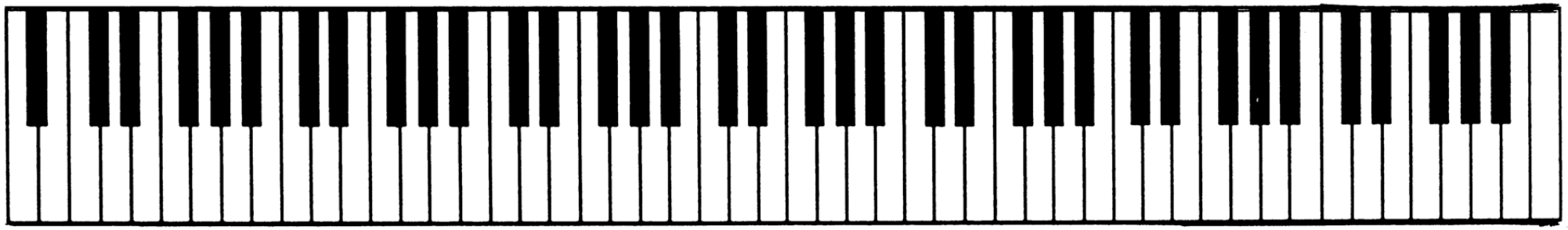
MIDI and extended pitches

Tuning and Temperament

“Pitch”: Notated pitch *relative* to key



- Absolute key number
  - 36 etc.
  - 48 C 8ve below Middle C
  - 60 Middle C
  - 72 C 8ve above Middle C
  - 84 etc.
- Absolute pitch = “90”

Pitch names (tonal music) are **contextual**

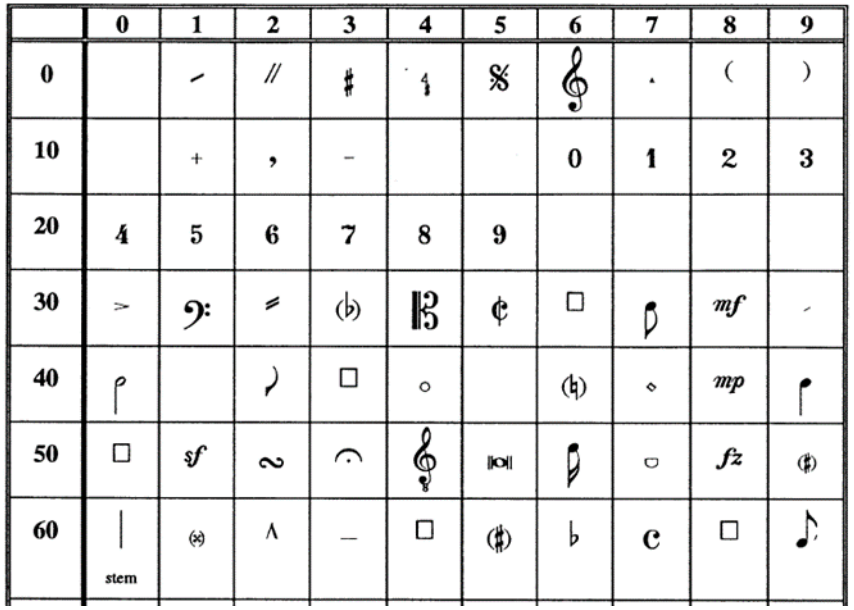
F#/Gb/E##

NotaMIDI (Kjell Nordli; Oslo, *c*1987)

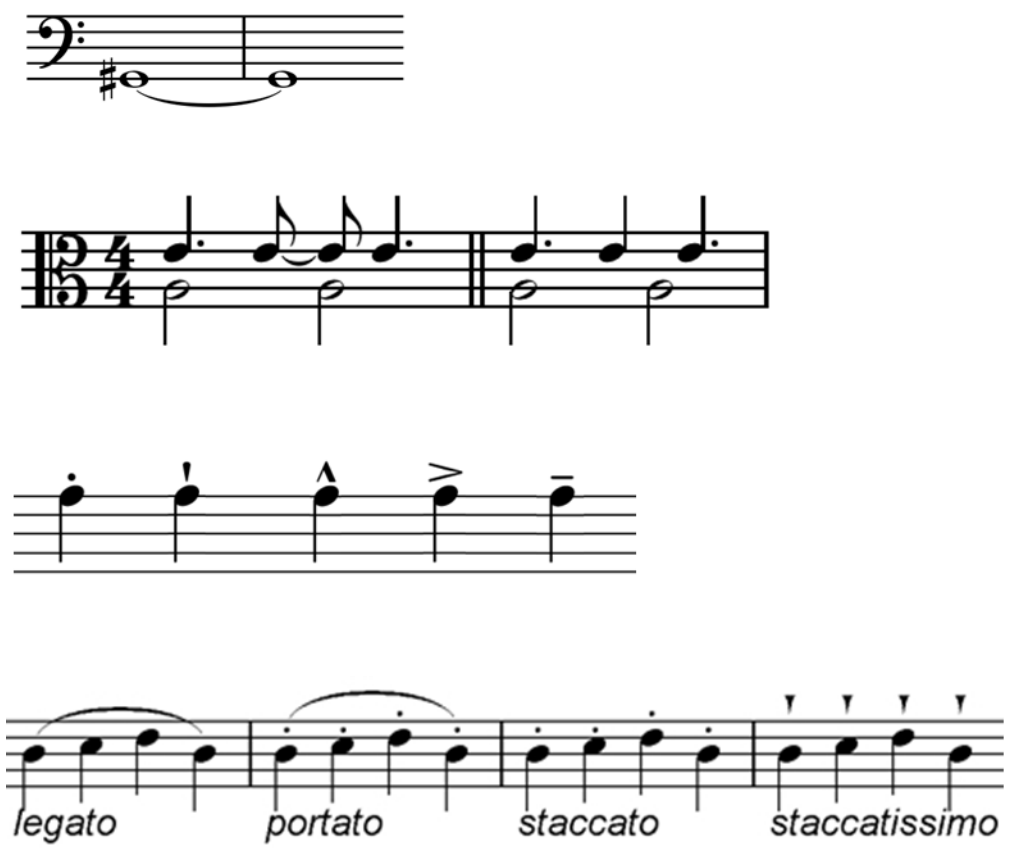
- Employed **meta-events** for extended info
- Emphasized elements of **notation**
  - Time signature
  - Key signature
  - Clef-sign
  - Crescendo, diminuendo
  - Accent
  - Slur
  - Enharmonic pitch
  - Tempo words (Allegro, Adagio, et al.)

Expressive MIDI (NG, Boyle, et al., Leeds, 1988)

- Based on **system-exclusive** messages
  e.g. Data byte 1 $0XXY_1Y_2Y_3Y_4Y_5$
- With look-up table (from early *Finale*)



MIDI vis-à-vis duration, articulation



Durations

- Ties (certain kinds)
- Ambiguity of articulation/ instrumentation
- Matching written values to sounding values

Articulations

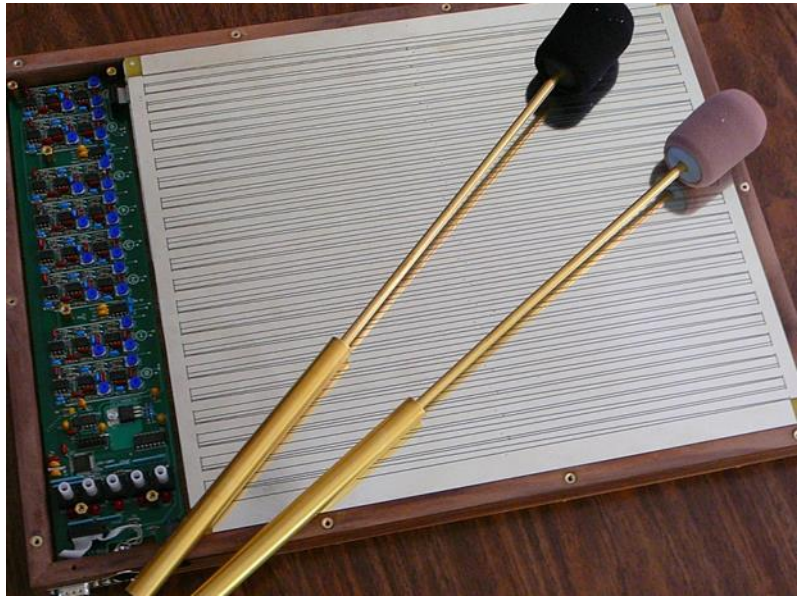
- Staccato
- Marcato
- Tentuto

MIDI: Tuning, temperament, expression

- Max Mathews, CCRMA: Radio Baton (emphasized expression—tempo, dynamics)
  - https://www.youtube.com/watch?v=3ZOzUVD4oLg

Augmented MIDI (M. Mathews, W. Hewlett)

- *Aim*: expressive control
  - For accents
  - For articulations
- *Method*: **bit-repurposing**
  - Bits from *Note-On* command OR
  - Bits from *Velocity byte*



Pitch and timbre: Music V and CSound

- **Approaches that define sounds**
  - Music V: Max Mathews (Bell Labs, 1968)
  - Csound: Barry Vercoe (Princeton, 1969; MIT)
    - score
    - scot
  - Strengths:
    - **decimal** system using **cents** (**frequency**)
    - Instruments can be arbitrary (scot)
    - Arbitrary objects can be encoded (*pling* command)

Music <N> history: https://120years.net/wordpress/music-n-max-mathews-usa-1957/

Tutorial: https://www.youtube.com/watch?v=rkBIUrJoJ3Y

Radio-drum/baton file (*c*1988)

GEN2	3	0.0	2	1	1	0	.5	0	.25	0	This statement defines an instrument. Here a wave-form table for the clarinet is set up. GEN2 calls an oscillator subroutine. The parameters are (1) an operation code [3 = generate function], (2) an action time, (3) an instrument number, (4) a table number, and (5–10) the relative amplitudes of harmonics 1..6.
NOT	1	2	0.0		.5		1		440		These statements cause notes to be played. The initial parameters are (1) an operation code [1 = play note], (2) an instrument number, (3) a start-of-action time, (4) event duration, (5) an absolute amplitude for the event, and (6) event frequency (Hz). These parameters may be followed by a variable number of user-defined parameters (not shown).
NOT	1	2	0.5		.5		2		554		
NOT	1	2	1.0		.5		3		660		
NOT	1	2	1.5		.5		4		554		
NOT	1	2	2.0		1.0		5		880		
NOT	1	2	3.0		.5		3		660		
NOT	1	2	3.5		.5		2		554		
NOT	1	2	4.0		.5		2		494		
NOT	1	2	4.5		.5		4		588		
NOT	1	2	5.0		1.0		5		740		

Example G1 Music V representation of Bars 1 and 2 of the *Clarinet* part of the Mozart trio.

Beyond MIDI, Glossary
http://beyondmidi.ccarh.org/beyondmidi-600dpi.pdf

MIDI vis-à-vis Notation

- Enharmonic *accuracy* hard to guarantee when input is MIDI-based
- Inherent non-alignment of **key numbers** vis-à-vis **note names**
- One more bit-based MIDI extension: Walter Hewlett's MIDIPlus
- See https://patents.google.com/patent/US5675100A/en?inventor=Hewlett+Walter+B.&oq=Hewlett+Walter+B.

MIDI Plus (Walter Hewlett)

(How to make MIDI enharmonically accurate)

- Method

  Reassign two bits from velocity byte

- US Patent #5675100 (1996)
- http://www.google.com/patents?id=6RclAAAAEBAJ&pg=PA2&source=gbs_selected_pages&cad=4#v=onepage&q&f=false

BINARY→ DECIMAL↓	x	64	32	16	8	4	2	1
88		1	0	1	1	0	0	0
89		1	0	1	1	0	0	1
90		1	0	1	1	0	1	0
91		1	0	1	1	0	1	1
92		1	0	1	1	1	0	0

Method for enharmonic accuracy

Key number = **90**

Note name depends on **context**

Captured bit specifies name:

00 not known

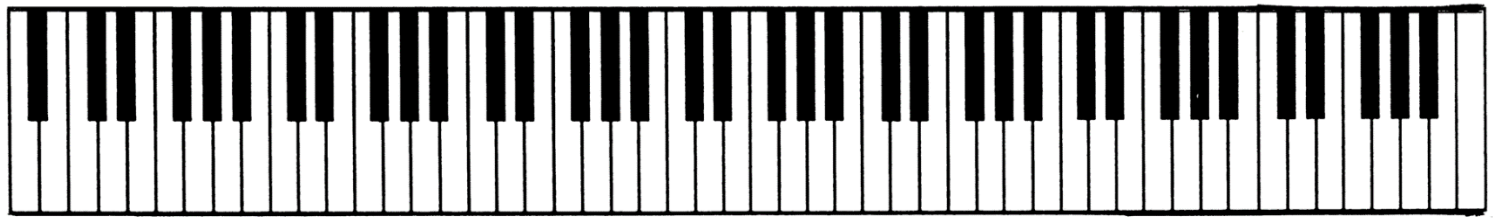
01 Gb

10 F#

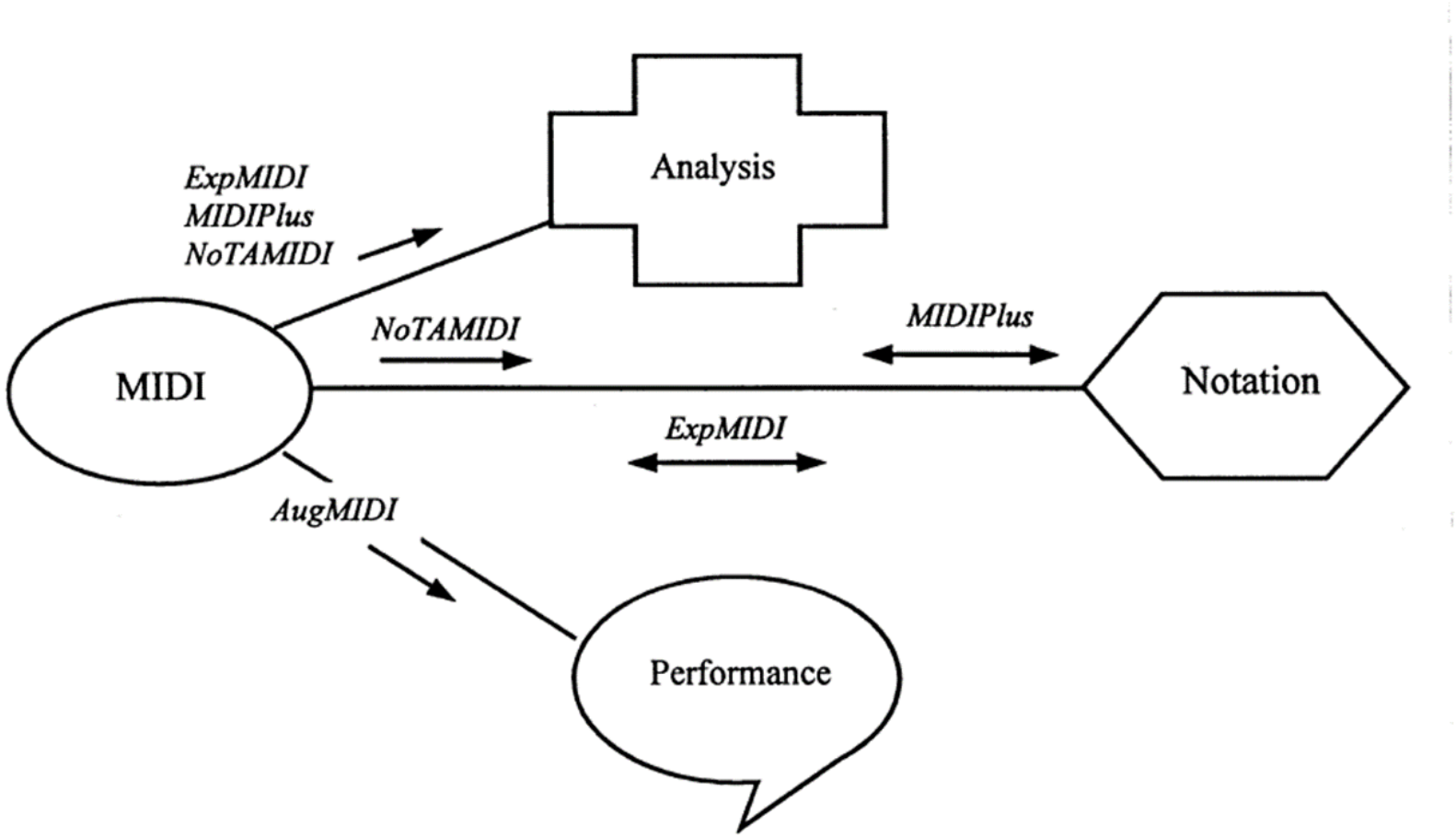
11 Ex (E##)

Pitch names are **contextual**
F#/Gb/E##

BINARY→ DECIMAL↓	x	64	32	16	8	4	2	1
88		1	0	1	1	0	0	0
89		1	0	1	1	0	0	1
90		1	0	1	1	0	1	0
91		1	0	1	1	0	1	1
92		1	0	1	1	1	0	0



Proposed extensions (never adopted)

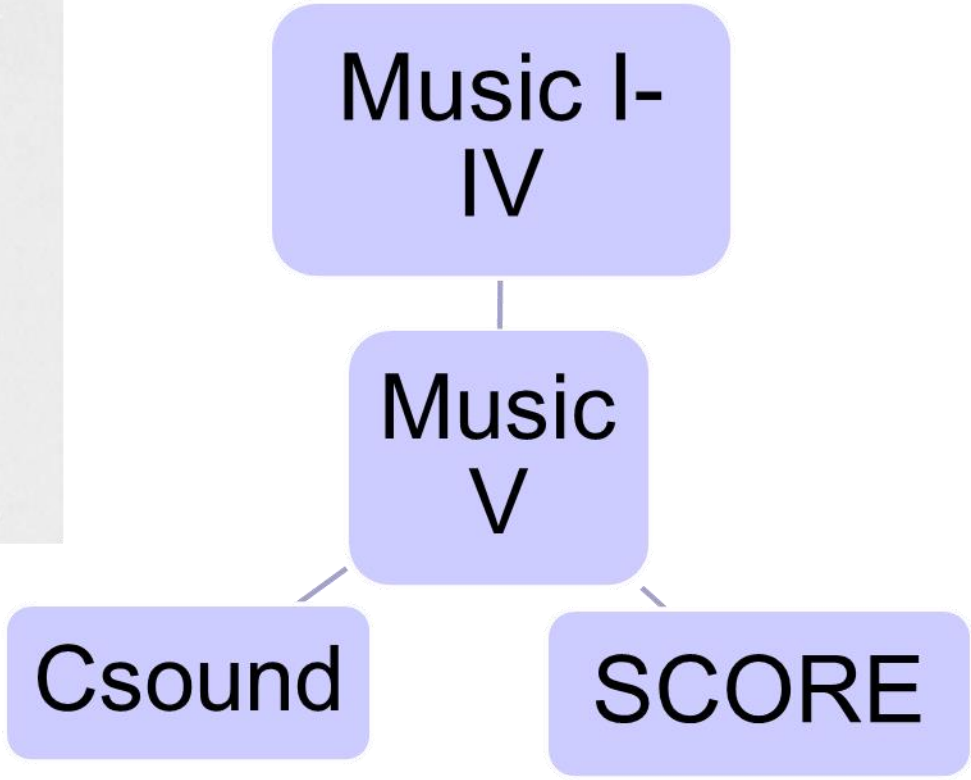


Mathews' influence via Music V

- [Mathews: Owed a debt to Pierre Boulez's wish for similar control for tapes]

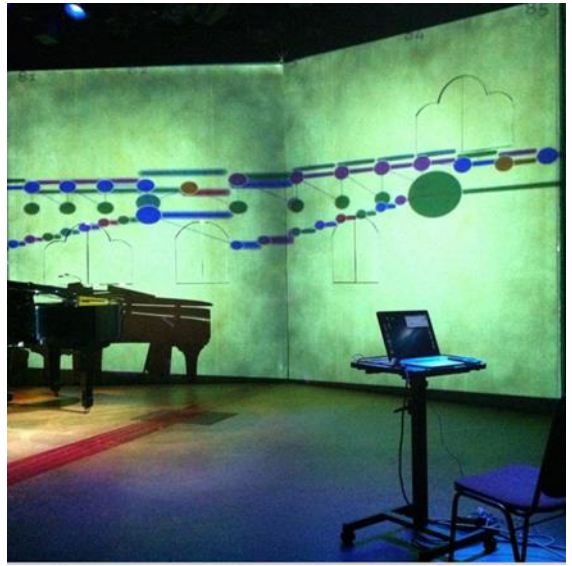
```
1  INS 0 1 ;
2  ØSC P5 P6 B2 F2 P30 ;
3  ØUT B2 B1 ;
4  END ;
5  GEN 0 1 2 0 0 .999 50 .999 205 −.999 306 −.999 461 0 511 ;
6  NØT 0 1 .50 125 8.45 ;
7  NØT .75 1 .17 250 8.45 ;
8  NØT 1.00 1 .50 500 8.45 ;
9  NØT 1.75 1 .17 1000 8.93 ;
10 NØT 2.00 1 .95 2000 10.04 ;
11 NØT 3.00 1 .95 1000 8.45 ;
12 NØT 4.00 1 .50 500 8.93 ;
13 NØT 4.75 1 .17 500 8.93 ;
14 NØT 5.00 1 .50 700 8.93 ;
15 NØT 5.75 1 .17 1000 13.39 ;
16 NØT 6.00 1 1.95 2000 12.65 ;
17 TER 8.00 ;
```

Music V: Sound generation, pre-MIDI

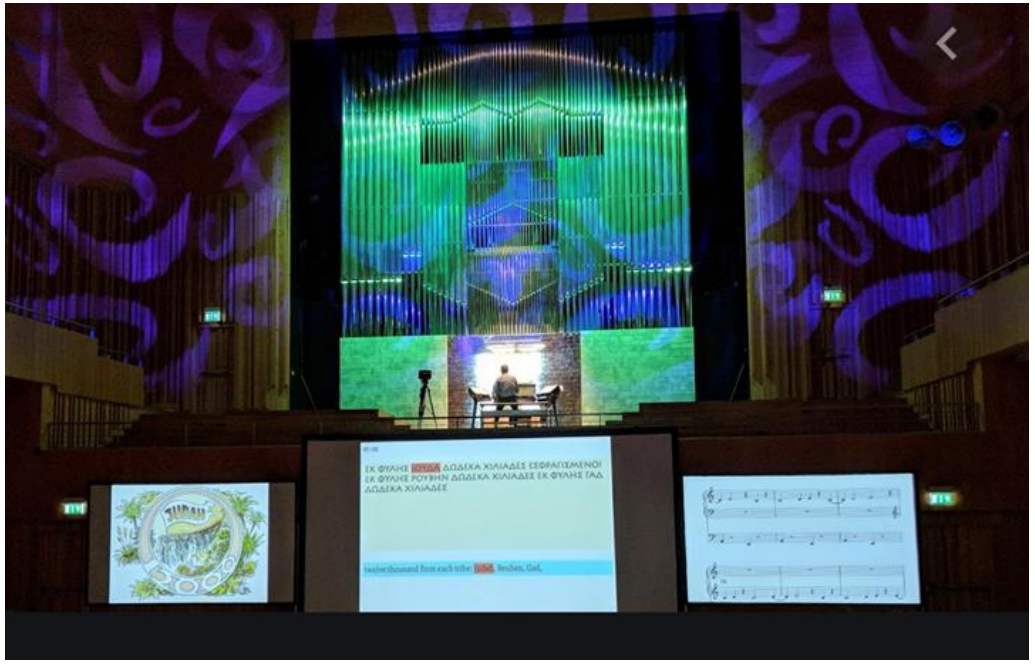


Controller legacies: Malinowski's "cranker"

- Radio Drum file: MIDI files with extra "conducting" track
- Mathews, Beethoven's Fifth, Malinowski (CCRMA, *c*1995)
- Malinowski's cranker for live performances (Hamburg, 2014 et al.)



Don Knuth: *Fantasia Apocalyptica* (2018)

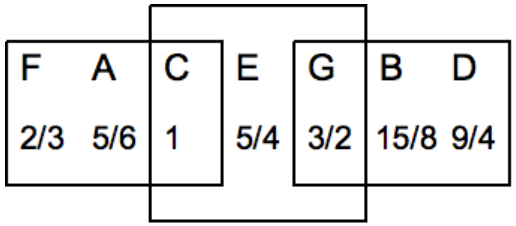


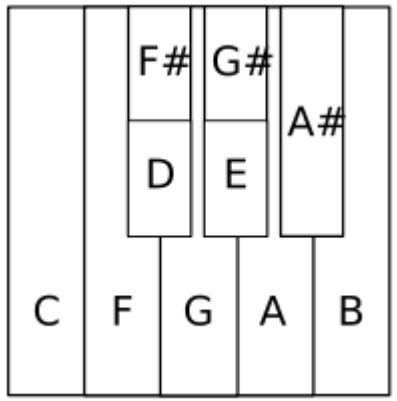
Piteå, Sweden

More info: https://www-cs-faculty.stanford.edu/~knuth/fant.html

Non-equal temperament

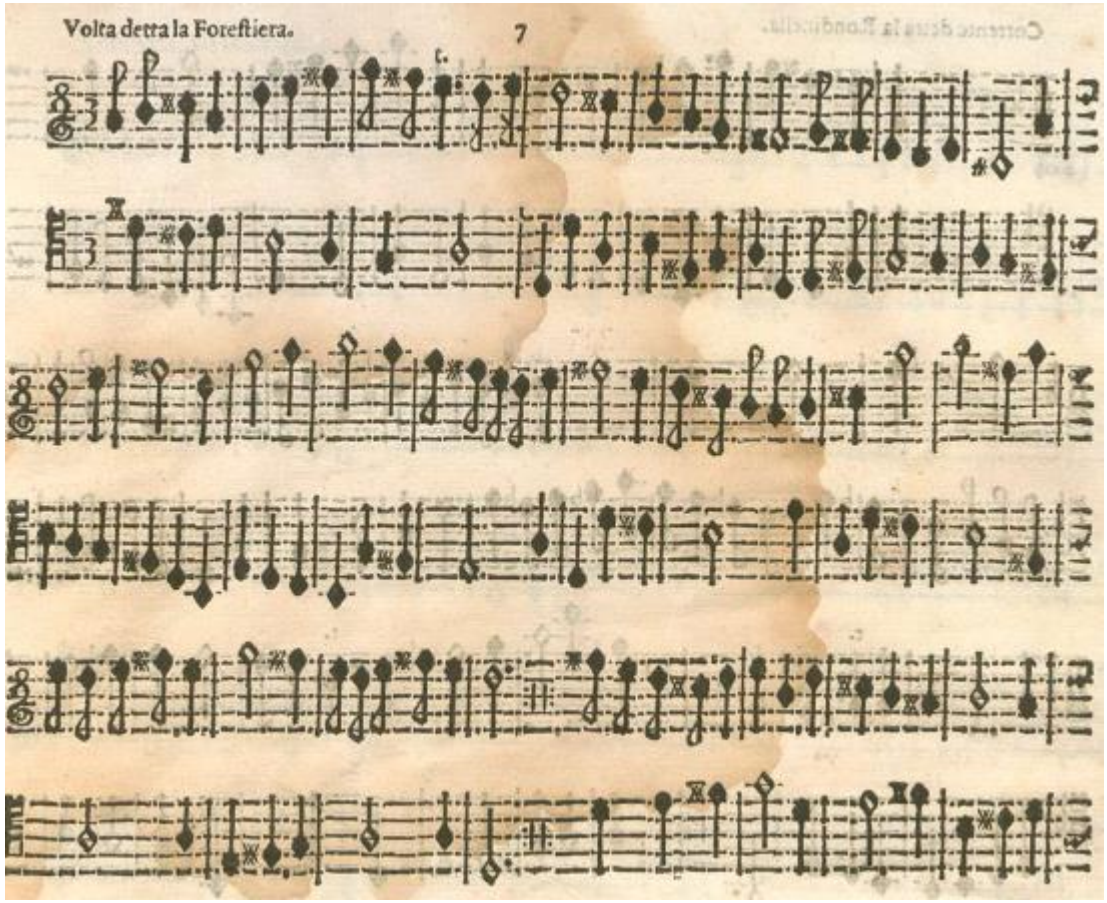
- Baroque tunings (18th century)
  - “Just” intonation
  - Meantone
  - Werckmeister III

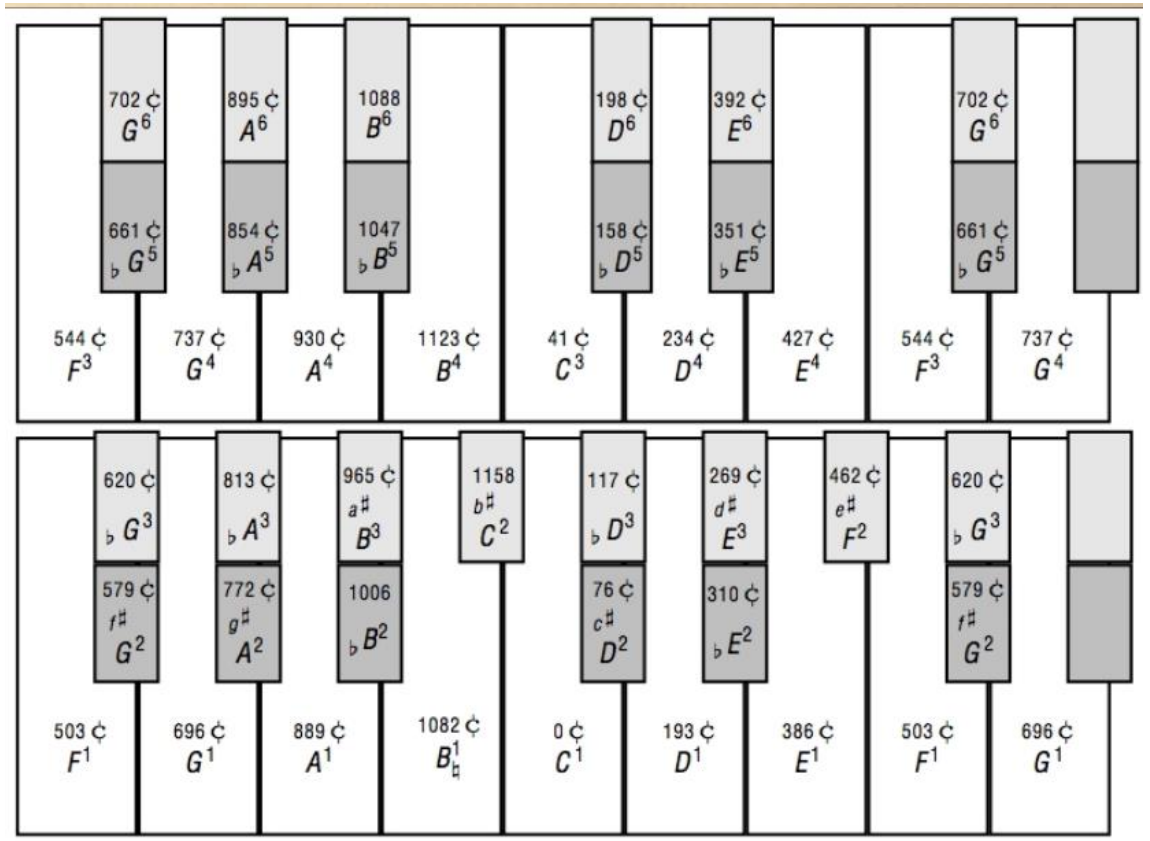




- Arbitrary 8ve arrangements (“short octaves”, split keys)

Vicentino's enharmonic harpsichord
(pitch equivalents in cents)





Music for enharmonic harpsichord (from *c*. 1550) here by Martino Pesenti (c. 1650)

Roland digital harpsichord series (1988--)

- Three modes
  - Equal-tempered
  - Meantone
  - Werckmeister III
- Two acoustic contexts
  - Room
  - Hall
- Two “instruments”
  - Organ
  - Harpsichord
- Five “stops”
  - Harpsichord 1-manual
  - Harpsichord 2-manual
  - Flemish
  - Lute
  - …

https://www.youtube.com/watch?v=zZSlHVifRps

MIDI in use: Historical vs digital harpsichords

- Original 16th-century instrument: National Music Museum, Vermilion, SD
  - https://www.youtube.com/watch?v=aq9iwjyq6u0
- Alteration of tuning, temperament
  - https://www.youtube.com/watch?v=W2gOI1p_0iM [Vallotti tuning, English Renaissance music]
- Split keys, Renaissance harpsichords:
  - https://www.youtube.com/watch?v=D0OveRacKH0