

# New directions in ergonomic headjoints



**Katherine Saenger**  
New York Flute Fair  
April 11, 2021

# OUTLINE

**Presenter (KS) interests and background**

**What's an ergonomic headjoint?**

**What's out there already:**

- Designs, past and present
- Hardware options for holding the flute
- Additional resources

**My “Articulated Tee” Headjoints**

- Motivation (what got me started)
- Project goals and scope
- The basic design (and why I like it)
- Favorite configurations (from the infinite possibilities)
- Factors affecting playability and intonation/harmonicity

**Break for questions/discussion**

**How do they sound? Your choice of video demos...**

**Topics NOT for this presentation**

- A step-by-step guide to fabrication
- Measurements and simulations used for optimization (hopefully this will be a paper....)
- Plans for future collaboration and/or commercialization

## About me:

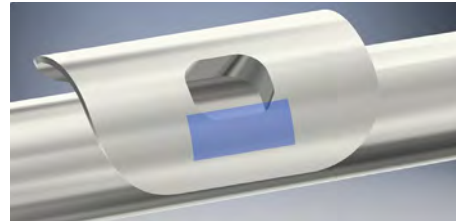
Longtime avocational flutist and  
now-retired IBM scientist/inventor



## Some past flute-related projects:

### Acoustic knife-edge:

[*Flutist Quarterly* Vol. XXII, Fall  
1996; NY FF 2017]



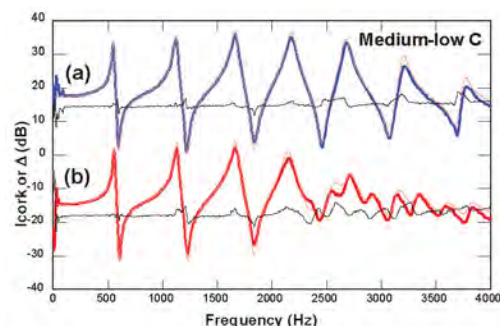
### Artificial blowers:

“MechMouth: the mechanical student flutist,” for  
longtones and teaching demos [NY FFs in 2014, 2015]



### Measurements and modeling:

“A pressure-based transfer matrix  
method and measurement technique  
for studying resonances in flutes and  
other open-input resonators” [*J.  
Acoust. Soc. Am.* **147**, 2556 (2020)]



**This work (today):** New directions in ergonomic headjoints

## **What's an ergonomic flute headjoint?**

**A headjoint that allows the flute to be played in a more comfortable position.**

**Shape the flute to fit the player**

**vs.**

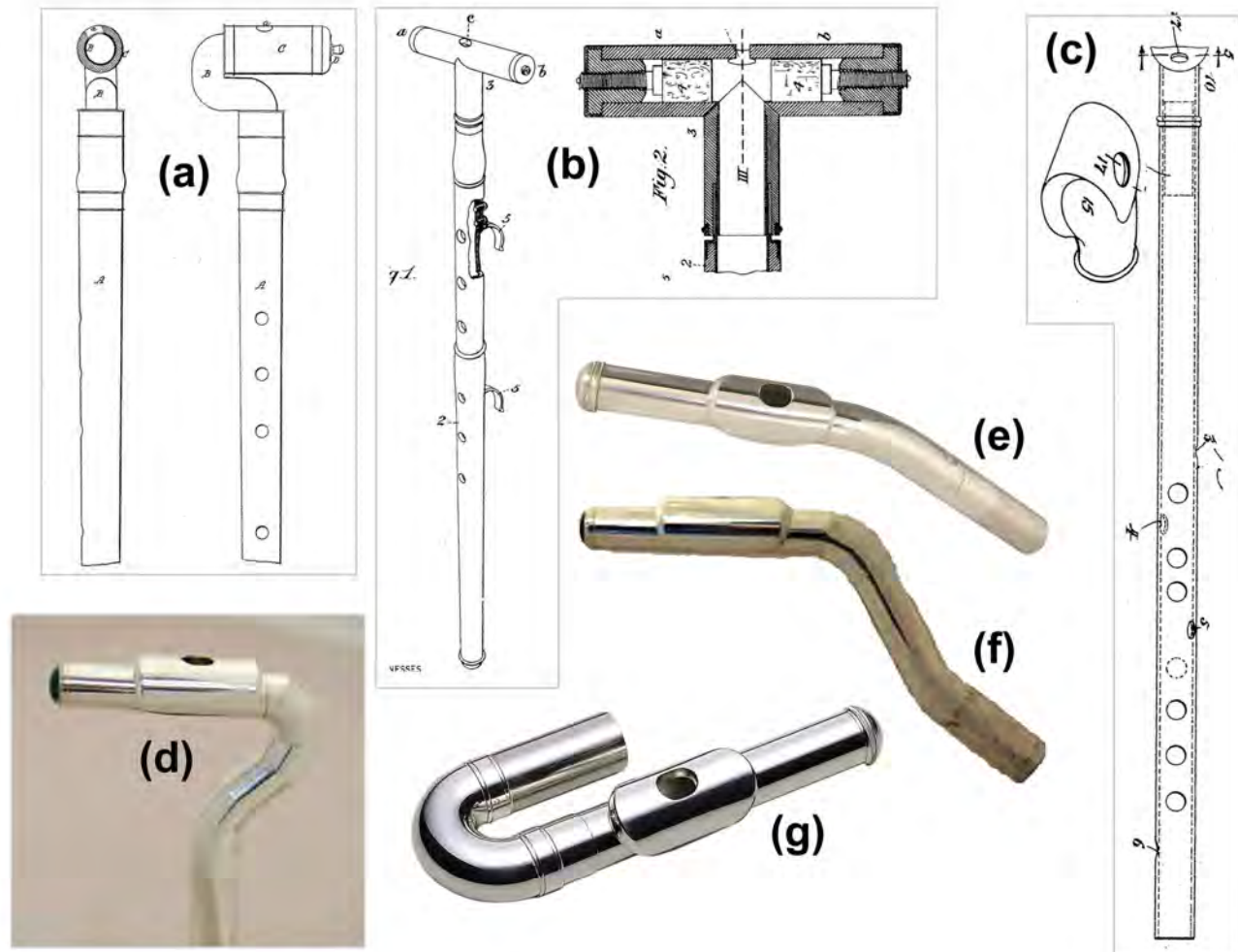
**Making the player adapt to a “one-size-fits-all” flute, risking discomfort and injury.**

**Ergonomic headjoints typically used by**

- **Children with short arms**
- **Older adults with musculoskeletal disorders (temporary or permanent)**

**Ergonomic headjoints NOT much used by professionals...**

# What's out there already: Flute/headjoint designs, past and present



## Examples of ergonomic flutes and headjoints:

- a) Pfaff's transversely-blown vertical flute (US Patent dated 1857)
- b) Guenther's end-blown vertical Tee flute (US Patent, dated 1891)
- c) Giorgi's end-blown vertical flute (US Patent, dated 1897)
- d) a modern version of a Pfaff headjoint by M. Visser ([flutelab.com](http://flutelab.com))
- e) an angled headjoint by Albert Cooper
- f) a swan headjoint by M. Visser ([flutelab.com](http://flutelab.com))
- g) a generic modern recurved headjoint

## Not shown:

Drelinger's version of the Pfaff and Wesley's version of the Giorgi<sub>5</sub>

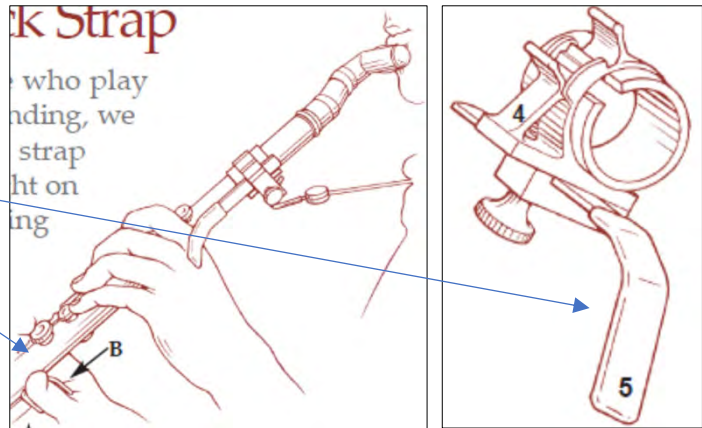


# An underappreciated component: SUPPORT HARDWARE

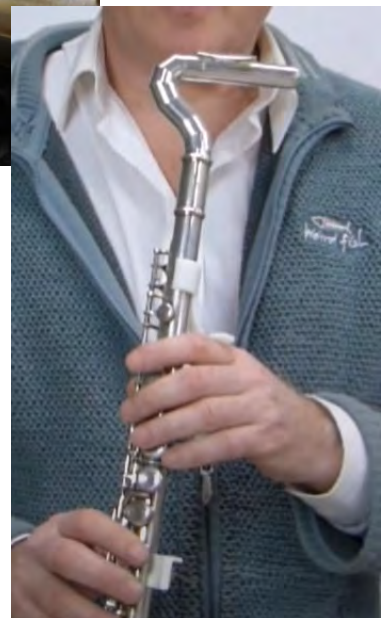
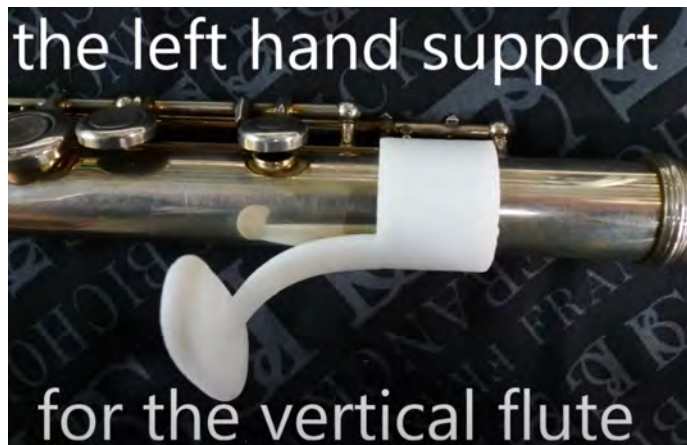
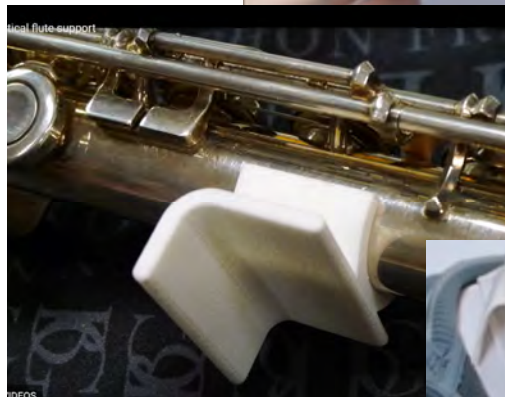
What's out there already:

## Drelinger UpRite

support hardware includes a left-hand support, neck strap, right thumb rest, and (not shown) a knee support



## FluteLab (Martin Visser)



# For more information, check out:

## National Flute Association website:

[nfaonline.org/committees/performance-healthcare-committee](https://nfaonline.org/committees/performance-healthcare-committee)

- Chip Shelton's summary of the 2018 NFA convention presentation, *"Flute Pain: Is the keyed, Boehm system, End Blown Flute a Viable Adjunct?"* (article link, bottom of page)

## Martin Visser website: [flutelab.com](https://flutelab.com)

- Links to *"Reshaping the flute"* ([flutelab.com/wp-content/uploads/2020/04/Reshaping-the-Flute.pdf](https://flutelab.com/wp-content/uploads/2020/04/Reshaping-the-Flute.pdf))
- an online guide to buying adaptive musical instruments ([takeitaway.org.uk/wp-content/uploads/2020/06/Guide-to-Buying-Adaptive-Musical-Instruments.pdf](https://takeitaway.org.uk/wp-content/uploads/2020/06/Guide-to-Buying-Adaptive-Musical-Instruments.pdf))



## Chip Shelton website: [chipshelton.com](https://chipshelton.com)

- Chip is a NYFC member, frequent Flute Fair presenter, and member of the NFA's Performance Health Care Committee.
- Some nice videos, including his 2020 Flute Fair presentation, *"Playing without Pain: Prevention and Management"*
- *"Ergonomic Headjoint Design,"* Flutist Quarterly **44**, 4-59 (2019).



# Motivation (what got me started)

NYFC member **Malcolm Spector** needed an ergonomic headjoint. In August 2019 he bought one and let me try it.

**My impression:**  
**Uninspiring tone quality, poor intonation...**  
**I bet I could do better.**

**By this time, I had**

- A nice basement shop (with a micro lathe and mini milling machine)
- Community-college courses in CAD, 3-D printing, and machining
- Some new techniques for measuring and modeling the flute's passive resonances

**as a supplement to**

- A longstanding interest in flute headjoint acoustics
- Some early 1980s experience making flute headjoints with parts from Emerson



## **PROJECT GOAL**

**A headjoint for a conventional Boehm flute  
with**

- a range of comfortable playing positions
- great sound quality and playing characteristics

### **Design approach:**

**Modular construction with interchangeable parts**

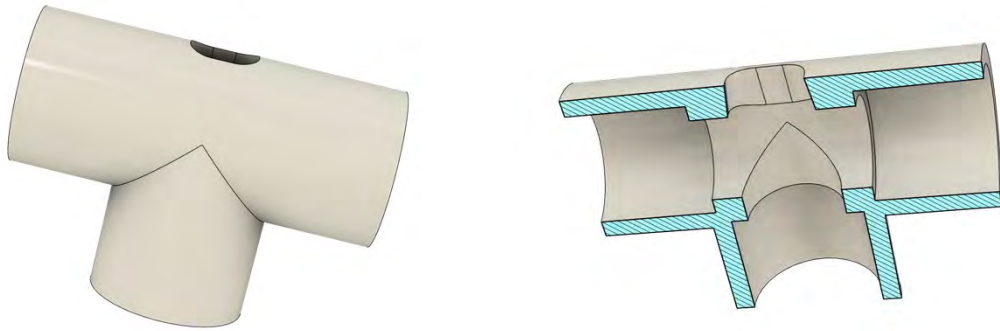
- Effects of single components can be isolated (for easier optimization)
- No need to restart from zero if one part is bad (easier manufacturability)
- Maximize use of off-the-shelf components

### **Status:**

Goals mostly met, though the adaptive headjoints may not be a first choice for top-tier professional flutists (sound quality closer to good than great)

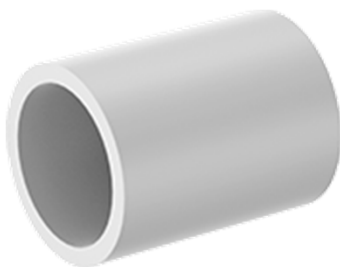
## THE BASIC DESIGN

- Embouchure hole in a 1/2" PVC Tee



- A modular jointed neck connecting Tee to flute

Options for joints:



Straight (0o)



22.5o elbow



45o elbow

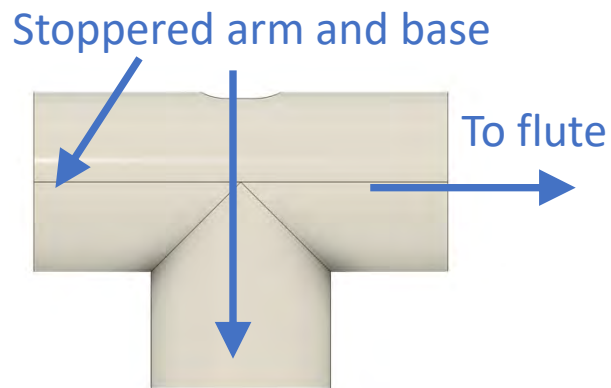


Double 45o elbow

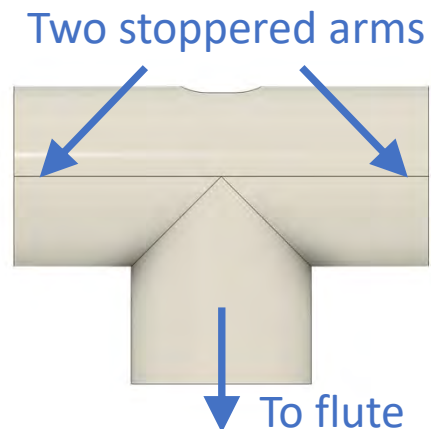
## THE BASIC DESIGN (and why I like it)

The same Tee can be played in two configurations  
(though switching takes a bit of work)

### TRANSVERSE ("conventional")



### VERTICAL/END-BLOWN) (like the Giorgi, Guenther, and Wesley flutes)



The modular jointed neck allows a  
huge range of positions.  
Let's take a look at this flexibility....

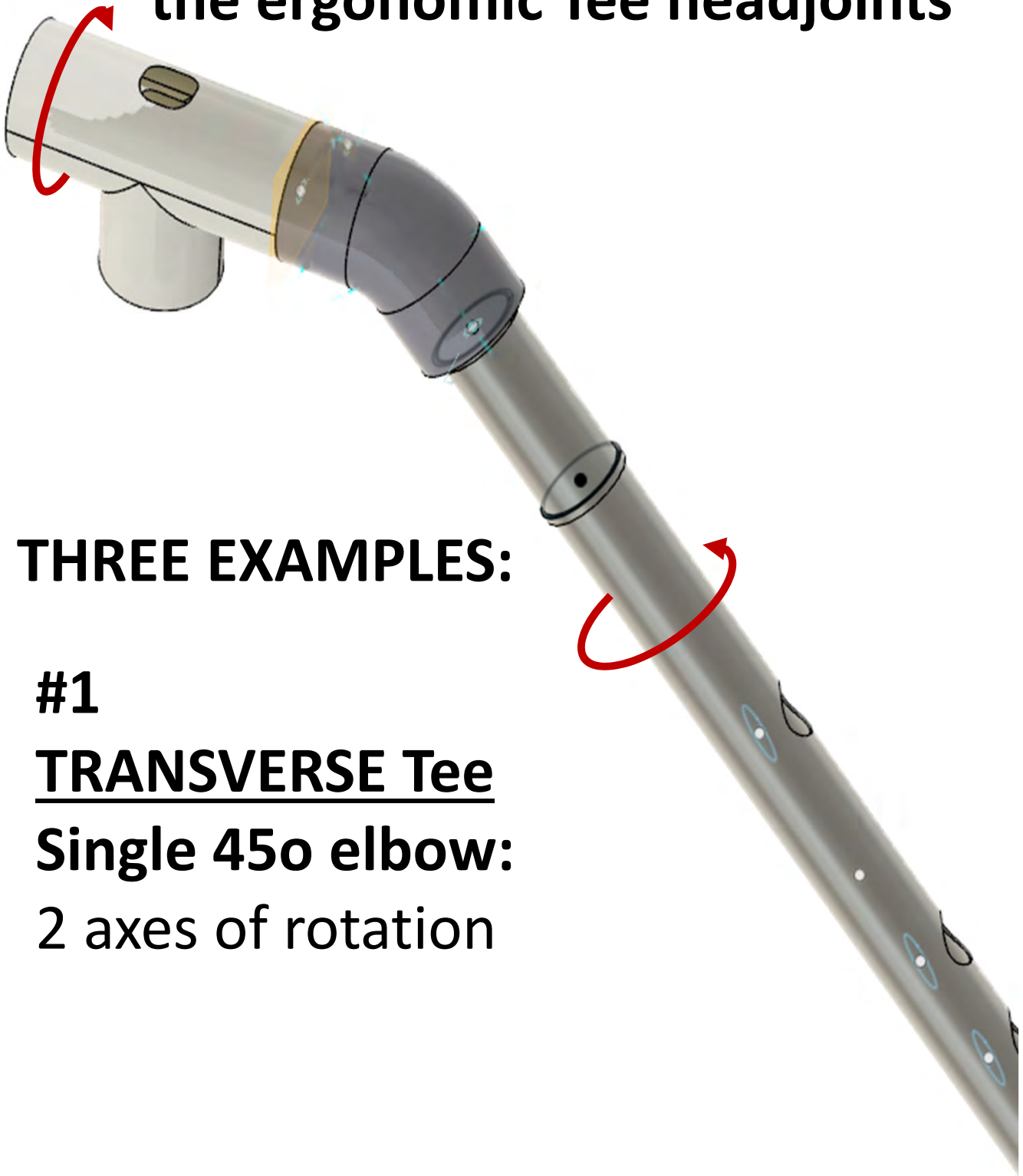
# “CONVENTIONAL” TRANSVERSE FLUTE



**Limited positional flexibility:**

Only ONE axis of rotation

**More positional flexibility with  
the ergonomic Tee headjoints**



**THREE EXAMPLES:**

**#1**

**TRANSVERSE Tee**

**Single 45o elbow:**

**2 axes of rotation**



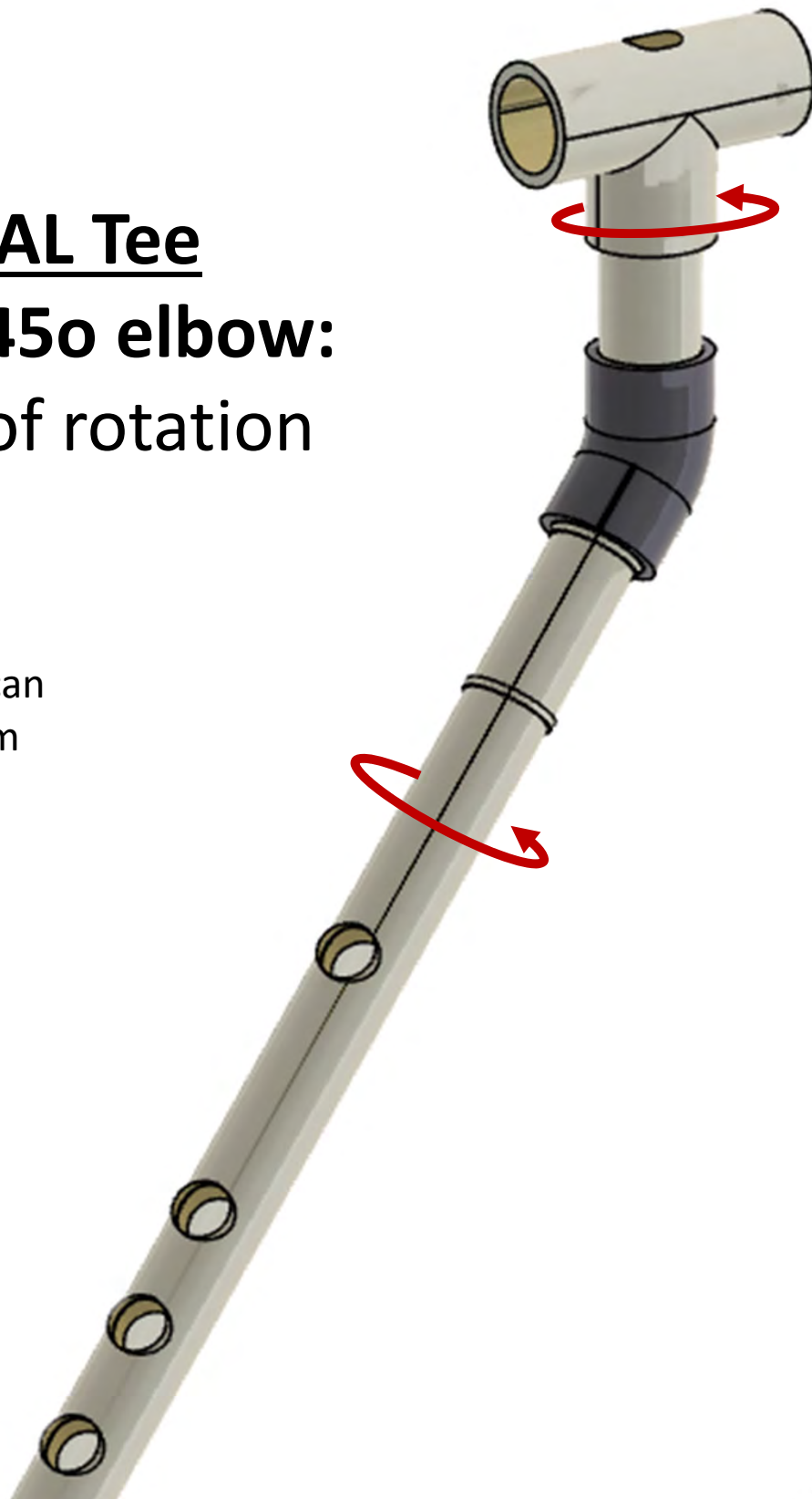
**#2**

## **VERTICAL Tee**

**Single 45o elbow:  
2 axes of rotation**

Note:

Vertical Tees can  
be played from  
either side.



**#3**

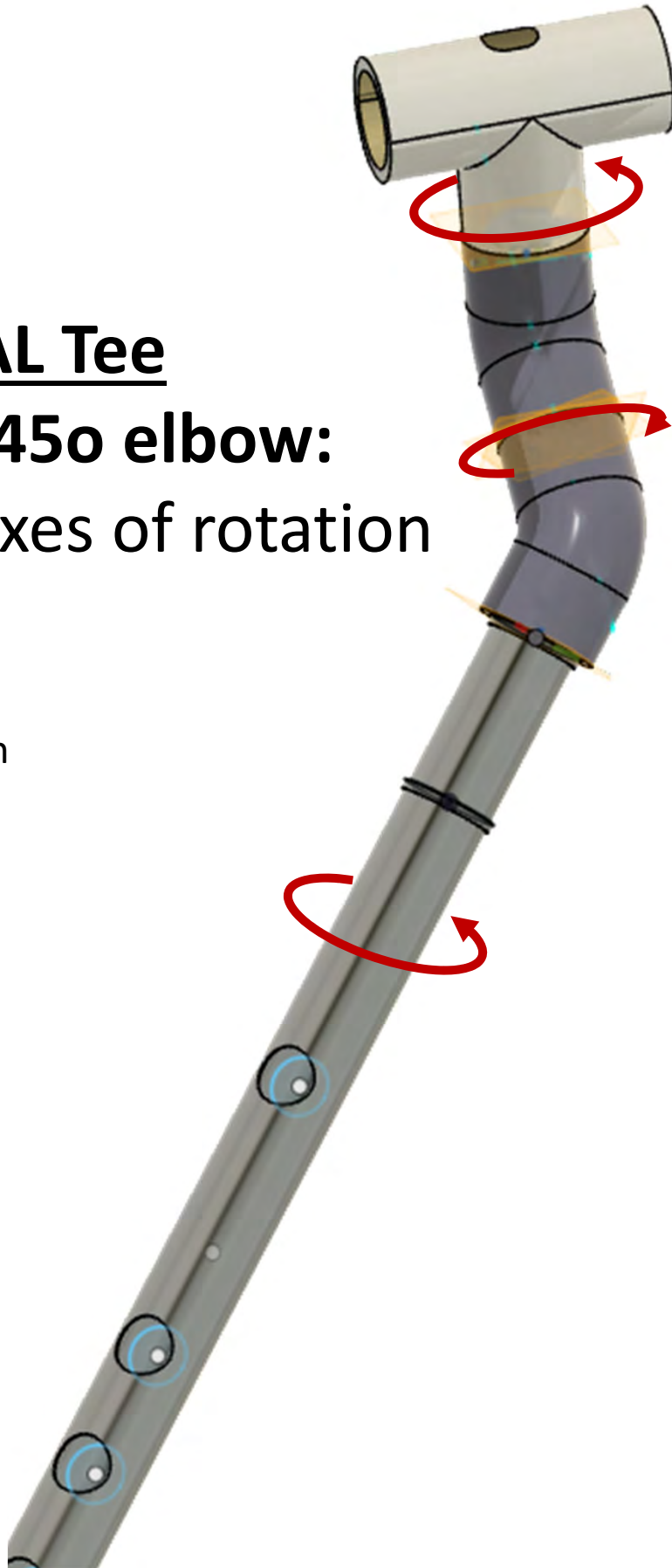
## **VERTICAL Tee**

**Double 45o elbow:**

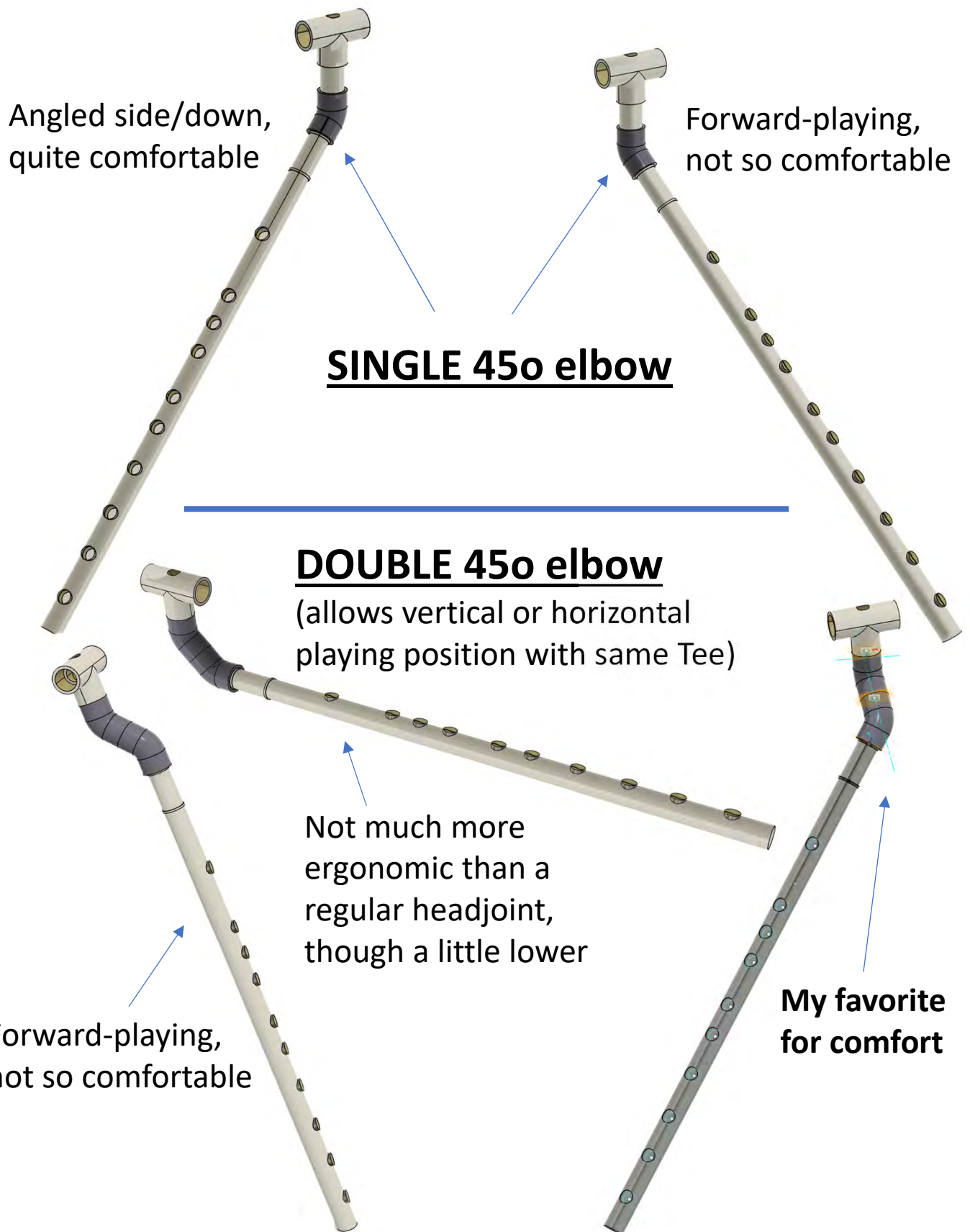
**THREE axes of rotation**

Note:

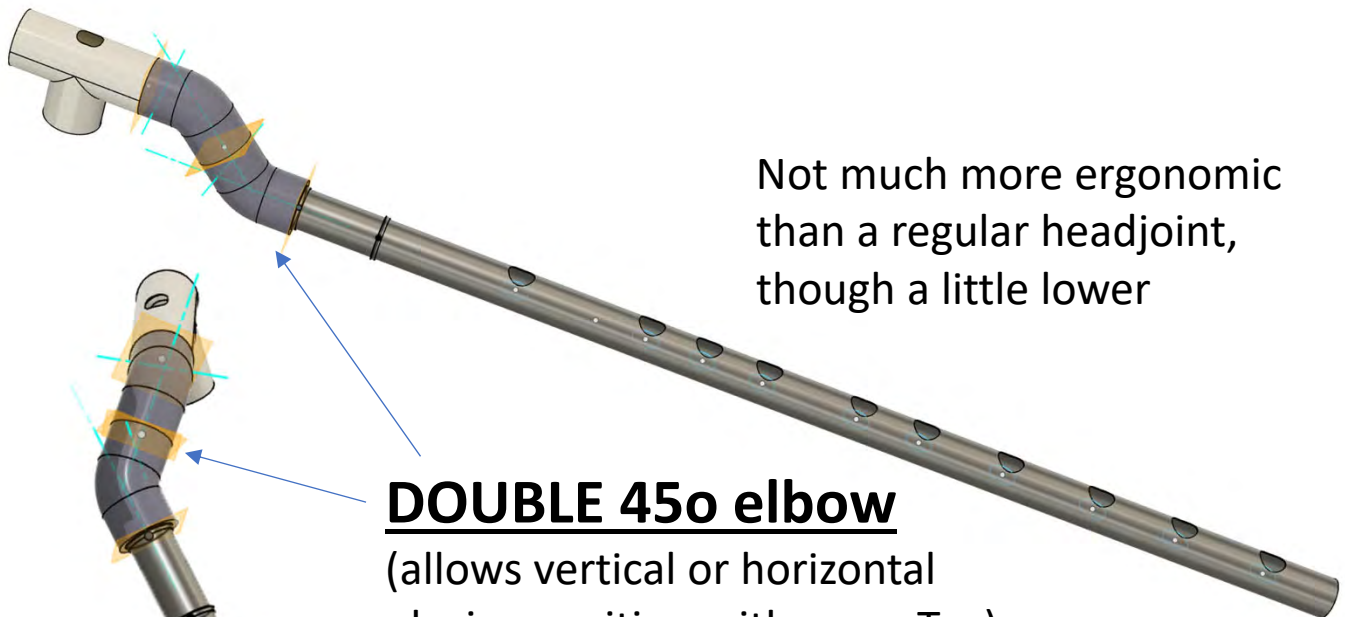
Vertical Tees can  
be played from  
either side.



## VERTICAL Tee options (not all ergonomic...)



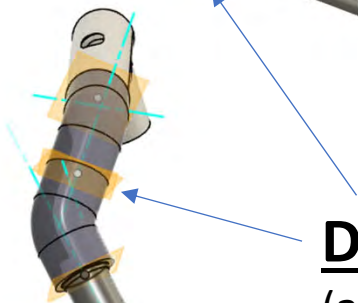
## TRANSVERSE Tee options (not all ergonomic)



Not much more ergonomic than a regular headjoint, though a little lower

### DOUBLE 45o elbow

(allows vertical or horizontal playing position with same Tee)



### SINGLE 45o elbow

Probably the best of the transverse Tee options; almost as comfortable as my favorite vertical Tee



Angled side/down: playable, but not a favorite

# BOTTOM LINE on ERGONOMICS:

A huge range of positions are available with the modular jointed neck.

The odds are good that one will be right for you....

***Cautionary note:** if you find a double elbow configuration that you particularly like, write down the exact angle settings of joints to be sure you can get back to it!*



## NEXT: SUPPORT HARDWARE

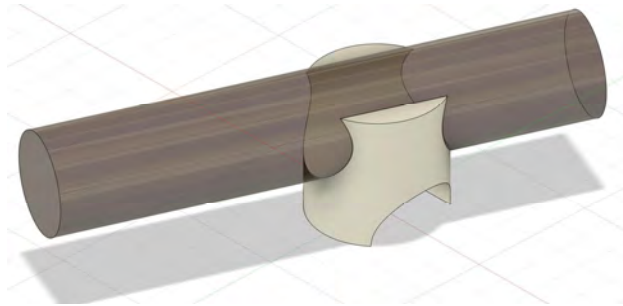
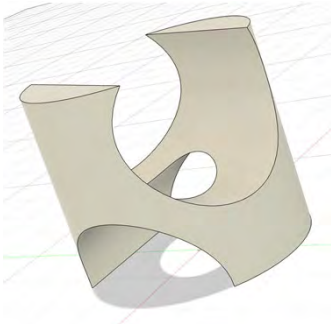


## Support hardware: More necessary as flute orientation becomes more vertical.

- Normal support points are (i) base of left index finger and (ii) right thumb.
- Orchestral excerpts with high G# work well as a test.
- The supports shown below work well for me.

### Delrin supports (machined from rods or tubes):

**RIGHT THUMB support:** snaps on to flute body near the R index finger hole

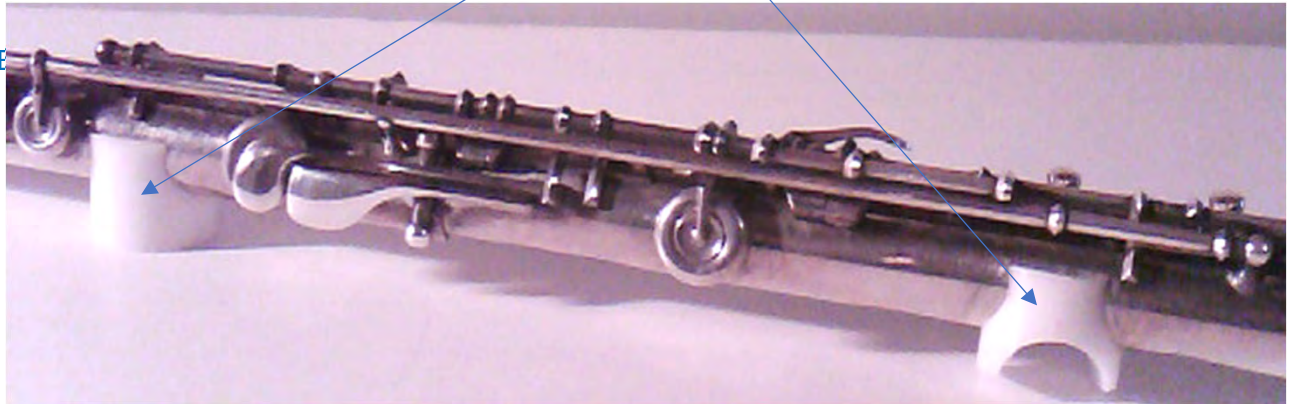


**LEFT HAND support:** snaps on to flute body just upstream of the thumb key



# Images of support hardware installed on the flute

BELOW: Flute with **left-hand support** and **right thumb support** in place.



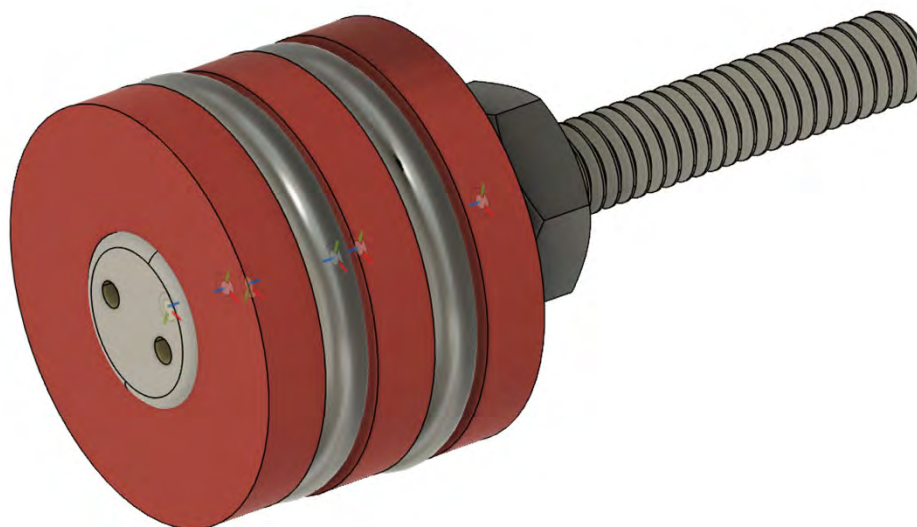
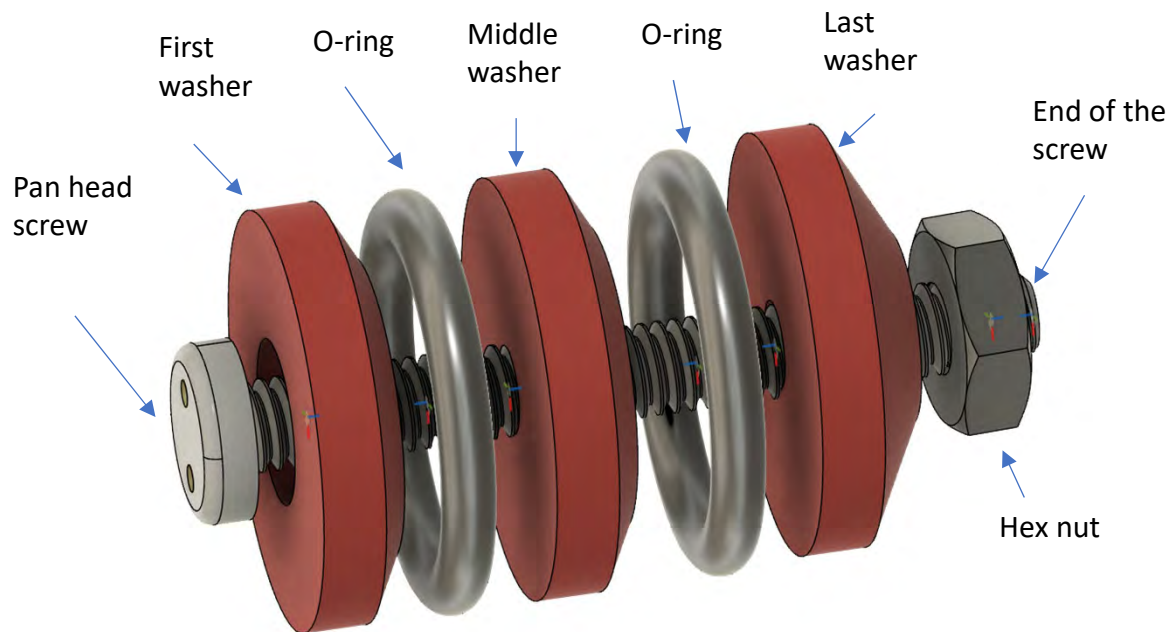
RIGHT: **Left-hand support** on flute with my favorite version of the double-elbow vertical Tee.



LEFT: Both supports with hands in playing position

# The cork assembly (part of the infrastructure...)

**Below: the core parts of the cork assembly before tightening**



**Above: The basic cork assembly after tightening**

## NEXT: PLAYING CHARACTERISTICS

*A comfortable playing position is only part of the solution...*

How does the headjoint sound?

## INTONATION and HARMONICITY

Intonation: how well the played notes are in tune

- in absolute terms (typically you want your low A at 440-442 Hz)
- relative to the other notes in the scale

Harmonicity: how well the instrument's upper resonances line up (important for tone quality).

Typically the frequency of the  $n$ th resonance ( $f_n$ ) is approximately an integer multiple of the fundamental ( $f_1$ ):

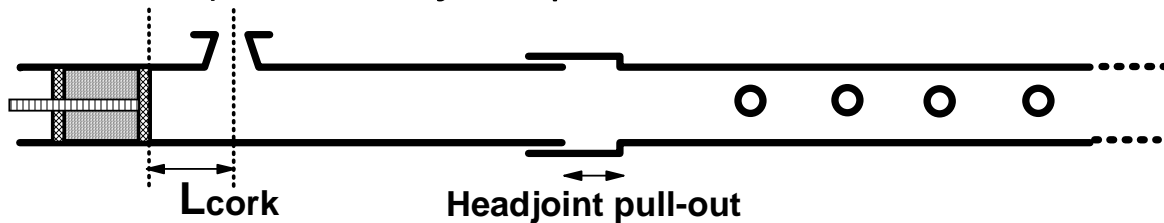
$$f_n \approx n \cdot f_1$$

$n$  is an integer ( $n=1, 2, 3, 4$ , etc.)

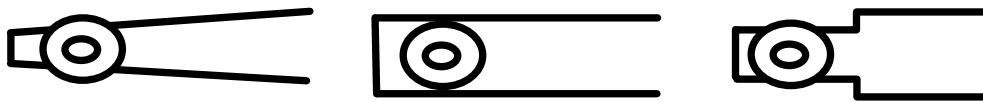


## Headjoint factors affecting harmonicity and intonation:

- Cork-to-embouchure hole spacing ( $L_{\text{cork}}$ , normally  $\sim 17\text{mm}$ ) and headjoint pull-out

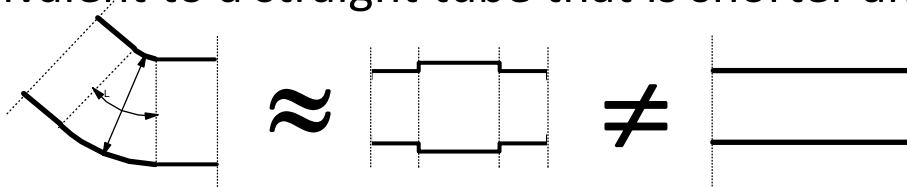


- Bore diameter/shape (tapered, cylindrical, stepped...)

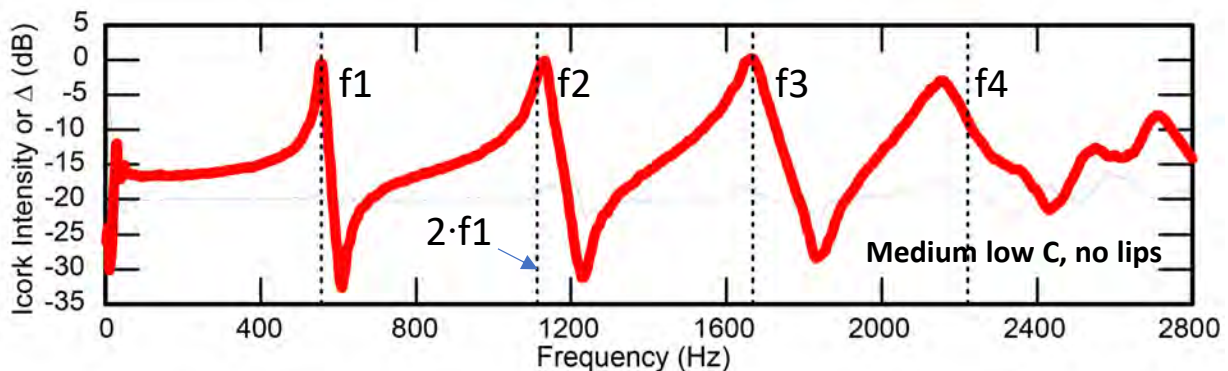


## Some little-known acoustical facts relevant to ergonomic headjoint construction:

- A tube with a bend is approximately (but not exactly) equivalent to a straight tube that is shorter and wider.



- Most good flutes are not perfectly harmonic: supposedly best if the 2nd resonance is a bit sharp ( $\sim 20$  cents), a characteristic known as a “wide octave.”



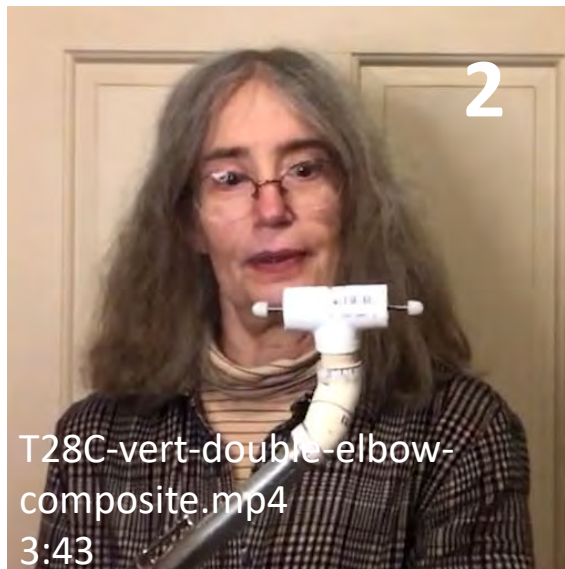
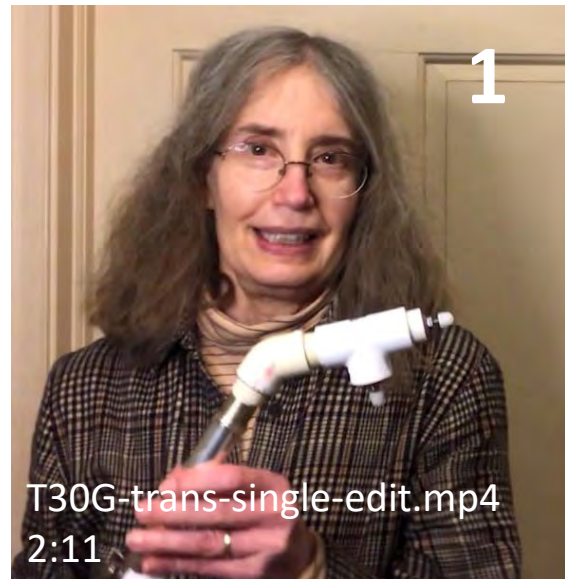


**There are more little-known facts, but these are enough for now.....**

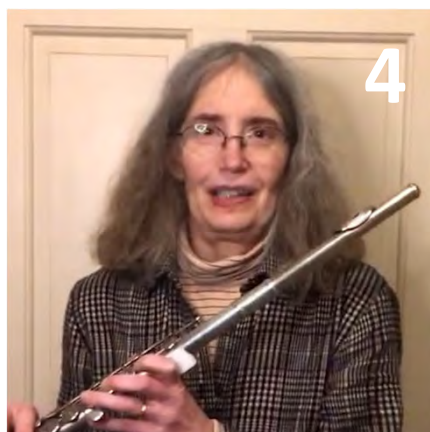
**Any QUESTIONS?**

**For offline questions contact me at [klsaenger@yahoo.com](mailto:klsaenger@yahoo.com)**

**Now it's time for the video demos.....**



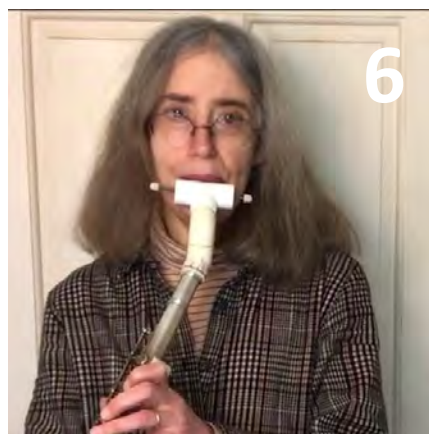
# *How do they sound?*



Ergonomic-Brannen-120.mp4 1:49



T30G-trans-double-edit.mp4 1:58



Ergonomic-T31C-vert-double-124-edit.mp4 2:03



T31C-vert-double-sax-edit-127.mp4  
2:18

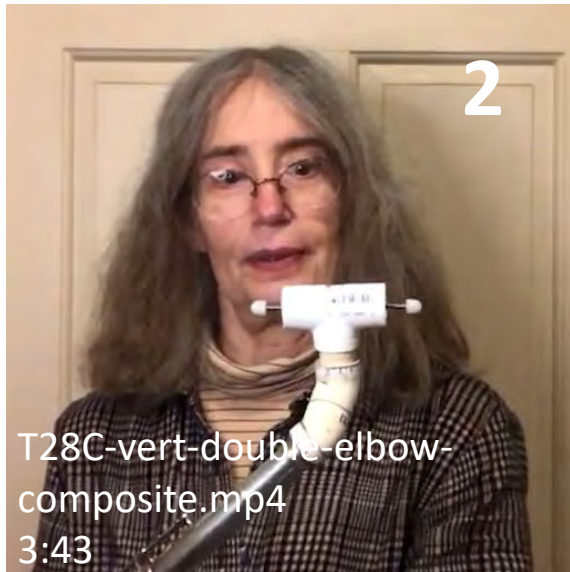




***How do they sound?***

[https://youtu.be/7KNVVk\\_2CZs](https://youtu.be/7KNVVk_2CZs)





2

***How do they sound?***

<https://youtu.be/IgUbsqRPWy0>







3

***How do they sound?***

<https://youtu.be/7NusKxYFyg8>





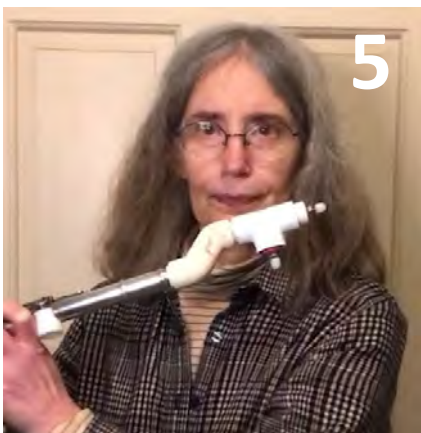


***How do they sound?***

Ergonomic-Brannen-  
120.mp4 1:49

[https://youtu.be/\\_9YGajz92vQ](https://youtu.be/_9YGajz92vQ)





***How do they sound?***

T30G-trans-double-  
edit.mp4 1:58

<https://youtu.be/zgHLAyA4z4c>



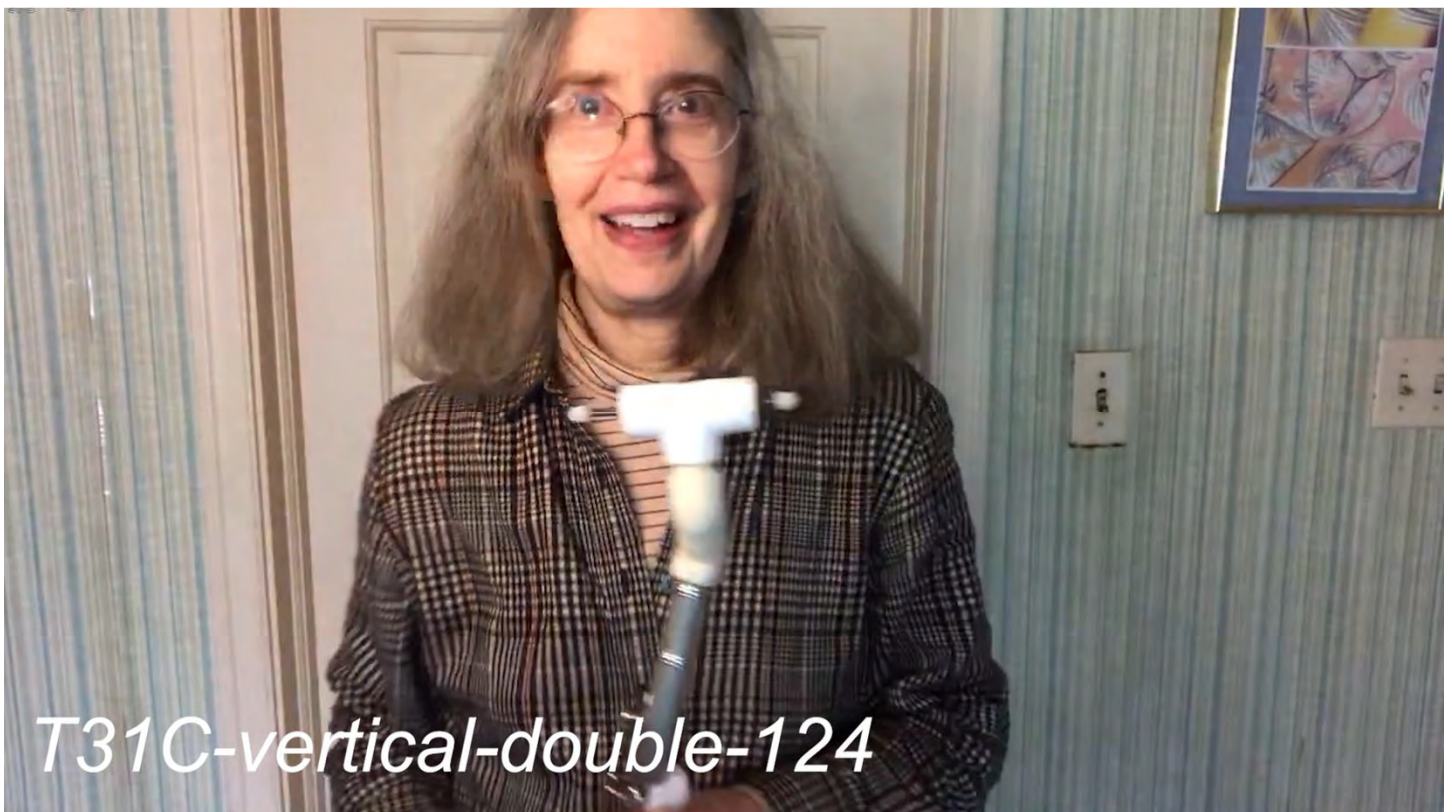




## ***How do they sound? Video 6***

Ergonomic-T31C-  
vert-double-124-  
edit.mp4 2:03

<https://youtu.be/kC8TX0eupew>





***How do they sound?***

T31C-vert-double-  
sax-edit-127.mp4  
2:18

[https://youtu.be/Bsz9m\\_CwGp8](https://youtu.be/Bsz9m_CwGp8)



## ABSTRACT

### **New directions in ergonomic headjoints**

Flutists interested in finding a more ergonomic headjoint for use with an existing flute have limited choices. After a brief review of currently available options, scientist/inventor Kathy Saenger will describe some ergonomic headjoints she has been making in her home lab. The design features an embouchure hole in a Tee-shaped fixture that can be attached to the flute either vertically (via the Tee base) or transversely (via one of the Tee arms) by means of one or more tube segments and rotatable joints. Factors affecting playability, intonation/harmonicity, and mechanical stability will be discussed in general terms, followed by side-by-side demonstrations of several preferred Tee configurations and a traditional headjoint reference.

## BIO

Scientist/inventor **Katherine Saenger** retired from the IBM T.J. Watson Research Center in 2013 after a 30-year career in semiconductor technology and materials science. Since then she has been working in her home lab pursuing interests in flute acoustics, artificial blower development, and ergonomic headjoint construction. She received an AB in physics from Barnard College in 1975 and a PhD in chemical physics from Harvard University in 1981. As a young flutist, she studied with John Wummer, Harold Bennett, and Thomas Nyfenger. She has been editor of the *NYFC Newsletter* since 1999 and is currently the NYFC's membership secretary and webmaster.

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