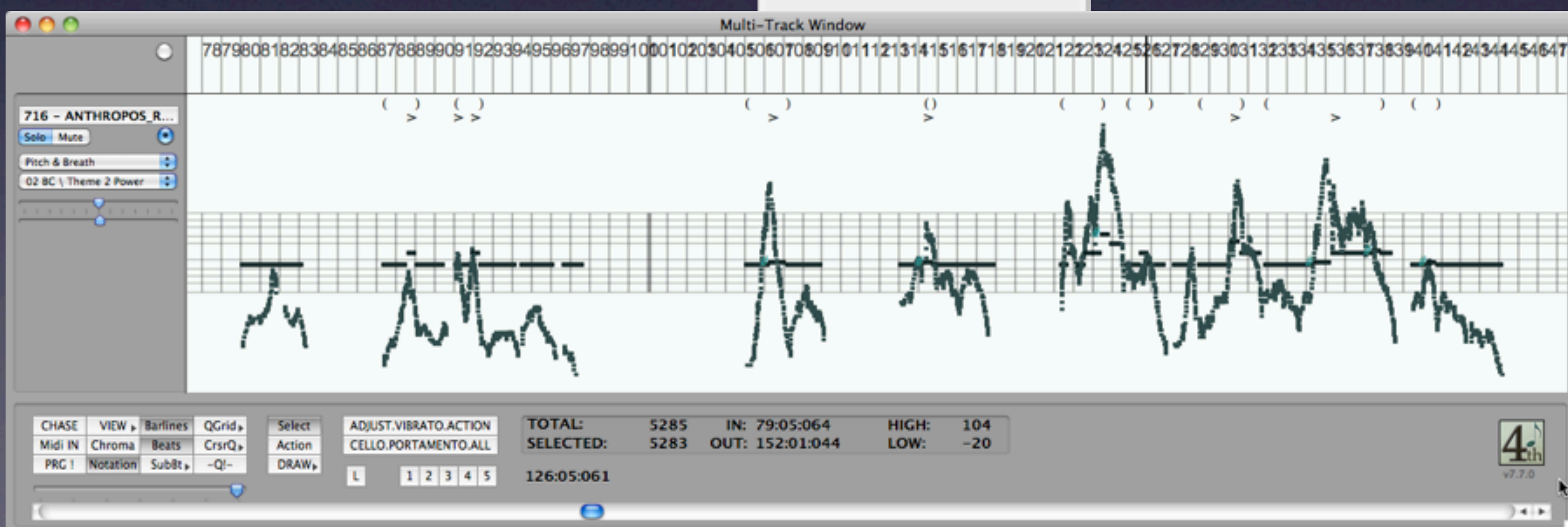
# Anthropos - In Memoriam



# Anthropos - In Memoriam

- PLANETARY INTENSITY AFFECTS:
  - pitch width
  - dynamics
  - rhythmic activity
  - harmonicity
- Uses the Transformation Engine compositional renderer

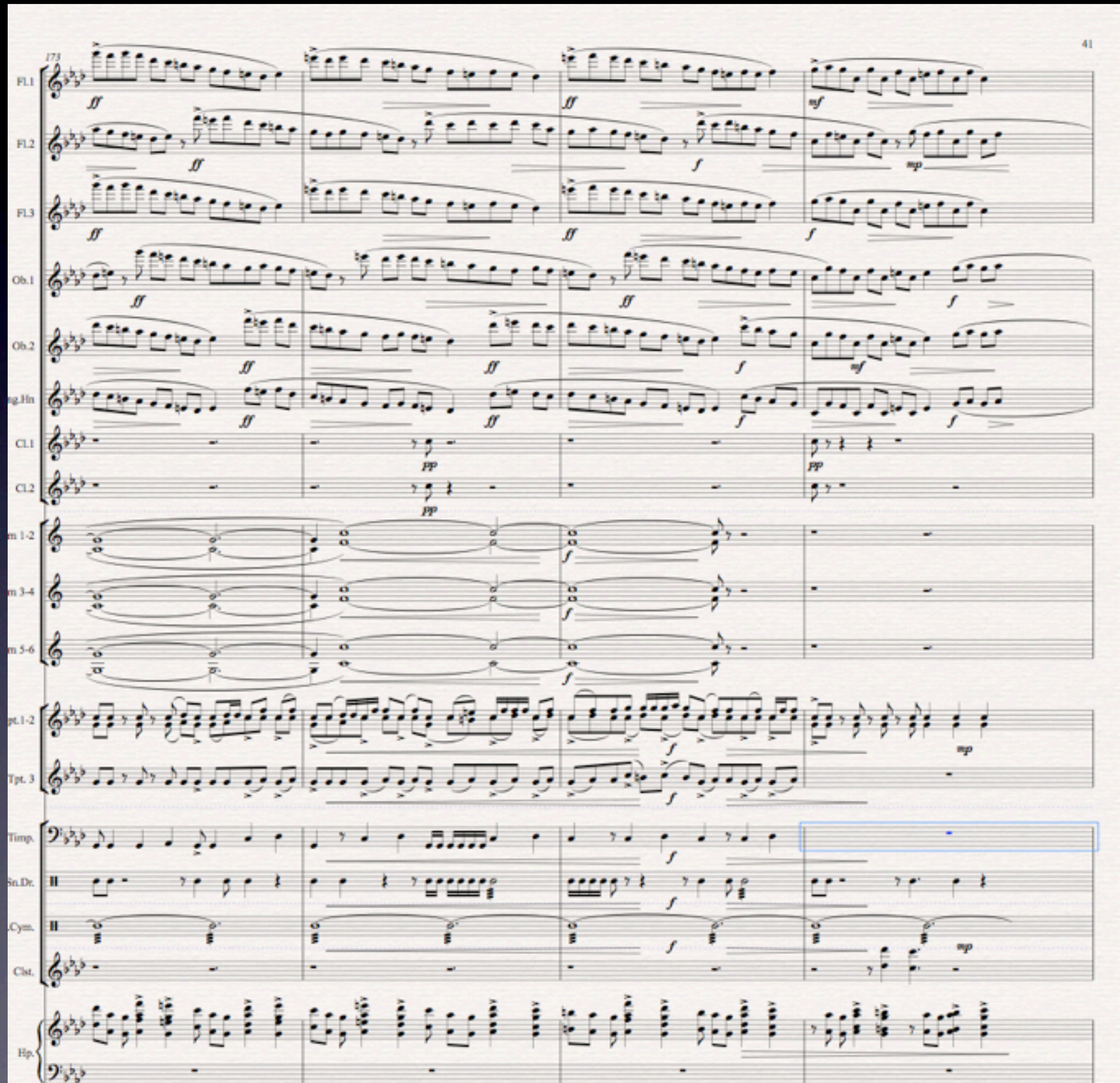


# Anthropos - In Memoriam

- ORCHESTRAL CORRESPONDENCES

- Moon - Flutes, Oboes,& Harp
- Sun - Strings
- Mars - Trumpets, Snare drum, Timpani
- Mercury - Clarinets, Bassoons & Xylophone
- Venus - Sopranos, Celesta
- Jupiter - French Horns
- Saturn - Trombones, Tuba, Bass Clarinets, Contrabassoon, Bass Drum & Gong



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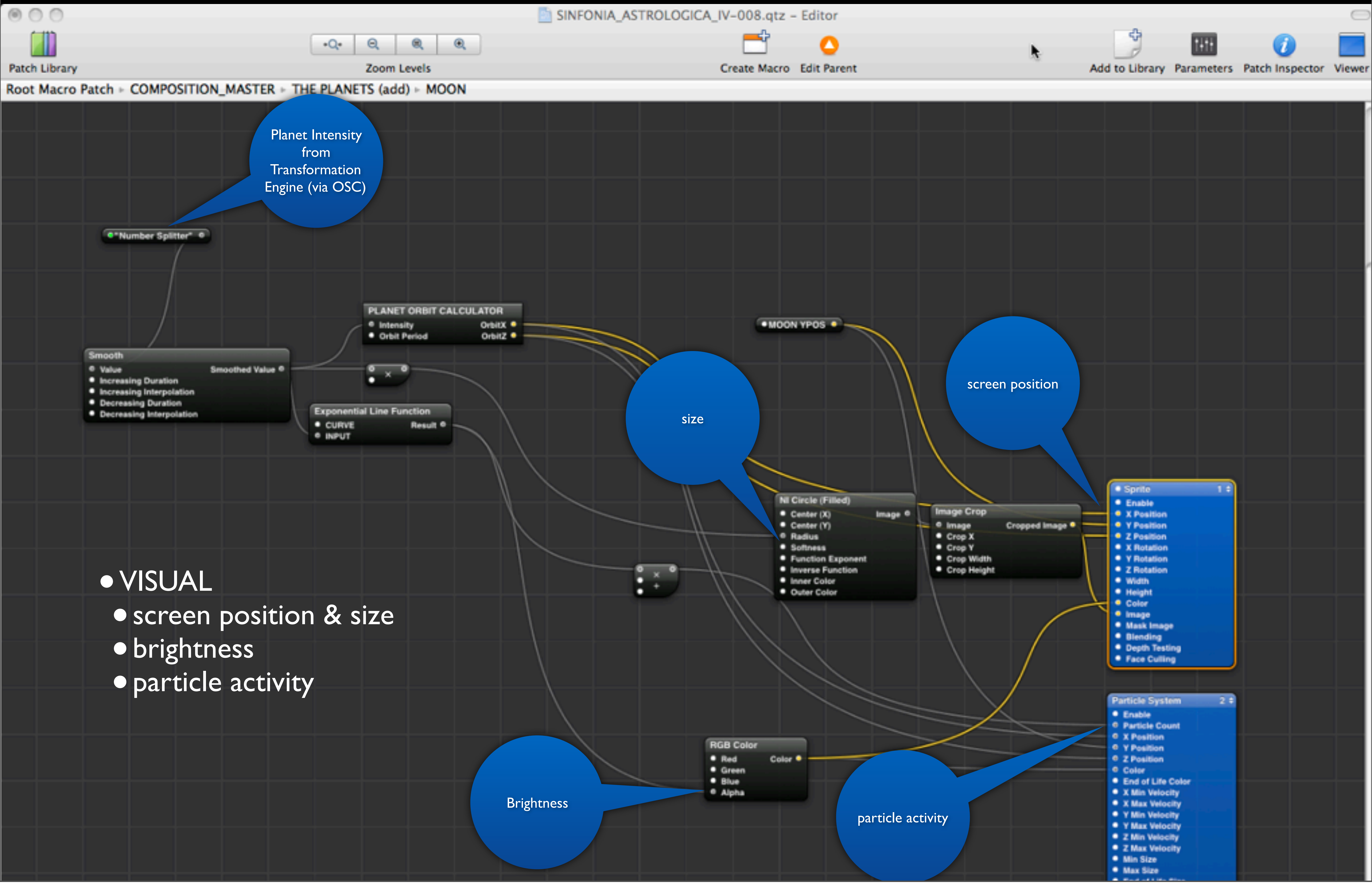


- VISUAL
  - screen position & size
  - brightness
  - particle activity

# Anthropos - In Memoriam