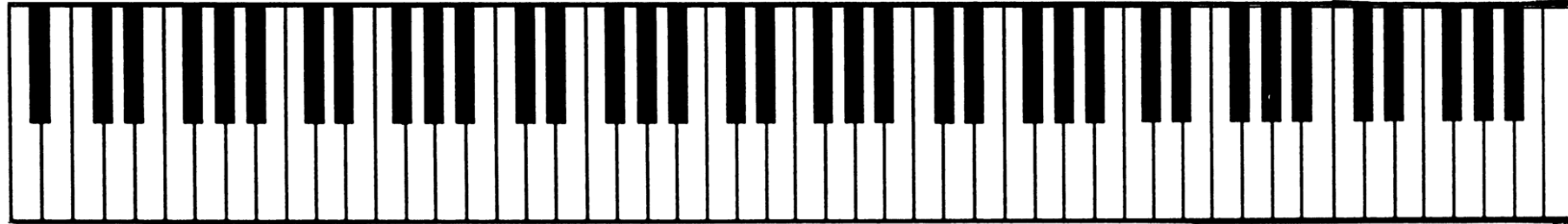


# MIDI and extended pitches

Tuning and Temperament

# “Pitch”: Notated pitch *relative* to key



- Absolute key number      Pitch names are **contextual**
    - 36 etc.
    - 48 C 8ve below Middle C
    - 60 Middle C
    - 72 C 8ve above Middle C
    - 84 etc.
  - Absolute pitch = “90”
- F#/Gb/E##*

# MIDI: Tuning, temperament, expression

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

# Pitch and timbre: Music V and CSound

- **Approaches that define sounds**

- Music V: Max Mathews (Bell Labs, 1960s, 1970s)

- Csound: Barry Vercoe (MIT, 1980s, 1990s)

- score

- scot

- Strengths:

- **decimal** system using **cents** (**frequency**)

- Instruments can be arbitrary (scot)

- Arbitrary objects can be encoded (*pling* command)

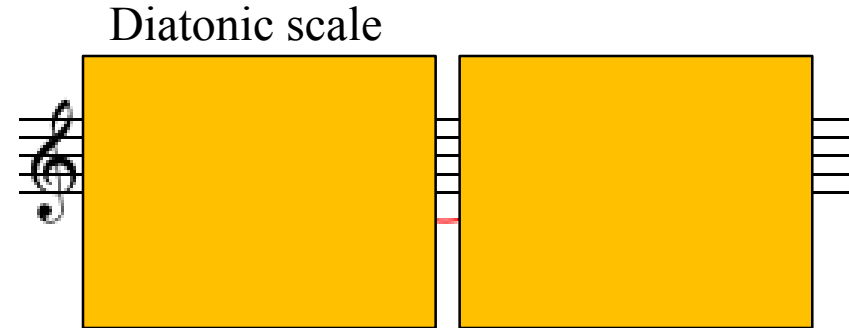
- **Canonical Csound Reference Manual:** <http://csounds.com/manual/html/indexframes.html>

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

# Shortcomings: tuning, Temperament

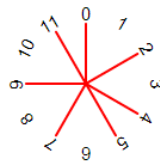
## Pitch

- Non-Western
- Non-equally tempered
- Interpretation of accidentals (inflections)

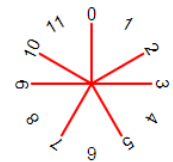


Modes vs. chromatic scale

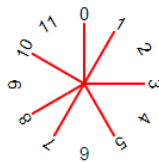
Ionian Mode (I)



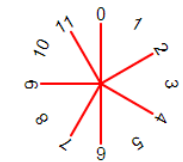
Dorian Mode (II)



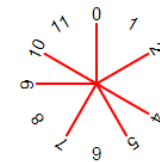
Phrygian Mode (III)



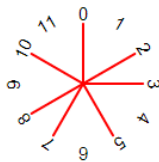
Lydian Mode (IV)



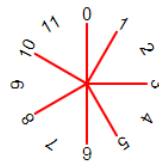
Mixolydian Mode (V)



Aeolian Mode (VI)

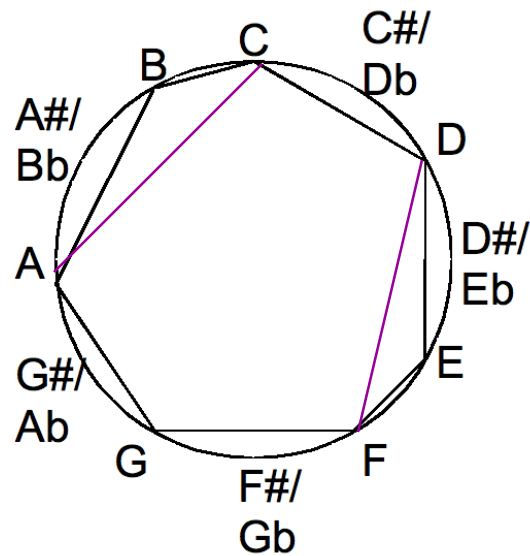


Locrian Mode (VII)



# Mapping (or not) to the chromatic scale

- Diatonic=8 tones
- **Chromatic=12 tones**
- Pentatonic=5 tones



Lady playing tanpura, c. 1735

# 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: Hewlett's MIDIPlus
- See <https://patents.google.com/patent/US5675100A/en?inventor=Hewlett+Walter+B.&q=Hewlett+Walter+B.>

# Hewlett's MIDI Plus for accurate tonal notation

(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](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:**

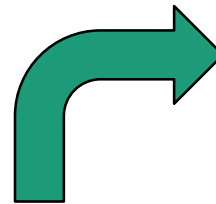
00 not known

01 Gb

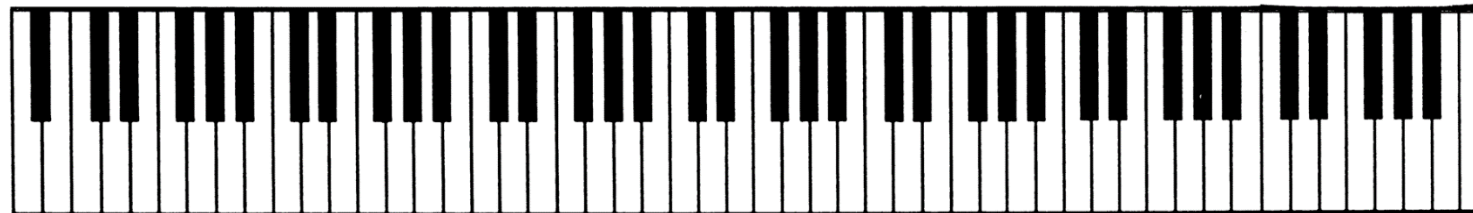
10 F#

11 E (E##)

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



BINARY →	x	64	32	16	8	4	2	1
DECIMAL ↓								
		1	0	1	1	0	0	0
		1	0	1	1	0	0	1
		1	0	1	1	0	1	0
		1	0	1	1	0	1	1
		1	0	1	1	1	0	0



# MIDI Plus

(How to make MIDI enharmonically accurate)

- **Method**

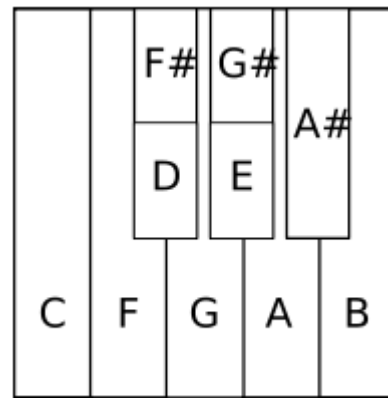
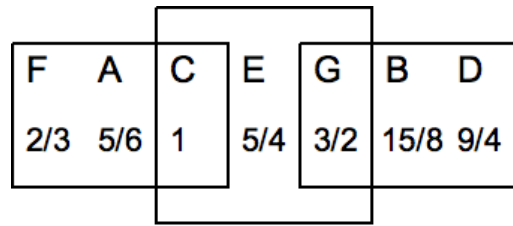
Reassign two bits from velocity byte

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

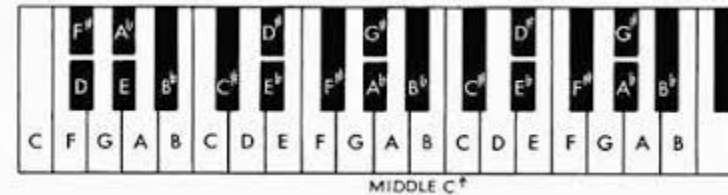
BINARY → DECIMAL ↓	x	64	32	16	8	4	2	1
88		1	0	1	1	0	0	0
89		1	0	1	1	0	0	1
90		1	0	1	1	0	1	0
91		1	0	1	1	0	1	1
92		1	0	1	1	1	0	0

# Non-equal temperament

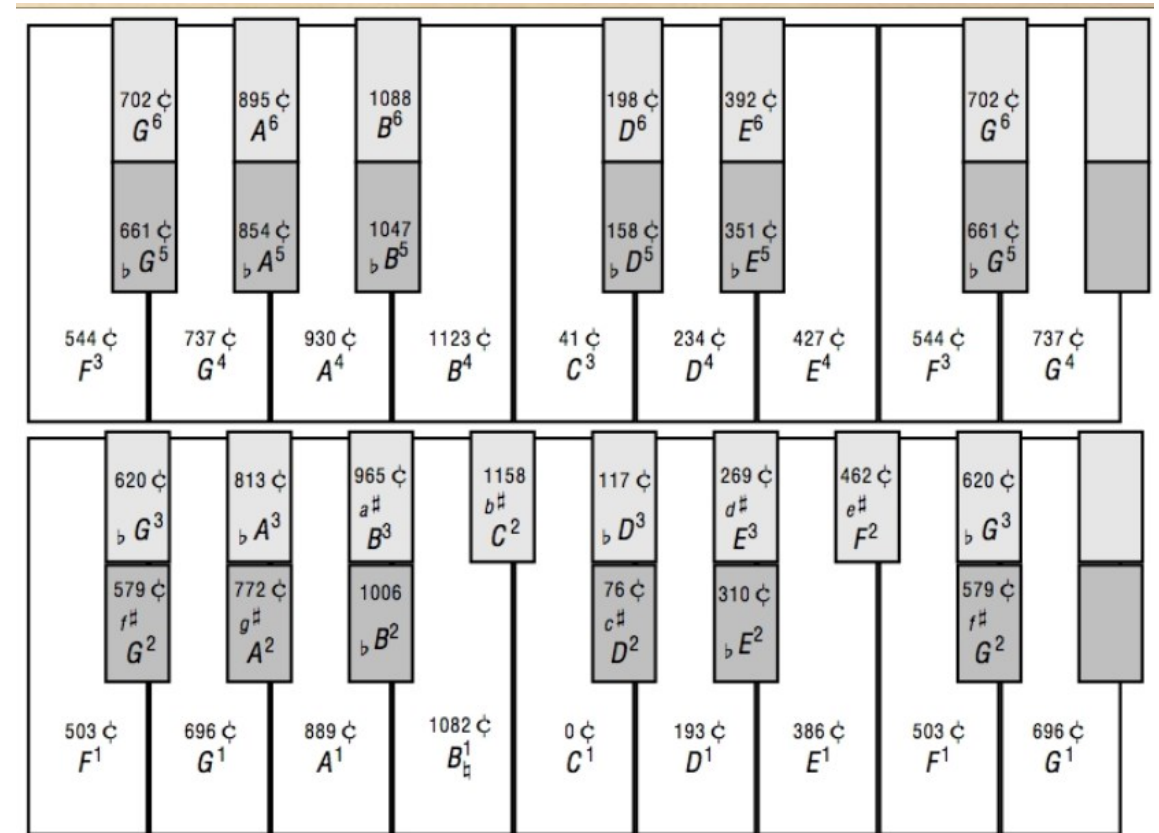
- Baroque tunings
  - “Just” intonation
  - Meantone
  - Werckmeister III



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



# Vicentino's enharmonic harpsichord (pitch equivalents in cents)



# 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=zZSIHVifRps>



# MIDI in use: Historical vs digital harpsichords

- Original 16<sup>th</sup>-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](https://www.youtube.com/watch?v=W2gOI1p_0iM) [Vallotti tuning, English Renaissance music]
- Split keys, Renaissance harpsichords:
  - <https://www.youtube.com/watch?v=D00veRacKH0>